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IAEA

International Atomic Energy Agency

INDC

INTERNATIONAL NUCLEAR DATA COMMITTEE

Summary Report of the Technical Meeting on

International Network of Nuclear Reaction Data Centres

IAEA Headquarters, Vienna, Austria

14 – 17 June 2022

Prepared by

Naohiko Otuka
IAEA Nuclear Data Section, Vienna, Austria

and

Sandor Takács
Institute for Nuclear Research (ATOMKI), Debrecen, Hungary

August 2022

IAEA Nuclear Data Section, Vienna International Centre, A-1400 Vienna, Austria

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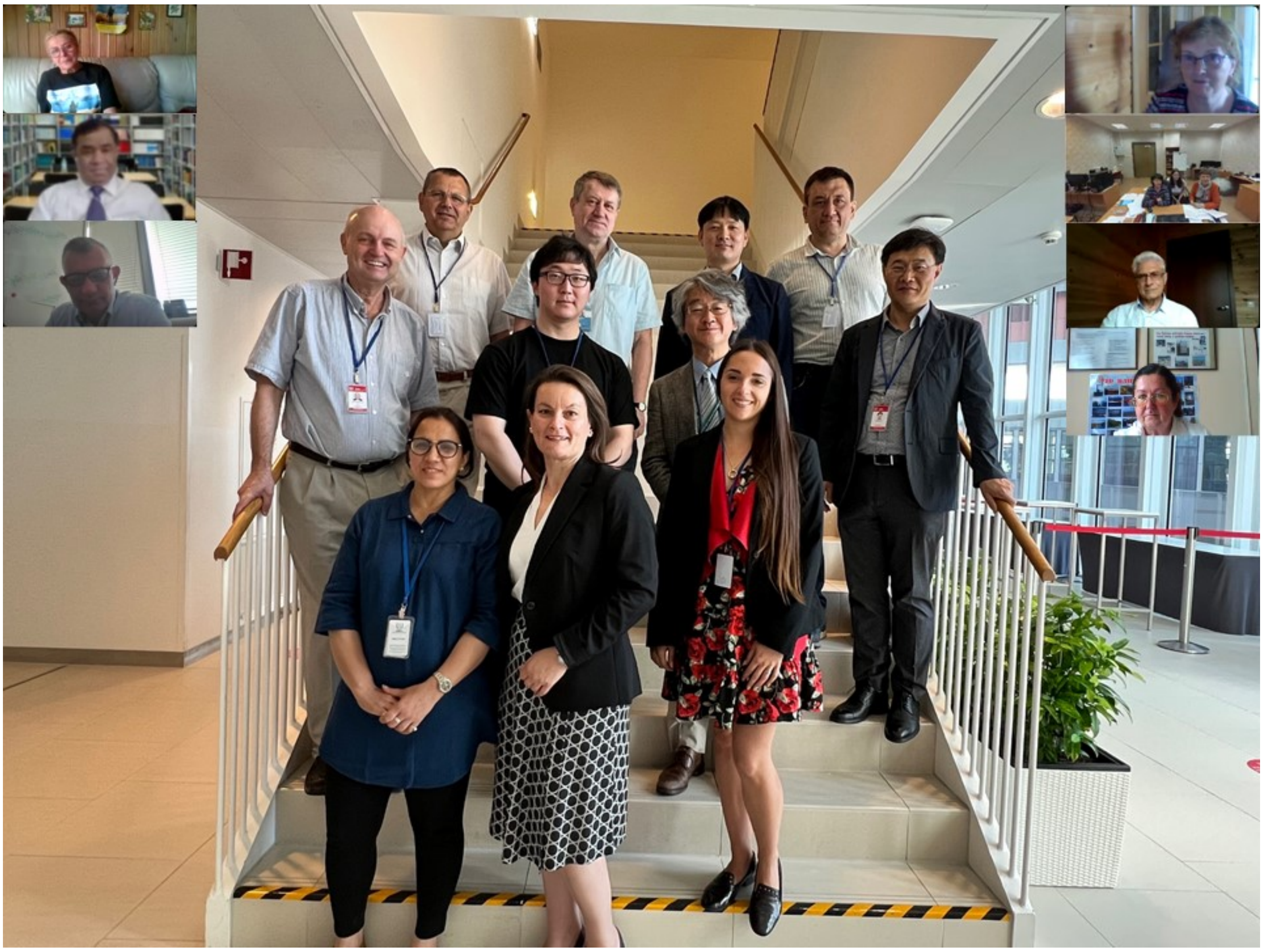
Abstract

This report summarizes the IAEA Technical Meeting on the International Network of Nuclear Reaction Data Centres held at the IAEA Headquarters in Vienna, Austria from 14 to 17 June 2022. The meeting was attended by 24 participants representing 13 cooperative Centres from eight Member States (China, Hungary, India, Japan, Korea, Russia, Ukraine and USA) and two International Organisations (NEA, IAEA) as well as a participant from Kazakhstan. A summary of the meeting is given in this report along with the conclusions and actions.



Technical Meeting on International Network of Nuclear Reaction Data Centres
IAEA Headquarters, Vienna, Austria, 14 – 17 June 2022

First row (from the left)

Vidya Devi, IAEA

Lidija Vrapcenjak, IAEA

Daniela Foligno, NEA

Second row (from the left)

Boris Pritychenko, USA

Seungheon Shin, Japan

Naohiko Otsuka, IAEA

Do Heon Kim, Korea

Third row (from the left)

Sandor Takács, Hungary

Viktor Zerkin, IAEA

Sung Chul Yang, Korea

Timur Zholdybayev, Kazakhstan

Remote participants (left, from the top)

Olena Gritzay, Ukraine

Devesh Raj, India

Daniel Lopez Aldama, IAEA

Remote participants (right, from the top)

Svetlana Dunaeva, Russia

Sophiya Taova, Svetlana Selyankina, Galina Pikulina, Russia

Vladimir Varlamov, Russia

Marina Mikhailiukova, Russia

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THE INTERNATIONAL NETWORK OF NUCLEAR REACTION DATA CENTRES

National, regional and specialized nuclear reaction data centres, coordinated by the International Atomic Energy Agency, cooperate in the compilation, exchange and dissemination of nuclear reaction data in order to meet the requirements of nuclear data users in all countries. At present, the following data centres participate in the network:

NNDC	US National Nuclear Data Center, Brookhaven National Laboratory, Upton, USA
NEA DB	OECD NEA Data Bank, Boulogne-Billancourt, France
NDS	IAEA Nuclear Data Section, Vienna, Austria
CJD	Russian Nuclear Data Centre, Institute of Physics and Power Engineering, Obninsk, Russia
CNDC	China Nuclear Data Centre, China Institute of Atomic Energy, Beijing, China
ATOMKI	Charged-Particle Nuclear Reaction Data Group, Institute for Nuclear Research (ATOMKI), Debrecen, Hungary
NDPCI	Nuclear Data Physics Centre of India, Bhabha Atomic Research Centre, Trombay, Mumbai, India
JAEA/NDC	Nuclear Data Center, Japan Atomic Energy Agency, Tokai-mura, Japan
JCPRG	Nuclear Reaction Data Centre, Hokkaido University, Sapporo, Japan
KNDC	Nuclear Data Center, Korea Atomic Energy Research Institute, Daejeon, Republic of Korea
CDFE	Centre for Photonuclear Experiments Data, Moscow State University, Moscow, Russia
CNPD	Centre of Nuclear Physics Data, Institute of Nuclear and Radiation Physics, Russian Federal Nuclear Center –All-Russia Research Institute of Experimental Physics, Sarov, Russia
UkrNDC	Ukrainian Nuclear Data Centre, Institute for Nuclear Research, Kyiv, Ukraine

A detailed description of the objectives of the network and the contributions of each Centre to these activities are given in INDC(NDS)-401 (Rev.6), "International Network of Nuclear Reaction Data Centres".

PREVIOUS NRDC MEETINGS

Vienna, 14-17 June 2022	Technical	INDC(NDS)-0857
Virtual, 4-7 May 2021	Technical	INDC(NDS)-0829
Vienna, 9-12 April 2019	Technical	INDC(NDS)-0792
Bahadurgarh, 1-4 May 2018	Centre Heads + Technical	INDC(NDS)-0762
Vienna, 23-26 May 2017	Technical	INDC(NDS)-0736
Beijing, 7-10 June 2016	Centre Heads + Technical	INDC(NDS)-0718
Vienna, 21-23 April 2015	Technical	INDC(NDS)-0686
Smolenice, 6-9 May 2014	Centre Heads + Technical	INDC(NDS)-0661
Vienna, 23-25 April 2013	Technical	INDC(NDS)-0633
Paris, 16-19 April 2012	Centre Heads + Technical	INDC(NDS)-0618
Vienna, 23-24 May 2011	Technical	INDC(NDS)-0593
Sapporo, 20-23 April 2010	Centre Heads + Technical	INDC(NDS)-0573
Vienna, 25-26 May 2009	Technical	INDC(NDS)-0558
Obninsk+Moscow 22-25 Sept. 2008	Centre Heads + Technical	INDC(NDS)-0536
Vienna, 8-10 October 2007	Technical	INDC(NDS)-0519
Vienna, 25-28 September 2006	Centre Heads + Technical	INDC(NDS)-0503
Vienna, 12-14 October 2005	Technical	INDC(NDS)-0480
Brookhaven, 4-7 October 2004	Centre Heads + Technical	INDC(NDS)-464
Vienna, 17-19 June 2003	Technical	INDC(NDS)-446
Paris, 27-30 May 2002	Centre Heads + Technical	INDC(NDS)-434
Vienna, 28-30 May 2001	Technical	INDC(NDS)-427
Obninsk, 15-19 May 2000	Centre Heads + Technical	INDC(NDS)-418
Vienna, 18-20 May 1999	Technical	INDC(NDS)-407
Vienna, 11-15 May 1998	Centre Heads + Technical	INDC(NDS)-383
Vienna, 26-28 May 1997	Technical	INDC(NDS)-374
Brookhaven, 3-7 June 1996	Center Heads + Technical	INDC(NDS)-360
Vienna, 2-4 May 1995	Technical	INDC(NDS)-343
Paris, 25-27 April 1994	Center Heads + Technical	INDC(NDS)-308
Vienna, 1-3 Sept 1992	Technical	INDC(NDS)-279
Obninsk, 7-11 Oct 1991	Center Heads + Technical	INDC(NDS)-0262
Vienna, 13-15 Nov 1990	Technical	Memo CP-D/210
Vienna, 2-4 Oct 1989	Centre Heads + Technical	Memo CP-D/200
Vienna, 4-6 Oct 1988	Technical	Memo CP-D/190
Brookhaven, 27-29 Oct 1987	Center Heads + Technical	INDC(NDS)-204
Vienna, 7-9 Oct 1986	Technical	Memo CP-D/159
Saclay, 9-11 Oct 1985	Center Heads + Technical = 8th NRDC Meeting	INDC(NDS)-178
Vienna, 19-21 Sept 1984	Technical	Memo CP-D/131
Obninsk+Moscow, 17-21 Oct 1983	7th NRDC Meeting	INDC(NDS)-154
Vienna, 3-7 May 1982	6th NRDC Meeting	INDC(NDS)-141
Brookhaven, 29.9 - 2.10.1980	5th NRDC Meeting	INDC(NDS)-125
Karlsruhe, 8-13 Oct 1979	4th NRDC Meeting	INDC(NDS)-110
Paris, 19-23 June 1978	3rd NRDC Meeting	INDC(NDS)-99
Kiev, 11-16 April 1977	2nd NRDC Meeting = 3rd CPND + 13th 4-C	INDC(NDS)-90
Vienna, 28-30 April 1976	2nd CPND Meeting	INDC(NDS)-77
Vienna, 26-27 April 1976	12th 4C-Meeting	INDC(NDS)-78
Vienna, 8-12 Sept 1975	CPND Meeting	INDC(NDS)-69+71
Brookhaven, 10-14 March 1975	11th 4C-Meeting	INDC(NDS)-68
Paris, 6-10 May 1974	10th 4C Meeting	INDC(NDS)-58
Vienna, 24-26 April 1974	CPND + PhotoND	INDC(NDS)-59+61
Moscow/Obninsk, 4-8 June 1973	9th 4C Meeting	INDC(NDS)-54
Vienna, 16-20 Oct 1972	8th 4C Meeting	INDC(NDS)-51
Brookhaven, 25-29 Oct 1971	7th 4C Meeting	INDC(NDS)-41
Paris, 5-9 Oct 1970	6th 4C Meeting	INDC(NDS)-28
Moscow, 17-21 Nov 1969	5th 4C Meeting	INDC(NDS)-16

LIST OF ACRONYMS

ATOMKI	Nuclear Research Institute, Debrecen, Hungary
BARC	Bhabha Atomic Research Centre, Trombay, Mumbai, India
BNL	Brookhaven National Laboratory, Upton, New York, USA
BROND	Russian Evaluated Neutron Reaction Data Library
C4	Computational format for EXFOR data
CAJaD	Centre for Nuclear Structure and Reaction Data, Kurchatov Institute, Moscow, Russia
CDFE	Centr Dannykh Fotojad. Eksp., Moscow State University, Russia
CENDL	Chinese Evaluated Neutron reaction Data Library
CHEX	EXFOR check program (originating from NNDC)
CIAE	Chinese Institute of Atomic Energy, Beijing, China
CINDA	A specialized bibliography and data index on nuclear reaction data operated by NRDC
CJD	Russian Nuclear Data Centre, IPPE, Obninsk, Russia
CNDC	China Nuclear Data Centre, CIAE, Beijing, China
CNPD	Centre of Nuclear Physics Data at RFNC-VNIIEF, Sarov, Russia
CP...	Numbering code for memos exchanged within the NRDC
CPND	Charged-particle nuclear reaction data
CRP	Coordinated Research Project (of the IAEA Nuclear Data Section)
CSEWG	US Cross Section Evaluation Working Group
DOI	Digital Object Identifier, *e.g.* for bibliographic references
ENDF-6	International format for evaluated data exchange, version 6
ENDF/B	US Evaluated Nuclear Data File/B
ENSDF	Evaluated Nuclear Structure Data File
EXFOR	Format for the international exchange of nuclear reaction data
GSYS	Data digitizing system by JCPRG
IAEA	International Atomic Energy Agency, Vienna, Austria
IBANDL	Ion Beam Analysis Nuclear Data Library, maintained at IAEA
INDC	International Nuclear Data Committee
IPPE	Institute of Physics and Power Engineering, Obninsk, Russia
IRDFF	International Reactor Dosimetry and Fusion File, maintained by the IAEA-NDS
JAEA	Japan Atomic Energy Agency

JANIS	Java Nuclear Information System of NEA-DB
JCPRG	Nuclear Reaction Data Centre, Hokkaido University, Sapporo, Japan
JEFF	Joint Evaluated Fission and Fusion File, coordinated by NEA-DB
JENDL	Japanese Evaluated Nuclear Data Library
KAERI	Korea Atomic Energy Research Institute, Daejeon, Korea
KNDC	Nuclear Data Center, KAERI, Daejeon, Korea
KINR	Kyiv Institute of Nuclear Research
LEXFOR	Part of the EXFOR manual containing physics information for compilers
MBDAV	Management Board for the Development, Application and Validation of Nuclear Data and Codes
NDS	IAEA Nuclear Data Section, Vienna, Austria
NEA	OECD Nuclear Energy Agency, Boulogne-Billancourt, France
NEA-DB	OECD/NEA Data Bank, Boulogne-Billancourt, France
NEANDC	OECD/NEA Nuclear Data Committee
NNDC	National Nuclear Data Center, Brookhaven National Laboratory, USA
NRDC	International Network of Nuclear Reaction Data Centres
NRDF	Japanese Nuclear Reaction Data File
NSDD	International Network of Nuclear Structure and Decay Data Evaluators
NSR	Nuclear Science References, a bibliographic system
OECD	Organization for Economic Cooperation and Development, Paris, France
ORDER	EXFOR program for addition of record identification
PhND	Photonuclear data
RIKEN	Institute of Physics and Chemistry Research, Wako-Shi, Saitama, Japan
TRANS	Name of transmission tapes for data exchange in the EXFOR system
UKRNDC	Ukraine Nuclear Data Centre at KINR, Kyiv, Ukraine
VNIIEF	Russian Federal Nuclear Centre, Sarov, Russia
WPEC	Working Party on International Nuclear Data Evaluation Co-operation
XTRACT	EXFOR indexing program
X4TOC4	Conversion program from EXFOR to computational format “C4”
ZCHEX	Current version of CHEX, updated and maintained by NDS
4C...	Numbering code of memos exchanged among the four Neutron Data Centres

MEETING SUMMARY

1. Introduction

This report summarizes the IAEA Technical Meeting on the International Network of Nuclear Reaction Data Centres held at the IAEA Headquarters in Vienna, Austria from 14 to 17 June 2022. The meeting was attended by 24 participants representing 13 cooperative Centres from eight Member States (China, Hungary, India, Japan, Korea, Russia, Ukraine and USA) and two International Organisations (NEA, IAEA) as well as a participant from Kazakhstan. (see **Appendix A**). Meetings of this network are held annually, with full meetings involving Centre Heads and technical staff every two years. (The last full meeting was planned to be held in May 2020 at the IAEA Headquarters, but it has been postponed due to COVID-19.)

Main topics of the present meeting were various statistics, manuals and dictionaries, compilation needs, quality control, coding rules as well as software and dissemination (see **Appendix B**). The participants summarized the results of the discussions in 37 conclusions and 96 actions (see **Appendix C**).

2. Brief Summary

2.1 Opening

A. Koning, Head of the IAEA Nuclear Data Section welcomed the participants. S. Takács was elected as the chairperson, and the agenda was adopted.

2.2 Progress Reports

Progress reports from 12 attending Centres were presented by **A. Koning**, **V. Varlamov, S. Shin**, **M. Mikhailiukova**, **O. Gritzay**, **S. Taova**, **D.H. Kim**, **S. Takács**, **Ge Zhigang, D. Raj, D. Foligno** and **B. Pritychenko**, who highlighted the staffing, compilation, dissemination and other nuclear data related activities of interest to the network. See progress reports P2021-01 to P2021-10 (**Appendix F**) for further details.

2.3 EXFOR General

N. Otsuka presented the statistics of transmissions, journal scanning and preliminary tape checking. He reported that 551 new entries and 1264 revised entries have been newly finalized since the last (2021) NRDC meeting.

V. Devi reported that the CJD, CNDC, CNPD, NDS, NNDC and UkrNDC share responsibility for scanning of 54 journals. She mentioned some journals have not been scanned more than three months since no new issues have been published since last scanning.

2.4 Manuals and Dictionaries

N. Otsuka reported that (1) the revision of EXFOR Formats Manual and LEXFOR submitted to other centres as appendices of Memo CP-D/1044 and 1045, and (2) comments on these revised manuals were received from CJD. The revised manuals were approved. He mentioned there is a plan (1) to move the file type of these manuals from Microsoft Word to LaTeX, and

(2) to organize a series of Consultants' Meeting to review the manuals (*e.g.*, comparison with the NDS EXFOR Manual, IAEA-NDS-3 (Rev. 96/11).

S. Takács explained there are two definitions of the "cumulative cross section" with and without the "cumulative factor", and the cumulative cross section defined with the cumulative factor is always higher than the sum of the corresponding cross sections due to presence of the cumulative factor. He proposed improvement of the description of "supracumulative cross section" (cumulative cross section defined with the cumulative factor) in LEXFOR. The participants concluded that the "conditional cumulative cross section" is a more appropriate name of this quantity than the supracumulative cross section.

V. Zerkin reported the family flags (family codes) included in Dictionary 24 (Data headings) are used in ZCHEX and EXFOR Converter System (a tool to produce the X4+ output). He found ZCHEX uses these flags (1) to define presence of dependent variables, and also (2) to check the codes under the keyword EN-SEC, HALF-LIFE, MISC-COL, EMS-SEC and MOM-SEC. He concluded that the flag should be maintained in the dictionary for ZCHEX.

2.5 CINDA

V. Zerkin reported that (1) regular automatic updates using the EXFOR and NSR databases have been frozen since December 2018 because NSR database is no longer available; (2) Import from EXFOR was performed once (2022-06-02).

2.6 EXFOR Compilation Needs

N. Otsuka reported CJD, CNDC, NDPCI and NDS finished compilation of the fission product yield data published in the articles listed by NNDC in Memo CP-C/0464, 0465, 466 and the articles listed by NDS in Memo CP-D/0979. Four centres still need to compile articles in these lists – CDFE (3 articles), JCPRG (2 articles), NEA DB (59 articles) and NNDC (17 articles). He also mentioned 18 photofission data articles have not been compiled due to absence of the responsible centres.

2.7 EXFOR Quality Control

R. Shimizu reported review of the questionable level energies coded in EXFOR entries for coded in the γ, n, d, t, ^{3}He and α induced reaction and spontaneous fission datasets. He extracted the E-LVL values from the EXFOR Master File for these projectiles, and he checked the source articles if the deviation of the E-LVL value from any known level energies compiled in the RIPL3 library is more than 5%. He concluded 177 items must be fixed by correction of number, data heading, data unit, REACTION code etc. Some errors are due to coding of the level energy not mentioned in the source article but taken by the compiler from the literature (*e.g.*, Table of Isotopes), and the participants concluded we should use LVL-NUMB in such cases.

V. Devi presented her analysis of EXFOR outliers. She checked plots made by A. Koning for production cross sections for γ, p, d, t, ^{3}He and α induced reactions compiled in the EXFOR and TENDL-2021 libraries, and completed their reviews for γ, d and α induced reactions. She found some errors originated from wrong REACTION code, wrong data unit, inclusion of data points belonging to another subentry etc. She also found the data compiled in old entries are sometimes converted from the data presented in the source articles to get a standard expression before compilation (*e.g.*, conversion of cross section per the target mass number to cross section). The participants agreed to introduce a new modifier DMN (divided by the mass number of the target nuclide) to avoid such conversion by the compiler. She also mentioned there is ambiguity for choice of the REACTION SF3 code (ABS, TOT, N, SCT etc.) for the data explained as "photo absorption cross section".

N. Otsuka reported situation of the neutron quasi-elastic scattering data in EXFOR based on the review done by Stanislav Simakov. He mentioned contribution of the inelastic scattering to low-lying excitation levels (e.g., ^{181}Ta 6.2 keV level) is often included in the datasets compiled with (N,EL) under REACTION. He proposed to compile such datasets (1) as partial scattering data (*e.g.*, REACTION SF3=SCT and SF5=PAR) with an approximate upper boundary of the excitation levels (e.g., neutron energy resolution in full-width) under heading E-EXC-MAXA, or (2) as elastic scattering data with SF5=EXL (low-lying excitation contribution included), and the proposal was approved.

2.8 EXFOR Coding Rule

S. Dunaeva proposed (1) use of the heading NUMBER (instead of NUMBER-CM) to compile the coefficients obtained from fitting to the angular differential cross sections in the centre-of-mass system, and (2) compilation of the 0th Legendre coefficients (a_0) with ,SIG,,D4PI (cross section divided by 4π) rather than ,DA,,LEG. For the second proposal, **M. Mikhailiukova** expressed her concern with the following two reasons: 1) the a_0 value is reported by the authors as a fitting coefficient (not as $\sigma/4\pi$), and we should compile a_0 and higher order coefficients in the same data subentry, and 2) the users who need σ should not obtain the value by multiplying a_0 by 4π but should perform integration of the angular differential cross section.

S. Dunaeva proposed the following three items for compilation of alternative results: 1) use of flags rather than multiple reaction formalism when each dataset contains only one data point; 2) compilation of alternative results and their average in different subentries separately with the modifier AV for the average dataset; and 3) change of the LEXFOR "Status" subsection tile "Interdependent data" to "Interdependent data and alternative results". **B. Pritychenko** suggested replacement of the term "alternative" with "additional" or "complemental". **M. Mikhailiukova** reminded the term "additional result" is reserved for the information kept under the keyword ADD-RES. Finally, Dunaeva's proposals were approved with replacement of "alternative" with "complemental".

2.9 Tools for Compilation and Dissemination

B. Pritychenko presented "NSR tutorial" including the role of NSR keyword and NSR indexed search. He also reported NNDC is trying to make various papers kept in the NNDC Library (*e.g.*, memo of private communication) more usable by creation of their electronic copies.

L. Vrapcenjak reported that collection of articles with the IAEA library becomes sometimes very difficult and lengthy procedure these years, especially for the articles in other than English (mostly Chinese and Russian). She proposed 1) coding of English translation as the first reference when it exists, and 2) distribution of the responsibility of obtaining the articles to the regional centres, and these proposals were accepted.

N. Otsuka introduced Tcalc, a tool developed by Ryosuke Shimizu for calculation of the threshold energy. He demonstrated one can obtain a list of all possible reaction channels for production of a particular nuclide even for an elemental (natural) target. He also reported this tool is included in the JCPRG Web EXFOR Compilation Tool to check if SF3=X is legal.

V. Zerkin reported progress in EXFOR-ENDF databases, retrieval systems, tools and software.

He introduced various new functions including 1) plotting of the angular differential cross sections in centre-of-mass system after conversion to those in laboratory system, 2) automatic renormalization in terms of new monitor cross sections and decay data, 3) plotting of the retrieved results by Plotly in addition to Web-ZVView.

V. Zerkin also introduced X4Pro (fully relational EXFOR database). The conventional NDS EXFOR relational database includes data points (numerical data) as a binary large object (BLOB), and it requires various additional tools for further use of the numerical data (*e.g.*, reader, parser, converter). He mentioned the database is extended by tables for data points (in original EXFOR and C4/C5) so that the database allows to retrieve numerical data using only SQL command. The participants expressed their support to further development of X4Pro.

2.10 Other Business

T. Zholdybayev reported that the Central Asian group (Kazakhstan and Uzbekistan) compiled four articles since the last NRCD meeting (EXFOR 31847, D8044, D8045 and D8049). He reported his institute published many articles recent years due to importance of publications for funding, and 14 articles are still waiting compilation.

2.11 Closing

N. Otsuka proposed the dates and places for the next full NRDC meeting (Vienna, Austria, 9 to 12 May 2023) and for the next technical NRDC meeting (Vienna, 2nd quarter of 2024), and they were approved.

S. Takács called an adjournment of the meeting, and the participants thanked for his chairmanship. **N. Otsuka** also expressed his thanks to support by Charisse Monfero (Team Assistant of NDS/NDSU) for her smooth operation of the meeting including arrangement of remote participations and change of the meeting room during the meeting period.

Appendix A

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Appendix B

AGENDA

Tuesday, 14 June 2022

9:30 – 13:00 (CET)

1	**Opening Items**			
1.1	Welcome address	10 min		A. Koning
1.2	Announcement	5 min		C. Monfero
1.3	Election of chairperson, adoption of the agenda, announcements	5 min		N. Otsuka
2	**Progress Reports**			
2.1	NDS	10 min	P2022-01	A. Koning
2.2	CDFE	10 min	P2022-02	V. Varlamov
2.3	JCPRG	10 min	P2022-03	S.H. Shin
2.4	CJD	10 min	P2022-04	M. Mikhailiukova
2.5	UkrNDC	10 min	P2022-05	O. Gritzay
2.6	CNPD	10 min	P2022-06	S. Taova
2.7	KNDC	10 min	P2022-07	D.H. Kim
2.8	ATOMKI	10 min	P2022-08	S. Takács
2.9	CNDC	10 min	P2022-09	Ge Zhigang
2.10	NDPCI	10 min		D. Raj
2.11	NEA DB	10 min		D. Foligno
2.12	NNDC	10 min		B. Pritychenko
		150 min		

14:00 – 16:00 (CET)

3	**EXFOR Statistics and Coverage**			
3.1	Transmission statistics since the last NRDC meeting	10 min	WP2022-02	N. Otsuka
3.2	Status of new article compilation (A1)	10 min	WP2022-03	N. Otsuka
3.3	Time interval between submission of preliminary and final tapes	10 min	WP2022-04	N. Otsuka
3.4	New publications scanned by NDS and other centres	10 min	WP2022-05	V. Devi
3.5	Progress in correction of items on Feedback List (A2)	10 min	WP2022-06	N. Otsuka
3.6	Other actions (A3)	10 min	WP2022-01	Chairperson
4	**Manual and Dictionary**			
4.1	Updated Formats Manual (A5, CP-D/1044, 4C-4/0232)	20 min	WP2022-07	N. Otsuka
		80 min		

Wednesday, 15 June 2022

9:00 – 13:00 (CET)

4	**Manual and Dictionary (cont.)**			
4.2	Updated LEXFOR (A6, CP-D/1045, 4C-4/0232)	20 min	WP2022-08	N. Otsuka
4.3	Future plan of manual updates	10 min		N. Otsuka
4.4	Conclusions 43 of NRDC 2021 meeting (CP-D/1036)	10 min	WP2022-09	
4.5	Data headings ANG-AZ and ANG-AZ-RL (CP-D/1019)	10 min	WP2022-10	N. Otsuka
4.6	Method codes ASEP, MASSP and OLMS (CP-D/1020)	10 min	WP2022-11	N. Otsuka
4.7	Multiplicity (CP-D/1046)	20 min	WP2022-12	N. Otsuka
4.8	Multiple reaction formalism (CP-D/1048)	10 min	WP2022-13	N. Otsuka
4.9	Supracumulative cross section (CP-D/1042)	20 min	WP2022-14	S. Takács
4.10	Coding of EPJ/A supplemental issues (CP-D/1039)	10 min	WP2022-15	S. Dunaeva
4.11	Cross section integral (CP-D/1037)	10 min	WP2022-16	V. Varlamov
4.12	Role of family flags (family codes) in ZCHEX program (A7)	10 min	WP2022-17	V. Zerkin
4.13	Future maintenance of Dictionary 227 (Nuclides)	10 min		N. Otsuka
4.14	Other actions (A4, A8-A13)	10 min	WP2022-01	Chairperson
5	**CINDA**			
5.1	Status of CINDA database (A14)	10 min	WP2022-18	V. Zerkin
5.2	Other actions (A15)	5 min	WP2021-01	Chairperson
		175 min		

14:00 – 16:00 (CET)

6	**EXFOR Compilation Needs**			
6.1	Compilation of articles with priority (A16, A21-A24)	10 min	WP2022-19	N. Otsuka
6.2	Compilation of articles from completeness checking (A17-A20, A27-A29)	10 min	WP2022-20	N. Otsuka
6.3	Progress in compilation of fission product yields (A25-A26)	10 min	WP2022-21	N. Otsuka
6.4	Individual data requests	10 min	WP2022-22	N. Otsuka
6.5	Other actions (A30-A33)	10 min	WP2022-01	Chairperson
7	**EXFOR Quality Control**			
7.1	Pending corrections (A34-A36, A44-A47, A49-A53)	10 min	WP2022-23	N. Otsuka

7.2	Suspicious use of REACTION SF3=X for production cross sections (CP-D/1017)	10 min	WP2022-24	N. Otsuka
7.3	Use of branch codes M+ and (M) without isomeric flag in REACTION SF4 (CP-D/1023)	10 min	WP2022-25	N. Otsuka
		80 min		

18:00-

Social event (Weinhof Zimmermann, Mitterwurzergasse 20, 1190 Wien. Bus 35A or 39A "Agnessgasse")

Thursday, 16 June 2022

9:00 – 13:00 (CET)

7	**EXFOR Quality Control (cont.)**			
7.4	Erroneous E-LVL values (CP-D/1043)	30 min	WP2022-26	R. Shimizu
7.5	Analysis of outliers	30 min		V. Devi
7.6	Questionable replacement of a STATUS code with TABLE (CP-D/1041)	10 min	WP2022-27	S. Dunaeva
7.7	Multiple appearance of heading DATA (CP-D/1027)	10 min	WP2022-28	N. Otsuka
7.8	Neutron quasi-elastic scattering data coded with SF3=EL (4C-3/0420 Rev.)	20 min	WP2022-29	N. Otsuka
7.9	Other actions (A37-A43, A48)	10 min	WP2022-01	Chairperson
8	**EXFOR Coding Rule**			
8.1	Use of NUMBER-CM and compilation of 0th order Legendre coefficients (CP-D/1021)	20 min	WP2022-30	N. Otsuka
8.2	Combination of branch code M+ or (M) with parameter FY (CP-D/1024)	10 min	WP2022-31	N. Otsuka
8.3	Usage of heading MONIT-ERR (CP-D/1026)	10 min	WP2022-32	N. Otsuka
8.4	Alternative results (CP-D/1031)	20 min	WP2022-33	S. Dunaeva
9	**Software and Dissemination (cont.)**			
9.1	NSR tutorial	30 min		B. Pritychenko
		200 min		

14:00 – 16:00 (CET)

9	**Software and Dissemination (cont.)**			
9.2	Collection of non-English articles	10 min		L. Vrapcenjak
9.3	Recent development of GSYS	15 min		S.H. Shin
9.4	Threshold calculator and its application to REACTION SF3 checking (CP-D/1047)	10 min	WP2022-34	N. Otsuka
9.5	Eta-value plotting (4C-3/0419)	10 min	WP2022-35	N. Otsuka
9.6	Progress in development of "EXFOR-ENDF" databases, retrieval systems, tools and software	15 min		V. Zerkin
9.7	X4Pro – fully relational EXFOR database; EXFOR offline distribution	30 min		V. Zerkin
9.8	Other actions (A54-A56, A58-A79)	10 min	WP2022-01	Chairperson
		100 min		

Friday, 17 June 2022

9:00 – 12:00 (CET)

10.	**Other Business**			
10.1	Compilation of experimental nuclear reaction data from Central Asia	10 min	WP2022-	T. Zholdybayev
11.	**Closing**			
11.1	Dates and places of next meetings	5 min		N. Otsuka
11.2	Review of Conclusions and Actions	60 min		Chairperson
		75 min		

Appendix C

CONCLUSIONS AND ACTIONS

Conclusions

General	
C1	The next full NRDC meeting will be held in Vienna, Austria from 9 to 12 May 2023.
C2	The next technical NRDC meeting will be held in Vienna, Austria in the 2nd quarter of 2024.
C3	The next EXFOR compilation workshop will be held in Vienna, Austria from 13 to 16 December 2022.
EXFOR Statistics and Coverage	
C4	The Network finalized 551 new entries since the NRDC 2021 meeting (1227 new entries between the NRDC 2019 and 2021 meetings, and 448 new entries between the NRDC 2018 and 2019 meetings).
Manuals and Dictionary	
C5	EXFOR Formats Manual revised according to Action 5 of the NRDC 2021 meeting and CP-D/1044=WP2022-07 was approved.
C6	LEXFOR revised according to Action 6 of the NRDC2021 meeting and CP-D/1045=WP2022-08 was approved. In “other major updates”, (1) 26-FE-0 must be 26-FE-58 in the example of “Activation”, and (2) “REACTION code 3” must be “REACTION code”.
C7	“X+* and not *+X” should read “*+X and not X+*” in Conclusions 43 of the NRDC 2021 meeting as proposed in CP-D/1036=WP2022-09.
C8	The headings ANG-AZ. ANG-AZ1 and ANG-AZ2 will be made obsolete. ANG-AZ-RL will be used instead of ANG-AZ as proposed in CP-D/1019=WP2022-10.
C9	The method code MASSP will be made obsolete. OLMS will be used for on-line mass separation of a product, and ASEP will be used for off-line mass separation as proposed in CP-D/1020=WP2022-11.
C10	Revised LEXFOR “Multiplicity and product yield” proposed in CP-D/1046=WP2022-12 was approved.

C11	Revised LEXFOR "Multiple reaction formalism" proposed in CP-D/1048=WP2022-13 was approved. This formalism can be used for production cross sections of various products from the same combination of the target nuclide and projectile only when they are based on the same systematics or theoretical considerations.
C12	Revised LEXFOR "Independent and cumulative data" proposed in CP-D/1042=WP2022-14 was approved. N.B. "conditional cumulative cross section" will replace "supracumulative cross section".
C13	The journal code EPJ/AS will be made obsolete. EPJ/A will be used instead. The issue number must be coded for both regular and supplemental issues of this journal published in Vols. 18-19, 22 and 24-28 as proposed in CP-D/1039=WP2022-15.
C14	Revised LEXFOR "Cross sections" (cross section integral over a given incident energy range) was approved as proposed in CP-D/1037=WP2022-16. The integral of the unfolded cross section (,SIG,,BRS) will be coded with ,INT,,BRS.
C15	The family flags (also known as family codes, see EXFOR Formats Manual Chapter 6) of Dictionary 24 must be kept because ZCHEX uses them as summarized in WP2022-17.
C16	Dictionary 227 (Nuclides and natural isotopic mixtures) will be produced from NUBASE files. (See F.G. Kondev et al., Chinese Phys.C,45(2021)030001 for NUBASE2020 evaluation.)
C17	The numerical data compiled with the status code BERMAN can be different from those tabulated in the article by the author.
C18	A new branch code EXL (excitation of low-lying levels) and new heading code E-EXC-MAXA (approximate upper limit of excitation energy, instead of E-EXC-MX-A) were approved as proposed in 4C-3/0420 Rev.=WP2022-29. The heading E-EXC-MAXA must be always explained under the keyword EN-SEC (e.g., "(E-EXC-MAXA,92-U-235) Neutron energy resolution (FWHM)".
C19	The heading NUMBER-CM will be made obsolete. The heading NUMBER will be used for fitting in both laboratory and centre-of-mass systems as proposed in CP-D/1021=WP2022-30.
C20	The new modifier D4PI (divided by 4 pi) and the quantity code ,SIG,,D4PI (cross section divided by 4 pi) were approved as proposed in CP-D/1021=WP2022-30.
EXFOR Coding Rule	
C21	The level number must be coded under the heading LVL-NUMB when the author provides it without the level energy in the source article (c.f. CP-D/1043=WP2022-26). Compilers should not take such level energies from another source (e.g., ENSDF).

C22	Data presented by authors must be compiled without numerical conversion. Compilers are encouraged to propose a new code (e.g., modifier, unit code) so that the data can be compiled without conversion. The conversion to a standard expression by compilers may introduce an error, and it should be done by computer codes processing EXFOR entries (c.f. Vidya Devi's presentation).
C23	The status code TABLE may replace a status code indicating conversion from another data library (e.g., SCSRS) only when the authenticity of the numerical data is confirmed (e.g., presence of the same numerical data in an article). See also CP-D/1041=WP2022-27.
C24	Revised LEXFOR "Fission yields" proposed in CP-D/1024=WP2022-31 was approved. The parameter code FY will not be combined with the branch code M+ or (M). Contribution of isomeric transition in the measured ground state fission product yields will be indicated by the branch code CUM instead.
C25	The heading MONIT-ERR is for the uncertainty in the monitor value, and not for the uncertainty in the quantity of interest propagated from the uncertainty in the monitor value. Only the fractional (%) uncertainty can be coded under MONIT-ERR when the absolute monitor value is unknown as proposed in CP-D/1026=WP2022-32.
C26	Revised LEXFOR "Flags", "General quantity modifiers" (AV-modifier) and "Status" were approved as proposed in CP-D/1031=WP2022-33. N.B. "alternative result" should read "complemental result".
C27	Conclusion 41 of the NRDC 2021 meeting will be amended to: When the numerical data are copied from a table or digitized from a figure of a reference, the table or figure number must follow the status code TABLE or CURVE and the code string of the reference under the keyword STATUS even if only one reference is coded under REFERENCE. Note that (1) the reference code string coded under STATUS and REFERENCE must be the same, and (2) the table/figure number must be in free text. when the STATUS format is extended for accommodation of the reference code under STATUS.
C28	The zeroth order Legendre coefficients will be compiled with ,SIG,,D4PI instead of ,DA,,LEG as proposed in CP-D/1021=WP2022-30 to utilize them as cross sections after multiplication by 4π by computer codes.
C29	The English translation will be the primary reference (=the reference coded on the first line of REFERENCE) when it exists.
Tools for Compilation and Dissemination	
C30	(1) The NDS will keep copies of the non-English articles as they are available. (2) The originating centre is responsible to collect the original non-English article when its English translation exists.

C31	The "Recent EXFOR database updates" website maintained by NDS for preliminary tapes indicates absence of copies of their source articles in the NDS article collection. The originating centres are encouraged to help NDS to obtain such copies.
C32	A new version of EXFOR-Editor (Ver. 4.01) and an updated manual are available on the CNPD website.
C33	A new version of GSYS (Ver. 2.4.9) was released on 16 May 2022 on the JCPRG web page. A preliminary version of GSYS 2.6 (e.g. Ver.2.5.22) including new functions (e.g., Undo, Redo, resizable glass) is also available as a "development version" on the JCPRG website.
C34	A new threshold calculator "Tcalc" is available on the JCPRG website. It is included in the JCPRG EXFOR Compilation Tool to check presence of illegal REACTION SF3=X as reported in CP-D/1047=WP2022-34.
C35	η (neutron production factors) compiled in EXFOR can be compared with those calculated from ENDF files with PREPRO as demonstrated in 4C-3/0419=WP2022-35. N.B. The fourth line of the PREPRO input in the paper should cover all MT numbers belonging to absorption, those are library and reconstruction rules (MT.DAT) dependent.
C36	The Network supports X4Pro (fully relational EXFOR database) as a useful tool of EXFOR dissemination.
C37	Distribution and redistribution of the EXFOR Master File must be done with indication of (1) Version (date and URL), (2) citation of the reference article, and (3) copy right notice (e.g., "© 2022 The International Network of Nuclear Reaction Data Centres (NRDC)").

Actions

EXFOR Statistics and Coverage		
A1	All	(Standing action) Give the highest priority to compilation of new articles.
A2	All	(Standing action) Correct erroneous entries listed on the EXFOR Feedback List according to the indicated priorities. All urgent corrections must be done by the next meeting.
A3	Otsuka	(Continuing action) Send transmission statistics and correction statistics to centres every four months.
Manuals and Dictionaries		
A4	Otsuka	(Continuing action) Update Dictionaries every six months.

A5	Otsuka	(Continuing action) Propose a revised NRDC Protocol Appendix B "Scanning responsibility" for elimination of journals assigned to a centre but also scanned by NDS (c.f. WP2021-05).
A6	Zerkin Otsuka	(Continuing action) Propose a numbering scheme for compound codes defined in Dictionary 209.
A7	Otsuka	Release the updated EXFOR Formats Manual after the revisions proposed in 4C-4/0232=WP2022-07.
A8	Otsuka	Release the updated LEXFOR after the revisions proposed in 4C-4/0232=WP2022-08 as well as (1) CP-D/1046=WP2022-12 (Multiplicity and product yield), (2) CP-D/1048=WP2022-13 (Multiple reaction formalism), (3) CP-D/1042=WP2022-14 (Supracumulative cross section), (4) CP-D/1037=WP2022-16 (Cross sections), (5) CP-D/1024=WP2022-31 (Fission yields), (6) CP-D/1026=WP2022-32 (Errors), (7) CP-D/1031=WP2022-33 (Flags, General quantity modifiers, Status).
A9	Otsuka	Update Dictionaries 25 (data units) and 26 (unit families) to implement proper checking of the multiplicities and product yields by ZCHEX as proposed in CP-D/1046=WP2022-12.
A10	Otsuka	Make the journal code EPJ/AS obsolete in Dictionary 5 as suggested in CP-D/1039=WP2022-15.
A11	Otsuka	Develop a procedure to update Dictionary 207 (nuclides) with the NUBASE evaluation file instead of the Nuclear Wallet Cards and Atomic Mass Evaluation files.
A12	Otsuka	Add a new modifier DMN (divided by mass number of the target nucleus) and quantity ,SIG,,DMN (cross section divided by mass number of the target nucleus) for compilation of the cross section divided by the atomic number of the target nucleus. (c.f. Vidya Devi's presentation)
A13	Otsuka	Make the data heading NUMBER-CM obsolete in Dictionary 24 as suggested in CP-D/1021=WP2022-30.
A14	Otsuka	Add description on the restriction on the usage of MONIT-ERR in Dictionary 24 and LEXFOR "Entries" as suggested in CP-D/1026=WP2022-32.
A15	Otsuka	Submit a LEXFOR draft describing compilation of quasi-elastic scattering data (c.f. 4C-3/0420=WP2022-29).
CINDA		

A16	Zerkin	(Continuing action) Export EXFOR to CINDA, and distribute it to other Centres every month.
A17	Zerkin	Keep NRDC informed about the situation about import of NSR to CINDA.
EXFOR Compilation Needs **(**Underlined items are registered in the Article Allocation List.)		
<u>A18</u>	Pritychenko	(Continuing action) Compile with priority W.G. Alberts+,R,NUREG/CP-0029,433,1982 in CP-D/0838.
<u>A19</u>	Pritychenko	(Continuing action) Compile the thermal neutron-induced reaction data cited in Mughabghab's "Atlas of Neutron Resonances" and listed in 4C-3/0395.
<u>A20</u>	Foligno	(Continuing action) Compile G.N.Kim+,C,2002BRUSS,,613,2002 listed in 4C-3/0400=WP2016-16.
<u>A21</u>	Pritychenko	(Continuing action) Compile F. Bischoff,R,RPI-328-87,146,1966 listed in 4C-3/0404= WP2016-19.
<u>A22</u>	Pritychenko	(Continuing action) Compile P.L.Reeder+,J,PR/C,15,2108,1977 listed in 4C-3/0410=WP2018-20.
<u>A23</u>	Pritychenko	(Continuing action) Compile with priority R.G.Lanier+,R,UCAR-10062-89,71,1989 listed in CP-D/0725 Rev. (~WP2012-19).
<u>A24</u>	Pritychenko	(Continuing action) Compile with priority T.Mo+,J,NP/A,198,153,1972 listed in CP-D/0832 Rev.
<u>A25</u>	Pritychenko Tada Taova	(Continuing action) Compile with priority the light charged-particle induced isotope production cross sections listed in CP-D/0757.
<u>A26</u>	Pritychenko Tada	(Continuing action) Compile with priority the neutron source spectra listed in CP-D/0700 (Rev.3).
<u>A27</u>	Foligno Pritychenko Tada Varlamov	(Continuing action) Compile articles reporting experimental fission product yields and listed in CP-C/464, 465, 466 and CP-D/0979. Inform Devi if an article in the lists is not for EXFOR compilation. Transmit EXFOR entries relevant to these lists separately from other EXFOR entries.
<u>A28</u>	Pritychenko	(Continuing action) Compile deuteron-induced reaction data compiled by the Frascati group and listed in CP-D/0758.

A29	Devi Pritychenko Tada	Compile the data published in the four articles and requested by individual EXFOR users (J,NT,41,109,1978, J,NIM,157,567,1978, J,NP/A,173,273,1971 and C,2016KOLKAT,,314,2016).
A30	Gritzay	(Continuing action) Compile data measured with filtered neutrons measured at the KINR research reactor with numerical neutron spectra.
A31	Pritychenko	(Continuing action) Monitor availability of P.E. Koehler's time-of-flight spectra on DVDs received from ORELA in 2015 for EXFOR compilation. N.B. ^{95}Mo transmission and capture yields have been published in J,PR/C,88,041305,2013 and J,PR/C,105,054306,2022.
A32	Pritychenko	(Continuing action) Perform EXFOR completeness checking for the list of articles (4C-3/0401, articles cited in S. Mughabghab's "Atlas of Neutron Resonances") to identify articles missing in EXFOR, and assign responsibility of compilation of the identified articles to centres by a memo.
A33	Zholdybayev	(Continuing action) Scan domestic publications (*e.g.*, journals, laboratory reports) to identify articles for EXFOR compilation.
EXFOR Quality Control (Underlined items are registered in the EXFOR Feedback List.)		
A34	Pritychenko	(Continuing action) Replace REACTION SF3=A with EL in C0753.002 (CP-D/0960=WP2019-31).
A35	Pritychenko	(Continuing action) Revise DECAY-DATA and DECAY-MON records including EC (electron capture) listed in CP-D/0989=WP2021-07.
A36	Pritychenko Tada	(Continuing action) Revise REACTION SF3 and SF7 listed in Appendices 1, 2 and 3 of CP-D/1014=WP2021-10 (Combination of particle codes and their order in REACTION SF7).
A37	Pritychenko	(Continuing action) Revise REACTION SF8 listed in Memo CP-D/1007=WP2021-15 (LEXFOR "Fitting Coefficients").
A38	Pritychenko	(Continuing action) Replace EL and INL in REACTION SF3 of 12373.008 with SCT (Memo CP-D/0991=WP2021-26).
A39	Devi Tada	(Continuing action) Revise entries involving isomers of Nb-102, Tc-102, Rh-108, Sb-128 and Sb-132 according to Appendix of Memo CP-D/1009 (Rev.)=WP2021-28.
A40	Foligno Pritychenko	(Continuing action) Revise entries involving several variable atomic and/or mass numbers listed in CP-D/0984 in WP2021-31.
A41	Pritychenko	(Continuing action) Revise entries relevant to 511 keV gamma emission listed in CP-D/1005=WP2021-33.

A42	Pritychenko	Replace X+A in REACTION SF3 of T0178.003 with A+X as listed in CP-D/0993(Rev.)=WP2021-34.
A43	Foligno Pritychenko, Tada	Add the issue numbers for Vols. 18-19, 22 and 24-28 of EPJ/A and EPJ/AS articles (and also replace EPJ/AS with EPJ/A if EPJ/AS is coded) as proposed in CP-D/1039=WP2022-15.
A44	Tada	Replace ,INT,,BRA with ,INT,,BRS in K2191.007-010 as listed in CP-D/1037=WP2022-16.
A45	Pritychenko Tada	Replace X with an appropriate code or code combination REACTION SF3 of entries listed in CP-D/1017=WP2022-24.
A46	Pritychenko	Add -G in REACTION SF4 of C1762.002 and eliminate M+ in REACTION SF5 of T0196.031 as suggested in CP-D/1023=WP2022-25.
A47	Foligno Pritychenko Tada Taova	Revise entries relevant to assessment of suspicious E-LVL values as listed in CP-D/1043=WP2022-26.
A48	Devi Pritychenko	Replace TABLE with SCSRS or update the free text unless the numerical data are published in source articles as listed in CP-D/1041=WP2022-27.
A49	Devi Foligno Pritychenko Tada Varlamov	Replace the extra heading DATA with an appropriate one as listed in CP-D/1027=WP2022-28.
A50	Devi Foligno	Replace IND/M+ with CUM in subentries 21592.010-011, 32789.005 and B0153.003 (CP-D/1024=WP2022-31).
A51	Foligno	Add the comments (1) and (2) on 23046.002 in "Note added by NDS" of INDC(GER)-0053 in this subentry.
A52	Devi Foligno Mikhailiukova Pritychenko	(Continuing action) Consider addition of numerical data which are not superseded (SPSDD) and suitable for digitization, but still unobtainable (UNOBT) for neutron-induced reaction data published in old literature.
A53	Foligno	(Continuing action) Provide a report on mistakes in bibliographies and spells on each preliminary tape.

A54	Pritychenko	(Continuing action) Revise EXFOR entries compiling data sets from ORELA 40 m flight station listed in the Appendix of 4C-3/407=WP2017-30 by addition of 1) the corrigendum under REFERENCE of the common subentry, 2) STATUS=OUTDT to each data subentry with the correction factor in free text.
A55	Soppera	(Continuing action) Provide JANIS Import Log created from the EXFOR Master File to Otsuka on a regular basis.
A56	Otsuka	(Continuing action) Assess the JANIS Import Log provided by Soppera as above, and register important errors to the EXFOR Feedback System.
A57	Zerkin	Provide ZCHEX output from an EXFOR Master File to Otsuka.
A58	Otsuka	Assess the ZCHEX output from an EXFOR Master File provided by Zerkin as above, and (1) register important errors to the EXFOR Feedback System, and (2) suggest Zerkin updates of ZCHEX to eliminate unnecessary messages.
A59	Otsuka	Propose corrections of entries compiling neutron quasi-elastic scattering datasets based on 4C-3/0420=WP2022-29 and newly introduced codes E-EXC-MAXA and EXL.
A60	Otsuka	Review the neutron quasi-elastic scattering cross sections for natural target nuclides and total scattering cross sections similar to the review summarized in Memo 4C-3/0420=WP2022-29.
EXFOR Coding Rule		
A61	Takács Otsuka	Check presence of the cross sections compiled as total (=ground state plus metastable state) independent production cross sections but deviation of the measured values from the actual total cross sections may be non-negligible.
A62	Varlamov Otsuka	Review the usage of (G,TOT), (G,ABS), (G,SCT) and (G,N) for the cross sections declared as “absorption cross sections” or “total cross sections” by the authors.
A63	Zerkin Otsuka	Propose an extension of the code field for the keyword STATUS to accommodate the reference code string.
Tools for Compilation and Dissemination		
A64	Foligno	(Continuing action) Make available on the NEA Data Bank web site the EANDC and NEANDC reports compiled in EXFOR and not available as INDC reports.

A65	Pikulina	(Continuing action) Continue development and testing of the EXFOR-Editor and InpGraph in cooperation with NDS and other data Centres.
A66	All	(Continuing action) Provide Pikulina feedback on EXFOR-Editor and InpGraph.
A67	Suzuki	(Continuing action) Continue development and testing of GSYS in cooperation with NDS and other centres.
A68	All	(Continuing action) Provide Suzuki feedback on GSYS.
A69	Soppera	(Continuing action) Continue development and testing of the JANIS TRANS Checker in cooperation with NDS and the other centres.
A70	All	(Continuing action) Provide Soppera feedback on JANIS TRANS Checker.
A71	Bhattacharyya	(Continuing action) Keep centres informed about the progress in development of the EXFOR-I editor.
A72	Nayak	(Continuing action) Monitor progress in development of the EXFOR-I editor.
A73	Otsuka	(Continuing action) Provide EXFOR News every month and consider updates to the IAEA NDS website.
A74	Otsuka	(Continuing action) Support update of the Japanese editor (HENDEL) as time permits.
A75	Zerkin	(Continuing action) Update ZCHEX based on comments from compilers.
A76	All	(Continuing action) Provide feedback to NDS on the existing ZCHEX version (on bugs as well as desired additions.). Bugs must be reported with sample entries which are checked and not checked properly by ZCHEX.
A77	Zerkin	(Continuing action) Develop and distribute the program package including a standalone platform independent program to generate X4+ from a standalone EXFOR entry.
A78	All	(Continuing action) Consider to use the X4+ format for author approval, and also send feedback to Zerkin.
A79	Zerkin	(Continuing action) Continue development of the EXFOR upload web tool.
A80	Zerkin	(Continuing action) Produce: (a) EXFOR Master file with Dictionary-236 and X4Map after every database update, and (b) Dictionaries in MS Access after every Dictionaries update (see also A4).

A81	Zerkin	(Continuing action) Continue development of the additional database encompassing correction factors and relevant comments for suspect/erroneous data (X4-evaluated) presented in WP2010-19; keep NRDC informed about results, impact and usage statistics of the database.
A82	Zerkin Pritychenko	(Continuing action) Continue joint development of the EXFOR and NSR databases.
A83	Jin Suzuki Pikulina Zerkin	(Continuing action) Study problems in 2D calibration of original pictures, and process of approval of results of digitizing using plotting facilities.
A84	Foligno Devi Pritychenko	(Continuing action) Finalize and submit EXFOR entries including covariance data provided by Zerkin (WP2017-Z3).
A85	Pritychenko	(Standing action) Provide NSR database to Zerkin with the name aliases to improve the search of EXFOR entries by the author name (WP2014-53).
A86	All	(Continuing action) Preparing for NRDC-2023 discussion about policy (methods/formats) of off-line dissemination of EXFOR data by NRDC members to external users' communities and conditions/requirements for further re-distribution (Zerkin's presentation-3 of the NRDC 2021 meeting).
A87	All	(Continuing action) Investigate possibility for opening public Web access to lab reports of the institutes of EXFOR-Area responsibility.
A88	Zerkin	(Continuing action) Submit a memo explaining how to use EXFOR Database Update Error Report and other tools to avoid duplication.
A89	Pritychenko Zerkin Otsuka	(Continuing action) Investigate assignment of Digital Object Identifiers (DOI) for EXFOR data sets using DataCite and one of EXFOR formats. Start a pilot project and produce several DOI for EXFOR data sets. Report results at the next NRDC meeting in 2022.
A90	Zerkin	Collaborate with the IAEA INIS Unit for technical matching of the pdf databases maintained by NDS and the Unit.
A91	Zerkin	Arrange a letter to IPPE for opening public access from the NDS web retrieval system to IPPE reports.
A92	Zerkin	Prepare a manual describing the EXFOR database related tools available on the NDS web site.
A93	Zerkin	Provide training of the X4Pro (fully relational EXFOR database) in the EXFOR Workshop in December 2022.

A94	Pritychenko	To investigate NNDC library for missing private communication relevant to EXFOR compilation.
A95	Vrapcenjak	Collect articles coded under REFERNECE of newly submitted preliminary tapes but missing in the NDS article collection.
A96	All	Collaborate with Vrapcenjak for collection of articles coded under REFERENCE of newly submitted preliminary tapes but missing in the NDS article collection.

Appendix D

LIST OF WORKING PAPERS

Number	Title	Presented by
WP2022-01	Conclusions and action of the 2021 NRDC Meeting	
WP2022-02	Transmission statistics since the last NRDC meeting	N. Otsuka
WP2022-03	Status of new article compilation (A1)	N. Otsuka
WP2022-04	Time interval between submission of preliminary and final tapes	N. Otsuka
WP2022-05	New publications scanned by NDS and other centres	V. Devi
WP2022-06	Progress in correction of items on Feedback List (A2)	N. Otsuka
WP2022-07	Updated Formats Manual (A5, CP-D/1044, 4C-4/0232)	N. Otsuka
WP2022-08	Updated LEXFOR (A6, CP-D/1045, 4C-4/0232)	N. Otsuka
WP2022-09	Conclusion 43 of NRDC 2021 meeting (CP-D/1036)	N. Otsuka
WP2022-10	Data headings ANG-AZ and ANG-AZ-RL (CP-D/1019)	N. Otsuka
WP2022-11	Method codes ASEP, MASSP and OLMS (CP-D/1020)	N. Otsuka
WP2022-12	Multiplicity (CP-D/1046)	N. Otsuka
WP2022-13	Multiple reaction formalism (CP-D/1048)	N. Otsuka
WP2022-14	Supracumulative cross section (CP-D/1042)	N. Otsuka
WP2022-15	Coding of EPJ/A supplemental issues (CP-D/1039)	N. Otsuka
WP2022-16	Cross section integral (CP-D/1037)	N. Otsuka
WP2022-17	Role of family flags (family codes) in ZCHEX program	V. Zerkin
WP2022-18	Status of CINDA database (A14)	V. Zerkin
WP2022-19	Compilation of article with priority (A16, A21-A24)	N. Otsuka
WP2022-20	Compilation of articles from completeness checking (A17-A20, A27-A29)	N. Otsuka

WP2022-21	Progress in compilation of fission product yields (A25-A26)	N. Otsuka
WP2022-22	Individual data requests	N. Otsuka
WP2022-23	Pending corrections (A34-A36, A44-A47, A49-A53)	N. Otsuka
WP2022-24	Suspicious use of REACTION SF3=X for production cross sections (CP-D/1017)	N. Otsuka
WP2022-25	Use of branch codes M+ and (M) without isomeric flag in REACTION SF4 (CP-D/1023)	N. Otsuka
WP2022-26	Erroneous E-LVL values (CP-D/1043)	R. Shimizu
WP2022-27	Questionable replacement of status code with TABLE (CP-D/1041)	N. Otsuka
WP2022-28	Multiple appearance of heading DATA (CP-D/1027)	N. Otsuka
WP2022-29	Neutron quasi-elastic scattering data coded with SF3=EL (4C-3/0420 Rev.)	N. Otsuka
WP2022-30	Use of NUMBER-CM and compilation of 0th order Legendre coefficients (CP-D/1021)	N. Otsuka
WP2022-31	Combination of branch code M+ or (M) with parameter code FY (CP-D/1024)	N. Otsuka
WP2022-32	Usage of heading MONIT-ERR (CP-D/1026)	N. Otsuka
WP2022-33	Alternative results (CP-D/1031)	S. Dunaeva
WP2022-34	Threshold calculator and its application to REACTION SF3 checking (CP-D/1047)	N. Otsuka
WP2022-35	Eta-value plotting (4C-3/0419)	N. Otsuka
WP2022-36	Compilation of experimental nuclear reaction data measured in Central Asia region	T. Zholdybayev

Note: These working papers are available online: http://nds.iaea.org/nrdc/nrdc_2022/.

Appendix E

LIST OF PRESENTATIONS

TITLE	Presented by
Center of Nuclear Physics Data	S. Taova
IAEA Nuclear Data Section	A. Koning
JCPRG progress report	S. Shin
Progress report	M. Mikhailiukova
Center of Nuclear Physics Data	S. Taova
Korea Nuclear Data Center progress report for 2021-2022	D. H. Kim, S. C. Yang
Progress Report for NRDC Meeting 2022 ATOMKI	S. Takács
2021/22 status report of China Nuclear Data Center	J. M. Wang
BARC progress report	D. Raj
NEA Data Bank Progress Report 2021-2022	D. Foligno
The present status of the EXFOR project: Area #1	B. Pritychenko
Erroneous E-LVL values (CP-D/1043)	R. Shimizu
Cumulative cross sections	S. Takács
Analysis of EXFOR outliers	V. Devi
Neutron quasi-elastic scattering data	N. Otsuka
NSR tutorial	B. Pritychenko
Recent development of GSYS	R. Suzuki
Progress in EXFOR-ENDF databases, retrieval systems, tools and software	V. Zerkin
X4Pro - fully relational EXFOR database	V. Zerkin
Compilation of experimental nuclear reaction data measured in Central Asia region	T. Zholdybayev

Note: These presentations are available online: http://nds.iaea.org/nrdc/nrdc_2022/.

Appendix F

PROGRESS REPORTS

Number	Title	Presented by
P2022-01	IAEA Nuclear Data Section: Progress Report for period 2021-2022	A. Koning
P2022-02	Progress report on the CDFE photonuclear data activity for 2021/2022	V.V. Varlamov
P2022-03	Japan Nuclear Reaction Data Centre (JCPRG) Progress Report	S. Shin
P2022-04	Progress Report for NRDC2022 Technical Meeting (14-17 June 2022)	M. Mikhailiukova
P2022-05	Ukrainian Nuclear Data Centre: Progress Report for period 2021-2022	O. Gritzay
P2022-06	Center of Nuclear Physics Data (CNPD), RFNC-VNIIEF. Technical paper for the NRDC Meeting, IAEA, June 14-17, 2022	S. Taova
P2022-07	Korea Nuclear Data Center (KNDC) Progress Report for period 2021-2022	D.H. Kim
P2022-08	Progress Report NRDC-2022 Technical Meeting	S. Takács
P2022-09	2021/22 Status Report of China Nuclear Data Center	Ge Zhigang
P2022-10	A brief status update on the nuclear reaction data activities in BARC during 2021-2022	D. Raj

Note: These progress reports are available online: http://nds.iaea.org/nrdc/nrdc_2022/.

IAEA Nuclear Data Section: Progress Report for period 2021-2022

Summary of Nuclear Data Activity by Staff of the IAEA Nuclear Data Section

April 2021 – May 2022

IAEA Technical Meeting, 14-17 June 2022
Vienna, Austria

Web: https://nds.iaea.org/
E-mail: nds.contact-point@iaea.org

1. Staff Changes

The authorized staff level of the Nuclear Data Section (NDS) consists of a total of 16.25 professionals and support staff. The latest staff changes include:

- Mark O'Connell (Information Systems Assistant) retired in April 2022.

2. Compilations

2.1 EXFOR transmission

During the reporting period, the following final tapes have been transmitted:

- 10 neutron final TRANS tapes (3199–3207, V039) containing 67 new entries and 174 revised entries;
- 16 CPND final TRANS tapes (B031-B033, D130-D136) containing 96 new entries and 149 revised entries;
- 2 PhND final TRANS tapes (G047-G048) containing 13 new entries and 3 revised entries.

These include contributions from NDS (**50 new entries**), five other centres (ATOMKI, CNDC, KNDC, NDPCI, UkrNDC) as well as two compilers (Myagmarjav Odsuren, Timur Zholdybayev).

Timur Zholdybayev (Institute of Nuclear Physics, Almaty) is coordinating compilation of data measured in Central Asia (*e.g.*, Kazakhstan, Uzbekistan) for area 3, D and G

Myagmarjav Odsuren (National Univ. of Mongolia, Ulaanbaatar) is compiling heavy-ion induced reaction data measured in area 2 countries (*e.g.*, France, Germany, Italy) for area D.

Two regular transmissions of the EXFOR/CINDA dictionaries (TRANS.9124–9125) were done in TRANS, DANIEL (backup) and archive format.

Number of new entries transmitted by final tapes since the NRDC 2021 meeting
(TZ: Timur Zholdybayev, MO: Myagmarjav Odsuren)

	NDS	**ATOMKI**	**CNDC**	**KNDC**	**NDPCI**	**UkrNDC**	**TZ**	**MO**	**Sum**
Neutron	20		19	4	23	1			**67**
CPND	30	7		6	32	7	3	11	**96**
PhND				3	0	10			**13**
Sum	50	7	19*	13	55	18	3	11	**176**

* Area S entries are transmitted by CNDC and therefore not included in these statistics.

2.2 EXFOR quality control

During the reporting period, **108 preliminary tapes** (PRELIM) uploaded to the NDS open area for checking by NDS and other centres. Both ZCHEX and JANIS TRANS Checker are regularly used. The finalized tapes are also checked against comments from centres before uploading to the NDS open area. NDS also registers comments on EXFOR entries from users and centres to the **EXFOR Feedback List** (https://nds.iaea.org/nrdc/error/) and monitors the correction process by checking each preliminary tape against the feedback list.

Additionally,

- Stanislav Simakov (NDS consultant) extracted neutron elastic scattering angular differential and integrated cross sections which may include contribution of inelastic scattering to lower excitation levels, and reviewed each case by checking the source article. See Memo 4C-3/0420 for further details.

- Ryosuke Shimizu (NDS intern) extracted questionable energies coded under the heading E-LVL, and reviewed each case by checking the source article and ENSDF library. See Memo CP-D/1043 for further details.

2.3 EXFOR coverage control

Under the EXFOR compilation control system, **38 journal titles** are regularly scanned by NDS and registered to the EXFOR Compilation Control System (X4CoCoS), and they are listed in the **Article Allocation List** (https:/nds.iaea.org/nrdc/alloc/). This list also includes the scanning records of 18 journal titles received from other centres. The newly published articles are also listed on https://nds.iaea.org/exfor-master/x4compil/. EXFOR statistics for compilers was extended by indicating waiting time for PRELIM files.

2.4 CINDA

Regular automatic updates using the EXFOR and NSR databases have been frozen because NSR database is not available since 2019. Import from EXFOR and NSR-2018 was performed once to keep maintenance system alive.

2.5 Evaluated data libraries, files and programs

Various new and revised evaluated data libraries, files and programs for data checking, processing and graphical presentation were added, developed and distributed via the NDS Web site (see below).

3. Services

3.1 Web Services

Further improvements have been implemented in the Web EXFOR-CINDA-ENDF-IBANDL database retrieval systems and Web-Tools for nuclear data compilers and evaluators since the last NRDC meeting:

- ENDF (Evaluated Nuclear Data Files):
  - new and updated evaluated libraries in the ENDF database:
    - JENDL-5 Japanese evaluated nuclear data library 2021 (incl. Errata March-2022)
    - JENDL/DDF-2015 JENDL Decay Data File 2015, Japan
    - FENDL-3.2b Fusion Evaluated Nuclear Data Library, IAEA, 2022
    - IRDFF-II/DD: decay data sub-library of International Reactor Dosimetry and Fusion File, IAEA 2019
    - INDEN-Feb2022: evaluations produced by International Nuclear Data Evaluators Network (coordinated by the IAEA)
    - IAEA-Std17: IAEA Standard and Reference Cross Sections, 2017
    - UKDD-2020 : UK Decay Data Library, UK, 2020
  - software news:
    - radioactive decay data (MF8.MT457): output to JSON, plot, comparison data of different libraries from ENDF database and LARA files from DDEP-2021 and ENSDF-2021
    - plotting groupwise data running GROUPIE code on the fly on 175, 640, 725, 765 groups
    - API for search and download data of MF4, MF5, MF6 in JSON
- EXFOR:
  - new section “Evaluator”: search for ENDF users by <Target, Projectile, MF, MT>
  - automatic renormalization using decay data: intensity of lines (AR, DG, X from DECAY-DATA and DECAY-MON)
  - option: “cm2lab” for angular distributions
- EXFOR-NRS PDF database
  - updates: 85, added 3,092 PDF files
  - ready to open public Web access to Lab reports of JINR, Dubna (via INIS)
  - database content (PDF files):

        - total: +3,092 => 223,350
        - EXFOR-PDF: +1,081 => 26,904 (77.1% of 34,876)
        - NSR-PDF: +1,837 => 188,903 (~79.2% of 238,544)
- IBANDL: 4 database updates
- Web-ZVView: on-line translation (via intermediate JSON) and plot by Plotly-2.0

Development of the Web-Tools for EXFOR compilers, ENDF and ENSDF evaluators:

- MyExfor: 6 updates by new versions of ZCHEX and new Dictionaries
- MyEnsdf: added/upgraded codes: JAVA_NDS (+online LaTeX to PDF), GABS, GTOL, BrIcc, ALPHAD_RadD, ALPHAD

The Web EXFOR-CINDA-ENDF database retrieval system is functioning at NNDC (USA), BARC (India) and "Atomstandart" (Russia). Statistics for usage of the Web retrieval system are presented in figures below.

3.2 Packages for Web downloading (former CD/DVD-ROM's)

New and updated packages:

- new release of GRUCON evaluated data processing code (V.Sinitsa, Kurchatov Institute, Moscow, Russia).

- new release of "X4Apps/X4Lite" EXFOR-CINDA database (SQLite) with GUI (Java) retrieval system for Windows, Linux, MacOSX. Provides scripts and utility codes for EXFOR data search, retrieval and conversion to: Html, XML, JSON, C5. Includes Endver/GUI package integrated with Prepro, EXFOR, ZVView.

- new product (to be released): "X4Pro" extends EXFOR Relational database (SQLite) with experimental data points in original and computational form; comes with demo on Python and Fortran with (a) retrievals of CS, DA, DAP, DE, DAE from local EXFOR and remote ENDF databases, (b) EXFOR data renormalization to new standards and decay data, (c) user's modifications and (d) plotting with Plotly package. All works on Windows, Linux and MacOS.

3.3 Document Services

Nuclear Data Services Unit (NDSU) continued supporting the Member States by providing documentation and data libraries as requested.

The documents produced by the Nuclear Data Section are now shared via links to our webpage, and hardly any hardcopies are being sent.

Due to technologies also constantly improving, the data libraries are now only downloaded from the we webpage https://nds.iaea.org/cdroms/. There were only two requests for the data to be sent out physically in the reporting period.

Any improvement suggestions should be sent to our contact address (nds.contact-point@iaea.org).

Number of reports published between April 2021 and May 2022

Report code	Country of origin	Reports
IAEA-NDS	Nuclear Data Section	3
INDC(JPN)	Japan	1
INDC(USA)	United States	1
INDC(NDS)	Nuclear Data Section	20
INDC(SEC)	NDS Secretariat	1

3.4 Nuclear Data Newsletters

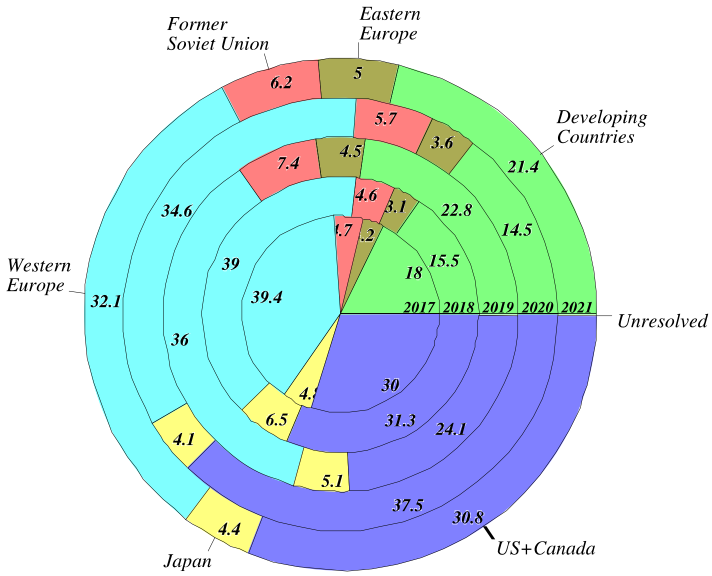
The Nuclear Data Newsletter is published biannually to inform the scientific community about actual NDS work, meetings held, projects, and new data libraries. During the reporting period, we published two issues of the Newsletter (71 and 72). Next one, No 73 is in preparation and will be published in August 2022. We currently have 94 recipients of hardcopies and 1288 recipients of electronic version.

4. Visits and Inter-centre Cooperation

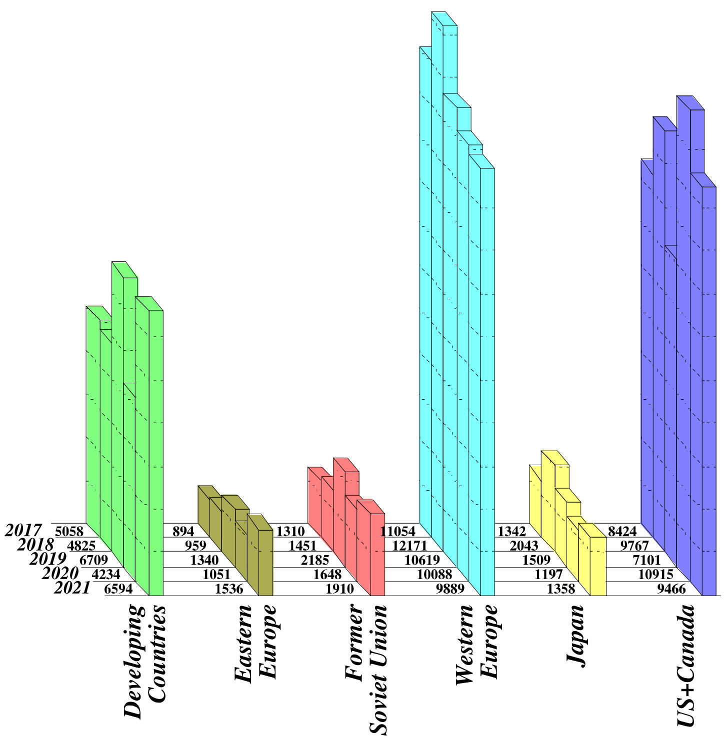
- V. Zerkin (NDS) visited NNDC from 1 to 19 May 2022 to deploy and further develop software for ENDF-EXFOR-PDF database management, Web retrieval system, tools and output formats; to extend schema and contents of EXFOR, ENDF and EXFOR-NSR PDF databases.

IAEA Nuclear Data Services: Web Statistics 2017-2021

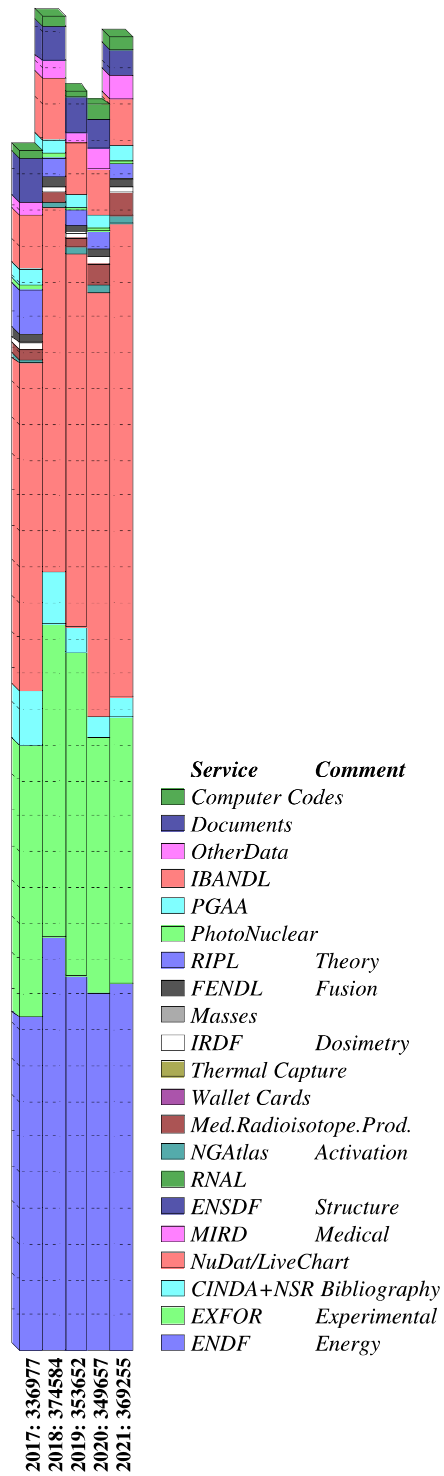
Geographical Distribution (%)



Average per Month
(Number of accesses + retrievals)



Total per Year
(Number of accesses + retrievals)
*2020 extrapolated 5 months



5. Nuclear Data Developments

The Nuclear Data Section undertakes long term nuclear data development by implementing Coordinate Research Projects (CRP) and Data Development Projects (DDP). The staff members of NDS who manage NRDC also follow the currently running CRPs and DDPs to observe the actual trends and needs for nuclear reaction data.

5.1. Coordinated Research Projects (CRP)

- Recommended Input Parameter Library (RIPL) for fission cross section calculations (2017-2021): *Ongoing.*
- Updating fission yield data for applications (2020-2025): *Ongoing*.

5.2 Data Development Project (DDP)

- Intercomparison of PIGE analysis codes to calculate PIGE yields for the analysis of bulk samples: *Ongoing*
- Evaluation of nuclear moments: *Ongoing*
- Verification of data processing codes for generating ACE-formatted files: *Ongoing*
- Stopping power database: *Ongoing*
- Nuclear data libraries for advanced systems: Fusion devices: *Ongoing*
- Nuclear Data for Medical Applications: *Ongoing*
- Maintain the international Neutron Standards file and evaluation techniques: *Ongoing*

6. Training Activities (Schools, Workshops)

- Joint ICTP-IAEA Workshop on "Atomistic Modelling of Radiation Damage in Nuclear Systems", 2021, Trieste, Italy (virtual).

7. Nuclear Data Journal Publications (2021-2022)

EXFOR-NSR PDF database: a system for nuclear knowledge preservation and data curation

V.V. Zerkin, B. Pritychenko, J. Totans, L. Vrapcenjak, A. Rodionov, G.I. Shulyak, *J. Instrum*. **17** (2022) P03012

Iterative Bayesian Monte Carlo for nuclear data evaluation

E. Alhassan, D. Rochman, A. Vasiliev, M. Hursin, A.J.Koning, H. Ferroukhi, *Nucl. Sci. Tech.* **33** (2022) 50.

Impact of H in H2O thermal scattering data on criticality calculation: uncertainty and adjustment

D.A. Rochman, A. Vasiliev, H. Ferroukhi, A. Koning, J.-Ch. Sublet, *EPJ Nucl. Sci. Technol.* **8** (2022) 3.

Advanced breakup-nucleon enhancement of deuteron-induced reaction cross sections

M. Avrigeanu, D. Rochman, A.J. Koning, U. Fischer, D. Leichtle, C. Costache, V. Avrigeanu, *Eur. J. Phys.* ***A58** (2022) 3.*

Radioisotope products and the medicine of the future: an IAEA perspective
A. Jalilian, A. Korde, V. Starovoitova, J.Jr. Osso, A. Koning, N. Pessoa Barradas, C. Horak, M. Denecke, *Bull. Sci. Cent. Expert Eval. Med. Prod.* (2022) 539.163:615.31:615.849.

Nuclear data evaluation with Bayesian networks
G. Schnabel, R. Capote, A. Koning, D. Brown, *Arxiv preprint* **arxiv:2110.10322** (2021)

Development and application of marginal likelihood optimization for integral parameter adjustment
D. Siefman, M. Hursin, G. Schnabel, H. Sjoestrand, *Ann. Nucl. En.* **159** (2021).

Application of JADE V&V capabilities to the new FENDL v3.2 beta release
D. Laghi, M. Fabbri, L. Isolan, M. Sumini, G. Schnabel, A. Trkov, *Nucl. Fusion* **61** Issue 11 (2021) 116073.

Investigating High-Energy Proton-Induced Reactions on Spherical Nuclei: Implications for the Pre-Equilibrium Exciton Model
Morgan B. Fox, Arjan J. Koning, et l., *Phys. Rev. C* **103** (2021) 034601.

Conception and software implementation of a nuclear data evaluation pipeline
G. Schnabel, H. Sjoestrand, J. Hansson, D. Rochman, A. Koning, and R. Capote, *Nucl. Data Sheets* **173** (2021) 239-284.

Measurement and Modeling of Proton-Induced Reactions on Arsenic from 35 to 200 MeV
Morgan B. Fox, Arjan J. Koning, et al., *Phys. Rev. C* **104** (2021) 064615.
Improved modelling of alpha-particle emission in nucleon induced reactions
A.Yu. Konobeyev, D. Leichtle, A.J. Koning, *KIT Scientific Working Papers* **176** (2021).

Fast-neutron induced reaction cross section measurement of tin with dual monitor foils and covariance analysis
R.Pachuau, N.Otuka, C.V.Midhun, A.Gandhi, A.Mazumdar, H.Krishnamoorthy, A.Reza, V.Vatsa, S.V.Suryanarayana, B.K.Nayak, L.S.Danu, T.Patel, S.Bishnoi, I.Pasha, A.Kumar, V.Nanal, *Eur. Phys. J. A* **57** (2021) 268.

Activation cross section measurement of alpha-particle induced reactions on natural neodymium
M. Sakaguchi, M. Aikawa, N. Ukon, Y. Komori, H. Haba, N. Otuka, S. Takács, *Appl. Radiat. Isot.* **176** (2021) 109826.

Erratum to "Uncertainty propagation in activation cross section measurements" [Radiat. Phys. Chem. 140 (2017) 502-510]
N. Otuka, B. Lalremruata, M.U. Khandaker, A.R. Usman, L.R.M. Punte, *Radiat. Phys. Chem.* **184** (2021) 109440.

Progress report on the CDFE photonuclear data activity for 2021/2022.

V.V.Varlamov, A.I.Davydov, V.N.Orlin, V.V.Chesnokov

Progress report for the Technical Meeting of the International Network of Nuclear Reaction Data Centres, 14 to 17 June 2022.

The report contains the short review of the Centre for Photonuclear Experiments Data (Centr Dannykh Fotoyadernykh Eksperimentov - CDFE) of the Russia Lomonosov Moscow State University Skobeltsyn Institute of Nuclear Physics main results obtained for the period of time from the Technical Meeting of the International Network of Nuclear Reaction Data Centres at the IAEA's Headquarters in Vienna, Austria, from 4 to 7 May 2021. The new photonuclear data compilations, old data corrections, and the results of analysis and evaluation of photonuclear data obtained in various experiments are presented.

EXFOR Compilation

7 new CDFE EXFOR **trans.m111 – m117** TRANSes and two ***prelim.m118 and prelim.m119*** have been produced and transmitted to the IAEA NDS. All TRANSes contain **128** ENTRYs, new compiled (11 ENTRYs) and old corrected (117 ENTRYs) in accordance with the contents of the NRDC Network Memos, the NDS database "Articles for compilation" (https://www-nds.iaea.org/nrdc/alloc/), the new EXFOR format rules and the comments and recommendations of the NRDC experts, first of all Naohiko Otsuka and Daniela Foligno.

The contents of all CDFE TRANSes transmitted to the IAEA NDS are presented in Table.

Table

New and *Old* trans.m* and *prelim.m** contents

TRANS	*Old*	**New**	Total
m111	*3*	**3**	6
m112	*23*	**-**	23
m113	*13*		13
m114	*1*	**4**	5
m115	*3*	**3**	6
m116	*3*	**1**	4
m117	*20*		20
prelim.m118	*24*		24
prelim.m119	*27*	**0**	27
Common	*117*	**11**	128

Photonuclear Data Evaluation

The CDFE photonuclear data evaluation program was continued. Using the objective physical data reliability criteria new data for partial (γ, 1n), (γ, 2n), (γ, 3n) and total (γ, tot) = (γ, 1n) + (γ, 2n) + (γ, 3n) photoneutron reaction cross sections were evaluated using experimental-theoretical method for nuclei ^{58,60}Ni, ^{197}Au, ^{206,207}Pb.

Main publications

1. V.V.Varlamov, A.I.Davydov. Experimemtal and evaluated data on photodisintegration of ^{197}Au. Physics of Atomic Nuclei, 85, N1 (2022) 1 - 11.

2. V.V.Varlamov, A.I.Davydov, V.N.Orlin. Photodisintegration of ^{206,207,208}Pb nuclei: experimental and theoretical cross sections of photoneutron reaction. Bull. Rus. Acad. Sci. Phys., 86, №4 (2022) 465 - 472.

3. V.V.Varlamov, A.I.Davydov, V.N.Orlin. Reliability of photonuclear experiments results for ^{58}Ni. Yadernaya Fizika, 85, N4 (2022) 237 - 248.

4. V.V.Varlamov, A.I.Davydov, V.N.Orlin. New evaluated data on photonuclear reactions cross sections for ^{60}Ni. Physics of Atomic Nuclei, 85, N5 (2022), in print.

5. V.V.Varlamov, A.I.Davydov, V.N.Orlin. The specific features of photoneutron reactions on ^{58}Ni. Eur. Phys. J. A, in print.

Short-term (2022/2023) Program

The main items of CDFE (2022/2023) program, main priorities and most important tasks are traditional and the following:

- continuation of new photonuclear data compilation using EXFOR format, production of new TRANSes (M120, M121, etc.);
- correction of old ENTRYs in accordance with new EXFOR coding rule changes and the NRDC Network expert's comments and recommendations;
- continuation of analysis and evaluation using objective physical criteria of total and partial photonuclear reaction cross sections obtained in various experiments.

Japan Nuclear Reaction Data Centre (JCPRG)

Progress Report

Nuclear Reaction Data Centre (JCPRG),
Faculty of Science, Hokkaido University
http://www.jcprg.org

IAEA's Technical Meeting on the
"International Network of Nuclear Reaction Data Centres"
June 14-17, 2022

0. General

The Japan Nuclear Reaction Data Centre (JCPRG) is a research center for nuclear data activities in Hokkaido University Sapporo. The main objectives of JCPRG are as follows:

Compilation of nuclear reaction data for two databases, NRDF and EXFOR
Evaluation of nuclear reaction data
Development of software and systems for compilation and evaluation
Education of the graduate school students

1. Compilation

1.1 NRDF

NRDF database is the original nuclear reaction database of JCPRG. Our initial EXFOR entries were provided by converting the NRDF format to the EXFOR format. Nowadays, both NRDF and EXFOR formats are generated simultaneously using the database creation editor HENDEL. From May 2021 to May 2022, we have compiled 32 new papers of charged particle and photonuclear reaction data.

1.2 EXFOR

Since the last NRDC meeting, we have transmitted 32 new and 2 revised entries as 4 trans files (E131-E134) to the NDS open area. Our transmissions are summarized in Tables 1.

Table 1. EXFOR E-entries transmitted from JCPRG to NDS IAEA in 2021.

TRANS	TRANS Status	ENTRY Tot.	ENTRY New	ENTRY Rev.
E131	Final (2021/06/07)	10	10	0
E132	Final (2021/06/22)	11	11	0
E133	Prelim (2022/01/20)	2	0	2
E134	Prelim (2022/03/05)	11	11	0

2. System Development

2.1 Data Retrieval System

We have 3 data retrieval systems mentioned below.

- NRDF (http://www.jcprg.org/nrdf/)
- NRDF/A (http://www.jcprg.org/nrdfa/)
- EXFOR/ENDF (http://www.jcprg.org/exfor/)

The relational database management system MySQL has been adopted for the databases to search and retrieve NRDF, EXFOR and ENDF data. For EXFOR, new trans files are copied from the NDS open area, and the MySQL database is updated periodically.

2.2 Coding Software

We have a coding editor and digitizing software applicable for the coding purpose

Coding editor "HENDEL" (https://www.jcprg.org/manuals/hendel/)

Digitization software "GSYS" (https://www.jcprg.org/gsys/2.4/)

CJD Progress Report
for NRDC2022 Technical Meeting
(14-17 June 2022)

1. EXFOR activity.

EXFOR compilation statistics

Trans	Status	Date	Entries total	Entries new	Entries revised	Subents total	Subents New	Subents Revised
4194	Final	2021-06-07	8	4	4	24	14	10
4195	Final	2021-08-10	43	0	43	175	0	175
4196	Final	2021-08-10	16	0	16	57	2	55
4197	Final	2021-09-14	16	0	16	85	1	84
4198	Final	2021-09-15	3	2	1	8	7	1
4199	Final	2021-10-01	6	0	6	26	1	25
4200	Final	2021-11-12	38	1	37	385	25	360
4201	Final	2022-01-13	13	0	13	213	2	211
4202	Final	2022-01-31	20	5	15	124	41	83
4203	Final	2022-03-05	18	0	18	136	1	135
	Final		**181**	**12**	**169**	**1233**	**94**	**1139**
4204	Prelim	2022-03-25	46	0	46	271	2	269
4205	Prelim	2022-04-01	8	2	6	38	14	24
4206	Prelim	2022-04-29	12	0	12	53	5	48
4207	In prep.	2022-		2				

2. Journal YK - https://vant.ippe.ru/

The journal “Yadernye Konstanty” (YK) is continued to be published in IPPE as the online journal “Yadernye and Reaktornye Konstanty” ("Problems of Atomic Science and Technology. Series: Nuclear and Reactor Constants").

Four regular issues during 2021 year and one regular issue during 2022 year were published.

3. Proposals in memos

-229 2021-12-23 New code for EXFOR dictionary 236.

-230 2022-04-21 New journal code for EXFOR dictionary 5.

4. NRDC2021 Actions.

A1-A2 – continue as usual

A26 – finished.

A46 – finished.

A50 – finished.

A56, A58, A60, A66, A68 – Feedback were not sent – no questions

A76 – no questions

A77 – a message about lab. reports was sent 21 June 2021

5. Acknowledgments

- Dmitriy Gremyachkin, Vladimir Piksaykin, Pavel Prusachenko, Shakir Zeinalov, Saltanat Dabylova, Nikita Fedorov for sent experimental data and explanations of experiment details,
- Naohiko Otsuka for detailed checking of preliminary transes and productive discussions,
- Daniela Foligno, Manuel Bossant for useful comments of preliminary transes,
- Lidija Vrapcenjak (IAEA) for providing pdf-files of articles,
- Viktor Zerkin for preparation and Lidija Vrapcenjak for sending of CD-disks containing EXFOR, CINDA, computer codes and evaluated libraries.

Ukrainian Nuclear Data Centre: Progress Report for period 2021-2022

Summary of Nuclear Data Activity by Staff of the Ukrainian Nuclear Data Centre

April 2021 – May 2022

O. Gritzay, O. Kalchenko

IAEA Technical Meeting, 14-17 June 2022
Vienna, Austria

Web: http://ukrndc.kinr.kiev.ua/
e-mail: ogritzay@ukr.net

Ukrainian Nuclear Data Centre (UkrNDC) is subdivision within the Neutron Physics Laboratory at the Institute for Nuclear Research of the National Academy of Sciences of Ukraine.

Compilation

We continue collection and compilation of experimental neutron, charged particle and photonuclear data. Number of the new/renew EXFOR's entries sent to the NDS IAEA by UkrNDC is the following:

- for neutron data – 1 new entry (32251);
- for charged particle data – 9 new entries (D5184, D5187÷D5194);
- for photonuclear data – 11 new entries (G4089÷G4099) and 1 updated entry (G4042).

We realize review of compilation scope in home journals:

- Nuclear Physics and Atomic Energy;
- Ukrainian Journal of Physics;
- Problems of Atomic Science and Technology, Series Nuclear Physics Investigations;
- East European Journal of Physics;

.

Collaboration

We continue our collaboration with the Nuclear Physics Department of Taras Shevchenko National University of Kyiv.

- The teaching course "*Nuclear Data for Science and Technology and modern computer codes for nuclear data processing*" (42 hours) was lectured in 2021-2022 for the fifth-course students of the NPD KNU. This course includes the following items: ENDF/B libraries, EXROR system, ENSDF library, the use of the PREPRO code in work with the ENDF/B libraries, the introduction to NJOY code system, the Network of Nuclear Reaction Data Centers and the use of the on-line services.

- We continue our activity within the framework of educational and scientific program of the Institute for Nuclear Research of the National Academy of Sciences of Ukraine on the preparation of a doctor of philosophy in specialty 01.04.16 (physics of the nucleus, elementary particles and high energies).

- The teaching course "Experimental methods of nuclear power engineering" (26 hours) was lectured in September-October 2021 and May 2022 for post-graduate students in the 2nd year of study.

- The teaching course "Modern codes and nuclear data" (26 hours) was lectured in May 2022 for post-graduate students in the 2nd year of study.

Customer Services

- The UkrNDC site is operating. Ukrainian customers, especially students and those physicists, who wish to prepare the point-wise and multi-group cross sections self-dependently, but do not have a good experience in it, use this site very often. Address of the UkrNDC site: *http://ukrndc.kinr.kiev.ua*.

Experimental and Computational Activity

Simulation of a new neutron filter with average energy 1.6 keV has been completed.

V. A. Libman, O. O. Gritzay Simulation of a new neutron filter with average energy 1.6 keV// Nucl. Phys. At. Energy 2021, volume 22, issue 3, pages 308-311.

Improvement of an interference neutron filter with an average energy of 45 keV is in process.

Acknowledgement. We are very thankful to Naohiko Otsuka and all colleagues for comments in preparation of the final versions of the UkrNDC entries and also to Lidija Vrapcenjak for sending all requested articles needed for compilation.

Center of Nuclear Physics Data (CNPD), RFNC-VNIIEF

Technical paper for the NRDC Meeting, IAEA, June 14-17, 2022

S. Taova

Russian Federal Nuclear Center-VNIIEF
Russia, 607188, Sarov, Nizhnii Novgorod region, Mira Ave., 37

Compilation activity

Eight files TRANS.F083, TRANS.F084, TRANS.F085, TRANS.F086, TRANS.F087, PRELIM.F088, TRANS.A098 and PRELIM.A099 have been submitted for the EXFOR data library within the last period. Files with letter "A" include the revised entries only. Files with letter "F" include both new and the revised entries.

Recently particular attention has been paid to the compilation of new articles. In general 28 new entries were prepared for the Exfor.

Software

EXFOR-Editor

New version of EXFOR-Editor - 4.01 was placed on the web page of CNPD www.vniief.ru/en/partnership/cnpd/Download. In this version there appears a possibility of entering data on neutron spectra with a keyword SUPPL-INF (Supplemental Information). To input such information two regimes are provided: the Wizard mode and the mode of working in a separate dialog window. At present there are 31 entries in Exfor containing neutron spectra. Evidently the input of such type of data will be continued.

In the new version of ExfData 4.01 there is also a possibility of creating and processing the exchanged file TRANS to transfer the compiled experimental data into the IAEA Nuclear Data Section.

Description of the 4.01 version of EXFOR-Editor is presented in a new Manual which is also located on the web page of CNPD. It includes both the description of the main functions of the program and the new modes of data processing.

Update of Dictionaries and checking codes (CHEX and JANIS TRANS Checker) is being carried out on continuing basis.

General

Scanning of journals “Izvestiya Akademii Nauk” and “Yadernaya Fizika” is being performed regularly to reveal articles relevant to be compiled to Exfor library. The reports on scanning results are submitted to the NDS, IAEA every month.

This year we celebrate the 25-th anniversary of the Centre of Nuclear Physics Data. Contribution of CNPD to the development of Exfor data library is essential. Total number of entries transferred to Exfor by the Center within the period of its functioning is 2165.

Now we prepare a paper about our Centre activities, which will include different directions of its development: compilation of experimental data, design of software, issue of posters and booklets.

Korea Nuclear Data Center (KNDC)

Progress Report for period 2021-2022

Technical Meeting on the International Network of Nuclear Reaction Data Centers (NRDC 2022)
14 - 17 June, 2022

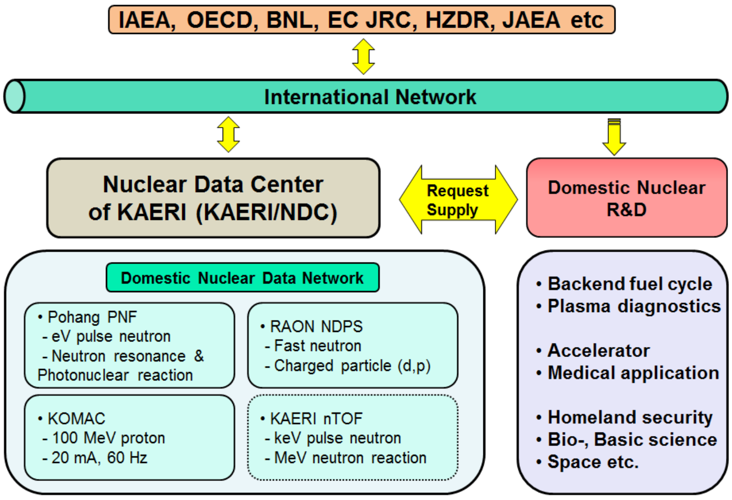
Korea Atomic Energy Research Institute
Daejeon, Korea
Web: http://atom.kaeri.re.kr/
E-mail: kimdh@kaeri.re.kr

1. General

Korea Nuclear Data Center (KNDC, formerly 'Nuclear Data Evaluation Lab.') was established in 1997 to start research on nuclear data in Korea and joined the International Network of Nuclear Reaction Data Centers (NRDC) in 2000. KNDC at Korea Atomic Energy Research Institute (KAERI) performs the following main tasks:

- Evaluation and method development for nuclear reaction data
- Establishment of processing and validation system of nuclear reaction/covariance data
- Measurement of nuclear reaction data and establishment of measurement facility
- Production and validation of atomic/molecular collision data

The mission of our center includes disseminating the outcomes of cooperation with international networks as well as promoting nuclear data research activities and supporting nuclear/radiation R&Ds in Korea. KNDC is also coordinating the measurement activities using domestic accelerators for producing various nuclear reaction data.



KNDC continues to cooperate with the international nuclear data network as follows:

- Participating in IAEA CRP, TM, and CM on nuclear data evaluation, nuclear data processing and validation, atomic/molecular data network, etc.
- Collecting nuclear reaction measurement data in Korea for EXFOR compilation under the guidance of IAEA/NDS
- Participating in the JEFF and WPEC subgroups of OECD/NEA
- Conducting joint research on evaluation, measurement, and validation of nuclear data with foreign research institutes

As of 2022, KNDC consists of 9 regular staffs, a post-retirement researcher, and a Ph.D. student. The latest staff changes include:

- Choong-Sup GIL retired in May 2022 and joined as a post-retirement researcher in June 2022.
- Jounghwa LEE, who was a post-doctor, is scheduled to join as a regular staff in July 2022.

They are working in the following fields:

- Nuclear data evaluation: 2 regular staffs
- Nuclear data measurement: 3 regular staffs
- Nuclear data processing/validation/application: 2 regular staffs, a post-retirement researcher, a Ph.D. student
- Atomic/molecular data production: 2 regular staffs

2. EXFOR Activity

The compilation of nuclear reaction data in Korea continues to be carried out under the guidance of IAEA/NDS. Since the last meeting in 2021, 10 new entries were registered in the EXFOR DB and 5 entries were transmitted after compilation. (See Table 1.)

Table 1. Compilation statistics of KNDC

No.	TRANS	ENTRY	SUBJECT	STATUS
1	3201	30847	Neutron	EXFOR
2	3200	30848	Neutron	EXFOR
3	G047	G3136	Gamma	EXFOR
4	G047	G3137	Gamma	EXFOR
5	G048	G3138	Gamma	EXFOR
6	3206	30849	Neutron	EXFOR
7	3206	30850	Neutron	EXFOR
8	D135	D7028	Alpha	EXFOR
9	D135	D7029	Alpha	EXFOR
10	D135	D7030	Proton	EXFOR
11		D7031	Proton	Compiled
12		D7032	Proton	Compiled
13		D7033	Proton	Compiled
14		D7034	Proton	Compiled
15		D7035	Proton	Compiled

- **Checking Code**

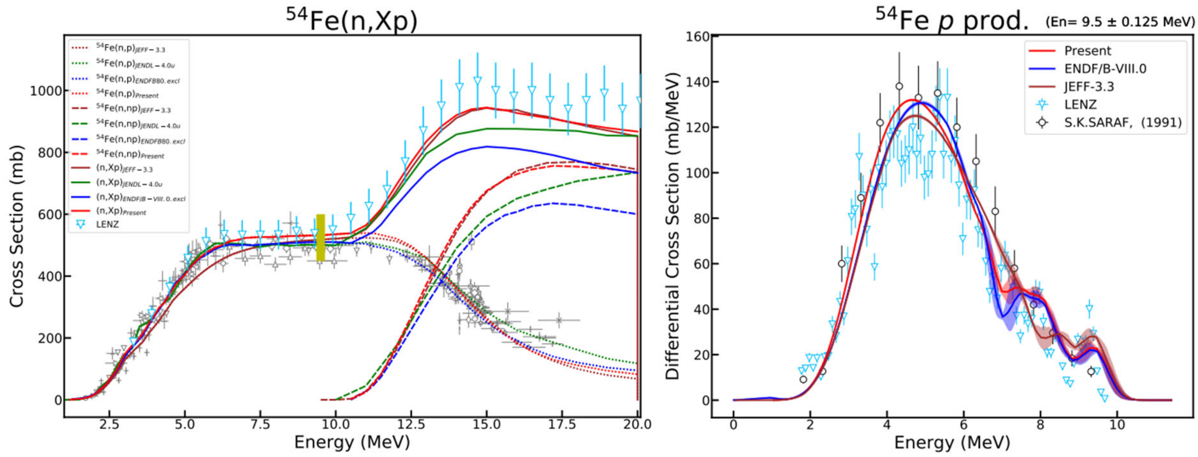
The draft was checked through a tool of JCPRG. (http://www.jcprg.org/exfor/tool/)

3. Nuclear Data Activities

3.1 Evaluation

A research on improving angular distributions and energy spectra of neutron-induced charged particle is continuing through the International Nuclear Energy Research Initiative (I-NERI) project with Los Alamos National Laboratory (LANL). A collaborative work is underway to analyze the experimental data for angular distributions and spectra of (n,p) and (n,a) on several structural materials such as Fe, Ni and Zn isotopes and evaluate/update the accompanying data.

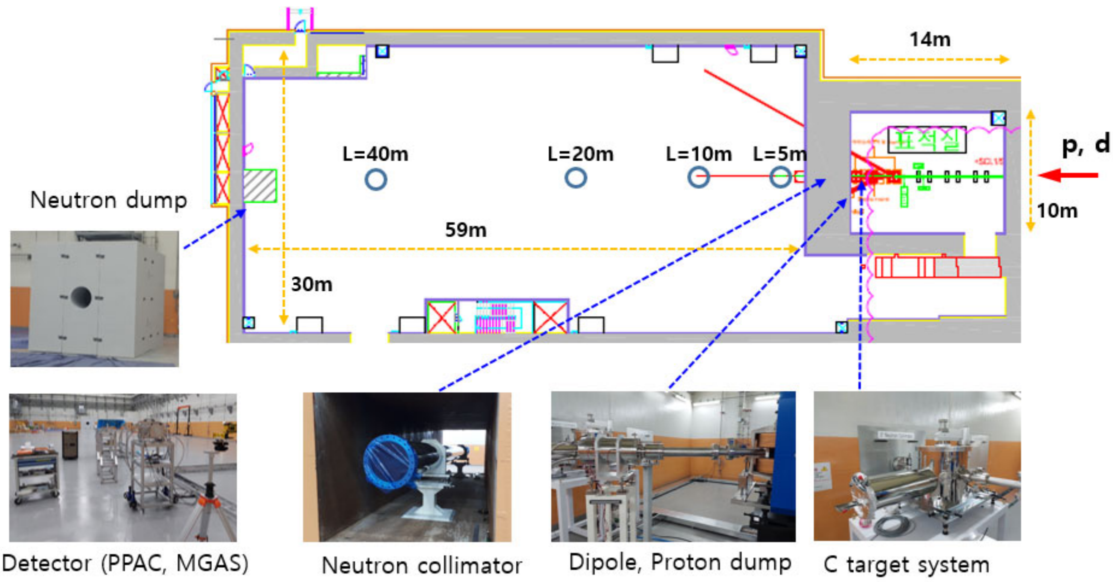
As one of preliminary results, the figures below show the newly evaluated (n,Xp) cross section (left) and proton spectra induced by 9.5 MeV neutron (right) on ^{54}Fe, which are compared to newly measured data using the Low Energy Neutron-induced Charged-particle (Z) Chamber (LENZ) instrument at Los Alamos Neutron Science Center and available libraries, JEFF-3.3, JENDL-4.0u and ENDF/B-VIII.0.



A new project on the “Development of Thermal Neutron Scattering Data Production Technology for Future Advanced Nuclear Reactors” was launched in April 2022. The purpose of this project is to establish an MD-based TSL data production system and to produce, validate, and support TSL data of coolant/moderator materials for future advanced nuclear reactor development in Korea.

3.2 Measurement

Nuclear Data Production System (NDPS) is being constructed for nuclear science and applications at RAON (Rare Isotope Accelerator complex for ON-line experiments), IBS in Korea. The components of the NDPS facility (beam line, vacuum system, pulse beam generator, neutron target system, collimator, beam dumps, etc.) were designed, manufactured, and installed in cooperation with domestic research groups (IBS, KAERI, SKKU, UNIST). NDPS will provide white neutrons by bombarding a thick graphite target with 49 MeV/u deuterons and mono-energetic neutrons by bombarding thin lithium targets with 20~83 MeV proton beams.



14m
p, d
표적실
L=40m
L=20m
L=10m
L=5m
Neutron dump
59m
10m
30m
Detector (PPAC, MGAS)
Neutron collimator
Dipole, Proton dump
C target system

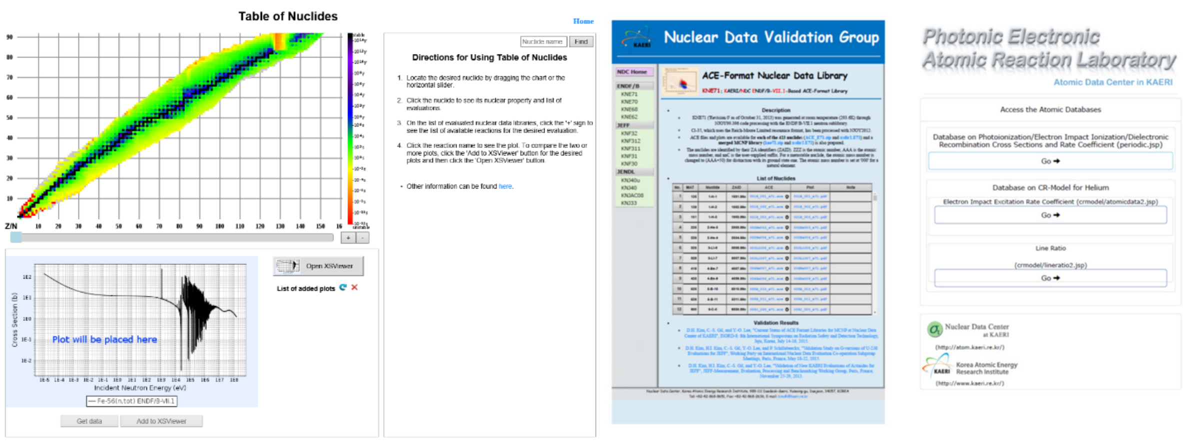
3.3 Cooperation

The 11th Korea-Japan Joint Summer School on Accelerator and Beam Science, Nuclear Data, Radiation Engineering and Reactor Physics will be held in Gyeongju, Korea from August 1 to 4, 2022. This event is organized by KOMAC of KAERI and supported by KNDC. The purpose is to introduce the latest research activities on accelerators, reactor physics, nuclear data, etc. in Korea and Japan to graduate students and to inspire their research motivation.

3.4 Web Service

KNDC provides the following three main web services. These websites are constantly being updated.

- Nuclear Data Chart (http://atom.kaeri.re.kr/nuchart/): nuclide information, nuclear reaction data, cross section data plot and comparison
- Application Library (http://atom.kaeri.re.kr/NDVG/): processed nuclear data library for Monte Carlo (ACE) and deterministic (MATXS) neutron transport codes, processed covariance data (COVFIL), fission product yield and decay data for SCALE
- Atomic Data (http://pearl.kaeri.re.kr/pearl/): atomic database including photoionization cross section, electron impact ionization (EII) rate coefficient, and dielectronic recombination (DR) rate coefficient



3.5 Support for Nuclear/Radiation R&Ds

KNDC supports domestic and foreign nuclear/radiation R&Ds by providing nuclear data related information, how to process nuclear data, working libraries for application, etc. The main support details for 2021 were as follows:

- NJOY-processed multigroup KERMA data of Si isotopes for VHTR analysis (KAERI)
- Advisory on covariance data (company)
- ACE-format libraries (with 18 temperatures) based on ENDF/B-VIII.0 for research reactor analysis (KAERI)
- ACE-format TSL library (with 18 temperatures) of ZrH, CH_2, and BeO for micro-reactor analysis (KAERI)

Progress Report
NRDC-2022 Technical Meeting
(14-17 June, 2022, Vienna)

Institute for Nuclear Research, ATOMKI
(S. Takács)

Nuclear Data Activities at ATOMKI in 2021-2022

The usual experimental work was affected by COVID-19 situation and change / upgrade of infrastructure at atomki.

1. Staff

The organizational structure of the institute had changed from laboratory level to group level.

The following groups may publish EXFOR related experimental data:

Nuclear reaction data group: Overall staff number: 10.5 persons. Staff reduced by 1 physicist. One PhD student joined to the group.

The main task is to measure reaction cross sections of charged particle induced nuclear reactions.
Evaluation of nuclear reaction data
Applications: medical applications
thin layer activation and
activation analysis

Nuclear astrophysics group: Overall staff number: 10 persons, 7 permanent staff member and 3 PhD students.

The main task is to measure charged particle induced reaction data at low energies relevant for various astrophysical processes.

Nuclear spectroscopy data group: Overall staff number: 11 persons, 8 permanent staff member and 3 PhD students.

The main task is to determine experimental nuclear structure and decay data of exotic nuclei using radioactive beams, study of exotic shapes of nuclei, excitation modes and decay of nuclei.

2. EXFOR compilation

7 new entries were compiled during the period 2021 and 9 new entries in 2022.

The compiled entries covered all the newly published articles for the covered period associated with atomki.

3. IAEA related activity:

- EXFOR: Compilation of all newly measured and published experimental data.
- TC: Evaluation of cross sections for medical isotope production and charged particle beam monitoring.
- CRP: Imaging Technologies for Process Investigations and Components Testing: Radioactive tracing of industrial processes by using Thin Layer Activation (TLA) and Positron Emission Tomography.

4. Publications in 2021 - 2022:

Nuclear reaction data group at ATOMKI

Production cross sections of ^{47}Sc via alpha-particle-induced reactions on natural calcium up to 29 MeV
Aikawa, Masayuki ; Hanada, Yukina ; Ichinkhorloo, Dagvadorj ; Haba, Hiromitsu ; Takács, Sándor ; Ditrói, Ferenc ; Szűcs, Zoltán
NIM/B 515 pp. 1-6. (2022)

Cross sections for formation of Y, Sr and Rb radionuclides induced by proton irradiation of natSr up to 33.6 MeV
Hermanne, A. ; Tárkányi, F. ; Takács, S. ; Ditrói, F.
NIM/B 511 pp. 91-104. (2022)

Upgrade of recommended nuclear cross section data base for production of therapeutic radionuclides
Tárkányi, F. ; Hermanne, A. ; Ignatyuk, A. V. ; Takács, S. ; Capote, R.
JRNC 331; 3 pp. 1163-1206. (2022)

Therapeutic Radiopharmaceuticals Labelled with Copper-67, Rhenium-186 and Scandium-47
Aboudzadeh-Rovais, M. ; Alliot, C. ; Al Rayyes, A. ; Bilewicz, A. ; Chakraborty, S. ; Gagnon, K. ; Gizawy, M. ; Jalilian, A. ; Khandaker, M.U. ; Lapi, S.E. et al.
Wien, Austria : International Atomic Energy Agency (IAEA) (2021)
ISBN: 9789201350213

Alternative Radionuclide production with a cyclotron
Alves, F. ; Comor, J. ; Gagnon, K. ; Haji Saied, M. ; Jalilian, A. ; Lapi, S. ; Schlyer, D.J. ; Takács, S.
Vienna, Austria : International Atomic Energy Agency (IAEA) (2021) , 69 p.
ISBN: 9789201030214

Excitation functions for Rh, Ru and Tc radionuclides obtained by proton irradiation of ^{nat}Ru up to 33.6 MeV
Hermanne, A. ; Tárkányi, F. ; Takács, S.
NIM/B 502 pp. 205-218. (2021)

Upgrade of IAEA recommended data of selected nuclear reactions for production of PET and SPECT isotopes
Hermanne, A. ; Tárkányi, F.T. ; Ignatyuk, A.V. ; Takács, S. ; Capote, R.
NDS 173 pp. 285-308. (2021)

IAEA activities on ^{67}Cu, ^{186}Re, ^{47}Sc Theranostic radionuclides and Radiopharmaceuticals
Jalilian, Amir R ; Gizawy, Mohamed A. ; Alliot, Cyrille ; Takacs, Sandor ; Chakarborty, Sudipta ; Rovais, Mohammad Reza Aboudzadeh ; Pupillo, Gaia ; Nagatsu, Kotaro ; Park, Jeong Hoon ; Khandaker, Mayeen Uddin et al.
Current Radiopharmaceuticals 14 : 4 pp. 306-314. (2021)

Measurement of production cross sections of 175Hf in the natLu(p,x) and natLu(d,x) reactions
Komori, Y. ; Haba, H. ; Aikawa, M. ; Saito, M. ; Takács, S. ; Ditrói, F.
RIKAGAKU KENKYUJO ACCELERATOR PROGRESS REPORT 54 p. 171 (2021)

Production cross section of medical radioisotope 153Sm in alpha-particle-induced reaction on natural neodymium
M., Sakaguchi ; M., Aikawa ; N., Ukon ; Y., Komori ; H., Haba ; N., Otuka ; S., Takacs
RIKAGAKU KENKYUJO ACCELERATOR PROGRESS REPORT 54 p. 168 (2021)

Activation cross section measurement of alpha-particle induced reactions on natural neodymium
Sakaguchi, Michiya ; Aikawa, Masayuki ; Ukon, Naoyuki ; Komori, Yukiko ; Haba, Hiromitsu ; Otuka, Naohiko ; Takács, Sándor
JARI 176 Paper: 109826 (2021)

Cross sections of alpha-particle-induced reactions on natNi: Production of ^{67}Cu
Takács, S. ; Aikawa, M. ; Haba, H. ; Komori, Y. ; Ditrói, F. ; Szűcs, Z. ; Saito, M. ; Murata, T. ; Sakaguchi, M. ; Ukon, N.
RIKAGAKU KENKYUJO ACCELERATOR PROGRESS REPORT 54 p. 164 (2021)

Cross section measurement of alpha-particle-induced reactions on ^{nat}Sb
Takács, S. ✉ ; Ditrói, F. ; Szűcs, Z. ; Brezovcsik, K. ; Haba, H. ; Komori, Y. ; Aikawa, M. ; Saito, M. ; Murata, T. ; Sakaguchi, M. et al.
NIM/B 505 pp. 24-33. (2021)

Activation cross sections of gamma-emitters produced in deuteron induced reactions on 209Bi up to 50 MeV
Tárkányi, F. ; Takács, S. ; Ditrói, F. ; Szűcs, Z. ; Brezovcsik, K. ; Hermanne, A. ; Ignatyuk, A. V.
EPJ/A 57 : 7 Paper: 233 (2021)

Investigation of activation cross-sections of deuteron induced reactions on ruthenium up to 50 MeV
Tárkányi, F. ; Ditrói, F. ; Takács, S. ; Hermanne, A. ; Ignatyuk, A.V. ; Spahn, I. ; Spellerberg, S.
JARI 168 Paper: 109401 (2021)

Investigation of cross sections of deuteron induced nuclear reactions on selenium up to 50 MeV
Tárkányi, Ferenc ; Takács, Sándor ; Ditrói, Ferenc ; Szűcs, Zoltán ; Brezovcsik, Károly ; Hermanne, Alex ; Ignatyuk, Anatolij V.
EPJ/A: 4 p. 117 (2021)

Activation cross section data of deuteron induced nuclear reactions on rubidium up to 50 MeV
Tárkányi, Ferenc ; Hermanne, Alex ; Ditrói, Ferenc; Takács, Sándor ; Ignatyuk, Anatolij V. ; Spahn, Ingo ; Spellerberg, Stephan
EPJ/A 57 : 1 Paper: 21 (2021)

Production cross sections of ^{45}Ti in the deuteron-induced reaction on ^{45}Sc up to 24 MeV
Tsoodol, Zolbadral; Aikawa, Masayuki ; Ichinkhorloo, Dagvadorj ; Khishigjargal, Tegshjargal ; Norov, Erdene ; Komori, Yukiko ; Haba, Hiromitsu ; Takács, Sándor ; Ditrói, Ferenc ; Szűcs, Zoltán
JARI 168 Paper: 109448 (2021)

Evaluation of Wear Measurement with Radioactive Isotopes for DLC Coatings Affected by Abrasive Particles
Zellhofer, Manuel ; Jech, Martin ; Badisch, Ewald ; Ditrói, Ferenc ; Kübler, Andreas ; Mayrhofer, Paul Heinz
TRIBOLOGY LETTERS 70 : 2 Paper: 55 (2022)

Deuteron induced nuclear reactions on Mo up to 10 MeV: experimental investigation and nuclear model calculations
Elbinawi, A. ; Ali, B. M. ; Mohamed, Gehan Y. ; Ditrói, F. ; Al-abyad, M.
EPJ/A 57 : 11 p. 312 (2021)

Compound-Specific Imaging of Methanol Fuel Cell for Performance and Degradation Studies Using a Mini Positron Emission Tomograph
Sarkadi-Priboczki, Eva ; Varga, Mate ; Valastyan, Ivan ; Brezovcsik, Karoly ; Fenyvesi, Andras ; Molnar, Jozsef
Chemistry–Methods 1 : 7 pp. 315-322. , 8 p. (2021)

Pairing of thorium with selected primary target materials in tandem configurations: Co-production of $^{225}Ac/^{213}Bi$ and $^{230}U/^{226}Th$ generators with a 70 MeV H− cyclotron
Steyn, G.F.; Motetshwane, M.A. ; Szelecsényi, F. ; Brümmer, J.W.
JARI 168 Paper: 109514 (2021)

Large-scale production of ^{88}Y and $^{88}Zr/^{88}Y$ generators: A proof of concept study for a 70 MeV H − cyclotron
Steyn, G.F. ; van der Walt, T.N. ; Szelecsényi, F. ; Perrang, C. ; Brümmer, J.W. ; Vermeulen, C. ; van der Meulen, N.P. ; Motetshwane, M.A. ; van Heerden, M.R.
JARI 168 Paper: 109469 (2021)

Nuclear Astrophysics Group at ATOMKI

Determination of the $^{7}Be(p,\gamma)^{8}B$ cross section at astrophysical energies using a radioactive ^{7}Be ion beam
Buompane, R. ; Di Leva, A. ; Gialanella, L. ; D'Onofrio, A. ; De Cesare, M. ; Duarte, J.G. ; Fülöp, Z. ; Gasques, L.R. ; Gyürky, Gy. ; Morales-Gallegos, L. et al.
PHYSICS LETTERS B 824 Paper: 136819 (2022)

Study of the $^{20}Ne(p,\gamma)^{21}Na$ reaction at LUNA
Caciolli, Antonio ; Zavatarelli, Sandra ; Fülöp, Zsolt ; Gyürky, György ; Elekes, Zoltán ; Csedreki, László ; Szücs, Tamás ; LUNA, COLL
EPJ WEB OF CONFERENCES 260 p. 11007 (2022)

Probing the early Universe from deep underground
Cavanna, Francesca ; Fülöp, Zsolt ; Gyürky, György ; Elekes, Zoltán ; Csedreki, László ; Szücs, Tamás ; LUNA, COLL
EPJ WEB OF CONFERENCES 260 p. 08005 (2022)

Final results on the $^{13}C(\alpha,n)^{16}O$ cross section at low energies at LUNA
Ciani, Giovanni Francesc ; Csedreki, Laszlo ; Rapagnani, David ; Best, Andreas ; Formicola, Alba ; Fülöp, Zsolt ; Gyürky, György ; Elekes, Zoltán ; Szücs, Tamás ; LUNA, COLL
EPJ WEB OF CONFERENCES 260 p. 08003 (2022)

The challenging direct measurement of the 65 keV resonance strength of the $^{17}O(p,\gamma)^{18}F$ reaction at LUNA
Ciani, Giovanni Francesco ; Piatti, Denise ; Gesuè, Riccardo Maria ; Fülöp, Zsolt ; Gyürky, György ; Elekes, Zoltán ; Csedreki, László ; Szücs, Tamás ; LUNA, COLL
EPJ WEB OF CONFERENCES 260 p. 11003 (2022)

Activation cross section measurement of the $^{14}N(p,\gamma)^{15}O$ astrophysical key reaction
Gyürky, Gy. ; Halász, Z. ; Kiss, G. G. ; Szücs, T. ; Fülöp, Zs.
PHYSICAL REVIEW C 105 : 2 Paper: L022801 (2022)

Challenges and Requirements in High-Precision Nuclear Astrophysics Experiments
Gyürky, György
UNIVERSE 8 : 4 Paper: 216 (2022)

First direct limit on the 395 keV resonance of the $^{22}Ne(\alpha,\gamma)^{26}Mg$ reaction
Masha, Eliana ; Fülöp, Zsolt ; Gyürky, György ; Elekes, Zoltán ; Csedreki, László ; Szücs, Tamás ; LUNA, COLL
EPJ WEB OF CONFERENCES 260 p. 11017 (2022)

Underground measurement at LUNA found no evidence for a low-energy resonance in the $^{6}Li(p,\gamma)^{7}Be$ reaction
Piatti, Denise ; Fülöp, Zsolt ; Gyürky, György ; Elekes, Zoltán ; Csedreki, László ; Szücs, Tamás ; LUNA, COLL
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Measurement and analysis techniques for a study of $^{12}C(p,\gamma)$ and $^{13}C(p,\gamma)$ deep underground

Skowronski, Jakub ; Fülöp, Zsolt ; Gyürky, György ; Elekes, Zoltán ; Csedreki, László ; Szücs, Tamás ; LUNA, COLL
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Direct Measurement of the $^{13}C(\alpha,n)^{16}O$ Cross Section into the s -Process Gamow Peak
Ciani, G. F. ; Csedreki, L. ; Rapagnani, D. ; Aliotta, M. ; Balibrea-Correa, J. ; Barile, F. ; Bemmerer, D. ; Best, A. ; Boeltzig, A. ; Broggini, C. et al.
PHYSICAL REVIEW LETTERS 127 : 15 Paper: 152701 , 7 p. (2021)

Characterization of the LUNA neutron detector array for the measurement of the $^{13}C(\alpha,n)^{16}O$ reaction
Csedreki, L. ; Ciani, G.F. ; Balibrea-Correa, J. ; Best, A. ; Aliotta, M. ; Barile, F. ; Bemmerer, D. ; Boeltzig, A. ; Broggini, C. ; Bruno, C.G. et al.
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Measurement of the $^{91}Zr(p,\gamma)^{92m}Nb$ cross section motivated by type Ia supernova nucleosynthesis
Gyürky, Gy ; Halász, Z ; Kiss, G G ; Szücs, T ; Huszánk, R ; Török, Zs ; Fülöp, Zs ; Rauscher, T ; Travaglio, C
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Low-energy Measurement of the $^{96}Zr(\alpha,n)^{99}Mo$ Reaction Cross Section and Its Impact on Weak r -process Nucleosynthesis
Kiss, G. G. ; Szegedi, T. N. ; Mohr, P. ; Jacobi, M. ; Gyürky, Gy. ; Huszánk, R. ; Arcones, A.
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Indirect determination of the astrophysical factor for the (reaction using the asymptotic normalization coefficient method
Kiss, G.G. ; La, Cognata M. ; Yarmukhamedov, R. ; Tursunmakhatov, K.I. ; Wiedenhöver, I. ; Baby, L.T. ; Cherubini, S. ; Cvetinović, A. ; D'Agata, G. ; Figuera, P. et al.
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First direct measurement of 395 keV resonance of the $^{22}Ne(\alpha,\gamma)^{26}Mg$ reaction at LUNA
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Mohr, P. ; Fülöp, Z. ; Gyürky, G. ; Kiss, G.G. ; Szücs, T. ; Arcones, A. ; Jacobi, M. ; Psaltis, A.

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Activation thick target yield measurement of $^{100}Mo(\alpha,n)^{103}Ru$ for studying the weak r-process nucleosynthesis
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Evidence against the wobbling nature of low-spin bands in ^{135}Pr
Lv, B. F. ; Petrache, C. M. ; Lawrie, E. A. ; Guo, S. ; Astier, A. ; Dupont, E. ; Zheng, K. K. ; Ong, H. J. ; Wang, J. G. ; Zhou, X. H. et al.
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Experimental evidence for transverse wobbling bands in ^{136}Nd
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Candidate revolving chiral doublet bands in ^{119}Cs
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New anomaly observed in ^{4}He supports the existence of the hypothetical X17 particle
Krasznahorkay, A. J.; Csatlós, M. ; Csige, L. ; Gulyás, J. ; Krasznahorkay, A. ; Nyakó, B. M. ; Rajta, I. ; Timár, J. ; Vajda, I. ; Sas, N. J.
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Evidence for enhanced neutron-proton correlations from the level structure of the N=Z+1 nucleus Tc44 4387
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PHYSICAL REVIEW C 103 : 4 Paper: 044308 (2021)

Medium-spin states of the neutron-rich nucleus ^{87}Br
Nyakó, B. M. ; Timár, J ; Csatlós, M. ; Dombrádi, Zs. ; Krasznahorkay, A. ; Kuti, I. ; Sohler, D. ; Tornyi, T. G. ; Czerwiński, M. ; Rząca-Urban, T. et al.
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Observation of excited states in the neutron-rich nucleus ^{89}Br
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Complete set of proton excitations in ^{119}Cs
Zheng, K. K. ; Petrache, C. M. ; Zhang, Z. H. ; Astier, A. ; Lv, B. F. ; Greenlees, P. T. ; Grahn, T. ; Julin, R. ; Juutinen, S. ; Luoma, M. et al.
PHYSICAL REVIEW C 104 : 4 Paper: 044305 (2021)

Rich band structure and multiple long-lived isomers in the odd-odd nucleus
Zheng, K.K. ; Petrache, C.M. ; Zhang, Z.H. ; Astier, A. ; Lv, B.F. ; Greenlees, P.T. ; Grahn, T. ; Julin, R. ; Juutinen, S. ; Luoma, M. et al.
PHYSICAL REVIEW C 104 : 4 Paper: 044325 (2021)
Evidence of oblate-prolate shape coexistence in the strongly-deformed nucleus ^{119}Cs
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Neutron excitations in ^{119}Ba
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Fission resonances observed in the ^{237}Np(d,pf) reaction and the fission barrier topology of ^{238}Np
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DOI WoS Scopus
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γ decay to the ground state from the excitations above the neutron threshold in the ^{208}Pb(p,p'γ) reaction at 85 MeV
Wasilewska, B. ; Kmiecik, M. ; Ciemała, M. ; Maj, A. ; Crespi, F.C.L. ; Bracco, A. ; Harakeh, M.N. ; Bednarczyk, P. ; Bottoni, S. ; Brambilla, S. et al.
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New narrow resonances observed in the unbound nucleus ^{15}F
Girard-Alcindor, V. ; Mercenne, A. ; Stefan, I. ; De, Oliveira Santos F. ; Michel, N. ; Płoszajczak, M. ; Assié, M. ; Lemasson, A. ; Clément, E. ; Flavigny, F. et al.
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A first glimpse at the shell structure beyond ^{54}Ca: Spectroscopy of ^{55}K, ^{55}Ca, and ^{57}Ca
Koiwai, T. ; Wimmer, K.; Doornenbal, P. ; Obertelli, A. ; Barbieri, C. ; Duguet, T. ; Holt, J.D. ; Miyagi, T. ; Navrátil, P. ; Ogata, K. et al.
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Pairing Forces Govern Population of Doubly Magic ^{54}Ca from Direct Reactions
Browne, F.; Chen, S. ; Doornenbal, P. ; Obertelli, A. ; Ogata, K. ; Utsuno, Y. ; Yoshida, K. ; Achouri, N.L. ; Baba, H. ; Calvet, D. et al.
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PHYSICAL REVIEW C 104 : 3 Paper: 034318 (2021)

Signature splitting of the g 7/2 [404] 7/2 + bands in ^{131}Ba and ^{133}Ce
Ding, B. ; Petrache, C. M. ; Guo, S. ; Lawrie, E. A. ; Wakudyanaye, I. ; Zhang, Z. H. ; Wang, H. L. ; Meng, H. Y. ; Mengoni, D. ; Qiang, Y. H. et al.
PHYSICAL REVIEW C 104 : 6 Paper: 064304 (2021)

Persistence of the Z=28 shell gap in A=75 isobars: Identification of a possible (1/2-) μ s isomer in Co 75 and β decay to Ni 75
Escrig, S. ; Morales, A.I.; Nishimura, S. ; Niikura, M. ; Poves, A. ; Xu, Z.Y. ; Lorusso, G. ; Browne, F. ; Doornenbal, P. ; Gey, G. et al.
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First spectroscopic study of v 63 at the N=40 island of inversion
Juhász, M.M. ; Elekes, Z. ; Sohler, D. ; Sieja, K. ; Yoshida, K. ; Ogata, K. ; Doornenbal, P. ; Obertelli, A. ; Baba, H. ; Browne, F. et al.
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First spectroscopic study of ^{51}Ar by the (p,2p) reaction
Juhász, M.M. ; Elekes, Z.; Sohler, D. ; Utsuno, Y. ; Yoshida, K. ; Otsuka, T. ; Ogata, K. ; Doornenbal, P. ; Obertelli, A. ; Baba, H. et al.
PHYSICS LETTERS B 814 Paper: 136108 (2021)

Investigation of the ground-state spin inversion in the neutron-rich isotopes
Linh, B.D. ; Corsi, A. ; Gillibert, A.; Obertelli, A. ; Doornenbal, P. ; Barbieri, C. ; Chen, S. ; Chung, L.X. ; Duguet, T. ; Gómez-Ramos, M. et al.
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Lifetime measurements in the even-even isotopes

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2021/22 Status Report of China Nuclear Data Center

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1. General Information of China Nuclear Data Center

China Nuclear Data Center (CNDC) was established in 1975 and joined the nuclear data activities of IAEA as the national nuclear data center of China since 1984. As a window, CNDC has been open to the world since 1978 and CNDC has established a good cooperative relationship with the IAEA, OECD/NEA, and major nuclear data centers and institutions in the world.

1-1. The current main task of CNDC

1) The management of domestic nuclear data activities.
2) The nuclear data evaluations, libraries and relevant methodology studies.
3) Nuclear data measurements and methodology studies
4) The exchange of nuclear data activities with IAEA, foreign nuclear data centers and agencies.
5) The services for domestic and foreign nuclear data application users.

1-2. Mainly Tasks of CNDC in 2021/2022

1) New Five Years Plan (2021-2025) for nuclear data (CENDL Project).
2) Data evaluation for next CENDL version and sub-library.
3) Methodological studies of nuclear data evaluation (incl. theoretical and experimental for fission process…).
4) Nuclear data measurements and related methodological studies.
5) The compilations for EXFOR.
6) Nuclear data services.

2. Nuclear Data Evaluation

2-1. Neutron Activation File - CNAF

The first release CENDL-CNAF included 818 nuclei from ^{1}H to ^{257}Fm within the neutron energy region of from 10^{-5} eV to 20 MeV. The ENDF/B-6 data format was adopted. The general information, comments (MF=1), reactions cross sections (MF=3), nucleus dictionary (MF=8), and split threshold reaction channels (MF=10) are included in the library. Evaluations were obtained using APMN, Unified Hauser-Feshbach and Exciton model (UNF series), Full and Diagonal Reduced R-matrix (FDRR) model calculations or systematic analysis based on available experimental data. When there have many experimental data for a reaction channel, the evaluated experimental data were selected for curve fitting by using a program of orthogonal polynomial fit or spline function fit from threshold to 20 MeV. The fitting results were adopted. For convenient used in applications, all resonance parameters are already converted into a linearized point-wise format, and reasonably connected at the boundary energy. To calculate the point-wise cross, The ENDF/B Pre-processing codes (PREPRO) were used.

2-2. Radioactive Decay Data File: DDL1.0

The CENDL-DDL included 2350 nuclei between A=66 to A=172 FY region. ENSDF and ENDF format were adopted. Evaluations taken from: (1) CNDC+ Jilin Univ.: ~500 nuclei; (2) DDEP: ~200 nuclei; (3) ENSDF: ~1500 nuclei; (4) JEF3.2: ~150 nuclei (only for stable nuclei). The Q-values of the decay modes are updated to the Atomic Mass Evaluation (AME) released in 2021Wa16. Jπ for g.s. (Jilin Univ.): by systematical comparison, physical analysis and theoretical calculation, spin for ground states is re-assigned for which lacks measurement or questionable. All T1/2 are revised by new measurements (2021, 12). Mean energies for β & γ: from TAGS measurements when available, otherwise from theoretical calculation. For even-even nuclides, from theoretically analysis which employed the self-consistent quasi-particle random phase approximation (QRPA) approach based on covariant density functional theory (CDFT) in Jilin University. Beta-delayed n, p, α emitted are adopted: P1n, P2n from eva. of 2015Bi05, 2020Li32; P1p,P1α from eva. of 2020Ba07 when measurements available. Otherwise from systematics or theoretical calculation.

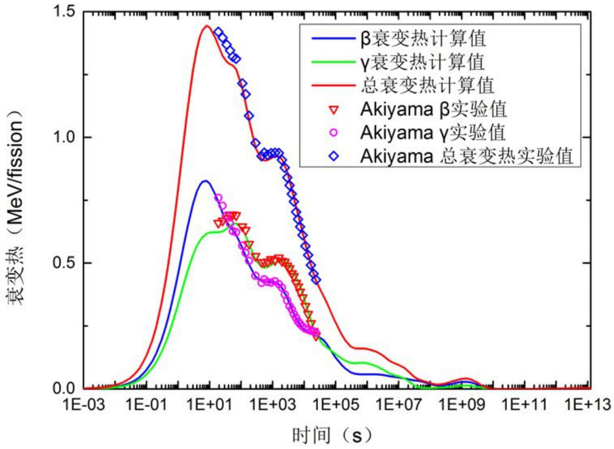

Fig.1 Decay heat after ^{235}U fast neutron fission.

2-3. The CENDL Sub-library: Photonuclear Data file:PD

The photonuclear data for a total number of 264 materials are all newly evaluated and outputted with the standard ENDF-6 format. All of the photonuclear data are mainly evaluated based on the theoretical calculations with the Chinese photonuclear reaction codes GLUNF for the light 6 nuclei and MEND-G for the medium-heavy 264 nuclei. The incident photon energies for the medium-heavy nuclei are up to 200MeV. In order to extend the incident energy to 200MeV, the n, p, d, t, He-3, α are considered to totally 18th particle emission reactions in the MEND-G code.

To ensure the availability and reliability of the PD file, nuclear data processing code system NJOY2016 and MCNP6 are used to verify and validate the PD library. The testing results show that the data structure of each nuclide is complete, the data content is reasonable, and can be applied to the simulation of Monte Carlo transport.

Table 1 Nuclides List for CENDL-3.2/PD

Light elements	Be-9,B-10,11,C-12,N-14,O-16	6
Medium -heavy elements	Mg-25,26,Al-27,Si-28,29,30,P-31,S-32,33,34,36,Cl-35,37,Ar-36,38,40,K-39,40,41,Ca-40,42,43,44,46,Sc-45,Ti-46,47,48,49,50,V-50,51,Cr-50,52,53,54,Mn-55,Fe-54,56,57,58,Co-59,Ni-58,60,61,62,64,Cu-63,65,Zn-64,66,67,68,70,Ga-69,71,Ge-70,72,73,74,76,As-75,Se-74,76,77,78,80,82,Br-79,81,Kr-78,80,82,83,84,86,Rb-85,87,Sr-84,86,87,88,Y-89,Zr-90,91,92,94,96,Nb-93,Mo-100,92,94,95,96,97,98,Ru-100,101,102,104,96,98,99,Rh-103,Pd-102,104,105,106,108,110,Ag-107,109,Cd-106,108,110,111,112,113,114,116,In-113,115,Sn-112,114,115,116,117,118,119,120,122,124,Sb-121,123,Te-120,122,123,125,126,128,130,I-127,Xe-124,126,128,129,130,131,132,134,136,Cs-133,Ba-130,132,134,135,136,137,138,La-138,139,Ce-136,138,140,142,Pr-141,Nd-142,143,144,145,146,148,150,Sm-144,147,148,149,150,152,154,Eu-151,153,Gd-152,154,155,156,157,158,160,Tb-159,Dy-156,158,160,161,162,163,164,Ho-165,Er-162,164,166,167,168,170,Tm-169,Yb-168,170,171,172,173,174,176,Lu-175,176,Hf-174,176,177,178,179,180,Ta-180,181,W-180,182,183,184,186,Re-185,187,Os-184,186,187,188,189,190,Ir-191,193,Pt-190,192,194,195,196,198,Au-197,Hg-196,198,199,200,201,202,204,Tl-203,205,Pb-204,206,207,208, Bi-209	258

3. Fundamental theory study for fission data

Method 1: The Langevin approach is extendedly applied to study the dynamical process of nuclear fission within the Fourier shape parameterization.

- macroscopic energy – Lublin-Strasbourg Drop model
- single-particle levels – Yukawa-folded potential
- shell correction – Strutinsky method
- pairing correction – BCS method

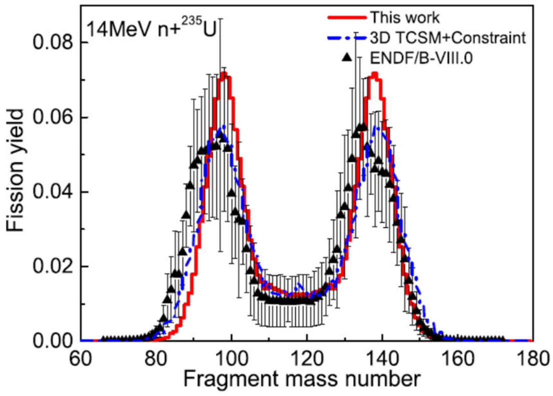

Fig. 2 The calculated fragment mass distribution in 14 MeV n + ^{235}U fission with the present model (red curve) compared with the result calculated with the 3D Langevin approach plus a constraint on the heavy fragment deformation based on the TCSM (blue dashed-dot curve) and the evaluated data from ENDF/B-VIII.0.

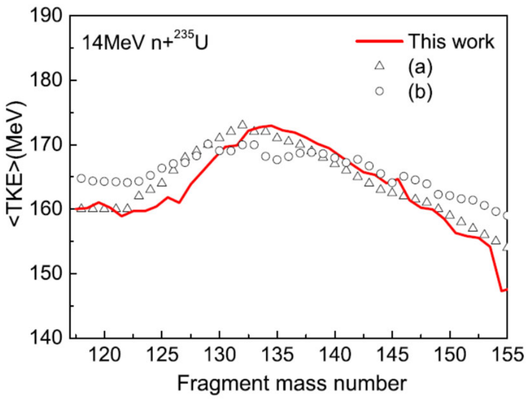

Fig. 3 The calculated TKE as a function of the heavy fragment mass in 14 MeV n + ^{235}U fission compared with the experimental data.

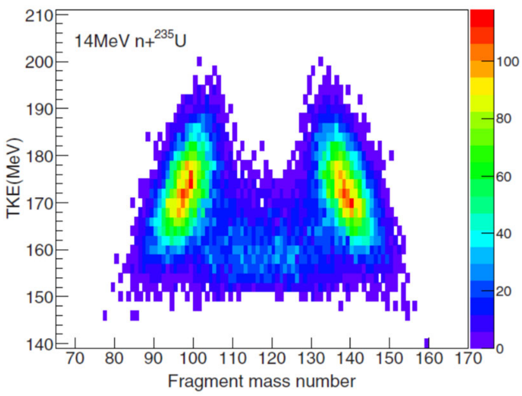

Fig. 4 The calculated mass-energy correlation of the fission fragments in 14 MeV n + ^{235}U fission.

Method 2: Using the 3D Langevin approach within the two-center shell model parameterization, the fission fragment mass distributions of U, Np and Pu isotopes are well reproduced and the systematic dependence of the averaged TKE on the Coulomb parameter is also well reproduced.

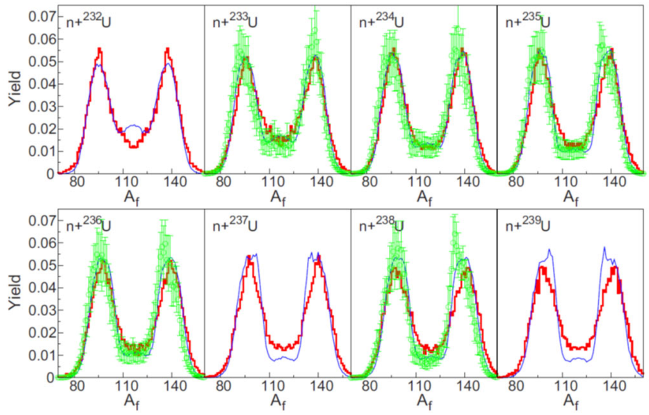

Fig.5 The calculated fragment mass distribution in 14 MeV n + $^{232-239}$U fission (red curve), compared with the primary fragment mass distribution calculated with the GEF model (blue curve) and the evaluated data from ENDF/B-VIII.0 (green circle).

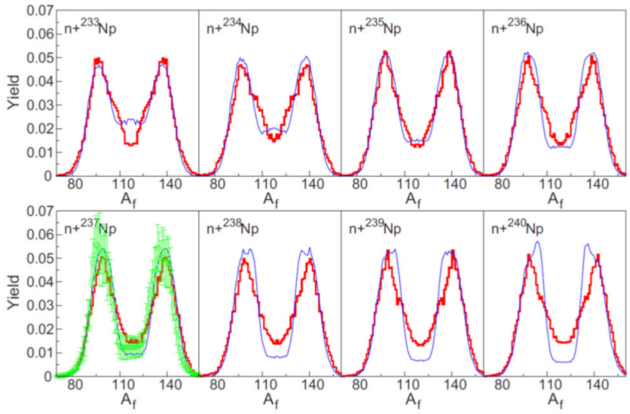

Fig.6 The calculated fragment mass distribution in 14 MeV n + $^{233-240}$Np fission (red curve), compared with the primary fragment mass distribution calculated with the GEF model (blue curve) and the evaluated data from ENDF/B-VIII.0 (green circle).

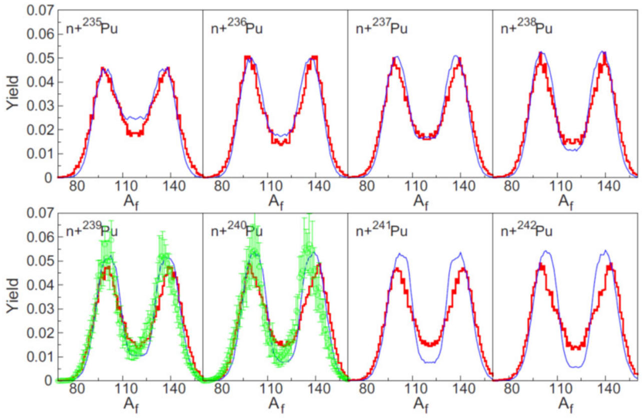

Fig.7 The calculated fragment mass distribution in 14 MeV n + $^{235-242}$Pu fission (red curve), compared with the primary fragment mass distribution calculated with the GEF model (blue curve) and the evaluated data from ENDF/B-VIII.0 (green circle).

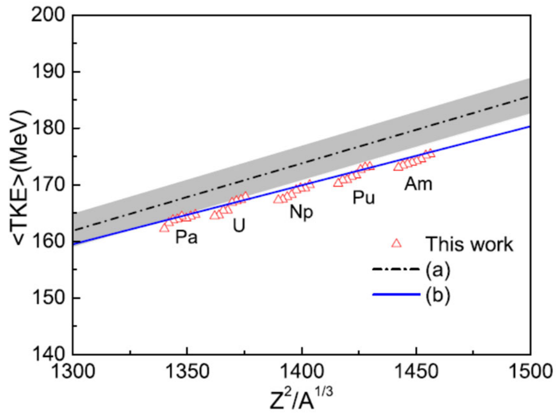

Fig.8 The calculated systematic dependence of the averaged TKE on the Coulomb parameter Z2/A1/3 of the fissioning systems.

4. EXFOR activities and nuclear data services

4-1. EXFOR Compilation

More than 445 entries were compiled at CNDC. Since 2010, more than 315 entries were finalized, which included 164 neutron and 151 charged particle entries. Feedback and correction performed for more than 110 entries. Since the last NRDC meeting (2021-04-14), 35 new entries have been finalized and 16 entries have been revised, more than 98 articles under compiling.

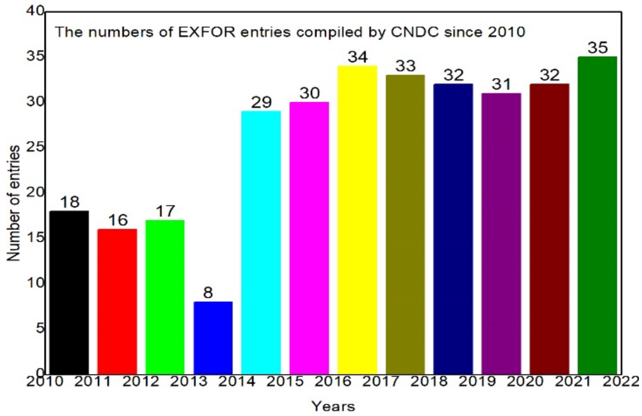

Fig. 9 The number of the finalized EXFOR entries

Table 2 New entries since the last NRDC meeting (2021-04-14)

No.	Entry No.	1st author	Reference	Status
1	32765	Changlin Lan	J,EPJ/A,53,131,2017	3200
2	32768	Qiang Wang	J,ARI,147,144,2019	3200
3	32770	S.Q.Yan	J,AJ,848,98,2017	3200
4	32778	Zhang Zhengwei	J,RPC,141,138,2017	3200
5	32784	Qiang Wang	J,RPC,152,125,2018	3206
6	32795	Fengqun Zhou	J,NIM/B,451,24,2019	3200
7	32797	Xiaojun Sun	J,CPL,36,112501,2019	3200
8	32799	Qiang Wang	J,NIM/B,469,28,2020	3200

No.	Entry No.	1st author	Reference	Status
9	32801	Chuanxin Zhu	J,CPH/C,44,034001,2020	3200
10	32802	Zhiling Yuan	J,JRN,324,277,2020	3200
11	32805	Junhua Luo	J,EPJ/A,56,125,2020	3200
12	32806	Su Shen	J,NIM/B,476,59,2020	3200
13	32811	Zhizhou Ren	J,PR/C,102,034604,2020	Finalized
14	32813	Haoyu Jiang	J,CPH/C,44,114102,2020	3206
15	32815	Nanru Ma	J,EPJ/CS,239,01007,2020	3206
16	32846	Shi Shuting	J,CNPR,24,29,2007	3206
17	32847	Jiang Jing	J,CNPR,32,435,2015	3207
18	32848	Wang Taofeng	J,CNPR,32,280,2015	3207
19	32851	Xinyi Chang	J,ARI,170,109588,2021	3206
20	32855	Junhua Luo	J,RCA,109,513,2021	Finalized
21	32856	Xin-Rong Hu	J,CNST,32,101,2021	Finalized
22	32858	Haoyu Jiang	J,EPJ/A,57,6,2021	3206
23	S0233	Yiming Duan	J,NIM/B,483,1,2020	S030
24	S0234	G. S. Li	J,PR/C,102,054607,2020	S030
25	S0235	F.F. Duan	J,PL/B,811,135942,2020	Finalized
26	S0250	Ma Nanru	J,CNPR,34,351,2017	S030
27	S0254	Li Junsheng	J,CNPR,34,545,2017	S030
28	S0255	Chen Zhijun	J,CNPR,34,705,2017	S030
29	S0261	Wang Tieshan	J,CST,35,496,2001	Finalized
30	S0262	Sun Xufang	J,CST,42,875,2008	Finalized
31	S0265	K. Wang	J,PR/C,103,024606,2021	S030
32	S0268	Jipeng Zhu	J,NIMB,494-495,23,2021	S030
33	S0269	C. H. Rong	J,EPJ/A,57,143,2021	S030
34	S0272	Wei Hua	J,CPH/C,45,044003,2021	S030
35	S0273	W. H. Ma	J,PR/C,103,L061302,2021	Finalized

4-2. Nuclear data services and dissemination

CNDC provides the nuclear data service for institutes, universities or other requirements in China. CNDC joined the developing of Chinese basic database and established the Website of “The Database of Nuclear Physics”. The Fission Yield (1.0beta) App was developed by CNDC. This App can retrieve the fission product yield data of neutron-induced fission and spontaneous fission from various evaluated data libraries: CENDL-TMSR, ENDF/B-VIII.0, JENDL-5.0, and JEFF-3.3 etc. The retrieved data can be shown as plot and saved in JPG and text formats for exchange.

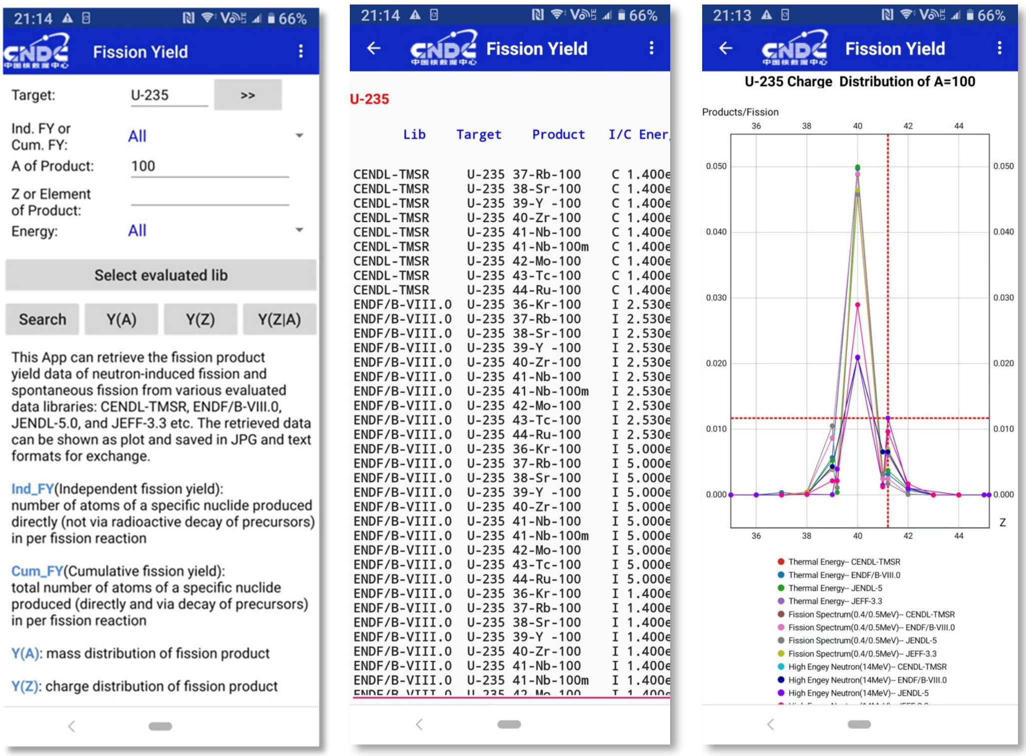

Fig.10 Interface of the Fission Yield (1.0beta) App

A BRIEF STATUS UPDATE ON THE NUCLEAR REACTION DATA ACTIVITIES IN BARC DURING 2021-2022

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(With inputs from nuclear data physicists of India)

Introduction

BARC is responsible for broad range of nuclear data activities in India. BARC, Mumbai, is part of DAE (Department of atomic Energy) and collaborates with IAEA-NDS, CERN, NRDC and other organisations to obtain qualified data. Several units of DAE is responsible for theoretical, experimental nuclear physics research and code development for the implementation of Indian nuclear programme. This include nuclear data generation, processing, and use of nuclear data for the reactor system design. The projects are overviewed and supported by DAE scientists as principal collaborator. Many research activities have been done in DAE and collaborative efforts with Indian universities are also taken up. A brief compilation of the different activities on Nuclear Reaction data performed over the past two years is presented here.

1.0 Activity related to EXFOR compilation

BARC has been involved successfully conducted eight DAE-BRNS Workshop cum Theme Meetings on nuclear reaction data and EXFOR compilation of Indian experimental nuclear data. These workshops have given impetus to nuclear data compilation activity and have resulted in substantial contributions to the IAEA-EXFOR database as well as encouraged Indian nuclear experimentalists to endeavour for international reckoning by making EXFOR compilation an integral part of their research, especially in DAE-BRNS supported collaborative research projects on nuclear data activities.

The said workshop and the IAEA supported AASPP (Asia-Africa Science Platform Program) could not be held during last two years due situation prevailing worldwide.

Table 1: Number of new entries compiled since the NRDC 2021 meeting

Sl. No.	Reaction Type	No. of Entries	
1.	Incident Neutron Nuclear Reaction Data	23	**Total=55**
2.	incident Charged Particle Nuclear Data	31	
3.	Incident Photon Nuclear Reaction Data	01	

2.0 A compilation of few research projects on experimental nuclear data and nuclear data that are coordinated by BARC

	Title of the Project	Status
1	Thermal Neutron Scattering Data for Materials of Interest in Nuclear Reactors (BeO, graphite and SiC)	Ongoing
2	Measurement Analysis, Evaluation and Compilation of Nuclear Reaction Data at Low and Medium Energy	Completed
3	Measurement of section of metastable states of a few nuclei produced through Photon	Completed
4	Nuclear Structure & Decay Data Evaluation for Nuclear Models and Dosimetric Applications	Completed

3.0 Nuclear Data Processing and Evaluation Work

3.1 Evaluation of neutron cross section data of 100Mo(n,2n)99Mo reaction using EXFOR database

In this work evaluation of neutron cross section data of 100Mo(n, 2n)99Mo reaction is performed using experimental data available in IAEA-EXFOR database library and nuclear model-based data generated using Talys 1.9 code by applying a novel method of combining Kalman filtering technique with Machine Learning (ML) regression algorithms. The neutron cross section data evaluation has been performed after a detailed study of all the EXFOR papers corresponding to 100Mo(n, 2n)99Mo reaction and nuclear model based cross section generation by executing T6 random input files using Talys 1.9 code. The evaluated curve generated is then compared with the existing evaluated curve of 100Mo (n, 2n) 99Mo reaction from nuclear data libraries such as ENDF/B-VIII.0, JEFF-3.3, JENDL-4.0, CENDL-3.1 and TENDL 2017 and found to be in good agreement with them. Chi-square and generalized Chi-square tests were employed to assess the proposed evaluation techniques and found them to be good in estimating evaluated mean values and evaluated uncertainties of cross section.

Publication: Application of Kalman filtering technique for Evaluation of neutron cross section data of ^{100}Mo(n, 2n)^{99}Mo reaction, S. Prasanna Ram, J. Nair, S. V. Suryanarayana and S. Ganesan, Nuclear Inst. and Methods in Physics Research, A 1020 (2021) 16585

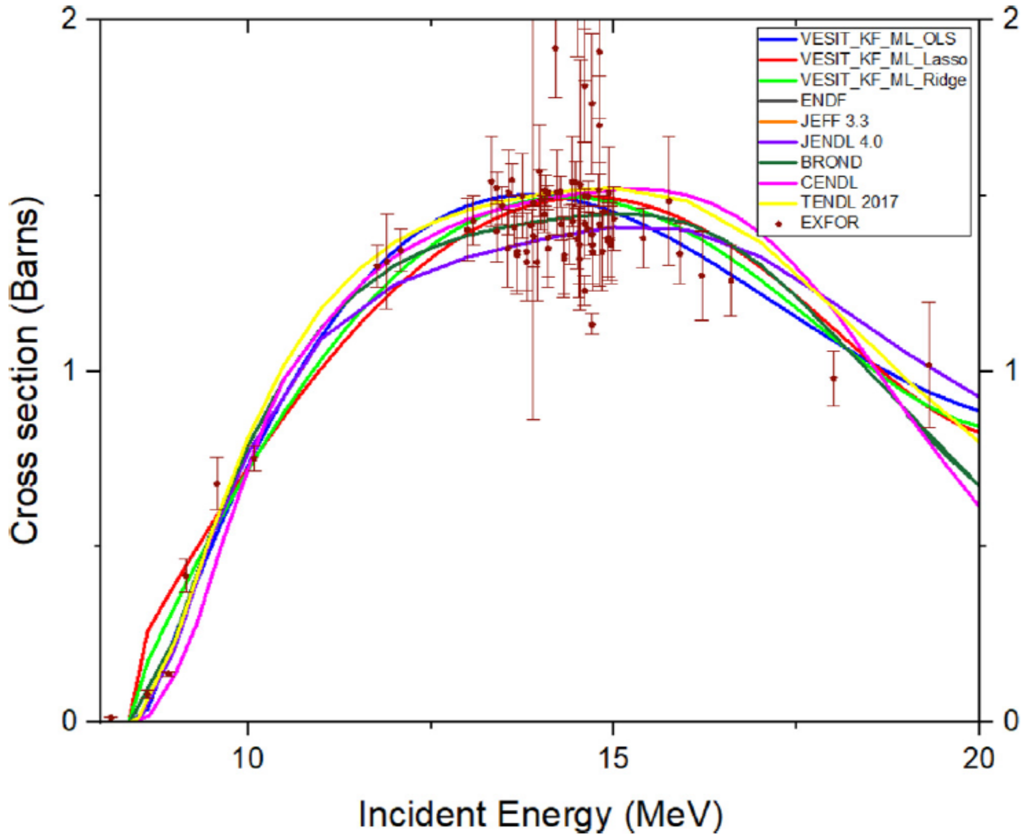


Fig. 10c. Comparison of evaluation curves. Comparison of the evaluation curves of cross-section data of ^{100}Mo (n, 2n) ^{99}Mo reaction generated using KF in combination with ML algorithms of OLS, Lasso and Ridge regression, with the standard evaluated nuclear data libraries such as ENDF/B-VIII.0 [31], JEFF-3.3 [32], JENDL-4.0 [33], BROND-3.1 [34], CENDL-3.1 [35] and TENDL 2017 [36] and EXFOR database [2].

3.2 Generation of qualified reaction cross section data for fuel cycle analysis

The current ENDF/B-VII.I based IAEA release of WIMS formatted library contains nuclear data for the 185 nuclides including 35 actinides and 57 fission products The spectrum averaged one group effective microscopic cross sections for each fuel region has been generated and tested from a PHWR and an Advanced heavy water Reactor (AHWR) fuel cycle. The decay data for actinides have also been obtained. The self-shielded burnup dependent cross section have been obtained from transport theory simulations. The development of AHWR reactor specific data library has facilitated estimation of fuel cycle parameters like discharge fuel composition, activity and decay heat. The activity in the reprocessed uranium due the decay of bred 232U and it decay product has also been estimated. The results show the rise in activity in reprocessed uranium. The in-situ breeding potential of 233U in AHWR has been estimated.

Publication : Devesh Raj and Umasankari Kannan, "Development of computer code ADWITA and data library for the solution of transmutation chain equations and application to the analysis of nuclear fuel cycles", Annals of Nuclear Energy 164 (2021) 108619

3.3 Use of updated delayed neutron spectrum data for reactor simulations

The delayed neutron fraction data has been processed for U-235, U-238, Pu-239, Pu-241, Pu-242, Am-241, Am-243, Cm-242 from ENDF/B-VII.1and updated explicitly in the transport simulation of reactor lattices using WIMSD code. The delayed neutron fraction and delayed neutron spectrum has been used to estimate the burnup dependent effective delayed neutron fraction, mean generation time and mean lifetime of PHWR and IPWR fuel lattices. Delayed neutron fraction of IPWR decreases by inclusion of contribution from higher actinides while there are no major changes in natural uranium based PHWR lattice.

Publication:: Development of WIMS-Beta with inclusion of more nuclides and estimation of kinetic parameters PHWR and IPWR with same, Anindita Sarkar, Umasankari Kannan, RPDD/GEN/44/30th June2021.

4.0 Experiments and Work related to Nuclear Reaction and Data and related Publications.

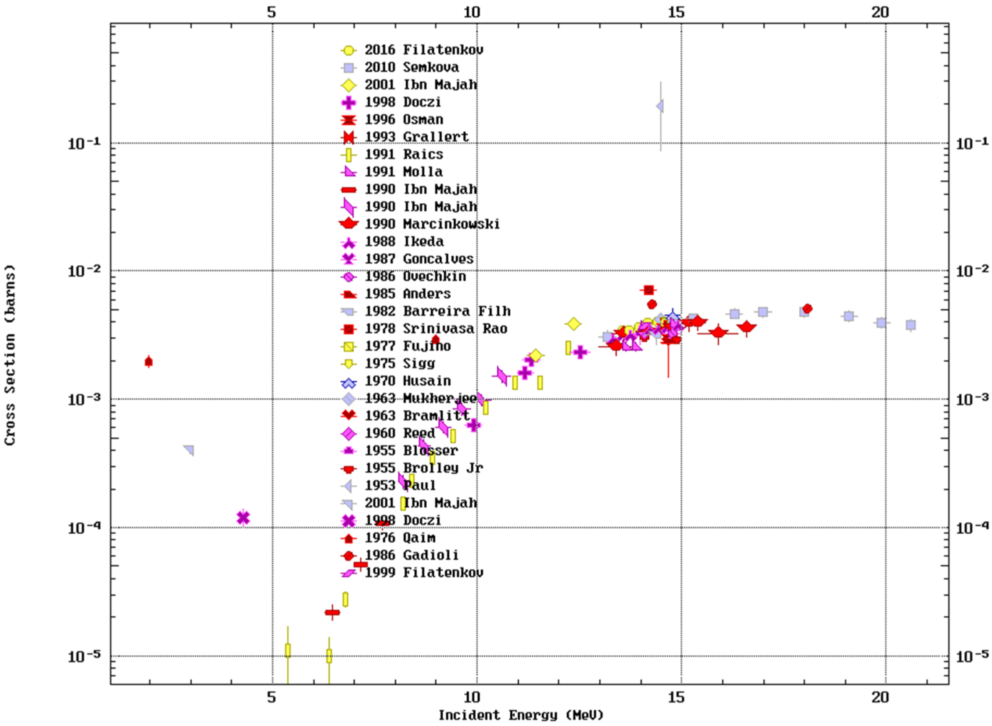
4.1 Measurements of 98-Mo(n,gamma) cross section using photoneutron source from e-LINAC

Recently the capture cross section of Mo-98 was measured in a Ta-Beo-HDP set-up using photo neutrons from 10 MeV e-LINAC moderated to thermal energies. The neutron flux was about 1 x10^6 n/cm^2/s for 3 kW power. The measured cross section was about was relatively highly that that obtained in thermal reactor spectrum.

Publication : Kapil Deo, Rajeev Kumar and Umasankari Kannan, "Feasibility of producing 99Mo using electron accelerator", 2nd RCM on CRP on New ways of producing Tc-99m and Tc-99 generators (beyond fission and cyclotron methods), May 2019.

4.2 ^{90}Zr(n, α)^{87m}Sr and ^{90}Zr(n, p)^{90m}Y reaction cross-section measurements

It is proposed to carry out the above reaction cross-section measurements using 9Be(p,n) reaction at the 6M elevation level of the BARC-TIFR Pelletron Linac accelerator facility. The measurements will be carried out using neutron activation method combined with off-line gamma-ray spectroscopy. The proton beam of nearly 5 MeV energies (~ 500nA current) will be used. Neutron fluxes incident on the sample will be monitored using 94Zr present in the sample itself. Additionally, Fe foil will also be placed to monitor the fast neutron fluxes using 54Fe(n, p) reaction. The irradiation may be required for nearly 10 hrs for sufficient activity build-up in the sample.



Measured ^{90}Zr(n, α)^{87m}Sr cross-sections in EXFOR database

4.3 Other activities related to nuclear reaction data and its use for reactor analysis

A few researches on the use of reaction cross section data and its influence on reactor performance are compiled in the recent publications below.

Recent publications in nuclear reaction data analysis in national symposium ARP-2022

1. Analysis of Doppler reactivity (Mosteller) benchmarks using ENDFB8GX library, V. Harikrishnan, R. Karthikeyan and Usha Pal, Proc of Advances in Reactor Physics (ARP-2022), May 19-21, 2022.
2. Stochastic Interpolation of Nuclides to Represent Doppler Broadened Data in Reactor Physics Calculation, Rashbihari Rudra, Rashmi Rai, K. P. Singh and Umasankari Kannan, *ibid*
3. Lattice Level Sensitivity Analysis of Indian PHWR, Ishi Jain, Manish Raj, Sherly Ray and M.P.S. Fernando, *ibid*
4. Studies on the Variation of Reactor Kinetic Parameters with Latest ENDF-6 Nuclear Data Libraries, Arun Stanley, Puspendu Hazra, T. Sathiyasheela, K. Devan, *ibid*
5. Development of a New Neutron Multi-Group Cross Section Set in ABBN Format from the Latest ENDF-6 Files for Fast Reactors, Puspendu Hazra, A. Riyas, K. Devan, ibid
6. Quantification of Nuclear Data Contribution to Uncertainty in Fuel SA Decay Power, G. Pandikumar and A. John Arul, *ibid*
7. Estimation of Uncertainty in The Control Rod Worth in CANDU PHWR , M. Mohideen Abdul Razak, ibid
8. Dynamic Uncertainty Analysis in the Power Transient of CANDU PHWR, M. Mohideen Abdul Razak, *ibid*
9. Nuclear Data Sensitivity of VVER-1000 Pin-Cell Benchmark, V. Harikrishnan, Anek Kumar and Usha Pal
10. Uncertainty and Sensitivity Analysis of Neutron Multiplication Factor in CANDU ReactorM. Mohideen Abdul Razak, P. Ravindra Babu.
11. Theoretical Calculation of Excitation Function of Proton Induced Reaction and Evaluation of Recommended data by TALYS – 1.95 and Empire – 3.2.2 Code , Sourav Mondal and Rebecca Lallunthluangi, *ibid*
12. Production of Ru-105 and Rh-105 through Proton Induced Reaction on Natural Uranium, Najumunnisa T, M. M. Musthafa, C. V. Midhun, Alok Saxena, P. Surendran, J. P. Nair and Anil Shanbhag,obid

13 A Study of Alpha-Induced Pre-Equilibrium Neutron Emission in Natural Titanium, Gokul Das H, MM Musthafa, Midhun C V, Swapna B, Vafiya T, Najmunnisa T, F S Shana, Rijin N T, S Dasgupta, J Datta, S Ganesan, S V Suryanarayana, ibid

4.4 Collective enhancement in nuclear level density

Several experimental investigations have reported evidence of collective enhancement of the nuclear level density and its fadeout. However, a suitable method is needed for experimental determination of the enhancement factor as a function of excitation energy. In this study, neutron spectra were measured in coincidence with evaporatedα particles produced in the reactions 11 B + 181 Ta, 197 Au. The nuclear level density parameter has been extracted for the Os(A ≈ 188) and Pb(A ≈ 204) isotopes by comparing neutron spectra with statistical model prediction. Evidence for collective enhancement has been found for Os nuclei whereas no such enhancement has been seen for Pb nuclei. The energy-dependent enhancement factor has been extracted by simultaneous fitting of the neutron spectra at various excitation energies. Near a temperature of 0.8 MeV, the enhancement starts to fadeout which is lower than the theoretically predicted temperature of 1.4 MeV for 187 Os. Also, free energy surface calculation shows that the 187 Os nucleus undergoes a transition from collective prolate to noncollective oblate shape close to the temperature of 0.8 MeV, corroborating the early fadeout. No such shape transition is seen for 203 Pb.

Publication: Collective enhancement in nuclear level density, G. Mohanto, A. Parihari, P. C. Rout, S. De, E. T. Mirgule, B. Srinivasan, K. Mahata, S. P. Behera, M. Kushwaha, D. Sarkar, B. K. Nayak, and A. Saxena. Physical Review C 100, 011602(R) (2019)

4.5 Probing collective enhancement in nuclear level density with evaporation α particle spectra

Collective enhancement in nuclear level density (CELD) and its fadeout has been studied experimentally using neutron and high energy γ-ray spectra earlier. Attempts to probe CELD with α-particle spectra were made for compound nucleus (CN) 178 Hf in the excitation energy 54–124 MeV, but no signature of CELD was found. The possible reason behind this nonobservance has been discussed in a few subsequent reports. In our previous study, evidence of CELD was found using neutron spectra and enhancement faded away near 25 MeV of excitation energy. This implies that the effect of CELD on α particles, if any, would be found at excitation lower than 25 MeV. With the aim to observe CELD and its fadeout with α-particle spectra, two reactions 12C+116 Sn, 159 Tb, forming CN in different mass region (A ≈ 128 and

A ≈ 171) were studied. Evaporation α-particle spectra were measured for the reactions in singles as well as in coincidence with neutrons. Experimental data were compared with statistical model calculations and inverse level density parameter (k) were obtained from α-particle spectra. As a function of CN excitation energy, the k value showed peak like structure for the reaction 12C+159 Tb which indicates fadeout of CELD. No such evidence was found for the reaction 12C+116 Sn. Collective enhancement factor for daughter nuclei populated in 12C+159 Tb reaction was extracted. Critical energy of the fadeout was found to be similar to that of mass A ≈ 188 region.

Publication: Probing collective enhancement in nuclear level density with evaporation α -particle spectra, G. Mohanto, P. C. Rout, K. Ramachandran, K. Mahata, E. T. Mirgule, B. Srinivasan, A. Kundu, A. Baishya, R. Gandhi, T. Santhosh, A. Pal, S .Joshi, S. Santra, D. Patel, Prashant N. Patil, S. P. Behera, P. Yashwantrao, N. K. Mishra, D. Dutta, A. Saxena, B. K. Nayak , Phys. Rev. C 105, 034607 (2022).

4.6 Signature of fusion suppression in complex fragment emission

The effect of weak binding of 9 Be on complete fusion has been explored through the study of complex fragment emission in 20 Ne+ 9 Be reaction. The yields of the fragments 6,7 Li and 7,9 Be emitted from the excited compound nucleus 29 Si ∗ have been compared with the respective statistical model predictions. Emission of same fragments from another close-by compound nucleus 28 Si ∗ at similar excitation energy, formed by the fusion of two strongly bound nuclei, 16 O+ 12 C, has been studied for comparison. It has been observed that for the system 16 O+12 C, the yields of 6,7 Li and 7,9 Be fragments are close to the predictions of the statistical model. However, for the 20 Ne+ 9 Be system, although the experimental yield pattern follows the statistical model prediction, there is substantial reduction in yield for all detected fragments. These observations have been attributed to the suppression of complete fusion in 20 Ne+ 9 Be system due to the weak binding of 9 Be, a dynamical effect which is not incorporated in the conventional statistical models. It is the first time that a clear signature of the suppression of complete fusion in light systems involving weakly bound nucleus has been observed in complex fragment emission from fully equilibrated composite produced in fusion well above the barrier.

Publication: Signature of fusion suppression in complex fragment emission: S. Manna et al., Phys. Rev. C 105, L021603 (2022).

4.7 Evidence for competing bi-faceted compound nucleus fission modes in 232 Th(α, f) reaction

Relative isotopic yield distributions have been extracted for nine correlated fission fragment pairs following a detailed analysis of prompt $\gamma - \gamma$ coincidence events from 232 Th(α ,f) reaction at E lab = 30 MeV. Simultaneously, the charge and mass yield distributions of the even-even fission fragments have been obtained from the measured relative isotopic yields. The onset of a triple-hump structure is seen in the extracted charge as well as mass yield distributions of the fragments. The results are consistent with the two-mode fission hypothesis of compound nucleus and in good agreement with the theoretical predictions, based on relevant fission models. The detailed results provide experimental evidence for the presence of two distinct compound nucleus fission modes, where the asymmetric and symmetric fission components are 83% and 17%, respectively. An average neutron multiplicity value of 4.60 ± 0.09 has been obtained, and the extracted neutron multiplicity distribution pattern corroborates the observed features of the multifaceted fission modes. Comparing the measured yield distributions following the 232 Th(α ,f) surrogate reaction, which produces 236 U ∗ at an excitation energy of 21.5 MeV, with that of the direct reaction of 14 MeV neutron induced fission of 235 U, an increase of about 11% in the yield of the symmetric component has been observed.

Publication: Evidence for competing bi-faceted compound nucleus fission modes in 232Th(a, f) reaction, Aniruddha Dey et. al., Phys. Lett. B 825, 136848 (2022).

4.8 Search for the Hoyle analogue state in 16 O

The Hoyle analogue state in 16 O was explored by inelastic scattering of 45 MeV αs on a Mylar target. The break up 4αs of 16 O have been detected in coincidence with the inelastically scattered α beam particle to probe the Hoyle analogue state of 16 O in complete kinematics, for the first time. The data have been analysed for all possible configurations and the excitation function of 16 O has been reconstructed directly from 4α as well as for specific decay channels like 12 C(0 + 2) + α, 12 C(3 − 1) + α and 8 Be + 8 Be. Several previously known states have been observed above the 4α break-up threshold (14.44 MeV) in the above mentioned decay channels. However, the signature of the 15.1 MeV state, most preferable to be the Hoyle analogue state according to the theoretical prediction, remains inconclusive.

Publication: Search for the Hoyle analogue state in 16O, S. Manna et al.,.Eur. Phys. J A57, 286 (2021).

4.9 Measurement of light output response in scintillator based neutron detectors using quasi-monoenergetic neutrons

Conventional liquid scintillator (BC501A) and pulse shape discrimination capable plastic scintillator (EJ-299-33A) based detector of dimension; 5 inch diameter and 5 inch long, have been used to study pulse height response for quasi-monoenergetic neutrons of energy in the range 3 to 15 MeV generated using 7 Li(p,n) 7 Be reaction. Scintillation light output of plastic scintillator having pulse shape discrimination property is found to be 75% of the liquid scintillator at neutron energy (maximum recoil proton energy) of 3MeV which improves with the increase in energy. Functional dependence of the scintillation light output in terms of recoil protons energy has been determined for the liquid and the plastic scintillator detectors for neutron energy in the range 3 to 15MeV. This functional dependences were used in the Geant4 simulation to calculate the pulse height responses at several neutron energies.

Publication: Measurement of light output response in scintillator based neutron detectors using quasi-monoenergetic neutrons: A. S. Roy et al., JINST 16 P07045 (2021).

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Appendix G

REVIEW OF NEUTRON QUASI-ELASTIC SCATTERING DATA

S. Simakov, N. Otuka
(Memo 4C-3/0420 Rev.2)

The neutron scattering cross sections compiled with EL in REACTION SF3 in EXFOR entries often include contribution of inelastic scattering to low-lying excitation levels due to insufficient energy resolution. It disturbs people who performs evaluation with models, and it has been urged to improve the situation. Therefore, we performed review of the relevant EXFOR entries by the following **Tasks**:

1. extracting EXFOR entries compiling neutron elastic scattering angular differential and integrated cross sections which (1) incident energy is higher than 1.5 MeV, (2) excitation energy of the 1st level less than 200 keV, and (3) target mass heavier than 40 (Ca);
2. checking their source articles to find if there is any description on inclusion of the inelastic scattering contribution;
3. summarize the suggestions for update of each EXFOR entry.

1. Explanations and general information to the recommendations for the EXFOR Entry corrections

The extraction of the EXFOR entries compiling the neutron elastic scattering angular differential and integrated cross sections from EXFOR Master Ver. 2021-10-01 were performed automatically with the criteria formulated above in the first item of **Tasks**. The found 234 sub-Entries were written in the Excel file “*EL-20211001-extract.xlsx”*. The content of each one was then analysed by checking their source articles and information already available in Entries to find if there are any details about the separation or inclusion of the inelastic scattering contribution. The final recommendations are given below in Section 2. The present section summarizes the explanations to recommendations as well as the general information on the experimental resolving of elastically and inelastically scattered neutrons.

The analysed **(sub) Entries** are listed in the ascending mode and are hyperlinked to the EXFOR retrieval system on the NDS/IAEA web site. The latter allows to open each Entries by one click and consult with information which was available there in the time period when the present work was performed (until May 2022).

The first **author and publications** are explicitly given to refer from where the detailed information about the experiment was taken to decide whether the EL or SCT process was measured and by which way. Several Entries have references only to the short or abstract description of experiment, e.g. in the Bulletin of the American Physical Society. In such cases more descriptive publications were searched in internet that sometimes resulted in success.

The given final **recommendations** for the reaction field SF3, as either **EL** or **SCT**, are highlighted by colour for convenience: green colour does not require modification, red - does. When SCT is identified the additional changes of the REACTION string is proposed. Thus, for identification of how many excited levels are included in the scattering the level numbers LVL-NUMB, level excitation energy (Ex) E-LVL or the maximum excitation level E-LVL-MAX are additionally given. *Italic font in this case means that values for E-LVL or E-LVL-MAX are not given explicitly by authors but are extracted from presently adopted nuclear level schemes (NDS/IAEA Livechart) or from the auxiliary information in publications and own analysis.*

The maximum excited level number or its energy Ex, inelastic scattering to which was not separated from elastic, is often not specified by the authors of the experiment. In such cases we tried to find the total energy resolution of spectrometer, which is usually characterized by the Full Width at Half Maximum (FWHM) and has to include all factors: incident energy spread, scattered neutron detection resolution or registration threshold. Then we assumed that all residual nucleus levels up to the excitation energy Ex less than FWHM were not separated from transition to the ground state, i.e. the elastic scattering, and hence the measured data are the partial scattering (SCT) cross section for all levels within interval $0 \leq Ex \leq FWHM$.

As an illustration, Fig. 1 displays two Gaussian lines: one is the elastically scattered neutrons with mean energy E_{elas} = 10.5 MeV and the second – "inelastically" scattered neutrons with energy E_{inel} = 9.5 MeV. The resolution (FWHM) for both is equal to 1 MeV and thus exactly coincides with the difference between their mean energies, from which the discrete level excitation energy could be estimated as $Ex = E_{elas} - E_{inel}$ = 1 MeV. To mimic the differential scattering at various angles the three elastic peaks with different amplitudes are considered, whereas the inelastic one was assumed to be the angle independent. As seen in Fig. 1, in the case when Ex ≤ FWHM the elastic and inelastic peaks start to fuse into one peak, i.e. will be experimentally observed as one group of neutrons. In this situation an analytical treatment of the scattering peak (e.g., fitting by combination of two peaks of the pre-known shapes, subtracting the peak measured with bare neutron source, etc,) still may allow to separate the contribution of elastic and inelastic processes (that however was not always done by authors).

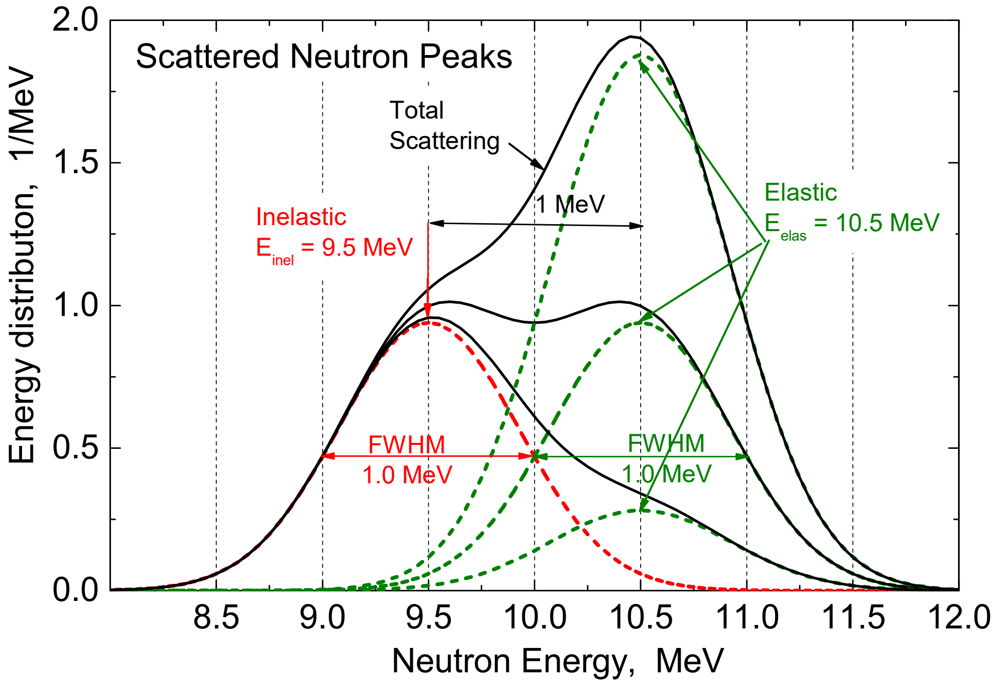

Fig. 1. The energy distribution (line shape) of elastic peak of various amplitude with the mean energy E_{elas} = 10.5 MeV and FWHM = 1 MeV (green dash line), and of the "inelastic" peak with E_{inel} = 9.5 MeV and FWHM = 1 MeV (red dash line). Their sum, i.e. total scattering peak is plotted by the black solid line.

<u>It is obvious that the value of FWHM, the separation criteria Ex ≤ FWHM and the found nearest level E-LVL-MAX are not high accuracy quantities but rather serve for approximate quantification of how many excited levels probably were not resolved from the ground state.</u> Some original publications do not contain the definitive values for Ex or for the overall energy experimental resolution. In such cases we still try to estimate it from the incomplete information we have found in source documentation, that may bring an estimate but only as the limit or range for Ex.

For the incident neutron energies above several MeV, the typical experimental energy resolution amounts (5 – 10)% that results in the large FWHM value up to 1 MeV. The latter may exceed the first level in many middle or heavy mass nuclei, so the issue "EL or SCT" may also concern the other elements which were measured by authors but were not found by the EXFOR automatic search and not listed in file "*EL-20211001-extract.xlsx*". Such sub-Entries were analysed too, and proper recommendations were given.

As was shown in the several publications, for the forward small angles (up to ≈ 30 degrees) the neutron scattering on the middle or heavy mass nuclei, the differential elastic cross section exceeds the inelastic ones to the unresolved levels by several orders of magnitude. It means that elastic and scattering cross sections are practically equal, especially considering the measurement uncertainties which are at level of a few percent in the best cases. In the present analysis such cases are considered as SCT.

Justifications which were copied from the original publications are included in the quotation marks, but those formulated by us – as a normal text. When EL is required to be replaced by SCT, the text of justification could be (partially) copied in CRITIQUE or elsewhere in Entry to explain the decision taken and to help the EXFOR users.

Further corrections of the Entry, found during analysis, comprise: (i) an important information about the experiment which is still missing in the particular Entry; (ii) recommendation to replace EL by SCT for other reactions (sub-Entries) which were not listed in the file "*EL-20211001-extract.xlsx*" but will require this basing on the analysis performed. The phrases in red are recommended for inclusion in Entry under the identified KEYWORDs.

Remarks to the EXFOR collection of publications (library *x4pdf*) were made when authors' publications needed for the analysis of the Entries were not included there. The name of the proper document was highlighted in red (the remark in green means that NDS/IAEA has operatively provided them).

General information on the neutron elastic scattering experiments and possible admixture of inelastic scattering.

1. From the view of measuring technique all experiments reporting the elastic angular differential cross section or polarization data could be arranged in two groups.

To the first one the measurements without neutron spectrometry, i.e. without determination of energy, could be ascribed (see for example, Entries 21858, 22029, 40706, etc.). Typically they have used the scintillation (i.e., hydrogen containing) detectors, which are characterized by the quasi flat distribution of pulse heights in response to the monoenergetic neutrons. To reduce the impact of the inelastic scattering neutrons and to suppress the sensitivity to the γ-rays, the discrimination level was set rather high but still below the high energy end of the pulse height distribution caused by the incident neutrons. Only counting rate of the detector was measured. Such experimental method was rather often used for the measurement of angular distribution and polarization power of the elastically scattered neutrons in the narrow forward directions, i.e. at angles up to ≈ 10° - 20°. The inelastic scattering differential cross section was supposed to be substantially lower than elastic and thus was ignored. This approach was used in the experiments carried in the time period ≈ 1950 - 1970.

The second group of experiments uses the neutron energy spectrometry. The energy of the scattered neutrons could be determined by the measuring of distribution of the pulse heights (PH) or by Time of Flight (TOF). Both are characterised by the final energy resolution, that is important in the present context. The most advanced and often used technique is TOF (see for example the data of Holmqvist' group in Entries 20019, 20162, 20346). In this method the neutron energy E is derived from the measured time t which neutron requires to fly from the sample to the detector located at flight path distance L (non-relativistic kinematics approximation):

$$E\ [\mathrm{MeV}] \approx (72.3\ L[\mathrm{m}]\ /\ t[\mathrm{ns}])^2 \qquad (1).$$

The TOF or derived energy spectrum of the scattered neutrons principally allows to observe the elastic and inelastic groups of neutrons. This capability depends, however, on the overall energy resolution ΔE of the TOF spectrometer, which is a derivative of the neutron energy E, incident neutron energy E_0, time of flight t, beam time bunching Δt_b, detector resolution Δt_D, flight path length, sizes of the scattering sample ΔL_S and neutron detector ΔL_D, and the incident neutron energy spread ΔE_0. Differentiation of Eq. (1) results in:

$$\Delta E = E\sqrt{\Delta E_0^2/E_0^2 + 4(\Delta t_b^2 + \Delta t_D^2)/t^2 + 4(\Delta L_S^2 + \Delta L_D^2)/L^2} \qquad (2).$$

It has to be stressed that in the present context we interpret the uncertainty ΔX for every variable X in Eq. (2) as the resolution, i.e. the Full Width at Half Maximum (FWHM). Additionally other factors may impact on the overall resolution: asymmetric or non-gaussian time response of spectrometer, multiple neutron scattering in the sample. Since the later factors are unknown, even when all resolution components are reported by author, our calculations according to Eq. (2) still may underestimate the total energy resolution.

If the overall energy resolution achieved in the experiment is comparable or less than energy spacing between the ground and the first excited state Ex, the corresponding groups of neutrons are clearly separated or could be still resolved by fitting the peak shapes, see Fig. 1. In this case the author report the genuine elastic differential cross sections and (n,n') to the excited single or grouped levels. On contrary, the worse resolution results to overlapping of elastic and inelastically scattered neutrons. Still in this case, some experimentalists try to clean the observed "elastic" neutron scattering. For this the shape or response to the monoenergetic neutrons is determined by measuring the neutron flux from the bare neutron source or scattered by heavy nucleus with high first excited state, e.g. ^{208}Pb. Then this shape is fitted to the high energy half part of "elastic" peak, where the contribution of (n,n') is supposed to be absent. However, it is obviously not valid when Ex << ΔE, i.e. when the peaks from (n,n'$_1$) and (n,n$_{el}$) are superimposed without notable energy shift. As an example, the nuclei ^{181}Ta with Ex = 6.2 keV or ^{235}U with Ex = 0.076 keV could be mentioned.

In both approaches when elastic and inelastic scattering to the first levels could not be separated the experimentalist sometimes tried to derive the elastic cross section by subtracting the (n,n') cross section found in the literature, measured in the same experiment etc. after its dividing by 4π. The validity of such procedure is often questionable since it depends on many factors: whether the angular distribution is really isotropic, are the required (partial) inelastic cross sections well known, etc.

2. Many elastic scattering data have been measured with 14 MeV neutrons produced via interaction of the 100 – 300 keV deuterons with the tritium absorbed in solid material, usually titanium (see for example Entries 12069, ...). The mean neutron energy, yield and spread (i.e., FWHM of the peak in the energy distribution) depend on neutron emission angle. The energy spread was estimated by J. Csikai et al. in paper "Investigation on the properties of D+D and D+T neutron sources", Report IAEA-TECDOC-0410, p. 296. There Figure 6 shows the dependence of ½ FWHM versus the neutron emission angle Θ at several deuteron energies E_d varying from 125 and 220 keV. For example, at E_d = 175 keV, FWHM decreases from maximum value ≈ 400 keV at Θ = 0°, to the value ≈ 240 keV at Θ = 45° and then to the minimum ≈ 120 keV at Θ ≈ 105°. The neutron experiments presently analysed have utilized the neutron beam at between zero or 90 degrees, that means the spread of the initial neutron energy can varies in range 400 to 120 keV.

Besides the energy spreading due to deuteron stopping in the solid target and due to the T(d,n) reaction kinematics, an additional energy spread arises from the variation of the mean neutron energy within the angle subtended by the sample. The latter depends on the experimental set-up, i.e. the finite sizes of sample and distance to the solid target. This also is often the main reason of the scattering angle uncertainty which experimentalists try to minimize when they measure the angular differential neutron elastic scattering.

2. Recommendations for the SF3 field and other improvements of Entries content.

Entries: 10034.002 (67-HO-165(N,EL)67-HO-165,,SIG) and
10034.003 and (67-HO-165(N,EL)67-HO-165,,DA,,LEG/RS)

Ex of 1st level (MeV): 0.0947

Author and Publication: J. Meadows et al., zp_243_171_1971_.pdf

Recommendation for SF3: **EL**

Justification: There is no doubt below 1 MeV: "resolution was sufficient below 1 MeV". Above 1 MeV the authors still separated the elastic and inelastic neutrons and properly increase the cross section uncertainty: “As the incident energy increased the resolution became less definitive in the context of the more complex scattered neutron spectrum. … The larger uncertainties occurred at higher energies where the resolution of elastic and inelastic contributions was more difficult.”

Further correction of Entry: (.002) ERR-ANALYS: The uncertainty in the total elastic scattering cross section was estimated to be ≈ 8%. (.003) ERR-ANALYS: The relative uncertainties in the individual differential cross section measurements varied from 3-10 %.

Entries: 10179.003 (94-PU-240(N,EL)94-PU-240,,SIG) and
10179.004 (94-PU-240(N,EL)94-PU-240,,DA,,LEG/RS)

Ex of 1st level (MeV): 0.0428

Author and Publication: A. Smith et al., nse_47_19_1972_.pdf

Recommendation for SF3: **EL**

Justification: "The scattered neutron resolution was not generally sufficient at incident energies of > 1.0 MeV to differentiate the elastic neutron group from inelastic neutrons resulting from the excitation of the 42-keV state in 240Pu. Careful measurements at selected angles with an improved resolution of ~ 0.75 nsec/m qualitatively established the inelastic component to ~1.3 MeV. Assuming an isotropic inelastic neutron distribution and interpolating and extrapolating measured inelastic values with theoretical guidance (see below) the measured elastic cross sections were corrected for inelastic neutron contributions above ~1.0 MeV. This correction was small at forward scattering angles but appreciable at large scattering angles.”

Entries: 10234.006 (73-TA-181(N,EL)73-TA-181,,DA)

Ex of 1st level (MeV): 0.0062

Author and Publication: S. Pearlstein et al., jne_ab_19_497_1965_.pdf

Recommendation for SF3: **SCT:** (73-TA-181(N,SCT)73-TA-181,PAR,DA) with *E-LVL-MAX ≈ 1.8 MeV*

Justification: “For the scattering geometry used, the energy resolution is 13 per cent at 14.1 MeV”, i.e. FWHM ≈ 1.8 MeV. It was supposed that levels with excitation energy up to 1.8 MeV will not be resolved from the elastically scattered neutrons. Fig. 2 (“Experimental scattered neutron energy distributions”, see Ta) of jne_ab_19_497_1965_.pdf graphically confirms this.

Entries: 10264.002 (79-AU-197(N,EL)79-AU-197,,DA) and
10264.003 (79-AU-197(N,EL)79-AU-197,,DA)

Ex of 1st level (MeV): 0.0774

Author and Publication: M. Hoffman et al., la-5552_1974.pdf ; 71knox_2_868_1971.pdf

Recommendation for SF3: **EL** below 80 keV, but above – total **SCT:** (79-AU-197(N,SCT)79-AU-197,,DA)

Justification: The source was a moderated nuclear explosion, the TOF method was used for the incident neutron energy determination. At the bombarding neutron energy below 80 keV, i.e. the opening of the inelastic scattering to the first excited level in 197Au, the data in these subentries are the elastic scattering cross sections. Above 80 keV and until 2.75 MeV they are scattering cross sections since the used 3He scintillator detectors in current mode have registered both elastic an inelastically scattered neutrons. Since “the scattered foils and detectors were completely enclosed by a shielded of neutron moderating and absorbing material”, probably efficiency of neutron detector drops down but only below 10 eV (as seen in Fig. 3 of la-5552_1974.pdf). It means that scattering (elastic + total inelastic) cross sections were measured above 80 keV.

Entries: 10366.004 (93-NP-237(N,EL)93-NP-237,,SIG)

Ex of 1st level (MeV): 0.0332

Author and Publication: M. Semon et al., bap_21_655(je3)_1976.pdf

Recommendation for SF3: **EL** below 35 keV, but above – total **SCT:** (93-NP-237(N,SCT)93-NP-237,,DA)

Justification: Neither single referencing document bap_21_655(je3)_1976.pdf nor this Entry 10366 does not report how the neutron elastic scattering was measured, which detector was used, ... (search of other relevant publications in the internet was unsuccessful; two Hoffman’ letters dated 06.08.1975 and 30.03.1976 are not helpful too). Following the description given by M. Hoffman et al. for Au197(n,el) (la-5552_1974.pdf and 71knox_2_868_1971.pdf; Entry 10264.002), it might be recommended to consider these data as elastic cross section below 35 keV and as total scattering above this energy, when the inelastic scattering to the first excited level in Np237 opens and the scattered neutrons are counted by practically non-threshold detectors.

Entries: 10370.005 (73-TA-181(N,EL)73-TA-181,,DA)

Ex of 1st level (MeV): 0.0062

Author and Publication: P. Benenson et al., np_a_212_147_1973_.pdf

Recommendation for SF3: **SCT:** (73-TA-181(N,SCT)73-TA-181,PAR,DA) with *E-LVL-MAX = 4.0 MeV*

Justification: “The time window permitted inelastically scattered neutrons corresponding to excitation energies of approximately 4 MeV to give valid counts. Since forward inelastic scattering differential cross sections are typically three orders of magnitude lower than elastic for En ~ 15 MeV, no correction for the former was included.” It means that inelastic cross sections for the levels up to ≈ 4 MeV excitation energy are experimentally presented in these data.

Entries: 10473.002 (92-U-238(N,EL)92-U-238,,DA) and 10473.005 (92-U-238(N,EL)92-U-238,,DA)

Ex of 1st level (MeV): 0.0449

Author and Publication: L. Beghian et al., nse_69_191_1979_.pdf

Recommendation for SF3: **EL**

Justification: Extensive efforts were undertaken to obtain an energy resolution of ~ 20 keV (half of 1st level excitation) especially at higher bombarding neutron energies. Moreover, when the first two neutron groups could not always be resolved completely, an unfolding procedure was applied using an empirically determined prompt neutron profile.

Further correction of Entry: (.001) CORRECTION: Unfolding procedure was applied to resolve elastically and inelastically scattered neutrons.

Entries: 10510.003 (92-U-238(N,EL)92-U-238,,DA)

Ex of 1st level (MeV): 0.0449

Author and Publication: W. Bucher et al., prl_35_1419_1975_.pdf , nim_111_237_1973_.pdf

Recommendation for SF3: **SCT**: (92-U-238(N,SCT)92-U-238,PAR,DA) with *E-LVL-MAX = 210 keV* (at EN = 7.0 MeV), *270 keV (at EN = 9.0 MeV), 330 keV (at EN = 11.0 MeV) or 420 keV (at EN = 14.0 MeV)*

Justification: The experiment was optimized for the forward neutron elastic scattering cross section measurements at energy 7 – 14 MeV. The NE type scintillation detector and moderate flight path 3 m are not sufficient to resolve the first inelastically scattered neutron components in the case of U238 target by TOF. From the Fig. 7 of nim_111_237_1973_.pdf it is possible to define the energy resolution of spectrometer FWHM ≈ 30%. Supposing that U238 levels up to excitation energies FWHM will not be resolved from ground state, the maximum E-LVL-MAX ≈ 0.210 MeV (at EN = 7.0 MeV), ≈ 0.270 MeV (at EN = 9.0 MeV), ≈ 0.330 MeV (at EN = 11.0 MeV) and ≈ 0.420 MeV (at EN = 14.0 MeV).

Entries: 10570.003 (92-U-238(N,EL)92-U-238,,DA)

Ex of 1st level (MeV): 0.0449

Author and Publication: L. Yu et al., bap_20_1496(bd9)_1975.pdf, Nucl. Phys. A324(1979)160

Recommendation for SF3: **EL**

Justification: The small angle neutron scattering with a good angular resolution was a goal of this experiment. Since the incident neutron spectrum was continuum, TOF was used to determine only bombarding neutron energy within energy interval 0.6 – 2.2 MeV. The overall flight path 10 m and 1.5 ns pulsed proton beam were only sufficient for getting the cross section averaged over rather wide energy bins 100 keV. The used NE218 scintillator detector is not capable to resolve elastic and inelastic scattered neutrons which have an energy different only by 45 keV. However, the authors did make the proper correction in following way: "Cross sections for 238U were corrected for inelastic scattering with the previously measured inelastic cross sections summarized by Lambropoulos. The magnitude of this correction at 1.5 deg ranged from about 10% at low energies to less than 1% at high energies. Use of a more recent set of evaluated cross sections would not substantially alter the results."

Further correction recommended for Entry (.001):

REFERENCE and TITLE, add this: L.L. Yu, J.C. Overley, Small-angle neutron scattering from Pb and 238U between 0.6 and 2.2 MeV, Nucl. Phys. A324 (1979)160; DOI: 10.1016/0375-9474(79)90085-X

INC-SOURCE (P-LI7), replace by this: 1.5 ns pulsed 4 MeV proton beam stroked thick lithium metal target and produced neutron energy continuum spectrum.

METHOD (TOF), add this: Time-of-flight. Neutron flight paths from source to scatterer and from scatterer to detector were each 5 m. Data were averaged over 100 keV incident energy bins.

DETECTOR: NE218 scintillator. Bias levels were set to reject events corresponding to recoil protons of less than 0.4 MeV and greater than 6 MeV. Pulse shape discrimination against y-rays was also employed.

CORRECTION, add this: Cross sections for ^{238}U were corrected for inelastic scattering with the previously measured inelastic cross sections summarized by Lambropoulos. The magnitude of this correction at 1.5 deg ranged from about 10% at low energies to less than 1% at high energies. Use of a more recent set of evaluated cross sections would not substantially alter the results. Inelastic scattering corrections for lead were negligible.

Entries: 10633007 (25-MN-55(N,EL)25-MN-55,DI,DA), 10633011 (41-NB-93(N,EL)41-NB-93,,DA), 10633018 (67-HO-165(N,EL)67-HO-165,,DA), 10633019 (73-TA-181(N,EL)73-TA-181,,DA)

Ex of 1st level (MeV): 0.1359 (Mn55), 0.0308 (Nb93), 0.0947 (Ho165), 0.0062 (Ta181)

Author and Publication: J. Ferrer et al., np_a_275_325_1977_.pdf

Recommendation for SF3: SCT:
(25-MN-55(N,SCT)25-MN-55,PAR,DA) with LVL-NUMB = 0, 1 (E-LVL = 0, 126 keV)
(41-NB-93(N,SCT)41-NB-93,PAR,DA) with LVL-NUMB = 0, 1 (E-LVL = 0, 31 keV)
(67-HO-165(N,SCT)67-HO-165,PAR,DA) with E-LVL-MAX = 360 keV
(73-TA-181(N,SCT)73-TA-181,PAR,DA) with E-LVL-MAX = 360 keV

Justification: "The overall energy resolution of the system for 11 MeV neutrons was 360 keV (FWHM). … With the energy resolution of the present experiment, neutrons inelastically scattered from low-lying excited states of V, Mn, Nb, In, Ho and Ta were not resolved from the elastic peak." It could be supposed that inelastically scattered neutrons to the levels with excitation energy FWHM = 360 keV were not resolved from elastic scattering.

Further correction recommended for Entry: SCT instead of EL in subentries
.006 (23-V-51(N,SCT)23-V-51,PAR,DA) with LVL-NUMB = 0, 1 (E-LVL = 0, 321 keV)
.016 (49-IN-0(N,SCT)49-IN-0,PAR,DA) with LVL-NUMB = 0, 1 (E-LVL = 0, 336 keV In115, 392 keV In113)

Entries: 10718.006 (62-SM-152(N,EL)62-SM-152,,DA)

Ex of 1st level (MeV): 0.1218

Author and Publication: D. Coope et al., pr_c_16_2223_1977_.pdf

Recommendation for SF3: **EL**

Justification: "The time resolution of the system, as can be seen in the TOF spectrum of Fig. 2, was good enough to resolve well the first excited state of 152Sm at 122 keV excitation energy from the elastic scattering peak."

Entries: 10803.005 (74-W-182(N,EL)74-W-182,,DA), 10803.006 (74-W-184(N,EL)74-W-184,,DA),
10803.007 (74-W-186(N,EL)74-W-186,,DA), 10803.008 (74-W-182(N,EL)74-W-182,,SIG),
10803.009 (74-W-184(N,EL)74-W-184,,SIG), 10803.010 (74-W-186(N,EL)74-W-186,,SIG)

Ex of 1st level (MeV):, 0.1001 (W-182), 0.1112 (W-184), 0.1226 (W-186)

Author and Publication: T. Guenther et al., pr_c_26_2433_1982_.pdf

Recommendation for SF3: **EL**

Justification: Following explanations of authors and their Figs. 2 and 3 definitely prove that EL was measured: "The primary problem in the elastic-scattering measurements was the resolution of the elastic neutron group from the inelastic components corresponding to the excitation of the ≈ 110 keV level. Most of the measurements were made with flight paths of ≈ 5.4 m. At higher energies some measurements were made with ≈ 20 m flight paths in order to improve the resolution of the elastic scattered components and the results were also used to correct the shorter-flight-path values, measured at similar energies, for unresolved inelastic-neutron contributions."

Entries: 10807.016 (60-ND-150(N,EL)60-ND-150,,DA), 10807.017 (60-ND-150(N,EL)60-ND-150,,DA,,LEG), 10807.026 (60-ND-150(N,EL)60-ND-150,,SIG)

Ex of 1st level (MeV): 0.1302

Author and Publication: D. Coope et al., bap_24_854(gc10)_1979.pdf

Recommendation for SF3: **EL**

Justification: From the short information given in single publication bap_24_854(gc10)_1979.pdf "Differential cross sections for neutron elastic and inelastic scattering to excited levels of even-A Nd isotopes have been measured for an incident energy of 2.5 MeV", it follows that both elastic and inelastic neutron groups were resolved. It is confirmed by subentry 10807.018 of the same author for reaction (60-ND-150(N,INL)60-ND-150,PAR,DA), i.e. inelastic excitation of the first level 0.132 MeV. Additionally, this experiment seems was performed at the same facility of University of Kentucky as those by D. Coope et al., pr_c_16_2223_1977_.pdf, **Entries:** 10718.006 (62-SM-152(N,EL)62-SM-152,,DA).

Entries: 10876.003 (47-AG-107(N,EL)47-AG-107,,DA), 10876.004 (47-AG-107(N,EL)47-AG-107,,SIG)

Ex of 1st level (MeV): 0.0931

Author and Publication: A. Smith et al., np_a_332_297_1979_.pdf, anl-ndm-46_1979.pdf

Recommendation for SF3: **EL**

Justification: "The experimental scattered-neutron velocity resolution with flight paths of ≈ 5 m was sufficient to resolve the elastically scattered neutron component from all known inelastic-neutron groups to incident energies of ≈ 3 .0 MeV. The resolutions were less favourable at energies > 3.0 MeV. However, selected measurements with better resolution obtained with 20 m flight paths indicated that inelastically scattered neutrons did not appreciably contaminate the "elastic" neutron groups observed at the shorter (5 m) flight paths." Additional justification: separated subentry 10876.005 reports (47-AG-107(N,INL)47-AG-107,PAR,SIG) for separated levels Ex = 0.103 MeV, 0.425 MeV and higher.

Entries: 10899.002 (94-PU-242(N,EL)94-PU-242,,DA), 10899.003 (94-PU-242(N,EL)94-PU-242,,SIG)

Ex of 1st level (MeV): 0.0445

Author and Publication: D. Drake et al., la-7855-ms_1979.pdf

Recommendation for SF3: **EL**

Justification: At bombarding neutron energies 0.57 MeV and 1.0 MeV the total energy resolution of the TOF spectrometer was sufficient to separate the inelastic scattering to the first excited state of ^{242}Pu (Ex = 45 keV and 148 keV) from elastic (as shown in Figs. 3 - 5 and Table I). However, at incident neutrons 1.5 MeV “it was impossible to separate elastically scattered neutrons from those inelastically scattered by low-lying excited states, so we analyzed the observed scattering as if it were one state. From these differential cross sections, we subtracted the 46 mb/sr that were estimated as the isotropic differential cross sections of the first two excited states” (see Fig. 7 and Table I). Exactly this information is already given as FLAG in these sub-entries for incident energy 1.5 MeV.

Entries: 11202.017 (41-NB-33(N,EL)41-NB-93,,DA)

Ex of 1st level (MeV): 0.0308

Author and Publication: J. Hopkins et al., nse_36_275_1969_.pdf, np_a_107_139_1968_.pdf

Recommendation for SF3: **SCT:** (41-NB-93(N,SCT)41-NB-93,PAR,DA) with *LVL-NUMB = 0, 1*

Justification: The description of experiment is given in: np_a_107_139_1968_.pdf. There the energy resolution is quantified as “the neutron energy spreads were 62 keV, 47 keV, 230 keV and 170 keV for incident neutron energies of 3.35 MeV, 4.83 MeV, 5.74 MeV and 7.5 MeV, respectively”. Obviously, the energy spread 170 – 230 keV was not sufficient to separate the 1st excited level 31 keV of ^{93}Nb at incident neutron energy 5.95 to 7.47 MeV. An indirect confirmation is given by the following authors’ statement for the n + ^{7}Li data: “the 5.74 MeV and 7.5 MeV data include the scattering to the first excited state at 0.478 MeV” - these data are correctly compiled in sub-Entry 11153.014 (3-LI-7(N,SCT)3-LI-7,PAR,DA).

Since the second 686 keV and higher excited levels of ^{93}Nb have the energies exceeding the spectrometer energy spread, probably they were separated from (n,el + n1) and included in inelastic.

Entries: 11215.046 (79-AU-197(N,EL)79-AU-197,,SIG) and
11215.049 (79-AU-197(N,EL)79-AU-197,,DA)

Ex of 1st level (MeV): 0.0774

Author and Publication: M. Walt et al., pr_98_677_1955_.pdf

Recommendation for SF3: **SCT:** (79-AU-197(N,SCT)79-AU-197,PAR,SIG) and
(79-AU-197(N,SCT)79-AU-197,PAR,DA) with *E-LVL-MAX = 0.9 MeV*

Justification: The incident “neutrons of 4.1 MeV with an energy spread of about 80 keV were produced ... “. Additionally to this spread, the energy sensitive scintillation neutron detector was operated at three biases (thresholds): “In order to obtain estimates of the energy lost by the neutrons in inelastic collisions the detector was operated at three different biases having detection thresholds at about 2.0, 2.6, and 3.2 MeV. Thus, the presence of neutrons which lost less than 2 MeV in inelastic collisions would be indicated by differences in the cross sections obtained at the three biases.” The measured angular differential scattering cross sections are presented for these three biases, for Au – in Fig. 7. Comparison of the numerical data given in sub-Entry 11215.046 (79-AU-197(N,EL)79-AU-197,,SIG) with Fig. 7 proves that compiled data are those measured with the highest bias of neutron detector, i.e. 3.2 MeV. It means that all inelastically scattered neutron leaving ^{197}Au at excitation energy approximately up to (4.1 – 3.2) MeV = 0.9 MeV are partially included in (n,el) process.

Entries: 11223.005 (73-TA-181(N,EL)73-TA-181,,DA)

Ex of 1st level (MeV): 0.0062

Author and Publication: L. Rosen et al., pr_107_824_1957_.pdf

Recommendation for SF3: **SCT**: (73-TA-181(N,SCT)73-TA-181,PAR,DA) with *E-LVL-MAX ≈ 2.0 MeV*

Justification: In this experiment the nuclear emulsions situated at some distance from scatter was employed as neutron detectors. “The scatterer detector geometry and selection criteria afford a maximum angular spread of ± 8° and a maximum energy spread of ± 7%”, however “no corrections were made for the finite angular and energy resolution presented by the target-detector geometry.” Thus, the 14% energy resolution at 14.0 MeV results to FWHM ≈ 2.0 MeV. I suppose that levels with excitation energy up to approximately 2.0 MeV will not be resolved from the elastically scattered neutrons. Such E-LVL-MAX ≈ 2.0 MeV is confirmed by Fig. 5 (the energy distribution of the neutrons from 14-MeV neutrons on Ta) and by Fig. 3 (angular distributions of the nonelastic neutrons from 14-MeV neutrons on Ta, obtained as integration up to 12 MeV, i.e. 14.0 – 2.0 MeV).

CORRECTION: the paper has a dedicated “Section III. Corrections” which describes a set of corrections applied – information from there is recommended to include in Entry.

Further correction recommended for Entry: similar as for Ta-181 but now for Bi-209 (see Figs. 4 and 6)

SCT instead of EL in subentry .011 (83-BI-209(N,SCT) 83-BI-209,PAR,DA) *with E-LVL-MAX ≈ 2.0 MeV*

Entries: 11287.027 (45-RH-103(N,EL)45-RH-103,,SIG), 11287.028 (45-RH-103(N,EL)45-RH-103,,DA)

Ex of 1st level (MeV): 0.0398

Author and Publication: R. Wilenzick et al., np_62_511_1965_.pdf

Recommendation for SF3: **SCT**: (45-RH-103(N,SCT)45-RH-103,PAR,DA) with *E-LVL-MAX ≈ 0.23 MeV*

Justification: “The average energy of the neutrons incident on the scatterer was determined as 6.04 MeV, with an energy spread which was approximately triangular and whose full width at half-maximum was 230 keV”. “For most medium and heavy nuclei a continuous spectrum of inelastically scattered neutrons is observed, since the time resolution is insufficient to resolve the neutrons from the many levels in the residual nucleus (see fig 3)”. However, the authors noted: “since the elastic and inelastic neutron groups were not perfectly resolved, it was necessary to perform a subtraction by fitting a known the shape to the elastic peak. … The decomposition of the elastic and inelastic groups was performed manually”. Still “the inelastic cross sections were determined using only neutrons within the energy range 0.5 to 4.0 MeV, the data above 4 MeV being considered unreliable because of uncertainties associated with the decomposition of the observed spectra into its elastic and inelastic parts”. Considering all this information it looks unrealistic to separate the 39.8 keV inelastic peak from elastically scattered on ^{103}Rh. For other nuclei in this Entry such separation looks more reliable if the 1st level lay higher than 230 keV.

Further correction recommended for this Entry (.001):

MONITOR (6-C-12(N,SCT)6-C-12,,SIG) => (6-C-0(N,TOT)6-C-0,,SIG), 1.12 ± 0.02 b at 6.04 MeV.

All sample were natural materials. Then should it be in .003: REACTION (6-C-12(N,EL)6-C-12,,DA) or C-0 ?

Entries: 11495.008 (25-MN-55(N,EL)25-MN-55,,DA), 11495.018 (33-AS-75(N,EL)33-AS-75,,DA), 11495.028 (41-NB-93(N,EL)41-NB-93,,DA), 11495.036 (53-I-127(N,EL)53-I-127,,DA), 11495.050 (79-AU-197(N,EL)79-AU-197,,DA), 11495.060 (41-NB-93(N,EL)41-NB-93,,DA)

Ex of 1st level (MeV): 0.1259 (Mn-55), 0.1986 (As-75), 0.0308 (Nb-93), 0.1259 (I-127), 0.0774 (Au-197)

Author and Publication: D. Thomson, pr_129_1649_1963_.pdf

Recommendation for SF3: **SCT**: (25-MN-55(N,SCT) 25-MN-55,PAR,DA), (33-AS-75(N,SCT)33-AS-75,PAR,DA), (41-NB-93(N,SCT)41-NB-93,PAR,DA), (53-I-127(N,SCT)53-I-127,PAR,DA), (79-AU-197(N,SCT)79-AU-197,PAR,DA), (41-NB-93(N,SCT)41-NB-93,PAR,DA) with *E-LVL-MAX ≈ 1.0, 1,25, 1,50 and 1.75 MeV at incident energies 4, 5, 6 and 7 MeV correspondingly.*

Justification: "Counts corresponding to elastically scattered neutrons were subtracted by fitting an appropriate monoenergetic neutron line shape to the elastic peak of the time spectrum. It was found that the spectrum for indium at 4.0 MeV gave a strong elastic peak at forward angles which agreed in shape with the gamma-ray peak within a few percent for each channel having an amplitude of 5% or more of the peak channel. … An example of the subtraction procedure is shown in Fig. 11. The original time spectrum was plotted on a log scale, and the gamma-ray line shape was plotted on another log sheet. The two plots were superimposed and fitted so that the gamma-ray line was normalized to the height of the peak corresponding to the energy of the elastically scattered neutrons. <u>All of the neutron counts in the normalized curve were assumed to be elastic</u> and were subtracted. … Typical resolution functions, which include both target thickness and burst duration, are shown in Fig. 10." In this Figure the FWHM could be estimated as ≈ 1 MeV at neutron energy E = 4 MeV. Employing the ratio FWHM/E = 25%, we come to E-LVL-MAX ≈ 1.0, 1,25, 1,50 and 1.75 MeV at incident energies 4, 5, 6 and 7 MeV correspondingly.

Further correction recommended for Entry: similar as for As-75, Nb-93, I-127, Au-197 the corrections SCT and PAR instead of EL *with E-LVL-MAX ....* has to be implied for all other elements and sub-Entries (but excluding Pb-206) since their first excited levels have energy less then FWHM: Al-27 (Elvl1 = 0.8438), V-0 (0.3208), Fe-0 (0.8468, and low levels in other isotopes …), Cu-0 (min Elvl1 = 0.6699 in ^{63}Cu, …), Se-0 (0.1619 in ^{77}Se, …), Sr-0 (0.3885 in ^{87}Sr, …), In-0 (0.3362 in ^{115}In, …), Sb-0 (0.0371 in ^{121}Sb, …), La-0 (0.1659 in ^{139}La, …), Ce-0 (0.6413 in ^{142}Ce, …), Ta-0 (0.0062 in ^{181}Ta, …), W-0 (0.1001 in ^{182}W, …), Tl-0 (0.2037 in ^{205}Tl, ...), Bi-209 (0.8963).

Entries: 11511.008 (25-MN-55(N,EL)25-MN-55,,DA), 11511.016 (33-AS-75(N,EL) 33-AS-75,,DA),
11511.031 (59-PR-141(N,EL)59-PR-141,,DA)

Ex of 1st level (MeV): 0.1259 (Mn-55), 0.1986 (As-75), 0.1454 (Pr-141)

Author and Publication: R. Becker, np_89_154_1966_.pdf

Recommendation for SF3: **EL**

Justification: The authors have definitely stated "pulse-height discrimination was used to exclude inelastically scattered neutrons". It is possible without TOF, however the pulse height measurement method has also own energy resolution. Regrettably but any relevant information about such details are absent in paper. Only the incident energy resolution is given: "a calculated neutron energy in the forward direction of 3200 keV with an r.m.s. energy variation of about 100 keV".

Supposing a typical relative energy resolution for "detector, a scintillation counter employing stilbene or NE 213 liquid mounted … on photomultiplier …" at level ≈ 5% will result to ΔE = FWHM = 5% * 3.2 MeV = 160 keV. Consequently, for most of 36 elements compiled in this Entry 11511 the EL has to be replaced by SCT with exception for Co-59 (Elvl1 = 1.099 MeV) and Bi-209 (Elvl1 = 0.8963). However, <u>since 5% energy resolution is merely our suggestion which provokes a contradiction to the authors statement</u> "pulse-height discrimination was used to exclude inelastically scattered neutrons", <u>we refused from such modification or recommendation</u>.

Entries: 11638.011 (90-TH-232(N,EL)90-TH-232,,DA)

Ex of 1st level (MeV): 0.0494

Author and Publication: S. Darden, pr_100_1315_1955_.pdf

Recommendation for SF3: **SCT**: (90-TH-232(N,SCT)90-TH-232,PAR,DA)
with E-LVL-MAX ≈ 0.3, 0.4 or 0.5 MeV at incident energy 0.50, 1.00 and 1.55 MeV, correspondingly.

Justification: The authors have specified only the incident energy spread: “Differential cross sections for elastic scattering have been measured for several elements at neutron energies 0.50, 1.00 and 1.55 MeV with a neutron energy spread of about 100 keV”. The scattered neutrons were registered in the following way: “for a neutron energy of 1 MeV, data were taken at two biases set so that no neutrons with energies less than 660 and 790 keV, respectively, were detected. … At 0.50 MeV, the two biases were set to discriminate against neutrons having energies less than 200 and 300 keV, respectively. At 1.55 MeV, the data presented were taken with discriminator set such that neutrons of energy less than 1.1 MeV were not detected”.

It means that up to excitation energy Ex = 0.5 – 0.25 = 0.25 MeV at initial energy E_0 = 0.50 and Ex = 1.0 – 0.73 ≈ 0.37 MeV at E_0 = 1.0 and Ex = 1.55 – 1.1 ≈ 0.45 MeV at E_0 = 1.55. Quadratically summing with initial energy spread 0.1 MeV and rounding to the first significant digit we will get Ex ≈ 0.3, 0.4 and 0.5 MeV, correspondingly.

Further correction recommended for this Entry 11638: consequently, for the next elements Ti-0 (Ti-47 Elvl1 = 0.1594 MeV), Fe-0 (Fe-57 Elvl1 = 0.0144 MeV), Ag-0 (Ag-109 Elvl1 = 0.0880 MeV), Cd-0 (Cd-111 Elvl1 = 0.2454 MeV), Sn-0 (Sn-119 Elvl1 = 0.0238 MeV), Sb-0 (Sb-121 Elvl1 = 0.0371 MeV) and Ta-0 (Ta-181 Elvl1 = 0.0062 MeV) the EL has to be replaced by SCT since the excitation energy of the first level in the one of stable isotopes is below Ex.

SF3 should remain EL for elements Cu-0 (Cu-63 Elvl1 = 0.6693 MeV), Zr-0 (Zr-94 Elvl1 = 0.9188 MeV), Ce-0 (Ce-136 Elvl1 = 0.5520 MeV), Pb-0 (Pb-207 Elvl1 = 0.5697 MeV) and Bi-209 (Elvl1 = 0.8963), since incident energy is less than minimal first level excitation energy among stable isotopes and thus only elastic scattering will be kinematically allowed.

Entries: 11854.005 (41-NB-93(N,EL)41-NB-93,,DA,,LEG/RS), 11854.006 (41-NB-93(N,EL)41-NB-93,,DA)

Ex of 1st level (MeV): 0.0308

Author and Publication: D. Reitman et al., np_48_593_1963_.pdf

Recommendation for SF3: **SCT**: (41-NB-93(N,SCT)41-NB-93,PAR,DA,,LEG/RS),
(41-NB-93(N,SCT)41-NB-93,PAR,DA) with *LVL-NUMB = 0, 1*

Justification: For ^{93}Nb it was clearly stated by authors: “in no instance was an inelastic component corresponding to the excitation of the first state at 0.029 MeV observed. Such a group could have been experimentally resolved only if it were relatively intense at incident neutron energies below 0.7 MeV. Any inelastic component leading to the excitation of this first level was included in the elastic group. Such a contribution is expected to be small on theoretical grounds …”.

In the case of natural Zr “the only levels which could be expected to be observed in this experiment are those in Zr^{94}, and Zr^{92} and possibly in Zr^{91} at ~ 0.92 MeV”. The inelastic scattering to such high excitation energies are well resolved from elastic scattering as seen in Fig. 1 and following comments of authors: “the remaining group shown in this portion of the figure corresponds to inelastically scattered neutrons which leave the Zr nucleus in an excited state at 0.92 MeV”. Thus the SF3 field in the (40-ZR-0(N,EL)40-ZR-0,…) sub-entries should be left as EL.

Entries: 11877.003 (41-NB-93(N,EL)41-NB-93,,DA), 11877.007 (59-PR-141(N,EL)59-PR-141,,DA)
11877.009 (79-AU-197(N,EL)79-AU-197,,DA), 11877.012 (90-TH-232(N,EL)90-TH-232,,DA)

Ex of 1st level (MeV): 0.0308 (Nb-93), 0.1454 (Pr-141), 0.0774 (Au-197), 0.0494 (Th-232)

Author and Publication: S. Buccino et al., zp_196_103_1966_.pdf

Recommendation for SF3: **SCT**: (41-NB-93(N,SCT)41-NB-93,PAR,DA), (59-PR-141(N,SCT)59-PR-141,PAR,DA), (79-AU-197(N,SCT)79-AU-197,PAR,DA), (90-TH-232(N,SCT)90-TH-232,PAR,DA) with *E-LVL-MAX ≈ 0.450 MeV*

Justification: The energy spread of incident 5 MeV neutrons is given by authors: "the average energy spread in the deuterium beam due to energy loss in the gas and inhomogeneity of the foil (~ 10%) was 320 keV". An energy resolution of the TOF spectrometer we can calculate as 310 keV from following information: "a flight path of 1.4 m and an overall resolution of 7 nsec for the scattered neutrons were sufficient to separate the elastic peak from the inelastic continuum in the time spectra. The elastic peak was not perfectly symmetrical but included a "tail" on the side nearest the continuum. Since the tail was not resolved from the continuum, the relative yield was determined by symmetrizing the entire peak around the centroid of the upper portion of the peak". Then quadratically summing both, we get the total energy resolution FWHM = 445 keV. It means that all elastically and inelastically scattered neutrons within peak of ≈ 0.450 MeV width were separated from other (n,n') continuum and interpreted by authors as elastic scattering.

Further correction recommended for this Entry 11877: The same consideration and corrections (SF3 = SCT) of REACTION should be applied to the following natural elements Ag, Sb, Ta, Tl and U. However, SF leaves to be EL for: Zr-0 (min Elvl1 = 0.9188 MeV in ^{94}Zr), Ce-0 (min Elvl1 = 0.5521 MeV in ^{136}Ce), Pb-206 (Elvl1 = 0.803 MeV).

Entries: 11977.004 (79-AU-197(N,EL)79-AU-197,,DA), 11977.006 (90-TH-232(N,EL)90-TH-232,,DA)

Ex of 1st level (MeV): 0.0774 (Au-197), 0.0494 (Th-232)

Author and Publication: F. Kuchnir et al., pr_176_1405_1968_.pdf

Recommendation for SF3: **EL**

Justification: "These data were corrected ... and for the presence of inelastically scattered neutrons. … The contribution from inelastically scattered neutrons was evaluated from the known energy dependence of the detector efficiency and the measured inelastic scattering cross sections under the assumption that these neutrons are distributed isotropically in angle. Inelastic scattering contributed about 0.10 b/sr to the measured differential cross sections for U, Th, and W, about half as much for Au, and a negligible amount for Cd and Pb. The measured cross sections of U and Th were not corrected for the effect of fission neutrons since this contribution was estimated to be negligible for our experimental conditions". From this it follows that correction for contribution of (n,n') was applied by authors – that is also reflected under keyword CORRECTION of each sub-Entry.

Entries: 12039.002 (53-I-127(N,EL)53-I-127,,DA,,LEG/RS), 12039.003 (53-I-127(N,EL)53-I-127,,SIG)

Ex of 1st level (MeV): 0.0576

Author and Publication: A. Smith et al., eandc(us)-62_1965.pdf, 65antwerp_509(36)_1965.pdf

Recommendation for SF3: EL

Justification: "The experimental scattered neutrons resolutions were tailored to the specific requirements of the individual measurements with particular attention to the resolution of the elastically and of the inelastically scattered components". For Iodine the authors has declared "incident neutron energy spread 20 - 30 keV". This looks to be sufficient to separate neutron groups populating 57.6 keV and g.s. of ^{127}I.

Similarly SF3 leaves to be EL for other natural elements this Entry 12039: Yb-0 (“incident neutron energy spread ≈ 20 keV”, min Elvl1 = 0.0667 MeV in ^{171}Yb) and Pb-0 (“incident neutron energy spread 20 keV”, min Elvl1 = 0.5697 MeV in ^{207}Pb).

Remark to the EXFOR pdf collection: 65antwerp_509(36)_1965.pdf is not available.

Entries: 12054.002 (57-LA-139(N,EL)57-LA-139,,DA), 12054.003 (57-LA-139(N,EL)57-LA-139,,DA,LEG), 12054.004 (57-LA-139(N,EL)57-LA-139,,SIG), 12054.005 (59-PR-141(N,EL)59-PR-141,,DA), 12054.006 (59-PR-141(N,EL)59-PR-141,,DA,LEG), 12054.007 (59-PR-141(N,EL)59-PR-141,,SIG)

Ex of 1st level (MeV): 0.1659 (La-139), 0.1454 (Pr-141)

Author and Publication: D. Bernard et al., 68wash_2_755_1968.pdf

Recommendation for SF3: **SCT**: (57-LA-139(N,SCT)57-LA-139,PAR,DA), (57-LA-139(N,SCT)57-LA-139,PAR,DA,LEG), (57-LA-139(N,SCT)57-LA-139,PAR,SIG), (59-PR-141(N,SCT)59-PR-141,PAR,DA), (59-PR-141(N,SCT)59-PR-141,PAR,DA,LEG), http://www-nds.iaea.org/EXFOR/12054.007(59-PR-141(N,SCT)59-PR-141,PAR,SIG) with *E-LVL-MAX ≈ 0.800 MeV*

Justification: The authors wrote: “No effort has been made to extract inelastic contributions to the elastic neutron groups as evidence indicates that such contributions are small and within statistical counting uncertainties. … it was assumed that the contribution of the most energetic inelastic neutrons (leaving praseodymium in its 0.140 MeV excited state) to the elastic peak was negligible. Similar results were obtained with the lanthanum scatterer”. Caption to Fig. 3 specifies that “the neutron energy resolution is about 800 keV”.

Remark to the EXFOR pdf collection: 68wash_2_755_1968.pdf is not available.

Entries: 12069.002 (41-NB-93(N,EL)41-NB-93,,DA), 12069.010 (41-NB-93(N,EL)41-NB-93,,SIG)

Ex of 1st level (MeV): 0.0308

Author and Publication: G. Western et al., afwl-tr-65_216_2_1966.pdf

Recommendation for SF3: **SCT**: (41-NB-93(N,SCT)41-NB-93,PAR,DA), (41-NB-93(N,SCT)41-NB-93,PAR,SIG) with *E-LVL-MAX ≈ 0.700 MeV*

Justification: For Nb and V the authors wrote: “the data were integrated over energy to obtain the differential cross section … for nonelastic scattering … for 4.5 ≤ E ≤ 14 MeV”. It looks that neutrons in the energy group 14.0 ≤ E ≤ 14.7 and higher were included in the elastic scattering. We use the difference 14.7 – 14.0 MeV as estimation for Ex = 0.7 MeV. Additionally, it could be noticed that such Ex is larger than energy resolution 0.060 MeV of the TOF spectrometer (computed with flight path 2.9 m and time resolution Δt = 1.6 ns plotted in Fig. 5.3) and the spread of “the energy of neutrons entering the scatterer is 14.7 ± 0.2 MeV”.

Further correction recommended for this Entry 12069: The same consideration and corrections (SF3 = SCT) of REACTION should be applied for V-0 (Elvl1 = 0.2262 and 0.3201 MeV in ^{50}V and ^{51}V) in sub-Entries .003 and .011. The SF3=EL should be left for C-0 (12069.004) in sub-Entries .004 and .012: “… the channel separation of the elastic and inelastic (Q = 4.433 MeV) peaks in the time spectrum of neutrons scattered from carbon”.

Entries: 12175.002 (73-TA-181(N,EL)73-TA-181,,DA), 12175.003 (73-TA-181(N,EL)73-TA-181,,SIG),
12175.004 (73-TA-181(N,EL)73-TA-181,,DA,,LEG/RS)

Ex of 1st level (MeV): 0.0062

Author and Publication: A. Smith et al., anl-6727_1963.pdf

Recommendation for SF3: **SCT**: (73-TA-181(N,SCT)73-TA-181,PAR,DA), (73-TA-181(N,SCT)73-TA-181,PAR,SIG), (73-TA-181(N,SCT)73-TA-181,PAR,SIG) with LVL-NUMB = 0, 1

Justification: "Throughout this experiment, the resolution was insufficient to distinguish the reported first excited, $9/2^-$, state at 6 keV in ^{181}Ta from the ground state. As a result, any processes possibly involving this first level were referenced the ground state instead". The inelastic neutron scattering to the several next excited levels in ^{181}Ta are resolved and reported separately.

Entries: 12180.005 (90-TH-232(N,EL)90-TH-232,,SIG), 12180.006 (90-TH-232(N,EL)90-TH-232,,DA)

Ex of 1st level (MeV): 0.0494

Author and Publication: C. Hudson et al., pr_128_1271_1962_.pdf

Recommendation for SF3: **SCT**: (90-TH-232 (N,SCT) 90-TH-232,PAR,DA),
(90-TH-232 (N,SCT) 90-TH-232,PAR,SIG) with *E-LVL-MAX ≈ 1.800 MeV*

Justification: "With the 179-cm flight path used in this experiment, and for 15.2-MeV neutrons, the time resolution of 3 nsec corresponds to an energy resolution of 2.5 MeV. In the actual data reduction, an integral number of channels of the time-of-flight spectrum were used as the "elastic scattering peak," corresponding to a spread in flight time of slightly more than 3 nsec. Figure 3 gives the relative efficiency for detection of neutrons of energy E for the time-of-flight system used in this experiment. If the energy resolution is defined as the energy loss for which neutrons are detected with 50% efficiency relative to elastically scattered neutrons, the system has an energy resolution of 1.8 MeV".

Further correction recommended for this Entry 12180: the same consideration and corrections (SF3 = SCT) of REACTION should be applied for Ta-0 (Elvl1 = 0.0062 MeV in ^{181}Ta), Bi-209 (Elvl1 = 0.8963 MeV) and U-0 (Elvl1 = 0.0130 MeV in ^{235}U and 0.0449 MeV in ^{238}U).

Entries: 12191.003 (79-AU-197(N,EL)79-AU-197,,DA)

Ex of 1st level (MeV): 0.0774

Author and Publication: W. Day, Priv. Comm: Day (1965)

Recommendation for SF3: description of experiment is not given, however likely SF3 should be **SCT**:
(79-AU-197 (N,SCT)79-AU-197,PAR,DA), with LVL-NUMB = 0, 1

Justification: This Entry has neither information about how this experiment was done nor reference to any publication. An attempt was made to find the relevant information in internet. Following document was found at osti.org: WASH-1033 "REPORTS TO THE AEC NUCLEAR CROSS SECTIONS ADVISORY GROUP MIT AND YALE", by J.R. Stehn, August 29-31, 1961. This document is available as pdf on Google book WASH-1033, where the page 29 tells us:

"A. NEUTRON REACTION
1. Elastic Neutron Scattering   Levin, Day

Data have been taken at neutron energies of 1.0, 2.5, and 4.1 MeV for the elastic scattering angular distributions of Au, Tl, Pb^{206}, Pb^{207}, Pb^{208}, and Bi^{209}. Similar data are being taken at 0.5 MeV. In general, the data have a statistical accuracy of 1% and a systematic error of the order of 3%. Further work at higher energies is being deferred until next year when the bunching magnet arrives since the present system does not have adequate resolution to resolve the elastic scattering from the inelastic scattering at higher energies."

From the last sentence one may suppose that for nuclei with extremely low first level excitation energy, like ^{197}Au or Tl, the measured cross sections was a sum of elastic and inelastic scattering, i.e. the scattering.

Further correction recommended for this Entry: add reference to WASH-1033, p. 29 and information available there.

Entries: 12240.002 (79-AU-197(N,EL)79-AU-197,,DA,,LEG/RS),
12240.003 (79-AU-197(N,EL)79-AU-197,,DA)

Ex of 1st level (MeV): 0.0774

Author and Publication: J.A.M. De Villiers, zp_183_323_1965_.pdf

Recommendation for SF3: EL

Justification: from the following authors' explanations, it is clear that elastic scattering cross sections were explicitly separated or properly corrected for the inelastic one: "The optimum scattered neutron energy resolution was 15 - 20 keV. … At incident neutron energies of less than ~ 1.0 MeV the velocity resolution was sufficient to resolve the elastic groups from essentially all inelastic components. … At incident neutron energies of greater than 1.0 MeV, the inelastic contributions were determined at one angle with the best possible resolution and the elastic angular distributions determined with less resolutions corrected for their inelastic content assuming isotropy in the inelastic processes.… In this work the 77 (1/2 +) state in Au was clearly resolved."

Entries: 12277.002 (90-TH-232(N,EL)90-TH-232,,DA),
12277.004 (90-TH-232(N,EL)90-TH-232,,SIG)

Ex of 1st level (MeV): 0.0494

Author and Publication: A.B. Smith, pr_126_718_1962_.pdf

Recommendation for SF3: EL

Justification: from explanations given by author, it is clear that elastic scattered neutrons were explicitly separated or corrected for the inelastic group: "In Fig. 2 elastically scattered neutrons and inelastically scattered neutrons resulting in the excitation of the first excited state of 50 ± 2 keV are clearly resolved. These two components are distinguishable up to incident neutron energies of 1.0 MeV. … The measurements above an incident neutron energy of 1.0 MeV have been corrected for the contribution of the first inelastic group using the extrapolated inelastic cross section given in Fig. 10 (which will be discussed later). At lower incident energies the elastic component is experimentally resolved from all inelastic components."

Entries: 12892.003 (41-NB-93(N,EL)41-NB-93,,DA)

Ex of 1st level (MeV): 0.0308

Author and Publication: X. Wang, np_a_465_483_1987_.pdf

Recommendation for SF3: **SCT**: (41-NB-93(N,SCT)41-NB-93,PAR,DA), with E-LVL-MAX ≈ 0.400 MeV

Justification: "The time resolution was about 2.0 ns which corresponds to an energy resolution of ~ 400 keV for 7 MeV neutrons." Consequently, the measured elastic cross sections have to include the inelastic excitation of levels up to 400 keV.

Entries: 12935.008 (41-NB-93(N,EL)41-NB-93,,DA), 12935.011 (73-TA-181(N,EL)73-TA-181,,DA)
12935.012 (79-AU-197(N,EL)79-AU-197,,DA)

Ex of 1st level (MeV): 0.0308 (Nb-93), 0.0062 (Ta-181), 0.0774 (Au-197)

Author and Publication: L. Hansen et al., pr_c_31_111_1985_.pdf

Recommendation for SF3: **SCT**: (41-NB-93(N,SCT)41-NB-93,PAR,DA), (73-TA-181(N,SCT)73-TA-181,PAR,DA), (79-AU-197(N,SCT)79-AU-197,PAR,DA), with *E-LVL-MAX ≈ 0.120 MeV*

Justification: There are no information in the paper about energy resolution or subtraction of the inelastically scattered neutrons, except this: "The beam was bunched, 1—2 ns wide, and swept at a 2.5 MHz burst rate. … In the present work the elastic differential cross sections were measured between 9.2° and 159° and the flight path was 10.75 m for all the detectors. The neutron detector bias was 5.4 MeV, and pulse-shape discrimination was used to reduce the gamma-ray background". Using 2 ns as a deuteron beam burst width and 10.75m flight path to 5.1 cm long detector, we can estimate the energy resolution $\Delta E \approx 22$ keV for the 14.6 MeV neutrons. C. Wong et al. in PR_C26(1982)889 described the LLNL TOF spectrometer, mentioning "Fig. 2. … The prompt gamma ray time width is 2.7 ns, corresponding to an energy resolution of 0.16 MeV for 8 MeV neutrons". Using 2.7 ns for the total spectrometer time resolution we got $\Delta E \approx 30$ keV at 14.6 MeV or 22 keV at 8.0 MeV, that essentially underestimates 160 keV given by C. Wong.

Thus, the most reasonable estimate of the energy resolution (FWHM) would be ΔE (14.6 MeV) = 160 keV (8.0 MeV) * sqrt(8.0MeV/14MeV) ≈ 120 keV.

Entries: 12995.002 (41-NB-93(N,EL)41-NB-93,,DA)

Ex of 1st level (MeV): 0.0308 (Nb-93)

Author and Publication: R. Pedroni et al., pr_c_43_2336_1991_.pdf

Recommendation for SF3: **SCT**: (41-NB-93(N,SCT)41-NB-93,PAR,DA), with LVL-NUMB = 0, 1

Justification: "The experimental resolution was not sufficient to extract σ(Θ) or A(Θ) values for inelastic scattering to discrete states in ^{93}Nb, so only values for elastic scattering were determined. Any yield from inelastic scattering to the first excited state at 0.030 MeV would not be distinguished from elastic scattering. However, as discussed later, the contribution from this inelastic group is negligible. … The total energy spread … decreases monotonically from 190 to 94 keV from energies 8 to 14 MeV. The energy spread at 17 MeV is 300 keV because a high energy was used at this energy".

Since the ^{93}Nb second excited level energy Elvl2 = 686.8 keV is higher than the energy resolution specified by authors at all incident energies, we can use LVL-NUMB = 0, 1 instead of E-LVL-MAX.

Entries: 13011.002 (79-AU-197(N,EL)79-AU-197,,DA)

Ex of 1st level (MeV): 0.0774 (Au-197)

Author and Publication: S. Cox, anl-7910_20_1972.pdf

Recommendation for SF3: **EL**

Justification: Author did not describe the experimental procedure but stated that it was the same as in the previous experiment at incident neutron energy ~ 1 MeV, see Report ANL-7935(1972). There the author wrote: "To obtain the accurate elastic scattering cross sections for all elements, inelastically scattered neutrons must be eliminated from the data. Because of the way the discrimination level is set on the detector outputs, the detection system is insensitive to neutrons inelastically scattered from levels > 300 keV above the ground state. For levels < 300 keV above the ground state, a correction must be made. The correction is based on known inelastic scattering cross sections and the measured efficiency curves of the detectors. … The correction to the differential scattering cross section varies from zero for most of the lighter even-Z/even-A nuclides to as high as 100 mb for uranium."

From this information it is seen that author has corrected the elastic scattering for contribution of inelastic scattered neutrons. Since there are no detailed information and we can not quantitatively estimate the energy resolution and hence E-LVL-MAX, the only reasonable recommendation seems to be to leave these data as they are, i.e. elastic.

Entries: 13503.002 (90-TH-232(N,EL)90-TH-232,,DA)

Ex of 1st level (MeV): 0.0494 (Th-232)

Author and Publication: G. Goswami et al., nse_100_48_1988_.pdf

Recommendation for SF3: **EL**

Justification: The authors have applied a lot efforts to separate experimentally or resolve overlapping the elastic and two first inelastic (excitation of 49 keV and 162 keV states) neutron groups, that is confirmed by detailed information and Figures in their paper.

Entries: 13532.002 (41-NB-93(N,EL)41-NB-93,,DA)

Ex of 1st level (MeV): 0.0308 (Nb-93)

Author and Publication: W. Finlay et al., Priv. Comm. (1991)

Recommendation for SF3: **SCT**: (41-NB-93(N,SCT)41-NB-93,PAR,DA), with E-LVL-MAX ≈ 0.400 MeV

Justification: This entry contains elastic cross sections at 20 MeV for ^{93}Nb and ^{209}Bi, which were privately communicated without referring to any document. On other side, the same group of authors have reported in another Entry 13521 the neutron emission spectra for the same targets ^{93}Nb and ^{209}Bi at the same incident energy. From the referenced paper of A. Marcinkowski et al. (np_a_530_75_1991_.pdf) it becomes practically obvious that the (n,n) and (n,xn) data were obtained concurrently in the same experiment. Paper np_a_530_75_1991_.pdf states: "The overall energy resolution of the spectrometer was better than 600 keV". Both entries, approved by authors, declare however the energy resolution 400 keV.

From this information we recommend to assign SF3 = SCT and E-LVL-MAX = 0,4 MeV in case of the ^{93}Nb(n,n) elastic data but leave SF3 = EL for ^{209}Bi(n,n), since first excited state of residual Elvl1 = 0.896 MeV.

Entries: 13547.002 (21-SC-45(N,EL)21-SC-45,,DA), 13547.003 (21-SC-45(N,EL)21-SC-45,,DA)

Ex of 1st level (MeV): 0.0124 (Sc-45)

Author and Publication: A. Smith et al., jp_g_19_655_1993_.pdf, anl-ndm-125_1992.pdf

Recommendation for SF3: **SCT**: (21-SC-45(N,SCT)21-SC-45,PAR,DA), with E-LVL = 0 and 0.0124 MeV

Justification: "Incident neutron energy spreads varied from ≈ 300 keV at 4.5 MeV to ≈ 100 keV at 10 MeV. … Another problem inhibiting the inelastic scattering measurements is the presence of a very low-lying excited level in ^{45}Sc (12.4 keV, 3/2+). … Moreover, in no observations were the neutrons due to the inelastic excitation of the 12.4 keV (3/2+) level resolved from the elastically scattered contribution. ... As noted above, this level could not be resolved experimentally from the elastically-scattered component. …The second and third excited levels in "Sc are at 377(3/2-) and 543(5/2+) keV, respectively. Scattered neutrons due to the excitation of these two levels have energies very close to those resulting from elastic scattering of the second neutron group from the ^{7}Li(p,n)^{7}Be source reaction. As a result, corrections for the second component of the source reaction were made using the Monte Carlo correction procedures …".

From this it is obvious that elastic data include the inelastic excitation of the first level 12.4 keV but exclude the second (377 keV) and higher levels. It is true for both subentries .002 and 0.003.

Entries: 13552.003 (76-OS-190(N,EL)76-OS-190,,DA)

Ex of 1st level (MeV): 0.1867 (Os-190)

Author and Publication: S. Hicks, thesis_Hicks_1987.pdf

Recommendation for SF3: **EL**

Justification: "The energy resolutions for the two experiments were found to be 72 keV and 108 keV at 2.53 and 4.64 MeV, respectively". Such resolution was quite sufficient for author to separate elastically scattered neutrons from those inelastically scattered to the first 2+ and higher levels in ^{190}Os, which are compiled in subentry .004.

Entries: 13589.002 (45-RH-103(N,EL)45-RH-103,,DA)

Ex of 1st level (MeV): 0.0398 (Rh-103)

Author and Publication: A. Smith et al., jp_g_20_795_1994_.pdf

Recommendation for SF3: **SCT**: (45-RH-103(N,SCT)45-RH-103,PAR,DA), with E-LVL = 0.0. 0.0398 and 0.0930 MeV

Justification: "The first two excited states in ^{103}Rh are at 39.8 (7/2+) and 93.0 (9/2+) keV [2]. The corresponding inelastic-scattering cross sections are small. However, in all of the present measurements neutrons due to the inelastic excitation of these two states were not resolved from the elastically scattered component. Herein. what is termed 'elastic' scattering is actually a composite of the elastically and the first two or more inelastically scattered neutron groups, as defined below." Starting from level 295 keV the "inelastically-scattered neutron groups were observed corresponding to excitations of 0.334 ± 0.013, 0.536 ± 0.010, 0.648 ± 0.025 …" and are probably compiled in 12796.005.

Entries: 13804.008 (41-NB-93(N,EL)41-NbB-93,,DA)

Ex of 1st level (MeV): 0.0308 (Nb-93)

Author and Publication: E. Christodoulou et al., nse_132_273_1999_.pdf

Recommendation for SF3: **SCT**: (45-RH-103(N,SCT)45-RH-103,PAR,DA), with *E-LVL-MAX = 0.4 MeV*

Justification: The authors have not reported implicitly the total energy resolution of its TOF spectrometer. Only several components are given: "The overall resolution achieved for 14-MeV neutrons with the NE-213 neutron detector is 2.4 ns. … Flight path 8.62 m, Detector length 7.6 cm. …". If we will use this information, then will get an energy resolution ΔE(FWHM) = 0.034 MeV, which is too small. An alternative option to estimate the real energy resolution of this experiment –

to use information given in "Fig. 13. Experimental data of the elastic and first inelastic (Q = -0.85 MeV) neutron scattering peaks of natural iron, at 80.5 deg, fitted with the function given by Eqs. (2) and (3)". This plot shows that elastic peak has a FWHM approximately = ½ of distances between itself and the inelastic group which corresponds excitation of the first level 0.85 MeV in ^{56}Fe. From this, we estimate E-LVL-MAX = ΔE(FWHM) ≈ 0.85/2 ≈ 0.4 MeV.

Entries: 13965.002 (73-TA-181(N,SCT)73-TA-181,PAR,DA)

Ex of 1st level (MeV): 0.0062 (Ta-181)

Author and Publication: A. Smith et al., ane_32_1926_2005_.pdf, anl-ndm-160_2005.pdf

Recommendation for SF3: **SCT**: (73-TA-181(N,SCT)73-TA-181,PAR,DA), with E-LVL = 0.00 and 0.062 MeV up to EN = 1.0 MeV; plus E-LVL = 0.136 and probably 0.158 MeV up to 1.5 MeV; then E-LVL-MAX = 0.338 MeV above 4.5 MeV.

Justification: The author, A. Smith, has clearly described the meaning of the 'elastic' scattering measured by himself and also has professionally commented this issue in general: "All of these 'elastic' distributions certainly include contributions due to the inelastic excitation of the 6.2 keV level. It is not technologically feasible to experimentally resolve these two scattered components. In some cases considerably more inelastic contamination is included in the measured 'elastic' distributions due to excitation of higher-lying levels and lesser experimental resolution. The scattered neutron resolutions are reasonably known for the present measurements. All of those results up to incident energies of approximately 1.0 MeV include only elastic and first-inelastic components. For incident energies of ≈ 1.0 – 1.5 MeV some of the present measurements were estimated to include the elastic component plus inelastic contributions from the excitation of ≈ 6, ≈ 136 and ≈ 158 keV levels. Above incident energies of ≈ 4.5 MeV the present 'elastic' results include inelastic contributions due to the excitation of all levels up to and including the 338 keV state. The measurements reported in the literature certainly have similar inelastic-scattering contamination but it is difficult to assay, particularly in the older measurements with less resolution. Where these literature results were used in the model determinations the inelastic contributions were subjectively estimated as best as possible."

Presently the subentry 13965.002 declares SCT as a transition to the two levels 0.0 and 6.2 keV that is true but only up to EN = 1 MeV. Above this energy the corrections are required as recommended.

Entries: 13966.002 (74-W-182(N,EL)74-W-182,,DA), 13966.003 (74-W-184(N,EL)74-W-184,,DA)

Ex of 1st level (MeV): 0.1001 (W-182), 0.1112 (W-184)

Author and Publication: J. Annand et al., np_a_442_234_1985_.pdf

Recommendation for SF3: EL, but adding (e.g., in CRITIQUE) the authors' warning "At forward angles elastic scattering dominates and it was not possible to reliably extract 2+ cross sections forward of 20° for the 6 MeV experiment and beyond 30° for the 4.87 MeV experiment".

Justification: The authors have reached rather good "resulting energy resolutions for elastically scattered neutrons were 65 keV and 75 keV, respectively, the limiting factor being the energy spread in the source reaction". This has allowed them to observe many low excitation energy states in ^{182,184}W and separated them from elastic scattering: "The upper spectrum shows 0+, 2+, 4+, 6+, 2'+ groups scattered from ^{182}W for incident energy 6.00 MeV and 72.5 ° scattering angle. It is noticeable that the 2+ peak is much stronger at this angle than the elastic peak. At forward angles elastic scattering dominates and it was not possible to reliably extract 2+ cross sections forward of 20° for the 6 MeV experiment and beyond 30° for the 4.87 MeV experiment. … Cross sections were calculated from the areas under the appropriate time-of-flight peaks, which were determined using non-linear least squares fitting techniques. The skewed line shape shown in fig. 1, with something

of a low-velocity tail, was optimized to fit well-determined single peaks. Fig. 1 shows the individual lines as well as the sum of the lines used to fit the experimental spectra”.
Thus it would be reasonable to recommend to leave SF3 = EL, with addition of the authors’ warning “At forward angles elastic scattering dominates and it was not possible to reliably extract 2+ cross sections forward of 20° for the 6 MeV experiment and beyond 30° for the 4.87 MeV experiment.”

Entries: 14002.003 (79-AU-197(N,EL)79-AU-197,,DA,,REL)

Ex of 1st level (MeV): 0.0774 (Au-197)

Author and Publication: M. O’Connor, 94gatlin_1_260_1994.pdf

Recommendation for SF3: **EL**

Justification: This Gatlinburg conference paper reports the first results and has few information about the energy resolution of spectrometer, except “The FWHM of the zero degree neutron time-of-flight peak indicated that the targets had a thickness 20 – 30 keV”. Obviously, it was sufficient to separate the inelastically scattered neutrons leading to the excitation of the 77-keV and higher states in ^{197}Au, which are also presented in this paper and are compiled in sub-entry .002.

This group of authors has also measured the similar cross sections but at other incident energies, see “Neutron scattering measurements in ^{197}Au from 850 keV to 2.0 MeV”, https://www.osti.gov/biblio/255511 – this document has to be found and considered for compilation. – NDS has found the thesis of O’Connor “Fast neutron scattering cross sections of ^{197}Au” appeared in 1996

Entries: 14033.002 (79-AU-197(N,EL)79-AU-197,,DA)

Ex of 1st level (MeV): 0.0774 (Au-197)

Author and Publication: A. Smith, nse_155_74_2007_.pdf, anl-ndm-161_2005.pdf

Recommendation for SF3: **SCT**: (79-AU-197(N,SCT)79-AU-197,PAR,DA), with E-LVL = 0.000, 0.077, 0.269 and 0.279 MeV

Justification: “The present experimental results consist of 12 elastic scattering distributions approximately equally spaced in incident energy between ≈ 4.5 and 10.0 MeV. The scattered-neutron experimental resolutions were ≈ 0.3 MeV so these elastic distributions certainly included inelastic contributions due to the excitation of the 77 keV (1/2+), 269-keV (3/2+), and 279-keV (5/2+) states in ^{197}Au”.
It is obvious that SF3 should be SCT, i.e. it has to include the partial (n,n’) cross sections for excitation of 3 levels in ^{179}Au: 77, 269 and 279-keV.

Entries: 14329.046 (41-NB-93(N,EL)41-NB-93,,DA), 14329.089 (92-U-235(N,EL)92-U-235,,DA), 14329.114 (92-U-238(N,EL)92-U-238,,DA), 14329.138 (94-PU-239(N,EL)94-PU-239,,DA)

Ex of 1st level (MeV): 0.0308 (Nb-93), 0.0001 (U-235), 0.0449 (U-238), 0.0079 (Pu-239)

Author and Publication: J. Kammerdiener, ucrl-51263_1972.pdf

Recommendation for SF3: **SCT**: (41-NB-93(N,SCT) 41-NB-93,PAR,DA), (92-U-235(N,SCT)92-U-235,PAR,DA), (92-U-238(N,SCT)92-U-238,PAR,DA), (94-PU-239(N,SCT)94-PU-239,PAR,DA) with *E-LVL-MAX ≈ 0.800 MeV*

Justification: The author’s PhD has no numerical information on the total TOF spectrometer resolution, except reporting some components: “Time resolution was less than 1.5 nanoseconds FWHM (full-width half-maximum) at 831 centimeters flight path”. Using this information, the calculated energy resolution will be only 22 keV. This estimate is substantially less than what we can derive from following statement of author: "The 2+ levels of Fe and Ni were clearly resolved but 3- levels expected at similar excitation energies in ^{239}Pu, ^{238}U, ^{235}U were not seen". The excitation energies of the first 2+ levels are 848 keV in ^{56}Fe and (1173 – 1454) keV in ^{58,60,62,64}Ni, the first 3- level in ^{238}U - 732 keV. From this we may suppose that the total energy resolution for the 14 MeV neutrons was approximately 800 keV.

Entries: 20019.081 (25-MN-55(N,EL)25-MN-55,,SIG), 20019.082 (25-MN-55(N,EL)25-MN-55,,DA), 20019.090 (25-MN-55(N,EL)25-MN-55,,DA,,LEG)

Ex of 1st level (MeV): 0.1259 (Mn-55)

Author and Publication: B. Holmqvist et al., ae-366_1969.pdf, af_38_403_1968_.pdf

Recommendation for SF3: **EL**

Justification: The authors have reported that the spectrometer time resolution was 3 ns, scatterer-detector distance 300 cm and detector length 5 cm. Additionally, Report AE-375 (1969) says "the total energy spread for the T(p,n) and D(d,n) reactions was ± 50 keV and ± 90 keV, respectively. Included in these figures are the energy spreads caused by the loss of energy in the gas, charged particle straggling in the nickel foil, and energy spread of the target neutrons, taking into account the finite solid angle subtended by the target-scatterer system." (the latter 50 and 90 keV are compiled in sub-entries as EN-RSL-HW). Using these values we compute the energy resolution ΔE(FWHM) = 110 keV at 2.47 MeV and 200 keV at 8.05 MeV.

Fortunately the specific details about separation procedure are presented in several publications of this group.

(1) Paper af_38_403_1968_.pdf:

"6.1. The methods of analysis of the data.

The experimental results collected in the time-of-flight measurements were converted to punched tape for processing on a computer, i.e. for normalization, background subtraction, and plotting of the spectra. The area of a peak representing a certain neutron group in a time-of-flight spectrum was determined by calculating an area limited and defined by the tangents of the high and low energy slopes and the time axis. This method of analysis is of course, straight-forward when the peaks of a spectrum are well separated from each other. However, in a number of cases elastic and inelastic scattering peaks were overlapping because of insufficient energy resolution.

The analysis of a spectrum consisting of one inelastic peak partly overlapping the elastic one can be performed if the line shapes of the peaks are known. The use of this method usually becomes more difficult as the energy separation decreases. However, assuming that the inelastic excitation function as well as inelastic angular distributions have been measured at neutron energies where the elastic and inelastic peaks are separated, the contribution of the inelastic effect at higher energies can be estimated by extrapolation making the assumption that the inelastic cross section varies smoothly with the energy. For the cases studied here, for which this method of analysis must be applied the assumptions made above are relevant.

When there is more than one inelastic peak partly overlapping the elastic peak, the technique of using known line shape is difficult and impracticable. A measure of the elastic scattering contribution has been obtained from the high energy part of the elastic peak defined as the area above an energy defined by the position of the maximum of the elastic peak in the time-of-flight spectrum on the assumption that the high energy tails of the inelastic peaks do not give contributions by overlapping. However, this method may be difficult to use when the inelastic cross sections are much larger than the elastic one, since the contribution from the high energy tails of the inelastic peaks may then be considerable. But this has not been the case in any of the analyses performed here.

6.2. The analyses of the data

The analyses of S, Ca and Ni have-been simple and straightforward since the elastic and inelastic peaks have been well resolved in the time-of-flight spectra at all energies. Thus the elastic contributions have been obtained for these elements by calculating the total areas of the corresponding peaks. For Al, Cr, Fe, Co and Zn good energy separation has been obtained up to 4.6 MeV neutron energy. Above 4.6 MeV energy the elastic scattering effects have been obtained for these elements, as well as for C and Bi, by calculating the areas of the high energy part of the elastic peaks. However, for Al, Cr, Fe and Cu at 7 and 8 MeV neutron energies the high energy tails of the first inelastic peaks may interfere somewhat with the high energy part of the elastic peaks. (These inelastic peaks correspond to the excited states at 0.84 MeV for Al^{27}, 056 MeV for Cr^{53} (9.5 per cent abundance), 0.67 MeV and 0.77 MeV for Cu^{63} (69 per cent abundance) and Cu^{65}, and 0.85 MeV for Fe^{56} (92 per cent abundance) [53]). But the contributions from the neutron groups leading to the lowest excited states of Al^{27}, Cr^{53}, Cu^{63} and Cu^{65} have been observed to be small and are estimated to be negligible from the extrapolation of the excitation functions of the inelastic scattering. On the other hand for Fe^{56} the intensity of the neutron group of the lowest state is of about the same magnitude as that of the elastic one at some angles. At an illustration a time-of-flight spectrum observed for Fe at 8.05 MeV and at scattering angle of 110º is shown in Fig. 7. The analysis by means of known line shape is shown in the figure. For comparison the shadowed area represents the high energy part of the elastic peak which was used as a measure of the scattering effect. It is seen that the high energy tail of the inelastic peak contributes somewhat to that part of the elastic peak and must be corrected for.

The analysis of Mn is somewhat complicated because of the very low-lying excited state of 0.126 MeV [53]. Time-of-flight spectra of Mn at the neutron energies 2.47, 3.49 and 4.56 MeV and 90º scattering angle are plotted in Fig. 8, showing the analyses by means of a known line shape. By extending this analysis to several angles the inelastic angular distribution of the 0.126 MeV state has been found to be isotropic within the experimental errors at each energy between 2.47 and 4.56 MeV. The corresponding excitation function is included in Fig. 8, showing that the inelastic cross section decreases smoothly with increasing neutron energy. The differential elastic cross sections have been determined up to 4.56 MeV from the shadow peak areas properly corrected for the contributions of the high energy tails of the inelastic peaks. Above 4.56 MeV neutron energy, when the inelastic contributions could not be graphically corrected for, the inelastic scattering effects were taken into account simply by subtraction of the inelastic cross sections obtained by extrapolation of the excitation function. Since the inelastic cross section is small and decreasing (only about l0 mb/sr at 4.56 MeV), the error introduced by this procedure is negligible."

(2) Report AE-375, 1969 and paper Nucl. Phys. A146(970)321 (for ^{51}V): "The time resolution was not sufficient to enable individual levels in the residual nucleus to be resolved at all neutron energies. However, neutron groups leading to the excitation of the 0.320, 0.930, 1.609, 1.813, 2.409, 2.545, 2.675, 2.699 and 2.790 MeV levels in ^{51}V have been observed in the time-of-flight spectra (Figs. 5 and 6). … At 3.00 MeV neutron energy and above the inelastic scattering peak corresponding to the 0.320 MeV state interferes with the elastic one. The interference effect was avoided by taking only the high energy part of the elastic peak (shaded in Fig. 6) as a measure of the elastic scattering effect. At neutron energies above 4.56 MeV the inelastic scattering peaks corresponding to the 0.320 MeV state and even the 0.930 MeV state would interfere with the high energy part of the elastic peak, but the contributions are negligible because of the small inelastic cross sections".

(3) Conference paper 70Helsinki 2(1972)349 (for ^{93}Nb and ^{209}Bi): "The resolution of the time-of-flight spectrometer is demonstrated in Fig. 1, showing two typical spectra of scattering from Nb recorded at 2.50 MeV primary neutrons and Bi at 3.78 MeV". In Fig. 1 it is seen that 29 keV level in ^{93}Nb (inelastic scattering) is not resolved from g.s. (elastic).

Summary.

From the information given specifically for ^{55}Mn it follows that at incident neutron energy EN ≤ 4.56 MeV the inelastic scattering to the first level was separated by the graphical analysis of overlapping neutron lines in the TOF spectra. At higher energies the found (n,n_1) cross sections were extrapolated and subtracted too. Thus, SF3 could be left EL.

Extreme case of the lowest first level Ex = 6.2 keV for ^{181}Ta. It is likely the corresponding sub-Entries with the ^{181}Ta data 20019.199 (73-TA-0(N,EL)73-TA-0,,DA), 20019.198 (73-TA-0(N,EL)73-TA-0,,DA,,SIG) and 20019.206 (73-TA-0(N,EL)73-TA-0,,DA,,LEG) have to be corrected as: SF3 = SCT with *E-LVL-MAX = 0.300 MeV below 3 MeV and = 0.900 MeV above 4.56*, since there are no relevant information for this nucleus in publications.

Remark to the EXFOR pdf collection: it has not B. Holmqvist, "A systematic study of fast neutron elastic scattering in the energy region 1.5 to 8.1 MeV", Arkiv Fysik 38 (l969) 403 – later was provided by NDS

Entries: 20036.002 (92-U-235(N,EL)92-U-235,,DA), 20036.012 (94-PU-239(N,EL)94-PU-239,,DA)

Ex of 1st level (MeV): 0.0001 (U-235), 0.0449 (Pu-239)

Author and Publication: R. Batchelor et al., awre-o-55_69_1969.pdf

Recommendation for SF3: **SCT:** (92-U-235(N,SCT)92-U-235,PAR,DA),
(94-PU-239(N,SCT)94-PU-239,PAR,DA),
with *E-LVL-MAX ≈ 0.55 MeV at EN = 2.0 and 3.00 MeV; E-LVL-MAX ≈ 1.25 MeV at EN = 4.00 MeV*.

Justification: The authors have described the procedure of the elastic cross section extraction from the measured secondary neutron emission spectra: "The first step in the analysis of the secondary neutron spectra is to estimate the differential cross sections for those neutrons in the peaks. This was done by interpolating each continuous non-elastic spectrum underneath the elastic 'peak' and subtracting to give counts in the peak. If the interpolation is a true representation of the non-elastic spectrum (this would not be the case if the excitation of low-lying levels is enhanced by direct interactions), the subtracted counts represent only true elastic counts. The continuous non-elastic time spectra resulting from the subtraction of the elastic peaks are then converted to the energy spectra in histogram form, each energy band corresponding roughly to a resolution width (in fact, about 0.8 of a resolution width for energies above 1 MeV)".

From this we conclude that the interpolation underneath the elastic peak and subtraction of the inelastic excitation of low-lying levels made by authors may be not a physically correct procedure (since, as we know now, there are indeed enhancement by direct interactions etc.). The maximum excitation energy of such levels E-LVL-MAX we found from the difference of incident neutron energy EN and lower energy boundary of that band which the elastic neutrons belong to (see Table 3 or 20036.009 for ^{235}U and Table 4 or 20036.019 for ^{239}Pu): E-LVL-MAX = 2.000 - 1.429 = 0.57 MeV at EN = 2.0 MeV, E-LVL-MAX = 3.000 – 2.460 = 0.53 MeV at EN = 3.00 MeV and E-LVL-MAX = 4.000 – 2.744 = 1.25 MeV at EN = 4.00 MeV.

Further correction recommended for this Entry: replace E-EXC-MAX and E-EXC-MIN by the secondary emission neutron energies E-MAX and E-MIN in the sub-entries with energy spectra (DE).

Entries: 20162.005 (33-AS-75(N,EL)33-AS-75,,SIG), 20162.006 (33-AS-75(N,EL)33-AS-75,,DA), 20162.007 (33-AS-75(N,EL)33-AS-75,,DA,,LEG), 20162.008 41-NB-93(N,EL)41-NB-93,,SIG), 20162.009 (41-NB-93(N,EL)41-NB-93,,DA), 20162.010 (41-NB-93(N,EL)41-NB-93,,DA,,LEG), 20162.023 (79-AU-197(N,EL)79-AU-197,,SIG), 20162.024 (79-AU-197(N,EL)79-AU-197,,DA),
20162.025 (79-AU-197(N,EL)79-AU-197,,DA,LEG)

Ex of 1st level (MeV): 0.1986 (As-75), 0.0308 (Nb-93), 0.0774 (Au-197)

Author and Publication: B. Holmqvist et al., ae-430_1971.pdf, jne_27_543_1973_.pdf,
np_a_146_321_1970_.pdf; M. Salama ae-452_1972.pdf,

Recommendation for SF3: **EL**

Justification: In this Entry as well as in 20019 (see above), the authors have gave the same information about the experimental procedure (the author' reports or papers refer back to same primary publications). Due to this the justification and recommendations are generally similar to those given for the abovementioned Entry 20019.

Report ae-452_1972.pdf additionally informs: "The method used for the determination of the area under the elastic peak of the time-of-flight spectrum, is described elsewhere [19 = *AF 38(1968)403*]. From the sample spectra shown in fig. 9 it can be seen that the inelastic scattering contributions from the different nuclear levels are well resolved in the cases of Cr, Fe and Ni. However, in the cases of As, Nb, Mo, Cd, Sb, Hf, Au, Radiogenic lead and Pb at the 8.05 MeV measurements, the analyses were somewhat more complicated since the nearby inelastic peaks were partly overlapping the elastic peaks because of insufficient energy resolution. In the case of good energy resolution, the area under a peak was defined by the tangents of the high and low energy slopes and the time axis. This method was used in the analysis of Cr, Fe and Ni. However, in case of one or more inelastic peaks partly overlapping the elastic one, the application of the line shape technique is difficult and impracticable. In that case the high energy part of the elastic peak can be used (shaded in fig. 10) as a measure of the elastic scattering effect. This method was used in the analyses of As, Nb, Mo, Cd, Sb, Hf, Au, Radiogenic lead and Pb, However, the high energy tail of the inelastic peak may interfere somewhat with the high energy part of the elastic peak but this contribution has been observed to be small and negligible because of the small inelastic cross sections". Fig 10 shows the "Time-of-flight spectrum observed for Au at 8.05 MeV and at a scattering angle of 90^o. The curves drawn represent the analysis by means of known line shapes. The shadowed area is the part of the elastic peak used to determine the differential cross section when corrected for the contribution due to the high energy tail of the inelastic peak" – it is seen that authors have separated the contribution of inelastic excitation of 0.077 MeV level of ^{197}Au to the elastic.

Following the detailed information given in Report ae-452_1972.pdf, we may could state that inelastic scattering was separated (was not directly resolved but was analytically subtracted applying the described procedures) from elastic one for nuclei As, Nb, Mo, Cd, Sb, Hf, Au, Radiogenic lead and Pb even at highest incident energy 8.05 MeV, i.e. SF3 = **EL**.

Remark to the EXFOR pdf collection: it doesn't have M. Salama et al. Reports AE-452 (1972) and M. Etemad AE-485 (1974) – later was provided by NDS.

Entries: 20195.022 (92-U-238(N,EL)92-U-238,,DA)

Ex of 1st level (MeV): 0.0449 (U-238)

Author and Publication: G. Deconninck et al., jpr_22_652_1961_.pdf

Recommendation for SF3: **SCT:** (92-U-238(N,SCT)92-U-238,PAR,DA) with *E-LVL-MAX ≈ 0.57 MeV*

Justification: The measurements have been carried out by the transmission technique. The 28.4 MeV neutrons were produced by the (d,n) reaction in the tritium gas target. "L'énergie des deutérons au moment de la réaction est d'environ 11 MeV et les neutrons émis à 0° par rapport au faisceau ont une énergie de 28,4 MeV. L'étalement en énergie des neutrons issus de la réaction est dû principalement à l'étalement du faisceau à la sortie du cyclotron (environ 150 kV) et au straggling dans la cible. On peut estimer cet étalement à' environ 2% ce qui est négligeable pour des mesures de σ_{tot}". - From this we conclude that the energy spread of neutrons (FWHM) was around 28.4 MeV * 2% = 0.57 MeV.

The main purpose of this work was to measure the total cross sections by transmission in a good geometry: "A cause de la bonne géométrie, on peut en effet supposer que tous les neutrons sont diffusés à 0°". However the correction for contribution of the elastic scattered neutrons at 0^o degree was needed and authors have estimated it by supplemented measurements at 5^o: "Les valeurs de $d\sigma_{el}/d\omega(0°)$ sont inconnues à cette énergie. Afin de pouvoir estimer la correction, nous avons mesuré cette valeur pour un angle de 5°. L'appareillage utilisé est celui de la référence [4]. La mesure a été effectuée pour 3 corps de poids atomiques différents: ^{12}C, ^{118}Sn et ^{238}U, pour les autres corps on a procédé à une interpolation." - These results are given in the author paper's Table and are compiled in 20195.022, .020 (C) and .021 (Sn).

The authors have used NE102 scintillator detector of neutrons with suppression of γ-rays. They rather shortly described the determination of detector threshold and the minimal energy up to which the inelastically scattered neutrons were counted: "La figure 3 montre l'excellente linéarité du détecteur entre 14 et 28 MeV et permet de déterminer le seuil de détection dans nos expériences. Les points expérimentaux correspondent à l'endroit de mihauteur du spectre. … Les mesures ont été effectuées à l'aide d'un analyseur 400 canaux type RIDL. L'intérêt de cette méthode est de détecter à chaque mesure le plateau de neutrons et d'éviter ainsi la détection de γ ou neutrons de break up. De plus, elle permet d'éviter les erreurs dues à un glissement de l'électronique ainsi qu'à l'effet d'empilement des impulsions, effet qui varie suivant le taux de comptage, ainsi que suivant le pouvoir d'absorption de l'échantillon pour les γ. On réduit toutes ces erreurs en ne comptant que les impulsions situées, dans la partie horizontale du plateau éliminant ainsi la queue du spectre." – From this it is difficult to derive the exact value of threshold or minimum energy used (it could be a half of EN or 14 MeV ?), hence we omit this component of E-LVL-MAX (could be 28.4 – 14 MeV = 14 MeV ?).

Finally, we estimate the maximum excitation energy of such levels E-LVL-MAX from the value of FWHM of EN, i.e. as 0.57 MeV.

Further correction recommended for this Entry: the similar correction should be certainly done for 20195.021: **SCT:** (50-SN-0(N,SCT)50-SN-0,PAR,DA) with *E-LVL-MAX ≈ 0.57 MeV*.

Entries: 20337.008 (59-PR-141(N,EL)59-PR-141,,DA), 20337.009 (59-PR-141(N,EL)59-PR-141,,DA,,LEG)

Ex of 1st level (MeV): 0.1454 (Pr-141)

Author and Publication: S. Tanaka et al., np_a_179_513_1972_.pdf

Recommendation for SF3: **EL**

Justification: The authors have rather clearly described the relevant issues: "The energy spreads of the neutrons incident on the samples were about 40 keV in the energy region above 2 MeV and 60 keV below this energy. … Unresolved peaks in the time spectra were separated by a peeling-off method." They also clearly stated that among all studied nuclei the elastic scattering includes (n,n_1) only for Er: "In fig. 4 open circles indicate that the inelastic cross sections for the first levels in erbium isotopes are combined with the elastic data, since the first levels are too close-lying to the ground levels to be resolved". Additional confirmation: the $^{141}Pr(n,n1)$ cross sections are compiled in separated sub-Entries.

Entries: 20346.002 (33-AS-75(N,EL)33-AS-75,,SIG), 20346.003 (33-AS-75(N,EL)33-AS-75,,DA), 20346.004 (33-AS-75(N,EL)33-AS-75,,DA,,LEG), 20346.005 41-NB-93(N,EL)41-NB-93,,SIG), 20346.006 (41-NB-93(N,EL)41-NB-93,,DA), 20346.007 (41-NB-93(N,EL)41-NB-93,,DA,,LEG), 20346.017 (79-AU-197(N,EL)79-AU-197,,SIG), 20346.018 (79-AU-197(N,EL)79-AU-197,,DA), 20346.019 (79-AU-197(N,EL)79-AU-197,,DA,LEG)

Ex of 1st level (MeV): 0.1986 (As-75), 0.0308 (Nb-93), 0.0774 (Au-197)

Author and Publication: M. Etemad et al., ae-482_1973.pdf , ae-430_1971.pdf, ae-366_1969.pdf, ae-385_1971.pdf, jne_27_543_1973_.pdf, np_a_146_321_1970_.pdf

Recommendation for SF3: **EL**

Justification: In report **ae-482_1973.pdf**, the authors have described the separation of the elastic neutrons as following: "The time-of-flight ermined by calculating an area under the peak limited by the tangents of the high and low energy slopes and the time axis. This method of analysis is straightforward when the peaks of a spectrum are well separated. However, in a number of cases the time resolution was not sufficient for the complete separation of elastically scattered neutrons from those scattered inelastically to low-lying excited states. In these cases, the time-of-flight spectra were unfolded using known spectrometer line shapes. This technique is described more fully in a previous report [5 = Etemad AE-481] dealing with neutron inelastic scattering measurements".

The cited report **ae-482_1973.pdf** writes:

"The time-of-flight spectra were then plotted by hand. The area of a peak representing a certain neutron group in a spectrum was determined by calculating an area under the peak limited by the tangents of the high and low energy slopes and the time axis.

This method of analysis is straightforward when the peaks of a spectrum are well separated. However, in a number of cases the inelastic scattering peaks overlapped because of insufficient energy resolution. In these cases the analyses of the spectra were performed by subtracting the contributions of the neighbouring peaks assuming that the line shapes of the peaks were known. The known line shapes were taken from the time-of-flight spectra of the other elements measured under exactly the same experimental conditions. The line shape is dependent upon the energy of the scattered neutrons and the mass of the target nucleus. Therefore, those line shapes were used which represented the same neutron energy as the overlapping peaks and they were taken from the time-of-flight spectra of elements having mass numbers close to those of interest. Care was taken in the choice of these line shapes, i.e. only those lines were chosen which represented single neutron groups and which were well separated from other peaks. The time resolution in the present measurements was not sufficient to enable all the individual levels in the residual nucleus to be resolved at all primary neutron energies. In such cases cross sections were determined for groups of levels.

3.2 The analysis of the data.

The data analyses for the elements Al, V, Mn, Fe and Bi were comparatively simple. In these cases, the different peaks representing different neutron groups in the time-of-flight spectra were either separated from each other or were only slightly influenced by the high or low energy tails of neighbouring peaks. Thus, the contributions of neutron inelastic scattering corresponding to different states of these elements were analysed on the basis of known line shapes when the excitation energies were below 2 MeV. On the other hand, above 2 MeV excitation energy some of the levels could not be resolved with that technique and the cross sections were determined for groups of levels. The method of analysis used for the elements mentioned above is illustrated in Fig. 4 which shows time-of-flight spectra for Al at the neutron energies 2.5, 2.77 and 3.01 MeV.

More complicated spectra were obtained for the other elements. In the case of natural Ti, for instance, the inelastic contributions corresponding to energy levels of the individual isotopes of Ti could not be separated due to the complex level schemes of its isotopes (^{46,47,48,49,50}Ti). Therefore, the inelastic cross sections were determined for groups of transitions belonging to the natural element. Furthermore, the data analysis for Ti could not be continued for primary neutron energies higher than 3.25 MeV because of the complexity of the neutron time-of-flight spectra. Rather complex spectra were also obtained for the elements Ni and Nb at higher neutron energies. Therefore, the data analyses of these elements were limited to neutron incident energies below 3.25 and 3.5 MeV, respectively. The time-of-flight spectrum obtained for Nb at 2.5 MeV neutron primary energy is given in Fig. 5 and shows the complexity of the spectrum.

Samples of natural lead (Pb) and radiogenic lead (Pb_r) were used to measure the cross sections of the lead isotopes. Radiogenic lead was chosen because of its large content of Pb (88.2 %) which enables a measurement of the cross sections for levels of that nucleus. These data were also used to analyse time-of-flight spectra observed for natural lead. However, for this element the inelastic cross sections were only determined for neutron transitions to excited states having excitation energies below about 1.6 MeV. Above this energy rather complicated spectra were obtained because of the complex level diagrams of lead isotopes."

Relying on the methodology described in these reports and in all another documents of Holmqvist' group (see Entries 20019, 20162) we suppose that the undertaken efforts had to results in effective separation of inelastic neutron scattering from elastic, i.e. SF3 = **EL**

Remark to the EXFOR pdf collection: it has not [5] M.A. Etemad, "Neutron Inelastic Scattering Cross Sections in the Energy Range 2 to 4.5 MeV. Measurements and Calculations", Report AE-481 (1973) – was afterwards provided by NDS.

Entries: 20761.006 (53-I-127(N,EL)53-I-127,,DA)

Ex of 1st level (MeV): 0.0576

Author and Publication: R. Galloway et al., np_a_318_173_1979_.pdf

Recommendation for SF3: **SCT:** (53-I-127(N,SCT)53-I-127,PAR,DA) with E-LVL-MAX = 0.745 MeV

Justification: The authors have clearly stated that "… the Fe, Cu and Pb values have been corrected for inelastic scattering while no such correction could be applied to the I and Hg values in view of the lack of appropriate data (table 2)." Specifically for Iodine they wrote: "5.3. THE NUCLEUS I … since the data could not be corrected for any inelastic contribution, the inelastic differential cross sections were also calculated using the program CINDY for the nine states which can contribute neutrons above the 1.9 MeV discrimination level applied to the neutron detectors. The nine inelastic differential cross sections were scaled by appropriate relative detection efficiencies for the neutron energies concerned and combined with the elastic calculations for comparison with the experimental data".
From this it is obvious that inelastic excitation of the "9 states from 0.057 → 0.745" in ^{127}I were not subtracted from elastic scattering.

Similarly the SF3 has to be changed to SCT for Hg in sub-Entry 20761.008: (80-HG-0(N,SCT)80-HG-0,,DA) with E-LVL-MAX = 0.610 MeV. It is justified by: "5.4. THE NUCLEUS Hg … Since the data could not be corrected for any inelastic contribution, it is compared with calculation in the same way as for the case of I above, taking the calculated inelastic contribution into account. The complication is the need to make calculations for the six principal isotopes" and "6 states from 0.160 → 0.610".

About the Polarisation data compiled in this Entry. The authors have carried out the proper investigations: "The possible influence of the inelastic component on the polarization value can be assessed if it is assumed that the inelastically scattered neutrons are unpolarized. … These factors applied to the polarization values in table 1 make no significant change in the angular dependence of polarization. Indeed, the angular dependence of polarization deduced directly from the experimental asymmetry data is little changed by any of the corrections applied". Relaying on this the SF3 = **EL** coding could be considered as a valid for the POL/DA sub-Entries.

Entries: 20801.004 (90-TH-232(N,EL)90-TH-232,,DA), 20801.005 (90-TH-232(N,EL)90-TH-232,,DA,,LEG)
20801.016 (92-U-238(N,EL)92-U-238,,DA), 20801.017 (92-U-238(N,EL)92-U-238,,DA,,LEG)

Ex of 1st level (MeV): 0.0494 (Th-232), 0.0449 (U-238)

Author and Publication: G. Haouat, indc-fr-0029L.pdf

Recommendation for SF3: EL

Justification: The authors have minimized the overall energy resolution (28 keV) to distinguish experimentally the elastic and inelastic scattered neutrons for even-even nuclei: "Angular distributions were obtained for elastic scattering by ^{208}Pb, ^{232}Th and ^{238}U and for inelastic scattering to the first 2^+ and 4^+ states of Th and U. It is the first time that the inelastic scattering to the first 2^+ and 4^+ states of Th and U is experimentally resolved from the elastic scattering at 3.4 MeV."

Entries: 20806.005 (67-HO-165(N,EL)67-HO-165,,DA)

Ex of 1st level (MeV): 0.0947

Author and Publication: V. Giordano et al., np_a_302_83_1978_.pdf, nim_135_483_1976_.pdf

Recommendation for SF3: **SCT:** (67-HO-165(N,SCT)67-HO-165,PAR,DA) with *E-LVL-MAX* ≥ *0.120 MeV*

Justification: Both author' papers have no information about the energy resolution or energy threshold of the TOF spectrometer, nor one word about the possible contribution of inelastic scattering or attempt to separate it. The authors have obviously neglected the impact of inelastic scattering at small angles ±2.1° to ±9.1°, where they measured the scattering cross sections and polarization.

From "the width of the proton beam pulses within 1.5 ns at half-maximum", the given incident energy resolution "(ΔE ≈ ± 0.05 MeV)", flight path and detector thickness one may estimate the lowest limit for energy resolution as ≈ 120 keV. On other side, from the sentence: "the second group of neutrons from the ^{7}Li(p,n)^{7}Be* reaction to the first excited state at 430 keV in ^{7}Be appears well separated" one may estimate the highest limit for the energy resolution as surely less than 430 keV.

Thus, the overall energy resolution is possible to estimate only as limits: 120 keV < FWHM << 430 keV. Hence it is very likely that excitation of the first level 94.7 keV is included in elastic, whether it is also true for the higher states 209.8 keV, 344.9 keV, … - is questionable.

Entries: 20839.003 (90-TH-232(N,EL)90-TH-232,,DA), 20839.006 (92-U-238(N,EL)92-U-238,,DA)

Ex of 1st level (MeV): 0.0494 (Th-232), 0.0449 (U-238)

Author and Publication: G. Haouat, indcfr013L.pdf

Recommendation for SF3: EL

Justification: Similar to their measurements at 3.4 MeV (Entry 20801), the authors have separated elastic and inelastic scattering also in this experiment at 2.5 MeV: "The overall neutron energy resolution was about 30 keV and, therefore, neutrons scattered by the ground state and the first 2^{+} and 4^{+} excited states of ^{232}Th and ^{238}U were experimentally resolved".

Entries: 21019.003 (90-TH-232(N,EL)90-TH-232,,DA), 21019.005 (92-U-238(N,EL)92-U-238,,DA),
21019.006 (90-TH-232(N,EL)90-TH-232,,SIG), 21019.011 (92-U-238(N,EL)92-U-238,,SIG)

Ex of 1st level (MeV): 0.0494 (Th-232), 0.0449 (U-238)

Author and Publication: R. Batchelor et al., np_65_236_1965_.pdf

Recommendation for SF3: **SCT:** (90-TH-232(N,SCT)90-TH-232,PAR,DA), (92-U-238(N,SCT)92-U-238,PAR,DA), (90-TH-232(N,SCT)90-TH-232,PAR,SIG), (92-U-238(N,SCT)92-U-238,PAR,SIG) with E-LVL-MAX = 0.57, 0.75, 1.5 and 2.6 MeV at 2, 3, 4 and 7 MeV incident neutron energy, respectively

Justification: "The time resolution is not sufficient to enable individual levels in the residual nucleus to be resolved. At 2 MeV incident energy, for example, the 2^{+}, 4^{+} and 6^{+} levels of the ground state rotational band are not resolved from elastic scattering. The two inelastic groups are due to the excitation of groups of levels around 0.6 to 0.8 MeV excitation and 1.0 to 1.2 MeV excitation, respectively. ... Figs. 5 and 6 and tables 1 and 2 give the corrected data for the differential elastic cross-sections. <u>In the case of the 2 MeV data these cross-sections include the excitation of the first four members of the ground state rotational band (i.e. levels up to 570 keV excitation)</u>. At higher incident energies the elastic counts were taken to be those counts in the 'elastic' peak above the smooth curve extrapolation of the non-elastic spectrum. Therefore, if this extrapolation is a true representation of the non-elastic spectrum, the data in figs. 5 and 6 will represent true elastic data. Since the region of low excitation (less than approximately 2 MeV) is not a continuum region and direct interactions can enhance the excitation of low-lying levels at high incident energies, the extrapolation is not truly representative of the non-elastic spectrum and this leads to an error if the data for 3 MeV and above in figs. 5 and 6 are regarded as true elastic data. We have empirically assigned this error as equal to the counts under the extrapolated portion of the non-elastic curve. The low-energy limits of the extrapolations correspond approximately to excitations of 0.75, 1.5 and 2.6 MeV at 3, 4 and 7 MeV incident neutron energy, respectively".

From this information one may conclude that the cross sections reported in the paper as elastic for both ^{232}Th and ^{238}U do include the inelastic scattering up to excitation energies of 0.57, 0.75, 1.5 and 2.6 MeV at 2, 3, 4 and 7 MeV incident neutron energy, respectively.

Further correction/improvement recommended for this Entry: the partial DA for ^{238}U(n,n') plotted in "Fig. 12. Differential cross-sections for excitation of levels between 0.57 and 0.87 MeV and between 0.87 and 1.38 MeV excitation in U-238 at 2 MeV incident neutron energy" should be compiled.

Entries: 21086.002 (92-U-235(N,EL)92-U-235,,DA,,4PI)

Ex of 1st level (MeV): 0.0001 (U-235)

Author and Publication: B. Armitage et al., 66paris_1_383_1967.pdf

Recommendation for SF3: **EL** but maybe with addition in form of CRITUQUE "*The Pb-shape peak subtraction of inelastically scattered neutrons probably not valid for the first level of ^{235}U with excitation energy 0.08 keV which is substantially lower than the spectrometer resolution 25 keV.*"

Justification: The authors have described and applied the procedure of subtracting of inelastically scattered neutrons: "Due to the existence of low-lying levels, the 'elastic' peak contains components due to inelastic scattering. To separate these, the spectrum of neutrons scattered from a natural lead sample was measured. This shape was normalized to the high energy edge of the observed 'elastic' peak and the area of the normalized 'lead shape' was used in determining the true U^{235} elastic scattering cross-section".

From this information one may conclude that the cross sections reported in the paper are basically elastic since the procedure of normalization and subtraction of the Pb elastic peak shape was at least applied. However, the suspicion about the validity of this procedure may arise for the case when the excitation energy is much less than overall resolution. Thus, in this experiment: the first two levels of ^{235}U are 0.08 and 13.03 keV, whereas "at 550 keV, which is experimentally favourable, a run was made with resolution of 25 keV. ... For another energies the resolution was in general worse than this ...".

The final recommendation would be to leave this sub-Entry as EL. but adding as CRITUQUE "The Pb-shape peak subtraction of inelastically scattered neutrons probably not valid for the first level of ^{235}U with excitation energy 0.08 keV which is substantially lower than energy resolution 25 keV".

Further critique for this sub-Entry 21086.002. Actually there: DATA "STATUS FROM FIGURE 3" and DATA Units = b. However Fig. 3 of 66paris_1_383_1967.pdf presents the "Differential cross section for elastic scattering of neutrons from ^{235}U. Scattering angle 90°" (likely the unit = barn on Y-axis is a typo and should be b/sr). The data in Fig. 3 do agree with the ENDF/B-VIII.0 data: at incident energy E = 1.04 MeV and Θ = 89.754° dσ/dΩ = 0.181 b/sr. The data presently compiled in 21086.002: for example at 1.0 MeV dσ/dΩ = 1.95 b/4π = 0.155 b/sr is visibly lower than the point in Fig. 3: dσ/dΩ ≈ 0.2 (b/sr).

Probably "STATUS .FROM FIGURE 3." should be removed.

Further correction recommended for another sub-Entry 21086.003 (92-U-235(N,INL)92-U-235,PAR,DA,,4PI): replace E-MIN and E-MAX by the excitation energies E-EXC-MIN and E-EXC-MAX – see Table 1 of 66paris_1_383_1967.pdf.

Remark to the EXFOR pdf collection: 66paris_1_383_1967.pdf is not available (I have extracted it from 66PARIS_1_1967.pdf).

Entries: 21242.003 (73-TA-181(N,EL)73-TA-181,,DA)

Ex of 1st level (MeV): 0.0062

Author and Publication: A. Remund, hpa_29_545_1956.pdf

Recommendation for SF3: EL, but would be better to add CRITUQUE *"The differential elastic cross section should be used with great concern because of the large contribution of inelastic scattering and non-reliable subtraction procedure".*

Justification: The energy of the scattered neutrons was not measured (e.g., by TOF), but only the total neutron yield was counted by two Anthracene scintillation detectors with n-γ discrimination to suppress gammas. The energy threshold of detectors was not reported in the paper. Likely the threshold was rather low, since the author has recognized that the inelastic scattering makes very large contribution: "Der Anteil der inelastisch gestreuten Neutronen am Wirkungsquerschnitt ist für unsere Neutronenenergie so gross, dass σ_{inel} für einen quantitativen Vergleich der gemessenen Winkelverteilung mit der Theorie in Betracht gezogen werden muss." The author has recognized that σ_{inel} should be measured somehow and then it could be subtracted after dividing by 4π (assuming the inelastic angular isotropy): "Für die inelastische Streuung darf mit gutem Recht eine isotrope Winkelverteilung σ_{inel} angenommen werden. Die Korrektur entspricht dem winkelunabhängigen Betrag von $\sigma_{(inel+\gamma)} / 4\pi$, der vom gemessenen Wert σ_{total}(ß) zu subtrahieren ist". To find the value of $\sigma_{(inel+\gamma)}$ the author has used rather complicated procedure of the graphical integration of the measured angular distributions from 30° to 150° and comparison with transmission measurements: "Die experimentell aufgenommene Kurve der Winkelverteilung ergibt durch grafische Integration über alle Streuwinkel den totalen Wirkungsquerschnitt. Vergleiche mit den mittels Transmissionsexperimenten direkt gemessenen Werten von σ_{total} erlauben, den Anteil der inelastisch gestreuten Neutronen und der γ-Strahlung zu bestimmen ....". Little useful information on relevant issue is also available in the previous papers: hpa_27_313_1954.pdf, R. Ricamo, Helv. Phys. Acta 24 (1951) 419.

Regarding this information the SF3 could be left as EL but addition of CRITUQUE "The differential elastic cross section should be used with great concern because of the large contribution of inelastic scattering and non-reliable subtraction procedure" may have sense.

Entries: 21292.004 (59-PR-141(N,EL)59-PR-141,,DA), 21292.005 (59-PR-141(N,EL)59-PR-141,,DA)

Ex of 1st level (MeV): 0.1454 (Pr-141)

Author and Publication: R. Singh et al., zp_a_272_47_1975_.pdf

Recommendation for SF3: **EL**

Justification: The authors have rather clearly described the relevant issue: "At 1.7 and 1.9 MeV the elastic scattering cross sections include the contribution of the inelastic scattering from the first excited state at 145 keV. However, in the time-of-flight spectrum observed at 1.2 MeV with a flight path of 2.27 m, it was possible to separate the inelastic peak from the elastic one. In this way, the value of the differential inelastic scattering cross section for 145 keV state was determined to be 89 ± 18 mb/sr. Assuming the inelastic scattering angular distribution to be isotropic, the necessary correction was made to the elastic angular distribution at this energy".

From this explanation it follows that SF3 should be **EL** for sub-Entries 004 (EN = 1.7 MeV), 005 (1.9 MeV) and 003 (1.2 MeV).

Entries: 21337.004 (62-SM-152(N,EL)62-SM-152,,DA)

Ex of 1st level (MeV): 0.1218 (Sm-152)

Author and Publication: M. McEllistrem et al., pr_c_15_927_1977_.pdf

Recommendation for SF3: **EL**

Justification: The authors have rather clearly described the issue of separation: "For ^{152}Sm the first excited and ground state groups were too close to each other to be separated except by Gaussian fitting procedures. The peak widths and positions for both groups were determined by using parameters determined from an adjacent ^{150}Sm run, such as that of Fig. 2. In this way good fits were obtained for the composite ^{152}Sm peak, and reliable yields were extracted for both ground state and excited level groups."

From this explanation it follows that SF3 should be EL.

Entries: 21338.006 (60-ND-150(N,EL)60-ND-150,,DA), 21338.016 (60-ND-150(N,EL)60-ND-150,,SIG)

Ex of 1st level (MeV): 0.1302 (Nd-150)

Author and Publication: G. Haouat et al., pr_c_20_78_1979_.pdf

Recommendation for SF3: **EL**

Justification: The authors have rather clearly described the relevant issue: "For ^{150}Nd the 130 keV energy separation of these two states was about the energy resolution; yields for the two scattered neutron groups were separated by line fitting procedures."

From this explanation it follows that SF3 should be **EL** The same is true for all other Nd isotopes (or sub-Entries): "The total energy spread at the neutron detectors was about 120 keV. This was sufficient to resolve the first excited 2^+ state from the ground state easily for ^{142,144,146,148}Nd."

Entries: 21564.004 (33-AS-75(N,EL)33-AS-75,,SIG), 21564.005 (53-I-127(N,EL)53-I-127,,SIG),
21564.009 (33-AS-75(N,EL)33-AS-75,,DA,,LEG), 21564.010 (53-I-127(N,EL)53-I-127,,DA,,LEG)

Ex of 1st level (MeV): 0.1986 (As-75), 0.1259 (I-127)

Author and Publication: B. Ramstein et al., jpr_37_651_1976_.pdf

Recommendation for SF3: **SCT**: (33-AS-75(N,SCT)33-AS-75,PAR,SIG), (53-I-127(N,SCT)53-I-127,PAR,SIG), (33-AS-75(N,SCT)33-AS-75,PAR,,DA,,LEG), (53-I-127(N,SCT)53-I-127,PAR,DA,,LEG) with E-LVL-MAX = 0.3 MeV.

Justification: In the case of As and I, as authors wrote, the first levels excited up to 300 keV are too close to the ground state that the corresponding groups of neutrons to be separated by apparatus: "Dans le cas de As et I, les premiers niveaux excités, jusqu'à 300 keV, sont trop proches des fondamentaux pour que les groupes de neutrons correspondants soient séparés par notre appareillage".

Thus for ^{75}As and ^{127}I the SF3 should be **SCT** with E-LVL-MAX = 0.3 MeV. SF3 remains to be **EL** for another isotopes/sub-entries: ^{31}P (Ex = 1.266 MeV), ^{59}Co (Ex = 1.099 MeV) and ^{209}Bi (Ex = 0.896 MeV),

Entries: 21664.012 (53-I-127(N,EL)53-I-127,,DA)

Ex of 1st level (MeV): 0.1259 (I-127)

Author and Publication: A. Begum et al., np_a_332_349_1979_.pdf

Recommendation for SF3: **EL** with advise to add (only for DA subentries) CRITUQUE "The differential elastic cross section may include contribution of inelastic scattering to the excitation energy up to ≈ 6.0 MeV"

Justification: In this experiment the authors have set the neutron detection threshold at 10 MeV (that corresponds to Ex = 16.1 - 10.0 ≈ 6.0 MeV): "Pulse-shape discrimination against gamma-rays and an energy discrimination bias of 10 MeV to reduce the importance of inelastically scattered neutrons were applied to each detector". They have used the TOF technique but "Because of the short distance between scatterer and detectors it was not possible to distinguish between elastic and inelastic scattering in the time-of-flight spectra, so that correction was also necessary for the inelastic component in the experimental data. The importance of inelastic scattering was however reduced by the 10 MeV discrimination bias applied to the detectors." Still they have applied a proper correction by subtracting the inelastic cross sections known at that time: "Correction for flux attenuation in the scattering sample and for multiple scattering was by the Monte Carlo program and for inelastic scattering used the data [9, 18 – 21, 23] referred to above in connection with polarization evaluation".

Since correction for inelastic scattering contribution was applied, the SF3 could be left as **EL**. However it has sense to add to all DA subentries following CRITUQUE "The differential elastic cross section may include contribution of inelastic scattering to the excitation energy up to ≈ 6.0 MeV".

The impact of inelastic scattering on polarization data (compiled in the POL/DA subentries) was shown by authors does play negligible role: "If a polarization P(Θ) is deduced for a mixture of elastically scattered neutrons of polarization $P_e(\Theta)$ and inelastically scattered neutrons of asymmetry $P_i(\Theta)$, then ... For all of the nuclei of concern here except for C, it was reasonable to assume $P_i = 0$ since P_i was an average over many excited states and in most cases over several isotopes". This statement removes the necessity to have abovementioned CRITIQUE for the polarization data too.

Entries: 21722.038 (25-MN-55(N,EL)25-MN-55,,DA), 21722.045 (33-AS-75(N,EL)33-AS-75,,DA)

Ex of 1st level (MeV): 0.1259 (Mn-55), 0.1986 (As-75)

Author and Publication: I. Fujita, nst_9_301_1972_.pdf

Recommendation for SF3: **SCT**: (25-MN-55(N,SCT) 25-MN-55,PAR,DA), (33-AS-75(N,SCT)33-AS-75,PAR,DA) with *E-LVL-MAX ≈ 3.3 - 4.2 MeV*.

Justification: The authors have recognized that "The present values of elastic cross sections may contain some contributions from low-lying levels". Crucial however is that they did not attempt to correct for, that was probably a reason of disagreement with known measurements for several nuclei: "The present values for Cr, Fe, Ni and Zn shown in Table 6 are considerably larger than those of Stelson et al. and Anderson et al. However, the present values might be acceptable if account is taken of the contributions from 1.3 and 4.2 MeV states for Cr, 1.2 and 4.2 MeV states for Ni, and 0.92 and 3.3 MeV states for Zn and also the effect of the large angular resolution of the present experiment".

The drawback of this 14 MeV experiment is very short flight path 1 m. Calculation of energy resolution with "2.5 ns overall time resolution" brings FWHM ≈ 0.3 MeV, that is already higher than first excitation level in ^{55}Mn and ^{75}As.

Finally, one may expect a contribution of inelastic scattering (authors did not even attempt to correct) with excitations up to 3.3 – 4.2 MeV to all nuclei in this Entry (sub-entries with EL and DA) and hence have to declare SF3 = SCT for them. PS: COMMENT existing in Entry has already proper statement but of qualitative character: "The values given may include some contributions from low-lying excited levels".

Entries: 21725.003 (92-U-238(N,EL)92-U-238,,SIG), 21725.004 (92-U-238(N,EL)92-U-238,,DA)

Ex of 1st level (MeV): 0.0449

Author and Publication: J. Voignier et al., cea-r-3503_1968.pdf

Recommendation for SF3: **SCT:** (92-U-238(N,SCT)92-U-238,PAR,SIG),
(92-U-238(N,SCT)92-U-238,PAR,DA) with *E-LVL-MAX ≈ 2.0 MeV.*

Justification: The authors did not mention in their report that they have corrected elastic scattering for the possible admixture of inelastic neutrons. Rather they seem just integrated the counts with energies above 12 MeV: "Les bornes d'intégration expérimentales sont 1 MeV et 12 MeV d'une part, 25° et 150° d'autre part". Fig 20 shows the measured energy spectra of scattered neutrons (after integration over angles) and confirms that elastic peak is asymmetric, i.e. it has contribution from (n,n'), and its tail extends down to 12 MeV.
From this it is clear that EL data do include contribution from inelastic scattering up to excitation energy 14.1 - 12.0 ≈ 2 MeV

Remark to the EXFOR pdf collection: cea-r-3503_1968.pdf is not available (I have download it from Internet).

Entries: 21782.003 (90-TH-232(N,EL)90-TH-232,,DA), 21782.008 (90-TH-232(N,EL)90-TH-232,,SIG),
21782.012 (92-U-233(N,EL)92-U-233,,DA), 21782.016 (92-U-233(N,EL)92-U-233,,SIG),
21782.023 (92-U-238(N,EL)92-U-238,,DA), 21782.028 (92-U-238(N,EL)92-U-238,,SIG),
21782.040 (94-PU-242(N,EL)94-PU-242,,SIG), 21782.045 (94-PU-242(N,EL)94-PU-242,,DA),
21782.046 (94-PU-242(N,EL)94-PU-242,,DA), 21782.047 (94-PU-242(N,EL)94-PU-242,,DA), 21782.048 (94-PU-242(N,EL)94-PU-242,,DA)

Ex of 1st level (MeV): 0.0494 (Th-232), 0.0404 (U-233), 0.0449 (U-238), 0.0445 (Pu-242)

Author and Publication: G. Haouat et al., nse_81_491_1982_.pdf

Recommendation for SF3: **EL**.

Justification: The authors have succeeded in achieving of sufficient energy resolution: "The flight paths, which were between 6 and 10 m, the incident neutron energy spread due to lithium target thickness, and the other experimental parameters were fixed so as to achieve a neutron overall energy resolution, at the energies of the measurements of, respectively, ≈ 8 keV at 0.6 and 0.7 MeV, ≈ 15 keV at 1.0 MeV, ≈ 18 keV at 1.5 MeV, ≈ 23 keV at 2.0 MeV, ≈ 27 keV at 2.5 MeV, and ≈ 28 keV at 3.4 MeV". Due to this they have got following results. "**^{232}Th Results**. The spectrometer energy resolution was sufficient to allow an easy separation of the elastic and inelastic scattering neutron groups at all energies". "**^{233}U Results**. Measurements on ^{233}U were performed at 0.7- and 1.5-MeV incident neutron energies. The energy spacing of the low-lying levels of this odd-mass nucleus is of the same order of magnitude as that of the even-even actinides (see Fig. 1), so that cross sections were obtained separately at 700 keV for the elastic scattering ($5/2^+$) and the inelastic scattering to the $7/2^+$ (40-keV) excited state, and at 1.5 MeV for the ground state and the $7/2^+$ (40-keV) and $9/2^+$ (92-keV) excited states". "**^{238}U Results**. Differential cross sections for ^{238}U were measured at 0.7-, 1.5-, 2.5-, and 3.4-MeV incident neutron energies. Angular distributions were obtained for elastic and inelastic scattering to the first 2^+ (45-keV) and 4^+ (148-keV) states ...". "**^{242}Pu Results**. Measurements on ^{242}Pu were completed at the incident neutron energies of 0.6, 1.0, 1.5, 2.0, 2.5, and

3.4 MeV. Differential cross sections were obtained for the elastic and the inelastic scattering to the 2^+ (45-keV) and 4^+ (147-keV) excited states."

From these explanations it clearly follows that SF3 should be **EL** for considered nuclei and sub-entries.

The energy resolution was however not enough for ^{235}U: "**^{235}U Results**. For ^{235}U, data were taken at 0.7 and 3.4 MeV. Because at both energies the experimental resolution was larger than the energy spacing of some levels of this nucleus (see Fig. 1), cross sections were extracted for two bunches of levels: ($7/2^-$ at ground state, $1/2^+$ at 75 eV, and $3/2^+$ at 13 keV) and ($9/2^-$ at 46 keV and $5/2^+$ at 52 keV)"; and for ^{239}Pu: "**^{239}Pu Results**. Cross sections for ^{239}Pu were measured at 0.7- and 3.4-MeV incident neutron energies. Since the experimental resolution at 3.4 MeV was insufficient to resolve all the scattered neutron groups, angular distributions were obtained for three bunches of levels: ($1/2^+$ at ground state and $3/2^+$ at 8 keV), ($5/2^+$ at 57 keV and $7/2^+$ at 76 keV), and ($9/2^+$ at 163 keV and $11/2^+$ at 173 keV) ...". Corresponding sub-Entries correctly reflects these data as SCT or EL.

Entries: 21858.010 (92-U-238(N,EL)92-U-238,,DA)

Ex of 1st level (MeV): 0.0449

Author and Publication: G. Deconninck et al., ass_75_102_1961.pdf, ass_74_136_1960.pdf

Recommendation for SF3: **SCT:** (92-U-238(N,SCT)92-U-238,PAR,DA) with *E-LVL-MAX ≈ 2.5 MeV*.

Justification: The authors have written in their paper ass_74_136_1960.pdf that they have chosen a threshold corresponding to a neutron energy of 11.5 MeV to achieve the sensitivity to neutrons inelastically scattered by the excited levels of the studied element practically negligible: "Nous avons choisi un seuil correspondant à une énergie de neutrons de 11.5 Mev, la sensibilité aux neutrons diffuses inélastiquement par les niveaux excites de l'élément étudié est donc pratiquement négligeable". In the paper with results ass_75_102_1961.pdf, they have once again stressed that the experimental method itself could suffer from the detection of inelastically scattered neutrons, however they believe that inelastic scattering cross sections are generally of another order of magnitude than the elastic scattering cross sections: "La méthode expérimentale elle-même pourrait être incriminée à cause de la détection de neutrons diffuses inélastiquement, cependant les sections efficaces de diffusion inélastique sont généralement d'un autre ordre de grandeur que les sections efficaces de diffusion élastique".

From this it becomes clear that reported elastic angular distribution may contain partial contribution from (n,n') which leads to the excitation energy En – Threshold = 14.0 – 11.5 MeV ≈ 2.5 MeV. Thus, SF3 should be SCT.

Further correction recommended for Entry: SF3 = SCT with *E-LVL-MAX ≈ 2.5 MeV* instead of EL in all other subentries in this Entry, since the excitation energy of the first level in all these nuclei is lower than 2.5 MeV.

Entries: 22029.007 (92-U-238(N,EL)92-U-238,,DA)

Ex of 1st level (MeV): 0.0449

Author and Publication: J. Annand et al., jp_g_11_1341_1985_.pdf, nim_206_431_1983_.pdf

Recommendation for SF3: **SCT:** (92-U-238(N,SCT)92-U-238,PAR,DA) with *E-LVL-MAX ≤ 0.8 MeV*

Justification: The authors wrote in their paper jp_g_11_1341_1985_.pdf: "Proton recoil spectra were collected with pulse shape discrimination against gamma rays and pulse height discrimination to reduce detection efficiency for inelastically scattered neutrons. ... Where possible, inelastic scattering contributions were rendered negligible by application of a suitably high pulse height bias. For the strongly excited first 2^+ states of ^{238}U and the tungsten isotopes this was not possible and the corrected analysing power data contain inelastic contamination." The section with optical model analysis further confirms this: "For ^{238}U, calculations for 0^+, 2^+ and 4^+ states were combined". In the paper nim_206_431_1983_.pdf, which describe spectrometer, they have written: "Recoil spectrum integration was performed starting with a lower energy limit of 1.5 MeV and raising the limit in 0.1 MeV steps up to 2.9 MeV. Differential cross sections and analysing powers were calculated after each integration and as would be expected if inelastically scattered neutrons have also been counted, the calculated cross sections initially fell, and the analysing powers rose slightly as the lower limit was raised as illustrated in fig. 12. The lower limit where calculated values had ceased to change rapidly was chosen as the final value. This was in general around the 2.2 MeV mark. ... The analysing power and differential cross section for the elastic scattering of 3.0 MeV neutrons from ^{209}Bi are presented in figs. 13 and 14. ... This nucleus has a high first excited state at 0.875 MeV and so a lower integration limit 2.2 MeV on the proton recoil spectra will exclude inelastic events almost completely."

From this information it is possible to deduce that reported elastic angular distribution may contain partial contribution from (n,n') leading to the excitations up to En – Threshold = 3.0 – 2.2 MeV ≈ 0.8 MeV. This value may vary from nuclei to nuclei, but regrettably the authors did not specify them more exactly. Thus, SF3 should be SCT.

Further correction recommended for this Entry: SF3 should be SCT with *E-LVL-MAX ≤ 0.8 MeV* instead of EL for U-238 sub-entry .013 (POL/DA), for W-0 sub-entries .002 (DA) and .008 (POL/DA).

Entries: 22136.004 (41-NB-93(N,EL)41-NB-93,,DA), 22136.008 (73-TA-181(N,EL)73-TA-181,,DA), 22136.016 (41-NB-93(N,EL)41-NB-93,,DA), 22136.018 (41-NB-93(N,EL)41-NB-93,,SIG), 22136.020 (73-TA-181(N,EL)73-TA-181,,DA), 22136.023 (73-TA-181(N,EL)73-TA-181,,SIG)

Ex of 1st level (MeV): 0.0308 (Nb-93), 0.0062 (Ta-181)

Author and Publication: A. Takahashi et al., oktav-a-92-01_1992.pdf, indc-jpn-0118.pdf

Recommendation for SF3: **SCT**: (41-NB-93(N,SCT)41-NB-93,PAR,DA), (73-TA-181(N,SCT)73-TA-181,PAR,DA), (41-NB-93(N,SCT)41-NB-93,PAR,SIG), (73-TA-181(N,SCT)73-TA-181,PAR,SIG), with *E-LVL-MAX ≤ 0.5 MeV*

Justification: The report oktav-a-92-01_1992.pdf is simply a compilation of the measured data, whereas report indc-jpn-0118.pdf has more details about the Nb and Ta experiments: "Angle-differential cross sections (ADX) for resolved discrete excited states in the measured DDX data were deduced by calculating peak area within the energy bins that were specified with the energy resolution of the present experiment (± 0.2 MeV)". For **Nb** the "ADX data for 'resolved peaks' were reduced for the elastic, the '1.08 MeV state' and the sum-peak of '2.18 - 2.98 MeV states', and are shown in Figs. 6a and 6b. .... The presently reduced ADX data for the 1.08 and 2.18 - 2.98 MeV states may correspond to those of their 0.93 and 2.34 MeV states". **Ta**: "In the case of ^{181}Ta, however, the measured spectrum in the 6 - 13 MeV region is rather 'monotonous', although a 'bump' is seen at about 10 MeV. These facts tell us that so many discrete states are directly excited with comparable magnitudes in this energy region, for ^{181}Ta. The present experiment has not been able to resolve these many discrete states."

From this description it follows that the authors did not analyse deeply the quasi-elastic 14 MeV peak shape, rather they have got the elastic yield by summation of emission DDX over several 0.2 MeV wide energy bins around 14 MeV. For Nb the inelastic peak of the '1.08 MeV state' corresponding to excitation of 0.93 MeV state was separated (and compiled separately in sub-Entry 005). This means that energy resolution ΔE was about 1.08 MeV /2 ≈ 0.5 MeV and inelastic neutrons exciting the first level 0.0308 MeV were surely summed together with real elastic neutrons. To which quasi discrete neutron group do belong the 2nd (0.6868 MeV), 3rd (0.7440) ... levels is not clear. Thus *E-LVL-MAX ≤ 0.5 MeV.* There is even less information about Ta, except that neutrons below 13 MeV are assigned to inelastic, that points to maximum Ex could be 14.1 – 13.0 ≈ 1 MeV. Since the total energy resolution was reported to be 2 MeV * 0.2 = 0.4 MeV, our final rough estimate could be within interval *0.4 MeV < E-LVL-MAX < 0.5 MeV*.

Entries: 22155.082 (25-MN-55(N,EL)25-MN-55,,DA), 22155.099 (25-MN-55(N,EL)25-MN-55,,SIG)

Ex of 1st level (MeV): 0.1259 (Mn-55)

Author and Publication: A. Takahashi et al., oktav-a-92-01_1992.pdf,
J. of Nucl. Sci. Techn. 25(1986)215, indc-jpn-0131.pdf

Recommendation for SF3: **SCT**: (25-MN-55(N,SCT) 25-MN-55,PAR,DA),
(25-MN-55(N,SCT)25-MN-55,PAR,SIG) with *LVL-NUMB = 0, 1.*

Justification: Additionally to the information given in our analysis for the previous Takahashi' Entry 22136, the report indc-jpn-0131.pdf confirms that "Incident neutron energy is 14.1 ± 0.2 MeV ..." and informs additionally about Mn: "Results for Mn are shown in Fig. 16 through Fig. 31 compared with JENDL-3T. Three peaks of the discrete inelastic scatterings (0.984, 2.822, and 4.41 MeV levels) and the elastic scattering peak could be resolved".

From this we may once again conclude that Ex ≈ 0.984 MeV / 2 ≈ 0.5 MeV or at least the first level Ex = 0.1259 MeV was summed with elastic scattering (the (n,n'$_2$) cross sections for the second level 0.984 MeV are reported and compiled separately in sub-Entry 0.083, 0.100).

Entries: 22278.010 (33-AS-75(N,EL)33-AS-75,,DA)

Ex of 1st level (MeV): 0.1986 (As-75)

Author and Publication: M. Gotoh and A. Takahashi, jaeri-m-92-027_301_1992.pdf

Recommendation for SF3: **SCT**: (33-AS-75(N,SCT)33-AS-75,PAR,DA), with *E-LVL-MAX ≤ 0.5 MeV*

Justification: Report jaeri-m-92-027_301_1992.pdf says about **Germanium**: "Some peaks can be seen; the largest one corresponds to elastic peak, and the others to discrete inelastic proceses. In fugure 1, it will be hard to distinguish a peak (Q = - 0.9 MeV) from elastic peak. However at the background angle, peak appears to be distinguished we do not show on this paper". Then the authors add about **Arsenic**: "Atomic number of arsenic is 33, compared with 32 of germanium. The spectra resemble much each other on the viewpoints of shape, magnitude and Q-values of discrete inelastic scattering. Almost the same things with the germanium data can be said as for arsenic".
From this and information given in previous analysis of Takashi' experiments in Entries 22136 and 22155, we recommend for Arsenic: SF3 = SCT with *E-LVL-MAX ≤ 0.5 MeV* (with this resolution value probably the first six excited levels are summed with elastic).

Further correction recommended for Entry: similar correction is recommended for Germanium (DA data in sub-Entry .008).

Entries: 22513.002 (74-W-182(N,EL)74-W-182,,DA), 22513.004 (74-W-183(N,EL)74-W-183,,DA),
22513.006 (74-W-184(N,EL)74-W-184,,DA), 22513.008 (74-W-186(N,EL)74-W-186,,DA)

Ex of 1st level (MeV): 0.1001 (W-182), 0.0465 (W-183), 0.1226 (W-184), 0.1112 (W-186)

Author and Publication: J. Delaroche et al., pr_c_23_136_1981_.pdf

Recommendation for SF3: **EL**

Justification: The authors have achieved sufficient resolution for their spectrometer: “The flight path from the sample to each detector was 8 m for the even-A W measurements and 10 m for the ^{183}W measurements, and the total energy resolution of the spectrometer was $\leq$ 50 and $\leq$ 28 keV, respectively. A time-of-flight spectrum for the ^{186}W sample is shown in Fig. 2 to illustrate the experimental resolution and the good separation of the scattered neutron peaks”. This has allowed them to separate elastic scattering from inelastic excitation of the first excited levels: “The elastic scattering cross sections, measured at E_n = 3.40 MeV neutron incident energy, for the even-A isotopes ^{182,184,186}W are plotted in Fig. 3 ... That these nuclei have very similar scattering properties is also reflected in the inelastic scattering cross sections to the first excited 2^+ state (Fig. 4) and 4+ state (Fig. 5). ... For the odd nucleus ^{183}W the data for elastic scattering ($1/2^-$) and inelastic scattering to the first $3/2^-$, and $5/2^-$ excited states are presented in Fig. 6.”

Entries: 22726.002 (64-GD-155(N,EL)64-GD-155,,DA), 22726.003 (64-GD-156(N,EL)64-GD-156,,DA),
22726.004 (64-GD-157(N,EL)64-GD-157,,DA), 22726.005 (64-GD-158(N,EL)64-GD-158,,DA),
22726.006 (64-GD-160(N,EL)64-GD-160,,DA)

Ex of 1st level (MeV): 0.0600 (Gd-155), 0.0890 (Cd-156), 0.545 (Cd-157), 0.0795 (Cd-158), 0.0753 (Cd-160)

Author and Publication: E. Bauge et al., pr_c_61_034306_2000_.pdf

Recommendation for SF3: **EL**

Justification: The authors have achieved sufficient resolution for their spectrometer: “The flight path from scattering sample to detector was 10 m long for all measurements. ... This flight-path length, the incident neutron energy spread due to target thickness, the beam pulse width and the other experimental parameters were fixed so as to achieve a neutron overall energy resolution of 40 and 27 keV at 4.10 and 2.5 MeV incident neutron energies, respectively”. This has allowed them to separate elastic scattering from inelastic excitation of the first excited levels: “Net yields were obtained for isolated peaks in the spectra both by direct summation of counts above a line fitted to the residual background in the neighbourhood of the peaks, and also by fitting Gaussian shapes to the peaks. The two methods yielded results consistent to within 3% for strong, well isolated peaks. For peaks too close to each other, as were the elastic ($3/2^-$) and first inelastic ($5/2^-$) peaks of ^{155}Gd (60 keV) and ^{157}Gd (54 keV) in the TOF spectra, especially at 4.10 MeV, yields were obtained by Gaussian-shape fitting procedures only. The peak widths and positions were determined by using parameters deduced from adjacent ^{156}Gd and ^{158}Gd runs. In this way, good fits were obtained for the composite ^{155}Gd and ^{157}Gd peaks, and reliable yields were extracted for both ground-state and excited level groups.”

Entries: 30463.041 (25-MN-55(N,EL)25-MN-55,,DA), 30463.042 (25-MN-55(N,EL)25-MN-55,,SIG), 30463.043 (25-MN-55(N,EL)25-MN-55,,DA,,LEG)

Ex of 1st level (MeV): 0.1259 (Mn-55)

Author and Publication: T. Schweitzer et al., zfk-262_33_1973.pdf

Recommendation for SF3: **SCT:** (25-MN-55(N,SCT)25-MN-55,PAR,SIG), (25-MN-55(N,SCT)25-MN-55,PAR,SIG), (25-MN-55(N,SCT)25-MN-55,PAR,DA,,LEG) *with LVL-NUMB = 0, 1*

Justification: It has to be noted that authors tried to separate the overlapping peaks, see zfk-324_39_1976.pdf: “The main problem in data preparation is to reduce strong overlapping neutrons peak. The overlap is naturally caused by the final energetical resolution of the experimental system.

...3. Partition in groups of experimental reference peaks which contain special structure of the equipment. .... We have used analytical functions of the nonsymmetrical Gaussian type, which give a sufficient representation of the time-of-flight peaks."

However, among several publications referred in this Entry, only zfk-262_33_1973.pdf has presented the ^{55}Mn data and only in the graphical form: Abb. 1 "Flugzeitspektren der elastischen und unelastischen Streuung an ^{23}Na and ^{55}Mn unter 55° bei E_n = 3.44 MeV; eingezeichnete Zahlenwerte: J^{π} und Anregungsenergie". It is seen that neutrons exciting 0.116 MeV ($7/2^-$) level overlaps even at middle angles with neutrons populating the g.s. ($5/2^-$). The next level 0.983 MeV ($9/2^-$), as seen, is well separated (corresponding DA are compiled in sub-Entry .044).

From this we conclude that first excited was not resolved, i.e.: SF3 = SCT with *LVL-NUMB = 0, 1*.

Entries: 30711.002 (41-NB-93(N,EL)41-NB-93,,SIG), 30711.003 (41-NB-93(N,EL)41-NB-93,,DA)

Ex of 1st level (MeV): 0.0308 (Nb-93)

Author and Publication: Li Jingde et al., cnp_7_106_1985.pdf

Recommendation for SF3: **SCT**: (41-NB-93(N,SCT)41-NB-93,PAR,SIG),
(41-NB-93(N,SCT)41-NB-93,PAR,DA), with *E-LVL-MAX ≥ 0.1 MeV*

Justification: Since the paper cnp_7_106_1985.pdf is short and written in Chinese, it is impossible to get necessary information about this experiment. Still, the lowest limit for the TOF spectrometer energy resolution ΔE can be estimated from the time resolution Δt = 1 ns, flight path L = 2.30 m and its uncertainties ΔL (square root sum of sample diameter 3 cm and detector thickness 5 cm). These values, which were taken from Entry 30711 and paper cnp_7_106_1985.pdf, eventually result to ΔE ≈ 0.090 MeV. Obviously, it is the lowest limit since the incident energy spread ΔE_0 is not given by authors, etc.

Even with ΔE ≈ 0.090 MeV, the inelastic excitation of the first level of ^{93}Nb will be not resolved from elastic neutrons. Therefore SF3 = SCT with *E-LVL-MAX ≥ 0.1 MeV.*

Entries: 30716.002 (92-U-238(N,EL)92-U-238,,DA), 30716.003 (92-U-238(N,EL)92-U-238,,DA)

Ex of 1st level (MeV): 0.0449

Author and Publication: Shen Guanran et al., cnp_6_193_1984.pdf

Recommendation for SF3: **SCT**: (92-U-238(N,SCT)92-U-238,PAR,DA),
(92-U-238(N,SCT)92-U-238,PAR,SIG), with E-LVL-MAX ≈ 1.0 MeV

Justification: The paper cnp_6_193_1984.pdf is written in Chinese and rather short to get necessary information about this experiment. However, Fig. 9, which compare obtained differential elastic cross sections with other measurements, contains remark "Q = - 1.0 MeV". Additionally the Entry 30716 informs: "ANALYSIS Due to limitation of energy resolution the elastic scattering angular distribution measured includes the contribution from low level (below 1 MeV) inelastic scattering."
.

From this we conclude that SF3 = SCT with E-LVL-MAX ≈ 1.0 MeV.

Further correction recommended for Entry: there should be mm instead of cm in "DETECTOR (SCIN) Liquid,105*50 cm,ST-451 type. China made."

Entries: 30762.011 (92-U-238(N,EL)92-U-238,,DA), 30762.019 (92-U-238(N,EL)92-U-238,,SIG,,,DERIV)

Ex of 1st level (MeV): 0.0449

Author and Publication: Ma Gonggui, Li Jingde et al., cnp_11_1_19_1989.pdf, INDC(CPR)-011 p. 135, cnp_8_245_1986.pdf

Recommendation for SF3: **SCT**: (92-U-238(N,SCT)92-U-238,PAR,DA), (92-U-238(N,SCT)92-U-238,PAR,SIG), with *E-LVL-MAX ≥ 0.1 MeV*

Justification: The paper cnp_11_1_19_1989.pdf (and report INDC(CPR)-011 p. 135) report: "The neutron energy threshold of the spectrometer was 3 MeV and its time resolution corresponding to source neutrons was 0.94 ns. ... The peak of elastic scattering neutrons was corrected in accordance with the shape of the primary neutron spectrum, with contribution of the inelastic scattering neutrons subtracted". cnp_8_245_1986.pdf and report INDC(CPR)-011 p. 135 are single documents, which present data on ^{238}U(n,el), in form of plot and table. However, they do not provide any quantitative information about the potential impact of inelastic scattering. We can only estimate the lowest limit for the TOF spectrometer energy resolution ΔE from the time resolution Δt = 0.94 ns, flight path L = 2.20 m, its uncertainties ΔL (square root sum of sample diameter 2.5 cm and detector thickness 5 cm): ΔE ≈ 0.070 MeV.
Even with ΔE ≈ 0.070 MeV, the inelastic excitation of the first level of ^{238}U will be not resolved from elastic neutrons. Therefore SF3 = SCT with rounded *E-LVL-MAX ≥ 0.1 MeV.*

Entries: 31263.002 (57-LA-139(N,EL)57-LA-139,,DA,,LEG/RS), 31263.006 (57-LA-139(N,EL)57-LA-139,,SIG), 31263.007 (59-PR-141(N,EL)59-PR-141,,DA,LEG/RS), 31263.011 (59-PR-141(N,EL)59-PR-141,,SIG), 31263.012 (57-LA-139(N,EL)57-LA-139,,DA),
31263.013 (59-PR-141(N,EL)59-PR-141,,DA)

Ex of 1st level (MeV): 0.1659 (La-139), 0.1454 (Pr-141)

Author and Publication: J. Malan et al., np_a_124_111_1969_.pdf

Recommendation for SF3: **EL**

Justification: The authors have declared that sufficiently good energy resolution of spectrometer is a goal of this experiment: "Previous data on the energy levels of ^{139}La are scanty, while most of the work on ^{141}Pr suffers from poor resolution. In addition, there has been considerable uncertainty about the existence of levels between 500 and 1100 keV in either nuclei. The present work was initiated in order to clarify and extend the available knowledge on their level schemes. Inelastic neutron scattering was employed using techniques designed to achieve adequate energy resolution of neighbouring levels". Nevertheless, at the highest incident energies the issue of resolving has arisen but was solved: "The angular distributions measured at 232 keV, 749 keV and 1105 keV are shown in fig. 6. Short flight paths (1.1 - 1.4 m) were used, therefore scattering from the first excited states could not be resolved from the elastic peak in the measurements at 874, 1105 and 1571 keV. At these energies, the cross sections for scattering to the first excited states were measured at 90° using longer flight paths, and corrections made to the combined measurements with the justified assumption of isotropy for inelastic scattering (see subsect. 4.2). The additional uncertainty introduced in this way was duly taken into account. ... 4.2. INELASTIC SCATTERING. From the present work on the level schemes, it seemed that the 166, 1228, 1264 and 1388 keV levels in ^{139}La, and the 145, 1131 and 1302 keV levels in ^{141}Pr would be amenable to a Hauser-Feshbach analysis. Therefore, excitation functions at 90° and angular distributions for scattering from these levels were measured".
The numerous details given in the paper (in particular "Fig. 1. Spectra of scattered neutrons observed at a long flight path in order to measure the cross sections for scattering to the first excited states of ^{139}La and ^{141}Pr at an incident neutron energy of 1.700 MeV" and scattering angle 90°) and (n,n_1) data compiled in sub-Entries .014, .016 (^{139}La) and .015, .017 (^{141}Pr) serve as a confirmation.

Entries: 32001.026 (41-NB-93(N,EL)41-NB-93,,SIG), 32001.027 (41-NB-93(N,EL)41-NB-93,,DA), 32001.028 (41-NB-93(N,EL)41-NB-93,,DA,,LEG)

Ex of 1st level (MeV): 0.0308 (Nb93)

Author and Publication: M. Adel-Fawzy, D. Schmidt et al., zfk-385_17_1979.pdf, nse_96_159_1987_.pdf, indc-ccp-0221.pdf, np_a_440_35_1985_.pdf, indc-gdr-0018.pdf, np_a_440_35_1985_.pdf

Recommendation for SF3: SCT: (41-NB-93(N,SCT)41-NB-93,PAR,SIG), (41-NB-93(N,SCT)41-NB-93,PAR,DA), (41-NB-93(N,SCT)41-NB-93,PAR,DA,,LEG) with *E-LVL-MAX* ≈ *0.25 MeV*

Justification: The single paper with the ^{93}Nb measured data, zfk-385_17_1979.pdf, reports too few information: "Die Peakflächenbestimmung für die Peaks der elastisch gestreuten Neutronen in den Flugzeitspektren erfolgte mit Hilfe des Programms ASYVAR". Report indc-gdr-0018.pdf explains the procedure ASYVAR used by this laboratory for unfolding of the overlapping elastic and inelastic peaks. There in "Fig. 12 Angle-integrated energy spectra of the ^{93}Nb(n,n') reaction ..." at 7.0 and 7.23 MeV it is seen that all studied unfolding methods do not separate the peaks within first several hundreds keV of the excitation energy. From the DA/DE data compiled in sub-Entries .029, .032 and .035 we see that ^{93}Nb(n,n') spectra are given above the excitation energy (which equals to incident neutron energy minus outgoing neutron energy) or above 0.25 MeV.
From the publications with ^{6,7}Li data, indc-ccp-0221.pdf and nse_96_159_1987_.pdf, we may get an estimate for the TOF spectrometer resolution $\Delta E \geq 0.478$ MeV: "The insufficient energy resolution of the spectrometer prevented us from separating the group of elastically scattered neutrons from the group of inelastically scattered neutrons corresponding to the Li level excitation at 0.478 MeV".

Finally, relying on resolution for the ^{93}Nb(n,n') experimental data rather than on ^{6,7}Li(n,n$_1$) we would recommend to use SF3 = **SCT** with *E-LVL-MAX* ≈ *0.25 MeV*.

Entries: 32517.002 (92-U-238(N,EL)92-U-238,,DA)

Ex of 1st level (MeV): 0.0449

Author and Publication: Wan Dairong et al., cnp_6_193_1984.pdf

Recommendation for SF3: **SCT**: (92-U-238(N,SCT)92-U-238,PAR,DA) with *E-LVL-MAX* ≥ *0.1 MeV*

Justification: The paper cnp_6_193_1984.pdf is written in Chinese. It is impossible to derive even minimal relevant information (flight path L = ?, Δt = 0.85 ns ?, ΔE_0 = ?) needed for estimation of at least the low limit for energy resolution ΔE .... The report INDC(CPR)-011, May 1988, p. 131 (in English) does not specify the flight path too.
Due to this, it is proposed to use for *E-LVL-MAX* ≥ *0.1 MeV* which was recommended for the same reaction measured in the same laboratory (Sichuan Univ., Chengdu) at similar facility and compiled in 30762.011.

Further correction recommended for Entry: add to REFERENCE (R,INDC(CPR)-011,131,198803)

Entries: 32521.003 (41-NB-93(N,EL)41-NB-93,,DA)

Ex of 1st level (MeV): 0.0308 (Nb-93)

Author and Publication: Cao Jianhua, Wan Dairong et al., INDC(CPR)-011, p. 125, 1988

Recommendation for SF3: **SCT**: (41-NB-93(N,SCT)41-NB-93,PAR,DA) with *E-LVL-MAX* ≥ *0.1 MeV*

Justification: The short report INDC(CPR)-011, p. 125, 1988 does not provide information even about flight path L = ?, Δt = ?, ΔE_0 = ? needed for estimation of at least the lowest limit for energy resolution ΔE ...
Due to this, it is proposed to use for *E-LVL-MAX* ≥ *0.1 MeV* which was also recommended for the similar measurements in the same laboratory (Sichuan Univ., Chengdu) at similar facility and compiled in 30762.011.

Further correction recommended for Entry: For ^{93}Nb and ^{nat}Mo the incident neutron energy EN should be 14.2 MeV instead of 14.7 MeV.

Entries: 32523.003 (41-NB-93(N,EL)41-NB-93,,DA)

Ex of 1st level (MeV): 0.0308 (Nb-93)

Author and Publication: Wan Dairong, private communication

Recommendation for SF3: **SCT**: (41-NB-93(N,SCT)41-NB-93,PAR,DA) with *E-LVL-MAX* ≥ *0.1 MeV*

Justification: There are neither publication nor sufficient information in the Entry itself about this experiment.
Due to this, it is proposed to use for *E-LVL-MAX* ≥ *0.1 MeV* which was recommended for the similar measurements in the same laboratory (Sichuan Univ., Chengdu) at similar facility and compiled in 30762.011.

Entries: 32603.002 (92-U-238(N,EL)92-U-238,,DA)

Ex of 1st level (MeV): 0.0449

Author and Publication: Qi Huiquan et al., cnp_13_343_1991.pdf, 91beijin_13_1991.pdf

Recommendation for SF3: **SCT**: (92-U-238(N,SCT)92-U-238,PAR,DA) with *E-LVL-MAX* ≥ *0.1 MeV*

Justification: The paper cnp_13_343_1991.pdf reports that flight path L = 2.494 m, Δt = 2 ns and the U sample thickness and position sensitive scintillator diameter, but does not report the incident energy resolution ΔE_0. Employing these known values we estimate the lowest energy limit for the TOF spectrometer resolution as around 0.1 MeV at 12 – 14 MeV neutron energies.
Since there is no more relevant information, it is proposed to use for *E-LVL-MAX* ≥ *0.1 MeV*.

Entries: 32605.002 (92-U-238(N,EL)92-U-238,,DA)

Ex of 1st level (MeV): 0.0449

Author and Publication: Qi Huiquan et al., cnp_13_343_1991.pdf, 91beijin_13_1991.pdf, 88mito_799_1988.pdf, indc(cpr)-30_1_1993.pdf, nse_111_309_1992_.pdf, cnp_14_15_1992.pdf

Recommendation for SF3: **SCT**: (92-U-238(N,SCT)92-U-238,PAR,DA) with E-LVL-MAX ≈ 1 MeV

Justification: The paper 88mito_799_1988.pdf reports "The energy resolution of the measurement system was about 1 MeV. It could not separate the neutrons scattered elastically and the neutrons scattered inelastically from low-lying excited levels. So the results of present measurement include the contribution of such inelastic neutrons."

From this it follows that SF3 = SCT and E-LVL-MAX ≈ 1 MeV.

Entries: 32616.012.1 (92-U-238(N,EL)92-U-238,,DA), 32616.012.2 (92-U-238(N,EL)92-U-238,,DA)

Ex of 1st level (MeV): 0.0449

Author and Publication: Qi Bujia, Tang Hongqing et al., 91beijin_32_1991.pdf, 94gatlin_2_901_1994.pdf, 91juelic_436_1991_.pdf

Recommendation for SF3: **SCT**:
32616.012.1 (92-U-238(N,SCT)92-U-238,PAR,DA) with *E-LVL-MAX ≈ 0.74 MeV*
32616.012.2 (92-U-238(N,SCT)92-U-238,PAR,DA) with *E-LVL-MAX ≈ 0.23 MeV*

Justification: The conference papers 91beijin_32_1991.pdf and 94gatlin_2_901_1994.pdf report that "The energy resolution is about 2.4% for 10 MeV neutrons measured by the normal TOF spectrometer and about 12% for 4 MeV neutrons measured by the abnormal TOF spectrometer". From this we get the energy resolution for 9.6 MeV incident neutrons ΔE = 9.6 MeV * 0.024 = 0.230 MeV for the normal TOF spectrometer. For the abnormal TOF spectrometer ΔE = 4.0 MeV * 0.12 = 0.480 MeV at 4.0 MeV, then extrapolation to the higher energies results to ΔE = sqrt(9.6/4.0) * 0.480 MeV ≈ 0.74 MeV at 9.6 MeV. The higher energy resolution for the abnormal TOF spectrometer is qualitatively confirmed by Fig. 8 in 91beijin_32_1991.pdf: "Double differential neutron emission spectra of ^{238}U induced by 10 MeV neutrons at 45° ..." measured by both spectrometers (similar Fig. 3 - in 94gatlin_2_901_1994.pdf).
The recommendation would be SF3 = SCT with *E-LVL-MAX ≈ 0.74 MeV* for 32616.012.1 (abnormal spectrometer), *E-LVL-MAX ≈ 0.23 MeV* for 32616.012.2 (normal spectrometer).

Further recommendations or corrections for the EXFOR pdf collection or Entry: (1) The first two pages in the pdf file "94gatlin_2_901_1994.pdf" are the scan of other paper – these two pages were deleted by NDS; (2) It would be desirable to refer additionally to (C,91JULIC,,436,1991...) graphs only in REFERENCE.

Entries: 40066.013 (41-NB-93(N,EL)41-NB-93,,DA)

Ex of 1st level (MeV): 0.0308 (Nb-93)

Author and Publication: N. Biryukov et al., FEI-272 (1971)

Recommendation for SF3: **SCT**: (41-NB-93(N,SCT)41-NB-93,PAR,DA) with *E-LVL-MAX = 0.6 MeV*

Justification: The single referenced report FEI-272 is not available in the EXFOR pdf collection. However, the subentry has information about Incident projectile energy resolution (Half width) EN-RSL-HW = 0.3 MeV.
From this, it would be recommended for SF3 = SCT and for *E-LVL-MAX = 0.6 MeV.*

Remark for the EXFOR pdf collection: include their report FEI-272.

Entries: 40101.009 (41-NB-93(N,EL)41-NB-93,,DA)

Ex of 1st level (MeV): 0.0308 (Nb-93)

Author and Publication: V. Popov et al., 71kiev_1_223_1971.pdf

Recommendation for SF3: **SCT**: (41-NB-93(N,SCT)41-NB-93,PAR,DA) with *E-LVL-MAX = 0.280 MeV*

Justification: The conference paper 71kiev_1_223_1971.pdf informs that “Spectrometer resolution was 280 keV including target thickness.” Additional but indirect confirmation of the 280 keV resolution, could be the reported discrete inelastic cross sections in Table 2: the minimal excitation energy of resolved level is 440 keV in ^{24}Na.
From this, it would be recommended for SF3 = SCT and for *E-LVL-MAX = 0.280 MeV*.

Entries: 40179.022 (41-NB-93(N,EL)41-NB-93,,DA,,LEG) , 40179.023 (41-NB-93(N,EL)41-NB-93,,SIG)

Ex of 1st level (MeV): 0.0308 (Nb-93)

Author and Publication: I. Korzh et al., bas_35_757_1972.pdf, INDC(CCP)-15,56,1971, ufz_13_1781_1968.pdf

Recommendation for SF3: **SCT**: (41-NB-93(N,SCT)41-NB-93,PAR,DA,,LEG),
(41-NB-93(N,SCT)41-NB-93,PAR,SIG) with *E-LVL-MAX = 0.18 MeV*

Justification: The paper bas_35_757_1972.pdf informs that “The neutron energy spread of ± 90 keV was determined mainly by the target thickness”. Additionally, ufz_13_1781_1968.pdf informs that the detector threshold was set so high that “The inelastically scattered neutrons were practically totally cut off”. On other hand it is obvious that all scattered neutrons with energies close to incident energy En = (1.5 ± 0.09) MeV should be countered by such detectors.
From this, it would be recommended for SF3 = SCT and for *E-LVL-MAX = 2 * 0.09 MeV = 0.18 MeV*.

Entries: 40221.017 (41-NB-93(N,EL)41-NB-93,,DA), 40221.018 (41-NB-93(N,EL)41-NB-93,,SIG),
40221.029 (53-I-127(N,EL)53-I-127,,DA), 40221.030 (53-I-127(N,EL)53-I-127,,SIG)

Ex of 1st level (MeV): 0.0308 (Nb-93), 0.0576 (I-127)

Author and Publication: G. Gorlov et al., spd_9_806_1965.pdf

Recommendation for SF3: **SCT**: (41-NB-93(N,SCT)41-NB-93,PAR,DA,,LEG),
(41-NB-93(N,SCT)41-NB-93,PAR,SIG) with E-LVL-MAX = 1 MeV

Justification: The paper spd_9_806_1965.pdf reports that “Here we present briefly main results for neutrons of energy 4.00 ± 0.05 MeV”. Additionally, it informs: “The flux arising from inelastic scattering (energy loss not less than 1 MeV) was corrected for on the assumption that the differential cross section for inelastic scattering is isotropic over the range from 50 to 150°”. We understand the latter author’s sentence as the subtraction of inelastic scatting but only those part that leads to excitation of levels above 1 MeV. The reason for the much worse energy resolution for outgoing neutrons (≈ 1 MeV) than for incoming (≈ 0.05 MeV *2 = 0.1 MeV) is the spectrometer used: “The scattered neutrons were detected by six scintillation counters (stilbene crystals working onto FEU-33) ... . The neutron energies were deduced from the pulse spectra recorded by six-channel analyzers”. Probably only six-channels used for analysis of pulse height distribution ... has resulted to the relatively poor resolution ≈ 1 MeV / 4 MeV = 25% for scattered neutrons.
From this, it would be recommended for SF3 = SCT and for E-LVL-MAX = 1 MeV.

Further recommendations or corrections for the EXFOR pdf collection or Entry: (1) (J,DOK,158,(3),574,196409) is not available in pdf collection – later was provided by NDS; (2) spd_9_806_1965.pdf reports that “... neutrons of energy 4.00 ± 0.05 MeV, whereas in this Entry: EN-ERR = 0.5 MeV.

Entries: 40603.003 (73-TA-181(N,EL)73-TA-181,,DA)

Ex of 1st level (MeV): 0.0062 (Ta-181)

Author and Publication: S. Simakov et al., yk_49_17_1982.pdf, indc(ccp)-197_17_1982.pdf

Recommendation for SF3: **SCT**: (41-NB-93(N,SCT)41-NB-93,PAR,DA,,LEG),
(41-NB-93(N,SCT)41-NB-93,PAR,SIG) with E-LVL-MAX ≈ 1.1 MeV

Justification: The paper yk_49_17_1982.pdf reports that "Separation of the elastic and inelastic scattering was carried out in the TOF spectra, the line of elastically scattered neutrons have been derived from the spectrum of neutrons measured with bare neutron source". However this procedure has limits due to: (a) "at larger energies and forward angles the uncertainty of subtraction reaches (5 – 20)%"; (b) validity until the high-end secondary neutron energy limit. The corresponding maximal excitation energy E-LVL-MAX could be found as a difference between the incident energy and the highest secondary neutron energy which are given in the DA/DE sub-Entry .007: 5.19 MeV - 4.15 MeV = 1.04 MeV, 6.47 - 5.47 = 1.00 MeV, 7.49 - 6.38 = 1.11 MeV, 7.94 - 6.71 = 1.23 MeV. Regarding the proximity of this estimation, the averaged excitation value will be 1.1 MeV.
From this, it would be recommended for SF3 = SCT and for E-LVL-MAX ≈ 1.1 MeV.

Entries: 40623.003 (41-NB-93(N,EL)41-NB-93,,DA)

Ex of 1st level (MeV): 0.0308 (Nb-93)

Author and Publication: S. Simakov et al., snp_37_477_1983.pdf

Recommendation for SF3: **SCT**: (41-NB-93(N,SCT)41-NB-93,PAR,DA) with E-LVL-MAX ≈ 1.1 MeV

Justification: Similar as for Entry 40603.003, the corresponding maximal excitation energy E-LVL-MAX could be found as a difference between the incident energy and maximal secondary neutron energy which are given in the DA/DE sub-Entry .004: 5.23 MeV - 4.35 MeV = 0.88 MeV, 6.22 - 5.26 = 0.96 MeV, 7.23 - 6.02 = 1.21 MeV, 8.01 - 6.75 = 1.26 MeV. Regarding the proximity of this estimation, the averaged value will be 1.1 MeV.
From this, it would be recommended for SF3 = SCT and for E-LVL-MAX ≈ 1.1 MeV.

Entries: 40643.004 (92-U-238(N,EL)92-U-238,,DA)

Ex of 1st level (MeV): 0.0449

Author and Publication: B. Guzhovskiy et al., sja_11_1041_1962_.pdf

Recommendation for SF3: **SCT**: (92-U-238(N,SCT)92-U-238,PAR,DA) with *E-LVL-MAX ≈ 0.94 MeV*

Justification: The paper sja_11_1041_1962_.pdf reports: "Neutrons with an average energy of 15 ± 0.4 MeV were formed from bombardment of a thick zirconium-tritium target with deuterons that had been accelerated up to an energy of 290 keV in an electrostatic generator. ... This method, which is based on the use of an organic scintillator as a coarse neutron spectrometer, assured an energy resolution equal to approximately 500 keV; thus it permitted us to a considerable extent to exclude the effect produced by inelastically scattered neutrons and γ-rays". We estimate the total energy resolution from incident neutron spread and organic detector resolution ΔE = sqrt((2 * 0.4 MeV)**2 + (0.5 MeV)**2) = 0.94 MeV.
From this, it would be recommended for SF3 = SCT and for *E-LVL-MAX ≈ 0.94 MeV.*

Entries: 40706.002 (90-TH-232(N,EL)90-TH-232,,SIG), 40706.012 (41-NB-93(N,EL)41-NB-93,,SIG),
40706.016 (53-I-127(N,EL)53-I-127,,SIG), 40706.023 (25-MN-55(N,EL)25-MN-55,,SIG),
40706.024 (73-TA-181(N,EL)73-TA-181,,SIG)

Ex of 1st level (MeV): 0.0494 (Th-232), 0.0308 (Nb-93), 0.0576 (I-127), 0.1259 (Mn-55), 0.0062 (Ta-181)

Author and Publication: L. Kazakova et al., eandc-50-s_2_200_1965.pdf, 65antwerp_576(202)_1965.pdf

Recommendation for SF3: **SCT**: (90-TH-232(N,SCT)90-TH-232,PAR,SIG),
(41-NB-93(N,SCT)41-NB-93,PAR,SIG), (53-I-127(N,SCT)53-I-127,PAR,SIG),
(73-TA-181(N,SCT)73-TA-181,PAR,SIG) with *E-LVL-MAX ≥ 0.100 MeV*

Justification: The paper eandc-50-s_2_200_1965.pdf reports: "The mean incident neutron energy was 2 MeV with a spread of about 100 keV. .... The energy threshold of detectors was chosen so that the neutrons with the energy below 1 MeV were not detected. This threshold provided in most cases practically full discrimination against inelastic scattering of neutrons. When this threshold is being insufficient, the contribution of inelastic scattering was calculated on the basis of the published spectra of inelastic scattering and detector efficiency curve and then it was subtracted from measured cross-sections. Inelastic scattering was assumed to be isotropic". Fig. 2 shows detector efficiency rising from zero at 1 MeV up to maximum at 2 MeV. It is unbelievable that in 1965 the authors had enough and consistent data about σ(n,n') in this energy interval for reliable subtraction from the measured scattering cross sections. Having no more information from this paper, we have to declare that inelastic scattering, which result to the excitation of the levels at least within initial energy spread 100 keV, could be admixed in this experiment results.
From this, it would be recommended for SF3 = SCT and for *E-LVL-MAX ≥ 0.100 MeV.*

Further recommendations for Entry: why the angle differential cross sections, plotted in Fig. 3 of eandc-50-s_2_200_1965.pdf, are not compiled ? As a confirmation, it is worth to cite: "... intensity of scattered neutrons was measured as function of the scattering angle by the two detectors", i.e. firstly DA was measured, then SIG was derived by integration over the angle.

Entries: 40772.002 (92-U-238(N,EL)92-U-238,,DA), 40772.003 (92-U-238(N,EL)92-U-238,,DA),
40772.004 (94-PU-239(N,EL)94-PU-239,,DA), 40772.005 (94-PU-239(N,EL)94-PU-239,,DA)

Ex of 1st level (MeV): 0.0449 (U-238), 0.0079 (Pu-239)

Author and Publication: G. Anikin et al., sja_60_66_1986_.pdf, AE 60(1986)51

Recommendation for SF3: **EL**

Justification: The specific difference of this experiment from all others considered in present analysis: the incident neutrons were not monoenergetic but having the wide energy distribution, since they were produced by the fast reactor BR-10. Both the incident on sample and scattered neutron spectra were measured by scintillation detector. Their pulse height distributions were parabolic smoothed, differentiated and eventually the cross section as a function of neutron energy was derived from the ratio of scattered and incident spectra. The neutron scattered spectra obviously contain the cumulative neutron yields from all nuclear reactions on target nucleus: elastic, inelastic, fission etc. To this issue the author's paper sja_60_66_1986_.pdf additionally reports: "Corrections are introduced into the final data on the cross sections shown in Tables 2 - 4 for multiple and inelastic scattering, for fission neutrons, and for plutonium, and for scattering by the sample container. These corrections were calculated by the Monte Carlo method with the BRAND program [10] using the NEDAM and BNAB-78 nuclear constants. The total value of the corrections varies from 20 - 30% in the soft part of the spectrum to 6 - 8% in the hard part".

Conclusion: if the applied Monte Carlo code and evaluated data have correctly taken into account all the physical processes occurring in the sample, detector resolution, etc., then after proper corrections the derived cross sections could be indeed pure elastic.

Further recommendations for Entry: to the existing information "INC-SPECT Well-collimated fast neutron beam" it may be sensible to add the reference given in author' paper to "7. L.A. Trykov et al., 'Energy distribution of neutrons emerging from BR-10 reactor channels,' At. Energ., 39, 56 (1975)" or to L.A. Trykov et al. Soviet Atomic Energy 39 (1975) 631.

x4pdf collection: for better understanding of the experimental details it would useful to have G.V. Anikin and I.I. Kotukhov, "A technique of measuring neutron spectra of powerful sources," At. Energ. 54 (1983) 372.

Entries: 40791.003 (90-TH-232(N,EL)90-TH-232,,SIG)

Ex of 1st level (MeV): 0.0494 (Th-232)

Author and Publication: Yu. Aleksandrov, G. Anikin et al., jet_13_1319_1961.pdf,
jet_6_228_1958_.pdf = JET,33,294,1957,
60vienna_643_1960.pdf

Recommendation for SF3: **SCT**: (90-TH-232(N,SCT)90-TH-232,PAR,SIG), with
E-LVL-MAX > 0.2 MeV at 0.8 MeV (sub Entry 002) and
E-LVL-MAX ≈ 1.8 MeV at 2.8 MeV (sub Entry 003)

Justification: The paper jet_13_1319_1961.pdf reports: "The work was carried out with a fast-neutron reactor. Measurements were made in two energy intervals with average energies of 0.8 and 2.8 MeV. The neutrons, with an average energy of 0.8 MeV, were separated out of a broad spectrum of reactor neutrons by radiotechnical collimation of the recoil protons[4]. The measurement at an average energy of 2.8 MeV were made with a threshold detector (as was done in references 2 and 3)".

Incident Energy 0.8 MeV (sub-Entry 002). The cited paper 4) Г.В. Аникин, Ю.А. Александров и А.С. Солдатов "Спектрометрия быстрых нейтронов с помощью водородной камеры" (60vienna_643_1960.pdf, in Russian) describes the used "... method for separating specific energy groups from a wide neutron spectrum, recorded by a cylindrical, hydrogen-filled ionization chamber. The method is based on the electronic collimation of recoil-protons devised for measurements of the differential neutron-scattering cross-sections using a fast reactor as a neutron source". The neutrons with desired energy were selected by coincidence with the recoiled protons from (n,p) scattered to the specific angle. For this the following property of the hydrogen filled cylindrical ionization chamber was employed: the speed of the signal front growth correlates with the angle between the proton track and central wire-electrode. Naturally this method has internal restrictions that results to the 20 - 25% energy spread at 1 MeV and 2 MeV and even higher at 3 MeV: "Спектры импульсов, соответствующих «лобовым» столкновениям, снятые стоканальным анализатором типа АИ-100 для энергий нейтронов 1 Мэв, 2 Мэв и 3 Мэв, приведены на рис. 3. Как видно из рисунка, при энергиях 1 и 2 Мэв разрешение составляет 20-25%. Уширение пика при энергии нейтронов 3 Мэв связано, по-видимому, с возрастанием роли «эффекта пересечения» нити камеры треком протона отдачи."

Incident Energy 2.8 MeV (sub-Entry 003). The cited paper 2) jet_6_228_1958_.pdf reports "The detector was a cylindrical chamber filled with He^4 to a pressure of 15 atmos. In order to improve the characteristics of the chamber, as well as to determine the energy scale, 5% of N_2 was added to the chamber. ... The counting efficiency was several percent for neutrons of energy on the order of 1.3

MeV. The operation of the chamber was tested by the $N^{14}(n,p)C^{14}$ reaction with thermal neutrons, which gives 600 keV protons. The differential pulse amplitude distribution is shown in Fig. 1. In measuring the angular distribution, the analyzer separated the band from 680 to 890 keV. The energy spectrum of neutrons counted by the chamber was found by calculation, and is shown in Fig. 2. The spectrum was calculated using the data of Adair[3] and Seagrave[4]". Fig. 1 seems depicts the calculated efficiency of the He^4/N_2 detector where one can see that detector threshold is ≈ 1 MeV and maximum at 1.3 MeV.

From this information it follows that the SCT process was measured and reported by authors.

EN = 0.8 MeV, sub-Entry 002: due to the used method of selection of quasi mono-energy 0.8 MeV from the fast reactor spectrum with uncertainty > 25%, the levels up to maximum excitation energy E-LVL-MAX > 0.8 MeV * 0.25 = 0.2 MeV were included.

EN = 2.8 MeV, sub-Entry 003: from the detector threshold ≈ 1 MeV found in Fig. 2 of jet_6_228_1958_.pdf, we could suppose that *E-LVL-MAX ≈ 2.8 MeV - 1.0 MeV = 1.8 MeV.*

Further recommendations for Entry: similar to (90-TH-232(N,EL)90-TH-232,,SIG) the another two sub-Entries 40791.004 (92-U-0(N,EL)92-U-0,,DA) at EN = 0.8 MeV and 40791.005 (92-U-0(N,EL)92-U-0,,DA) at EN = 2.8 MeV have to be corrected correspondingly.

Entries: 40959.003 (92-U-235(N,EL)92-U-235,,DA), 40959.004 (92-U-238(N,EL)92-U-238,,DA), 40959.006 (92-U-235(N,EL)92-U-235,,DA,,,DERIV), 40959.007 (92-U-238(N,EL)92-U-238,,DA,,,DERIV)

Ex of 1st level (MeV): 0.0001 (U-235), 0.0449 (U-238)

Author and Publication: V. Morozov, Yu. Zubov et al., snp_46_778_1987.pdf

Recommendation for SF3:

1.620 – 1.926 MeV data 40959.003 (92-U-235(N,SCT)92-U-235,PAR,DA) with E-LVL-MAX = 3.5 keV,
40959.004 (92-U-238(N,EL)92-U-238,,DA),
40959.006 (92-U-235(N,SCT)92-U-235,PAR,DA,,,DERIV) with E-LVL-MAX = 3.5 keV,
40959.007 (92-U-238(N,EL)92-U-238,,DA,,,DERIV)

4.32 – 5.34 MeV data 40959.002 (92-U-0(N,SCT)92-U-0,PAR,DA) with E-LVL-MAX ≈ 140 keV,
40959.005 (92-U-0(N,SCT)92-U-0,PAR,DA,,,DERIV) with E-LVL-MAX ≈ 140 keV,

Justification: The paper snp_46_778_1987.pdf reports: "Measurements of differential cross sections are reported for the elastic scattering of neutrons by uranium at small angles in the neutron-energy region En = 1.62 – 1.93 MeV with energy resolution 3.5 keV and in the region En = 4.00 – 5.34 MeV with energy resolution ~ 140 keV". Since the paper cited in Entry as "J,PTE,,(6),33,1986) Exp. details only. First author Yu.G. Zubov" is not available, the contribution of other apparatus components to the total energy resolution is not known.

Due to this the actual Recommendation for SF3 is given as see above.

Entries: 41215.002 (90-TH-232(N,EL)90-TH-232,,DA), 41215.008 (90-TH-232(N,EL)90-TH-232,,SIG)

Ex of 1st level (MeV): 0.0494 (Th-232)

Author and Publication: V. Popov, spn_224_1963.pdf, sja_3_1379_1957_.pdf

Recommendation for SF3: SCT: (90-TH-232(N,SCT)90-TH-232,PAR,DA),
(90-TH-232(N,SCT)90-TH-232,PAR,SIG) with *E-LVL-MAX ≈ 0.21 MeV*

Justification: The paper spn_224_1963.pdf presents results for ^{232}Th at initial energy 3.1 MeV. Important details about experimental set-up are given in paper sja_3_1379_1957_.pdf: "The neutron source was a target of heavy ice bombarded by deuterons accelerated to an energy of 150 keV. The mean energy of the neutrons incident on the scatterer was 2.9 ± 0.1 MeV. The neutron detector was a spherical ionization chamber (Fig. 2) with an external electrode diameter of 13 cm, filled with a mixture of 5 atmos of hydrogen and 5 atmos of argon; this ionization chamber registered recoil protons. ... It was possible, with, this chamber, to investigate the spectrum of neutrons with energies from 0.8 to 3.0 MeV with a resolving power of 7% in the energy. ... The spectra obtained were treated by a ratio method involving division of the recoil proton spectrum from the scattered neutrons (after subtracting out the background) by the recoil proton spectrum from unscattered neutrons. ... In addition, this method makes it possible to find the differential cross sections for inelastic scattering in the same relative units for all scattering angles. .... RESULTS Differential elastic scattering cross sections of 2.9-MeV neutrons were measured for iron, copper, lead, and bismuth in the range of scattering angles from 30° to 150° at intervals of 30° (and sometimes 15°). In addition, differential inelastic scattering cross sections were measured for excitation of several levels of these nuclei. ... Figures 5 and 6 give the ratio curves for iron and bismuth. In both cases three neutron groups are well resolved. One of these is the elastically scattered group, and the other two are the inelastically scattered ones corresponding to excitation of the first two nuclear levels in iron and bismuth. These curves are the immediate experimental results. The ratio curve for copper (Fig, 7) can be used for satisfactory separation of the elastically scattered neutron from the inelastically scattered ones, but the resolution is not sufficient to separate the latter into groups related to the two copper isotopes each of which has its own level system. The same reason made it difficult to resolve even the elastic scattering in lead".

These author's detailed and clear explanations allow us to conclude that this experimental method is generally capable to separate inelastic and elastic scattered groups of neutrons, but it depends on the specific values of the spectrometer resolution (ΔE = 3 MeV * 7% = 0.21 MeV) and excitation energy of the first levels in the nucleus of interest. For ^{232}Th it is impossible since Ex of the 1st level (0.0494 MeV) is substantially smaller.

Thus SF3 should be SCT and *E-LVL-MAX ≈ 0.21 MeV.*

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