International Atomic Energy Agency

Report on Consultancy Meeting (CM)

"Neutron Source Spectra for EXFOR"

held 13-15 April 2011, IAEA, Vienna

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NRDC Meeting 23-24 May 2011, IAEA, Vienna

CM Objectives and EXFOR status

- make EXFOR data base more representative and complete
  by including comprehensive information on neutron sources energy spectra
- this necessity mainly appears when:
  - a neutron source has a relatively broad energy distribution (white, broad peak, tails ...)
  - and the cross section (XS) under study varies significantly over this interval
- Present EXFOR status: only 3 Entries with XS have incident neutron spectra
- NB: spectra from accelerator driven neutron sources are traditionally compiled
  in EXFOR (even if XS measurements were not reported)
  - valuable information on energy distributions and intensities
    for verification of the charged particles reaction models

Coverage of the different Neutron sources by Participants of CM:

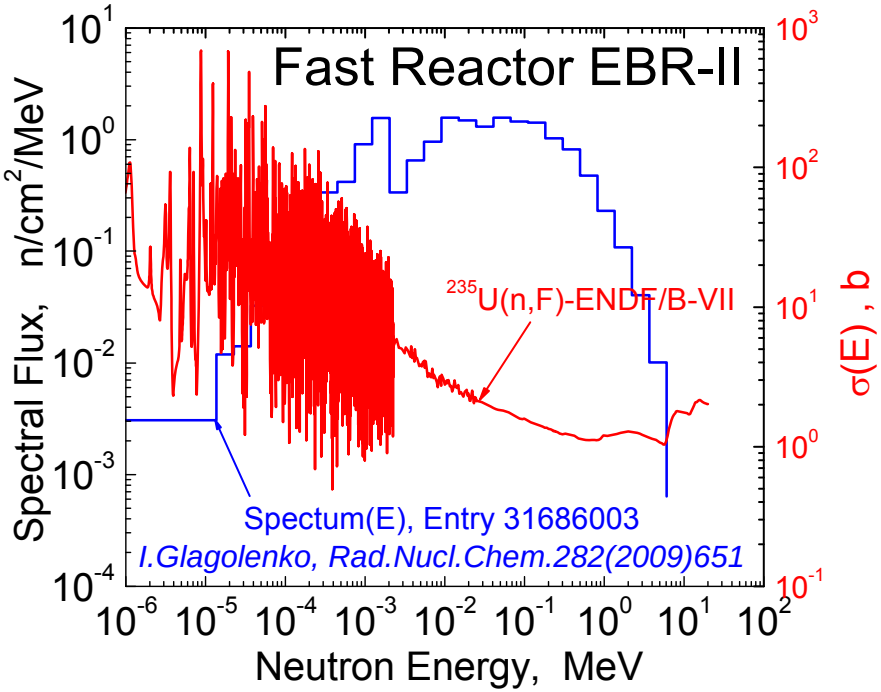
- Thermal, fast and filtered beams from Reactors
  H.Harada (JAEA, Japan), T.Belgya (KFKI, Hungary) , O.Gritzay (KINR, Ukraine)

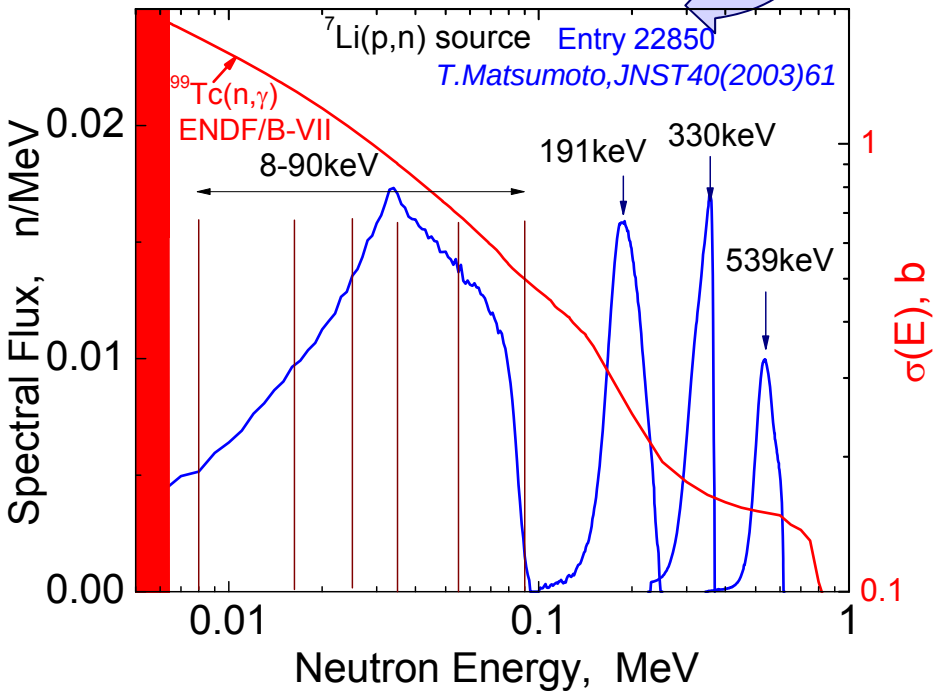
-Accelerator driven neutron sources: kev, a few MeV and 14 MeV
F.Kaeppeler (KIT, Germany), M.Drosg (Viena University, Austria), M.Pillon (ENEA, Italy)

-Accelerator driven neutron sources: high energies (above 14 MeV)
S.Qaim (FZJ, Germany), P.Bém (NPI, Czech Republic)

EXFOR status before CM (3 source spectra available)

Entry #	Institute	Source	Presentation Format
31686	1USAINL	REACtor	28 groups, fraction of neutron (1/bin), normalized to 1
21816	2FR CAD	REACtor	18 groups, fraction of neutron (%/bin), normalized to 1
22850	2JPNTIT	P-LI7	Point-wise neutron flux (1/MeV), normalized to 1





Source spectra are broad and XS essentially varies – source distribution is really needed

EXFOR status before CM: non EXFOR resources - IRDF-2002 - spectra for dosimetry XS validation http://www-nds.iaea.org/irdf2002/

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ENTRY 30568
FACILITY   (REAC,3RUMPIT) VVR-S reactor, Inst.Nucl.Power Reactors, Romania
INC-SOURCE (THCOL) VVR-S thermal column with Sigma-Sigma-ITN facility
INC-SPECT   Sigma-Sigma neutron reference spectrum (fast reactor spectrum),
            calculated by means of ANISN-code and ENDF/B-III library.
EN-DUMMY    ERR-1    ERR-S
KEV         PER-CENT PER-CENT
  450.      0.9      0.5
REACTION (22-TI-46(N,P)21-SC-46,,SIG,,SPA)
DATA ERR-T
MB   MB
2.51 0.12
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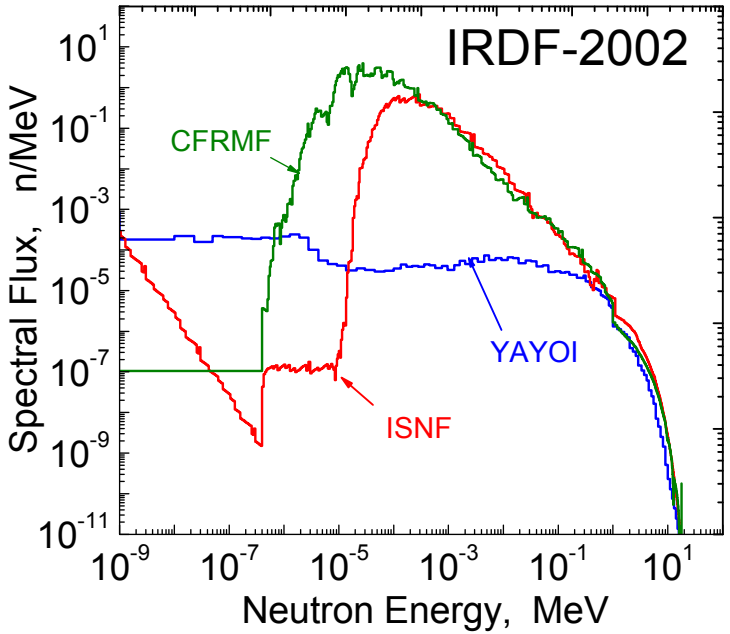
?!

Natural/Reactor Sources:

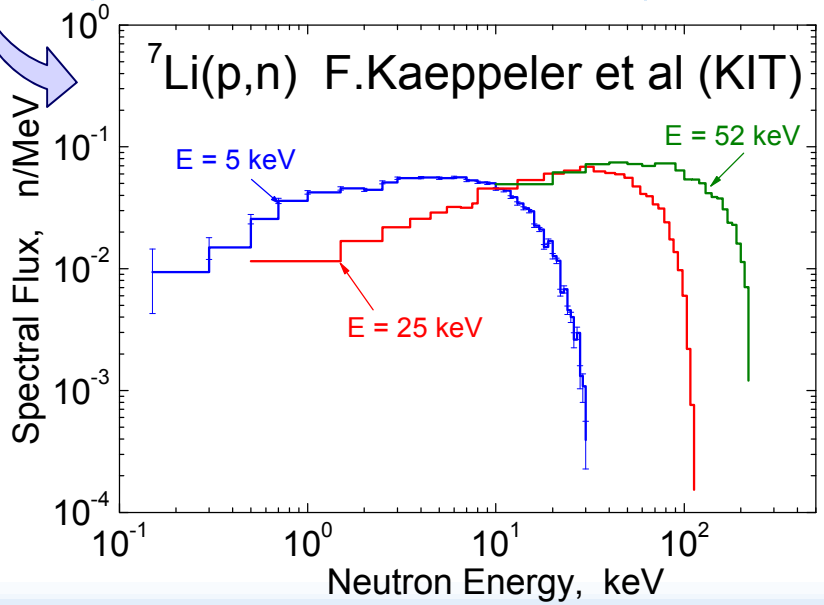
Cf-252 - isolated point source
U-235 - U-235 in thermal flux
Thermal Maxwellian – thermal columns
ISFN – Intermediate-energy Standard Neutron Field
CFRMF - Coupled Fast Reactivity Meas. Facility
Σ-Σ – coupled thermal/fast Uranium
YAYOI – 2kW fast neutron reactor
Big-Ten – 10% enriched Uranium Cylindrical

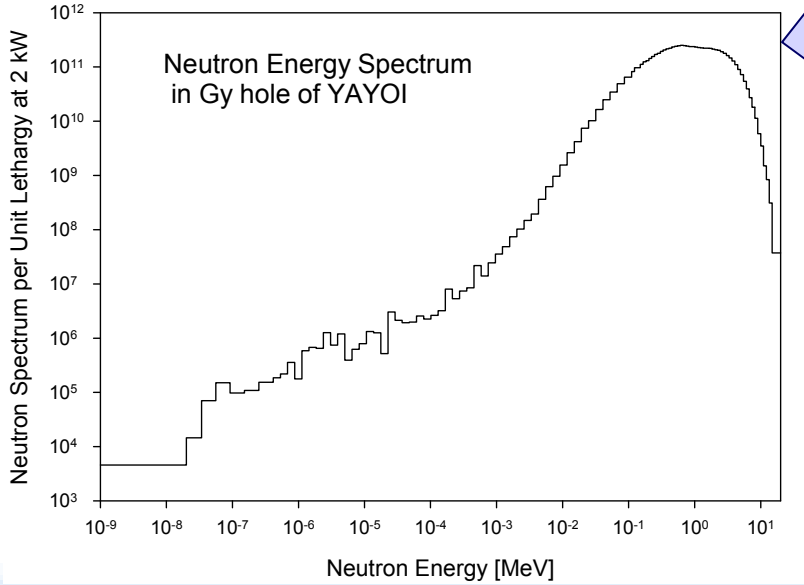


- many EXFOR entries have energy averaged dosimetry cross sections (SIG,,SPA), (SIG,,FIS)
- are these spectra indeed reference fields or facility independent (?),
  then it is reasonable to link relevant EXFOR Entries to IRDF-2002 spectra

EXFOR status after CM (n-spectra from Participants)

Source	Institute	Entries	Spectra Status
YAYOI fast reactor	JAEA, Tokyo	a few	submitted
Reactor/Cold beam	KFKI, Budapest	~ 18	promised
Reactor/Filtered beam	KINR, Kiev	3	submitted
Li(p,n)/Thick target	KIT, Karlsruhe	~ 47	submitted
T(d,n)/14 MeV	ENEA, Frascati	a few	promised
Be(d,xn)/22MeV	FZJ, Julich	~ 135	promised
Li(p,n)/20-40MeV	NPI, Rez	a few	promised





- see O. Gritzay' presentation "Storage of numerical n-source spectra" (Agenda, 5.1)

EXFOR after CM: accelerator driven Neutron Source (DDX and TTY/DEA) - compilation of still missed data

(see complete list of ≈150 sets in WP2011-13, Memo CP-D/700)

p-Li source:

CYRIC: 20 - 40 MeV, 7Li(0.2cm)+C(1.2cm),	TTY, Y. Uwamino et al., NIMA389(1997)463	under compilation, E1826
TIARA: 43 - 88 MeV, 7Li(0.4-0.7cm),	DDX, M. Baba et al., NIM A428 (1999) 454	under compilation, E1808
RIKEN: 70 - 210 MeV, 7Li(1cm),	TTY, N. Nakao et al., NIM A420 (1999) 218	under compilation, E2298
RCNP: 246 and 389 MeV, natLi(1cm),	DDX, Y. Iwamoto et al., NIM A629 (2011) 43	under compilation, E2297

p-Be, C sources:

E. Kim et al., NSE 129 (1998) 209	under compilation, 22653
Y. Uwamino et al., NSE 111 (1992) 391; NIMA 271 (1988) 546	under compilation, E2296

d-Li source (DDX):

Ed=17 MeV: P. Bem et al., Report NPI ASCR Rez EXP(EFDA)-05/2004	???
Ed=40 MeV: M. Hagiwara et al., Fusion Sci. Tech. 48(2005) 1320	E1986
Ed=25MeV: M. Hagiwara et al., Journal of Nucl. Materials XX(2011)YYYY	under compilation, E2322

d - Li, C, Be, H2O, D2O sources:

H.I. Amols et al., Med. Phys. 4 (1977) 486	under compilation
T. Aoki et al., J. of Nucl. Sci. Tech. 41 (2004) 399-405	E1893
M. Sugimoto, d-Li at 32 MeV, Private communication (1995)	under compilation
H.J. Brede et al., Nucl. Instr. Meth A274 (1989) 332-344	D0523
V.K. Daruga et al., Atomnaya Energiya, 30(1971) 399(Sov. Atom.Energy 30(1971) 493)	under compilation
M.A. Lone et al., Nucl. Instr. Meth. 143 (1977) 331-344	under compilation
J.P. Meulders et al., Phys. Med. Biol. 20 (1975) 235-243	under compilation
Z. Radivojevic et al., Nucl. Instr. Meth. B 183 (2001) 212-220	O1050
M.J. Saltmarsh et al., Nucl. Instr. Meth. 145 (1977) 81-90	under compilation
G.W. Schweimer, Nucl. Phys. A100 (1967) 537-544	under compilation
L.S. August et al., Report NBSIR 77-1279 (1977)	under compilation
C.E. Nelson et al., Report NBIR-77-1279 (1977) 1	under compilation
K.A. Weaver, Nucl. Sci. Eng. 52, 35-45 (1973)	F0218
M. Hagiwara, J. Nucl. Mat. 329-333 (2004) 218-222	E1985.002
K. Shin, Phys. Rev. C, 29 (1984) 1307	under compilation
G. Lhersonneau, et al., Nucl. Inst. Meth. A 603 (2009) 228-235	O174600*

+ all reactions (p, d, He3, He4 beams on Mo, Cu, Fe, Ta, W, Au, Pt, Pb targets) reported in these articles

EXFOR after CM: Radioactive Neutron Sources

Justification: radioactive neutron sources used for averaged cross section measurements detector calibration, as reference fields, benchmarking evaluated data files

Reactions: **^{238,239}Pu –Be, ^{242,244}Cm-Be, ^{226}Ra-Be and ^{210}Po-B, ^{238}Pu-^{10,11}B**

Designs: homogeneous (isotropic) and heterogeneous "sandwich" (angular dependent)

Memo CP-D/694

Present Status of Entries: ~242 with XS and INC-SOURCE A-BE :

incident source code A-BE is used for both accelerator driven α-Be and all decay α-Be neutron sources.

Proposal:

to improve the accessibility of neutron spectrum averaged cross section –
new incident source codes for Radioactive sources but leaving A-BE for accelerator driven ones:

Dictionary 19 (Incident Source Codes)

AM-BE	Americium-Beryllium neutron source	(12 Entries with averaged XS to correct)
CM-BE	Curium-Beryllium neutron source	(1 Entries with averaged XS to correct)
PO-BE	Polonium-Beryllium neutron source	(4 Entries with averaged XS to correct)
PU-BE	Plutonium-Beryllium neutron source	(3 Entries with averaged XS to correct)
RA-BE	Radium-Beryllium neutron source	(15 Entries with averaged XS to correct)
RN-BE	Radon-Beryllium neutron source	(2 Entries with averaged XS to correct)
TH-BE	Thorium-Beryllium neutron source	(1 Entries with averaged XS to correct)

EXFOR after CM: Radioactive Neutron Sources – Class of Data missed - Literature resources

1. Comprehensive book reviews (in Russian) – IPPE measurements and references to other experiments (last decade - collaboration with Rez):

Yu.I. Kolevatov et al., “Neutron and gamma spectrometry in radiation physics”, Energoatomizdat, Moscow, 1990

I.V. Goryachev et al., "Integral Experiments in the Problem of the Transfer of Ionizing Radiations", Moscow, 1985

V.I. Kuchtevich et al., “One crystal spectrometer”, Atomizdat, Moscow, 1971

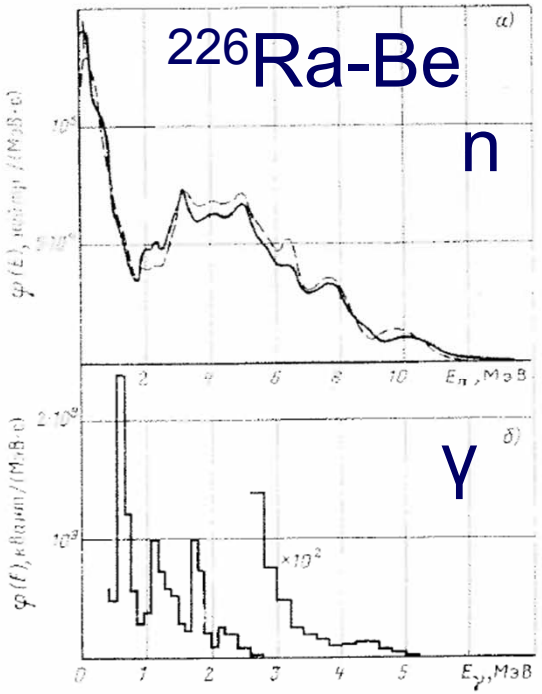


Рис. 2.1. Радионуклидный источник ^{226}Ra—Be: *а* — энергетический спектр нейтронов: ——— — эксперимент; — — — — расчет [13]; *б* — энергетический спектр γ-излучения

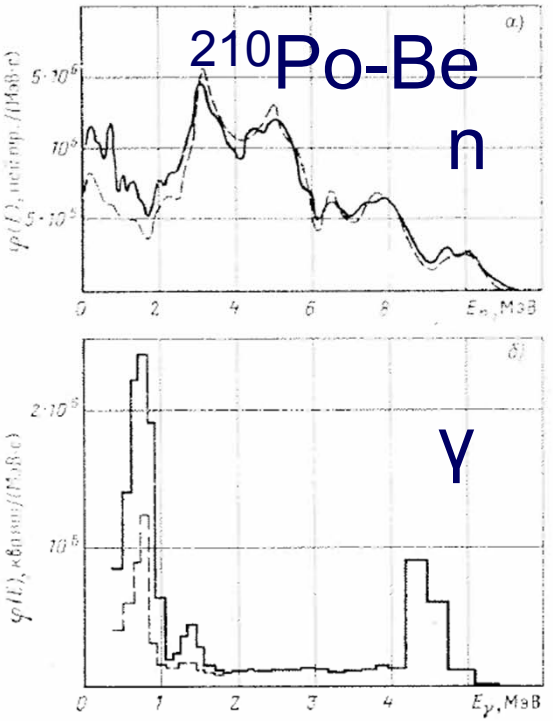


Рис. 2.2. Радионуклидный источник ^{210}Po—Be: *а* — энергетический спектр нейтронов: ——— эксперимент; — — — — расчет [13]; *б* — энергетический спектр γ-излучения

EXFOR after CM: Radioactive Neutron Sources
- Class of Data missed C - Literature resources

2.“**Compendium of Neutron Spectra and Detector Responses for Radiation Protection Purposes**”,
Technical Reports Series No 403, IAEA, 2001

TABLE 4.I. REFERENCE FIELDS

Spectrum	Ref.	Calculated or measured	Table
ISO, unmoderated Cf	[90]	C	4.V
ISO, moderated Cf	[90]	C	4.V
ISO, Am–Be	[90]	C	4.V
ISO, Am–B	[90]	C	4.V
PTB, unmoderated Cf, without shadow cone	[23]	M	4.VI
PTB, unmoderated Cf, with shadow cone	[23]	M	4.VI
PTB, unmoderated Cf, the difference	[23]	M	4.VI
PTB, moderated Cf, without shadow cone	[23]	M	4.VII
PTB, moderated Cf, with shadow cone	[23]	M	4.VII
PTB, moderated Cf, the difference	[23]	M	4.VII
Tohoko, Fe moderated Cf	[91]	M	4.VIII
Tohoko, C moderated Cf	[91]	M	4.VIII
Tohoko, PE moderated Cf	[91]	M	4.VIII
JINR, PE (29.2 cm dia.) moderated Cf	[92]	M	4.VIII
JINR, PE (12.7 cm dia.) moderated Cf	[92]	M	4.VIII
PTB, Am–Be, without shadow cone	[23]	M	4.IX
PTB, Am–Be, with shadow cone	[23]	M	4.IX
PTB, Am–Be, the difference	[23]	M	4.IX
CERN, Pu–Be, 1 m from source	[93]	M	4.X
CERN, Pu–Be, 2 m from source	[93]	M	4.X
CERN, Pu–Be, 3 m from source	[93]	M	4.X
CERN, PE mod. Pu–Be, 1 m from source	[93]	M	4.X
CERN, PE mod. Pu–Be, 2 m from source	[93]	M	4.X

90. International Organization for Standardization “Neutron Reference Radiations for Calibrating Neutron Measuring Devices ….” Standard ISO/DIS 8529, Geneva (1989).

23. A. Alevra et al., Rad. Prot. Dos. 44(1992)223

93. A. Aroua et al., Rad. Prot. Dos. 44(1992)183

Proposal: collect references for clean n and g- Radioactive Sources , assign them for compilations