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INDC International Nuclear Data Committee

Summary Report of the Workshop on the

Compilation of Experimental Nuclear Reaction Data

IAEA Headquarters, Vienna, Austria

22 - 25 October 2018

Prepared by
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December 2018

IAEA Nuclear Data Section

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Abstract

The Workshop on the Compilation of Experimental Nuclear Reaction Data was held at IAEA Headquarters in Vienna from 22 to 25 October 2018. The workshop was organized to discuss various aspects of the compilation process including compilation rules, different techniques for nuclear reaction data measurements, software developments of experimental nuclear reaction database, EXFOR. A summary of the presentations and discussions that took place during the workshop is reported here.

December 2018

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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 International Network of Nuclear Reaction Data Centres (NRDC):

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".

1 Introduction

The Workshop on the Compilation of Experimental Nuclear Reaction Data was held at IAEA Headquarters, Vienna, Austria from 22 to 25 October 2018. Twenty participants from different Nuclear Reaction Data Centres and five staff from the IAEA attended the Workshop.

The workshop was organized to discuss various aspects of the EXFOR compilation process including compilation rules, different techniques for nuclear reaction data measurements, software developments, digitization, and the application of new technologies.

The EXFOR database contains wide range of physical quantities for various types of nuclear reactions including not only neutron-induced reactions but also charged-particle-induced and photonuclear reactions. Maintaining the database completeness and the consistency of the compilations for the same type of data requires regular reviewed and update of the EXFOR content and compilation rules. The recent increase in interests on the fission product yield (FPY) for various fields of applications stresses the importance of the completeness and consistency of FPY data in the EXFOR database. Such database completeness assessments have just started. Some of the presentations covered the underlying theoretical and experimental concepts, completeness investigations, EXFOR compilation rules and recommendations. The workshop consists of the combination of presentations and hands-on trainings of compilations of selected publications concerning FPY measurements. Participants from US National Nuclear Data Centre (US, NNDC), Hokkaido University (Japan, JCPRG), IET Bhaddal (India), and National University of Mongolia presented centre's nuclear data compilation activities. Some NRDC centres contribute to the international collaboration by developing various compilation tools and web retrieval, and plotting systems. Recent progress in software developments was demonstrated. A summary of the presentations and discussions that took place during the workshop is reported here.

Delivering the welcome address by the IAEA Nuclear Data Section Head, A. Koning, greeted participants of the workshop and reiterated the high importance and impact of the EXFOR database and the value of the continual work by the NRDC members. In particular this year, the importance of the FPY data and upcoming IAEA coordinated research project (CRP) on the evaluation of the FPY have been introduced.

B. Pritychenko was elected Chairperson of the Workshop and it was agreed that the use of a repository system would allow participants to co-operate in the drafting of this summary record. As a result, no Rapporteur was required.

The agenda was discussed and adopted (see APPENDIX A). The list of participants is available (see APPENDIX B).

During the Workshop participants gave presentations, led intensive discussions and carried out compilation exercises. The presentations and working papers are available at:

https://www-nds.iaea.org/nrdc/wksp_2018/

The Nuclear Data Section acknowledged all participants for their cooperation and contribution to this Workshop.

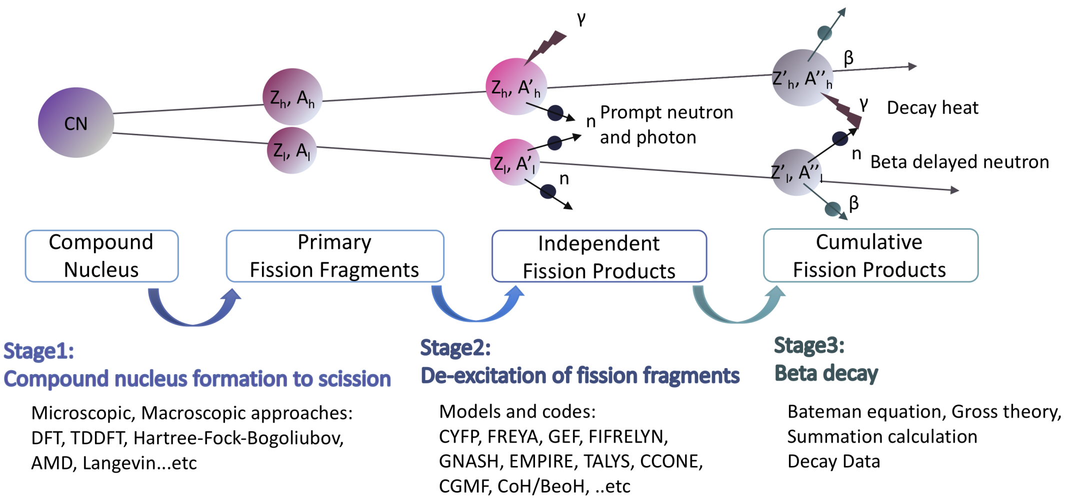
2 Presentation summaries

2.1 Use of EXFOR for fission product yield prediction, S. Okumura

The fission product yield (FPY) data is the important ingredients for studying nuclear energy applications. Due to an increasing demand for the high quality FPY data in these applications, the more attention has been paid to improve an accuracy, quality, and comprehensiveness of FPY data. In particular, the FPY data for higher actinides and wide range of energy have become of great interest. However, the available evaluated data in the current nuclear data libraries are insufficient to satisfy such new demands.

The experimental data for FPY other than $^{235}\mathrm{U(n_{th}, f)}$ is scarce due to the very short timescale of the nuclear fission and prompt decay that makes the direct measurement difficult. The present evaluation of nuclear data is compiled by combining available experimental data and some phonomenological models, e.g., Los Alamos model (LAM) for prompt fission neutron spectrum [1], Wahl systematics for independent FPY [1] that include limited experimental information. The FPY and the other observables (e.g. neutron and photon multiplicities, energy spectra, delayed neutron yield, etc.) are evaluated separately. Therefore they are not well consistent with each other[3].

Many theoretical models and codes have been developed for predicting fission observables such as FPY. However, it is still difficult to calculate all the fission observables simultaneously and consistently. A complete calculation of fission yields involves at least three stages; (1) The formation of compound nucleus induced by an incident neutron, and its deformation towards scission, (2) excited complementary primary fission fragments de-excite by emitting the prompt neutrons and photons to reach their ground-state or long-lived isomeric states, and (3) the post particle emitted fission fragment, also called fission products, and β-decay which leads further delayed neutron and photon emissions.



We have developed the Hauser-Feshbach statistical decay code, HF^{3}D [4], for the decay of excited fission fragment pairs at the stage (2), and the model outputs are concatenated with the beta decay process (3) with an incident neutron energy dependent manner. The calculation starts from a unique set of the primary fission fragment distributions which is characterized by mass, charge, excitation energy, spin and parity $Y(A, Z, E_{ex}, J, \Pi)$. Such distributions are deterministically generated and numerically integrated for all fission fragments by HF^{3}D code. Such distributions are generated by using experimentally available mass and total kinetic energy (TKE) distributions of neutron induced fission of ^{235}U(n$_{th}$,f) taken from EXFOR database. We limit our calculation to ^{235}U(n,f) and the incident neutron energy up to 5 MeV, which is the multi-chance fission threshold. The calculated fission observables such as independent and cumulative FPY, the prompt neutron and photon emission multiplicity and spectra, decay heats, and delayed neutron yield are compared with the evaluated nuclear data and the experimental data that are also taken from EXFOR database.

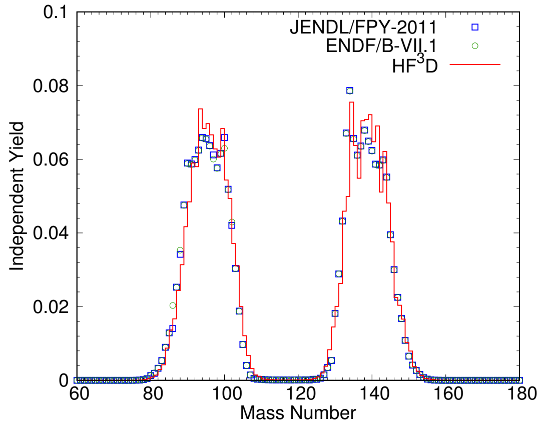


Figure 1: The mass total of independent FPY of ^{235}U(n$_{th}$,f) calculated by the HF^{3}D model shown with JENDL/FPY-2011 and ENDF/B-VII.1

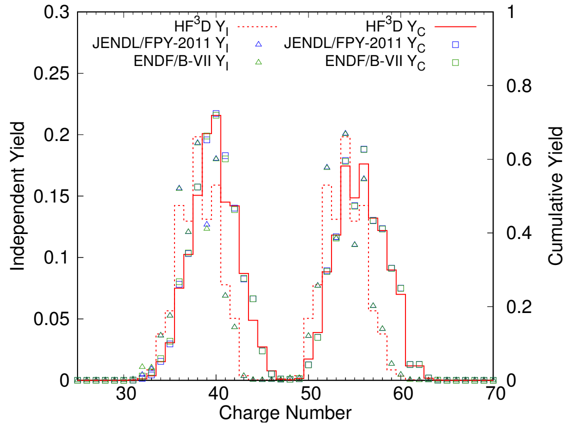


Figure 2: The charge total of independent($\mathrm{Y_I}$) and cumulative($\mathrm{Y_C}$) FPY of ^{235}U(n$_{th}$,f) calculated by the HF^{3}D model with JENDL/FPY-2011 and ENDF/B-VII.1

For instance, Fig. 1 illustrates the fission product mass dependence of the independent FPY for ^{235}U(n$_{th}$,f). For mass dependence of the independent and cumulative FPY for ^{235}U(n$_{th}$,f) are relatively well studied experimentally and the evaluated data follow the experimental data. We compare our calculation and JENDL/FPY-2011.

The calculation well reproduces the structures of the independent FPY, seen as peaks (A = 99 and 134) and dips (A = 98 and 136). These fine structures are evaluated from some experimental data. The cumulative FPY was obtained by performing the β-decay calculation using the calculated independent FPY. Figure 2 shows that the charge distribution of the independent FPY has quite clear even-odd effect and the charge distribution of the cumulative FPY shifts towards the heavy charge because of the β decay. We compared another fission observables as well, such as prompt neutron multiplicity and delayed neutron yield, in an energy dependent manner. Although there are some discrepancies between the calculated and experimental results, the overall predictions are quite successful.

The scalability of the combination of HF^{3}D model and β-decay calculations enables us to perform series of consistent calculations on wide range of actinides and energy by connecting the theoretical fission models.

Reference

[1] D.G. Madland and J.R. Nix. New calculation of prompt fission neutron spectra and average prompt neutron multiplicities. *Nuclear Science and Engineering*, 81(2):213–271, 1982.

[2] A. C. Wahl. Systematics of fission-product yields. *Technical Report LA-13928*, Los Alamos National Laboratory, 2002.

[3] P. Jaffke. Identifying inconsistencies in fission product yield evaluations with prompt neutron emission. *Nuclear Science and Engineering*, 190(3):258–270, 2018.

[4] S. Okumura, T. Kawano, P. Jaffke, P. Talou, and S. Chiba. ^{235}U(n, f) independent fission product yield and isomeric ratio calculated with the statistical Hauser-Feshbach theory. *Journal of Nuclear Science and Technology*, 0(0):1–15, 2018.

2.2 Compilation of fission yields, B. Pritychenko

Compilations of experimental nuclear reaction data have started at Brookhaven National Laboratory in the early 50s and eventually evolved into EXFOR project. The initial compilation scope was focused on neutron cross section data, and these data were either directly obtained from authors or extracted from tables. Many important nuclear physics quantities such neutron fission yields, charged-particle and photonuclear reaction parameters were excluded from the compilation scope until 80s. This led to the situation when many important publications were ignored by the EXFOR compilers, and the "missing data" problem was created. In the present days compilation of nuclear data is a very broad activity that includes nuclear reaction, structure and bibliography databases or EXFOR, XUNDL and NSR, respectively. These databases contain extensive records of nuclear science measurements and completely based on modern computer technologies. It represents an interest to explore them for topics of interest and create complete data records.

In this contribution I will explore the EXFOR and NSR databases that contain 22294 and 229594 data entries, respectively, for missing data. The analysis of EXFOR database contents for neutron-induced, spontaneous and photo-induced fission yields shows that it contains 817 experiments, 1611 reactions and 2992 data sets. The Nuclear Science References (NSR) has been created as a nuclear structure and decay bibliographical database in 1960 and may contain many complementary fission yield references. The initial analysis of the NSR database for missing in EXFOR data indicates 384 neutron-induced, 142 spontaneous and 126 photo-induced fission yields references; 540 fission yields PDF files were identified and added to the joint EXFOR-NSR PDF database during the analysis. These findings are under further critical review and will be summarized in three NRDC memos.

In order to estimate the volume of work the pilot fission yields project has been conducted at the National Nuclear Data Center. The project scope included compilation of 15 new and revision of 18 existing EXFOR fission yield compilations. The compilation time for new and revised entries was 180 and 90 hours, respectively. Several rules for the compilation of fission yields, spallation reactions and beta-shielded nuclei were re-examined during this effort and helped to clarify the possible challenges of future work.

Finally, the NSR-EXFOR database comparison demonstrated the large potential of two databases and produced multiple complementary findings. These findings would improve the EXFOR database fission yields contents and create additional avenues for the improvements such as a recent IAEA project on NSR-CINDA integration. These results would create a basis for reevaluation of neutron fission yields that would produce a broad impact in many areas of applied and basic science.

2.3 Compilation and dissemination of experimental fission product yields, N. Otsuka

The IAEA Nuclear Data Section (NDS) is planning to start a new Coordinated Research Project on fission product yields (FPY). To support this CRP, NDS started an attempt to improve completeness of EXFOR for FPY. This quantity was outside the EXFOR compilation scope when Four Centre collaboration started in 1969, and two pioneer evaluation groups in USA (Meek, Rider, England et al.) and UK (Crouch, Mills et al.) collected experimental data independently from EXFOR. The data sets in USA compilation has been systematically converted to EXFOR by V. McLane (NNDC), M. Lammer (NDS), Wang Dao (CNDC) et al. in 1980s. On the other hand, such a systematic effort was not made for the UK compilation. NDS is checking EXFOR against the citation list of the UK compilation, and will summarize experimental works in the UK compilation but missing in EXFOR. In addition to compilation, dissemination of experimental FPY (e.g., end-user format, plotting) must be also improved. Various options of REACTION codes were presented for FPY data sets measured with indirect reactions (e.g., transfer reaction followed by fission).

2.4 Visualization of fission product yield by NDPlot, Y.L. Jin

NDPlot is an efficient plotting tool for nuclear data. It is not only a plotting tool for nuclear data, but also integrated application software. We have released the beta version of NDPlot with an NDPlot

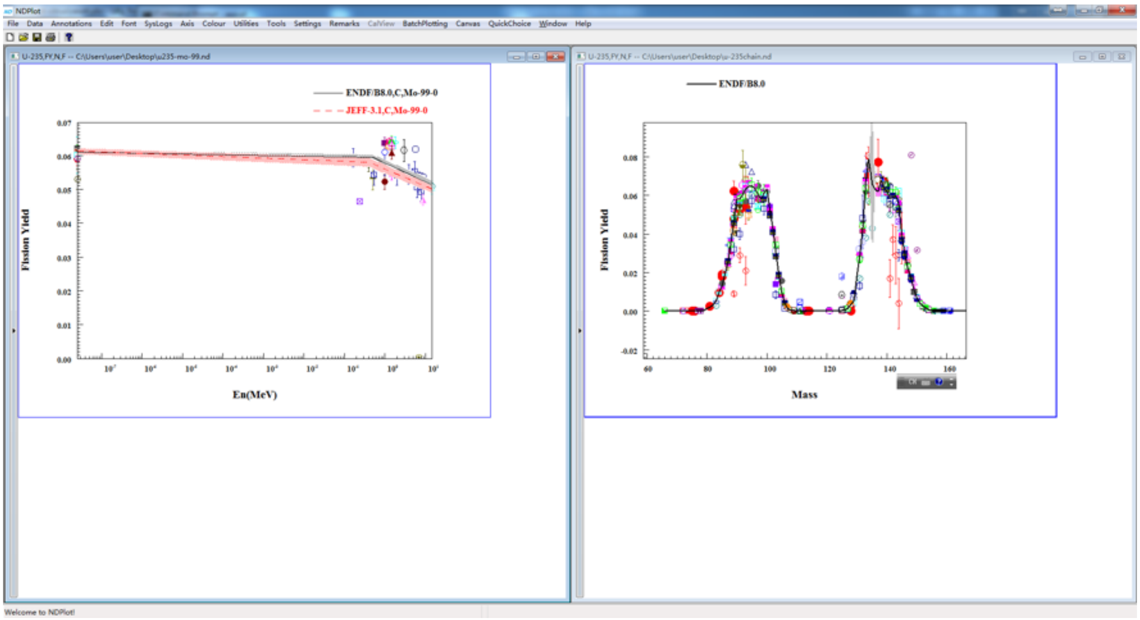


Figure 3: Screenshot of NDPlot

server on the internet. NDPlot can plot experimental and evaluated data of reaction cross sections, angular distributions of secondary particles, energy distributions of secondary particles and energy-angle distributions of products.

Since September 2018, it has been able to draw the chain yields and energy dependent fission product yields, including experimental data and evaluated data. NDPlot also provides tools to filter fission yield data and correct the data with new gamma data.

2.5 Fission product yield compilation, V. Semkova

The experimental data for the fission fragments mass distributions are important for the nuclear science and nuclear technologies research and developments. Fission yields data are needed for the assessment of the current and innovative reactors' spent fuel inventory, residual power, radiotoxicity of spent fuel etc. The fission is one of the most complex phenomena on the nuclear scale. The high quality experimental data are important to validate and improve the nuclear models' predictions and nuclear data evaluations. The recent experimental and theoretical advances in fission research provided more detailed and precise information. Measurements in inverse-kinematics, utilization of radioactive ion beams and multi-nucleon transfer reactions have opened new horizons by providing data for the regions and excitation energies beyond the traditional experiments with light projectiles and heavy (actinide) targets. However, the new innovative experimental techniques involve in some cases different types of interactions, sequential processes or additional considerations. The specific aspects of those measurements needed to be discussed in order to establish the EXFOR compilation rules for the experimental information and nuclear data quantities. In this respect the main topic of the EXFOR Workshop 2018 is very timely in order to discuss the best practices for compilation of the various methods and experimental techniques utilized in the fission studies and particularly in the fission fragments mass distribution (FFMD) measurements.

The evolution of the fission process depends on the nuclear potential energy as a function of the compound nucleus deformation. The "liquid drop model" LDM proposed in 1939 [1] describes the total binding energy of the uniformly charged incompressible nucleus as:

$$B = a_v A + a_s A^{2/3} + \frac{a_c Z(Z-1)^2}{A^{1/3}} - a_a (A-2Z)^2/A \pm \delta(A,Z) \qquad (1)$$

The potential energy of the system during deformation and oscillation depends mainly on the balance between the Coulomb and surface energies terms. However, the pairing effects can reflect the energy that the fissionning nucleus dissipates as it deforms. In 1967 Strutinsky added shell model corrections [2] that transformed the shape of the potential energy as a function of deformation to a double-humped barrier. That changed the fission barrier penetrability giving rise to subthreshold fission and transmission resonances. The shell structure of the compound nucleus as well as the two nascent fragments influence the fission fragments yield, energy and angular distributions.

The total energy released after fission is determined by the energy balance between the interacting particles and primary fission fragments and subsequently is shared between the products and radiation released from the fission. The largest part is carried out by the fission fragments. The fission fragments kinetic energies are defined at scission by the charge and the distance between the effective centres of the fragments. In addition the fission fragments are left in an excited state. The total excitation energy is shared between intrinsic excitation, deformation and collective excitation. The primary fission fragments release excitation energy by emission of neutrons and gamma rays.

The main fission observables and quantities are:

- Fission cross-sections as a function of incident energy. The fission cross sections have complex energy dependence. For reactions with Q>0 the cross section in the thermal energy region have 1/v dependence followed by resolved resonance region, where the energy dependence can be presented by resonance parameters determined by R-matrix theory. At higher energies the space between levels in the compound nucleus are very small and the resonances cannot be resolved. The cross section is presented by average resonance parameters determined by statistical and level density models. A step-like structure caused by second chance ((n,n'f)), third chance ((n,2nf)) etc. fission is typical for the fission cross section in the fast energy range.
- Fission fragments (FF) kinetic energy, mass, and charge yield and angular distribution. The FFs kinetic energy and mass distributions depends on the mass of the compound nucleus and excitation energy. For example singe-humped mass distribution was observed for lighter systems at low excitation energies. Asymmetric fission prevails from A=227 to A=256. The position of the heavy peak remains unchanged with increasing the mass of the compound nucleus while the position of

the light peak moves towards the heavy peak leading to a single peak at higher energies. Symmetric fission with narrow mass distribution is observed between ^{256}Fm and ^{258}Fm.

- Prompt neutrons and gamma rays multiplicity, energy and angular distributions depend on the deformation of fission fragments at scission, the sharing of the excitation energy between the fragments and the dynamics of the fission possess itself.
- Fragments' beta and gamma decay radiation. Due to the excess of neutrons the fission fragments undergo beta-decays towards the valley of stability emitting characteristic radiation.
- Beta-delayed neutrons probabilities and energy distributions. The emission of beta-delayed neutrons take place when $Q_\beta > S_n$. The decay of a precursor may be followed by a decay chain with emission of more than one beta-delayed neutron.

The following methods are applied for the determination of the mass A and atomic number Z of the fission products:

- Measurements applying kinematic analysis of the interacting nuclei and the fission fragments registered in coincidence based on mass and momentum conservation law. The method allows fragment mass identification based on FFs kinetic energy (2E) or kinetic energy and velocity (2E-2v) measurements. In the double energy method (2E) the post-neutron emission FFs are obtained. To deduce the pre-neutron emission mass distributions correction for the average neutron multiplicity as a function the mass of the fission fragment have to be applied in case-by-case analysis. The double energy double velocity method allows simultaneous measurement of the pre- and post-neutron emission mass distributions, however such measurements require very good timing properties. Various types of detectors are employed for the measurements of the FFs kinematic characteristics such as:
- Proportional Counters + grids to obtain angular information (Frisch-gridded IC)
- Multiwire proportional counter (MWPCs) = Parallel plate ionization chamber and Parallel plate avalanche counters
- Gas scintillation chambers
- Solid-state silicon detectors
- Diamond detectors (poly-crystalline and single-crystal chemical vapor-deposited (pCVD and sCVD))
- Time projection chamber. 3D ionization profile allows particle identification and separation.
- Gamma-rays spectrometry of the characteristic radiation associated with the beta-decay of the fission products. The method allows the isotope identification, however particularly in the off-line measurements, only cumulative yields are usually determined and no information on the prompt neutron emission and FFs kinematic properties. Recently, in some laboratories independent FFMDs are obtained by in-beam gamma-spectrometry.
- Pre-separation of FFs by means of mass spectrometry. A fragments selection is achieved by combination of magnetic and electric fields based on the different A/q and E/q values. Where, A is the mass number, q is the ionic charge and E is the kinetic energy.

Many the experimental setups combine different techniques to achieve wither range of mass/charge identification and higher presision.

The numbers of fissioning systems and excitation energies that may be studied by direct kinematics are limited. Considerable expansion in the fission studies has been achieved by experiments in inverse kinematics, radioactive beams and multi-nucleon transfer reactions. One of the difficulties from the experimental point of view for the measurements in direct kinematics is that the charge of the heavy fragment cannot be measured with sufficient resolution. This problem is overcome in inverse-kinematics experiments due to the boost of the fission fragments kinetic energy. Several compound nuclei lying further away from stability can be produced by a single multi-nucleon transfer reaction. The mass of the fissioning system is identified only when the mass of the ejectile is determined by charged-particle E-dE measurements in coincidence with the fission products. However, certain assumptions in the kinematical analysis need to be applied to determine the excitation energy of the compound nucleus. The so-called "surrogate" method allows relating the measured FFMDs to other target-projectile systems leading to the same compound nucleus and excitation energies. The evolution of the multi-nucleon transfer reaction to compound nucleus and fission requires compilation of the reaction with sequential particle emission and additional conditions for determine of the compound nucleus and its excited state. Such compilation will create difficulties for users to find the data. It is possible to separate the two parts of the process and consider possible solutions for the link and search options.

The following methods were studied in details and discussed trough the compilation exercises of some high quality FFMD measurements:

1. Measurements based on reaction kinematic by double energy method. A. Al-Adili, F.-J. Hambsch, S. Pomp, S. Oberstedt, and M. Vidali, Fragment-mass, kinetic energy, and angular distributions for 234U(n, f) at incident neutron energies from En = 0.2 MeV to 5.0 MeV, PHYSICAL REVIEW C 93, 034603 (2016).
2. Pre-separation of FFs by means of mass spectrometry in combination with mass yield measurements with ionization chamber and isotopic yield measurements by gamma-ray spectrometry. A. Bail, O. Serot, L. Mathieu, O. Litaize, T. Materna, U. Koster, H. Faust, A. Letourneau and S. Panebianco, Isotopic yield measurement in the heavy mass region for 239Pu thermal neutron induced fission, PHYSICAL REVIEW C 84, 034605 (2011).
3. FFMDs obtained in the multi-nucleon transfer reactins. Katsuhisa Nishio, Kentaro Hirose, Romain Leguillon, Hiroyuki Makii, Riccardo Orlandi, Kazuaki Tsukada, James Smallcomb, Satoshi Chiba, Yoshihiro Aritomo, Shouya Tanaka, Tsutomu Ohtsuki, Igor Tsekhanovich, Costel M. Petrache, and Andrei Andreyev, Experimental fission study using multi-nucleon transfer reactions, EPJ Web of Conferences 146, 04009 (2017).

Reference

[1] N. Bohr and J.A. Wheeler, Phys. Rev 56, 50, 1939
[2] V.M. Strutinsky, Nucl. Phys. A 95, 42, 1967

2.6 Experimental information required for R-matrix analysis, S. Kunieda

Firstly, he emphasized that the experimental cross section is definitely necessary for the evaluation of resonant cross-sections. Indeed, structure of the compound nucleus is so complicated that only the theoretical approach is virtually hopeless for the estimation of the resonant cross-sections. The R-matrix theory, which is based on the quantum mechanics, is a framework to obtain the energy eigenvalues and reduced-width amplitudes for each explicit channel from experimental observables. Therefore, the theory is quite useful to interpolate/extrapolate experimental cross-sections. Furthermore, once such resonance parameters are obtained, the angular distribution of emitted particle could be predicted since the S-matrix (or collision matrix) is obtained in the theory.

He presented some example results of R-matrix analysis with his code AMUR. In his analysis on the n+^{19}F cross sections, measured total and radioactive-capture cross sections are successfully fitted simultaneously once the Reich-Moore approximation is introduced. It is noted that the calculated angular distribution of elastic-scattering is quite different from the values in nuclear data library (e.g., JENDL-4.0). It was because the optical model and statistical decay model, which can calculate only the energy-averaged quantities, have been applied to the evaluation. Example results of cross-section covariance was also presented, where he emphasized that R-matrix (coupled with Kalman filtering method) is one of the useful tools not only to estimate covariance/uncertainty of the evaluated cross-sections but also to visualize nature in resonance reaction (such as the unitarity).

Finally, he mentioned about experimental information required for R-matrix analysis. The statistical and systematic uncertainty of the cross-section data should be given separately. This is relevant with not only the evaluation of cross sections but also for the estimation of covariance matrix. The resonant parameters are strongly constrained by the angular distribution data since a number of partial waves are involved in the calculation. Therefore, such differential data could reduce uncertainty of the resonance parameters. He finally emphasized that it is important to simulate experimental conditions in the resonance analysis to obtained more reliable resonance parameters. For example, information on the experimental conditions such as temperature, thickness, possible contaminants in the sample material are necessary. In addition, he suggested that it is necessary to compile information on the resolution, possible calibration, and specification of self-shielding/multiple-scattering corrections.

2.7 Compilation of neutron source spectra and other supplemental data, O. Gritzay

It was presented a proposal of N. Otsuka, O. Gritzay to create a new keyword SUPPL-INF (Supplemental information) providing supplemental information in free text, and allow to have a subentry which has this keyword without REACTION in BIB section. This is a useful option when the supplemental information is voluminous, and it improves the situation with including in EXFOR incident neutron spectra and resolution/response function.

2.8 Technical issues on EXFOR compilation at JCPRG, T. Tada

The 2nd 0+ state of ^{12}C, the Hoyle state have been investigated in many years. And the relationship between the Hoyle state and the other positive parity states have been discussed. But for the negative parity states, a few researches exist. Then we investigated the negative parity states in ^{12}C by using Real Time Evolution Method. We calculated energy, root mean square radius and transition strength in ^{12}C.

We discussed the relationship between the Hoyle state and 1- state. Next, I focus on hypernuclei in my doctor course. In 2010 and 2013, the neutron stars which have around 2.0 solar mass were observed. But the calculation including hyperon cannot reproduce the large mass. This problem is called hyperon puzzle. The YN interaction is important to solve the hyperon puzzle. Then we will investigate Ξ hypernuclei to learn Ξ-N interaction.

In JCPRG, we compile papers by using "buntan" list, HENDL (Hyper Editor for Nuclear Data Exchange Libraries), and GSYS. The buntan list is a distribution list for compilers. My internship tasks are closely related to JCPRG task. I will compile the old E entries to clear the buntan list and correct for the IAEA comments.

2.9 Uncertainty propagation in neutron activation cross section measurement using Monte Carlo and unscented transform methods, V. Devi

Data uncertainties and their covariances play an important role in quantifying the uncertainties in the evaluated data. Most frequent used method for uncertainty propagation is deterministic first order sensitivity analysis method (also known as sandwich formula) which is applicable when the joint probability density functions of the random input parameters are identified completely by the mean and covariance. Generally, first order sensitivity analysis method is based on the first order approximation of Taylor series expansion of the function of the input parameters. It works well and gives satisfactory results for most smooth non-linear functions, with relatively small uncertainties.

Monte Carlo method is a stochastic approach that relies upon repeated random sampling to obtain numerical results for modeling uncertainty. It also gives the probability distribution of the cross section that contains more information than mean and standard deviation value. On the contrary, calculations are simple in deterministic method of Unscented Transform and produces better results for error propagation in non-linear case. We present the application of Monte Carlo method and Unscented Transform method to error propagation of neutron activation cross section measurement as an alternate approach to first order sensitivity analysis method.

To study the application of three methods (Sandwich formula, Monte Carlo and Unscented transformation) in measurement of neutron induced activation cross section using activation method. Experimental work of Shivashankar et. al. had been taken as an example for the purpose. The experiment was performed using 14 UD BARC-TIFR Pelletron facility at Mumbai, India.

2.10 Digitization of unusual scales plot, M. Mikhailiukova

The possible way of digitization of plots with not-typical (round) scale for angle was presented for two figures:

386 *Yurevich V. I., Nikolaev V. A., Yakovlev R. M.*

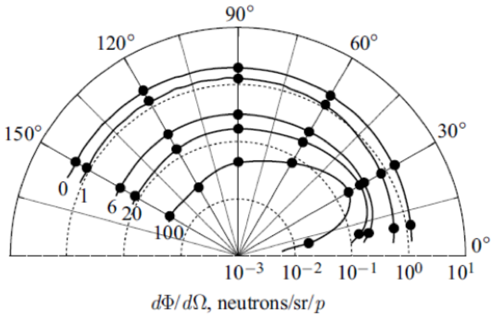


Fig. 3. Angular distributions of neutrons for different energy groups obtained for a proton energy of 0.99 GeV: the points — the experimental data; the curves — the polynomial fits; the numbers — the minimal neutron energy in MeV

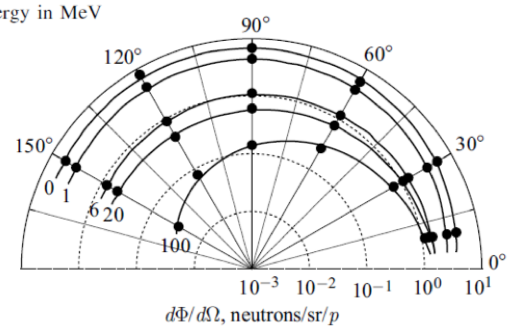


Fig. 4. The same as in Fig. 3 for a proton energy of 3.65 GeV

Figure 4: Figures for angular distributions of neutrons in Ref. [**?**]

The neutron angular distributions were digitized from these two plots and are given in two tables. The data will be inserted in EXFOR Entry 41652 as the incident neutron spectra.

Reference

[1] V.I.Yurevich, V.A.Nikolaev, R.M.Yakovlev *Journal Fizika Elementarnykh Chastic i Atomnogo Yadra, Letters*, 13(2):382, 2016.

2.11 Analysis of digitization accuracy and typical mistakes in old compilation, S. Dunaeva

The influence of non-equal distance between two ticks on an axis; non orthogonality between two axes and scanner resolution were discussed. Several examples of figure images selected from articles published in 1960s to 1980s were presented to stress the importance of checking of digitized data when an old entry is retransmitted, considering nonorthogonality between two axes, utilizing many ticks on the axes if the digitization tool allows and using GSYS with caution for digitization from old images.

2.12 Digitizer InpGraph to input numeric data into EXFOR library, S. Taova and G. Pikulina

InpGraph is a specialized software to digitize numeric data for the international library EXFOR. InpGraph may serve as an example of fruitful cooperation between the members of NRDC. They are active participants in the InpGraph testing, sending feedbacks and proposals.

InpGraph works under the control of Microsoft Windows operating system. Basic program functions are available from the InpGraph main window presented in Figure 5.

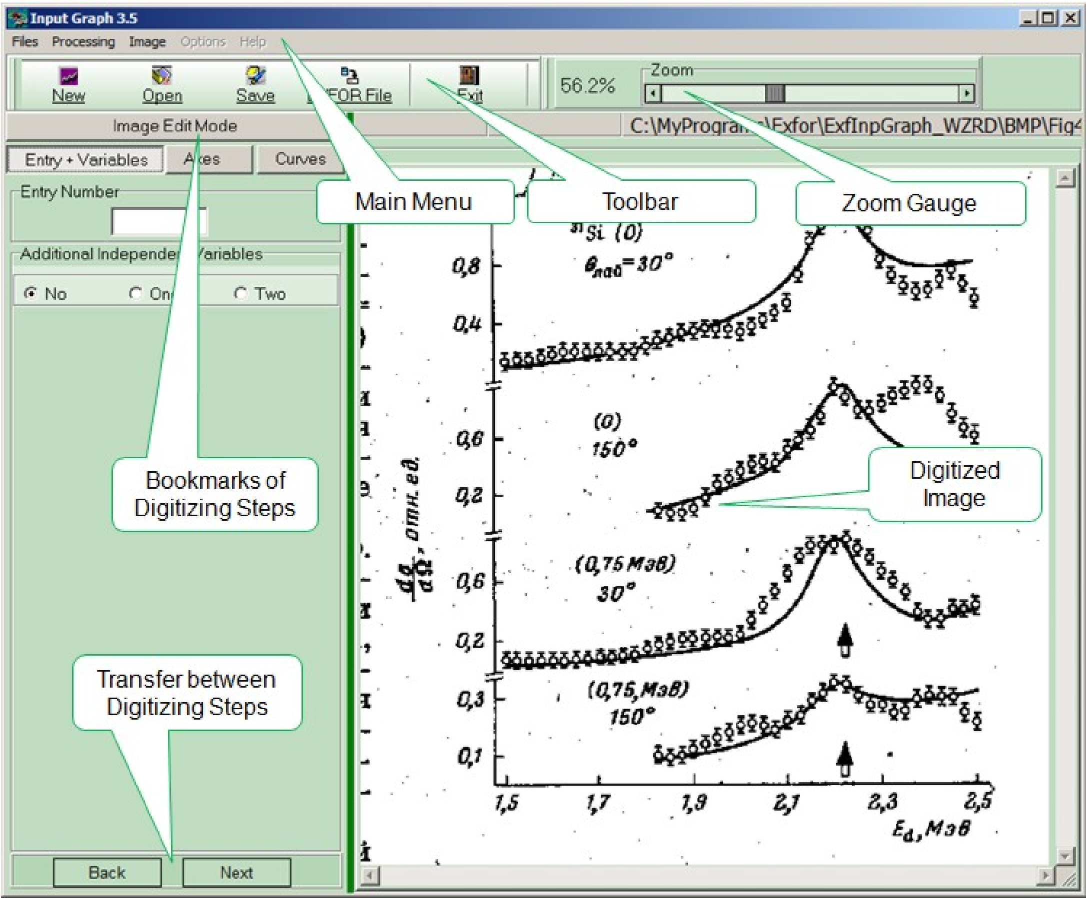


Figure 5: The InpGraph main window with example digitized data

Thus, the digitizer InpGraph has the following advantages:

- taking into account of axes ticks nonlinearity;
- taking into account of axes nonorthogonality;
- calculation of systematic error and quantization error at converting image coordinates to physical coordinates. The systematic digitizing error is calculated as a mean-square (standard) deviation of the ticks introduced along X- and Y- axes in the coordinate system of graphic representation. The quantization error is calculated as a half of an image pixel size expressed in physical coordinates;
- possibility of experienced users to correct the digitization process by making changes in the service files;
- easy-to-use interface; and
- possibility to interrupt the digitization process and resume it at any stage, make corrections and changes in the information digitized.

As the result, the InpGraph program forms completely the sections of numeric data: `DATA SECTION` and `COMMON SECTION` - according to the EXFOR rules. The DataTable mode was introduced into the last version of the InpGraph program. It provides the following possibilities: input and editing of numeric data; setting of numeric data precision; manipulation with table rows and columns; calculations;

sorting of rows into three columns; graphic presentation of numeric data; verification of data correctness; numeric data export and import in text format, Microsoft Word and Microsoft Excel formats.

Our plans consist in further development and updating of the InpGraph program.

2.13 Validation of EXFOR, the world nuclear data libraries, and TALYS, A. Koning

The current status of the so-called newbase system was outlined. Newbase (which is still a working name and deserves a better title) is a Fortran software package which reads in the entire EXFOR database in both x4 and xc4 format, as well as the corresponding data from all major world libraries. The code then produces a so called newbase/ directory, which is a directory structured database of EXFOR. For example newbase/n/Ni/060/xs/103 contains all experimental cross sections for Ni60(n,p), one file per measurement and in x-y-dy format. The entire translation process takes about 1.5 hours. In the process, newbase performs all kinds of statistics, like producing C/E and χ^2 factors for every measured data point and data set., and sort them according to their deviation from the nuclear data libraries. In this way, outliers can be detected. Also the status of uncertainties can be studied, from non-existing, obviously too small to obviously too large uncertainties. Finally automatic plots with EXFOR data and data libraries are produced for all nuclear reactions which are present in EXFOR. The whole database is a direct input to the 'T6' system which produced the TENDL library. With this systematic approach, an NEA project to make quality scores for EXFOR cross sections could be finalized in the past 5 years.

Future work includes: further determination of the "quality per author", a controversial item, output of F factors per world library separately to be send to those library projects for analyses of the quality of their libraries, and a consistent comparison between unnormalized and normalized (with newer standards etc) EXFOR.

2.14 Managing nuclear information, Z. Hakopov

The International Nuclear Information System (INIS), created to facilitate international information exchange in the broad range of scientific and technical fields related to peaceful applications of nuclear technology. Established as a system to collect and share information on nuclear research and supporting areas and driven by the efforts of the Member States of the International Atomic Energy Agency and its mandate to foster peaceful usage of nuclear technology, the International Nuclear Information System has since then massively evolved, with many factors affecting the shape and development of the system, from economic and international communication, to technological and scientific. The mandate to collect, index and store information, and at the same time create and maintain a list of subjects and related keywords which then formed the most extensive thesaurus in a multi-subject field, was the very foundation of what has later on evolved into a full-scale Knowledge Organization System.

Given the perspective, it would be natural to expect the alignment of INIS with the efforts of the knowledge management organization, and integration of the repository and the thesaurus in a global KOS with application of state of the art semantic technologies. INIS currently employs a Knowledge Organization System (KOS) consisting of an advanced multi-lingual thesaurus and an expert system. To maximize the efficiency of document indexing and utilize the possibilities of KOS to its full extent, a set of applications has been developed to automate the indexing and subject classification, and subsequently replace the manual process of input by subject specialists. The work-flow for the automated KOS-based subject indexing presented in this paper showcases the method of gradual improvement of the assistance tools. This leads to substantial improvements, both in the amount of manual work necessary and in the quality of the resulting indexing.

At present, INIS is an Open Access digital repository that provides access to over 4 Million bibliographic records, accessed over 3 Million times a year. It also hosts a full-text repository containing over 600.000 documents, and in addition, through links, leads to over 1 million full-text documents available elsewhere.

2.15 EXFOR-NSR PDF database, V. Zerkin

EXFOR-NSR PDF relational database was created in 2011 by the contents of private collections of PDF files, and regularly extended by the files exchange between tree centers: IAEA-NDS, NNDC (USA), PNPI (Russian Federation). The database is available on Web for authorized users.

History

- 2005, "Central storage of EXFOR source papers", V.Zerkin, NRDC-WP2005-14
- 2005, EXFOR source papers are systematically stored in the IAEA-NDS PDF archive
- 2011, PDF files are included to EXFOR relational database (common between NNDC and IAEA-NDS)
- 2011, EXFOR Web retrieval system provided access to PDF files from the database for authorized users on NNDC and IAEA-NDS Web sites
- 2012, PDF files of original papers of NSR are exchanged between NNDC (J.Totans, B.Pritychenko) and IAEA-NDS, and shared between NSR and EXFOR systems
- 2015, ENSDF evaluators donated their PDF collections to common database: A.Rodionov, G.Shulyak, B.Singh, G.Audi, F.Kondev
- 2015, NSR Web retrieval system provided access to PDF files for authorized users
- 2016, PNPI joined regular exchange of PDF files between NNDC and IAEA-NDS
- 2016, CINDA Web retrieval system provided access to PDF files for authorized users
- 2016, IAEA-INDC reports are publicly opened via Web EXFOR and NSR

Current status:

- content: 194,048 PDF files from 2000 to 2018 (19 years) NSR: 164,133 (72% of 229,505), EXFOR: 23,111 (73% of 31,688)
- Web access via: EXFOR, NSR, CINDA, MyEnsdf, MyExfor, etc. for authorized users: members of NRDC and NSDD networks, IAEA-CRP participants.

Database operations:

- upload PDF files to the database (with checking vs. EXFOR and NSR database)
- save PDF's from database to files
- backup/restore
- online display (Web)
- transfer PDF files from center to center

Files storage.

Original PDF files are stored in the directory structure: rootyearname.pdf. Name is created using following naming convention:

- EXFOR: REFERENCE code without issue and month; year is presented in 4-digits notation. Examples: "1974J,NIM,115,345,1974.pdf"; "1972R,ORNL-4823,1972.pdf"
- NSR: name starts with NSR-Keyno and can be extended by the version description. Example: "19881988FR23.pdf"

Two directions of development:

- extension of the contents through mini-projects based on the filtered "to-do" file
- efforts to increase public accessibility for lab reports and preprints are ongoing through official channels

2.16 Interactive 2D calibration on Web-ZVView, V. Zerkin

The problem of 2D scales calibration of the digitized pictures was in 2012 [1] with the goal: *to check correctness of the data - result of digitizing*. Further work on the problem has lead the author to the need of development of more general algorithms (and software) for image processing using 2D image calibration allowing to solve inverse problem: *to recover initial image from distorted picture*.

In 2012-2014 task of distorting picture was implemented in ZVView on C. Since 2017, all software implementing all operations for image processing was rewritten on Java and disconnected from plotting procedure, although works on Web together with Web-ZVView. Now the system is available on Web and offered together with plotting. It contains the following steps: uploading users image (source of digitizing); 2D calibration: marking scales and processing markers to "net" with optional smoothing (Fig. 6); and final step: distorting plot produced be Web-ZVView or recovering user's image (Fig. 7).

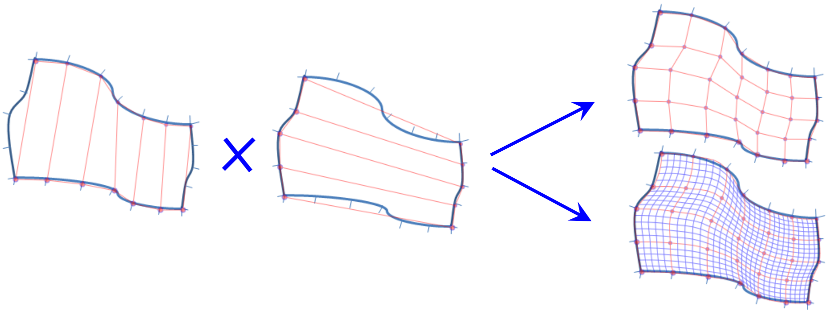


Figure 6: 2D-calibration

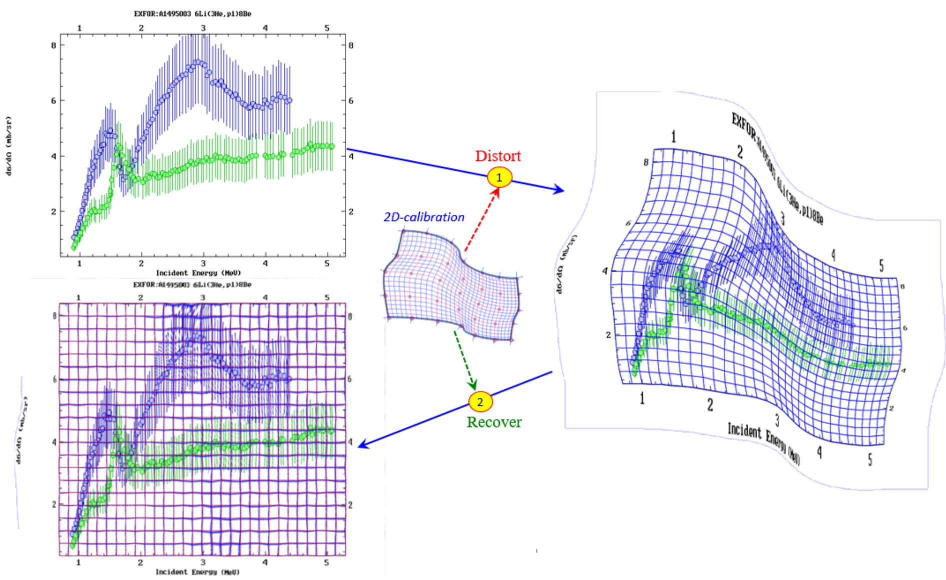


Figure 7: Self-test

Next stage of the development is preparing the package for work with the practical cases (e.g. when top/right scales are absent) and convenient Web interface.

Reference

[1] V.Zerkin, Some requirements for digitizing software and using advanced plotting for checking results, Benchmarking of Digitization Software Consultants' Meeting, 12 to 14 November 2012, IAEA

2.17 Use of 21st century software paradigms and tools for EXFOR, M. Fleming

The exchange of information for the EXFOR database is a complex and important process, which requires a rigorous Quality Assurance (QA) system and version control of many preliminary versions before data is finally submitted to the official databases.

The OECD-NEA has recently implemented a GitLab repository system to provide version control, QA and project management tools to support various activities. A specific implementation of processes for EXFOR intellectual property contract delivery has been developed and was shown in a live demonstration of the system to the NRDC Workshop participants.

This was followed with a high-level description of project workflows and how Git systems can facilitate and streamline international co-operative projects, as well as the Continuous Integration (CI) system and automated testing of version controlled content. An example was demonstrated with the Workshop Summary Report and participants were invited to engage in an exercise of directly uploading their presentation descriptions into the collaborative report.

2.18 Updates of EXFOR compilation web tool, N. Otsuka

Two new functions of the EXFOR compilation web tool installed on the JCPRG web server (http://www.jcprg.org/exfor/) were introduced. The first new function is conversion of upper cases in free text of old EXFOR entries to lower cases. Such tools have been already developed by some compilers (e.g., Feliks Chukreev, Svetlana Dunaeva). The approach adopted in the newly developed tool is different from their tools. The new tool converts all characters to upper cases, and then convert only known words to lower cases (e.g., CRYSTAL → crystal) by using GNU ASPELL (a freely available spell checker). Strings not understood by the spell checker are left to upper cases (e.g., NAI(TL), EXFOR), and they must be further corrected manually. This tool is useful to detect typos in old EXFOR entries because typos are also left to upper cases. The second new function is generation of BIB records for TITLE and AUTHOR. CrossRef, a registration agency of DOI, is distributing "metadata" of each article (e.g., title, authors, journal name, volume, page, publication year) in XML. If user of the web tool submit a reference identifier in either EXFOR style (e.g., J,NDS,120,272,2014) or DOI (e.g., 10.1016/j.nds.2014.07.065), the new tool generates the TITLE and AUTHOR. In addition to the EXFOR BIB output, the tool also generates a BIbTeX output. Below is a sample output from the tool:

```
BibTeX output =======================
  @article{example,
    author ={Otuka, N. and Dupont, E. and Semkova, V. and Pritychenko, B.
    and Blokhin, A.I. and Aikawa, M. and Babykina, S. and Bossant, M.
    and Chen, G. and Dunaeva, S. and Forrest, R.A. and Fukahori, T.
    and Furutachi, N. and Ganesan, S. and Ge, Z. and Gritzay, O.O.
    and Herman, M. and Hlava\v{c}, S. and Kat\={o}, K. and Lalremruata, B.
    and Lee, Y.O. and Makinaga, A. and Matsumoto, K. and Mikhaylyukova, M.
    and Pikulina, G. and Pronyaev, V.G. and Saxena, A. and Schwerer, O.
    and Simakov, S.P. and Soppera, N. and Suzuki, R. and Tak{\'a}cs, S.
    and Tao, X. and Taova, S. and T{\'a}rk{\'a}nyi, F. and Varlamov, V.V.
    and Wang, J. and Yang, S.C. and Zerkin, V. and Zhuang, Y.},
    title  ={Towards a More Complete and Accurate Experimental Nuclear
    Reaction Data Library (EXFOR): International Collaboration Between
    Nuclear Reaction Data Centres (NRDC)},
    journal={Nuclear Data Sheets},
    year   ={2014},
    volume ={120},
    pages  ={272--276},
    doi    ={10.1016/j.nds.2014.07.065}
  }
EXFOR output  =======================
TITLE      Towards a More Complete and Accurate Experimental
            Nuclear Reaction Data Library (EXFOR): International
            Collaboration Between Nuclear Reaction Data Centres
            (NRDC)
AUTHOR     (N.Otuka, E.Dupont, V.Semkova, B.Pritychenko,
            A.I.Blokhin, M.Aikawa, S.Babykina, M.Bossant, G.Chen,
            S.Dunaeva, R.A.Forrest, T.Fukahori, N.Furutachi,
            S.Ganesan, Z.Ge, O.O.Gritzay, M.Herman, S.Hlavac,
            K.Kato, B.Lalremruata, Y.O.Lee, A.Makinaga,
            K.Matsumoto, M.Mikhaylyukova, G.Pikulina,
            V.G.Pronyaev, A.Saxena, O.Schwerer, S.P.Simakov,
            N.Soppera, R.Suzuki, S.Takacs, X.Tao, S.Taova,
            F.Tarkanyi, V.V.Varlamov, J.Wang, S.C.Yang, V.Zerkin,
            Y.Zhuang)
END           =======================
```

3 Summary of discussion and recommendations

The workshop has encouraged the compilation, the software development, and the digitization for the EXFOR database and has facilitated the information exchange between the NRDC centers. This information exchange will enhance the compilation productivity and improve the overall quality of the EXFOR database.

In particular, we have focused on the compilation and analytics of the fission product yield (FPY) data aimed at helping to proceed the upcoming IAEA coordinated research project (CRP) on the evaluation of the FPY. The FPY nuclear data is the essential ingredient for numerous nuclear applications such as the conception of new generation reactors, ADS systems, nuclear fuel cycle developments, and medical applications. With increase in needs by those applications, FPY for wide variety of actinides and wide ranges of energy have become of great interest. For the complete and accurate evaluation of FPY data, a complete set of the experimental data is desired. Presentations and the compilation workshop have led to extensive discussions and produced valuable suggestions that are listed below in chronological order.

2.1 Use of EXFOR for fission product yield prediction, S. Okumura
- The experimental isomeric ratio data in the independent FPY is very scarce even for $^{235}\mathrm{U}(\mathrm{n_{th}},\mathrm{f})$.
- More experimental data helps to improve not only fission theories and models but also the quality of the evaluated nuclear data, and *vice-versa*.

2.2 Compilation of fission yields, B. Pritychenko
- FPY records in EXFOR do not fully covered the available FPY data and many missing data exist.
- Neutron FPY compilation statistics are analyzed by complementary check of FPY using NSR database. Data verification is basically done by O. Schwerer.
- We have to care about completeness of the EXFOR database and the FPY is the good case for the first step to check it.

2.3 Compilation and dissemination of experimental fission product yields, N. Otsuka
- Some individual FPY corrections and compilations for the evaluation purpose have been done in 1970s. Some data in such corrections are not covered in EXFOR.
- IAEA NDS starts checking the existence of records in EXFOR and CINDA based on Robert Mills' list in his Ph.D. thesis.

2.4 Visualization of fission product yield by NDPlot, Y.L. Jin
- The software is free and runs for MS Windows system. It can be downloaded from their official web site.

2.5 Fission product yield compilation(1)-(3), V. Semkova and M. Mikhailiukova
- A. Al-Adili et. al., PRC93, 034603, 2016 is compiled by all participants.
  * HISTORY: Some subentries(010-014,018,019) were corrected based on one of the author's comments and such correction should be visible from user to avoid confusions.
  * STATUS: Journal abbreviation should be given by the normal abbreviation, because free text does not expand in the X4+ format.
  * Putting all information on the free text is not recommended because it makes users confused and it may difficult them to catch an important text.
- A. Bail et al., Phys. Rev. C84 (2011) 034605 is compiled by all participants.
  * MONITOR: Need to add the way of transformation using JEFF as free text.
  * DECAY_DATA: Not directory connected to the FPY determination, but need to keep it.
- K. Nishio et al., EPJ Web Conf. 146 (2017)5 is compiled by all participants.
  * REACTION: New reaction coding for surrogate reaction have been discussed and summarized in the end of the workshop.

2.6 Experimental information required for R-matrix analysis, S. Kunieda

- Utilize the R-matrix for evaluation, the accurate experimental data is crucial. If there are differences between some experimental data, evaluators want to know the origin of the differences.
- Some experimental information which could be very helpful for evaluators if provided in the EXFOR entry are:
  1. resolution,
  2. temperature,
  3. possible contaminants on the sample,
  4. sample thickness,
  5. possible calibration error,
  6. specification of self-shielding/multiple -scattering corrections,
  7. information on double-bunch (but only the case for J-PRAC data)
- Extracting the data from EXFOR and coding own code by users or evaluators is faster, S. Kunieda mentioned that it is worth considering to provide dynamic EXFOR/C5 with e.g., Python, Ruby, ROOT, etc.
- To implement a change in a system, a strong demand is needed, but sometimes such demand is not permanent and become unnecessary after few years. Therefore keeping the EXFOR system general always comes first. However if one wants to get data in a special format for limited users, it is also possible to create and provide for them.
- Raw data (not processed experimental data) is more important, but difficult to store in EXFOR database.

2.7 Compilation of neutron source spectra and other supplemental data, O. Gritzay
- MEMO CP-D/965 on neutron source data and supplemental data in SUPPL-INF and LEXFOR update for this aim was presented and accepted.
- The trial will start with no standard data format, free format from author, and will decide later based on our trials.

2.8 Technical issues on EXFOR compilation at JCPRG, T. Tada
- Current status of compilation at the JCPRG is presented. He shared the situation of the operation with a limited number of staff.

2.9 Uncertainty propagation in neutron activation cross section measurement using Monte Carlo and unscented transform methods, V. Devi
- EXFOR compilation activity and successful contribution to create EXFOR entries in the workshop held at India are explained.

2.10 Digitization of unusual scales plot, M. Mikhailiukova
- The digitization technique of the unusual semicirculer shape and scale for the incident neutron spectra was shared.

2.11 Analysis of digitization accuracy and typical mistakes in old compilation, S. Dunaeva
- Non-linear scale (not logarithmic, the scale is not located equally distance, the experimental points are at correct position, but scales (ticks) are not at correct positions.) case should be treated by a precise way. [e.g. Appl.Rad.1975, 20886]
- We should not forget to check the digitized data by an old digitizer when revising old entries.

2.12 Digitizer InpGraph to input numeric data into EXFOR library, S. Taova and G. Pikulina
- Publication concerning the InpGraph is strongly recommended so that researchers or evaluators can refer it.

2.13 Validation of EXFOR, the world nuclear data libraries, and TALYS, A.Koning
- For the modern nuclear data evaluation, it is important to specify inclusion or exclusion of the experimental data based on their quality.
- For such purpose, the inverse route of the quality assessment by using the evaluated nuclear data libraries and TALYS to check quality of data in EXFOR was presented. This allows us to check the origin of erroneous data possibly by complier's mistakes or experimental techniques.

- 2.14 Managing nuclear information, Z. Hakopov
  - Old publication's digitization is done by OCR technique, but the digitization from images (graphs or figures) is out of the scope of INIS.
  - The expansion $SCOAP^3$ to low energy nuclear physics was discussed.
- 2.15 EXFOR-NSR PDF database, V. Zerkin
  - INIS and EXFOR pdf corrections should corporate each other.
  - Discussed the possibility for providing/sharing PDF by INIS to overcome the copyright issue.
- 2.16 Interactive 2D calibration Web-ZVView, V. Zerkin
  - The 2D calibration algorithms and software were redesigned and have already been available at EXFOR web.
- 2.17 Use of 21st century software paradigms and tools for EXFOR, M. Fleming
  - We should move forward to introduce more convenient management system for NRDC activities on exchange the data among data centers.
  - Traditional methods and proposed repository systems are compared in pros and cons.
  - GitHub is proposed to use collaborative work for NRDC activities.
  - More discussion is required in terms of most appropriate software, target activities, responsibility of the server management and more.
- 2.17 Updates of EXFOR compilation web tool, N. Otsuka
  - A web tool on JCPRG server for (1) conversion of upper cases to lower cases for old EXFOR entries, and (2) automatic TITLE and AUthor record creation have been implemented and is available at: http://www.jcprg.org/exfor/tool/.

- Additional discussion on the coding for surrogate reactions for fission observables, V. Semkova and N. Otsuka
  - New REACTION coding for the surrogate reaction was discussed.
  - Proposal 1: REACTION (92-U-238(8-O-18,8-O-17+F),PRE/SEQ/PAR/PRV,AP,LF/U239)
    * SF5 is not understandable, but physically realistic.
    * ANALYSIS (SURGT) is not necessary if the reaction code is expressed as they are measured.
  - Proposal 2: REACTION (92-U-238(N,F),PRE,AP,LF,DERIV)
    ANALYSIS (SURGT) 238U(18O,17O+F) was measured.
    * Treating as a neutron induced fission, but with SURGT keyword in ANALYSIS.
  - Proposal 3: REACTION (92-U-239-X(0,F),PRE,AP,LF)
    ANALYSIS (SURGT) 238U(18O,17O+F) was measured.
    * Treating as a spontaneous fission, but with SURGT keyword in ANALYSIS.
    * Spontaneous fission coding way is more simpler and does not require complex reaction code.
  - There are pros and cons. N. Otsuka will discuss with evaluators at the consultant meeting on May, 2019.
  - So far, we should use the Proposal 1 which is based on the actual measurement and the current coding rule.

A Agenda

Workshop on the

Compilation of Experimental Nuclear Reaction Data

22 - 25 October 2018, Vienna, Austria

Meeting Room: Vienna International Centre Room C0440

AGENDA (Draft 2018-10-19)

(Coffee break as appropriate)

Monday, 22 October 2018

9:30 – 13:00

1	**Opening**		
1.1	Welcome address	10 min	A. Koning
1.2	Self-introduction	10 min	All
1.3	Announcement	5 min	A. Oechs
1.4	Election of chairperson and rapporteur, adoption of the agenda, announcements	5 min	N. Otsuka
2	**Presentation (1)**		
2.1	Use of EXFOR for fission product yield prediction	45 min	S. Okumura
2.2	Compilation of fission yields	45 min	B. Pritychenko
2.3	Compilation and dissemination of experimental fission product yields	45 min	N. Otsuka
2.4	Visualization of fission product yield by NDPlot	45 min	Y.L. Jin

14:00 – 17:00

3	**Exercise (1)**		
3.1	Fission product yield compilation (1)	30 min	V. Semkova
3.2	Compilation exercice (1) - A. Al-Adili et al., Phys. Rev. C**93** (2016) 034603.	150 min	All

Tuesday, 23 October 2018

9:00 – 13:00

3	**Exercise (1) – Cont.**		
3.3	Presentation of the EXFOR draft (1)	60 min	M. Mikhailiukova
4	**Presentation (2)**		

4.1	Experimental information required for R-matrix analysis	45 min	S. Kunieda
4.2	Compilation of neutron source spectra and other supplemental data	45 min	O. Gritzay
4.3	Technical issues on EXFOR compilation at JCPRG	45 min	T. Tada
4.4	Uncertainty propagation in neutron activation cross section measurement using Monte Carlo and unscented transform methods	45 min	V. Devi

14:00 – 17:00

5	**Exercise (2)**		
5.1	Fission product yield compilation (2)	30 min	V. Semkova
5.2	Compilation exercise (2) – A. Bail et al., Phys. Rev. C**84** (2011) 034605	150 min	All

Wednesday, 24 October 2018

9:00 – 13:00

5	**Exercise (2) – Cont.**		
5.3	Presentation of the EXFOR draft (2)	60 min	M. Mikhailiukova
6	**Presentation (3)**		
6.1	Digitization of unusual scales plot	45 min	M. Mikhailiukova
6.2	Analysis of digitization accuracy and typical mistakes in old compilation	45 min	S. Dunaeva
6.3	Program InpGraph to input numerical data into Exfor library: new features.	30 min	G. Pikulina
6.4	Examples and exercises to work with the program of discrete image treatment InpGraph	60 min	S. Taova

14:00 – 17:00

7	**Exercise (3)**		
7.1	Fission product yield compilation (3)	30 min	V. Semkova
7.2	Compilation exercise (3) – K. Nishio et al., EPJ Web Conf. **146** (2017) 04009	150 min	All

19:00 –

Social diner (Heuriger “Zum Pospisil”, Bloschgasse 9, 1190 Wien. Meeting at Gate I at 18:15 or at the entrance of U4 Heiligenstadt at 18:40.)

Thursday, 25 October 2018

9:00 – 13:00

7	**Exercise (3) – Cont.**		
7.3	Presentation of the EXFOR draft (3)	60 min	V. Semkova
8	**Presentation (4)**		
8.1	Validation of EXFOR, the world nuclear data libraries, and TALYS	30 min	A. Koning
8.2	Managing nuclear information	30 min	Z. Hakopov
8.3	EXFOR-NSR PDF database	15 min	V. Zerkin
8.4	Interactive 2D calibration on Web-ZVView	60 min	V. Zerkin
8.5	Use of 21st century software paradigms and tools for EXFOR	30 min	M. Fleming
8.6	Updates of EXFOR compilation web tool	30 min	N. Otsuka
11.	**Closing**		
11.1	Review of workshop summary	30 min	Chairperson
11.2	Closing address	10 min	

B List of participants

Workshop on the

Compilation of Experimental Nuclear Reaction Data

22 - 25 October, 2018, Vienna, Austria

Meeting Room: Vienna International Centre Room C0440

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