

Report on the 5th DAE-BRNS Theme Meeting on EXFOR Compilation of Nuclear Data

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Abstract

This report summarizes the contents of the workshop on EXFOR compilation of the nuclear data. The workshop goal is to understand the idea of nuclear database. A start description of introduction, main topics of the agenda, status report in India compilation EXFOR activities, concluding remarks, list of participants and programme are given.

1 Introduction

We start with the definition of nuclear data and their types. **Nuclear Data:** Quantitative results of any scientific investigation of the nuclear properties of matters, nuclear physics data or “Nuclear constants” for example: cross sections, half-lives decay modes and decay radiation properties, gamma rays from radio nuclides

Nuclear Data types: The Nuclear data types that are available at the data centres are:

Bibliographic data	→	CINDA, NSR
Experimental data	→	EXFOR
Nuclear Reaction data	→	ENDF
Nuclear structure and decay data	→	ENSDF

A server in BARC, Mumbai (www-nds.indcentre.org.in) is at present mirroring the nuclear data services of the IAEA, NDS website (www-nds.iaea.org), Vienna. Users can get all the recommended nuclear data from the mirror websites, which is now fully operational. Scientists are invited to make maximum use of this facility for recommended values of nuclear data for use in research and other applications including raw data in EXFOR database. The scientists who have worked on measurements of basic nuclear data, are also welcome to code their own published nuclear data into the EXFOR system. The network was established to coordinate the world-wide collection, compilation and dissemination of nuclear reaction data.

Based upon India’s EXFOR compilation activities, India was invited and joined the NRDC network as 14th member in September 2008. The DAE-BRNS conducted successfully five EXFOR training workshops in BARC, Mumbai (2006, 2007), University of Rajasthan, Jaipur (2008) and Panjab University Chandigarh (2011). The fifth Indian EXFOR workshop was successfully organized by Department of Physics Banaras Hindu University Varanasi during February 18-22, 2013. In each of these five workshops, more than 50 delegates (Institute staff, University faculty, Ph.D

International Network of Nuclear Reaction Data Centres (NRDC)

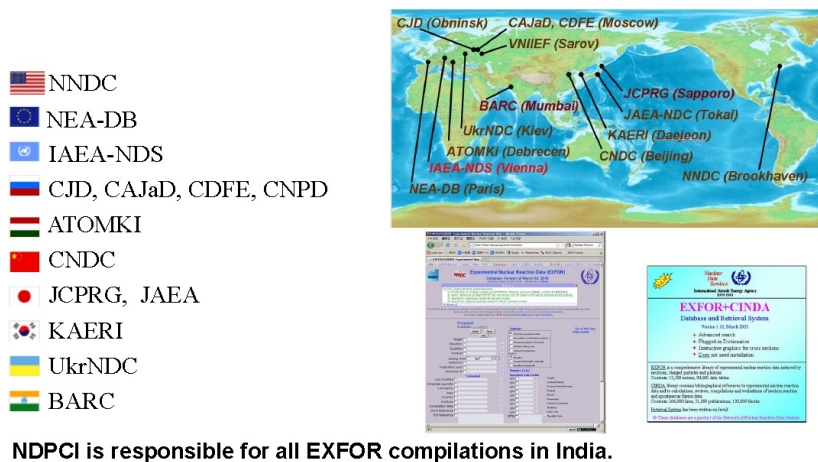


Fig. 1: The International Network of Nuclear Reaction Data Centres (NRDC) constitutes a world-wide cooperation of nuclear data centres under the auspices of the International Atomic Energy Agency.

and M.Sc students) took active part and got a first time exposure to a classical nuclear data physics activity of EXFOR compilation culture.

The “The 5th DAE-BRNS Theme Meeting on EXFOR” was attended by about 50 participants from various institutes in India, Japan, IAEA and Russia. The participants included not only a wide geographical scope of Indian institutions from South to North and from East to West, but with a wide range of scientific career profiles from graduate students to distinguished senior professors which included nuclear physicists, theoreticians, experimentalists and reactor physicists.

Over 50 delegates worked from 9:30 AM to 7:00 PM every day. This theme meeting was not in the nature of a usual seminar or conference. During the theme meeting, the delegates had a lot of discussions and EXFOR coding tasks were performed in a focused manner for placing the Indian nuclear physics experimentalist nuclear physics data into the IAEA EXFOR database.

Brief Minutes

P.D. Krishnani, A. Saxsena and **S. Ganesan** from Bhabha Atomic Research Centre (BARC), Mumbai inaugurated and addressed the session. **P.D Krishnani** clarified that all nuclear research have to be theoretically validated for the use of different purposes. He further said that India was at the threshold of utilizing nuclear energy and Uranium resources in India were just about 1% of that of the world. **S. Ganesan**, Raja Ramanna Fellow, from BARC delivered a special talk on the personal perspectives on challenges and excitement in research and development for physicists in nuclear industry. He described the importance of designing the best nuclear reactor. He described the importance of designing the best nuclear reactor that can be exceptionally safe, proliferation resistant and produce minimum radioactive waste. He reported about the nuclear data, their different types and evaluation of the data. He also emphasized on the need to address the problem of well understanding the use of the nuclear data with errors and co-variances. He stressed that even after 60 years of nuclear energy, the uncertainties in nuclear data dominate over many other uncertainties necessitating a large number of one to one integral critical experiments. **N. Otsuka**

from the IAEA, Vienna, Austria, gave a description of EXFOR, EXFOR entries, importance of EXFOR in basic nuclear physics, nuclear programme and applications. He also reported about the goal and scope of this EXFOR workshop. The goal of the workshop is to understand the idea of EXFOR nuclear database and train future EXFOR compilers of India.



Fig. 2: S. Ganesan delivering a talk

2 Objectives

The purpose of this EXFOR workshop is to perceive the idea of nuclear database to understand the utility of the EXFOR compilation in basic nuclear physics, nuclear programme and applications and to use the nuclear data library in structure data and nuclear reaction data.

In the EXFOR workshop there were fifty participants in total, one from the IAEA, Vienna, Austria, one from RFNC-VNIIEF, Russia, one from (JCPRG) Japan and all others participants from the different parts of India.

3 Main Topics of the Agenda

The agenda covered in the EXFOR workshop is discussed below:

a) Introduction of various databases:

Introduction of various databases like NSR, ENSDF, etc., was discussed by **N. Otsuka**. He gave the description of EXFOR and different databases used worldwide. He also spoke about the way to access the EXFOR search by reactions and EXFOR cross sections plot from the website (<http://www-nds.iaea.org/exfor>). Plotting of EXFOR data with theoretical data and comparison with evaluated data libraries were also the main topics of his talk. He provided some exercises to the participant to make them proficient in using EXFOR. All the participants had actively participated to solve these exercises. He also demonstrated the utilities of the EXFOR compilation.

b) Various tools of compilation:

The various tools of compilation were described by **S.Dunaeva**. She told the method of installation of the new EXFOR editor and introduced the different functions and keywords of the EXFOR editor. **B. Lalremrula**, who is the national co-ordinator for Indian EXFOR compilations, had distributed a new research article to each participant for compilation.



Fig. 3: N. Otsuka delivering a talk on EXFOR Format

c) Introduction of EXFOR Format (BIB, COMMON and DATA Sections):

In this section, **N. Otsuka** introduced the EXFOR Format and discussed about the duplication of the entries. He suggested that it is better to send the entry to the author after compilation to improve the quality of the entry. **S. Dunaeva** described in detail about the basic concepts e.g section, major, keywords, coded information, free text etc. She also reported major bib keywords and the creation of common subentry using the EXFOR editor. Participants had done exercises with assigned entry in the practical session.

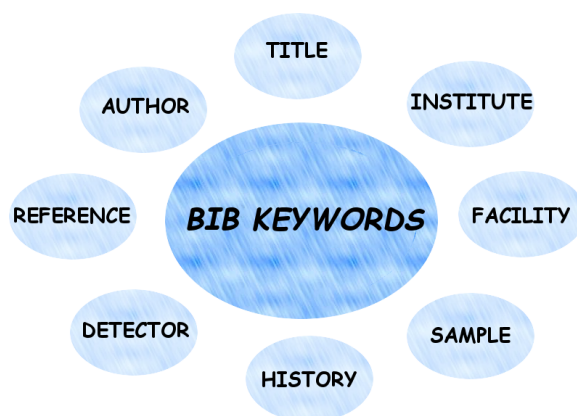


Fig. 4: Description of EXFOR Format

d) Introduction of EXFOR Format (Nuclide and Reaction specifications):

EXFOR Format was introduced by **N. Otsuka** and **S. Dunaeva**. This section contained the data description, reaction, error-analysis, status and heading unit. N.Otsuka reported about the reaction codes and sub fields within reaction codes.

$(\$SF1(\$SF2, \$SF3)\$SF4) \longrightarrow$ Reaction Field
 $(\$SF5, \$SF6, \$SF7, \$SF8, \$SF9) \longrightarrow$ Quantity Field

He also reported many examples to understand these reaction codes and sub fields in reaction codes e.g cross section, (Proton) angular cross section, (Proton) double differential cross section, (Proton) Rutherford ratio, prompt fission neutron multiplicity, prompt fission neutron spectrum etc. He also taught about the covariance and the related topics.

S. Dunaeva described about the compilation of decay-data, error-analysis, status and data heading by taking an entry as an example. After that all the participants practiced with the assigned entries in the practical session.

e) Introduction Digitizer:

V. Devi reported about the Gsys 2.4.3 digitizer. She described about the installation and different function of the Gsys 2.4.3. She introduced the digitization of the numerical data, symmetric, asymmetric error and output of the numerical data by demonstrating one example. She also taught about the guidelines for the expression of digitized data in EXFOR and explained the recommendations to all the EXFOR compiler participating in the workshop. The participants were then provided related exercises in the practical session.



Fig. 5: V. Devi delivering a talk on Gsys.

f) Data table presentation

Data table description was reported by the **S. Dunaeva**. She taught the procedure to insert the numerical data in the EXFOR format to all participants. After the presentation all participants had actively participated in assigned entry.

g) Presentation on Experimental Facility

Measurement of elastic and inelastic differential neutron cross sections for ^{23}Na between 1 and 4 MeV was presented by **A. Tyagi**. He talked about the Experimental facility, TOF spectra and fitting, neutron detector efficiency, scattering cross-section values and multiple scattering and attenuation corrections.

h) Presentation on Covariance

Covariance matrices in relative measurement of neutron cross-section were reported by **B.S. Shivshankar**. He is a Ph.D. student of **S Ganesan**. He demonstrated, in his talk about the following:



Fig. 6: A. Tyagi delivering a talk on experimental facility.



Fig. 7: B.S. Shivashankar delivering a talk on covariance.

- the meaning of mean $\pm$ uncertainty from the perspective of probabilistic inference.
- meaning of uncertainty due to random and systematic errors.
- derivation of uncertainty propagation formula with examples.
- introduction to the concept of partial uncertainty and micro-correlations and its applications in nuclear data evaluation with efficiency calibration as an example.
- discussion of relative cross-section measurement and generating covariance matrix from the methods developed.
- idea of generalized least square method and its applications.

4 A Status report on Indian EXFOR compilation activities

India's successful contribution in EXFOR entries are:

- 10 new entries in 2006 Workshop (Faculty: **O. Schwerer** Manual entries)
- 31 new entries in 2007 Workshop (Faculty: **S. Dunaeva**, EXFOR editor)
- 55 new entries in 2009 Workshop (Faculty: **S. Dunaeva**, EXFOR editor software)
- 80 new entries in 2011 Workshop (Faculty: **S. Dunaeva**, EXFOR editor software used)
- 40 new entries in 2013 Workshop (Faculty: **S. Dunaeva** and **N. Otsuka**, EXFOR editor software used)

In this workshop, 40 new entries of important Indian data which were missing in EXFOR were compiled during the workshop, which is a remarkable achievement. The data compiled at the workshop were entered into the database through NDS after the usual and final checking procedures done at NDS.

After finishing the EXFOR coding, every participant checked their respective EXFOR entries with the help of the JANIS Online TRANS Checker (www.oecd-neo.org/janisweb). These entries were submitted to **A. Saxena** and **S. Dunaeva** after removing the errors in it who gave their comments and suggestions to the participant. **S. Dunaeva** spent about a week, as a visiting scientist, at BARC, Mumbai after the BHU theme meeting to finalize the entries before they can be sent for approval from authors and finally submitted to the IAEA data base. She also sought clarifications from the authors wherever the information was missing. She could correct almost all the entries and the corrected entries were sent to individual compilers and to the authors for final approval of numerical data as required by EXFOR protocols.

5 Summary

The summary of the EXFOR workshop :

- The workshop was phenomenally successful and left a lasting influence on each participant. The participants compiled 40 EXFOR entries in total. These Indian EXFOR workshops present a new managerial initiative by BARC and has enhanced the positive image of BARC even further. The EXFOR compilations in India have helped to provide increased visibility to India's nuclear physics experiments through the EXFOR database.

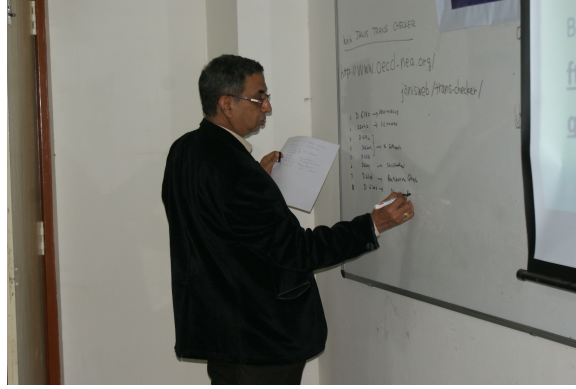


Fig. 8: A. Saxena reporting about the compiled entries.

- It is good to see that in India a number of young nuclear scientists are willing and able to take up compilation work. The most of young scientists have shown a keen interest in nuclear physics.
- It is very nice to note that Indian nuclear physics experimentalists compile their own work.
- The overall organization and infrastructure of the workshop were excellent. The organizers invested much personal initiative, work and thought in the organization of the workshop, including selection of the most promising participants and expressed their willingness to host other events such as an NRDC meeting or ICTP- workshops and certainly would be able to handle these types of meetings.
- The 6th EXFOR workshop as per informal thoughts that occurred in the workshop may be proposed to NDPCI authorities to be held in December 2014 or January 2015 for a week in Bangalore University, Karnataka.



Fig. 9: Group Photo 1



Fig. 10: Group Photo 2

Acknowledgement

The authors would like to acknowledge the support by "'R&D' Platform Formation of Nuclear Reaction Data in Asian Countries (2010-2013)", Asia-Africa Science Platform Program, Japan Society for the Promotion of Science. I am thankful to:

- **Dr. S. Ganesan, Dr. A. Saxsena and Dr. P. D. Krishnani** for organizing the theme meeting on "EXFOR Compilation of Nuclear Data".
- **Dr. N. Otsuka** for sharing his experience of EXFOR with participants.
- **Dr. Ms. S. Dunaeva** for help in using new EXFOR Editor and checking the compilations sent to the IAEA.
- **Dr A. Tyagi** and Department of Physics, Banaras Hindu University, Varansi for continuous encouragement.

In addition, I would like to acknowledge the support by "'R&D' Platform Formation of Nuclear Reaction Data in Asian Countries (2010-2013)", Asia-Africa Science Platform Program, Japan Society for the Promotion of Science.

Annex. I

List of Participants

NAME	AFFILIATION
N. P. Sathik	Bharathi Dasan University, Tiruchirappalli, India
E. Jeyasingh	Bharathi Dasan University, Tiruchirapalli, India
N. Hind	University of Calicut, Kerala, India
K. K. Rajesh	University of Calicut, Kerala, India
T. Najmunnisa	University of Calicut, Kerala, India
M. M. Musthafa	University of Calicut, Kerala, India
B. Jyrwa	North Eastern Hill University, Shilong, India
H. Kumar	Aligarh Muslim University, Aligarh, India
A. Pritam	Devi Ahilya Vishwavidyalaya, Indore, India
P. Mishra	Devi Ahilya Vishwavidyalaya, Indore, India
U. S. Ghosh	Visva-Bharati University West Bengal, India
K. Mondal	Visva-Bharati University West Bengal, India
A. Srivastava	Bhabha Atomic Research Centre, Mumbai, India
B. Trivedi	Maharaja Sayajirao University, Baroda, India
S. Ganesan	Department of Atomic Energy, Mumbai, India
V. K. Mullik	University of Pune, India
M. B. Chatterjee	Saha Institute of Nuclear Physics, Kolkata, India
M. Gupta	Bareilly College, Bareilly, Uttar Pradesh, India
P. Kumari	National Institute of Technology, Jalandhar, Panjab, India
K. C. Jagadeesan	Bhabha Atomic Research Centre, Mumbai, India
V. Vansola	Maharaja Sayajirao University, Baroda, India
B. S. Shivshankar	Manipal University, Karnataka, India
C. K. Raj	Bharathiar University, Coimbatore, India
B. Lalremruata	Mizoram University, Aizawl, India
Hranghmingthanga	Mizoram University, Aizawl, India
A. Kr. Bajpei	Rajiv Gandhi Institute of Petroleum Technology, Rae Bareilly, India
K. Kumar	Aligarh Muslim University, Aligarh, India
B. Rudraswamy	Bangalore University, Karnataka, India

N. Bansal	Panjab University, Chandigarh, Panjab, India
S. N. Ray	Visva-Bharati University West Bengal, India
S. Dutt	Bareilly College, Bareilly, Utter Pradesh, India
M. Balasubramaniam	Bharathiar University, Coimbatore, India
L. Punte	Mizoram University, Aizawl, India
S. Kumar	Chaudhary Charan Singh University, Meerut, India
C. Singh	Chaudhary Charan Singh University, Meerut, India
B. Satheesh	National Institute of Technology, Calicut, India
A. Kumar	DAV (PG) College, Muzaffarnagar, Utter Pradesh, India
K. S. Babu	Amrita Sai Inst. of Science and Tech, Andhra Pradesh, India
S. A. Dunaeva	Center of Nuclear-Physics Data (CNPd), Russian Federal Nuclear Center-VNIIEF, Russia
N. Otsuka	International Atomic Energy Agency (IAEA), Vienna, Austria
A. Saxena	Bhabha Atomic Research Centre, Mumbai, India
A. Chakraborty	Bhabha Atomic Research Centre, Mumbai, India
C. Kr. Gupta	Delhi University, Delhi, India
A. Rohilla	Delhi University, Delhi, India
R. Ghosh	North Eastern Hill University, Shilong, India
S. Badwar	North Eastern Hill University, Shilong, India
A. Bhattaacharya	Bhabha Atomic Research Centre, Mumbai, India
S. S. Manian	Valliappan Olaganthan Chidambaram College, Tuticorin, India
V. Devi	Meme Media Laboratory, Hokkaido University, Sapporo, Japan
S. Rai	Mizoram University, Aizawl, India
H. B. Sachhidananda	Siddaganga Institute of Technology, Tumkur, India
S. Charaborty	Banaras Hindu University, Varanasi, India

Annex. II

PROGRAM

Feb. 18	(Monday)	
09:00-09:30	Registration	
09:30-10:00	Inaugural/Introductory Session	
10:00-10:30	Tea/Coffee break	
10:30-11:00	Introduction to the scope, contents and objectives of the Workshop-Importance of EXFOR in basic nuclear physics research, nuclear programme and applications http://www-nds.indcentre.org.in/exfor/	N. Otsuka (IAEA-NDS)
11:00-13:00	Lectures/presentation	
13:00-14:00	Lunch break	
14:00-16:00	Lecture-Various database: NSR, ENSDF etc Exercise-Various database: NSR, ENSDF etc	N. Otsuka (IAEA-NDS)
16:00-16:15	Tea/Coffee break	
16:15-18:00	Lecture-EXFOR/ENDF database: EXFOR and ENDF Exercise-EXFOR/ENDF database : EXFOR and ENDF	S. Dunaeva (Russia)
18:00-19:00	Popular evening lecture	
19:30	Dinner	
Feb. 19	(Tuesday)	
09:30-11:00	Lecture-EXFOR format I: Basic concepts (section, major, keywords, coded information, free text) Lecture-Editor I: Major BIB keywords (title, author, institute, facility, sample, detector, history)	N. Otsuka (IAEA-NDS) S. Dunaeva (Russia)
11:00-11:15	Tea/Coffee break	
11:15-13:00	Exercise-Editor I: Major BIB keywords for a short article	
13:00-14:00	Lunch break	
14:00-16:00	Lecture-Review of the morning exercise: Creation of common subentry using software EXFOR editor :Pitfalls Exercise-Editor II: Major BIB keywords for new Indian entries	S. Dunaeva (Russia)
16:00-17:00	Evening lecture and visit to physics department	S. Ganesan (BARC)
19:00	Dinner	
Feb. 20	(Wednesday)	

09:30-11:00	Lecture-EXFOR format II: Data description (reaction, error-analysis, status, heading, unit)	N. Otsuka (IAEA-NDS)
	Lecture-Editor III: Data description (reaction, error-analysis, status, heading, unit)	S. Dunaeva (Russia)
11:00-11:15	Tea/Coffee break	
11:15-13:00	Exercise-Editor III: reaction, error-analysis, status, heading, unit for a short article	
13:00-14:00	Lunch break	
14:00-16:00	Lecture-Review of the morning exercise: Creation of data subentry using software EXFOR editor: Pitfalls	S. Dunaeva (Russia)
	Exercise-Editor IV: reaction, error-analysis, status, heading, unit for new Indian entries	
16:00-16:15	Tea/Coffee break	
16:15-18:00	Exercise-Editor IV	
18:00-19:30	Excursion (Boat trip) IV	
19:30	Dinner	
Feb. 21	(Thursday)	
09:30-11:00	Lecture/presentation: Lecture-Digitizer	V. Devi (JCPRG, Japan)
11:00-11:15	Tea/Coffee break	
11:15-13:00	Lecture-Editor III: Inclusion of numerical data to EXFOR entry	S. Dunaeva (Russia)
	Exercise-Digitizer and data table preparation I: Digitization and data table inclusion for a short article	
13:00-14:00	Lunch break	
14:00-16:00	Lecture-Review of morning exercise: Creation and inclusion of data table: Pitfalls	S. Dunaeva (Russia)
	Exercise-Digitizer and data table preparation II: Digitization and data table inclusion for Indian entries	
16:00-16:15	Tea/Coffee break	
16:15-18:00	Exercise-Digitizer and data table preparation II	
19:30	Dinner	
Feb. 22	(Friday)	
09:30-11:00	Exercise-Creation of new Indian entries	
11:00-11:15	Tea/Coffee break	
11:15-13:00	Exercise-Creation of new Indian entries	N. Otsuka (IAEA-NDS)
	Lecture: Transmission of your EXFOR entries to the IAEA	
13:00-14:00	Lunch break	