A BRIEF STATUS UPDATE ON THE ACTIVITIES OF BARC DURING 2016-2018

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On behalf of nuclear data scientists in India

Introduction

BARC (Bhabha Atomic Research Centre) is the nodal centre for design, development and the application of nuclear technology for the welfare of mankind. BARC is responsible for broad range of nuclear data activities in India. BARC, Mumbai, is part of DAE (Department of atomic Energy) and is the nodal centre for the collaboration with IAEA-NDS, CERN, NRDC and others. The BARC is responsible for theoretical, experimental nuclear physics research and code development for the implementation of Indian nuclear programme. This include nuclear data generation, processing, and use of nuclear data for the reactor system design. At present the BRNS has sanctioned many collaborative research projects on experimental nuclear reaction and nuclear structure data, and compilation of the data to research groups in universities and institutes with full financial support from BRNS. The projects are overviewed and supported by DAE scientists as principal collaborator. Many projects in the field of nuclear data including experimental measurement and theoretical evaluation has been granted and completed under purview of BARC and BRNS. BARC has been able to accomplish in all the fields of nuclear data as well as nuclear system development activities of interest to DAE. This report is based on work done by various research teams and groups for the duration of 2016-2018. This report includes the work reported by the BRNS supported research teams and the contribution of individual scientists of BARC and other constituents of DAE, namely, VECC and IGCAR. This report is not an exhaustive statement on all the activities in India. This report is prepared for the presentation and submission in NRDC-2018.

1.0 Activity related to EXFOR compilation

1.1 Biennial workshop Nuclear Reaction and EXFOR compilation at NEHU, Shillong, during March 06-10, 2017.(https://www-nds.iaea.org/nrdc/india/ws2017/)

Biennial EXFOR workshop is organised by the Nuclear Data Physics Centre of India, BARC through BRNS. The 8th biennial workshop on nuclear reaction and EXFOR compilation was convened by Department of Physics, NEHU at "North East Hill University", Shillong during March 04-10, 2017.

The series of biennial workshop has been very successful in spreading the skill and practice of EXFOR to the scholars under BRNS project and university students who attend the workshop in large number. This workshop was attended by about 40 participants and about 40 entries were made (Fig 1.1). The workshop also consisted of lectures on various topics of interest by senior participants. The workshop was conducted by Dr. N. Otsuka, IAEA with the help of local team, Ms. Rituparna Ghosh, Ms. Sylvia Badwar and visiting faculties Dr. Vidya Thakur (IET), Dr. Rema (Mizoram Univ.), Mr. Devesh Raj (BARC), Dr. B.K. Nayak.

Fig 1.1 Session in Progress

1.2. BRNS funded research project on experimental nuclear data and nuclear data compilation

BRNS is the nodal agency for the funding of collaborative research projects in the field of nuclear sciences. Since 2015, BRNS has dedicated committee for the projects falling in the category of nuclear data and application.

BRNS funded project on experimental nuclear data research requires the team concerned to make EXFOR compilation of their experimental result. This compilation work is often accomplished during the Biennial BRNS EXFOR workshop under expert supervision. The BRNS project under Dr. Vidya Thakur, Associate Professor of Physics, IET is responsible for the coordination with Dr. Otsuka in checking of the compiled data with the compiling group for the corrections and compiling errors and provide final entry to be included in EXFOR data base. The projects at BHU, Varanasi, BU, Bangalore, MSU, Vadodara, CU, Calicut, PU, Pune are having incident neutron data measurement and its compilation as deliverables while project under Dr. Vidya Thakur is exclusively for the EXFOR compilation of Indian nuclear

reaction data measurements. BRNS has also granted a three year project on nuclear structure data evaluation and ENSDF compilation.

Following are the listing of ongoing and sanctioned projects on nuclear data measurement and compilation.

Table 1.2

Sanction Number/File No.	Title of the Project	Principal Investigator	Principal Collaborator	Cost and Duration	Status
36(6)/14/92/2014-BRNS	Compilation of Experimental Nuclear Reaction Data using EXFOR Editor and Measurement of Nuclear Reaction Cross section using Kamini Reactor	Dr.Rudraswamy.B Dept of Physics, Jnanabharathi campus,Bangalore University Bangalore- 560056	Dr. G. Pandikumar, IGCAR Dr. E. Radha, IGCAR	24.12 Lakhs 3 years 2014-2017 (Extended)*	Project Ongoing
36(6)/14/21/2016-BRNS ♣	EXFOR compilation of nuclear data	Dr Vidya Devi Department of Physics, IET Bhaddal Technical Campus, Bhaddal, P.O. Mianpur, District Ropar	Dr. Alok Saxena, Head, NPD, BARC Devesh Raj, RPDD, BARC	16.00 Lakhs † 3 years 2016-2019	Project Ongoing
36(6)/14/23/2016-BRNS	Cross section measurements for Sodium, Iron and Data compilation	Dr Ajay Kumar B-42, Brij Enclave, Sunderpur, Near Life Line Hospital Varanasi, Uttar Pradesh.	Dr B. K Nayak, NPD, BARC	19.43 Lakhs 3 Years	. Project Ongoing
36(6)/14/22/2016-BRNS	Study of neutron induced reaction cross section up to 18 MeV for advanced reactor design	Prof Surjit Mukherjee Professor of Physics Physics Department, M.S. University of Baroda, Vadodara	Dr. B. K. Nayak, NPD, BARC Dr. S. V. Suryanarayana, NPD, BARC	16.18 Lakh 3 Years s	Project Ongoing
36(6)/14/30/2017-BRNS	Measurement, Analysis, Evaluation and Compilation of Nuclear Reaction Data at Low And Medium Energy	Dr. M. M. Musthafa Prof. of Physics University of Calicut	Dr. S. Jagadeesan BARC	30.00 Lakh 3 Years	Project Ongoing
36(6)/14/49/2016-BRNS	Measurement of formation cross	Dr. Sanjay Daga Dhole,	Dr. Rahul Tripathi	42.13 Lakh 3 Years	Project Ongoing

	section of metastable states of a few nuclei produced through Photon	Prof. of Physics Mhatma Jyoti Ba Phule Pune University, Pune	RCD, BARC		
36(6)/14/60/2016-BRNS ♥	Nuclear Structure & Decay Data Evaluation for Nuclear Models and Dosimetric Applications	Dr. Sukhjeet S. Dhindsa Associate Prof. Physics Akal University	Dr. Gopal Mukherjee VECC, Kolkata	23.00 Lakh 3 Years	Project Ongoing

***1 Lakh= 100, 000 (Hundred Thousand) ~ USD1500**

† The cost of the project is increased according to the government rule

♣ Project exclusively for EXFOR compilation

♥ Project exclusively on ENSDF evaluation

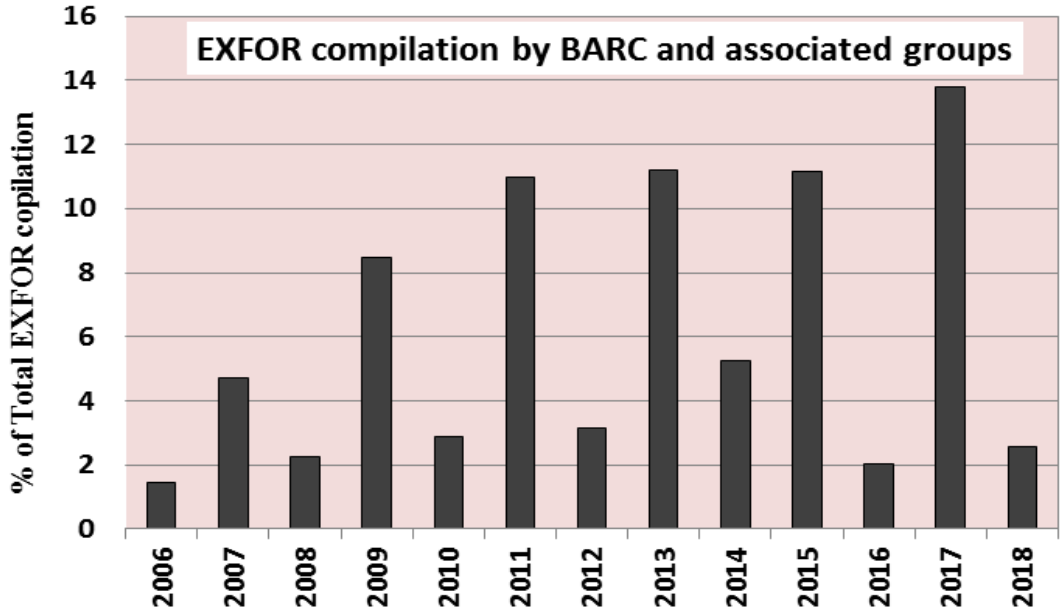
1.3.The statistics of the EXFOR compilation work

The table 1.3 and figure 1.3 depict the contribution of Indian compilers to the EXFOR data base. The compilation has been done by the scholars and PIs of the BRNS funded projects with active support from Dr. Naohiko Otsuka, IAEA, and Dr. Alok Saxena, Devesh Raj, Dr. G. Mohanto of BARC. The finalization of submission to IAEA NDS is done by Dr. Vidya Thakur who is PI of the BRNS funded project exclusively granted for the EXFOR compilation. Apparent discrepancy of falling and rising of number of compilation is due to the Biennial EXFOR workshop mentioned earlier. Each odd year the EXFOR workshop is conducted which results in substantial increase in number of contributed entries.

Table 1.3

	NNDC	NEA-DB	NDS	CJD	ATOMKI	CDFE	CNDC	CNPD	JCPRG	UkrNDC	*BARC*	KNDC	CAJaD	Sum
2018	--	--	025	04	--	--	--	07	--	01	*01*	01	--	039
2017	112	030	037	30	21	33	24	29	002	11	*54*	08	--	391
2016	119	071	052	05	29	07	31	27	019	16	*08*	07	--	391
2015	103	069	058	07	17	27	30	29	020	12	*49*	19	--	440
2014	092	104	054	07	23	21	26	42	027	14	*23*	04	01	438
2013	124	083	035	14	11	12	07	25	059	16	*51*	03	16	456
2012	128	201	045	09	22	20	18	41	057	10	*19*	09	26	605
2011	078	097	054	19	16	37	10	50	050	13	*59*	08	47	538
2010	075	100	067	20	08	20	19	53	057	09	*14*	10	30	482
2009	132	178	085	11	26	19	11	70	104	19	*63*	07	19	744
2008	94	192	145	19	15	27	--	84	022	27	*15*		20	660
2007	125	196	037	21	15	25	--	84	149	34	*34*		--	720
2006	159	158	099	26	16	26	21	50	080	25	*10*		10	680

Figure 1.3



Once all the projects having EXFOR compilation as one of the components comes in to force such gap will be reduced considerably. About 12% of the total compilation was accomplished by Indian compilers in 2015 and about 14% in 2017.

1.1 Work accomplished by the Project titled "EXFOR compilation of nuclear data",

1.2 The list of compiled EXFOR entries under preview of PI Dr. Vidya Thakur and Dr. N. Otsuka, IAEA

Table 2.1 List of entries compiled

S.No	ENTRY	TITLE	REFERENCE
1	D6220	Inclusive and exclusive measurements in the projectile breakup of ^{7}Li	J,PRM,53,541,1999
2	D6246	Isobaric analogue resonances in ^{71}As through proton elastic scattering on ^{70}Ge	J,PRM,12,653,1979
3	D6247	Yields of evaporation residues and average angular momentum in heavy ion induced fusion reactions leading to compound nucleus ^{96}Ru	J,PRM,38,291,1992
4	D6249	Fission fragment angular distribution in alpha-particle-induced fission of actinide elements.	J,PRM,45,519,1995
5	D6254	Systematic study of pre-equilibrium emission at low energies in ^{12}C and ^{16}O induced reactions.	J,PR/C,91,14603,2015
6	D6258	Experimental study of ^{26}Al through the 1n pick-up reaction	J,PR/C,91,054611,2015

		^{27}Al (d,t).	
7	D6275	Deformation effects on sub-barrier fusion cross sections in $^{16}O+^{174,176}Yb$	J,PR/C,93,054622,2016
8	D6278	Precompound emission in low energy heavy ion interactions from recoil range and spin distributions of heavy residues: A new experimental method.	J,PR/C,94,044617,2016
9	D6279	Hexadecapole deformation studies in $^{148,150}Nd$.	J,PRM,61,507,2003
10	D6280	Elastic scattering and fusion cross-sections in $^{7}Li + ^{27}Al$ reaction	J,PRM,81,587,2013
11	D6281	Fission fragment mass distributions via prompt gamma- ray spectroscopy	J,PRM,85,379,2015
12	D6282	Level density parameter in exotic nuclei of mass A~80 from proton and alpha evaporation spectra	J,NP/A,712,23,2002
13	D6285	Direct evidence of washing out of nuclear shell effects.	J,PR/C,91,044620,2015
14	D6288	Intermediate structure in 12C+16O system through alpha-induced reactions on 24Mg in the energy range Ealpha = 26-37 MeV	J,PR/C,39,1856,1989
15	D6290	Pre-equilibrium emission effects in the measured isomeric yield ratios in alpha-induced reactions on ^{197}Au .	J,PR/C,45,1171,1992
16	33102	Emission of Prompt Neutrons in the Thermal Neutron Fission of ^{235}U .	J,PR,131,283,1963
17	33103	Prescission neutron emission in ^{235}U (nth,f) through fragment-neutron angular correlation studies.	J,PR/C,51,3127,1995

2.2 Journal Survey of Indian Published Paper for EXFOR:

S.No	ENTRY	TITLE	REFERENCE
1	D6248	Fission cross section and fragment angular distribution in gold fission induced by 55 MeV alpha particles using solid state nuclear track detectors.	J,PRM,39,85,1992
2	D6250	Energy dependence of pre-equilibrium emission for the (p,xn) reactions in niobium.	J,IJP,86,913,2012
3	D6251	Measurement of the excitation functions in alpha-induced reactions on 93-Nb from threshold energy to 39.5 MeV.	J,KPS,67,1474,201
4	D6252	Thick target double differential neutron energy distribution	J,NIM/A,800,29,2015

		from $^{12}C + ^{27}Al$ at 115 MeV.	
5	D6253	Excitation function and isomeric ratio of Tc-isotopes from the ^{93}Nb (A,XN) reaction.	J,NP/A,935,65,2015
6	D6255	Experimental study of cross sections in the $^{12}C + ^{27}Al$ system at 3 to 7 MeV/nucleon relevant to the incomplete fusion process.	(J,PR/C,91,024608,2015)
7	D6256	Role of p-induced population of medium-mass (A~150) neutron-rich nuclei.	J,PR/C,91,024617,2015
8	D6257	Barrier distribution functions for the system $^{6}Li + ^{64}Ni$ and the effect of channel coupling.	J,PR/C,91,034615,2015
9	D6259	Investigation of the threshold anomaly for the $^{7}Li + ^{159}Tb$ system.	J,PR/C,91,054614,2015
10	D6260	Measurement of yield of residues produced in $^{12}C + ^{nat}Y$ reaction and subsequent separation of ^{97}Ru from Y target using cation exchange resin.	J,RCA,103,7,2015
11	D6261	Fusion measurements for the $^{18}O + ^{194}Pt$ reaction and search for neutron shell closure effects.	J,JP/G,42,095105,2015
12	D6262	Understanding the two neutron transfer reaction mechanism in ^{206}Pb $(^{18}O,^{16}O)^{208}Pb$.	J,NP/A,940,167,2015
13	D6263	Probing nuclear dissipation via evaporation residue excitation functions for the $^{16,18}O+^{198}Pt$ reactions.	J,PR/C,91,044621,2015
14	D6264	Multinucleon transfer study in $^{206}Pb(^{18}O, X)$ at energies above the Coulomb barrier.	J,PR/C,92,024603,2015
15	D6265	Threshold behavior of interaction potential for the system $^{7}Li+^{64}Ni$: Comparison with $^{6}Li+^{64}Ni$.	J,NP/A,953,80,2016
16	D6266	Evolution of fusion hindrance for asymmetric systems at deep sub-barrier energies.	J,PL/B,755,332,2016
17	D6267	Experimental investigation of T = 1 analog states of ^{26}Al and ^{26}Mg.	J,PR/C,93,044601,2016
18	D6268	Probing the fusion of ^{7}Li with ^{64}Ni at near-barrier energies.	J,PR/C,93,044616,2016
19	D6269	Probing transfer to unbound states of the ejectile with weakly bound ^{7}Li on ^{93}Nb.	J,PR/C,93,061602,2016

20	D6270	Experimental probe for the production of ^{97}Ru from the $^{7}Li+^{93}Nb$ reaction: A study of precompound emissions	J,PR/C,94,044603,2016
21	D6271	Survival of cluster correlation in dissipative binary breakup of $^{24,25}Mg^{*}$.	J,PR/C,94,051601,2016
22	D6272	Resonant, direct, and transfer binary breakup of $^{24,25}Mg^{*}$	J,PR/C,94,061602,2016
23	D6273	Quasi-elastic scattering and transfer angular distribution for $^{10,11}B+^{232}Th$ systems at near-barrier energies	J,PR/C,94,064610,2016
24	D6274	Measurement of multinucleon transfer cross-sections in $^{58}Ni,^{56}Fe(12C,X);X:^{13,11}C,^{11,10}B,^{10,9,7}Be,^{8}Beg.s$ and $^{7,6}Li$ at E(12C)=60 MeV.	J,PRM,86,97,2016
25	D6276	Incomplete fusion studies in the $^{19}F+^{159}Tb$ system at low energies and its correlation with various systematics.	J,PR/C,94,014613,2016
26	D6277	Fission fragment angular distributions in pre-actinide nuclei.	J,PR/C,94,044607,2016
27	D6283	Angular distribution of neutrons from deuteron-bombarded lithium	J,IPA,8,108,1970
28	D6284	Angular distribution of D-D neutrons in 9Be+d reaction.	J,IPA,10,567,1972
29	D6286	Study of the neutrons produced on deuteron bombardment of lithium.	J,IPA,2,364,1964
30	D6287	Properties of the alpha cluster states of ^{212}Po from elastic scattering of alpha particles from ^{208}Pb	S,AIP-1491,321,2012
31	D6289	Alpha-induced fission of ^{235}U at extreme sub-barrier energies	J,PR/C,40,R1854,1989
32	D6291	^{116}Sn from $^{116}Cd(\alpha,4n\gamma)$ reaction	J,PR/C,42,2737,1990

2.3 Some of the publications by Dr. Vidya Thakur

1. Aman Sharma, Jagjit Singh , Vidya Devi and S. Ganesan, Uncertainty propagation in efficiency calculation of HPGe detector using Unscented Transform Method, Proc. Symp. on Nucl. Phys. (India), 62, 128 (2017).
2. Aman Sharma, Jagjit Singh , Vidya Devi and S. Ganesan, Uncertainty propagation in efficiency calculation of HPGe detector using Monte Carlo Method, Proc. Symp. on Nucl. Phys. (India), 62, 130 (2017).
3. Vidya Devi and J. B. Gupta, Nuclear Structure of Uranium isotopes in the frame work of two parameter formula, Proc. Symp. On Nucl. Phys. (India), 62, 136 (2017).
4. Sukanya De, et al., ``Determination of hexadecapole deformation for nucleus using quasi-elastic scattering.'' DAE-BRNS Symposium, 62, 398 (2017).

5. Vidya Devi and J. S. Kanwar, =2 staggering in Ce nuclei, Proc. Symp. on Nucl. Phys. (India), 62,138 (2017).
6. Vidya Devi and H. M. Mittal, Identical energy band of and isotopes by using two parameter formula, Proc. Symp. on Nucl. Phys. (India), 62, 138 (2017).

3.0 Progress Report for DAE-BRNS Research Project on measurement of incident neutron data on Sodium and Iron (BHU, Varanasi)

The theoretical analysis of some measured experimental data for neutron induced reactions at energy around ~14 MeV was recently done. These data were measured by research group in NPD, BARC. The calculations were done by the JRF associated with the project. Some of the results for the reactions ^{67}Zn, ^{92,96}Mo, ^{208}Pb (n, p) and ^{70}Zn, ^{100}Mo (n, 2n) at energy around ~14 MeV and experimental data of some reactions is shown in fig. 3.0a and 3.0b

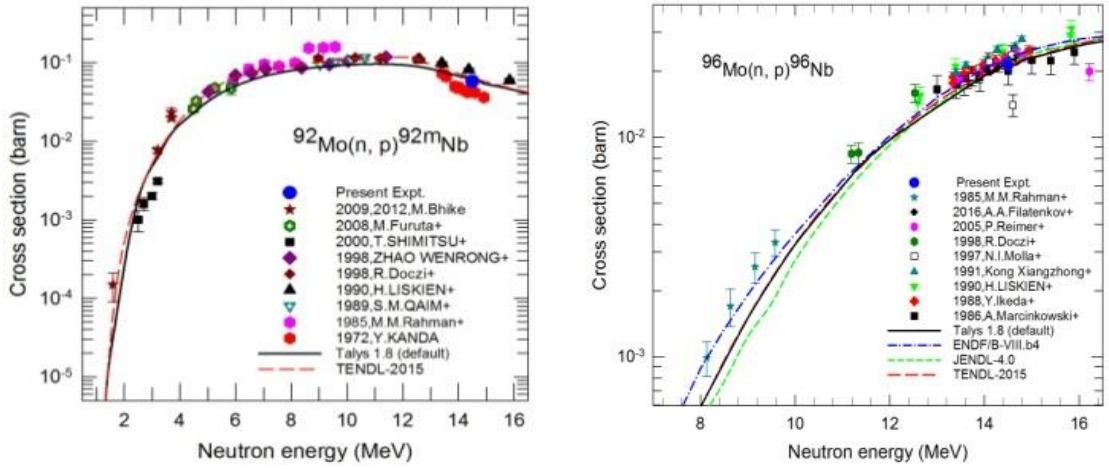


Fig.3.0a Talys 1.8 Calculation result with EXFOR data and evaluated nuclear data files ^{92}Mo (n, p) and ^{96}Mo (n, p) reactions

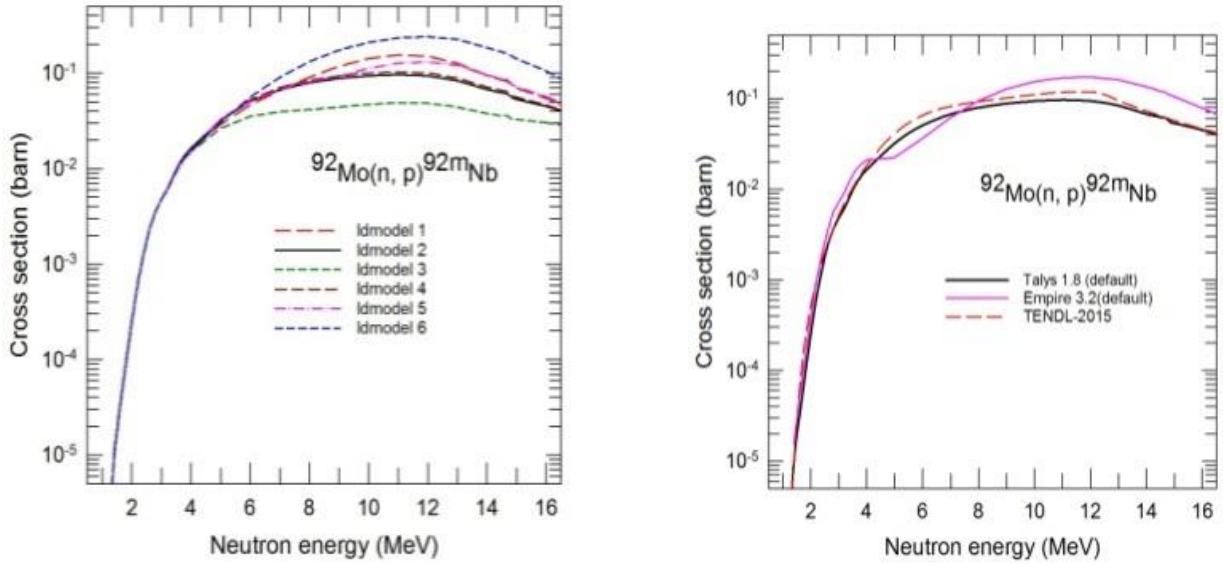


Fig.3.0b Variation of cross section with different level density models in Talys 1.8 and comparison between Talys 1.8 and Empire 3.2 results for ^{92}Mo (n, p) reaction

3.1 Work at Dubna-Russia in 2017 and 2018

The visiting team worked on TANGRA set up for the "Measurement of neutron inelastic scattering gamma rays produced from the 14.1 MeV neutrons using ING-27 neutron generator" in FLNP laboratory, JINR, during may 20th May to 14th August 2017. Figure 3.2.

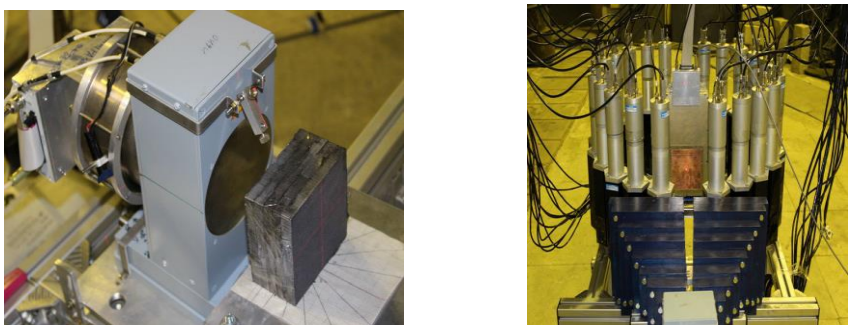


Fig. 3.2: ING-27 neutron generator and TANGRA set up with NaI Gamma rays detector array name "Romashka"

During second visit to JINR, Dubna, Russia from 26th January to 25th March 2018 the data analysis for the beam profile-meter was done. The result obtained from the analysis is shown in fig. 4.

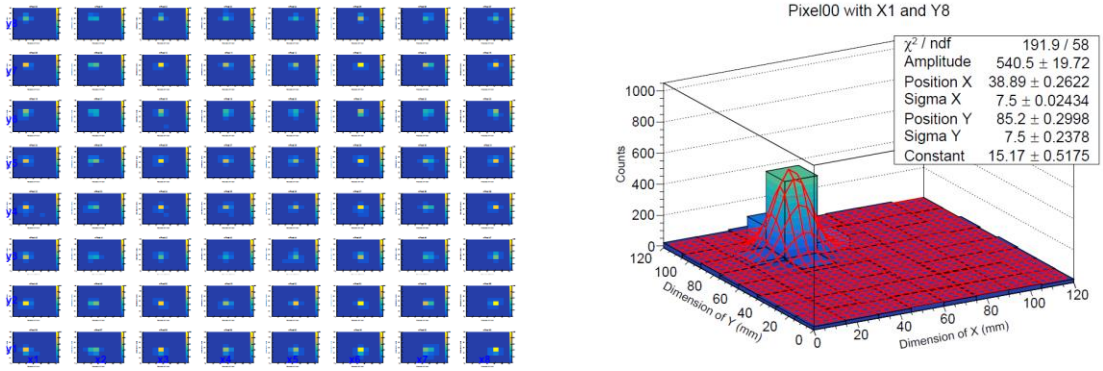


Fig. 3.3: 64-pixel neutron beam profile (left side) and 2-D fitting of pixel 00 using root script to get the position of x and y dimension of the neutron beam.

Paper Published/Submitted in 2016-2018 by BHU group

1. "Effect of the energy variation on the dissipative evolution of the system in the heavy ion fusion reactions", N.K. Rai, V. Mishra, A. Gandhi and Ajay Kumar, International Conference in Nuclear Physics with Energetic Heavy Ion Beams (15-18 March 2017) held in Department of Physics, Punjab University, Chandigarh.

2. "Calculation of neutron multiplicity to investigate the nature of nuclear dissipation", Vivek Mishra, N.K. Rai, A. Gandhi and Ajay Kumar International Conference in Nuclear Physics with Energetic Heavy Ion Beams (15-18 March 2017) held in Department of Physics, Punjab University, Chandigarh.

3. "Evaluation of Neutron Induced Cross Section Data Using Empire 3.2.2 and Talys 1.8 Codes", A. Gandhi, B.J. Roy, V. Mishra, N.K. Rai, V. Kumar, Y. Sawant, B.K. Nayak, A. Saxena, S. Mukherjee, N.L. Singh, Yu.N. Kopatch, I.N. Ruskov, and A. Kumar, 25th International Seminar on Interaction of Neutrons with Nuclei: "Fundamental Interactions & Neutrons, Nuclear Structure, Ultracold Neutrons, Related Topics", Dubna, Russia, 22-26 May 2017.

4. “Tagged neutrons as a tool for studying inelastic scattering of neutrons on nuclei”, N.A. Fedorov, T.Yu. Tretyakova, V.M. Bystritsky, Yu.N. Kopatch, I.N. Ruskov, V.R Skoy, D.N. Grozdanov, N.I. Zamyatin, V. Dunmin, F.A. Aliyev, K. Khramko, A. Kumar, A. Gandhi, S. Dabylova, E.P. Bogolyubov, Yu.N. Barmakov, International Conference: The XXI International Scientific Conference of Young Scientists and Specialists (AYSS-2017), October 2-6, 2017, Joint Institute for Nuclear Research, Moscow Region, Russia.

5. “Effect of Isotopic and N-Z ratio in (n, p) reaction cross section for stable elements from reaction threshold to 20 MeV”, A. Gandhi, V. Mishra, N.K. Rai, V. Kumar, and Ajay Kumar in the “Marie Curie Sesquicentennial Conference-2017” (MCSC-2017) during November 5-7, 2017 at the Jawaharlal Nehru University (JNU), New Delhi.

6. “The method of labelled neutrons in experiments on the study of nuclear reactions”, N.A. Fedorov, T.Y. Tretyakova, V.M. Bystritsky, Yu.N. Kopatch, I.N. Ruskov, V.R. Skoy, D.N. Grozdanov, N.I. Zamyatin, B. Dongming, F.A. Aliyev, K. Khramko, A. Kumar, A. Gandhi, S. Dabylova, E.P. Bogolyubov, Y.N. Barmakov, Russian National Conference: XVIII Inter scientific school of young specialists "Concentrated energy flows in space technology, electronics, ecology and medicine" December 4-5, 2017, Research Institute of Nuclear Physics, Moscow, Russia.

7. “Study of neutron induced reactions using EMPIRE-3 and TALYS”, A. Gandhi, B.J. Roy, V. Mishra, N.K. Rai, V. Kumar, Y. Sawant, B.K. Nayak, A. Saxena, Yu.N. Kopatch, I.N. Ruskov and A. Kumar, Proceedings of the DAE Symp on Nucl. Phys. 62 (2017) 504.

8. “TANGRA: Tagged Neutrons and Gamma Rays”, A. Gandhi, D.N. Grozdanov, F.A. Aliyev, W. Dongming, N.A. Fedorov, Yu.N. Kopatch, V.R. Skoy, V.M. Bystritsky, I.N. Ruskov, C. Hramco, E.P. Bogolyubov, Yu.N. Barmakov, V. Kumar, V. Mishra, N.K. Rai, and A. Kumar, Proceedings of the DAE Symp on Nucl. Phys. 62 (2017) 1074.

9. “Romashka and Romasha” gamma-ray spectrometers, V.M. Bystritsky, Yu.N. Kopatch, V.R. Skoy, I.N. Ruskov, T.Yu. Tretyakova, N.A. Fedorov, D.N. Grozdanov, A. Gandhi, F.A. Aliyev, C. Hramco, W. Dongming, Yu.N. Barmakov, E.P. Bogolyubov, A. Kumar, V. Kumar, V. Mishra, and N. K. Rai, Proceedings of the DAE Symp on Nucl. Phys. 62 (2017) 1008.

10. “Determination of hexadecapole deformation of ^{176}Yb,” G. Mohanto, A. Parihari, A. Pal, A. Gandhi, S. De, E.T. Mirgule, K. Ramachandran, B. Srinivasan, K. Kalita, A. Kumar, K. Rani, A. Tejaswi, C. Vadagama, Vishal Bharud, Y.K. Gupta, L.S. Danu, B.J. Roy, M. Kushwaha, D. Sarkar, B.K. Nayak, and A. Saxena, Proceedings of the DAE Symp on Nucl. Phys. 62 (2017) 552.

11. “Study of inelastic scattering of neutrons with energy of 14.1 MeV on oxygen and silicon nuclei” (N.A Fedorov, T.Y Tretyakova, V.M Bystritsky, Yu.N. Kopatch, I.N Ruskov, V.R Skoy, D.N Grozdanov, N.I Zamyatin, D. Van, F.A Aliyev, K. Khramko, A. Kumar, A. Gandhi, M.G. Sapozhnikov, Yu.N. Rogov, E.A. Razinkov, S. Dabylova, E. Bogolyubov, Y. Barmakov) - "Scientific notes of the Faculty of Physics".

12. “Measurement of angular distributions of gamma-quanta in reactions of inelastic scattering of neutrons with energy 14.1 MeV on nuclei of carbon and oxygen”, D.N. Grozdanov, N.A. Fedorov, V.M. Bystritsky, Yu.N. Kopatch, I.N. Ruskov, V.R. Skoy, T.Yu. Tretyakova, N.I. Zamyatin, D. Van, F.A. Aliyev, K. Khramko, A. Gandhi, A. Kumar, S. Dabylova, E.P. Bogolyubov, Yu.N. Barmakov - in "Nuclear Physics" - Russian publications.

13. “Measured response of a liquid scintillation detector to quasi-mono energetic electrons and neutrons”, P.C. Rout, A. Gandhi, T. Basak, R.G. Thomas, C. Ghosh, A. Mitra, G. Mishra, S.P. Behera, R. Kujur, E.T.

Mirgule, B.K. Nayak, A. Saxena, Suresh Kumar, V.M. Datar, Journal of Instrumentation (2018), https://doi.org/10.1088/1748-0221/13/01/P01027.

4.0 Studies in Shell effect on nuclear level density parameter. (NPD, BARC)

An experiment has been done at BARC-TIFR Pelletron to understand the shell effect on level density. The experiment was planned in an attempt to explain diminishing shell effect with increasing excitation energy. For this the experiment was performed to study excitation energy dependent nuclear level density parameter for two reactions $^{11}B+^{181}Ta$, ^{197}Au. Alpha particle gated neutrons were detected for these two reactions using 15 liquid scintillator detectors to obtain neutron spectra using time of flight technique. Sillicon strip detectors (ΔE-E) were placed at back angles ($\pm 150^0$) to detect evaporated alpha particles in coincidence with neutrons. The experimental neutron spectra was measured to derive nuclear density parameters by fitting. The selection of different windows of alpha particle energy, different excitation energies of the residual nuclei (after evaporating 1 alpha from compound nucleus) can be accessed. The $^{11}B+^{181}Ta$ and $^{11}B+^{197}Au$ form compound nuclei ^{192}Pt and ^{208}Po, respectively which after 1 alpha evaporation produces daughter nuclei ^{188}Os and ^{204}Pb respectively. The ^{204}Pb has proton shell closure (neutron N=122) whereas, ^{188}Os has Z=76, N=112. Comparison of these two reactions will reveal the effect of shell closure.

Experimental data has been analysed to obtain alpha and neutron spectra. Statistical model calculations are in progress to extract nuclear level density parameters from the experimental data.

5.0 Development of a highly forward focused fast neutron source to study the fast neutron induced fission of actinides, (NPD, BARC)

Transmutation of Minor Actinides (MA), produced as high level nuclear waste in nuclear power plants, into short lived fission products is now actively considered worldwide to eliminate them. Fast neutrons, particularly in the region of 1 MeV - 4 MeV, produced in a Fast Reactor (FR) and/or Accelerator Driven System (ADS) are considered most appropriate for such purpose as fission to capture ratio is higher compared to thermal spectrums. In order to study the characteristics of fission products produced in high energy fission a suitable source with the appropriate detector system is required. Therefore, it is proposed to develop a forward focused fast neutron facility at the 25 degree beam line (hill side) of the FOTIA facility to measure Mass, Charge, Kinetic energy distributions of fission fragments along with neutron gamma and x-ray spectra produced in the fast neutron induced fission of Actinides. The quasi-monoenergetic neutron source will be produced by the $p(^7Li,n)^7Be$ inverse-kinematic reaction and the detection system primarily involves a Back-to-Back twin grid ionization chamber to detect the fission fragments. In addition, a number of neutron, gamma and x-ray detectors will also be implemented.

As the reaction is inverse-kinematic in nature, the neutrons produced will be highly forward focused maximizing the neutron flux at the target and minimizing the background due to scattering of neutrons. The typical characteristics of the reaction are given in table 5.0:

Table 5.0

(Neutron flux expected at the fissioning target is ~ 10^6 n/cm^2/s for beam currents ~ 100 nA)

Beam Energy (7Li)	Energy range of neutrons
13.5 MeV	1.2-1.8 MeV
15.5 MeV	3 – 3.3 MeV
17.5 MeV	3.8 – 4.4 MeV

The Back-to-Back twin grid ionization chamber has already been developed and is now being characterized with spontaneous fission source. The angular distribution and the kinetic energy distributions are obtained and is being benchmarked with literature values. Optimization of operating characteristics is under progress. A VME based data acquisition system along with pulse processing electronic systems are also implemented.

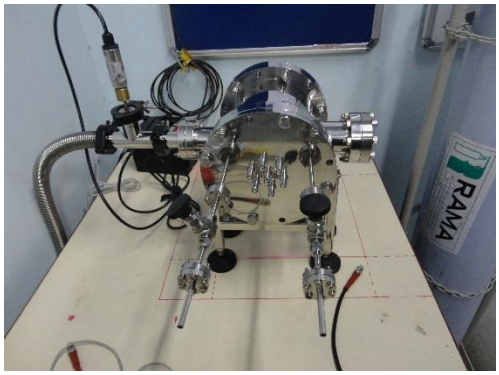


Figure 5.0 A

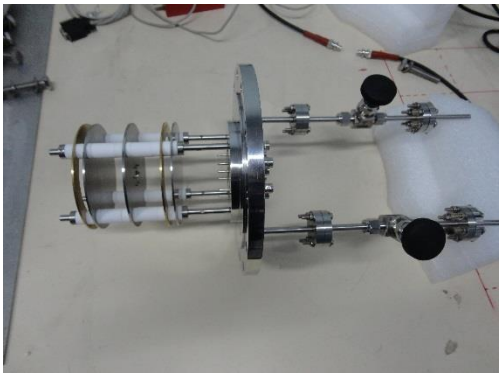


Figure 5.0 B

Development of the Gas target for the production of neutrons is in progress. A small cylindrical gas cell of length 2-7 cm and diameter of 2-3 cm with a thin tantalum window is being developed along with a gas control system with adequate safety features. The cell will operate at 1.5-2 atm. of hydrogen gas to act as the hydrogen target. The design is finalized and the fabrication work is under way.

Measurement of fast neutron induced fission of ^{238}U, ^{237}Np, ^{232}Th targets will be conducted after the development of the fast neutron target.

6.0 Report on the research activities in University of Calicut under UGC, BRNS and other schemes

Department of Physics, University of Calicut is undertaking various activities in basic and applied nuclear Physics research under BRNS funded project and other research scheme. Following are the broad description of theoretical and experimental nuclear data activity being carried out at the University. Measurement and analysis have been carried out for a number of reactions induced by light and heavy ions. Application of radiation on electronic device as well as production of neutron from medical linear accelerators are also being studied

Fusion fission and fission evaporation measurements were performed in an experiment conducted in July2017 on^{48}Ti+^{138}Ba system at IUAC using Pelletron LINAC accelerator. The preparation of Ba-138 target needs expertise and was published [1]. Theoretical analysis are being done using PACE4 and CCFULL for the study of reactions ^{19}F+^{187}Re & ^{30}Si+^{176}Yb both of which producing^{206}Po as compound nucleus[2-4].

Publications/Conference proceedings by Calicut team

1. KK Rajesh et al, Vacuum, 141 (2017) 230-234, http://dx.doi.org/10.1016/j.vacuum.2017.04
2. Rajesh et al., Evaporation residue excitation function measurements for the reaction48Ti+138Ba, Proceedings of the DAE Symp. on Nucl. Phys. 62 (2017)www.sympnp.org/poceedings).
3. Rajesh et al., A study of entrance channel mass-asymmetry effect on quasifission, Proceedings of the DAE Symp. on Nucl. Phys. 61 (2016) www.sympnp.org/proceedings).
4. Hajara K et. al., National seminar on Radiation, Department of physics, Sir Syed college, Thalipparamba during 22,-23 Nov. 2016.

7.0 Research in nuclear data under BRNS project at Bangalore University

7.1 Experiment performed for the measurement of cross sections

1. The newly acquired sources and equipment were commissioned. The measurement of gamma spectra of newly procured calibration sources such as Ba-133, Cs-137,Co-60, Co-57, Na-22 was performed with HPGe detector (DSG make) & MCA multiport-II (Canberra make) existing in the newly established research laboratory of our Department.
2. High purity activation foils such as Gold, Nickel, Tungsten(supplied by Alfa Aesar, USA), has been irradiated using neutron beam by placing in Dry tube-I of KAMINI reactor during 27/11/2017 to 29/11/2017 and 8/01/2018 to 11/01/2018.
3. The gamma spectra of irradiated foils were measure using HPGe (DSG make) and MCA existing in FBTR laboratory of IGCAR.
4. Estimation of Efficiencies & generation of Covariance matrices for both Eu-152 and the activated foils has been done.

8.0 Work on "**Nuclear Structure & Decay Data Evaluation for Nuclear Models and Dosimetric Applications**"

The BRNS funded project on ENSDD was granted with following mandate

I. Nuclear Structure and Decay Data Evaluation
II. Development and update of Analysis and Utility Codes required for NSDD evaluation
III. Horizontal Evaluations
IV. Theoretical Nuclear Structure Calculations

The project has performed well on all assigned deliverables. Following are some details

8.1 NUCLEAR STRUCTURE AND DECAY DATA (NSDD) EVALUATIONS

The following are details of Nuclear Data Sheets published and ongoing mass chain evaluations Table:8.1

Table: 8.1

#	Mass chain	Collaboration	Status & Reference
1.	A=217	Joint ICTP-IAEA Workshop on Nuclear Structure and Decay Data (ICTP, Italy) (2016) Mr. Sushil Kumar, Research Associate in DAE-BRNS project participated in this workshop.	Published Nuclear Data Sheets 147, 382-458 (2018). Ref. [1]
2.	A=139	HBCSE Mumbai, IIT Roorkee, Akal University and McMaster University Canada	Published Nuclear Data Sheets 138, 1-292 (2016). Ref. [2]
3.	A=227	Joint ICTP-IAEA Workshop on Nuclear Structure and Decay Data (ICTP, Italy) (2014) Mr. Sushil Kumar, Research Associate in DAE-BRNS project participated in this workshop.	Published Nuclear Data Sheets, 132, 257-354 (2016). Ref. [3]

4.	A=221	HBCSE Mumbai, IIT Roorkee and Akal University	Submitted (April-2018)
5.	A=216	Akal University, IIT Roorkee and HBCSE Mumbai	Final Stage of Submission (April-2018)
6.	A=223	Workshop on Evaluation of Nuclear Structure and Decay Data (Workshop held at HBCSE Mumbai)	Final Stage of Submission (May-2018)
7.	A=219	VECC Kolkata, IIT Roorkee, HBCSE Mumbai, McMaster University Canada, Akal University and SSSIHL Andhra Pradesh	(2018)

8.2 Development and update of analysis and utility codes required for NSDD evaluation

The RadD program was developed for deduction of radius parameter of odd-A and odd-odd nuclei using evaluated even-even radii presented by Akovali (1998AK04). The preliminary version of this program was presented by Dr. Sukhjeet Singh Dhindsa in 21st IAEA technical meeting of NSDD evaluators held at IAEA, Vienna during April 20-24, 2015. The comments and suggestions received from NSDD international network were incorporated and final version is now available at *https://www-nds.iaea.org/public/ensdf_pgm/*

As per suggestions of NSDD network, RADD code is appended as a subroutine in original ALPHAD program which leads to a single code(ALPHAD + RadD). This new ALPHAD automatically deduces radius parameter of odd-odd, odd-A nuclides and calculates the corresponding values of Hindrance Factors for given alpha decay data set(s). The Preliminary version of this program is available at *https://www-nds.iaea.org/public/ensdf_pgm/*.

Additionally, following critical issues of earlier version of ALPHAD are fixed in collaboration with National Nuclear Data Center, Brookhaven National Lab., USA

- There was problem with unplaced ALPHA records and same has been fixed in revised version of ALPHAD.
- The earlier version of this program gave unexpected Hindrance factors for alpha records with no given intensities. This issue has also been fixed.
- Similarly, in earlier version of ALPHAD code, the calculated theoretical half-lives and abundance were not in physical limits for the cases where alpha intensities are not known. This problem has also been resolved.

Final version of this revised code will be distributed to network of Nuclear Structure and Decay Data in **April-2018.**

8.3 Horizontal Evaluation / Compilations

I. Updating of table of radius parameter

In current evaluation, we deduced radius parameter (r_0) of total 183 even-even alpha decaying nuclides. This evaluation also provides evaluated list of $T_{1/2}$ and α-branching of above said even-even nuclides. There were total 154 even-even nuclides for which radius parameters are listed in 1998AK04 (Akovali, 1998AK04).

II. The table of magnetic and anti-magnetic rotational bands

Experimental data of new 59 MR bands observed in 29 different nuclides were added after literature survey. Additionally, earlier compilation of MR bands has also been extended by including 16 anti-magnetic rotational bands observed in 12 different nuclides. The earlier compilation by Amita *et al.* (2006)contains, the gamma-ray energies, associated level energies with spins and parities, level lifetimes, B(M1) and B(E2) values when available, and probable configurations pertaining to 178 Magnetic Rotational (MR) bands.

8.4 Theoretical Nuclear Structure Calculations

The project is also working for the theoretical understanding of high-spin features of two and three quasiparticle rotational bands [4-7]

Recent Publications (Published)

1. Nuclear data sheets for A=217
2. F.G. Kondev, E.A. McCutchan, B. Singh, K. Banerjee, S. Bhattacharya, A. Chakraborty, S. Garg, N. Jovancevic, S. Kumar, S.K. Rathi, T. Roy, J. Lee, R. Shearman, Nuclear Data Sheets 147, 382-458 (2018).
3. Nuclear Data Sheets for A = 139, Paresh K.Joshi, Balraj Singh, Sukhjeet Singh and Ashok K. Jain, Nuclear Data Sheets 138, 1-292 (2016).
4. Nuclear Data Sheets for A = 227, Filip Kondev, Elizabeth McCutchan, Balraj Singh, Jagdish Tuli, Paraskevi Dimitriou, Stefan Lalkovski, Alexander Rodionov, Georgi Shulyak, Khalifeh Abusaleem, Sudeb Bhattacharya, Paresh Joshi, Stanimir Kisyov, Mouftahou Latif, Maria Marginean, Sherif Nafee, Sorin Pascu, Sushil Kumar Rathi, M. Sainath, K. Vijai Sai , Dong Yang., Nuclear Data Sheets, 132, 257-354 (2016).
5. Signature effects in Gallagher Moszkowski doublets of doubly-odd ^{162,164}Ho and ^{164}Tm nuclei, Sushil Kumar, Sukhjeet Singh, A.K. Jain, J. K. Sharma, European Physical Journal Plus 131, 224-243 (2016).
6. Signature Splitting in Two Quasiparticle Rotational Bands of ^{180,182}Ta, Sushil Kumar, Sukhjeet Singh, J. K. Sharma, A. Goel, Kawalpreet Kalra, Parmana Journal of Physics, 87, 1-12 (2016).
7. Signature inversion in $\pi h_{11/2} \otimes \nu i_{13/2}$ band of ^{152}Eu and ^{154,156}Tb,Sushil Kumar, Sukhjeet Singh, Vandana Sharma, J. K. Sharma,European Physical Journal A 53, 76-88 (2017).
8. Generalization of GM Rules for three-quasiparticle states Sukhjeet Singh, Sushil Kumar, S.S. Malik, A.K. Jain, Physical Review C (To be submitted May-2018).

International Conferences

1. Estimation of α-decay branching and $T_{1/2}$ of even-even alpha emitters using systematics of r_0 parameters, Sushil Kumar, Sukhjeet Singh, Balraj Singh and A.K. Jain, 10thInternational conference on Direct Reactions with Exotic Beams (DREB 2018) to be held during 04-06-2018 to 08-06-2018 at Kunibiki Messe, Japan (Accepted)
2. Complexities in 3QP Coriolis Mixing Calculations, Sushil Kumar, Sukhjeet Singh, 10thInternational conference on Direct Reactions with Exotic Beams (DREB 2018)to be held during 04-06-2018 to 08-06-2018 at Kunibiki Messe, Japan. (Accepted)

3. Evaluation of nuclear radius parameter (r_0) for even-even nuclei, Sukhjeet Singh, Sushil Kumar, Balraj Singh and A.K. Jain, Conference on Frontiers in Gamma ray Spectroscopy (FIG2018) organized by Tata Institute of Fundamental Research, Mumbai, India, from 12th - 14th March 2018.

4. Signature Splitting in Kπ=1- and 6- :7/2[523]π⊗5/2[642]ν Gallagher Moszkowski doublet of 162Ho, Sukhjeet Singh, Sushil Kumar, J.K. Sharma and A.K. Jain, International Conference: European Physical Society (EPS) Divisional Conference: Towards EURISOL Distributed Facility held at Katholieke Universiteit Leuven, Belgium during Oct. 18-21, page: 38 (2016)

5. Configuration assignment to πh11/2⊗νi13/2 band of 154Tb , Sukhjeet Singh, Sushil Kumar, J.K. Sharma and A.K. Jain, International Conference: European Physical Society (EPS) Divisional Conference: Towards EURISOL Distributed Facility held at Katholieke Universiteit Leuven, Belgium during Oct. 18-21, page: 40 (2016).

9.0 Fourth DAE-BRNS Theme Meeting on Covariance Matrix

Fourth DAE-BRNS Theme Meeting on the generation and use of covariance matrices in the application of nuclear data, cosponsored by BRNS, held between December 09 -13, 2017. Technical sessions consisted of about 30 lectures, 3 tutorial sessions and plenary discussions. Lectures consisted of discussion on different methodologies such as applications of Least Square Methods, Generalized Least Square Methods, Bayesian Methods, Kalman Filter Methods and Total Monte Carlo Methods in generating covariance information of nuclear data measurements. Lectures and tutorials on TALYS nuclear model code were delivered. There were 26 Speakers in DAE-BRNS Theme Meeting including Arjan Koning , Iaea, Austria, Helmut Leeb , Tu Wien, Atominstitut, Austria, Kallol R Oy , Bharatiya Nabhikiya Vidyut Nigam Ltd, Kalpakkam, India, Uttiyoarnab Saha , HBNI, IGCAR, India, Alok Saxena , Bhabha Atomic Research Centre, India, Peter Schillebeeckx , European Commission - Joint Research Centre, Belgium, Henrik Sjöstrand , Uppsala University, Sweden.

In the experiments and associated activities described below in articles 10.0 to 15.0 there were active participation from guides and students from various universities and institutes. Some of them are Dr. Haladhara Naik, Ex-BARC, Mizoram University, Aizawl, NEHU, Shillong, Manipal University, Manipal, M S University of Baroda, Vadodara, Bangalore University, Bangalore, SAMEER, Mumbai, G. B. Pant University of Agriculture and Technology, Electron Beam Centre, Kharghar.

10.0 Surrogate nuclear reactions for determining compound nuclear reaction cross sections of unstable nuclei (NPD, BARC).

Extending the use of surrogate reaction methods like surrogate ratio method following cross sections have been measured at BARC-TIFR Pelletron facility using Li(p, n) source. The ^{55}Fe(n, p) cross section was measured using its surrogate reaction ^{52}Cr(^{6}Li,d)^{56}Fe*->^{55}Mn+p. The ^{55}Fe(n, a) cross section was measured using surrogate reaction ^{52}Cr(^{6}Li,d)^{56}Fe*->^{52}Cr+α. Similarly for ^{59}Ni(n, p) reaction ^{56}Fe(^{6}Li,d)^{60}Ni*->^{59}Co+p was used. The cross sections for ^{53}Mn(n, p),^{55}Mn(n, p) was also measured by SRA approach. It is found that for the given Li(p, n) source at TIFR Pelletron several reactions are possible to measure. For example ^{65}Zn(n, p) at 14MeV can be measured by enriched ^{63}Cu : a-p coincidence measurements in ^{63}Cu(^{7}Li,a)^{66}Zn ->^{65}Cu+p.

Similarly the ^{65}Zn(n, p) at 14MeV can use reaction d+p coincidence with enriched target ^{62}Ni(^{6}Li,d)^{66}Zn->^{65}Cu+p. The reaction cross section ^{65}Zn(n, α) at 14MeV can be use d+α coincidence measurement in reaction ^{62}Ni(^{6}Li,d)^{66}Zn->^{62}Ni+ α. Likewise some other suggested schemes are

^{57}Co(n,p) reactions : α +p coincidence for ^{56}Fe(^{6}Li,a)^{58}Co->^{57}Fe+p

^{58}Co(n,p) reactions ^{57}Fe (6Li,a)^{59}Co-->^{58}Fe+p

^{60}Co(n,p) reactions by ^{58}Fe(0.28%)(^{7}Li,a)^{61}Co->^{60}Co+p

It is found that with the given Li(p, n) source the ^{63}Ni(n,x) reactions are not feasible by surrogate method as surrogate pairs are difficult to get. Same is the case with ^{59}Fe(n,p) as surrogate pair is difficult to get.

11.0 Measurements of the cross sections of the $^{186}W(n,\gamma)^{187}W$, $^{182}W(n,p)^{182}Ta$, $^{154}Gd(n,2n)^{153}Gd$, and $^{160}Gd(n,2n)^{159}Gd$ reactions at neutron energies of 5 to 17 MeV (NPD)

The cross sections of the $^{186}W(n,\gamma)^{187}W$, $^{183}W(n,p)^{183}Ta$ and $^{154}Gd(n,2n)^{153}Gd$, $^{160}Gd(n,2n)^{159}Gd$ reactions were measured at the neutron energies 5.08 ± 0.165, 8.96 ± 0.77, 12.47 ± 0.825, and 16.63 ± 0.95 MeV. Standard neutron activation analysis technique and off-line γ ray spectrometry were used for the measurement and analysis of the data. The results from the present work are compared with the literature data based on the EXFOR database. The experimental results are supported by theoretical predictions using nuclear modular codes TALYS 1.8 and EMPIRE 3.2.2. The predictability of different one-dimensional models available in TALYS 1.8 and level density options in EMPIRE 3.2.2 were tested. A detailed comparison of experimental results with theoretical model calculations is made. Published as Physical Review C96, 024608 (2017)

12.0 Measurement of photo-neutron cross-sections of Gd and Ce using bremsstrahlung with an end-point energy of 10 MeV (NPD and RCD).

^{159}Gd and ^{141}Ce are the beta emitting radio-nuclides with short half-life, which makes them useful for nuclear medicinal purposes. The average cross-sections for the $^{160}Gd(c,n)^{159}Gd$ and $^{142}Ce(c,n)^{141}Ce$ reactions have been measured relative to the cross-section of $^{197}Au(c,n)^{196}Au$ reaction at the bremsstrahlung end-point energy of 10 MeV. The average cross-sections of $^{160}Gd(c,n)^{159}Gd$ and $^{142}Ce(c,n)^{141}$ Ce reactions were determined using an off-line c-ray spectrometric technique and were found in close agreement with the literature data. The uncertainties of the measurements have been studied using covariance analysis of the experimental data for the photo-nuclear reactions. Published as Journal of Radioanalytical and Nuclear Chemistry 314 (2017) 1983.

13.0 Measurement of formation cross-section of $^{100}Mo(n,2n)$ reactions ^{99}Mo from the $^{98}Mo(n,\gamma)$ (NPD and RMC)

The formation cross-section of medical isotope ^{99} Mo from the ^{98} Mo(n,γ) reaction at the neutron energy of 0.025 eV and from the ^{100} Mo(n,2 n) reaction at the neutron energies of 11.9 and 15.75 MeV have been determined by using activation and off-line γ-ray spectrometric technique. The thermal neutron energy of 0.025 eV was used from the reactor critical facility at BARC, Mumbai, whereas the average neutron energies of 11.9 and 15.75 MeV were generated using ^{7} Li(p,n) reaction **i**n the Pelletron facility at TIFR, Mumbai. The experimentally determined cross-sections were compared with the evaluated nuclear data libraries of ENDF/B-VII.1, CENDL-3.1, JENDL-4.0 and JEFF-3.2 and are found to be in close agreement. The ^{100} Mo(n,2n) ^{99}Mo reaction cross-sections were also calculated theoretically by using TALYS-1.8 and EMPIRE-3.2 computer codes and compared with the experimental data. Published as Applied Radiation and Isotopes, 129 (2017), p117-123.

14.0 Determination of ^{55} Mn(n,γ) ^{56} Mn reaction cross-section at the neutron energies of 1.12, 2.12, 3.12 and 4.12 MeV (NPD)

The ^{55}Mn(n,γ)56Mn reaction cross-sections at the neutron energies of 1.12, 2.12, 3.12 and 4.12 MeV were determined by using activation and off-line γ-ray spectrometric technique. The neutron energies of 1.12 and 2.12 MeV were generated from the ^{7} Li(p,n) reaction by using the proton energies of 3 and 4 MeV from the folded tandem ion beam accelerator (FOTIA) at BARC. For the neutron energies of 3.12 and 4.12 MeV, the proton energies used were 5 and 6 MeV from the Pelletron facility at TIFR, Mumbai. The ^{115}In(n,γ)116mIn reaction cross-section was used as the neutron flux monitor. The $^{55}Mn(n,\gamma)^{56}Mn$ reaction cross-section at the neutron energies of 4.12 MeV are reported for the first time, whereas at 1.12, 2.12 and 3.12 MeV, they are in between the literature data. The $^{55}Mn(n,\gamma)^{56}Mn$ reaction cross-section was also calculated theoretically by using the computer code TALYS 1.6 and EMPIRE 3.2.2. The experimental data of present work are found to be in between the theoretical values of TALYS and EMPIRE. Published as Radiochim. Acta 2016; 104(11): 749–755.

15.0 Measurements of neutron capture cross sections on ^{70}Zn at 0.96 and 1.69 MeV (NPD and Mizoram University)

The cross sections of the ^{70}Zn(n,γ) ^{71}mZn (T 1/2 = 3.96 ± 0.05-h) reaction have been measured relative to the ^{197}Au(n,γ)^{198}Au cross sections at 0.96 and 1.69 MeV using a ^{7}Li(p,n) ^{7}Be neutron source and activation technique. The cross section of this reaction has been measured for the first time in the MeV region. The new experimental cross sections have been compared with the theoretical prediction by TALYS -1.6 with various level-density models and γ -ray strength functions as well as the TENDL -2015 library. The TALYS -1.6 calculation with the generalized superfluid level-density model and Kopecky-Uhl generalized Lorentzian γ -ray strength function predicted the new experimental cross sections at both incident energies. The ^{70} Zn(n,γ) $^{71g+m}$ Zn total capture cross sections have also been derived by applying the evaluated isomeric ratios in the TENDL -2015 library to the measured partial capture cross sections. The spectrum averaged total capture cross sections derived in the present paper agree well with the JENDL -4.0 library at 0.96 MeV, whereas it lies between the TENDL -2015 and the JENDL -4.0 libraries at 1.69 MeV. Published as Physical Review C95, 024619 (2017).

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