A Brief Status Update on The Activities Of BARC and allied units (2016-2018)

Devesh Raj

Bhabha Atomic Research Centre

Mumbai-400085, India

(*On behalf of the nuclear data scientists in India)*

IAEA NRDC-2018, May 01-04, 2018

GCNEP (Global Centre of Nuclear Energy Partnership), Bahadurgarh, India

BARC (Bhabha Atomic Research Centre)

- Nodal centre for design, development and the application of nuclear technology for the welfare of humanity. (Nuclear medicine, Agriculture, Desalination and Nuclear Energy)
- Responsible for broad range of nuclear data activities in India
- Nodal centre for the collaboration with IAEA, CERN, NRDC and others.
- Theoretical, experimental nuclear physics research and code development.
- Funding of collaborative research projects institutes and universities

Nuclear Data Related Activities

- Nuclear Data Activity at BARC and in Universities with fully supported projects
- EXFOR compilation activity and statistics
- Nuclear Structure and Decay Data evaluation, compilation related programme development.
- Workshops on Nuclear Reaction data and Application (NRA-2016)

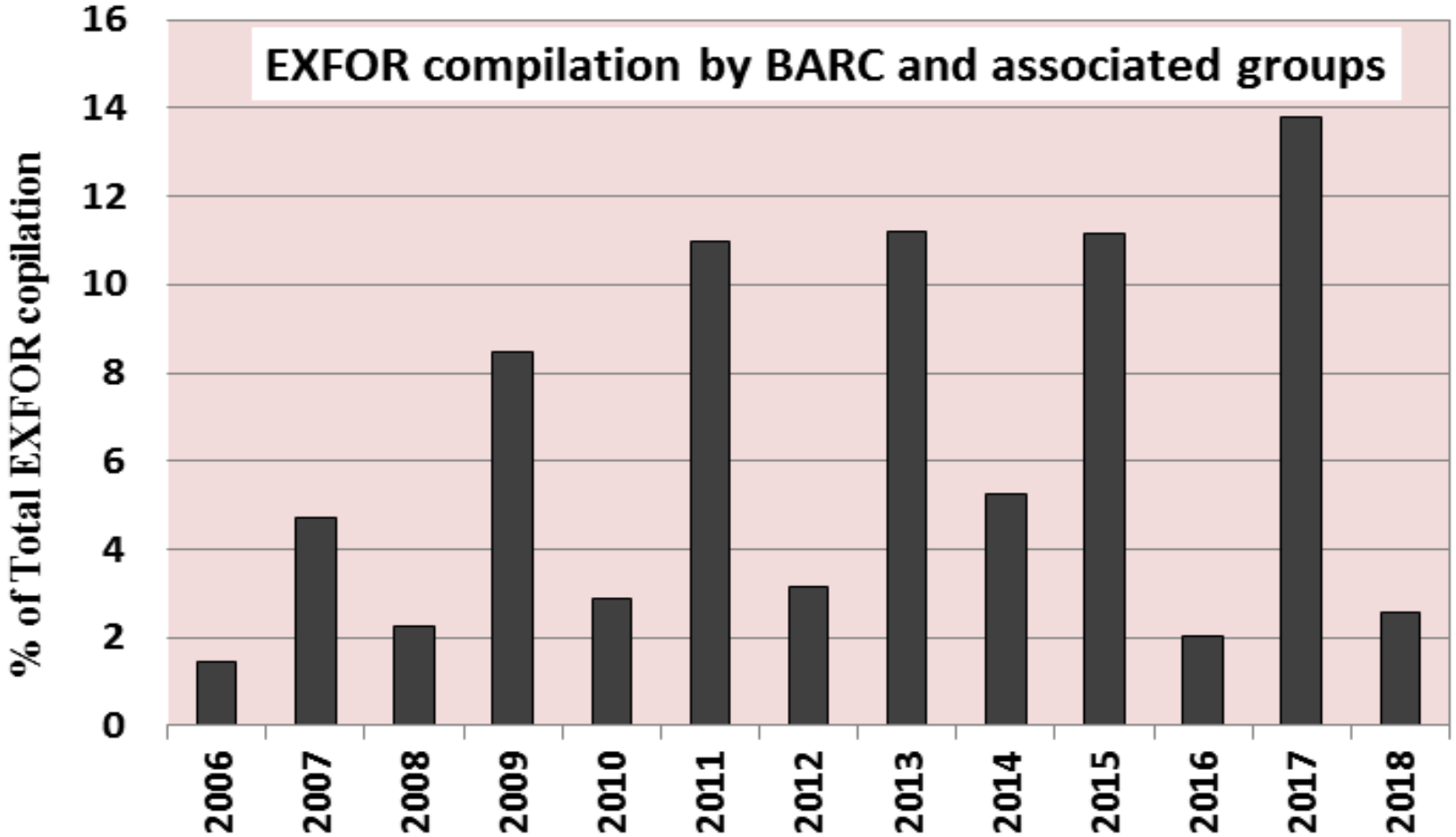
  EXFOR workshop
- International conferences on Nuclear Physics (Nuclear Physics Symposium-), Advances in Reactor Physics (ARP-2017)

Nuclear Data Activity at BARC and in Universities with fully supported projects

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

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, 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 Department of Physics, BHU, Varanasi	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 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 section of metastable states of a few nuclei produced through Photon	Dr. Sanjay Daga Dhole, Prof. of Physics Mhatma Jyoti Ba Phule Pune University, Pune	Dr. Rahul Tripathi RCD, BARC	42.13 Lakh 3 Years	Project Ongoing
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, Punjab	Dr. Gopal Mukherjee VECC, Kolkata	23.00 Lakh 3 Years	Project Ongoing

Statistics of EXFOR Compilation



Statistics of EXFOR Compilation

	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

Statistics of EXFOR Compilation

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 ^{27}Al (d,t).	J,PR/C,91,054611,2015
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

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 from $^{12}C + ^{27}Al$ at 115 MeV.	J,NIM/A,800,29,2015

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

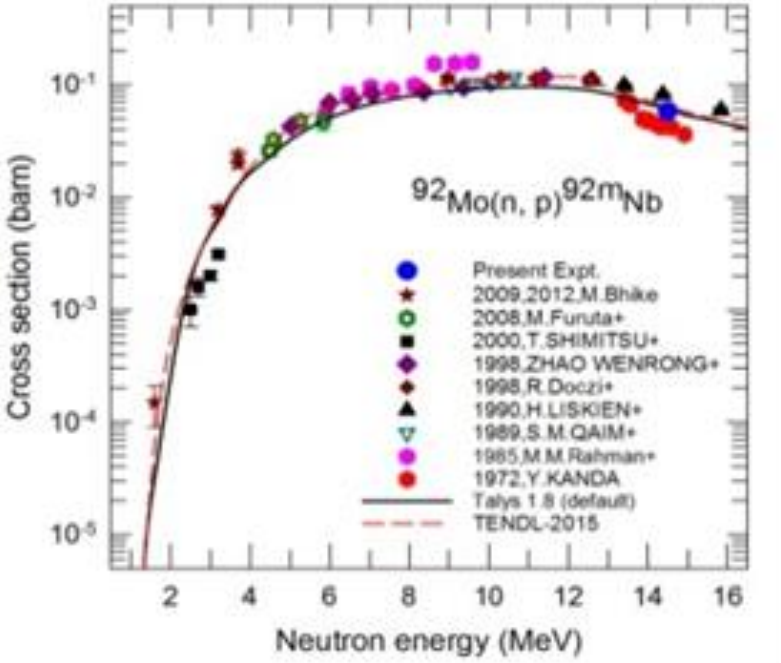
26	D6277	Fission fragment angular distributions in pre-actinide nuclei.	J,PR/C,94,044607,2016
27	D6283	Angular distribution of neutrons from deuteron-bombarded lithium	J,IPA,8,108,1970
28	D6284	Angular distribution of D-D neutrons in 9Be+d reaction.	J,IPA,10,567,1972
29	D6286	Study of the neutrons produced 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

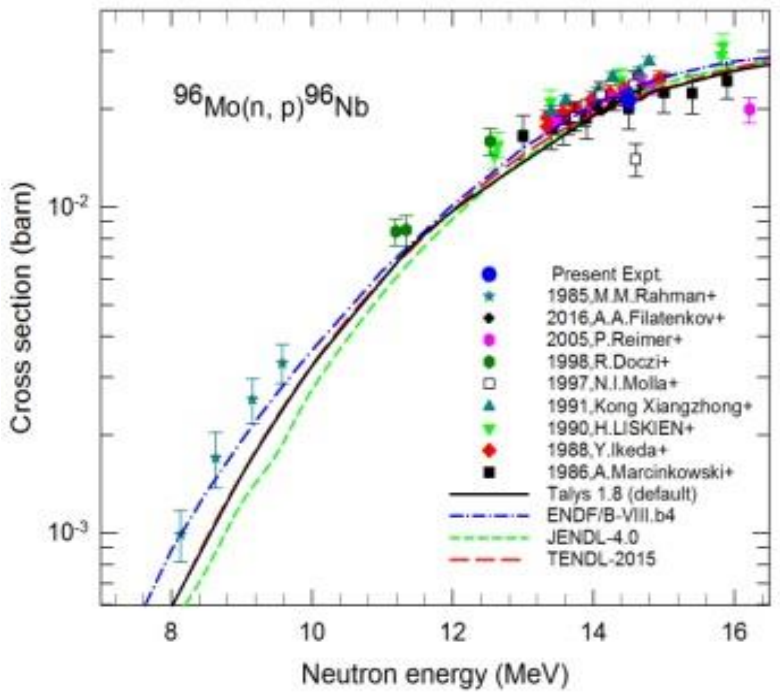
The theoretical analysis of some measured experimental data

(BHU fully funded BRNS Project)

The theoretical analysis of some measured experimental data for neutron induced reactions at energy around ~14 MeV

^{67}Zn, ^{92,96}Mo, ^{208}Pb (n, p) and ^{70}Zn, ^{100}Mo (n, 2n) at energy around ~14 MeV





Work at Dubna-Russia in 2017 and 2018

During may 20th May to 14th August 2017 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

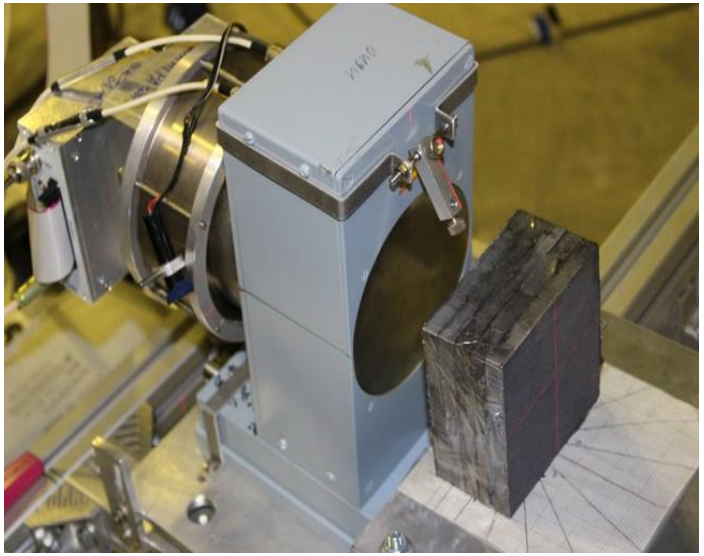
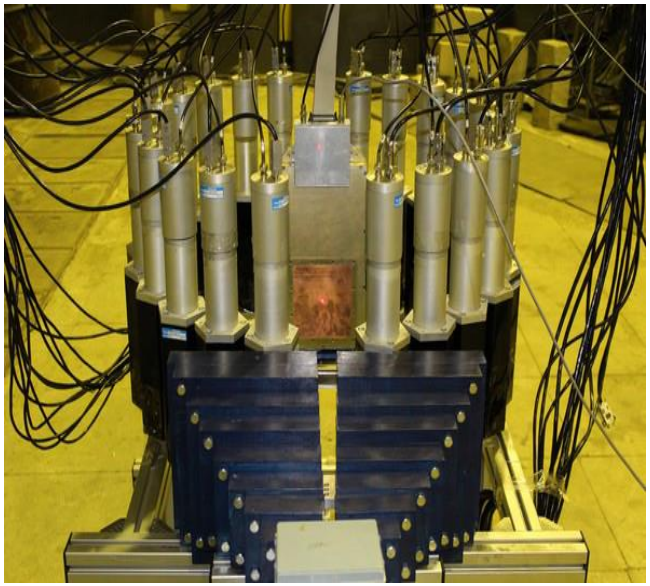


Fig. ING-27 neutron generator (Left)

TANGRA set up with NaI Gamma rays detector array name “Romashka” (Right)



During second visit to JINR, Dubna, Russia from 26th January to 25th March 2018 the data analysis for the beam profile-meter was done

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

The experiment was performed to study excitation energy dependent nuclear level density parameter for two reactions $^{11}B+^{181}Ta$, ^{197}Au

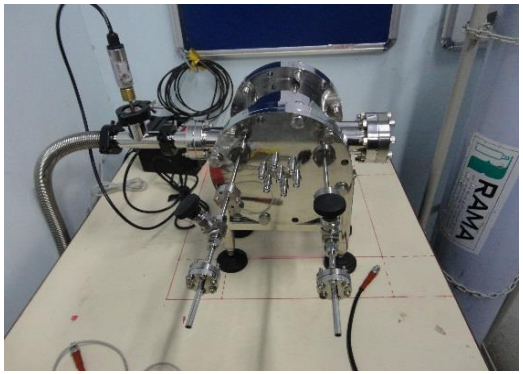
The $^{11}B+^{181}Ta$ and $^{11}B+^{197}Au$ form compound nuclei ^{192}Pt and ^{208}Po, respectively which after 1 alpha evaporation produces daughter nuclei ^{188}Os and ^{204}Pb respectively. The ^{204}Pb has proton shell closure (neutron N=122) whereas, ^{188}Os has Z=76, N=112. Comparison of these two reactions will reveal the effect of shell closure

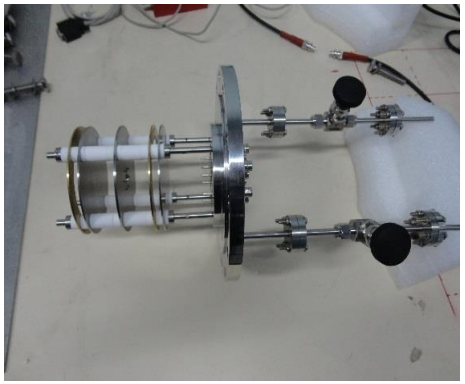
Alpha particle gated neutrons were detected for these two reactions using 15 liquid scintillator detectors to obtain neutron spectra using time of flight technique. Sillicon strip detectors (ΔE-E) were placed at back angles ($\pm 150^0$) to detect evaporated alpha particles in coincidence with neutrons. 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.

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

- The quasi-monoenergetic neutron source will be produced by the p(^{7}Li,n)^{7}Be inverse kinematic reation.
- The detection system involves a Back-to-Back twin grid ionization chamber to detect the fission fragments.
- Maximizing the neutron flux at the target and minimizing the background due to scattering of neutrons.
- **N**eutron 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
- 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

NUCLEAR STRUCTURE AND DECAY DATA (NSDD) EVALUATIONS

Nuclear Data Sheets published and ongoing mass chain evaluations

#	Mass chain	Collaboration	Status & Reference
1.	A=217	Joint ICTP-IAEA Workshop on Nuclear Structure and Decay Data (ICTP, Italy) (2016).	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)	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)

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/*.

- There was problem with unplaced ALPHA records and same has been fixed in revised version of ALPHAD code.
- 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.

Horizontal Evaluation / Compilations

I. Updating of table of radius parameter

Radius parameter (r_0) of total 183 even-even alpha decaying nuclides deduced. 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.

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).

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).

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

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.
^{59}Ni(n, p) reaction using ^{56}Fe(^{6}Li,d)^{60}Ni*->^{59}Co+p
The cross sections for ^{53}Mn(n, p),^{55}Mn(n, p) was also measured by SRA approach.

Possibility of other measurements for the given Li(p, n) source at TIFR Pelletron established. 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.

- **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).** Published as Physical Review C96, 024608 (2017)

- **Measurement of photo-neutron cross-sections of Gd and Ce using bremsstrahlung with an end-point energy of 10 MeV (NPD and RCD).** Published as Journal of Radioanalytical and Nuclear Chemistry 314 (2017) 1983.

- **Measurement of formation cross-section of 100Mo(n,2n) reactions 99Mo from the 98Mo(n,γ) (NPD and RMC).** Published as Applied Radiation and Isotopes, 129 (2017), p117-123.

- **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).** Published as Radiochim. Acta 2016; 104(11): 749–755.

- **Measurements of neutron capture cross sections on ^{70}Zn at 0.96 and 1.69 MeV (NPD and Mizoram University).** Published as Physical Review C95, 024619 (2017).

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

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

Thank You for
Your Kind
Attention !!!!