

NDPCI Progress report: Nuclear Data Activities in India 2018-2019

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This report summarizes the Regular compilation activities of NDPCI bringing from year 2018-2019. All works were carried out in close cooperation with IAEA Nuclear Reaction Data Centre Network.

Report

The Nuclear Data Physics Centre of India (NDPCI) is a research center for nuclear data activities in Bhabha Atomic Research Centre (BARC) in India. 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 main objectives of NDPCI are as follows:

1. Main Objectives of NDPCI

- Compilation of nuclear reaction data.
- Promoting collaborative research on experimental nuclear reaction, nuclear structure data, and compilation of the data by providing project to research groups in universities and institutes
Evaluation of nuclear reaction data
- Journal survey of Indian Published Journal such as Indian journal Pure and Applied Physics and Pramana etc.

List of EXFOR Entries Compiled and Checked 2018-2019

S.No.	Entry No.	Reference	Author
1.	G0512	J,JNR,314,1983,20172	H. Naik
2.	33106	J,ARI,127,92,2017	H. Naik
3.	33107	J,ARI,127,150,2017	R.Makwana
4.	33108	J,ARI,129,117,2017	H. Naik
5.	33109	J,EPJ/A,53,46,2017	P.Panikkath
6.	33110	J,JNR,314,457,2017	H. Naik
7.	33111	J,PR/C,96,024608,2017	S.Mukherjee
8.	33112	J,NSE,187,302,2017	M.S.Barough
9.	D6301	J,JP/G,44,015102,2017	S Adhikari
10.	D6302	J,JNR,314,1803,2017	Y.Sunitha
11.	D6303	J,NP/A,960,53,2017	H.Kuma
12.	D6304	J,NP/A,964,86,2017	H. Naik
13.	D6305	J,PR/C,95,014614,2017	D.R.Chakrabarty
14.	D6306	J,PR/C,95,034615,2017	A.Kundu

15.	D6307	J,PR/C,95,064602,2017	A.Maiti
16.	D6308	J,PR/C,95,064603,2017	R.Pandey
17.	D6309	J,PR/C,96,014617,2017	A.Maiti
18.	D6310	J,PR/C,96,014620,2017	A.Sood
19.	D6311	J,PR/C,96,024603,2017	A.Pal
20.	D6312	J,PR/C,96,034620,2017	A.Shrivastava
21.	D6313	J,PR/C,96,044616,2017	S.K.Pandit
22.	D6314	J,PR/C,96,054613,2017	A.Parihari
23.	D6315	J,PR/C,96,064609,2017	A.Sen
24.	D6316	J,PR/C,95,014612,2017	S.Sodaye
25.	D6317	J,PR/C,95,024604,2017	R.Tripathi
26.	D6318	J,PR/C,95,034610,2017	E.Prasad
27.	D6319	J,PR/C,96,014614,2017	Khushboo
28.	D6320	J,PR/C,96,034613,2017	B.R.Behera
29.	D6321	J,PR/C,96,044607,2017	M.Nandy
30.	D6322	J,PR/C,96,044608,2017	R.Tripathi
31.	D6323	J,PR/C,96,044614,2017	A.Yadav
32.	D6324	J,PR/C,96,054605,2017	A.Kumar
33.	D6325	J,PR/C,96,054614,2017	V.R.Sharma
34.	D6292	J,NP/A,974,9,2018	P.T.Muhammed Shan
35.	D6293	J,PR/C,44,2644,1991	R.H.Iyer
36.	D6294	J,IMP/E,3,239,1994	M.K.Bhardwaj
37.	D6295	J,PR/C,48,87,1993	R.H.Iyer

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

Sanction Number/ File No.	Title of the Project	Principal Investigator	Principal Collaborator	Cost and Duration	Status
36(6)/14/9 2/2014- BRNS	Compilation of Experimental Nuclear Reaction data using EXFOR Editor and Measurement of Nuclear Reaction Cross section using Kamini Reactor	Dr. Rudraswamy B., Department 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)/14/2 1/2016- BRNS	EXFOR compilation of Nuclear Data	Dr. Vidya Devi, Department of Physics, IET Bhaddal Technical	Dr. Alok Saxena, Head, NPD, BARC	16.00 Lakhs 3 Years	Project Ongoing

		Campus, Bhabha, Ropar	Devesh Raj, RPDD, BARC	2016-2019	
36(6)/14/2 3/2016- 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)/14/2 2/2016- BRNS	Study of neutron induces reaction cross section up to 18 MeV for advanced reactor design	Professor Surjit Mukherjee, Physics Department, M.S. University of Baroda, Vadodara	Dr. B.K. Nayak, NPD, BARC, Dr. S.V. Suryanarayana, NPD, BARC	16.18 Lakhs 3 Years	Project ongoing
36(6)/14/3 0/2017- BRNS	Measurement Analysis, Evaluation and Compilation of Nuclear Reaction Data at Low and Medium Energy	Dr. M.M. Musthafa, Professor of Physics, University of Calicut	Dr. S. Jagdeesan, BARC	30.0 Lakhs 3 Years	Project ongoing
36(6)/14/4 9/2016- BRNS	Measurement of section of metastable states of a few nuclei produced through Photon	Dr. Sanjay Daga, Professor of Physics, Mhatama Jyoti Ba Phule Pune University, Pune	Dr. Rahul, RCD, BARC	42.13 Lakhs 3 Years	Project ongoing
36(6)/14/6 0/2016- BRNS	Nuclear Structure & Decay Data Evaluation for Nuclear Models and Dosimetric Applications	Dr. Sukhjeet S. Dhindsa, Associate Professor, Physics, Akal University	Dr. Gopal Mukherjee, VECC, Kolkata	23.00 Lakhs 3 Years	Project ongoing

3. DAE-BRNS Research Project on measurement of incident neutron data on Sodium and Iron (BHU, Varanasi)

Two neutron activation experiments were performed at different neutron energies. The neutrons were produced through $d(t,\alpha)n$ and ${}^7\text{Li}(p,n){}^7\text{Be}$ reactions respectively using Purnima and FOTIA facilities in BARC, Mumbai. The cross section for different reaction channels such as (n,γ) , (n,p) , (n,α) and $(n,2n)$ for the Sodium and other different reactor structural elements like Potassium, Iodine and Copper were studied. In the case of 14.92 MeV neutrons, ${}^{27}\text{Al}(n,\alpha){}^{24}\text{Na}$ monitor reaction was used for the neutron flux measurement and for low energy neutrons we have used ${}^{115}\text{In}(n,n'){}^{115m}\text{In}$ as a monitor reaction. The gamma-ray counting for both the experiments was done in the FOTIA control room using the lead-shielded HPGe detector.

a. Theoretically Using the EMPIRE-3.2 and TALYS-1.8 code:

1. The evaluation of the nuclear excitation functions of fast neutron induced reactions on ^{52}Cr and ^{56}Fe using EMPIRE-3.2 and TALYS-1.8 codes.
2. The cross section calculation for (n,p) and (n,2n) nuclear reactions for Zn, Mo and Pb isotopes with ~14 MeV neutrons using EMPIRE-3.2 and TALYS-1.8.
3. The evaluation for the variation of neutron induced cross-section for ^{23}Na , ^{39}K and ^{41}K isotopes in fast neutron energy range from threshold to 20 MeV, and fitted the experimental data with the theoretical predicted results by adjusting the fitting parameters such as “m2constant” and “rvadjust” available in the TALYS-1.8 code.

4. Experimental work done at Bangalore University under DAE-BRNS Research Project

An experiment was carried out using neutron beam to irradiate foils such as Molybdenum, Niobium, Cerium, Gold, Indium, and Tungsten with FOTIA and PURNIMA neutron generator facilities available in BARC, Mumbai to get the following Nuclear reactions.

- i. FOTIA: $^{100}\text{Mo}(n,\gamma)^{101}\text{Mo}$, $^{115}\text{In}(n,n')^{115}\text{In}$
- ii. PURNIMA: $^{92}\text{Mo}(n,p)^{92m}\text{Nb}$, $^{92}\text{Mo}(n,a)^{89}\text{Zr}$, $^{96}\text{Mo}(n,p)^{97}\text{Mo}$, $^{97}\text{Mo}(n,p)^{97}\text{Nb}$,
 $^{93}\text{Nb}(n,2n)^{92m}\text{Nb}$, $^{93}\text{Nb}(n,a)^{90m}\text{Y}$, $^{140}\text{Ce}(n,2n)^{139g}\text{Ce}$, $^{142}\text{Ce}(n,2n)^{141}\text{Ce}$, $^{197}\text{Au}(n,2n)^{196}\text{Au}$,
 $^{115}\text{In}(n,2n)^{114}\text{In}$

5. Evaluation Work

Covariance Analysis of some experimental data. India’s programme of nuclear data science includes nuclear data physics experiments, Cross-section evaluations and processing of covariances, raw data compilations in EXFOR (IAEA) formats, use of covariances to define error margins due to uncertainties in nuclear data.

We calculated uncertainty propagation in cross section measurement by using three different methods such as Sandwich formula, Unscented Transform method and Monte Carlo method.

Paper Published/Submitted in 2018-2019

1. N.A. Fedorov, D.N. Grozdanov, V.M. Bystritskiy, Yu.N. Kopach, I.N. Ruskov, V.R. Skoy, T.Yu. Tretyakova, N.I. Zamyatin, D. Wang, F.A. Aliev, C. Hramco, A. Gandhi, A. Kumar, S. Dabylova, E.P. Bogolubov and Yu.N. Barmakov, “Measurements of the gamma-quanta angular distributions emitted from neutrons inelastic scattering on ^{28}Si ”, EPJ web of conferences, EDP Sciences, 177, P02002, (2018).
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- gamma-quanta in reactions of inelastic scattering of neutrons with energy 14.1 MeV on nuclei of carbon and oxygen”, *Physics of atomic nuclei* 81(5), 588-594, (2018).
4. N.K. Rai, Vivek Mishra and Ajay Kumar, “Effect of energy variation on the dissipative evolution of the system in heavy-ion fusion reactions”, *Physical Review C*, 98, 024626, (2018).
 5. S. Dutt , M. Saxena, R. Kumar, A. Jhingan, A. Agarwal, A. Banerjee, R.K.Bhowmik, C. Joshi, J. Kaur, A. Kumar, M. Matejska-Minda, V. Mishra, I.A. Rizvi, A. Stolarz, H.J. Wollersheim and P.J. Napiorkowski, “Re-measurement of reduced transition probabilities in $^{132}\text{Ba}^*$ ”, *Acta Physica Polonica B*, No. 3, 535, Vol.49, (2018).
 6. S. Chakraborty, H.P. Sharma, S. S. Tiwary, C. Majumder, P. Banerjee, S. Ganguly, S. Kumar, A. Kumar, A. Kumar, R.P. Singh and S. Muralithar, “Negative parity three-quasiparticle band in ^{127}I ”, *Eur. Phys. Journal. A* 54: 112 (2018).
 7. E.E. Peters, P.Van Isacker, A. Chakraborty, B.P. Crider, A. Kumar, S.H. Liu, M.T. McEllistrem, C.V. Mehl, F.M. Prados-Estevez, T.J. Ross, J.L. Wood, and S.W. Yates, “Seniority structure of $^{136}\text{Xe}_{82}$ ”, *Physical Review C*, 98, 034302, (2018).
 8. P.K. Prajapati, Ajay Kumar, “K and L- shell X-ray Transition-Probability Ratios by Proton Bombardment”, *International Journal of Scientific Research in Physics and Applied Sciences*, Vol.6, Issue.4, pp.10-16, (2018).
 9. A. Gandhi, N.K. Rai, P.K. Prajapati, B.K. Nayak, A. Saxena, B.J. Roy, N.L. Singh, S. Mukherjee, Yu. N. Kopatch, I.N. Ruskov, D.N. Grozdanov, N.A. Fedorov and A. Kumar, “Evaluation of the nuclear excitation functions of fast neutron-induced reactions on ^{52}Cr and ^{56}Fe isotopes”, Published Online on 8-2-2019 in *Indian Journal of Physics* (2019), <https://doi.org/10.1007/s12648-019-01397-8>.
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 11. S. Mukhopadhyay, B.P. Crider, B.A. Brown, A. Chakraborty, A. Kumar, M.T. McEllistrem, E.E. Peters, F.M. Prados-Estevez and S.W. Yates, “Inelastic neutron scattering studies of ^{76}Se ”, *Physical Review C*, 99, 014313, (2019).
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