REPORT ON EXFOR COMPILATION AND SOME SELECTED NUCLEAR PHYSICS EXPERIMENTS IN INDIA

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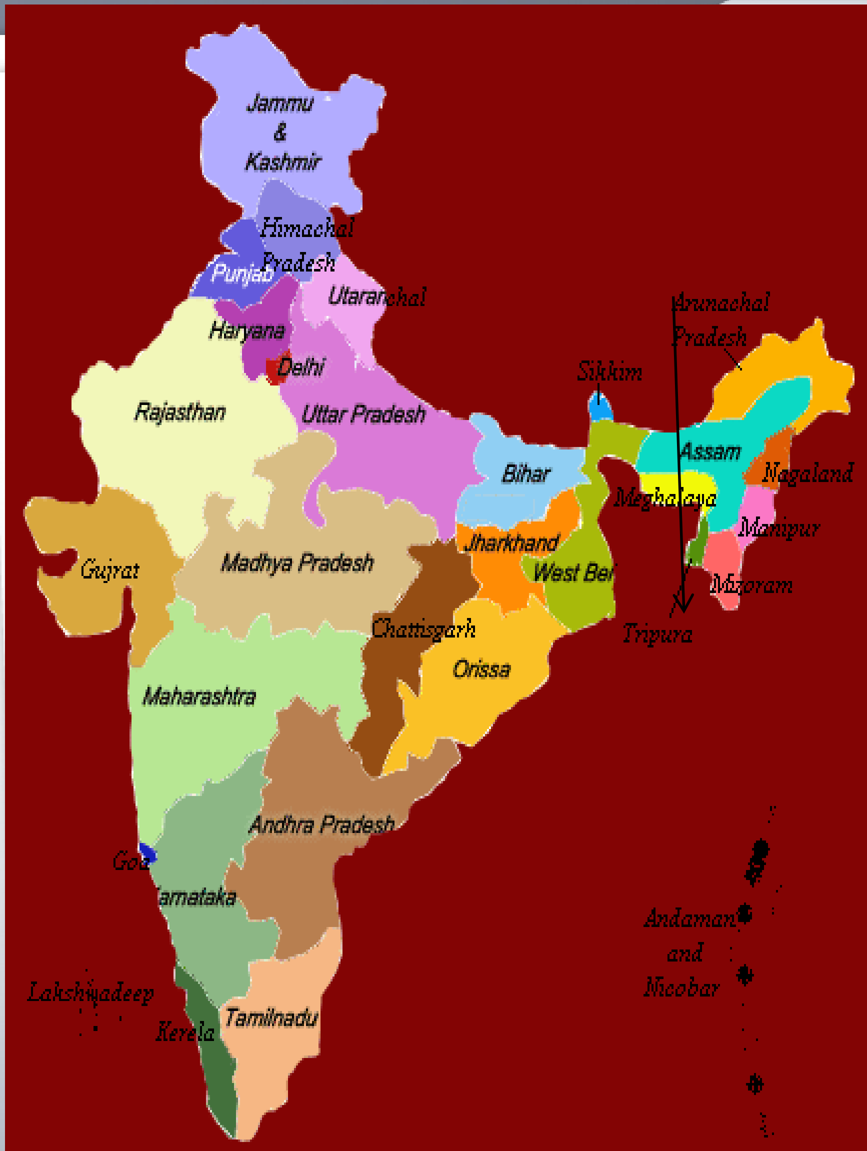
Workshop on EXFOR Compilation,
IAEA Headquaters, Vienna,
27-30 August, 2013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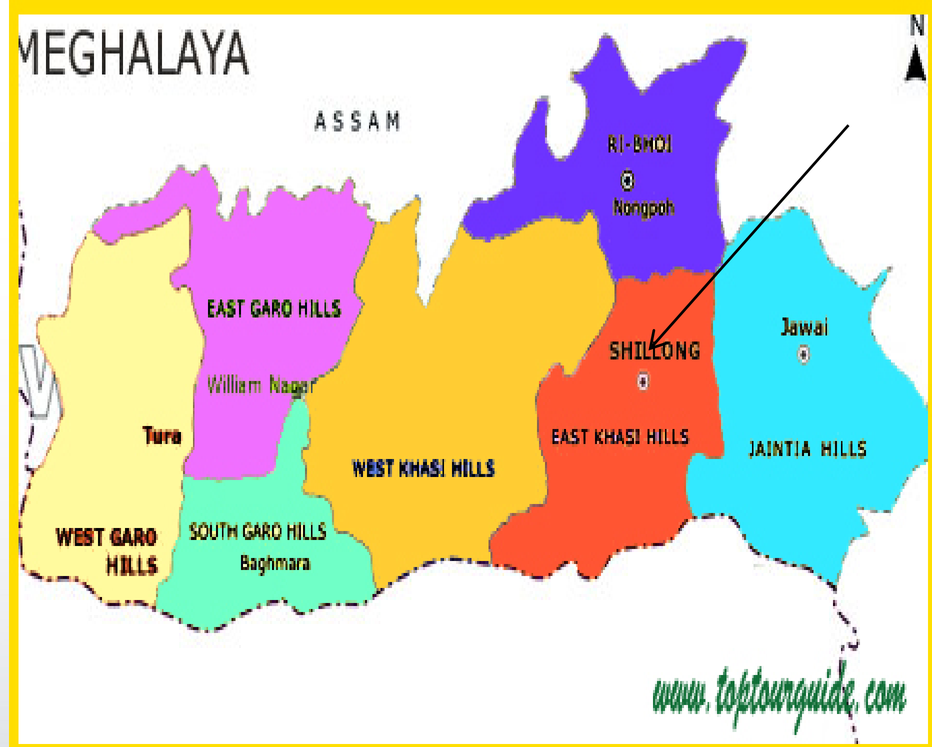
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INTRODUCTION

- **EXFOR** compilation has been initiated since 2006 in the Indian system by BARC. It is now an obligation by the **NDPCI** to **NRDC**.

- **NDPCI** joined **NRDC** as a member from September 2008.

- **NDPCI** encourages Indian users to use **EXFOR** data in the **IAEA** mirror website of India www-nds.indcentre.org.in which is basically a compilation of published nuclear reaction data for incident neutrons, gammas and charged particles on various targets.

- The **DAE-BRNS** project on **EXFOR** compilation given to **NEHU** for 2 years (May 2011- April 2013) is aimed to help NDPCI in compiling several new EXFOR entries for the **IAEA-EXFOR** database. Thus far, **24** entries are successfully completed by **NEHU** team and accepted by **IAEA**.

Some Objectives of NDPCI

- **NDPCI** with the assistance from the **IAEA-NDS** is responsible for all **EXFOR** compilations of nuclear data measured in Indian facilities.

- The following are among some of the objectives of **NDPCI**:

- Coordinating **EXFOR** compilation in India with the help of the **IAEA-NDS** through **NDPCI** Projects/funds in Indian universities in collaboration with different DAE units.

- Organizing **EXFOR** theme meetings/workshops. India has thus far successfully organized *5 EXFOR workshops* and is looking forward to organize the 6th one in Bangalore in December, 2014 in collaboration with the **IAEA**. The phenomenally successful **EXFOR** workshops conducted in India since 2006 represent a new managerial initiative in India. These workshop provided a unique forum to bring together experimentalist, theoreticians, nuclear physicists, radio chemists, health physicists, mathematicians, faculty members in Universities, research scholars, students together.

Some Objectives of NDPCI(contd…)

These workshops have helped **NDPCI** to recognize potential, motivated and young EXFOR compilers. The awareness on EXFOR culture among Indian scientists has been increased.

- Encouraging and using voluntary compilers including young researchers. Due to NDPCI EXFOR workshops, authors (who are experimentalists) of the articles in some cases have compiled their own experimental data.
- Basic nuclear data physics measurements using facilities in India and abroad.
- Nuclear model based calculations using codes such as TALYS and EMPIRE are being continued. Workshops related to nuclear data evaluations have also been conducted.

Some Objectives of NDPCI(contd…)

- Promote research and work on generation of covariance error matrices for nuclear data physics experiments in India. Presently, Shivashankar under the guidance of Prof. S. Ganesan is writing a detailed research paper for favour of publication and entitled, "MEASUREMENT AND COVARIANCE ANALYSIS OF REACTION CROSS-SECTIONS FOR 58Ni (n, p) 58Co AT EFFECTIVE NEUTRON ENERGIES En=5.99, 10.21 and 15.70MeV". The draft paper is under improvement at this time.
- Financially supporting researchers partly/fully to attend national as well as international conferences, wherever possible.
- Improved nuclear structure and decay data for nuclear models in the heavy nuclides region.

Some Objectives of NDPCI(contd…)

- Preparation of integral Indian experimental criticality benchmarks for integral nuclear data validation studies for the International Criticality Safety Benchmark Evaluation Project (http://icsbep.inl.gov). India has contributed by successful international benchmarking of KAMINI (2005), PURNIMA-II (2007) and PURNIMA-I (2012). This activity is a milestone development in Indian reactor physics activities for integral nuclear data and codes validation studies.

- Our benchmarking of KAMINI has already enabled India join, since 2005, the select band of countries which contribute to International Criticality Safety Benchmarks Evaluation Project of the US-DOE/NEA-DB.

- As a consequence, India has full official access to all experimental criticality benchmarks for nuclear data and code validation studies related to nuclear reactor safety .

Forthcoming NDPCI Workshop Nuclear Data Covariance

- The DAE-BRNS workshop on Covariance in Nuclear Data will be held from Dec.16-19, 2013 at Seminar Hall, Homi Bhabha National Institute, Anushaktinagar, Mumbai-400094. India.
- This workshop aims to bring together people who are interested in and working on covariance error matrices in nuclear data. The DAE-BRNS Theme Meeting will include invited tutorials and talks on covariance error matrix and its applications with reference to reactor fuel cycle.
- The participation is expected to be about 50 selected young researchers and scientists from various Indian Universities and Institutes.

INDIAN EXFOR COMPILATIONS

- India started making EXFOR compilations since the year 2006.

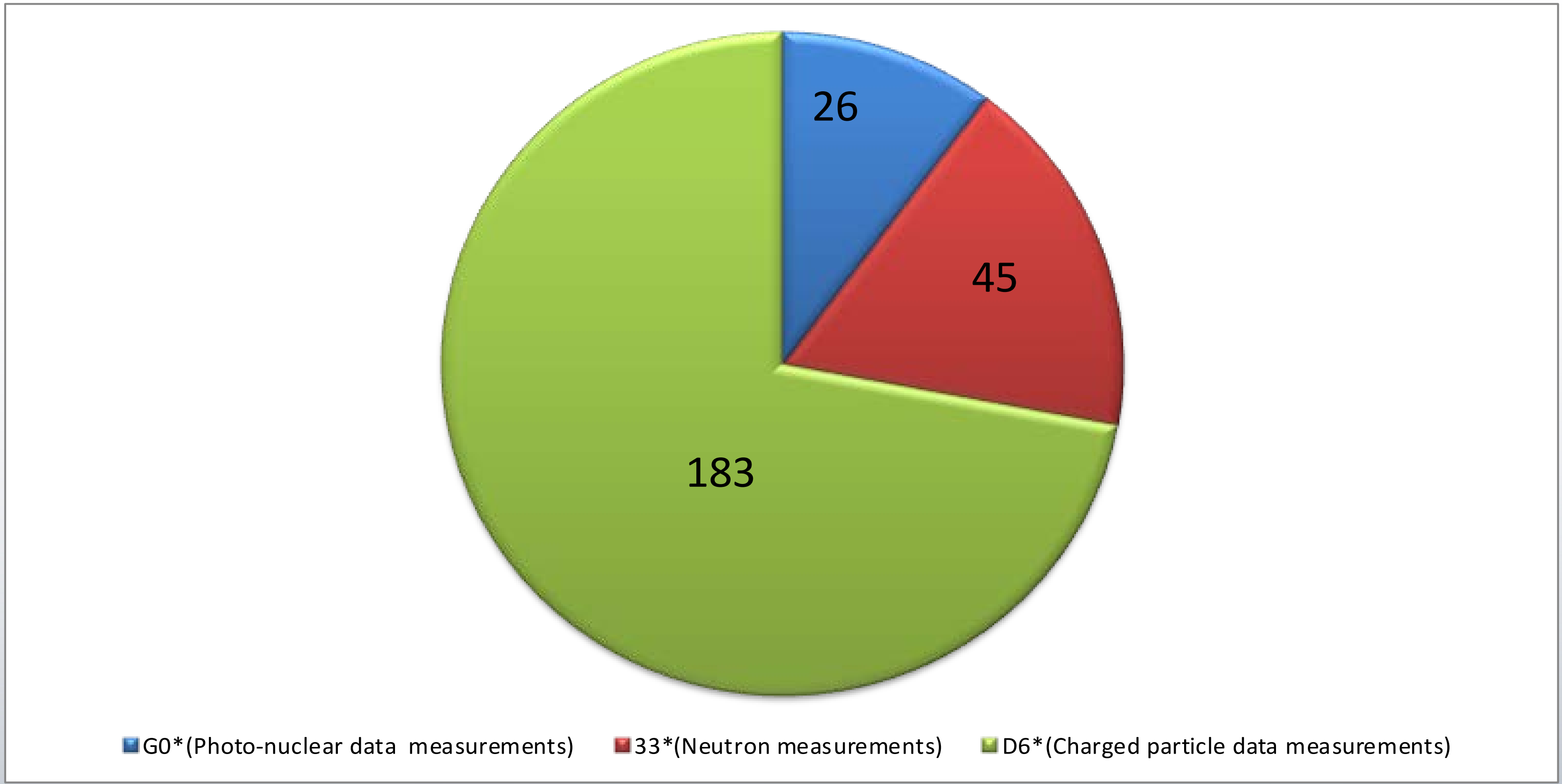
- Five phenomenally successful workshops have been conducted in INDIA so far: 2006 (Mumbai) , 2007 (Mumbai), 2009 (Jaipur), 2011 (Chandigarh), 2013(Banaras Hindu University, Varanasi) .

- Total number of Indian EXFOR Entries thus far accepted by the IAEA= **254*.**

- The EXFOR compilation activity has enhanced the international visibility to INDIA's nuclear physics work. The 6th Indian EXFOR workshop is planned for December, 2014 in Bangalore University, Karnataka, South of India (tentative dates; funds for application to be made).

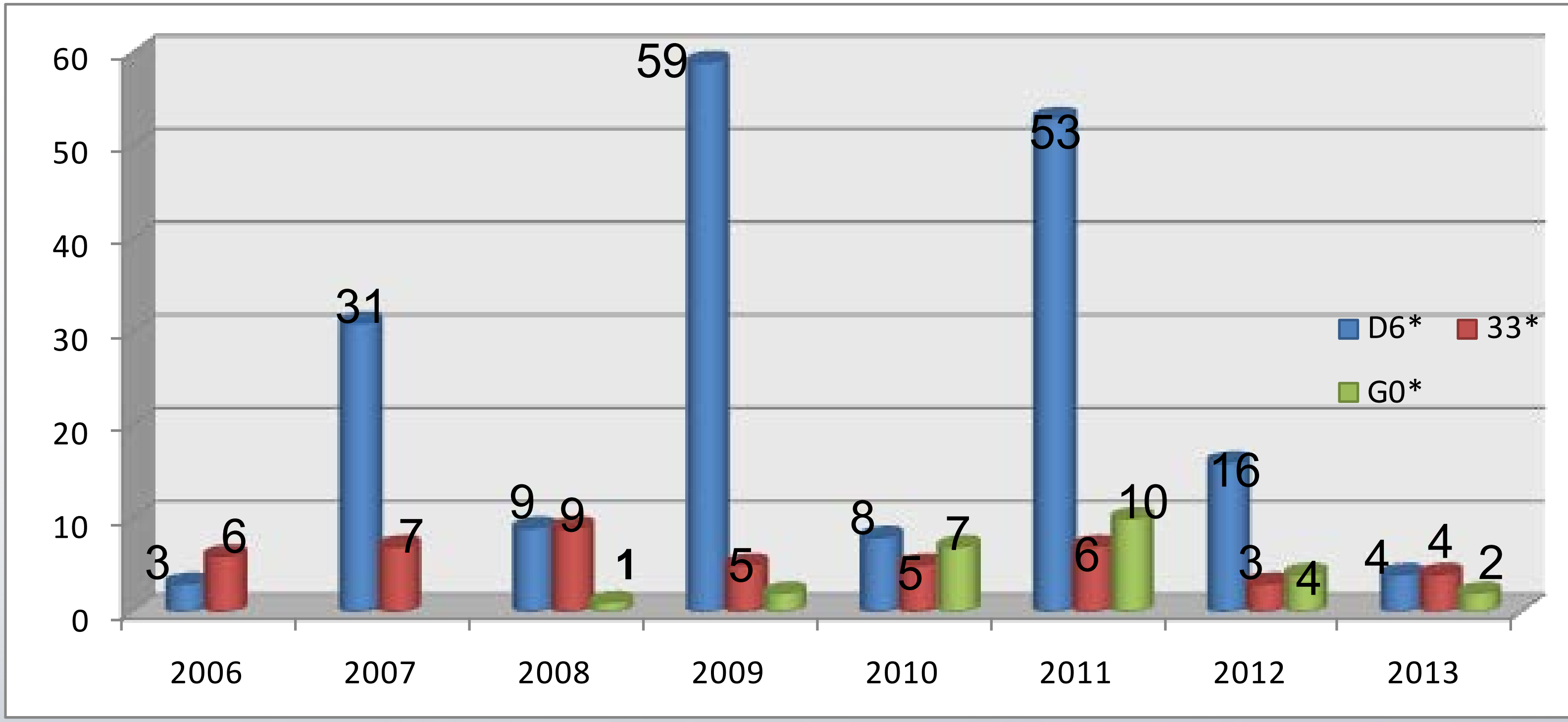
*www-nds.iaea.org/exfor

Number of EXFOR Entries In Each Dataset*



*www-nds.iaea.org/exfor

NUMBER OF INDIAN EXFOR ENTRIES VS YEAR*.



*www-nds.iaea.org/exfor

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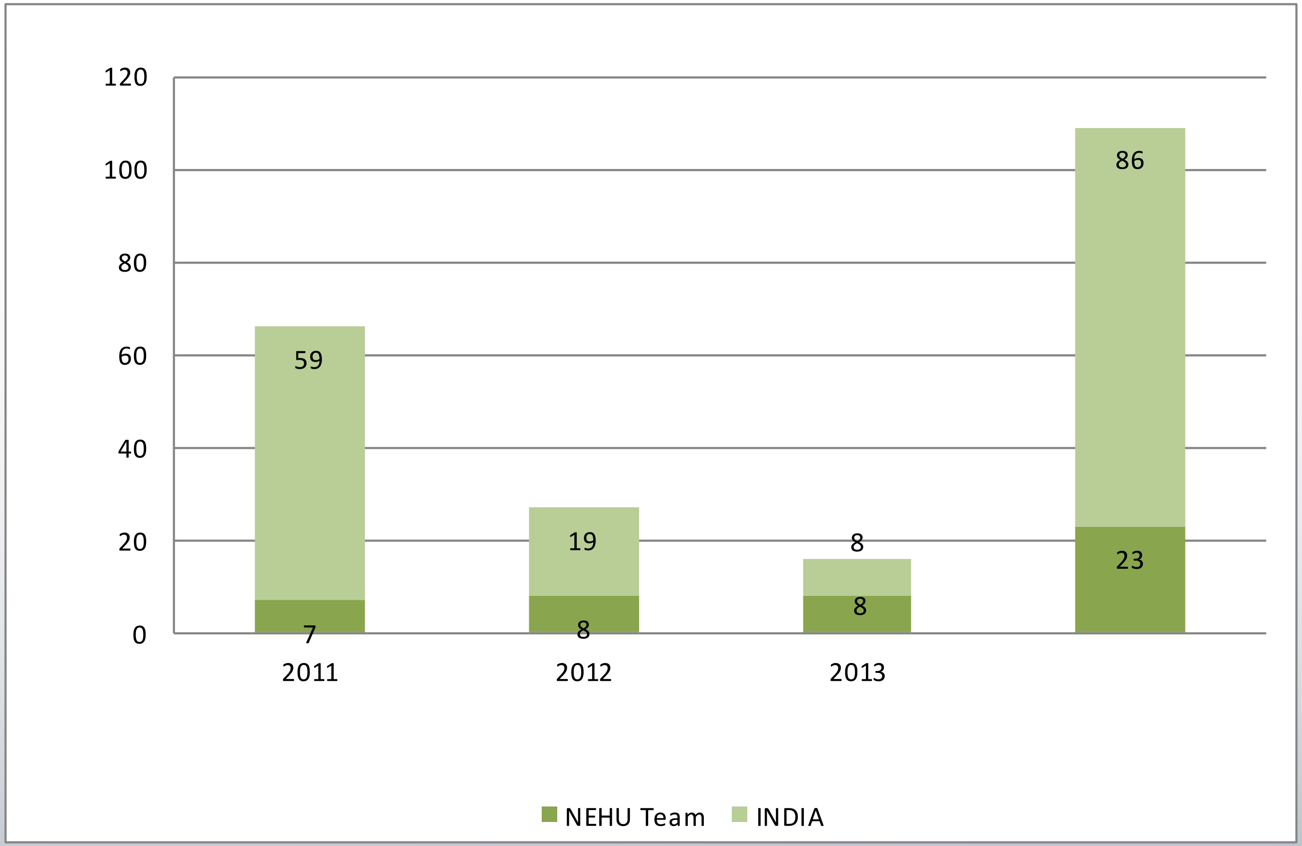
Entries done by NEHU Team (Dr. B.M.Jyrwa, S.Badwar, R.Ghosh)

Sl. nos	Entry Nos	Journal reference	Year
1.	D6095	NPA **96** (1967) 521-528	2010
2.	D6103	EPJ A **44** (2010) 403-410	2011
3.	D6112	PRAMANA **57** (2001) #1 209-213	2011
4.	D6114	Z.Physik A **278** (1976) 281-290	2011
5.	D6111	PRL **106** (2011) 022501----4	2011
6.	D6149	PRC **52** # 2 (1995) 798-806	2011
7.	D6166	PRC **44** # 3 (1991) 1049-1056	2011

Sl. nos	Entry Nos	Journal reference	Year
8.	D6129	PRC **49**,#2, 932 (1994)	2011
9.	D6083	Eur. Phys. J.A **44**,385-392(2010)	2012
10.	D6133	Pramana J.Phys **27**, #3365-379 (1989)	2012
11.	D6158	J.Phys. G. Nucl. Part. Phys **35** 025101 (2008)	2012
12.	D6152	PRC **53** #2 803-810 (1996)	2012
13.	D6156	ITB Hannover +495117628998 Seite 2 von 3 (2012)	2012
14.	D6157	Pramana **52** # 6 609-621 (1999)	2012
15.	D6169	PRC **81** 054607 (2010)	2012

Sl. nos	Entry Nos	Journal reference	Year
16.	D6165	International Journal of Modern Physics E **14** # 7 (2005) (1063-1071)	2012
17.	D6132	Pramana J. Phys **27** # 6 (1986) 747-760	2013
18.	D6173	Eur. Phys. J. A **47** 156 (2011)	2013
19.	D6188	PRC **84,** 011602(R) (2011)	2013
20.	D6171	CHINESE JOURNAL OF PHYSICS. **49**, # 4, 884	2013
21.	D6190	PRC **84,** 024614 (2011)	2013
22.	D6176	PRC	2013
23.	33046	Eur. Phys. J. A, **16,** 495 (2003)	

CONTRIBUTION OF NEHU TEAM



2013 shows the entries accepted the IAEA till date. 40 EXFOR entries has been made by India in the Varanasi workshop.
Of 8 entries made so far by NEHU team 2 has been accepted by the IAEA.

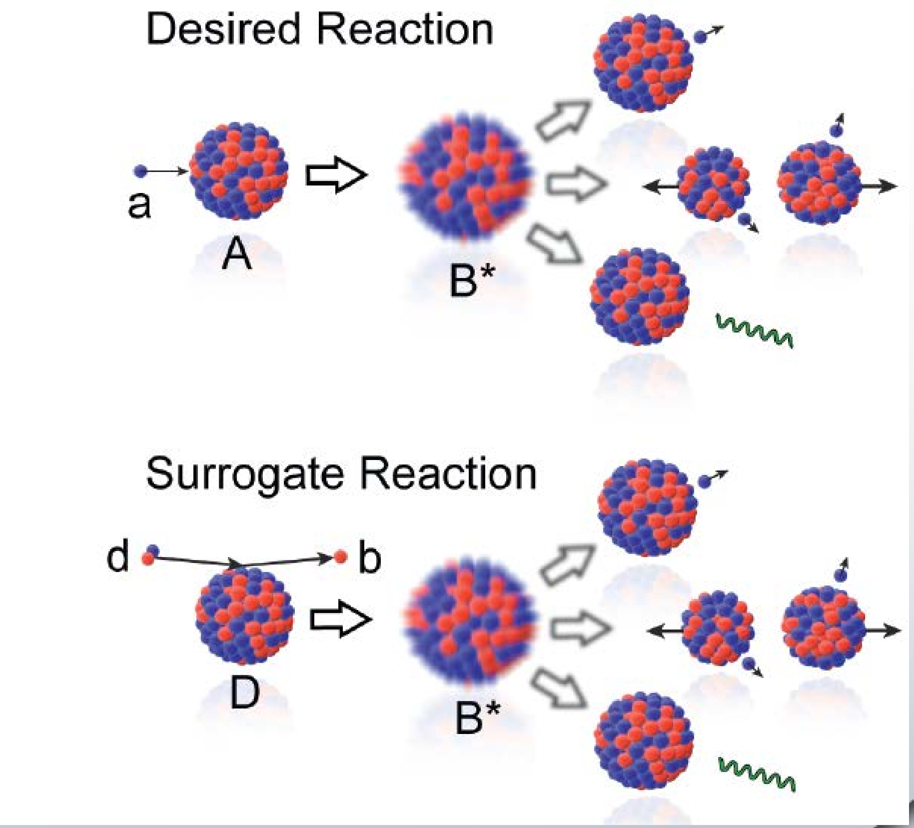
Recent Experimental Activities In INDIA

- India is making significant original contributions to measurement of "difficult to measure," nuclear physics data via surrogate reaction experiments.
- Dr. S.Ganesan, **Raja Ramanna Fellow (Hon) of the DAE Bhabha Atomic Research Centre,** formally proposed in 2004 at the DAE-BRNS Theme Meeting on "neutron sources for reactor applications" to Nuclear Physicists in India that they should start working on surrogate nuclear reaction experiments. The meeting was hosted in Shillong by NEHU. The proposal by him continued informally until realization 2 years later.
- Dr. B.K.Nayak, Dr. A. Saxena and others in BARC were the first to take up the challenge with 6Li beam in TIFR-Pelletron with a target of 232Th and do the surrogate experiments. The first published paper in the series was on ^{233}Pa(n,f) in PRC, 78, 061602, (2008) by B. K. Nayak, A. Saxena, D. C. Biswas, E. T. Mirgule, B.V. John, S. Santra, R. P. Vind, R. K. Choudhury, and S. Ganesan. This was followed by 2 recent publications in 2013 on ^{241}Pu(n, f) and ^{239}Np (n, f), ^{240}Np(n, f).

EXCITING SURROGATE TECHNIQUE

You do not have neutron beam. You do not have a target of an unstable nuclei. How do you get the cross section data for interaction of neutrons with unstable target nuclide?

Use of surrogate nuclear reactions.



Example of surrogate reaction

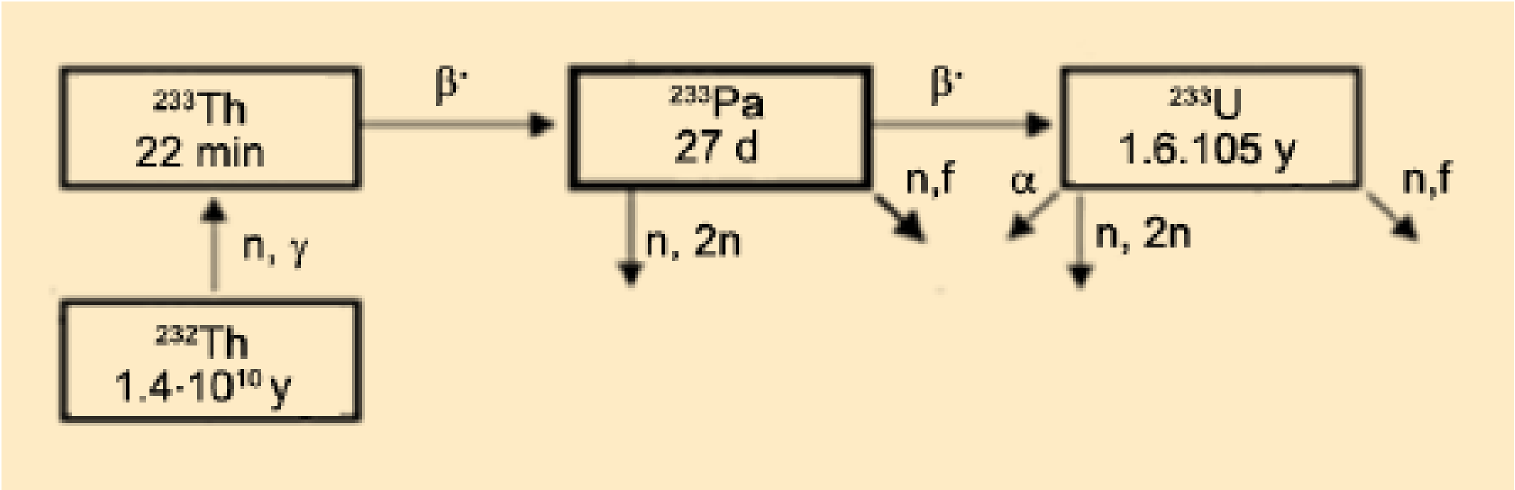


Fig.1: Schematic view of production and decay of ^{233}Pa and ^{233}U isotopes in Th-U fuel cycle.

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First paper in the series of Surrogate reactions

PHYSICAL REVIEW C **78**, 061602(R) (2008)

Determination of the ^{233}Pa(n, f) reaction cross section from 11.5 to 16.5 MeV neutron energy by the hybrid surrogate ratio approach

B. K. Nayak,[1] A. Saxena,[1] D. C. Biswas,[1] E. T. Mirgule,[1] B.V. John,[1] S. Santra,[1]
R. P. Vind,[1] R. K. Choudhury,[1] and S. Ganesan[2]
[1]*Nuclear Physics Division, Bhabha Atomic Research Centre, Mumbai-400085, India*
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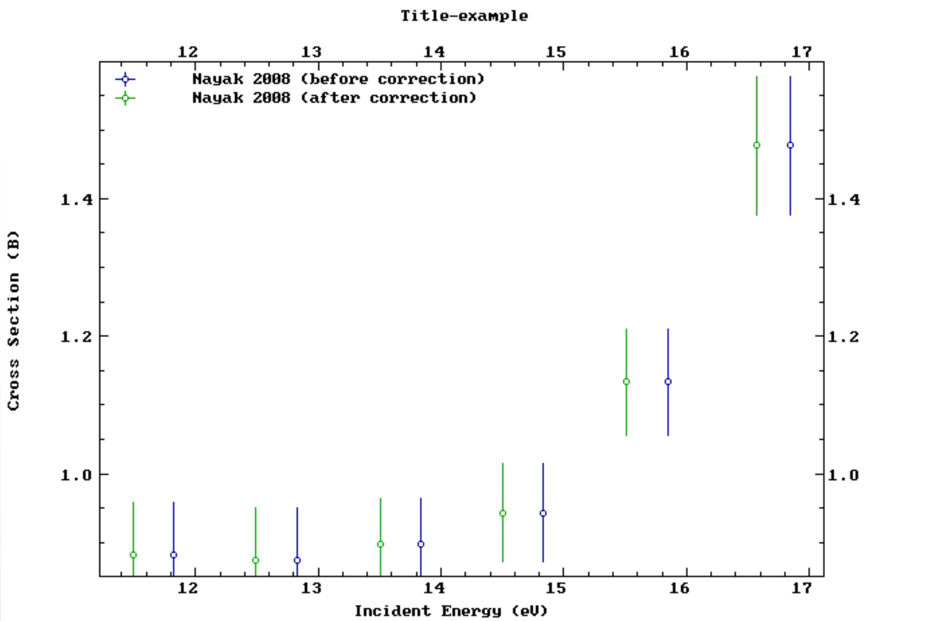
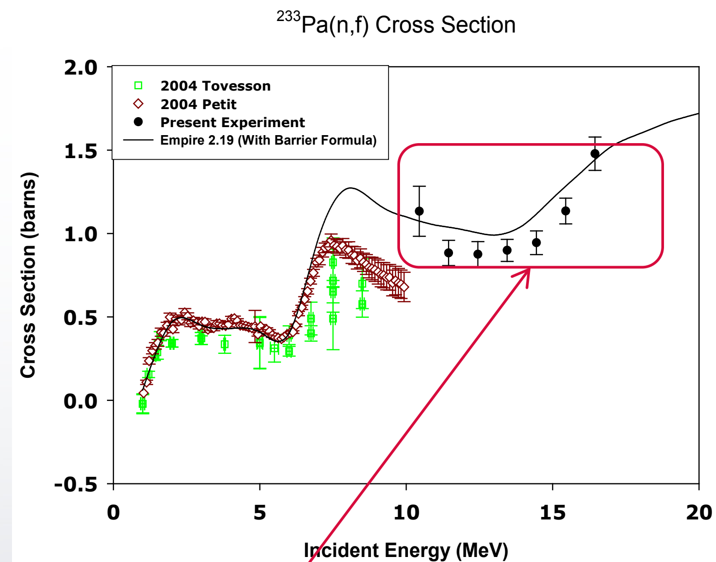
(Received 5 August 2008; published 12 December 2008)

A new hybrid surrogate ratio approach has been employed to determine neutron-induced fission cross sections of ^{233}Pa in the energy range of 11.5 to 16.5 MeV for the first time. The fission probability of ^{234}Pa and ^{236}U compound nuclei produced in ^{232}Th(^{6}Li, α)^{234}Pa and ^{232}Th(^{6}Li, d)^{236}U transfer reaction channels has been measured at $E_{\rm lab} = 38.0$ MeV in the excitation energy range of 17.0 to 22.0 MeV within the framework of the absolute surrogate method. The ^{233}Pa(n, f) cross sections are then deduced from the measured fission decay probability ratios of ^{234}Pa and ^{236}U compound nuclei using the surrogate ratio method. The ^{233}Pa(n, f) cross section data from the present experiment along with the data from the literature, covering the neutron energy range of 1.0 to 16.5 MeV have been compared with the predictions of statistical model code EMPIRE-2.19. While the present data are consistent with the model predictions, there is a discrepancy between the earlier experimental data and EMPIRE-2.19 predictions in the neutron energy range of 7.0 to 10.0 MeV.





The first time experimental data in the world >10MeV is from BARC, India

EXFOR Entry completed

EXFOR Entry nos:33023 and D6075 (CORRECTED FOR 2 INADVERTENT ERRORS IN THE PAPER). See Figure on top, Thanks, N. Otsuka.

Second paper in the series of Surrogate Reactions

PHYSICAL REVIEW C **87**, 034604 (2013)

Determination of ^{241}Pu(n, f) cross sections by the surrogate-ratio method

V. V. Desai,[1,*] B. K. Nayak,[1] A. Saxena,[1] D. C. Biswas,[1] E. T. Mirgule,[1] Bency John,[1] S. Santra,[1] Y. K. Gupta,[1] L. S. Danu,[1] G. K. Prajapati,[1] B. N. Joshi,[1] S. Mukhopadhyay,[1] S. Kailas,[1] P. K Pujari,[2] A. Kumar,[2] D. Patel,[3] S. Mukherjee,[3] and P. M. Prajapati[3]

[1]*Nuclear Physics Division, Bhabha Atomic Research Centre, Mumbai 400085, India*
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(Received 8 January 2013; published 5 March 2013)

The ^{241}Pu(n,f) cross sections have been determined by the surrogate ratio method in the equivalent neutron energy range 11.0–16.0 MeV by using ^{238}U(^{6}Li,d)^{242}Pu and ^{232}Th(^{6}Li,d)^{236}U transfer reactions at $E_{lab} = 39.6$ and 39.0 MeV, respectively. Results have been compared with direct measurement of ^{241}Pu(n,f) cross-section data and predictions of statistical model code EMPIRE 3.1 for different sets of values of fission barrier heights from evaluated data libraries. The present ^{241}Pu(n, f) cross-section data are observed to be consistent with the direct measurements, suggesting the applicability of surrogate methods. However, the EMPIRE 3.1 predictions are not in complete agreement with the experimental data in the neutron energy range 2.0–20.0 MeV for any set of the fission barrier data libraries. The consistency of experimental results on ^{241}Pu(n,f) cross section data from direct and surrogate measurements suggests the need for fission barrier heights for Pu isotopes that are different from those used in standard libraries. The fission barrier heights for various Pu isotopes have been obtained for best fit to the experimental data in the neutron energy range 2.0–20.0 MeV.

^{238}U(^{6}Li,d)^{242}Pu and ^{232}Th(^{6}Li,d)^{236}U transfer reactions

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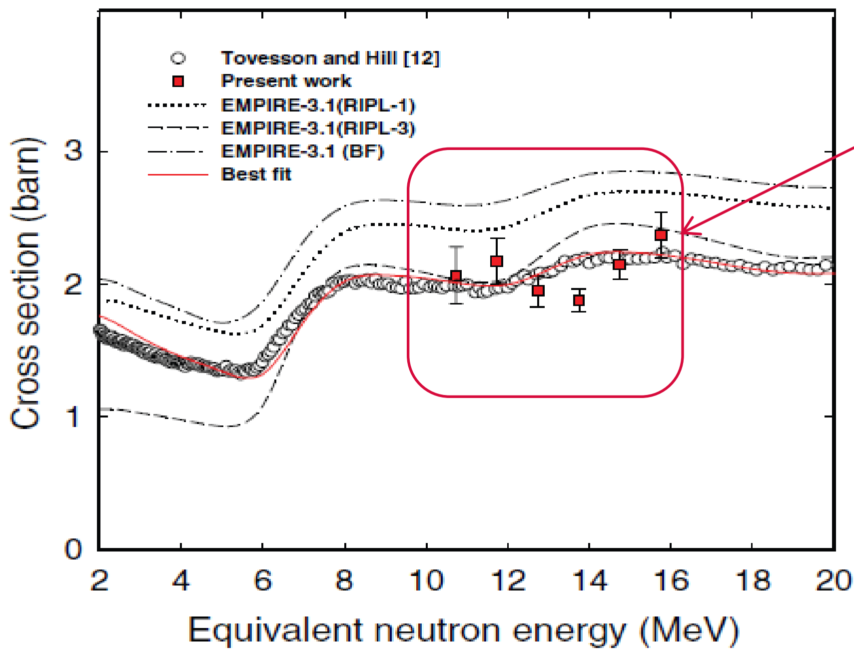

The first time experimental data in the world is from BARC, India

PHYSICAL REVIEW C **87**, 034604 (2013)

Determination of ^{241}Pu(n, f) cross sections by the surrogate-ratio method

V. V. Desai,[1,*] B. K. Nayak,[1] A. Saxena,[1] D. C. Biswas,[1] E. T. Mirgule,[1] Bency John,[1] S. Santra,[1] Y. K. Gupta,[1] L. S. Danu,[1] G. K. Prajapati,[1] B. N. Joshi,[1] S. Mukhopadhyay,[1] S. Kailas,[1] P. K Pujari,[2] A. Kumar,[2] D. Patel,[3] S. Mukherjee,[3] and P. M. Prajapati[3]

Third Indian paper in the series of Surrogate Reactions

PHYSICAL REVIEW C **88**, 014613 (2013)

Determination of the ^{239}Np $(n,\ f)$ and ^{240}Np$(n,\ f)$ cross sections using the surrogate reaction method

V. V. Desai,* B. K. Nayak, A. Saxena, E. T. Mirgule, and S. V. Suryanarayana
Nuclear Physics Division, Bhabha Atomic Research Centre, Mumbai 400 085, India
(Received 3 June 2013; published 29 July 2013)

The surrogate reaction method has been used to determine neutron-induced fission cross sections of the short-lived minor actinides ^{239}Np and ^{240}Np in the equivalent neutron energy range of 10.5–16.5 and 9.0–16.0 MeV, respectively. The ^{240}Np and ^{242}Pu compound nuclei are produced at similar excitation energies in ^{238}U(^{6}Li, $\alpha f)^{240}$Np and ^{238}U(^{6}Li, $df)^{242}$Pu transfer reactions at $E_{lab} = 39.6$ MeV. The fission decay probabilities of ^{240}Np [surrogate of ^{239}Np$(n,\ f)$] and ^{242}Pu [surrogate of ^{241}Pu$(n,\ f)$] compound systems have been measured experimentally as a function of excitation energy to determine ^{239}Np$(n,\ f)$ cross sections within the framework of hybrid surrogate ratio method by considering directly measured ^{241}Pu$(n,\ f)$ cross sections as reference. Similarly, ^{238}U(^{7}Li, $\alpha f)^{241}$Np and ^{238}U(^{7}Li, $tf)^{242}$Pu transfer reactions at $E_{lab} = 41.0$ MeV have been used to determine ^{240}Np(n, f) cross sections. The present results for ^{239}Np$(n,\ f)$ cross sections have been compared with recently reported ^{239}Np(n, f) cross sections obtained by the surrogate ratio method using ^{236}U(^{3}He, p) and ^{238}U(^{3}He, p) reactions [2] and also have been compared with the predictions of the statistical model code EMPIRE-3.1 for the fission barriers obtained from the barrier formula and the evaluated nuclear data libraries such as JENDL-4.0 and ENDF/B-VII.1. The present experimental results for ^{239}Np$(n,\ f)$ and ^{240}Np$(n,\ f)$ cross sections are found to be reasonably consistent with the EMPIRE-3.1 predictions.

^{238}U(^{6}Li, $\alpha f)^{240}$Np and ^{238}U(^{6}Li, $df)^{242}$Pu transfer reactions

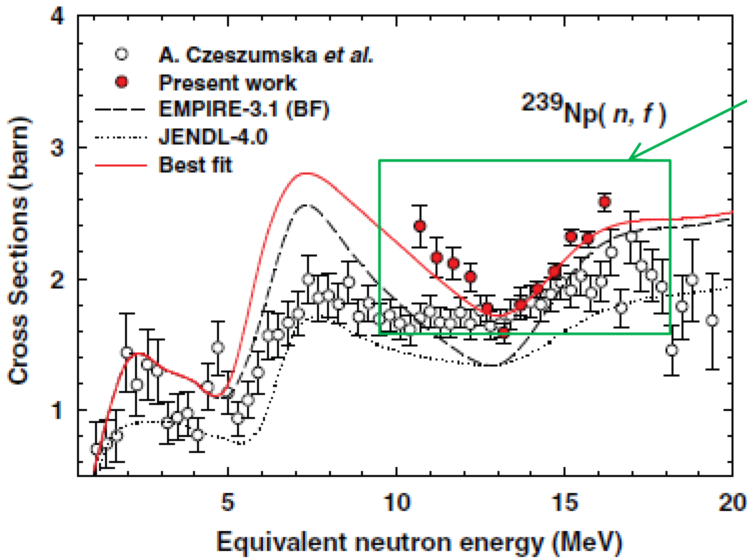

FIG. 2. (Color online) Experimental ^{239}Np(n, f) cross sections, present measurements (solid circles), and the work of Czeszumska *et al.* [2] (open circles). Calculated results are from the EMPIRE-3.1 code for fission barriers obtained from the barrier formula (BF) (short-dashed line). The adopted data from the JENDL-4.0 nuclear data library (dotted line) and the best fit (solid line) are also shown.

PHYSICAL REVIEW C **88, 014613 (2013)**

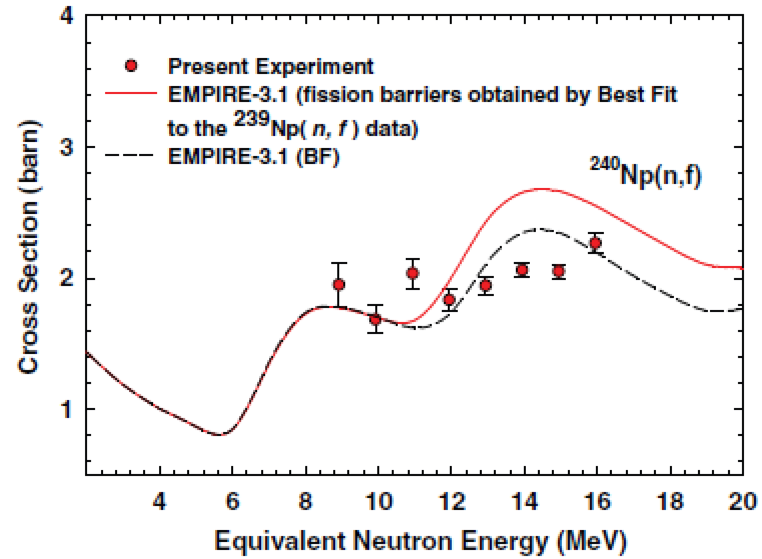

FIG. 3. (Color online) Experimental ^{240}Np(n, f) cross sections and calculated results using the EMPIRE-3.1 code.

nucleus formation cross section, $\frac{\sigma_{CN}^{n+^{239}Np}(E_{ex})}{\sigma_{CN}^{n+^{241}Pu}(E_{ex})}$ and $\frac{\sigma_{CN}^{n+^{240}Np}(E_{ex})}{\sigma_{CN}^{n+^{241}Pu}(E_{ex})}$, to obtain the compound nuclear reaction cross section ratios $\frac{\sigma_{f}^{n+^{239}Np}(E_{ex})}{\sigma_{f}^{n+^{241}Pu}(E_{ex})}$ and $\frac{\sigma_{f}^{n+^{240}Np}(E_{ex})}{\sigma_{f}^{n+^{241}Pu}(E_{ex})}$ at similar excitation energies using Eq. (1). The neutron-induced compound nucleus formation cross sections for the present reactions have been determined using the EMPIRE-3.1 code. The $\sigma_{f}^{n+^{241}Pu}(E_{ex})$ cross-section values as a function of excitation energy were used as the reference reaction; these have been derived from Tovesson and Hill [22] by using the neutron separation energy of ^{242}Pu

Photo-fission Experiments carried out by Dr.H.Naik, et al., in Korea

Nuclear Instruments and Methods in Physics Research B 267 (2009) 1891–1898

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BEAM INTERACTIONS WITH MATERIALS AND ATOMS

Product yields for the photo-fission of ^{209}Bi with 2.5 GeV bremsstrahlung

Haladhara Naik [a], Sarbjit Singh [a], Annareddy Venkat Raman Reddy [a], Vijay Kumar Manchanda [a], Guinyun Kim [b,*], Kyung Sook Kim [b], Man-Woo Lee [b], Srinivasan Ganesan [c], Devesh Raj [c], Hee-Seock Lee [d], Young Do Oh [d], Moo-Hyun Cho [d], In Soo Ko [d], Won Namkung [d]

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2.5 GeV Bremsstrahlung
Photo-fission of ^{209}Bi
Catcher foil

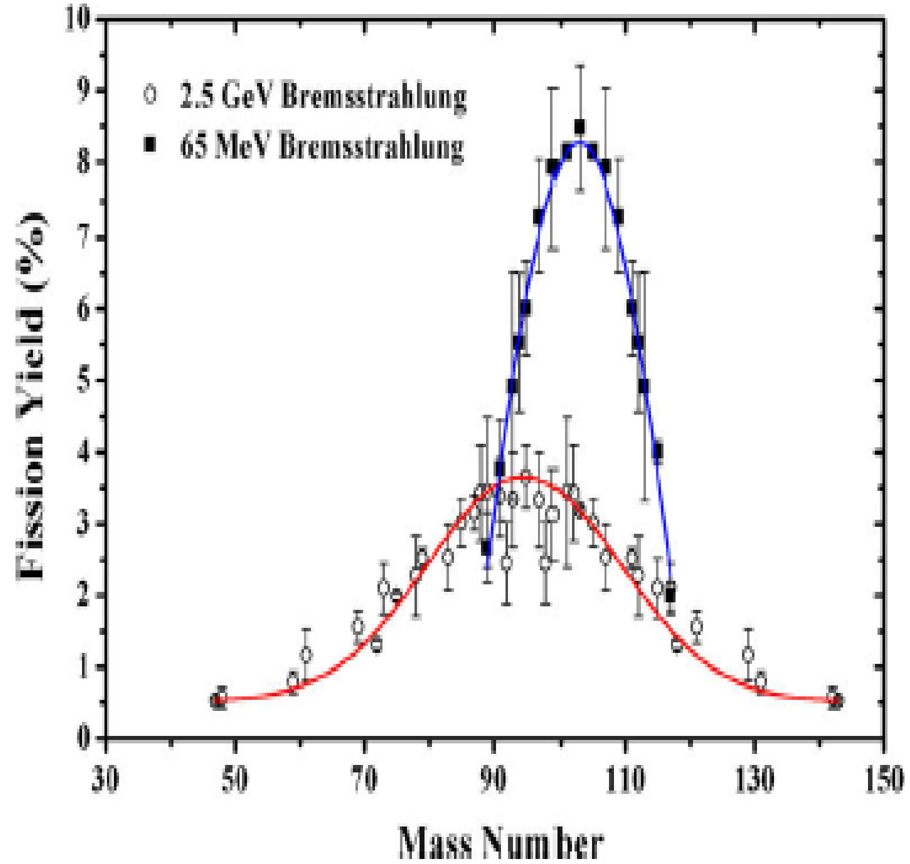
ABSTRACT

The mass-yield distribution of fission products in the 2.5 GeV bremsstrahlung-induced fission of ^{209}Bi have been determined by using the recoil catcher and the off-line γ-spectrometry technique in the high energy electron linac at the Pohang Accelerator Laboratory. The mass-yield determination involves the measurements of cumulative yields for 32 fission products and independent yields of 17 fission products in the photo-fission of ^{209}Bi nuclei. It was found that the mass-yield distribution of fission products in ^{209}Bi is symmetric with an average mass of 95 ± 0.5 and a FWHM of 51 ± 2.0 mass units. Present data at 2.5 GeV along with the literature data at 1 GeV, 700–600 MeV, and 85–28 MeV were interpreted from the point of increase of multi-chance fission and multi-nucleon emission probabilities with an increase in excitation energy. It was found that the average mass of the mass-yield distribution of the fission products decreases from 103 ± 0.5 at 28–85 MeV to 95 ± 0.5 at 2.5 GeV. On the other hand, the FWHM of the mass-yield distribution increases from 19 mass units at 28–40 MeV to 51 mass units at 2.5 GeV. It was also found that the nuclear structure effect observed at the photo-fission of ^{209}Bi with 28–85 MeV bremsstrahlung is washed out at higher energy.

The mass-yield distribution of fission products in the 2.5 GeV bremsstrahlung-induced fission of ^{209}Bi have been determined by using the recoil catcher and the off-line γ-spectrometry technique in the high

The most important result:
"The graph displays fission yield data for two bremstrahhlung end point energies corresponding to the electron energies 2.5 GeV and 65 Mev. The results show that for higher energy a reduction in peak and a broadening occur.
This is an interesting new result.“

Nuclear Instruments and Methods in Physics Research Section B, 267,1891(2009).



EXFOR entry for this has already been made; Entry Number **G0015**

Photo-fission Experiments carried out by Dr.H.Naik, et al. in India

Mass distribution in the bremsstrahlung-induced fission of ^{232}Th, ^{238}U and ^{240}Pu

H. Naik [a,*], V.T. Nimje [b], D. Raj [c], S.V. Suryanarayana [d], A. Goswami [a], Sarbjit Singh [a], S.N. Acharya [b], K.C. Mittal [b], S. Ganesan [c], P. Chandrachoodan [e], V.K. Manchanda [a], V. Venugopal [a], S. Banarjee [f]

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Abstract

The yields of various fission products in the 10 MeV bremsstrahlung-induced fission of ^{232}Th, ^{238}U and ^{240}Pu were determined using a recoil catcher and off-line γ-ray spectrometric techniques. From the yield data, mass yield distributions were obtained using charge distribution corrections. The higher yields of fission products around mass numbers 133–135, 138–140, 143–145 and their complementary products in the neutron and bremsstrahlung-induced fission of ^{232}Th, ^{238}U and ^{240}Pu were interpreted based on nuclear structure effects. From the mass yield distribution, the peak-to-valley (P/V) ratio was also obtained for the above fissioning systems. The present data, along with data from the literature on different bremsstrahlung- and mono-energetic neutron-induced fissions of ^{232}Th and ^{238}U are interpreted to examine the influence of excitation energy on the peak to valley ratio. For the same compound nucleus $^{240}Pu^*$, the data in the 10–30 MeV bremsstrahlung-induced fission of ^{240}Pu were compared with similar data of thermal to 14 MeV neutron-induced fission of ^{239}Pu and the spontaneous fission of ^{240}Pu to examine the role of excitation energy due to bremsstrahlung radiation and mono-energetic neutrons.

The yields of various fission products in the 10 MeV bremsstrahlung-induced fission of ^{232}Th, ^{238}U and ^{240}Pu were determined using a recoil catcher and off-line γ-ray spectrometric techniques. From the

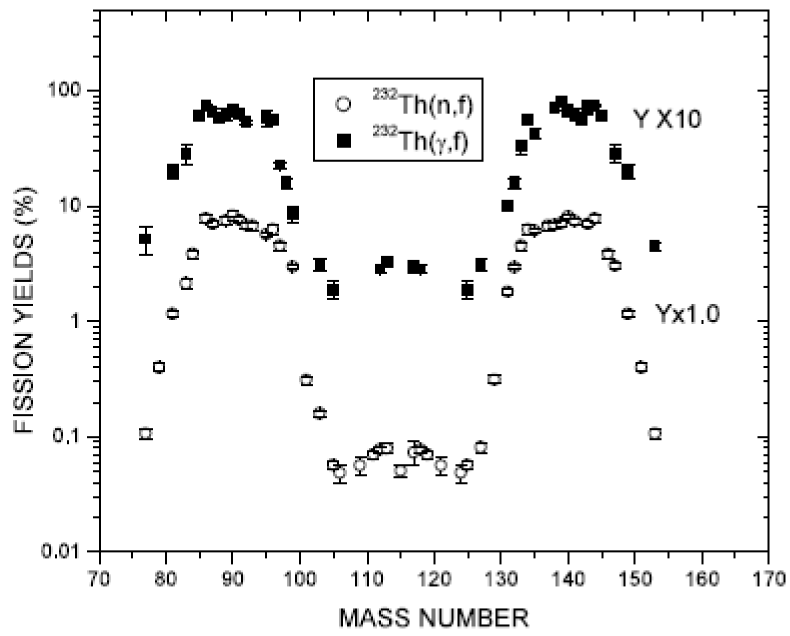

Fig. 2. Plot of yields of fission products (%) (in log scale) vs. their mass number in the bremsstrahlung- (end point energy 10 MeV) and neutron (average $E_n = 1.9$ MeV) -induced fission of ^{232}Th.

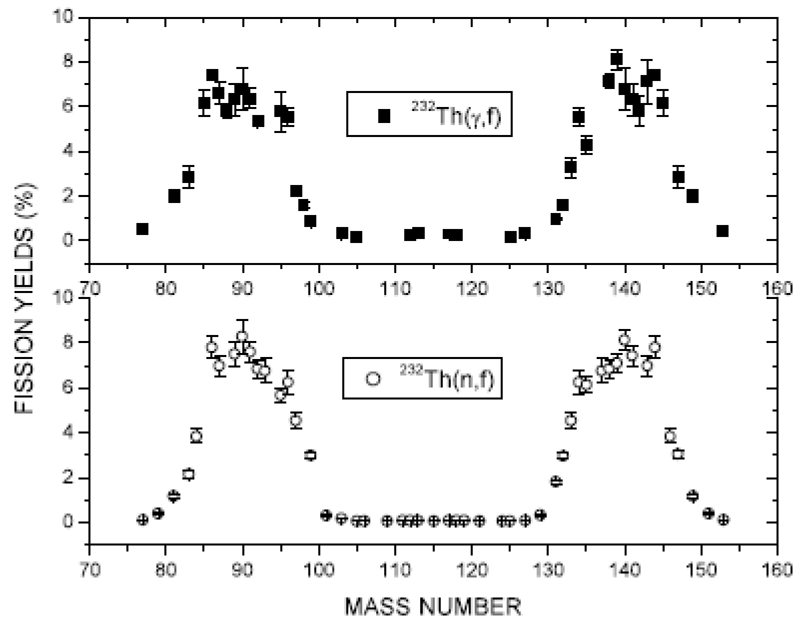

Fig. 3. Plot of yields of fission products (%) (in linear scale) vs. their mass number in the bremsstrahlung- (end point energy 10 MeV) and neutron (average $E_n = 1.9$ MeV) -induced fission of ^{232}Th.

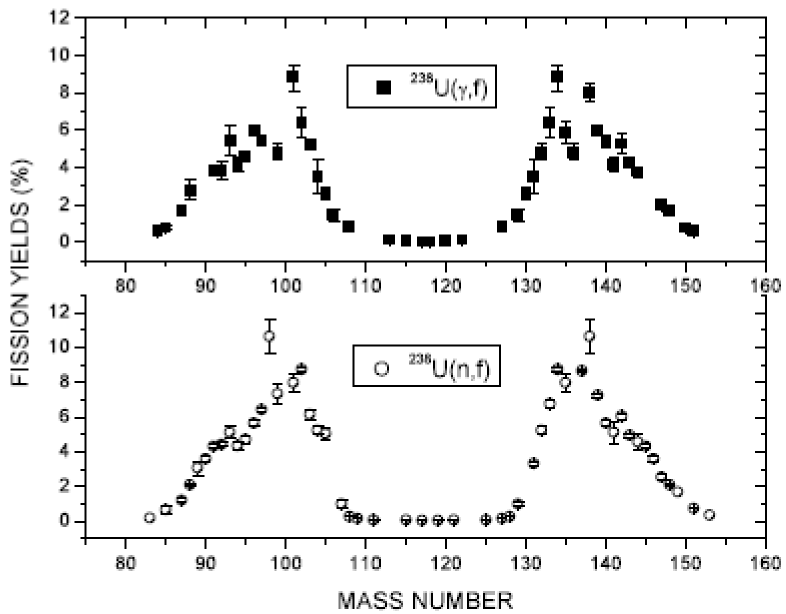

Fig. 4. Plot of yields of fission products (%) vs. their mass number in the bremsstrahlung- (end point energy 10 MeV) and neutron (average $E_n = 1.9$ MeV)-induced fission of ^{238}U.

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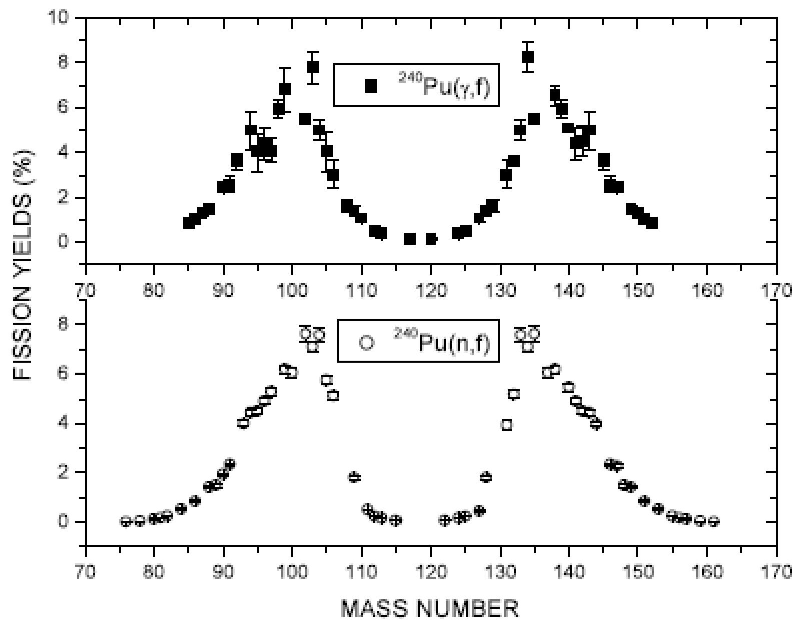

Fig. 5. Plot of yields of fission products (%) vs. their mass number in the bremsstrahlung- (end point energy 10 MeV) and neutron (average $E_n = 1.9$ MeV)-induced fission of ^{240}Pu.

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Mass distribution in the 50-, 60-, and 70-MeV bremsstrahlung-induced fission of ^{232}Th

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The postneutron yields of various fission products in the mass regions of 77–153 have been determined in the 50-, 60-, and 70-MeV bremsstrahlung-induced fission of ^{232}Th by using a recoil catcher and an off-line γ-ray spectrometric technique in the electron linac at the Pohang Accelerator Laboratory, Korea. The mass-yield distributions were obtained from the fission-product yield data using charge-distribution corrections. The fission yields of the present paper and the existing data from the ^{232}Th(γ,f) reaction at various energies are compared with those from the ^{232}Th(n,f), the ^{238}U(n,f), and the ^{238}U(γ,f) reactions. We observe that the yields of fission products for $A = 133$-134, $A = 138$-139, $A = 143$-144, and their complementary products in the above fissioning systems are higher than those of other fission products, which is explained based on the nuclear-structure effect. However, we observed that the yields of fission products for $A = 133$-134 were lower than those for $A = 143$-144 in the ^{232}Th(γ,f) reaction compared to those of the ^{232}Th(n,f), ^{238}U(n,f), and ^{238}U(γ,f) reactions. The yields of fission products for $A = 133$-134 increase, but those for $A = 143$-144 decrease with an increase in the excitation energy in the ^{232}Th(γ,f) and ^{232}Th(n,f) reactions; however, those trends are reversed in the ^{238}U(γ,f) and ^{238}U(n,f) reactions. The increasing or decreasing trends for the yields of fission products for $A = 133$-134 and $A = 143$-144 with the excitation energy in the ^{232}Th(γ,f), ^{232}Th(n,f), ^{238}U(n,f), and ^{238}U(γ,f) reactions are explained from the shell effect of the complementary products based on the static scission-point model and the standard I and II channels of bimodal fission. The peak-to-valley (P/V) ratio for the above fissioning systems also was obtained from the mass-yield distribution. The P/V ratio for the ^{232}Th(γ,f) and ^{238}U(γ,f) reactions at different energies from the present data and the existing literature data are interpreted to examine the role of excitation energy.

The postneutron yields of various fission products in the mass regions of 77–153 have been determined in the 50-, 60-, and 70-MeV bremsstrahlung-induced fission of ^{232}Th by using a recoil catcher and an off-line γ-ray spectrometric technique in the electron linac at the Pohang Accelerator Laboratory, Korea. The mass-yield distri-

Experiment performed at BARC by Dr. B. Lalremruata of Mizoram University

Abstract: The radiative neutron capture cross section is important both for reactor physics applications as well as for nuclear astrophysics and hence accurate data are very important. The cross section for the $^{70}Zn(n,g)^{71}Zn$-m has not been measured in the past for the energy range above 25 KeV. In the present paper, the neutron radiative capture cross section of ^{70}Zn has been measured using $^{7}Li(p,n)^{7}Be$ neutron source at four proton energies viz. 2.25 MeV, 2.6 MeV, 2.8 MeV and 3.5 MeV. The activation technique is used and the cross section is measured relative to the reactions $^{115}In(n,n')^{115}In$-m, $^{197}Au(n,g)^{198}Au$. Experiment has been performed at the FOTIA accelerator - BARC, India. Theoretical calculations of cross sections were carried out using GEANT4, and our own code EPEN for neutron spectra, and later on using the computer code TALYS 1.4. ***The preliminary data analysis are going on.***

It was proposed by Dr. B. Lalremruata to present this in the present workshop.

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THANK YOU