



# Center Report from India

## 1. *ENSDF work*

## 2. *CRP on beta delayed neutron emitters*

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**\*\*\*Akal University, Bhatinda**



# Mass Chain Evaluation-Present status(A=215-218)





Mass Chain	Year of Evaluation	Reference/Journal	Earlier Evaluator	New data sets to be included/Present status
215	2013	NDS 114, 2023 (2013)	B. Singh <i>et al.</i>	09
216	2007	NDS 108, 1057 (2007)	C.Wu	06
217	2003	NDS 100, 141 (2003)	Y.A.Akowali	Being evaluated IAEA-ICTP workshop -2016
218	2006	NDS 107, 1027 (2006)	A.K. Jain and Balraj Singh	09
219	2001	NDS 93, 763 (2001)	E. Browne	Being evaluated
220	2011	NDS 112, 1115 (2011)	E. Browne and JK Tuli	03
221	2007	NDS 108, 883 (2007)	Ashok Jain, Sukhjeet Singh, Suresh Kumar, Jagdish Tuli	09
222	2011	NDS 112,2851 (2011)	Sukhjeet Singh,AK Jain, Jagdish Tuli	02
223	2001	NDS 93, 763 (2001)	E. Browne	Being evaluated (Assignment at Mumbai workshop)
224	2015	NDS 130,127 (2015)	Sukhjeet Singh & Balraj Singh	NIL
225	2009	NDS 110, 1409 (2009)	A. K. Jain , R. Raut , J. K. Tuli	02
226	1996	NDS 77, 433 (1996)	Y.A.Akowali	will be submitted June-2017
227	2016	NDS 132, 257 (2016)	Kondev et al.	NIL
228	2014	NDS 116, 163 (2014)	Khalifeh Abusaleem	NIL
229	2008	NDS 109, 2657 (2008)	E. Browne and JK Tuli	06

# Mass chain evaluations - Progress

## Mass chains evaluated

- Nuclear data sheets of  $A=224$ , NDS 130,127 (2015)
- Nuclear data sheets of  $A=139$ , NDS 138, 1 (2016) with Balraj
- Nuclear data sheets of  $A=227$ , NDS 132, 257 (2016) a part of it only  
( $A=227$  mass chain was evaluated as a part of ICTP workshop -2014 : Sushil Kumar participated in this workshop and contributed in the evaluation of  $^{227}\text{Ac}$ )

## Mass chains in final phase

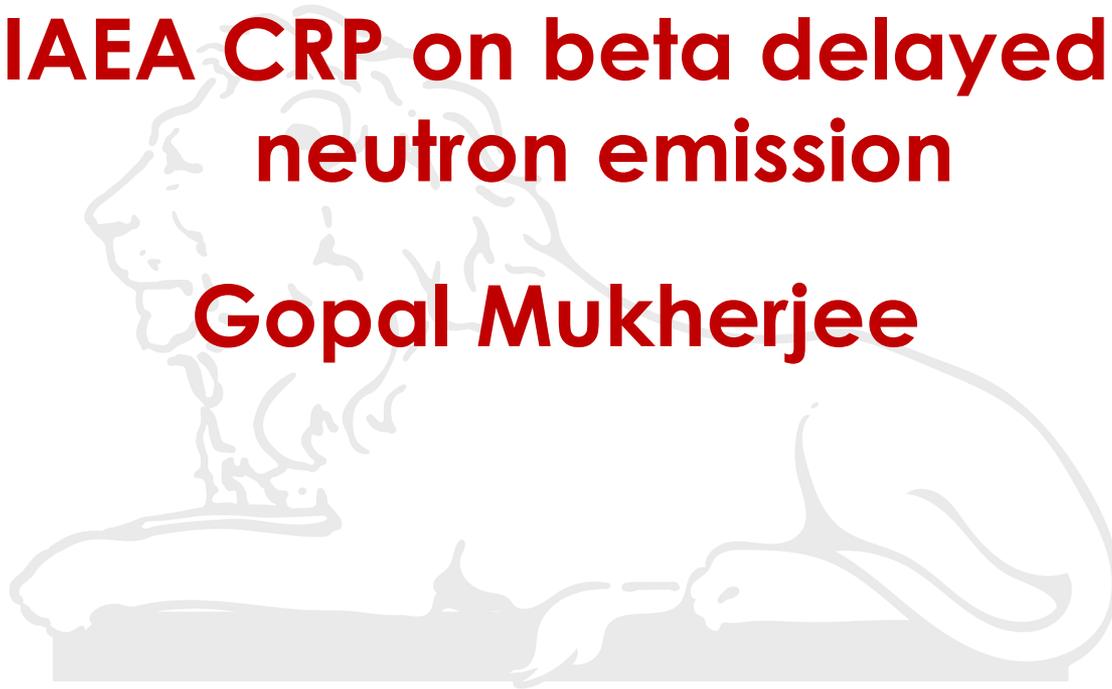
- Nuclear data sheets of  $A=226$  (Sukhjeet, Ashok)
- Nuclear data sheets of  $A=223$  (Mumbai workshop)
- Nuclear data sheets of  $A=219$  (Gopal, Sukhjeet, Ashok)

## Mass chains being evaluated

- Nuclear data sheets of  $A=90$  : S.K. Basu
- Nuclear data sheets of  $A=98$  : S.K. Basu and Anagha Chakrabarty
- Nuclear data sheets of  $A=221$ : Paresh, Sukhjeet, Ashok (being taken up)

# IAEA CRP on beta delayed neutron emission

**Gopal Mukherjee**

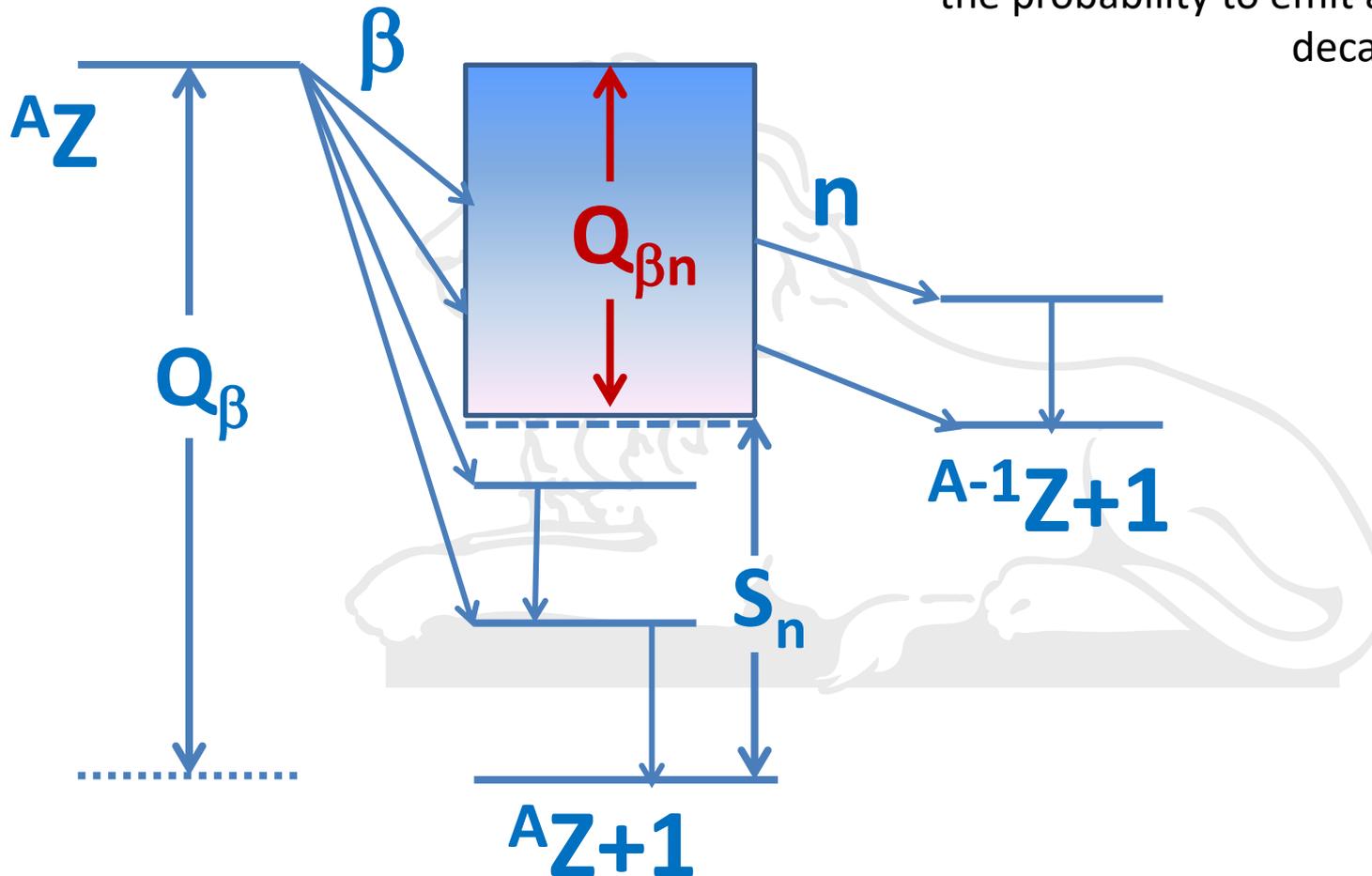


# Beta-delayed neutron emission



$P_n$  :

the probability to emit a neutron following  $\beta$  decay



# Status of experimental data on Beta-delayed neutron emission from VECC (Dr. Kaushik Banerjee and Gopal Mukherjee)

Pn ( $\beta$ n-emission probabilities) data: Co-ordinator (Dr. Balraj Singh)

## Our Assignment:

- Compilation and Evaluation of beta-delayed neutron emitters for **all the nuclei** in the range **Z = 41 – 50: modified as Z = 41- 48**
- All the beta-delayed neutron emitters as well as on “**potential**” beta delayed neutron emitters.
- Potential bdn emitters are **estimated** from the **Q-value** and the  **$S_n / S_{2n} / S_{3n}$**  values of the daughters.
- **Parameters** to be evaluated are:  **$T_{1/2}, P_n, P_{2n}, P_{3n}$**  etc
- The detailed comment on the **methods** of measurements.
- **Detailed evaluation** on methods and adopted values.
- **Digitization** of neutron spectra from **1985Gr15** and **Barddy’s** thesis

**Digitization from Braddy’s thesis is in progress. All other assignments are completed**

## Some features

We have **completed** the compilation and evaluation of 103 beta delayed neutron emitters or potential bdN emitters.

This includes isotopes from element Nb ( $Z = 41$ ) to Cd ( $Z = 48$ )

There are about **10 isomeric** excited states bdN.

**Two** tables were made:

- (i) The **compilation table**: which has information on all the measurements and references with comments for each nucleus and
- (ii) Table of **Adopted values**: This includes only the evaluated adopted values for each nucleus.

We were also requested to **review** all the bdN evaluation done by the whole group (including Chinese group) for elements with  $Z = 29 - 57$ .

The review is also **completed** and a report has been sent.

A **full paper** on this is being prepared by the Co-ordinator.

# Compilation Table



1	Nuclide	Reference	Half-life	%P(1n)	%P(2n)	%P(3n)	Method	Neutron Spectr	Half-Life Comments	P(n) Comments
2	103Nb		(s)							
3	109Tc		(s)							
4		1976Tr02	1.4(4)	-	N/A	N/A	$\gamma$	no	No gamma rays could be attributed unambiguously to the decay of 109Tc, the half-l	
5		1996Me09	0.82(1)	0.08(2)	N/A	N/A	$\beta$ - $\gamma$ n	no	half-life determined by beta gating and neutron singles multiscaling curves by fitting to	
6		2009Pe06	1.14(31)	$\leq 1$	N/A	N/A	fragment- $\gamma$	no	T1/2 using Least square method, T1/2 = 1.04 (107) s using maxim	beta delayed neutrons v
7										
8	110Tc		(s)							
9		1976Tr02	1.0(2)	-	N/A	N/A	$\gamma$	no	110Tc produced by thermal-neutron-induced fission of 249Cf, have been identified usin	
10		1990PeZY	0.86(8)	-	N/A	N/A	$\beta$ - $\gamma$ coin	no	$\gamma$ lines used in the hlf life estimation are 96.2, 128.7 and 138.2 keV.	
11		1990Ay02	0.920 (30)	-	N/A	N/A	$\beta$ - $\gamma$ coin	no	10 points in the fit, approximate 6 half lives measured.	
12		1996Me09	0.78(0.15)	0.04(2)	N/A	N/A	$\beta$ - $\gamma$ n	no	half-life determined by beta gating and neutron singles multisc	efficiency calibration usi
13		2009Pe06	0.91(14)	$\leq 4$	N/A	N/A	fragment $\gamma$	no	T1/2 using Least square method, T1/2 = 0.82 (55) s using maxim	beta delayed neutrons v
14										
15	111Tc		(s)							
16		1988Pe13	0.3(3)	-	N/A	N/A	$\beta$ - $\gamma$ coin	no	Half life determined from daughter $\gamma$ ray observed in coincidence with beta ray. I	
17		1996ME09	0.29(2)	0.85(20)	N/A	N/A	$\beta$ - $\gamma$ n	no	half-life determined by beta gating and neutron singles multisc	efficiency calibration usi
18		2009PE06	0.35(11)	$\leq 1$	N/A	N/A	fragment $\gamma$	no	T1/2 using Least square method, T1/2 = 0.35 (21) s using maxim	beta delayed neutrons v
19										
20	112Tc		(s)							
21										
22		1990Ay02	0.28(30)	-	N/A	N/A	$\beta$ - $\gamma$ coin	no	Only one decay component was observed. 8 points in the fit, approximately 3 half lives i	
23		1996ME09	0.23 (2)	2.6 (5)	N/A	N/A	$\beta$ - $\gamma$ n	no	half-life determined by beta gating and neutron singles multisc	Efficiency calibration usi
24		1999WA09	0.29(20)	1.5(2)	N/A	N/A	$\beta$ - $\gamma$ n	no	Half-life determined from single neutron time spectra by fitting	Efficiency determined u
25		2009PE06	0.29(11)	4(1)	N/A	N/A	fragment $\gamma$	no	T1/2 using Least square method, T1/2 = 0.29 (22) s using maxim	beta delayed neutrons v
26		2015LO04	0.323(6)	-	N/A	N/A	recoil- $\beta$ corr	no	Half lives deduced by fitting the decay curve with unbinned maximum likelihood methc	

2	Nuclide	$T_{1/2}$	$P_{1n}$	$P_{2n}$	$P_{3n}$	Comm.
3	103Nb	1.5	-	-	-	From 1987Gr18 only measurement
4	104Nb(GS)	4.9(4)	0.06(0.03)			Weighted average From 1996Me09 only measurement
5	104Nb(Iso)	0.8(2)				From 1976Ah06
6	105Nb	2.8(1)	1.7(9)			From 1996Me09 on From 1996Me09 only measurement
7	106Nb	1.20(2)	4.5(3)			Weighted average Weighted average of
8	107Nb	0.29(2)	6.04(1)			Weighted average Weighted average of 1996Me09 and 2009Pe06
9	108Nb	0.193(20)	6.3(2)			Weighted average Weighted average of 1996Me09 and 2009Pe06
10	109Nb	0.147(8)	31(5)			Weighted average From 1996Me09
11	110Nb	0.0824(20)	40(8)			Weighted average From 1996Me09 only measurement
12	111Nb	0.053(2)				Weighted average of 2011Ni01 and 2015Lo04
13	112Nb	0.038(2)				Weighted average of 2011Ni01 and 2015Lo04
14	113Nb	0.032(4)				From 2015Lo04 only measurement
15	114Nb	0.017(5)				From 2015Lo04 only measurement
16	115Nb	0.023(8)				From 2015Lo04 only measurement
17						
18	109Mo	0.556(14)	1.3(6)			Weighted average From 2009Pe06 only measurement
19	110Mo	0.292(26)	2.0(7)			Weighted average From 2009Pe06 only measurement
20	111Mo	0.186(9)	$\leq 12$			From 2011Ku16 From 2009Pe06 only measurement

## Table of Adopted values

# 2<sup>nd</sup> ENSDF Workshop in Mumbai

1<sup>st</sup> was held in VECC, Kolkata in Nov. 2012

**2<sup>nd</sup> BRNS Workshop on Evaluation of Nuclear Structure and Decay Data (ENSDD- II), Jointly hosted by NDPCI & HBCSE (TIFR) February 29 - March 04, 2016**

Date: Feb. 29 – Mar 04, 2016.

Venue: Homi Bhabha Centre for Science Education (TIFR), Mumbai

Convener: Dr. P.K. Joshi

Co-Convener: Dr. Gopal Mukherjee

About 40 students from about 20 different institutes and Univ. in India

10 lecturers Including

J.K. Tuli (NNDC, BNL, USA)

P. Demetriou (IAEA, Vienna, Austria)

Evaluation of  $A = 223$  mass chain

To discuss **Nuclear Structure & Decay Data Evaluation and Work on a mass chain.** The workshop will cover several topics related to ENSDF Evaluation and will be accompanied by tutorials. The participants will also be working on a particular mass chain.



**ADVISORY COMMITTEE**

- A. K. Jain
- A. Mohanty
- B. Singh
- D. K. Srivastava
- D. Roy
- E. Brown
- F. G. Kondev
- J. K. Tuli
- J. Ramadas
- P. D. Krishnani
- P. Dimitriou
- S. Ganesan
- S. K. Basu
- S. Kailas

**ORGANISING COMMITTEE**

- A. Saxena
- D. Raj
- G. Mukherjee (Co-convener)
- P. K. Joshi (Convener)
- R. Palit
- S. Singh
- V. P. Raul

All those who are interested to attend please contact the Convener/Co-Convener latest by **November 15, 2015**

Contact E-mail: [pkjoshi@tifr.res.in](mailto:pkjoshi@tifr.res.in), [gopal@vecc.gov.in](mailto:gopal@vecc.gov.in)

## TENTATIVE LIST OF SPEAKERS

A. K. JAIN	A. SAXENA
F. G. KONDEV	G. MUKHERJEE
J. K. TULI	P. K. JOSHI
P. DIMITRIOU	R. PALIT
S. S. DHINDSA	S. K. BASU

**Venue:**  
Homi Bhabha Centre for Science Education  
Mankhurd, Mumbai 400 088.



Group No. & Group In charge	Group No. & Group In charge	Group No. & Group In charge	Group No. & Group In charge
Group-1 J. Tuli / Suresh Kumar	Group-2 P. Dimitrou / P.K. Joshi	Group-3 G. Mukherjee & Anagha	Group-4 A.K. Jain/ S.S. Dhindsa
Vivek Kumar Nautiyal Neelam Prof. Pragnesh N Dave K. Vijay Sai Rani Devi <i>Shanthe Shale mansal</i> <i>Snpalthy-mansal</i> <i>S. muralithar</i>	Harshvardhan G. Kadvekarh Sana Abdul Wahid Khan Somsunder Mukhopadhyay Nidi R. Sethi S. Murthy K M Sachhidananda H.B.	A. Biswas C. Mandal A.K. Mandal T. Rai U. Ghosh S. Bhattacharya <i>Derek Raj BARC</i>	Archana Sexena ✓ Pragati ✓ Swati Garg ✓ Sushil Kumar ✓ Rajiv Gupta ✓ Neeru Gupta ✓ <i>Kamisha Sharma</i> ✓
<b>Nuclides to be updated/checked</b>			
$^{223}\text{Ra}$	$^{223}\text{Pa}$	$^{223}\text{Fr}$ , $^{223}\text{Th}$	$^{223}\text{Ac}$ + ( $^{223}\text{Bi}$ , $^{223}\text{Pa}$ , $^{223}\text{At}$ , $^{223}\text{Rn}$ , $^{223}\text{U}$ , $^{223}\text{Am}$ )

- Evaluation of all these nuclei has been completed and submitted to me
- **except for  $^{223}\text{Ra}$  (Adopted data not received).**
- First round of checking has been done.
- Included **2017WA10** for Q-values.
- Expected to be submitted soon.

# Horizontal Evaluations

- Atlas of Nuclear Isomers
- Table of MR and AMR bands



# Participation in ND2016 Conference

**ND2016: 11 – 16 Sept., 2016, Bruges, Belgium**

Gopal  
Mukherjee

**Full support (Airfare + local expenses) from the IAEA  
Registration fee Waiver by the ND2016 Organizers**

**ND2016**





No. of Participants from India: 3

- GM:**
1. Invited
  2. Regular
  3. Poster with Short presentation

Thursday 15 September 08:30-12:20 Mo

Morus

Topic track: Nuclear masses, structure and decay data measurements  
 Session Title: Nuclear masses, structure and decay data measurements I

1 Chair: M. Fallot, SUBATECH - University of Nantes - CNRS/IN2P3 - EMN, Nantes, France

08:30 I378 Measurement and interpretation of nuclear structure data in heavy mass region  
 Mukherjee G. (Variable Energy Cyclotron Centre, Kolkata, India)

09:00 R379 Structure of single particle states in  $75,77\text{Cu}$   
 Hadynska-Klek K. (INFN Laboratori Nazionali di Legnaro, Legnaro, Italy)

15:40 S465 The measurements of the decay data of Lu-173 and Lu-174g  
 Shi Q. (Northwest Institute of Nuclear Technology, Xi'an, P.R. China)

15:45 S466 Beta feeding anomaly in  $43\text{K}(\beta)43\text{Ca}$   
 Mukherjee G. (Variable Energy Cyclotron Centre, Bidhan Nagar, Kolkata, India)

2 11:40 R385 Gamma-decay in light nuclei. Halo isomers  
 Izosimov I.N. (Joint Institute for Nuclear Research, Dubna, Russia)  
 12:00 R386 Study of isomers and their decays in  $193,195\text{Bi}$   
 Mukherjee G. (Variable Energy Cyclotron Centre, Kolkata, India)

**3<sup>rd</sup> ENSDF Workshop in India will be held in Nov. 2018**

**Possible Venues:**

- 1. Akal Univ., Bhatinda, Punjab (S.S. Dhindsa)**
- 2. Visva Bharati Univ., Santiniketan, West Bengal  
(Angha Chakrabarti)**
- 3. IIT Roorkee (AKJ)**

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