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# Nuclear Data Project

McMaster University

Status Report: Oct. 1, 2012-June 30, 2013

(Includes work from July 1-Sept 30, 2013)

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Balraj Singh

US-NDP meeting at BNL: Nov 18-20, 2013

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# Nuclear Structure and Decay Data (85%)

- ENSDF
  - XUNDL (includes papers on Atomic masses)
  - NSR (PRC: includes papers on nuclear reactions)
  - Topical Evaluations: B(E2); Beta-delayed neutron emitters
  - ENSDF training workshops
  - Collaborative research projects
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# ENSDF-related publications

(oct 1, 2012 –Oct 1, 2013)

## ■ NDS Publications:

- **A=89**: B. Singh, NDS 114, 1-208 (2013)
- Compilation of directly measured **nuclear spins of ground states and Isomers**: A. MacDonald, B. Karamy, K. Setoodehnia, B. Singh, NDS 114, 397-433 (2013)
- **A=31**: C. Ouellet, B. Singh, NDS 114, 209-396 (2013)
- **A=211**: B. Singh, D. Abriola, C. Baglin, P. Demetriou, T. Johnson, E. McCutchan, G. Mukherjee, S. Singh, A. Sonzogni, J. Tuli (IAEA-ICTP workshop August 2012): NDS 114, 661-749 (2013). (Coordinated by B. Singh).
- **A=75**: A. Negret, B. Singh, NDS 114, 841-1040 (2013)

# ENSDF cont.

- Submitted A-chains/nuclides:
- A=86, 215 (ENSDD workshop at VECC, Kolkata, India)  
+ 86 individual nuclides (total of 111 nuclides)
- Final versions of A-chain for NDS with NNDC: A=215
- Post-review versions, near final versions: A=85, 129 (URGENT!)
- A=42, 43, 61, 164: at pre-, review- or post-review stage.
- In progress: A=76, 130, 139, 189, 190 + individual nuclides
- Collaborators from other centers: T. Johnson (NNDC), N. Negret (Bucharest), J. Timar and Z. Elekes (ATOMKI), A. Rodionov and Yu. Khazov (PNPI), P.K. Joshi (TIFR), A. Farhan (Kuwait), A.K. Jain (IIT, Roorkee); many others from IAEA-ICTP workshop in Aug 2012 and ENSDD workshop in Kolkata in Nov 2012.

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# ENPDF Workshops:

## 1. August 2012: IAEA-ICTP: A=211: coordinated and published

- **Principal author and coordinator:**

Balraj Singh (McMaster Univ, Canada)

- **Authors:**

Daniel Abriola (IAEA, Austria)

Coral Baglin (LBNL, USA)

Vivian Demetriou (IAEA, Austria)

Timothy Johnson (NNDC, BNL, USA)

Elizabeth McCutchan (NNDC, BNL, USA)

Gopal Mukherjee (VECC, India)

Sukhjeet Singh (M.M. Univ, Ambala, India)

Alejandro Sonzogni (NNDC, BNL, USA)

Jagdish Tuli (NNDC, BNL, USA)

- **Reviewer:**

Edgardo Browne (LBNL, USA)

- **Trainees:**

Pavel Blokhin (NSI-RAS, Russia)

Yong Chen (CIAE, China)

Sansar Enkhbold (National Univ, Mongolia)

Oleksandr Gorbachenko (Taras Shevchenko Univ, Ukraine)

Maryam Hassanvand (Isfahan Univ, Iran)

Hanxiong Huang (CIAE, China)

Mazhar Hussain (GC Lahore Univ, Pakistan)

Jasmeet Kaur (Panjab Univ, India)

Gehan Khalil (AEA, Egypt)

Jeong Lee (Sejong Univ, South Korea)

Hai Nguyen (NRI, Vietnam)

Monika Patial (IIT Roorkee, India)

Neha Sharma (B.R. Ambedkar NIT, India)

Ariel Tarazaga (CNEA, Argentina)

Natasa Todorovic (Novi Sad Univ, Serbia)

Jia Wang (IAPCM, China)

Bo Yang (IAPCM, China)

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# ENSDF Workshops:

2. Nov 2012: ENSDD: VECC, Kolkata, A=215: coordinated, final with NNDC

- **Principal Author and Coordinator:**

Balraj Singh (McMaster Univ, Hamilton, Canada)

- **Author and Coordinator:**

Gopal Mukherjee (Variable Energy Cyclotron Centre (VECC), Kolkata, India)

- **Authors:**

Daniel Abriola (International Atomic Energy Agency (IAEA), Vienna, Austria)

Swapan Kumar Basu (VECC, Kolkata, India)

Paraskevi Demetriou (IAEA, Vienna, Austria)

Ashok Jain (Indian Institute of Technology (IIT), Roorkee, India)

Suresh Kumar (Delhi University, Delhi, India)

Sukhjeet Singh (M.M. University, Mullana, Ambala, India)

Jagdish Tuli (Brookhaven National Laboratory (NNDC,BNL), Upton, NY, USA)

- **Reviewer:**

Edgardo Browne (NNDC,BNL, Upton, NY, USA)

- **Trainees:**

Srijit Bhattacharya (Barasat Government College, Kolkata, India)

Sudeb Bhattacharya (Saha Institute of Nuclear Physics, Kolkata, India)

Shinjinee Dasgupta (VECC, Kolkata, India)

A. De (Raniganj Girls' College, Burdwan, India)

R. Gowrishankar (S.S. Institute of Higher Learning (SSIHL), Prasanthi Nilayam, India)

Navneet Kaur (Panjab University, Chandigarh, India)

S. Lakshmi (IIT, Roorkee, India)

Jeong-Yeon Lee (Sejong Univ, Seoul, Korea)

Bhoomika Maheshwari (IIT, Roorkee, India)

Debasish Mondal (VECC, Kolkata, India)

Aman Rohilla (Delhi University, Delhi, India)

K. Rojeeta Devi (Delhi University, Delhi, India)

K. Vijay Sai (SSIHL, Prasanthi Nilayam, India)

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## Participation in ENSDF-related Meetings: Oct 2012-Oct 2013:

- October 8-10, 2012: DDEP workshop: Paris: 2 presentations
  - Jan 27-31, 2013: IAEA-NSDD meeting, Kuwait: 3 presentations
  - ND-2013, March 4-8, 2013: 3 presentations, 2 posters
  - May 2-3, 2013: B-DN North American workshop, ORNL, 1 presentation
  - May 16-17, 2013: XUNDL W-G workshop: TUNL: 1 presentation
  - August 26-30, 2013: 1st RCM of B-DN IAEA-CRP, Vienna, 1 presentation
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# Topical ENSDF-related Evaluations

- Beta-delayed neutron probabilities ( $P_n$ ), associated half-lives, digitization (EXFOR style) of available neutron spectra.  $P_n$  and  $T_{1/2}$  for  $A < 73$  region has been evaluated, double-checking being done, and preparation of an article: McMaster + CNEA + TRIUMF + NNDC effort. Work has started on fission region, joint with groups in India and China.
- $B(E2)$  evaluation of first  $2+$  states in e-e nuclei: update of Raman's 2000 evaluation (2001Ra27): first draft is completed for all nuclei, paper is being prepared. NNDC + McMaster U. + Central Michigan U. effort.



# Other ENSDF-related publications 2012-13

- A. Chakraborty, E.E. Peters, B.P. Crider, C. Andreoiu, P.C. Bender, D.S. Cross, G.A. Demand, A.B. Garnsworthy, P.E. Garrett, G. Hackman, B. Hadinia, S. Ketelhut, Ajay Kumar, K.G. Leach, M.T. McEllistrem, J. Pore, F.M. Prados-Estevez, E.T. Rand, **B. Singh**, E.R. Tardiff, Z.-M. Wang, J.L. Wood, S.W. Yates: Phys. Rev. Lett. 110, 022504 (2013):  
Collective Structure in  $^{94}\text{Zr}$  and Subshell Effects in Shape Coexistence
- J. Pradler, **B. Singh**, I. Yavin; Phys. Lett. B 720, 399 (2013): On an unverified nuclear decay and its role in the DAMA experiment. (Unverified decay in  $^{40}\text{K}$ !)
- L.S. Danu, P.K. Joshi, D.C. Biswas, S. Mukhopadhyay, A. Goswami, P.N. Prashanth, L.A. Kinage, R.K. Choudhury, **B. Singh**; Eur. Phys. Jour. A 48, 186 (2012): Revisiting the decay scheme and half-life of  $^{139}\text{Ba}$ . (This work is in connection with on-going A=139 evaluation)
- E.A. McCutchan, A.A. Sonzogni, T.D. Johnson, D. Abriola, **M. Birch**, **B. Singh**; Phys.Rev. C 86, 041305 (R) (2012); Improving systematic predictions of  $\beta$ -delayed neutron emission probabilities.
- B. Pritychenko, **J. Choquette**, M. Horoi, **B. Karamy**, **B. Singh**: *An update of the  $B(E2)$  evaluation for  $0^+_1 \rightarrow 2^+_1$  transitions in even-even nuclei near  $N \sim Z \sim 28$* : ADND Tables 98, 798 (2012)
- P.C. Sood, M. Sainath, R. Gowrishankar, **B. Singh**; Eur. Phys.Jour. A 48, 136 (2012) ; Level structures in  $^{156}\text{Pm}$  from  $^{156}\text{Nd}$   $\beta$ - decay.

# Single-Gamma Levels: $I_\gamma$ values in Adopted

- October 2012: Roberto Capote from IAEA-NDS sent a file retrieved from ENSDF database with 10260 gamma rays with no relative photon branching ratio listed in Adopted datasets. This omission produced problems with their calculation of yields in some reactions.
- November 2012: on my request, received another more relevant and filtered file from R. Capote which contained 2438 such gamma-ray records. Another updated list was obtained in August 2013.
- Nov 12 to present: I have gone through 27 nuclides and sent corrections (i.e. enter 100 where justified) to Jagdish Tuli, which he has edited in ENSDF. I will continue with the rest.

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# XUNDL

Nov 1, 2012 to Nov 8, 2013

- 353 new datasets
  - 18 datasets updated for new papers
  - 93 (65 from TUNL, 28 from ANL) checked/edited
  - Represent about 250 papers.
  - At McMaster: undergraduate students: E. Thiagalingam since March 2012; E. McNeice since Jan 2013.
  - Active communication with authors continued to resolve data-related inconsistencies and/or to request additional data details. Excellent response to such requests. Benefits both the data compilers/evaluators and researchers
  - Mass compilations (post AME-2012): 15 papers: 130 data points; posted on [www.nuclearmasses.org](http://www.nuclearmasses.org) at ORNL.
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## ■ PRC articles:

In FY-13 about 680 keyword abstract were prepared from about 1200 articles (Aug 2012 to July 2013 PRC). M. Birch, E. Thiagalingam, E. McNeice prepared first drafts.

B. Singh provided training for the key-wording process. Draft of keywords checked and edited for technical content, wording, and run through NSR-PREP code to resolve formatting errors, prior to sending to NNDC.

# Collaborative experimental projects

- Dr. Anagha Chakraborty from India visited McMaster for 3 weeks in May 2013 to work on the analysis of  **$^{94}\text{Zr}$  experiment** at TRIUMF carried out in Sept 2011. B. Singh had participated in this experiment run. Anagha also learnt some ENSDF data evaluation. Currently He is compiling some papers for XUNDL database.
- Deformed Structures and Shape Coexistence in  **$^{98}\text{Zr}$** : experiment run in July 2013 for 8 days at ISAC-TRIUMF. Spokespersons: S.W. Yates, P.E. Garrett, J.L. Wood. B. Singh participated in this experiment at ISAC-TRIUMF. Data from this experiment are being analyzed at Guelph Univ. This experiment is also expected to produce data for beta-delayed neutron probability for  $^{98}\text{Y}$  decay.
- **$^{28}\text{Si}(^3\text{He}, p\gamma)^{30}\text{P}$**  at University of Tsukuba Tandem Accelerator, Japan.  
By product of an experiment on  $^{30}\text{S}$  for nuclear astrophysics carried out by McMaster Nuclear Astrophysics group. Results presented at ND-2013.

# Collaborative experimental projects

Proposal to the ISOLDE-CERN and Neutron Time-of-Flight Committee

**Beta-delayed neutrons from oriented  $^{137,139}\text{I}$  and  $^{87,89}\text{Br}$  nuclei.**

- [submitted Oct 1, 2013; Defended, partially approved October 25, 2013]
- R.Grzywacz <sup>1,2</sup>, J.R.Stone <sup>1,3,4</sup>, N.J.Stone <sup>1,3,4</sup>, U. Köster <sup>5</sup>, **B. Singh**<sup>6</sup>, C.R.Bingham <sup>1</sup>, S. Gaulard <sup>7</sup>, K. Kolos<sup>1</sup>, M. Madurga<sup>1,2</sup>, J. Nikolov <sup>8</sup>, T. Otsubo <sup>9</sup>, S. Roccia <sup>7</sup>, M. Veskovic <sup>7</sup>, P. M. Walker <sup>10</sup>, W. B. Walters <sup>3</sup>
- **Abstract:** We propose a world-first measurement of the angular distribution of beta -delayed neutrons and gamma radiation from **oriented**  $^{137,139}\text{I}$  and  $^{87,89}\text{Br}$  nuclei, polarised at low temperature at the NICOLE facility.....  
.....The experiments described in this proposal have direct relevance to a recently initiated Coordinated Research Project (CRP) at the International Atomic Energy Agency (IAEA) in Vienna on the development of a “Reference Database for Beta---delayed Neutron Emission Evaluation.
- Requested 34 shifts in 2014 and 2015 for above experiment.

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## Division of effort Oct 1, 2012 to June 30, 2013

- TOTAL: 0.75 FTE + 0.21 (temp) (DOE funded)
  - ENSDF: 0.40 FTE
  - XUNDL, Mass compilation: 0.20 FTE + 0.06 FTE (temp)
  - NSR key-wording, training of students, etc. : 0.15 FTE
  - $^{30}\text{P}$  experimental structure data analysis: 0.15 FTE (temp)
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## Current collaborations (ENSDF-related work):

1. NNDC, Brookhaven National Lab.: Drs. B. Pritychenko, T. Johnson, J.K. Tuli, E.A. McCutchan, A.A. Sonzogni
  2. Physics Department, Kuwait University: Dr. A. Farhan
  3. Petersburg Nuclear Physics Institute, Gatchina: Drs. A.A. Rodionov, Y. Khazov
  4. Nuclear Research Institute (ATOMKI), Debrecen: Drs. J. Timar, Z. Elekes
  5. Institute of Nuclear Physics (IFJ-PAN), Krakow: Dr. K. Zuber
  6. National Institute of Physics and Nuclear Engineering , Bucharest: Dr. A. Negret
  7. Tata Institute of Fundamental Research (TIFR), Mumbai: Dr. P.K. Joshi
  8. CNEA, Buenos-Aires, Argentina: Dr. D. Abriola
  9. Indian Institute of Technology, Roorkee, India: Dr. A.K. Jain
  10. Nuclear Engineering Division, Argonne National Lab: Dr. J. Chen.
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## Personnel and Funding

- A.A. Chen: Assoc. Professor, PI of Data Project.
- J. C. Waddington: Emeritus-Professor, Co-PI of Data Project.
- J. A. Cameron: Emeritus-Professor: *Volunteer work* (1999-2012)
- B. Singh: Senior Research Scientist/Nuclear Data Evaluator  
(retired June 30, 2013)
- K. Seetodehnia: Post-doctoral Fellow (Oct 1, 2012 to Feb 28, 2013: 50% time)

### Undergraduate students:

- M. Birch: until April 2013
  - E. Thiagalingam: since March 2012
  - E. McNeice: since Jan 2013
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- Financial support: Office of Nuclear Physics, Office of Science, DOE, USA.  
(Undergraduate students partially supported from sources within McMaster)
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# Staff data for Oct 1, 2012-June 30,2013

- Scientific Permanent staff: 4  
US-NDP funded: 0.75 FTE (DOE)
- Scientific Temporary staff: 1      US-NDP funded: 0.21 FTE
- Scientific External collaborators: 15; US-NDP funded: 5 at NNDC  
(Partial coverage of expenses for visiting scientists to McMaster)
- Technical/Support staff: none
- New Hires: none
- Resignations/Retired: one staff retirement, June 30, 2013

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# THANKSGIVING

## 1978-2013

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# ORNL: where it all began

Dr. Murray Martin (The Guru)

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# KUWAIT CONNECTION

## 1978-1984

Dr. Adnan Shihab-Eldin

Dr. David Viggars

Dr. Ameenah Farhan

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# McMaster Shelter

(1980-2013, and onwards...)

Dr. Martin Johns

Dr. John Kuehner

Dr. Jim Waddington

Dr. John Cameron

Dr. Alan Chen

Dr. Chris Ouellet

Dr. Jun Chen

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# LBNL Hospitality (1986-1997)

Dr. Janis Dairiki

Dr. Eddie Browne

Dr. Rick Firestone

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# NNDC: Help, Patience and Tolerance

Dr. Charles Dunford

Dr. Jagdish Tuli

Dr. Tom Burrows

Dr. Pavel Oblozinsky

Dr. Michal Herman

Dr. Alejandro Sonzogni

Dr. Boris Pritychenko

Ms. JoAnn Totans

Ms. Marion Blennau

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# Undergraduate undertaking 1999-2013

XUNDL, NSR, Code writing, Many other projects

Jordan Chenkin

George Reed

Michelle Lee

Roy Zywina

Joel Roediger

Maxim Mitchell

Scott Geraedts

Allison MacDonald

Babak Karamy

Jeremie Choquette

Michael Birch

Ervin Thiagalingam

Elaine McNeice

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## Visiting Scientists for ENSDF evaluations: (2003-2013)

Dr. Alexander Rodionov: PNPI, St. Petersburg, Russia

Dr. Ashok Jain, IIT, Roorkee, India

Dr. Caroline Nesaraja, ORNL, USA

Drs. Janos Timar and Zoltan Elekes, ATOMKI, Hungary

Dr. Ninel Nica, Texas A&M, USA

Dr. Kazek Zuber, IFJ-PAN, Poland

Dr. Paresh Joshi, TIFR, India

Dr. Khalifeh Abu-Saleem, Univ. Jordan, Jordan

Dr. Alexandru Negret, NIPNE, Romania

Dr. Alan Nichols, U. of Surrey, UK.

Dr. Boris Pritychenko, NNDC, BNL

Dr. Anagha Chakraborty, Krishnath College, India

I also thank many other colleagues in NSDD, IAEA-NDS and US-NDP who have helped me over the years in various ways!

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Last but not the least

Most essential support came from

Natural Sciences and Engineering Research Council of  
Canada (NSERC): 1980-2011

Office of Nuclear Physics, Office of Science, DOE, USA  
1986-1989, 1991-1997: through LBNL

1998-2013: through McMaster.

MANY THANKS TO YOU ALL !

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