
Nuclear Data Project

McMaster University

Status Report: Oct. 1, 2010-Sept. 30, 2011

Alan Chen (McMaster)

USNDP meeting: Nov 16-18, 2011

Part 1: Nuclear Structure and Decay Data Evaluation

Prepared by: Balraj Singh

ENSDF Work

- **Permanent Responsibility:**

A=1 (2005);

31 (1998,s,pr), **32** (2011),
33 (2011), **34** (1998,s,pr,*),
35(2011), **36,37**(1998,s,pr,*),
38 (2007), **39** (2006),**40** (2004),
41 (2001), **42** (2000,w),
43 (2001,s,r), **44** (2011).

64 (2006), **89** (1998,s,pr),

98 (2003), **100** (2007),

149 (2004), **151** (2008),

164 (2001), **188** (2002,w) (ANL+JYFL)

190 (2003), **194** (2006)

- Number in parentheses gives the year of last revision in ENSDF
- w: work in progress
- s: revision submitted
- pr: post-review stage
- r: review-stage
- *: collaboration with Ninel Nica
- During FY-2011, work was also done on A-chains and nuclides, outside our A-chain responsibility

A=31-44 region started in 1999 is completed. Hopefully A=31, 34, 36, 37 will be in ENSDF database and NDS by the middle of 2012.

We have started this region for reevaluation. A=44, 43 done; A=42 in progress.

ENSDF work cont.

Mass-chain Evaluations Published/submitted since October 1, 2010

- **A=32:** C. Ouellet and **B. Singh**, NDS 112, 2199-2355 (2011) (*)
- **A=33:** J. Chen and B. Singh, NDS 112, 1393-1511 (2011)
- **A=35:** J. Chen, J. Cameron and B. Singh, NDS 112, 2715-2850 (2011)
- **A=44:** J. Chen, B. Singh and J.A. Cameron, NDS 112, 2357-2495 (2011): submitted May 2011
- **A=50:** Z. Elekes, J. Timar and **B. Singh**, NDS 112, 1-131 (2011) (*)
- **A=71:** K. Abu-Saleem and **B. Singh**, NDS 112, 133-273 (2011) (*)
- **A=43:** B. Singh and J. Chen (submitted Sept 2011) (review stage)
- **A=62:** A.L. Nichols, **B. Singh** and J.K. Tuli (submitted Sept 2011) (review stage) (*)
- **A=75:** A. Negret and **B. Singh** (submitted July 2011) (review stage) (*)

(*) Shared with other centers (McMaster effort: at least 50%)

ENPDF work cont.

Mass-chain Evaluations at post-review/review stage

- **A=31:** C. Ouellet and B. Singh (submitted Sept 2009) (post-review)
- **A=34:** N. Nica and **B. Singh** (submitted Sept 2009) (post-review) (*)
- **A=36:** N. Nica, **J. Cameron** and **B. Singh** (submitted Sept 2010) (post-review) (*)
- **A=37:** **J. Cameron, J. Chen, B. Singh,** N. Nica (submitted Sept 2010) (post-rev) (*)
- **A=61:** K. Zuber and **B. Singh** (submitted Sept 2010) (review stage) (*)
- **A=77:** **B. Singh** and N. Nica (submitted Sept 2009) (post-review) (*)
- **A=89:** B. Singh and J. Chen (submitted Sept 2009) (post-review stage)
- **A=129:** J. Timar, Z. Elekes and **B. Singh** (submitted Sept 2010) (post-review) (*)

(*) Shared with other centers (McMaster effort: at least 50%)

ENSDF work cont.

Nuclide updates for ENSDF database

75 nuclides were updated for ENSDF (Singh, Birch)

(Includes 3 nuclides with Tim Johnson (BNL) and 3 with Daniel Abriola (IAEA) for IAEA-Trieste workshop)

Mostly far-off the stability **New Nuclides** and/or nuclides for which **excited state and/or gamma-ray data** became available for the first time.

- Review work: $A=161$, $A=114$ and 12 nuclides for ENSDF / NDS;
($A=114$ review shared by J. Chen)
Two nuclides for DDEP;
Two papers for NP-A and Applied Rad. & Isotopes.
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ENSDF work cont.

Participation in IAEA-Trieste ENSDF workshop October 2010; Visits related to ENSDF and other evaluation work.

- B. Singh participated in IAEA-Trieste ENSDF workshop Oct 11-15, 2010. Talk on “Adopted datasets in ENSDF”, and co-ordination of ENSDF evaluation of 10 nuclides.
 - Participated in the international IAEA-NSDD meeting (Vienna) – several presentations.
 - A. L. Nichols from Surrey visited McMaster for 2 weeks in Nov 2010 to work on A=62 evaluation
 - A. Negret from Bucharest visited McMaster for 2 weeks in July 2011 to work on A=75 evaluation
 - B. Pritychenko from NNDC visited for one week in September 2011 to work on B(E2) evaluation in Z=2-22 region.
 - B. Singh visited ATOMKI in Debrecen, Nuclear Physics Institute, in Krakow in June 2011; and gave talks at both places on nuclear structure data evaluation activities. He also made a short visit to GSI to start participation in compilation and evaluation of beta-delayed neutron data for all the nuclides (see Nov 16, 2011, morning session).
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ENSDF work cont.

Work in progress as of October 2011

A=42: J. Chen and B. Singh (previous: 2000)

A=57: with Dr. K. Zuber (Krakow). (previous: 1999) (*)

A=76: with Dr. A. Farhan (Kuwait U). (previous: 1994) (*)

A=86: with Dr. A. Negret (Bucharest). (previous: 1999) (*)

A=139: with Dr. P. Joshi (TIFR, Mumbai), A.K. Jain (IIT,Roorkee), J.K. Tuli (NNDC,BNL)
(previous: 2001) (*)

A=189, 190: with Dr. T. Johnson (NNDC, BNL) (previous: 2003) (*)

(*) Shared with other centers (McMaster effort will be at least 50%)

XUNDL work

Compilation of Data from Current Literature: Oct 6, 2010 to Oct 6, 2011

- 477 compiled datasets by McMaster group
- 16 datasets by McMaster + collaborators
- 101 compiled at other US-NDP centers (TUNL, ANL, LBNL) were checked/edited.
- 30 datasets in XUNDL were updated to incorporate newer related papers from the same groups.
- Represents about 340 primary publications in experimental nuclear structure.
- Frequent scanning of web pages of primary nuclear physics journals:
(PR-C, PRL, NP-A, PL-B, EPJ-A, JP-G, IJMP-E, Chin Phys Lett, Phys of Atomic Nucl., others)
- About 10 papers have been compiled, datasets pending to be checked;
another 5 current papers are being compiled.
- At McMaster, participation in this effort by undergraduate students: Babak Karamy (April 2009-April 2011), Jeremie Choquette (since Feb 2010), Michael Birch (since March 2011)
- Communication with authors actively continue to resolve data-related inconsistencies and/or to request additional data details. Excellent response to such requests.

XUNDL work will continue in 2011-12

NSR compilation work (key-wording of articles in PR-C) (Oct 1, 2010 – Sept 30, 2011)

~1100 articles in PR-C: keywords written for about 650.

B. Karamy, J. Choquette, M. Birch: prepared first drafts.

B. Singh provided local training for the key-wording process; draft of keywords checked and edited for technical content, wording, and checking through NSR-PREP code to resolve formatting errors.

Other Related Activities:

- **Compilations of new mass measurements since AME-2003.**

Nov 2010 – Oct 2011: 23 primary papers (~ 130 data points) compiled by B. Singh and M. Birch. The data file has been sent to Michael Smith at ORNL for his consideration to post on his webpage www.nuclearmasses.org (see presentation on XUNDL-status report)

- **NDS software:** JAVA code development for NDS: work continued in 2010-2011

- J. Chen, S.D. Geraedts, C. Ouellet and B. Singh, Evaluation of half-life of Au-198, Applied Radiation & Isotopes **69**, 1064-1069 (2011)

- B. Pritychenko, **J. Choquette**, M. Horoi, **B. Karamy** and **B. Singh**, An update of B(E2) evaluation for 0_1^+ to 2_1^+ transitions in even-even nuclei near N~Z~28, Atomic Data and Nuclear Data Tables (In press, 2011)

- Chakraborty, J.N. Orce, S.F. Ashley, B.A. Brown, B.P. Crider, E. Elhami, M.T. McEllistrem, S. Mukhopadhyay, E.E. Peters, **B. Singh** and S.W. Yates, Status of vibrational structure in ^{62}Ni , Phys. Rev. **C 83**, 0343316-1:11 (2011) . (B. Singh participated in one-week experiment at Kentucky in October 2008)

- B. Pritychenko, E. Betak, M.A. Kellett, **B. Singh** and J. Totans, The Nuclear Science Reference (NSR) Database and Web Retrieval System, Nucl. Instr. Meth. Phys. Res. **A 640**, 213-218 (2011)

Other Related Activities (cont.)

Phonon-Coupled Excitations and Mixed-Symmetry States in Zr-94 from the decay of Y-94.

B. Singh participated in experiment conducted Sept 19-26, 2011 at TRIUMF using 8π gamma-detector array and other detector systems for beta, and conversion electrons. Extensive event-by-event data were collected in various timing correlations. These are currently being analyzed.

Participants at the experiment run

U. of Kentucky: **S.W. Yates (spokesperson)**, E. Peters, B. Crider

TRIUMF: A. Garnsworthy

U. of Guelph: P.E. Garrett, B. Hadinia, E. Rand, K.G. Leach

Simon Fraser U.: D. Cross, K. Starosta, C. Andreoiu

McMaster U.: B. Singh

Previous paper on this decay study that is adopted in current ENSDF for Y-94 to Zr-94 decay
B. Singh, H.W. Taylor, and P.J. Tivin, J. Phys. G: Nucl. Phys. 2, 397 (1976).

Division of effort

- 2 FTE + 1 volunteer
 - ENSDF: 1.4 FTE + 1 volunteer (John Cameron)
 - Nuclear Astrophysics data (evaluation): 0.2 FTE
 - XUNDL, Mass compilation: 0.25 FTE
 - NSR comp, training of students, etc. : 0.15 FTE
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Current collaborations (ENSDF and other work):

- 1. National Nuclear Data Center, Brookhaven National Lab.: Drs. B. Pritychenko, T. Johnson, J.K. Tuli
 - 2. Physics Department, Kuwait University, Kuwait: Prof. A. Farhan
 - 3. Department of Physics, University of Kentucky, Lexington, KY, USA: Prof. S.W. Yates.
 - 4. Petersburg Nuclear Physics Institute, Gatchina, Russia: Drs. A.A. Rodionov, Y. Khazov
 - 5. Nuclear Research Institute (ATOMKI), Debrecen, Hungary: Drs. J. Timar, Z. Elekes
 - 6. Institute of Nuclear Physics (IFJ-PAN), Krakow, Poland: Dr. K. Zuber
 - 7. National Institute of Physics and Nuclear Engineering , Bucharest, Romania:
Dr. A. Negret
 - 8. Cyclotron Institute, Texas A&M, USA: Dr. N. Nica
 - 9. Tata Institute of Fundamental Research (TIFR), Mumbai, India: Dr. P.K. Joshi
 - 10. Indian Institute of Technology (IIT) Roorkee, India: Prof. A.K. Jain.
 - 11. Department of Physics, University of Surrey, UK: Dr. A.L. Nichols
 - 12. International Atomic Energy Agency (IAEA-NDS): Dr. D. Abriola
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Personnel and Funding

- A. Chen: Assoc. Professor, Principal Investigator of Data Project.
- J. C. Waddington: Emeritus-Professor, Co-PI of Data Project.
- J. A. Cameron: Emeritus-Professor: **Volunteer work** since 1999 on ENSDF evaluation of A=31-44 region
- B. Singh: Research Scientist/Nuclear Data Evaluator.
- J. Chen: Post-doctoral Fellow: since July 2009

Undergraduate students:

- B. Karamy: up to April 2011
 - J. Choquette: Feb 2010 -
 - M. Birch: Since March 2011
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- Financial support: Office of Nuclear Physics, Office of Science, DOE, USA; and NSERC, Canada.
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Staff data for 2010-2011

- Scientific Permanent staff: 4;
US-NDP funded: 0.6 FTE (DOE), 0.4 FTE (NSERC, Canada)
 - Scientific Temporary staff: 1; US-NDP funded: 1.0 FTE (DOE)
 - Scientific External collaborators: 9; US-NDP funded: none
(Partial coverage of expenses for visits to McMaster)
 - Technical/Support staff: none
 - New Hires: none
 - Resignations/Retired: none
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Part 2: Astrophysics Data

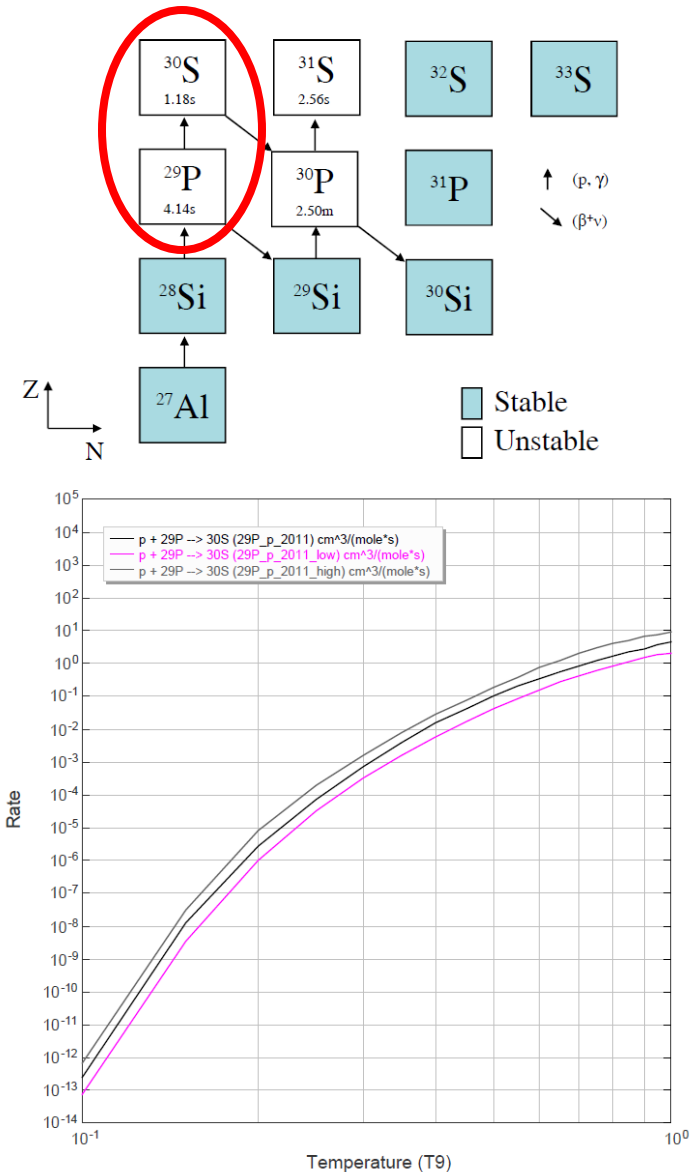
Prepared by: Jun Chen and Alan Chen

Astrophysics Data Evaluation

- Two reactions evaluated: $^{29}\text{P}(p,\gamma)^{30}\text{S}$ and $^{30}\text{P}(p,\gamma)^{31}\text{S}$
- Both closely tied to Alan Chen's research program
 - ⊕ $^{29}\text{P}(p,\gamma)^{30}\text{S}$, thesis project of Kiana Setoodehnia
 - studied ^{30}S levels of astrophysical interest via (p,t) and $(^3\text{He},n\gamma)$
 - discovered a new dominant state
 - ⊕ $^{30}\text{P}(p,\gamma)^{31}\text{S}$, thesis project of Dan Irvine
 - studied ^{31}S levels of astrophysical interest via (d,t)
 - data analysis in progress
- Rates submitted using the Computational Infrastructure for Nuclear Astrophysics at www.nucastrodata.org at ORNL
- Further update expected from the results of our group's research

$^{29}\text{P}(p,\gamma)^{30}\text{S}$ Rate

- ^{29}Si and ^{30}Si abundances are important to understand the nucleosynthesis occurring in nova explosions.
- It affects the production and destruction of ^{29}Si and ^{30}Si in nova outbursts.
- It increases the ^{30}Si abundance through $^{29}\text{P}(p,\gamma)^{30}\text{S}(\beta^+)^{30}\text{P}(\beta^+)^{30}\text{Si}$
- The rate is uncertain because the level structure above the proton threshold is poorly understood.
- Rate is dominated at Nova temperatures (0.1-0.4 GK) by two resonances at $E_R=296$ and 412 keV. Uncertainty is mainly from resonance strengths.
- $S_p=4399(3)$ keV from Audi's compilations in 2011



$^{30}\text{P}(p,\gamma)^{31}\text{S}$ Rate

- The $^{30}\text{P}(p,\gamma)^{31}\text{S}$ reaction has strong impact on the Si isotopic abundance ratios in presolar grains of nova origin
- It destroys ^{30}P and bypasses the production of ^{30}Si from $^{30}\text{P}(\beta^+)^{30}\text{Si}$
- Large uncertainties in level parameters above the proton threshold still remain.
- Rate is dominated by states up to about $E_x \sim 7$ MeV. Uncertainty is mainly from resonance strengths.
- $S_p=6130.9(4)$ keV from new mass measurement by Kankainen et al. (2010), 6131.4(10) from Audi's compilations in 2011

