Nuclear Data Project McMaster University

Status Report: Oct. 1, 2009-Sept. 30, 2010

USNDP: November 2-3, 2010

Part 1: Nuclear Structure and Decay Data Evaluation

Prepared by: B. Singh

ENSDF Work

- **Permanent Responsibility**:

  A=1 (2005);

  31 (1998,s), **32** (1998,s),
  33 (1998,s), **34** (1998,s,*),
  35(1998,s), **36,37**(1998,s,*),
  38 (2007), **39** (2006), **40** (2004),
  41 (2001), **42** (2000),
  43 (2001), **44** (1999,w).
  64 (2006), **89** (1998,s),
  98 (2003), **100** (2007),
  149 (2004), **151** (2008),
  164 (2001), **188** (2002),
  190 (2003), **194** (2006)

- Note: The number in parentheses gives the year of last revision in ENSDF database
- w: work in progress
- s: revision submitted
- *: collaboration with Ninel Nica
- During FY-2010, work was done on other A-chains and nuclides also, which are outside McMaster's A-chain responsibility

- A=31-44 region started in 1999 is now completed. Hopefully A=31-37 will all be in ENSDF database and NDS by the end of 2011.

Mass-chain Evaluations Published or Submitted Since October 1, 2009

- **A=182**: B. Singh and J.C. Roediger: NDS 111, 2081-2330 (2010)
- **A=163***: C.W. Reich and B. Singh: NDS 111, 1211-1469 (2010)
- A=58*: C.D. Nesaraja, S.D. Geraedts and B. Singh: NDS 111, 897-1092 (2010)
- **A=33**: J. Chen and B. Singh (submitted April 2010) (previous: Endt 1998)
- **A=35**: J. Chen, J. Cameron and B. Singh (submitted Aug 2010) (previous: Endt: 1998)
- **A=36***: N. Nica, J. Cameron and B. Singh (submitted Sept 2010) (previous: Endt: 1998)
- **A=37***: J. Cameron, J. Chen, B. Singh and N. Nica (submitted Sept 2010) (previous: Endt: 1998)
- **A=61**: K. Zuber and B. Singh (submitted Sept 2010) (previous: 1999)
- **A=129**: J. Timar, Z. Elekes and B. Singh (submitted Sept 2010) (previous: 1995)

* Shared with other US-NDP center (McMaster effort: at least 50%)

A=33, 35, 58, 61, 129: as part of mentoring and training effort.

Nuclide updates

53 nuclides were updated for ENSDF: (by Singh)

Mostly far-off the stability line New Nuclides and/or nuclides for which excited state and/or gamma-ray data became available for the first time. 31 new nuclides from one experiment published in July 2010.

- Review work: one A-chain for ENSDF / NDS; one nuclide for DDEP (by Singh)

XUNDL work

Compilation of Data from Current Literature: Oct 9, 2009 to Oct 6, 2010

- 305 compiled datasets by McMaster group
- 67 datasets by McMaster + groups in Poland and Jordan
- 111 compiled at other US-NDP centers (TUNL, ANL, LBNL) were reviewed (edited if needed)
- **40** datasets in XUNDL were updated to incorporate newer related papers from the same groups.
- Represent about 260 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 20 papers have been compiled, datasets pending to be checked;
  another 30 current papers are being compiled.
- At McMaster, participation by undergraduate students: Allison MacDonald (Oct 2008 – Dec 2009); Babak Karamy (since April 2009), Jeremie Choquette (since Feb 2010)
- Communication with authors actively continue to resolve data-related inconsistencies and/or to request additional data details. Excellent response to such requests.
- With pre-arrangement, data for 4 PRC/PRL papers published in 2008-2010 exist only in XUNDL;
  One such paper added in 2010.

NSR compilation work (key-wording of PR-C) (Oct 1, 2009 – Sept 30, 2010)

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

A. MacDonald , B. Karamy, J. Choquette: prepared first drafts.

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

Chinese Physics C (earlier High-Energy Physics and Nuclear Physics (China)):

listed in 80 journals regularly scanned for NSR, but somehow it slipped through the cracks. In May 2010, I found only one article in NSR.

Scanned 1983-2010 issues relevant to ENSDF. Identified ~220 articles. Through the help of Huang Xiaolong at Chinese data center in Beijing, all the articles have been stored in an open ftp site. These will be enetered in NSR.

Work in Progress
(as of October 1, 2010)

A=44 (previous 1999)

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

A=62: with Dr. A. Nichols (Surrey). (previous: 1999)

A=75: with Dr. A. Negret (Bucharest). (previous: 1999)

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

A=139: with Dr. P. Joshi (TIFR, Mumbai) (previous: 2001)

(Also experiments to study 139-Ba decay to 139-Cs proposed by B. Singh. The enriched 138-Ba material was supplied from McMaster lab. Some data have already been collected by a group of 5 researchers from BARC and Dr. Joshi at TIFR in India using two Clover HPGe detectors. Isotopic half-life and other gamma-ray spectroscopic studies are intended.)

XUNDL, mass compilation and NSR keywording will continue during 2010-2011.

Mentoring, Training
and Collaborative work in 2009-2010

- **A=33, 35:** Dr. Jun Chen, McMaster

- **A=61**: Dr. Kazimierz Zuber, IFJ-PAN, Krakow.
  Visited McMaster for two weeks in August 2010.

- **A=62**: Dr. Alan Nichols, University of Surrey, UK.
  Visited McMaster for one week in October 2010. Visiting Nov 10-24, 2010

- **A=71**: Dr. Khalifeh Abusaleem, University of Jordan.
  Visited McMaster for ten days in January 2010.

- **A=75**: Dr. Alexandru Negret, IFIN-HH, Bucharest.
  Planned visit to McMaster in July 2011.

- **A=129**: Drs. Janos Timar (ATOMKI) and Zoltan Elekes (Dresdan & ATOMKI);
  Dr. Timar visited McMaster for two weeks in September 2010.

- **A=139**: Dr. Paresh Joshi, TIFR, India.
  Visited McMaster for 2 weeks in July 2010.

Other Related Activities

- **Compilations of new mass measurements since AME-2003**.
  Oct 2009 – Oct 2010: 24 primary papers (~ 140 data points) compiled
  B. Singh and B. Karamy. The data file has been sent to Michael Smith
  at ORNL for his consideration to post on his webpage www.nuclearmasses.org

  Aug 2008 – Feb 2009 and Mar 2009 – Oct 2009 compilations available
  on www.nuclearmasses.org webpage.

- **Compilation of directly measured nuclear spins**: work in summers 2009 and 2010;
  Allison MacDonald, Babak Karamy, B. Singh. Plan to submit a paper to NDS.

- **NDS software**: JAVA code development for NDS (see presentation at this meeting)

Other Related Activities (cont.)

Phonon-Coupled Excitations and Mixed-Symmetry States in 94-Zr.

(Through the study of 94-Y decay to 94-Zr at TRIUMF-ISAC facility: using 8π array)

Experiment proposal by Steve Yates et al., accepted in July 2010 with high marks.

Participants:

U. of Kentucky: **S.W. Yates**, F. M. Prados, A. Chakraborty, E. Peters, B. Crider

TRIUMF: A. Garnsworthy, J.N. Orce

U. of Guelph: L. Bianco, B. Hadinia, C.E. Svensson, P.E. Garrett, J. Michetti-Wilson, A. Diaz Varela, S. Chagnon-Lessard, A. Laffoley, R. Dunlop, E. Rand, J. Wong, K.G. Leach, P. Finlay, B. Jimeddorj

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

McMaster U.: B. Singh

Georgia Tech.: W.D. Kulp, J.L. Wood

- Note: "In spite of the recent scrutiny 94-Zr has received, it is surprising that the β- decay of 94-Y has not been studied since the work of Singh, Taylor, and Tivin [16] in 1976."

[16] B. Singh, H.W. Taylor, and P.J. Tivin, J. Phys. G: Nucl. Phys. **2,** 397 (1976).

Other Related Activities (cont.)

- Coulomb-Excitation Measurements in 106Cd: B(E2) for first 2+ state by Coul. Ex.
- (Proposal submitted in Sept 2010 to JYFL facility, Finland)

- **S. F. Ashley**, T. Konstantinopoulos, M. Axiotis, T. J. Mertzimekis,
- A. Lagoyannis, S. Harissopulos
- Institute of Nuclear Physics, Tandem Accelerator Laboratory, NCSR
- "Demokritos", Aghia Paraskevi, Athens Gr. 153.10, Greece

- T. Grahn, P. M. Jones (on behalf of the JYFL Gamma group), R. Julin
- Department of Physics, University of Jyv¨askyl¨a, PO Box 35, FIN-40014,
- Jyv¨askyl¨a, Finland

- C. Fransen, M. Hackstein
- Institut f¨ur Kernphysik, Universit¨at zu K¨oln, Z¨ulpicher Strasse 77, D-50937
- K¨oln, Germany

- B. Singh
- Department of Physics and Astronomy, McMaster University, Hamilton,
- Ontario L8S 4M1, Canada

- Spokespersons for the experiment,
- (sfashley@inp.demokritos.gr and sharisop@inp.demokritos.gr)

Division of effort

- 2 FTE + 1 volunteer
- ENSDF: 1.5 FTE + 1 volunteer (John Cameron)
- Nuclear Astrophysics data (evaluation): 0.2 FTE
- XUNDL, Mass compilation: 0.2 FTE
- NSR comp, training of students, etc.: 0.1 FTE

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: Since Apr 2009
- J. Choquette: Since Feb 2010
- S. Geraedts: Summer 2010
- A. MacDonald: Since Oct 2008

- Financial support: Office of Nuclear Physics, Office of Science, DOE, USA; and NSERC, Canada.

Staff data for 2009-2010

- 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: 8; US-NDP funded: none
  (Partial coverage of expenses for visits to McMaster)
- Technical/Support staff: none
- New Hires: none
- Resignations/Retired: none

Part 2: Astrophysics Data

Prepared by: J. Chen and A. Chen

Nuclear Astrophysics Data Evaluation

- **thermonuclear reaction rates evaluated:**
  - **^{23}Mg(p,γ)^{24}Al**
    - **direct measurement at TRIUMF- ISAC**
    - **^{23}Mg radioactive beam + DRAGON recoil separator**

      (Erikson et al., PRC 81 045808 2010)
  - **^{29}P(p,γ)^{30}S**
    - **latest results from ^{32}S(p,t)^{30}S at Yale University**

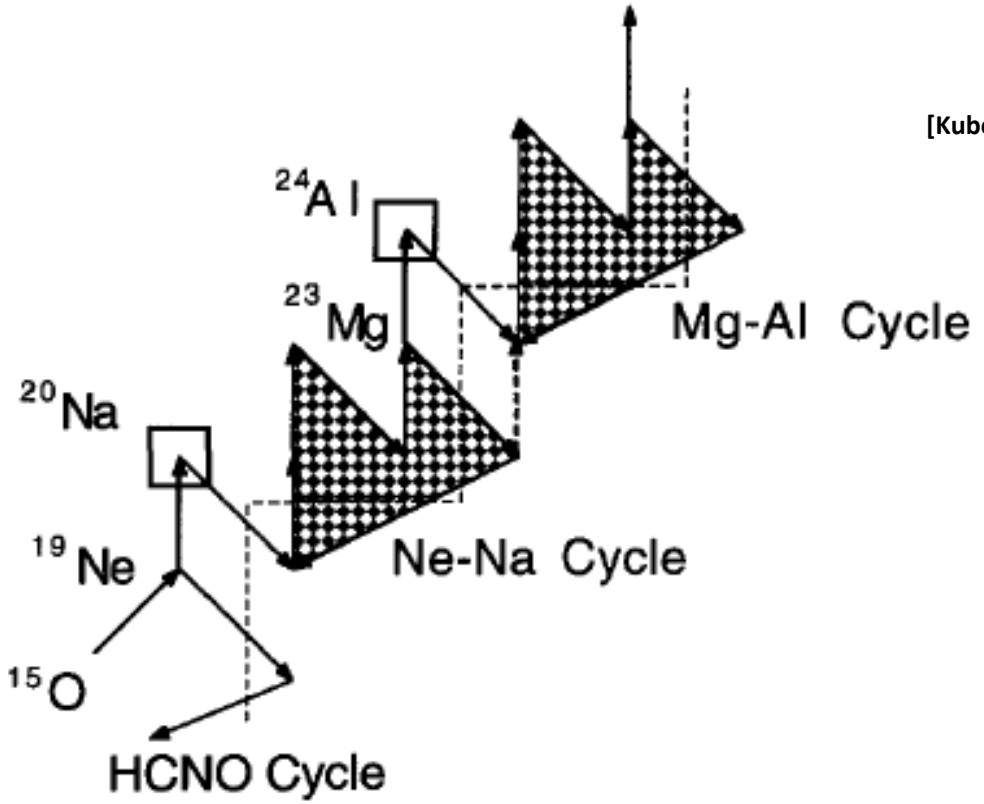
      (Setoodehnia et al., PRC 82 022801(R) 2010)
- **in progress: ^{25}Al(p,γ)^{26}Si**

  p(^{27}Si,d)^{26}Si at NSCL + p(^{25}Al,p)^{25}Al at RIKEN

  (Chen et al., NPA 834 667c 2010)
- **submitted to rates database: *computational infrastructure for nuclear astrophysics* at *www.nucastrodata.org* (ORNL)**

  (c.f. M. Smith's talk)

$^{23}Mg(p,\gamma)^{24}Al$: Mg-Al cycles in classical novae

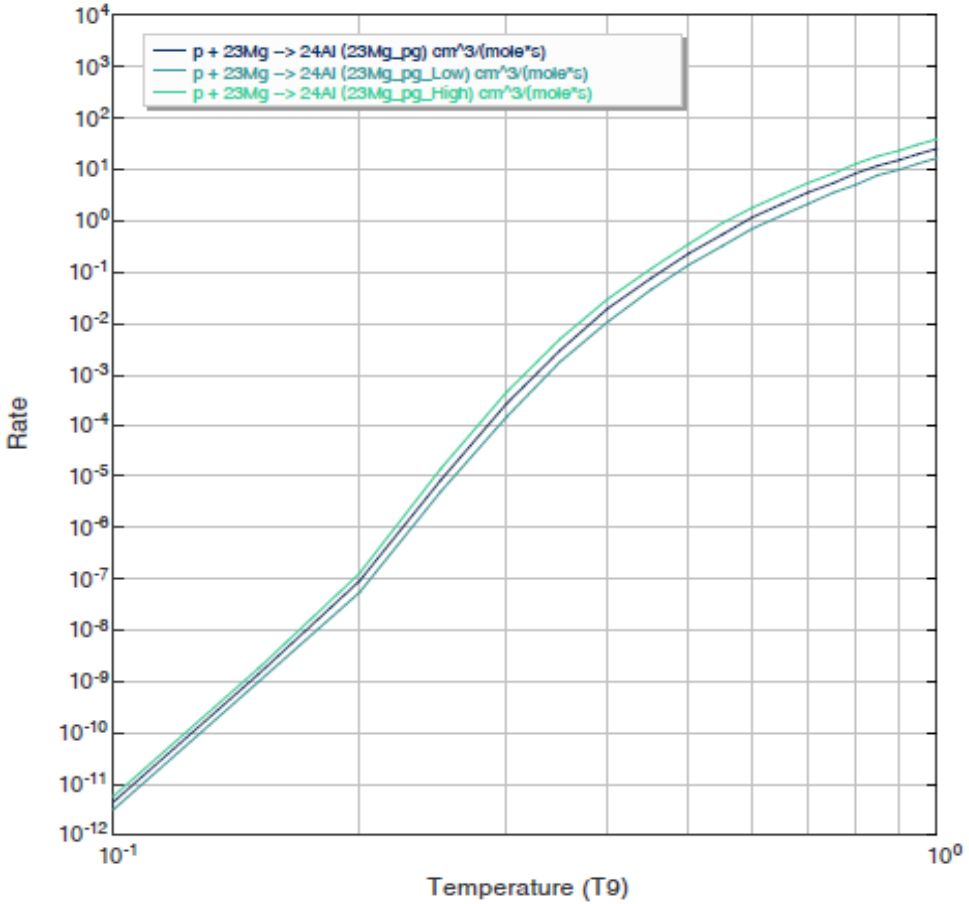


- bridges the NeNa cycles and the MgAl cycles in O-Ne classical novae
- influences synthesis of important gamma emitters – ^{22}Na and ^{26}Al – for nova diagnostics
- requires ^{24}Al level parameters:
  excitation energies (E_x), proton separation energy (S_p), resonance strengths ($\omega\gamma$)

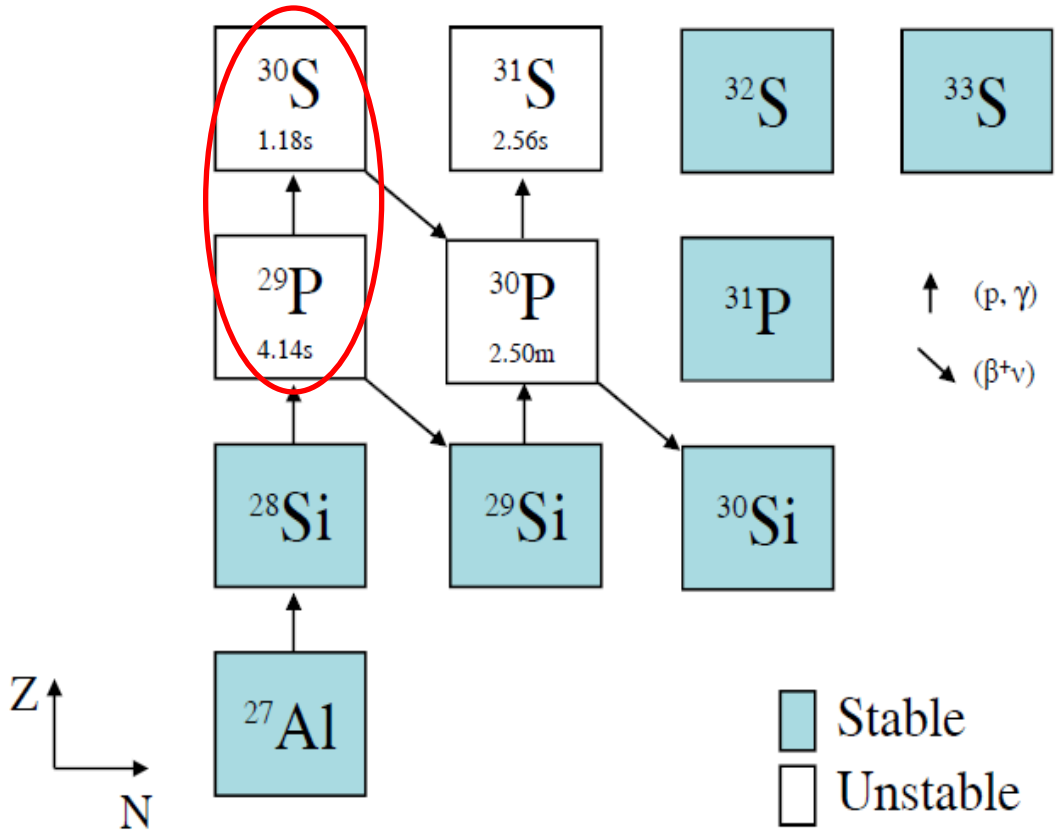
$^{23}Mg(p,\gamma)^{24}Al$: direct measurement – DRAGON

- Measured strength of dominant ^{23}Mg + p resonance [E_x=2349 keV, $J^\pi=(3^+)$]
  → $\omega\gamma$ = 38(17) meV

- E_R = 485.7(*15*) keV → reevaluated S_p = 1862.6(29) keV
  [c.f. S_p = 1872(3) keV from 2009AuZZ]



$^{29}P(p,\gamma)^{30}S$: silicon synthesis in classical novae



- $^{29}P(p,\gamma)^{30}S$: strongly influences synthesis of ^{29}Si and ^{30}Si in nova outbursts:

  $^{29}P(p,\gamma)^{30}S(\beta^+)^{30}P(\beta^+)^{30}Si$ vs. $^{29}P(\beta^+)^{29}Si$

  implications for Silicon isotopic ratios in meteoritic grains of nova origin

$^{29}P(p,\gamma)^{30}S$ via $^{32}S(p,t)^{30}S$ at Yale

- **Measured energies of two most important resonances:**
  E_R = 300(6) and 415(4) keV (NEW), corresponding to E_x= 4699 and 4814 keV

- **Adopted S_p=4399(3) keV from Audi's 2009 compilation**