



Department of
Physics & Astronomy

1280 Main Street West
Hamilton, Ontario,
Canada
L8S 4M1

Phone 905.525.9140
Ext. 24559, 24558
Fax 905.546.1252
Email physics@mcmaster.ca
<http://www.physics.mcmaster.ca>

November 14, 2014

Office of Science
U.S. Department of Energy
19901 Germantown Road
Germantown MD 20874-1290
U.S.A.

Ref.: Final technical report for award: **DE-FG02-98-ER41080**

Dear Sir/Madam,

Enclosed, please find a final technical report of our project “**Evaluation and Compilation of Nuclear Structure and Decay Data for US-NDP**” for the award years 1998-2013. It describes the activities of the project carried out and results produced during the validity of the above award from July 1, 1998 to June 30, 2013. I hope that you find this report in order. McMaster University research services office has, as I understand, supplied the DOE accounts office with the detailed financial reports from the years 1998-2013.

Yours sincerely,

A handwritten signature in black ink that reads "Alan A. Chen".

Alan A. Chen

E-mail: chenal@mcmaster.ca
Phone: 905-525-9140, ext 27096
Fax: 905-546-1252

CC: Dr. Ted Barnes, Program Manager, Office of Science, U.S. DOE: ted.barnes@science.doe.gov
Ms. Natasha McLaren-Doerr, Research Services, McMaster: doerrn@mcmaster.ca
Ms. Victoria Curry, DOE, e-mail: Victoria.Curry@hq.doe.gov

FINAL TECHNICAL REPORT

November 14, 2014

Report submitted to: Office of Science, Department of Energy.

DOE Award number: **DE-FG02-98-ER41080**

Grant Title: **EVALUATION AND COMPILATION OF NUCLEAR STRUCTURE
AND DECAY DATA FOR THE U.S. NUCLEAR DATA PROGRAM**

Personnel: Dr. A. A. Chen : PI (2006-2013), Associate Professor
Dr. J. C. Waddington: Co-PI (2006-2013), PI (1998-2006), Emeritus Professor
Dr. B. Singh: Research Scientist (1998-2013) *
Dr. C. Ouellet: Post-doctoral Fellow (2007-2009) *
Dr. J. Chen: Post-doctoral Fellow (2010-2012) *
Dr. K. Setoodehnia: Post-doctoral Fellow (Sept 2012-Feb 2013) *
*Supported by DOE Award DE-FG02-98-ER41080

Name of Submitter: Dr. Alan A. Chen, Principal Investigator.
Department of Physics and Astronomy,
McMaster University,
HAMILTON, Ontario, CANADA, L8S 4M1

Recipient Organization: McMaster University, 1280 Main Street West, HAMILTON,
Ontario, CANADA, L8S 4L8

Recipient Account number: 5-27105

Grant Period: July 1, 1998 to June 30, 2013

Reporting Period: July 1, 1998 to June 30, 2013

Report frequency: Final

Abstract:

The prime motivation of the project at McMaster University was to carry out the critical evaluation and compilation of Nuclear Structure and Decay data, and of nuclear astrophysics data with continued participation in the United States Nuclear Data Program (US-NDP). A large body of evaluated and compiled structure data were supplied for databases such as ENSDF, XUNDL, NSR, etc. residing on webpage of National Nuclear Data Center of the Brookhaven National Laboratory, Upton, New York, USA. Thermonuclear reaction rates of importance to stellar explosions, such as novae, x-ray bursts and supernovae, were evaluated as well. This effort was closely coupled to our ongoing experimental effort, which took advantage of radioactive ion beam and stable beam facilities worldwide to study these key reaction rates. This report contains brief descriptions of the various activities together with references to all the publications in peer-reviewed journals which were the result of work carried out with the award DE-FG02-98-ER41080, during 1998-2013.

Contents:

1. Publications in peer-reviewed international journals.
2. Contribution to ENSDF database.
3. Contribution to Astrophysical nuclear reaction rates.
4. Creation of XUNDL database and contributions.
5. Contribution to NSR database.
6. International coordination and mentoring in ENSDF evaluations.
7. Overall Impact.

Peer-reviewed journal publications based on work accomplished with the DE FG02-98-ER41080 award. These are related to Nuclear Structure and Decay Data evaluation, the ENSDF database and some experiments (McMaster University authors in bold letters):

1. Nuclear Data Sheets 120, 66-69 (2014): **M. Birch, B. Singh**, D. Abriola, I. Dillmann, T.D. Johnson, E.A. McCutchan, A.A. Sonzogni; *First Compilation and Evaluation of Beta-Delayed Neutron Emission Probabilities and Associated Half-Lives for $A \leq 72$ Nuclei*. doi: [10.1016/j.nds.2014.07.008](https://doi.org/10.1016/j.nds.2014.07.008)
2. Nuclear Data Sheets 120, 106-108 (2014): **M. Birch, B. Singh**; *Method of Best Representation for Averages in Data Evaluation*. doi: [10.1016/j.nds.2014.07.019](https://doi.org/10.1016/j.nds.2014.07.019)
3. Nuclear Data Sheets 120, 62-65 (2014): E.A. McCutchan, A.A. Sonzogni, T.D. Johnson, D. Abriola, **M. Birch, B. Singh**; *A New Approach to Estimating the Probability for β -delayed Neutron Emission*. doi: [10.1016/j.nds.2014.07.007](https://doi.org/10.1016/j.nds.2014.07.007)
4. Nuclear Data Sheets 120, 88-90 (2014): E. Mcneice, K. Setoodehnia, **B. Singh**, Y. Abe, D.N. Binh, **A.A. Chen, J. Chen**, S. Cherubini, S. Fukuoka, T. Hashimoto, T. Hayakawa, Y. Ishibashi, Y. Ito, D. Kahl, T. Komatsubara, S. Kubono, T. Moriguchi, D. Nagae, R. Nishikiori, T. Niwa, A. Ozawa, T. Shizuma, H. Suzuki, H. Yamaguchi, T. Yuasa; *In-beam γ -ray Spectroscopy of ^{30}P via the $^{28}\text{Si}(^3\text{He}, p\gamma)^{30}\text{P}$ Reaction*. doi: [10.1016/j.nds.2014.07.014](https://doi.org/10.1016/j.nds.2014.07.014)
5. Nuclear Data Sheets 120, 112-114 (2014): B. Pritychenko, **M. Birch**, M. Horoi, **B. Singh**; *$B(E2)$ Evaluation for $0^+_1 \rightarrow 2^+_1$ Transitions in Even-Even Nuclei*. doi: [10.1016/j.nds.2014.07.021](https://doi.org/10.1016/j.nds.2014.07.021)
6. Nuclear Data Sheets 120, 291-293 (2014): B. Pritychenko, E. Betak, **B. Singh**, J. Totans; *Nuclear Science References Database*. doi: [10.1016/j.nds.2014.07.070](https://doi.org/10.1016/j.nds.2014.07.070)
7. Nuclear Data Sheets 116, 1-162 (2014): **B. Singh, J. Chen**; *Nuclear Data Sheets for $A=85$* . doi: [10.1016/j.nds.2014.01.001](https://doi.org/10.1016/j.nds.2014.01.001)
8. Nuclear Data Sheets 121, 143-394 (2014): J. Timar, Z. Elekes, **B. Singh**; *Nuclear Data Sheets for $A = 129$* . doi: [10.1016/j.nds.2014.09.002](https://doi.org/10.1016/j.nds.2014.09.002)
9. Phys. Rev. C 88, 067301 (1-4) (2013): **M. Birch**, J. Flegenhimer, Z. Schaedig, **B. Singh**, M. Thoennessen; *Reexamining the half-lives of ^{195}Os and ^{195}Ir* . doi: [10.1103/PhysRevC.88.067301](https://doi.org/10.1103/PhysRevC.88.067301)

10. Phys. Rev. Lett. 110, 022504 (1-4) (2013); 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, A. 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; *Collective Structure in ^{94}Zr and Subshell Effects in Shape Coexistence*. doi: [10.1103/PhysRevLett.110.022504](https://doi.org/10.1103/PhysRevLett.110.022504)
11. Nuclear Data Sheets 114, 397-433 (2013): **A. MacDonald, B. Karamy, K. Setoodehnia, B. Singh**; *Compilation of directly measured nuclear spins of ground states and long-lived isomers*. doi: [10.1016/j.nds.2013.03.002](https://doi.org/10.1016/j.nds.2013.03.002)
12. Nuclear Data Sheets 114, 841-1040 (2013): A. Negret, **B. Singh**; *Nuclear Data Sheets for A = 75*. doi: [10.1016/j.nds.2013.08.001](https://doi.org/10.1016/j.nds.2013.08.001)
13. Nuclear Data Sheets 114, 209-396 (2013): **C. Ouellet, B. Singh**; *Nuclear Data Sheets for A = 31*. doi: [10.1016/j.nds.2013.03.001](https://doi.org/10.1016/j.nds.2013.03.001)
14. Phys. Lett. B 720, 399-404 (2013); Addendum to Phys. Lett. B 723, 168 (2013): J. Pradler, **B. Singh, I. Yavin**; *On an unverified nuclear decay and its role in the DAMA experiment*. doi: [10.1016/j.physletb.2013.02.033](https://doi.org/10.1016/j.physletb.2013.02.033)
15. Nuclear Data Sheets 114, 1-208 (2013): **B. Singh**; *Nuclear Data Sheets for A = 89*. doi: [10.1016/j.nds.2013.01.001](https://doi.org/10.1016/j.nds.2013.01.001)
16. Nuclear Data Sheets 114, 661-749 (2013): **B. Singh**, D. Abriola, C. Baglin, V. Demetriou, T. Johnson, E. McCutchan, G. Mukherjee, S. Singh, A. Sonzogni, J. Tuli; *Nuclear Data Sheets for A = 211*. doi: [10.1016/j.nds.2013.05.001](https://doi.org/10.1016/j.nds.2013.05.001)
17. Nuclear Data Sheets 114, 2023-2078 (2013): **B. Singh**, G. Mukherjee, D. Abriola, S.K. Basu, P. Demetriou, A. Jain, S. Kumar, S. Singh, J. Tuli; *Nuclear Data Sheets for A = 215*. doi: [10.1016/j.nds.2013.11.003](https://doi.org/10.1016/j.nds.2013.11.003)
18. Nuclear Data Sheets 113, 365-514 (2012): **J. Cameron, J. Chen, B. Singh**, N. Nica; *Nuclear Data Sheets for A = 37*. doi: [10.1016/j.nds.2012.02.001](https://doi.org/10.1016/j.nds.2012.02.001)
19. Eur. Phys. J. A 48, 186 (1-8) (2012): L.S. Danu, P.K. Joshi, D.C. Biswas, S. Mukhopadhyay, A. Goswami, P.N. Prashanth, L.A. Kinage, R.K. Choudhury, **B. Singh**; *Revisiting the decay scheme and half-life of ^{139}Ba* . doi: [10.1140/epja/i2012-12186-2](https://doi.org/10.1140/epja/i2012-12186-2)

20. Phys. Rev. C 86, 041305(R) (1-5) (2012): E.A. McCutchan, A.A. Sonzogni, T.D. Johnson, D. Abriola, **M. Birch, B. Singh**; *Improving systematic predictions of β -delayed neutron emission probabilities*. doi:[10.1103/PhysRevC.86.041305](https://doi.org/10.1103/PhysRevC.86.041305)
21. Nuclear Data Sheets 113, 1-155 (2012): N. Nica, **J. Cameron, B. Singh**; *Nuclear Data Sheets for A = 36*. doi:[10.1016/j.nds.2012.01.001](https://doi.org/10.1016/j.nds.2012.01.001)
22. Nuclear Data Sheets 113, 973-1114 (2012): A.L. Nichols, **B. Singh**, J.K. Tuli; *Nuclear Data Sheets for A = 62*. doi: [10.1016/j.nds.2012.04.002](https://doi.org/10.1016/j.nds.2012.04.002)
23. Nuclear Data Sheets 113, 1563-1733 (2012): N. Nica, **B. Singh**; *Nuclear Data Sheets for A = 34*. doi:[10.1016/j.nds.2012.06.001](https://doi.org/10.1016/j.nds.2012.06.001)
24. Atomic Data Nuclear Data Tables 98, 798-811 (2012): 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 $N \sim Z \sim 28$* . doi:[10.1016/j.adt.2012.06.004](https://doi.org/10.1016/j.adt.2012.06.004)
25. Nuclear Data Sheets 113, 1115-1314 (2012): **B. Singh**, N. Nica; *Nuclear Data Sheets for A = 77*. doi:[10.1016/j.nds.2012.05.001](https://doi.org/10.1016/j.nds.2012.05.001)
26. Eur. Phys. J. A 48, 136 (1-6) (2012): P.C. Sood, M. Sainath, R. Gowrishankar, **B. Singh**; *Level structures in ^{156}Pm from ^{156}Nd β decay*. doi: [10.1140/epja/i2012-12136-0](https://doi.org/10.1140/epja/i2012-12136-0)
27. Nuclear Data Sheets 112, 133-273 (2011): K. Abusaleem, **B. Singh**; *Nuclear Data Sheets for A = 71*. doi:[10.1016/j.nds.2010.12.002](https://doi.org/10.1016/j.nds.2010.12.002)
28. Phys. Rev. C 83, 034316 (1-11) (2011): A. 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**, S.W. Yates; *Status of vibrational structure in ^{62}Ni* . doi: [10.1103/PhysRevC.83.034316](https://doi.org/10.1103/PhysRevC.83.034316)
29. Appl. Radiat. Isot. 69, 1064-1069 (2011): **J. Chen, S.D. Geraedts, C. Ouellet, B. Singh**; *Evaluation of half-life of ^{198}Au* . doi: [10.1016/j.apradiso.2011.03.024](https://doi.org/10.1016/j.apradiso.2011.03.024)
30. Nuclear Data Sheets 112, 2357-2495 (2011): **J. Chen, B. Singh, J.A. Cameron**; *Nuclear Data Sheets for A=44*. doi: [10.1016/j.nds.2011.08.005](https://doi.org/10.1016/j.nds.2011.08.005)
31. Nuclear Data Sheets 112, 2715-2850 (2011): **J. Chen, J. Cameron, B. Singh**; *Nuclear Data Sheets A = 35*. doi: [10.1016/j.nds.2011.10.001](https://doi.org/10.1016/j.nds.2011.10.001)

32. Nuclear Data Sheets 112, 1393-1511 (2011): **J. Chen, B. Singh**; *Nuclear Data Sheets for A*
= 33. doi:[10.1016/j.nds.2011.04.003](https://doi.org/10.1016/j.nds.2011.04.003)

33. Nuclear Data Sheets 112, 1-131 (2011): Z. Elekes, J. Timar, **B. Singh**; *Nuclear Data Sheets for A = 50*. doi:[10.1016/j.nds.2010.12.001](https://doi.org/10.1016/j.nds.2010.12.001)

34. Nuclear Data Sheets 112, 2199-2355 (2011): **C. Ouellet, B. Singh**; *Nuclear Data Sheets for A = 32*. doi:[10.1016/j.nds.2011.08.004](https://doi.org/10.1016/j.nds.2011.08.004)

35. Nucl. Instrum. Methods Phys. Res. A640, 213-218 (2011): B. Pritychenko, E. Betak, M.A. Kellett, **B. Singh**, J. Totans; *The Nuclear Science References (NSR) database and Web Retrieval System*. doi: [10.1016/j.nima.2011.03.018](https://doi.org/10.1016/j.nima.2011.03.018)

36. Nuclear Data Sheets 111, 897-1092 (2010): C.D. Nesaraja, **S.D. Geraedts, B. Singh**;
Nuclear Data Sheets for A = 58. doi: [10.1016/j.nds.2010.03.003](https://doi.org/10.1016/j.nds.2010.03.003)

37. Nuclear Data Sheets 111, 1211-1469 (2010): C.W. Reich, **B. Singh**; *Nuclear Data Sheets for A = 163*. doi:[10.1016/j.nds.2010.04.001](https://doi.org/10.1016/j.nds.2010.04.001)

38. Nucl.Data Sheets 111, 2081-2330 (2010): **B. Singh, J.C. Roediger**; *Nuclear Data Sheets for A = 182*. doi:[10.1016/j.nds.2010.08.001](https://doi.org/10.1016/j.nds.2010.08.001)

39. Nuclear Data Sheets 110, 2815-2944 (2009): D. Abriola, M. Bostan, S. Erturk, M. Fadil, M. Galan, S. Juutinen, T. Kibedi, F. Kondev, A. Luca, A. Negret, N. Nica, B. Pfeiffer, **B. Singh**, A. Sonzogni, J. Timar, J. Tuli, T. Venkova, K. Zuber; *Nuclear Data Sheets for A = 84*. doi:
[10.1016/j.nds.2009.10.002](https://doi.org/10.1016/j.nds.2009.10.002)

40. Nuclear Data Sheets 110, 1917-2080 (2009): A.R. Farhan, **B. Singh**; *Nuclear Data Sheets for A = 78*. doi:[10.1016/j.nds.2009.08.001](https://doi.org/10.1016/j.nds.2009.08.001)

41. Nuclear Data Sheets 110, 1-264 (2009): **B. Singh**; *Nuclear Data Sheets for A = 151*. doi:
[10.1016/j.nds.2008.11.35](https://doi.org/10.1016/j.nds.2008.11.35)

42. Nuclear Data Sheets 109, 1-170 (2008): **J.A. Cameron, B. Singh**; *Nuclear Data Sheets for A*
= 38. doi:[10.1016/j.nds.2007.12.001](https://doi.org/10.1016/j.nds.2007.12.001)

43. Phys. Rev. C 77, 064301 (1-5) (2008): J.N. Orce, B. Crider, S. Mukhopadhyay, E. Peters, E. Elhami, M. Scheck, **B. Singh**, M.T. McEllistrem, S.W. Yates: *Determination of the $2^+_1 \rightarrow 0^+_1$ transition strengths in ^{58}Ni and ^{60}Ni* . doi:[10.1103/PhysRevC.77.064301](https://doi.org/10.1103/PhysRevC.77.064301)
44. Nuclear Data Sheets 109, 297-516 (2008): **B. Singh**; *Nuclear Data Sheets for A = 100*. doi:[10.1016/j.nds.2008.01.001](https://doi.org/10.1016/j.nds.2008.01.001)
45. Nuclear Data Sheets 109, 517-698 (2008): **B. Singh**, A.A. Rodionov, Y.L. Khazov; *Nuclear Data Sheets for A = 135*. doi: [10.1016/j.nds.2008.02.001](https://doi.org/10.1016/j.nds.2008.02.001)
46. Nuclear Data Sheets 109, 2439-2499 (2008): **B. Singh**, E. Browne; *Nuclear Data Sheets A = 240*. doi:[10.1016/j.nds.2008.09.002](https://doi.org/10.1016/j.nds.2008.09.002)
47. Nuclear Data Sheets 108, 79-196 (2007): **B. Singh**; *Nuclear Data Sheets for A = 199*. doi:[10.1016/j.nds.2007.01.001](https://doi.org/10.1016/j.nds.2007.01.001)
48. Nuclear Data Sheets 108, 197-364 (2007): **B. Singh**; *Nuclear Data Sheets for A = 64*. doi: [10.1016/j.nds.2007.01.003](https://doi.org/10.1016/j.nds.2007.01.003)
49. Nuclear Data Sheets 107, 1027-1074 (2006): A.K. Jain, **B. Singh**; *Nuclear Data Sheets for A = 218*. doi:[10.1016/j.nds.2006.03.002](https://doi.org/10.1016/j.nds.2006.03.002)
50. Nuclear Data Sheets 107, 1075-1346 (2006): A.K. Jain, A. Ghosh, **B. Singh**; *Nuclear Data Sheets for A = 165*. doi: [10.1016/j.nds.2006.05.002](https://doi.org/10.1016/j.nds.2006.05.002)
51. Atomic Data Nuclear Data Tables 92, 1-46 (2006): S. Singh, S.S. Malik, A.K. Jain, **B. Singh**; *Table of three-quasiparticle rotational bands in deformed nuclei $153 \leq A \leq 187$* . doi: [10.1016/j.adt.2005.08.001](https://doi.org/10.1016/j.adt.2005.08.001)
52. Nuclear Data Sheets 107, 225-354 (2006): **B. Singh**, J.A. Cameron; *Nuclear Data Sheets for A = 39*. doi:[10.1016/j.nds.2006.01.001](https://doi.org/10.1016/j.nds.2006.01.001)
53. Nuclear Data Sheets 107, 1531-1746 (2006): B. Singh; *Nuclear Data Sheets for A = 194*. doi:[10.1016/j.nds.2006.05.004](https://doi.org/10.1016/j.nds.2006.05.004)
54. Nuclear Data Sheets 107, 1923-2102 (2006): **B. Singh**, A.R. Farhan; *Nuclear Data Sheets for A = 74*. doi:[10.1016/j.nds.2006.05.006](https://doi.org/10.1016/j.nds.2006.05.006)

55. Nuclear Data Sheets 104, 497-790 (2005): Yu. Khazov, A.A. Rodionov, S. Sakharov, **B. Singh**; *Nuclear Data Sheets for A = 132*. doi: [10.1016/j.nds.2005.03.001](https://doi.org/10.1016/j.nds.2005.03.001)
56. Nuclear Data Sheets 105, 109-222 (2005): **B. Singh**, J.K. Tuli; *Nuclear Data Sheets for A = 233*. doi: [10.1016/j.nds.2005.05.002](https://doi.org/10.1016/j.nds.2005.05.002)
57. Nuclear Data Sheets 105, 223-418 (2005): **B. Singh**; *Nuclear Data Sheets for A = 80*. doi: [10.1016/j.nds.2005.06.002](https://doi.org/10.1016/j.nds.2005.06.002)
58. Nuclear Data Sheets 106, 601-618 (2005): **B. Singh**; *Nuclear Data Sheets for A = 1*. doi: [10.1016/j.nds.2005.11.004](https://doi.org/10.1016/j.nds.2005.11.004)
59. Nuclear Data Sheets 102, 293-513 (2004): **J.A. Cameron, B. Singh**; *Nuclear Data Sheets for A = 40*. doi: [10.1016/j.nds.2004.06.001](https://doi.org/10.1016/j.nds.2004.06.001)
60. Nuclear Data Sheets 103, 325-388 (2004): F.E. Chukreev, **B. Singh**; *Nuclear Data Sheets for A = 240*. doi: [10.1016/j.nds.2004.11.004](https://doi.org/10.1016/j.nds.2004.11.004)
61. Nuclear Data Sheets 101, 193-323 (2004): **B. Singh**; *Nuclear Data Sheets for A = 73*. doi: [10.1016/j.nds.2004.01.002](https://doi.org/10.1016/j.nds.2004.01.002)
62. Nuclear Data Sheets 102, 1-291 (2004): **B. Singh**; *Nuclear Data Sheets for A = 149*. doi: [10.1016/j.nds.2004.05.001](https://doi.org/10.1016/j.nds.2004.05.001)
63. Nuclear Data Sheets 99, 275-481 (2003): **B. Singh**; *Nuclear Data Sheets for A = 190*. doi: [10.1006/ndsh.2003.0009](https://doi.org/10.1006/ndsh.2003.0009)
64. Nuclear Data Sheets 98, 335-513 (2003): **B. Singh**, Z. Hu; *Nuclear Data Sheets for A = 98*. doi: [10.1006/ndsh.2003.0003](https://doi.org/10.1006/ndsh.2003.0003)
65. Nuclear Data Sheets 95, 387-541 (2002): **B. Singh**; *Nuclear Data Sheets for A = 188*. doi: [10.1006/ndsh.2002.0005](https://doi.org/10.1006/ndsh.2002.0005)
66. Nuclear Data Sheets 95, 995-1036 (2002): **B. Singh**; *Nuclear Data Sheets for ^{152}Dy* . doi: [10.1006/ndsh.2002.0009](https://doi.org/10.1006/ndsh.2002.0009)
67. Nuclear Data Sheets 96, 1-176 (2002): **B. Singh**; *Nuclear Data Sheets for A = 79*. doi: [10.1006/ndsh.2002.0010](https://doi.org/10.1006/ndsh.2002.0010)

68. Nuclear Data Sheets 97, 241-592 (2002): **B. Singh, R. Zywina, R.B. Firestone**; *Table of Superdeformed Nuclear Bands and Fission Isomers*. doi: [10.1006/ndsh.2002.0018](https://doi.org/10.1006/ndsh.2002.0018)
69. Nuclear Data Sheets 92, 783-891 (2001): **J.A. Cameron, B. Singh**; *Nuclear Data Sheets for A = 43*. doi: [10.1006/ndsh.2001.0009](https://doi.org/10.1006/ndsh.2001.0009)
70. Nuclear Data Sheets 94, 429-603 (2001): **J.A. Cameron, B. Singh**; *Nuclear Data Sheets for A = 41*. doi: [10.1006/ndsh.2001.0021](https://doi.org/10.1006/ndsh.2001.0021)
71. Nuclear Data Sheets 92, 1-145 (2001): **B. Singh, J.A. Cameron**; *Nuclear Data Sheets for A = 4*. doi: [10.1006/ndsh.2001.0001](https://doi.org/10.1006/ndsh.2001.0001)
72. Nuclear Data Sheets 92, 429-441 (2001): **B. Singh**; *Nuclear Data Sheets for ^{143}Tb* . doi: [10.1006/ndsh.2001.0005](https://doi.org/10.1006/ndsh.2001.0005)
73. Nuclear Data Sheets 92, 443-454 (2001): **B. Singh**; *Nuclear Data Sheets for ^{143}Dy* . doi: [10.1006/ndsh.2001.0006](https://doi.org/10.1006/ndsh.2001.0006)
74. Nuclear Data Sheets 93, 33-242 (2001): **B. Singh**; *Nuclear Data Sheets for A = 130*. doi: [10.1006/ndsh.2001.0012](https://doi.org/10.1006/ndsh.2001.0012)
75. Nuclear Data Sheets 93, 243-445 (2001): **B. Singh**; *Nuclear Data Sheets for A = 164*. doi: [10.1006/ndsh.2001.0013](https://doi.org/10.1006/ndsh.2001.0013)
76. Nuclear Data Sheets 94, 1-130 (2001): **B. Singh**; *Nuclear Data Sheets for A = 86*. doi: [10.1006/ndsh.2001.0017](https://doi.org/10.1006/ndsh.2001.0017)
77. Nuclear Data Sheets 94, 397-427 (2001): **B. Singh, G. Reed**; *Nuclear Data Sheets for ^{199}Pb* . doi: [10.1006/ndsh.2001.0020](https://doi.org/10.1006/ndsh.2001.0020)
78. Nuclear Data Sheets 93, 1-32 (2001): **J.K. Tuli, G. Reed, B. Singh**; *Nuclear Data Sheets for ^{99}Tc* . doi: [10.1006/ndsh.2001.0011](https://doi.org/10.1006/ndsh.2001.0011)
79. Atomic Data Nuclear Data Tables 74, 283-331 (2000): **Amita, A.K. Jain, B. Singh**; *Table of Magnetic Dipole Rotational Bands*. doi: [10.1006/adnd.2000.0831](https://doi.org/10.1006/adnd.2000.0831)
80. Nuclear Data Sheets 91, 317-422 (2000): **J. Huo, B. Singh**; *Nuclear Data Sheets for A = 62*. doi: [10.1006/ndsh.2000.0019](https://doi.org/10.1006/ndsh.2000.0019)

81. Nuclear Data Sheets 89, 1-212 (2000): **B. Singh**, A.R. Farhan; *Nuclear Data Sheets for A = 163*. doi:[10.1006/ndsh.2000.0001](https://doi.org/10.1006/ndsh.2000.0001)
82. Pramana 53, 463-468 (1999): Amita, A.K. Jain, A. Goel, **B. Singh**; *Signature Splitting in Magnetic Rotational Bands*
83. Nuclear Data Sheets 88, 299-416 (1999): **J.A. Cameron, B. Singh**; *Nuclear Data Sheets for A = 44*. doi:[10.1006/ndsh.1999.0028](https://doi.org/10.1006/ndsh.1999.0028)
84. Nuclear Data Sheets 86, 785-954 (1999): A.R. Farhan, **B. Singh**; *Nuclear Data Sheets for A = 75*. doi:[10.1006/ndsh.1999.0012](https://doi.org/10.1006/ndsh.1999.0012)
85. Czech. J. Phys. 49, 1047-1066 (1999): R.K. Sheline, **B. Singh**, P.C. Sood, S.Y. Chu; *Systematic Investigation of Hexadecapole Collectivity in Even-Even Nuclei*. doi:[10.1023/A:1022885825020](https://doi.org/10.1023/A:1022885825020)
86. Nuclear Data Sheets 87, 177-190 (1999): **B. Singh**; *Nuclear Data Sheets for ^{58}Cu* . doi:[10.1006/ndsh.1999.0016](https://doi.org/10.1006/ndsh.1999.0016)
87. Nuclear Data Sheets 87, 191-195 (1999): **B. Singh**; *Nuclear Data Sheets for ^{62}Ga* . doi:[10.1006/ndsh.1999.0017](https://doi.org/10.1006/ndsh.1999.0017)
88. Nuclear Data Sheets 87, 635-644 (1999): **B. Singh**; *Nuclear Data Sheets for ^{165}W* . doi:[10.1006/ndsh.1999.0024](https://doi.org/10.1006/ndsh.1999.0024)
89. Nuclear Data Sheets 88, 1-28 (1999): **B. Singh, J. Chenkin**; *Nuclear Data Sheets for ^{165}Lu* . doi:[10.1006/ndsh.1999.0025](https://doi.org/10.1006/ndsh.1999.0025)
90. Nuclear Data Sheets 84, 115-276 (1998): Yu.V. Sergeenkov, **B. Singh**; *Nuclear Data Sheets for A = 135*. doi:[10.1006/ndsh.1998.0010](https://doi.org/10.1006/ndsh.1998.0010)
91. Nuclear Data Sheets 84, 487-563 (1998): **B. Singh, J.L. Rodriguez**, S.S.M.Wong, J.K. Tuli; *Review of Log ft Values in β Decay*. doi: [10.1006/ndsh.1998.0015](https://doi.org/10.1006/ndsh.1998.0015)
92. Nuclear Data Sheets 84, 565-716 (1998): **B. Singh**; *Nuclear Data Sheets for A = 98*. doi:[10.1006/ndsh.1998.0016](https://doi.org/10.1006/ndsh.1998.0016)

93. Atomic Data Nuclear Data Tables 69, 349-358 (1998): **B. Singh**, P.C. Sood, A.K. Jain; *Intrinsic Structures and Associated Rotational Bands in Medium-Heavy Deformed Odd-Odd Nuclei II. Update Supplement*. doi:[10.1006/adnd.1998.0784](https://doi.org/10.1006/adnd.1998.0784)

94. Nuclear Data Sheets 85, 1-170 (1998): B. Singh; *Nuclear Data Sheets for A = 89*. doi:[10.1006/ndsh.1998.0019](https://doi.org/10.1006/ndsh.1998.0019)

Contribution to ENSDF (Evaluated Nuclear Structure Data File) database available at Brookhaven National Laboratory webpage: www.nndc.bnl.gov/ensdf/ : contents of about 70 publications above in Nuclear Data Sheets journal were incorporated directly in the ENSDF database, and through that recommended nuclear data for several hundred nuclides evaluated at McMaster center were available to the world-wide community. In addition, a large number of nuclides were updated in the ENSDF database for data on superdeformed bands during 1998-2004 or so when this field was very active, and later for data for new nuclides discovered through radioactive ion beam facilities. It is our estimate that about 19% of the total contents in the ENSDF database are from the McMaster data group supported essentially by the award from the DOE during 1998-2013. A commonly user accessed database from the Brookhaven lab webpage is NUDAT 2.6, which takes most of the data from the ENSDF database.

Closely related to ENSDF evaluations, several topical evaluations of interest in nuclear structure were carried out: Review of Log *ft* values in beta decay in 1998; Table of Superdeformed bands and fission isomers in 2002; Table of Magnetic-dipole rotational (shears) bands in 2000; Table of 3-qp structures in deformed region in 2006; Table of B(E2) values for first 2⁺ states in even-even nuclei in 2012, this work is still continuing for all mass regions; first evaluation of beta-delayed neutron emission probabilities in A<72 mass region started in 2012 and is continuing.

Contribution to evaluation of Nuclear reaction rates of astrophysical significance:

Between 2007 and 2013, astrophysical reaction rates for the following reactions were evaluated and sent for placement in www.nuastro.org webpage maintained at Oak Ridge National Laboratory:



Related research publications (McMaster University authors in bold):

1. Physical Review C 85 015805 (2012): **J. Chen, A. A. Chen**, G. Amadio, S. Cherubini, H. Fujikawa, S. Hayakawa, J. J. He, N. Iwasa, D. Kahl, L. H. Khiem, S. Kubono, S. Kurihara, Y. K. Kwon, M. La Cognata, J. Y. Moon, M. Niikura, S. Nishimura, J. Pearson, R. G. Pizzone, T. Teranishi, Y. Togano, Y. Wakabayashi, and H. Yamaguchi; *Strong $^{25}\text{Al} + p$ resonances via elastic proton scattering with a radioactive ^{25}Al beam*. doi:[10.1103/PhysRevC.85.015805](https://doi.org/10.1103/PhysRevC.85.015805)
2. Physical Review C 84, 065808 (2011): A. Parikh, K. Wimmer, T. Faestermann, R. Hertenberger, H. -F. Wirth, **A. A. Chen**, J. A. Clark, C. M. Deibel, C. Herlitzius, R. Kruecken, D. Seiler, **K. Setoodehnia**, K. Straub, and C. Wrede; *Production of ^{26}Al in stellar hydrogen-*

burning environments: spectroscopic properties of states in ^{27}Si .

doi: [10.1103/PhysRevC.84.065808](https://doi.org/10.1103/PhysRevC.84.065808)

3. Physical Review C 83, 045806 (2011): A. Parikh, K. Wimmer, T. Faestermann, R. Hertenberger, J. José, R. Longland, H. -F. Wirth, V. Bildstein, S. Bishop, **A. A. Chen**, J. A. Clark, C. M. Deibel, C. Herlitzius, R. Kruecken, D. Seiler, K. Straub, and C. Wrede; *Improving the $^{30}\text{P}(p, \gamma)^{31}\text{S}$ rate in ONe novae: constraints on J^π values for proton-threshold states in ^{31}S .* doi: [10.1103/PhysRevC.83.045806](https://doi.org/10.1103/PhysRevC.83.045806)

4. Physical Review C 83, 018803 (2011): **K. Setoodehnia**, **A. A. Chen**, T. Komatsubara, S. Kubono, D. N. Binh, J. F. Carpino, **J. Chen**, T. Hashimoto, T. Hayakawa, Y. Ishibashi, Y. Ito, D. Kahl, T. Moriguchi, H. Ooishi, A. Ozawa, T. Shizuma, Y. Sugiyama and H. Yamaguchi; *Spins and parities of astrophysically important ^{30}S states from $^{28}\text{Si}(^3\text{He}, n\gamma)^{30}\text{S}$.* doi: [10.1103/PhysRevC.83.018803](https://doi.org/10.1103/PhysRevC.83.018803)

5. Physical Review C 82, 035805 (2010): C. Wrede, J. A. Clark, C. M. Deibel, T. Faestermann, R. Hertenberger, A. Parikh, H. -F. Wirth, S. Bishop, **A. A. Chen**, K. Eppinger, B. M. Freeman, R. Krücken, O. Lepyoshkina, G. Rugel, and **K. Setoodehnia**; *Properties of ^{20}Na , ^{24}Al , ^{28}P , ^{32}Cl , and ^{36}K for studies of explosive hydrogen burning.* doi: [10.1103/PhysRevC.82.035805](https://doi.org/10.1103/PhysRevC.82.035805)

6. Physical Review C -- Rapid Communications 82, 022801 (2010): **K. Setoodehnia**, **A. A. Chen**, **J. Chen**, J. A. Clark, C. M. Deibel, **S. D. Geraedts**, D. Kahl, P. D. Parker, D. Seiler, and C. Wrede; *Structure of ^{30}S with $^{32}\text{S}(p,t)^{30}\text{S}$ and the thermonuclear $^{29}\text{P}(p, \gamma)^{30}\text{S}$ reaction rate.* doi: [10.1103/PhysRevC.82.022801](https://doi.org/10.1103/PhysRevC.82.022801)

7. Physical Review C 81, 045808 (2010): L. Erikson, C. Ruiz, F. Ames, P. Bricault, L. Buchmann, **A. A. Chen**, **J. Chen**, H. Dare, B. Davids, C. Davis, C. M. Deibel, M. Dombsky, S. Foubister, N. Galinski, U. Greife, U. Hager, A. Hussein, D. A. Hutcheon, J. Lassen, L. Martin, D. F. Ottewell, C. V. Ouellet, G. Ruprecht, **K. Setoodehnia**, A. C. Shotter, A. Teigelhöfer, C. Vockenhuber, C. Wrede, and A. Wallner; *First direct measurement of the $^{23}\text{Mg}(p, \gamma)^{24}\text{Al}$ reaction.* doi: [10.1103/PhysRevC.81.045808](https://doi.org/10.1103/PhysRevC.81.045808)

8. Journal of Physics G: Nuclear and Particle Physics 35 014034 (2008): C. Vockenhuber, **C.V. Ouellet**, L.S. The, L. Buchmann, J. Caggiano, **A.A. Chen**, John D'Auria, B. Davids, L. Fogarty, D. Frekers, A. Hussein, D.A. Hutcheon, W. Kutschera, D. Ottewell, M. Paul, M.M. Pavan, J. Pearson, C. Ruiz, G. Ruprecht, M. Trinczek, and A. Wallner; *$^{40}\text{Ca}(\alpha, \gamma)^{44}\text{Ti}$ and the production of ^{44}Ti in supernovae.* doi: [10.1088/0954-3899/35/1/014034](https://doi.org/10.1088/0954-3899/35/1/014034)

Contribution to XUNDL (Experimental Unevaluated Nuclear Data List) database available at Brookhaven National Laboratory webpage: www.nndc.bnl.gov/xundl/ : this database was started by Dr. B. Singh at McMaster in December 1998 in response to an observation of a DOE review panel circa 1996 that ENSDF database was outdated in several situations, especially those for high-spin physics. The purpose and scope of this database was to make available to the user community data files in ENSDF format, compiled from current journal publications in experimental nuclear structure physics and radioactive decays. Since 1998, about 3550 journal publications have been compiled critically, each dataset checked through computer codes used

for ENSDF evaluations. A large number of communications were made with the original authors to resolve data-related inconsistencies and to obtain additional data details, not present in the published papers. This database currently contains about 5800 datasets for about 2200 nuclides. Undergraduate students in Physics Honors program at McMaster have been heavily involved since we started this program in 1998. Our contribution to the XUNDL database in July 2013 was at least 80%, while Dr. Singh, as XUNDL coordinator, reviewed and edited datasets received from other two centers at ANL (Argonne National Lab.) and TUNL (Triangle Universities Nuclear Laboratory) in North Carolina. In addition current journal publications on atomic mass measurements between 2007 and 2013 were compiled separately and data files prepared from about 120 papers were made available on www.nuclearmasses.org webpage at Oak Ridge National Laboratory. A list of McMaster undergraduate students who worked on this project during 1998-2013 is given below, each student worked for 1-2 years, full-time during summer and part-time during winter semesters.

Jordan Chenkin (1998-2000); George Reed (2000-01); Michelle Lee (2000-2002); Roy Zywna (2001-2003); Joel Roediger (2003-2005); Maxim Mitchell (2005-2006); Scott Geraedts (2006-2008); Allison MacDonald (2008-2010); Babak Karamy (2009-2011); Jeremie Choquette (2010-2012); Michael Birch (2011-2013); Ervin Thiagalingam (2012-2013); Elaine McNeice (2013); Michael Walters (2013-)

Contribution to NSR (Nuclear Science References) database available at Brookhaven National Laboratory webpage: www.nndc.bnl.gov/nsr/ : since October 2007, we prepared keyword abstracts for articles in Physical Review C (PRC) journal which were then incorporated into the NSR database by the personnel at NNDC, BNL. Between October 2007 and June 2013, we estimate that about 6300 articles in PRC were consulted and keyword abstracts prepared for about 4100 articles. Undergraduate students were involved in this effort to prepare draft keywords.

International Coordination for ENSDF evaluations: Between 2003 and 2013, Dr. Singh provided training in ENSDF evaluations to several new practising nuclear physicists from overseas whose visits were partially covered through the DOE grant at McMaster. A list of the visiting scientists for training in ENSDF evaluations, and other collaborative projects, is given below; each visit was for 2-3 weeks.

Dr. Alexander Rodionov: St. Petersburg, Russia (2003, 2007, 2013)
Dr. Ashok Jain, IIT, Roorkee, India (2003, 2005)
Dr. Caroline Nesaraja, ORNL, USA (2007)
Drs. Janos Timar, ATOMKI, Hungary (2009, 2010)
Drs. Zoltan Elekes, ATOMKI, Hungary (2010)
Dr. Ninel Nica, Texas A&M, USA (2011)
Dr. Kazek Zuber, IFJ-PAN, Poland (2011)
Dr. Paresh Joshi, TIFR, India (2009)
Dr. Alexandru Negret, NIPNE, Romania (2012)
Dr. Alan Nichols, Surrey, UK. (2009, 2010)
Dr. Boris Pritychenko, NNDC, BNL (several visits during 2010-2013)
Dr. Tim Johnson, NNDC, BNL (two visits in 2011, 2012)
Dr. Anagha Chakraborty, Krishnath College, India (2013)

In 2005, the international biennial meeting of the IAEA's NSDD (Nuclear Structure and Decay Data) evaluators' network was hosted by the McMaster group. About 35 scientists from Canada, U.S., Australia, France, Russia, Austria, Japan, China, India and Bulgaria attended this event.

Dr. Singh lectured and coordinated the evaluation of isobaric mass chains at five international ENSDF workshops: Bucharest (2009), ICTP - Trieste (2010, 2012, 2014), VECC - Kolkata (2012). Evaluations from these workshops were published in Nuclear Data Sheets journal.

In 2011, Dr. Singh proposed to the IAEA to initiate a Coordinated Research Program (CRP) on the topic of beta-delayed neutron emission from neutron-rich nuclei in order to have a comprehensive database for neutron emission probabilities, as well as to encourage and coordinate new experimental measurements using state-of-the-art technologies in nuclear structure studies. This CRP was approved in December 2012, and the first international workshop for beta-delayed neutrons was organized by the McMaster group in 2012; about 20 scientists from Canada, U.S., Austria, Germany, Spain and Japan attended this event. The subsequent research coordination meeting (RCM) was held at the IAEA, Vienna, in August 2013.

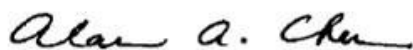
Overall Impact:

The work described above covers the evaluation of several hundred nuclides and compilation of data for 2200 nuclides in the nuclear chart. These data are made available to the world-wide community of nuclear scientists and technologists through the databases ENSDF, XUNDL, NSR, and NUDAT (primarily derived from ENSDF) at the NNDC, Brookhaven, and a parallel website at the Nuclear Data Section of the IAEA. The data retrieval statistics at the NNDC, BNL, suggests that all these databases are being heavily used by nuclear researchers and academicians.

Our evaluated rates have been included into the reaction database at ORNL (www.nucastrodata.org), to ensure that stellar modellers have access to reaction rates based on the latest experimental data.

The data files in the XUNDL database are used by researchers and the network evaluators, which potentially speeds up the evaluation process of nuclides for the ENSDF database. Timely communications with the original authors help to obtain additional (unpublished) data details and to clarify data-related inconsistencies.

Alan A. Chen



November 14, 2014