LBNL Isotopes Project

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Isotopes Project Collaborations

- **Budapest/Munich Reactors** – Zs. Revay, T. Belgya, L. Szentmiklosi
- **DICEBOX Calculations** – M. Krticka, Charles University, Prague
- **LLNL/LBNL ENDF Capture γ-ray Library** – B. Sleaford, N. Summers
- **LLNL/LBNL Stars+LiBerACE Collaboration** – J. Burke, L. Phair
- **National Ignition Facility/Stars+LiBerACE Collaboration** –

  L. Bernstein, D. Bleuel, J.A. Caggiano, D.H.G. Schneider, W. Stoeffl (LLNL)

  M. Wiedeking (iThemba Labs, South Africa)

  M. Krticka, F. Becvar (Charles University, Prague)

  S. Siem, A. Goergen, M. Guttormsen, A.C. Larsen (U. Oslo)
- **Youngstown State U. (Ohio)** – J. Carroll
- **IAEA EGAF/RIPL** – D. Abriola, R. Capote, M. Kellett, V. Zerkin

Isotopes Project Activities

Activity	Details
Nuclear Structure Evaluation	Nuclear Data Sheet publication RIPL library evaluations
Cross Section Evaluation	EGAF database ENDF capture gamma-ray library
Nuclear Data Measurements	Cold neutron beams – Budapest/Munich Surrogate reactions - STARS-LiBerACE Astophysics/Environmental research
Nuclear Data Calculations	DICEBOX – collaboration with Prague, LLNL COSMO – under development

Nuclear Structure Evaluation Status

FY2010 Mass Chain Publications

- A=30, S. Basunia, NDS 111, 2331-2424 (2010)
- A=65*, E. Browne and J.K. Tuli, NDS 111, 2425-2553 (2010)
- A=66*, E. Browne and J.K. Tuli, NDS 111, 1093-1209 (2010)
- A=168, C.M. Baglin, NDS 111, 1807-2080 (2010)
- A=184, C.M. Baglin, NDS 111, 275-523 (2010)

Isotope evaluations published in ENSDF

- ^{29}F, ^{29}Mg, ^{29}Al, ^{30}F, ^{30}Al, ^{30}Si – S. Basunia
- ^{172}Au, ^{172}Hg, ^{172}Pt – T. Kibedi and C.M. Baglin
- ^{170}Dy, ^{170}Pt – C.M. Baglin

Mass Chains in Review

- A=92, C.M. Baglin
- A=93, C.M. Baglin
- A=99*, E. Browne and J.K. Tuli
- A=192, C.M. Baglin

* Work supported by the NNDC

EGAF Status

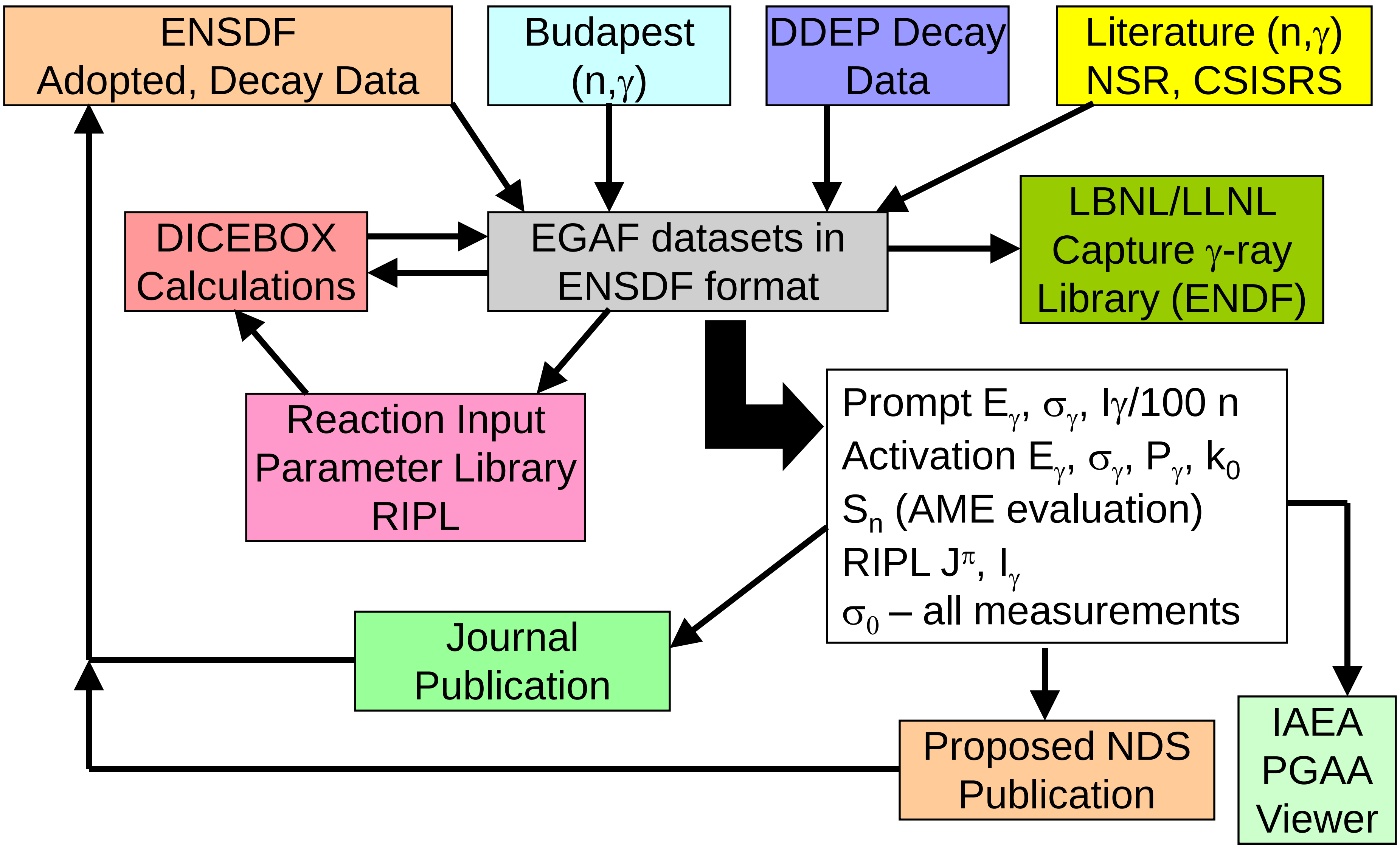
EGAF version 1.0 published and available on Internet

- *Database of Prompt Gamma Rays from Slow Neutron Capture for Elemental Analysis*, R.B. Firestone, et al, IAEA STI/PUB/1263, 251 pp(2007)
  Http://www-pub.iaea.org/MTCD/publications/PubDetails.asp?pubId=7030
- IAEA Prompt Gamma-ray Activation Analysis Viewer
  http://www-nds.iaea.org/pgaa/pgaa7/index.html
- LBNL Capture Gamma-ray Data
  http://ie.lbl.gov/ng.html

EGAF version 2.0 currently under development

- Updated evaluations – preliminary revision of decay data is 90% complete
- DICEBOX calculations – σ_0 measurements, improved RIPL
- Activation file – IAEA $k_0/\sigma_0/P_\gamma$ comparison completed
- σ_0 compilation of measurements – CSISRS/NSR review completed

EGAF Processing



EGAF Experiments and Publication

Evaluation progress

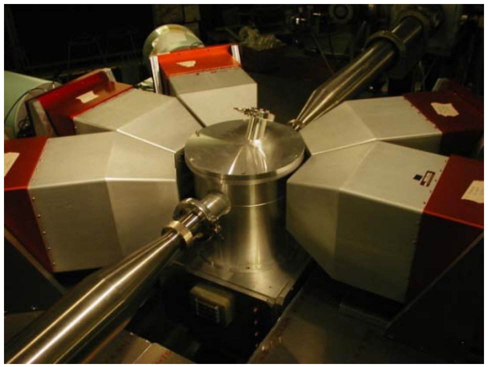
- $^{102,104,105,106,108,110}Pd$ published (Phys. Rev. C77, 054615(2008))
- Z=3-19 publications in preparation for FY2011
- $^{54,56,57,58}Fe$ DICEBOX calculations FY2011, compare to Raman data
- $^{151,153}Eu$ DICEBOX calculations, evaluation in progress
- $^{152,154,155,156,157,158,160}Gd$ evaluation complete, awaiting new (n,γ) TOF data
- $^{180,182,183,184,186}W$ DICEBOX calculations, evaluation in progress

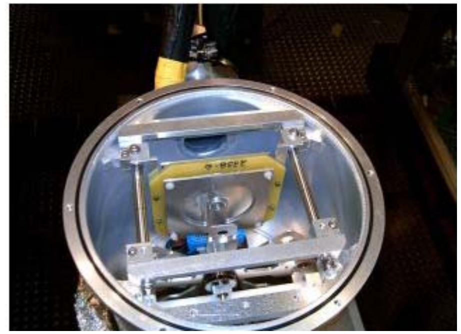
Planned neutron beam measurements FY2011

- ^{2}H, ^{3}He, $^{90,91,92,94,96}Zr$ - σ_0 measurements at the Munich Reactor
- ^{73}Ge - NIF collaboration σ_0 measurements at the Budapest Reactor
- $^{155,157}Gd$ - NTOF measurements at the Budapest Reactor
- $^{151,153}Eu$, ^{168}Er, $^{182,183,184,186}W$ – isotopic σ_γ measurements at the Budapest Reactor

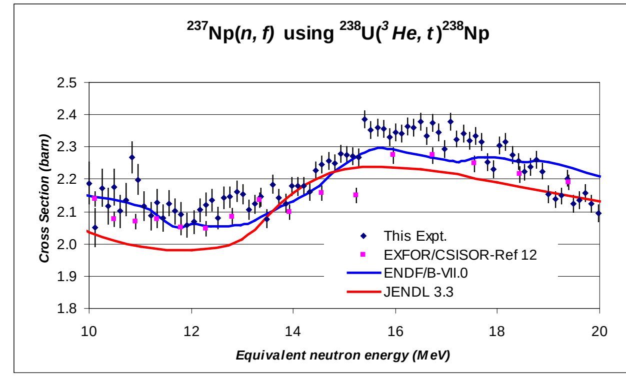
Surrogate Reaction Measurements

Target Chamber+6 “Clover” Ge





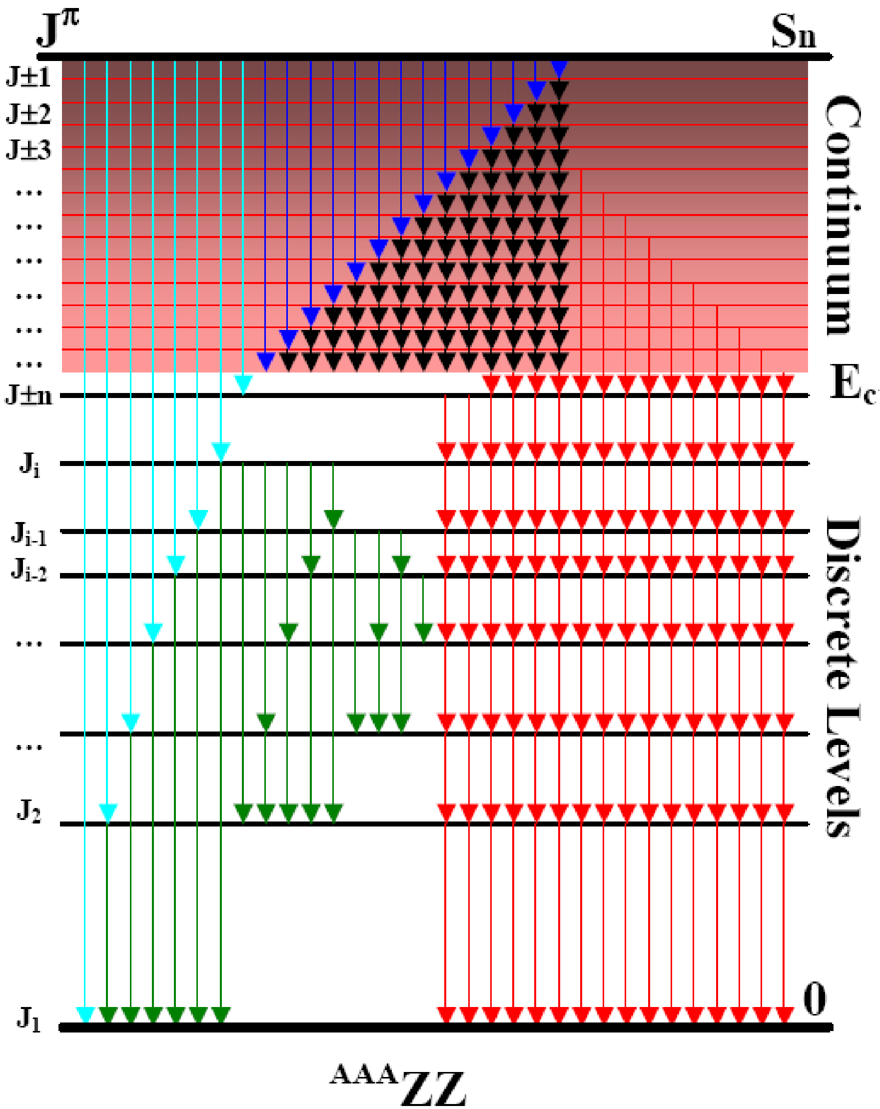
Interior w/S2 Si detectors



LBNL LIBERACE/STARS measurements FY2011

- ^{238}U(^{3}He,t) surrogate reaction to ^{237}Np(n,f), published NIM B267, 1899 (2009). See above right.
- ^{167}Er(d,p) – search for collective nuclear structure contribution to statistical decay.
- ^{106,108,110}Pd(p,p’) – ^{107}Pd s-process waiting point nucleus surrogate reaction cross section study (proposed).
- ^{73}Ge(d,p) – surrogate cross section measurement, preliminary NIF experiment (proposed).

DICEBOX Calculations



DICEBOX (M. Krticka, Prague)

Application of statistical models to determine σ_0 where

- Nuclear structure data below E_{crit} are from the RIPL library
- Primary γ-ray data populating levels below E_{crit} are from EGAF

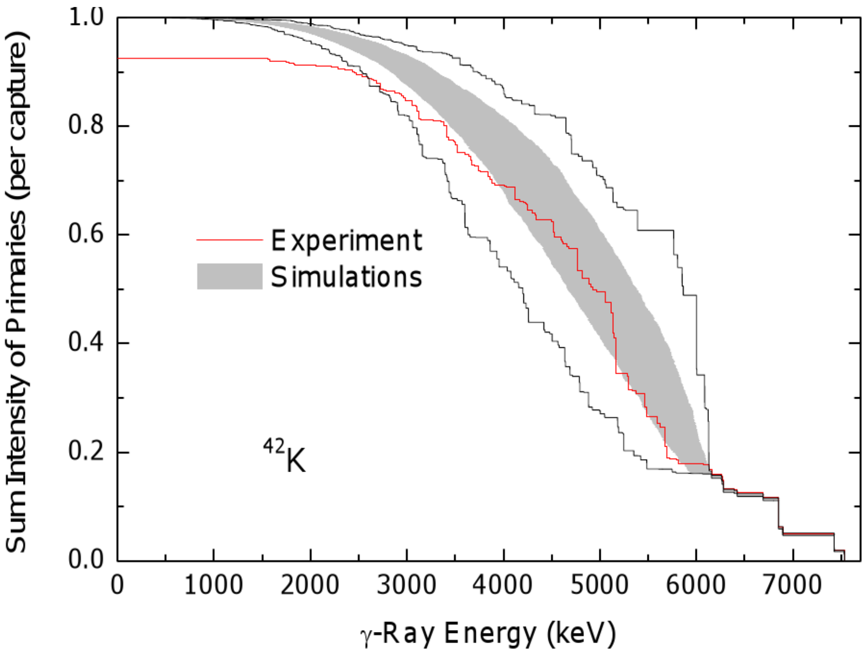
$$\sigma_0 = \sum \sigma_\gamma(GS)_{E<E_{crit}}^{EXPT} + \sum \sigma_\gamma(GS)_{E>E_{crit}}^{DICEBOX}$$

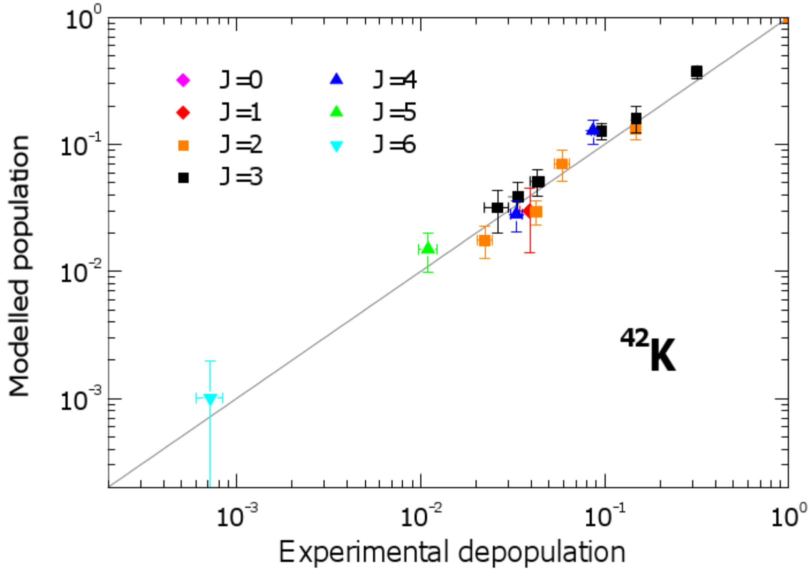
All EGAF data are being analyzed to determine σ_0 using DICEBOX

DICEBOX runs on LBNL Lawrencium computer cluster. Simplified input scripts have been developed by Neil Summers (LLNL).

Potassium DICEBOX Calculations

Cumulative distribution of primary transitions in ^{42}K. Simulated lines indicate extreme range where 68% of simulations fall in the gray region. (100 simulations.





^{42}K population/depopulation plot

Potassium σ_0 results		
Target	Atlas	Experiment
^{39}K(n,γ)	2.1(2)	2.25(4)
^{40}K(n,γ)	30(8)	94(7)
^{41}K(n,γ)	1.46(3)	1.54(3)

EGAF Proposed NDS Publication

EGAF Comments Dataset for Na

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Abstract: Evaluated thermal capture prompt and delayed γ-ray energies, σγ cross sections and k_0 valueswere determined for the ^{23}NA(n,γ) reaction. A revised version of the RIPL library for ^{24}Na was generated and a new, more precise value for S_n was determined.

General Policies and Organization of Material: See the January issue of the *Nuclear Data Sheets* or http://www.nndc.bnl.gov/nds/NDSPolicies.pdf.

Acknowledgments: This work was supported by the Director, Office of Science, Office of Basic Energy Sciences, of the U.S. Department of Energy under Contract No. DE-AC02-05CH11231.

General Comments: Neutron capture γ-ray σγ data from the cold neutron beam at the Budapest Reactor were combined with capture γ-ray data from ENSDF to determine an evaluated set of energies, σ_γ cross sections, and k_0 values for the ^{23}Na(n,γ)^{24}Na E=thermal reaction. The decay scheme is nearly complete with 0.540 3 b observed populating the ground state and 0.537 3 b deexciting the capture state. The activation cross section for ^{24}Na β− decay (14.997 h) was determined as 0.542 3 b and the activation cross section for ^{24}Na IT decay was determined as 0.501 3 b. A new Reaction Input Parameter Library was prepared with definite spins and parities determined for the first 30 levels. The neutron separation energy was determined as S_n=6959.527 8 keV in good agreement with S_n=6959.58(8) (2003Au03) adopted by Audi et al.

EGAF – General comments

$^{23}Na(n,\gamma)$ E=thermal

EGAF thermal neutron capture adopted E_γ, σ_0, and k_0 data.

σ_0=0.60 5 (Coltman, PR 69, 411, 1946). Original value σ_0=0.47 4 b corrected for monitor σ_0(B)=600 b.

σ_0=0.63 13 b (Seren, 1947Se33). Activation method.

σ_0=0.490 25 b (Pomerance,PR83,641,1951), Pile oscilator method. Corrected from original value σ_0=0.470 24 b calibrated assuming $\sigma_0(^{197}Au)$=95 b.

σ_0=0.560 32 b (Bartholomew, Can J. Chem 31, 204, 1953). Measured value σ_0=0.530 32 corrected for monitor value $\sigma_0(^{197}Au)$=93 b.

σ_0=0.511 5 b (Harris, ANL–5031 Report, p 68, 1953). Pile oscillator method. Corrected from original value σ_0=0.503 5 b assuming σ_0(B)=755 b.

σ_0=0.50 5 b (Brooksbank, ANS Transactions, 203, 1955). Activation cross section, monitor $\sigma_0{}^{55}$Mb=13.3 b.

σ_0=0.513 30 b (Grimeland, J. Nucl. En. 1, 231, 1955). Thermal column method. Corrected from original value σ_0=0.51 3 b calibrated assuming σ_0(B)=750 b.

σ_0=0.536 6 b (Cocking, J. Nucl. En. 4, 33, 1957). Measured by $4\pi\beta\gamma$ coincidence counting. Monitor $\sigma_0(^{197}Au)$=98.6 b.

σ_0=0.536 8 b (Jowitt, Prog. Nucl. En. 3, 242, 1959). Method dimple oscillator reactivity modulation. Monitor σ_0(B)=766.6 b.

σ_0=0.536 8 b. (Rose, Prog. Nucl. En. 3, 242, 1959). Pile oscillator method assuming σ_0(B)=771 b.

σ_0=0.531 8 b (Wolf, 1960Wo07). Measured by $4\pi\beta\gamma$ coincidence counting. Monitor $\sigma_0(^{197}Au)$=98.70 35 b.

σ_0=0.47 6 b (Meadows, 1961Me02) Pulse die away method. Monitor ^{197}Au.

σ_0=0.50 2 b (Koehler, Zeit. Nat. A18, 1339,1963). Activation cross section with ^{197}Au monitor.

σ_0=0.50 3 b (Yamamuro, Nucl. Sci. Eng. 41, 445 (1970). Measured neutron flux, natural Cd monitor.

σ_0=0.526 5 b (Ryves, 1970Ry05). Measured by $4\pi\beta\gamma$ coincidence counting. Monitor $\sigma_0(^{197}Au)$=98.8 3 b.

σ_0=0.54 2 b (Gleason, 1975Gl09). Activation method. Monitor $\sigma_0(^{197}Au)$=98.88 b.

σ_0=0.523 5 b (Heft, Conf. MAYAG, 1978). Activation with natural Sc flux monitor.

σ_0=0.577 8 b (Kaminishi, Jap. J. Appl. Phys. 21, 366 (1982). Activation method.

σ_0=0.513 6 b (De Corte, 2003De34). k_0 method.

σ_0=0.515 21 (Kennedy, J. Rad. Nucl. Chem. 257, 475, 2003). k0 method.

σ_0=0.527 8 b (Szentmillosi, 2006Sz05). Activation with neutron beam.

σ_0=0.540 3 b (Budapest prompt γ–ray data to ground state).

σ_0=0.534 3 b (Budapest prompt γ–ray data primaries).

σ_0=0.542 3 b (Budapest activation γ–ray data).

σ_0=0.517 4 b (Mughabghab, 2006MuZX). Evaluation.

Summary of σ_0 values from the literature (CSISRS) and this evaluation

EGAF – NDS Levels

^{24}Na Levels

E(level)§	Jπ#	$T_{1/2}$@	σγ(in)†	σγ(out)‡	Comments
0.0	4+	14.9590 h *12*	0.540_3		
472.2082 *8*	1+	20.20 ms *7*	0.508_4	0.501 *3*	
563.1974 *15*	2+	36 ps *6*	0.257_1	0.260 *3*	
1341.457 *5*	2+	60 fs *20*	0.120_1	0.118 *2*	
1344.644 *7*	(3)+	26 fs *6*	0.0388_3	0.0386 *22*	
1346.623 *5*	1+	4.4 ps *3*	0.0828_7	0.0805 *13*	
1515.70 *22*	5+		0.00013_3	0.00010 *2*	E(level): Level energy 3-keV higher than Adopted Level (2007Fi14) but consistent with energy shift in 2562.37 adopted level.
1846.021 *5*	2+	180 fs *25*			
1885.581 *4*	3+	26 fs *5*	0.0097_3	0.00979 *6*	
2513.413 *10*	3+	10 fs *3*	0.0103_1	0.0102 *1*	
2564.90 *18*	4+		6.4E-5_10	2.2×10^{-4} *4*	E(level): Level energy 3-keV higher than adopted level (2007Fi14) but consistent with energy shift in 1514.7 4 adopted level.
2904.025 *13*	3+	35 fs *6*	0.0054_2	0.0055 *1*	
2977.807 *12*	(2+)	<17 fs	0.0760_8	0.0775 *4*	Jπ: Adopted Jπ is (2+,3+). Strong popuation by (n,γ) favors 2+.
3216.7 *5*	(4+)		1.0E-4_1	7.5×10^{-5} *11*	Jπ: Adopted Jπ is (4+,2+). Weak population by (n,γ) favors 4+.

Cross section balance through the (n,γ) level scheme.

Justification of RIPL J$^{\pi}$ assignments.

EGAF - NDS Gammas

γ(^{24}Na)

Iγ normalization: Normalization to per 100 neutron captures assuming σ_0=0.540 b.

Eγ[†]	E(level)	σγ[‡@]	Mult.	α	Comments
90.9921 *14*	563.1974	0.250 *3*	M1	0.00213	k_0=0.0329 *4.*
242.30 *9*	3655.967	0.000110 *11*			$k_0=1.45\times10^{-5}$ *14.*
340.8 *3*	4527.3	0.000033 *9*			$k_0=4.3\times10^{-6}$ *12.*
373.24 *6*	3589.390	0.000075 *7*			$k_0=9.9\times10^{-6}$ *9.*
	3745.079	0.000075 *6*			$k_0=9.9\times10^{-6}$ *8.*
387.98 *18*	3977.342	0.000028 *6*			$k_0=3.7\times10^{-6}$ *8.*
472.2027 *11*	472.2082	0.501 *3*	M3	0.00047	k_0=0.0660 *4.*
499.383 *5*	1846.021	0.01474 *22*			k_0=0.00194 *3.*
501.30 *3*	1846.021	0.00308 *12*			k_0=0.000406 *16.*
504.57 *4*	1846.021	0.00140 *8*			$k_0=1.85\times10^{-4}$ *11.*
511.20 *2*	6959.527	0.0032 *2*			k_0=0.00042 *3.* Eγ,σγ: Expected primary γ–ray, Iγ from the intensity balance. Observed transition with E=510.94 9 keV, σγ=0.00552 23 b includes annihilation radiation from pair production.
543.94 *13*	4751.024	0.000042 *7*			$k_0=5.5\times10^{-6}$ *9.*
551.21[§] *4*	4207.152	0.000348 *13*			$k_0=4.59\times10^{-5}$ *17.*
563.1974 *16*	563.1974	0.00925 *8*			k_0=0.001219 *11.*
605.51[§] *3*	3977.342	0.000159 *10*			$k_0=2.10\times10^{-5}$ *13.*
617.84 *5*	4207.152	0.000143 *10*			$k_0=1.88\times10^{-5}$ *13.*
662.06 *25*	4527.3	0.00006 *4*			$k_0=8\times10^{-6}$ *5.*
665.14 *12*	5192.27	0.00042 *5*			$k_0=5.5\times10^{-5}$ *7.*
696.570 *20*	4441.655	0.000215 *17*			$k_0=2.83\times10^{-5}$ *22.*

Gamma ray cross sections and k_0 values

EGAF – NDS Activation data

^{24}Na β⁻ Decay (14.997 h)

Parent ^{24}Mg: E=0; Jπ=4+; $T_{1/2}$=14.997 h *12*; Q(g.s.)=5515.45 *8*; %β⁻ decay=100.

^{24}Mg Levels

E(level)†	Jπ†	$T_{1/2}$
0.0	0+	stable
1368.672 *5*	2+	
4122.889 *12*	4+	
4238.24 *3*	2+	
5235.12 *4*	3+	

† From adopted levels.

β⁻ radiations

Eβ⁻	E(level)	Iβ⁻†	Log *ft*	Comments
(280.33 *9*)	5235.12	0.076 *3*	6.60 *2*	av Eβ=89.24 *22*.
(1392.56 *8*)	4122.889	99.855 *5*	6.11 *1*	av Eβ=554.1 *3*.
(4146.78 *8*)	1368.672	0.064 *6*	11.34 *4*	av Eβ=1865.5 *3*.

† Absolute intensity per 100 decays.

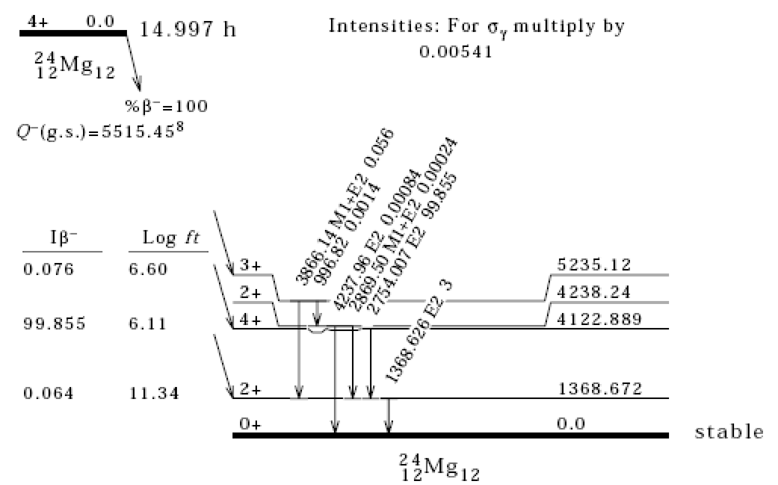
γ(^{24}Mg)

Eγ†	E(level)	P_γ†‡	Mult.	δ	α	I(γ+ce)‡	Comments
996.82 *9*	5235.12	0.0014 *2*					
1368.626 *5*	1368.672	99.9936 *15*	E2		1.3×10^{-5}	3	k_0=0.0492 *4*.
							k_0=0.0468 3 (IUPAC, 2003De34).
							P_γ: σγ(Budapest)=0.5409 25 b.
2754.007 *11*	4122.889	99.855 *5*	E2				P_γ: σγ(Budapest)=0.5433 35 b.
2869.50 *6*	4238.24	0.00024 *3*	M1+E2	−23 *9*			k_0=0.0491 *4*.
							k_0=0.0462 4 (IUPAC, 2003De34).
3866.14 *10*	5235.12	0.056 *7*	M1+E2	−17 *4*			P_γ: σγ(Budapest)=0.00042 6 b.
4237.96 *6*	4238.24	0.00084 *10*	E2				

† From DDEP evaluation (2004BeZr).
‡ Absolute intensity per 100 decays.

^{24}Na β⁻ Decay (14.997 h) (continued)

Decay Scheme



Pγ on table, conversion factor to σγ on drawing

RIPL data example

24Na RIPL File

```
24NA    24    11    86   361    13     0     6.959527      .000000
  1    .000000   4.0   1    5.39E+04   0 0      4+                     1
  2    .472208   1.0   1    2.02E-02   1 0      1+                     1
                                           1        .472   9.995E-01  1.000E+00  4.700E-04
  3    .563197   2.0   1    3.60E-11   2 0       2+                    0
                                           2        .091   9.623E-01  9.644E-01  2.130E-03
                                           1        .563   3.561E-02  3.561E-02  0.000E+00
  4   1.341457   2.0   1    6.00E-14   3 0      2+                     0
                                           3        .778   5.097E-02  5.097E-02  0.000E+00
                                           2        .869   9.482E-01  9.482E-01  0.000E+00
                                           1       1.341   8.297E-04  8.297E-04  0.000E+00
  5   1.344644   3.0   1    2.60E-14   2 0     (3)+                    0
                                           3        .781   4.503E-01  4.503E-01  0.000E+00
                                           1       1.345   5.497E-01  5.497E-01  0.000E+00
  6   1.346623   1.0   1    4.40E-12   2 0      1+                     0
                                           3        .783   1.106E-02  1.106E-02  0.000E+00
                                           2        .874   9.889E-01  9.889E-01  0.000E+00
  7   1.515700   5.0   1    0.00E+00   1 0      5+                     0
                                           1       1.515   1.000E+00  1.000E+00  0.000E+00
  8   1.846021   2.0   1    1.80E-13   5 0       2+                    0
                                           6        .499   4.479E-01  4.479E-01  0.000E+00
                                           5        .501   9.359E-02  9.359E-02  0.000E+00
                                           4        .505   4.254E-02  4.254E-02  0.000E+00
                                           3       1.283   1.674E-01  1.674E-01  0.000E+00
                                           2       1.374   2.486E-01  2.486E-01  0.000E+00
  9   1.885581   3.0   1    2.60E-14   2 0      3+                     0
                                           3       1.322   6.456E-01  6.456E-01  0.000E+00
                                           1       1.886   3.544E-01  3.544E-01  0.000E+00
 10   2.513413   3.0   1    1.00E-14   3 0      3+                     0
                                           4       1.172   1.379E-02  1.379E-02  0.000E+00
                                           3       1.950   8.808E-01  8.808E-01  0.000E+00
                                           1       2.513   1.054E-01  1.054E-01  0.000E+00
 11   2.564900   4.0   1    0.00E+00   3 0      4+                     0
                                           7       1.050   1.441E-01  1.441E-01  0.000E+00
                                           5       1.220   4.955E-01  4.955E-01  0.000E+00
                                           1       2.565   3.604E-01  3.604E-01  0.000E+00
```

Complete J^{π}, γ-ray data for first 35 levels in ^{24}Na. Previously, 12 levels

Preliminary Z≤19 cross sections

Isotope or ratio	σ0 (This work)		σ0 Atlas (2006)		Isotope	σ0 (This work)		σ0 Atlas (2006)	
	mb except where noted					mb except where noted			
2H*	0.549	0.010	0.508	0.015	27Al	232.2	1.7	231	3
6Li	38.2	0.5	38.5	3.0	28Si	187	3	177	4
7Li	43.9	0.3	45.4	2.7	29Si	128	4	119	3
9Be	9.1	0.7	8.49	0.34	30Si	116.3	2.3	107	2
10B	384	8	305	16	31P	169	5	165	3
11B	9.1	0.3	5.5	3.3	32S	542	7	518	14
12C	3.84	0.06	3.50	0.07	33S	449	17	454	25
13C	1.50	0.02	1.37	0.04	34S	284	8	256	9
14N	80.3	0.4	80.1	0.6	35Cl	44.22	0.18 b	43.6	0.4 b
15N	0.0378	0.0011	0.024	0.008	37Cl	407	12	433	6
16O	0.163	0.003	0.190	0.019	36Ar/40Ar	9.6	1.3	9.5	1.2
19F	9.51	0.11	9.51	0.09	39K	2250	40	2100	200
20Ne/22Ne	1.04	0.04	1.12	0.21	40K	94	7 b	30	8 b
23Na	541	3	517	4	41K	1530	30	1460	30
24Mg	53.9	0.2	53.8	1.3					
25Mg	196	8	199	3					
26Mg	38.8	1.4	38.4	0.6					

Publication of the Z≤19 σ_0 data is planned for 2011.

* Expected value based on new ^{12}C standard cross section. A new measurement is planned at Munich Reactor.

Preliminary Z≥20 cross sections

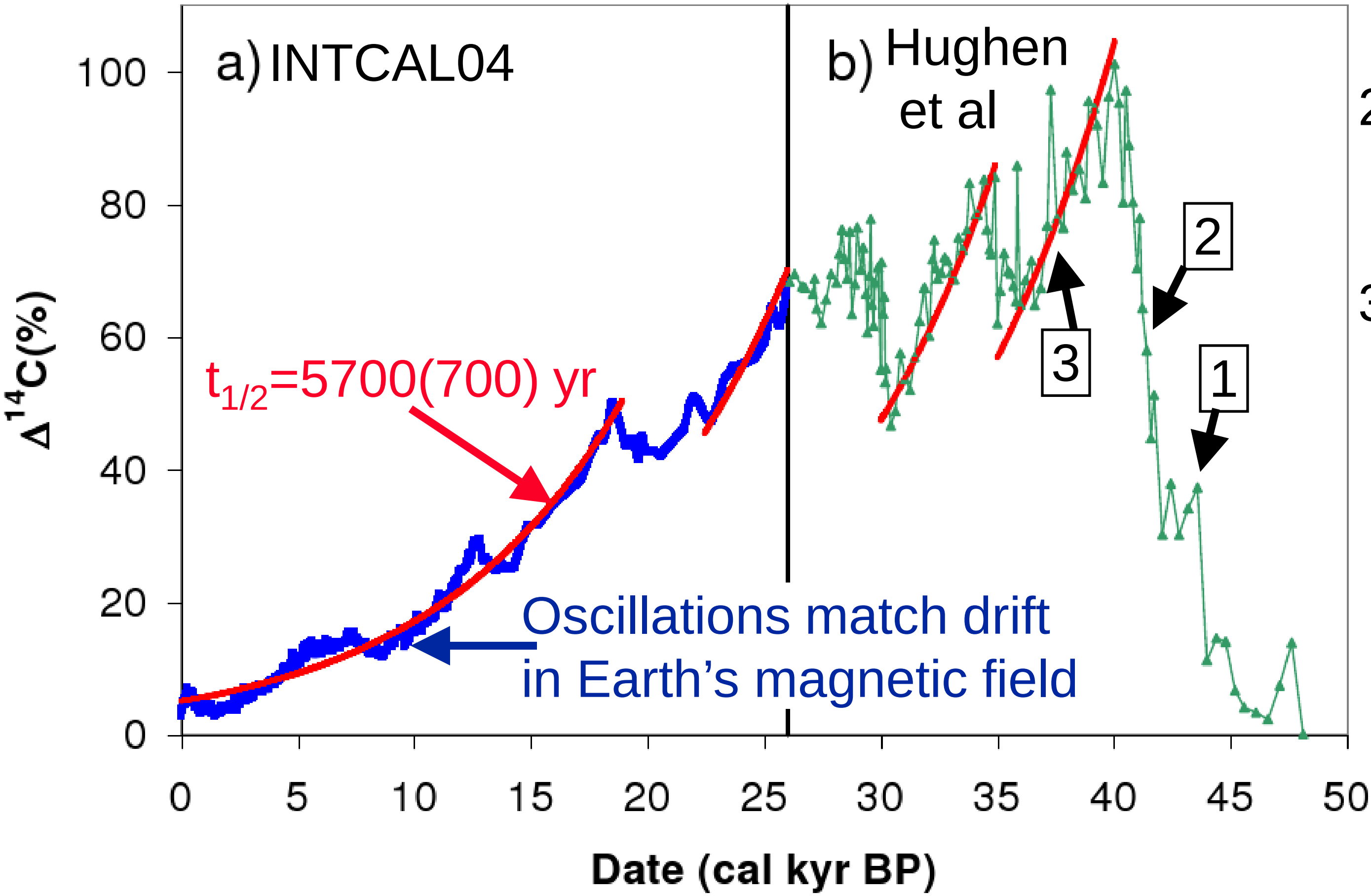
Isotope	σ0 (EGAF) b	σ0 (Atlas) b	Evaluator
^{54}Fe*	2.52±0.06	2.25±0.18	Firestone
^{56}Fe*	2.46±0.05	2.59±0.14	Firestone
^{57}Fe*	2.01±0.05	2.48±0.30	Firestone
^{58}Fe*	1.30±0.04	1.32±0.03	Firestone
^{151}Eu(0)	7,200±300	5,900±200	Basunia
^{151}Eu(46)	3,400±200	3,300±200	Basunia
^{153}Eu(0)	292±10	312±7	Basunia
^{155}Gd	66,000±4,000	60,900±500	Choi
^{157}Gd	216,000±5,000	254,000±815	Choi
^{182}W	18.4±0.8	19.9±0.3	Hurst
^{183}W	8.0±0.2	10.4±0.2	Hurst
^{184}W	1.4±0.2	1.7±0.1	Hurst
^{186}W	34.1±0.5	38.1±0.5	Hurst

Cross sections presented here are pending additional experiments.

* Comparable σγ data from Raman et al yet to be included in analysis

Analysis of the radiocarbon record

Radiocarbon calibration record from tree rings and ocean sediment cores



Supernova scenario

1. ^{14}C from γ-rays at time of SN
2. ^{14}C from cosmic rays produced in SNR for 2-3 kyr
3. Decay of excess ^{14}C with $t_{1/2}$=5730 yr

SN	Distance
44 kyr	110 pc
37 kyr	180 pc
32 kyr	160 pc
22 kyr	250 pc
(VELA SN)	

$E_{CR}=3\times10^{50}$ ergs

Future Directions

The LBNL Isotopes Project is shifting the majority of its effort towards neutron capture γ-ray evaluation (EGAF, RIPL)

- ARRA funding through FY2013 (Basunia)
- Office of Nuclear Physics funding through FY2012 (Hurst, Postdoc ???)
- New opportunities with NIF, NA22 are being investigated

Mass chain evaluation may continue at 2 FTE level

- Could be supplemented by EGAF publication in NDS

Measurement efforts are expected to increase through FY2013

- Budapest/Munich Reactors, STARS+LiBerACE

Retirements (RBF-2013), (CMB-???)

- Future continuation of the Isotopes Project is still in doubt

WWW Table of Radioactive Isotopes shutdown pending

- Many user complaints, no suitable alternative

18 Publications in FY2010

Publications

1. *Nuclear Data Sheets for* A=30, S. Basunia, NDS 111, 2331-2424 (2010)
2. *Nuclear Data Sheets for* A=65, E. Browne and J.K. Tuli, NDS 111, 2425-2553 (2010)
3. *Nuclear Data Sheets for* A=66, E. Browne and J.K. Tuli, NDS 111, 1093-1209 (2010)
4. *Nuclear Data Sheets for A=168*, C.M. Baglin, NDS 111, 1807 (2010).
5. *Nuclear Data Sheets for A=184*, C.M. Baglin, NDS 111, 275-523 (2010).
6. J. M. Allmond, C. W. Beausang, J. O. Rasmussen, T. J. Ross, M. S. Basunia, L. A. Bernstein, D. L. Bleuel, W. Brooks, N. Brown, J. T. Burke, B. K. Darakchieva, K. R. Dudziak, K. E. Evans, P. Fallon, H. B. Jeppesen, J. D. LeBlanc, S. R. Lesher, M. A. McMahan, D. A. Meyer, L. Phair, N. D. Scielzo, S. R. Stroberg, and M. Wiedeking*; Particle-γ spectroscopy of the (p, d-γ)155Gd reaction: Neutron single-quasiparticle states at N* = *91*; Physical Review C, 81, 064316, 2010.
7. D. Scielzo, J. E. Escher, J. M. Allmond, M. S. Basunia, C. W. Beausang, L. A. Bernstein, D. L. Bleuel, J. T. Burke, R. M. Clark, F. S. Dietrich, P. Fallon, J. Gibelin, B. L. Goldblum, S. R. Lesher, M. A. McMahan, E. B. Norman, L. Phair, E. Rodriquez-Vieitez, S. A. Sheets, I. J. Thompson, and M. Wiedeking; *Measurement of γ -emission branching ratios for 154,156,158Gd compound nuclei: Tests of surrogate nuclear reaction approximations for (n,γ) cross sections*; Physical Review C 81, 034608, 2010.
8. A.M. Hurst, N.C. Summers, B.W. Sleaford, R.B. Firestone, *Gamma spectrum from neutron capture on tungsten isotopes,* Proceedings of the International Conference on Nuclear Data and Technology 2010, Jeju Island, Korea.

Publications

9. A.M. Hurst, R.B. Firestone, B.W. Sleaford, Zs. Revay, M. Krticka, T. Belgya, M.S. Basunia, R. Capote, H. Choi, D. Dashdorj, J. Escher, A. Nichols, L. Zsentmiklosi, *Data evaluation methods and improvements to the neutron-capture g-ray spectrum,* Proceedings of the Second International Ulaanbaatar Conference on Nuclear Physics and Applications, July 26-30 2010, Ulaanbaatar Mongolia.
10. *The Case for the Younger Dryas Extraterrestrial Impact Event: Mammoth, Megafauna and Clovis Extinction*, R.B. Firestone, Journal of Cosmology 2, 286-288 (2009).- LBNL-79191
11. *Comparison of IUPAC k0 Values and Neutron Cross Sections to Determine a Self-consistent Set of Data for Neutron Activation Analysis*, R.B. Firestone and Zs. Revay, Radiochimica Acta (in press) - LBNL-79192
12. *Micrometeorite Impacts in Beringian Mammoth Tusks and a Bison Skull,* J.T. Hagstrum, R.B. Firestone, A. West, Z. Stefanka, and Z. Revay in the Proceeding of the International Conference "100 years since Tunguska phenomenon: Past, present and future", Moscow, Journal of Siberian Federal University, Engineering & Technologies 3, 123-132 (2010). - LBNL-79193
13. *Analysis of the Younger Dryas Impact Layer*, R.B. Firestone, A. West, Zs. Revay, J.T. Hagstrum, T. Belgya, S.S. Que Hee, and A.R. Smith, in the Proceeding of the International Conference "100 years since Tunguska phenomenon: Past, present and future", Moscow, Journal of Siberian Federal University, Engineering and Technologies 3, 30-62 (2010). - LBNL-79194

Publications

14. *Capture Gamma-Ray Libraries for Nuclear Applications,* B.W. Sleaford, R.B. Firestone, N. Summers, J. Escher, A. Hurst, M. Krticka, S. Basunia, G. Molnar, T. Belgya, Z. Revay, and H.D. Choi, Proceedings of the International Conference on Nuclear Data for Science and Technology, April 26-30, 2010, Jeju Island, Korea (in press). - LBNL-79195
15. *Gamma Spectrum from Neutron Capture on Tungsten Isotopes*, A.M. Hurst, N.C. Summers, B.W. Sleaford, and R.B. Firestone, Proceedings of the International Conference on Nuclear Data for Science and Technology, April 26-30, 2010, Jeju Island, Korea (in press). - LBNL-79198
16. *Evidence of Four Prehistoric Supernovae ≤250 pc from Earth during the Past 50,000 Years,* R.B. Firestone, American Geophysical Union Fall Meeting, 14-18 December 2009, San Francisco, CA, paper PP31D-1386. - LBNL-79199
17. *Geochemical data reported by Paquay et al. do not refute Younger Dryas impact event*, T.E. Bunch, A. West, R.B. Firestone, J.P. Kennett, J.H. Wittke, C.R. Kinzie, and W.S. Wolbach, PNAS 107, E58 (2010). - LBNL-79201
18. *Confirmation of the Younger Dryas boundary (YDB) data at Murray Springs*, AZ, R.B. Firestone, A. West, and T.E. Bunch, PNAS 107, E105 (2010). - LBNL-79203