The Abdus Salam
International Centre for Theoretical Physics

United Nations
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IAEA
International Atomic Energy Agency

1939-29

Joint ICTP-IAEA Workshop on Nuclear Structure and Decay Data: Theory and Evaluation

28 April - 9 May, 2008

NuDat

Alejandro SONZOGNI

National Nuclear Data Center
Brookhaven National Laboratoy
Upton, NY 11973
USA

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Alejandro Sonzogni
National Nuclear Data Center

BROOKHAVEN NATIONAL LABORATORY
a passion for discovery

Office of Science
U.S. DEPARTMENT OF ENERGY

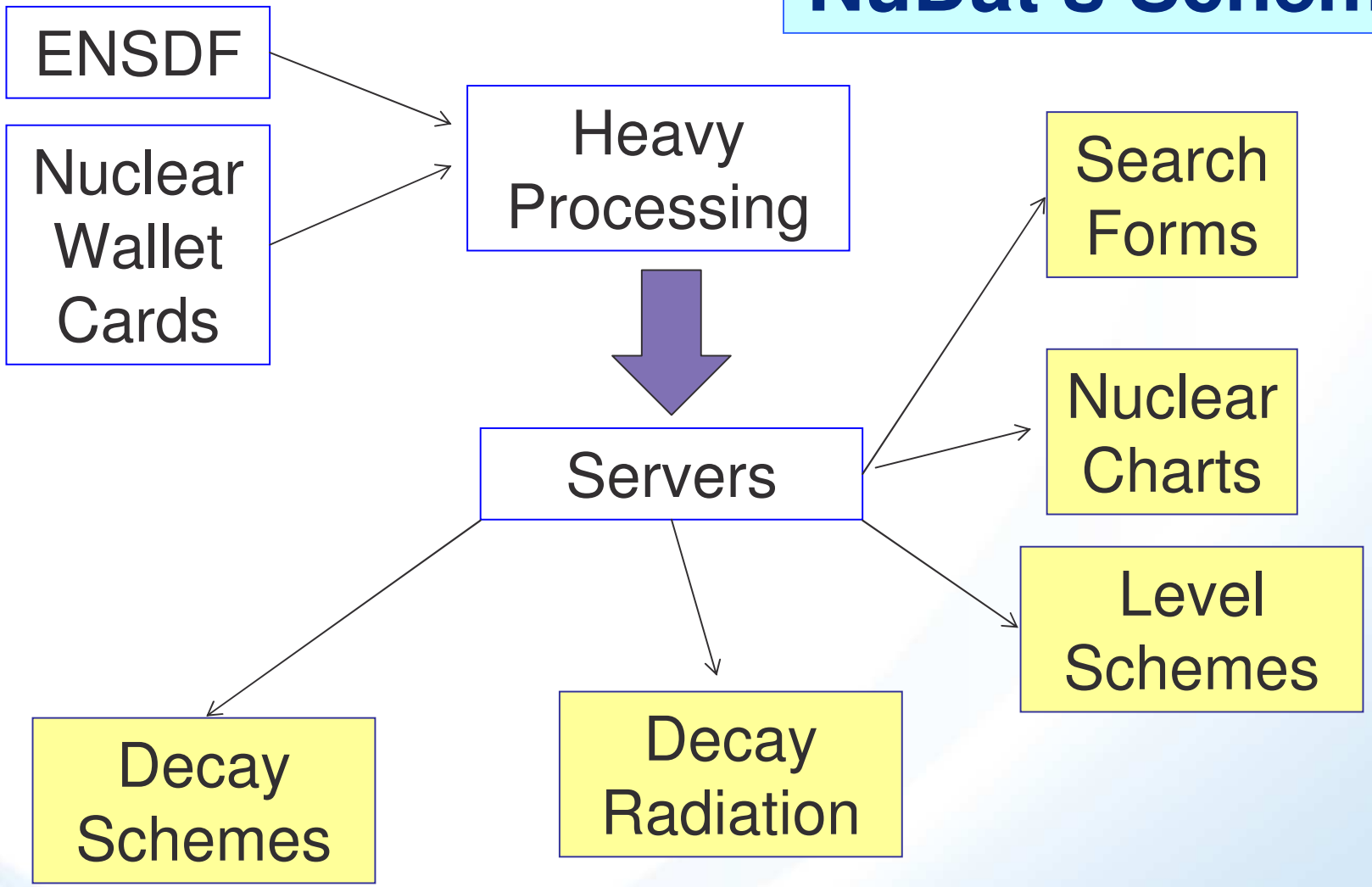
NuDat
www.nndc.bnl.gov/nudat2

NuDat is a web application with two main goals, a) to present nuclear structure and decay information from ENSDF in a user-friendly way, and b) to allow users to execute complex search operations in the wealth of data contained in ENSDF. NuDat provides an interactive chart of nuclides for navigation and an output in the Table of Isotopes style. NuDat contents are updated regularly as new evaluations are entered into ENSDF.

NuDat 2 was developed by the National Nuclear Data Center (NNDC) in Brookhaven National Laboratory Using NuDat 2, it is possible to search for nuclear level properties (energy, half-life, spin-parity), gamma-ray information (energy, intensity, multipolarity, coincidences), radiation information following nuclear decay (energy, intensity, dose).

More on www.nndc.bnl.gov/nudat2/help

NuDat's Scheme

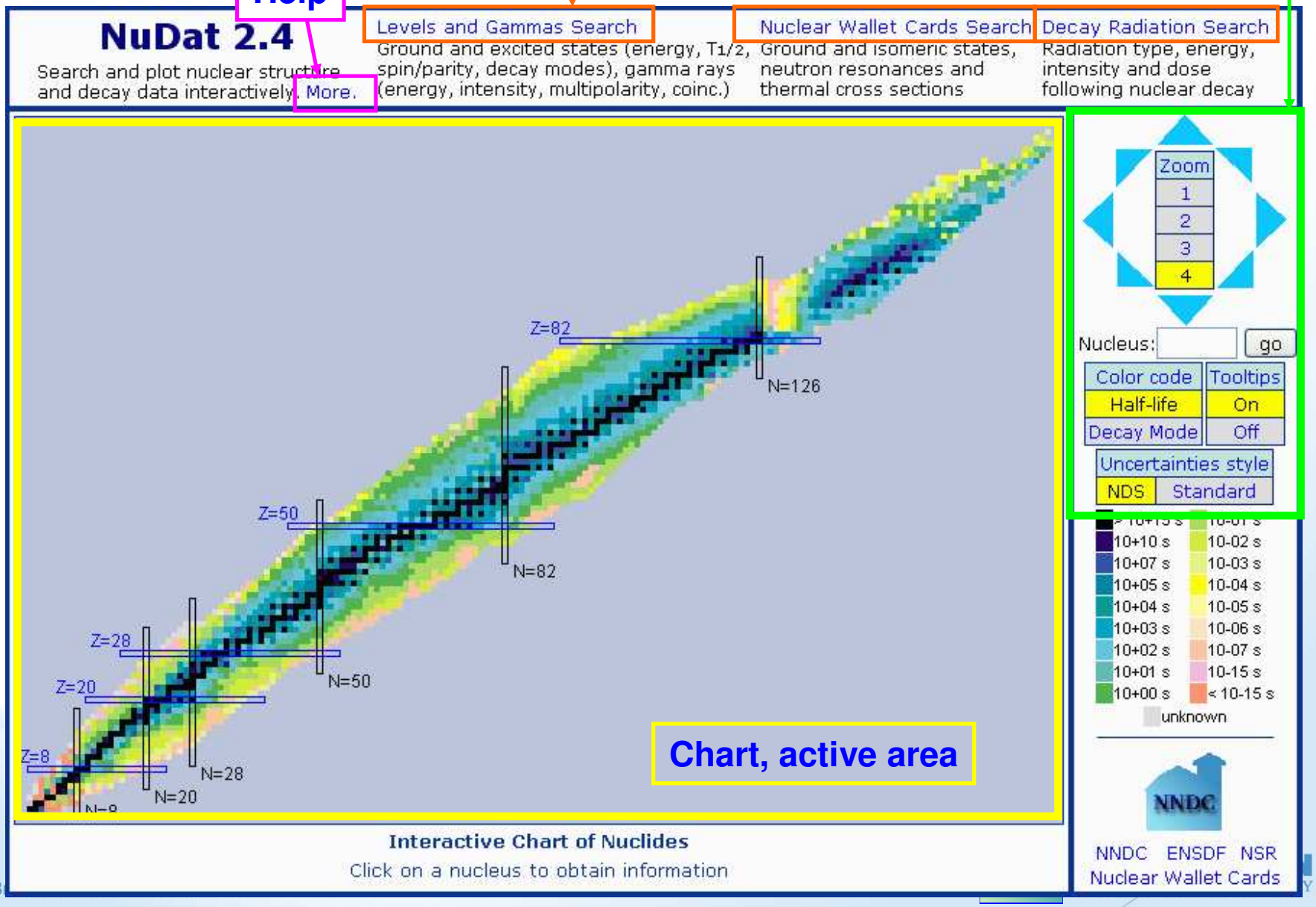


NuDat front pa

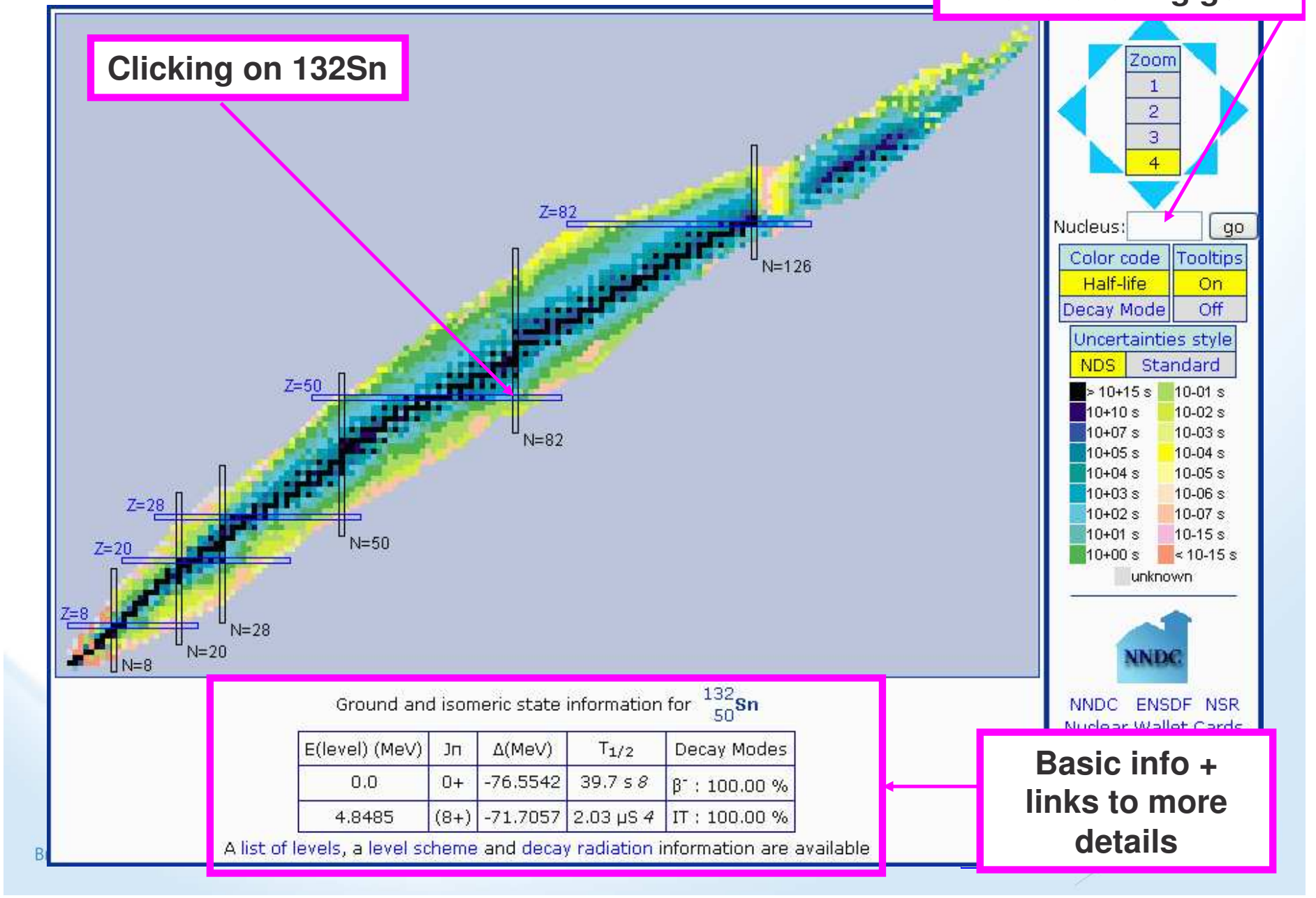
Search forms

Navigation Controls

Help

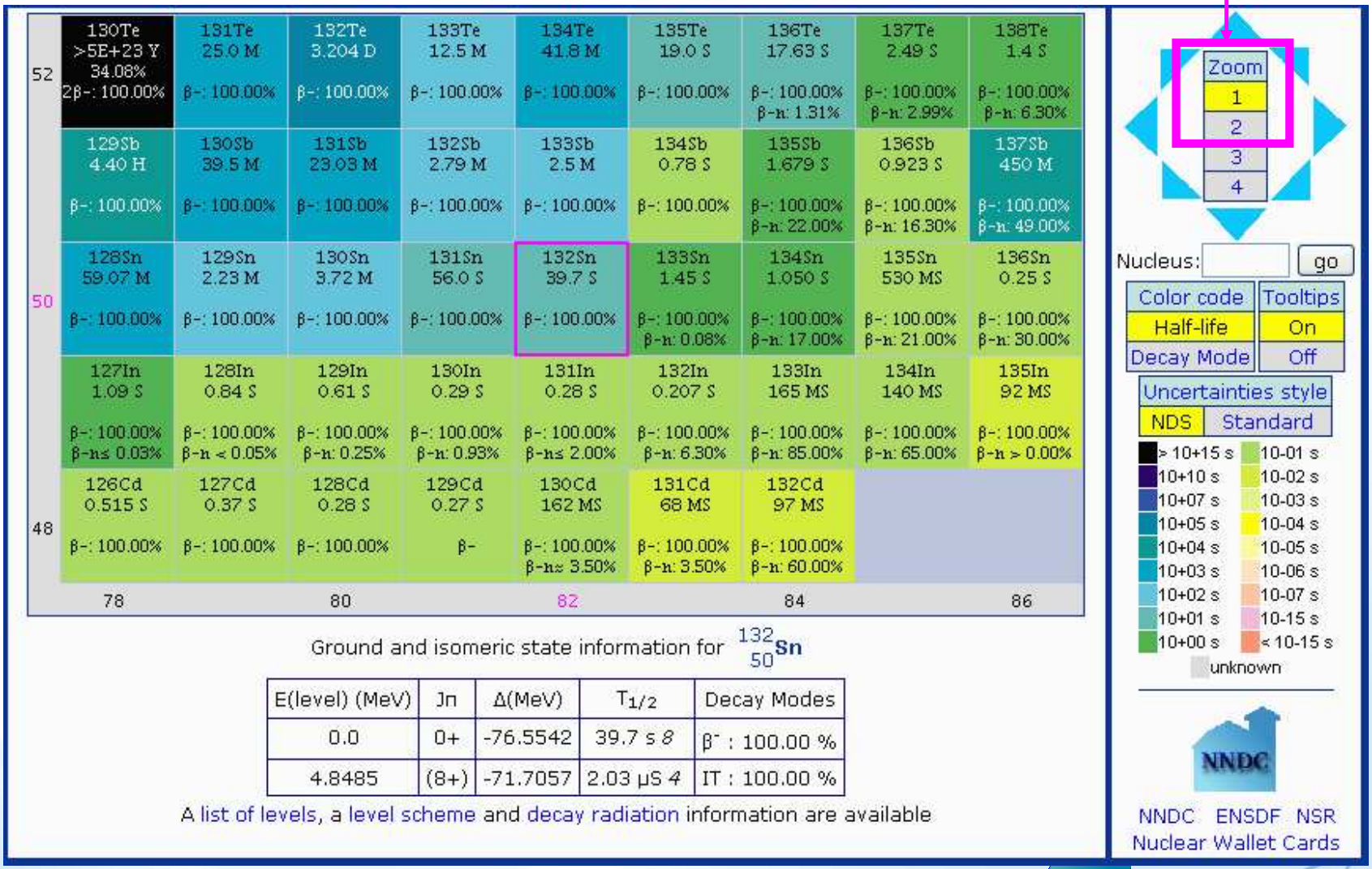


NuDat's chart



NuDat's chart

Changing the zoom value



Ground and isomeric state information for $^{132}_{50}Sn$

E(level) (MeV)	Jπ	Δ(MeV)	$T_{1/2}$	Decay Modes
0.0	0+	-76.5542	39.7 s *8*	β^- : 100.00 %
4.8485	(8+)	-71.7057	2.03 μs *4*	IT : 100.00 %

A list of levels, a level scheme and decay radiation information are available

NuDat's chart

Decay Mode colors

Standard uncertainties style

Nuclear Decay

A process where the protons and neutrons in a given nucleus are rearranged into a lower energy state. The transition may involve states of the same nucleus (gamma emission, electron conversion) or levels of different nucleus. Each different process is known as a 'decay mode':

* Gamma emission, electron conversion
* β- decay
* β+ decay
* Electron Capture (EC)
* β-delayed particle emission
* Double β decay
* Proton decay
* Alpha decay
* Cluster decay
* Spontaneous Fission (SF)

The probability of undergoing a given nuclear decay is often indicated using the percent sign followed by the decay mode name and the probability per 100 decays.

For instance, %β-=100 means 100% probability of β- decay.

The energy released during the decay is called 'Q-value'. For a given decay mode to have a probability larger than 0, the Q-value has to be positive.

Uncertainties

The uncertainty associated with a given quantity can be expressed in the so-called Nuclear Data Sheets style, or in a standard style. The Nuclear Data Sheets style has been used for a long time since it facilitates data storage, which was crucial in the early days. A table with a brief explanation of the Nuclear Data Sheet style is given below:

NDS Style	Standard style and meaning
4.623 3	4.623 +- 0.003
4.6 h 12	4.6 +- 1.2 hours
5.4×10^{3} *2*	5400 + - 200
4.2 *+8-10*	4.2 + 0.8 - 1.0
9.22 *SY*	9.22 is a result of a systematic study
9.22 CA	9.22 value is not an experimental one, but the result of a theoretical calculation

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ADOPTED LEVELS, GAMMAS for ^{132}Sn

Author: YU. KHAZOV, A.A. RODIONOV AND S. SAKHAROV, BALRAJ SINGH

Full ENSDF file

Q(β-)=3119 keV *9* S_n= 7311 keV 25 S_p= 15710 keV *30* Q_α= 11.69E3 keV *29*

References:
A: 132IN β- DECAY (0.207 S)
B: 132SN IT DECAY (2.03 μS)
C: 133IN β-N DECAY (165 MS)
D: 248CM SF DECAY
E: COULOMB EXCITATION

ENSDF file for 132SN

- ☐ ADOPTED LEVELS, GAMMAS
- ☐ 132IN B- DECAY (0.207 S)
- ☐ 132SN IT DECAY (2.03 US)
- ☐ 133IN B-N DECAY (165 MS)
- ☐ 248CM SF DECAY
- ☐ COULOMB EXCITATION

Retrieve selected datasets | Retrieve all datasets

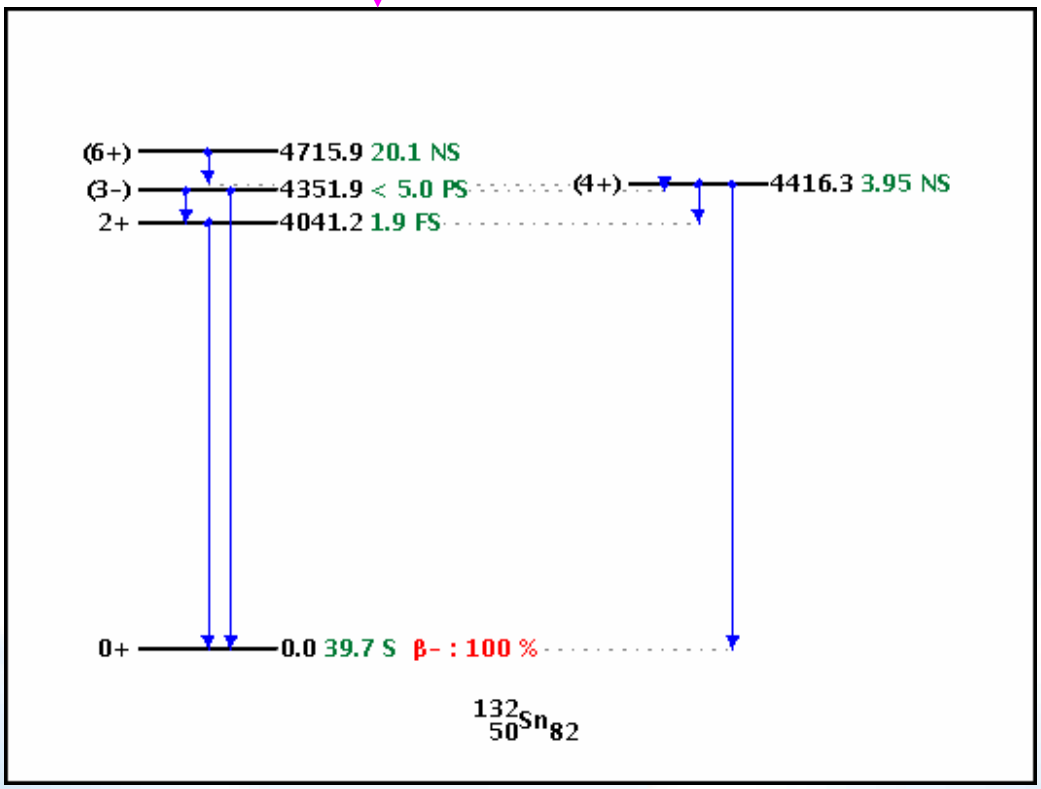
E_{level} (keV)	XREF	Jπ	$T_{1/2}$	E_γ (keV)	I_γ	γ mult.	Final level	
0.0	ABCDE	0+	39.7 s *8* % β^- = 100					
4041.20 *15*	AB DE	2+	1.9 fs *+14-6*	4041.1	100		0.0	0+
4351.94 *14*	A D	(3−)	< 5.0 ps	310.7 4351.9	11.0 100	(E1) [E3]	4041.20 0.0	2+ 0+
4416.29 *14*	AB D	(4+)	3.95 ns *13*	64.4 375.1 4416.2	1.3 100 *3* 17 *3*	[E1] (E2) [E4]	4351.94 4041.20 0.0	(3−) 2+ 0+

Ground and isomeric state information for $^{132}_{50}Sn$

E(level) (MeV)	Jπ	Δ(MeV)	$T_{1/2}$	Decay Modes
0.0	0+	-76.5542	39.7 *s 8*	β^- : 100.00 %
4.8485	(8+)	-71.7057	2.03 μS *4*	IT : 100.00 %

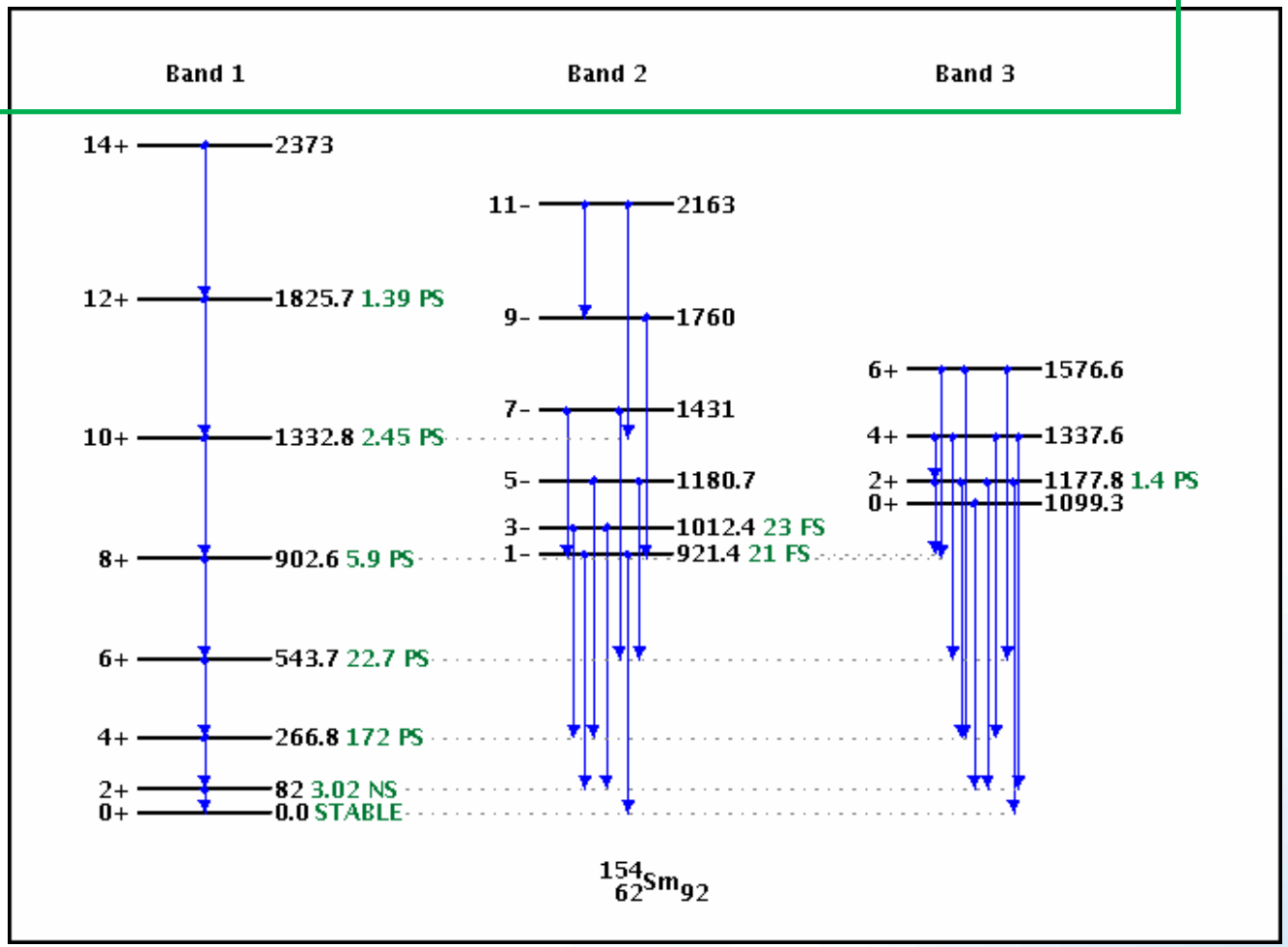
A list of levels, a level scheme and decay radiation information are available

Interactive Level Scheme



132Sn is doubly magic, how does a level scheme of a nucleus at mid-shell?

Rotational bands

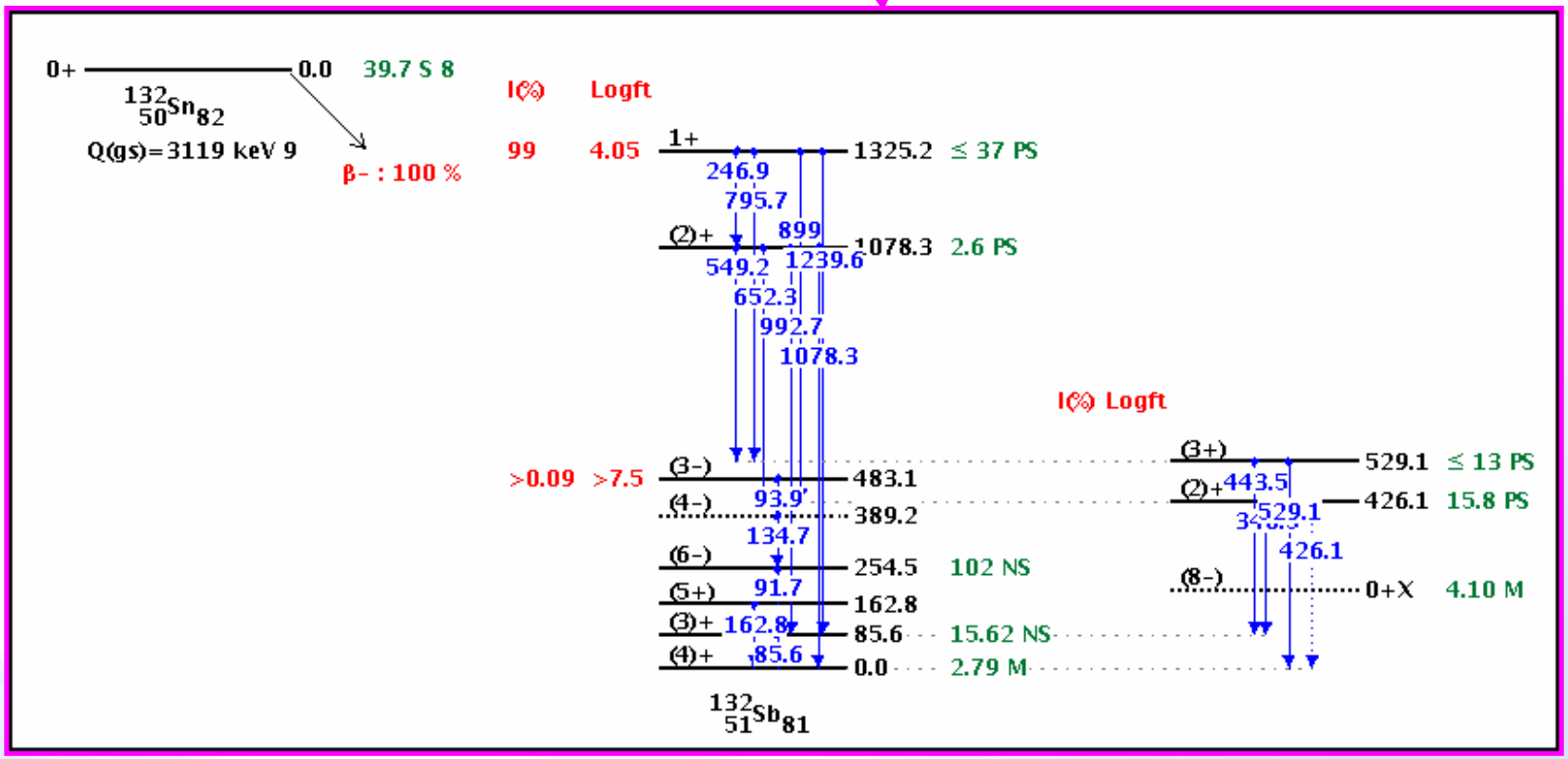


Partial view of 154Sm level scheme

Ground and isomeric state information for $^{132}_{50}Sn$

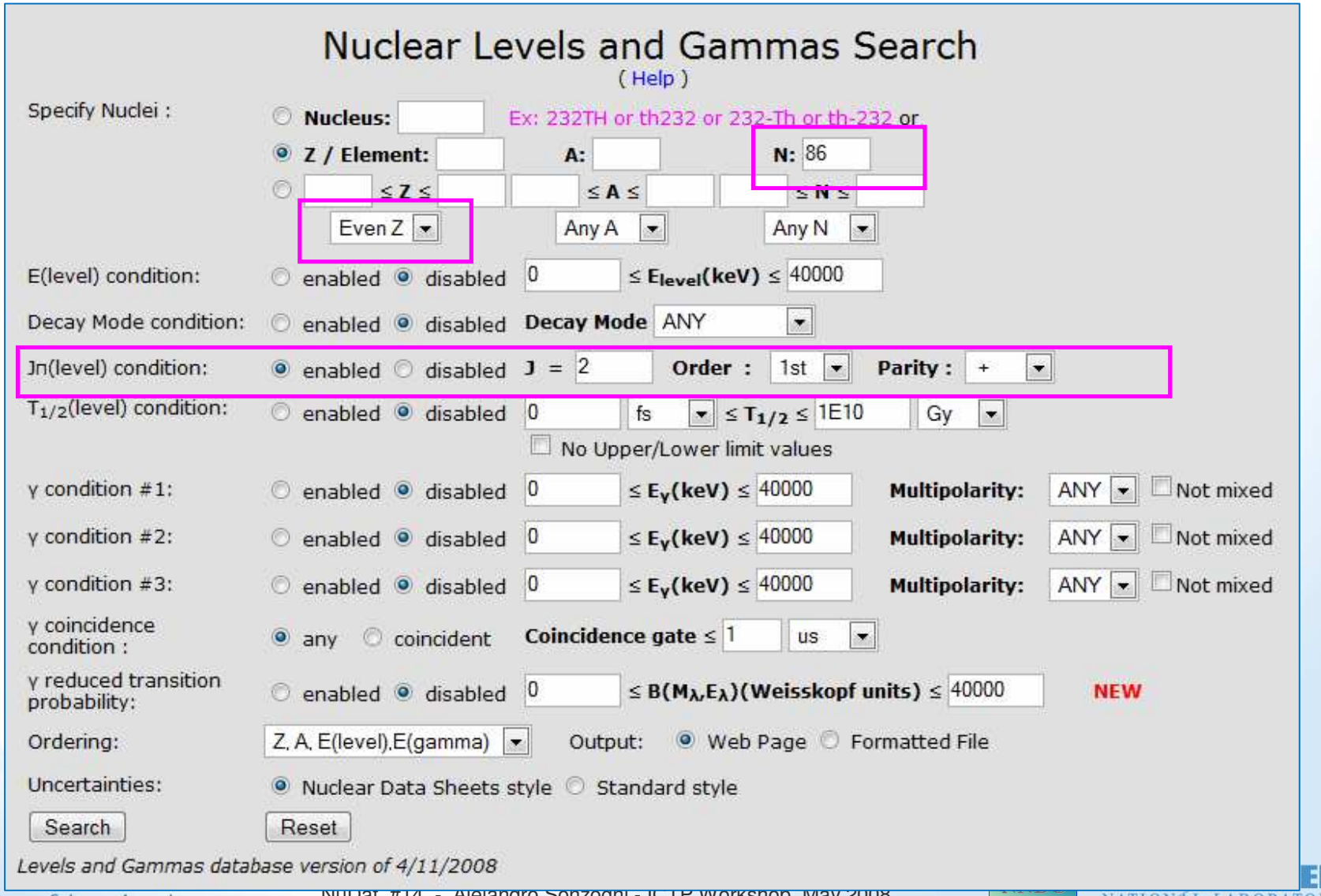
E(level) (MeV)	Jπ	Δ(MeV)	$T_{1/2}$	Decay Modes
0.0	0+	-76.5542	39.7 s *8*	β⁻ : 100.00 %
4.8485	(8+)	-71.7057	2.03 μs *4*	IT : 100.00 %

A list of levels, a level scheme and decay radiation information are available



Levels Search

Search for first 2+ states in N=86 Nuclides



Nuclear Levels and Gammas Search

(Help)

Specify Nuclei : Nucleus: Ex: 232TH or th232 or 232-Th or th-232 or

Z / Element: A: N: 86

≤ Z ≤ ≤ A ≤ ≤ N ≤

Even Z | Any A | Any N

E(level) condition: enabled disabled 0 ≤ E_{level}(keV) ≤ 40000

Decay Mode condition: enabled disabled Decay Mode ANY

Jn(level) condition: enabled disabled J = 2 Order : 1st Parity : +

$T_{1/2}$(level) condition: enabled disabled 0 fs ≤ $T_{1/2}$ ≤ 1E10 Gy

No Upper/Lower limit values

γ condition #1: enabled disabled 0 ≤ E_γ(keV) ≤ 40000 Multipolarity: ANY Not mixed

γ condition #2: enabled disabled 0 ≤ E_γ(keV) ≤ 40000 Multipolarity: ANY Not mixed

γ condition #3: enabled disabled 0 ≤ E_γ(keV) ≤ 40000 Multipolarity: ANY Not mixed

γ coincidence condition : any coincident Coincidence gate ≤ 1 us

γ reduced transition probability: enabled disabled 0 ≤ B(M_λ,E_λ)(Weisskopf units) ≤ 40000 NEW

Ordering: Z, A, E(level),E(gamma) Output: Web Page Formatted File

Uncertainties: Nuclear Data Sheets style Standard style

Search Reset

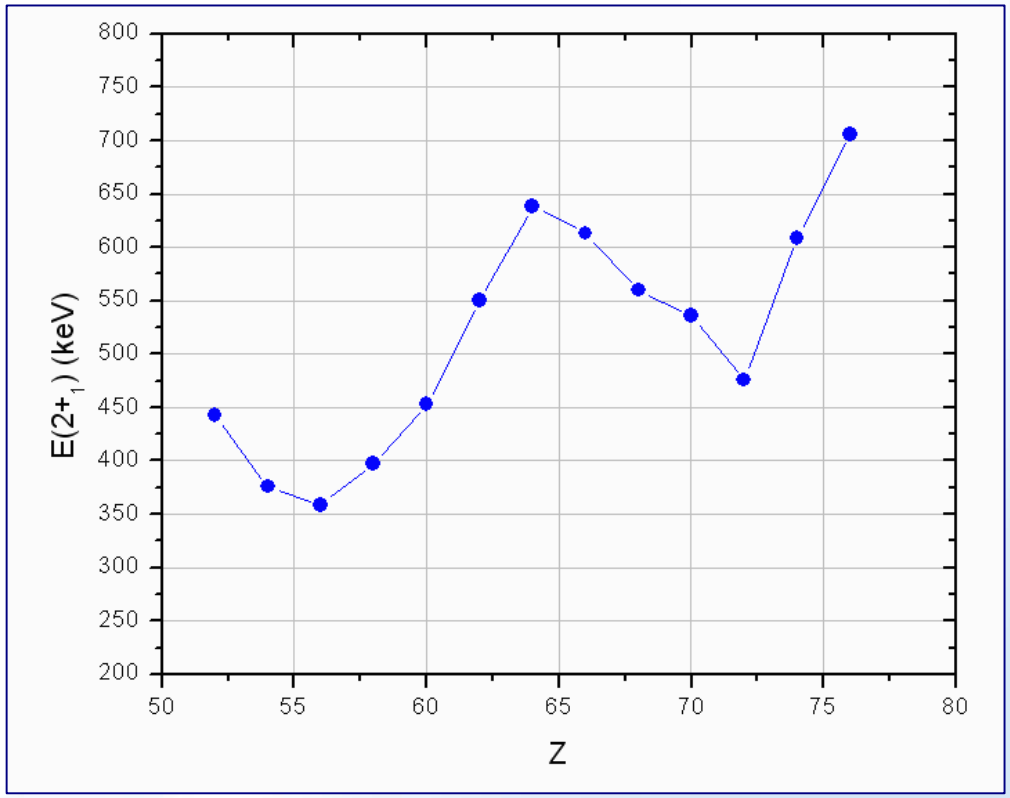
Levels and Gammas database version of 4/11/2008

Results

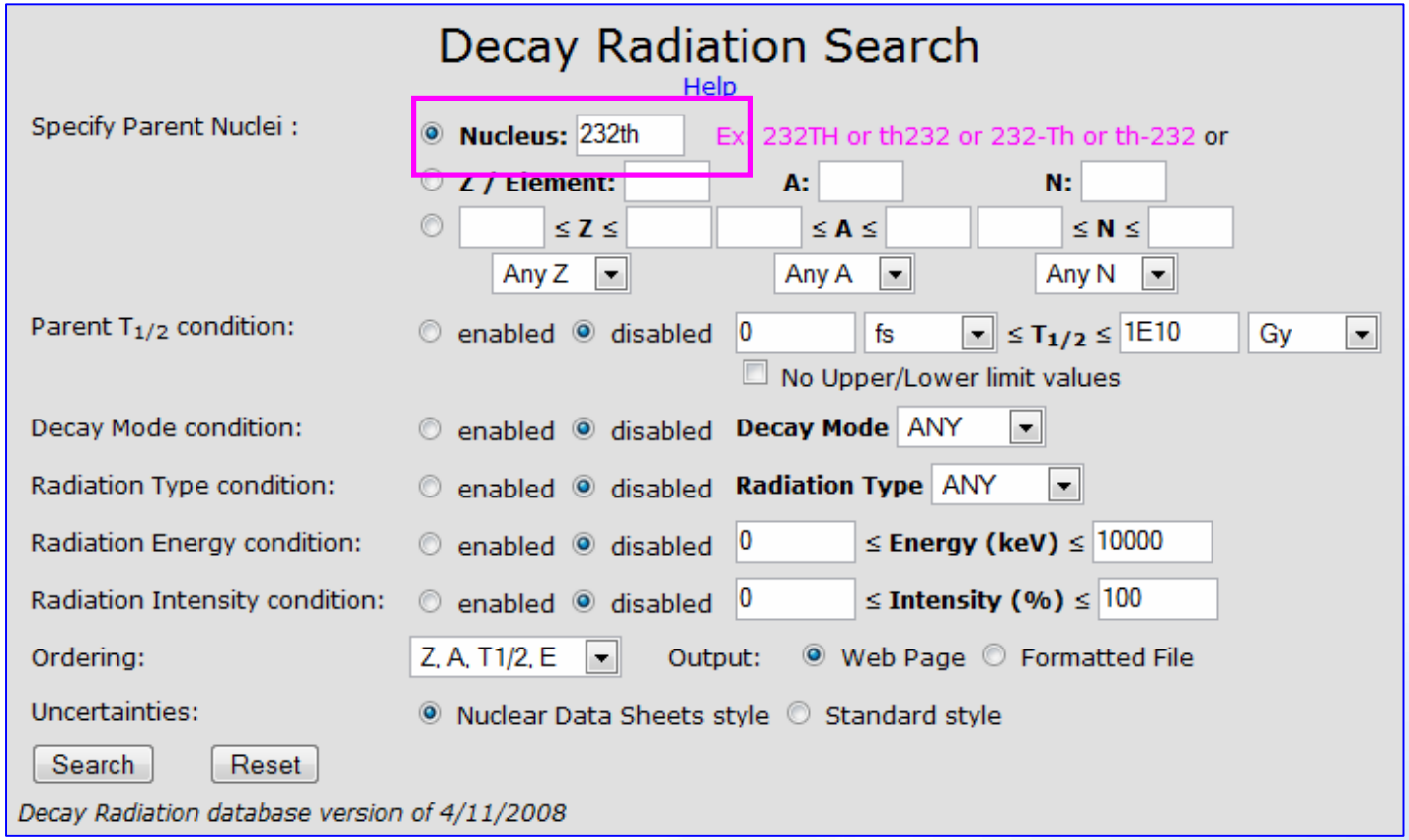
Nucleus	E_{level}(keV)	Jπ	$T_{1/2}$
138TE	443.1 *10*	(2+)	
140XE	376.658 *15*	2+	70.5 ps *22*
142BA	359.597 *14*	2+	65 ps *2*
144CE	397.441 *9*	2+	35.4 ps *20*
146ND	453.77 *5*	2+	21.6 ps *13*
148SM	550.255 *8*	2+	7.72 ps *32*
150GD	638.045 *14*	2+	
152DY	613.82 *7*	2+	10 ps *5*
154ER	560.8 *1*	2+	
156YB	536.4 *1*	2+	
158HF	476.36 *11*	2+	
160W	609.9 *2*	2+	
162OS	706.7 *3*	(2+)	

For more search examples, see Help file

Tool for systematic studies



Decay Search



Author: AGDA ARTNA-COHEN Citation: Nuclear Data Sheets 80, 723 (1997)

Parent Nucleus	Parent E(level)	Parent Jπ	Parent $T_{1/2}$	Decay Mode	GS-GS Q-value (keV)	Daughter Nucleus	Decay Scheme
$^{232}_{90}$Th	0	0+	14.05E+9 y *6*	α: 100 %	4082.8 *14*	$^{228}_{88}$Ra	

Results

Alphas:

Energy (keV)	Intensity (%)	Dose (MeV/Bq-s)
3811.1 *14*	0.069 % *13*	0.0026 *5*
3947.2 *20*	21.7 % *13*	0.86 *5*
4012.3 *14*	78.2 % *13*	3.14 *5*

Electrons:

	Energy (keV)	Intensity (%)	Dose (MeV/Bq-s)
Auger L	9.09	8.7 % *5*	7.9E-4 *4*
CE K	36.958 *13*	0.0060 % *11*	2.2E-6 *4*
CE L	44.573 *10*	15.8 % *8*	0.0070 *3*
CE M	58.988 *10*	4.27 % *21*	0.00252 *12*
CE NP	62.602 *10*	1.53 % *8*	9.6E-4 *5*
Auger K	65.9	1.9E-4 % *4*	1.3E-7 *3*
CE L	121.643 *10*	0.031 % *6*	3.8E-5 *7*
CE M	136.058 *10*	0.0084 % *16*	1.14E-5 *22*
CE NP	139.672 *10*	0.0030 % *6*	4.3E-6 *8*

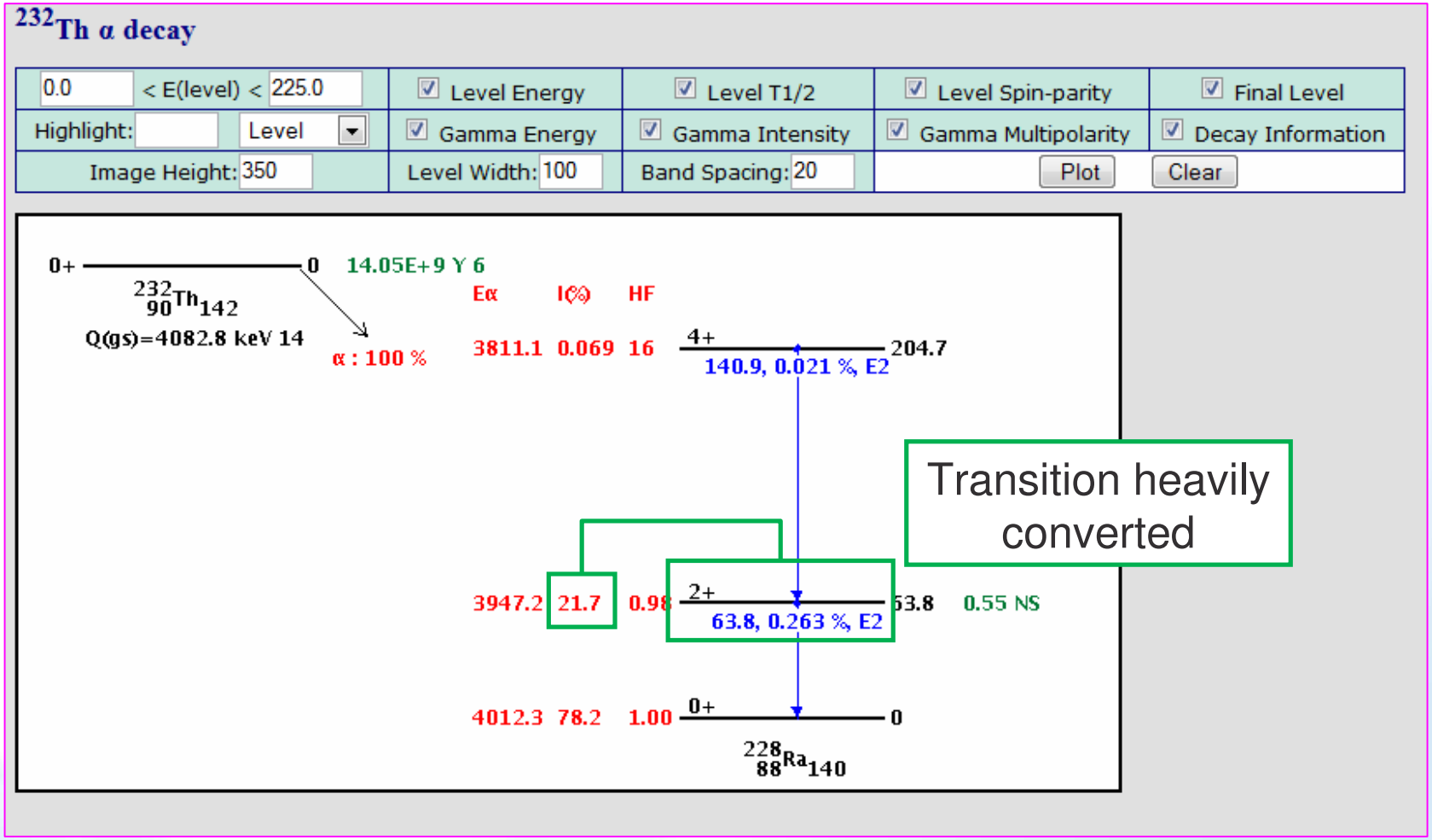
Gamma and X-ray radiation:

	Energy (keV)	Intensity (%)	Dose (MeV/Bq-s)
XR l	12.3	7.1 % *5*	8.8E-4 *6*
	63.81 *1*	0.263 % *13*	1.68E-4 *8*
XR kα2	85.431	0.0017 % *3*	1.4E-6 *3*
XR kα1	88.471	0.0028 % *5*	2.4E-6 *5*
XR kβ3	99.432	3.4E-4 % *6*	3.3E-7 *6*
XR kβ1	100.13	6.4E-4 % *12*	6.5E-7 *12*
XR kβ2	102.498	2.4E-4 % *5*	2.5E-7 *5*
	140.88 *1*	0.021 % *4*	3.0E-5 *6*

Where are the electrons coming from?

NNDC BROOKHAVEN NATIONAL LABORATORY

Interactive Decay Scheme



Q-calc
www.nndc.bnl.gov/qcalc

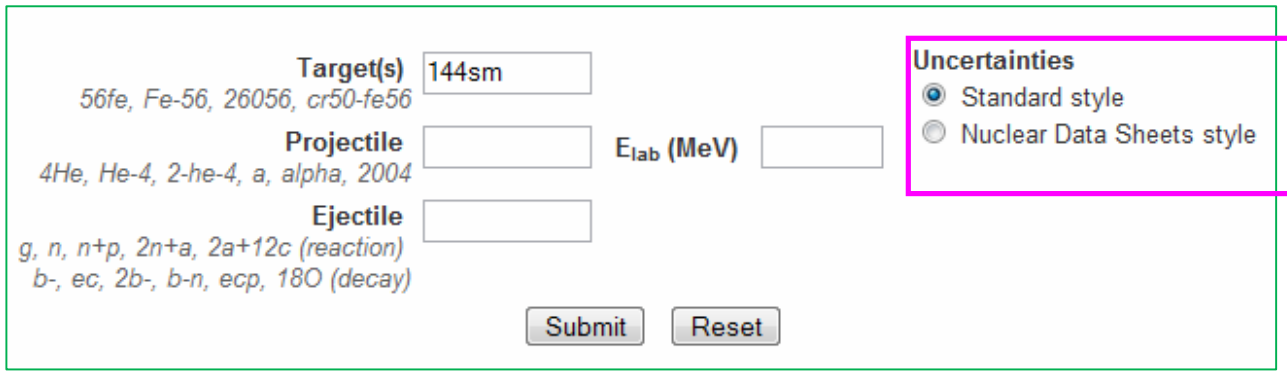
Nuclear reaction and decay Q-values can be calculated using the Q-Calc tool, which uses the 2003 atomic mass evaluation of Audi et al., G.Audi, A.H. Wapstra, C. Thibault, Nucl. Phys. A729, 337 (2003).

For a nucleus with Z protons, N neutrons and mass M(Z,N), the most common decay Q-values are:

β-	Q(β-)=M(Z,N)-M(Z+1,N-1)
Electron capture	Q(EC)=M(Z,N)-M(Z-1,N+1)
β+	Q(β+)=M(Z,N)-M(Z-1,N+1)– 2Me
Alpha emission	Q(α)=M(Z,N)-M(Z-2,N-2)-M(2,2)
Proton emission	Q(p)=M(Z,N)-M(Z-1,N-1)-M(1,1)
Double β-	Q(2β-)=M(Z,N)-M(Z+2,N-2)
Double EC	Q(2EC)=M(Z,N)-M(Z-2,N+2)

The neutron and proton separation energies are defined as:

S(p)=-Q(p)
S(n)=-Q(n)



In ENSDF evaluation, most of the time we are interested in decay Q-values, which can be obtained by simply giving the nucleus of interest

Mass and decay Q-values for ^{144}Sm

Quantity	(keV)
Mass Excess	−81971.96 *2.81*
Binding Energy/A	8303.723 *0.019*
Atomic Mass (AMU)	143.912 *0.00301* *
Atomic Mass/neutron Atomic Mass	142.67574 *0.00299* **
$Q_{\beta-}$	−6350.3 *10.9*
Q_{EC}	−550.85 *2.55*
$Q_{\beta+}$	−1573.05 *2.55*
Q_{n}	−10520.08 *2.36*
Q_{p}	−6295.19 *2.73*
Q_{2n}	−19121.7 *5.63*
Q_{2p}	−10594.7 *1.79*
Q_{α}	−145.1 *28.1*
$Q_{2\beta-}$	−10212.5 *28.1*