Nuclear Data Project: Why, What and Where

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Outline

- Introduction:
  - ✓ what is Nuclear Data
  - ✓ historical perspective
- Major Nuclear Physics Databases:
  - ✓ NSR, ENSDF, XUNDL, AME
- Other useful resources:
  - ✓ Nuclear Structure and Nuclear Astrophysics

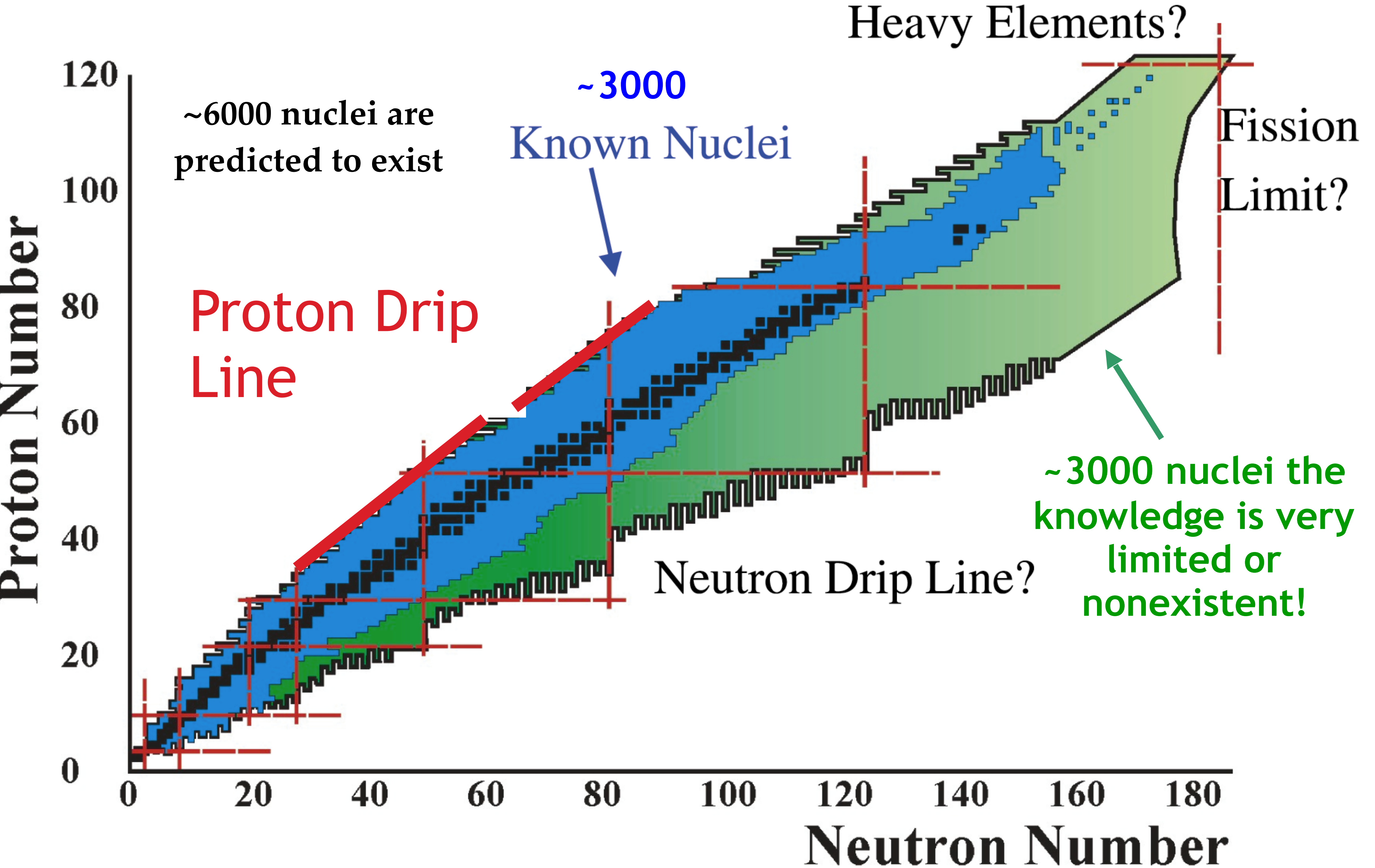
Some Historical Remarks …

The first American Nobel Laureate, Albert A. Michelson, in an 1894 speech at University of Chicago stated:

*"The most important fundamental laws and facts of physical science **have all been discovered**. These are now so firmly established that the possibility of their ever being supplanted in consequence of new discoveries **is exceedingly remote**. Our future discoveries must be looked for **in the sixth place of decimals**."*

Within a few years of this speech x rays (Roentgen 1895), electron (J.J. Thomson 1897) and radioactivity (H. Becquerel 1896) were discovered!!!

The Chart of the Nuclides

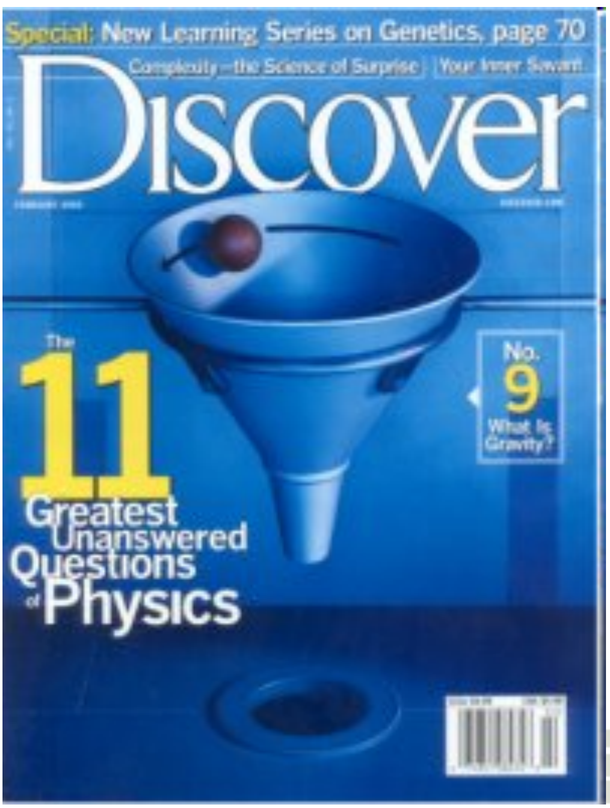


Nuclear Physics is (still) a Big Challenge

because of complicated forces, energy scale and sizes involved

The challenge is to understand properties of nuclei far from the line of stability; location and formation of new shell structures; how single-particle motions build collective effects like pairing, vibrations and shapes at the extremes of N/Z, angular momentum and excitation energy; how the heavy elements were made in nature

February 2002

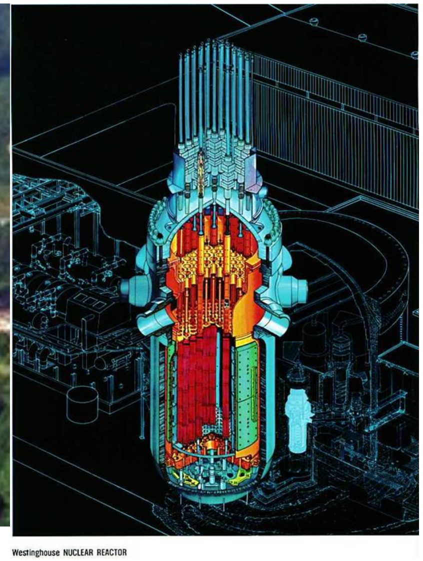


11 physics questions
for the new century

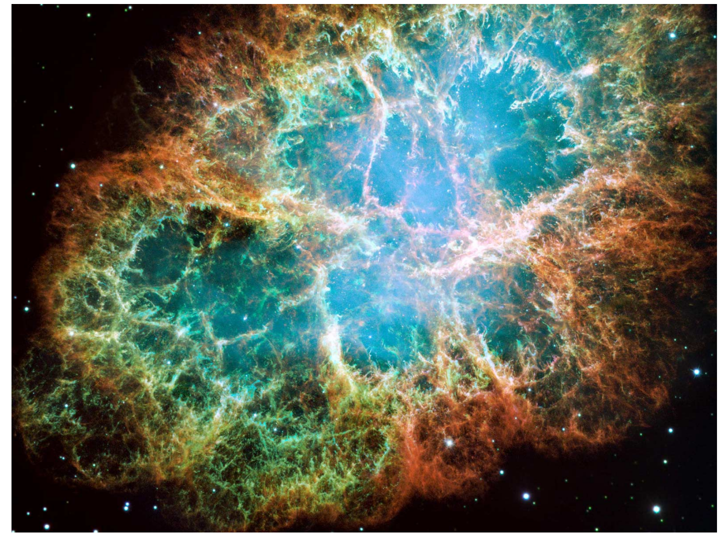
Question 3
How were the heavy elements from iron to uranium made?

Nuclear Physics in Important
astrophysics, medicine, energy production, security

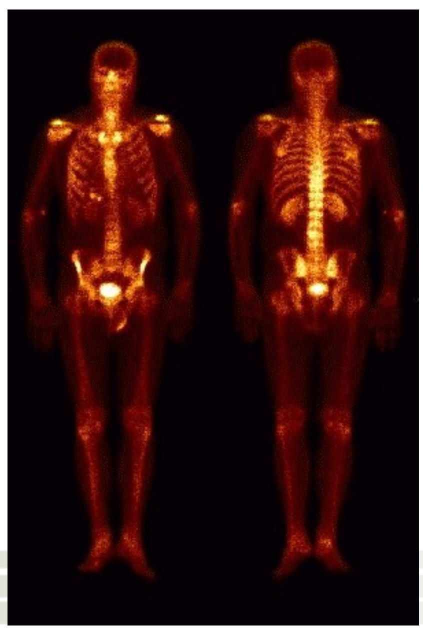
nuclear power plant



supernova explosion



^{99m}Tc bone scan



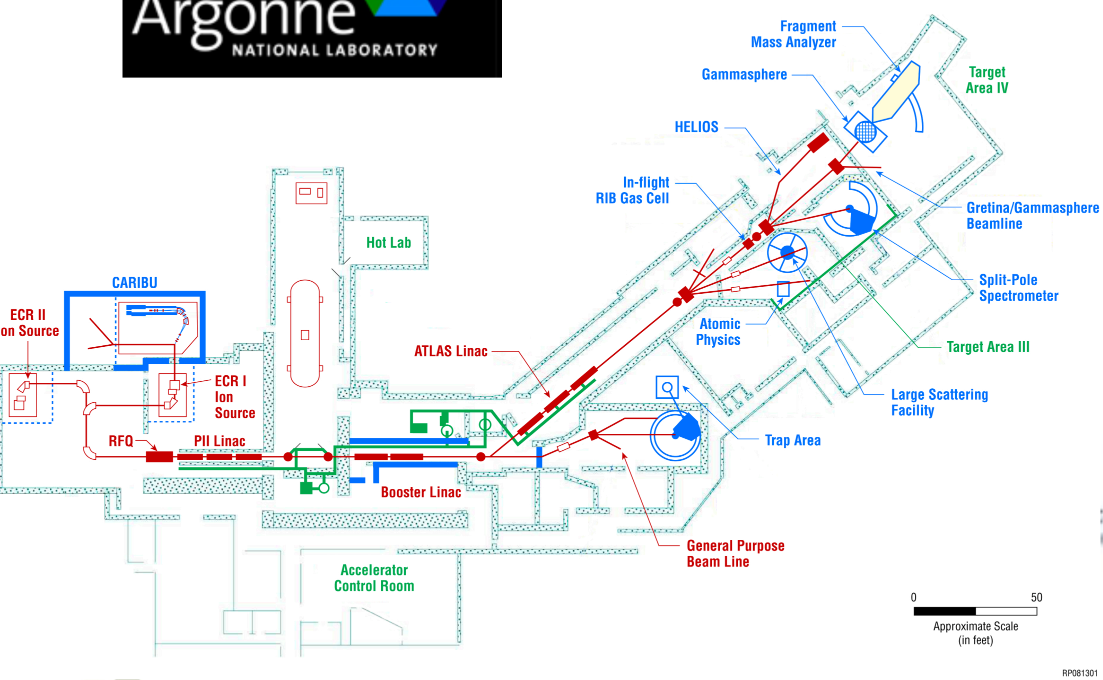
$^{238}PuO_2$(87.7 y)

Cassini spacecraft - Saturn

it is an exciting time in Nuclear Physics

with existing and new (RIB) facilities available (some just around the corner) there is an opportunity to make major contributions to the knowledge; with advances in theory there is a chance to understand the new discoveries; by **compiling & evaluating nuclear data** we can support various applications, advance scientific discoveries and preserve the **knowledge** for future generations

ATLAS Argonne NATIONAL LABORATORY

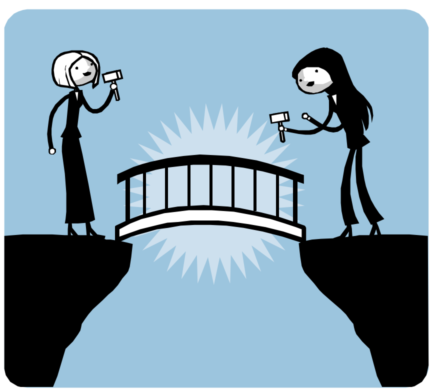


FACILITY FOR RARE ISOTOPE BEAMS

What is Nuclear Data?

- **Generally:** any result produced in a NP experiment can qualify
- **Historically:** associated with neutron cross sections and fission like applications

- Nuclear structure and decay data
- Experimental facilities and detection techniques
- Nuclear data measurements and analysis
- Nuclear theories, models and data evaluation
- Standards
- Evaluated nuclear data libraries and processing
- Validation, benchmarking of evaluated data
- Integral experiments
- Uncertainty quantification
- Data dissemination and international collaboration
- Fission energy applications
- Accelerator-related applications
- Fusion technology applications
- Dosimetry and shielding applications
- Safeguards and security
- Space, cosmic-ray applications, radiation effects on electronics
- Astrophysics and cosmology applications
- Medical and environmental applications



… too applied to the basic physics too academic to the applied physics …

Nuclear Structure Data Evaluation

associated with nuclear structure databases – complex nuclear level schemes and tables of numerical values, which quantify fundamental nuclear structure information, such as level energies and quantum numbers, lifetimes, decay modes, and other associated properties.

NATURE | VOL 405 | 11 MAY 2000 | www.nature.com

Science's neglected legacy

Large, sophisticated databases cannot be left to chance and improvisation.

Stephen M. Maurer, Richard B. Firestone and Charles R. Scriver

Today, far larger and more complex databases are urgently needed in many fields!

Nuclear Physics perhaps has one of the best!

databases are not only at the core of basic nuclear structure and nuclear astrophysics research, but they are also relevant to many applied technologies, including nuclear energy production, reactor design and safety, medical diagnostic and radiotherapy, health physics, environmental research and monitoring, safeguards, material analysis, etc.

Evaluation History

Oxford Dictionaries
The world's most trusted dictionaries

Compilation: from Latin *compilare (14th cent)*

"the action or process of producing something by assembling information collected from other sources"

in scientific fields it serves as a convenient source of detailed information

Evaluation: from French *évaluation (1842)*

"the making of a judgment about the amount, number, or value of something; assessment"

a good "evaluation" always involves "compilation"


GIORGIO FEA

TABELLE RIASSUNTIVE E BIBLIOGRAFIA
DELLE TRASMUTAZIONI ARTIFICIALI

Estratto dal *Nuovo Cimento*, Anno XII, N. 6
Giugno 1935

First Compilation of Nuclides ?

Giorgio Fea, Nuovo Cimento **6** (1935) 1

NICOLA ZANICHELLI, EDITORE
BOLOGNA 1935-XIII

courtesy of E. Browne (LBNL)

Evaluation History – cont.

REVIEWS OF
MODERN PHYSICS

VOLUME 9 JULY, 1937 NUMBER 3

Nuclear Physics

C. Nuclear Dynamics, Experimental*

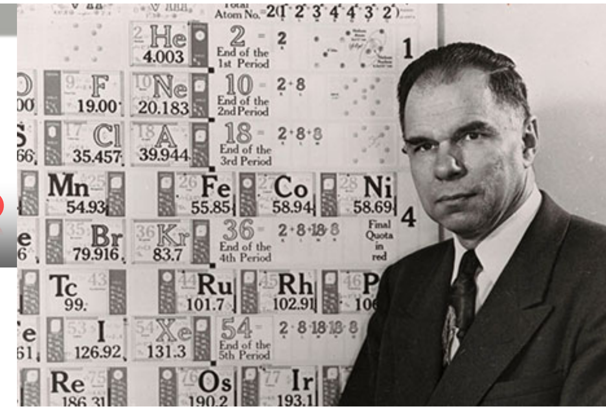
M. STANLEY LIVINGSTON AND H. A. BETHE†
Cornell University, Ithaca, New York

TABLE LXXIV. *Nuclear excitation levels.*

Nucleus	Level: No.	Energy MV	Width kv	Nuclear Mass	Spectr. Symbol	Class	Source	γ-rays
Li^7	1	0.44	—	7.018 65	$^2P_{1/2}$ *u*	*A*	Li^6-*d*-*pP*	∼0.4 Li^7-*α*-*α*
Be^8	1	2.9	780	8.011 1		*A*	B^{11}-*p*-*αP*, B^{10}-*d*-*αP*	
	2	∼4.8	∼1400	8.013 1	$^1D_2$ g	*B*	Li^8-ϵ^-*αP*	17.5 MV 4→0
	3	6–12	Large	8.014–20		*C*	B^{10}-*d*-*αP*, Li^8-ϵ^--*αP*	10–14 MV 4→1, 2
	4	17.50	9	8.026 72	1 *u*	*A*	Li^7-*p*-*γR*	(from Li^7-*p*-*γ*)
	5	17.86	Large	8.027 11		*B*	Li^7-*p*-*γR*	(from Li^7-*p*-*γ*)
Be^{10}	1	2.4	Small	10.019 3	^1D g ?	*C*	Be^9-*d*-*pP* ?	
B^{10}	1	0.5	"	10.016 9	*S* g ?	*B*	Be^9-*d*-*nP*	
	2	2.0	"	10.018 5	*D* g ?	*B*	"	
	3	3.3	"	10.019 8	*D* g ?	*B*	"	
	4	7.28	Large	10.024 13		*B*	Be^9-*p*-*γR*	(from Be^9-*p*-*γ*)
B^{11}	1	2.14	Small	11.015 22	*D* *u* ?	*A*	B^{10}-*d*-*pP*	
	2	4.43	"	11.017 68	F *u* ?	*B*	"	

nuclear decay modes, half-life, decay energy, production

Evaluation History – cont.



JANUARY, 1940 REVIEWS OF MODERN PHYSICS

A Table of Induced Radioactivities

J. J. LIVINGOOD AND G. T. SEABORG
Jefferson Physical Laboratory, Harvard University, Cambridge, Massachusetts, and Departments of Chemistry and Physics, University of California, Berkeley, California

The subsequent editions of **Table of Isotopes**

G.T. Seaborg, *ibid*. 16, 1 (**1944**)

G.T. Seaborg, I. Perlman, *ibid*. 20, 585 (**1948**)

J. M. Hollander, I. Perlman, and G.T. Seaborg, ibid., 25, 469 (**1953**)

D. Strominger, J.M. Hollander, G.T. Seaborg, ibid., 30, 585 (**1958**)

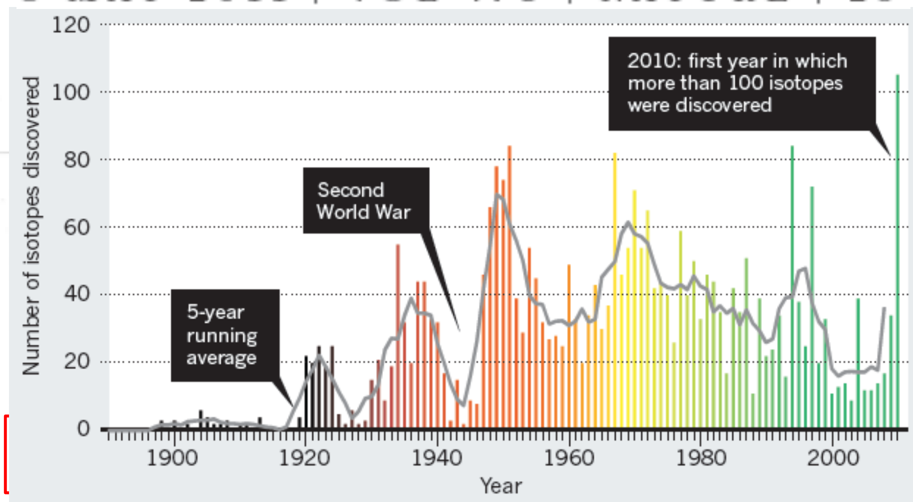
Evaluation History – cont.

From isotopes to the stars

Creating more exotic isotopes will reveal the stellar formation of atoms — a fitting tribute to Ernest Rutherford, say **Michael Thoennessen** and **Bradley Sherrill**.

THE AMERICAN PHYSICAL SOCIETY

5 MAY 2011 | VOL 473 | NATURE | 25



l, 1941

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MODERN
such
bly and
have

you prepare such a table?

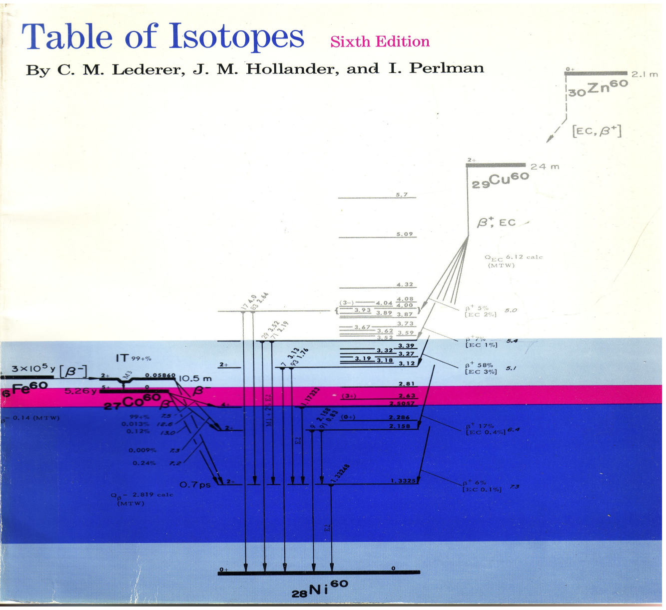
I have the new edition and noted the tables in them. I am quite

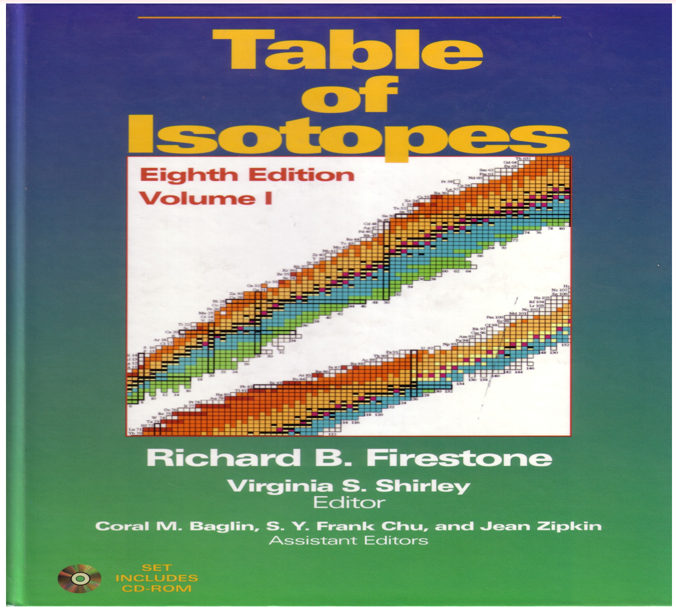
PRL **118,** 072701 (2017) PHYSICAL REVIEW LETTERS week ending 17 FEBRUARY 2017

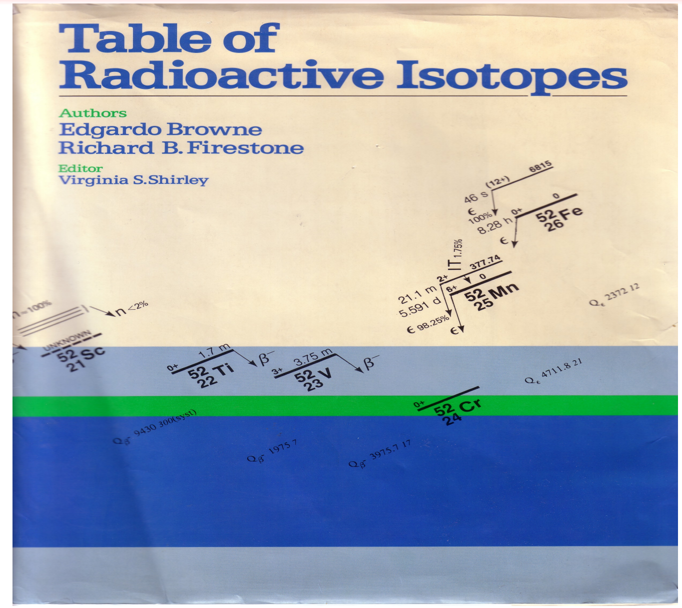
94 *β*-Decay Half-Lives of Neutron-Rich $_{55}$Cs to $_{67}$Ho: Experimental Feedback and Evaluation of the *r*-Process Rare-Earth Peak Formation

J. Wu,[1,2,*] S. Nishimura,[2] G. Lorusso,[2,3,4] P. Möller,[5] E. Ideguchi,[6] P.-H. Regan,[3,4] G. S. Simpson,[7,8,9] P.-A. Söderström,[2] P. M. Walker,[4] H. Watanabe,[10,2] Z. Y. Xu,[11,12] H. Baba,[2] F. Browne,[13,2] R. Daido,[14] P. Doornenbal,[2] Y. F. Fang,[14] G. Gey,[7,15,2] T. Isobe,[2] P. S. Lee,[16] J. J. Liu,[11] Z. Li,[1] Z. Korkulu,[17] Z. Patel,[4,2] V. Phong,[18,2] S. Rice,[4,2] H. Sakurai,[2,12] L. Sinclair,[19,2] T. Sumikama,[2] M. Tanaka,[6] A. Yagi,[14] Y. L. Ye,[1] R. Yokoyama,[20] G. X. Zhang,[10] T. Alharbi,[21] N. Aoi,[6] F. L. Bello Garrote,[22] G. Benzoni,[23] A. M. Bruce,[13] R. J. Carroll,[4] K. Y. Chae,[24] Z. Dombradi,[17] A. Estrade,[25] A. Gottardo,[26,27] C. J. Griffin,[25] H. Kanaoka,[14] I. Kojouharov,[28] F. G. Kondev,[29] S. Kubono,[2] N. Kurz,[28] I. Kuti,[17] S. Lalkovski,[4] G. J. Lane,[30] E. J. Lee,[24] T. Lokotko,[11] G. Lotay,[4] C.-B. Moon,[31] H. Nishibata,[14] I. Nishizuka,[32] C. R. Nita,[13,33] A. Odahara,[14] Zs. Podolyák,[4] O. J. Roberts,[34] H. Schaffner,[28] C. Shand,[4] J. Taprogge,[35,36] S. Terashima,[10] Z. Vajta,[17] and S. Yoshida[14]

Evaluation History – cont.







LBNL @ TOI

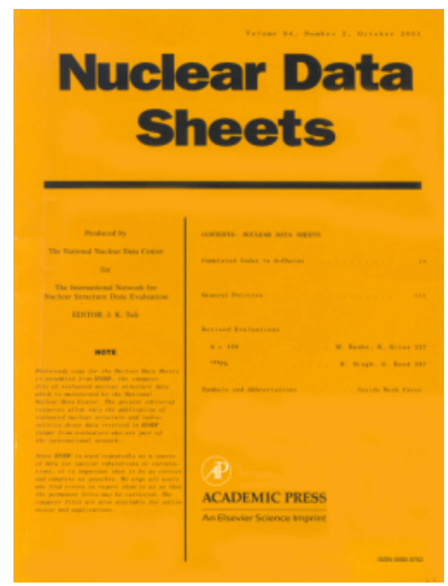
The 8th Edition (the last) – most of the data were derived from the Evaluated Nuclear Structure Data File (ENSDF)

TOI was discontinued after the 8th Edition – still heavily cited in the scientific literature

Evaluation History – cont.

- in 1945: Katherine Way (the first PhD student of John Wheeler) as a part of the Manhattan Project, started collected nuclear data at Clinton Laboratory (today Oak Ridge National Laboratory)

- in 1947: KW went to the US National Bureau of Standards (today NIST),Washington, DC where in 1953 under the National Research Council, US National Academy of Sciences she created the Nuclear Data Project; published the first collection of data in loose-leaf pages called *Nuclear Data Sheets*
- in 1964: under the leadership of Katherine Way, NDP moved back to ORNL – **Nuclear Science Reference (NSR) & Evaluated Nuclear Structure Data File (ENSDF)** formats were developed - E.B. Ewbank, M.J. Martin and co-workers at ORNL
- in *1966:* the journal *Nuclear Data Sheets* journal (Academic Press) started; currently published by *Elsevier*
- in 1974: the International Nuclear Structure and Decay Data Network, under the auspices of IAEA, was created – the main effort was shifted from ORNL to NNDC (BNL)
- since 1981 the main editorial work has been carried out at NNDC (J. Tuli – Editor until 2016; E. McCutchan – Editor since 2016)



Information courtesy of J. Tuli (NNDC)

Evaluation History – cont.

2007 National Medal of Science

- 1945 - Emilio Segre introduced the first chart, with *Z* along the x-axis, and *N* along the y-axis. Published as Los Alamos report.
- 1948 - G. Friedlander and M. Perlman published the first *General Electric (GE)* chart with Z and N

- 1948 – T. Lauritsen and F. Ajzenberg-Selove – U. Pennsylvania & TUNL
- 1950 – B. S. Dzhelepov, L. Peker and I. Selinov – USSR
- 1954 – P. M. Endt and C. Van der Leun, U. Utrecht, Netherlands
- mid 1970: C. Reich and R. Helmer, INEEL; J. Blashot, CEA, France; J. Cameron, M. Johns & B. Singh, McMaster U; S. Raman, ORNL; D. DeFrene, Gent U; T. Burrows, J. Tuli, NNDC

U.S. Nuclear Data Program

Nuclear Reactions ⟷ Nuclear Structure & Decay

- ❑ collaboration of scientists from ANL, LBNL, MSU, NNDC (BNL), ORNL, TUNL & Texas A&M U, supported by the Office of Nuclear Physics, Office of Science, US DOE
  - ✓ leveraged with effort from colleagues from several countries within the NSDD Network, established in 1974 under the auspices of IAEA, Vienna

What we do:

- ❑ Compile, Evaluate, Measure and Disseminate Nuclear Structure and Decay Data for ALL known nuclei (more than 3000!) that are used in basic science research and technology applications

NSDD Network

U.S. Nuclear Data Program

NSDD

Europe (Romania, Hungary & Russia), Asia (Japan, China, India), Australia

backbone of NSDD – leadership, technical expertise and mentoring host & maintain ENSDF, NSR & network programs

relatively small contribution; funding still an issue

International Atomic Energy Agency
Nuclear Data Services
Provided by the Nuclear Data Section

Organize bi-annual meetings & technical workshops

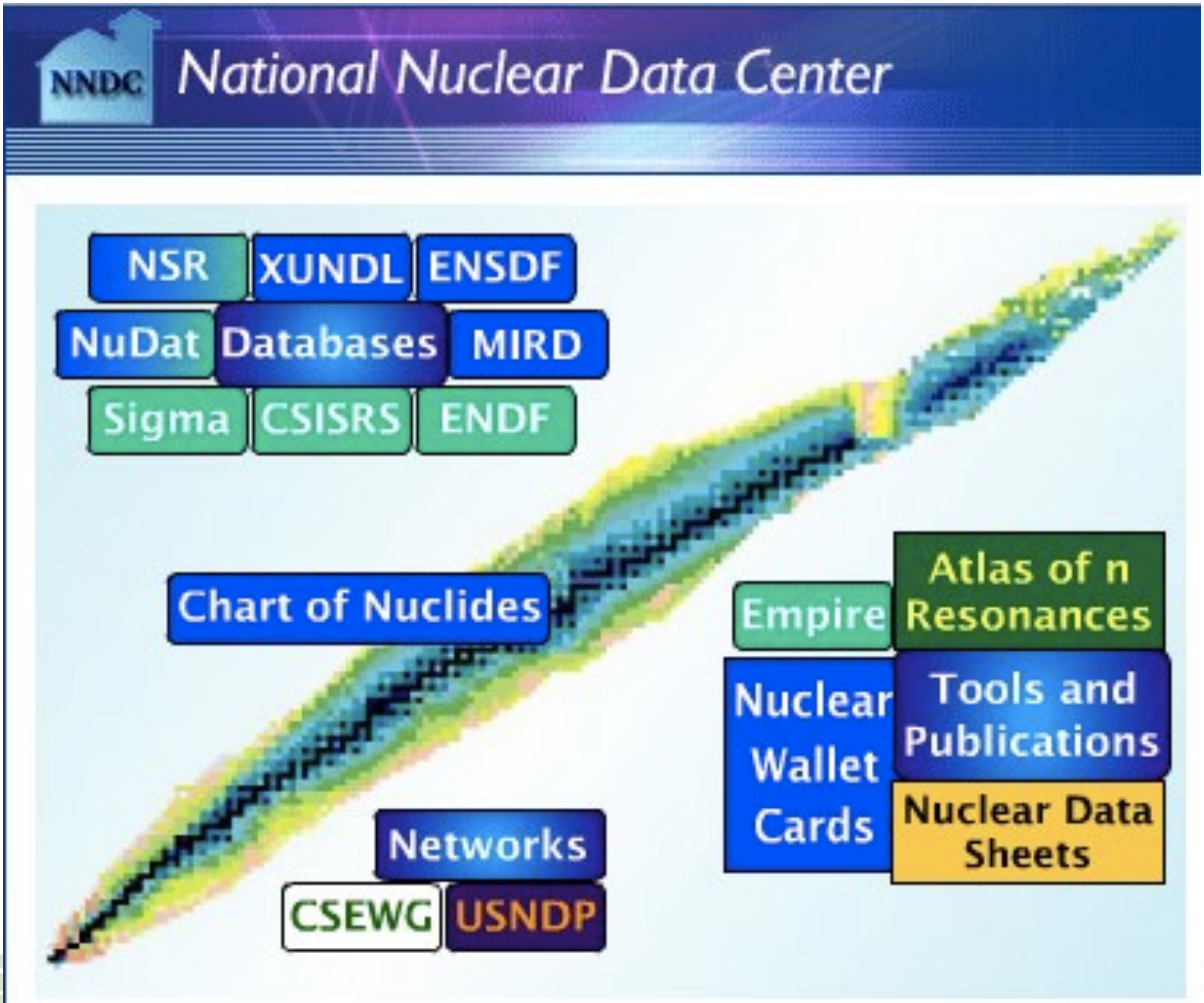
Dissemination

Provide research grants ($4K /y)

developing countries

Where - the focal point

www.nndc.bnl.gov



ENSDF – the core database

www.nndc.bnl.gov/ensdf

Contents: Evaluated nuclear structure and decay data for all known nuclei, organized in over 290 mass chains

ENSDF

Adopted
(best values)

Levels:
(E, J^{π}, $T_{1/2}$, μ, Q, configurations)

Gammas:
(E_{γ}, BR, M,δ, ICC)

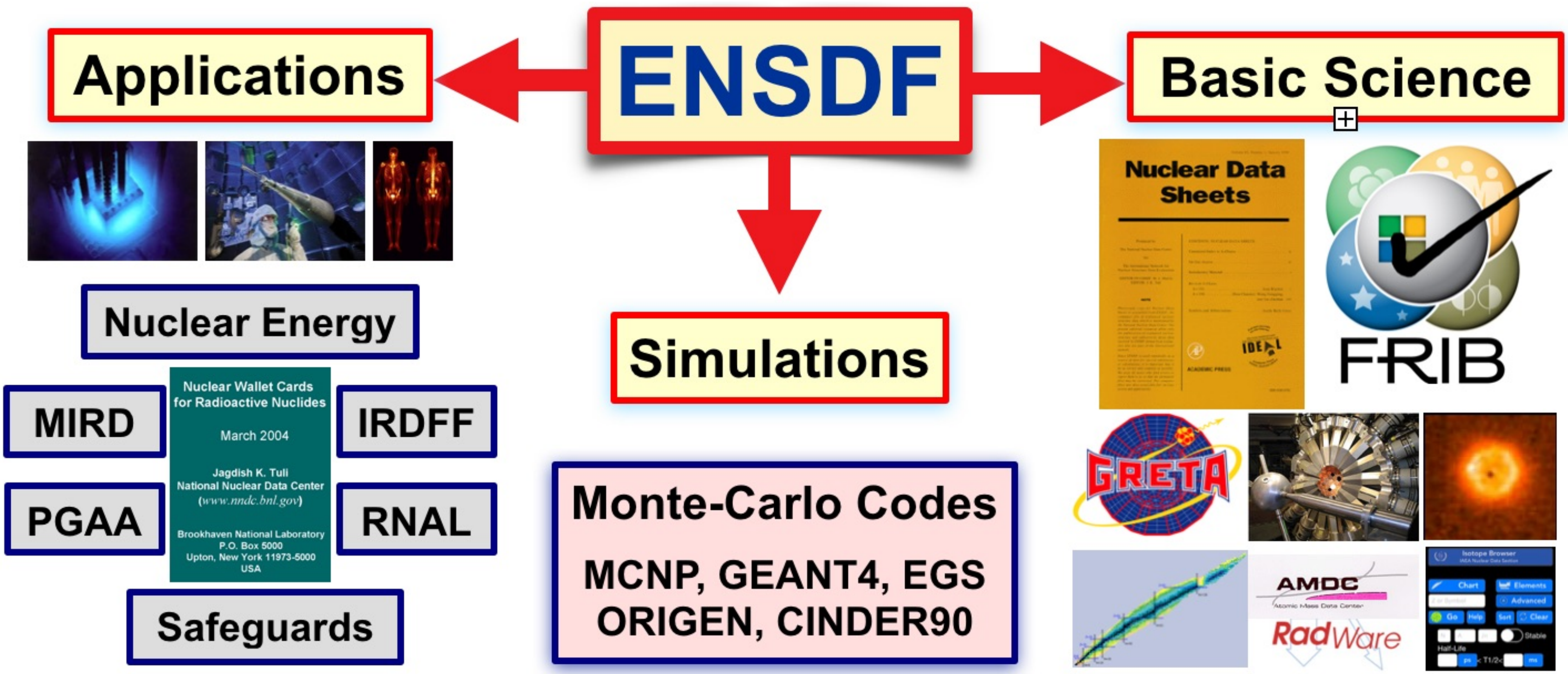
Decays
β^-
$\varepsilon+\beta^+$
α
β^-n
etc.

Reactions
(HI,xnγ)
(p,p')
(n, γ), (n,xnγ)
Coul. Exc.
(α,α'), (α,xnγ)
(d,p), etc.

ENSDF – the core database – cont.

ENSDF is the **only** Nuclear Structure database that is **updated continuously** – contains information for **ALL** nuclei and **ALL** nuclear **level properties & radiations** – currently contributed by members of the Nuclear Structure and Decay Data Network, under auspices of **IAEA**. It is maintained by NNDC and the **NSDD role is indispensible**!

No viable alternative exists in the world!



What takes to do a good evaluation

it is a time consuming effort!

- **critical reading** of all published (and sometime unpublished) work on a particular nuclide – working with the authors when possible
- **compilation of the results** in appropriate formats - prepare individual data sets
- **critical review** - recommends best values for a range of nuclear properties (not simply averaging numbers!)
  - ✓a number of computer codes are applied to check the data for consistency or to deduce some quantities, e.g. ICC, BXL, log *ft*, etc.
  - ✓the human factor is also very important
- **peer-review process** – completeness & quality
- **publication** in *Nuclear Data Sheets* (and on the Web)

What is the value of evaluated data?

- archival of all nuclear structure and decay data
- resolve differences between overlapping and contradictory results
- beneficial consequences for nuclear theory development
- beneficial to many applied areas such as nuclear medicine, reactor engineering, environmental impact assessment, nuclear waste management, activation analysis, etc.
- identify and stimulate needs for new measurements

www.nndc.bnl.gov/ensdf

Ex=36 MeV (^{149}Gd)

E6 in decay of the 19/2- (2.5 min) isomer in ^{53}Fe

J=68 (SD ^{152}Dy)?

^{130}Ag-22 n away from ^{109}Ag
^{169}Au-28 n away from ^{197}Au

from ~3000 known nuclei

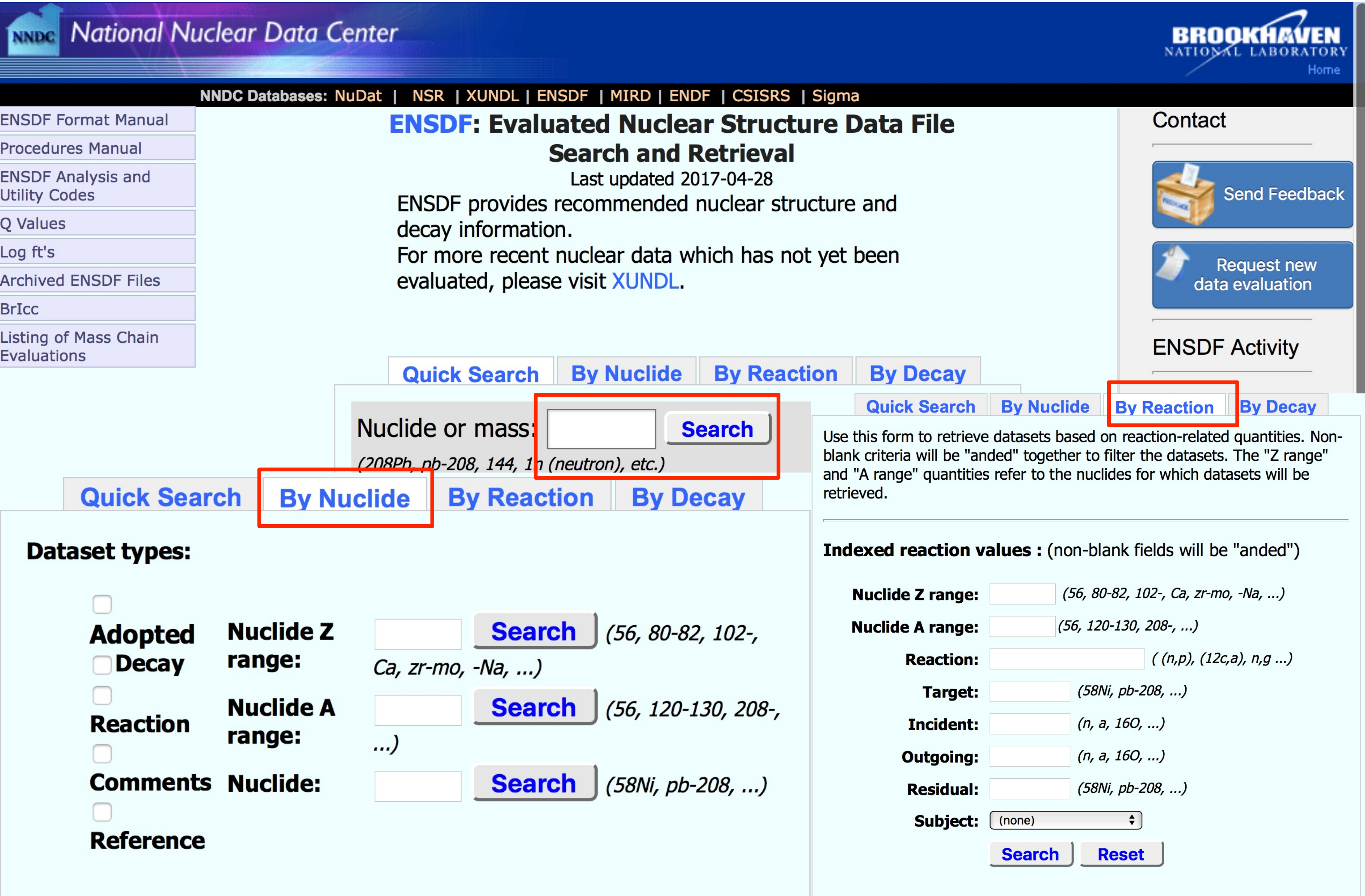
785 nuclei with only 1 level

1101 nuclei with no γ known

^{40}Ca – 578 levels

^{53}Mn – 1319 γ–rays

www.nndc.bnl.gov/ensdf



www.nndc.bnl.gov/ensdf

$^{177}_{71}Lu_{106}$-1

Matching

Retrieve sel

PDF Version

Select All
ADOPTED
177YB B-
177LU IT
176YB(3H
176LU(N,
176LU(D,
178HF(T,
(HI,XNG)

^{177}Lu IT decay (160.44 d) 1972Ch48,1981Hn03,1989Ma56

History

Type	Author	Citation	Cutoff Date
Full Evaluation	F. G. Kondev	NDS 98, 801 (2003)	1-Aug-2002

Parent: ^{177}Lu: E=970.1750 *24*; $J^\pi=23/2^-$; $T_{1/2}$=160.44 d *6*; %IT decay=21.4 *8*

^{177}Lu-%IT decay: from Σ I(γ+ce)[g.s.(^{177}Lu)] + Σ I(γ+ce)[γ rays from 1315.43, 1301.41, and 1260.26 keV levels in ^{177}Hf]=100%. Intensities in ^{177}Hf are from levels that do not have contribution from ^{177}Lu β^- decay (6.647 d).

parent data

Other: 1988Zh06, 1975Mo14, 1970Ka39, 1969Ro37, 1967Ha09, 1965Sy01, 1965Ma18, 1964Kr01, 1964Al04, 1964Bi16. 1964Al04, 1966Bo01, 1967Be34, 1967Ha09, 1969Hu06, 1970Ka39, 1971Gl09, 1972Bo55, 1974Kr12, 1990Bu31.

^{177}Lu Levels

E(level)†	J^π‡	$T_{1/2}$#
0.0@	$7/2^+$	6.647 d *4*
121.6211@ *5*	$9/2^+$	0.117 ns *4*
268.7849@ *5*	$11/2^+$	
440.6424@ *6*	$13/2^+$	
636.2028@ *7*	$15/2^+$	
854.3067@ *7*	$17/2^+$	
970.1750& *24*	$23/2^-$	160.44 d *6*

level information

† From least-squares fit to the γ-ray energies given in 1989Ma56.

‡ From $\gamma(\theta)$, measured electron conversion coefficients and the apparent band structure with both cascade (ΔJ=1) and crossover (ΔJ=2) transitions, unless otherwise specified.

From Adopted Levels.

@ π 7/2[404] ($g_{7/2}$). The assignment is supported by the observed in-band properties, such as alignment and g_K-g_R values ((g_K-g_R)/Q_0=+0.0475 *7*, weighted average from values deduced from the $11/2^+$ to $17/2^+$ levels) and systematics of similar structures in neighboring nuclei.

& $K^\pi=23/2^-$: configuration=π 7/2[404], ν 7/2[514], ν 9/2[624].

E(level)[†]	J^{π}[‡]	$T_{1/2}$[‡]	Comments
1344.6[a] *4*	15/2+		
1352.33[#] *22*	(21/2+)		
1356.47[c] *14*	15/2+	11.1 ns *10*	$T_{1/2}$: $T_{1/2}$=11.1 ns *11* in 2002DrZZ.
1389.33[&] *18*	17/2+		
1437.87[d] *25*	(17/2−)	<13 ns	$T_{1/2}$: From 2002DrZZ.
1502.51 *15*	13/2+		
1536.8[e] *3*	(27/2−)		
1542.8[b] *5*	(21/2−)		
1545.2[c] *3*	17/2+	0.8 ns *+2−1*	
1564.4[b] *5*	15/2−		
1589.2[@] *3*	(23/2−)		
1622.95[&] *20*	19/2+		
1629.5[#] *3*	(23/2+)		
1670.9[d] *3*	(19/2−)		
1678.8 *3*			
1749.0[c]	19/2+		
1772.9 *3*			
1804.1[a] *4*	(19/2+)		
1851.8[e] *3*	(29/2−)		
1872.6[@] *3*	(25/2−)		
1921.8[#] *3*	(25/2+)		
1925.3[d] *3*	(21/2−)		
1976.8[b] *5*	(25/2−)		
2174.2[@] *4*	(27/2−)		
2200.1[d] *4*	(23/2−)		
2345.1[a] *5*	(23/2+)		
2497.8[b] *5*	(29/2−)		
>2700?[f]	(39/2−)	6 min *+3−2*	E(level),J^{π}: Not observed experimentally. The existence of this isomer is uncertain. It is based on the observed long lifetime ($T_{1/2}$ =83 min *+16−3*) for the known K^{π}=37/2− isomer in ^{177}Hf ($T_{1/2}$ =51.4 min *5*) from 2002AlZY. The E(level) and J^{π} are tentative and they are based on theoretical predictions. $T_{1/2}$: From 2002AlZY using a two isomers fit to the growth of γ ray intensity as a function of time for transitions associated with the decay of the K^{π}=37/2− isomer ($T_{1/2}$ =51.4 min *5*) in ^{177}Hf.

$^{177}_{71}Lu_{106}$-1

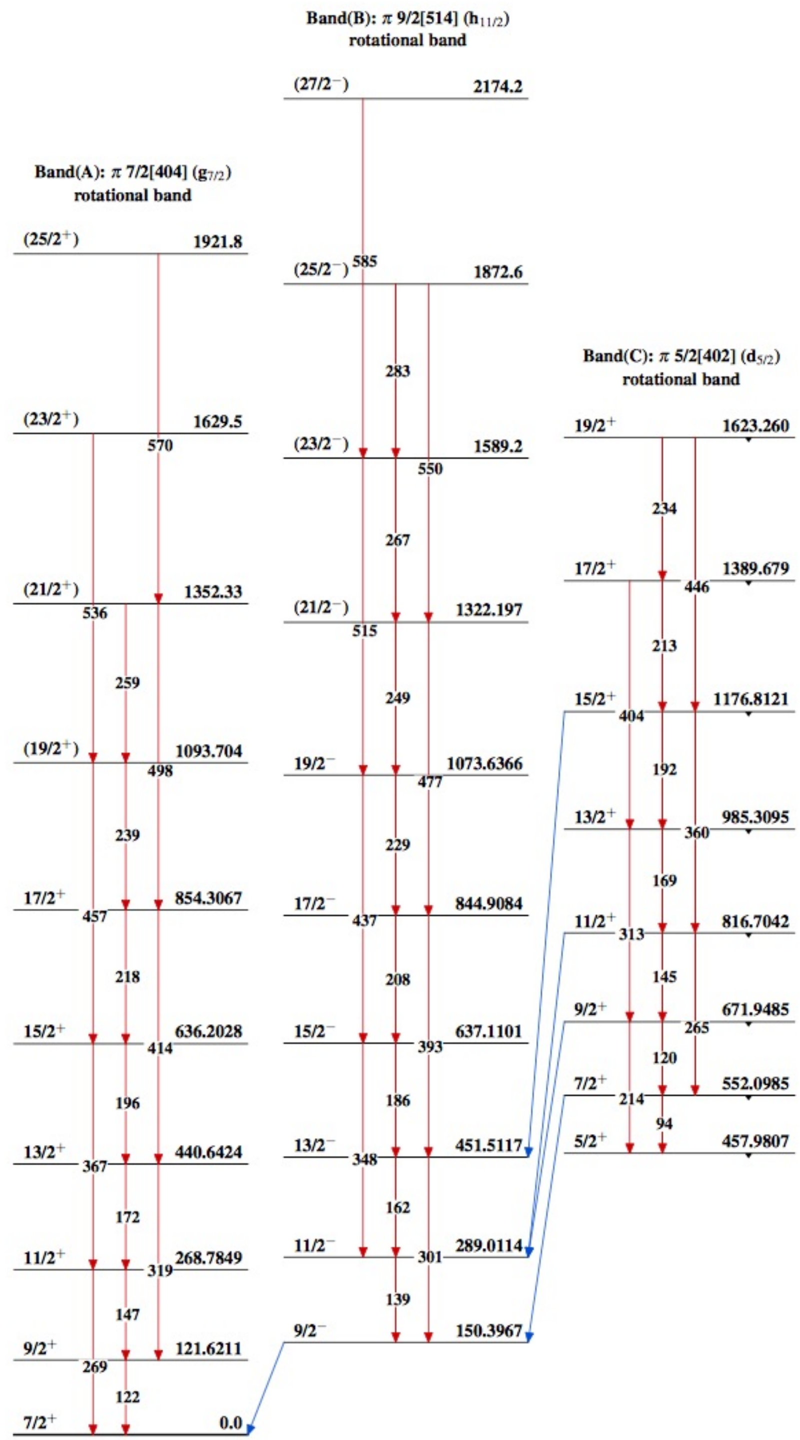
(HI,xnγ) 2002DrZZ

History			
Type	Author	Citation	Cutoff Date
Full Evaluation	F. G. Kondev	NDS 98, 801 (2003)	1-Aug-2002

Reaction: ^{176}Yb(^{7}Li,α2n); Beam energy: E=37 MeV; Target: 2.3 mg/cm^2, enriched to 96.43% in ^{176}Yb; Detectors: CAESAR array (6 HPGe detectors) and an array of fourteen fast/slow plastic scintillator detectors. Measured: Eγ, Iγ, γγ coin., particle γγ coin, γγ(t).

Other: 2002AlZX, 2002AlZY.

Adopted Levels, Gammas



ıtoff Date

Aug-2002

Q(β^-)=497.2 *8*; S(n)=

Note: Current evaluat

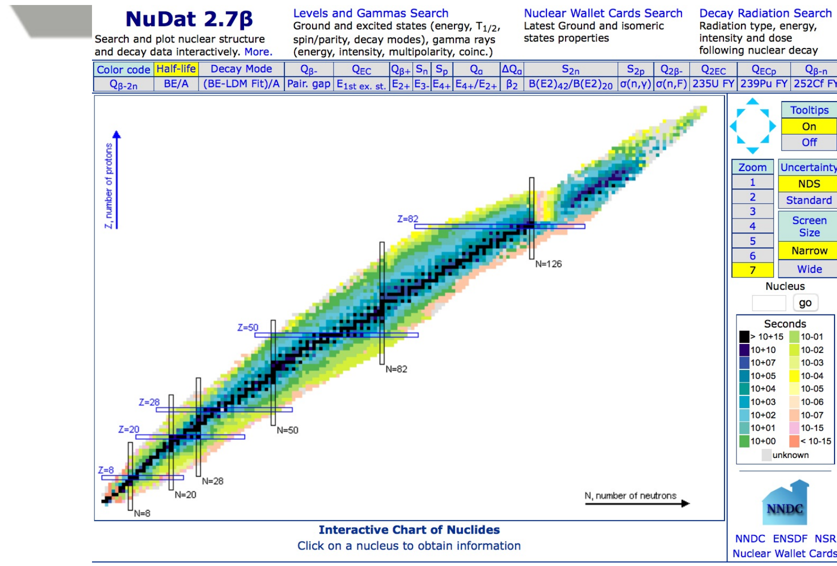
Q(β^-)=498.3 *8*; S(n)=

(α,t)

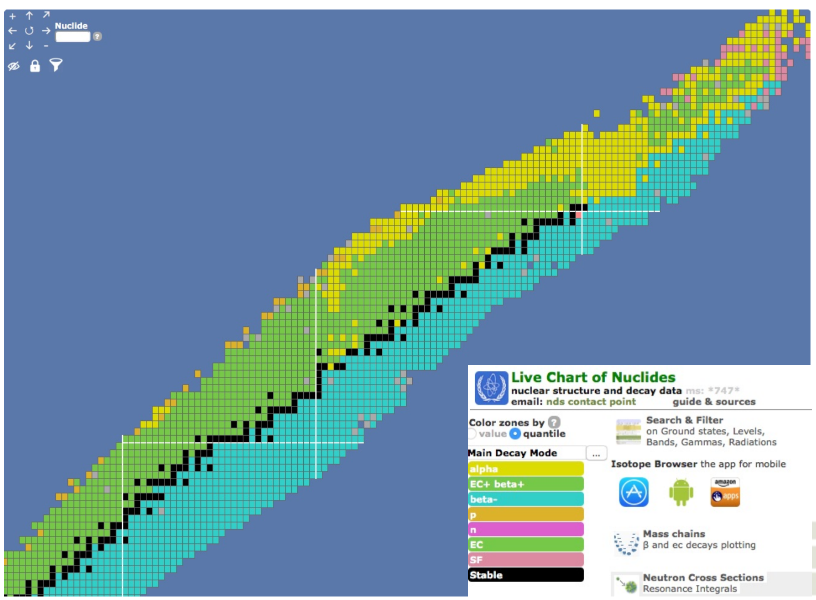
289.0114	11/2⁻	138.	Other: ce in ^{177}Yb β^- decay.
			m K/L ratio in ^{176}Lu(n,γ) E=thermal.
440.6424	13/2⁺	171.	Other: $\gamma(\theta)$ in ^{177}Lu IT decay (160.44 d).
		319.	Other: $\gamma(\theta)$ in ^{177}Lu IT decay (160.44 d).
451.5117	13/2⁻	162.	
		301.	
457.9807	5/2⁺	336.	(W.u.)>0.089
		457.	(W.u.)>0.00047
150.3967	10	9/2	Possible E2 admixtures.

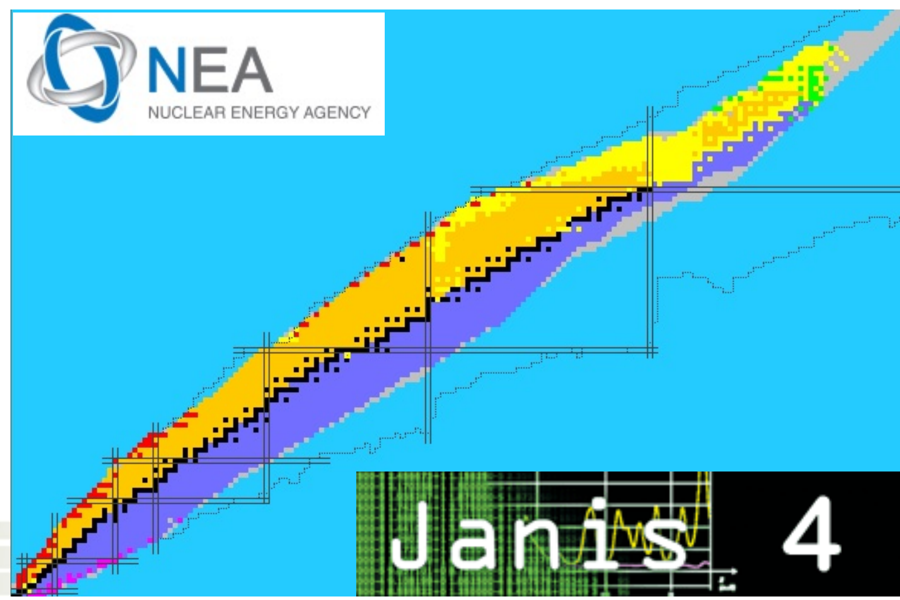
^{5}Lu(n,γ)

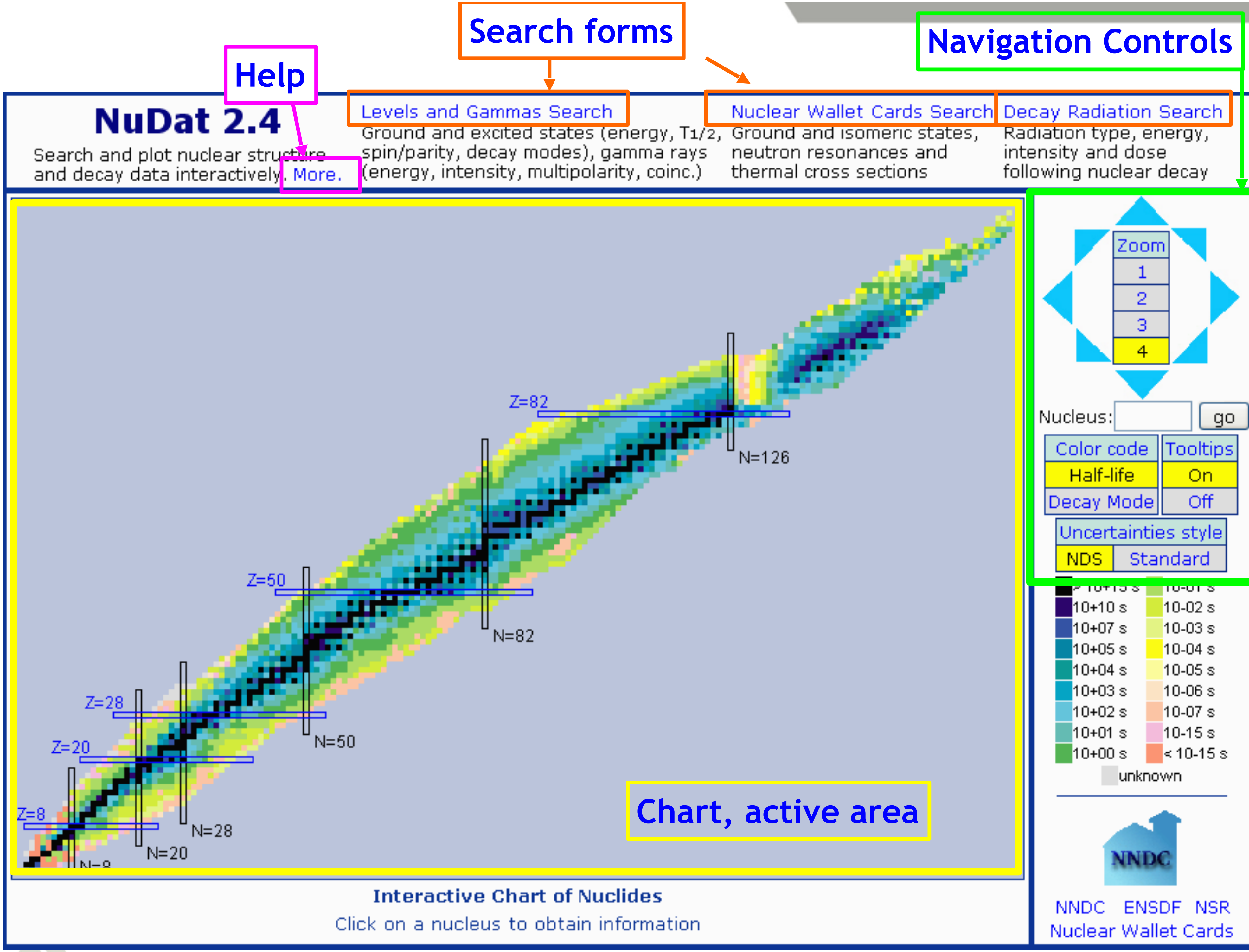

NUCLEAR WALLET CARDS
October 2011
Jagdish K. Tuli
National Nuclear Data Center
www.nndc.bnl.gov
Brookhaven National Laboratory
P.O. Box 500
Upton, New York 11973-5000
U.S.A.


NuDat 2.7β
Search and plot nuclear structure and decay data interactively. More.
Levels and Gammas Search
Nuclear Wallet Cards Search
Latest Ground and isomeric states properties
Decay Radiation Search
Radiation type, energy, intensity and dose following nuclear decay
Interactive Chart of Nuclides
Click on a nucleus to obtain information
NNDC ENSDF NSR
Nuclear Wallet Cards

ENSDF


Live Chart of Nuclides
nuclear structure and decay data
Main Decay Mode
alpha
EC+ beta+
beta-
p
n
EC
SF
Stable
Isotope Browser the app for mobile
Mass chains
Neutron Cross Sections
Resonance Integrals


NEA
NUCLEAR ENERGY AGENCY
Janis 4


Search forms
Help
Navigation Controls
NuDat 2.4
Search and plot nuclear structure and decay data interactively. More.
Levels and Gammas Search
Ground and excited states (energy, T1/2, spin/parity, decay modes), gamma rays (energy, intensity, multipolarity, coinc.)
Nuclear Wallet Cards Search
Ground and isomeric states, neutron resonances and thermal cross sections
Decay Radiation Search
Radiation type, energy, intensity and dose following nuclear decay
Z=82
N=126
Z=50
N=82
Z=28
Z=20
N=50
Z=8
N=28
N=20
Chart, active area
Zoom
1
2
3
4
Nucleus:
go
Color code
Tooltips
Half-life
On
Decay Mode
Off
Uncertainties style
NDS
Standard
10+10 s
10-02 s
10+07 s
10-03 s
10+05 s
10-04 s
10+04 s
10-05 s
10+03 s
10-06 s
10+02 s
10-07 s
10+01 s
10-15 s
10+00 s
< 10-15 s
unknown
NNDC
Interactive Chart of Nuclides
Click on a nucleus to obtain information
NNDC ENSDF NSR
Nuclear Wallet Cards

Nuclear Levels Properties - search

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] ≤ $\mathbf{E_{level}}$**(keV)** ≤ [40000]

Decay Mode condition: ○ enabled ◉ disabled **Decay Mode** [ANY ▾]

Jπ(level) condition: ◉ enabled ○ disabled **J** = [2] **Order :** [1st ▾] **Parity :** [+ ▾]

$T_{1/2}$(level) condition: ○ enabled ◉ disabled [0] [fs ▾] ≤ $\mathbf{T_{1/2}}$ ≤ [1E10] [Gy ▾]

☐ No Upper/Lower limit values

γ condition #1: ○ enabled ◉ disabled [0] ≤ $\mathbf{E_{\gamma}}$**(keV)** ≤ [40000] **Multipolarity:** [ANY ▾] ☐ Not mixed

γ condition #2: ○ enabled ◉ disabled [0] ≤ $\mathbf{E_{\gamma}}$**(keV)** ≤ [40000] **Multipolarity:** [ANY ▾] ☐ Not mixed

γ condition #3: ○ enabled ◉ disabled [0] ≤ $\mathbf{E_{\gamma}}$**(keV)** ≤ [40000] **Multipolarity:** [ANY ▾] ☐ Not mixed

γ coincidence condition : ◉ any ○ coincident **Coincidence gate** ≤ [1] [us ▾]

γ reduced transition probability: ○ enabled ◉ disabled [0] ≤ **B(Mλ,Eλ)(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

A. Sonzogni (NNDC)

Decay Radiation Search

Decay Radiation Search

Help

Specify Parent Nuclei : (●) **Nucleus:** 232th Ex: 232TH or th232 or 232-Th or th-232 or

( ) **Z / Element:** ___ **A:** ___ **N:** ___

( ) ___ ≤ **Z** ≤ ___ ___ ≤ **A** ≤ ___ ___ ≤ **N** ≤ ___

Any Z ▾ Any A ▾ Any N ▾

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

☐ No Upper/Lower limit values

Decay Mode condition: ( ) enabled (●) disabled **Decay Mode** ANY ▾

Radiation Type condition: ( ) enabled (●) disabled **Radiation Type** ANY ▾

Radiation Energy condition: ( ) enabled (●) disabled 0 ≤ **Energy (keV)** ≤ 10000

Radiation Intensity condition: ( ) enabled (●) disabled 0 ≤ **Intensity (%)** ≤ 100

Ordering: Z, A, T1/2, E ▾ Output: (●) Web Page ( ) Formatted File

Uncertainties: (●) Nuclear Data Sheets style ( ) Standard style

[Search] [Reset]

Decay Radiation database version of 4/11/2008

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*	$^{228}_{88}Ra$	

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*

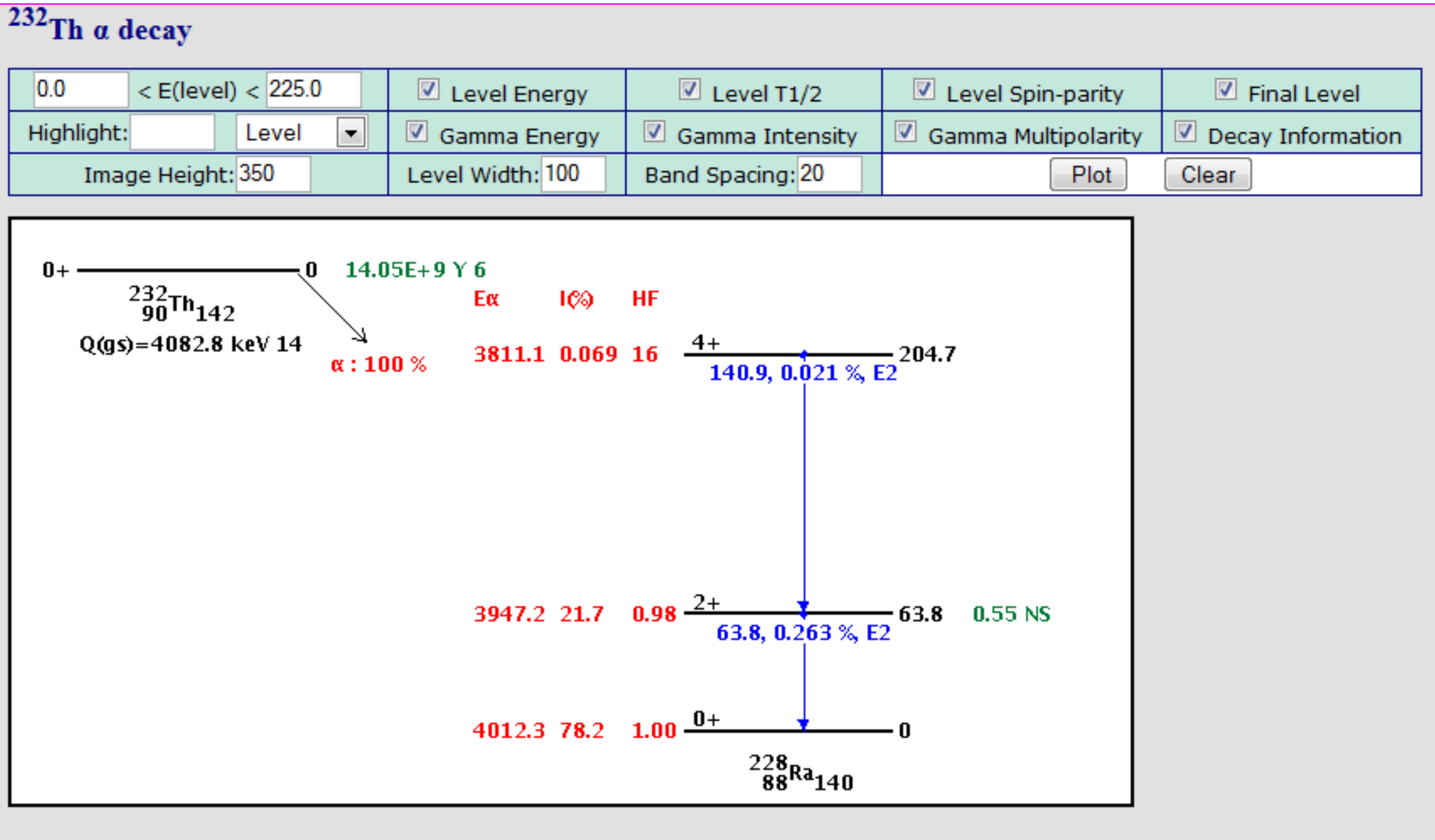
Gamma and X-ray radiation:

	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*

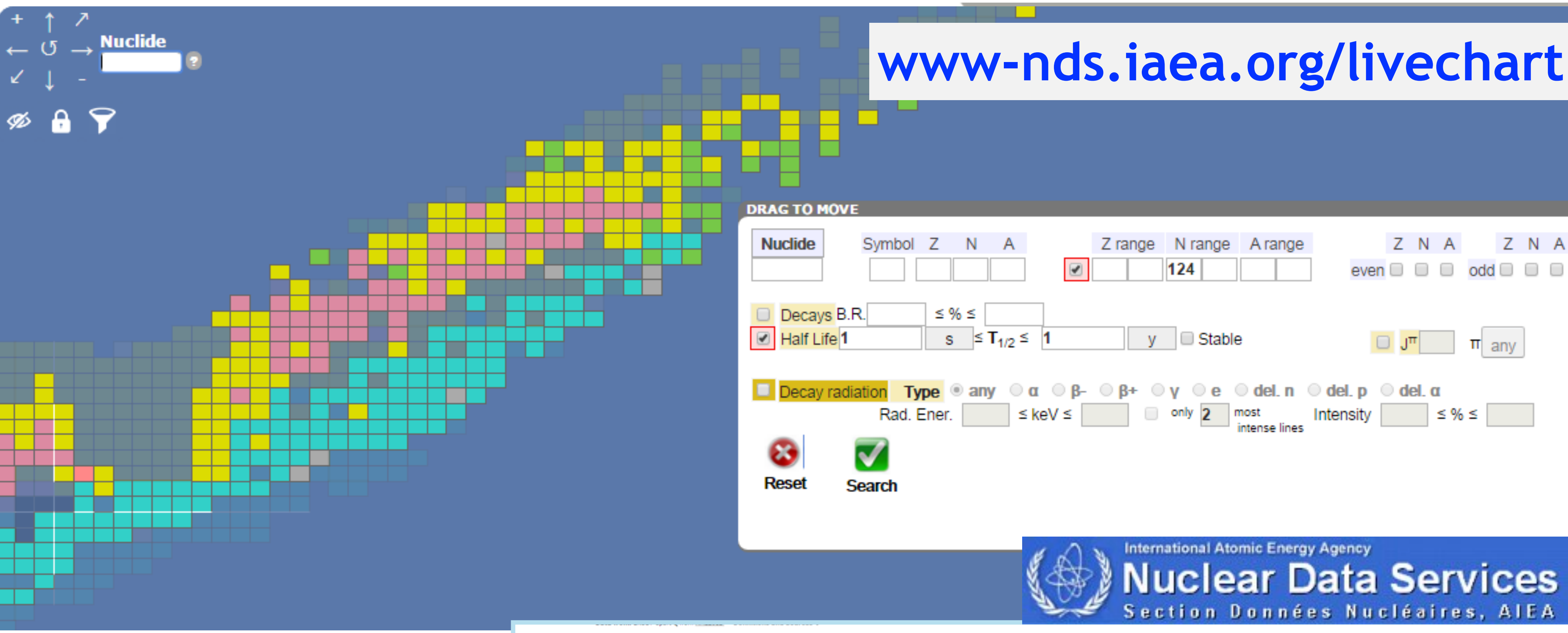
Electrons:

	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*

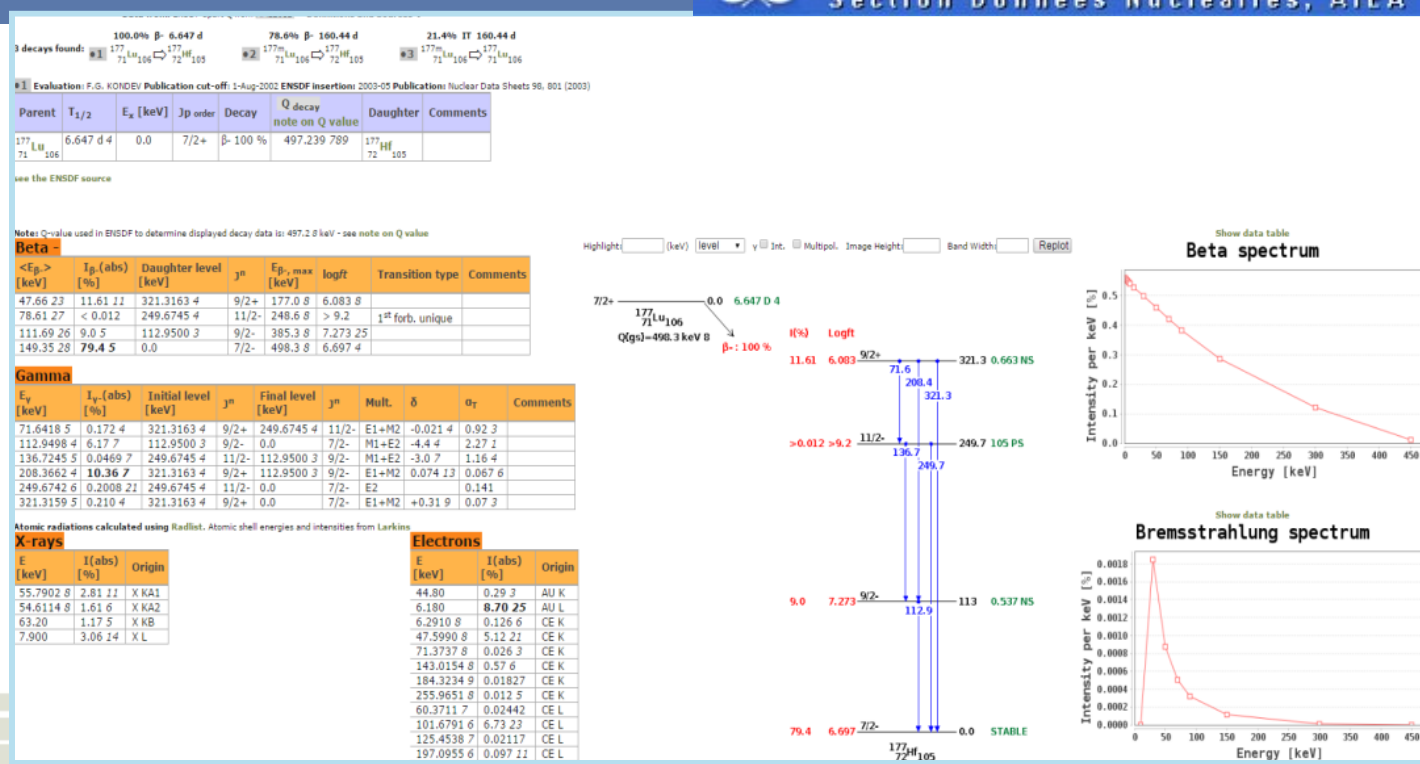
Interactive Decay Scheme



www-nds.iaea.org/livechart



International Atomic Energy Agency
Nuclear Data Services
Section Données Nucléaires, AIEA



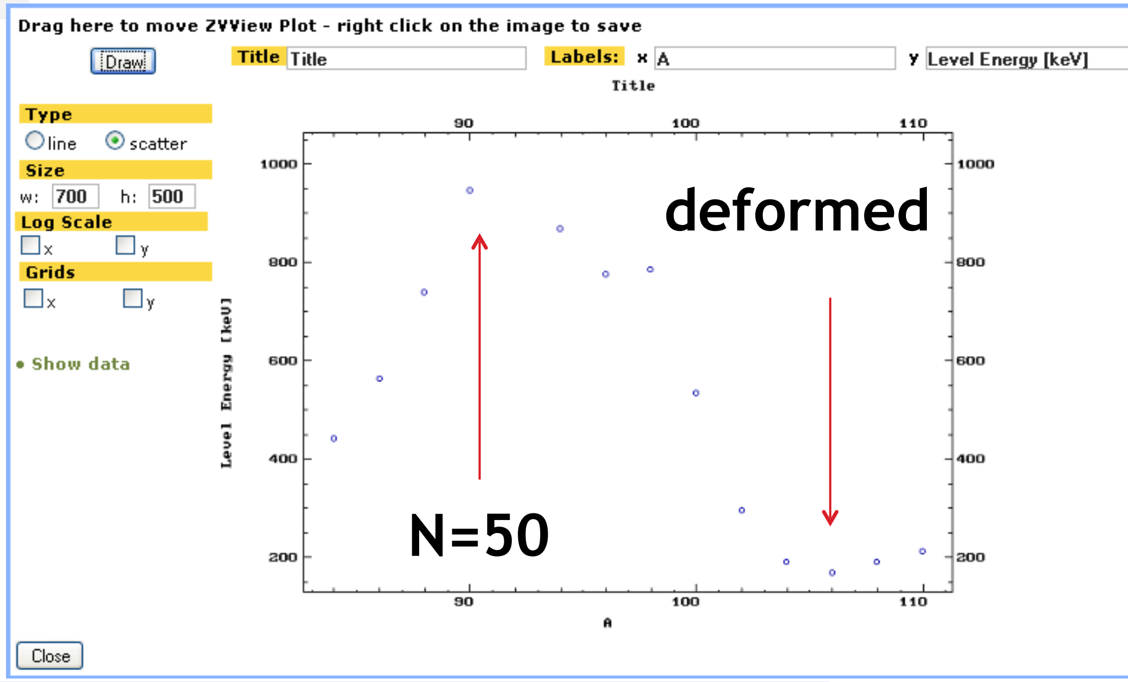
- ✓ friendly face of ENSDF & other nuclear structure data
- ✓ data tables with evaluators’ comments
- ✓ CSV download

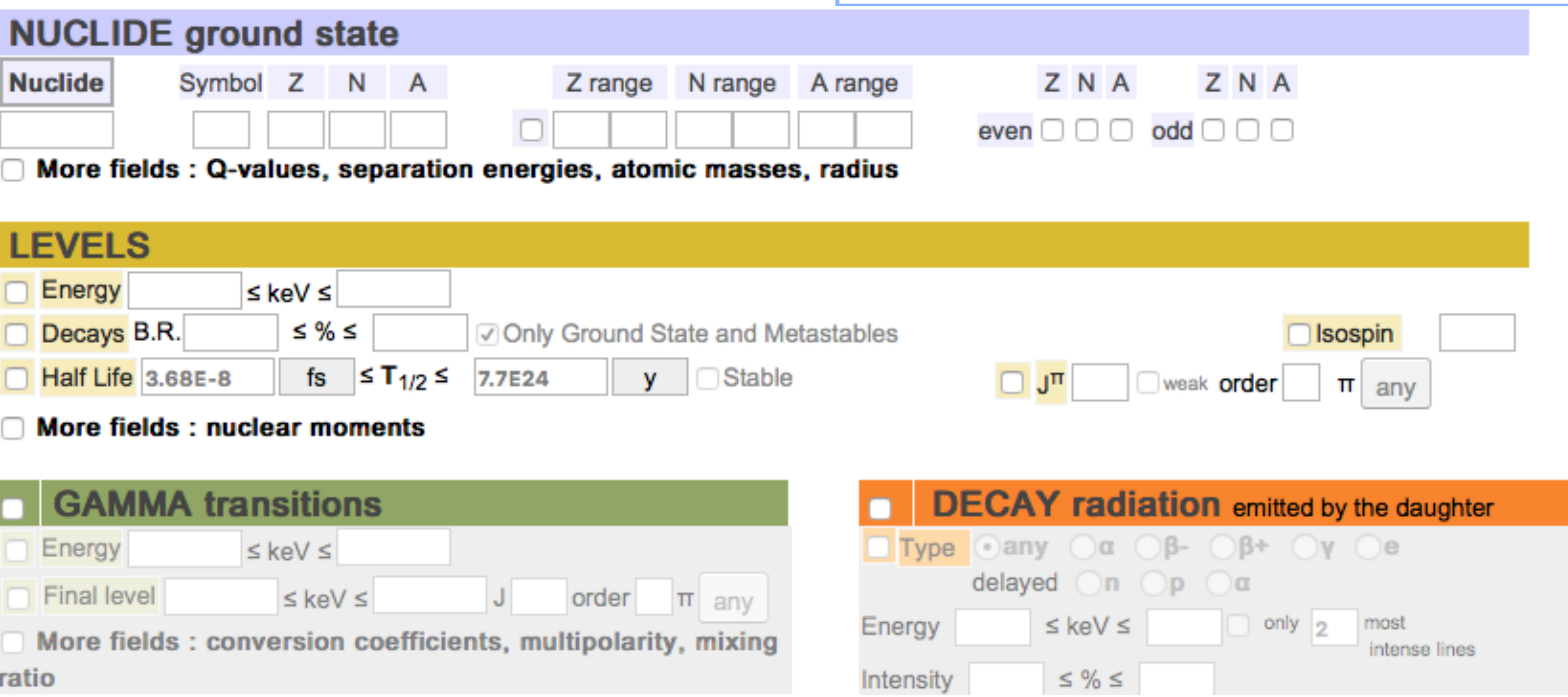
M. Verpelli (IAEA)

www-nds.iaea.org/queryensdf

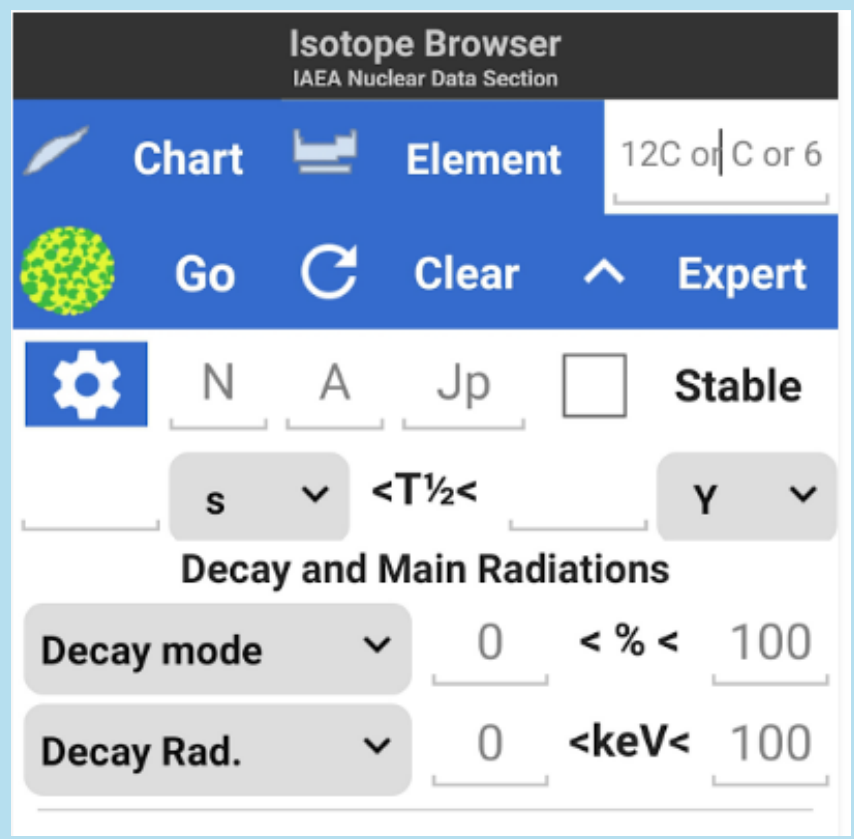
Build your own query on ENSDF

- ✓ Custom plotting
- ✓ Powerful searching capabilities
- ✓ CSV data downloading

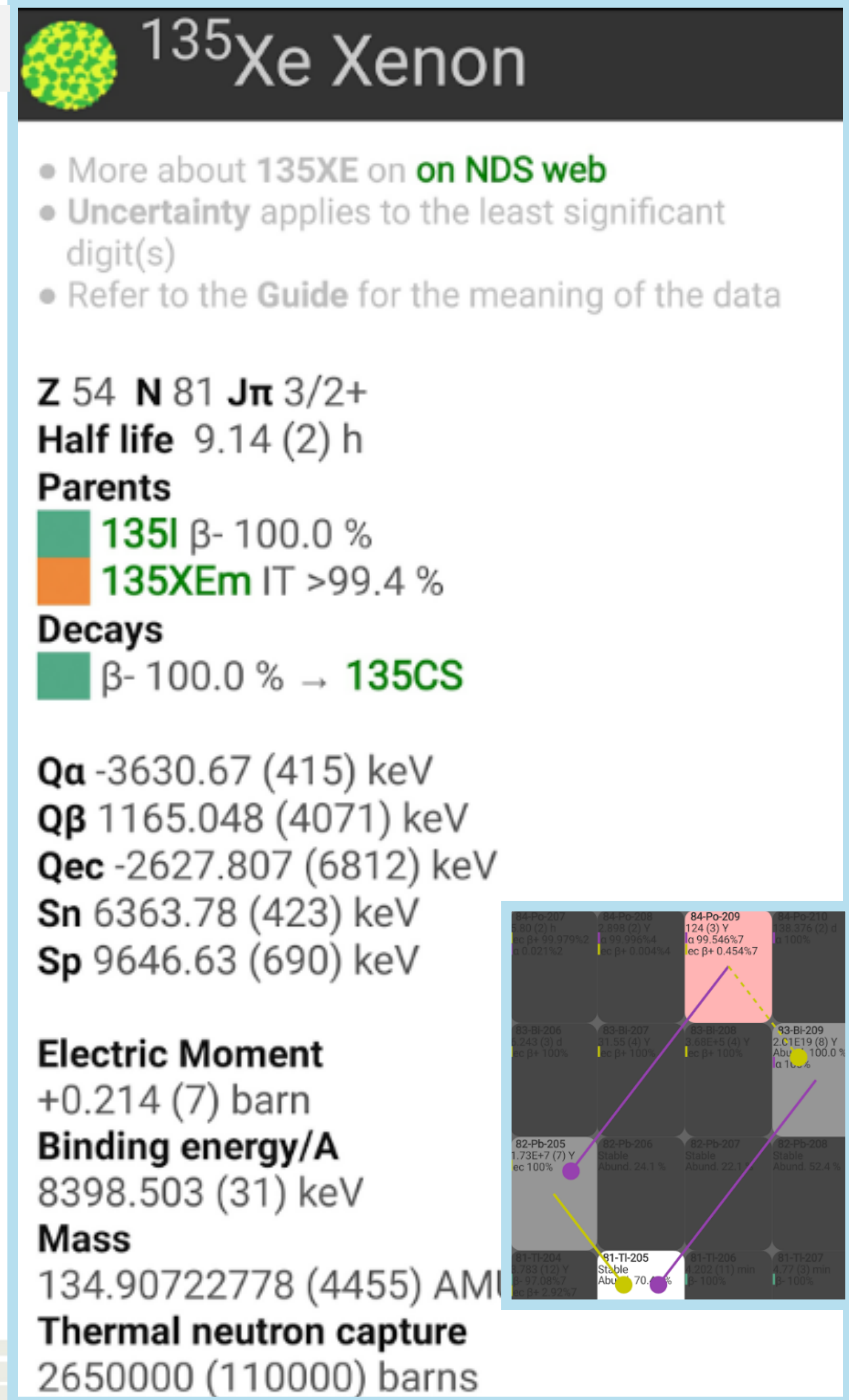




Isotope Browser - for mobile devices



- ENSDF & other nuclear structure data
- Query tool
- Chart with decay path

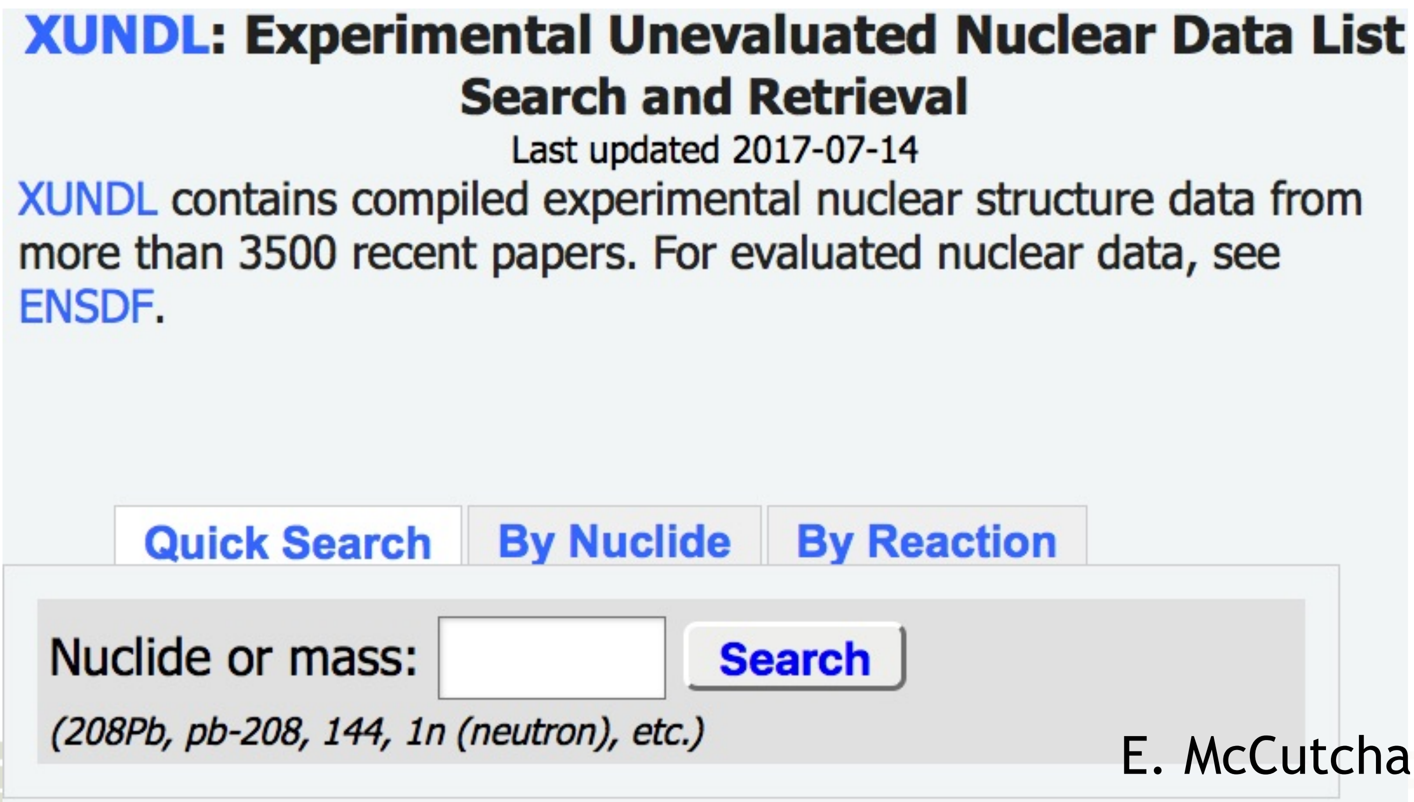


M. Verpelli (IAEA)

XUNDL Database www.nndc.bnl.gov/ensdf

Contents: Compiled (**un**evaluated) data from current publications

- >3000 nuclides (from ^{1}H to ^{294}118) with more than 4300 datasets & papers
- provide rapid access to formatted data from latest publications
- prompt updates (every week), as datasets arrive at NNDC
- often communications with the original authors exchanged either to obtain detail of data that do not appear in the paper or to resolve data-related inconsistencies



E. McCutchan (NNDC)

^{134}Ba(^{3}He,α):XUNDL-3 2016Sz03

Compiled (unevaluated) dataset from 2016Sz03: Phys Rev C94, 054314 (2016)- supplemental material.
Compiled by: F.G. Kondev (ANL); December 6, 2016.

E(^{3}He)=32 MeV beam with an average intensity of 100 nA provided by the ALTO Tandem accelerator at IPN, Orsay. Targets were 50-70 μg/cm^2 thick on a 40 μg/cm^2 carbon backing. Enge split-pole spectrometer was used to momentum analyze the outgoing ions. Their position, energy loss and residual energy were detected at the focal plane using a positive-sensitive gas chamber, a ΔE proportional counter and a plastic scintillator. The Q-value resolution was FWHM 100 keV. Measured differential cross sections. DWBA cross-section calculations were carried out using the PTOLEMY code.

Cross-section data (mb/sr)

Level	Jπ	σ(5.9°)	σ(10.9°)	σ(15.9°)	σ(20.9°)
0+12	1/2$^+$ + 3/2$^+$	0.31 2	0.23 3	0.19 1	0.19 2
288	11/2$^-$	3.65 5	2.99 7	1.96 3	1.51 6
540	1/2$^+$	0.022 5	0.050 9	0.027 4	0.040 11
578	7/2$^+$	0.22 2	0.150 14	0.112 7	0.10 2
631	5/2$^+$	0.105 14	0.069 10	0.074 5	0.072 13
791	7/2$^-$	1.19 10	0.77 6	0.59 2	0.47 3
1022	3/2$^+$	0.21 1	-	0.12 1	0.091 16
1111/1112	-	0.076 15	-	0.052 6	0.040 16
1329/1330	-	0.11 1	0.062 16	0.057 7	0.037 11
1353	7/2$^+$	0.28 1	0.21 2	0.164 12	0.109 16
1583	1/2$^-$	1.01 3	0.57 4	0.55 2	0.64 4
1771	5/2$^-$	0.25 2	0.16 2		
2177	5/2$^-$	0.32 2	0.20 3		
2455	-	0.120 2	0.17 1		
2625	-	0.32 2	0.23 2		
2765	-	0.23 2	0.10 2		
2955	-	0.18 1	0.10 2		
3310	-	0.13 1	-		
3470	-	0.17 1	-		
3710	-	0.22 2	-		

^{133}Ba Levels

E(level)†	Jπ†	$T_{1/2}$†	Comments
0.0	1/2$^+$	10.551 y *11*	
12	3/2$^+$	38.93 h *10*	
288	11/2$^-$		
540	1/2$^+$		
578	7/2$^+$		
631	5/2$^+$		
791	7/2$^-$		
1022	3/2$^+$		
1111			E(level): Two states, one at 1111.2 keV (Jπ=5/2$^-$,7/2$^-$) and another at 1112.346 keV (Jπ=3/2$^+$,5/2$^+$,7/2$^+$) are known in the Adopted Levels of the ENSDF database.
1329			E(level): Two states, one at 1329.5 keV (Jπ=7/2$^-$) and another at 1329.319 keV (Jπ=5/2$^+$) are known in the Adopted Levels of the ENSDF database.
1353	7/2$^+$		
1583	1/2$^-$		
1771	5/2$^-$		
2177	5/2$^-$		
2455‡			
2625‡			
2765‡			
2955‡			

"Google can do it all …"

Nuclear Science References (NSR)

Google scholar [24 Mg] [Search]

Results **1** - **10** of about **5,080,000**. (**0.16** sec)

a lifetime of a graduate student????

- ✓ access to the most relevant articles and evaluated data for a particular nuclide
- ✓ access the recommended (best) values for a range of nuclear properties
- ✓ search on a specific nuclear property, quantity or reaction

Quick search

Search the database by author or nuclide, within

Publication year range: [1910] to [2008]

Author: [ ] [Search]

Nuclide: [24Mg] [Search]

NSR Query Results

Publication year range : 1910 to 2008
Primary references only.

Output year order : Descending
Format : Normal

NSR database version of September 5, 2008.

Search: Nuclide = 24Mg

Found 2015 matches. Showing 1 to 100. [Next]

B. Pritychenko (NNDC)

NSR Database   www.nndc.bnl.gov/nsr

Nuclear Science References (NSR)

The previous version of Web Interface is here.

Database version of October 7, 2009

The NSR database is a bibliography of nuclear physics articles, indexed according to content and spanning nearly 100 years of research. Over 80 journals are checked on a regular basis for articles to be included. For more information, see the help page. The NSR database schema and web applications have undergone some recent changes. This is a revised version of the previous NSR Web Interface.

Quick Search | Text Search | Indexed Search | Keynumber Search | Combine View | Recent References

Author (Brown, B.A.Brown)

Nuclide (31Na, na-31)

Output format HTML BibTex Text

Publication Year from 1910 to 2009

Initialization Parameters

Publication year range: 1910 to 2009

Primary only: ☐ View All: ☐ Require measured quantity: ☐

Output year order: ○ Ascending ◉ Descending

Output format: ◉ HTML ○ BibTex ○ Text ○ Keynum ○ Exchange

◉ Search all entries ○ Search entries added since 10 / 8 / 2009 (month/day/year)

Search Parameters

(none) [ ] browse...

AND

(none) [ ] browse...

AND

(none) [ ] browse...

B. Pritychenko (NNDC)

NSR Database – cont. www.nndc.bnl.gov/nsr

NSR key number

Reference

Authors

2007DO17

Nucl.Phys. A792, 18 (2007)

C.Dossat, N.Adimi, F.Aksouh, F.Becker, A.Bey, B.Blank, C.Borcea, R.Borcea, A.Boston, M.Caamano, G.Canchel, M.Chartier, D.Cortina, S.Czajkowski, G.de France, F.de Oliveira Santos, A.Fleury, G.Georgiev, J.Giovinazzo, S.Grevy, R.Grzywacz, M.Hellstrom, M.Honma, Z.Janas, D.Karamanis, J.Kurcewicz, M.Lewitowicz, M.J.Lopez Jimenez, C.Mazzocchi, I.Matea, V.Maslov, P.Mayet, C.Moore, M.Pfutzner, M.S.Pravikoff, M.Stanoiu, I.Stefan, J.C.Thomas

The decay of proton-rich nuclei in the mass A = 36-56 region

NUCLEAR REACTIONS Ni(^{58}Ni, X), E=74.5 MeV/nucleon; measured fragments isotopic yields.

RADIOACTIVITY ^{36,37}Ca, ^{39,40,41}Ti, ^{43}V, ^{42,43,44,45}Cr, ^{46,47}Mn, ^{46,47,48,49}Fe, ^{50,51}Co, ^{49,50,51,52,53}Ni, ^{55}Cu, ^{55,56}Zn(β^+), (EC), (β^+p) [from Ni(^{58}Ni, X)]; measured $T_{1/2}$, β-delayed proton and γ spectra, branching ratios. ^{43,45}Cr, ^{46}Mn, ^{46,47,48}Fe, ^{50}Co, ^{50,51,52,53}Ni deduced levels. Two-proton decay observed. Comparison with model predictions.

doi: 10.1016/j.nuclphysa.2007.05.004

Data from this article have been entered in the XUNDL database. For more information, click here.

Link to article (PDF), requires subscritption

Keywords, which describe article's content

Link to data in article

Horizontal Evaluations & Topical Reviews

Nuclear Data Sheets v. 97 (2002) 241

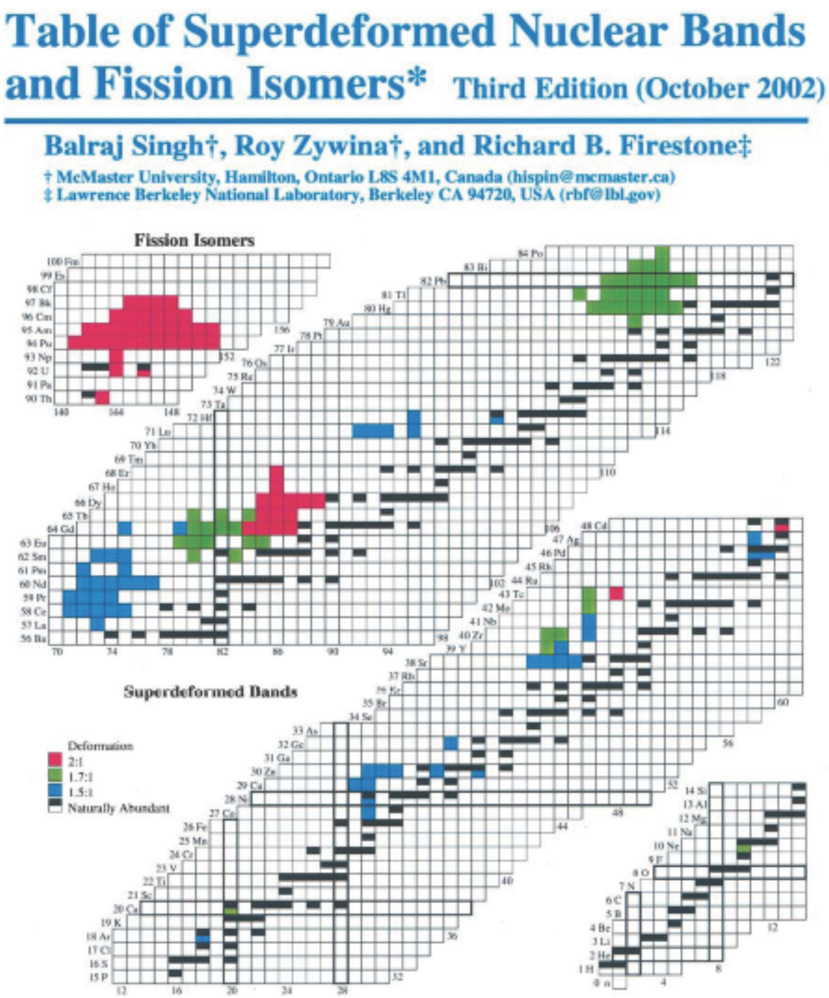


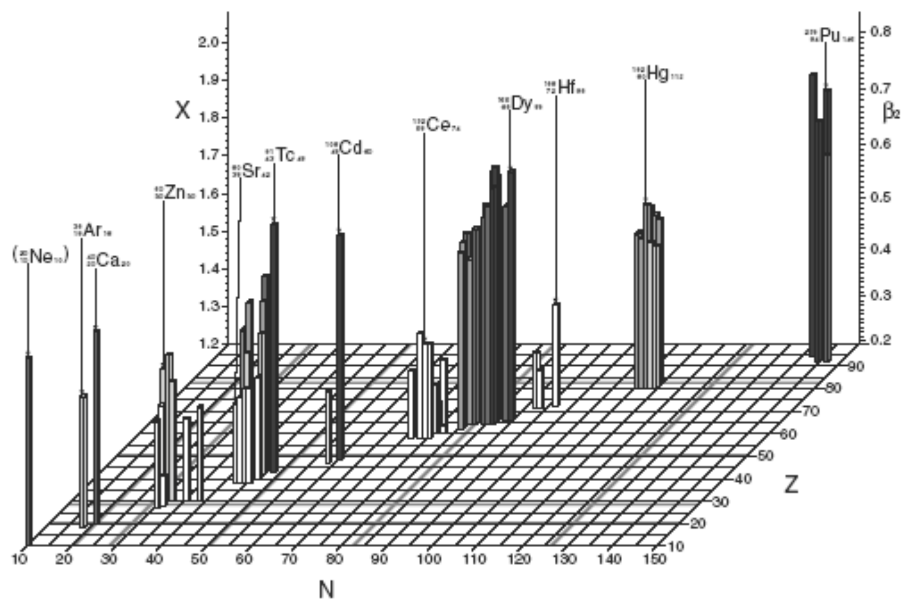
Table of Superdeformed Nuclear Bands and Fission Isomers* Third Edition (October 2002)

Balraj Singh†, Roy Zywina†, and Richard B. Firestone‡

† McMaster University, Hamilton, Ontario L8S 4M1, Canada (hispin@mcmaster.ca)
‡ Lawrence Berkeley National Laboratory, Berkeley CA 94720, USA (rbf@lbl.gov)

- ❑ Log *ft* values in β-/(e+b+) decay
- ❑ Alpha-decay HF from even-even nuclei
- ❑ Nuclear Moments (μ and Q_0)
- ❑ Proton Radioactivity Decay Data

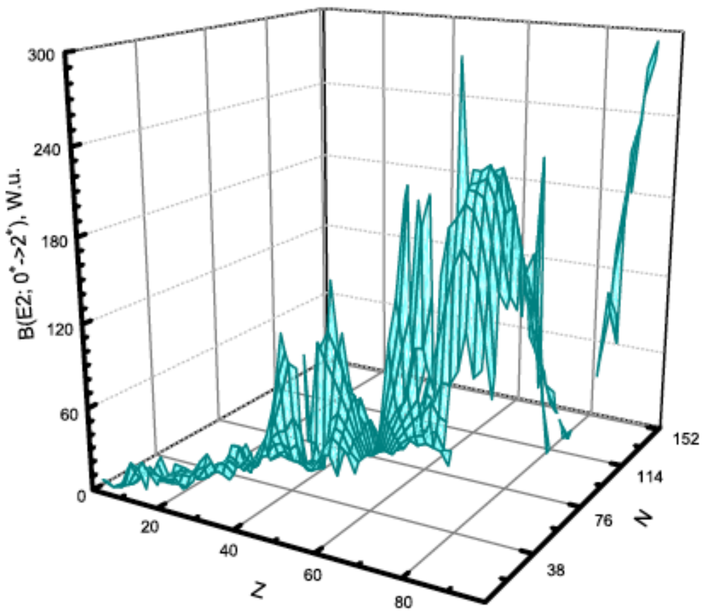
many other applications oriented …



Atomic Data and Nuclear Data Tables 107 (2016) 1–139

Tables of E2 transition probabilities from the first 2^+ states in even–even nuclei

B. Pritychenko [a,*], M. Birch [b], B. Singh [b], M. Horoi [c]



- Previous evaluation by S. Raman, C.W. Nestor, P. Tikkanen, At. Data and Nucl. Data Tables 78, 1-126 (2001)
- The new tables provide evaluated values; shell-model calculations for selected nuclei

www.nndc.bnl.gov/be2

Reduced Transition Probabilities or B(E2; $0^+ \rightarrow 2^+$) Values

Adopted Values | Experimental Values | Predicted Values

Recent data on electric quadrupole transition probabilities or **B(E2; $0^+ \rightarrow 2^+$)** values.
New Evaluation: ***Tables of E2 transition probabilities from the first 2^+ states in even-even nuclei***, B. Pritychenko, M. Birch, B. Singh, M. Horoi, At. Data Nucl. Data Tables **107**, 1 (2016).

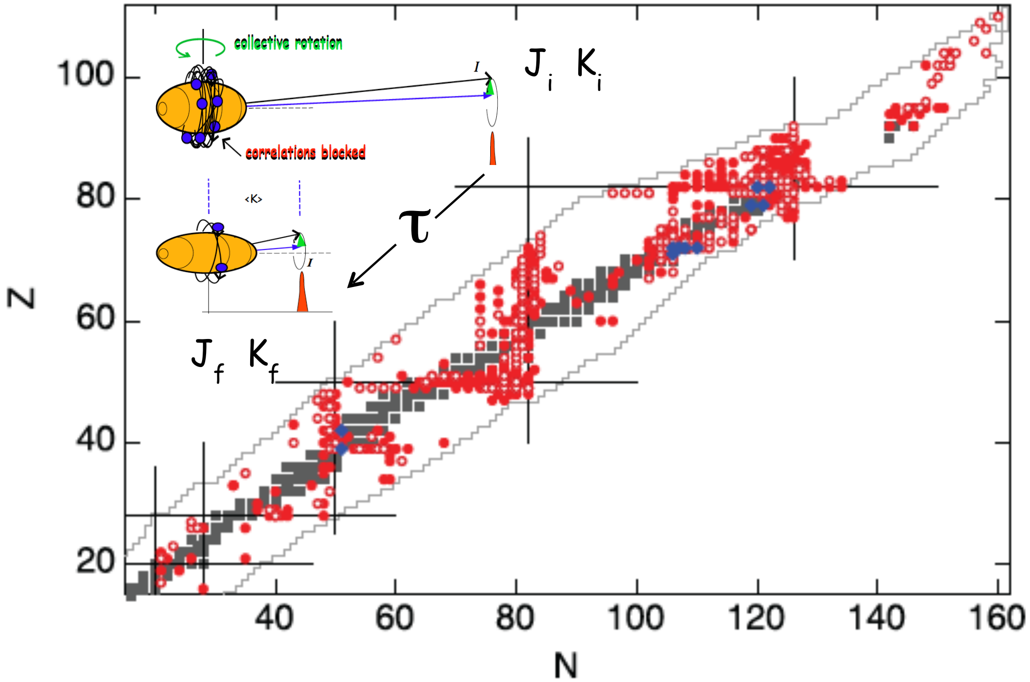
Nucleus
30Mg, mg-30, 12-mg-30, 12030
A
N
Z

Submit Reset

Atomic Data and Nuclear Data Tables 103–104 (2015) 50–105

Configurations and hindered decays of *K* isomers in deformed nuclei with A > 100

F.G. Kondev[a,*], G.D. Dracoulis[b,1], T. Kibédi[b]



Previous work:
K.E.G. Lobner, Phys. Lett. B26 (1968)
L.I. Russinov, Sov. Phys. Uspekhi 2 (1961)

- examined **373** isomers
- evaluated **1050** K-forbidden decays
  - ✓ compared to **250** by Lobner
  - ✓ compared to **22** by Rusinov

✓ reduced hindrance per degree of K-forbiddenness $f_\nu = F_w^{1/\nu}$
rule of thumb -> Fw increase by 100 per a unit of ν
✓ $Fw = F_0 \times f_0^{\nu}$: intrinsic and K-forbidden parts
ADNDT2015 -> Fw increase by ~10 per a unit of ν

IOP Publishing

Review of metastable states in heavy nuclei

G D Dracoulis[1,4], P M Walker[2] and F G Kondev[3]

Rep. Prog. Phys. **79** 07630

Nuclear Moments

Atomic Data and Nuclear Data Tables 90 (2005) 75–176

Table of nuclear magnetic dipole and electric quadrupole moments

N.J. Stone

Atomic Data and Nuclear Data Tables 111–112 (2016) 1–28

Table of nuclear electric quadrupole moments

N.J. Stone *

IAEA
International Atomic Energy Agency

INDC(NDS)-0658
Distr. ND

INDC International Nuclear Data Committee

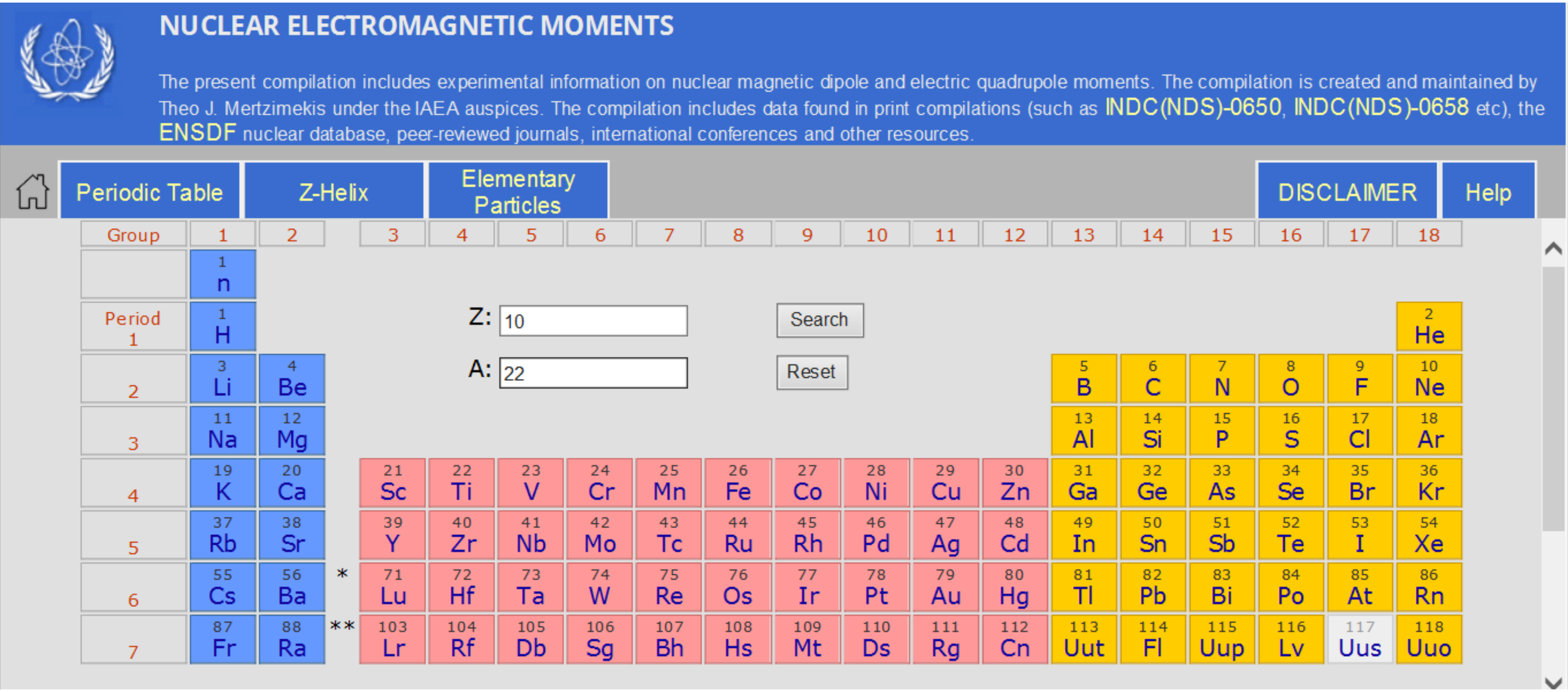
TABLE OF NUCLEAR MAGNETIC DIPOLE AND ELECTRIC QUADRUPOLE MOMENTS

https://www-nds.iaea.org/publications/

Nuclear Moments Database

Online access to printed compilations (Stone etc)

Access to references (DOI, NSR links)



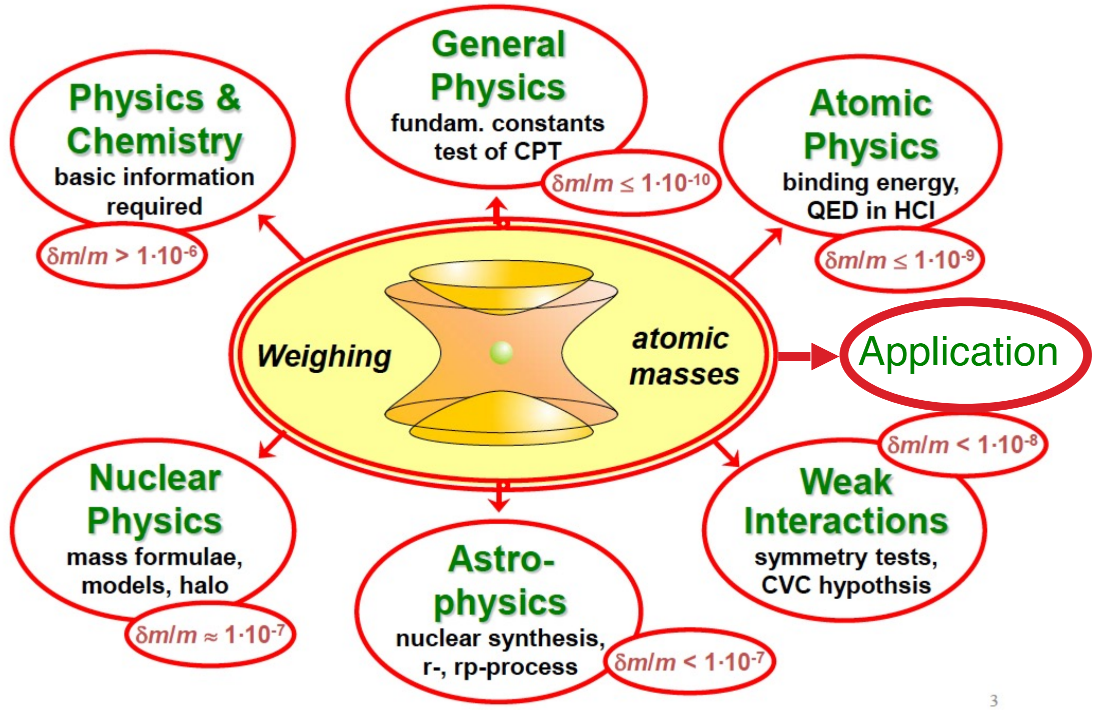
Future improvements: search criteria, plotting capabilities

wwww-nds.iaea.org/nuclearmoments/

Atomic Mass Evaluation & NuBase

- Correlations
  - ✓ pairing
  - ✓ p-n

- Binding energies
  - ✓ mass models
  - ✓ shell structure



- Reaction & decay phase space
  - ✓ Q values
  - ✓ decay & reaction probabilities

- The limits of existence
  - ✓ drip lines
  - ✓ specific configurations and topologies

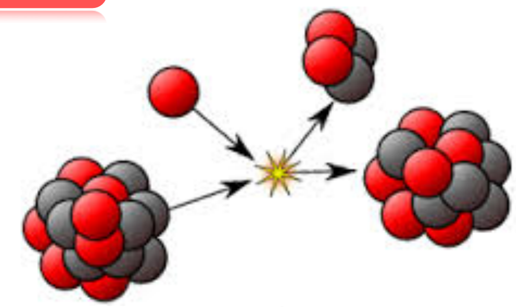
- combines the experimental results from mass and energy measurements produced in many nuclear physics laboratories using a procedure established by A.H. Wapstra in the early 1950's
  - ✓ recommended (best) values for the atomic masses and their uncertainties
  - ✓ extrapolation to the extremes using the smoothness of the mass surface

Experimental Data

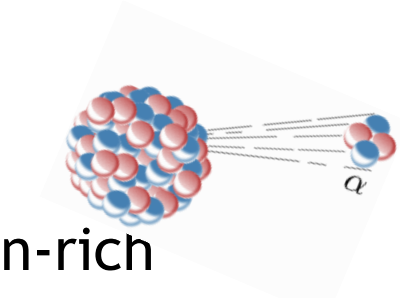
❑ Indirect methods:

✓ Reaction Energies – A(a,b)B: $Q_r = M_A + M_a - M_b - M_B$

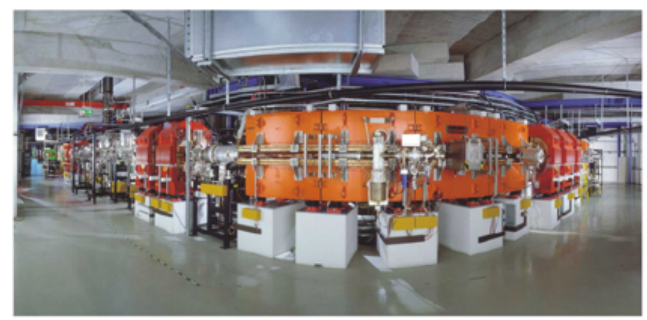
- (n,γ) and (p,γ) are the backbone
- self-calibrated - A(a,b)B vs. C(a,b)D
- close to stability



✓ Decay Energies in $\beta-$, α and p decays



- far from stability – α and p (proton-rich) & $Q_{\beta-}$ neutron-rich



❑ Direct methods:

✓ various mass spectrometry techniques using TOF, Penning Traps, Storage Rings spectrometers, etc.

- far from stability
- high precision

AME & NuBase - historical perspective

- **long & rich history**

  Ame1955, Ame1961, Ame1964, Ame1971, Ame1977
  Ame1983, Ame1993, Ame2003 -> A.H. Wapstra & G. Audi

citations: >1750

CPC(HEP & NP), 2012, **36**(12): 1603–2014 Chinese Physics C Vol. 36, No. 12, Dec., 2012

The AME2012 atomic mass evaluation *

(II). Tables, graphs and references

M. Wang[1,2,3], G. Audi[2,§], A.H. Wapstra[4,†], F.G. Kondev[5], M. MacCormick[6], X. Xu[1,7], and B. Pfeiffer[8,‡]

CSNSM — Centre de Sciences Nucléaires et de Sciences de la Matière

Ame2012

IPN — Institut de Physique Nucléaire Orsay

IMP

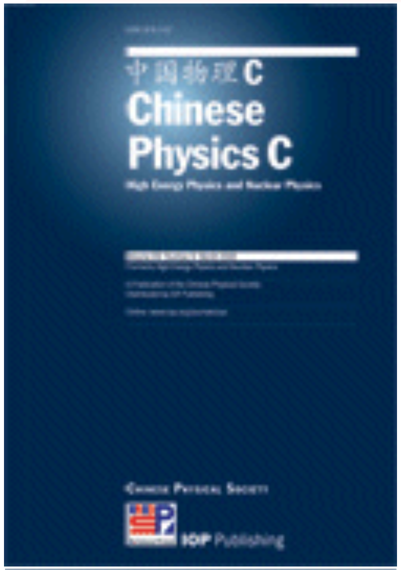
Max-Planck-Institut für Kernphysik

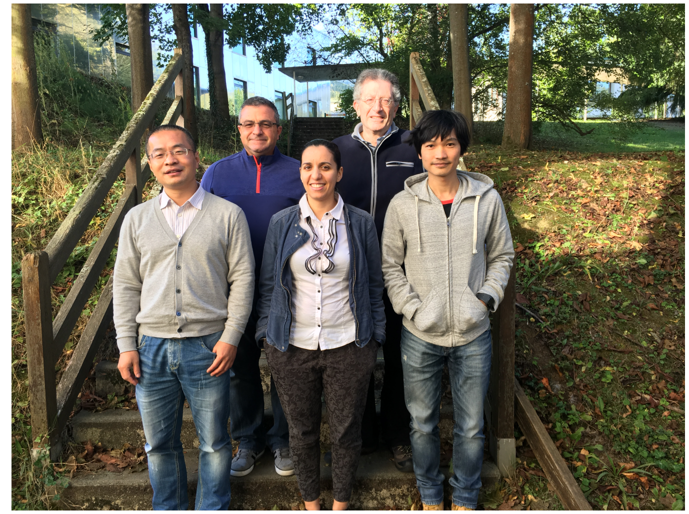
GSI

Argonne National Laboratory

collaborative effort led by G. Audi

AME2016





Chinese Physics C Vol. 41, No. 3 (2017) 030003

The AME2016 atomic mass evaluation *

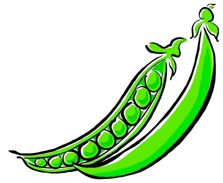
Meng Wang (王猛)[1,2;1)] G. Audi (欧乔治)[3] F.G. Kondev[4] W.J. Huang(黄文嘉)[3] S. Naimi[5] Xing Xu(徐星)

✓ **led by M. Wang (AME) and G. Audi (NuBase)**

- **AME2016**: continuing impact of direct mass spectrometry techniques using Penning Traps & Storage Rings spectrometers - high precision & far from stability … also new data in the region of heavy elements …

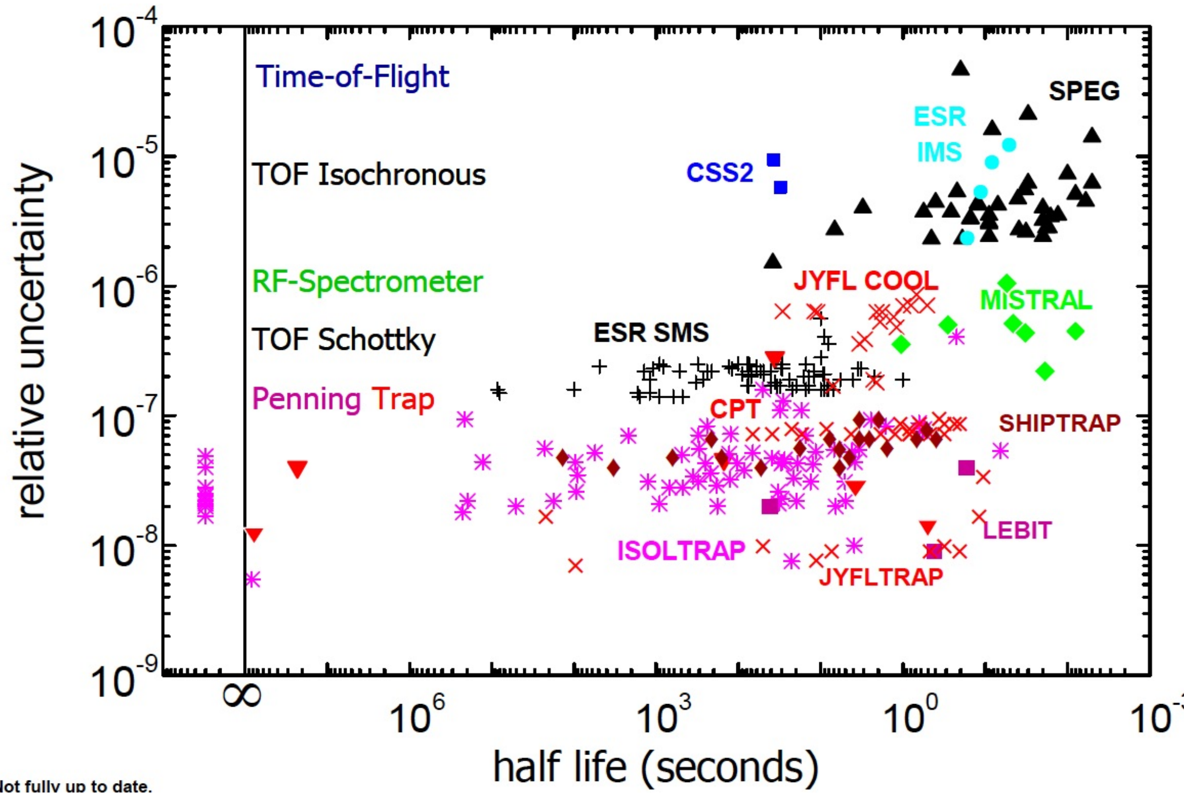
Experimental Data – cont.

M ~ 500 t = $5x10^8$ g
(Dreamliner)



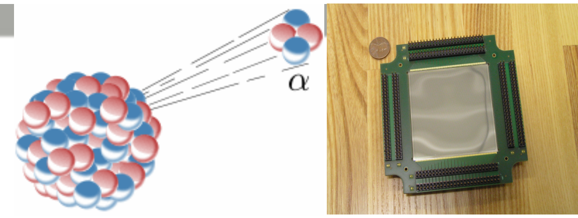
m ~ 1 g (bean seed)

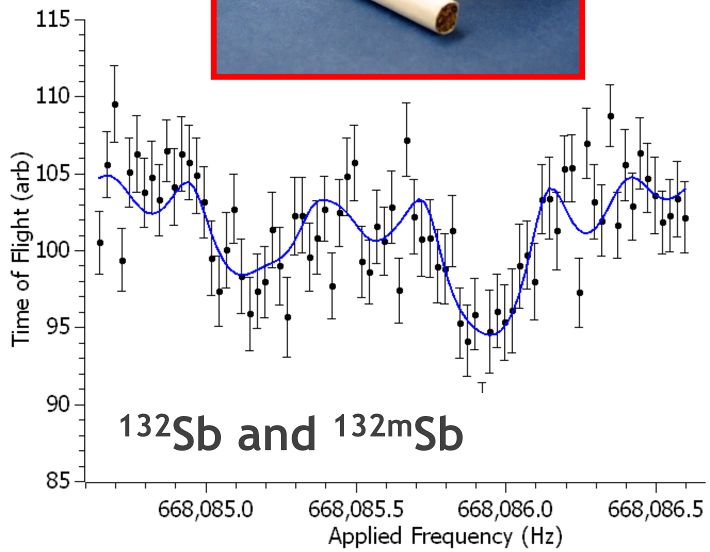
m/M=1 g / $5x10^8$ g = $5x10^{-9}$



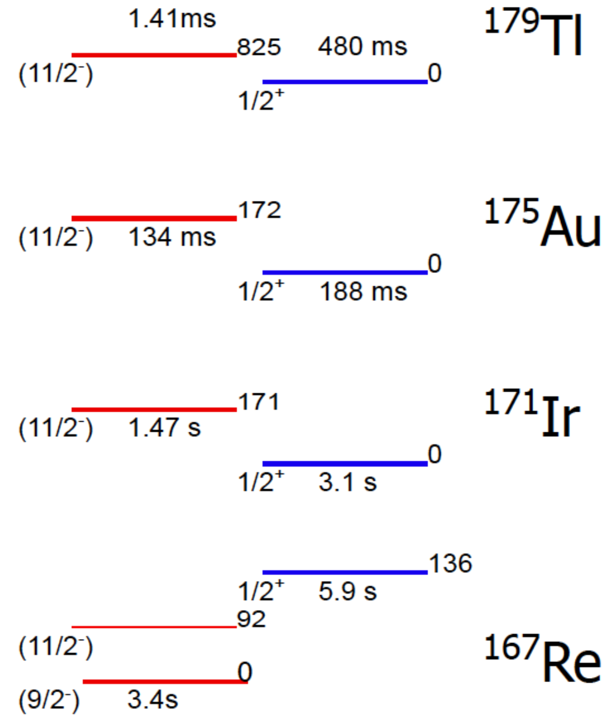
lot fully up to date.

AME & NuBASE - cont.

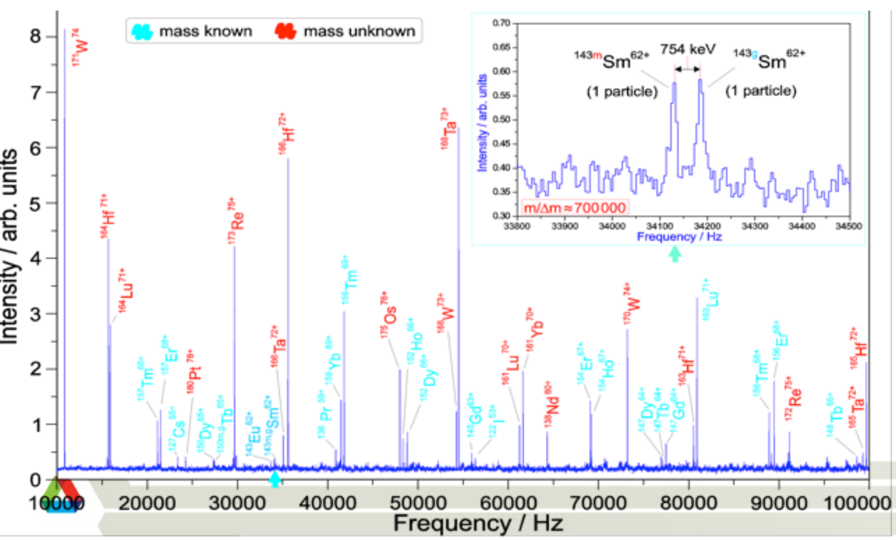




J. Van Schelt et al., PRL111 (2013) 061102



F.G. Kondev et al., EPJ (2013)



Beware of … Isomers

Do we have the right relation?

- ✓ Excitation energy
- ✓ Lifetime
- ✓ Decay mode

NuBASE2016

Chinese Physics C Vol. 41, No. 3 (2017) 030001

The NUBASE2016 evaluation of nuclear properties *

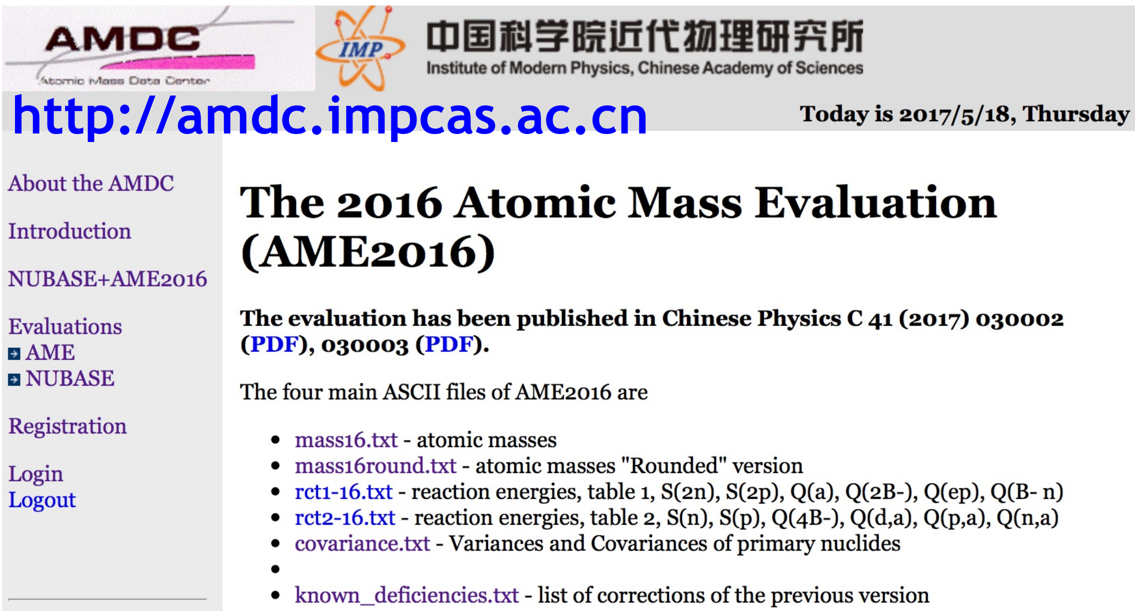
G. Audi (欧乔治)[1] F.G. Kondev[2] Meng Wang (王猛)[3,4;1)] W.J. Huang(黄文嘉)[1] S. Naimi[5]

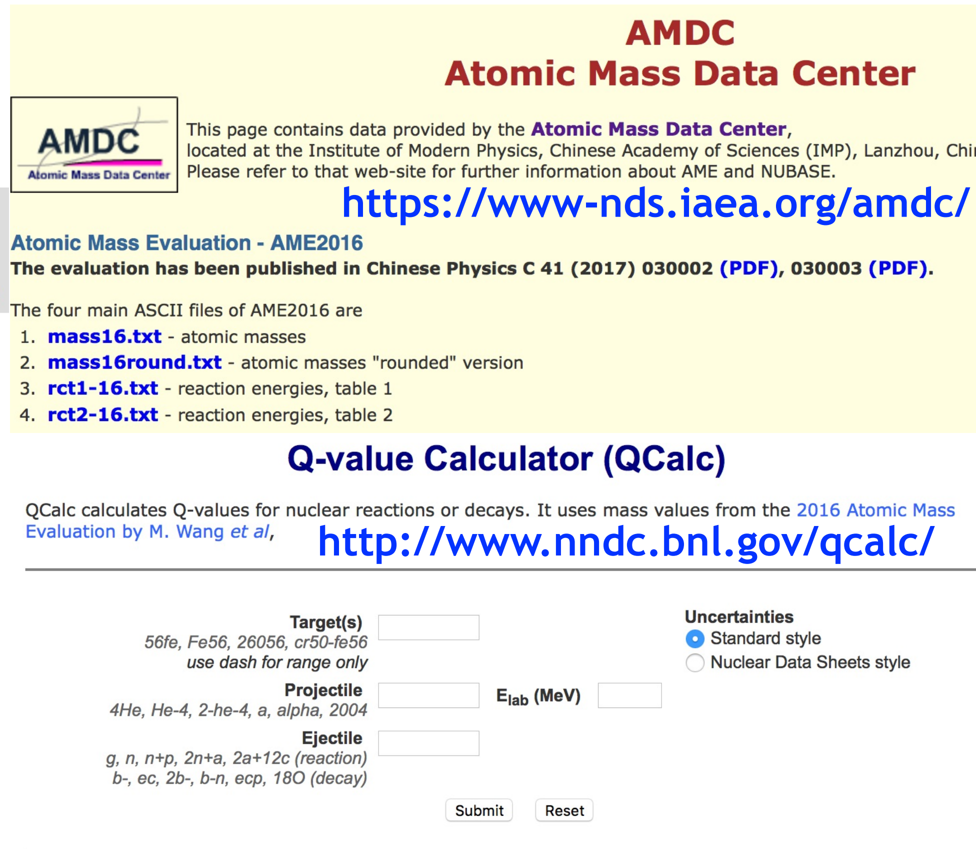
- basic nuclear level properties of relevance to AME: Ex, Jπ, $T_{1/2}$, decay modes: β−n, β−2n, ECp, EC2p,…

- independently evaluated; based on ENSDF, but includes new data from the most recent references

	ground state		isomer ($T_{1/2}$>100 ns)	
	NUBASE12	NUBASE16	NUBASE12	NUBASE16
# of cases	3379	3436	1769	1839
stable	286	286	1	1
with Jπ	3043 (92%)	3138 (93%)	1647 (93%)	1724 (94%)
with firm Jπ	1816 (55%)	1866 (55%)	724 (41%)	747 (41%)
with T1/2	3288 (99%)	3371 (100%)		
with T1/2 (exp)	2892 (87%)	3027 (90%)	1664 (94%)	1734 (94%)
β−	1343	1376	205	220
β+	1236	1259	334	343
α	852	872	194	205
p	63	74	26	27
SF	192	203	40	45
β-n	583	609	20	27
β+p	243	265	28	29

Dissemination



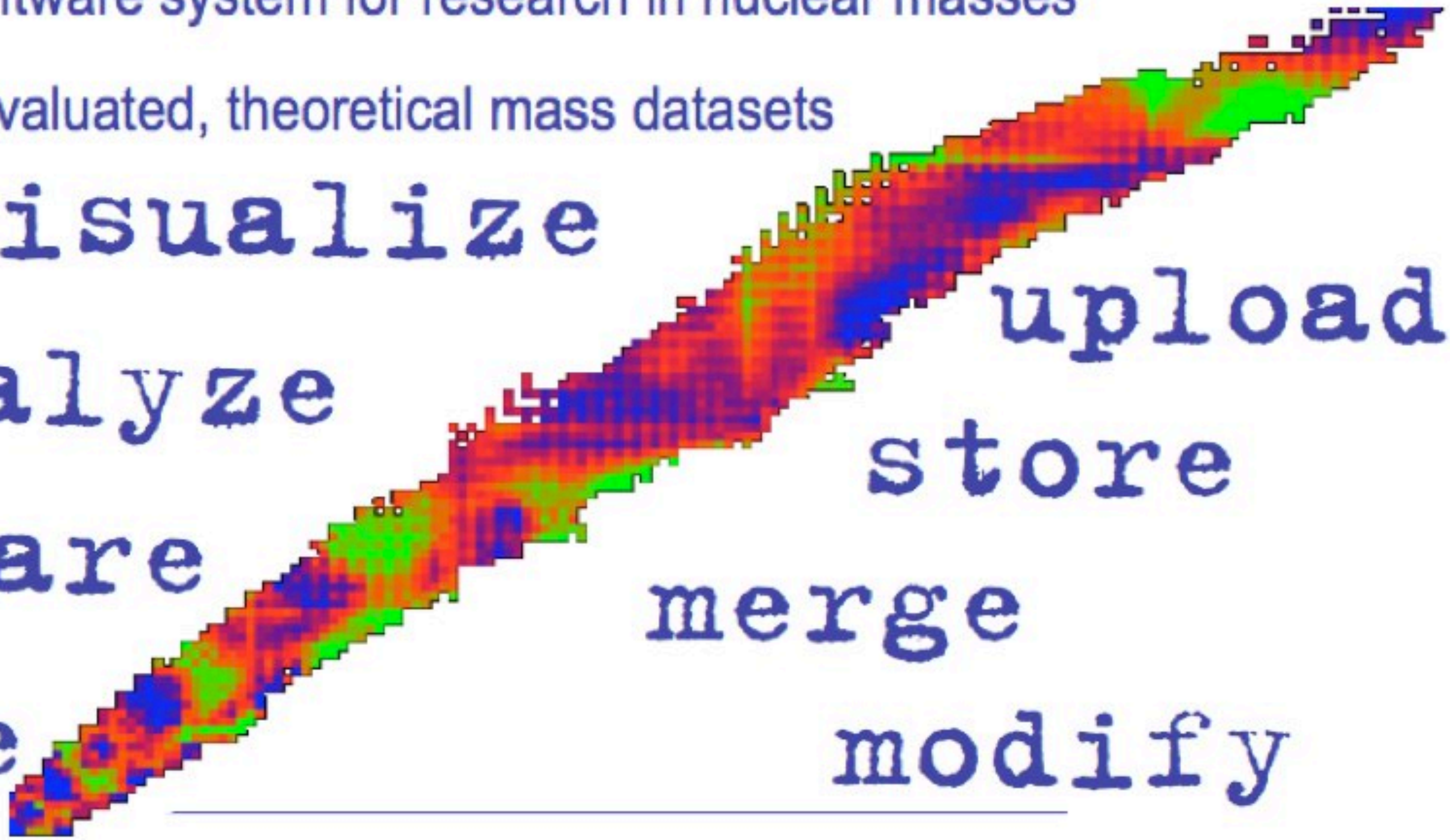


- the end users are recommended to use the data in the rct1-16.txt and rct2-16.txt files
  - ✓ take into account correlations (explained in the 2nd AME paper)
  - ✓ uncertainties for the most precise values are listed as '0.00' - the end users need to calculate them using the correlation matrix (2nd AME paper) and non-rounded mass data (mass16.txt)

nuclearmasses.org

free online software system for research in nuclear masses

experimental, evaluated, theoretical mass datasets



visualize

analyze

compare

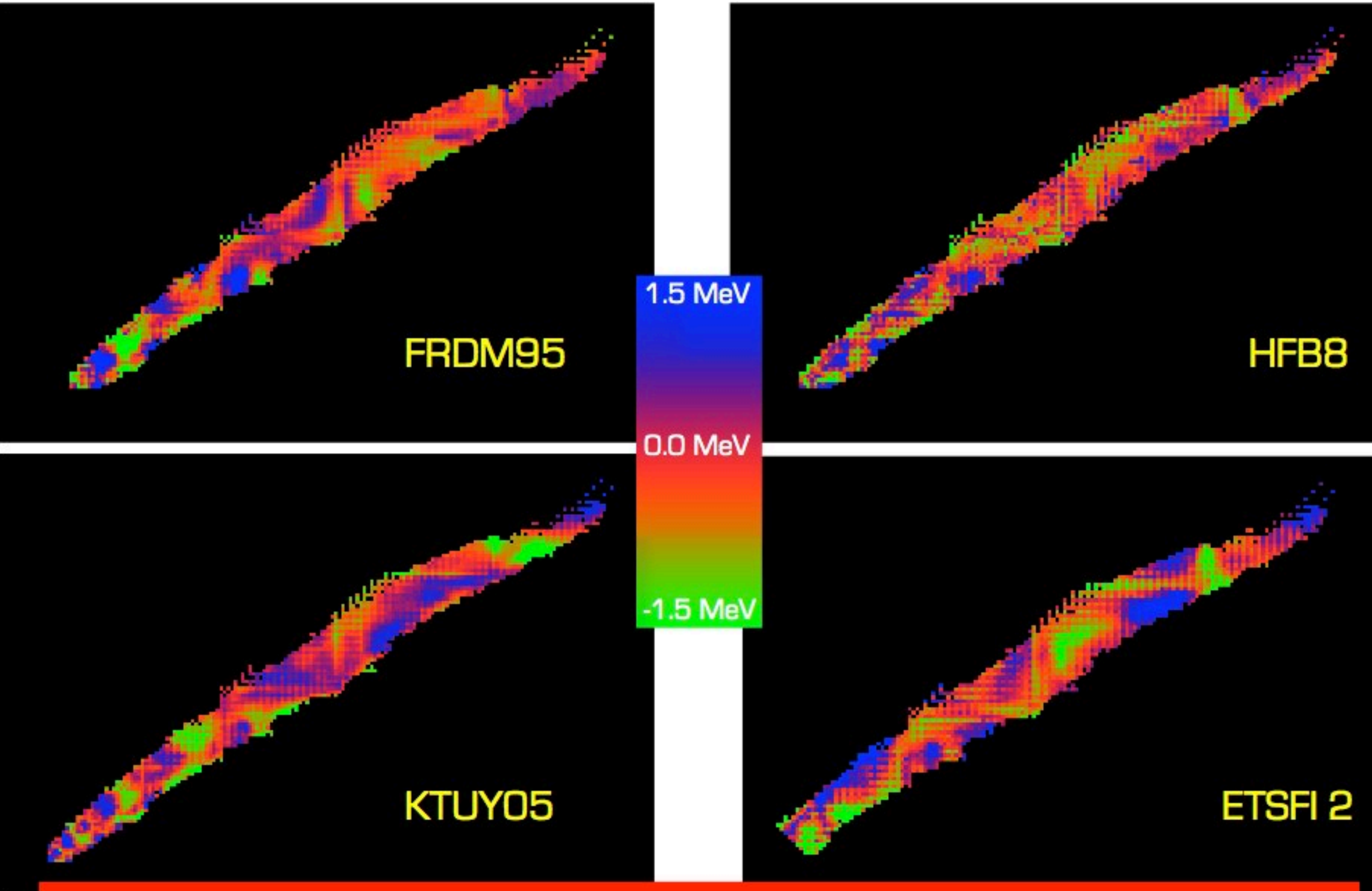
share

upload

store

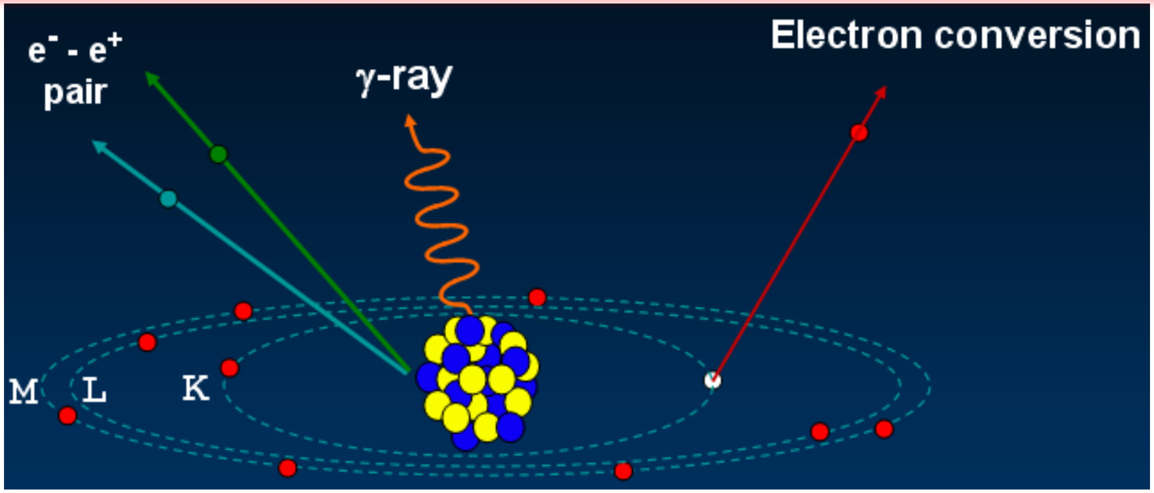
merge

modify

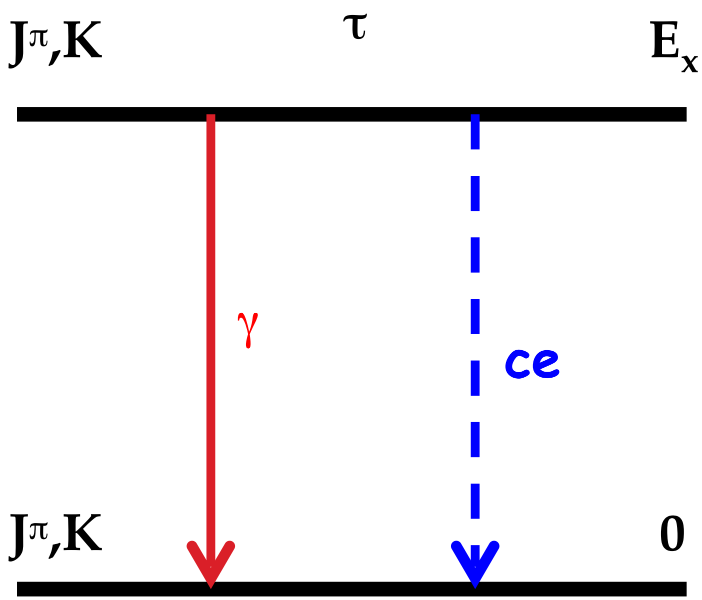


quickly compare mass differences between models & AME2003 masses

Internal Electron Conversion



$$\Gamma = \Gamma_\gamma + \Gamma_{CE} = \hbar/\tau$$



Transition probability

$$\lambda_T = \lambda_\gamma + \lambda_K + \lambda_L + \lambda_M \ldots\ldots + \lambda_\pi$$

Conversion Coefficient

$$\alpha_{ce,\pi} = \lambda_{ce,\pi} / \lambda_\gamma$$

$\alpha \sim E_\gamma$

Z – atomic number

electron shell or

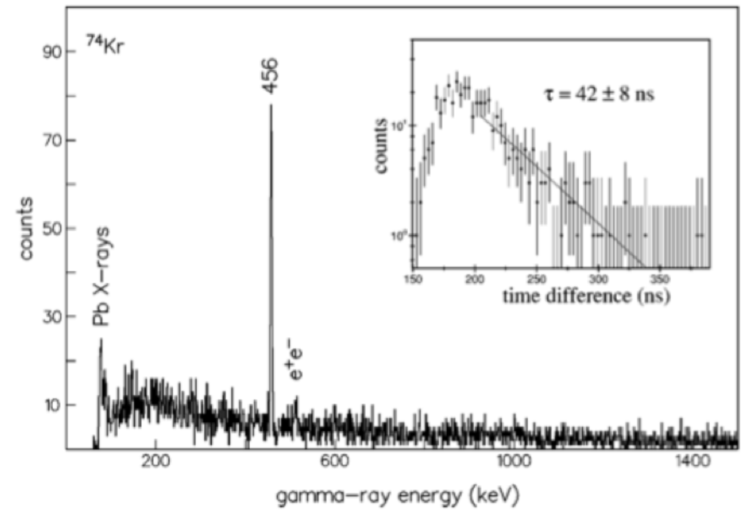
electron-positron pair

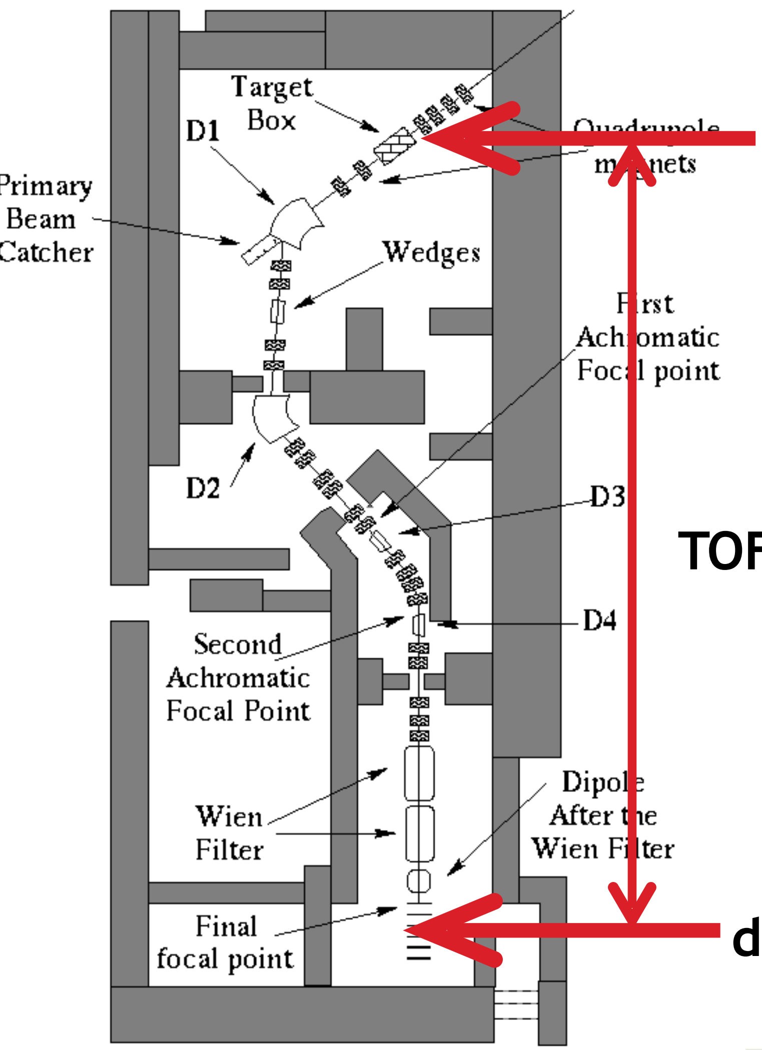
XL - transition multipolarity

very useful spectroscopy tool

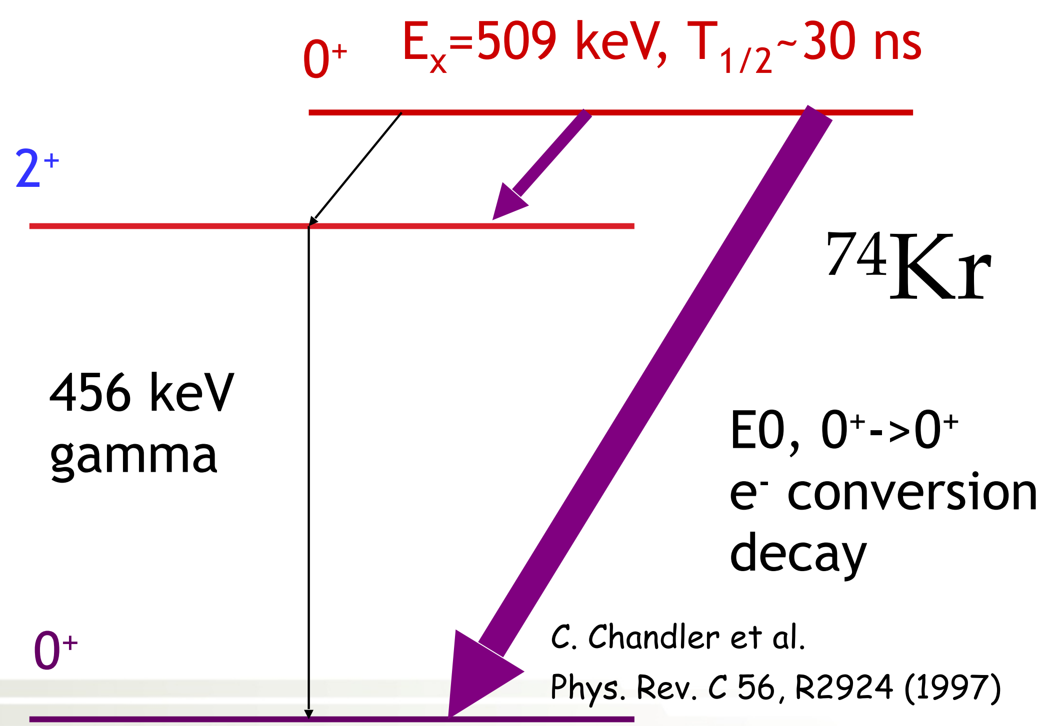
Manipulating lifetimes – undressing the isomer

$$\Gamma = \Gamma_\gamma + \Gamma_{CE} + \Gamma_{E0} = \hbar/\tau$$





Result is that the **bare nuclear isomeric lifetime is increased** compared to 'atomic' value. (important in explosive stellar scenarios).



C. Chandler et al.
Phys. Rev. C 56, R2924 (1997)

THE AUSTRALIAN NATIONAL UNIVERSITY

Department of Nuclear Physics

Research School of Physical Sciences and Engineering

http://www.rsphysse.anu.edu.au/nuclear/bricc/

Reference:
2008Ki07 T. Kibédi, T.W. Burrows, M.B. Trzhaskovskaya, P.M. Davidson, C.W. Nestor, Jr.
'Evaluation of theoretical conversion coefficients using BrIcc'
Nucl. Instr. and Meth. A 589 (2008) 202-229

BrIcc
- BrIcc Home
- Quick reference
- Data tables
- Program manual
- Obtaining BrIcc
- Version history
- Authors

Z (atomic number or symbol)
82

γ-energy (in keV)
300 Uncertainty

Enter (optional) uncertainty in energy as **x** or **+x-y**

Multipolarity
δ Uncertainty

Enter (optional) uncertainty in δ as **x** or **+x-y**

Show Subshells **Data Set** BrIccFO

Calculate Reset

BrIccS v2.2a (13-Jul-2008)

Z=82 (Pb, Lead)

γ-energy: 300 keV

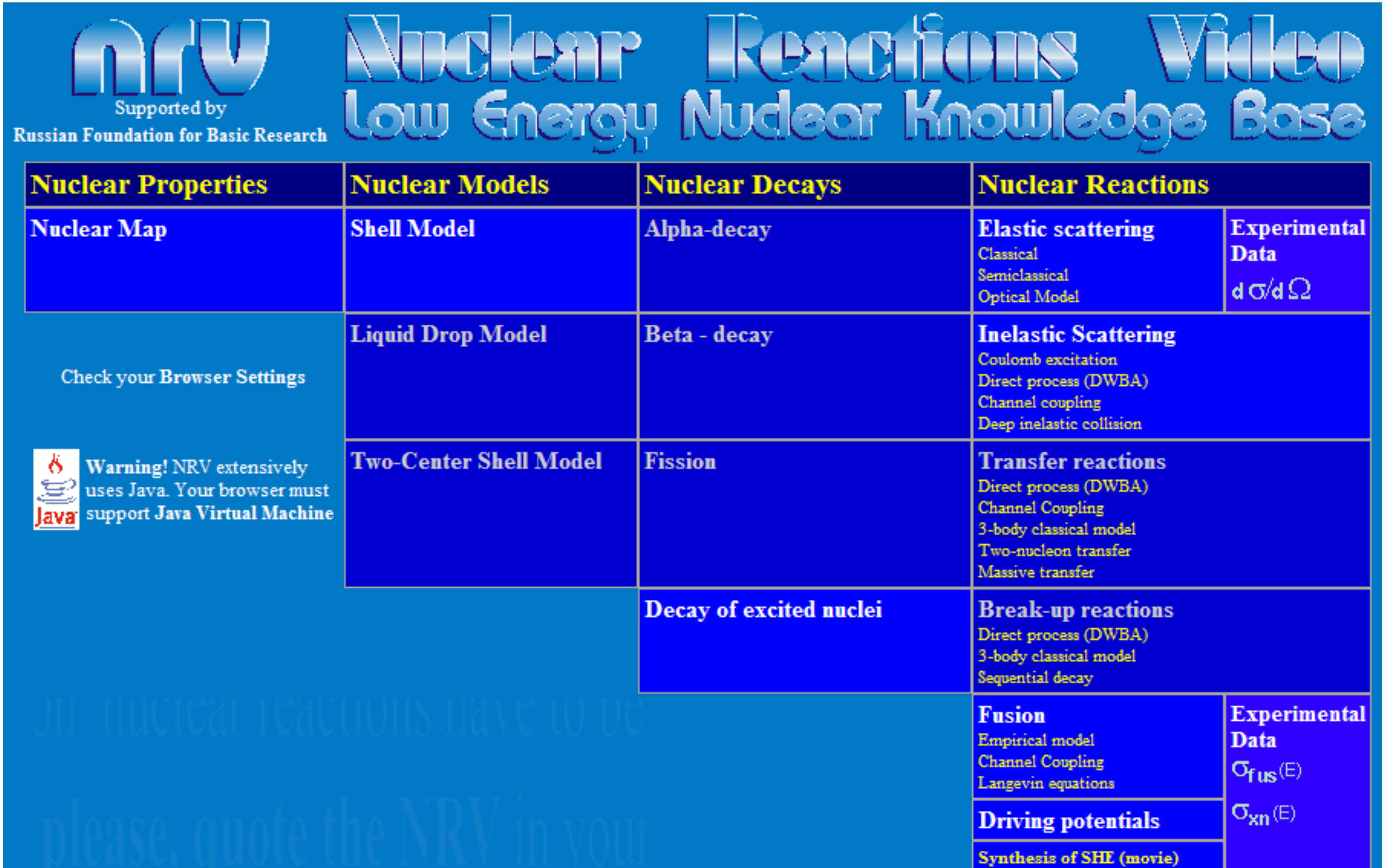
Data Sets: BrIccFO BeOmg

Shell	E(ce)	E1	M1	E2	M2	E3	M3	E4	M4	E5	M5
Tot		2.953E-02	4.265E-01	1.155E-01	1.593E+00	6.311E-01	5.203E+00	3.583E+00	1.870E+01	1.944E+01	7.574E+01
K	212.00	2.419E-02	3.487E-01	6.502E-02	1.202E+00	1.745E-01	3.292E+00	4.761E-01	8.847E+00	1.330E+00	2.385E+01
L-tot		4.090E-03	5.953E-02	3.787E-02	2.953E-01	3.381E-01	1.420E+00	2.271E+00	7.179E+00	1.301E+01	3.701E+01
M-tot		9.549E-04	1.394E-02	9.723E-03	7.269E-02	9.094E-02	3.746E-01	6.404E-01	2.038E+00	3.904E+00	1.133E+01
N-tot		2.406E-04	3.542E-03	2.458E-03	1.862E-02	2.313E-02	9.675E-02	1.641E-01	5.309E-01	1.010E+00	2.980E+00
N+		2.917E-04	4.324E-03	2.937E-03	2.267E-02	2.758E-02	1.169E-01	1.954E-01	6.372E-01	1.200E+00	3.554E+00
O-tot		4.675E-05	7.061E-04	4.518E-04	3.679E-03	4.209E-03	1.866E-02	2.964E-02	9.981E-02	1.802E-01	5.470E-01
P-tot		4.332E-06	7.553E-05	2.764E-05	3.676E-04	2.389E-04	1.537E-03	1.662E-03	6.420E-03	9.934E-03	2.701E-02

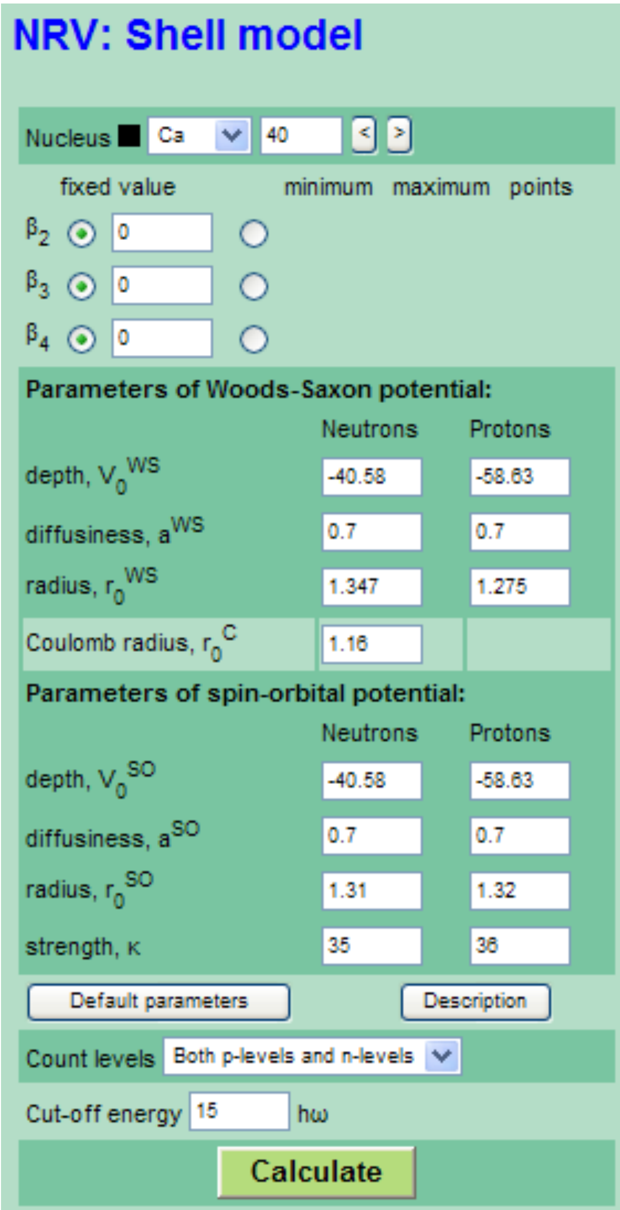
Shell	E(ce)	Ω(E0)
K	212.00	2.434E+11
L1	284.14	4.179E+10
L2	284.80	1.064E+09
Tot		2.863E+11
K/Tot		8.503E-01

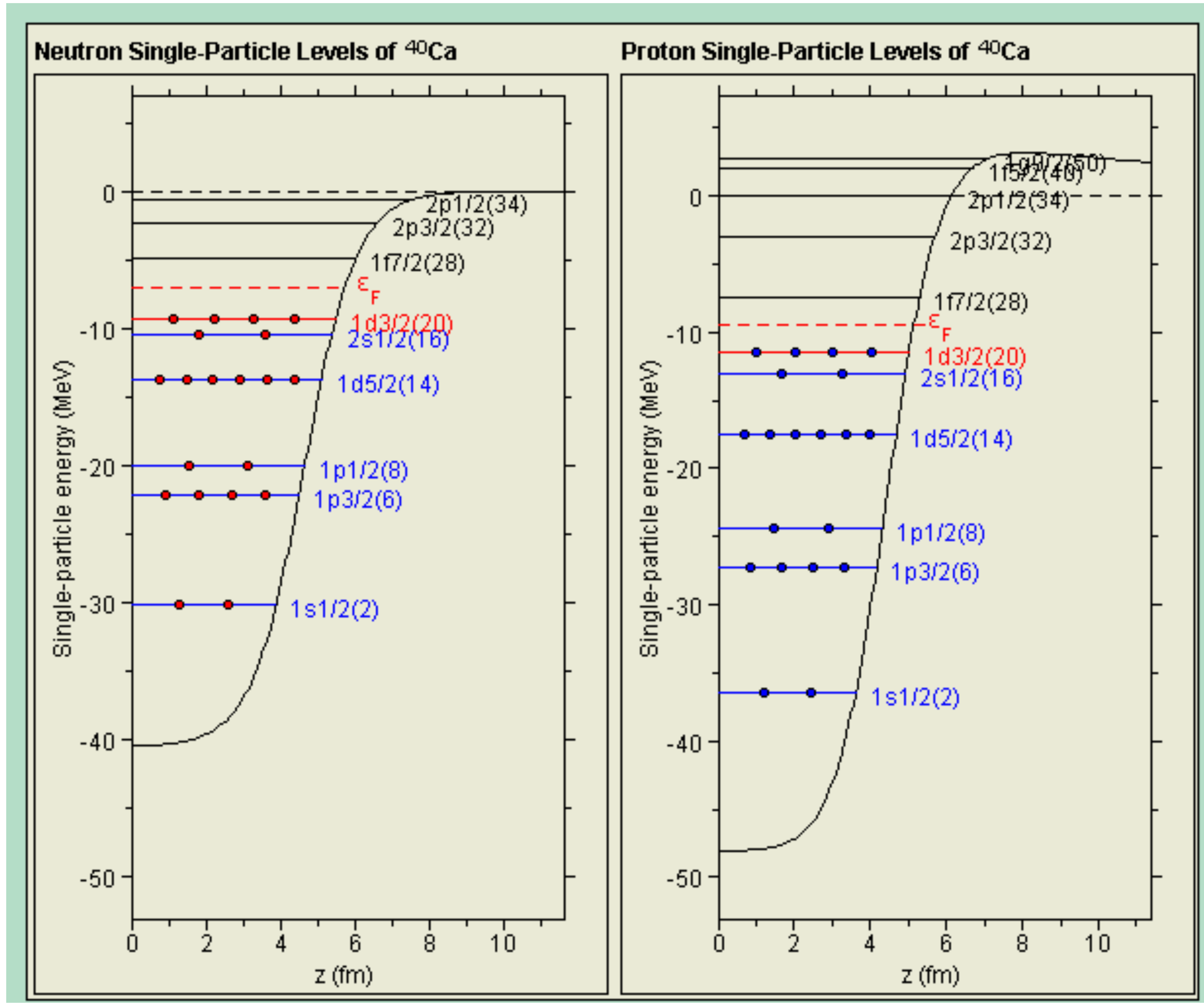
http://www-nds.iaea.org/

http://nrv.jinr.ru/nrv/

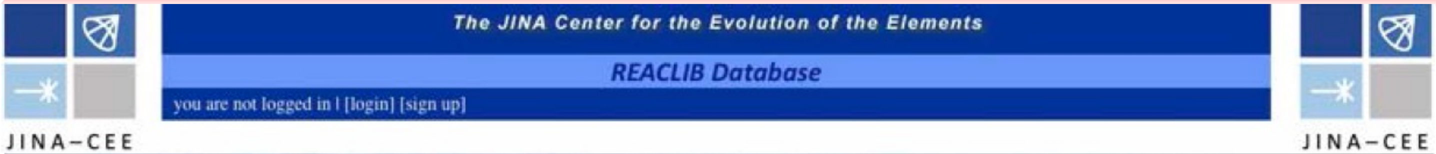


NRV – an example

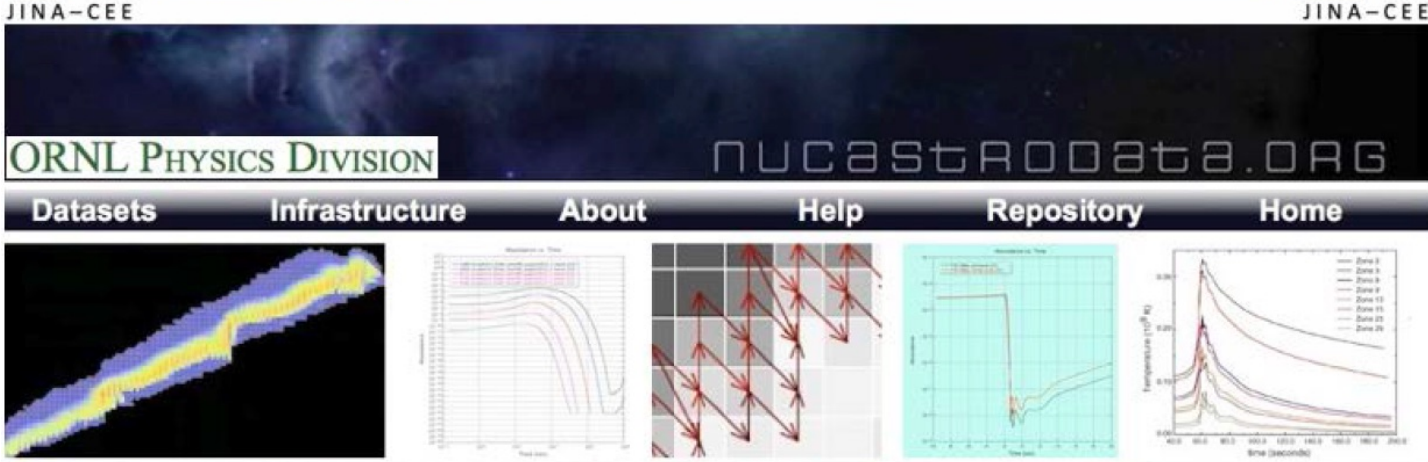




Nuclear Astrophysics



groups.nscl.msu.edu/jina/reaclib/db/@ MSU



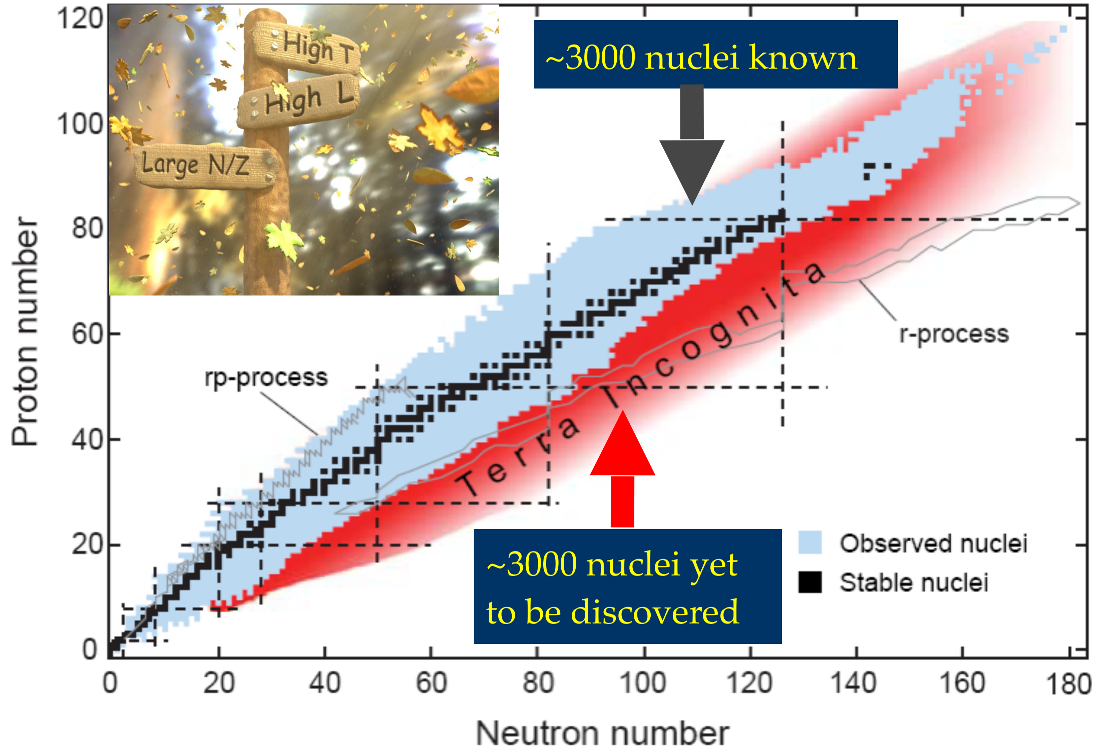
nucastrodata.org @ORNL

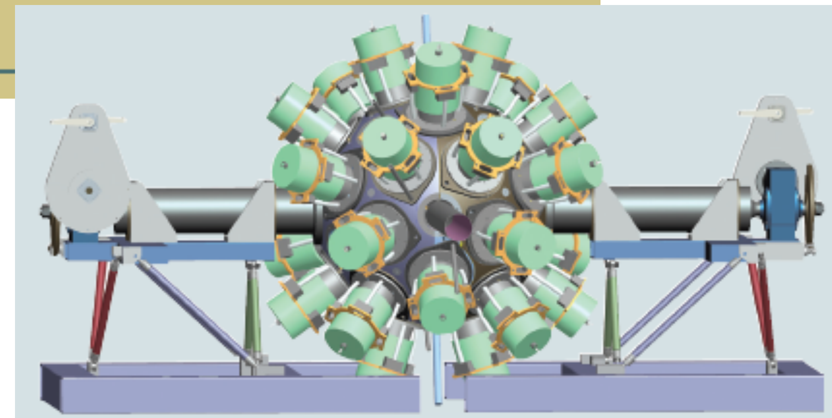
starlib.physics.unc.edu @UNC

The Frontiers of Nuclear Science

A LONG RANGE PLAN

Opportunities





GRETINA-AGATA γ–ray tracking arrays

a **surge** of new data can be foreseen in the near future – **nuclear structure & reactions** involving **radioactive nuclei far from the line of stability** – all new data need to be promptly compiled, evaluated & disseminated to **enhance scientific discoveries** and to **assist technology applications** - development of new **evaluation methodologies, strategies** & **dissemination tools** that are tailored to the specific needs of variety of users –

Overseas: RIKEN, TRIUMF, GANIL, CERN, GSI (planned)

U.S. facilities: ANL, ORNL & MSU

FRIB – the future in U.S.

The NP community would require even more sophisticated databases that couple Experiments, Theory & Data Evaluation with the modern computer technology