Nuclear Data Evaluation – Why, What and Where

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EBSS 12, August6-10, 2012, Argonne National Laboratory

Outline

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

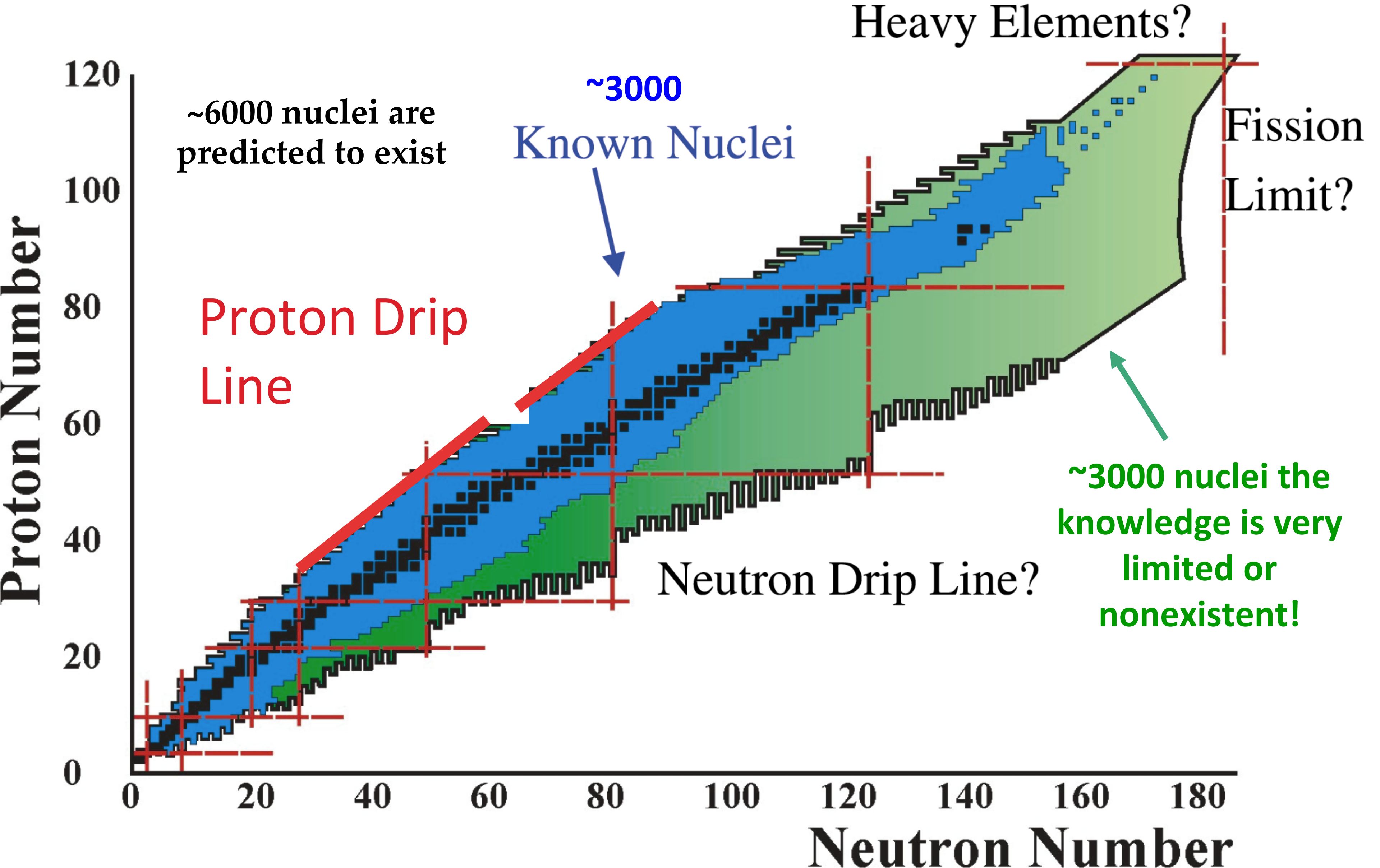
Some Historical Remarks …

The first American Nobel Laureate, *Albert A. Michelson*, in an 1894 speech at U 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, electron and radioactivity* 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 the nature

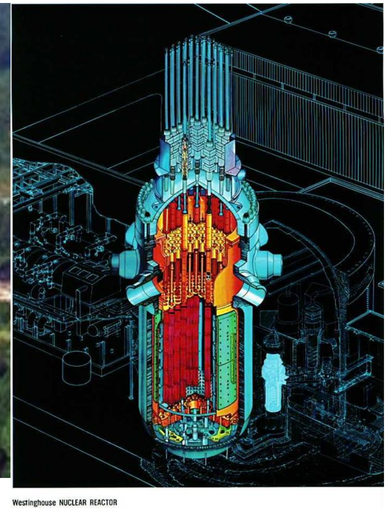
11 physics questions for the new century

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

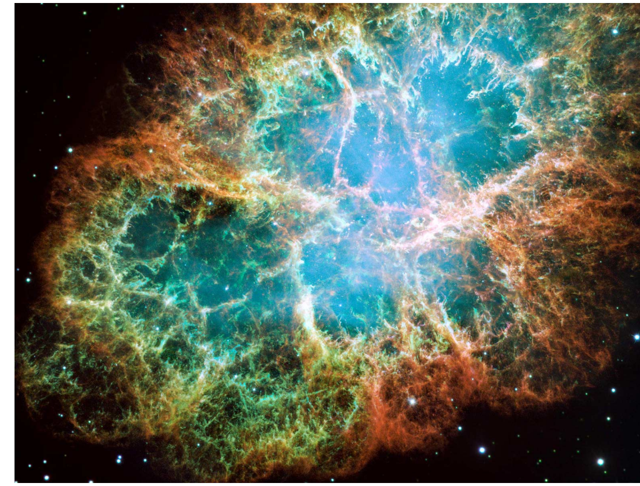
Nuclear Physics in Important

astrophysics, medicine, energy production, security

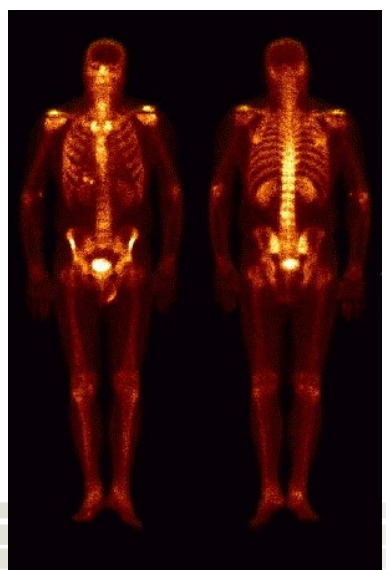
nuclear power plant



supernova explosion

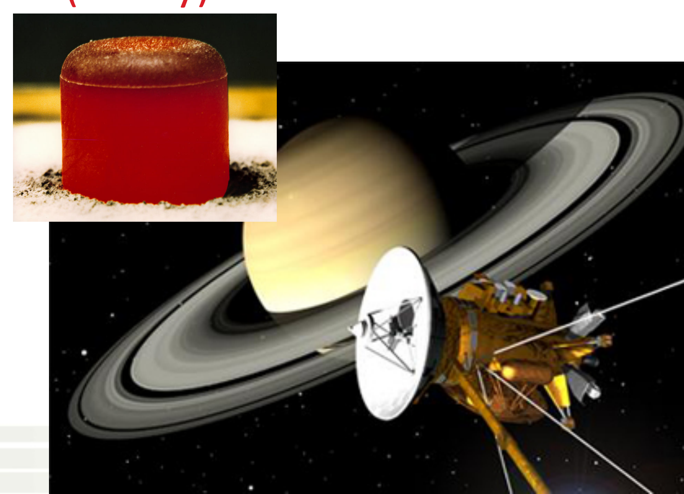


^{99m}Tc bone scan



$^{238}PuO_2$ (87.7 y)

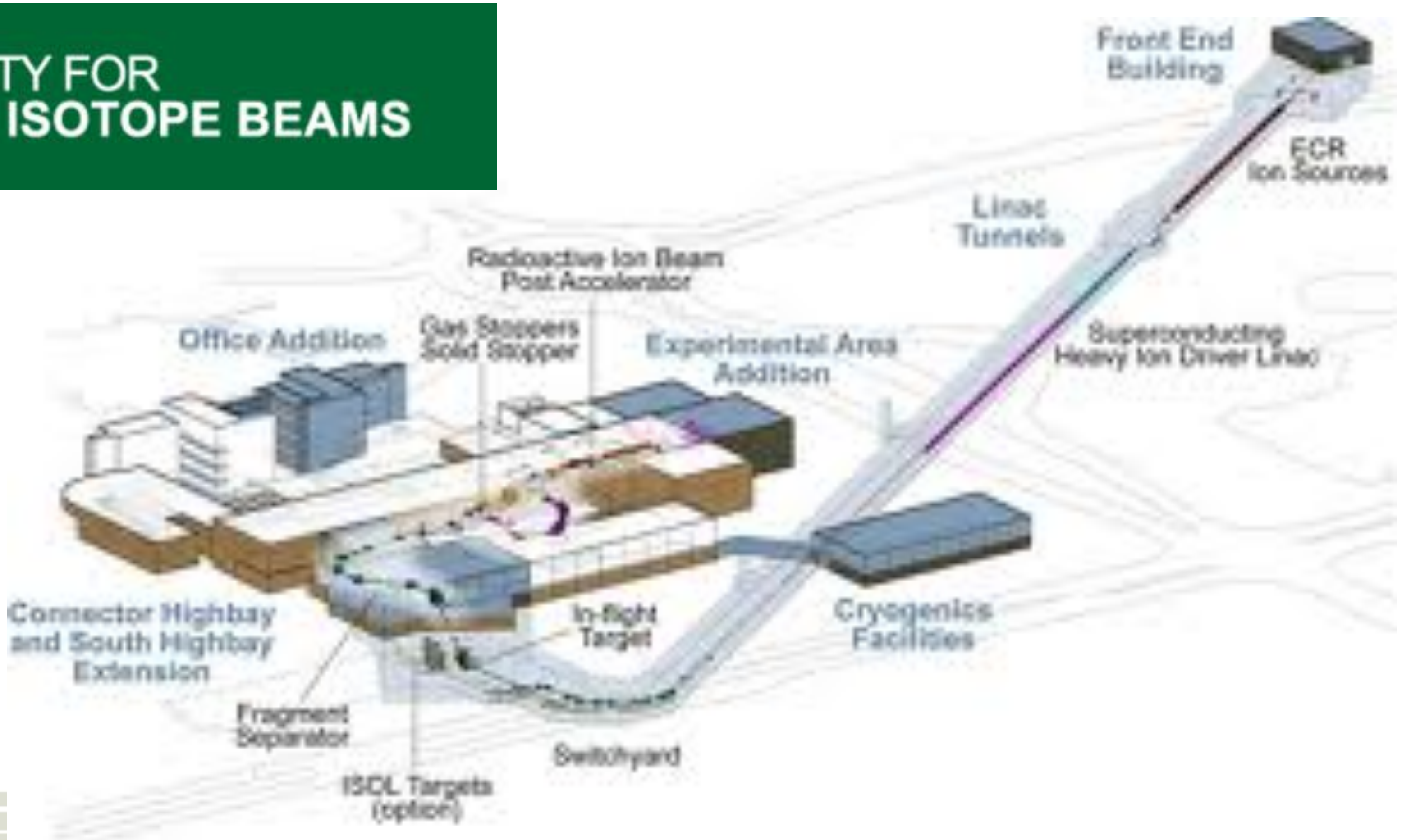
Cassini spacecraft - Saturn



it is an interesting time in Nuclear Physics

with new (RIB) facilities available (some just around the corner) we have a great chance to make major contributions to the knowledge; with advances in theory we have opportunities to understand it all; by compiling & evaluating nuclear data we can support various applications, assist scientific discoveries and preserve the knowledge for future generations

FACILITY FOR
RARE ISOTOPE BEAMS



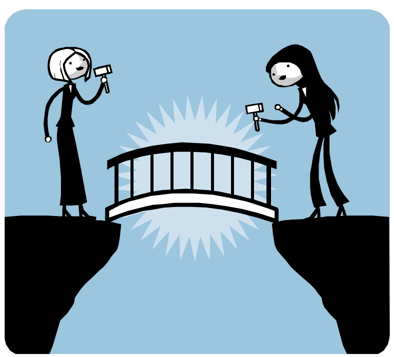
What is Nuclear Data?

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

Basic Physics



Applied Physics

… 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!

these 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.

Nuclear Data Evaluation

- ✓ network activity
- ✓ service to various communities

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

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)

"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 on 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]

What should a good database looks like?

- **Comprehensive:**
  - ✓ All related quantities should be included, together with estimates of their uncertainties
- **Reliable:**
  - ✓ Data should be correctly represented
- **Complete:**
  - ✓ All available data of each type should be included
- **Up-to-Date:**
  - ✓ Consequences of new measurements should appear promptly
- **Accessible:**
  - ✓ Data should be easily available to the users via modern dissemination tools

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

LABORAVI FIDENTER

NICOLA ZANICHELLI, EDITORE
BOLOGNA 1935-XIII

Evaluation History – cont.

REVIEWS OF

MODERN PHYSICS

VOLUME 9 JULY, 1937 NUMBER

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*-α*P*, B^{10}-*d*-α*P*	
	2	~4.8	~1400	8.013 1	$^1D_2\ g$	*B*	Li^8-ϵ^-α*P*	17.5 MV 4→0
	3	6–12	Large	8.014–20		*C*	B^{10}-*d*-α*P*, Li^8-ϵ^--α*P*	10–14 MV 4→1, 2
	4	17.50	9	8.026 72	1 *u*	*A*	Li^7-*p*-γ*R*	(from Li^7-*p*-γ)
	5	17.86	Large	8.027 11		*B*	Li^7-*p*-γ*R*	(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*-γ*R*	(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 VOLUME 12

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

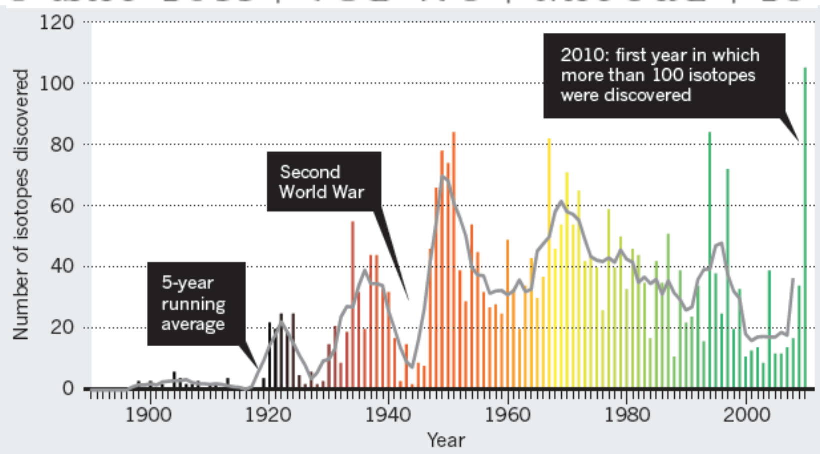
- ✓ G.T. Seaborg, *Rev. Mod. Physics* 16, 1 (**1944**)
- ✓ G.T. Seaborg, I. Perlman, *ibid*. 20, 585 (**1948**)
- ✓ J. M. Hollander, I. Perlman, and G. T. Seaborg, ibid., 25, 469 (**1953**)
- ✓ D. Strominger, J.M. Hollander, G.T. Seaborg, ibid., 30, 585 (**1958**)

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**.

5 MAY 2011 | VOL 473 | NATURE | 25



THE PHYSICAL REVIEW
REVIEWS OF MODERN PHYSICS

Conducted by

THE AMERICAN PHYSICAL SOCIETY
JOHN T. TATE, *Managing Editor*

University of Minnesota, Minneapolis, Minn., U. S. A.

March 21, 1941

Professor G. T. Seaborg
Department of Chemistry
University of California
Berkeley, California

Dear Professor Seaborg:

I believe your suggestion of a revised list of radioactive isotopes for the April or July, 1942 issue of the REVIEWS OF MODERN PHYSICS is a very good one. By that time the rate at which such radioactivities are discovered may be reduced very considerably and the table would itself become "stable". I should be glad to have you prepare such a table.

I have the new edition and noted the tables in them. I am quite sure it is not worth taking any action, even though some evidence exists for a "case".

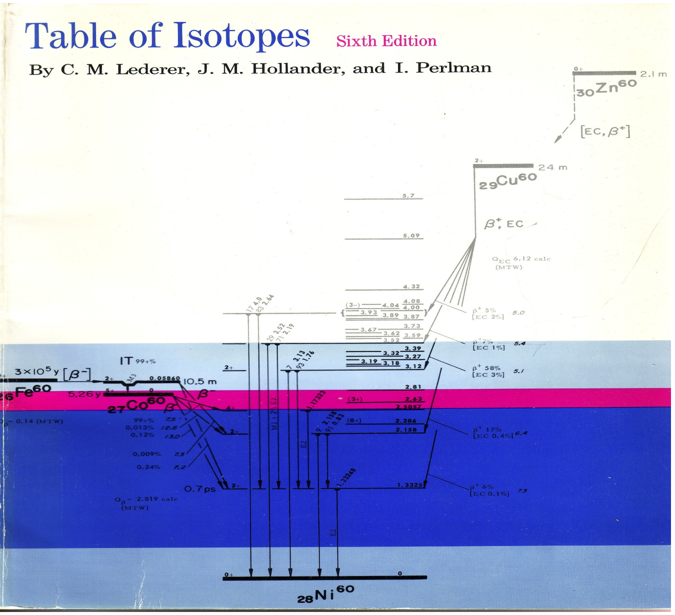
Sincerely yours,

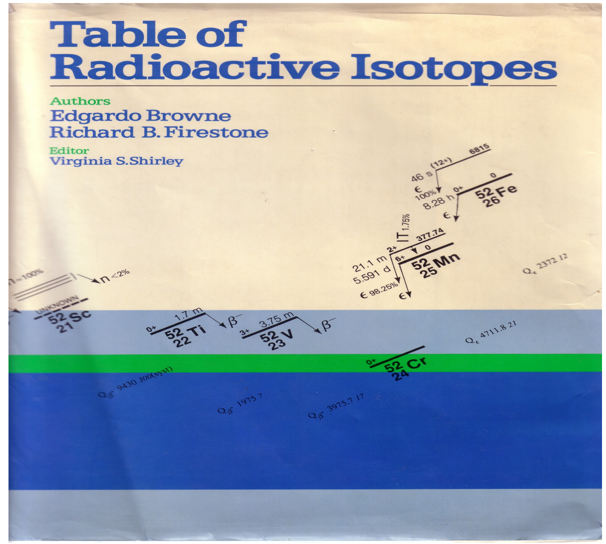
J. W. Buchta,
Assistant Editor

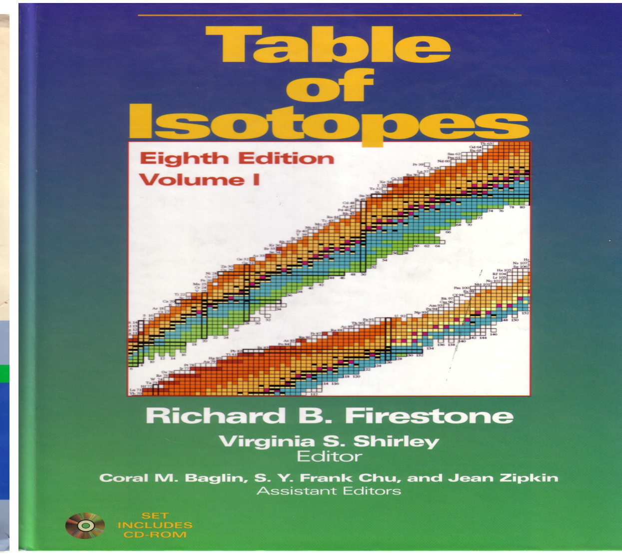
JWB:B

courtesy of E. Browne (LBNL)

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.

- Katherine Way, as a part of the Manhattan Project, collected nuclear data at Clinton Laboratory - today Oak Ridge National Laboratory (ORNL)
- in 1953 the Nuclear Data Project (NDP) moved under the National Research Council, US National Academy of Sciences to Washington, DC– 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 – **NSR & ENSDF** formats were developed
- in *1966 – 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 to NNDC (BNL)
- since 1981 the main editorial work has been carried out at NNDC (J. Tuli – Editor, E. McCutchan – Assistant Editor, since 2011)

Information courtesy of J. Tuli (NNDC)

Evaluation History – cont.

Other Evaluation Effort

- 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 reversed.
- 1948 – T. Lauritsen, and later, F. Ajzenberg-Selove – University of Pennsylvania.
- 1950 – B. S. Dzhelepov, and later L. Peker and others – USSR.
- 1954 – P. M. Endt, and later with C. Van der Leun, University of Utrecht, The Netherlands.

U.S. Nuclear Data Program

Nuclear Reactions ← → **Nuclear Structure & Decay**

❑ collaboration of scientists from ANL, LBNL, McMaster U. (Canada), 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, FSU & Turkey
Asia – Japan, China, India & Kuwait
S. America
Australia

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

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

Organize bi-annual meetings & technical workshops

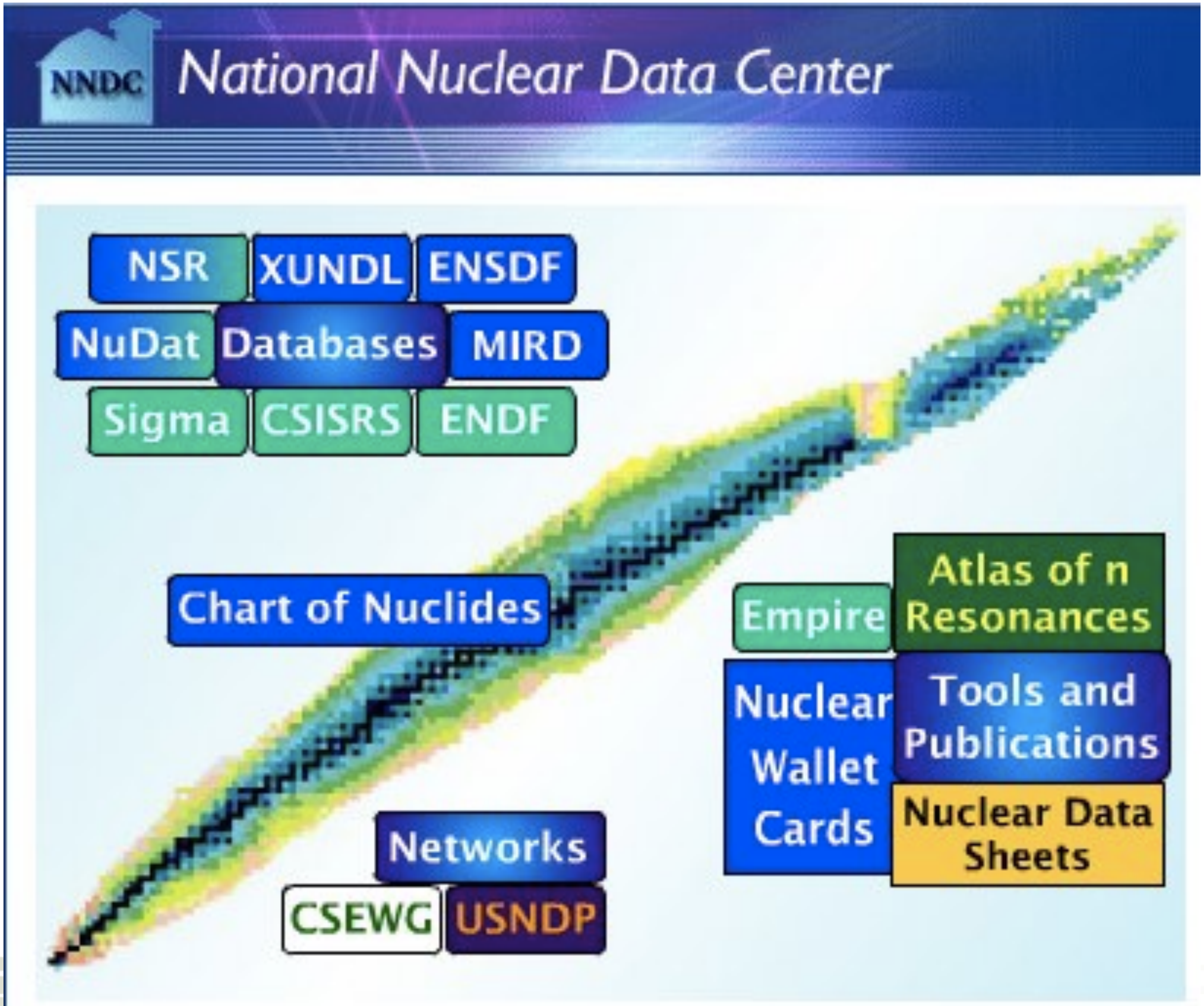
Contributions to NSR & ENSDF

Provide research grants ($4K /y)

developing countries

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!

ENSDF

Applications

Basic NP Research

Simulations

ENDF, JEFF, JENDL …

ORTEC & CANBERRA

MIRD

RIPL

PGAA

RNAL

Nuclear Wallet Cards for Radioactive Nuclides

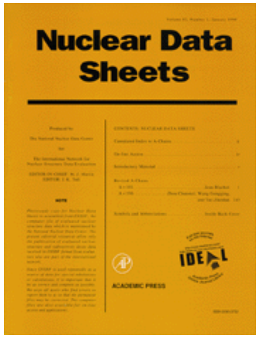
March 2004

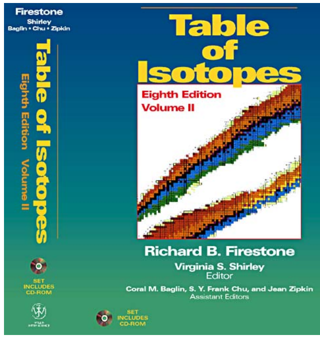
Jagdish K. Tuli
National Nuclear Data Center
(*www.nndc.bnl.gov*)

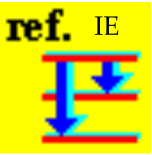
Brookhaven National Laboratory
P.O. Box 5000
Upton, New York 11973-5000
USA

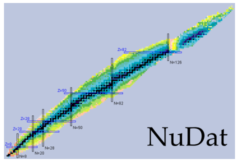
Monte-Carlo Codes
MCNP, GEANT, EGS4

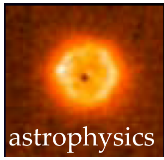
ORIGEN, CINDER90







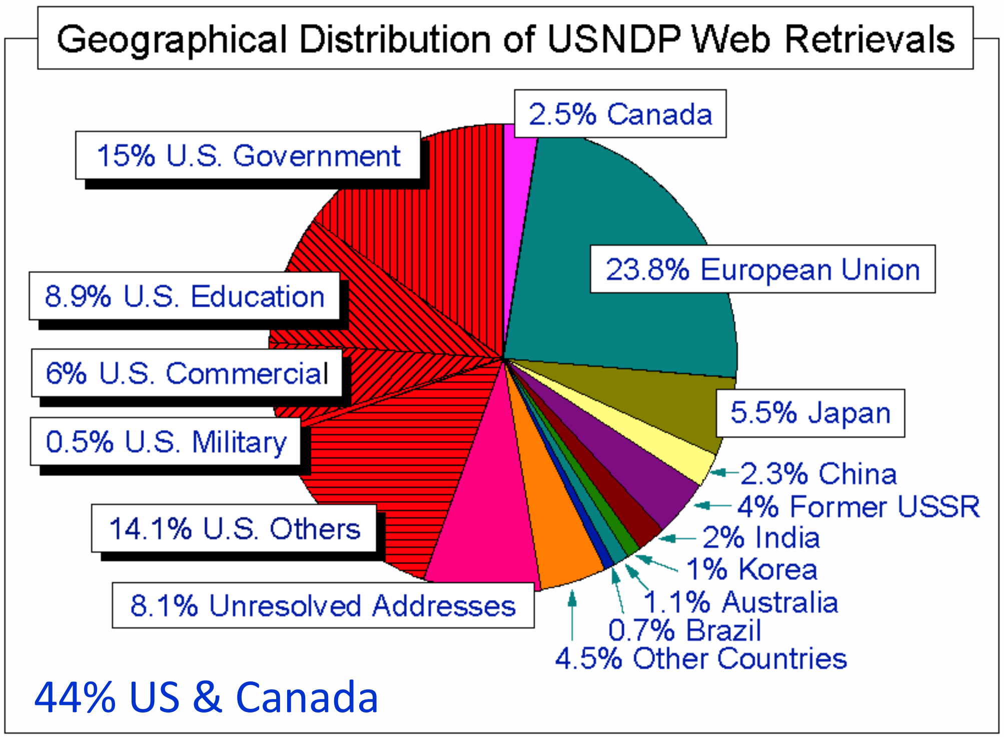


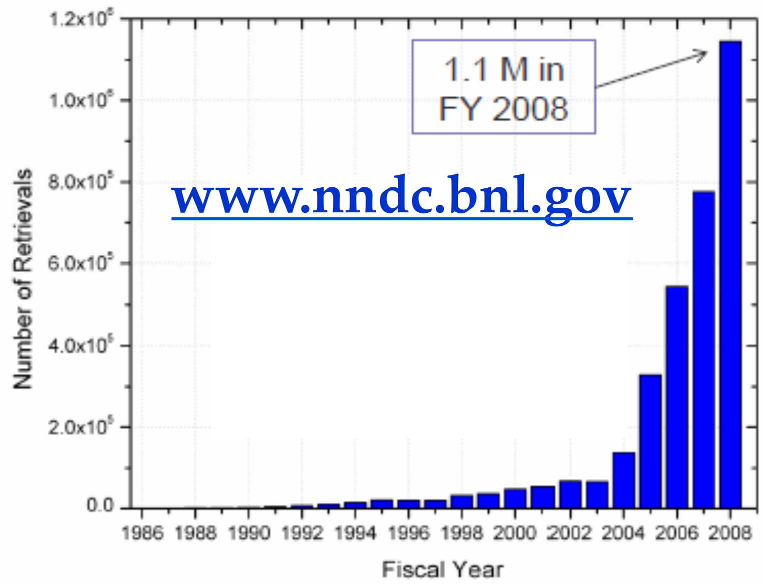


NUBASE

RADWARE

ENSDF usage

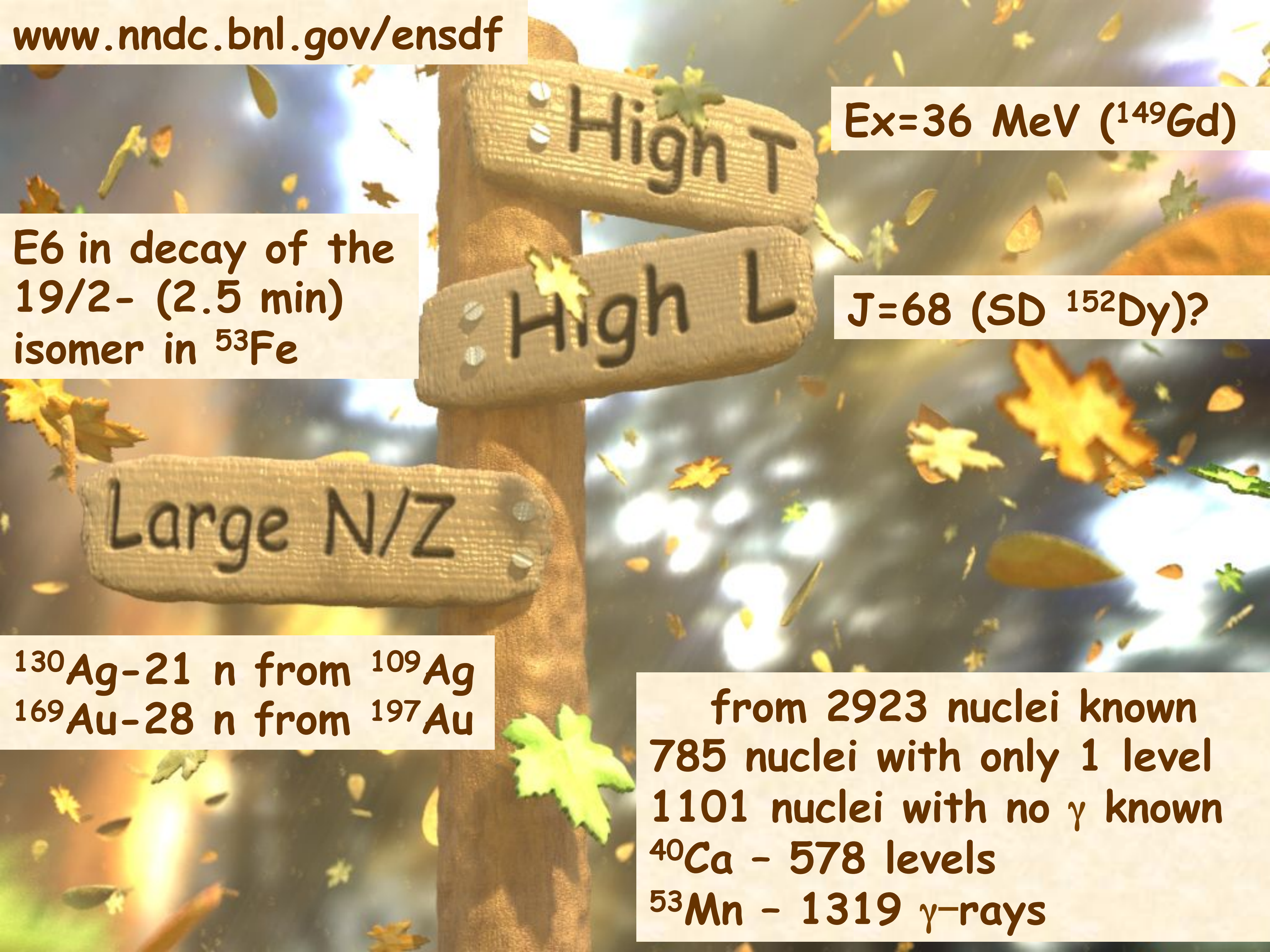




preparation of experiments – during experiments – data analysis & publications – journal reviewers etc.

NDS e-Subscr. (Elsevier) – 4705 accounts with 11.7K (paid) downloads (2007)

USA & Canada(25%), EU (39%), Asia (33%), Africa (1.5%) & Australia (1.5%)



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-21 n from ^{109}Ag
^{169}Au-28 n from ^{197}Au

from 2923 nuclei known
785 nuclei with only 1 level
1101 nuclei with no γ known
^{40}Ca – 578 levels
^{53}Mn – 1319 γ–rays

Evaluated Nuclear Structure Data File (ENSDF)

Database version of August 29, 2008

Experimental Unevaluated Nuclear Data List (XUNDL)

NNDC

To NNDC

Database version of August 29, 2008

The ENSDF database contains evaluated nuclear structure and decay information for over 2900 nuclides. The file is updated on a continuous basis. New evaluations are published in *Nuclear Data Sheets*.

The XUNDL database contains experimental data compiled from over 1700 recent nuclear structure papers.

www.nndc.bnl.gov/ensdf

Quick search: Retrieve all ENSDF datasets for a given nuclide or mass: [ ] Search *(208Pb, pb-208, 144, etc.)*

Browse datasets by element and mass.

Advanced search and retrieval options:

- Nuclide Search Retrieve datasets based on nuclide, charge, or mass.
- Reaction Search Retrieve datasets based on indexed reaction quantities.
- Decay Search Retrieve datasets based on indexed decay quantities.
- Recently added Retrieve recently added or modified datasets.

Database indices:

- Index to ENSDF Information on mass-chain evaluations and publication.

Datasets for ^{177}Ta

Matching datasets in ENSDF:

☐	^{177}Ta	ADOPTED LEVELS, GAMMAS	References
☐		177W EC DECAY	References
☐		11B(208PB,XG)	References
☐		170ER(11B,4NG)	References
☐		175LU(A,2NG)	References

Get selected ENSDF datasets: HTML Download View ENSDF

Get all ENSDF datasets : HTML Download View ENSDF

Reset

Data from AR_206722_1.ens

Download: AR_206722_1.ens **View:** Level schemes in the Nuclear Data Sheets style JPEG PDF PS

^{177}Ta ^{170}Er(^{11}B,4nγ) 2000Da09,1995Ar18,1993Ri09 **200305**

Published: 2003 Nuclear Data Sheets.

History

Type	Author	Citation	Cutoff Date
Full evaluation	F.G. Kondev	Nuclear Data Sheets 98, 801 (2003)	1-Aug-2002

2000Da09,1994Da11: Produced using the ^{170}Er(^{11}B,4nγ) reaction. Projectiles: ^{11}B, E=55 MeV. Targets: isotopically enriched ^{170}Er, 5.5 mg/cm^2 thick in the γγ(t) and γ(t) experiments, which stopped most of the recoiling nuclei and a 1.5 mg/cm^2 thick during the conversion electron measurements. Detectors: six HPGe Compton-suppressed detectors and one (unsuppressed) planar germanium detector (LEPS) during the γγ(t) and γ(t) experiments and a superconducting solenoid spectrometer with a Si(Li) detector and one HPGe Compton-suppressed detector during the conversion electron measurements. Pulsed beams of 1 ns on/1700 ns off (γγ(t)), 2 μs on/ 103 μs off (γ(t)) and 1 ns on/ 900 ns off, and 80 μs on/ 720 μs off (conversion electron experiment) were used. Measured: Eγ, Iγ, γγ coin, γ(t), γγ(t), γ(θ) and ce. Deduced: level scheme, lifetimes, transition multipolarities, Jπ, K, and configurations. See also 1994Da11.

1995Ar18, 1993Ri09: Produced using the ^{170}Er(^{11}B,4nγ) reaction. Projectiles: ^{11}B, E=55 and 60 MeV. Targets: ^{170}Er, two self-supporting 1.0 mg/cm^2 thick foils. Detectors: five HPGe Compton-suppressed detectors (55 MeV) and ten HPGe Compton-suppressed detectors with a 28-element BGO multiplicity filter (60 MeV). Measured: Eγ, Iγ and γγ coin. Deduced: level scheme, Jπ, K and configurations.

$^{170}Er(^{11}B,4n\gamma)$ 2000Da09,1995Ar18,1993Ri09

^{177}Ta levels

level properties

E_{level}[#]	J^π[@]	$T_{1/2}$[&]	Comments
0.0[a]	7/2+	56.56 h *6*	
70.59[d] *13*	5/2+	70.2 ns *19*	J^π: From adopted levels. $T_{1/2}$: $T_{1/2}$=69.3 ns 21 from 2000Da09.
73.36[e] *15*	9/2-	410 ns *7*	J^π: From adopted levels. $T_{1/2}$: $T_{1/2}$=410 ns 7 (2000Da09).
131.05[a] *14*	9/2+		
172.31[d] *19*	7/2+		
186.15[b] *6*	5/2-	3.62 μs *10*	Additional documentation [3] J^π: From adopted levels. $T_{1/2}$: $T_{1/2}$=3.67 μs 14 from 2000Da09.

γ−ray properties

E_γ[#]	E_{level}	I_γ[#]	Mult.[a]	Comments
26.2	2852.7	132 *32*	E1	**Mult.:** α(exp)=3.0 10 (2000Da09), α(M1)=36.9, α(E2)=1785.2 and α(E1)=2.6.
86.1	4656.3	2 *1*	E2	**Mult.:** α(exp)=7.3 9 (2000Da09), α(M1)=6.4, α(E2)=6.1 and α(E1)=0.5. α(L)exp=4.0 10 (2000Da09), α(L)(M1)=0.8, α(L)(E2)=3.8 and α(L)(E1)=0.07.
101.8	172.31	67[&] *6*	M1+E2	**Mult.:** A_2=0.10 17.
104.2	2956.9	211[&] *7*	E1	**Mult.:** A_2=-0.15 6. α(exp)=0.4 1 (2000Da09), α(M1)=3.9, α(E2)=3.2 and α(E1)=0.3. α(L) exp=0.05 5 (2000Da09), α(L)(M1)=0.52, α(L)(E2)=1.77 and α(L)(E1)=0.05. α(M)exp=0.03 5 (2000Da09), α(M)(M1)=0.12, α(M)(E2)=0.44 and α(M)(E1)=0.01.
115.6	186.15	455[&] *20*	E1	**Mult.:** From adopted gammas.
128.6	300.89	157 *13*	[M1+E2]	**δ:** δ=0.16 1 (2000Da09) and 0.26 4 (1995Ar18), assuming K=5/2.
131.2	131.05	196[&] *22*	(M1+E2)	**Mult.:** A_2=0.09 7. The value overlaps with that for the 131.9γ.
131.9	1737.40	100 *12*	(M1+E2)	**Mult.:** A_2=0.09 7. The value overlaps with that for the 131.2γ.

Adopted Levels, Gammas

Published: 2003 Nuclear Data Sheets.

View: Level schemes in the Nuclear Data Sheets style JPEG PDF PS

Band drawings in the Nuclear Data Sheets style JPEG PDF PS

Q_{β^-}=-2001 *SY* S_n=8.32×10[3] *10* S_p=4429 *4* Q_α=2740 *4* 1995Au04

History

Date	Type	Author	Citation	Cutoff Date	
16-Jul-2007	Errata	J. Tuli			Fixed
	Full evaluation	F.G. Kondev	Nuclear Data Sheets 98, 801 (2003)	1-Aug-2002	

^{177}Ta levels

Cross References (XREF) Flags

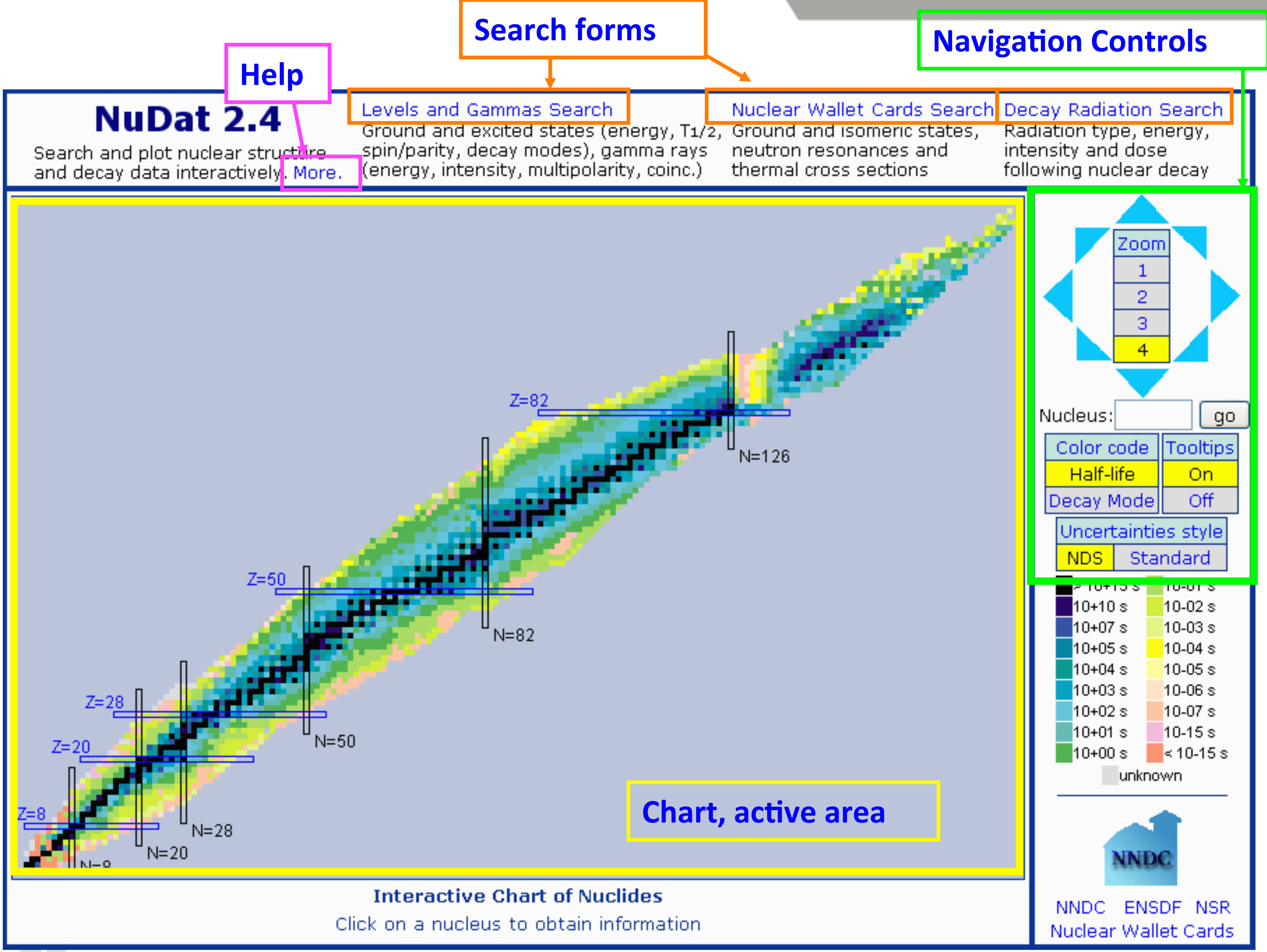
A ^{170}Er(^{11}B,4nγ) C ^{177}W Electron Capture Decay

B ^{175}Lu(α,2nγ) D ^{11}B(^{208}Pb,Xγ)

E_{level}[#]	Jπ[#@]	$T_{1/2}$[#]	XREF	Comments
0.0[&]	7/2+	56.56 h *6*	ABC	%ε+%β$^+$=100. **Jπ**: J=7/2 atomic beam (1978Ru04); Strong ε+β$^+$ feeding to the 7/2- and 9/2- levels in ^{177}Hf; Jπ systematics; band assignment. **$T_{1/2}$**: From 1961We11. Other values: 56.4 h 10 (1964Sa16) and 56 h 1 (1963Ra14). **μ**: μ=2.25 5 (1981Ha40, 1984Oh07, 1989Ra17) using the nuclear magnetic resonance on oriented nuclei technique. **configuration**: π 7/2[404] ($g_{7/2}$) Nilsson configuration. Based on the observed in-band properties, such as alignment and g_K-g_R values ((g_K-g_R)/Q_0=+0.0667 23 (^{170}Er(^{11}B,4nγ))), comparison between the measured μ with Nilsson model predictions and systematics of structures in neighboring nuclei.
70.59[c] *13*	5/2+	70.2 ns *19*	ABC	**Jπ**: 70.5γ M1+E2 from α(K)exp, α(L)exp, α(M)exp and ce(L1):ce(L2):ce(L3) exp (^{177}W ε decay), and angular distribution data (^{175}Lu(α,2nγ)) to the 7/2+ level; band assignment. **$T_{1/2}$**: Weighted average of 69.3 ns 21 in ^{170}Er(^{11}B,4nγ) (2000Da09), 73 ns 5 (1976Ao02), and 80 ns 10 (1973Sc20) in ^{175}Lu(α,2nγ). **μ**: μ=+4.7 5 (1974Ao01,1976Ao02,1989Ra17) deduced using the perturbed polarization-directional angular correlation technique. **configuration**: π 5/2[402] ($d_{5/2}$) Nilsson configuration. Based on the observed in-band properties, such as alignment and g_K-g_R values ((g_K-g_R)/Q_0=+0.191 7 (^{170}Er(^{11}B,4nγ))), comparison between the measured μ with Nilsson model predictions and systematics of similar structures in neighboring nuclei.

γ(^{177}Ta)

E_{level}	E_γ[#]	I_γ[#]	Mult.[#]	δ[@]	α	Comments
70.59	70.5	100	M1+E2	0.54 *3*	13.2 *1*	**Mult.**: From ^{177}W ε decay and ^{175}Lu(α,2nγ). **δ**: From ^{177}W ε decay. B(M1)(W.u.)=4.9×10^{-5} *3*; B(E2)(W.u.)=1.23 *15*
73.36	73.3	100	E1		0.826	B(E1)(W.u.)=7.3×10^{-7} *4* **Mult.**: From ^{175}Lu(α,2nγ).



Search forms
Navigation Controls
Help
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
Z=50
Z=28
Z=20
Z=8
N=126
N=82
N=50
N=28
N=20
N=8
Zoom
1
2
3
4
Nucleus:
go
Color code
Tooltips
Half-life
On
Decay Mode
Off
Uncertainties style
NDS
Standard
10+10 s
10+07 s
10+05 s
10+04 s
10+03 s
10+02 s
10+01 s
10+00 s
10-02 s
10-03 s
10-04 s
10-05 s
10-06 s
10-07 s
10-15 s
< 10-15 s
unknown
Chart, active area
Interactive Chart of Nuclides
Click on a nucleus to obtain information
NNDC
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 ≤ 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 ▾ ≤ $T_{1/2}$ ≤ 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

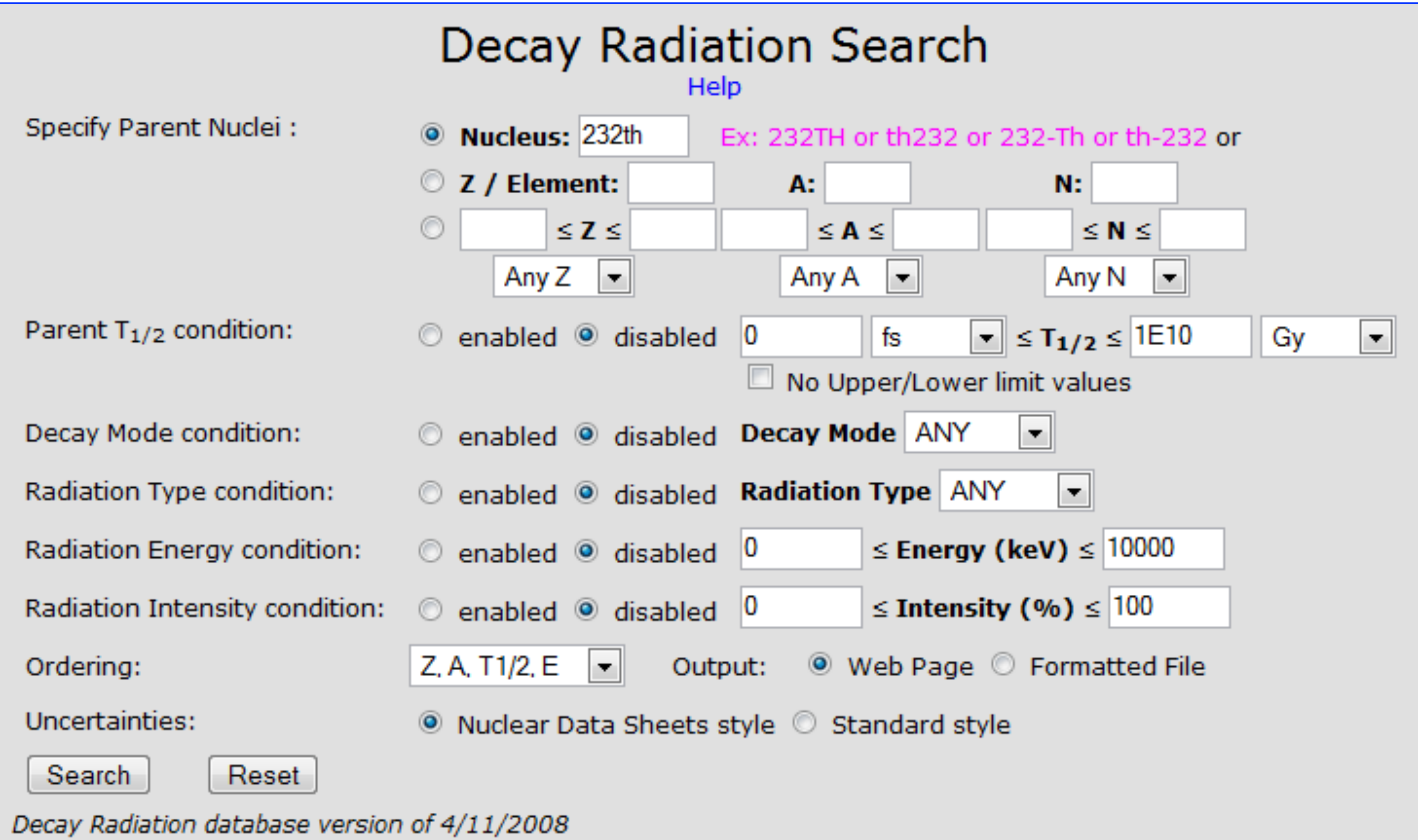
Uncertainties: ◉ Nuclear Data Sheets style ○ Standard style

[Search] [Reset]

Levels and Gammas database version of 4/11/2008

A. Sonzogni (NNDC)

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

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*

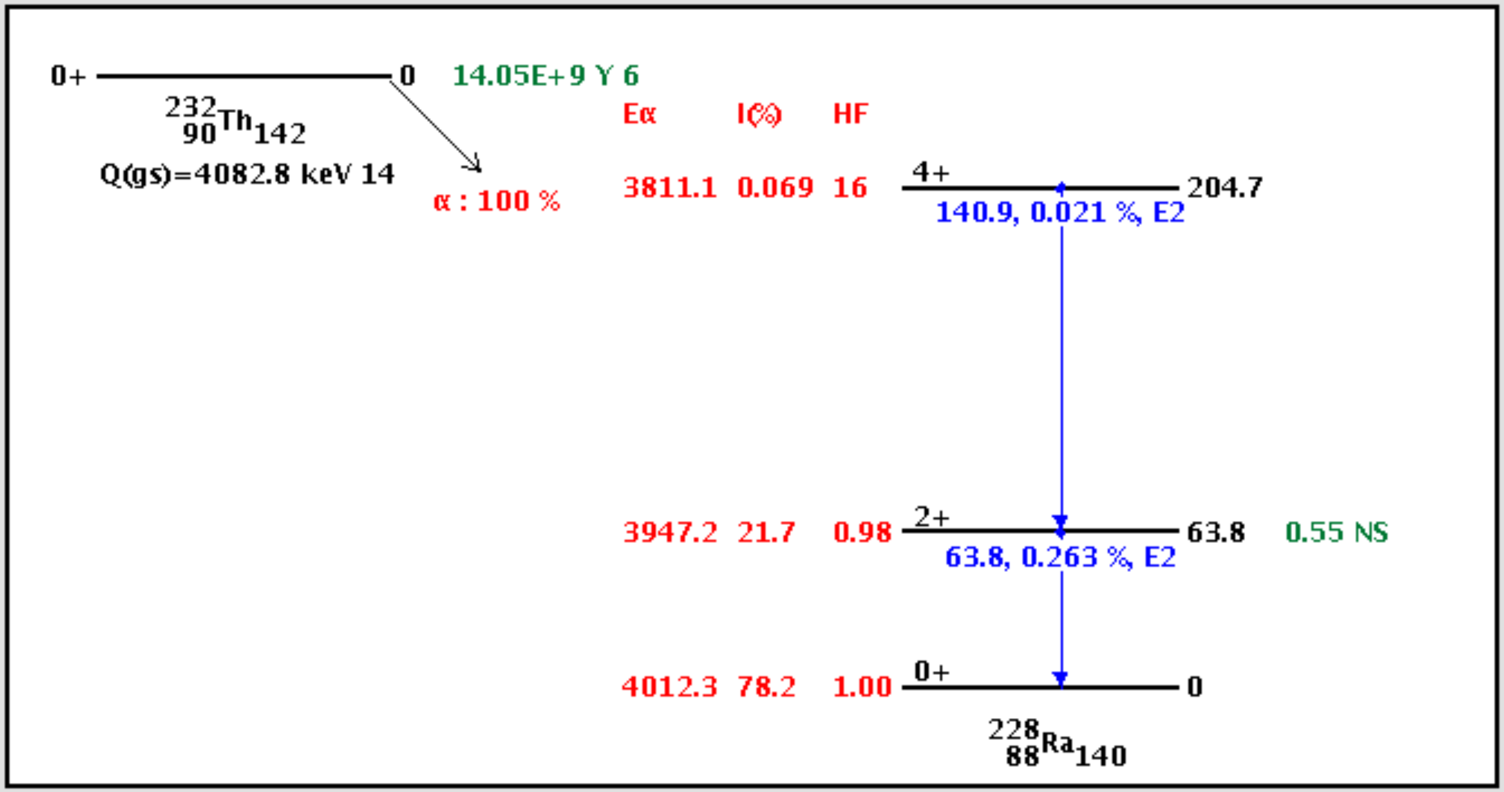
Gamma and X-ray radiation:

	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*

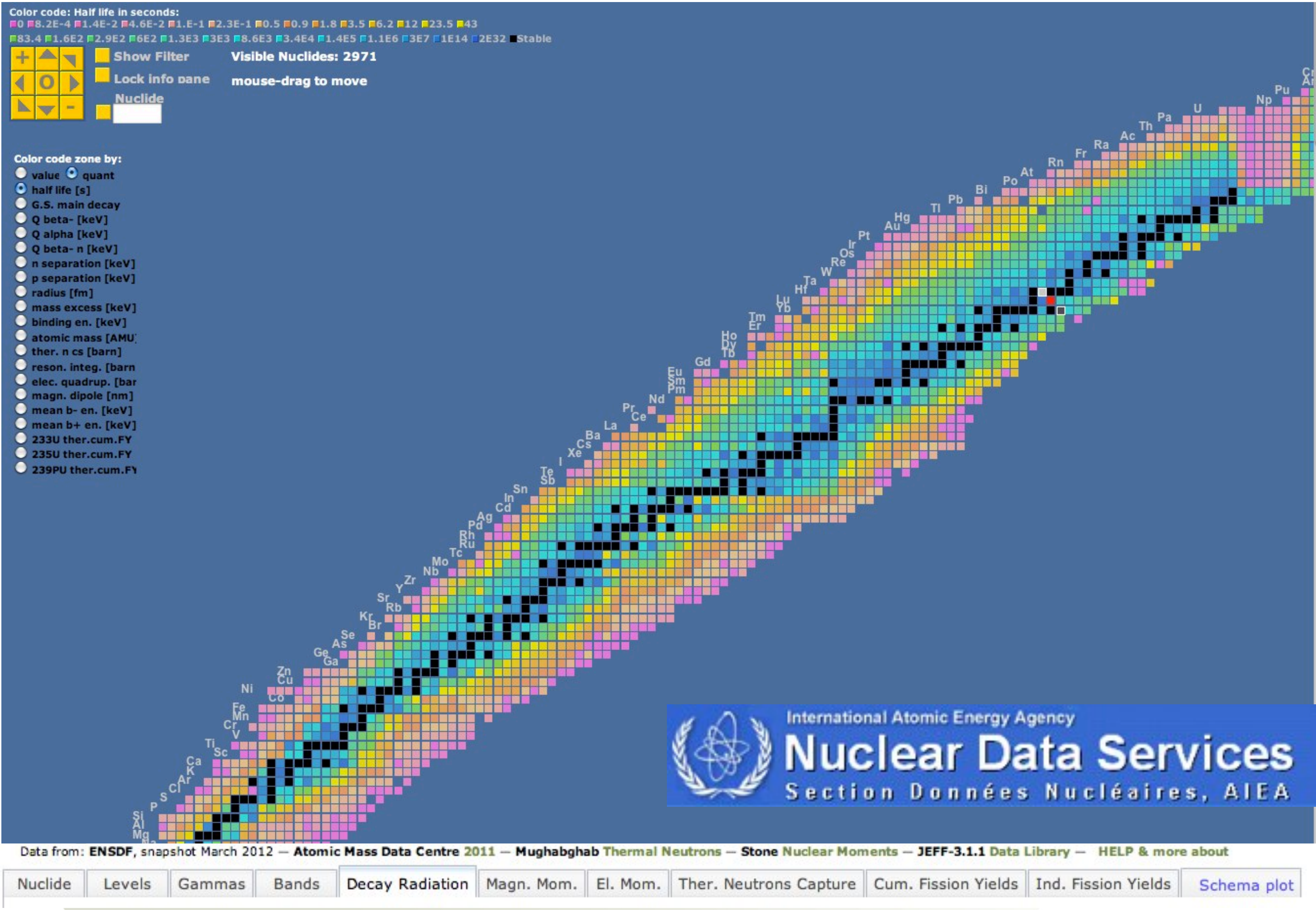
Interactive Decay Scheme

^{232}Th α decay

0.0 < E(level) < 225.0	☑ Level Energy	☑ Level T1/2	☑ Level Spin-parity	☑ Final Level
Highlight: [ ] Level ▾	☑ Gamma Energy	☑ Gamma Intensity	☑ Gamma Multipolarity	☑ Decay Information
Image Height: 350	Level Width: 100	Band Spacing: 20	Plot	Clear

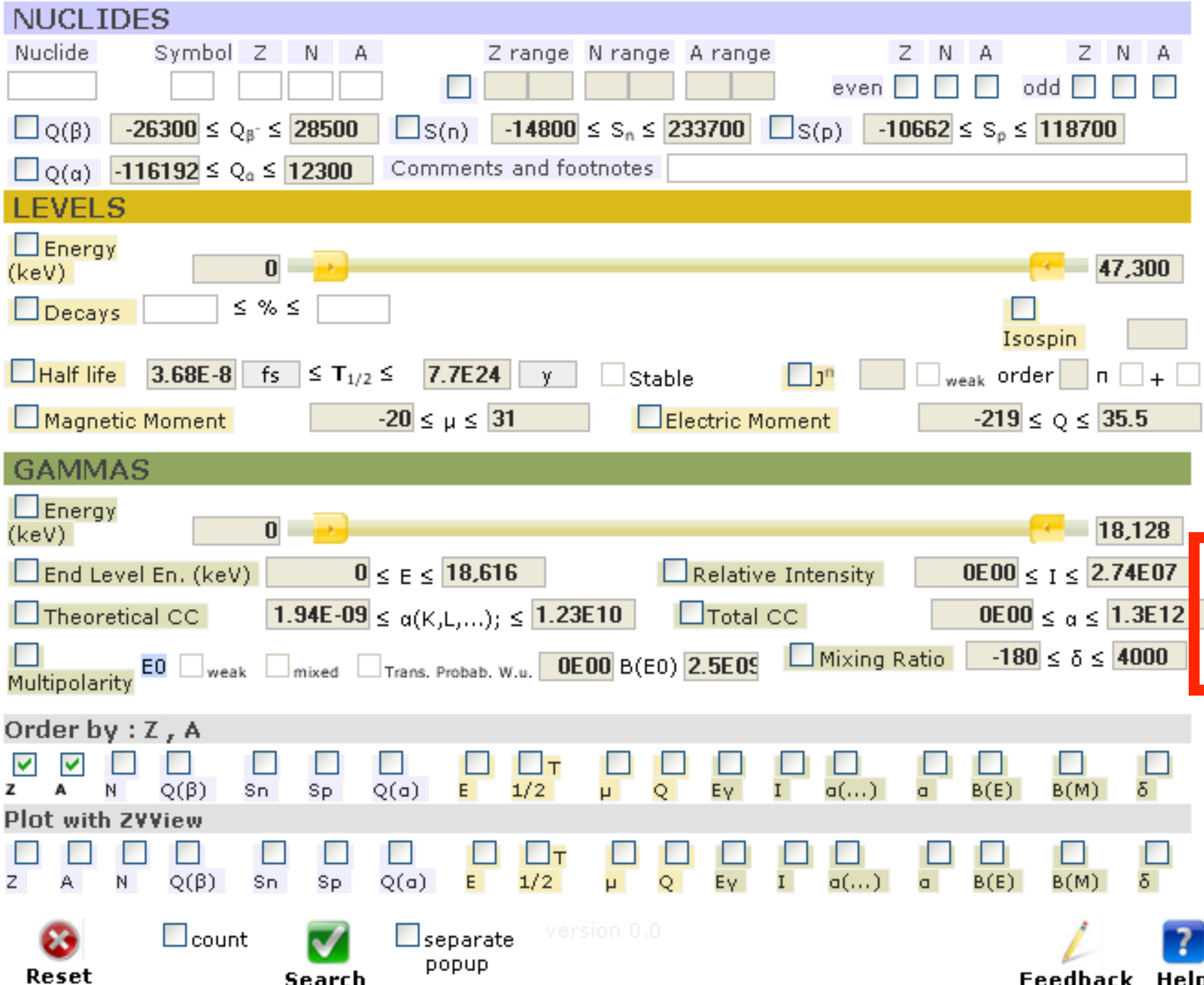


http://www-nds.iaea.org/relnsd/vchart/



http://www-nds.iaea.org/relnsd/NdsEnsdf/QueryForm.html

Marco VERPELLI, IAEA



Relational ENSDF

March 2008 snapshot of the ENSDF database maintained by the **International Nuclear Structure and Decay Data Network**, under the auspices of the IAEA

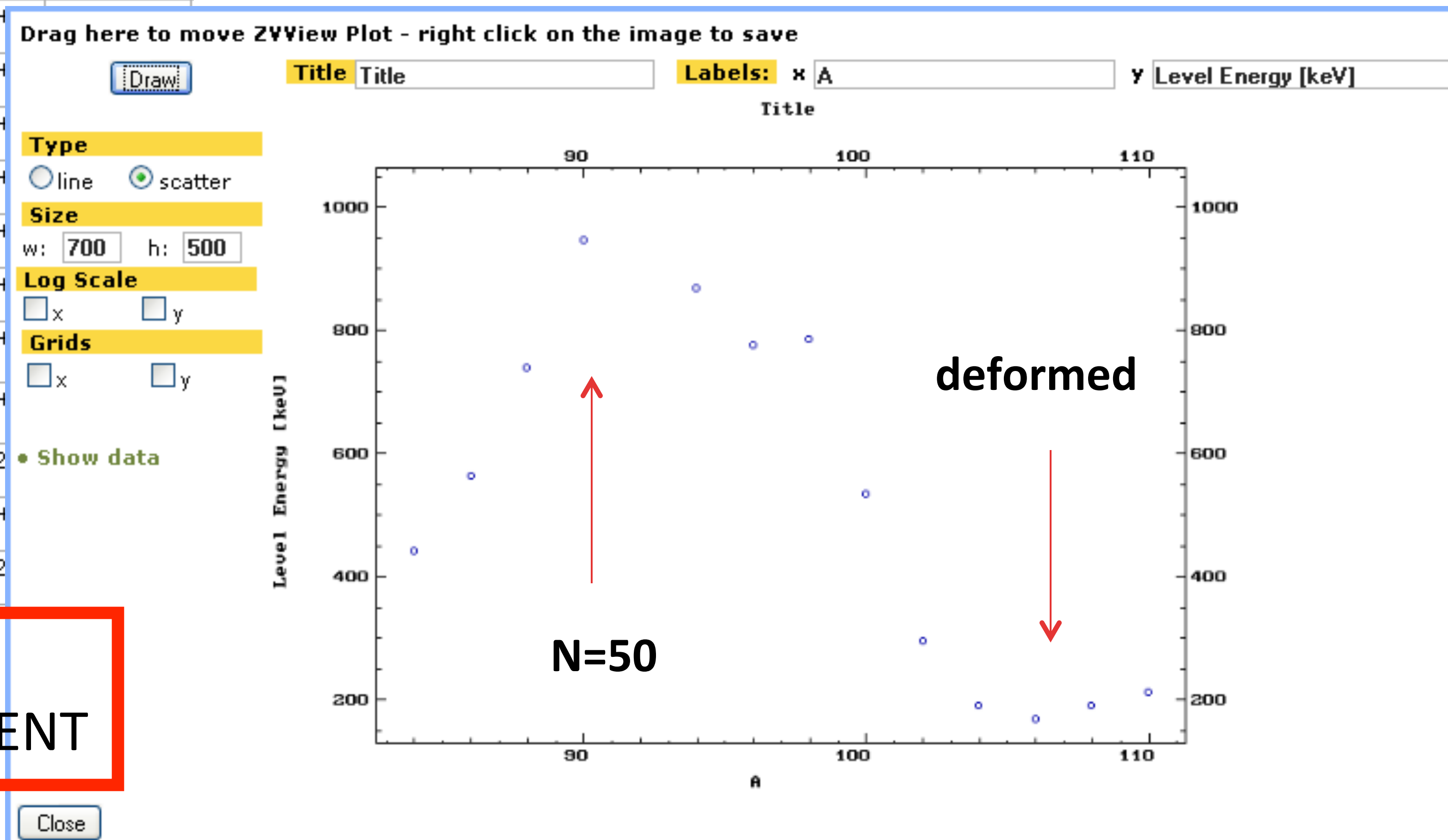
✓ **powerful & fast**

✓ **easy to navigate**

UNDER DEVELOPMENT

useful plotting capability

Nuclide	Energy (keV)	J^π	$T_{1/2}$
$^{84}_{42}Mo_{42}$	443.8 *3*	(2+)	
$^{86}_{42}Mo_{44}$	566.6 *4*	(2+)	
$^{88}_{42}Mo_{46}$	740.54 *4*	2+	
$^{90}_{42}Mo_{48}$	947.97 *9*	2+	
$^{94}_{42}Mo_{52}$	871.098 *16*	2+	
$^{96}_{42}Mo_{54}$	778.245 *12*	2+	
$^{98}_{42}Mo_{56}$	787.384 *13*	2+	
$^{100}_{42}Mo_{58}$	535.561 *22*	2+	
$^{102}_{42}Mo_{60}$	296.597 *12*	2+	
$^{104}_{42}Mo_{62}$	192.19 *9*	2+	
$^{106}_{42}Mo_{64}$	171.548 *8*	(2	
$^{108}_{42}Mo_{66}$	192.9	2+	
$^{110}_{42}Mo_{68}$	213.7 *3*	(2	



UNDER DEVELOPMENT

LBNL/Lund ENSDF Viewer ref.

Nuclide: 177Ta

Data set: All

Database: ENSDF

Get List | Help | Reset

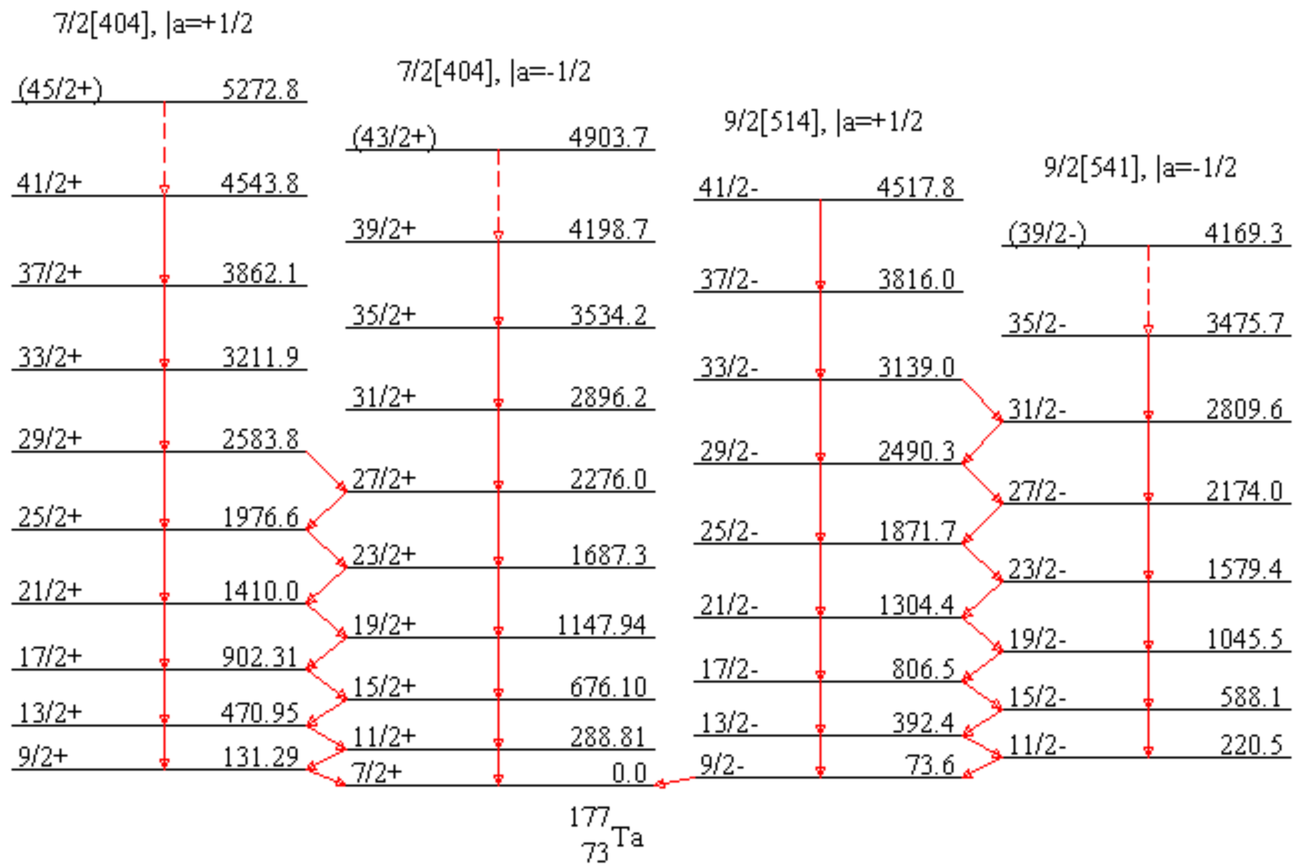
Settings:

New output window: 1

Data set: 177Ta Adopted Levels, Gammas

Level table | Display

->LevelID | Selband | Autoscale | + | - | REF | Coincidence | Filter | Gate | Reset | Tip on | About



E_{level}	E_γ	Jπ	$T_{1/2}$	Band	Xreferences	Comments
0.0		7/2+	56.56 h 6	1	A B C	%ε+β^+=100. Jπ: J=7/2 atomic beam (1978Ru04); Strong EC+B+ feeding to the 7/2- and 9/2- levels in 177HF; JPI systematics; band assignment. $T_{1/2}$: From 1961We11. Other values: 56.4 H 10 (1964Sa16) and 56 H 1 (1963Ra14).

http://ie.lbl.gov

IE on your computer – very useful

http://ie.lbl.gov/isoexpl/

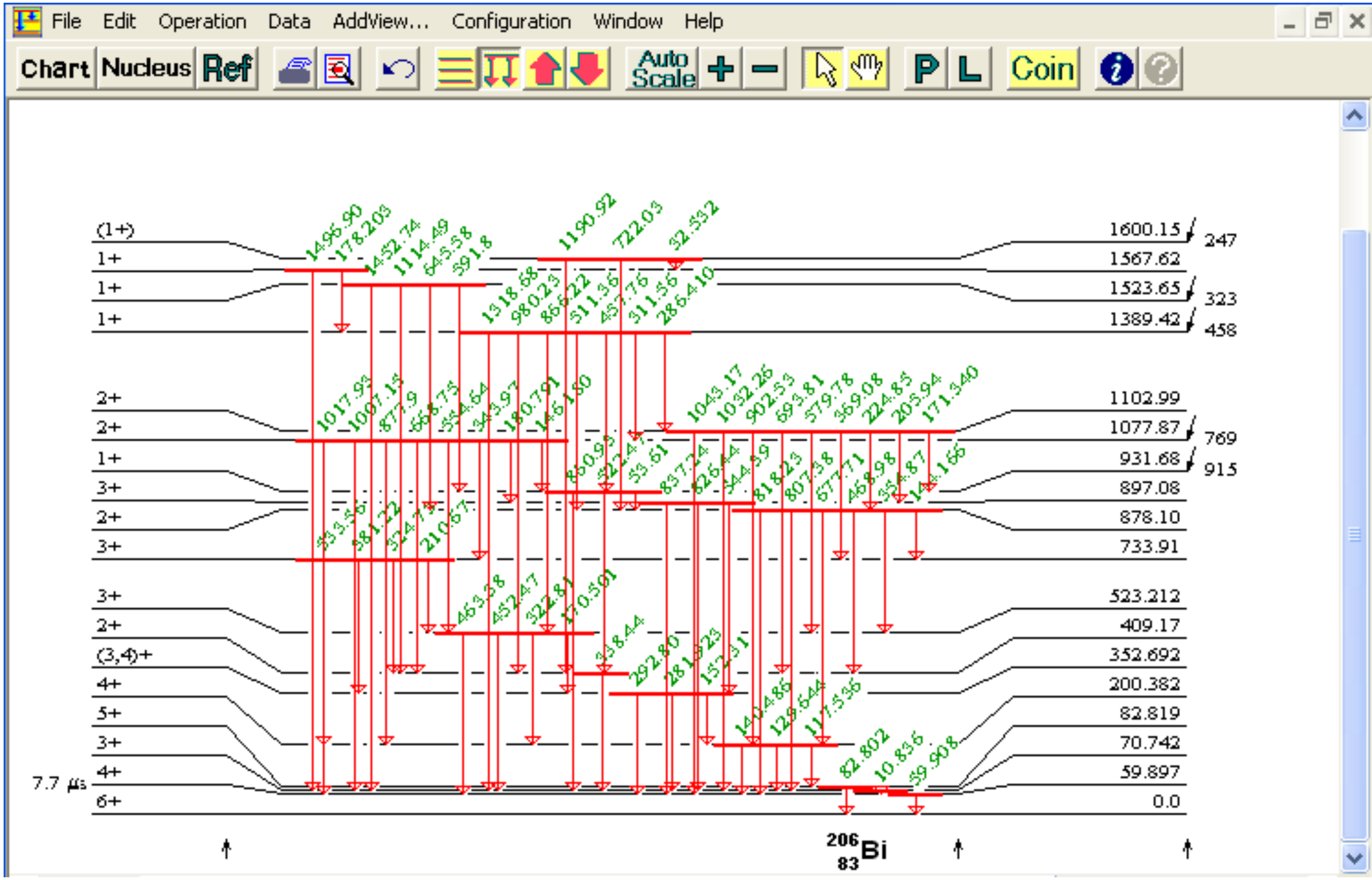
Tour of Isotope Explorer

Version 2.23:

Transfer and installation
User's manual
ENSDF manual
Sample nuclear charts

Table

E_γ ΔE	I_γ ΔI
121.7817 *3*	106.77 *21*
125.69 *13*	0.06 *2*
148.010 *17*	0.132 *14*
202.74 *13*	0.019 *4*
207.6 *3*	0.0181 *18*
212.568 *15*	0.0742 *20*
237.31 *5*	0.0035 *5*
239.42 *17*	0.04 *1*
244.6975 *8*	28.33 *7*
251.630 *7*	0.274 *9*
269.86 *6*	0.031 *3*
275.449 *15*	0.129 *7*
285.98 *3*	0.042 *4*
295.9390 *17*	1.669 *19*



ENSDF is only ~180 MB

XUNDL Database www.nndc.bnl.gov/ensdf

B. Singh - *McMaster University* - coordinator

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

- 2024 nuclides (from ^{1}H to $^{294}118$) with more than 4300 datasets & papers
- provide rapid access to formatted data from latest publications that can be processed with Radware and IE
- prompt updates (every week), as datasets arrive at NNDC
- primarily, carefully trained and closely supervised undergraduate students
- often communications with the original authors exchanged either to obtain details of data that do not appear in the paper or to resolve data-related inconsistencies

Data from XU_206722_4.ens

Download: XU_206722_4.ens **View:** Level schemes in the Nuclear Data Sheets style JPEG PDF PS

^{13}B **^{4}He(^{12}Be,^{13}Bγ): XUNDL-1 2008OtAA** **200808**

Compiled (unevaluated) dataset from 2008OtAA:

Phys Lett B 666, 311 (2008).

Compiled by F.G. Kondev (ANL), August 16, 2008.

Edited by B. Singh (McMaster), August 18, 2008.

Proton-transfer reaction. Identification of an intruder (deformed) state in ^{13}B at 4829 keV.

The experiment was performed at the RIKEN Accelerator Facility. A ^{12}Be beam was produced by the fragmentation reaction of a 100 MeV/nucleon ^{18}O beam on a ^{9}Be target with a thickness of 1.85 g/cm^2. The ^{12}Be beam was separated by the RIKEN Projectile- Fragment Separator (RIPS). The incident particles were deposited. The time-of-flight, over a path leng the last two foci of the RIPS. The intensity an

The 50 MeV/nucleon ^{12}Be beam bombarded condensed by a cryogenic refrigerator and ke velocity difference between outgoing particle array of six Ge detectors. Each detector conta them.

Measured γ and σ(θ) distribution of 4829γ, D

E(level)	Jπ	L	Population	Comments
0.0	3/2-			Jπ: from 'adopted levels, gammas' dataset for ^{13}B in ENSDF database.
3483			19 5	
3535			20 5	
3681			74 7	
3713			68 7	
4131			49 4	
4829	1/2+	0	100	L: from measured dσ/dΩ distribution and DWBA analysis. Jπ: from L(p)=0. C^2S=0.20 2; S=spectroscopic strength, C^2=isospin Clebsch- Gordan coefficient. Systematic uncertainty=60%. Configuration=π ½[220]^1⊗(^{12}B deformed core); interpreted by 2008OtAA as an intruder (deformed) state from the sd-shell. No cascading transitions to other states in ^{13}B were seen.

[#] Numerical values are from 'adopted levels, gammas' dataset for ^{13}B in ENSDF database.
@Relative population is normalized to 100 for 4829-keV state, the quoted uncertainties are statistical only.

γ(^{13}B)

E_γ[#]	E_{level}	E_γ[#]	E_{level}	E_γ[#]	E_{level}
3483[&]	3483	3681[@]	3681	4131	4131
3535[&]	3535	3713[@]	3713	4829	4829

[#] From γ-ray spectral figure 2 of 2008OtAA, note that the numerical values are the same as implied from level energies in the 'adopted levels, gammas' dataset for ^{13}B in ENSDF database.
@3681 and 3713 γ rays form an unresolved doublet.
& 3483 and 3535 γ rays form an unresolved doublet.

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

B. Pritychenko (NNDC)

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)

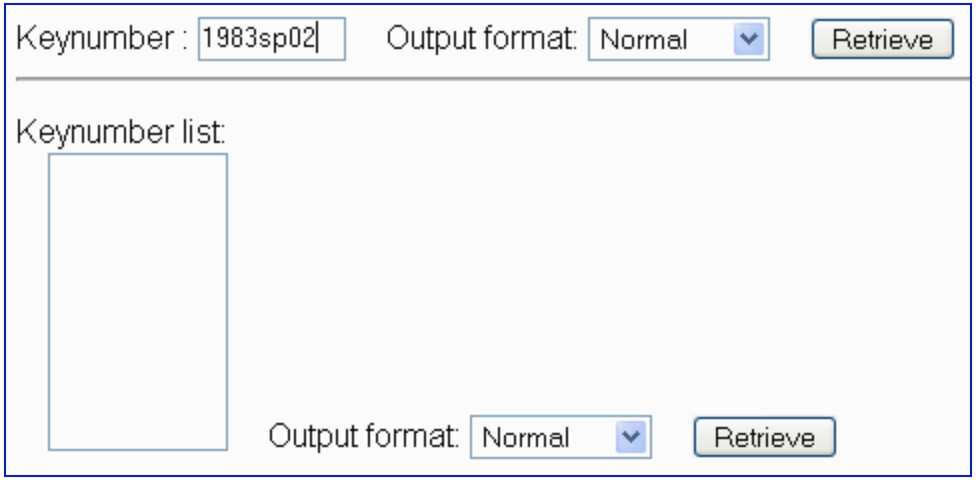
Search Parameters

(none) browse...
AND
(none) browse...
AND
(none) browse...

- ✓**Contributed by:** NNDC, IAEA and McMaster U
- ✓**Covers ~80 journals & secondary references; weekly updated**
- ✓**194K references total with ~4K per year covering ~100 years of NP research**

NSR Database www.nndc.bnl.gov/nsr

Keynumber retrieval - several options for the output. A very interesting one is the bibTex option, that allows to generate a bibTex file to be used in LaTex word processing



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.

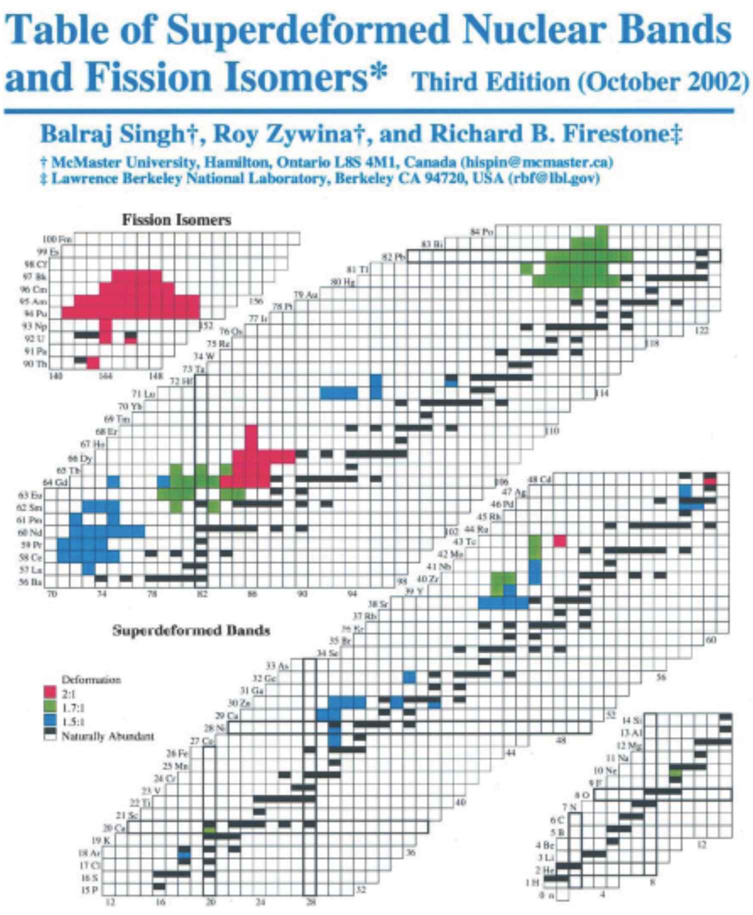
Link to article (PDF), requires subscritption

Keywords, which describe article's content

Link to data in article

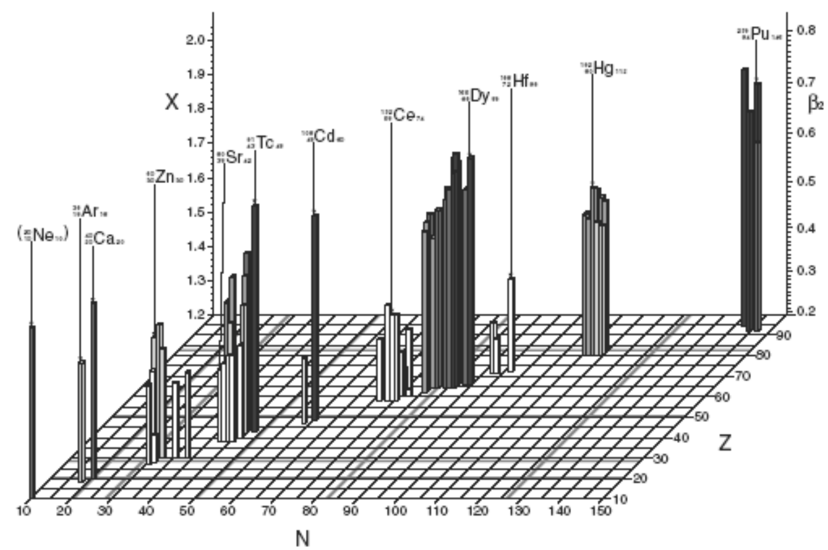
Horizontal Evaluations and Topical Reviews

Nuclear Data Sheets v. 97 (2002) 241



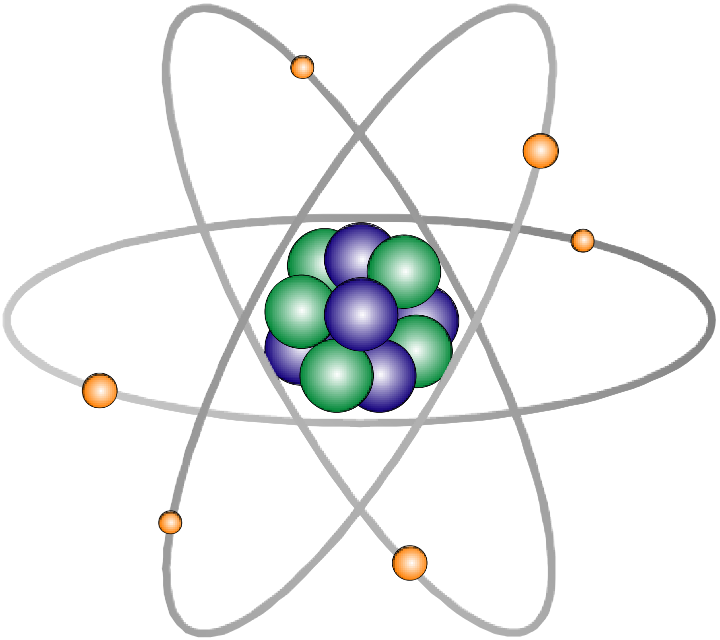
- ❑ Log *ft* values in β-/(e+b+) decay
- ❑ Alpha-decay HF from even-even nuclei
- ❑ Nuclear Moments (μ and Q_0)
- ❑ Proton Radioactivity Decay Data
- ❑ Nuclear Isomers (under development)

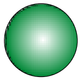
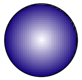
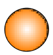
many other applications oriented …



Atomic masses

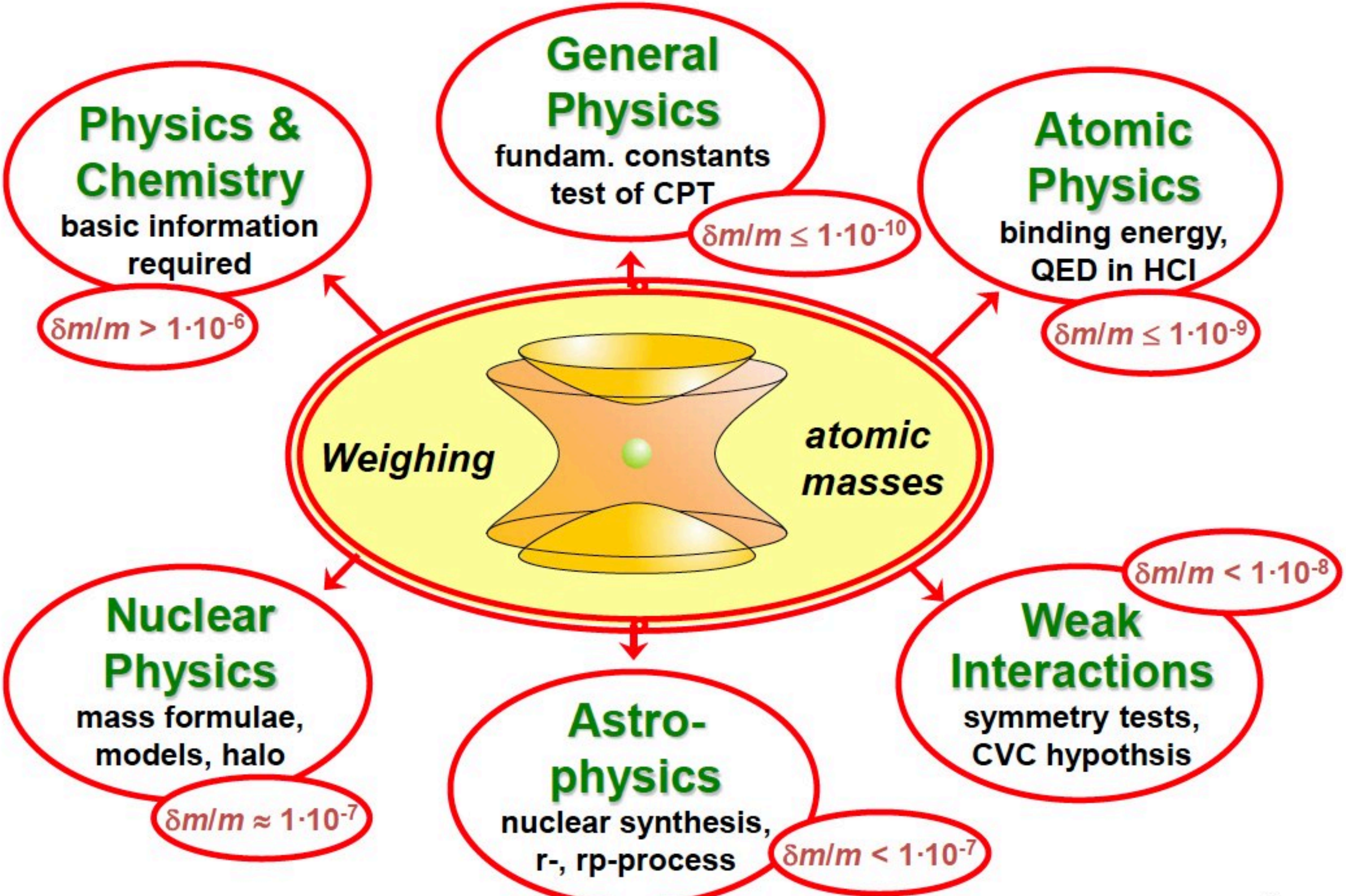
High-accuracy mass measurements allow one to determine the atomic and nuclear binding energies reflecting all forces in the atom/nucleus.



= $N \cdot$  $+ Z \cdot$  $+ Z \cdot$ 

– binding energy

$$M_{\text{Atom}} = N \bullet m_{\text{neutron}} + Z \bullet m_{\text{proton}} + Z \bullet m_{\text{electron}} - (B_{\text{atom}} + B_{\text{nucleus}})/c^2$$


General Physics
fundam. constants
test of CPT
δm/m ≤ 1·10^-10
Physics & Chemistry
basic information required
δm/m > 1·10^-6
Atomic Physics
binding energy,
QED in HCI
δm/m ≤ 1·10^-9
Weighing
atomic masses
Nuclear Physics
mass formulae,
models, halo
δm/m ≈ 1·10^-7
Astro-physics
nuclear synthesis,
r-, rp-process
δm/m < 1·10^-7
Weak Interactions
symmetry tests,
CVC hypothsis
δm/m < 1·10^-8

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Available online at www.sciencedirect.com

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NUCLEAR PHYSICS A

Nuclear Physics A 729 (2003) 129–336

www.elsevier.com/locate/npe

The AME2003 atomic mass evaluation *

(I). Evaluation of input data, adjustment procedures

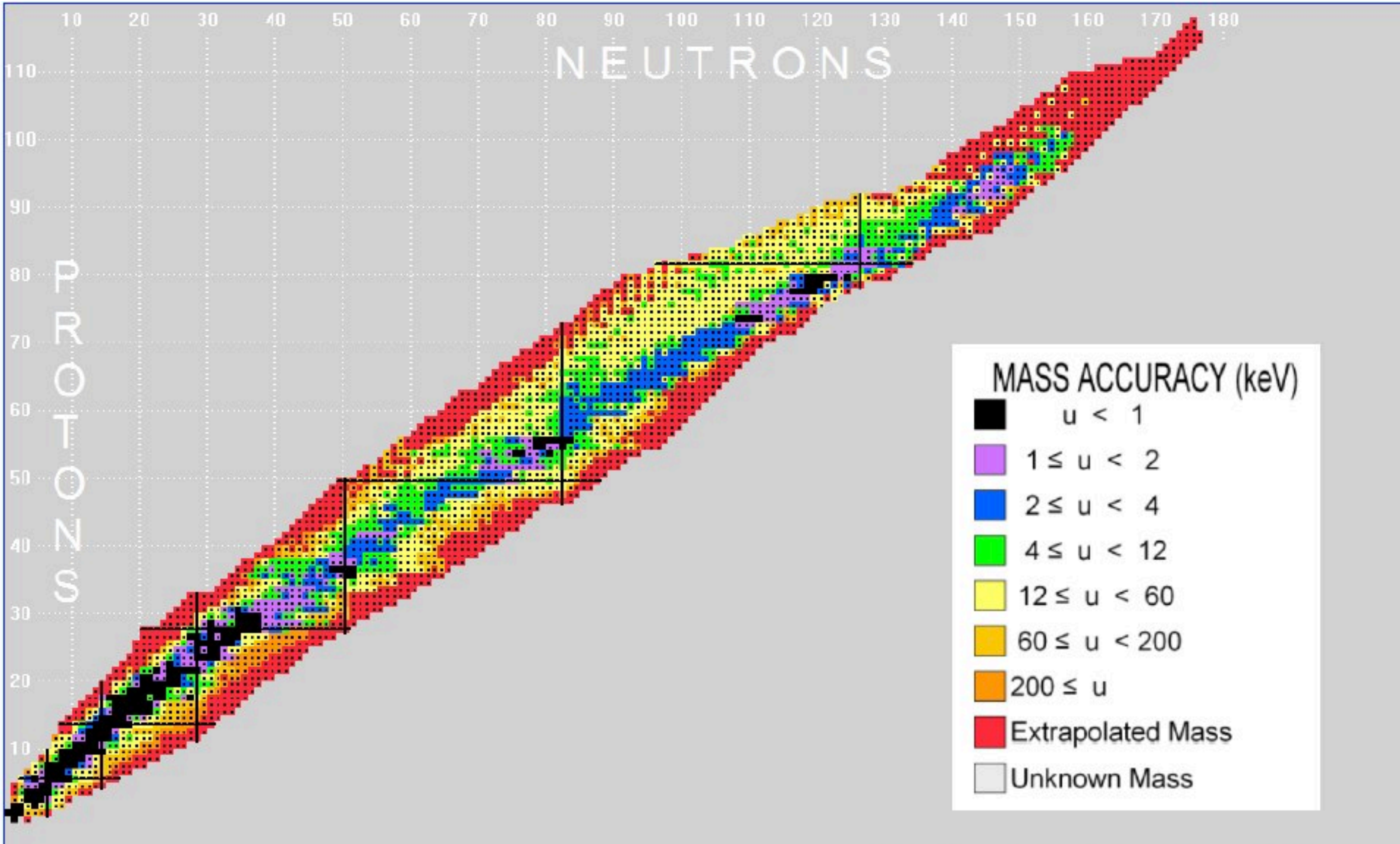
A.H. Wapstra[a], G. Audi[b,§] and C. Thibault[b]

AMDC

Atomic Mass Data Center

http://amdc.in2p3.fr/

http://amdc.in2p3.fr/



AME2003, *G. Audi et al.*, Nucl. Phys. A 729 (2003) 3

http://ribll.impcas.ac.cn/ame/

AMDC
Atomic Mass Data Center

IMP 中国科学院近代物理研究所
Institute of Modern Physics, Chinese Academy of Sciences

Today is 2012/8/6, Monday

- About the AMDC
- Introduction
- Evaluations
  - AME
  - NUBASE
- AME + Nubase 2012
  - Schedule
  - Ask for reprint
- Registration
- Login
- Logout

About the AMDC

The "Atomic Mass Data Center" (AMDC) and its electronic bulletin aim at being a meeting place where information on masses (experimental, evaluation or theory) can be exchanged. The main task of the AMDC is to give progress reports on the "Atomic Mass Evaluation" (AME) and the "Nubase Evaluation", and to put at the user's disposal the most recent tables.

The AMDC, presently located at Centre de Spectrométrie Nucléaire et de Spectrométrie de Masse (CSNSM), Orsay, France, will be transfered in 2013 to the Institute of Modern Physics, Chinese Academy of Sciences (IMP), Lanzhou, China.

A memorandum that defines and secures the future was signed on November 17, 2008.

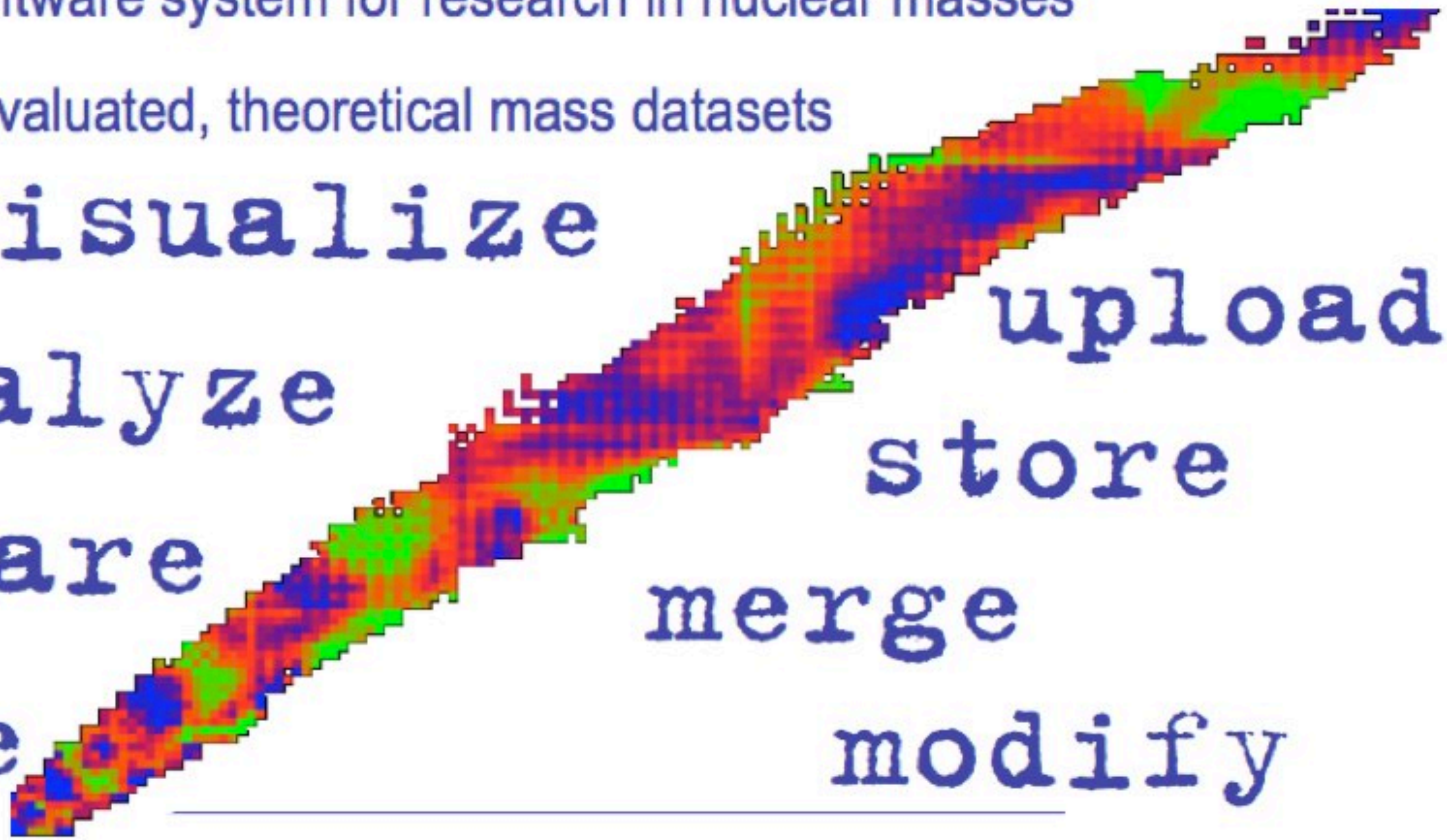
AME12

G. Audi, M. Wang, F.G. Kondev, B. Pfeiffer, M.MacCormick, Xing Xu
CSNSM-Orsay; IMP-Lanzhou; GSI-Darmstadt; ANL-Argonne; MPIK-Heildelberg; IPN-Orsay

nuclearmasses.org

free online software system for research in nuclear masses

experimental, evaluated, theoretical mass datasets



visualize

analyze

compare

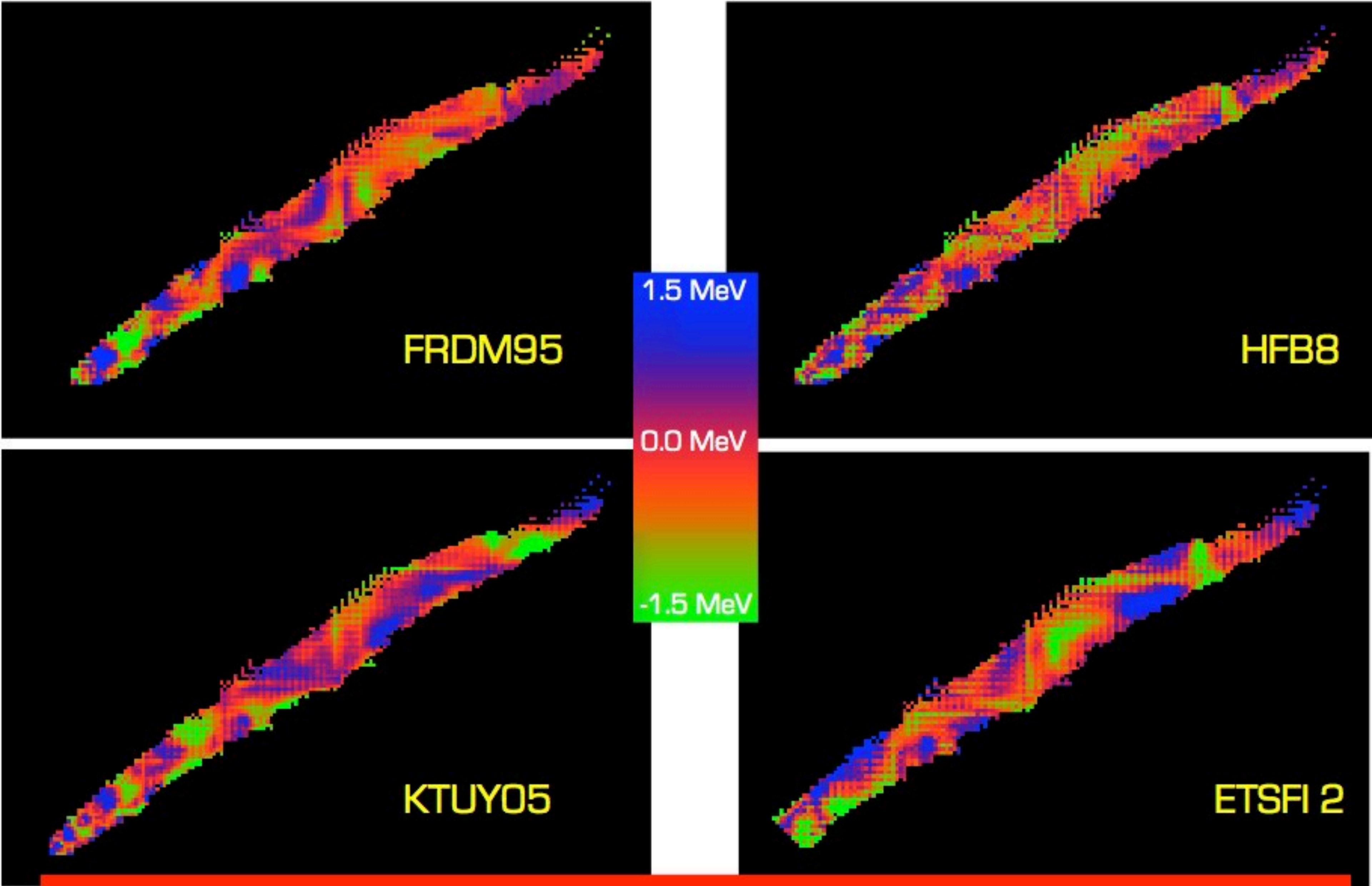
share

upload

store

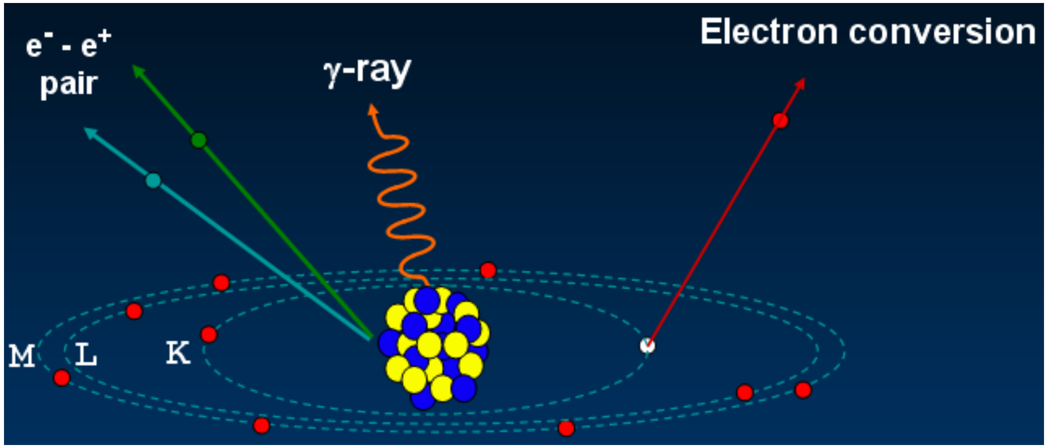
merge

modify

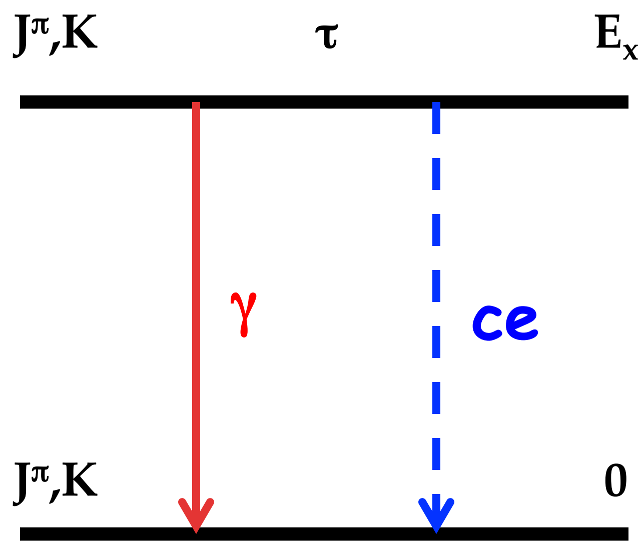


quickly compare mass differences between models & AME2003 masses

Internal Electron Conversion



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



Transition probability

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

Conversion Coefficient

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

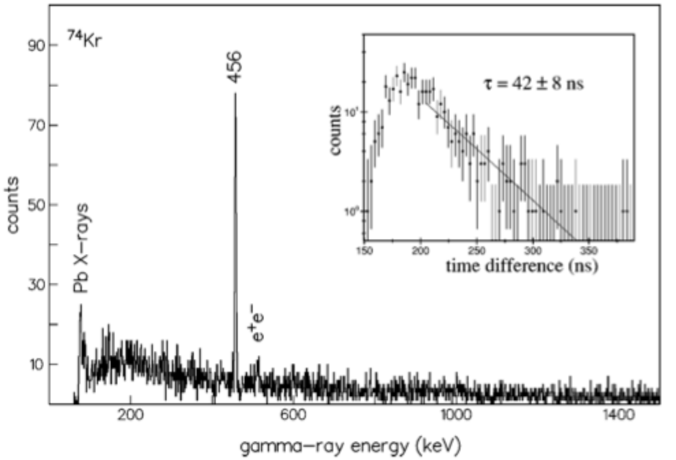
$\alpha \sim E_\gamma$

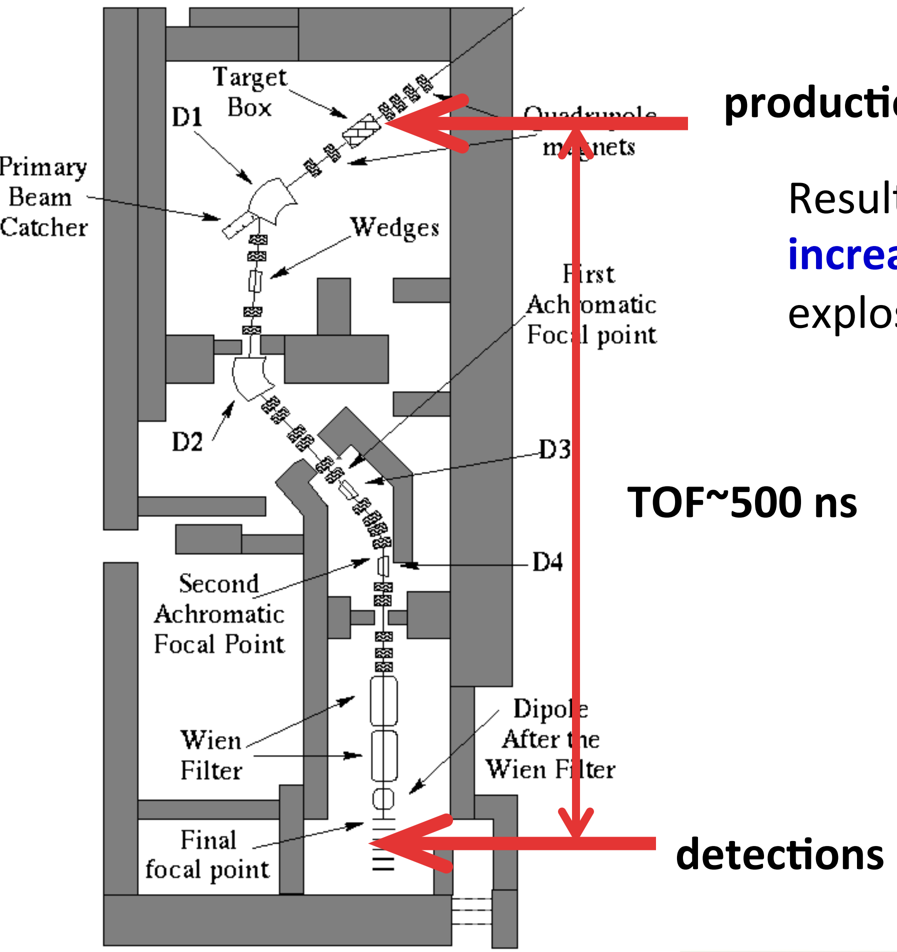
- Z – atomic number
- electron shell or
- electron-positron pair
- XL - transition multipolarity

very useful spectroscopy tool

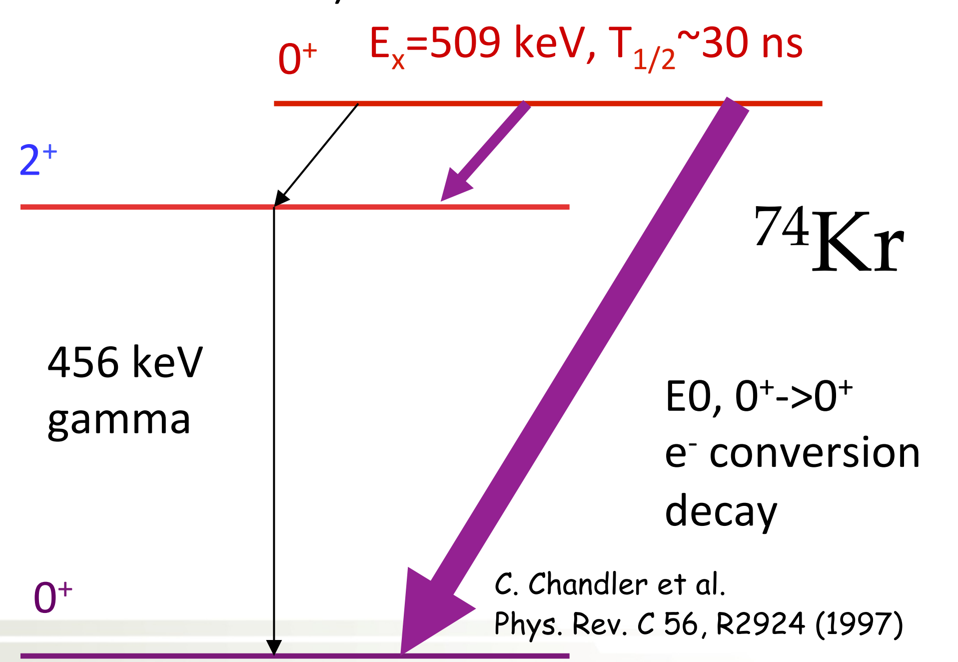
Manipulating isomeric lifetimes - undressing the isomer

$$\Gamma_{tot} = \Gamma_{E0} + \Gamma_{\gamma} + \Gamma_{CE} = \frac{\hbar}{\tau}$$





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)

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. rsphysse. anu. edu. au/nuclear/bricc/

Compare different ICC Tables

Z (atomic number or symbol)	82
γ-energy (in keV)	120 Uncertainty
Enter (optional) uncertainty in energy as **x** or **+x-y**	
Multipolarity	E2 δ Uncertainty
Enter (optional) uncertainty in δ as **x** or **+x-y**	
Show Subshells ☐ **Data Set**	Compare All

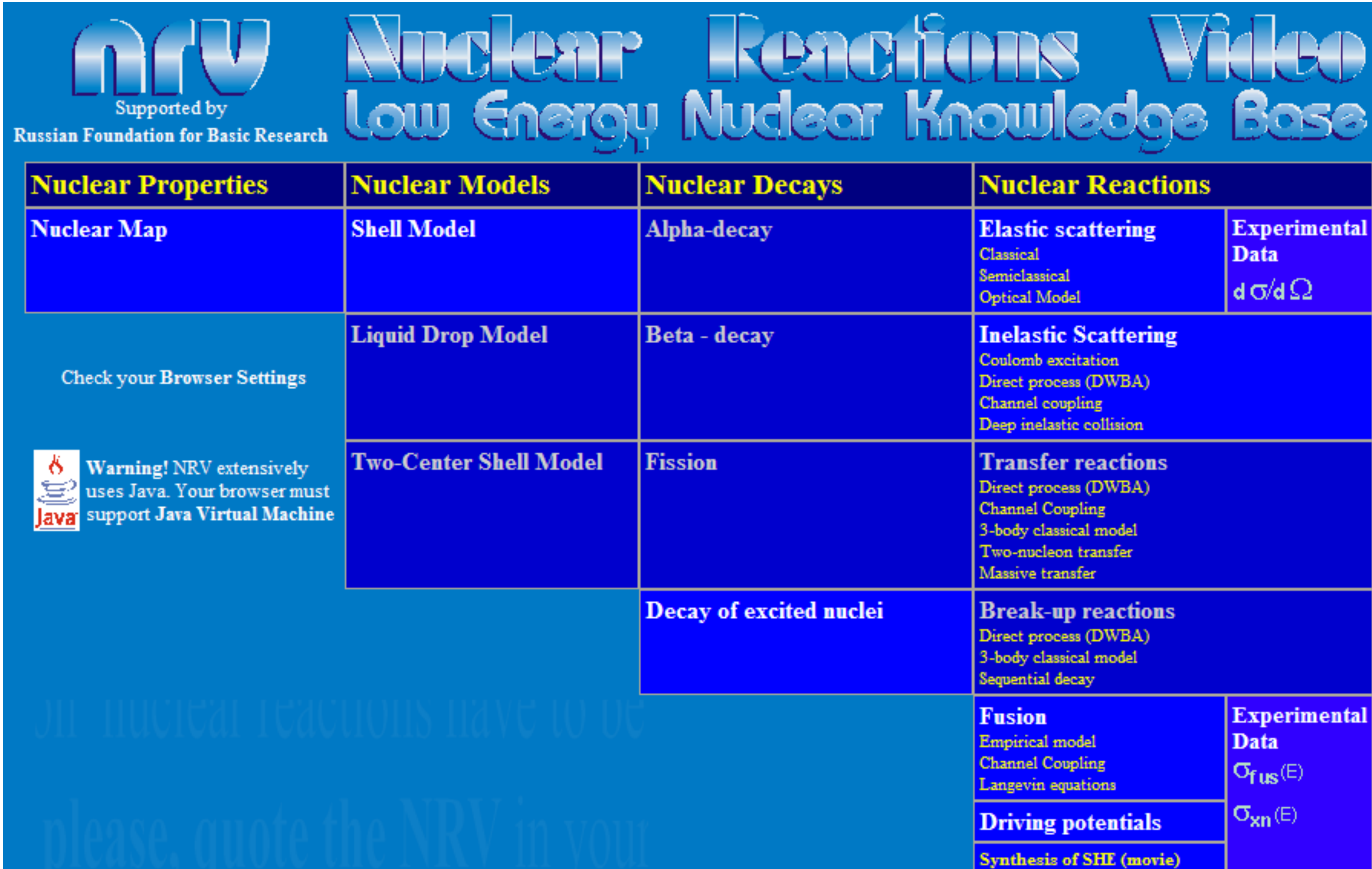
Calculate Reset

BrIccS v2.2a (13-Jul-2008)
Z=82 (Pb, Lead)
γ-energy: 120 keV
Multipolarity: E2

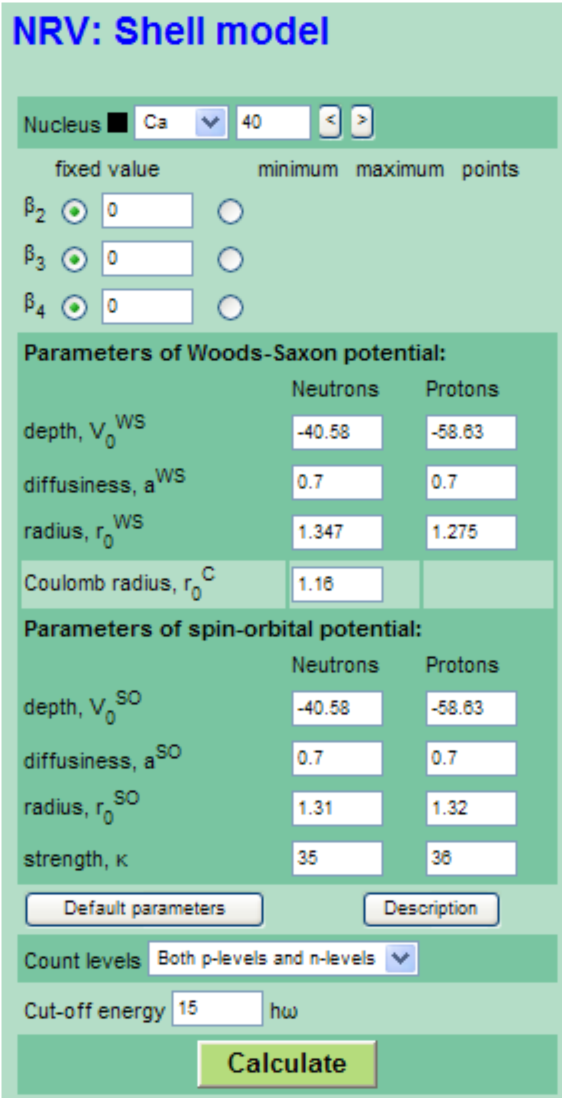
Shell	E(ce)	BrIccFO E2	BrIccNH E2	HsIcc E2	RpIcc E2
Tot		2.95 (5)	2.93 (5)	3.01 (9)	3.01 (9)
K	32.00	0.458 (7)	0.442 (7)	0.466 (14)	0.455 (14)
L-tot	105.66	1.86 (3)	1.85 (3)	1.88 (6)	1.90 (6)
K/L		0.247 (5)	0.238 (5)	0.248 (11)	0.240 (11)
M-tot	116.65	0.490 (7)	0.490 (7)	0.495 (15)	0.502 (15)
L/M		3.79 (8)	3.79 (8)	3.81 (17)	3.78 (16)
N-tot	119.28	0.1236 (18)	0.1236 (18)		0.129 (4)
L/N		15.0 (3)	15.0 (3)		14.7 (7)
O-tot	119.90	0.0221 (3)	0.0221 (3)		0.0249 (8)
L/O		84.1 (17)	84.0 (17)		76 (4)
P-tot	120.00	0.000911 (13)	0.000911 (13)		0.00117 (4)
L/P		2.04E3 (4)	2.04E3 (4)		1.62E3 (7)

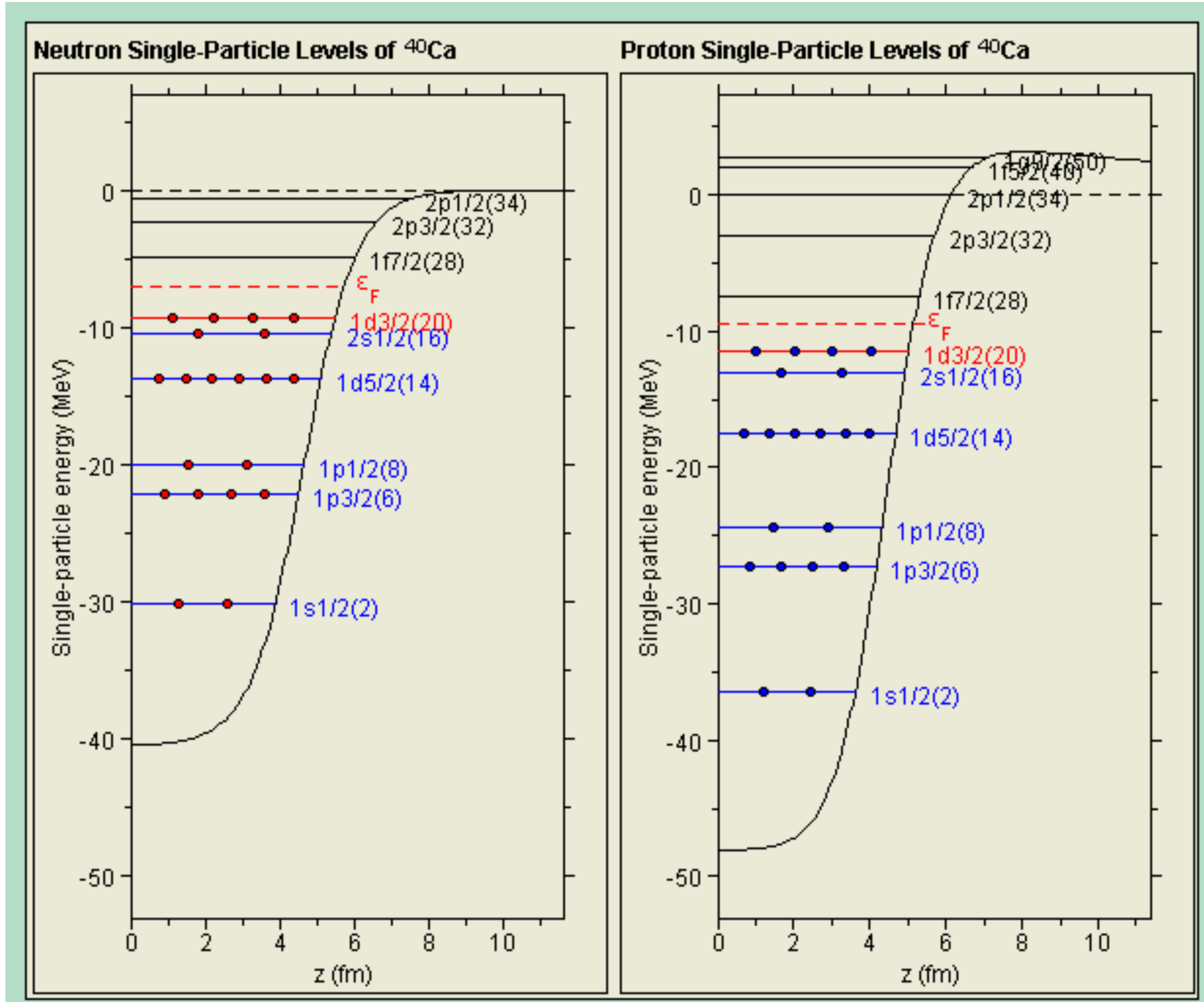
http://www-nds.iaea.org/

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



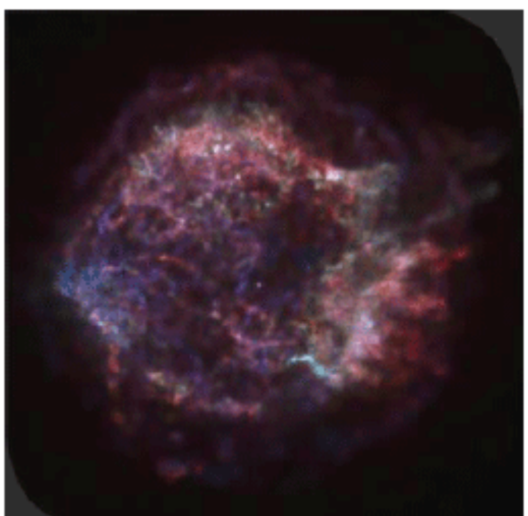
NRV – an example





nucastrodata.org @ ORNL (M. Smith)

WELCOME DATASETS REPOSITORY INFRASTRUCTURE



N U C A S T R O D A T A . O R G
is your WWW resource for creating, accessing, and managing nuclear physics information for astrophysics studies

D A T A S E T S
Hyperlinks to all online nuclear datasets, categorized and continually updated

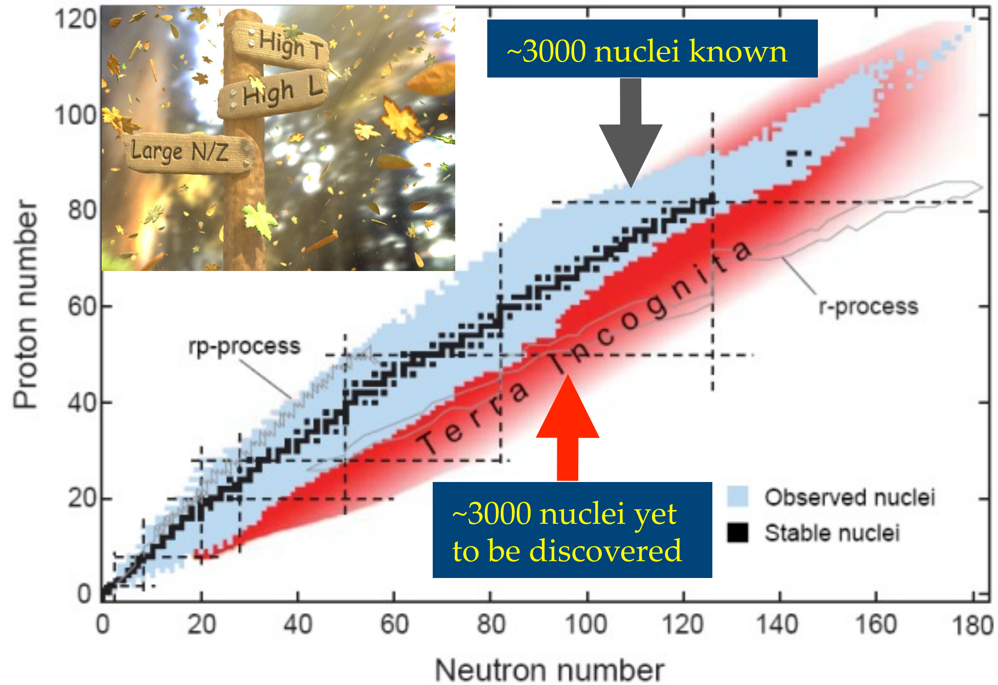
R E P O S I T O R Y
Share nuclear astrophysics files with colleagues; upload via the Infrastructure

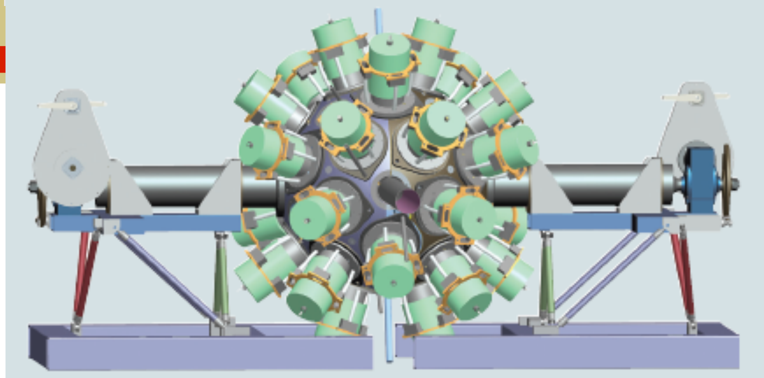
I N F R A S T R U C T U R E
A suite of codes with a graphical user interface enabling researchers to calculate thermonuclear reaction rates from nuclear physics input, put them into rate libraries, browse and plot the rates, and manage and share rate libraries with the community

The Frontiers of Nuclear Science

A LONG RANGE PLAN

Opportunities





GRETINA-AGATA γ−ray tracking arrays

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

U.S. facilities: ANL, ORNL & MSU

FRIB – the future in U.S.

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 – archive for future generations

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

up in the Cloud ....

Thank you!