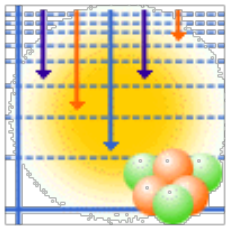
Argonne NATIONAL LABORATORY

Member of the US Nuclear Data Program

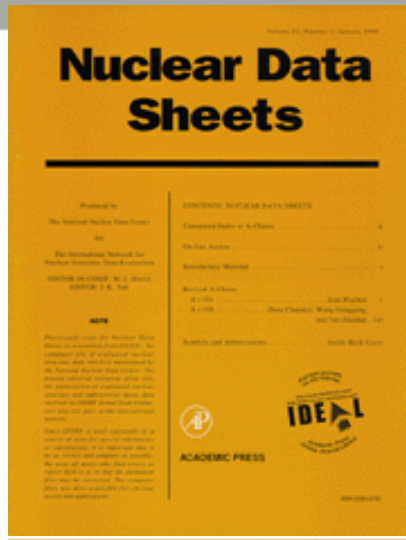
Argonne Nuclear Data Program



- **Nuclear Data Compilations & Evaluations - 90%**
  - ✓ nuclear structure compilations and evaluations - **ENSDF & XUNDL**
  - ✓ evaluation of atomic masses and nuclear properties - **AME & NuBase**
  - ✓ decay data evaluations in support of IAEA-CRP & other horizontal evaluations (nuclear isomers, medical isotopes, etc.)

- **Complementary ND Research Activities -10%**
  - ✓ intersections between basic and applied nuclear physics & astrophysics - via collaborative agreements with a little or no cost to USNDP

ENSDF evaluations



- **22** mass chains permanently assigned to **ANL (NSDD-IAEA)**

A	NDS	Evaluator
106	NDS 109 (2008)	D. DeFrenne & A. Negret
107	NDS 109 (2008)	J. Blachot
108	updated in 2008	J. Blachot
109	NDS 107 (2006)	S. Kumar, J. Chen & F.G. Kondev
110	NDS 113 (2012)	G. Gurdal & F.G. Kondev
111	NDS 110 (2009)	J. Blachot
112	NDS 124 (2015)	S. Lalkovski & F.G. Kondev
176	NDS 107 (2006)	M.S. Basunia
177	NDS 98 (2003)	F.G. Kondev
178	NDS 110 (2009)	E. Browne
179	NDS 110 (2009)	C.M. Baglin
199	NDS 108 (2007)	B. Singh
200	NDS 108 (2007)	F.G. Kondev & S. Lalkovski
201	NDS 108 (2007)	F.G. Kondev
202	NDS 109 (2008)	S. Zhu & F.G. Kondev
203	NDS 105 (2005)	F.G. Kondev
204	NDS 111 (2010)	C.J. Chiara & F.G. Kondev
205	NDS 101 (2004)	F.G. Kondev
206	NDS 109 (2008)	F.G. Kondev
207	NDS 112 (2011)	F.G. Kondev & S. Lalkovski
208	NDS 108 (2007)	M. Martin
209	NDS 126 (2015)	J. Chen & F.G. Kondev

- **outside the ANL region**
  - ✓ **A=133** with the St. Petersburg group
  - ✓ **A=188** (with S. Juutinen, U. Jyvaskyla and D. Hartley, USNA)
  - ✓ **A=87, 227** (ICTP-IAEA, Trieste workshops)

- **training & mentoring**
  - ✓ very good post-docs – C. Chiara (US Army Lab.), S. Zhu (ANL-PHY) & J. Chen (MSU)
  - ✓ NSDD collaborators - S. Lalkovski (U. Sofia) and S. Kumar (U. Delhi) – India-US fellowship stationed at ANL for 9 months
  - ✓ **new, positive development** (following the USNDP review) - **Yuichi Ichikawa (RIKEN)**

ENSDF evaluations - cont.

A	NDS	Evaluator
106	NDS 109 (2008)	D. DeFrenne & A. Negret
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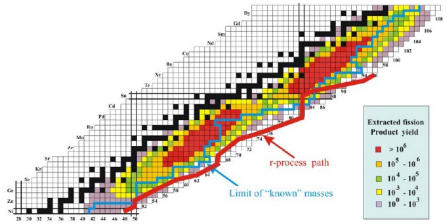
aligned well with the ANL research effort

CARIBU @ANL



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

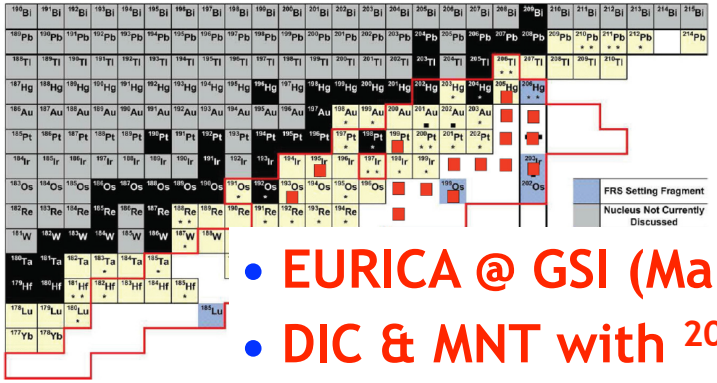
Configurations and hindered decays of K isomers in deformed nuclei with A > 100

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

IOP Publishing — Reports on Progress in Physics

Review of metastable states in heavy nuclei

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

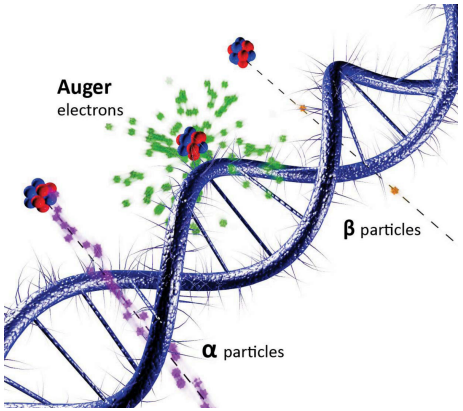


- EURICA @ GSI (March 2006)
- DIC & MNT with ^{208}Pb beams or targets & Gammasphere
- N=126 factory (future)

❑ contributions to **XUNDL** compilation effort

IAEA-CRPs & Medical Isotopes ND needs

- IAEA-CRP on "Nuclear data for charged-particle monitor reactions and medical isotope production" – led by R. Capote (IAEA-NDS)
  - ✓ decay data evaluations of ^{44}Ti, ^{67}Cu & ^{178}Ta
  - ✓ measurements: ^{66}Ga and ^{67}Cu - gaps in nuclear data



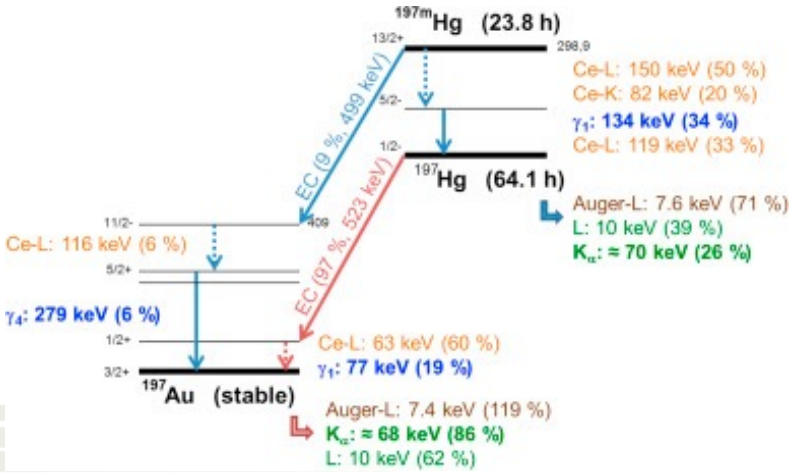
PHYSICAL REVIEW C 92, 044330 (2015)

Precise absolute γ-ray and β^--decay branching intensities in the decay of $^{67}_{29}$Cu

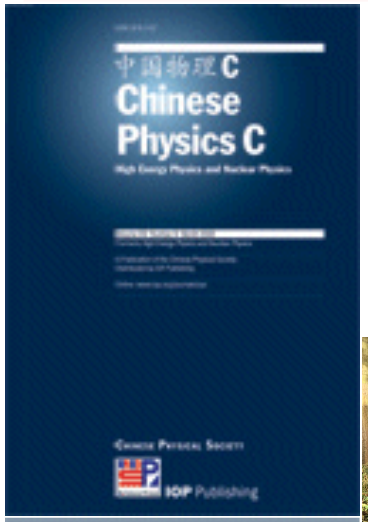
J. Chen,[1,*] F. G. Kondev,[1,†] I. Ahmad,[2] M. P. Carpenter,[2] J. P. Greene,[2] R. V. F. Janssens,[2] S. Zhu,[2] D. Ehst,[1] V. Makarashvili,[1] D. Rotsch,[1] and N. A. Smith[1]

- Continue collaborations with ANU and IAEA-NDS on improving atomic and decay data for Auger Emitters

- issues with ^{197m}**Hg** decay data
  - ✓ theranostic nuclide - imaging & **Auger**
  - ✓ collaboration with O. Lebeda (Academy of Science, Czech Republic) - both new measurements & evaluation



Atomic Mass Evaluation & NuBase



citations:
more than **1455**

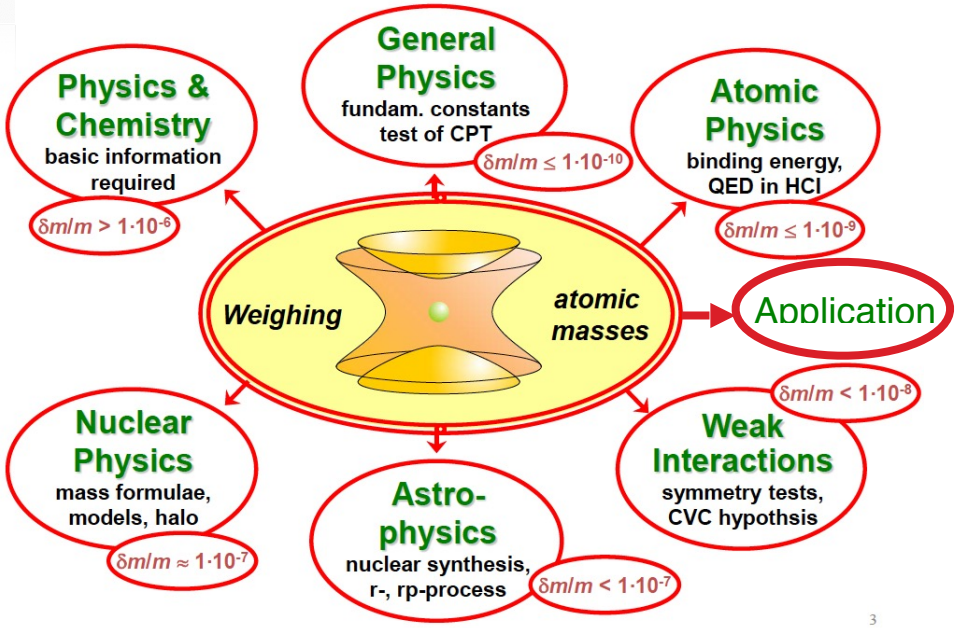
Argonne NATIONAL LABORATORY

CSNSM

IMP

RIKEN NISHINA CENTER

ANL has been contributing since 2008



AME2016 & NUBASE2016

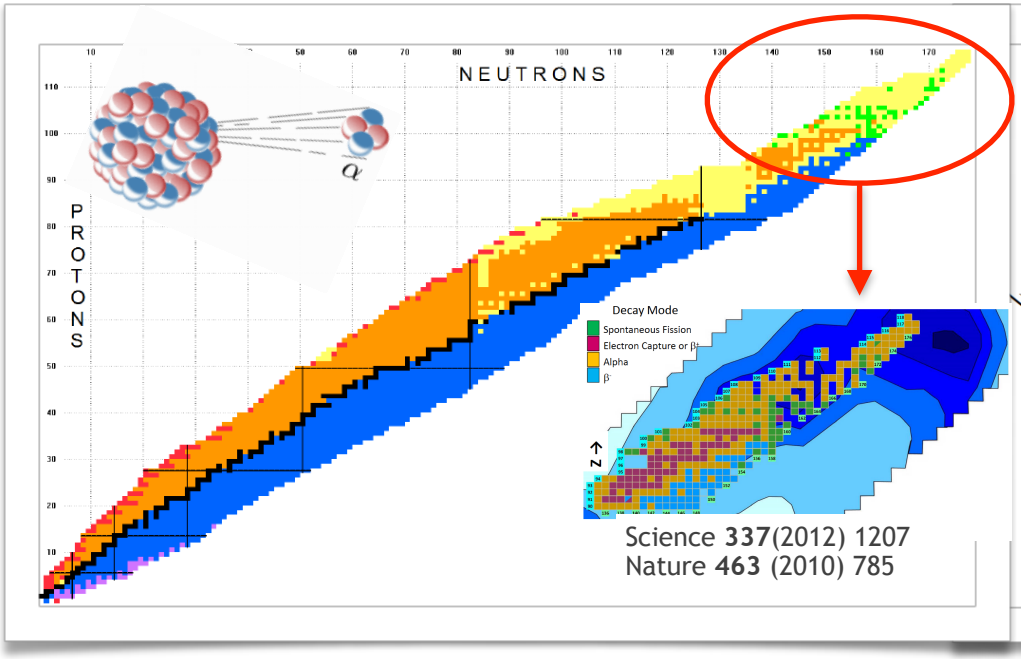
- ✓ work essentially completed - 4 years cycle
- ✓ will be published in February 2017 in Chinese Physics **C**

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

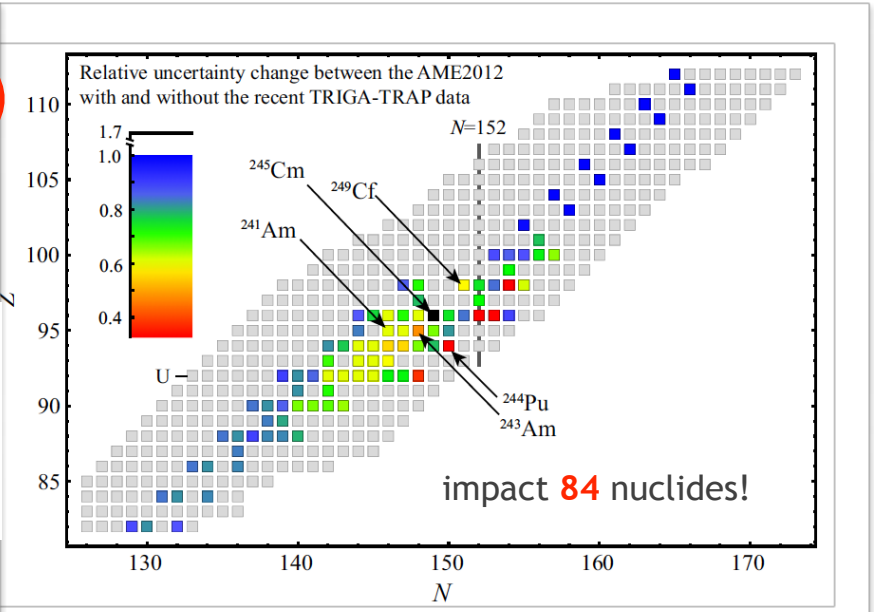
PHYSICAL REVIEW C **89**, 064318 (2014)

Direct high-precision mass measurements on ^{241,243}Am, ^{244}Pu, and ^{249}Cf

M. Eibach,[1,2,*] T. Beyer,[1] K. Blaum,[1] M. Block,[3] Ch. E. Düllmann,[3,4,5] K. Eberhardt,[2,5] J. Grund,[4] Sz. Nagy,[1] H. Nitsche,[6,7] W. Nörtershäuser,[2,3,8] D. Renisch,[2] K. P. Rykaczewski,[9] F. Schneider,[2,10] C. Smorra,[1,†] J. Vieten,[11] M. Wang,[1,12,13] and K. Wendt[10]



Science **337**(2012) 1207
Nature **463** (2010) 785



- ✓ experimental masses for 1/4 of the Chart of Nuclei rely on α-**decay data** that are measured using magnetic spectrographs or/and Si detectors
- ✓ BUT all those measurements are relative to callibrant nuclides - based on **29 absolute α-decay energy measurements** by A. Ritz, ADNDT **47** (1991) 205

PHYSICAL REVIEW C **89**, 064318 (2014)

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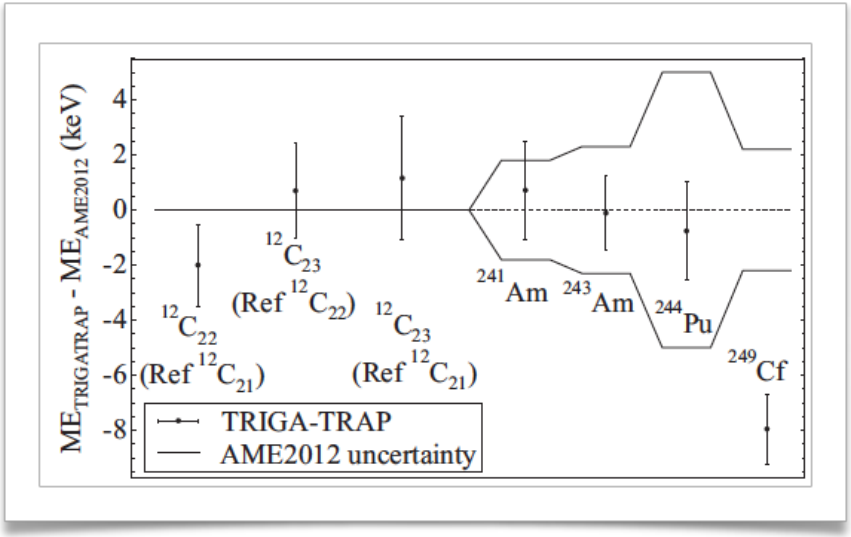
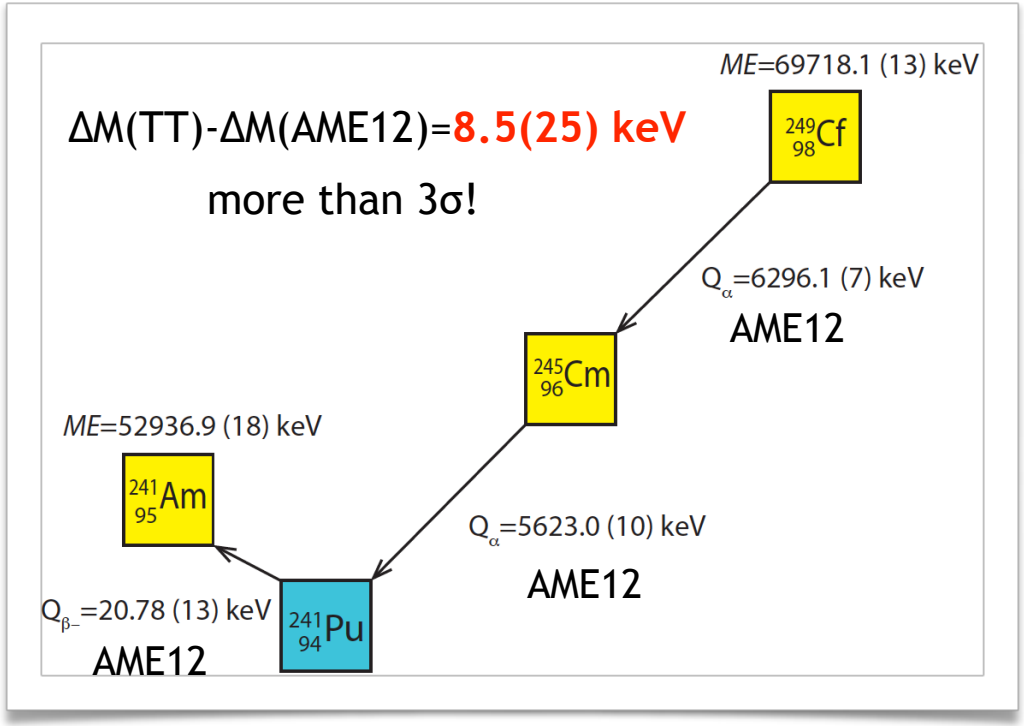
M. Eibach,[1,2,*] T. Beyer,[1] K. Blaum,[1] M. Block,[3] Ch. E. Düllmann,[3,4,5] K. Eberhardt,[2,5] J. Grund,[4] Sz. Nagy,[1] H. Nitsche,[6,7] W. Nörtershäuser,[2,3,8] D. Renisch,[2] K. P. Rykaczewski,[9] F. Schneider,[2,10] C. Smorra,[1,†] J. Vieten,[11] M. Wang,[1,12,13] and K. Wendt[10]





Recommendations: new, high-precision Eα values for ^{245}Cm and ^{249}Cf

Precise measurements of the ^{245}Cm α-decay energies and their relevance to the ^{249}Cf-^{241}Am mass anomaly

F.G. Kondev,* I. Ahmad, and J.P. Greene

(to be published)

PHYSICAL REVIEW C 91, 044310 (2015)

High-resolution α and electron spectroscopy of $^{249}_{98}$Cf

I. Ahmad, J. P. Greene, F. G. Kondev, and S. Zhu

Argonne National Laboratory, Argonne, Illinois 60439, USA

new, high-precision measurements at ANL

- ✓ thin, mass-separated sources of ^{249}Cf and ^{245}Cm
- ✓ PIPS (FWHM=9 keV) Si detectors (Ω<0.1%)
- ✓ ANL magnetic spectrograph (FWHM=5 keV) data for ^{249}Cf- digitized & reanalyzed

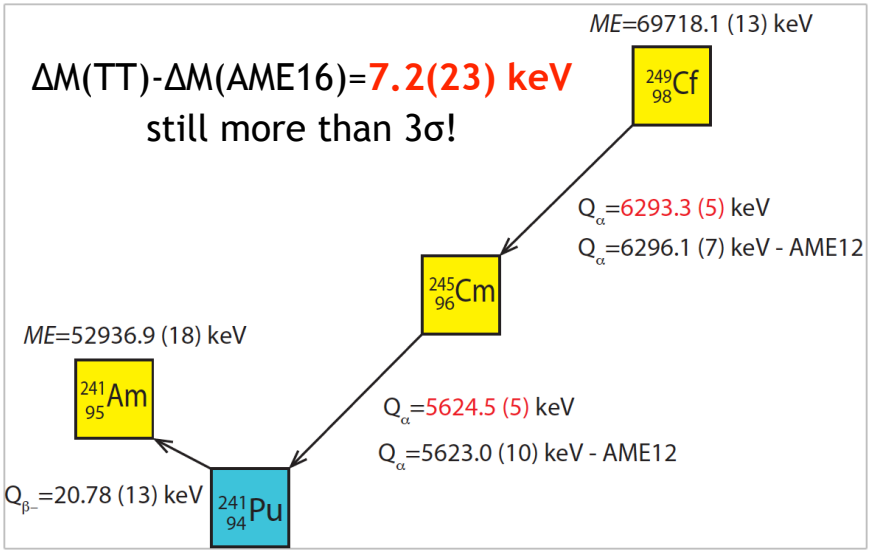
calibration (important!)

relative to absolute α-decay energies of 91Rytz

- ✓ Eα(^{250}Cf)=6030.22 (20) keV
- ✓ Eα(^{244}Cm)=5804.77 (5) keV
- ✓ Eα(^{248}Cm)=5078.38 (25) keV

ΔM(TT)-ΔM(AME16)=**7.2(23) keV**

still more than 3σ!



What could be wrong?

- ✓ Penning Trap data - possible, but unlikely …
- ✓ Ritz recommended (absolute) Eα values - there are some hints here - **HUGE impact** - we must reconsider all α-decay measurements in the Chart of Nuclides …

The path forward?

- ✓ **(short term)** new measurements with CPT to directly test Ritz absolute Eα using **^{228}Th** source -a chain of α emitters, e.g. **^{228}Th, ^{224}Ra, ^{220}Rn, ^{216}Po** (in collaboration with G. Savard's group at ANL)
- ✓ **(long term)** continuation of the Ritz evaluation work is urgently needed - larger international effort under the IAEA-NDS auspices?

Nuclear Data Research Activities

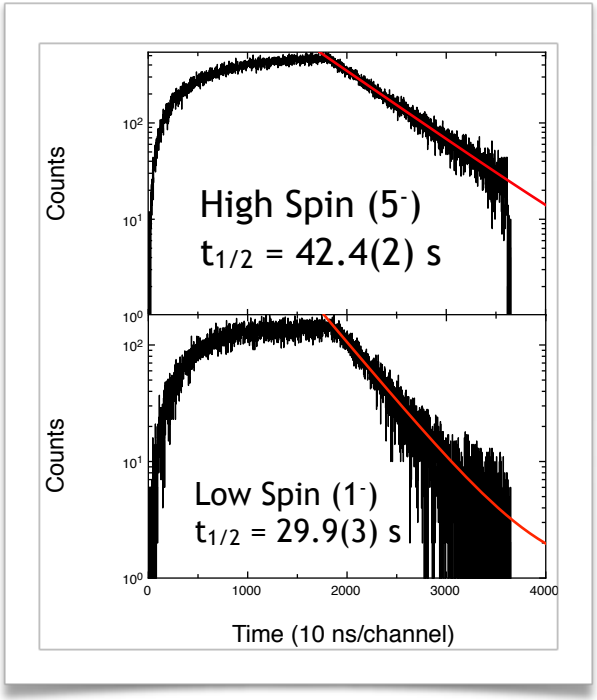
relatively small effort (0.1 FTE) - complements and benefits the evaluation activities – sought after collaborator with little or no cost to USNDP

- at **ANL** - nuclei far from stability, spectroscopy of heavy and super-heavy nuclei, K-isomers, beta-delayed spectroscopy & mass measurements; ***decay spectroscopy*** of actinide nuclei and nuclei of importance to applications of medical isotopes and metrology
  - ✓ **CARIBU** – properties of neutron-rich nuclei (nuclear structure & masses, astrophysics & applications - beta-delayed gamma's and neutrons, independent fission yields & isomeric ratios in fission)

- at **MSU** (Coulex & decay spectroscopy), **TRIUMF** (decay spectroscopy) & **RIKEN** (decay spectroscopy) – properties of neutron-rich nuclei far from the line of stability

- at **Australian National University** & **RCNP-Osaka** (isomers, astrophysics & medical isotopes physics), at **Jyvaskyla University** (spectroscopy of SHE)

Decay data on ^{160}Eu in the rare-earth region



CARIBU & X Array & SATURN @ANL

with D.J. Hartley (USNA) & ANL-PHY

Previous $T_{1/2}$: 31(4)s, 41(4)s, 50(10)s, 53(10)s, assuming a single (low-spin) ß-decaying state
Present $T_{1/2}$: lifetimes of γ's fell into 2 values (e.g. 2 isomers)

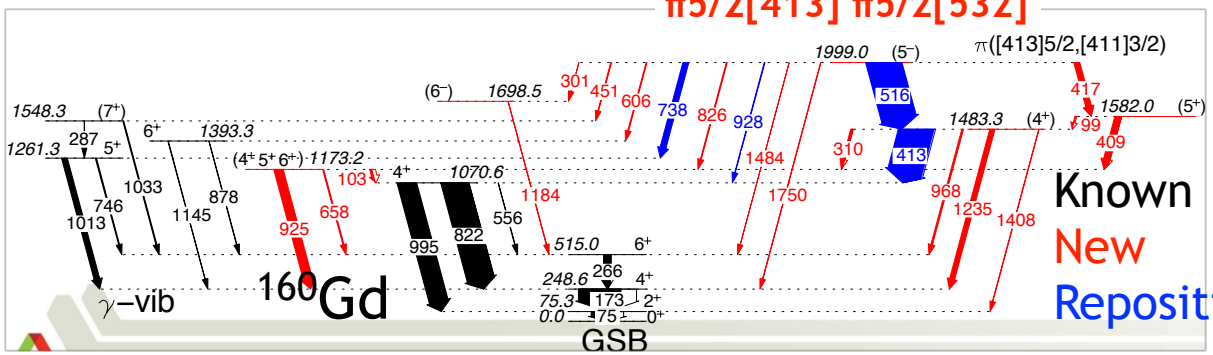
π5/2[413] ν5/2[523] -> K^{π} = 5^- & 0^-

Two different decay schemes proposed, ours differs from both!
- 1999-keV state: log *ft* ≈ 5.0 -> related configurations

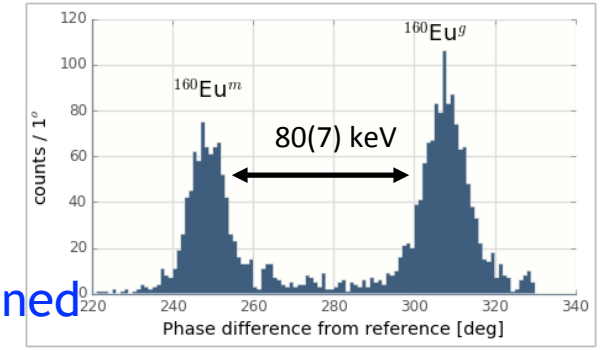
CPT mass measurements:
✓ excitation energy of the isomer
✓ independent FY isomeric ratio

^{160}Eu (5^-) **π5/2[413] ν5/2[523]**

π5/2[413] π5/2[532]



Known
New
Repositioned



Future (FY17 and beyond) Plans

- **Continue contributing to XUNDL & ENSDF - top priority**
  - ✓collaboration with RIKEN on training new data evaluators - there is a good opportunity for bringing new blood into ENSDF

- **Continue AME & NuBase collaborative activities**
  - ✓ maintain the currency (4yr cycle) and quality

- **Continue collaborations with IAEA-NDS and ANU** on medical isotopes Nuclear Data needs & improving the Nuclear Data for Auger emitters

- **Continue research activities** with emphasis on nuclear structure physics and astrophysics, and their intersection with the applied nuclear physics
  - ✓ **ATLAS/CARIBU** – nuclear structure, masses & astrophysics, beta-delayed gammas & neutrons, fission yields and isomeric ratios, …
  - ✓ **NSCL (FRIB), RIKEN & IMP**– nuclear structure, masses & astrophysics