Member of the US Nuclear Data Program

Experimental Activities
Argonne Nuclear Data Program

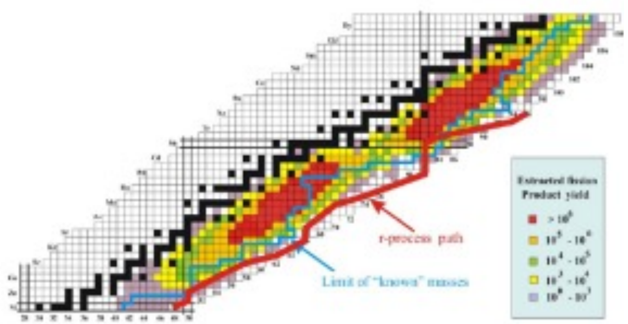
performed at ANL (**ATLAS & CARIBU**), **LBNL**, **NSCL** and at leading nuclear physics laboratories elsewhere (**RIKEN, TRIUMF, GSI, Orsay, ANU**) through collaborative arrangements

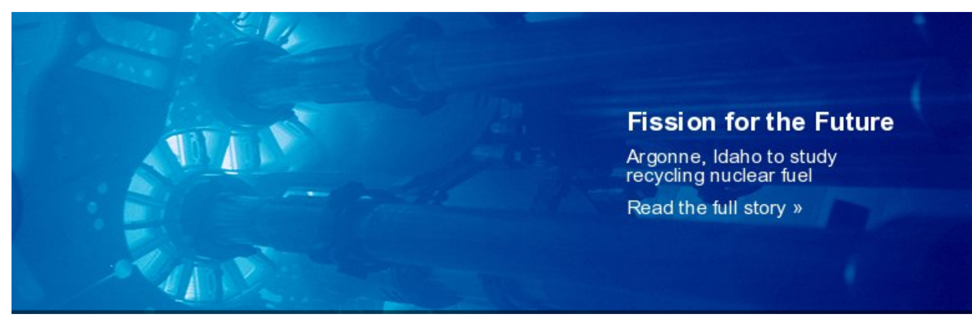
- data measurements aimed at providing answers to specific questions that arise from recent nuclear data evaluations and at improving the quality of existing databases in specific areas, such as (but not limited to) decay data of minor actinides, neutron-rich fission products & medical isotopes; emphasis on high-precision measurements; impact on applications of NP

- at forefront research areas – to maintain important collaborative connections with the NP research community, FRIB and GRETINA in particular; very beneficial to data evaluation - provide important training to the modern experimental equipment & techniques

ND Research Activities at ANL

- **Nuclear Structure studies: using Gammasphere, FMA & CARIBU at ANL** (with M.P. Carpenter, R.V.F. Janssens & G. Savard, ANL-PHY), **NSCL** (S. Lidick & others), **RIKEN** (H. Watanabe), **ALTO** (G. Georgiev), **LBNL** (K. Gregorich, P. Fallon & R. Clark) …
  - ✓ emphasis on nuclei far from stability, heavy-elements, nuclear isomers, …
- **Decay studies of selected actinide nuclei & nuclei of relevance to medical isotopes applications** (with I. Ahmad, J.P. Greene & S. Zhu, ANL-PHY)
  - ✓ singles & coincidences α-, β- and γ-ray decay studies
- **Contributions to DOE/ONP ARRA projects at ANL (ND staff is a Co-PI):**
  - ✓ *"Beam-decay Studies of Neutron-rich Fission Products for Advanced Fuel Cycle Applications"* (in collaboration with **ANL-PHY & UML**)
  - ✓ *"Measurements and Evaluation of Actinide Neutron Cross Sections Relevant to Advanced Fuel Cycles via Accelerator Mass Spectroscopy"* (with **ANL-PHY and INL**)





^{249}Bk half-life and β− decay endpoint energy

PHYSICAL REVIEW C **90**, 044302 (2014)

Precise measurements of the $^{249}_{97}$Bk ground state half-life and the β^--decay end-point energy

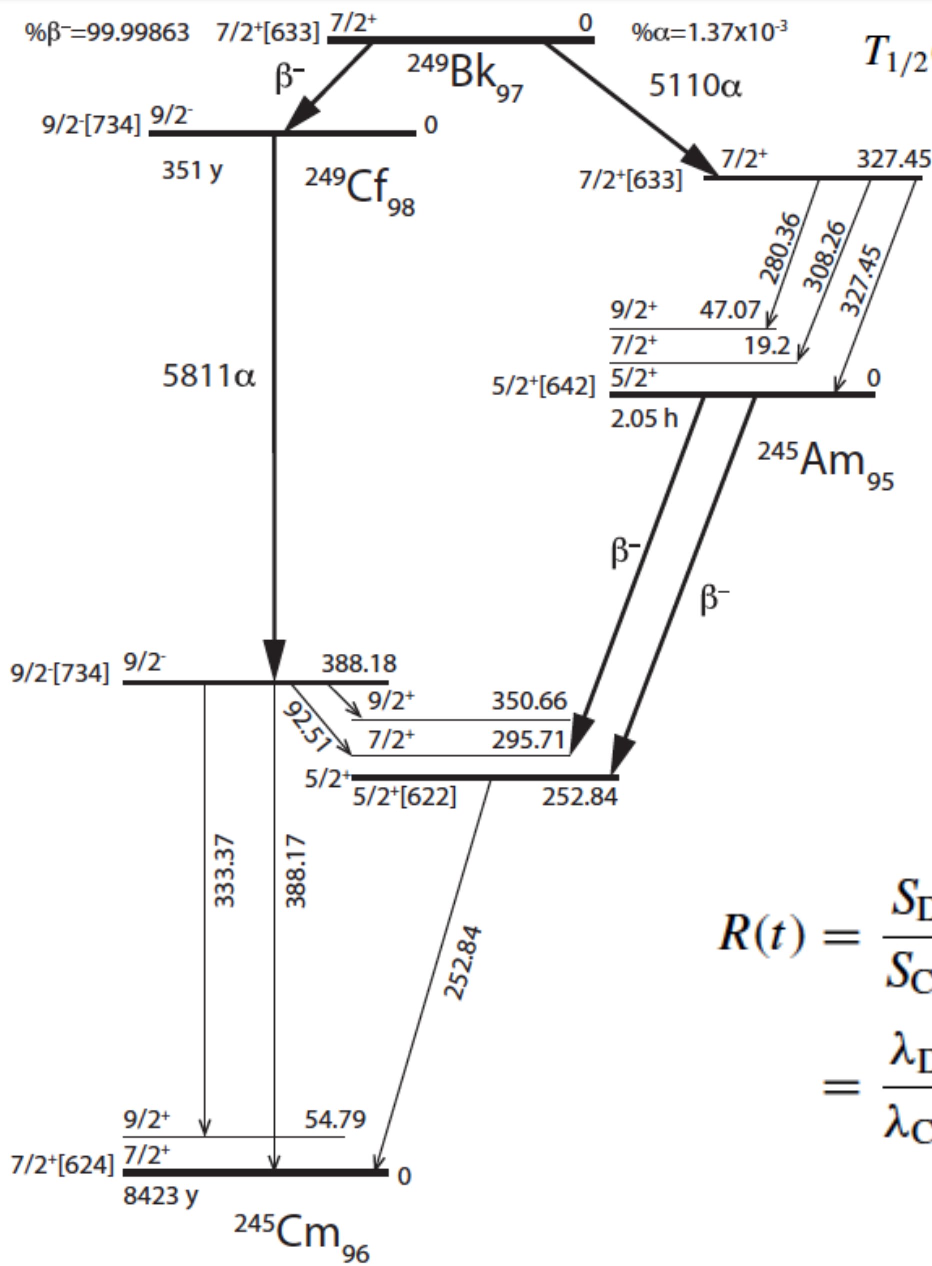
J. Chen, I. Ahmad, J. P. Greene, and F. G. Kondev*
Argonne National Laboratory, Argonne, Illinois 60439, USA
(Received 19 August 2014; published 3 October 2014)

- ✓ 330(4) d – NDS 112 (2011) 2129
- ✓ 320(6) d – TOI99 (based on NDS 59 (1990) 59)

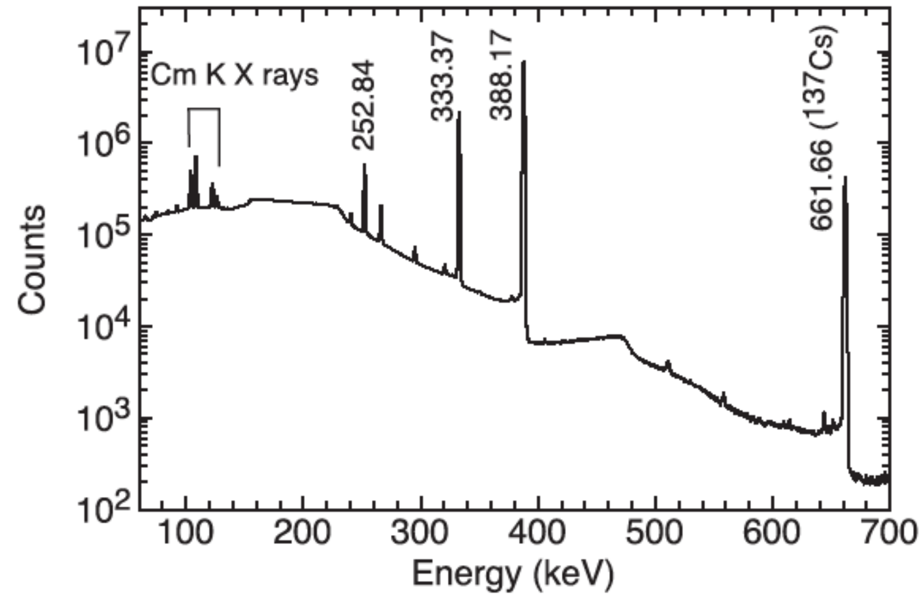
Half-life (d)	Method	Decay followed	$E_{\beta,max}$ (keV)	Method	Reference
290 ± 20	β^- activity	~140 d	80 ± 20	Absorption	[3]
~365	β^- activity		100 ± 20	Absorption	[16]
314 ± 8	β^- activity	~1 y	114 ± 15	Absorption	[4]
			125 ± 2	Fermi-Kurie	[17]
325 ± 7	β^- activity	~1 y	123 ± 3	Fermi-Kurie	[5]
329 ± 4[a]	β^- activity	~600 d			[6]
330 ± 4[a]	β^- activity	~1181 d			[7,8]

[a]The quoted uncertainty is two standard deviations (2σ).

^{249}Bk half-life and β− decay endpoint energy



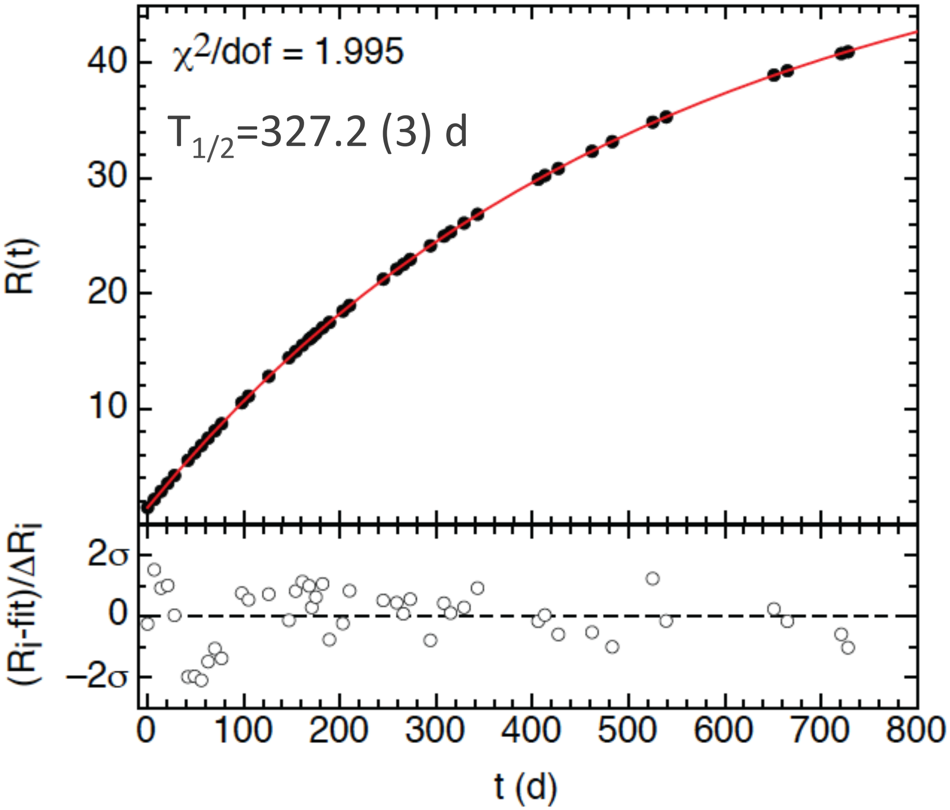
$T_{1/2}(\mathrm{D}) = 351 \pm 2$ y [9] and $T_{1/2}(\mathrm{Cs}) = 30.08 \pm 0.09$ y [14]



$$R(t) = \frac{S_{\mathrm{D}}(t)}{S_{\mathrm{Cs}}(t)} = \frac{\epsilon_{\mathrm{D}} \lambda_{\mathrm{D}} N_{\mathrm{D}}(t)}{\epsilon_{\mathrm{Cs}} \lambda_{\mathrm{Cs}} N_{\mathrm{Cs}}(t)}$$

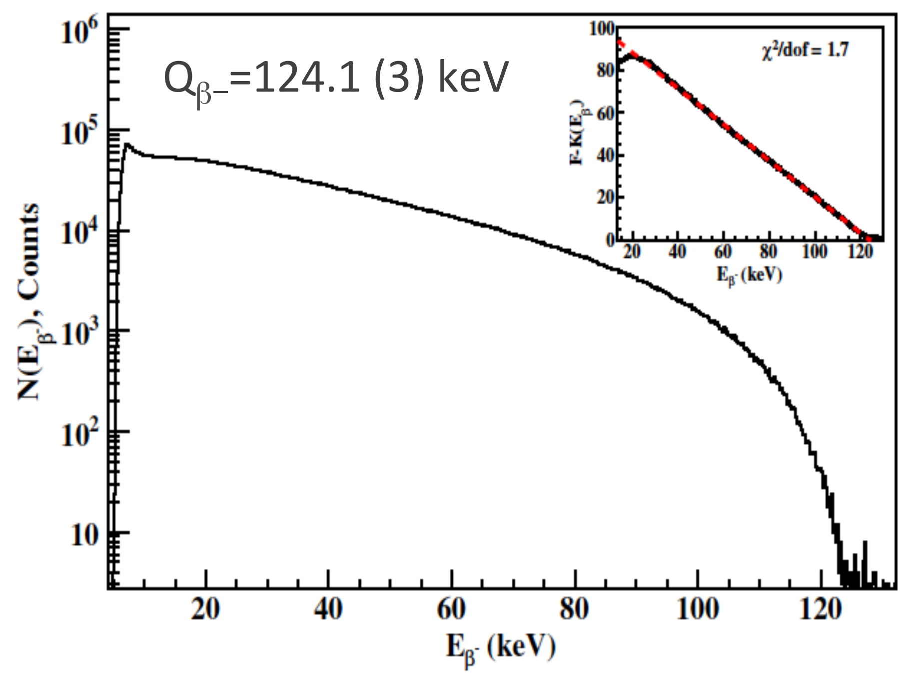
$$= \frac{\lambda_{\mathrm{D}}}{\lambda_{\mathrm{Cs}}} \left[A \frac{\lambda_{\mathrm{P}}}{(\lambda_{\mathrm{P}} - \lambda_{\mathrm{D}})} (e^{-\lambda_{\mathrm{D}} t} + e^{-\lambda_{\mathrm{P}} t}) + B \right] e^{\lambda_{\mathrm{Cs}} t},$$

^{249}Bk half-life and β− decay endpoint energy



- ✓ following the growth of the ^{249}Cf daughter for 738 d
- ✓ high-precision, singles γ−ray measurements

388 keV (^{249}Cf) relative to 661 keV (^{137}Cs)

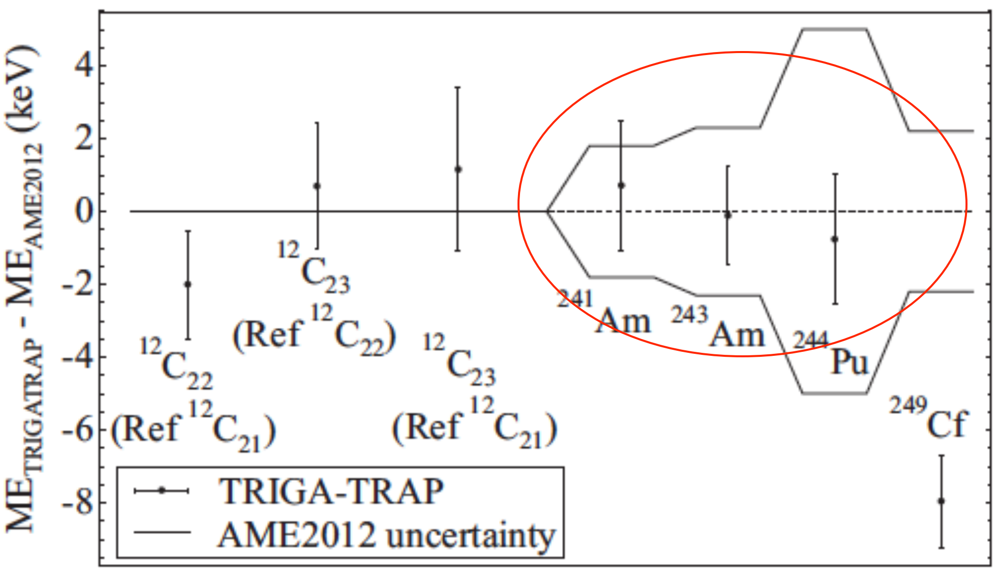


- ✓ better precision (order of magnitude!)
- ✓ comparable to recent Penning trap measurements in the region

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

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

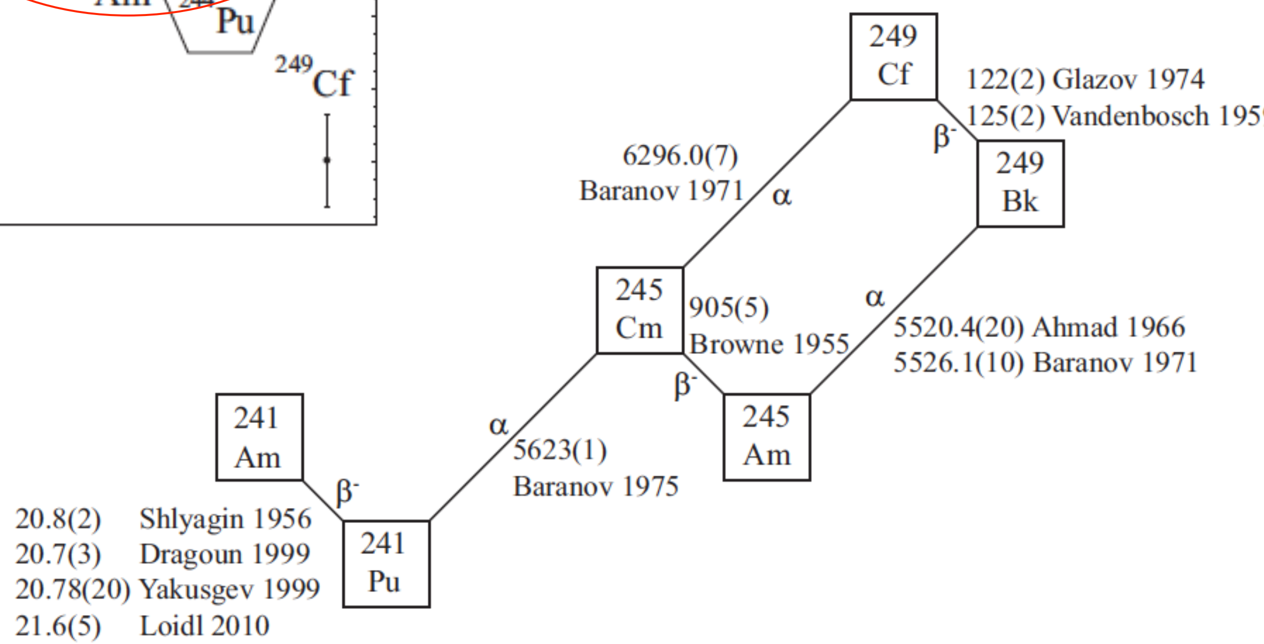
M. Eibach,[1,2,*] T. Beyer,[1] K. Blaum,[1] M. Block,[3] Ch. E. Düllmann,[3,4,5] K. Eberhardt,[2,5] J. Grund,[4] Sz. Nagy,[1] H. Nitsche,[6,7] W. Nörtershäuser,[2,3,8] D. Renisch,[2] K. P. Rykaczewski,[9] F. Schneider,[2,10] C. Smorra,[1,†] J. Vieten,[11] M. Wang,[1,12,13] and K. Wendt[10]

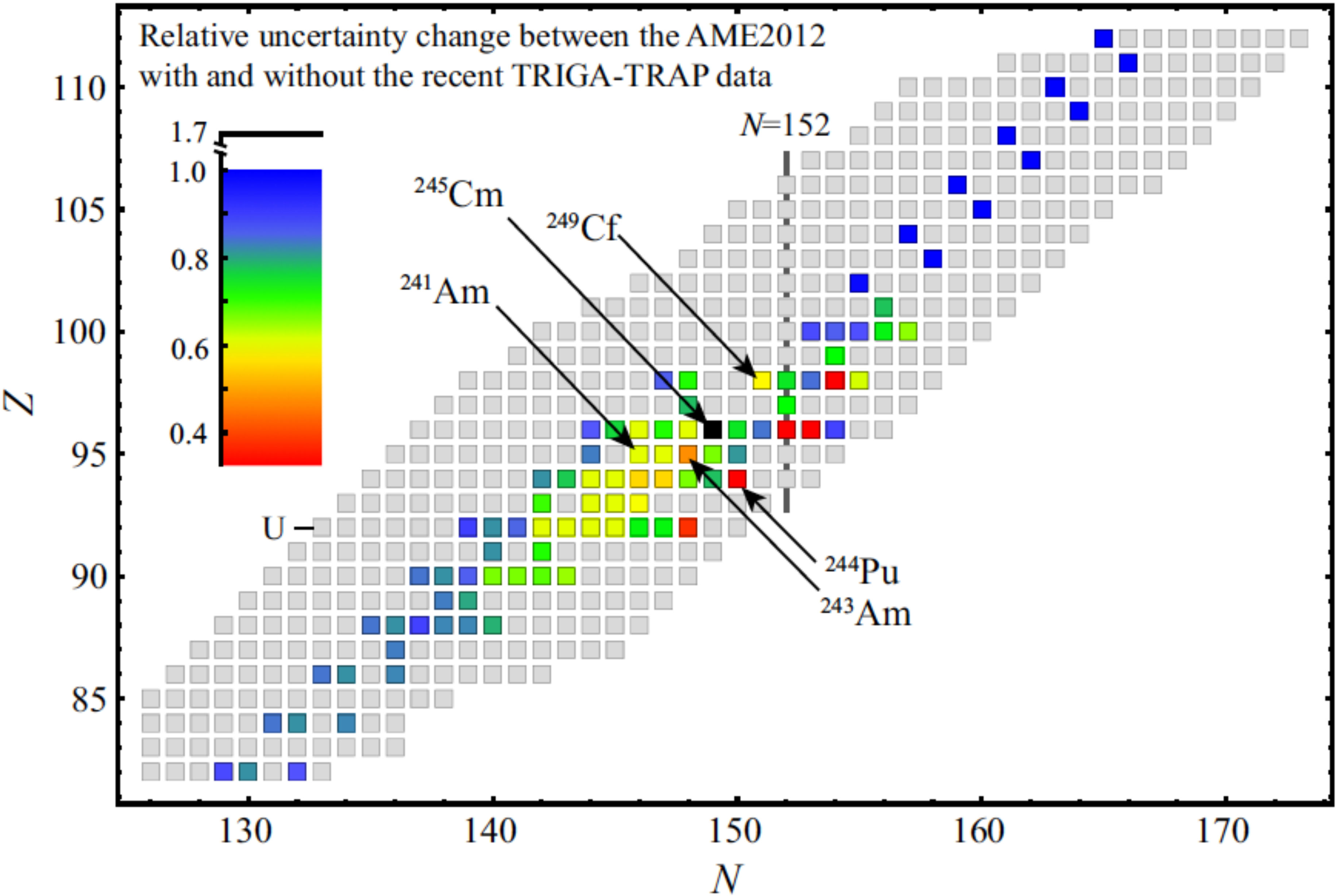


absolute measurements at **BIPM** – 1991Rytz

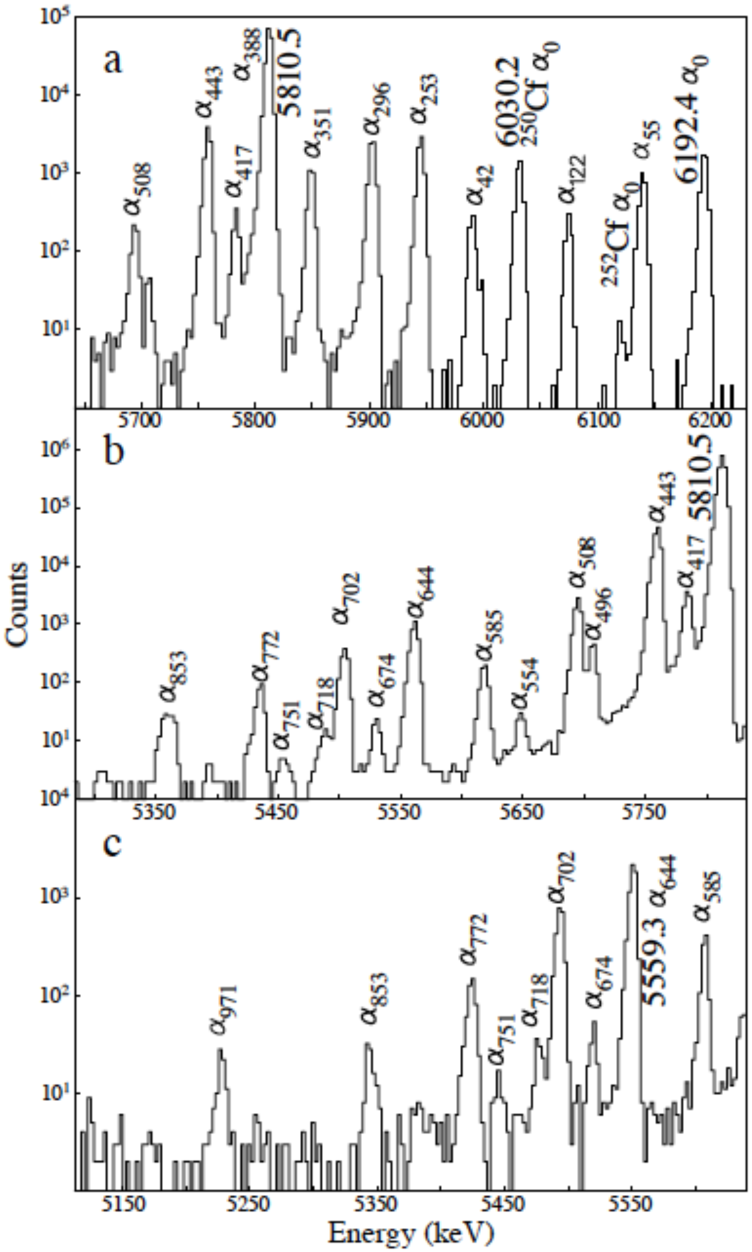
vs.

absolute measurements with Penning Traps




Relative uncertainty change between the AME2012
with and without the recent TRIGA-TRAP data
1.7
1.0
0.8
0.6
0.4
N=152
245Cm
249Cf
241Am
244Pu
243Am
U
110
105
100
95
90
85
Z
130
140
150
160
170
N

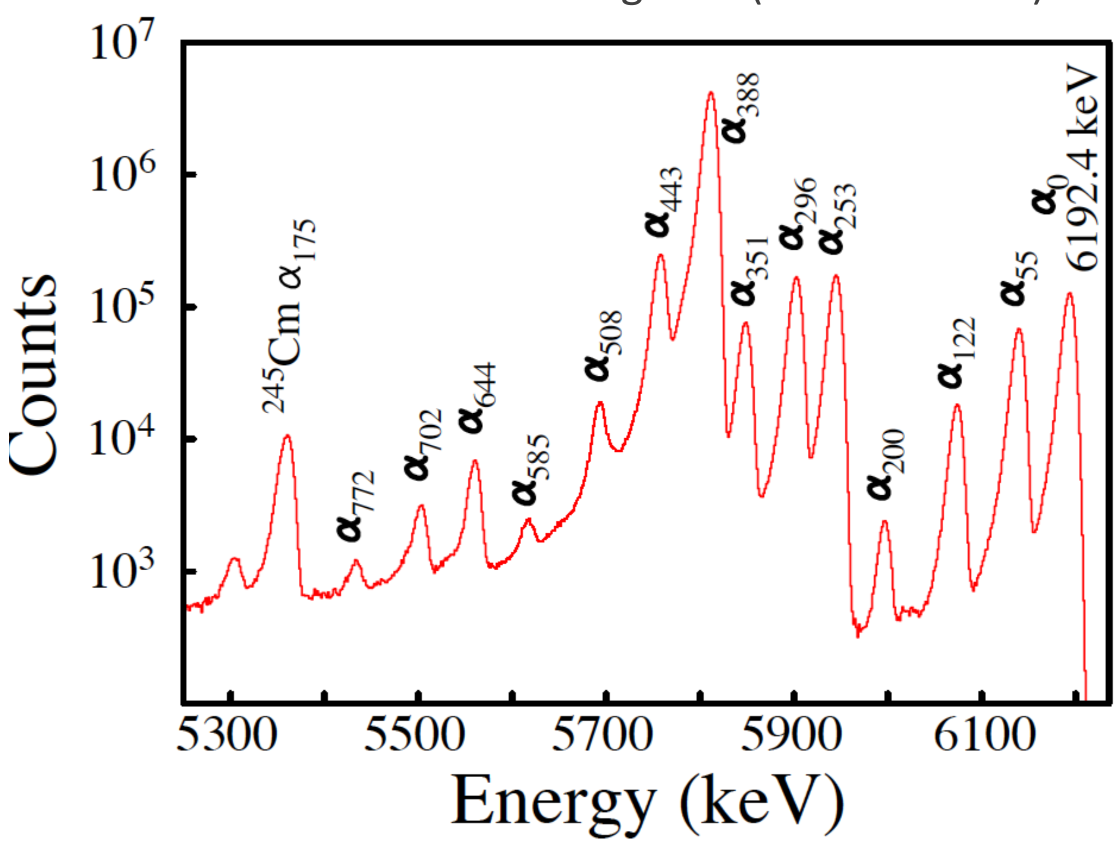
^{249}Cf α−decay measurements



ANL magnetic spectrograph (FWHM=5 keV) – relative to Eα(^{250}Cf)=6030.22(20) keV – absolute value

Eα=**5810.5 (5)** keV, compared to 5812.8 (16) keV in 1991Ry, based on Baranov et al.

data collected using PIPS (FWHM=9 keV)

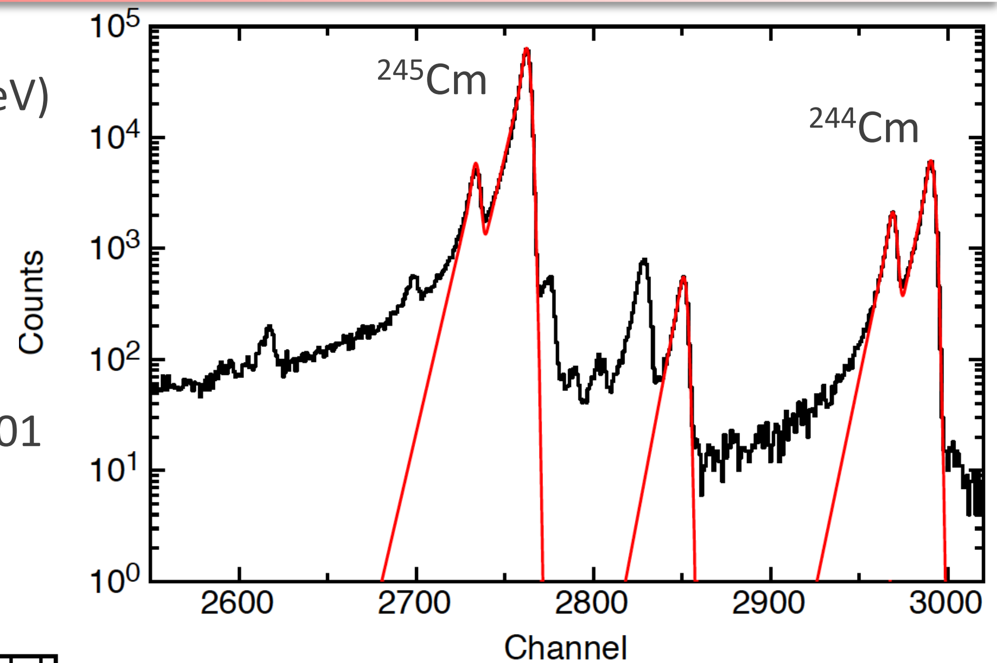


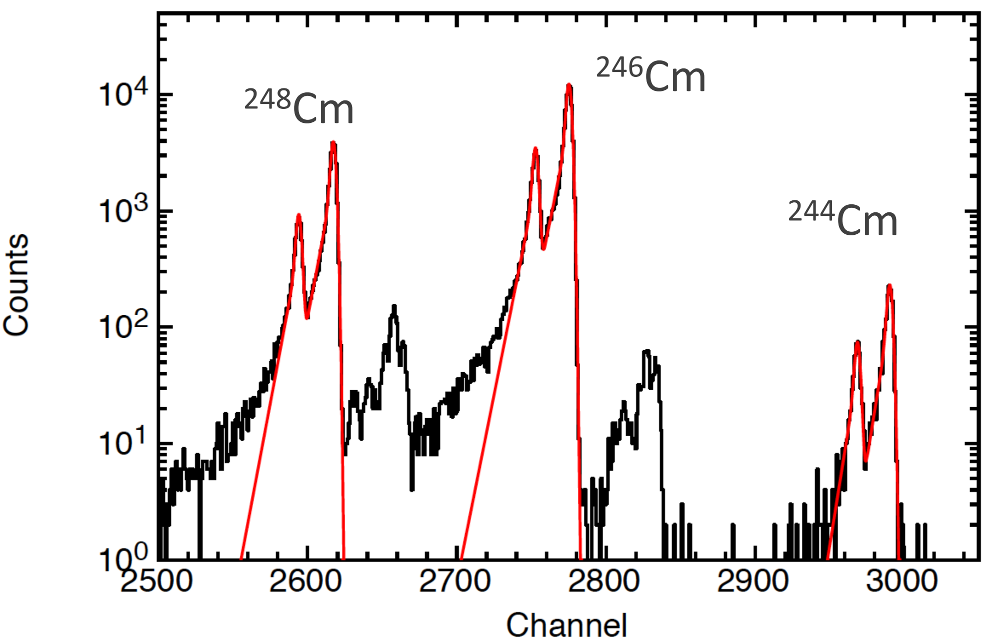
^{245}Cm & ^{244,246,248}Cm α−decay measurements

data collected using 500 μm PIPS (FWHM=9 keV)

relative to:
Eα(^{244}Cm)=5804.77(5) keV – abs. value
Eα(^{246}Cm)=5078.38(25) keV – relative to ^{240}Pu

Eα(^{245}Cm)=**5360.8 (5)** keV/5361.1(11) in 91Ry01
E(175-keV level)=175.051 (2) keV
E(Δα)=**175.6(7)** keV/**170.8(12)** in 91Ry01?





Eα(^{246}Cm)=5385.8(5) keV/5385.7(9) 91Ry01

^{249}Bk α−decay measurements

PHYSICAL REVIEW C **87**, 054328 (2013)

α decay of $^{249}_{97}$Bk and levels in $^{245}_{95}$Am

I. Ahmad,[1] J. P. Greene,[1] F. G. Kondev,[1] S. Zhu,[1] M. P. Carpenter,[1] R. V. F. Janssens,[1] R. A. Boll,[2] J. G. Ezold,[2]
S. M. Van Cleve,[2] and E. Browne[3]

Eα(^{249}Bk)=**5414 (2)** keV/**5419(3)** in 91Ry01
5421(1) Baranov et. al