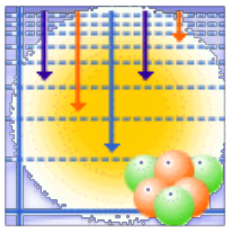
Argonne NATIONAL LABORATORY

Member of the US Nuclear Data Program

Argonne Nuclear Data Program



❑ Nuclear Data Compilations & Evaluations

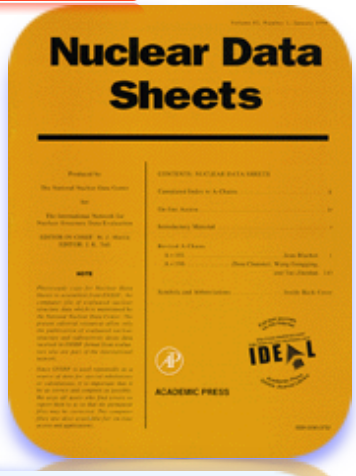
- ✓ nuclear structure compilations and evaluations - **ENSDF & XUNDL**
- ✓ evaluation of atomic masses and nuclear properties - **AME & NuBase**
- ✓ decay data evaluations in support of IAEA-led projects & other horizontal evaluations (nuclear isomers, B(E3), ND for Monitoring Applications)

❑ Complementary ND Research Activities

- ✓ intersections between basic and applied nuclear physics & astrophysics- via collaborative agreements with a little or no cost to USNDP
- ✓ contributions to DOE/NP FOA's - 2 funded at the FY17 call

Evaluations & Compilations - FY19

ENSDF



- A=177 was completed and published in NDS
- A=205 was completed and submitted to NNDC
- started working on A=203
- reviewed of A=100 (completed) and 190 (ongoing)

XUNDL

- compiled what we were asked to do - not much - a few papers from the IAEA-ICTP workshop …
- in the past compiled RIKEN-produced papers with Yuichi Ichikawa (RIKEN) - no requests for compilations during FY19 - discontinued the collaboration

AME & NUBASE

- continued compilation & evaluation activities

IAEA-NDS collaborations

- IAEA-ICTP workshop; NSDD;TM on Antineutrino spectra; TM on ENSDF codes (benchmarking & code development); TM on ND for monitoring applications

Nuclear Data Research Activities

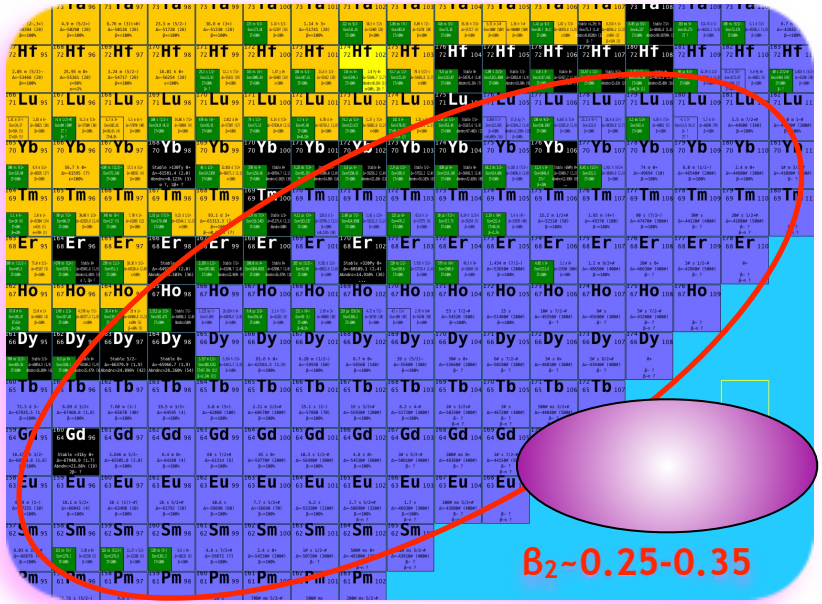
intersections between the basic and applied NP & astrophysics

- complements and benefits the evaluation activities
- sought after collaborator with little or no cost to USNDP

- at **ANL (ATLAS & CARIBU)** - nuclei far from stability, spectroscopy of heavy and super-heavy nuclei, K-isomers, beta-decay spectroscopy & mass measurements in the FP region; ***decay spectroscopy*** of actinide nuclei and nuclei of importance to applications of medical isotopes and metrology
  - ✓ **present: CARIBU** – properties of neutron-rich nuclei (nuclear structure & masses, astrophysics & applications); **FOA's** funded projects
  - ✓ **future: nuCARIBU & N=126 factory**

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

deformed light rare-earth region



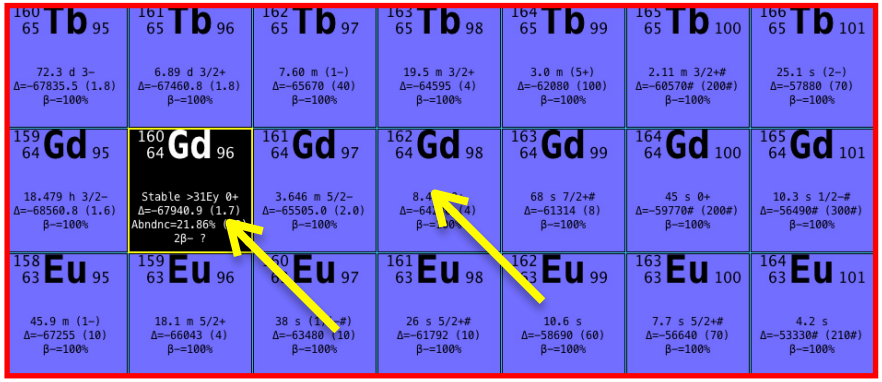
PHYSICAL REVIEW LETTERS **120,** 182502 (2018)

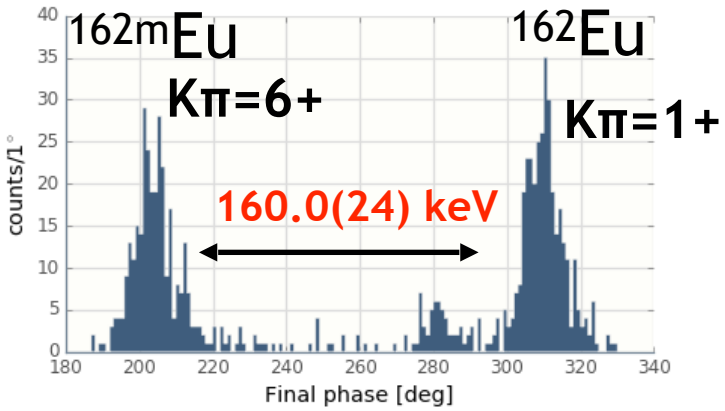
Masses and β-Decay Spectroscopy of Neutron-Rich Odd-Odd ^{160,162}Eu Nuclei: Evidence for a Subshell Gap with Large Deformation at $N=98$

D. J. Hartley,[1] F. G. Kondev,[2] R. Orford,[2,3] J. A. Clark,[2,4] G. Savard,[2,5] A. D. Ayangeakaa,[2,*] S. Bottoni,[2,†] F. Buchinger,[3] M. T. Burkey,[2,5] M. P. Carpenter,[2] P. Copp,[2,6] D. A. Gorelov,[2,4] K. Hicks,[1] C. R. Hoffman,[2] C. Hu,[7] R. V. F. Janssens,[2,‡] J. W. Klimes,[2] T. Lauritsen,[2] J. Sethi,[2,8] D. Seweryniak,[2] K. S. Sharma,[9] H. Zhang,[7] S. Zhu,[2] and Y. Zhu[7]

- combination of mass spectrometry (PI-ICR) & decay spectroscopy
- beta-decaying isomers in ^{160}Eu & ^{162}Eu - changes in the single-particle structures
- discrepancies with RIKEN (decay) & Jyvaskyla (masses - confirmed our results)

π5/2[413] ν7/2[633]





Contributions to FOA's funded projects

Objective
Significantly improve Nuclear Data in the Fission Product region - cross-cutting overlap with the main ND stakeholders **DOE-SC/NP** (Nuclear Structure & Astrophysics) & **DOE-NNSA/NA-22** (applications)

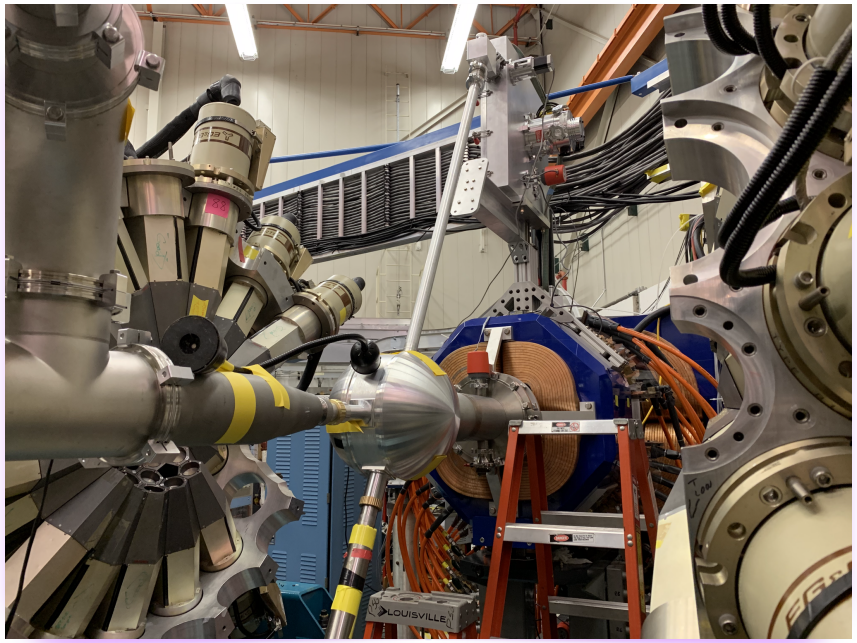
- Improving the Nuclear Data on Fission Product Decays at CARIBU (PI: G. Savard)
  - ✓ 5 years project
  - ✓ collaboration with LLNL - **$1M** from **DOE/SC/NP to ANL** and **$1M** from **NNSA/NA-22 to LLNL**

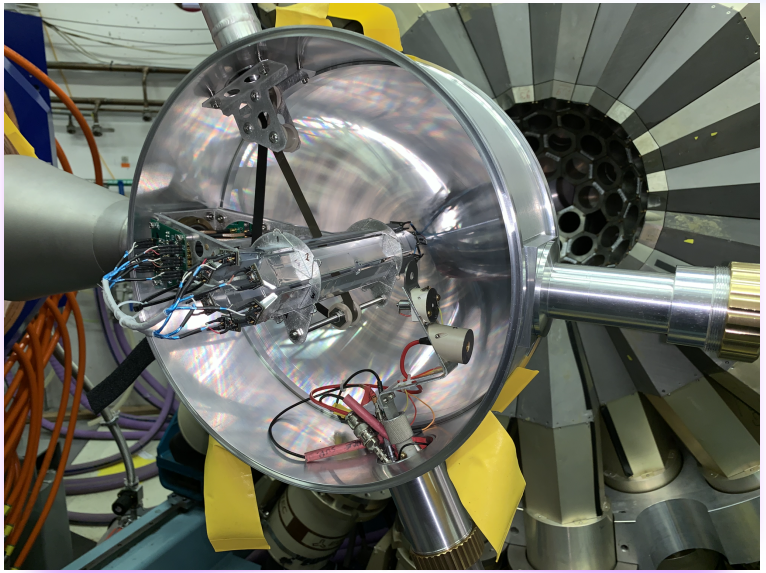
- Novel Approach for Improving Antineutrino Spectra Predictions for Nonproliferation Applications (PI: F.G. Kondev)
  - ✓ 3 years project - **$375K from DOE/SC/NP** and **$405K from NNSA/NA-22**
  - ✓ collaborations with LSU, WUSL & USNA & others via IAEA-NDS coordination

Gammasphere decay station

Advantages

- **discrete & calorimetry** γ-ray spectroscopy techniques within a single device
- **high granularity** & **resolving power** ($\Delta E\gamma$=2 keV, P/T~60% and ε_γ~85%) - ability to resolve week γ-ray cascades (10^{-5}-10^{-6} %)
- **complete decay schemes** - angular correlations for transition multipolarities & Jπ assignments - end game in nuclear spectroscopy

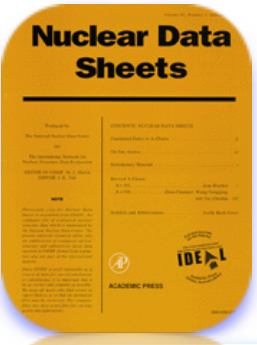


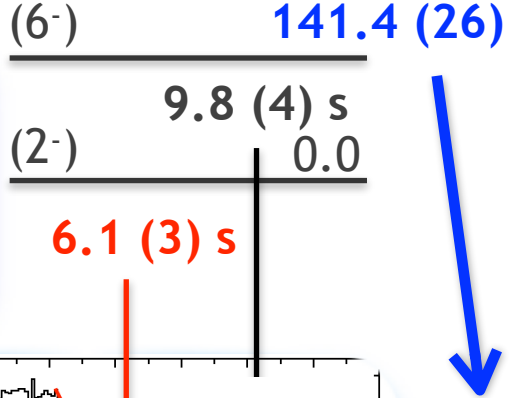


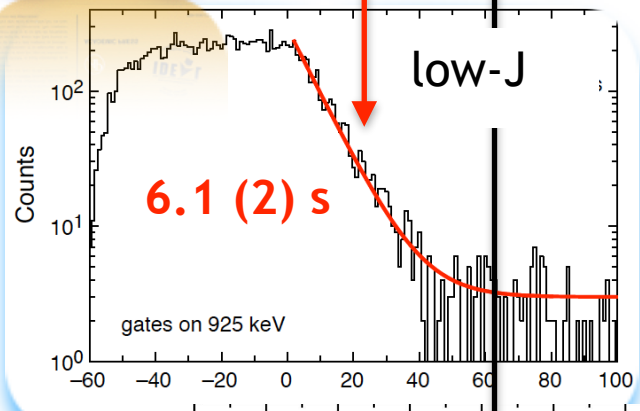
- **HEART** - HExagonal ARray for Triggering
  - ✓ 6 EJ-204 plastic scint. & 12 SiPM
  - ✓ ε_β~75% from β-γ singles & coin.
- powerful γ-γ-β-t coincidence device

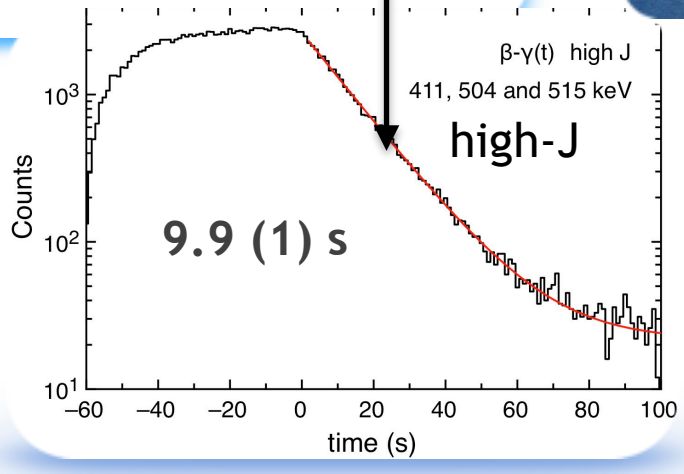
^{146g,m}La - masses & half-lives

Y. Khazov et al., NDS **136** (2016) 163









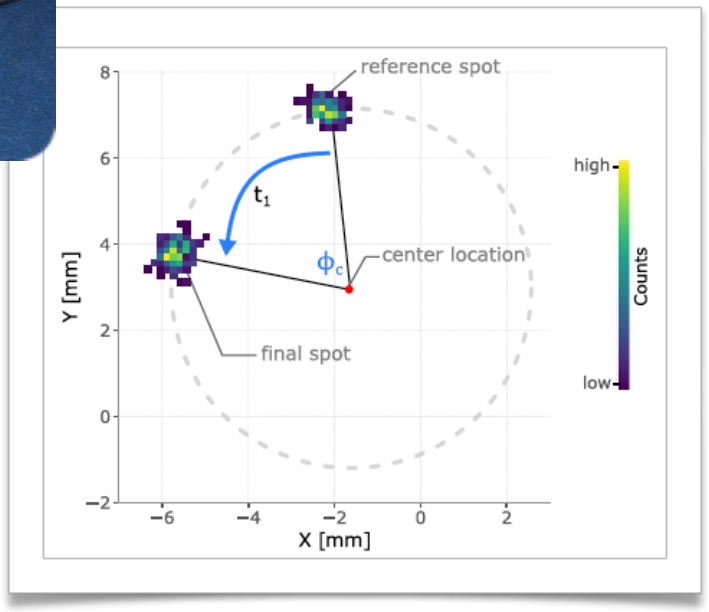
Contents lists available at ScienceDirect

Nuclear Inst. and Methods in Physics Research B

journal homepage: www.elsevier.com/locate/nimb

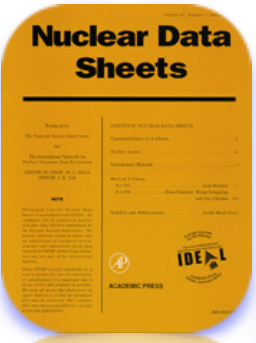
Improving the measurement sensitivity of the Canadian Penning Trap mass spectrometer through PI-ICR

R. Orford[a,b,*], J.A. Clark[b,c], G. Savard[b,d], A. Aprahamian[e], F. Buchinger[a], M.T. Burkey[d,b], D.A. Gorelov[c,b], J.W. Klimes[b], G.E. Morgan[c,b], A. Nystrom[e,b], W.S. Porter[e], D. Ray[c,b], K.S. Sharma[c]



^{146g,m}La - Gammasphere decay station

Y. Khazov et al., NDS **136** (2016) 163



(6^-) 0.0+X

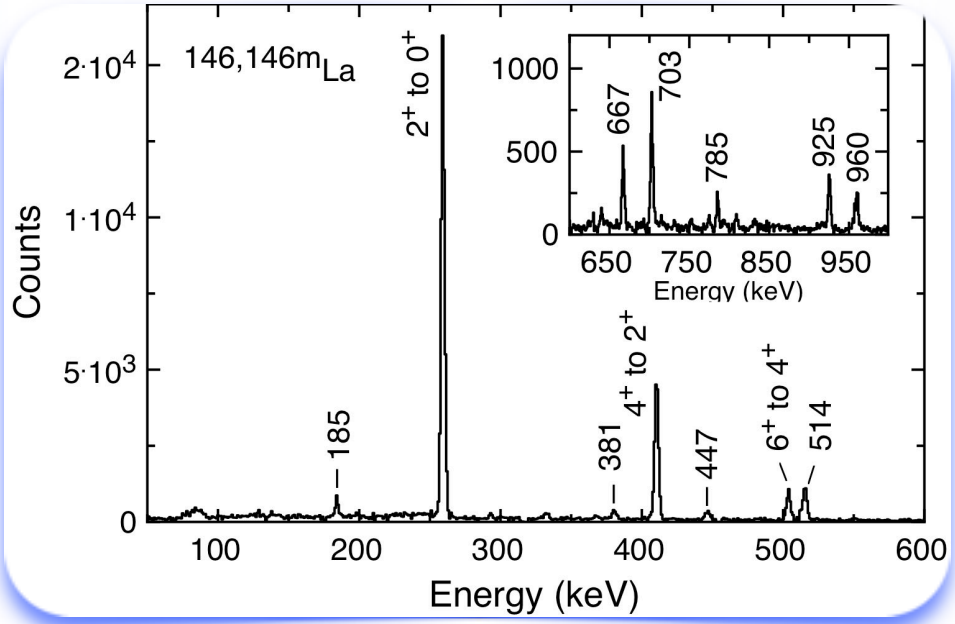
(2^-) 0.0

$(1^-,2^-)$ 141.4

(5^-) 0.0

π5/2+[413] ν1/2-[530]

π5/2+[413] ν5/2-[523]
Nilsson assignment



- resolved gs and isomer decays
- new levels and transitions
- new Jπ and configurations
- new nuclear structure interpretation
  - deformed shell model

Future (FY19 and beyond) Plans

- **Continue contributing to XUNDL & ENSDF - top priority - closer connections with ATLAS & FRIB user communities**

- **Continue AME & NuBase collaboration activities**
  - maintain the currency (5-6 yrs cycle) and quality

- **Continue topical collaborations with IAEA-NDS, other USNDP groups & wide nuclear physics community - B(E3) evaluation update (with T. Kibedi, ANU)**

- **Continue research activities** with emphasis on nuclear structure physics and astrophysics, and their intersection with the applied nuclear physics
  - **ATLAS & CARIBU (nuCARIBU):** nuclear structure, masses & astrophysics, with emphasis on properties of neutron-rich nuclei in the deformed, light rare-earth region (A~160)
  - **N=126 factory:** the heavy region south of ^{208}Pb - nicely overlaps with the ND evaluation responsibilities
  - **nuCARIBU:** contributions to FOA's and other interagency ND projects
  - **NSCL (FRIB), RIKEN & IMP (HIAF)** – nuclear structure, masses & astrophysics

Publications & Invited talks – FY19

- Publications in refereed journals: **17**
- Invited talks: **11**

Personnel & Effort – FY19 & FY20

- **base ND program**
  - ✓ **1** head (staff) - **0.85 FTE SC/NP/ND**
  - ✓ **0.15 FTE** (**FOA** funding from **NNSA/NA-22 & SC/NP**) - will expire in FY20
- **ND FOAs**
  - ✓ 2 heads (post-docs) - one funded through FY20, the other through FY22