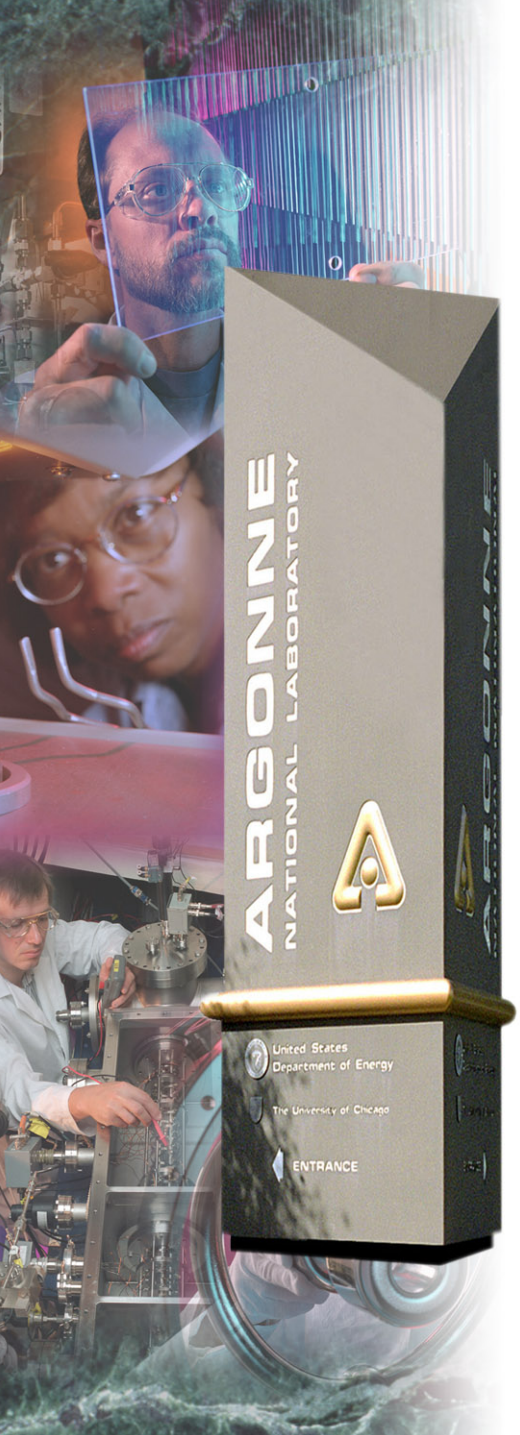


Experimental Activities ANL Nuclear Data Program

Filip G. Kondev
Nuclear Engineering Division

2005 CSEWG Meeting
Brookhaven National Laboratory, November 8-10, 2005

Argonne National Laboratory

Office of Science
U.S. Department of Energy

A U.S. Department of Energy
Office of Science Laboratory
Operated by The University of Chicago

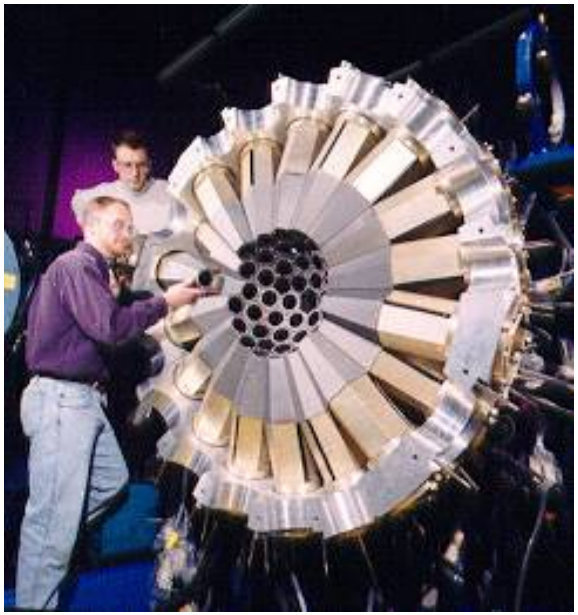
ANL Activities Overview

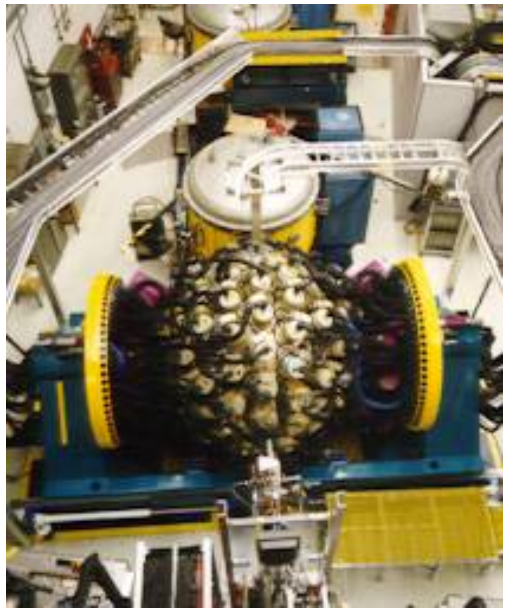
- Measurements with Gammasphere & FMA at ATLAS and gamma-ray spectroscopy studies at ANU, Canberra (AUS)
  - ✓ basic low-energy nuclear physics
  - ✓ non-energy applications, e.g. astrophysics, detector efficiency standards and others
  - ✓ NE applications, e.g. isomers, FP
- Development of a new generation Ge tracking detectors
  - ✓ 2 years ANL LDRD in collaboration with K. Lister/PHY
- Decay spectroscopy studies of heavy nuclei
  - ✓ both applied and basic physics communities
- Studies at the sub-critical facility YALINA
  - ✓ NE applied area – validation of ND models & libraries

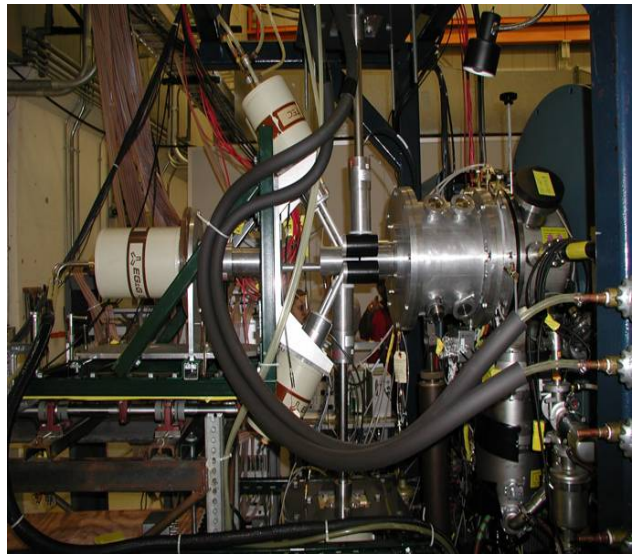
Measurements at ANL

- Properties of Nuclear K-Isomers in neutron-rich nuclei near A~180 and shell-model isomers near ^{132}Sn, including spectroscopy of FP – in collaboration with ANU, UML, U. Surrey (UK) and PHY/ANL
  - ✓completed ^{179}Ta & ^{174}Yb (published); ^{174}Lu near completion
  - ✓new studies of $^{185,\ 186,187}$Re initiated
- Spectroscopy of ^{237}U and ^{239}U using Unsafe Coulomb excitations – in collaboration with PHY/ANL
- Triaxial Superdef. and Wobbling mode in $^{171\text{-}175}$Hf and $^{170\text{-}171}$Ta - in collaboration with US Naval Academy/ANL-PHY
- Decay Spectroscopy of heavy nuclei – in collaboration with PHY/ANL
  - ✓Decay data on ^{251,253}Es, ^{255}Fm, ^{245,246,249}Cm, ^{251}Cf
  - ✓Decay data on high-K isomers in ^{254}No

Isomeric Research at Argonne







- ***Availability of a variety of HI beams and a flexible beam pulsing system***
  - ***from ^{4}He up to ^{238}U/ time-range from ns up to years!***
- ***Existence of high-efficiency detector systems, e.g Gammasphere, FMA***

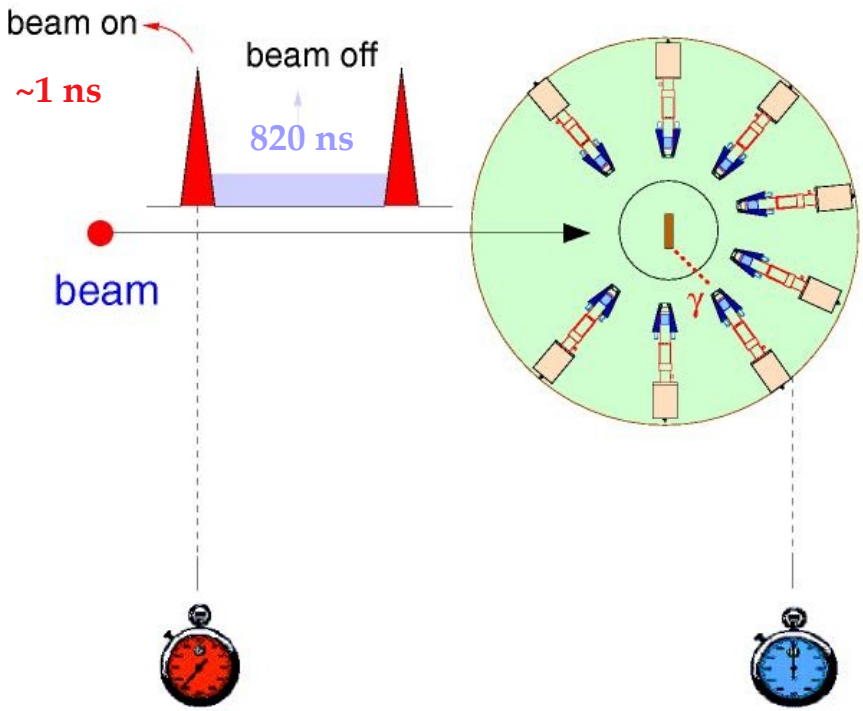
✓ ***Studying Isomers at extreme conditions:***

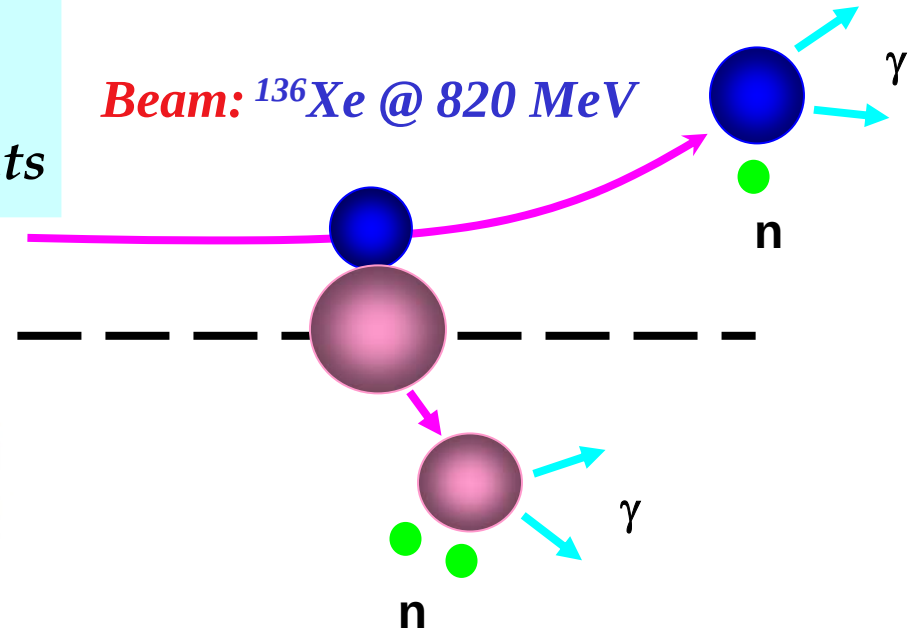
Heavy nuclei/ Proton Drip Line/ Neutron Rich Nuclei/High-spin & Seniority

Deep Inelastic Experiments with GS

Pulsed Beam Technique

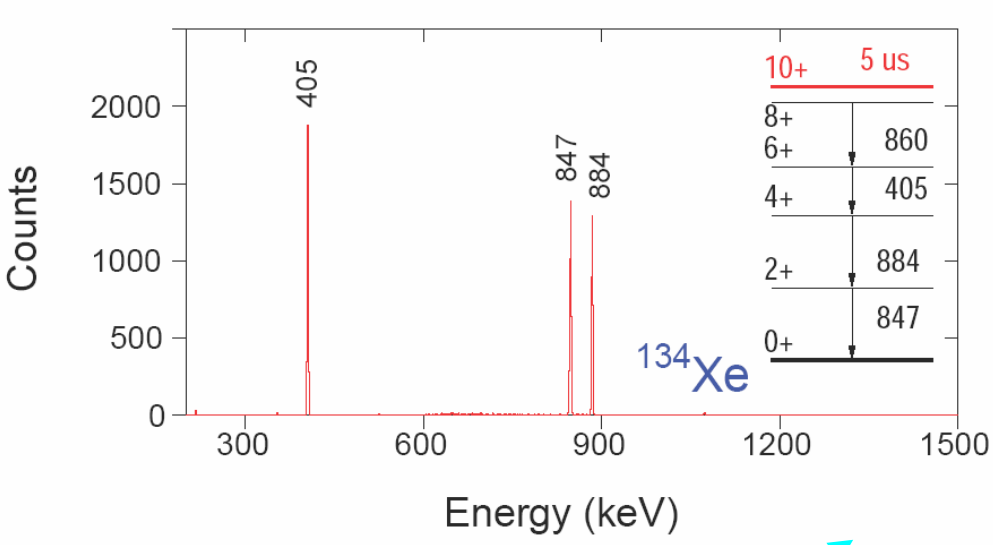
- *well defined "clock"*
- *sensitive to in-beam and decay events*

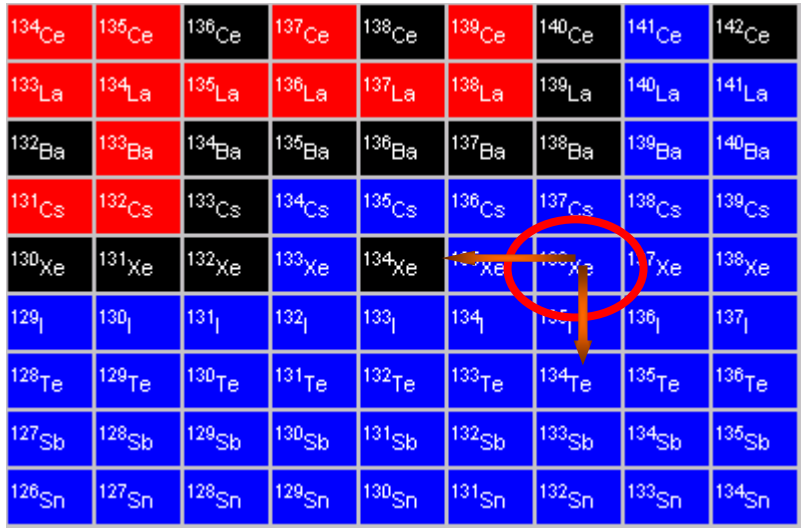


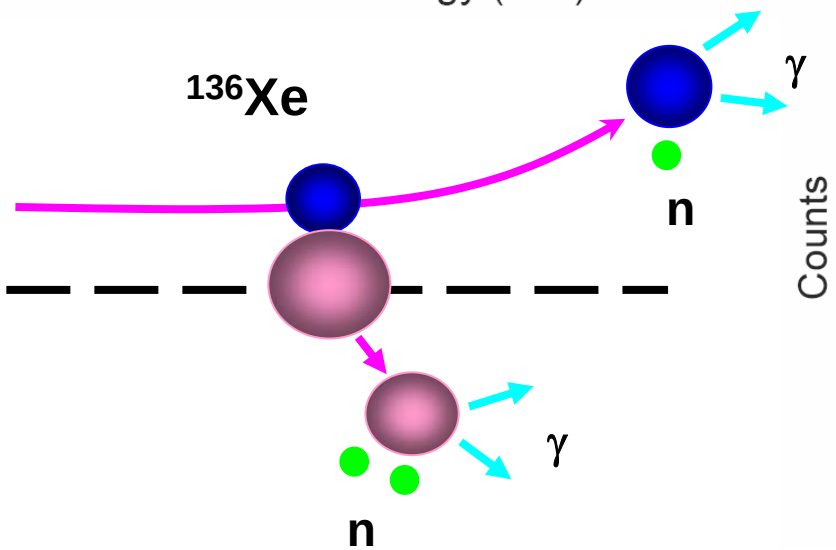


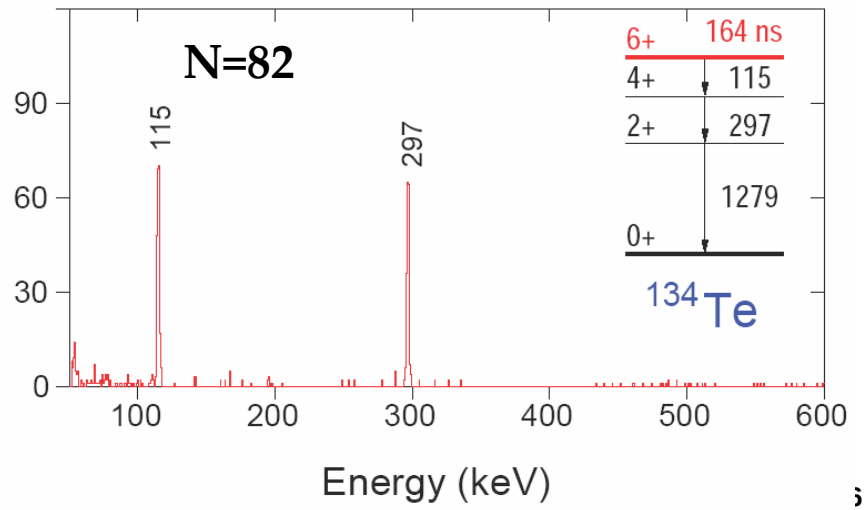
Targets: *^{176}Lu (enriched up to 50 %),*
^{175}Lu, ^{174}Yb (gsfma112)
^{176}Yb,^{185}Re (gsfma149)
Beam: *^{178}Hf on Pb target (gsfma150)*

Projectile-like nuclei

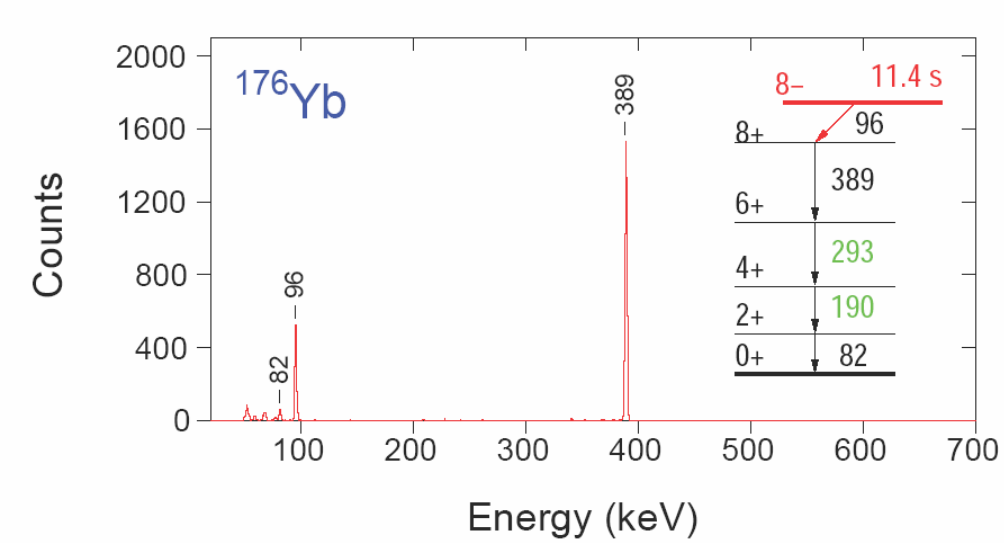


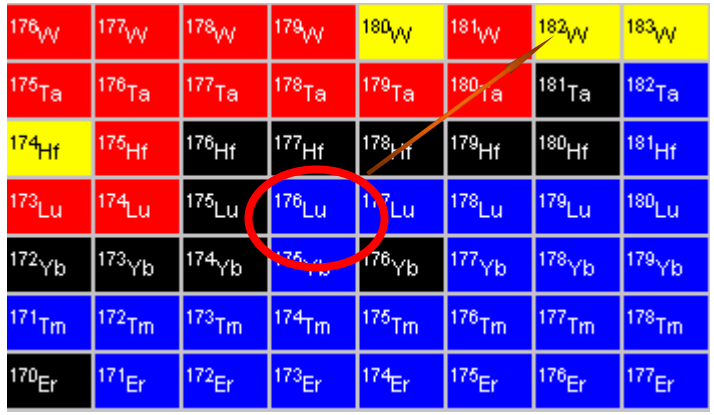


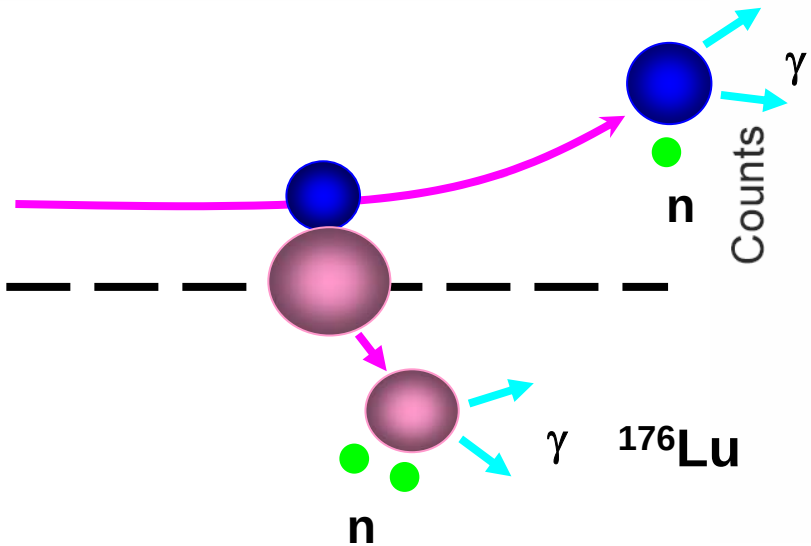


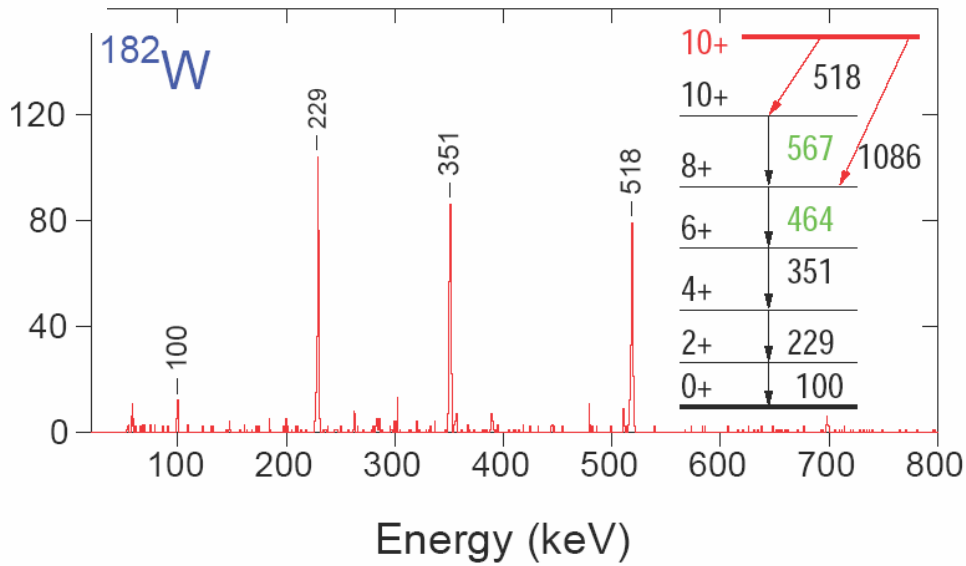


Target-like nuclei









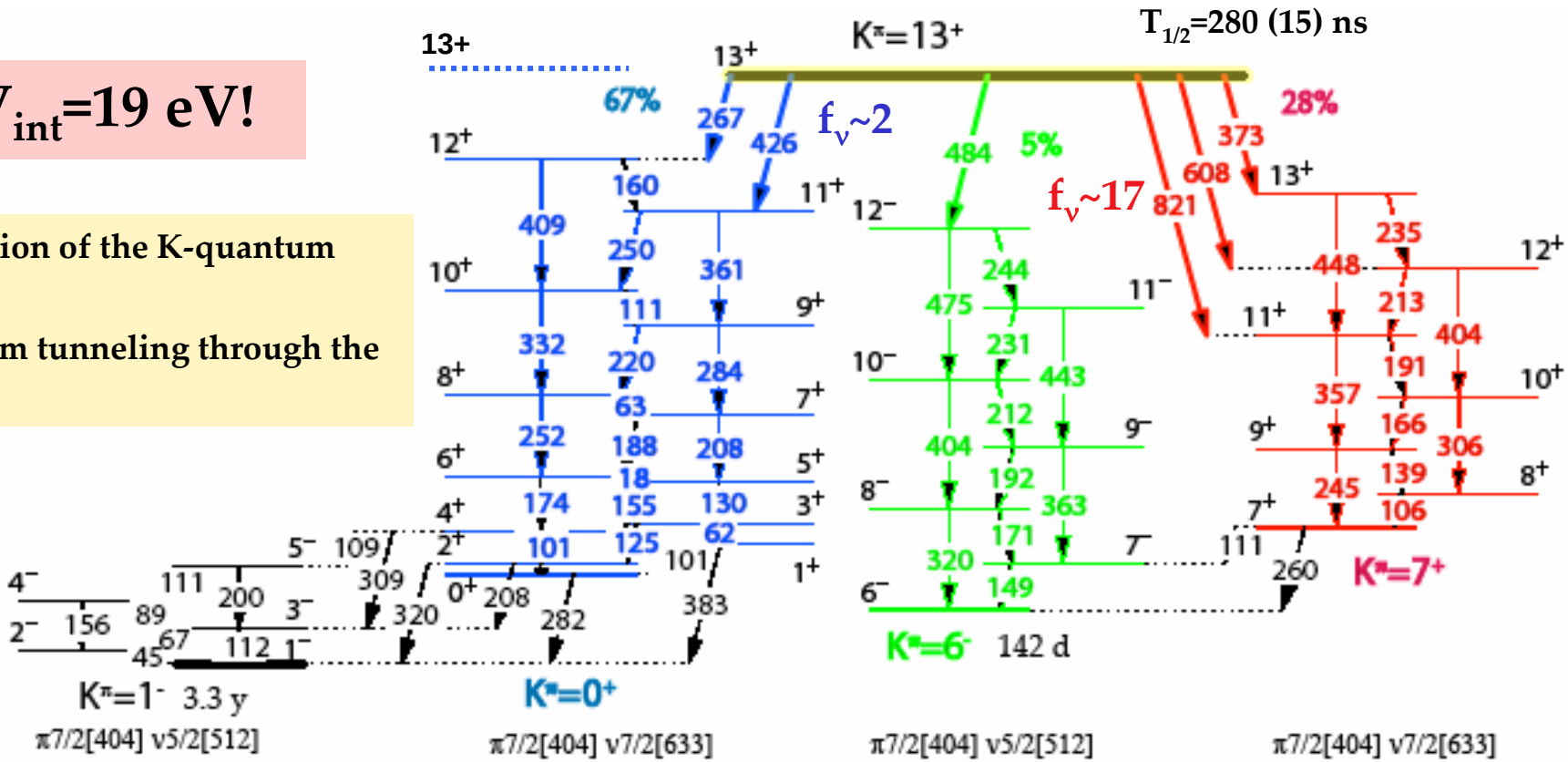
Unusual decay of the 13+ isomer

^{174}Lu

13+ level of the K=0+ band only a few keV (less than 7) above the isomer!

V_{int}=19 eV!

- no erosion of the K-quantum number
- quantum tunneling through the K-space

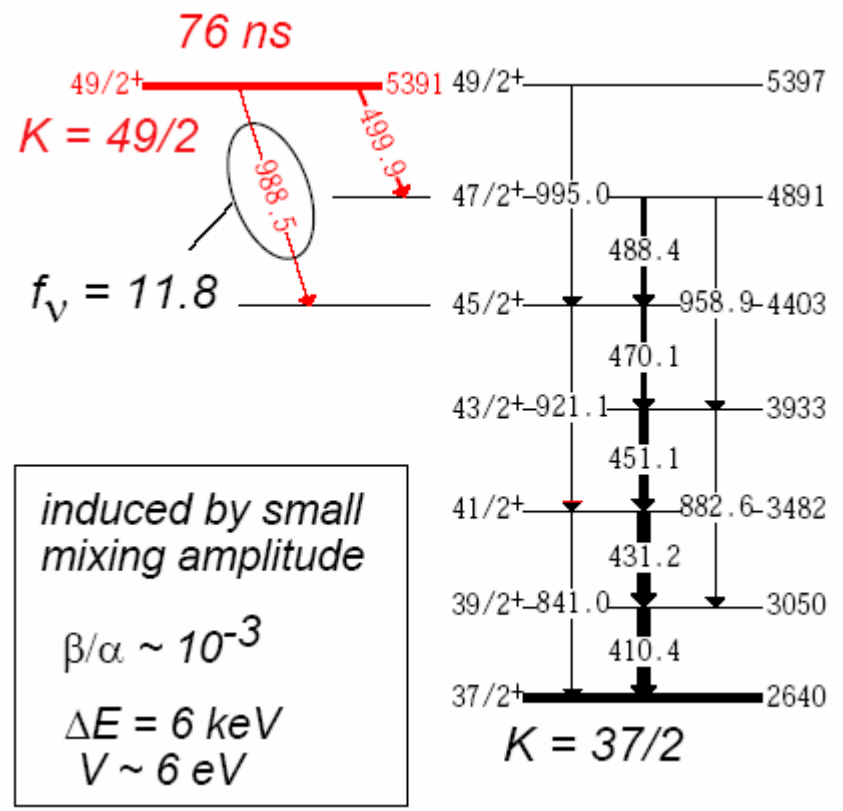


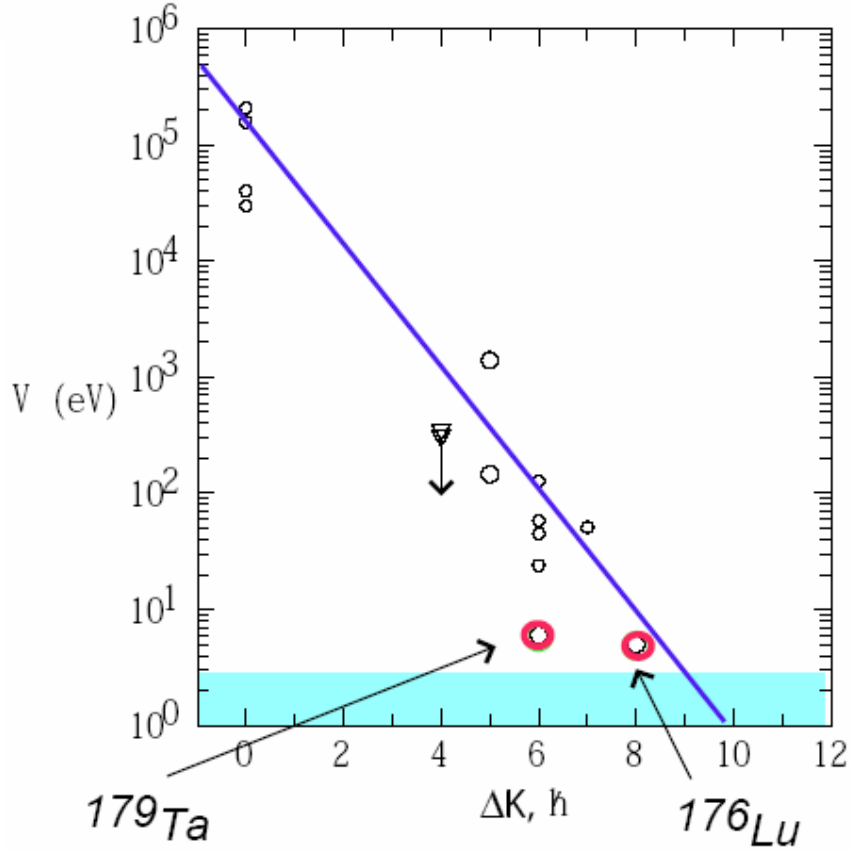
Eur. Phys. J. A 22, 23–27 (2004)
DOI 10.1140/epja/i2004-10025-9

THE EUROPEAN PHYSICAL JOURNAL A

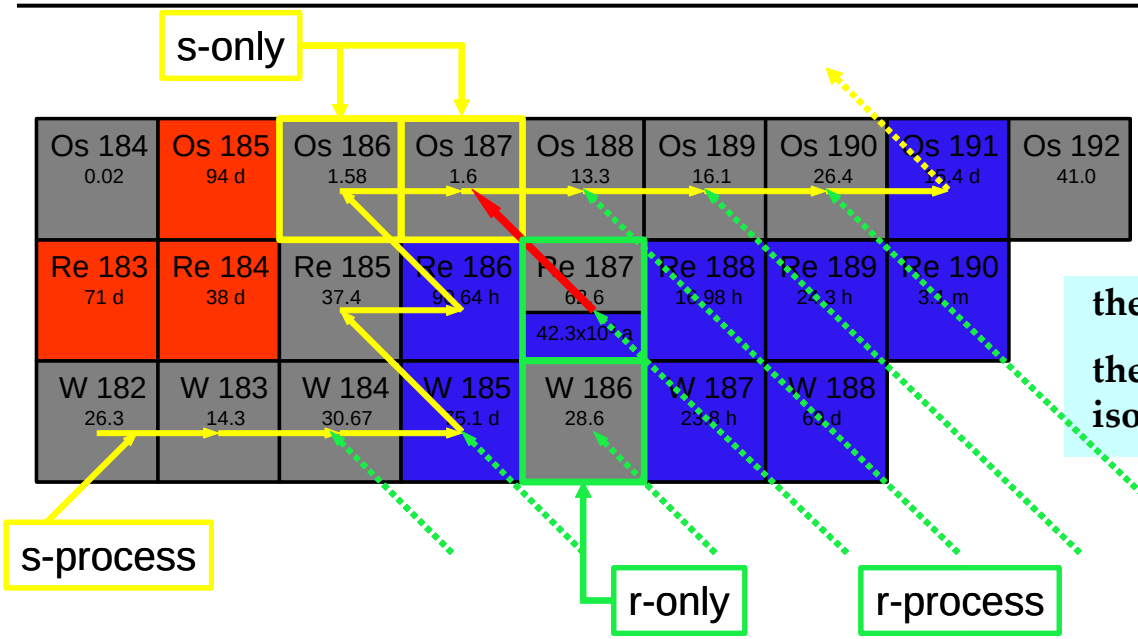
K-Mixing and fast decay of a seven-quasiparticle isomer in ^{179}Ta

F.G. Kondev[1,a], G.D. Dracoulis[2], G.J. Lane[2], I. Ahmad[3], A.P. Byrne[2,4], M.P. Carpenter[3], P. Chowdhury[5], S.J. Freeman[3,b], N.J. Hammond[3], R.V.F. Janssens[3], T. Kibédi[2], T. Lauritsen[3], C.J. Lister[3], G. Mukherjee[3,5,c], D. Seweryniak[3], and S.K. Tandel[5]





Studies of ^{186}Re of relevance for astrophysics

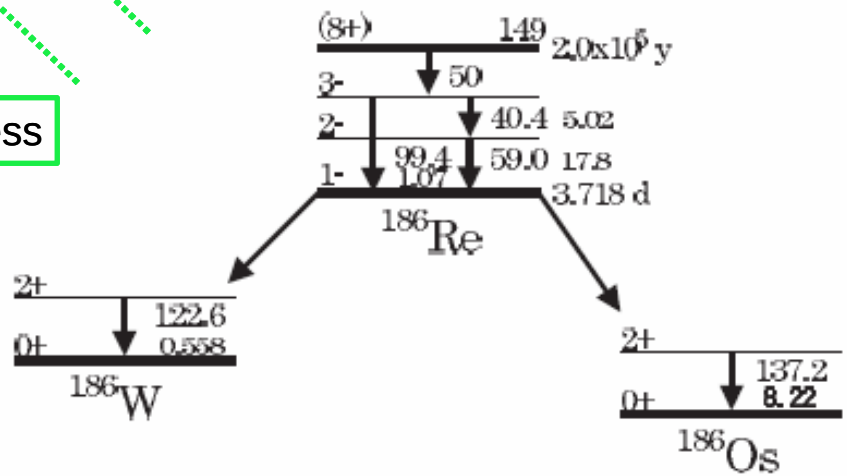


^{187}Re-^{187}Os cosmochronometer can be used to date the r-process

D.D. Clayton, Ap.J. 139 (1964) 637.

the existence of long-lived isomeric state

the production & destruction CS for the isomer are poorly known, but badly needed!



Activation Technique

✓ difficult owing to the long $T_{1/2}$

✓ $T_{1/2}$ - only one measurements without uncertainty

T. Hayakawa et al., Ap.J. 628 (2005) 533.

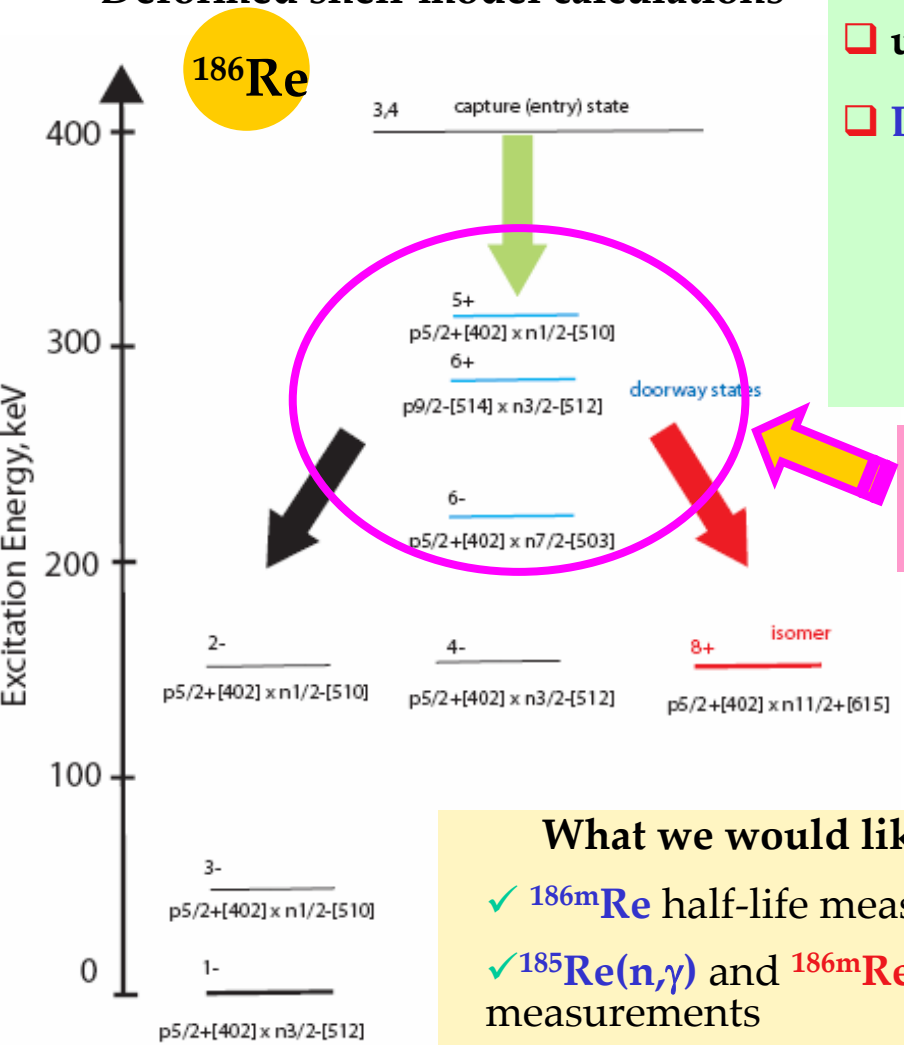
Using prompt γ–ray technique following n-capture, as recently demonstrated for ^{239}Pu(n,2n)^{238}Pu

L.A. Bernstein et al., Phys. Rev. C 65 (2003) 021601(R)

What is needed – detailed knowledge of the ^{186}Re levels above the isomer!

Studies of ^{186}Re of relevance for astrophysics

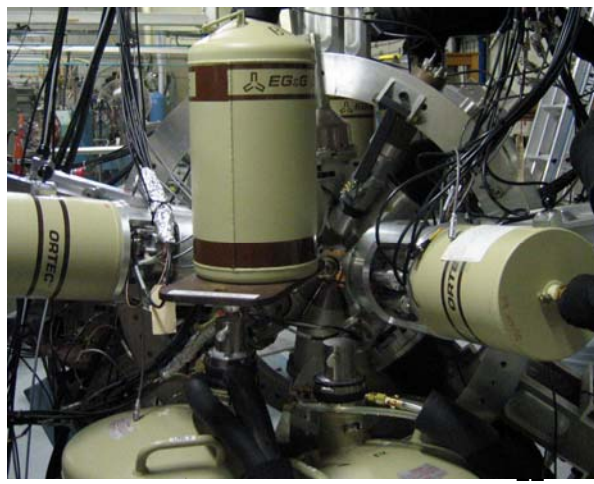
Deformed shell-model calculations



New Measurements

- using ^{186}W(d,2n) at ANU & γ–ray coin. technique
- DC beam & CAESAR array – 9 CSS Ge & 2 LEPS
  - ✓excitation functions from 12 MeV to 18 MeV
  - ✓γ–γ coin. at 12 MeV (near the barrier) – only a few channels are open – identification of ^{186}Re
  - ✓γ–γ coin. at 14 MeV to enhance population of the isomer

"doorway" states above the isomer have been discovered and characterized!



What we would like to do next?

- ✓ ^{186m}Re half-life measurements
- ✓^{185}Re(n,γ) and ^{186m}Re(n,γ) cross-section measurements