

# Recent isomer spectroscopy experiments at the FRS

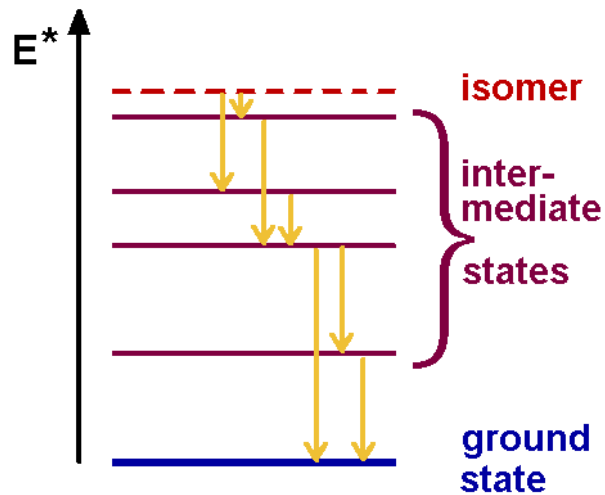
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GSI-Darmstadt

for the

GSI-FRS Isomer Collaboration

- Introduction
- Experimental method
- Preliminary results
- Outlook

## What can isomers tell us?!



$T_{1/2}(\text{isomer})$  is “long”

The initial and final states are different

( $\Delta E$ ,  $\Delta I$ ,  $\Delta K$ ,  $\Delta \beta$ , ...)

➡ decay is hindered

### EXPERIMENTAL:

- mere existence!
- properties:  $E^*$ ,  $I^\pi$ ,  $T_{1/2}$
- decay mode(s)
- intermediate levels:  $E^*$ ,  $I^\pi$ , lifetimes,...

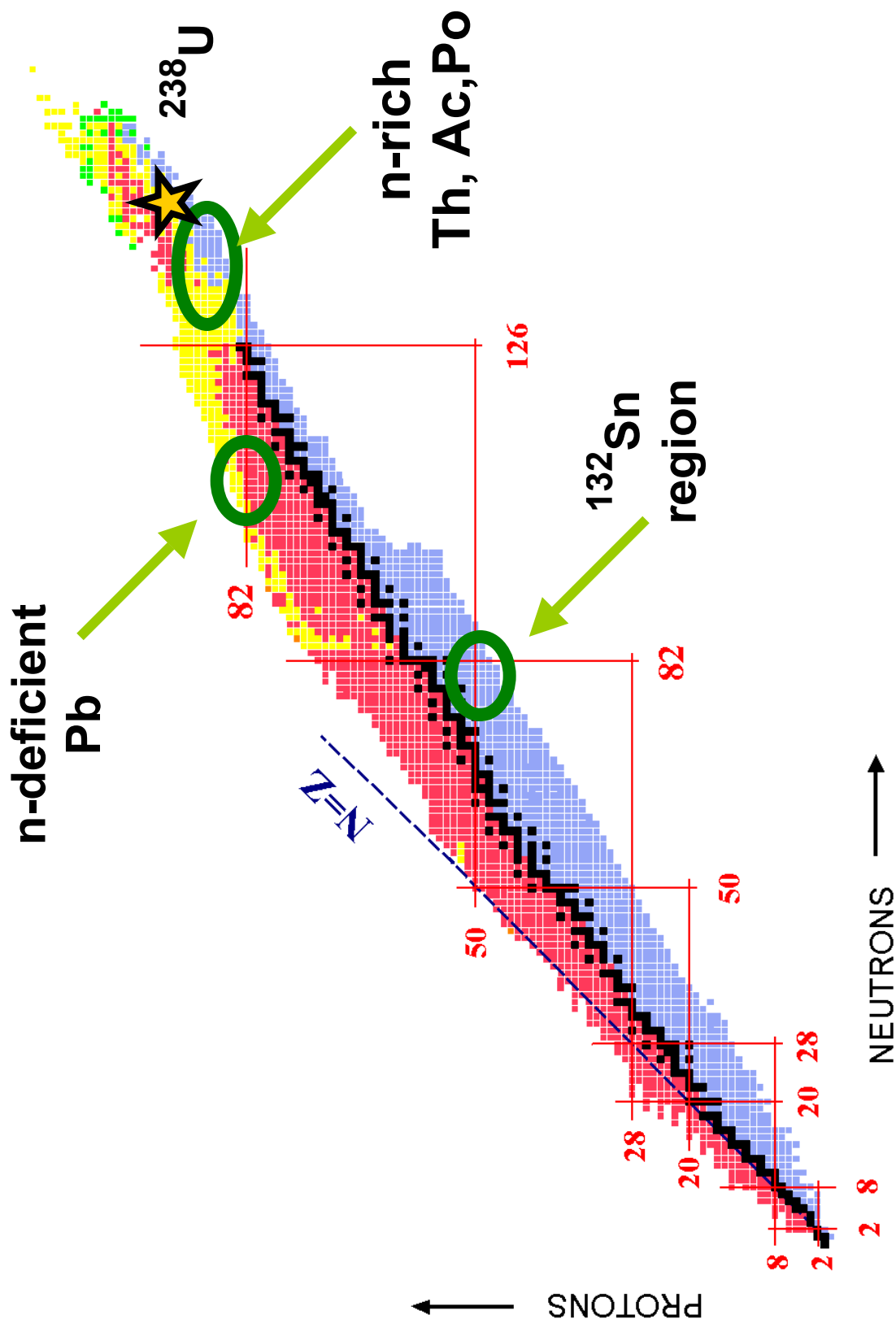
### THEORY:

- single-particle energies
- configurations
- interaction strengths
- deformation
- ...

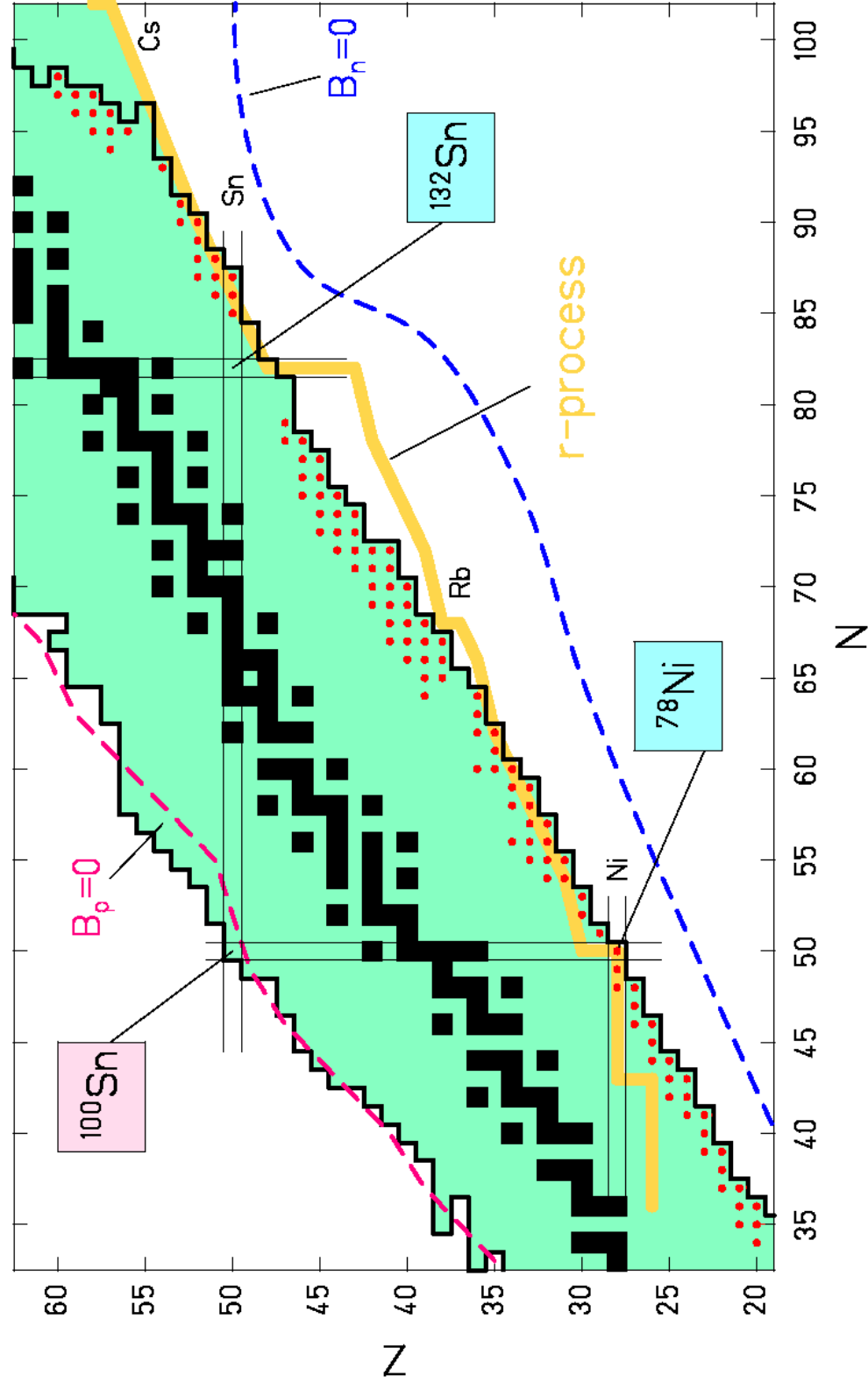
### “FUTURE”:

- Coulomb excitation of isomers
- interaction cross section gives radii
- fusion-evaporation using isomeric beams

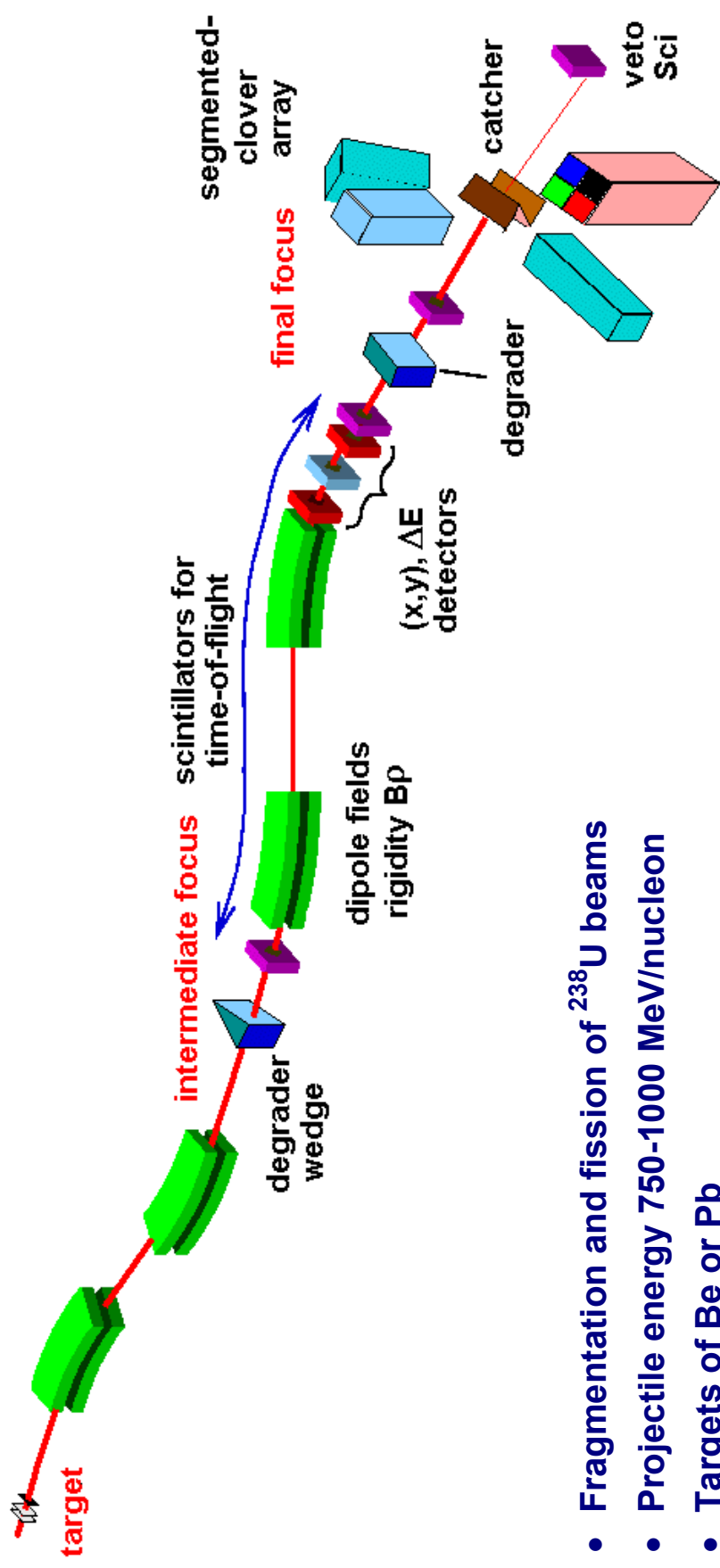
## S244 overview



## Using fission at GSI to study very neutron-rich nuclei

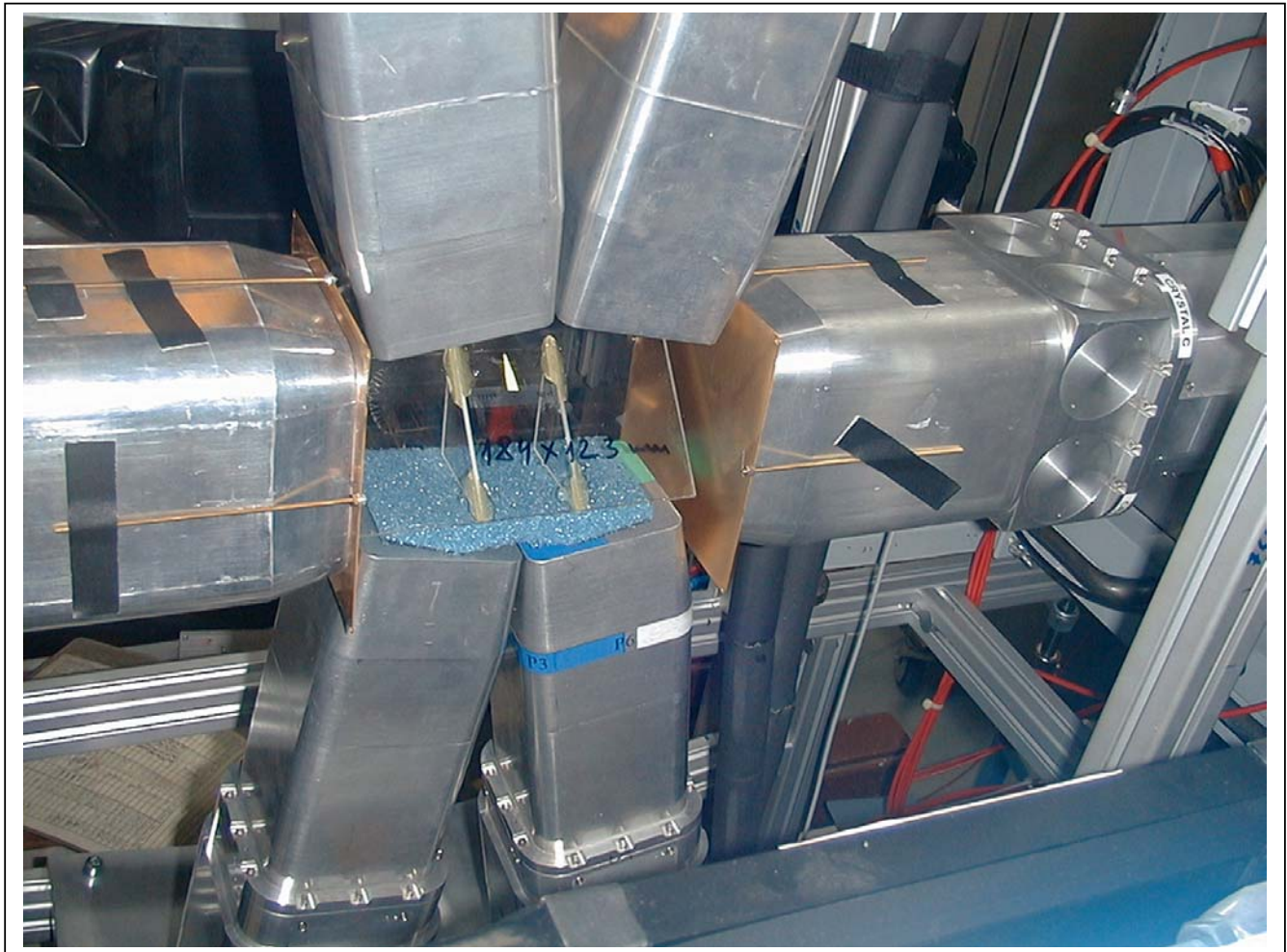


## Isomer experiments at the GSI fragment separator FRS



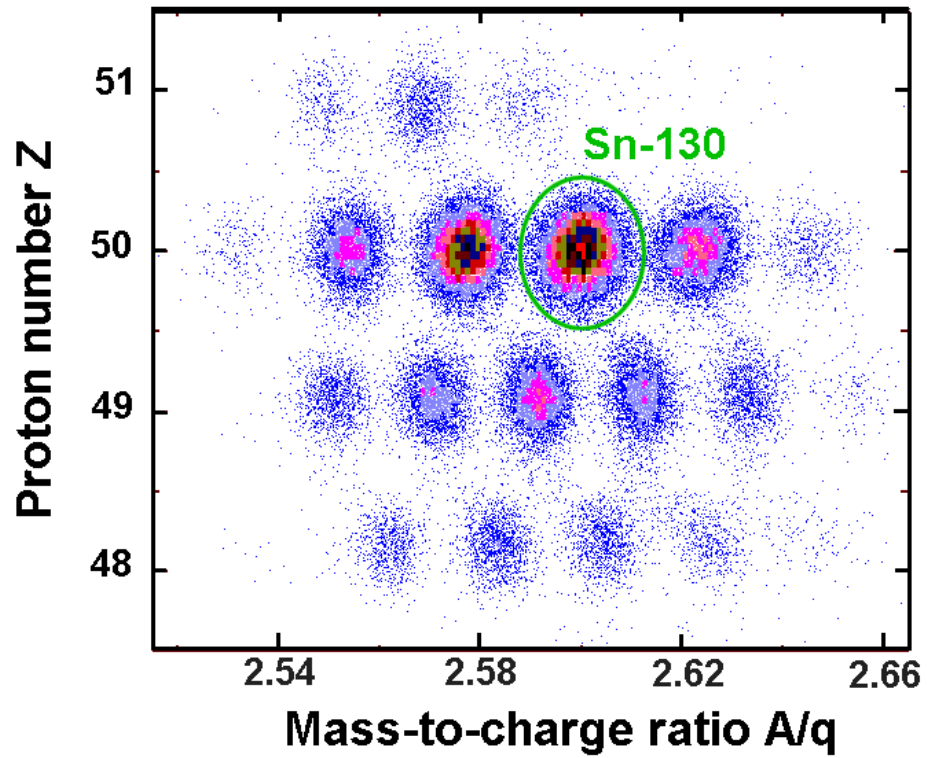
- Fragmentation and fission of  $^{238}\text{U}$  beams
- Projectile energy 750-1000 MeV/nucleon
- Targets of Be or Pb
- Dipoles select mass-to-charge ratio  $A/q$
- Event-by-event identification of reaction product (A,Z)
- Total time of flight  $\approx 400$  nanoseconds

## Ge-detectors and catcher



# FRS setting optimized on $^{130}\text{Sn}$

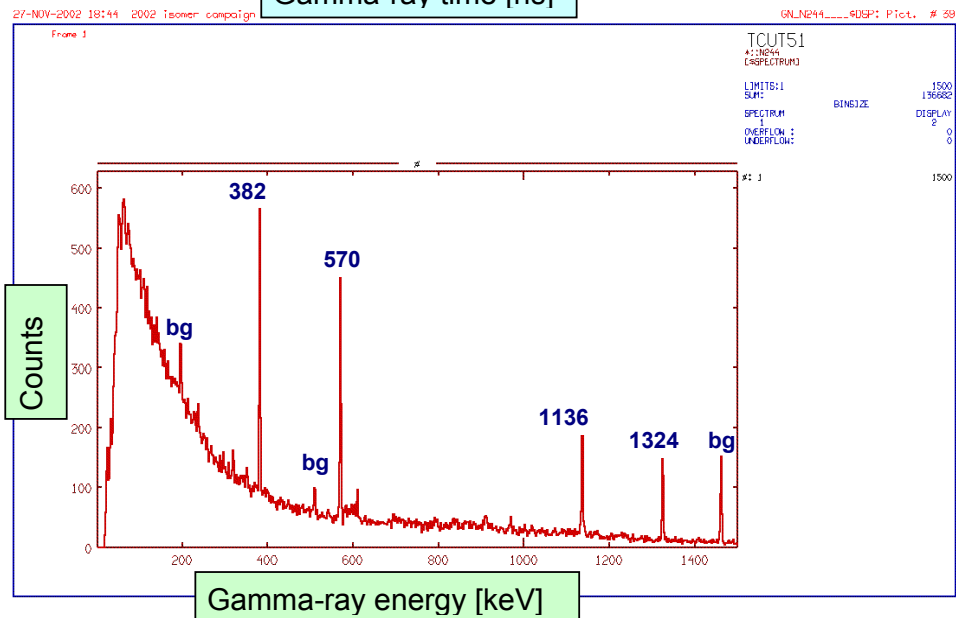
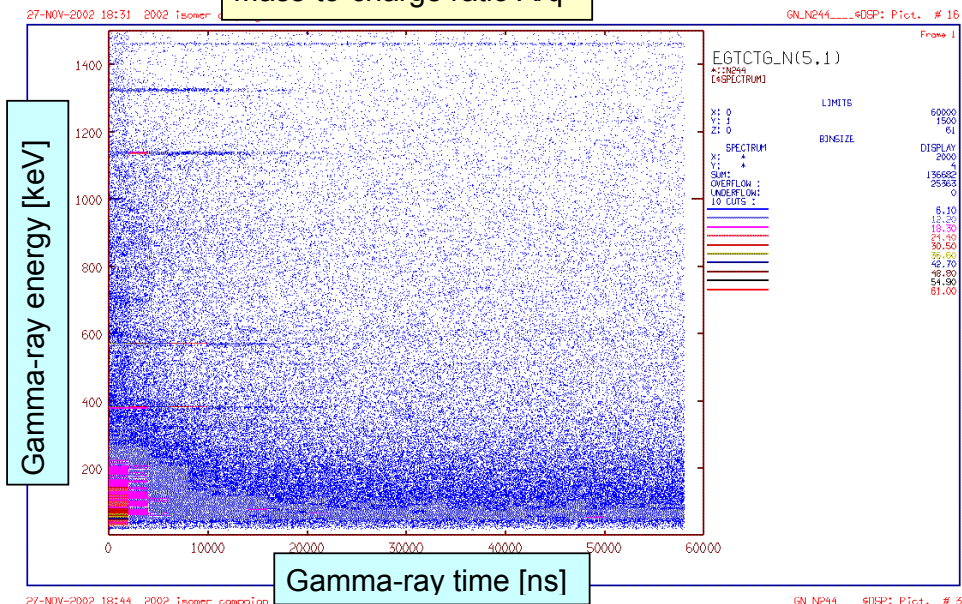
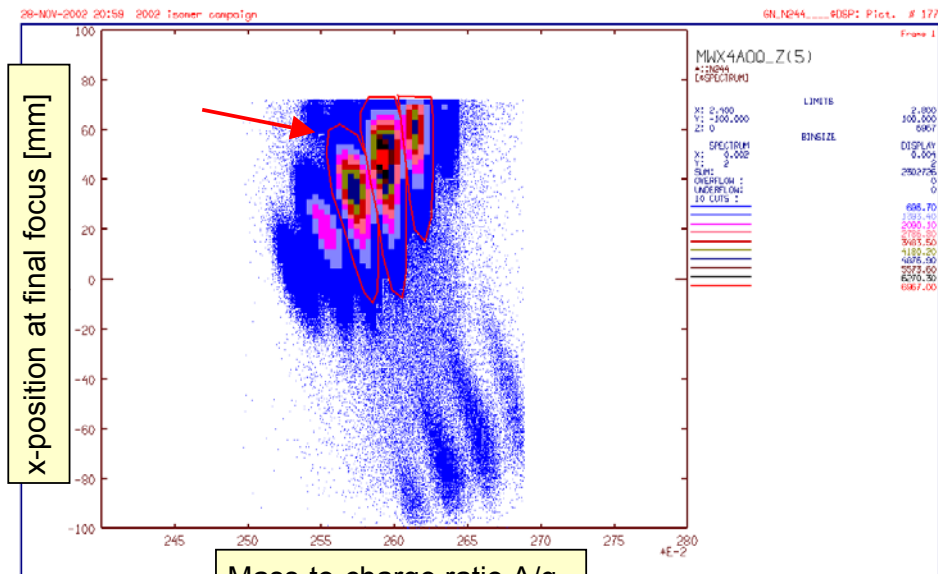
732 A·MeV  $^{238}\text{U} + ^{208}\text{Pb}$



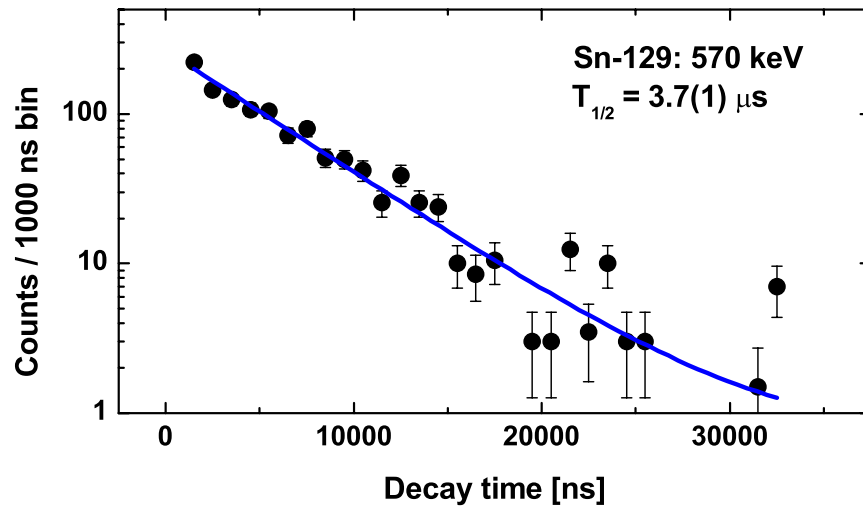
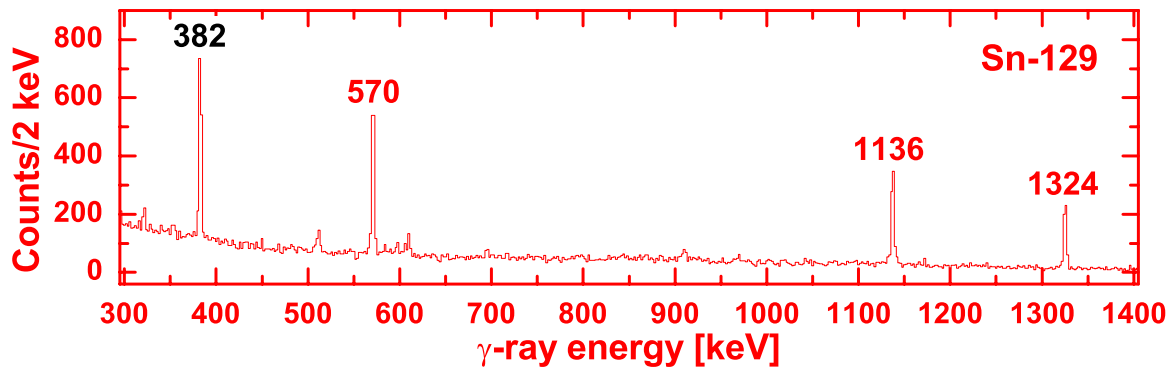
|                   |                   |                   |                   |                   |                   |                   |                   |
|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
|                   |                   |                   |                   | $^{130}\text{Sb}$ | $^{131}\text{Sb}$ | $^{132}\text{Sb}$ |                   |
|                   |                   | $^{127}\text{Sn}$ | $^{128}\text{Sn}$ | $^{129}\text{Sn}$ | $^{130}\text{Sn}$ | $^{131}\text{Sn}$ | $^{132}\text{Sn}$ |
|                   | $^{125}\text{In}$ | $^{126}\text{In}$ | $^{127}\text{In}$ | $^{128}\text{In}$ | $^{129}\text{In}$ | $^{130}\text{In}$ |                   |
| $^{123}\text{Cd}$ | $^{124}\text{Cd}$ | $^{125}\text{Cd}$ | $^{126}\text{Cd}$ | $^{127}\text{Cd}$ |                   |                   |                   |

Microsecond isomers: **known** & **new**

# Identifying an isomer: $^{129}\text{Sn}$



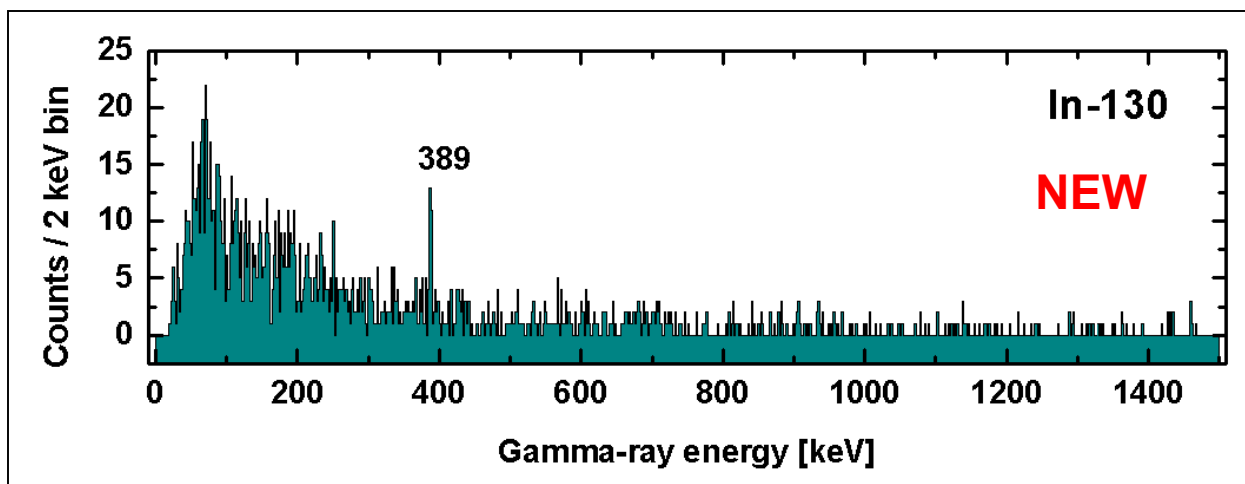
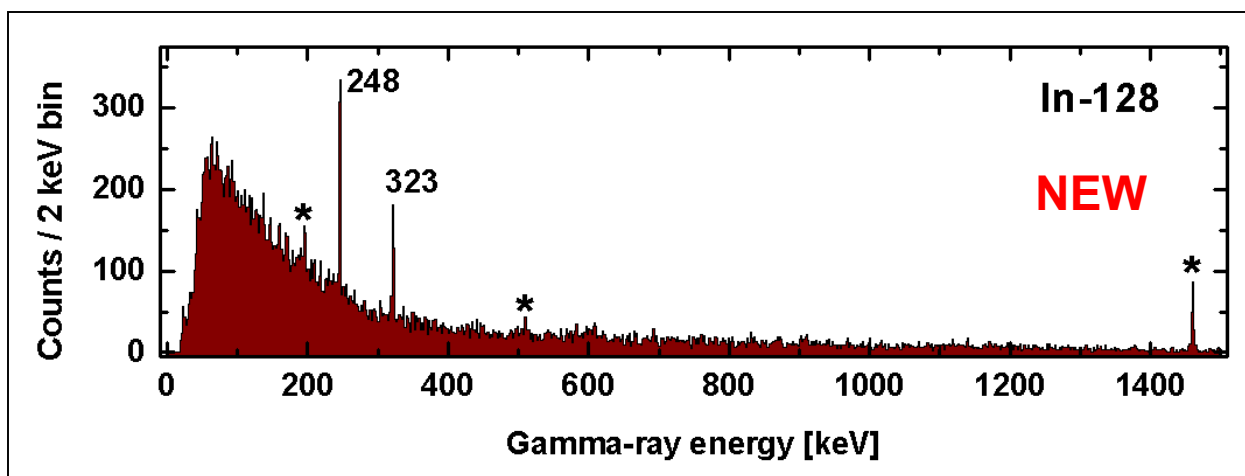
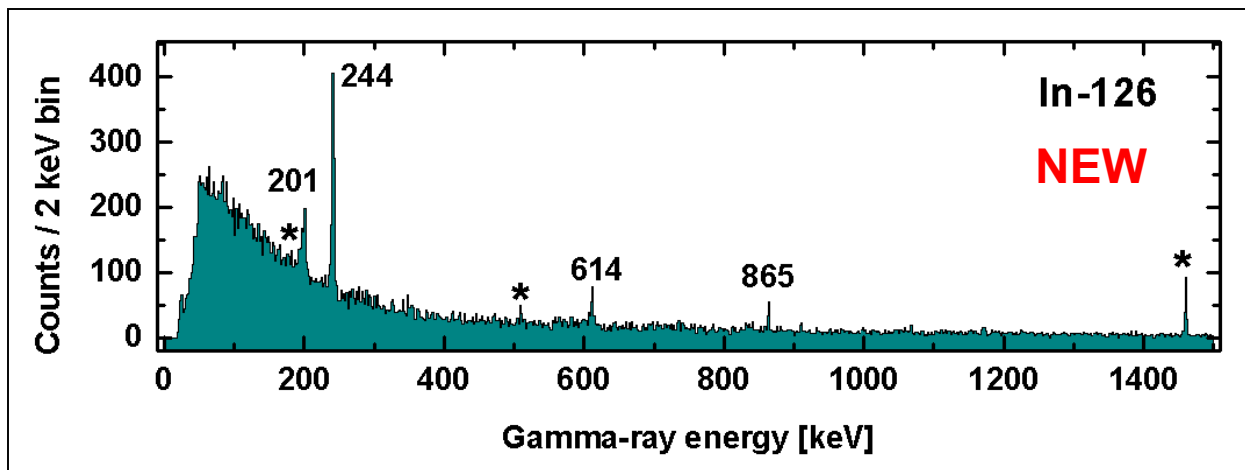
# $^{129}\text{Sn}$



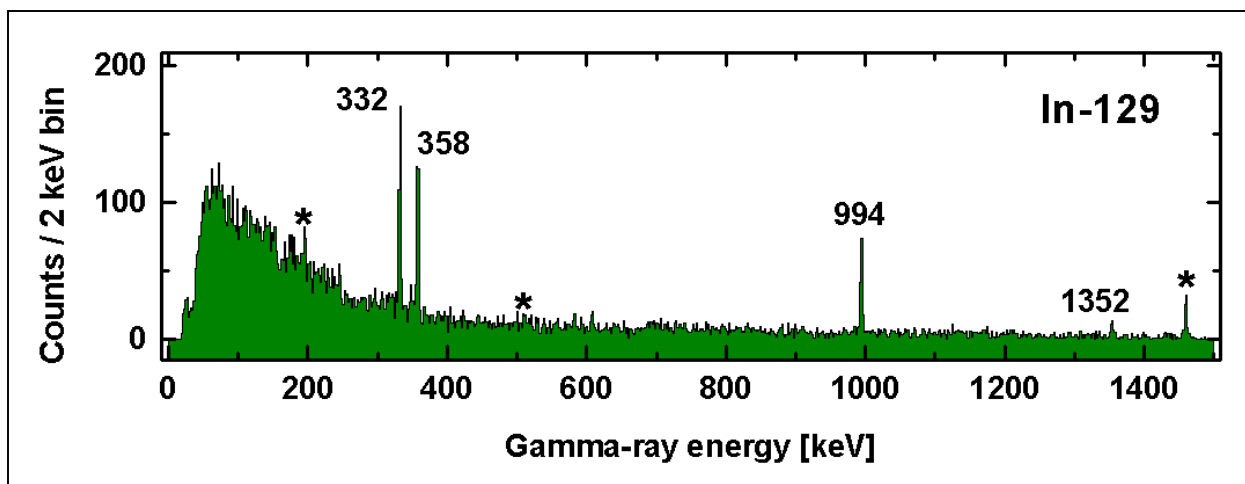
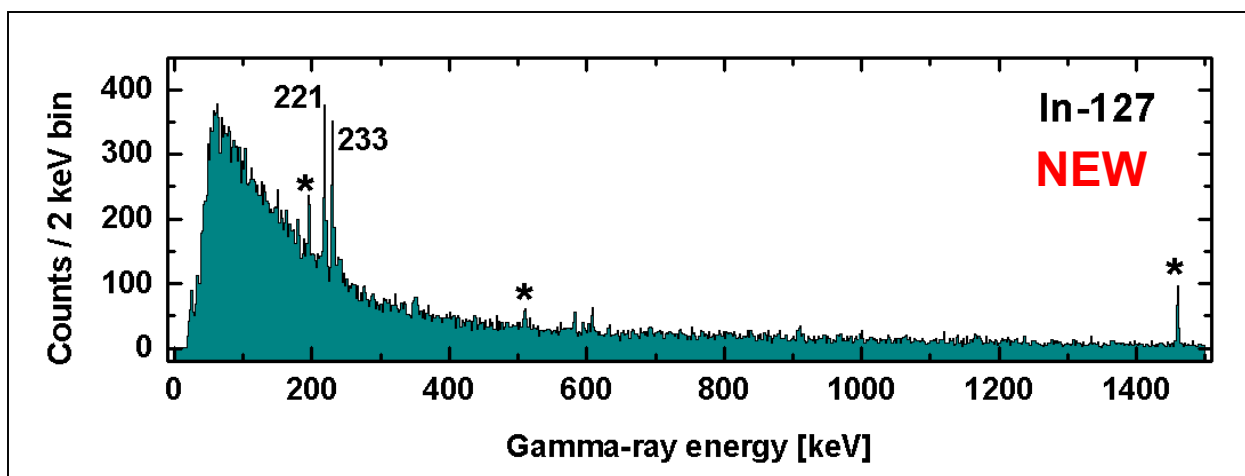
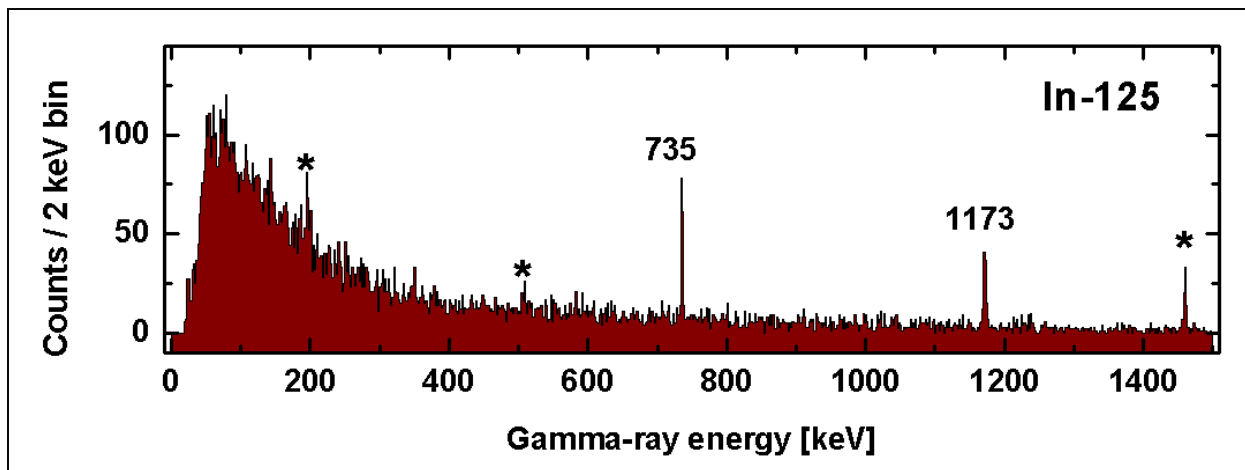
$19/2^+$ , 3.6(2)  $\mu\text{s}$  and  $23/2^+$ , 2.4(2)  $\mu\text{s}$

J. Genevey et al., *Phys. Rev. C* 65, 034322 (2002).

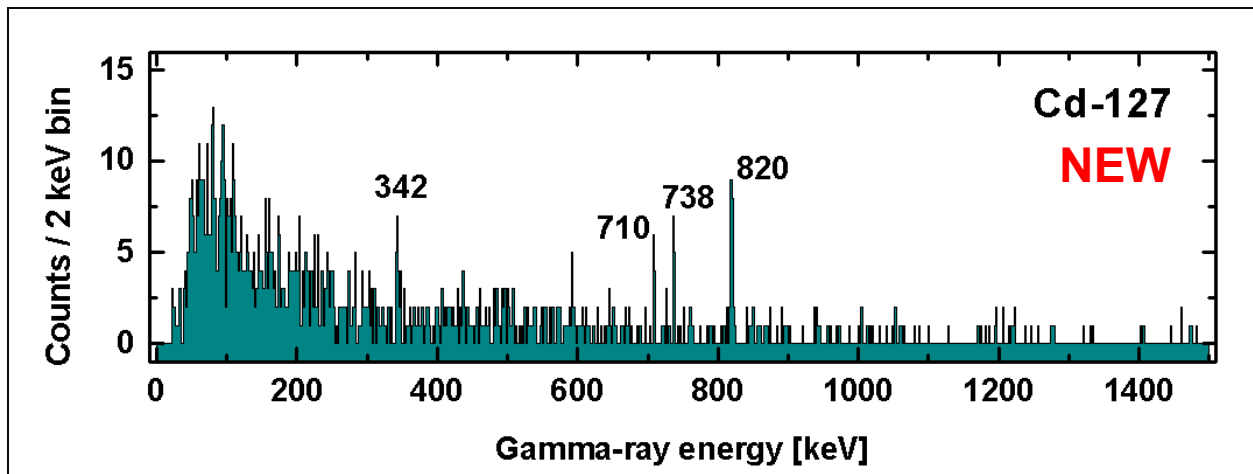
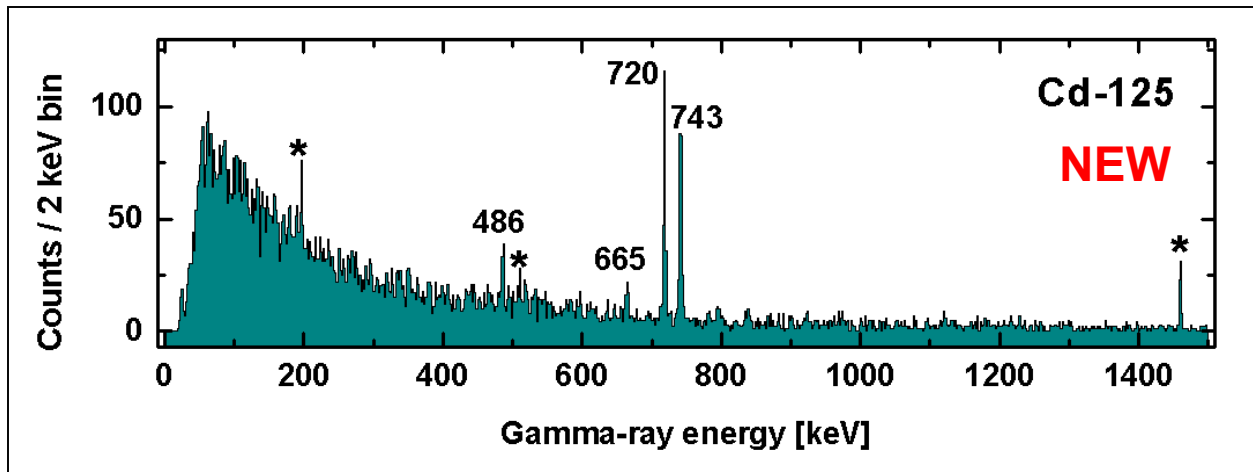
## Even-A indium isomers



# Odd-A indium isomers



# Odd-A cadmium isomers



## Summary & outlook

- Isomer spectroscopy program at the FRS since 1996
- Projectile fragmentation and fission at  $\sim 1$  GeV/nucleon produce isomers with  $\sim 10\%$  probability
- Majority of ions are fully stripped (75% in Pb region, 95% at Sn)
- Time-of-flight through the separator  $\sim 300$  ns  $\rightarrow$  isomers with half-lives 100 ns – 100 ms are accessible
- Unambiguous identification of heavy ions in-flight, delayed  $\gamma$ -rays measured by high-efficiency Ge detectors
- Highlights so far:
  - 1996: very n-rich Pb and neighbors
  - 1999: K-isomers at  $A \sim 180$  &  $^{132}\text{Sn}$  region
  - 2001: mechanism study, technical development
  - 2002:  $^{132}\text{Sn}$  region, p-rich Pb, n-rich Th/Ac
- ESR mass measurements of fission fragments (also isomers): started in 2002
- Further experiments are planned with RISING stopped beam configuration (2005-2006)

# The GSI-FRS Isomer Collaboration

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