First Beta-Decay Study with CARIBU and Gammasphere: ^{142,144}Cs to ^{142,144}Ba

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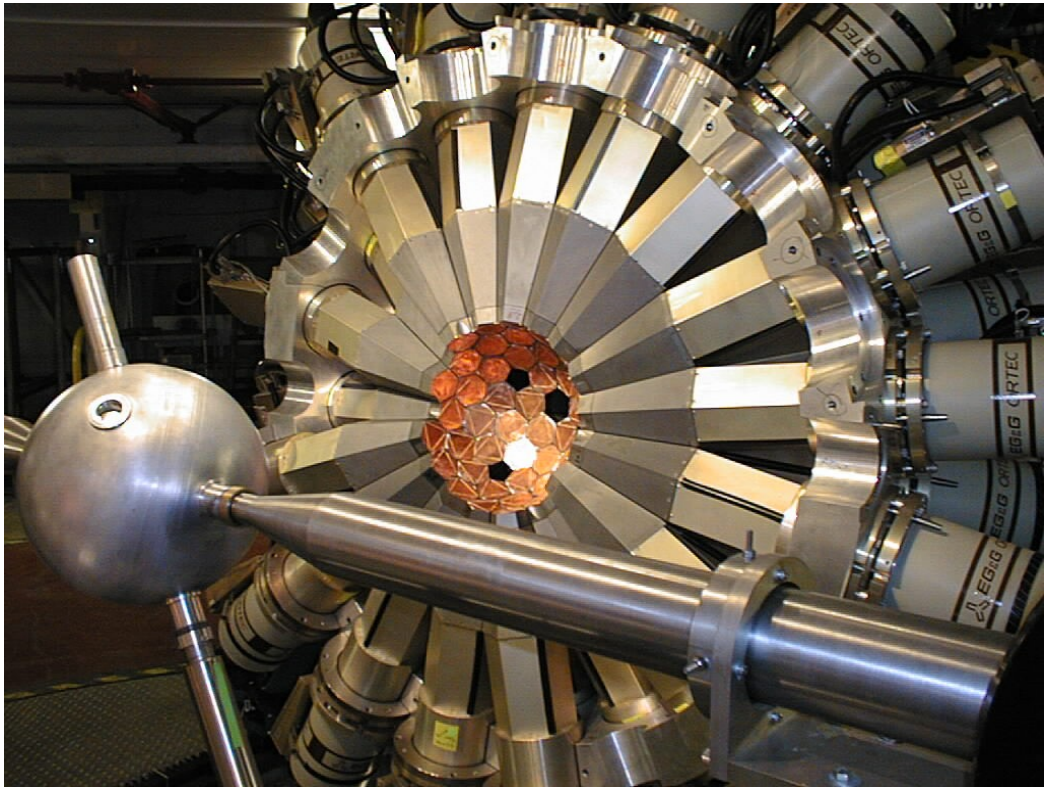
CARIBU beam at Gammasphere

1. **Coulomb excitation:**
   - **Reaccelerated Beams**
2. **Decay studies:**
   - **Low-energy Beam**
   - **Reaccelerated Beams**



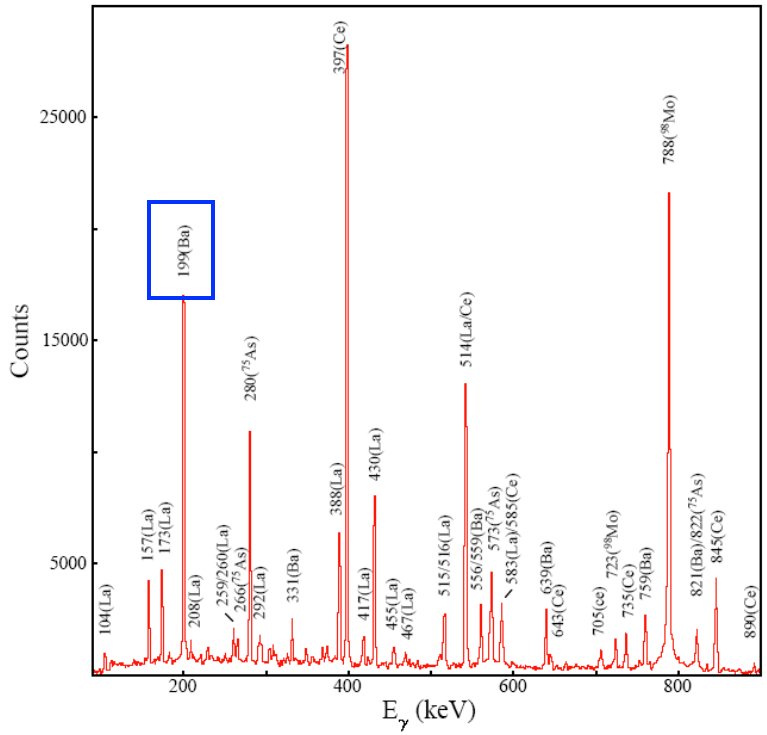
Limiting Factor:

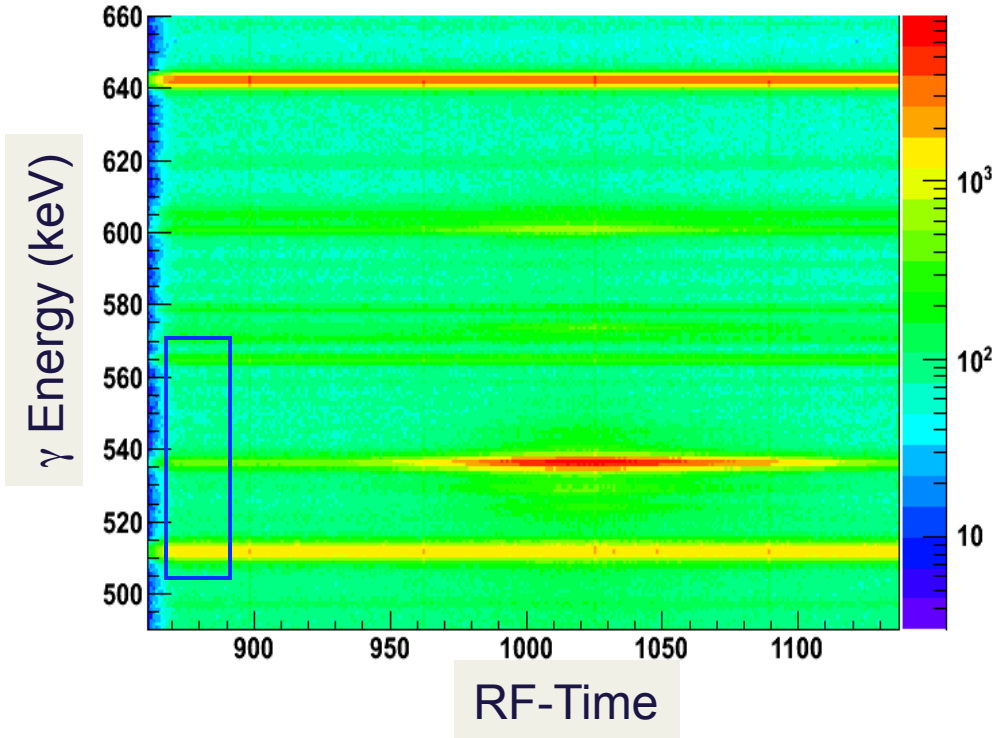
Beam Intensity (Source Strength, ATLAS efficiency)

Reaccelerated CARIBU beam on GS Target: ^{144}Cs

- ^{144}Ba: β-decay lifetime: 11.5 s; ^{144}Cs: β-decay lifetime: 1.0 s

Beam intensity: ~30 pps; total time of beam on target: 4 hours
Estimated stable beam intensity: ~$10^{6\text{-}7}$ pps



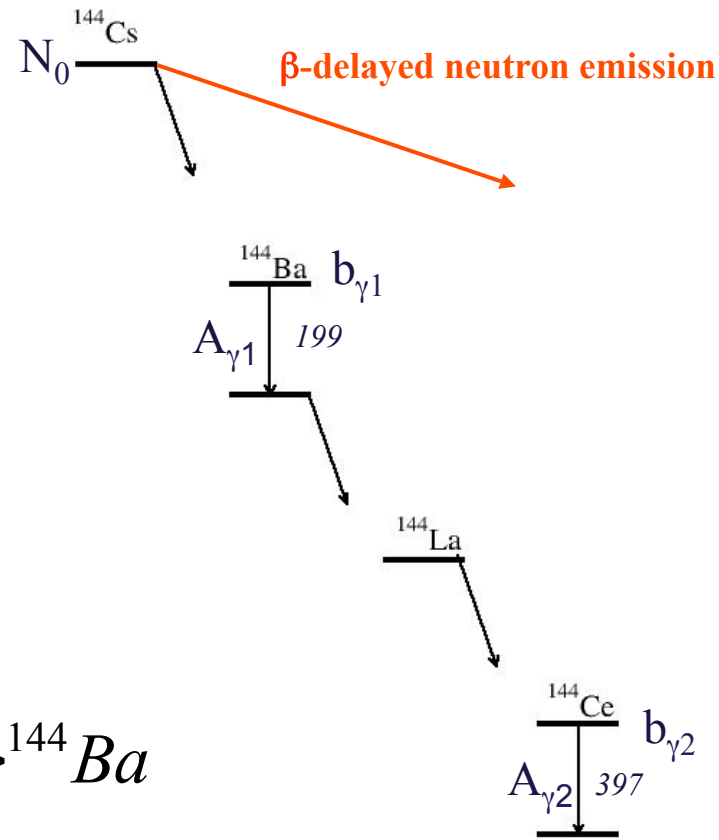


β-decay branching ratio of ^{144}Cs

$$A_{\gamma 1} = N_0 b_{\gamma 1} \varepsilon_{\gamma 1}$$

$$A_{\gamma 2} = N_0 b_{\gamma 2} \varepsilon_{\gamma 2}$$

$$b_{\gamma 1} = \frac{A_{\gamma 1} \varepsilon_{\gamma 2}}{A_{\gamma 2} \varepsilon_{\gamma 1}} b_{\gamma 2}$$



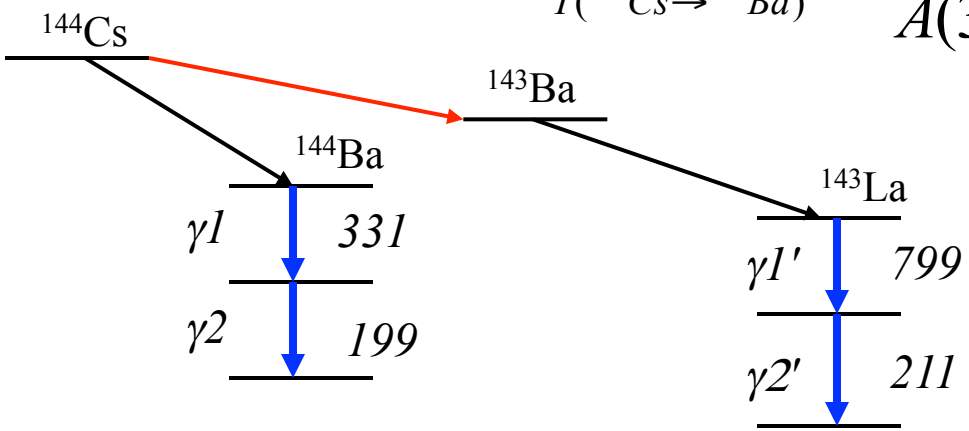
***A*: Peak Area of γ-ray in decay spectrum;**
***ε*: Relative efficiencies;**
***b*: γ intensities per 100 β-decay**

$$^{144}Cs \xrightarrow{\beta-decay} {}^{144}Ba$$

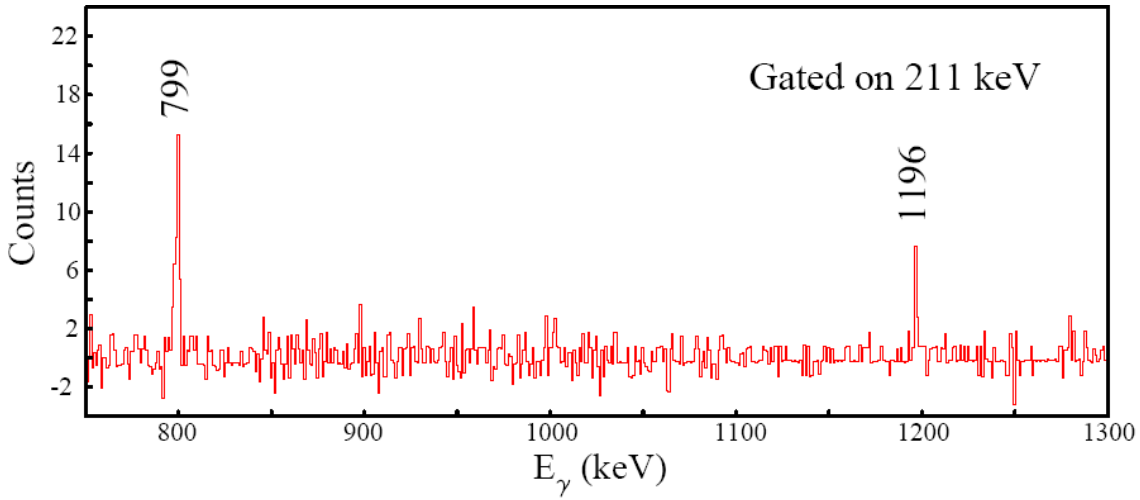
$$b_\gamma(199) = 52(2)$$

β-delayed neutron emission branching ratio of ^{144}Cs

$$\frac{I(^{144}Cs \rightarrow ^{143}Ba)}{I(^{144}Cs \rightarrow ^{144}Ba)} = \frac{A(799)/[\varepsilon(211)\varepsilon(799)b(799)]}{A(331)/[\varepsilon(199)\varepsilon(331)b(331)]}$$



***A*: Peak Area of γ-ray in gated spectrum;**
***ε*: Relative efficiencies;**
***b*: γ intensities per 100 β-decay**

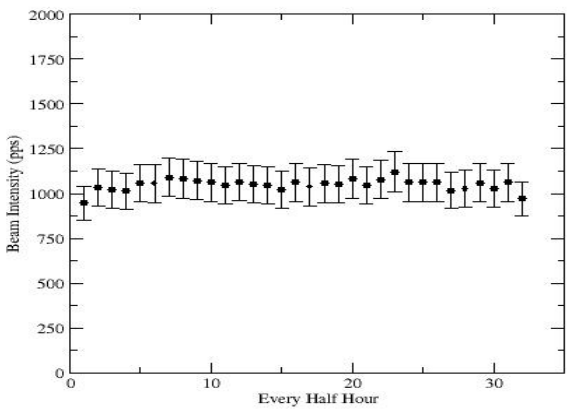


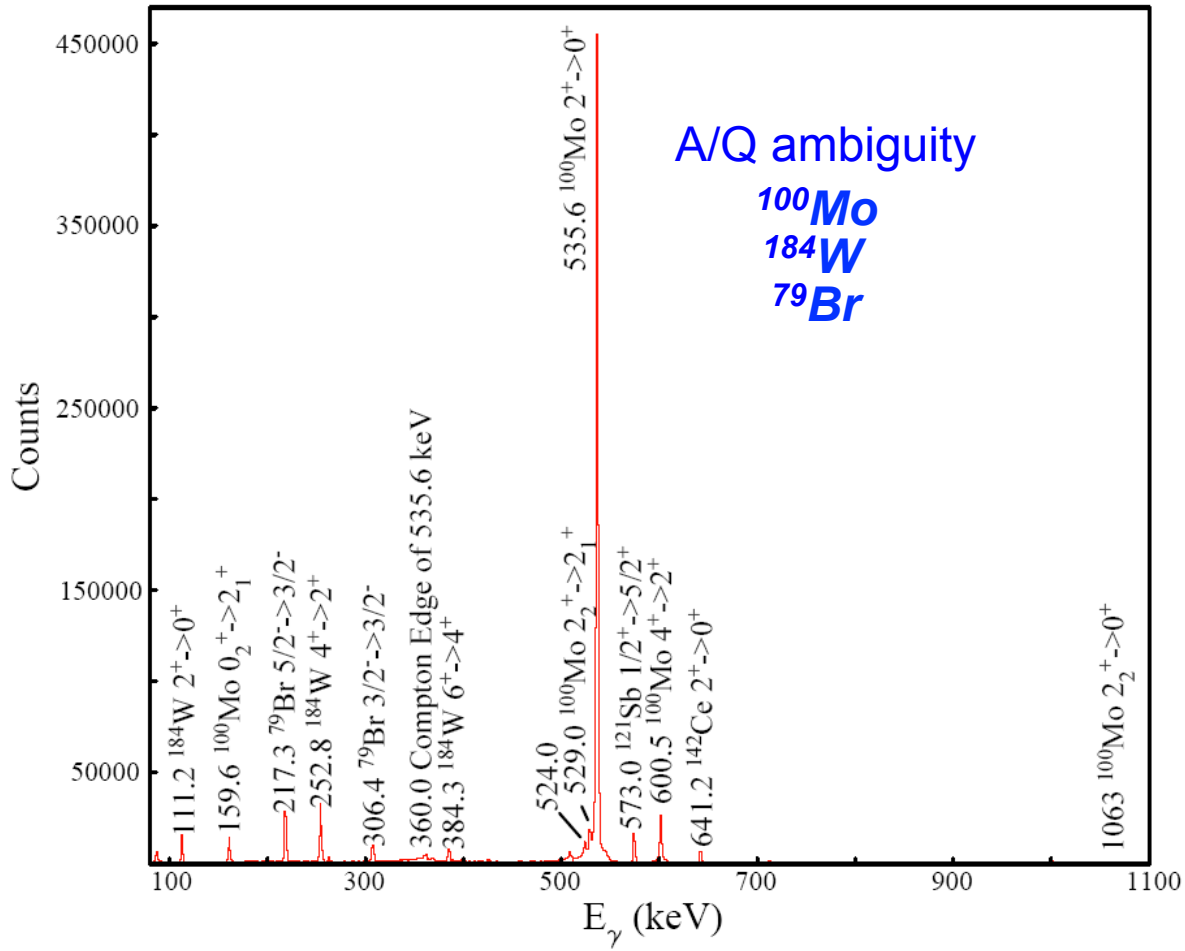
$$\frac{I(^{144}Cs \rightarrow ^{143}Ba)}{I(^{144}Cs \rightarrow ^{144}Ba)} = 0.03(1)$$

Adopted value: 0.0303(12)

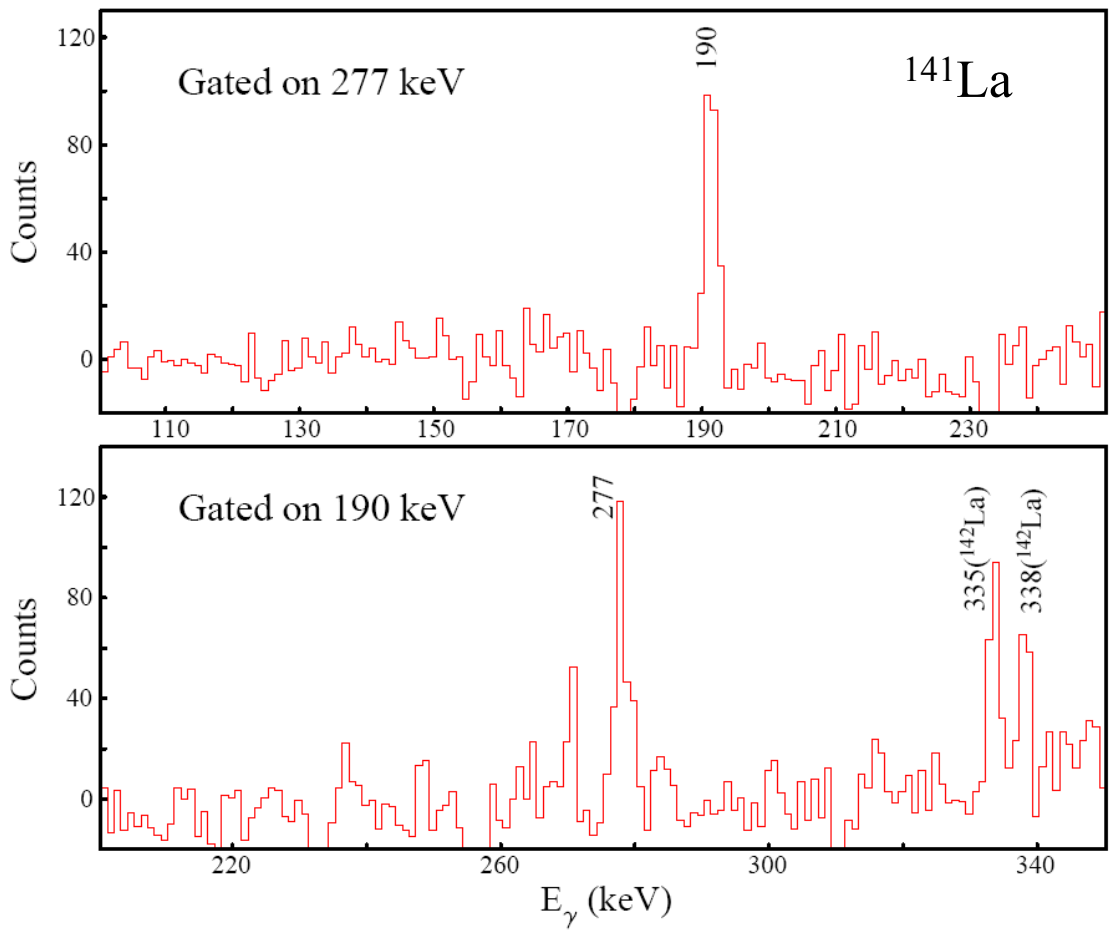
Nuclear Data Sheets 93, 599 (2001)

Reaccelerated CARIBU beam on GS Target: ^{142}Cs





β-delayed neutron emission branching ratio of ^{142}Cs

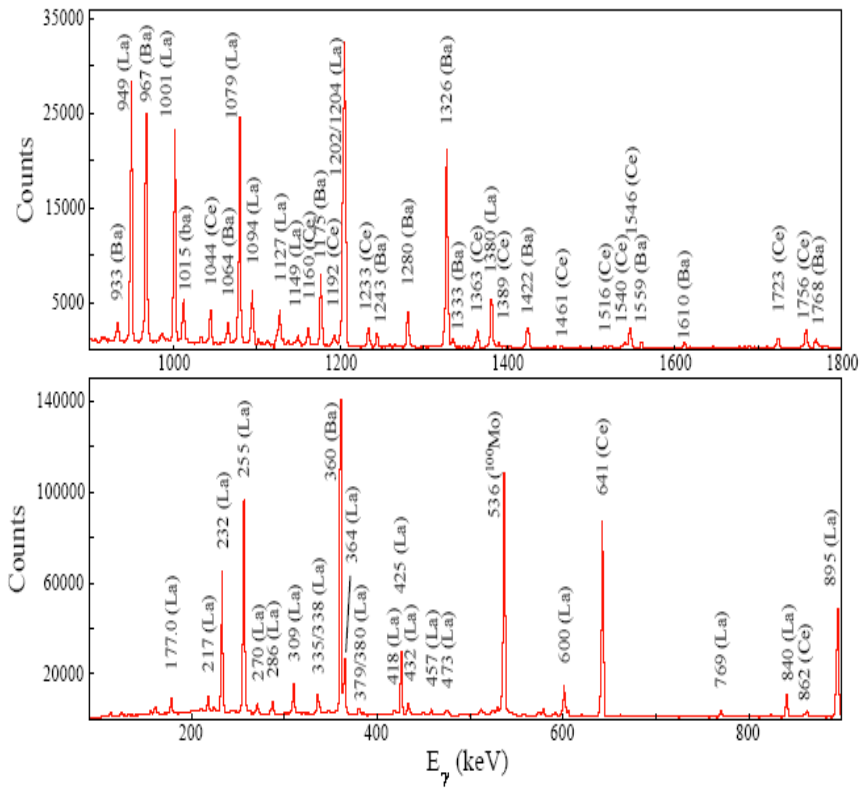


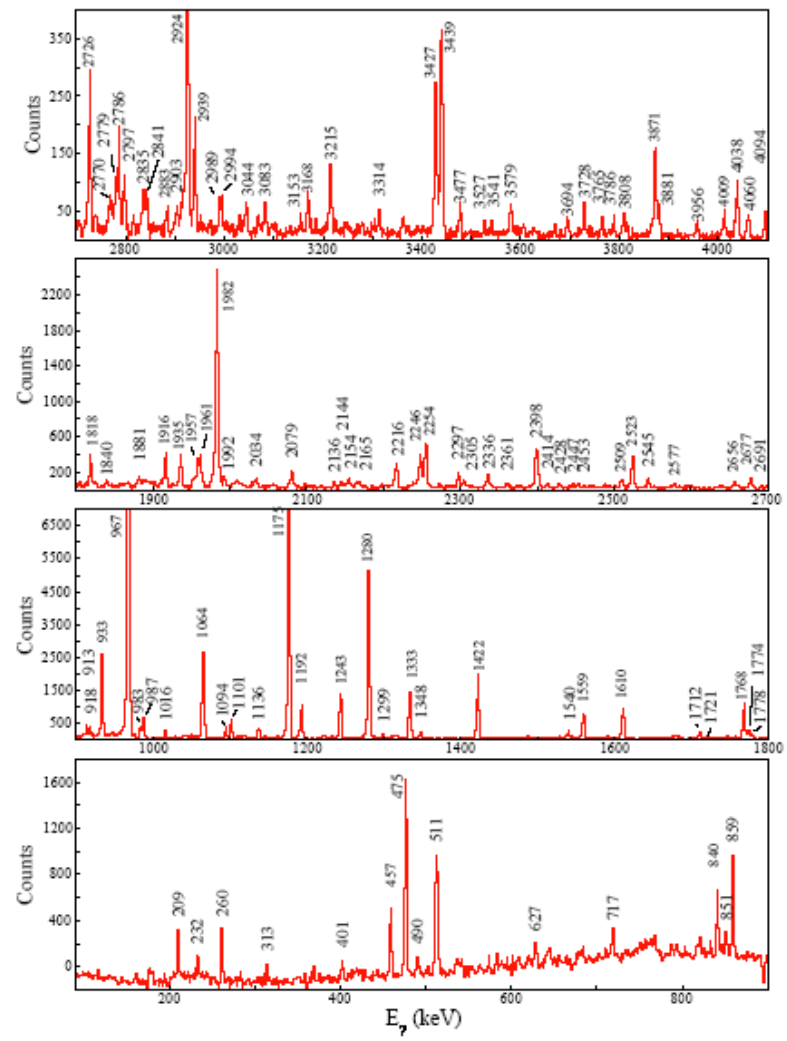
$$\frac{I(^{142}Cs \rightarrow ^{141}Ba)}{I(^{142}Cs \rightarrow ^{142}Ba)} = 0.0006(1)$$

Adopted value: 0.00090(4)

Nuclear Data Sheets 112, 1949 (2011)

γ-spectra of ^{142}Cs β decay

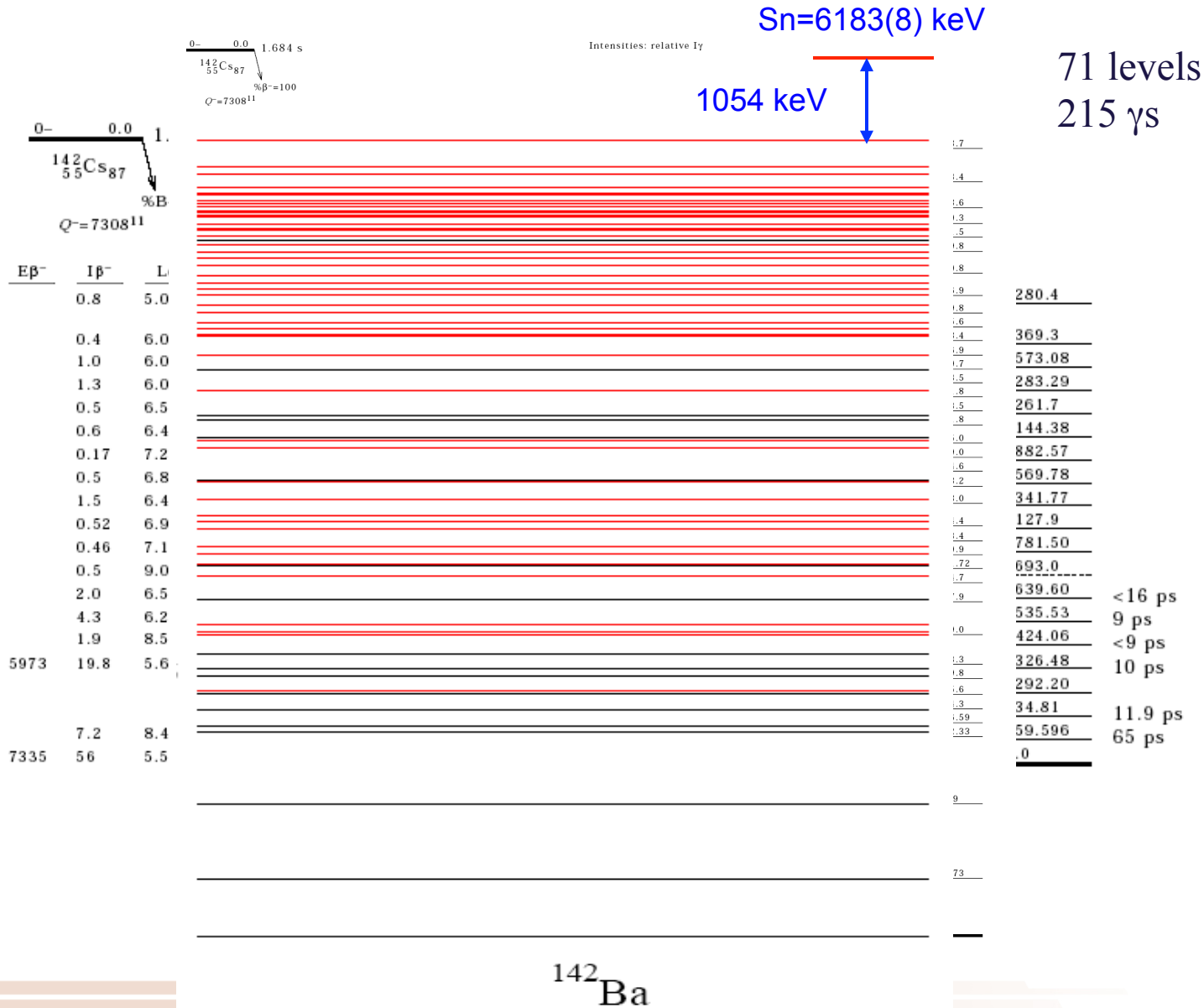




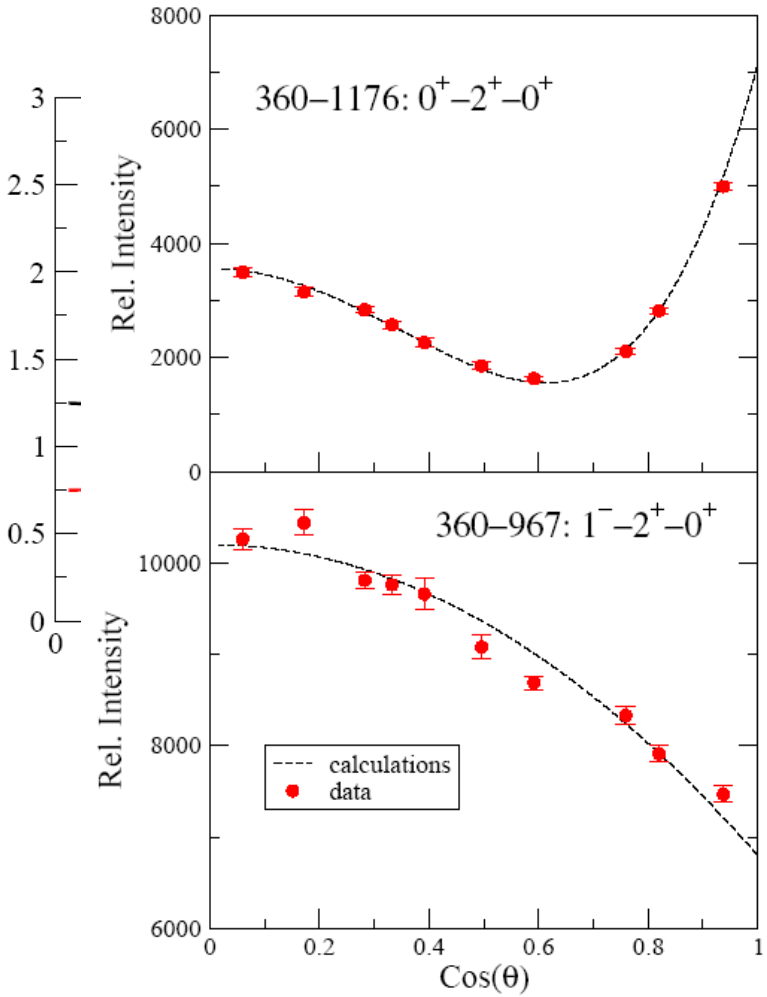
Total projections:
γ rays in ^{142}Ba, ^{142}La, and ^{142}Ce

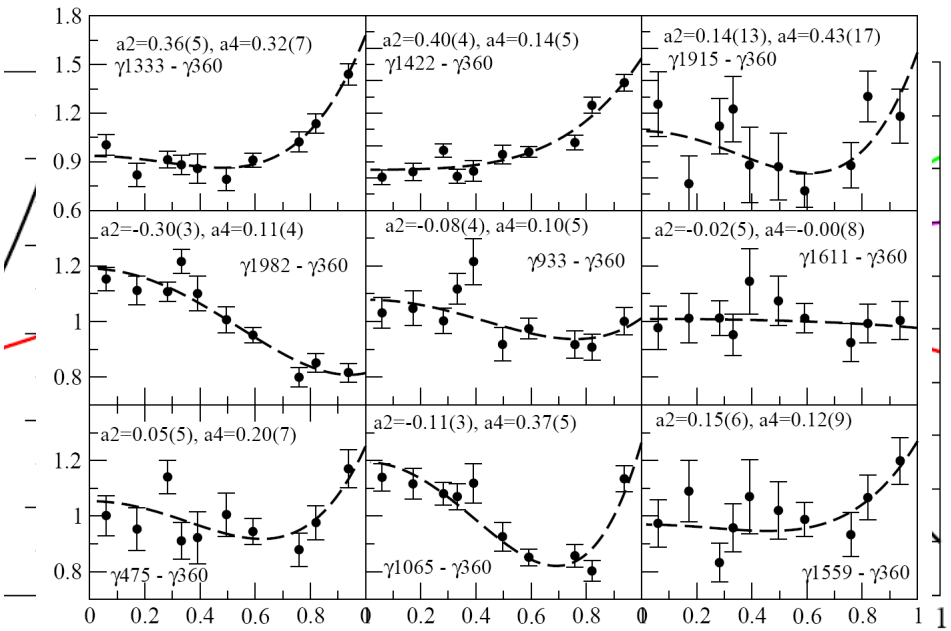
^{142}Ba: 360-keV($2^+ \rightarrow 0^+$) γ ray gated

Expanded β-decay level scheme of ^{142}Ba



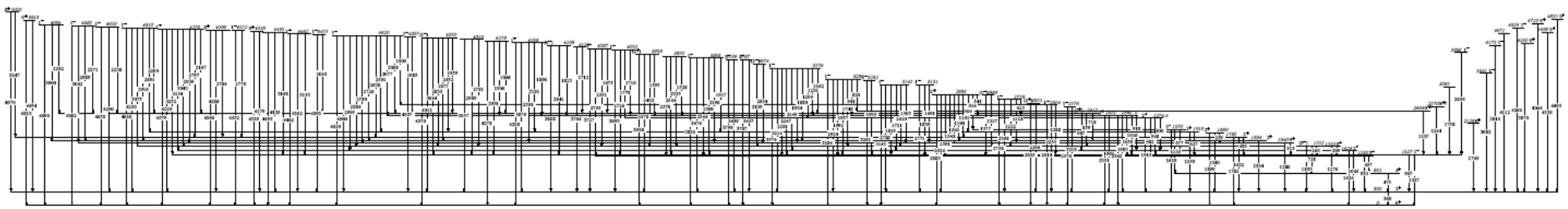
Spin Assignments: Angular Correlations





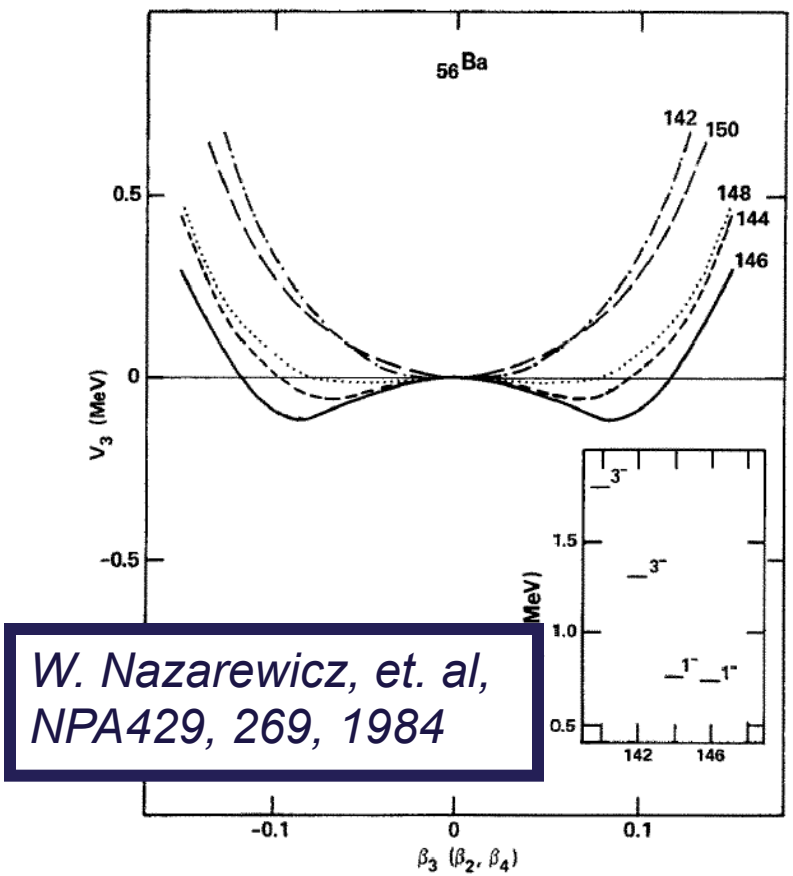
Weak Transitions: $I(\theta_{avg1})/I(\theta_{avg2})$
$\theta_{avg1}=31.5°$; $\theta_{avg2}=79.2°$

Understanding the decay scheme

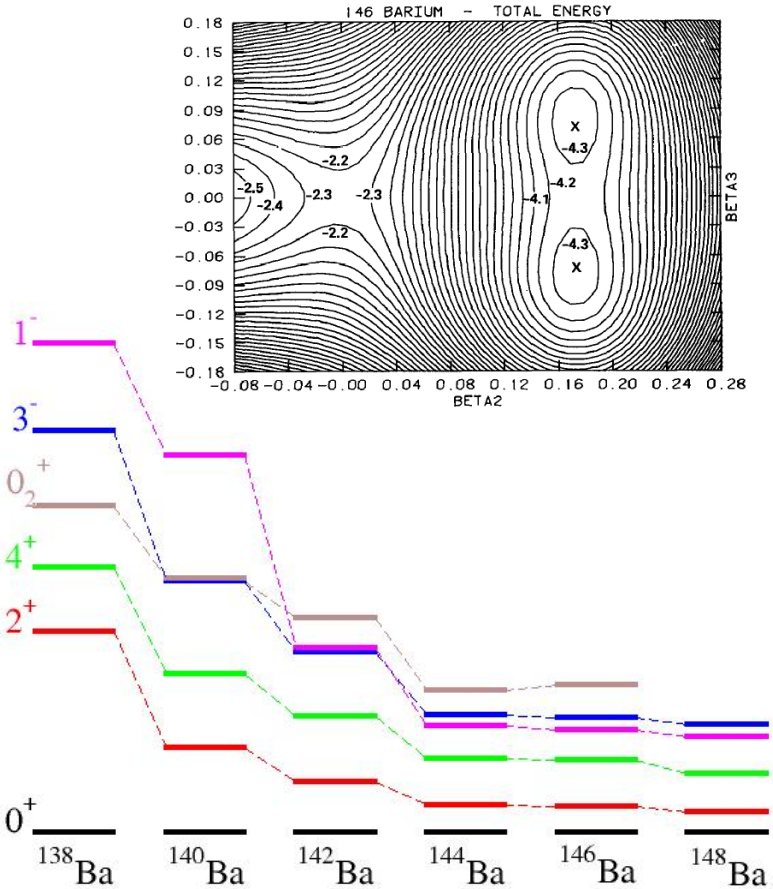


^{142}Ba

Systematics of quadrupole and octupole collectivities in neutron-rich barium nuclei:

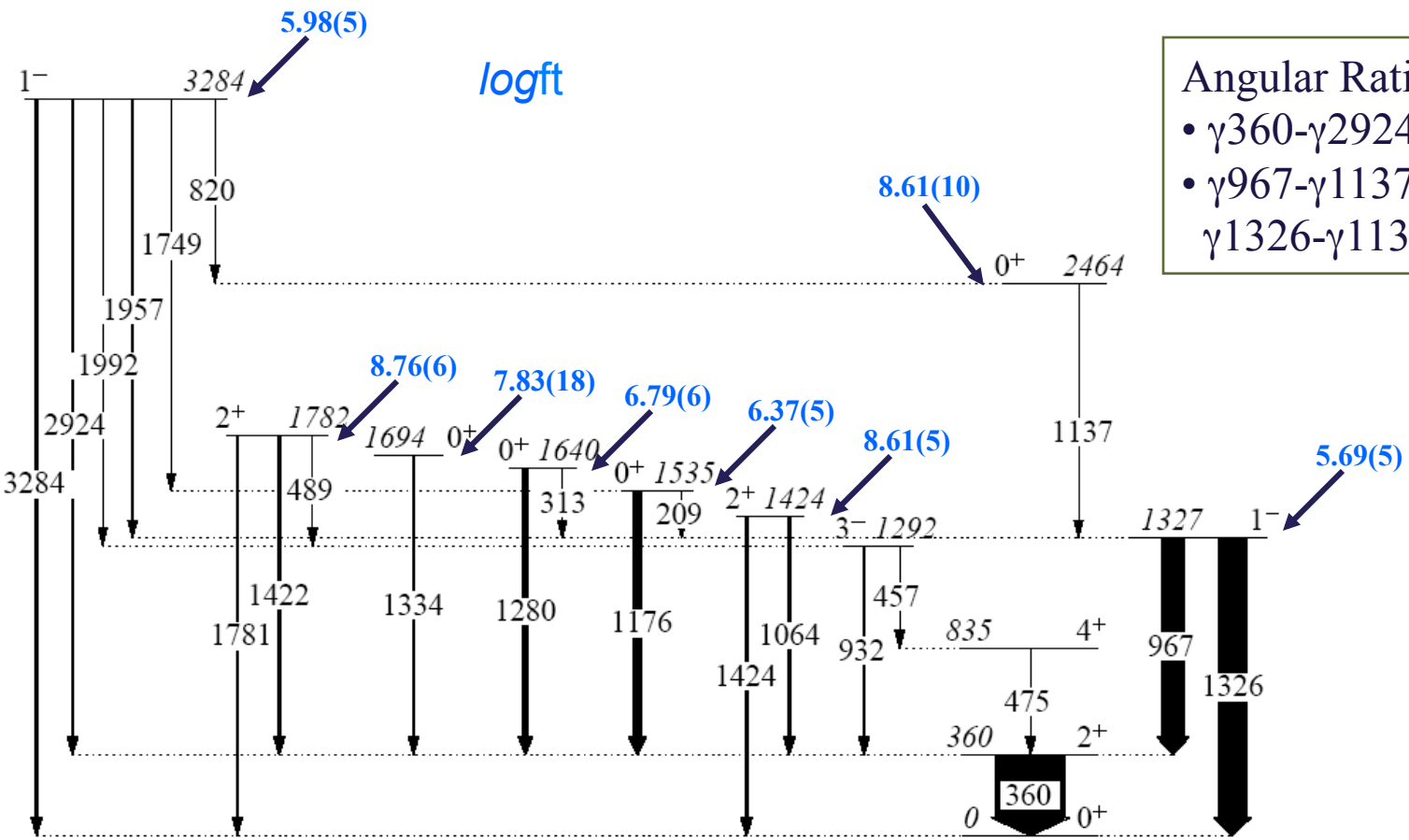


W. Nazarewicz, et. al, NPA429, 269, 1984



Coulomb excitation: direct measurements of *B(E1), B(E2), B(E3)*

Partial level scheme of ^{142}Ba

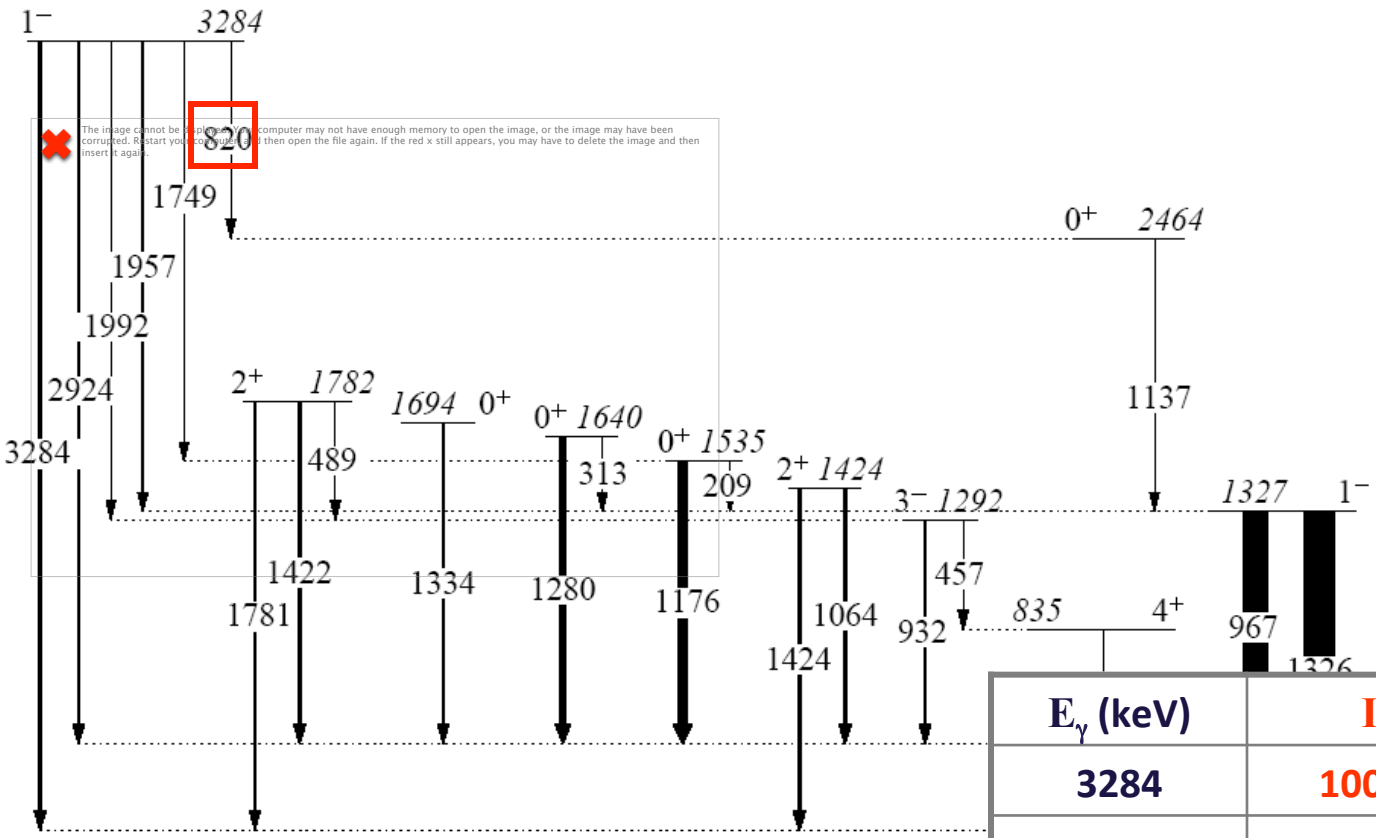


Angular Ratios:

- γ360-γ2924: 0.78(4)
- γ967-γ1137: 1.2(2)

γ1326-γ1137: 1.7(2)

Partial level scheme of ^{142}Ba: Multi-phonon states?



E_γ (keV)	I_γ	B_γ
3284	100(5)	100(5)
2924	80(4)	56(3)
1992	5.3(14)	13(3)
1957	15.3(18)	100(12)
1748	1.1(2)	7.5(14)
820	5.5(5)	353(32)

Summary

- Gammasphere is powerful in beta-decay studies of CARIBU beams;
- β-decay branching ratio to 2^+ and ground state in ^{144}Ba
- β-delayed neutron emission branching ratios of ^{142,144}Ba
- Spectroscopic information of ^{142}Ba from ^{142}Cs β-decay was extended substantially;
- Candidates of multi-phonon states were observed in ^{142}Ba

Collaborators

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