Octupole collectivity in ^{220}Rn and ^{224}Ra

Liam P. Gaffney

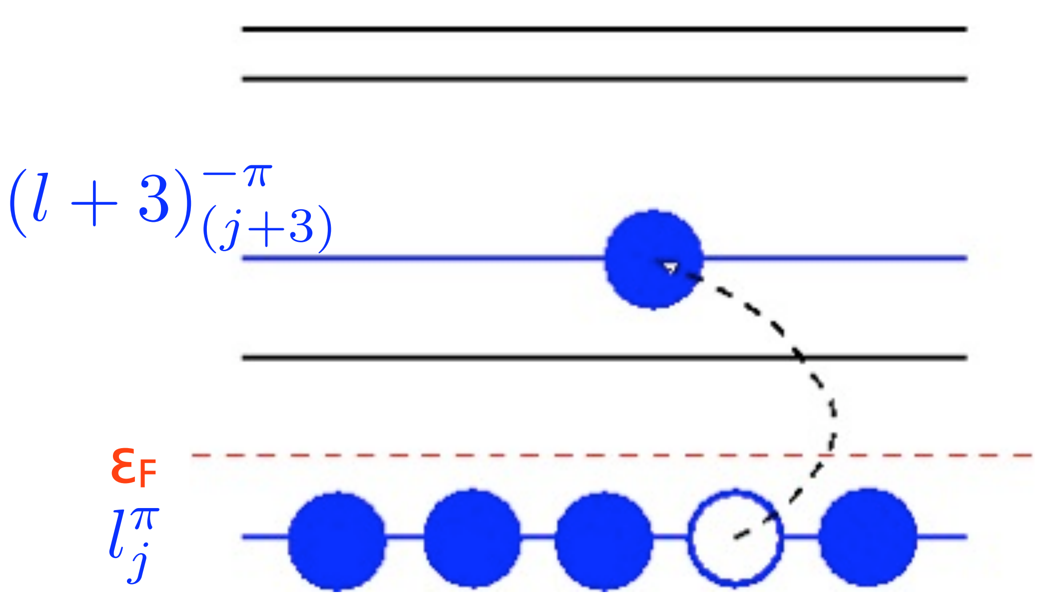
Oliver Lodge Laboratory, University of Liverpool, UK

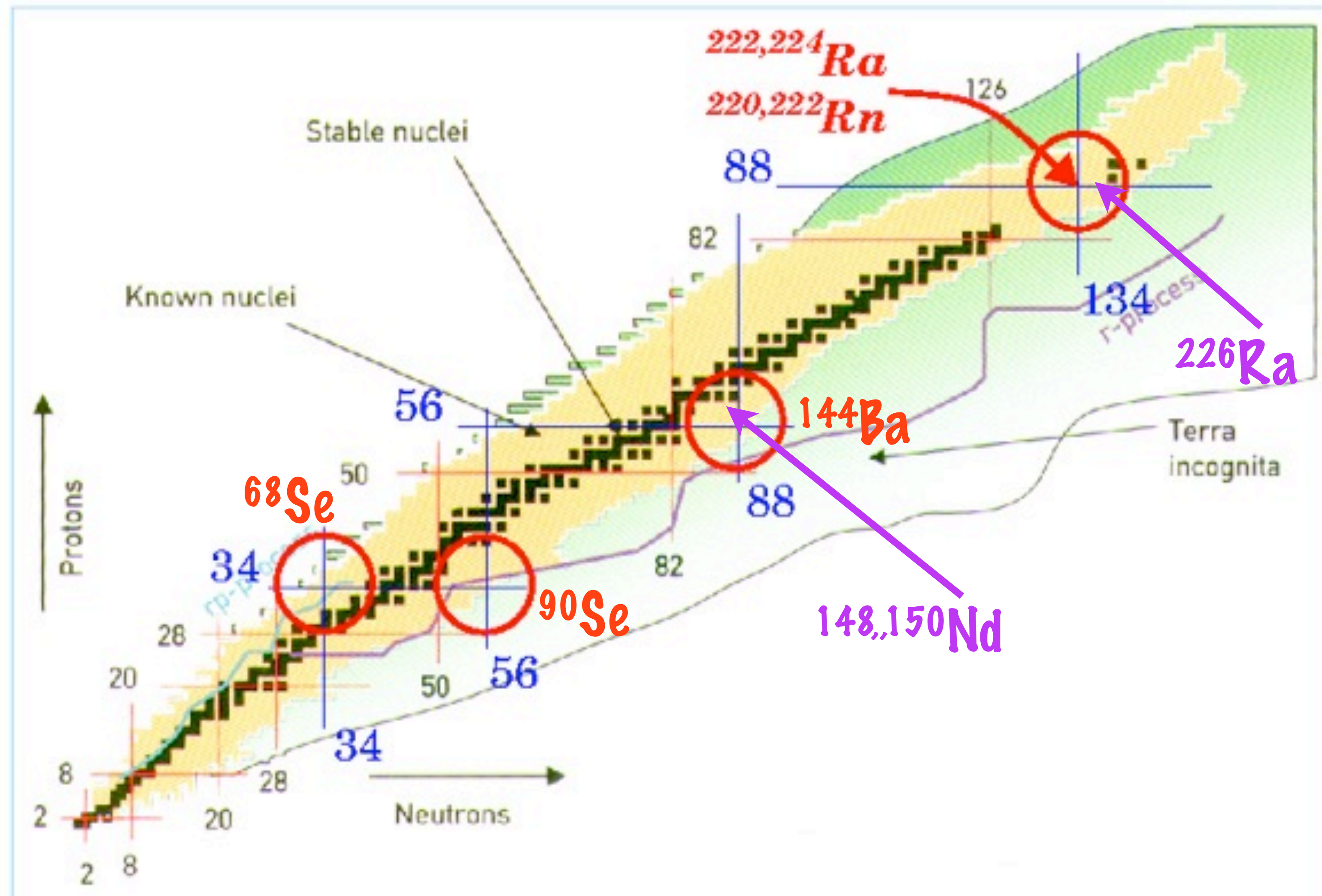
Octupole Collectivity

Octupole correlations enhanced at the magic numbers: **34, 56, 88, 134**

Microscopically...

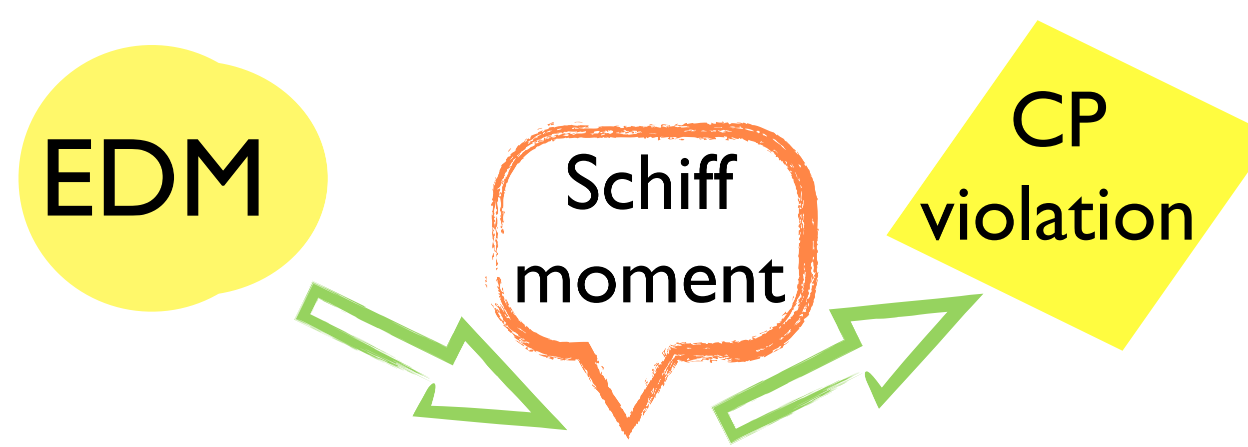
Intruder orbitals of opposite parity and **ΔJ, ΔL = 3** close to the Fermi level





^{220,222}Rn and ^{222,224}Ra lie near Z=88, N=134

$$\pi\left(f_{7/2} \to i_{13/2}\right) \quad \nu\left(g_{9/2} \to j_{15/2}\right)$$



Octupole Collectivity

Macroscopically...

Nuclei take on a "pear" shape

Reflection asymmetric

- β_3-vibration
- Static β_3-deformation
- Rigid β_3-deformation...

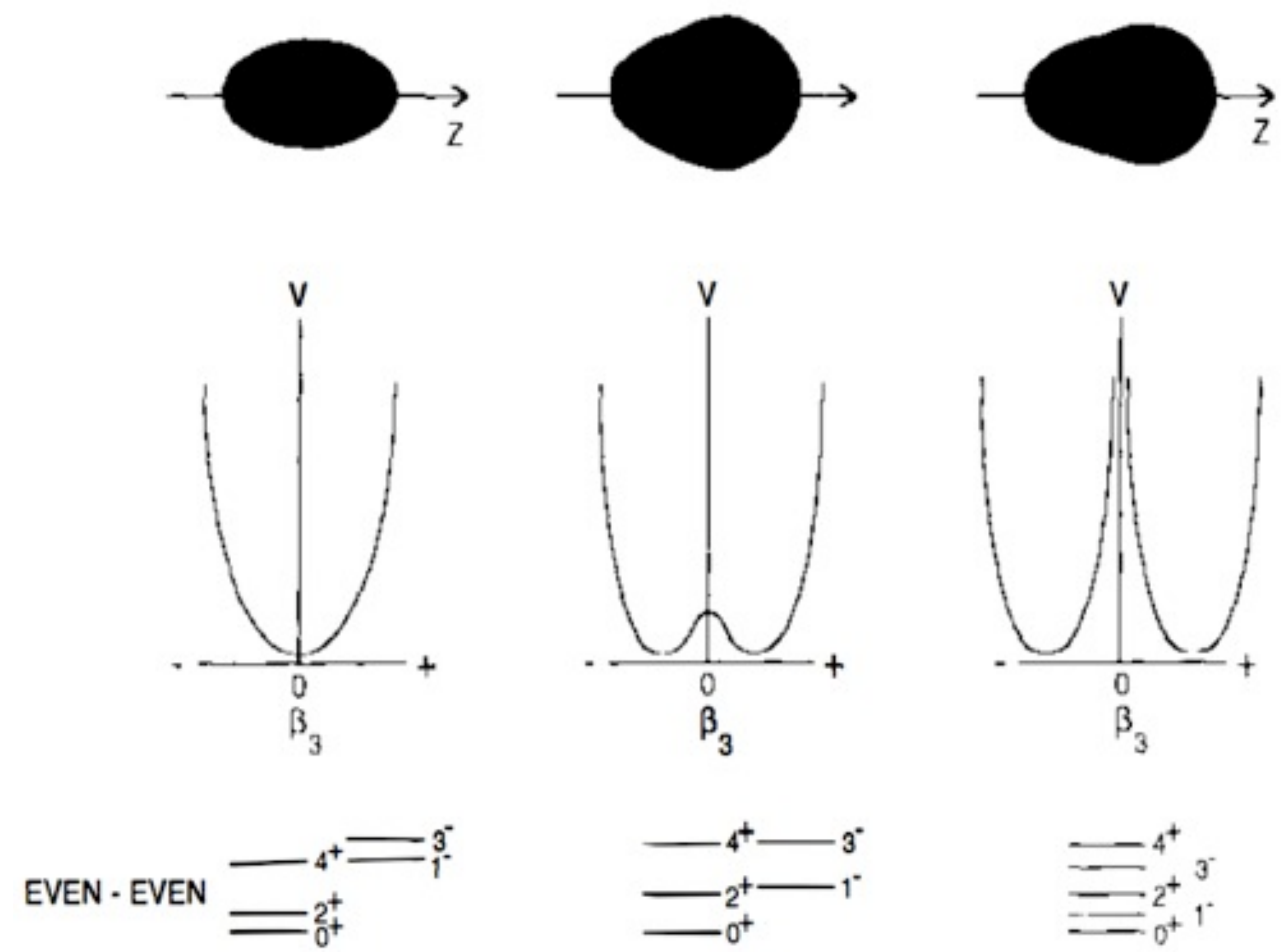


Image: I. Ahmed and P.A. Butler, Ann. Rev. Nucl. Part. Sci (1993) **43**

Signatures...

Odd-even staggering, negative parity

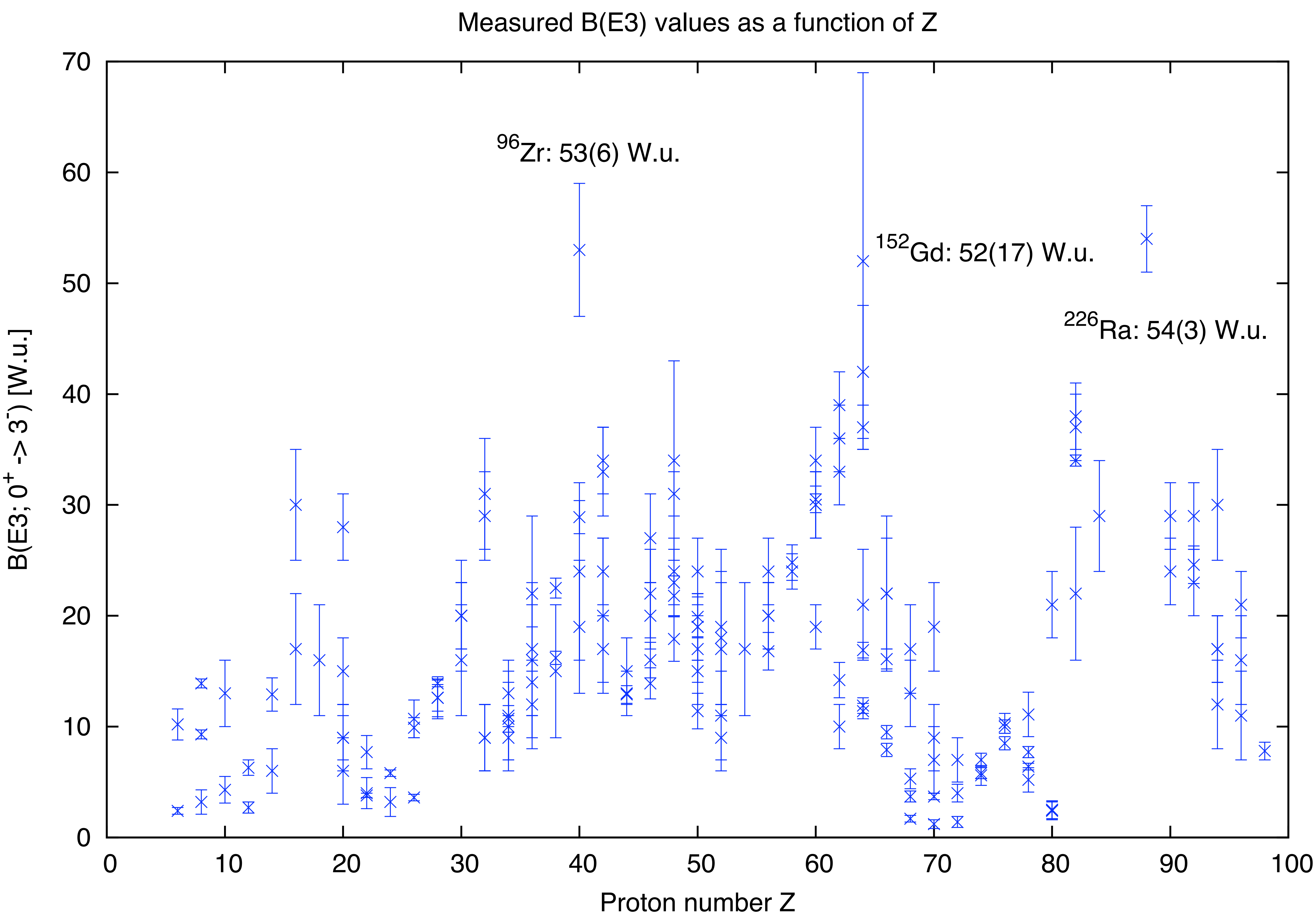
Parity doublets in odd-A nuclei

Enhanced E1 transitions

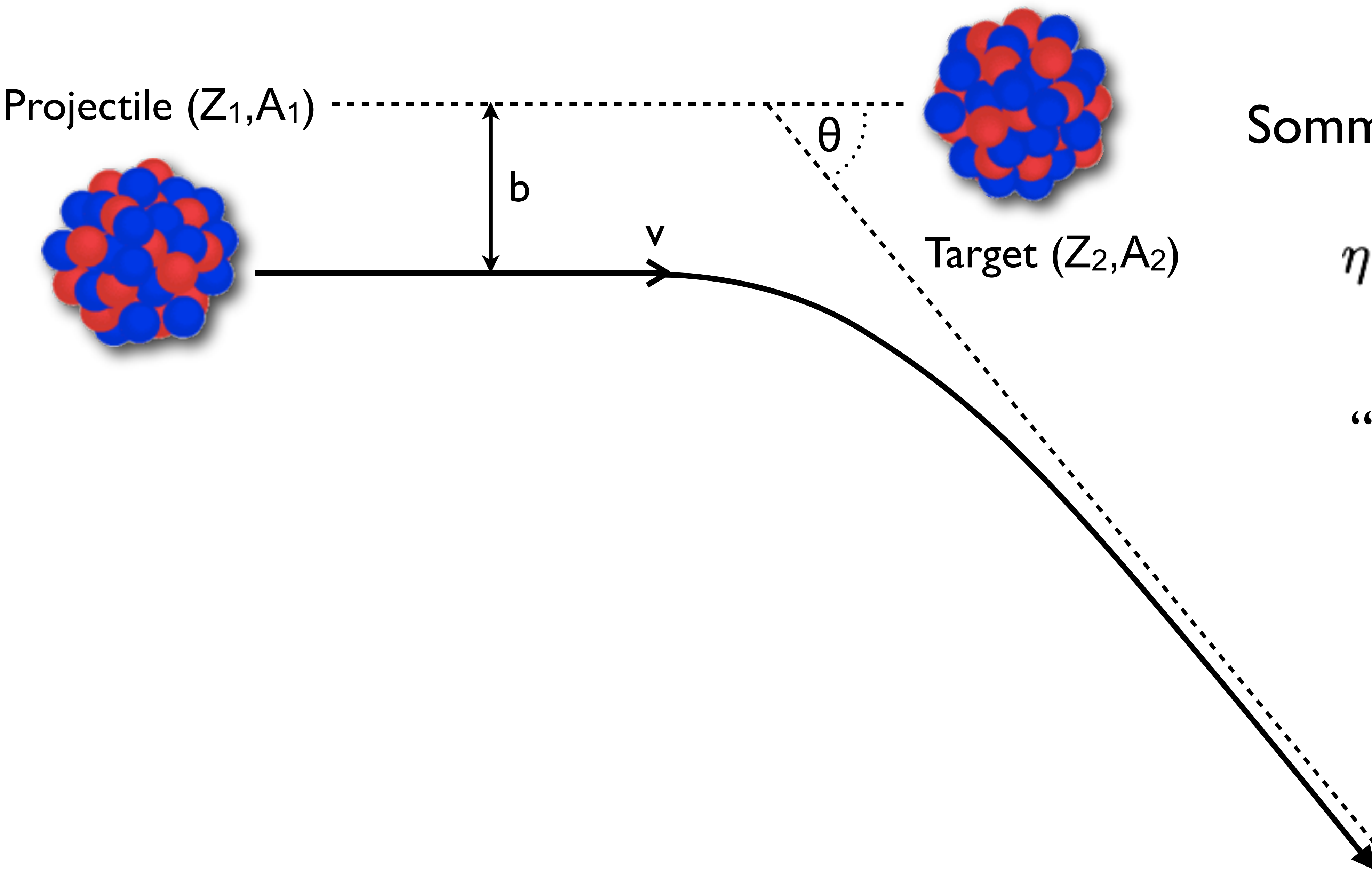
Large E3 strength → $B(E3; 0^+ \rightarrow 3^-)$ = $< 0^+||E3||3^- >^2$

2^L deformation -- β_L
L=2: Quadrupole, oblate/prolate shapes
L=3: Octupole, reflection asymmetry

Octupole Collectivity



Coulomb Excitation



Sommerfeld parameter:

$$\eta = \frac{Z_1 Z_2 e^2}{\hbar v}$$

“Safe” Coulex:

$$\eta \gg 1$$

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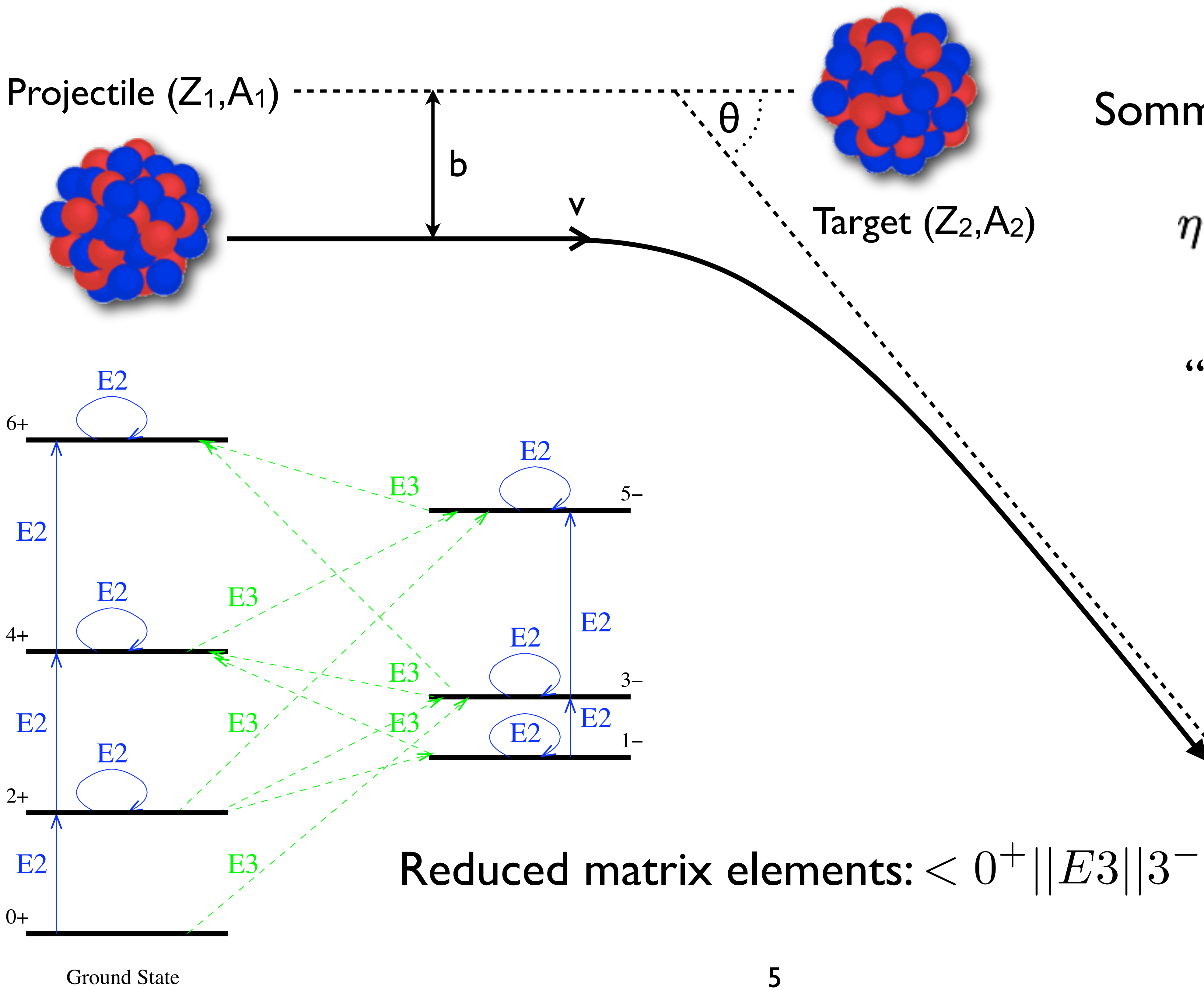
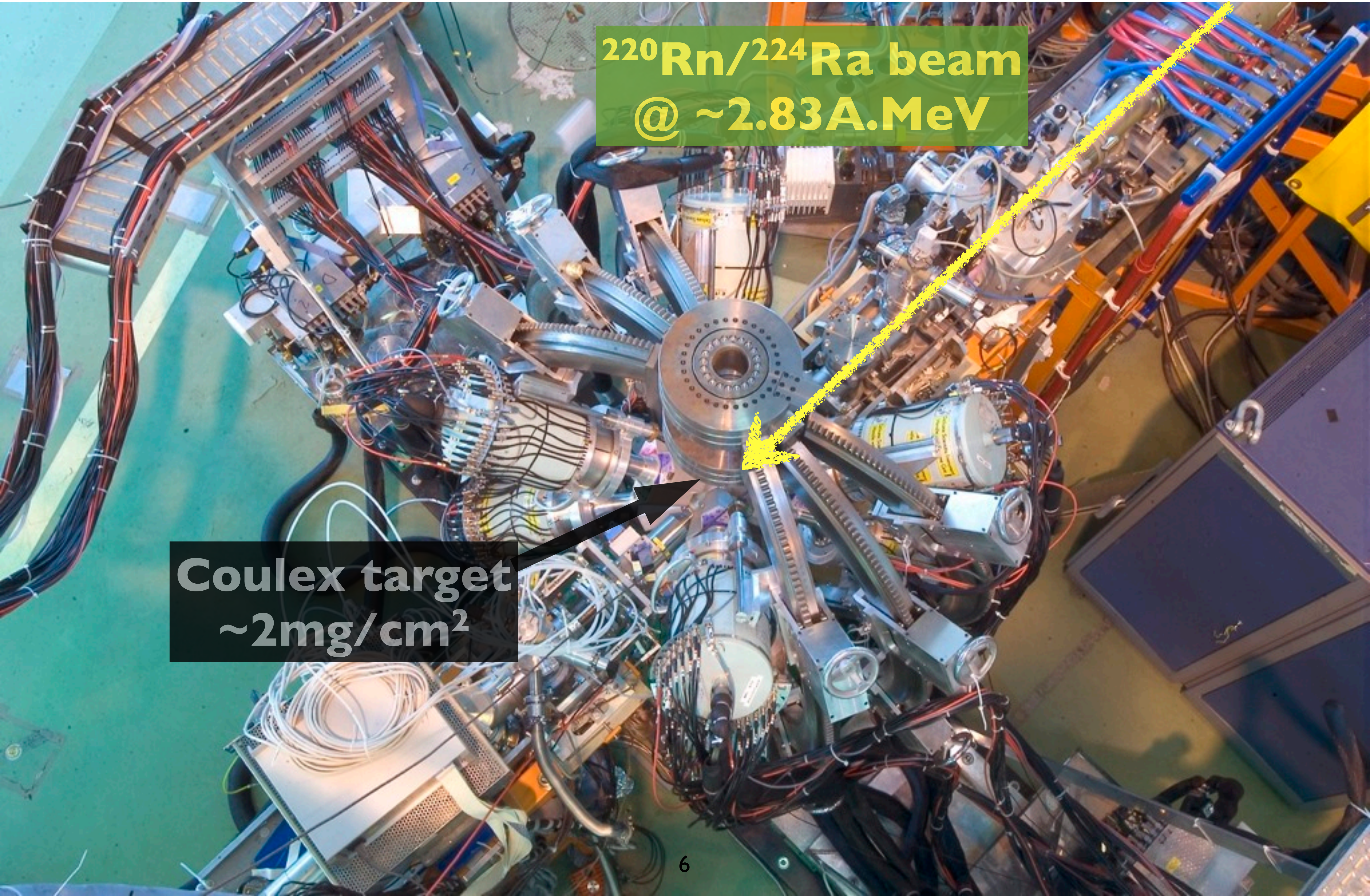
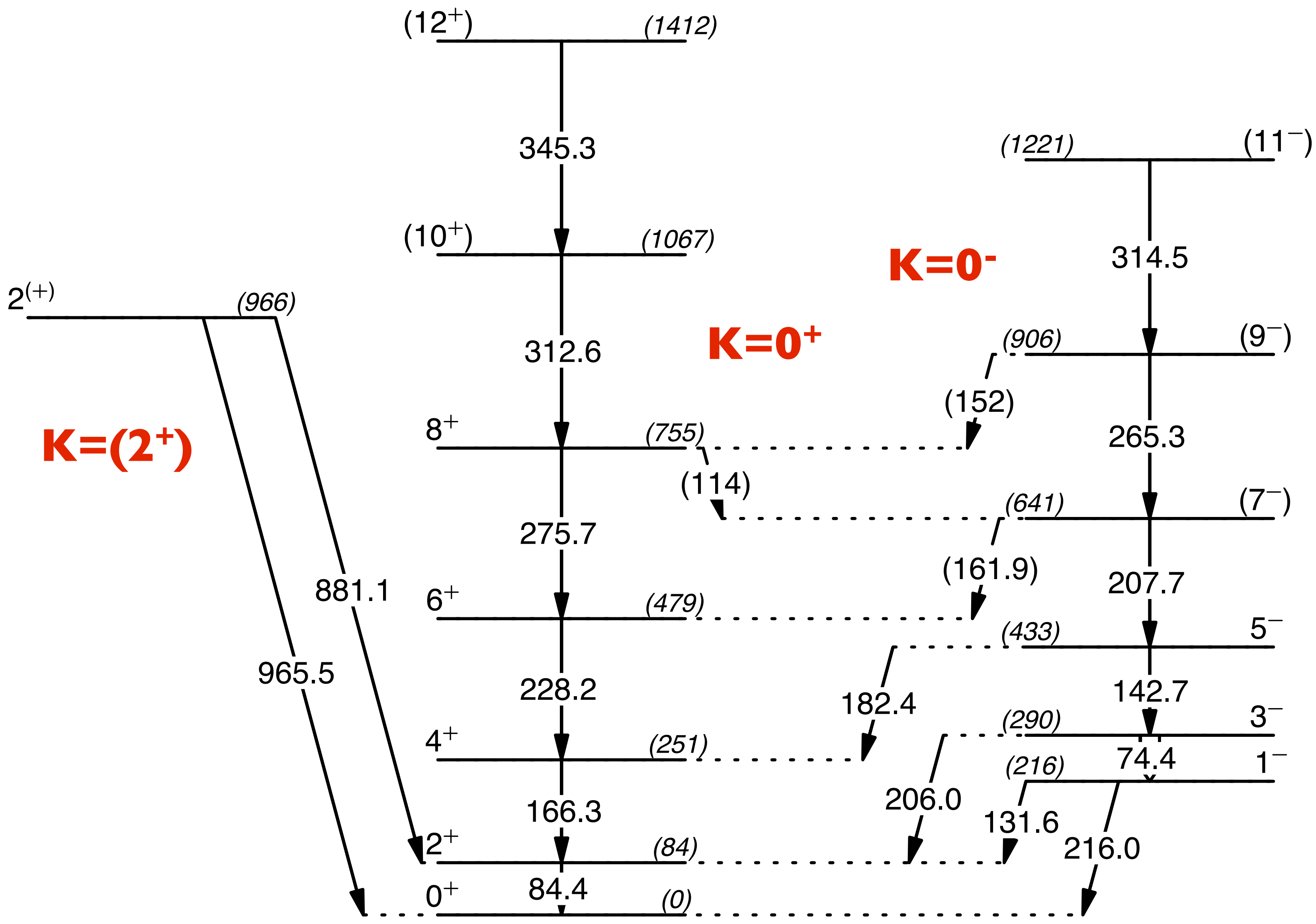


Reduced matrix elements: $< 0^+ || E3 || 3^- >$

MINIBALL



The experiment - ^{224}Ra



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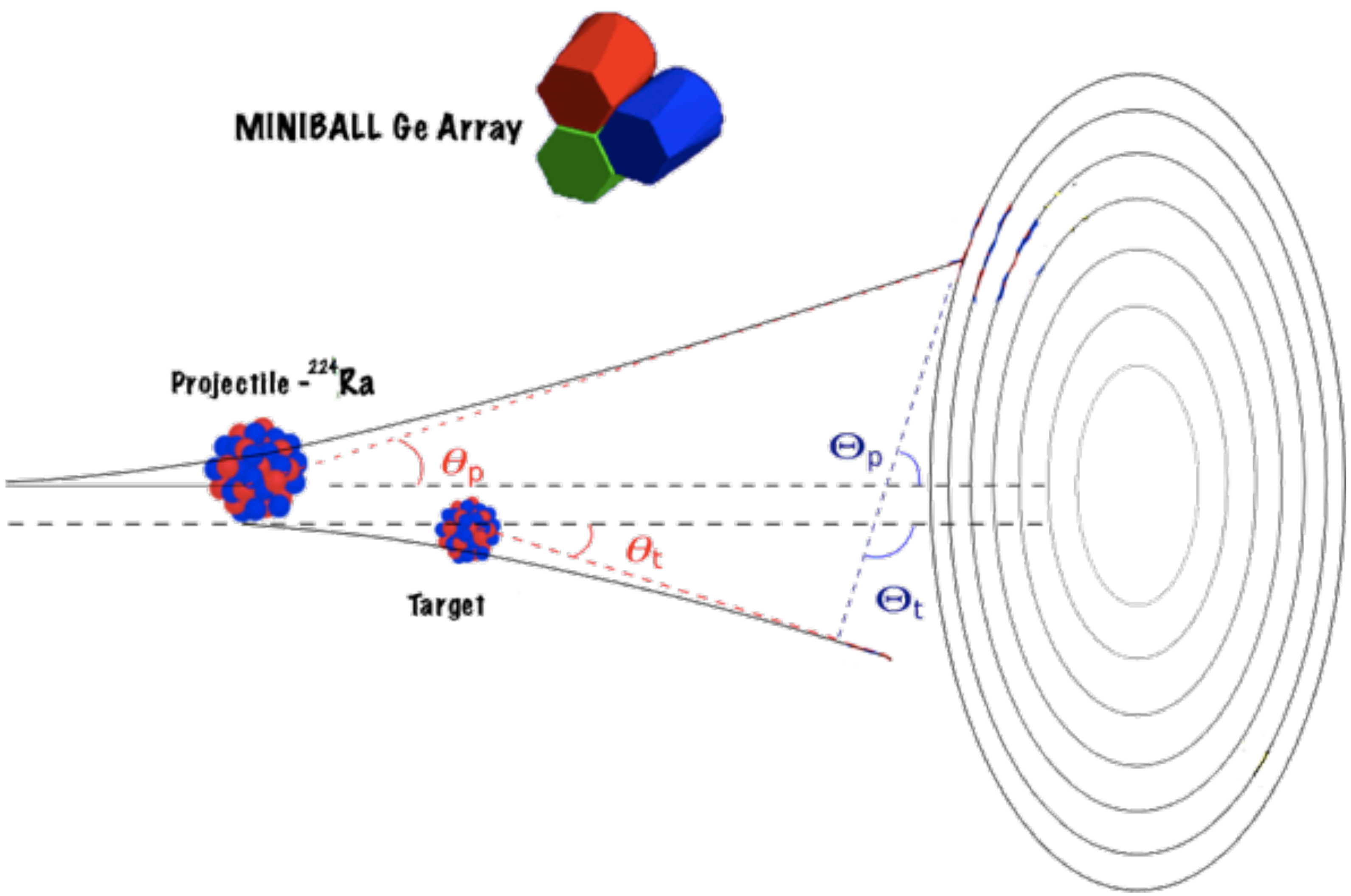

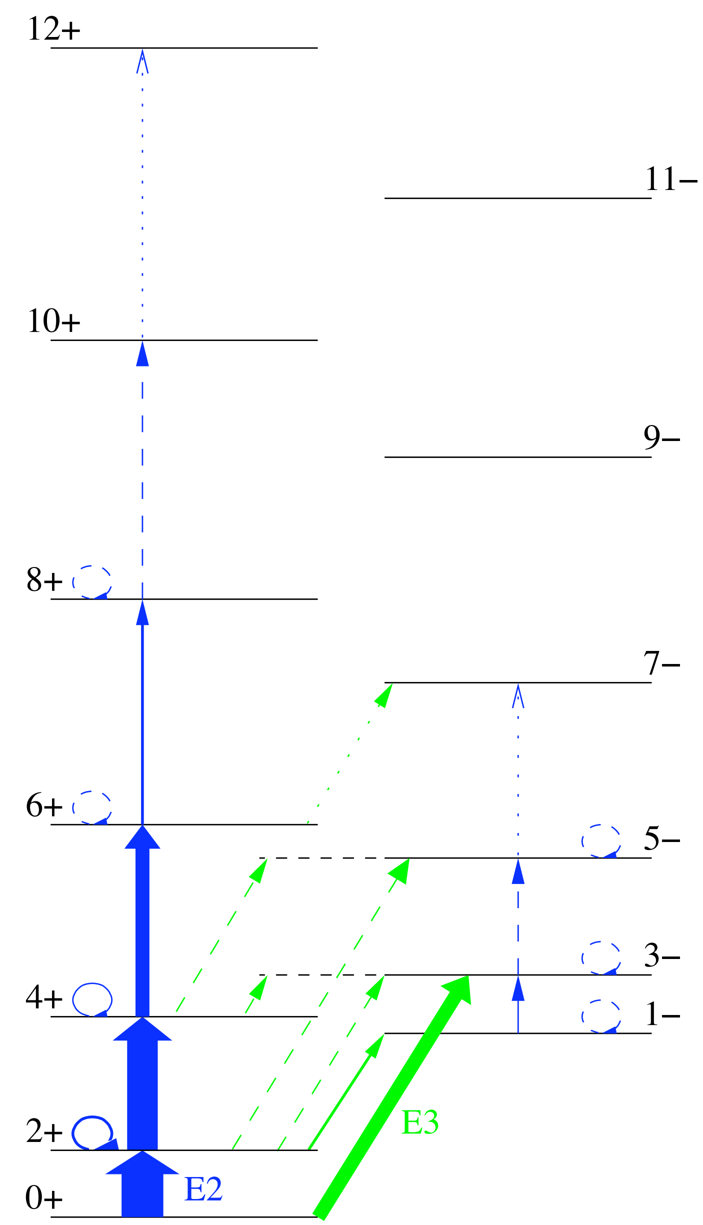

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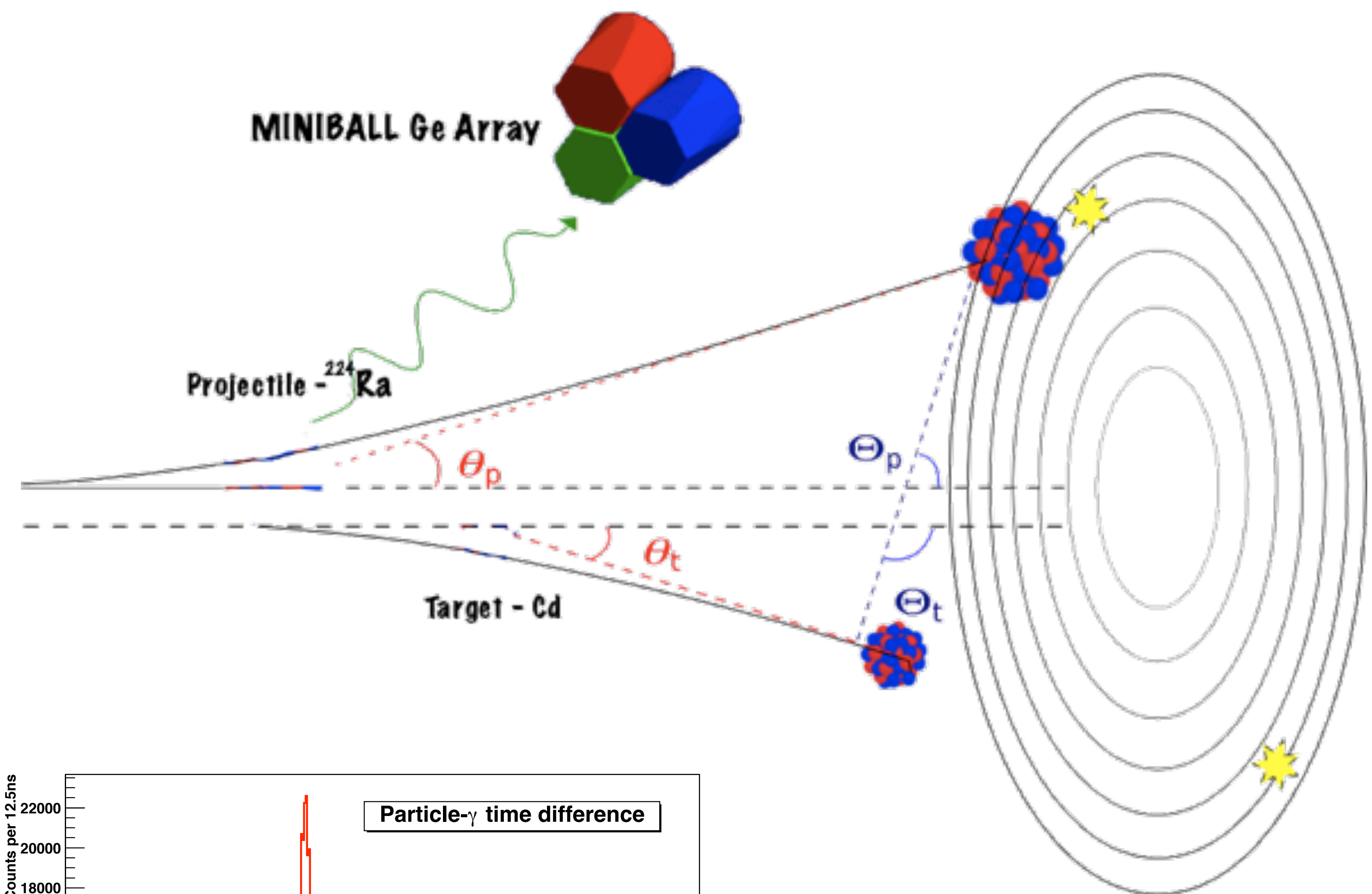
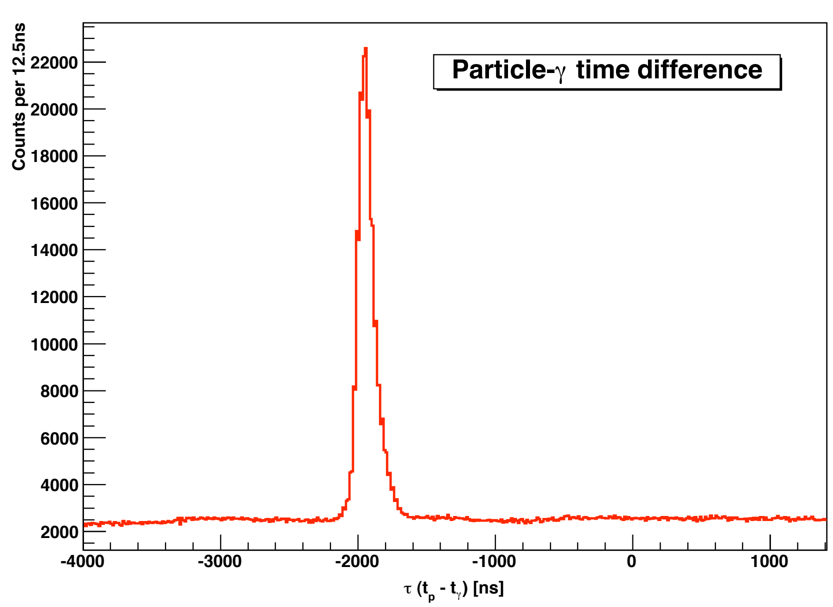
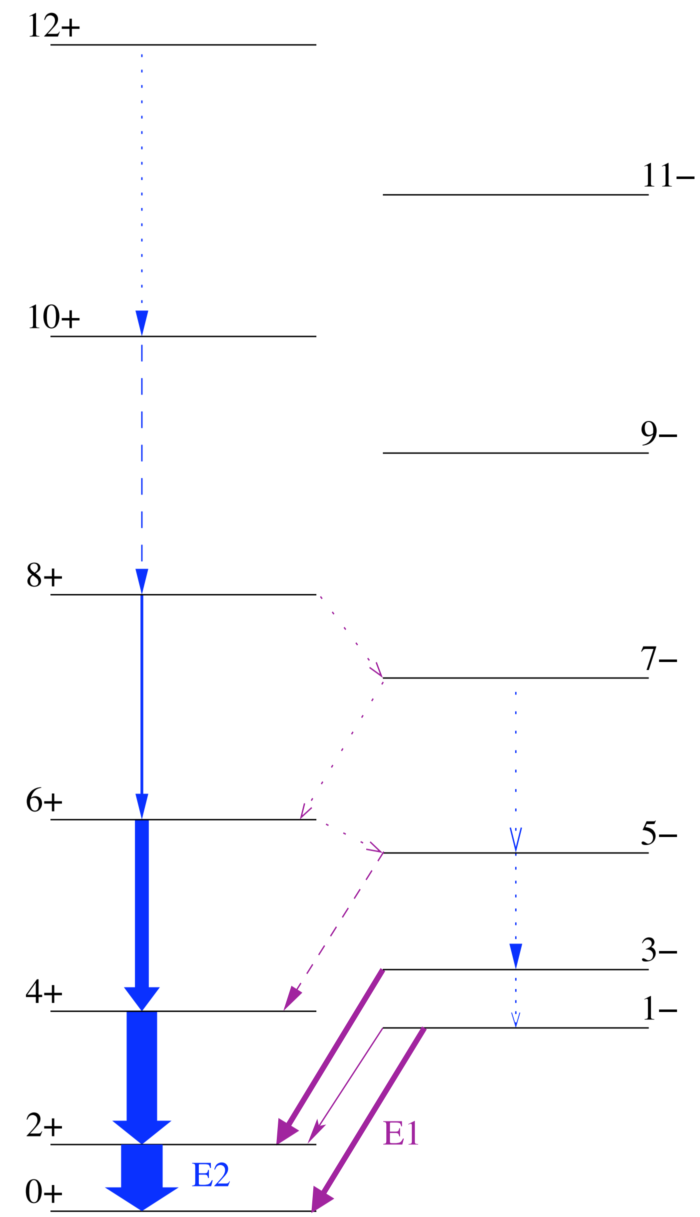
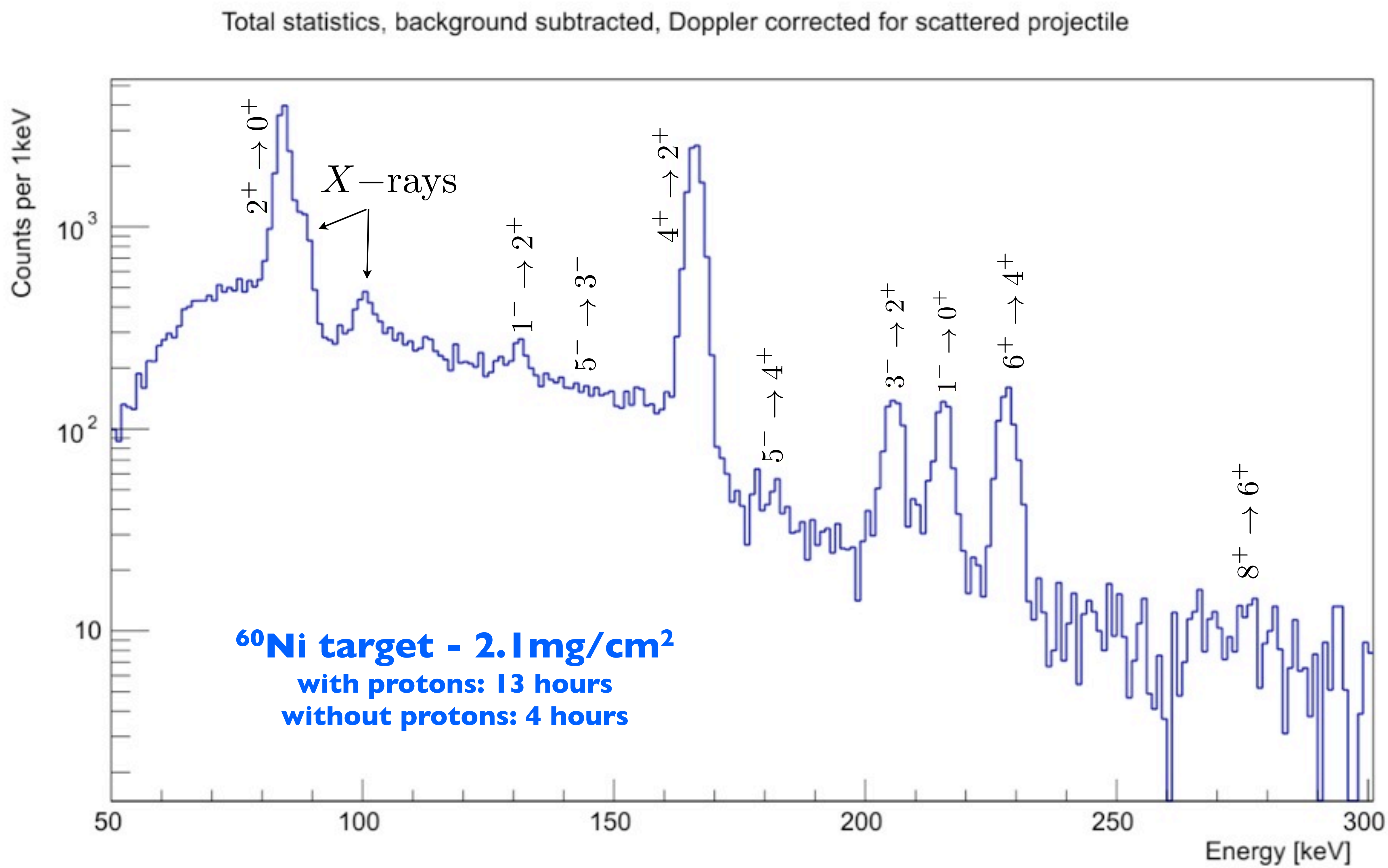






Analysis - ^{224}Ra



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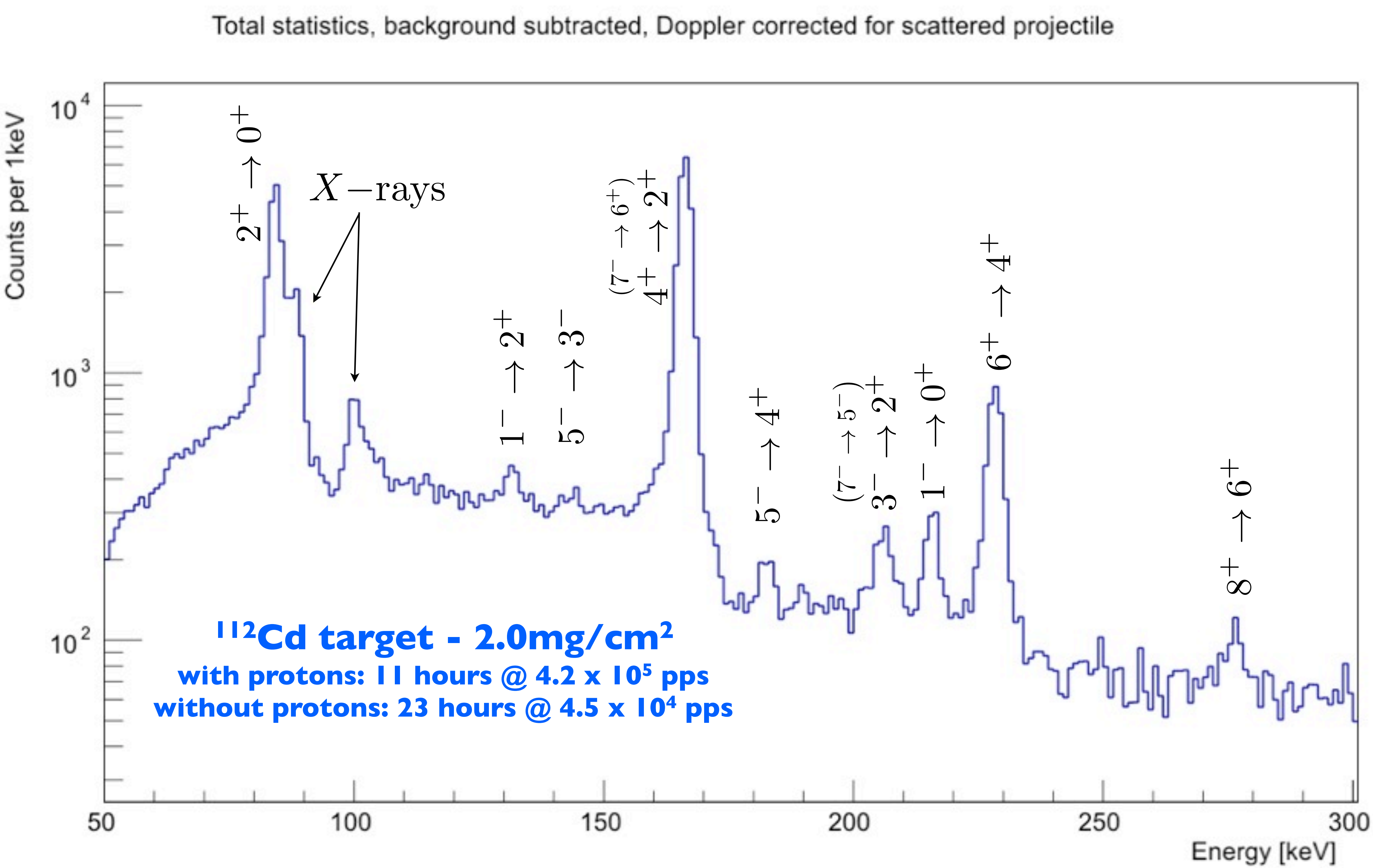

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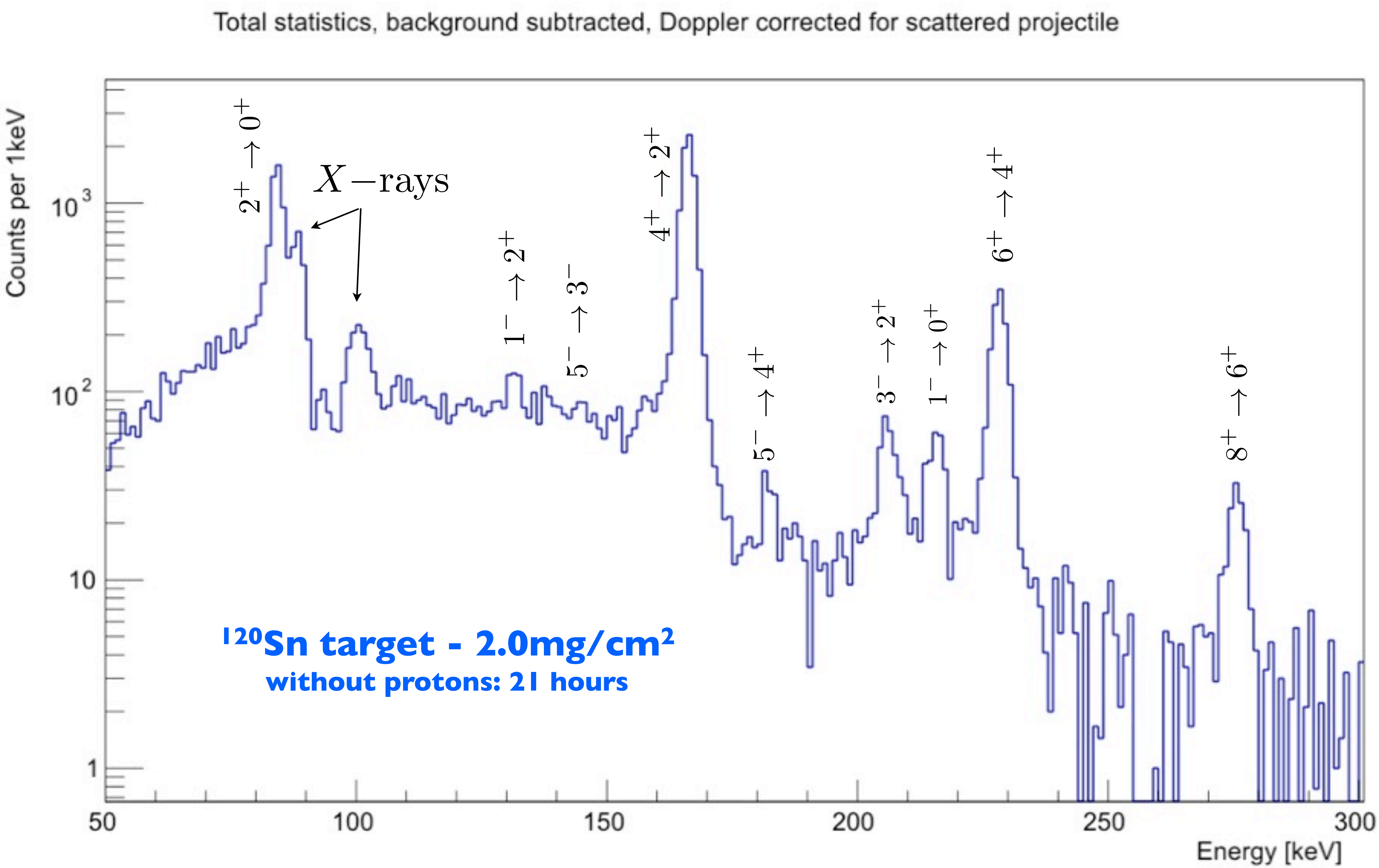

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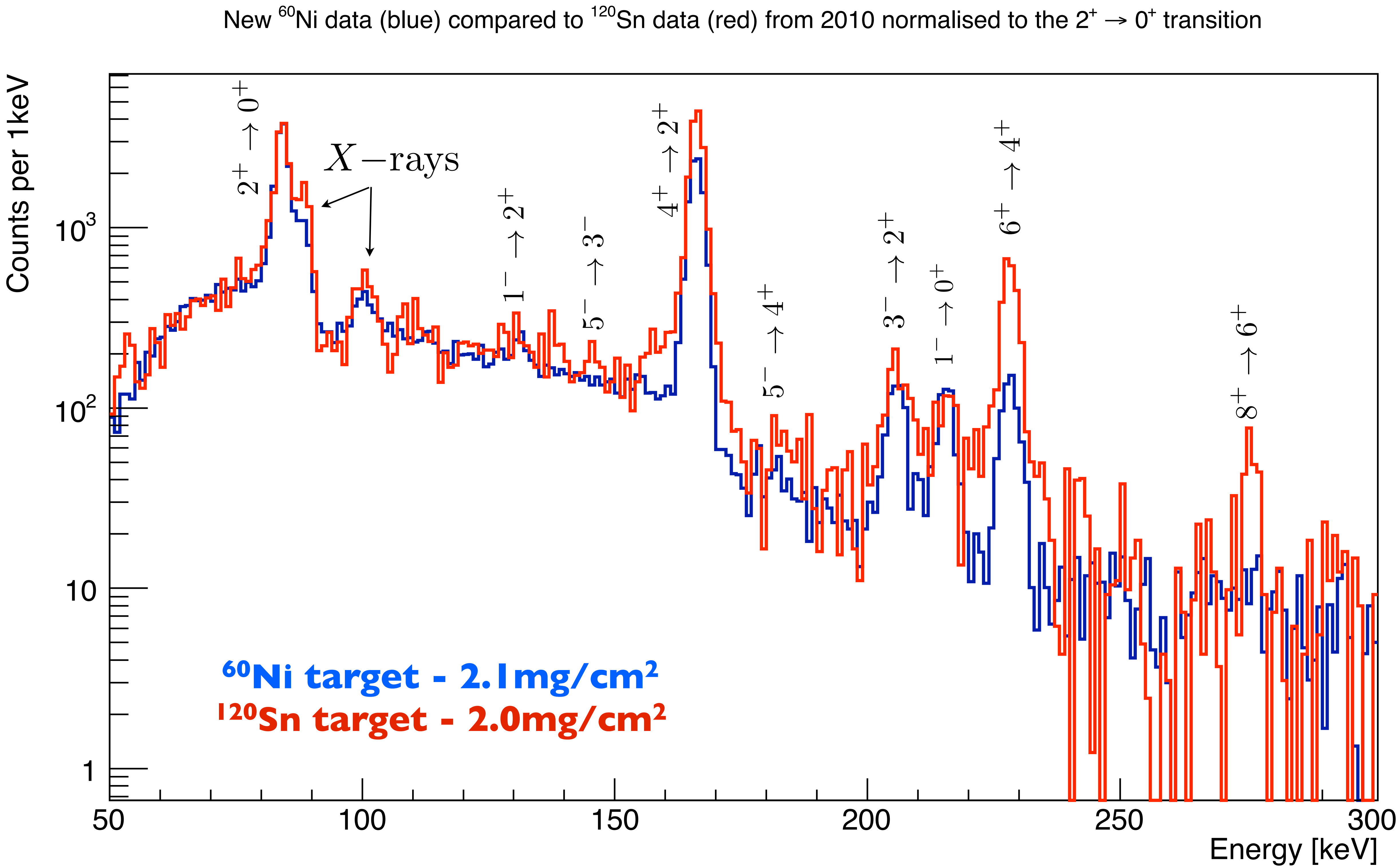
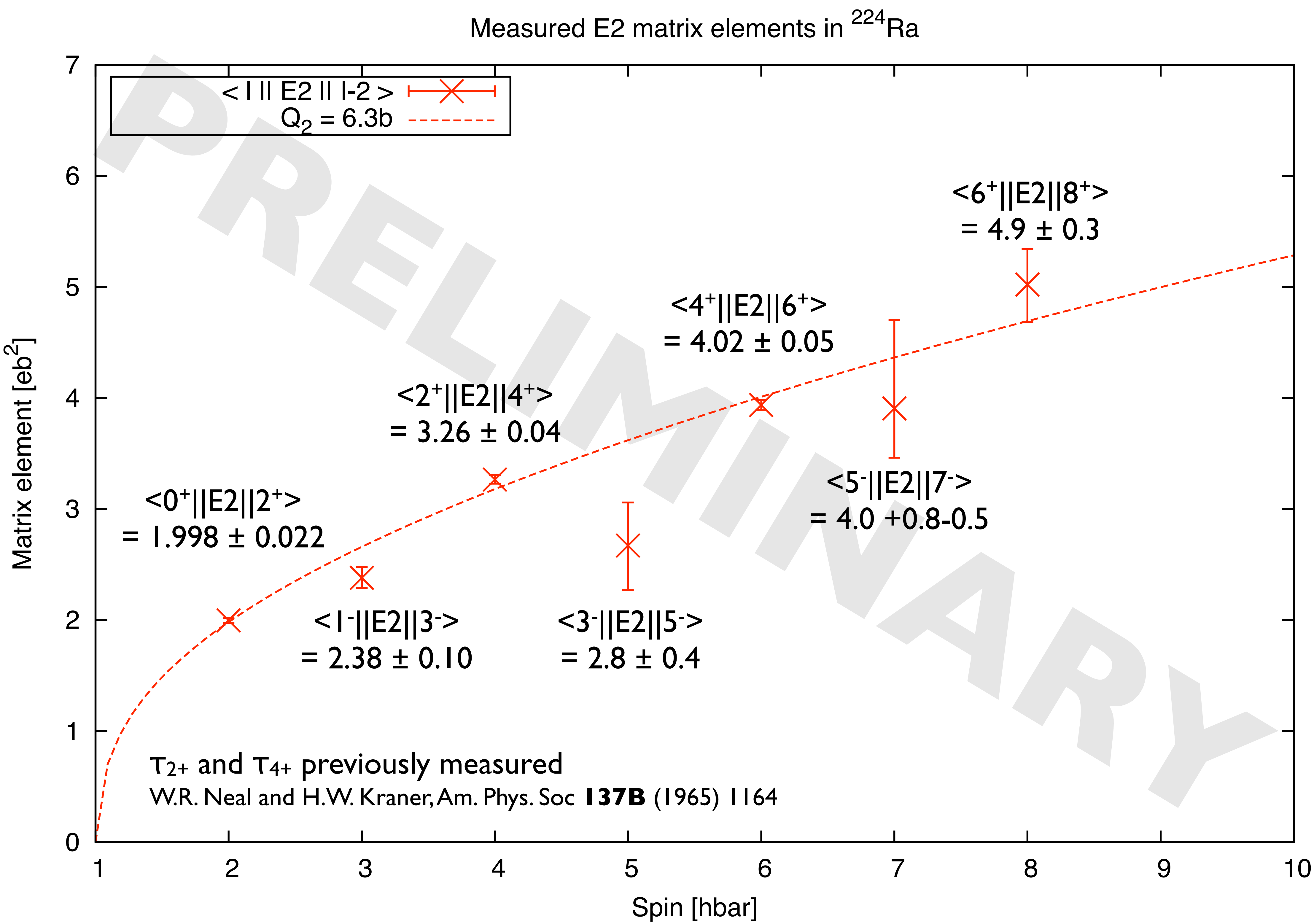


Results (^{224}Ra) - E2 matrix elements



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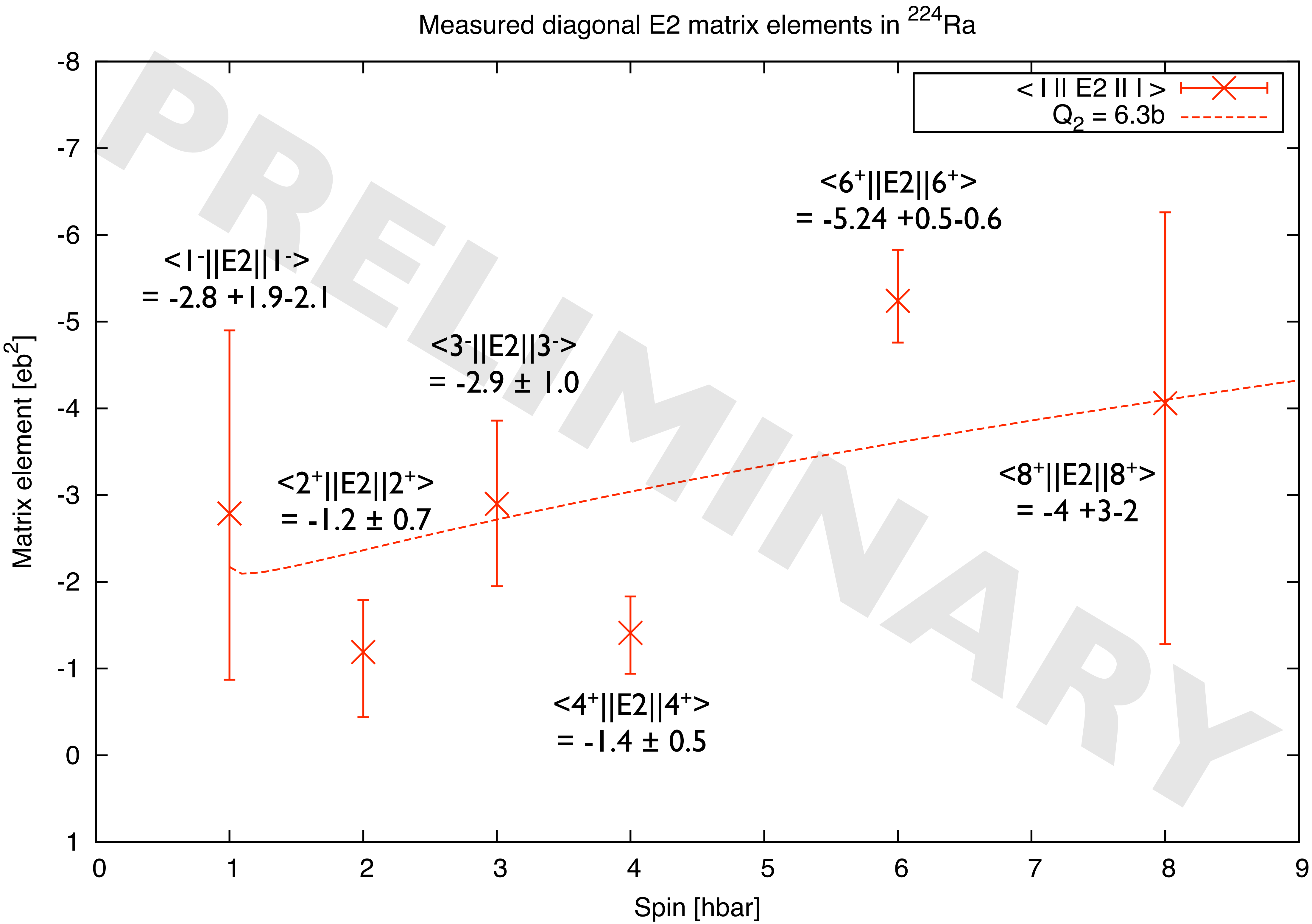
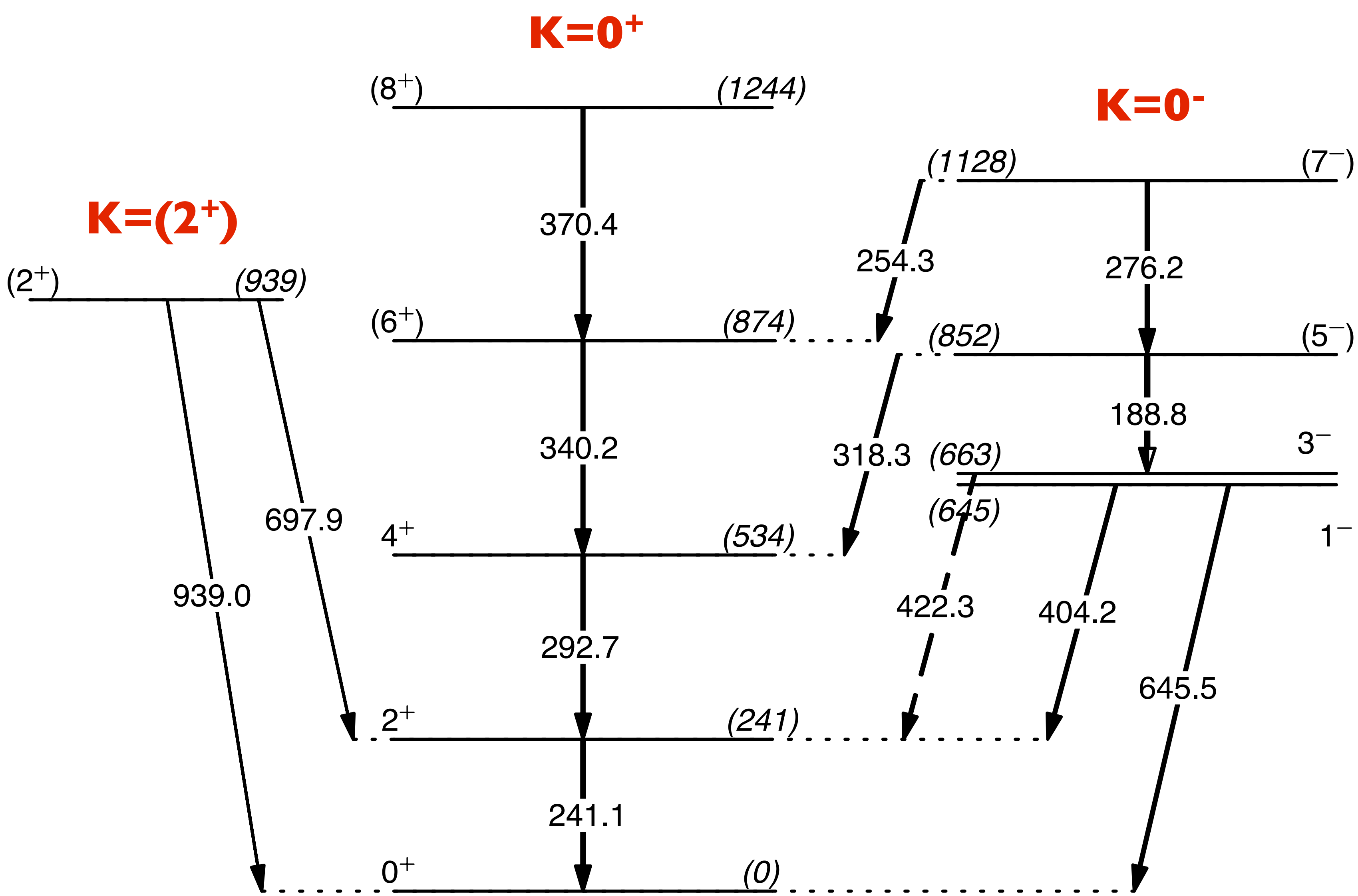


The experiment - ^{220}Rn



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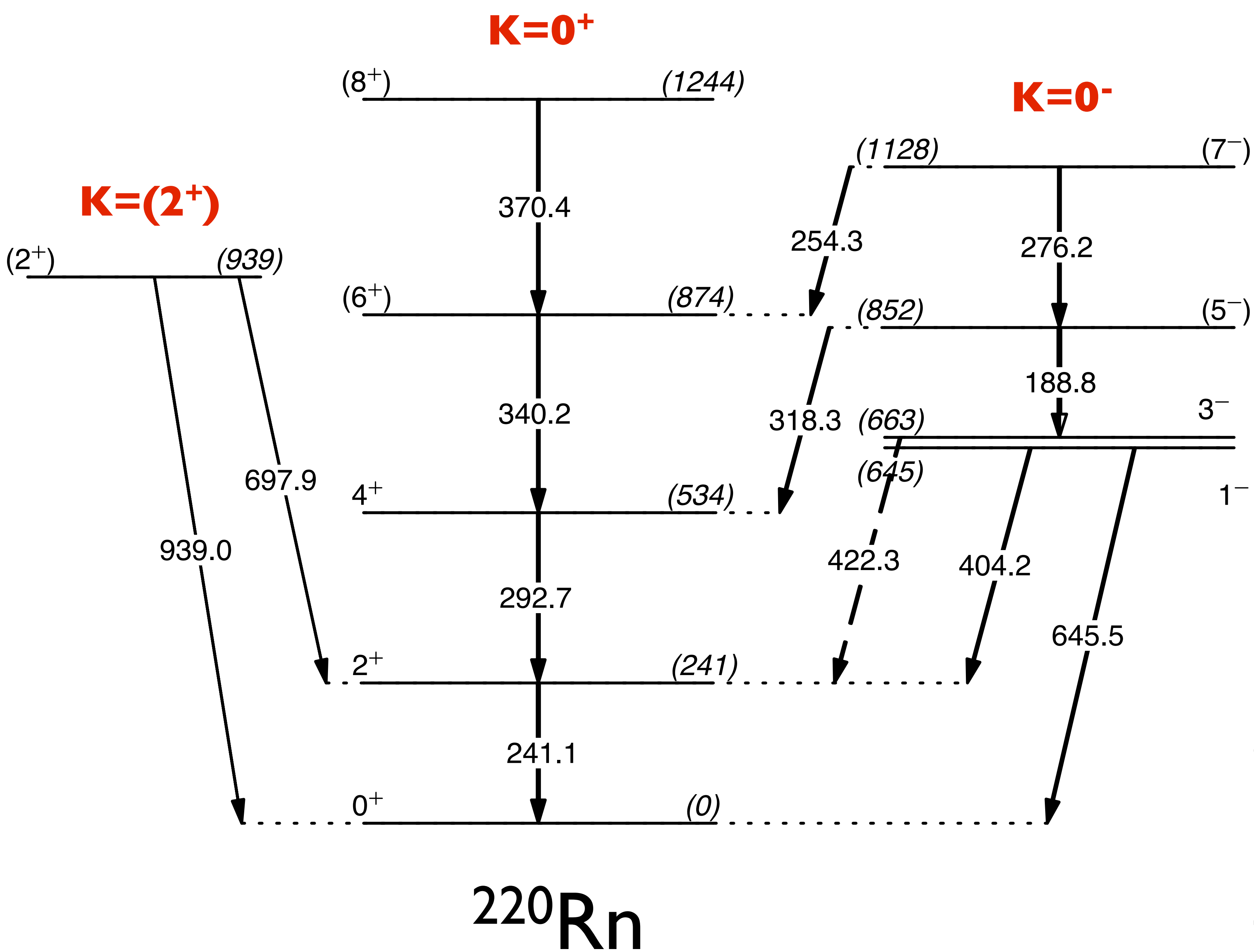

- Observed new state at 939keV
- Assigned to 2+ from decay and excitation paths
- Gamma-band from population strength and comparison to 224Ra

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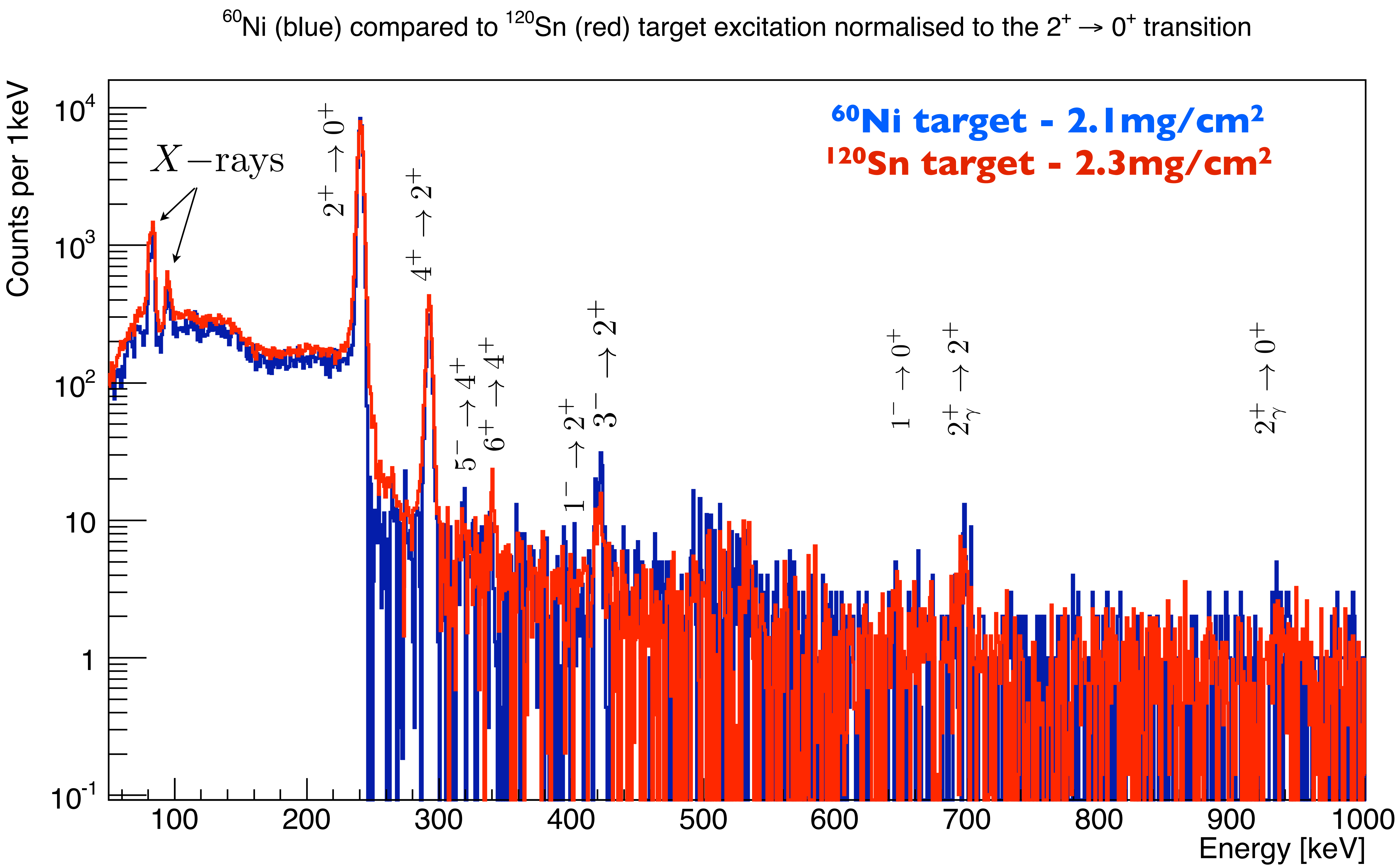
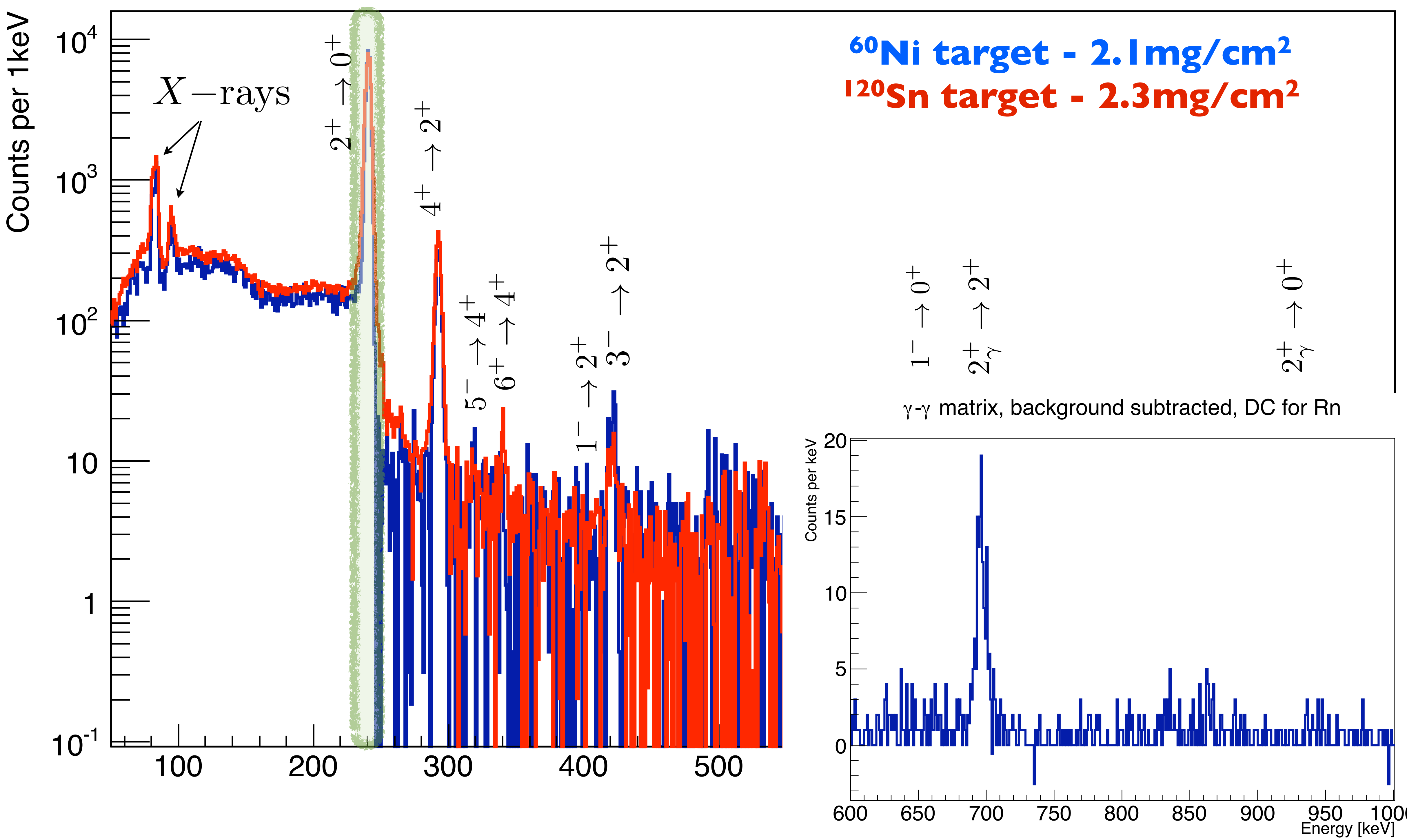


Analysis - ^{220}Rn

^{60}Ni (blue) compared to ^{120}Sn (red) target excitation normalised to the $2^+ \rightarrow 0^+$ transition



Discussion and Interpretation - ^{224}Ra

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- Mean field theory reproduces small D_0 and predicts β_2 = 0.128, β_3 = 0.105, β_4 = 0.075[2,3]
- Static quadrupole-octupole coupling only way to reproduce these values...
- Recent cluster model predicts $Q_3(3^-)$ = 2.89 eb$^{3/2}$ but cannot reproduce small D_0[4]

*[1] H. J. Wollersheim et al., Nucl. Phys. A **556** (1993) 261*
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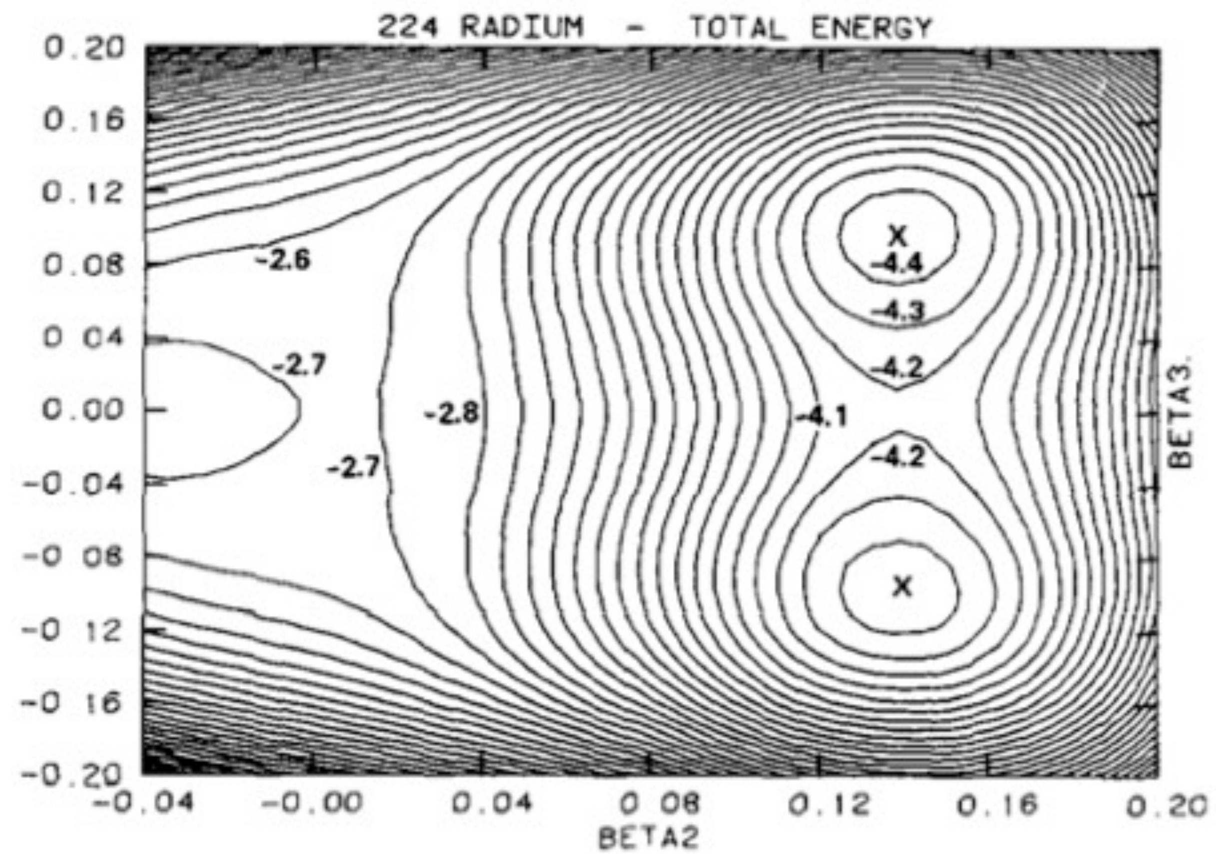

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- **First B(E3) measured with a radioactive beam?**

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- **First B(E3) measured with a radioactive beam?**

- **Heaviest (A=224) post-accelerated, radioactive beam?**

Collaborators

T.E. Cocolios, J. Pakarinen, J.Cederkall, D.Voulot, F.Wernander	**CERN-ISOLDE, Switzerland**
Th. Kröll, S. Bönig, C. Bauer, M. von Schmid	**TU Darmstadt, Germany**
B. Bastin	**Ganil, France**
T. Grahn, A. Herzan	**University of Jyväskylä, Finland**
A. Blazhev, M. Seidlitz, N. Warr, M. Albers, M. Pfeiffer, D. Radeck M. Rudigier, P. Thöle	**University of Köln, Germany**
P. van Duppen, N. Bree, J. Diriken, N. Kesteloot S. Sambi, K. Reynders	**KU Leuven, Belgium**
L. P. Gaffney, P.A. Butler, M. Scheck, D.T. Joss, S.V. Rigby	**University of Liverpool, UK**
E. Kwan	**Lawrence Livermore Laboratory, US**
T. Chupp	**University of Michigan, US**
D. Cline, C.Y. Wu	**University of Rochester, US**
M. Zielinska, P. Napiorkowski, M. Kowalczyk	**HIL University of Warsaw, Poland**
D.G. Jenkins	**University of York, UK**

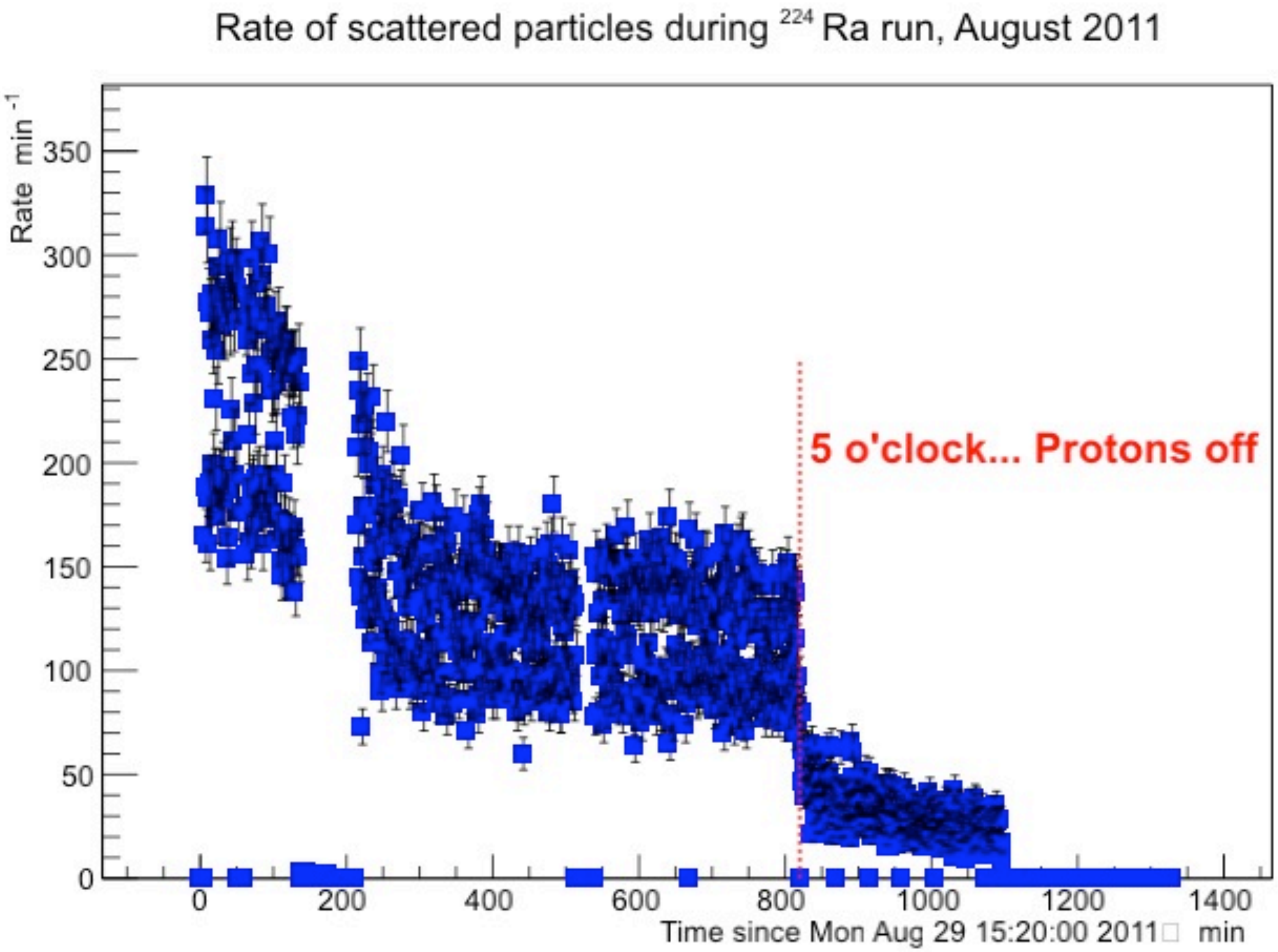
and the REX-ISOLDE and MINIBALL collaborations

Thank you!

UNIVERSITY OF LIVERPOOL

ISOLDE

Aside - Protons off...!



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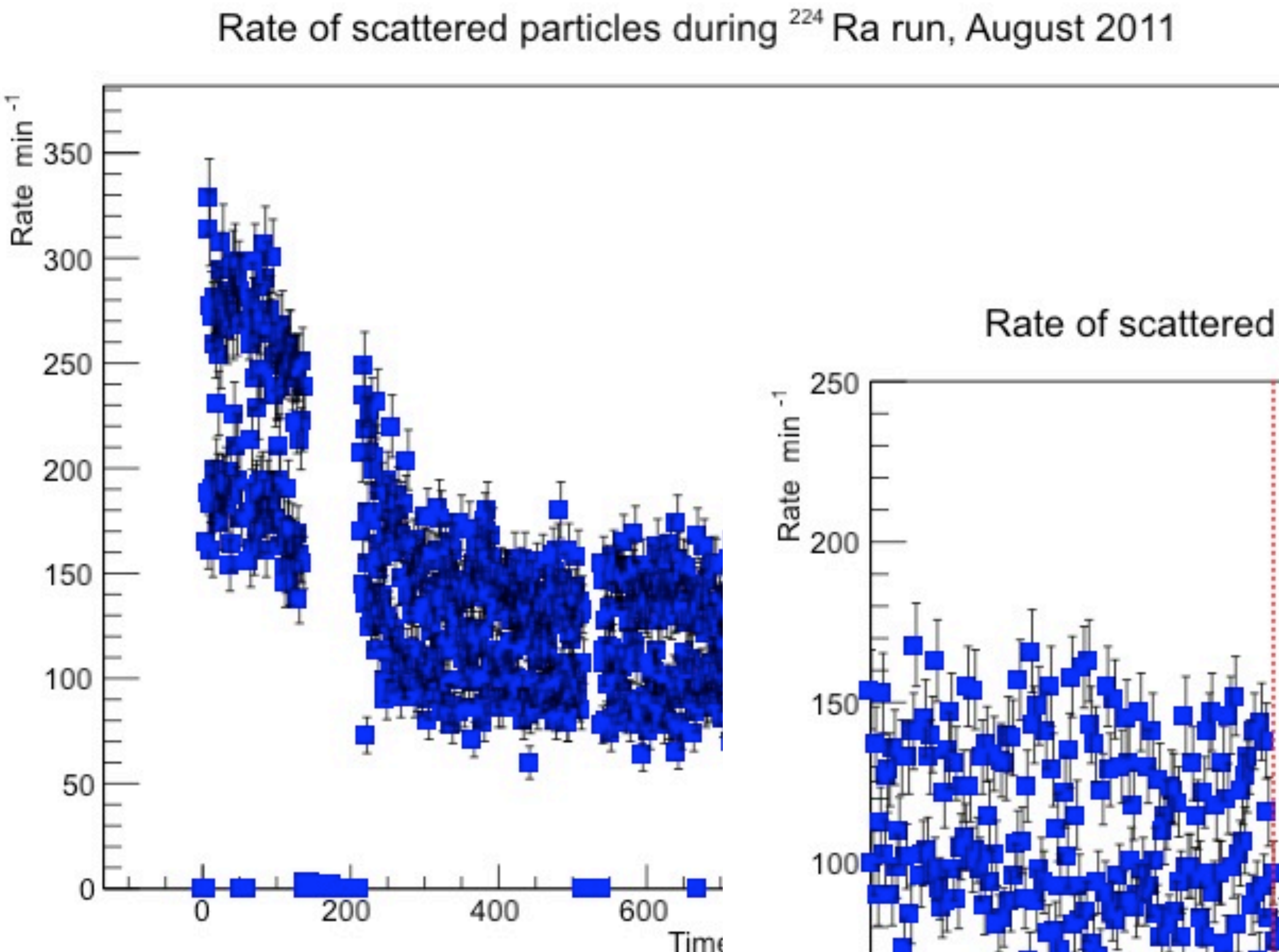
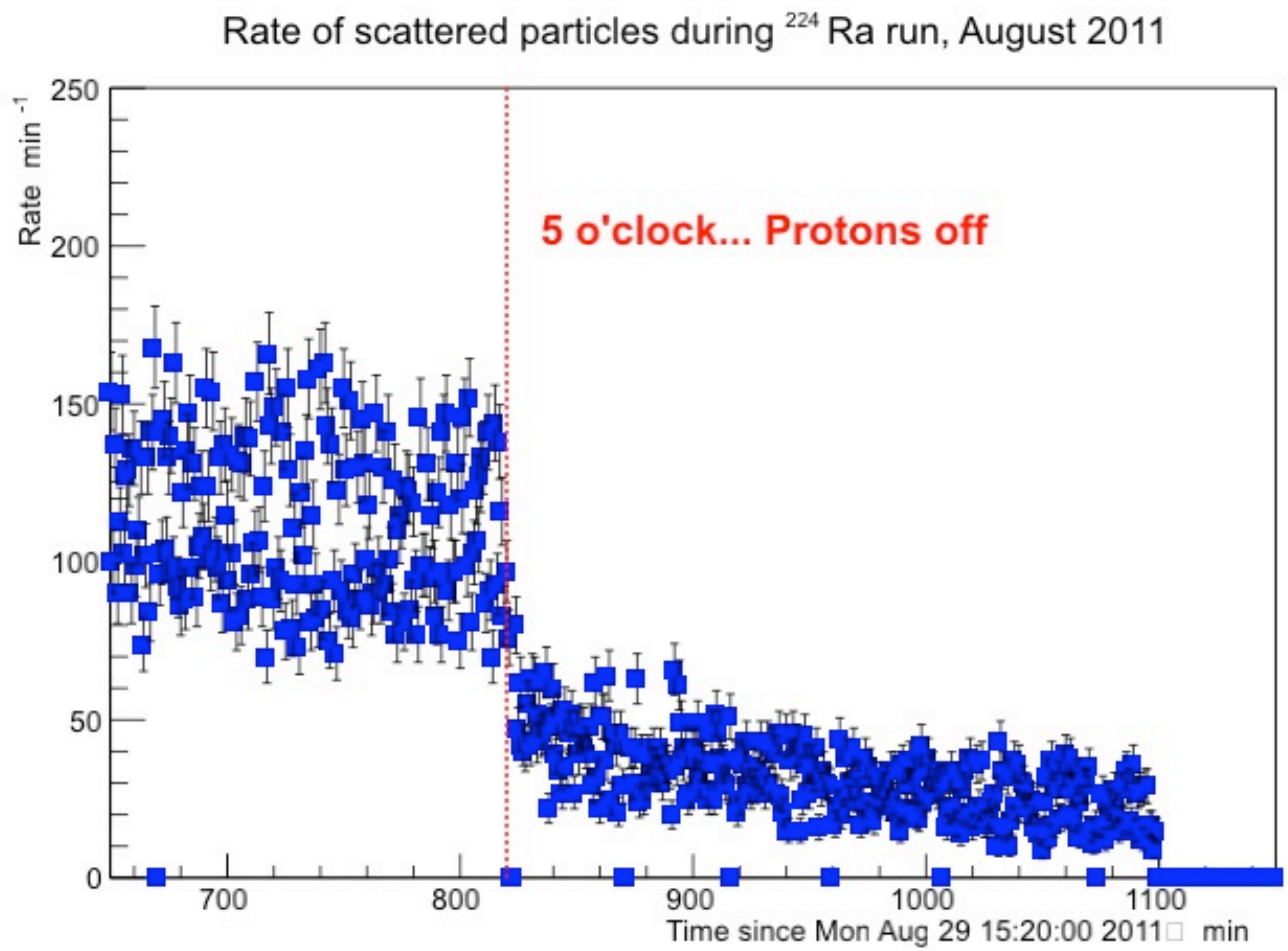
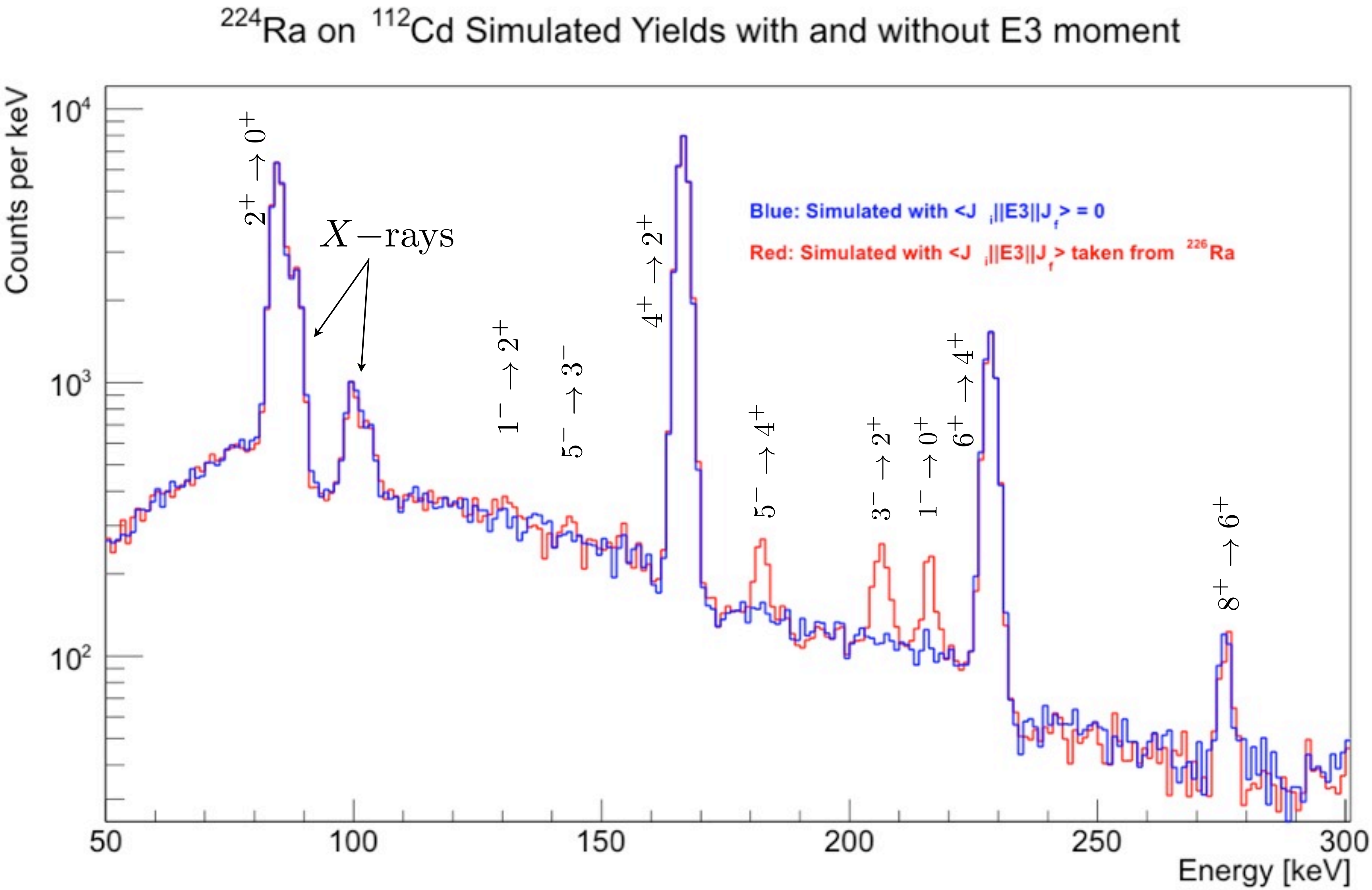




- Evidence of rapid exponential decay in beam rate after protons cease

- Comparison of direct production vs. alpha decay of parent ($T_{1/2}$ = 3.66 days)

Simulation - ^{224}Ra



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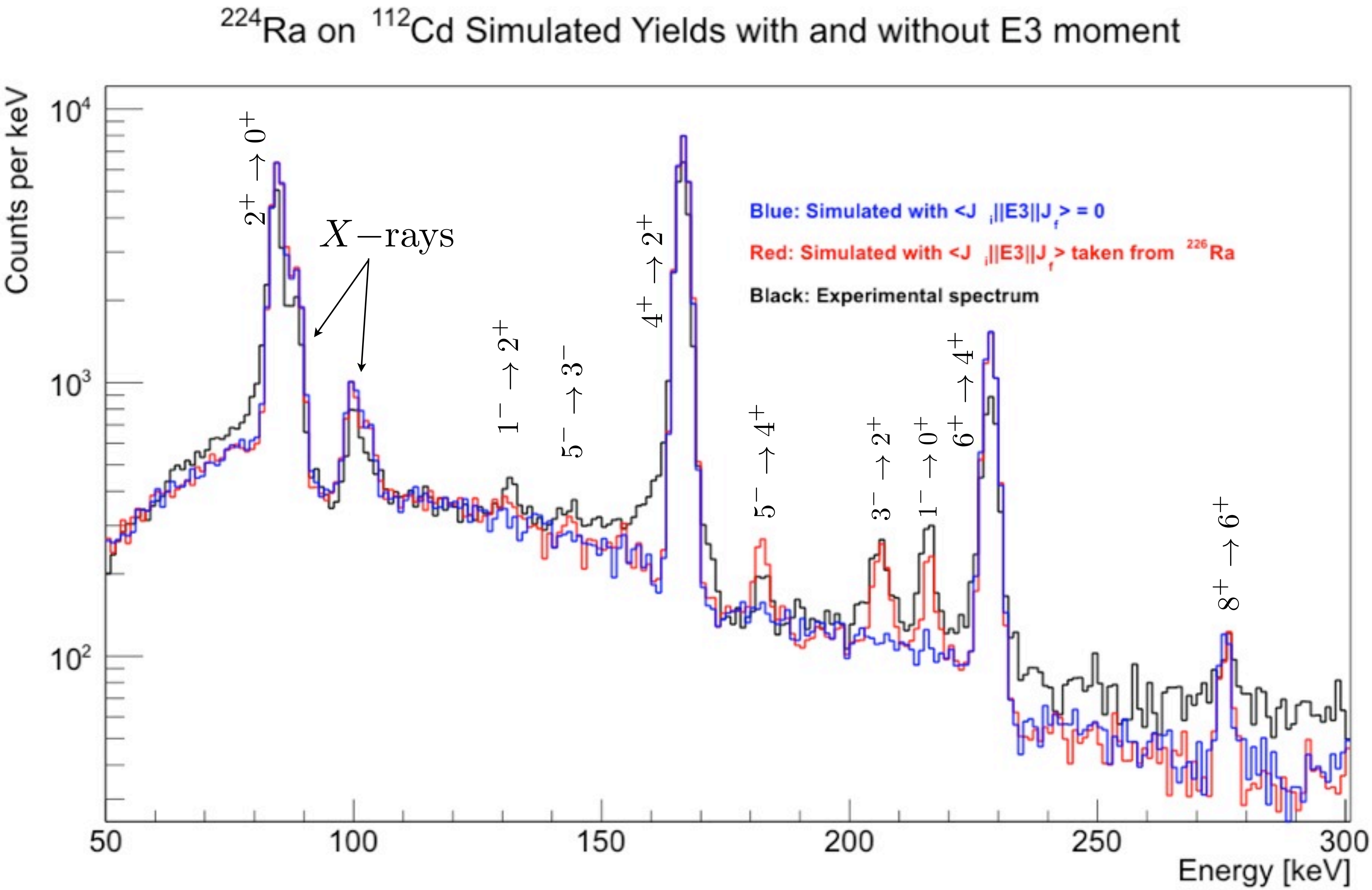
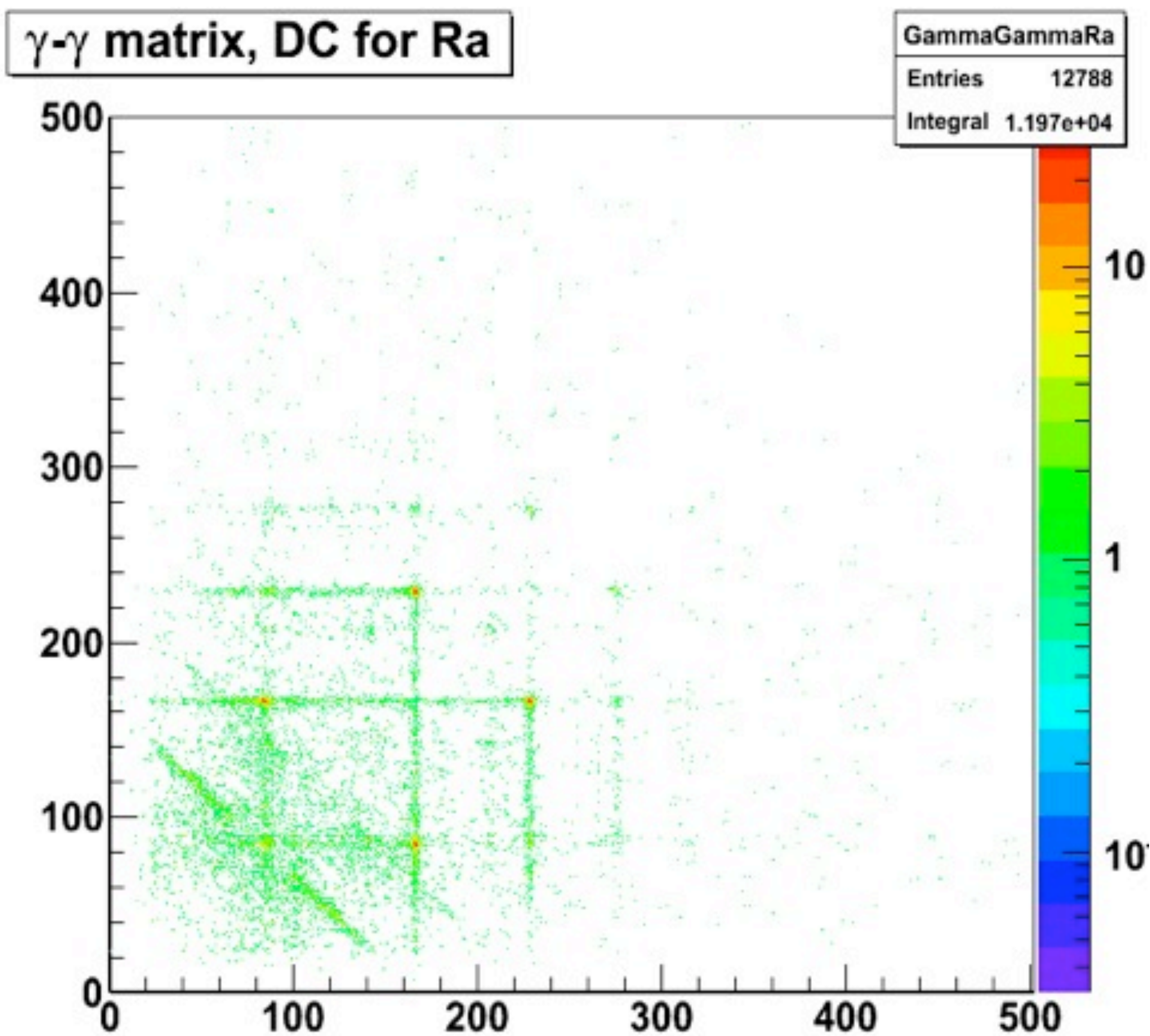
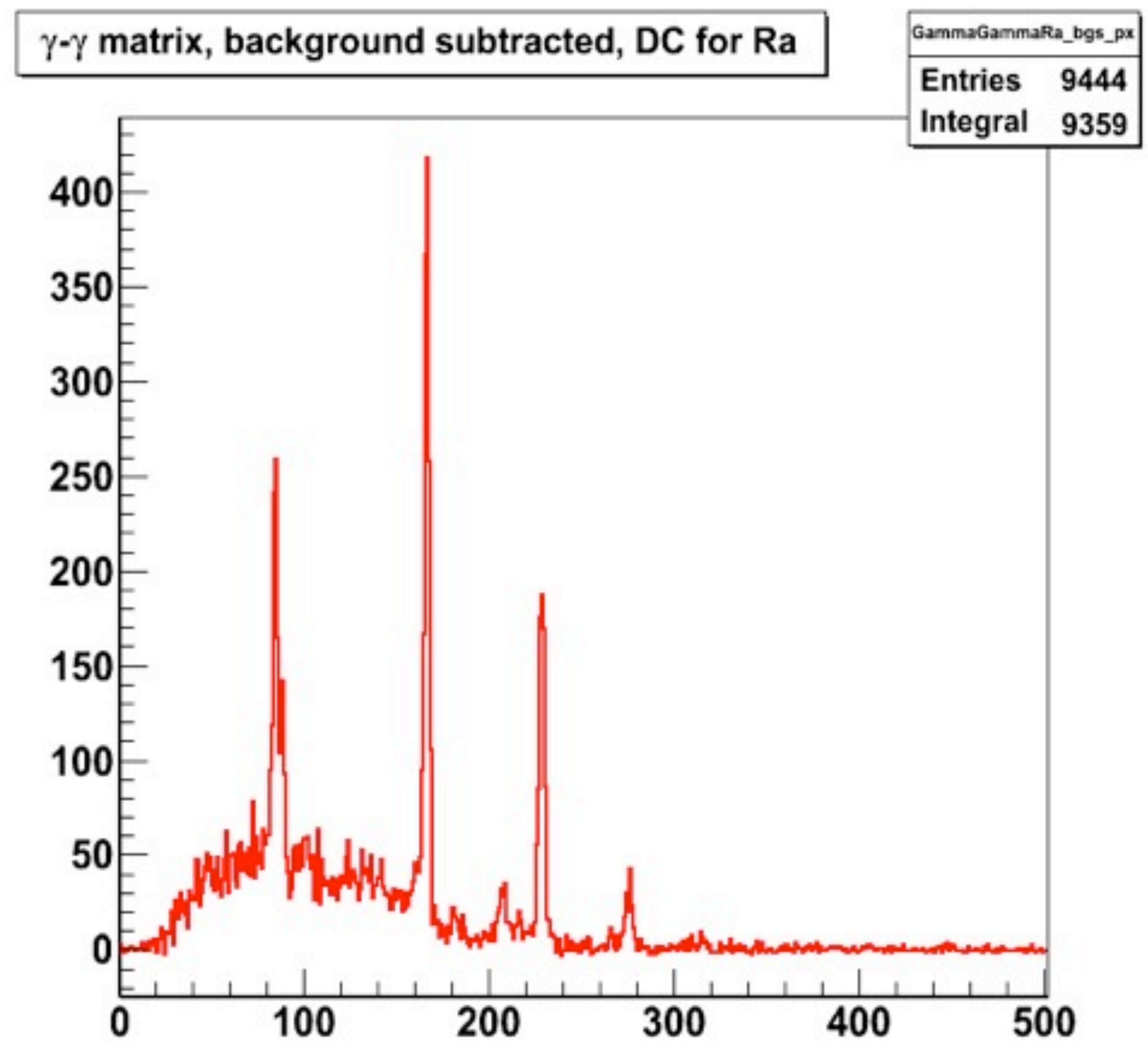
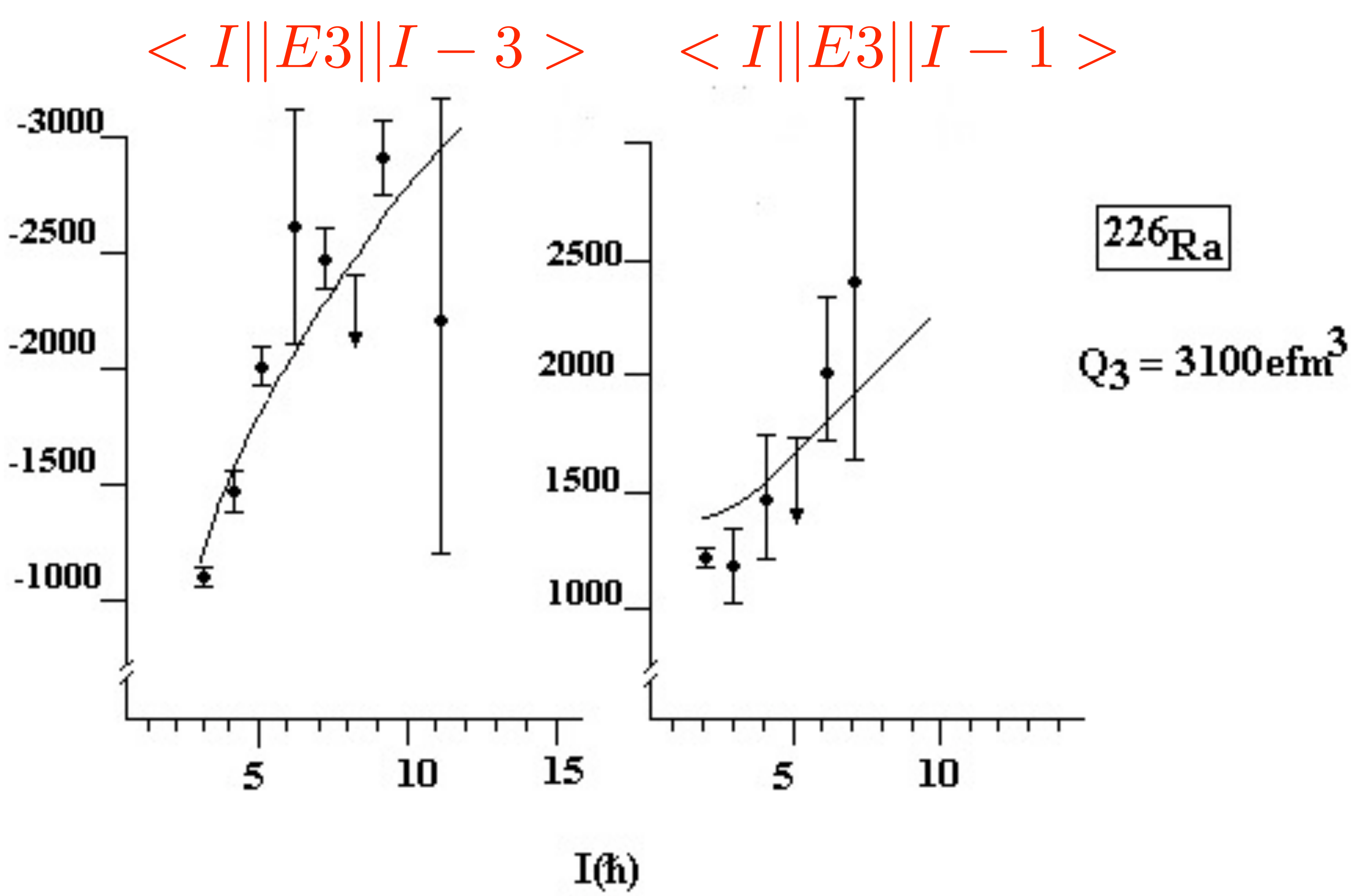


Gamma-Gamma Matrix - ^{224}Ra





Gosia Analysis



Measured E3 matrix elements [e·fm^3]

Stretched: $< I||E3||I-3 >$
Un-stretched: $< I||E3||I-1 >$

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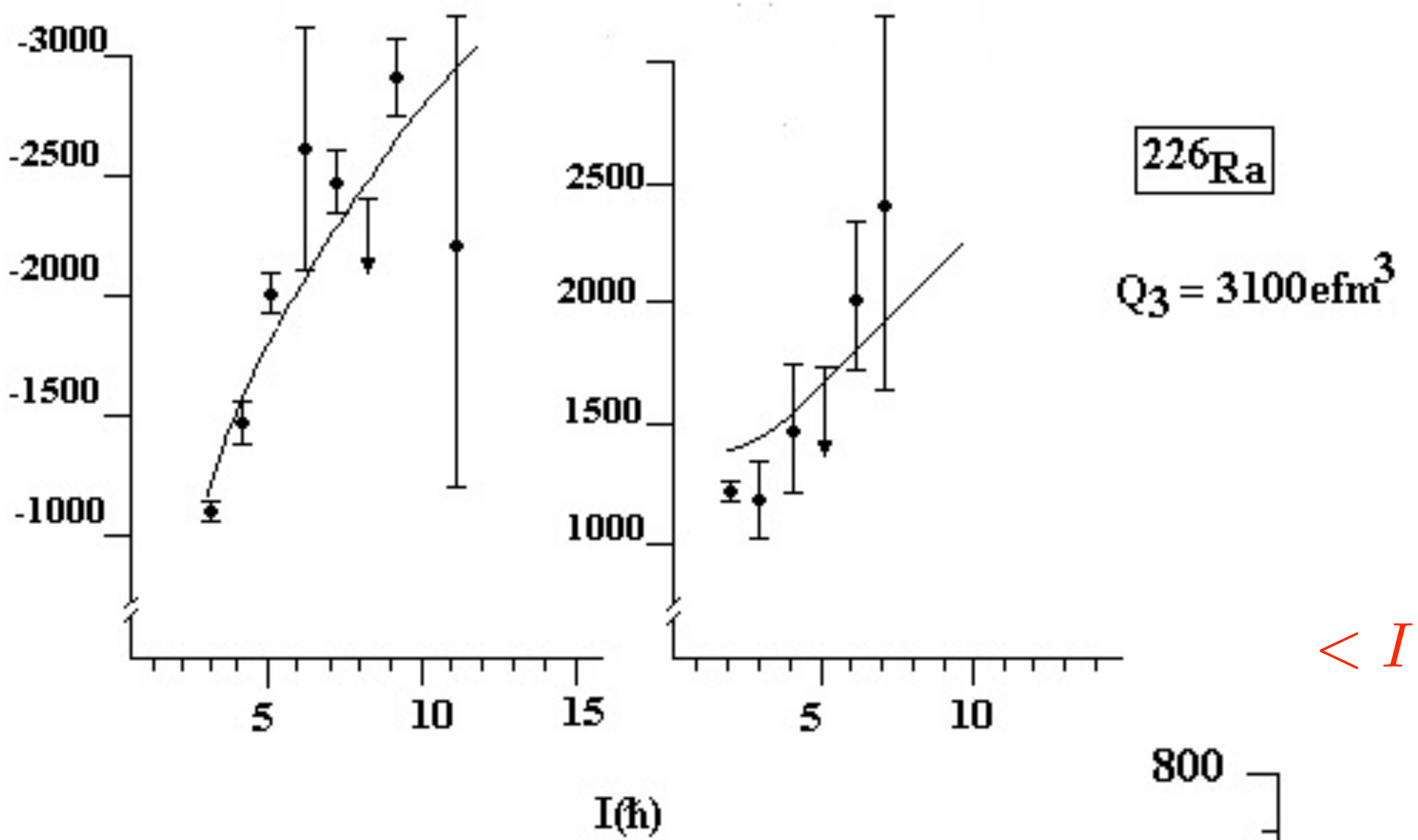

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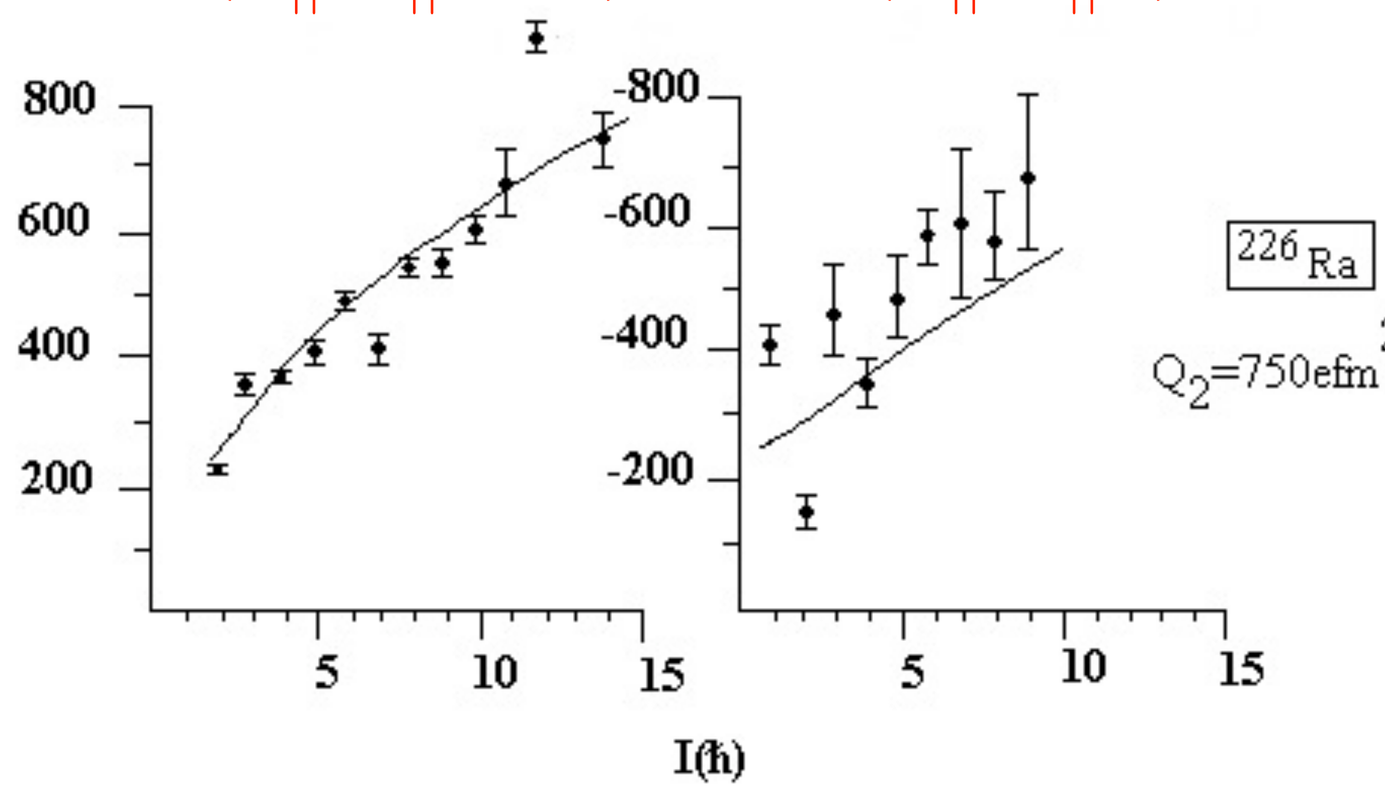
$< I||E2||I-2 >$ $< I||E2||I >$



Measured E2 matrix elements [e·fm^2]

Transitional: $< I||E2||I-2 >$
Diagonal: $< I||E2||I >$

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Gosia Analysis