Possible fast timing measurements in neutron rich Gd and Sm nuclei

Fast Timing Workshop at NPL

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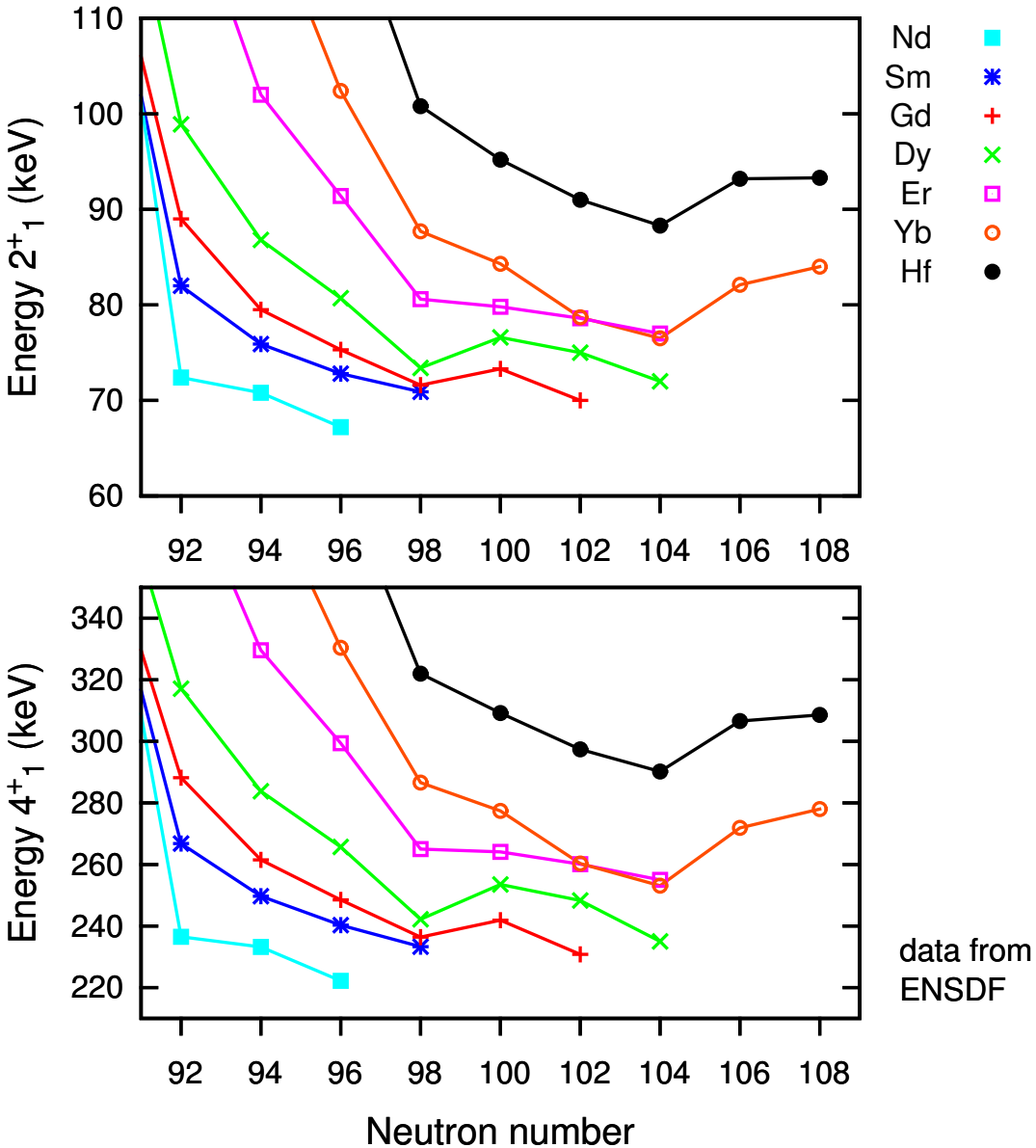
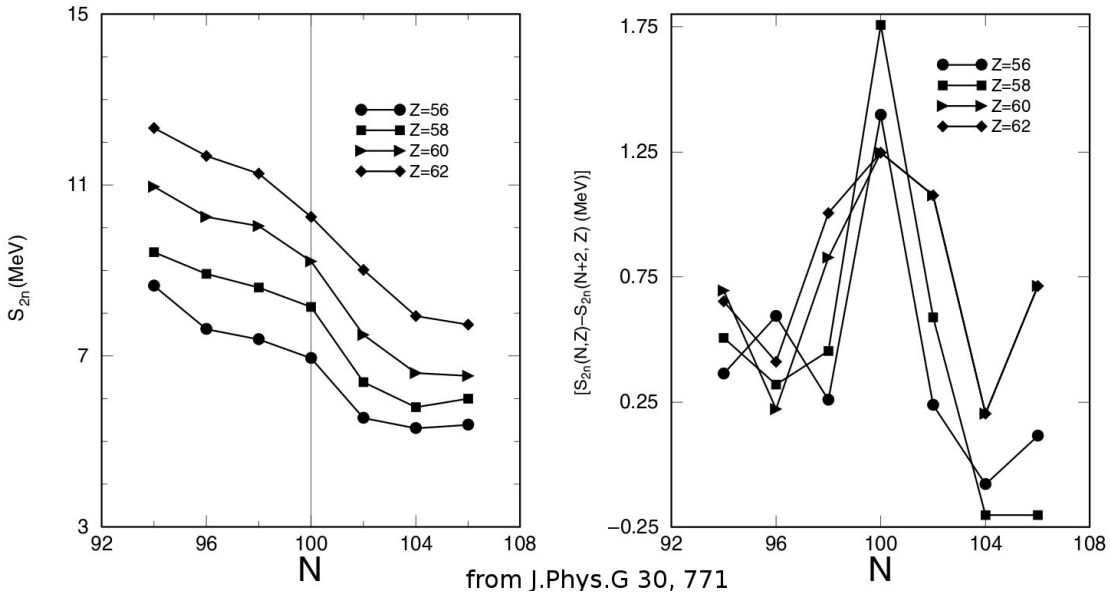
March 20, 2015

Kink in gsb energies at N=100



- Region of deformed nuclei
- midshell at N=104
- Dy and Gd show increase of gsb energies at N=100
- $R_{4/2}$ stays close to 3.33
- shell effect

Calculations predict magic number N=100



2-neutron-separation energy

- Satpathy *et al.* (J.Phys.G 30, 771 (2004))
- Prediction of deformed shell gap at N=100
- Stronges effect in Ce (Z=58)

Rare earth abundance peak

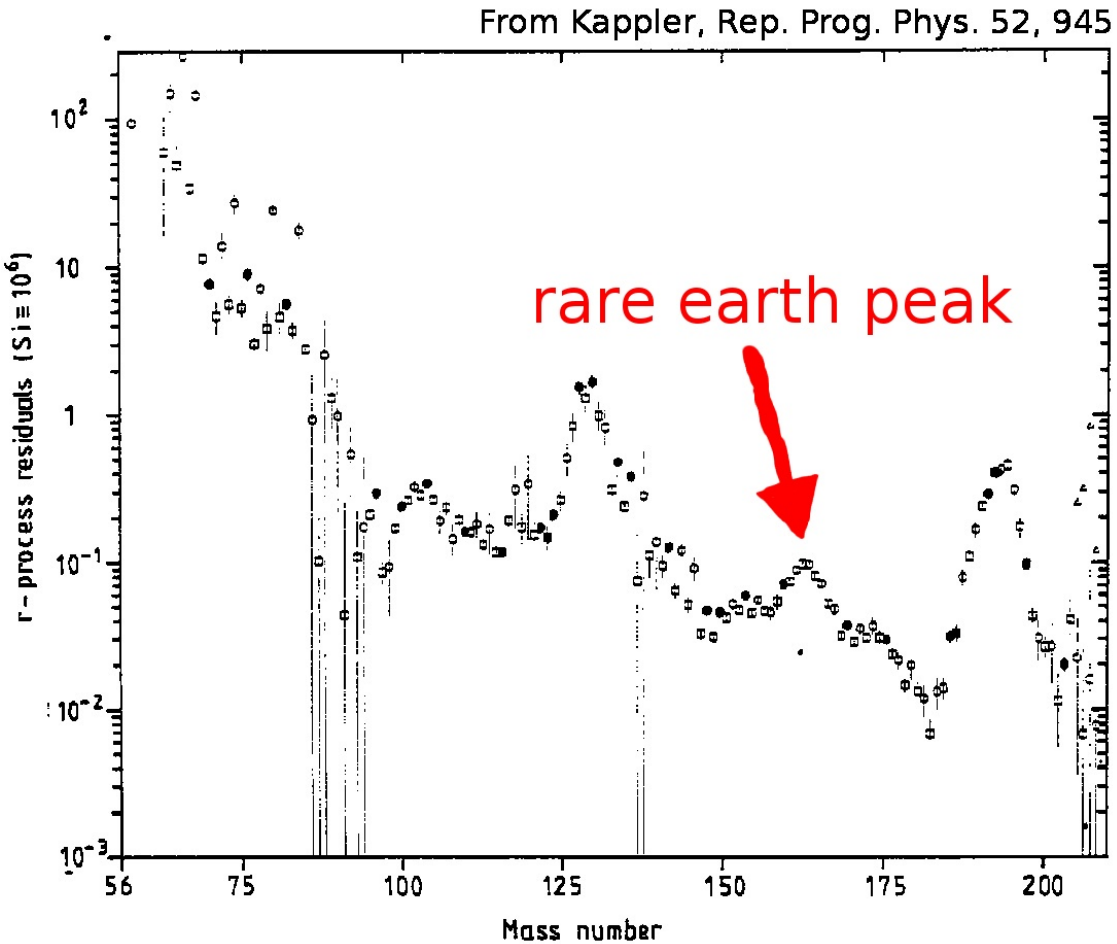
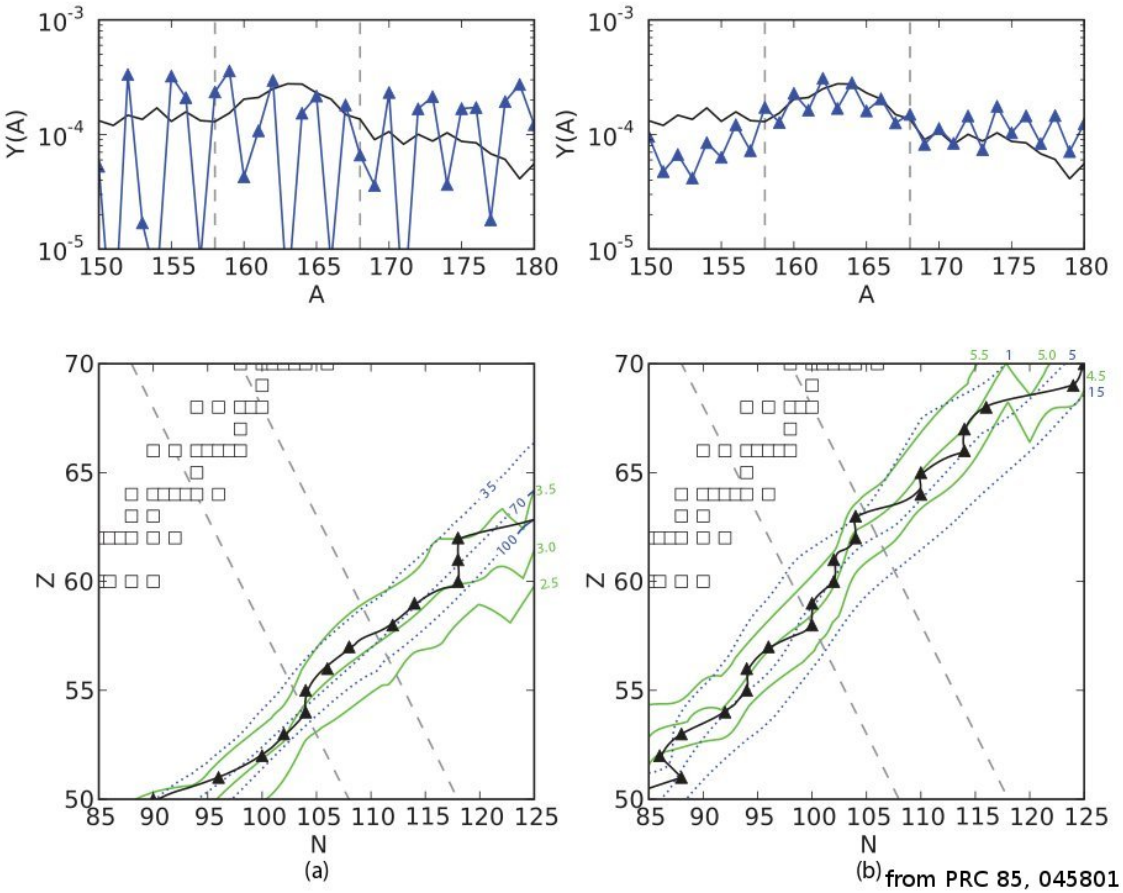


Figure 20. r-Process yields: the distribution of r-only isotopes (full points) and the abundances obtained by subtraction of s-process abundances from solar values (open symbols).

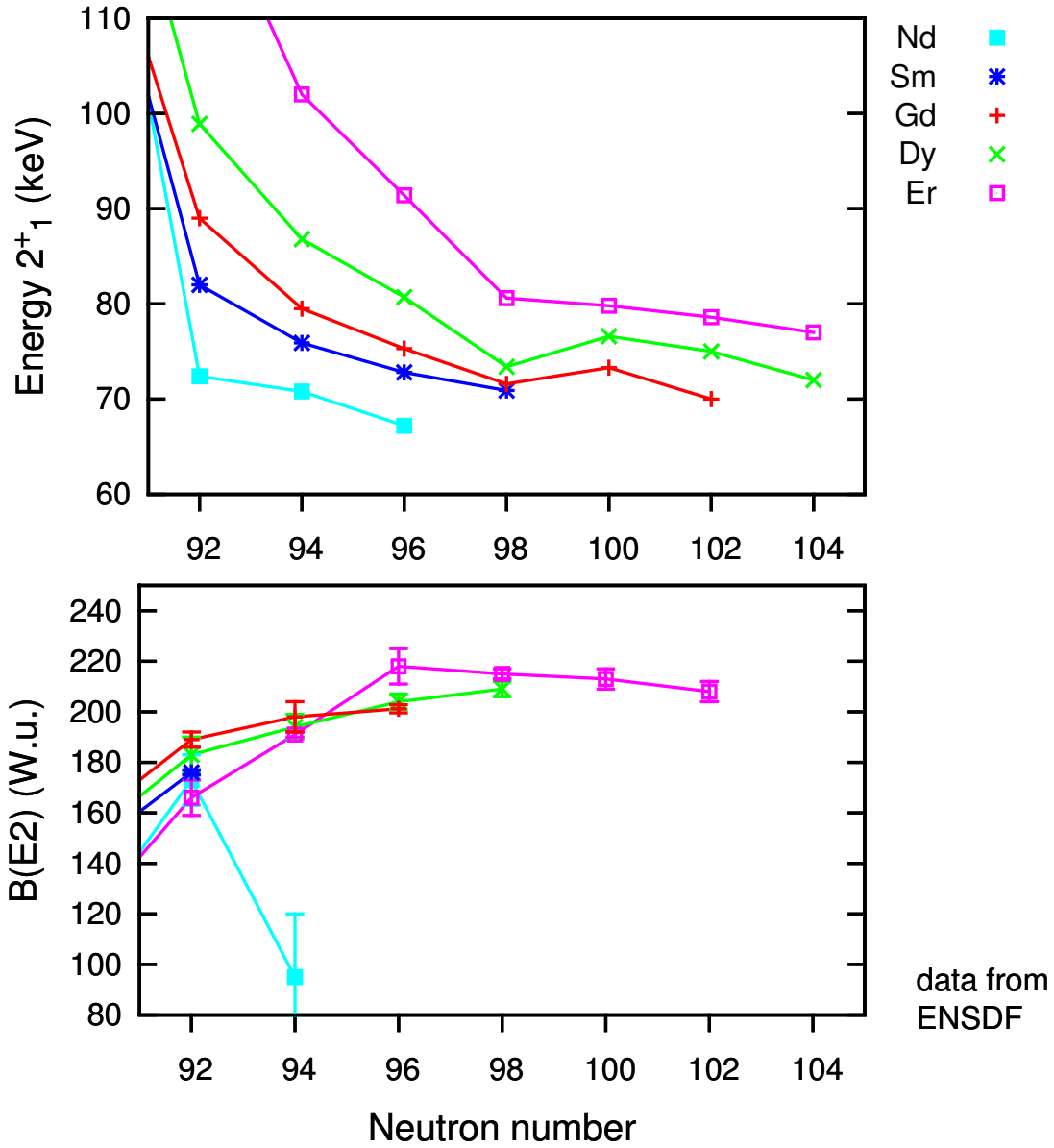
- abundance peak at A=160
- formed by r-process
- understood as resulting from strong deformation at midshell
- different mechanism than other peaks

Formation of the rare earth peak



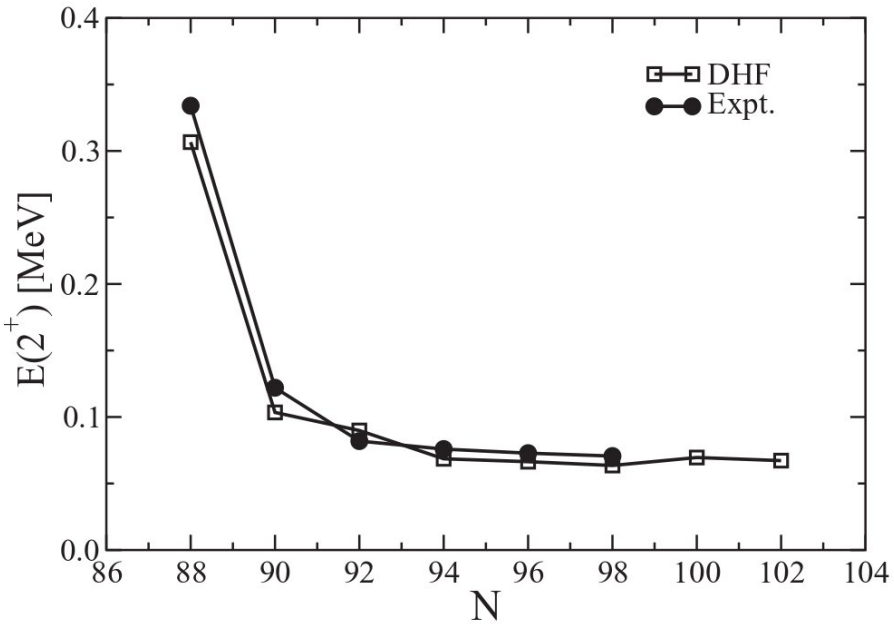
- calculations by Mumpower *et al.*
- r-process path crosses region during freeze out
- funnel-effect due to kink in neutron separation energies
- peak formation very sensitive to nulcear structure

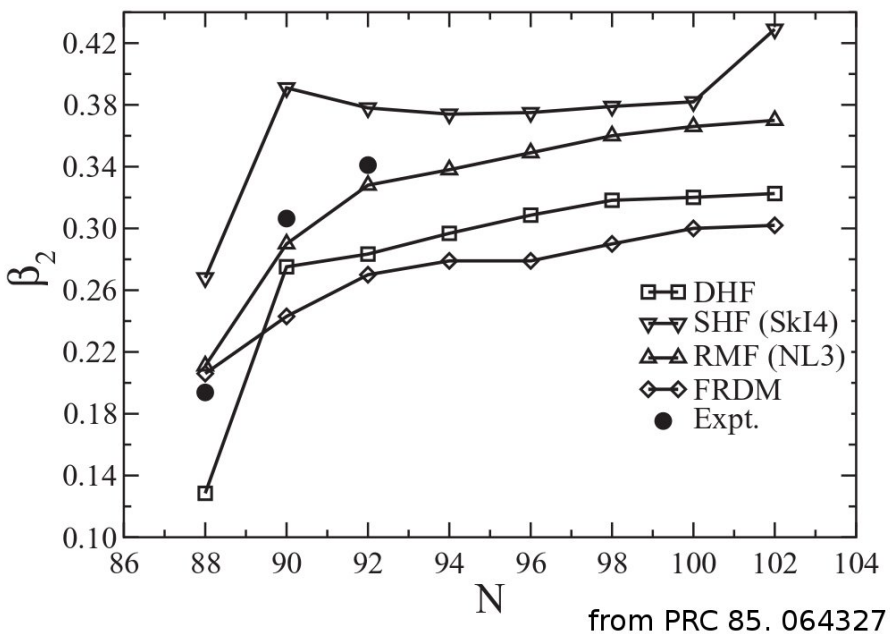
Should measure B(E2) values (esp. of $2_1^+ \rightarrow 0_1^+$)



- No lifetimes measured in/beyond kink region for $Z < 68$ (Er)
- Hardly any $B(E2;2_1^+ \rightarrow 0_1^+)$ known beyond N=96
- $\tau_{2_1^+}$ ns region
  $\tau_{2_1^+}$ 100 ps
  $\rightarrow$ Ideal for fast timing

Predictions for Sm (Z=62) isotopes





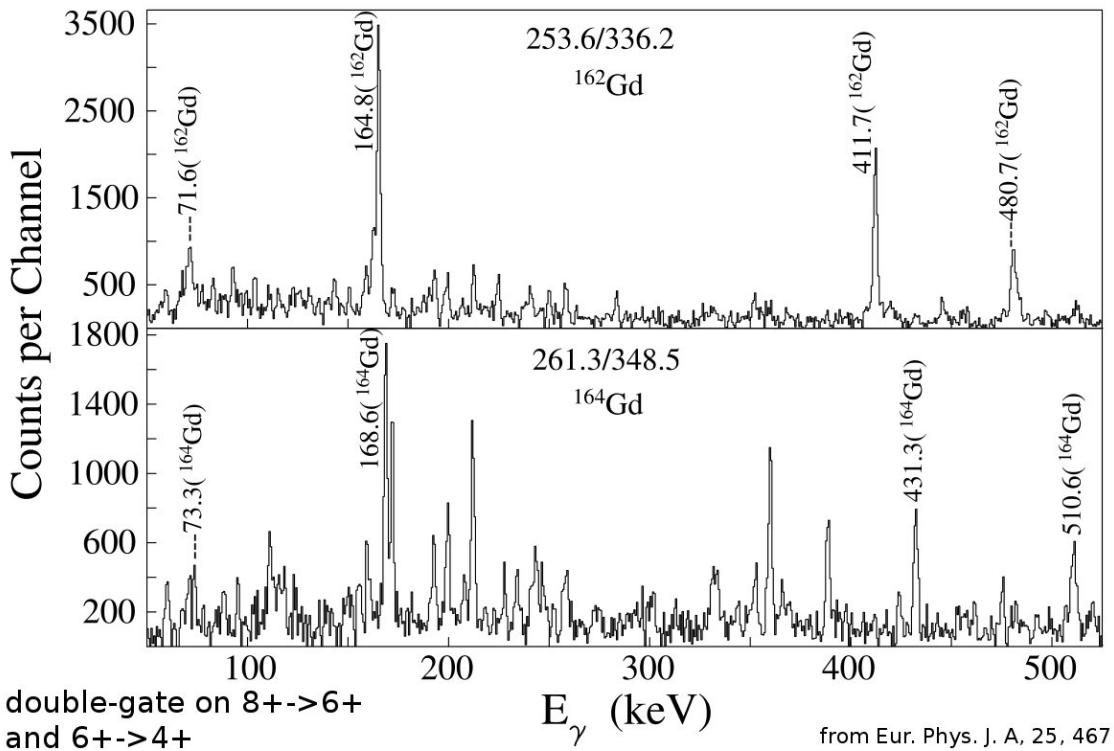
from PRC 85. 064327

- Ghorui *et al.* (PRC85, 064327) predict increase of $E(2_1^+)$ at N=100 for Sm
- like experimentally seen in Gd
- several models predict linear increase of deformation β_2 after N=92

How to measure these nuclei?

Available data:
recently ^{166}Gd and ^{164}Sm at RIKEN (Patel *et al.* PRL113,262502)

^{162,164}Gd at Gammasphere



with Gammasphere, ^{252}Cf (62 μCi),
101 detectors, 1 month

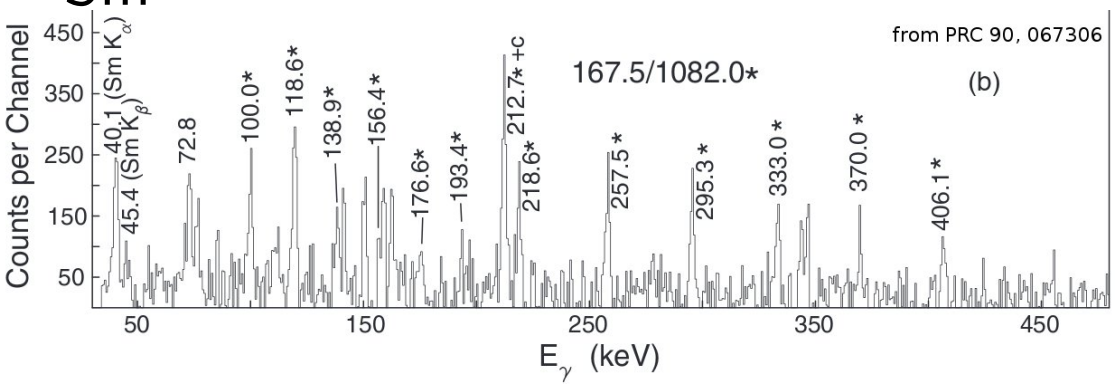
obvious problems:

- statistics
- large ICC of $2_1^+ \rightarrow 0_1^+$ transition ($\alpha > 8$!)

252Cf sf source

$\gamma - \gamma$ fast timing prob. possible for ^{160,162,164}Gd, ^{158,160,162}Sm from ^{252}Cf sf

^{158}Sm



with Gammasphere, ^{252}Cf (62 μCi), 101 detectors, 1 month

- high efficiency at $E_\gamma \approx 100$ keV
- good selectivity with possible gates from gsb transitions and/or fission partner
- (possibly X-rays)

Summary

- Deformed shell gap at N=100 (Ce, Nd, Sm, Gd)
- Shapes the rare earth abundance peak
- Nuclear structure info crucial for r-process calculations
- Lifetime of 2_1^+ (4_1^+) can be measured with fast timing
- Some accessible with ^{252}Cf source
- More exotic ones need dedicated experiments
- ce-spectroscopy with good energy and timing?