Experimental Level Densities and γ-Strength Functions in rare earth nuclei

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Today's Menu

- Aperitif: Motivation and Oslo Method
- Entrée: Level Densities and microcanonical temperature
- Plat principal: Radiative strength function and the M1(pygmy) resonance
- Dessert: Summary and outlook

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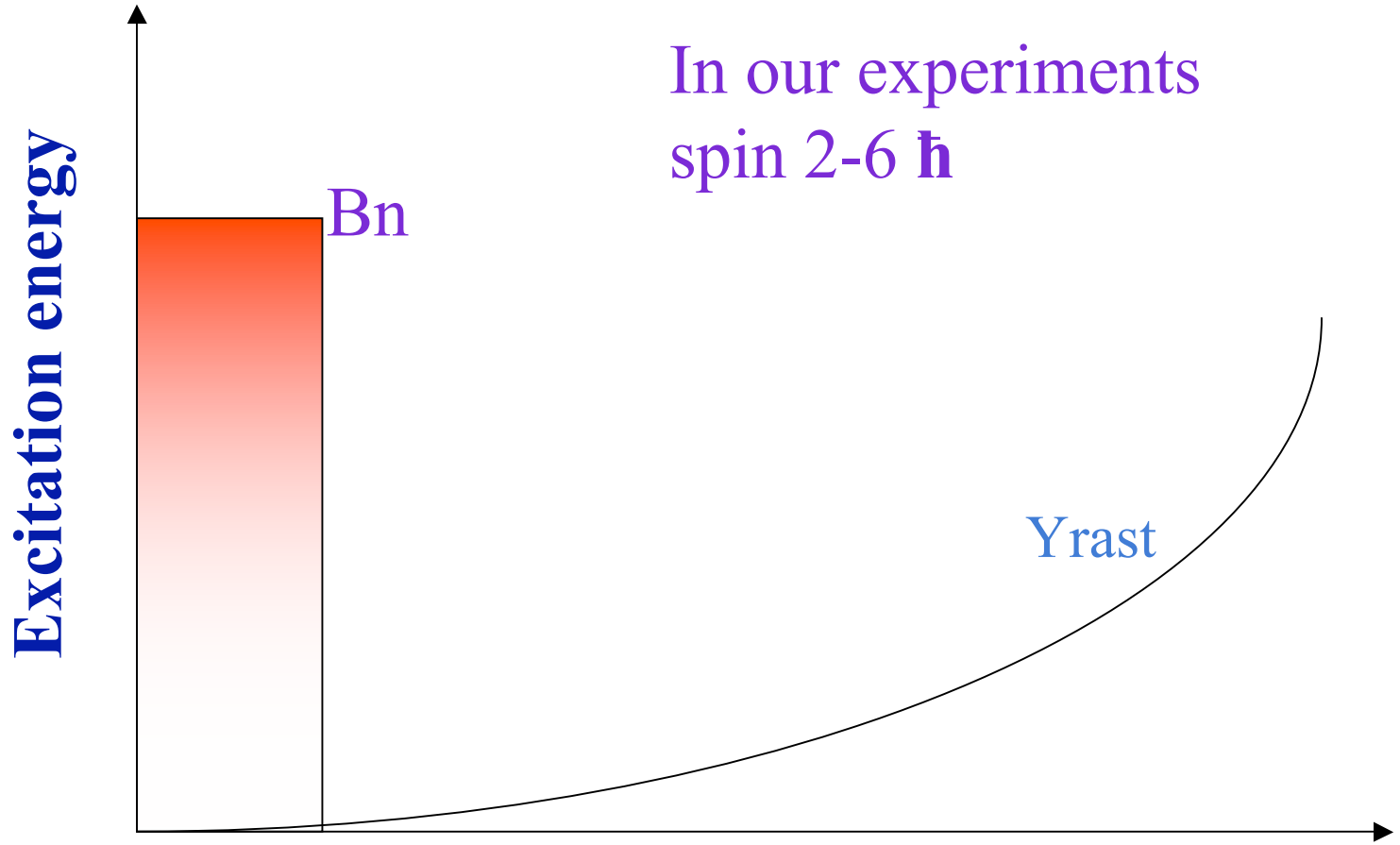
Spin energy diagram



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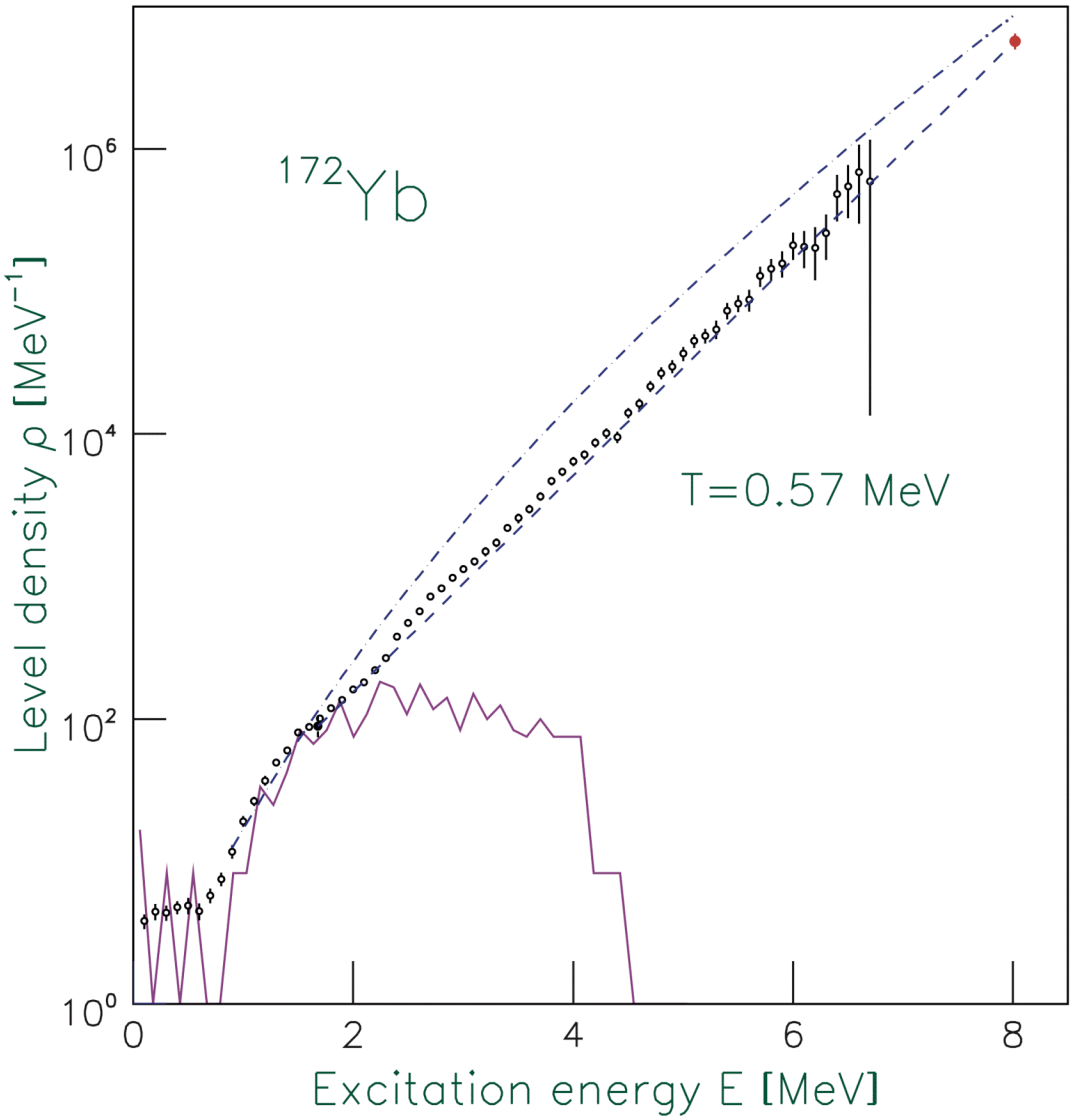

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CACTUS- experimental setup

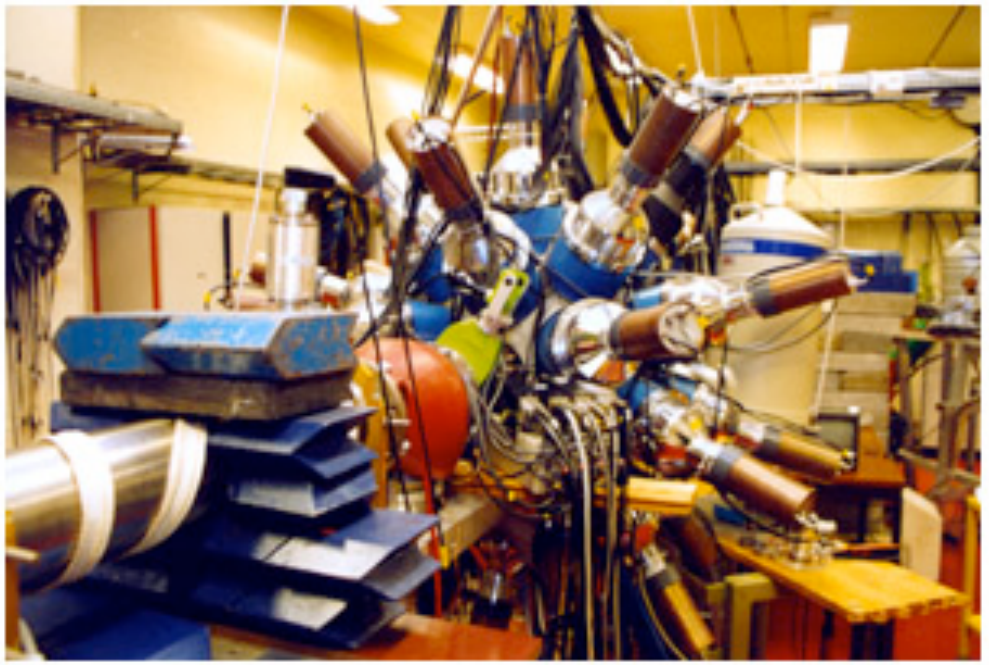
•Reactions: (^{3}He,α) and (^{3}He,^{3}He')

•Beam: 30-45 MeV

•Targets: Yb, Dy, Er, Sm, Nd, Si, Mo, Fe, Sn, V, Pb,Ti,Ni

•8 Si particle telescopes at Θ= 45 °

•Spin 2-6 ħ



•CACTUS detector array (28 NaI + 2Ge) has 15% efficiency

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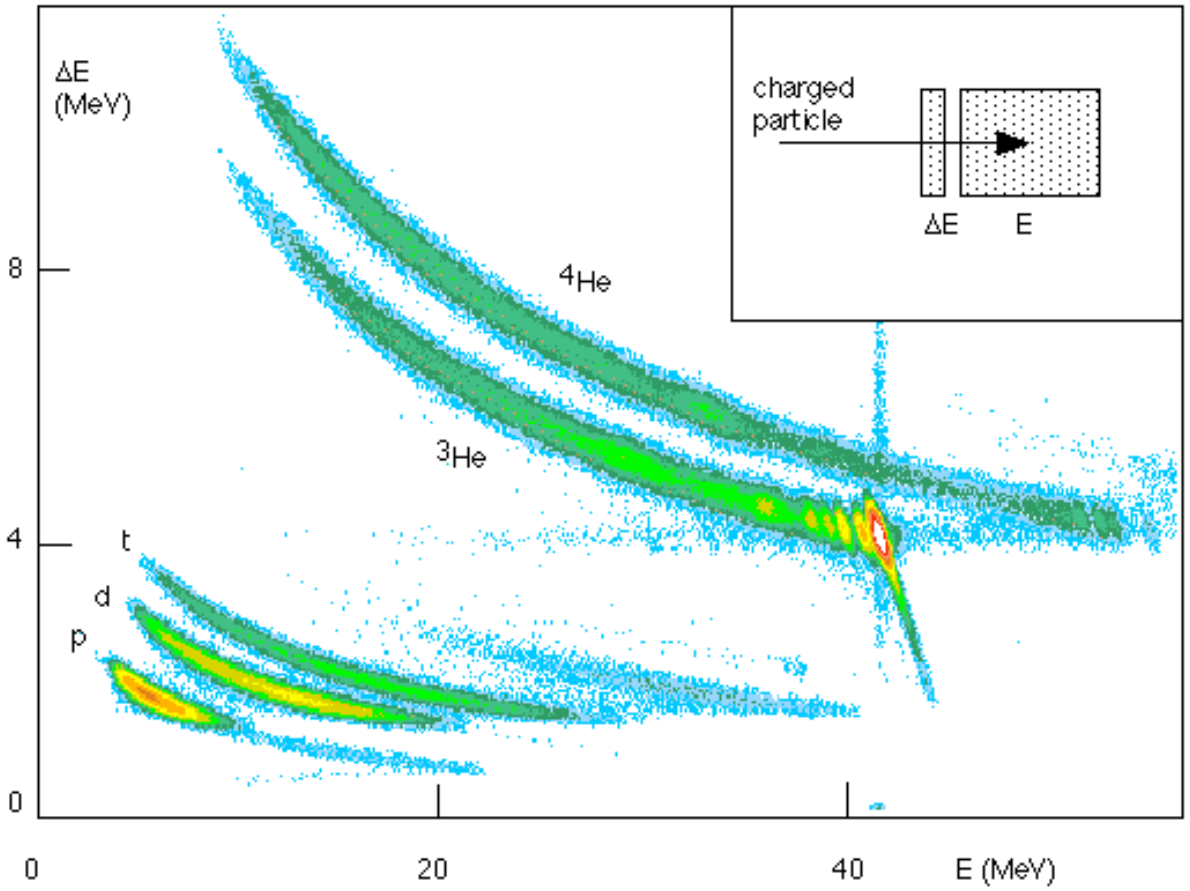

Typical banana plot used for particle identification

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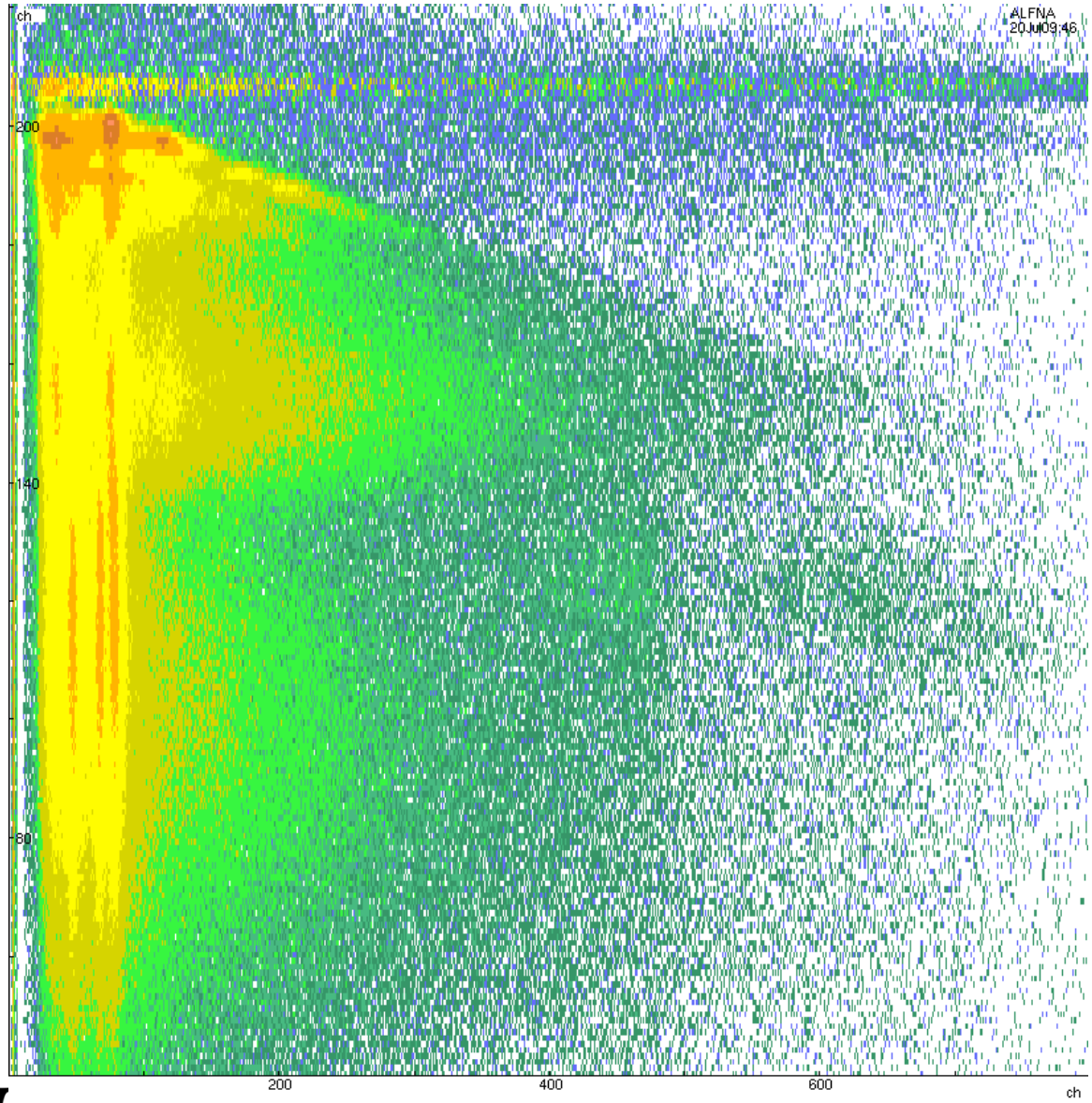
Alpha energy →

← Ex of nucleus



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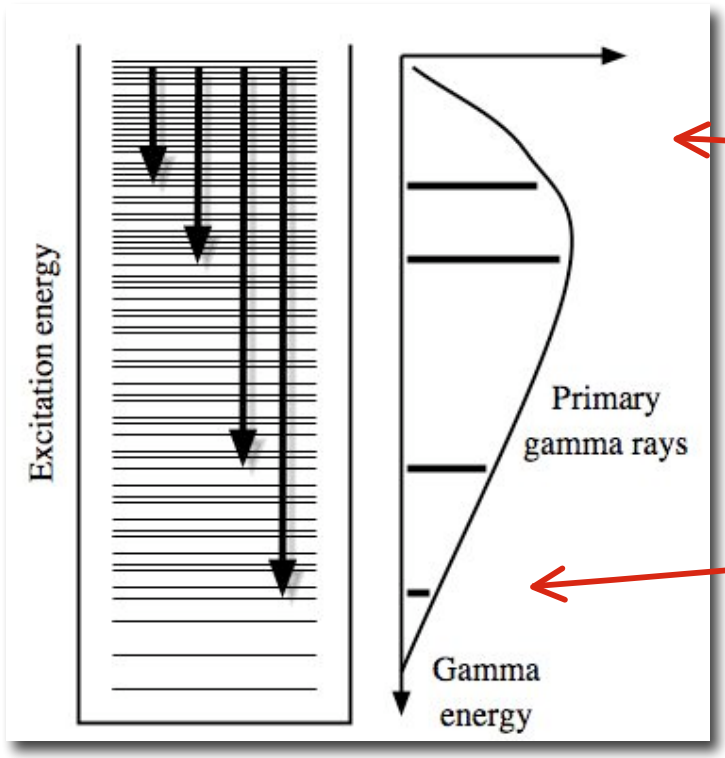
Eγ

The Brink Axel hypothesis



$$P(E_i, E_\gamma) \propto \rho(E_f) \cdot \mathcal{T}(E_\gamma)$$

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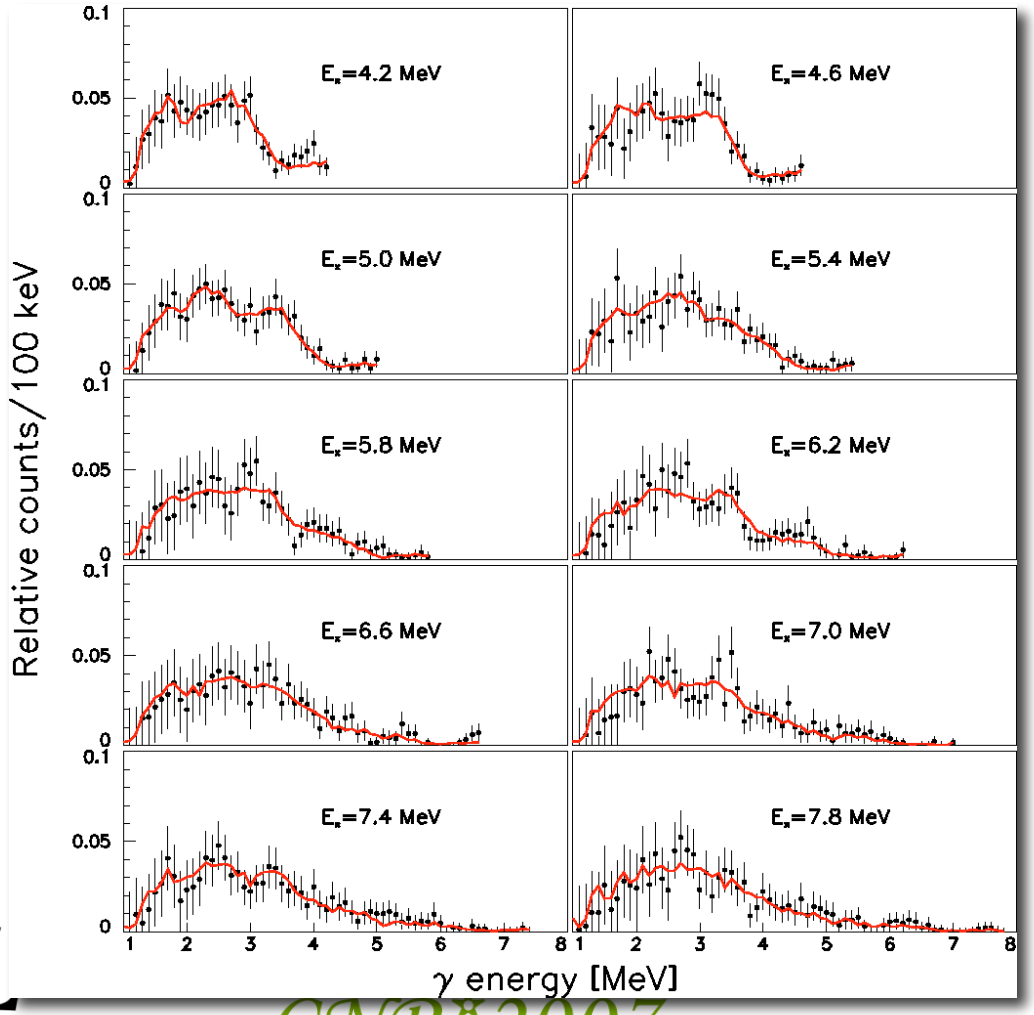
Does it work?



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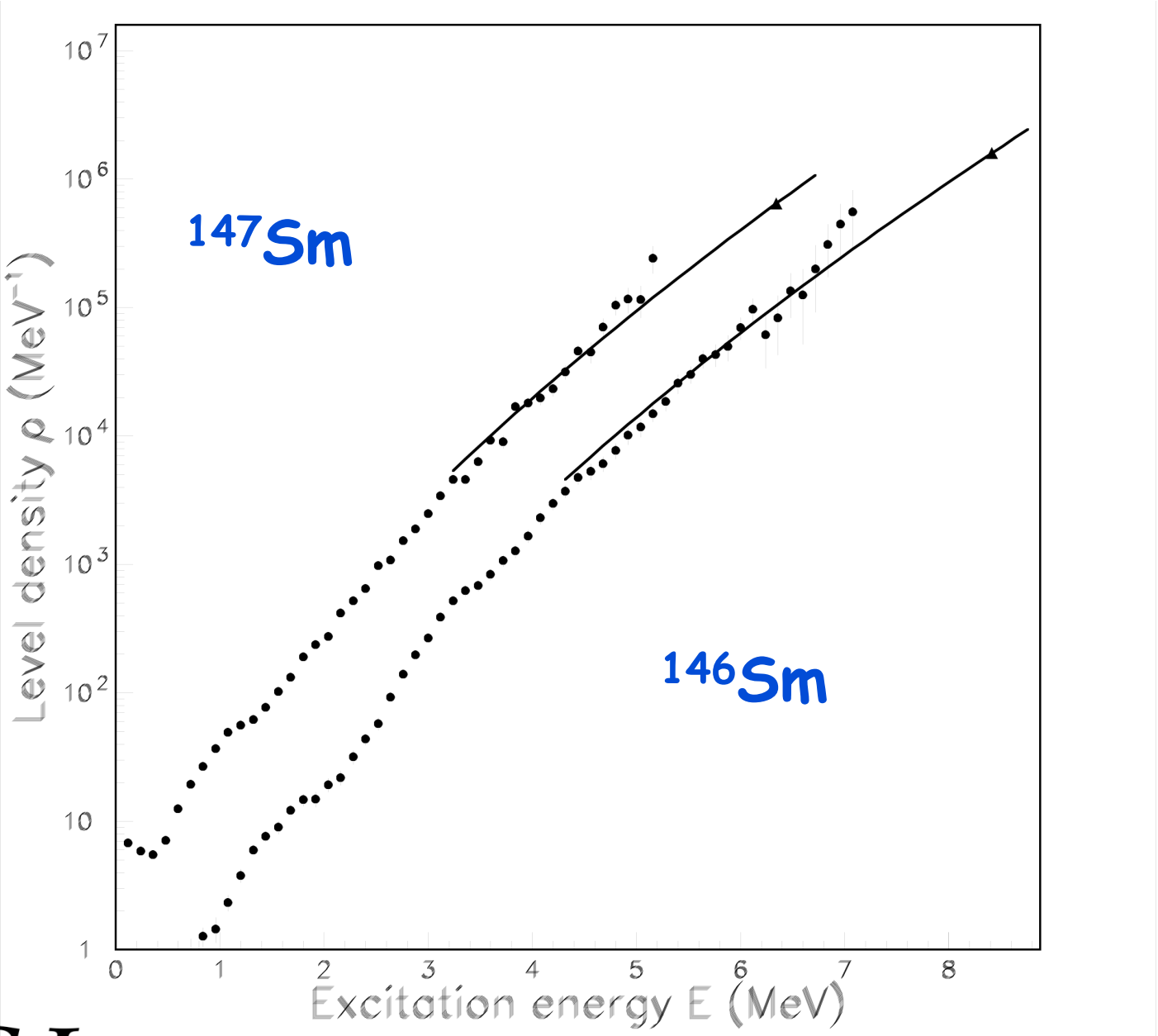

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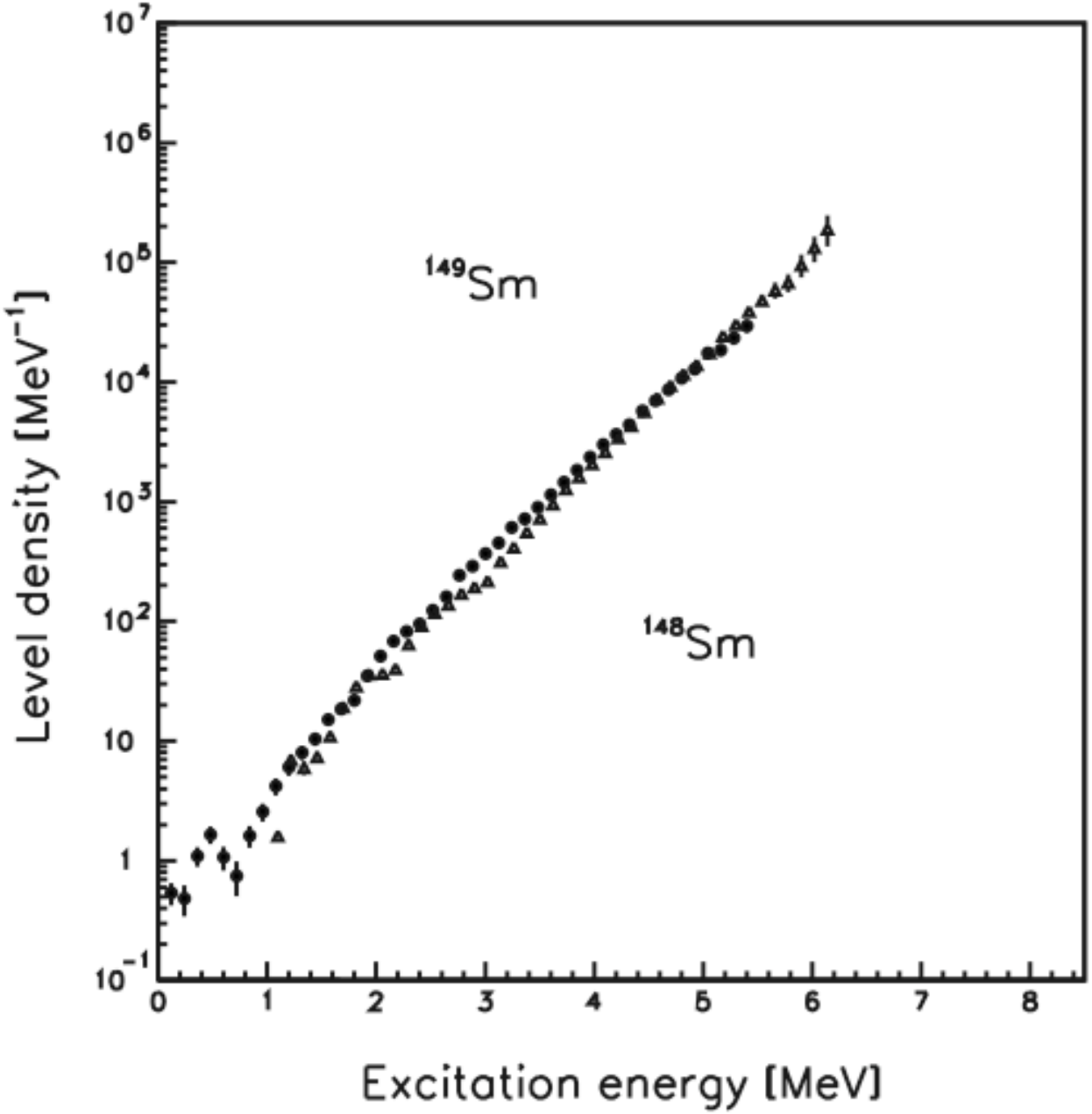
The excitation energy of 148Sm is shifted by the difference in mass excess



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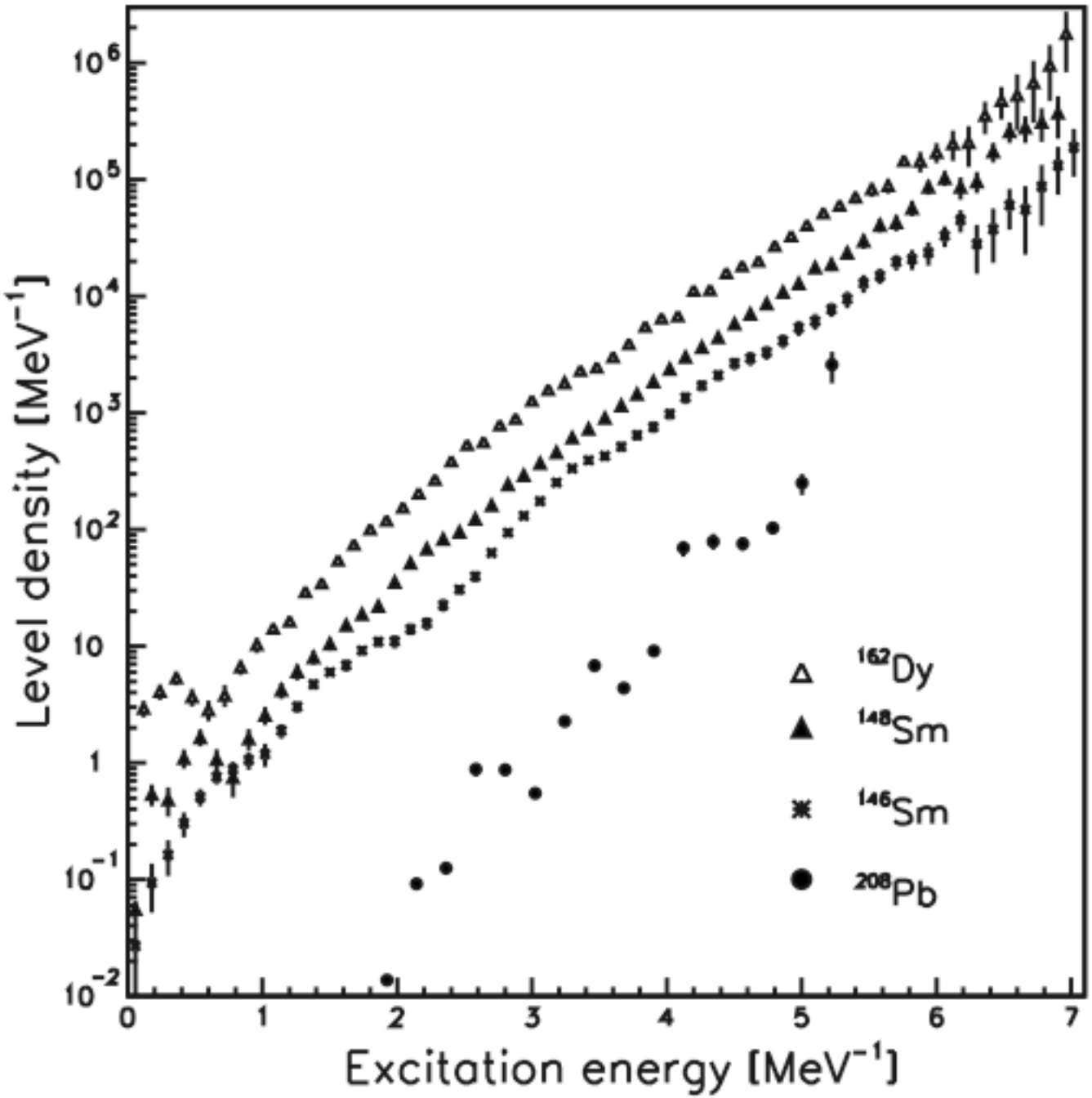

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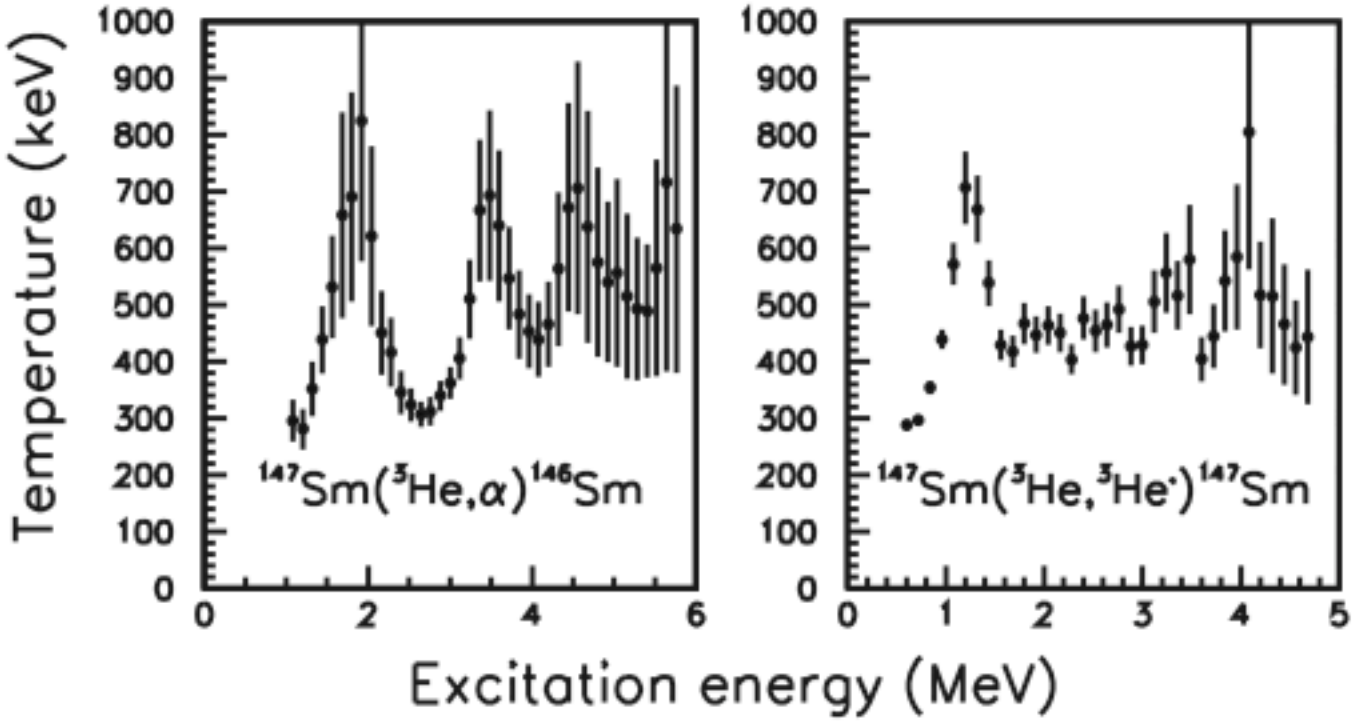
Microcanonical ensemble

$$S(E) = \ln \rho(E) + S_0$$

$$T(E) = \left(\frac{\partial S(E)}{\partial E} \right)_V^{-1}$$

$$C_V(E) = \left(\frac{\partial T(E)}{\partial E} \right)_V^{-1}$$

Microcanonical Temperature



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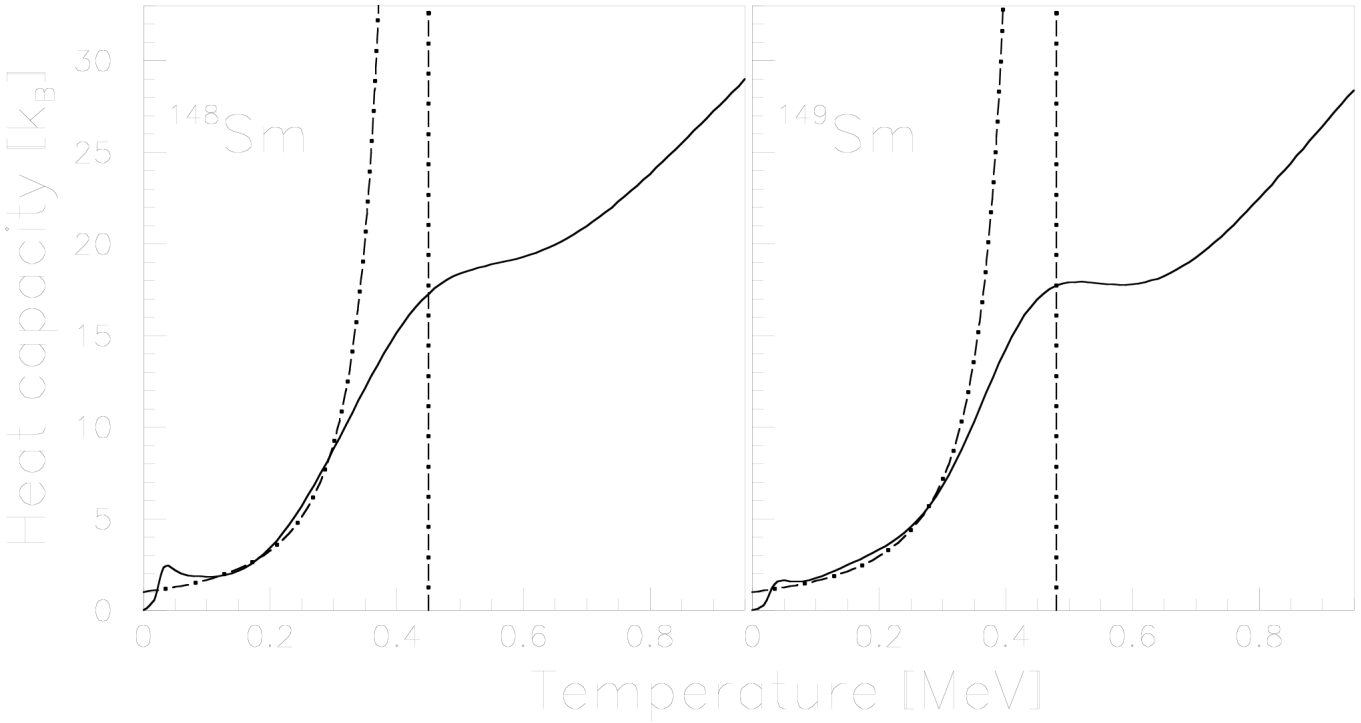
Heat capacity

derived within the in canonical ensamble



The dash-dotted line describes a constant temperature estimate:
$Cv(T)=\kappa_B\,(1-T/t)^{-2}$

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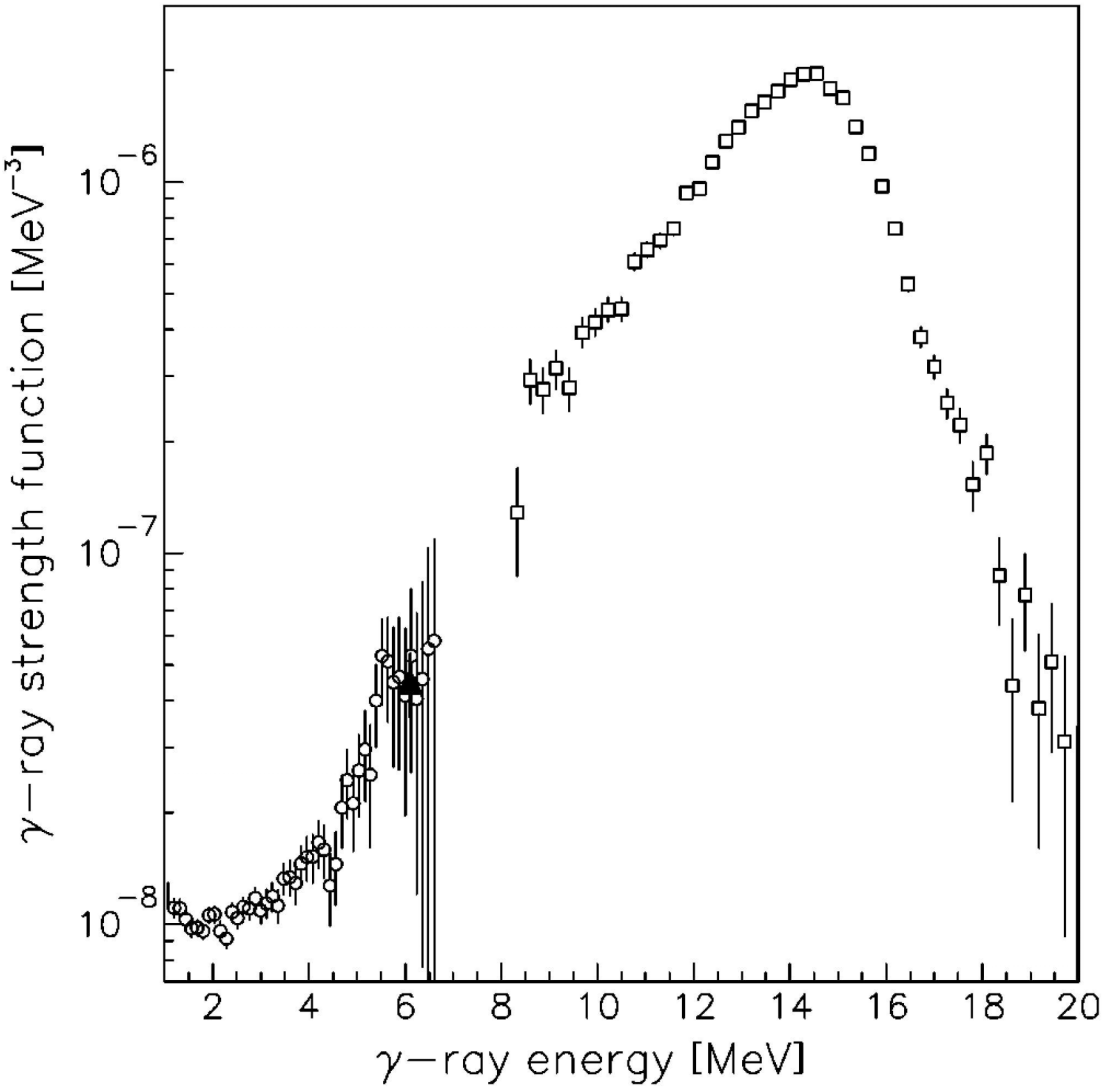
^{148}Sm strength function

- Circles our data
- Squares from photoabsorpsjon cross sections P.Carlos et al. NPA 225 (1974)
- Filled triangle is based on neutron capture in ^{147}Sm



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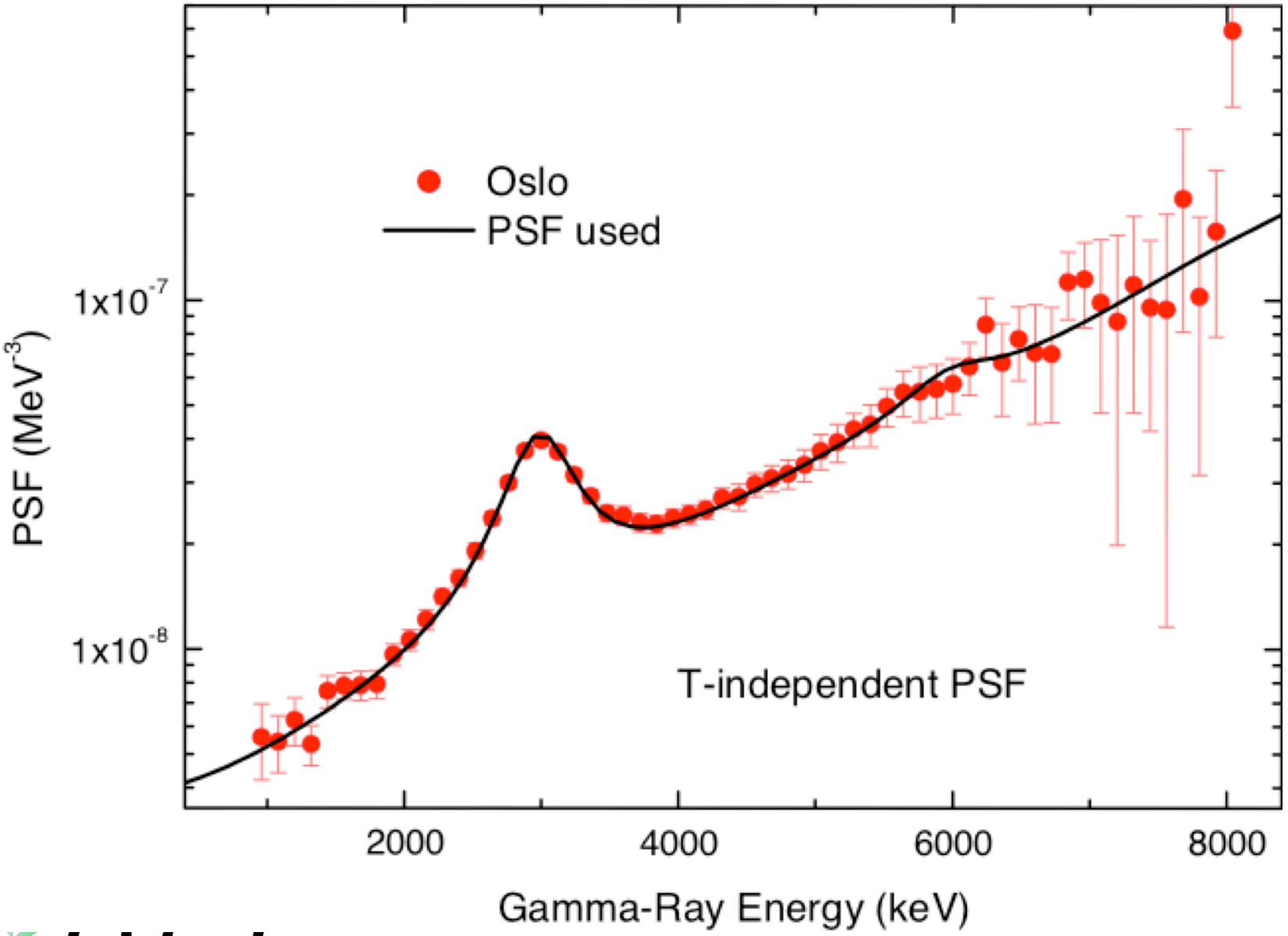

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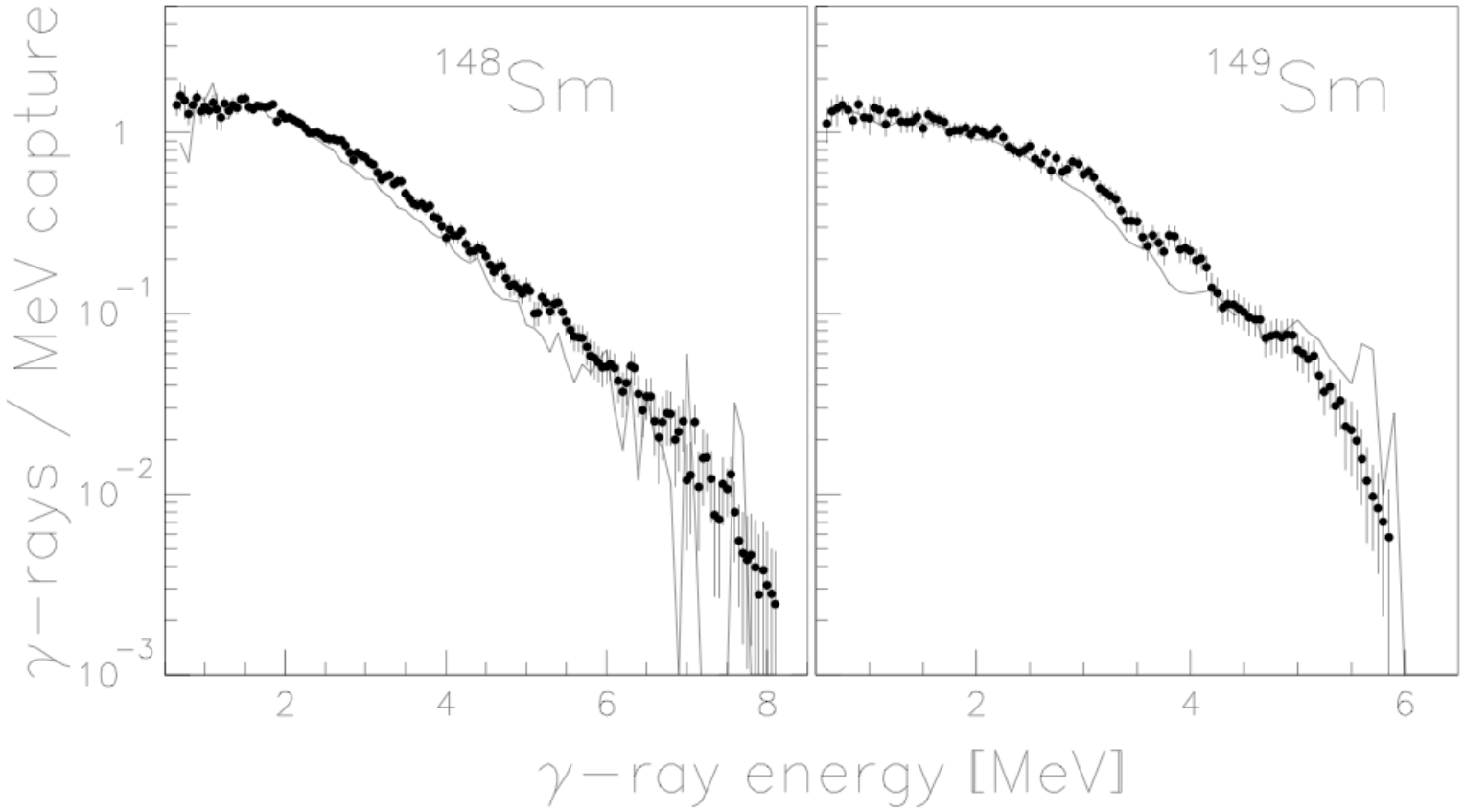
Total γ–spectrum from $E_x = B_n$



Data points from (n,χ)-experiments B.Duamet, M. Igashira et al. Nucl.Sci.Tec.36 (1999).
Solid line is calculated from our level densities and strength functions.

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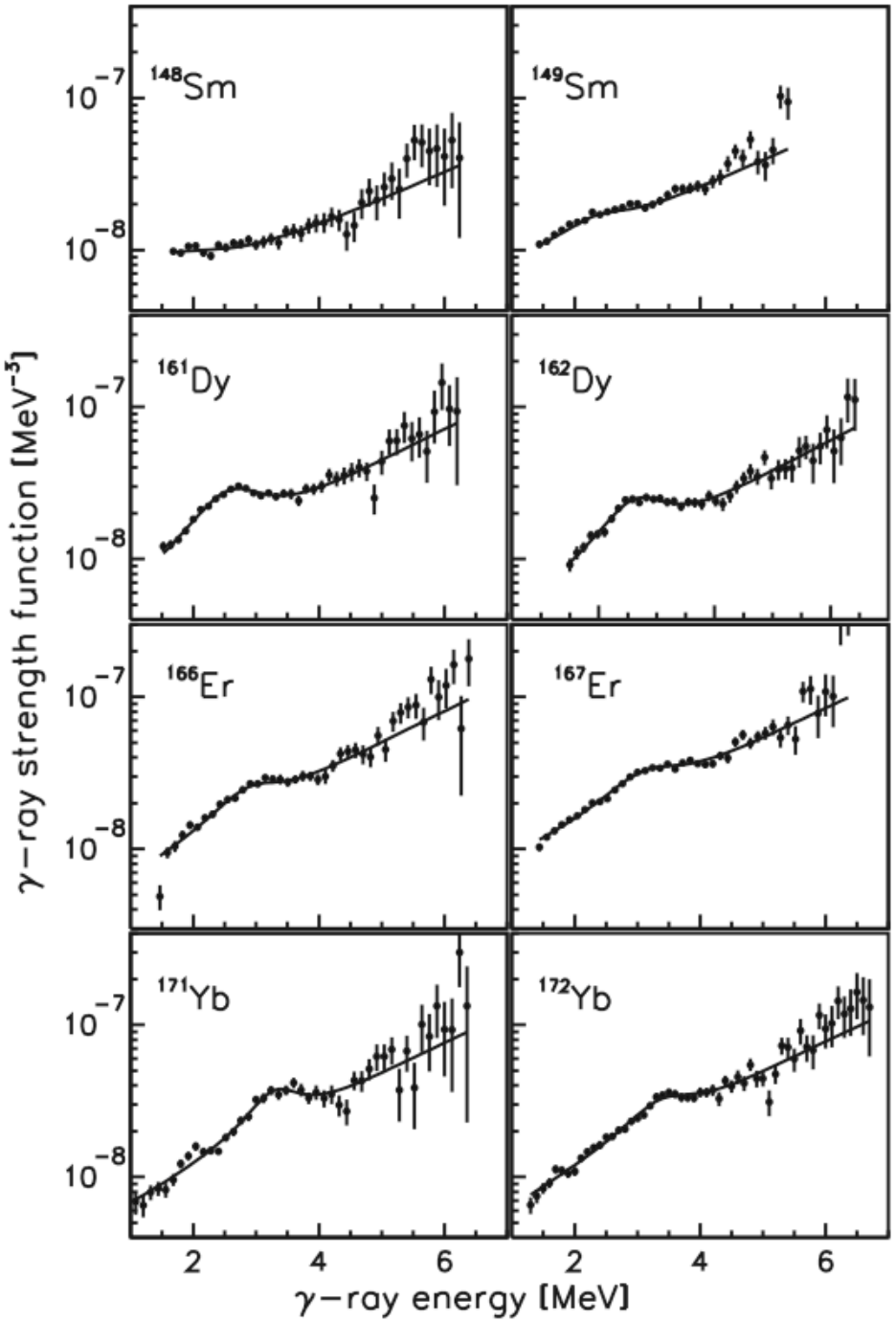

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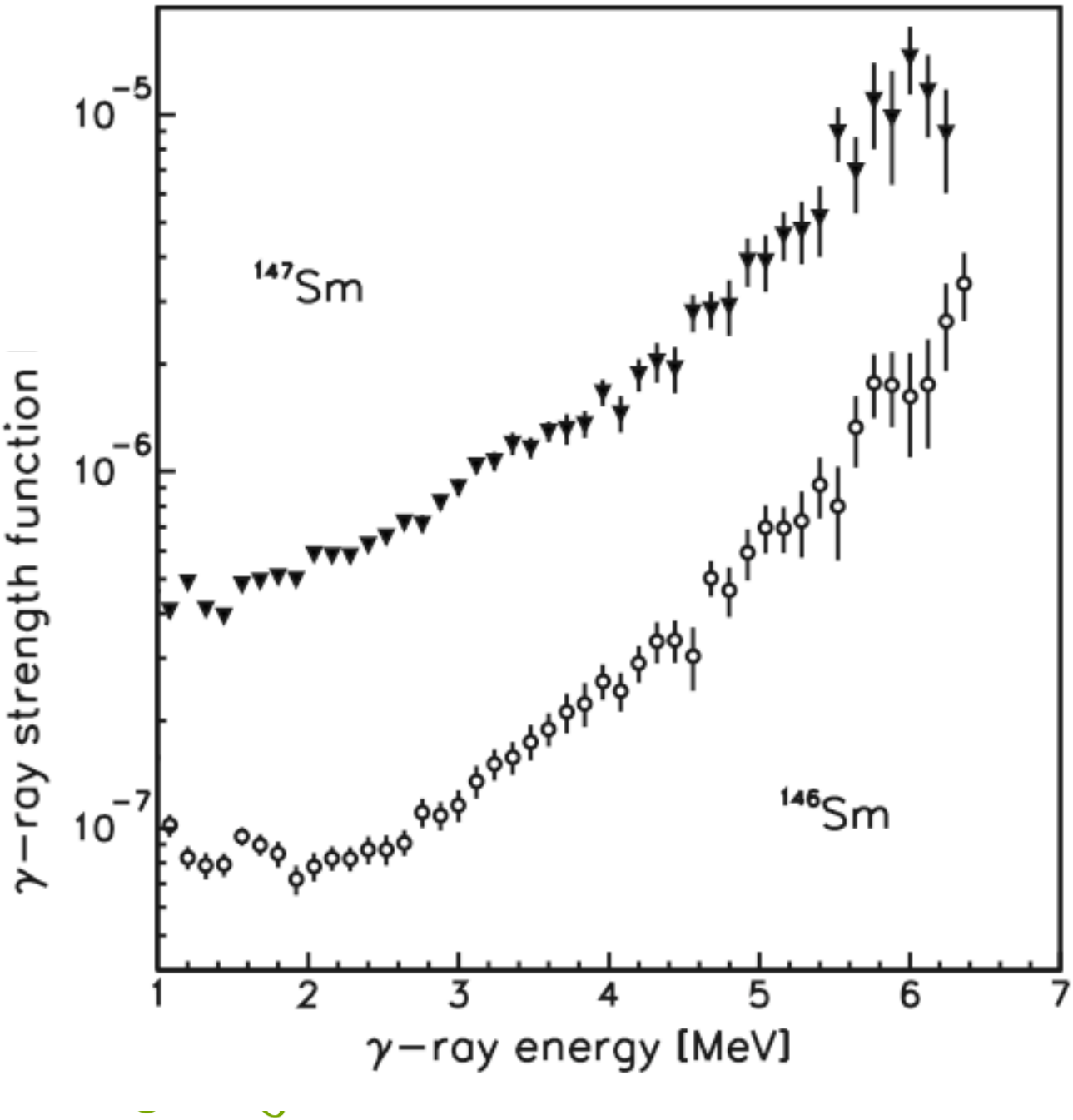

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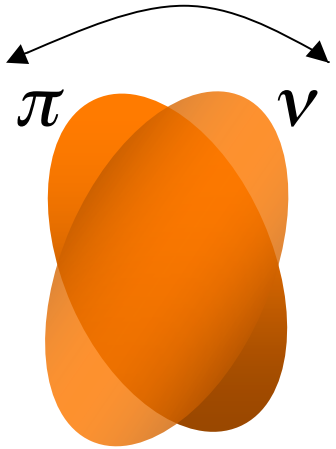
Scissors mode



Established M1 multipolarity of a pygmy resonance in ^{172}Yb at E_γ = 3.3 MeV

$$B(M1\uparrow) = \frac{9\hbar c}{32\pi^2}\left(\frac{\sigma\Gamma}{E}\right)_{py} = 6.5(15)\mu_N^2$$

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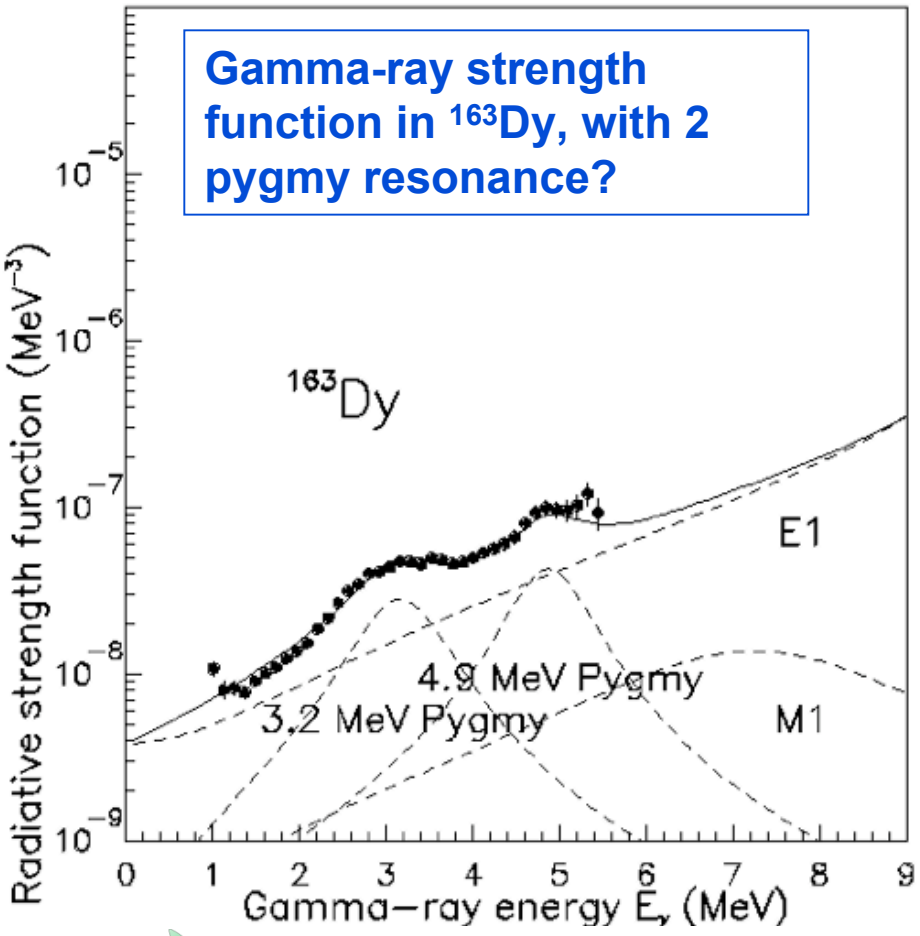
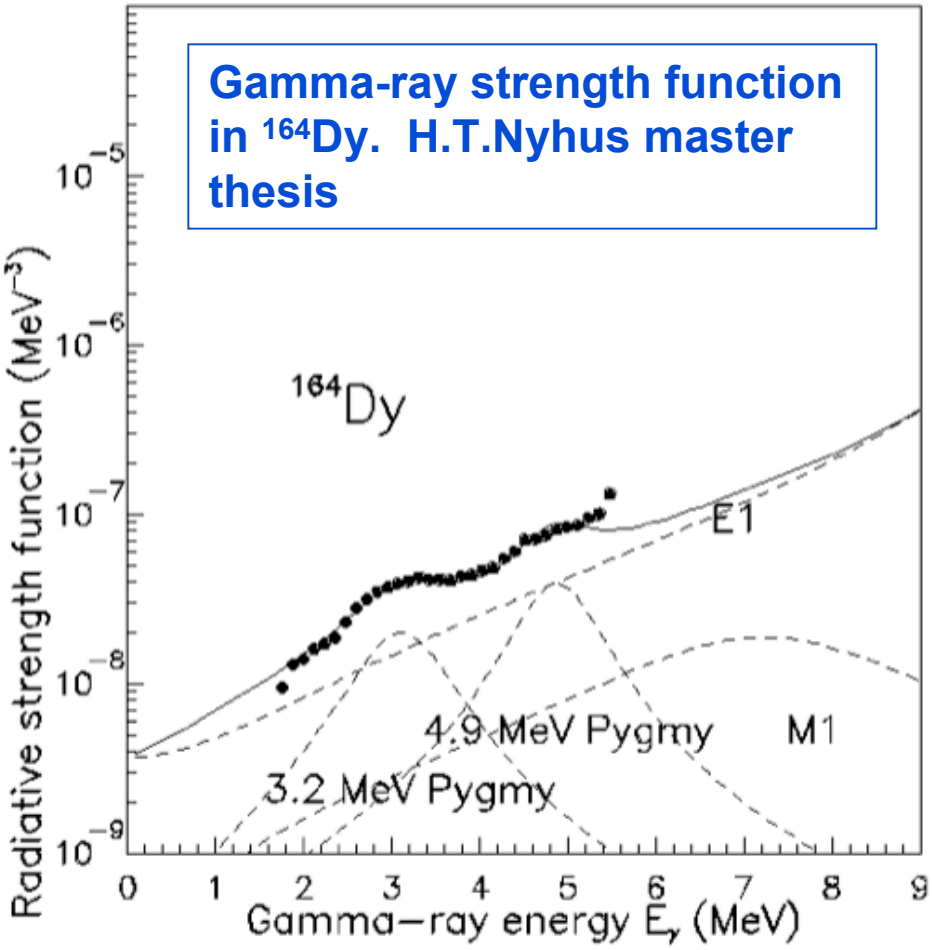
Preliminary!

Gamma-ray strength function in ^{163}Dy, with 2 pygmy resonance?



Gamma-ray strength function in ^{164}Dy. H.T.Nyhus master thesis



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Summary

- Unique technique to extract level densities and γ-strength function experimentally
- From the level density we can extract thermodynamical properties like T and Cv.
- New Sm and Pb data show that the level density has more structure and decrease as one approaches closed shells
- The M1 (scissors) resonance observed in deformed nuclei vanishes in the spherical Sm nuclei.
- Preliminary: a second resonance in 163,164Dy?

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Future outlook

- As soon as possible 163Dy(p,p´) to investigate the spin dependence of the width of the pygmy.
- New experiments on Zr and Sn isotopes
- New particle detector system, which will increase the efficiency 5-10 times
- Polarization measurments of the upbend in the strength function at low Eγ?
- Investigate/test possibility of using inverse reactions

In Oslo we now have:

2 PhD positions and

1 Postdoc position

To be filled as soon as possible.

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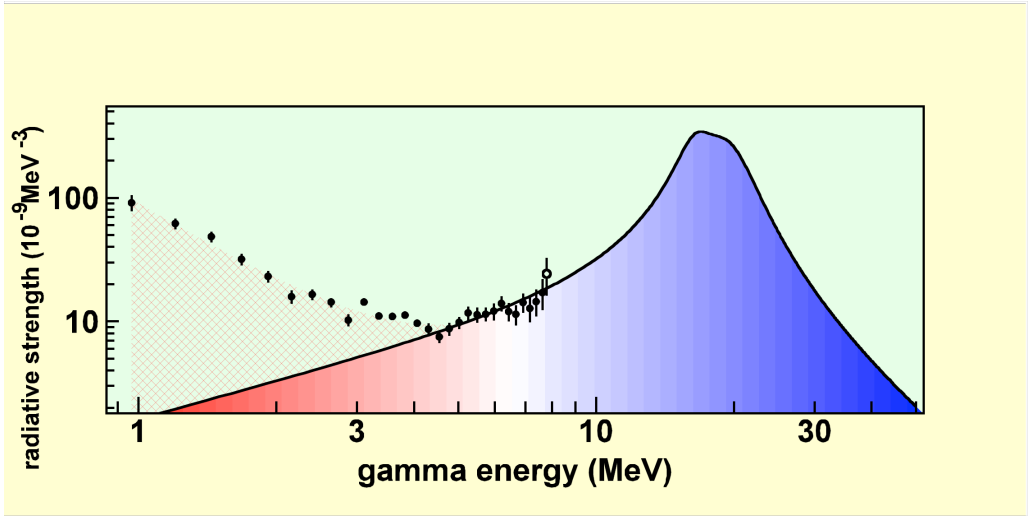

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Collaborators

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- A.Schiller, A.Voinov, Ohio University, USA
- T.Lønnroth, Åbo,Finland
- T.Belgya, Budapest, Hungary
- E.Algin, Turkey

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