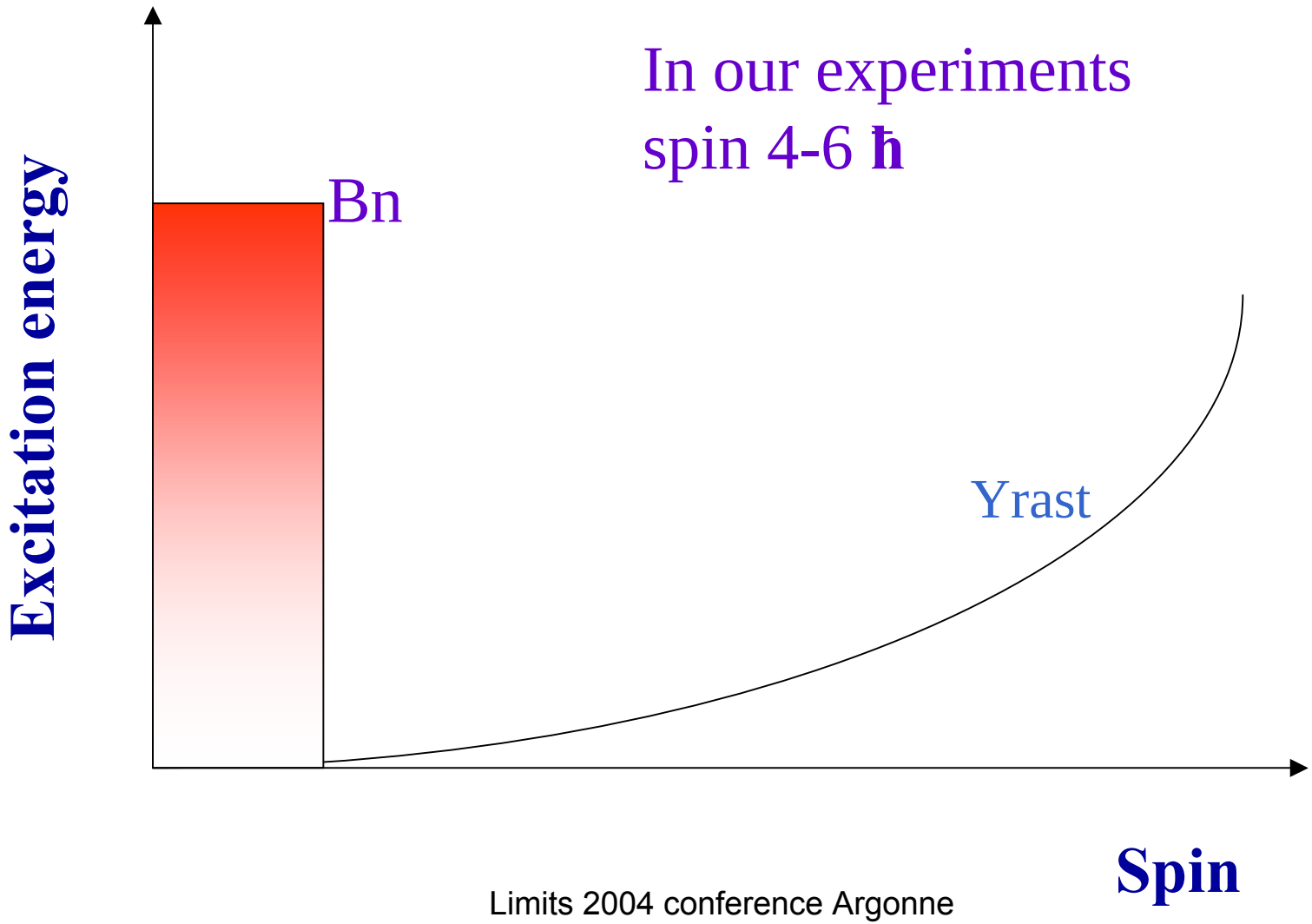
Today's Menu

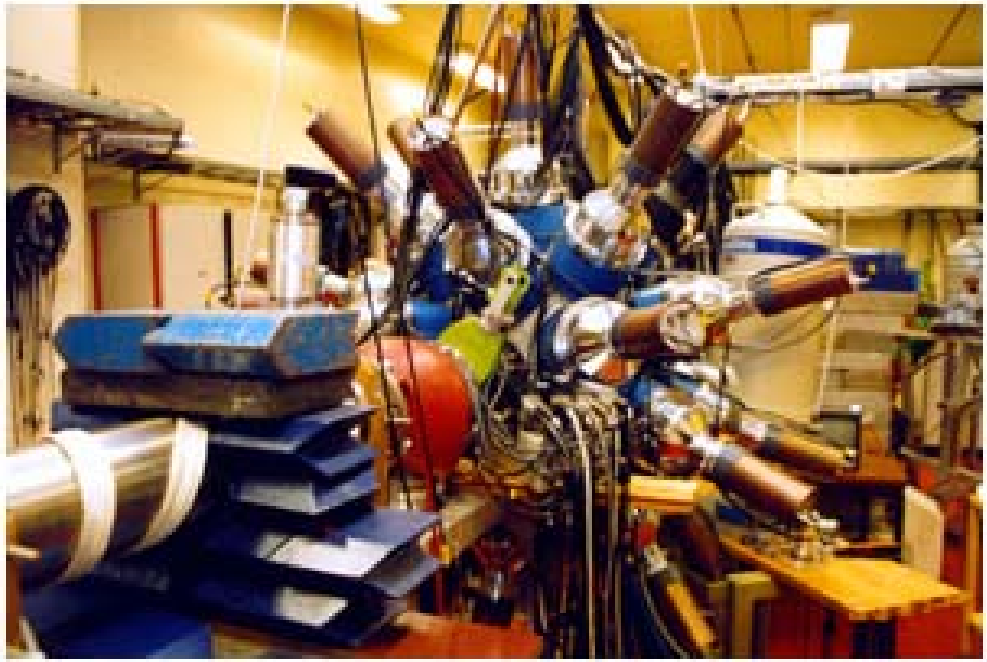
- Aperitif: Motivation
- Entrée: Experimental setup
- Plat principal: Level densities
  γ-strength functions,
- Fromage: Interpretations
- Dessert: Future perspectives

Spin energy diagram

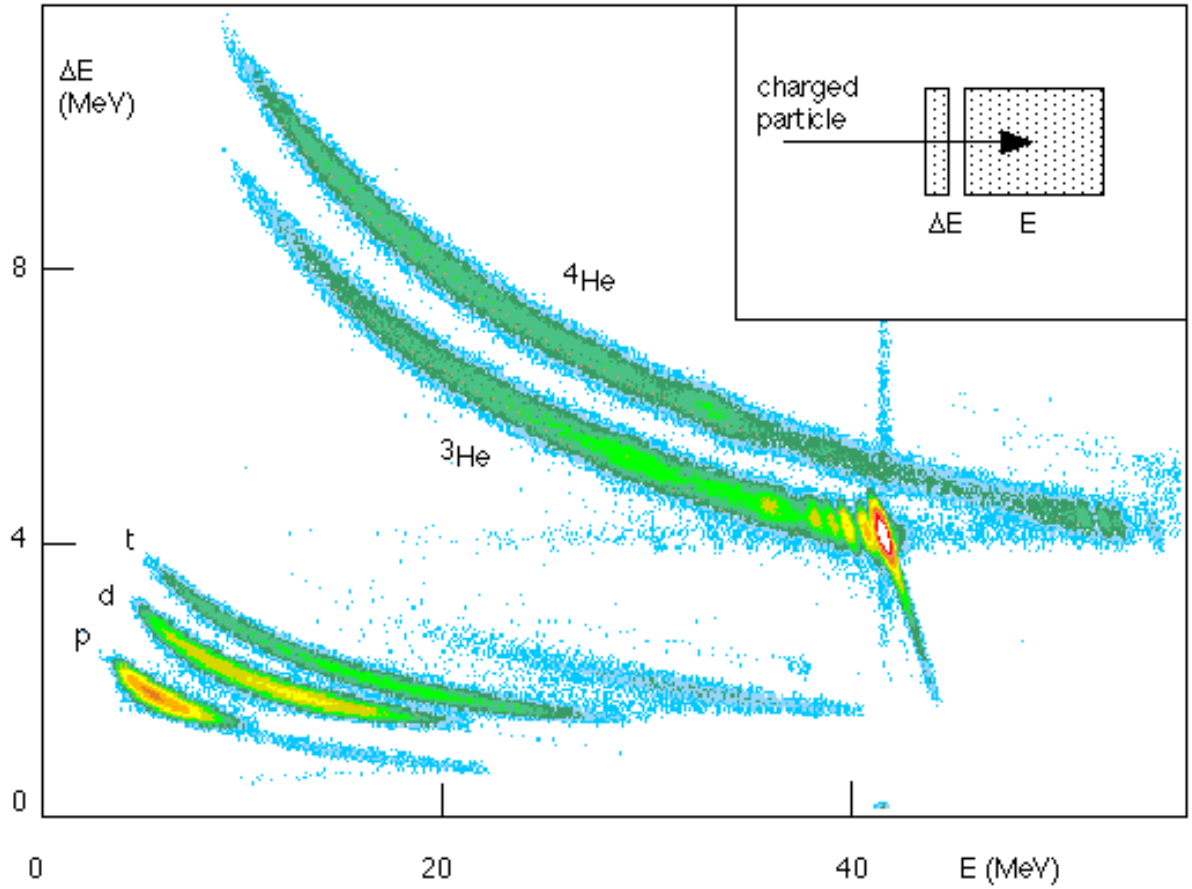


CACTUS- experimental setup

- Reactions: (^{3}He,α) and (^{3}He,^{3}He*)
- Beam: 45 MeV
- Targets: Yb, Dy, Er, Sm, Nd, Si, Mo, Fe, Sn, V, Pb++
- 8 Si particle telescopes at Θ= 45 °
- Spin 4-6 $\hbar$



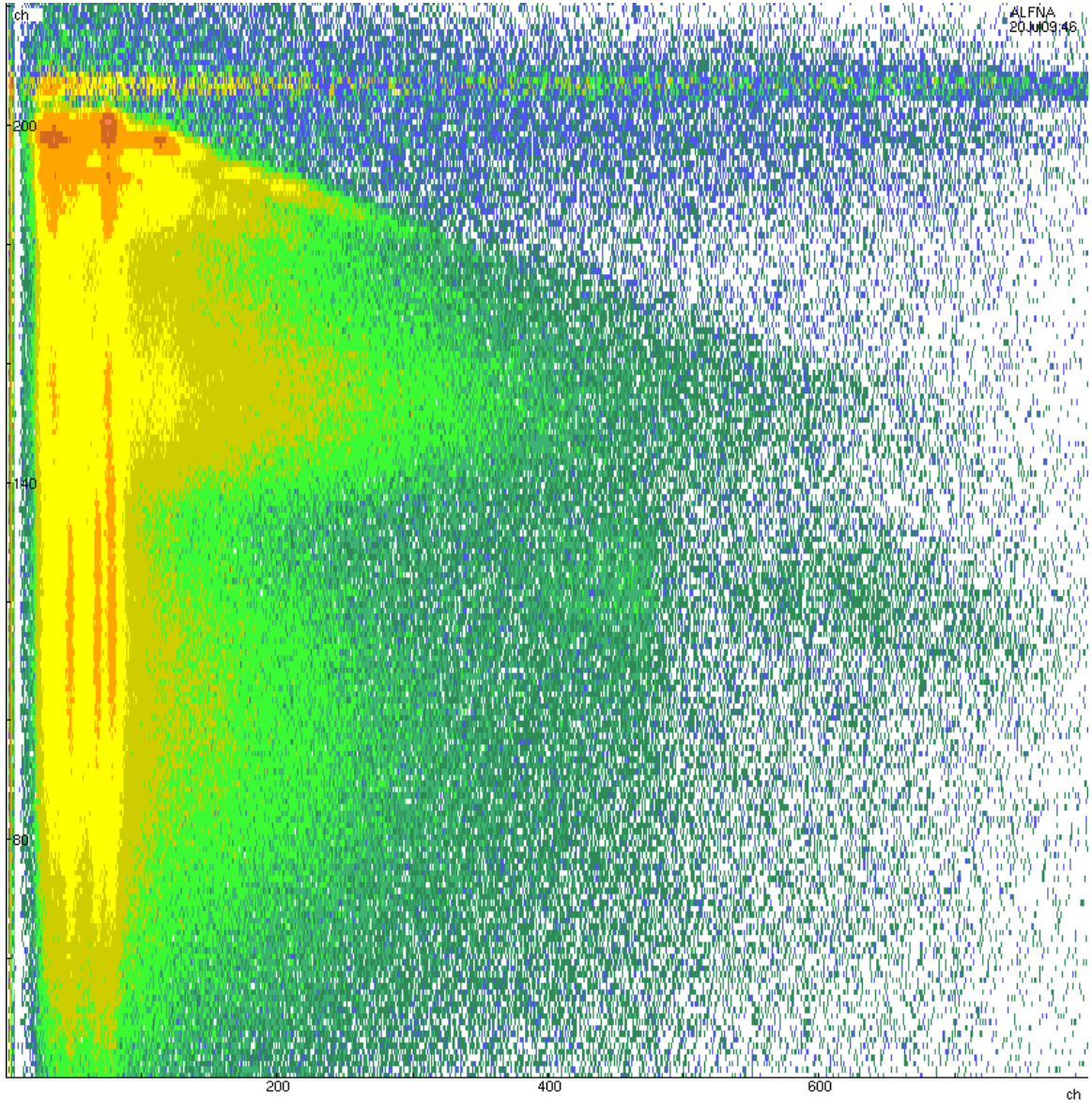
- CACTUS detector array (28 NaI + 2Ge) has 15% efficiency



Typical banana plot used for particle identification

Alpha energy →

← Ex of nucleus



Eγ

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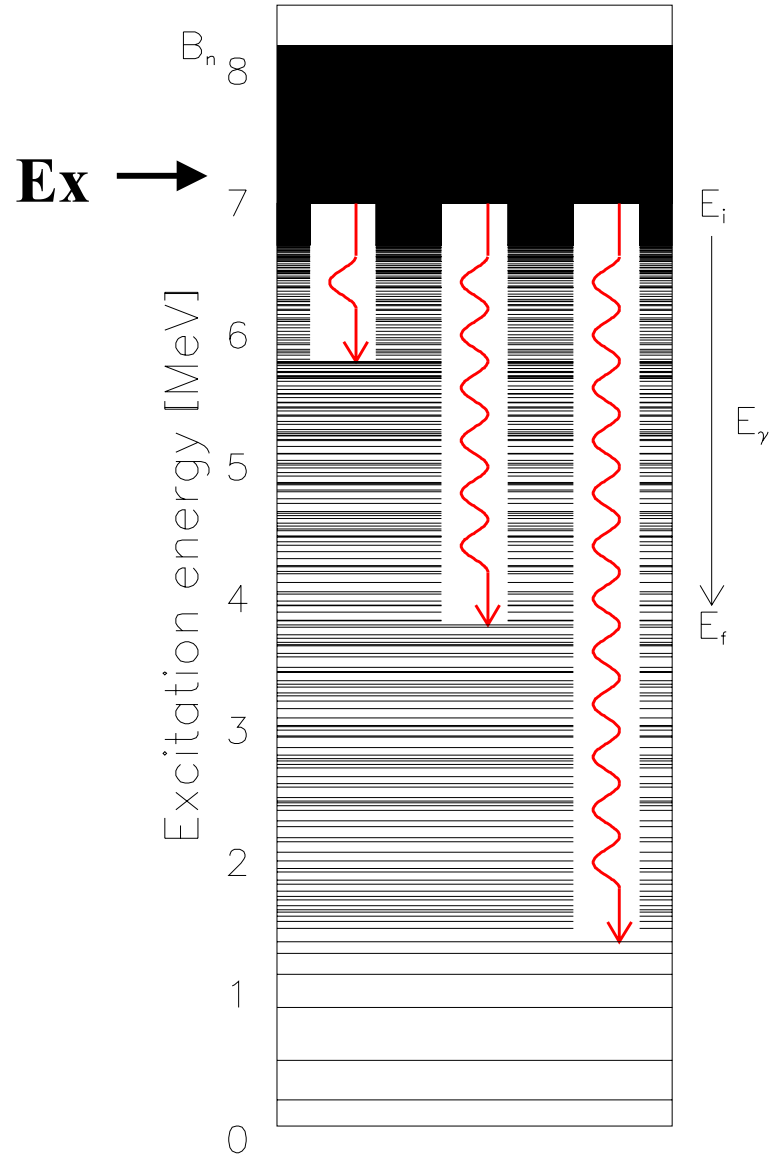
Energy distribution of primary γ rays contains info on:

level density ρ(Ef)

γray strength function T(Eγ)

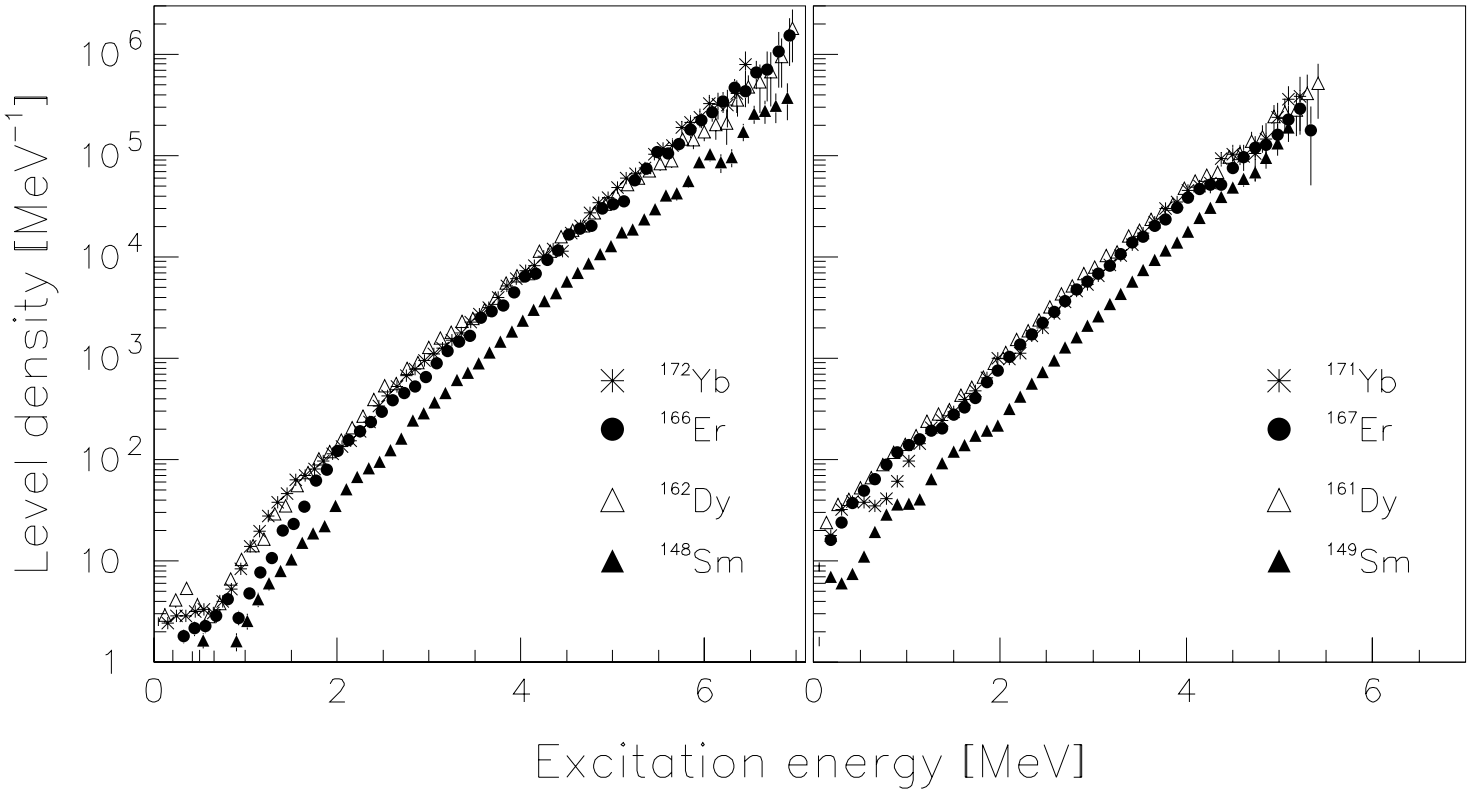
Brink-Axel:

P(Ex,Eγ) ~T(Eγ) ρ(Ef)



$P(E_i, E_\gamma) \propto \rho(E_f) T(E_\gamma)$

Level densities for even and odd rare earth nuclei



- The Sm nuclei (triangles) are closer to a closed shell and have smaller level density

S.Siem et al. PRC65(2002)

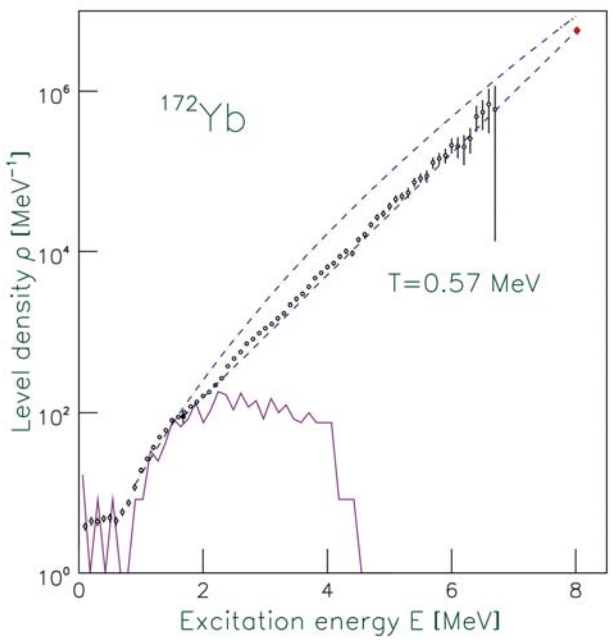
Microcanonical ensemble

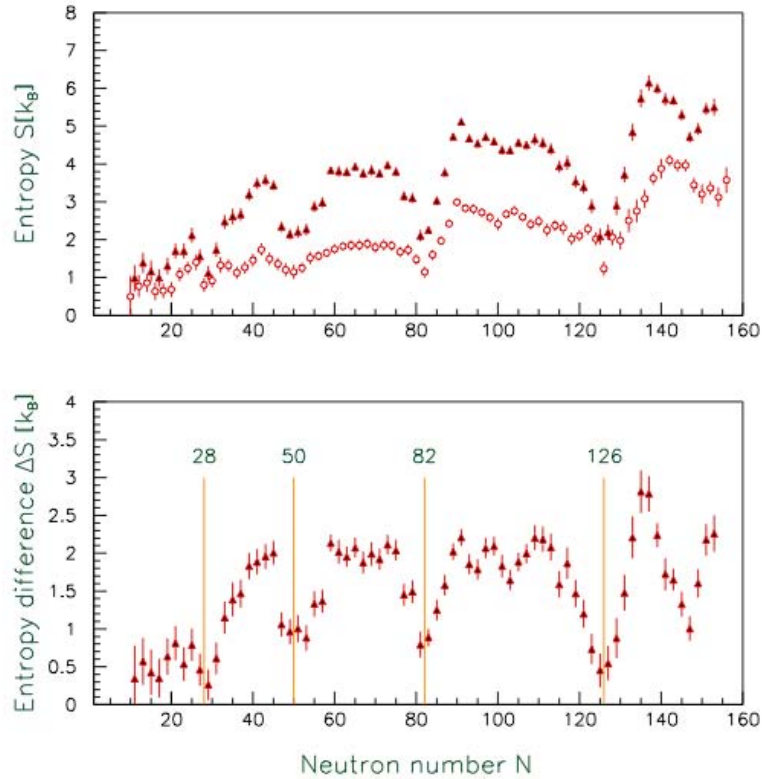
$$S(E) = \ln \boxed{\rho_{\exp}}(E) + S_0$$

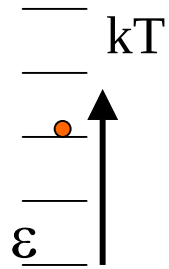
$$T(E) = \left(\frac{\partial S(E)}{\partial E} \right)^{-1}$$

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

Entropy per neutron = 2 k

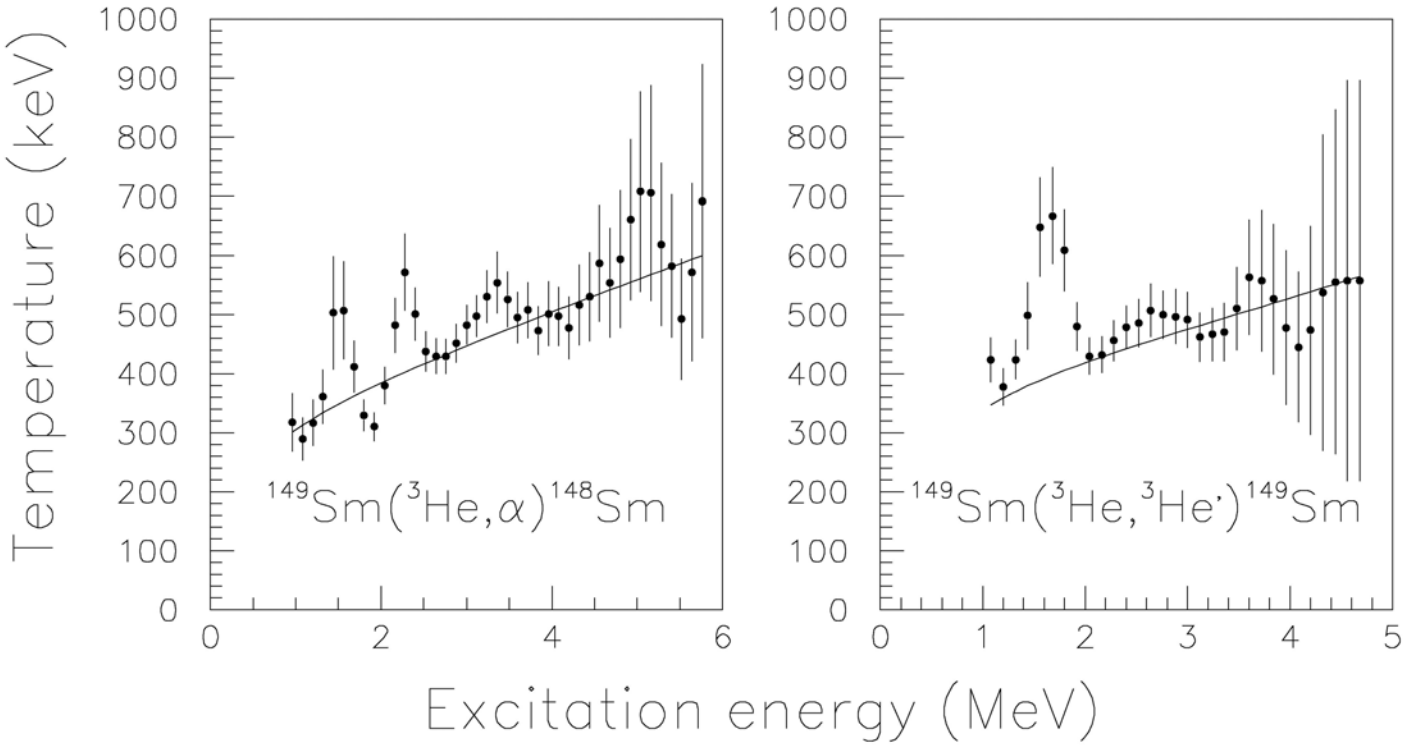






Limit

Microcanonical Temperature



S.Siem et al. PRC65(2002)

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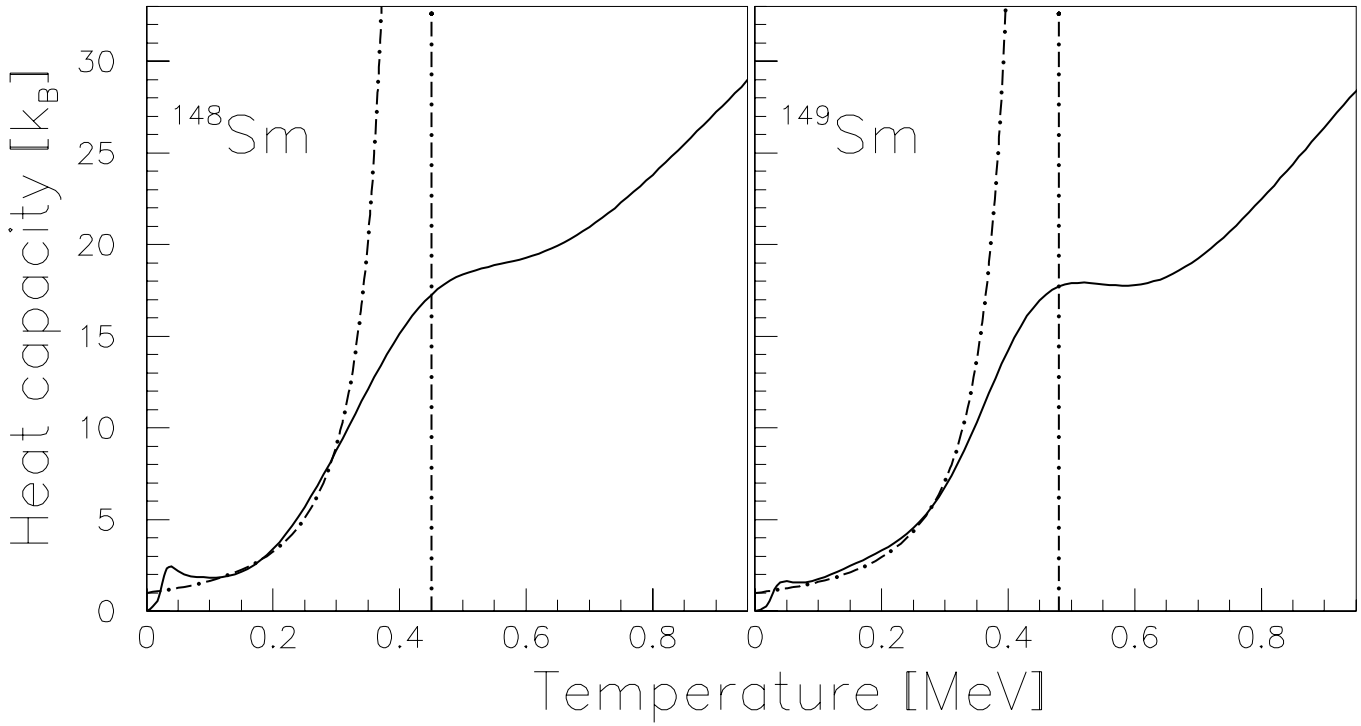
Heat capacity

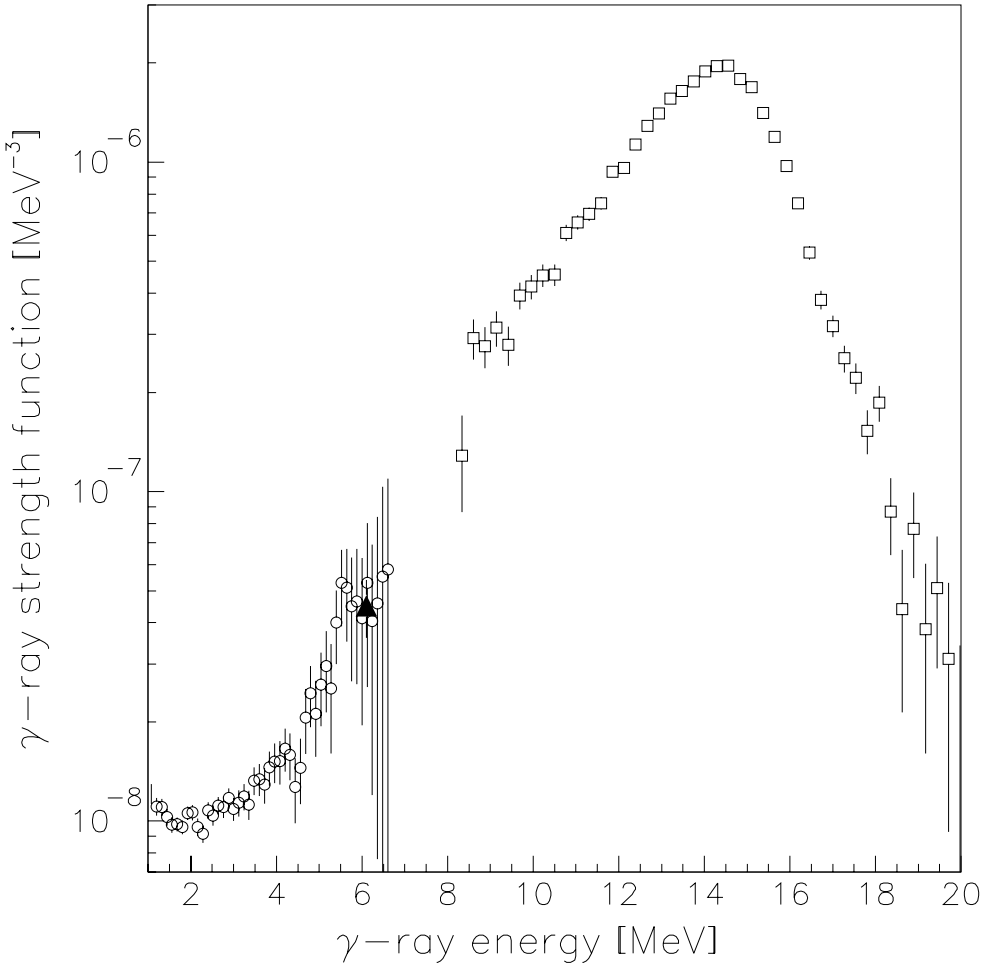
derived within the in canonical ensamble



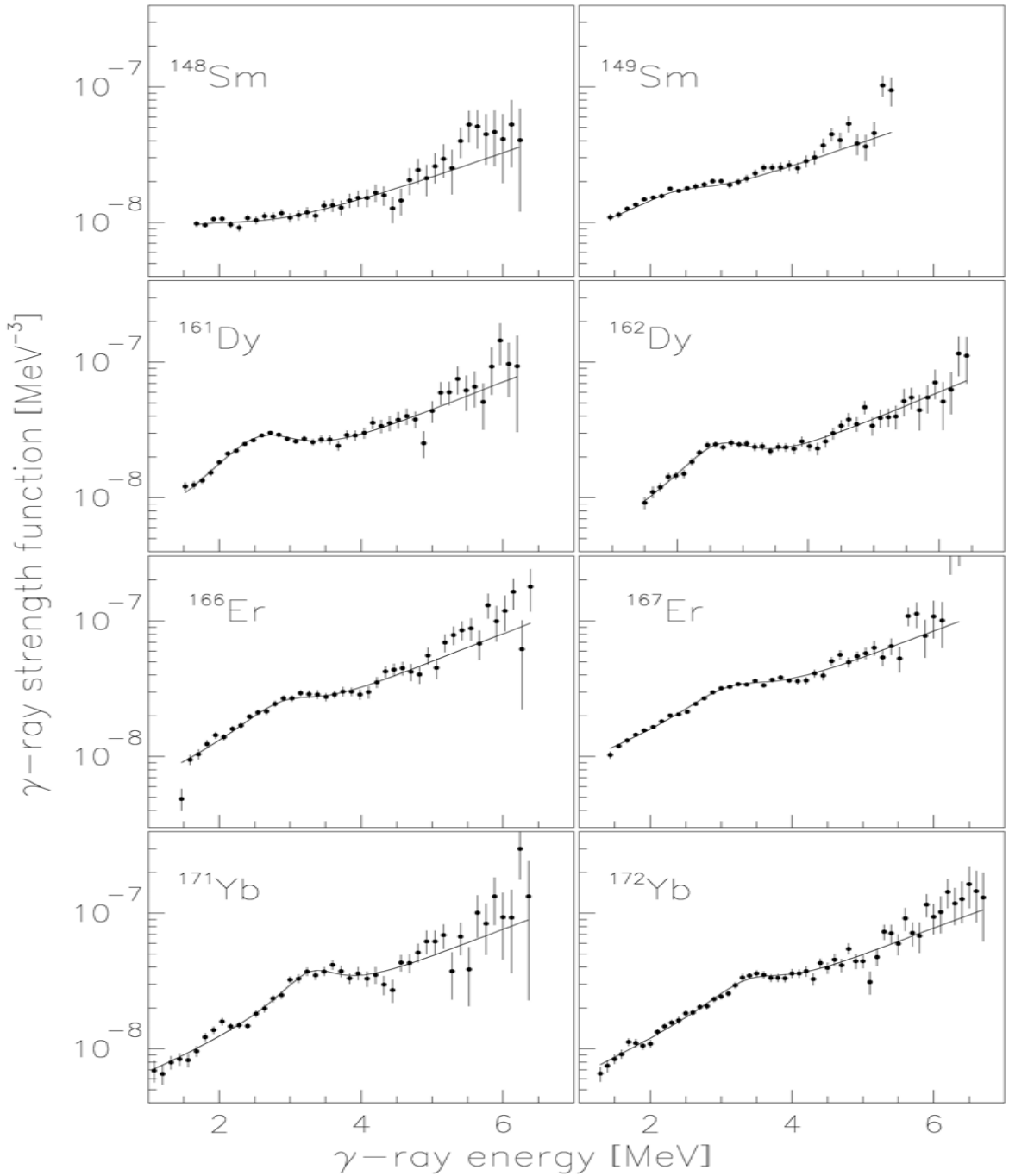
The dash-dotted line describes a constant temperature estimate:
$Cv(T)=\kappa_B\,(1-T/t)^{-2}$

^{148}Sm strength function

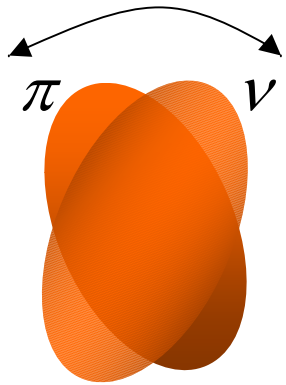
- Circles our data
- Squares from photoabsorpsjon cross sections P.Carlos et al. NPA 225 (1974)
- Filled triangle is based on neutron capture in ^{147}Sm



S.Siem et al. PRC65(2002)


^{148}Sm
^{149}Sm
^{161}Dy
^{162}Dy
^{166}Er
^{167}Er
^{171}Yb
^{172}Yb
10^{-7}
10^{-8}
2
4
6
γ−ray strength function [MeV^{-3}]
γ−ray energy [MeV]

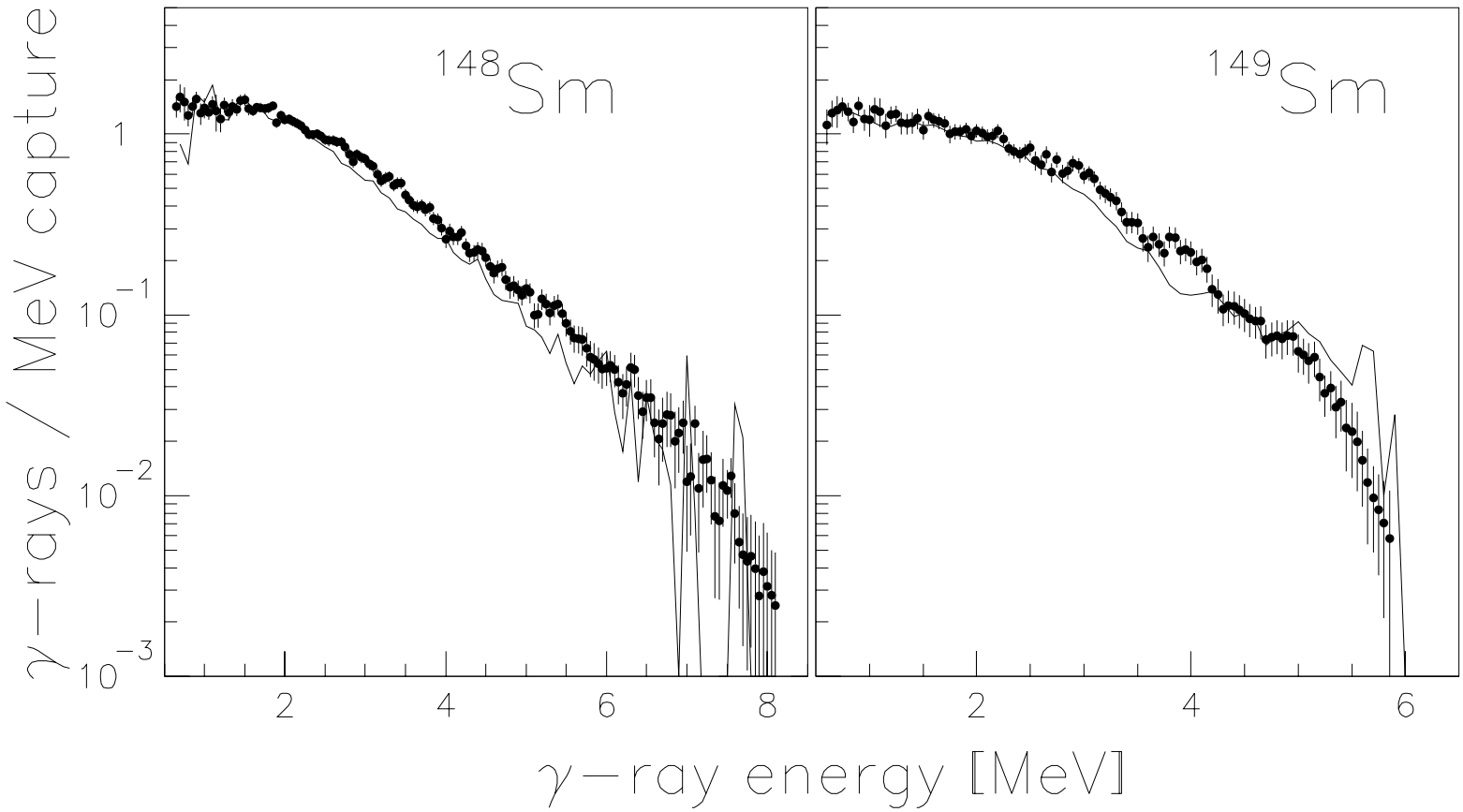
Scissors mode



Established M1 multipolarity of a pygmy resonance in ^{172}Yb at $E_\gamma = 3.3$ MeV

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

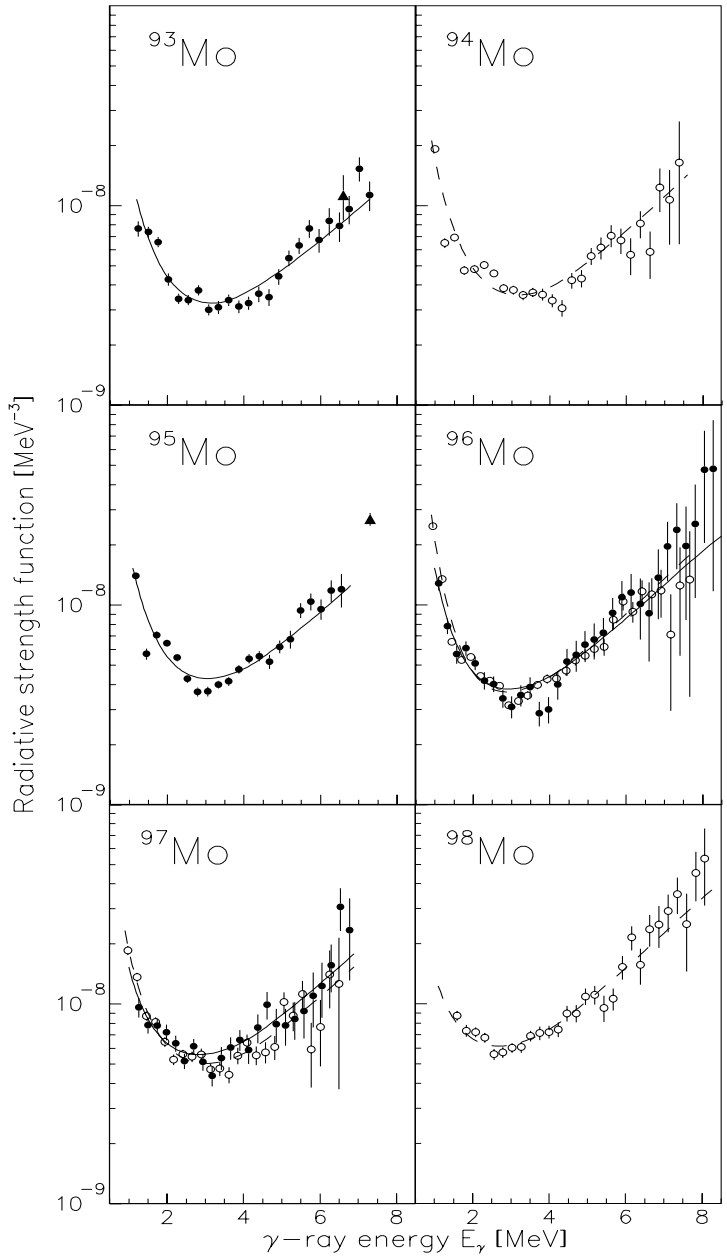
Total γ–spectrum from $E_x = B_n$



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

γ-strength functions in Mo isotopes

Filled circles: (3He,a)
Open circles: (3He,3He*)



R. Chankova PhD thesis

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Summary

- Unique technique to extract level densities and γ-strength function experimentally
- From level density we extract thermodynamic properties like Temperature and Cv . Indication of a phase transition around Temp=0.5MeV.
- A pygmy resonance is observed in several nuclei and from our data we conclude that its nature is M1, scissors mode.
- We don't understand the large enhancement in strength function for low $E\gamma$
- Analysis in progress on ^{143,144,146,147}Sm and ^{207,208}Pb and new exp on ^{205,206}Pb in september

Future outlook,

level density as a function of spin

- Experiment with **AGATA/GRETINA**: high efficiency, highly segmented and excellent energy resolution
- Possibility to gate on yrast transition of different spin and still have enough statistics to do our analysis
- Study level density as a function of spin and also 1-2MeV above Bn
- Polarization measurments of the upbend in the strength function at low $E\gamma$

Collaborators

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- E.Algin, Tyrkia