Inelastic scattering of fast neutrons from excited states in ^{56}Fe

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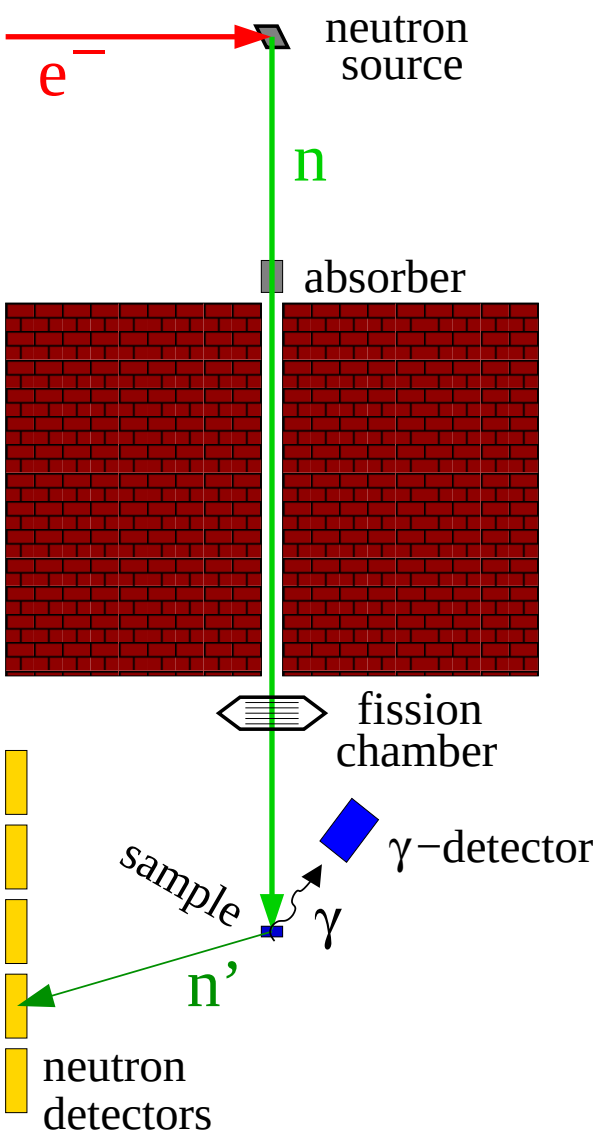
Setup at nELBE



- Target: cylinder of natural iron diameter 20 mm, thickness 8 mm
- HPGe detector at 125° to the neutron beam and a distance of 20 cm from the target
- Time difference between accelerator pulse and signal of the HPGe detector
  ⇒ time-of-flight of the incident neutrons
  ⇒ time resolution 10 ns

Neutron-scattering cross section

$$\sigma = \frac{N_\gamma(E_n)}{\varepsilon_\gamma \Delta E_n} \cdot \left[\frac{\Phi(E_n)}{\Delta E_\Phi} N_{\mathrm{at}} \right]^{-1} .$$

$N_\gamma(E_n)$ – number of events in the γ peak observed at a neutron energy E_n.

ε_γ – efficiency of the HPGe detector.

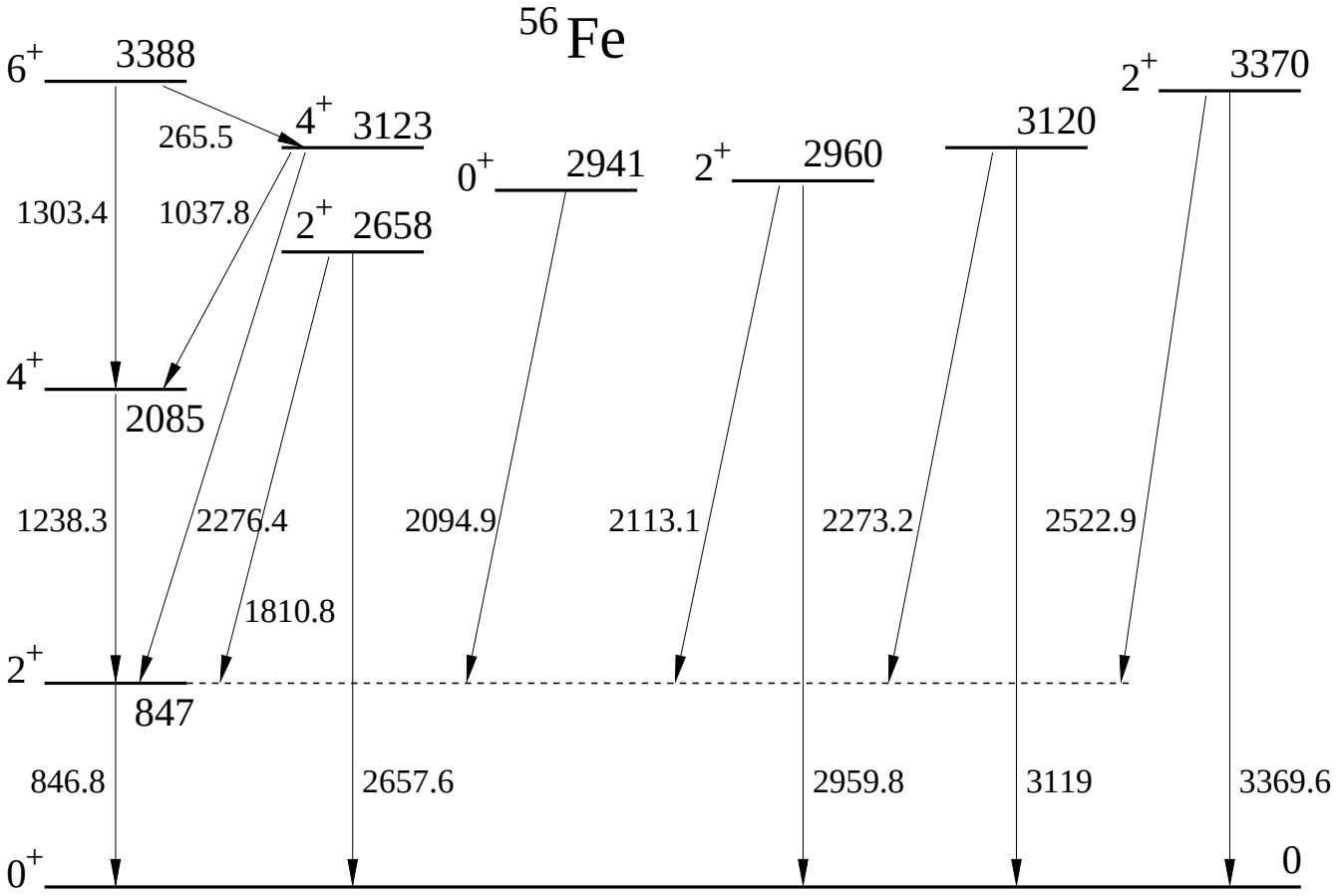
ΔE_n – energy-bin width deduced from the gate width in the time-of-flight spectrum.

$\Phi(E_n)$ – neutron fluence (time integral over the neutron-flux density) at E_n.

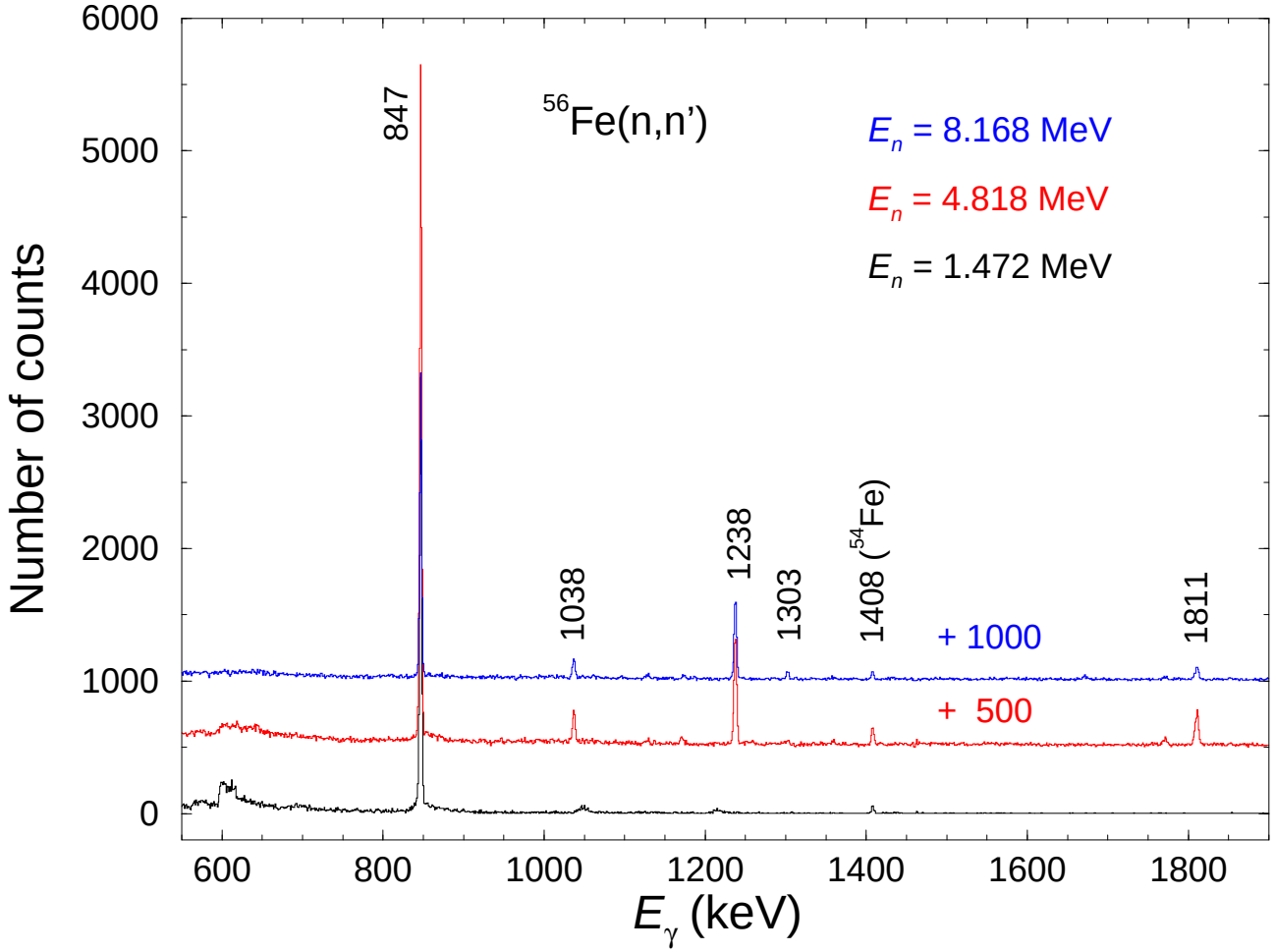
ΔE_Φ – energy-bin width of the neutron fluence.

N_{at} – number of atoms per target area.

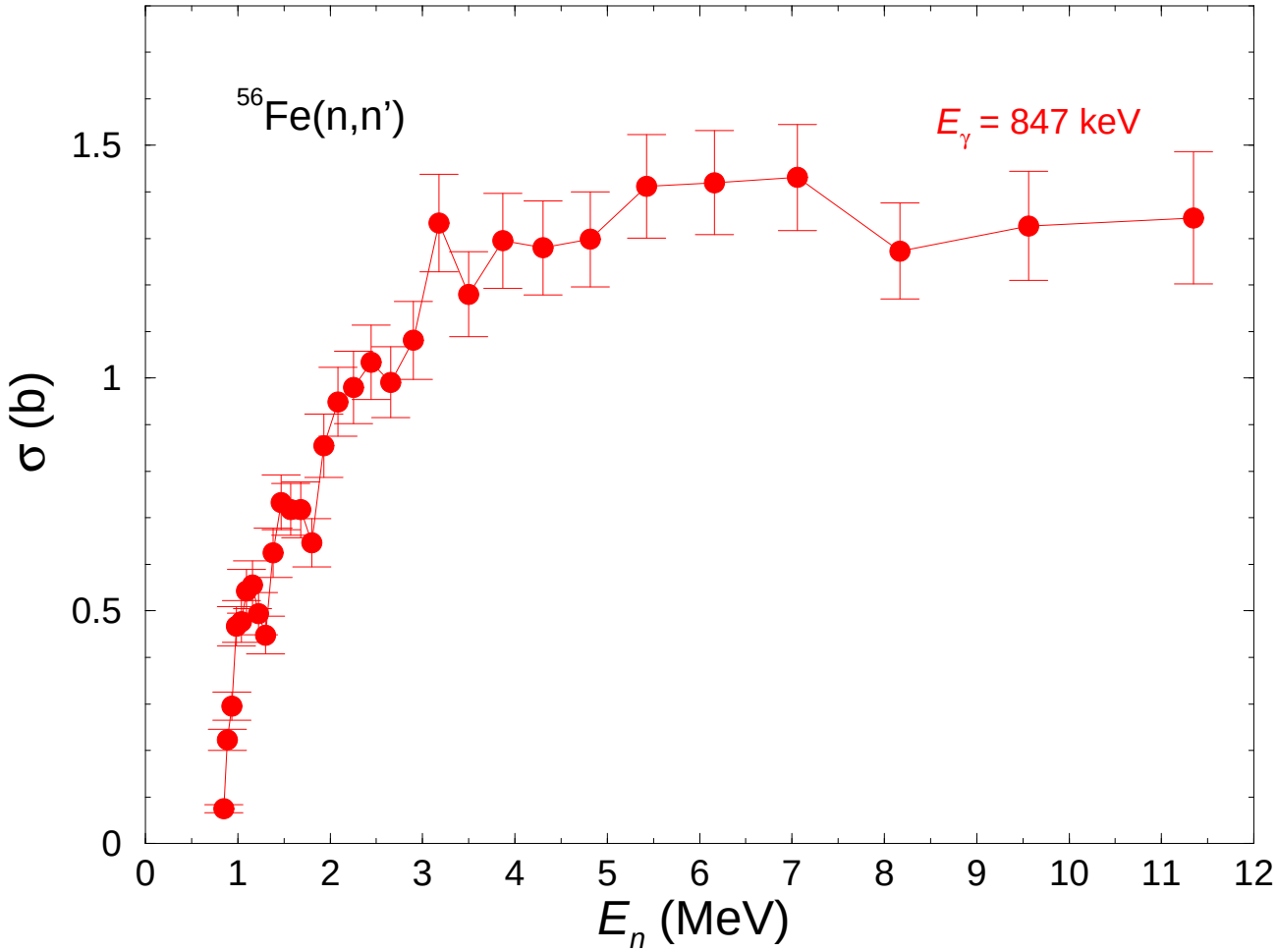
Excited states in ^{56}Fe



Gamma-ray spectra at various neutron energies



Cross section for inelastic scattering from ^{56}Fe



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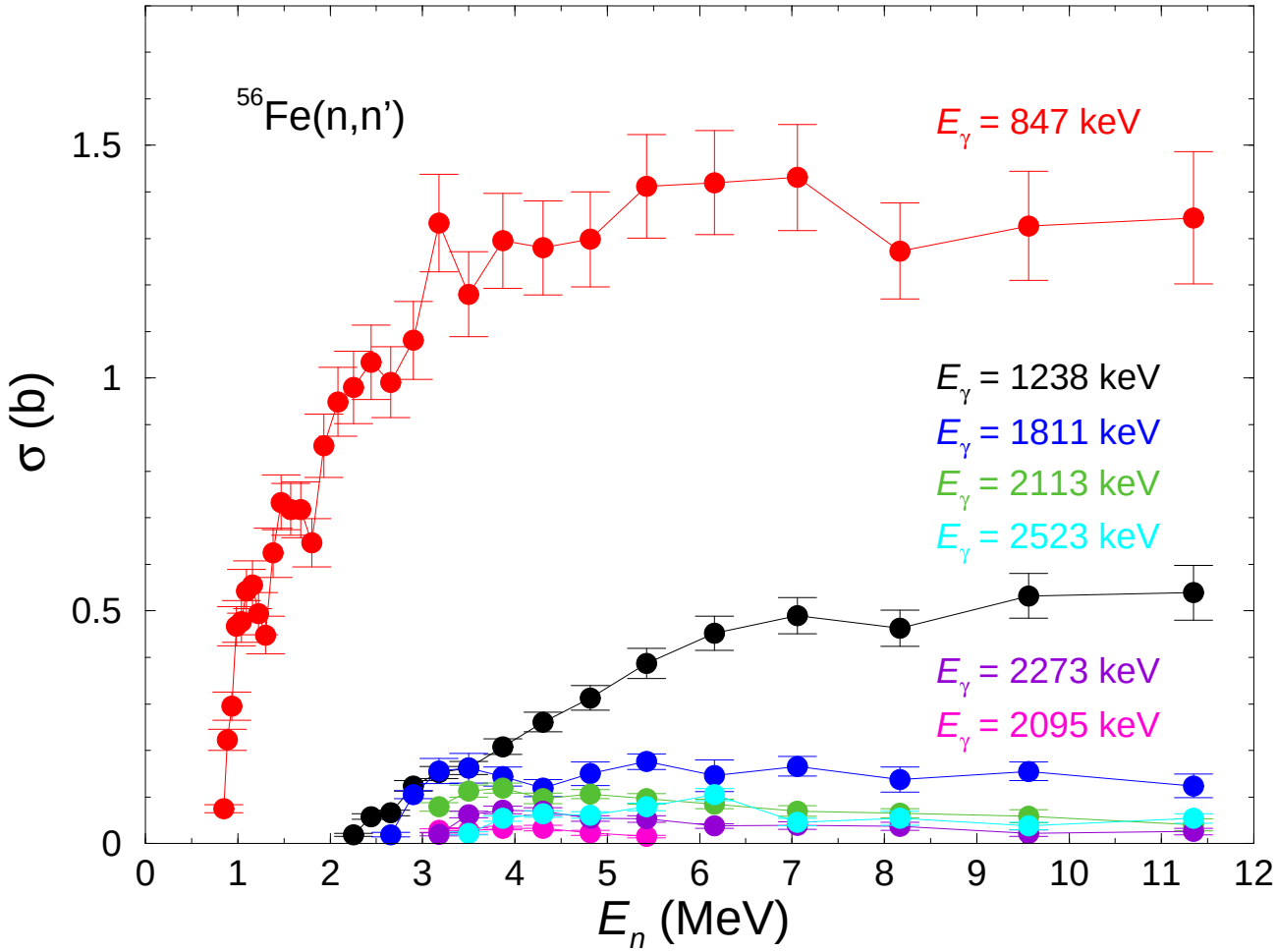

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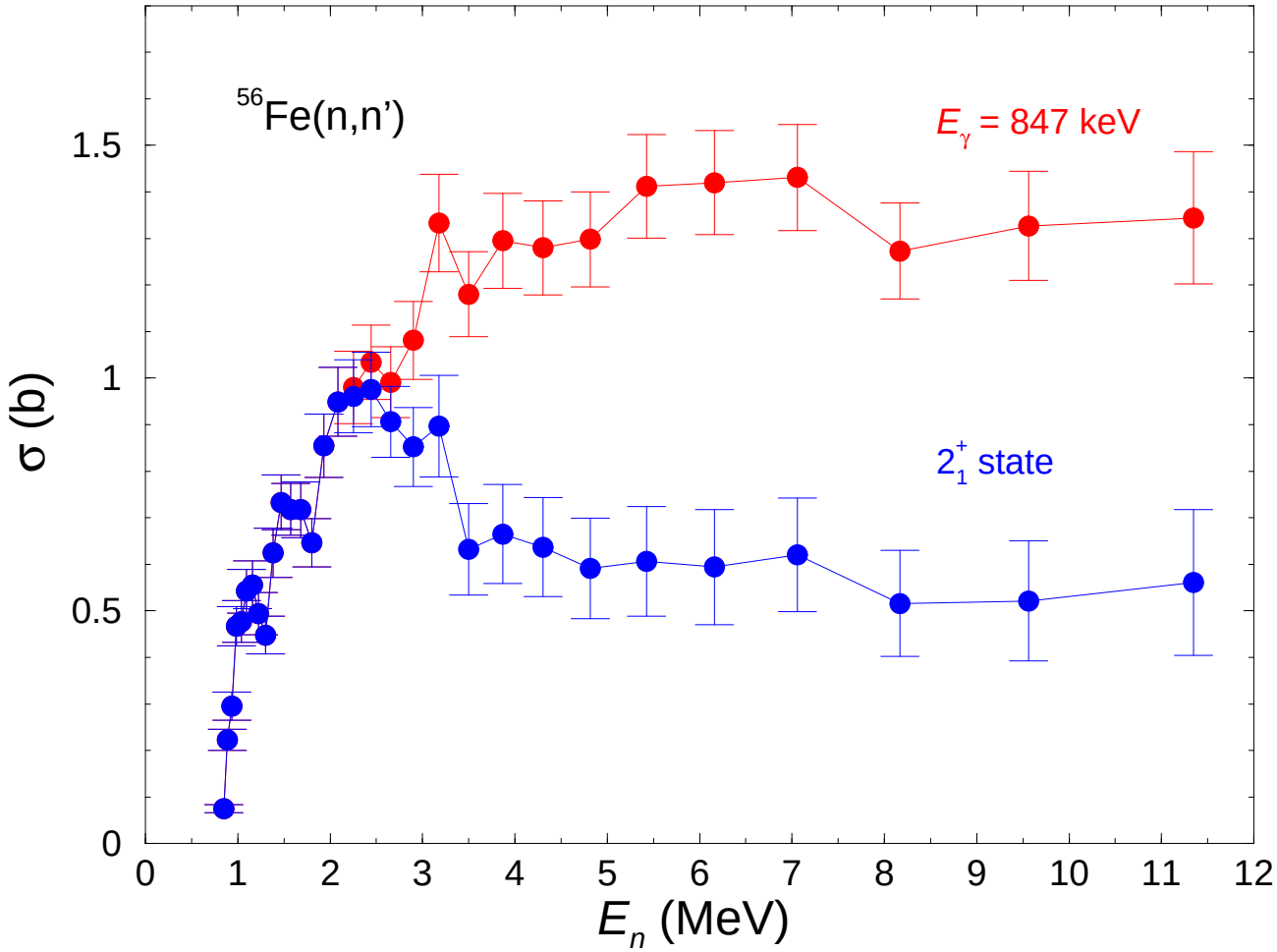

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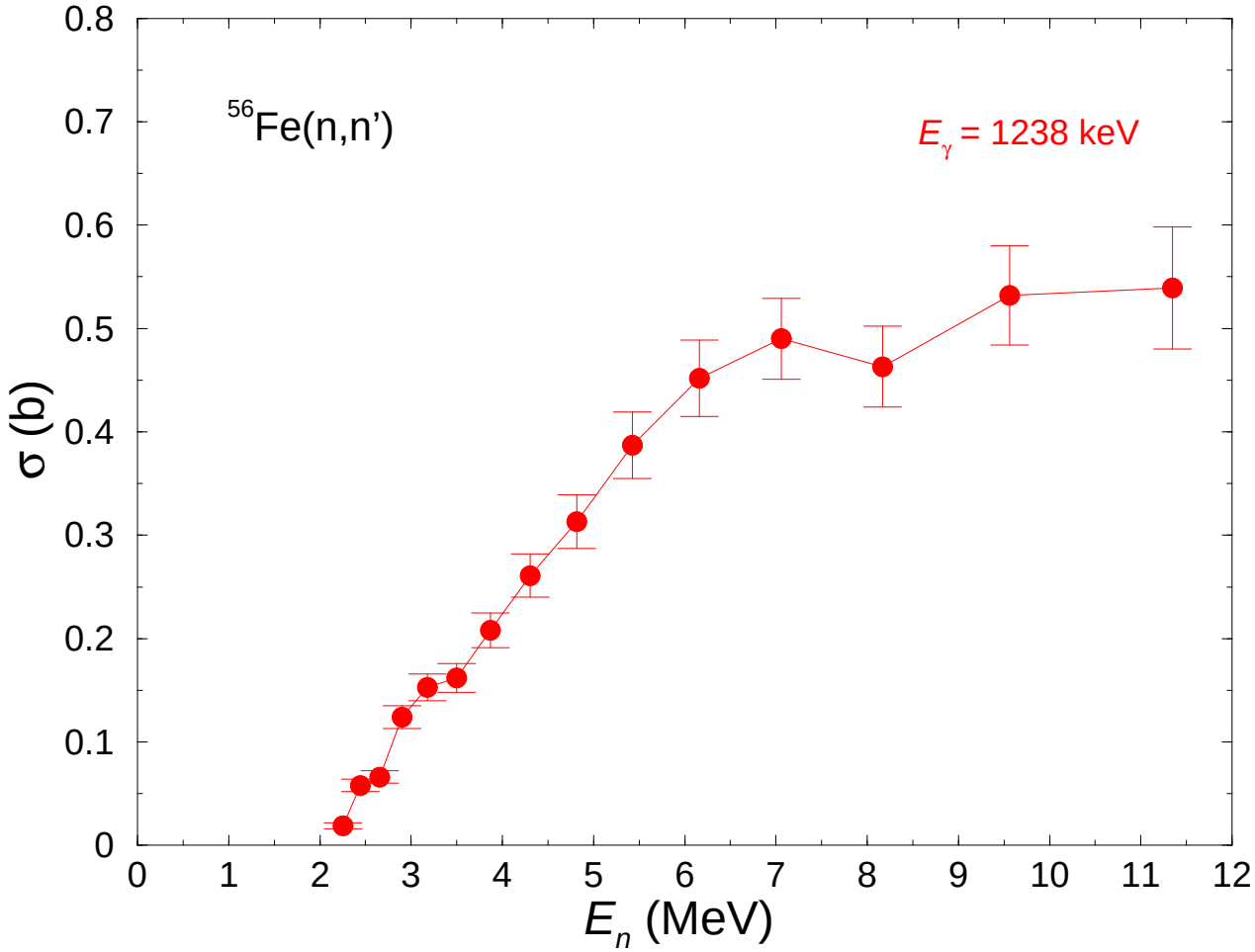

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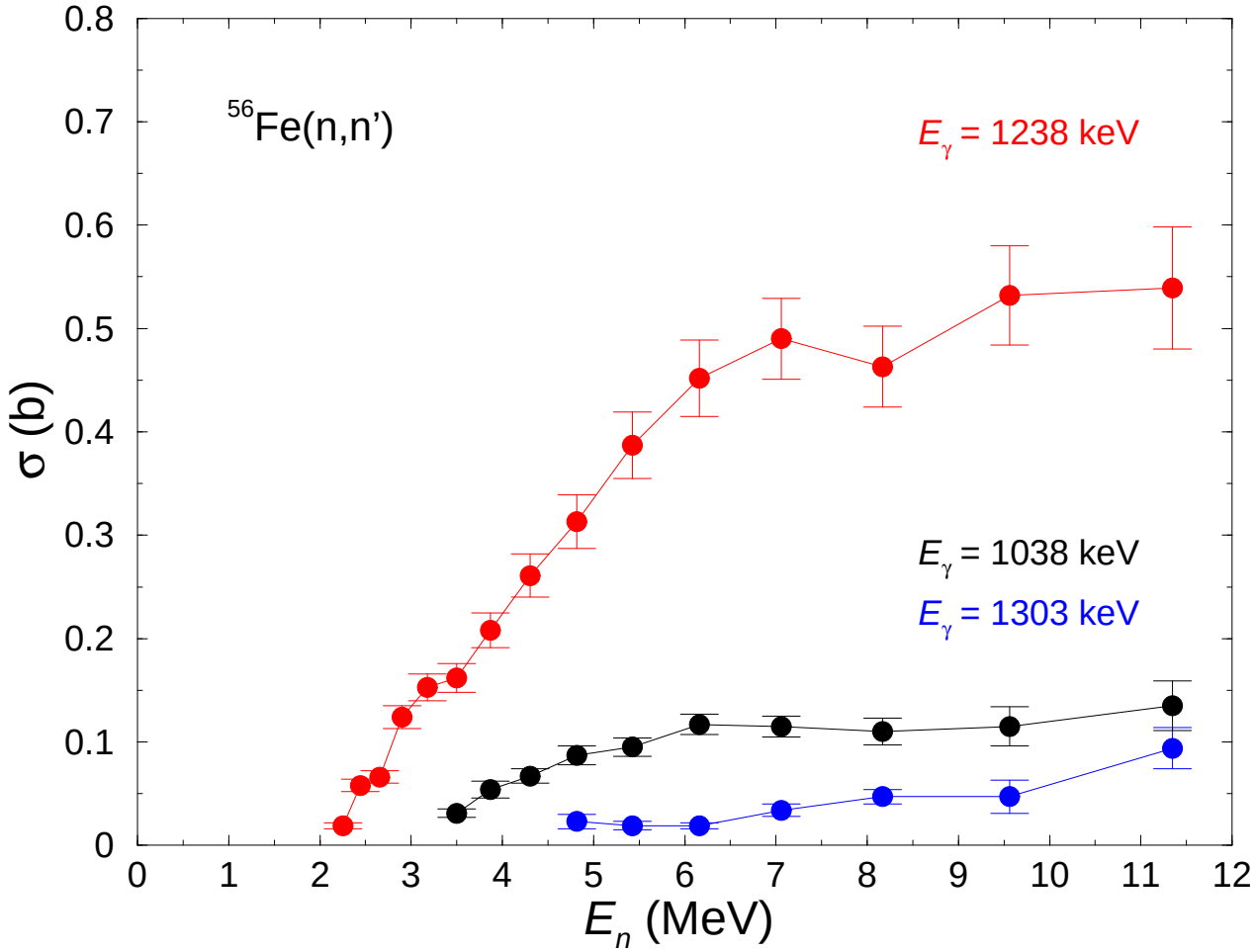

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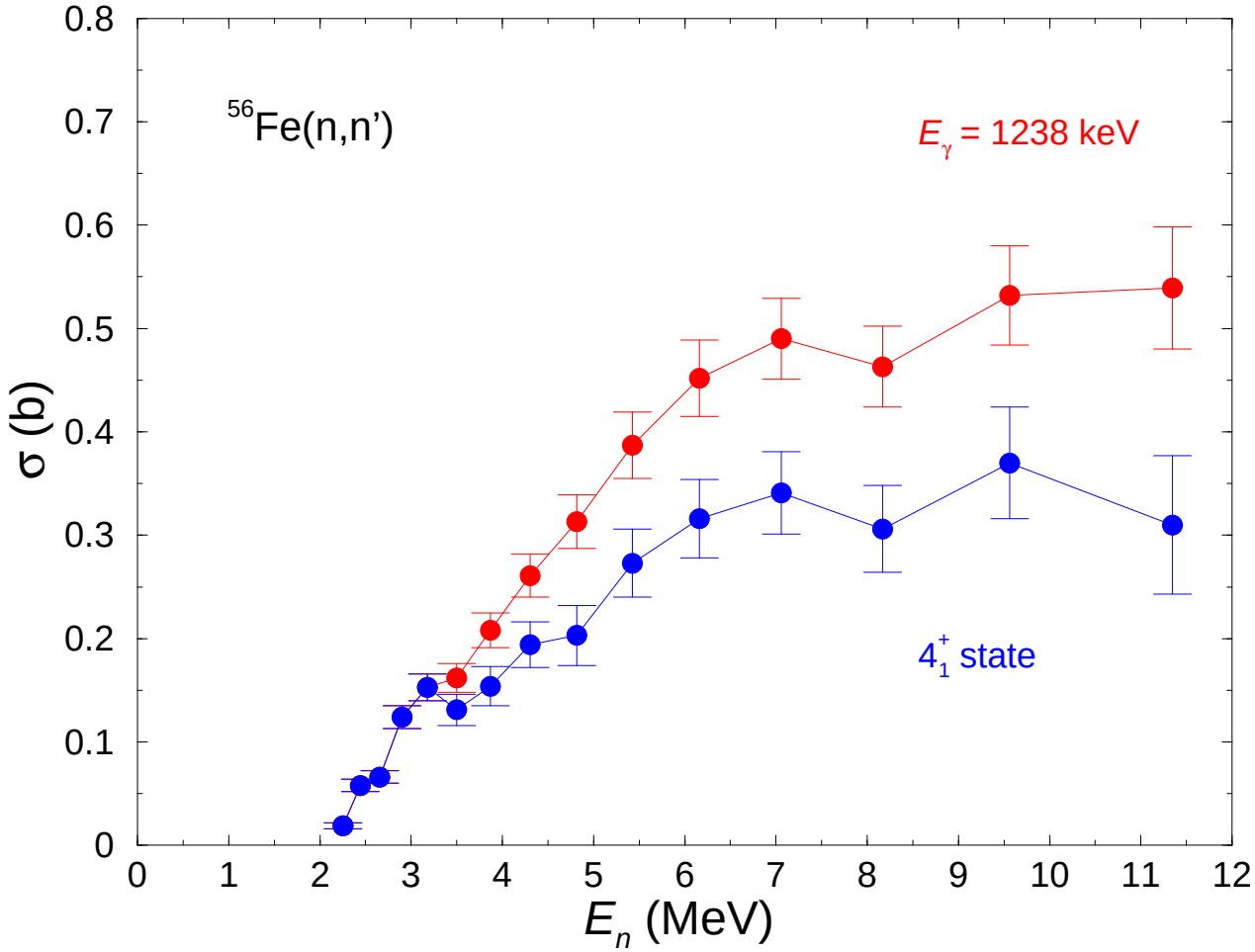

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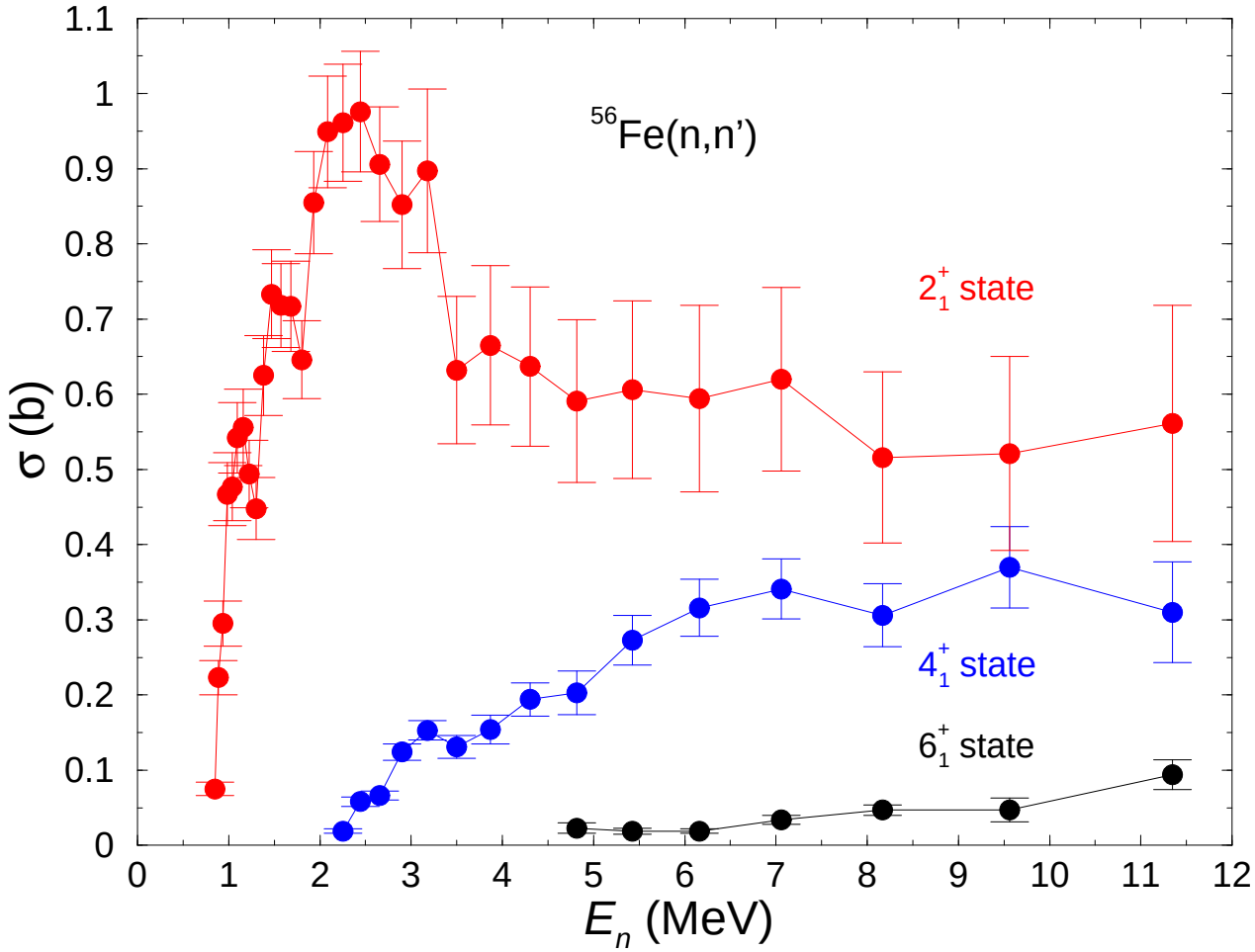

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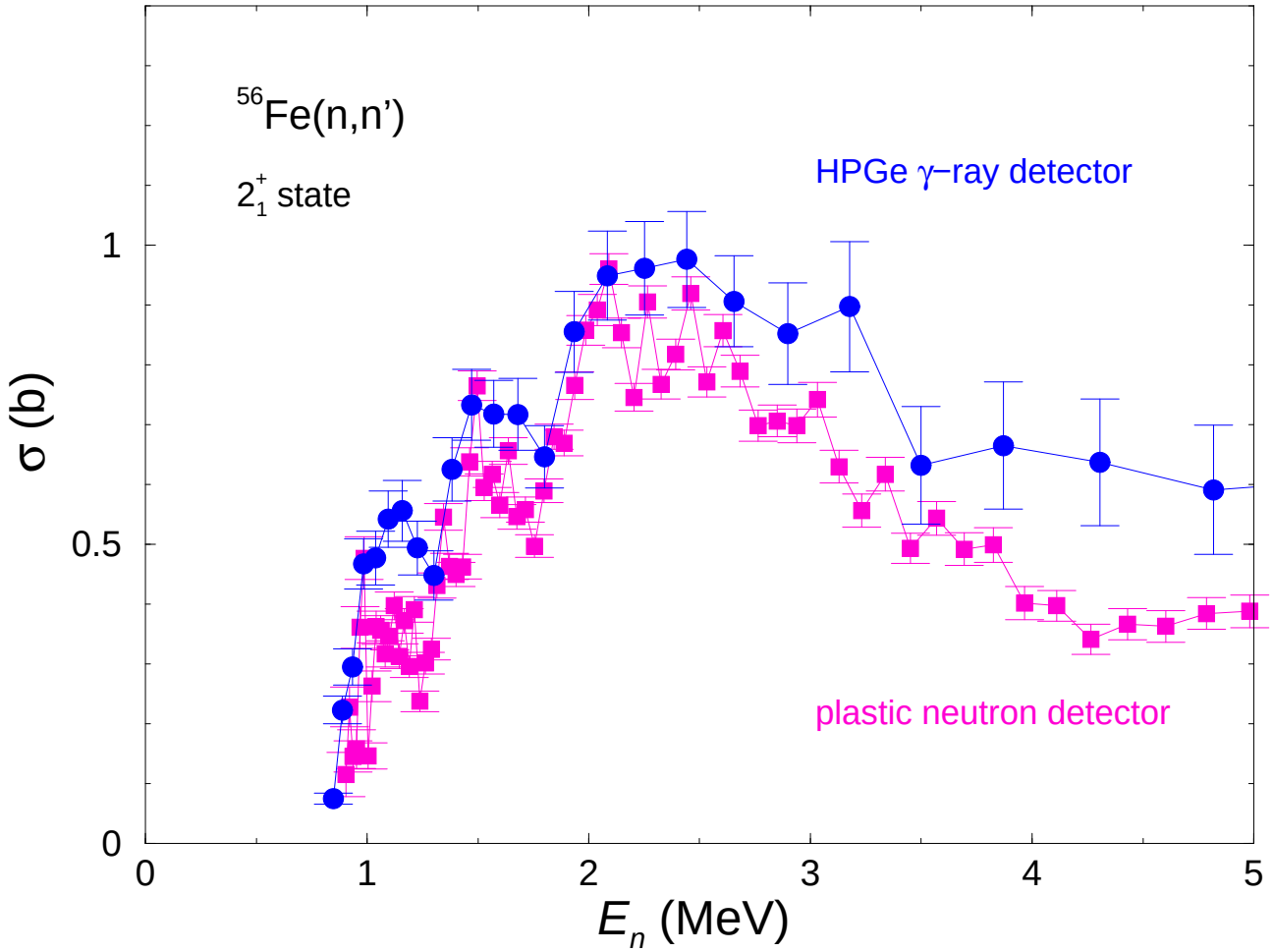

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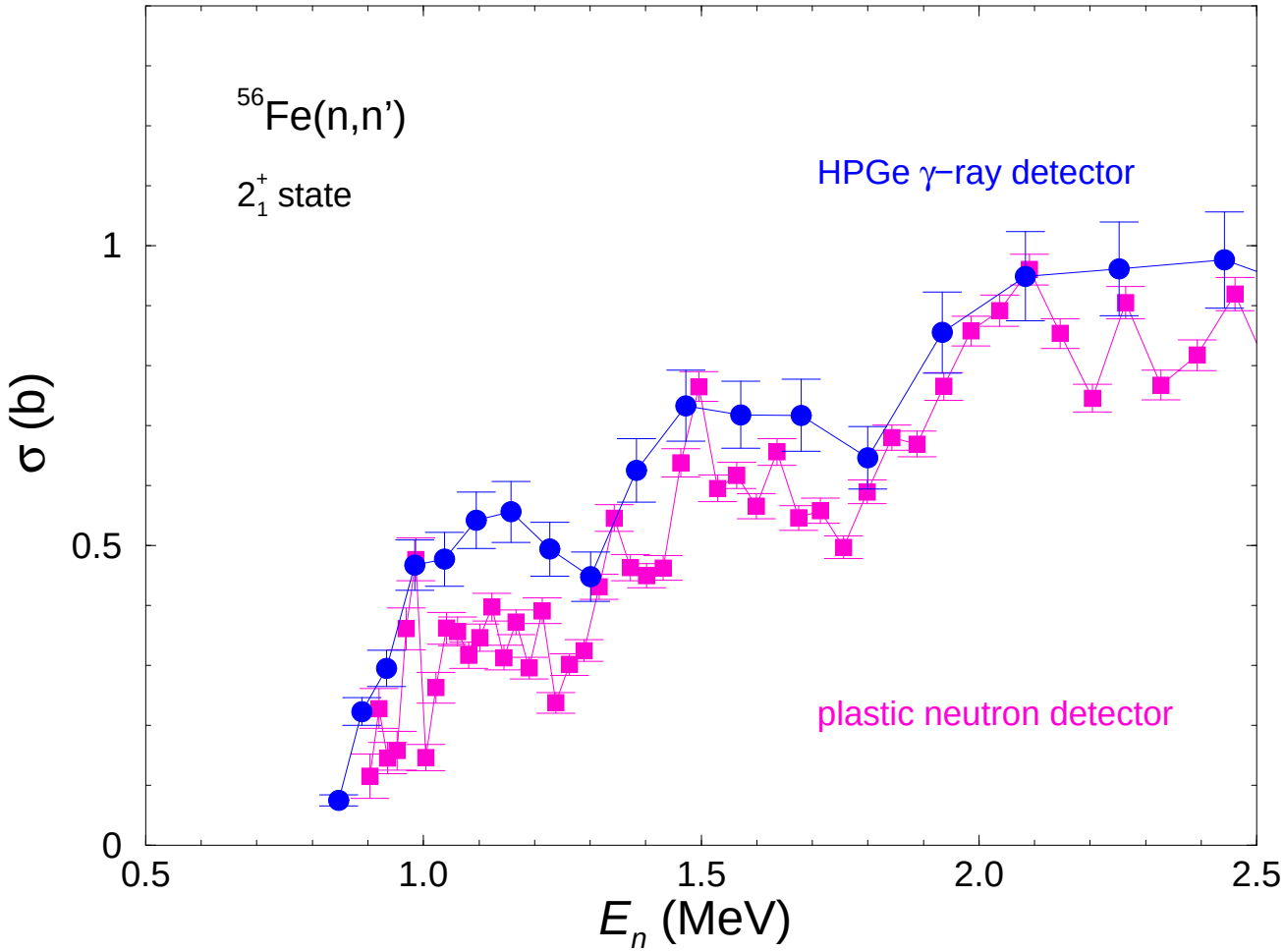
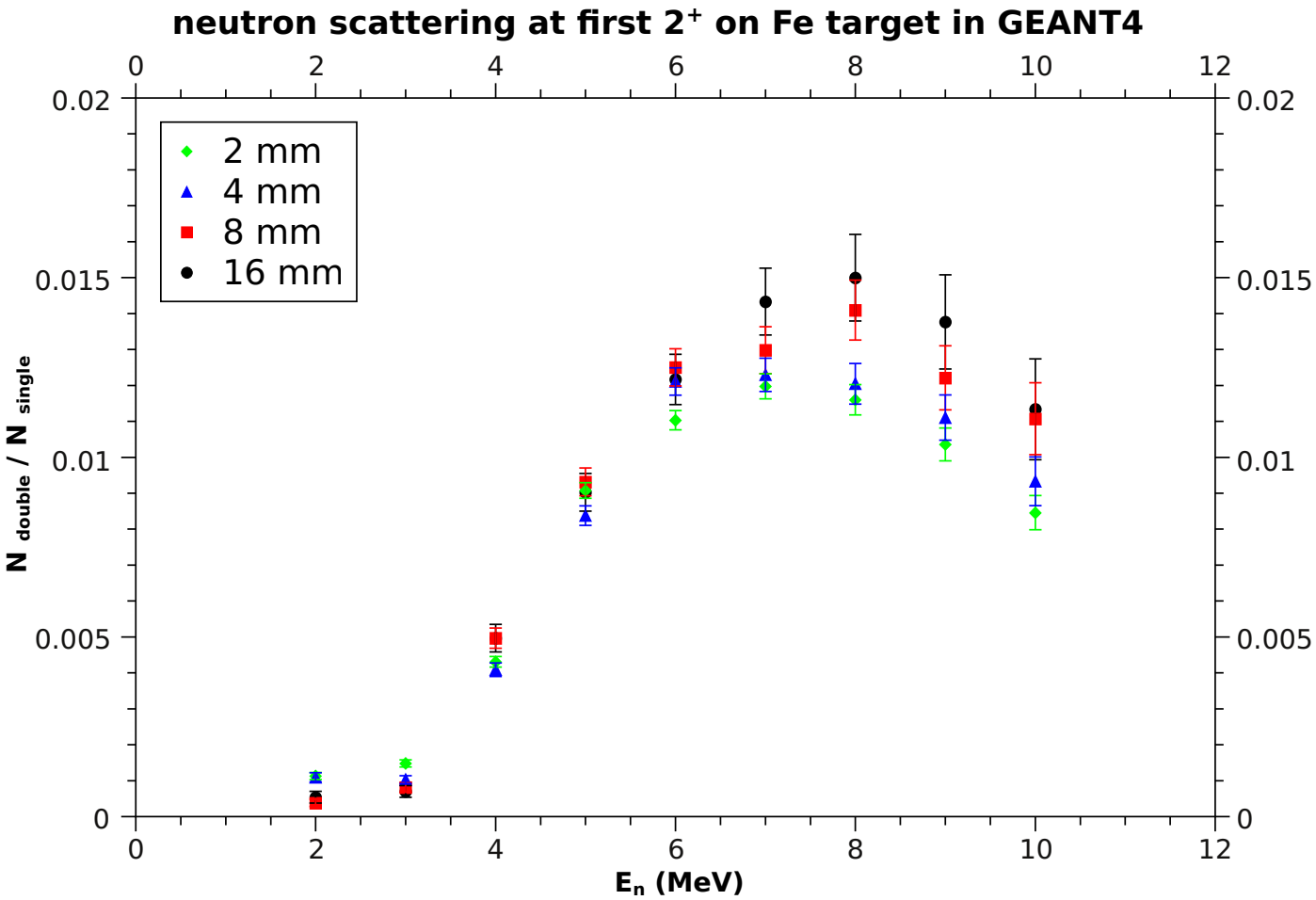


Multiple inelastic scattering from ^{56}Fe



Excitation of 2^+ states in two ^{56}Fe nuclei by one neutron and detection of the two 847 keV γ rays at 125°.

Conclusions

- High-resolution measurement of γ rays from states excited in inelastic neutron scattering.
- Determination of the cross section for individual excited states as a function of the neutron energy.
- Advantage of the measurement of γ rays with an HPGe detector: measurement of the time-of-flight of the scattered neutrons not needed.
  Disadvantage: time resolution of 10 ns compared with 0.7 ns of the plastic scintillators used for the detection of scattered neutrons.
  $\Rightarrow$ Fine structures of the cross sections may be washed out.