Characterization of a stilbene-based fast neutron spectrometer for studies with radioactive beams at ACCULINNA-2 fragment separator

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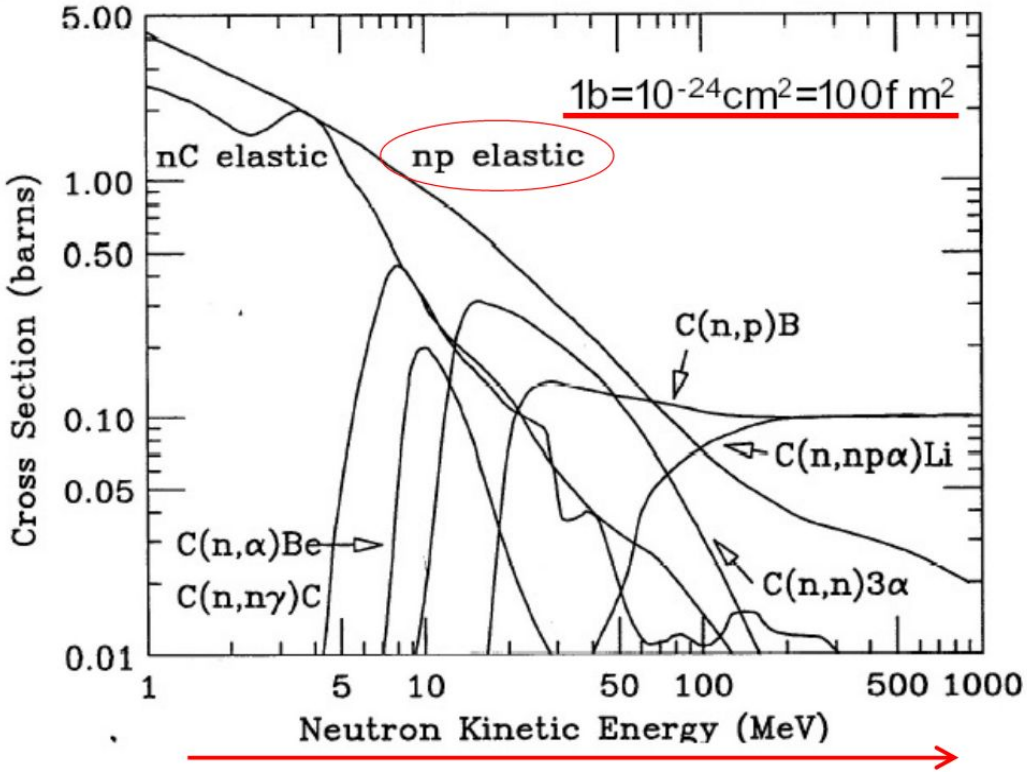
Neutron detection

Neutron-matter interaction cross-sections
in accordance with different neutron energies



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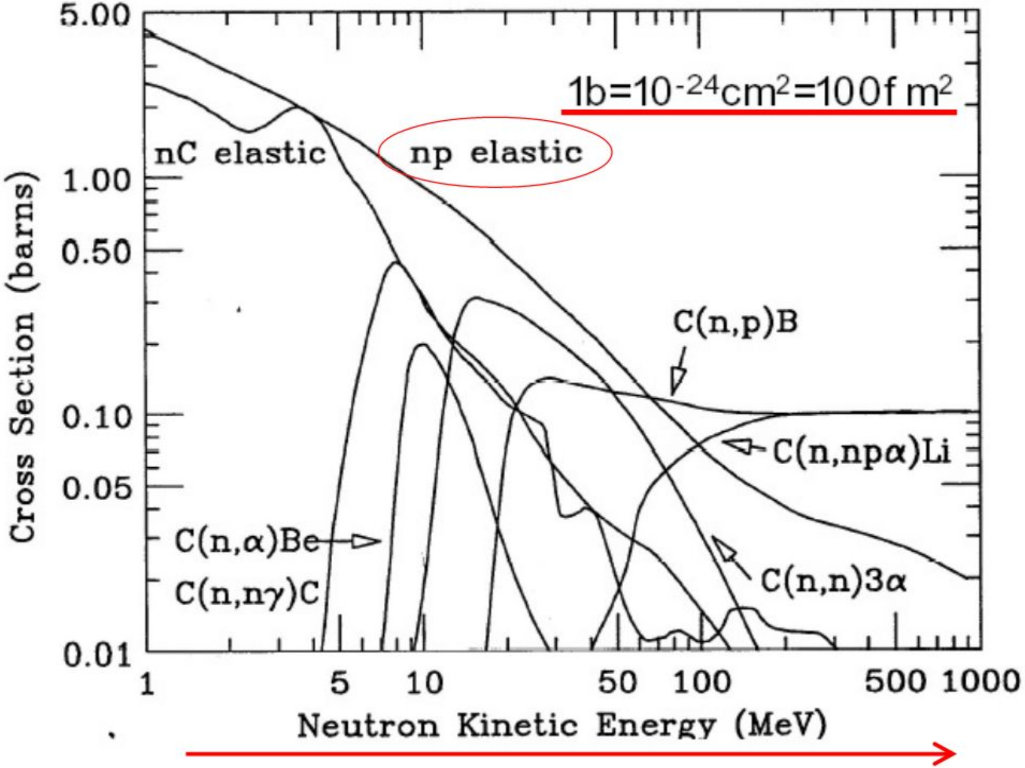

Stilbene crystals:

- high luminescence efficiency
- fast response time

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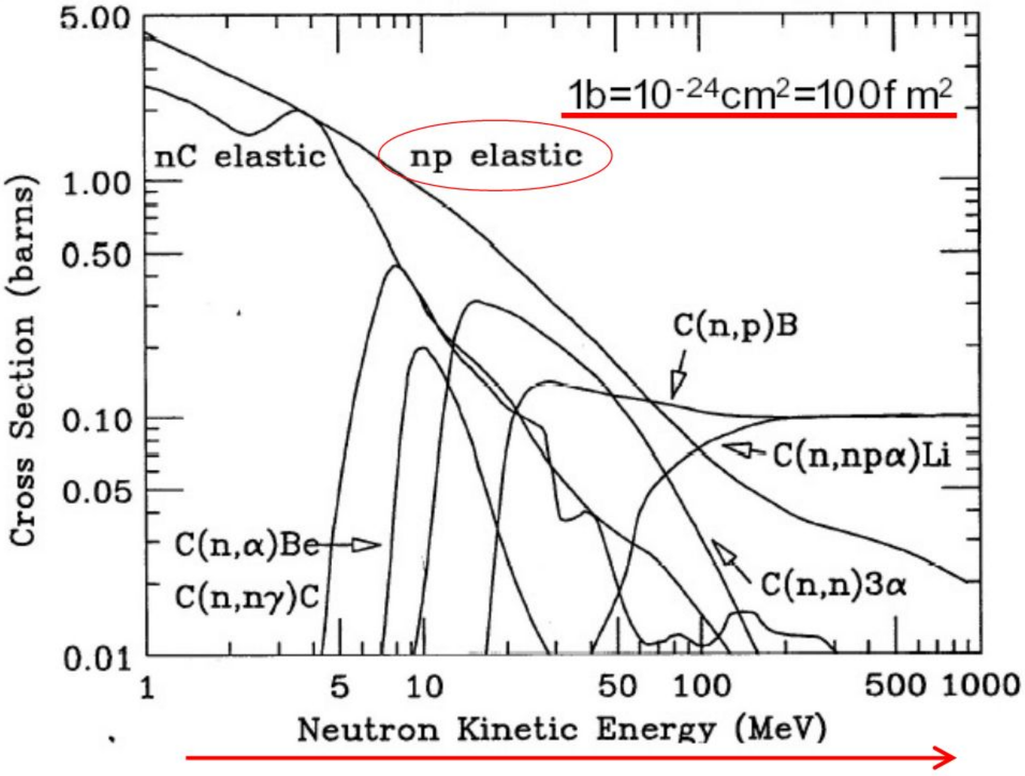

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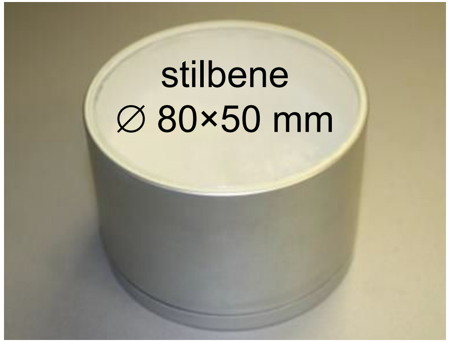
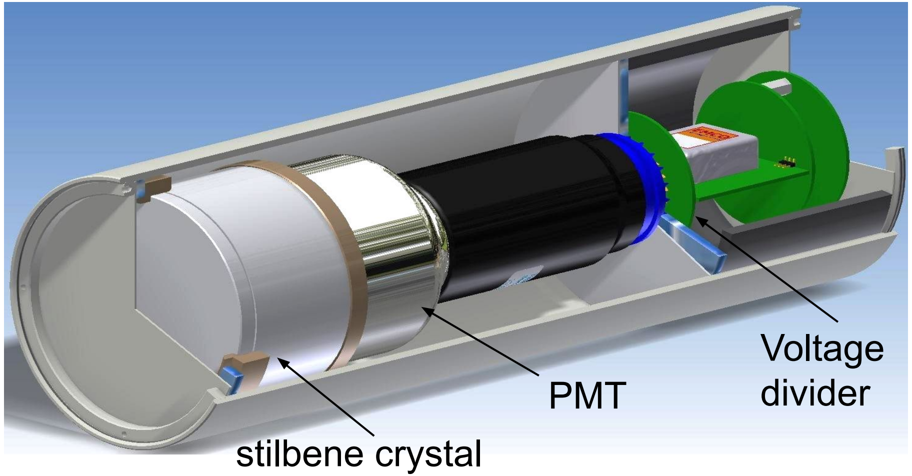
Stilbene crystals:

- high luminescence efficiency
- fast response time
- crystalline and solid
  → high durability, non-flammable
- greatly sensitive to neutrons
  → well-suited in our energy range
- excellent neutron-gamma discrimination

Stilbene crystals fit all qualifications
and were chosen to implement
in our neutron spectrometer @ ACCULINNA-2

Stilbene based neutron spectrometer

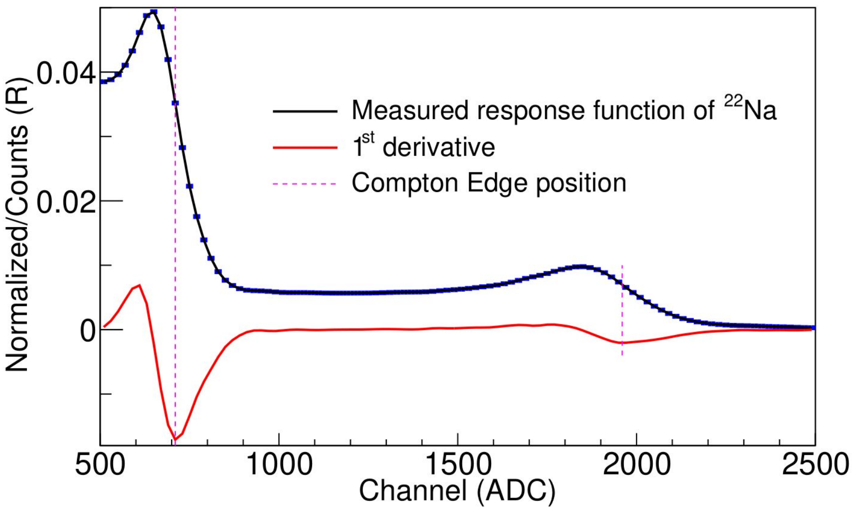




1. Gamma measurements

Energy calibration

An example of Compton edge (CE) from stilbene scintillator using ^{22}Na source



The Compton edge energy E_{CE}
is computed at a given gamma energy as follows

$$E_{CE} = E_{\gamma}(1 - \frac{1}{1 + \frac{2E_{\gamma}}{m_e c^2}})$$

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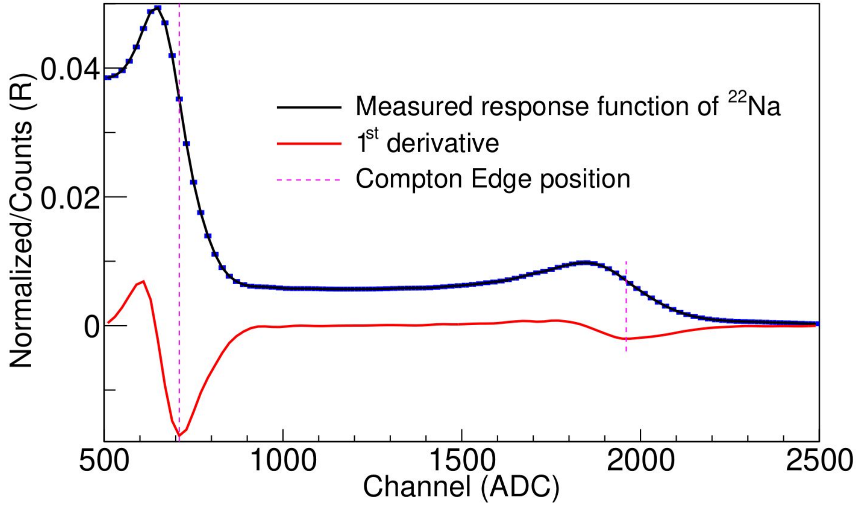
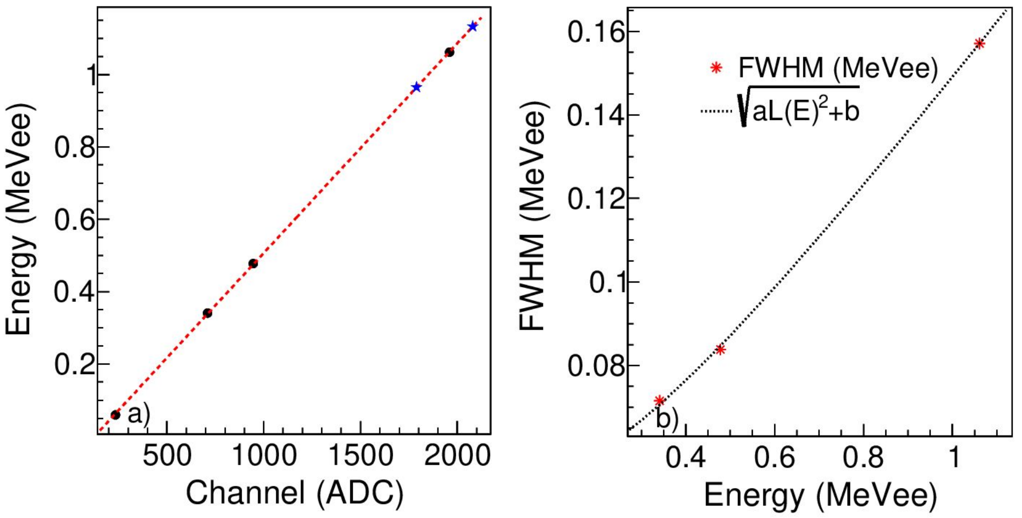


We utilized a set of common γ-sources ^{241}Am, ^{22}Na, ^{137}Cs and ^{60}Co for energy calibration



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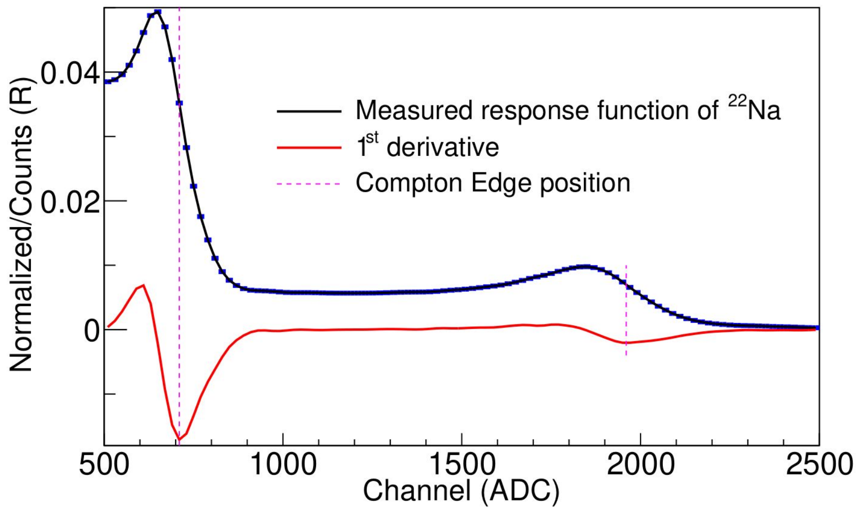

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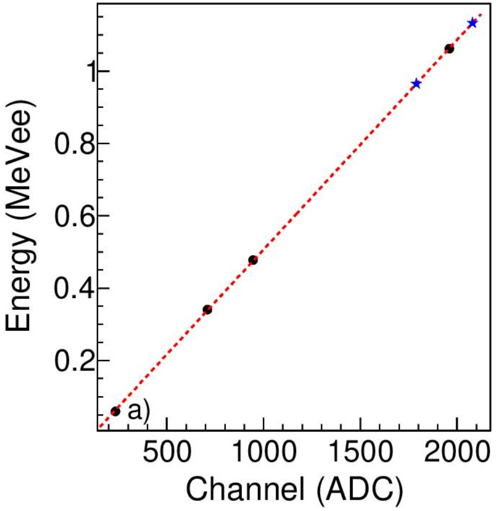
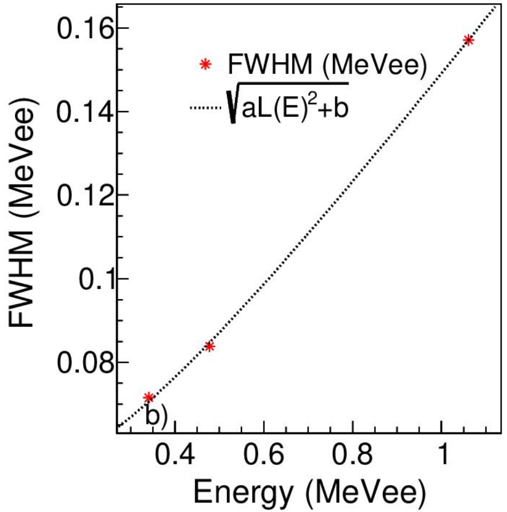




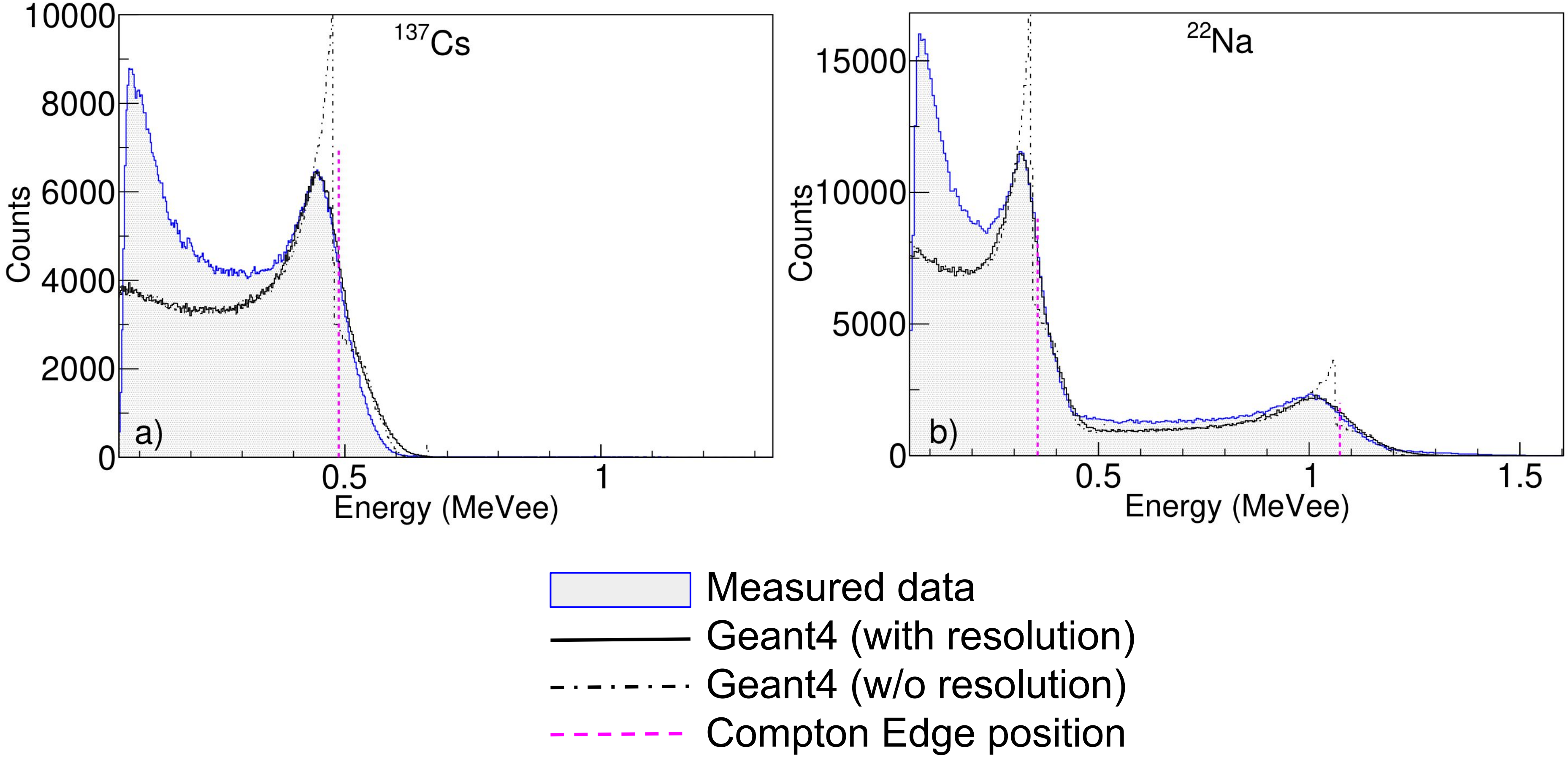
The Compton edge energy E_{CE} is computed at a given gamma energy as follows

$$E_{CE} = E_\gamma\left(1 - \frac{1}{1+\frac{2E_\gamma}{m_e c^2}}\right)$$

$$E(MeVee) = 0.00066478 \times Channel(ADC) - 0.030316$$

$$FWHM(MeVee) = \sqrt{0.0195 \times E^2(MeVee) + 0.00272}$$

Compared with GEANT4 simulation



Time resolution

γ-γ coincidence measurement with ^{60}Co

The 2D spectrum of the time difference
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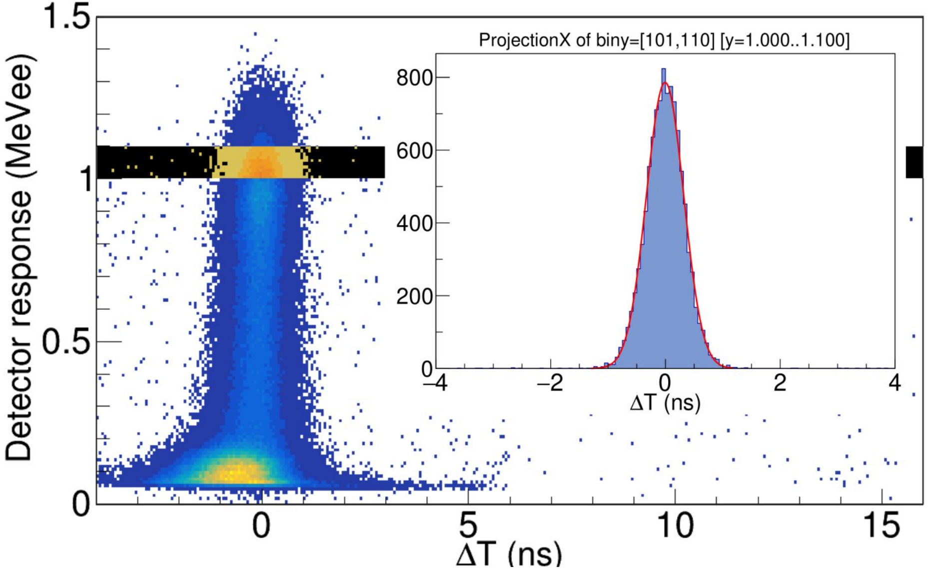

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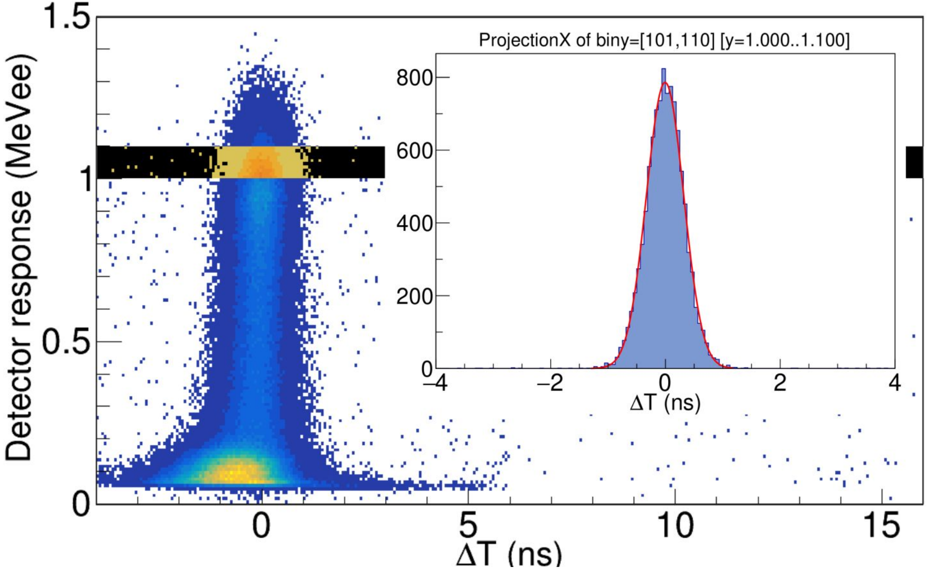
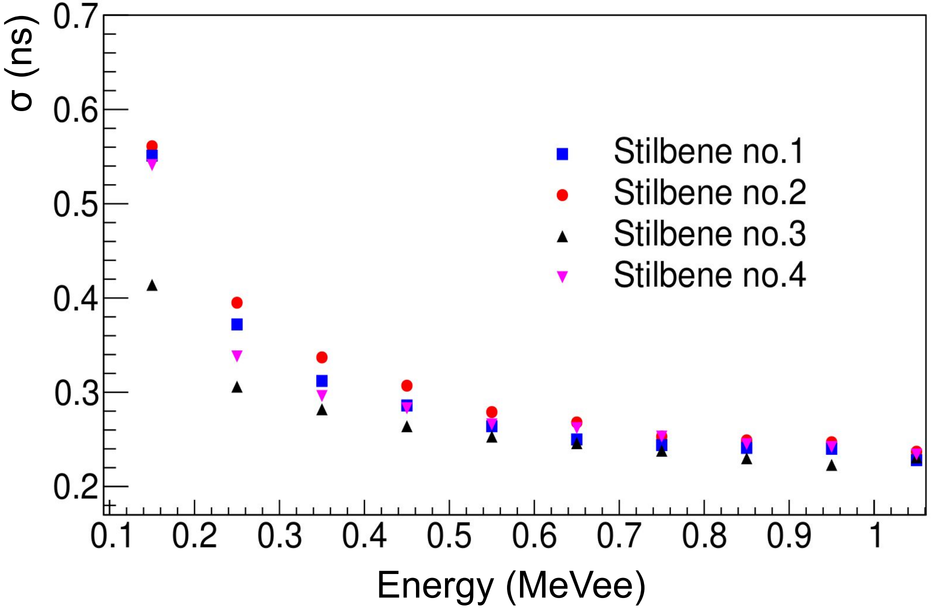


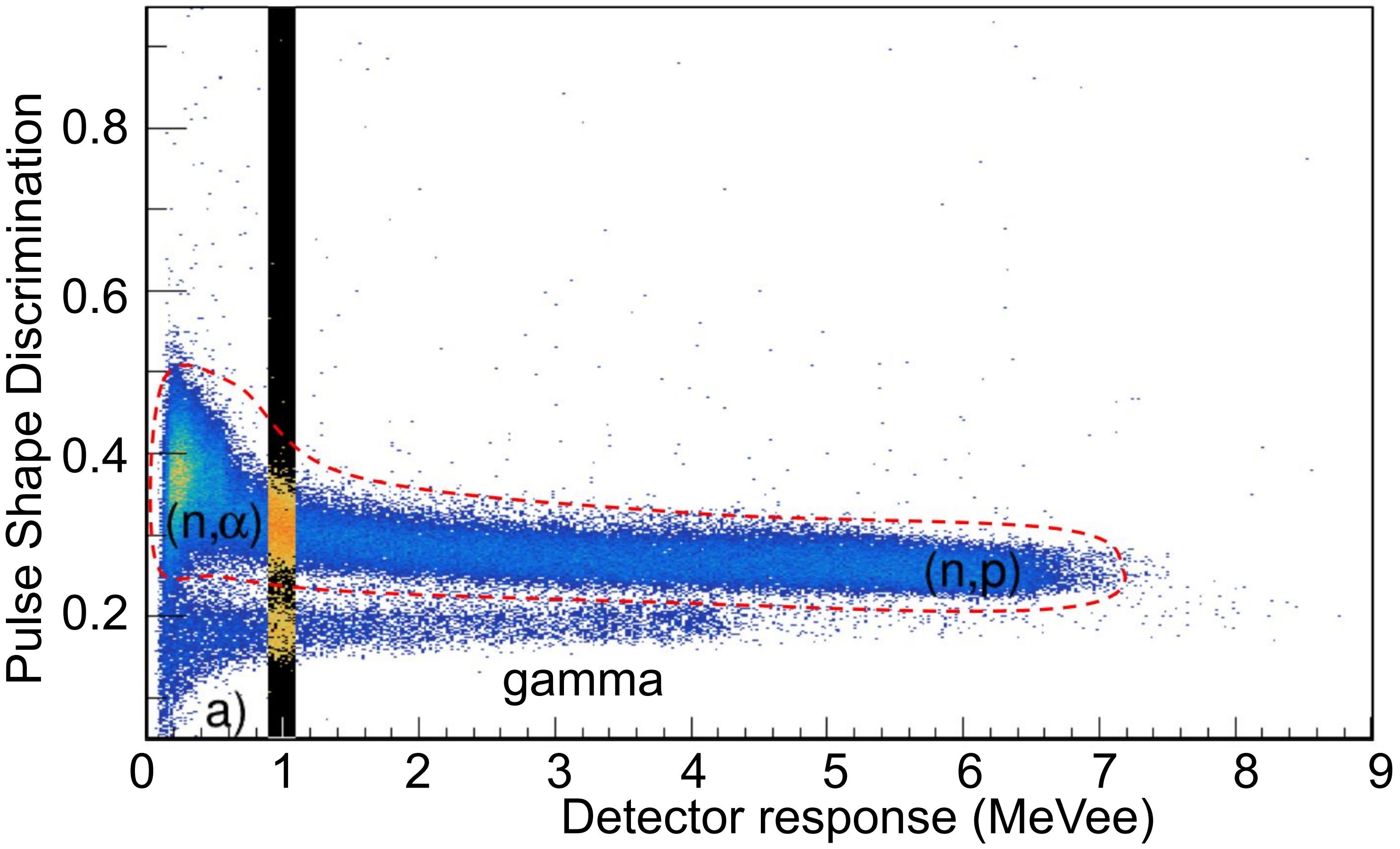
Energy dependence of the time resolution



- ➔ Different range of the data derives from disparate signal sizes.
- ➔ The resolution worsens with decreasing signal amplitude.
- ➔ Low-energy events are associated with the registration of rescattered γ-quanta.

2. Neutron measurement by means of ING-27 DT neutron generator

Neutron-gamma discrimination



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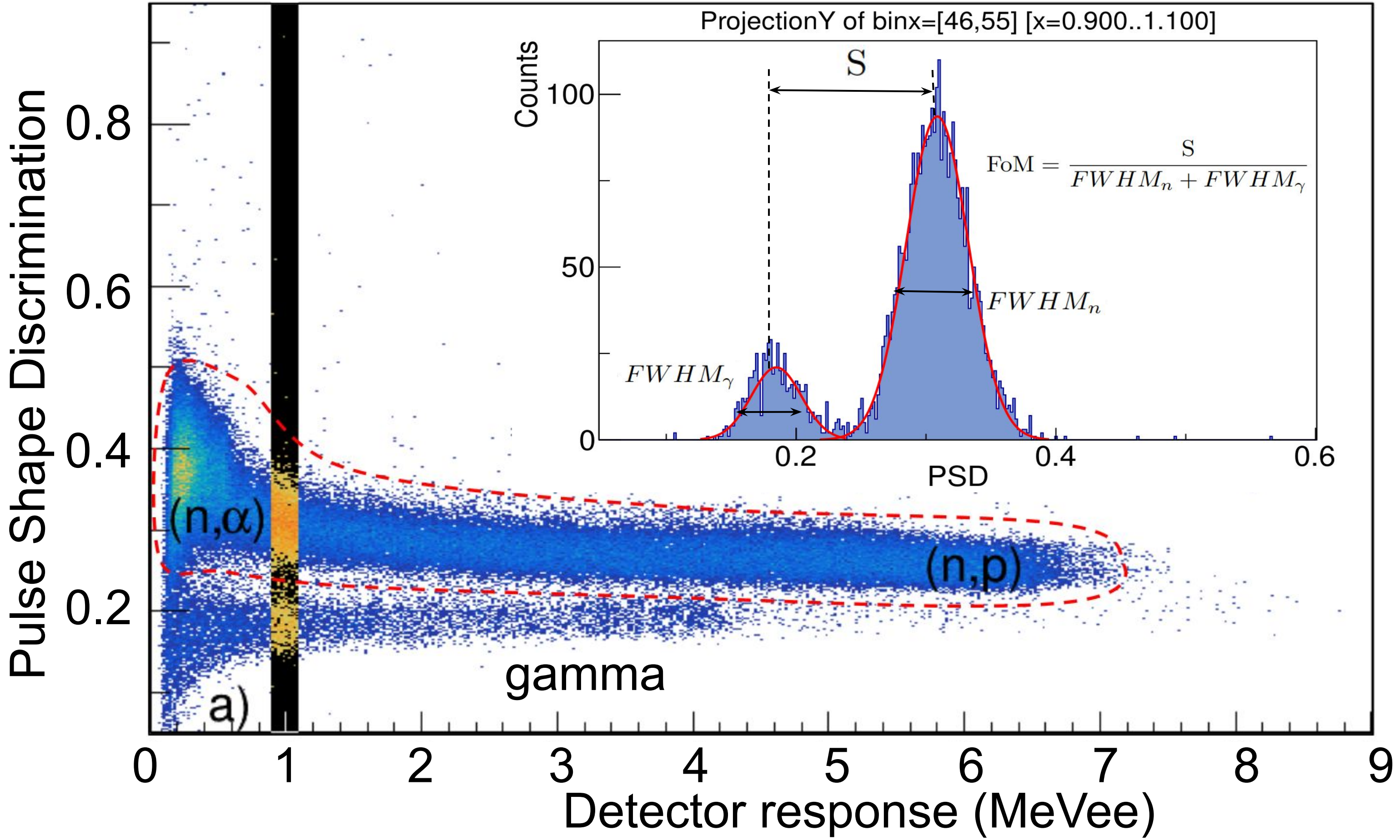
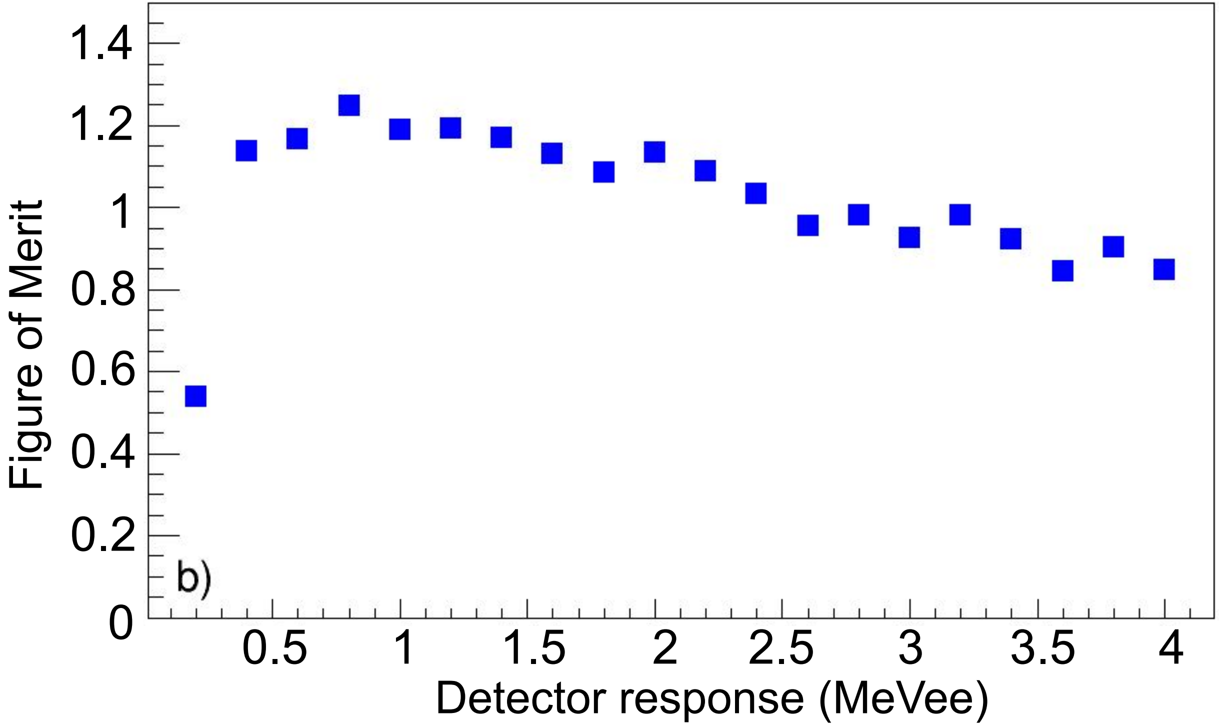


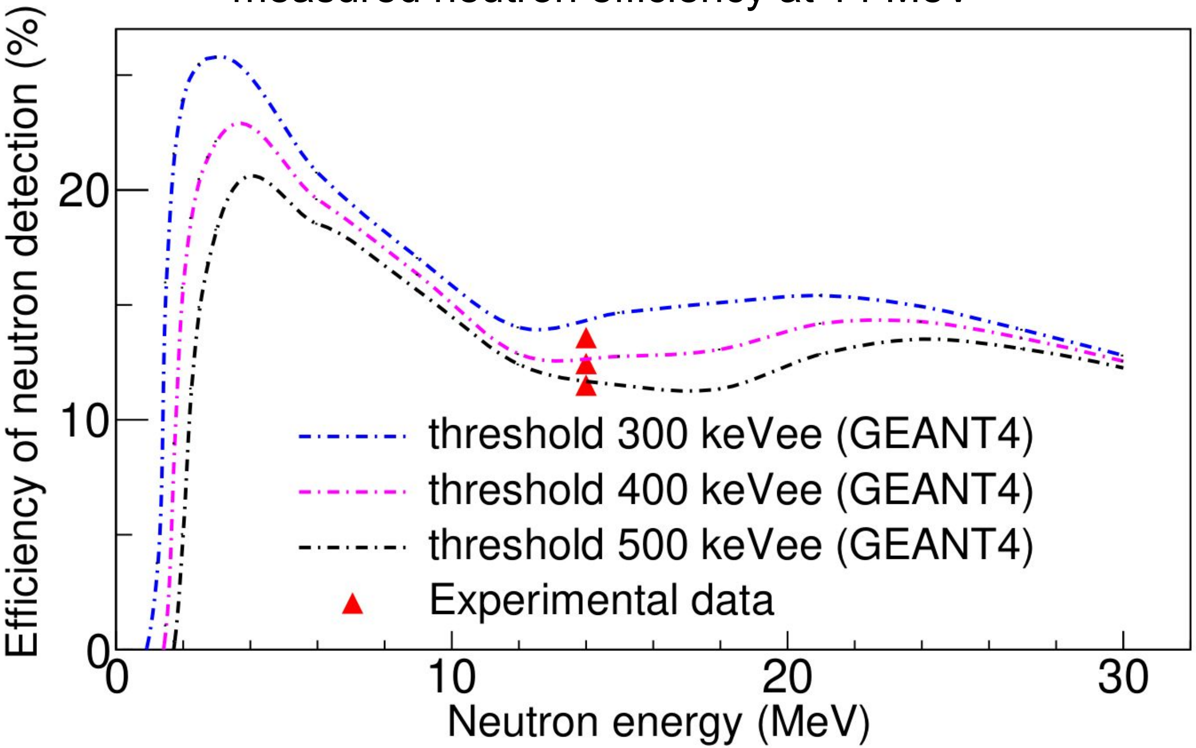
Figure of Merit (FOM)



- ➔ The FOM factors determine its neutron-gamma discrimination capacity.
- ➔ Apparently, the n–γ peaks are well separated @ above 0.3 MeVee, which is in accordance with the maximum neutron energy around 1 MeV.

Neutron registration efficiency

The calculated neutron detection efficiency of stilbene detector at different incident neutron energies 1-30 MeV compared to the measured neutron efficiency at 14 MeV



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- ➔ The 1st derivative of measured response combined with Geant4 simulations were to calibrate and extract the detector resolution,
- ➔ The energy dependence of the time resolution was obtained for four different detectors in the range of 0.1-1.0 MeVee,
- ➔ The neutron-gamma separation and neutron detection efficiency as a function of energy were determined by the use of 14 MeV neutron generator.

Thank you for your attention!