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► To cite this version:

A. Kanj, Clement Lynde, Frédérick Carrel, Camille Frangville, Mehdi Ben Mosbah, et al.. Measurement of the response function of a plastic scintillator using monoenergetic neutron and proton beams. ANIMMA 2023 - Advancements in Nuclear Instrumentation Measurement Methods and their Applications, Jun 2023, Lucca, Italy. , 2023. cea-04726954

HAL Id: cea-04726954

<https://cea.hal.science/cea-04726954v1>

Submitted on 8 Oct 2024

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Measurement of the response function of a home made plastic scintillator using mono-energetic neutron and proton beams.

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Application, motivation and objective

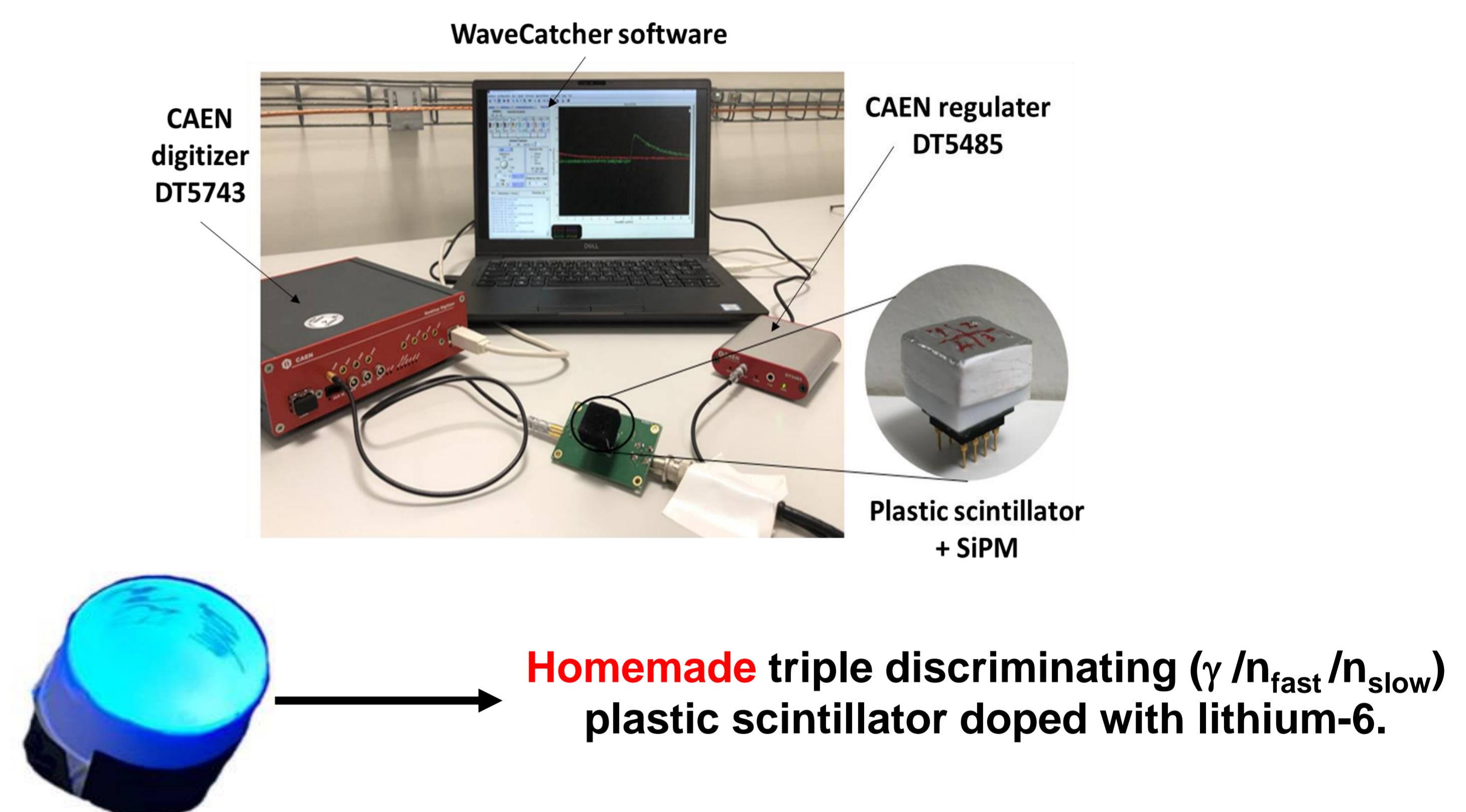
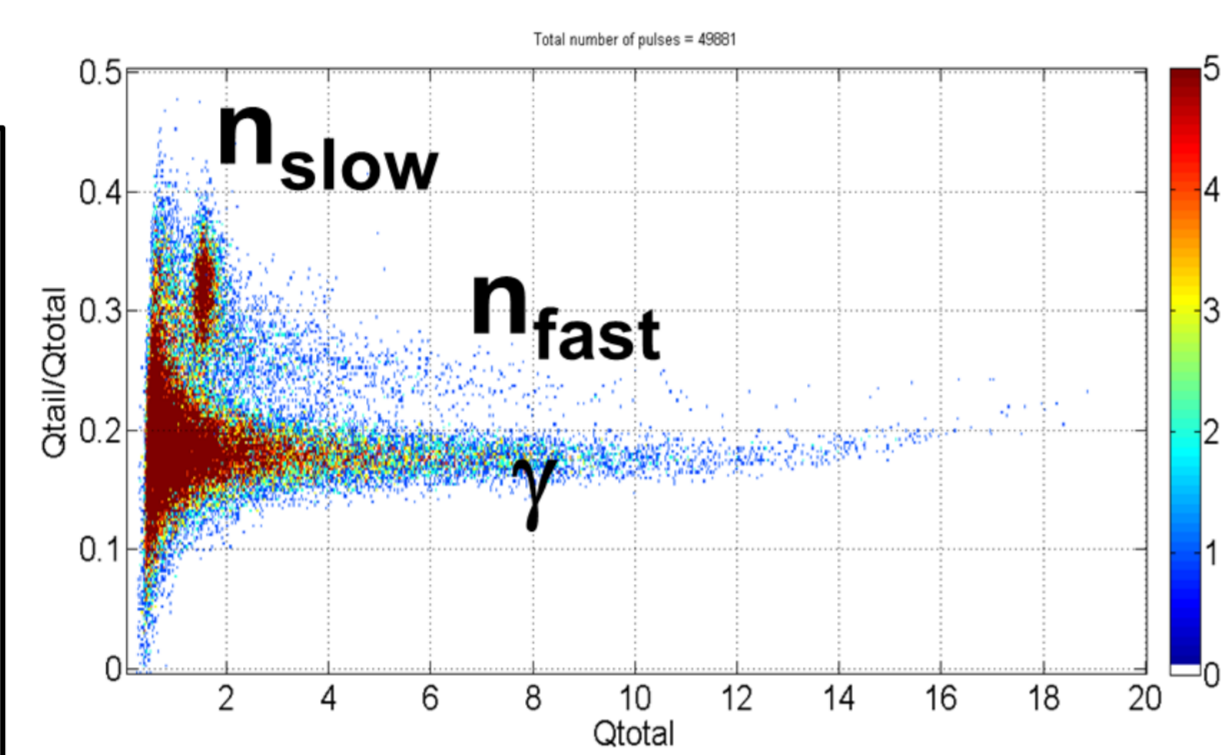
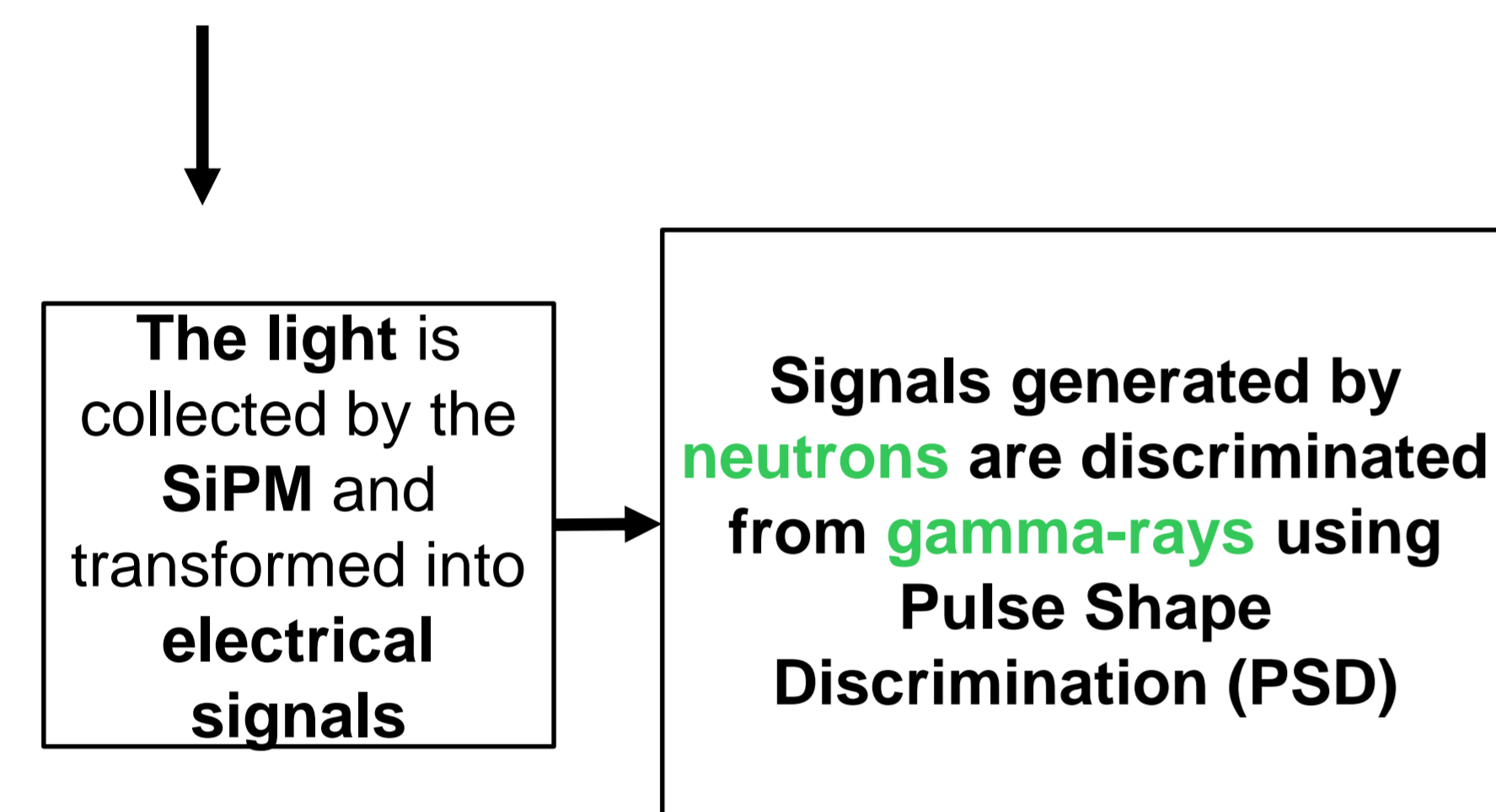
- Plastic scintillators are currently used as the main components of various neutron spectrometers, allowing to determine neutron energy spectra.
- To determine the neutron energy spectra, a finite calibration is required to determine the relation between incident neutron energy and the measured light yield.
- In this work, two calibration methods were conducted, using both neutron and proton mono-energetic beams, to measure the light output of a homemade triple discriminating plastic scintillator.

Experimental set-up and the physical phenomena behind the detector

Neutron detection:

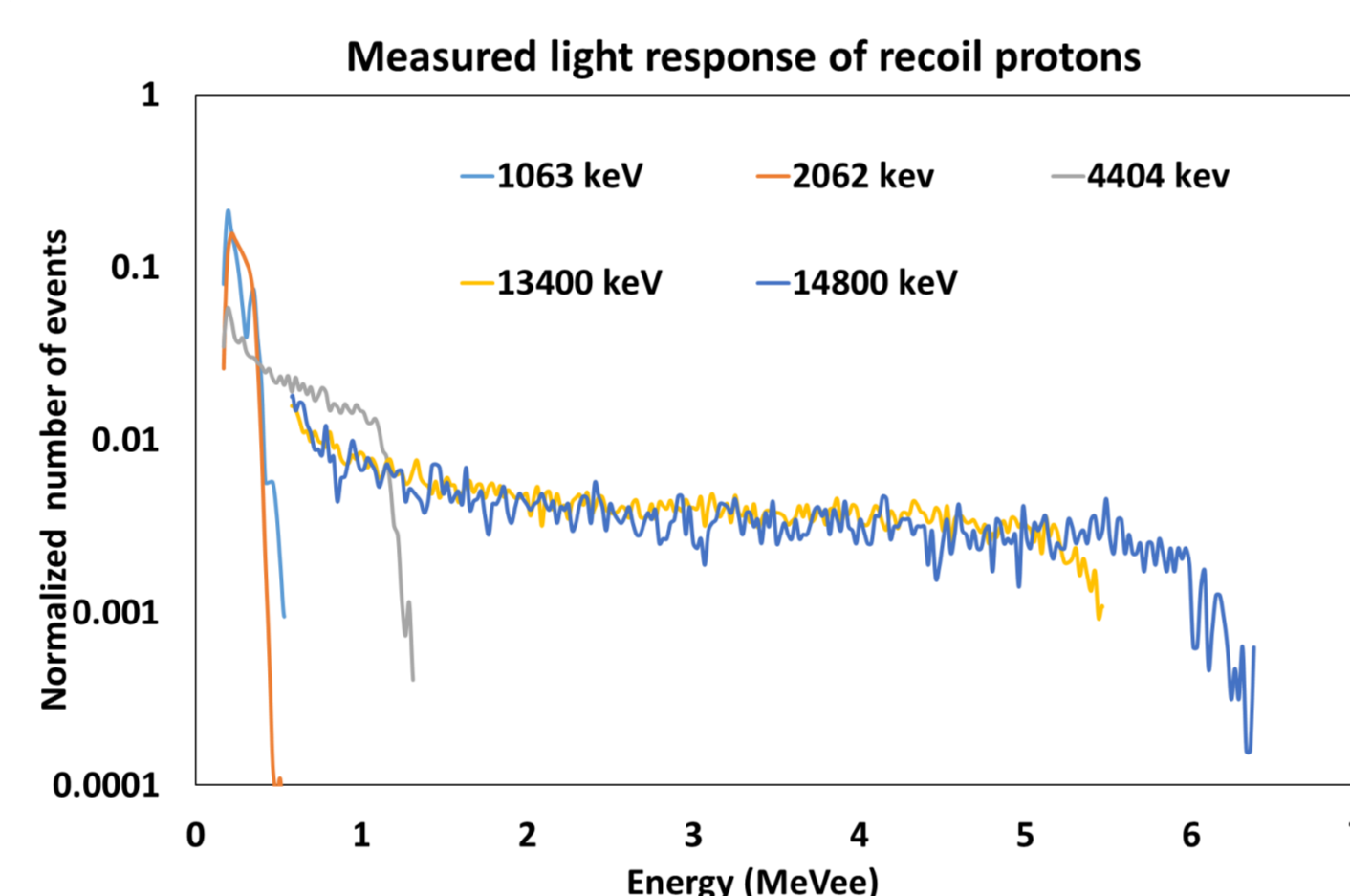
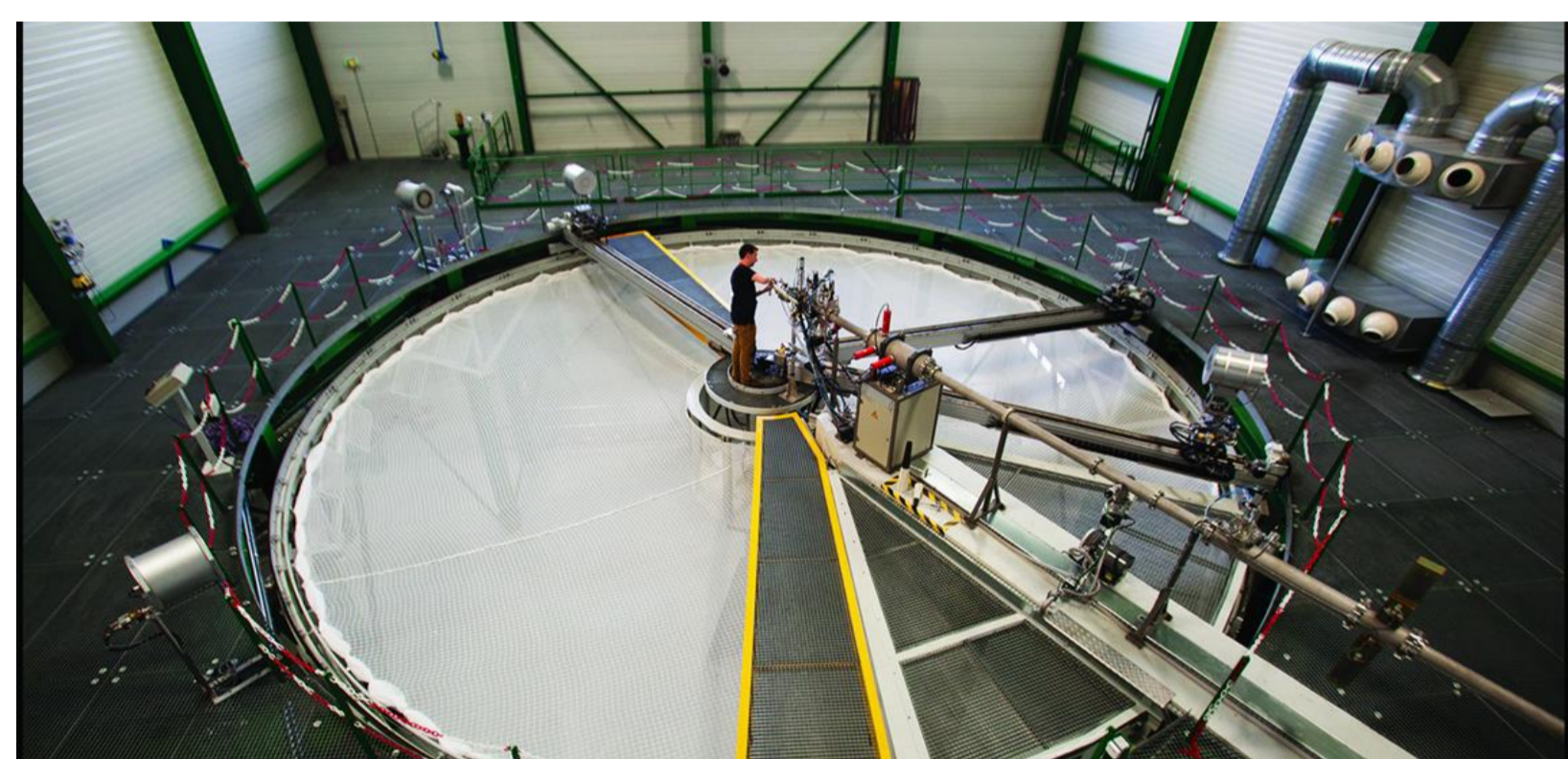
- A fast neutron interacts by elastic scattering on protons: $n + H \rightarrow n + H$
- The emitted protons ionize the scintillator and produce visible light.

Light yield \propto Proton deposited energy \rightarrow Quenching effect

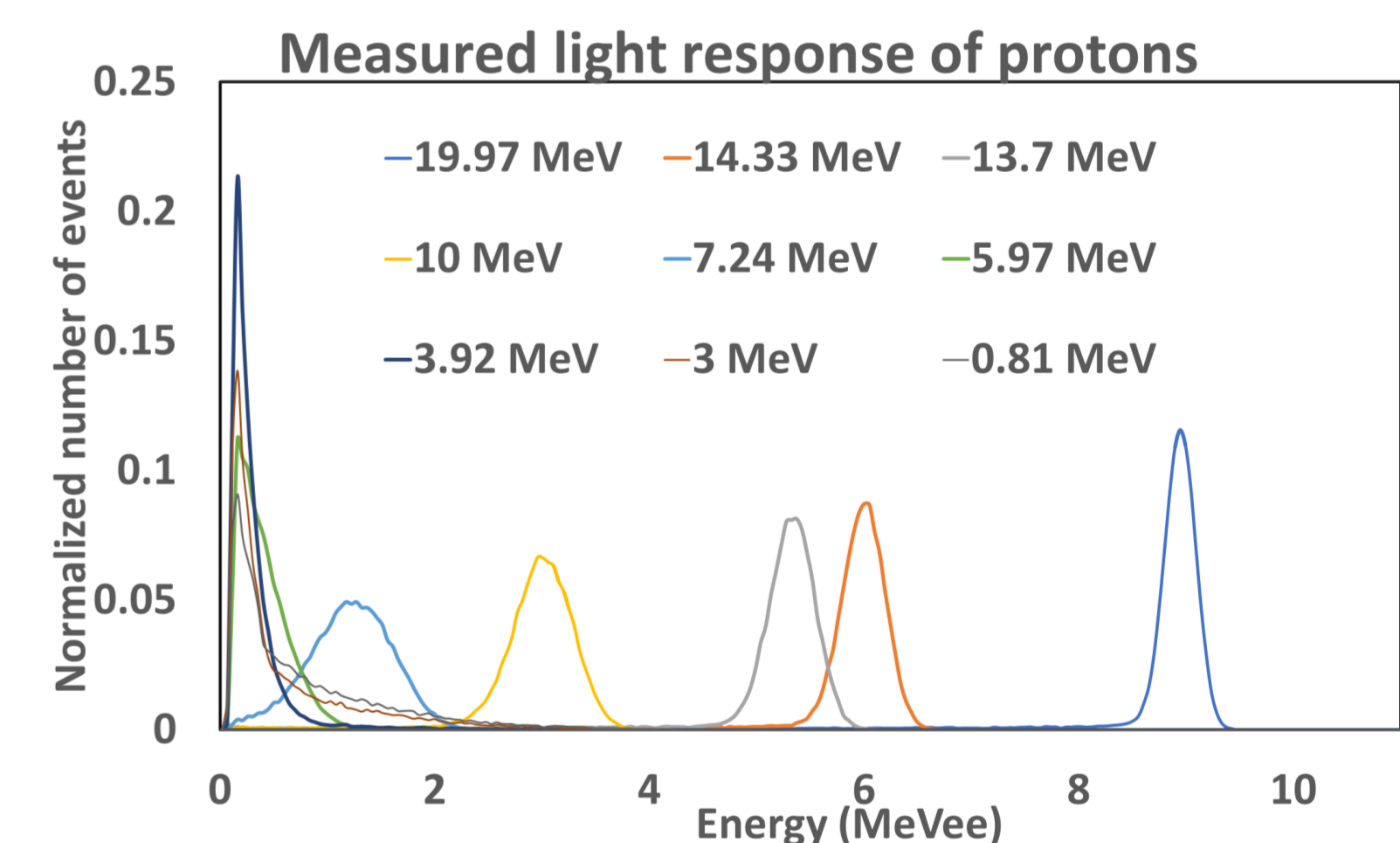


Experimental results and comparison between the two calibration method

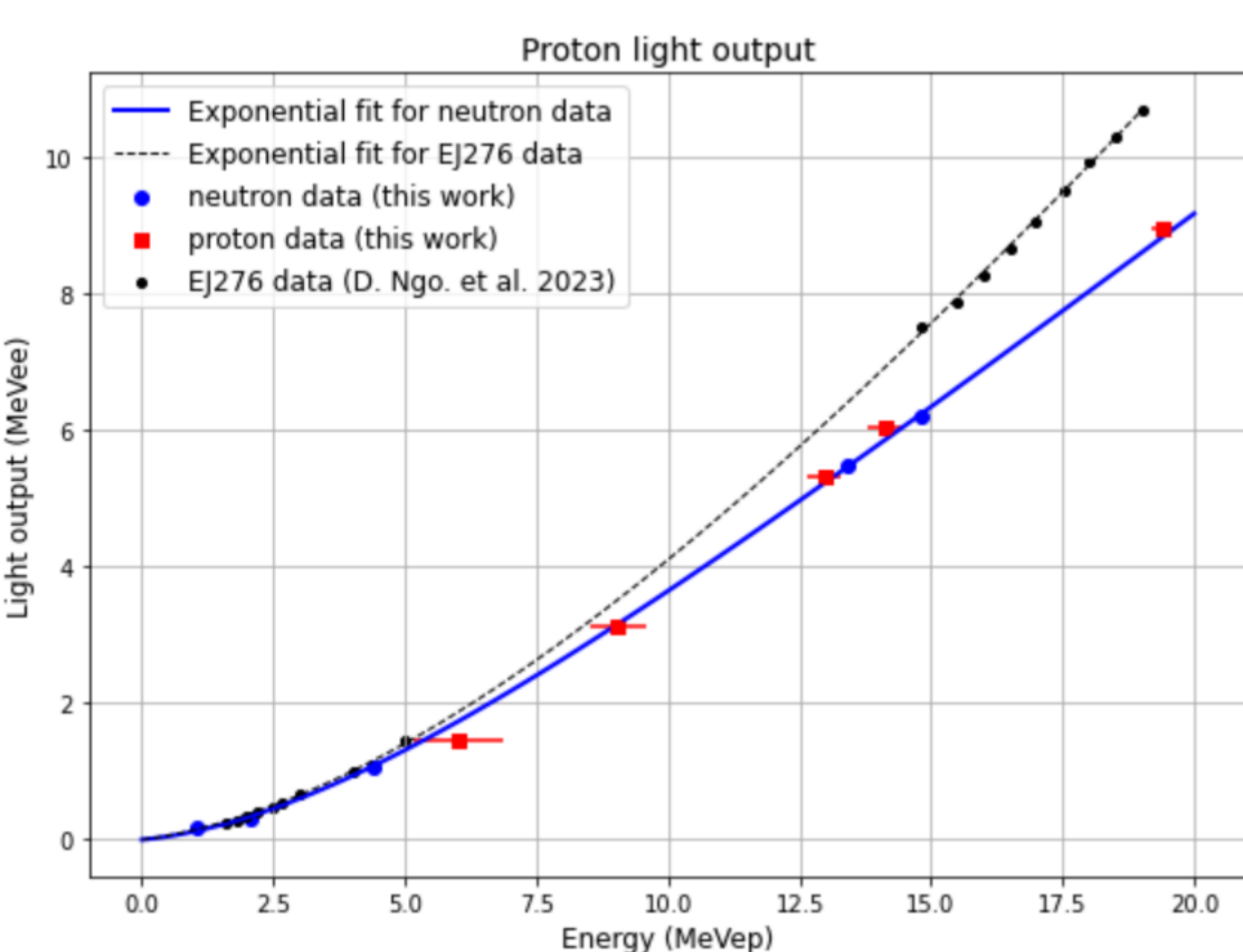
Measurement of the light output of the homemade scintillator by using a mono-energetic neutron beam of IRSN AMANDE facility



Measurement of the light output of the homemade scintillator by using a mono-energetic proton beam of CYRCE platform



Comparison of the two light output functions obtained with both mono-energetic beams



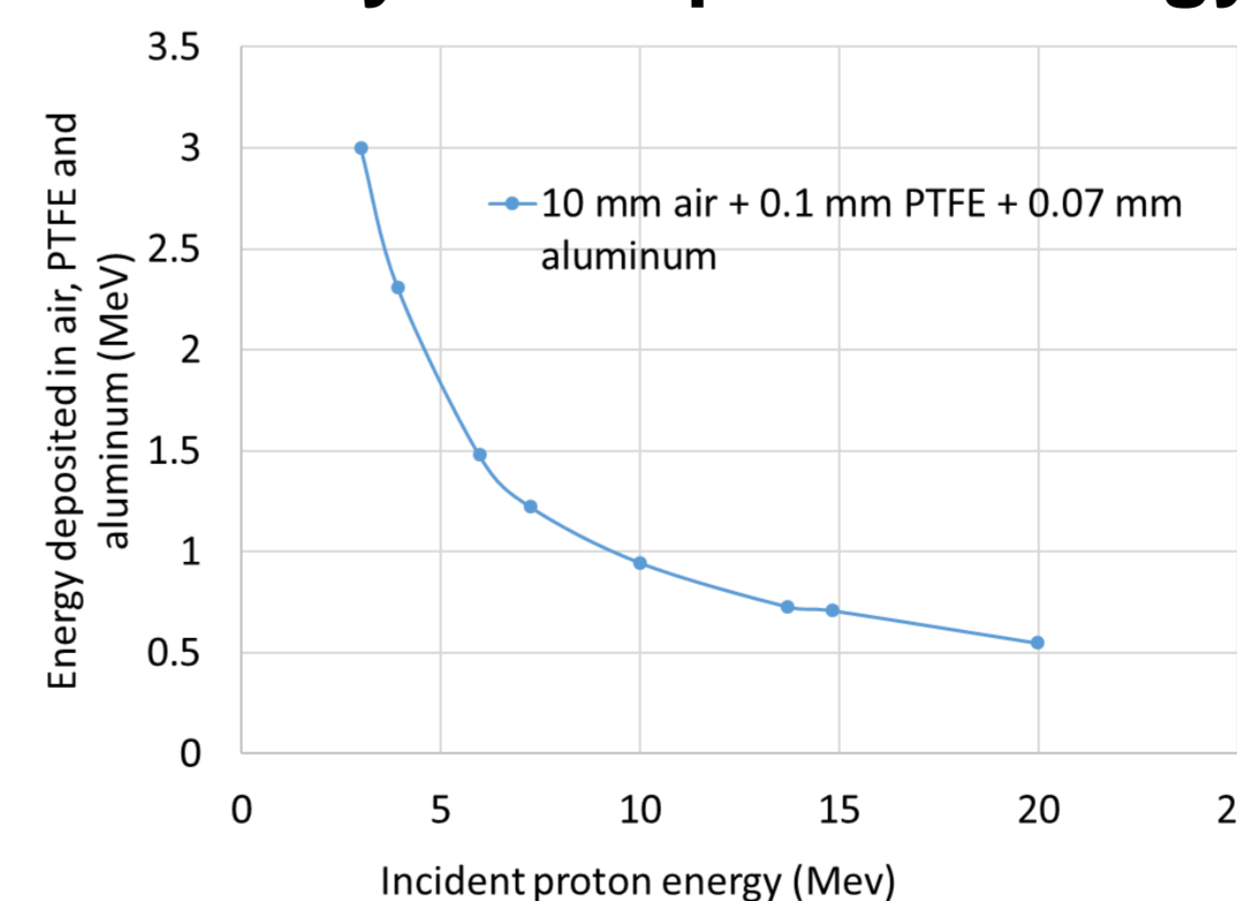
- ✓ The light output data obtained with the mono-energetic neutron beam was fitted using the following empirical model:

$$L(E_p) = aE_p - b(1 - e^{-cE_p})$$
 $a = 0.580, b = 2.48, \text{ and } c = 0.204$

- ✓ The fitting exponential curve used for the light output data obtained with the mono-energetic neutron beam fits well with the light output data obtained with the mono-energetic proton beam.

! The Teflon and Aluminum layer surrounding the scintillator causes a reduction in the energy of incident protons as they pass through it, leading to a decrease in their energy when they reach the scintillator.

- Study of the proton energy loss by using MCNP6 Monte Carlo code:



| The energy of the protons emitted by the beam (MeV) | 3 | 3.92 | 5.97 | 7.24 | 10 | 13.7 | 14.83 | 19.97 |
|--|---|------|------|------|------|-------|-------|-------|
| The energy of the incident protons on the scintillator (MeV) | 0 | 1.61 | 4.49 | 6.01 | 9.05 | 12.97 | 14.12 | 19.42 |

Key benefits of using a proton beam compared to a neutron beam

- ✓ The Gaussian shape of the light response makes the determination of calibration points easier.
- ✓ Absence of unwanted events such as gamma radiation.
- ✓ The availability of calibration data for proton energies between 5 and 13 MeV, for which neutron generator physics does not allow their production.
- ✓ It is possible to carry out an automatic beam collimation.

Conclusions and perspective

- ✓ We determine the light output function for the plastic scintillator neutron spectrometer.
- ✓ For the first time, a mono-energetic proton beam was used for carrying out a plastic scintillator energy calibration. This method is a complementary approach compared to a calibration step based on a mono-energetic neutron beam.
- ✓ To calibrate the scintillator using a proton beam, it is necessary to have precise control over the thicknesses of the material layers that the protons pass through before interacting with the scintillator.
- In future work, we will use the mono-energetic proton beam to calibrate the 12x12 pixelated plastic scintillator.