Energy threshold evaluation in the TW detector GSI 2021 data taking

Matteo Morrocchi

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Energy threshold evaluation
objective

- Evaluation, for each bar, of the energy corresponding to the hardware threshold of the WaveDAQ to include in the simulation the correct proton detection efficiency.

- Analysis performed mainly for 400 MeV/u on GSI 2021 data and corresponding simulations.

The following runs were used:

- Frag 400 MeV/u (1127663 evts)

  4303 4304 4308 4309 4310 4311 4312

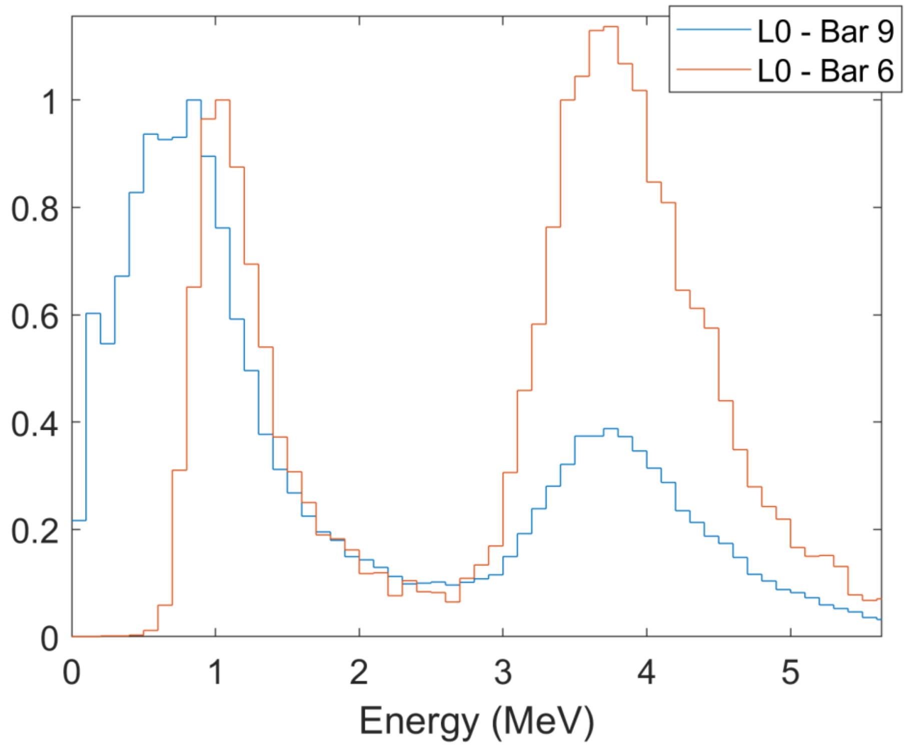
- Frag 200 MeV/u (196532 evts)

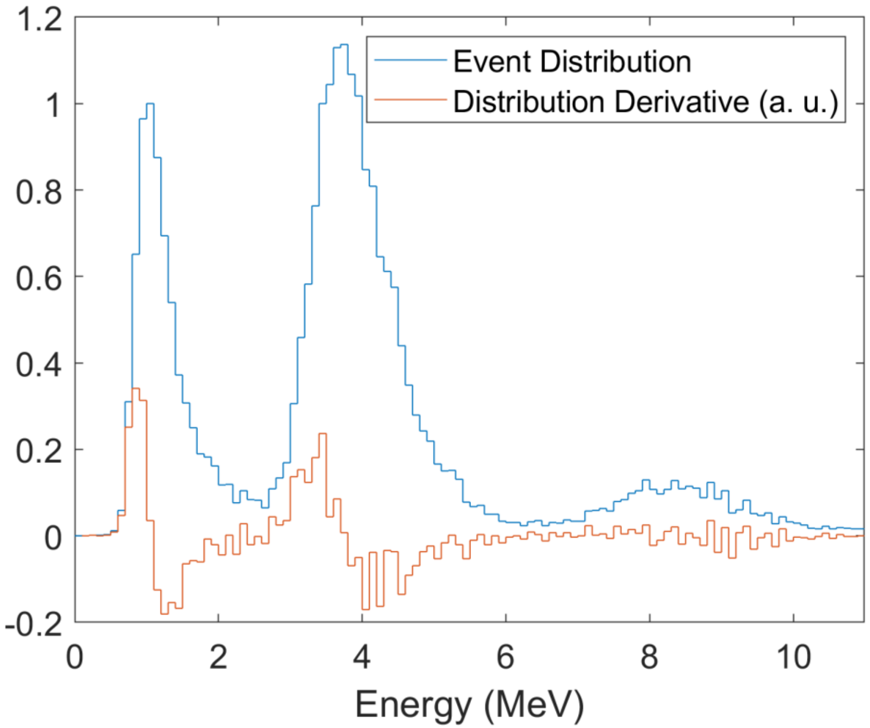
  4328 4329

- Min Bias 400 MeV/u (517388 evts)

  4305 4306 4307

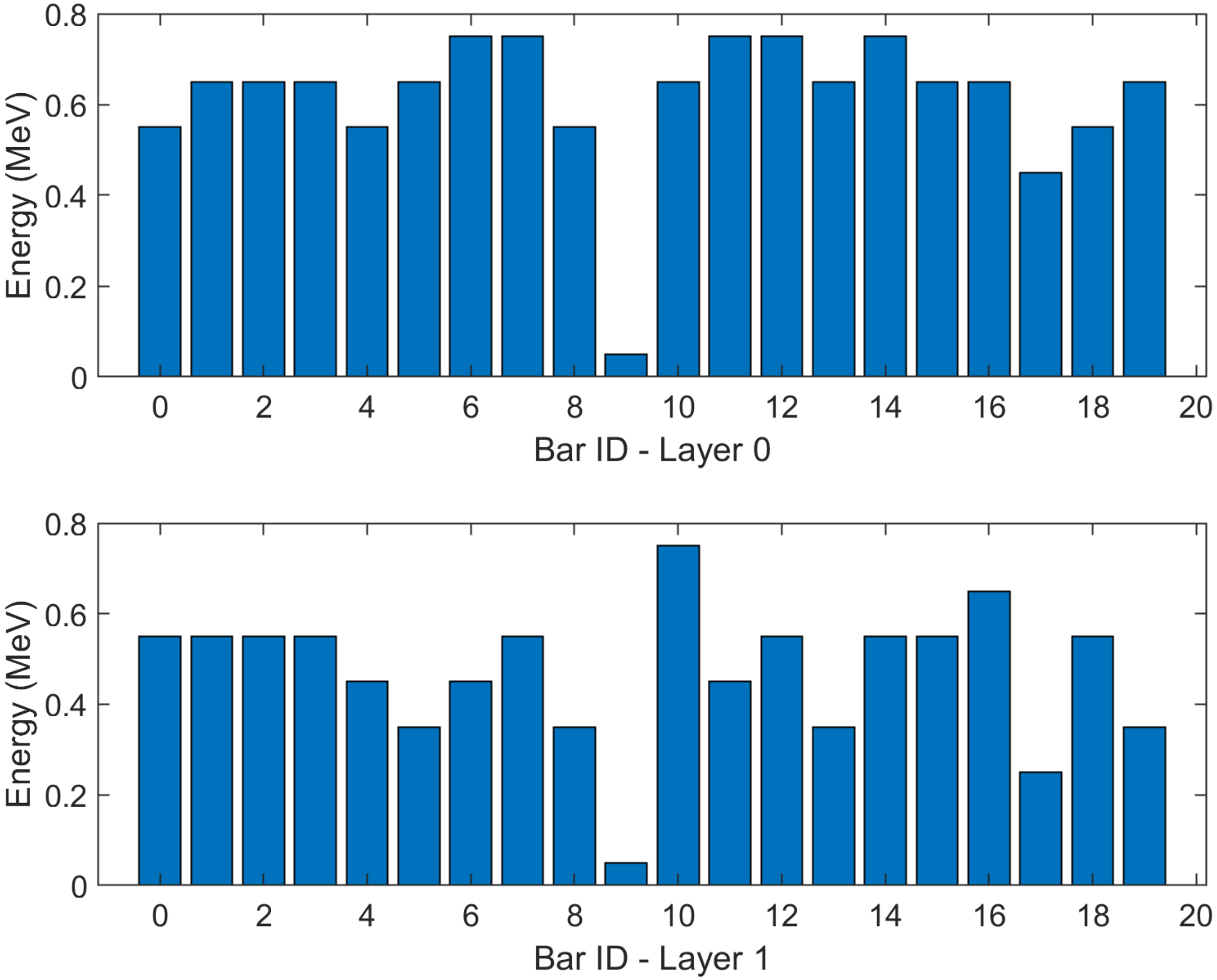
Energy threshold evaluation
A first approach





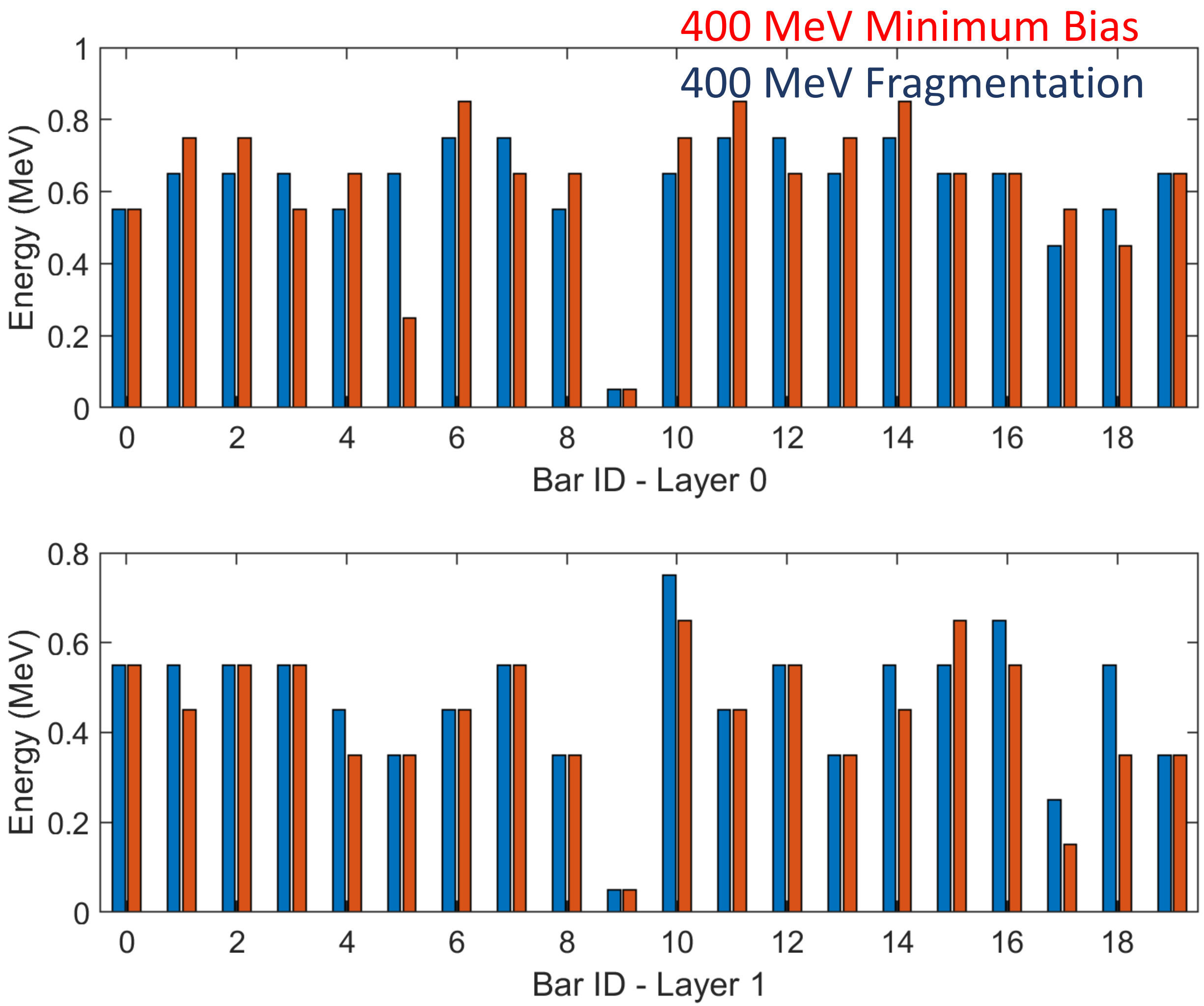
A first naive method was studied, based on the derivative of the energy distribution. If a cut is applied on the spectrum, a peak in the derivative should appear in correspondence of the threshold value.

Threshold map – 400 MeV/u
Fragmentation



- A set of thresholds was obtained for the 40 bars
- Using fragmentation data, the threshold corresponding to the veto bars cannot be determined. MB events were used for this purpose.

Threshold map – 400 MeV/u
Minimum Bias



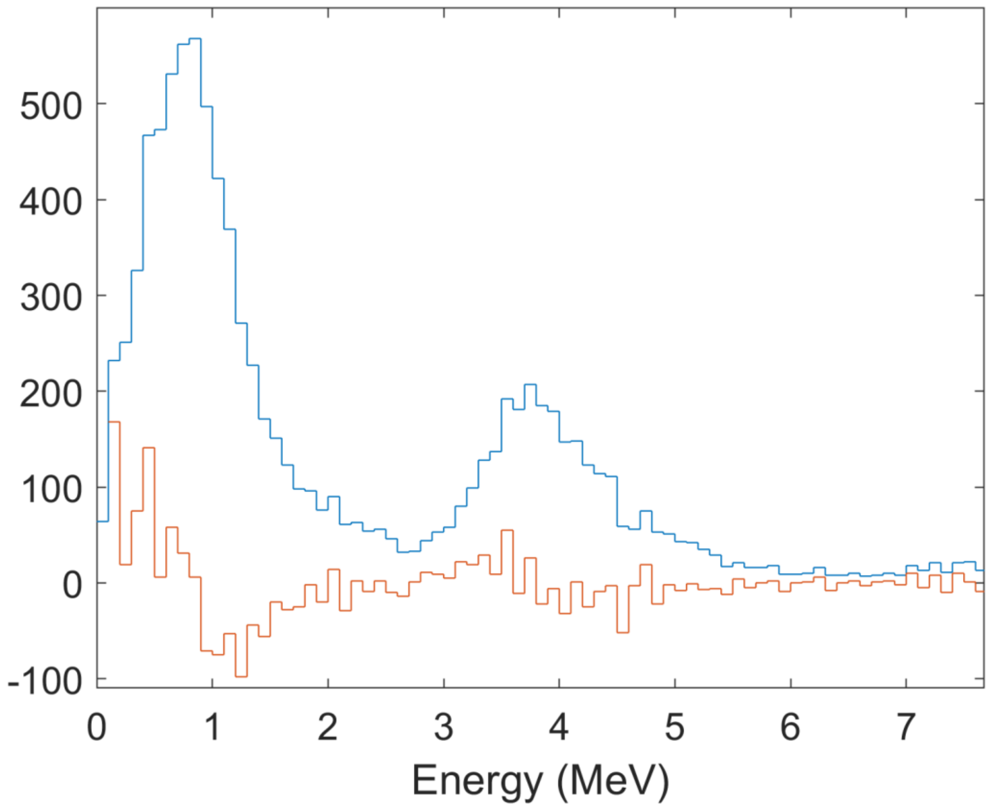
In both cases the achieved values seem compatible. In this case we expect to obtain a correct value for the central bars (that were connected to the veto), however a low value is obtained also in this case.

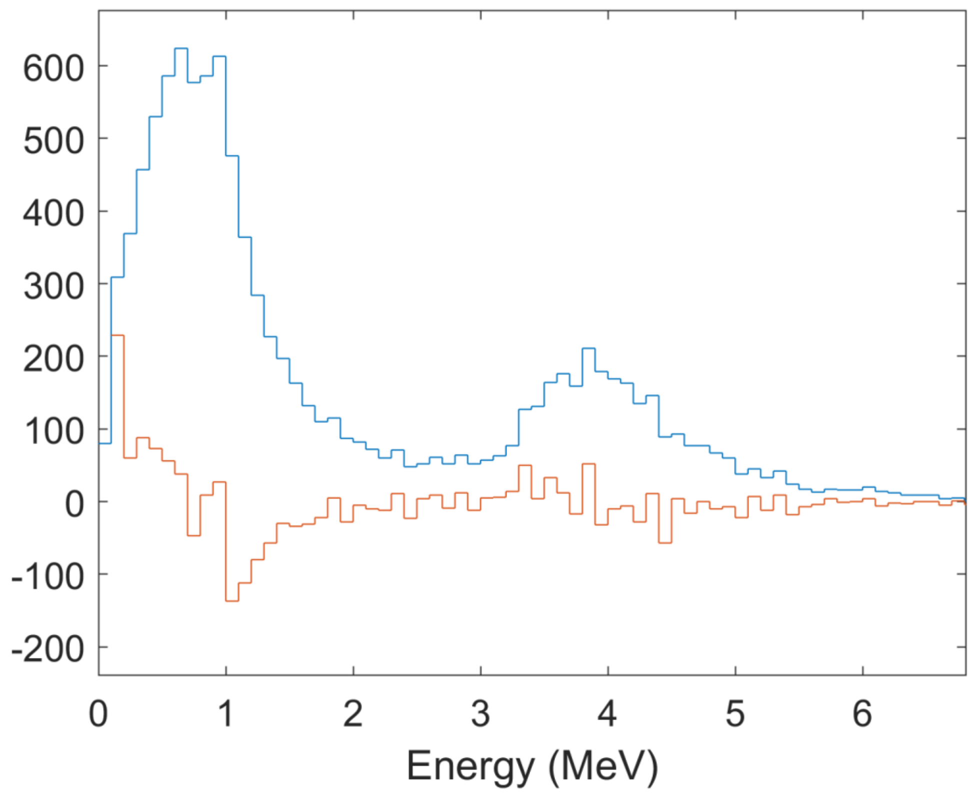
Is the result correct?

Central bars

Energy Spectra

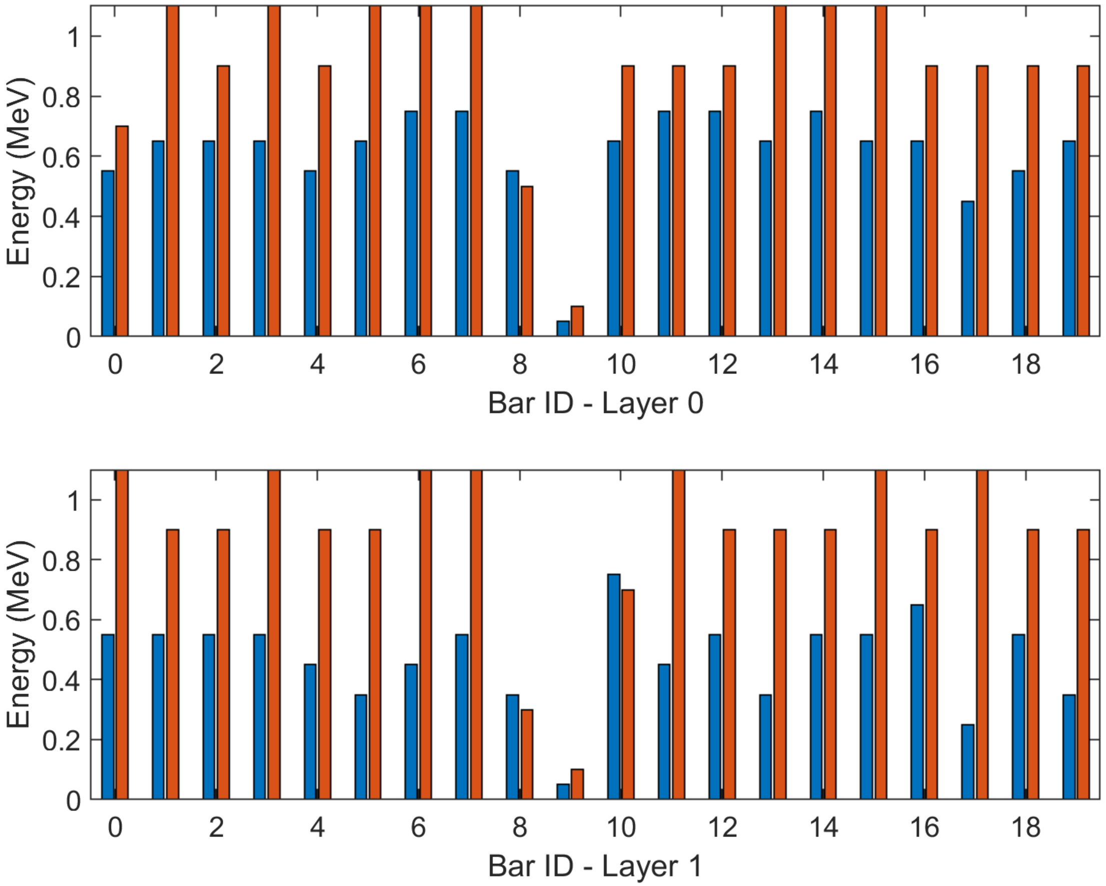
The spectra in the two central bars seem not to be cut by the hardware threshold. The two central bars were connected to a different board → less noise on that board? Zero suppression?





Threshold map – 200 MeV/u
Fragmentation

200 MeV/u
400 MeV/u



The same method was applied to the 200 MeV/u campaign. Thresholds seem systematically higher than in the previous case, but no changes in the WaveDAQ settings were applied!
To be noted that statistics was lower than with 400 MeV/u.

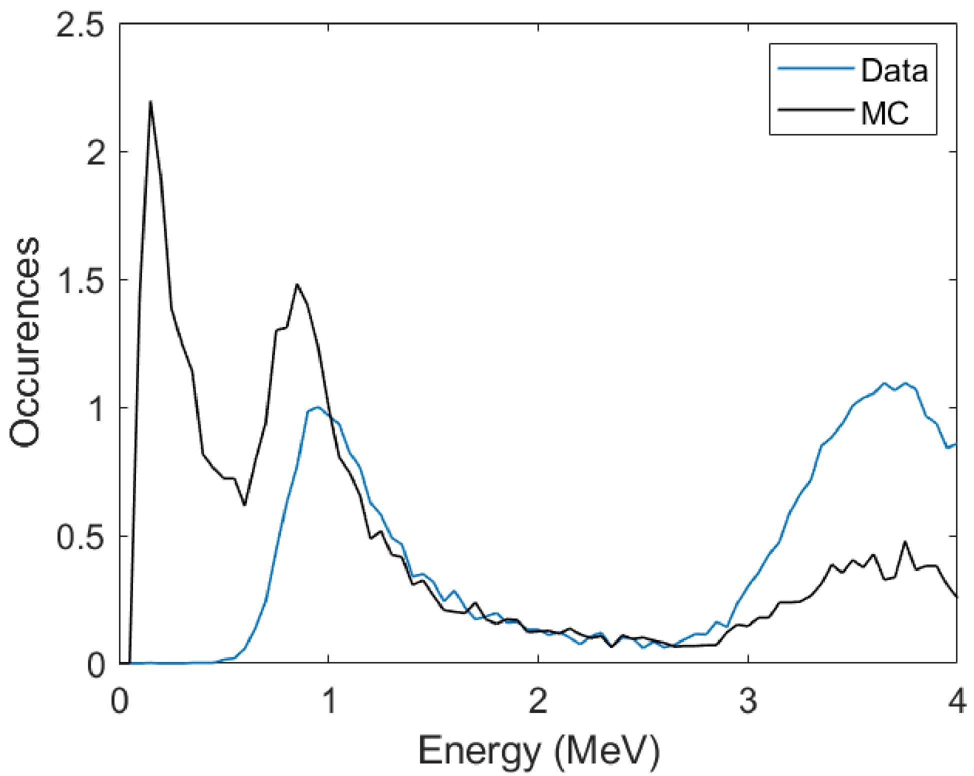
Since proton energy is different, also the distribution is different, and the proposed method may not give the right solution if the distribution is not cut enough.

200 MeV proton releases on average 1,335 MeV
400 MeV proton releases on average 0,9 MeV.

So, can we trust this numbers?

Comparision with simulated data
Energy Spectra

A better estimation of the hardware threshold can be obtained combining the collected data with the simulation output

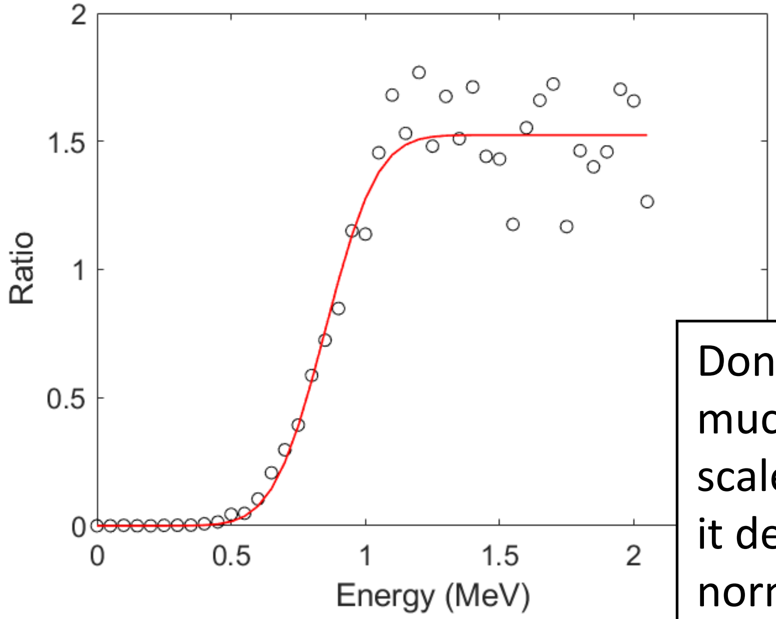


Assuming a reliable energy calibration, we could find a function that, multiplied by the simulated data, applied the correct weight to account for the threshold.

HIT Campaign

TW performance

1) Perform the ratio (bin-by-bin) between the energy spectra of real data and simulation.

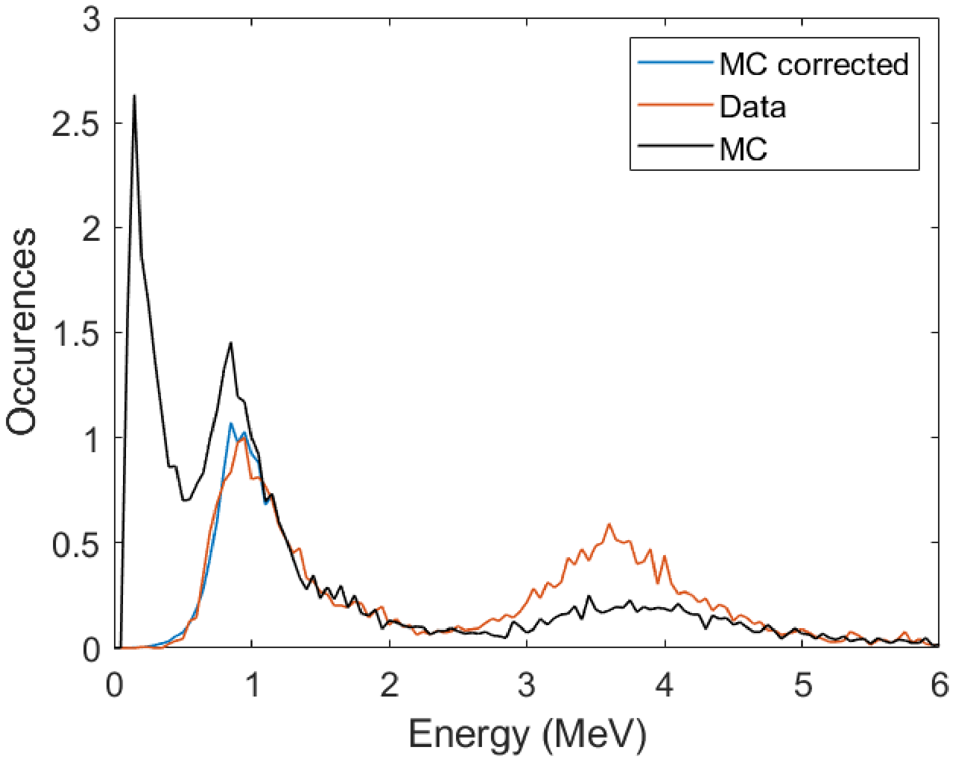


Don't care too much about the scale on the y axis, it depends on the normalization of the histograms.

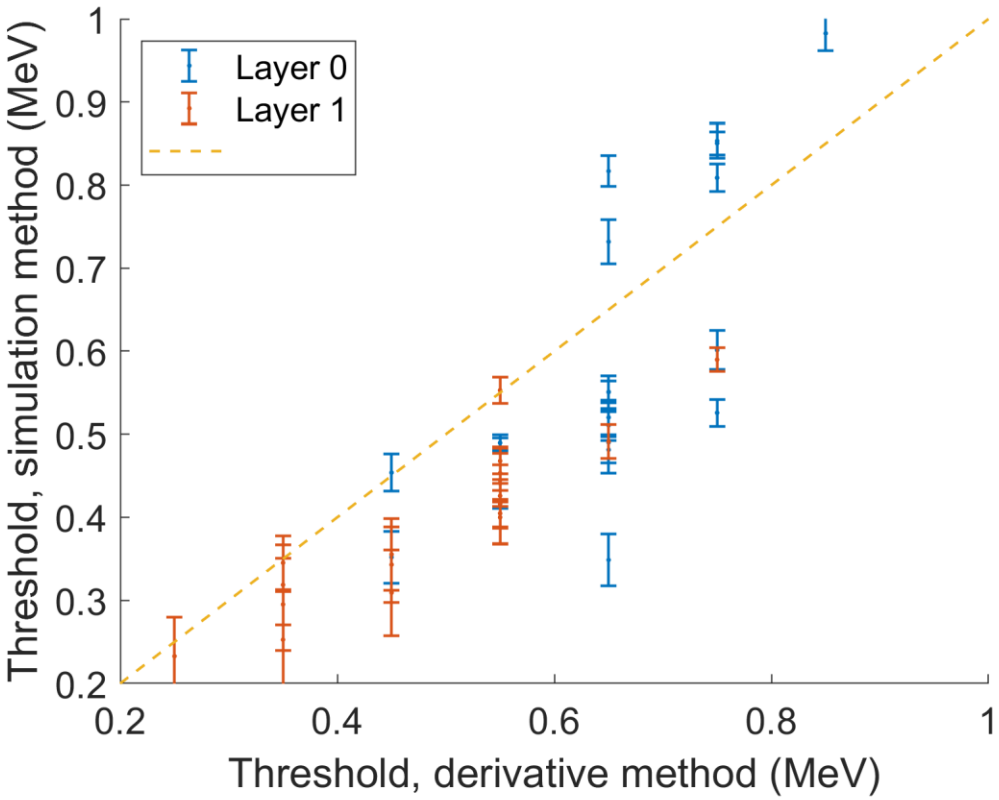
2) Fit with an error function

$$R = a * \left(1 + erf\left(s * (x - x_0)\right)\right)$$

3) Apply the function to the simulated spectra to verify that the cut is compatible with the acquired spectra.



Results – 400 MeV/u
Agreement between the two methods



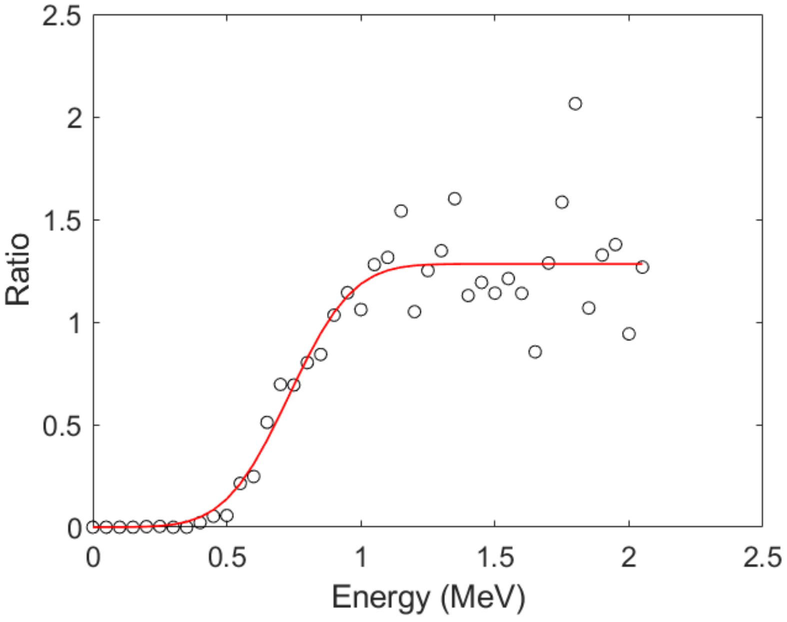
- The two methods seem correlated.
- In principle we could expect a higher agreement, but it is fair that the second method returns in general a lower threshold if the energy distribution is not cut.

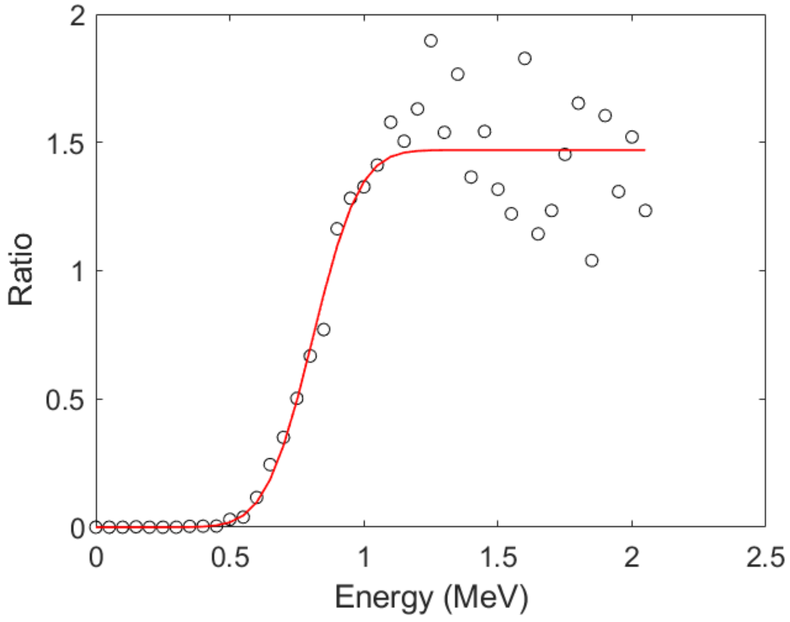
But let's take a closer look at the results bar-per-bar

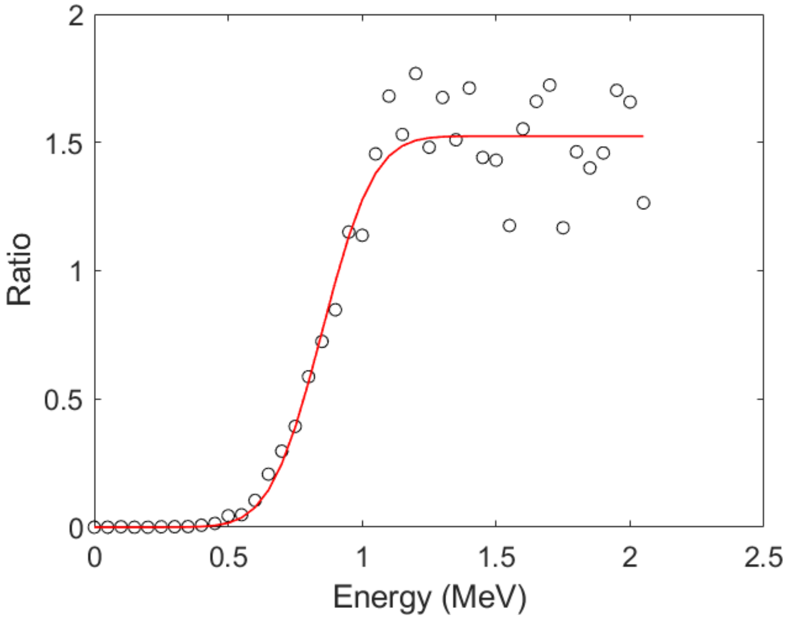
Sigmoidal fit results

Some examples…

The majority of the bars returns a good sigmoidal distribution in the proton energy range, and the threshold can be properly fitted. Some examples are shown below:



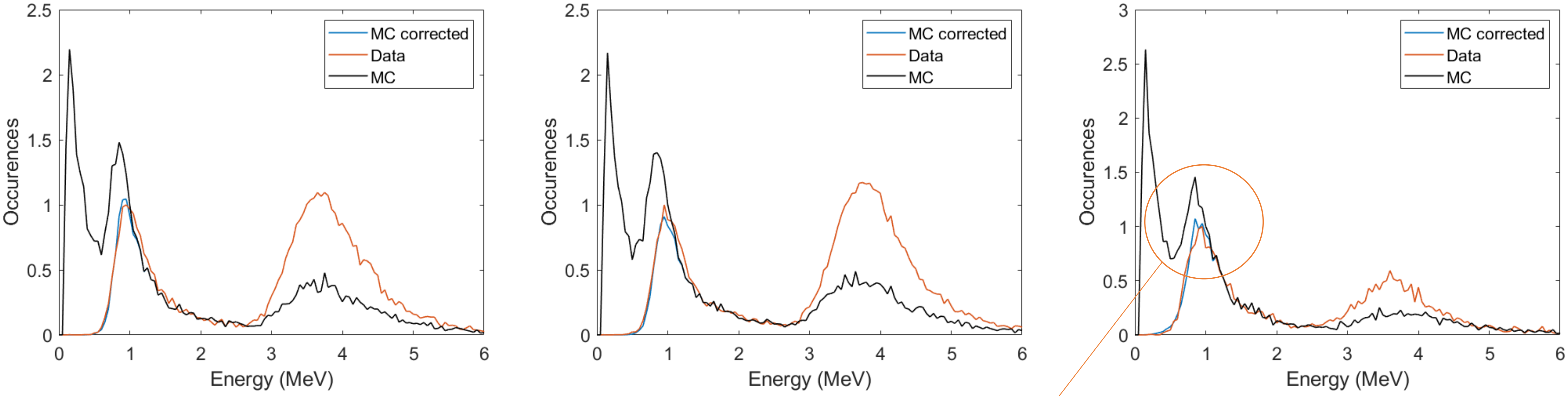




Sigmoidal fit results

Some examples...

In these cases, the application of the threshold to the simulated energy distribution behaves as expected.

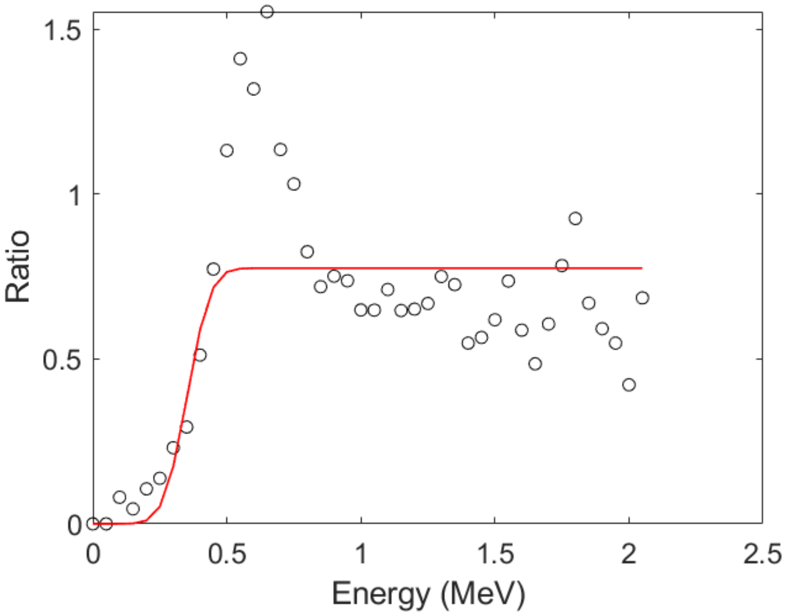


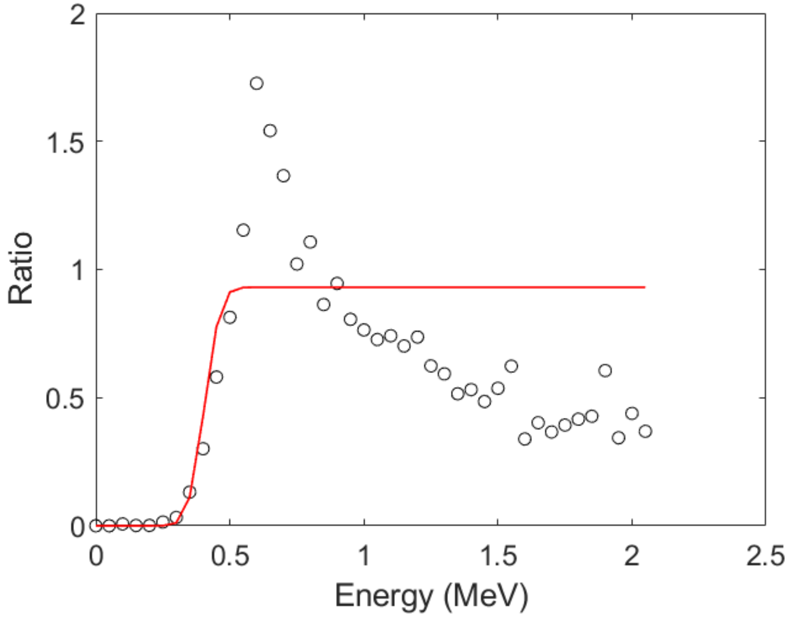
Part of the proton spectrum in the simulated data is cut. The threshold is not sharp, since a sigmoid is applied to the data.

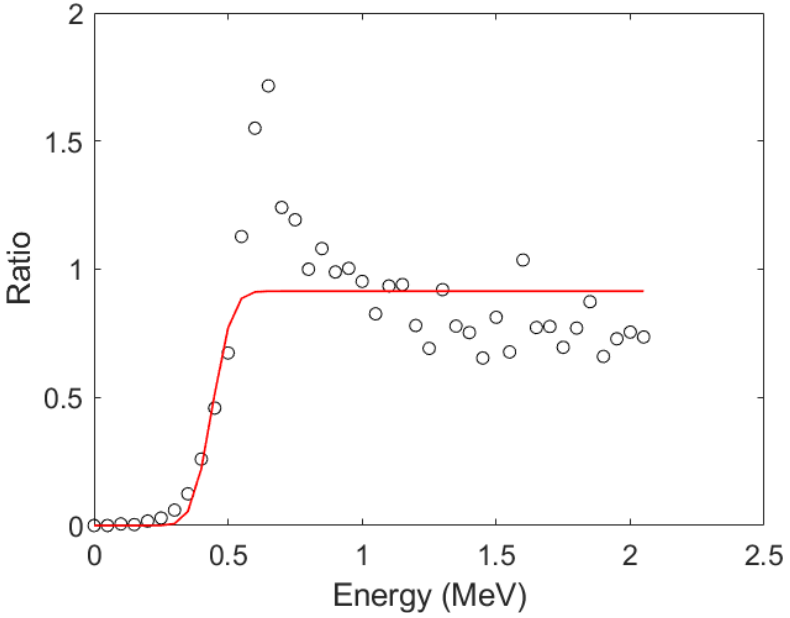
Sigmoidal fit results

Some more examples…

However, for some bars the ratio distribution is not as expected, and a peak is clearly visible in the proton region





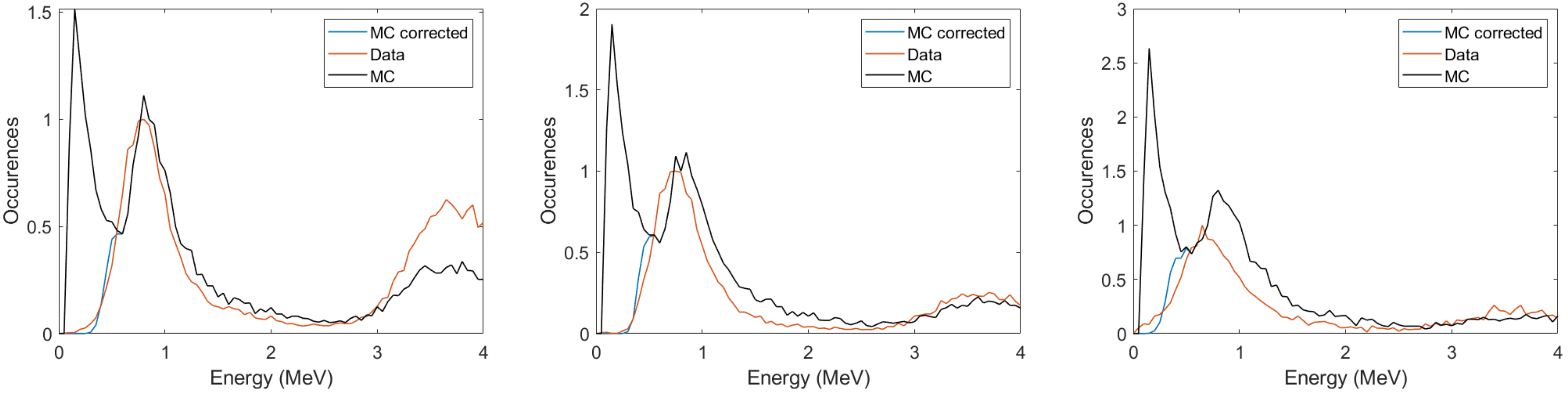


Sigmoidal fit results

Some more examples…

Can this effect be due to a wrong energy calibration of the bars in the proton range?

The effect is mainly visible in layer 1, without a precise correlation with the bar position.



!ATTENTION! If the proton peak in the data is at lower energies wrt the simulation, the effect is the one clearly observed in the previous slide. If it is at higher energies, no artifacts will appear in the plot of the ratio, simply a higher threshold compared to the real one will be found.

Conclusions

- A first set of thresholds was found using the derivative of the spectra
- A second method based on the comparison with MC data was implemented to verify the previous results
- The main issue concerns the robustness of energy calibration at proton energies, suggested by the artifacts observed in the ratio between the two energy spectra
- Ad-hoc measurements, in my opinion, are necessary to finally assess the proton detection efficiency and to calibrate proton energies
  → Efficiency tests need to be repeated every time the thresholds change