TUNL Data Analysis

Marie Vidal

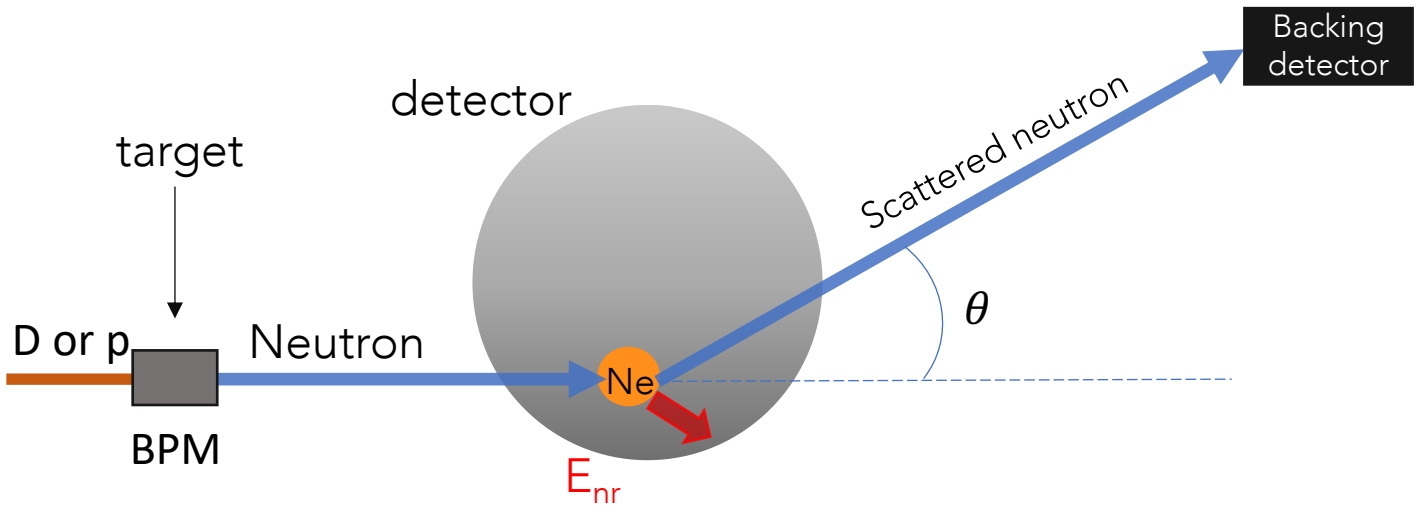
Collaboration meeting

June 12th 2019

Outline

- Recall campaign 2018
- Previous collaboration meeting
- Update on analysis
- Campaign 2019
- Analysis - develop model for expected recoils peak
- Next steps

Recall: QF experiment summary

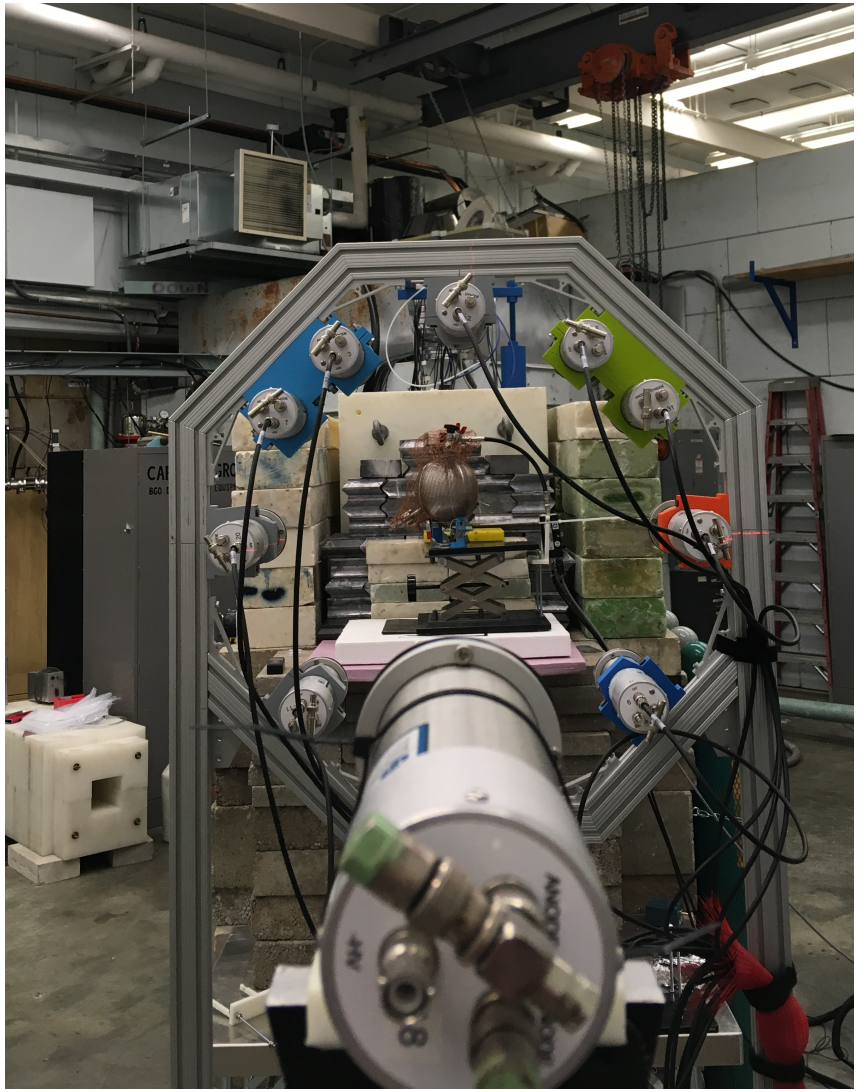


- E_n: known
- θ: chosen
- E_{nr}: calculated
- E_{ee}: extracted energy mean from energy spectrum

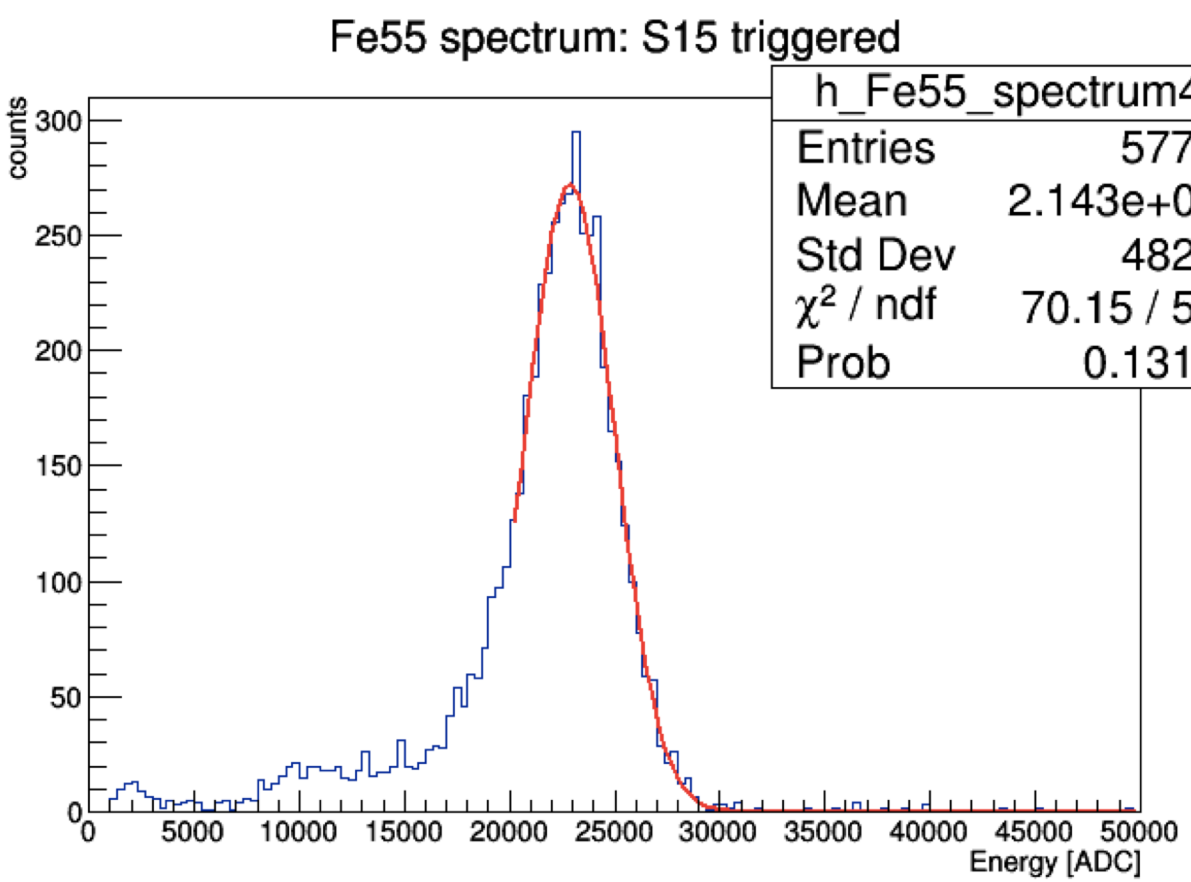
- Backing detectors (BD)
- Beam Pick-off Monitor (BPM)

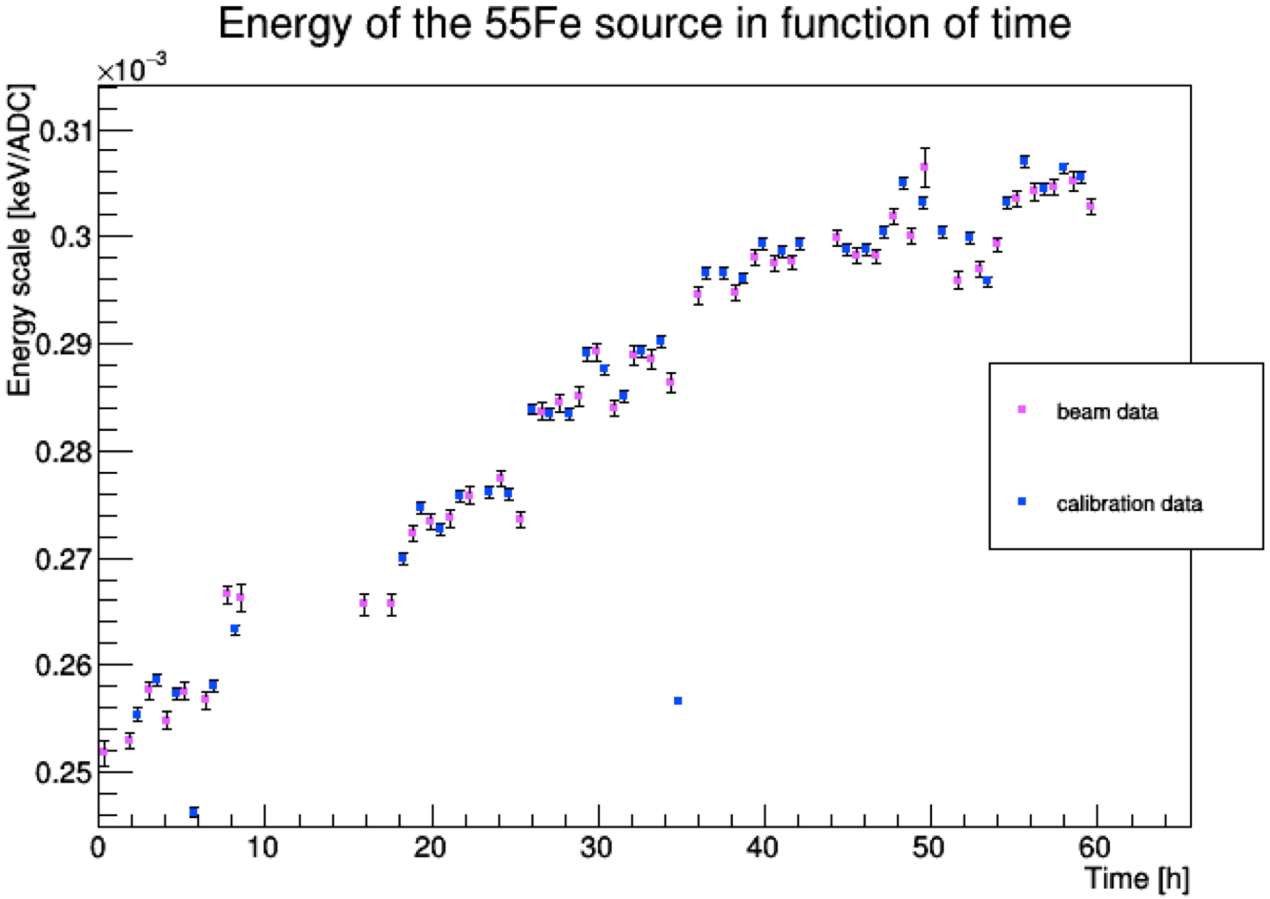
Recall campaign 2018

- Reaction: D+D→ n+^{3}He+γ
- Neutron beam 3.85 MeV
- Gas: Neon:CH_4 (97:3)
- Pressure: 500 mbar
- Calibration: ^{55}Fe source (during data taking and 5 min between each h of data taking)
- 4 energy points investigated: 27, 14.4, 8.5, 4.6 keV_{nr}



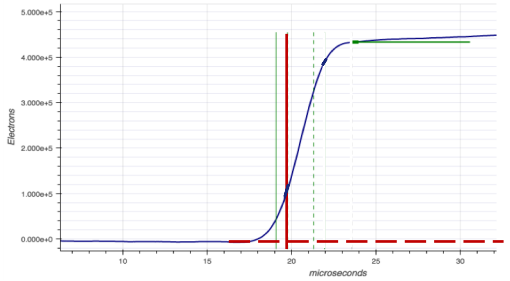
Energy calibration: Fe55 peak at 5.9 keV



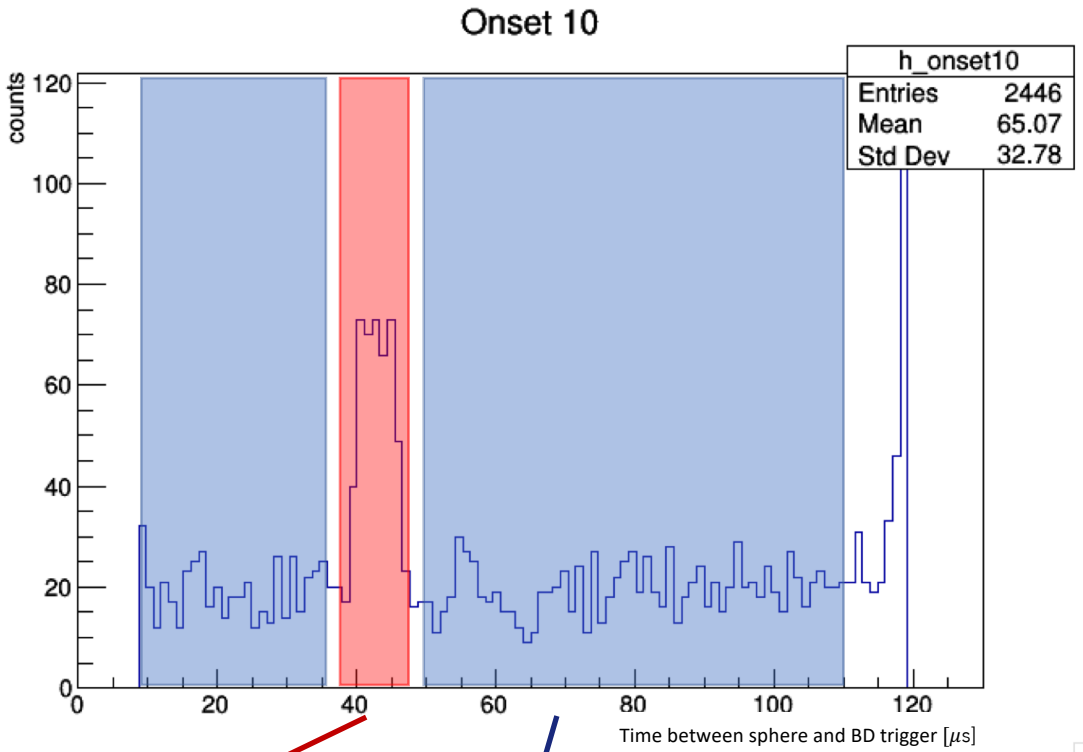


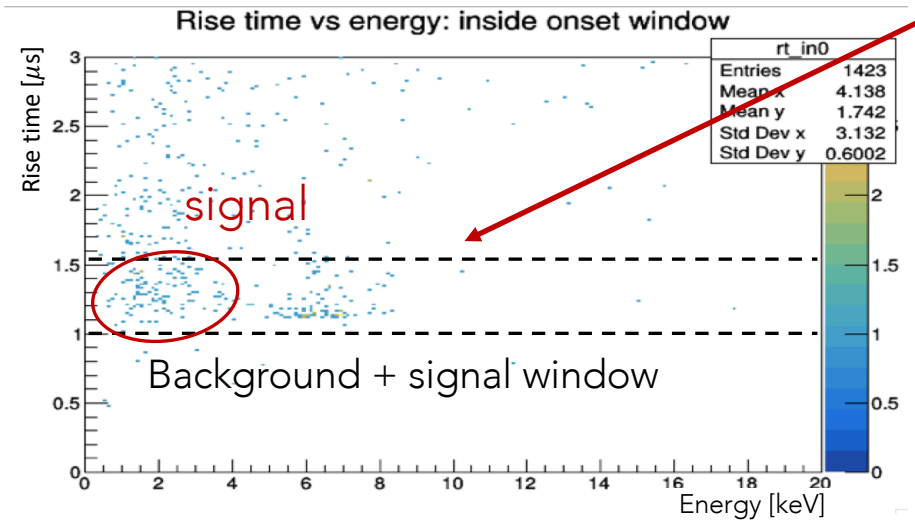
Recall: previous collaboration meeting

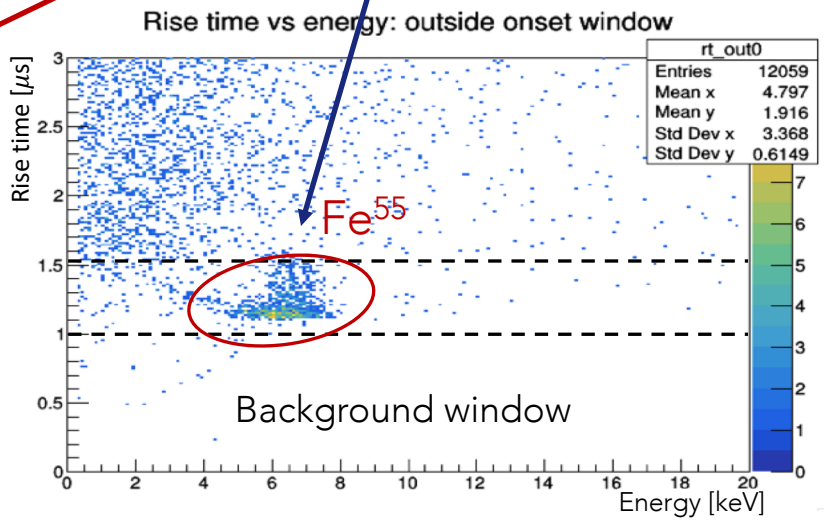
- psd: neutron/gamma identification (backing detector)
- TOF neutrons (backing detector - BPM)
- Rise time
- Onset time



10% of amplitude



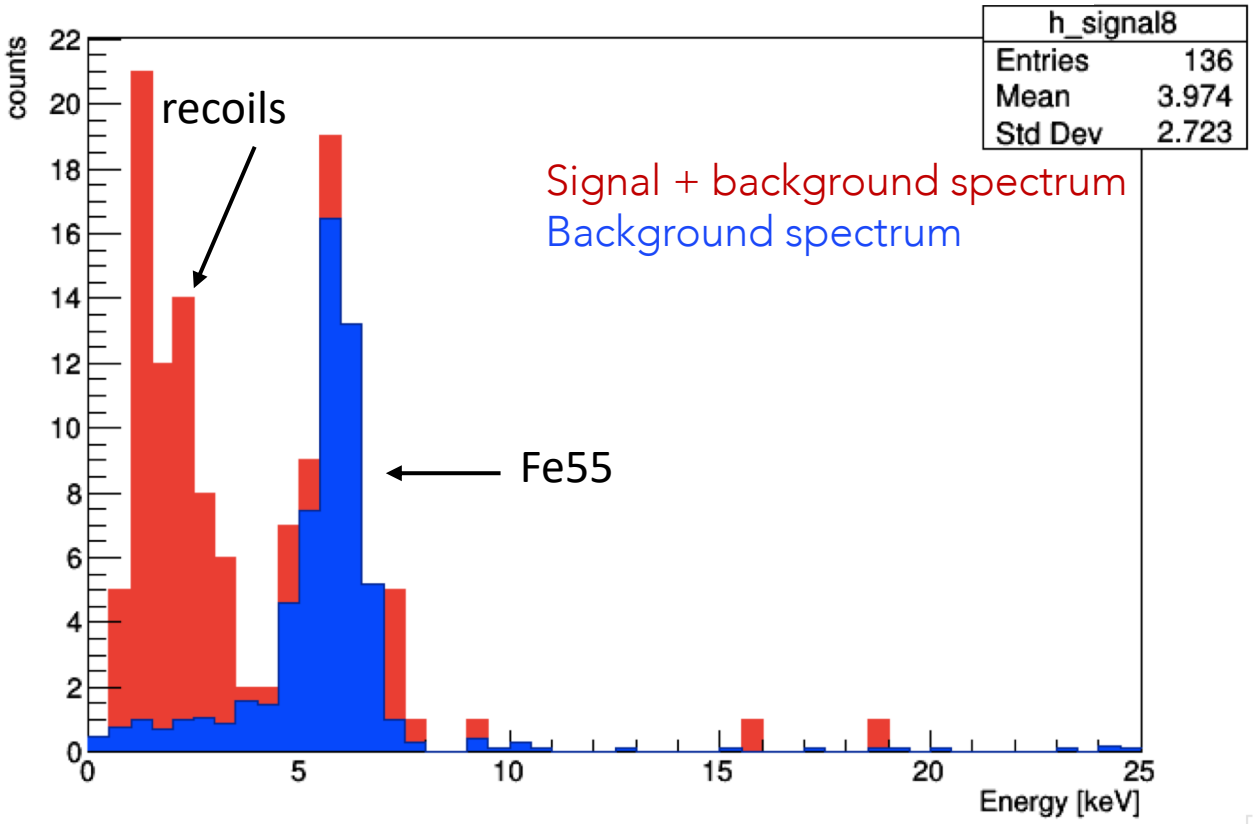




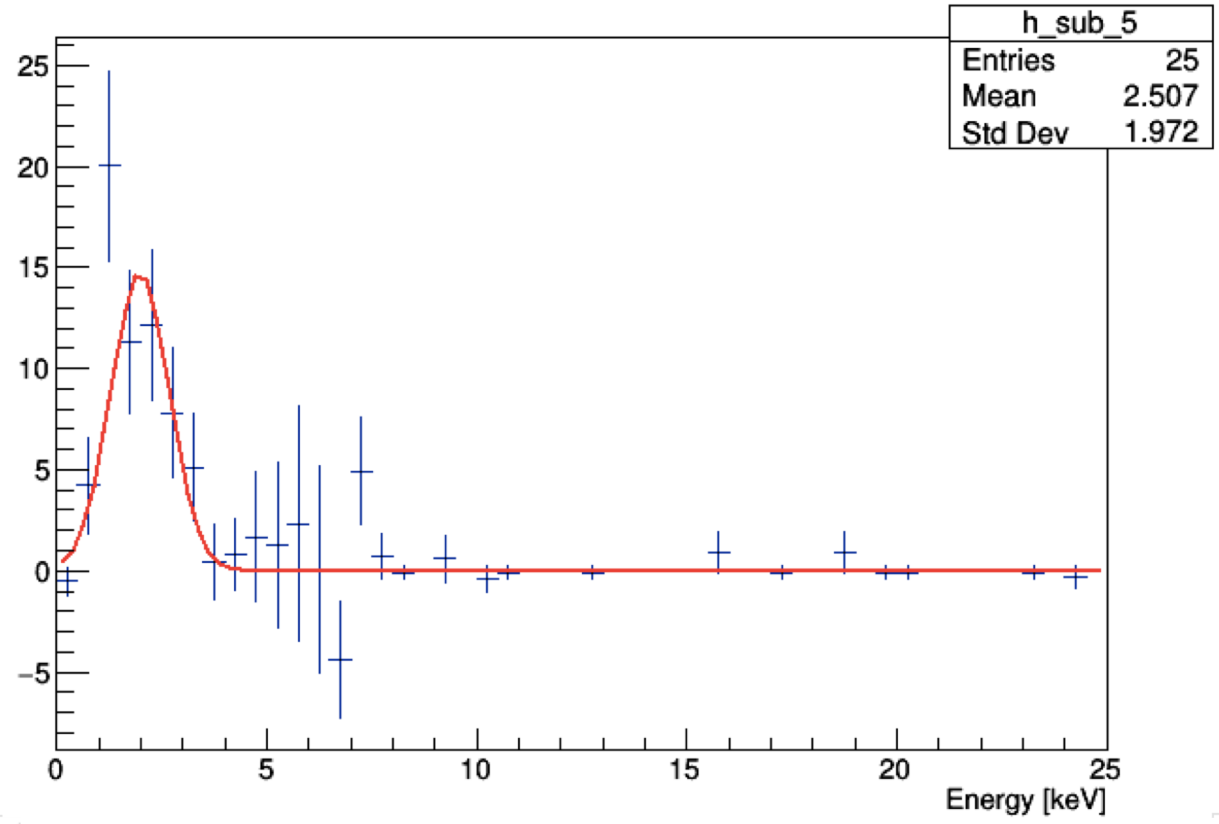
Simplified extraction of recoils peak

Background subtraction

Superimposition signal and background spectra

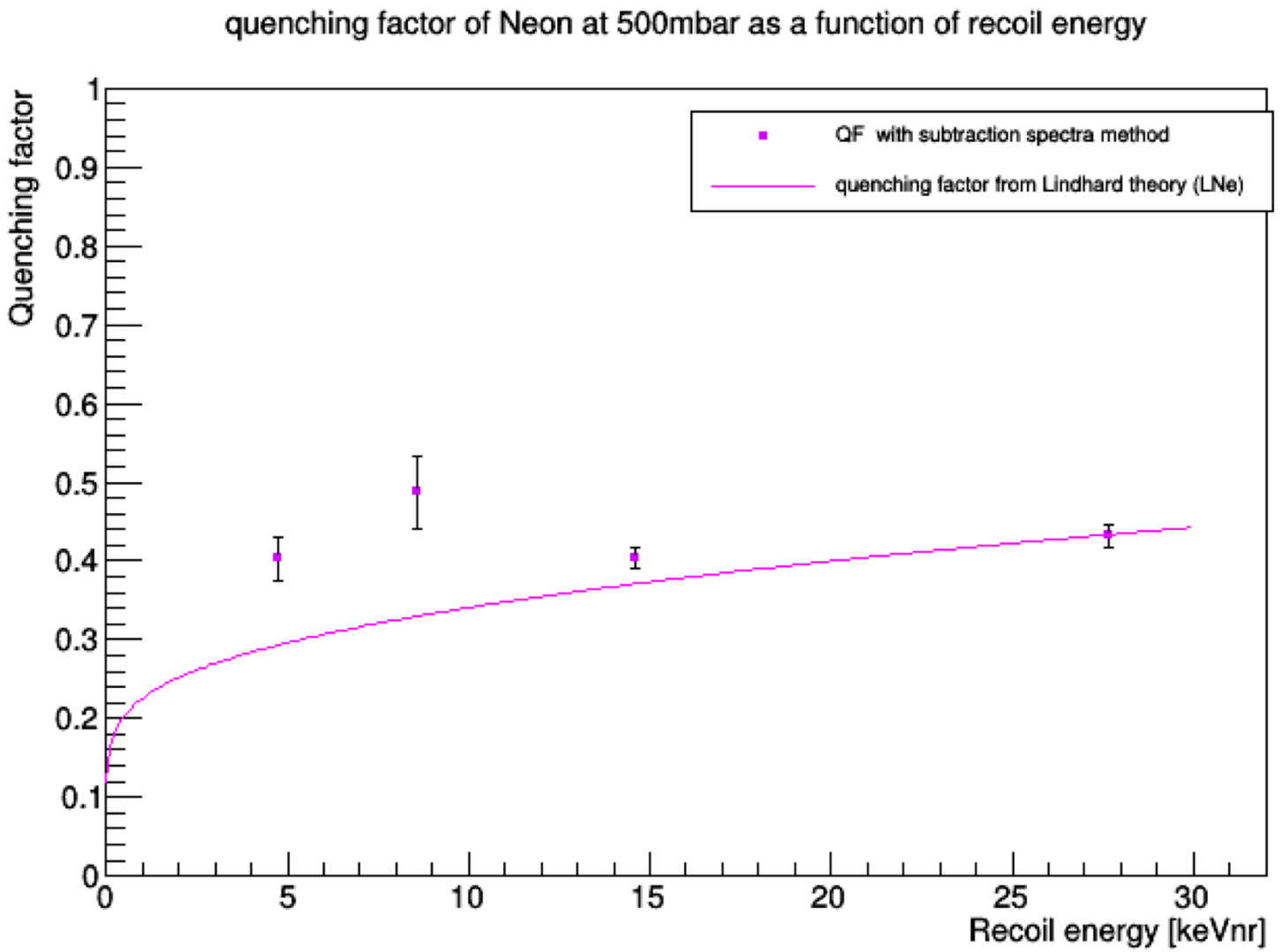


Recoil energy spectrum: 4.95 keVnr



Recall from previous campaign

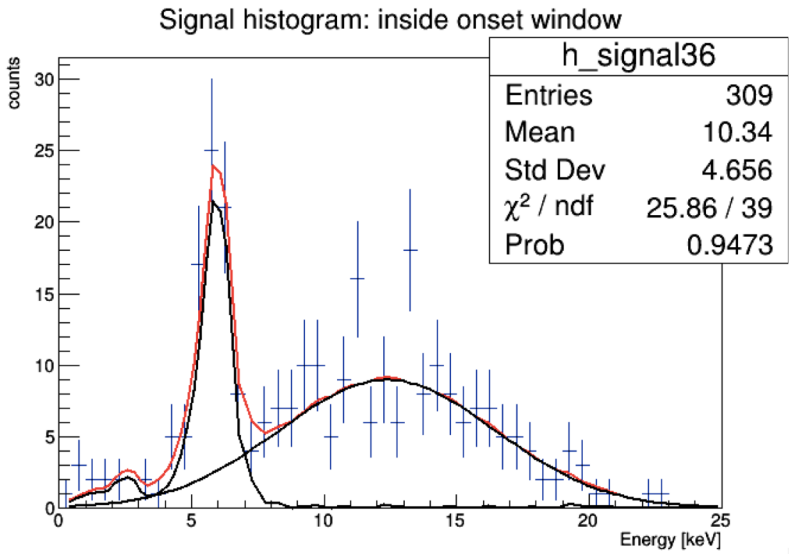
- 2018-12-12
- Error bars: uncertainty in energy mean, neutrons energy and scattering angle
- No systematics

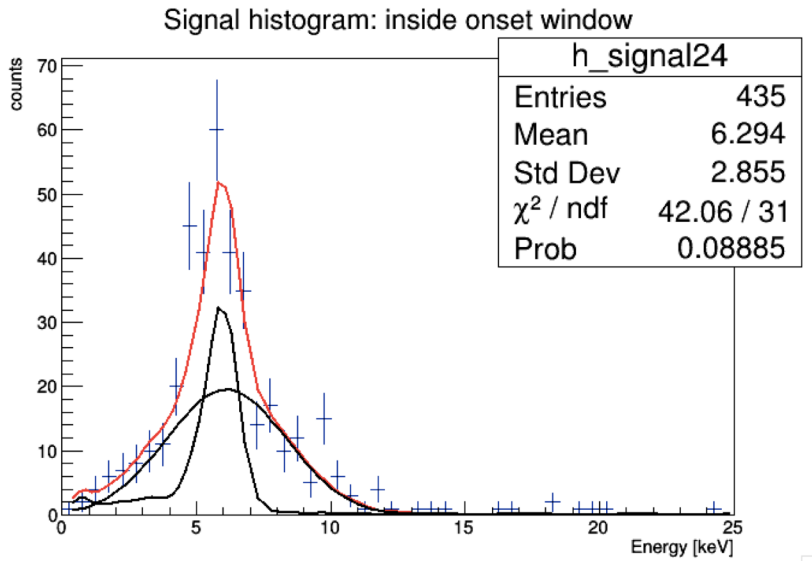


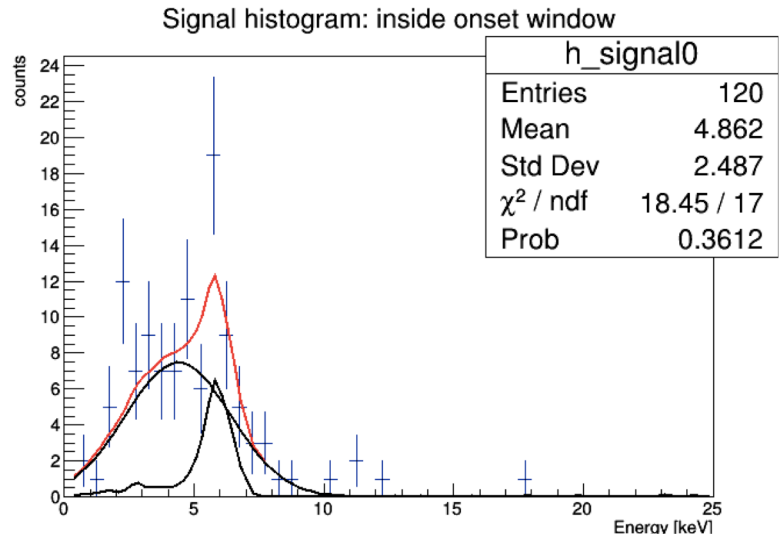
Analysis update: extraction E_{ee} mean

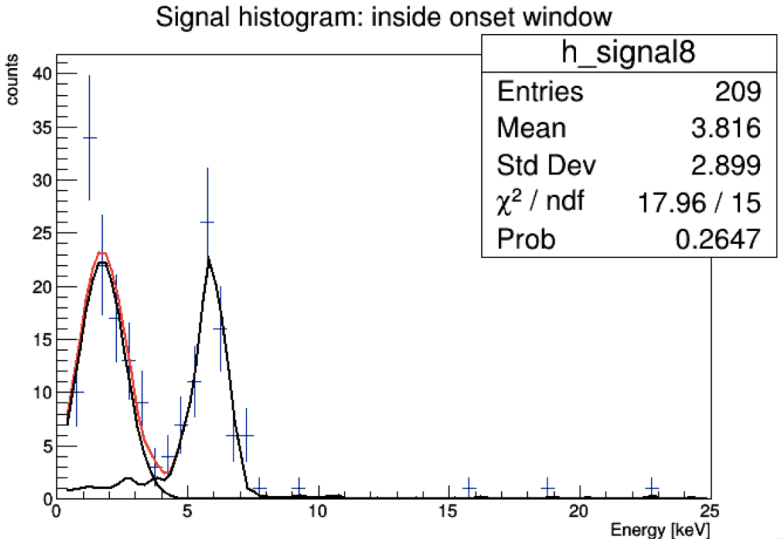
- Background pdf from background onset window
- Interpolation of background spectrum
- Model recoils peak with a gaussian

- Red curve: total fit
- Black curve: contribution of each source of events (BG and recoils)



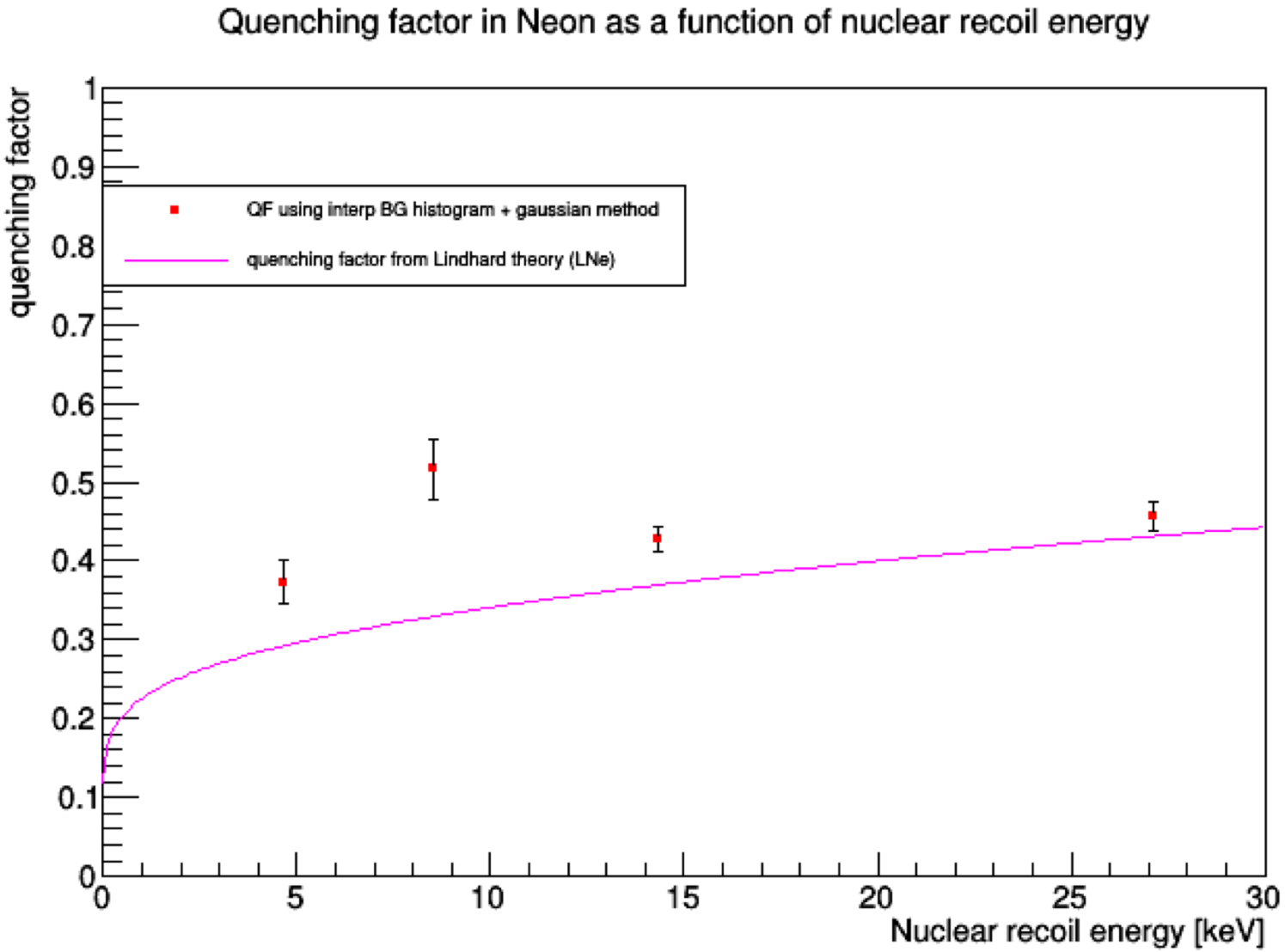






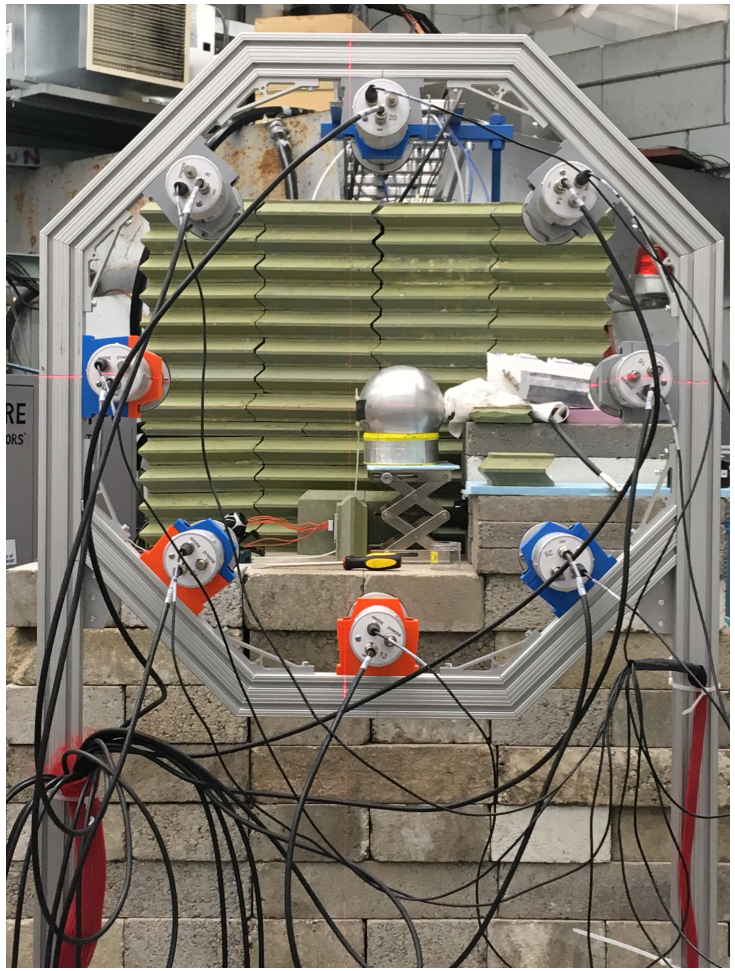
Quenching factor update

- Error bars: uncertainty in energy mean, neutrons energy and scattering angle
- No systematics
- Tuned processing parameters to narrow ^{55}Fe peak (5%)



Campaign 2019: lower recoil energies

- p + ^{7}Li → n + ^{7}Be+ γ
- Neutron beam energy 545 keV
- Gas: Neon:CH_4 (97:3)
- Pressure: 2 bar
- Al sphere + new sensor (glass tube)
- Improved shielding (neutrons/gammas)
- Calibration: ^{55}Fe source (5 min between each h of data taking)
- 8 energy points investigated: 6.52, 2.93, 1.98, 1.71, 1.29, 1, 0.73 and 0.34 keVnr



Annulus configuration

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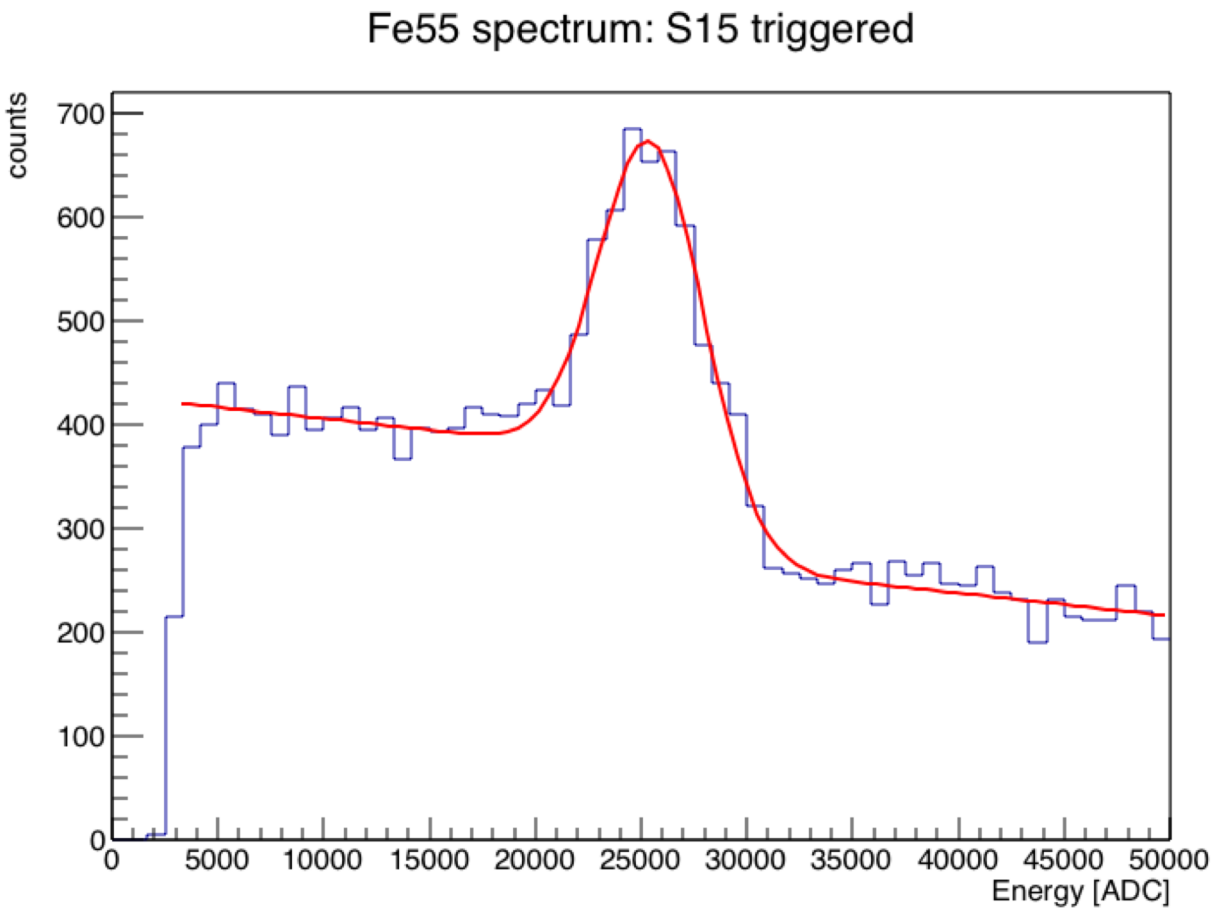
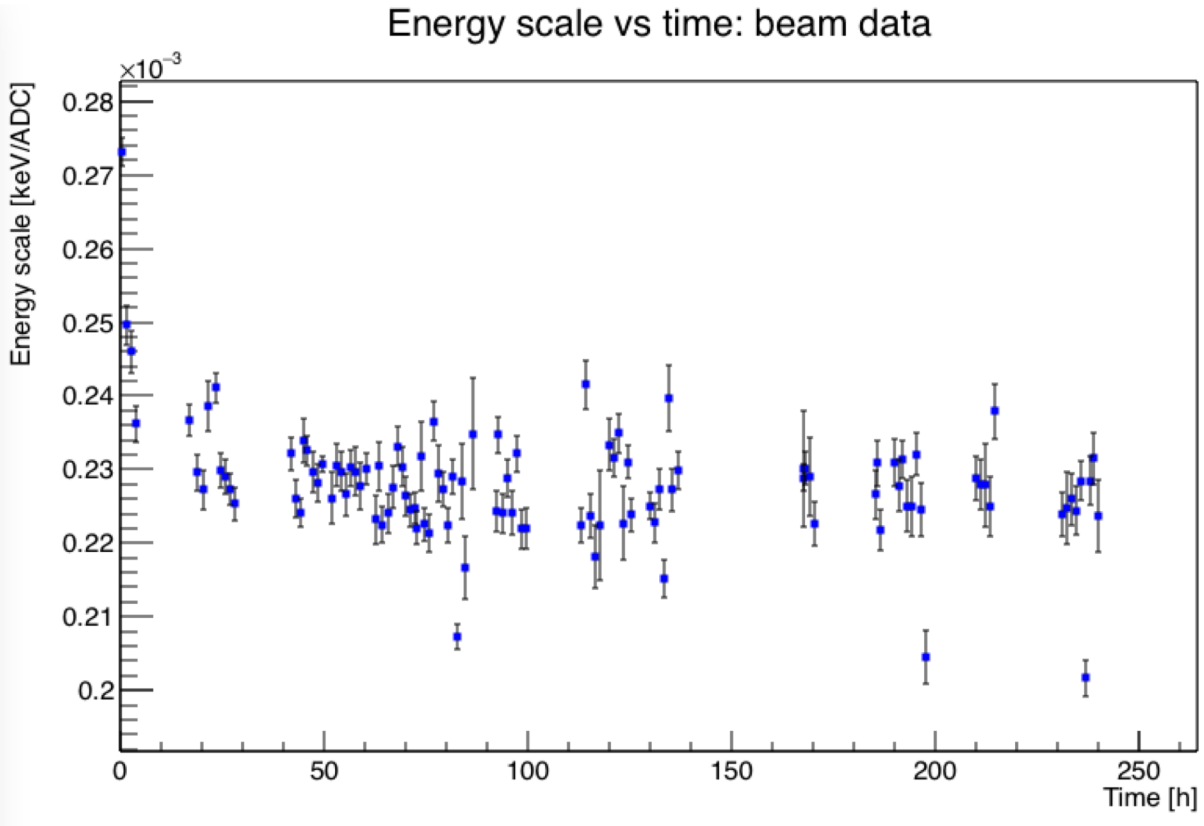
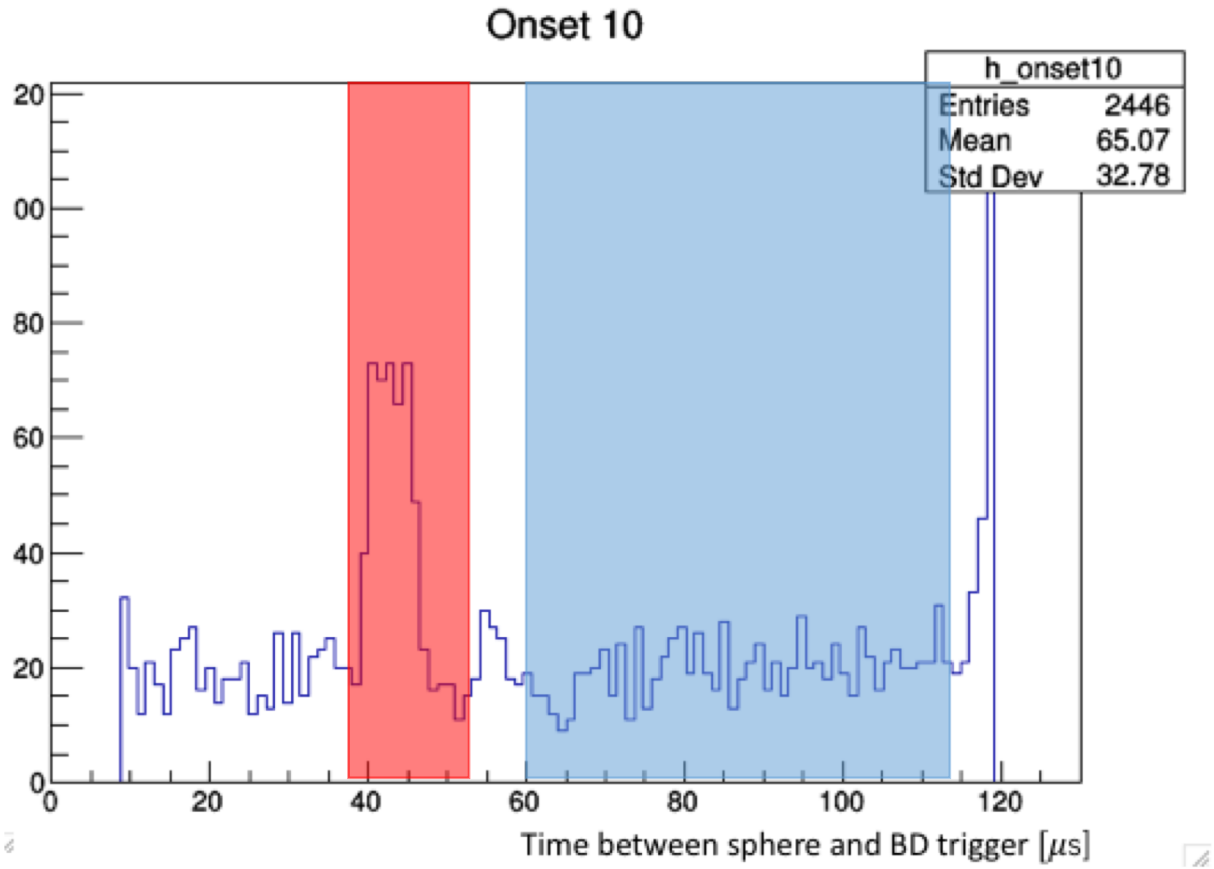
Multiple energies configuration

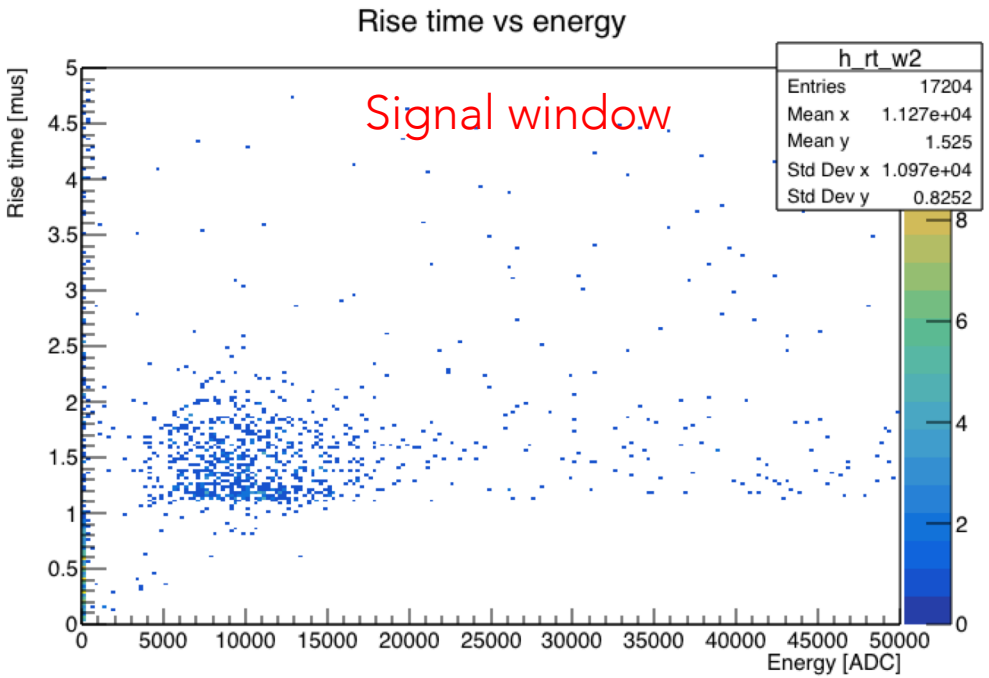
Energy calibration: Fe55 peak at 5.9 keV



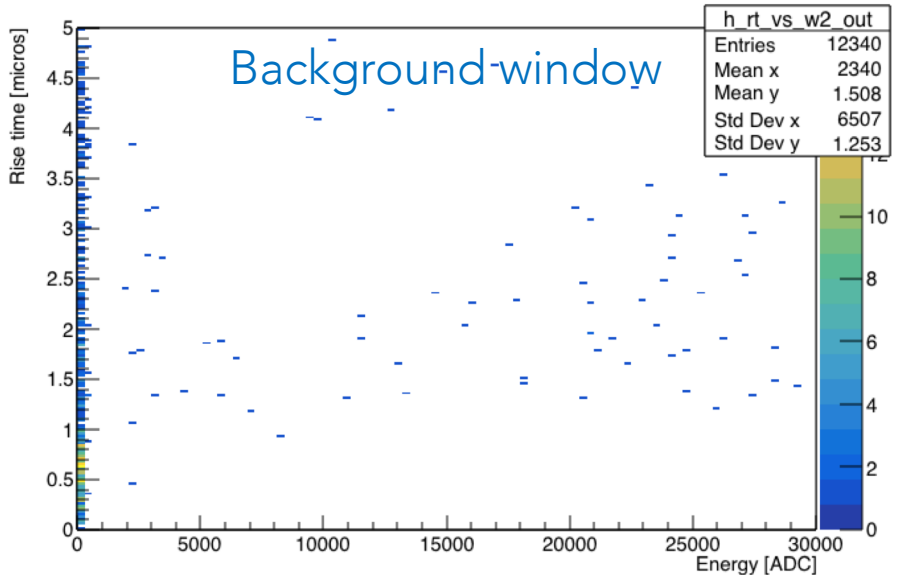


Recoils events selection

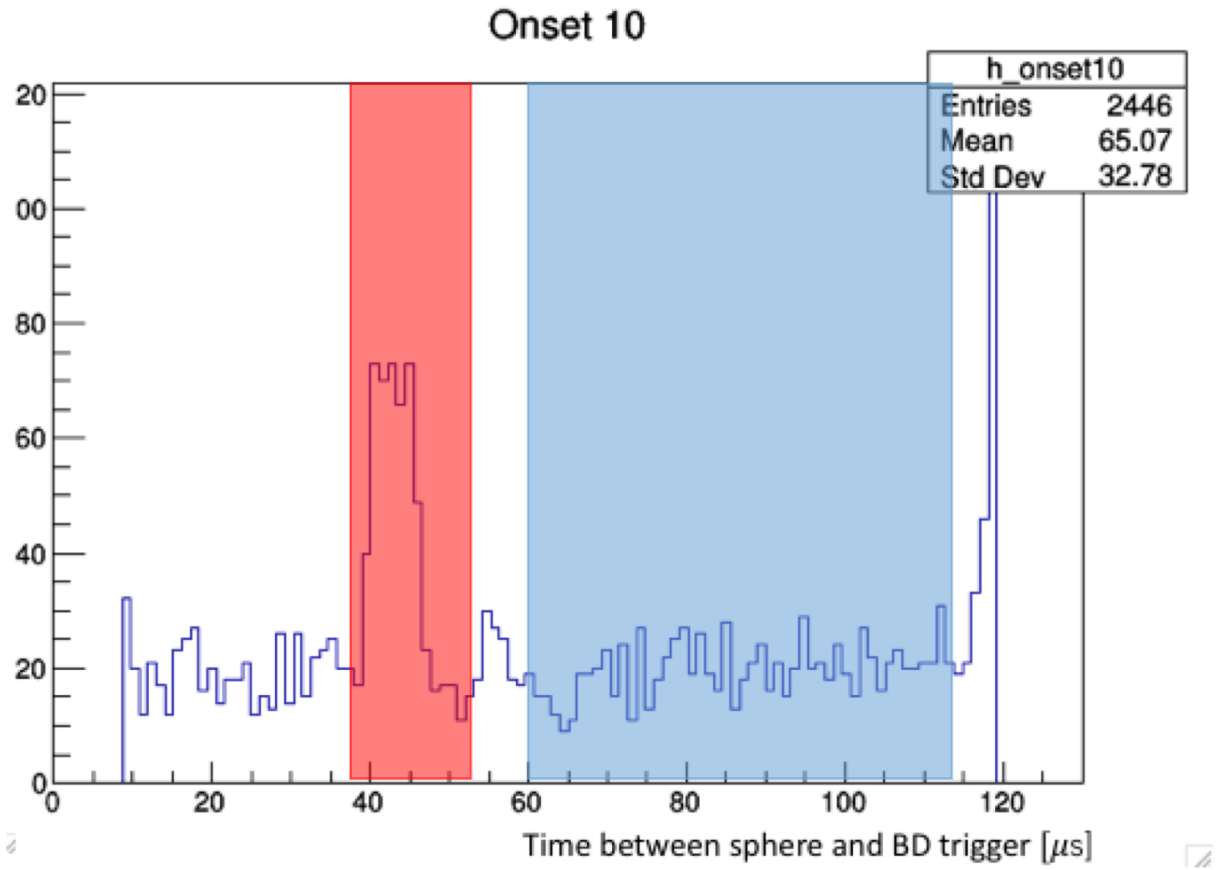


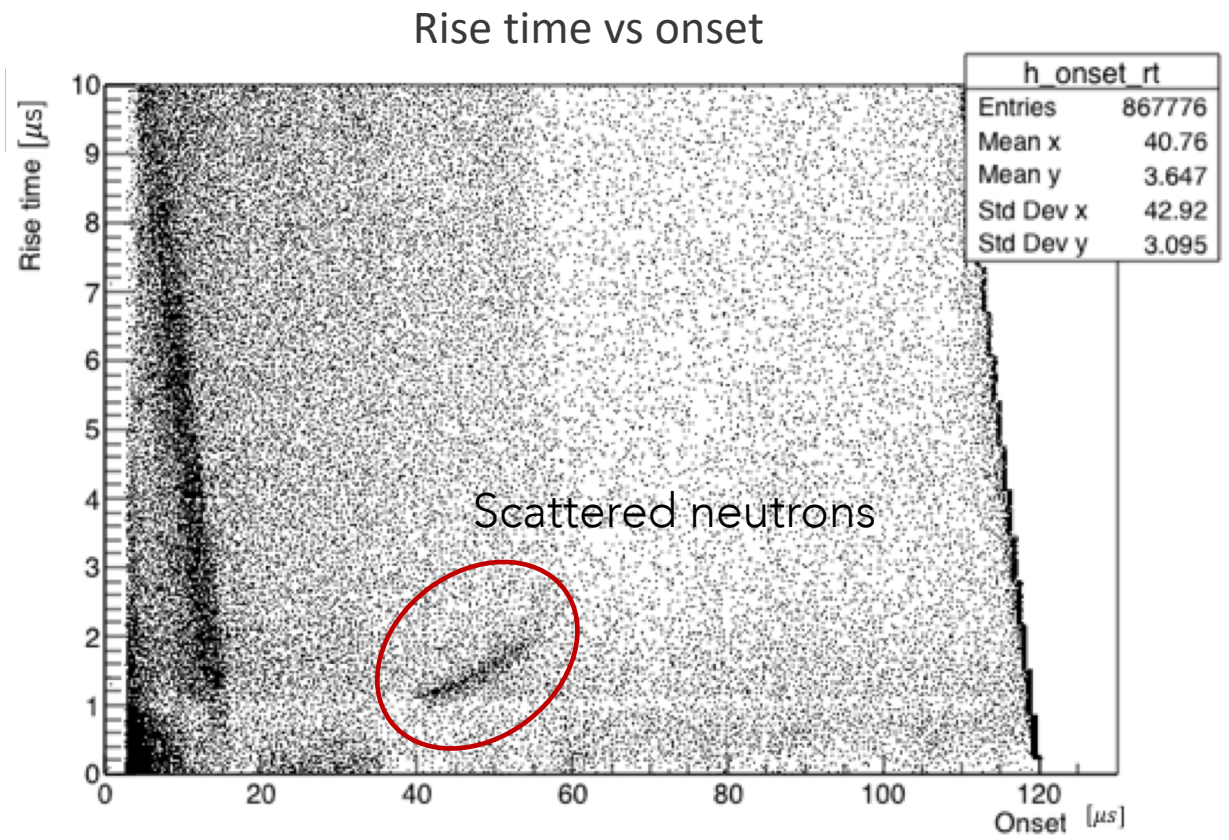


Rise time vs energy outside onset

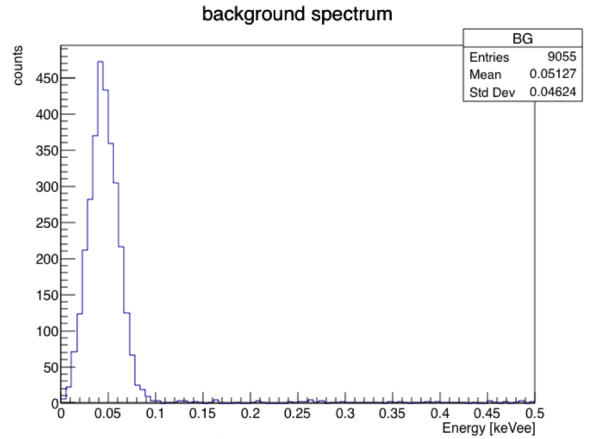


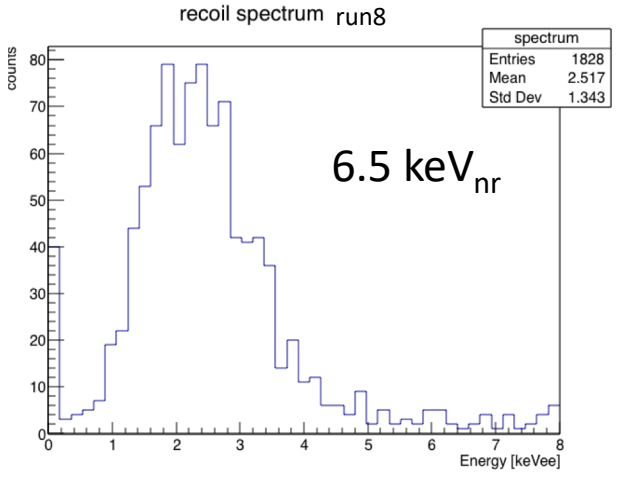
Recoils events selection

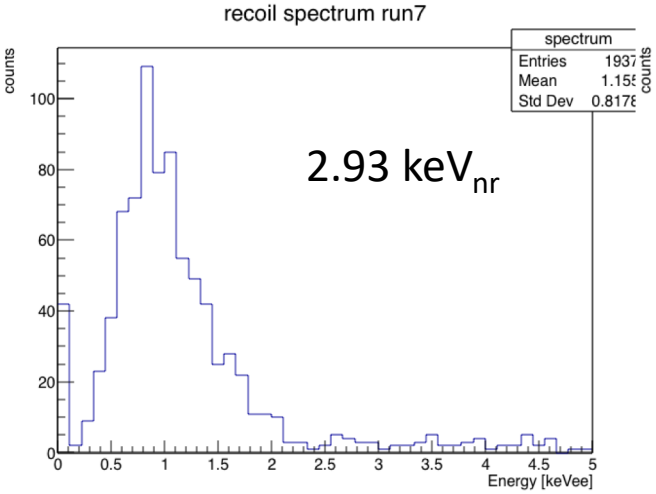


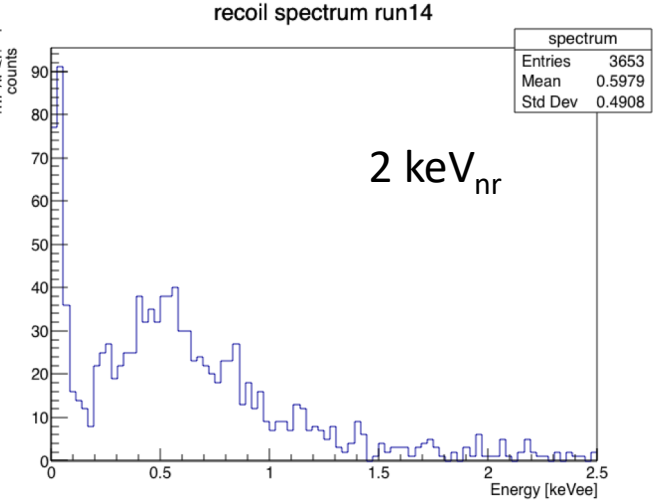


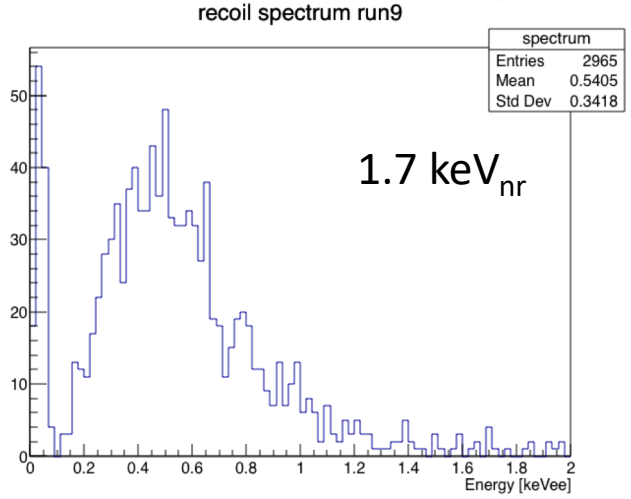
Recoils energy spectra

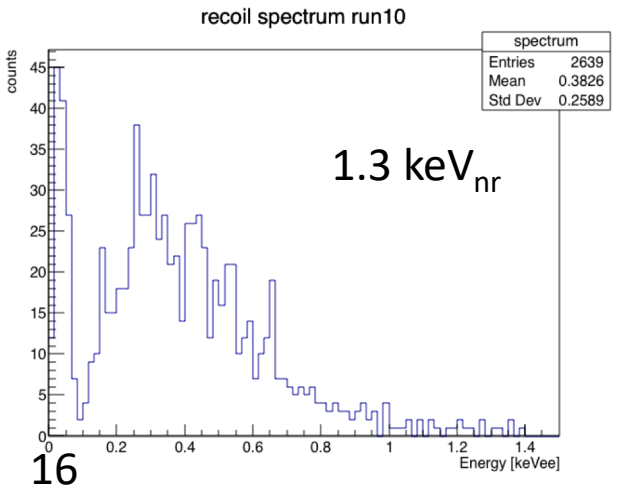


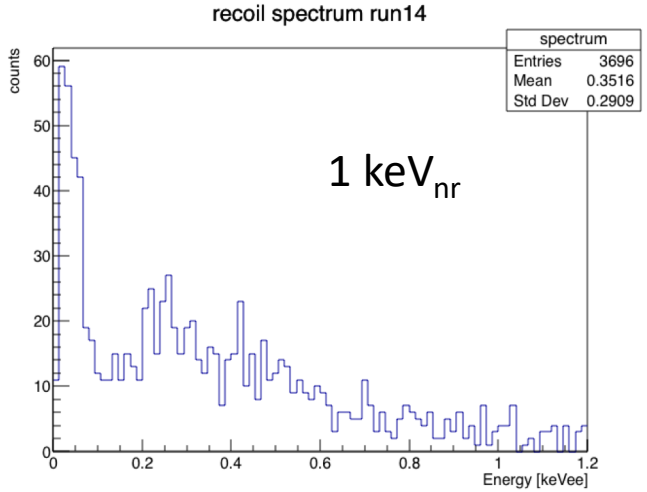


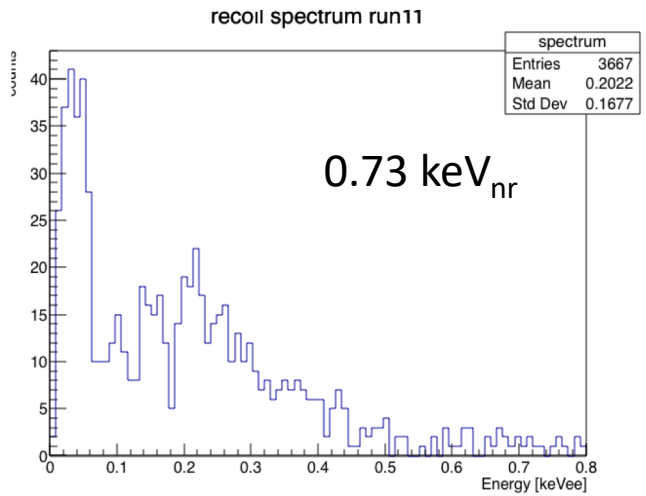


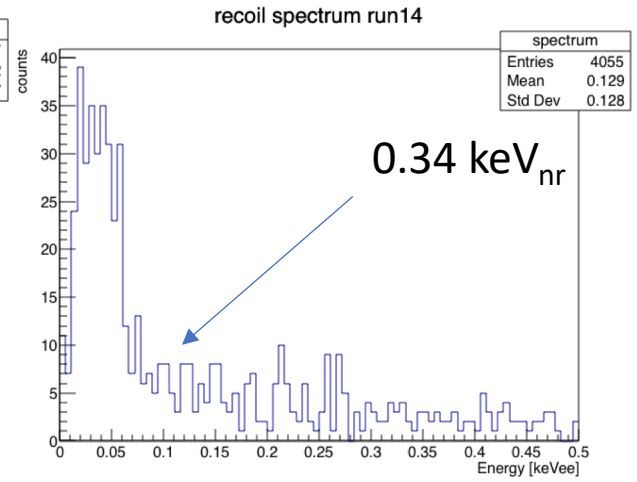




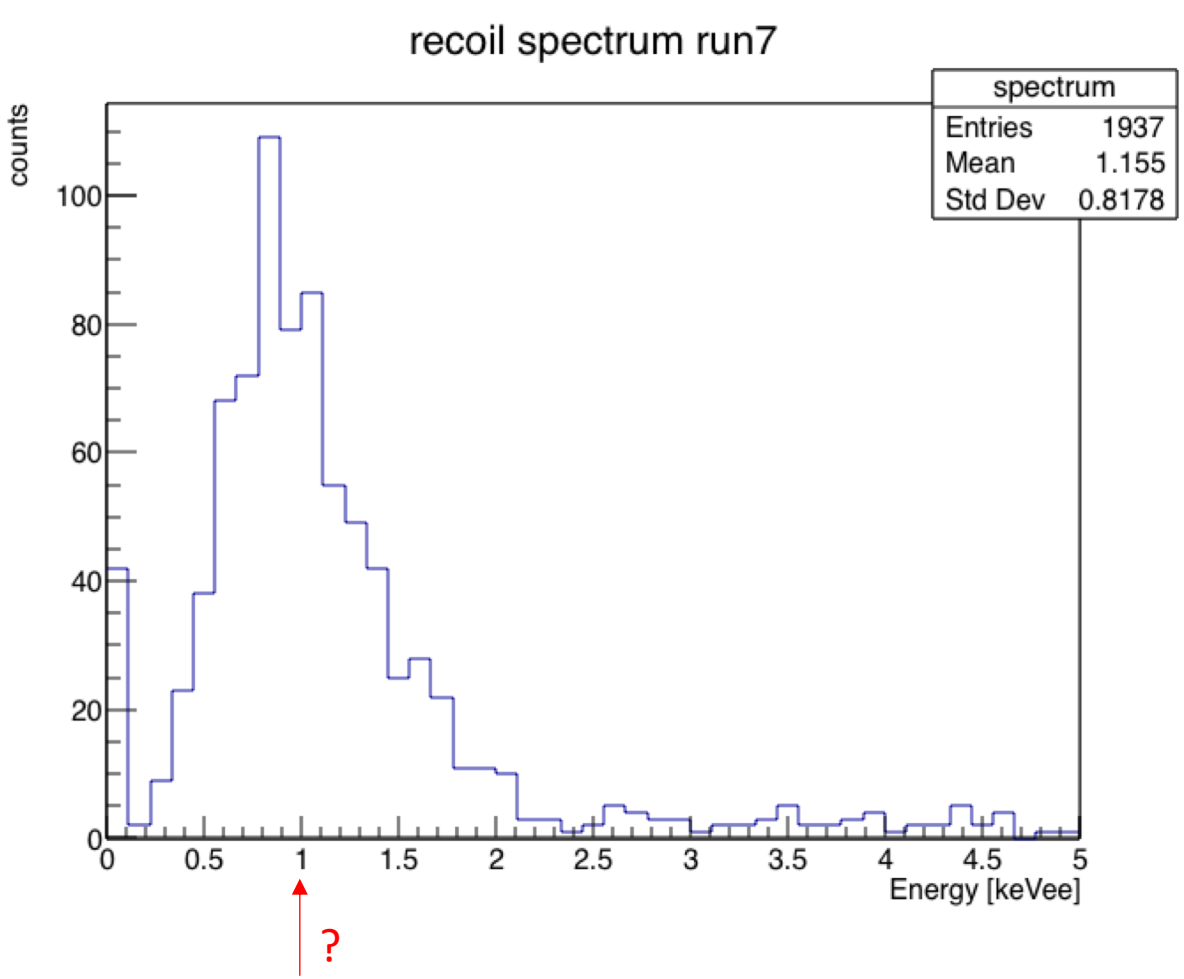


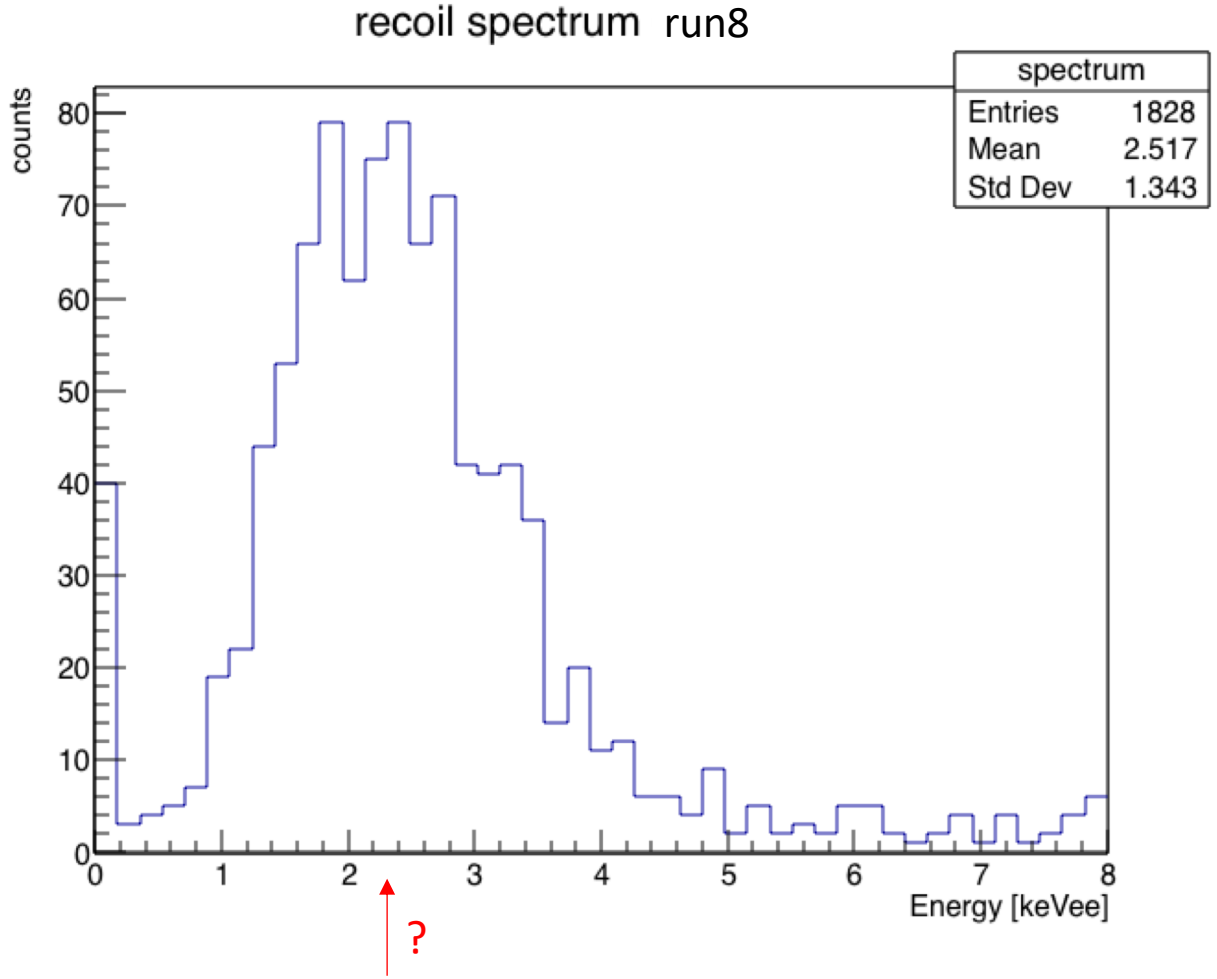




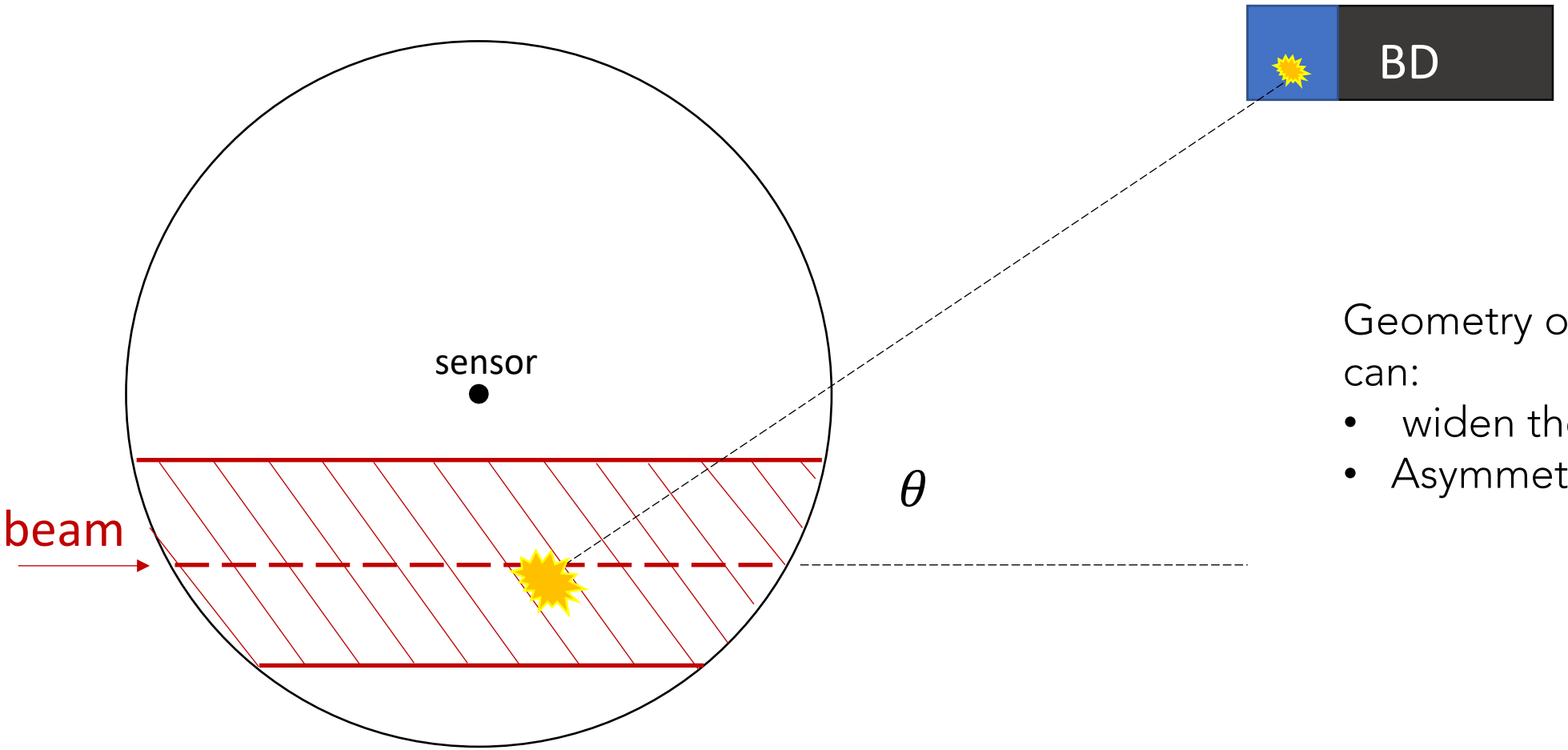


Recoils energy spectra: E_{ee} extraction





Study of the peak shape: geometry



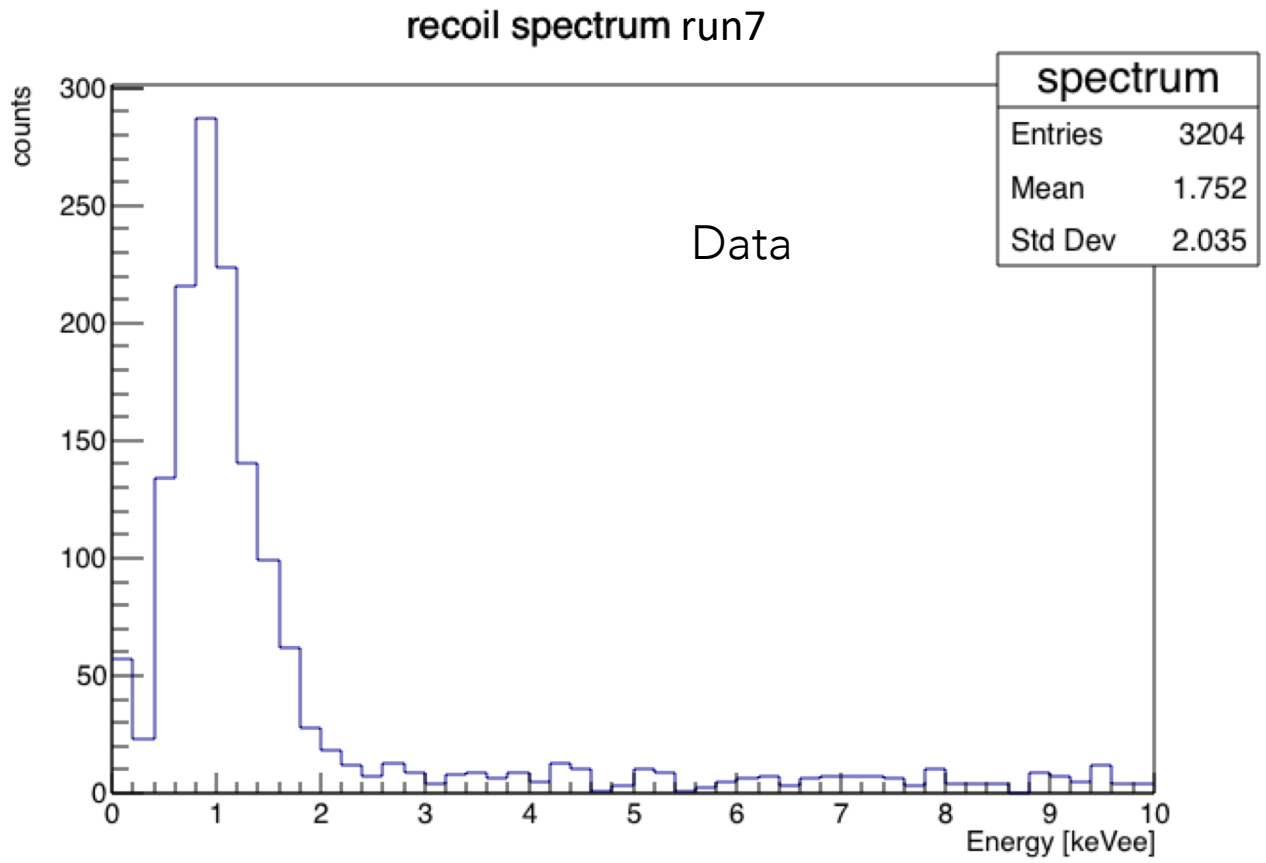
Geometry of the experiment can:

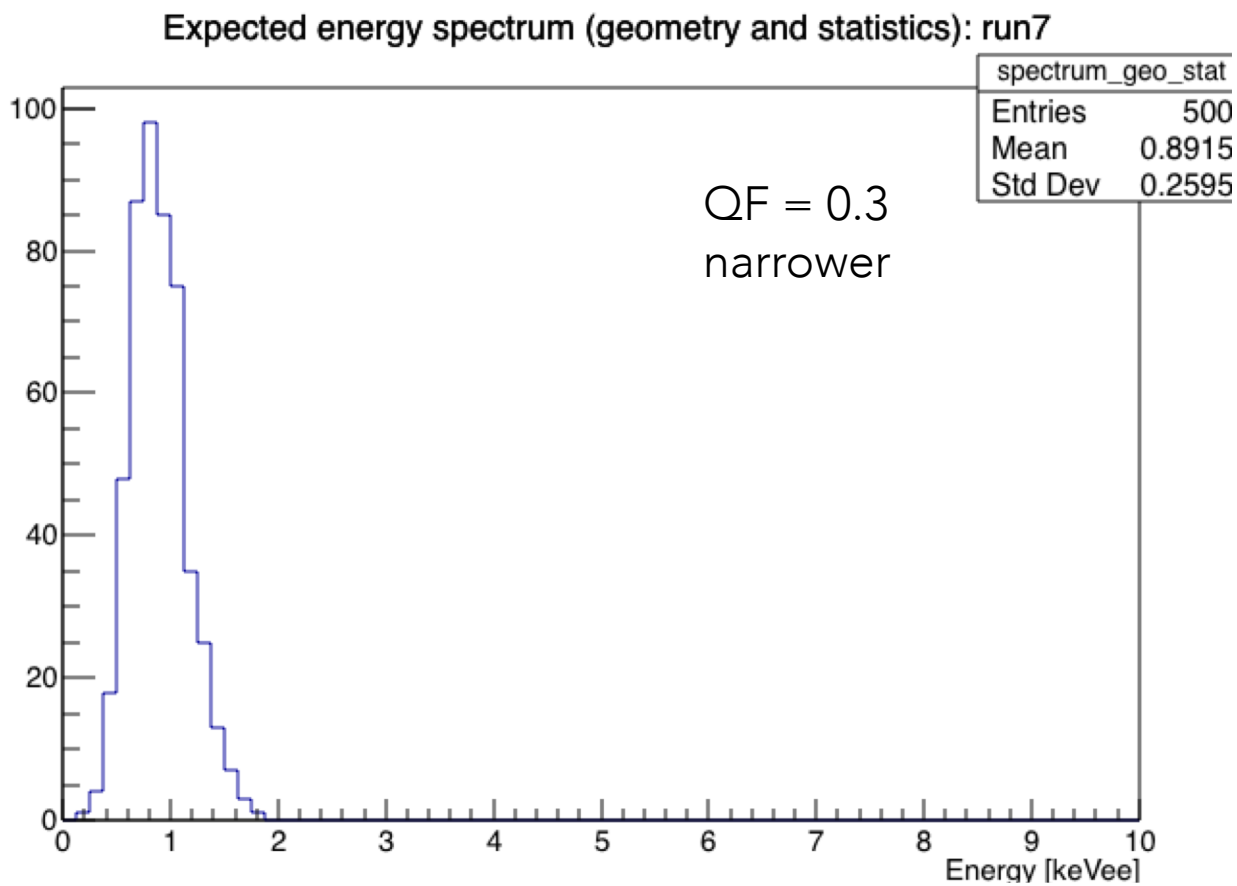
- widen the peak
- Asymmetric peak

Study of the peak shape: simulation

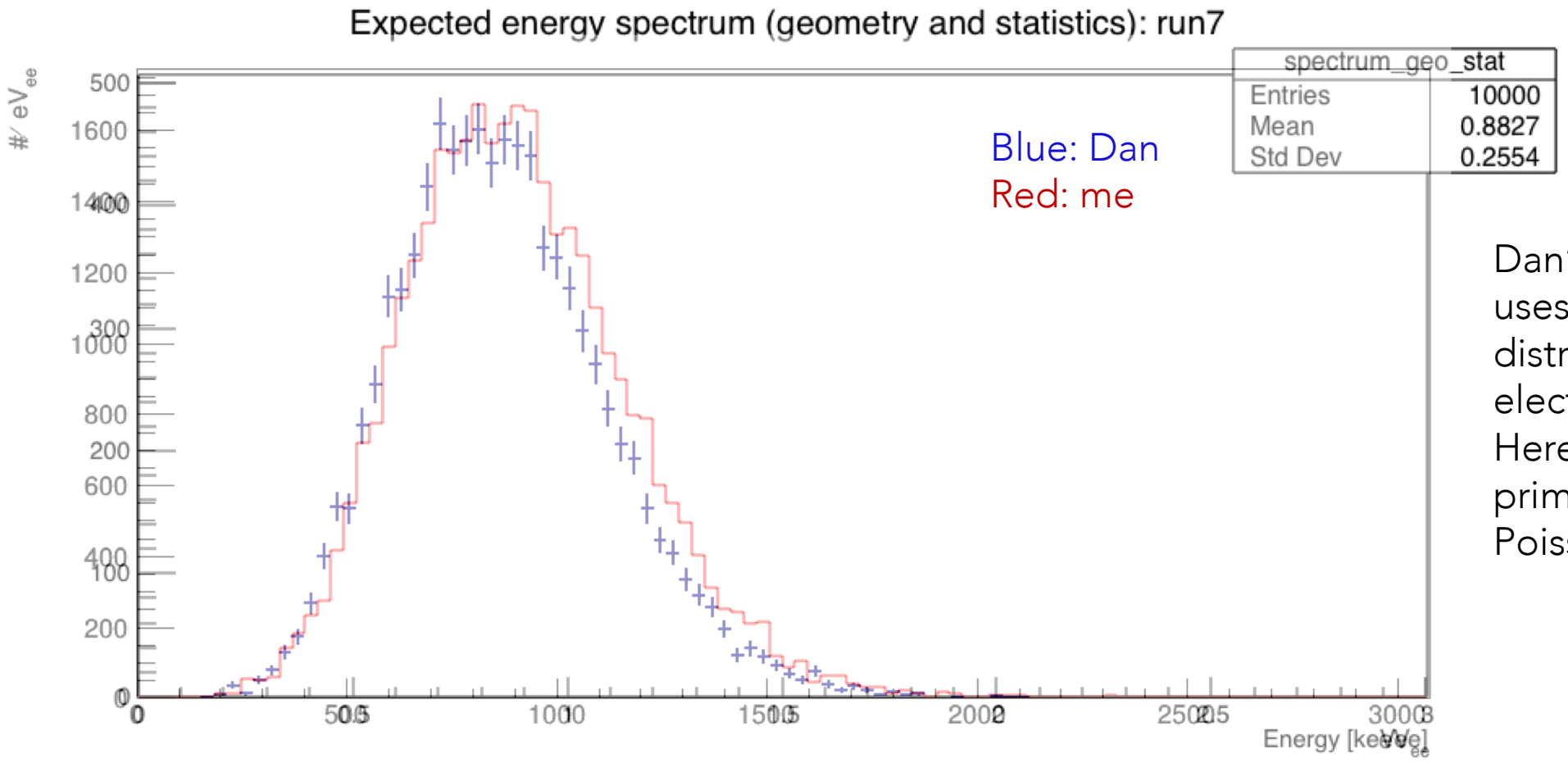
- Choose randomly coordinates of events
- Scattering angle from coordinates
- $E_{nr}(E_n, \theta)$
- $\mu(\#pe) = E_{nr} \times QF / W$ (W: energy necessary to create 1 e/i pair)
- #pe = Poisson(μ(#pe))/COM-Poisson
- #se = Nth_Polya(#pe) (convolution)
- Conversion from #se to eVee: using ^{55}Fe calibration
- Expected energy spectrum

Study of the peak shape: run7, 2.93 keV_{nr}



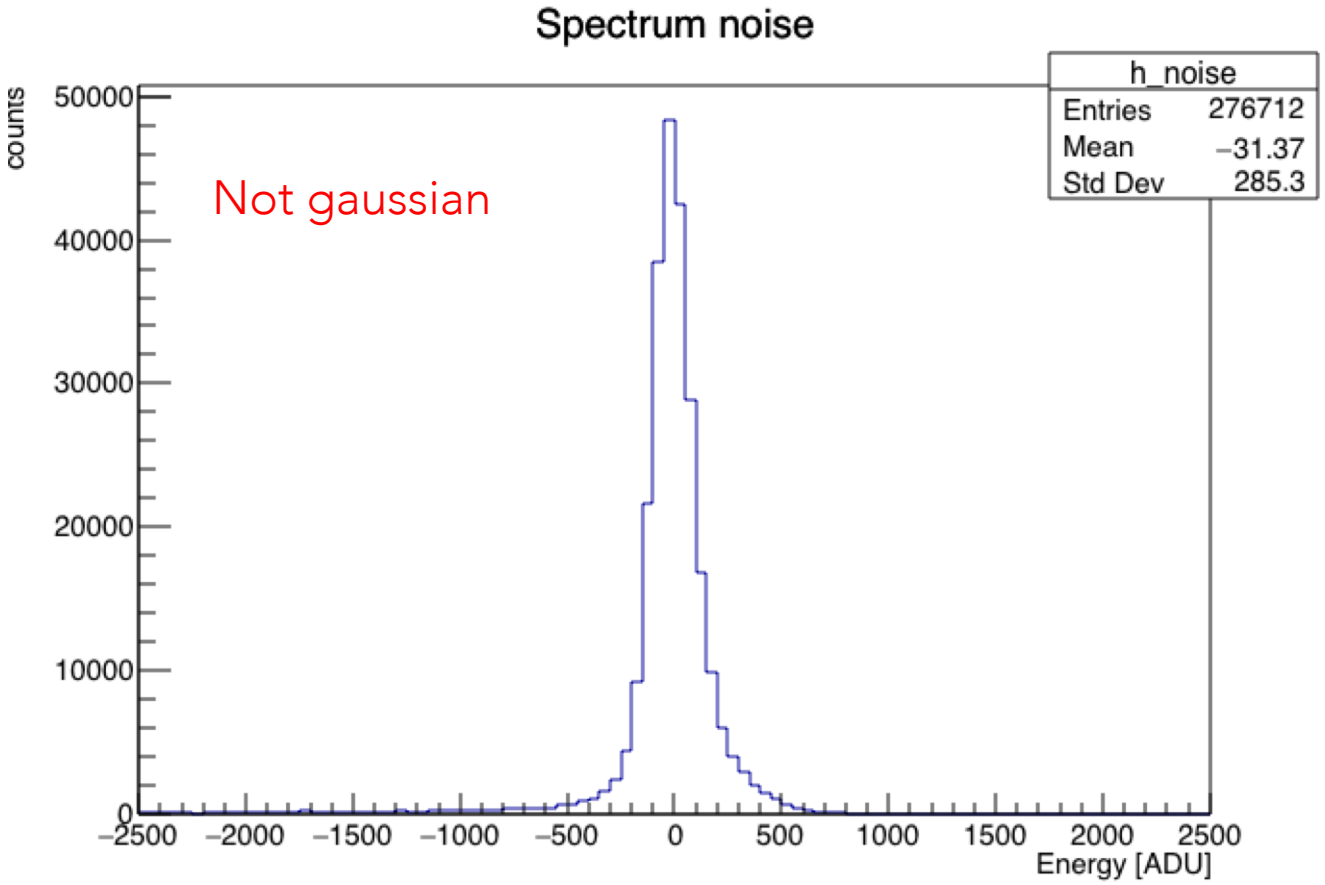


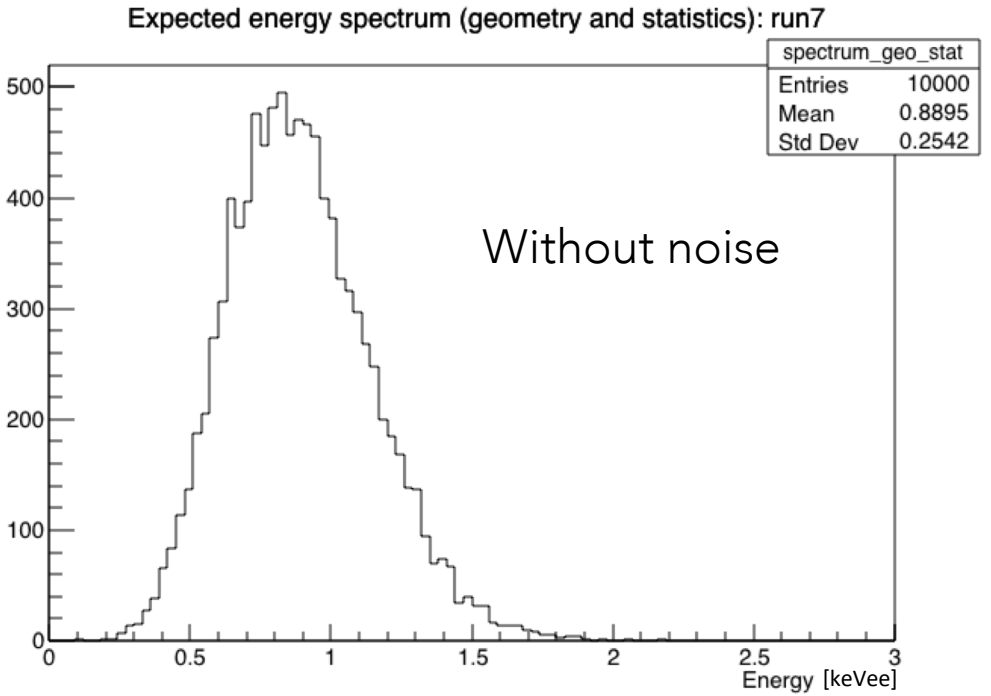
Comparison between Poisson and COM-Poisson

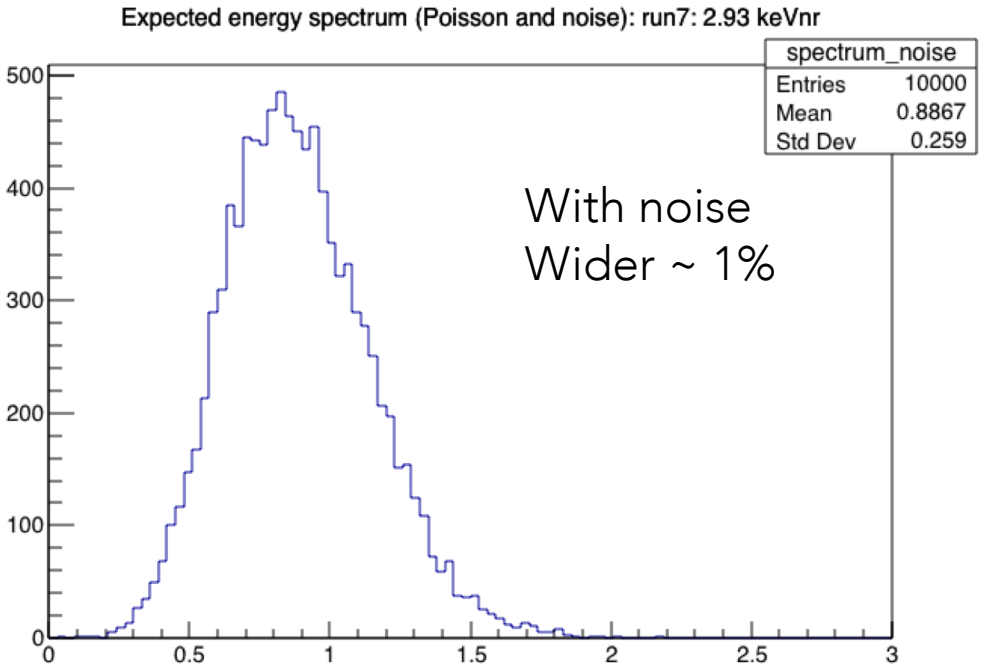


Dan's code:
uses COM-Poisson distribution for primary electrons
Here Fano = 1 so that the primary electron statistics is Poisson

Study of the peak shape: impact of the noise

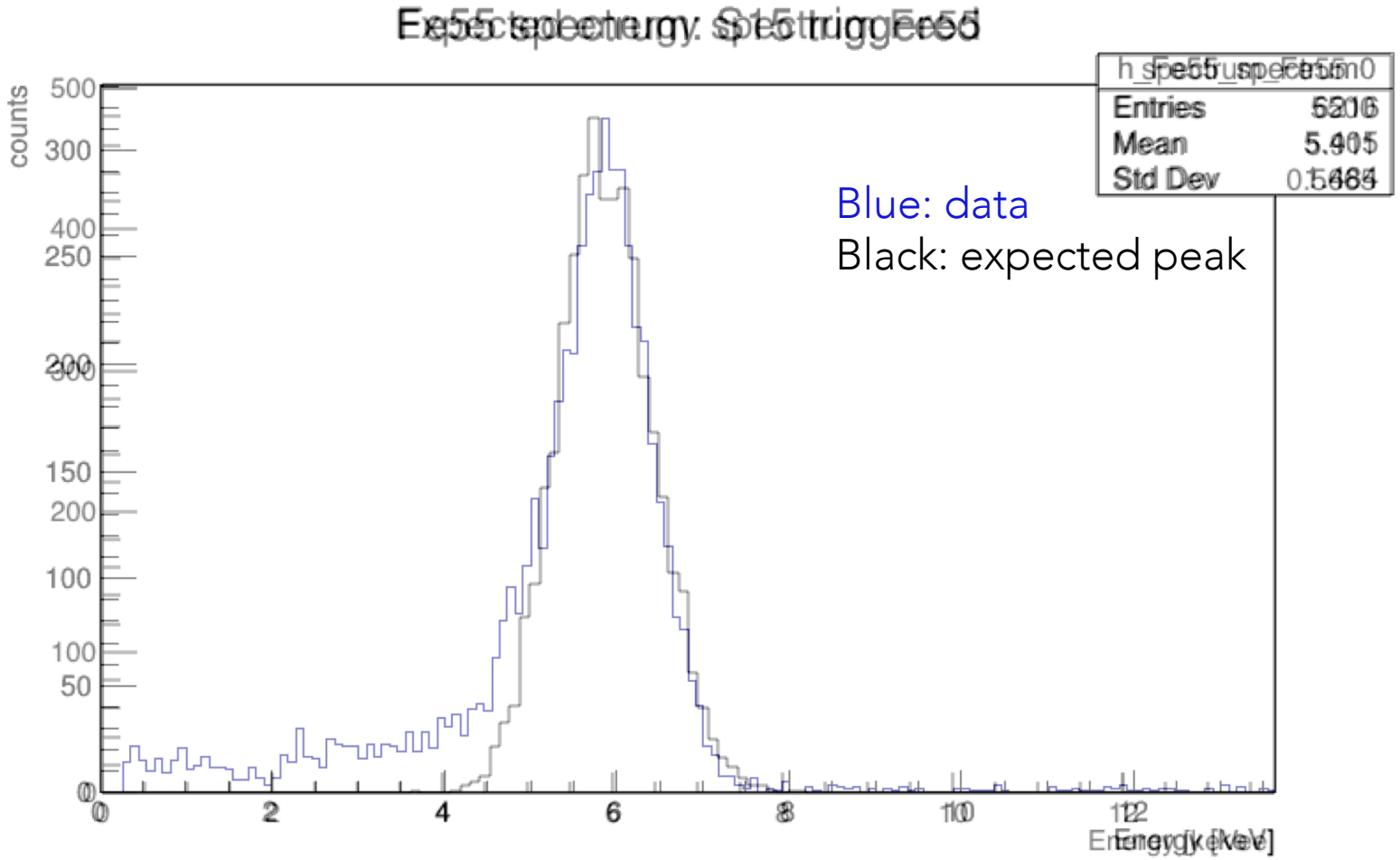






Study of the ^{55}Fe peak: gain check

- Choose to use the ^{55}Fe peak from the 2018 campaign to compare with the expected peak shape.
- Gain: 10^3
- First comparison: superimposition of data energy spectrum and expected energy spectrum.



Conclusion

- 2nd estimate of QF for 2018 campaign
- 2019 campaign down to single electron sensitivity: 0.34 keV_{nr}
- 12 energy points: 0.34 to 27 keV_{nr} in neon gas
- Develop a model for the recoils peak shape
- Worked with Dan to implement the COM-Poisson stat to my model

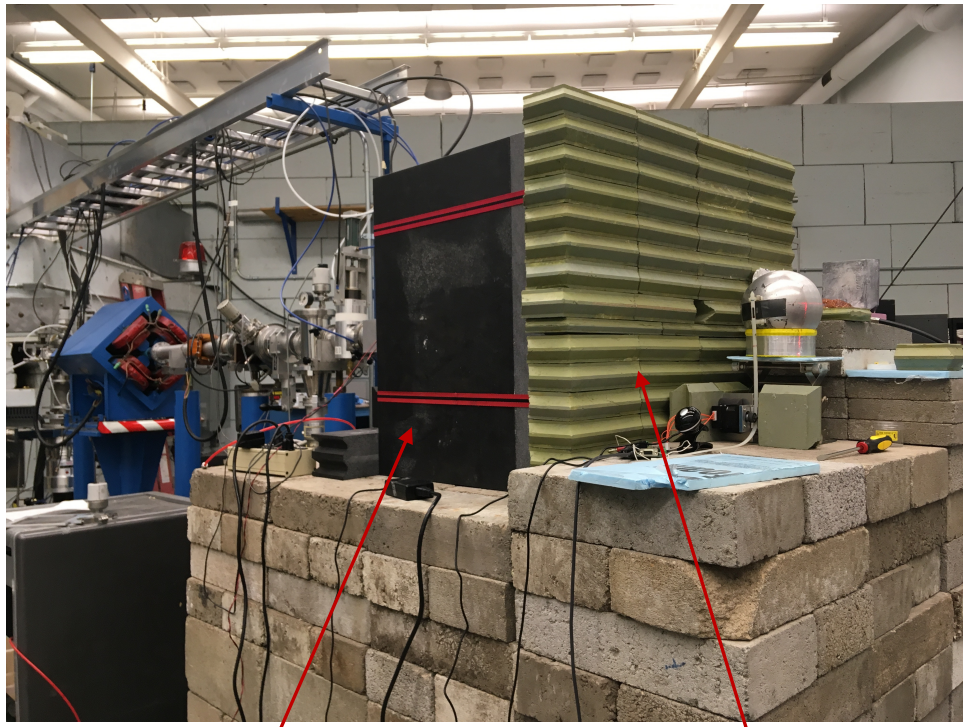
- Implement model peak shape to extract QF using unbinned likelihood
- Tune different processing parameters: impact on energy spectra
- Tune selection cuts: impact on energy spectra
- Study of systematic uncertainties

Thank you

Back up slides

New experiment conditions

Shieldings have been added around the beam line.



Polyethylene doped with ^{8}B for neutron capture

Lead wall for gammas

Lead shield on backing detectors to improve gammas background

Shielding