Progress on back-scattering analysis from TB16

FCAL software and analysis meeting

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Universität Hamburg
DER FORSCHUNG | DER LEHRE | DER BILDUNG

CLUSTER OF EXCELLENCE
QUANTUM UNIVERSE

FCAL Collaboration
High precision design

DESY.

Why it is interesting

Plans

1) Test EM physics lists for 180° scattering
2) Study back-scattering as a tool to measure beam intensity (LUXE)
3) Impact for e-/gamma identification?

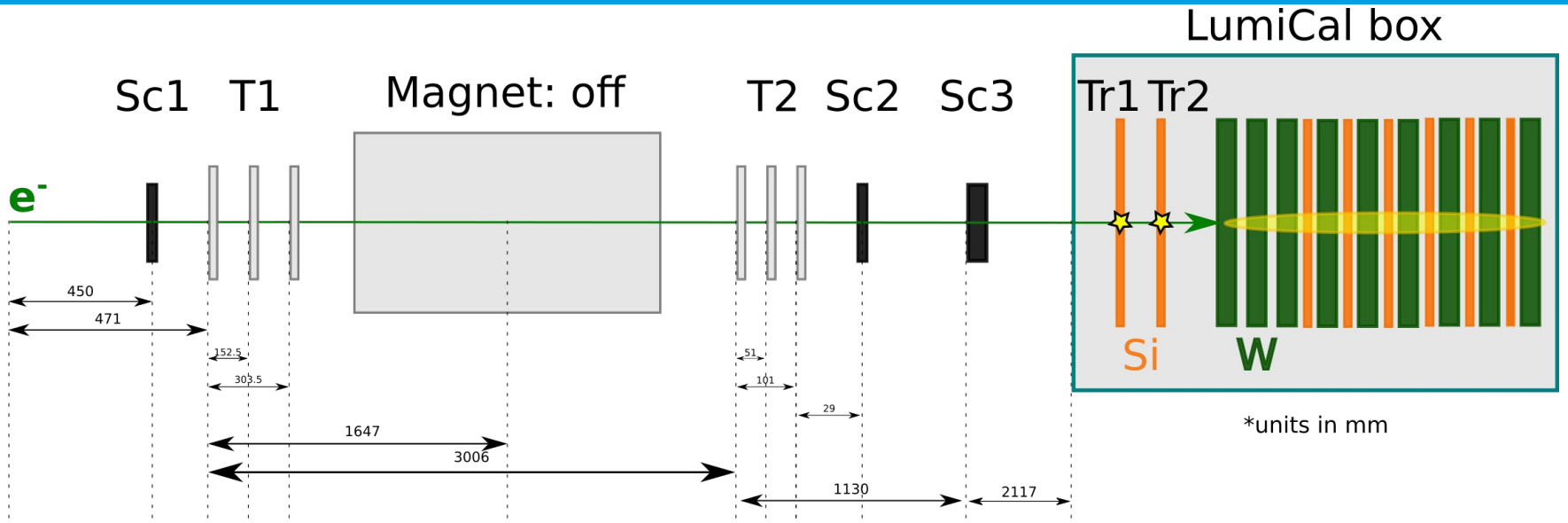
Status

1) **Currently ongoing**
2) Geant4 isn't enough?Is TB16 data can be useful?

   (1-5 GeV electrons | fixed distance ECAL-trackers | low statistics | leaking shower)?
3) Is it interesting outside of ILD design?

   (fixed distance ECAL-trackers | TB2020 w/o 1st absorber?)

Test beam 2016 (TB16)

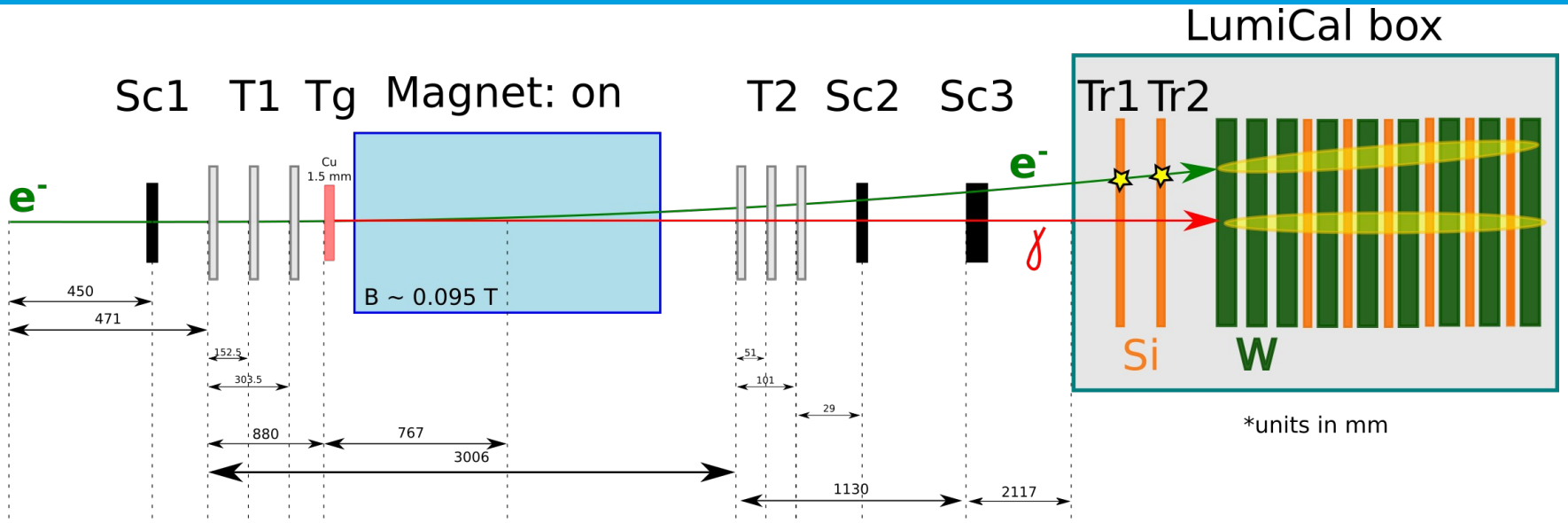


Source
- 5 ± 0.1 GeV electrons
- 5x5 mm^2 diamond colimator
- 0.75 mrad divergence

Electron only runs
- Magnet off
- No conversion target
- One cluster

DUT (LumiCal)
- Two Si planes in front
- 320 um Si sensors
- 3.5 mm W absorber

Test beam 2016 (TB16)



Source
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Photon runs
- Magnet on
- 1.5 mm Cu conv. target
- Two clusters

DUT (LumiCal)
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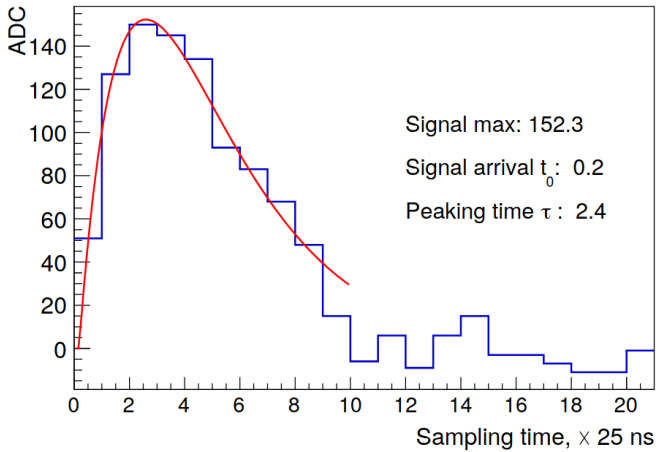
Signal selection

Fit signal shape with

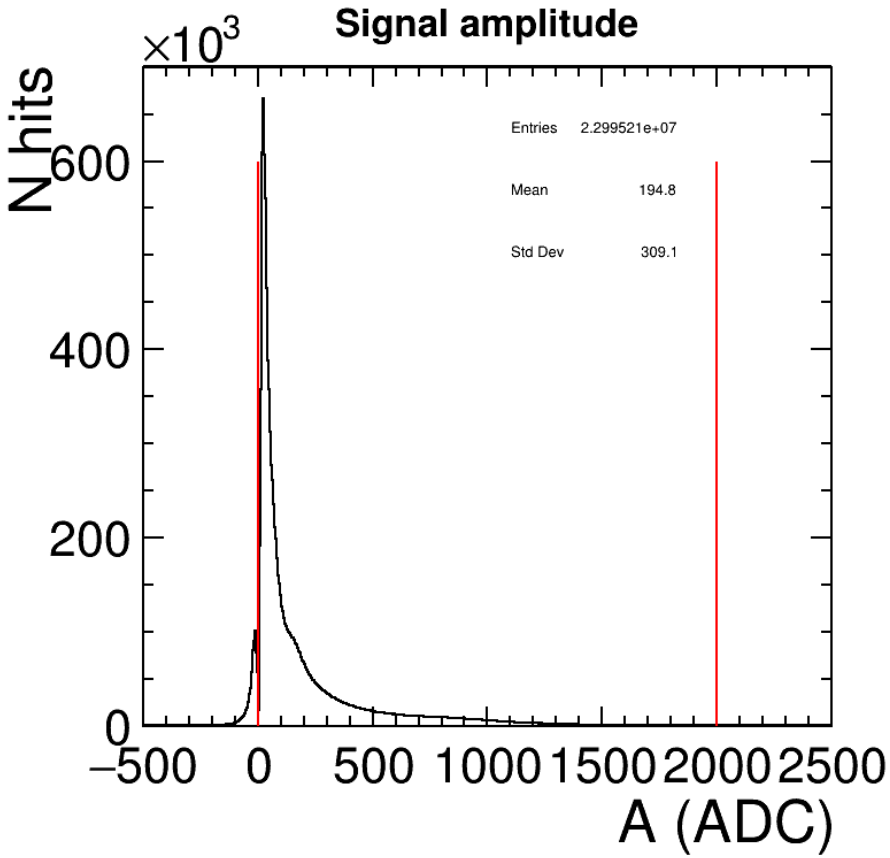
$$S(t) = A\frac{t - t_0}{\tau}e^{-\frac{t-t_0}{\tau}}$$

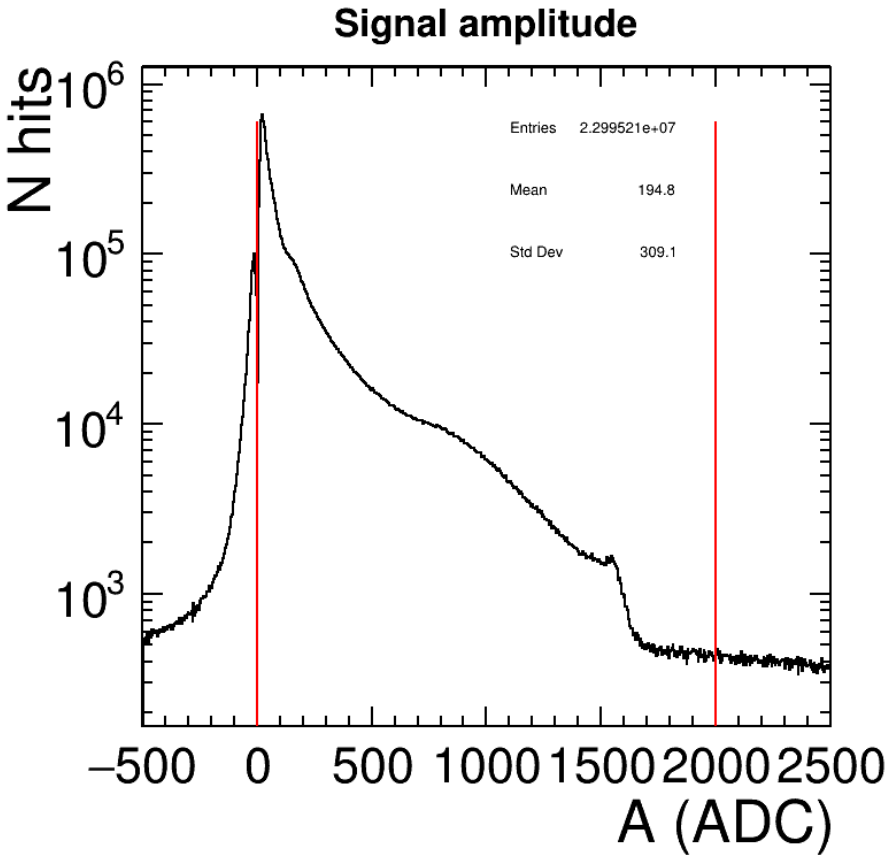


Copy signal selection from 2018 paper analysis

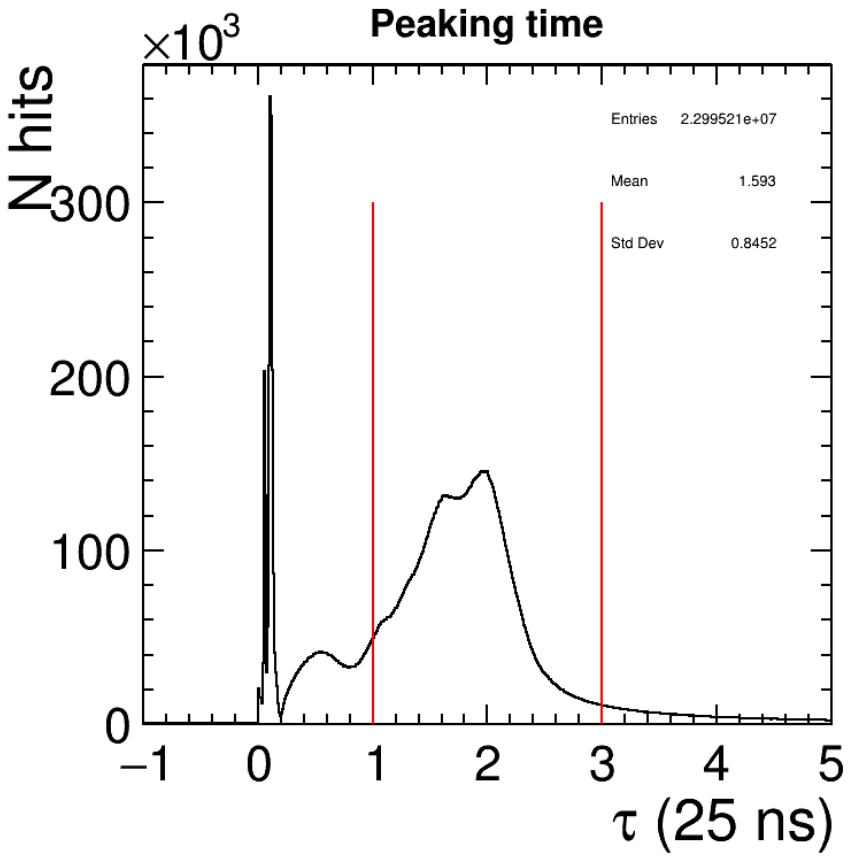
- $0 < A \leq 2000$ (ADC)
- $1 \leq \tau \leq 3$ (x25 ns)
- $-2.7 \leq t_0 - t_{1,bin} \leq -0.5$ (x25 ns)
- $NN_{output} \geq 0.5$

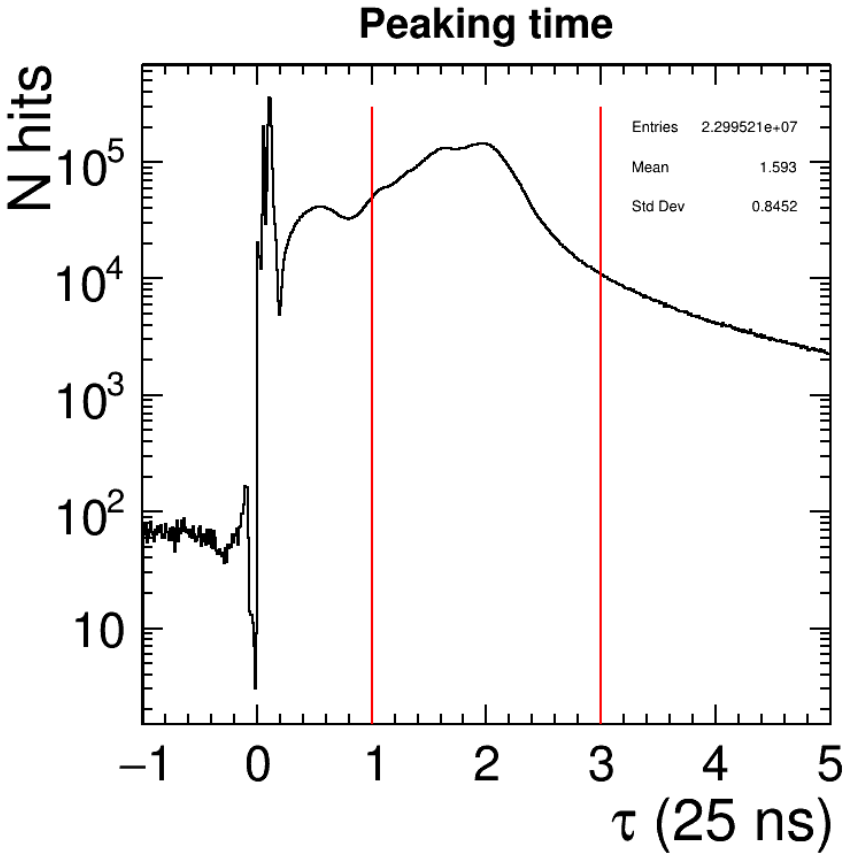
Signal selection



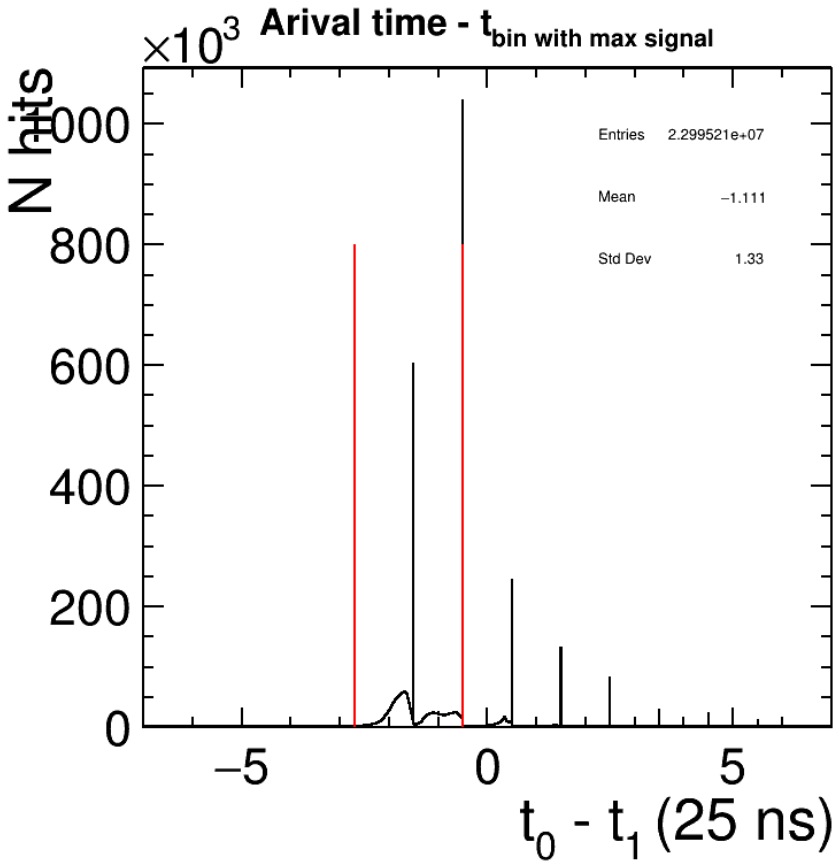


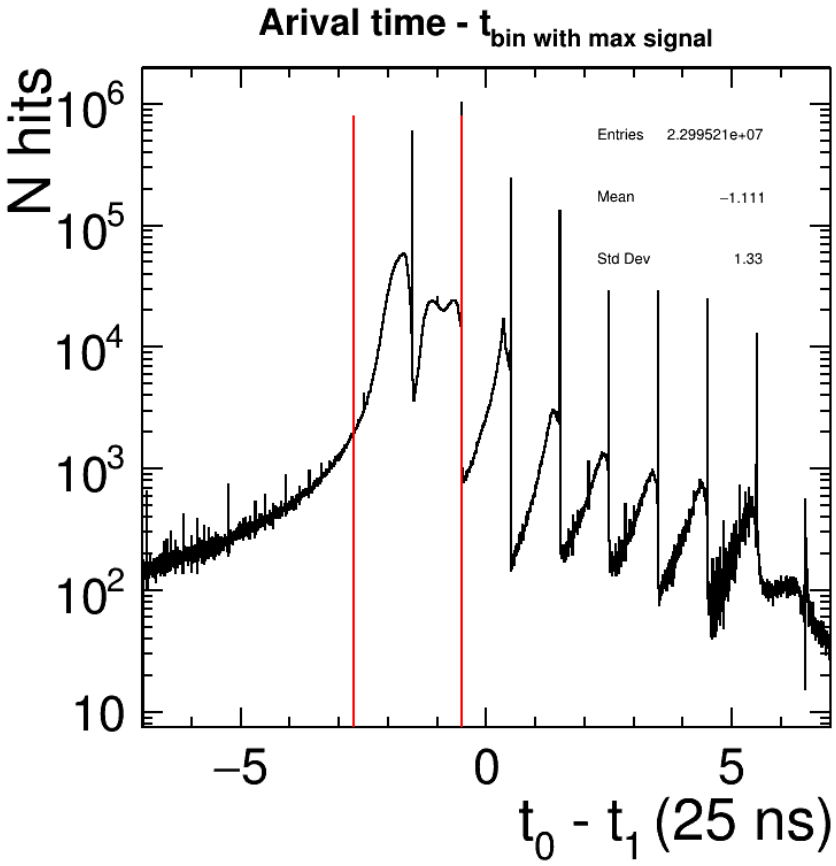
Signal selection



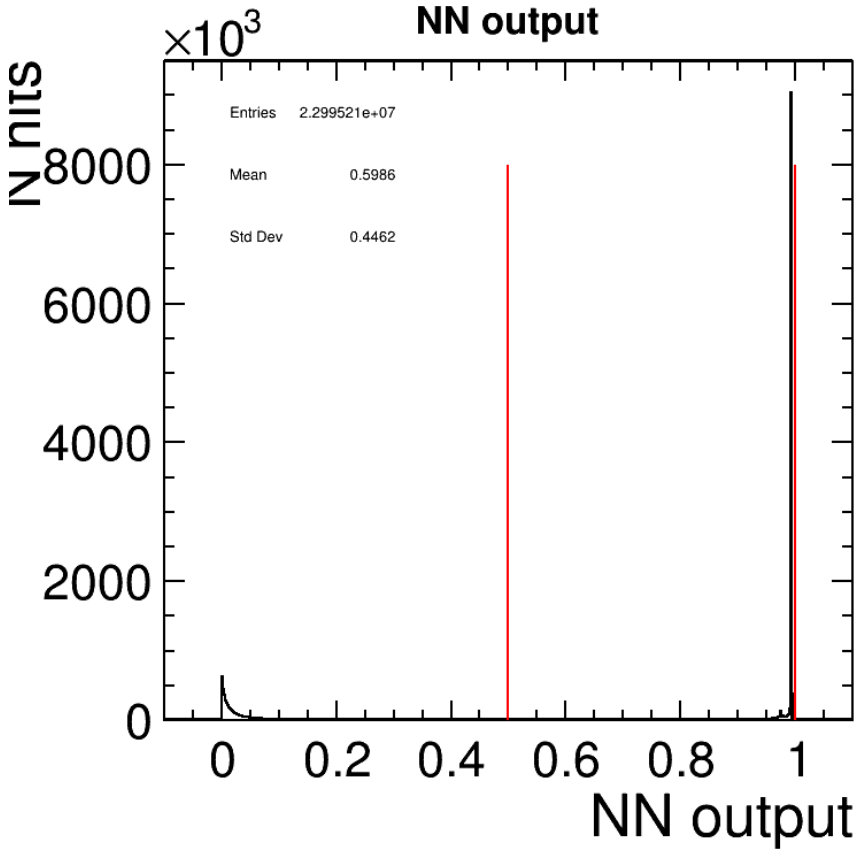


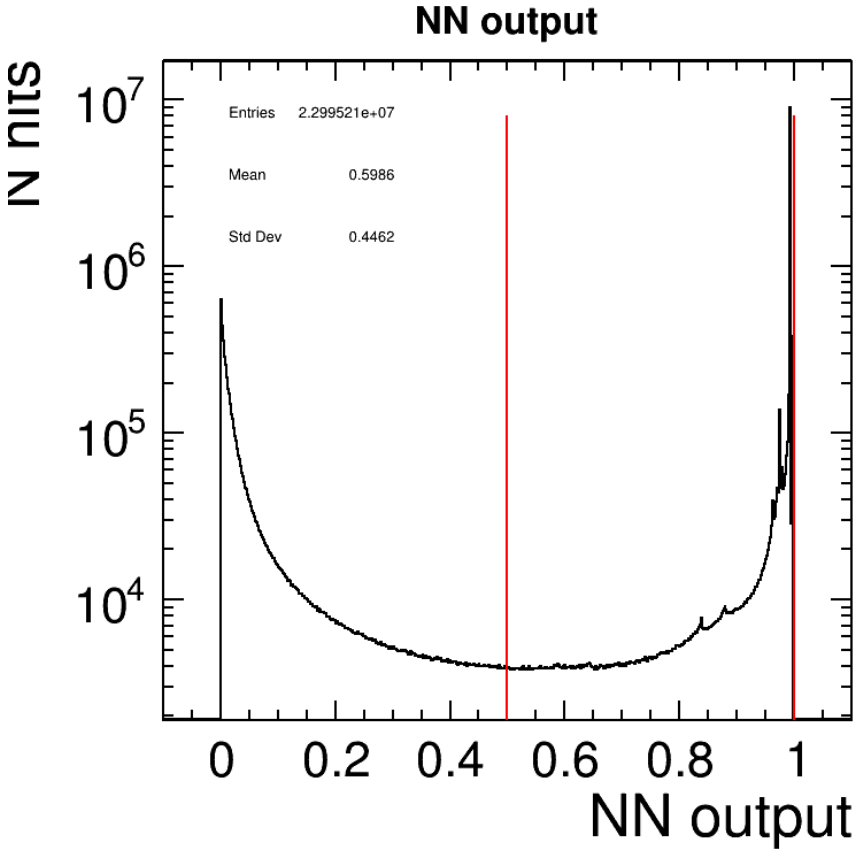
Signal selection





Signal selection





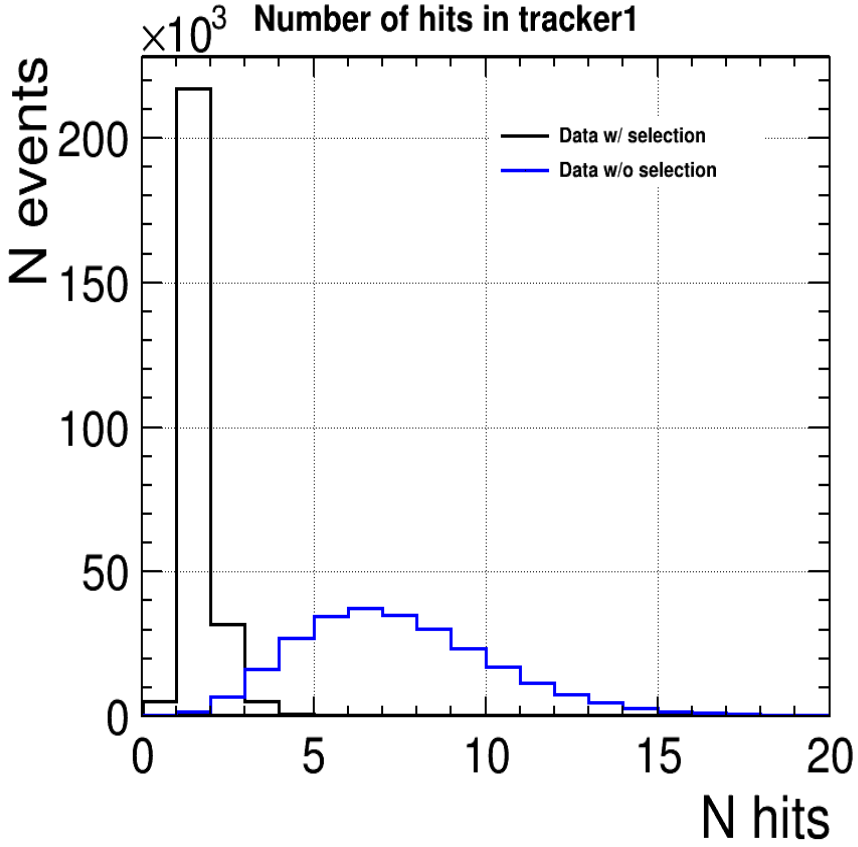
Signal selection

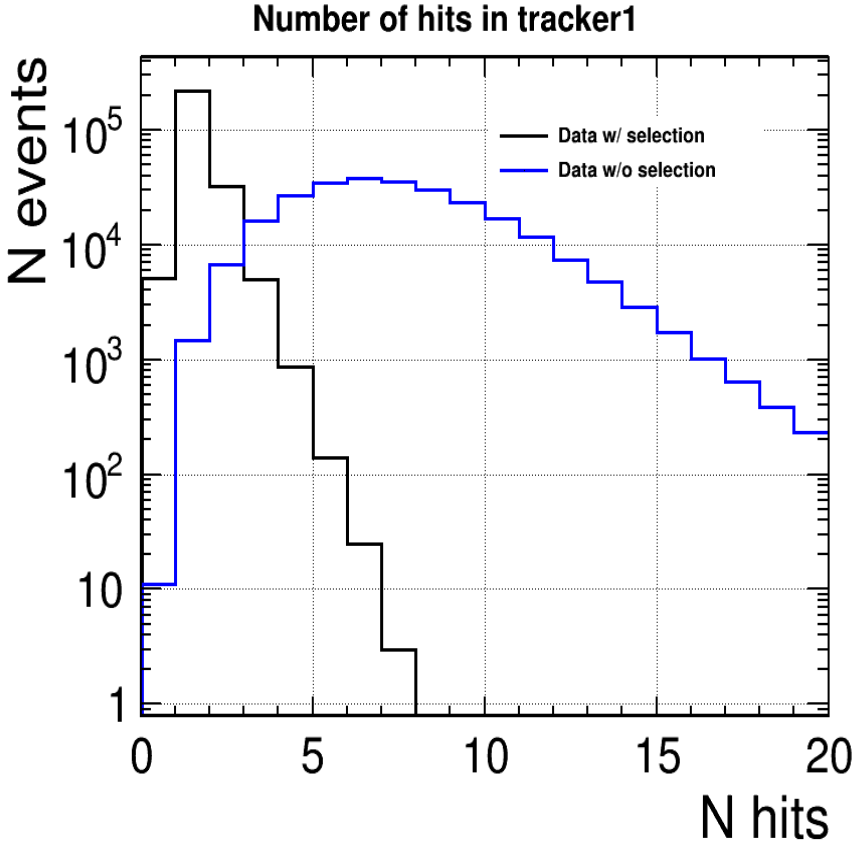
5 observables

- Hits energy
- Hits pad
- Hits sector
- N hits
- Total energy

- look only in the tracker1 (for now)
- 5 GeV electron runs
- no geometry cuts applied to see general picture
  e.g. (bad channels, side sectors, cross-talk area)

Effect of signal selection





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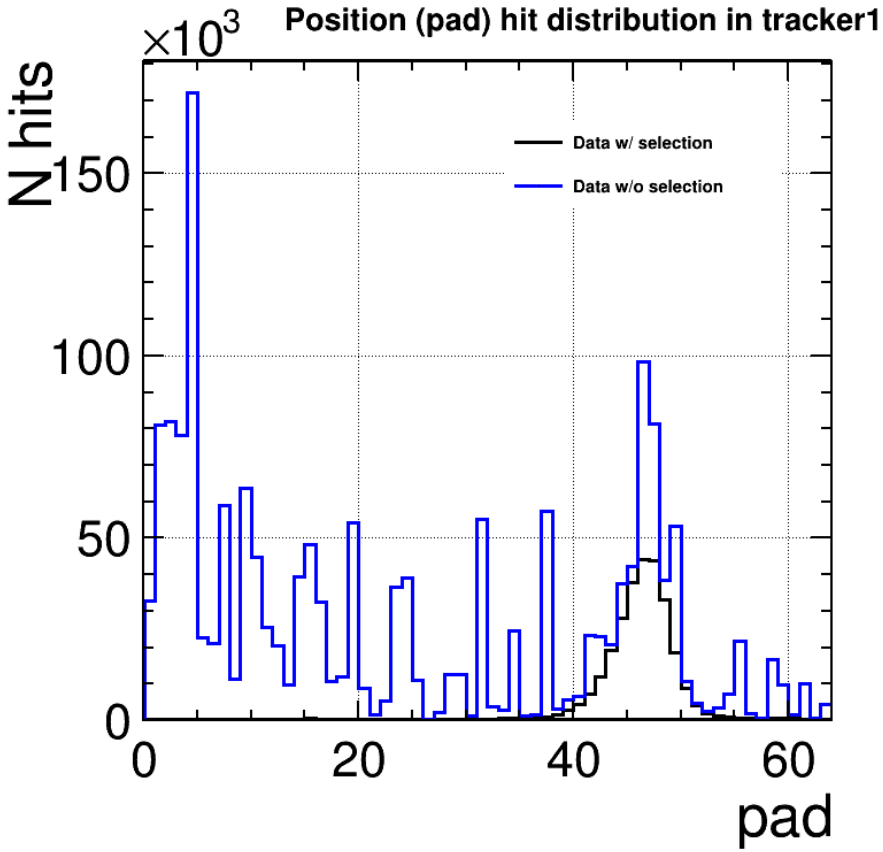
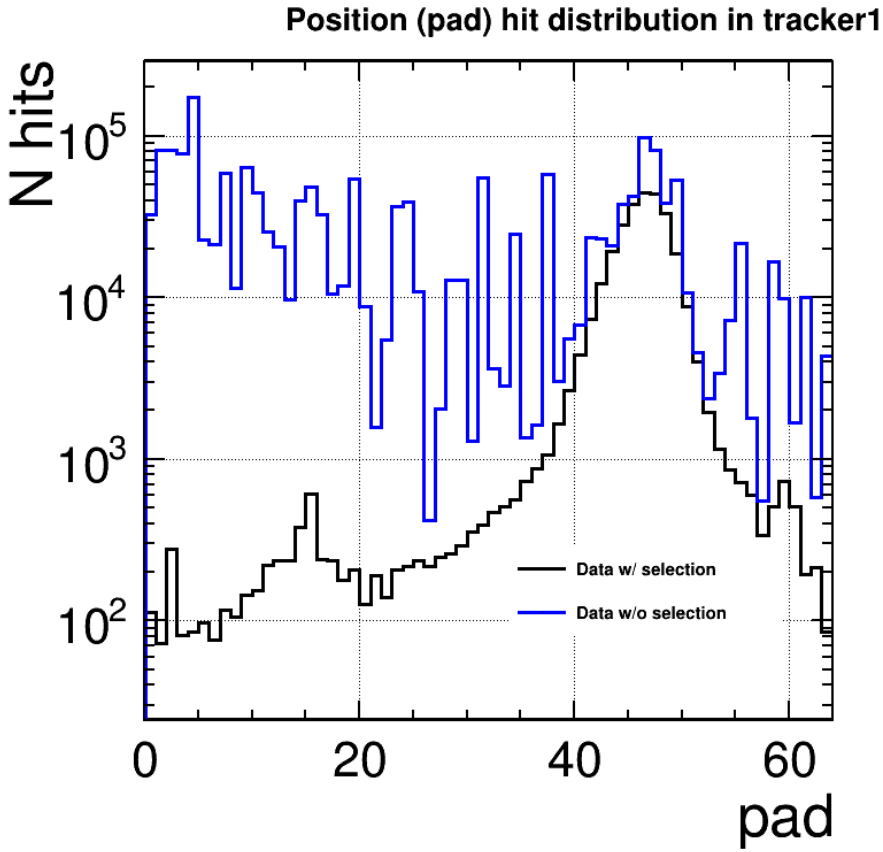
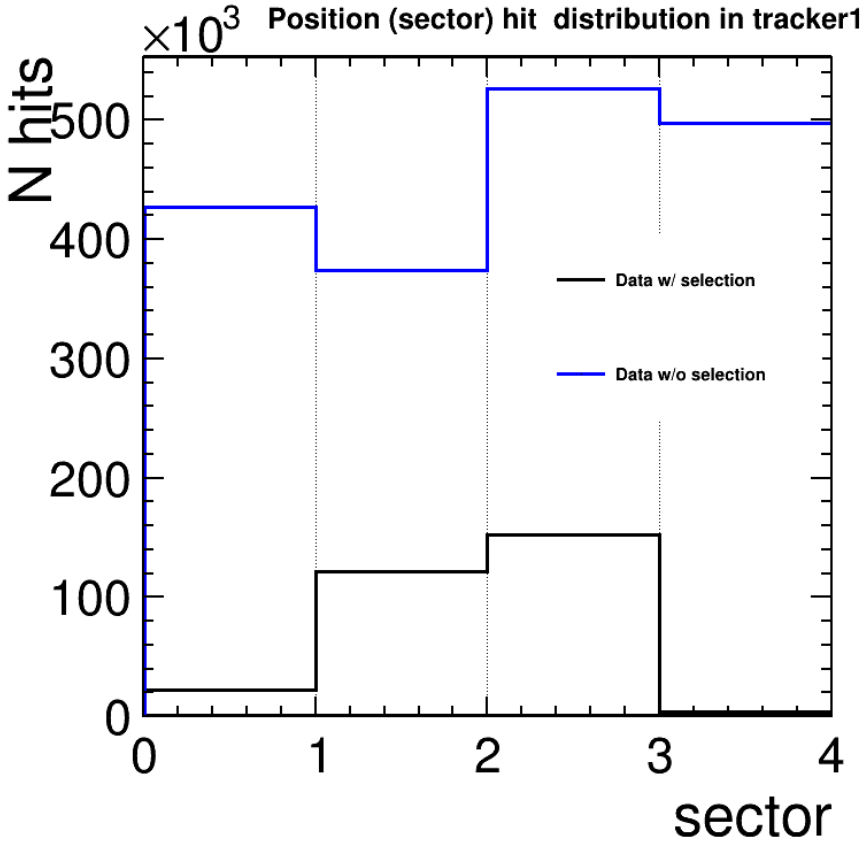
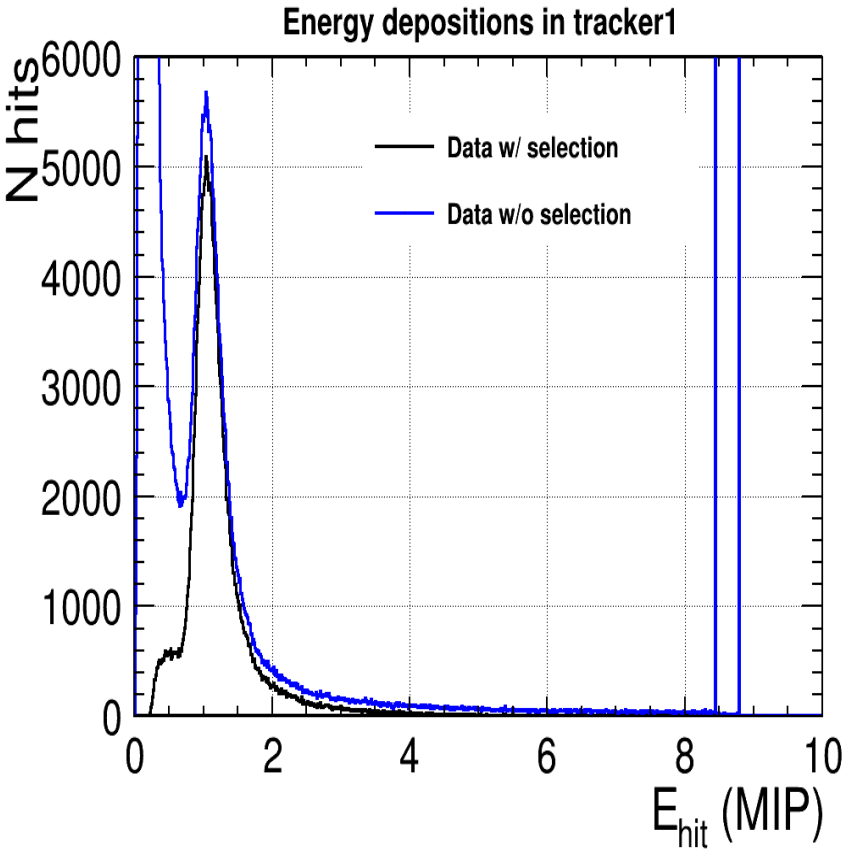


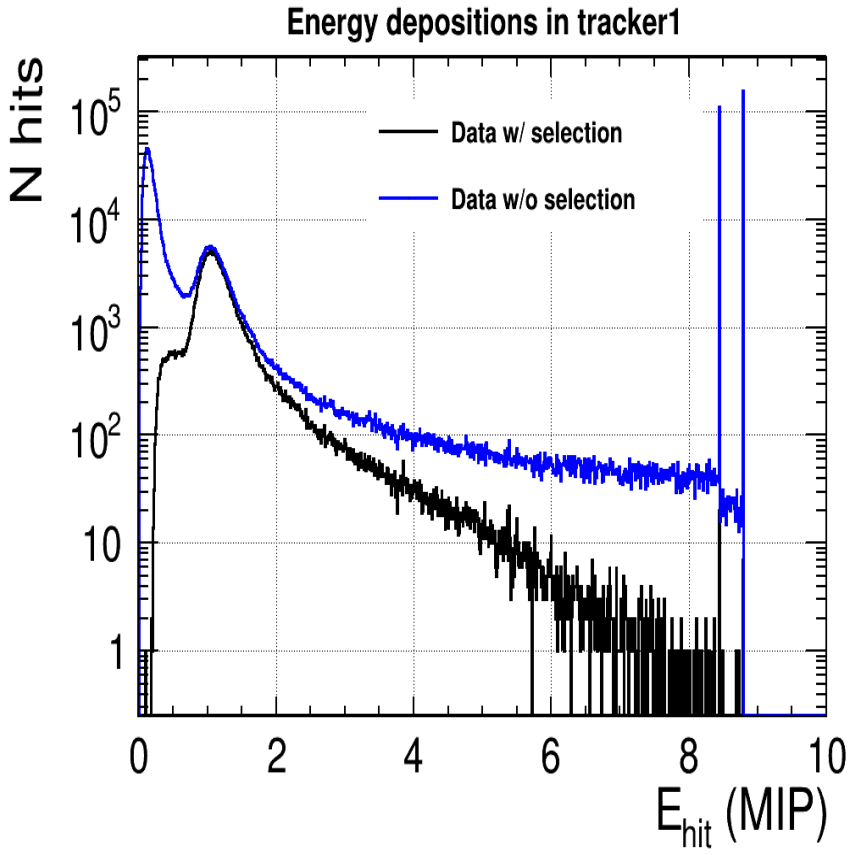


Effect of signal selection



Effect of signal selection





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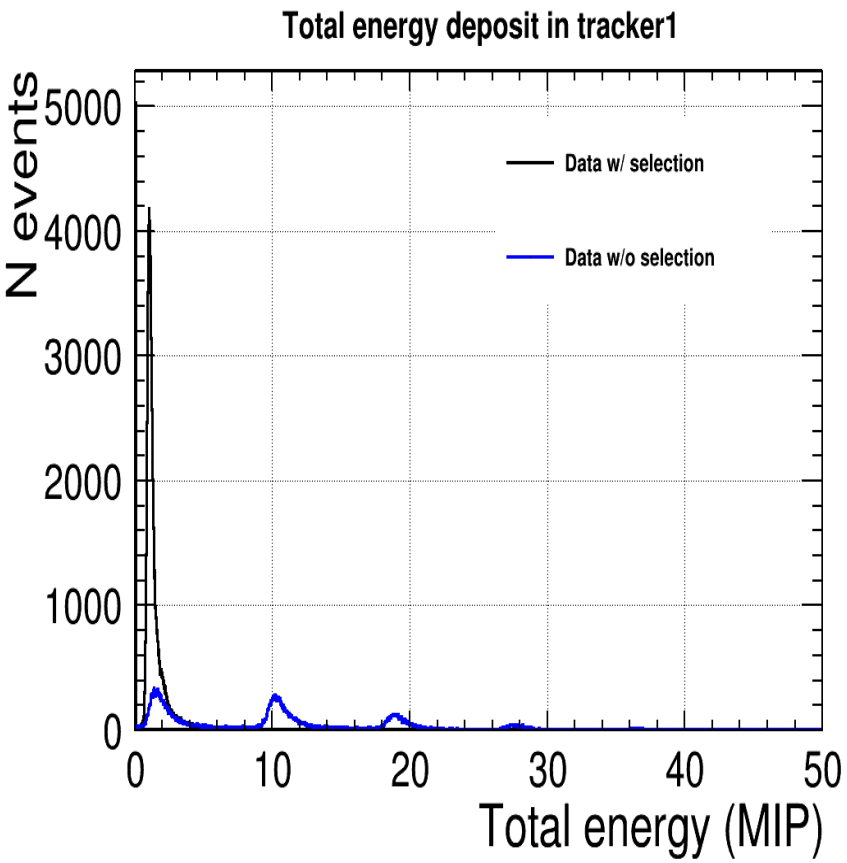
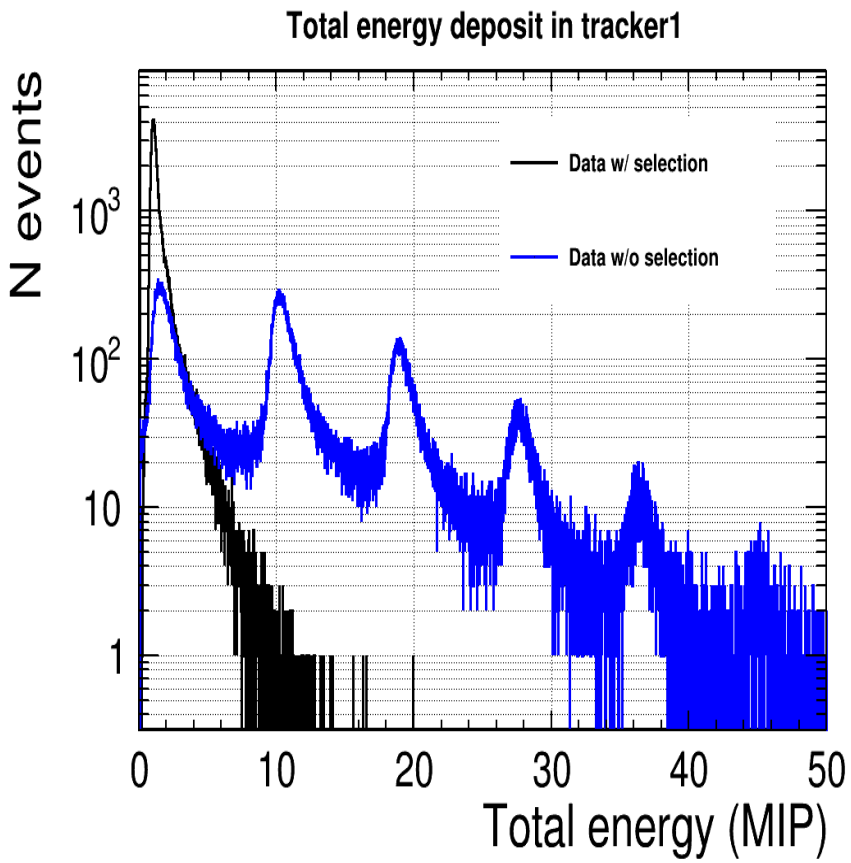




Effect of signal selection

Summary

- In general signal selection does a good job
- Cross-talk noise survives the cuts
- sector0 has remaining excess of noisy signals after signal selection
- Rejecting good high-energy/saturated signal hits?
- Funny periodic structure of the total energy in the sensor w/o cuts. Any explanation?

For now, I won't focus on tuning signal selection parameters.
Let's assume they work fine

Monte Carlo

Key points

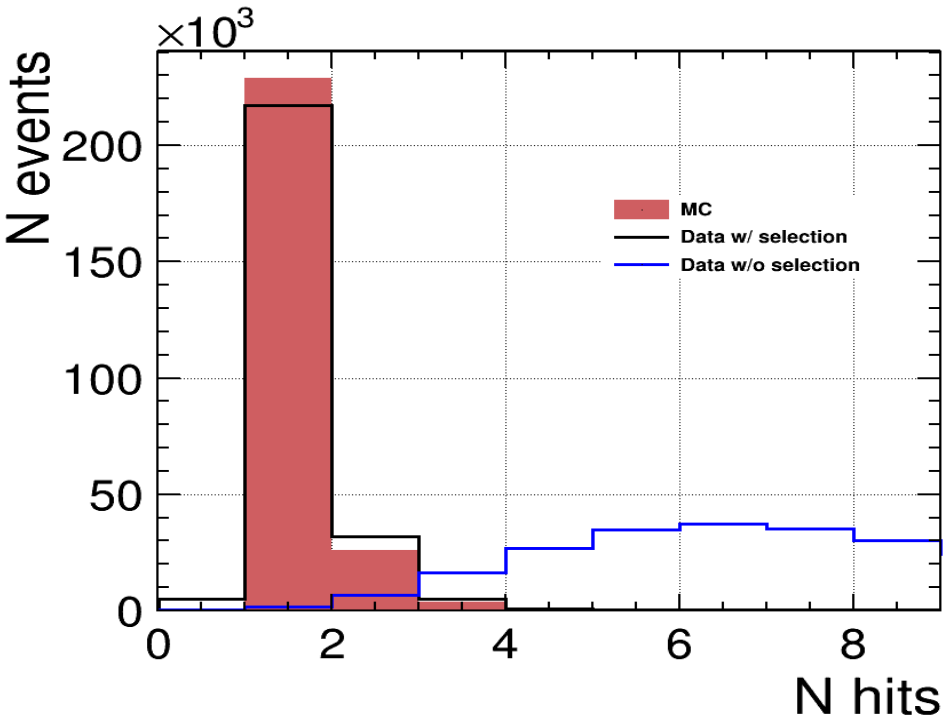
- Linear energy sharing within 100um to the **only closest** pad border
- In case of multiple contributions in the pad – write MCcotrib with the most deposited energy (previously awkward “mixed”)
- Electronic noise smearing (in analysis code)
- Suppress low energy hits to match data (in analysis code)

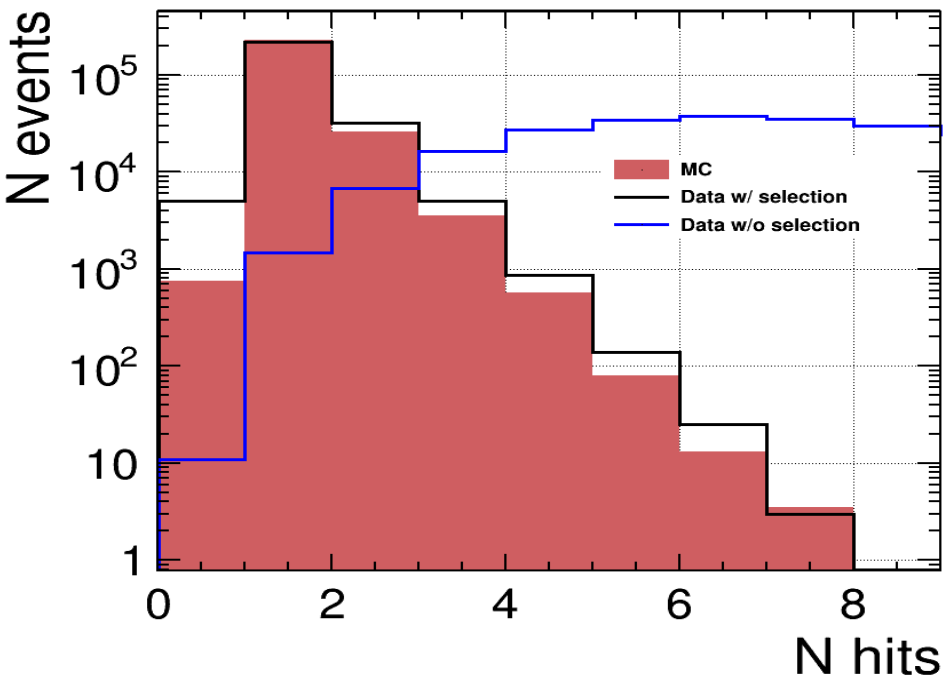
Minor points

- MIP = MeV / 0.0885
- Scintilators are sensitive volume (act as a trigger)

some details are in the backup

Control plots





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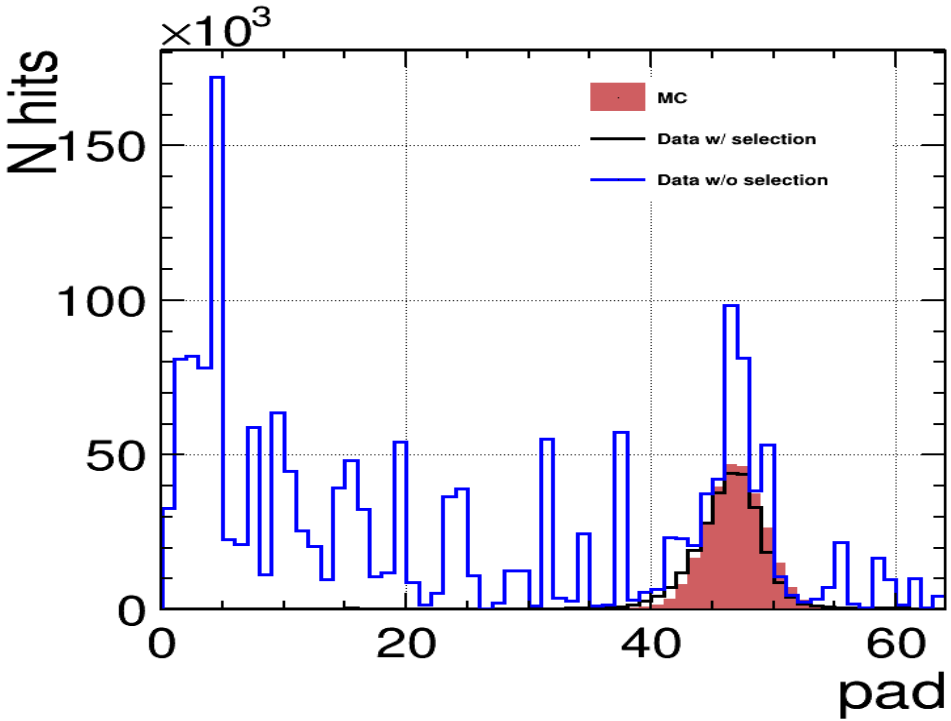

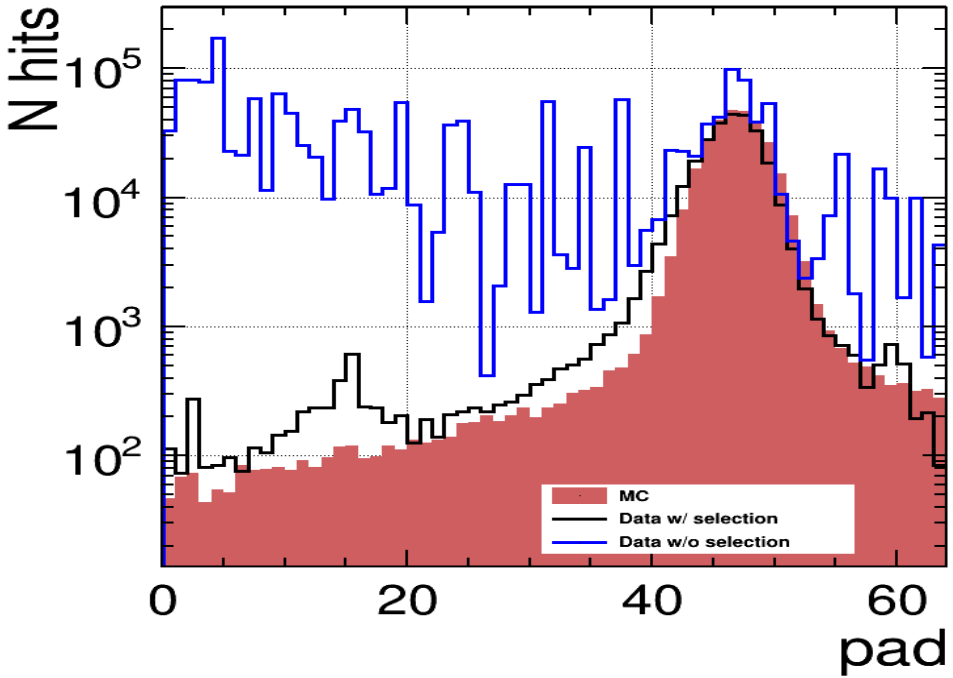

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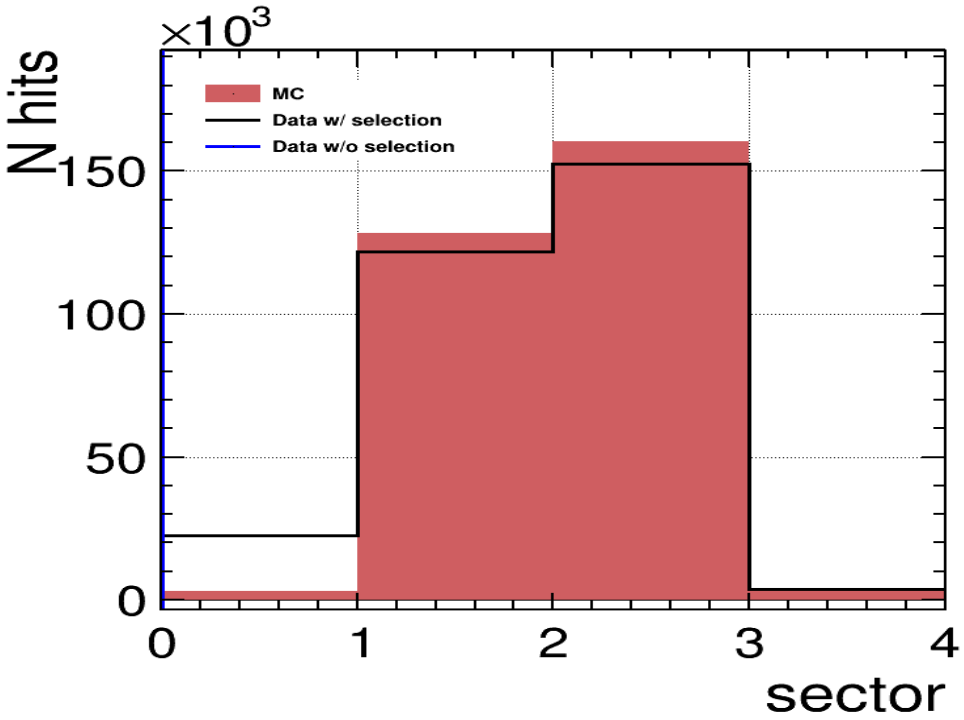

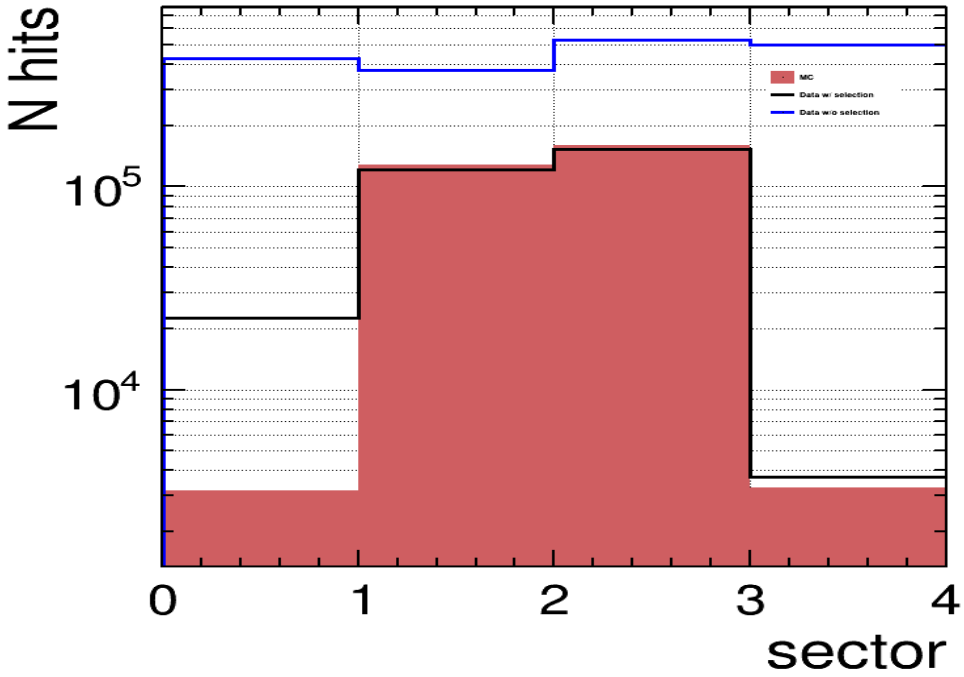

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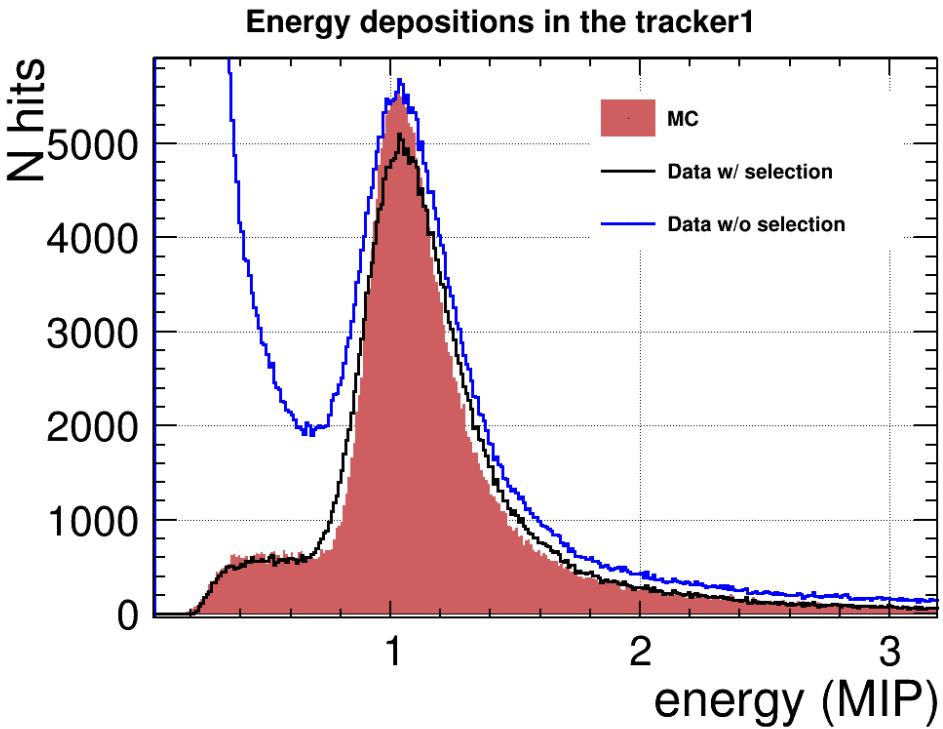

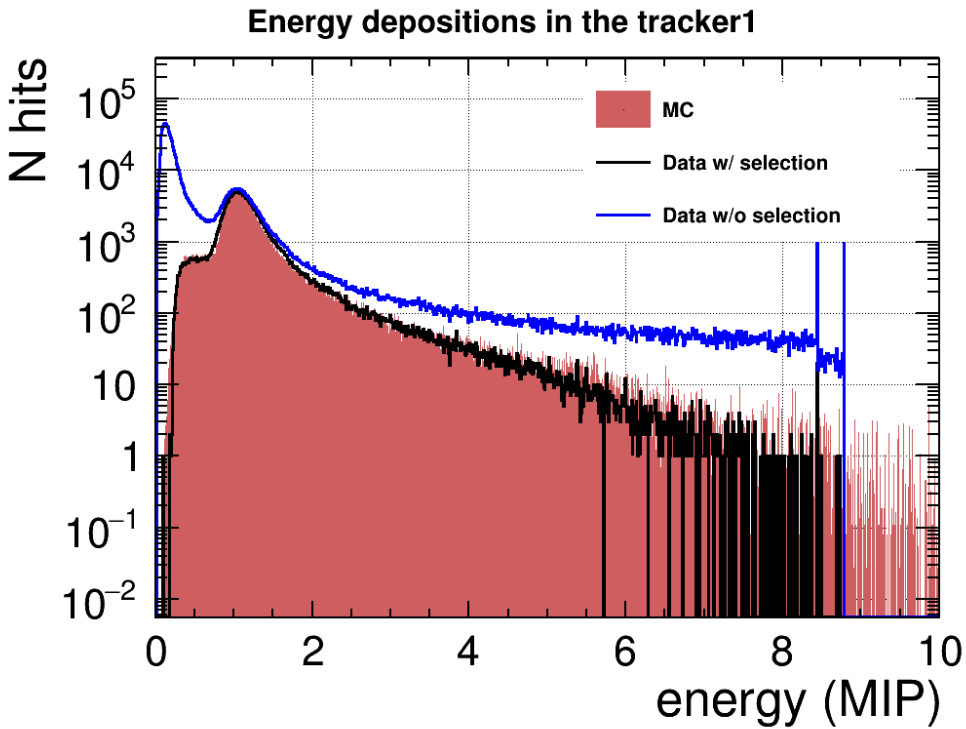

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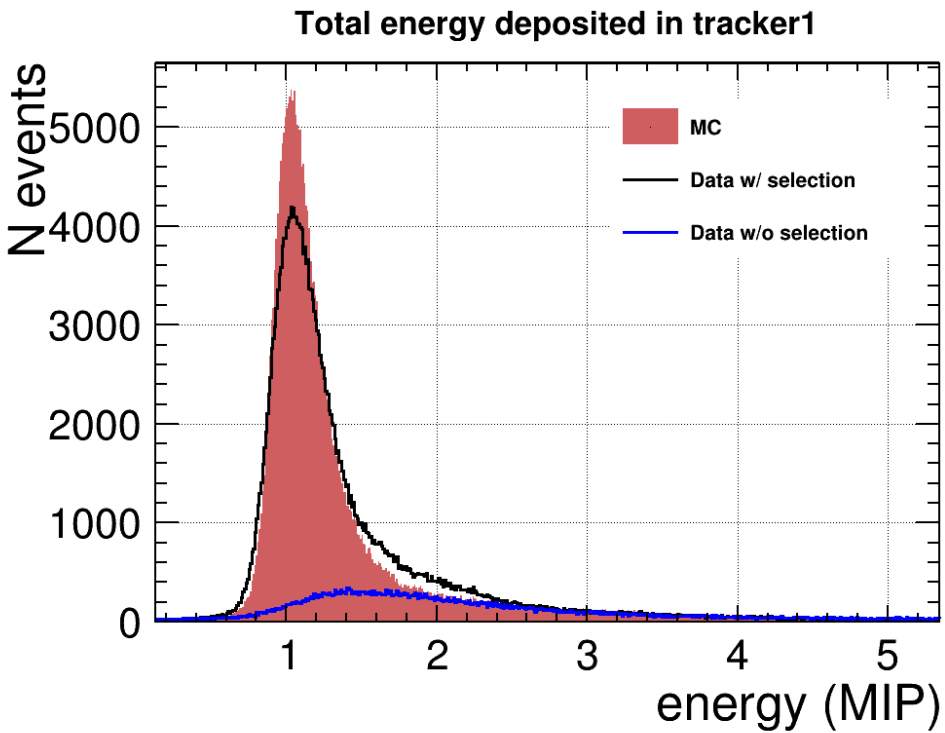
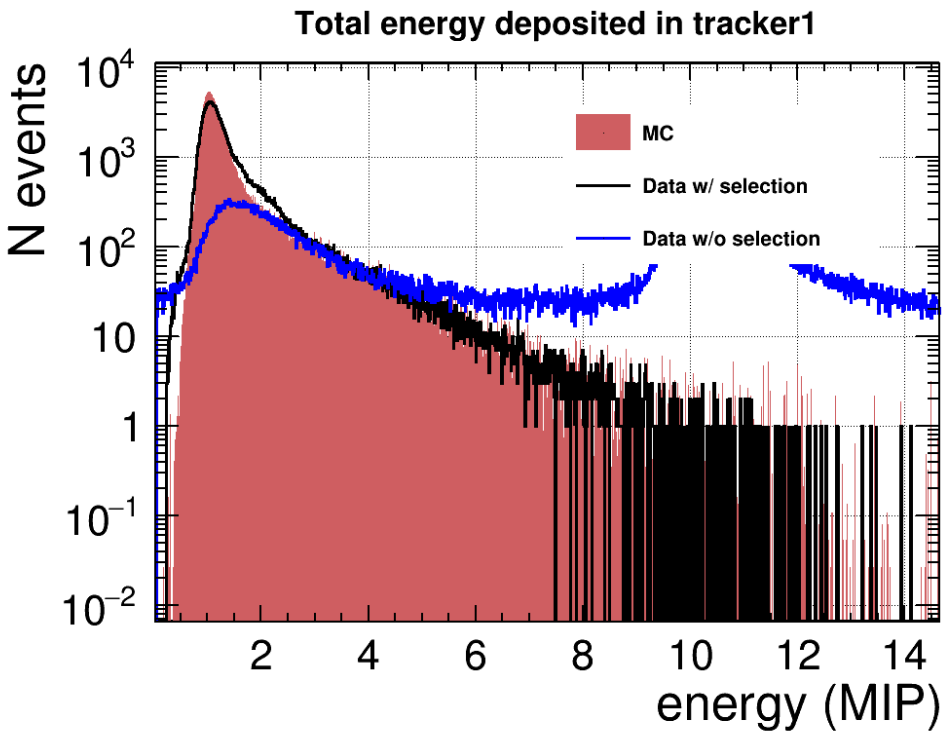
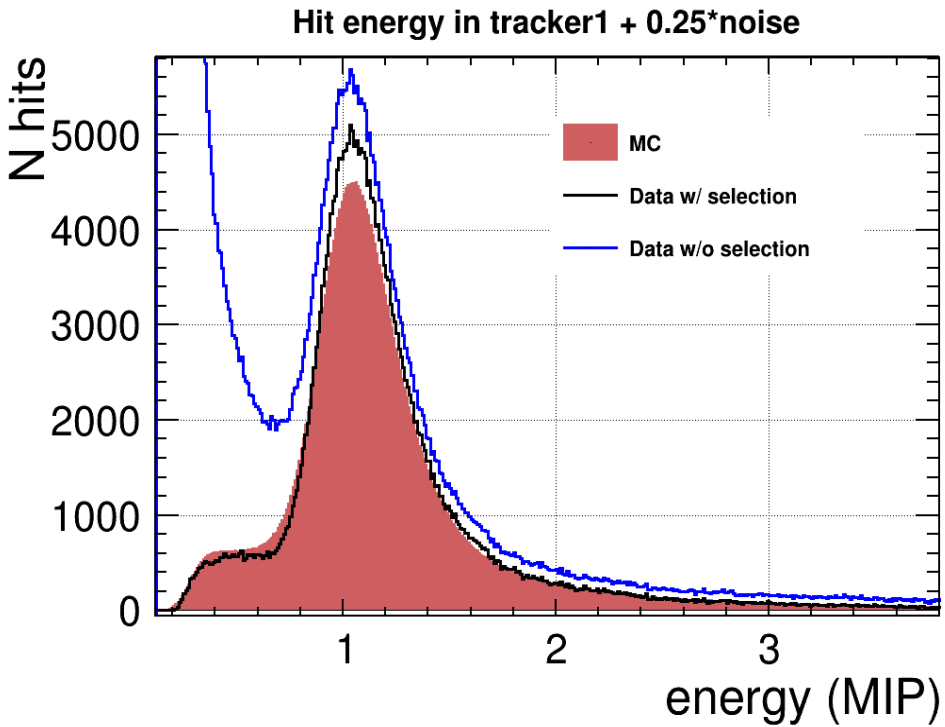
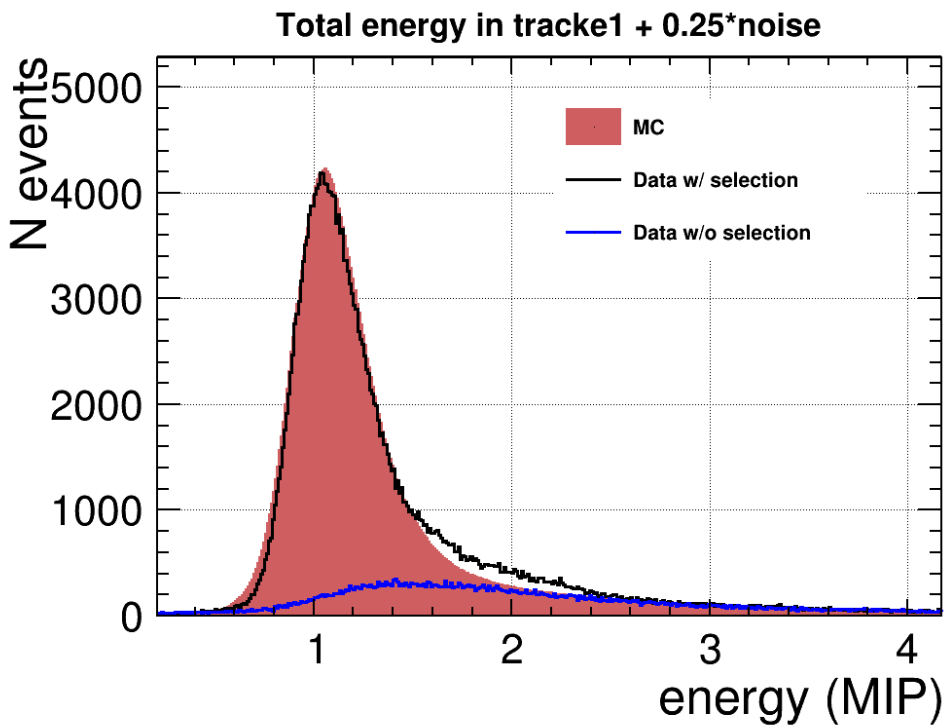




Electronic noise smearing





Conclusions

Summary

- Efficiency of signal selection and precision of MC simulation effects **overlap**
- Data shows more events with >2 hits (noise?) and less with 1 (extra splitting of MC? efficiency of the tracker?)
- Position distribution looks alike. Beam is not perfect gaussian, Lumical is not perfecly perpendicular. This is hard to simulate
- Weird scale for the noise (0.25) compare to previous weird scale (0.7)
- Energy spectrum pedestal looks nice. However noise doesn’t represent well both distributions

Conclusions

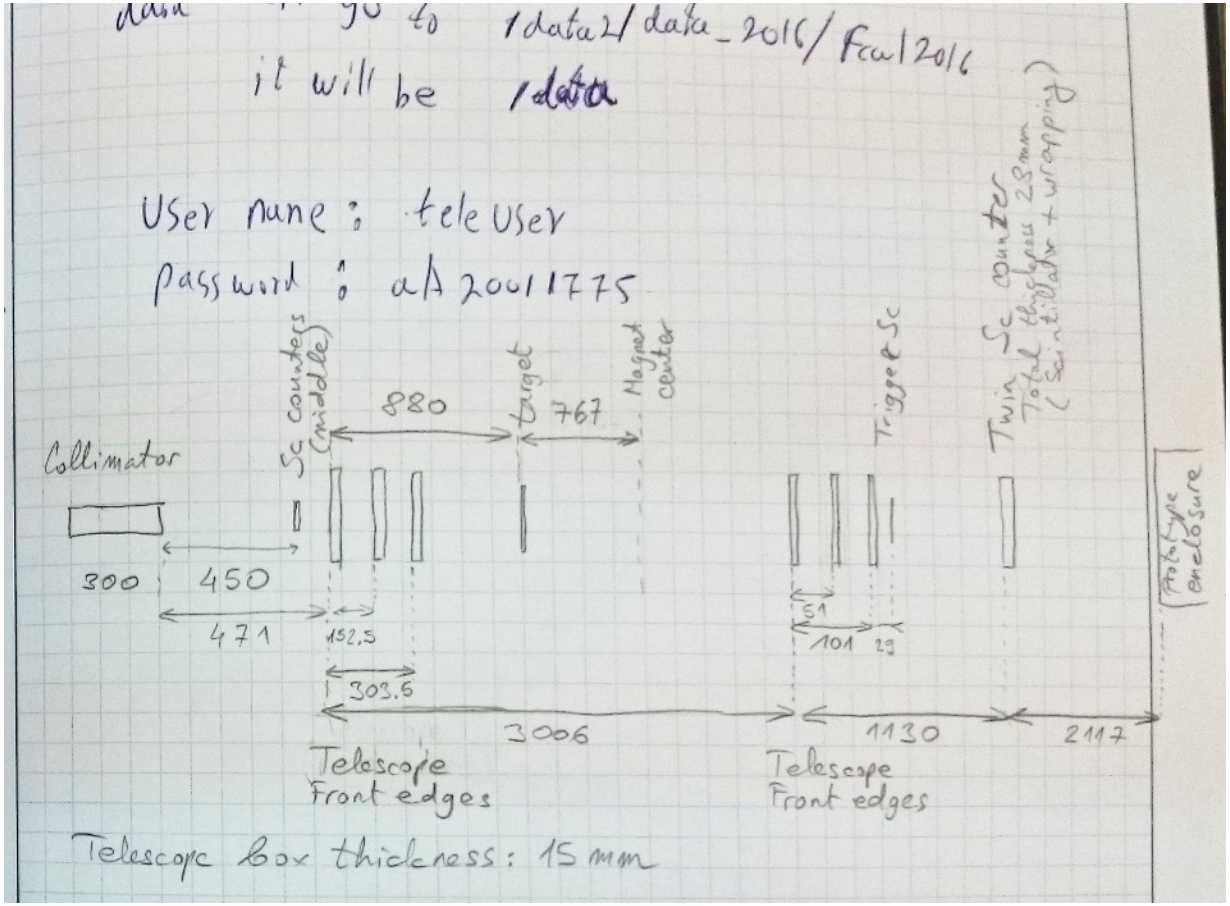
1) Establish concrete purpose of the paper. Let’s discuss
2) Hope this can be useful reference for TB2020 analysis
3) Total/ per-hit energy depositions are not described well simultaneously

TODOs:

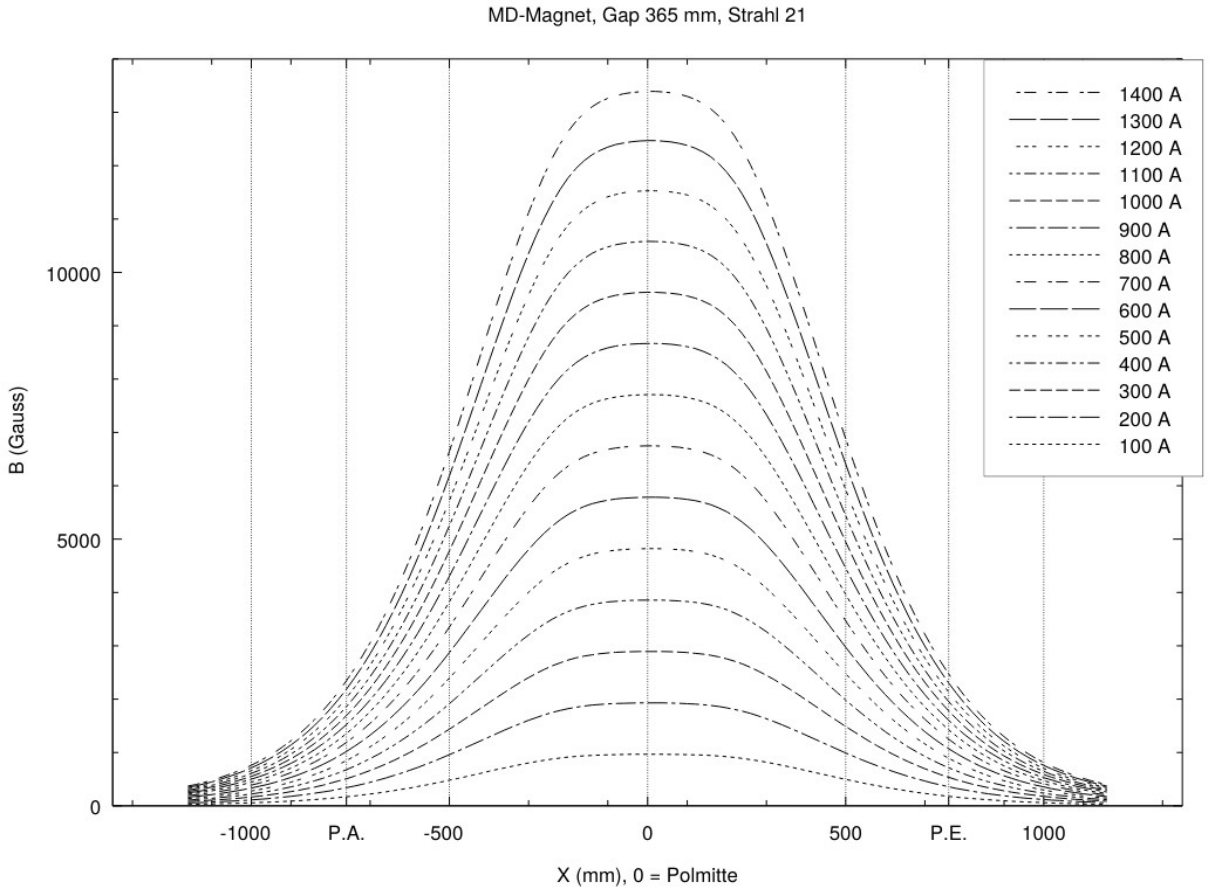
1) Establish concrete purpose of the paper. Let’s discuss
2) Split MC back-scattering to see the magnitude of the effect
3) Check multiple physics lists

BACK UP

TB16 distances

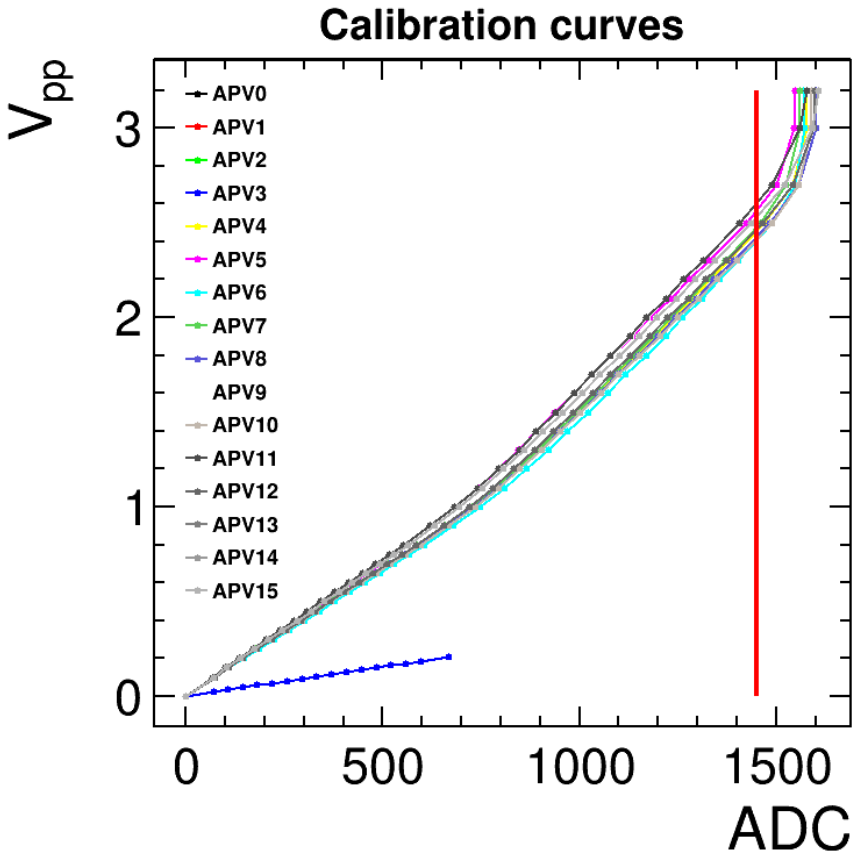


Magnetic field



- Magnet current at TB16 was: 90A
- 0.095 Tesla shows good agreement with MC as well
- Picture from TB facilities at DESY

Energy calibration



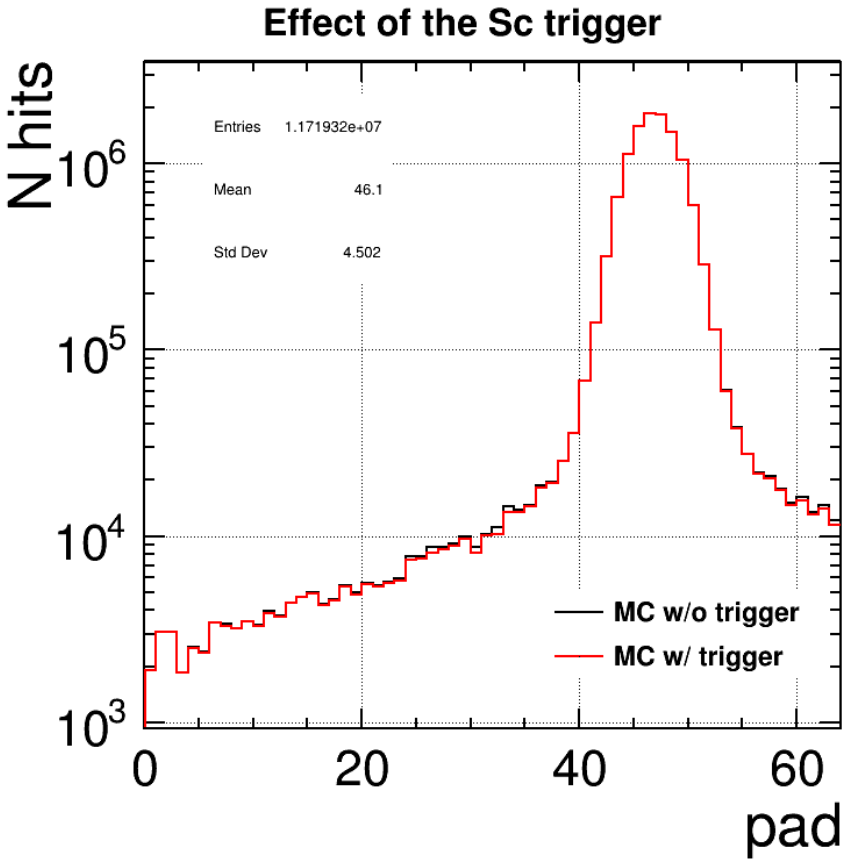
- APV0-3 were not measured during TB16
- APV0-3 w/o charge divider
- Saturate signal amplitude at 1450
- obtained from averaging calibration of 10 random channels in each apv

V_{pp} to MeV transition

match data and MC MPV and derive scale factor

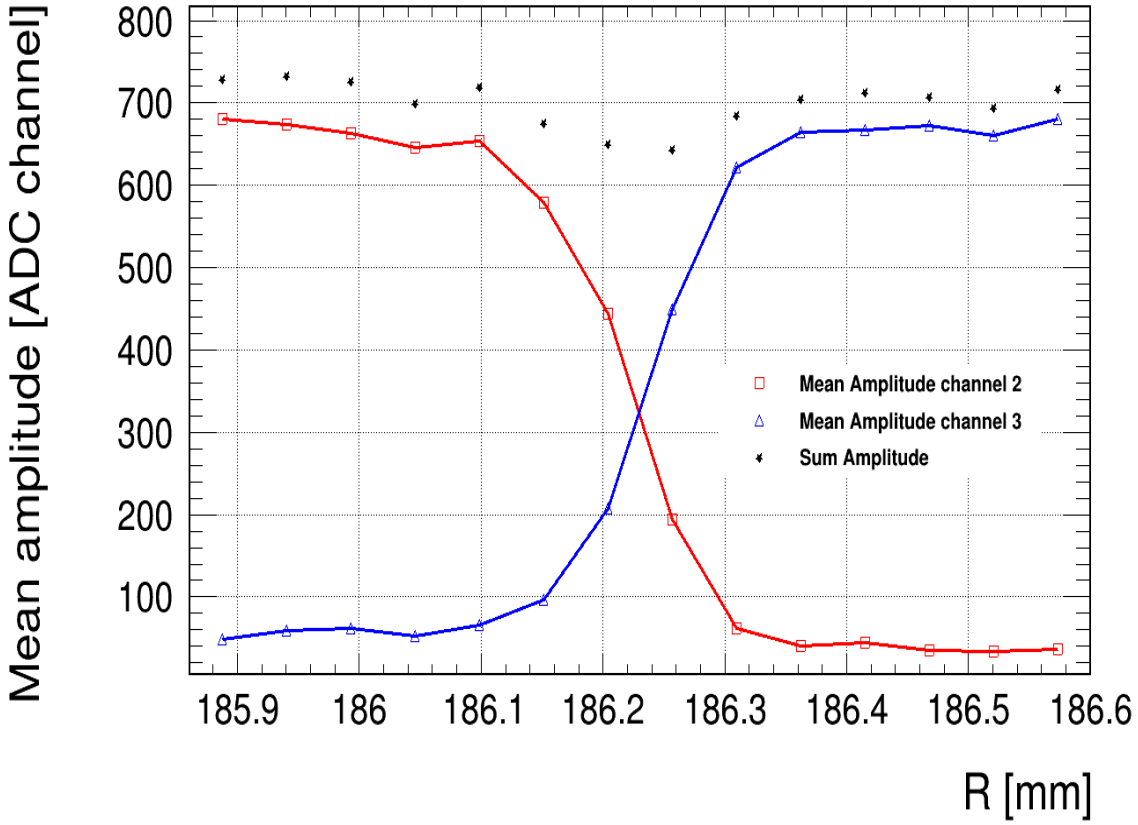
```
if (APV0) magic_scale = 19.032365;
else if (APV1) magic_scale = 18.303542363112417;
else if (APV2) magic_scale = 21.093676081159632;
else if (APV3) magic_scale = 20.77784418996082;
else magic_scale = 19.206;
```

Scintilator trigger effects



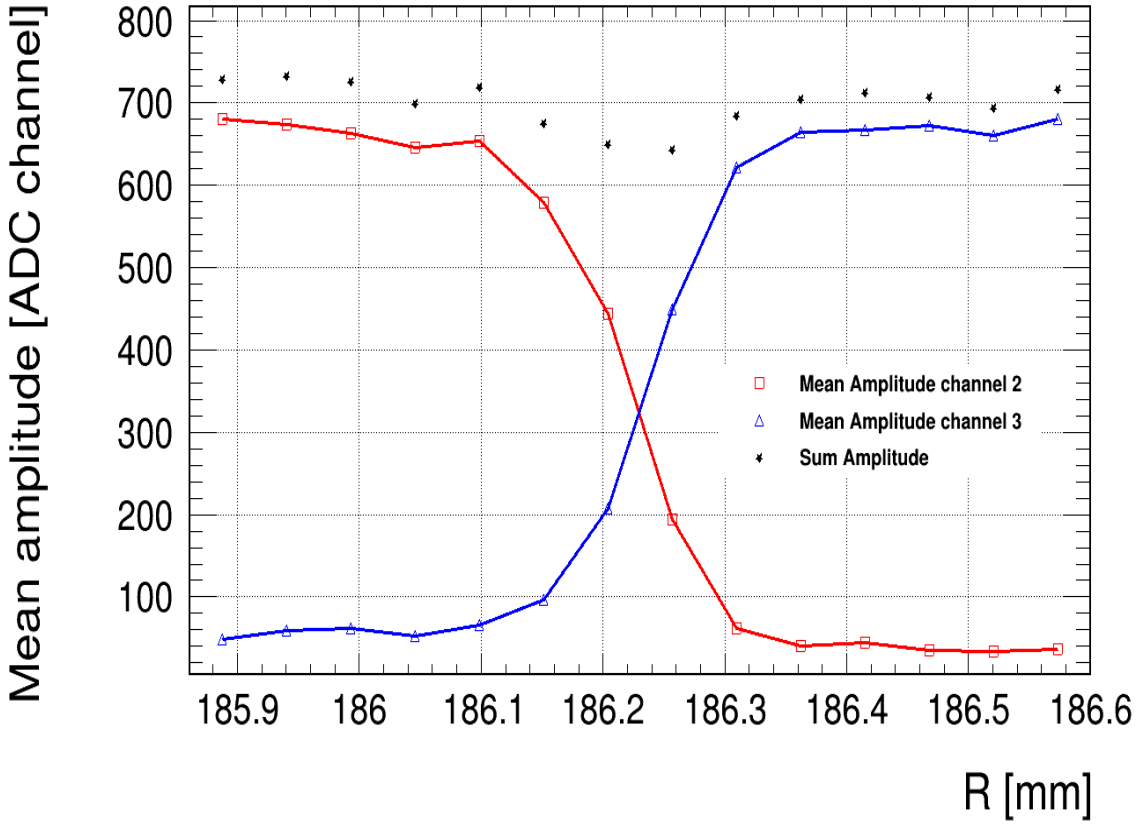
- Scintilator triggers have negligible effect on position distribution
- It rejects 0.3 % of events
- 0.16 % – e^- doesn't reach Sc2
- 0.14 % – e^- doesn't reach Sc3

Energy sharing



- Border edge for energy sharing is taken from this plot. (Thanks Itamar)
- I set the border to be 100um just by eye
- Good first approximation.
- Potentially can be modified to include energy drop as well as atan() behaiour.

Multiple contributions in the pad



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