FoCal-H:
Performance & Analysis Update

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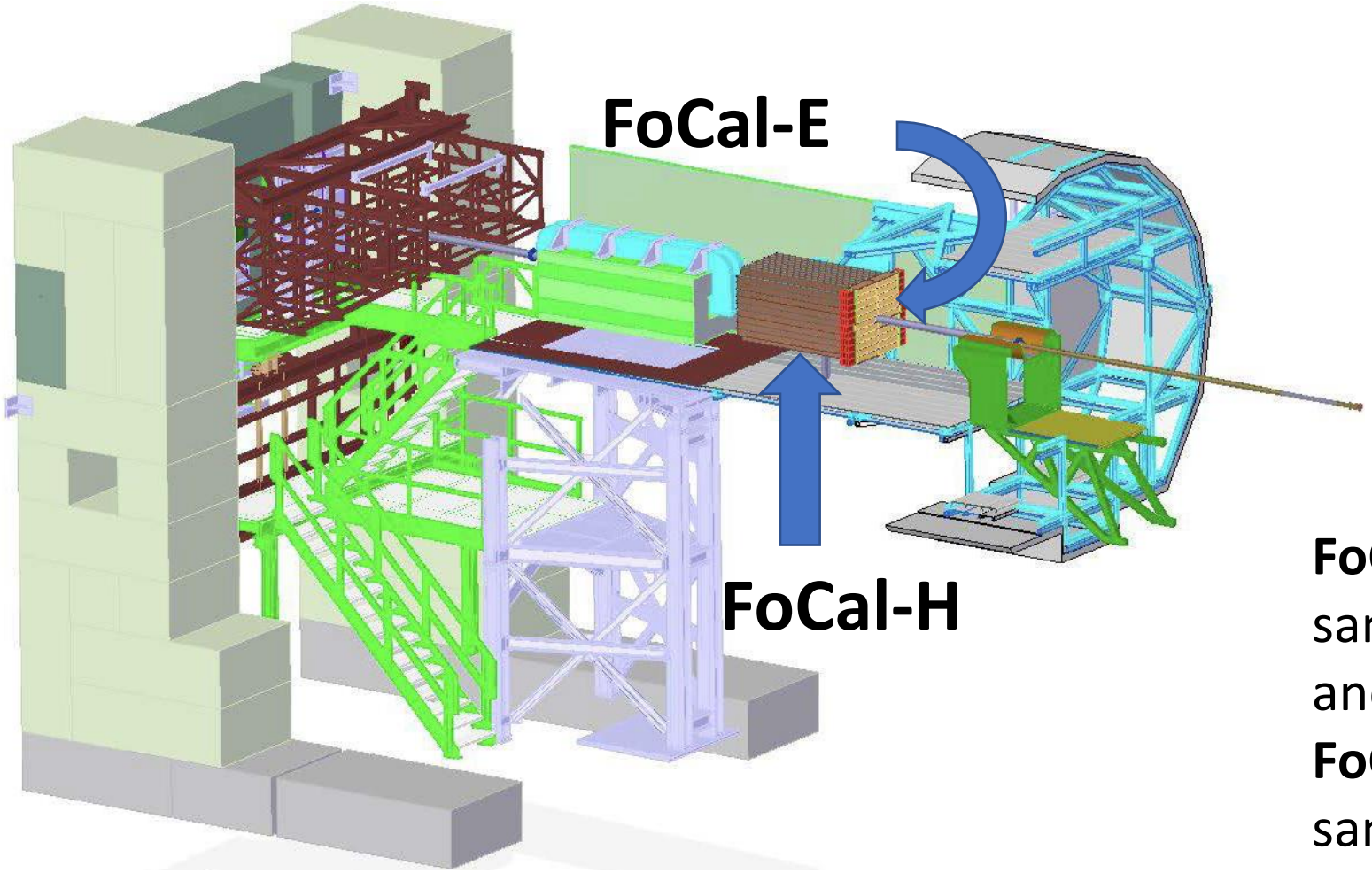
HEHI
Niels Bohr Institute, University of Copenhagen
27 February 2023

*on behalf of the hardworking students from Copenhagen and Sofia who didn't get to come to Japan

The Forward Calorimeter (FoCal):



$3.4 < \eta < 5.8$

FoCal-E: high-granularity Si-W sampling calorimeter for photons and π^0

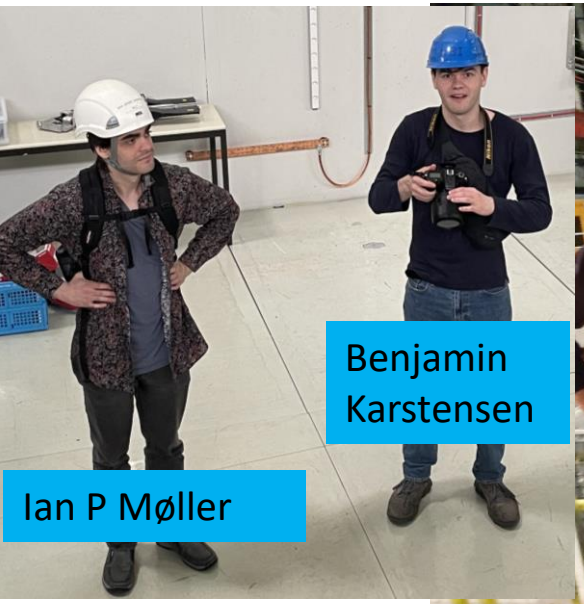
FoCal-H: absorber-scintillator sampling calorimeter for photon isolation and jets

FoCal-H development team

Niels Bohr Institute

UNIVERSITY OF COPENHAGEN

Your Logo Here



Focal-H funded by:

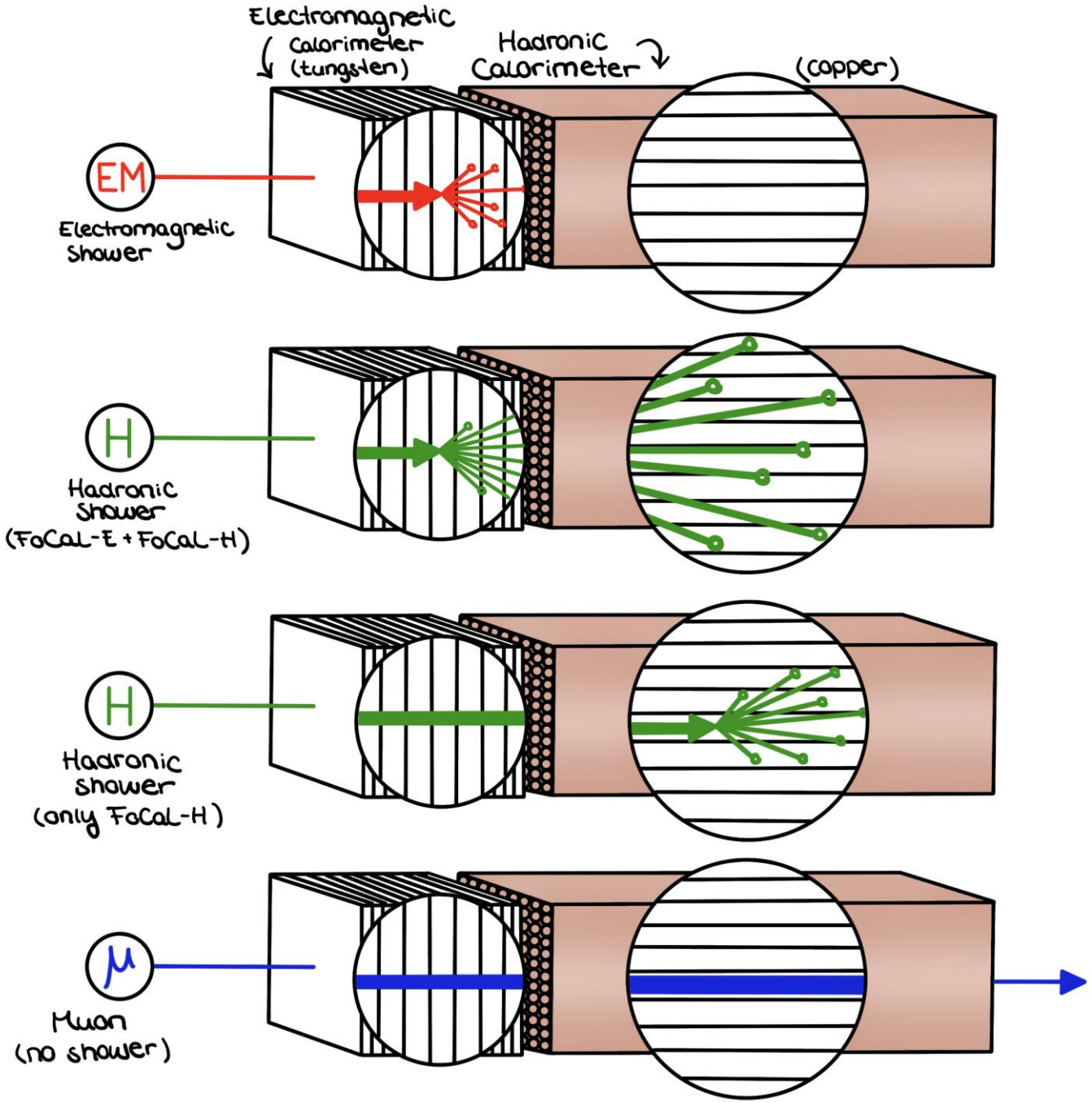
CARLSBERG FOUNDATION

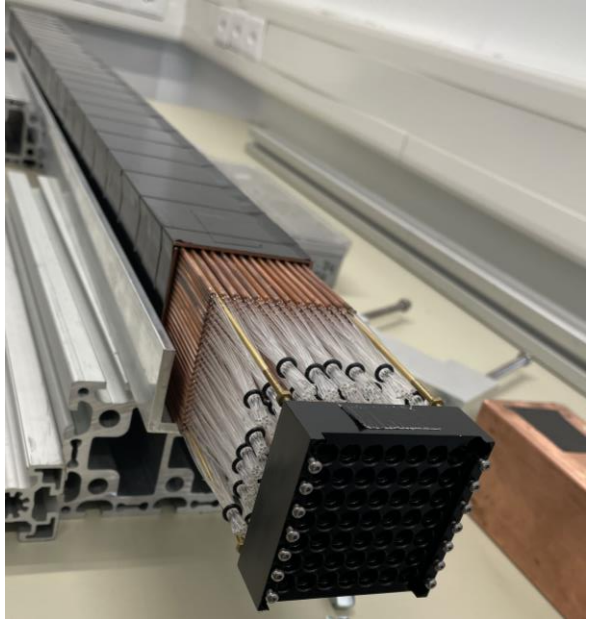
CF21-0606, Hadronic Calorimeter for Forward Physics

РЕПУБЛИКА БЪЛГАРИЯ
МИНИСТЕРСТВО НА ОБРАЗОВАНИЕТО И НАУКАТА

** partially supported by National Roadmap for Research Infrastructures – CERN D01-374/18.12.2020 г.*

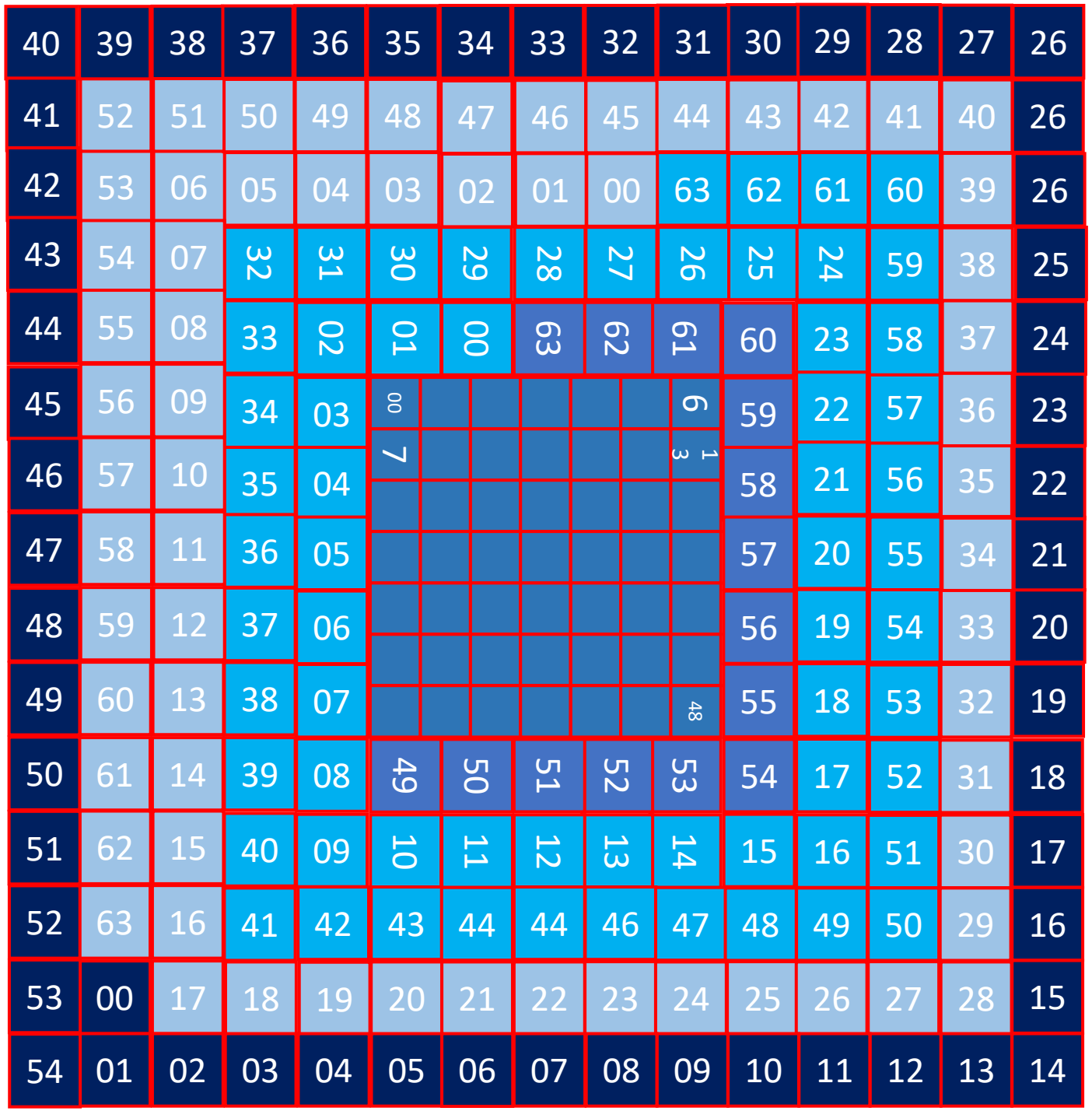
NICE:
The Danish National Instrument Center for CERN Experiments





The program so far:
Prototype 1: Test beams at SPS & PS 2021
5-120 GeV electrons & hadrons
Prototype 2: Test beams at SPS & PS 2022
1-350 GeV hadrons (electrons)

FoCal-H
Read out scheme
SPS H2 beam test
3.-10.November 2022

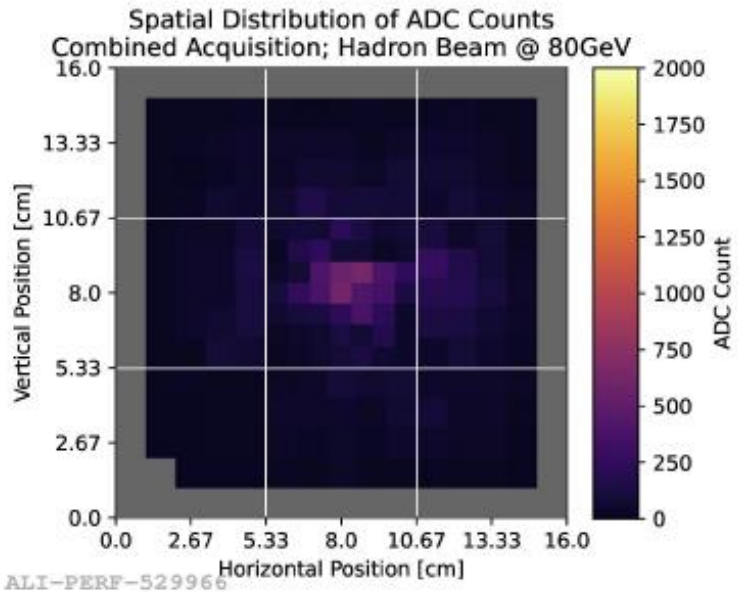


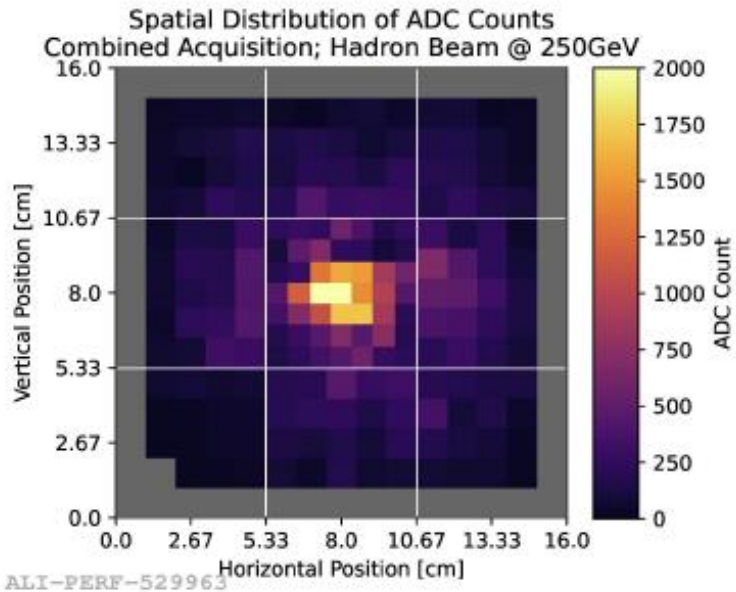
CAEN Board 0

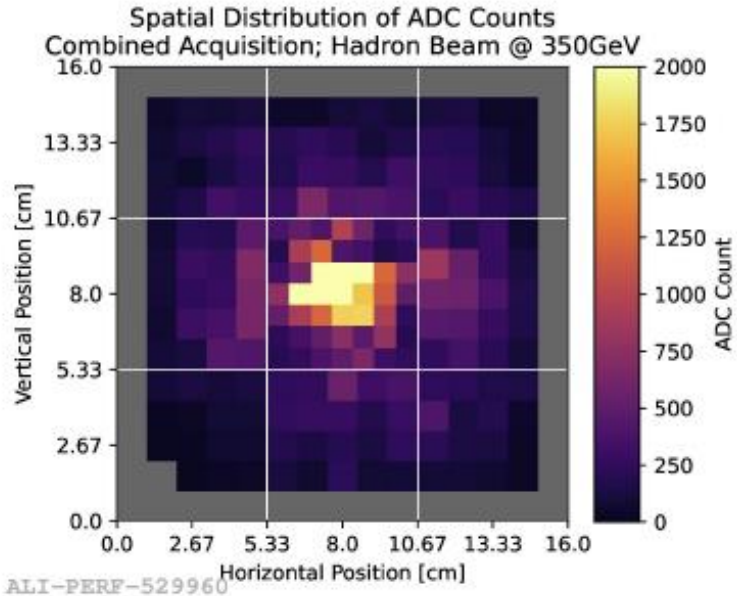
CAEN Board 1

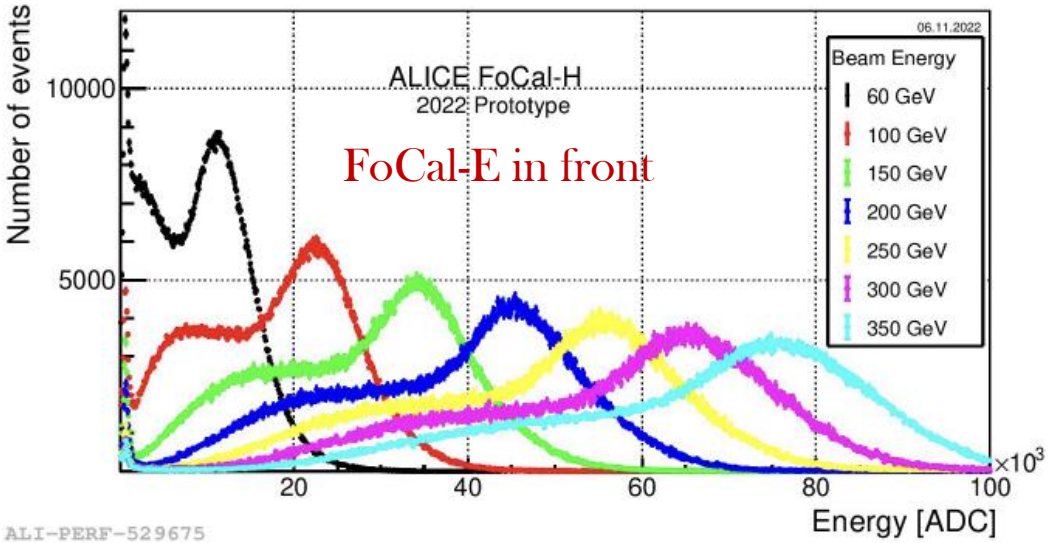
CAEN Board 2

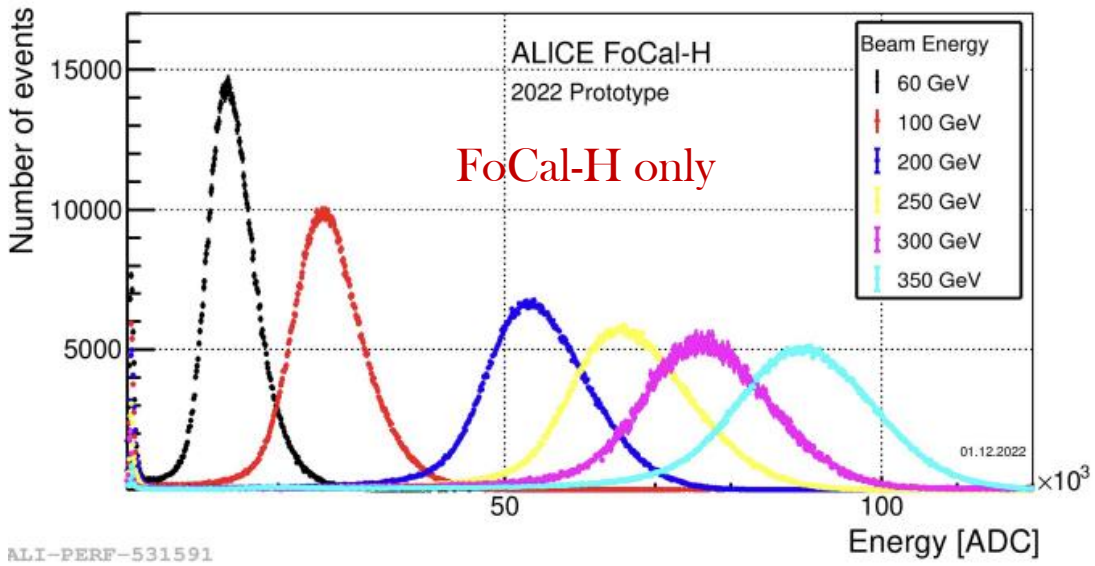
CAEN DT5202 based on CITIROC-1A


Spatial Distribution of ADC Counts
Combined Acquisition; Hadron Beam @ 80GeV
Vertical Position [cm]
Horizontal Position [cm]
ADC Count
ALI-PERF-529966

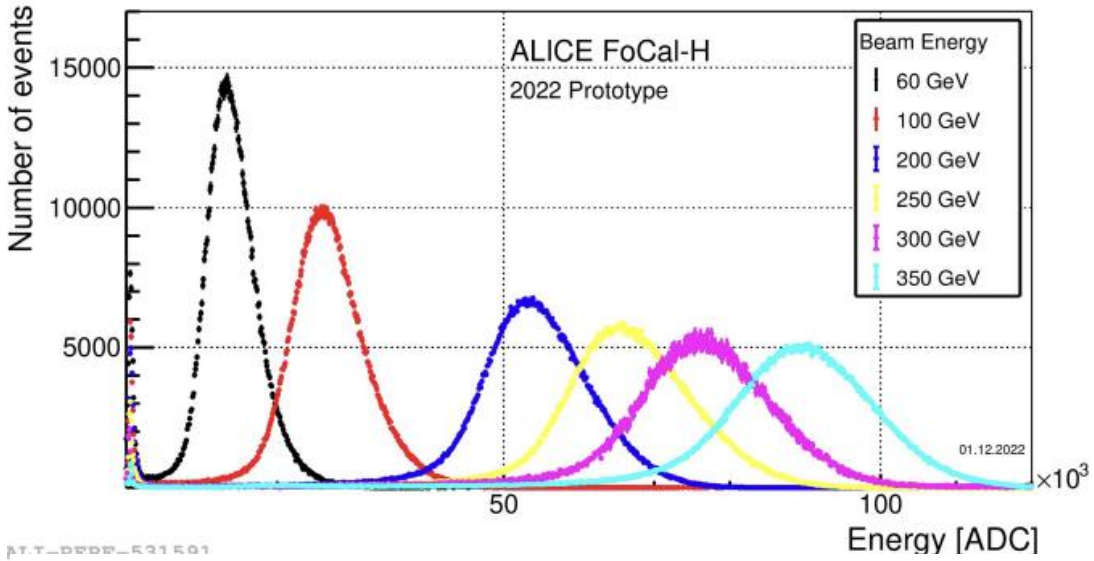

Spatial Distribution of ADC Counts
Combined Acquisition; Hadron Beam @ 250GeV
Vertical Position [cm]
Horizontal Position [cm]
ADC Count
ALI-PERF-529963

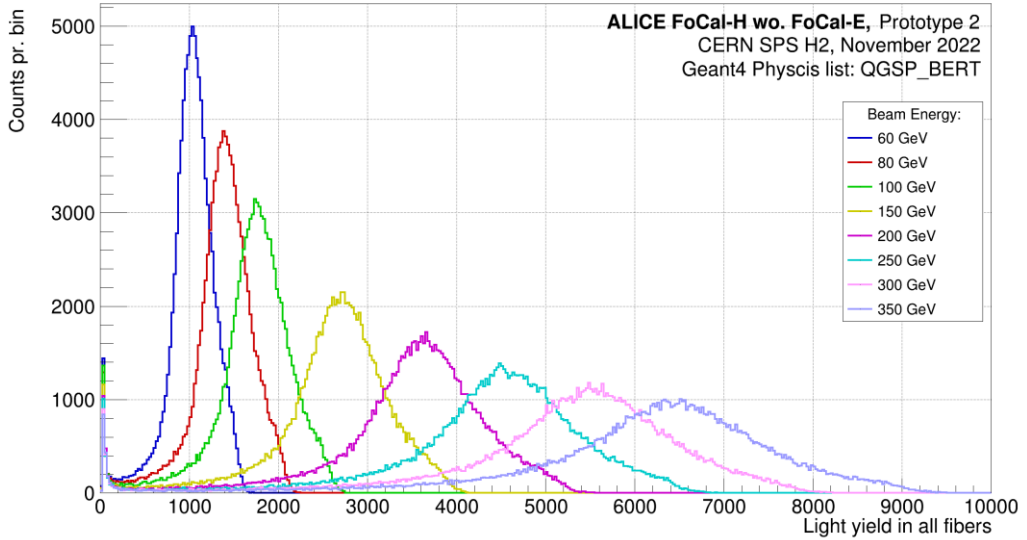

Spatial Distribution of ADC Counts
Combined Acquisition; Hadron Beam @ 350GeV
Vertical Position [cm]
Horizontal Position [cm]
ADC Count
ALI-PERF-529960

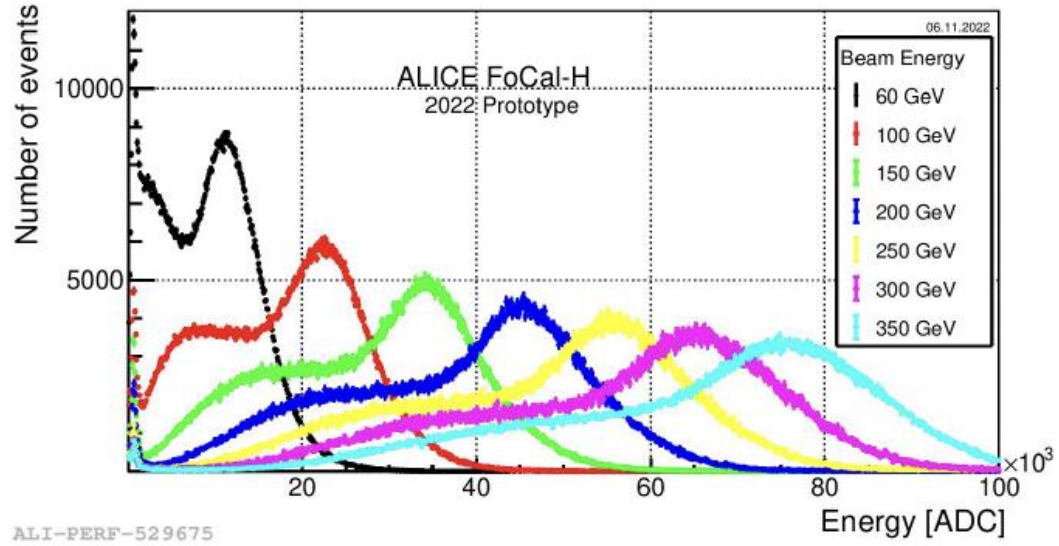

ALICE FoCal-H
2022 Prototype
FoCal-E in front
Beam Energy
60 GeV
100 GeV
150 GeV
200 GeV
250 GeV
300 GeV
350 GeV
Number of events
Energy [ADC]
06.11.2022
ALI-PERF-529675

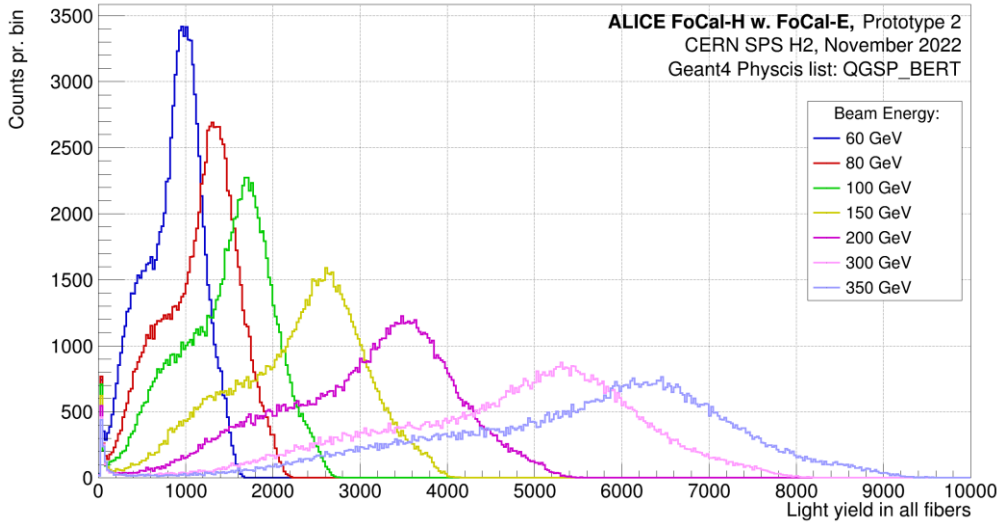

ALICE FoCal-H
2022 Prototype
FoCal-H only
Beam Energy
60 GeV
100 GeV
200 GeV
250 GeV
300 GeV
350 GeV
Number of events
Energy [ADC]
01.12.2022
ALI-PERF-531591

Questions: Linearity? Resolution?

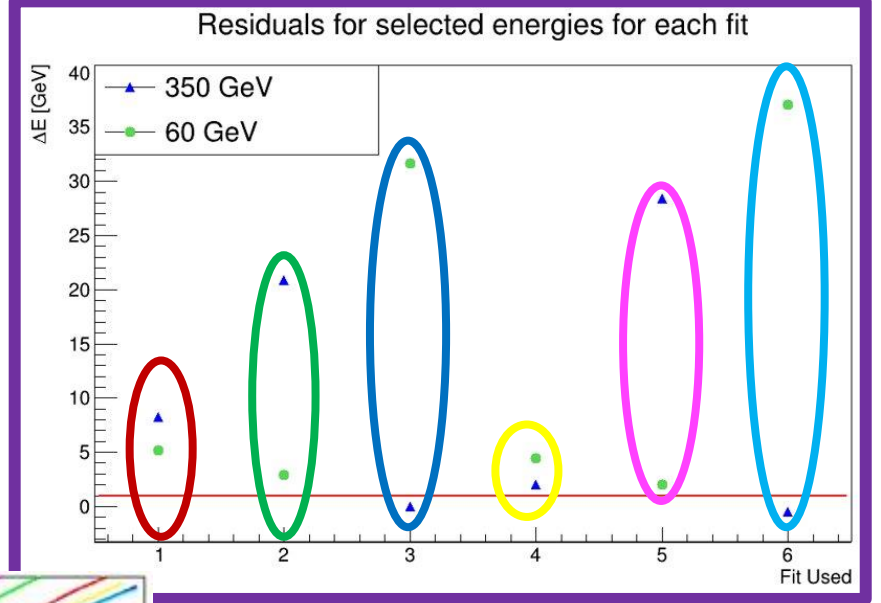


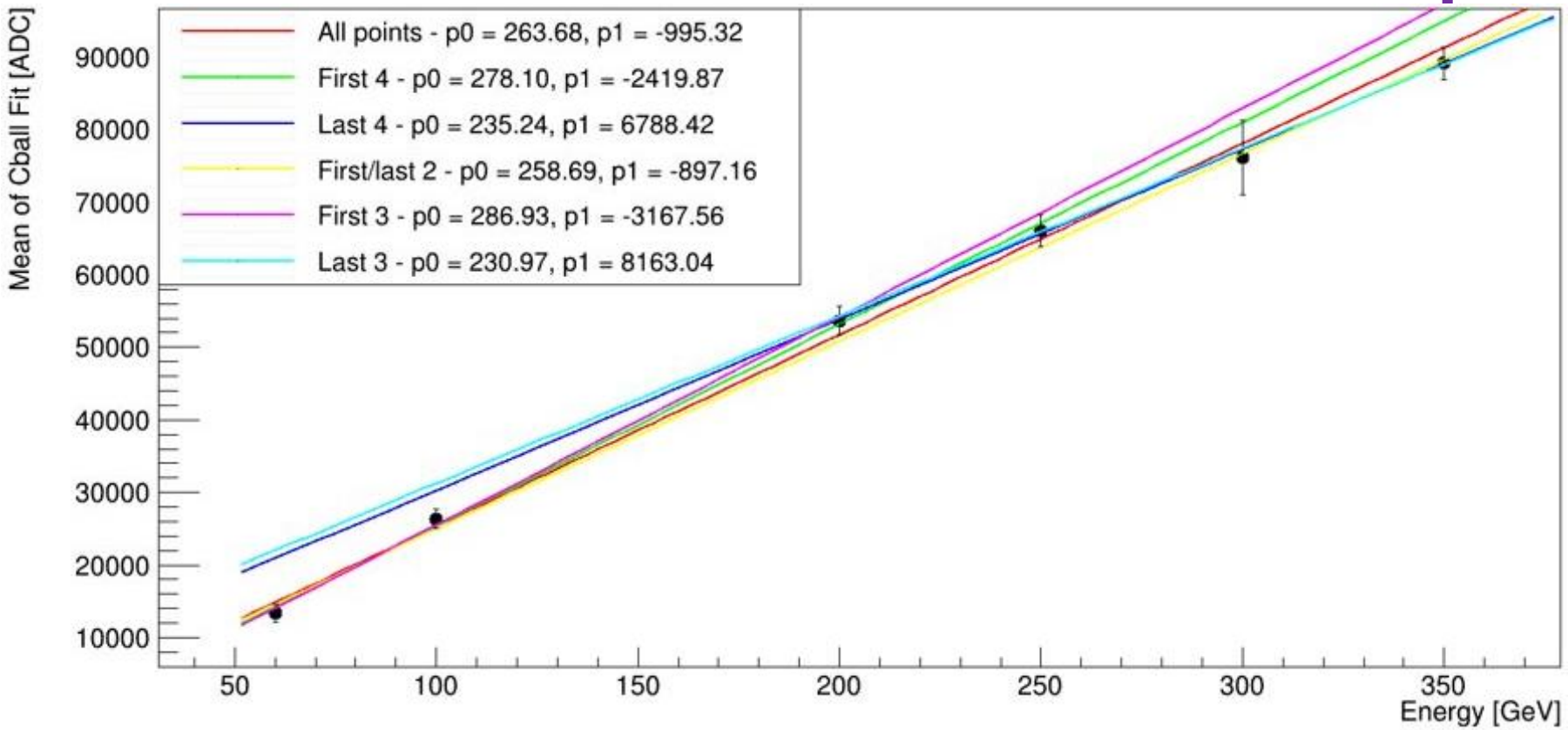






E calibration w/o FoCal-E: All fits ADC=$p_0(E_{beam})+p_1$

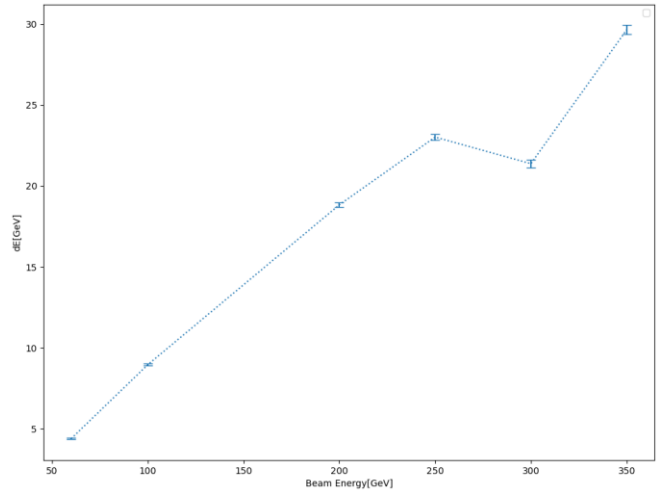


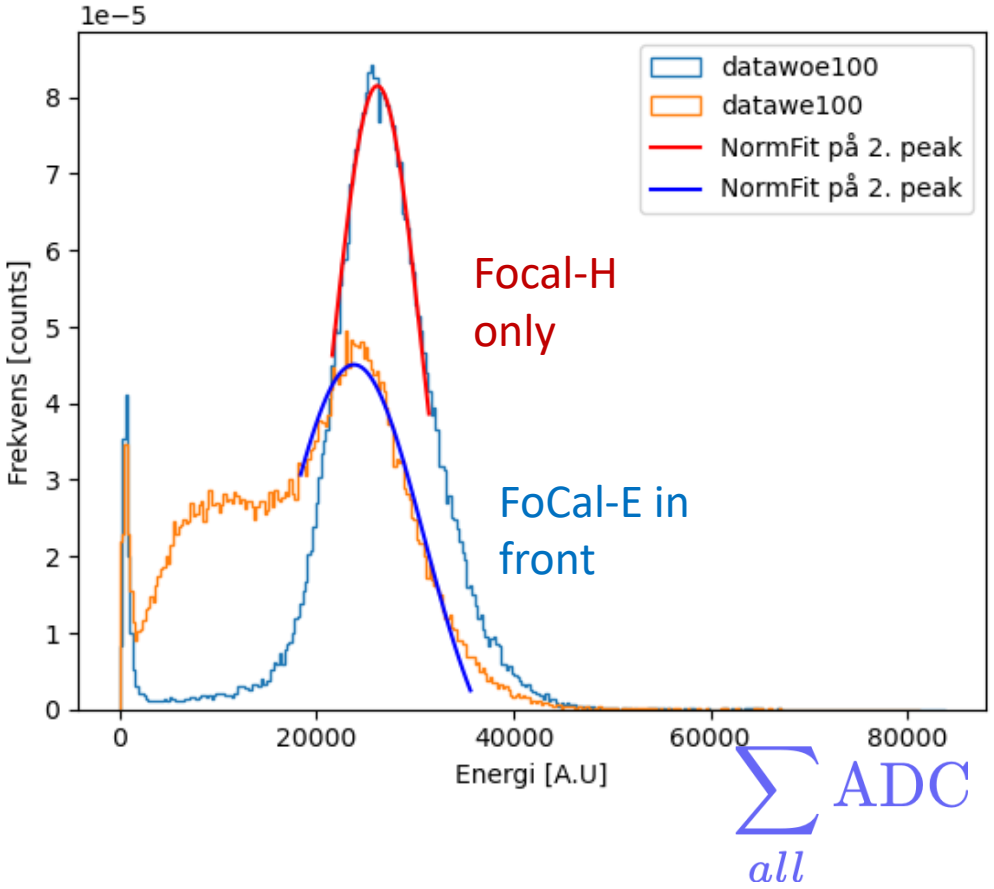


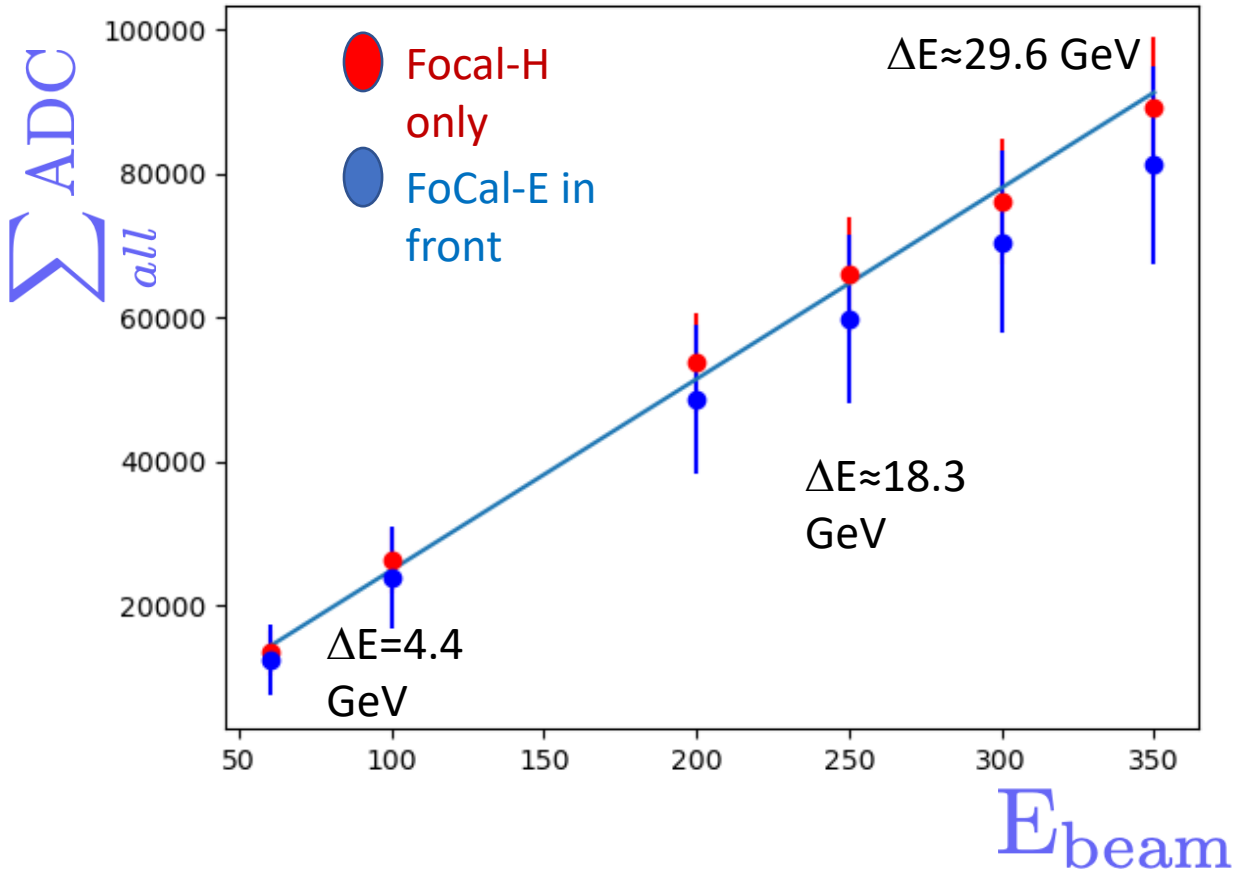
ΔE (E_{beam}-E_{cal}):
60&350GeV
for the 6 fits
1: all data points
2:60,100,200,250
3:200,250,300,350
4:60,100,300,350
5:60,100,200
6:250,300,350

Data with & w/o FoCal-E in front

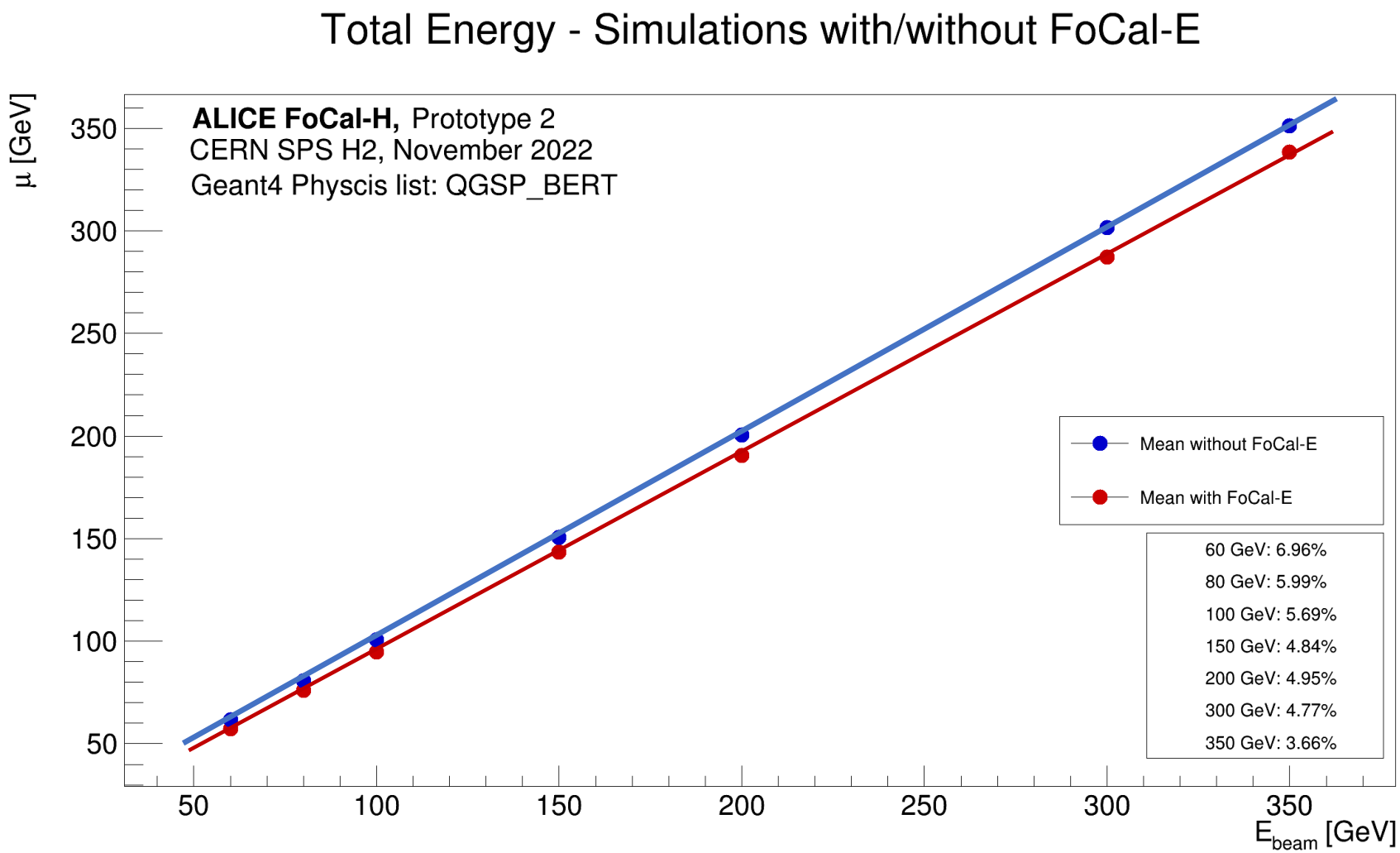
this analysis done by Alexander, Frederik, and Jonas for their 1st year project







Simulation with & w/o FoCal-E in front



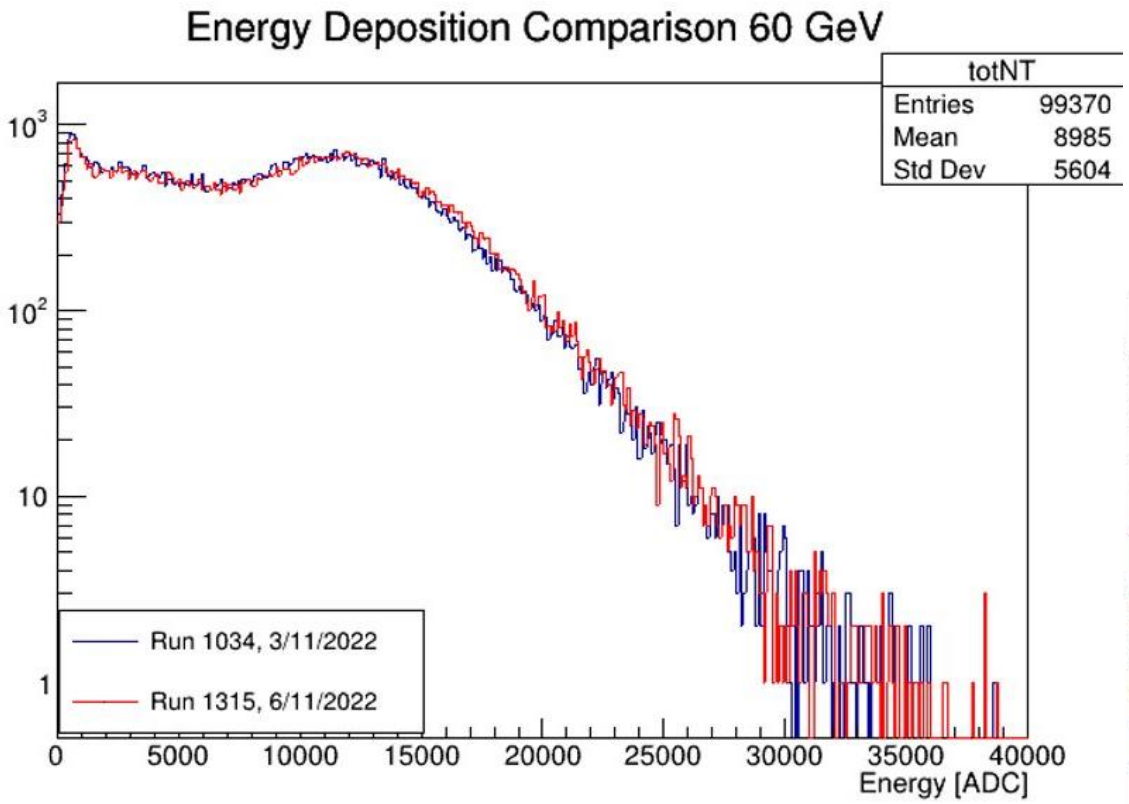
4.2GeV

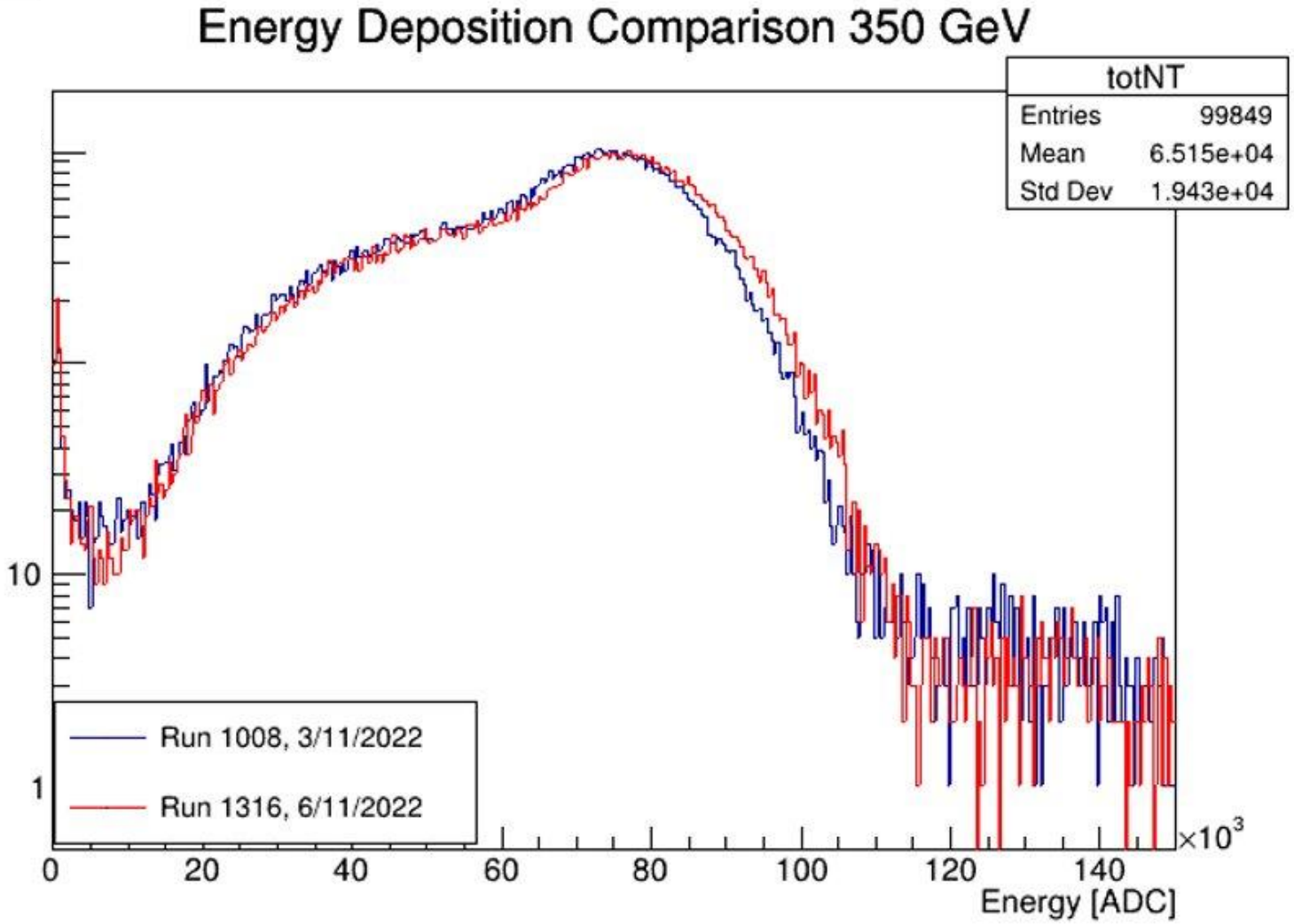
7.3GeV

12GeV

Is gain stable over time?

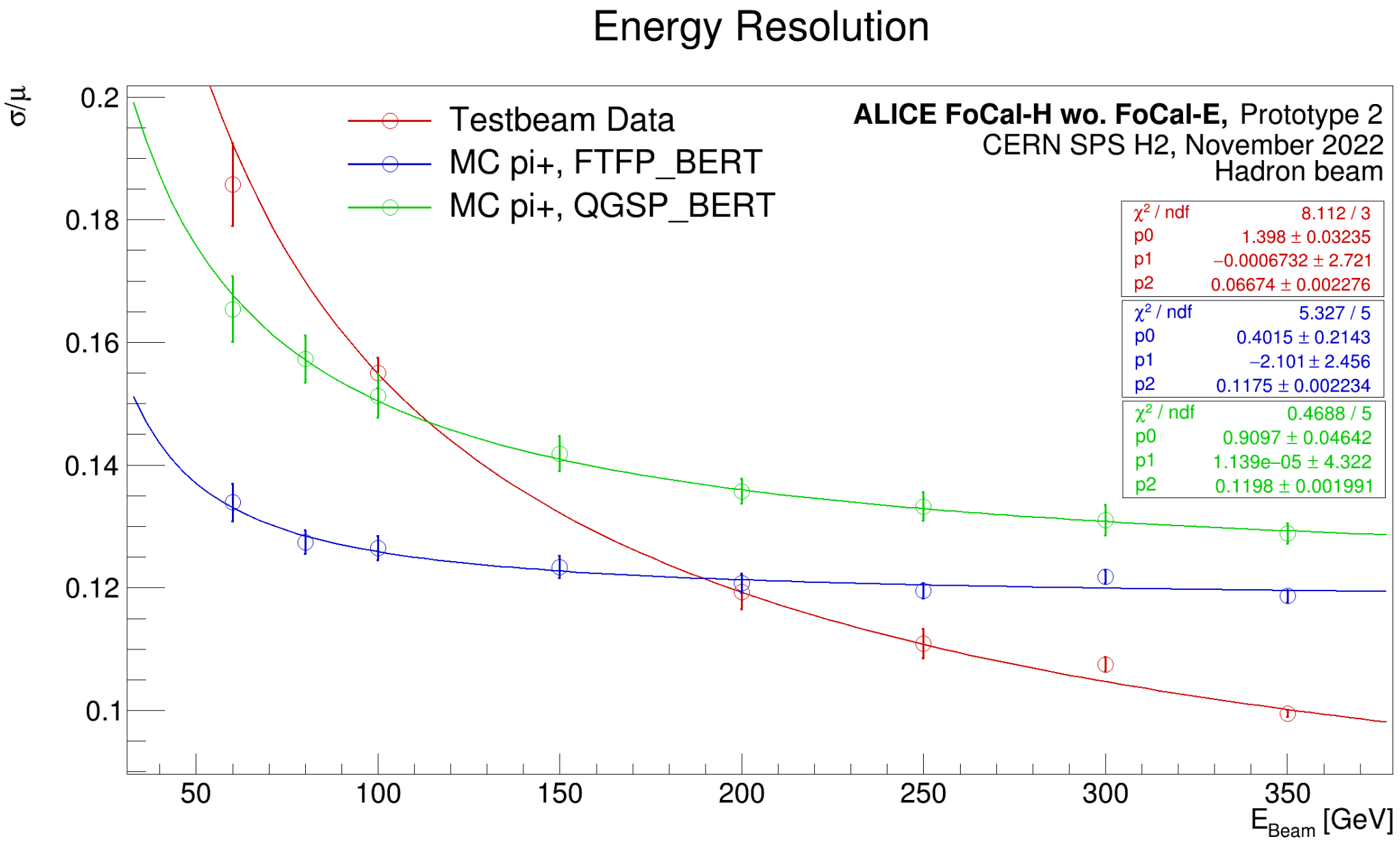
NB: we only had a few hours w/o FoCal-E on the last day
No 150GeV data as we prioritized VMM data.



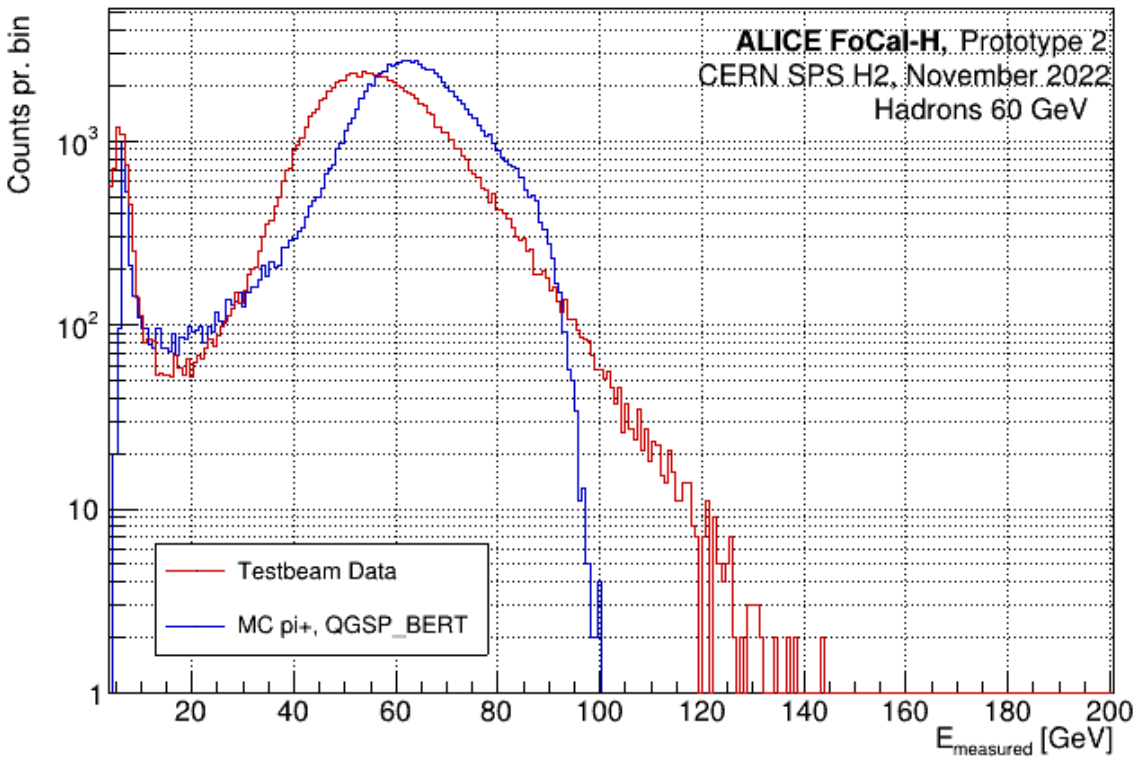


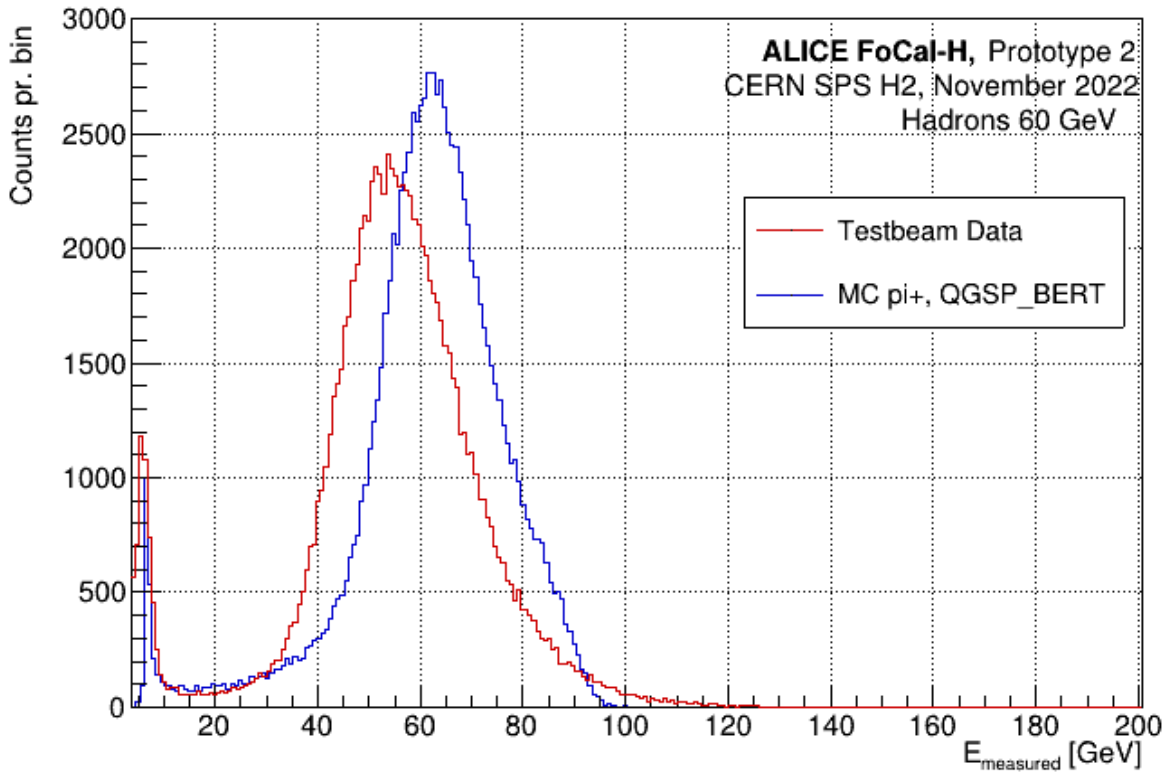
Both plots,
BLUE is November 3
RED is November 6

Resolution (FoCal-H only):



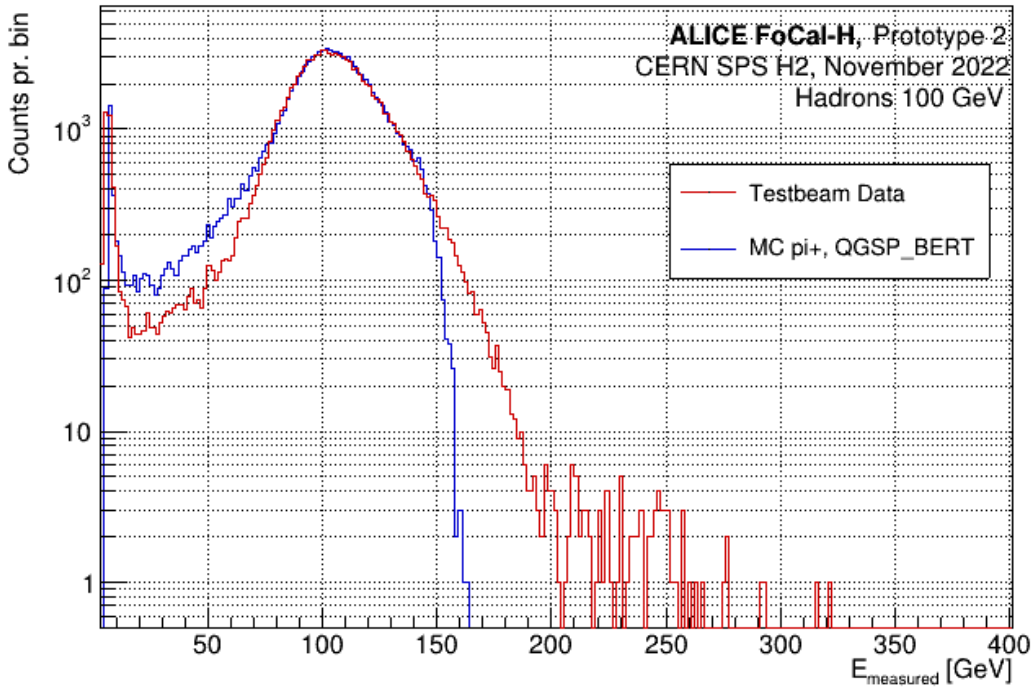
60 GeV

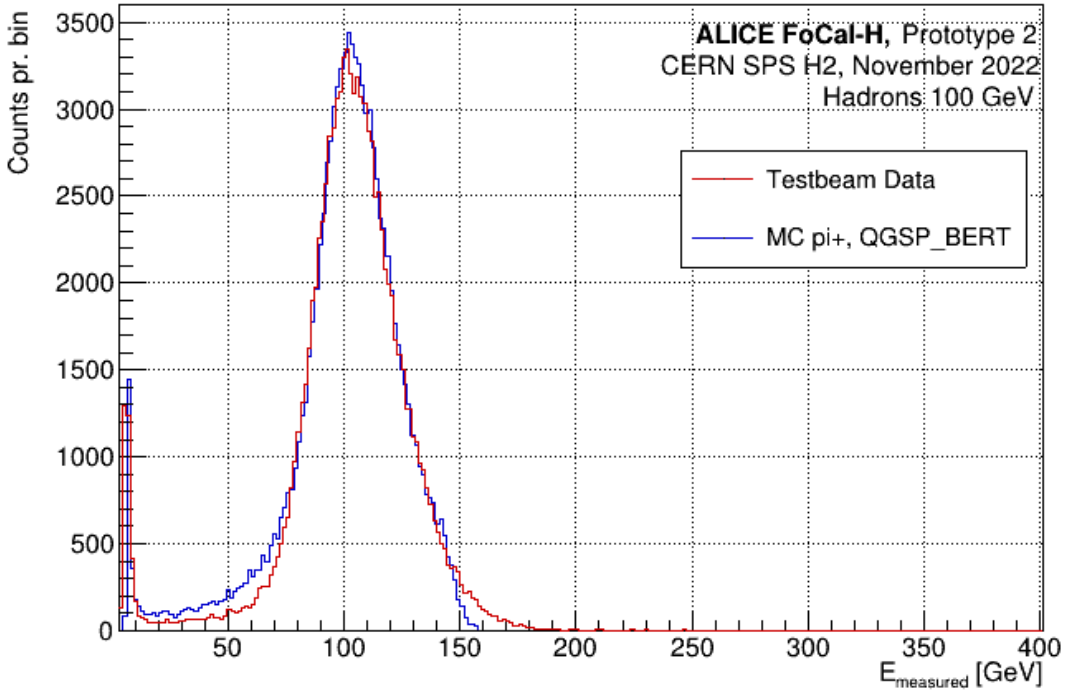

ALICE FoCal-H, Prototype 2
CERN SPS H2, November 2022
Hadrons 60 GeV
Testbeam Data
MC pi+, QGSP_BERT
Counts pr. bin
E_measured [GeV]


ALICE FoCal-H, Prototype 2
CERN SPS H2, November 2022
Hadrons 60 GeV
Testbeam Data
MC pi+, QGSP_BERT
Counts pr. bin
E_measured [GeV]

100 GeV

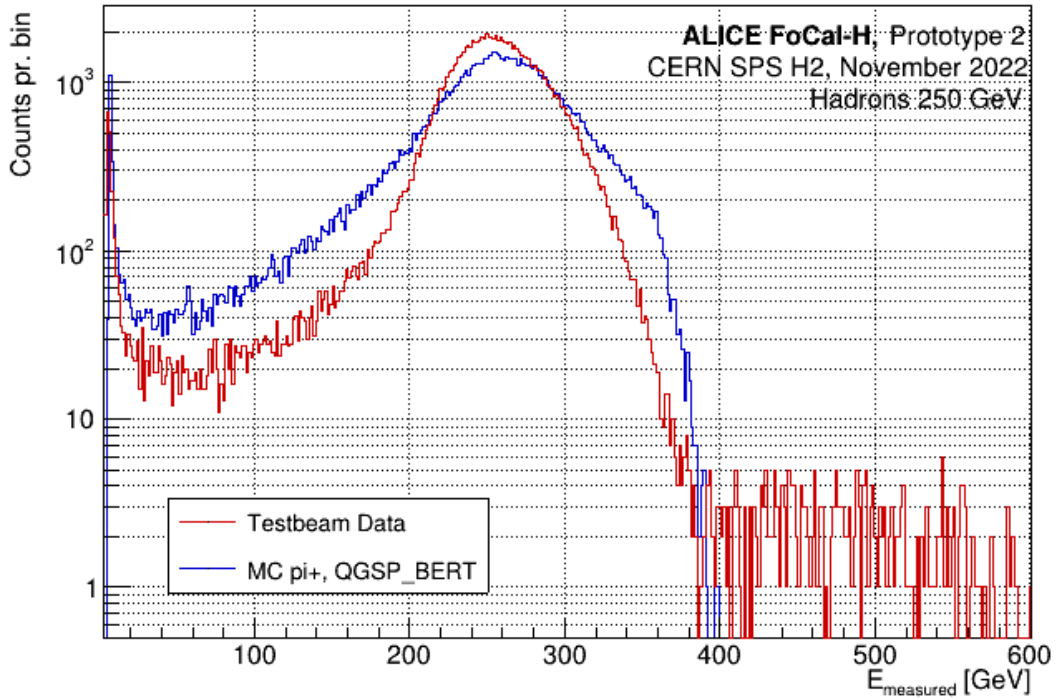
This plots is with the saturation study.

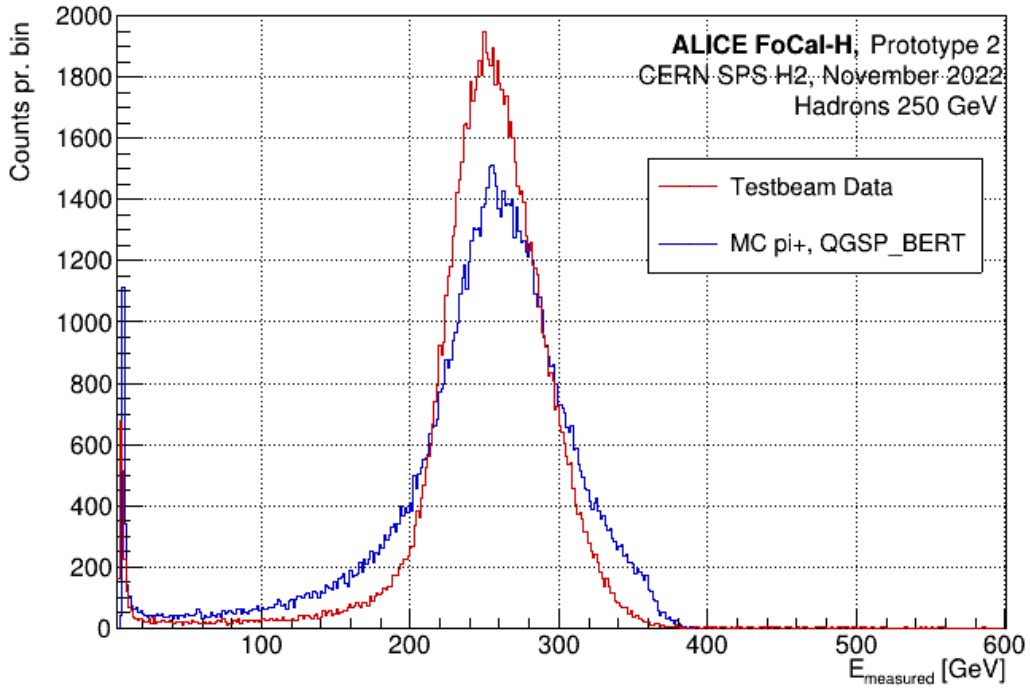




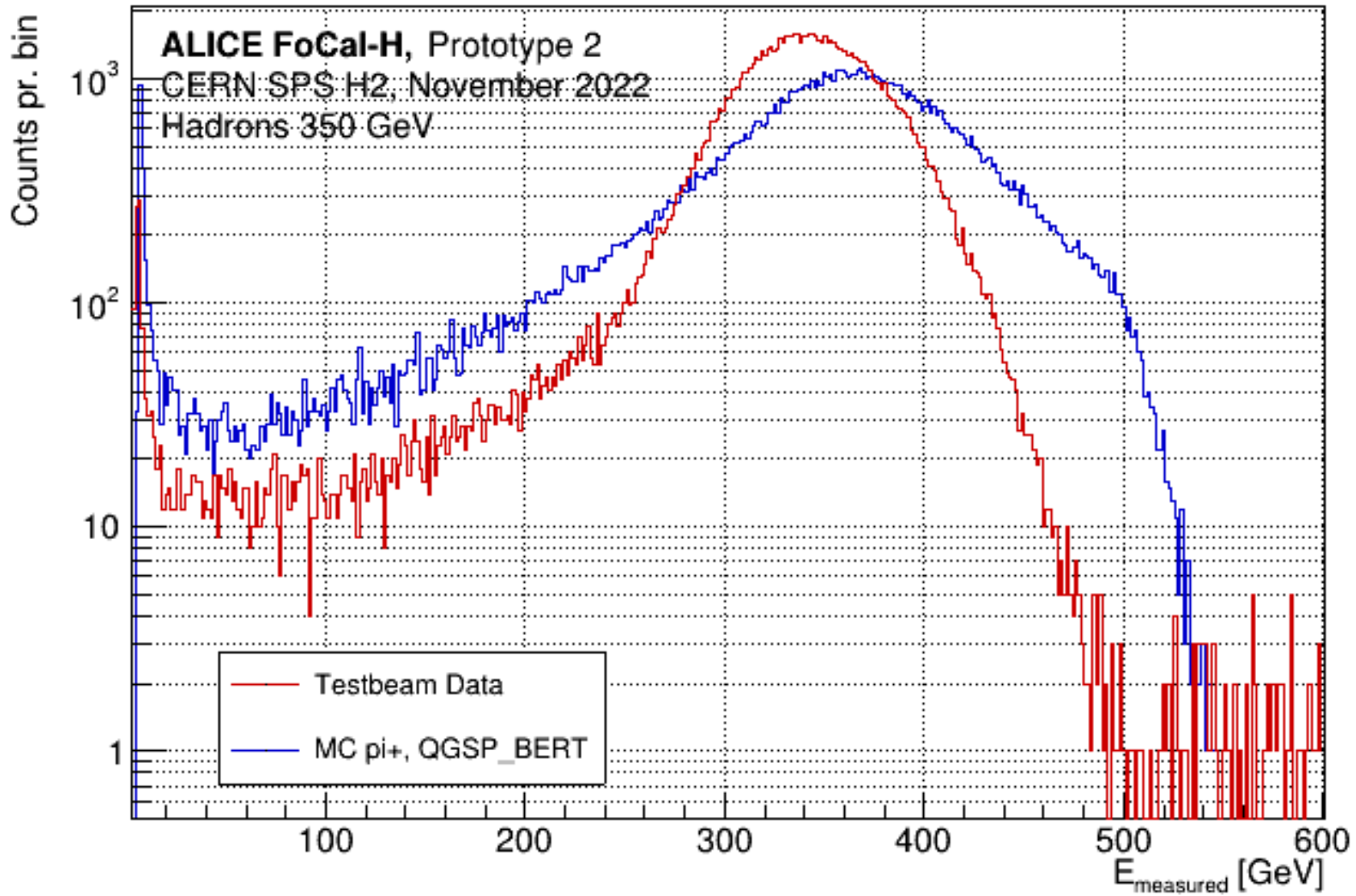
250 GeV

This plots is with the saturation study.

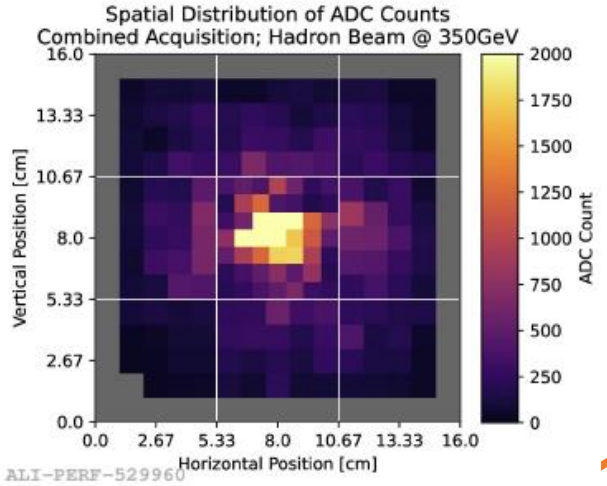


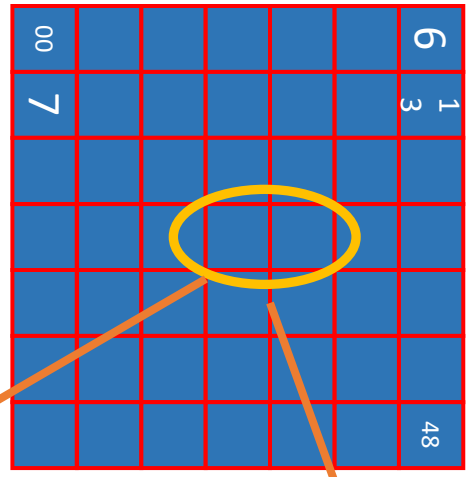


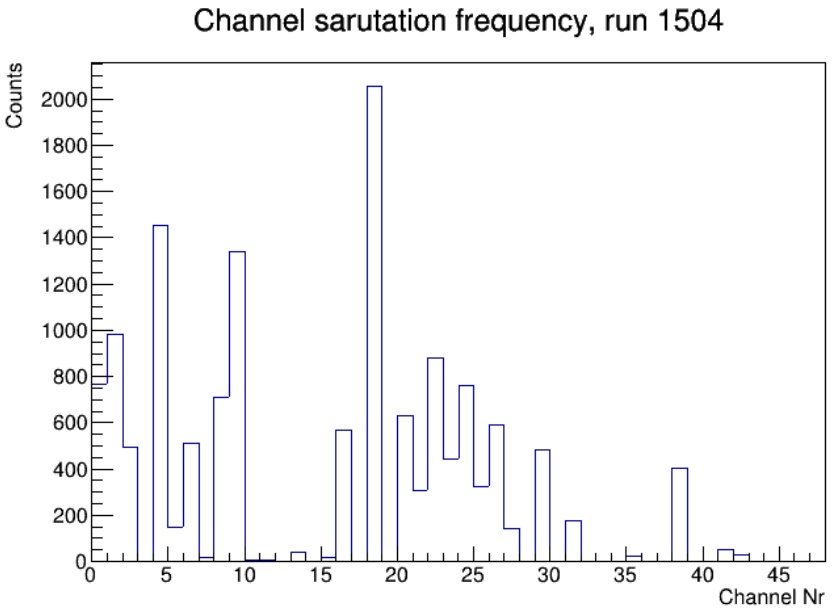
350 GeV

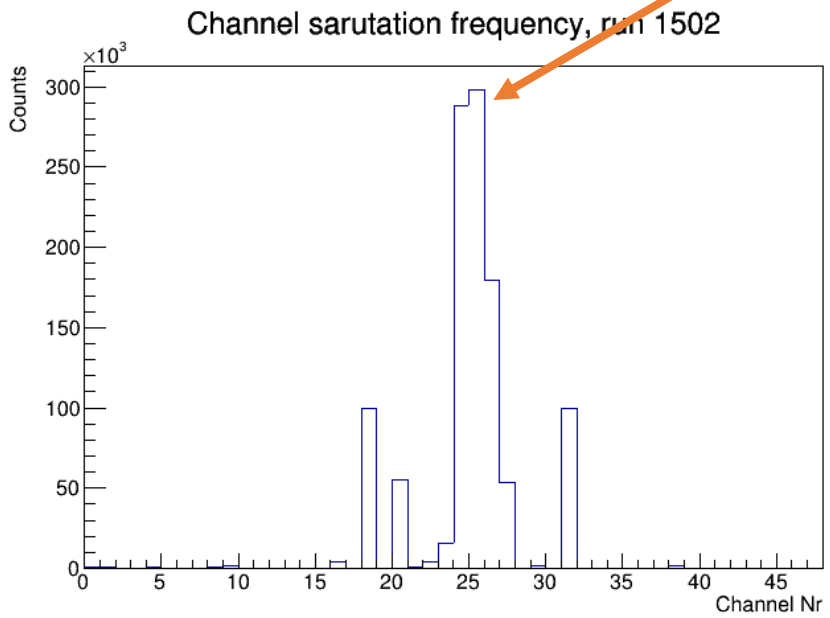

ALICE FoCal-H, Prototype 2
CERN SPS H2, November 2022
Hadrons 350 GeV
Counts pr. bin
10^3
10^2
10
1
Testbeam Data
MC pi+, QGSP_BERT
100
200
300
400
500
600
$E_{measured}$ [GeV]

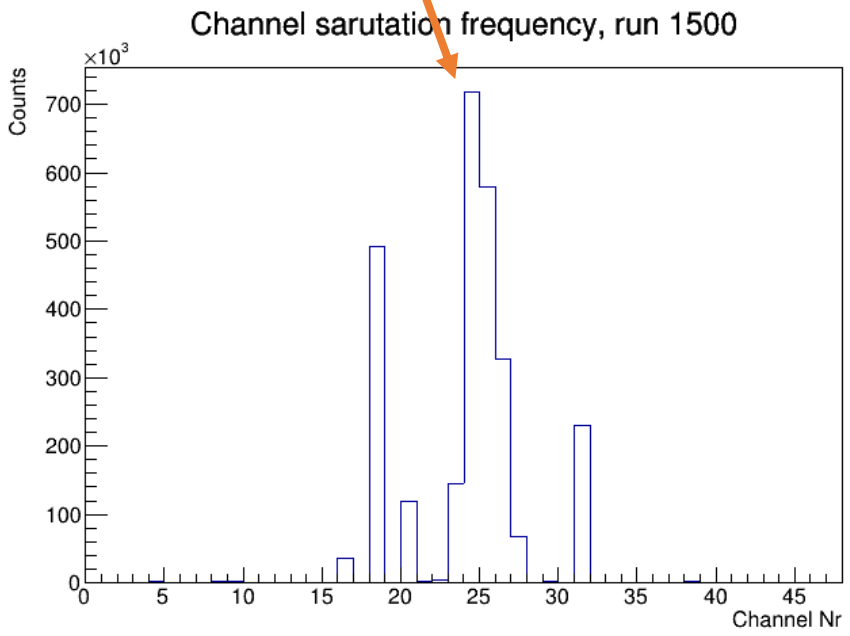
Saturation: how bad is it?



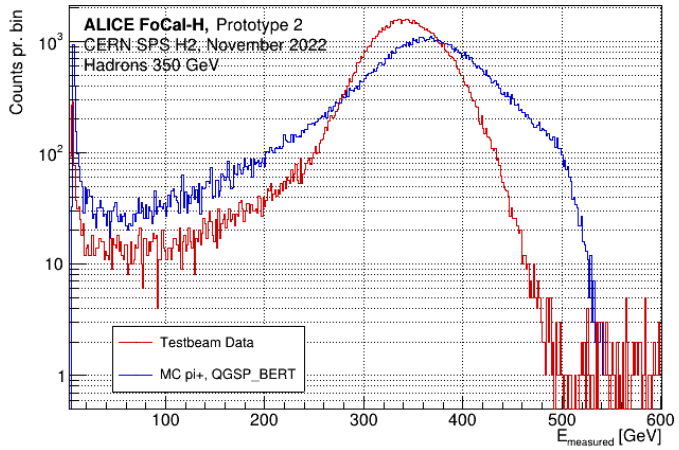


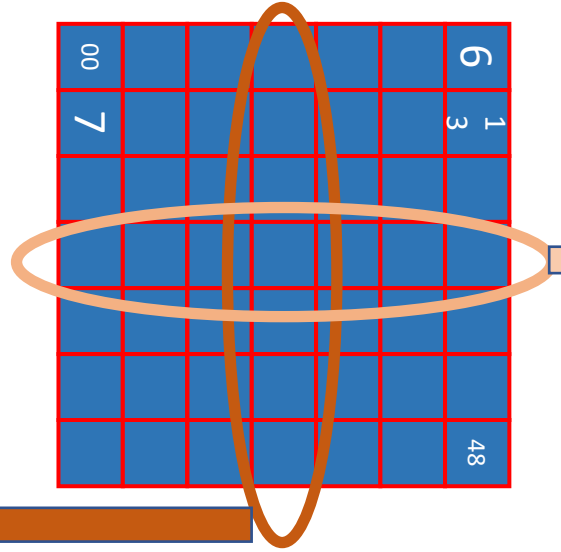




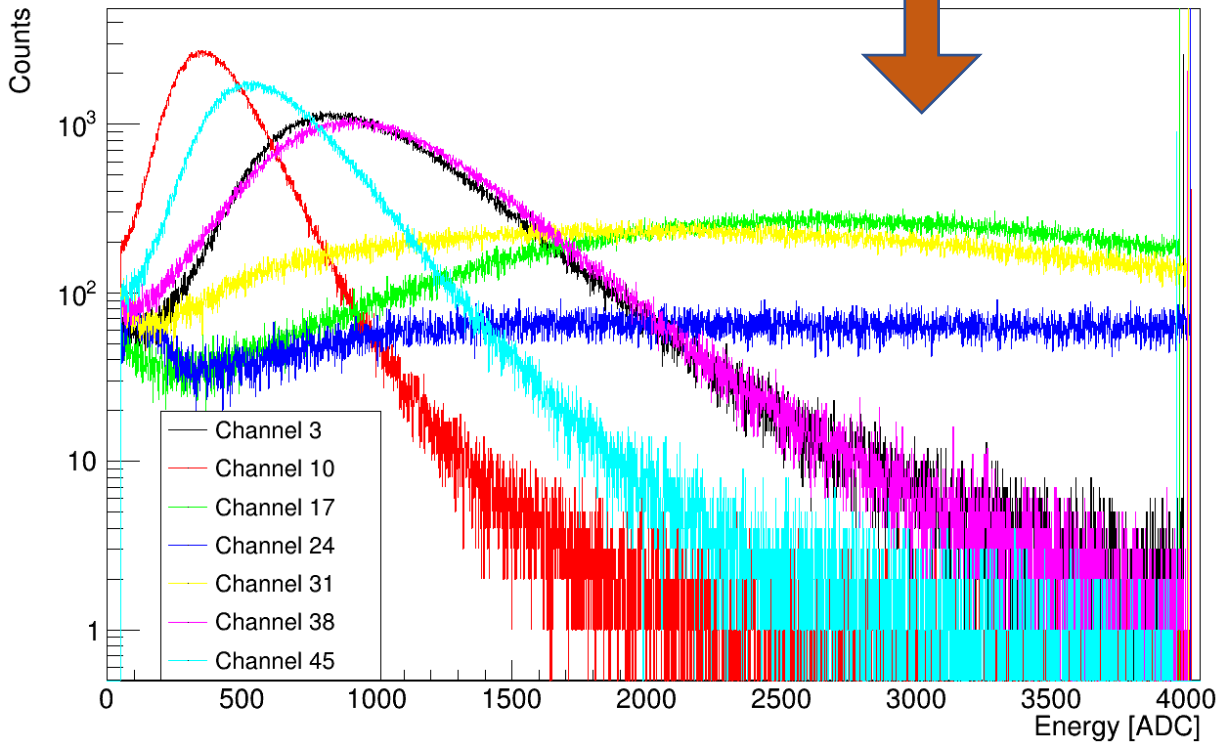


350 GeV

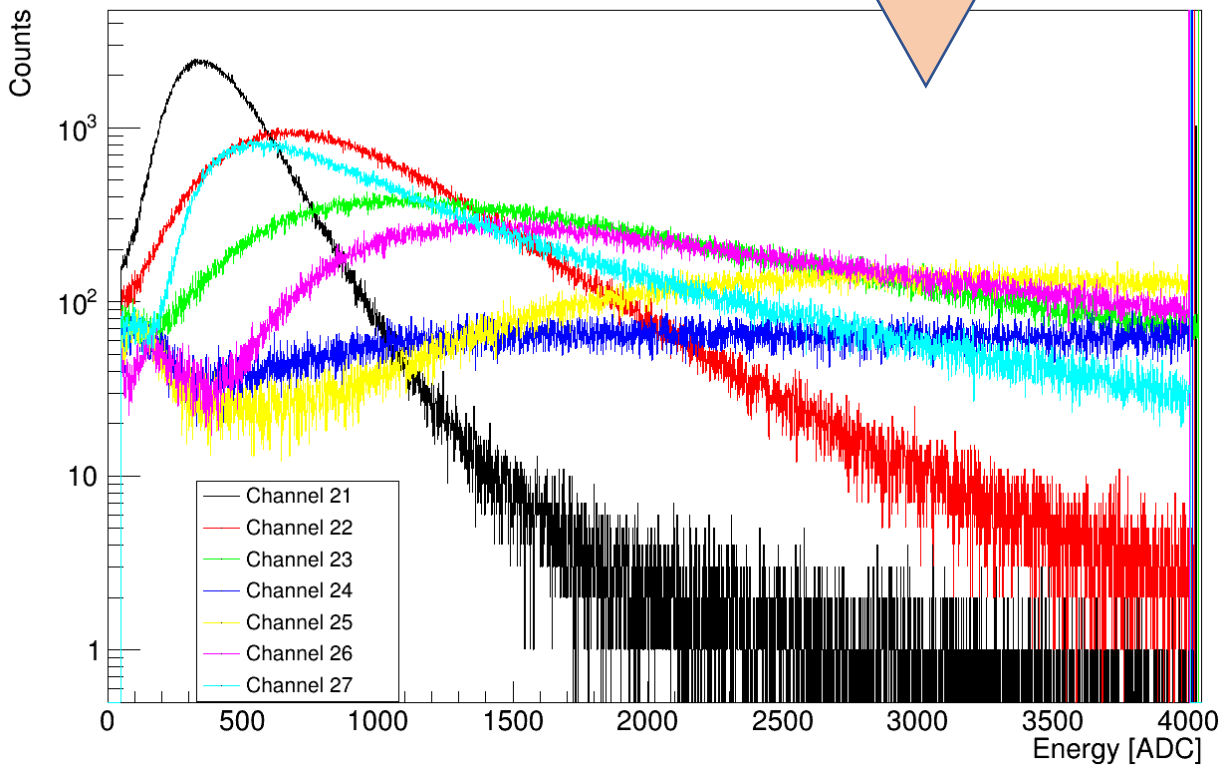




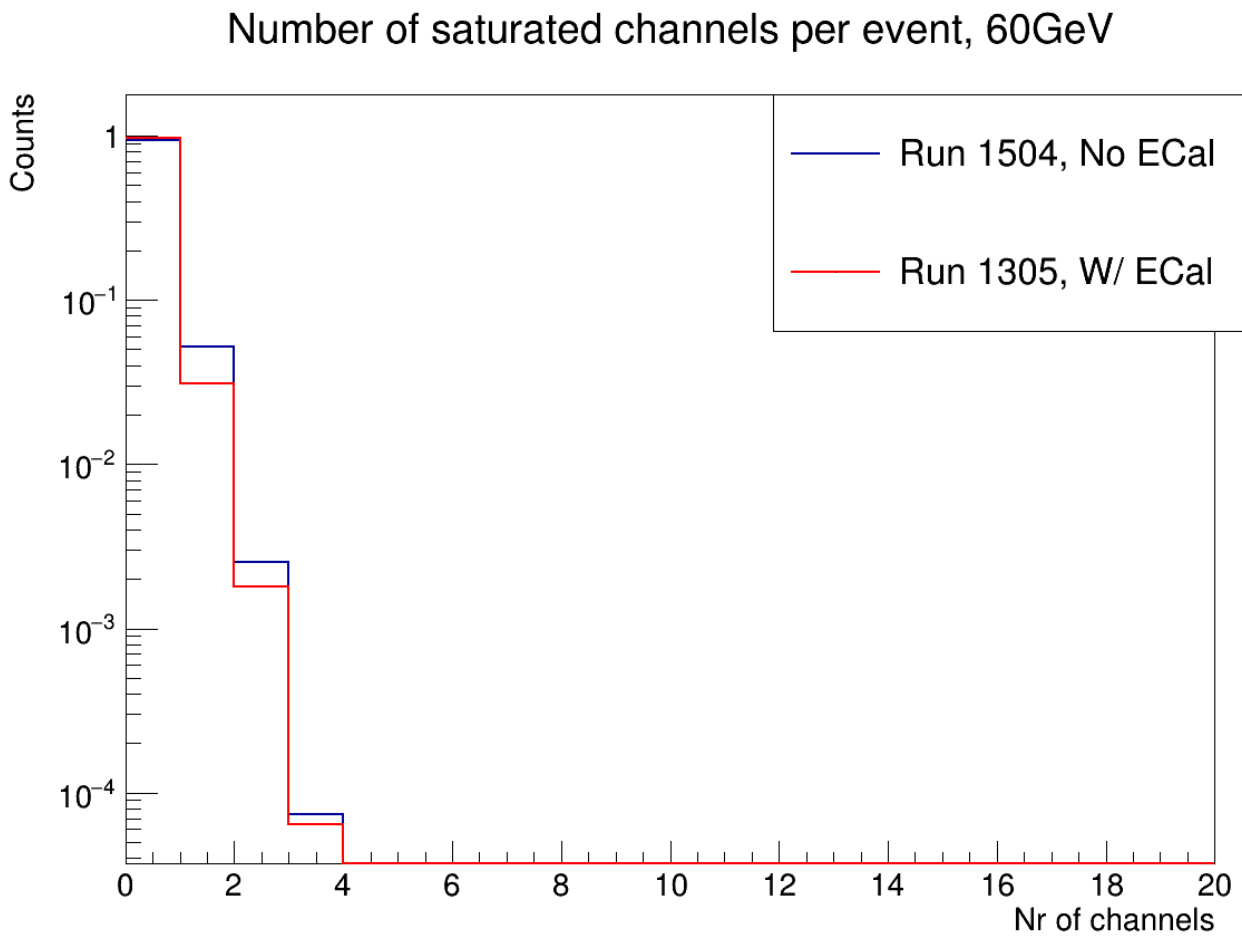
ADC distribution for channels in 'hit column'

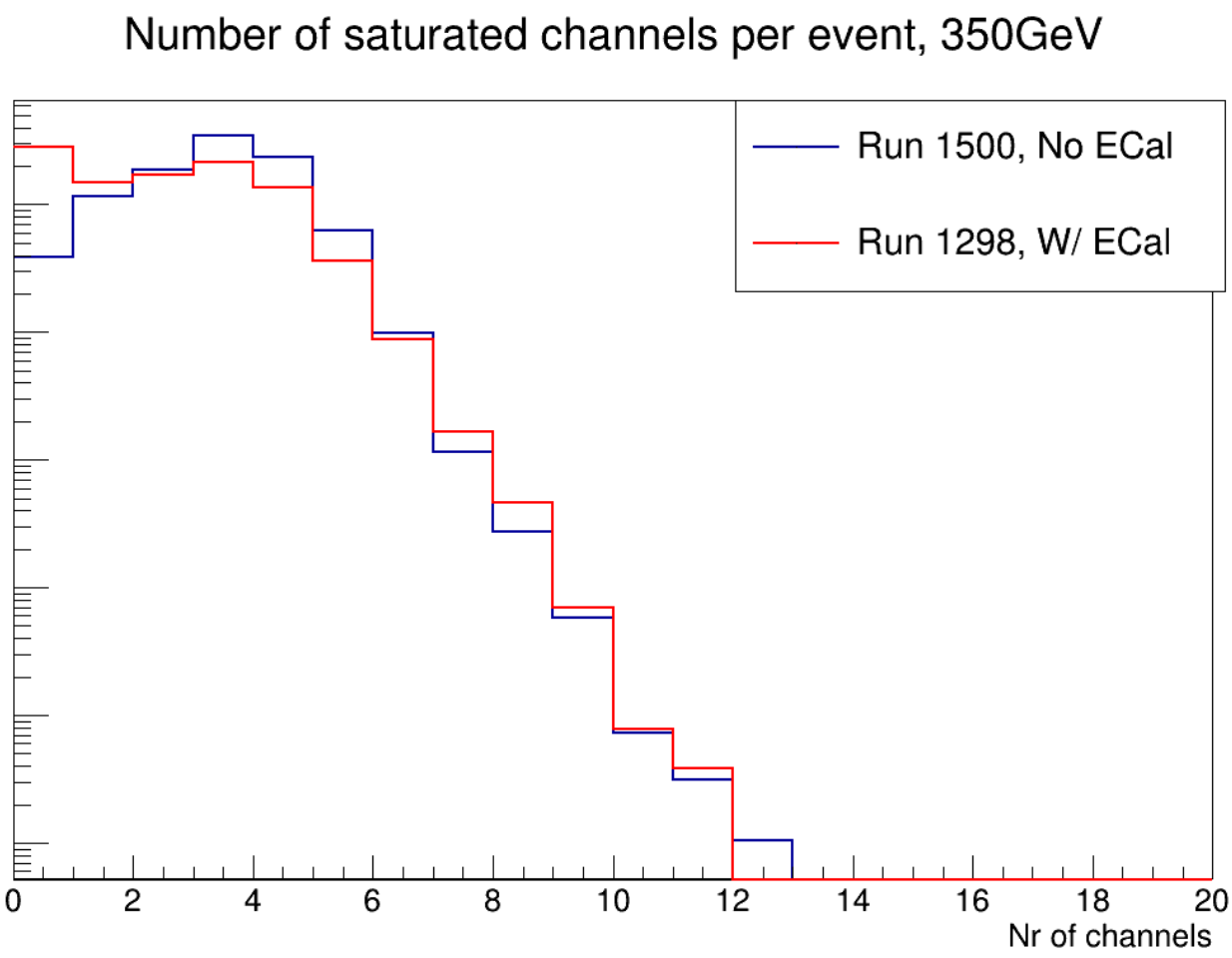


ADC distribution for channels in 'hit row'



Saturation: how bad is it?

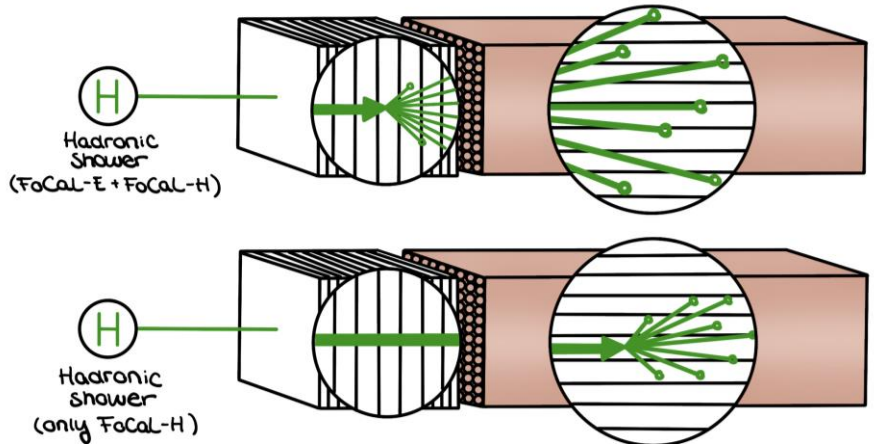


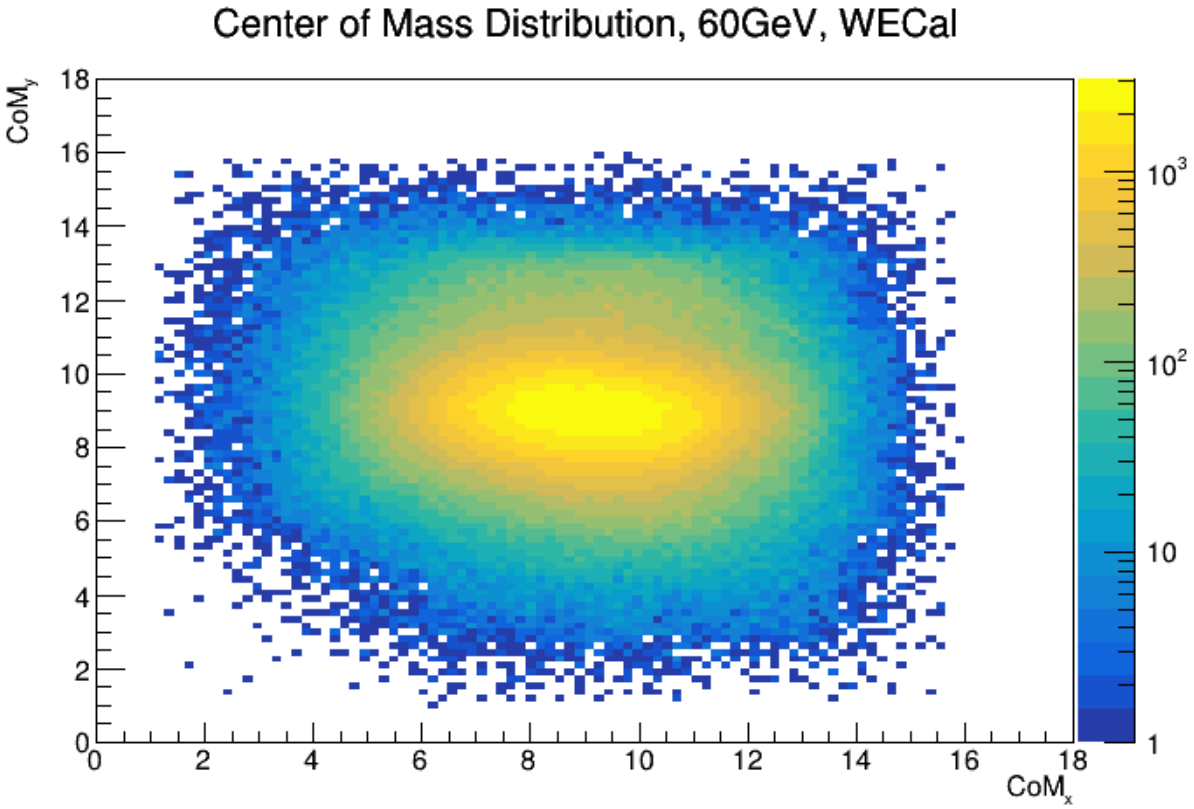


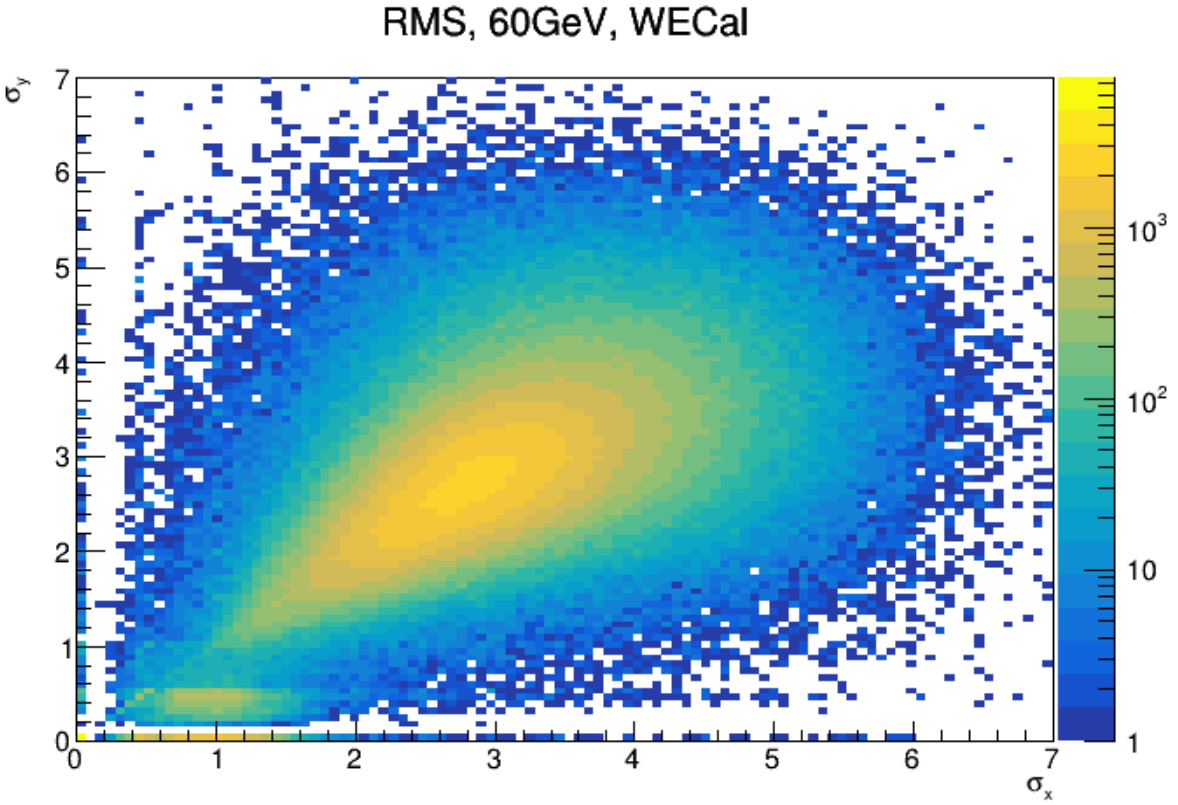
Conclusion(!?) on resolution & saturation

- Saturation is clearly a problem!
- Due to the limited dynamic range of CAEN DT5202.
- Fix: H2GCROC (which we hope to test at PS in May/June & SPS this autumn)
- Meanwhile, work on 2D fits to minimize effect of saturation.
- Not the only story: note the sharper peak in data compared to simulations on the low energy shoulder of the peak.
- Gain matching individual channels will improve resolution.

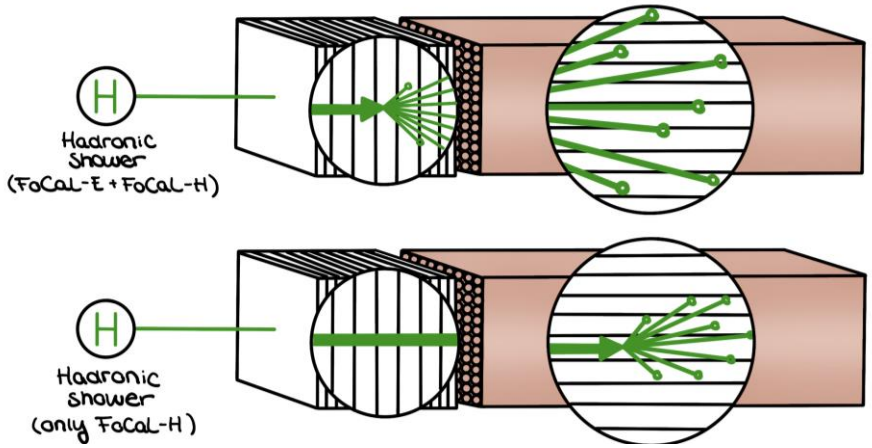
2D: CoM; RMS. 60GeV FoCal-E in front (AB)

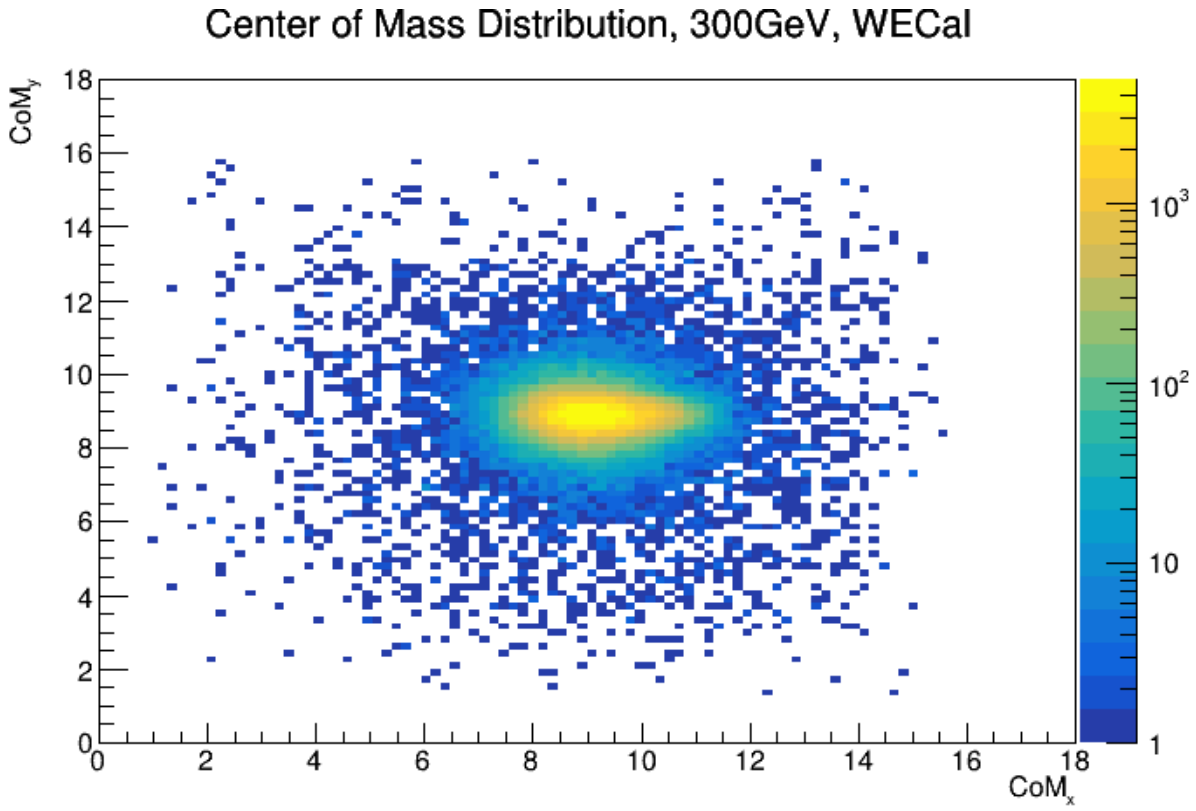


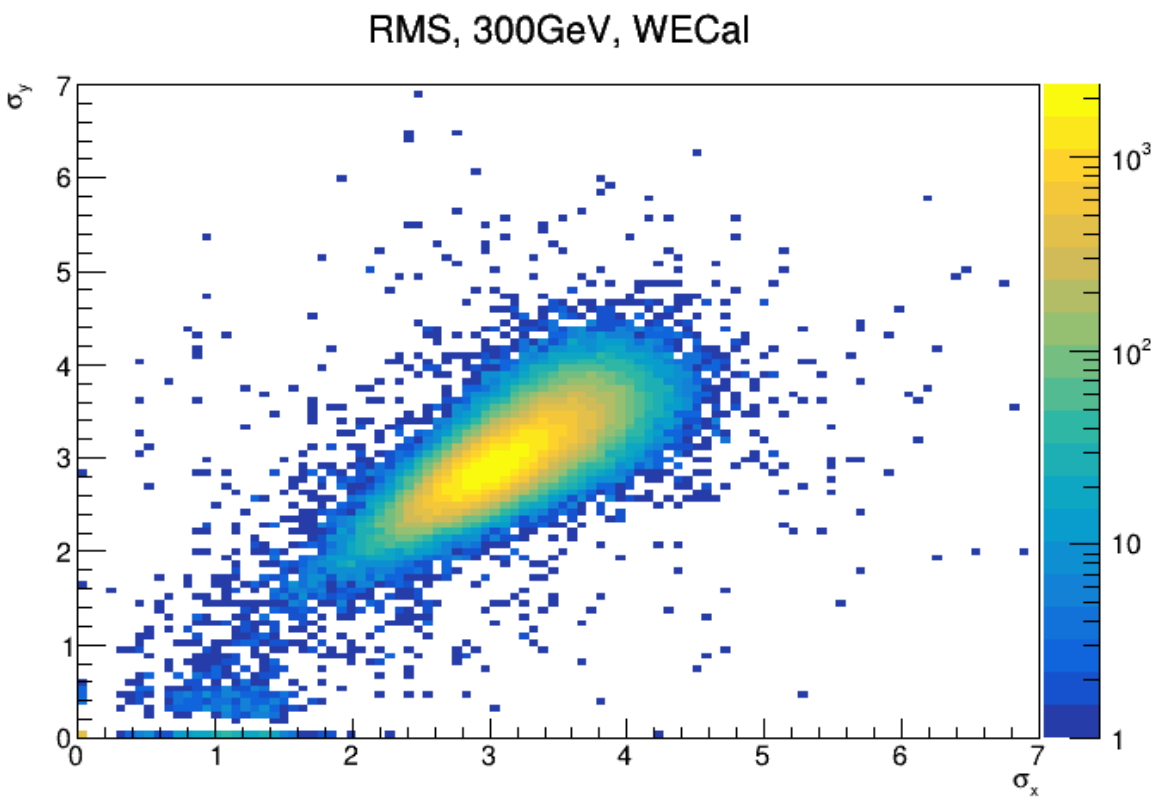




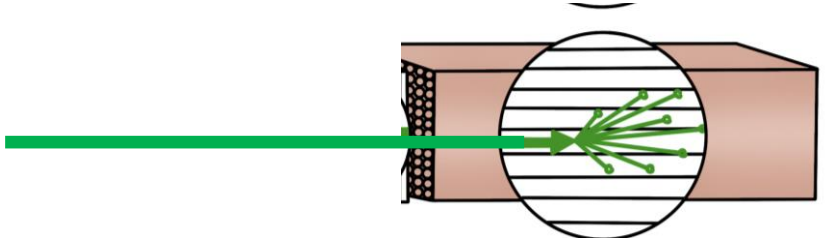
2D: CoM; RMS. 300 GeV FoCal-E in front

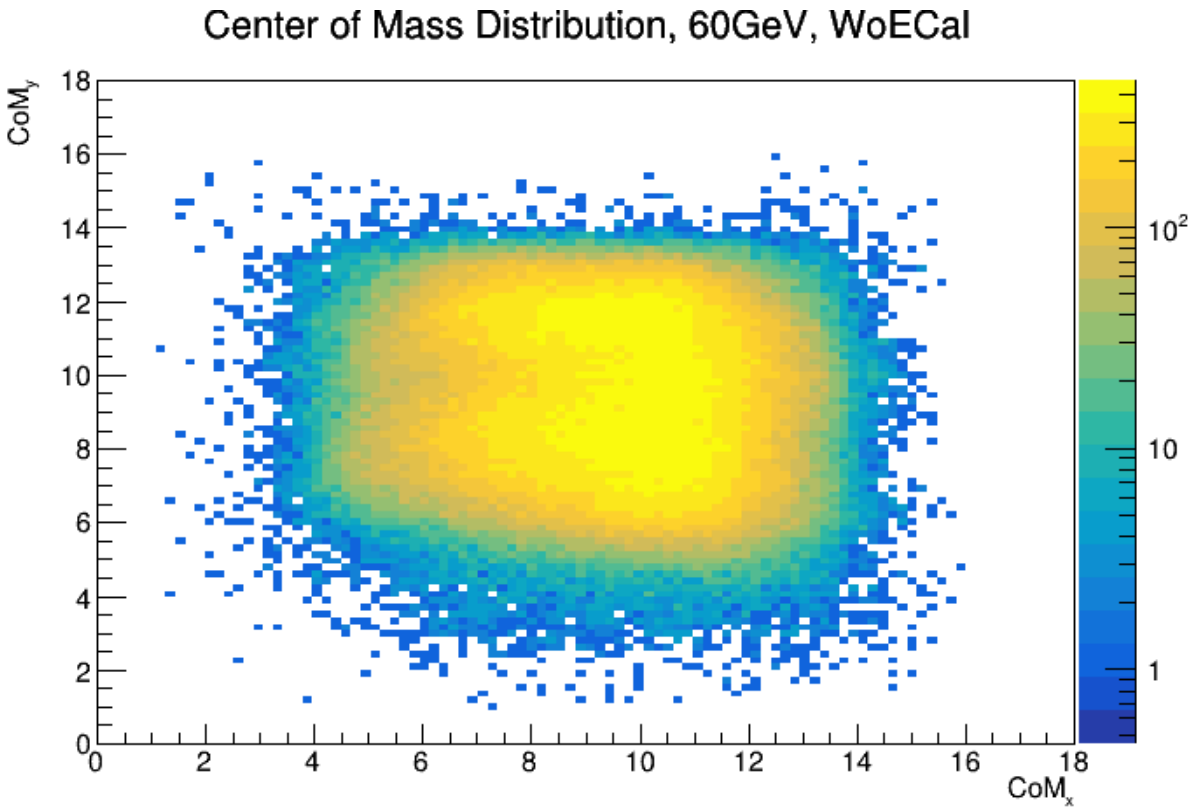


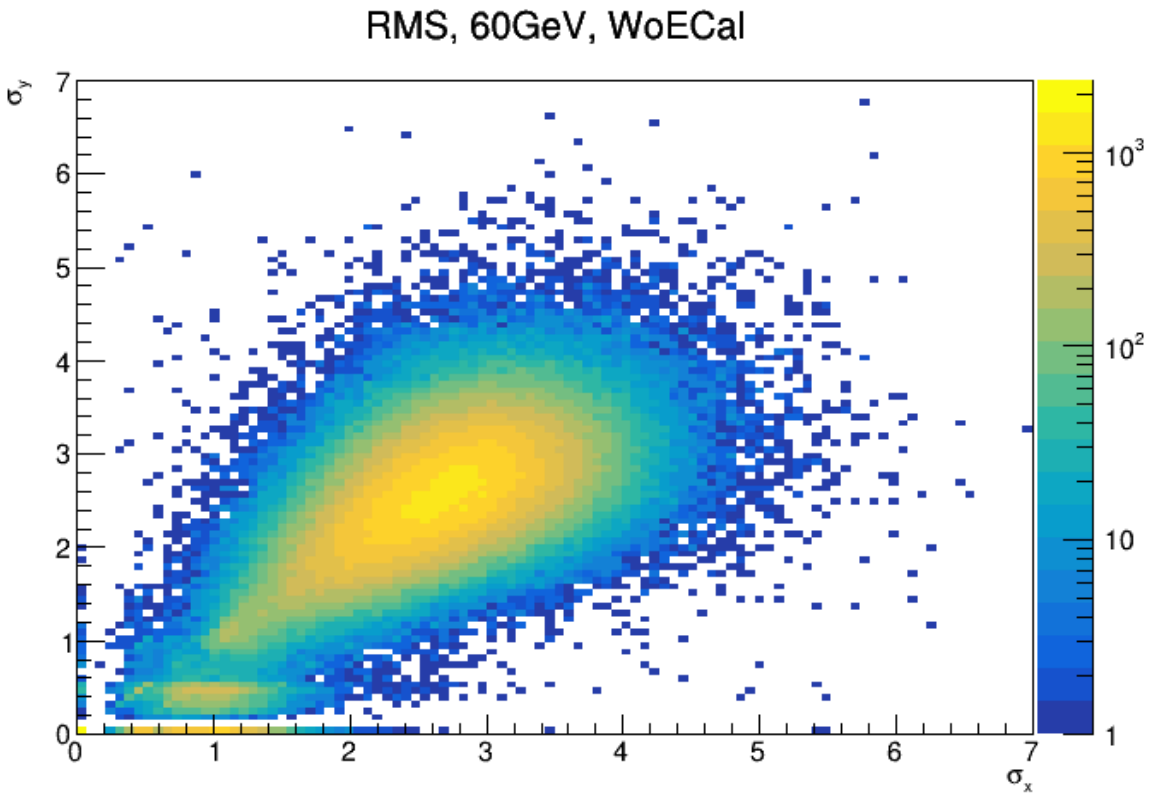




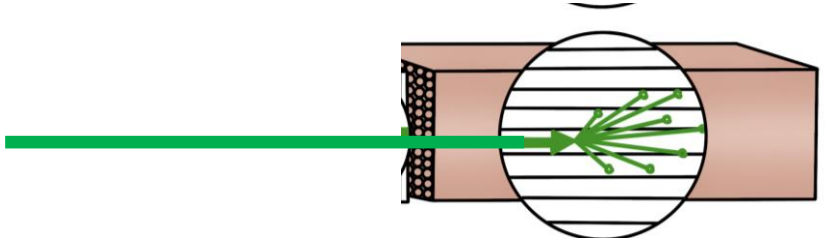
2D: CoM; RMS. 60 GeV FoCal-H only

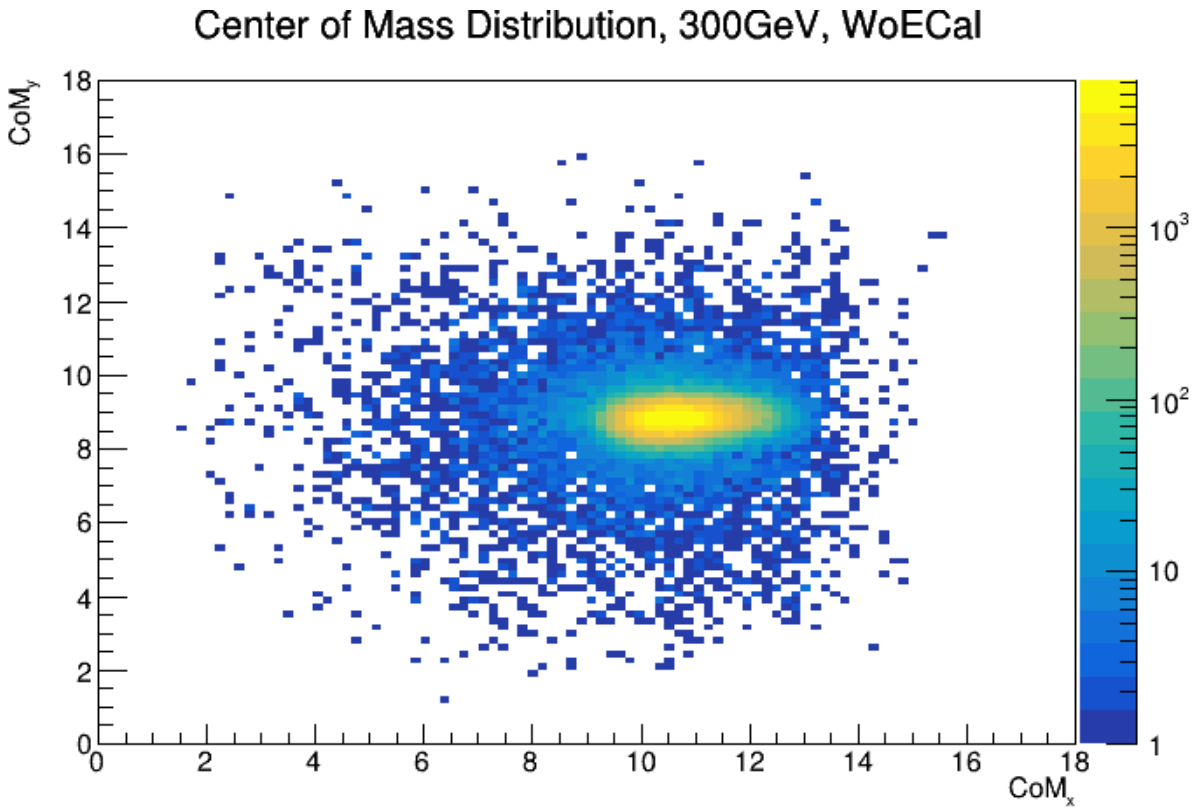


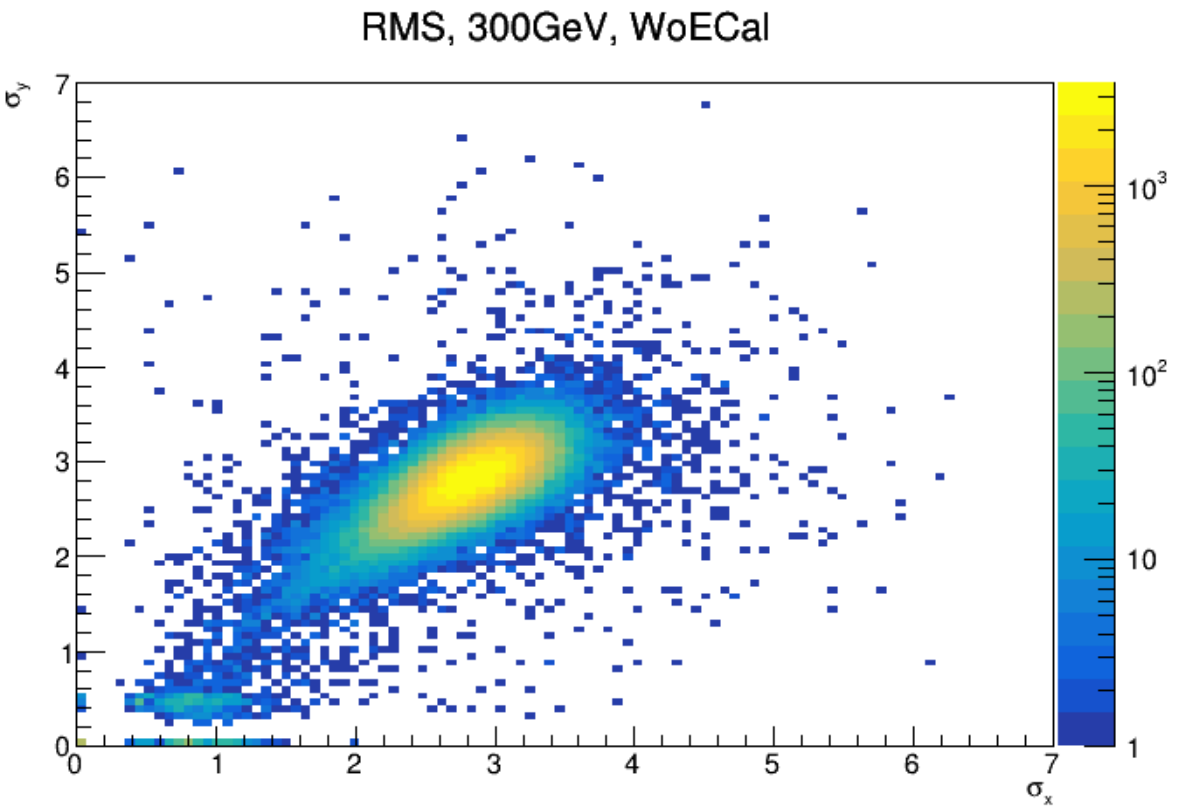




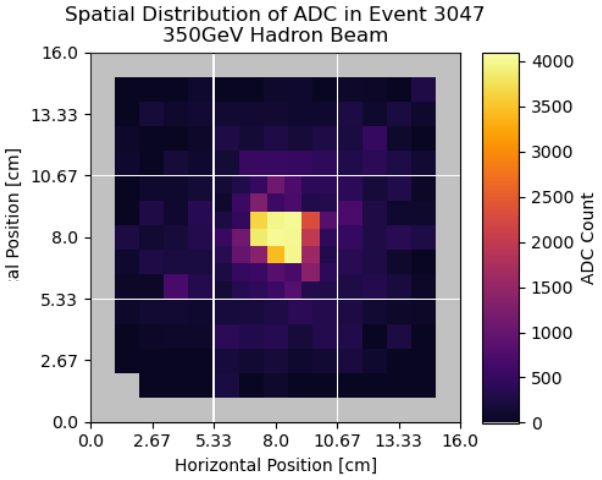
2D: CoM; RMS. 300 GeV FoCal-H only

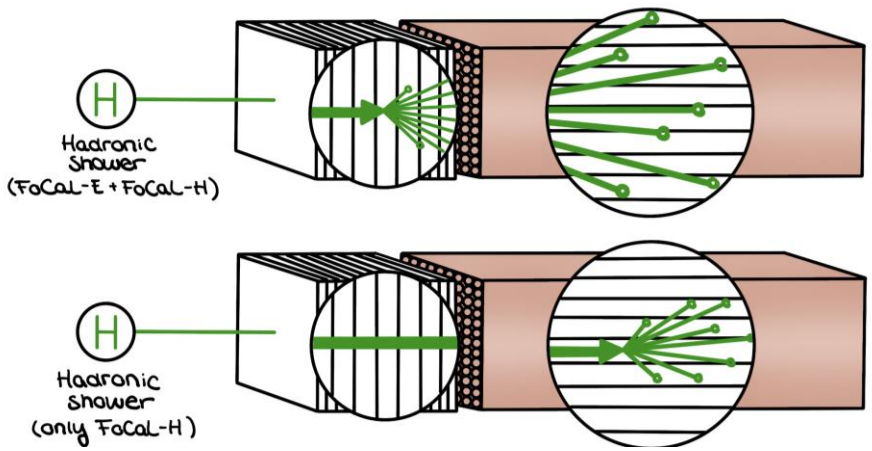


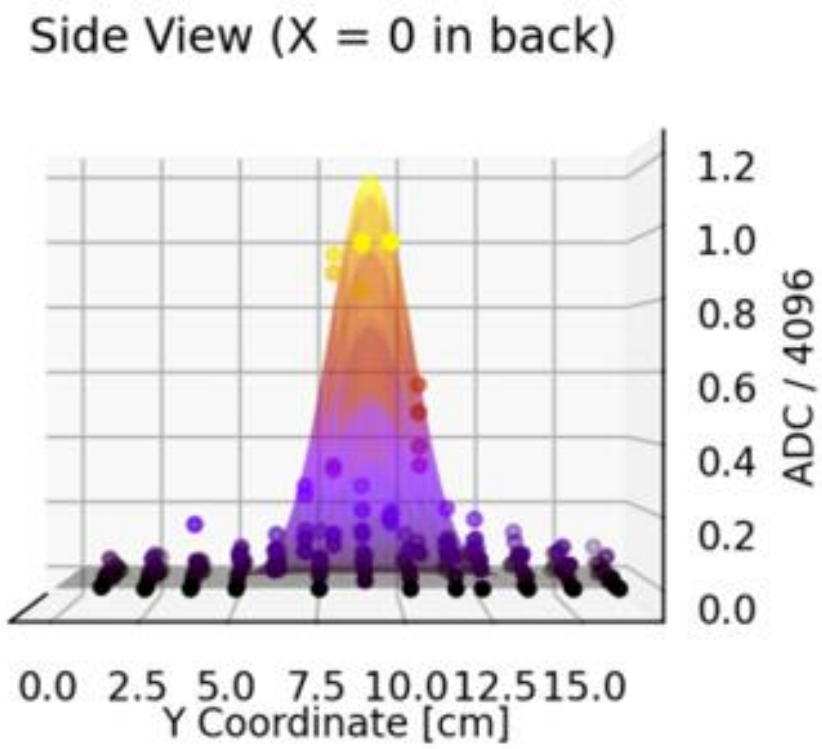


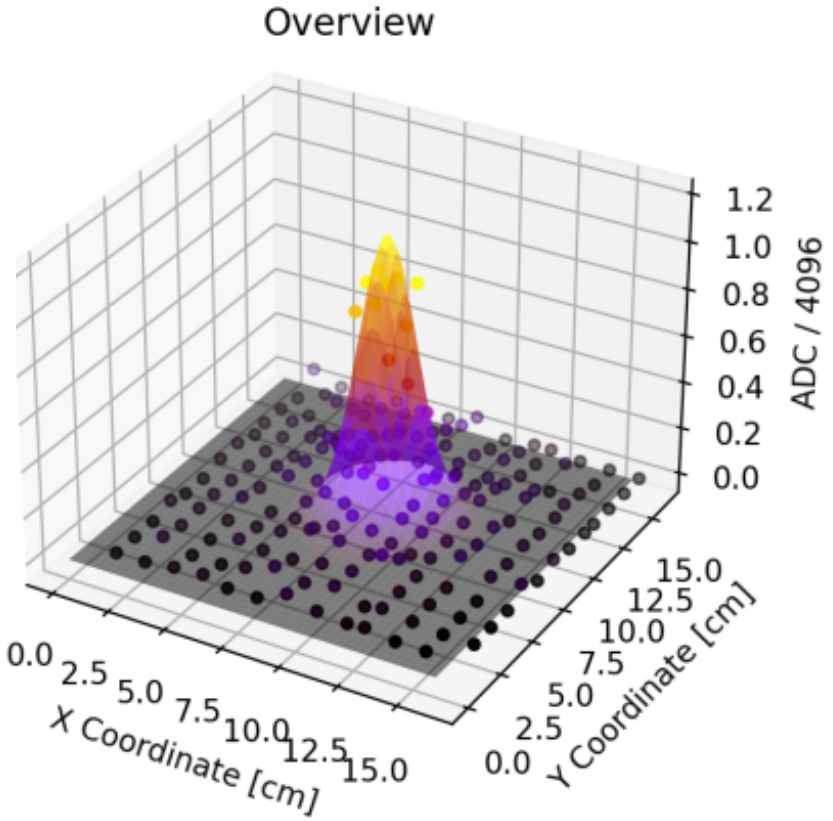


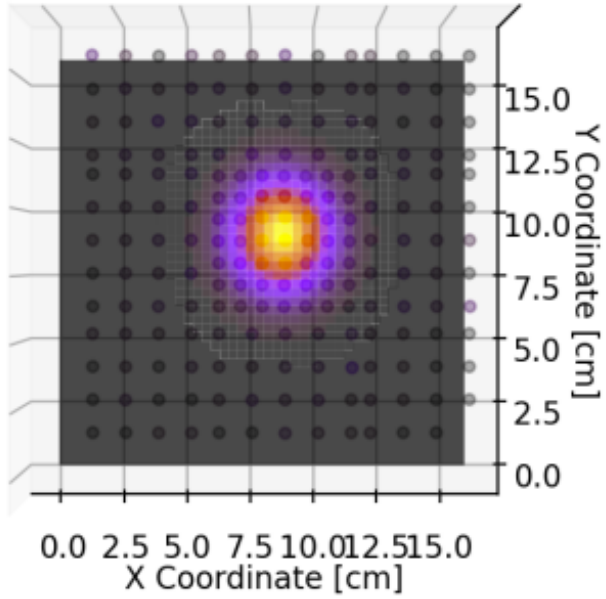
2D: Fit Gaussian to each event...



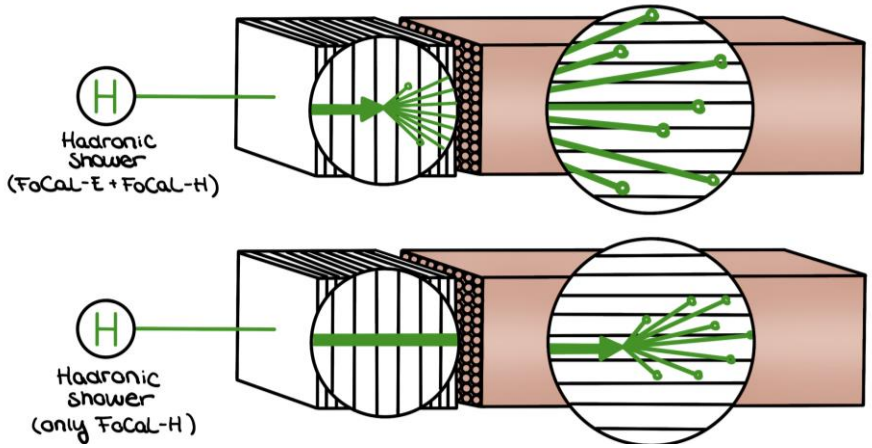


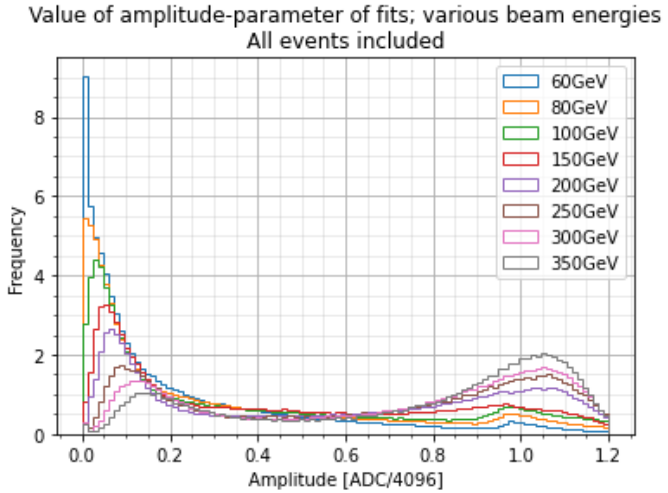




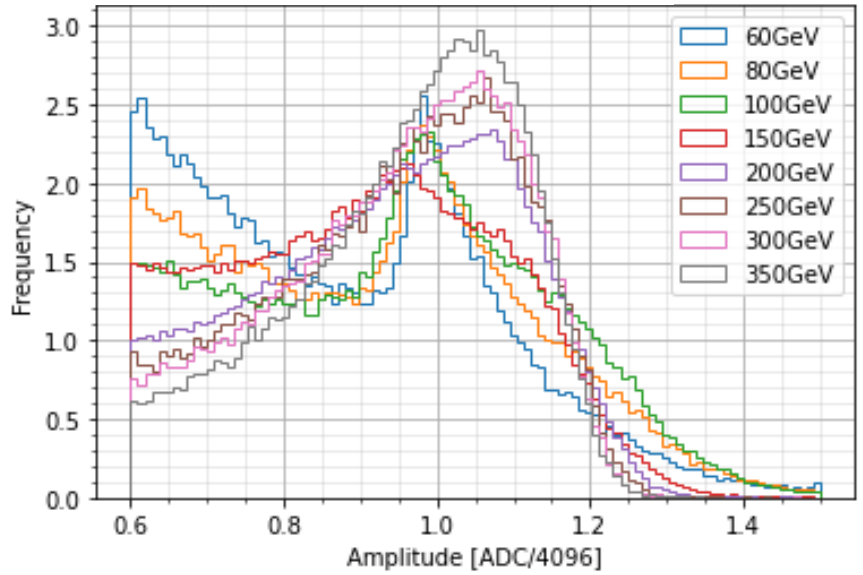


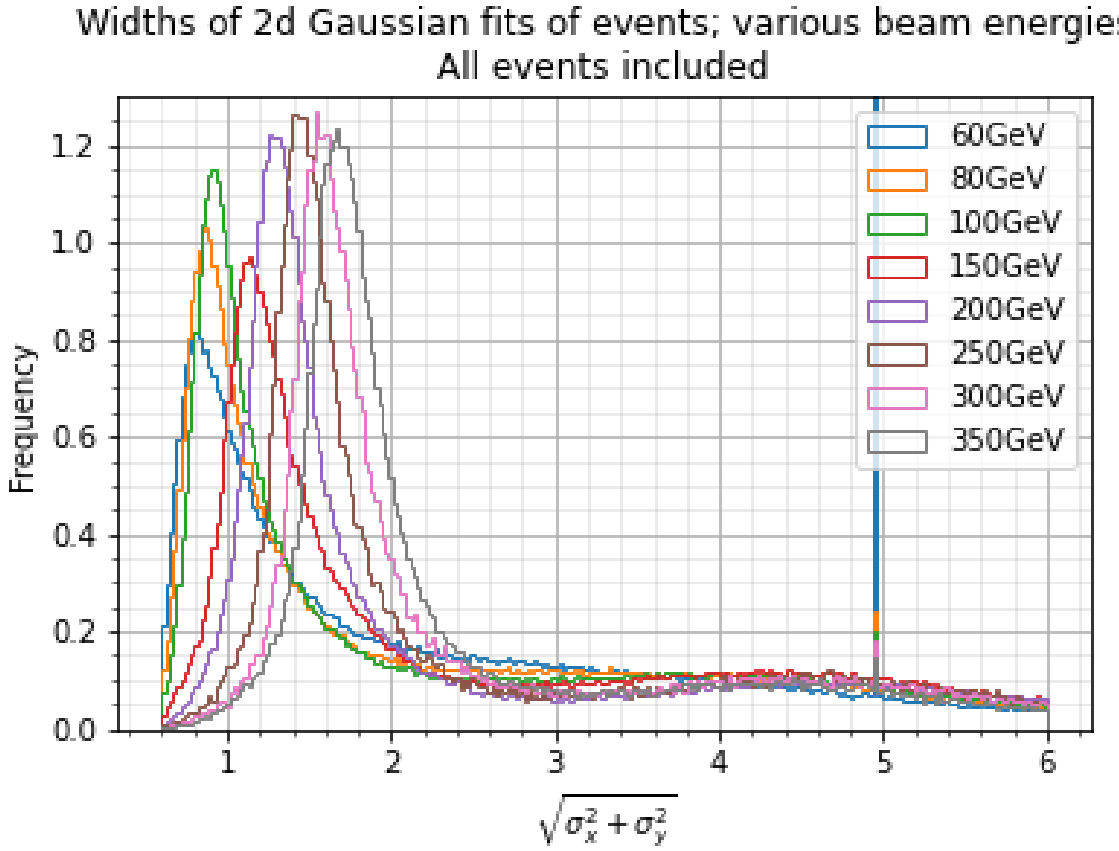
2D: Fit Gaussian to each event (IPM)



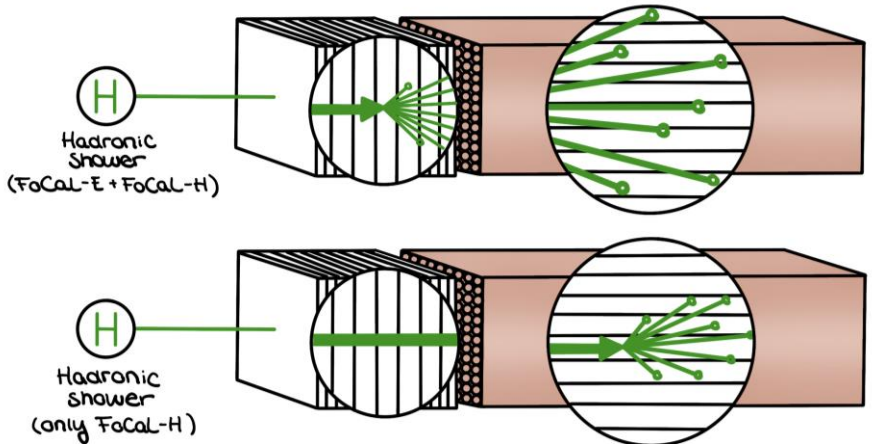


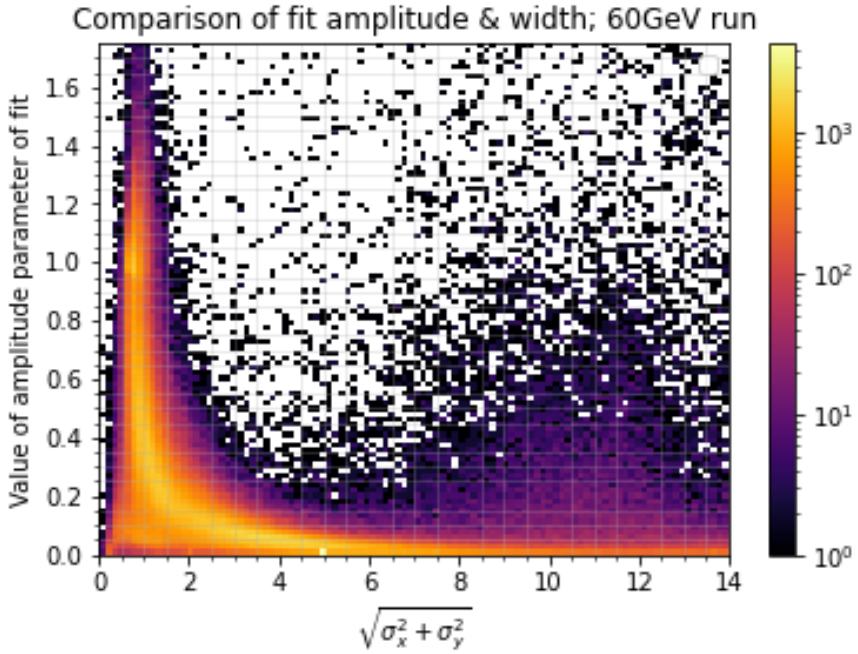
beam energies

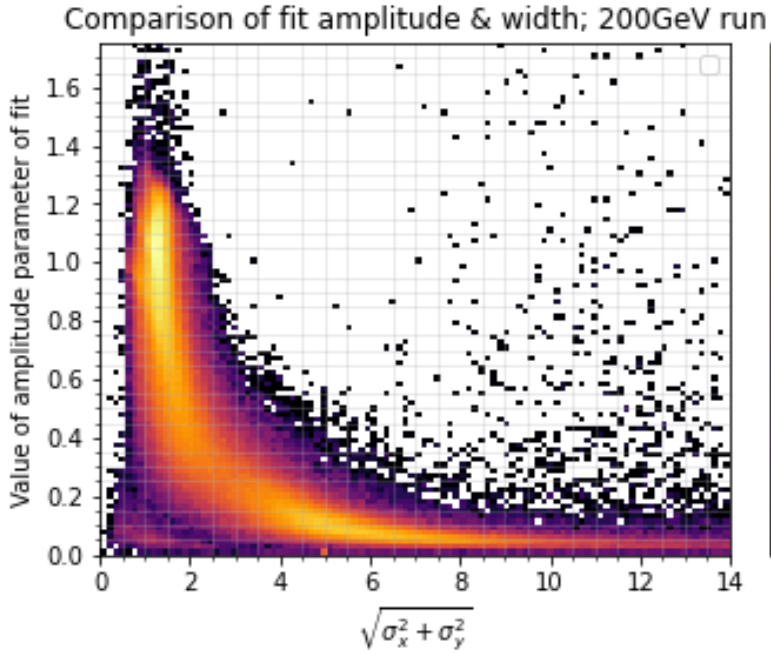


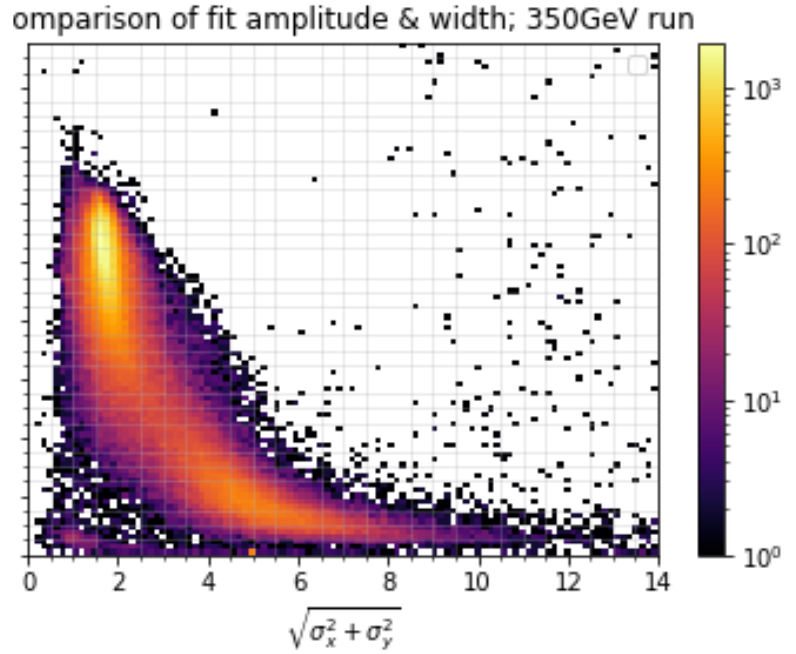


2D: Fit Gaussian to each event...





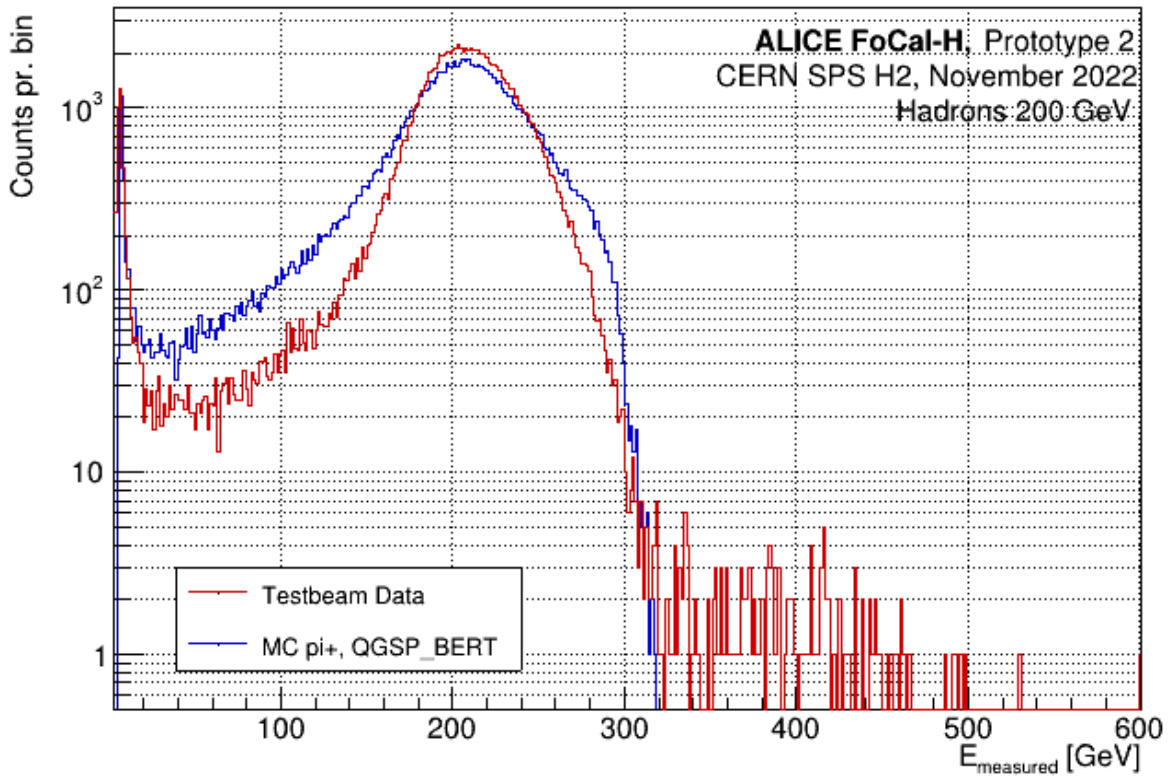


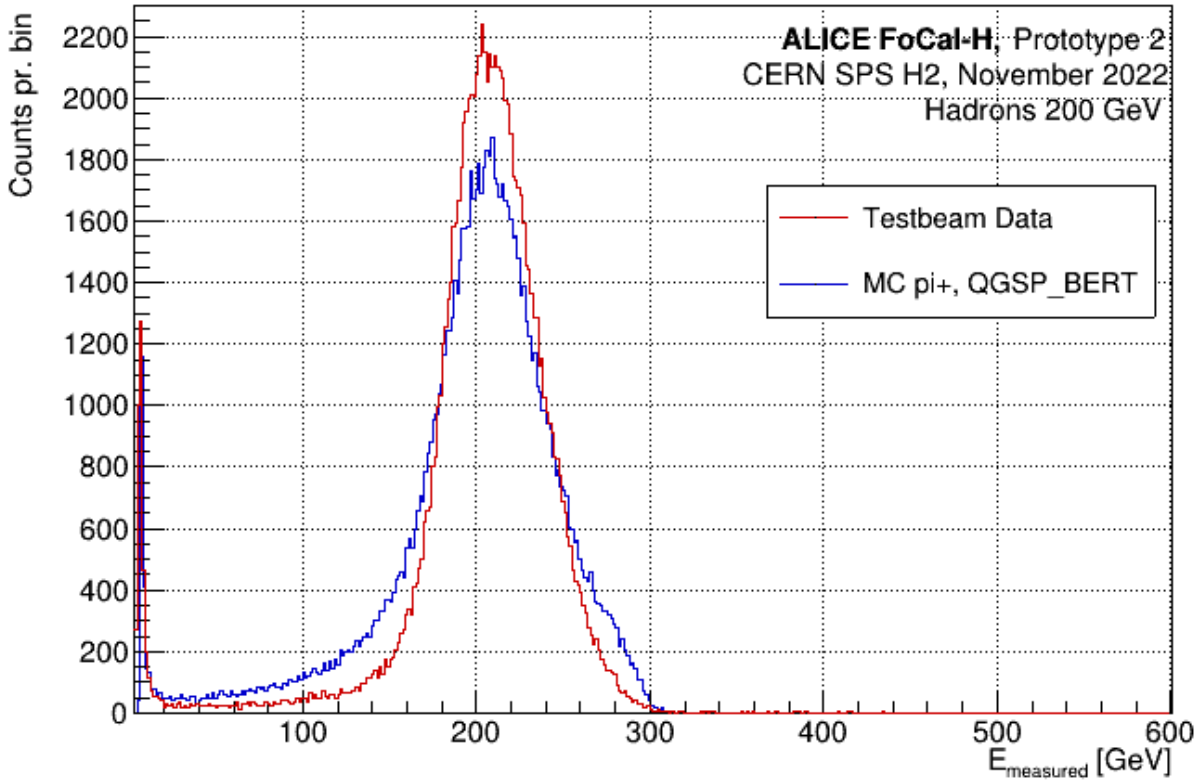


Summary

- Saturation is clearly a problem!
- Points to the urgency of H2GCROC
- Still, we have a working detector…and we are working on a better understanding of its performance.
- Spatial resolution good, perhaps can be improved with better fitting?
- Critical: look at FoCal-H performance for events with ToT in Pads 0.
- Critical: construct E from FoCal-E+FoCal-H.

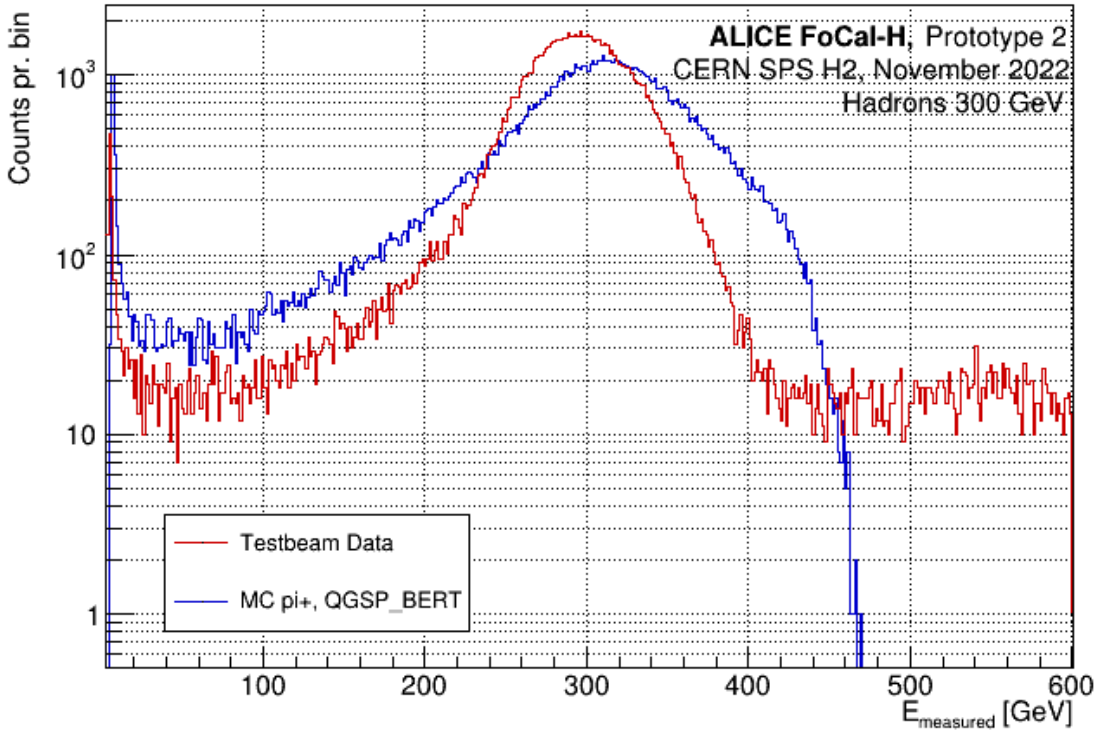
200 GeV

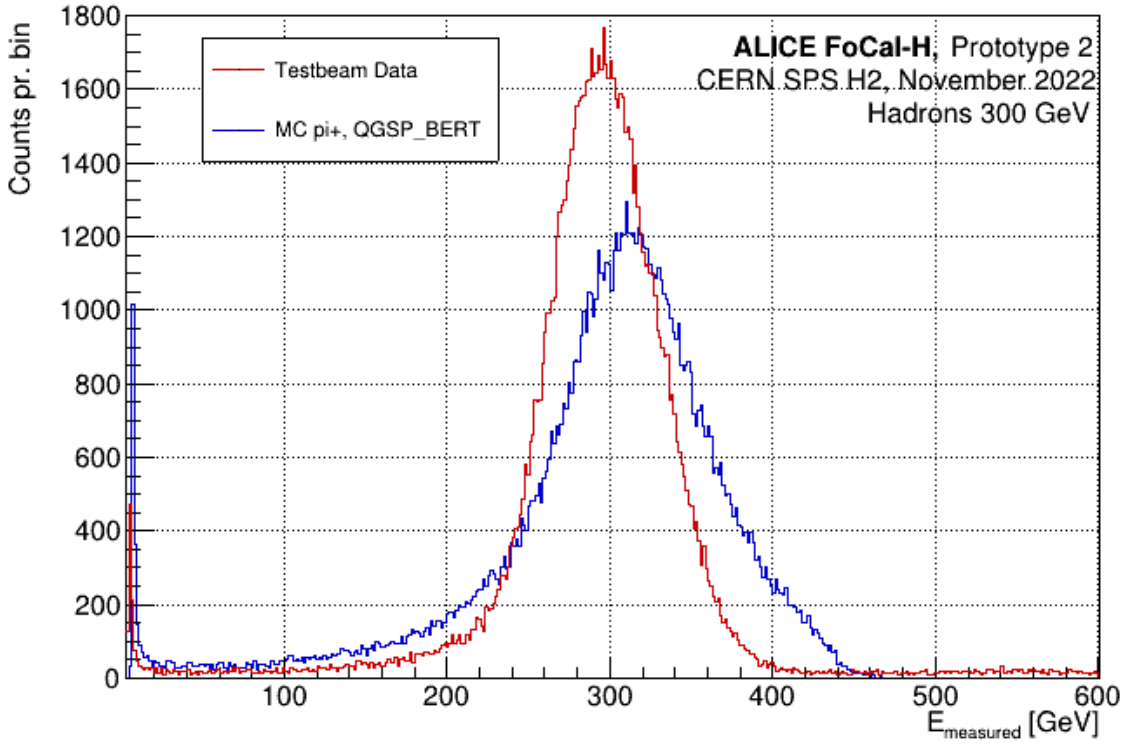

ALICE FoCal-H, Prototype 2
CERN SPS H2, November 2022
Hadrons 200 GeV
Testbeam Data
MC pi+, QGSP_BERT
Counts pr. bin
10^3
10^2
10
1
100
200
300
400
500
600
$E_{measured}$ [GeV]

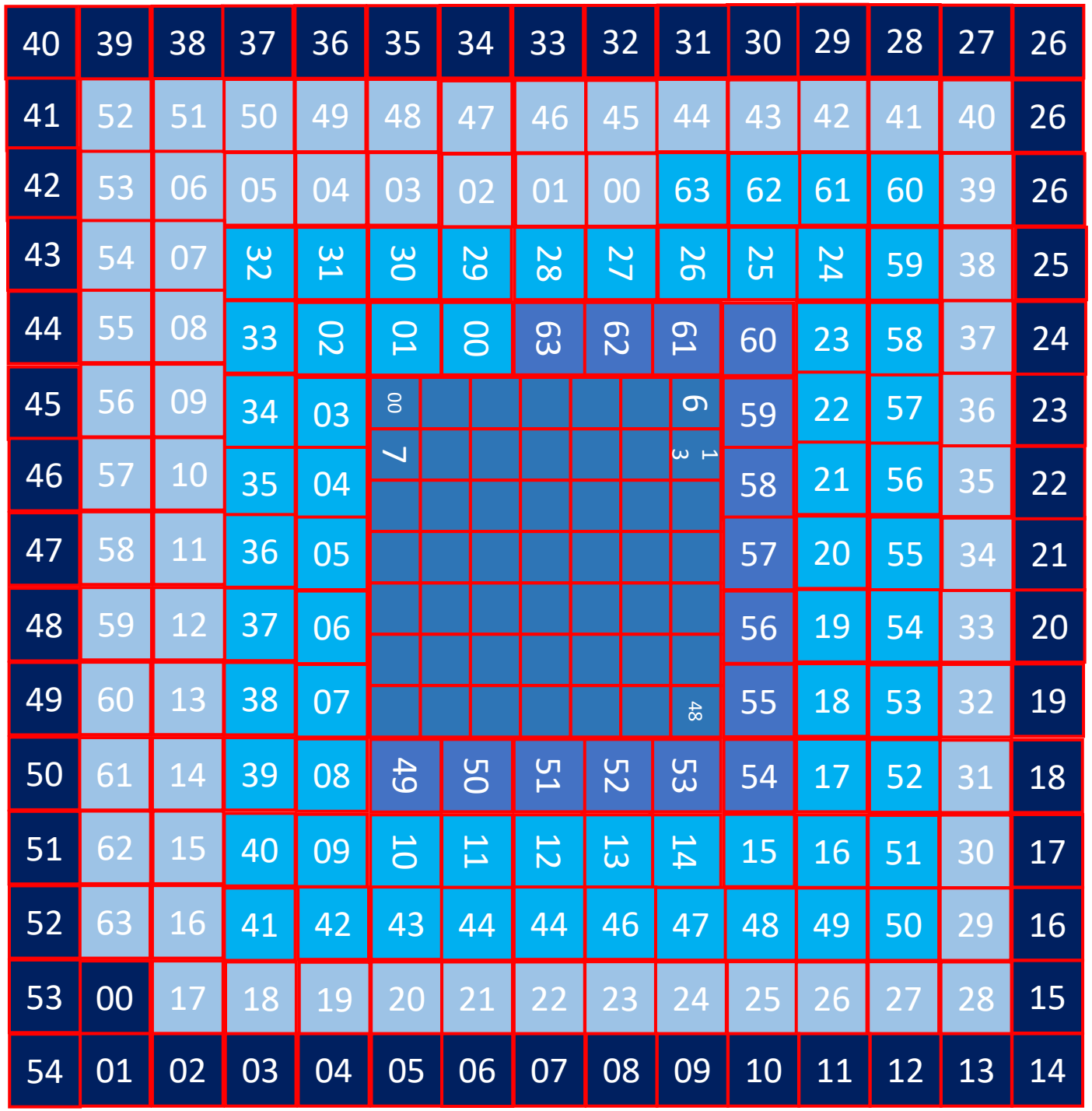

ALICE FoCal-H, Prototype 2
CERN SPS H2, November 2022
Hadrons 200 GeV
Testbeam Data
MC pi+, QGSP_BERT
Counts pr. bin
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
100
200
300
400
500
600
$E_{measured}$ [GeV]

300 GeV

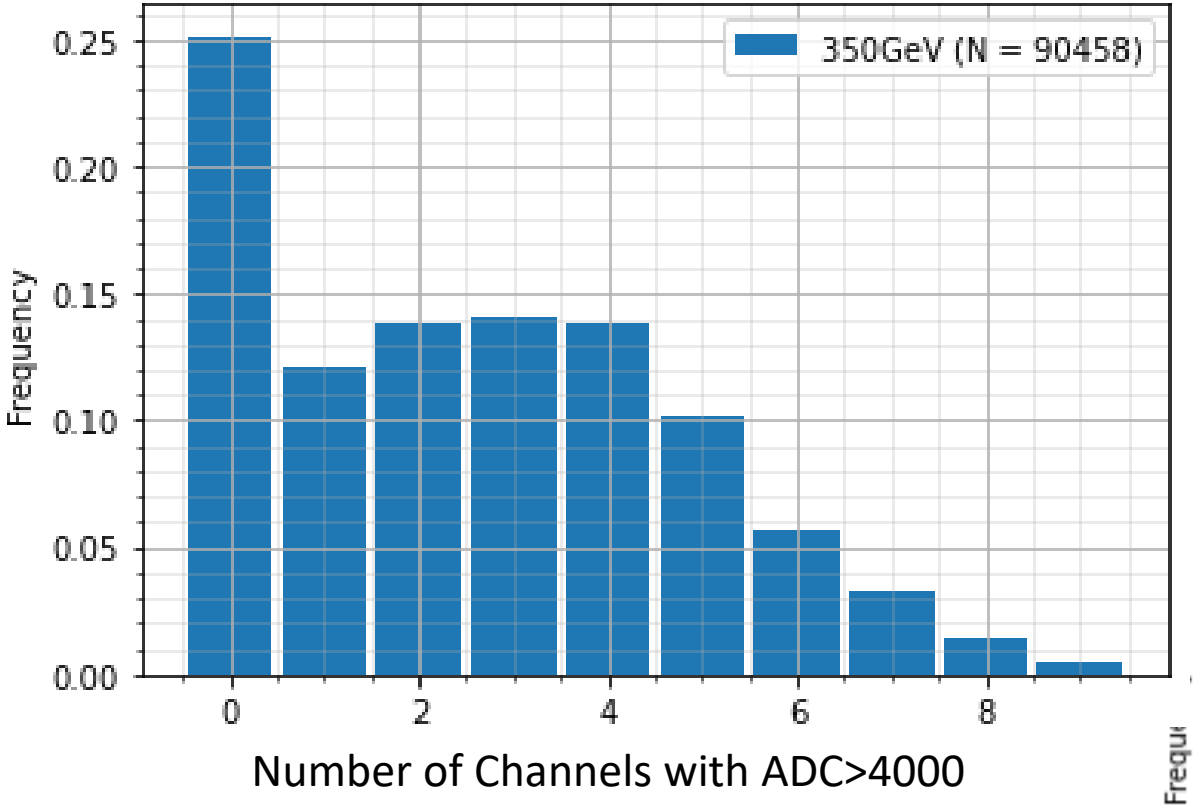
This plots is with the saturation study.

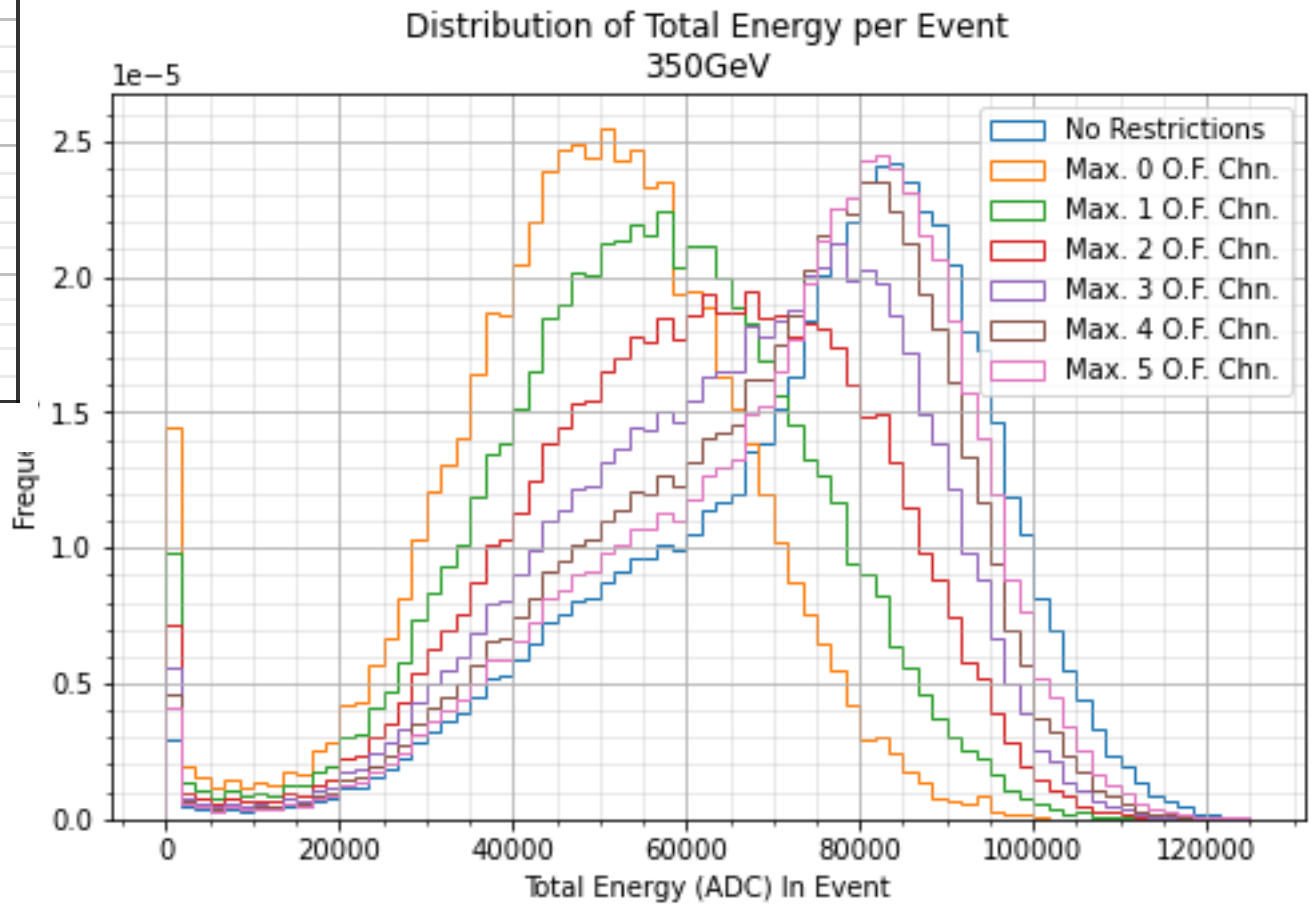





40 39 38 37 36 35 34 33 32 31 30 29 28 27 26
41 52 51 50 49 48 47 46 45 44 43 42 41 40 26
42 53 06 05 04 03 02 01 00 63 62 61 60 39 26
43 54 07 32 31 30 29 28 27 26 25 24 59 38 25
44 55 08 33 02 01 00 63 62 61 60 23 58 37 24
45 56 09 34 03 59 22 57 36 23
46 57 10 35 04 58 21 56 35 22
47 58 11 36 05 57 20 55 34 21
48 59 12 37 06 56 19 54 33 20
49 60 13 38 07 55 18 53 32 19
50 61 14 39 08 49 50 51 52 53 54 17 52 31 18
51 62 15 40 09 10 11 12 13 14 15 16 51 30 17
52 63 16 41 42 43 44 44 46 47 48 49 50 29 16
53 00 17 18 19 20 21 22 23 24 25 26 27 28 15
54 01 02 03 04 05 06 07 08 09 10 11 12 13 14

Evidence for saturation of ADC:





NB: these runs were with FoCal-E in front.
Presumably, the number of saturated channels is larger w/p FoCal-E

How does saturation affect signal?

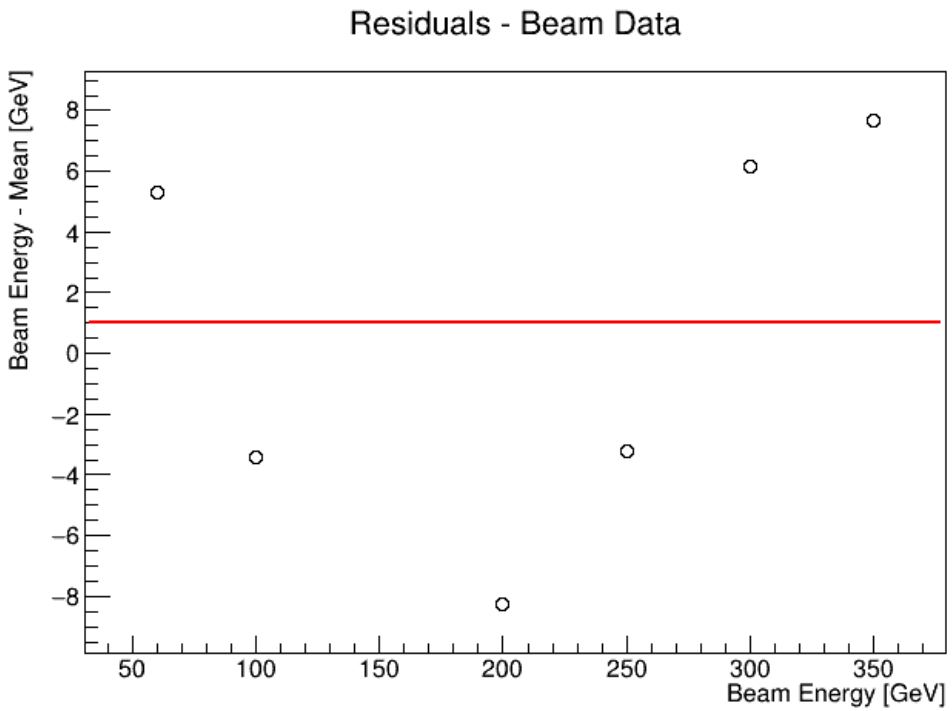
- Compare “high side” tails at various energies.
- Is our energy calibration linear? (See LMD plot of calibration re s. Question: what are uncertainties?)
- Compare fitting showers to simple ADC sum.
  - Hypothesis: fitted energy should be more linear than ADC sum if saturation is a large negative effect.
  - Hypothesis: resolution from fitted showers may be more accurate estimate than simple ADC sum IF saturation is important.
  - Assertion: saturation is in the CAEN ADC, not in the SiPM; action: check this empirically!

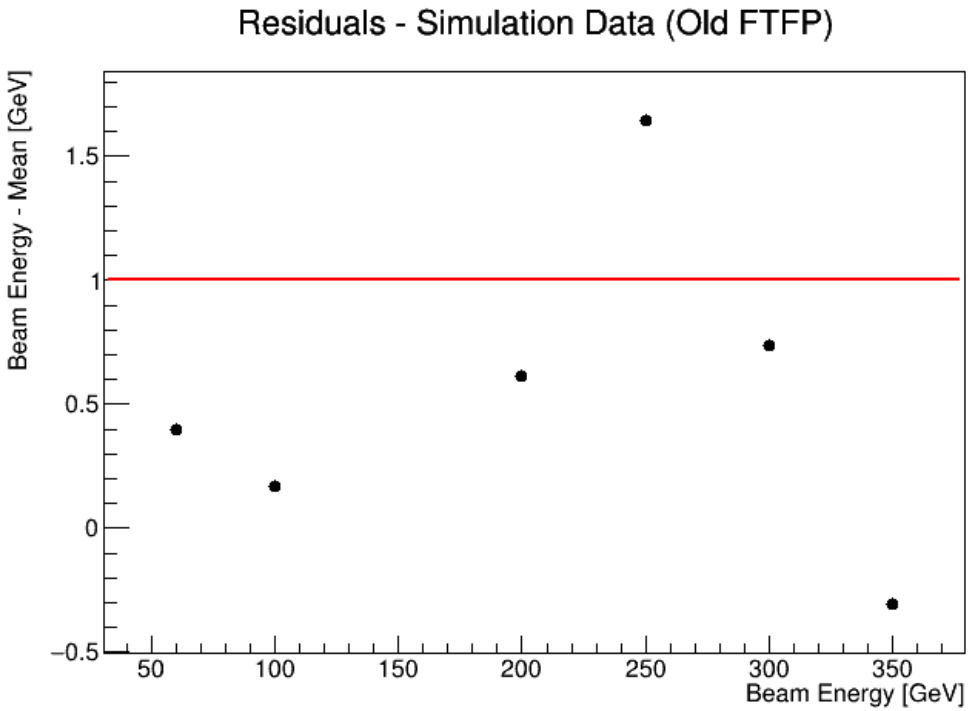
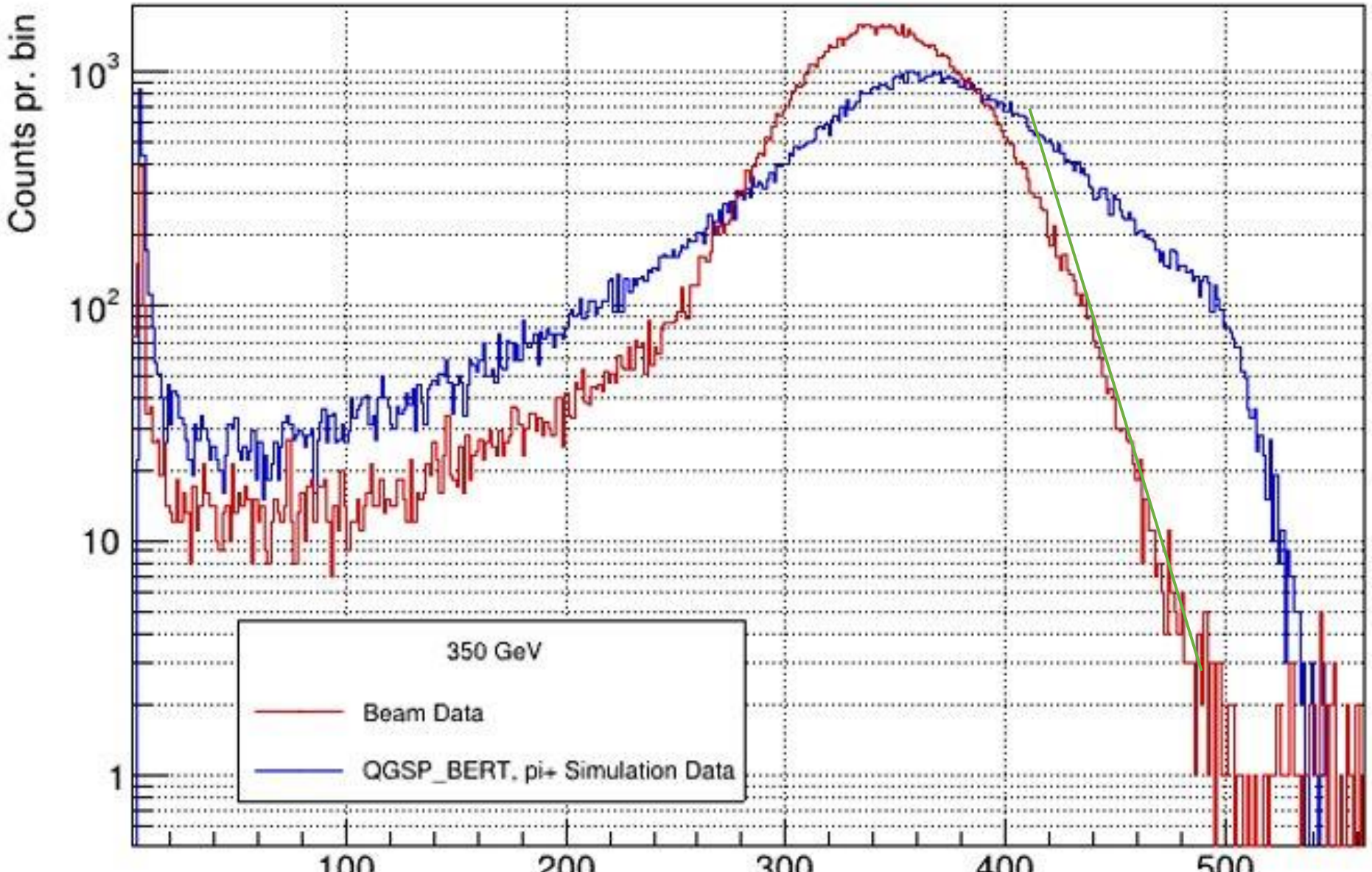
1

2

3

4


Residuals - Beam Data
Beam Energy - Mean [GeV]
8
6
4
2
0
−2
−4
−6
−8
50
100
150
200
250
300
350
Beam Energy [GeV]


Residuals - Simulation Data (Old FTFP)
Beam Energy - Mean [GeV]
1.5
1
0.5
0
−0.5
50
100
150
200
250
300
350
Beam Energy [GeV]

Let's look at high-side tails 350GeV: