FLAME
MC AGREEMENT DEBUGGING

24.11.2021

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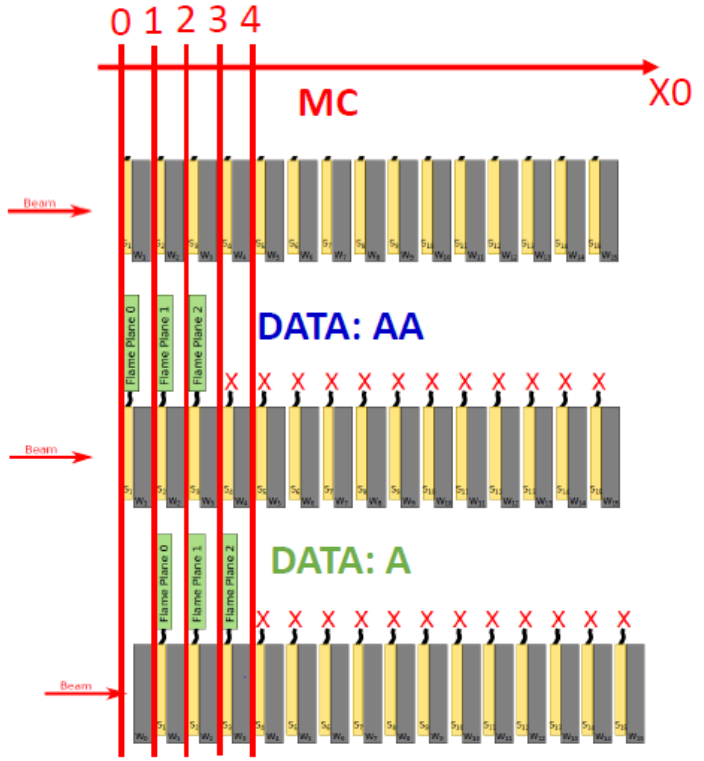
DATA:

- The 15-X0 data coverage is made merging different sets of runs (one run covers 3 X0)
- Noisy pixels are masked at FPGA level
- Signal threshold set at FPGA level
- Cluster = integrated signal from pads above threshold over whole frame
- Noise cuts:

0X0: 10 ADU	**1X0:** 6.4 ADU	**4X0 :** 6.5 ADU	**7X0 :** 9.5 ADU	**10X0 :** 10.5 ADU	**X13:** 9.5
	2X0 : 6.3 ADU	**5X0 :** 6.5 ADU	**8X0 :** 9.5 ADU	**11X0:** 10.5 ADU	**X14:** 6.5
	3X0 : 7.6 ADU	**6X0:** 9.5 ADU	**9X0 :** 8.5 ADU	**12X0:** 8.5 ADU	**X15:** 6.5



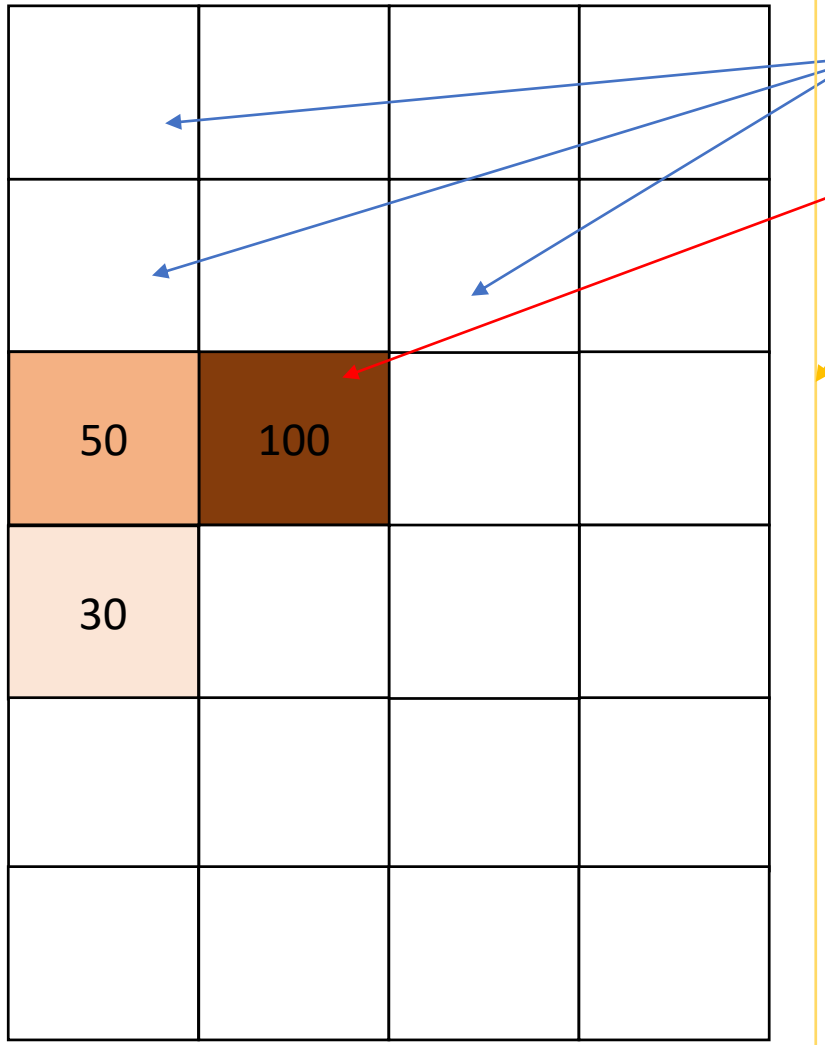
MONTE CARLO:

- The version send from Alina in November 2021
  - + request for 1GeV and 3GeV → also got from this month
- **MC postprocessing:**
  - GAIN : MC_signal = : MC_signal * FE_gain (=140)
  - NOISE : MC_signal = : MC_signal +gRandom→Gaus(0, FE_sigma_noise (=1))
  - DISCRIMINATOR THRESHOLD: if(MC_signal < FE_threshold (= 10)) MC_signal = 0
  - DIGITIZATION: not done

Normalization:

- To the number of events
  - MC : 10k /100k (5GeV only)
  - DATA : depending on run the different normalization constant is used – six different constants in general (plane 0, plane 1-3, plane 4-6, plane 7-9, plane 10-12, plane 13-15)

NAMING



PAD (=channel)

SEED – pad with the highest energy (=100)

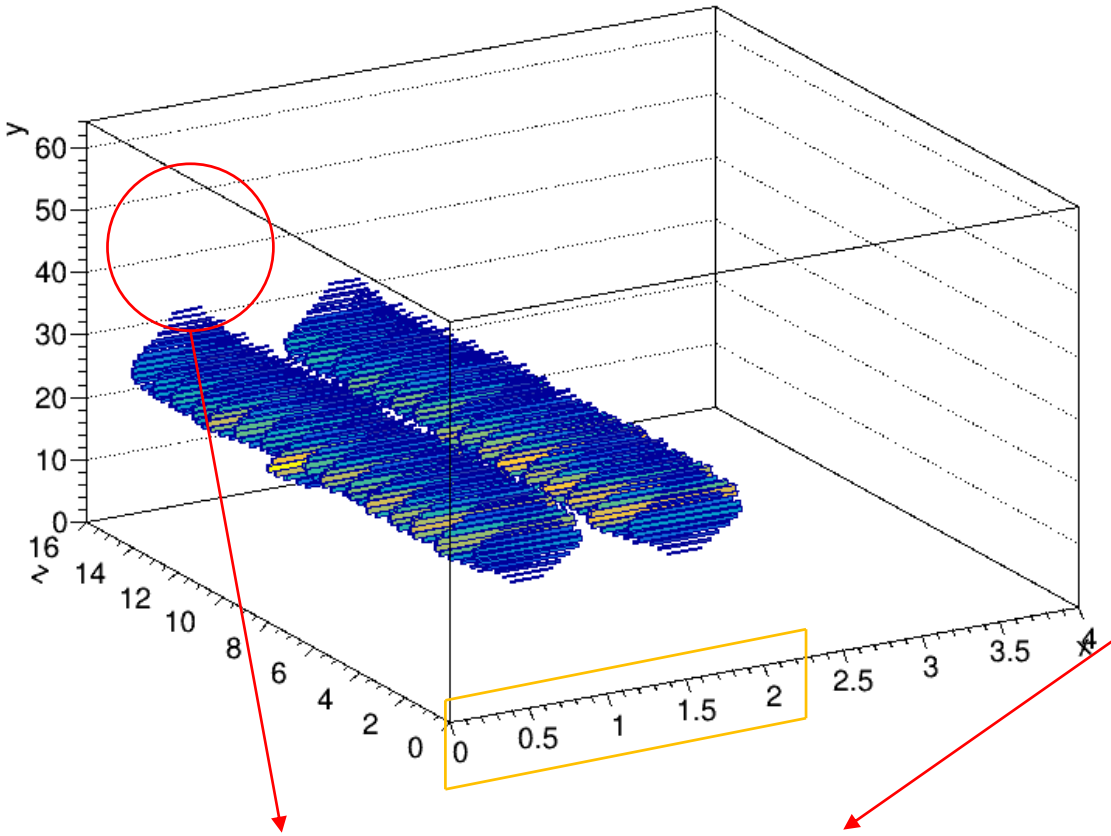
CLUSTER – all pads with signal for particular frame

CLUSTER SIZE = number of pads with signal in frame (=3)

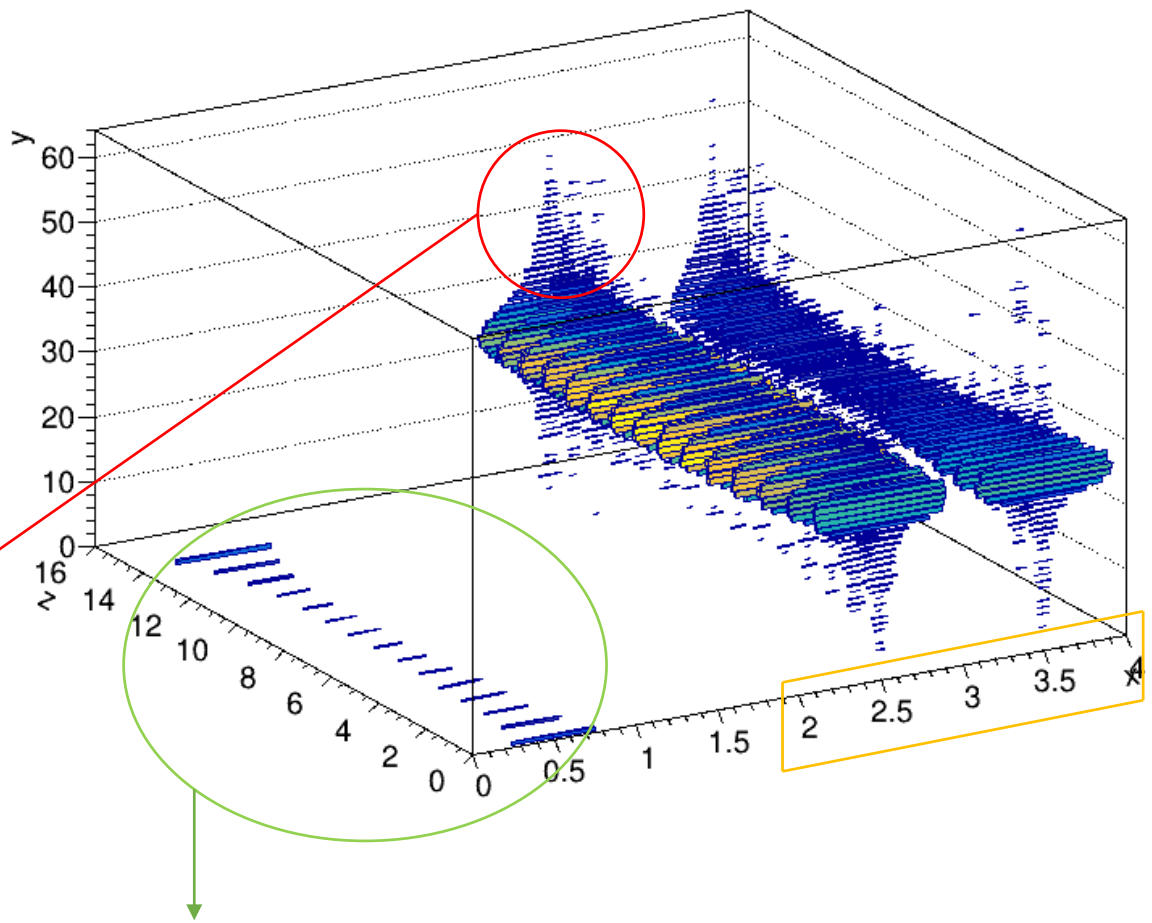
CLUSTER ENERGY = integrated energy over the frame (=180)

MC vs DATA – HIT MAP 3D

DATA



MC

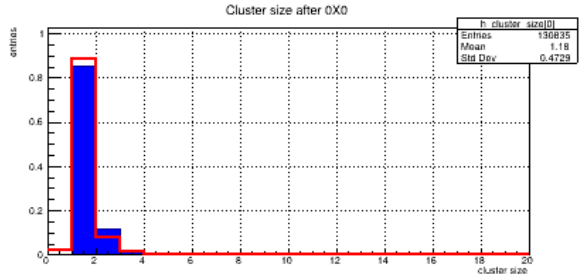


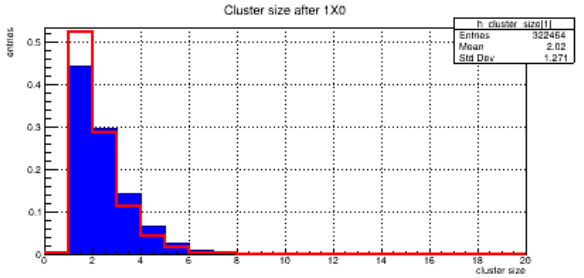
Monte Carlo sees much wider distribution in vertical direction than data

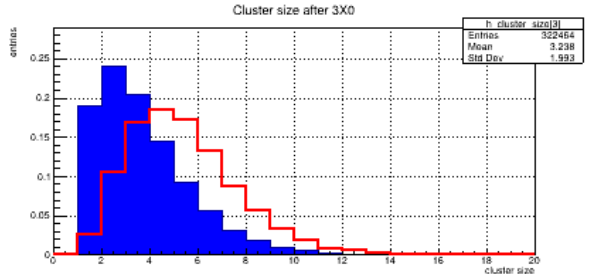
- FLAME has on-chip data processing (signal above threshold saved only)
- Low-signal noise cut in data analysis also – too high?

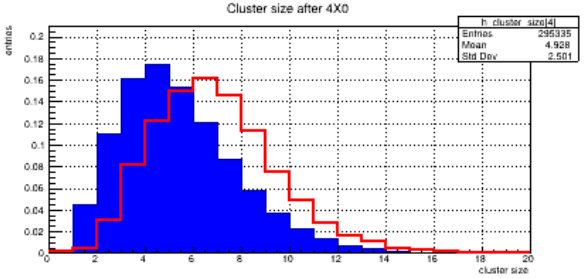
Some boundary entries in non-illuminated pads for MC → should be removed, but also should not influence strongly results

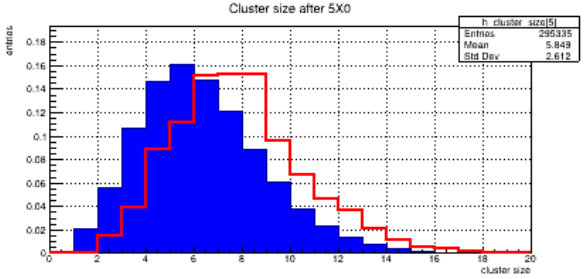
CLUSTER SIZE (number of pad with signal in frame) – per plane – DATA / MC

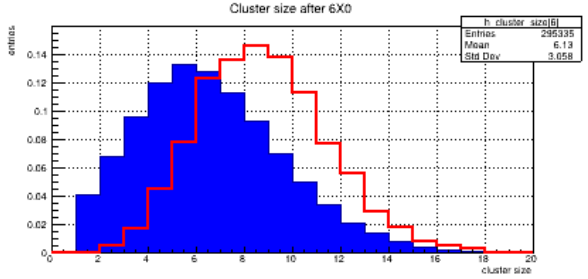


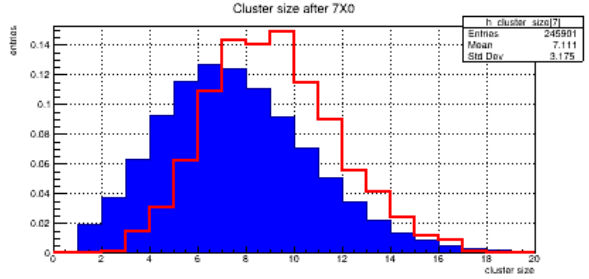


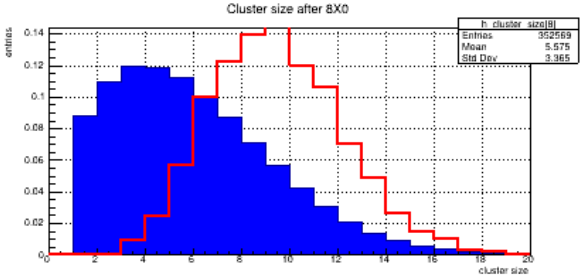


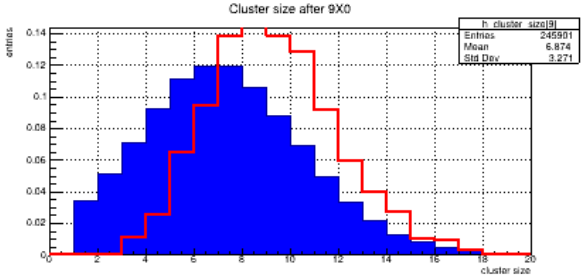


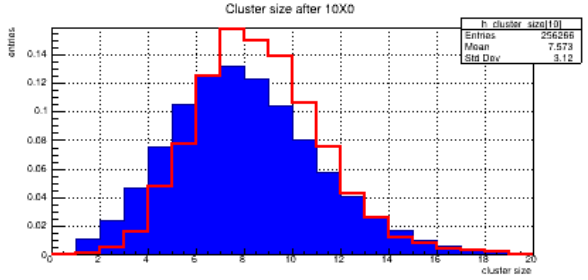


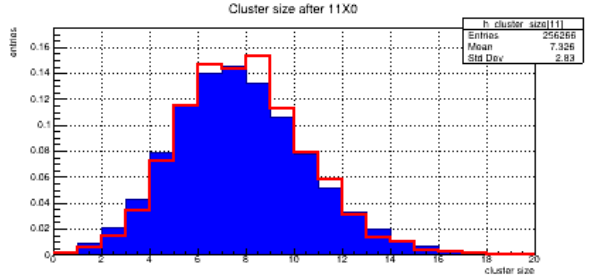


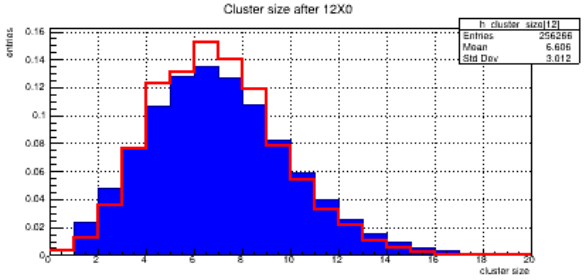


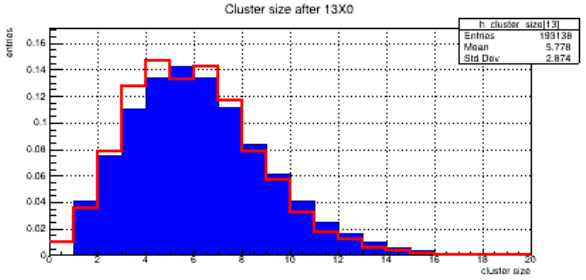


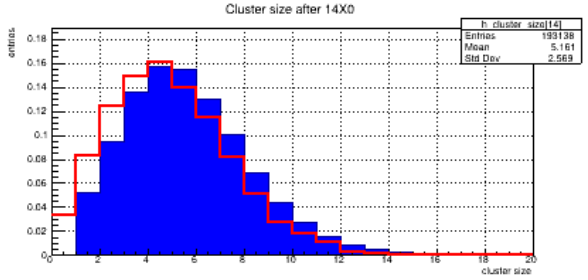


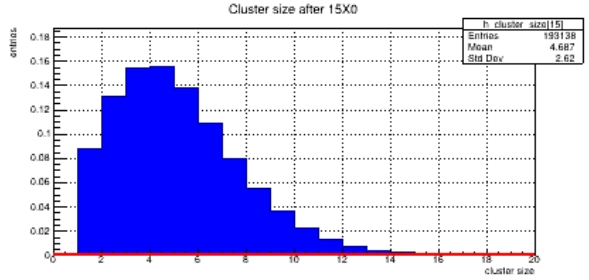




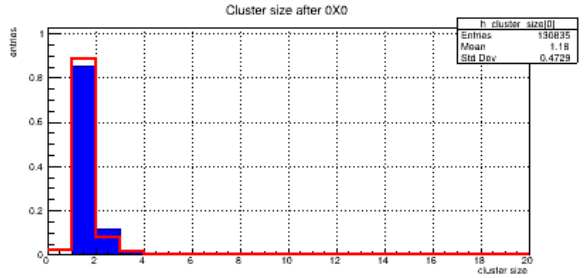


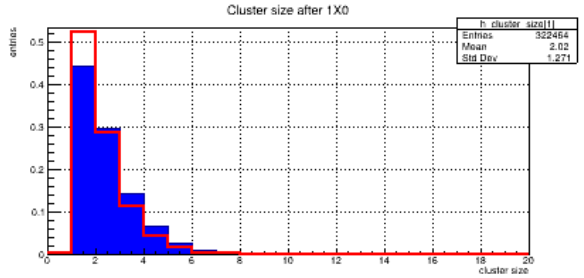


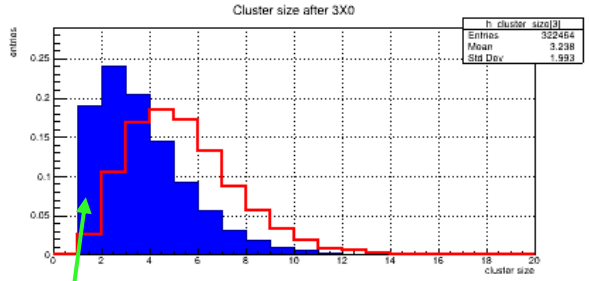


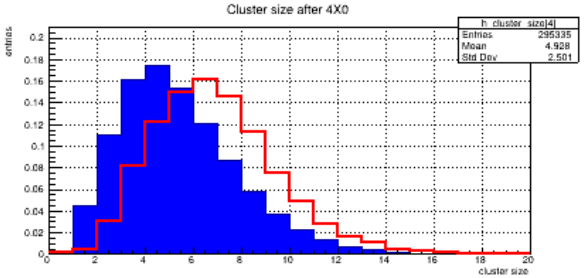


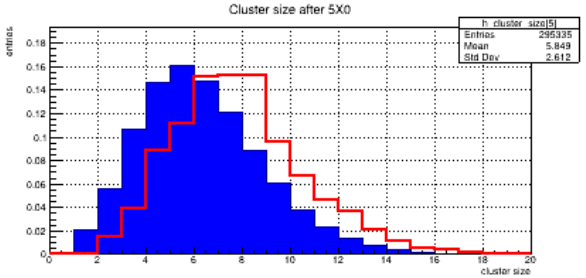
CLUSTER SIZE (number of pad with signal in frame) – per plane – DATA / MC

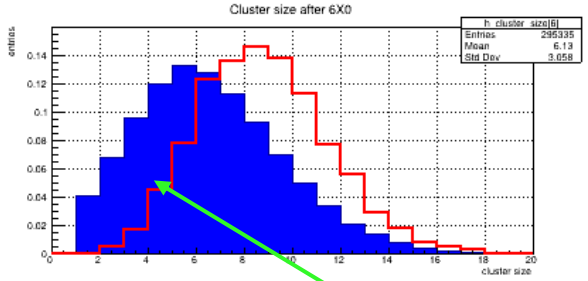


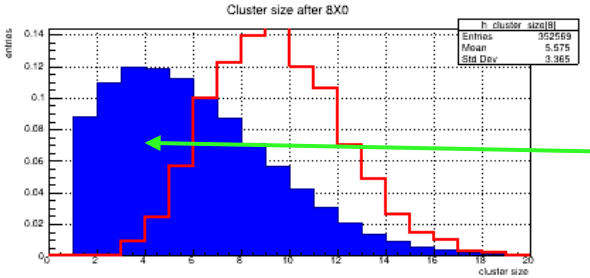


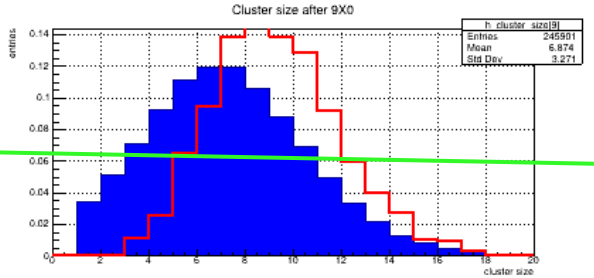


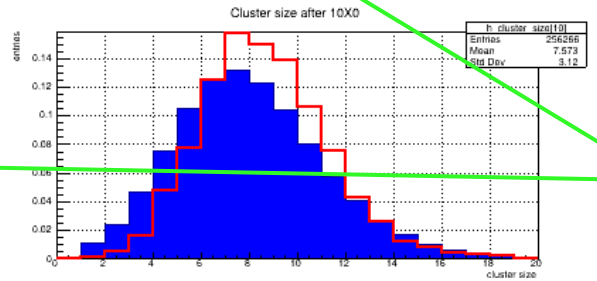


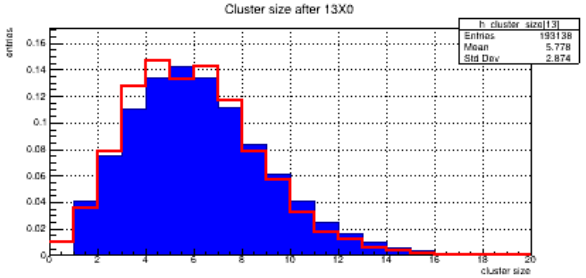


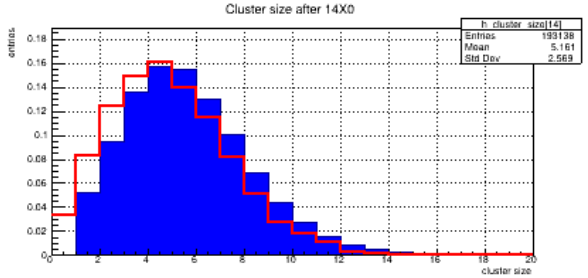










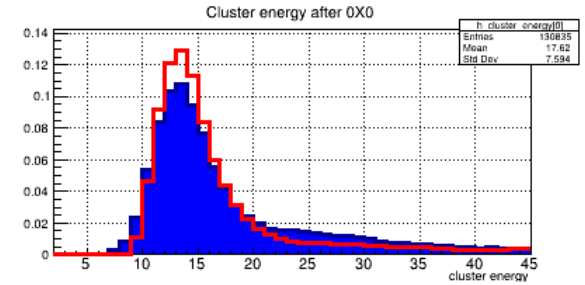


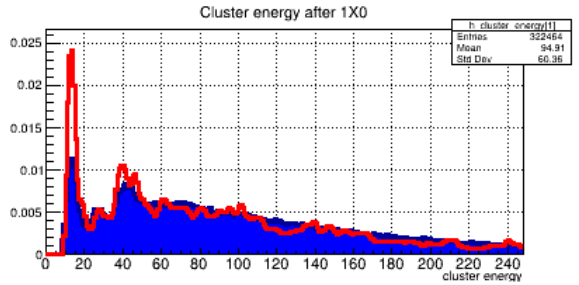
For DATA we see smaller average cluster size than MC

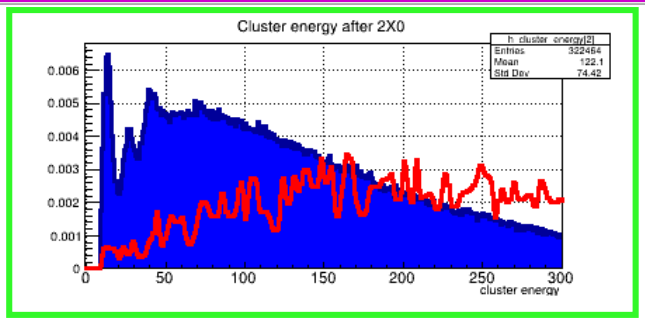
→ This might be caused by high noise cut

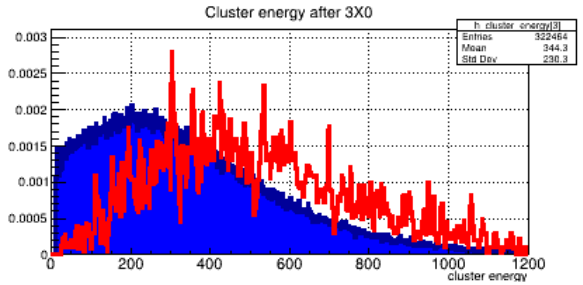
→ Should be investigated more

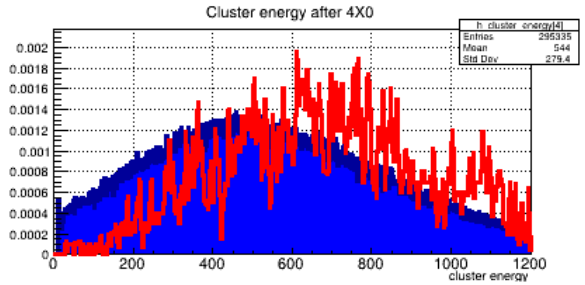
CLUSTER ENERGY (= total frame energy) per plane DATA / MC

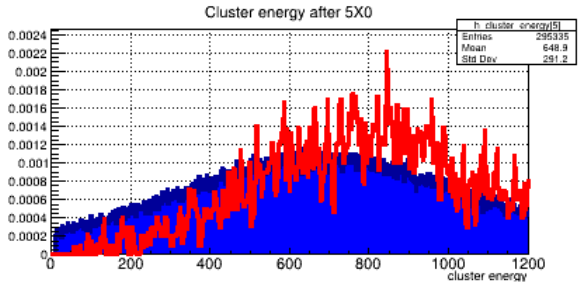


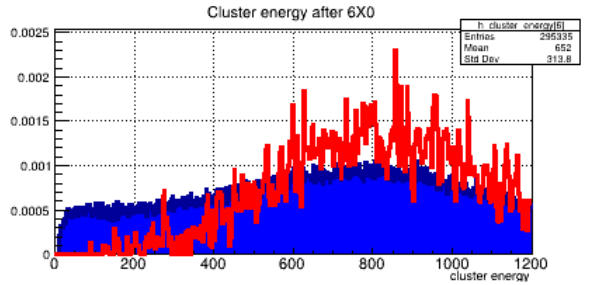


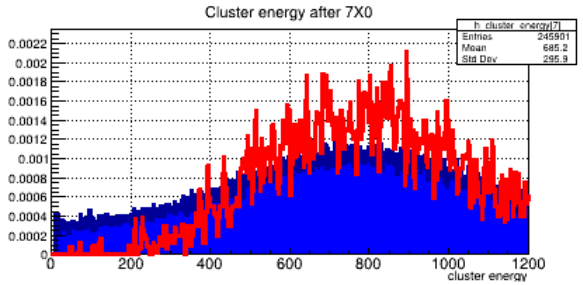


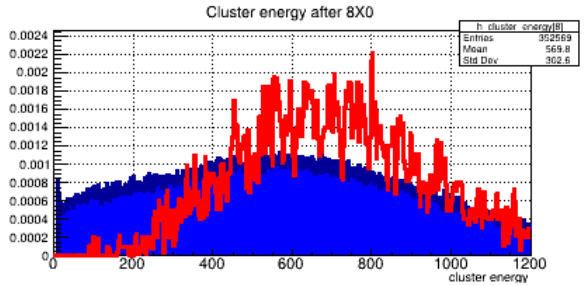


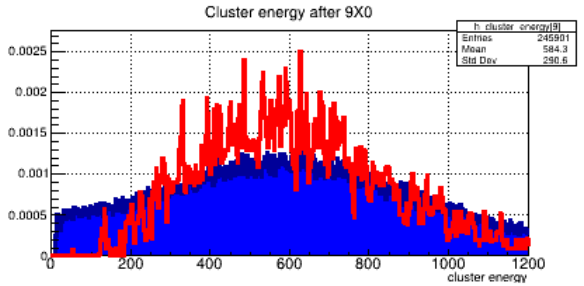


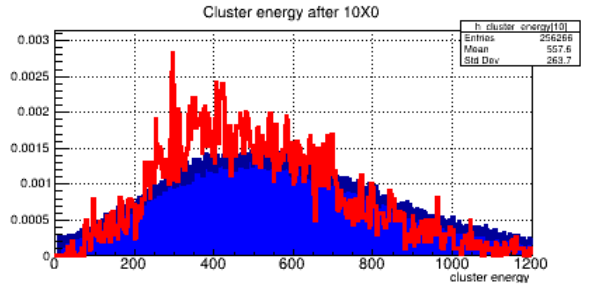


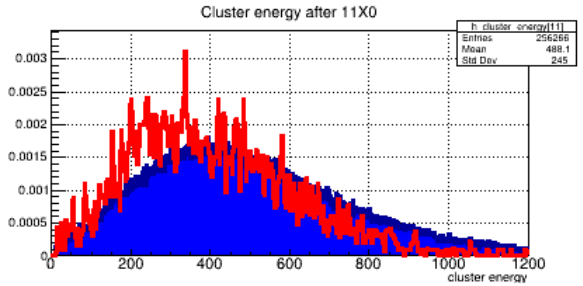


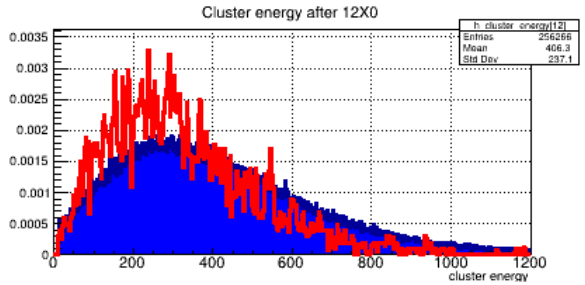


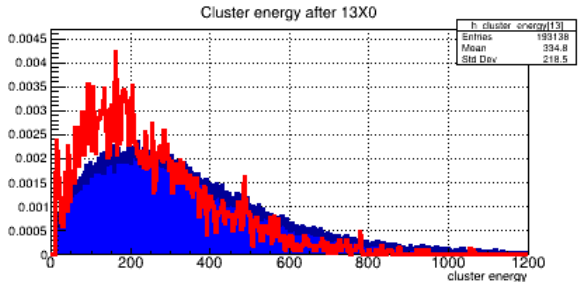


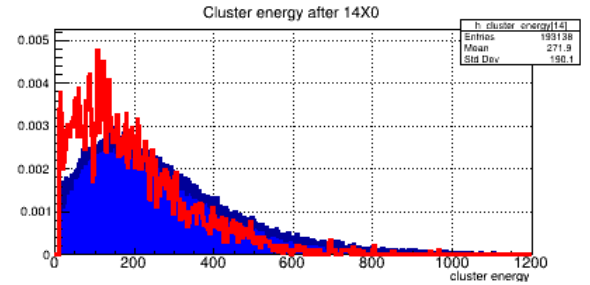


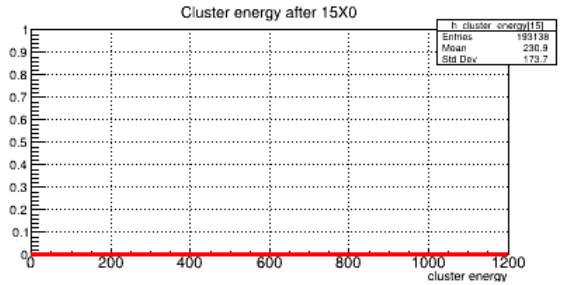






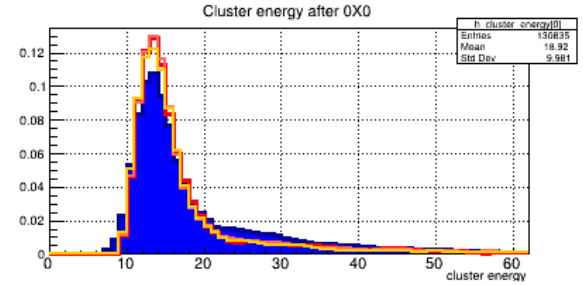


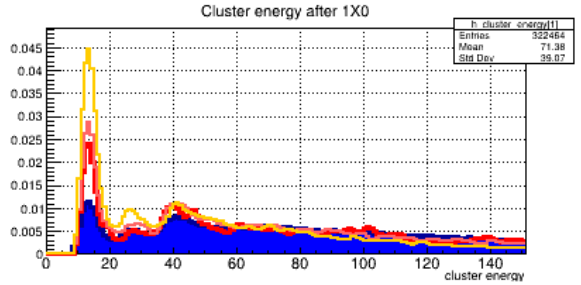


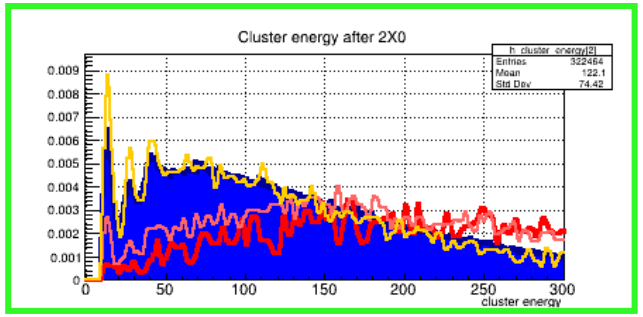


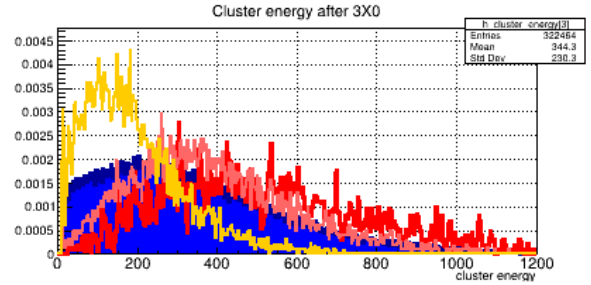
ISSUE: disagreement between DATA and MC starting from 2X0

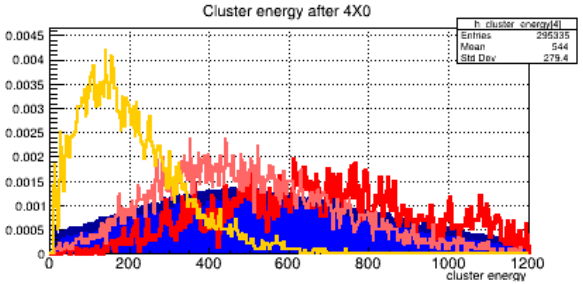
CLUSTER ENERGY (= total frame energy) per plane DATA 5GeV / MC 5 GeV / MC 3 GeV / MC 1 GeV

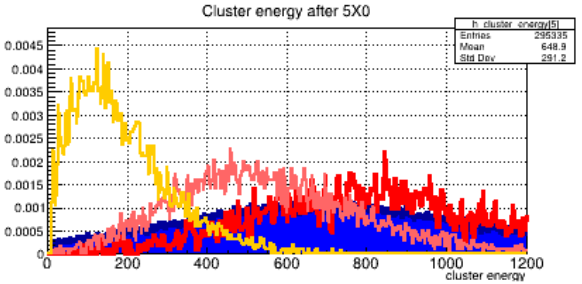


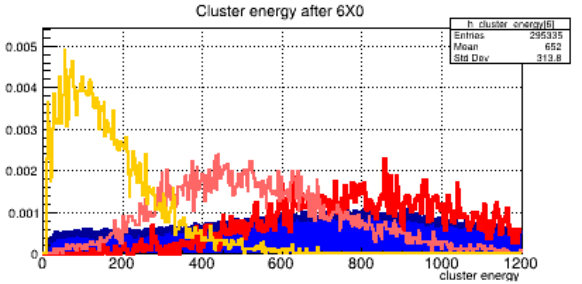


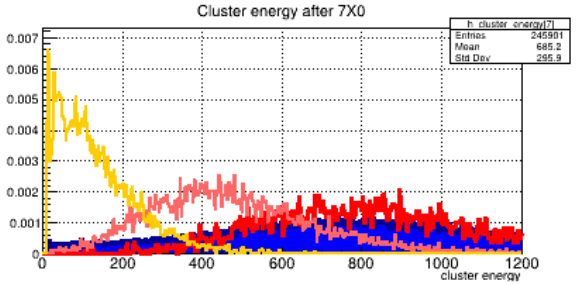


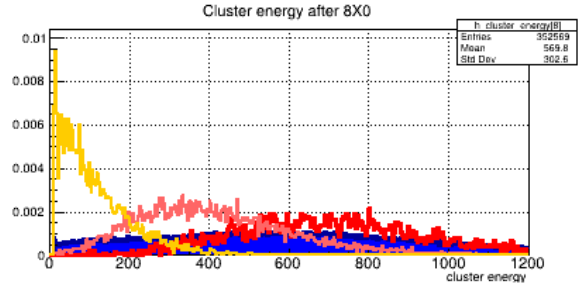


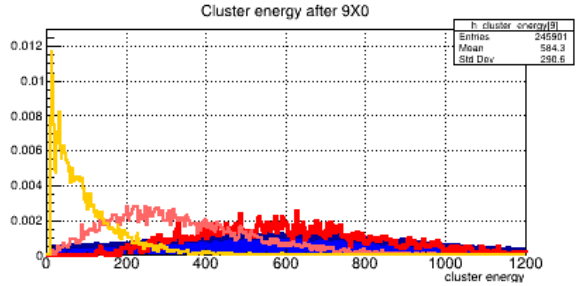


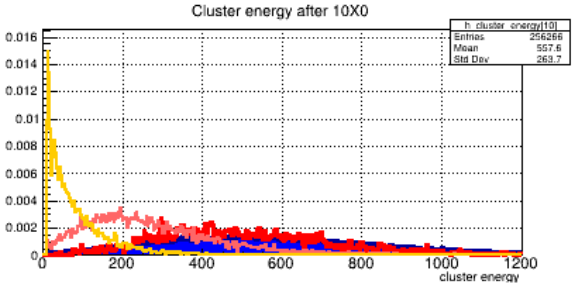


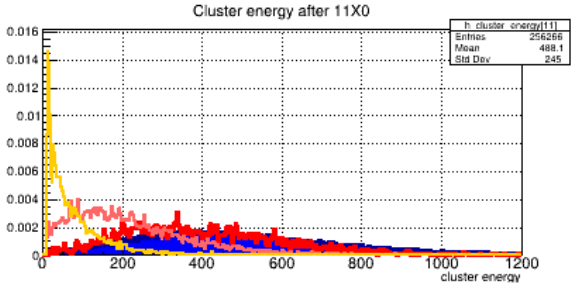


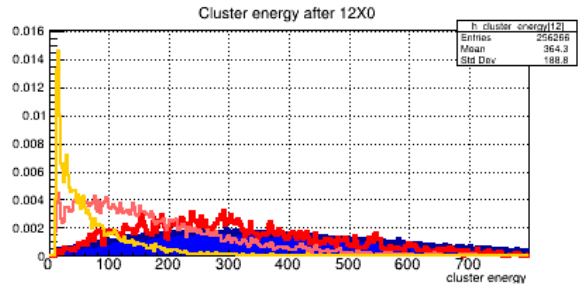


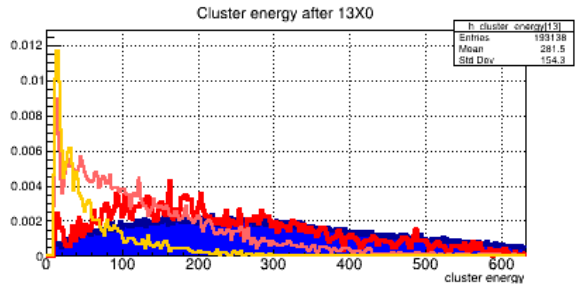


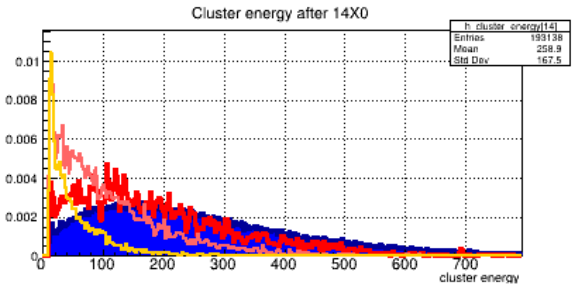


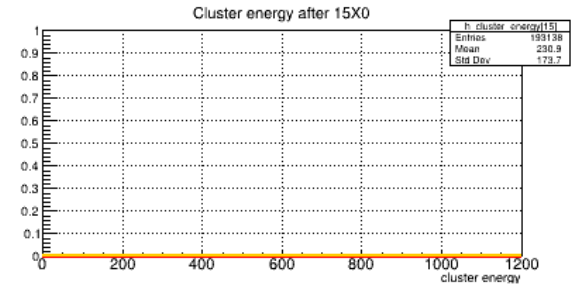




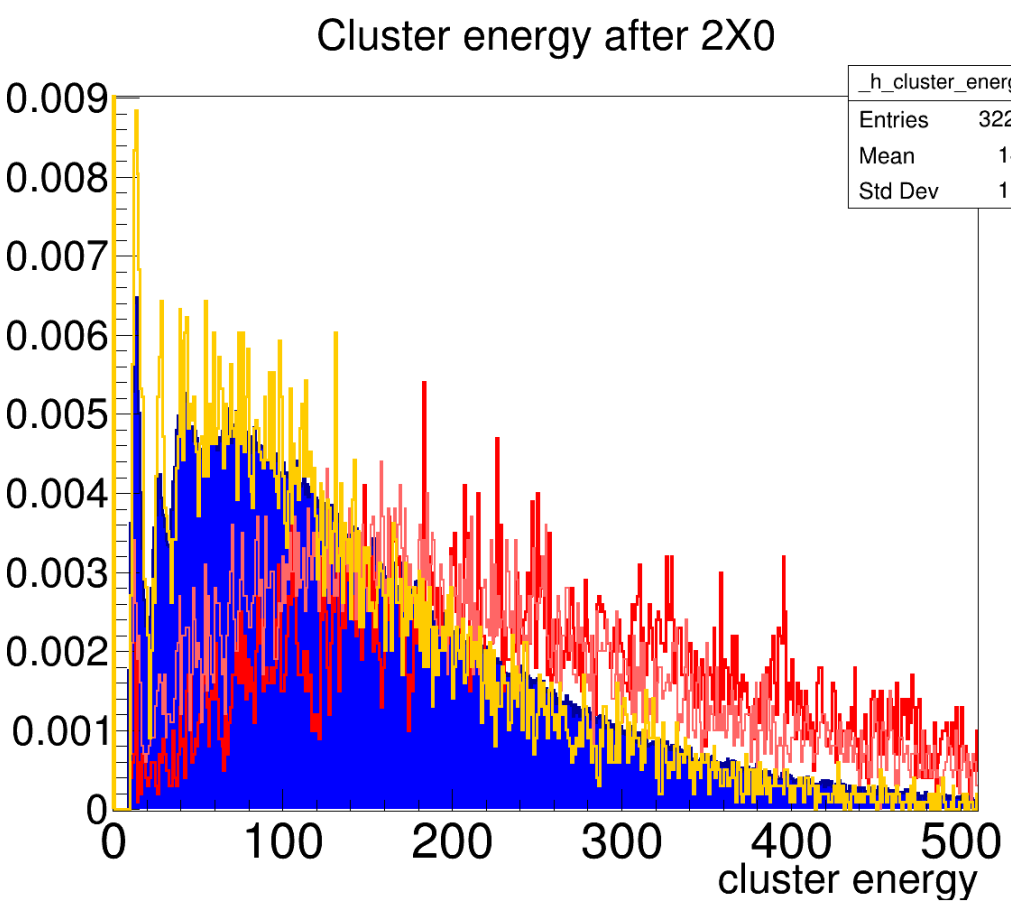




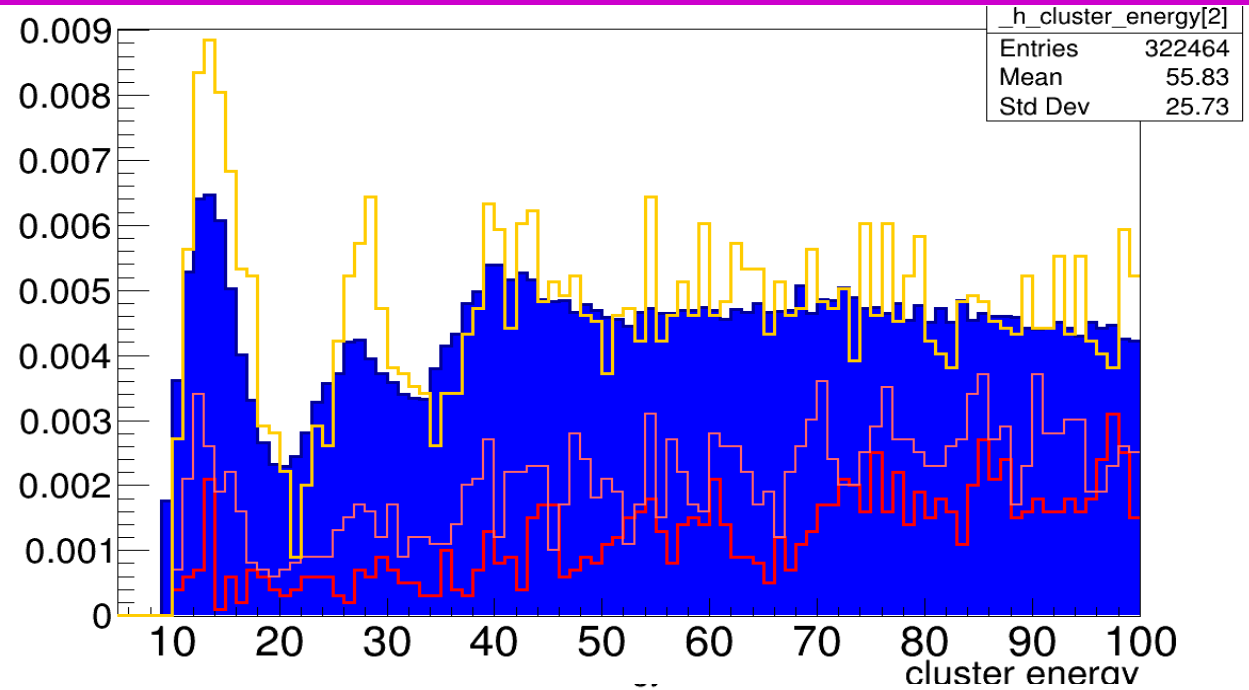




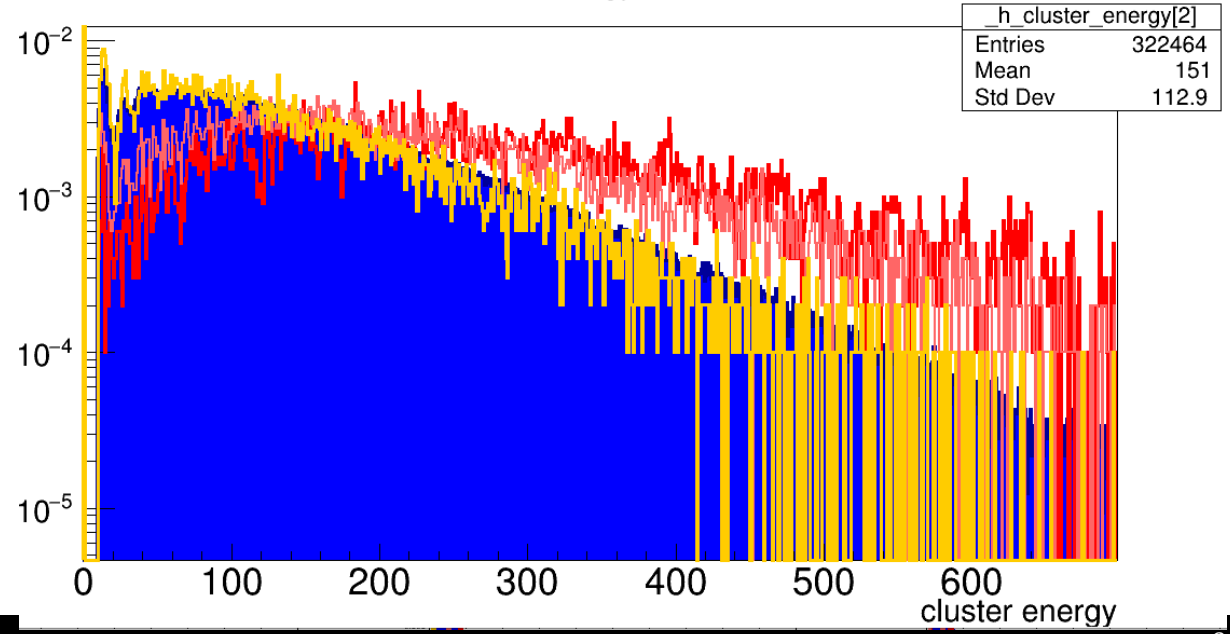
CLUSTER ENERGY – 2X0 zoom/log -- DATA 5GeV / MC 5 GeV / MC 3 GeV / MC 1 GeV



ZOOM

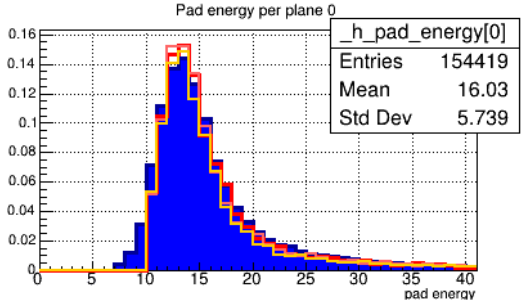


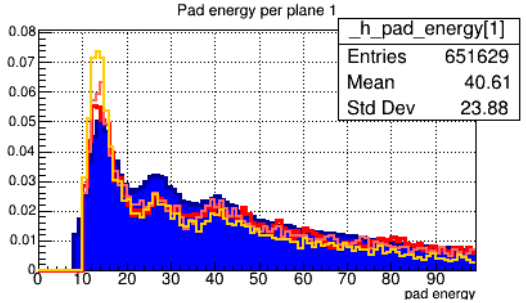
LOG

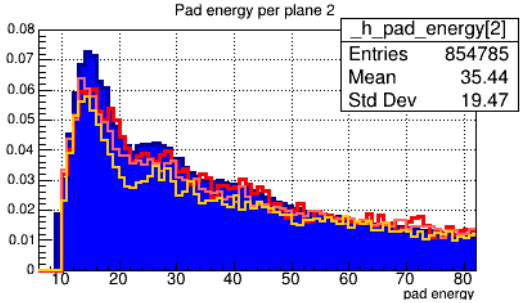


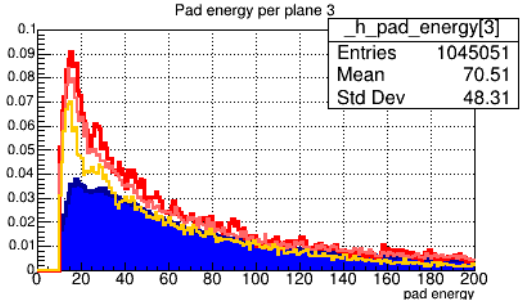
- In general: DATA still "sees" the MIP structure on 2X0, while MC for 5GeV doesn't have it
- 1 GeV MC matches well to the 5GeV DATA and shows the MIP structure
  - naive assumption: isn't the probability of interaction for lower energies higher ? = MIP's structure should disappear earlier for 1GeV than from 5GeV?

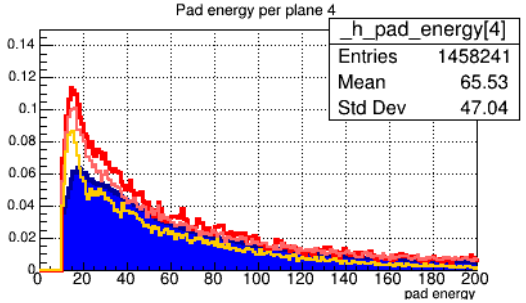
PAD ENERGY - per plane DATA 5GeV / MC 5 GeV / MC 3 GeV / MC 1 GeV

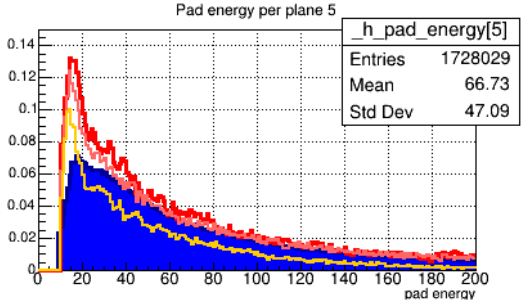


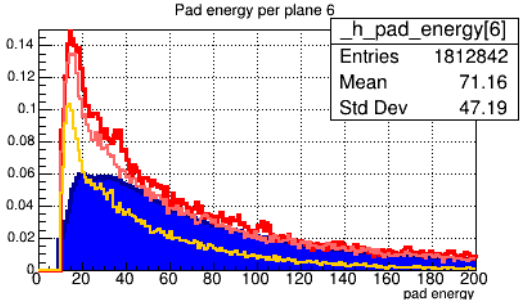


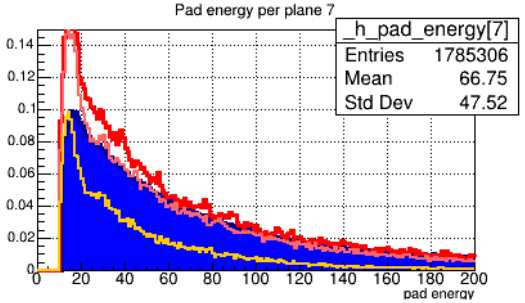


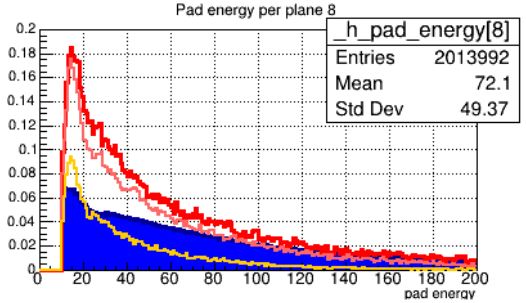


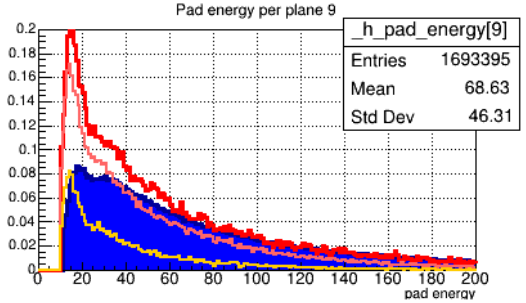


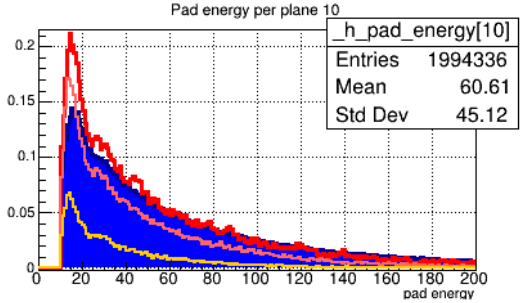


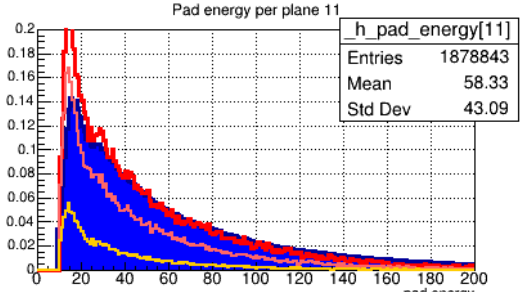


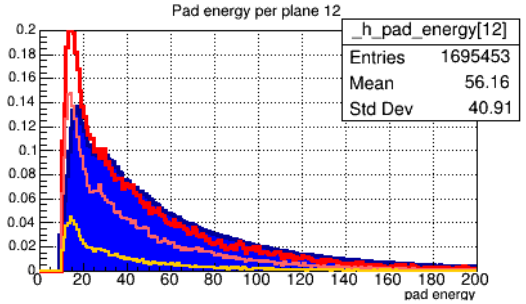


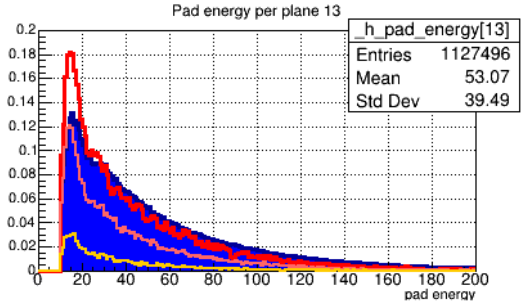


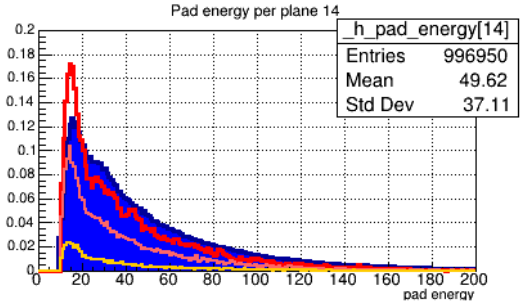




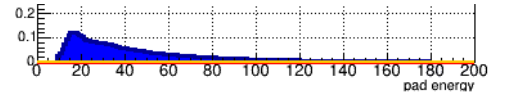


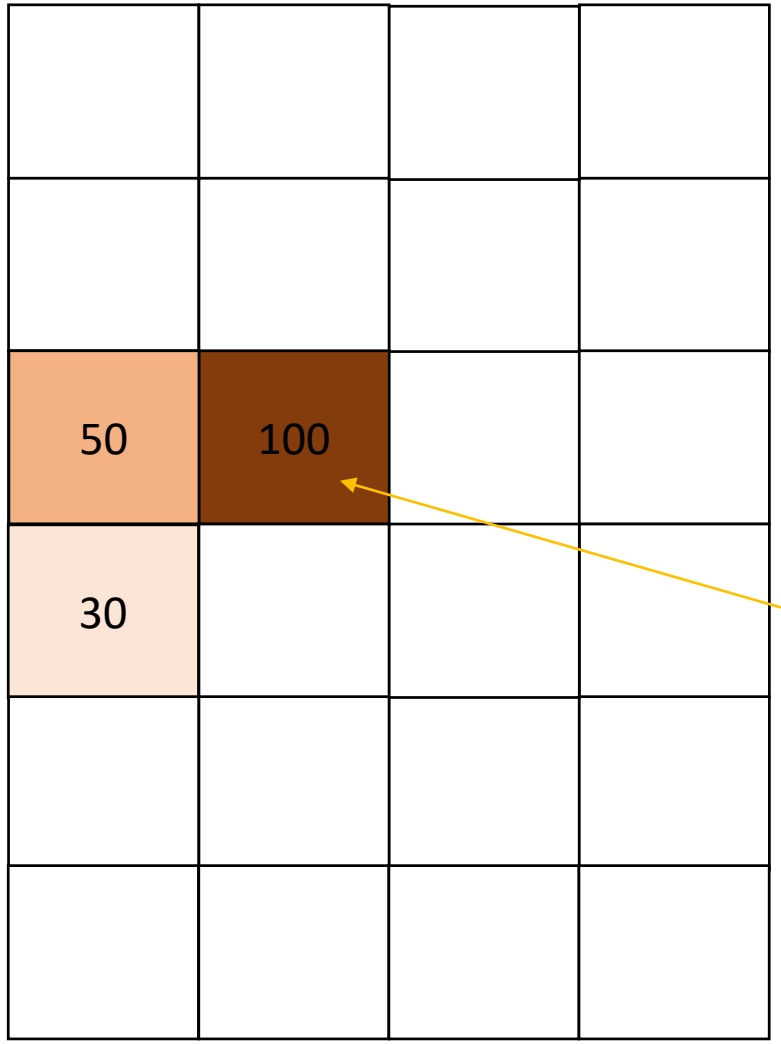






For DATA → we are missing low-energetic entries (also seen on cluster size) → can be still connected with noise cuts





PAD = (channel)

SEED – pad with the highest energy (=100 ADU)

CLUSTER – all pads with signal for particular frame

CLUSTER SIZE = number of pads with signal in frame (= 3 pads)

CLUSTER ENERGY = integrated energy over the frame (=180 ADU)

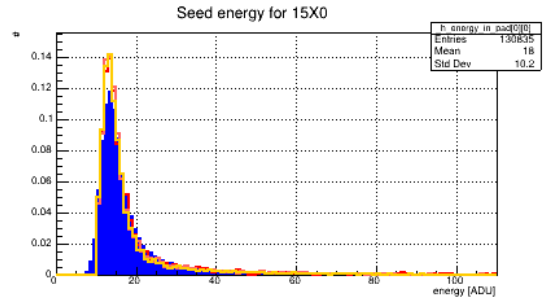
SEED SPECTRUM

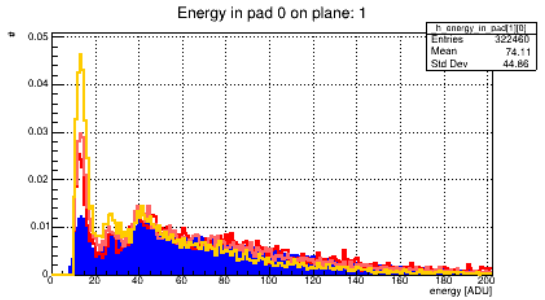
SEED ENERGY RATIO →

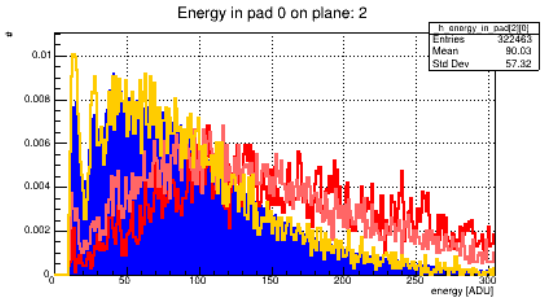
seed energy / cluster energy [%]
100 / 180 = 55 % (seed pixel is carrying 55% of the whole cluster energy)

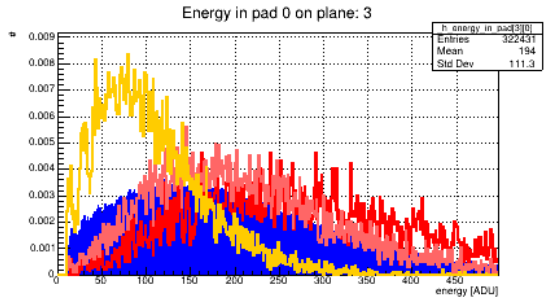
if cluster size = 1 (only one pad with signal) → 100%

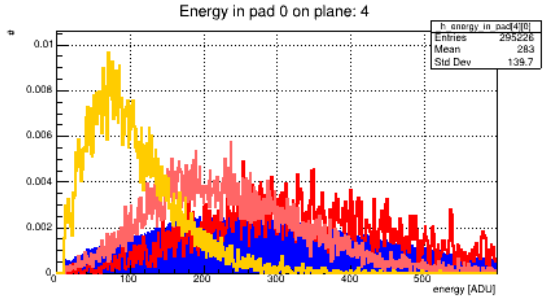
SEED PAD ENERGY (highest energetic pad) - per plane DATA 5GeV / MC 5 GeV / MC 3 GeV / MC 1 GeV

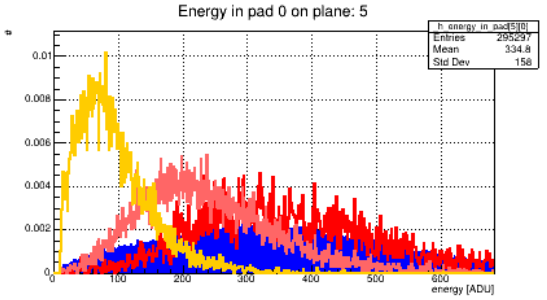


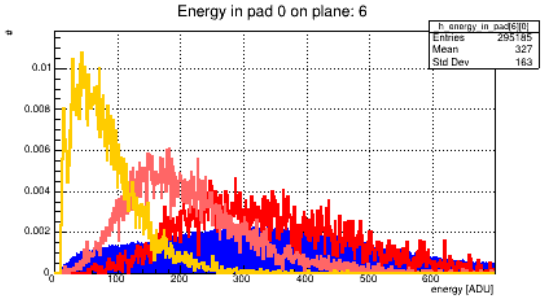


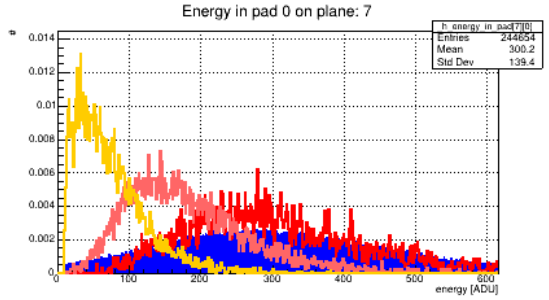


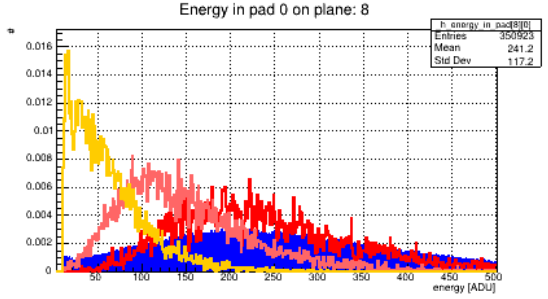


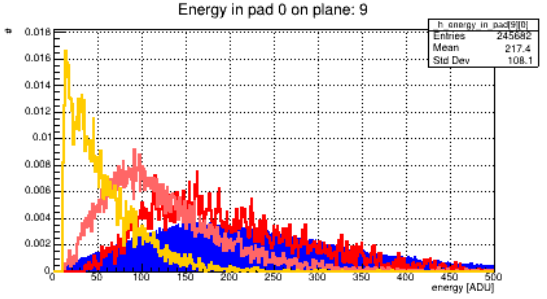


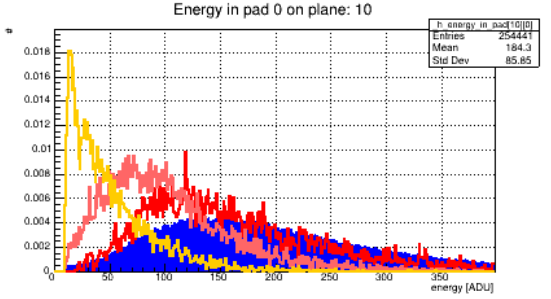


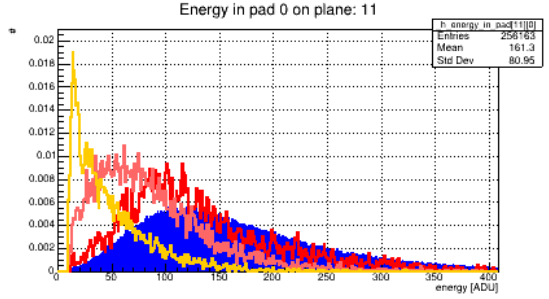


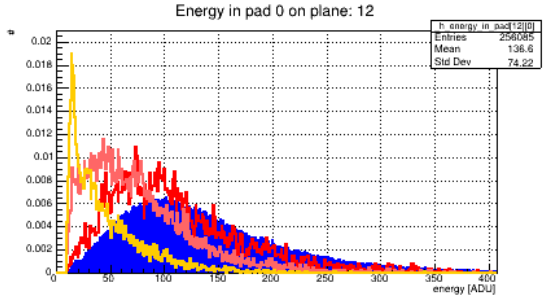


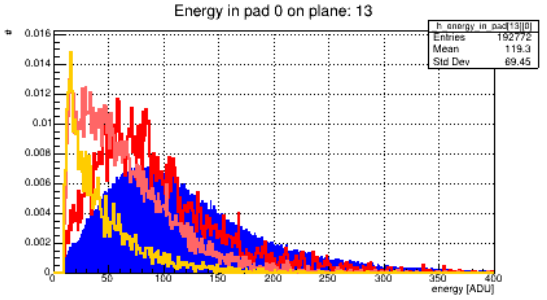


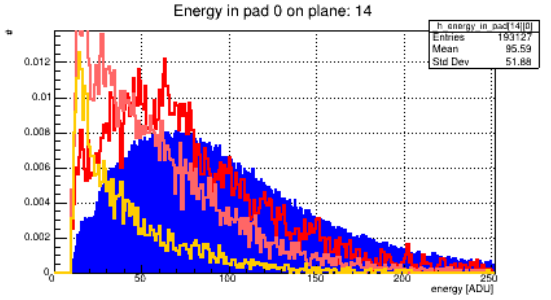






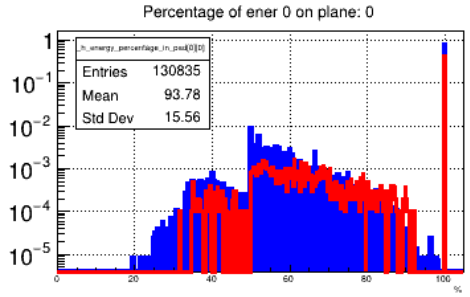


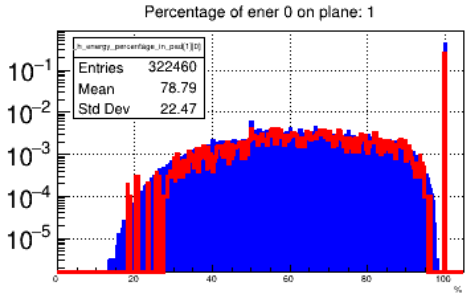


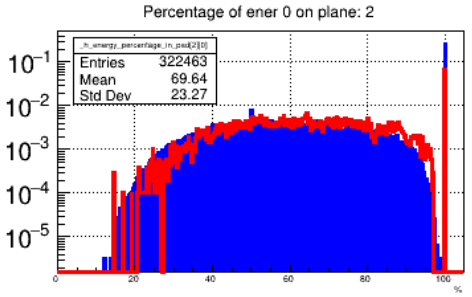


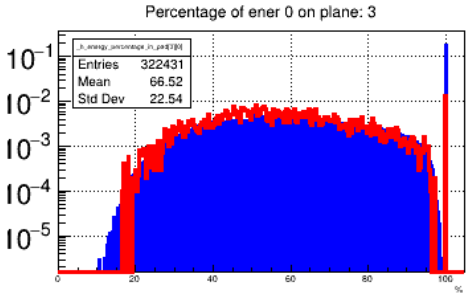
- Qualitatively seed energy spectrum very similar to cluster energy
- Disagreement DATA/MC shows up even on this level = before clustering
- Still on 2X0 good match to 1GeV → but not deeper in the stack

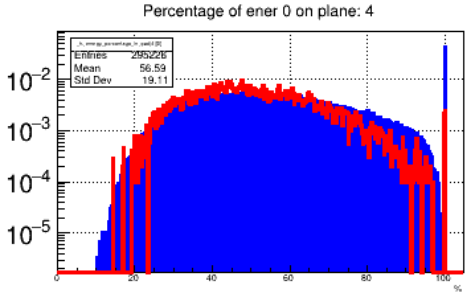
SEED ENERGY RATIO (highest energetic pad / whole cluster energy) - per plane DATA 5GeV / MC 5 GeV

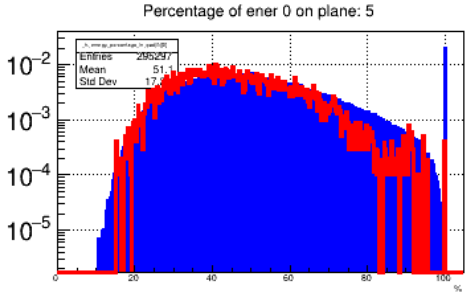


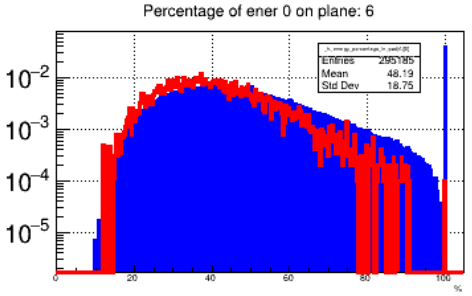


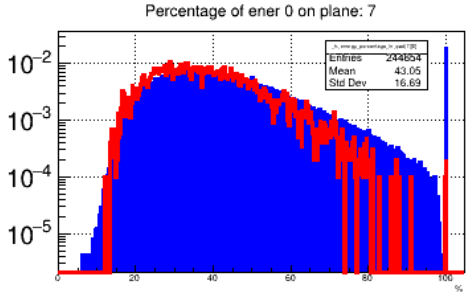


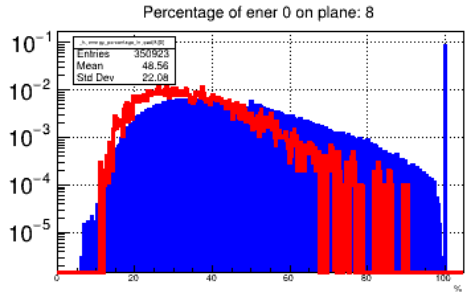


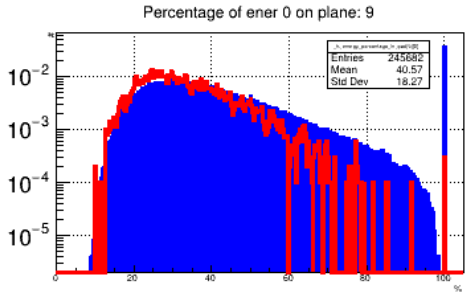


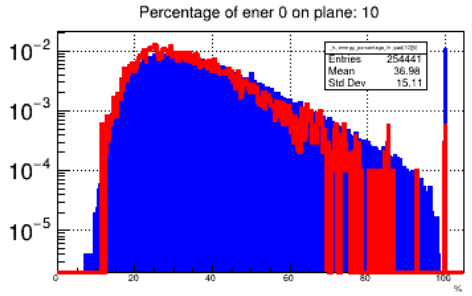


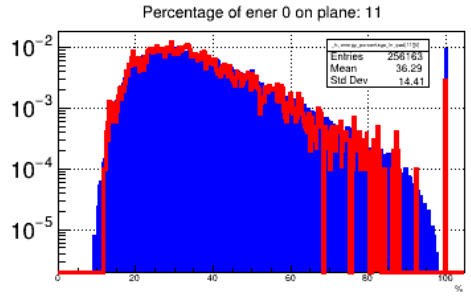


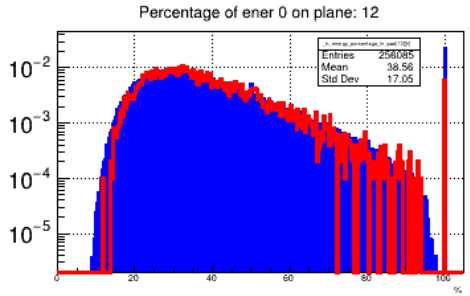


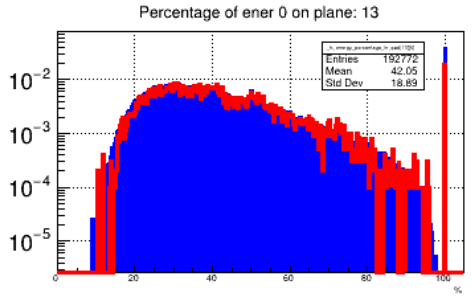


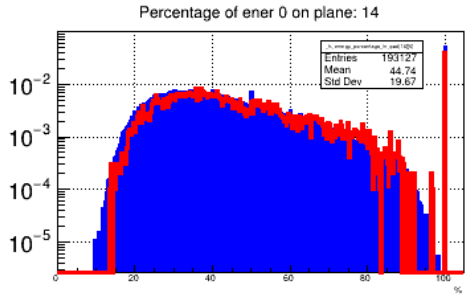


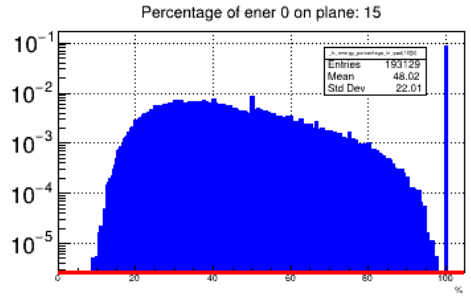






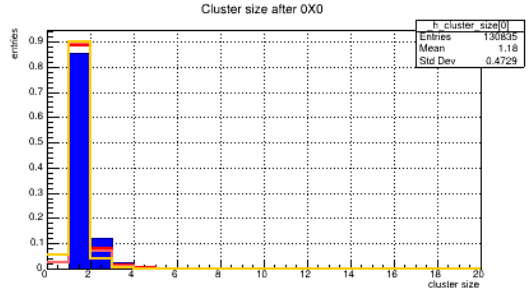


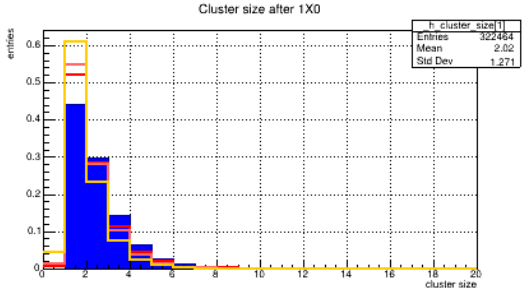


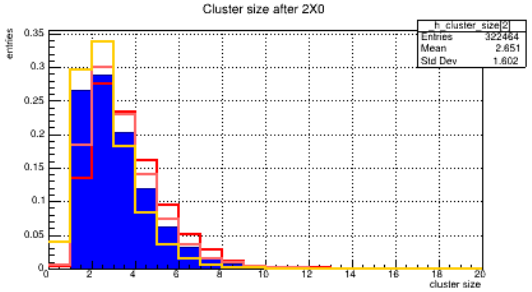


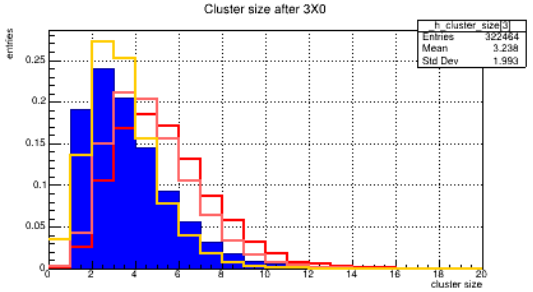
- Above 3X0 seed pad is carrying more energy of the whole cluster for DATA than MC
- DATA has more 1-pad clusters → noise contributions?

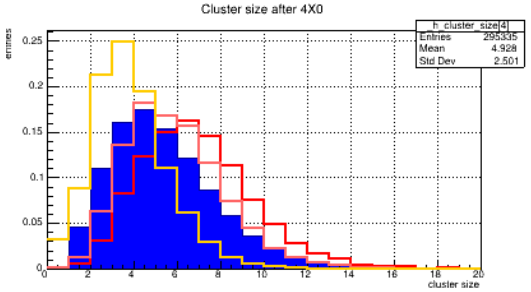
CLUSTER SIZE - per plane DATA 5GeV / MC 5 GeV / MC 3 GeV / MC 1 GeV

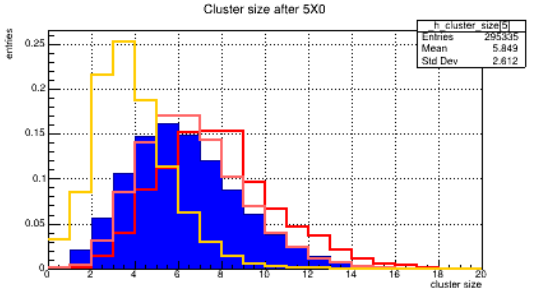


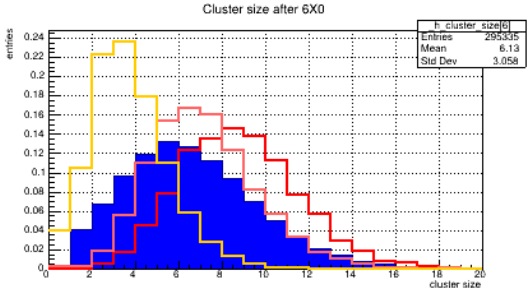


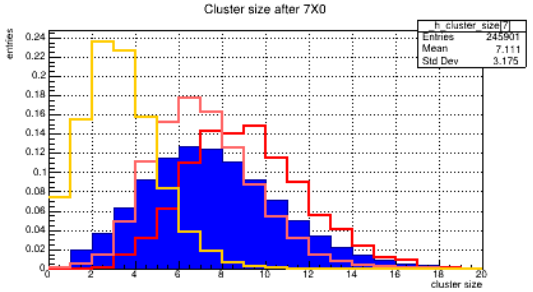


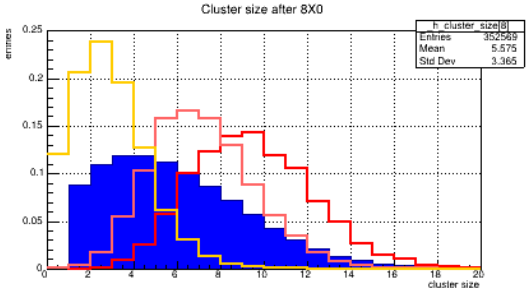


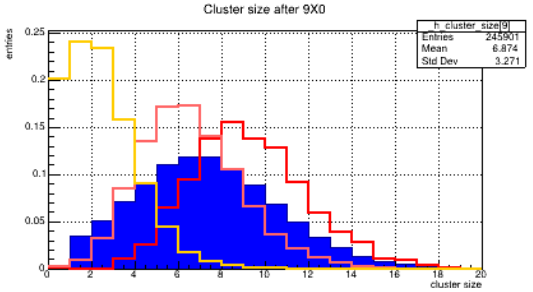


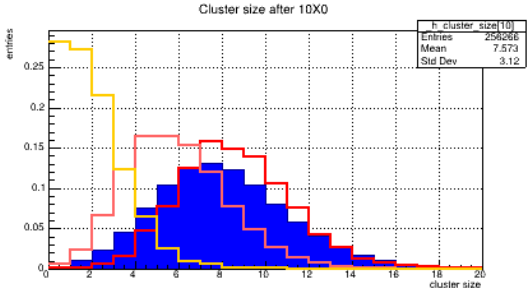


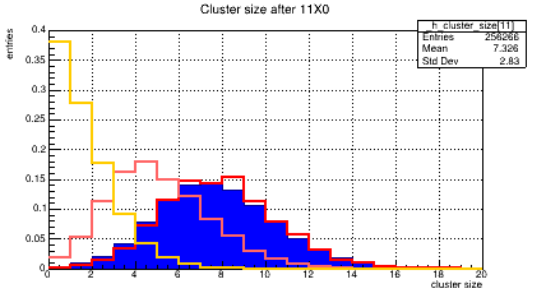


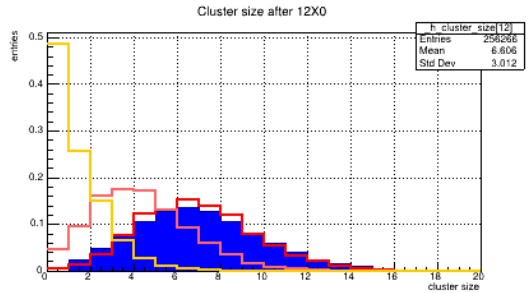


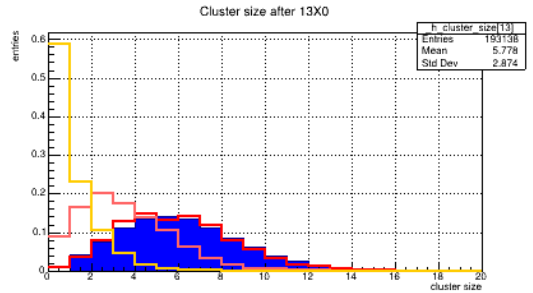


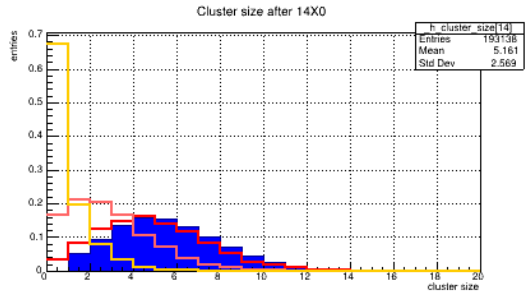


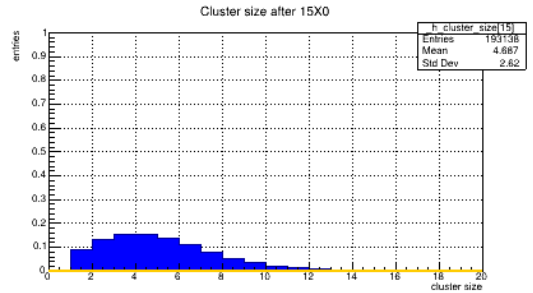








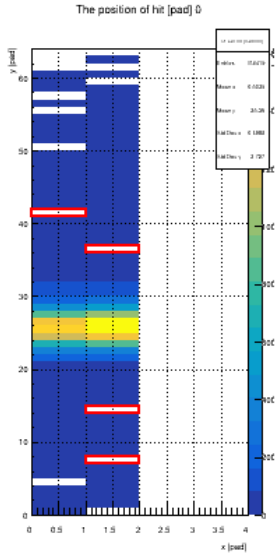


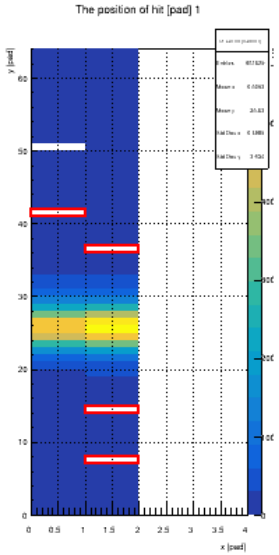


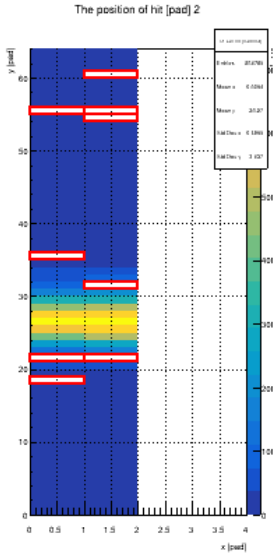
BACKUP

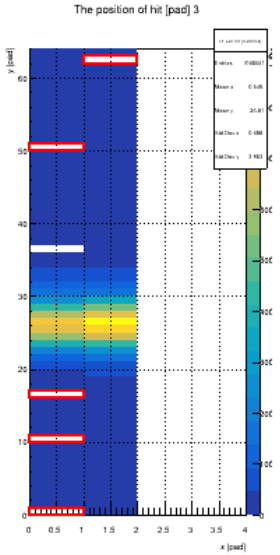
- **2D MAP of pad (with signal) position** [in pad] DATA – number of hits in pad per plane [integrated over the whole run] – page 15
- **2D MAP of pad (with signal) position** [in pad] MC – number of hits in pad per plane [integrated over the whole run] – page 16
- **2D MAP of cluster position** [in um] DATA – per plane [integrated over the whole run] – page 17
- **2D MAP of cluster position** [in um] MC – per plane [integrated over the whole run] – page 18
- **2D MAP of integrated energy** [in pad] DATA – page 19
- **2D MAP of integrated energy** [in pad] MC – page 20
- **Shower profile** – after alignment for DATA – page 21
- **Number of full events & frames -** to be verified, especially for MC – page 22
- **Empty events & frames** – to be verified, especially for MC – page 23
- **Mean cluster size** – mean cluster size (=number of pads with signal per frame per plane averaged over whole run) – page 24
- **Mean energy** – (cluster energy on plane averaged over the whole run) – page 25 – to be updated
- **Integrated pad energy for 1/2/3/4/5 GeV** for DATA – available only for 4X0, 5X0 and 6X0 - page 26
- **Integrated cluster energy for 1/2/3/4/5 GeV** for DATA – available only for 4X0, 5X0 and 6X0 page 27
- **Pad energy spectrum - comparison between MC and DATA** for 1, 3 and 5 GeV – available only for 4X0, 5X0 and 6X0 – page 28
- **Cluster energy spectrum - comparison between MC and DATA** for 1, 3 and 5 GeV – available only for 4X0, 5X0 and 6X0 – page 29
- **Ratio of the second energetic pad in the cluster to the whole cluster energy** – page 30
- **Spectrum of the second energetic pad in the cluster** – page 31
- **Ratio of the third energetic pad in the cluster to the whole cluster energy** – page 32
- **Spectrum of the third energetic pad in the cluster** – page 33
- **Correlation between cluster size on 1X0 and 2X0 and 2X0 and 3X0** – page 34

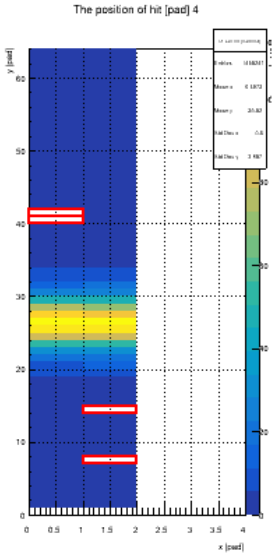
DATA – hits position [pad]

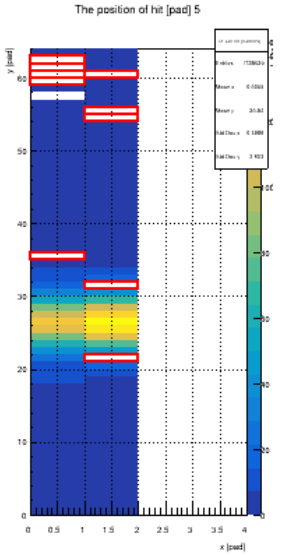


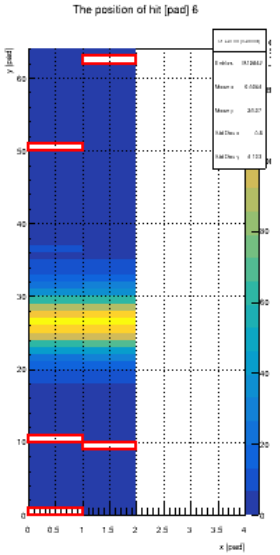


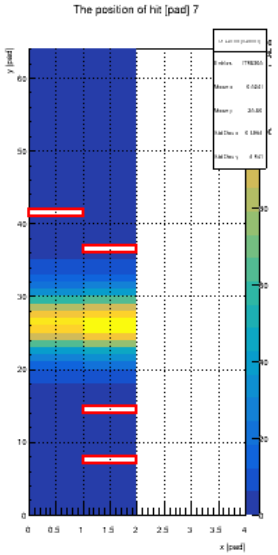


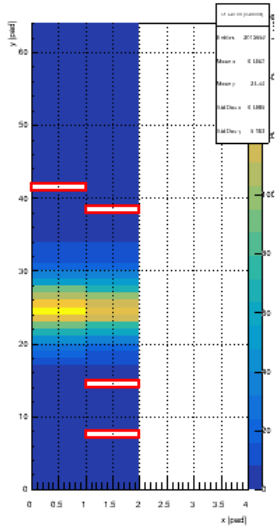


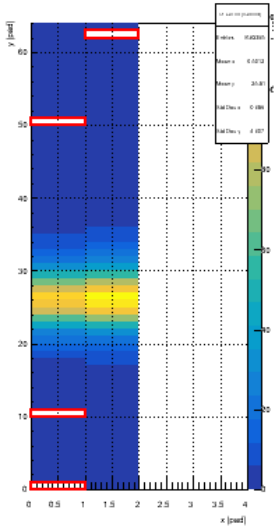


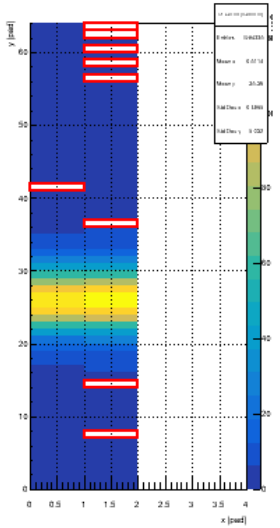


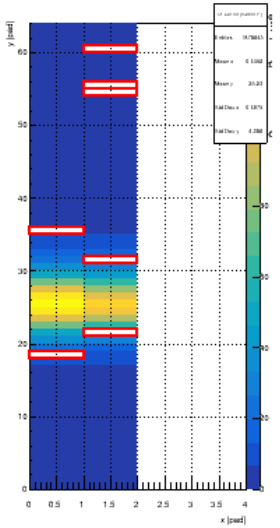


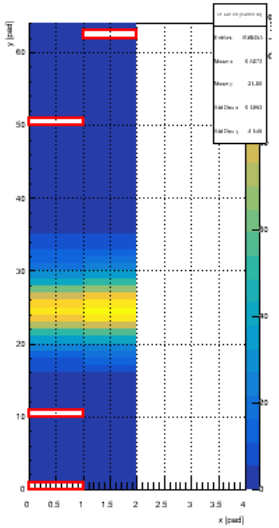


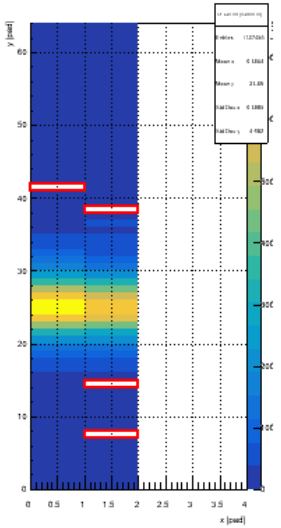


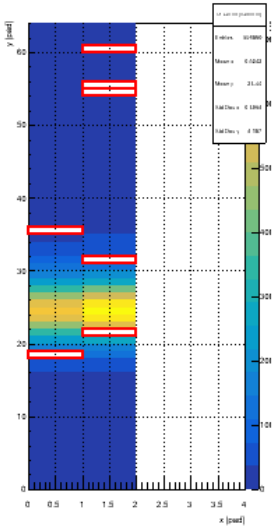


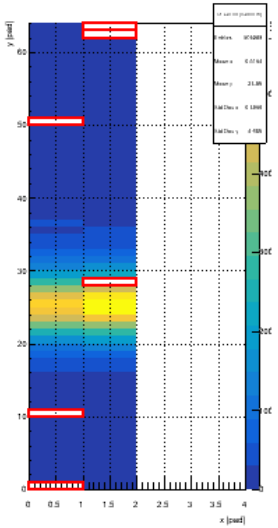




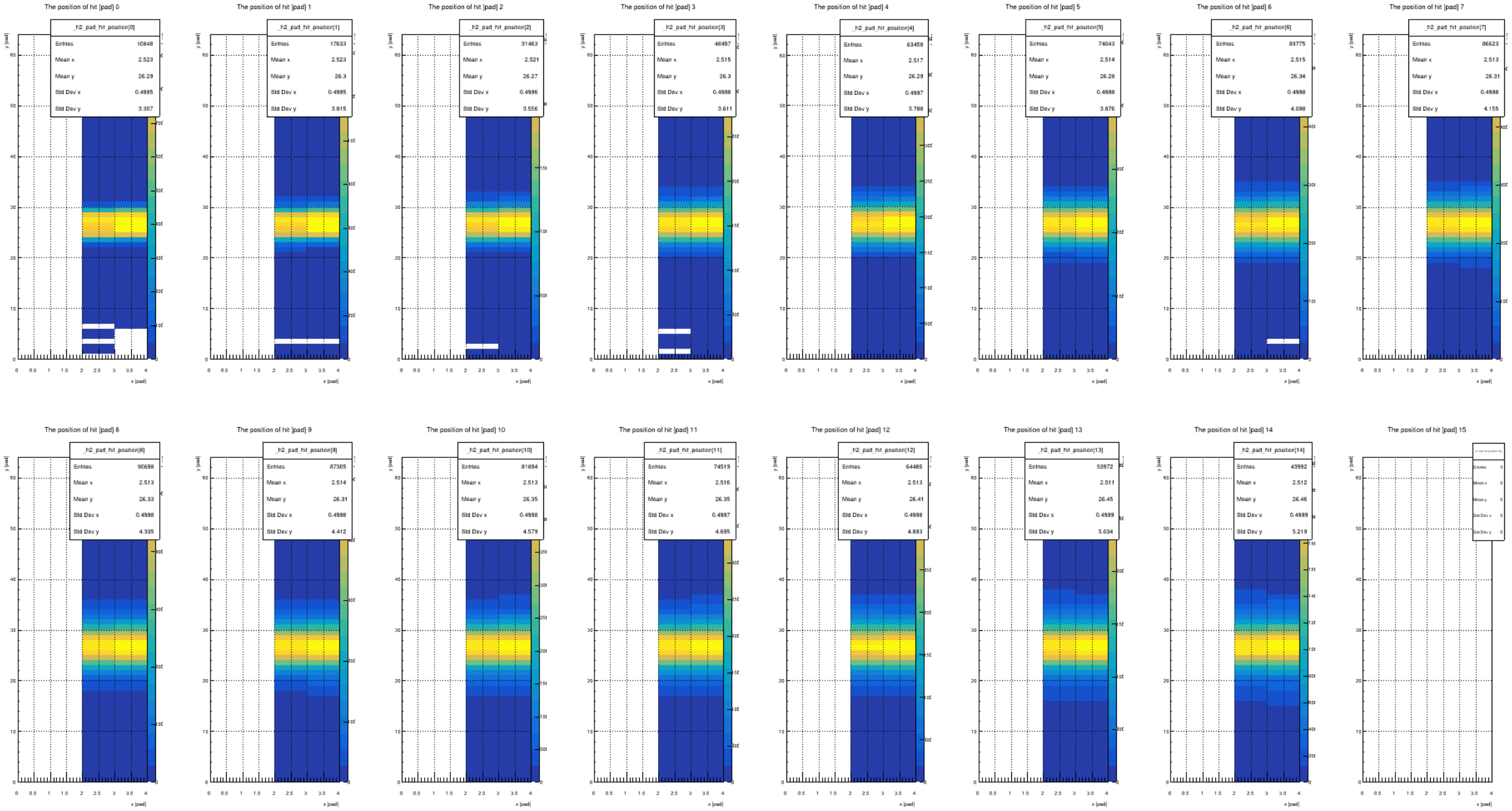




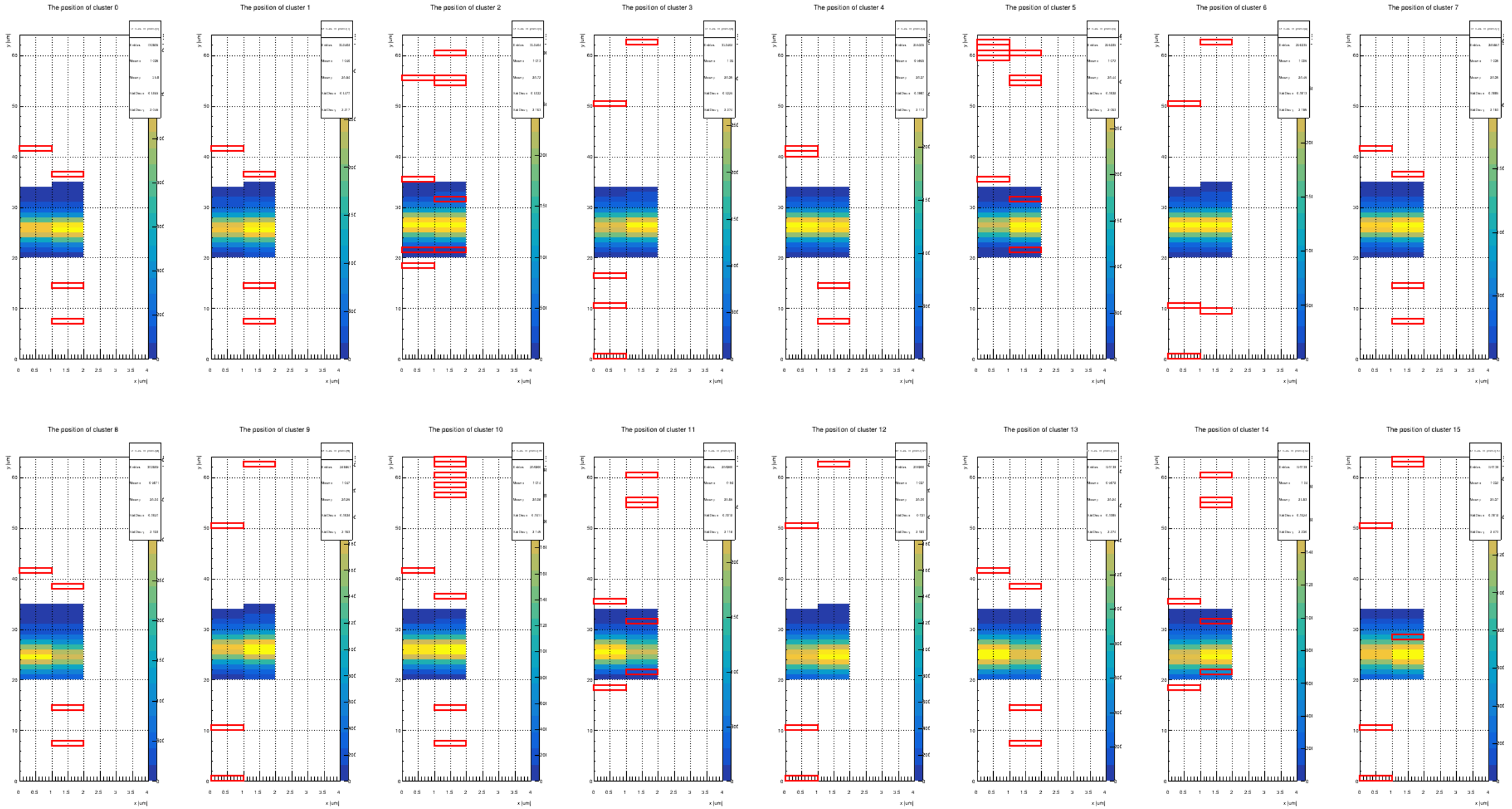




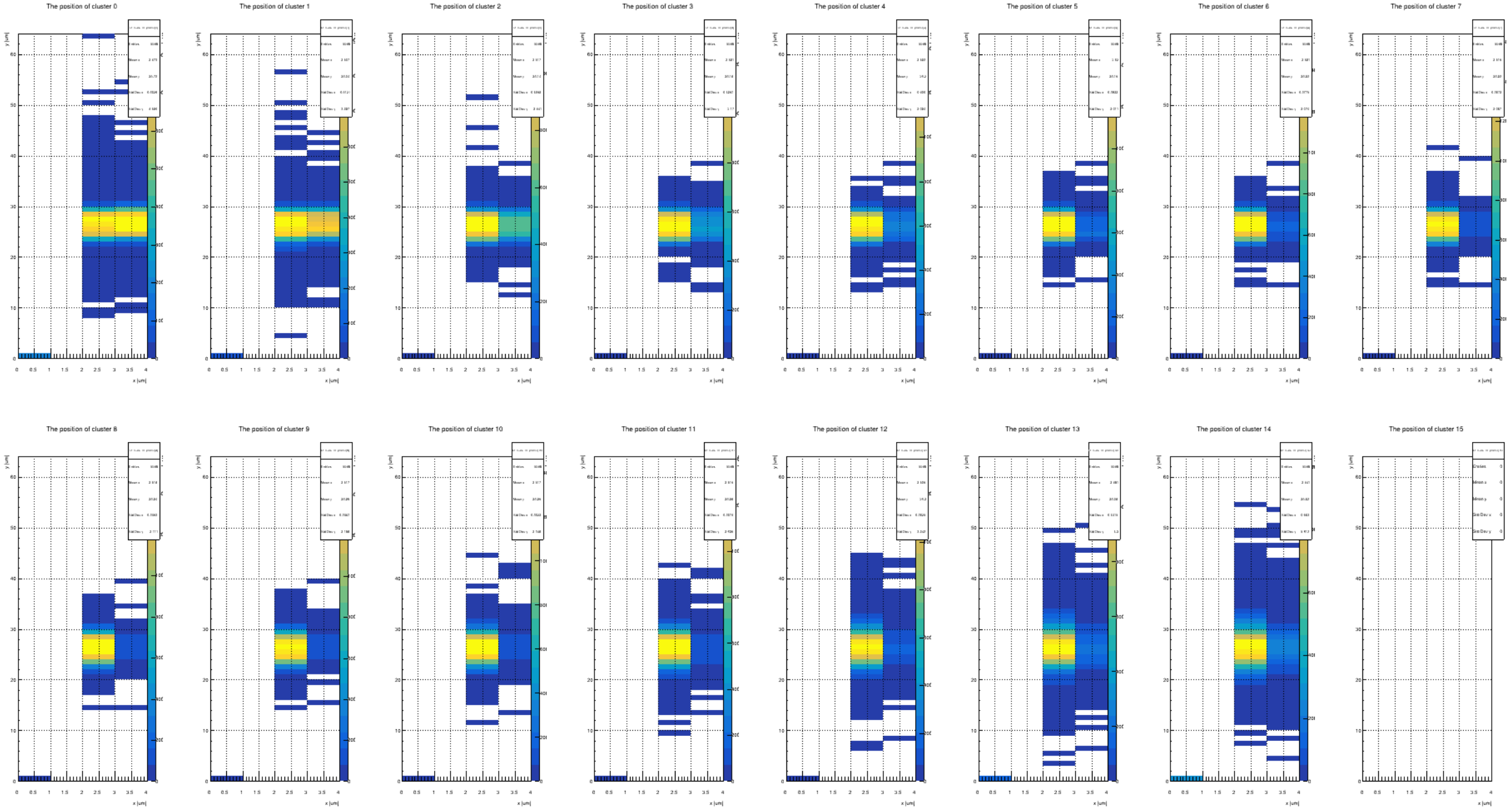
MC – hits position [pad]



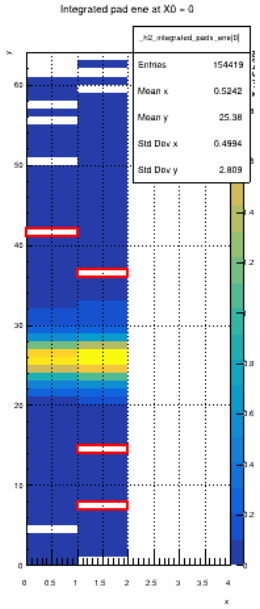
DATA– cluster position [um]

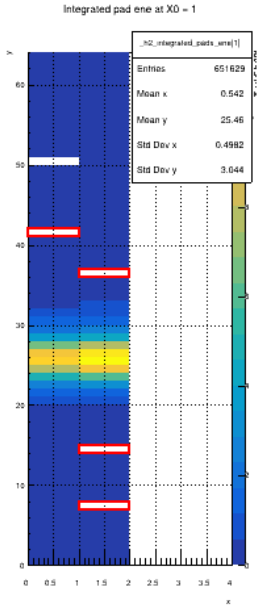


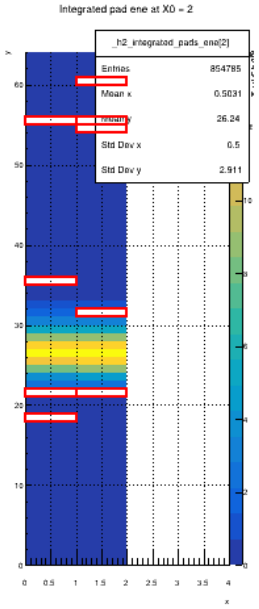
MC – cluster position [um]

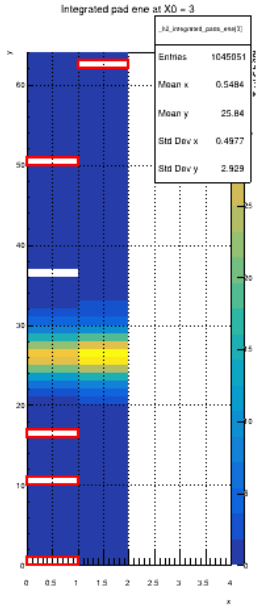


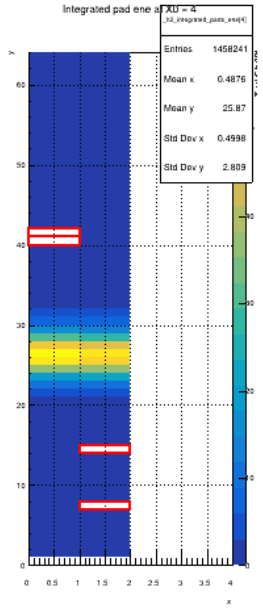
DATA - integrated pad energy (no clustering)

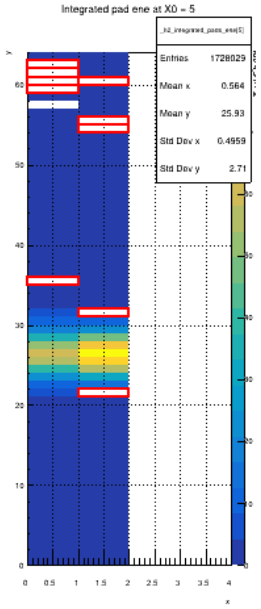


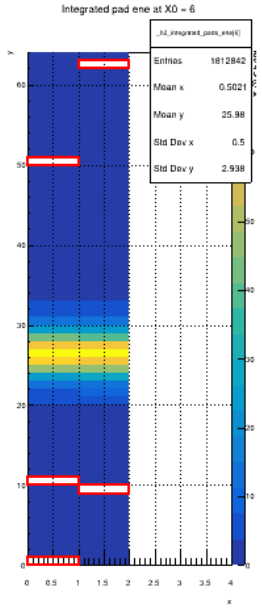


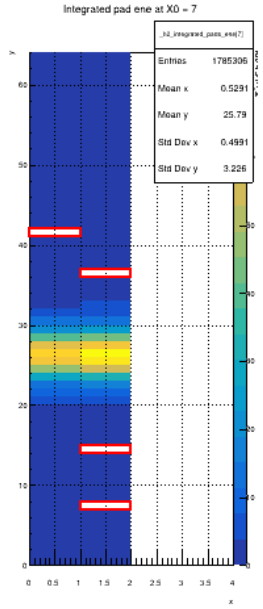


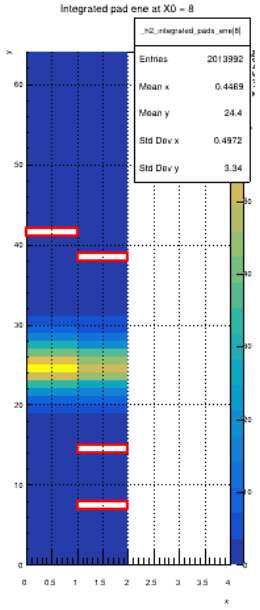


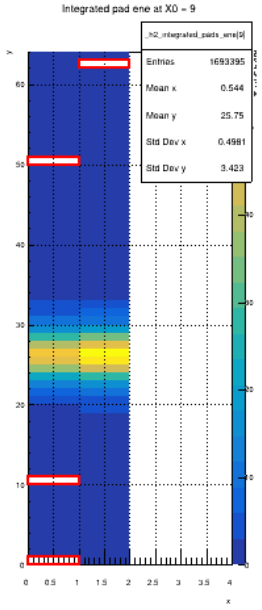


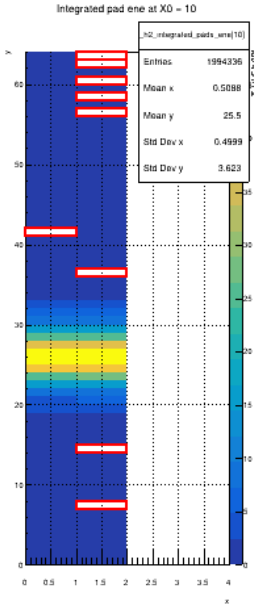


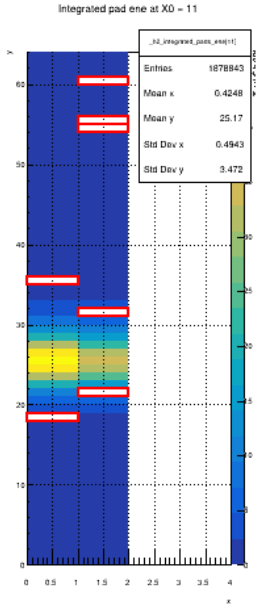


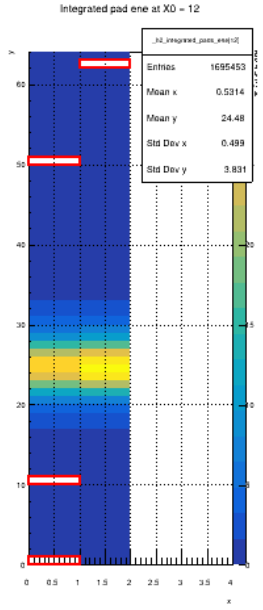


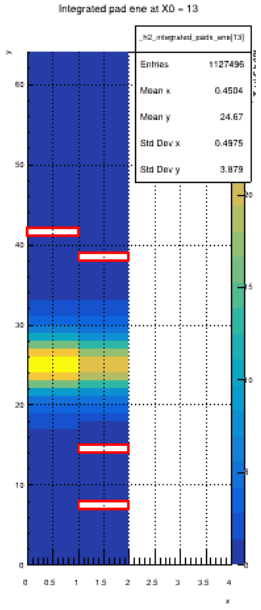


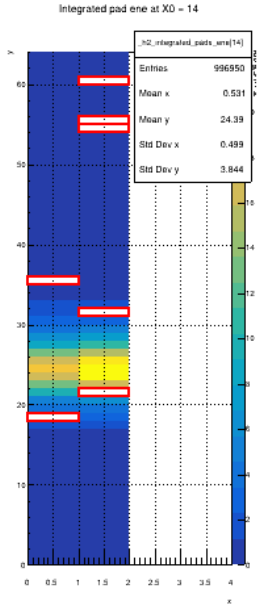


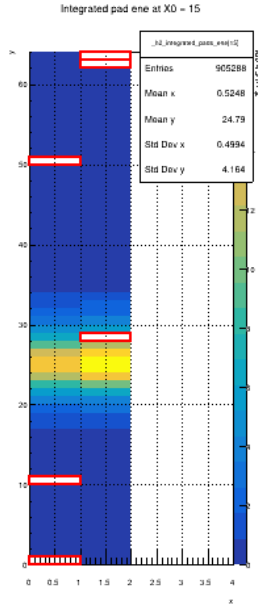




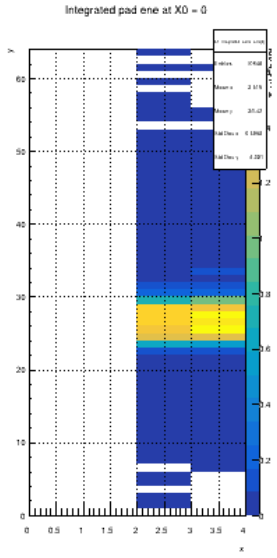


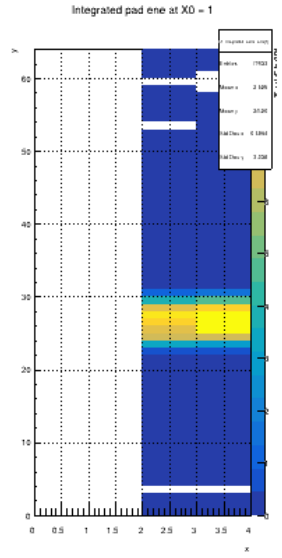


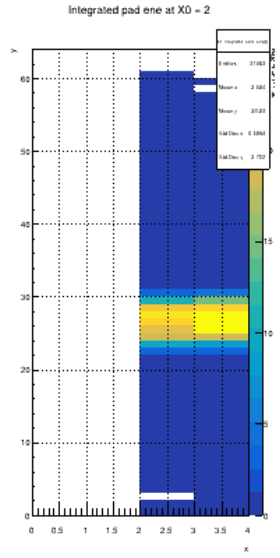


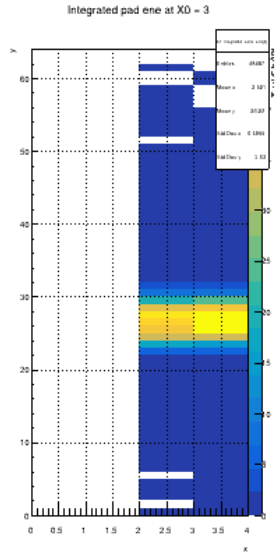


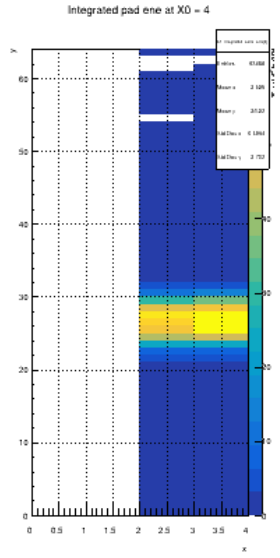
MC - integrated pad energy (no clustering)

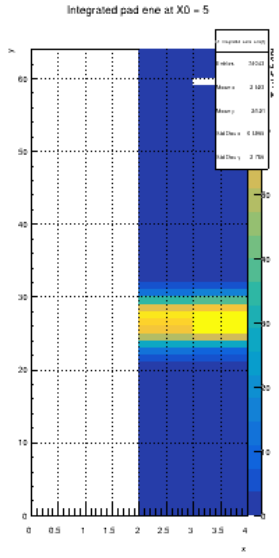


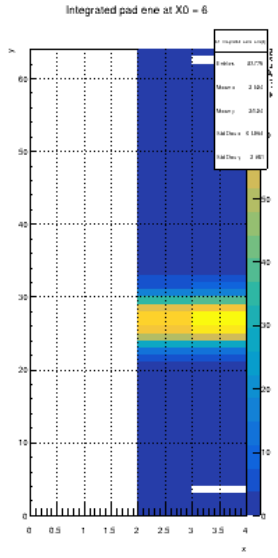


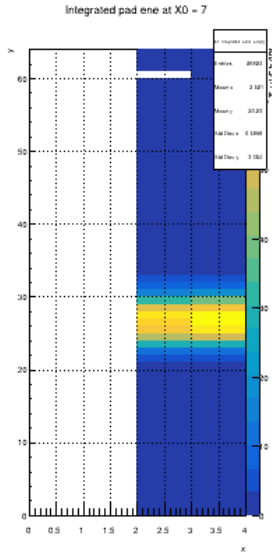


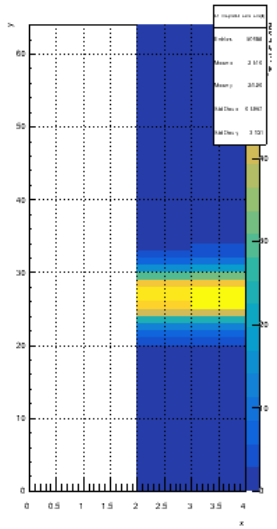


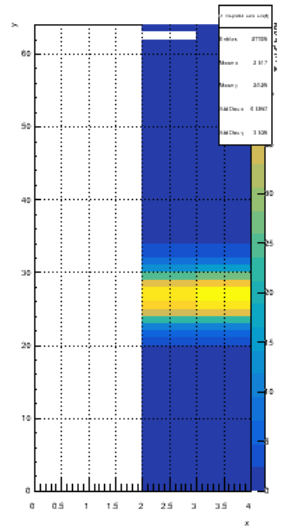


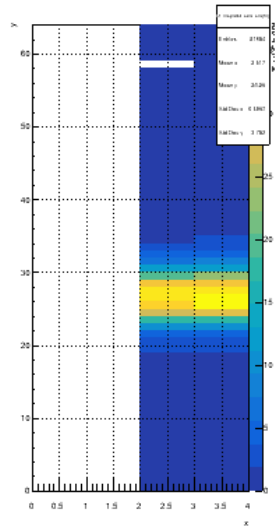


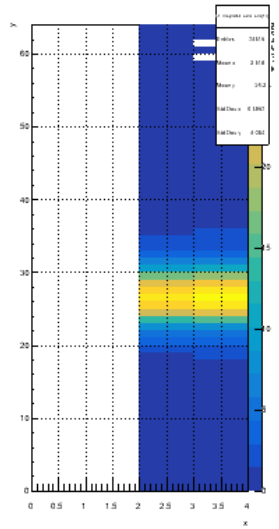


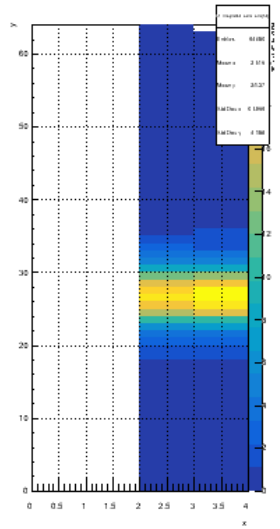


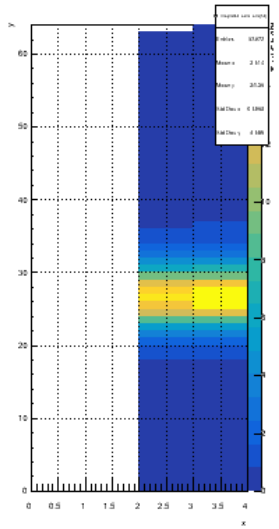


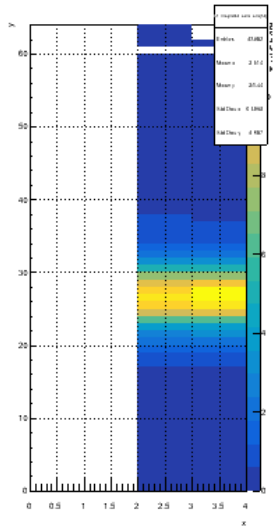


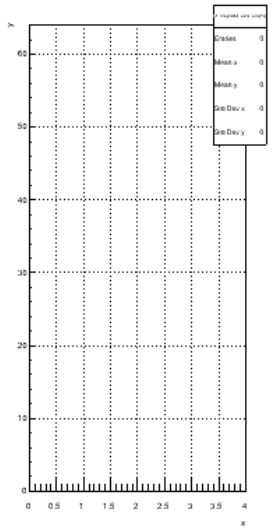






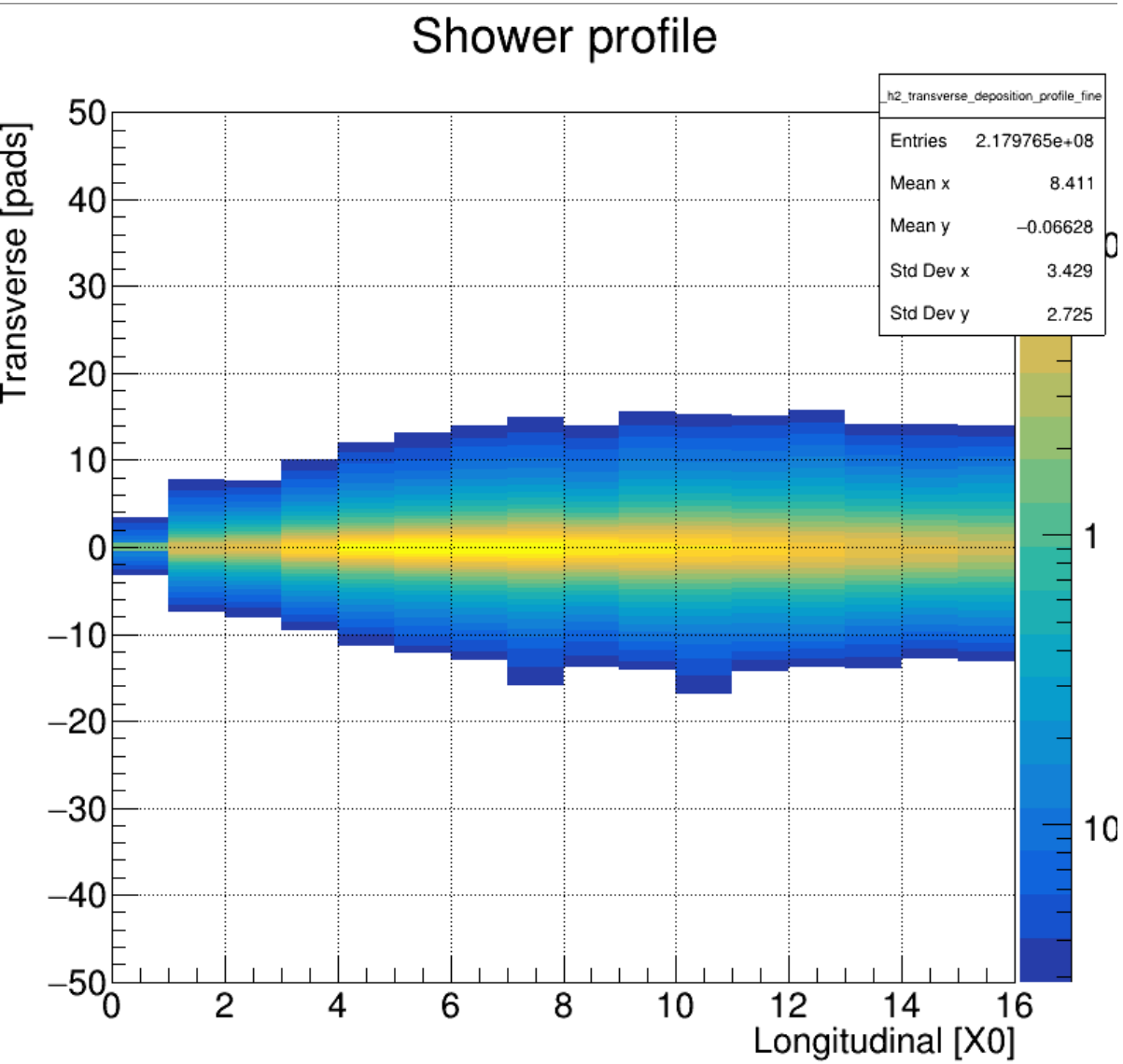




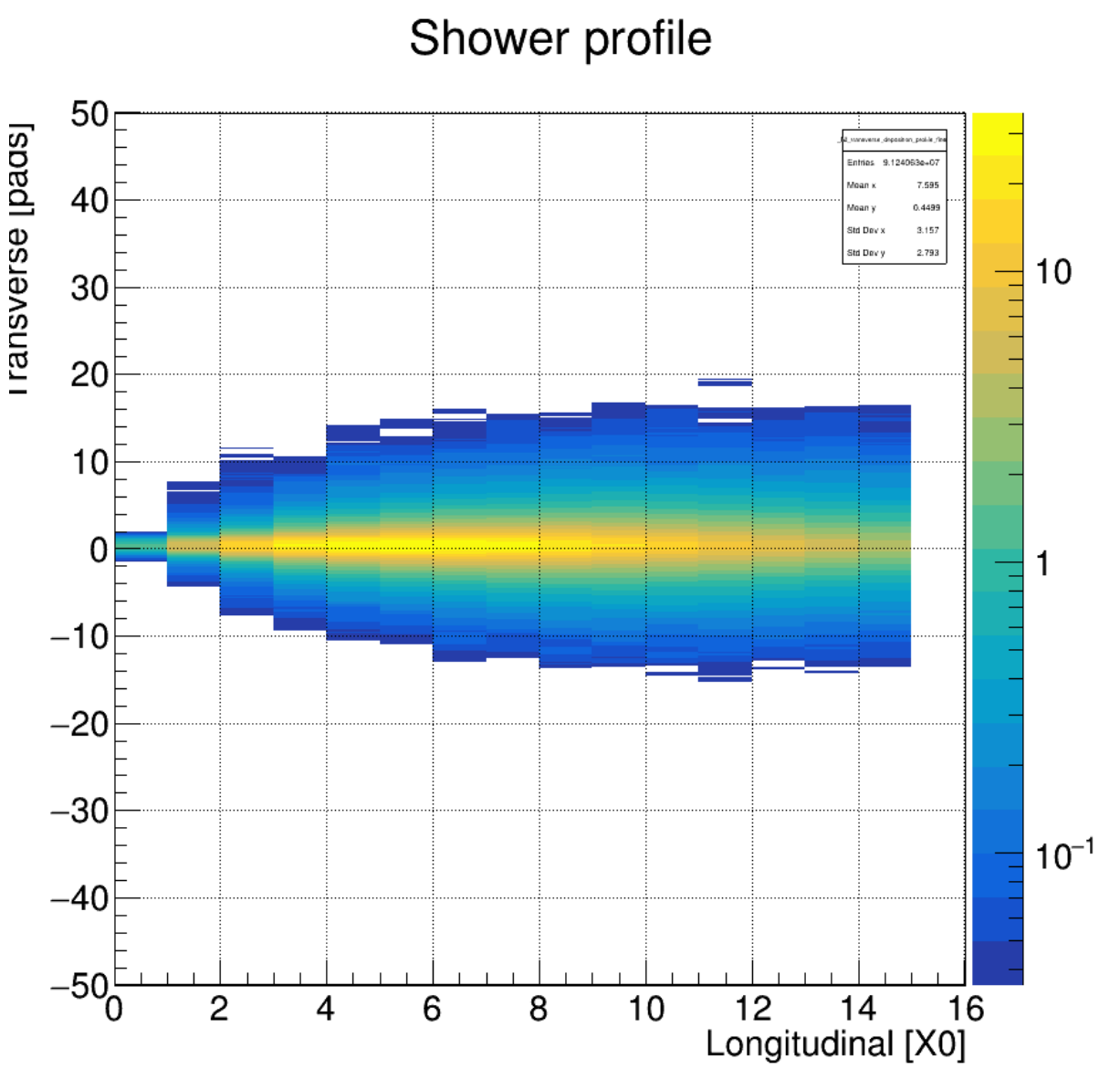


MC vs DATA – shower profile

DATA

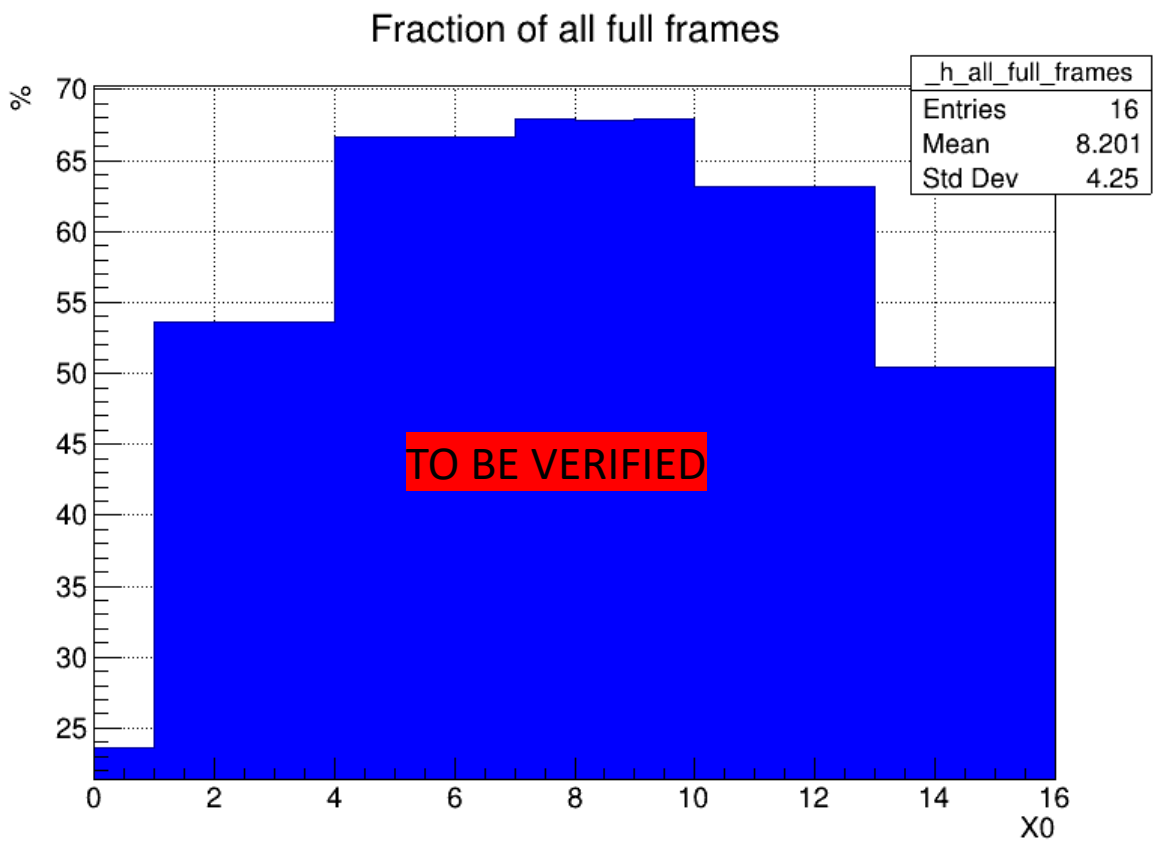


MC

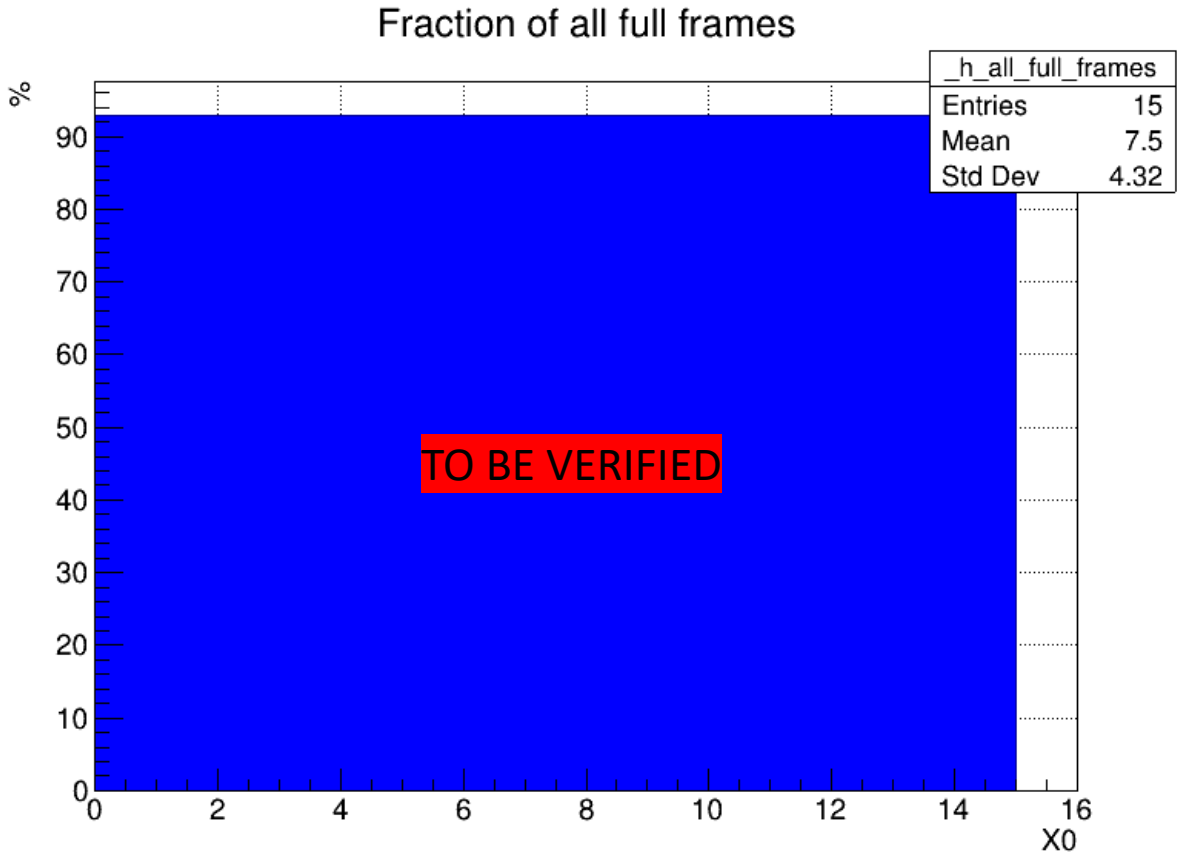


FRACTION OF ALL FULL FRAMES

DATA

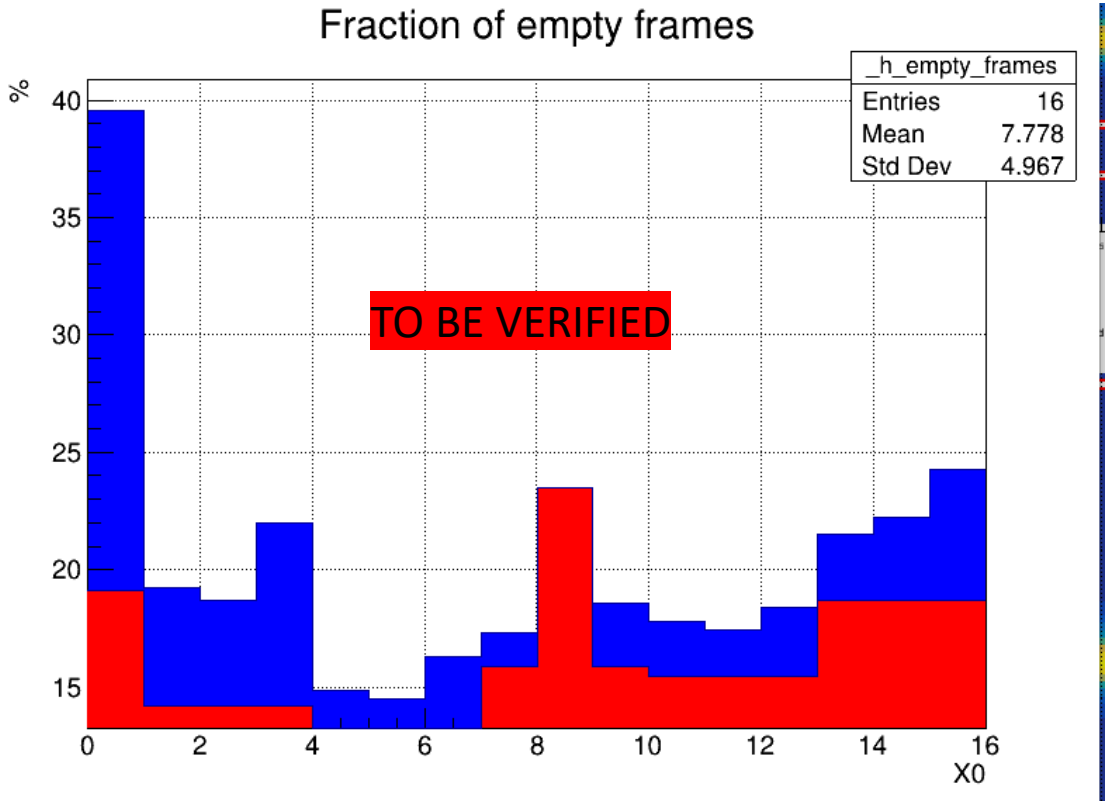


MC

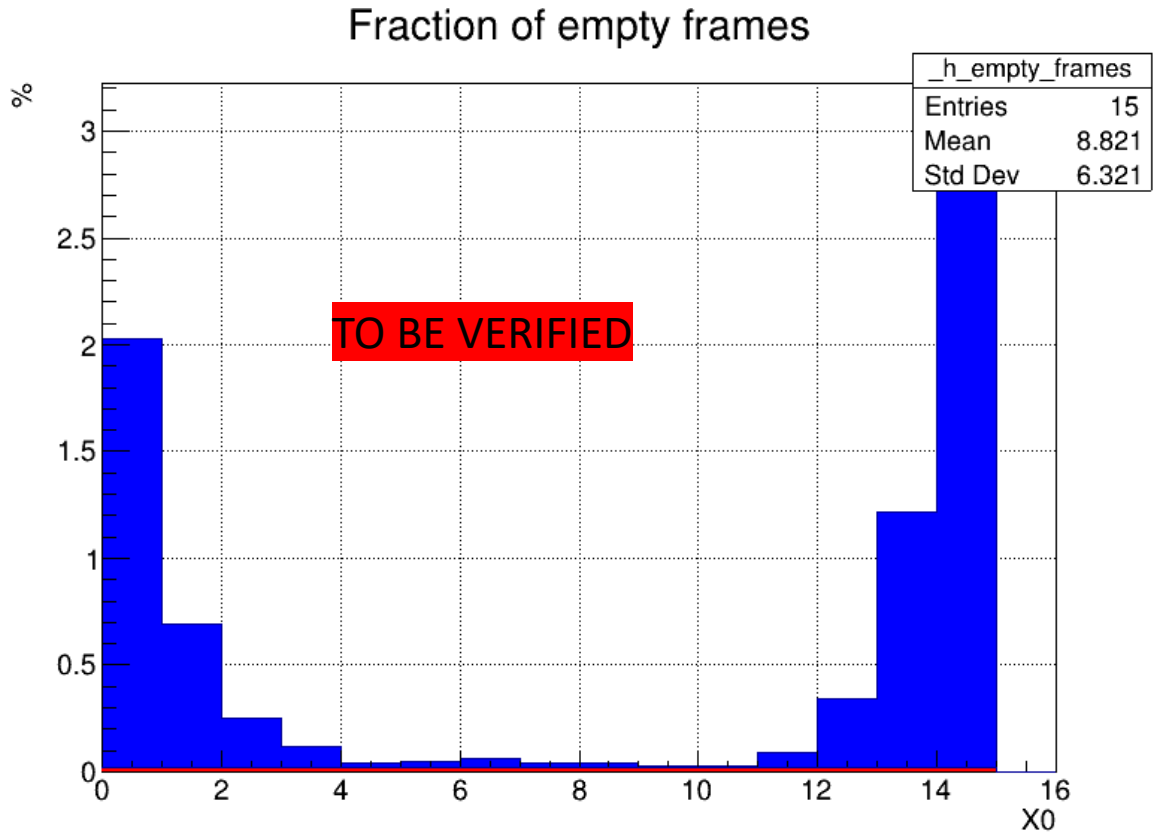


FRACTION OF EMPTY FRAMES

DATA

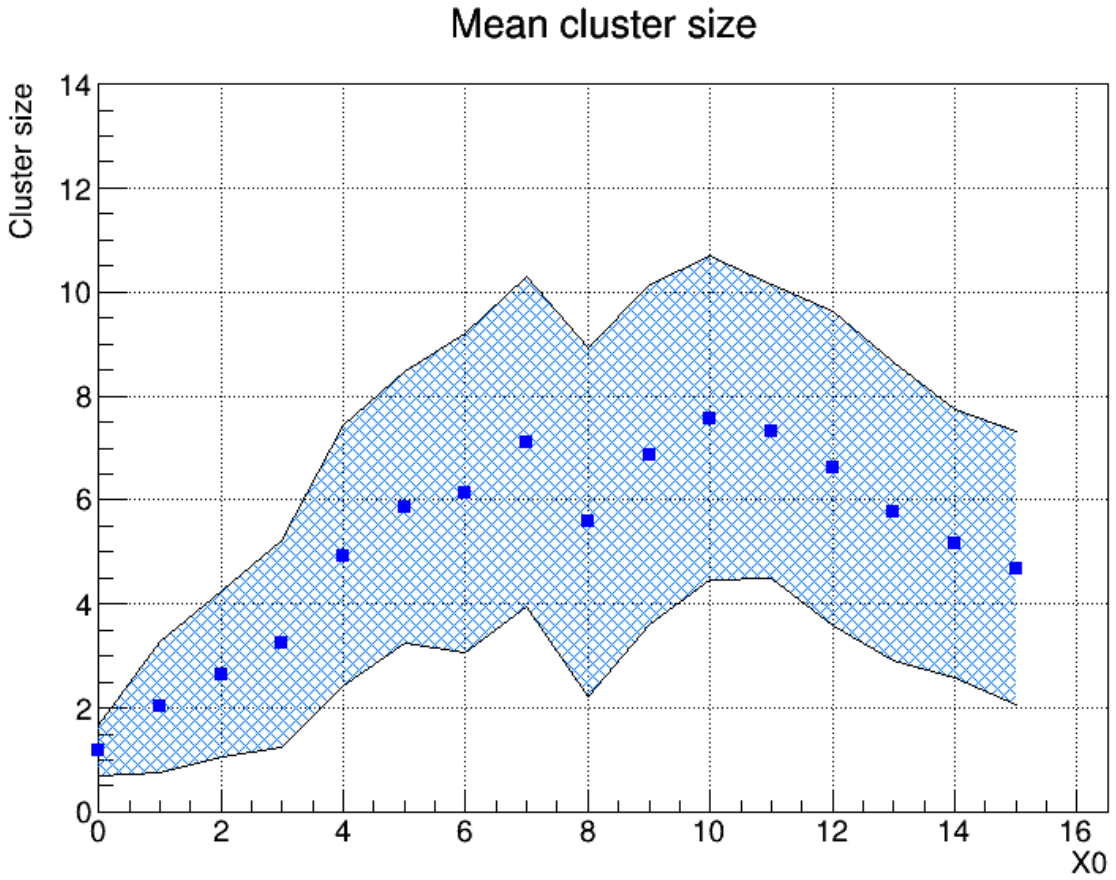


MC

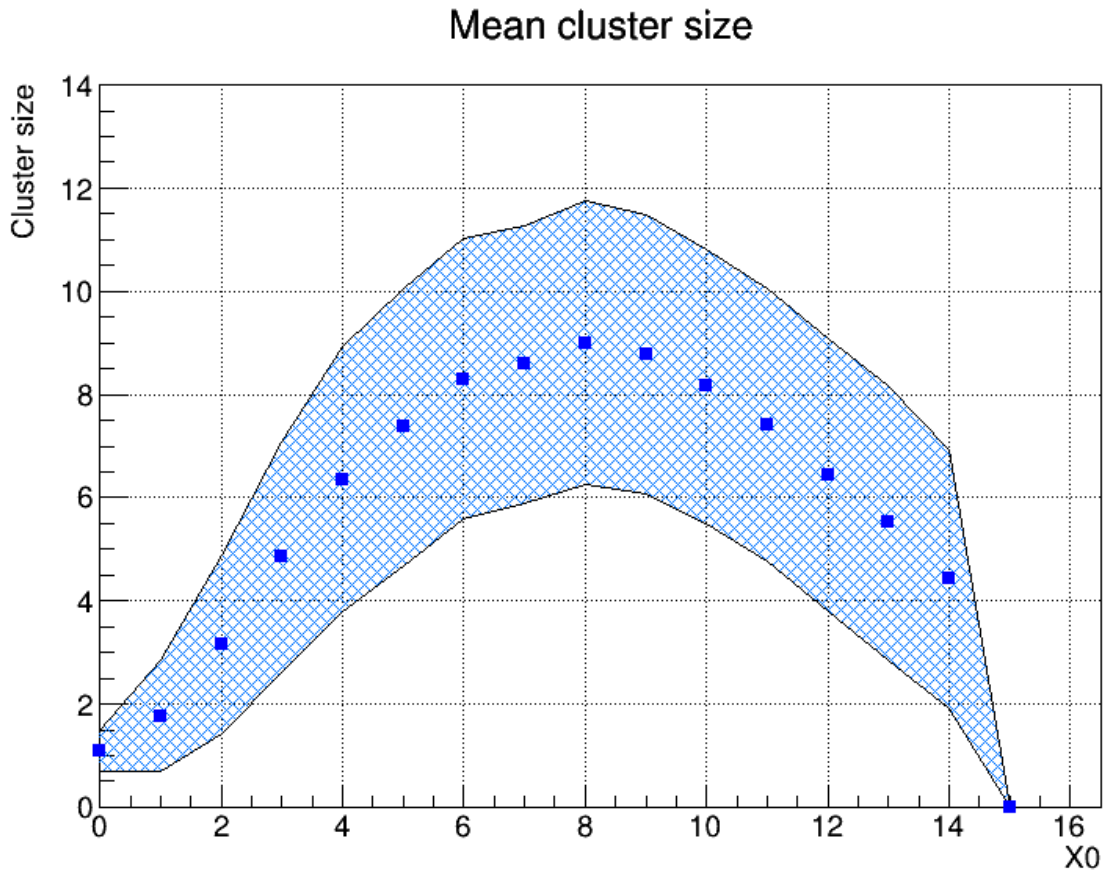


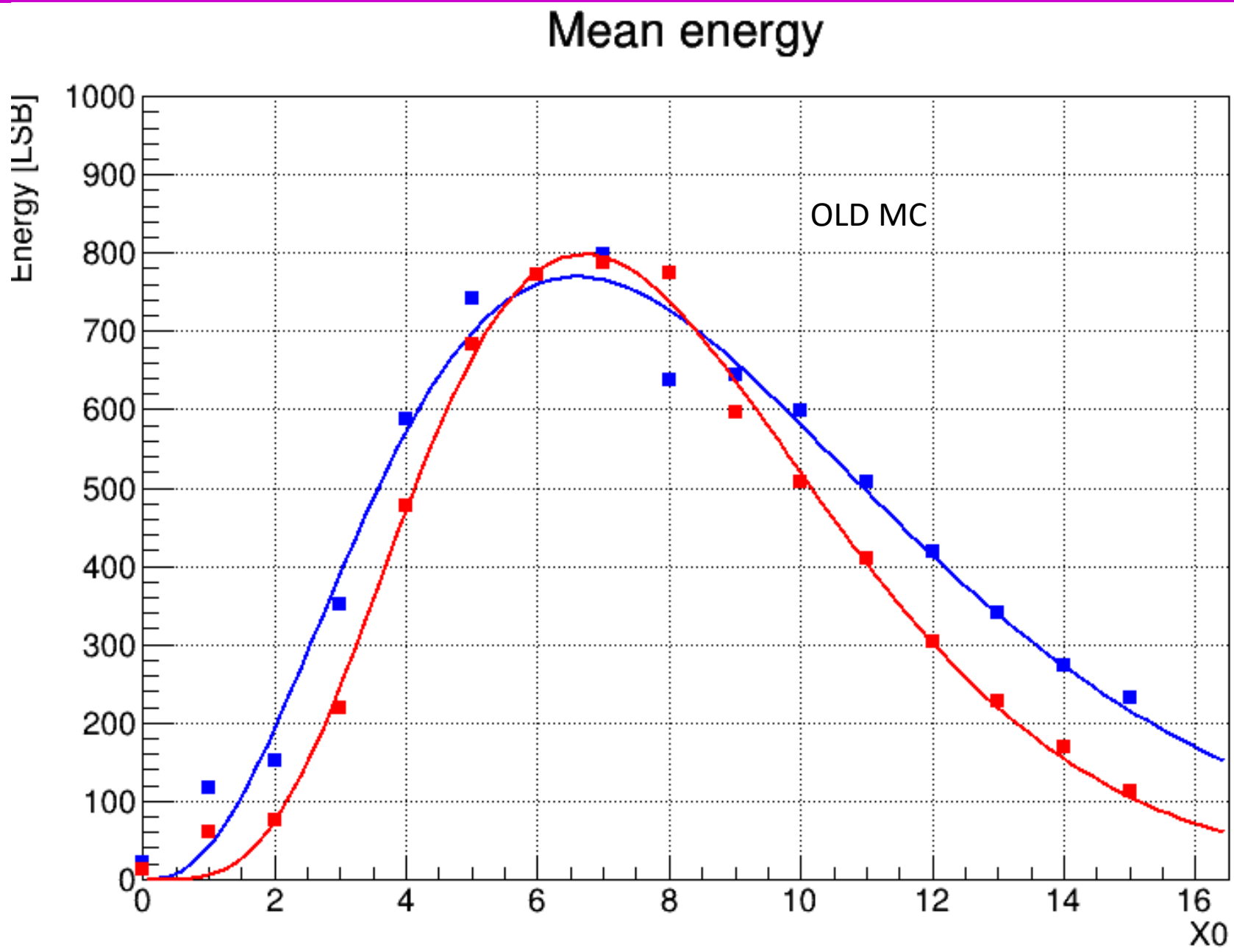
MC vs DATA – mean cluster size

DATA

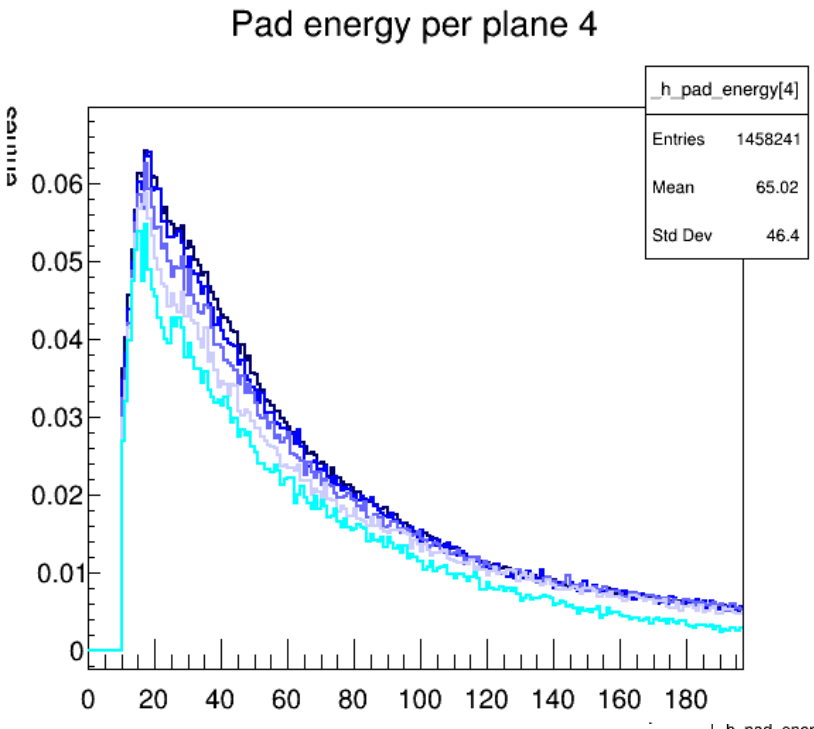


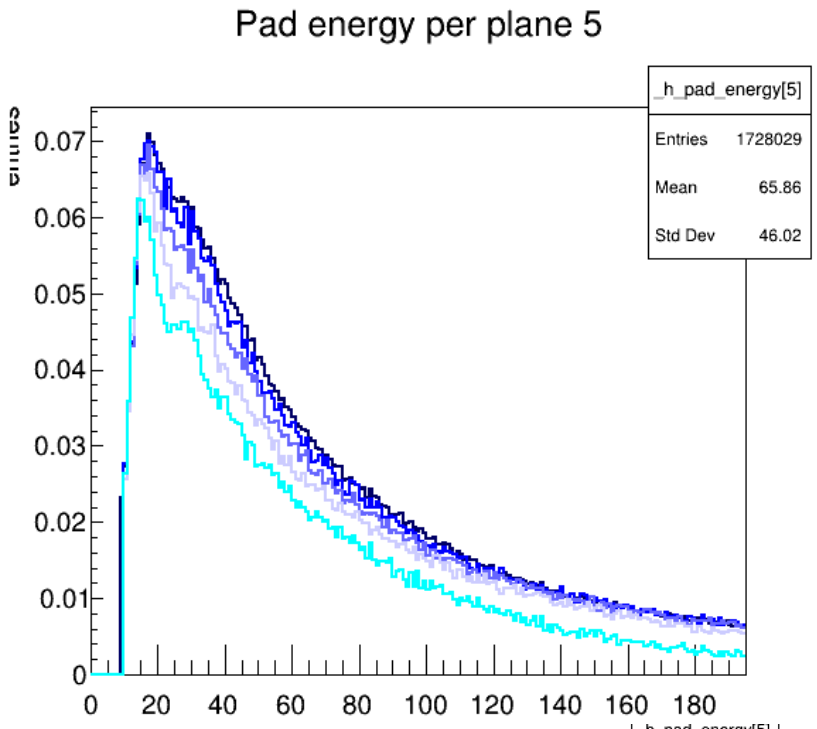
MC

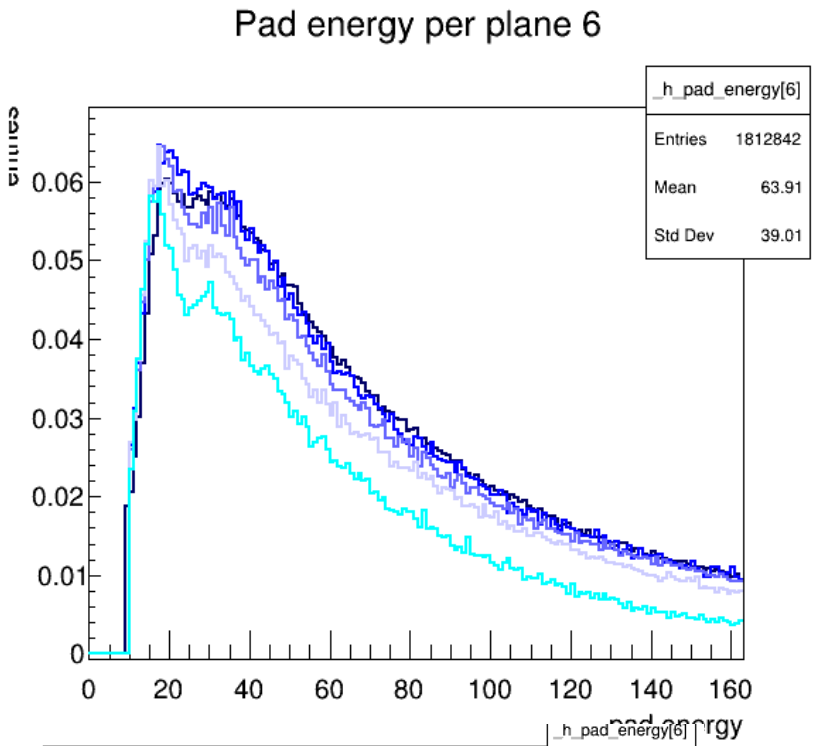


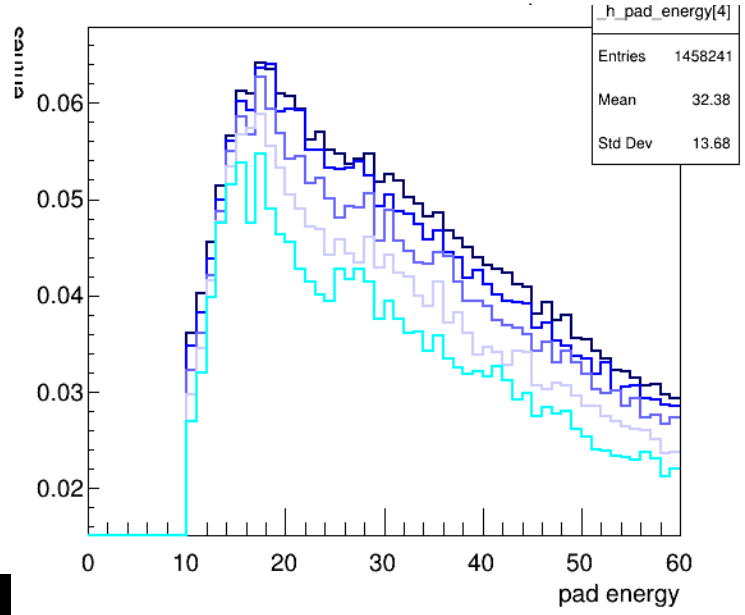

Mean energy
Energy [LSB]
1000
900
800
700
600
500
400
300
200
100
0
0
2
4
6
8
10
12
14
16
X0
OLD MC

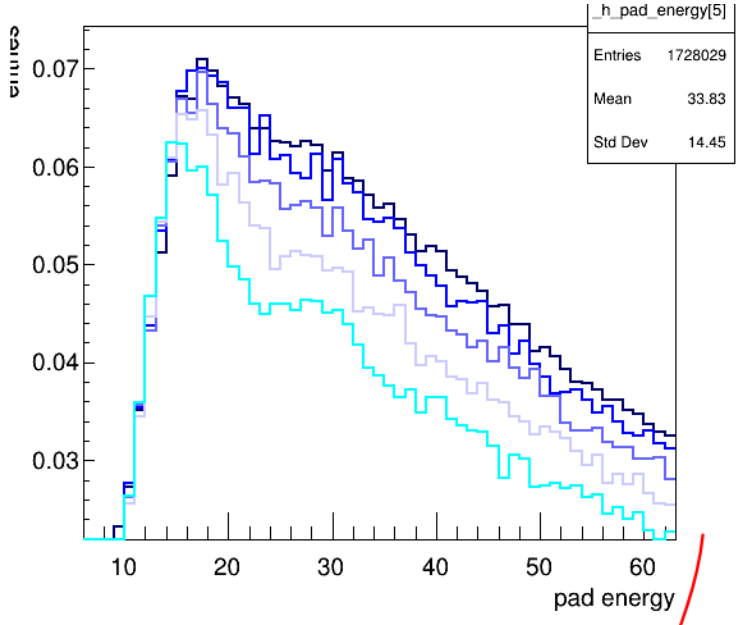
PAD ENERGY – 1GeV /2 / 3/ 4 / 5 -- DATA

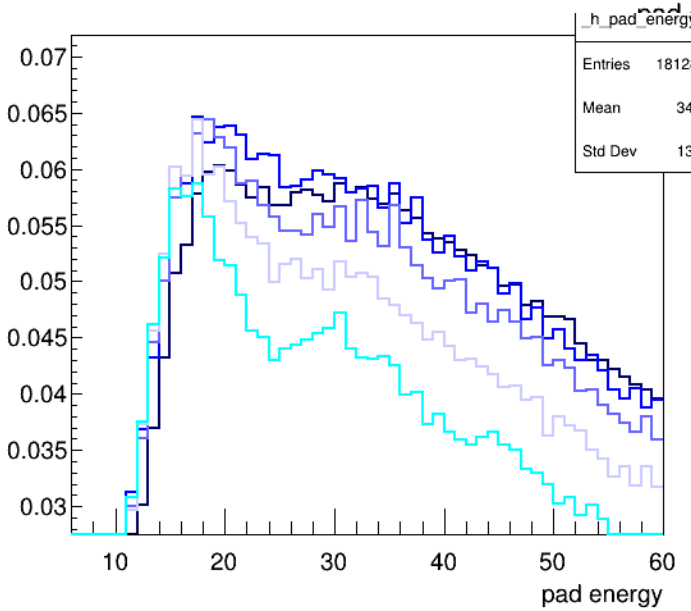




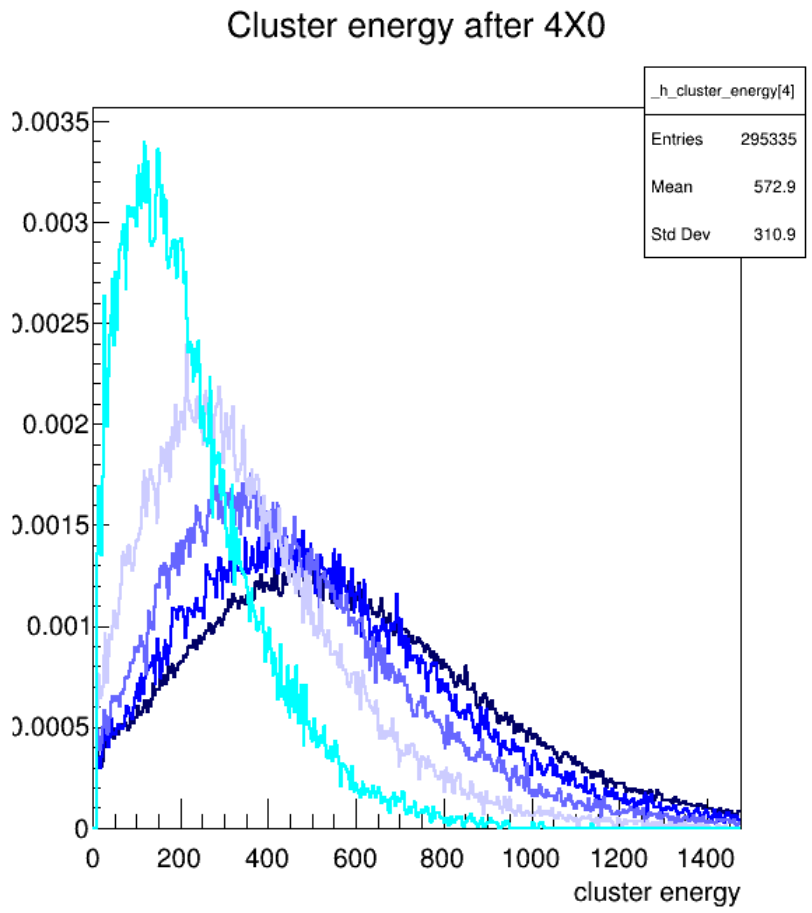


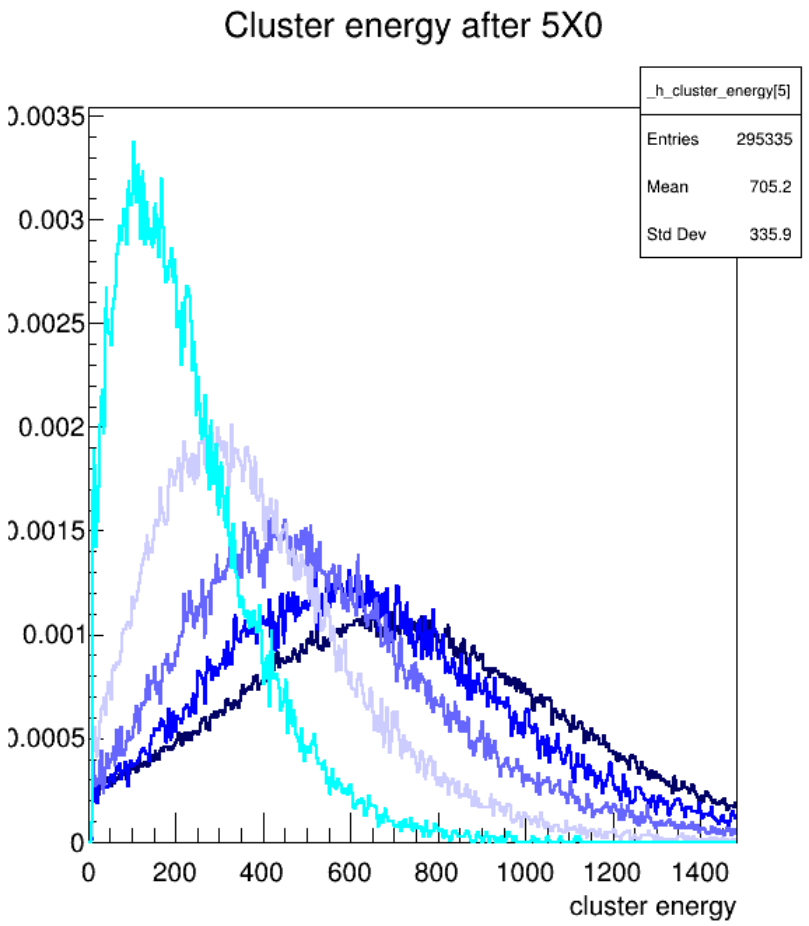


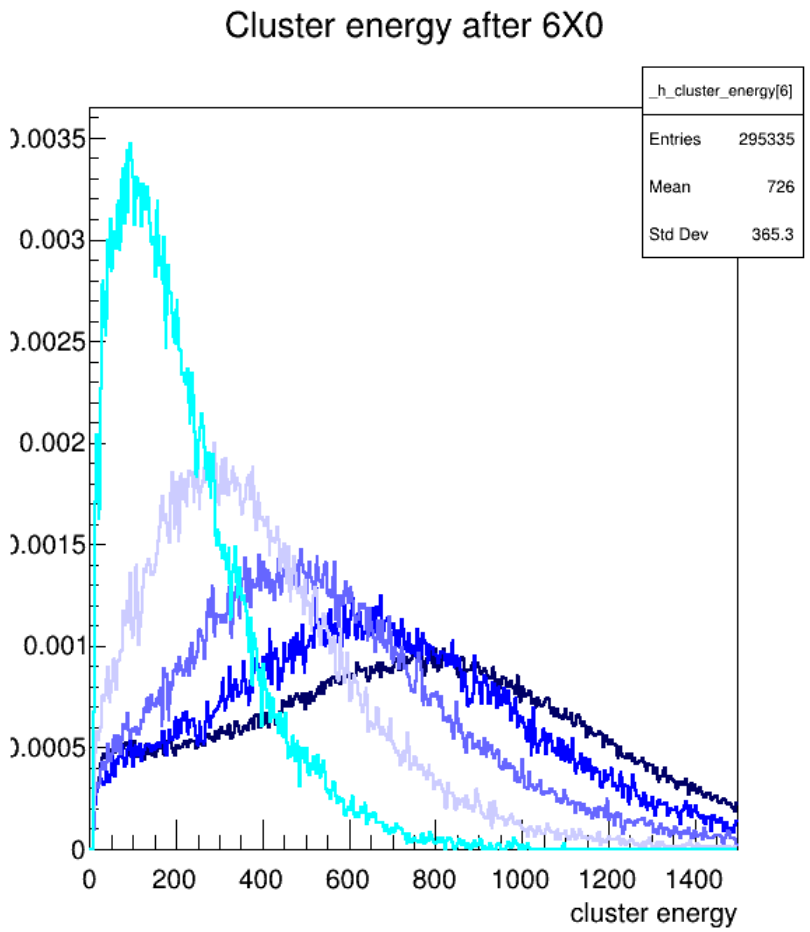




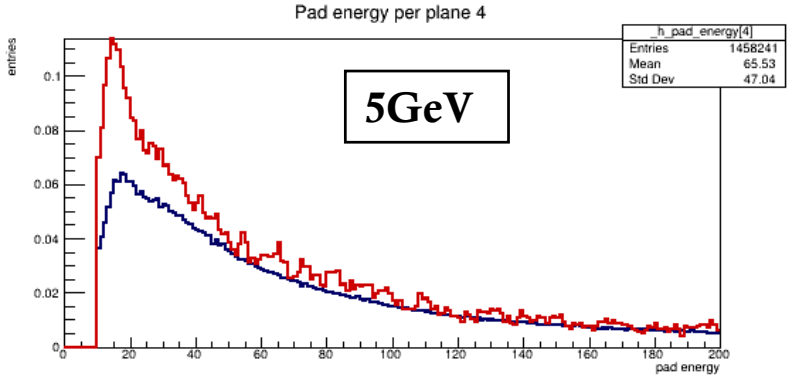
CLUSTER ENERGY – 1GeV /2 / 3/ 4 / 5 -- DATA

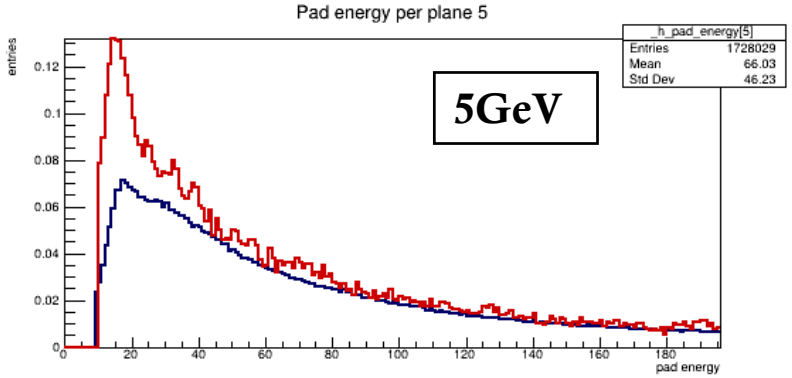


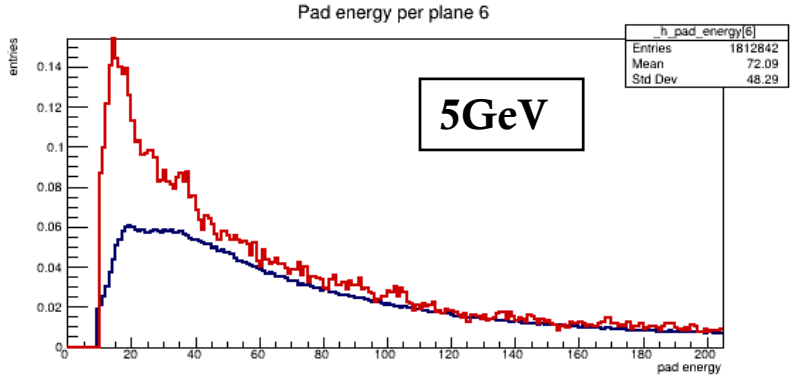


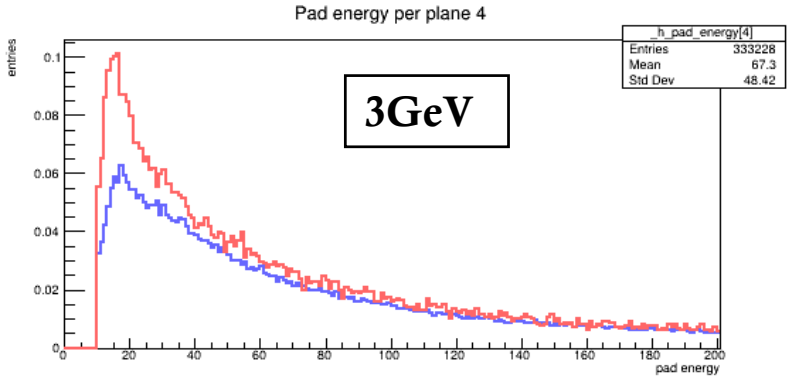


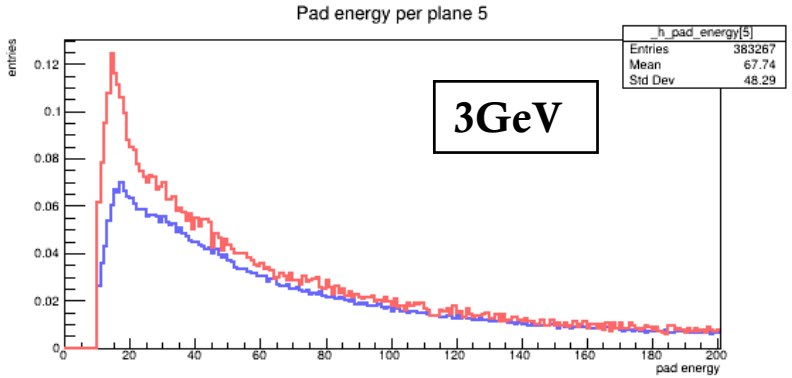
PAD ENERGY - DIFFERENT ENERGIES DATA (blue tone) vs MC (red tone)

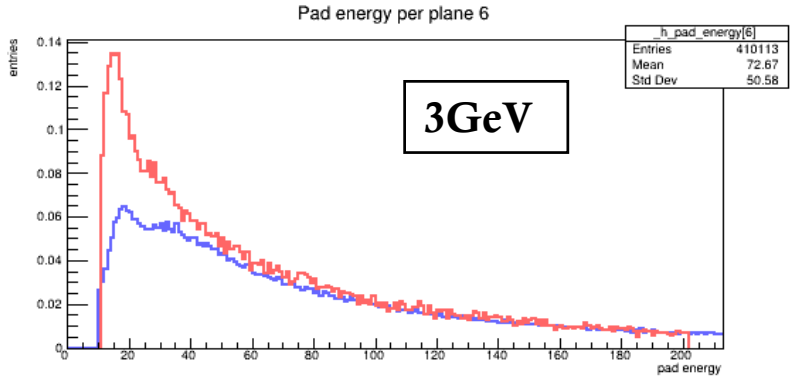


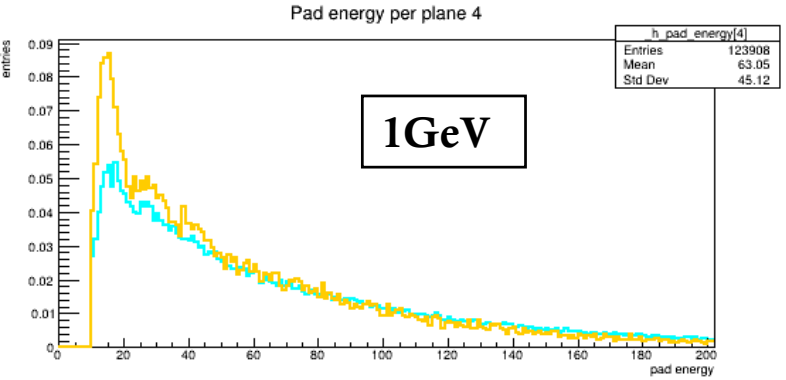


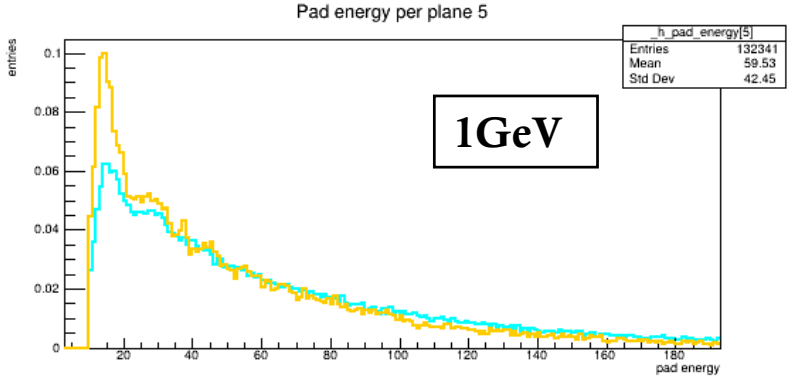


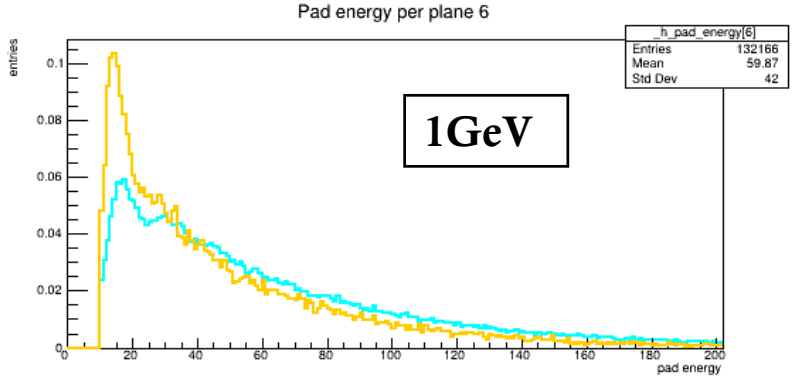




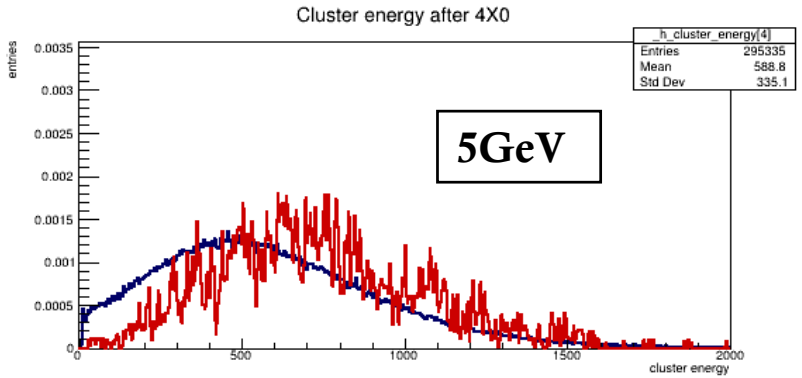


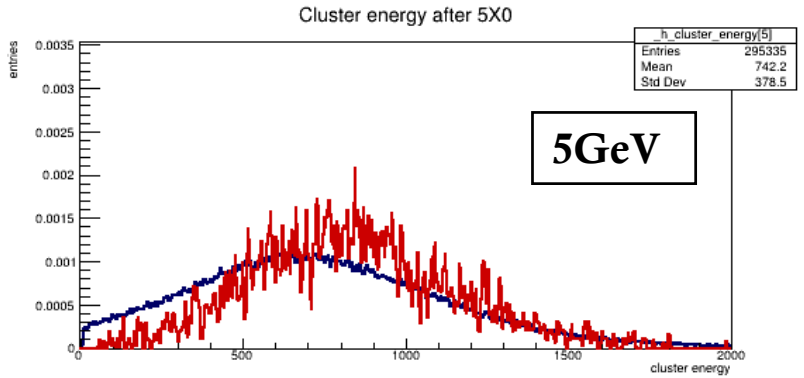


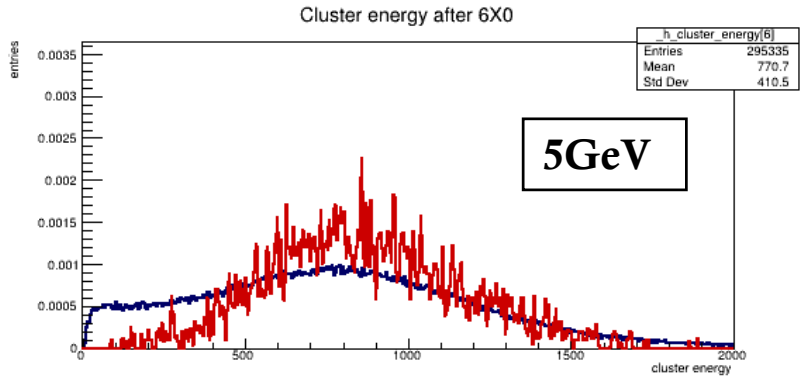


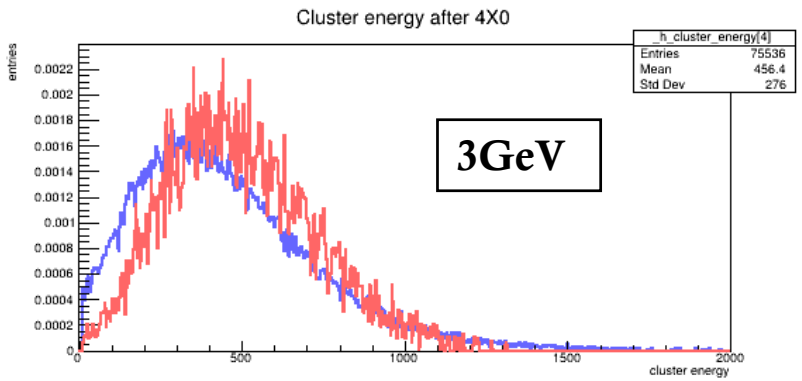


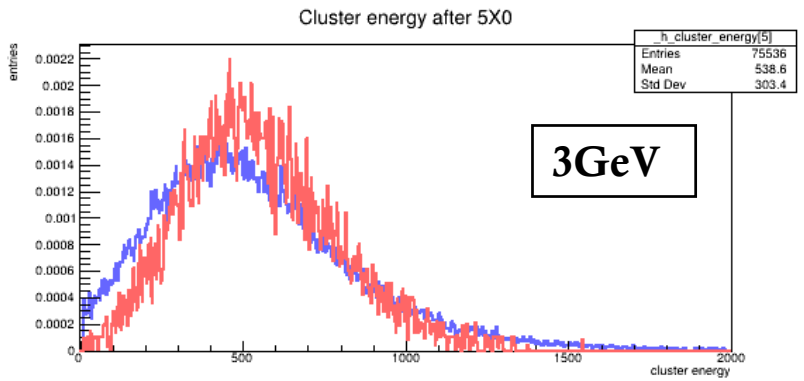
CLUSTER ENERGY - DIFFERENT ENERGIES DATA vs MC

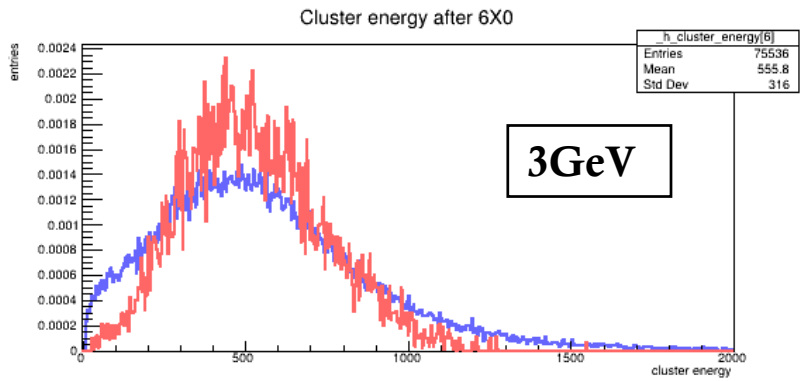


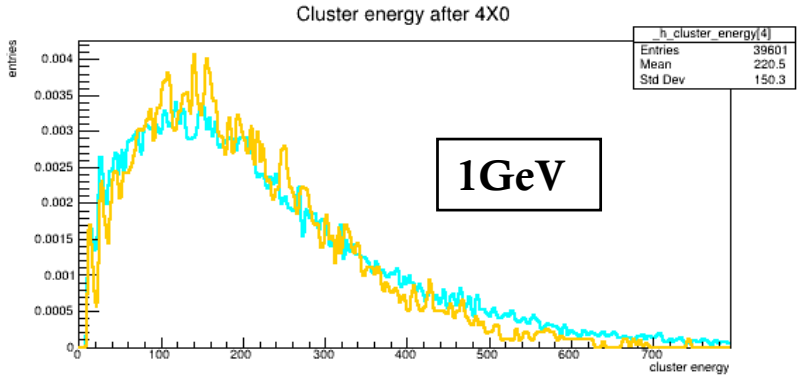


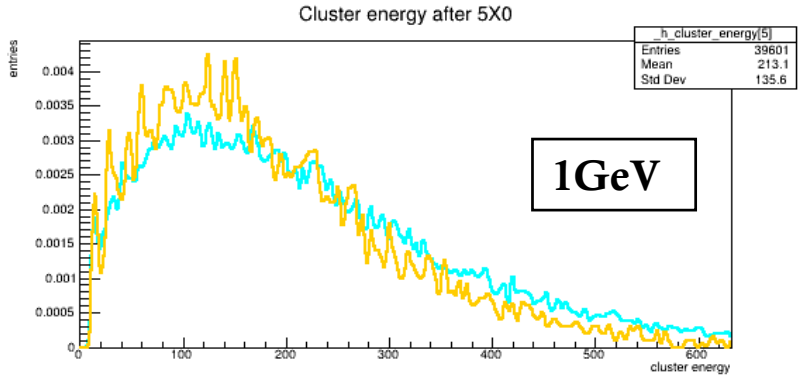


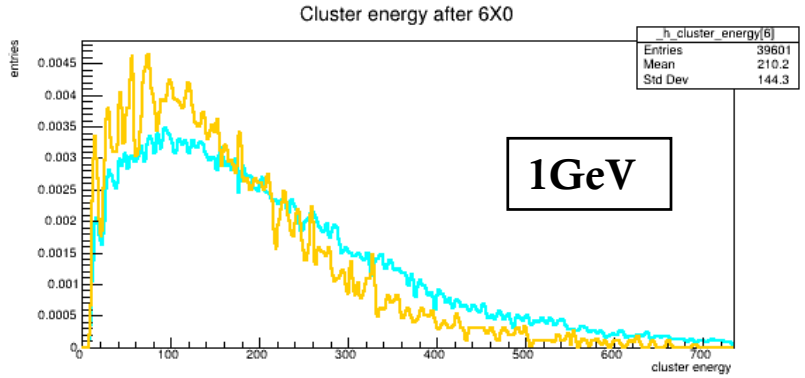




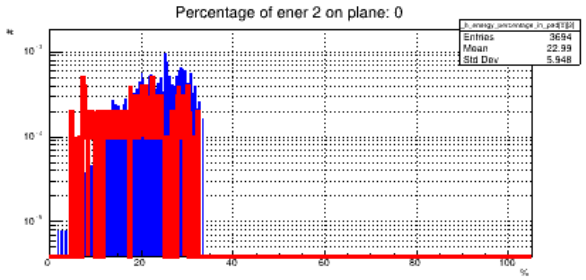


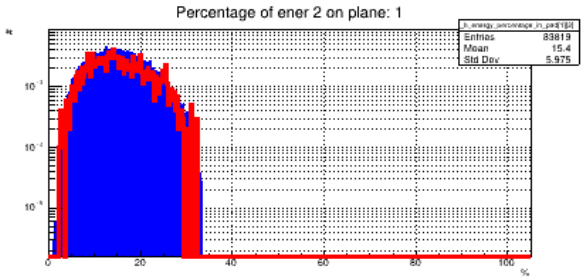


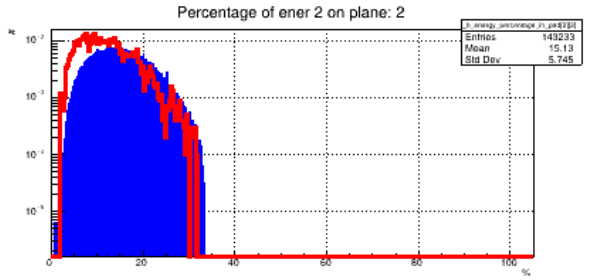


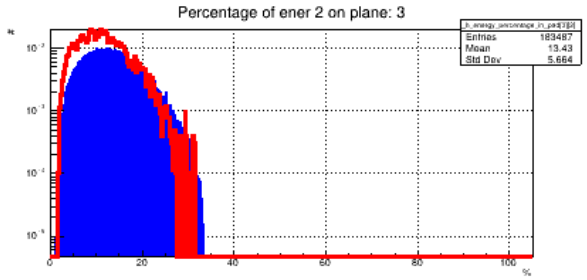


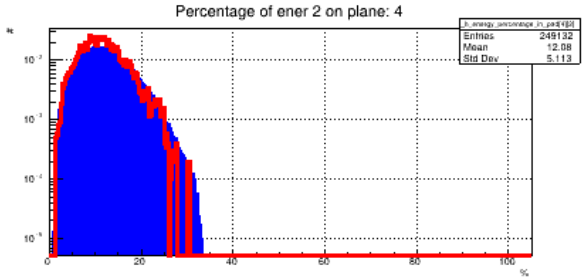
THE SECOND HIGHIEST ENERGY PAD / TOTAL CLUSTER ENERGY

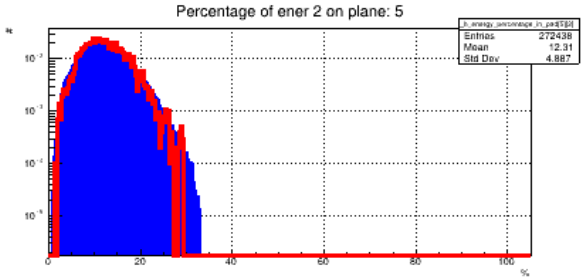


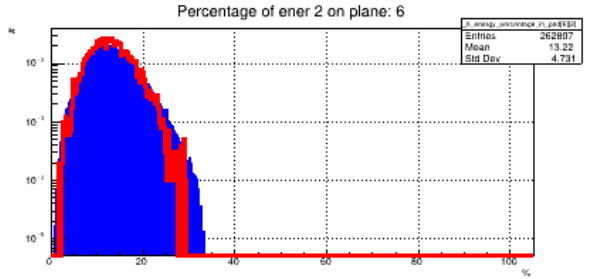


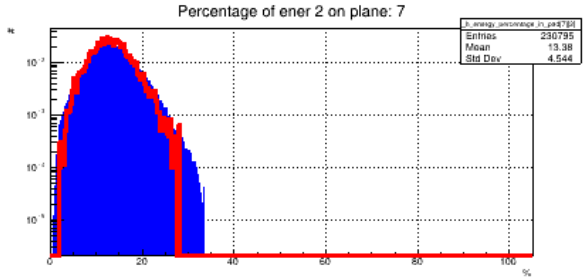


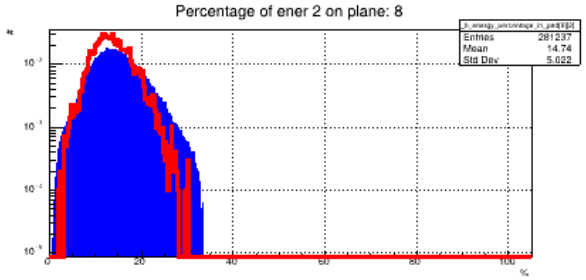


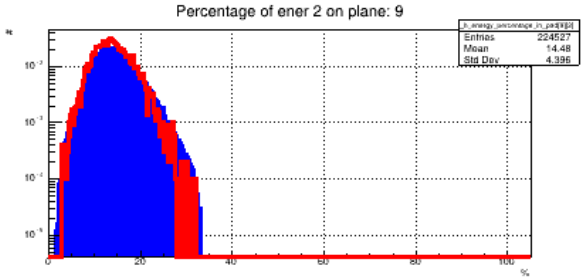


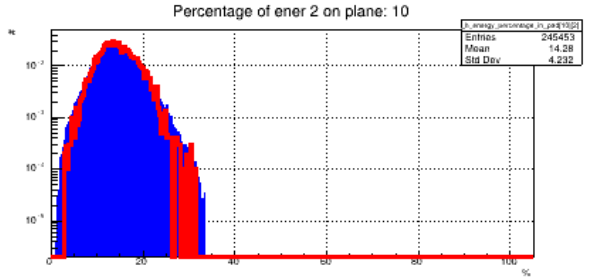


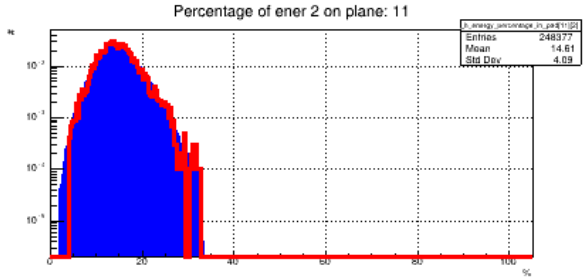


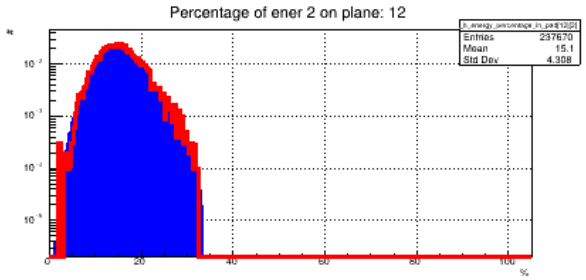


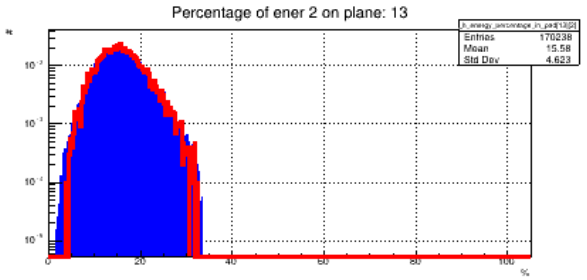


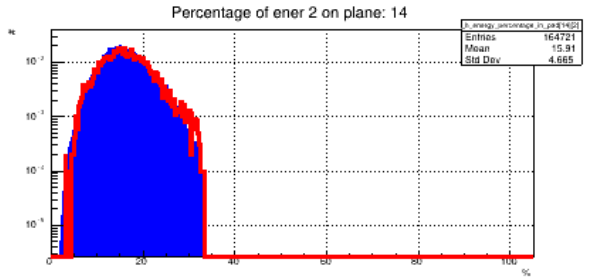


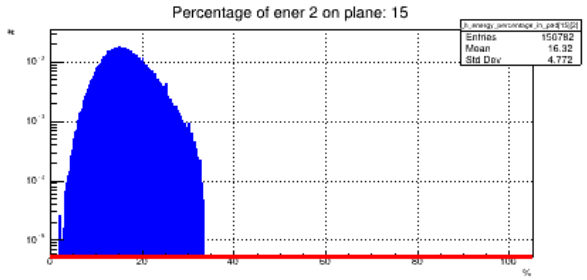




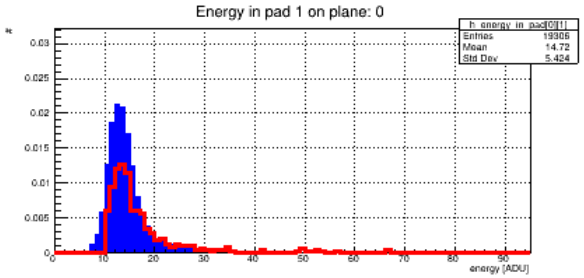


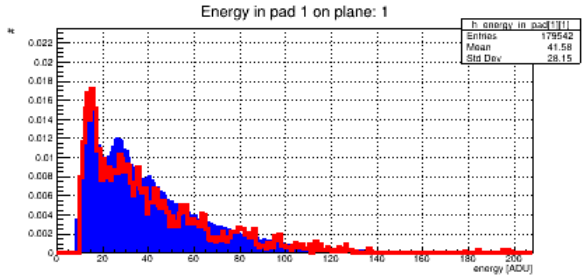


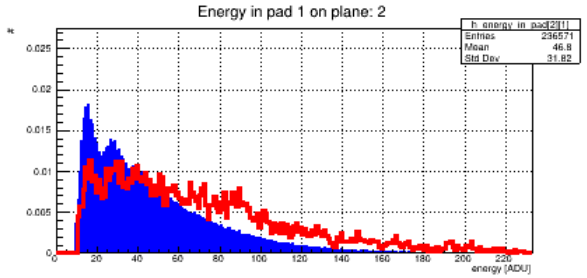


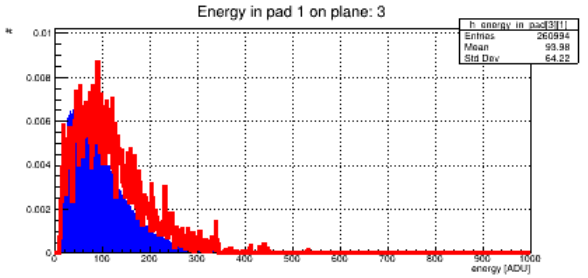


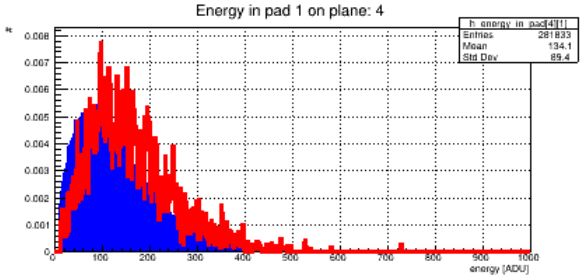
ENERGY SPECTRUM OF THE SECOND HIGHIEST ENERGY PAD

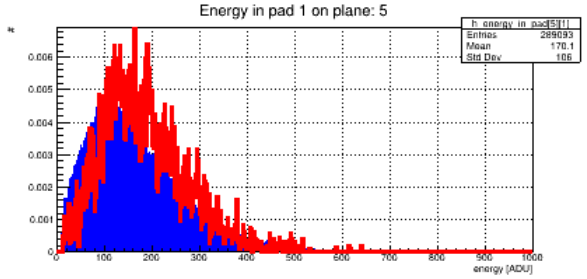


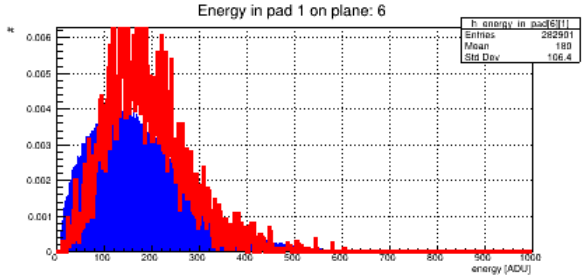


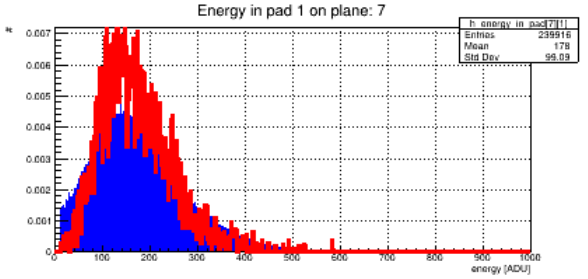


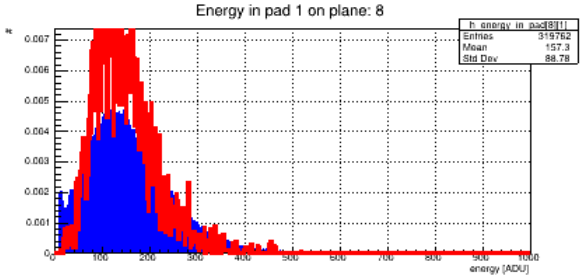


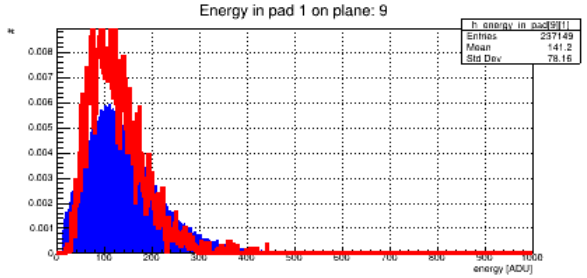


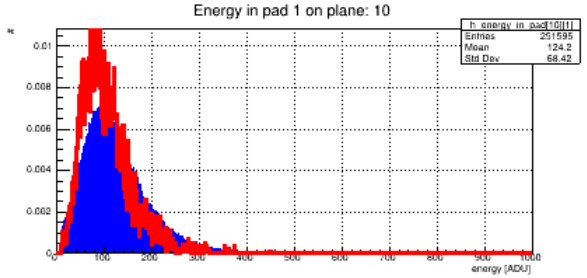


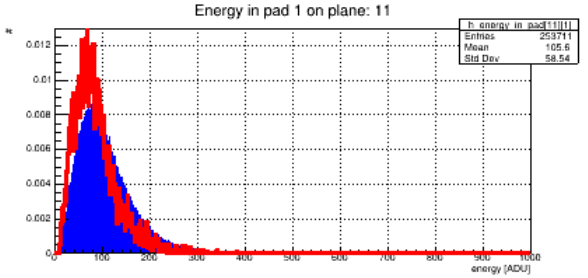


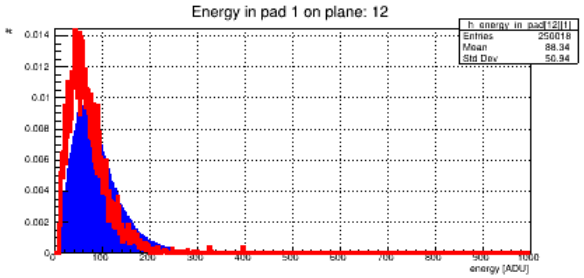


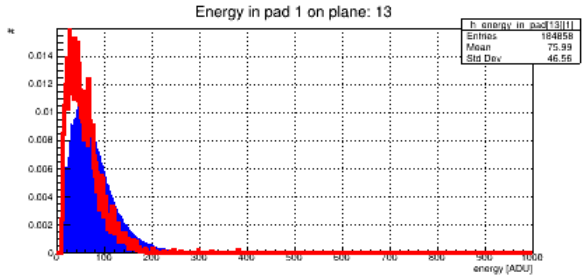


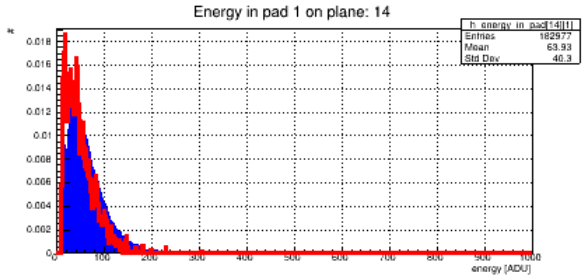


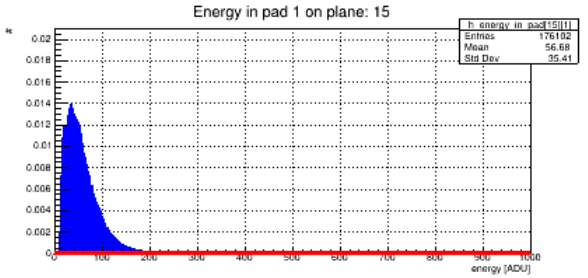




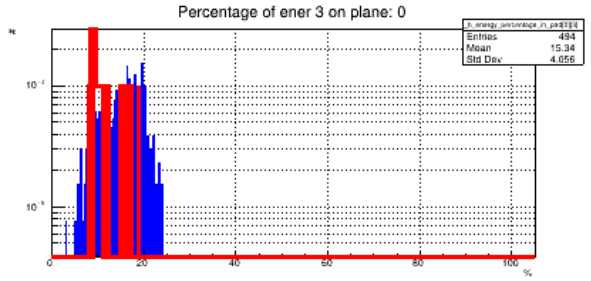


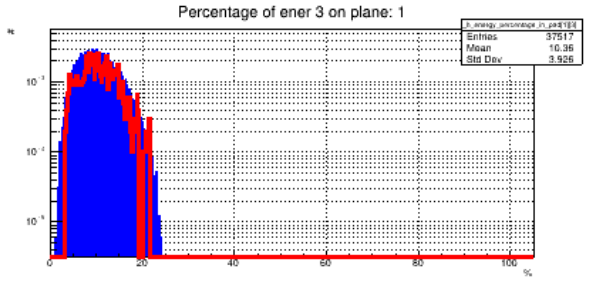


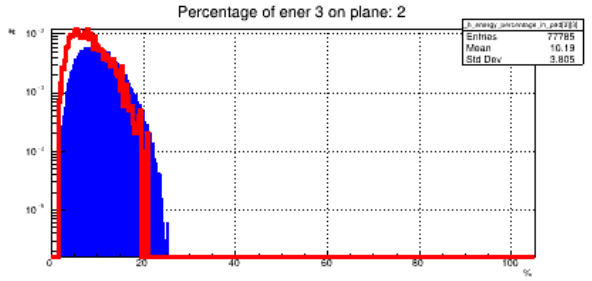


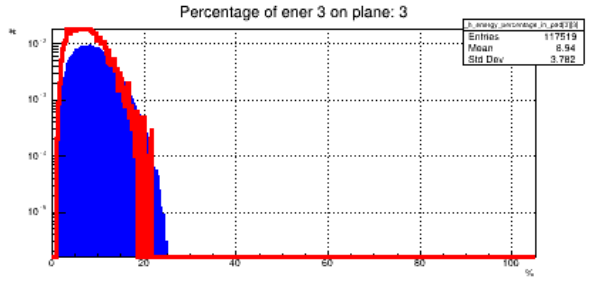


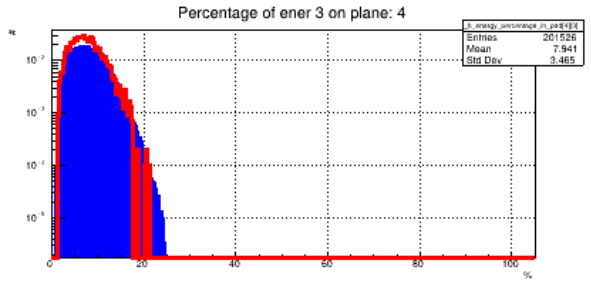
THE THIRD HIGHIEST ENERGY PAD (seed) / TOTAL CLUSTER ENERGY

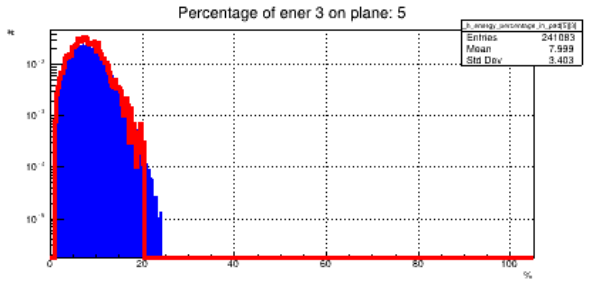


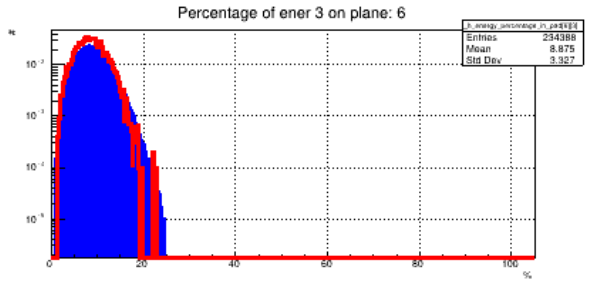


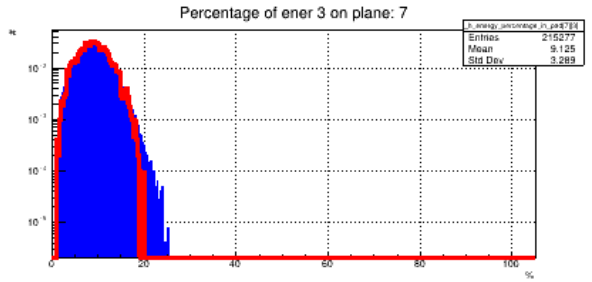


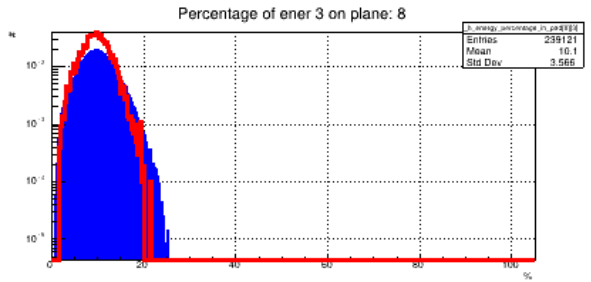


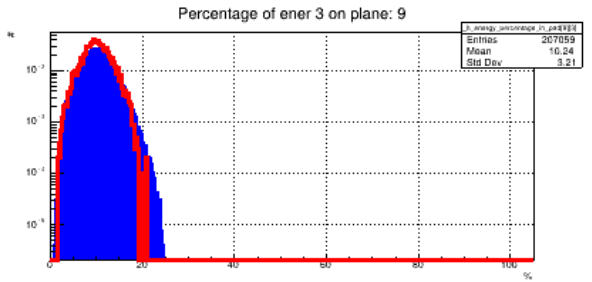


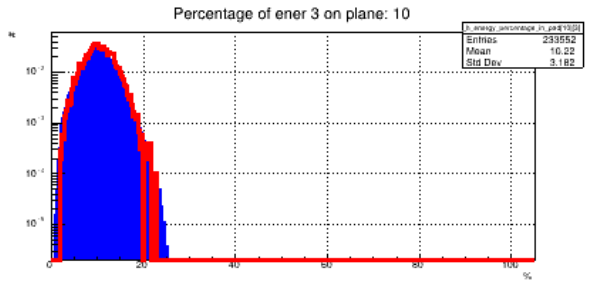


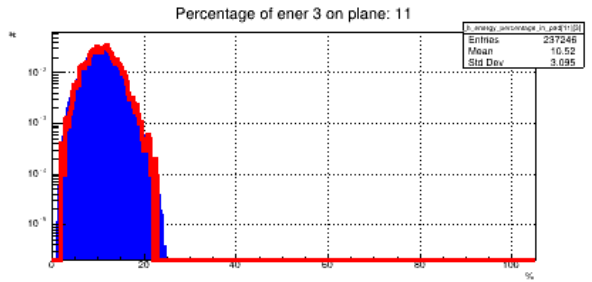


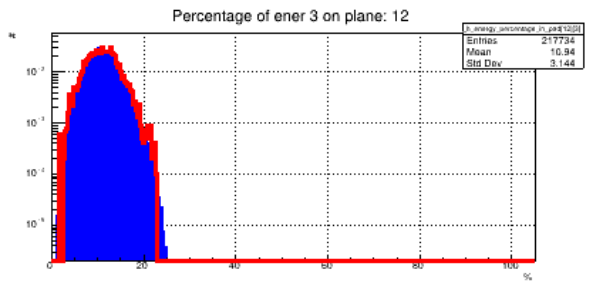


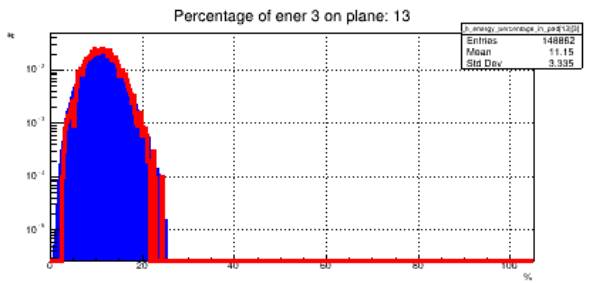


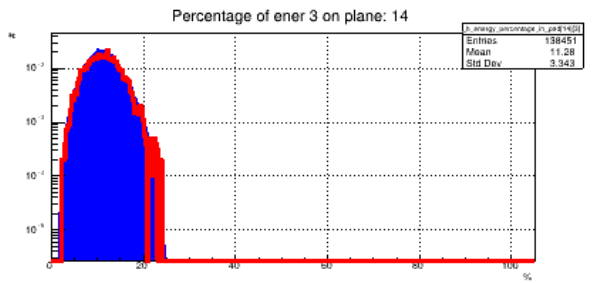


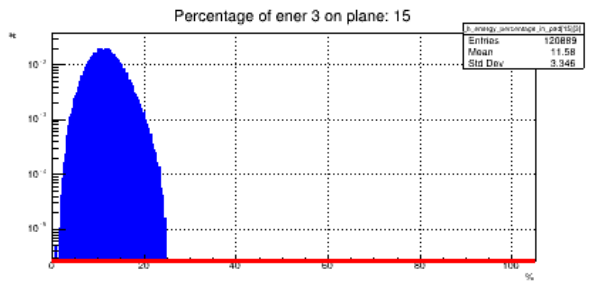




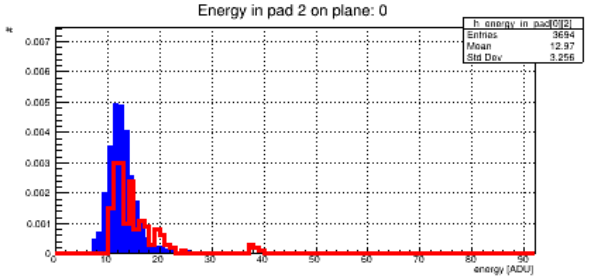


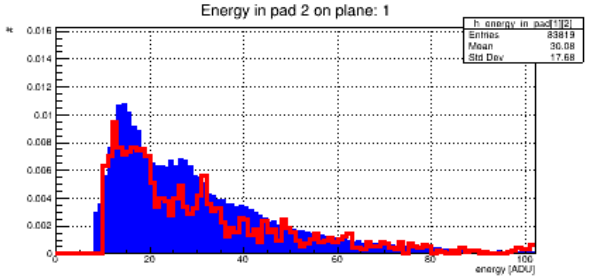


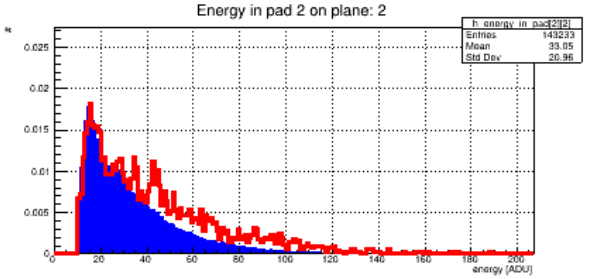


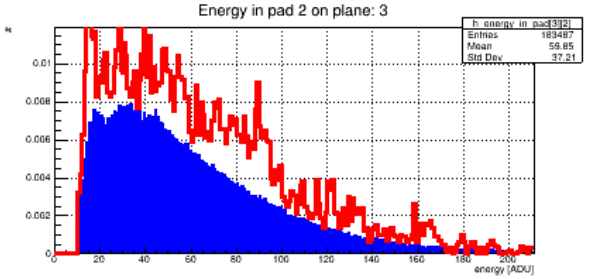


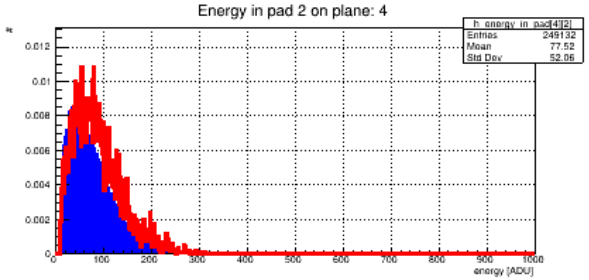
THE THIRD HIGHIEST ENERGY PAD SPECTRUM

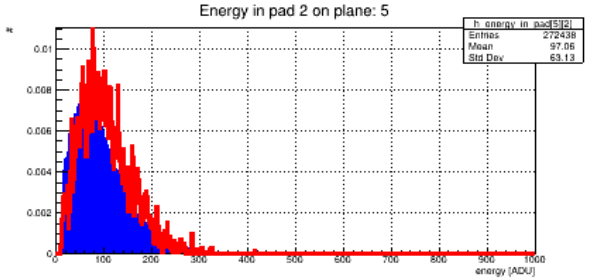


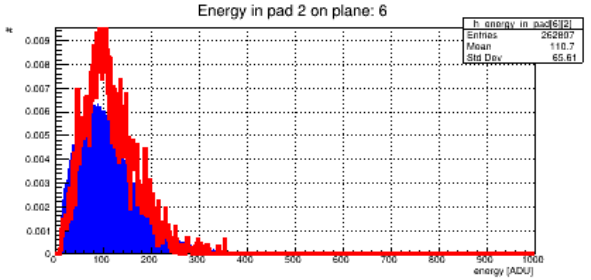


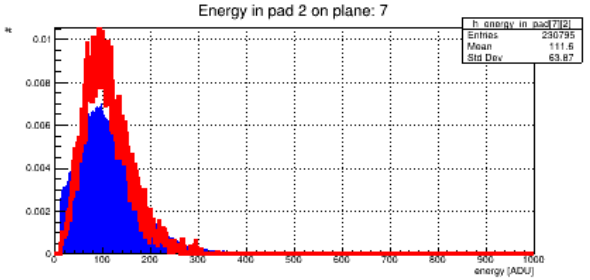


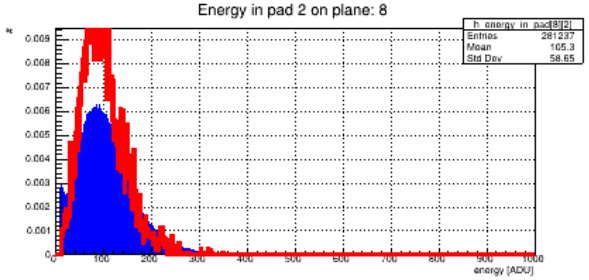


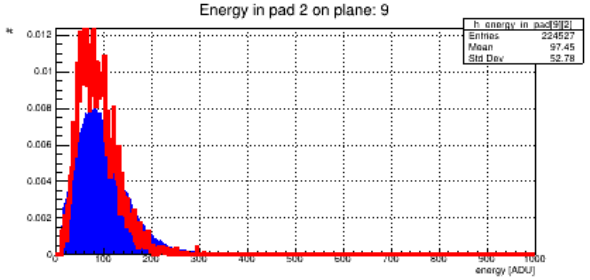


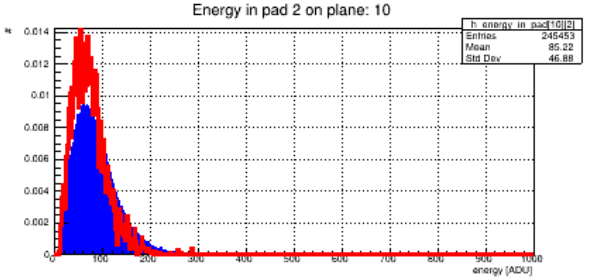


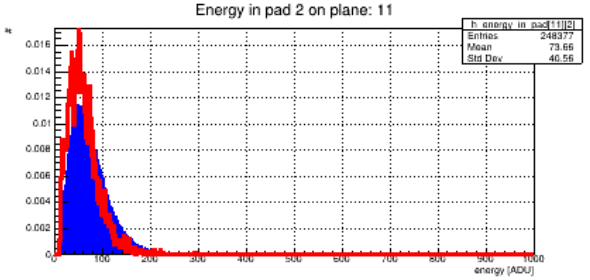


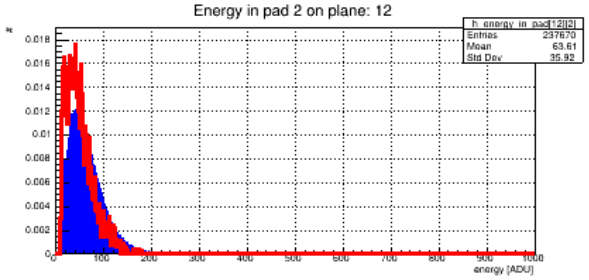


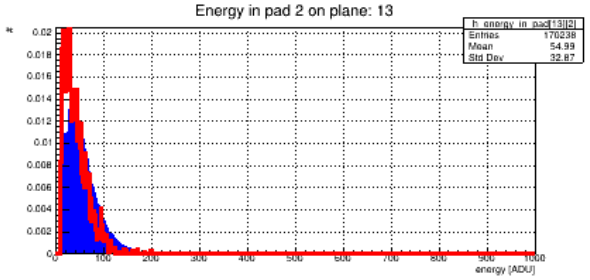


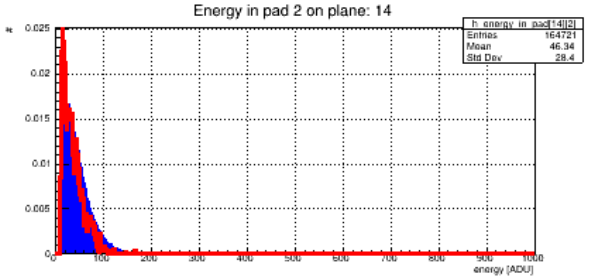


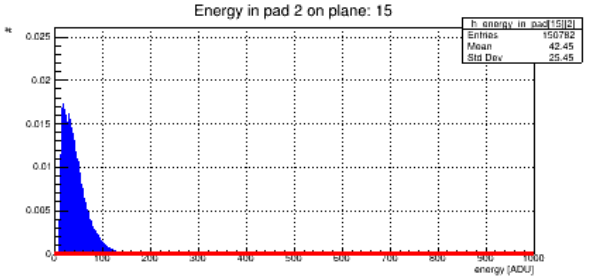












CS correlation

DATA

MC