Cosmics' deposited energy resolution

Lavinia Russo

Steps of the analysis

- I analyzed a run of cosmic rays taken at J-PARC with B field (run862)
- The data are reconstructed with hatRecon
- I looked at:
    - momentum reconstructed through the log(Q) method (Ulysse) → Don't know more ☺
    - dE/dx reconstructed with truncated mean method (Vlada)
- I disabled the merging between ERAMs

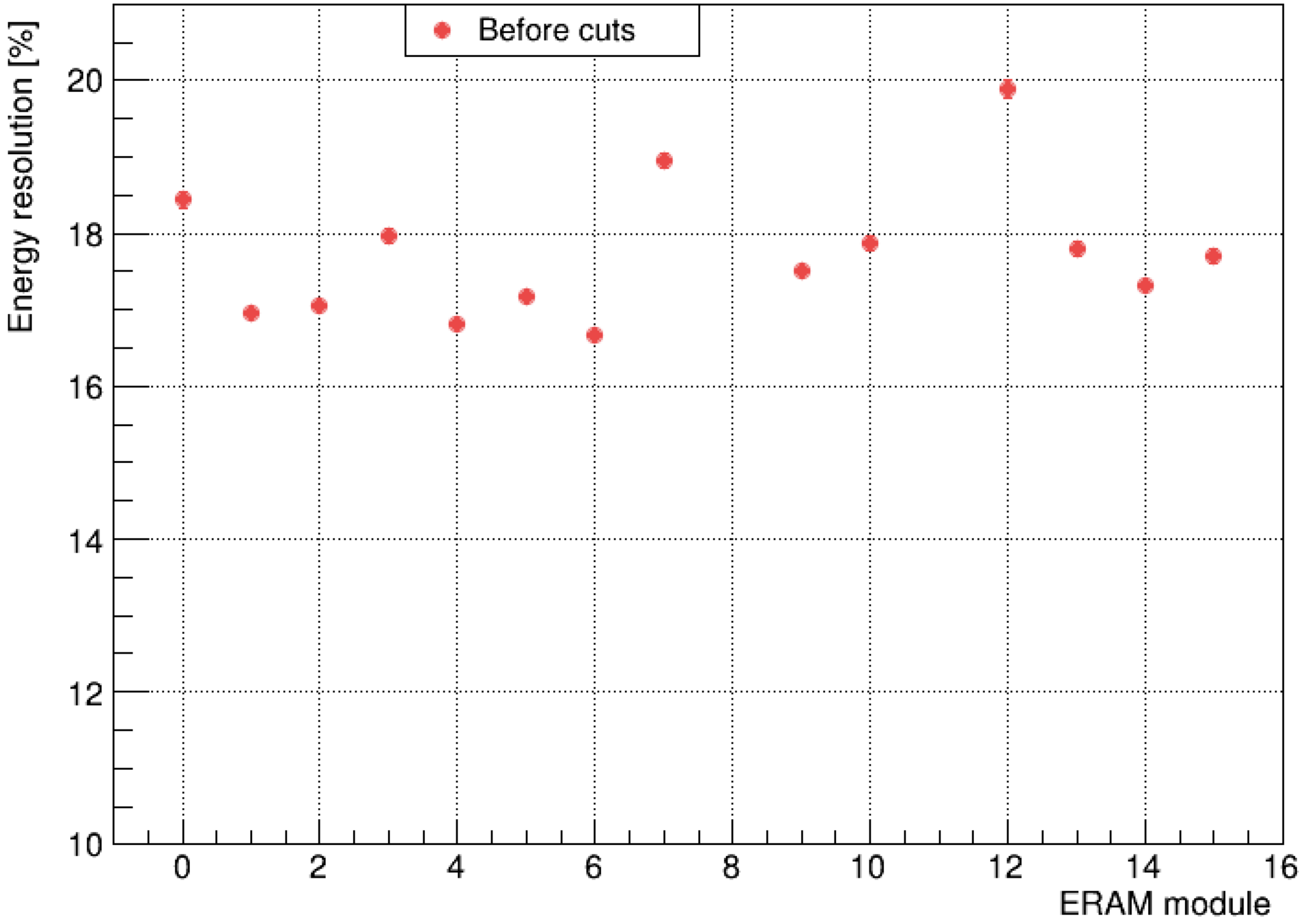
Module selection

End Plate 0	End Plate 1
pos[0] $<$ 0	pos[0] $>$ 0

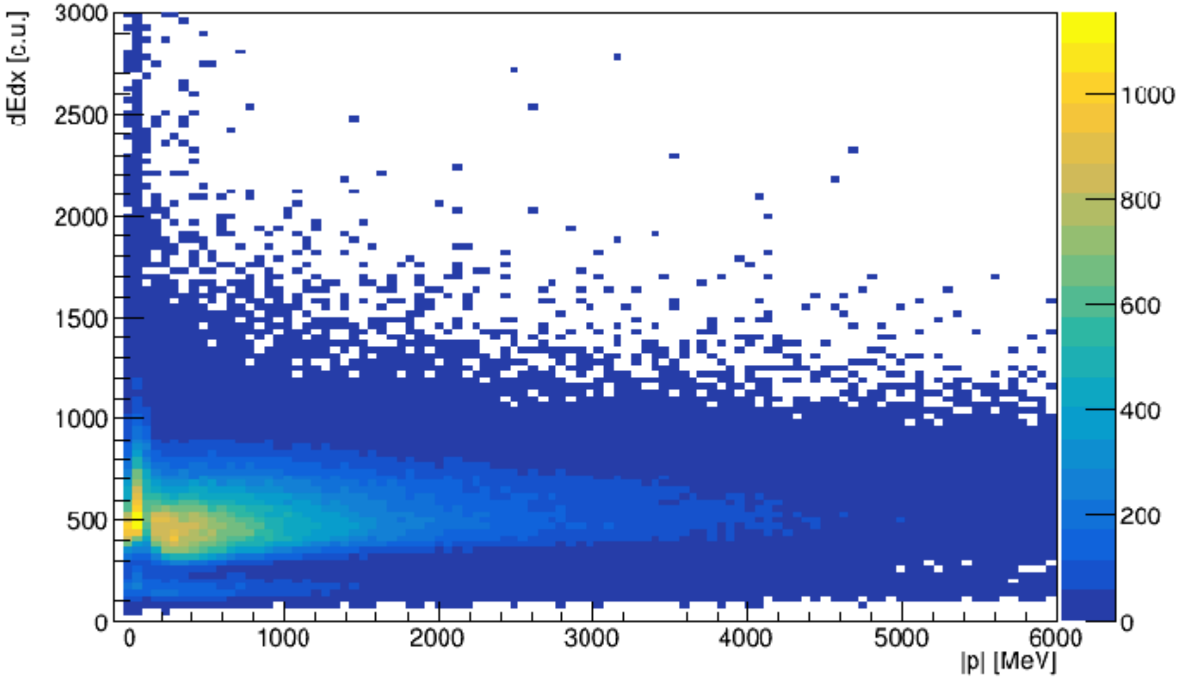
Row 0	Row 1
pos[1] $<$ -740	pos[1] $>$ -740

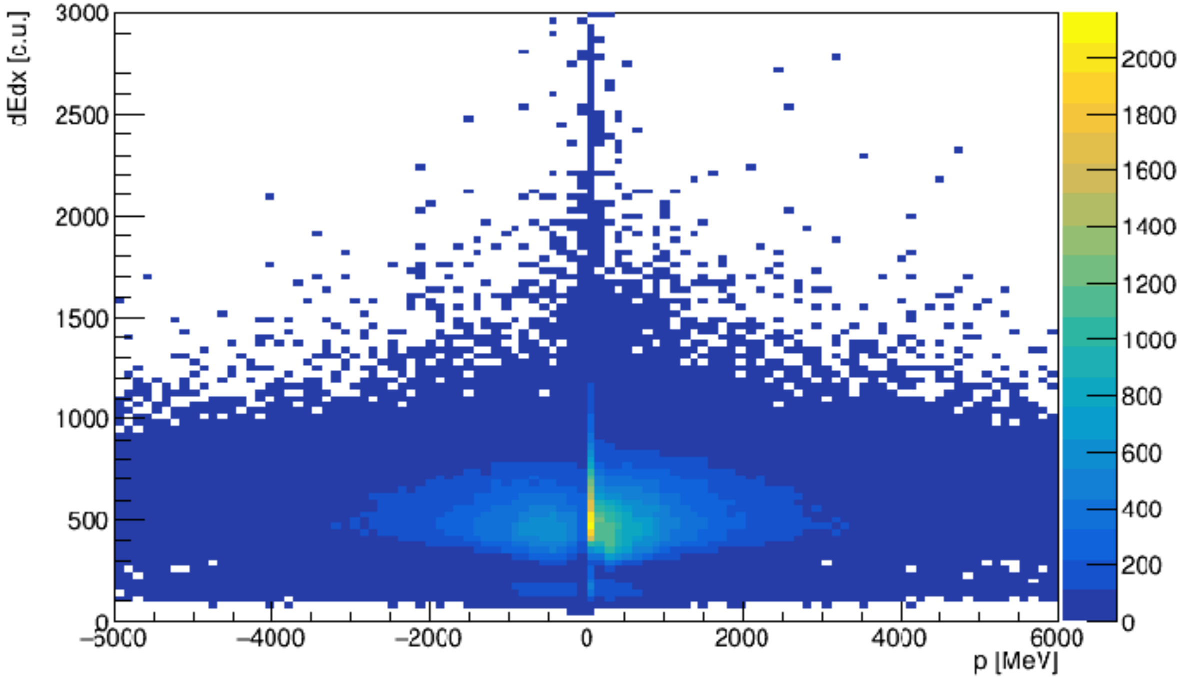
Col 0	Col 1	Col 2	Col 3
$-2790 \leq$ pos[2] < -2365	$-2365 \leq$ pos[2] < -1945	$-1945 \leq$ pos[2] < -1520	$-1520 \leq$ pos[2] < -1090

Energy resolution without cuts



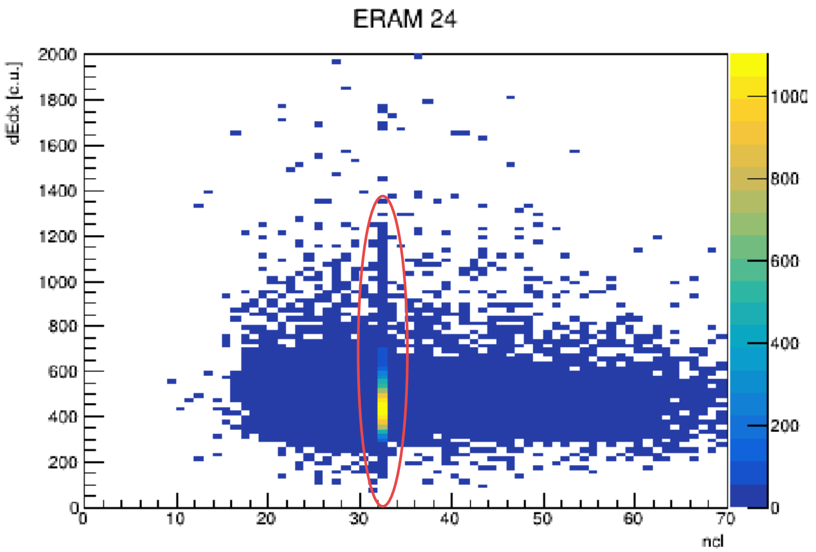
dEdx vs momentum

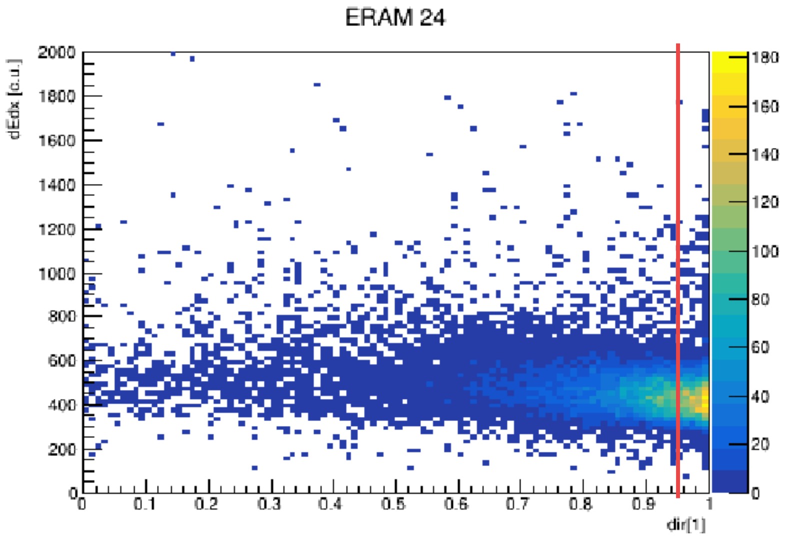


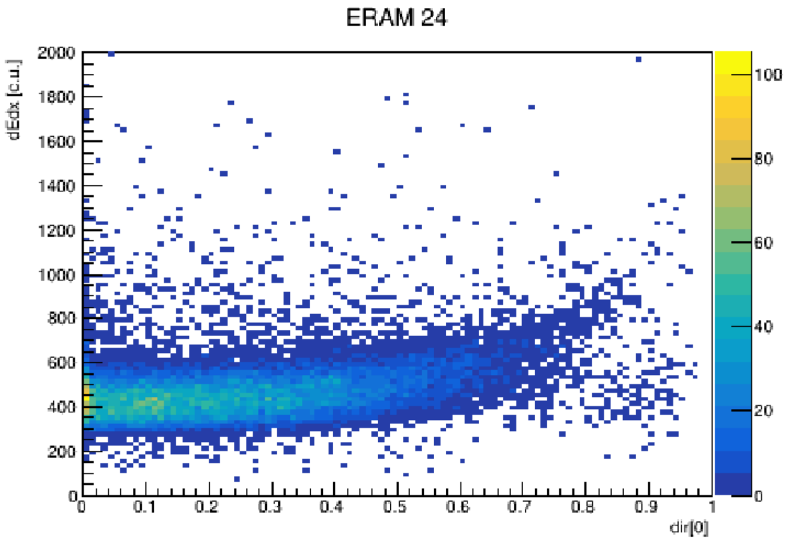


- electrons: |p|< 100 MeV
- muons: |p|> 0.4 GeV

Cuts







ncl = 32

Selection of tracks that cross all the module (merging is disabled)

abs(dir[1]) > 0.95

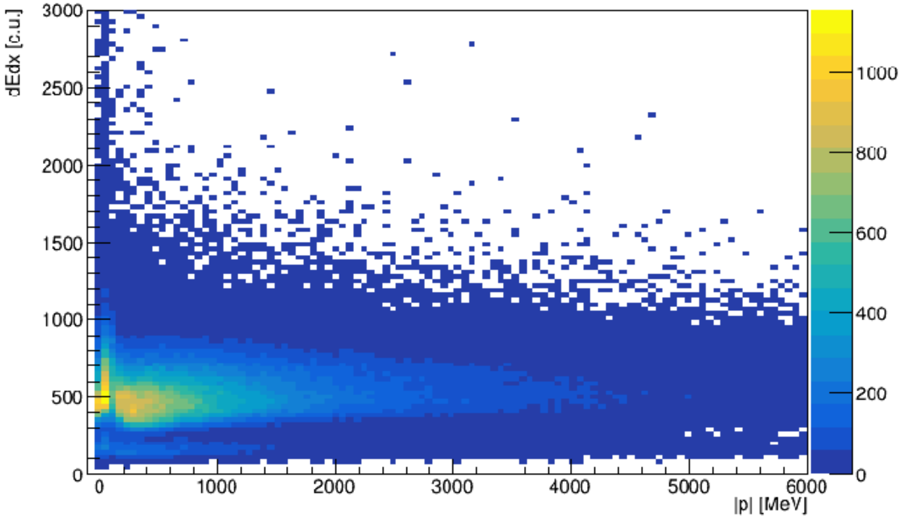
Selection of ~ vertical tracks

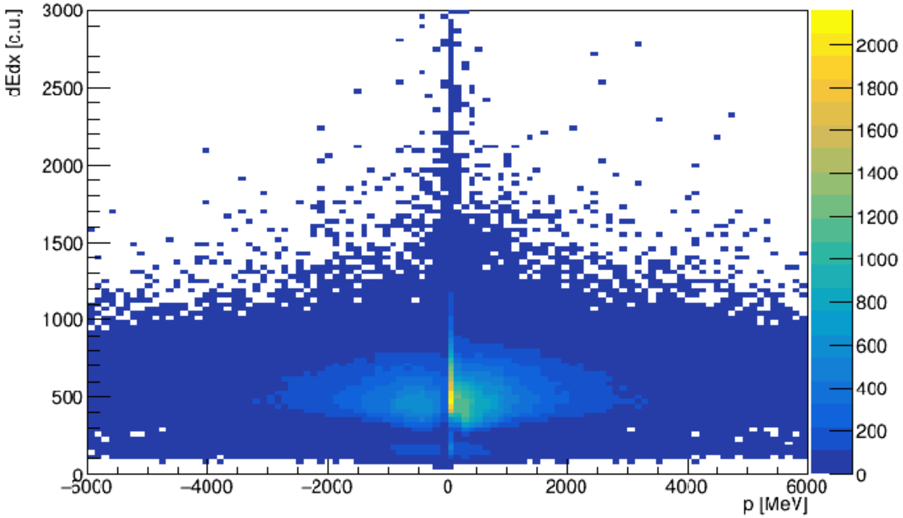
no cuts

Small dependence on dir[0]: the longer the track in dir[0], the more it deposits on the same pad

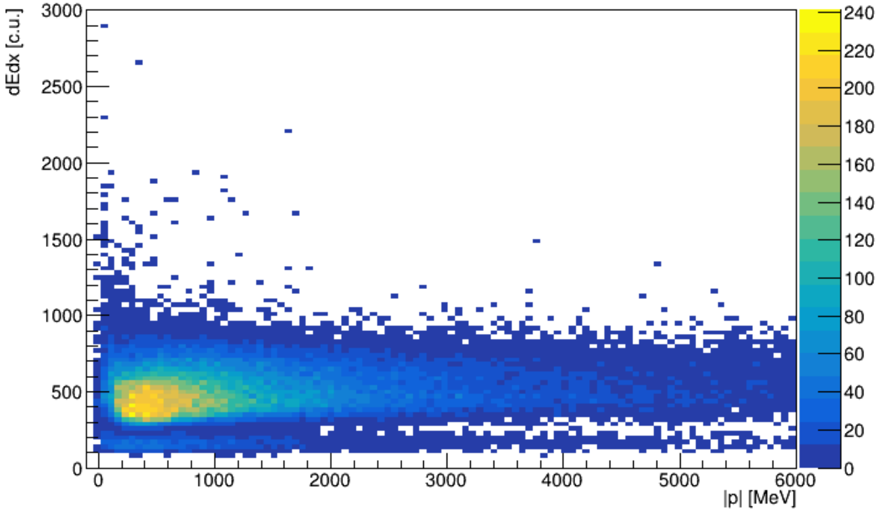
dEdx vs momentum

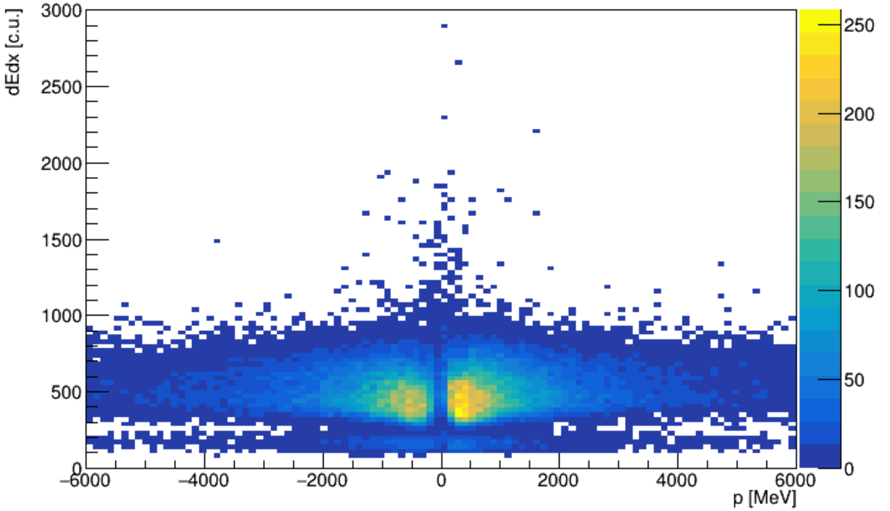
Before cuts:



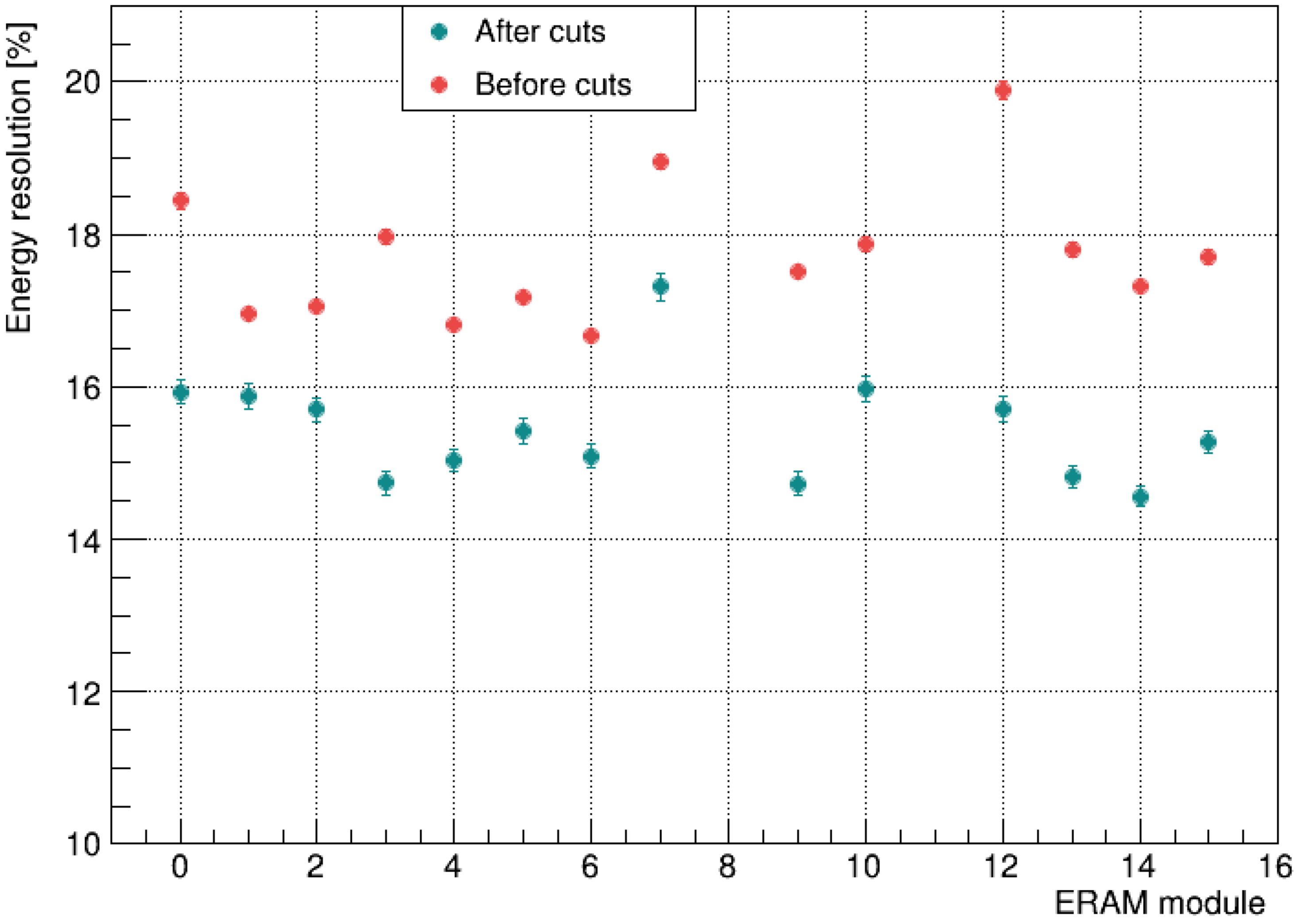


After cuts:
no more electrons for
|p|< 100 MeV

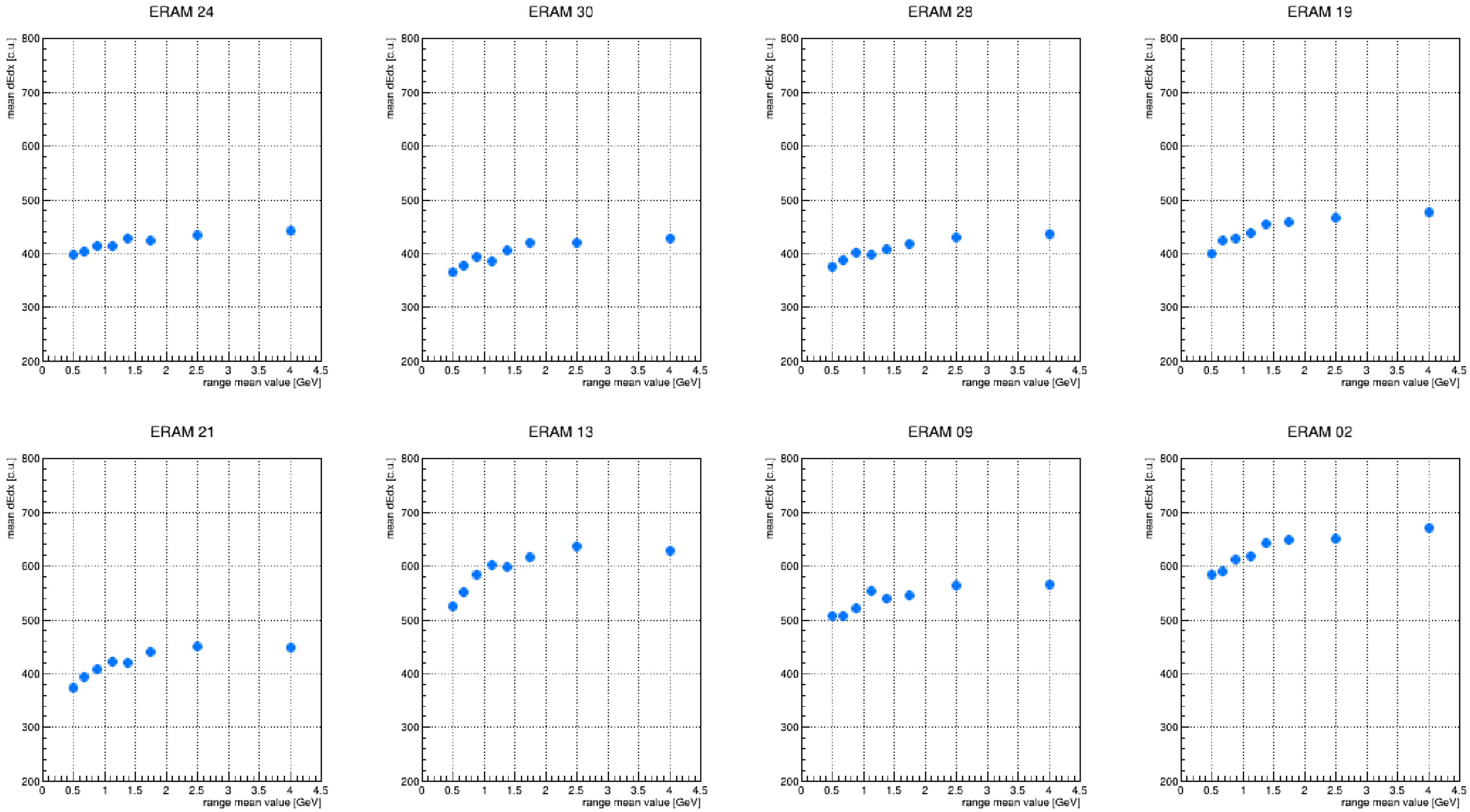




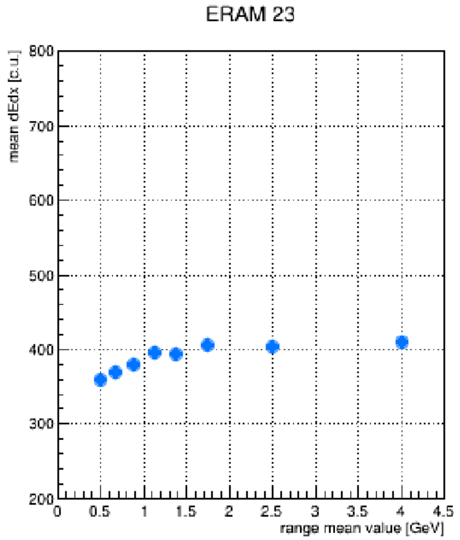
Energy resolution before and after cuts

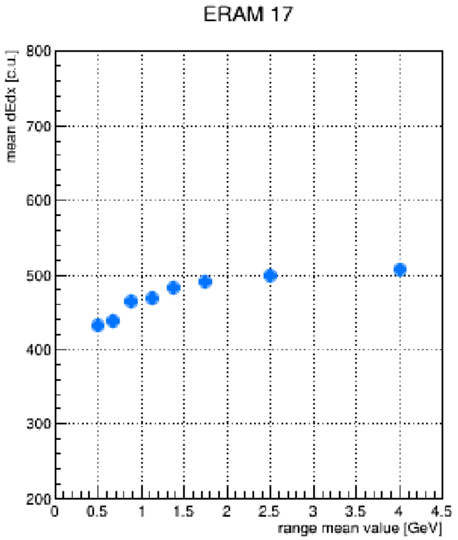


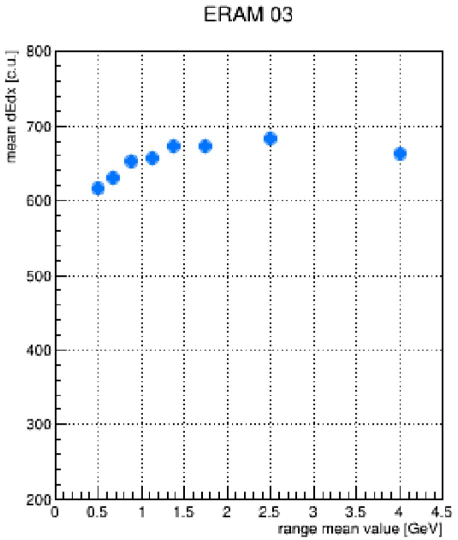
Mean dEdx for different |p| ranges

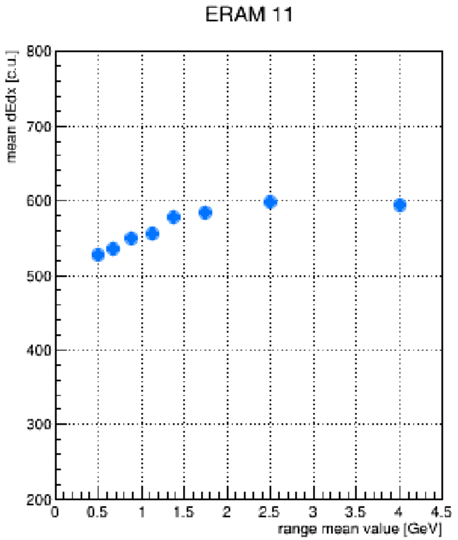


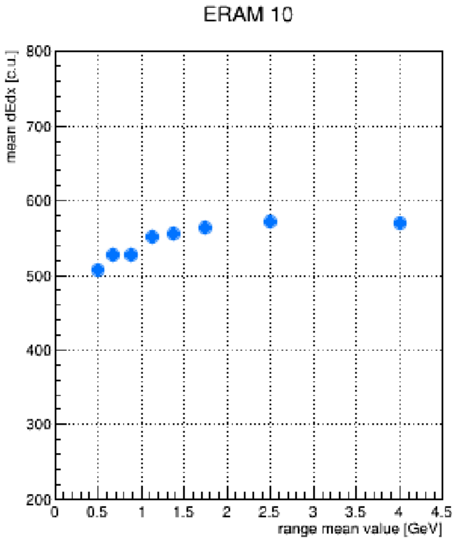
Mean dEdx for different |p| ranges

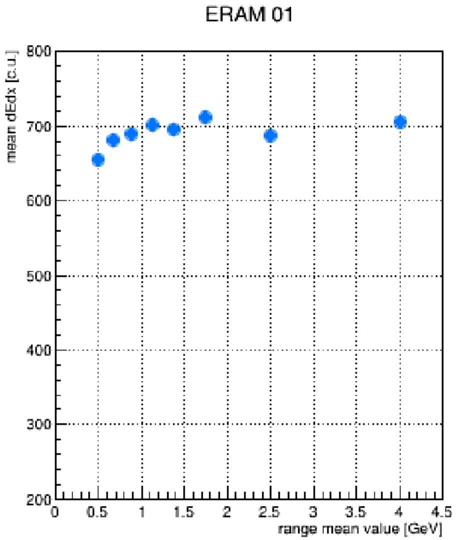




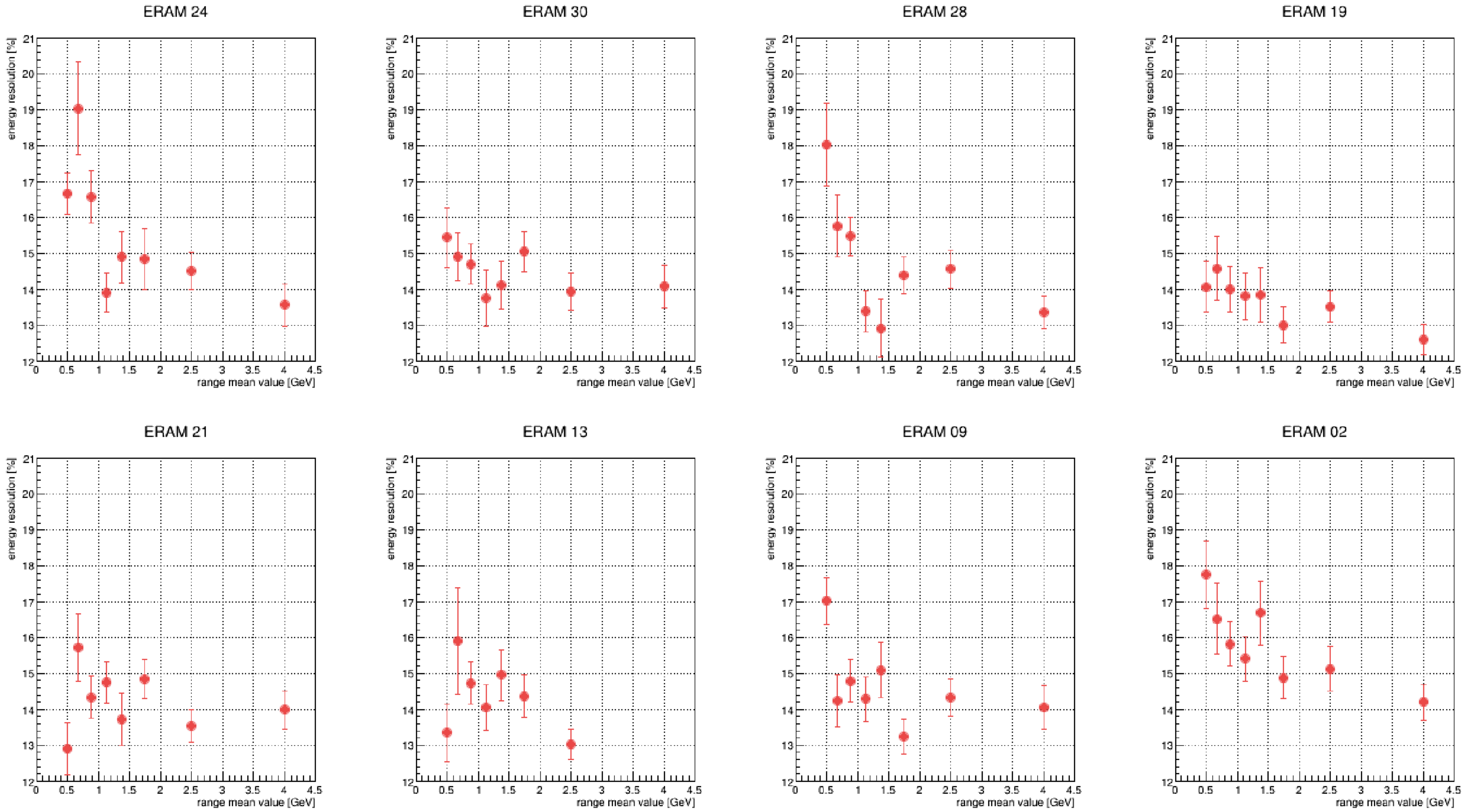




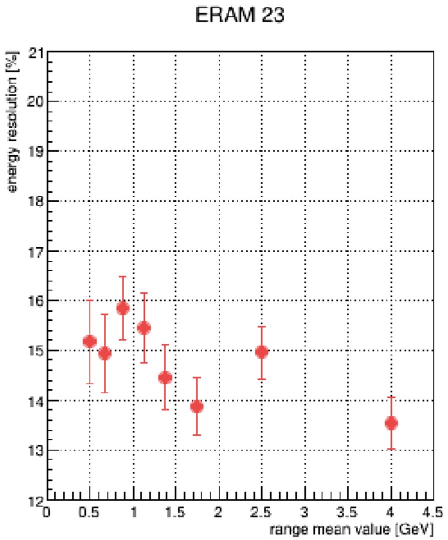


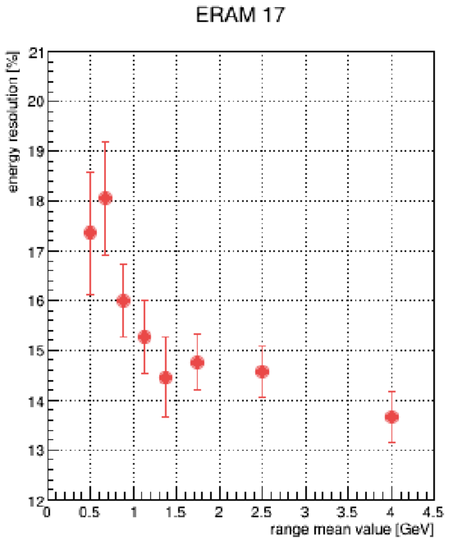


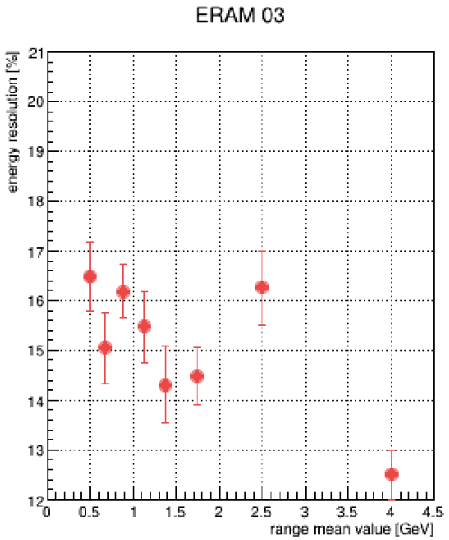
Energy resolution for different |p| ranges

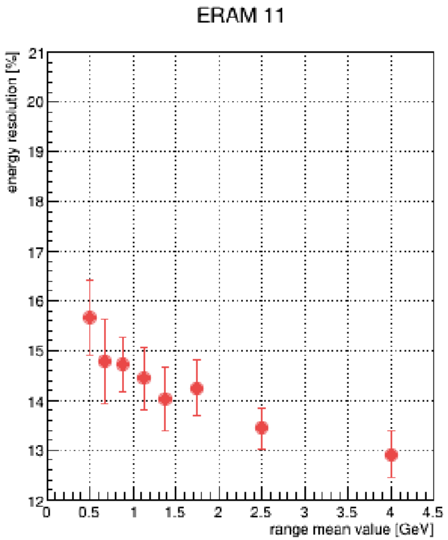


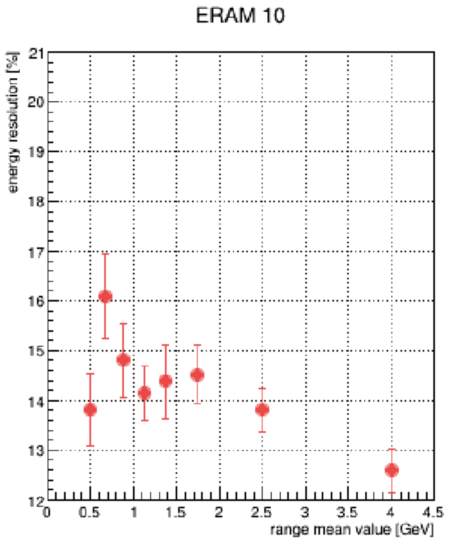
Energy resolution for different |p| ranges

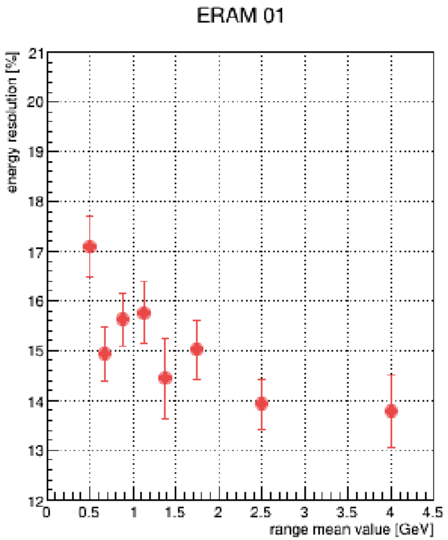




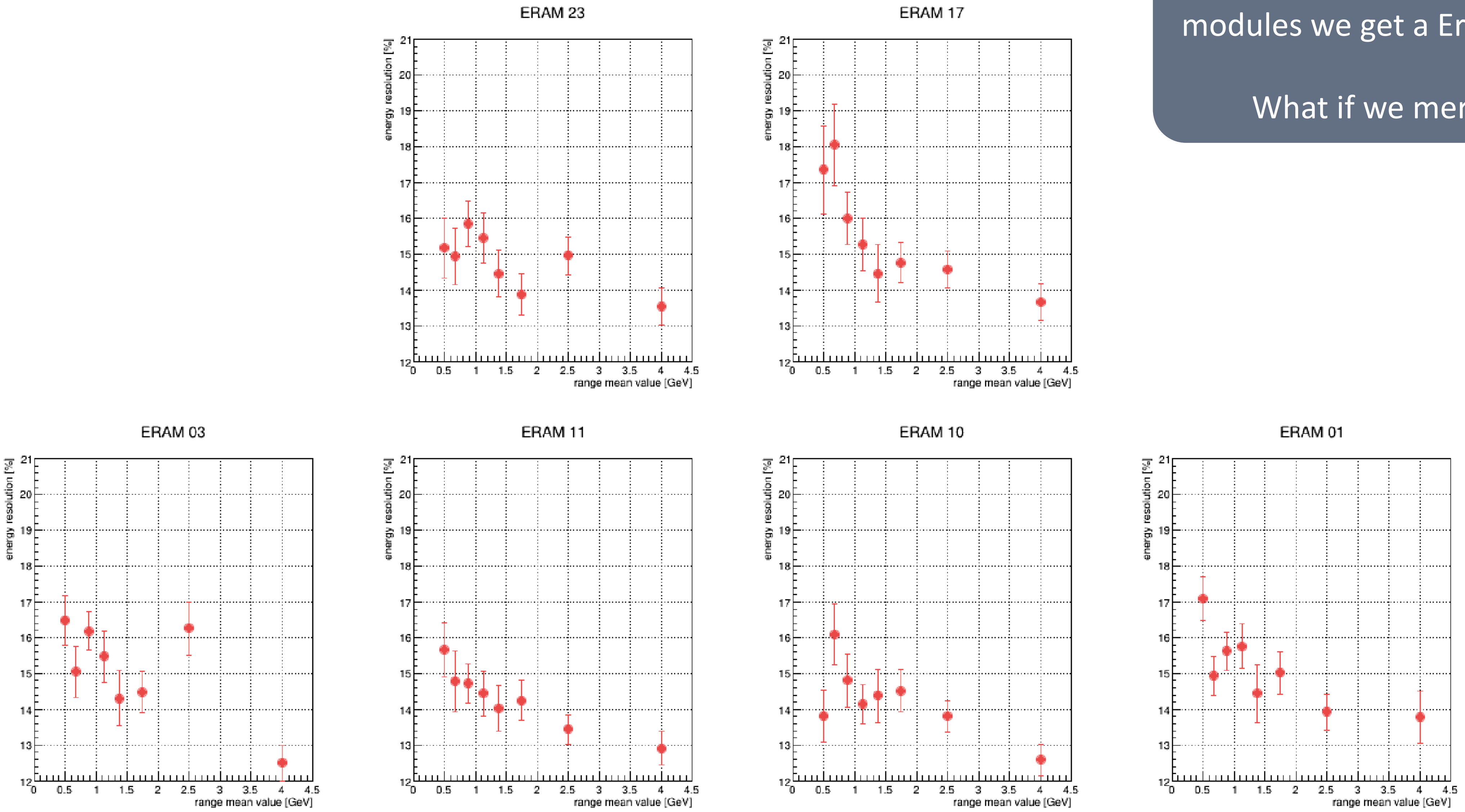








Energy resolution for different |p| ranges

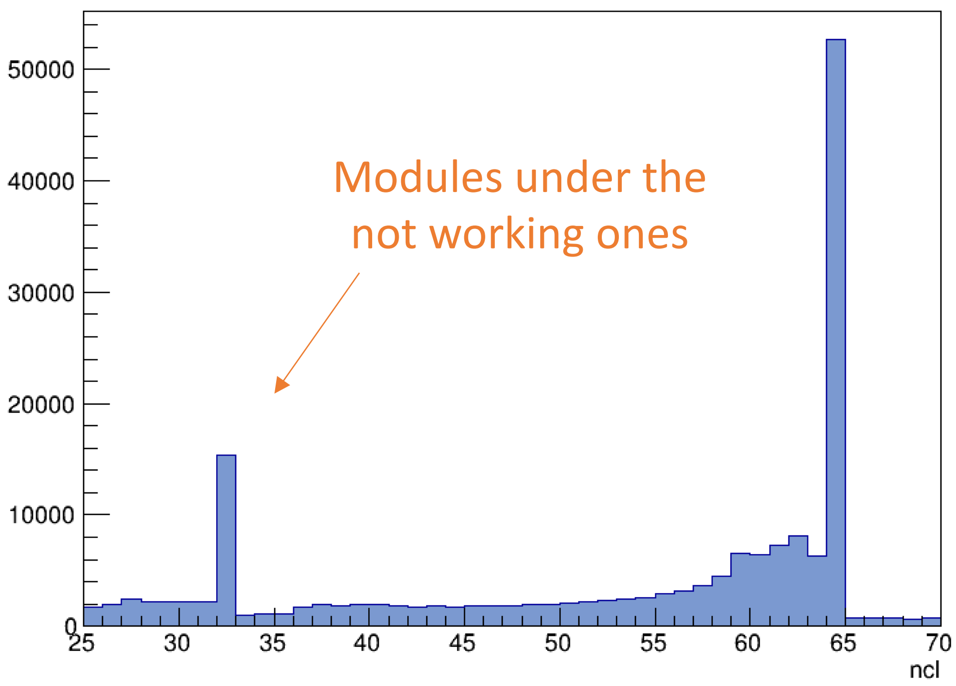


Without merging within two modules we get a Eres ~15%

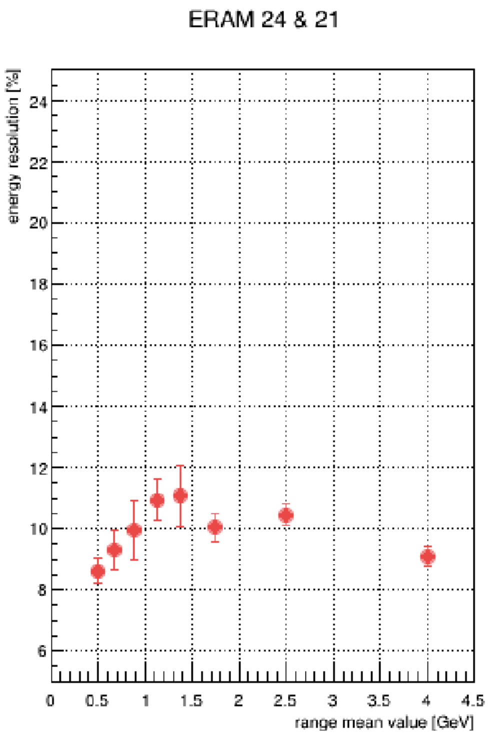
What if we merge?

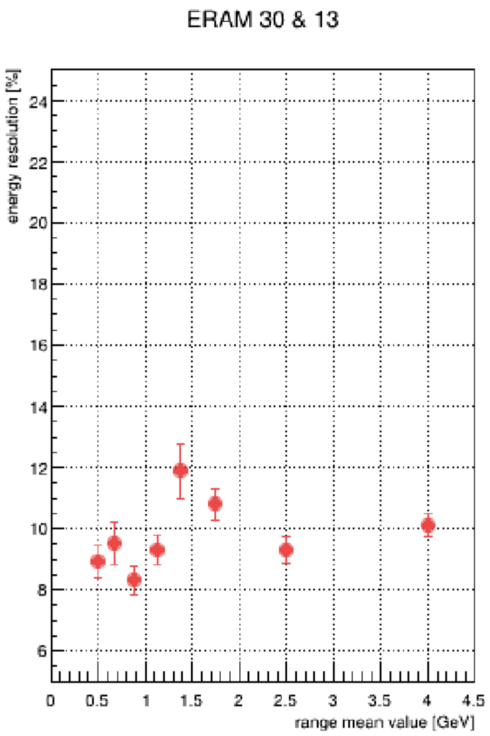
ncl with merging

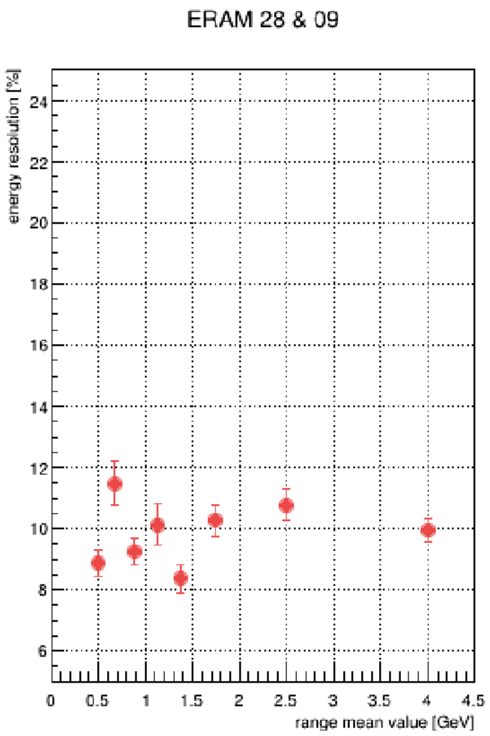
Number of cluster for all the 16 modules

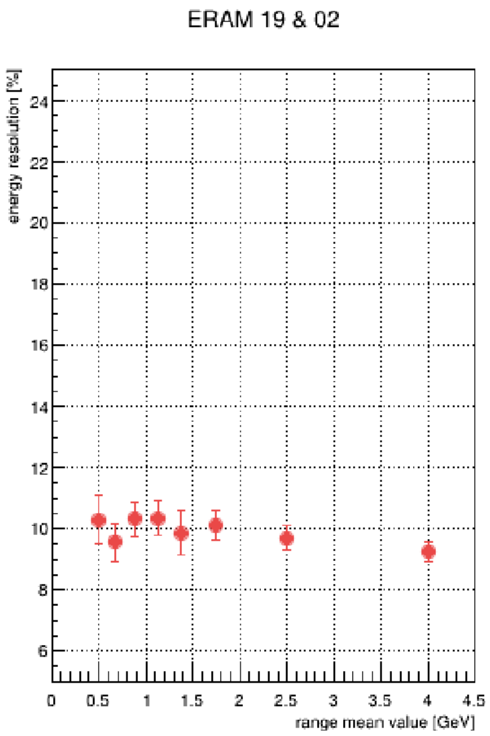


Energy resolution for different |p| ranges

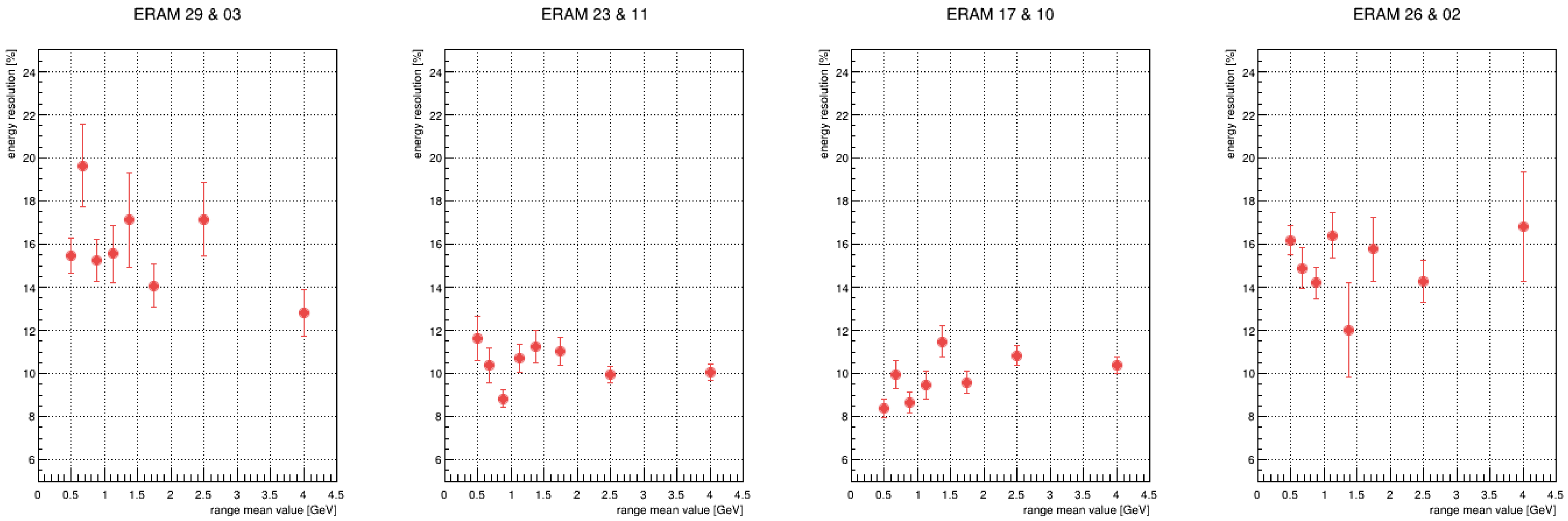








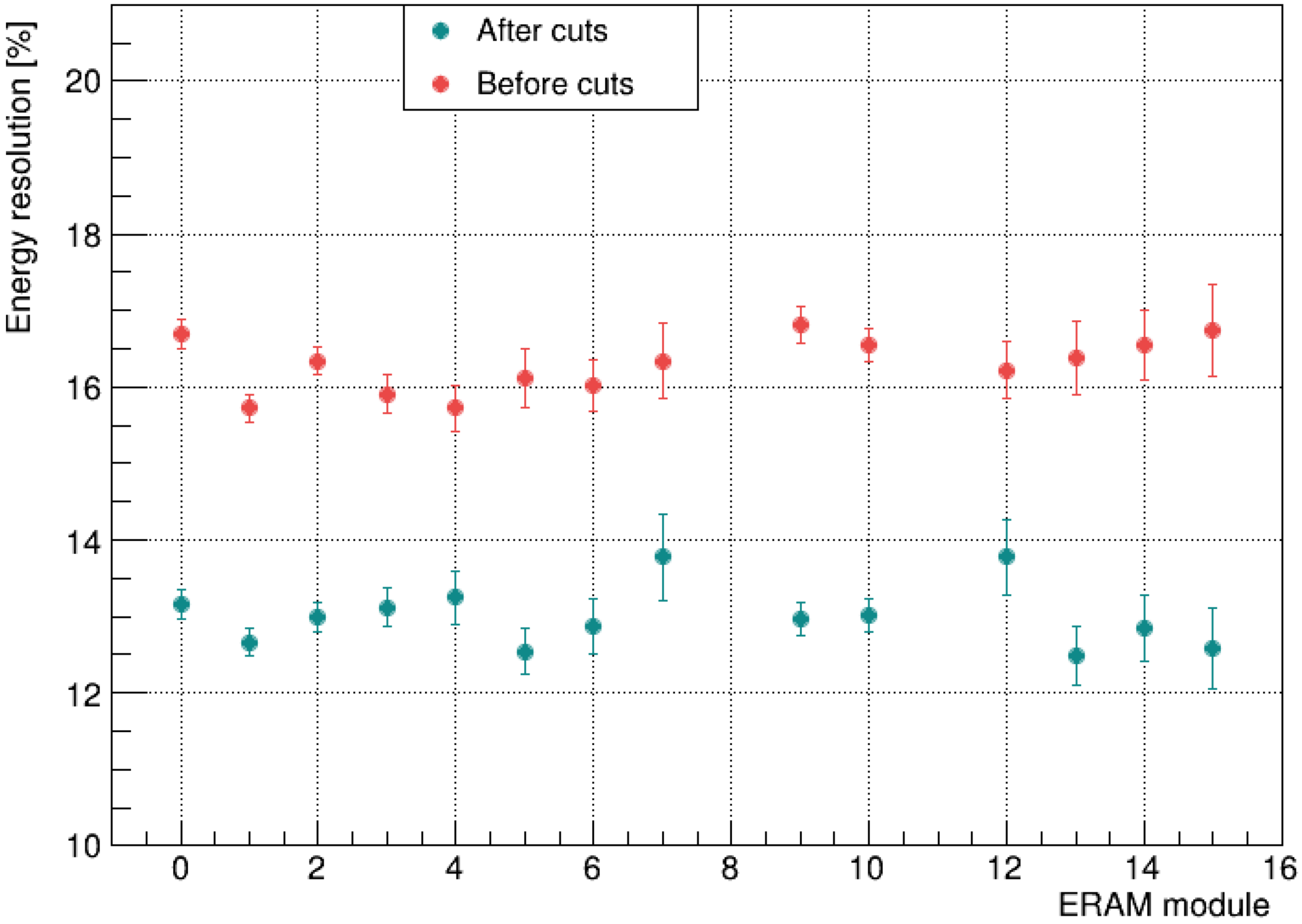
Energy resolution for different |p| ranges



- When a track crosses just one module Eres ~ 15%
- When a track crosses two modules Eres ~ 10%

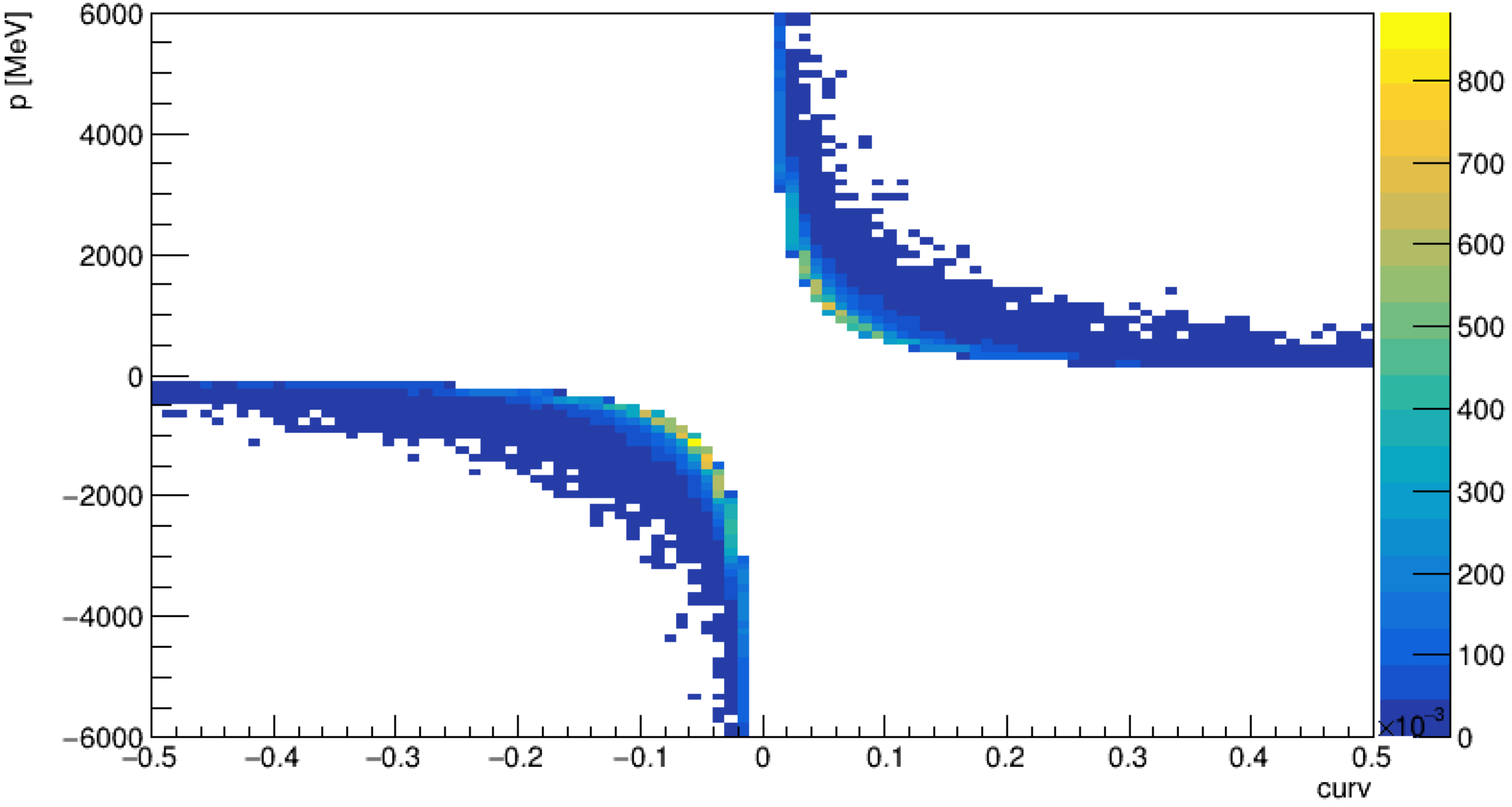
→ Consistent with $E_{res} \sim 1/\sqrt{ncl}$

MC data: Eres

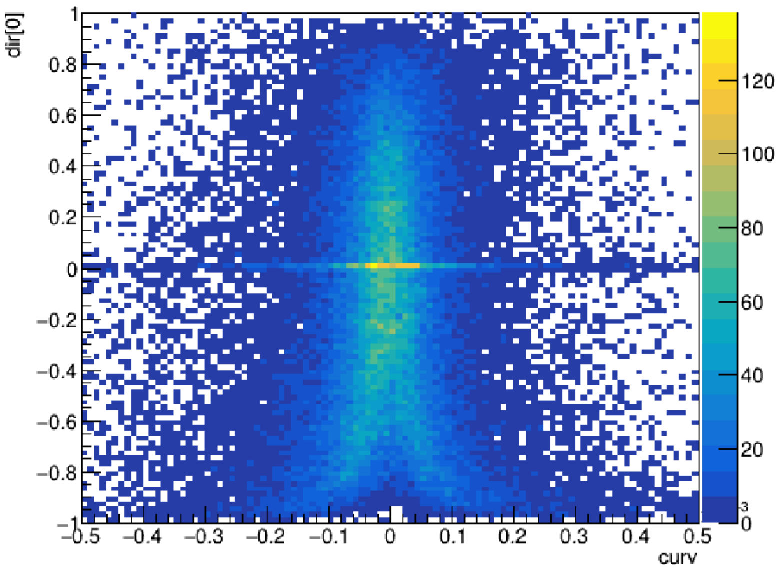


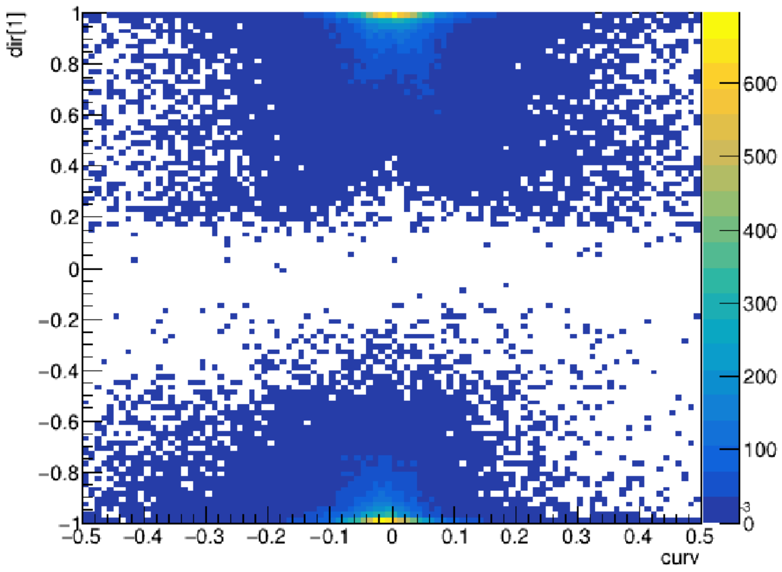
After cuts
Before cuts
Energy resolution [%]
10
12
14
16
18
20
0
2
4
6
8
10
12
14
16
ERAM module

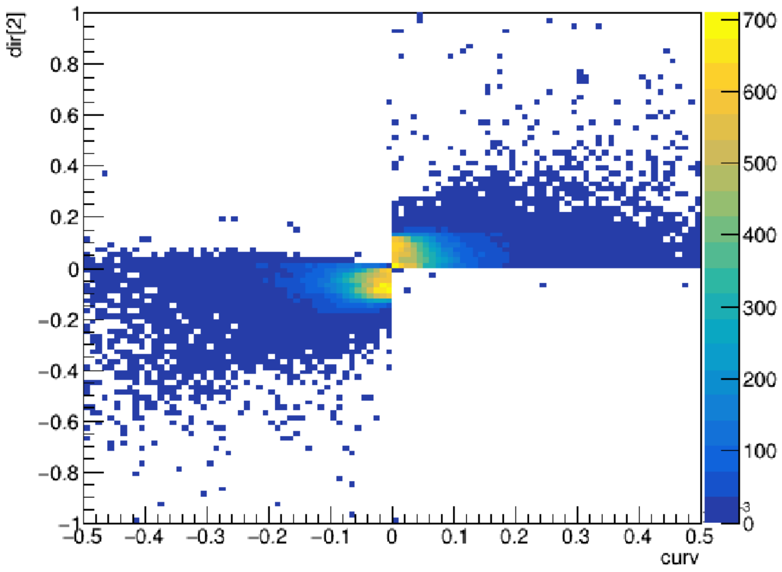
MC data: mom vs curv



MC data: dir[*] vs curv







Conclusions

- I’ve analyzed run862 of cosmic rays (mostly muons)
  - Tracks crossing one module: Eres $\sim$ 15%
  - Tracks crossing two modules: Eres $\sim$ 10%
- dE/dx in function of p follows Bethe-Bloch prediction
- Combining modules with different gain does not give a big effect on the Eres → ionization fluctuations dominate over detector effects
- It would be useful to have more cosmics with B field for a more careful characterization

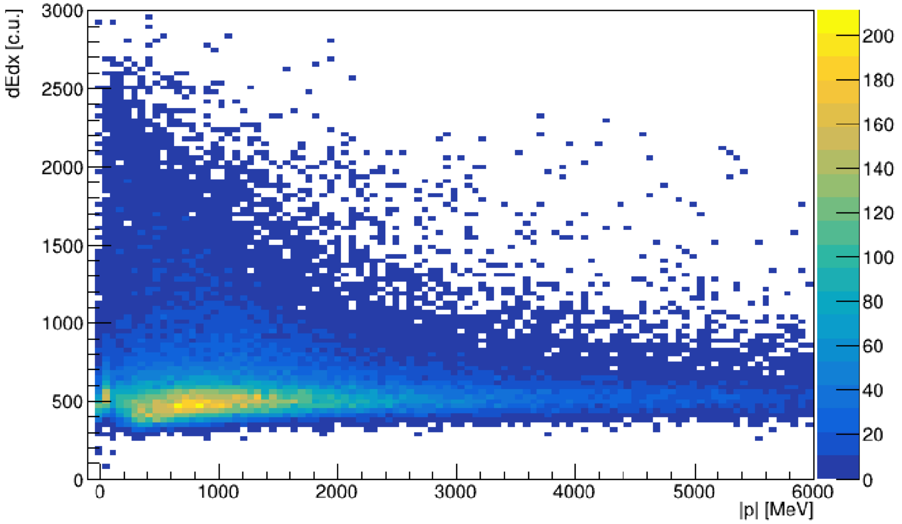
Next steps:

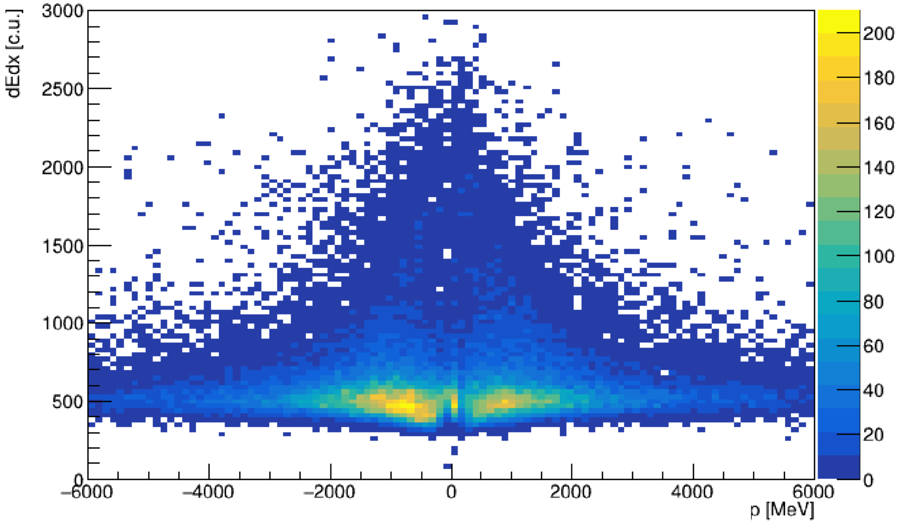
- Apply gain calibration constants using Shivam gain maps
- Analyze the MC data

Back up slides

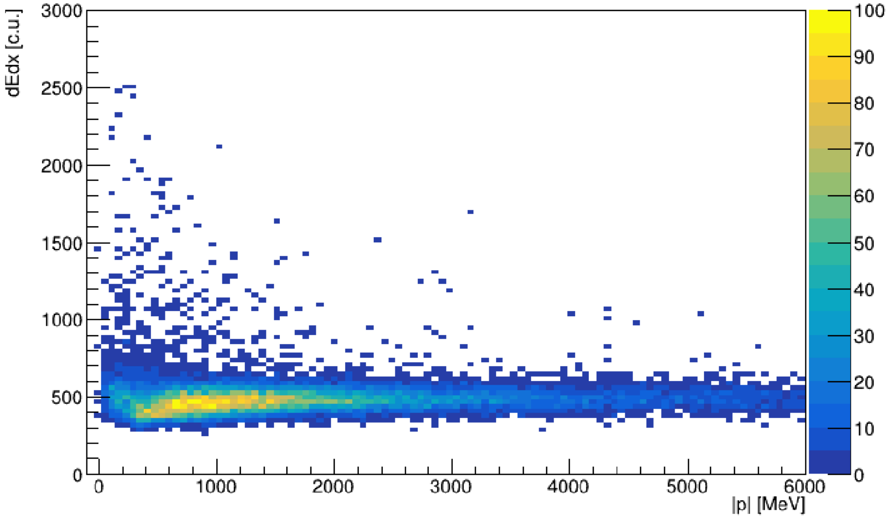
MC data: dEdx vs momentum

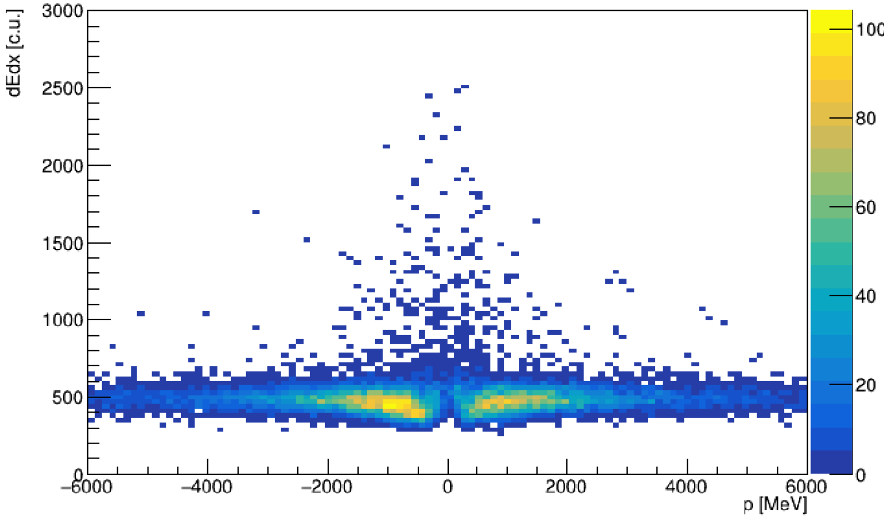
Before cuts:



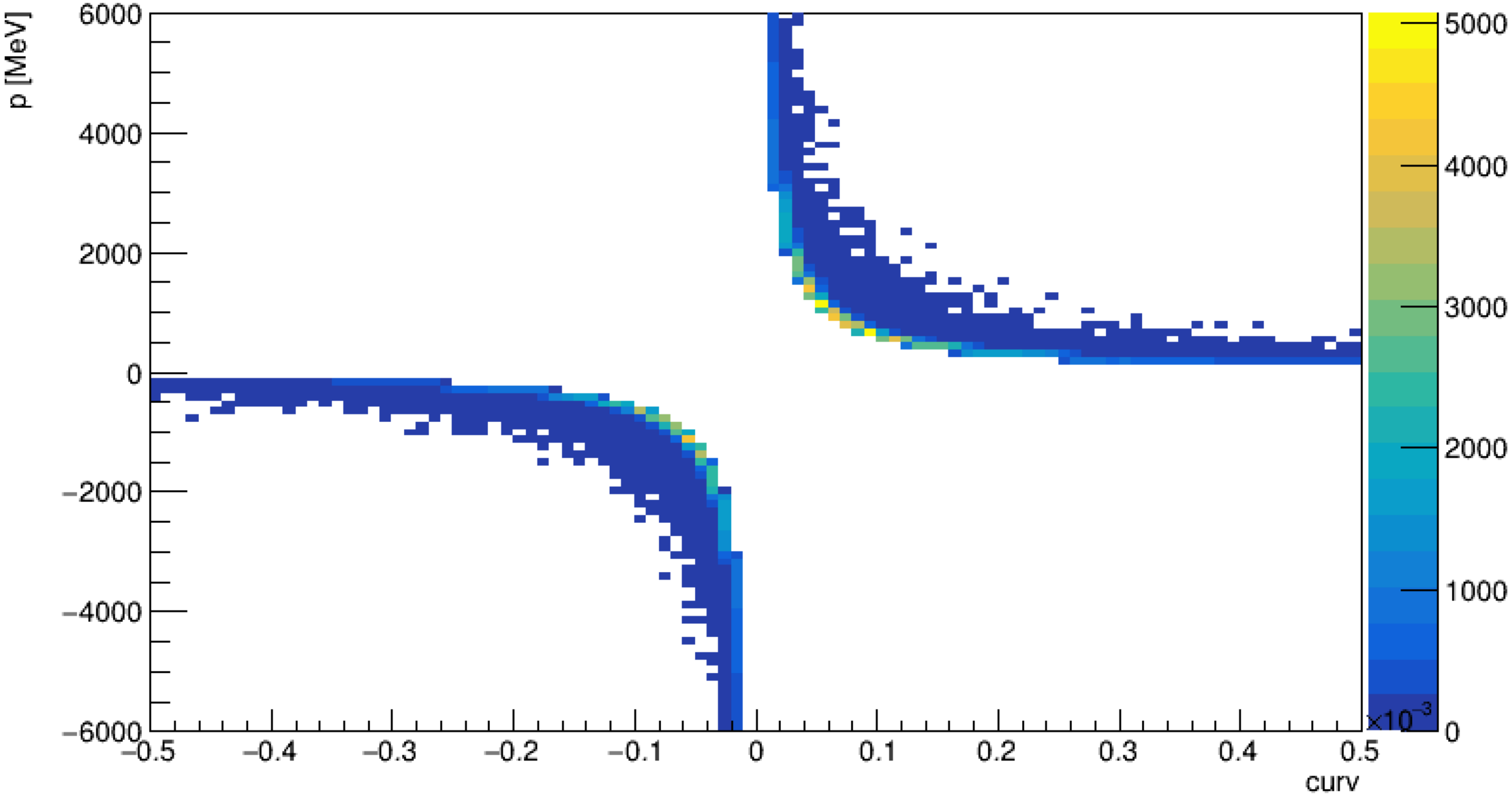


After cuts:

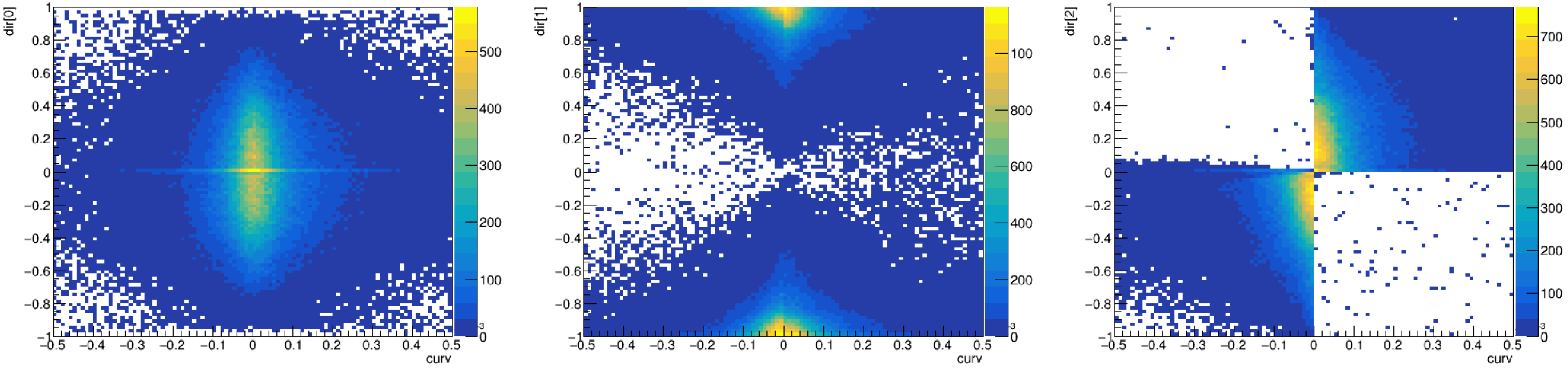




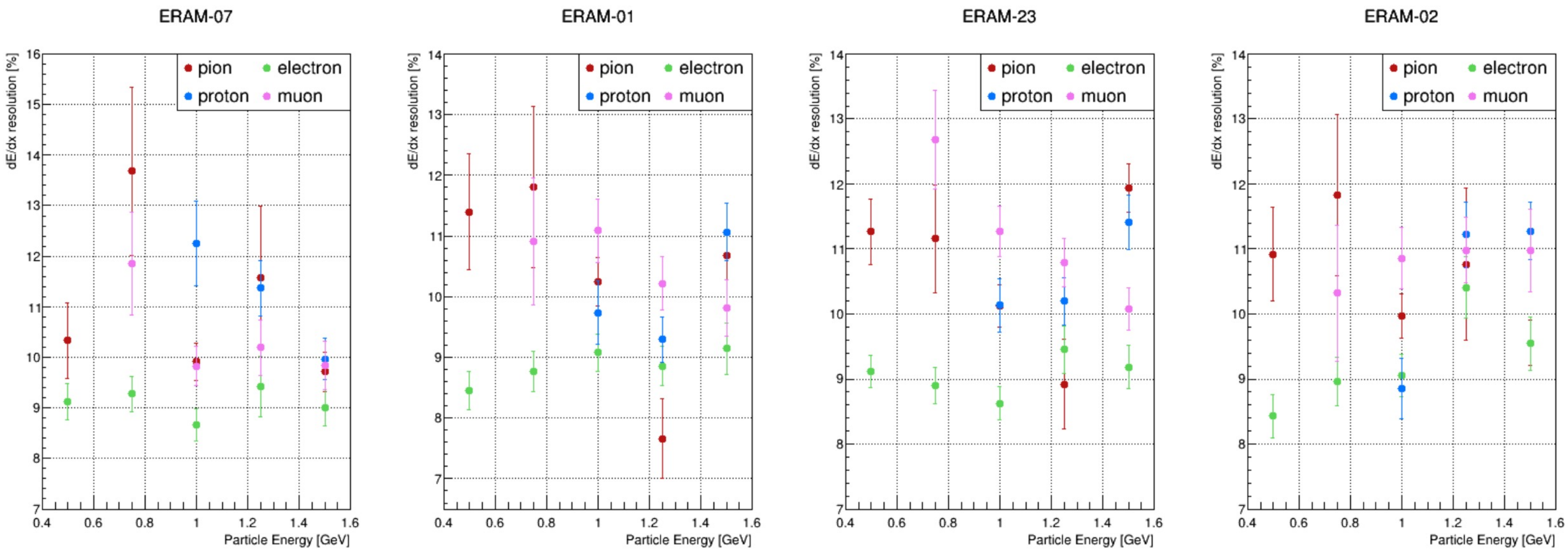
run862: mom vs curv



run862 : dir[*] vs curv

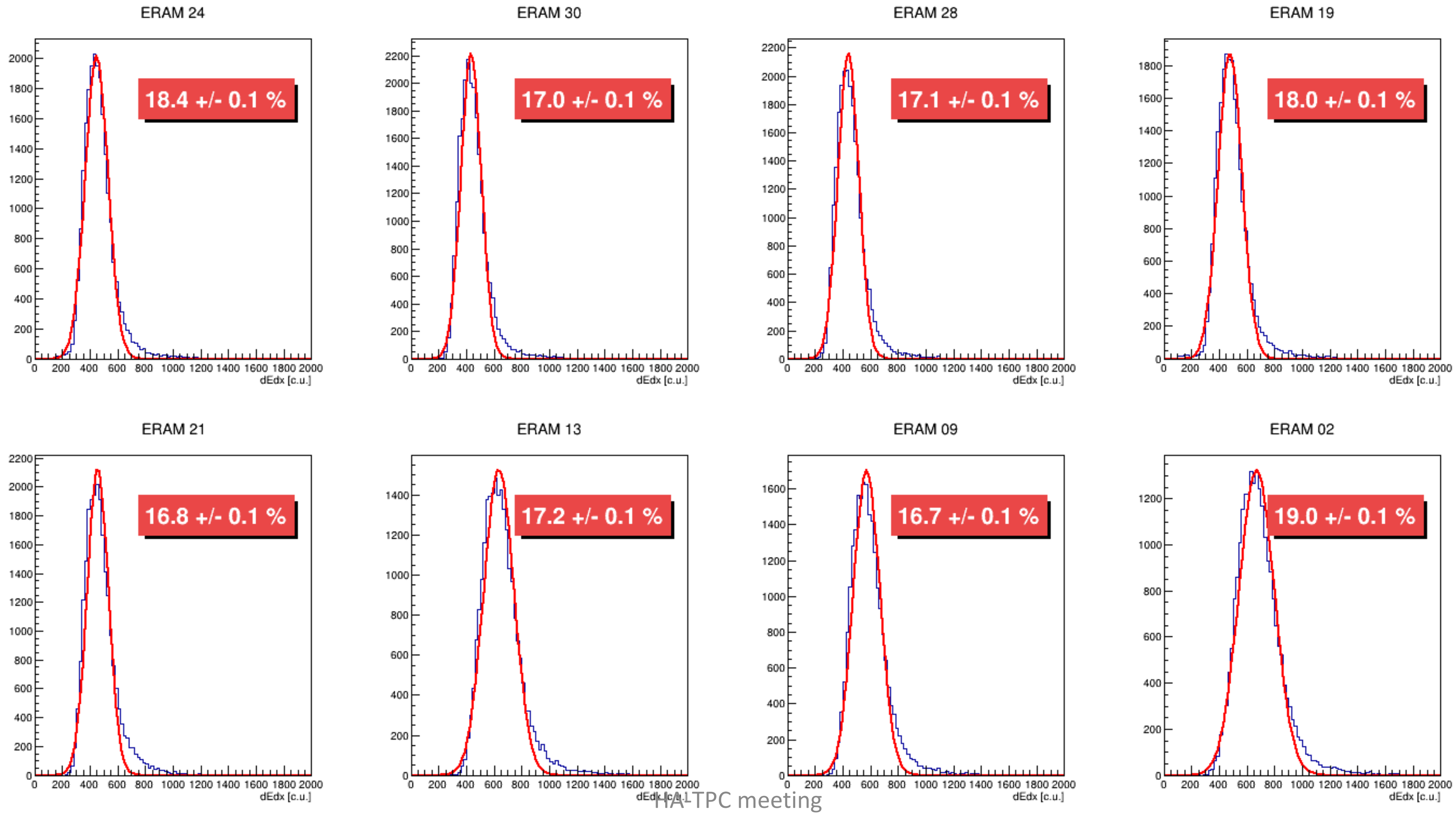


CERN 2022 test beam analysis



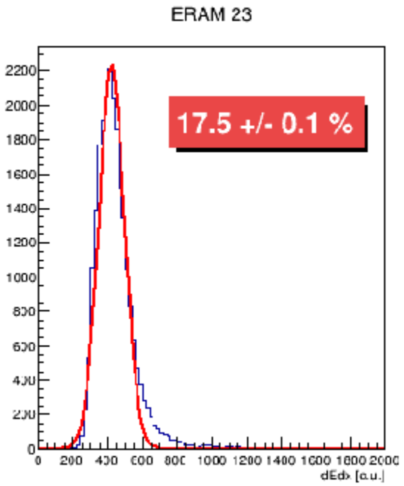
Energy resolution without cuts

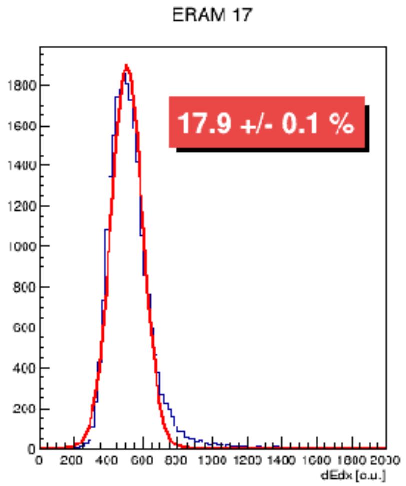
End Plate 0

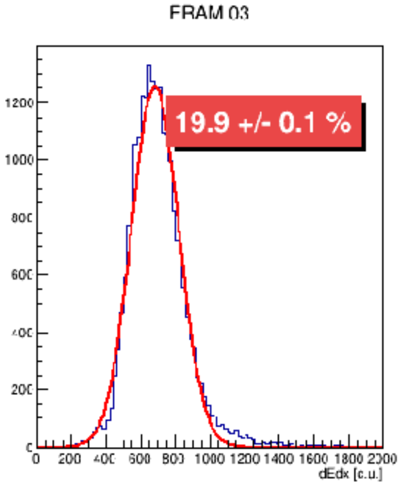


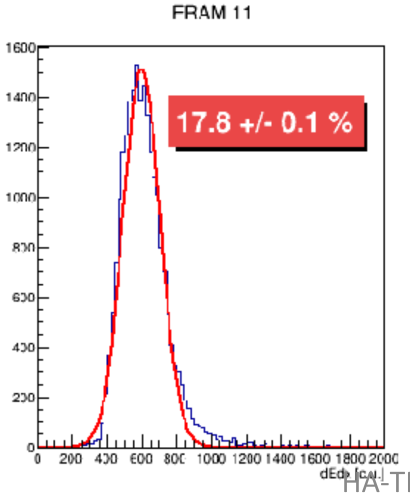
Energy resolution without cuts

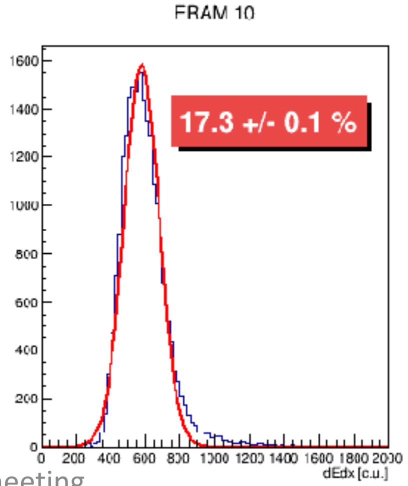
End Plate 1

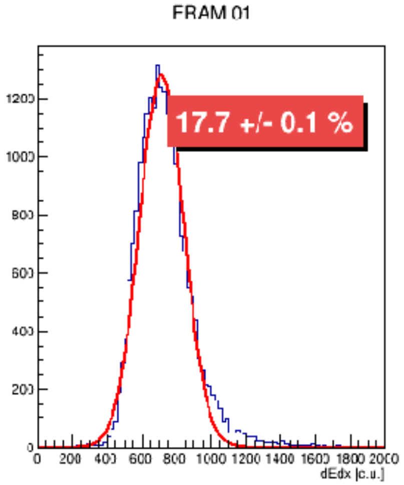








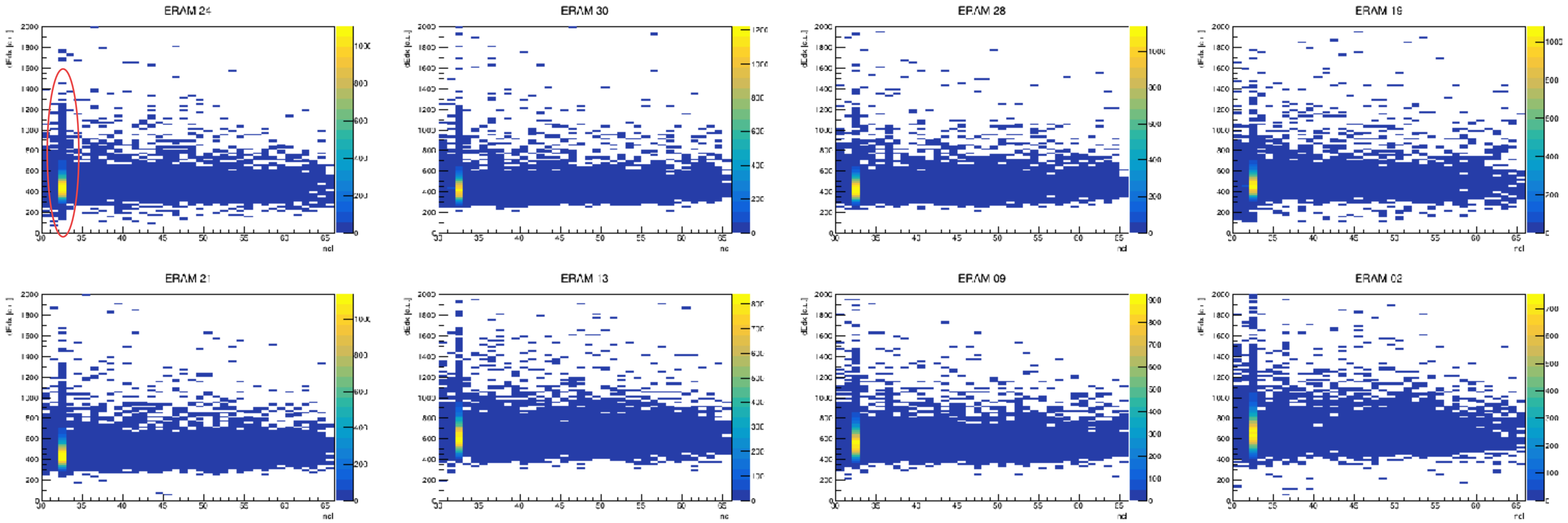




dEdx vs ncl

The tracks are not merged: Cuts: ncl == 32

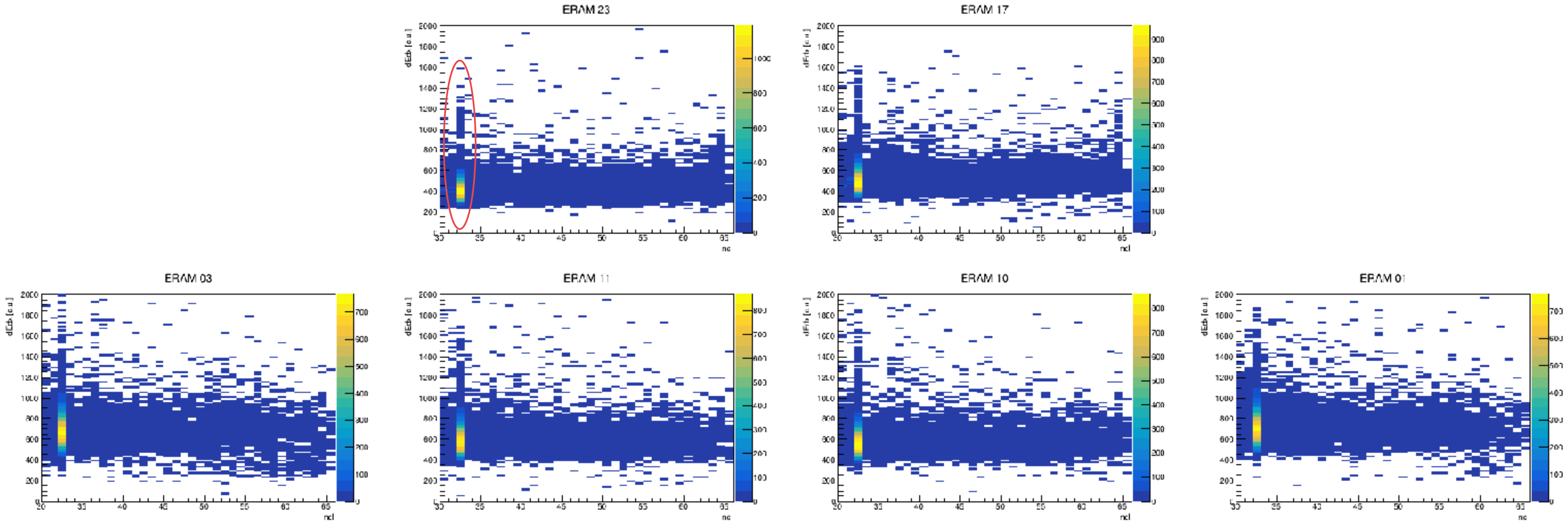
End Plate 0



dEdx vs ncl

The tracks are not merged: Cuts: ncl == 32

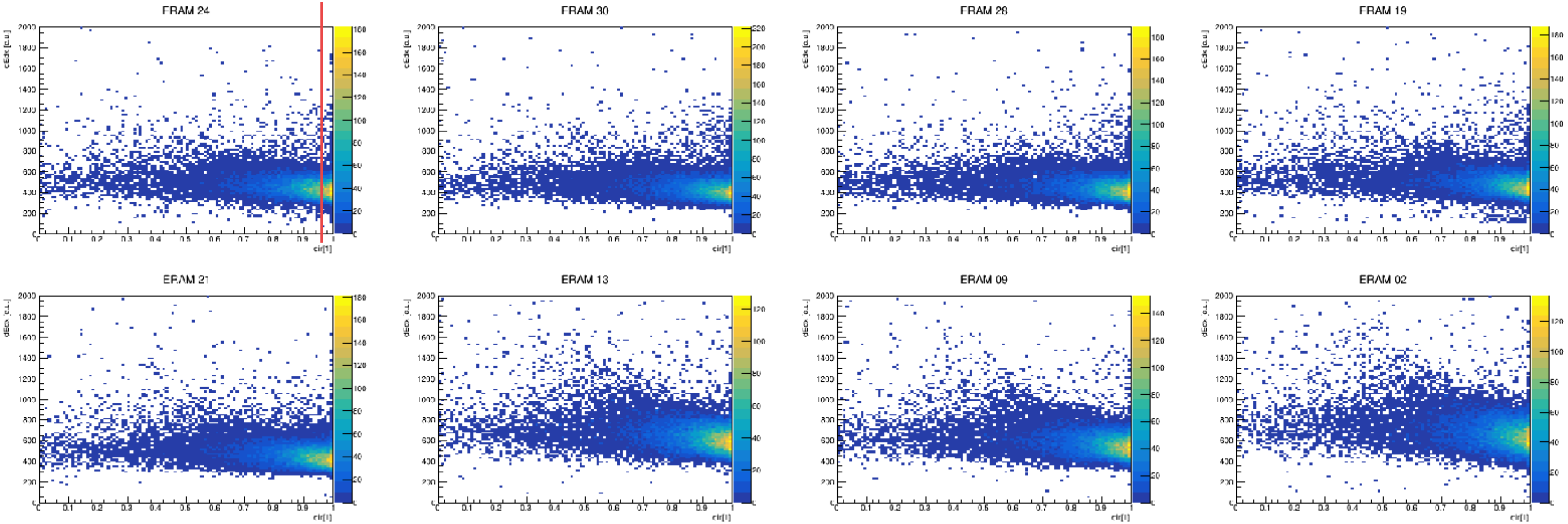
End Plate 1



dEdx vs dir[1]

Cuts: abs(dir[1]) > 0.95

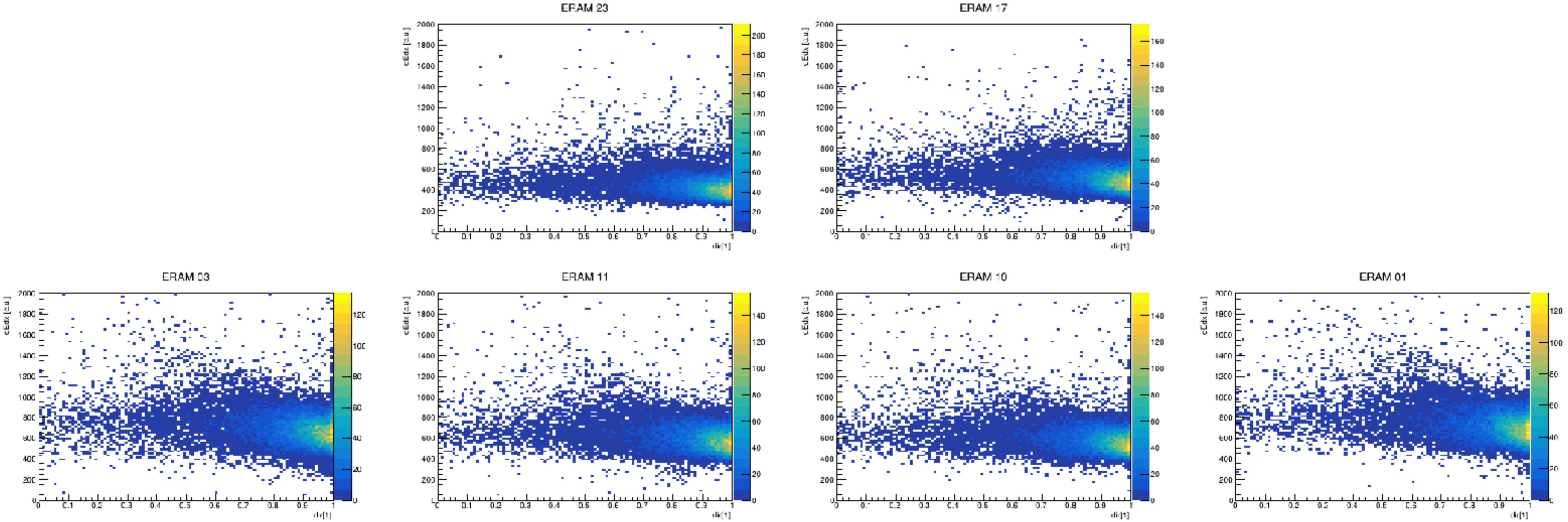
End Plate 0



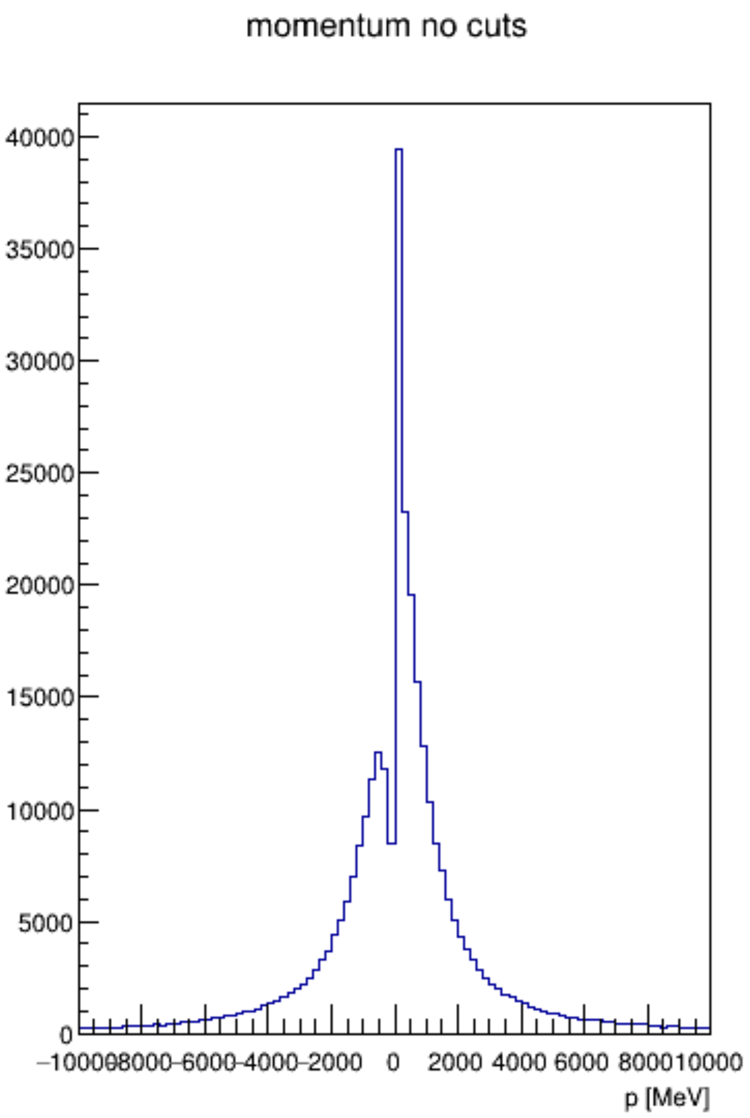
dEdx vs dir[1]

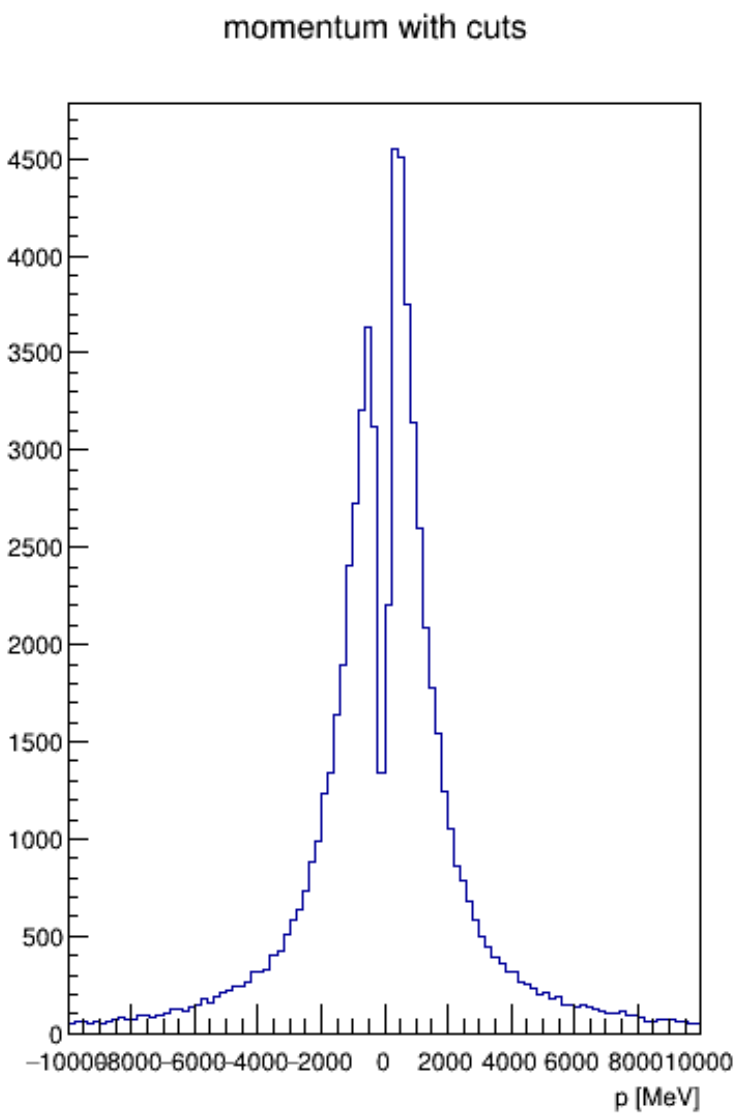
Cuts: abs(dir[1]) > 0.95

End Plate 1



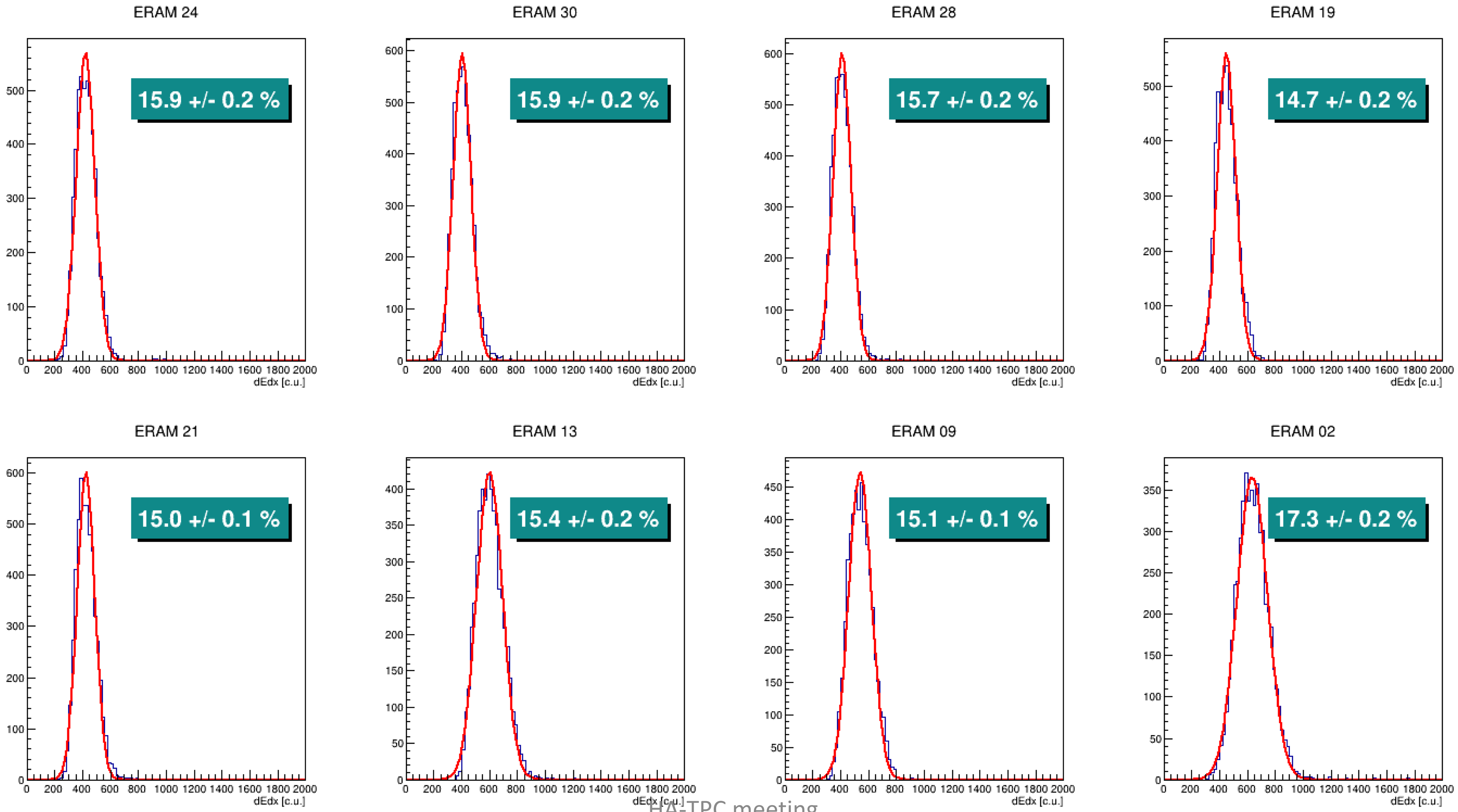
Momentum


momentum no cuts
40000
35000
30000
25000
20000
15000
10000
5000
0
−10000−8000−6000−4000−2000 0 2000 4000 6000 8000 10000
p [MeV]


momentum with cuts
4500
4000
3500
3000
2500
2000
1500
1000
500
0
−10000−8000−6000−4000−2000 0 2000 4000 6000 8000 10000
p [MeV]

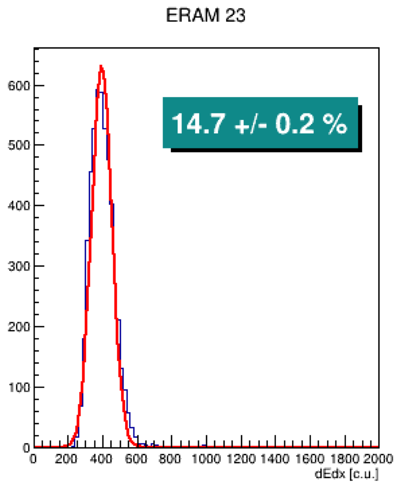
Energy resolution after cuts

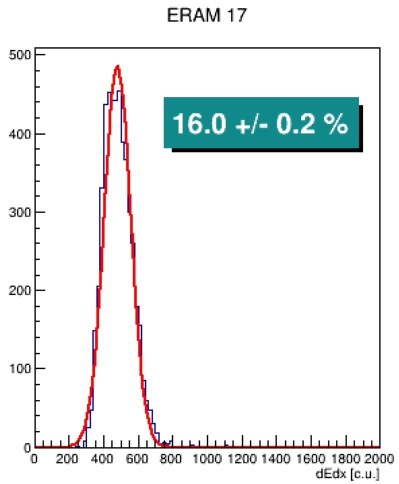
End Plate 0

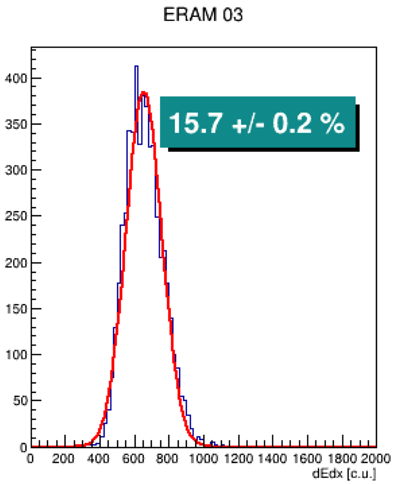


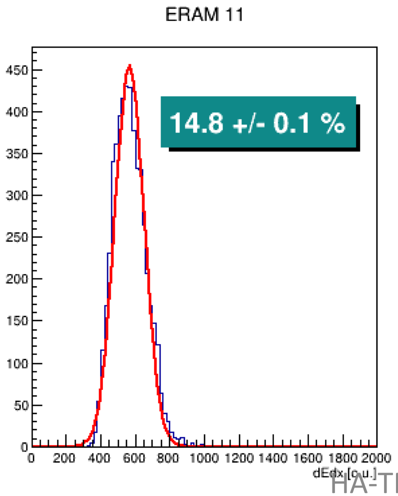
Energy resolution after cuts

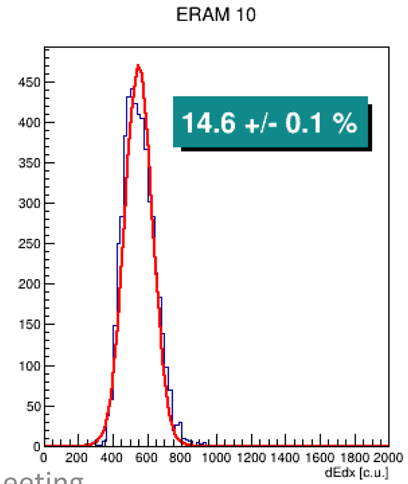
End Plate 1

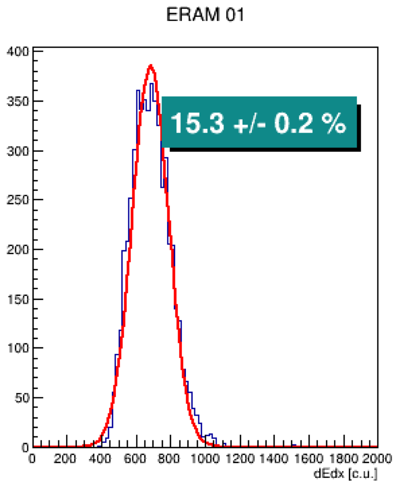












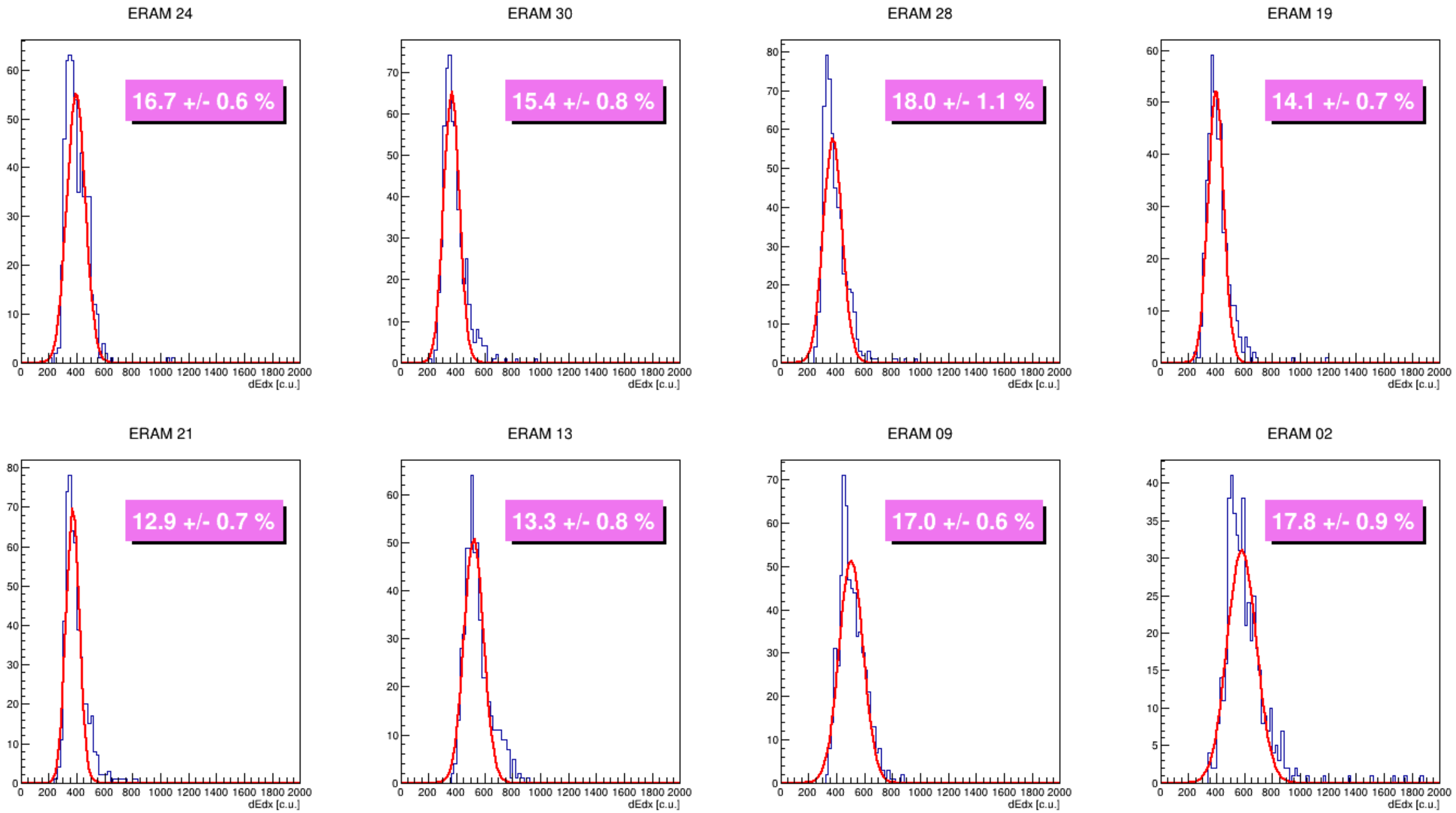
dEdx vs momentum

|p| range [GeV]	mean value [GeV]
0.4 - 0.6	0.5
0.6 - 0.75	0.675
0.75 - 1	0.875
1 - 1.25	1.125
1.25 - 1.5	1.375
1.5 - 2	1.75
2 - 3	2.5
3 - 5	4

Eres for a given momentum range

0.4 GeV < |p| < 0.6 GeV

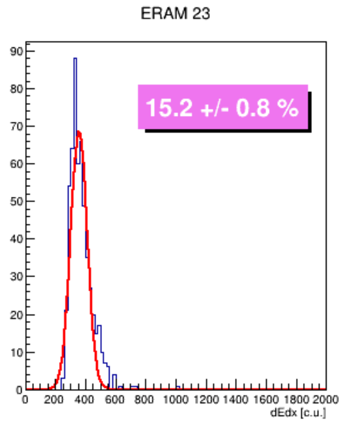
End Plate 0

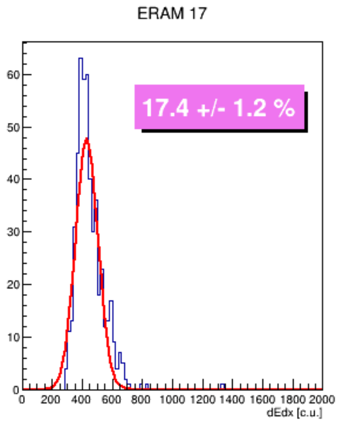


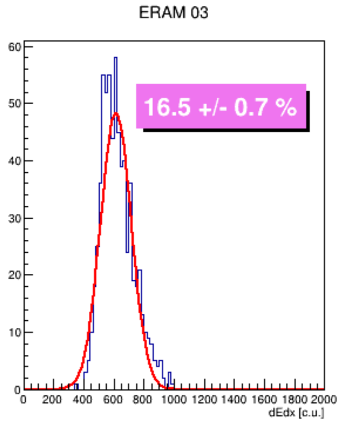
Eres for a given momentum range

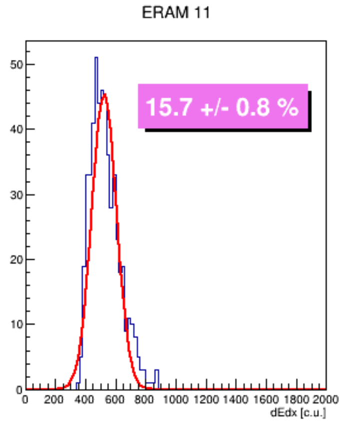
0.4 GeV < |p| < 0.6 GeV

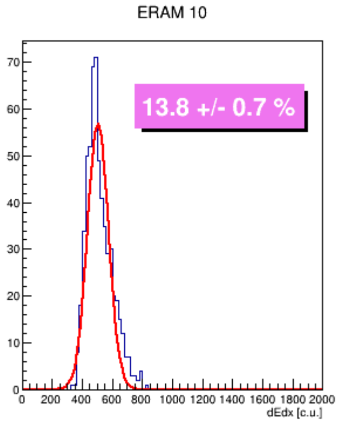
End Plate 1

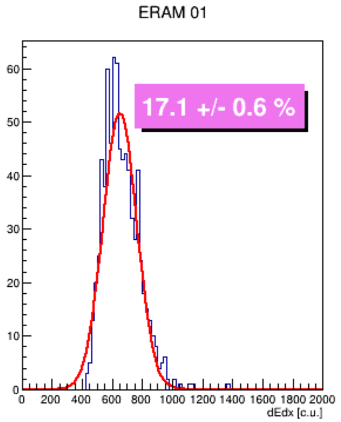








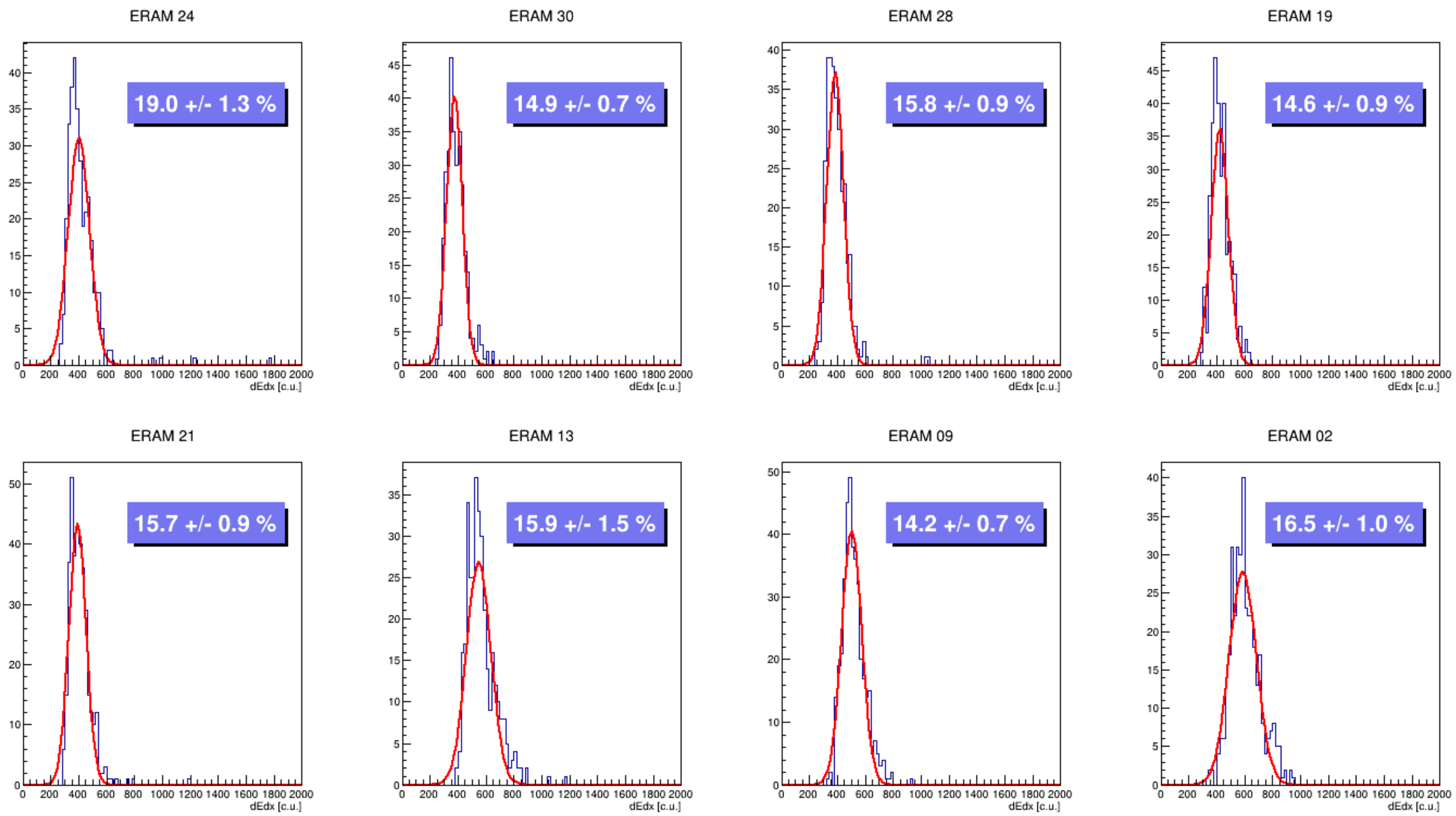




Eres for a given momentum range

0.6 GeV < |p| < 0.75 GeV

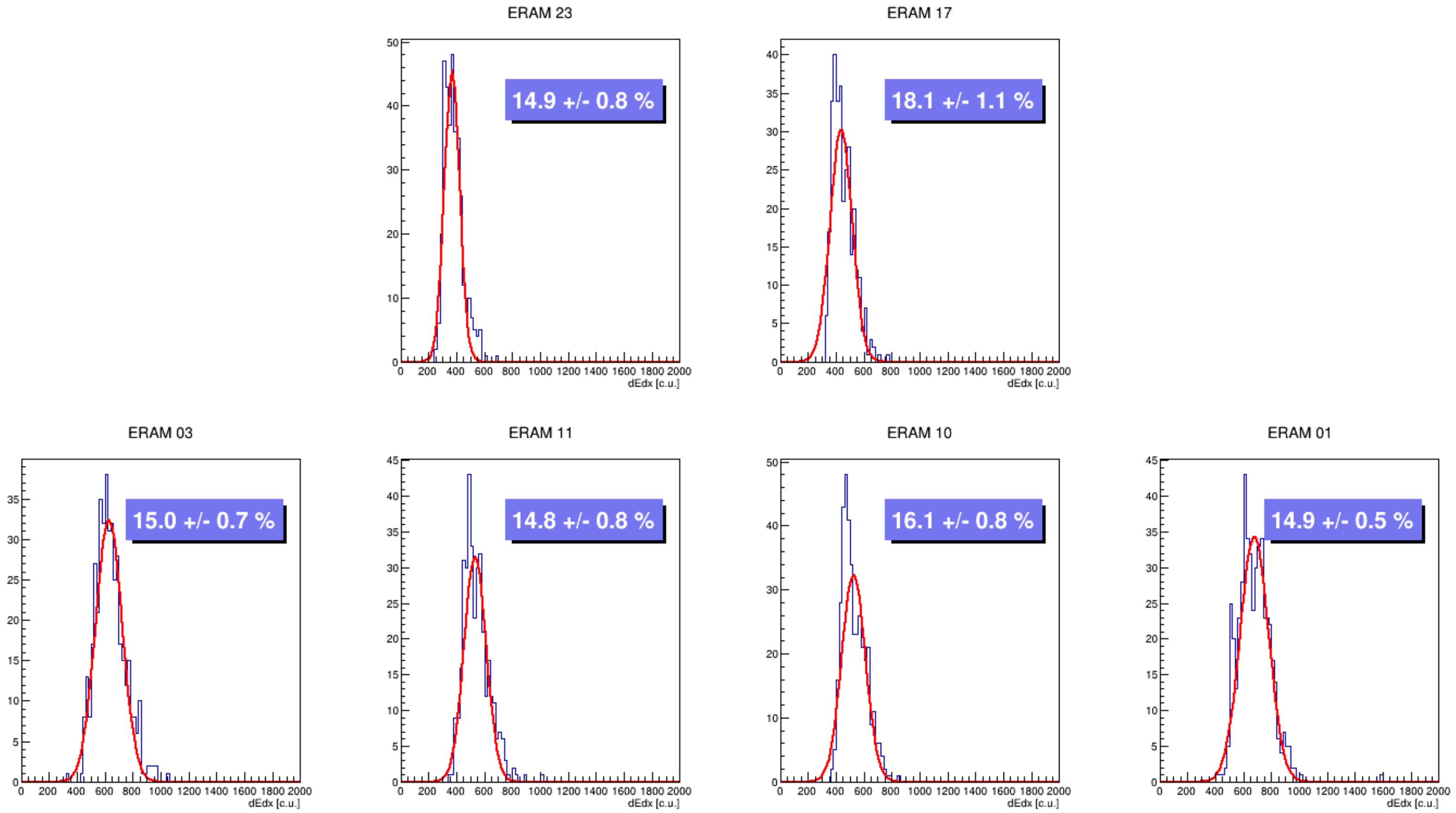
End Plate 0



Eres for a given momentum range

0.6 GeV < |p| < 0.75 GeV

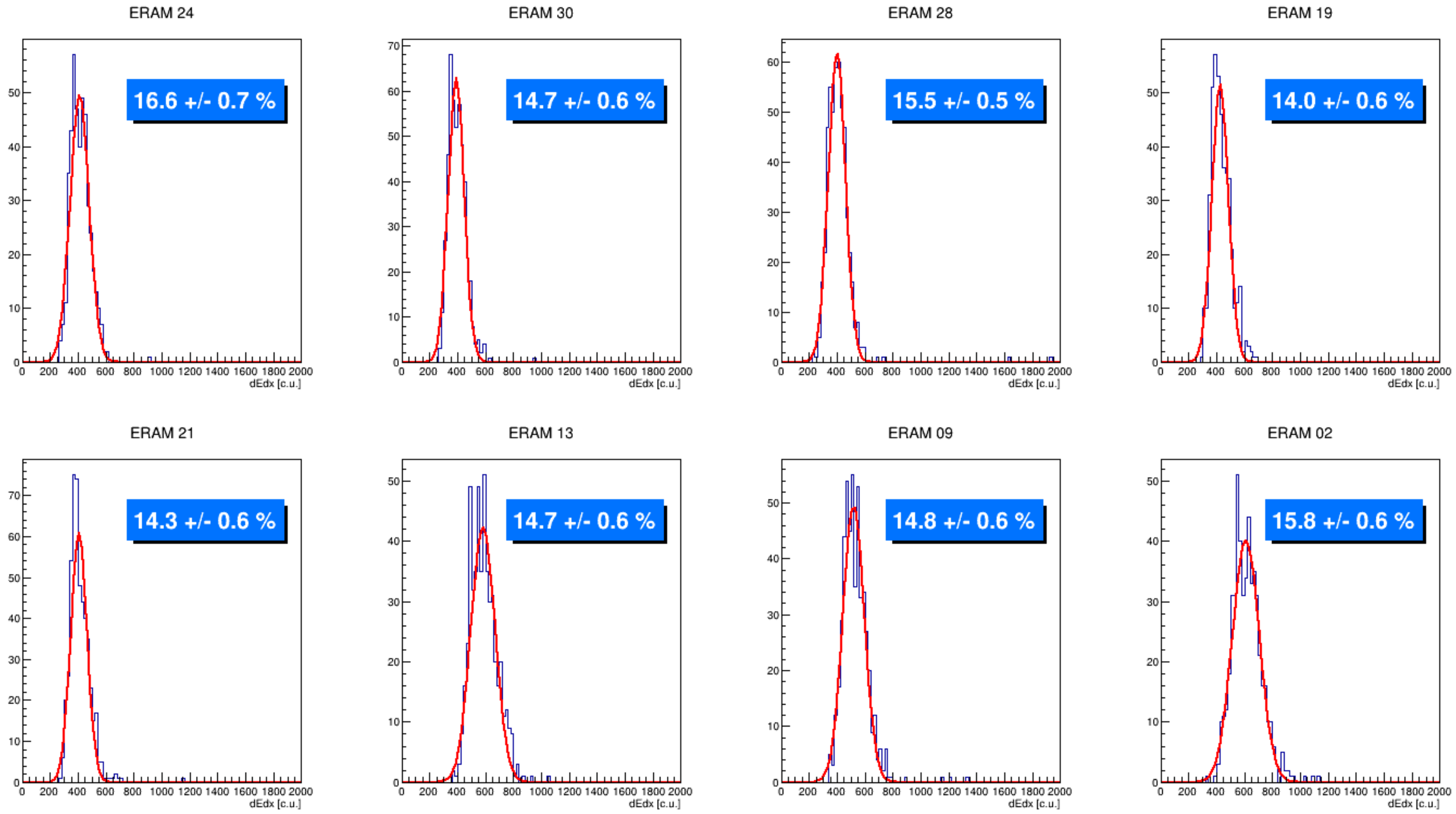
End Plate 1



Eres for a given momentum range

0.75 GeV < |p| < 1 GeV

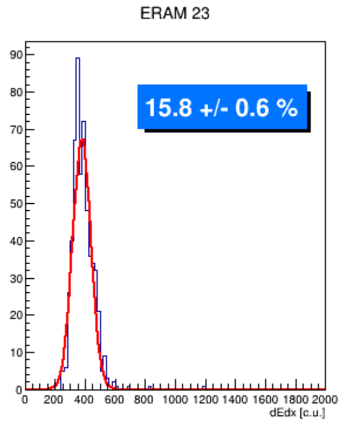
End Plate 0

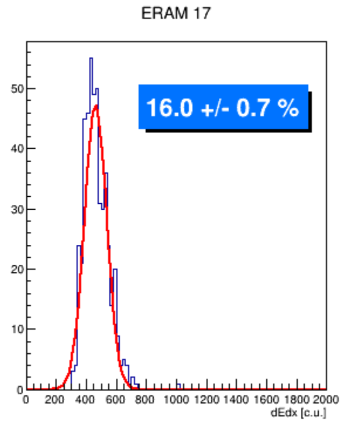


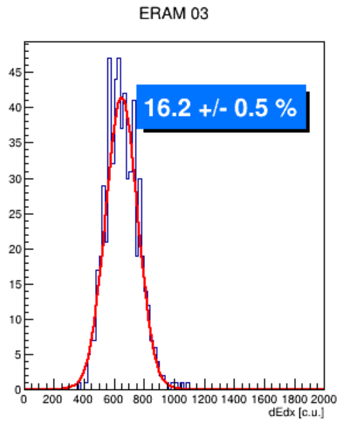
Eres for a given momentum range

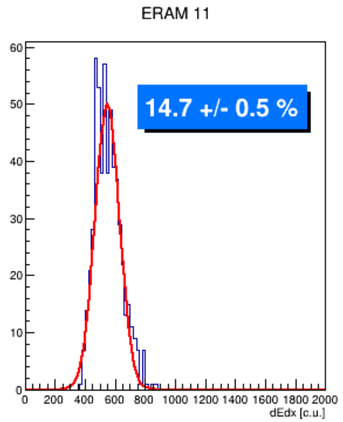
0.75 GeV < |p| < 1 GeV

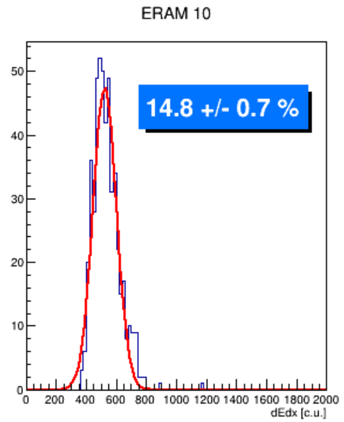
End Plate 1

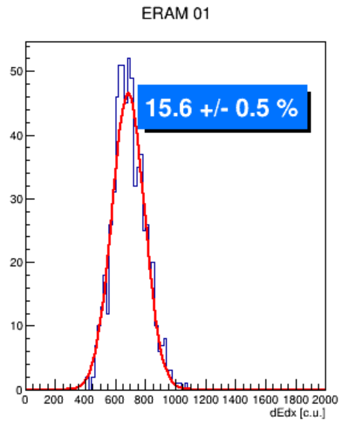








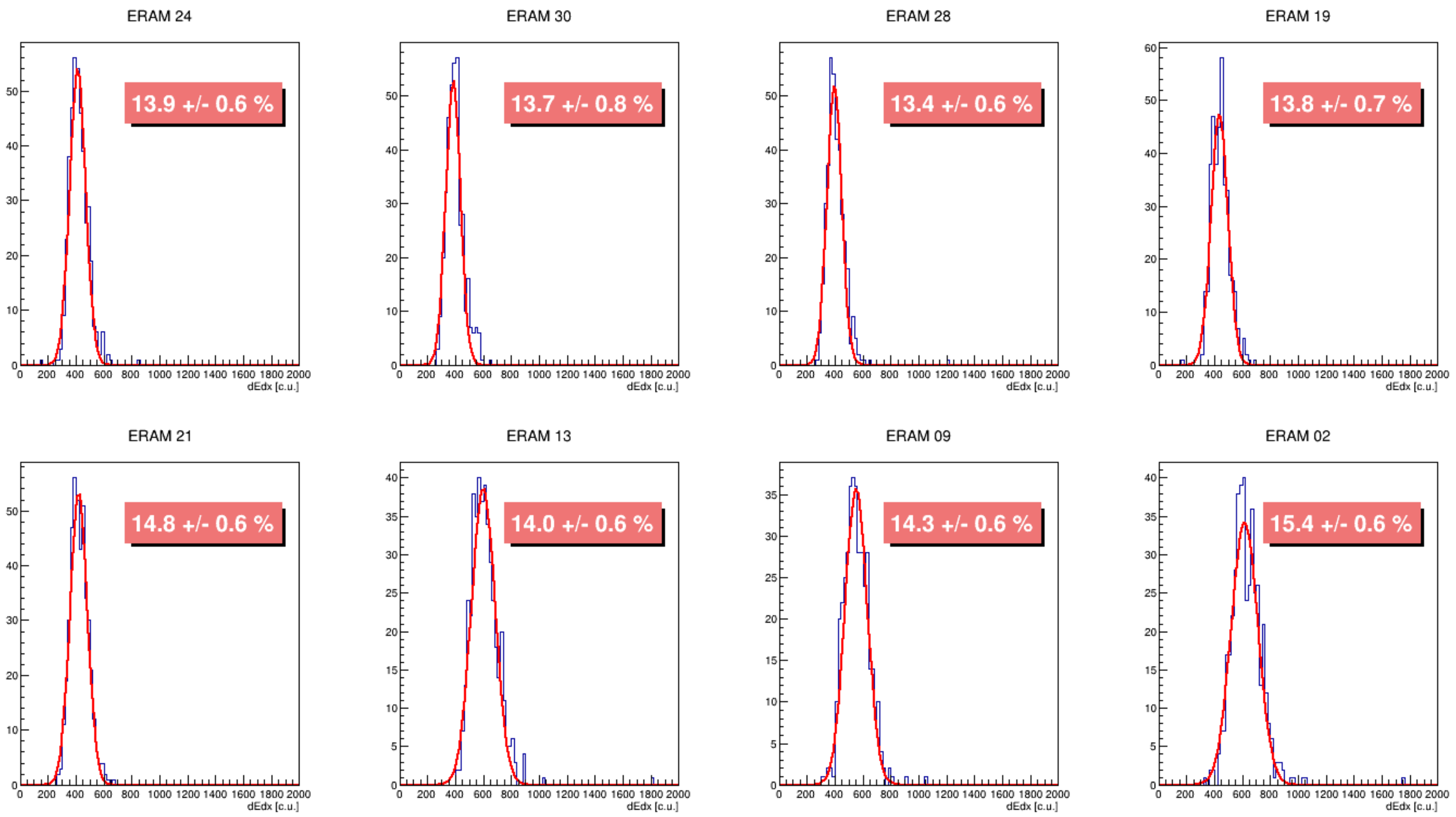




Eres for a given momentum range

1 GeV < |p| < 1.25 GeV

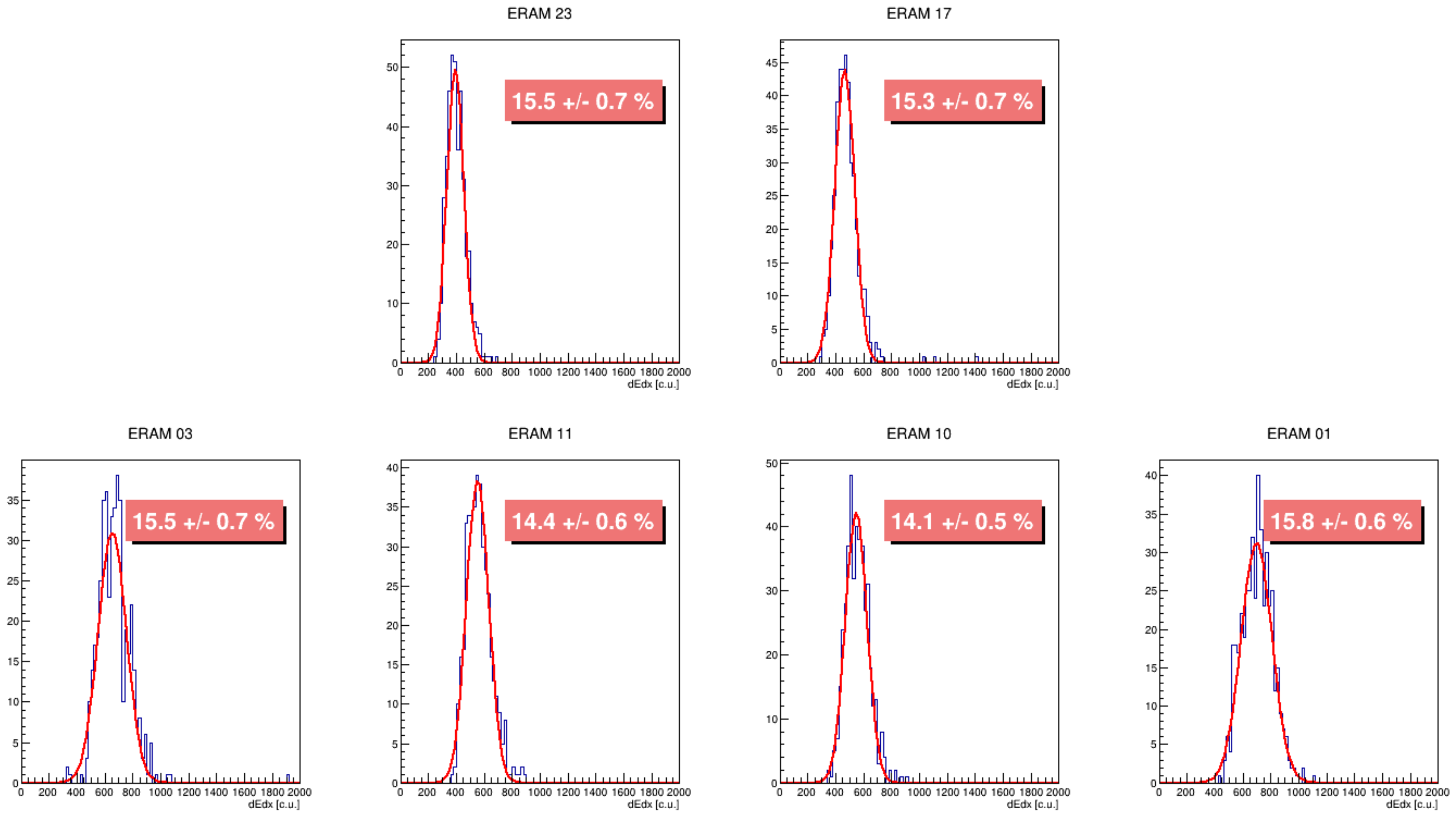
End Plate 0



Eres for a given momentum range

1 GeV < |p| < 1.25 GeV

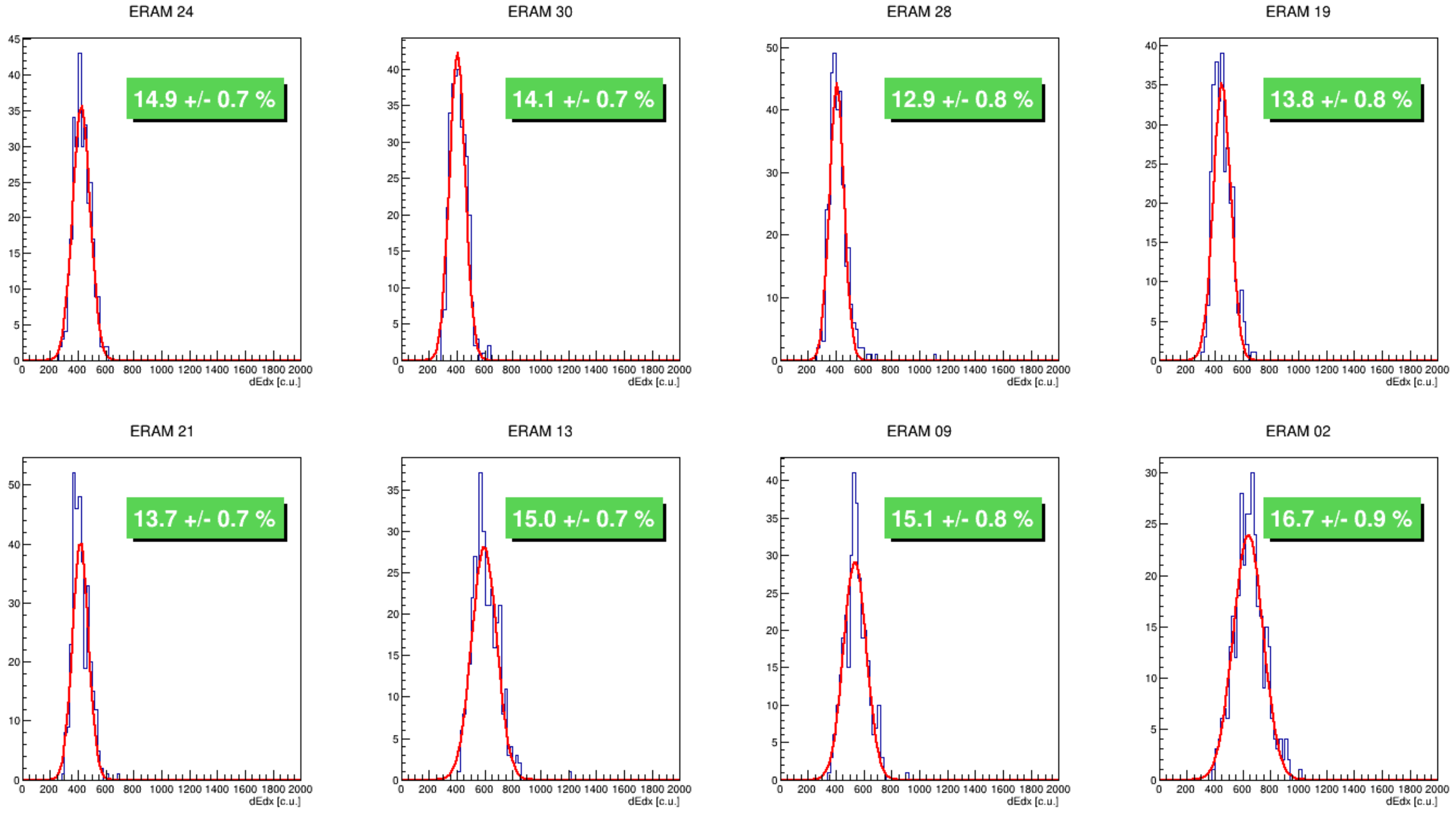
End Plate 1



Eres for a given momentum range

1.25 GeV < |p| < 1.5 GeV

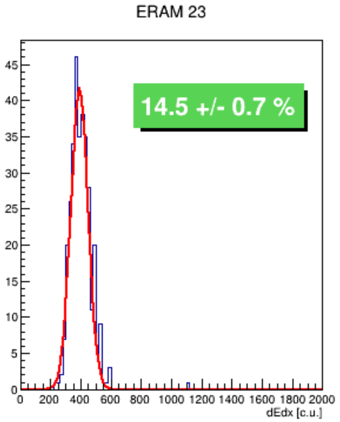
End Plate 0

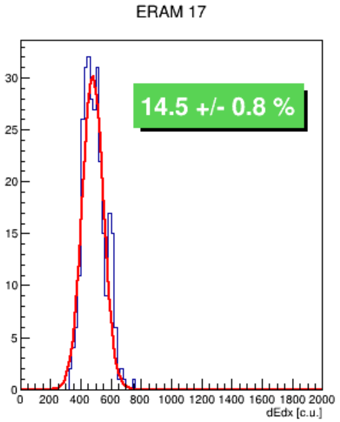


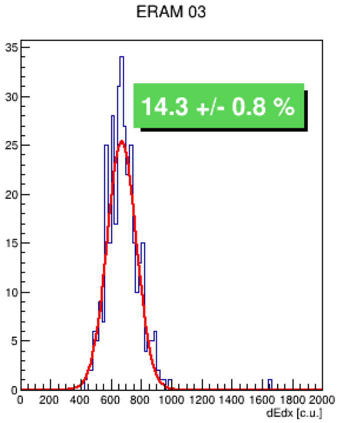
Eres for a given momentum range

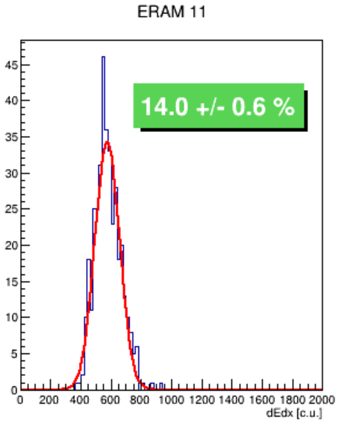
1.25 GeV < |p| < 1.5 GeV

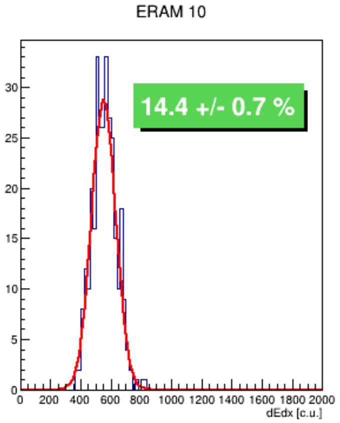
End Plate 1

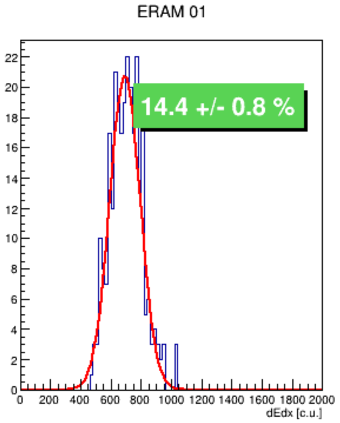








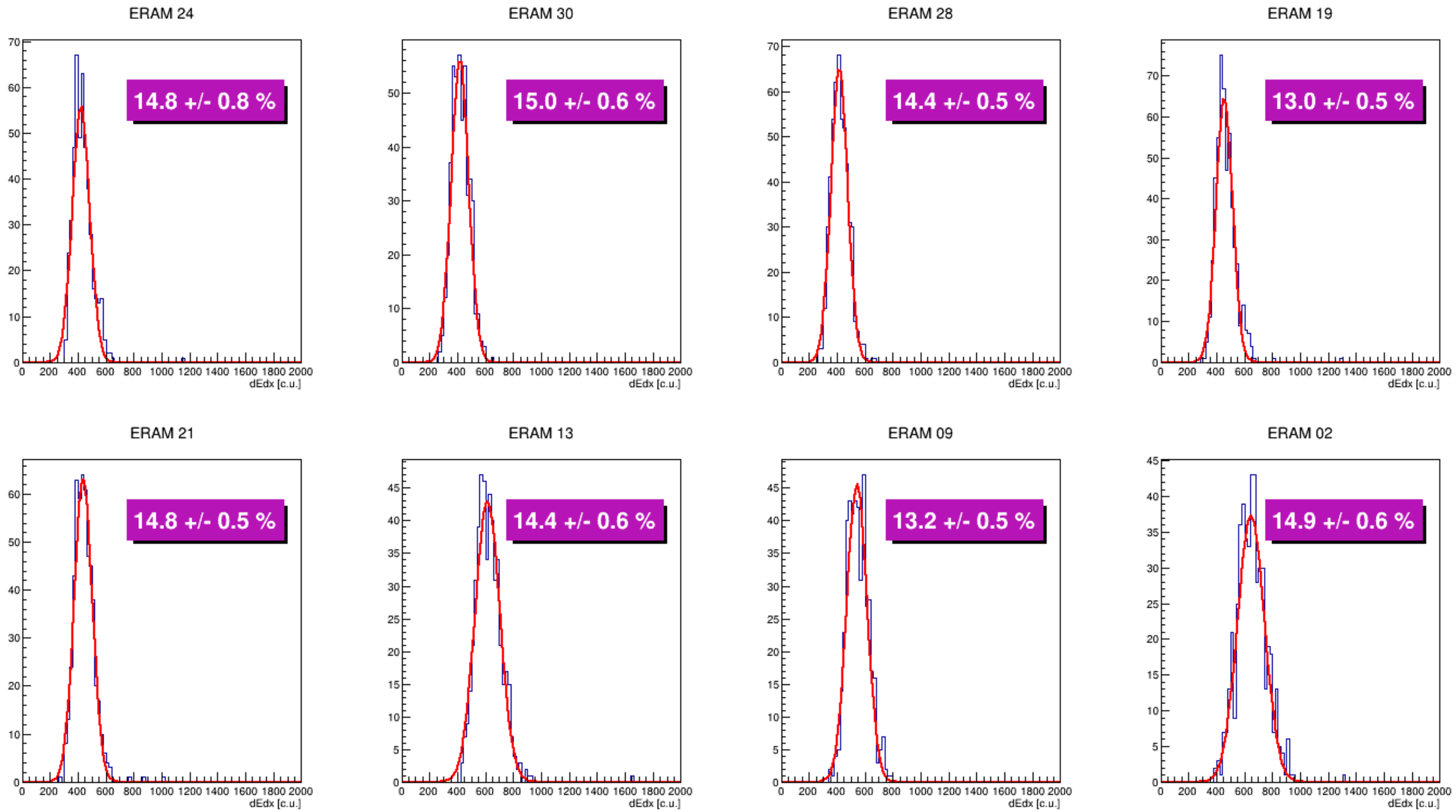




Eres for a given momentum range

1.5 GeV < |p| < 2 GeV

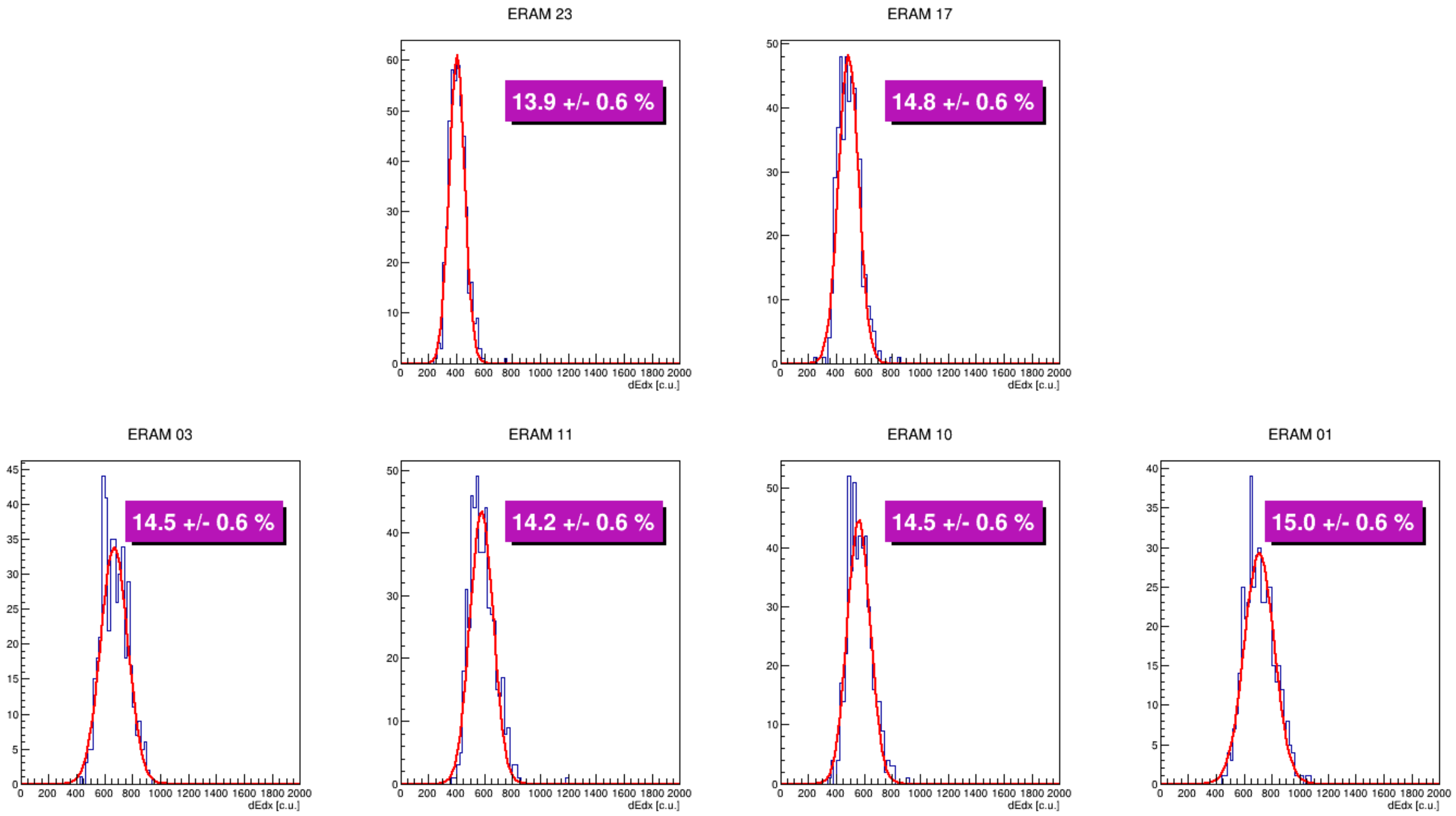
End Plate 0



Eres for a given momentum range

1.5 GeV < |p| < 2 GeV

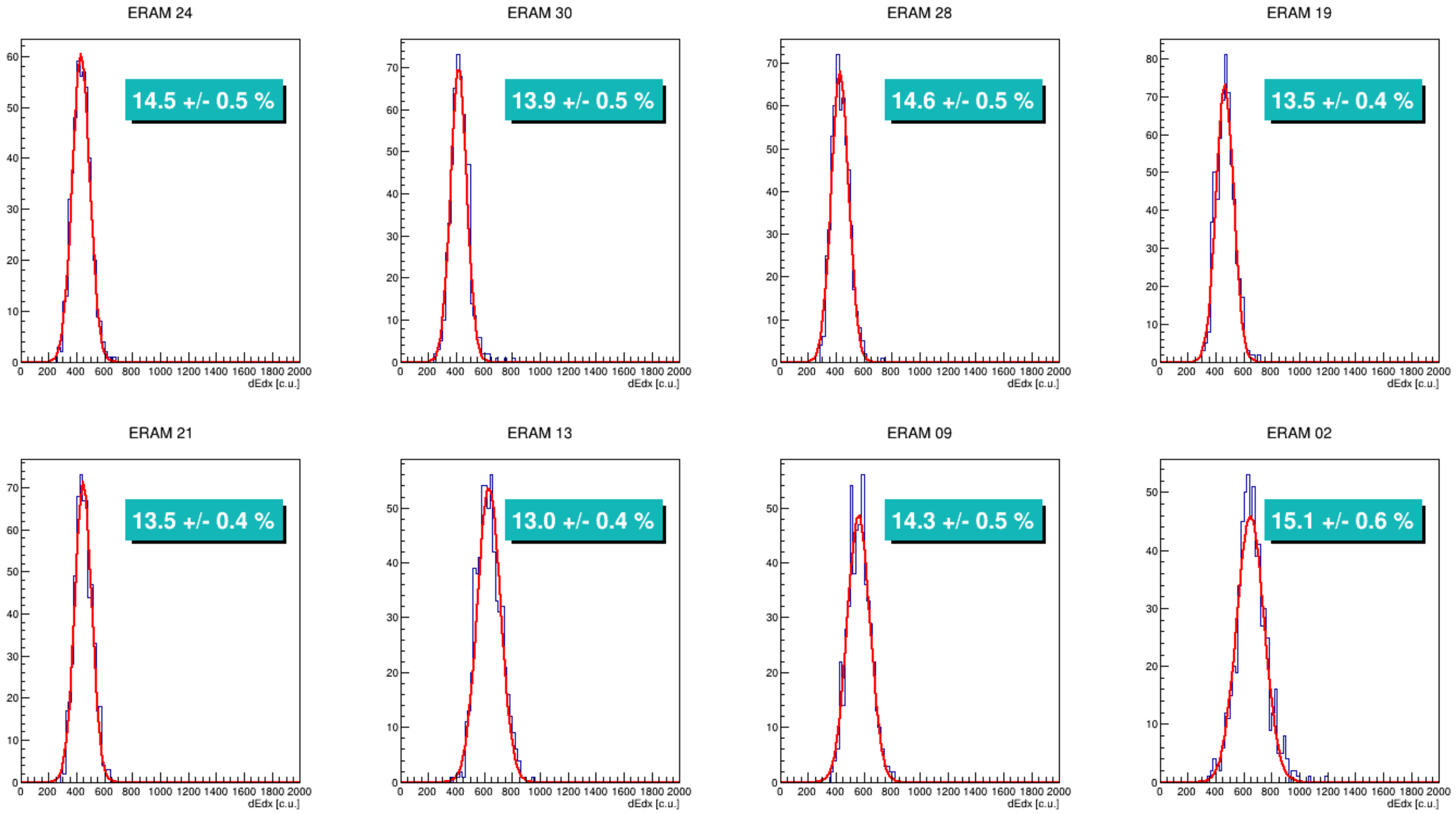
End Plate 1



Eres for a given momentum range

2 GeV < |p| < 3 GeV

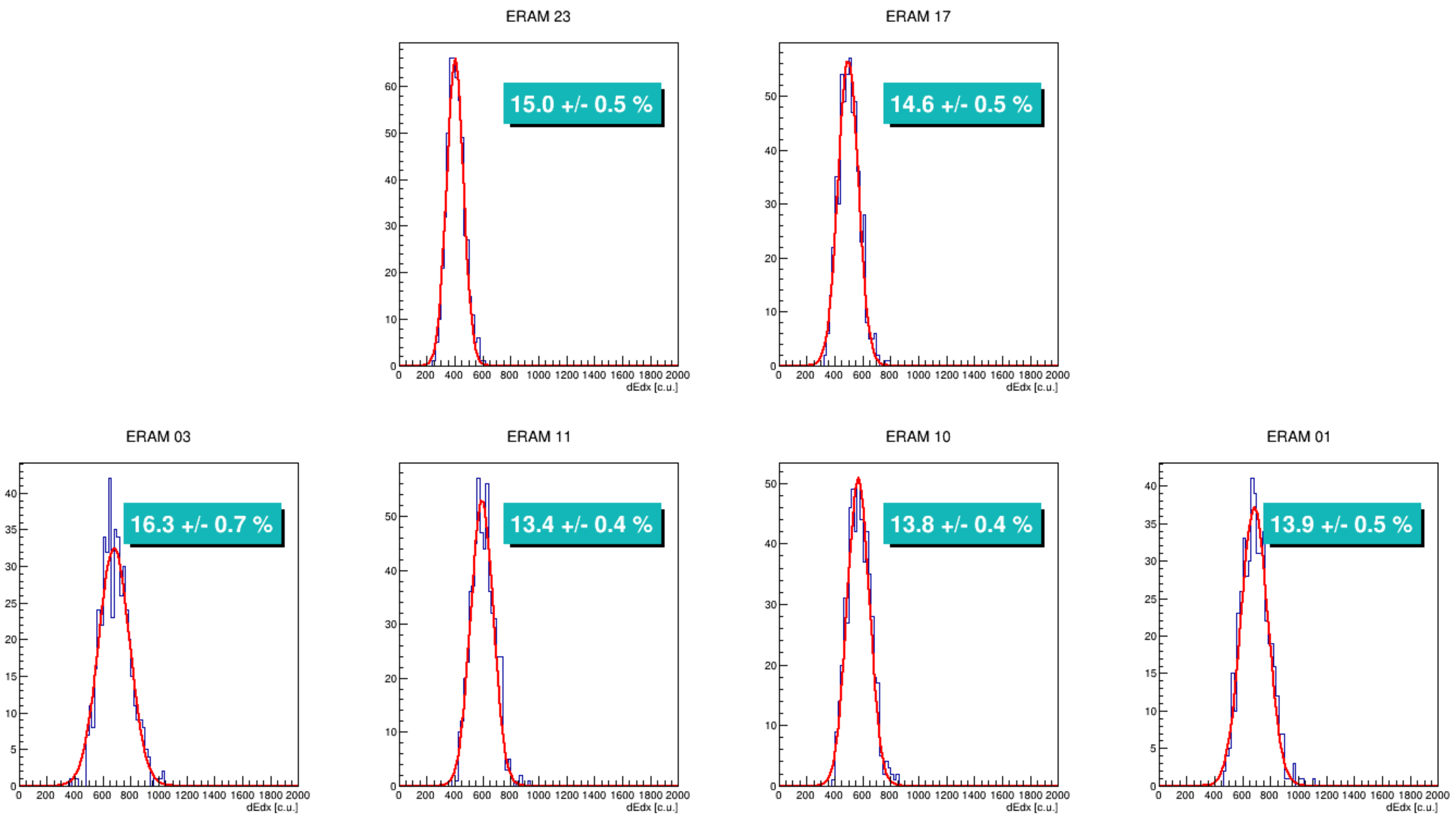
End Plate 0



Eres for a given momentum range

2 GeV < |p| < 3 GeV

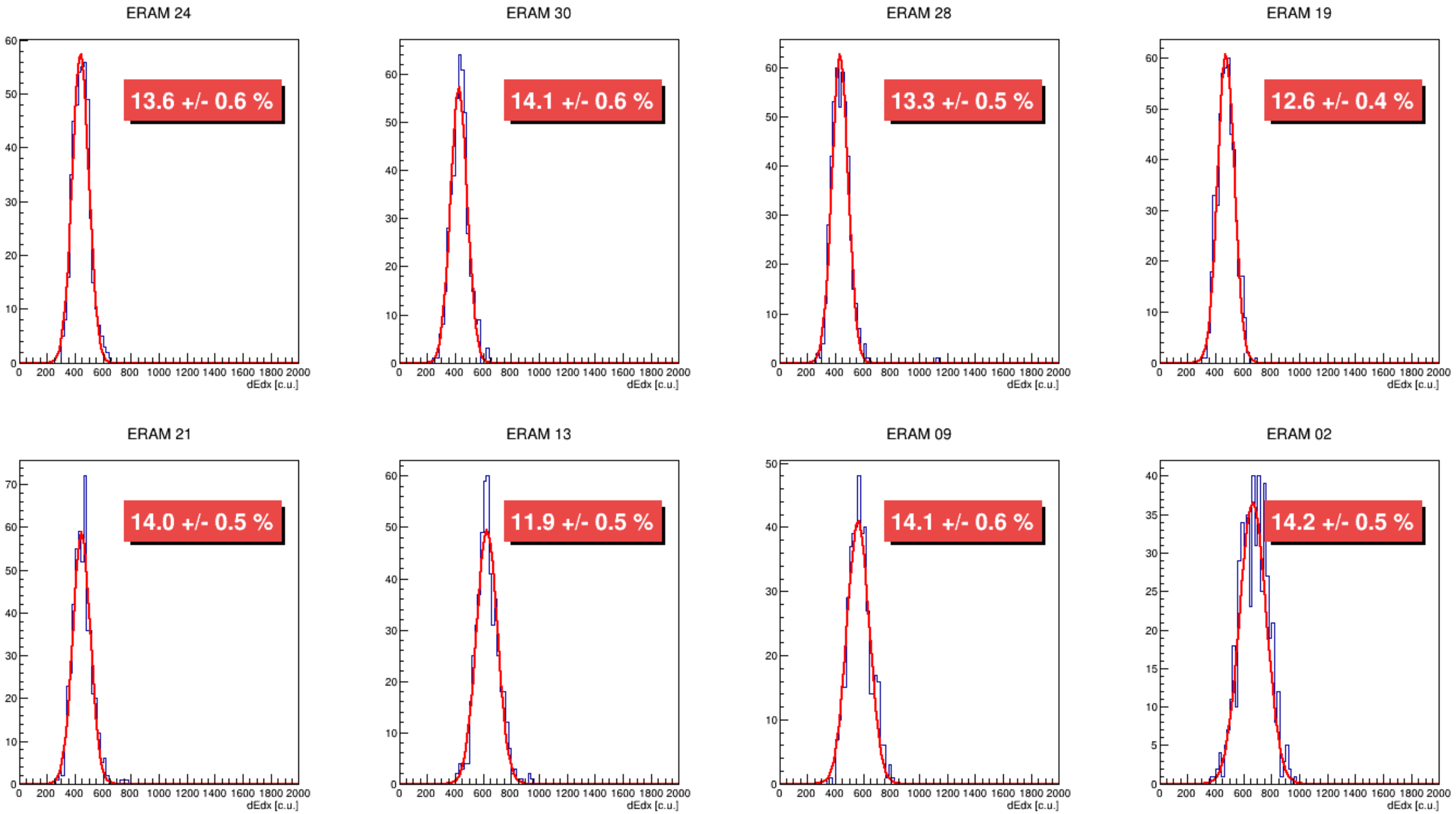
End Plate 1



Eres for a given momentum range

3 GeV < |p| < 5 GeV

End Plate 0



Eres for a given momentum range

3 GeV < |p| < 5 GeV

End Plate 1