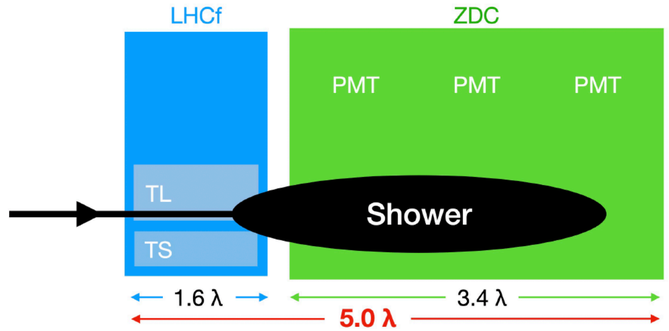
Position dependence of Energy distribution

Kobayashi Haruka

Introduction

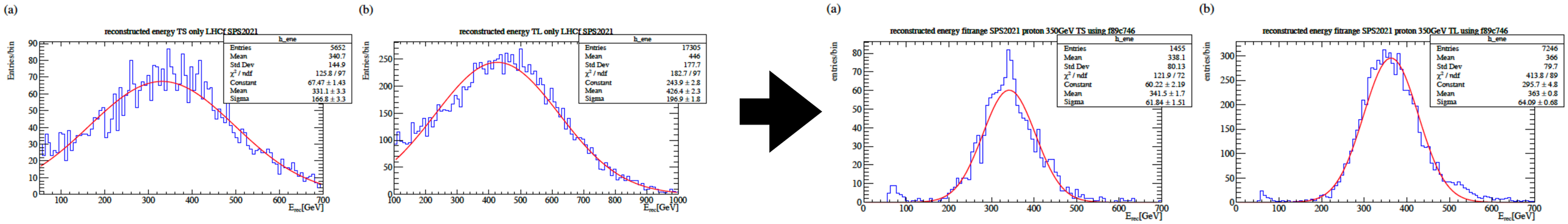
- Energy resolution for hadrons measured by only LHCf is not good because hadronic showers develop in the deeper layers.
- LHCf+ZDC enable to cover the whole hadronic showers and has better energy resolution



Introduction

- This work is taken over Kondo's work.
  She analyzed events that particle enter in center of LHCf detector.

- She confirmed improvement of the resolution with SPS2021 data.



Only LHCf

Mean TS:331.1GeV, TL:426.4GeV

Resolution TS: 50.4%, TL:46.2%

LHCf+ZDC

Mean TS:341.5GeV, TL:363GeV

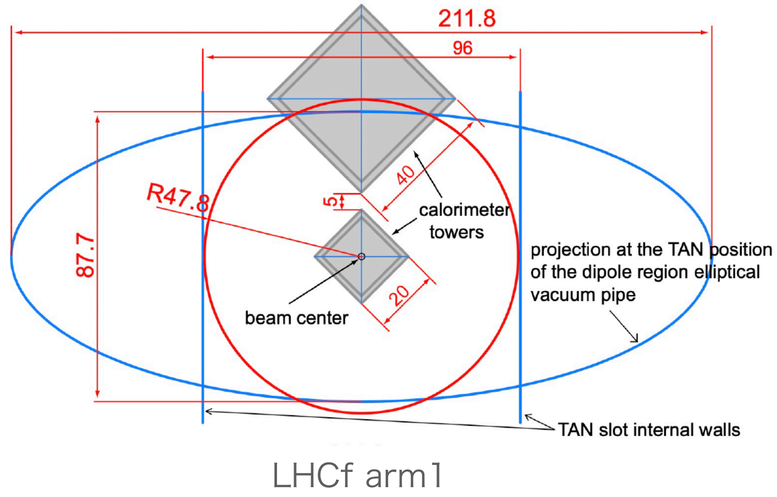
Resolution TS: 18.1%, TL:17.7%

Introduction

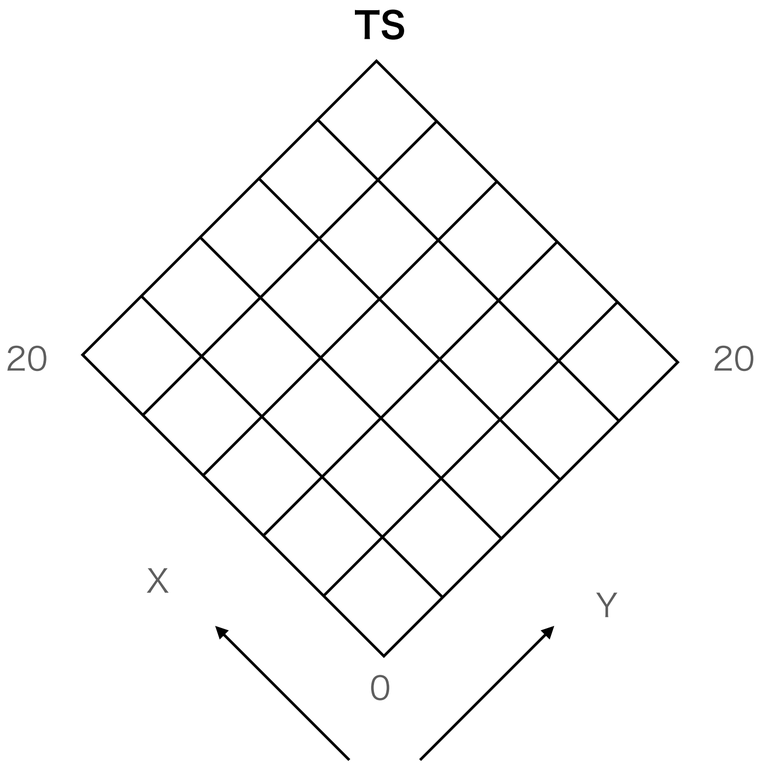
- Check hit position dependence of energy.
- Motivation is to check ①light yield correction, ②position of ZDC fiber, ③effect of the shower leak of vertical direction.

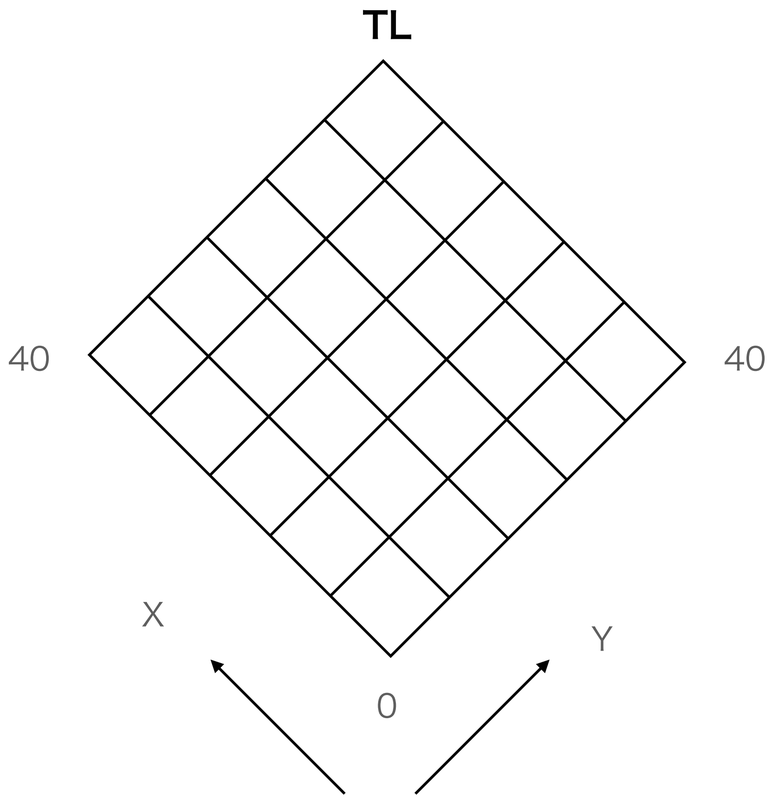
Hit position block

- Divide hit position into 5*5 position blocks .
- Analyze block by block
- Exclude 2mm edge regimes.

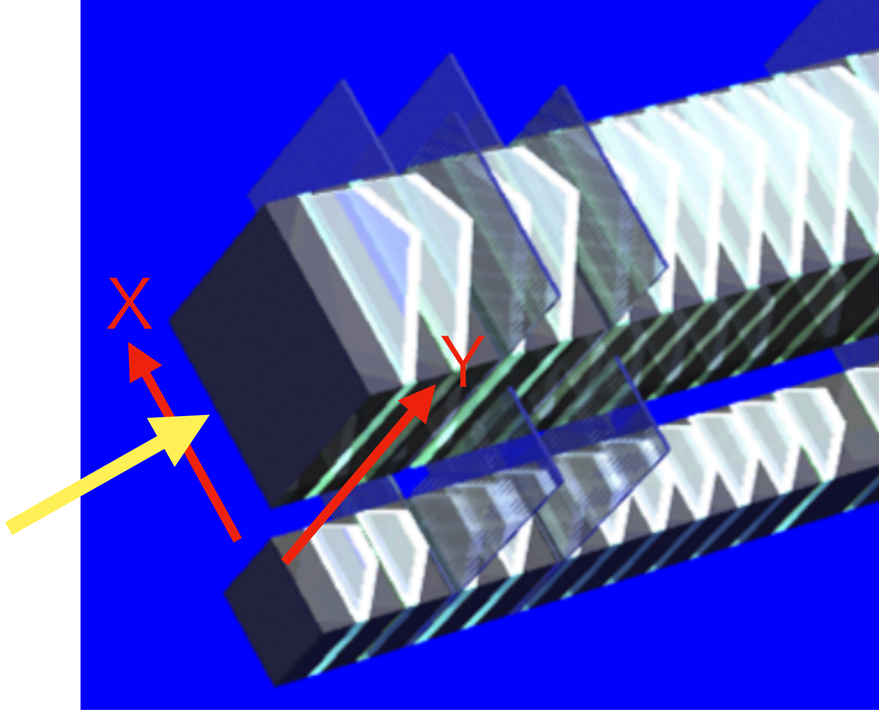


LHCf arm1

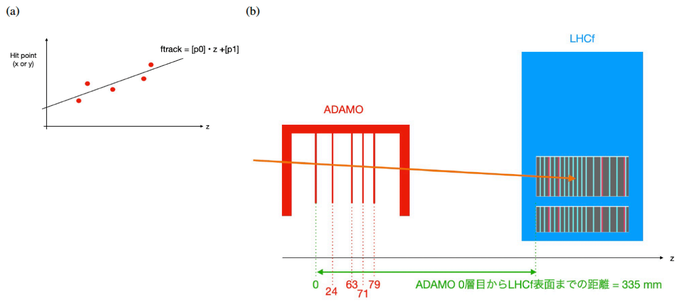




Data



- TS
  SPS2021: 350GeV proton,
  run 70293, 70298, 70299, 70304, 70306, 70307
- TL
  SPS2021: 350GeV proton,
  run 70294-70297, 70309-70311, 70314-70318, 70339-70341
- In only LHCf analysis, hit position is determined by position sensitive detectors in LHCf(GSO bar).
- In LHCf+ZDC analysis, the position is determined by ADAMO



Method to reconstruct energy(E_ZDC)

The method was defined by Konda-san

- In Data analysis,
  E_ZDC[module] = lvl2_a1->fOpenADC[i];
  E_ZDC = (E_ZDC[0]-pedestal(0))*ratio(0)
  + (E_ZDC[1]-pedestal(1))*ratio(1)
  + (E_ZDC[2]-pedestal(2))*ratio(2)

- In MC analysis,
  E_ZDC += lvl2_a1->fZDC[i]

Method to reconstruct energy(E_LHCf)

- 2<=layer<11, E_LHCf+=lvl2_a1->fCalorimeter[tower][layer]*LY_TL[layer][ix][iy]
  layer>=11, E_LHCf+=2*lvl2_a1->fCalorimeter[tower][layer]*LY_TL[layer][ix][iy]

LY_TL[layer][ix][iy], LY_TS[layer][ix][iy] is Light Yield correction which is made by Kondo.

- E_est = E_LHCf+αE_ZDC

- E_rec = f(E_est)

f is quadratic function in this time
For $E_{est} = x$,

TS: $f = -0.01269x^2 + 43.17x + 50.36$

TL: $f = -0.0069x^2 + 34.91x + 45.07$

α is scale factor.

Pick up the events which correlation of E_LHCf and E_ZDC is more liner.

This liner function is $E_{ZDC} = -34.04E_{LHCf} + b$ in TS, $E_{ZDC} = -25.52E_{LHCf} + b$ in TL.

In TS, $E_{est} = b/34.04$. In TL, $E_{est} = b/25.52$.

Scale factor is TS: $\alpha = 1/34.04 = 0.029$, TL: $\alpha = 1/25.52 = 0.039$.

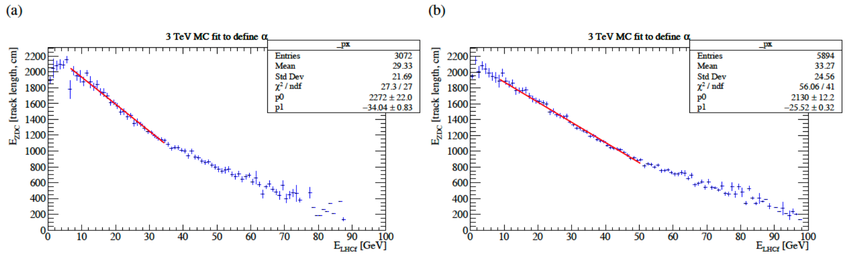
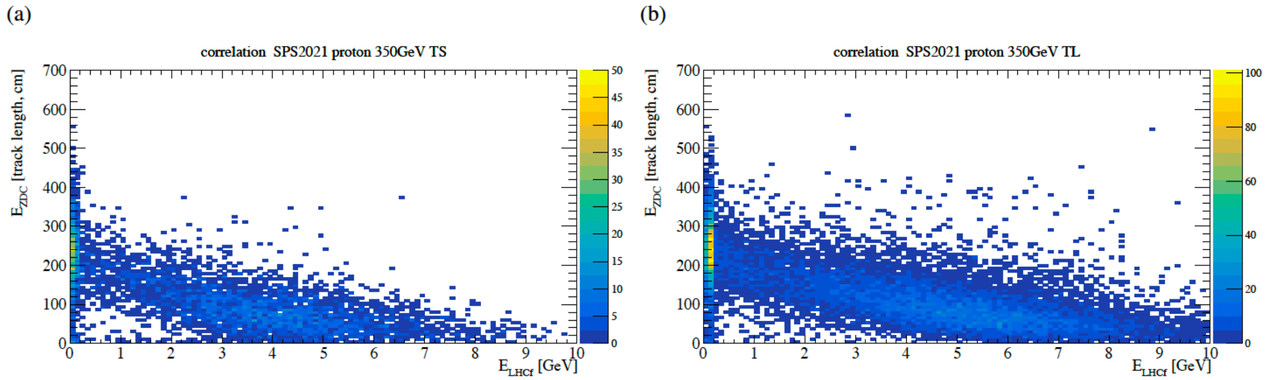


図 6.7 ZDC スケールファクターの決定。LHCf と ZDC のエネルギーの相関の傾きを用いて関係式を導き、式 (6.6) と比較することで ZDC スケールファクターを得る。得られた補正係数は TS の場合 $\alpha = 0.029$、TL の場合 $\alpha = 0.039$ である。 (a)、(b) はそれぞれ TS、TL を表す。

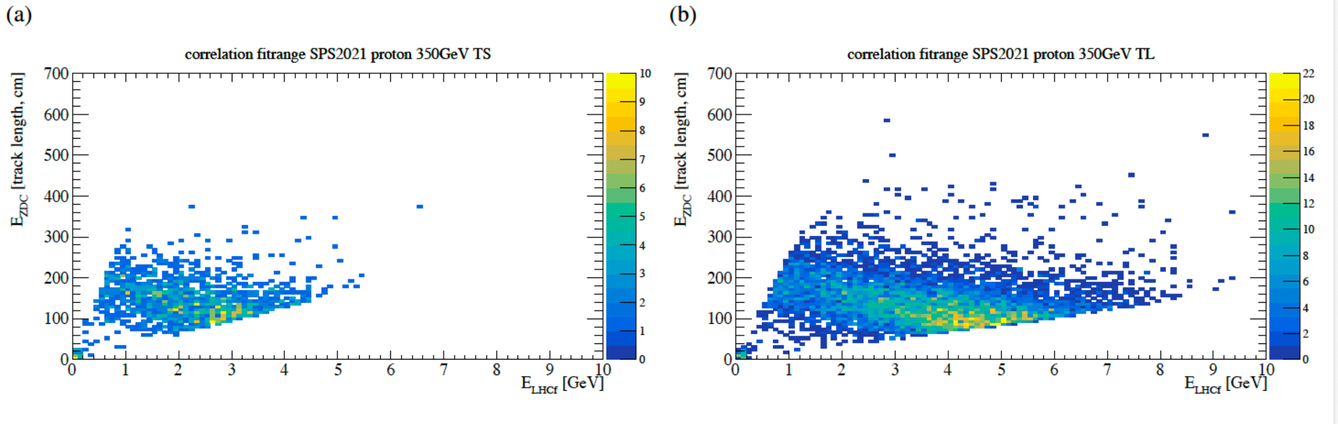
Correlation between E_LHCf and E_ZDC

- Method3: all events



Ideally, E_LHCf and E_ZDC should be proportional. But, in low energy and high energy range, the events violate this proportional relation.

- Method4(fitrange): limit the events



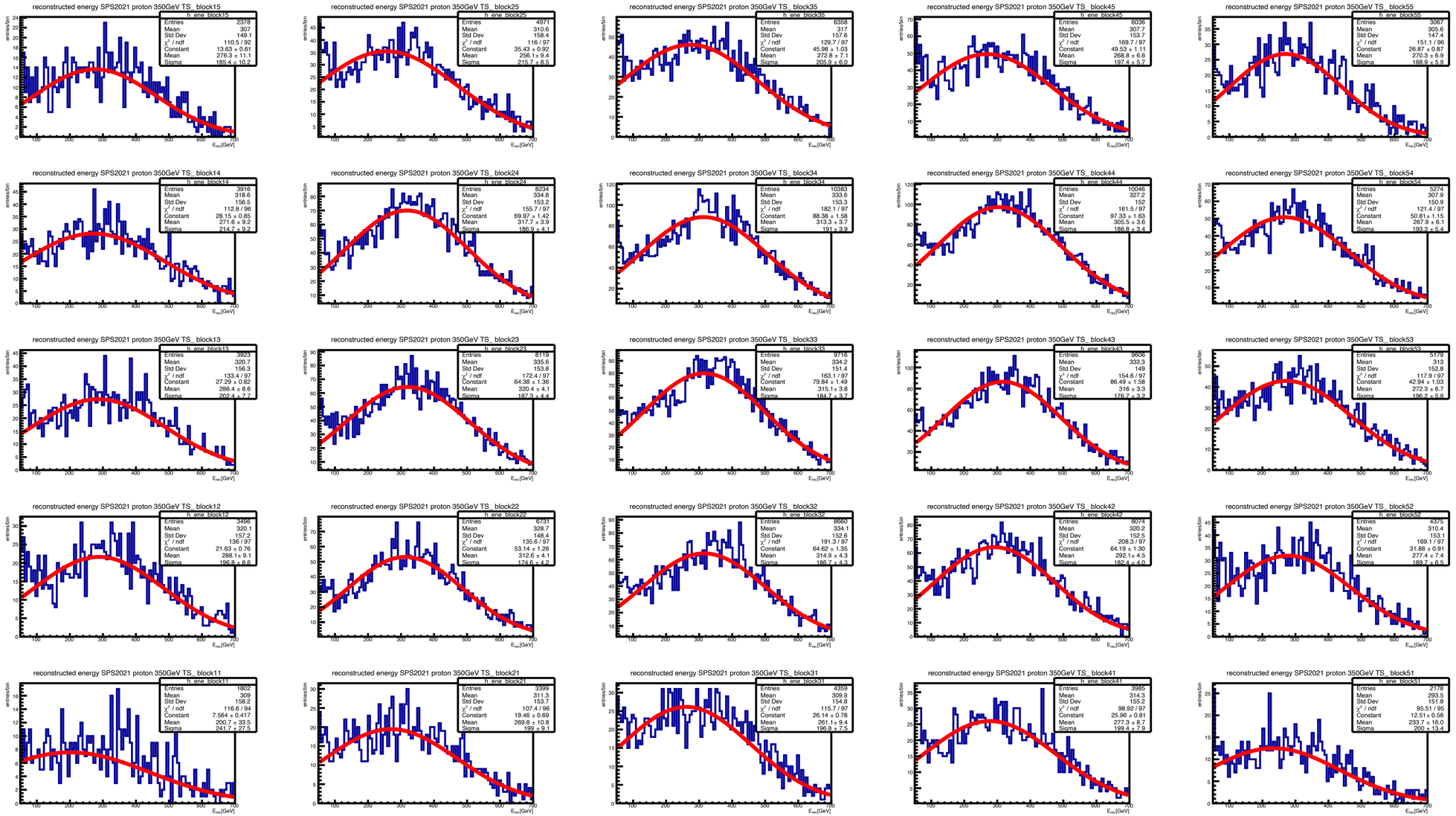
This 2 methods are from Kondo's work.

MC Data (by Kondo-San)

- TS
  SPS2021 350GeV proton
  total number of events: 55837(with 2mm edge cut)
- TL
  SPS2021 350GeV proton
  total number of events: 141112(with 2mm edge cut)
- Hit position is uniform.

Energy distribution in each blocks(LHCf only)

yblock



Small tower

Blue: data histogram

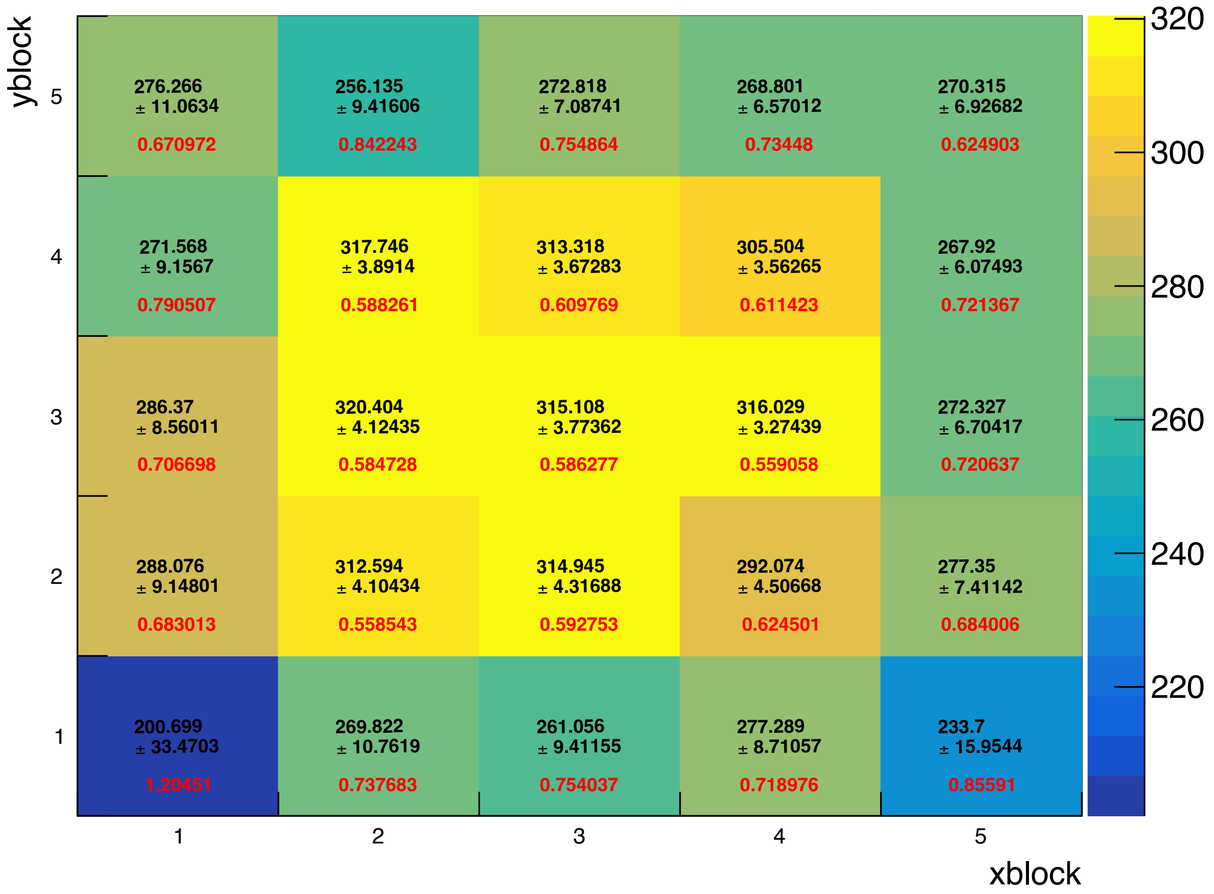
Red line: gaus fitting

Xblock

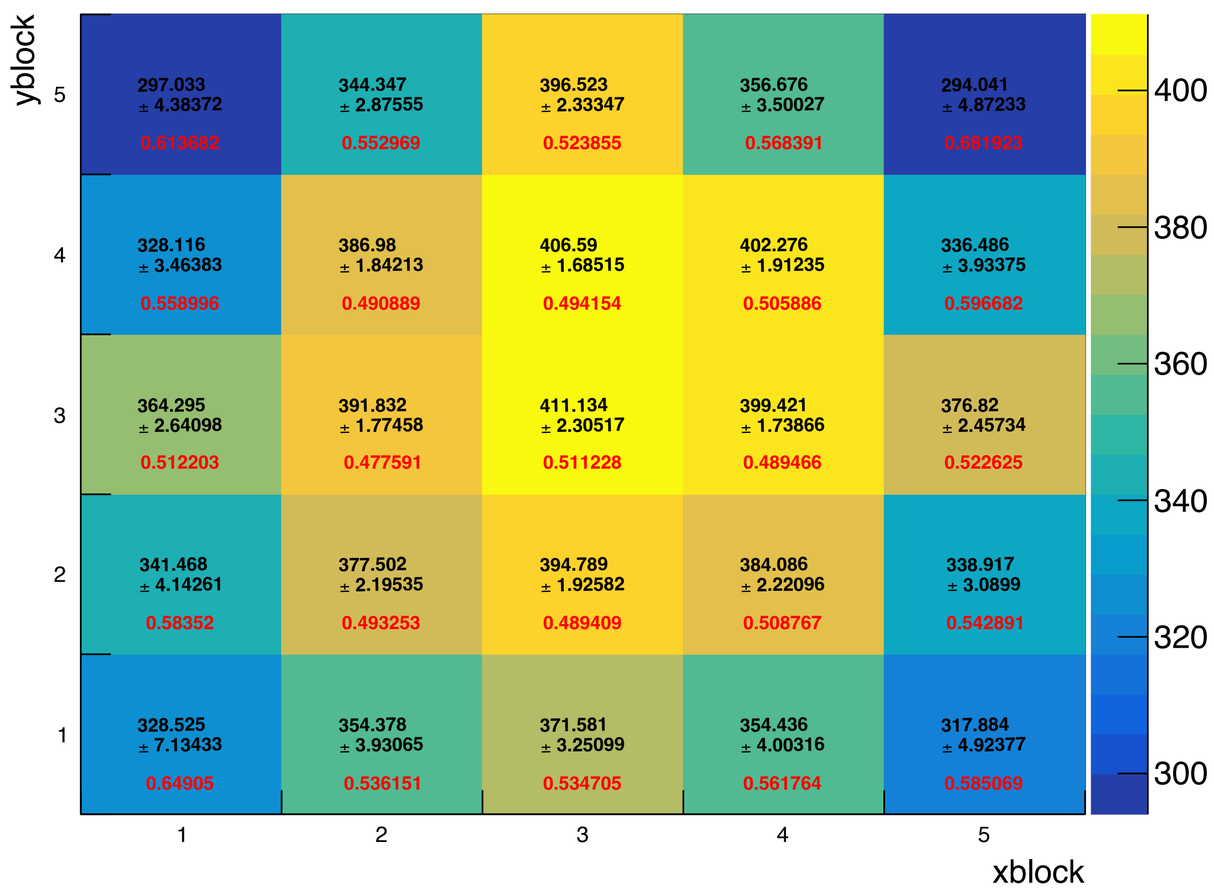
Result by only LHCf

Black: energy mean (gaus fitting)
Red: energy resolution (gaus fitting)

Energy uniformty TS onlyLHCf



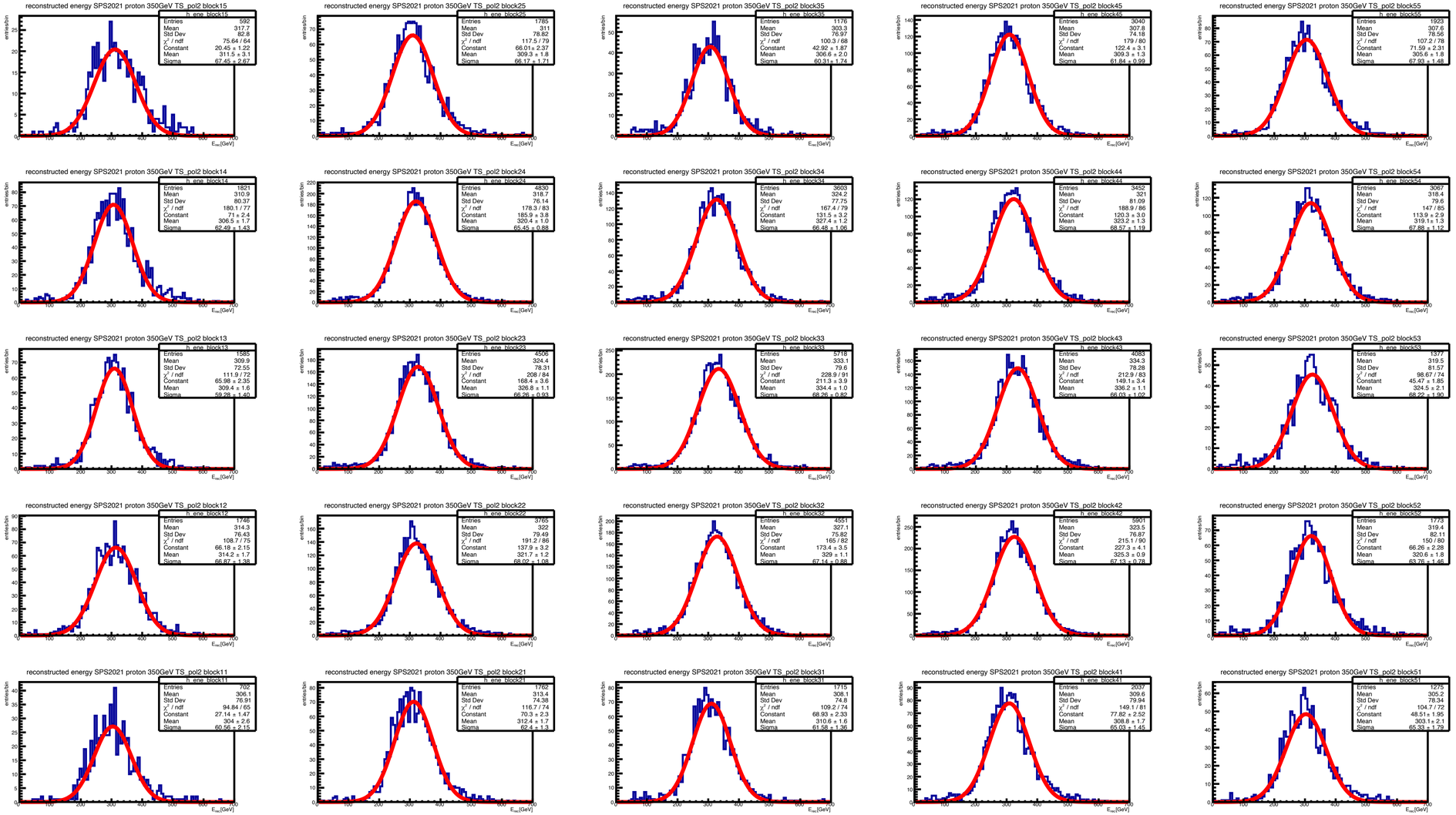
Energy uniformty TL onlyLHCf



Energy distribution in each blocks(LHCf+ZDC)

For example of TS

yblock



Blue: data histogram

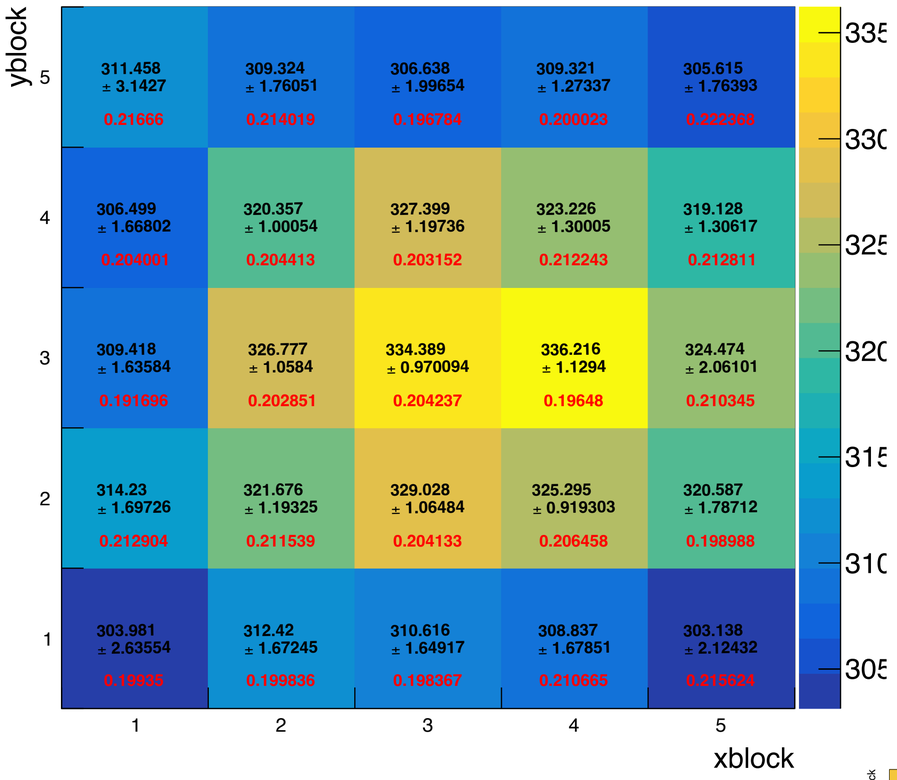
Red line: gaus fitting

Xblock

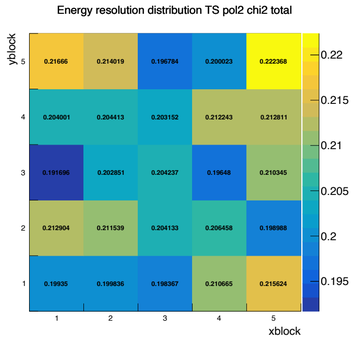
Black: energy mean (gaus fitting)
Red: energy resolution (gaus fitting)

Result by LHCf+ZDC

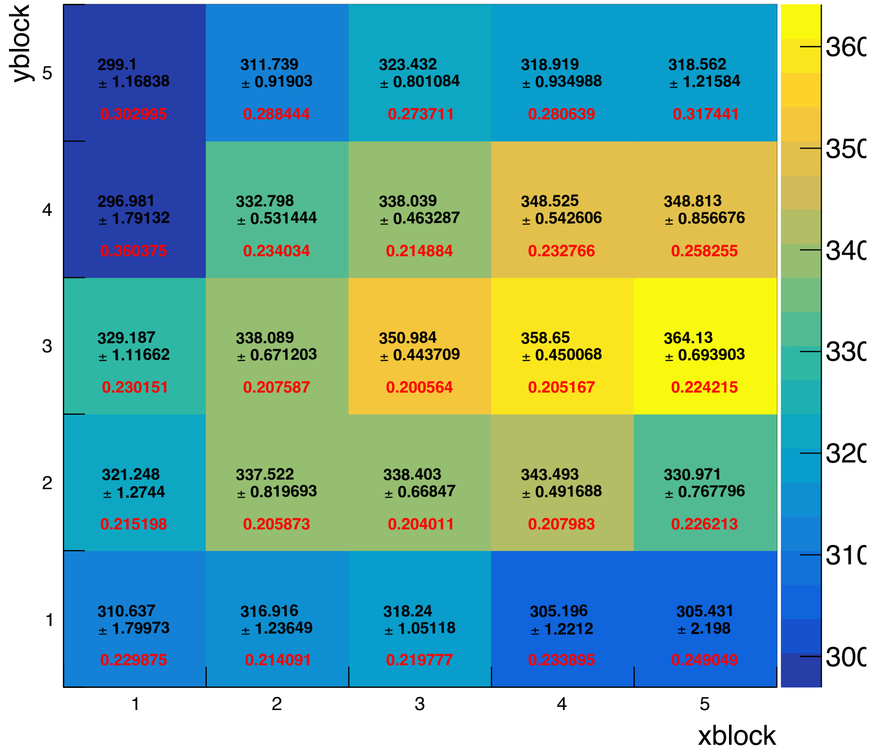
Energy uniformty TS pol2 chi2 total



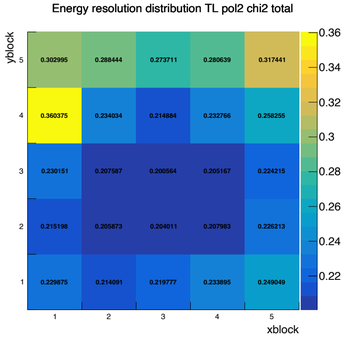
Resolution distribution



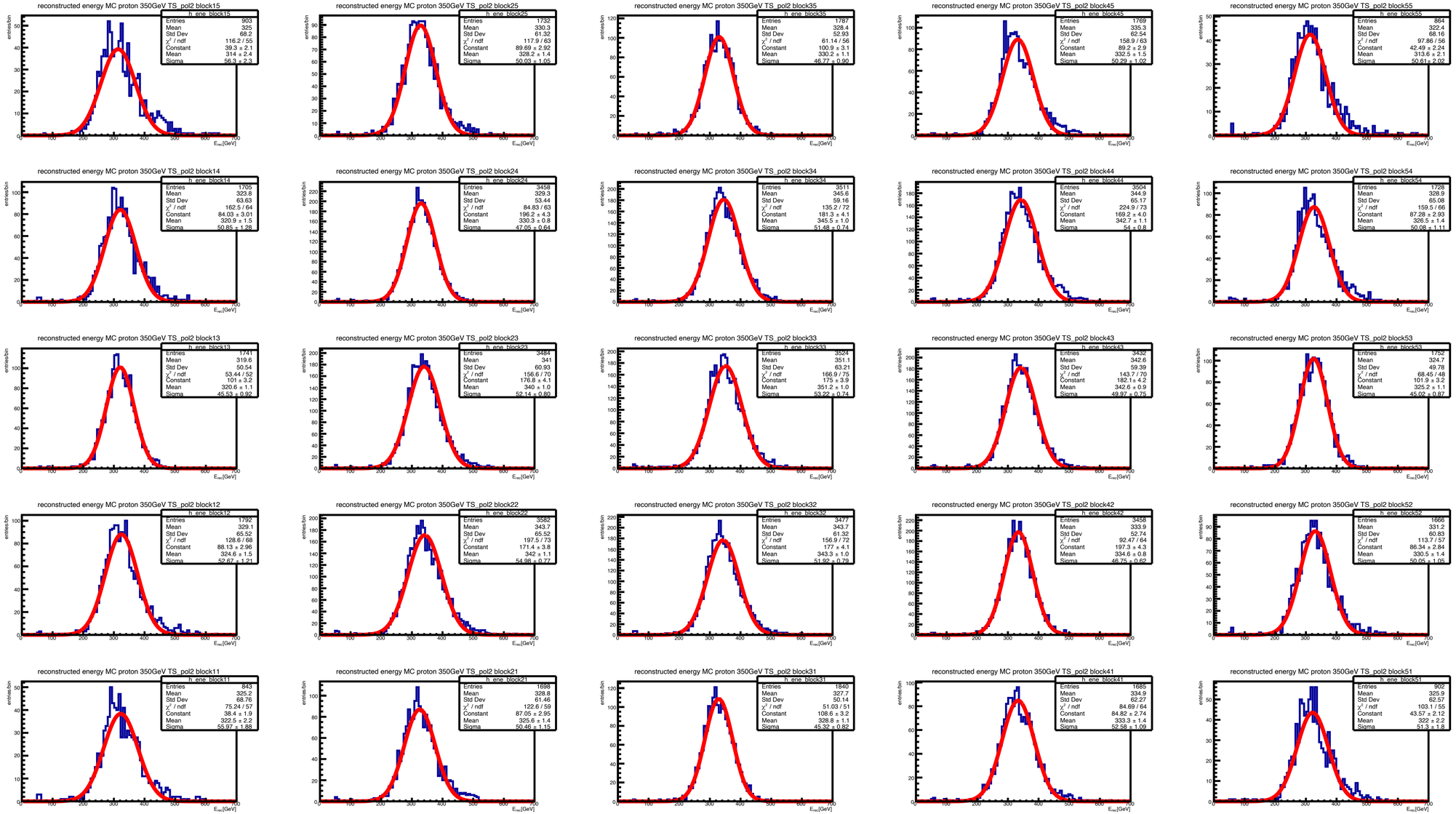
Energy uniformty TL pol2 chi2 total



Resolution distribution



MC(LHCf+ZDC)



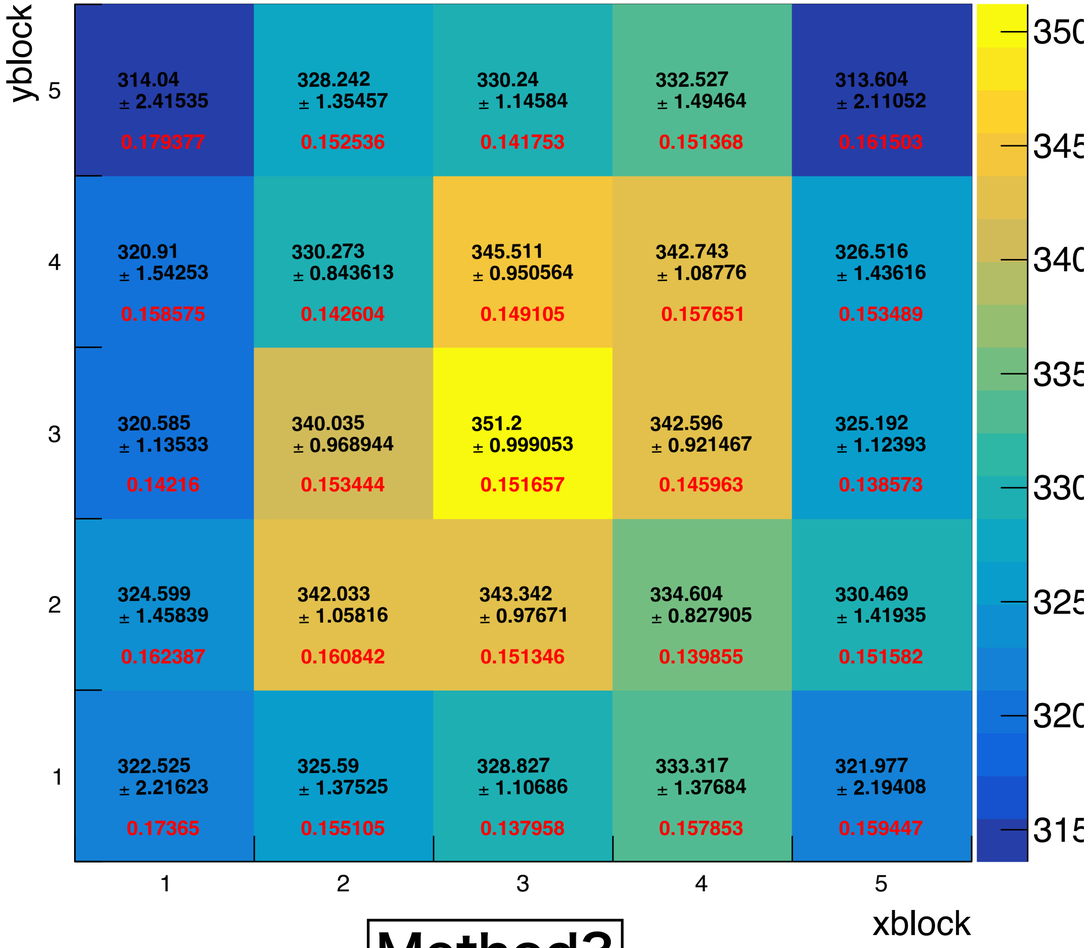
Blue is histogram.
Red is gaus fitting.

MC(LHCf+ZDC) Small Tower

Position dependence exist

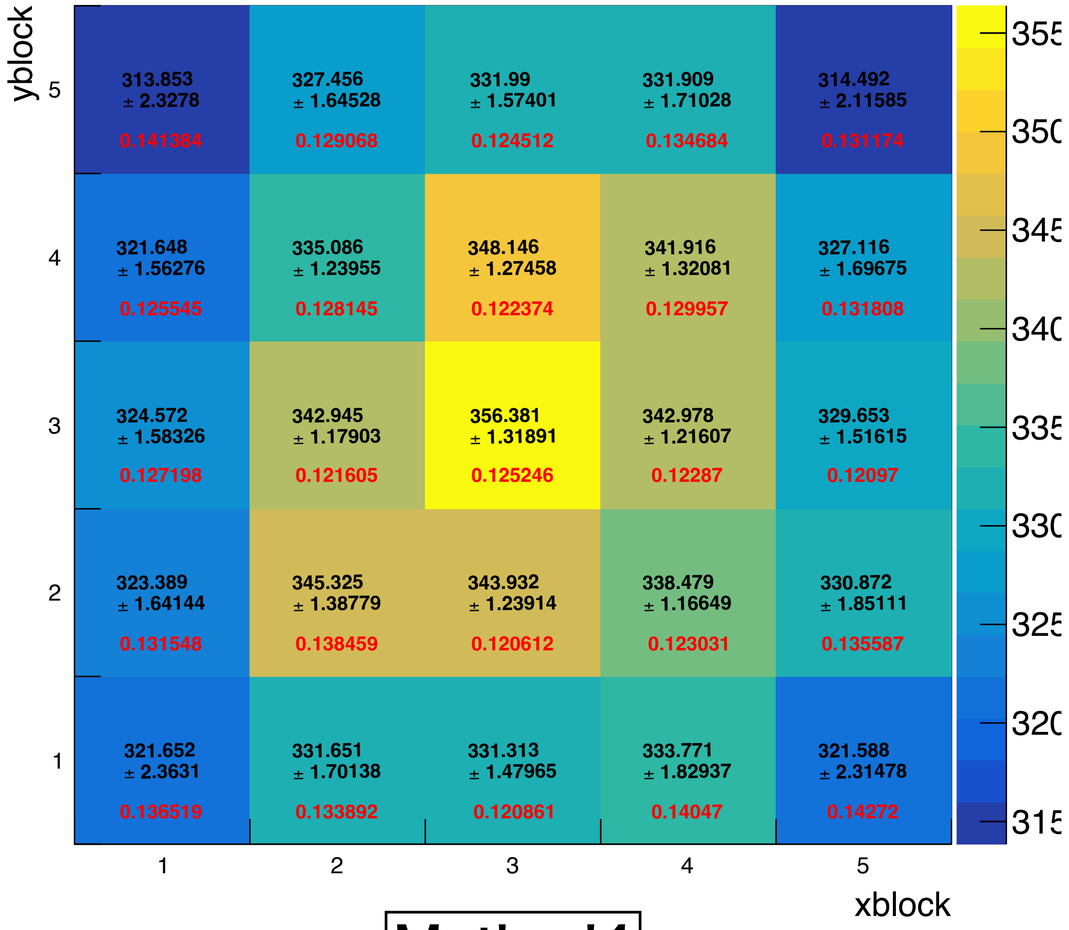
Black: mean+-error
Red: resolution

Energy uniformty MC TS pol2 chi2



Method3

Energy uniformty MC TS pol2 chi2 fitrange



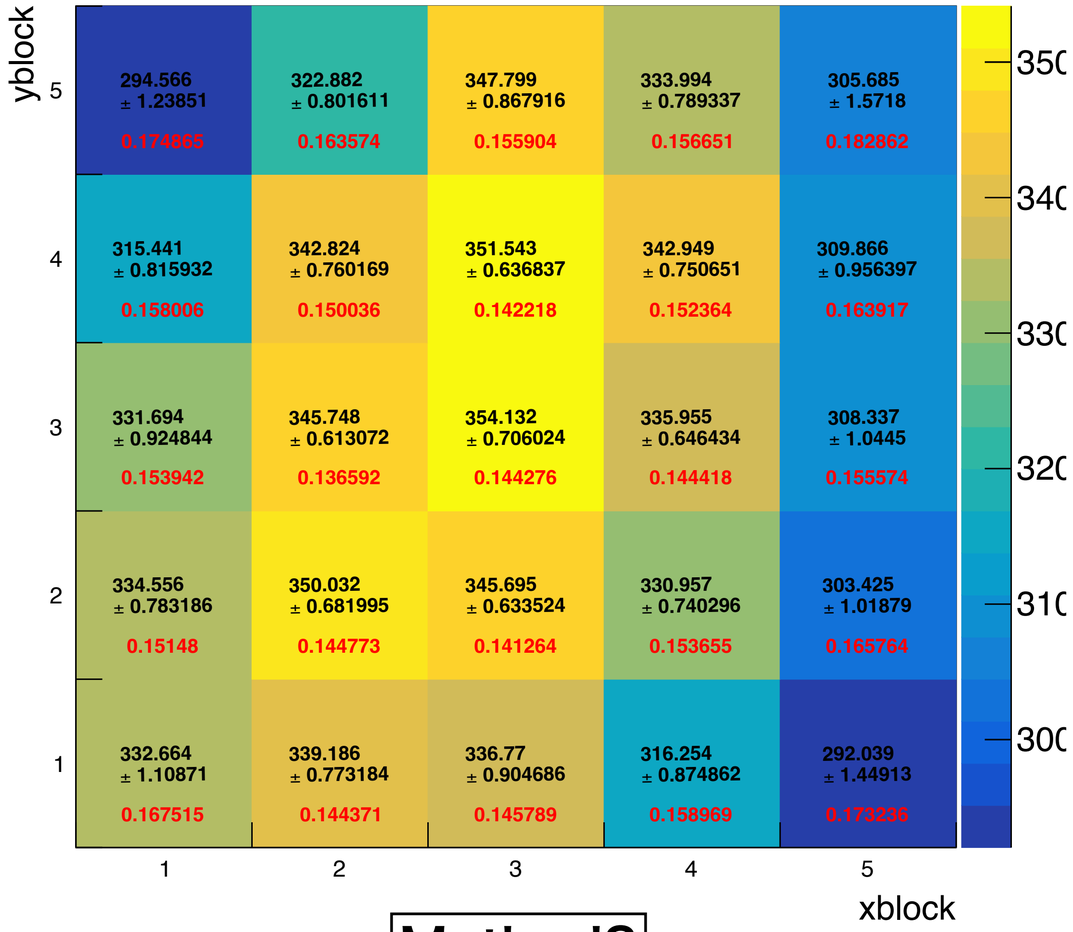
Method4

MC(LHCf+ZDC) LargeTower

In figure right side, energy is obviously small

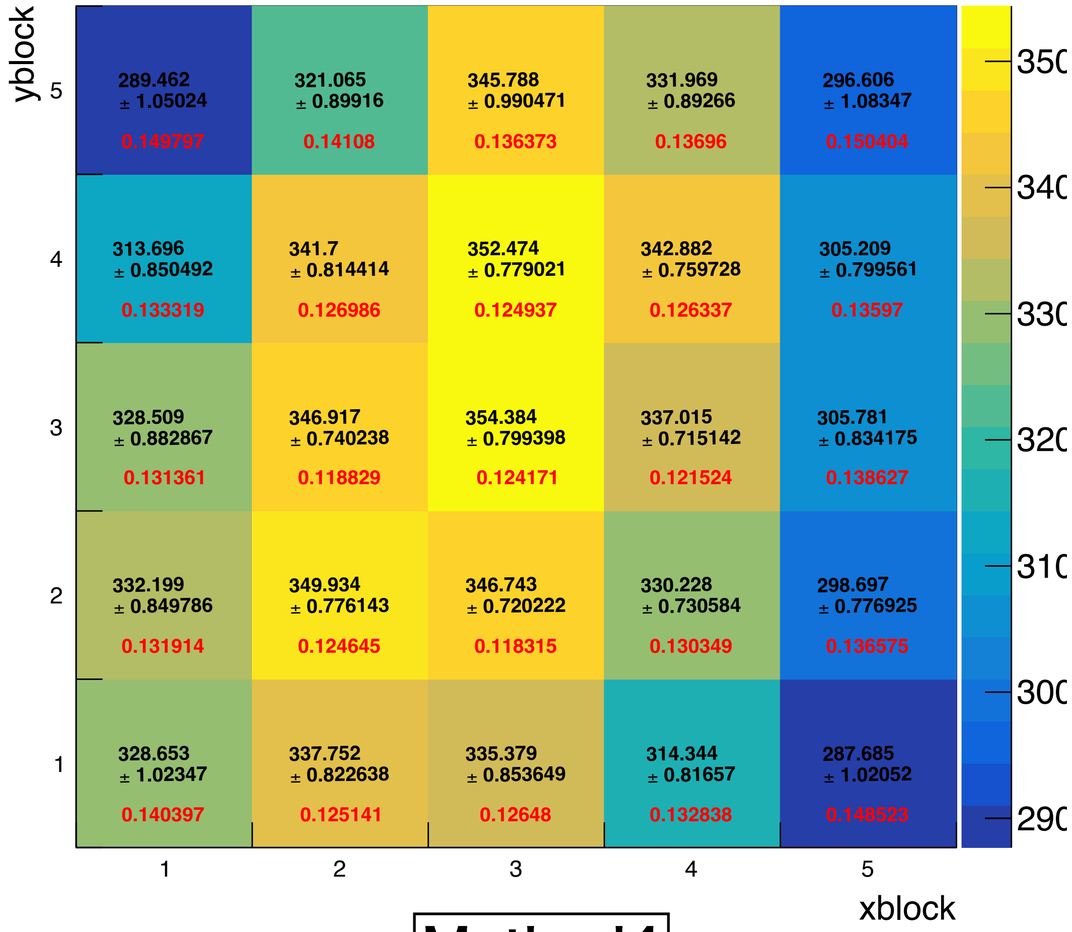
Black: mean+-error
Red: resolution

Energy uniformty MC TL pol2 chi2



Method3

Energy uniformty MC TL pol2 chi2 fitrange



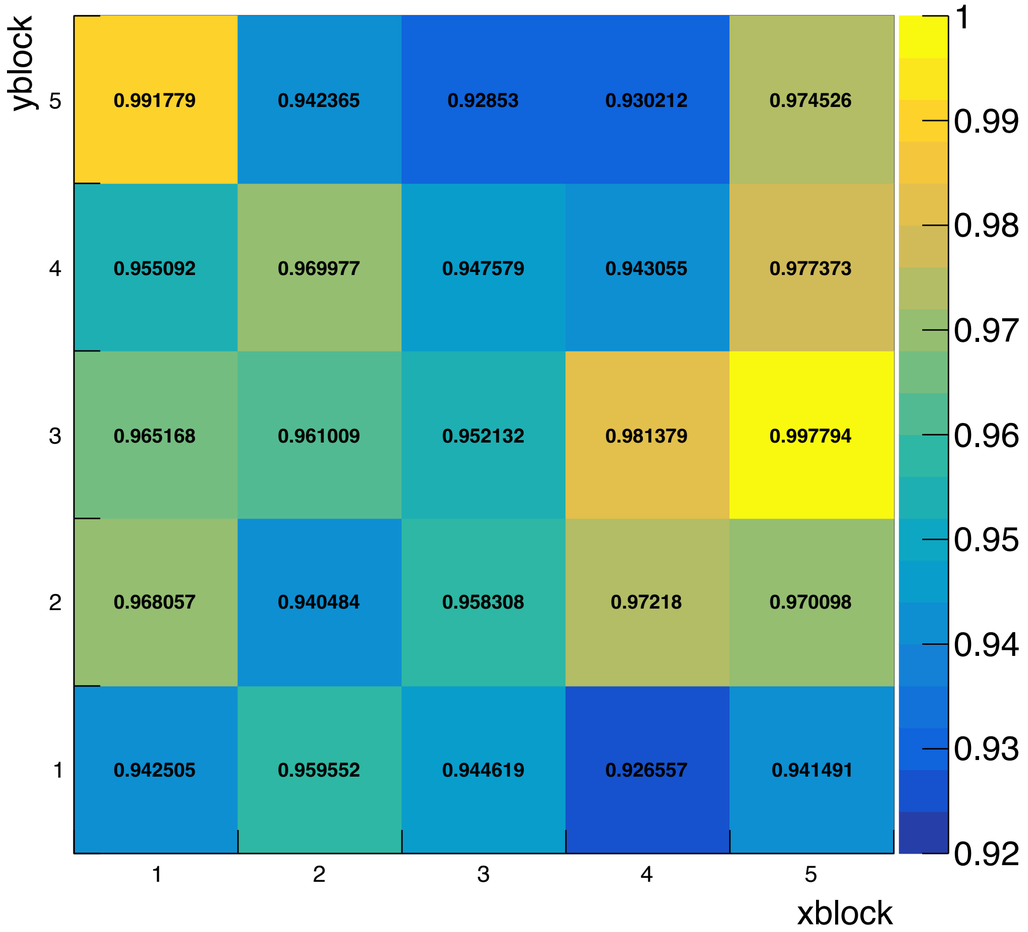
Method4

$$\text{Data/MC ratio in block(x, y)} = \frac{\text{mean Energy of Data in block(x, y)}}{\text{mean Energy of MC in block(x, y)}}$$

Data/MC (Small Tower)

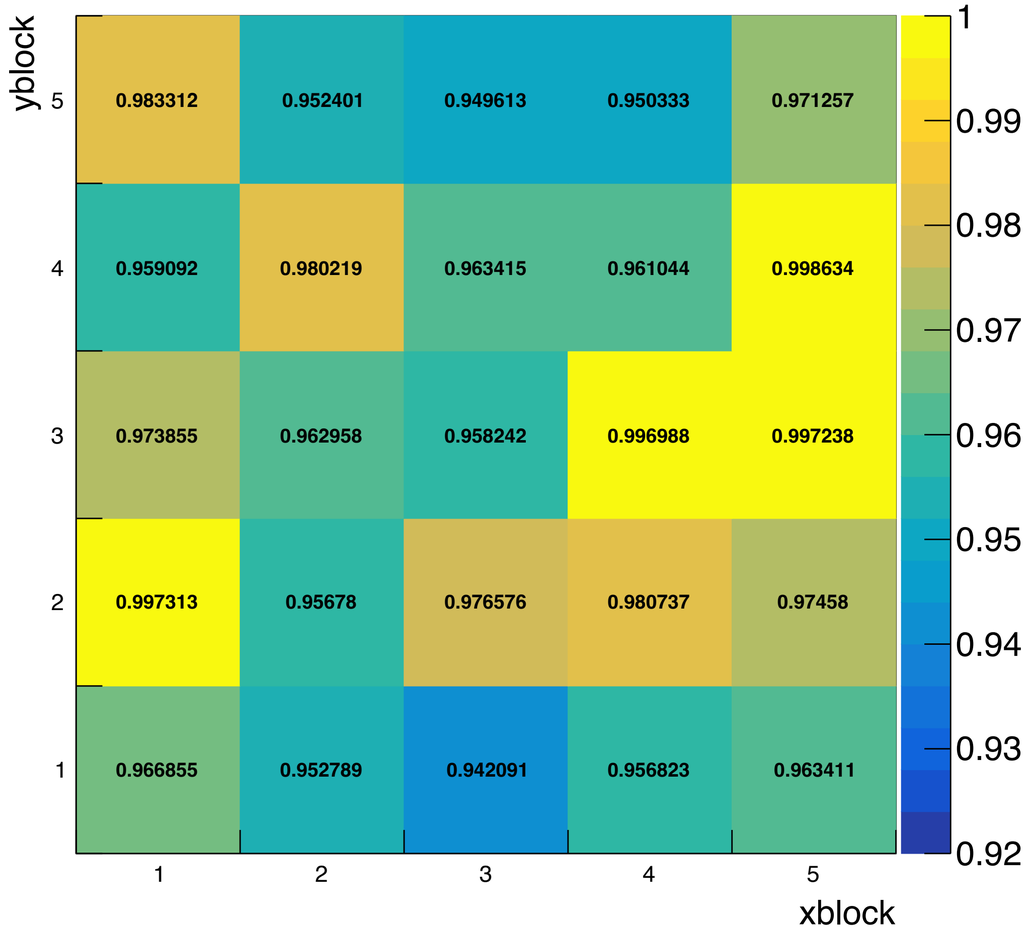
Ratio is small overall

meanratio(Data/MC) TS proton350 M3



Method3

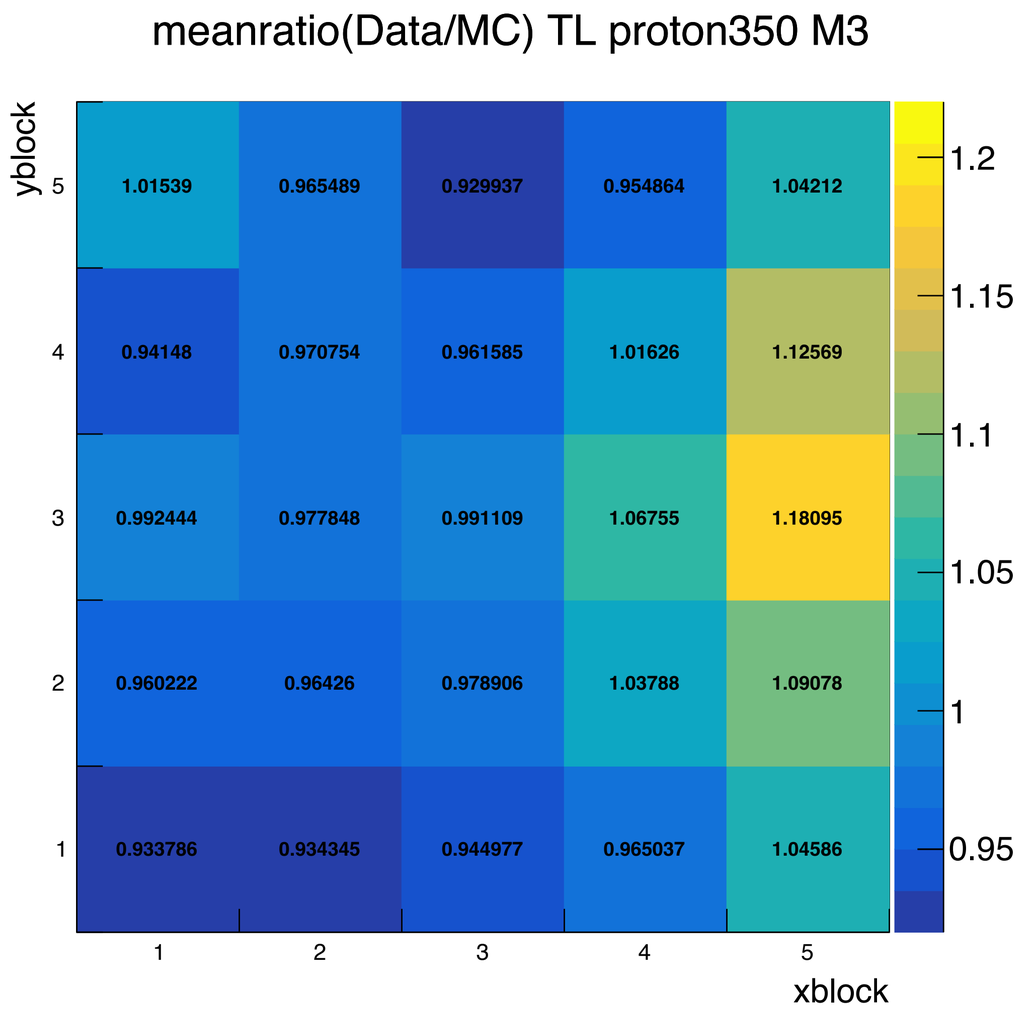
meanratio(Data/MC) TS proton350 M4

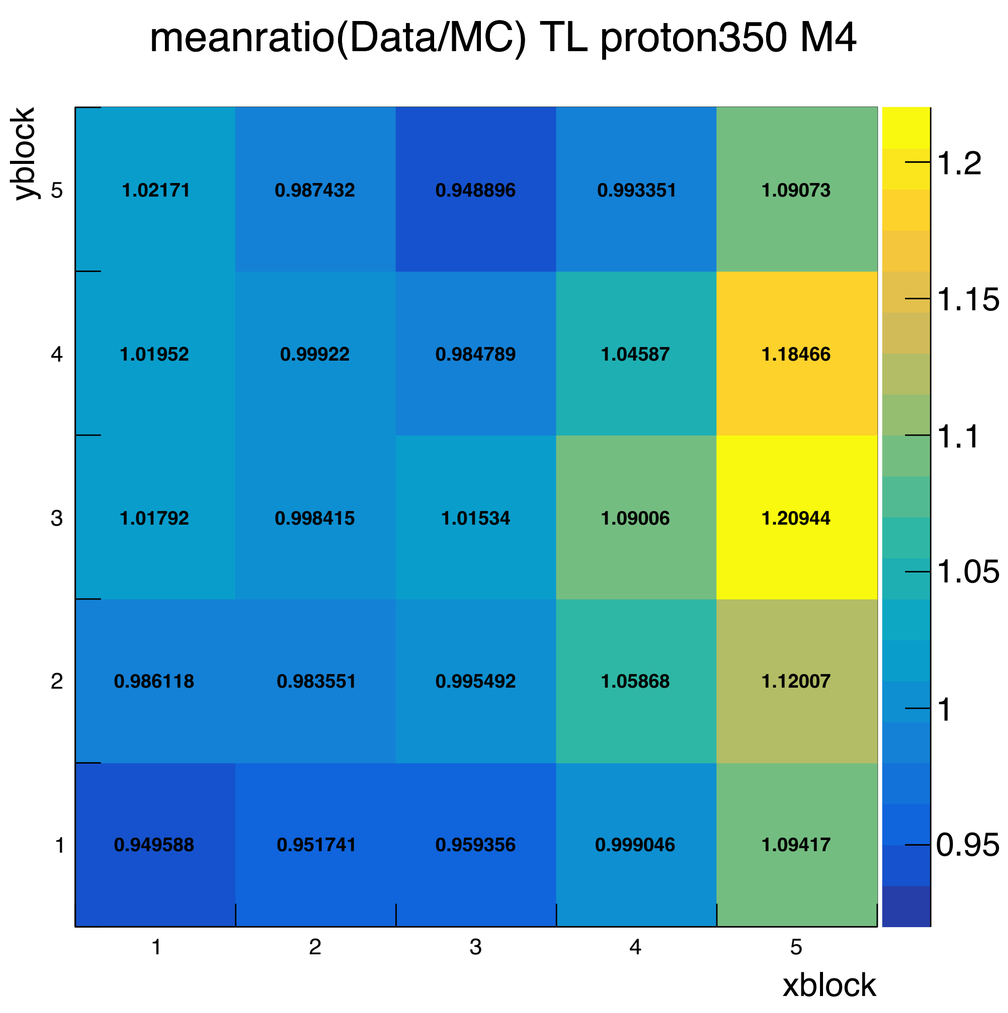


Method4

Data/MC Large Tower

In right side area, ratio is higher.
Value is small in MC and it is high in Data.





Method3

Method4

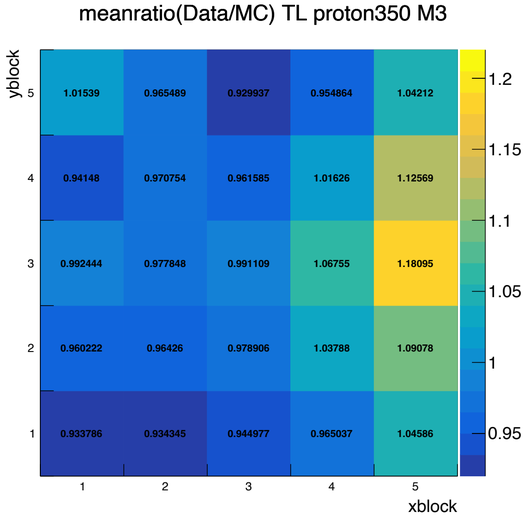
Compare E_LHCf

Large tower

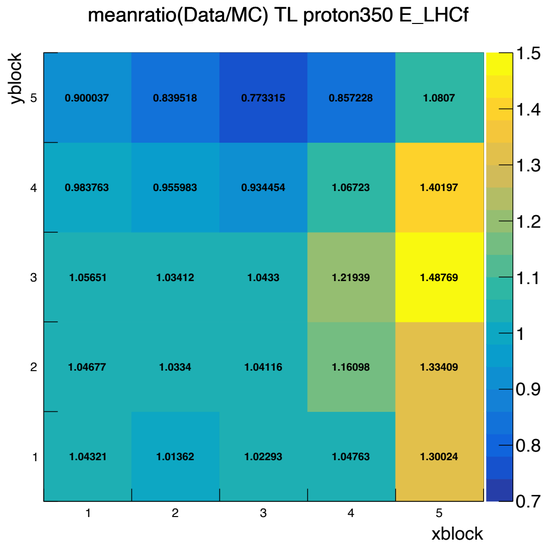
Red: data
Green: MC

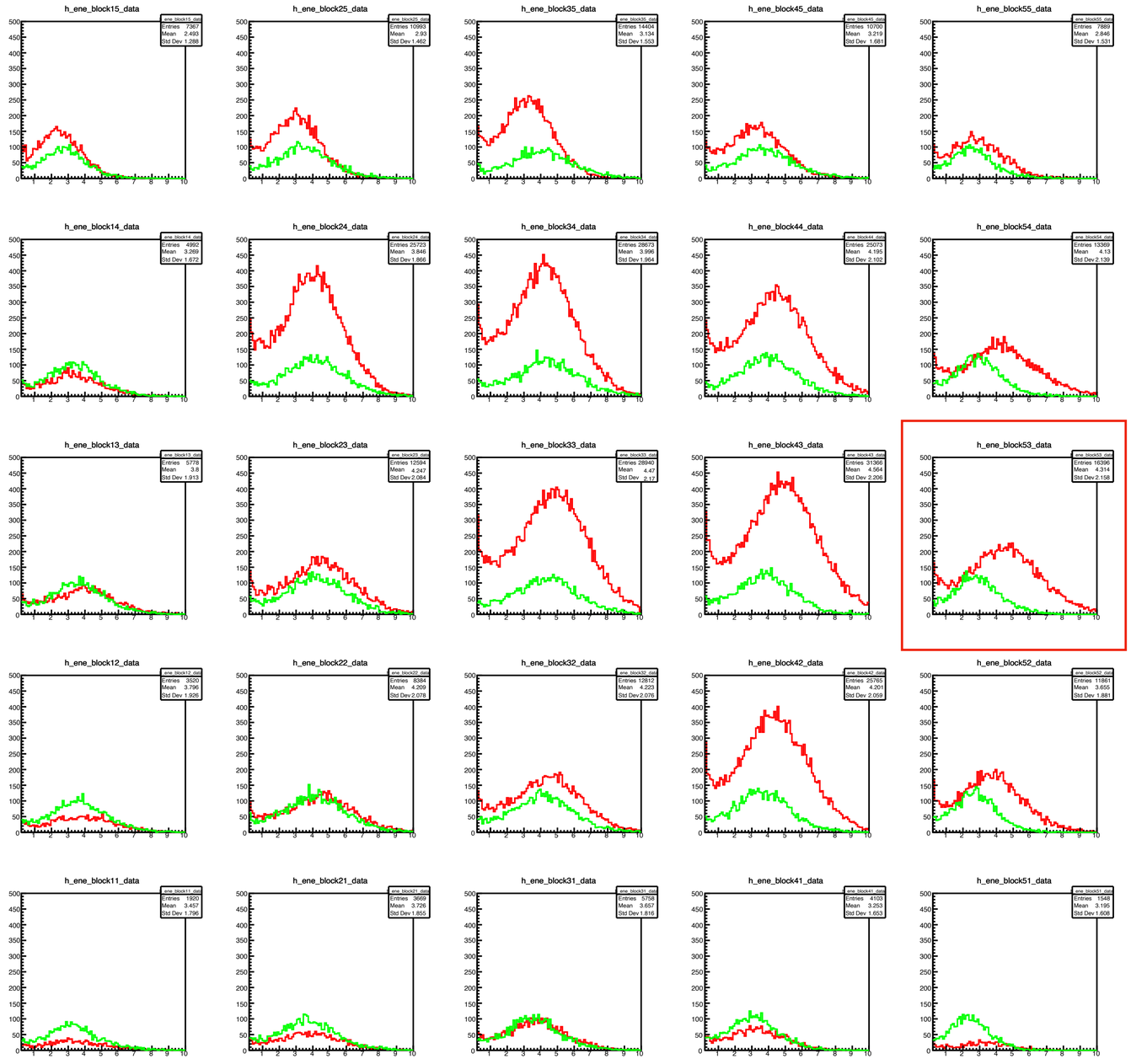
Differences of E_LHCf is between MC and SPS2021data

E_rec



Only E_LHCf





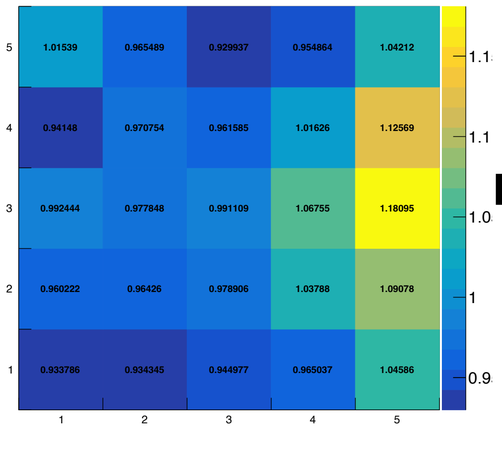
Compare E_ZDC

Large Tower

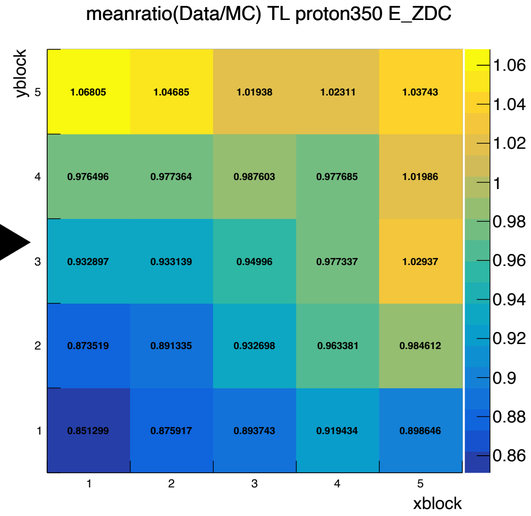
Red: data
Green: MC

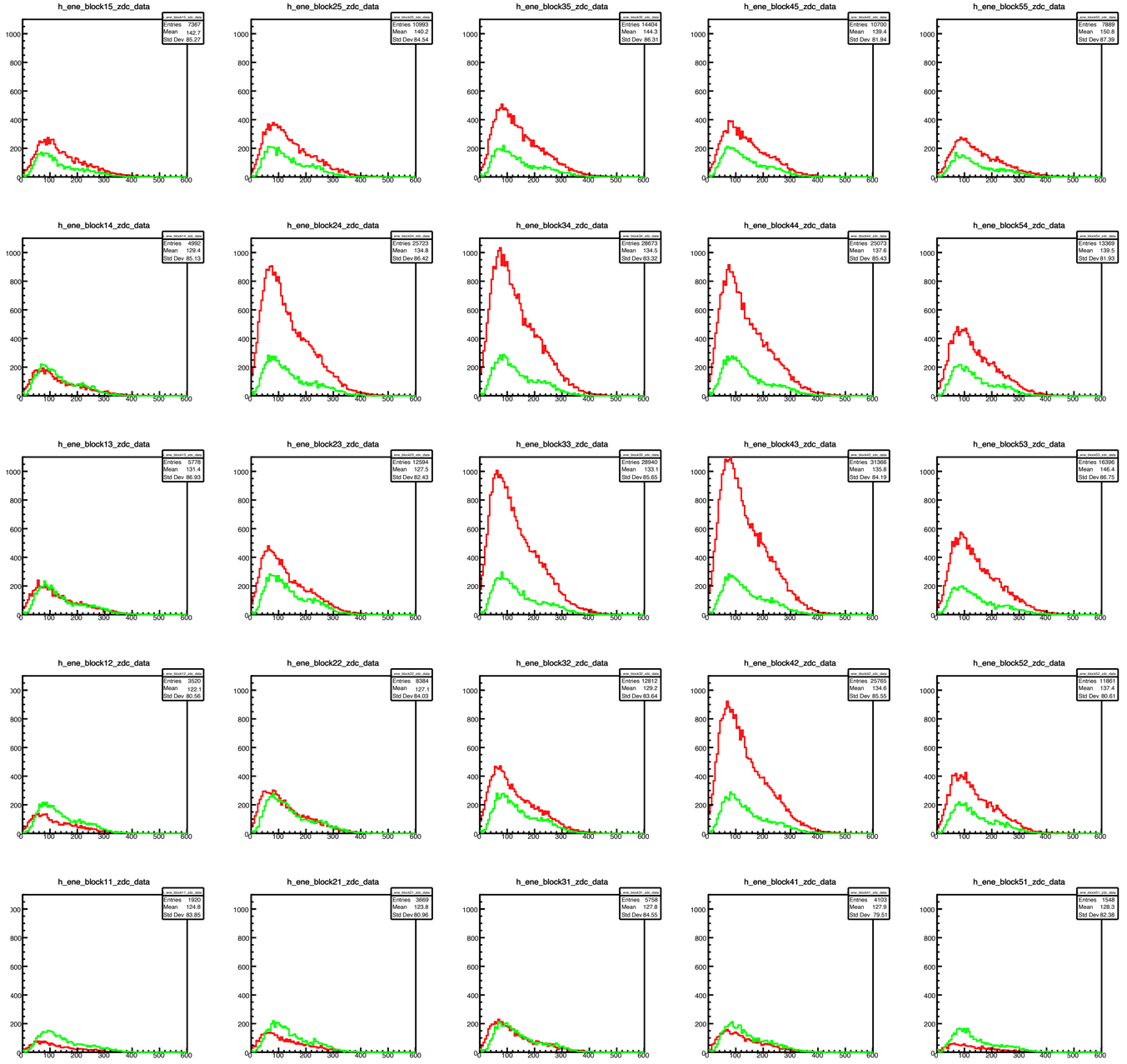
Difference betwwen MC and data peak is not clearly seen.
→position dependence is LHCf problem!

E_rec



Only E_ZDC



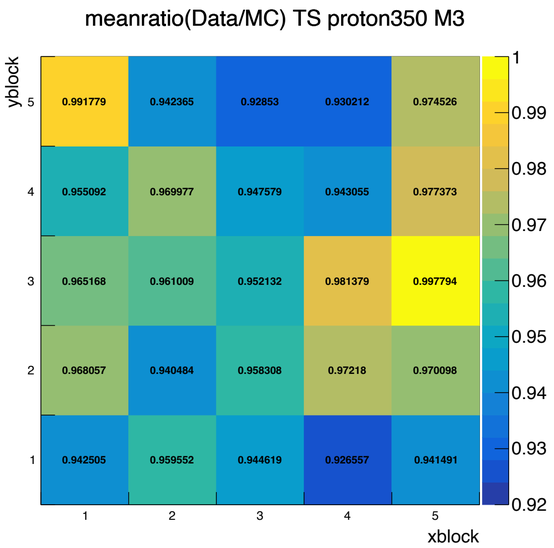


Compare E_LHCf

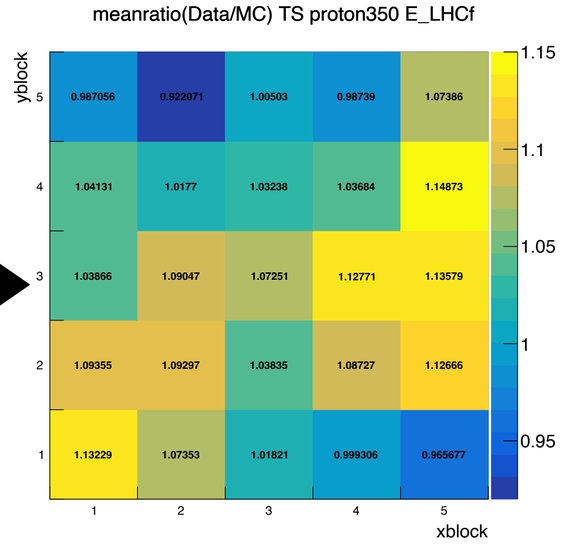
Small tower

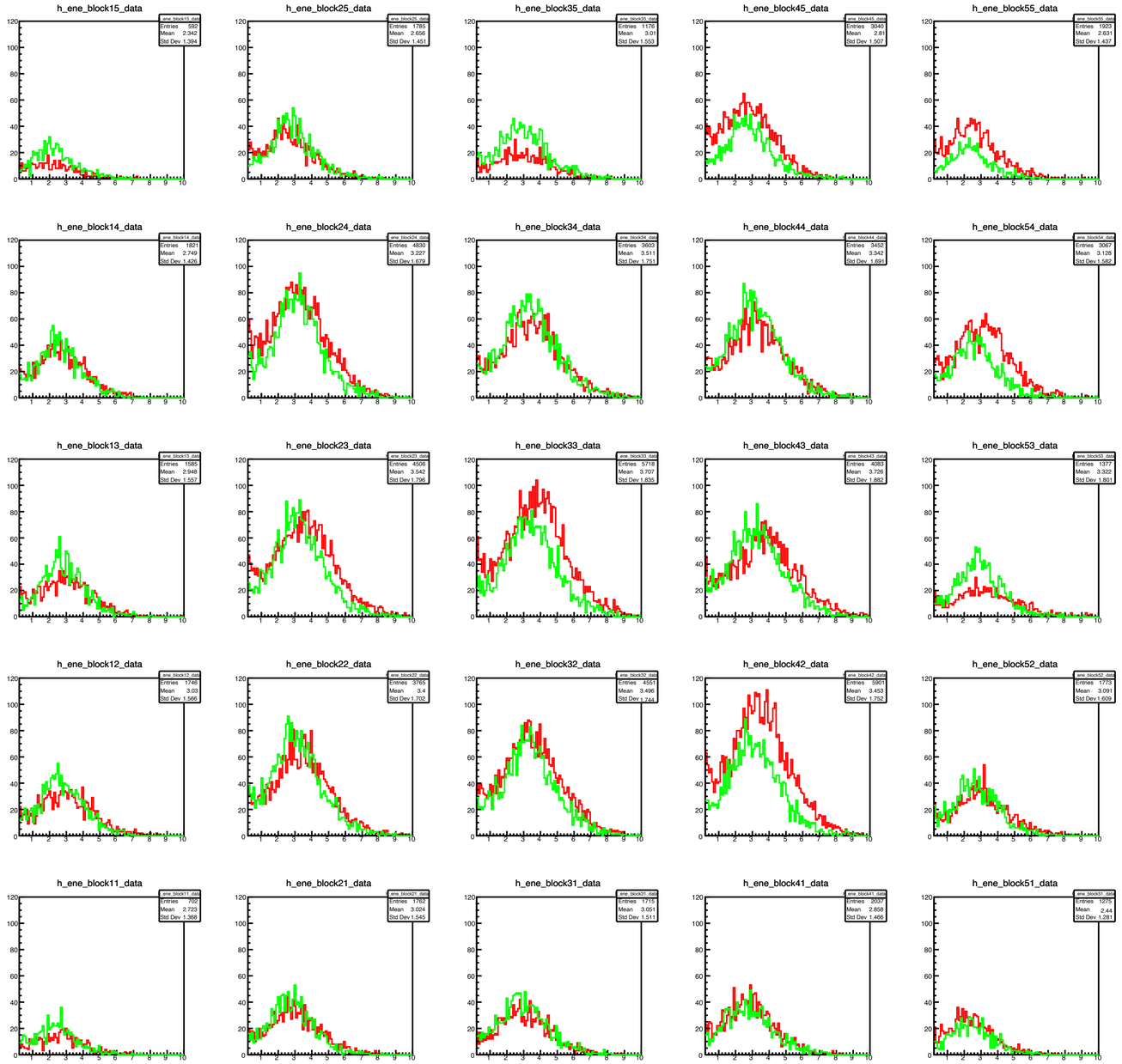
Red: data
Green: MC

E_rec



Only E_LHCf





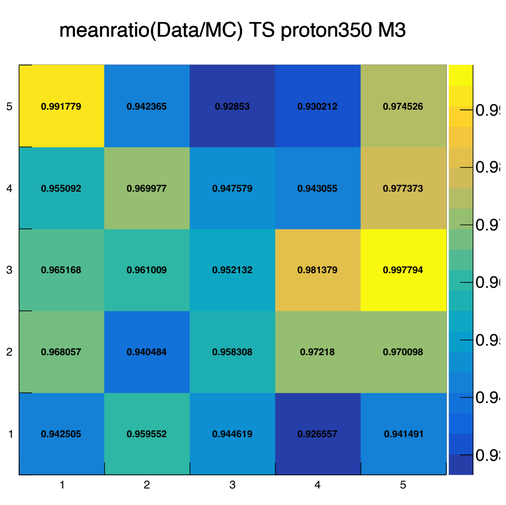
Compare E_ZDC

Small tower

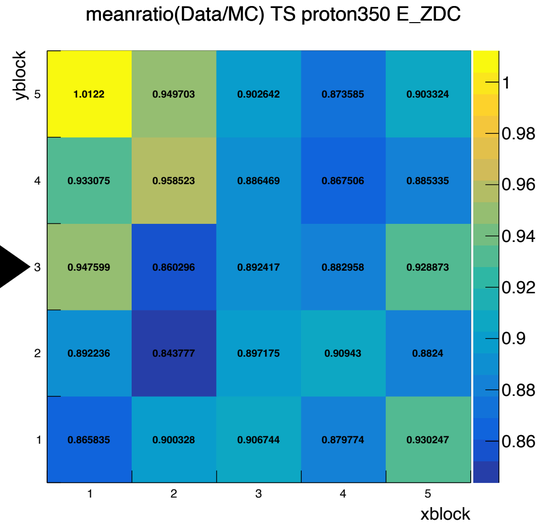
Red: data

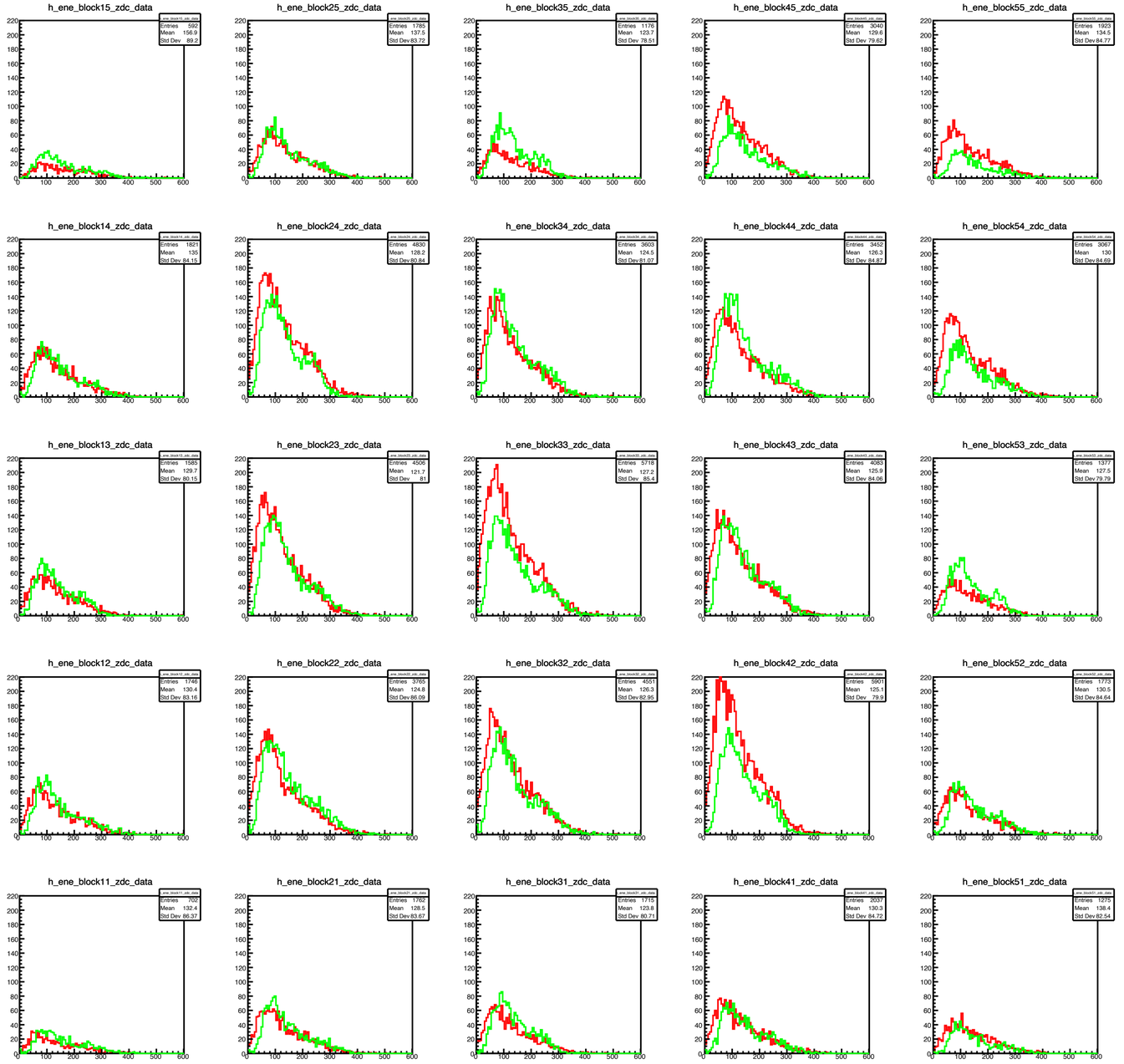
Green: MC

E_rec



Only E_ZDC





Summary and Future work

- Position dependence of energy was found ,especially in large tower.
- Position dependence may be caused by LHCf side.
- I will also analyze SPS2022 electron 197.3GeV data, and check the position dependence. (if it is possible, I will check layer by layer.)