STAR Run 2013 p+p 510 GeV BEMC Calibration

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Run 13 W A_L analysis group

Outline

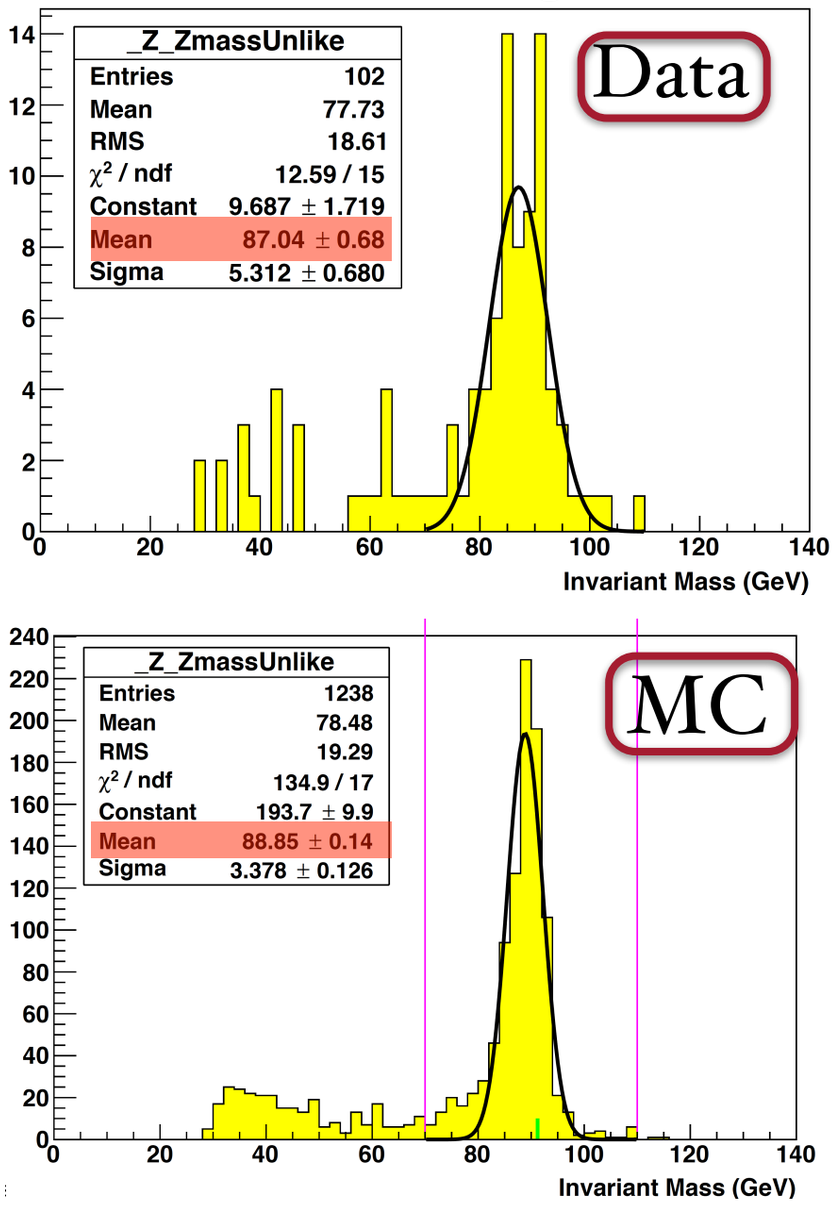
- Executive summary
- Motivation
- MIP-relative Calibration
- E / p Electron Calibration
- Consistency check to high energy probes
- Systematic error calculations
- Summary

Executive Summary

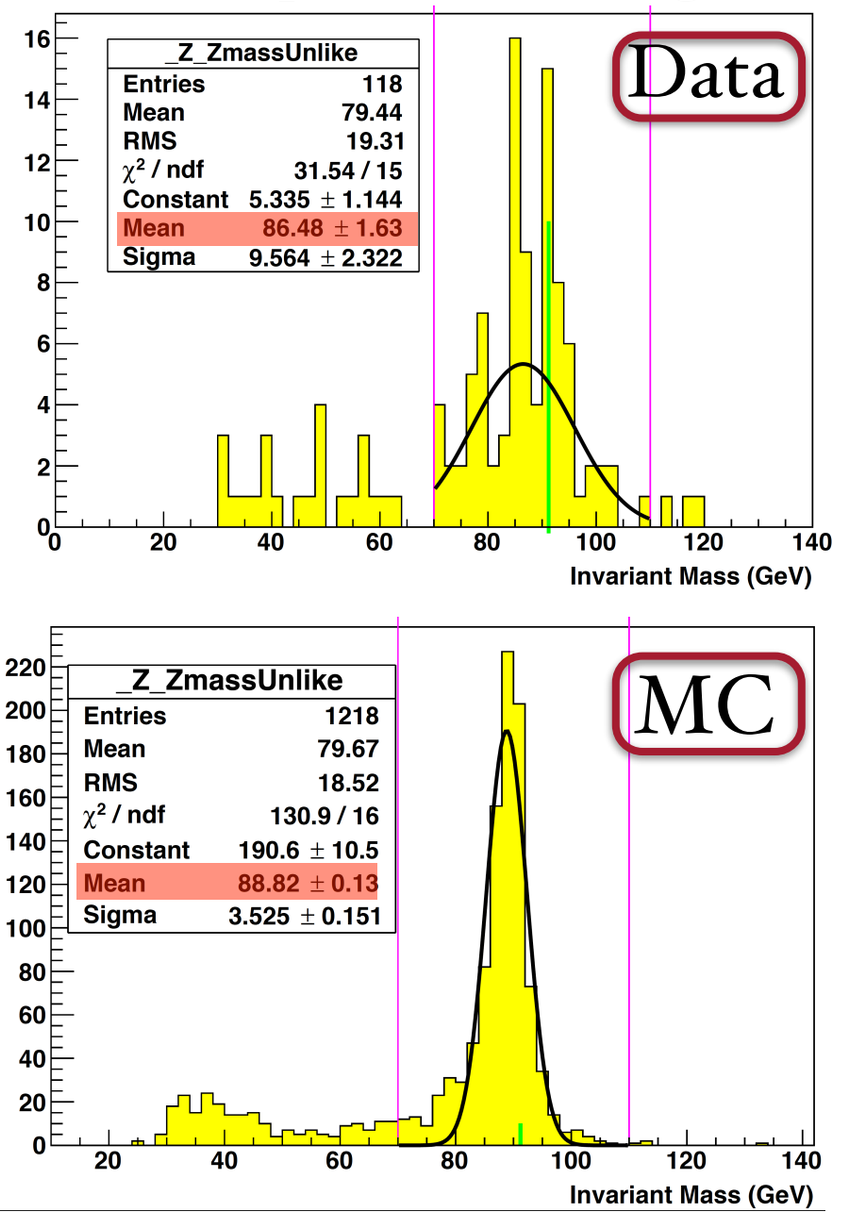
- The first p+p 510 GeV BEMC Calibration (preliminary) at STAR is completed using STAR run 2013 data.
- Conventional single tower method was used for E / p calibration to obtain gain constants. A second method was developed which requires some further studies and will not be used for now concerning a preliminary result for W AL 2013.
- Run 13 period 1 gain constants are on average ~4% larger than run 9 gain constants and ~5% larger than run 12 gain constants.
- Run 13 period 2 gain constants are on average ~2.5% larger than period 1 gain constants.
- Consistency check is done between low-energy calibration probes (electron E / p) and high energy probes (Z / W).
- Prelim. Run 13 BEMC calibration concluded with 3% systematic uncertainty for period 1 and 2% systematic uncertainty for period 2 : Overall assignment of systematic uncertainty of 3% for Run 13.
- Analysis NOTE is ready and will be sent to the list soon.

Motivation - Z mass shift

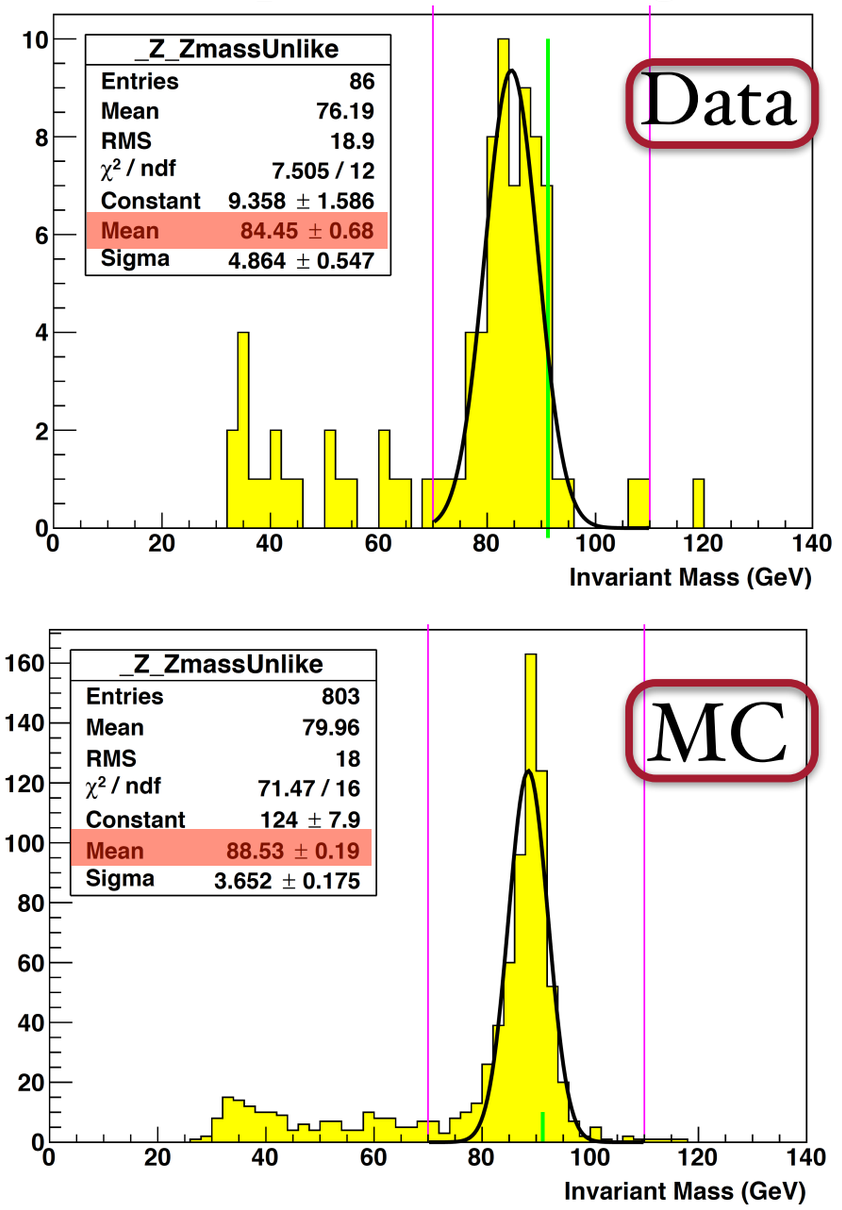
Run 12 / Run 9 gains



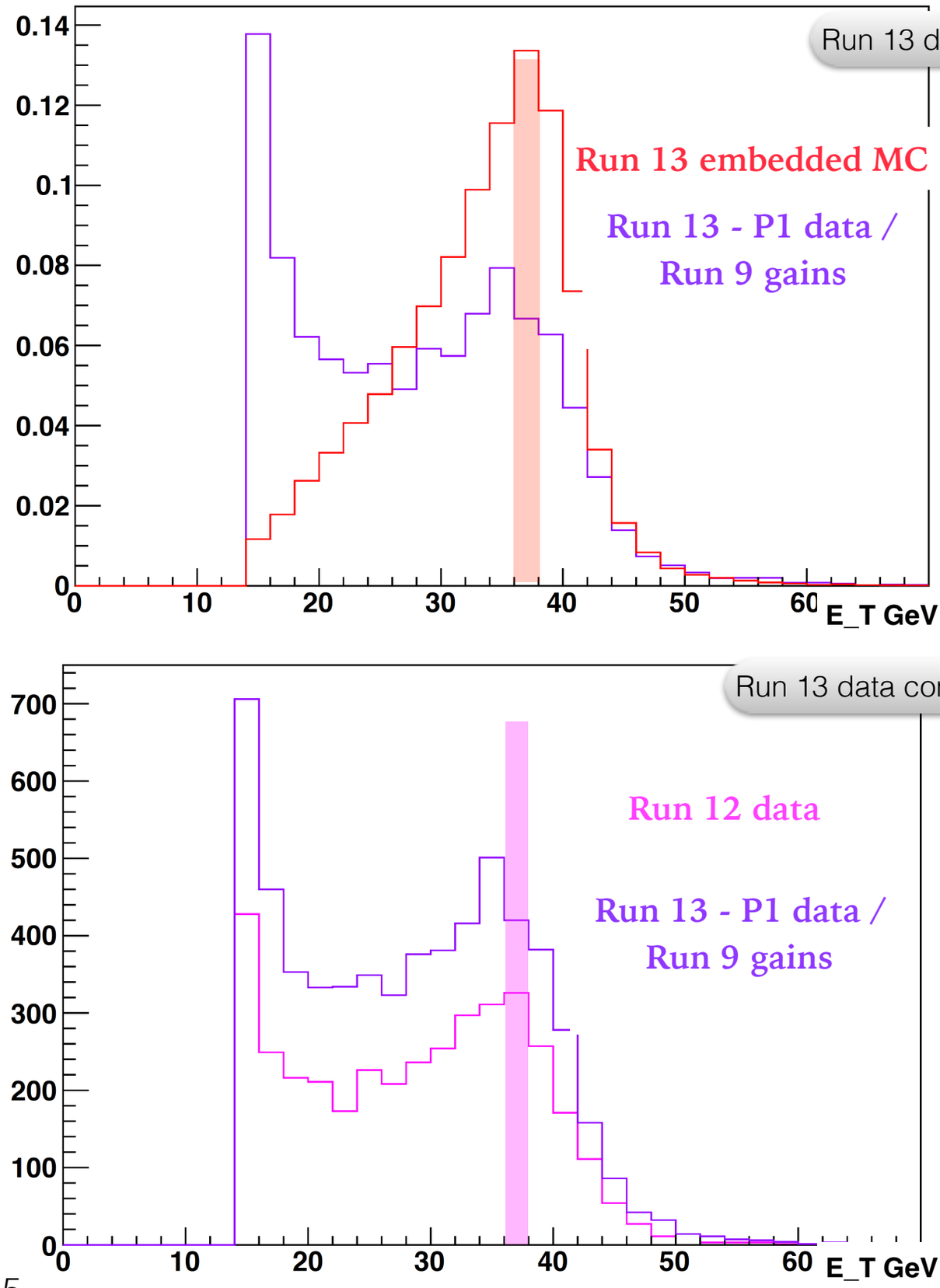
Run 13 -period 1 / Run 9 gains

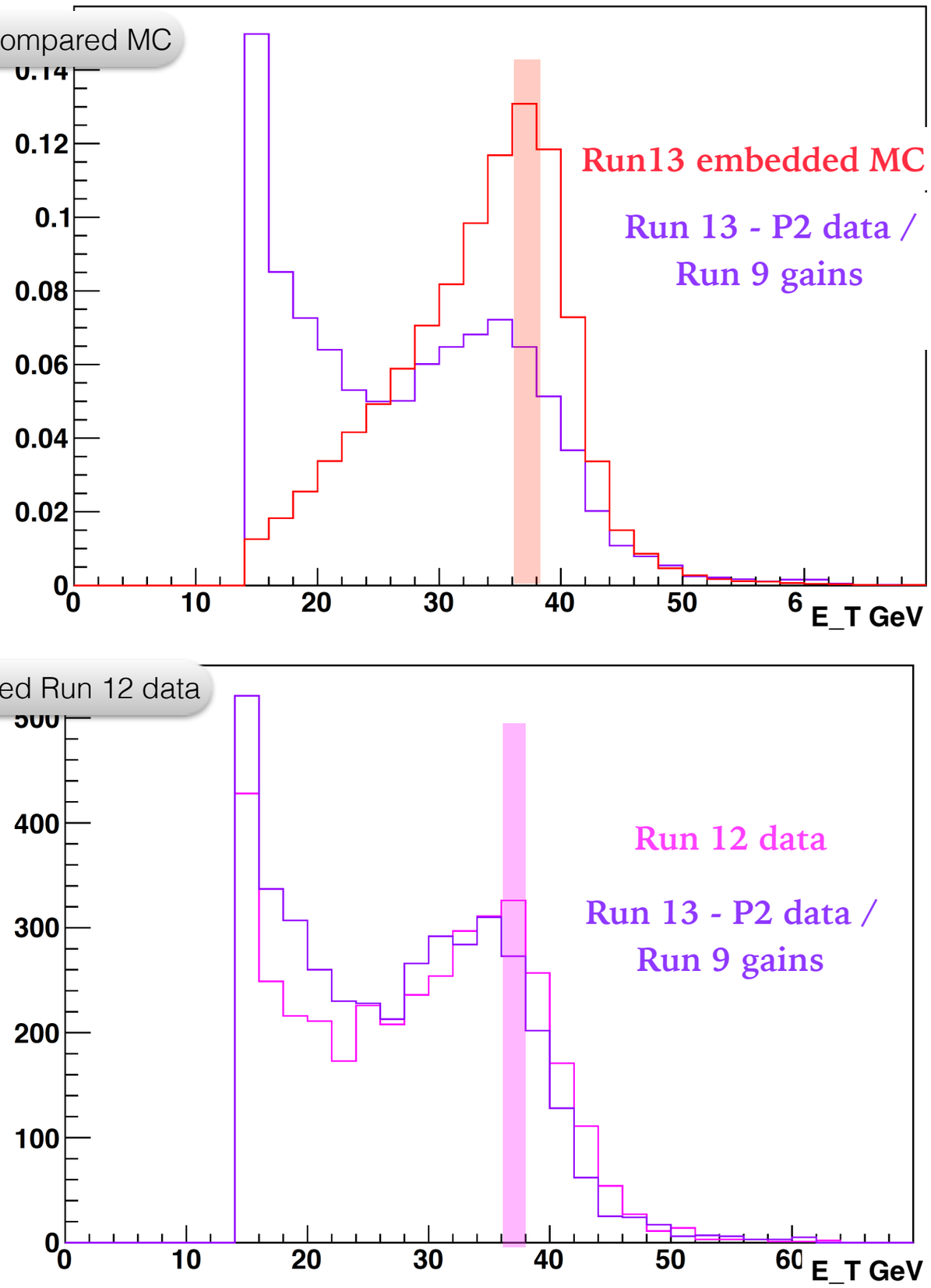


Run 13 -period 2 / Run 9 gains



Motivation - W - Jacobean Peak





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Procedure

Relative Calibration

$$C_{relative} = \frac{0.264\left(1 + 0.056\eta^2\right)}{ADC_{MIP}\sin\left(\theta\right)}$$

- Produce MIP ADC spectrum for each tower.
- Fit with appropriate Gaus*Landau (a function which best describes the MIP energy loss and MIP statistics in the tower) to obtain characteristic ADC value (mean, rms) for each tower.
- Calculate $C_{relative}$ using above formula for each tower to feed in to electron analysis and do a MIP QA to tag bad towers (Towers with low statistics, low ADC, large spread between fitted mean and histogram mean, …).

Absolute Calibration

$$C_{absolute} = \frac{C_{relative}}{\left\langle E/p \right\rangle}$$

- Obtain electron E / p spectrum for group of towers (eta ring-by-ring).
- Fit with appropriate Gaus+exponential (a function which best describes signal and BG) to obtain <E / p> per ring.
- Calculate $C_{absoulte}$ using above formula for each tower to obtain gain constant.

Relative gain calibration using MIPs

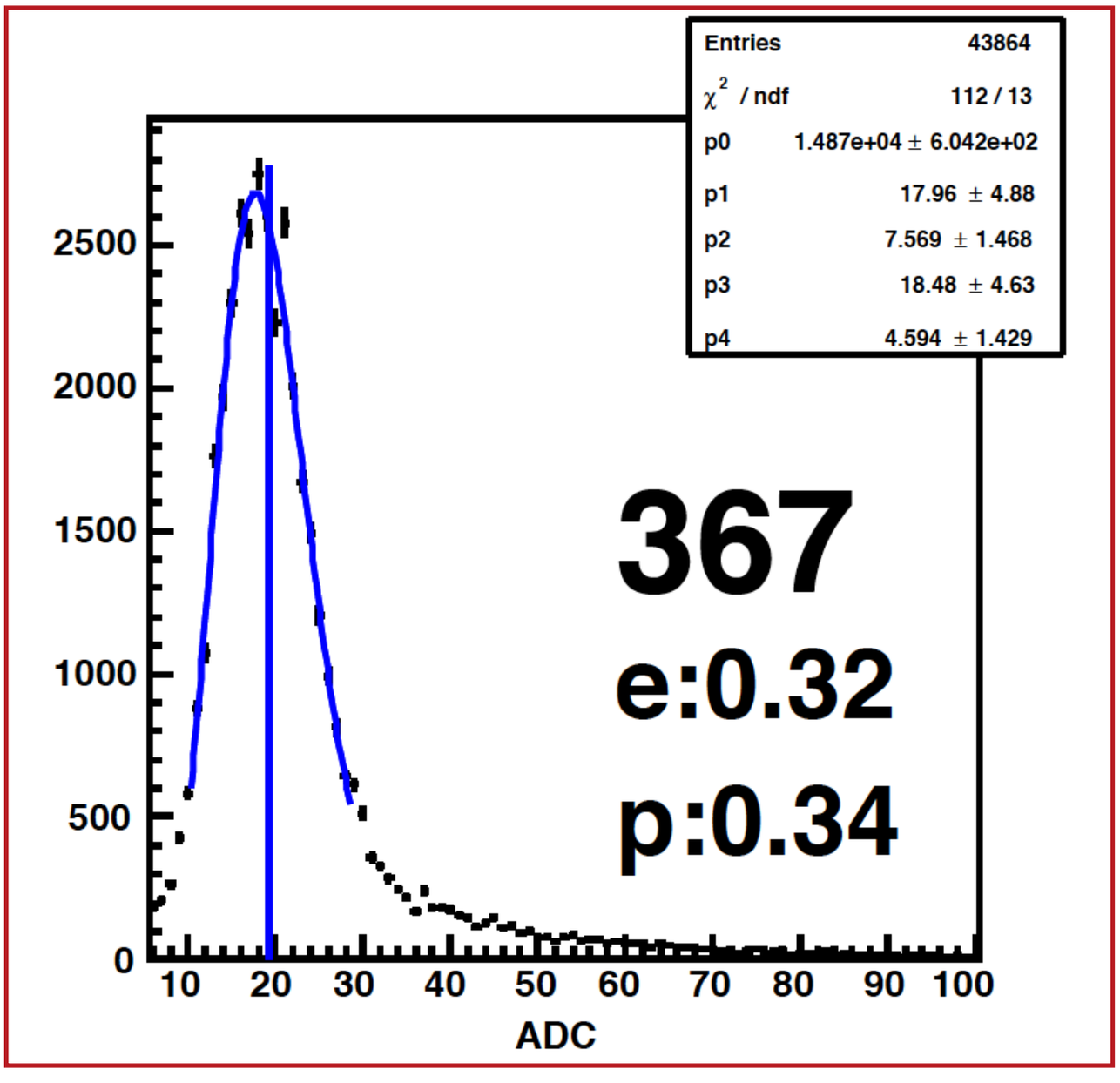
MIP - analysis cuts

- Vertex Rank > 1e6
- |vertex-Z| < 30 cm
- only one track per tower per event
- Track momentum > 1 GeV/c
- (ADC-ped) > 2.5 ped RMS
- Track must enter and exit the same tower
- Neighboring tower in 3x3 cluster adc-pedestal < 2 pedRMS

Relative gain calibration using MIPs

Typical MIP ADC distribution

[0]*Gaus(x,[1],[2])*Landau(x,[3],[4])



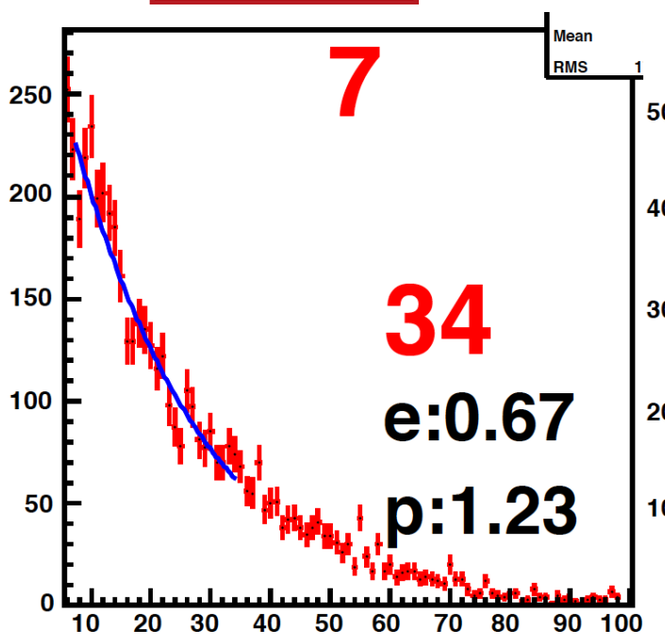
MIP Tower QA

- by Code
  - Entries < 25
  - Fit mean < 6
  - |Fit mean -distribution mean| > 10
- by Hand
  - low counts
  - low (abnormal) mean
  - Large mean ADC (warm towers)
  - Strange distribution (double peak)
  - Bad Fitting

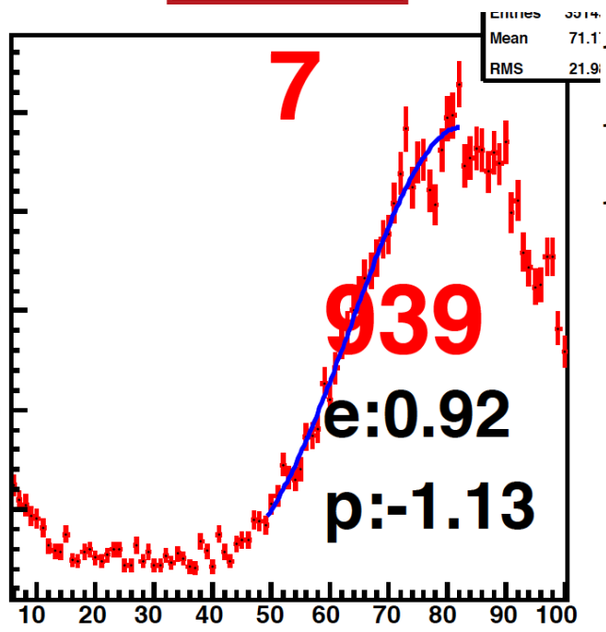
Relative Calibration - Results

examples for BAD towers

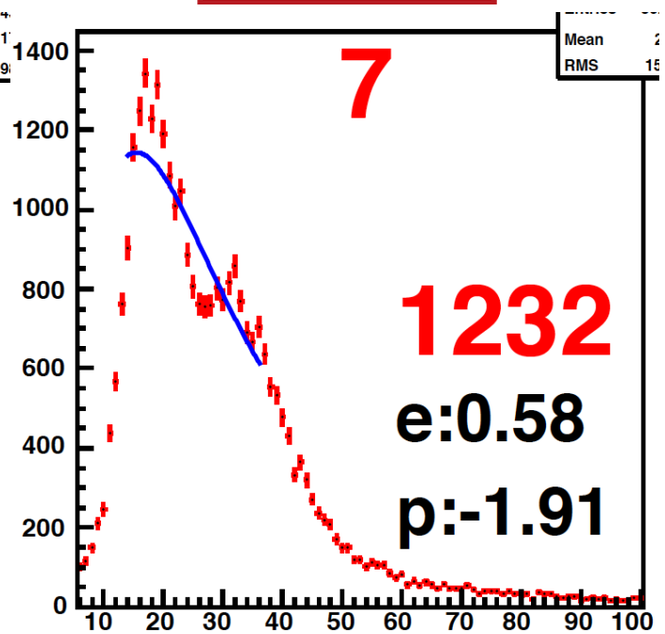
low counts



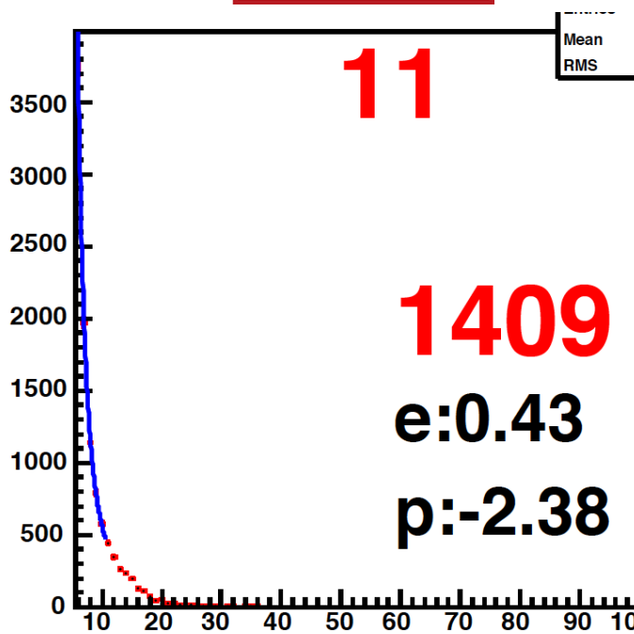
Hot tower



double-peak



cold-tower

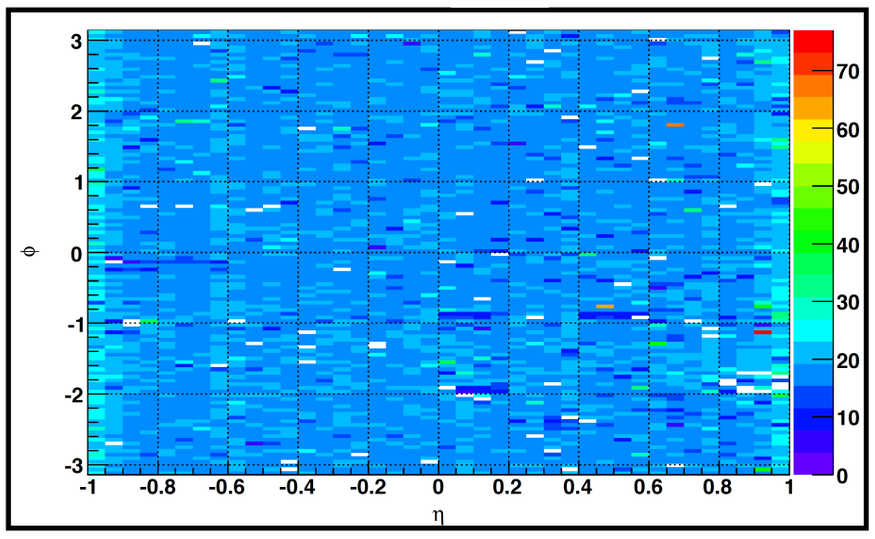


STATISTICS

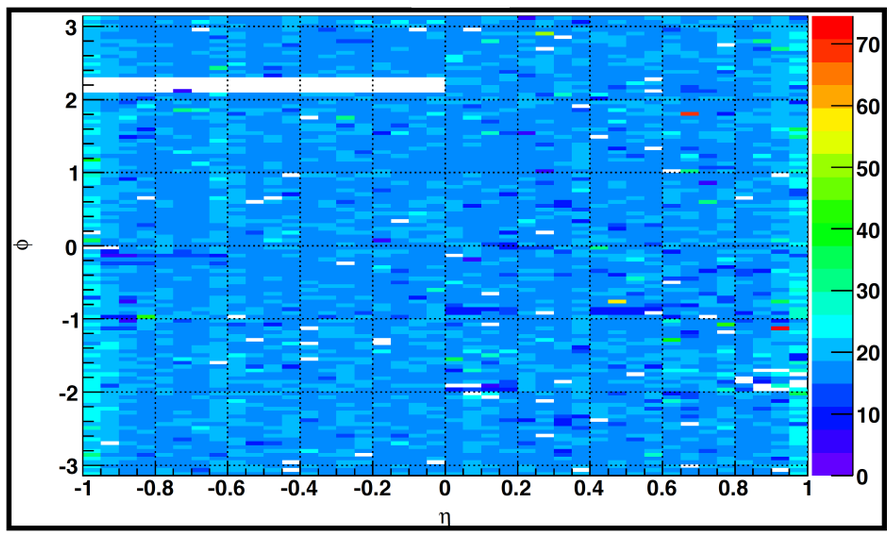
	GOOD	BAD	bad(%)
P 1	4576	224	4.7
P 2	4507	293	6.1

BEMC MIP-gains [eta-phi]

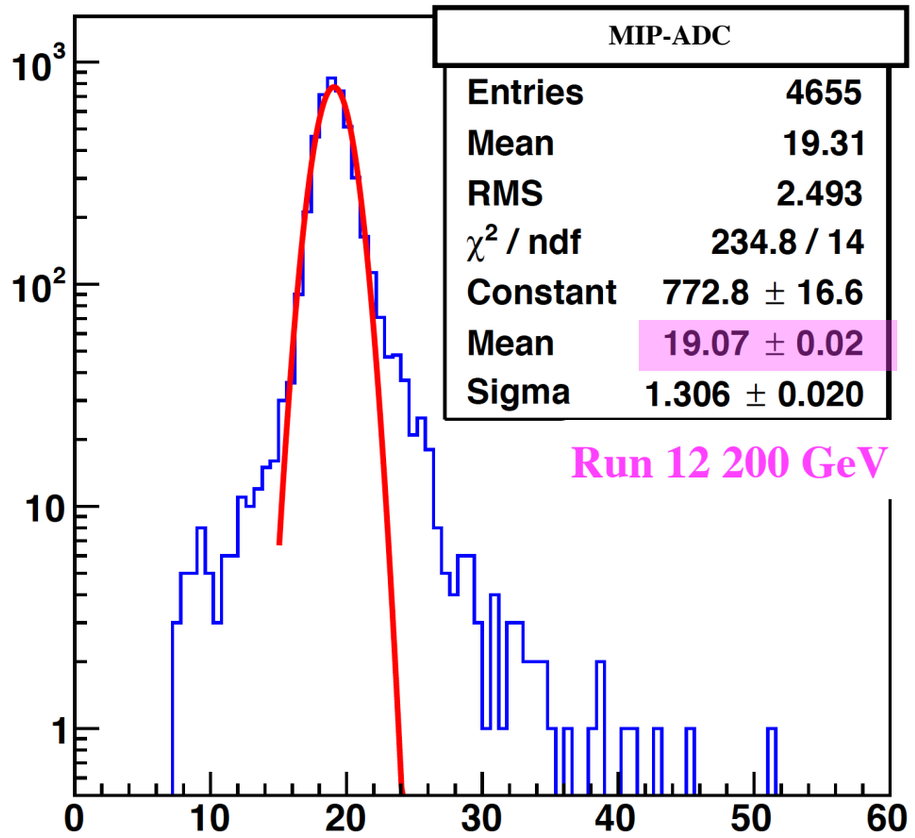
P 1



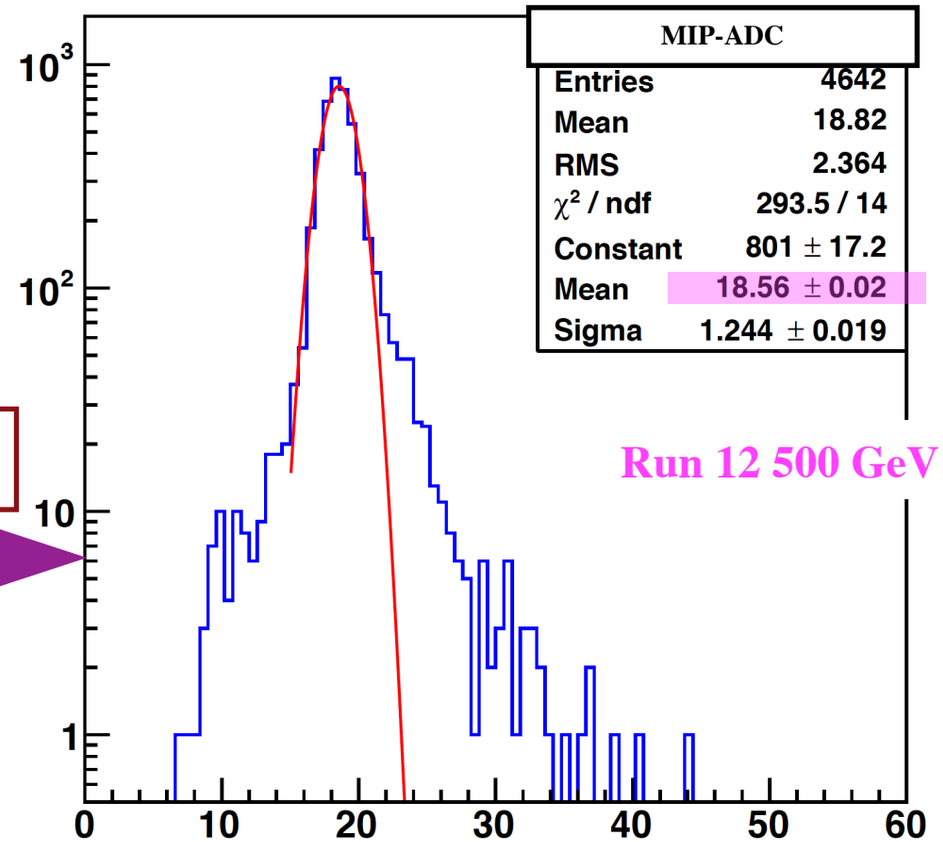
P 2



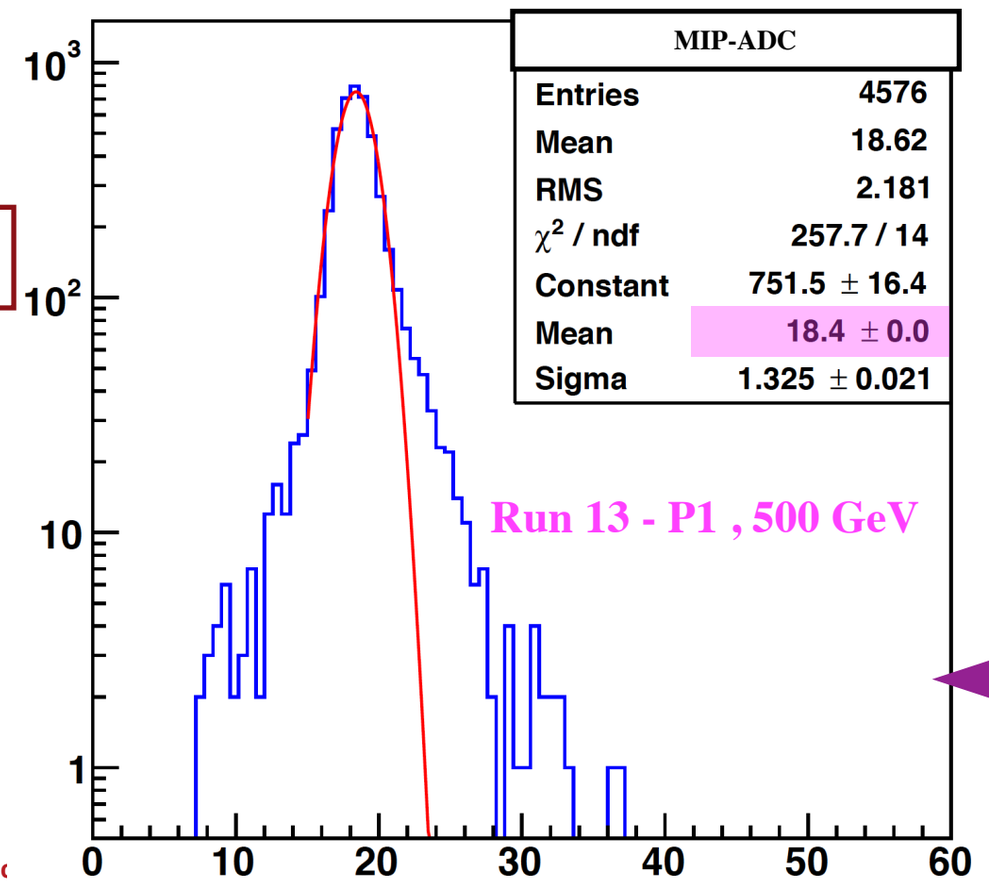
MIP mean comparison



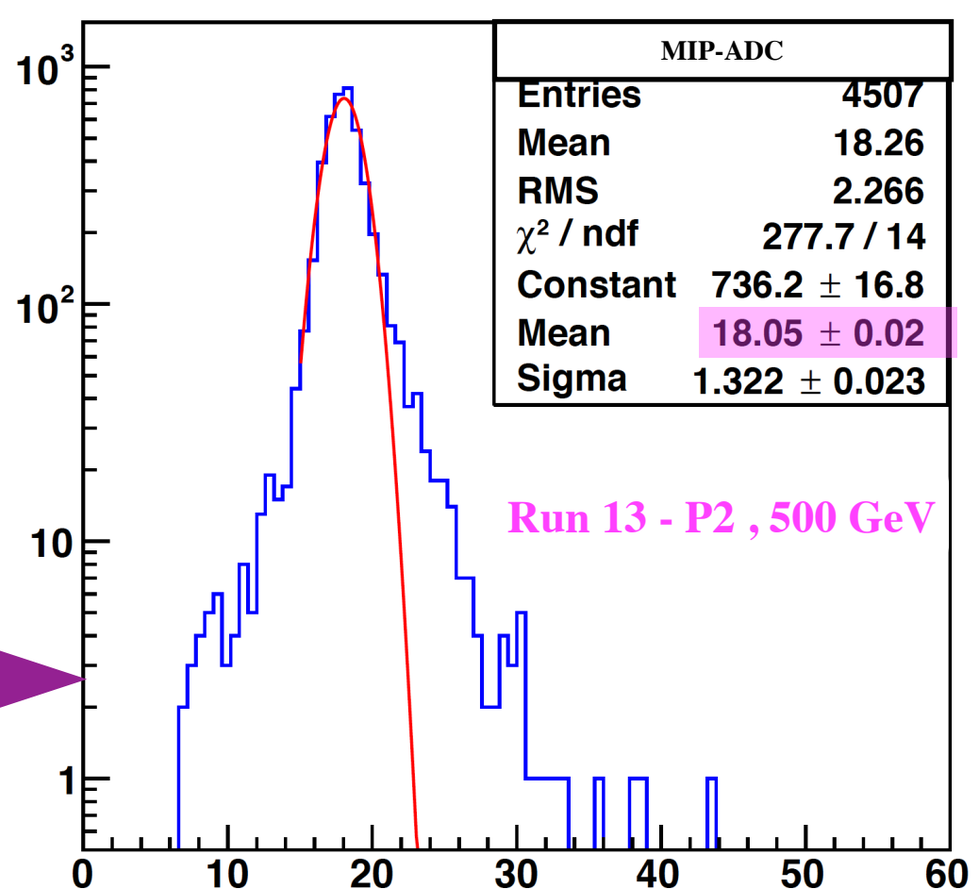
~ 2.7%



~ 3.6%

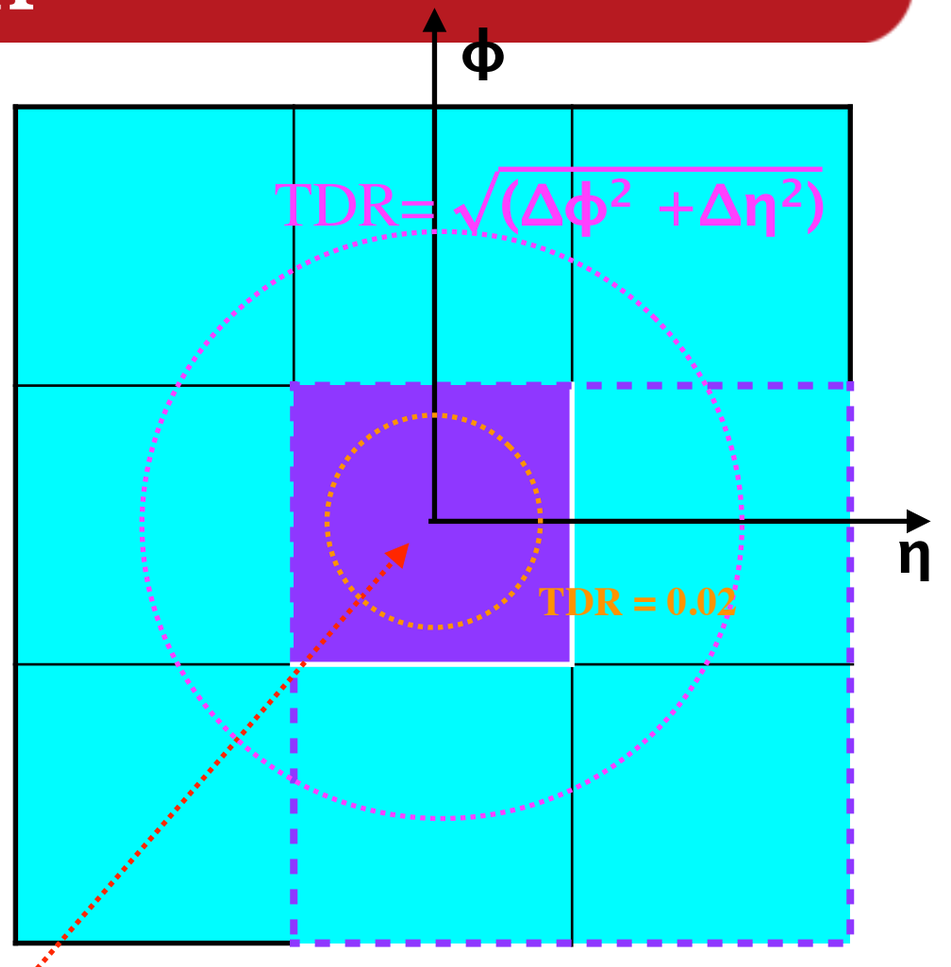


~ 2%



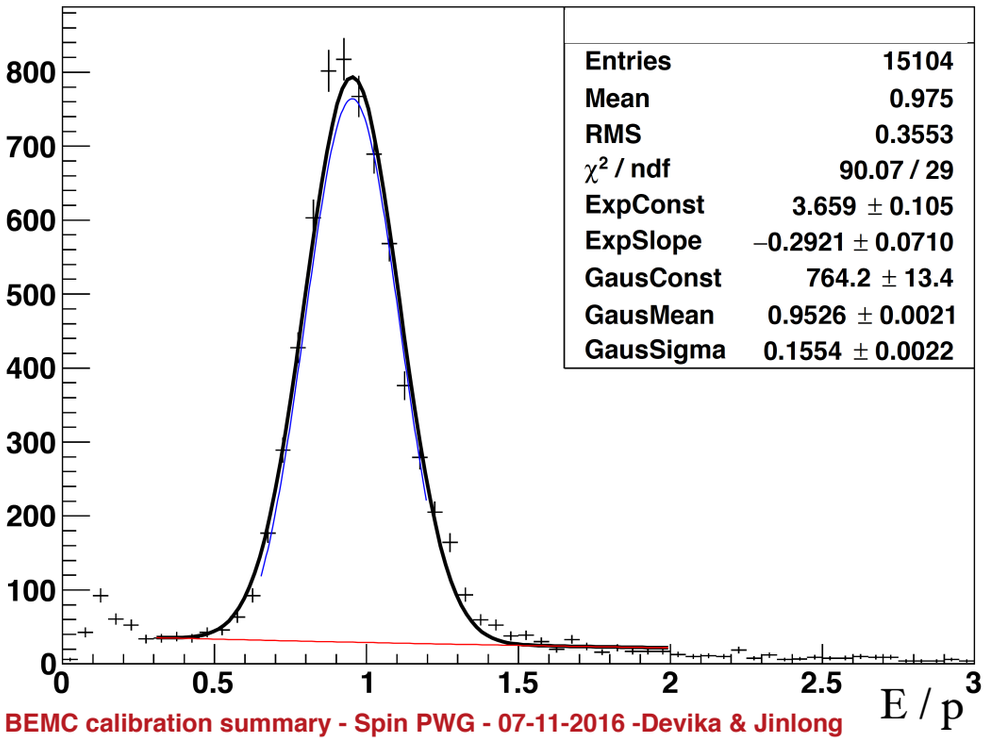
E / p Calibration

- We consider all tracks of a triggered event regardless if the event was fired by an electron or any other particle or jet or high energetic photon.
- Project track to a tower (Central tower) and require that no other tracks fall into a 3X3 array around the central tower and that this central tower yields the max. energy of all towers for the respective 3X3 array.
- Energy is corrected using correction factors obtained using GEANT simulations based on tower track ΔR.



$$E / p = \frac{\text{corrected single tower E}}{\text{track p}}$$

Typical E / p distribution with a Fit



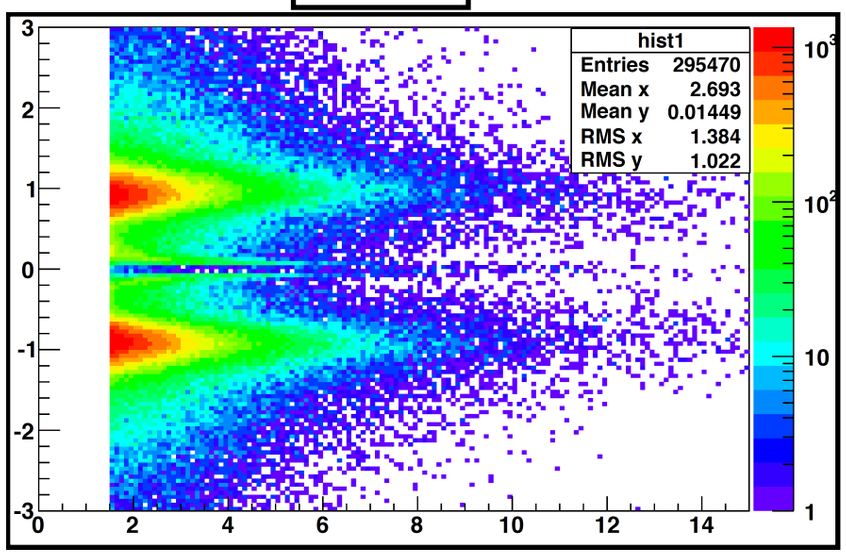
- Gaussian fit to signal region
- Exponential fit to background

Electron Analysis Cuts

- Vertex Rank > 1e6
- |vertex-Z| < 30 cm
- only one track per tower per event
- Track momentum > 1.5 GeV/c **(2.0)**
- Track nHits > **25** **(10)**
- (ADC-ped) > 2.5 ped RMS
- 3.5e-6 < dE/dX < 5e-6
- Exclude -1 < nSigmaPion < **3** **(2.5)**
- Include -1 < nSigmaElectron < 2
- MIP status and offline tower status is 1
- Tower/Track (TDR) dR < 0.02
- Track must enter and exit the same tower
- Center tower in 3x3 cluster doesn't have tracks in neighboring towers
- Maximum Energy must be deposited in the central tower.

Trigger Option

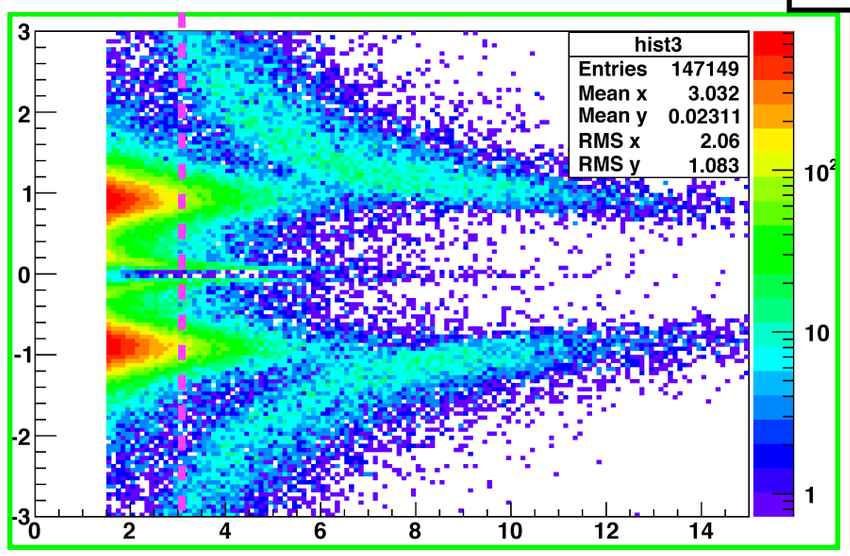
non HT



JP2->didFire()

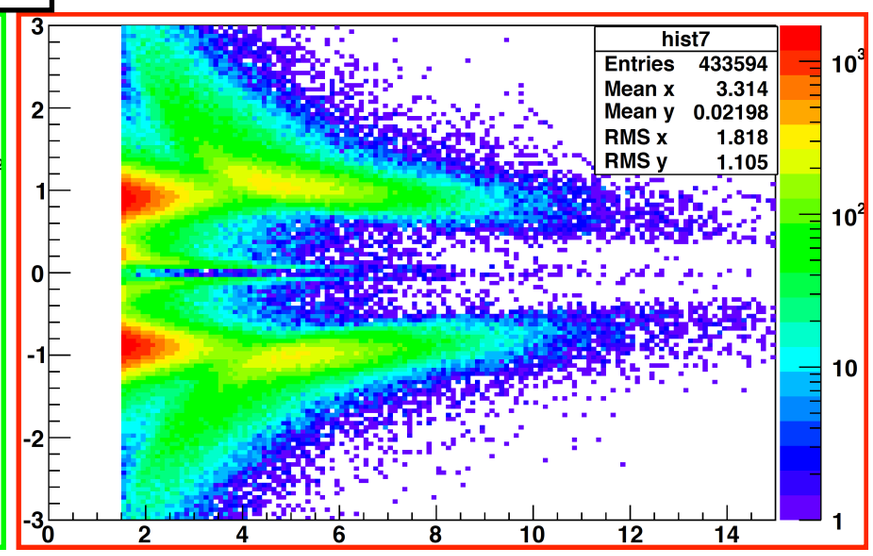
No significant momentum dependance. Include in the momentum range available, [0-10] GeV.

HT



BHT3->didFire()

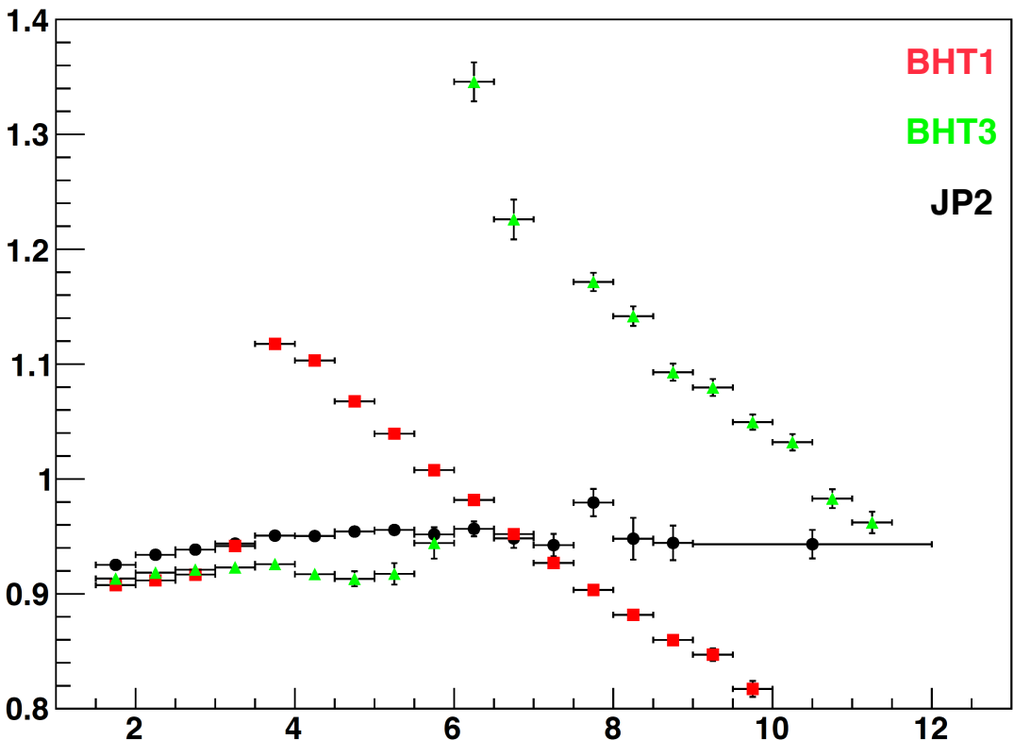
Include in the momentum, P < 3 GeV in order to avoid trigger threshold effect



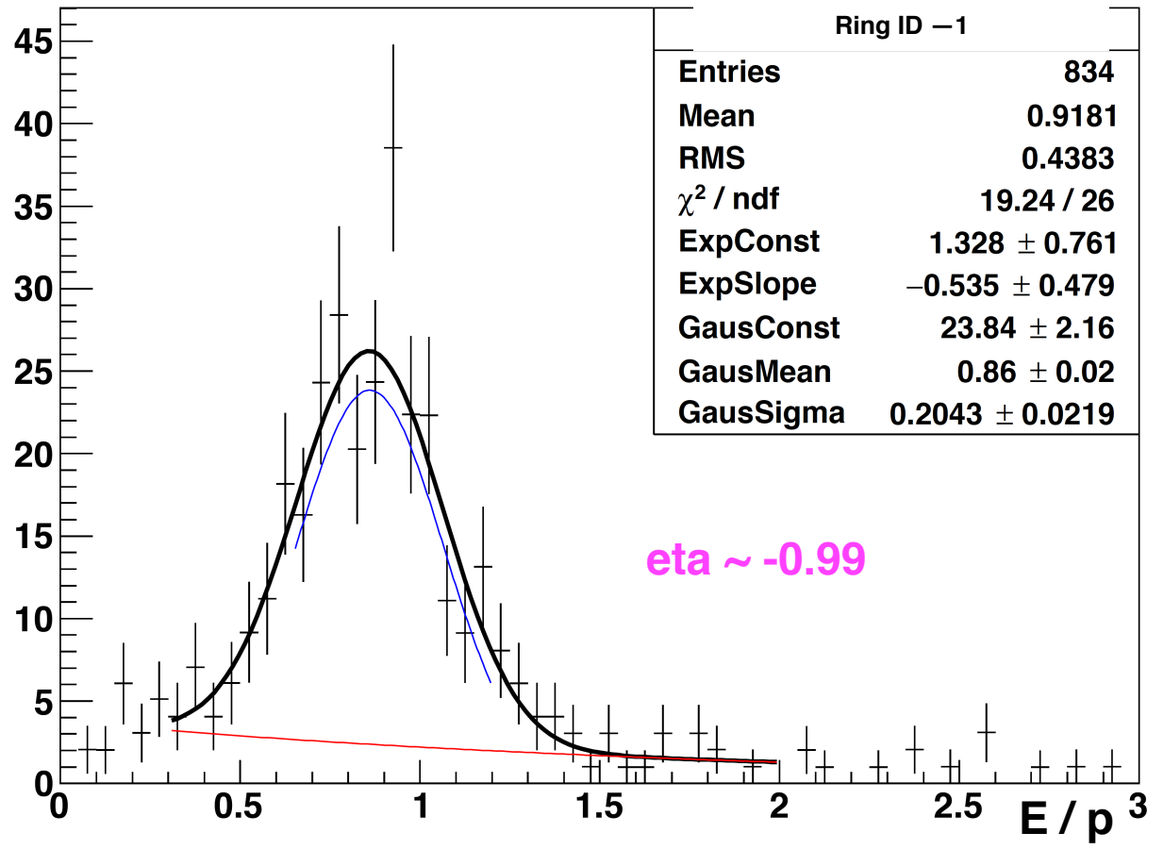
BHT1->didFire()

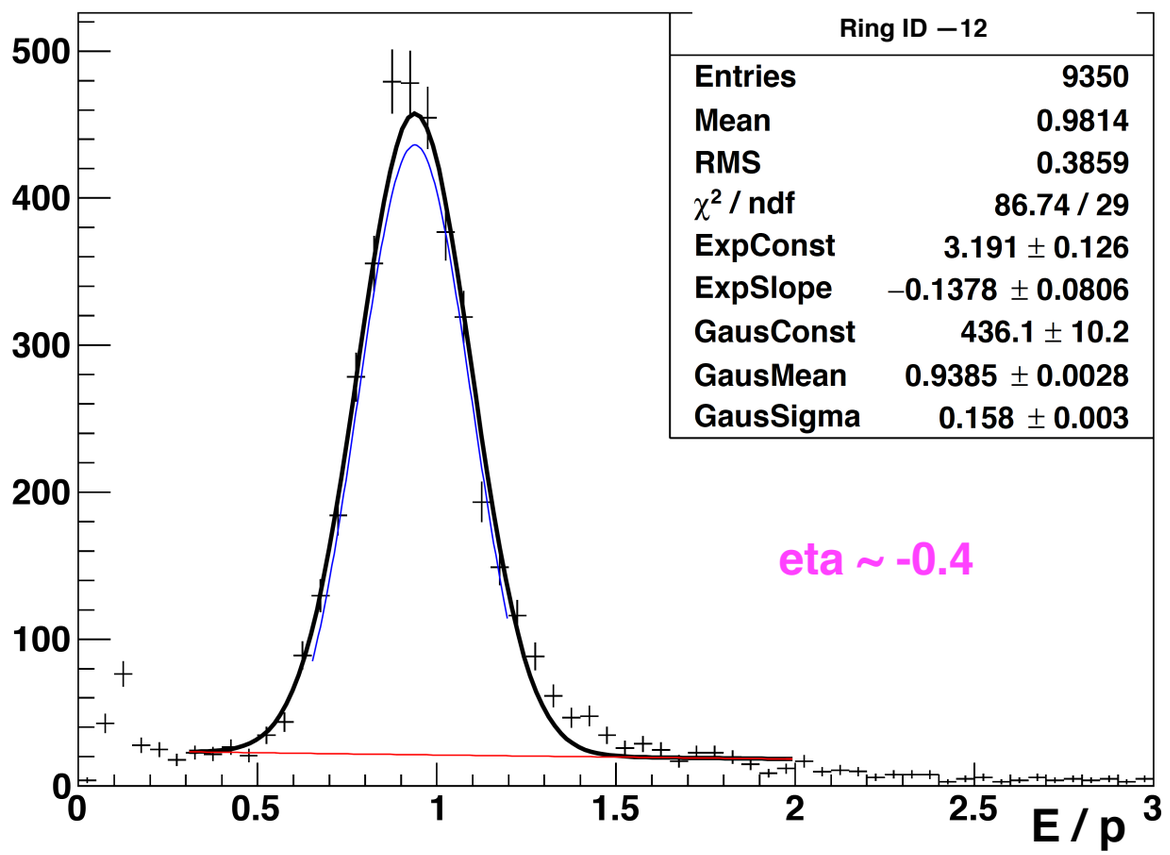
Exclude from the analysis due to significant momentum dependance of E / p

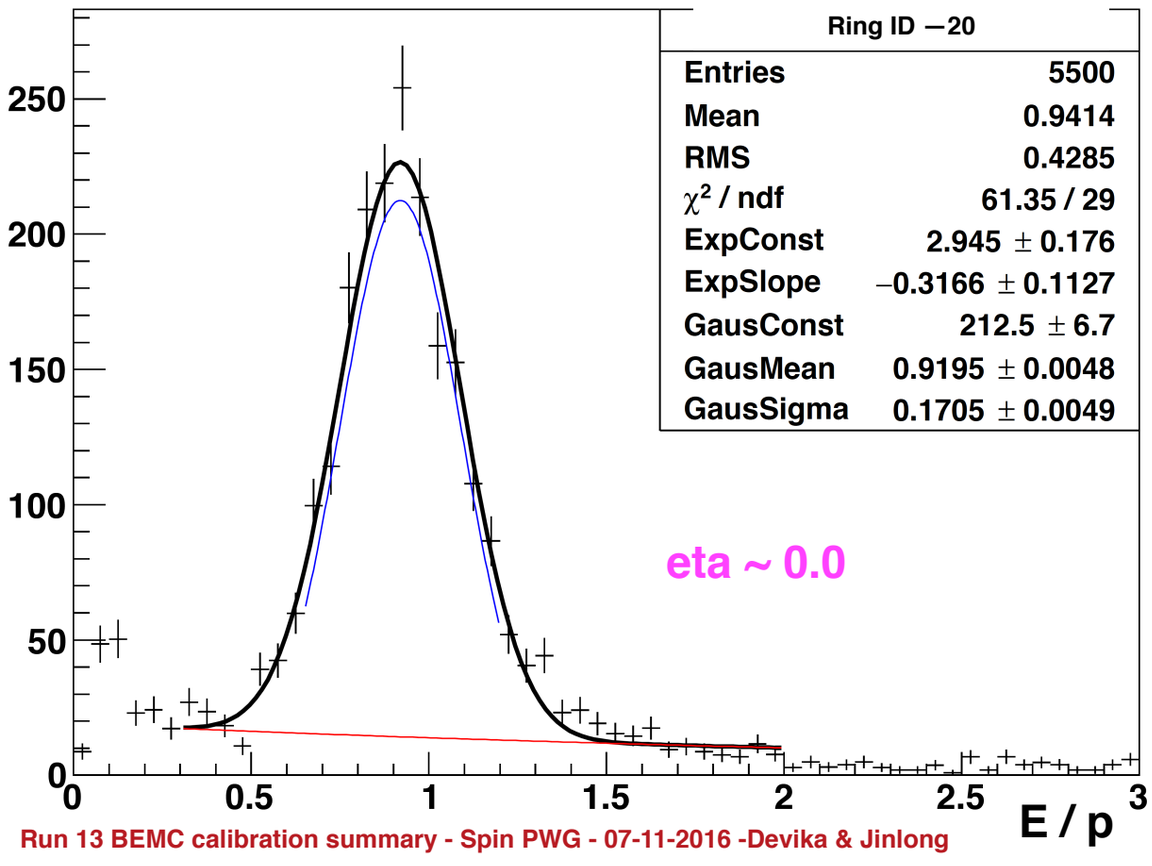
- Both HT and non HT, available trigger options were considered.
- E / p value shows significant momentum dependance for HT trigger.
- Therefore, BHT1 trigger events excluded from the analysis.
- BHT3 triggered events considered for momenta below 3 GeV

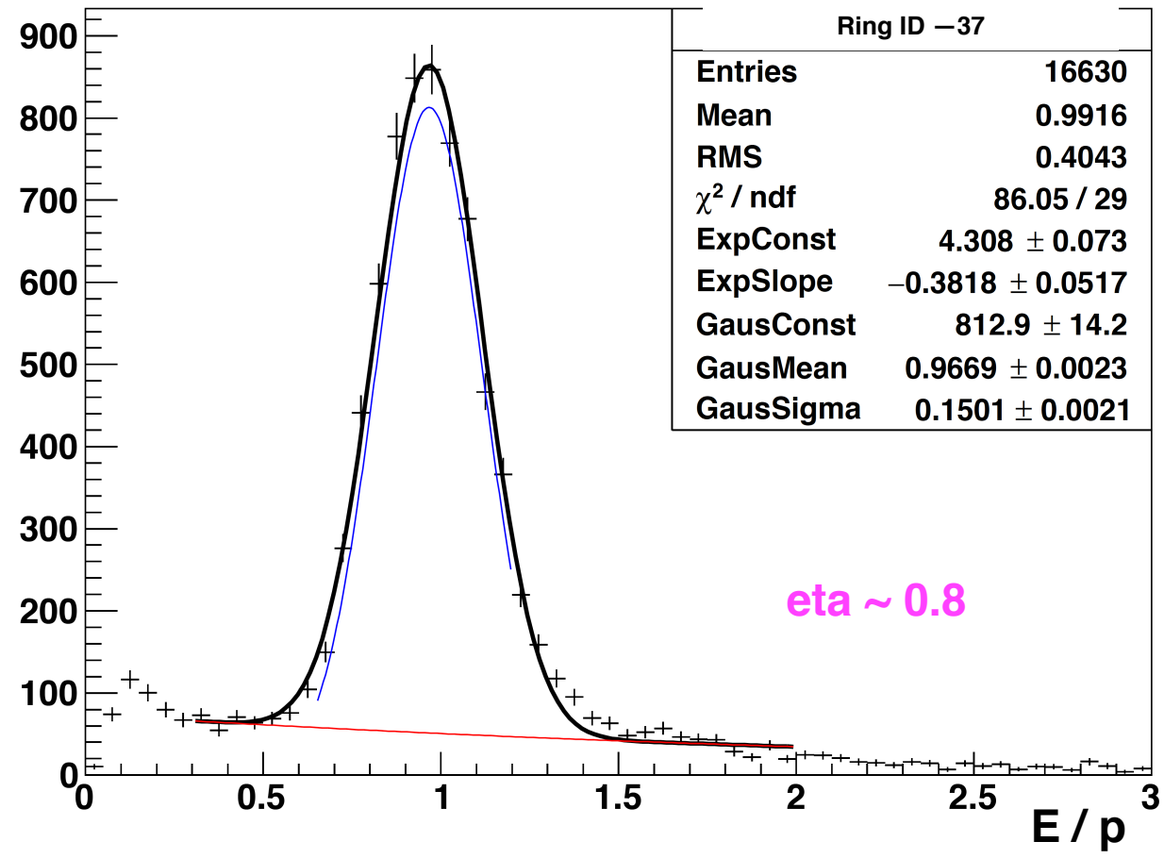


E / p Fit Results

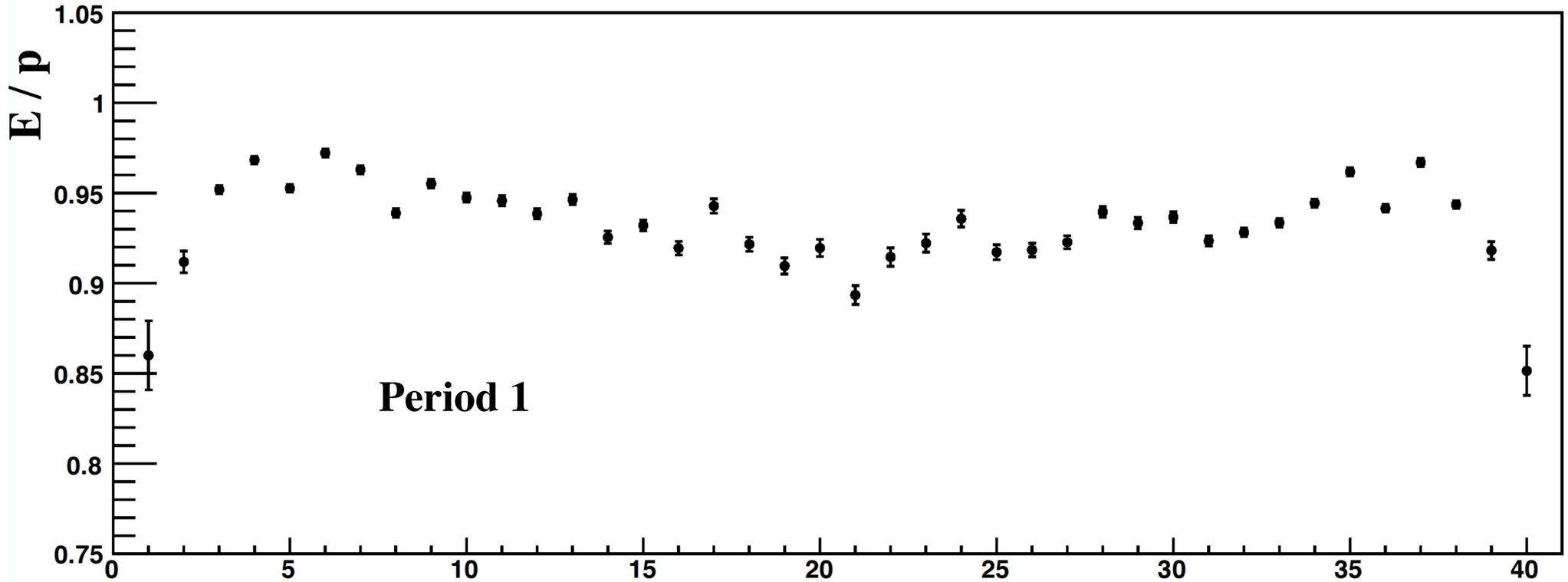


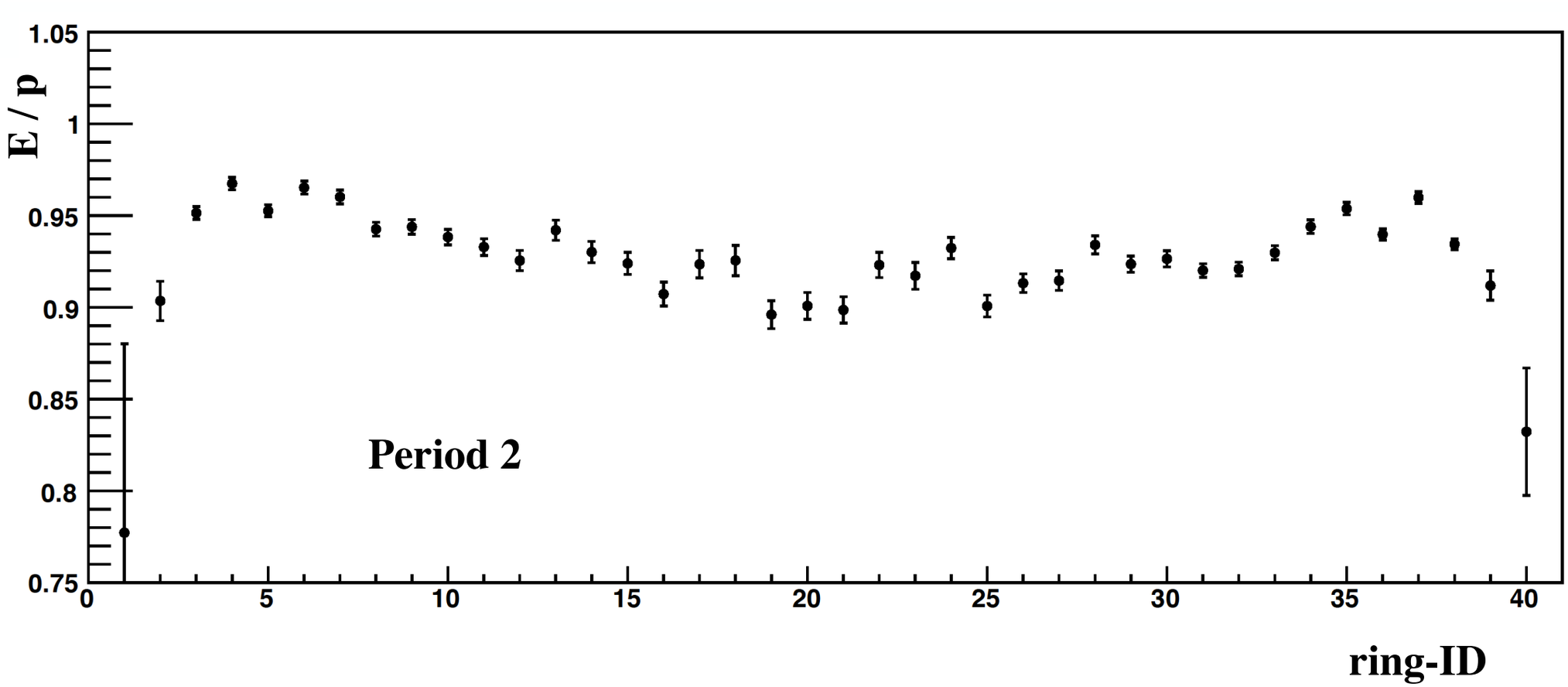






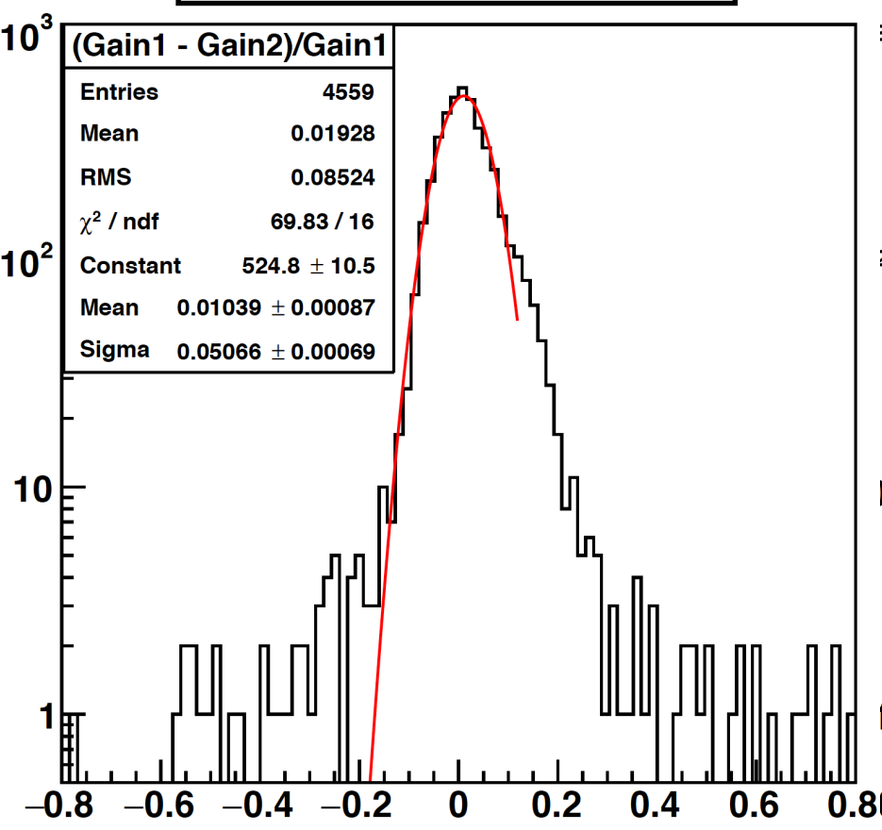
Mean E / p from the fit per eta ring



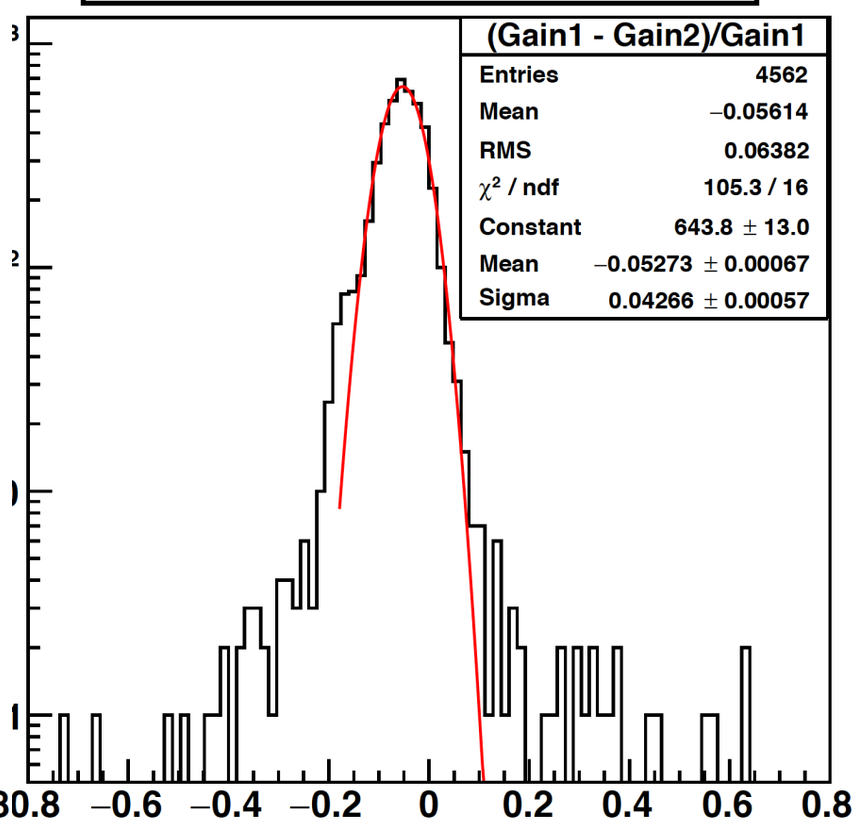


Absolute Gain Comparison

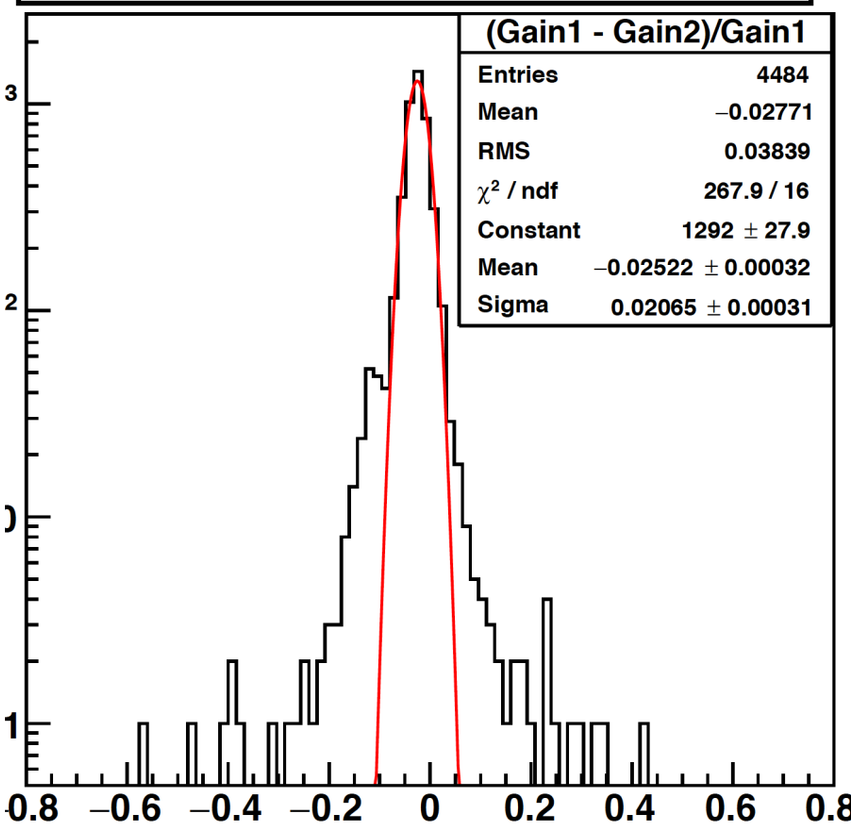
(Run 9 - Run 12) / Run 9



(Run 12 - Run 13 P1) / Run 12



(Run 13 P1 - Run 13 P2)/ Run 13 P1

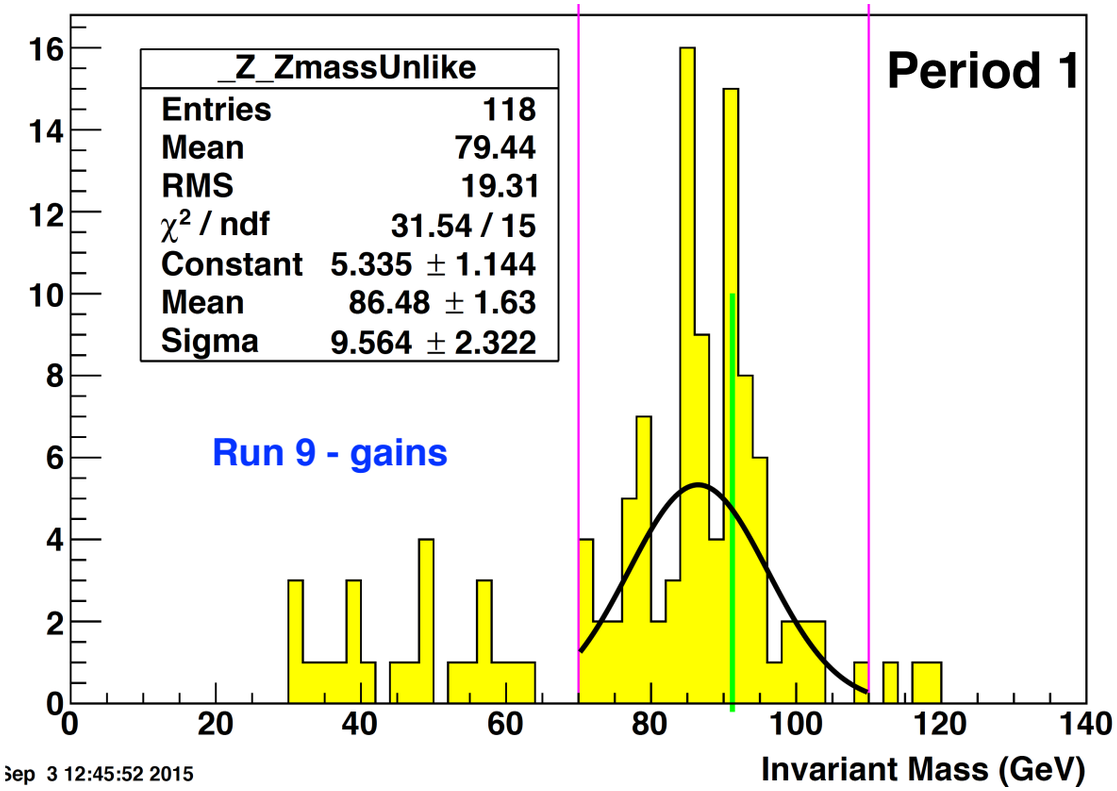


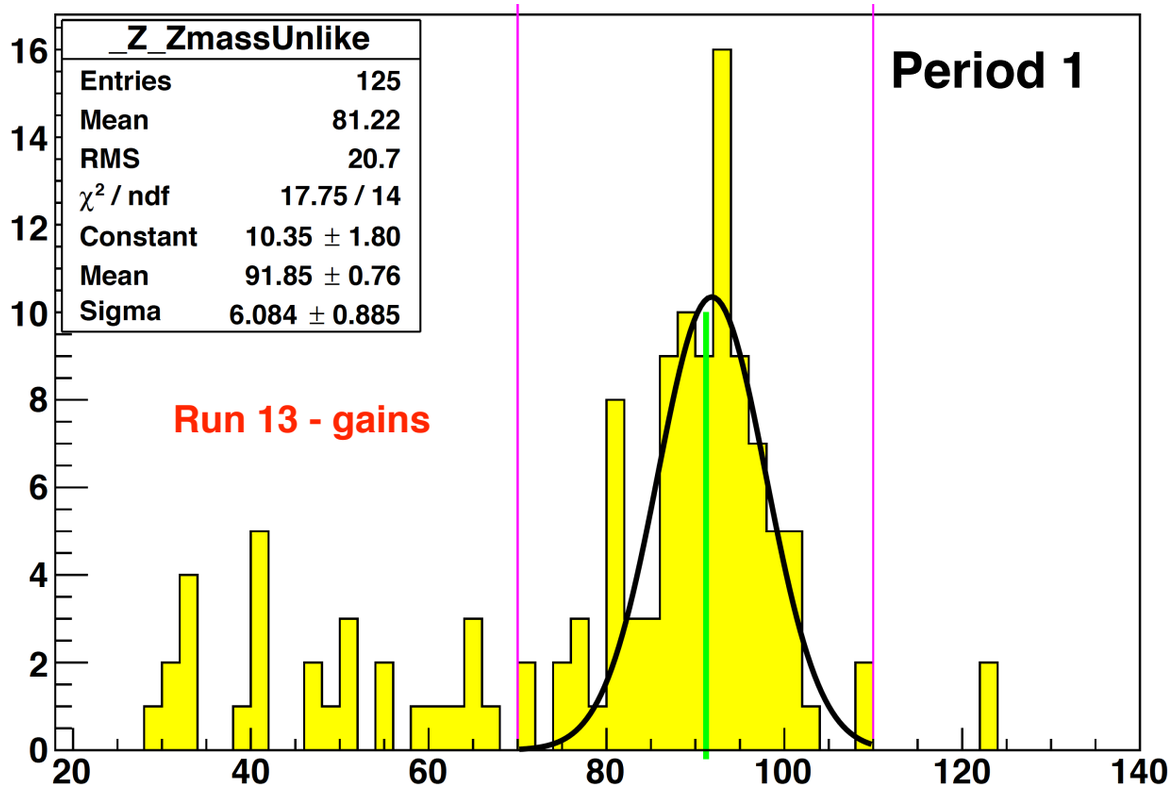
	Run 12 200 GeV	**Run 13 - P1 510 GeV**	**Run 13 - P2 510 GeV**
Run 9 200 GeV	< ~ 1%	**> ~ 4%**	> ~ 6.5%
Run 12		> ~ 5%	> ~ 7.5%
Run 13 P1			**> ~ 2.5 %**

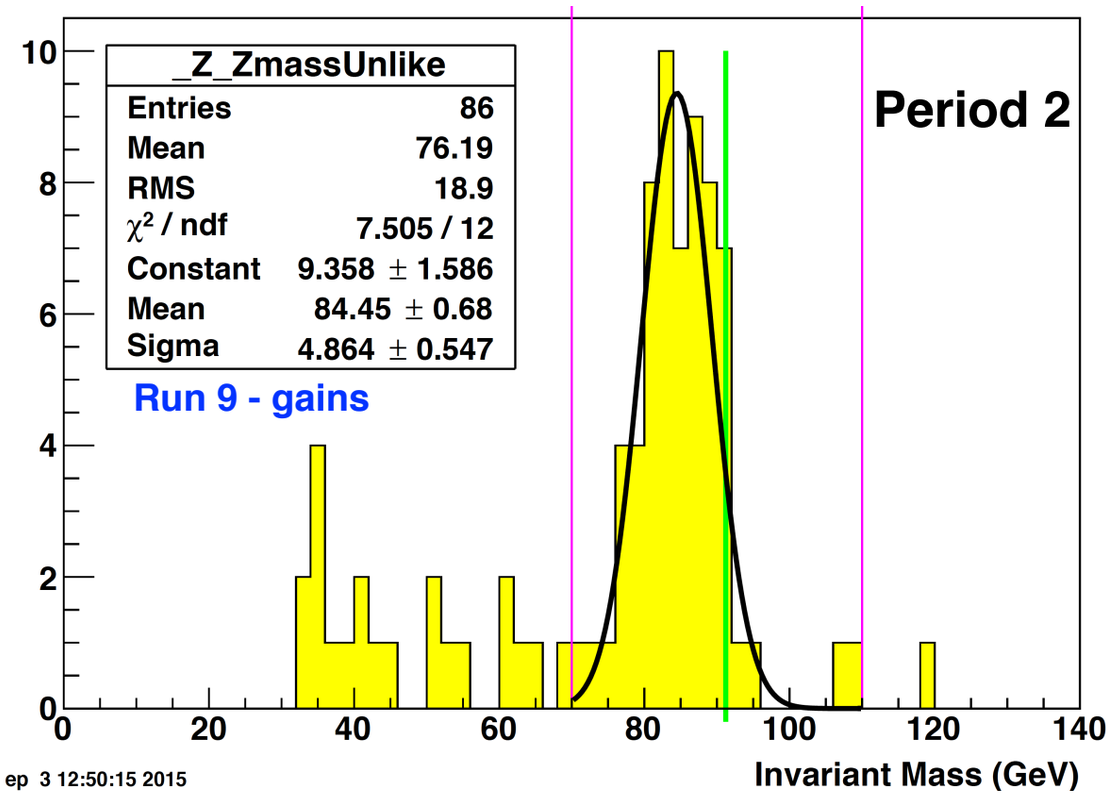
Check of consistency of calibration at low energies (0-10 GeV) with high energy probes (Z/W) (30 -70 GeV).

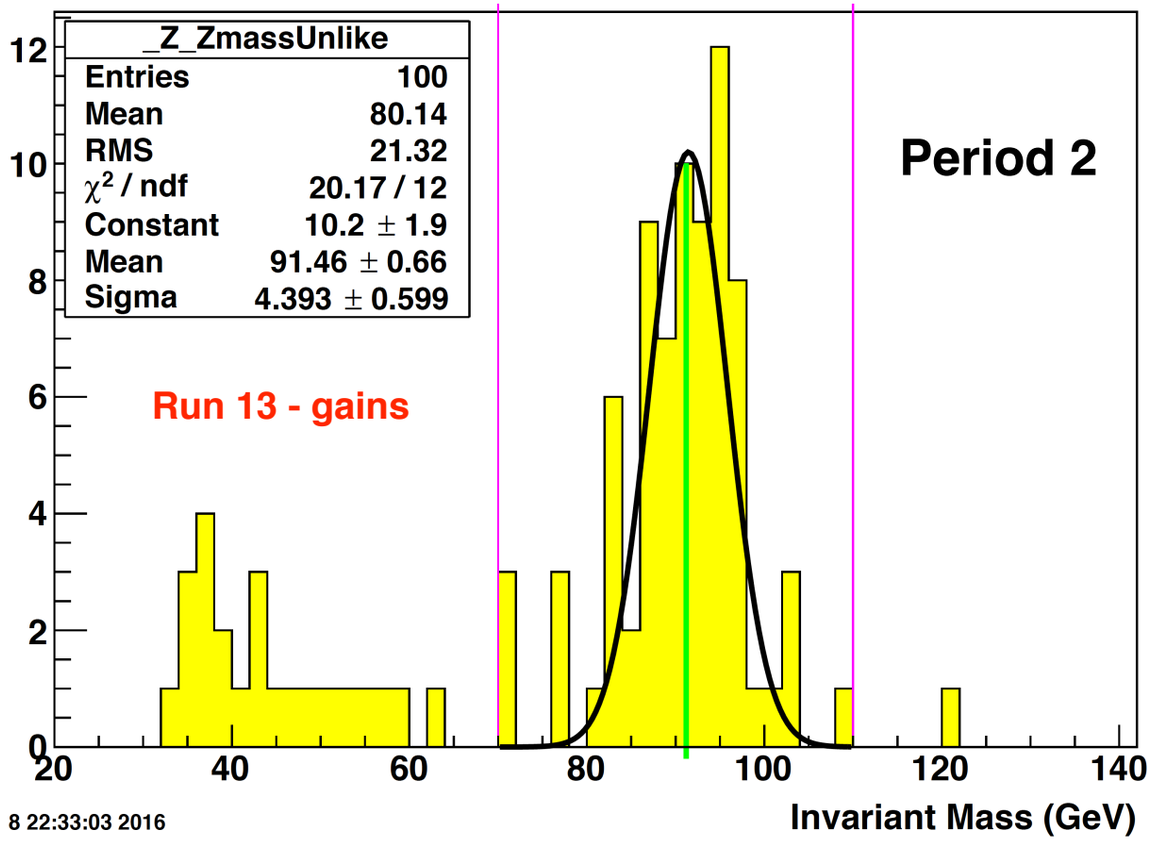
- Z invariant mass
- W Jacobean peak

Run 13 Z invariant mass



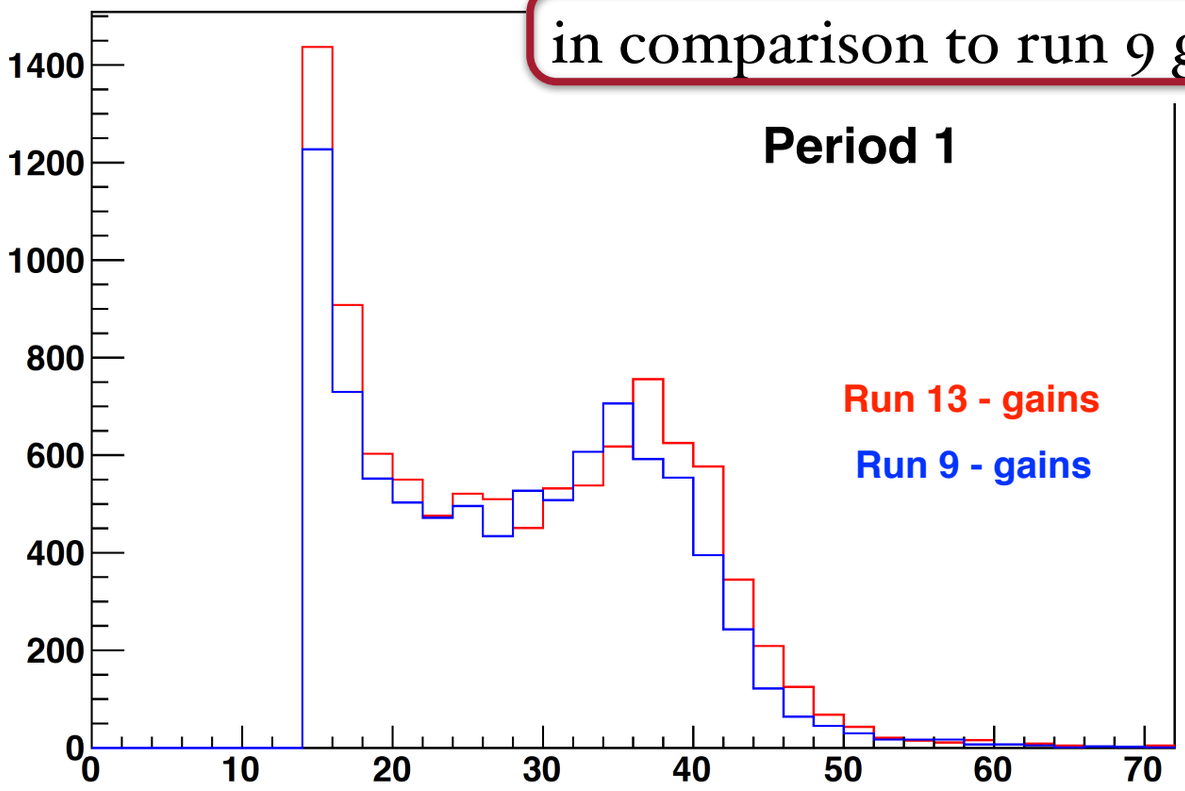


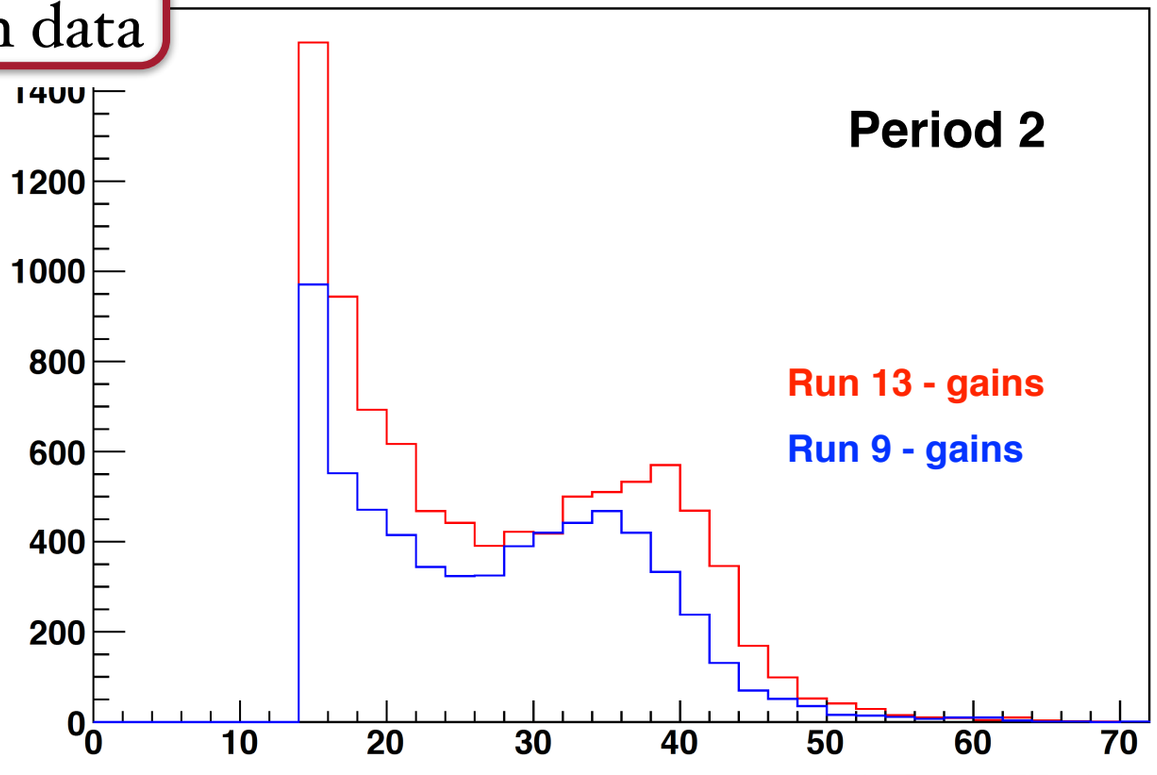




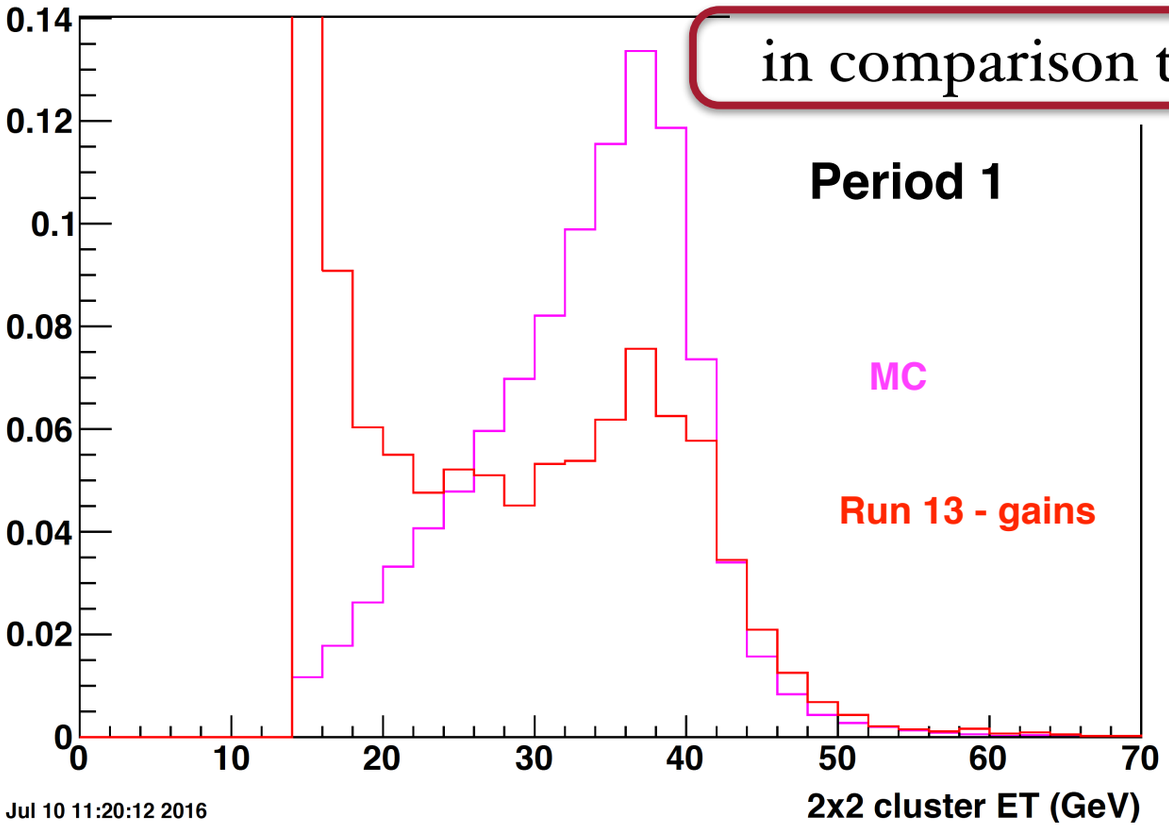
W - Jacobean Peak Shift

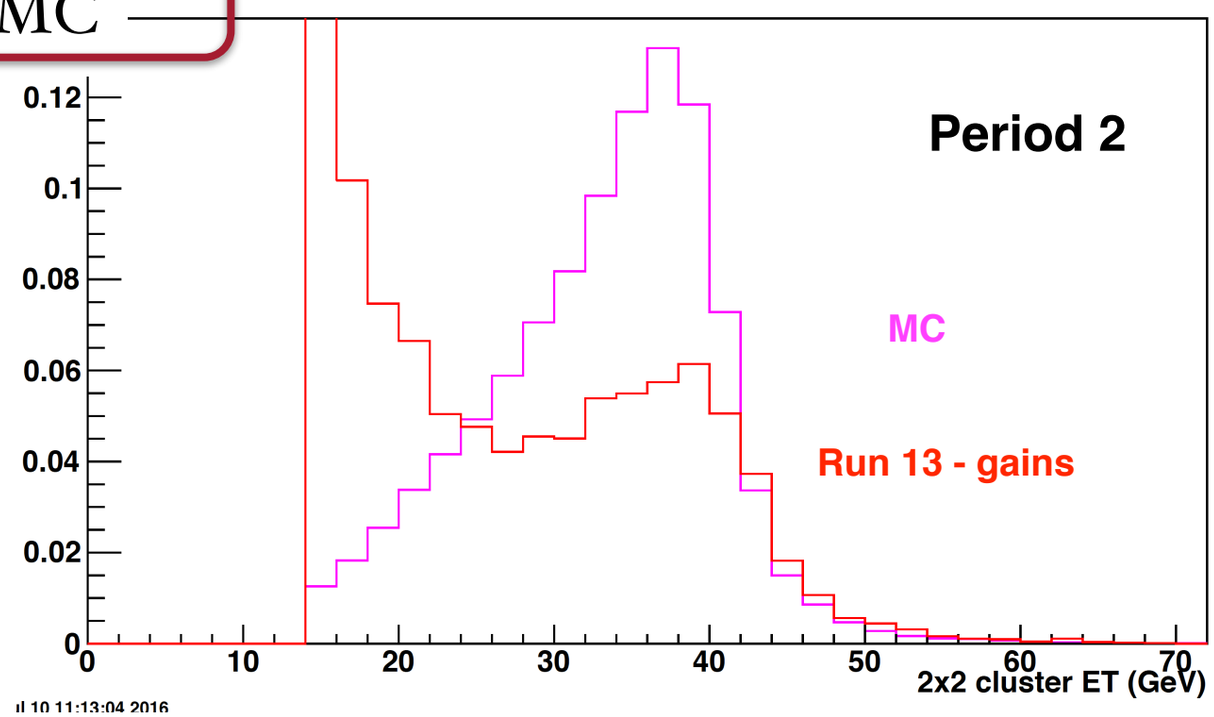
in comparison to run 9 gain data





in comparison to MC





Systematic Errors - Summary

Systematic error:	Systematic Error Value Period 1	Systematic Error Value Period 2
1 Trigger bias	1.4%	1.2%
2 Low Momentum cut	2.2%	1.1%
3 Tower track ΔR cut	0%	0%
4 Time dependance	0.8%	0%
5 Luminosity (ZDCx) dependance	0%	0%
6 Crate dependance	1.2%	1.2%
Total (quadrature)	**3.0%**	**2.0%**

1 Systematic Errors - Trigger bias

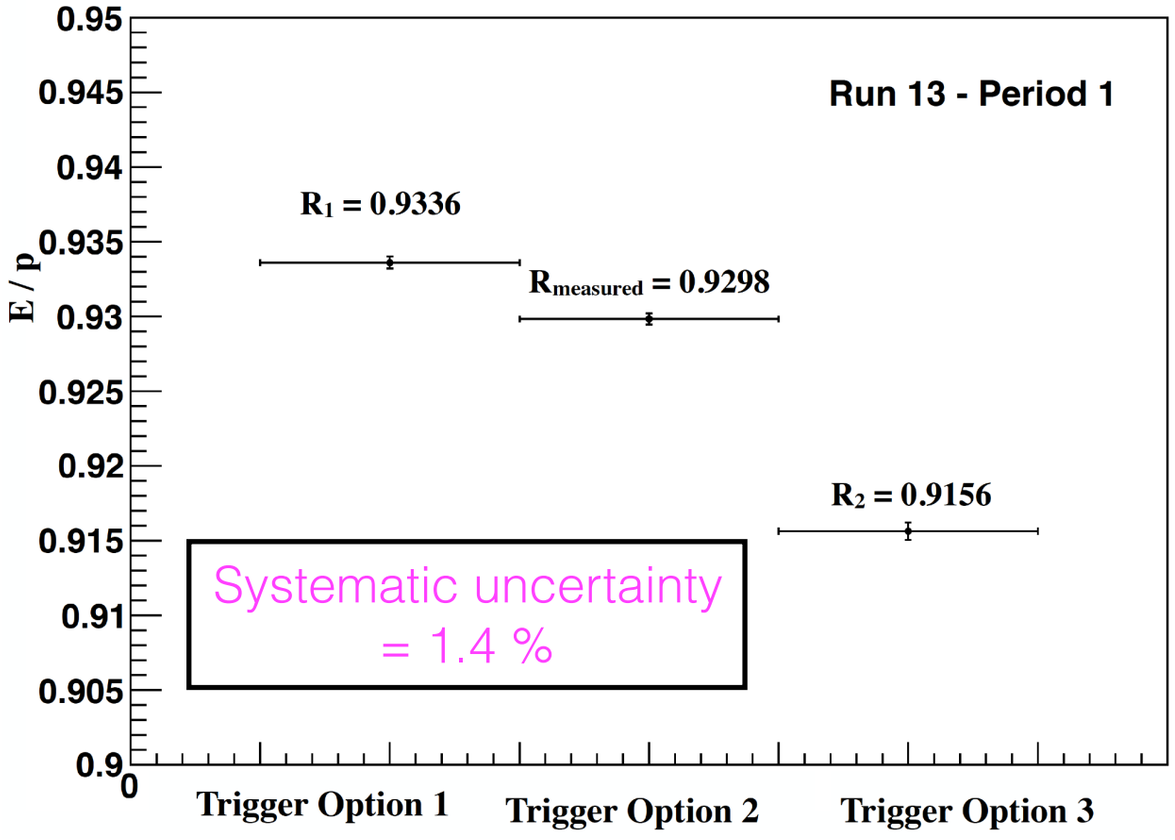
- Impact on E / p from HT and non HT trigger events.
- Consider 3 different scenarios, take <E / p> over all the Eta rings.

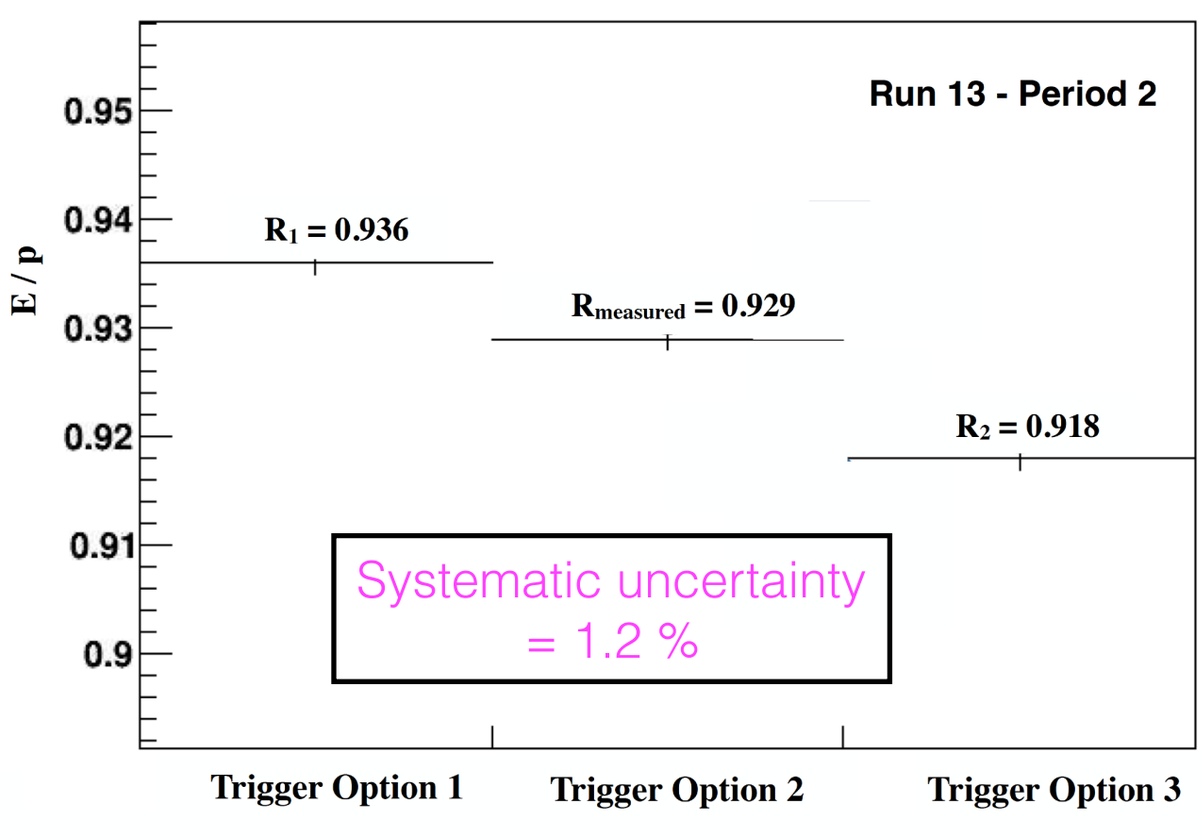
  1. Only non HT trigger events : JP2->didFire(), (0<P<10) GeV : <E / p> = R_1

  2. Only HT trigger : BHT3->didFire(), (0<P<3) GeV : <E / p> = R_2

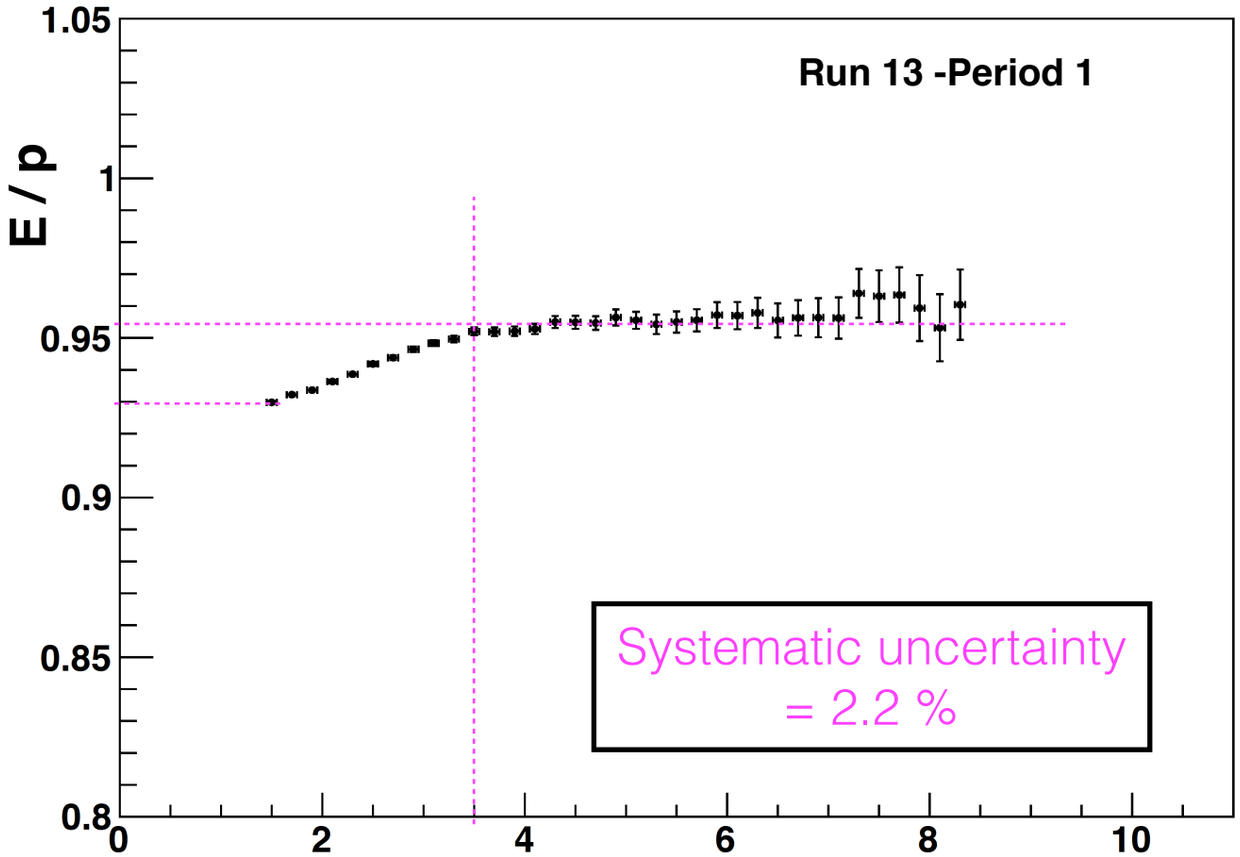
  3. Both nonHT and HT (this is the trigger option used for the E /p calibartion) : JP2->didFire(), (0<P<10) GeV || BHT3->didFire , (P < 3) GeV : <E / p> = R3 = $R_{meausred}$

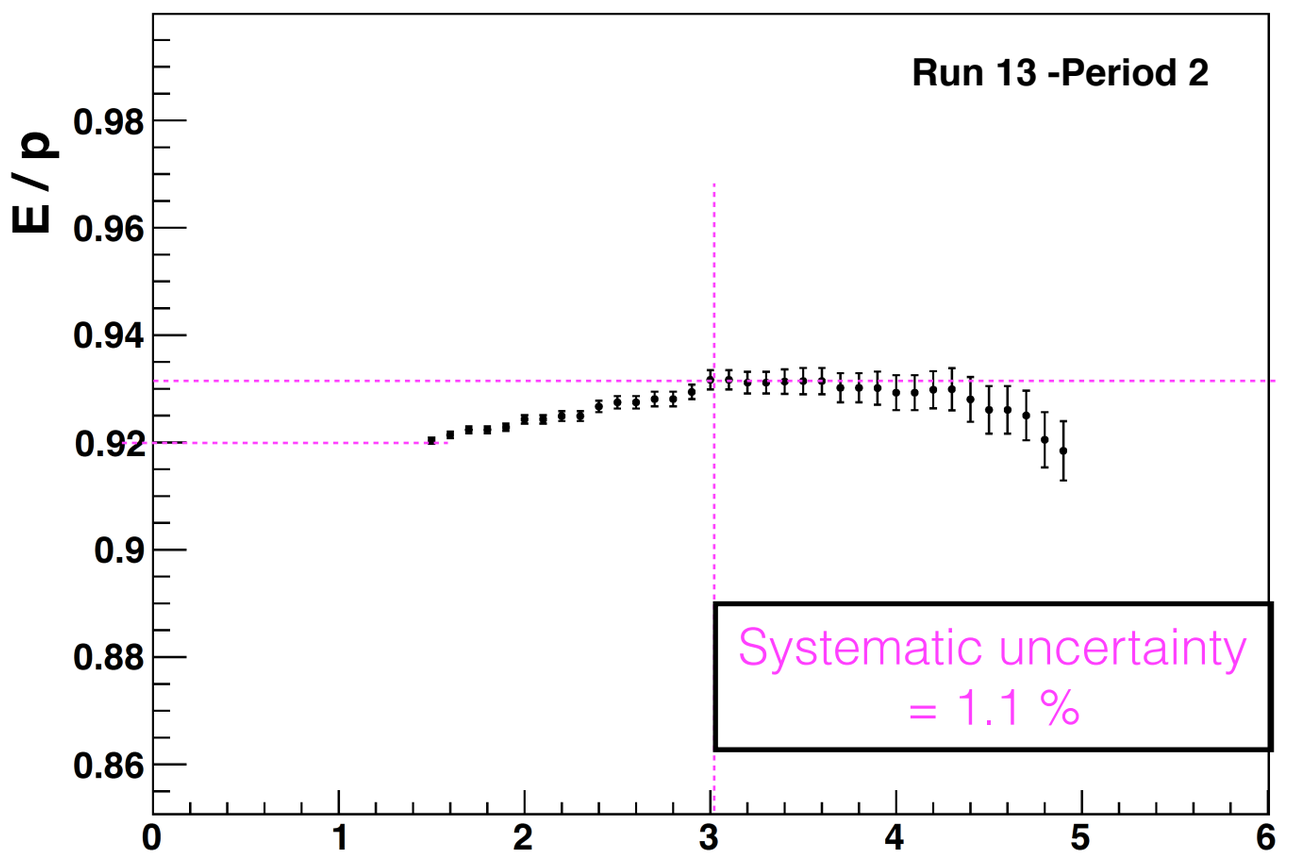
- Consider the largest difference between $R_{measured}$ and Ri s as the uncertainty from trigger scheme





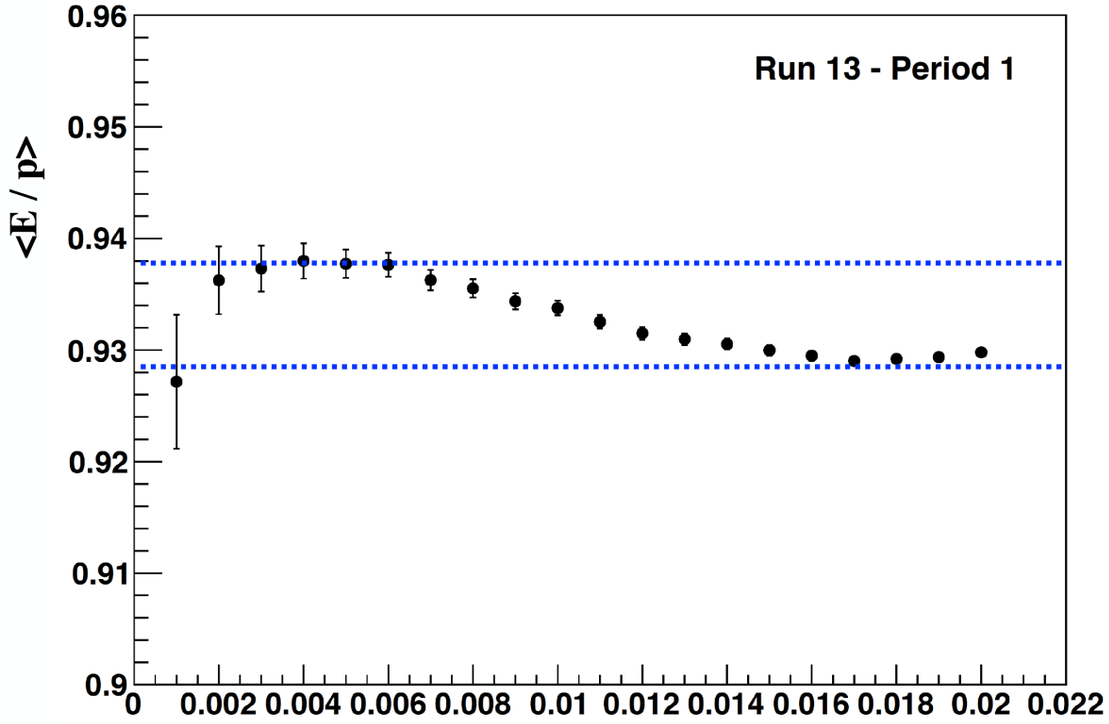
2 Systematic Errors - Low momentum cut

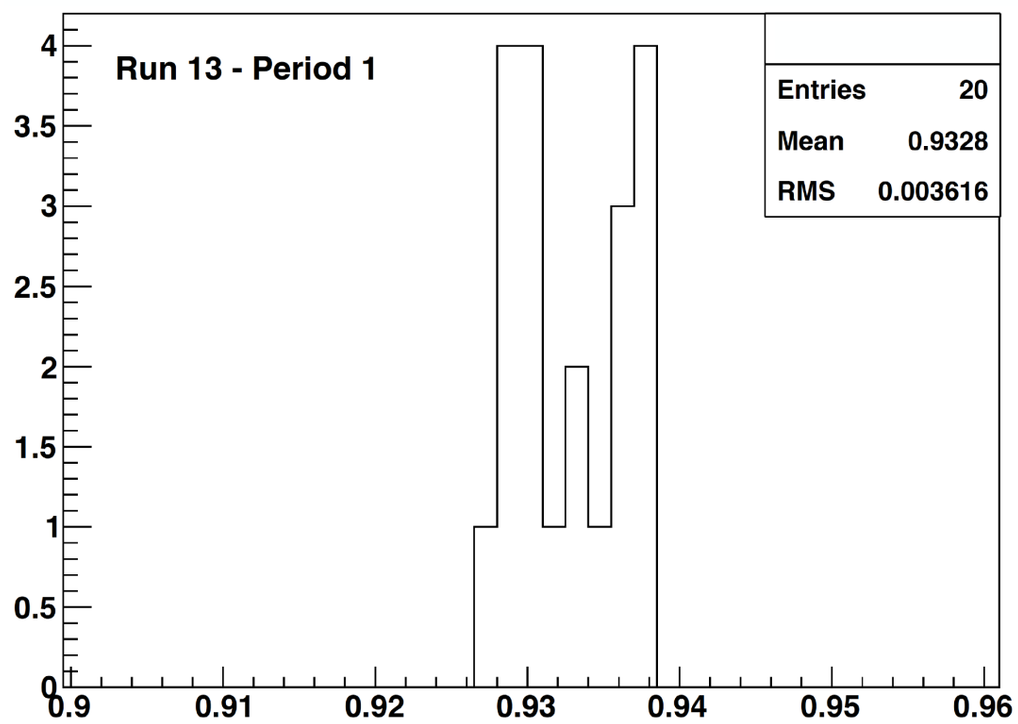




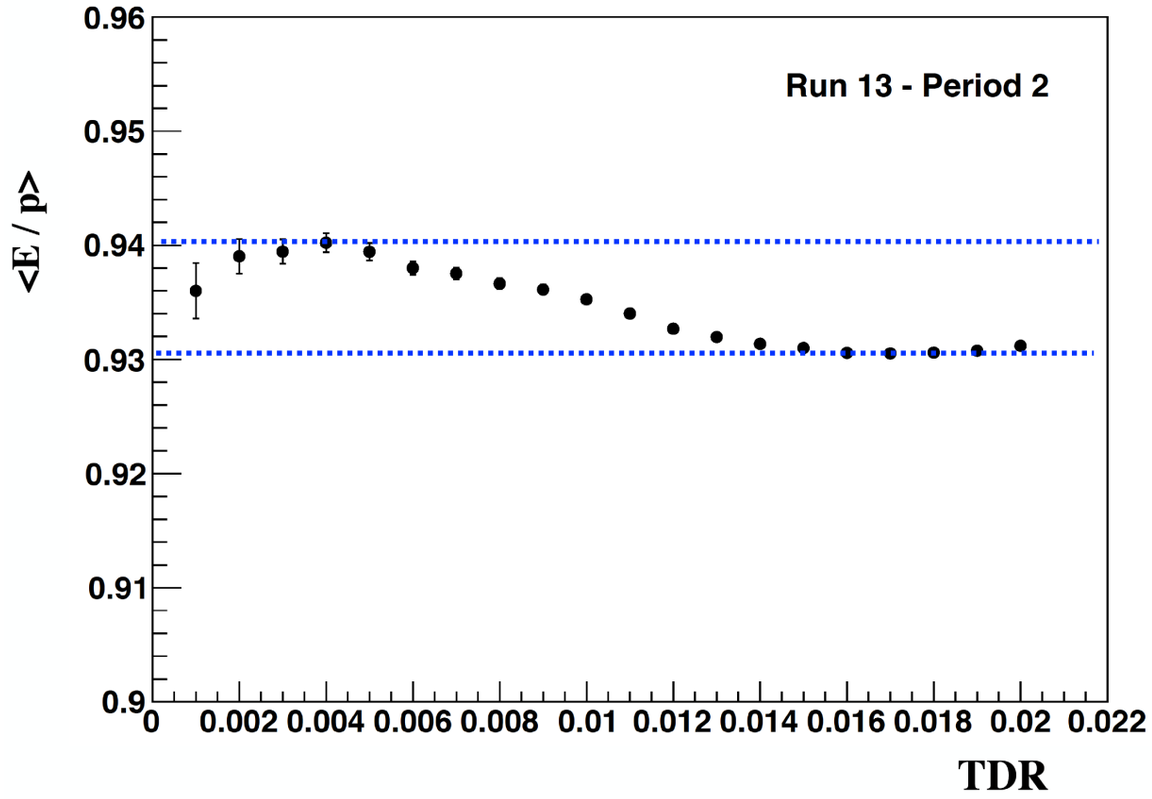
- E / p shows steady increasing behavior from 1.5 to 3.5 (3.0) GeV and fairly stable behavior above for period 1 (period 2) .
- Obtain <E / p> for the whole detector between [Low P cut - 10 GeV]
- Assign absolute difference of E / p between 1.5 and 3.5 (3.0) for Period 1 and period 2.

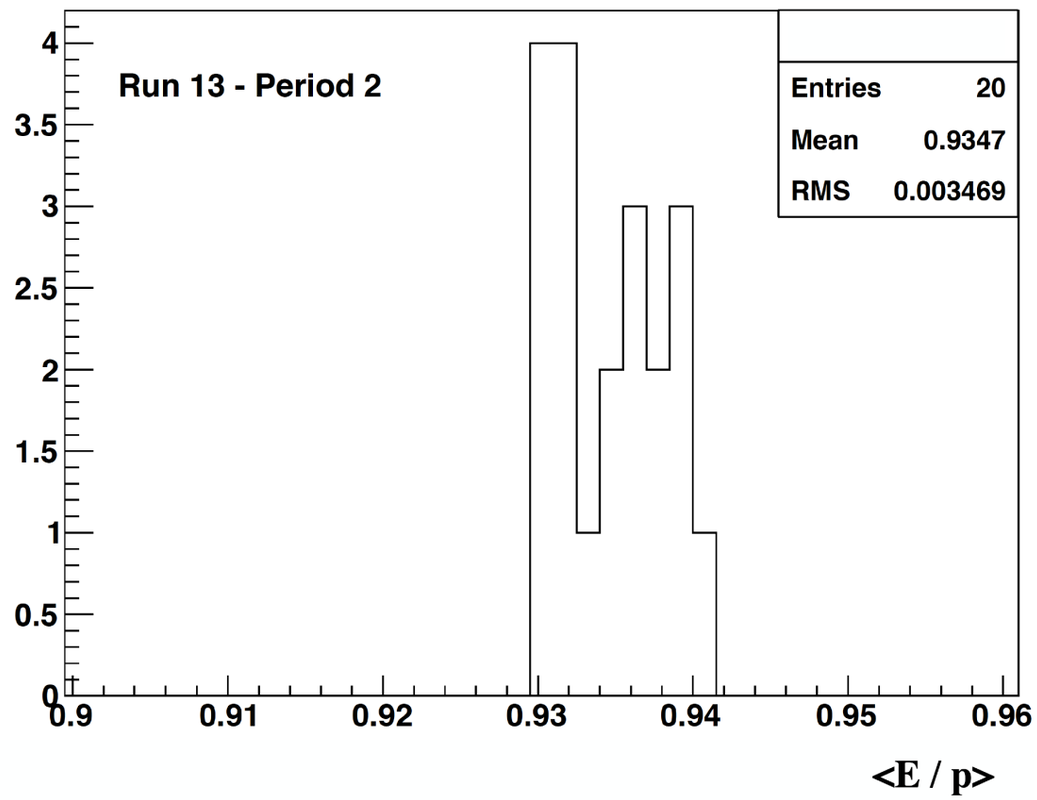
3 Systematic Errors - TDR Cut



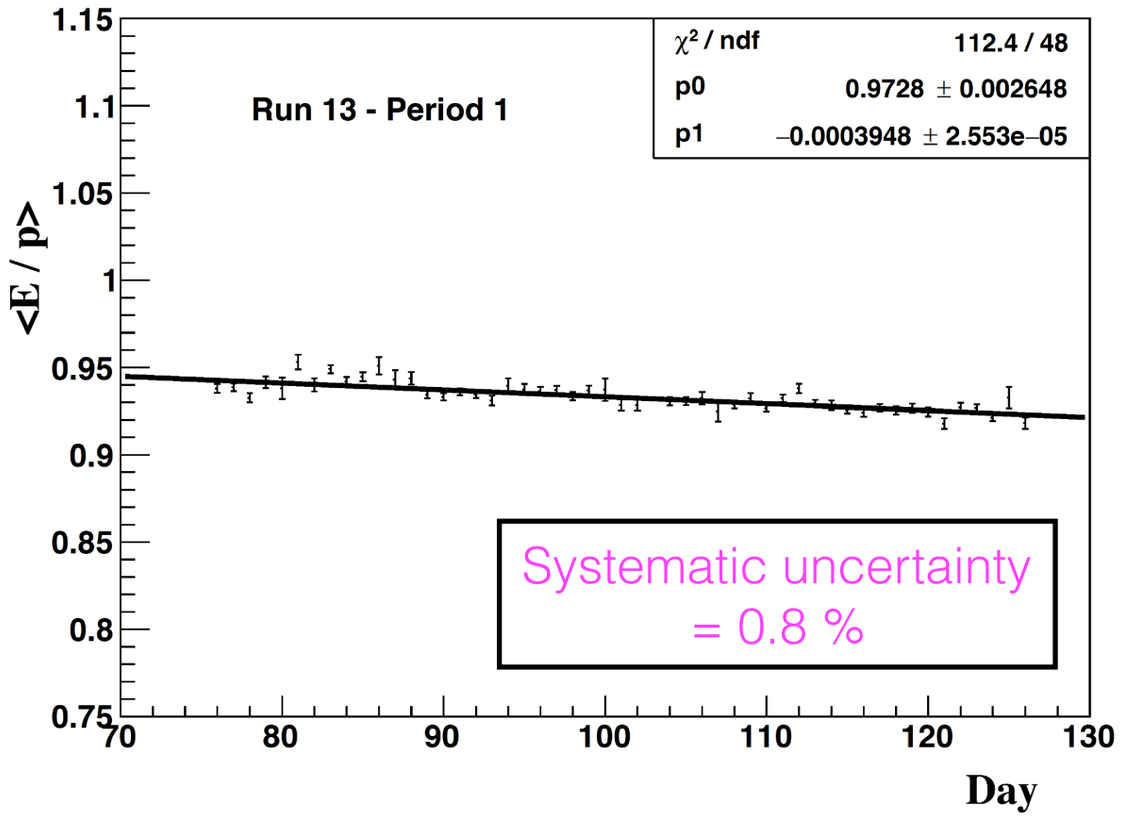


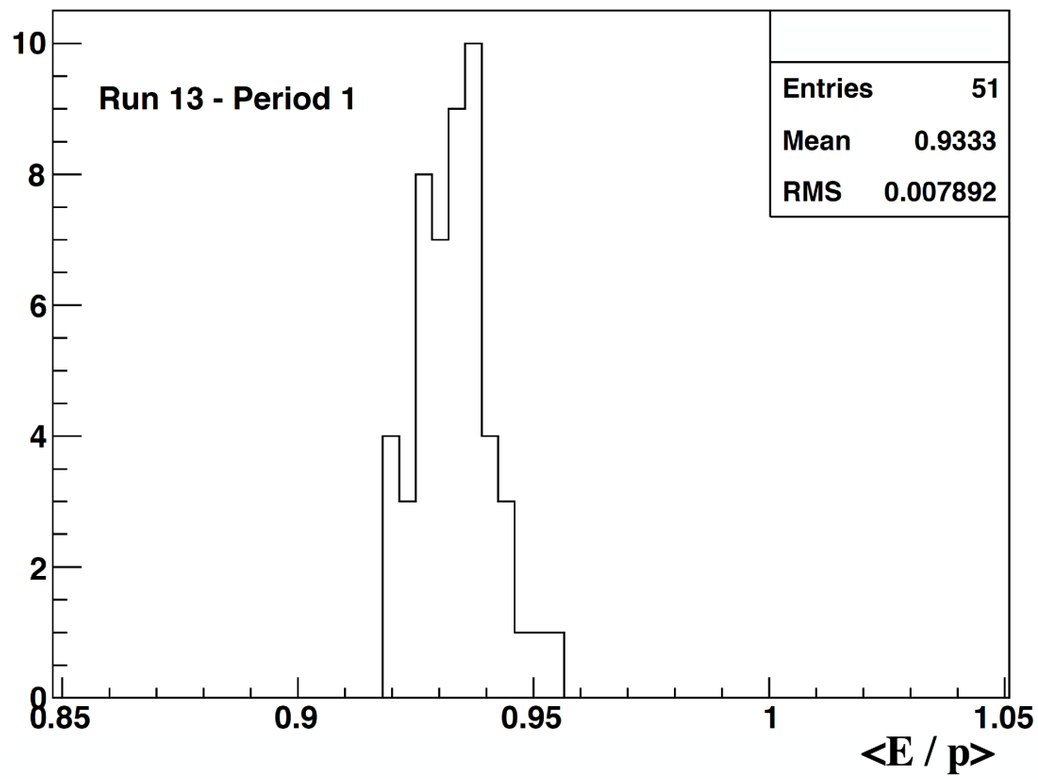
No significant dependance , Therefore no systematic assigned!

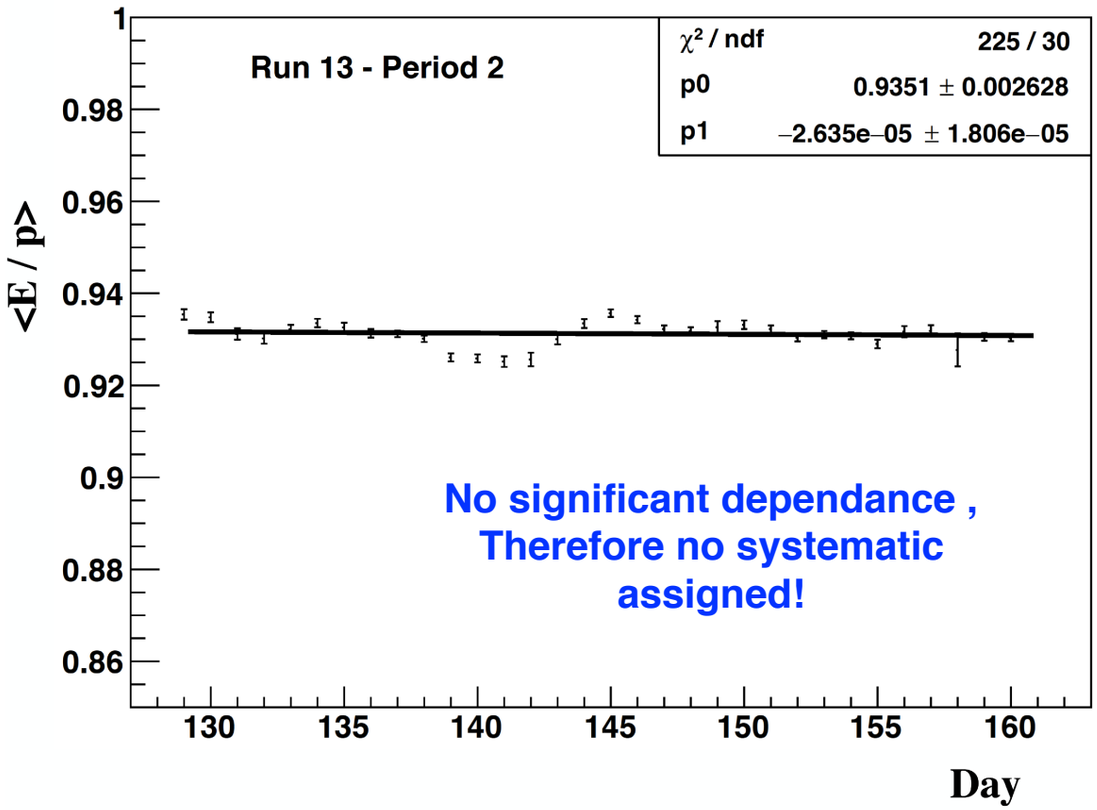


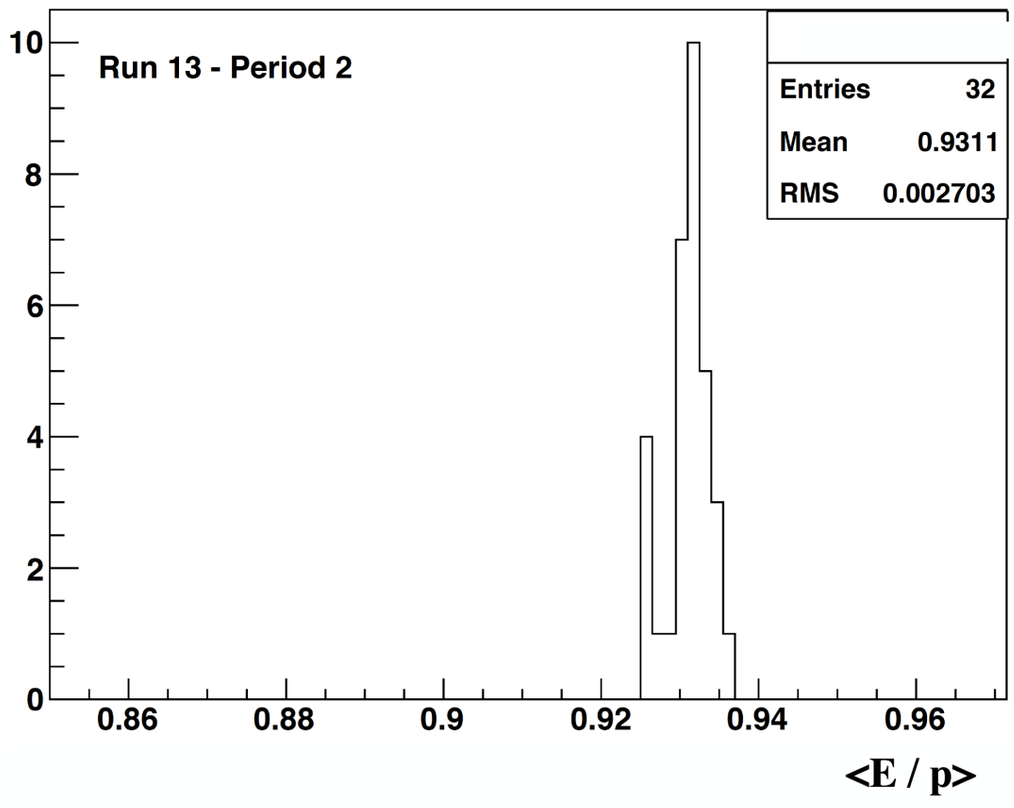


4 Systematic Errors - Time Dependance

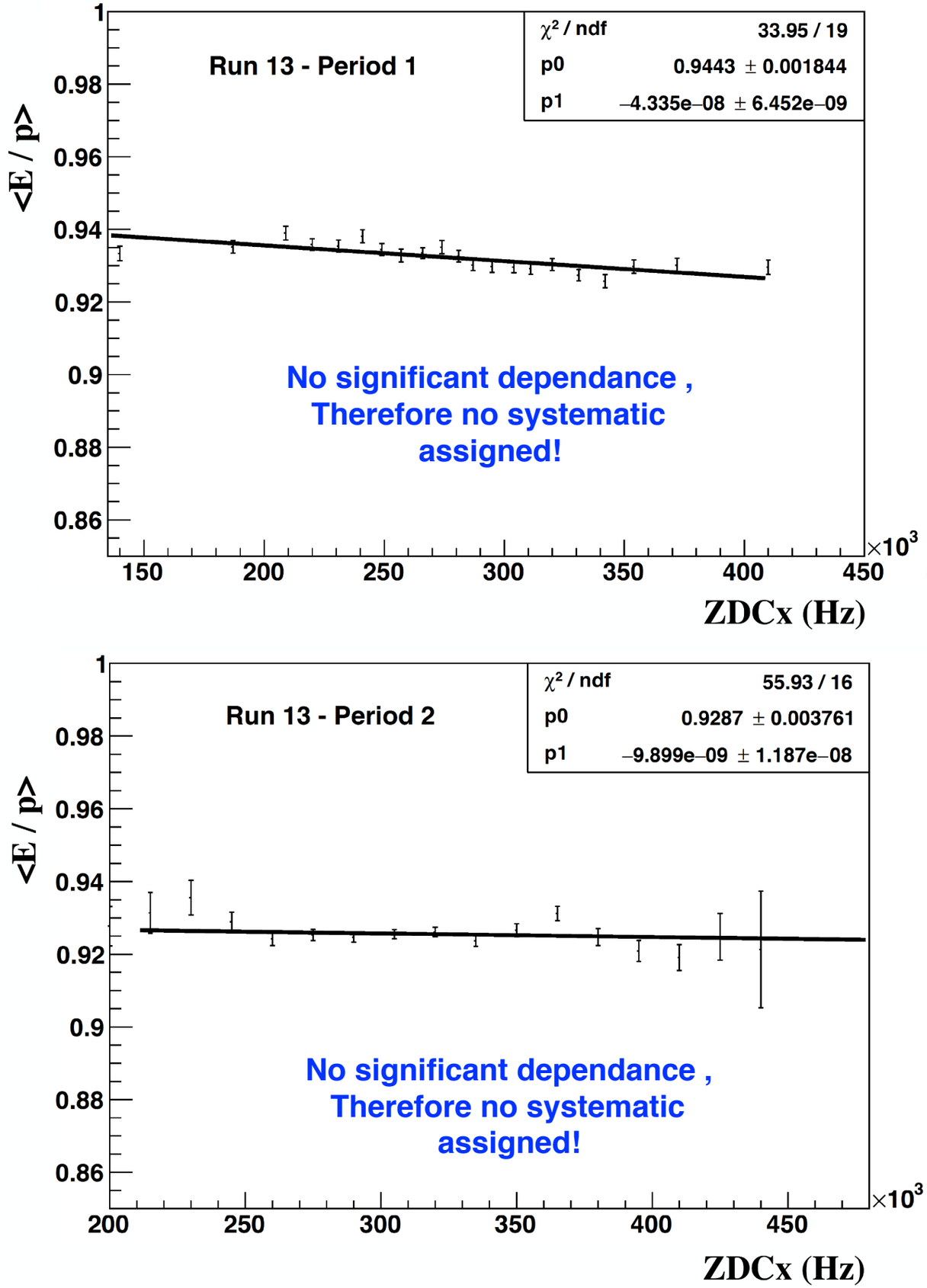


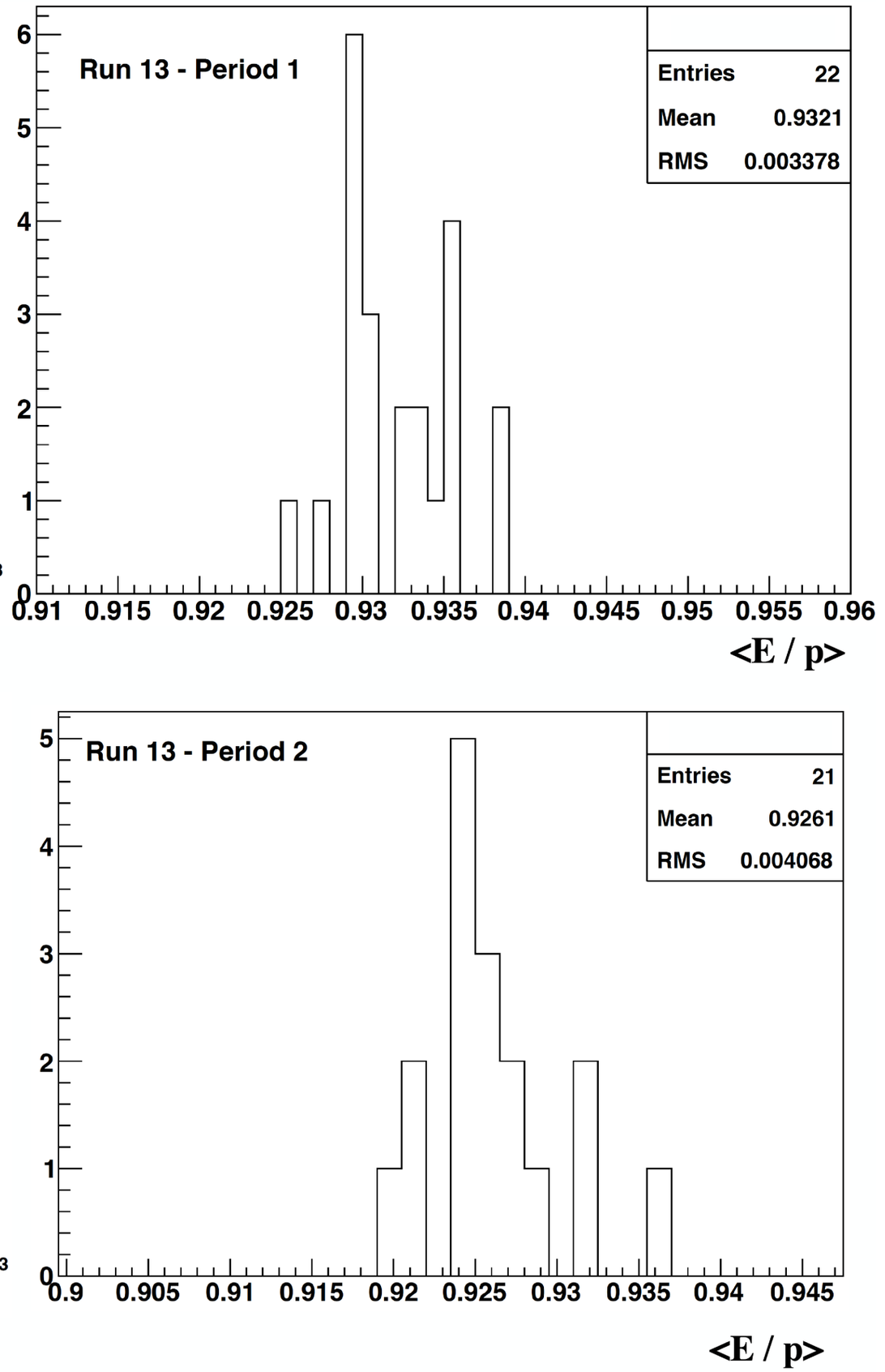




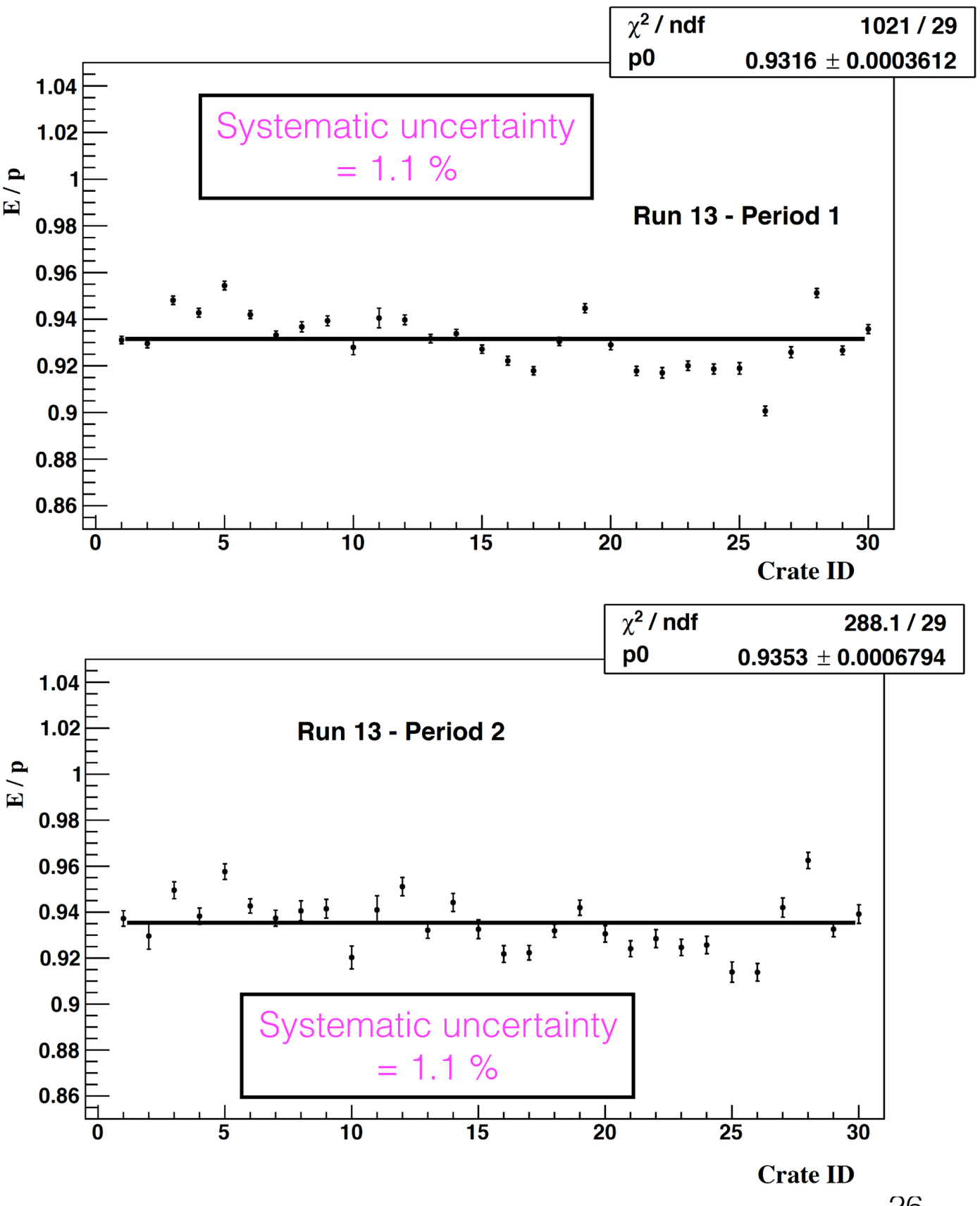


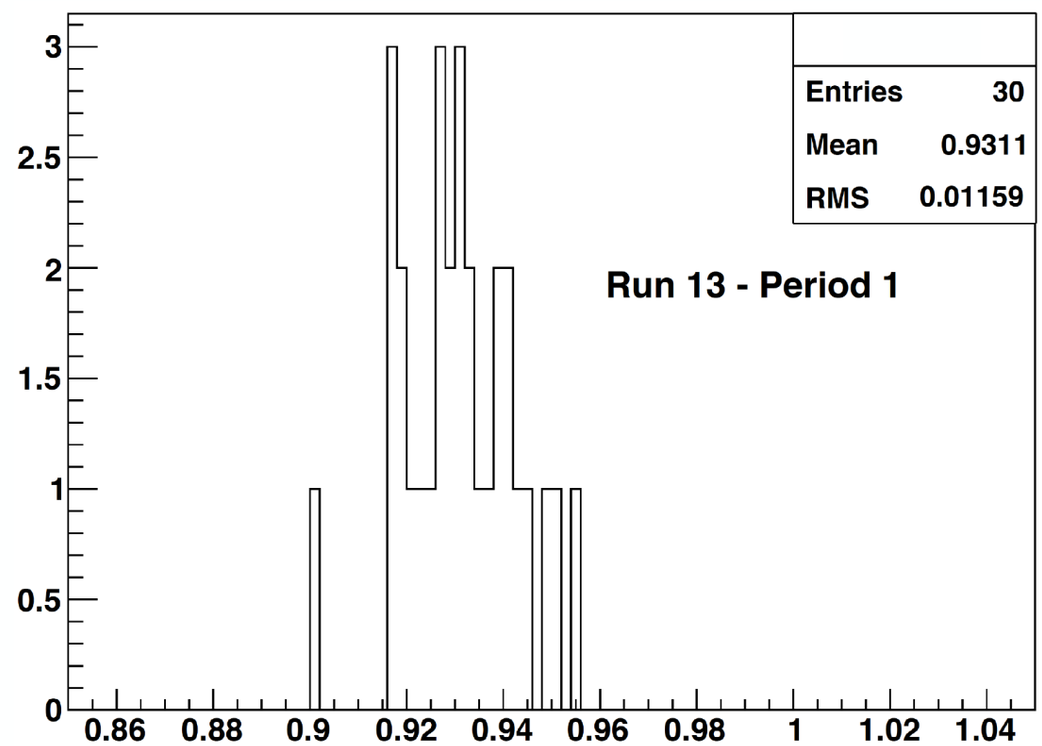
5 Systematic Errors - Luminosity (ZDCx) Dependance

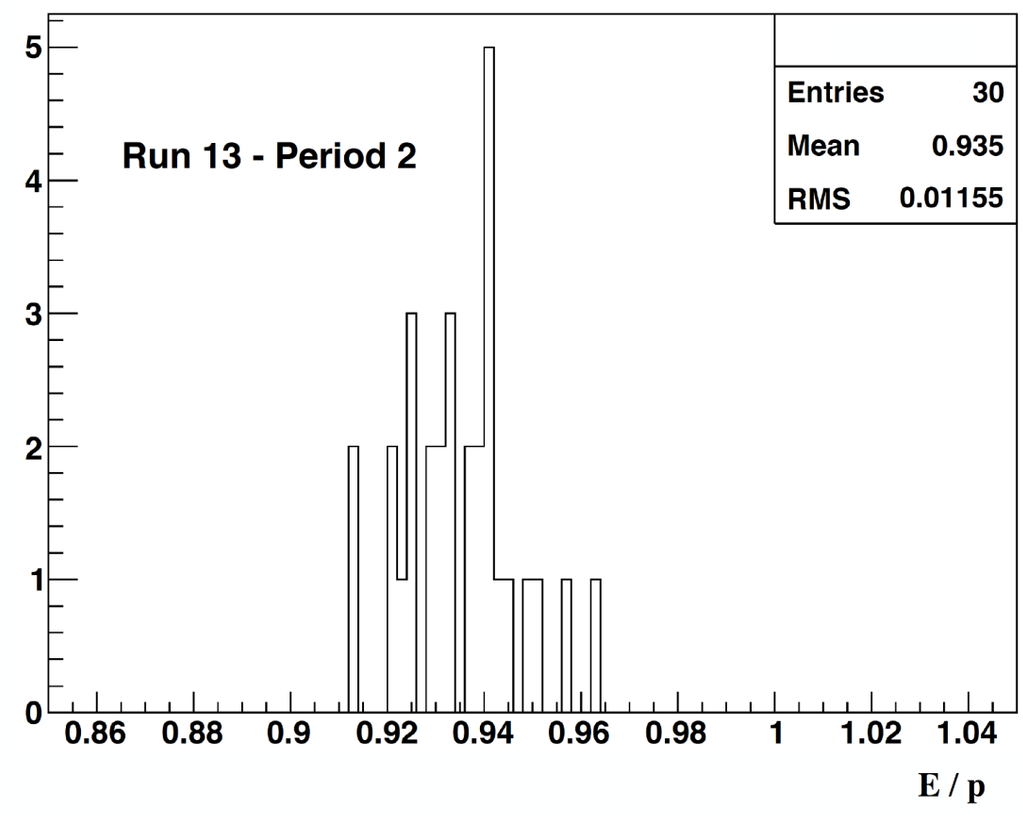




6 Systematic Errors - Crate Dependance







Summary

Final gain comparison

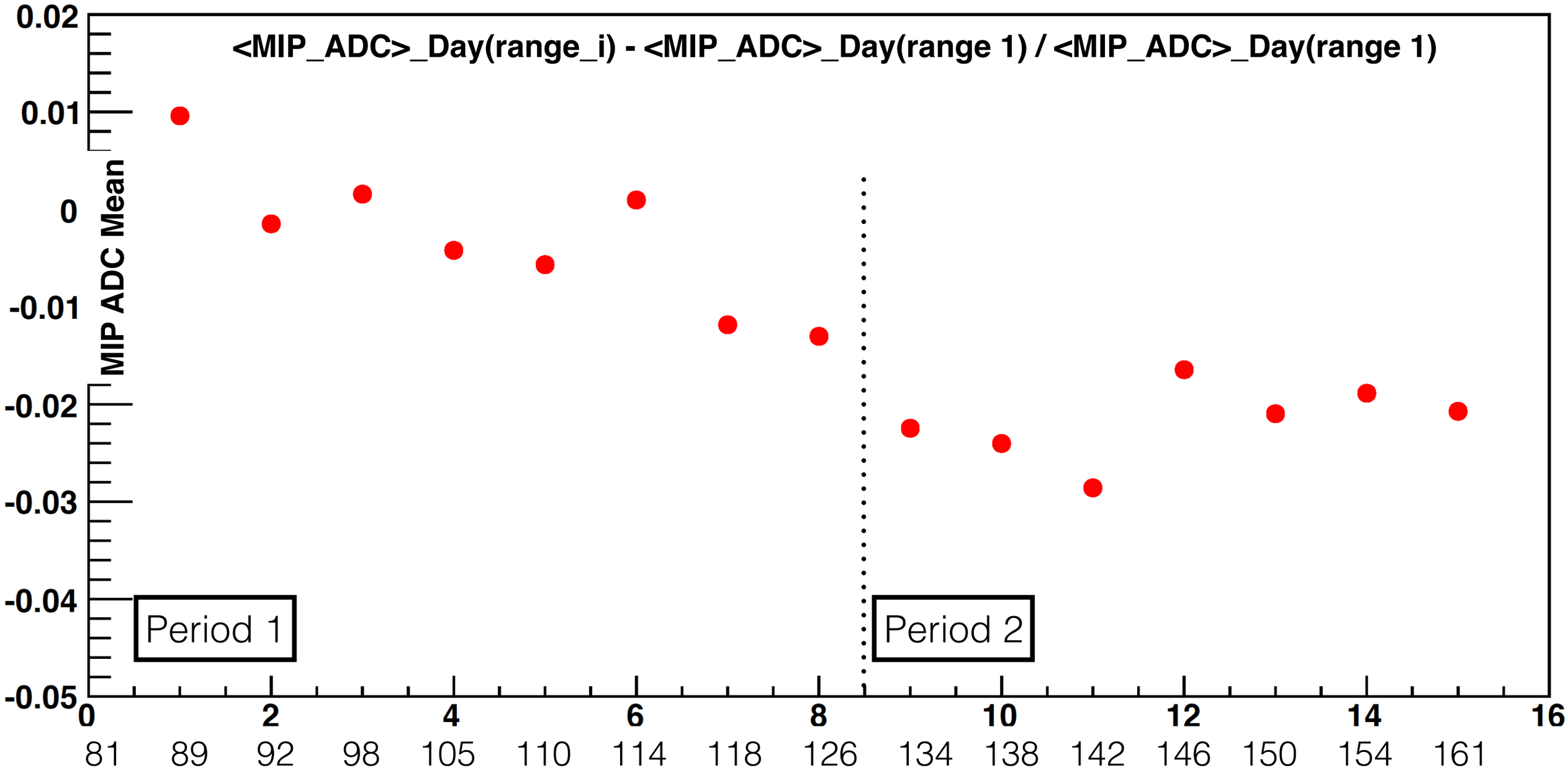
RHIC Run	**Run 12 200 GeV**	**Run 13 - P1 510 GeV**	**Run 13 - P2 510 GeV**
Run 9 200 GeV	< ~ 1%	**> ~ 4%**	> ~ 6.5%
Run 12		> ~ 5%	> ~ 7.5%
Run 13 P1			**> ~ 2.5 %**

Systematic errors	Systematic Error Value Period 1	Systematic Error Value Period 2
1 Trigger bias	1.4%	1.2%
2 Low Momentum cut	2.2%	1.1%
3 TDR (ΔR) cut	0%	0%
4 Time dependance	0.8%	0%
5 Luminosity (ZDCx) dependance	0%	0%
6 Crate dependance	1.2%	1.2%
Total (quadrature)	**3.0%**	**2.0%**

- Run 13 pp 510 GeV BEMC calibration is completed with systematic uncertainty of 3% for period 1 and 2% for period 2 .
- Calibration derived at lower energies is consistent with high-energy probes (Z/W)
- Run 13 BEMC preliminary gain tables are ready to be used for run13 analyses.
- Run 13 BEMC preliminary calibration systematic error comparable to Run 12 estimates using same tower-based method!

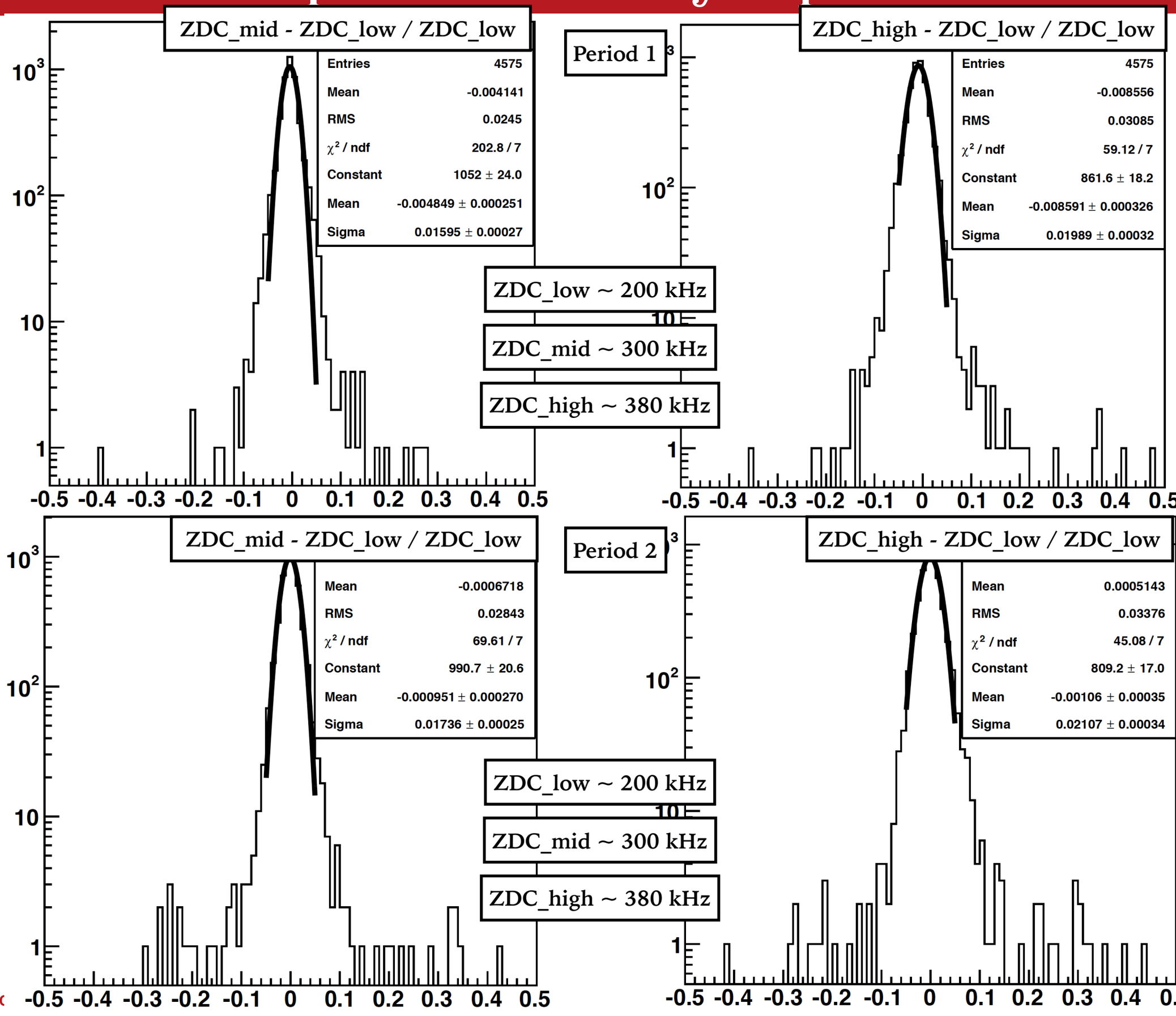
Backup

MIP-peak Time dependance

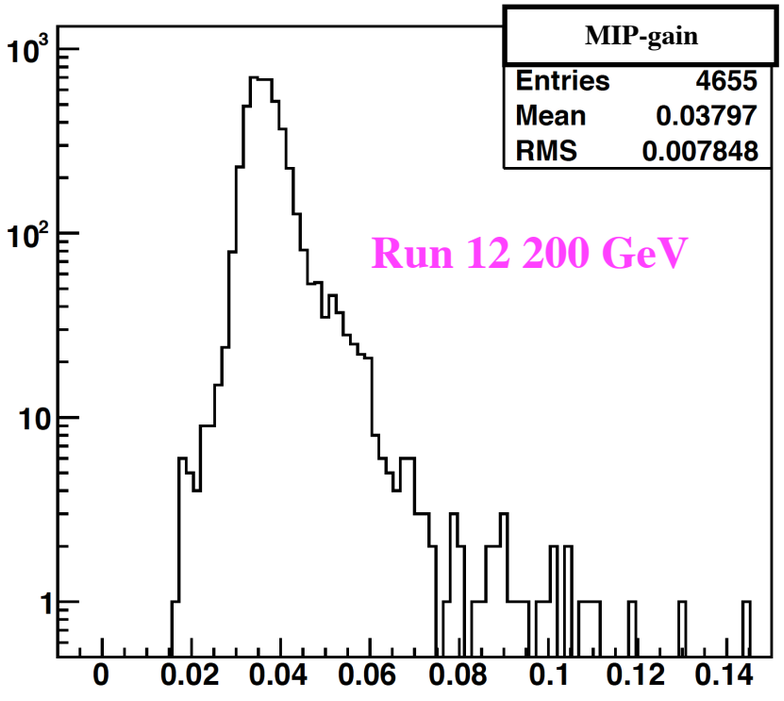


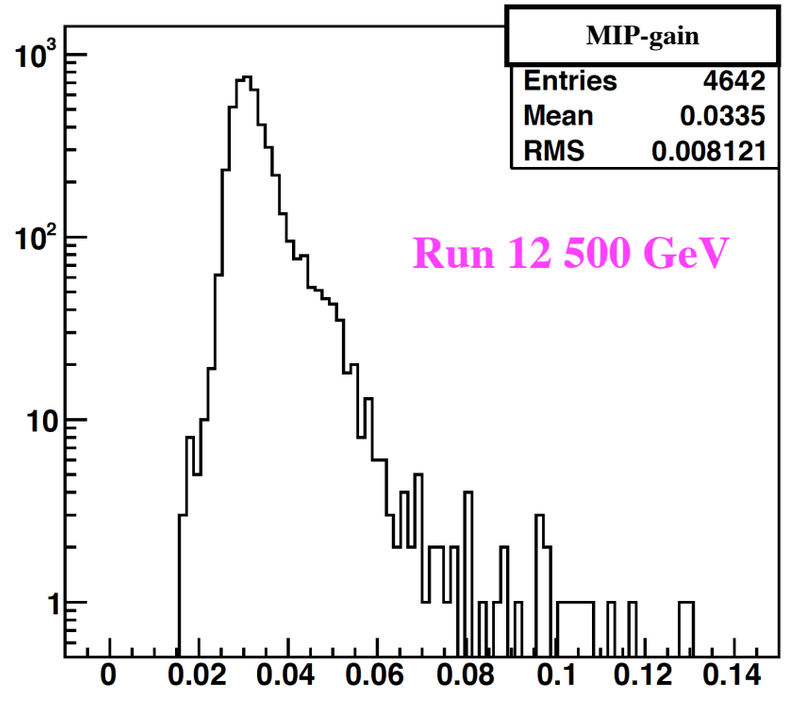
- Tendency of Average MIP -ADC response to drop as a function of time. On average ~2% change from Period 1 to Period 2.

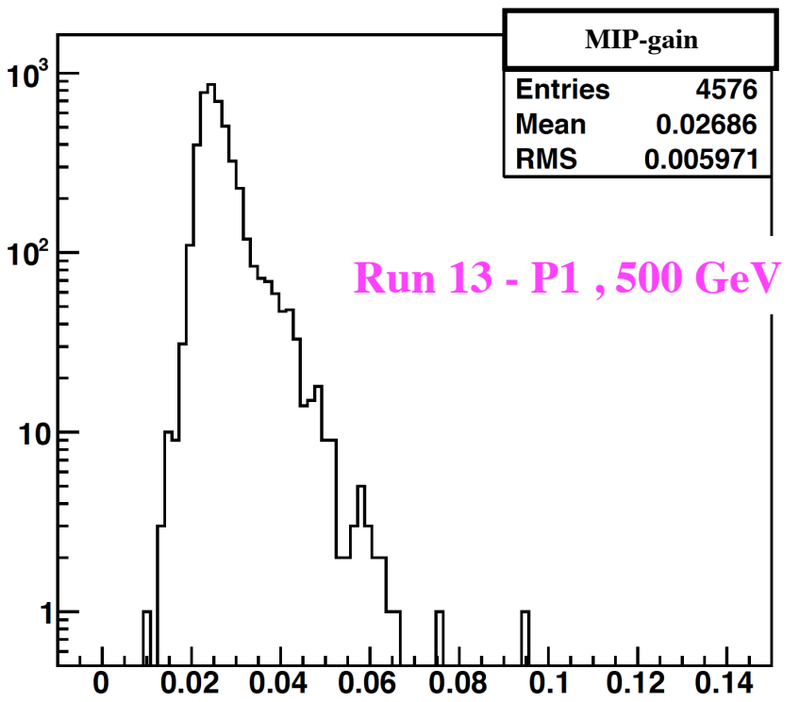
MIP peak luminosity dependance

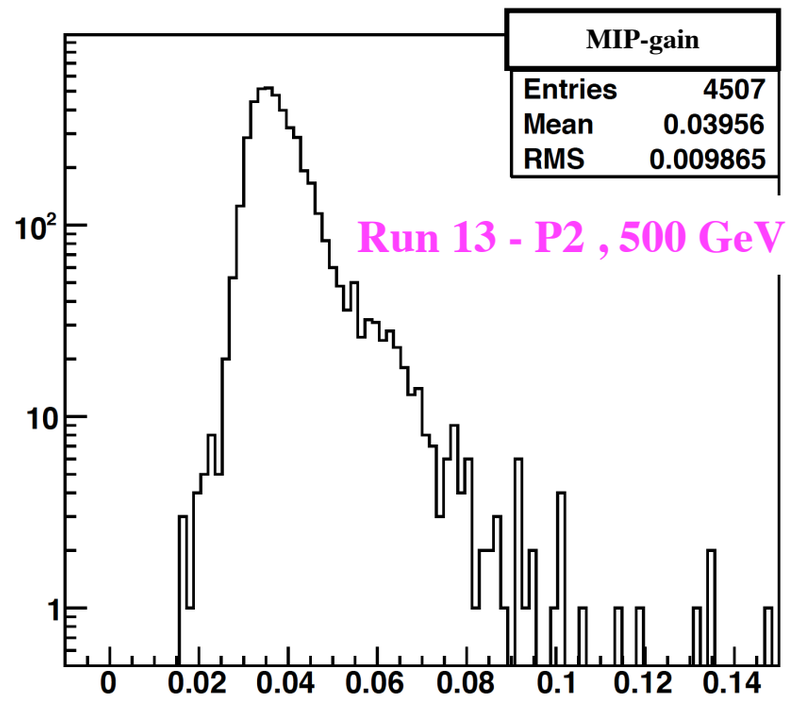


MIP - gain comparisons





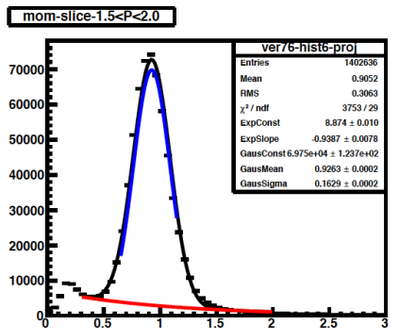


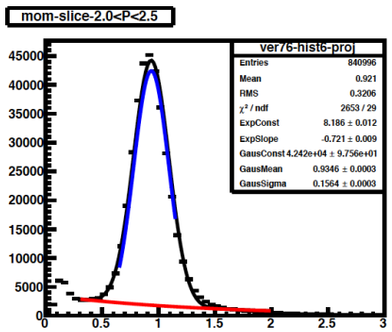


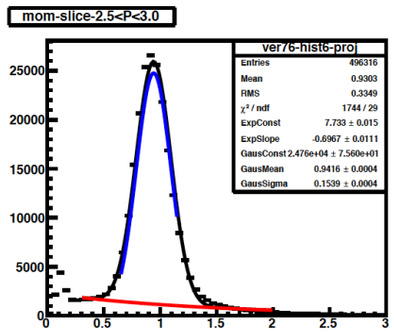
STAR 2013 available trigger options for the calibration

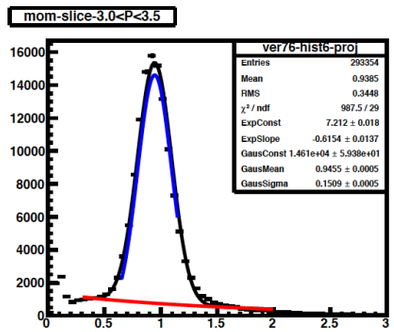
	Run 12 pp200 GeV	Run 13 pp500 GeV period 1, period2	L (pb-1)	Nev (M)	AV_prescale
1	BHT0*VPDMB	BHT0*VPD	0.139	10.095	759.65
2	BHT1*VPDMB	BHT1*VPDMB	61.635	282.985	1.729
3	BHT2	BHT2, BHT2*BBCMB, BHT2*BJP1	~38	~35	~22
4	BHT2*BBCMB	BHT3	305.562	126.949	1.000
5		JP2	286.880	162.027	1.000

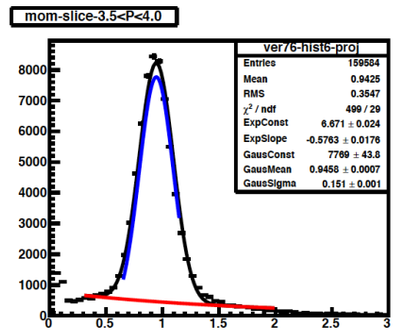
JP2 E / p distributions in momentum slices

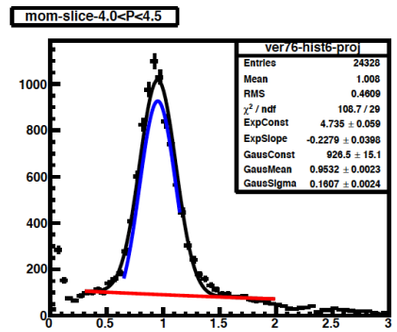


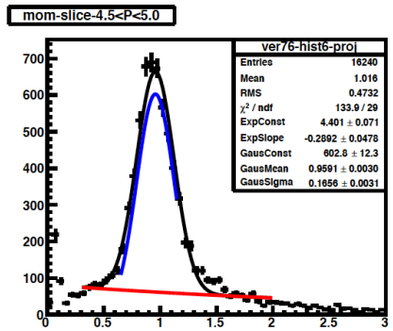


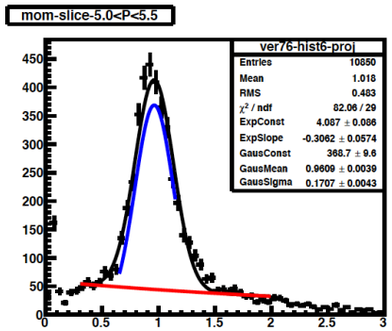


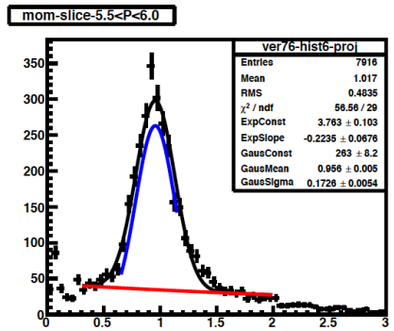


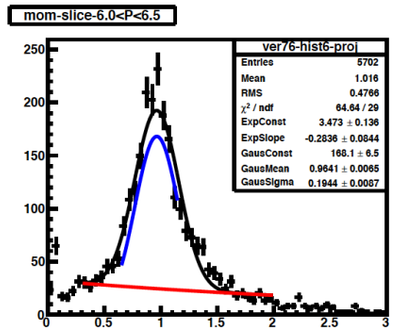


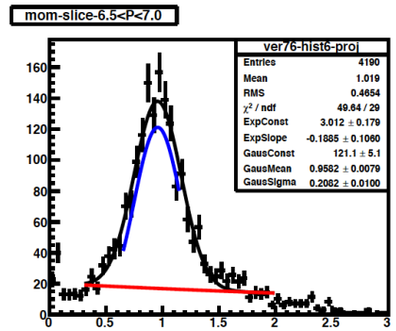


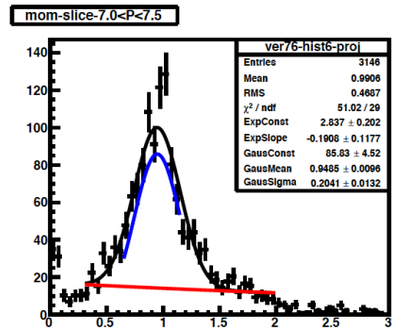


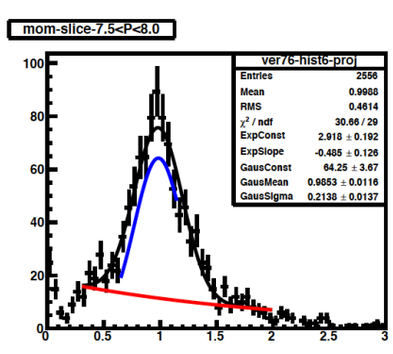


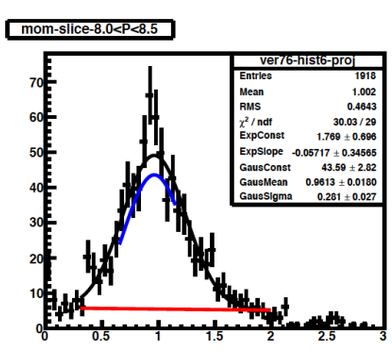


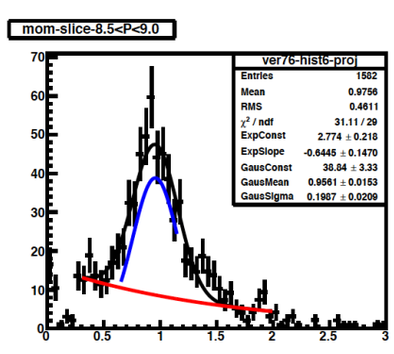


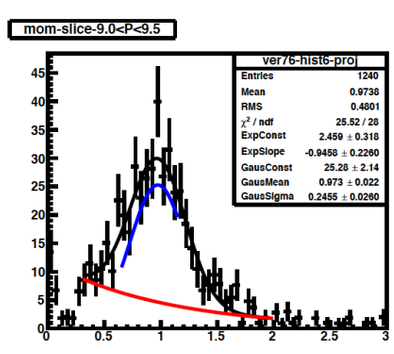


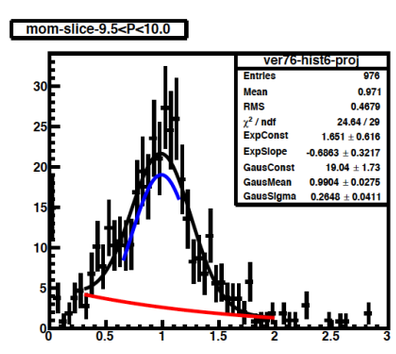




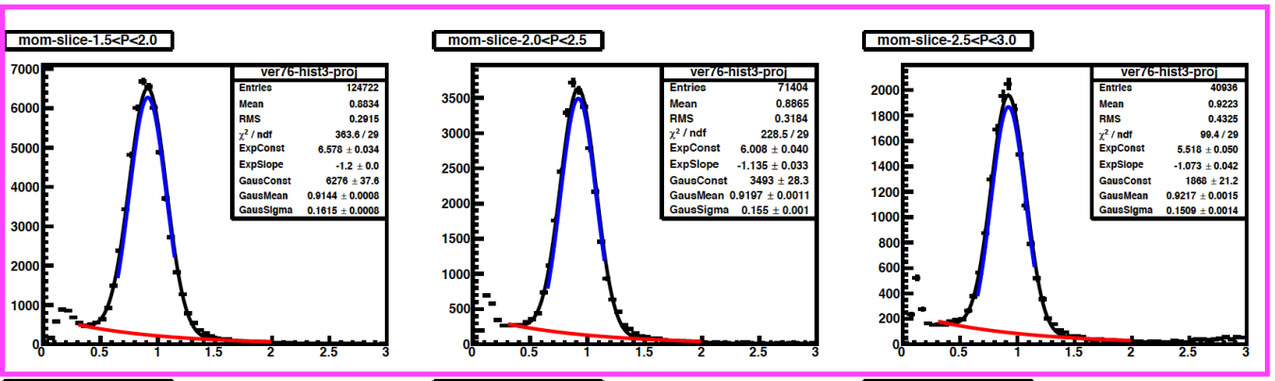






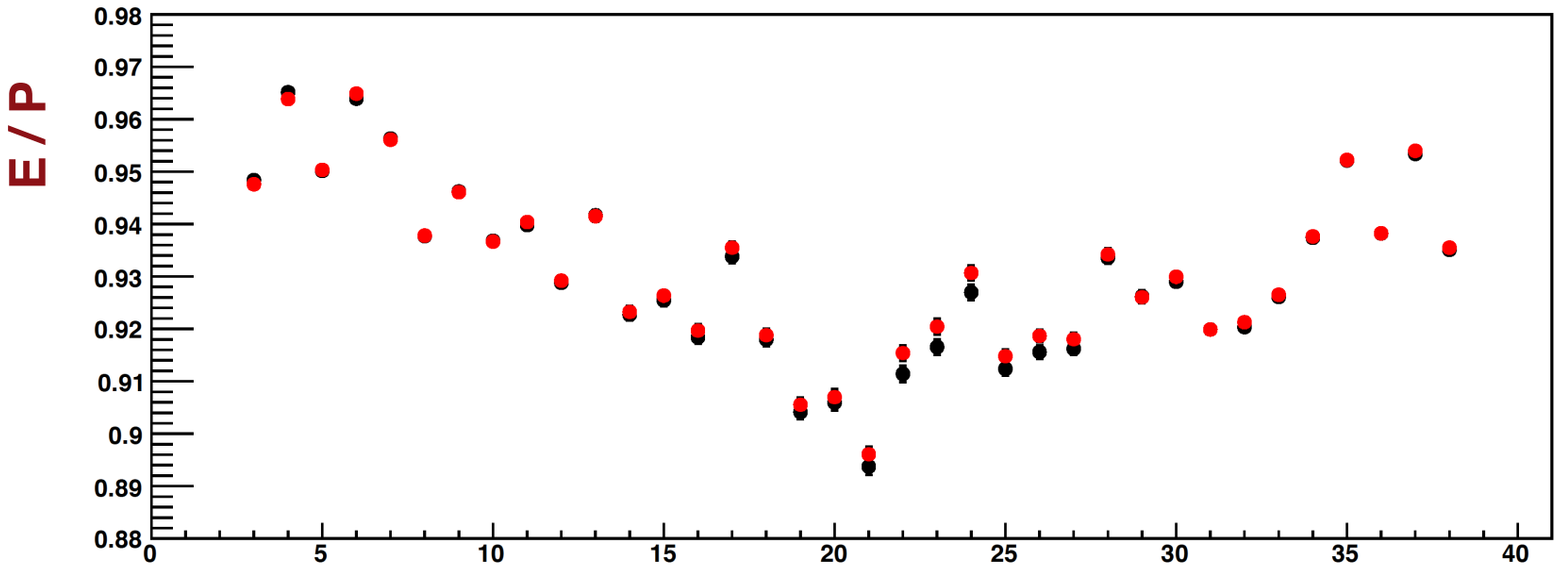


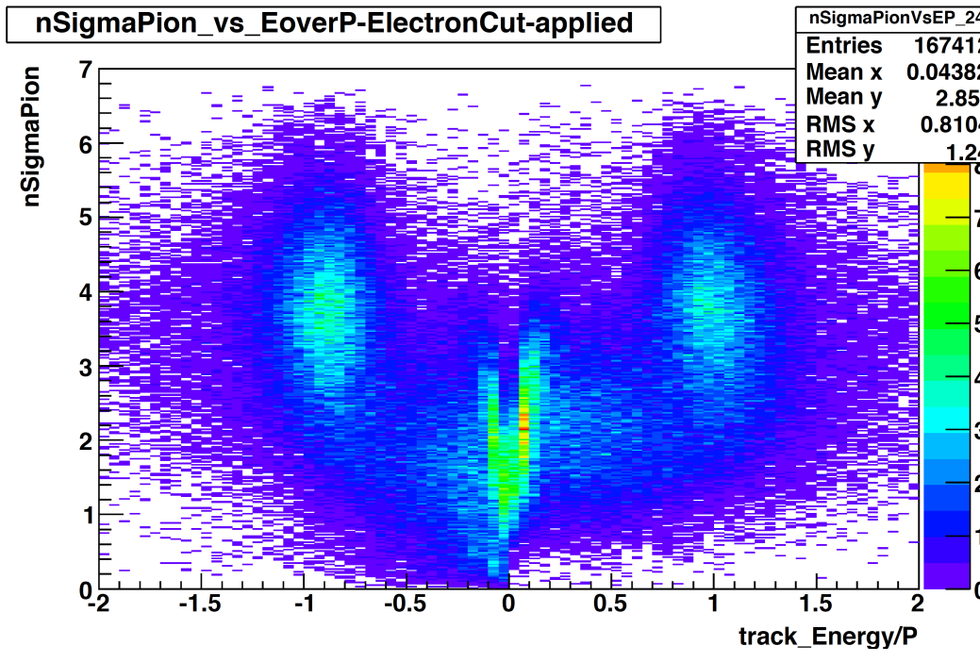
BHT3 E / p distributions in momentum slices



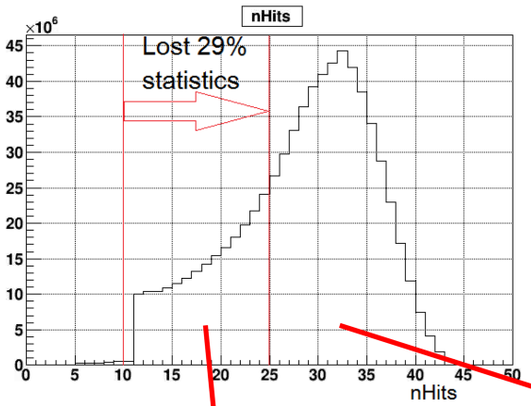
Impact of cut modification

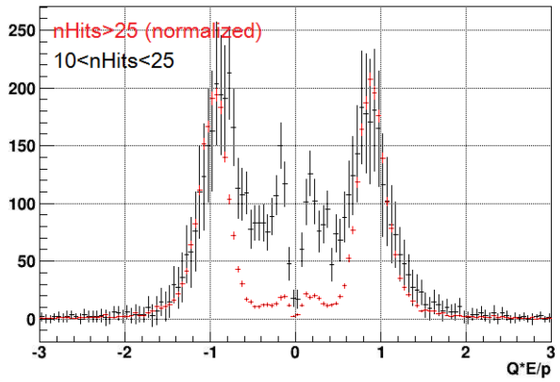
Pion Cut

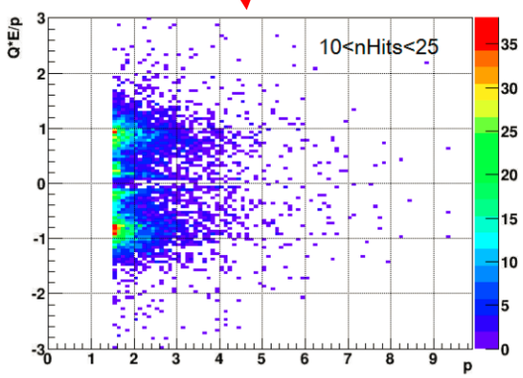


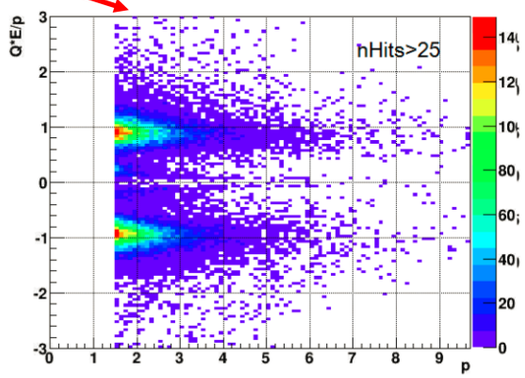


nHit Cut



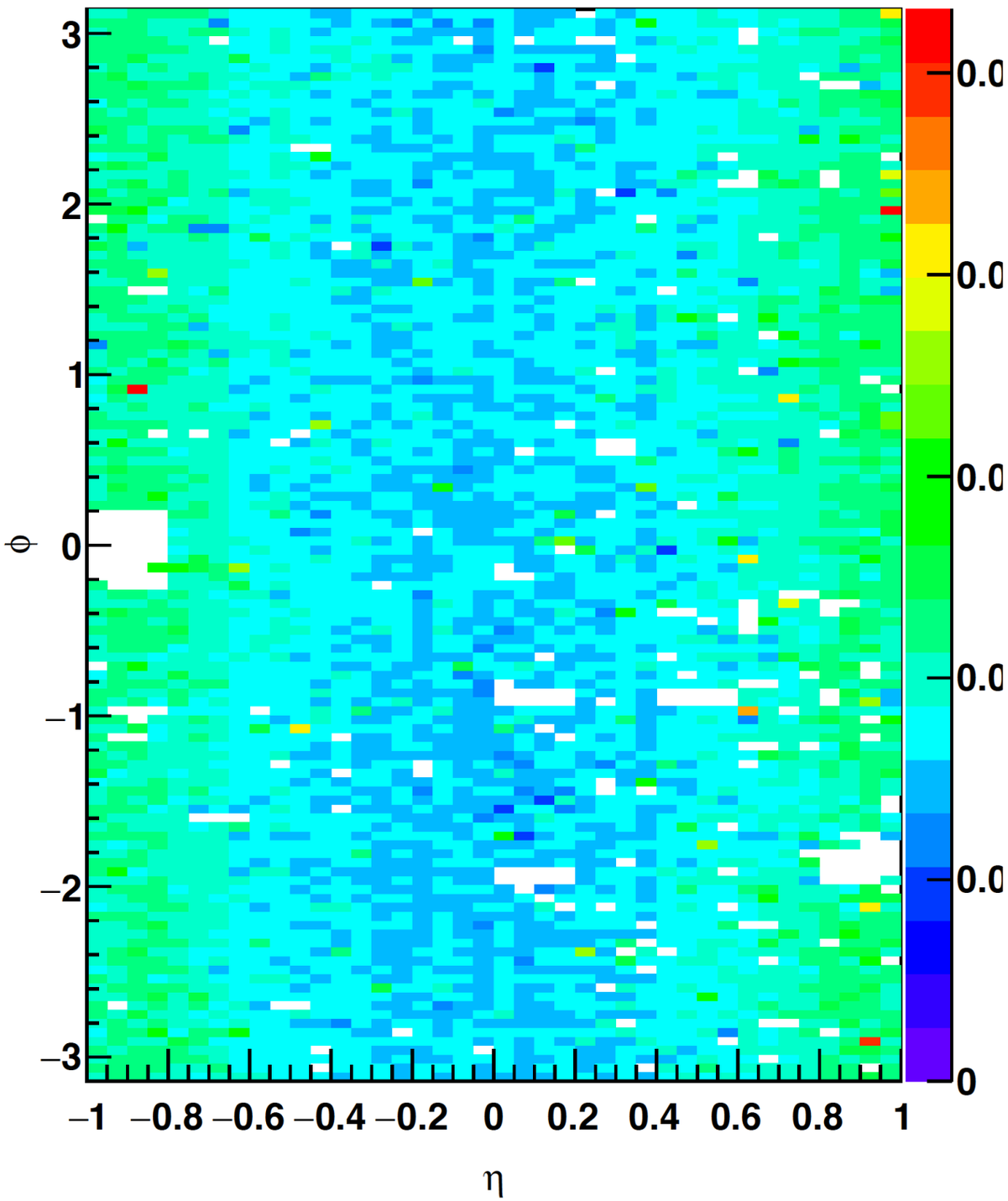




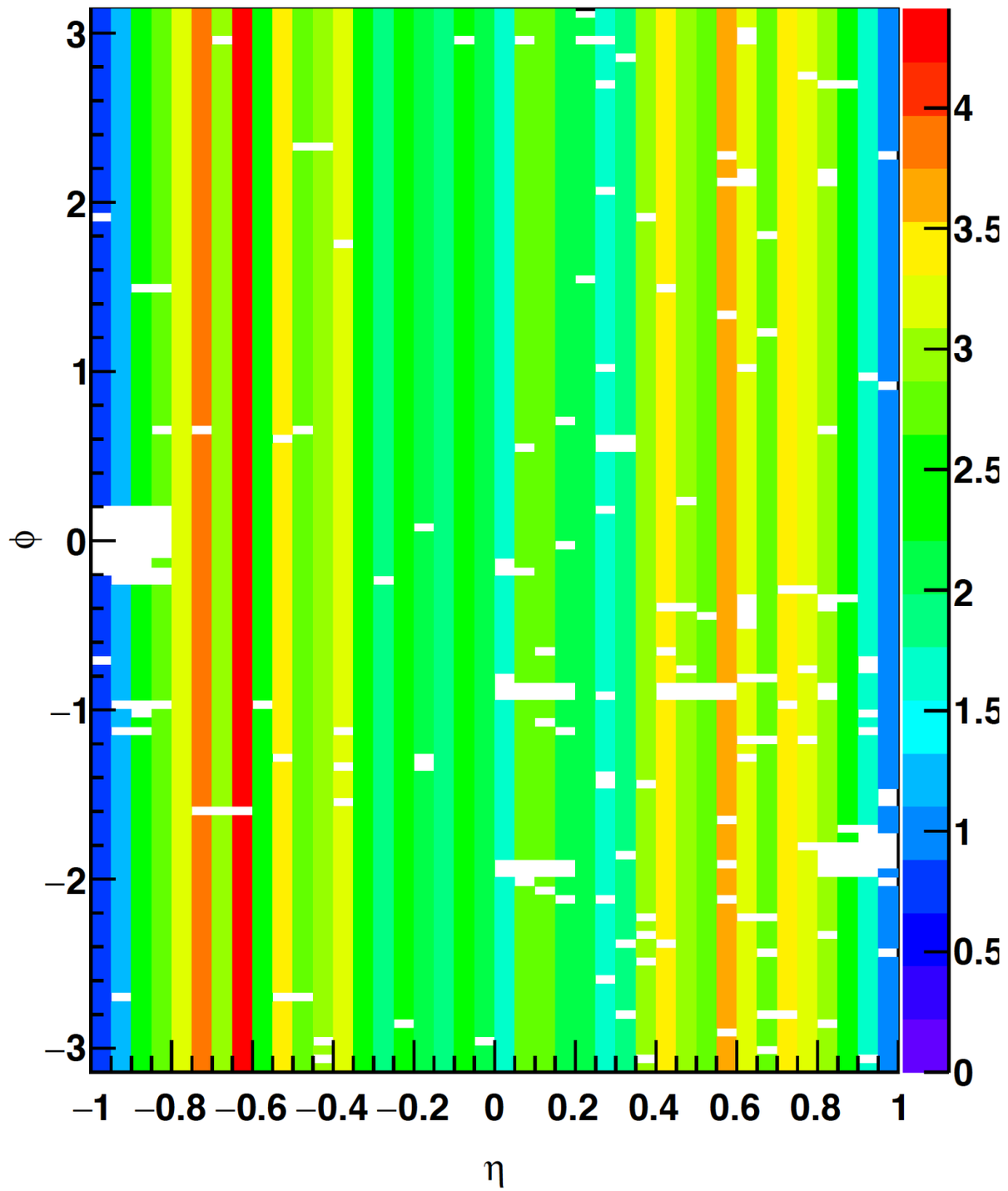


Absolute Gains - P1

Absolute Gains

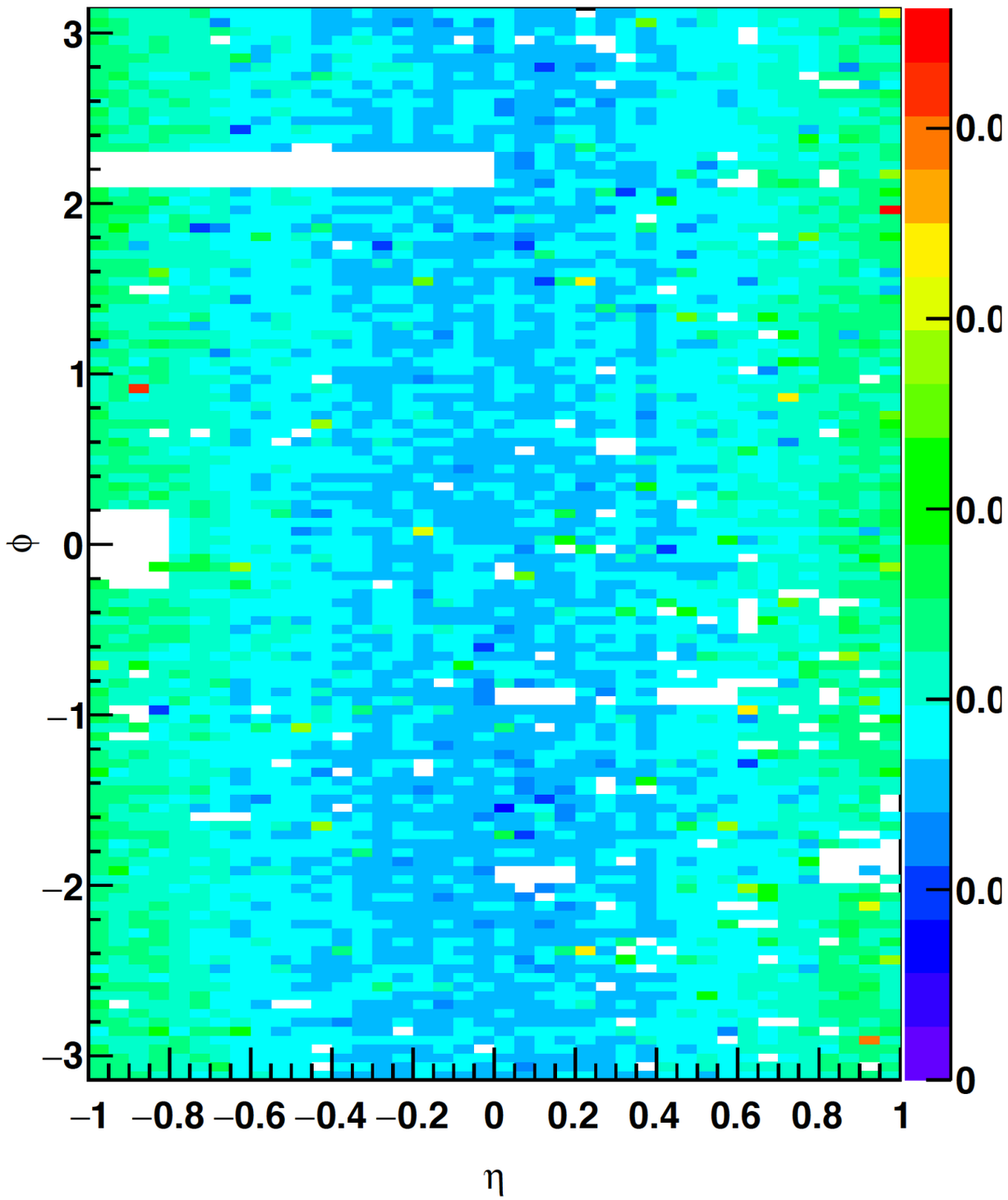


χ^2/dof

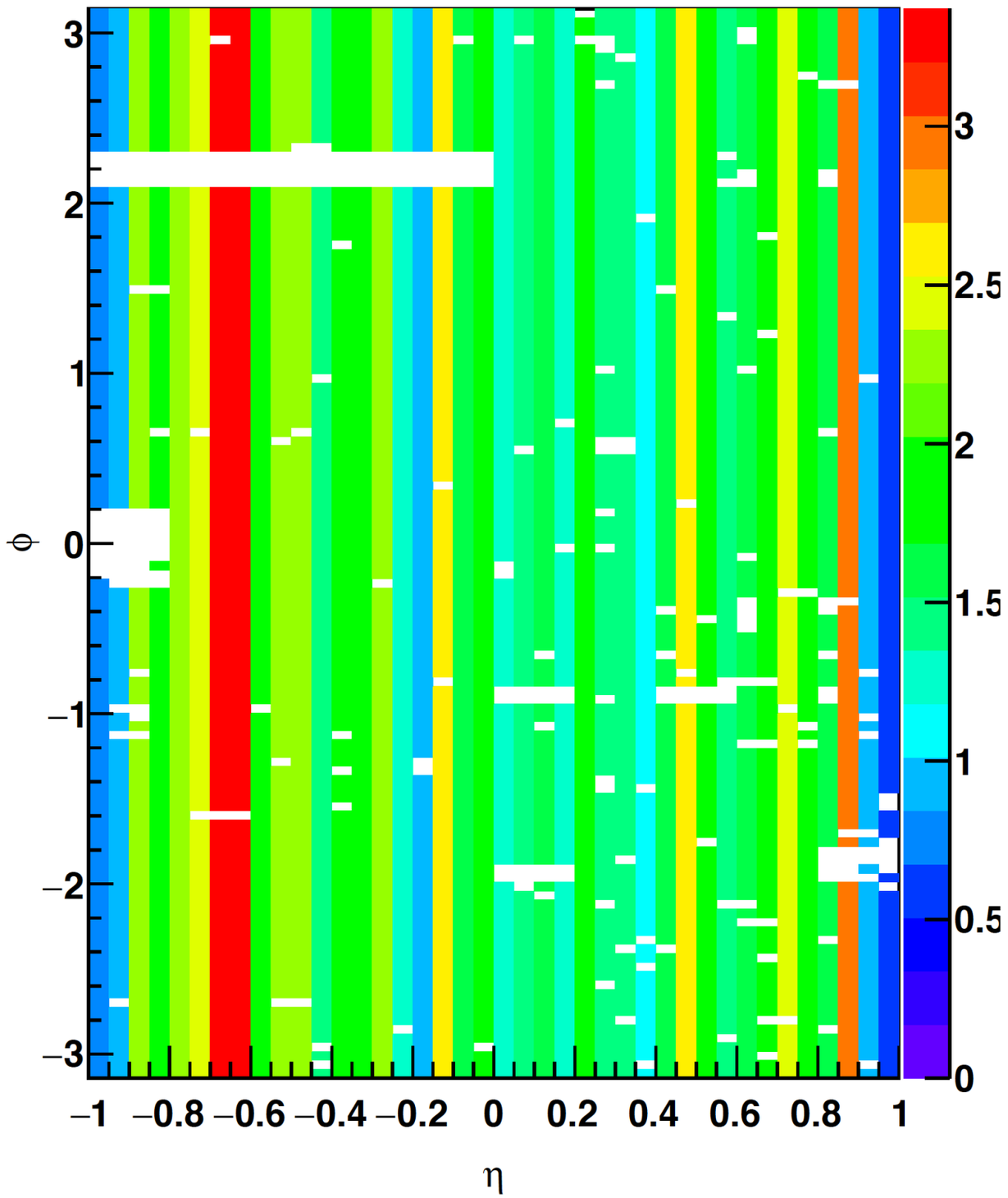


Absolute Gains - P2

Absolute Gains



χ^2/dof



Run 12 200 GeV calibration : Systematic Analysis [not Final]

Type of Error	Inner Ring Value	Outer Ring Value
Global/Primary Tracks	0	0
e^+e^- Difference	0.9%	0.9%
Time Dependence	1.43%	1.43%
ΔR Dependence	0.67%	2.45%
Trigger bias	0.11%	0.11%
Crate effect	1.7%	1.7%
Rate Dependence	0	0
η Dependence	0	0
TOTALS (quadrature)	2.5%	3.43%

Run 13 gains applied to STICA- Zmass