DVCS Calorimeter Analysis :
E12-06-144 (Fall 2014/Spring2015)

DVCS Meeting
18 January 2016

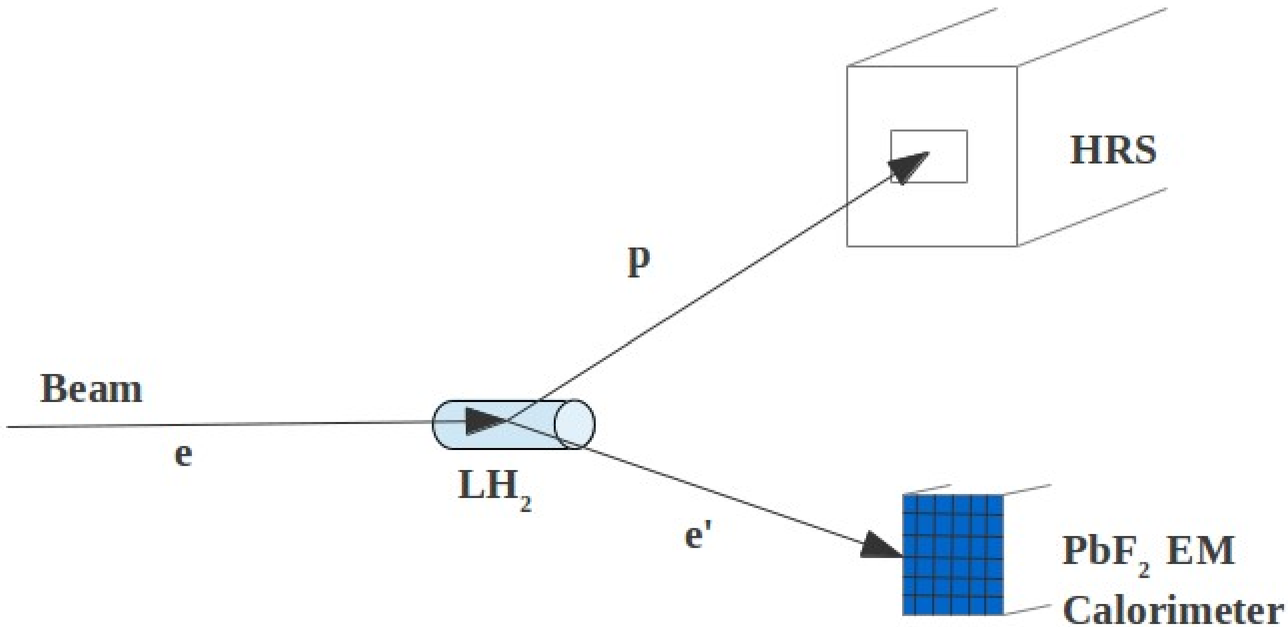
Mongi Dlamini

Outline:

- Elastic Calibration(s)
- Extraction of reference pulses
- Coincidence time optimization
- Resolution studies with high current and pileup

Calorimeter elastic calibration

Experiment setup



Calorimeter elastic calibration

Calibration Procedure

→ The goal is to extract energy conversion coefficients and hence adjust the HV for all blocks accordingly

→ We define a χ^2 and minimize it to get 208 linear equations

$$\chi^2 = \sum_{j=0}^{Nevents} \left(E_j - \sum_{i=0}^{Nblocks} (C_i A_i^j) \right)^2$$

* E_j : electron energy for event j, from HRS,
* A_i^j : signal amplitude for block i,
* C_i : calibration coefficient for block i.

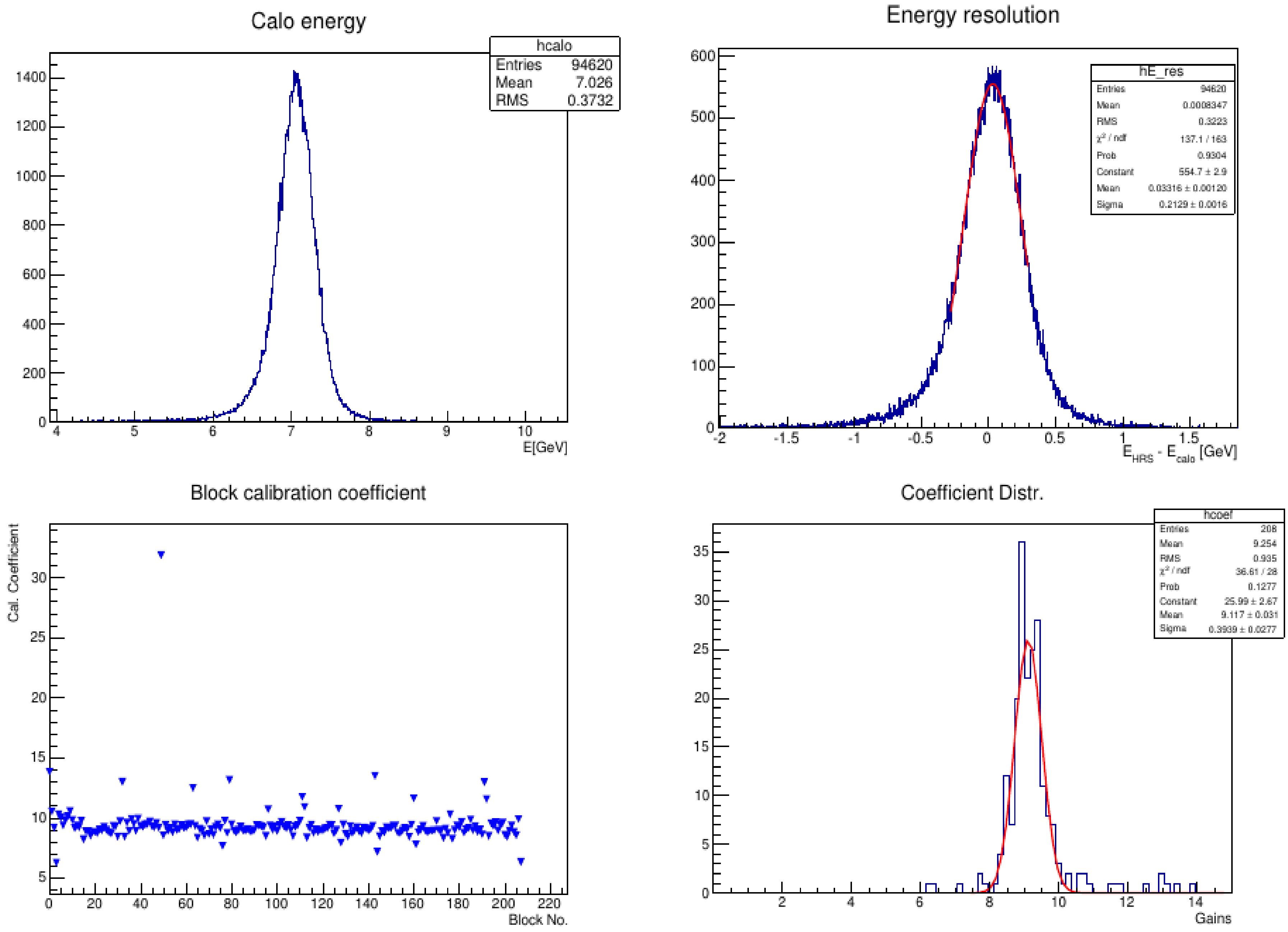
minimization

$$\sum_{i}^{Nblocks} \left(\sum_{j=1}^{Nevents} A_j^k A_j^i \right) C_i = \sum_{j=1}^{Nevents} E_j A_j^k$$

→ We invert 208 by 208 matrix to obtain coefficients

Calorimeter elastic calibration

Calibration results (Spring 2015)



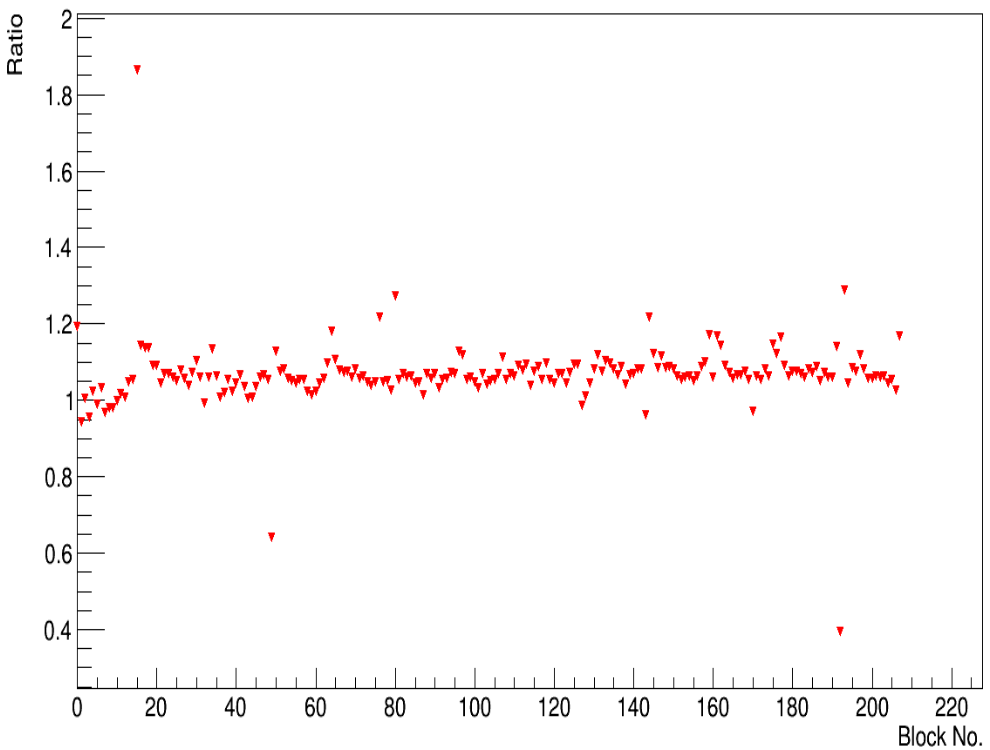
Calorimeter elastic calibration

Comparing calibration coefficients

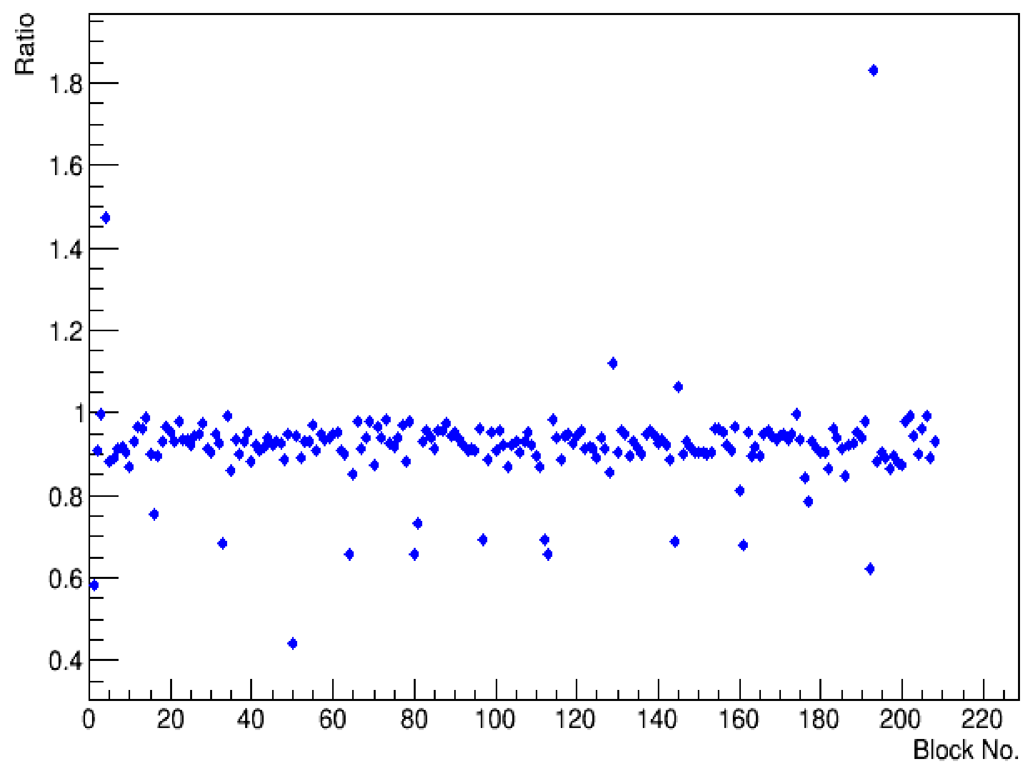
→ comparing coefficients to check consistency

$$\frac{C_2}{C_1} = \left(\frac{V_1}{V_2}\right)^{\beta} \longrightarrow 1 = \frac{C_1}{C_2}\left(\frac{V_1}{V_2}\right)^{\beta}$$

Comparison of calibration coeffients (WF-Fall1/Fall2)



Comparison of calibration coeffients (WF-Fall2/Spring15)

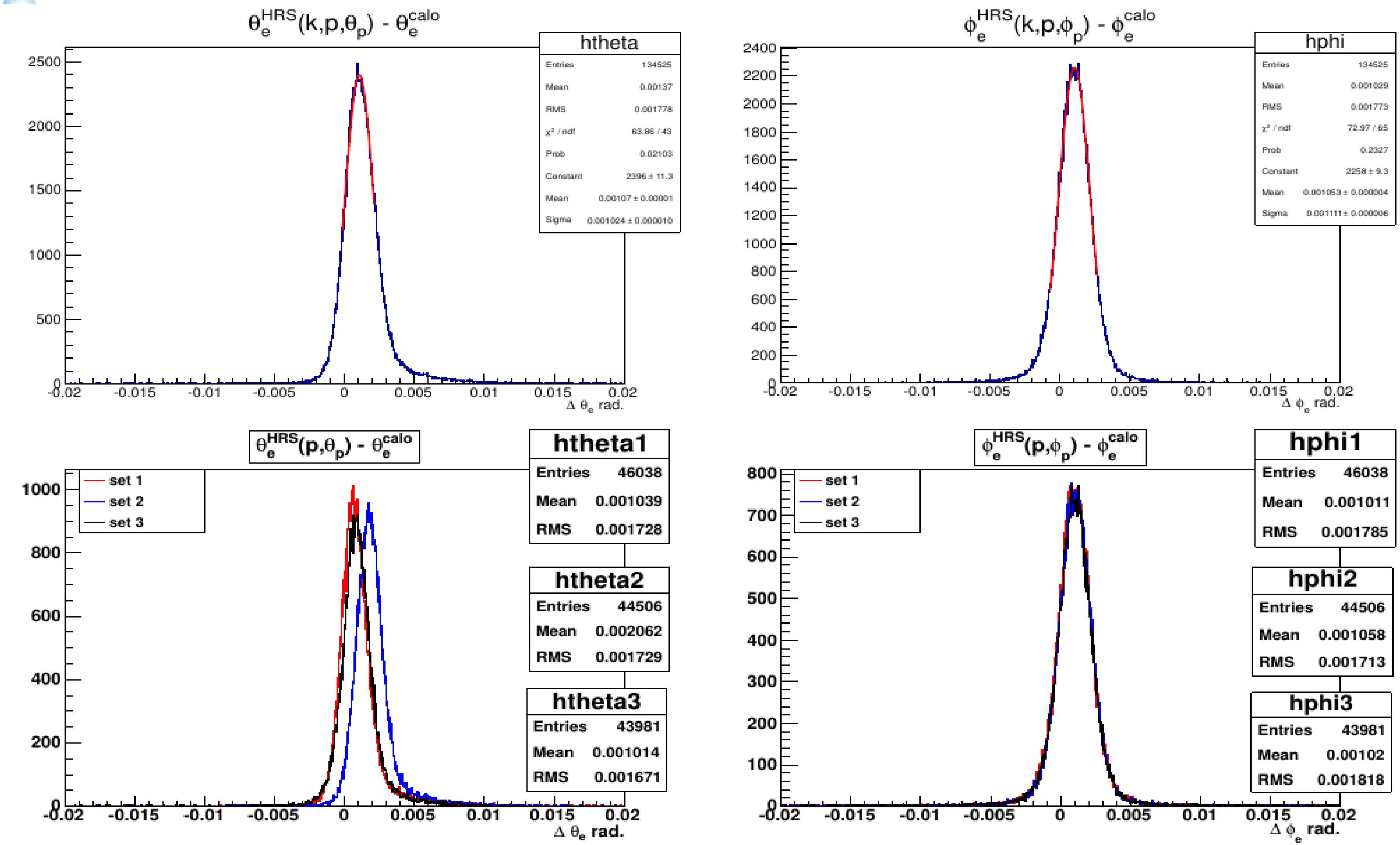


Calorimeter elastic calibration

Calibration results (Spring 2015)

$$\theta^{e}_{calo} = atan\left(\frac{p'_{ex}}{p'_{ez}}\right) \qquad \theta^{e}_{HRS} = atan\left(\frac{-p'_{Px}}{E_b - p'_{Pz}}\right)$$

$$\phi^{e}_{calo} = atan\left(\frac{p'_{ey}}{\sqrt{(p'_{ex})^2 + (p'_{ez})^2}}\right) \qquad \phi^{e}_{HRS} = atan\left(\frac{-p'_{Py}}{\sqrt{(p'_{Px})^2 + (E_b - p'_{Pz})^2}}\right)$$



Calorimeter elastic calibration

Calibration Summary

Calibration	Beam energy (GeV)	Energy resolution(%)	Angular res.(θ) [mrad]	Angular res.(Φ) [mrad]	Θ Offset (mrad)	Φ offset (mrad)
Fall 1 07 Dec' 14	7.3	4.1	1.1	1.5	-1.0	0.9
Fall 2 09 Dec' 14	7.3	3.5	1.2	1.4	-1.4	1.0
Spring 15 23 March 15	9.6	3.0	1.0	1.1	1.1	1.1

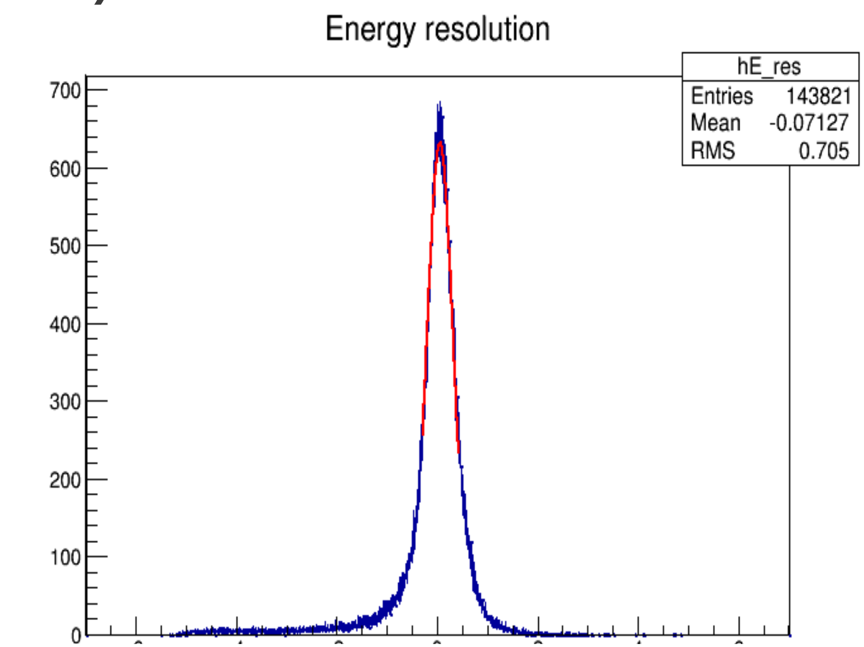
Calorimeter elastic calibration

Calibration using trigger (ADC) signals?

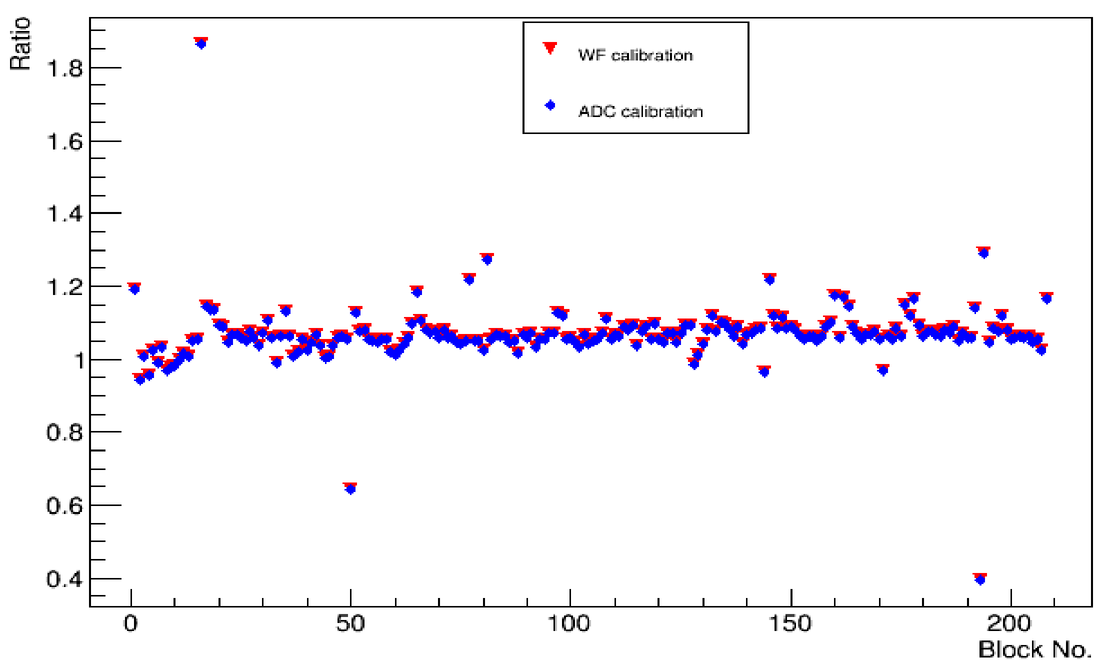
→ This could be faster than the full energy calibration

→ It can be also useful for comparison with the full energy calibration

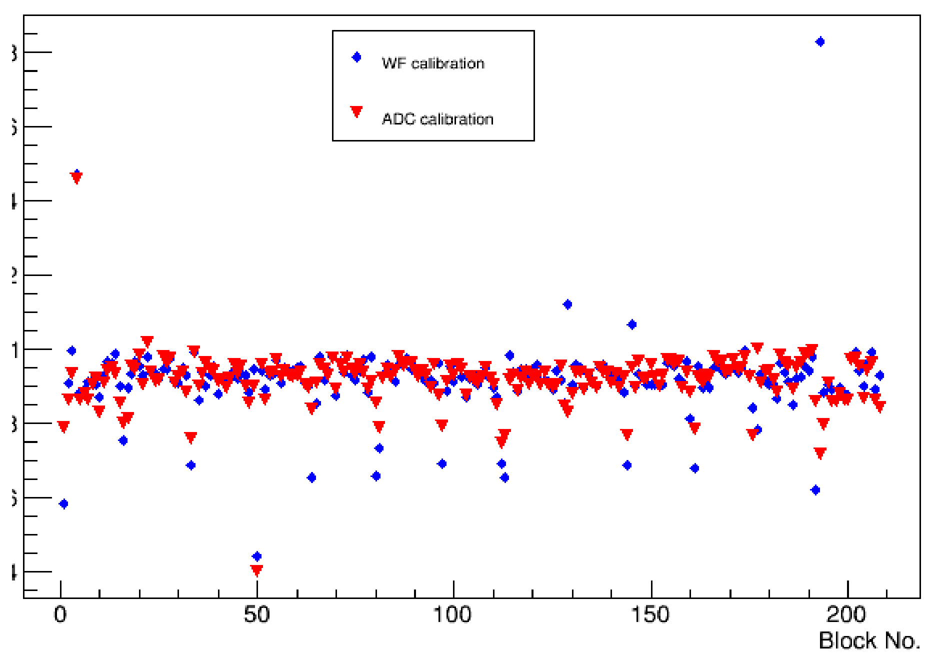
→ Energy resolution of 3.6% for Spring 15 (compare to **WF~3.0%**)



Comparison of calibration coeffients (Fall1/Fall2)

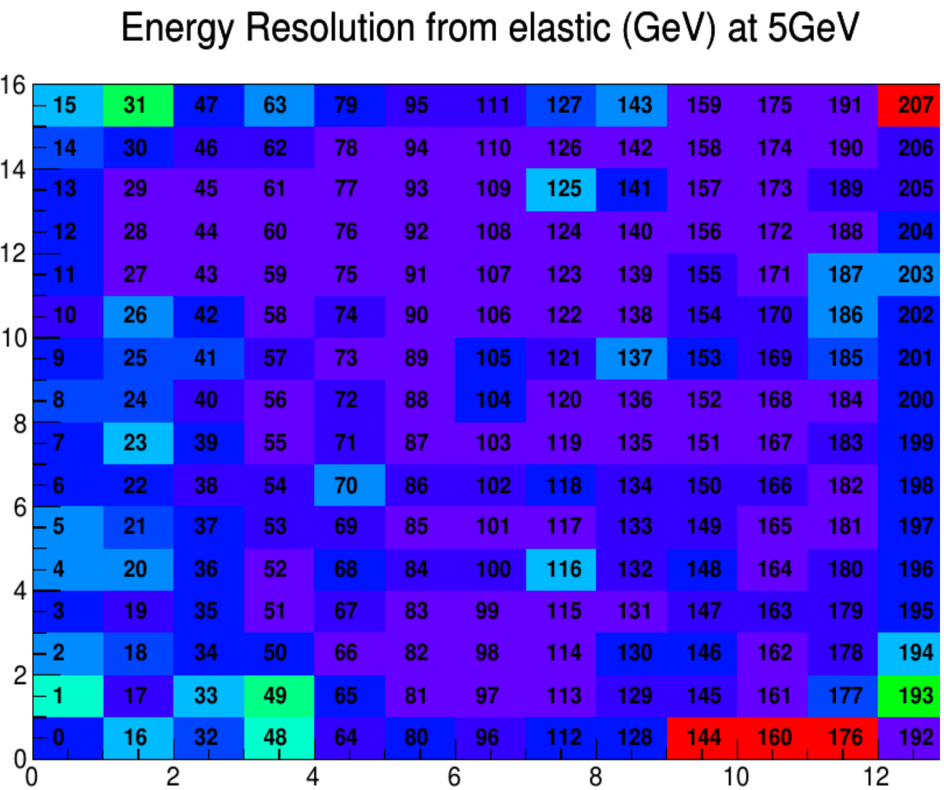


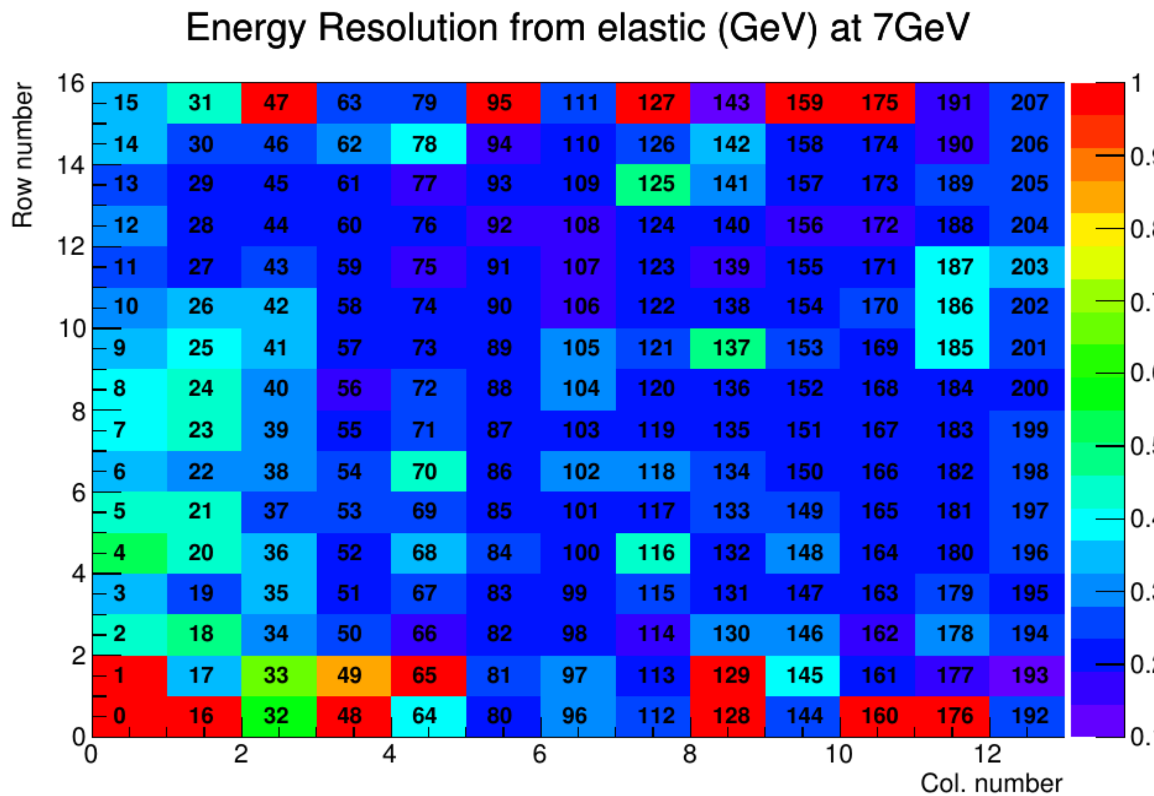
Comparison of calibration coeffients (Fall2/Spring15)

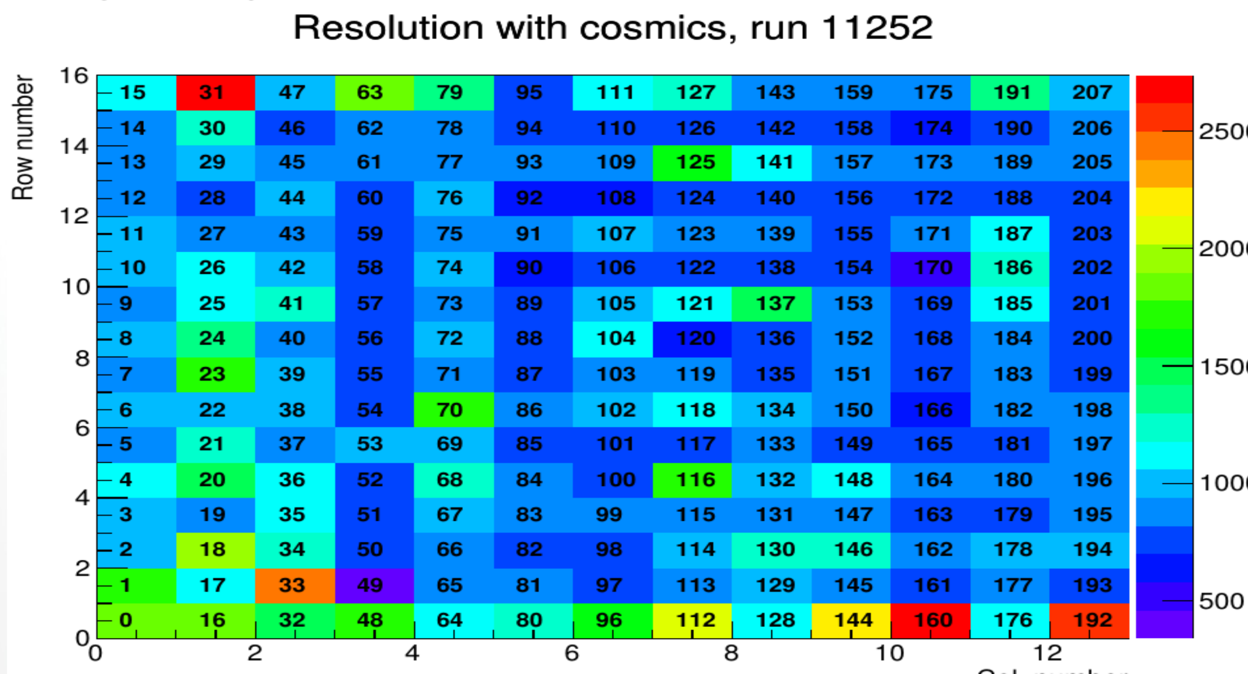


Calorimeter elastic calibration

Energy resolution per block







Resolution dominated by photon statistics

Res.~ √N ~ σ

Several blocks Recommended for fixing

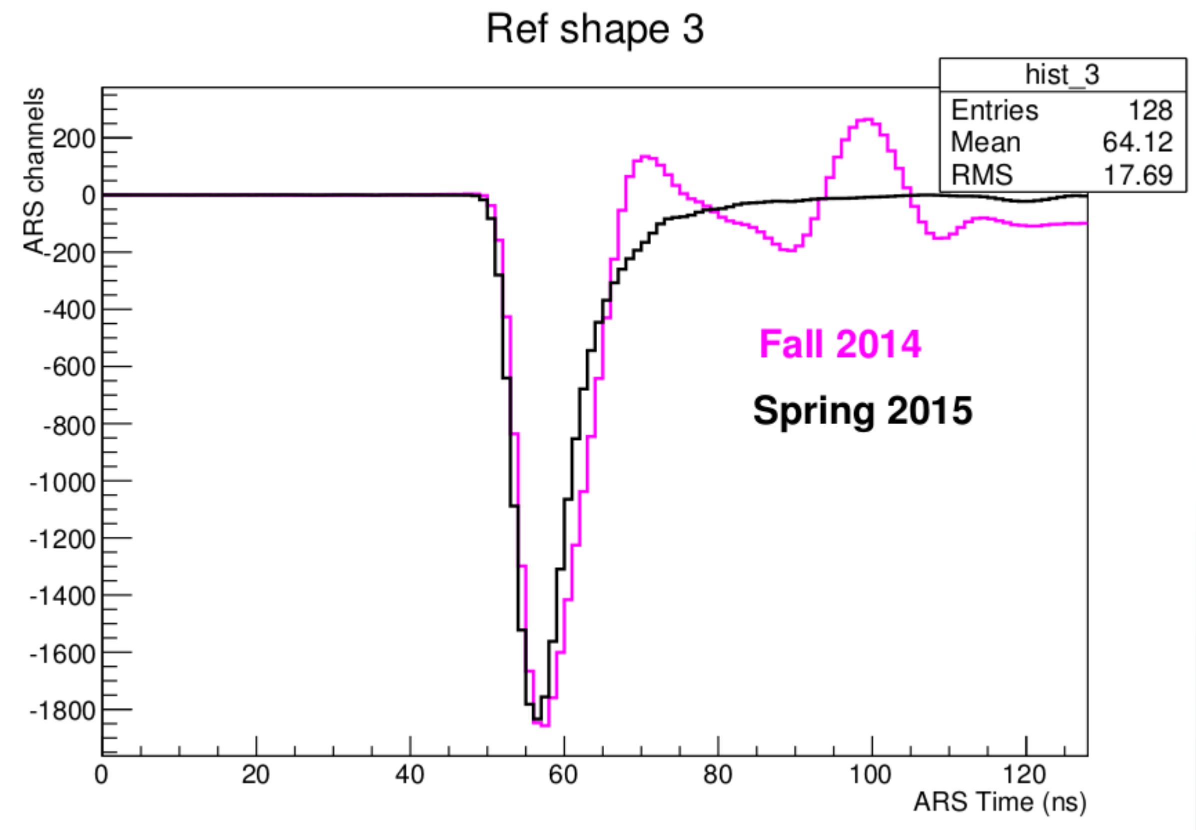
Signal analysis: Reference shapes

→ Reference pulses are extracted from elastic data (clean)

→ A reference pulse is created for each block

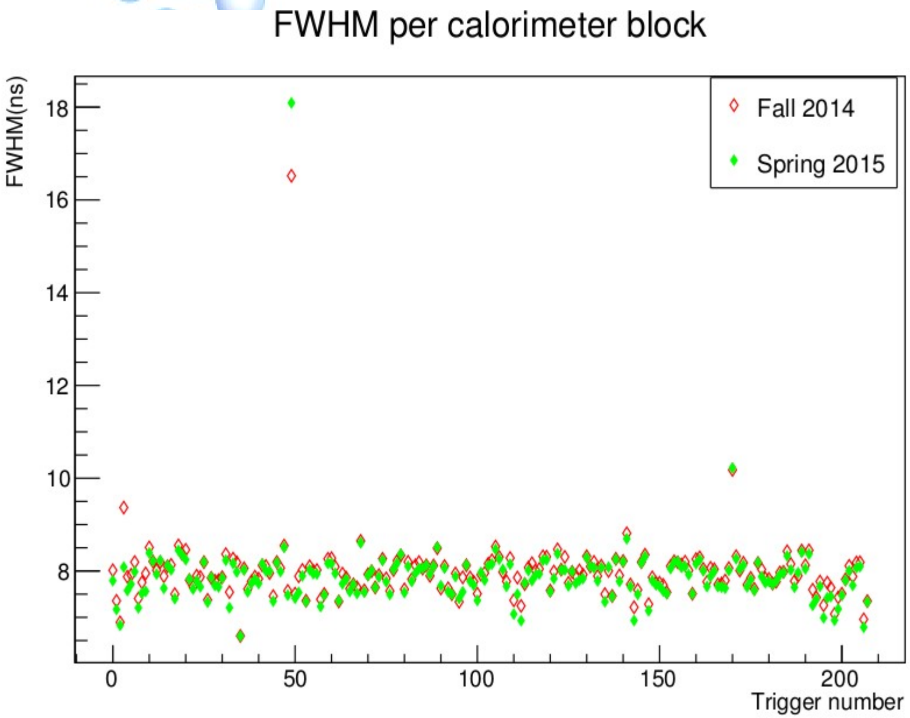
→ A selection of signals with a high response from the PMTs is done for candidate pulses

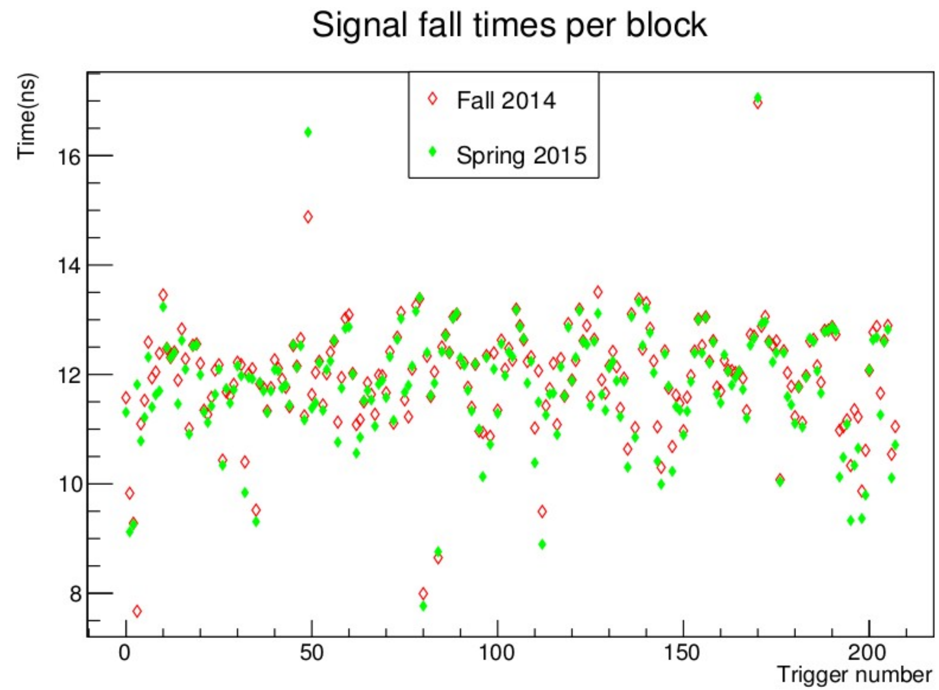
→ An iterative averaging in both time and amplitude is done for all selected pulses in a block

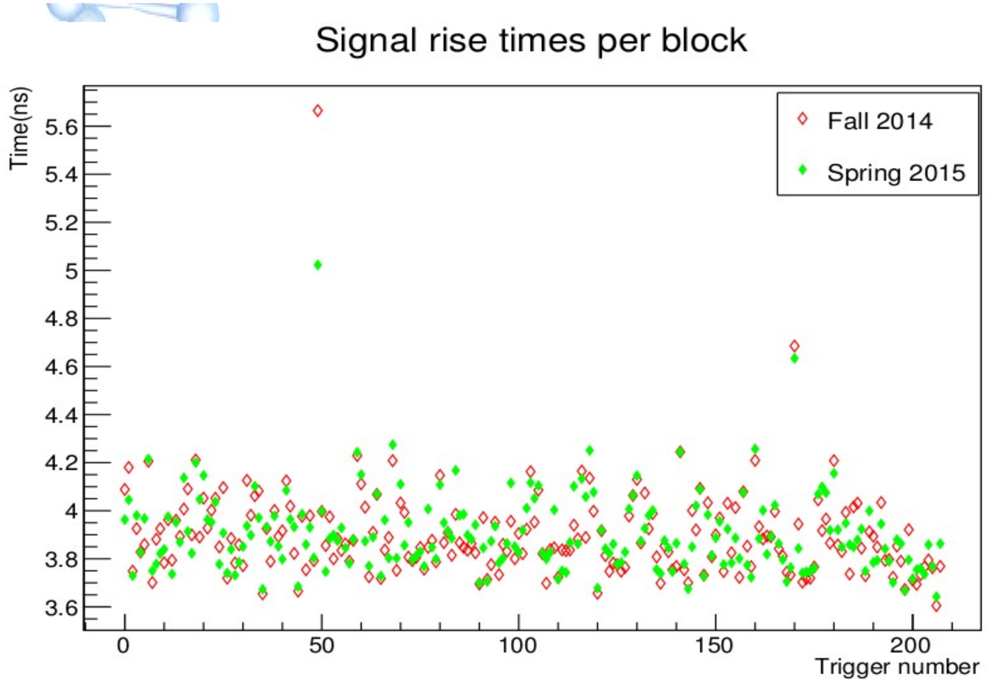


Signal analysis: Reference shapes

→ Can we use just one reference shape?







→ After investigation of FWHM, rise and fall times for each reference shape, we conclude they are different.

Signal analysis: Coincidence time Optimization

→ The goal was to reduce the dispersion of the coincidence time For each calorimeter block to less than 1 ns standard deviation

→ A narrow coincidence window will close out many accidentals and improve the energy resolution of the calorimeter

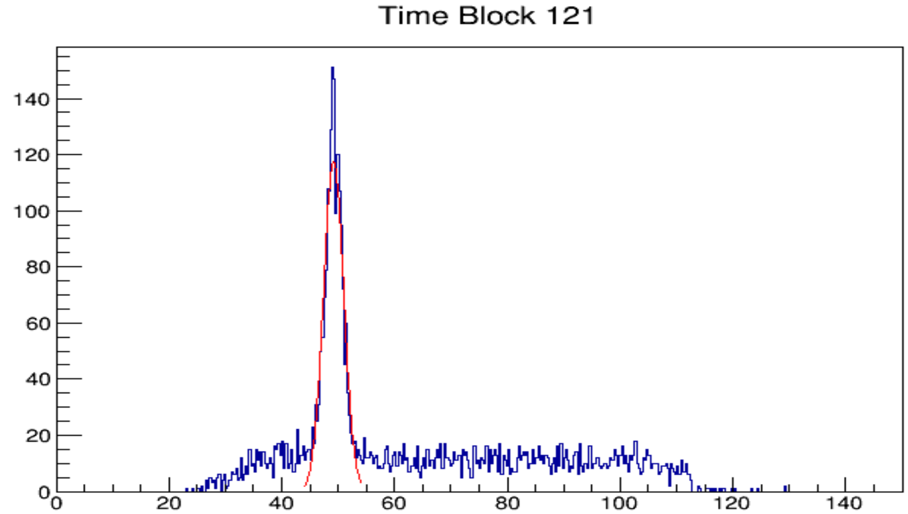
→ Corrections were applied to consider different calorimeter block positions, cable lengths, electron and light propagation distances in HRS. These include:

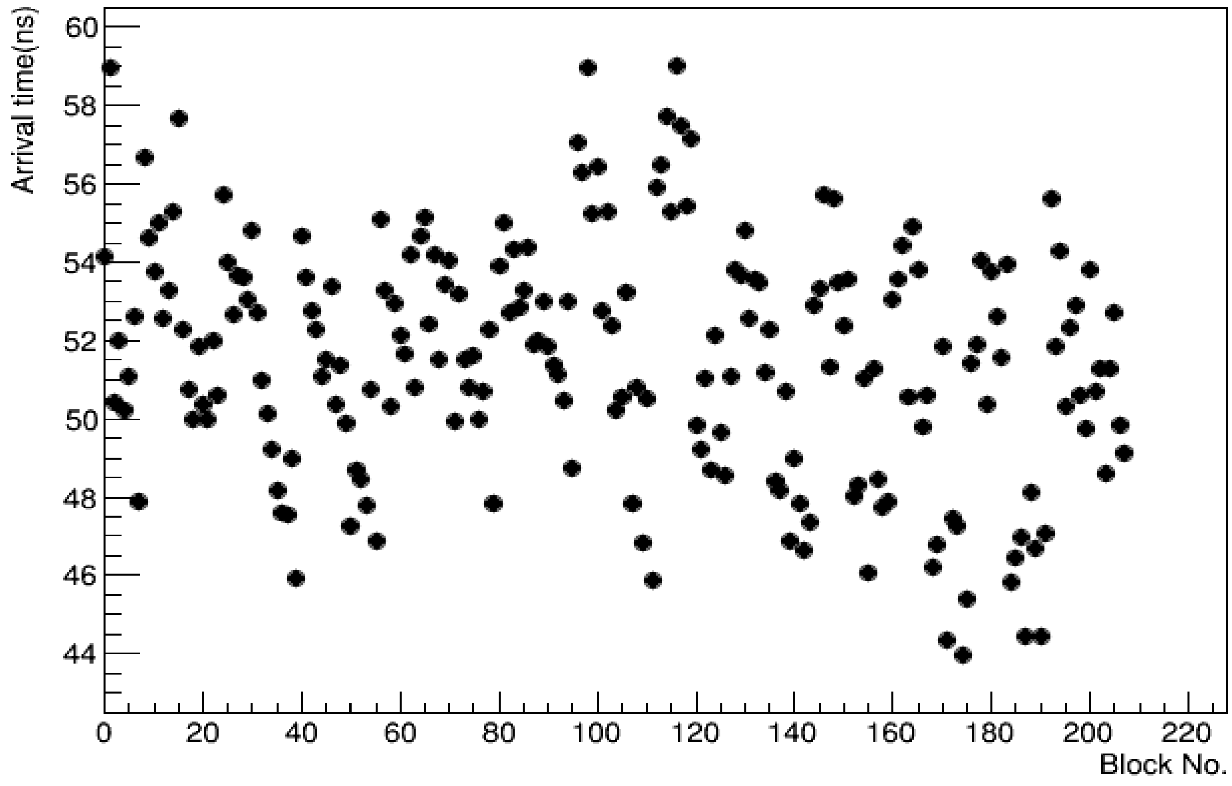
- → Time per calorimeter block
- → ARS stop trigger jitter
- → S2m scintillator paddle centering
- → Light propagation in S2m scintillators
- → Electron path in HRS

Signal analysis: Coincidence time Optimization

Time per calorimeter block

Typical time distribution, block 121





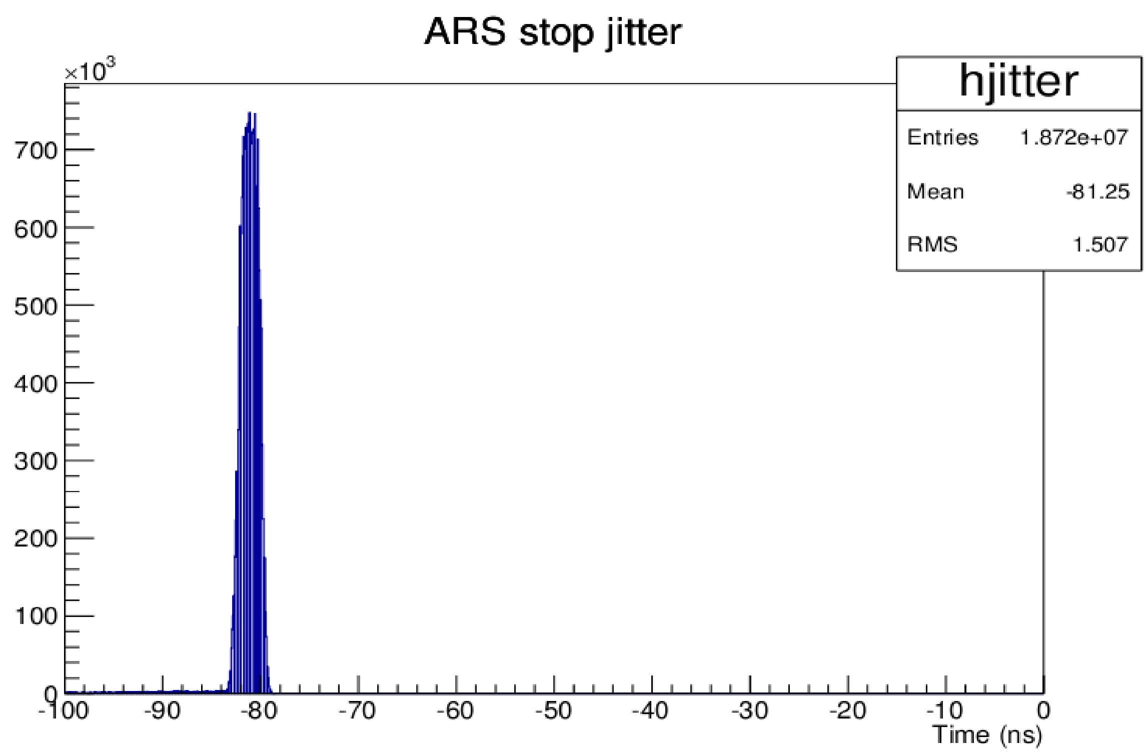
Signal analysis: Coincidence time Optimization

ARS stop trigger jiiter

→ The ARS timing is not uniquely defined by the S2m arrival

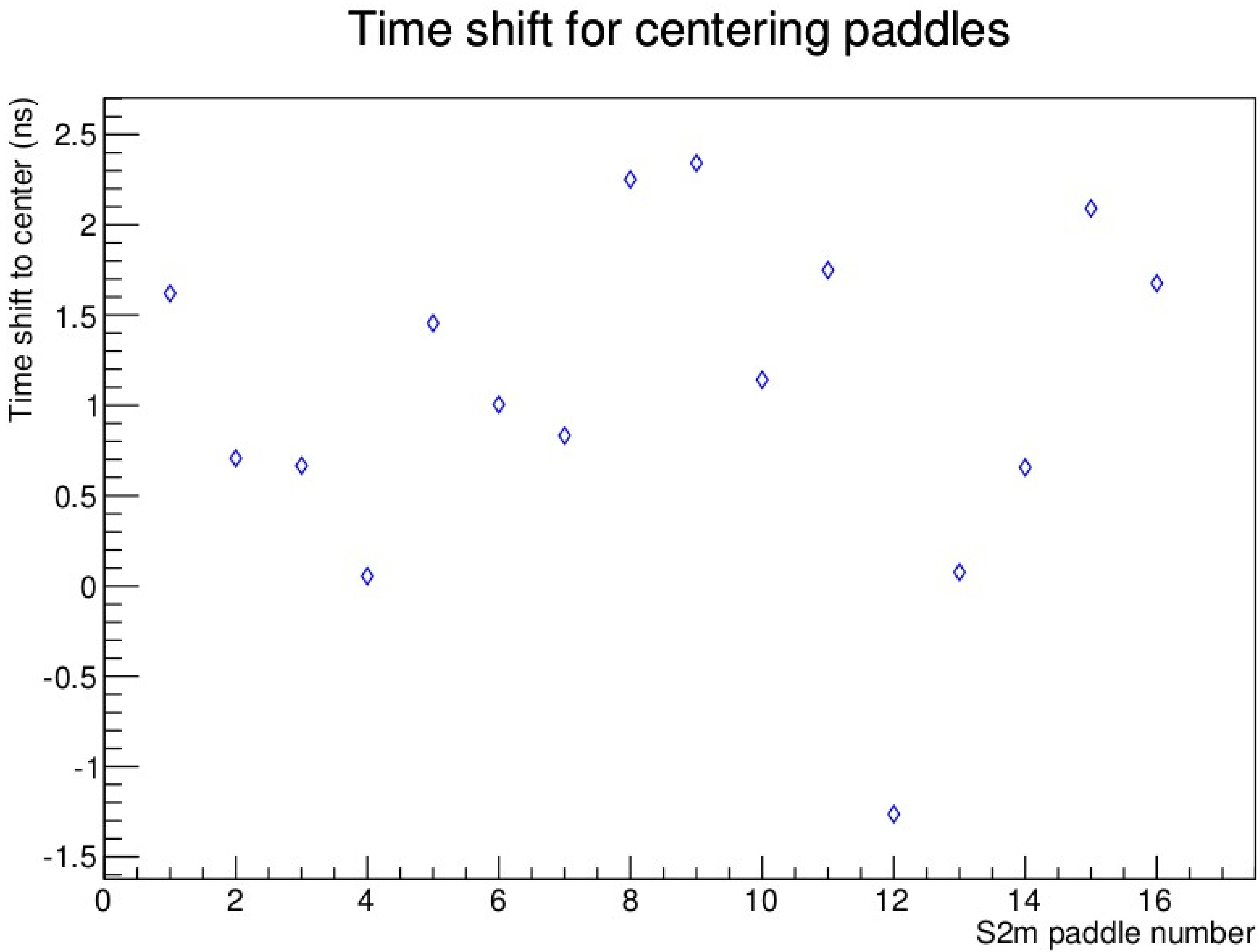
→ correction for the time difference between the S2m and the ARS stop

$$T_{corr} = t_{av} + \text{ tdcval[3] - tdcval[7]) /10 (ns)}$$



Signal analysis: Coincidence time Optimization

S2m scintillator paddles centering

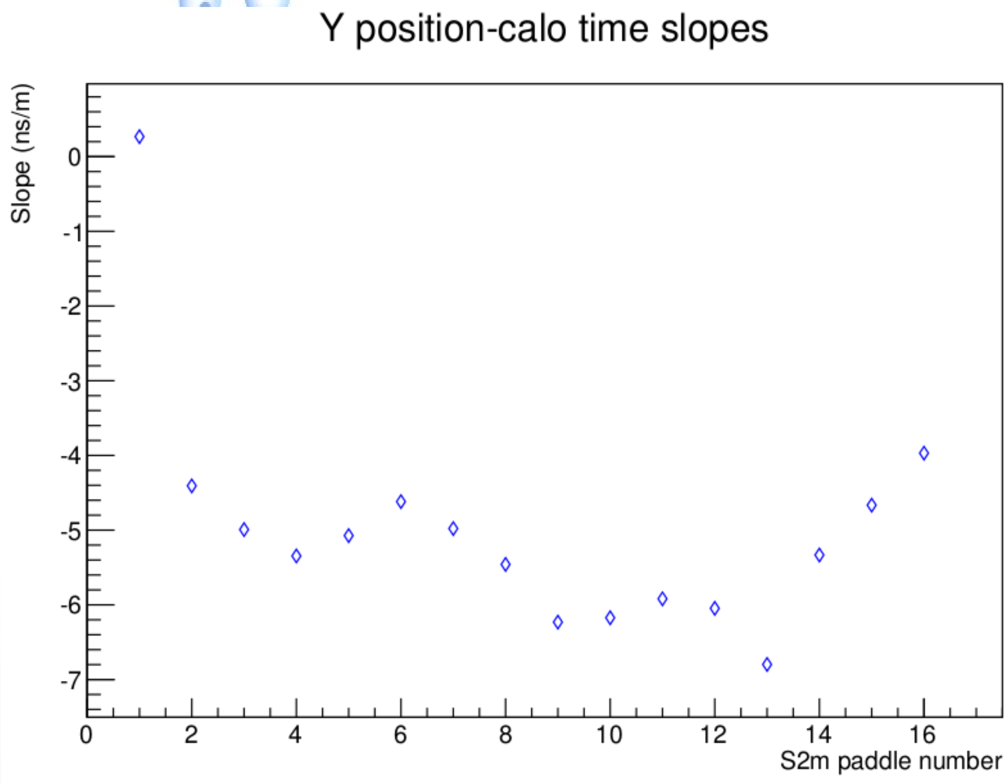


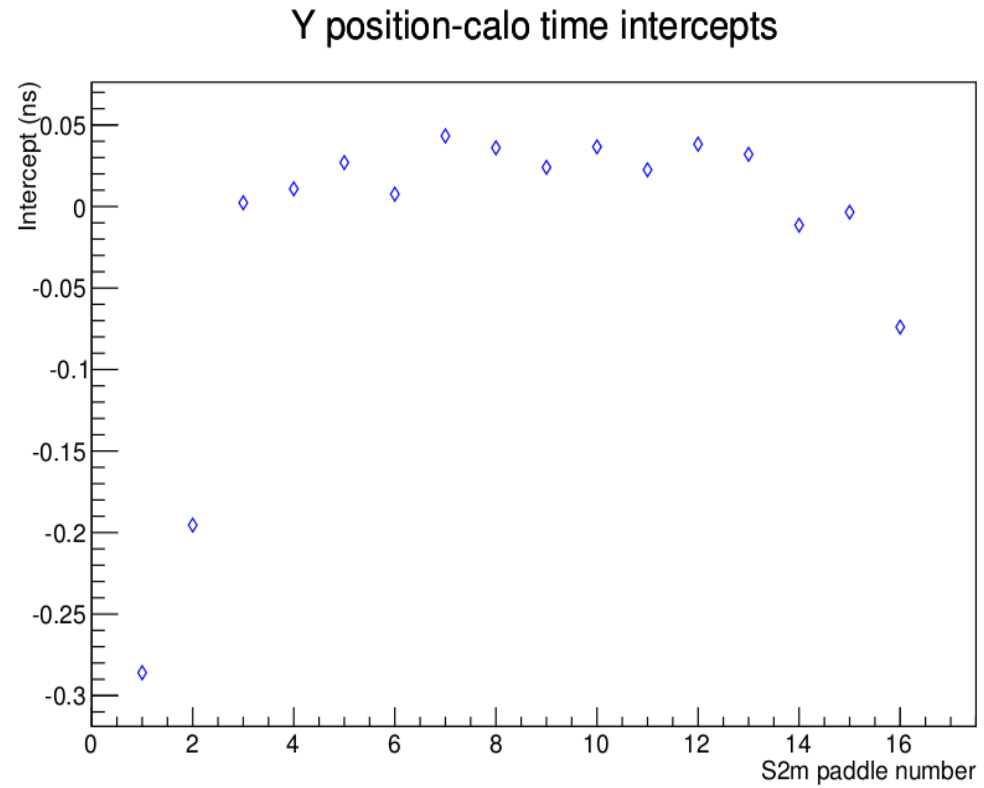
Signal analysis: Coincidence time Optimization

Light propagation in S2m

→ Based on a linear y position vs. time correlation:

$$T_{corr} = m*y + c$$



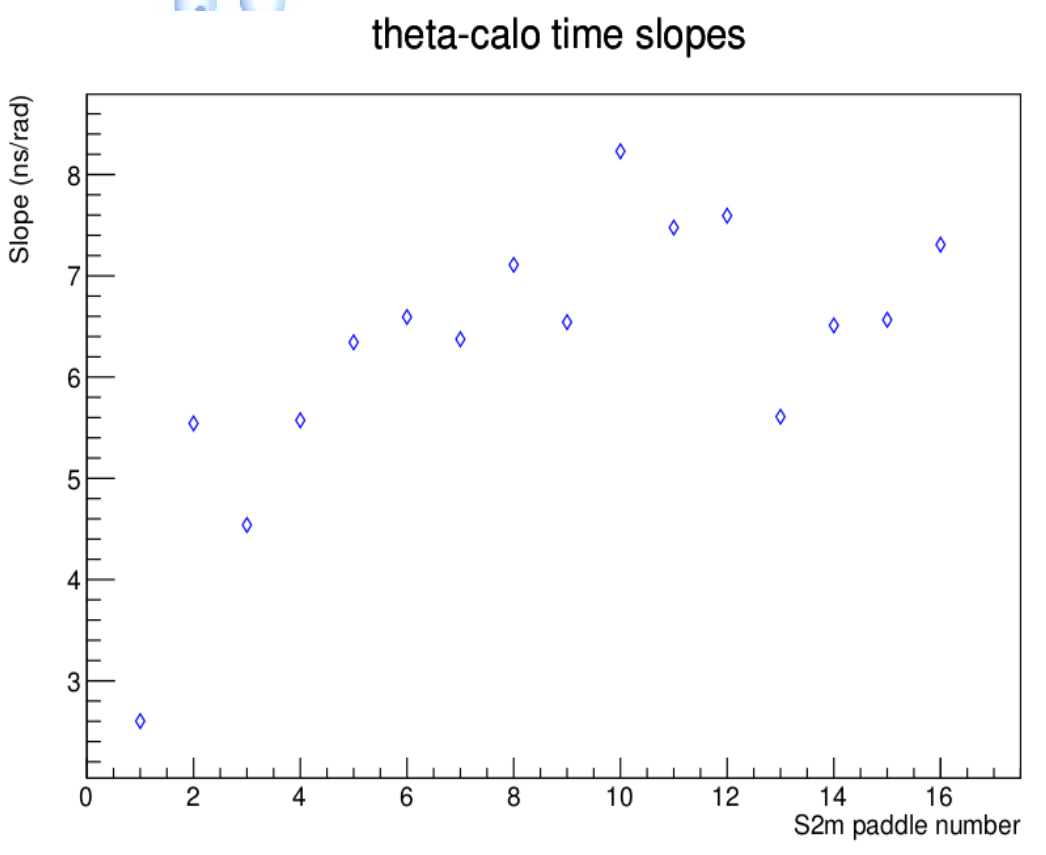


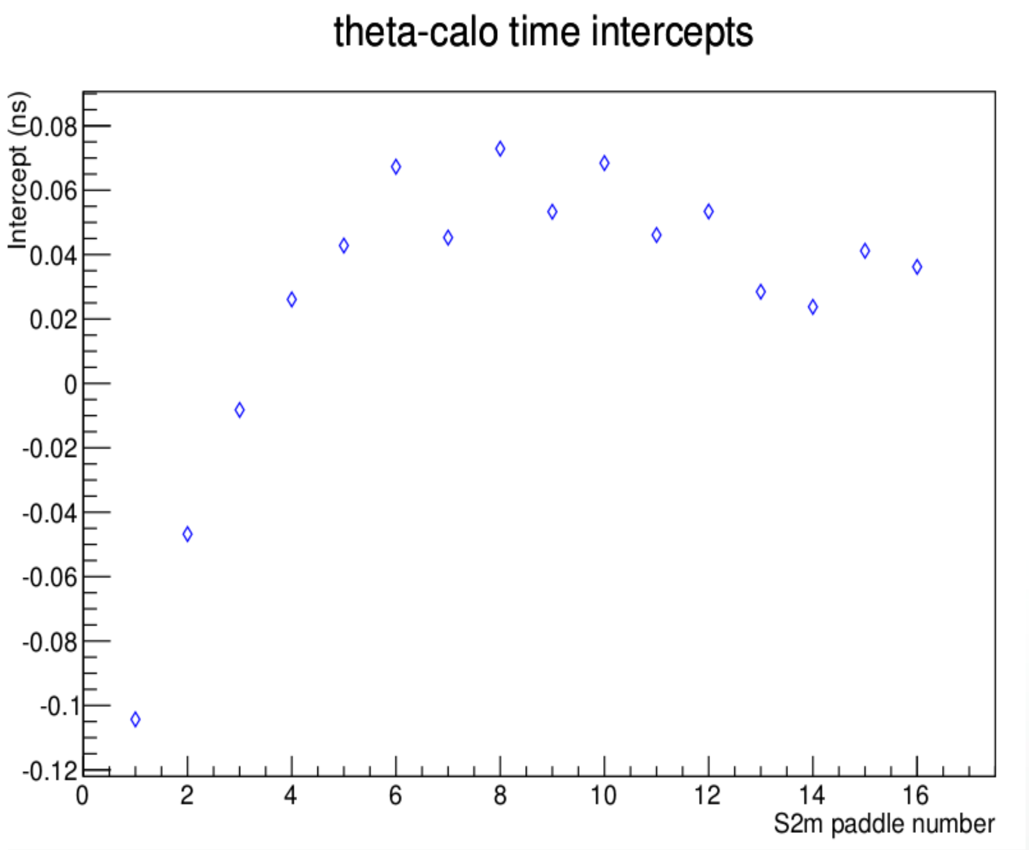
Signal analysis: Coincidence time Optimization

Electron path length in HRS

→ Based on a linear y position vs. time correlation:

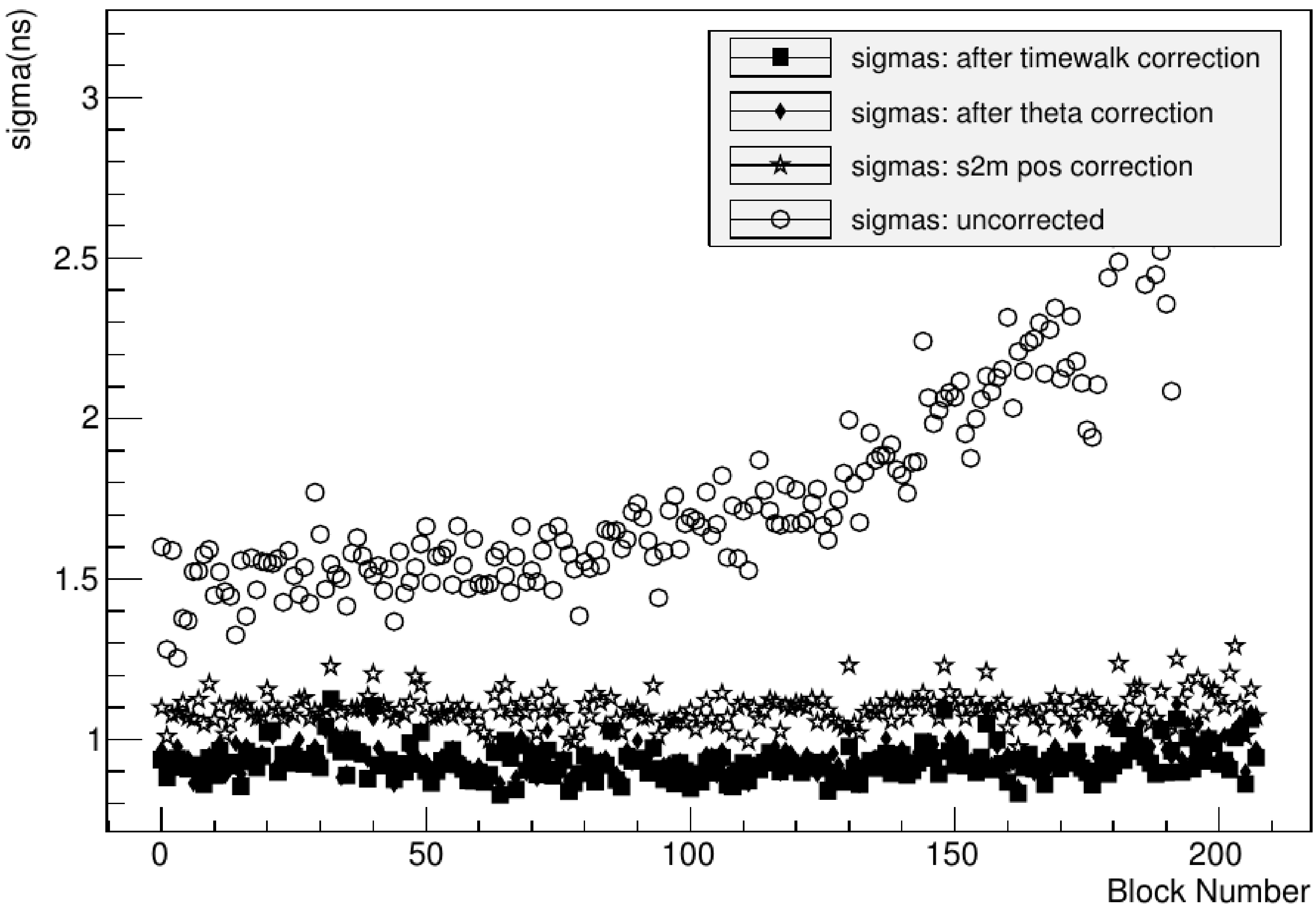
$$T_{corr} = m*\theta + c$$





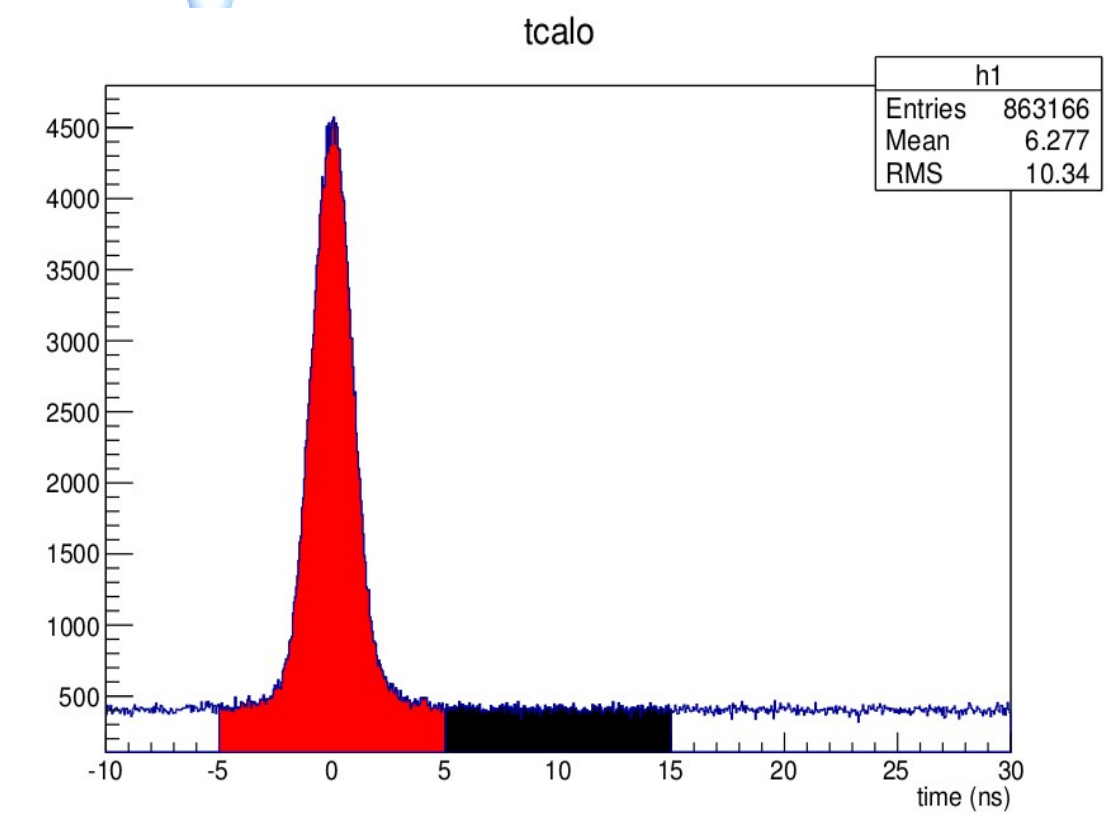
Signal analysis: Coincidence time Optimization

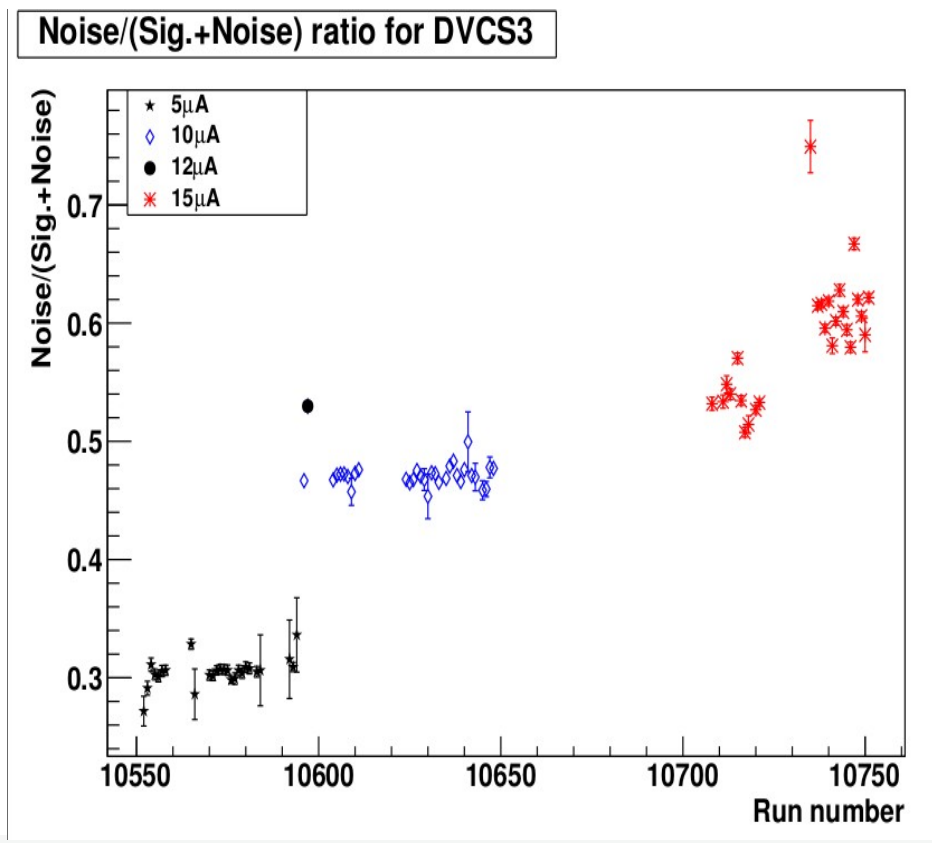
Summary plot for dispersion per block



Signal analysis: Higher current and energy resolution

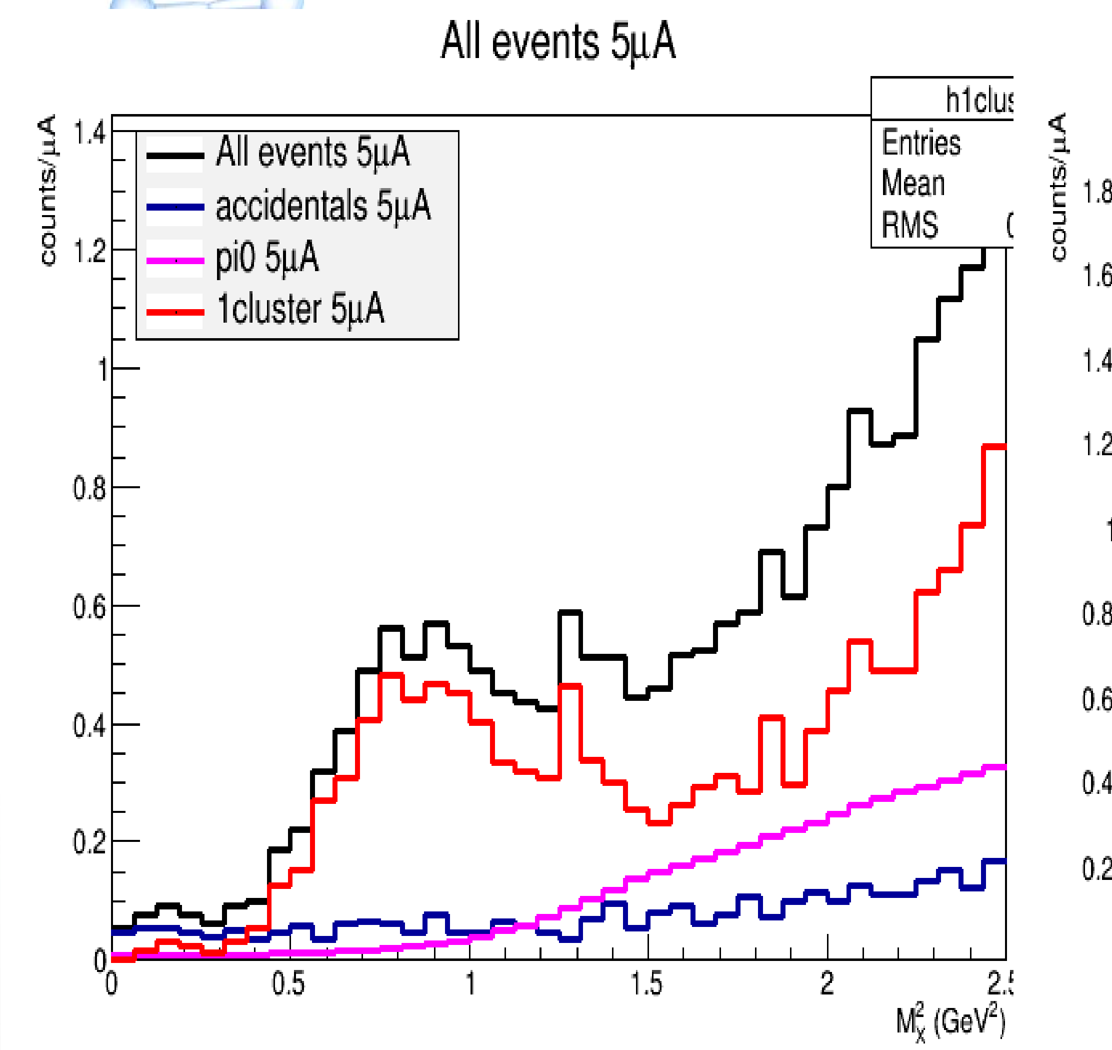
→ Analysis to study the effect of increasing beam current on the Calorimeter resolution.
→ in this analysis, we went beyond the standard 1 cluster and 1 pulse fitting to consider the possibility of pileup and increasing Significance of 2 clusters.
→ A sample of the data was considered for this analysis

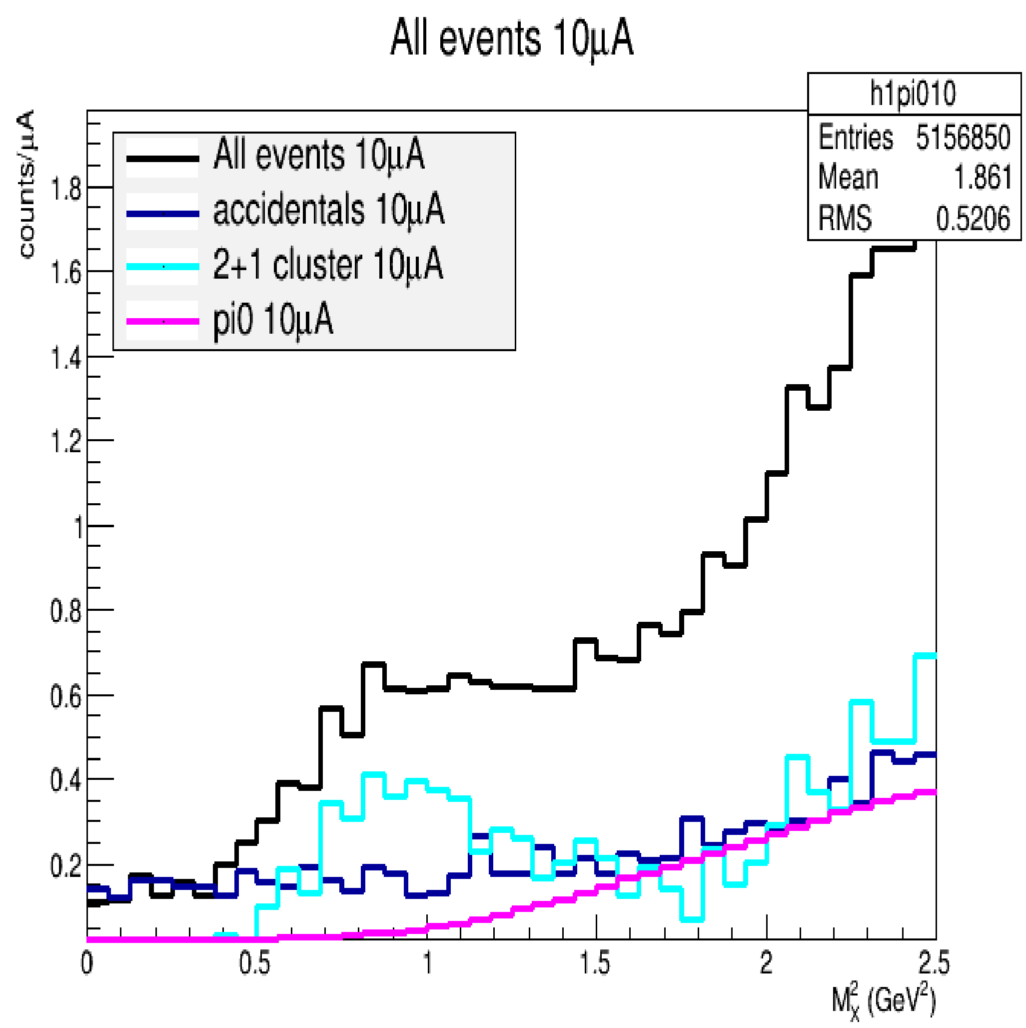




Signal analysis: Higher current and energy resolution

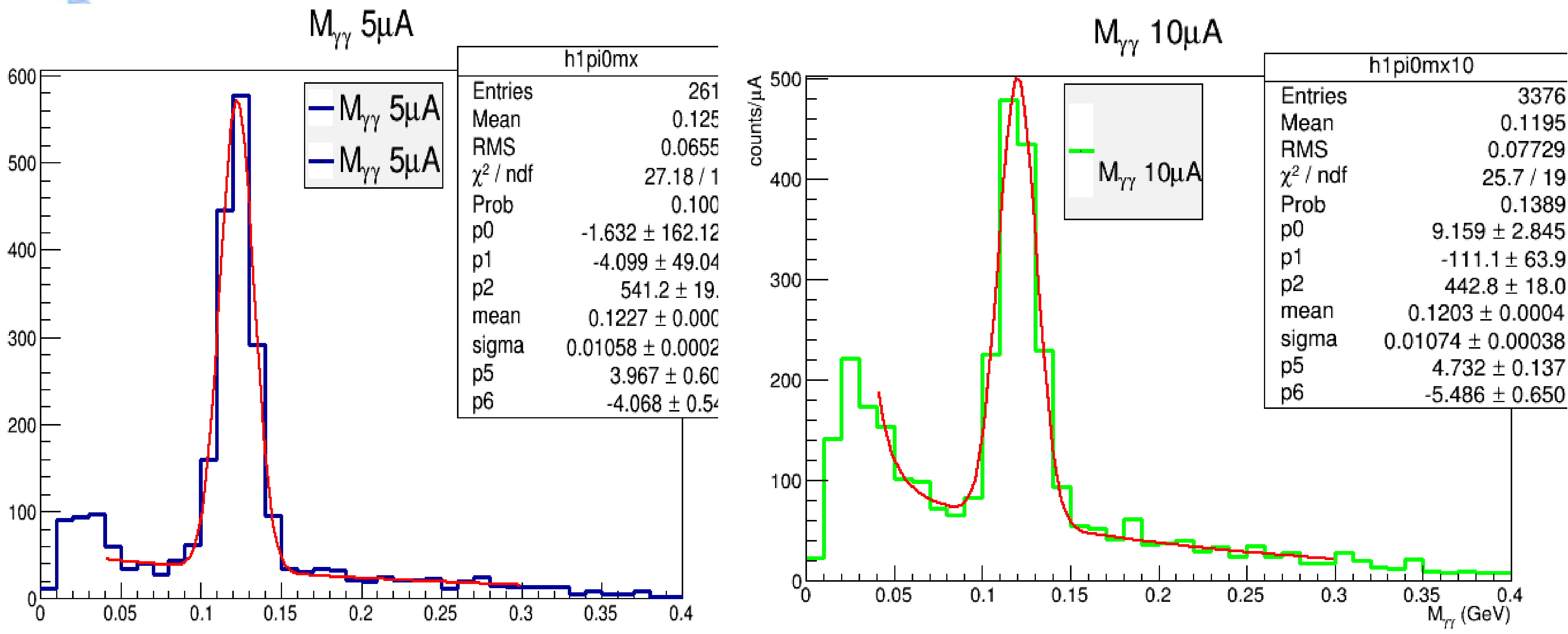
One to Two cluster analysis, Missing mass





Signal analysis: Higher current and energy resolution

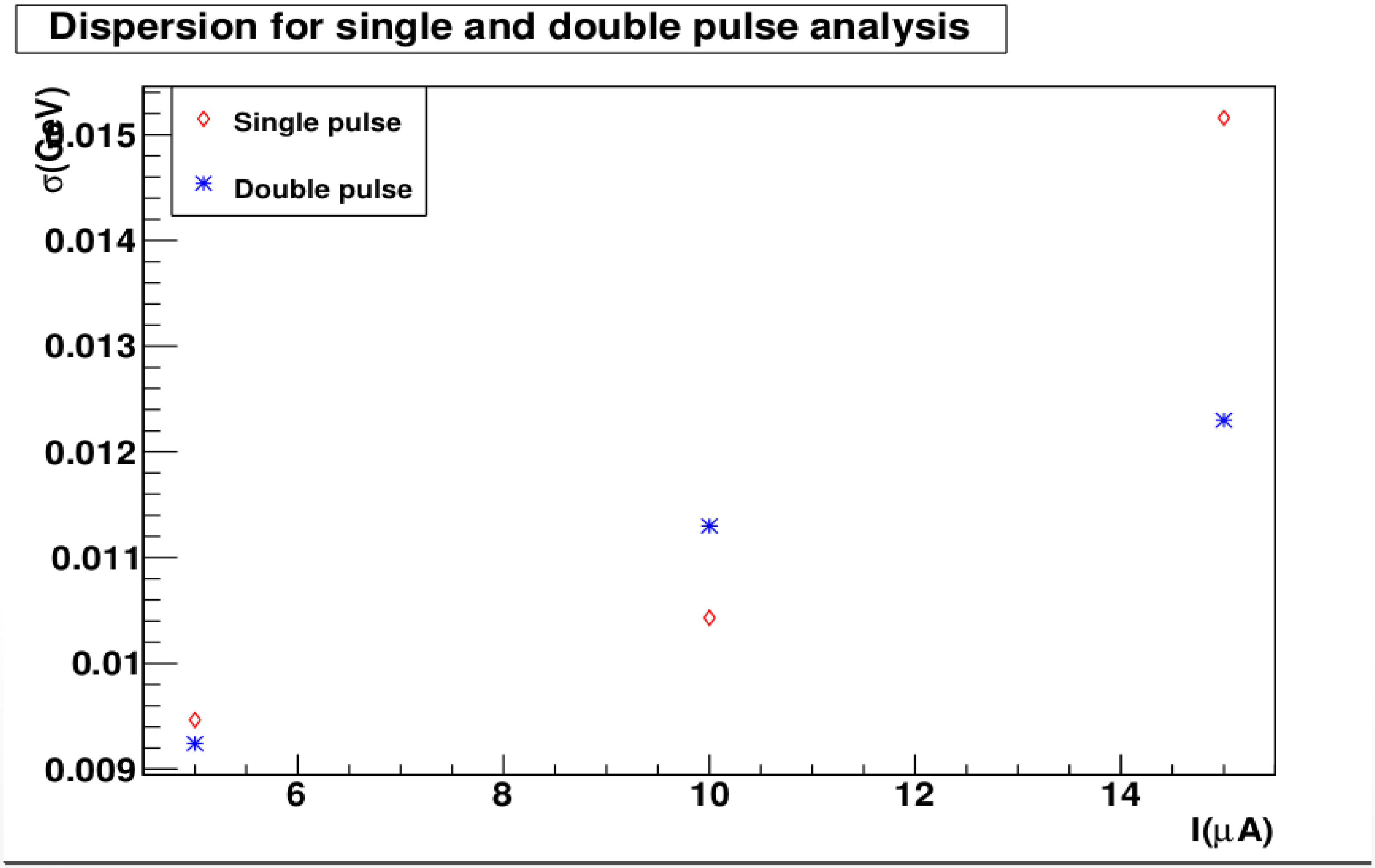
Two cluster analysis, pi0 invariant mass



No big loss of resolution observed between 10 and 5 micro Amperes

Signal analysis: Higher current and energy resolution

→ Summary plot for 1 pulse and 2 pulse analysis showing the resolution Of the pi0 invariant mass distribution across all 3 beam currents



Conclusions:

→ New reference shapes extracted and implemented

→ Time corrections were done for one kinematic

→ Elastic calibrations were analyzed

→ Consideration about ADC calibration??

→ Pileup studies conducted and growing pileup observed
At higher running current