Time Resolution of LASPD from Cosmic Test

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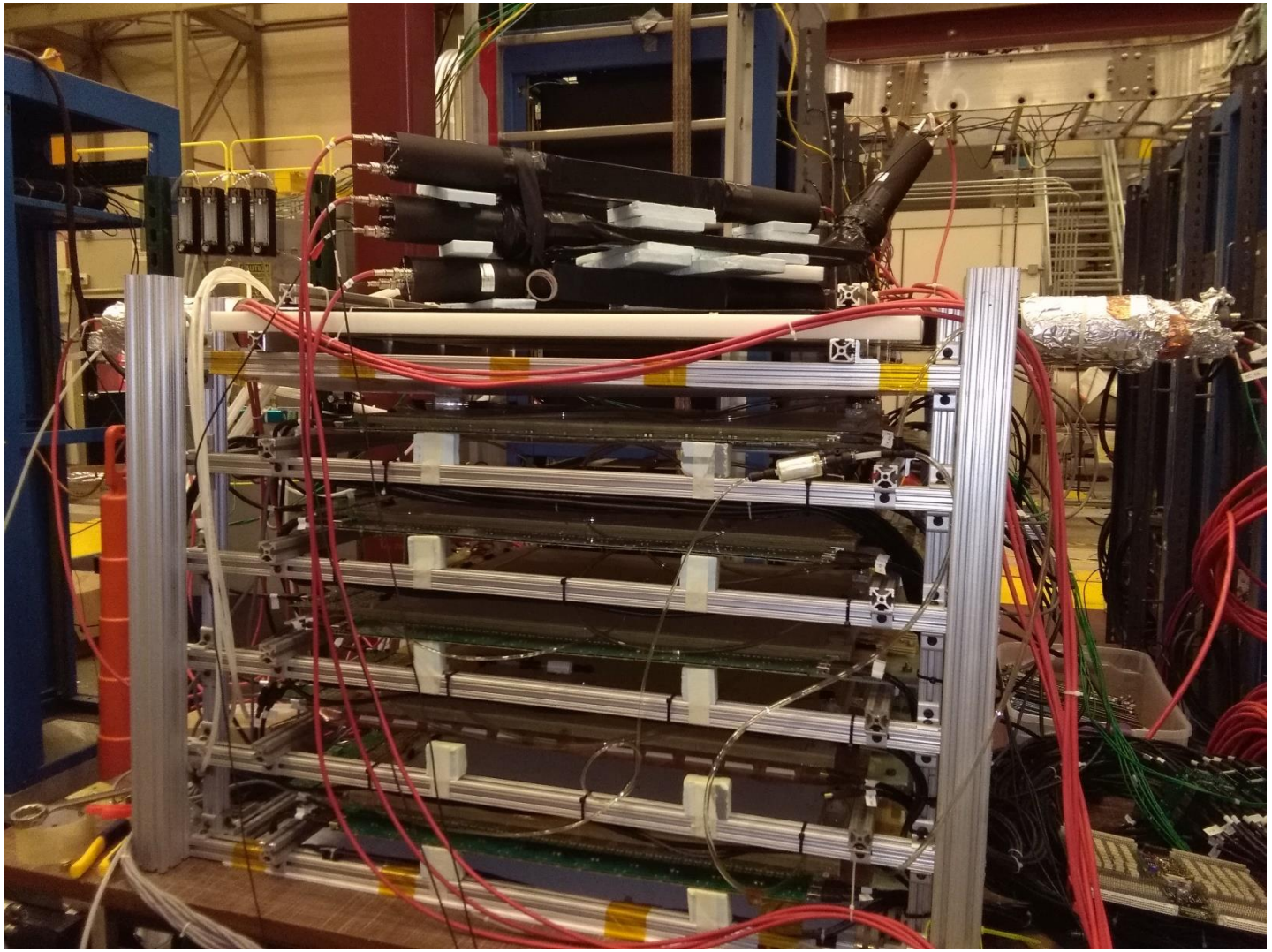
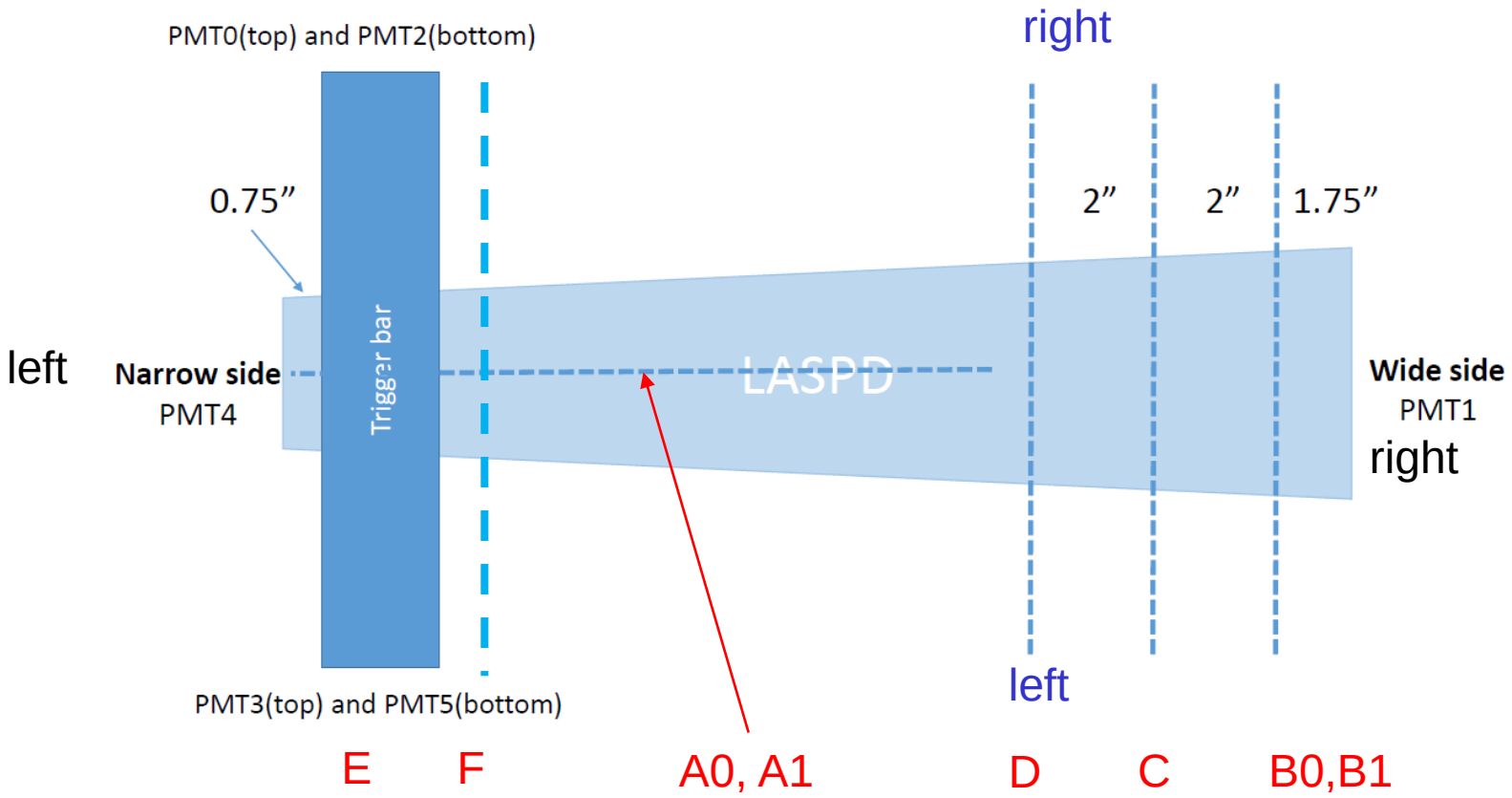
Experiment Setup



Experiment Setup



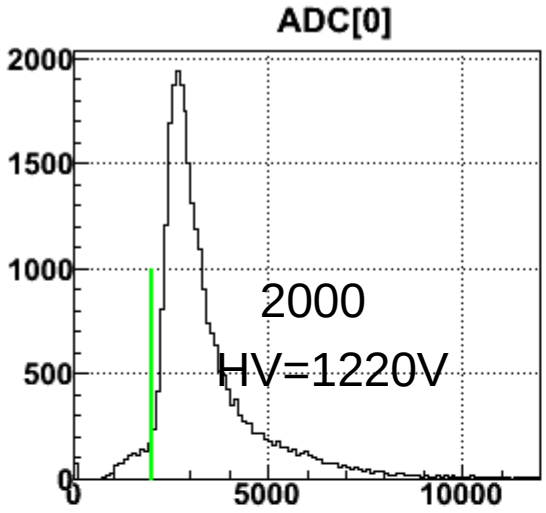
Low HV: A0, B0, C, D
High HV: A1, B1, E, F

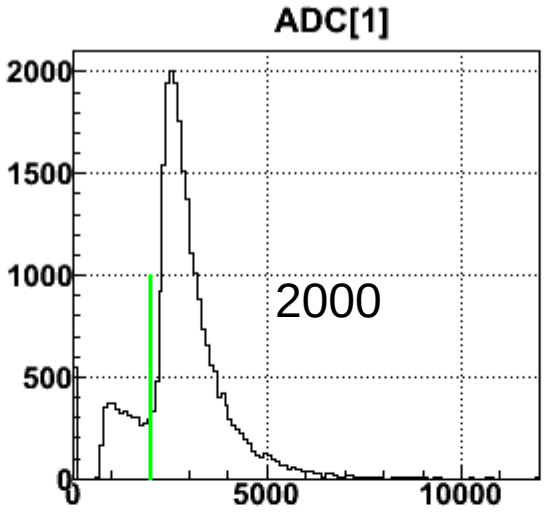
Data set F uses only 2 GEM detectors.
All the others use 3 GEM detectors

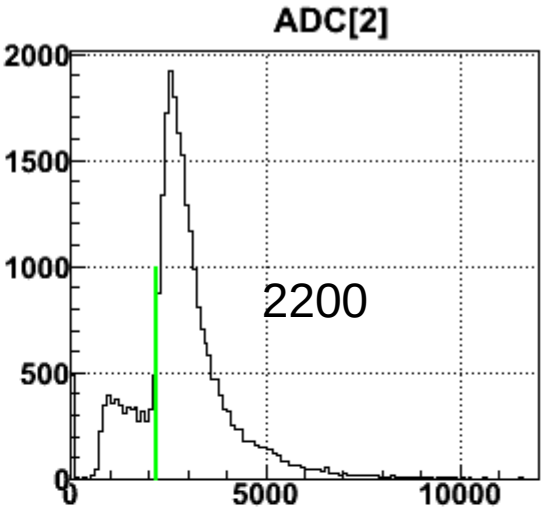
Available Data

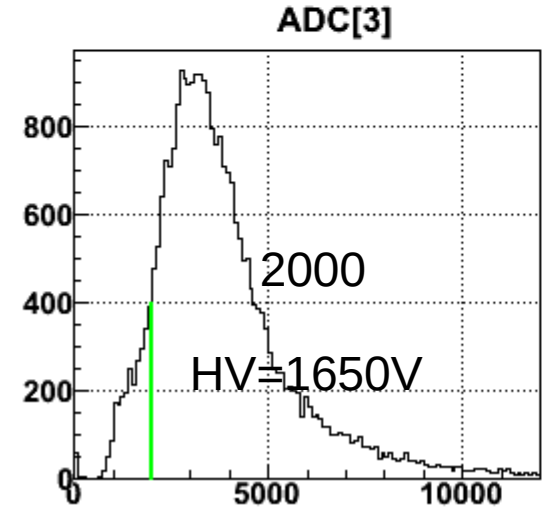
Data-set	A0+A1	B0+B1	C	D	E	F
Trigger#	363.1k	26.3k	33.0k	25.3k	28.6k	95.9k
+ADC	219.1k	16.7k	21.7k	17.0k	17.1k	53.9k
+GEM	55.8k	2828	3660	2859	2908	7770
#/cm^2	372	57	73	57	58	155

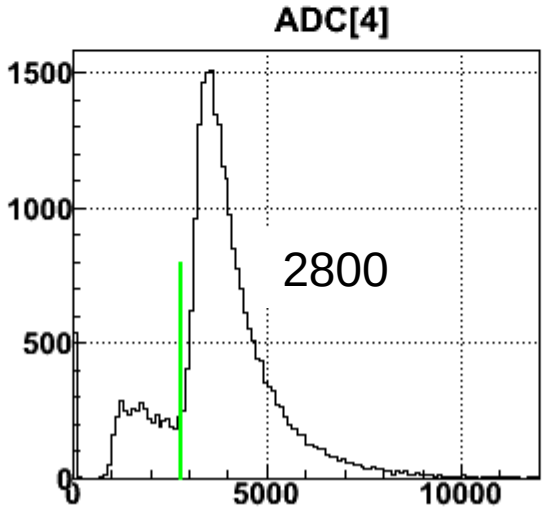
ADC Cut (high HV)

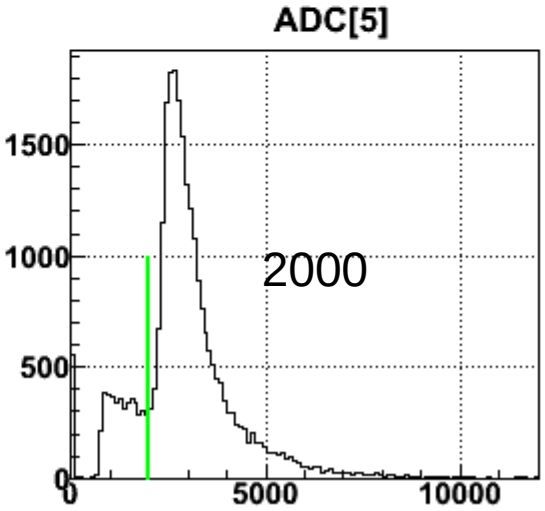




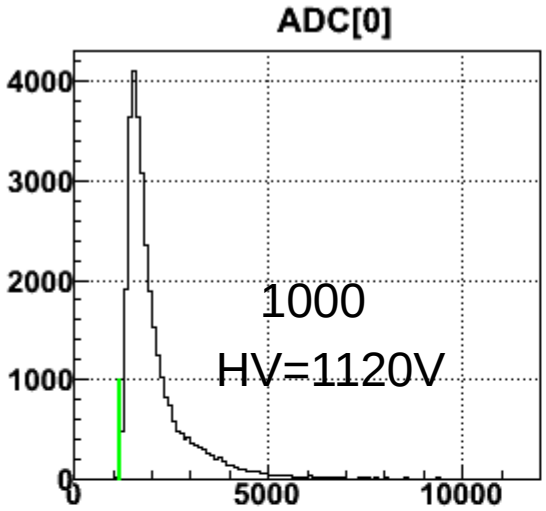


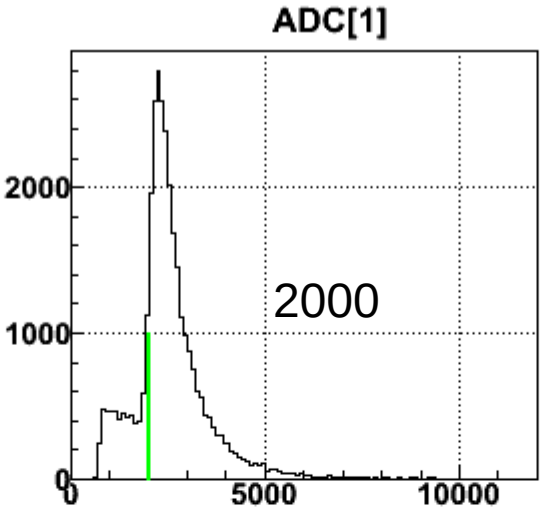


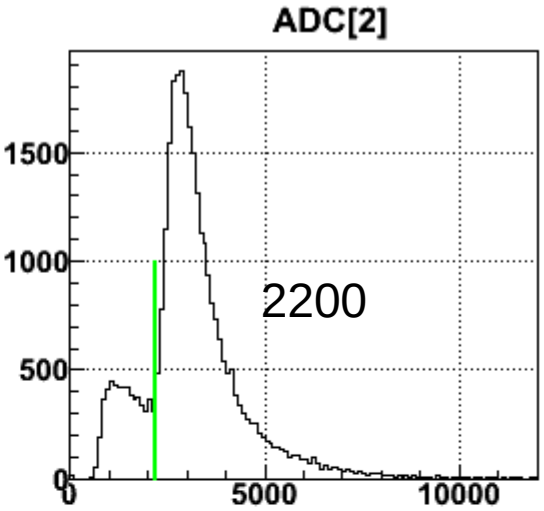


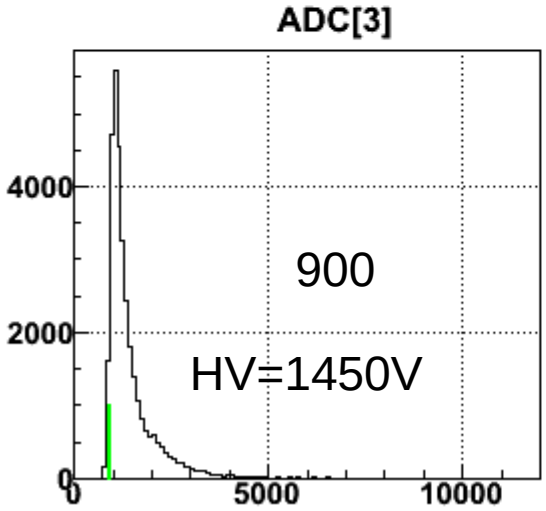


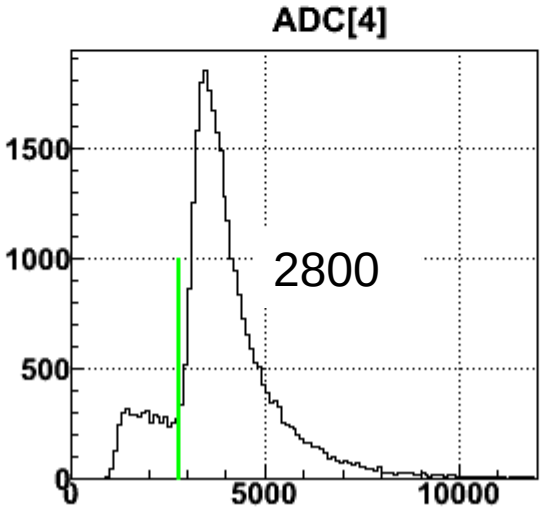
ADC Cut (low HV)

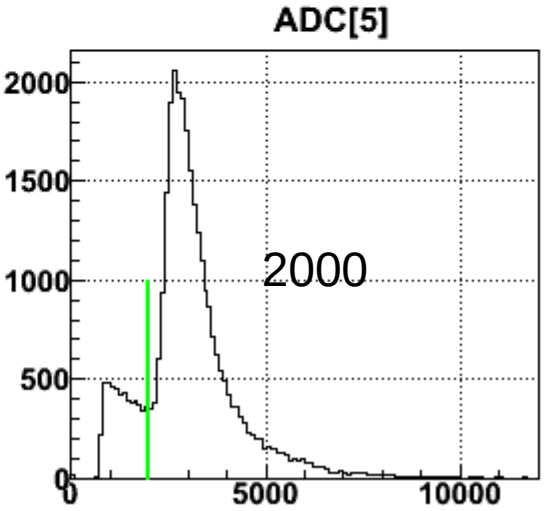




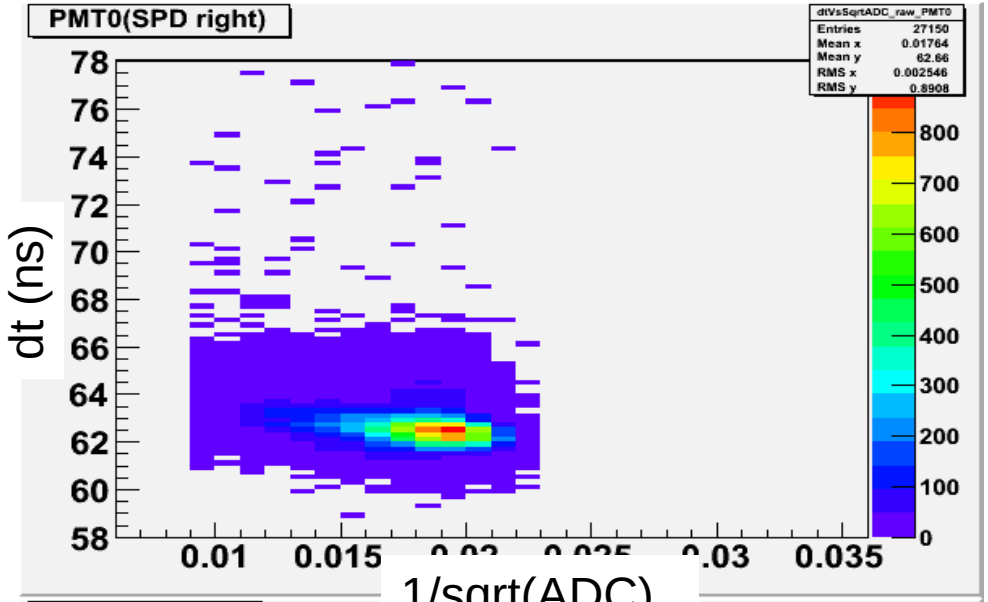


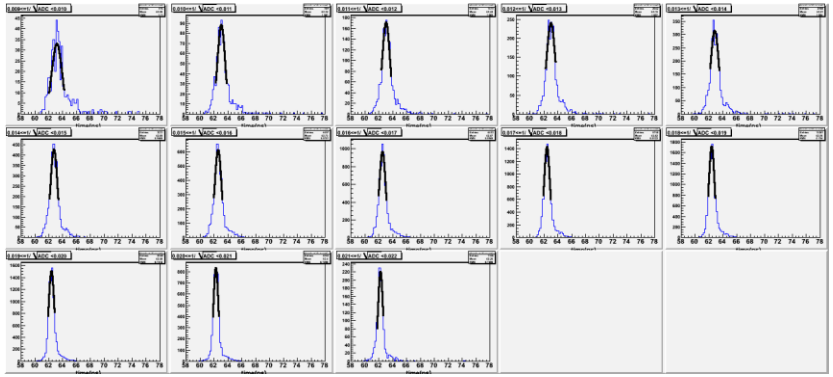




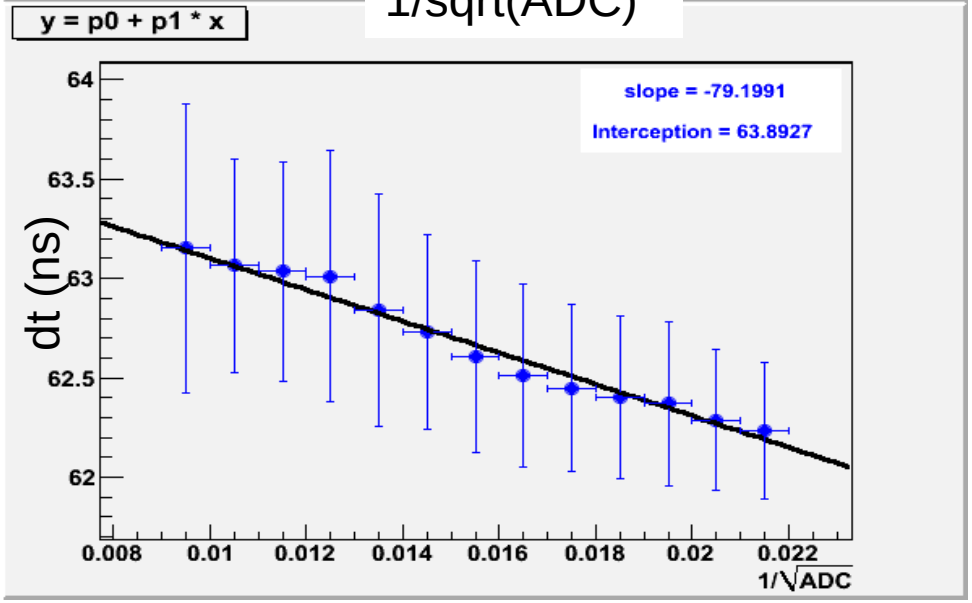


How to do Time-Walk Calibration



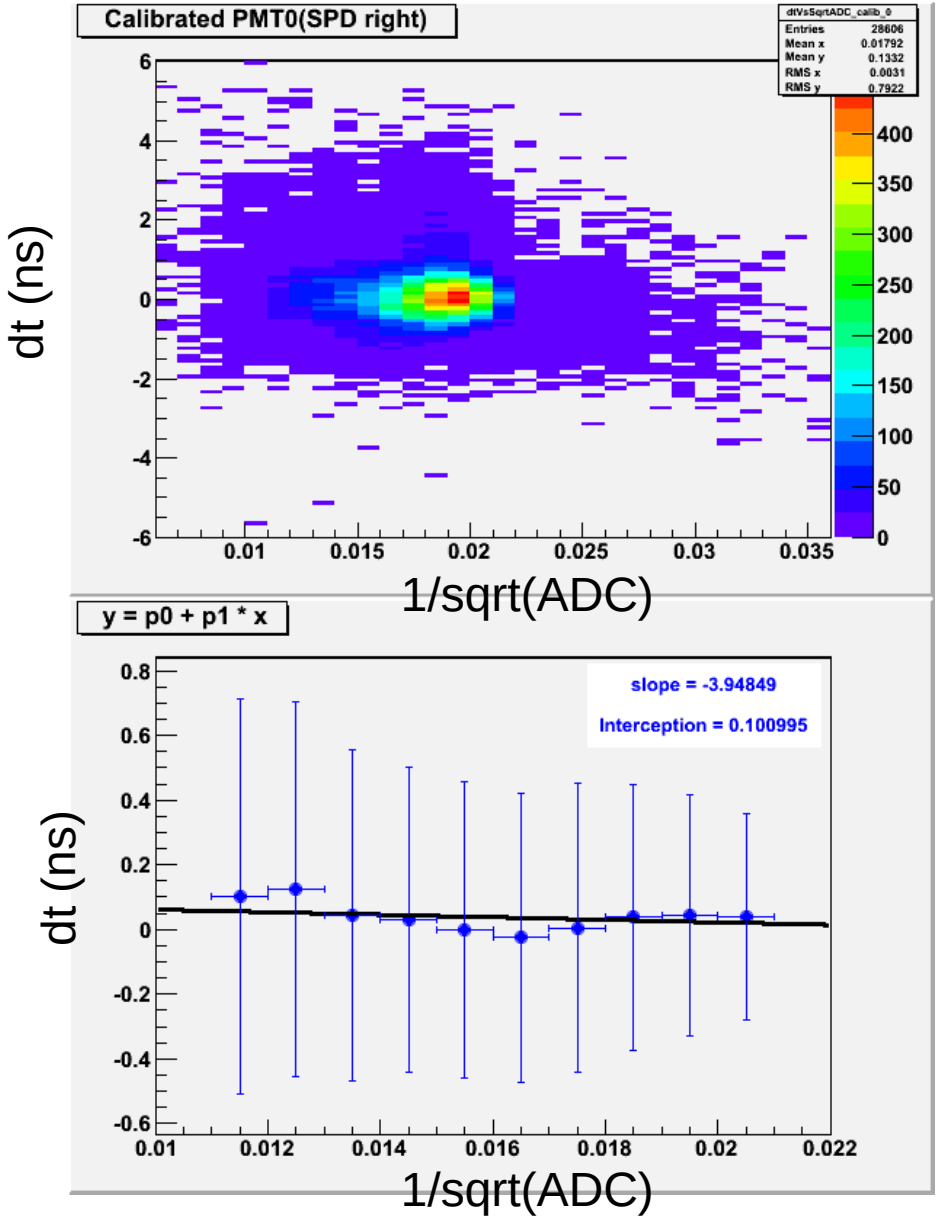


dt = Time – TriggerTime



- For PMT 0, 2, 3, 5
- Apply trigger cut and ADC cut
- Fit each vertical slices to get the mean and sigma, then fit “mean Vs 1/sqrt(ADC)” by 1st order polynomial, using the sigma as error bar of each mean value.
- It should have x-y dependence, but so far not able to fit it in x-y-ADC 3-D grid yet.

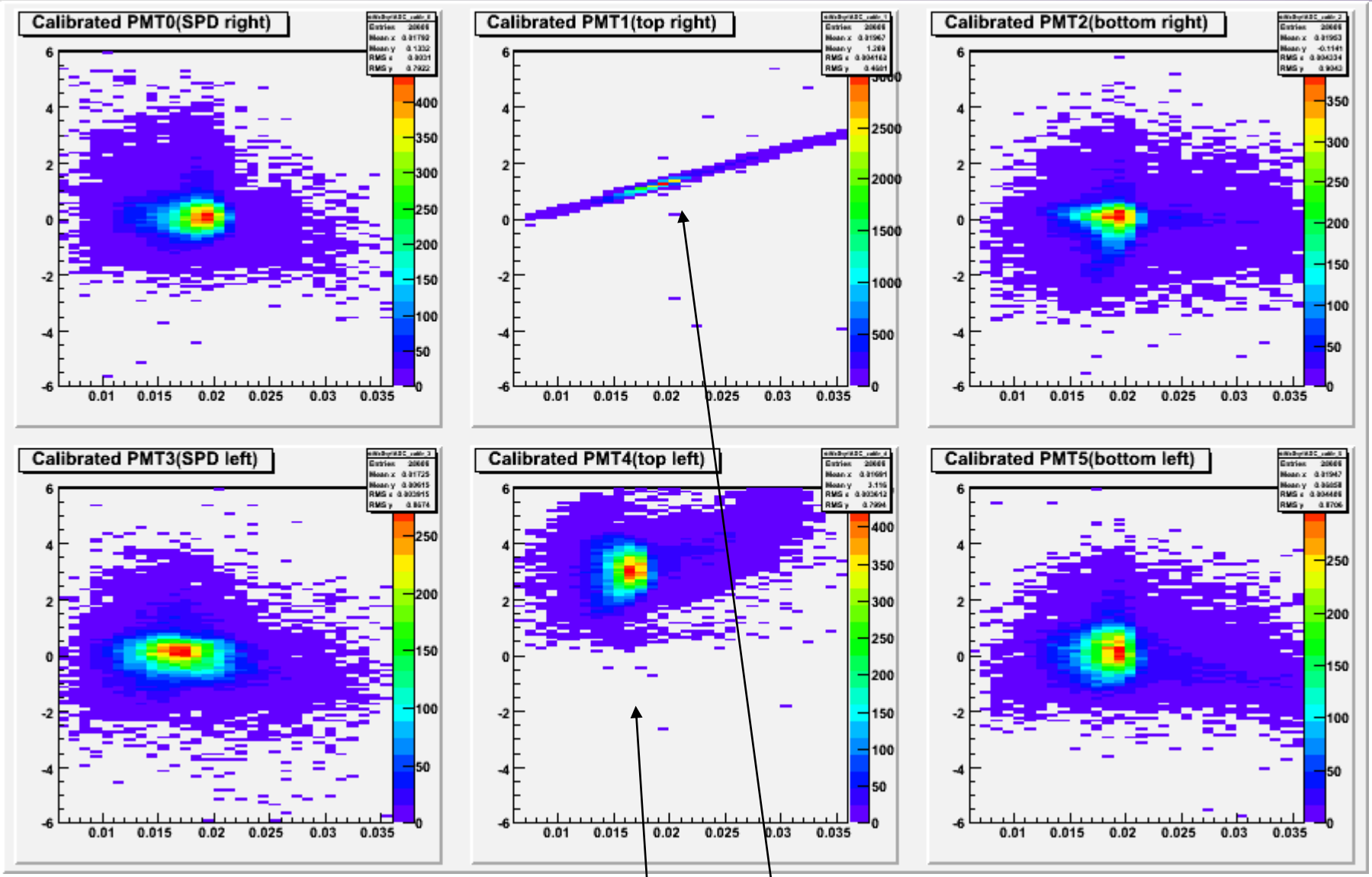
After Time-Walk Calibration



dt = Time – TriggerTime

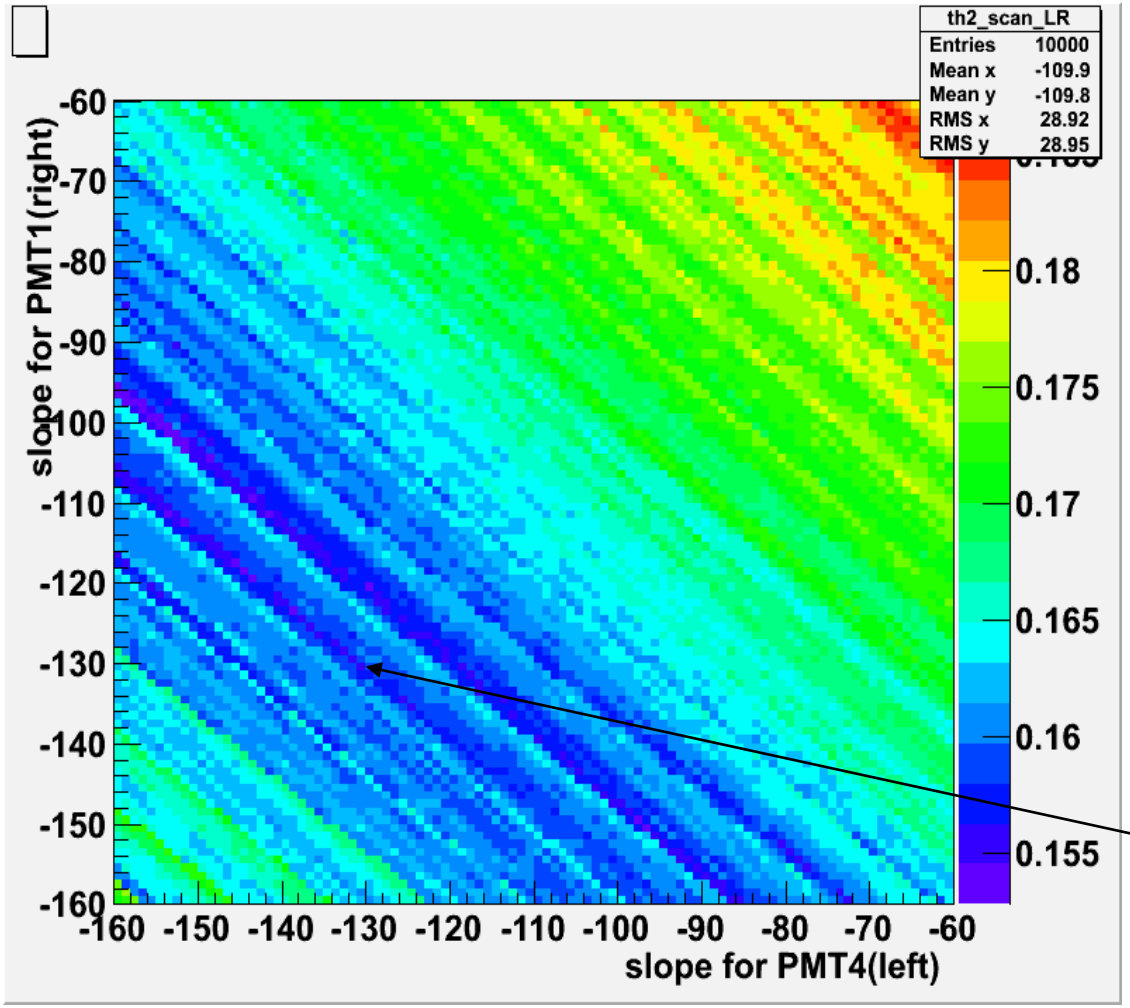
- For PMT 0, 2, 3, 5
- After applying calibration
- Fit each vertical slices to get the mean and sigma, then fit “mean Vs 1/sqrt(ADC)” by 1st order polynomial, using the sigma as error bar of each mean value.
- The uncertainty of this calibration is estimated using the mean values. It could be off by ~100ps.

Calibration Result



Previous calibration method does not work for timing bar.

Another Time-Walk Calibration

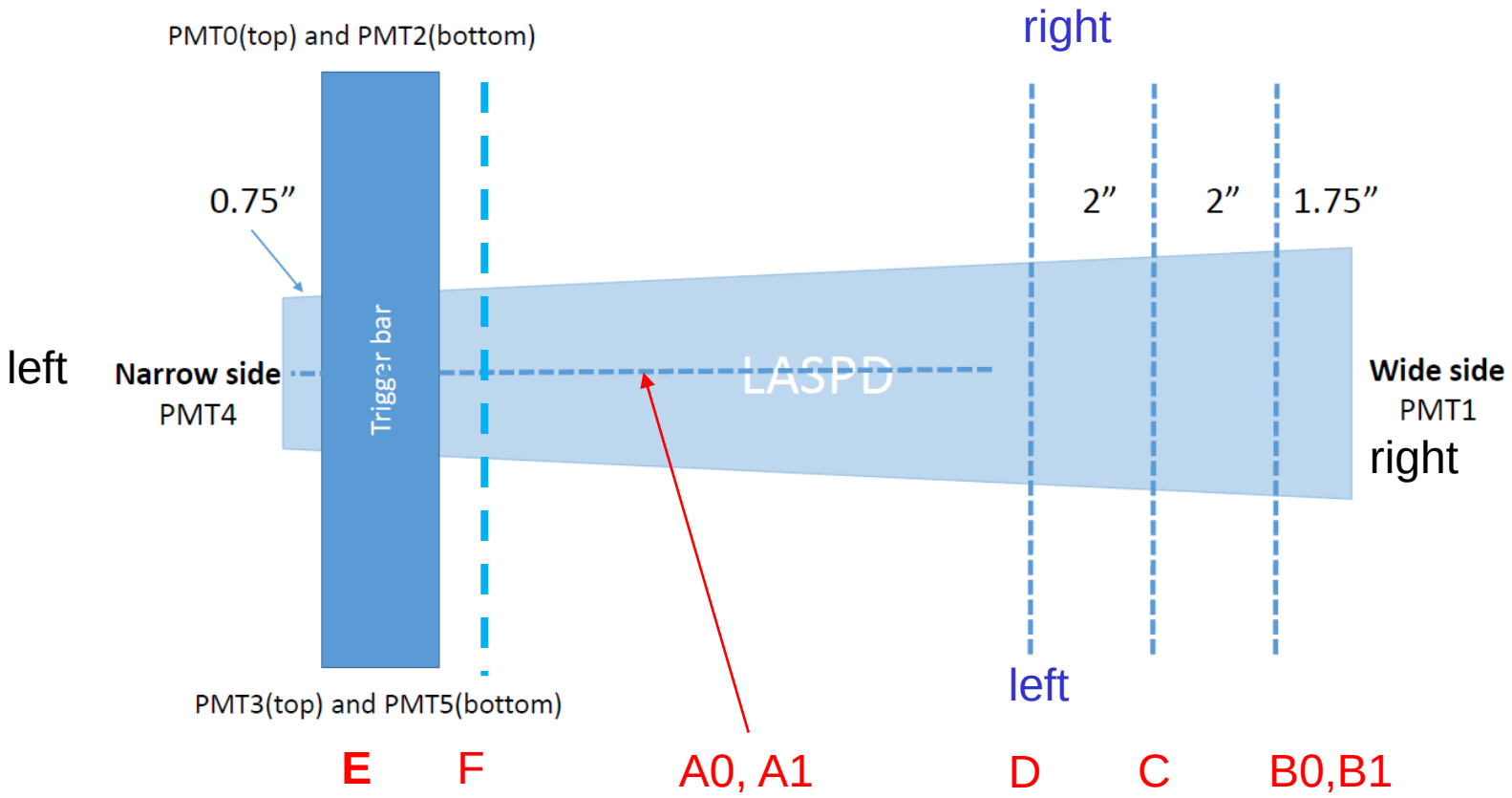


$dt = (t1+t4 + t2 + t5)/4 - (t0+t3)/2$

- For PMT 1, 4 only
- After applying calibration for PMT 0,2,4 and 5. Scan slope of PMT 1 and 4 in the range shown in picture, step size is 1.0
- For each point, fit dt distribution with Gaussian function, using the sigma as z value for that point.
- Pick the slopes that give the minimum z value in this picture.

Z axis is the time resolution from both left and right PMTs of LASPD

Analysis for Data Set E



Low HV: A0, B0, C, D
High HV: A1, B1, E, F

Data set F uses only 2 GEM detectors.
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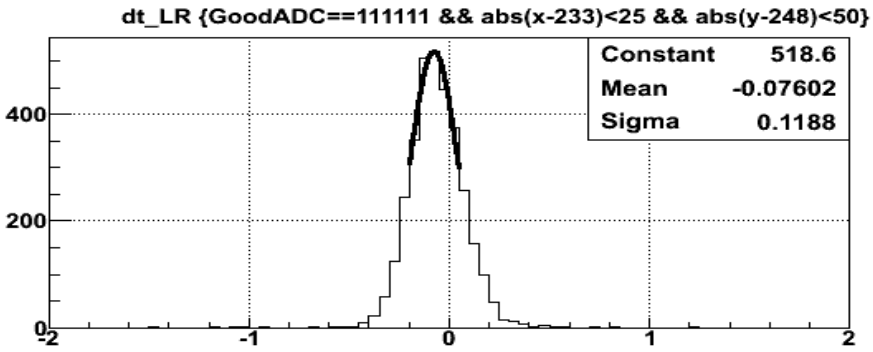
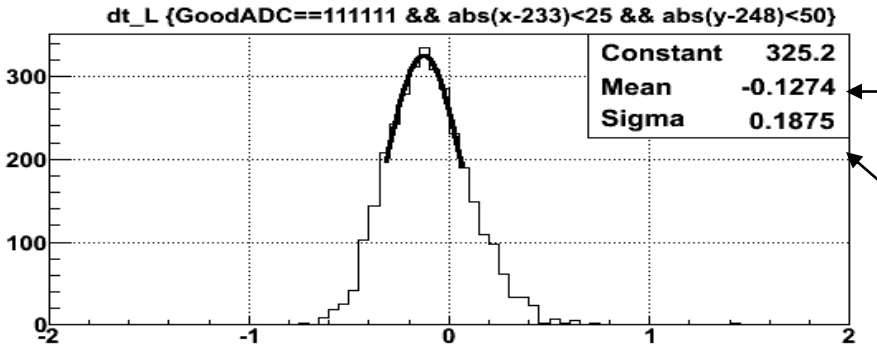
Analysis for Data Set E



dt_LR = (t1+t4 + t2 + t5)/4 – (t0+t3)/2

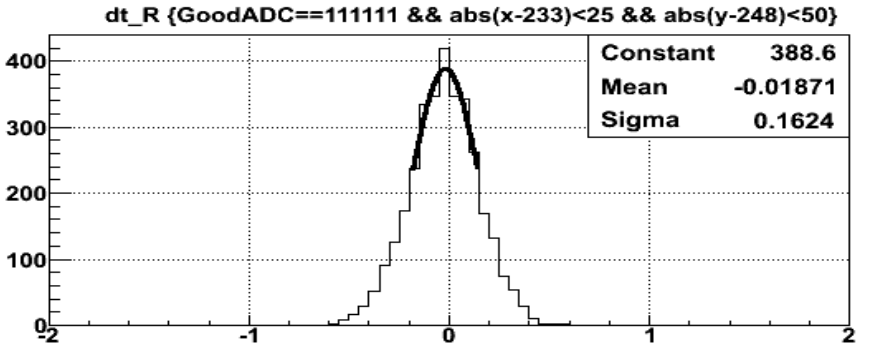
dt_L = (t1+t4 + t2 + t5)/4 – t3

dt_R = (t1+t4 + t2 + t5)/4 – t0



Mean: indicates how good is the calibration

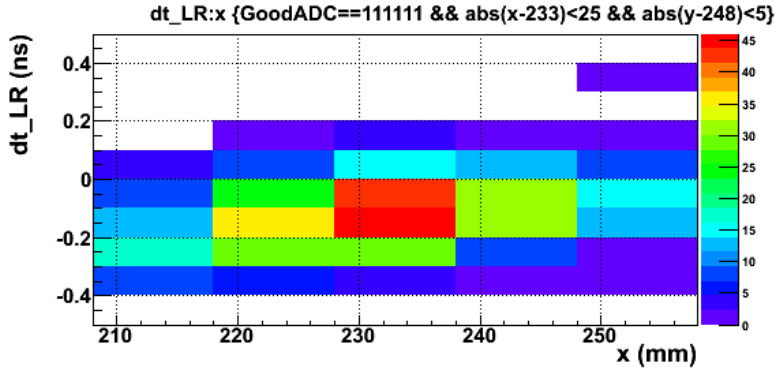
Sigma: time resolution

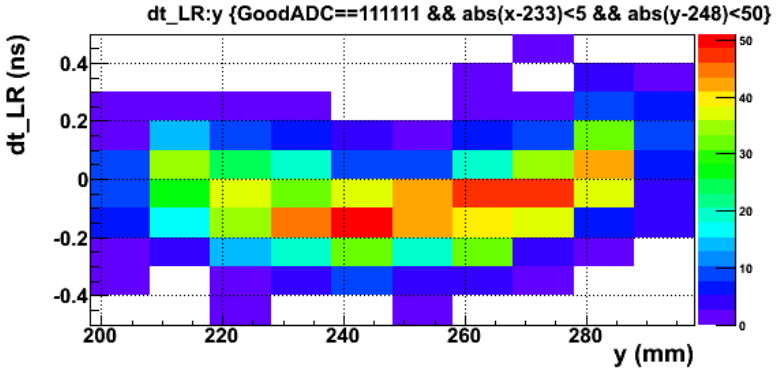


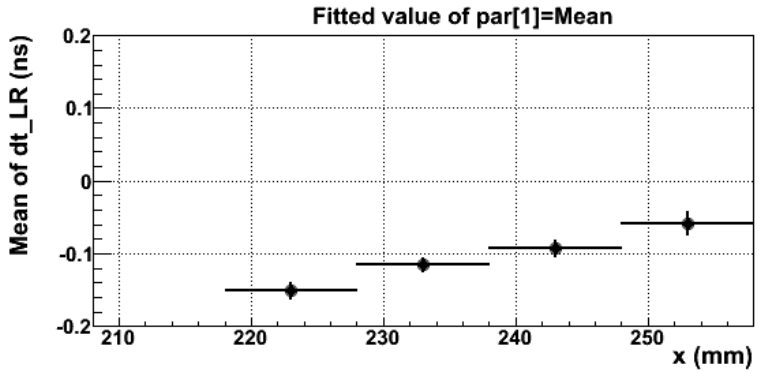
Overall result after manually tune some of the calibration constants

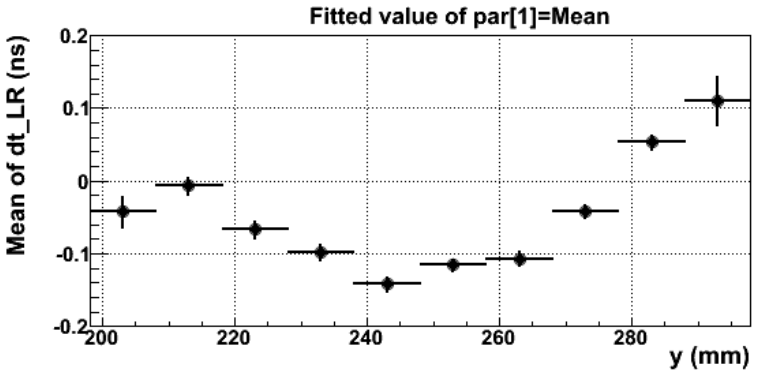
Use 5 cm (x) by 10cm (y) area.
Requiring only one track from GEM.

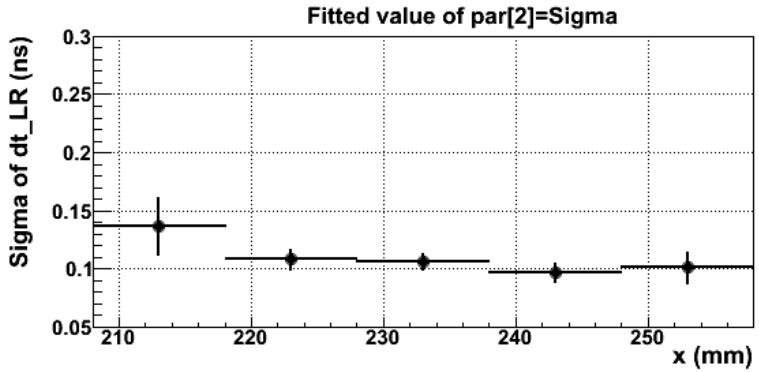
Data Set E: 1cm x 1cm, dt_LR

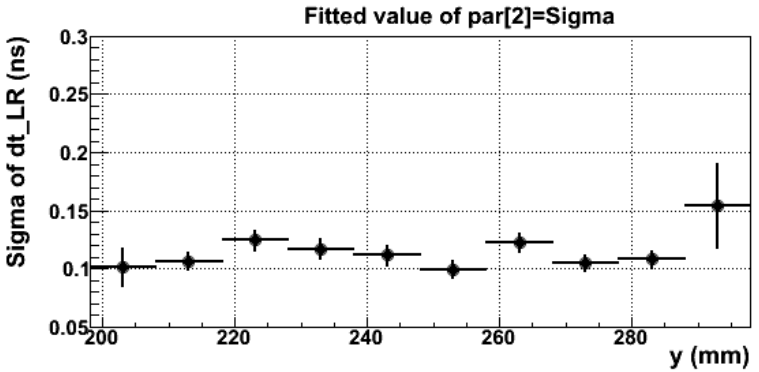






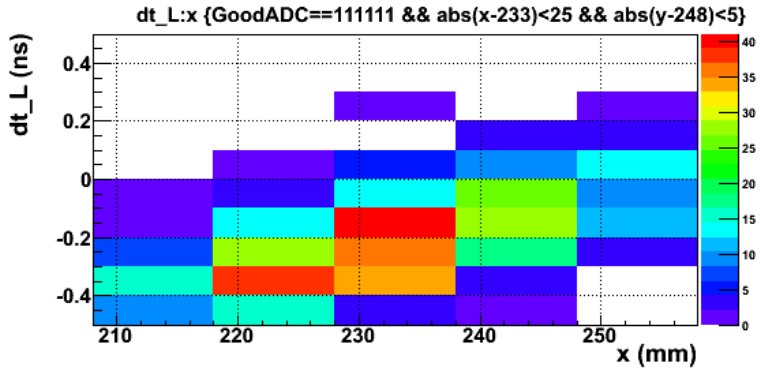


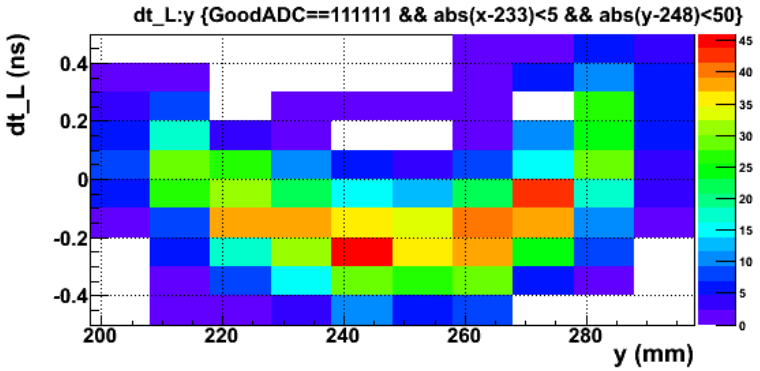


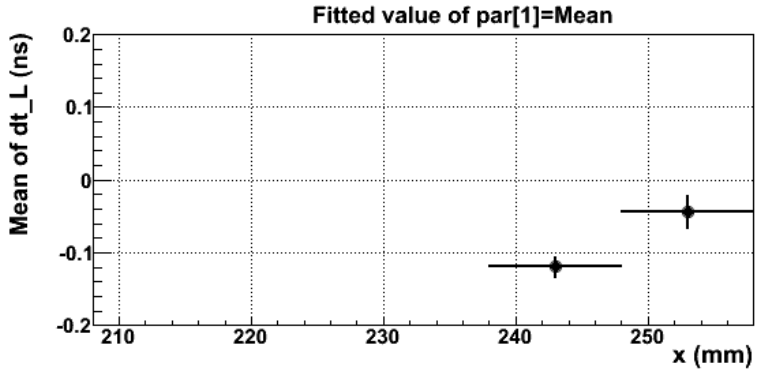


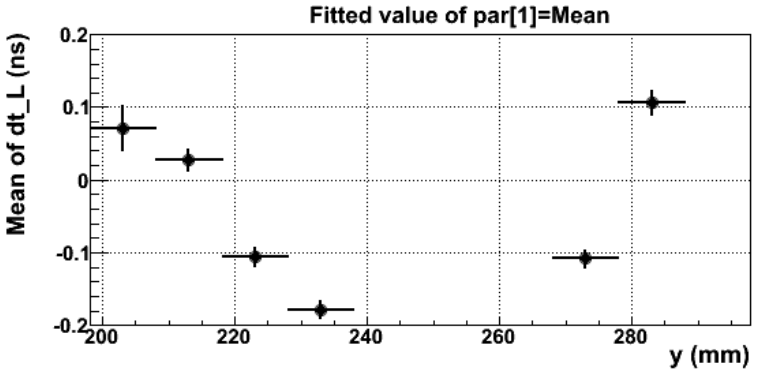
dt_LR = (t1+t4 + t2 + t5)/4 – (t0+t3)/2

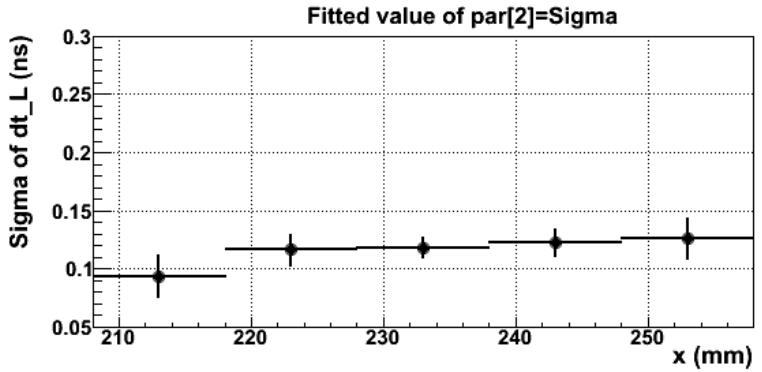
Data Set E: 1cm x 1cm, dt_L

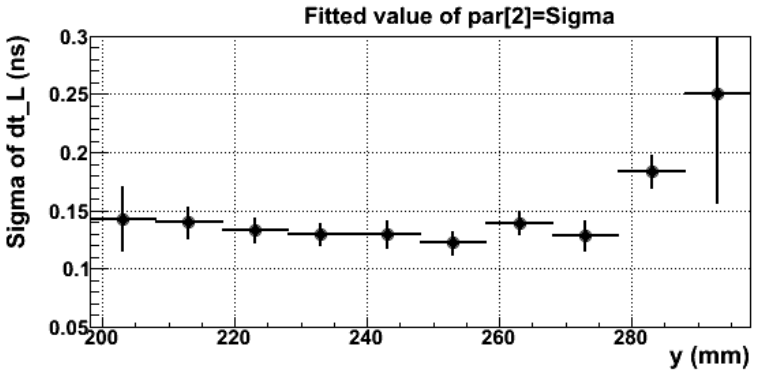






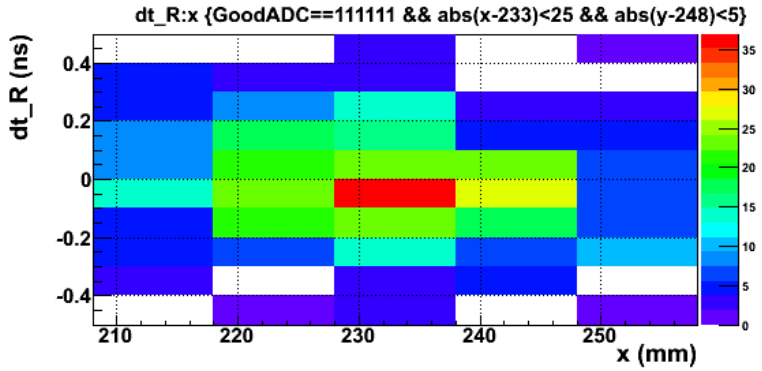


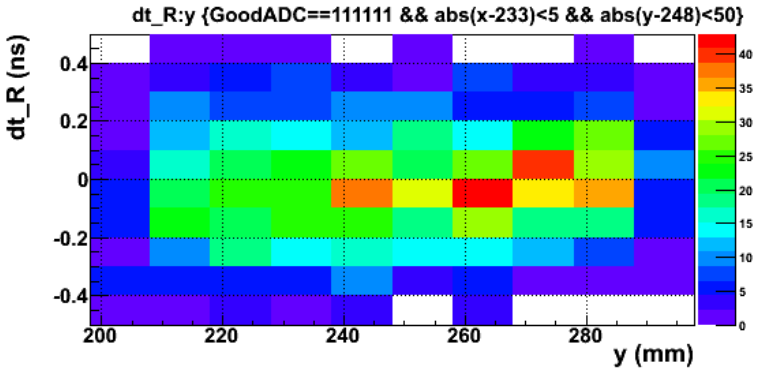


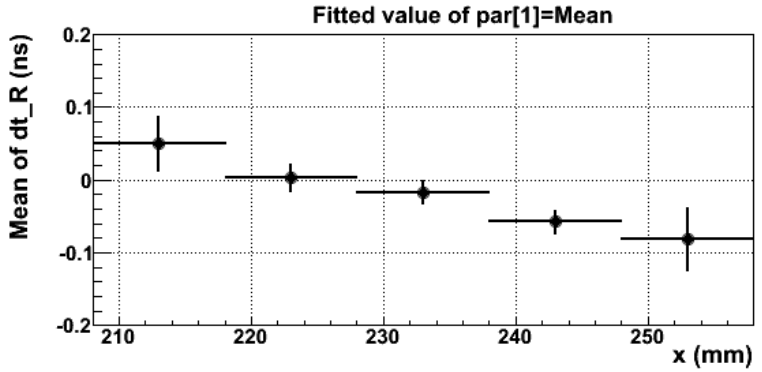


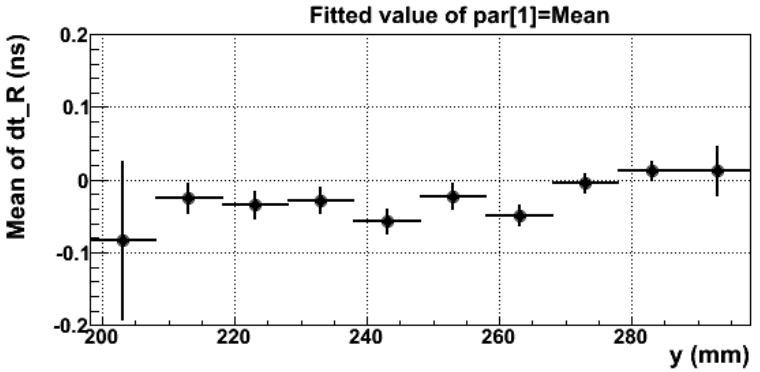
dt_L = (t1+t4 + t2 + t5)/4 – t3

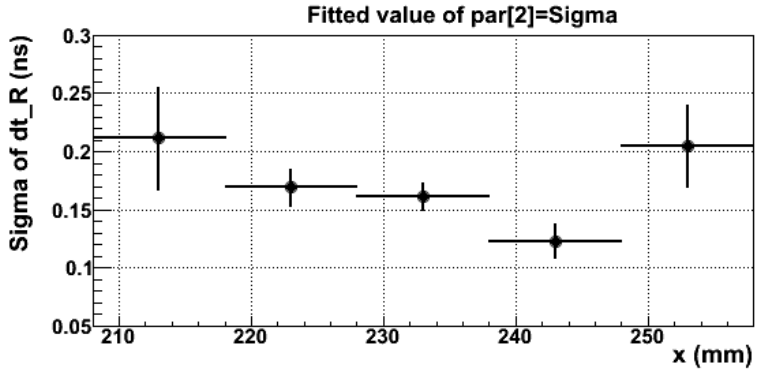
Data Set E: 1cm x 1cm, dt_R

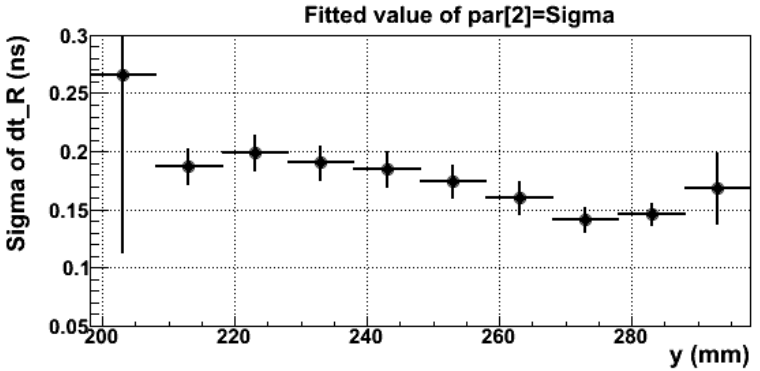






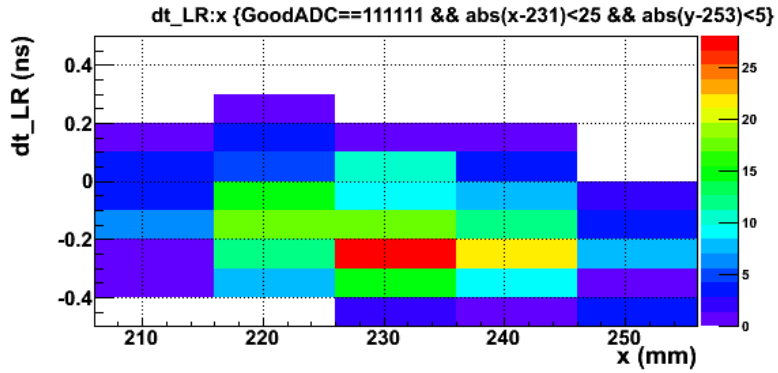


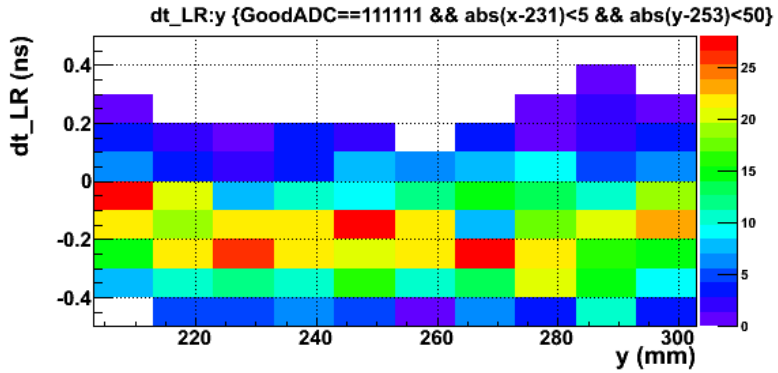


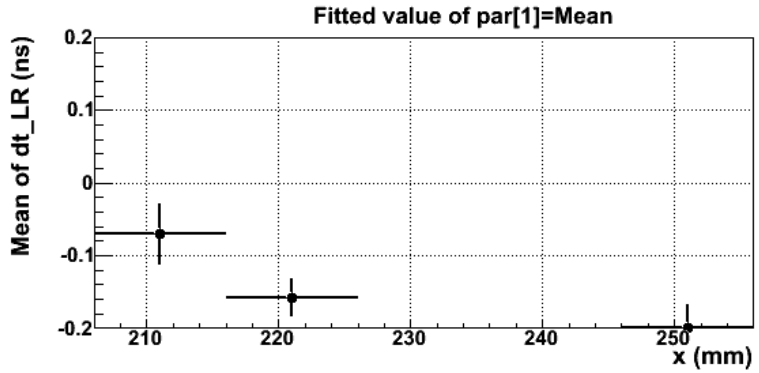


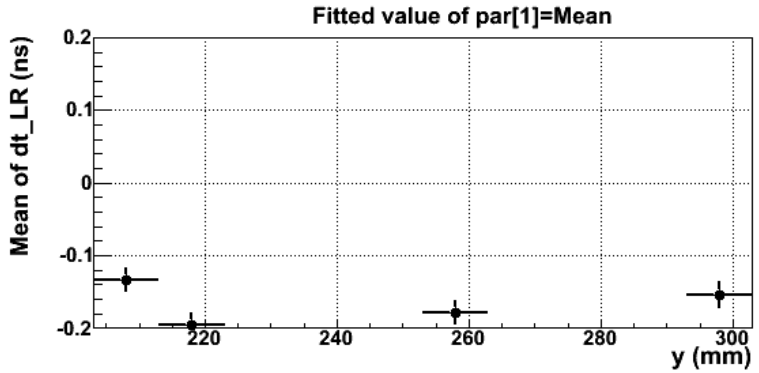
$dt\_R = (t1+t4 + t2 + t5)/4 - t0$

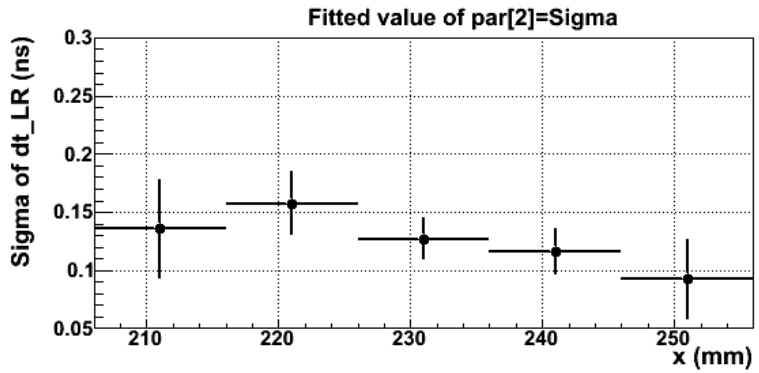
Data Set B1: 1cm x 1cm, dt_LR

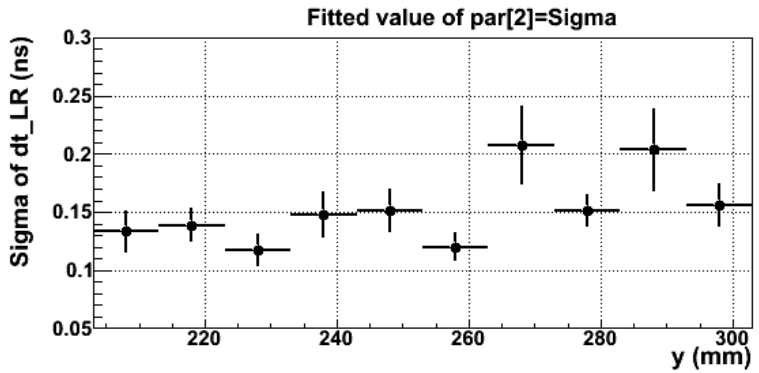






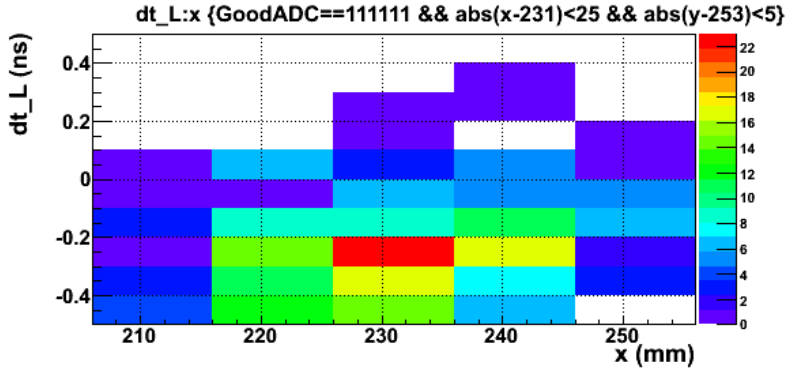


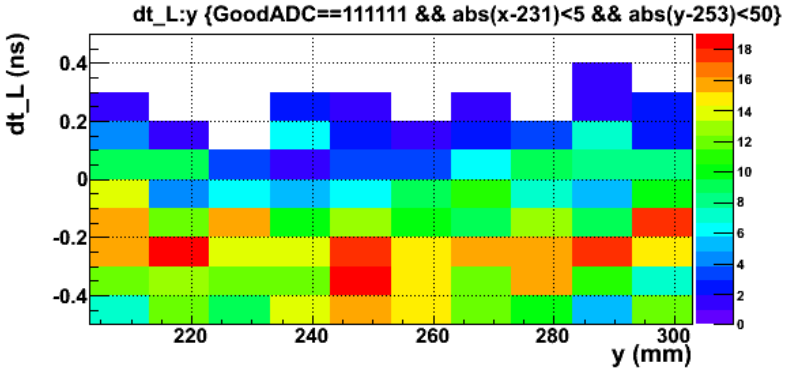


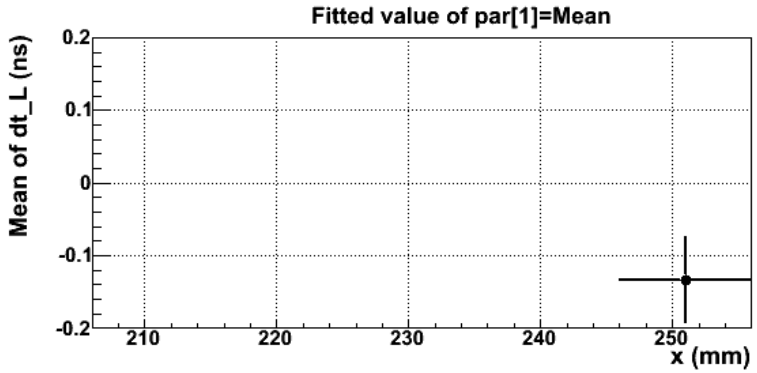


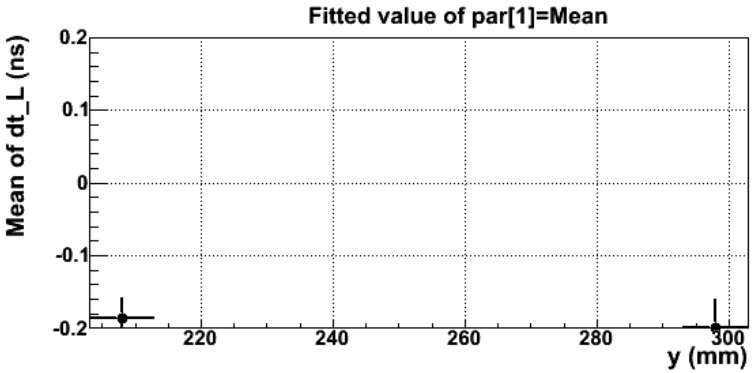
dt_LR = (t1+t4 + t2 + t5)/4 – (t0+t3)/2

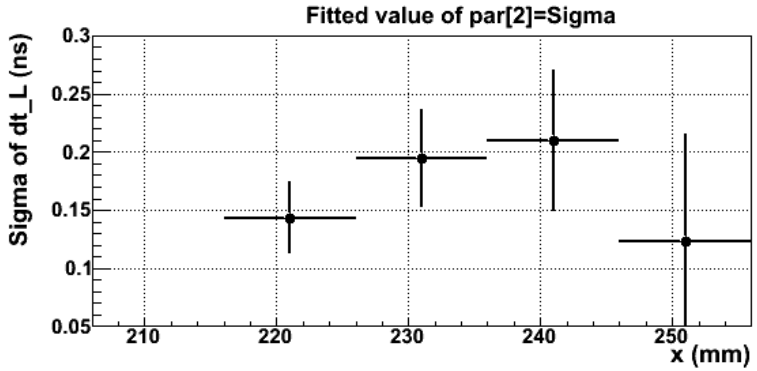
Data Set B1: 1cm x 1cm, dt_L

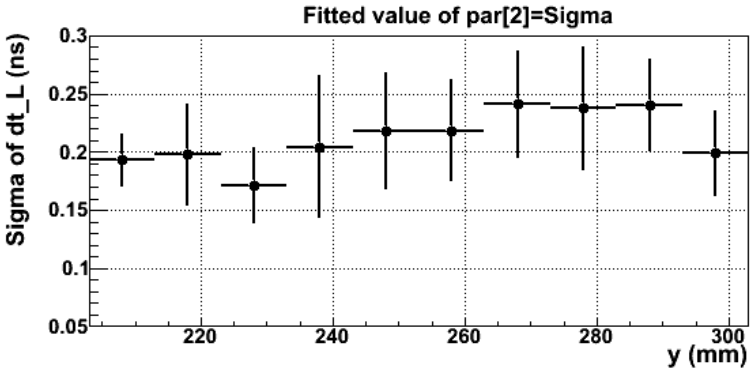






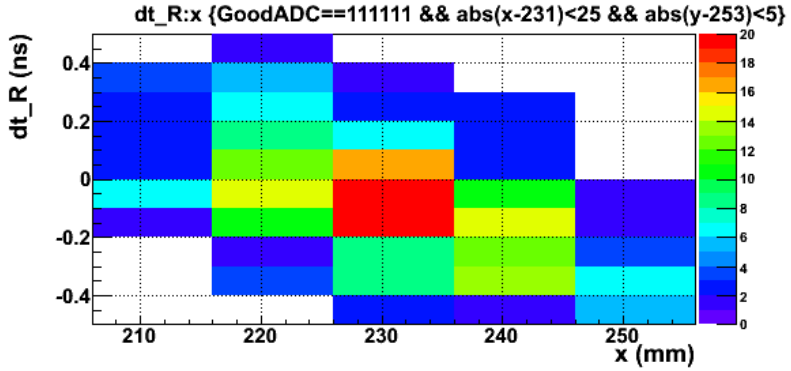


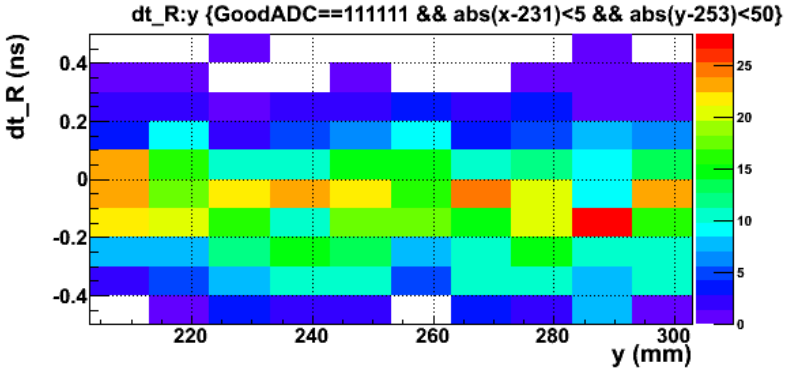


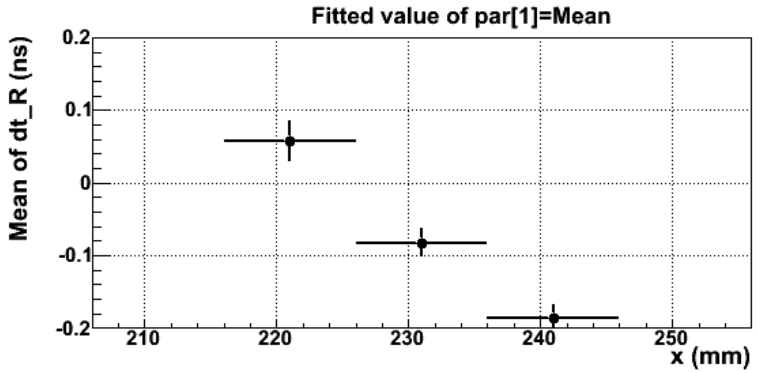


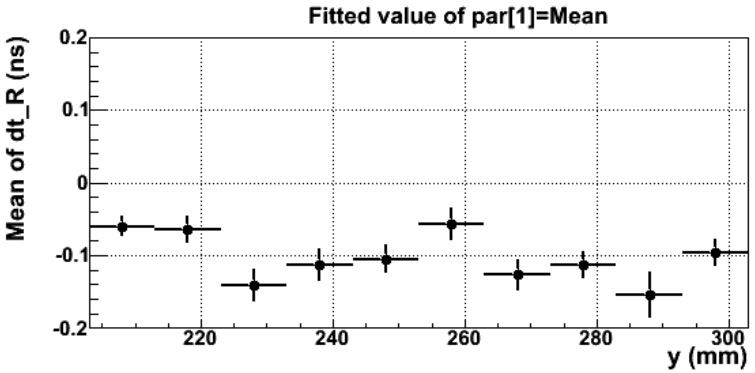
dt_L = (t1+t4 + t2 + t5)/4 – t3

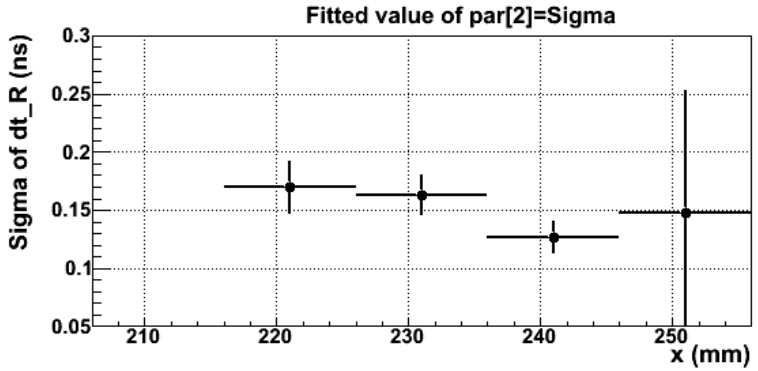
Data Set B1: 1cm x 1cm, dt_R

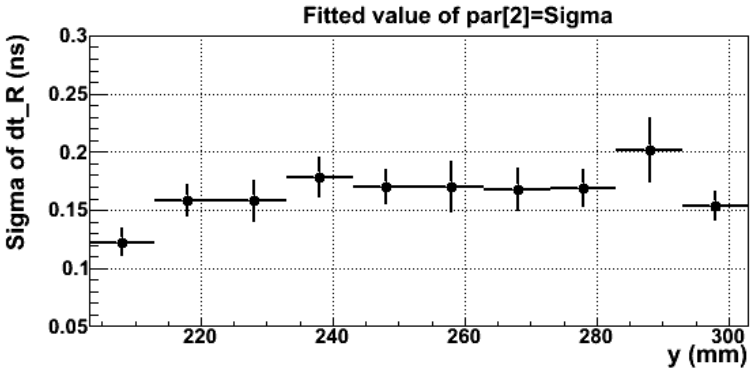






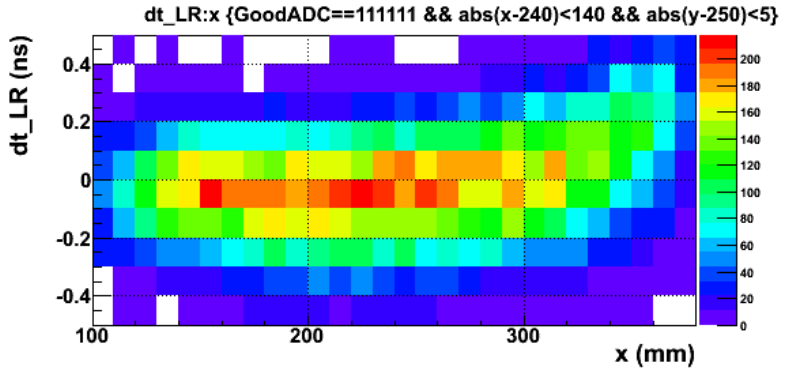


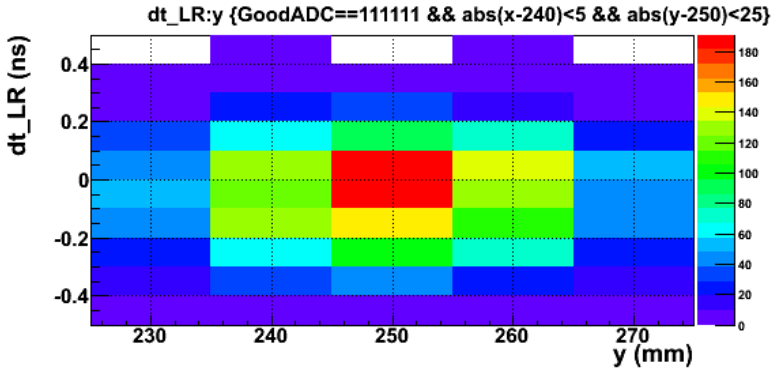


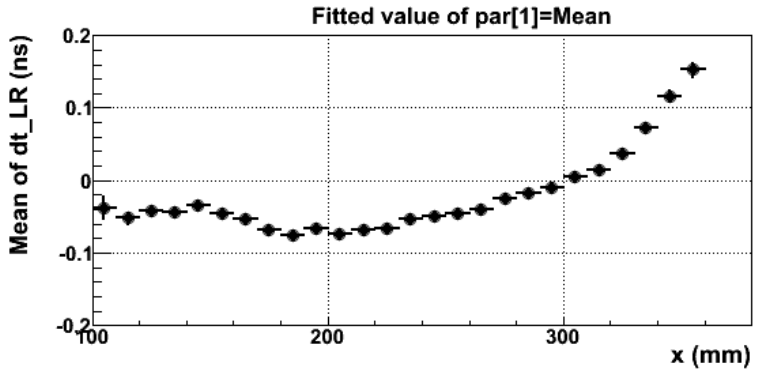


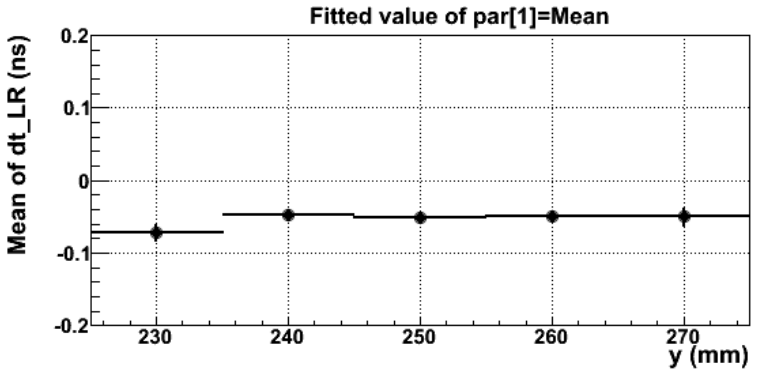
$dt\_R = (t1+t4 + t2 + t5)/4 - t0$

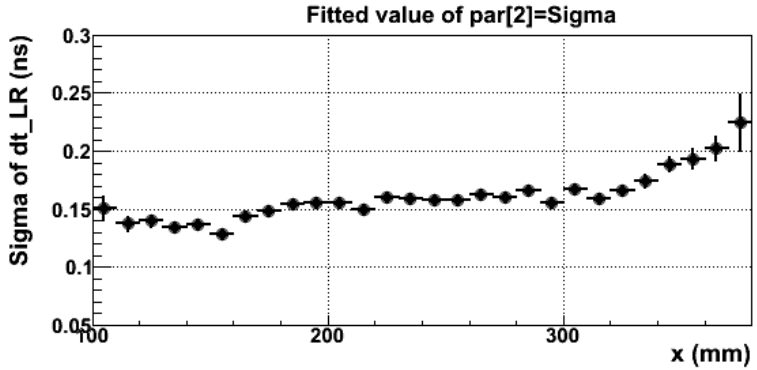
Data Set A1: 1cm x 1cm, dt_LR

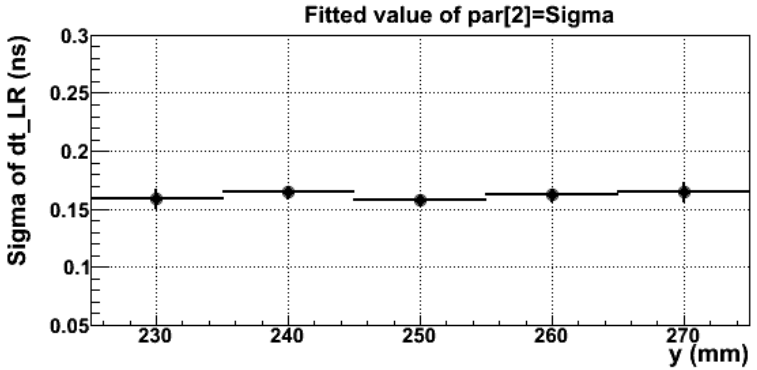






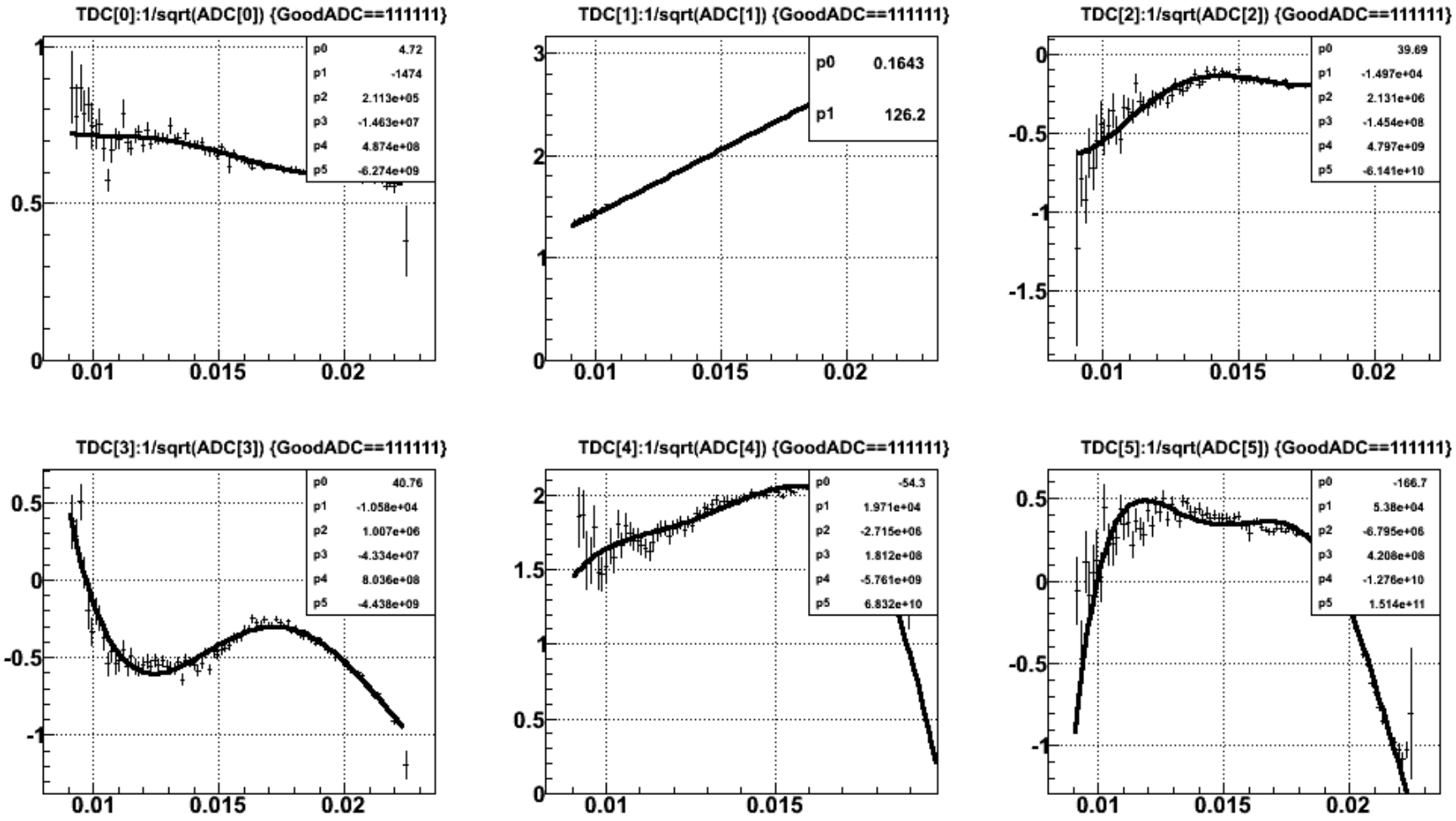






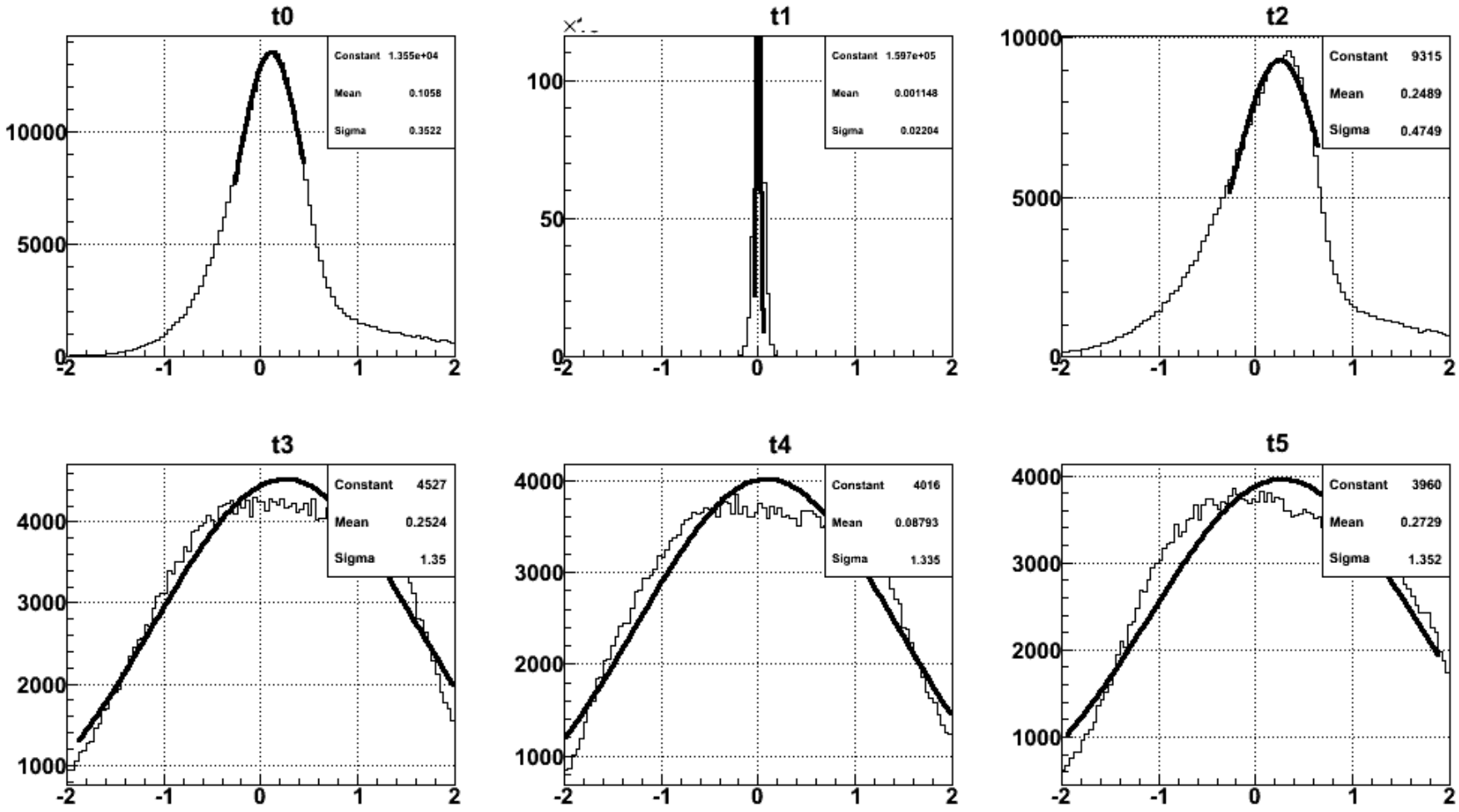
dt_LR = (t1+t4 + t2 + t5)/4 – (t0+t3)/2

Data Set A1: what is wrong?



Current calibration is not good at all. Will use the above fit do do 2nd order calibration.

Data Set A1: After 2nd order calibration



Even the 2nd order calibration is not good enough ……
Need to think another way ……

Summary

- We have taken 6 data sets of data to find LASPD time resolution and its position dependence. After applying ADC cuts and GEM cut, only ~60 data points per cm^2 available.
- Data set E has been fine tuned and analyzed. The time resolution can reach <100ps for left+right PMTs, ~110ps for only left PMT and <150ps for only right PMT.
- Data set B1 (with higher HV) has also been analysis. Under current calibration constants, right PMT can reach 150ps resolution. There is still rooms to improve the calibration.
- Data set A1 (with higher HV) has been looked at. We need to redo the calibration.
- The other data sets with lower HV also need to redo the calibration.
- New data set F is still under taking data. Hopefully this setting will provide enough statistics to do x-y-ADC 3-D calibration. Need to develop new tracking for this setting.