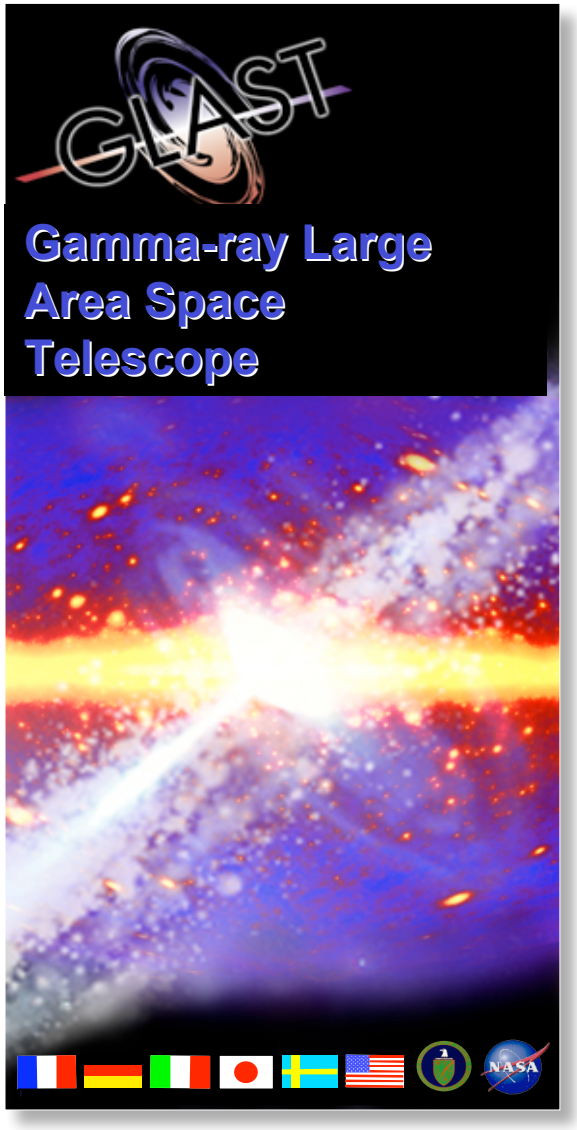


GLAST Large Area Telescope:

TKR TOT/Threshold Calibrations

Hiro Tajima (SLAC)

TKR

TKR Parameters Relevant to TOT Calib

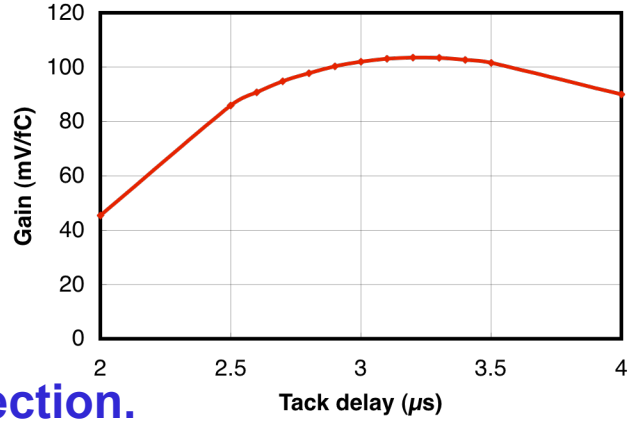
- TACK timing.
  - TOT is initiated by TACK (trigger acknowledge), not TREQ (trigger request).
  - TACK is ~2 us later than TREQ.
    - Different between GASU and non-GASU system.
- GTFE charge injection scale.
  - GTFE calibration DAC determines charge for charge injection tests.
    - Affect threshold calibration.
  - Use muon TOT peak for absolute calibration.
    - Requires correct GTFE threshold and tot parameters.
- GTFE Threshold.
  - Higher threshold, shorter TOT.
- TOT gain parameter.
  - Correlate input charge and TOT.
    - Requires correct TACK timing and GTFE threshold.
- Above parameters are cross-dependent.
  - Requires interactive process to optimize the parameters.

TOT Calibration Sequence

- Determine TACK timing for charge injection test.
- TOT calibration procedure.
  - GTFE Threshold calibration assuming calibration DAC scale is correct.
  - TOT-charge calibration.
    - Measure TOT vs. input charge and fit to 2nd order polynomial to obtain TOT "gain" parameter.
    - Pretend input charge (calibration DAC scale) is correct.
    - Factor out channel dependence.
  - Charge scale calibration.
    - Use TOT gain parameters to convert TOT to charge.
    - Muon MIP peak to calibrate input charge (calibration DAC) scale.
  - Second iteration of Threshold DAC calibration.
    - Use the calibration DAC scale obtained above.
  - Second iteration of TOT-charge calibration.

TACK Timing Determination

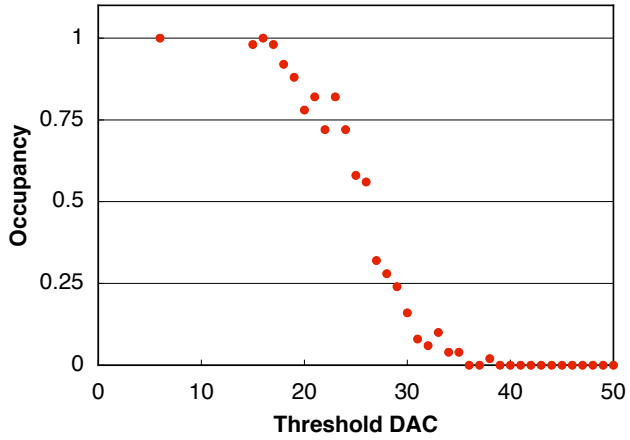
- TACK timing for charge injection needs to be determined.
  - Peak TACK timing for charge injection.
    - TACK timing at TKR pulse peak.
    - Obtain from TACK scan.

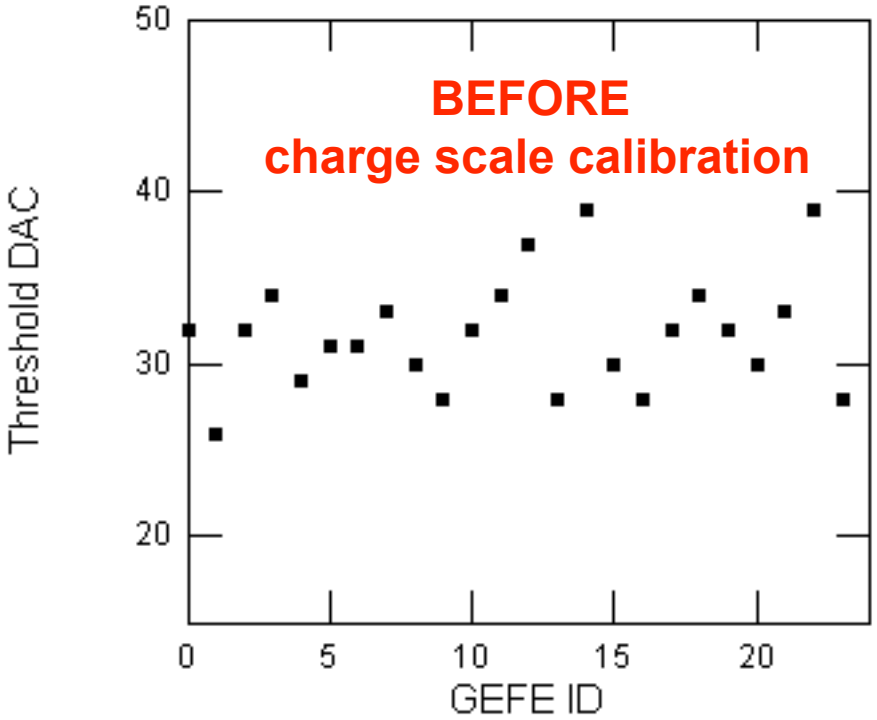


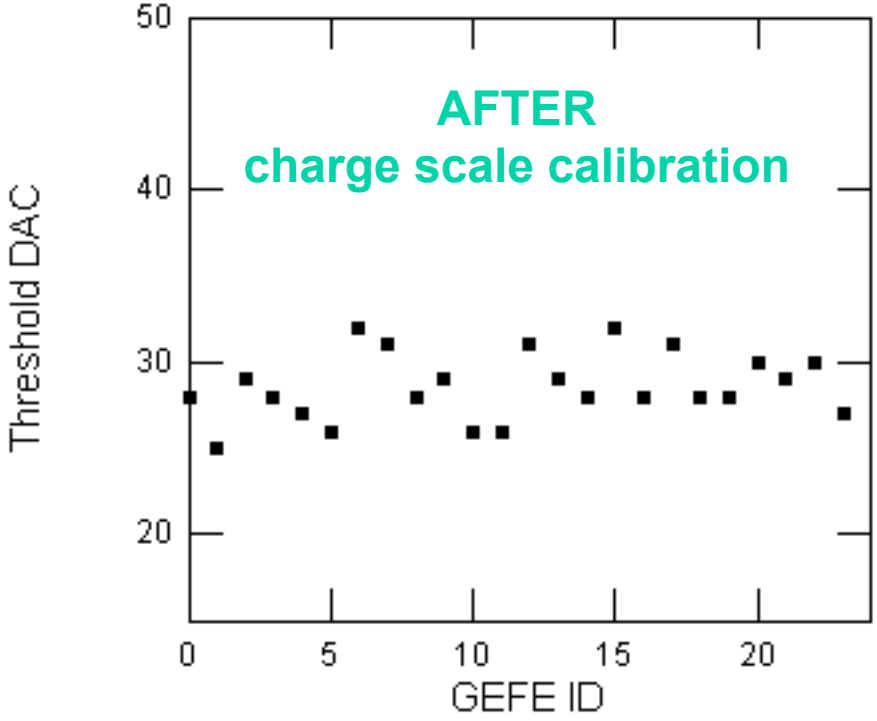
  - Data capture TACK timing for charge injection.
    - TACK timing corresponding to data capture with TKR trigger.
    - Determine data capture timing with respect to the peak timing for TKR trigger.
      - TACK scan with external scintillator trigger peaks at 0.25 μs with trigger window width=1.
      - This corresponds to -0.25 μs for TKR trigger. (TKR trigger is 0.5 μs later than the external scintillator trigger.)
      - In the real data taking, the data is captured at 0.55 μs (trigger window width = 12).
      - The distance between the peak and the data capture is 0.8 μs (0.55 + 0.25 μs).

Threshold DAC Calibration

- Scan threshold DAC for a given input charge (1.4 fC ~ 0.27 MIP)
- Fit to error function.

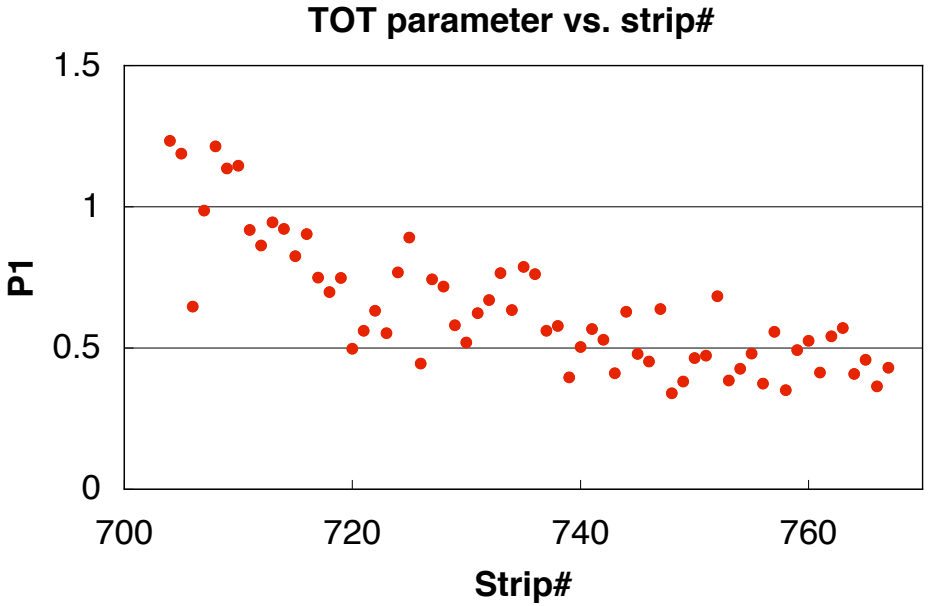


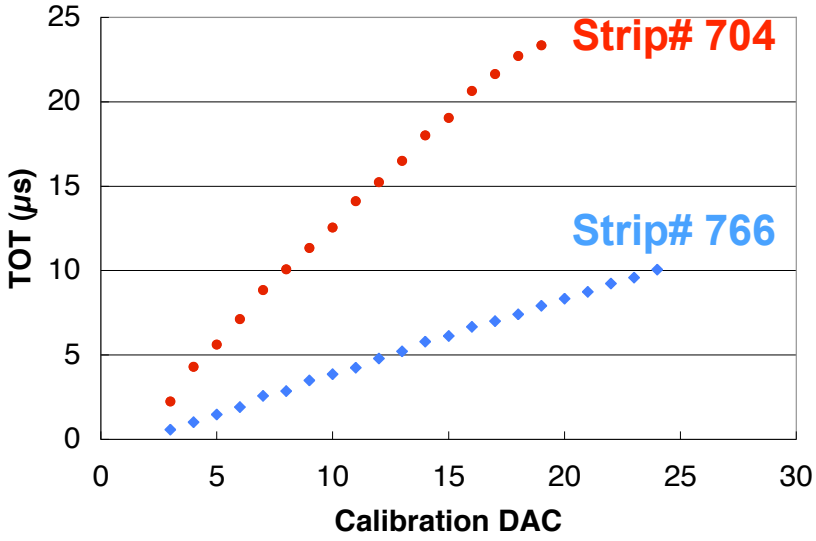




TOT-Charge Calibration

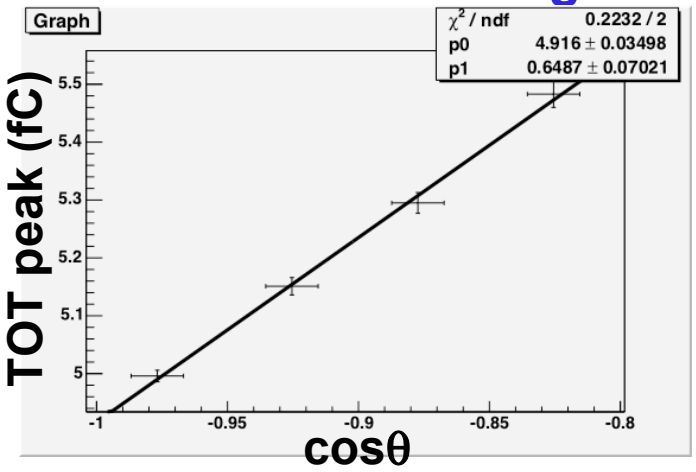
- **Charge injection test.**
  - **Measure TOT as a function of input charge.**
  - **Fit to second order polynomial.**
    - **Charge = p0 + p1*TOT + p2*TOT^2**
  - **Large dispersion of conversion parameters within GTFE.**
    - **Due to shaper circuitry limitation.**





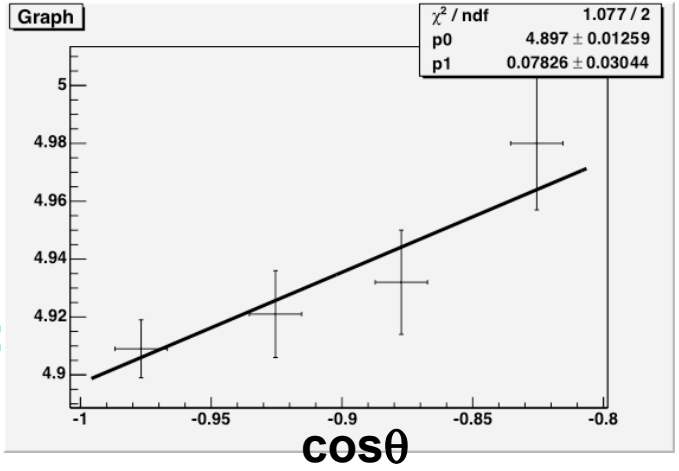
TOT Peak for Charge Scale Calibration

- **MC studies on incident angle dependence and bias.**
  - **Incident angle dependence.**

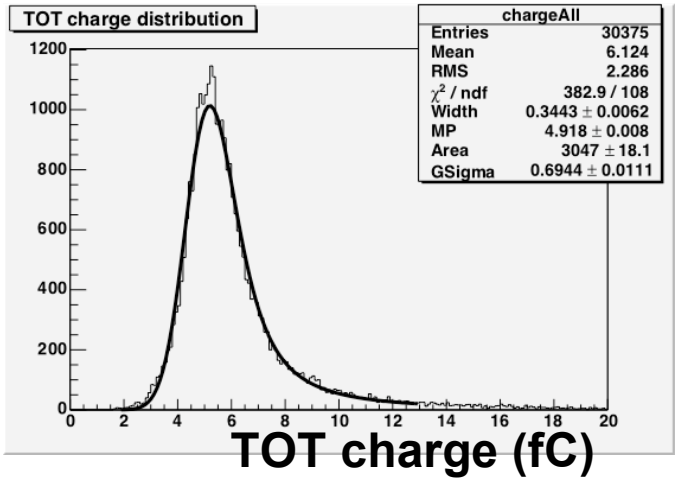


Before angle correction: 10% effect

After angle correction: 1% effect

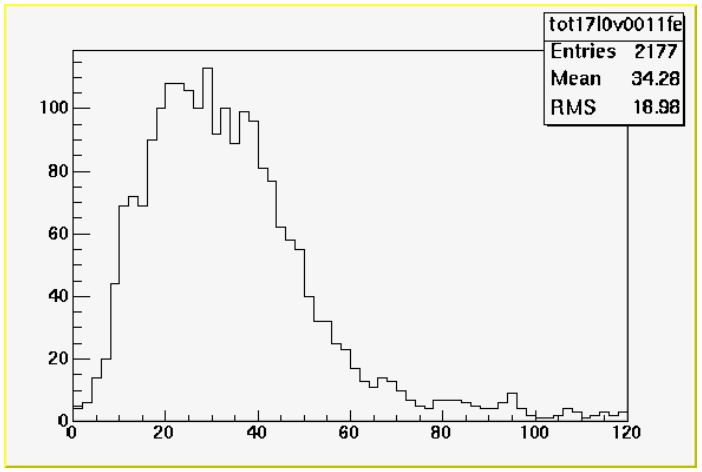


  - **Bias due to fit, charge sharing and angle correction**
    - **Peak at 4.92 fC**
    - **This bias is taken into account in charge scale calibration**
    - **Muon energy distribution could affect the peak.**

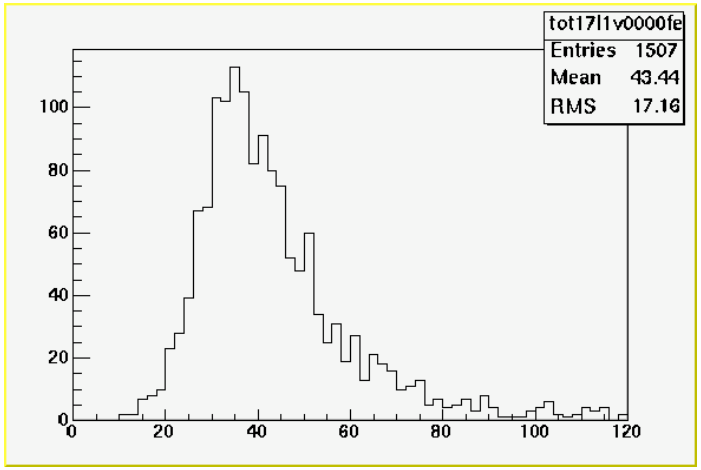


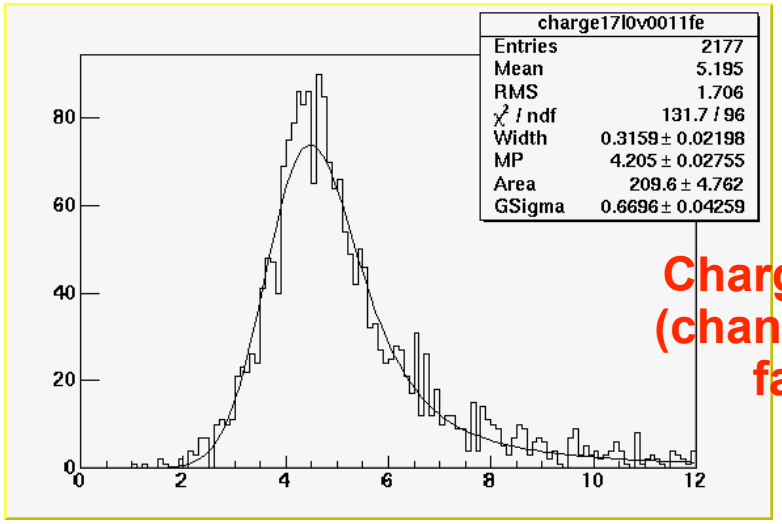
Charge Scale Calibration

- **Fit muon charge distribution for each GTFE.**
  - **Gaussian convolved Landau distribution.**

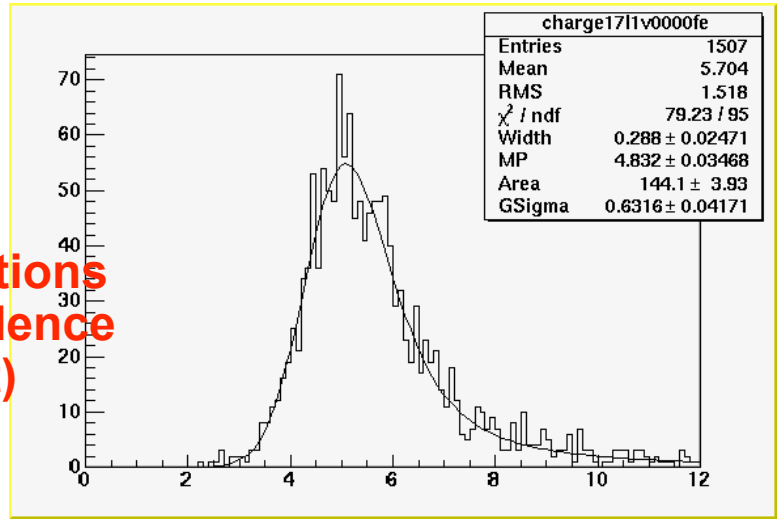


Raw TOT Distributions





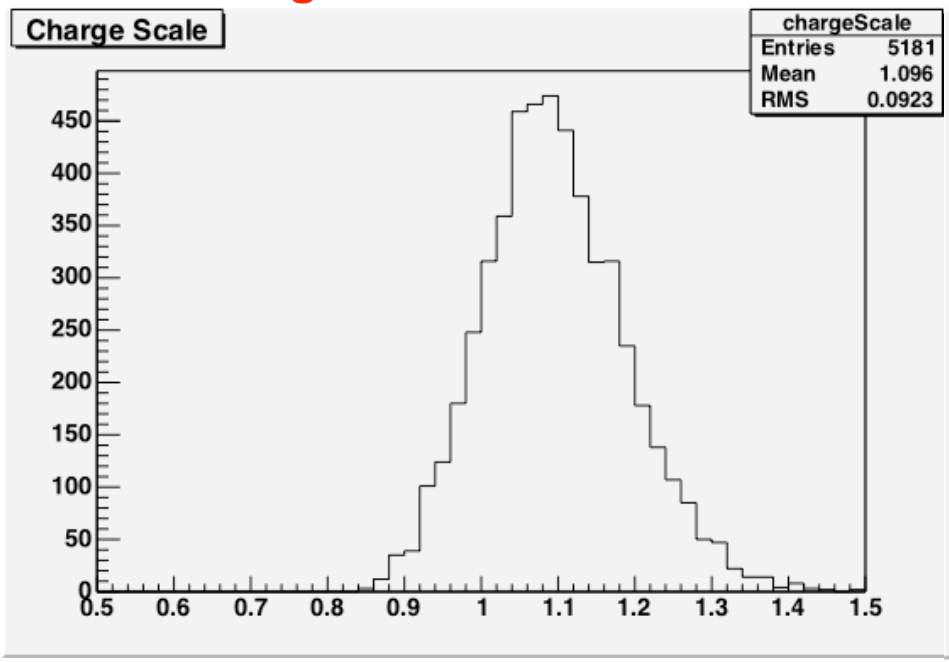
Charge Distributions (channel dependence factored out)



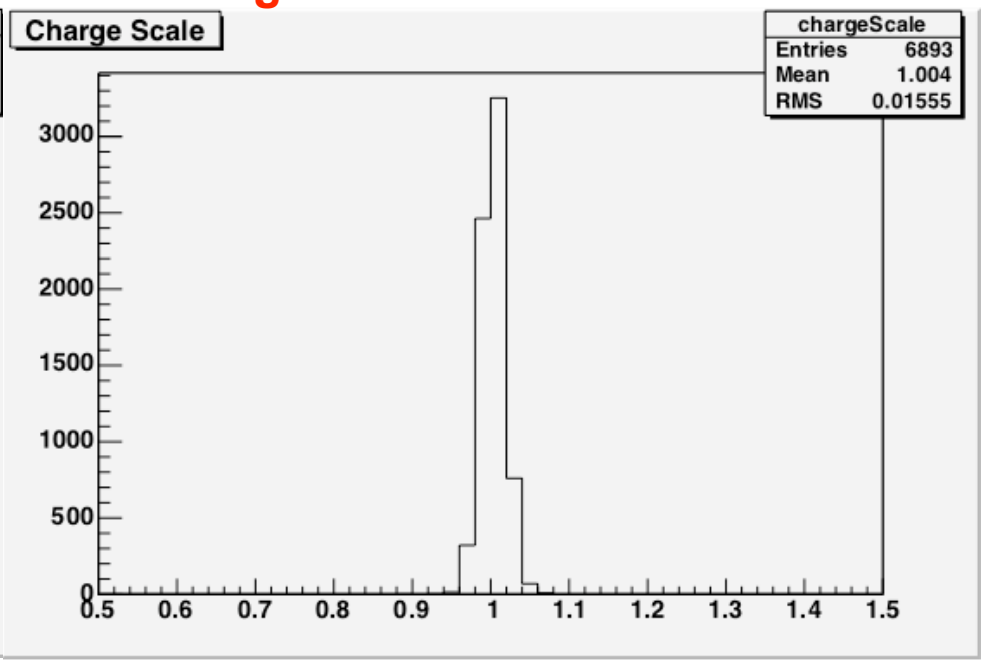
Charge Scale after TOT Calibrations

- **Definition of charge scale.**
  - **Plot ratio 4.92/peak. (4.92 fC is expected for MIP) (should be 1.0 if calibration is correctly applied.)**

Before charge scale calibration

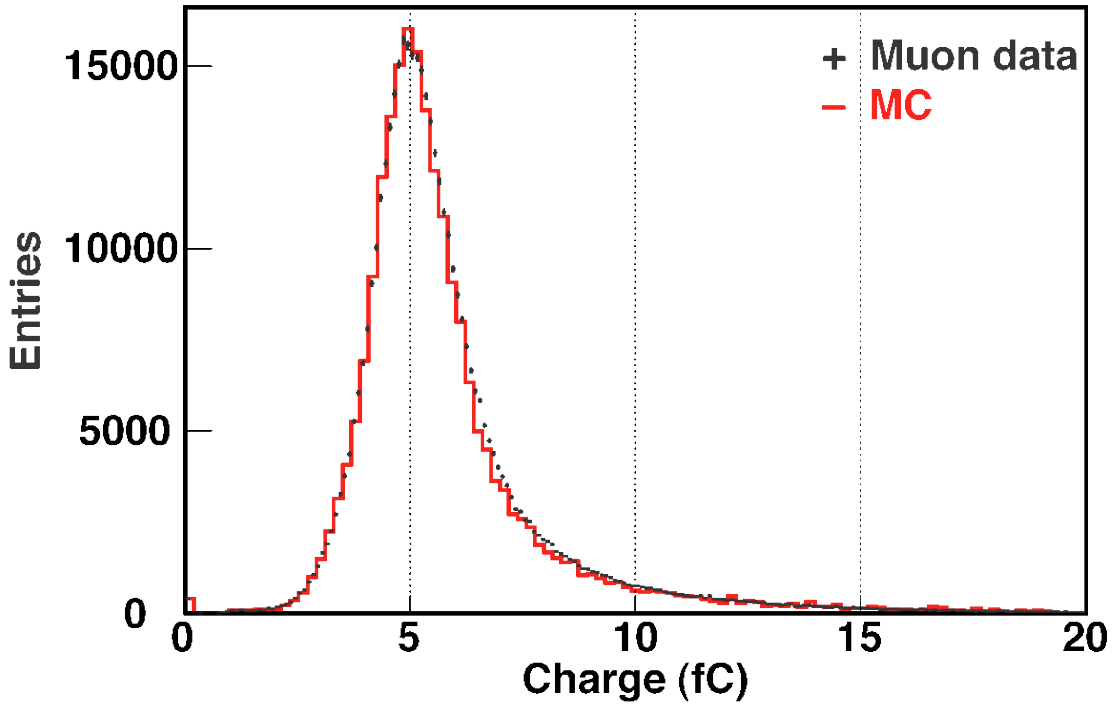


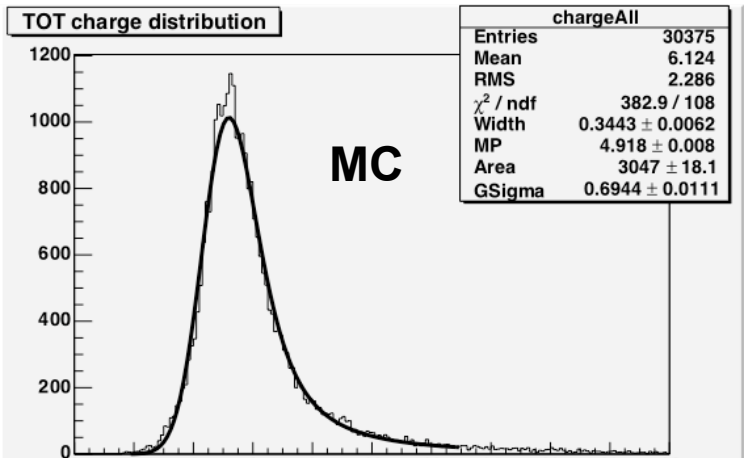
After charge scale calibration

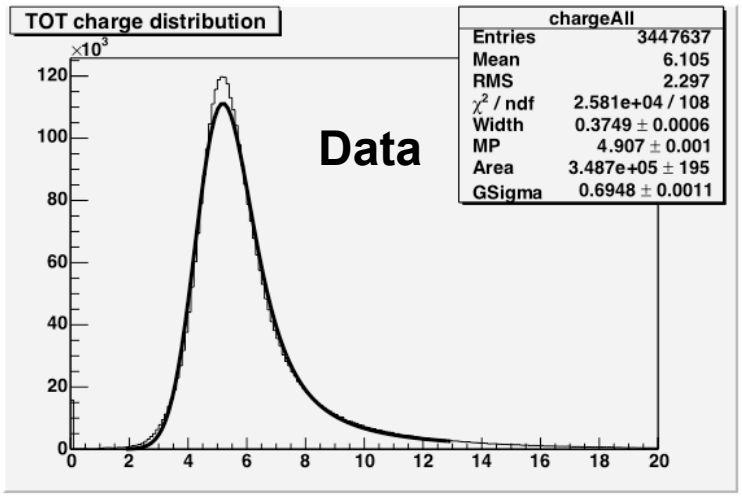


Data/MC Comparison: TOT Distribution

- **Fit parameters for data and MC are very similar**
  - **Gaussian convolved Landau distribution function**
  - **Peak at 4.91 : 4.92 fC**
  - **Landau width at 0.375 : 0.344**
  - **Gaussian sigma at 0.69 : 0.69**







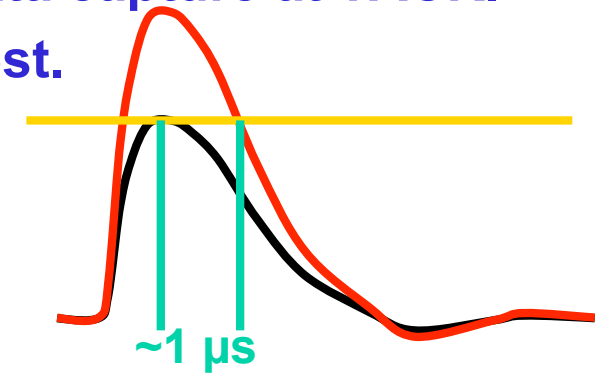
Effect of Calibration

- Threshold dispersion improves in the second iteration.
  - Order of 10% change due to charge scale.
- Change of TOT offset, gain and charge scale is minimal.
  - Stable against 10% level change of threshold.

Parameter	First Iteration		Second Iteration		Ratio, Xi(2nd)/Xi(1st)	
	Mean	RMS	Mean	RMS	Mean	RMS
Threshold	28.4	2.3	26.5	2.1	0.93	0.04
TOT offset (fC)	1.23	0.21	1.23	0.21	1.01	0.08
TOT gain (fC/μs)	0.59	0.14	0.59	0.14	1.00	0.04
Charge scale	1.11	0.09	1.10	0.10	1.01	0.02

Effective Data Threshold

- Effective data threshold is higher than the trigger threshold.
  - Trigger threshold: charge required to trigger at pulse peak.
  - Data threshold: charge required for data capture at TACK.
    - TACK: ~1 μs after the trigger request.



Trigger threshold
Mean: 1.43 fC
RMS(channel): 5.2%
RMS(GTFE): 2.7%

Data threshold
Mean: 1.58 fC
RMS(channel): 8%
RMS(GTFE): 7%