

# Muon g-2

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## Gain Systematics

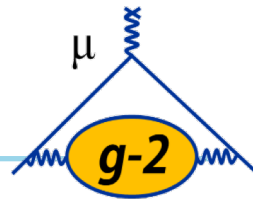
Matthias Smith

MUSE General Meeting

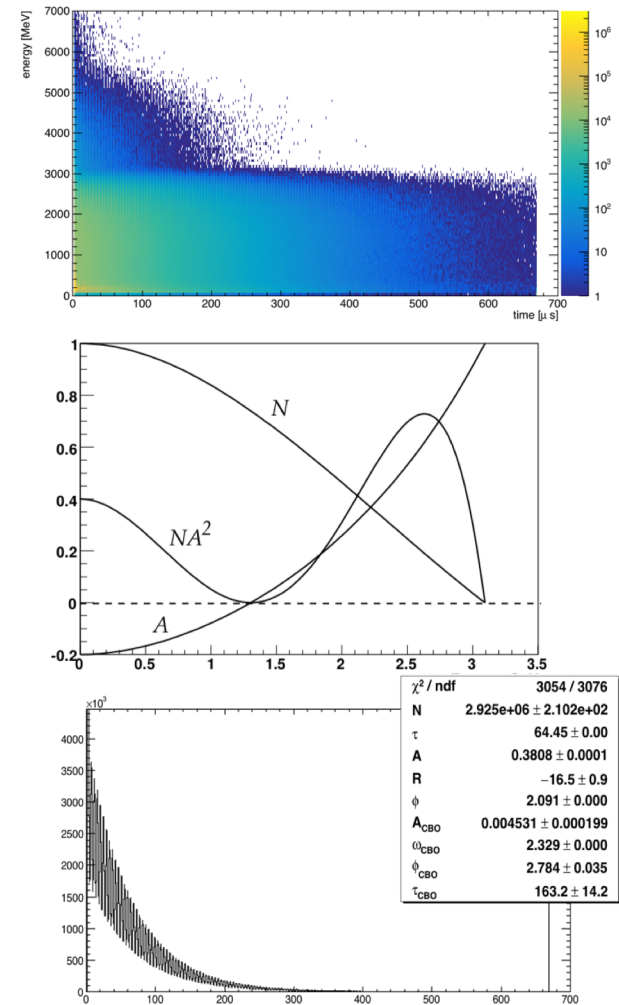
22 Oct 2018



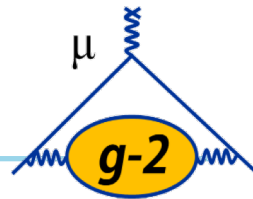
# Motivation for Gain Corrections



- Use an energy cut to create standard “wobble” plot
- Gain fluctuations smear this cut with possible systematic effects
- Rate dependent effects are anticipated which can cause early to late phase changes
- Goal:  $\delta G/G < 10^{-3}$  over 700  $\mu\text{s}$  fill

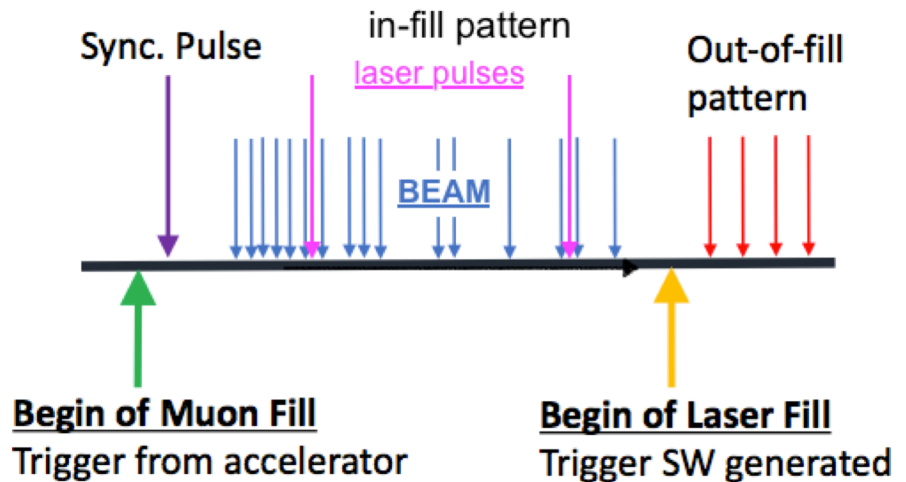
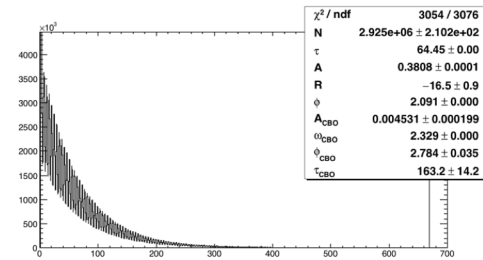


# Laser Gain Correction Philosophies

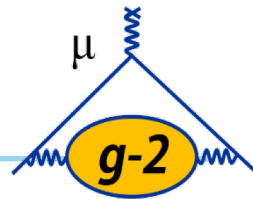


- Out-of-fill
  - Why? To correct the long-term gain variation (mostly temperature dependence of the SiPMs)
  - How? By firing the laser between fills
- In-fill
  - Why? To correct systematic gain shifts while positrons are present
  - How? By firing the laser within fills
- Double Pulse
  - Why? The SiPM gain drops after one pulse, so next could have lower energy
  - How? Separate DAQ mode to systematically vary E1, E2, dt

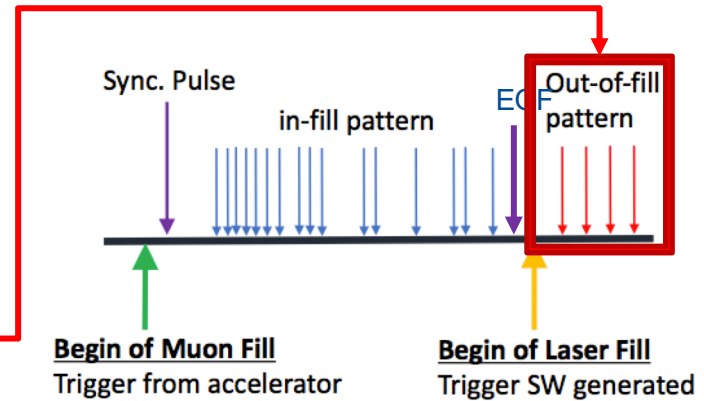
$\omega_a$  Wiggler Plot



# Out-of-fill Correction



- It corrects SiPM's gain fluctuations due to temperature variations using the **out-of-fill pulses**
- A correction factor for each of the 1296 calorimeters channels per subrun:



Correction every subrun	Avg. SiPM response to oof laser pulse	Laser fluctuations monitored with the SMs
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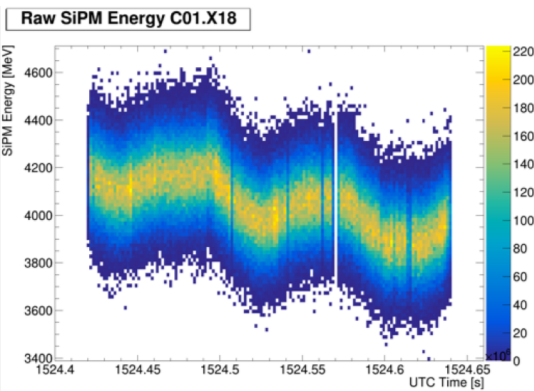
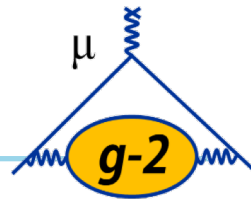
  

$$C^{OOF}(\text{subrun}) = \frac{G(\text{subrun})}{G_0} = \frac{L(\text{subrun})}{L_0} * \frac{SM_0}{SM(\text{subrun})}$$

NEW!

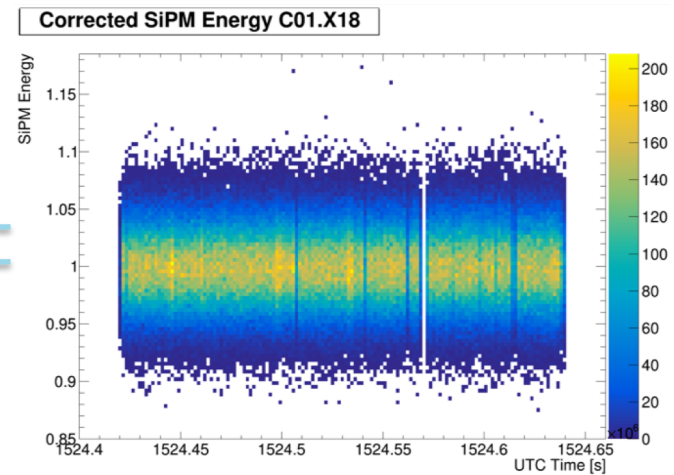
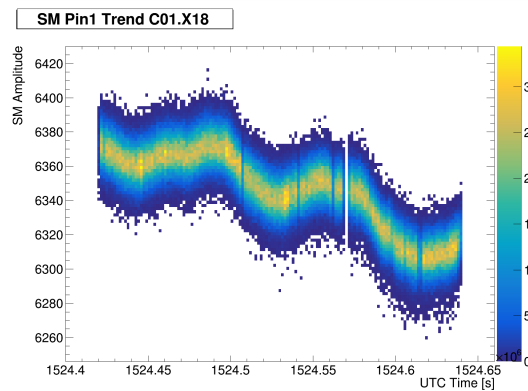
Correction wrt reference Run (same run used for energy calibration, 14395 for Run1 )

# Out-of-fill Correction Diagram

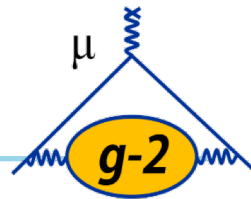


<SiPM>

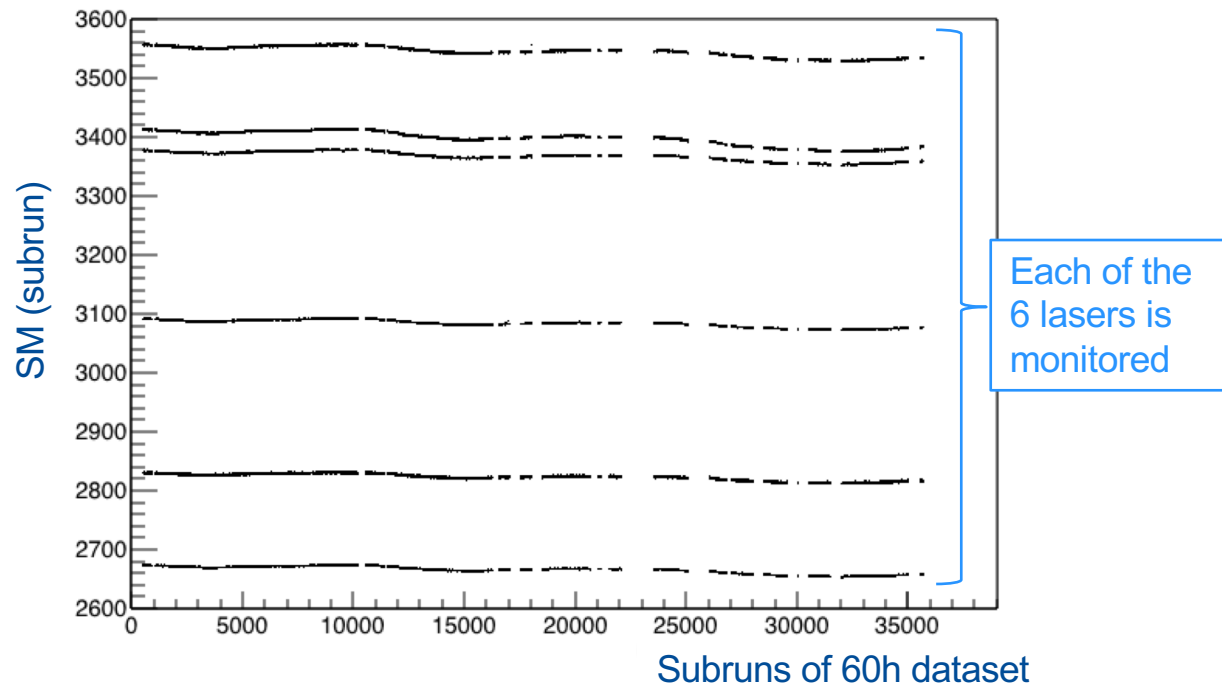
<Source Monitor>



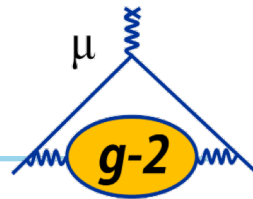
# Out-of-fill Correction for 60h Dataset



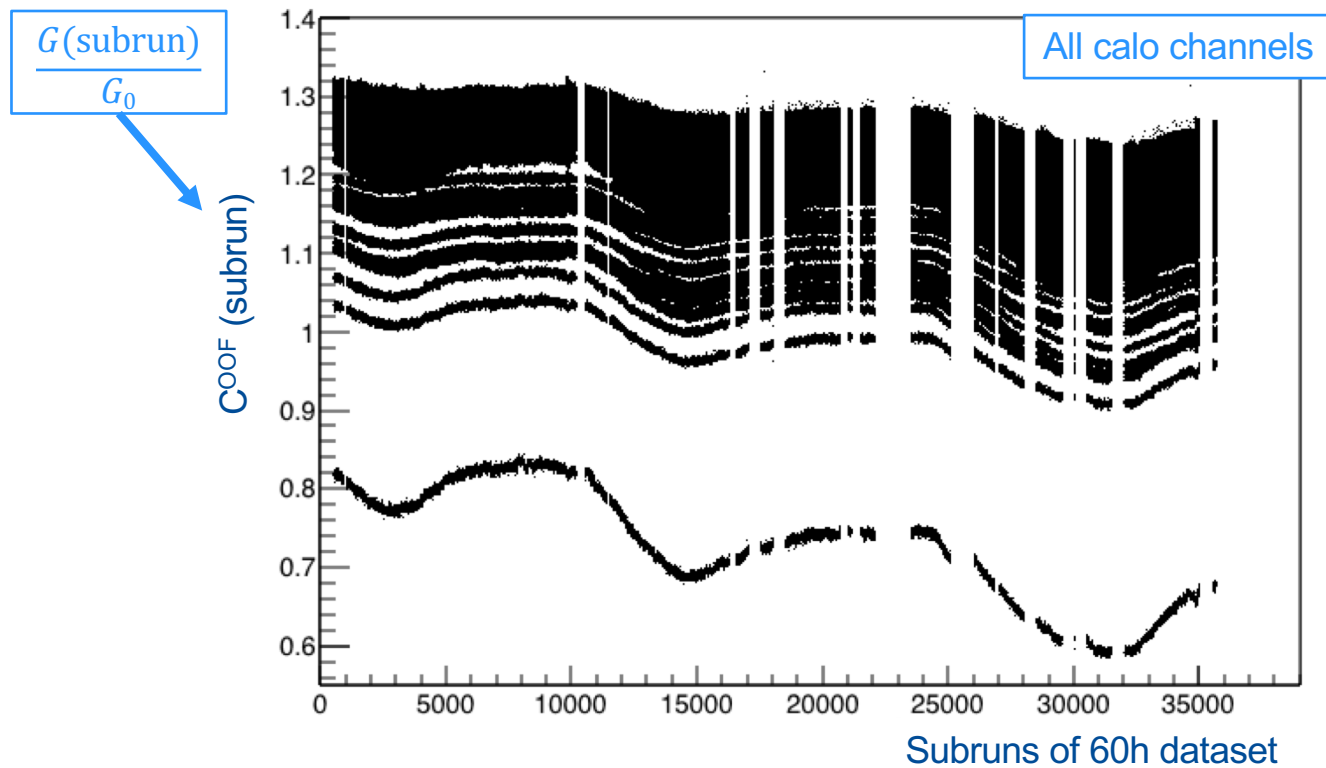
- Variation of the laser pulse amplitude:



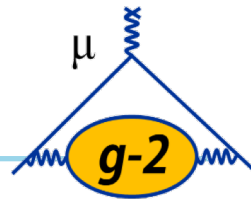
# Out-of-fill Correction for 60h Dataset



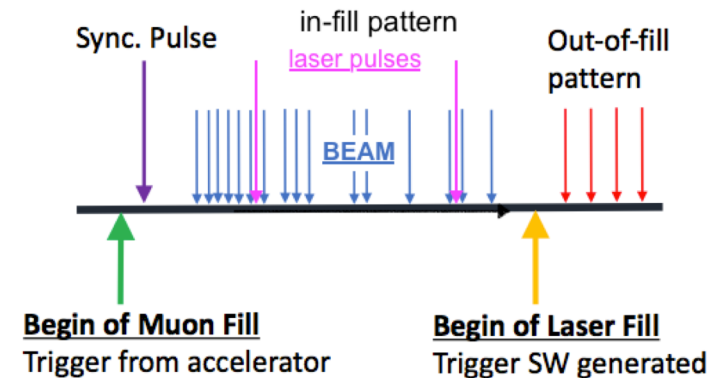
- The corrections wrt run 14395:



# In-fill Gain Correction

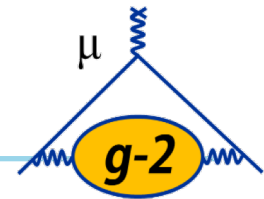


- Measure using laser pulses mixed with positrons in subset of fills
- Tunable Parameters
  - Prescale rate
  - Number of pulses per fill
  - Pulse Separation
  - Timing shift between subsequent probe pulses
  - Carves out gain function for any needed in-fill gain times and granularity





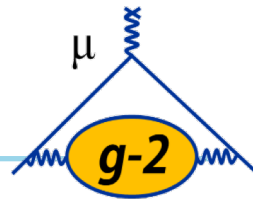
# In-fill Gain Correction Procedure



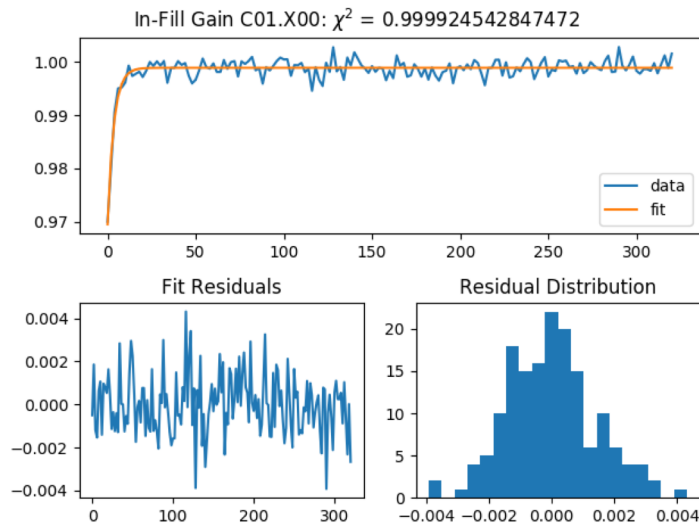
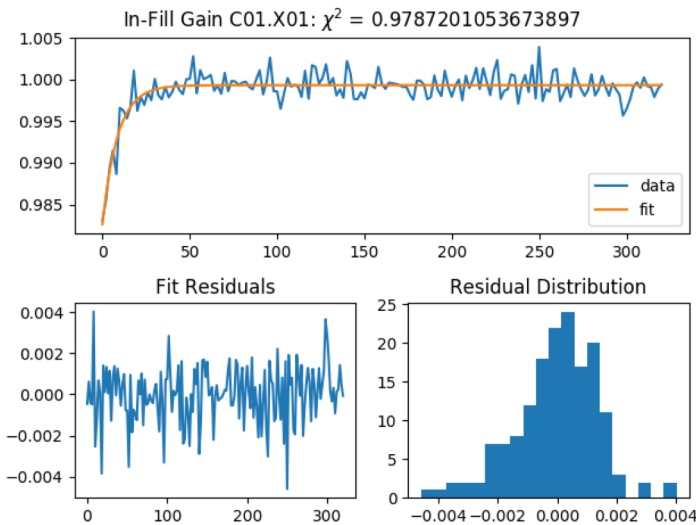
- Build using laser data
- Find algorithm to model function
- Apply model to data

$$G_{ifg}(t) = \frac{SiPM(t)}{\langle SiPM \rangle_{oof,subrun}} \frac{\langle SM \rangle_{oof,subrun}}{\langle SM \rangle_{if,subrun}} \frac{\langle SiPM \rangle_{oof,dataset}}{SiPM_0}$$

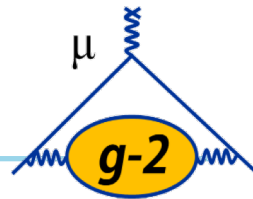
# Modeling the In-fill Gain Function



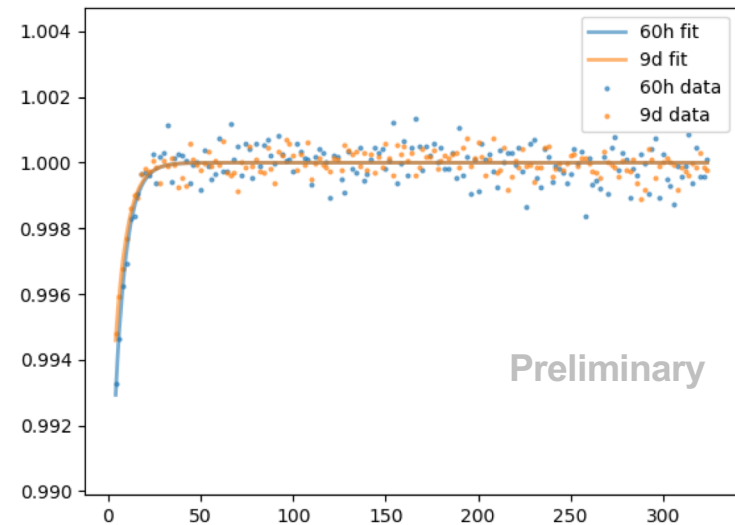
- Exponential decay
  - $f(t) = g (1 - a \exp[(t-t_0)/\tau])$



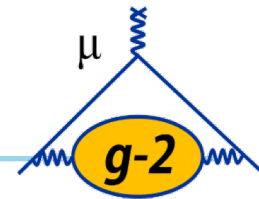
# In-fill Gain Function Stability



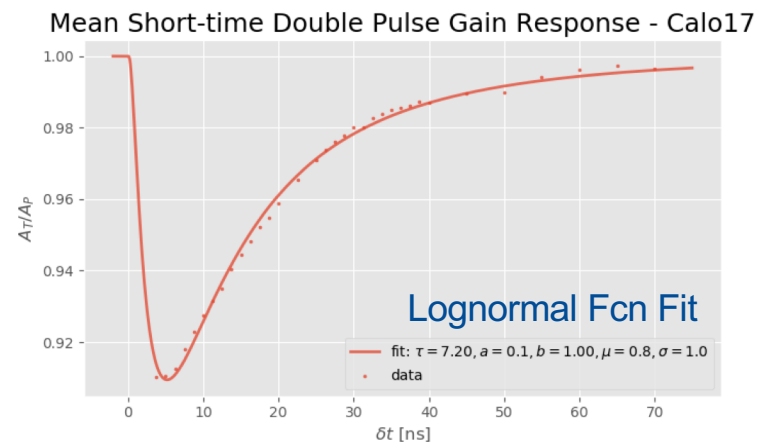
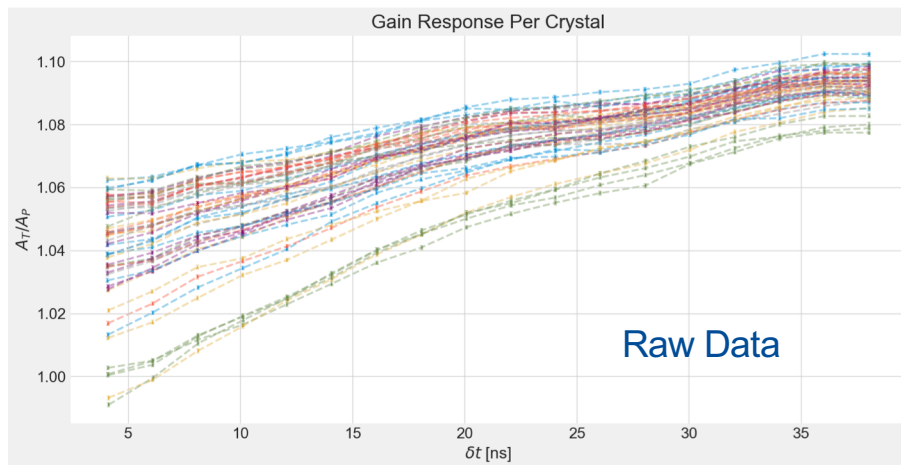
- Built the in-fill gain function for two different datasets
- Functions similar but not identical
- Must be modeled separately for each set of stable configurations



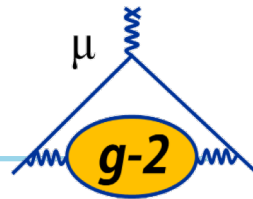
# Short-time Double Pulse Early Results



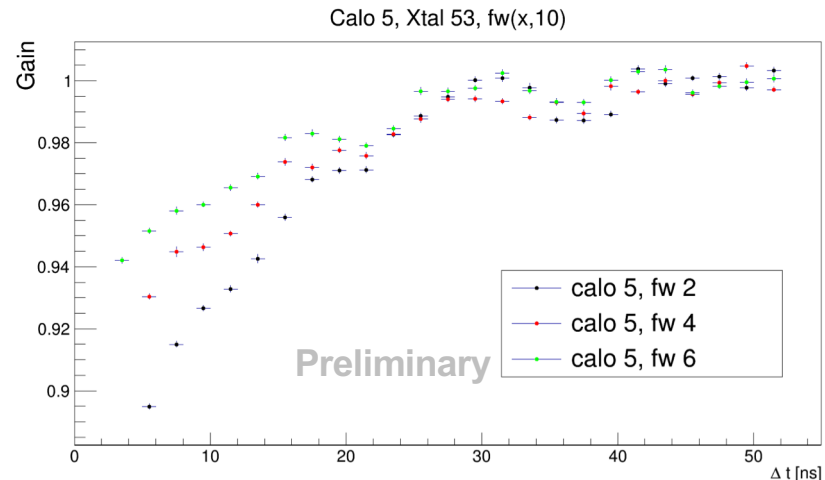
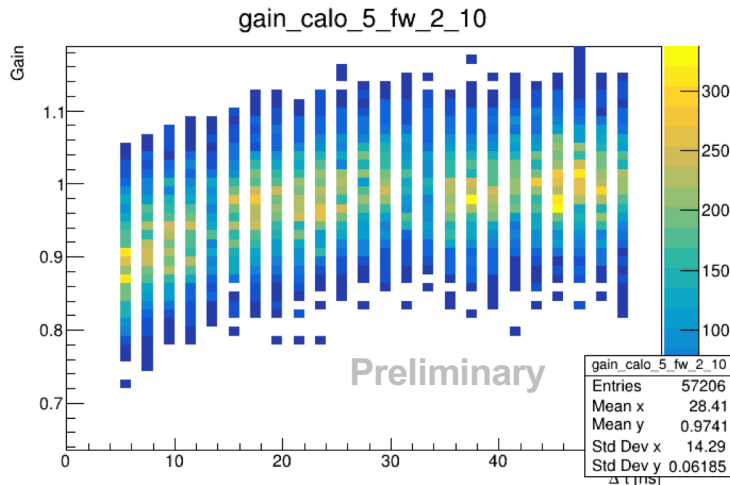
- Goal to build per crystal function
  - $G(E1, E2, \Delta t)$
- Summary Plots



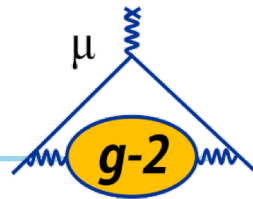
# Short-time Double Pulse Further Analysis



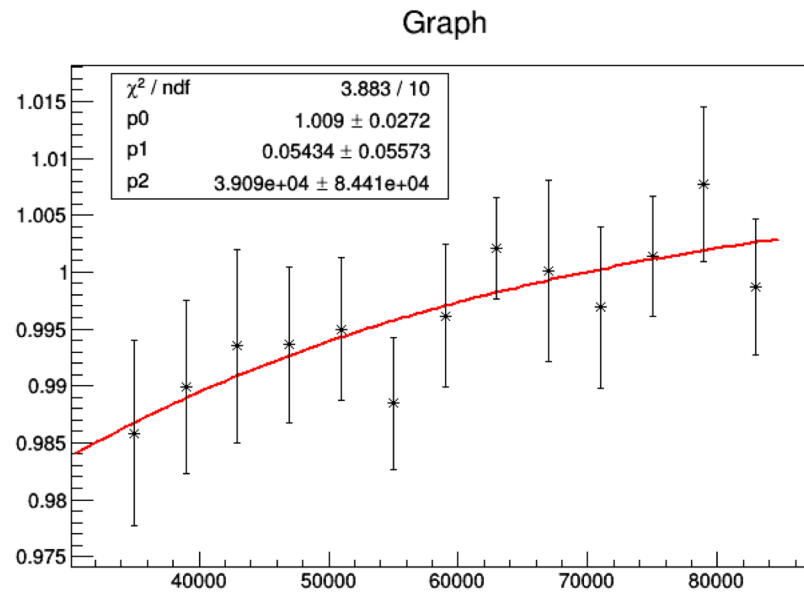
- Paolo Girotti analyzing datasets
- Data from March, new data in October



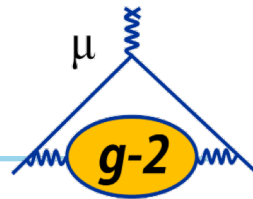
# Long-time Double Pulse Preliminary Result



- Being analyzed by Elia Bottalico



# Summary



- Monitor and model systematic gain changes at different time scales
- Out-of-fill Gain Correction model implemented
  - Achieves long timescale goal of  $< 1\%$
- In-fill Gain Correction model implemented
  - Able to model to gain fluctuations to  $\sim 0.05\%$  for 60h dataset
- Work for double-pulse corrections is ongoing