GMN analysis status

Andrew Puckett, UConn

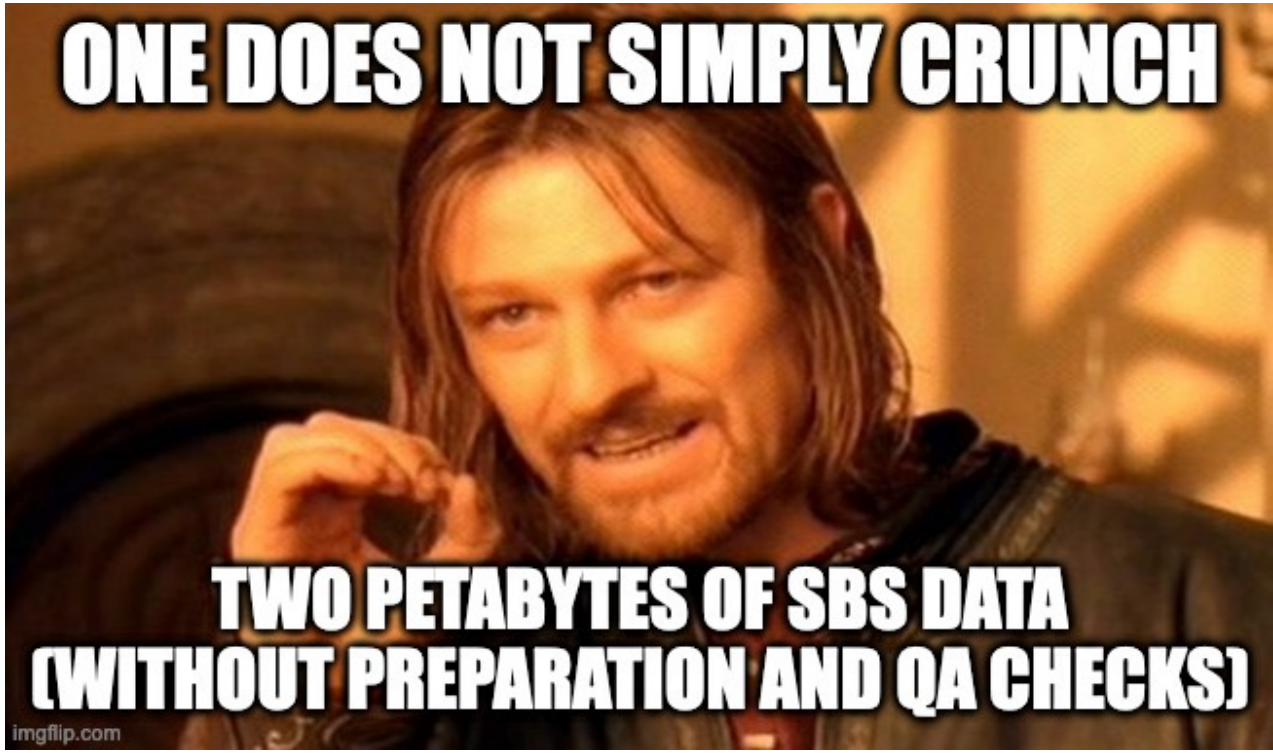
SBS Weekly Meeting

5/23/2022

UCONN

Summary of GMN analysis status

- First-pass calibrations for all kinematic settings are essentially complete:
  - Tracking
  - BigBite optics
  - BBCAL energy, position, and timing
  - HCAL energy, position, and timing
  - Hodoscope timing
  - GRINCH
  - Beamline*
- Present status: quality assurance testing of a representative subset of the data to certify readiness for full replay across kinematics and targets



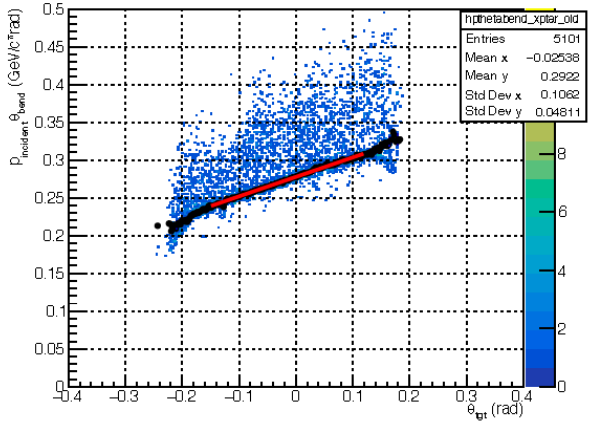
* Beam *charge* analysis is well calibrated, but beam *position* analysis will not be well calibrated in time for pass 1

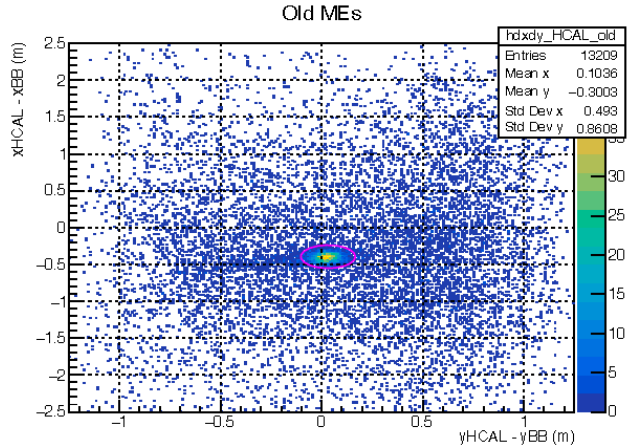
Timeline and Goals

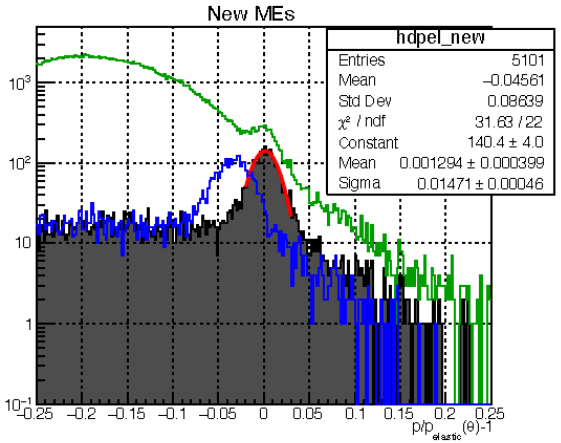
- The last major obstacle to launching “pass 1” cooking of the full dataset is the tracking quality assurance tests. This is presently my responsibility, and I will complete it this week
- The goal is to complete (or at least start) all or most of the full replays for “pass 1” before the Users’ Meeting.
- Physics analysis and GMN extraction machinery are not yet sufficiently developed to expect preliminary results that we could show at the Users’ Meeting. We are still working on getting event reconstruction/PID/elastic event selection cuts in place.
- Assuming no major surprises in QA testing or delays in batch farm throughput, we will freeze the “pass 1 release” versions of the SBS-offline code and SBS-replay databases by this Friday (May 27)

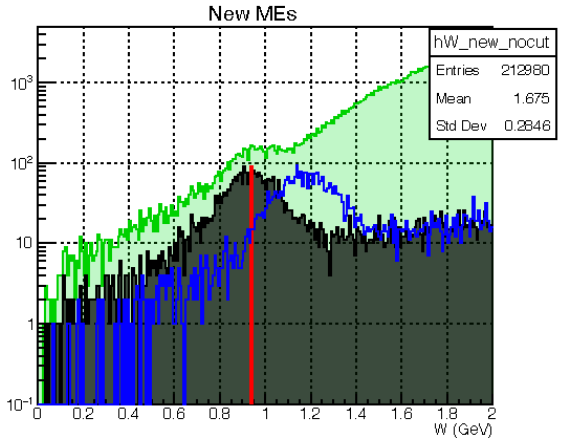
Recent Analysis Highlights and Developments

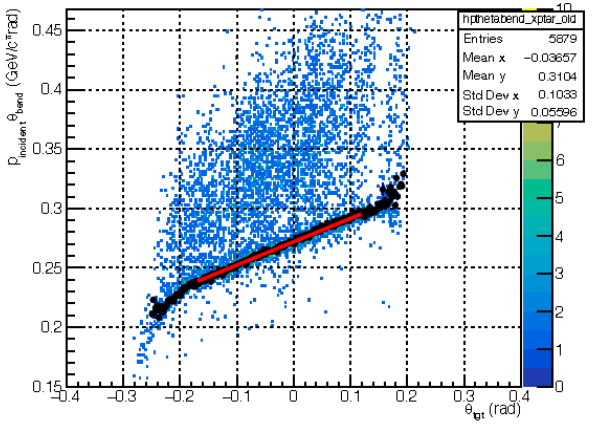
BigBite Momentum Calibration using LH_2 elastic @10 and 13.6 GeV^2

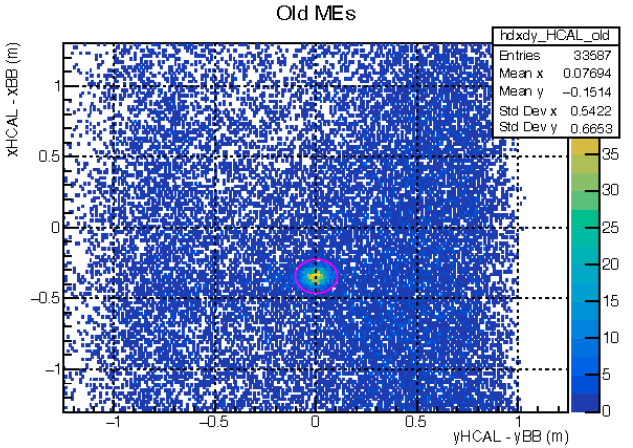


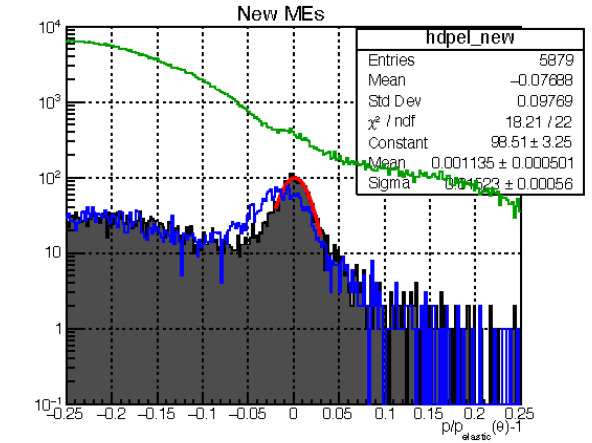


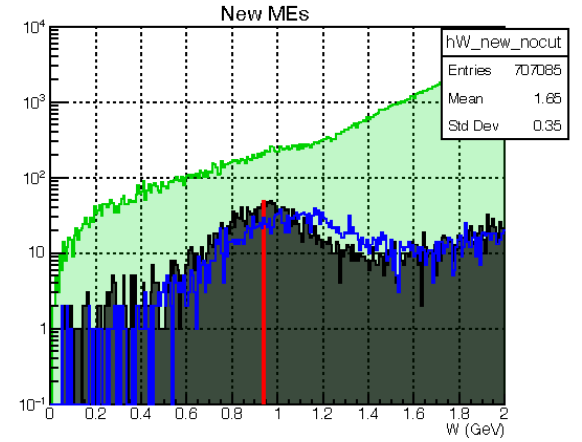








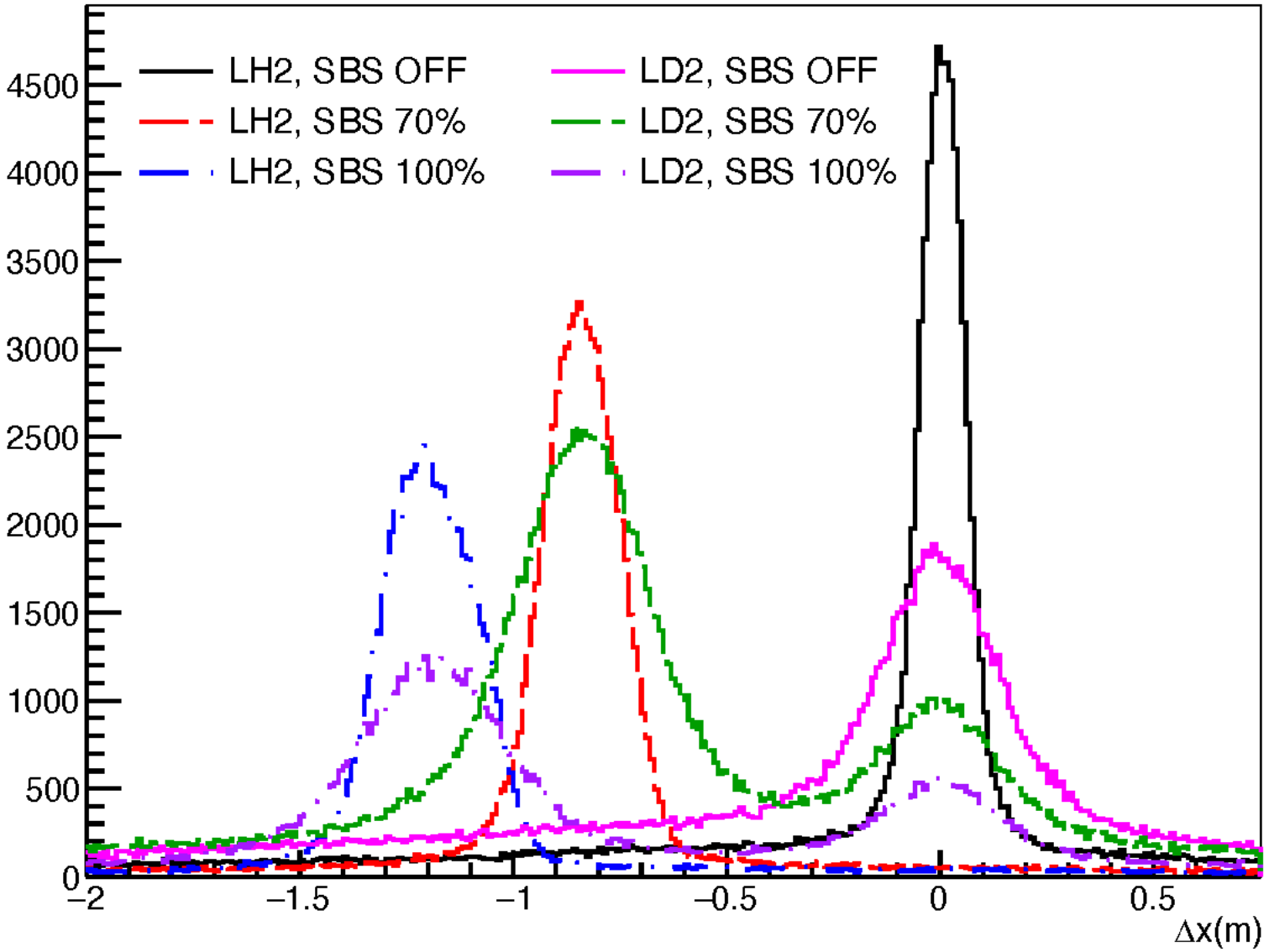




$Q^2 = 10\ GeV^2$ (SBS-7)

$Q^2 = 13.6\ GeV^2$ (SBS-11)

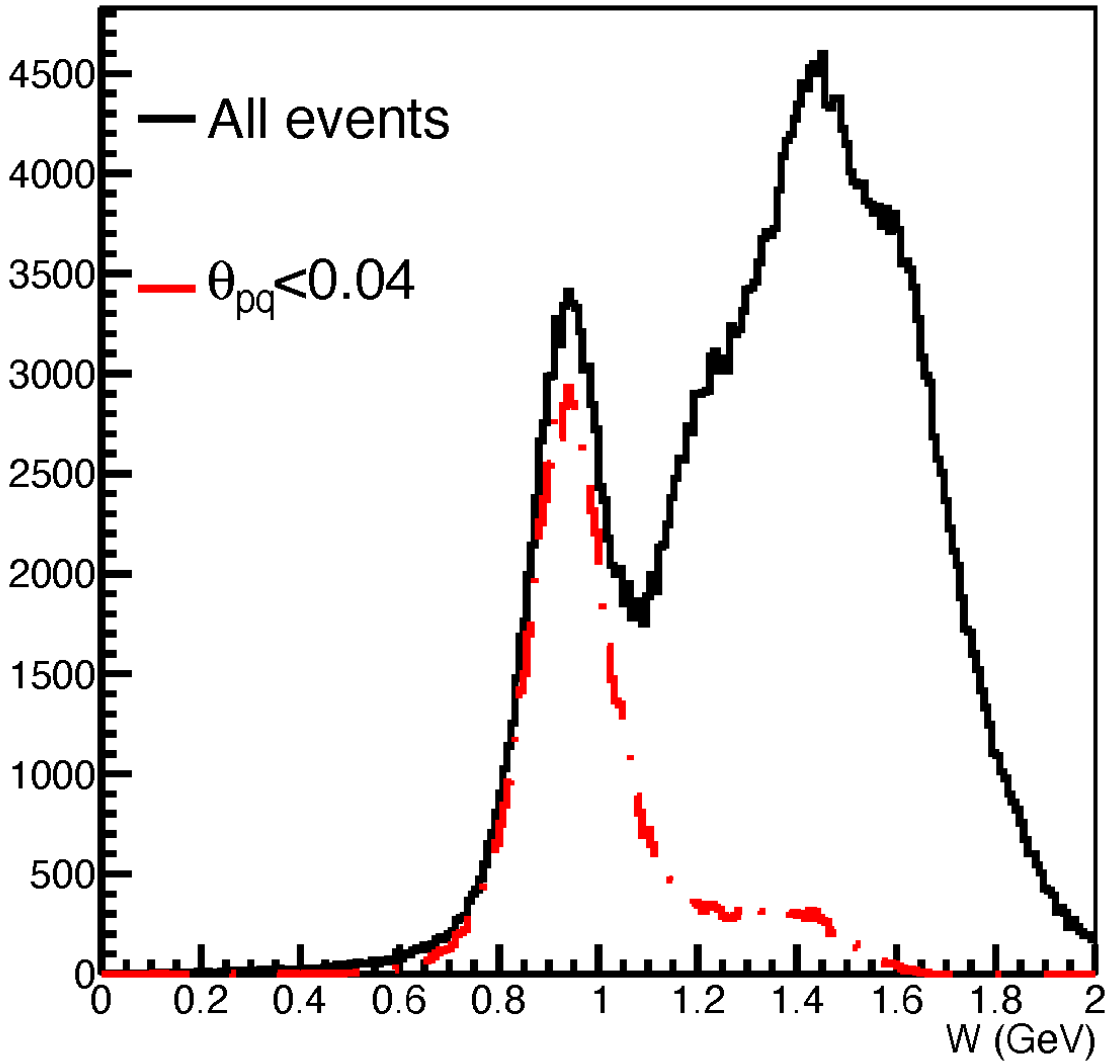
Elastic and Quasi-Elastic Event Selection, SBS-8 ($Q^2 = 4.5\ GeV^2, E = 6\ GeV$)



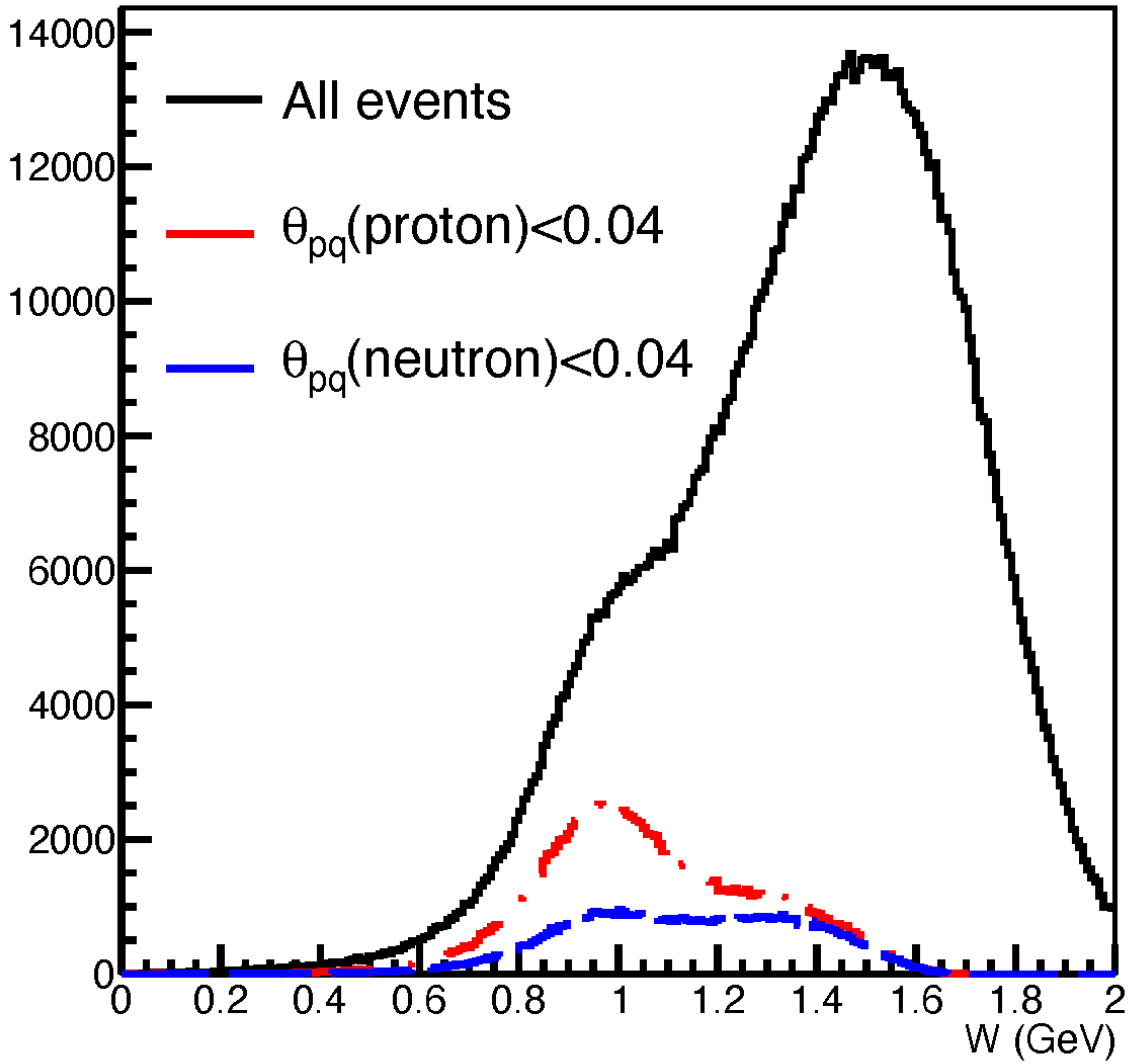
- Vertical deflection of protons for LH2 and LD2 targets as a function of SBS field setting:
  - LH2 distributions show only the elastic proton peak, width determined by detector resolution and momentum dispersion of SBS
  - LD2 distributions show proton and (undeflected) neutron peak, width dominated by Fermi smearing

LH2 and LD2 invariant mass distributions, SBS-8

LH2



LD2

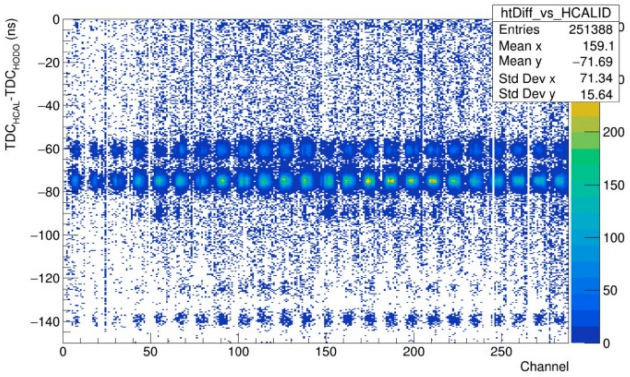


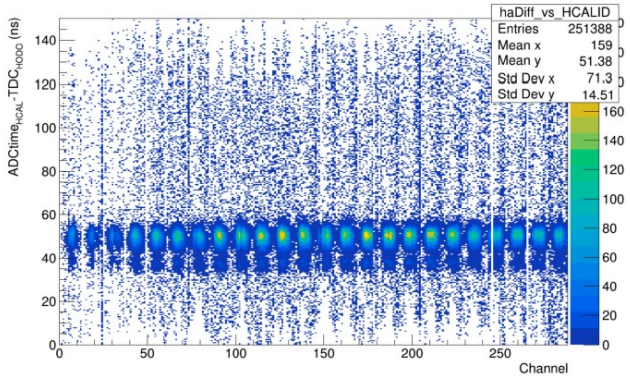
HCAL Calibrations, I (Sebastian Seeds, UConn)

HCal Calibration Quality Checks - Alignment

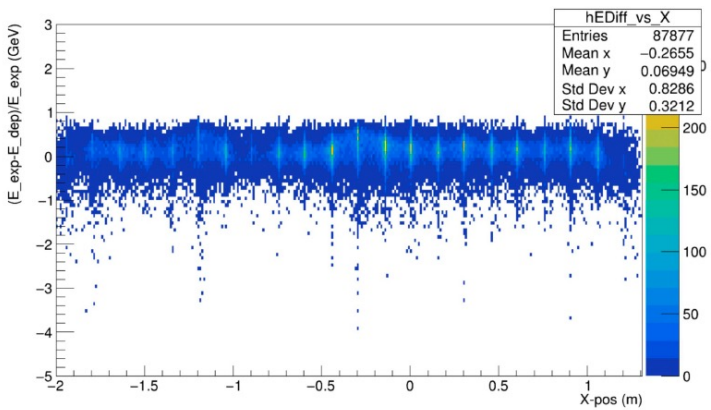
1. Calibration Quality Checks
   a. Timing (SBS4, LH2)
      i. Quasi-elastic cuts and hodoscope max cut on clusters
      ii. Corrected with TOF and average timewalk by PMT type
      iii. Channels aligned with means from ~3.5M events
      iv. Will check again after replay for better statistics
   b. Energy (SBS8, LH2)
      i. Quasi-elastic cuts
      ii. (Reconstructed Energy from q-vector) - (Energy deposited in cluster)
      iii. Channels aligned via diagonalization of matrix elements from ~11.5M events

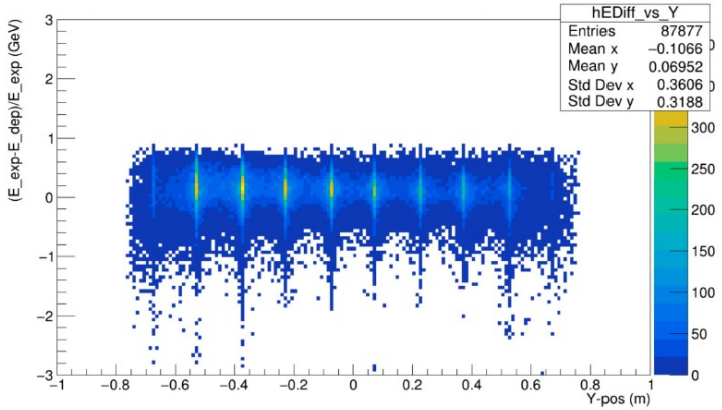
Timing Alignments





Energy Calibrations

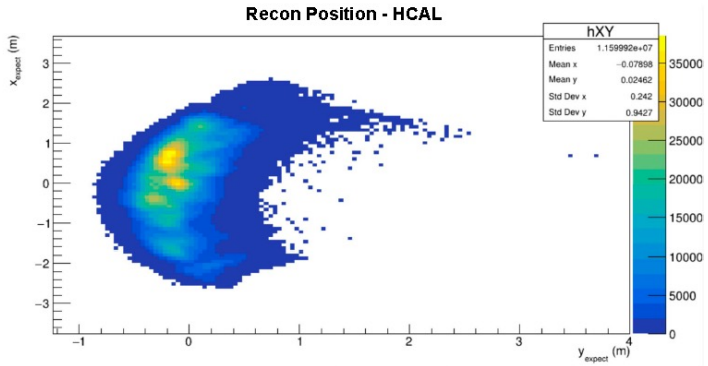


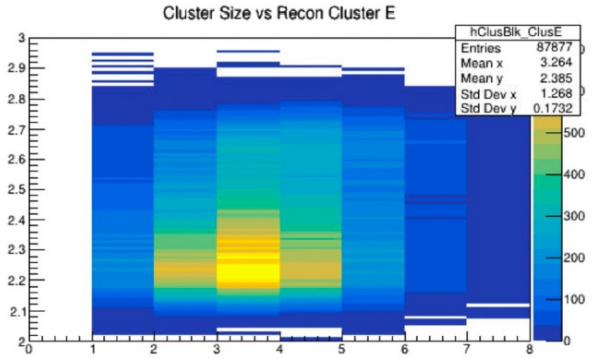


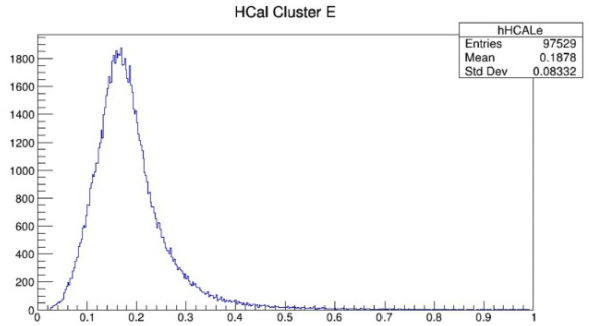
HCAL Calibrations, II

Calibration Quality Checks Elastic Cuts

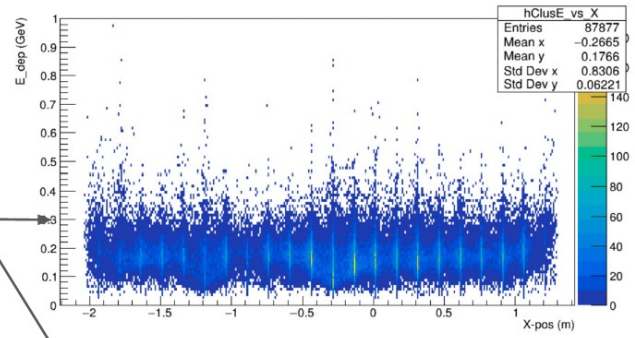
1. Calibration Quality Checks
   a. Cluster Size vs Rec E
   b. Cluster Energy
      i. Global and vs position
   c. Reconstructed hadron position on HCal

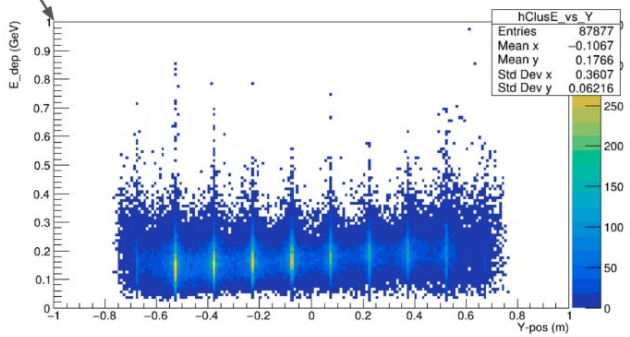






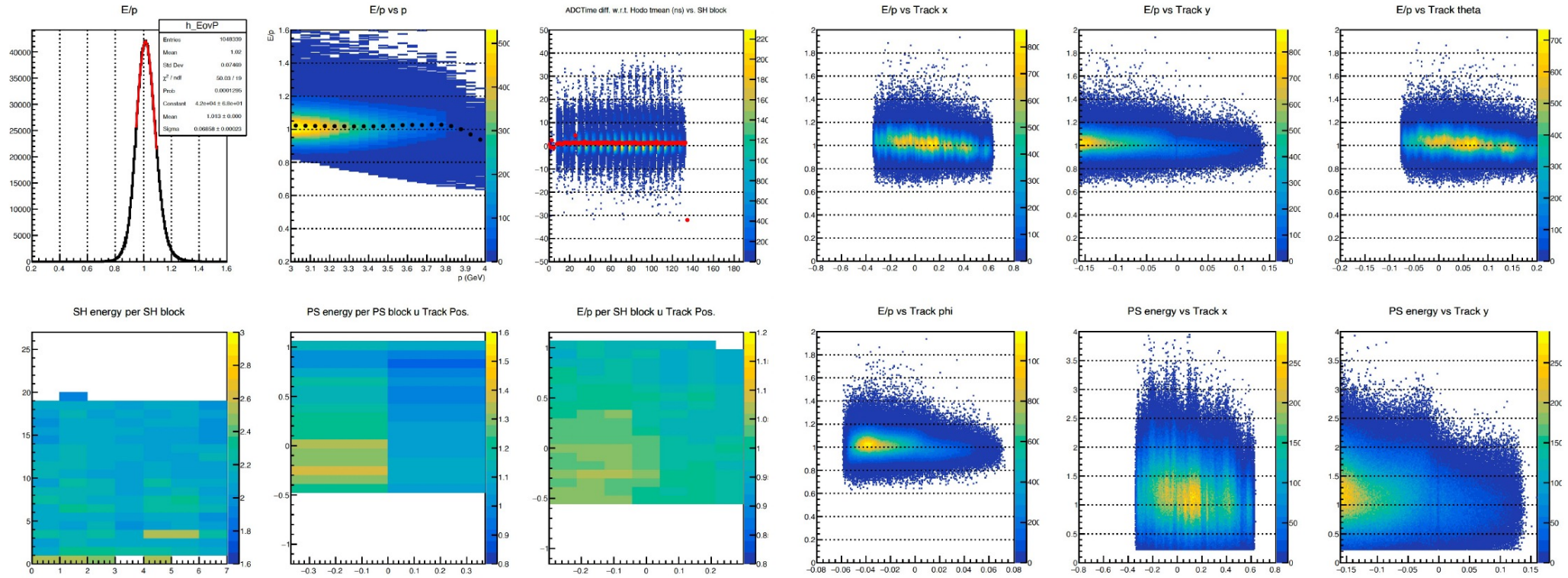
Dep E vs Position





BBCAL Calibrations and QA checks (Provakar Datta, UConn)

Quality Assurance (QA) Plots (SBS4, 30% SBS filed)

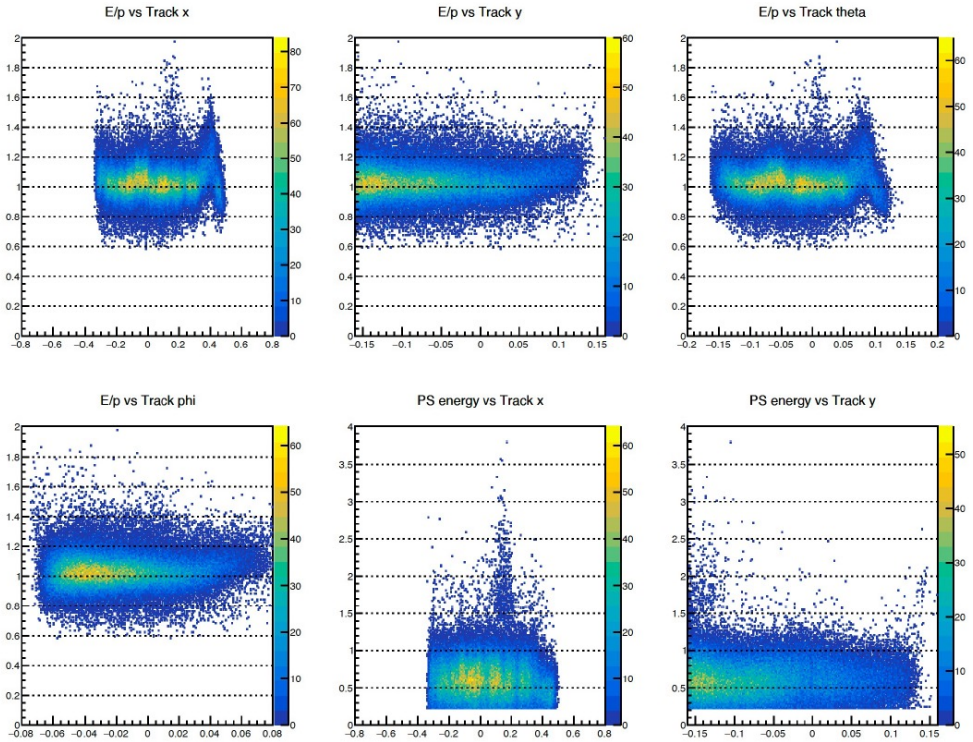


- Updated BBCAL QA script generates more interesting plots.
- The script, qaualityA_plots_BBCAL.C, can be found in SBS-replay/scripts/bbcal/ .

BBCAL energy calibrations improving…

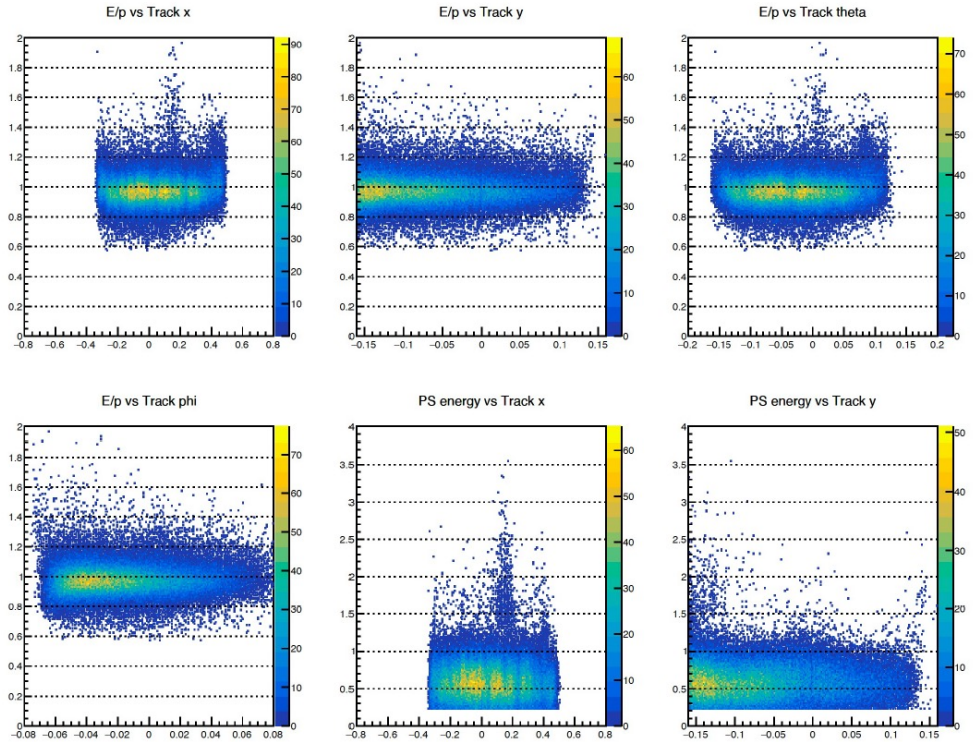
Issues with SBS9 Calibration

Before



- Weird correlations between E/p and track variables.

After

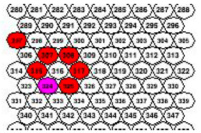


- Weirdness gone after recalibration.

GRINCH analysis (Maria Satnik, W&M)

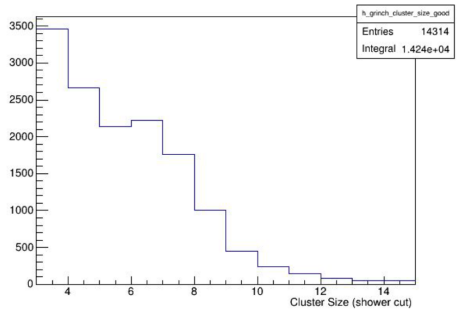
Cluster Finding and Efficiencies

13460 89% Effiency (was 69% using only the first hit as before)



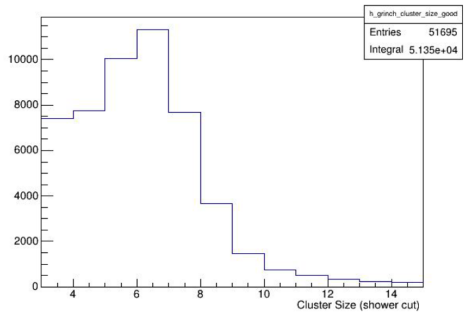
Example of Cluster Size 6

Cluster Size Before: First Hit Selected



Run 13620, first hit selected

Cluster Size Now: All good Hits from multi-hit TDC



Run 13460, all good hits

Background Estimates

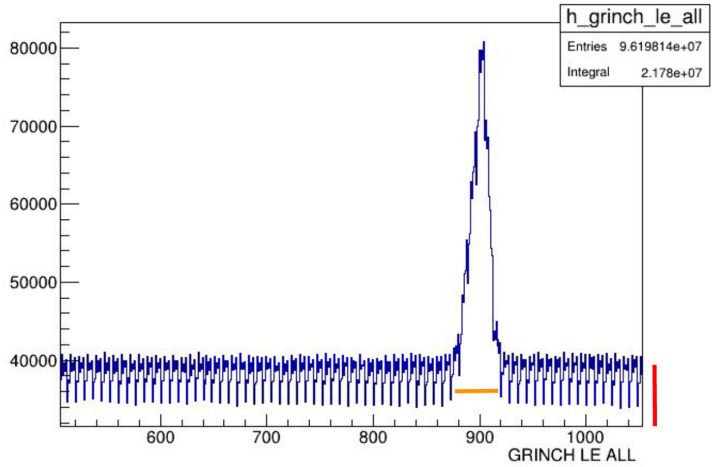
390000 hits/bin of "junk", 1 ns bins, 40 ns window where "real" events are expected.

390000 x 40 = 1560000 "junk" hits expected in the time cut window.

2382000 total hits in that 40ns window (integral)

1560000/2382000 = 0.65

About 65% of the hits that pass our time cut are expected to be "junk".

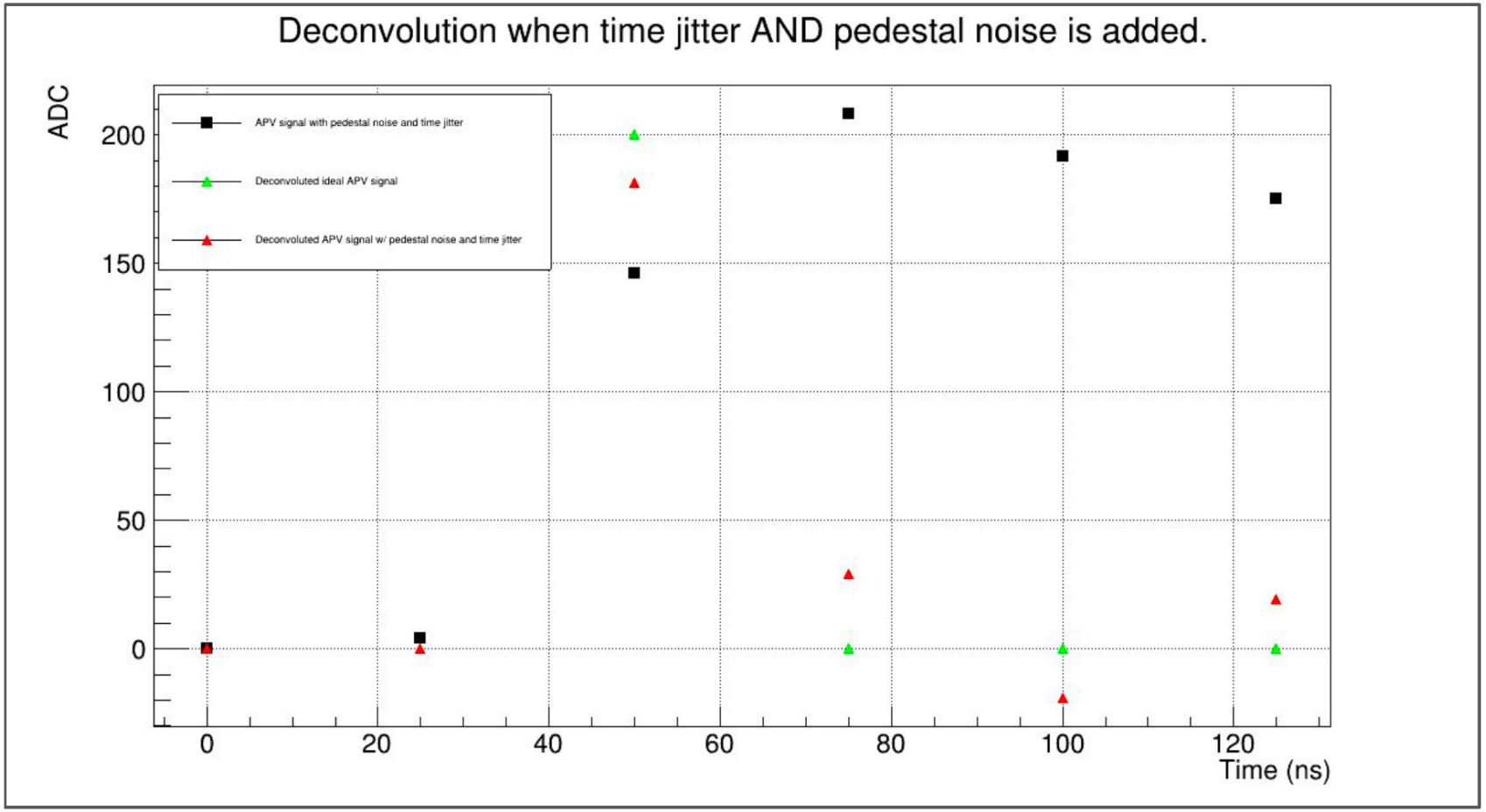


LE for all the hits (on the multi-hit tdc) and all 510 PMTs, Run 13460

- Clustering and efficiency studies (left)
- Preliminary rate and occupancy analysis (right)

Simulation of GEM time sample deconvolution (Anuruddha Rathnayake, UVA)

Simulation results - Deconvolution for a MIP APV signal arriving at t=25 ns w when time jitter AND pedestal noise are added into the APV signal



Other currently ongoing efforts

- Timing hodoscope calibrations and analysis:
  - Ralph Marinaro, Glasgow U.
- GEM (software) Gain Matching: Ezekiel Wertz, W&M
- GEM common-mode correction studies (and developing improvements for future experiments): Sean Jeffas (UVA) and A. Puckett
- GEM Cross-Talk analysis and corrections: John Boyd (UVA)
- Beam position and beam charge analysis: Nathaniel Lashley-Colthirst (Hampton) and David Flay (JLab).
- Developing GMN Monte Carlo Simulations for physics analysis:
  - E. Fuchey, Provakar Datta (UConn)
- Improving understanding of GEM background rates/occupancies/high-rate analysis/comparison to simulation:
  - Andrew Puckett, Sean Jeffas, Weizhi Xiong, Eric Fuchey, other GEM and software experts.

Summary and Conclusions

- We are still on track to finish (or mostly finish) the first-pass "cooking" of the GMN data set before the Users' Meeting, which is our (self-imposed) goal. However, the timeline to complete this is getting short, and we don't yet have experience with the batch farm turnaround time for such a large dataset.
  - We also want to avoid rushing the first pass out the door and making costly mistakes that waste JLab compute resources.
- Our weekly software and analysis meetings are well-attended and productive. Progress of student-led analysis efforts is monitored and regular feedback/expert input is provided. Each of the 8 GMN/nTPE thesis students is reporting once every 4 weeks.
- There is much to do, and we welcome involvement of additional collaborators.