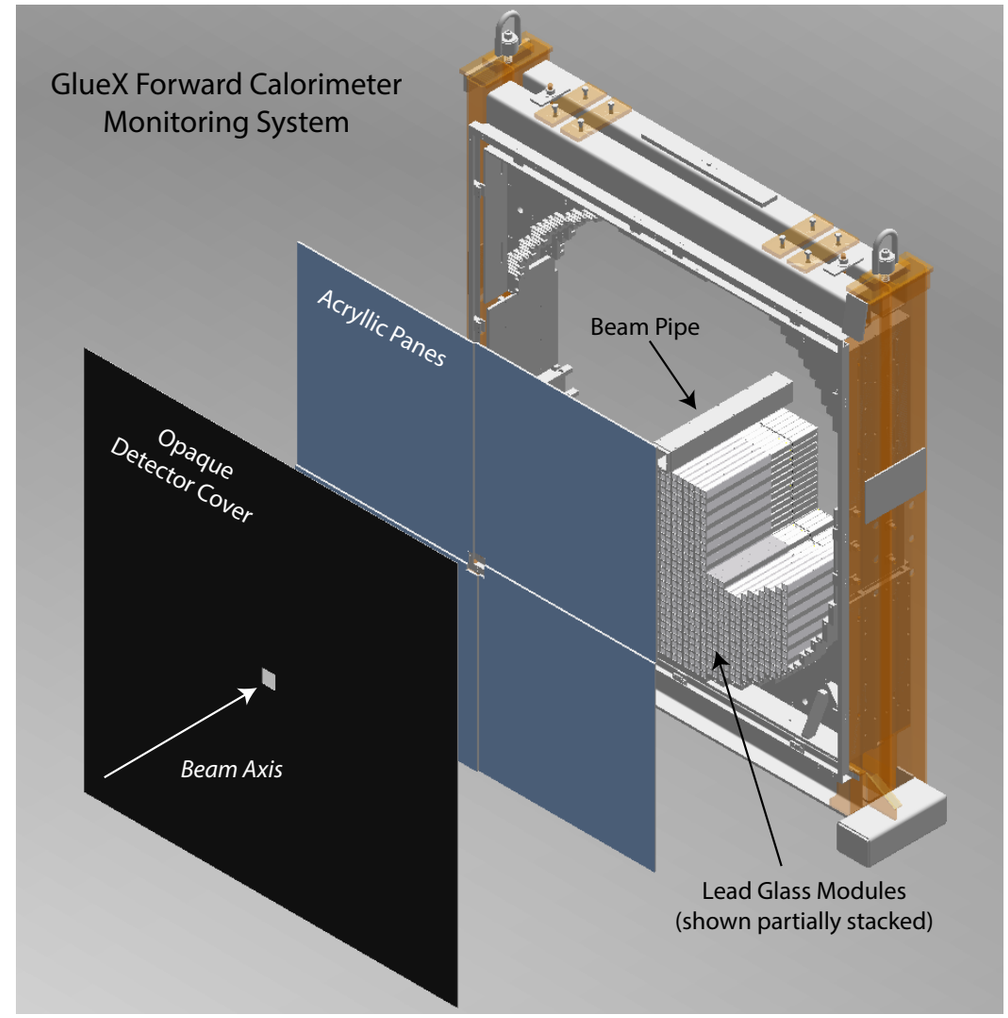
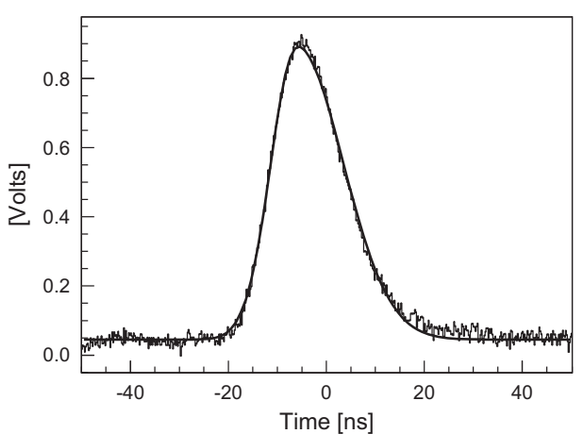
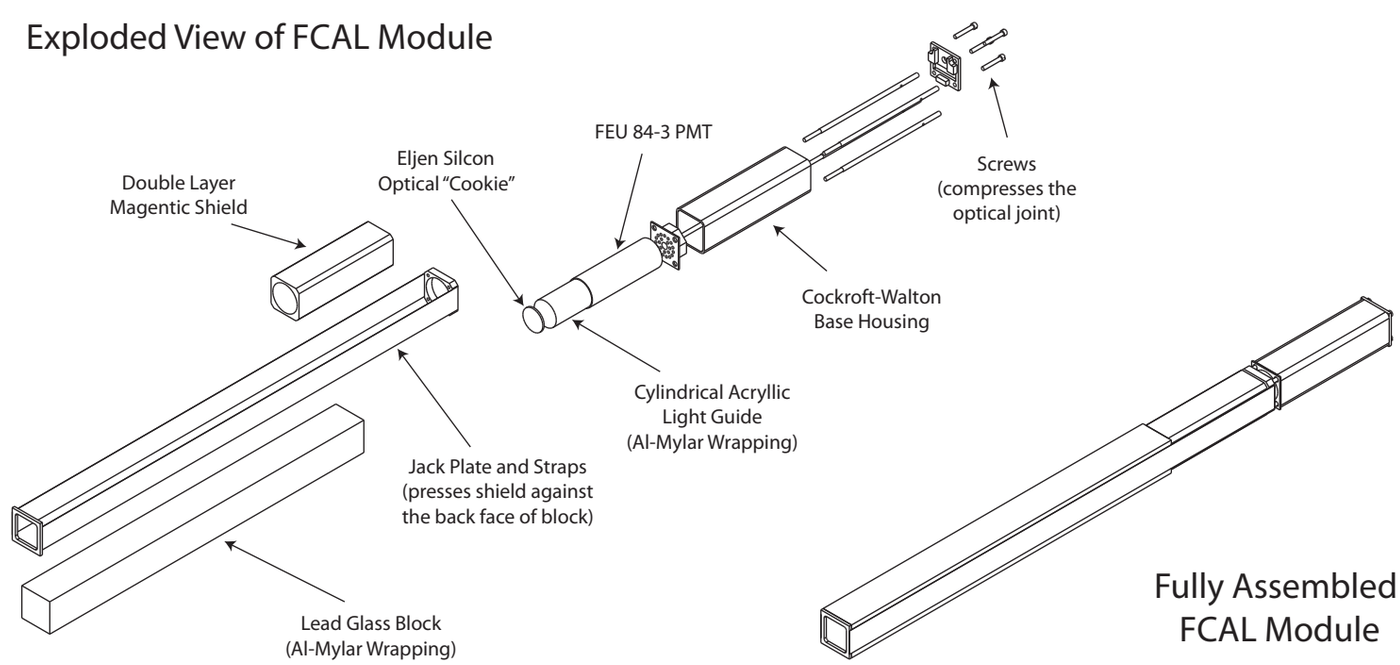
FCAL

- PMT pulses are digitized with a flash ADC
- For those channels above some programmed threshold provide energy and time
- PMT HV is used to make hardware adjustments to gain







FCAL Calibration and Monitoring

- Types of calibrations:
  - Block level: convert electronics signals into physics signals
  - Shower level: calibrates detector response to photons as a function of their energy or position
- Calibration inputs:
  - Physics events: π^0 decays are particularly useful
- Monitoring inputs (provides online diagnostic tool; time independent signal):
  - PMT base voltage and temperature
  - Response to (electronic only) PMT base pulser
  - Response to LED monitoring pulses (adjustable wavelength)

FCAL Block Calibration Strategy

Measure

- PMT pulse integral
- relative PMT pulse arrival time at fADC
- Block location

Reconstruction Input

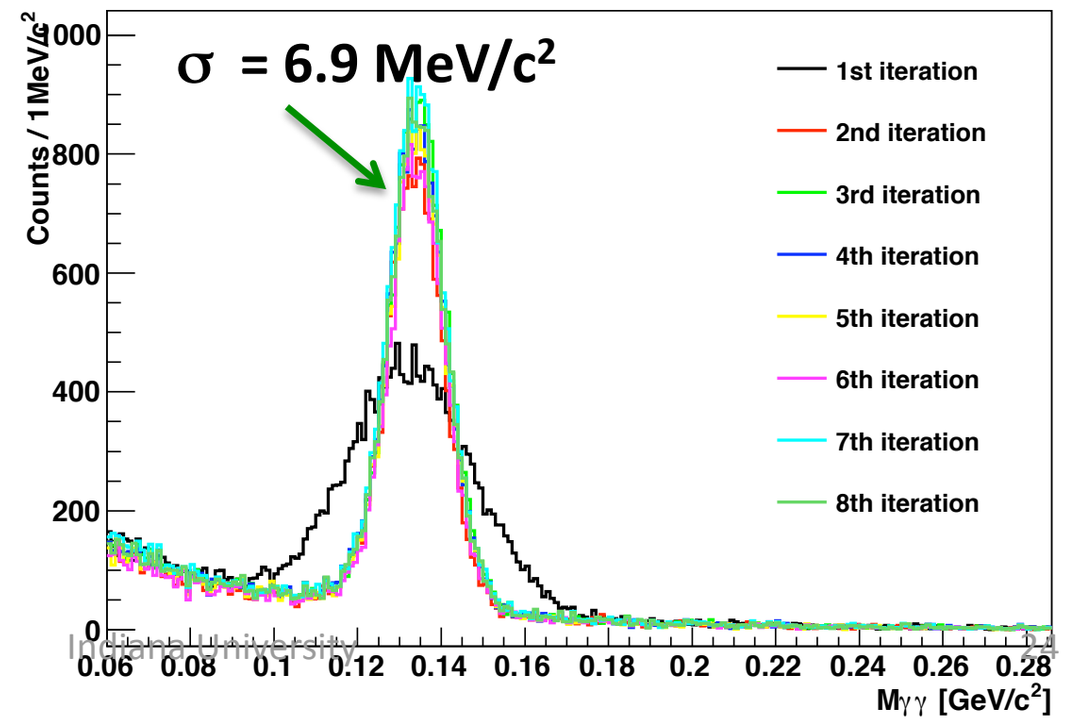
- Energy deposition in block
- absolute time of energy deposition in bar
- Position of block relative to beam

Calibration and Alignment

- 2800 multiplicative gain constants
- 2800 timing offsets
- 3-5 numbers to specify position of array (survey sufficient)

FCAL Block Gain Calibration

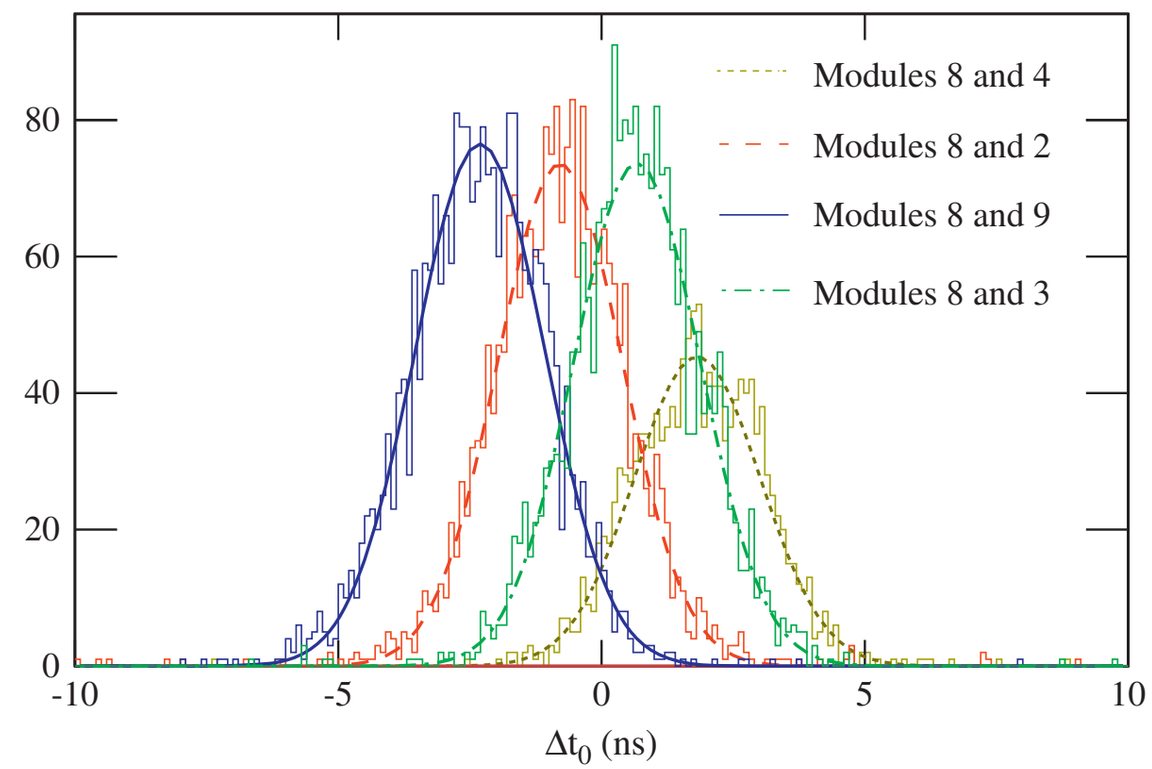
- Use recipe outline by R.T. Jones *et al.* in NIM A 566, 366 (2006) developed for RadPhi
- Adjust block scale factor to minimize width and set scale of γγ invariant mass for π^0 decay candidates
- Iterative process; minor technical bumps in implementation
  - inversion of 2800 element matrix is slow



Procedure tested by Claire Tarbert using ~3 hours of beam at 10^7 γ/s
GlueX-doc-1615

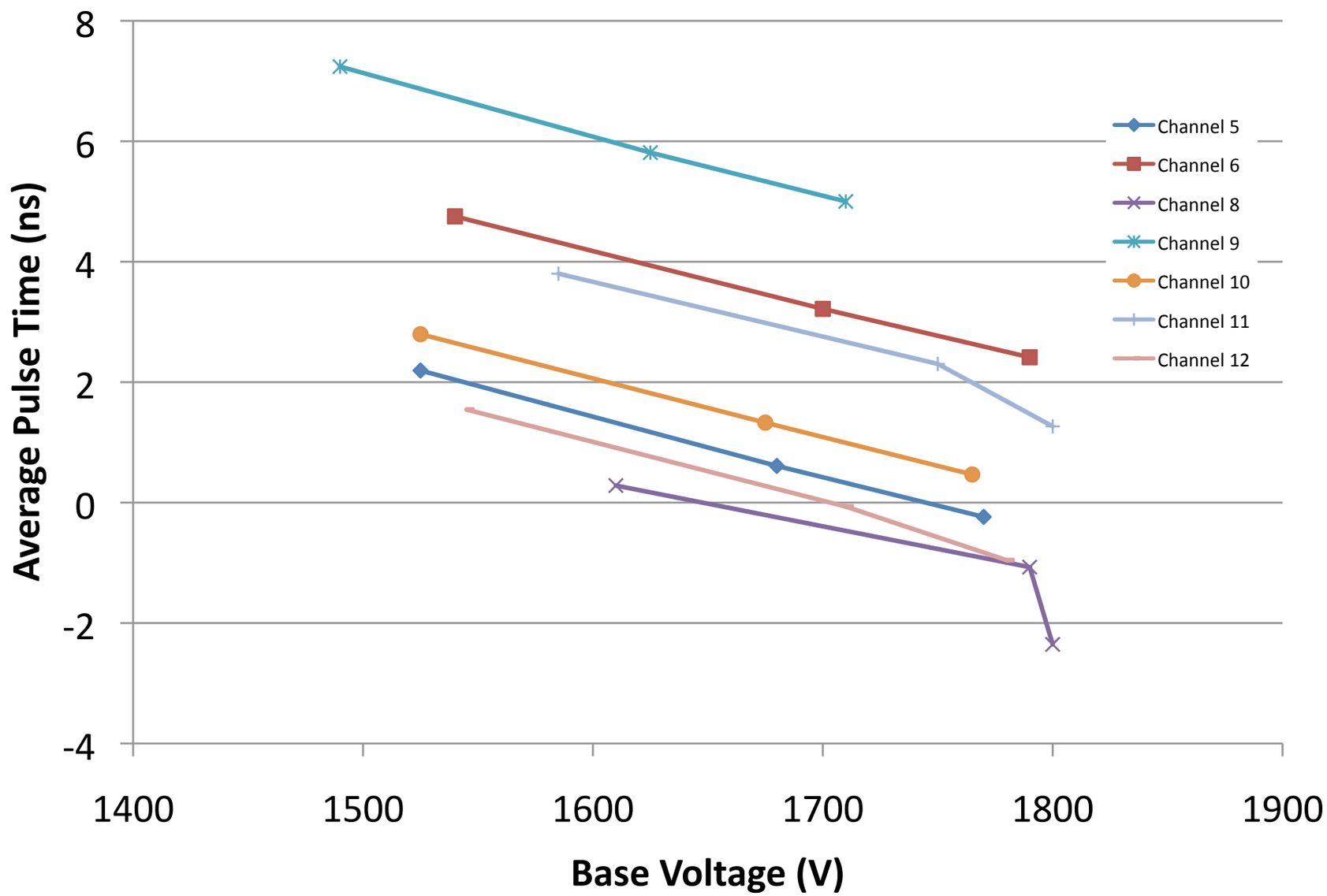
Block Timing Offsets

- Compare time of near-neighbor blocks: elements populated by the same physical photon at the same time
  - mean: time difference
  - rms: time resolution of two channels added in quadrature
- Shift all elements to align time; e.g. set t=0 for blocks around the beamline
- No expected "time walk" with energy; simple fit is sufficient



From FCAL Beam Test Results
K. Moriya *et al.*, NIM A 726, 60 (2013)

PMT Transit Time Variation

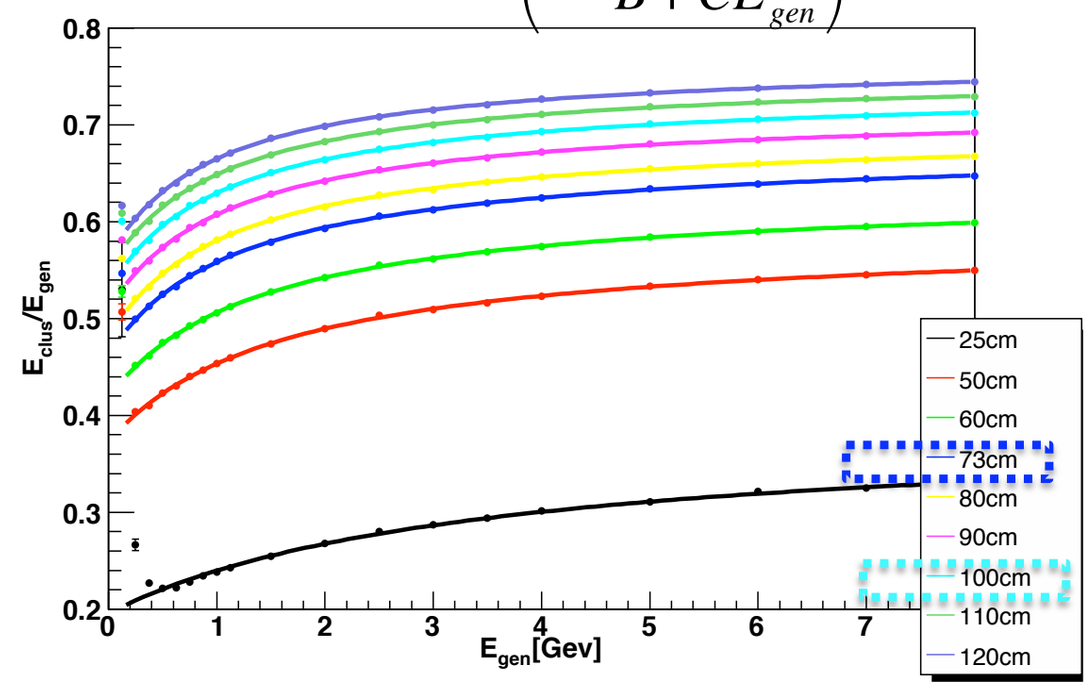


(of course the gain factors also must have a strong dependence on PMT HV)

FCAL Cluster Calibration

- Attenuation length of glass causes non-linearity in response
  - higher energy incident photons generate more light closer to the PMT
- Dependence is on cluster (photon) energy not block energy
- "Global Property": only a few numbers needed to describe the effect
  - analysis time correction
- Variations in incident angle may necessitate position and energy corrections (need investigation)
  - GlueX incident angles are small

$$E_{clust} = AE_{gen}\left(1 + \frac{E_{gen}^{1+\varepsilon}}{B + CE_{gen}}\right)$$



FCAL Startup

- Dead-reckon relative gains and PMT HV set points using cataloged PMT test data
- Use pulsed LED system to
  - improve relative gains: ensure "smoothness" of response even if it is not uniform
  - make first pass at timing offsets between channels
- Use first data to
  - block level gain calibration using π^0's
  - precise relative time offsets for blocks
- Use calibrated block data to
  - develop nonlinear corrections to photon energy

FCAL Simulation

- May need additional constants/calibration for accurate simulation of FCAL
- Gain variation and variation of pedestal width has the effect of producing a different energy threshold for each block
  - Need to translate hardware zero-suppression threshold to energy using calibrated gain constant
  - Can also be used as a dead channel mask
- May require replication/access to configuration of the fADC (which is presumably stored in a database)

Monitoring the Calibration

- Precision calculation should be achievable with less than a shifts worth of data
- It would be useful to have a nearly continuous calibration process running
  - supplement the monitoring system
  - requires a calibration algorithm that can work with uncalibrated inputs from other systems (seems possible)
- Any limits to frequency or size of data envisioned by calibration system?
  - Single FCAL block level calibration: 5600 numbers
  - Can we repeat this 3-4 times a day?