



Overview of NO ν A Calibration

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- Detector Intro
- What needs to be calibrated
- Cell light calib
- E calib w/ stopping muons
- Timing calib w/ muons



NOvA @ the Surface

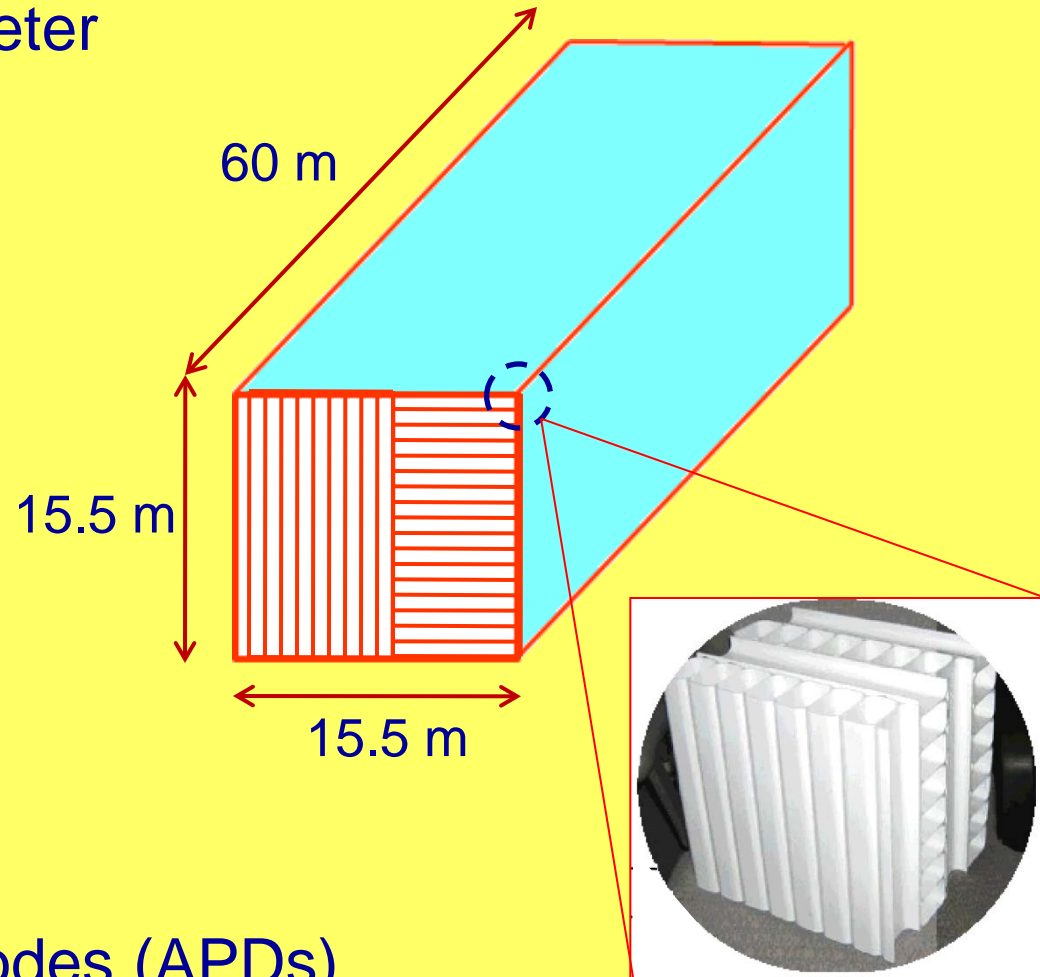




NO ν A Far Detector Overview

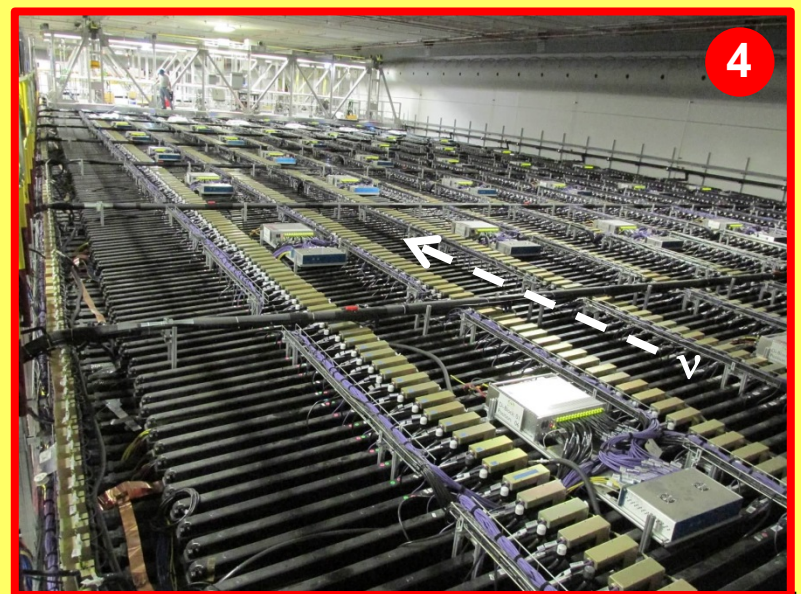
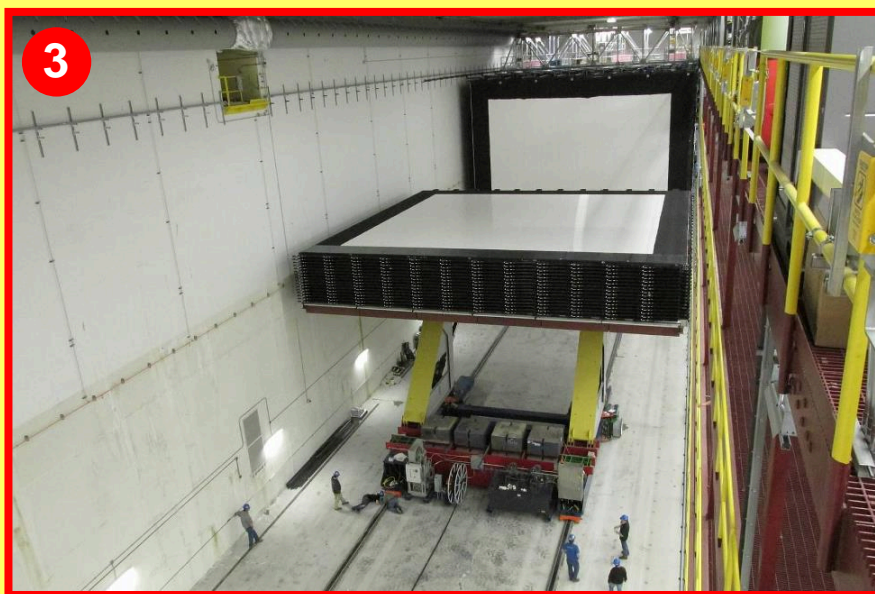
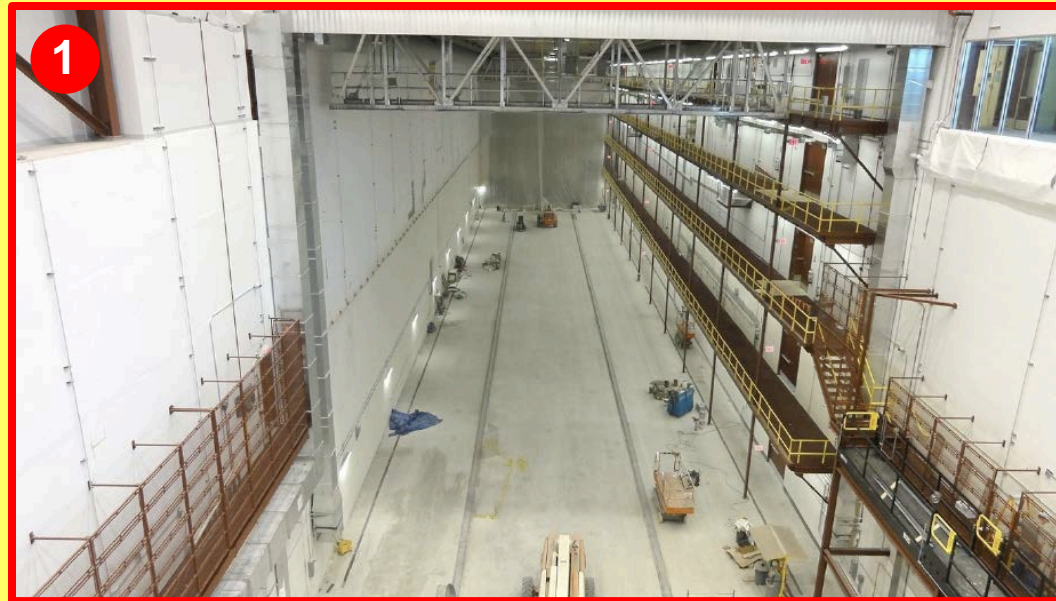


- Low-Z tracking calorimeter
65% active
- Surface location
- 14 kT total mass
- 896 Detector planes
Alternate x-y layers
0.15 X_0 /layer
 $R_M = 9.8$ cm (2.5 cells)
- Liquid scintillator cells
> 32 PEs from far end
- 1-sided readout/plane
via avalanche photodiodes (APDs)





Far Detector Construction

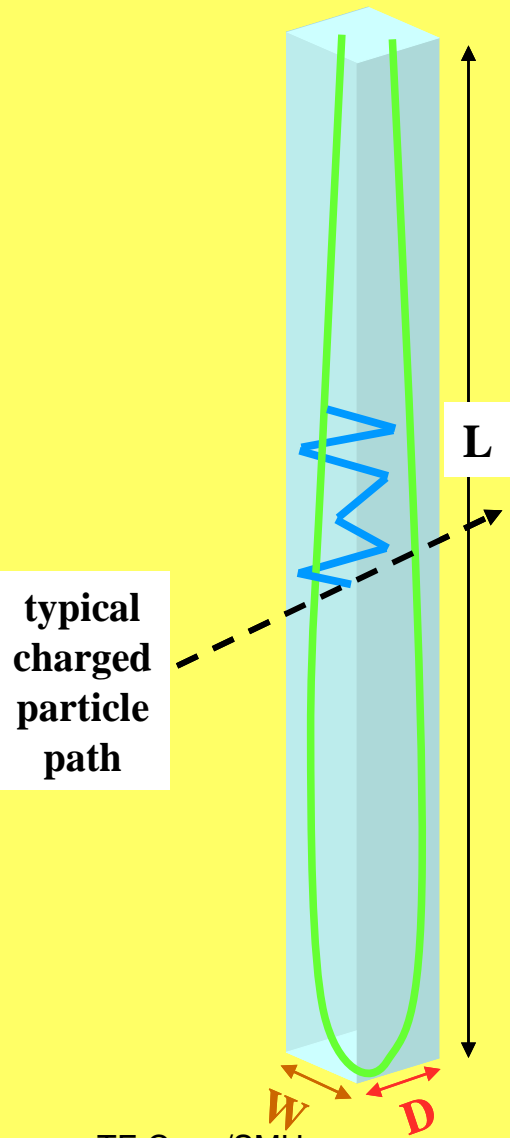




NO ν A Detector “Atom”

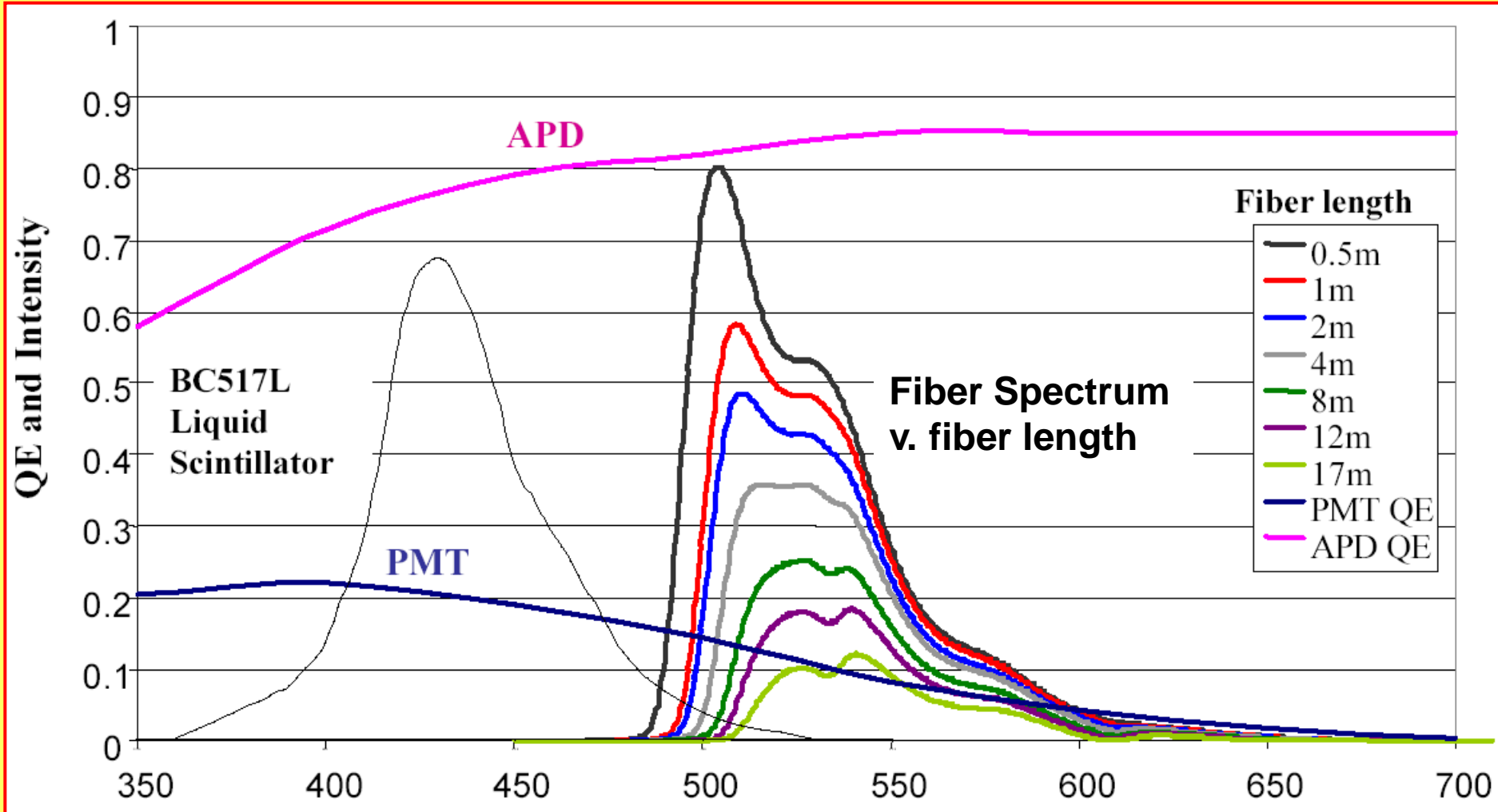


To 1 APD pixel





Why APDs

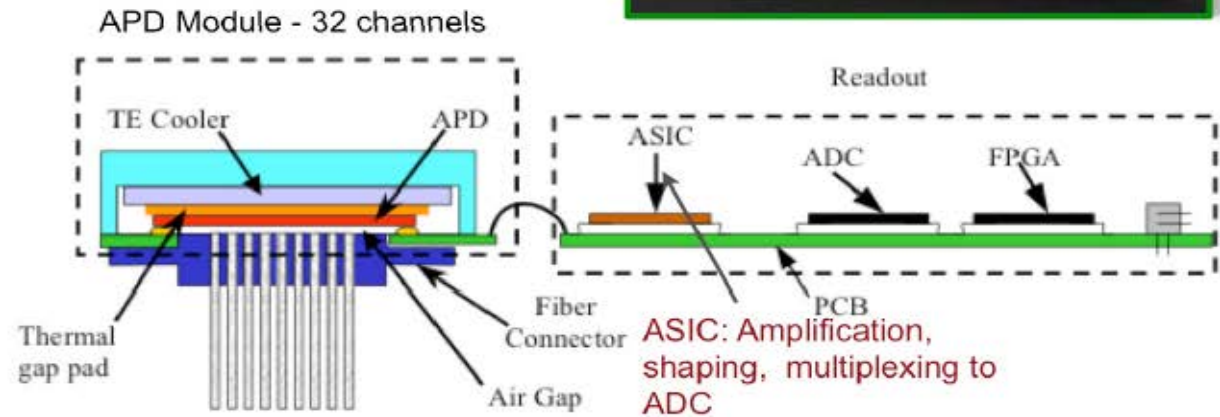




Front-end Electronics



APD



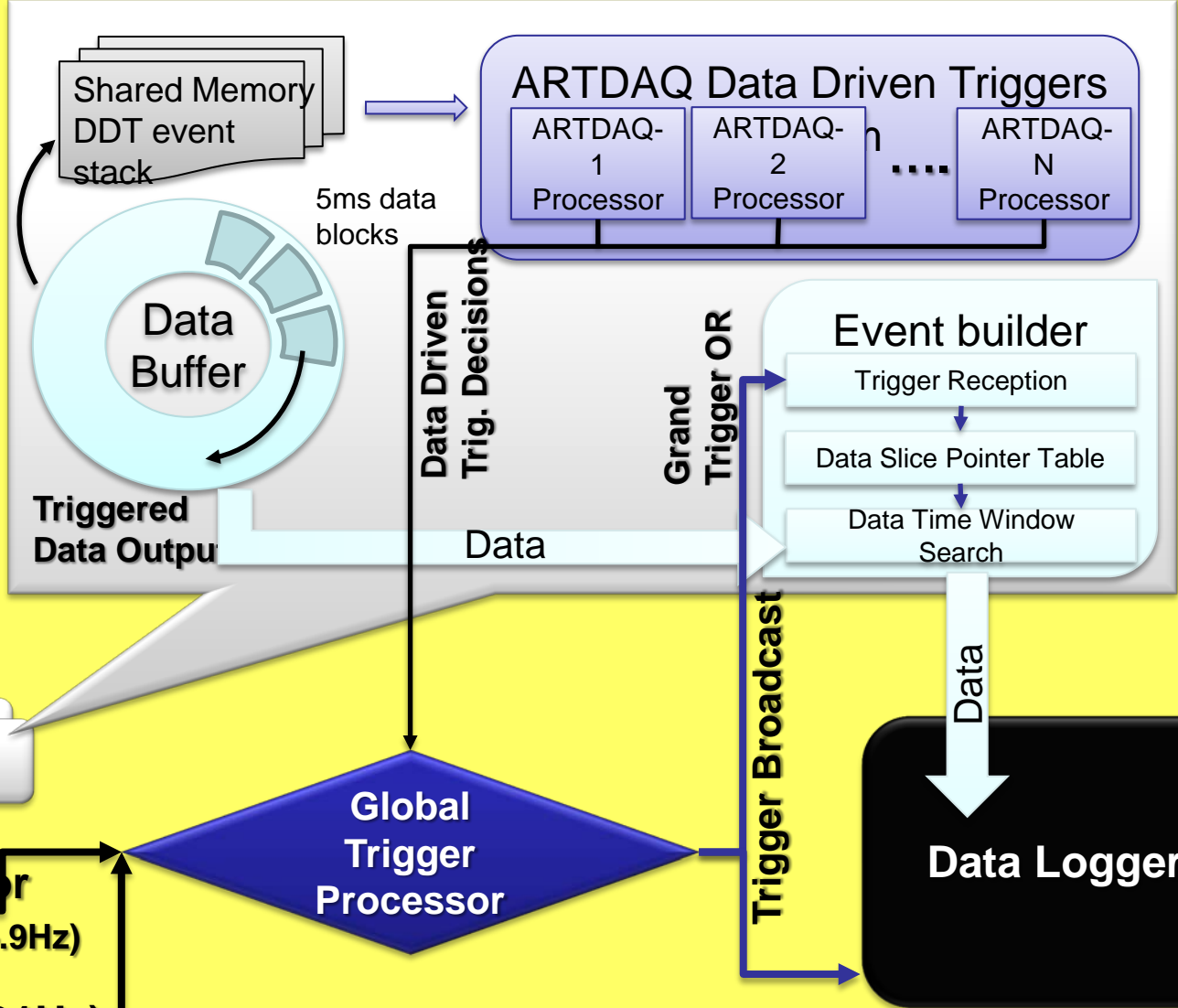
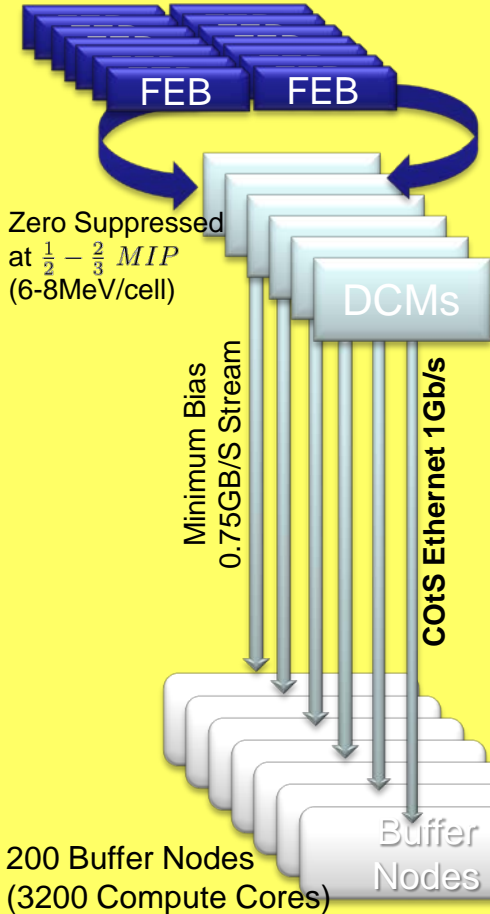


DAQ Architecture



DAQ: Triggerless, continuous, no dead-time

10 752 FEBs
(344 064 det. channels)



Beam Spill Indicator
(Async from FNAL @ .5-.9Hz)

Calib. Pulser (50-91Hz)



DAQ Output



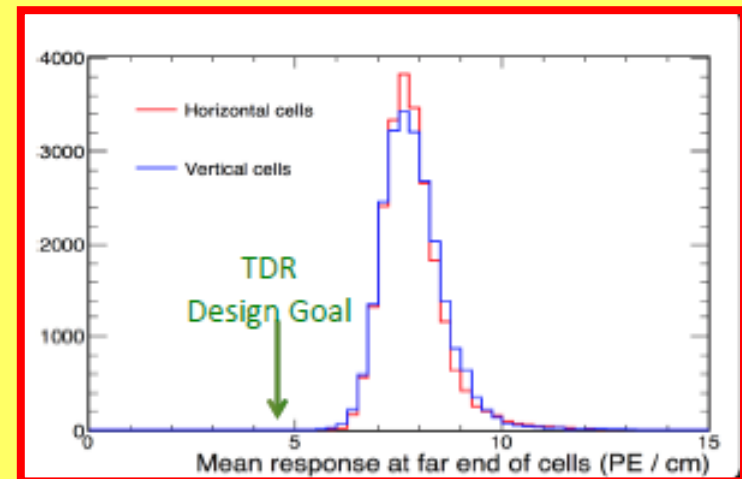
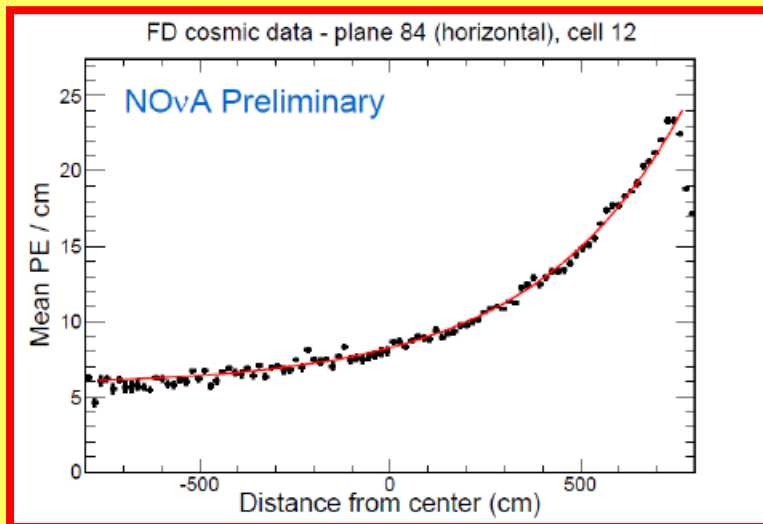
- Cell ID (geographic position and orientation)
- ADC value of hit cell
- Time of hit
- No explicit trigger to open frontend electronics
- Relevant hits are found in data buffer consistent w/ time of spill.



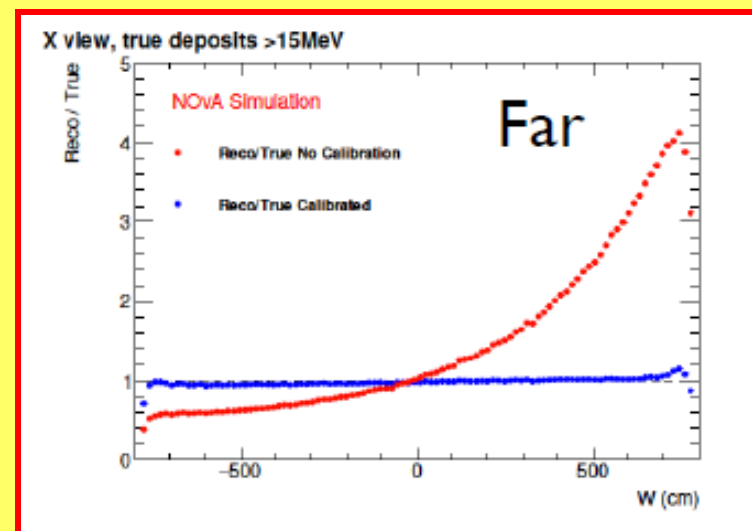
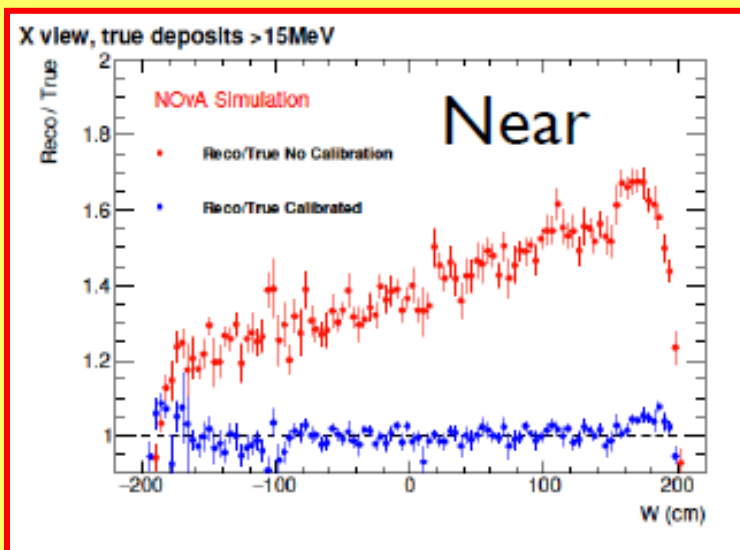
Calibrate Light Response of Cells



- Surface location \Rightarrow 50-70 μ 's per 550 μ s trigger window.
- LR calib requires through-going μ 's (same probe for each cell).
- LR requires well-defined trk lengths in each cell.
- Light output fit to double exponential (2 paths to APD).
- MC "threshold" corrections applied (data driven in progress)
- 99% of channels "attenuation" calibrated.



Check Light Response Calib

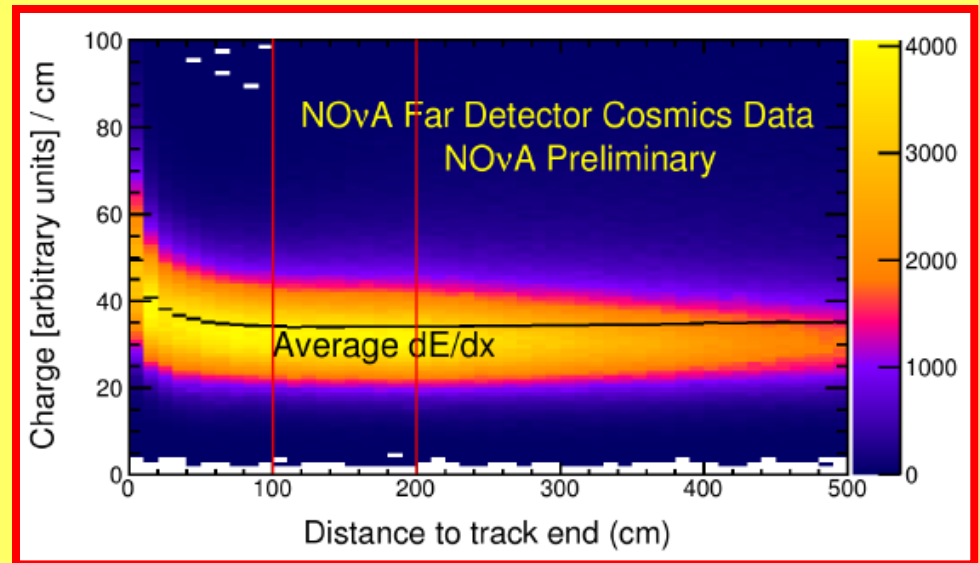
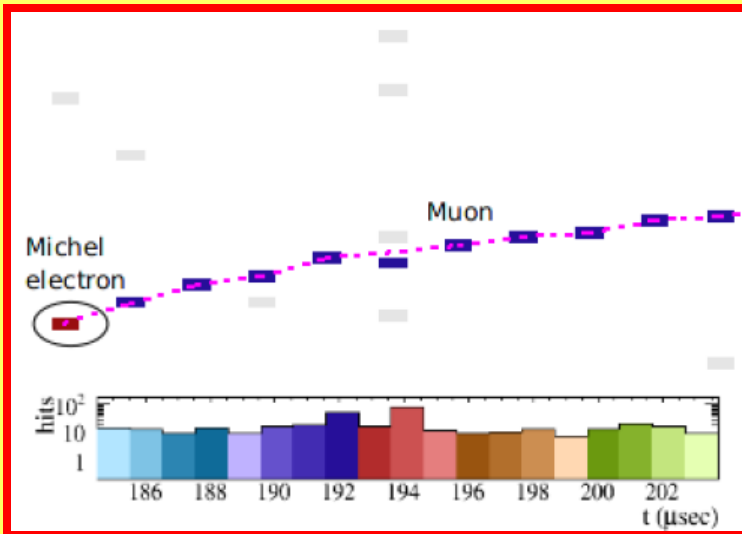




Absolute Energy Scale

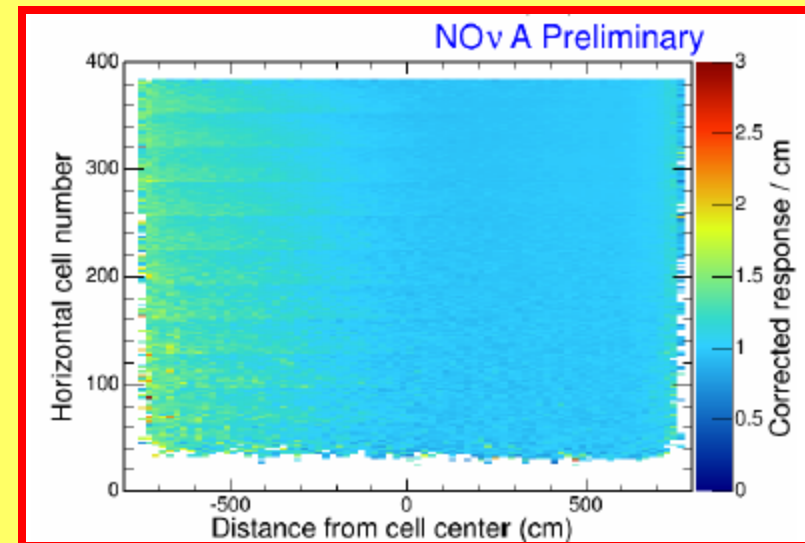
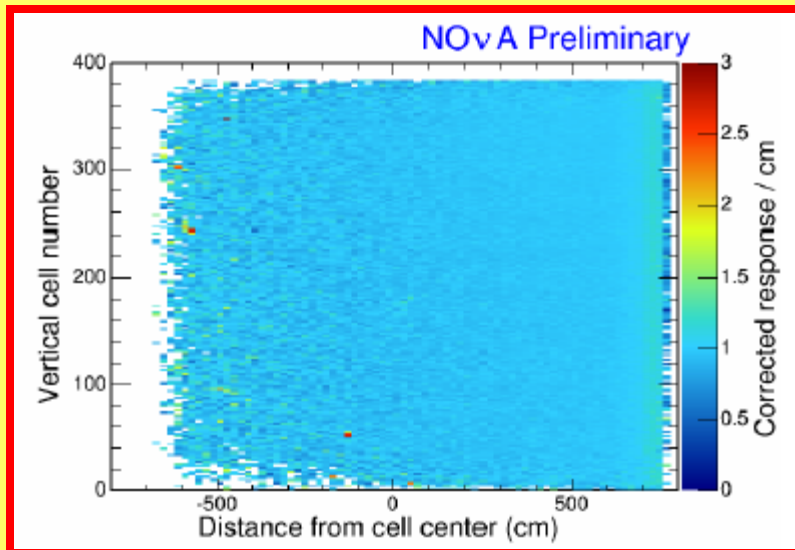
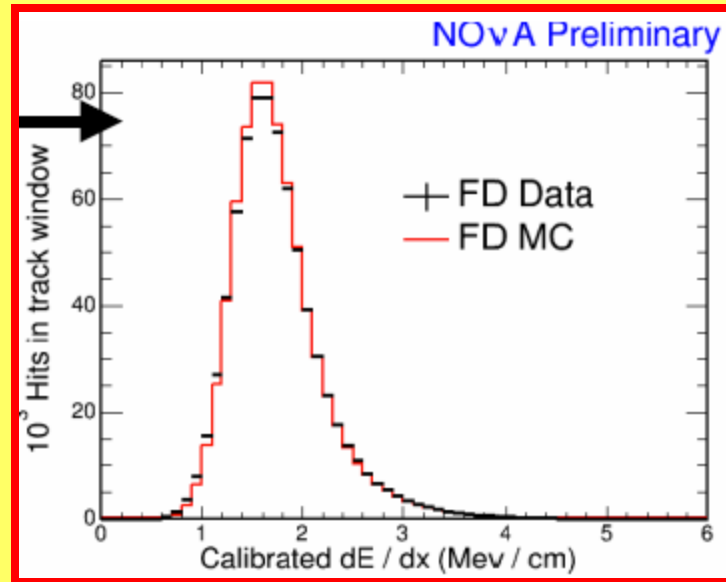


- Use stopping muon tracks w/ ID'd Michel electrons.
- From end point back up 1 meter.
- Detector response used in a window 1-2 m from trk end.





Calib of dE/dx





E Calib Systematics



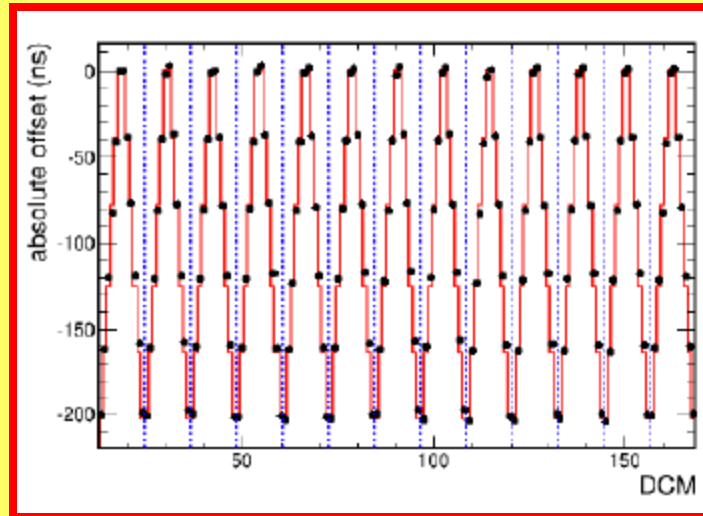
- Some discrepancy btwn data/MC in beam muons (3.6%)
- Some discrepancy btwn data/MC in Michel e-'s (5%)
- Work ongoing ...



Timing Calibration



- Need all cells on the same clock.
- Use well-measured muon tracks.



- $\sigma_{\text{FEB}} \sim 16 \text{ ns}$.



Summary



- ❑ NO_vA calibrates its cells with muons
- ❑ Other schemes for E calib afloat (π^0 's, Michel e-'s + Δ 's (?))