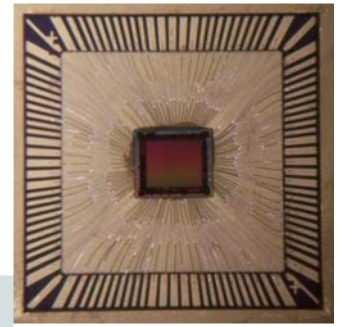
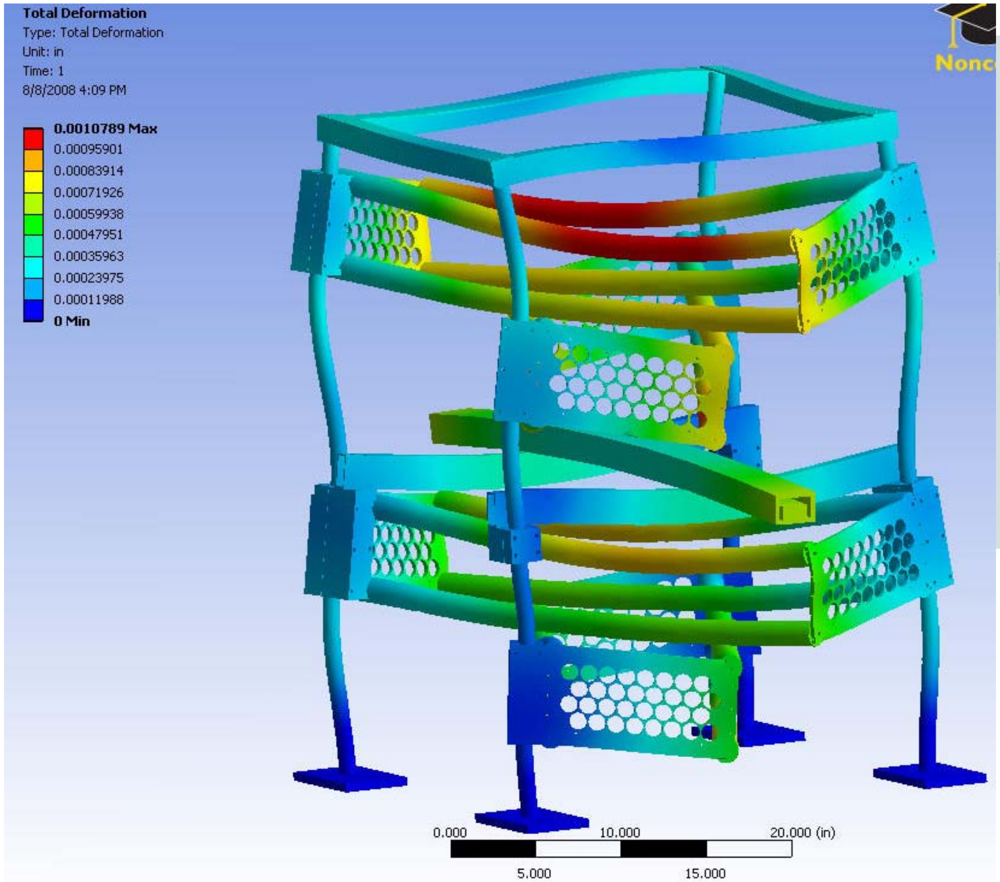
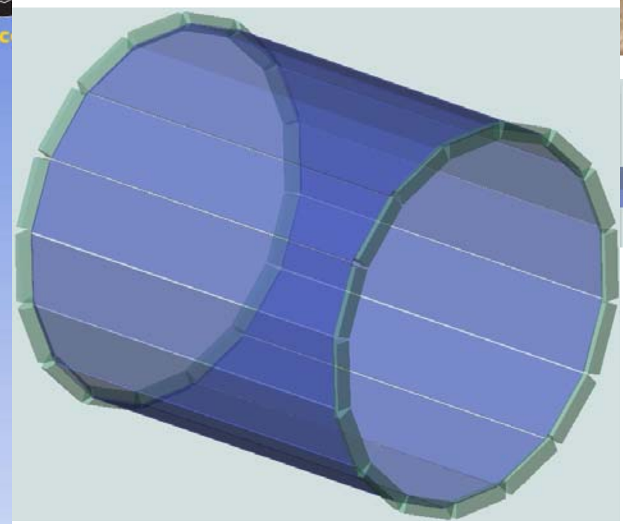
Updates from Hawaii



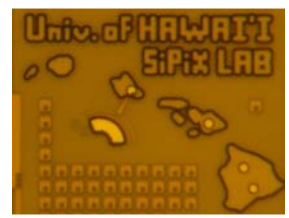




Tom Browder, Bryce Jacobson, James Kennedy, Kurtis Nishimura, Marc Rosen, Wen Yen, Andrew Wong

Larry Ruckman and Gary S. Varner

UNIVERSITY OF HAWAII AT MANOA

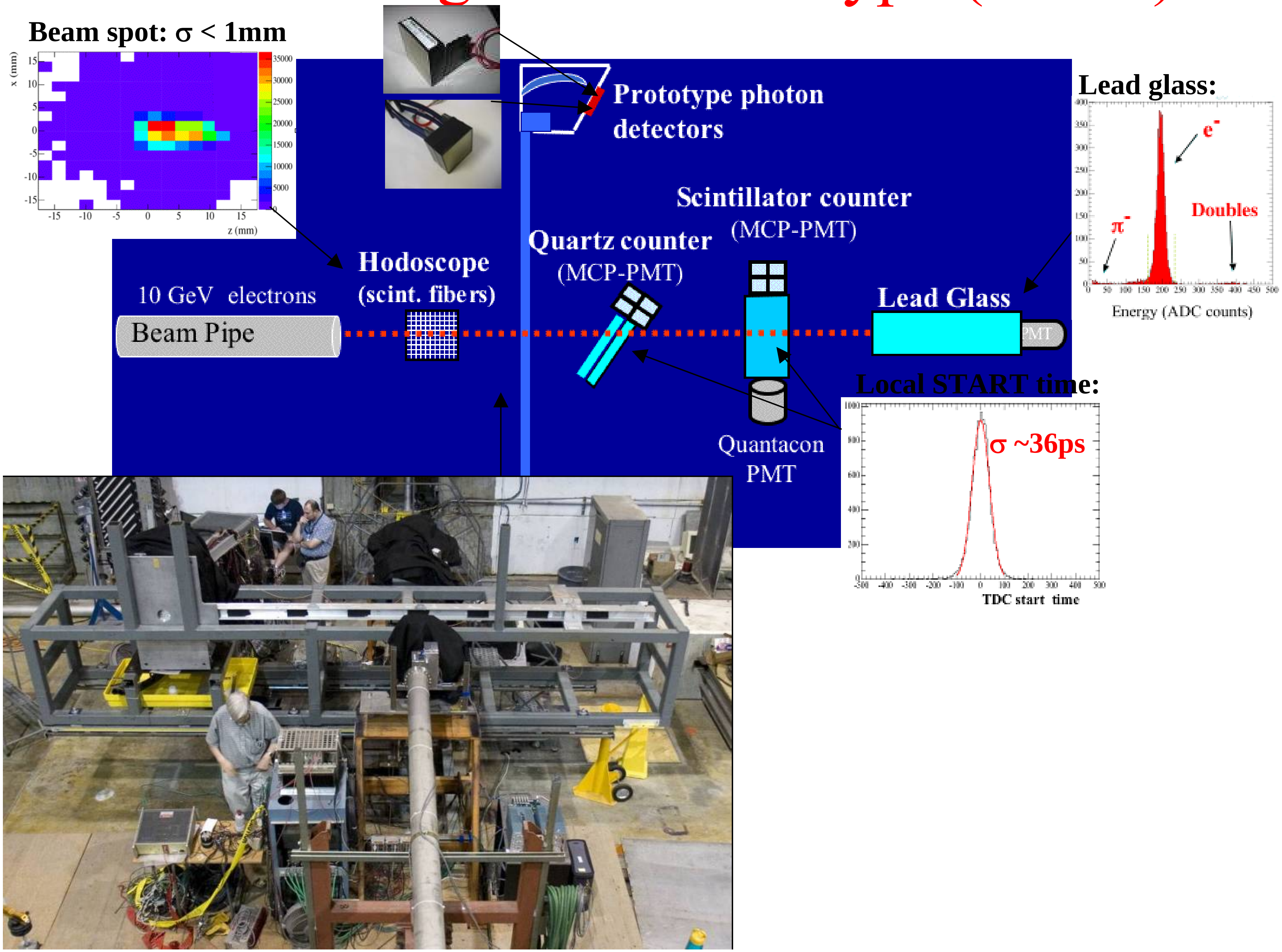


Super-B PID meeting 17-SEP-08

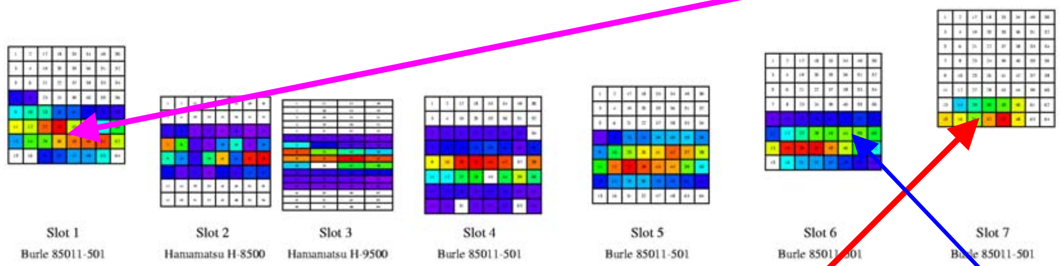
Today's Topics

- Further studies with Fast Focusing-DIRC
  - Enhanced (waveform sampling) readout
  - Cosmic Ray running with new readout
- Readout ASIC Update
  - Initial BLAB2 Performance
  - Plans for full system
- Quartz bar t,{x,y} studies (Hawaii cosmic)
  - Cosmic test stand (close GEANT4 loop)
  - Dense imaging plane concept
- Schedule and Plans

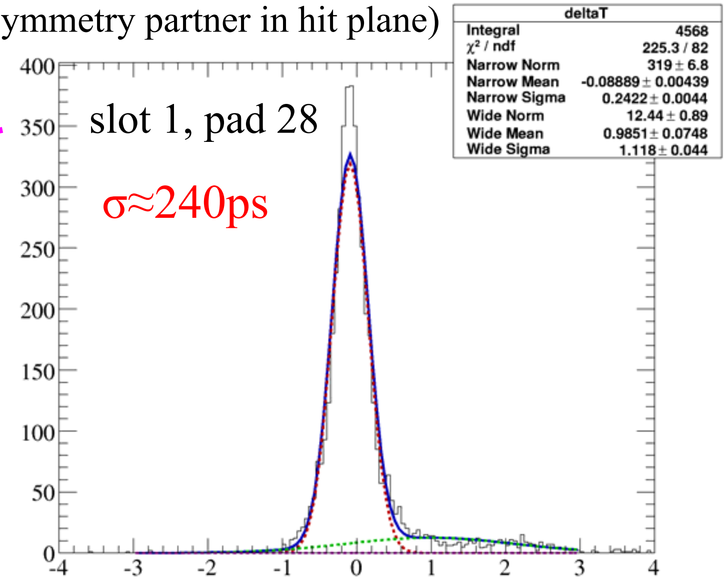
Focusing DIRC Prototype (T-492)



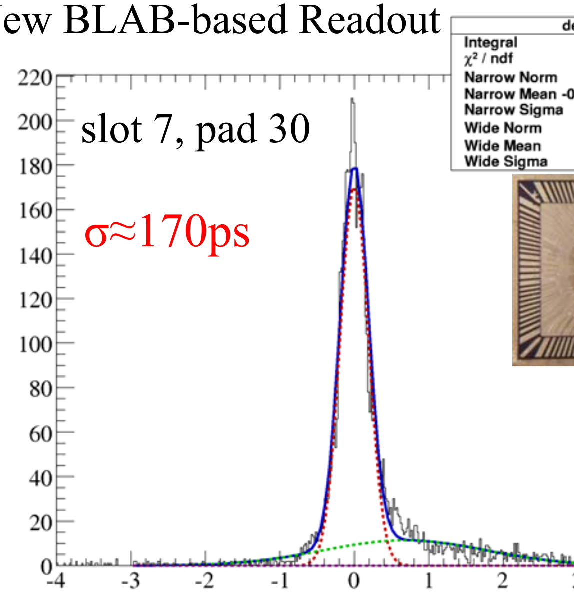
Test results: timing slot 7, pad 15
to Philips slot 1&6
for run 27, pos 1, direct photons

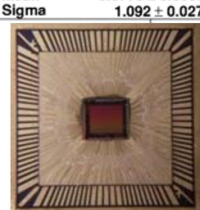


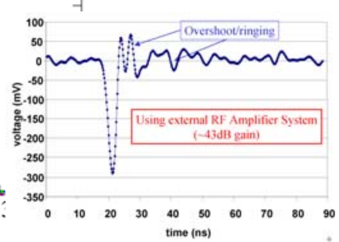
(symmetry partner in hit plane)



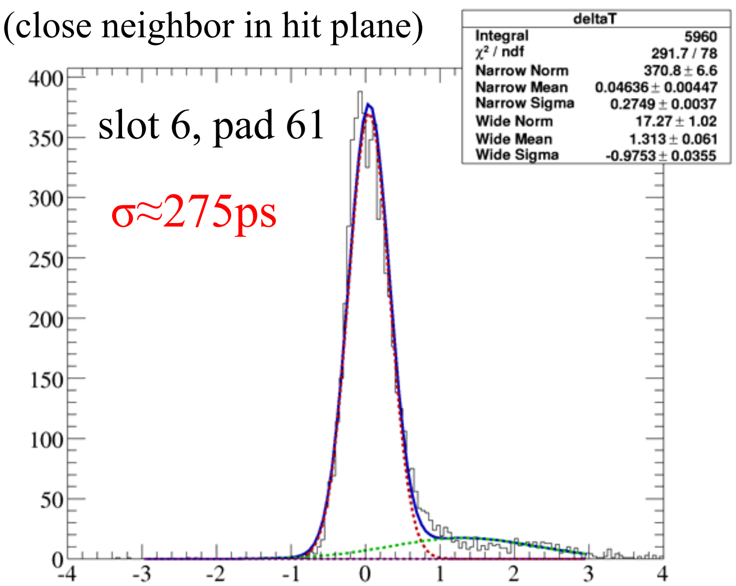
New BLAB-based Readout







(close neighbor in hit plane)

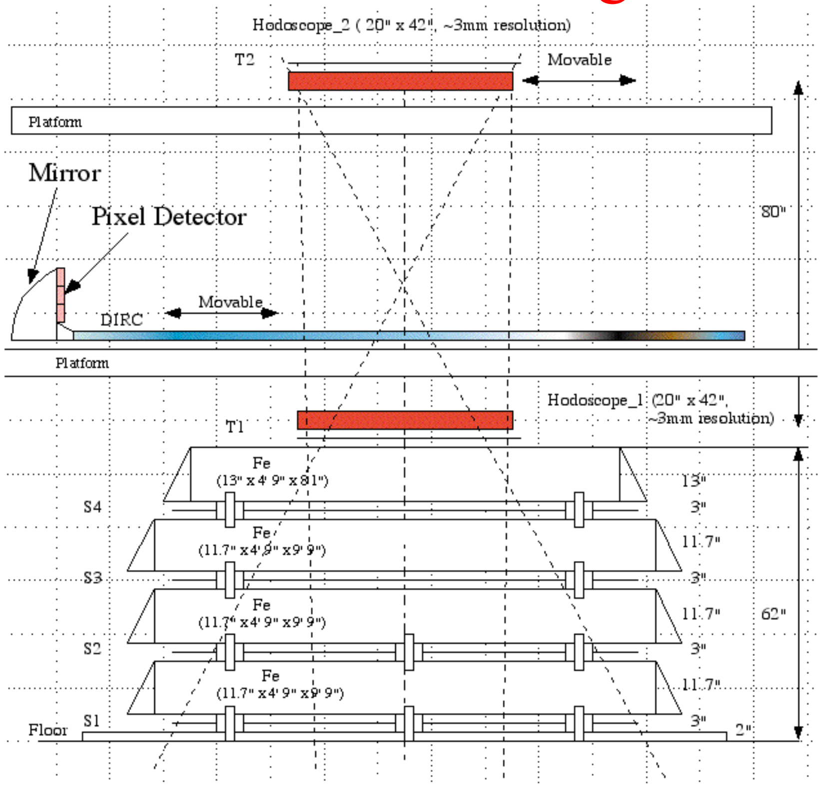


delta(time) (ns)

Decided to upgrade all channels to new BLAB electronics

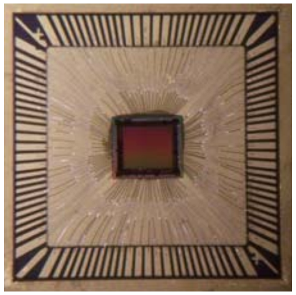
Moving to Bldg. 121

- LCLS Operations
  - Parasitic running possible, but
  - Rad safety system in ESA
- Move to nice cosmic stand
  - 1 mrad resolution
  - Precision timing and further studies w/ new electronics

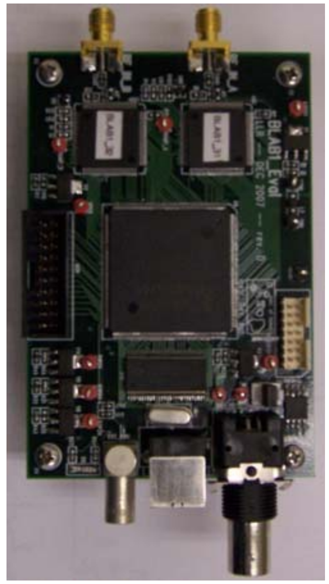


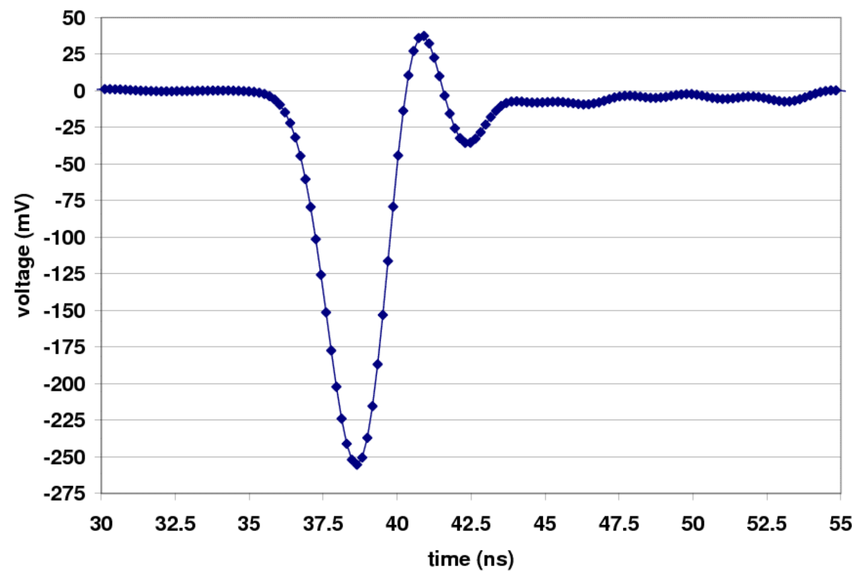
1.6GeV/c P_min through range stack

BLAB ASIC further studies

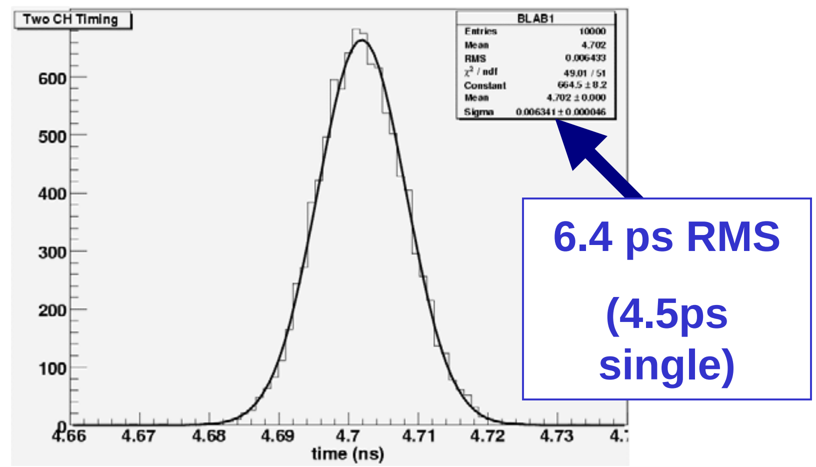


BLAB1 -- NIM **A591** (2008) 534





- Comparable performance to best CFD + HPTDC
- MUCH lower power, no need for huge cable plant!
- Using full samples significantly reduces the impact of noise
- Photodetector limited



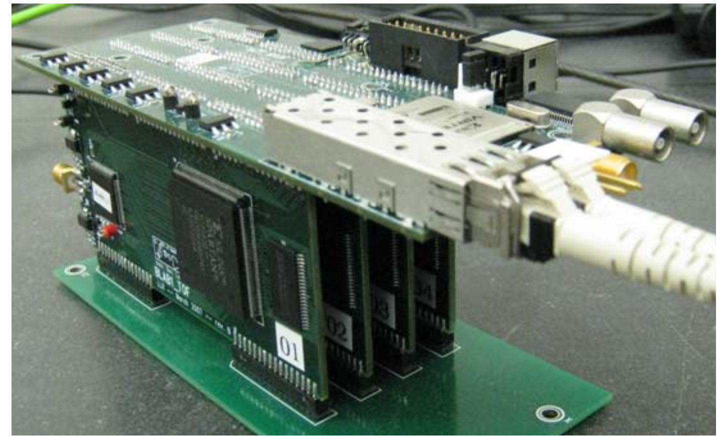
Submitted NIM, arXiv:0805.2225

Highly Integrated Readout

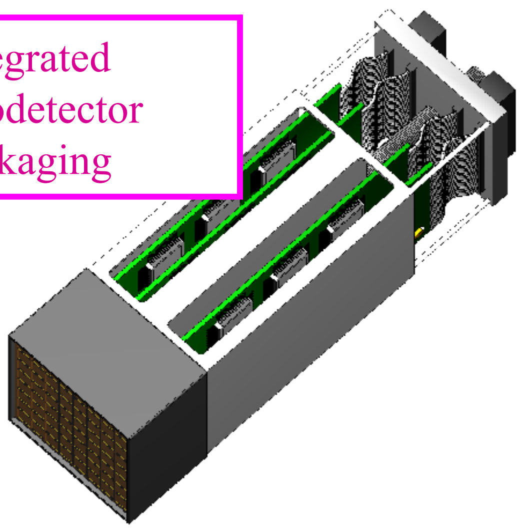
- **Buffered LABRADOR**

TABLE II: *BLAB2 ASIC Specifications.*

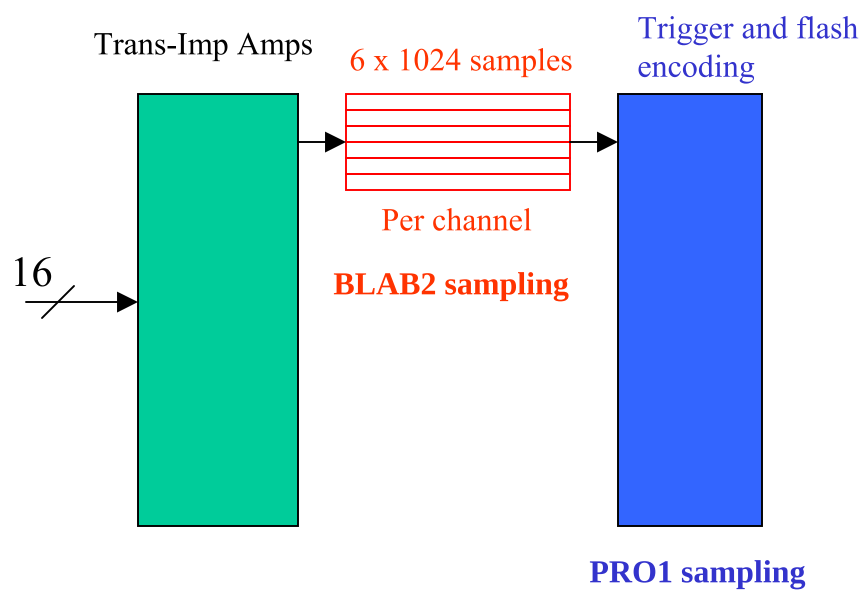
Item	*Value*
Photodetector Input Channels	16
Linear sampling arrays/channel	~~2~~ → 6
Storage cells/linear array	~~512~~ → 1024
Sampling speed (Giga-samples/s)	2.0 - 10.0
Outputs (Wilkinson)	32



Integrated Photodetector packaging

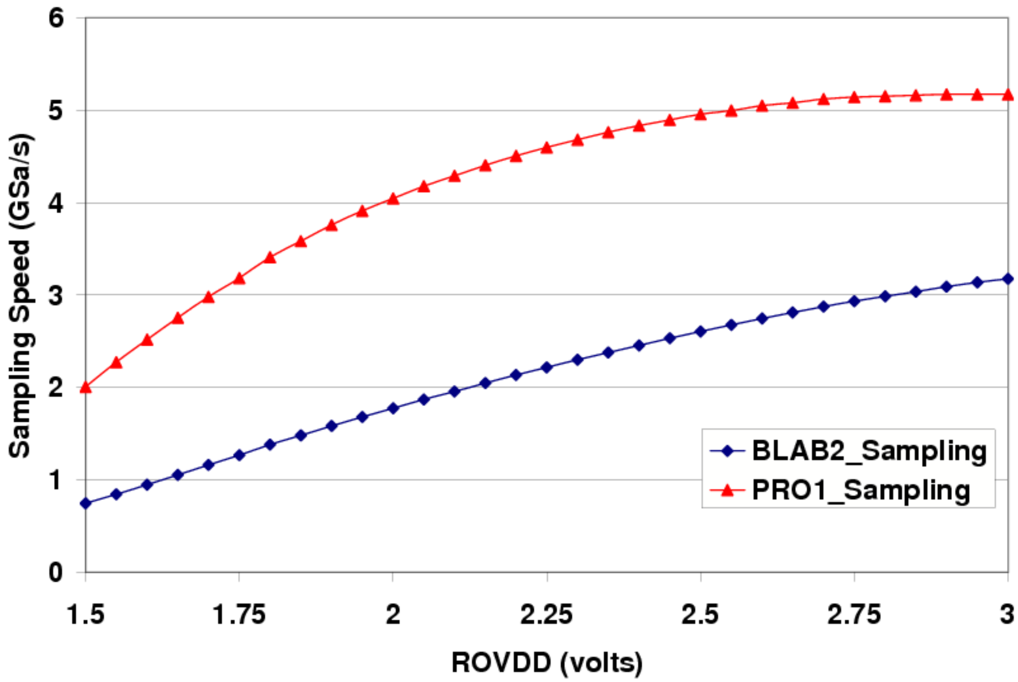


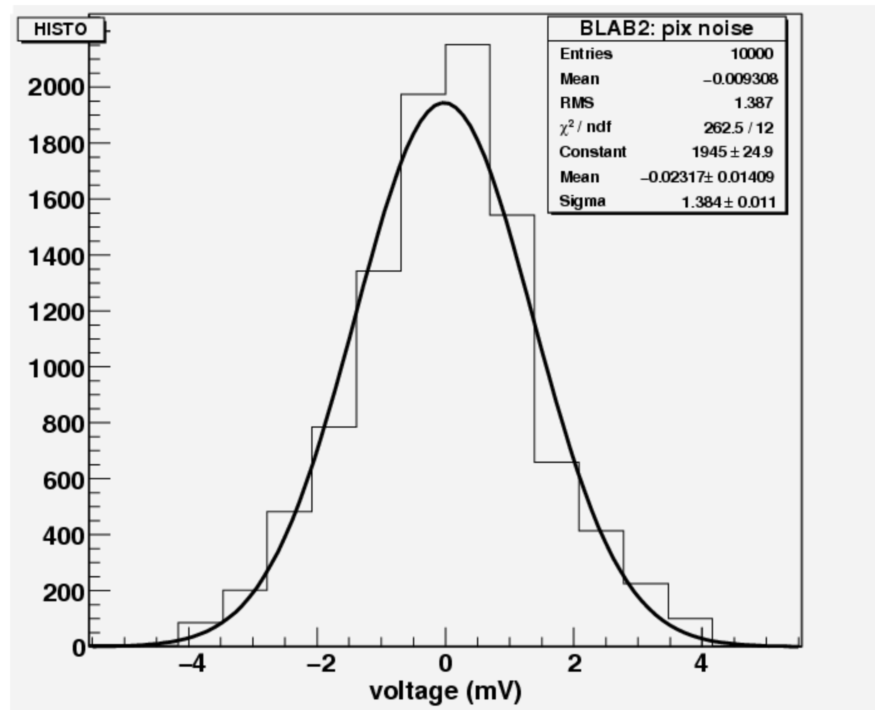
BLAB2 ASIC

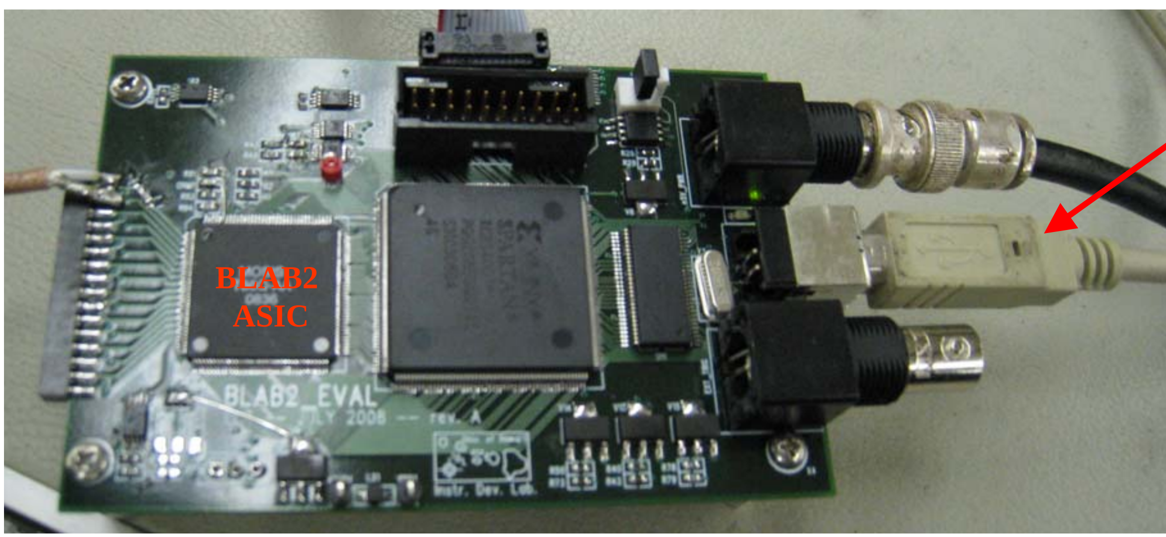


BLAB2 submit 6/23, ASICs received last Monday

Sampling Speed and noise







Eval board USB2

-Win XP

- Linux

- Mac OS-X

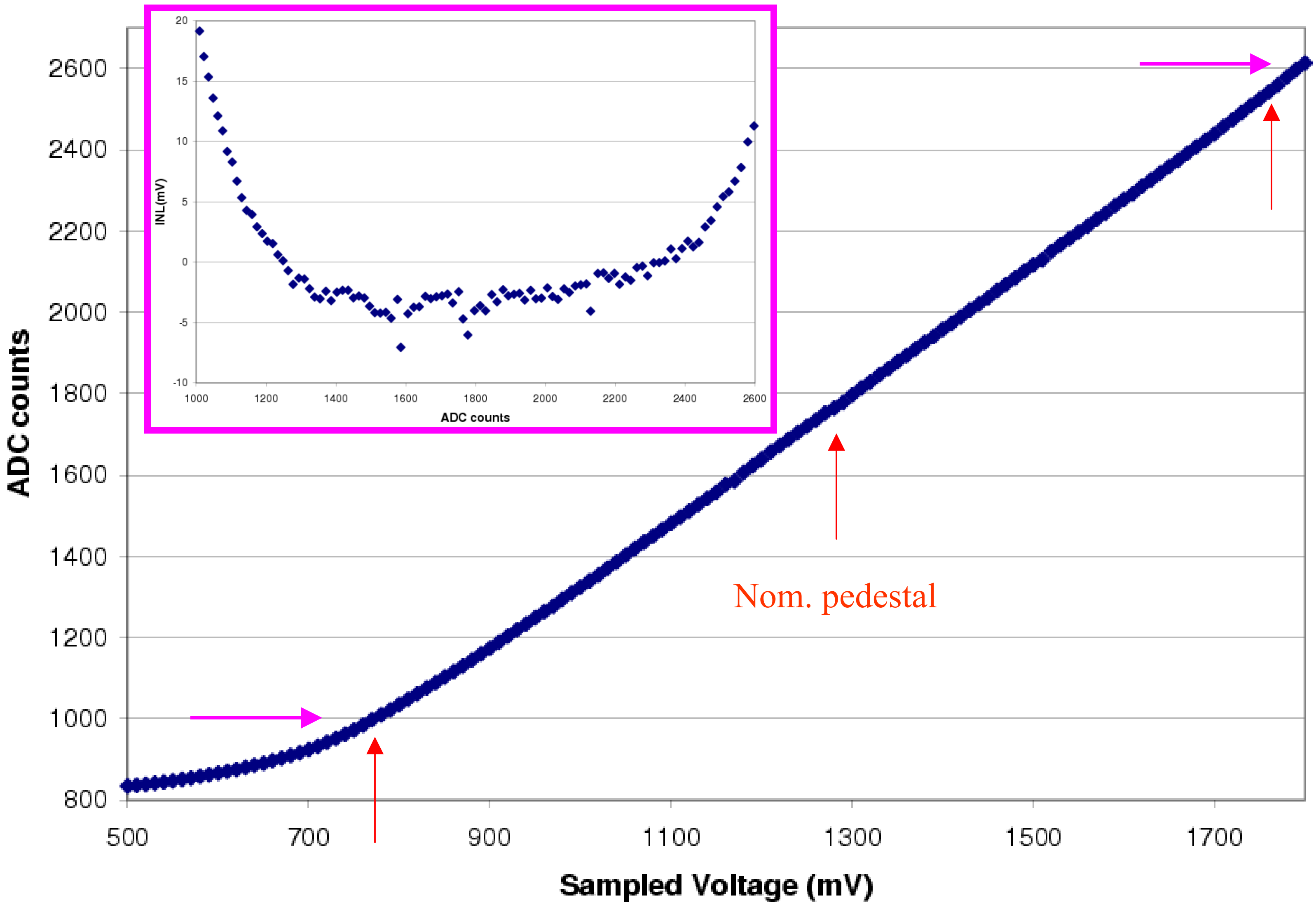
80 ASICs total

(1280 channels)

[448 needed f-fDIRC]

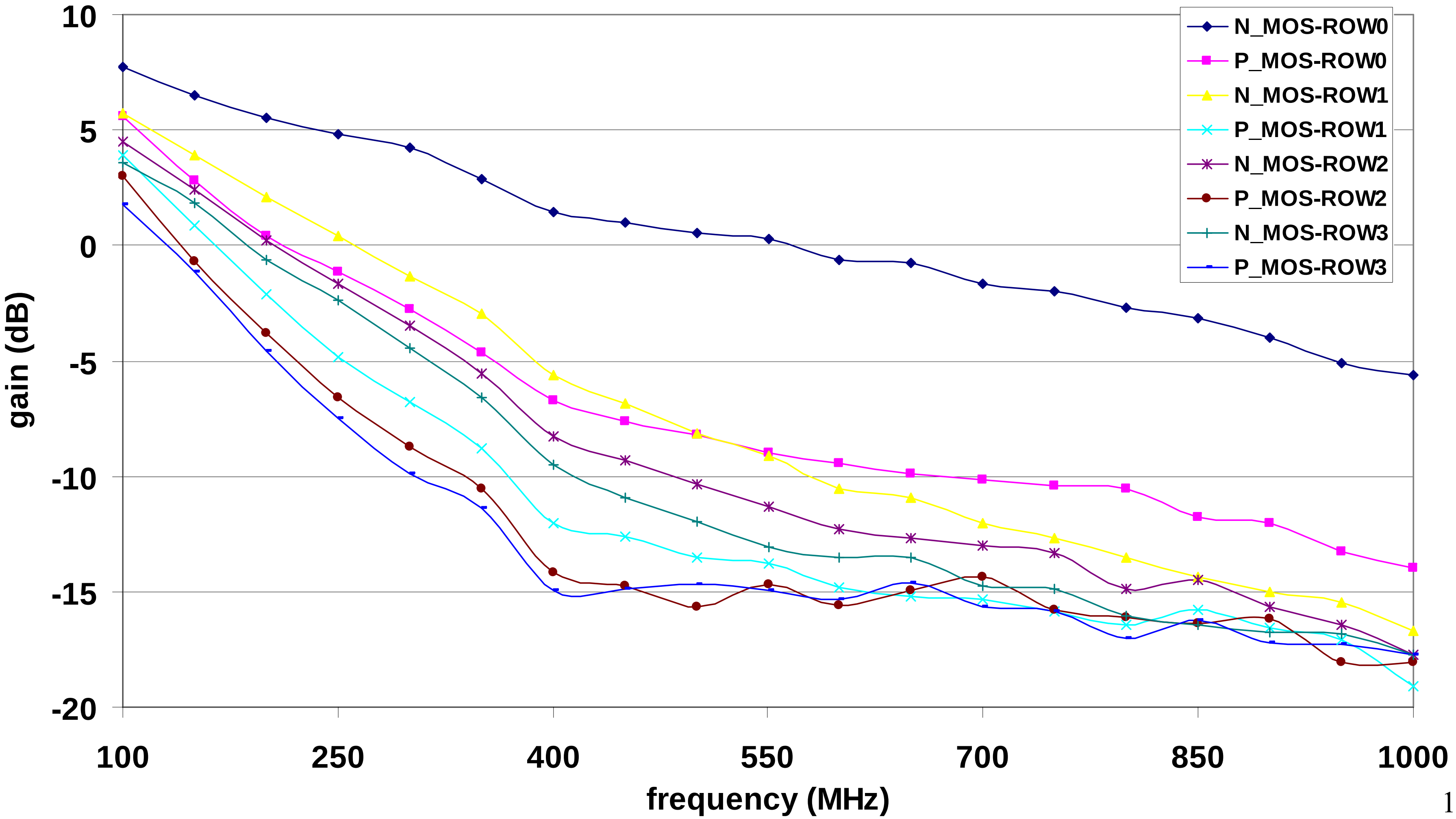
Linearity

In practice, correct with LUT so INL ~1-2 mV

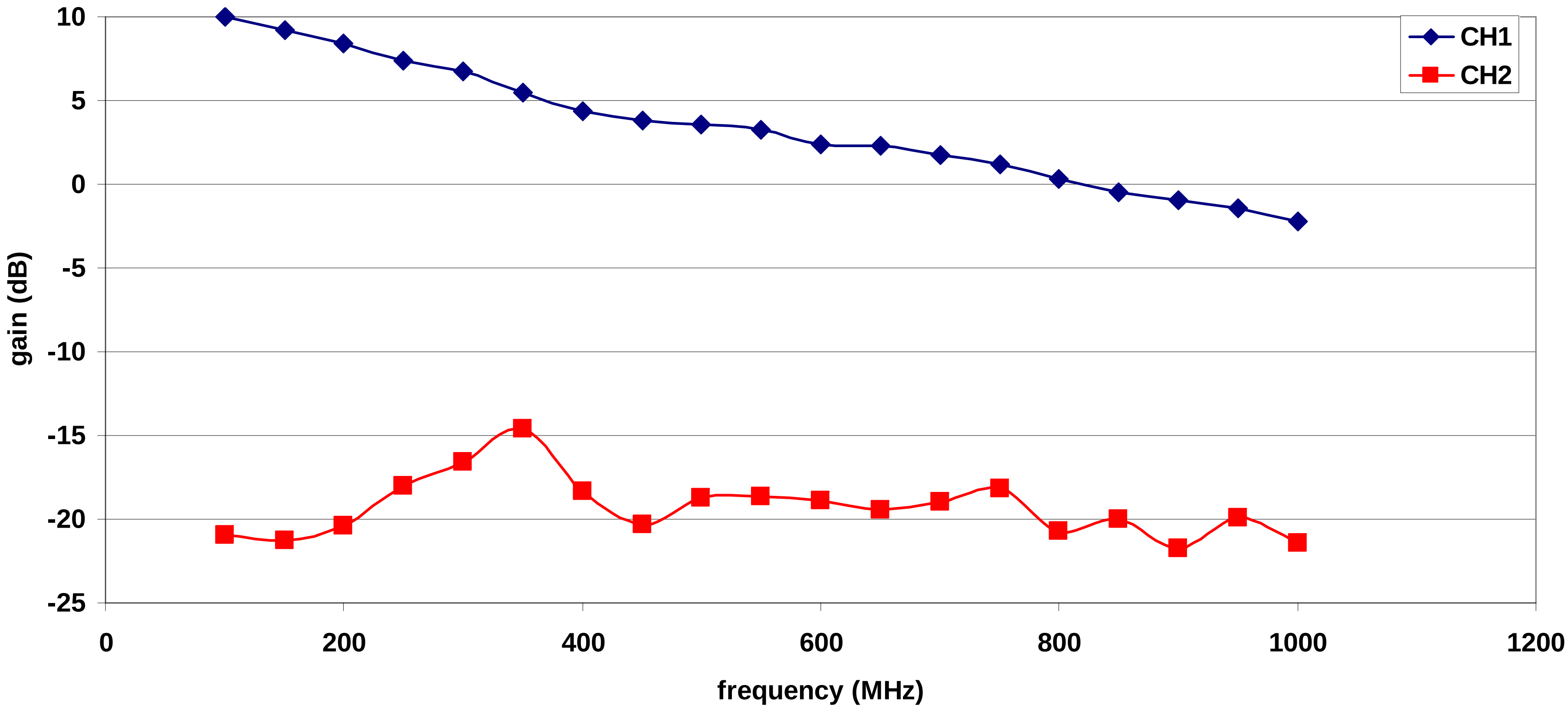


Frequency Response (with TIA)

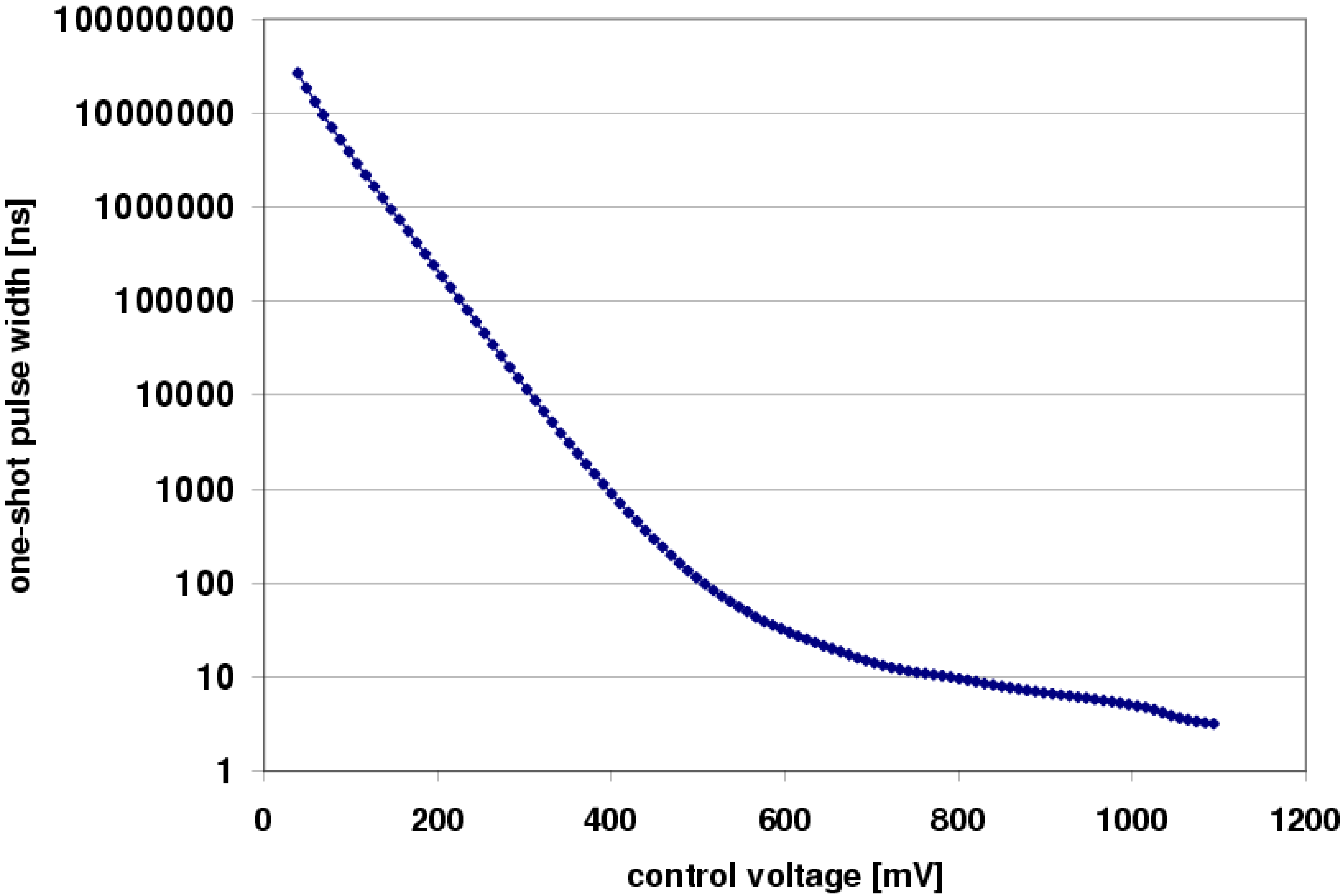
Each channel has 6 storage rows of 1024 samples (512 NMOS and 512 PMOS interleaved)



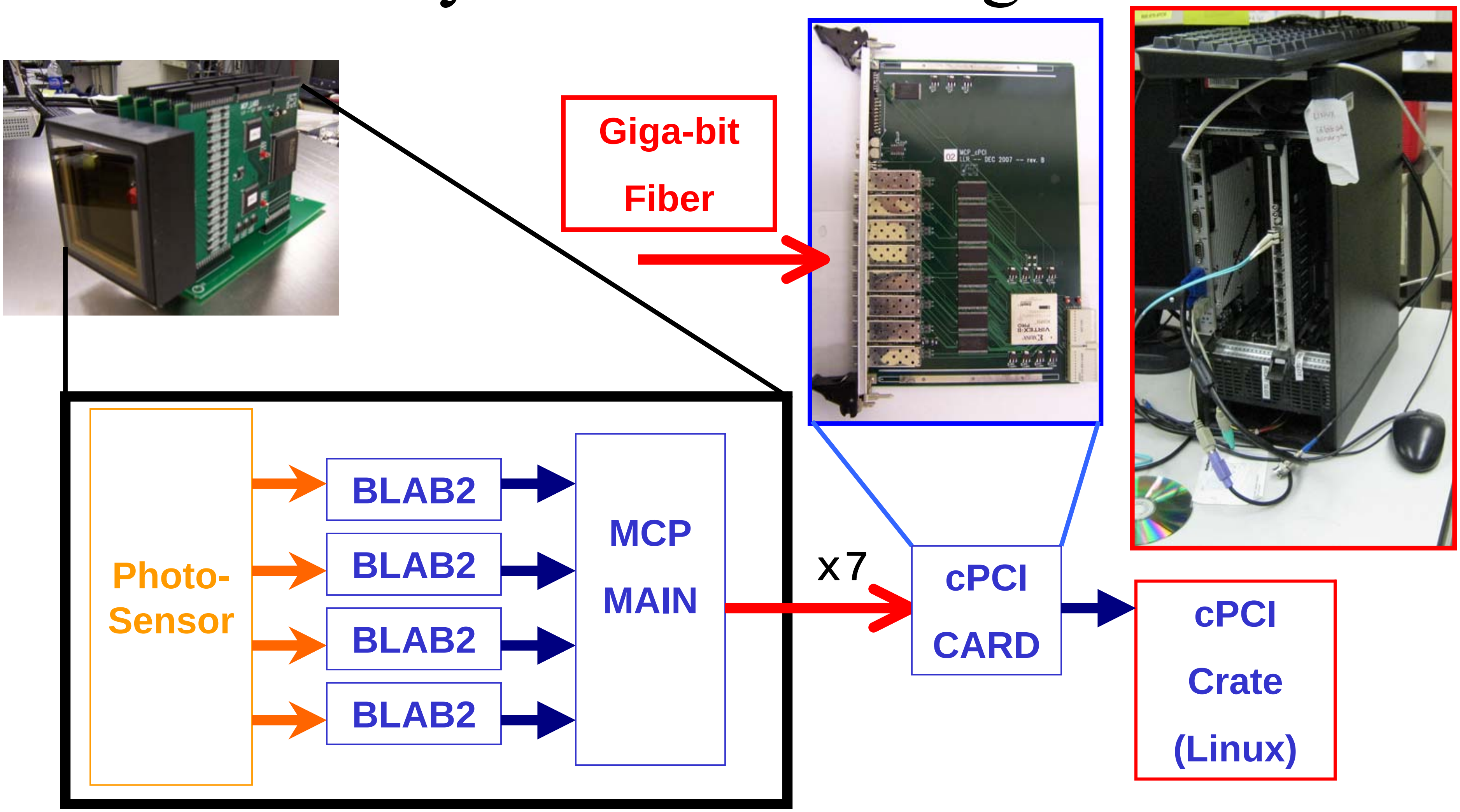
Measured cross-talk



Trigger Performance



Readout System Block Diagram

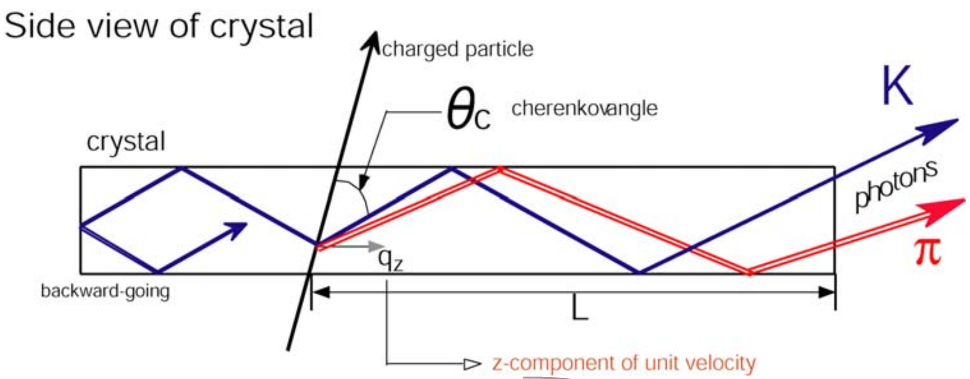


- Up to 7x64 channels per cPCI card
- Very portable DAQ
- Up to 32,256 channels/cPCI crate

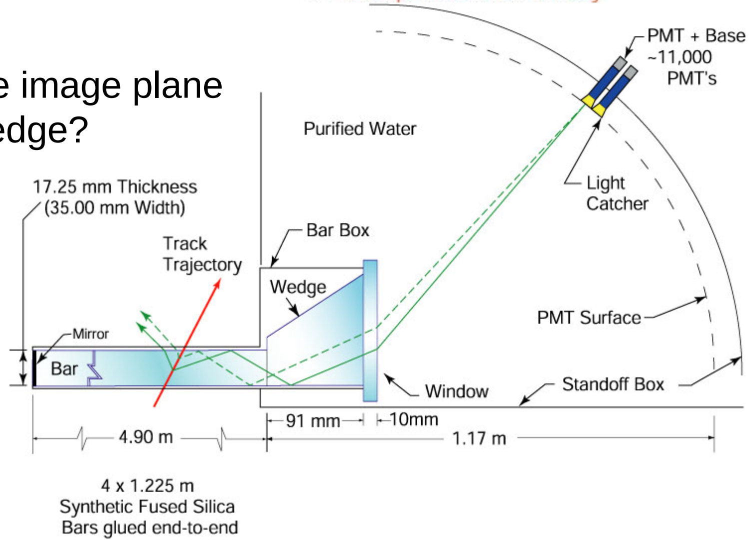
Very cost effective, board hardware already exists, firmware/software dev.

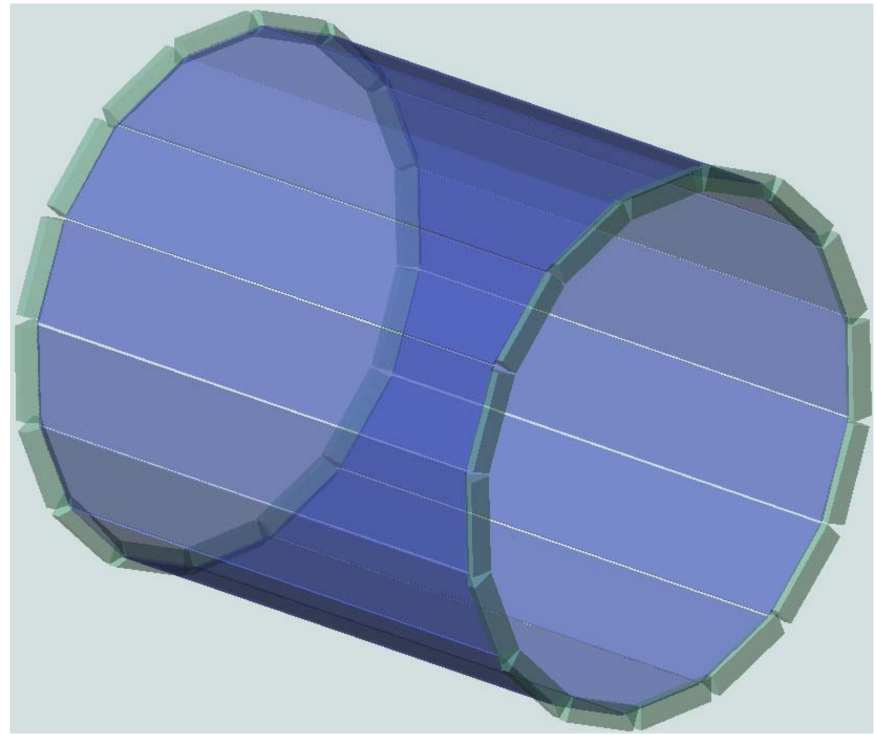
Improved readout timing

Concept: Use best of both ToF + TOP (timing) and DIRC and fit inside detector (background)



Scale image plane to wedge?

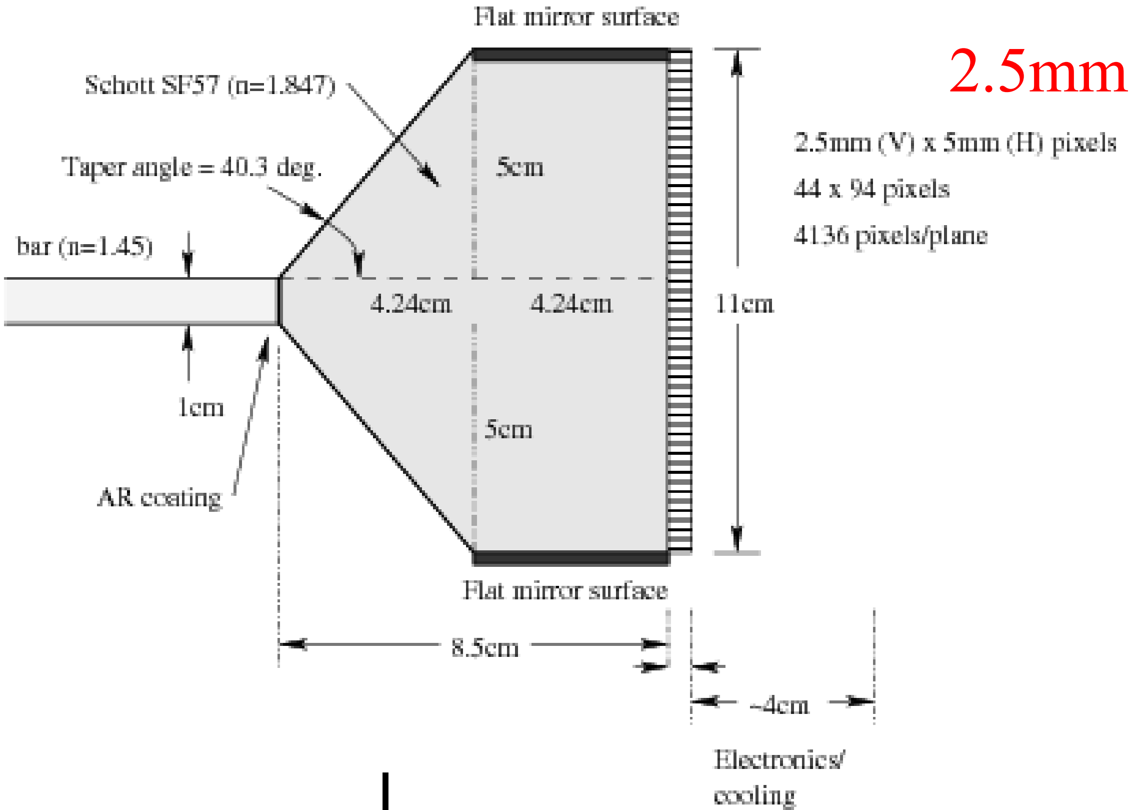




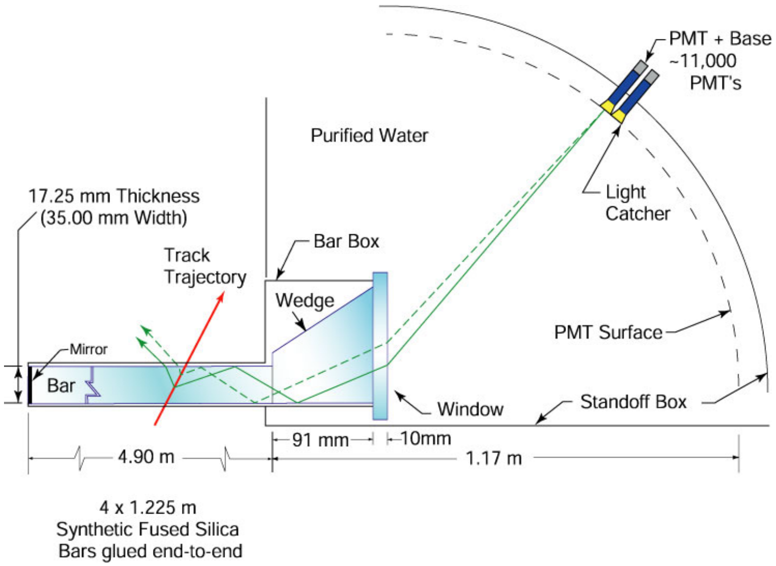
- Use new, compact solid-state photon detectors, new high-density electronics
- Use simultaneous T, θc [measured-predicted] for maximum K/π separation
- Keep pixel scale comparable to DIRC

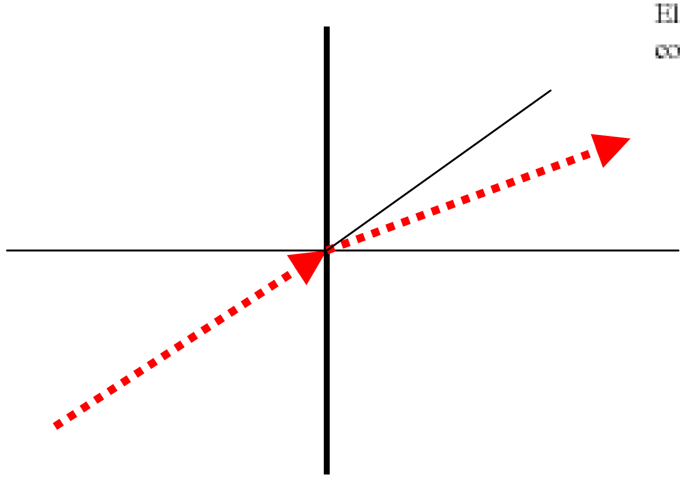
(too) Simple initial idea

2.5mm

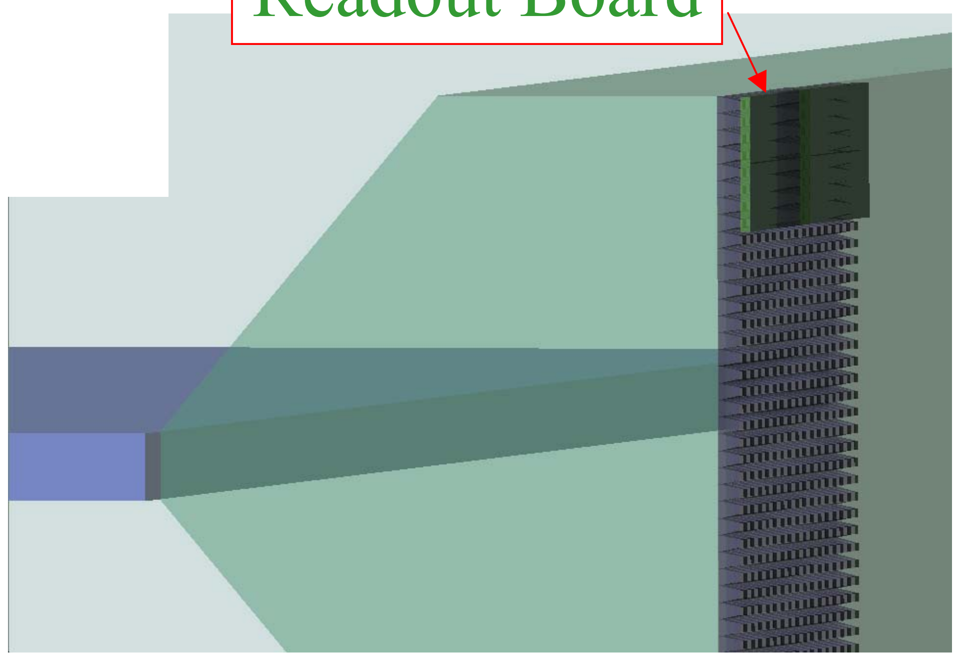


29mm

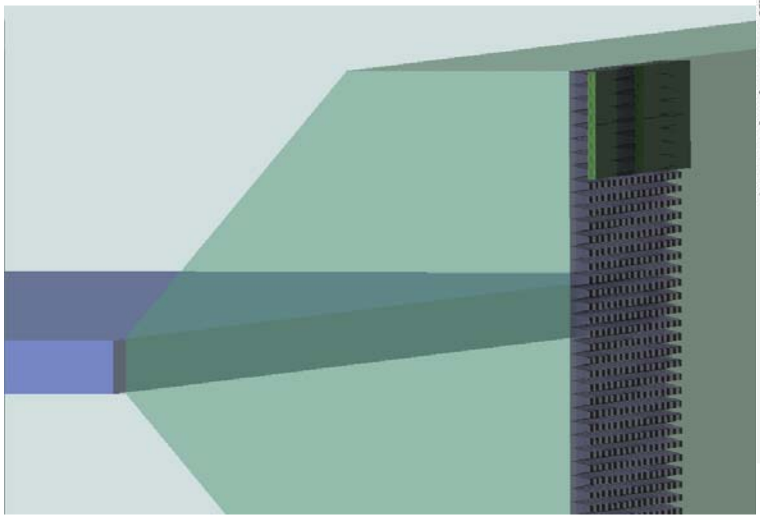


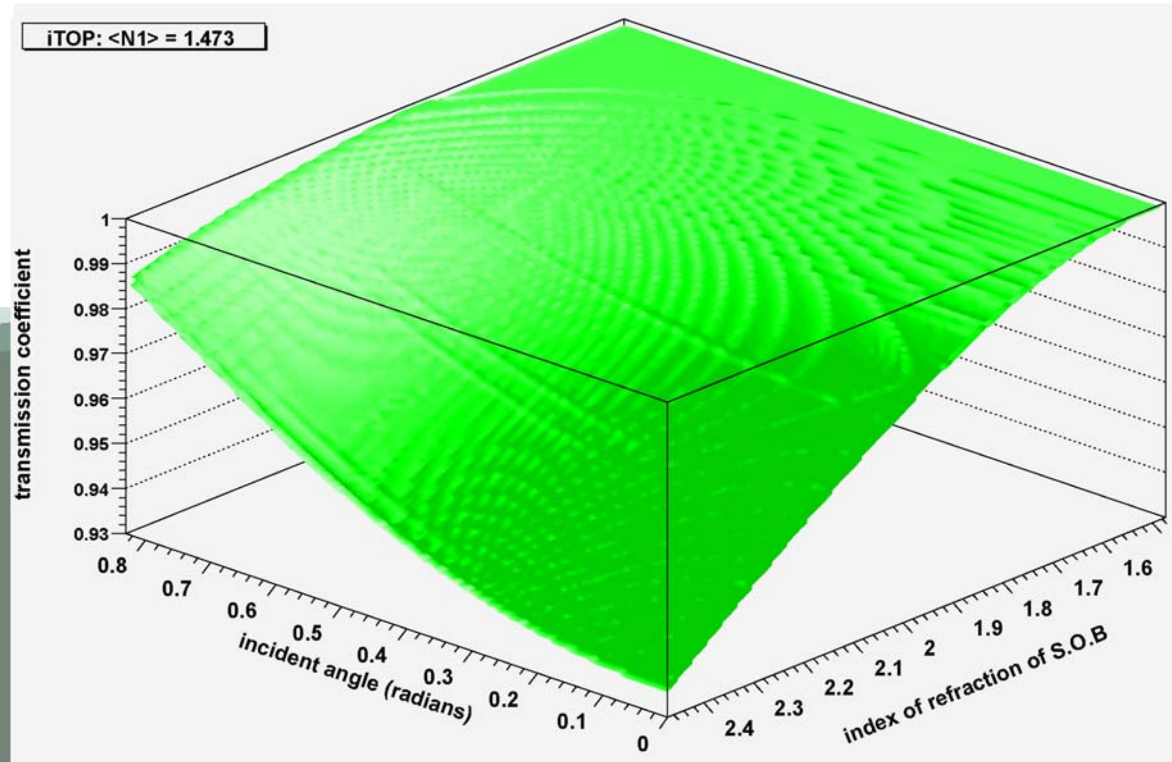


Readout Board



Stand-Off Block (SOB) Coupling



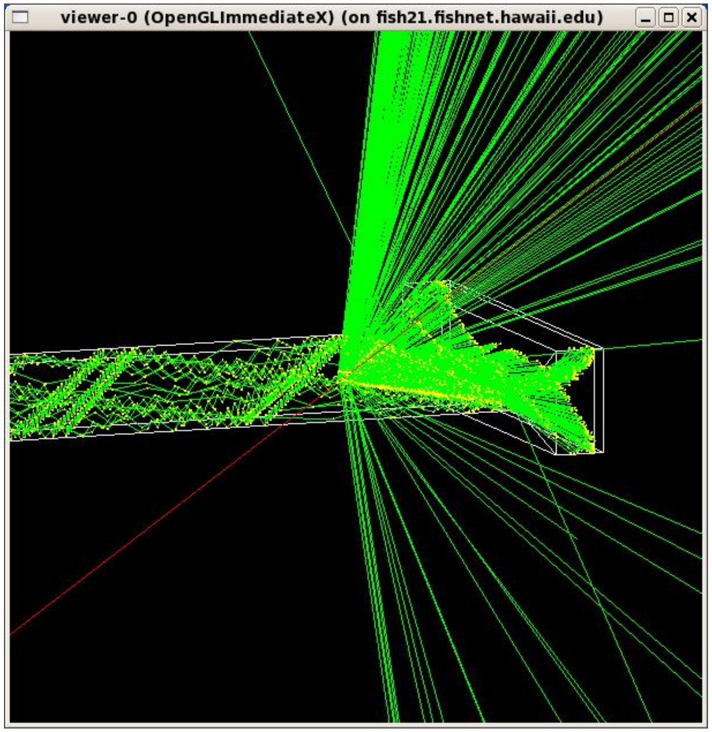


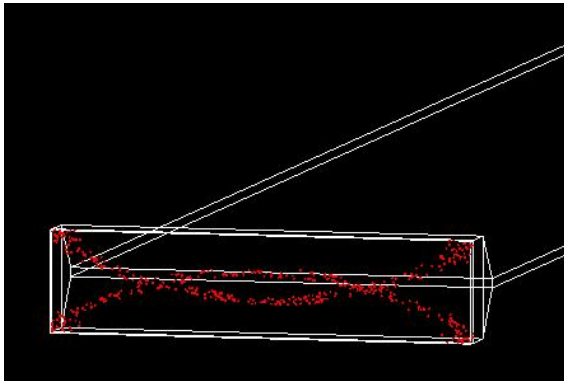
44 x 92 pix/plane = 4048 channels
16 bars x 2 ends x 4048 = ~130k channels

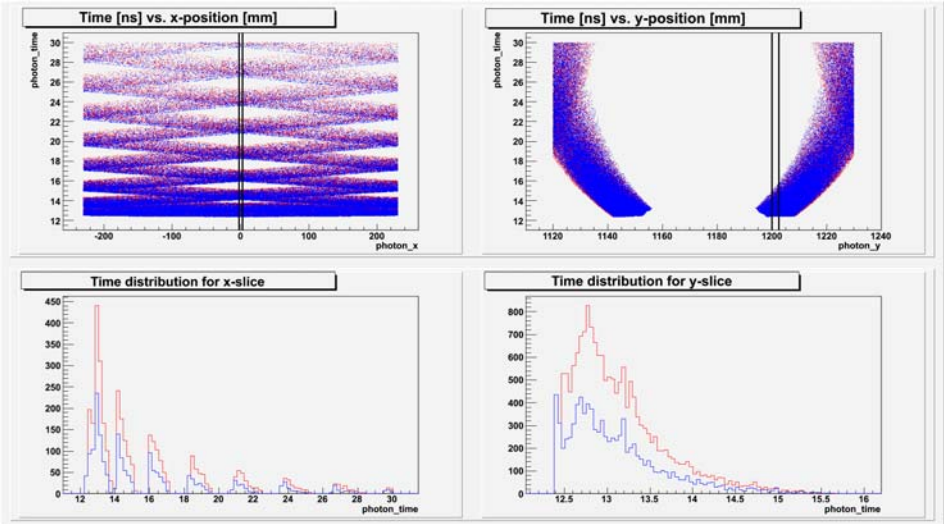
Problem is, once get in, hard to get out…
Exploring a number of concepts

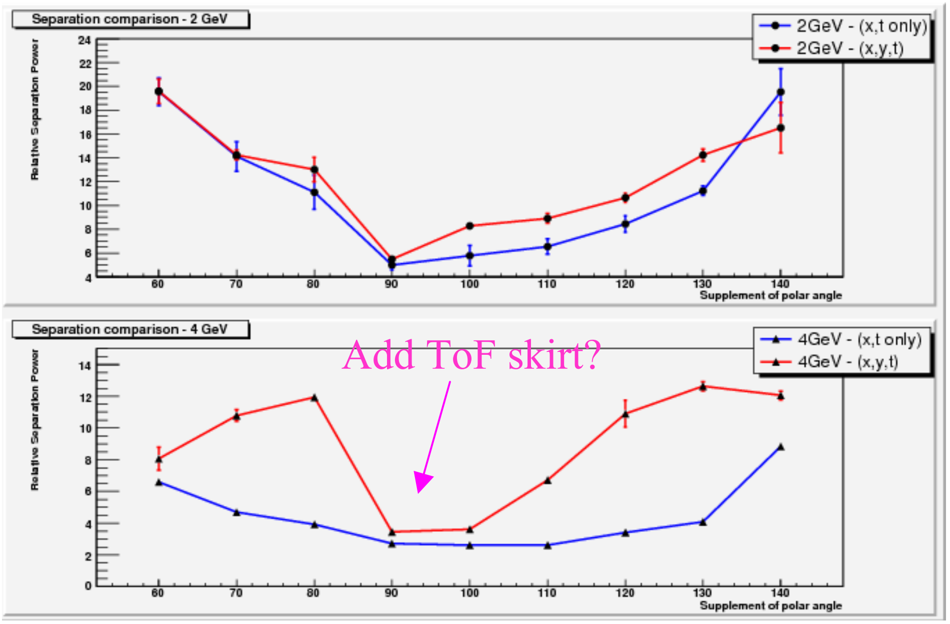
GEANT4 Simulation

Kurtis Nishimura/Larry Ruckman





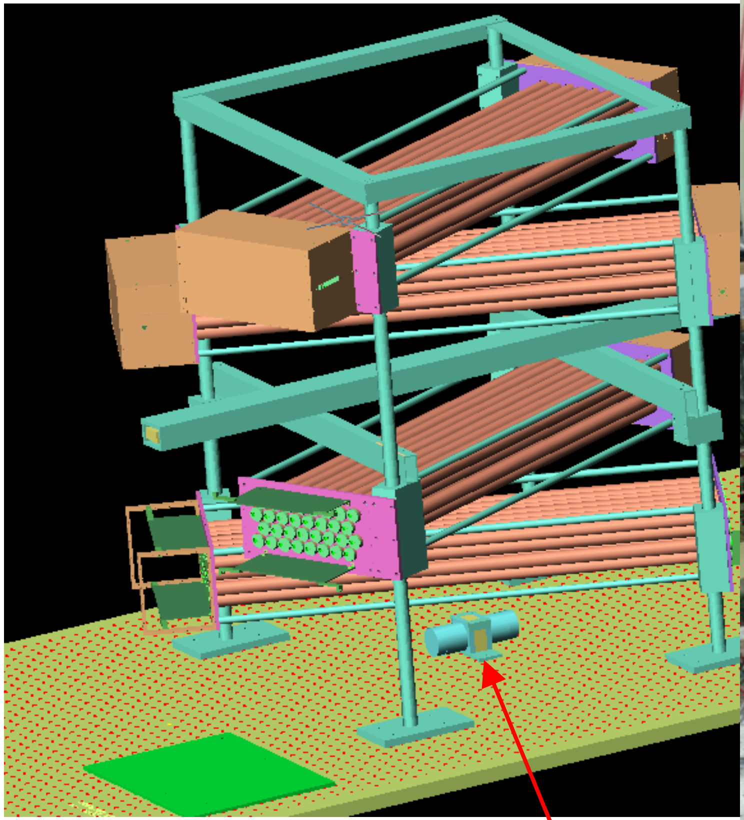


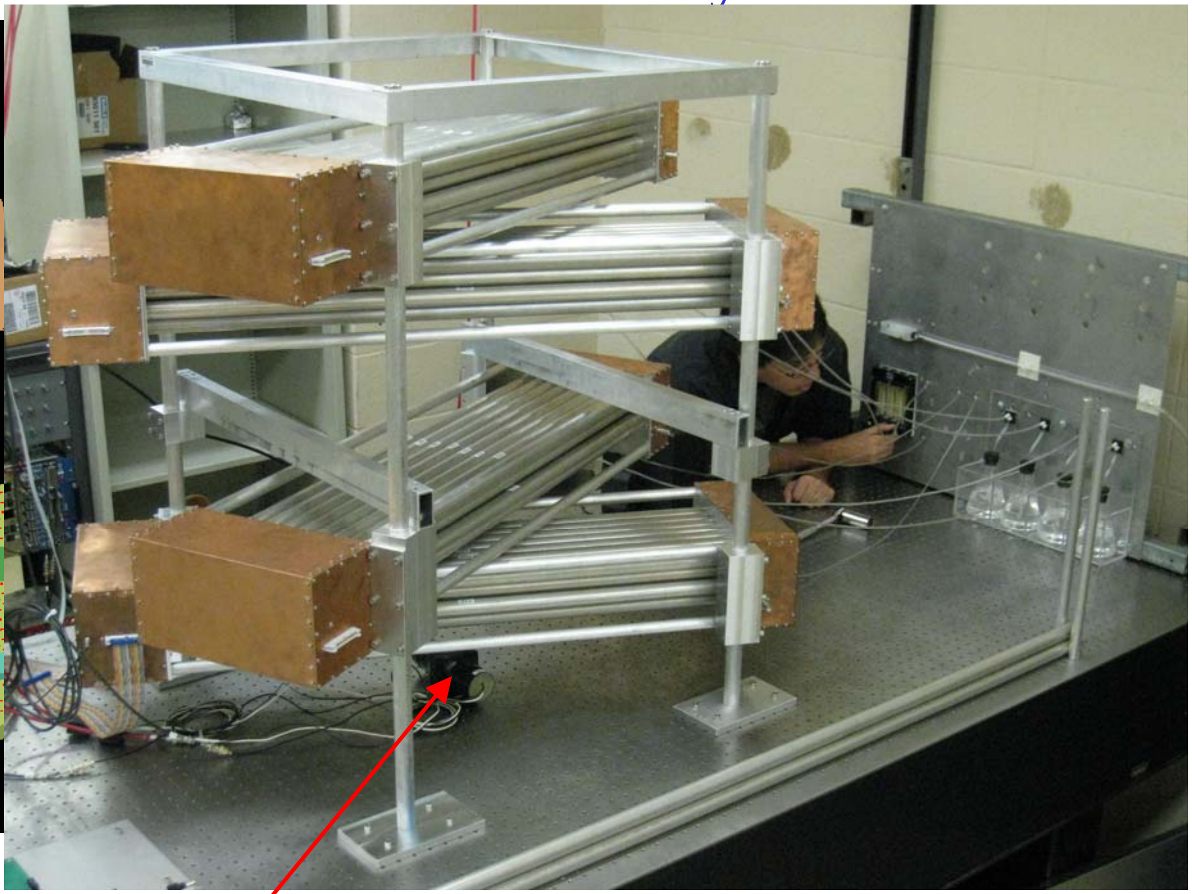


Looks promising, need to test

Cosmic Test Bench

- Quartz bar test bed – 128 drift tube array

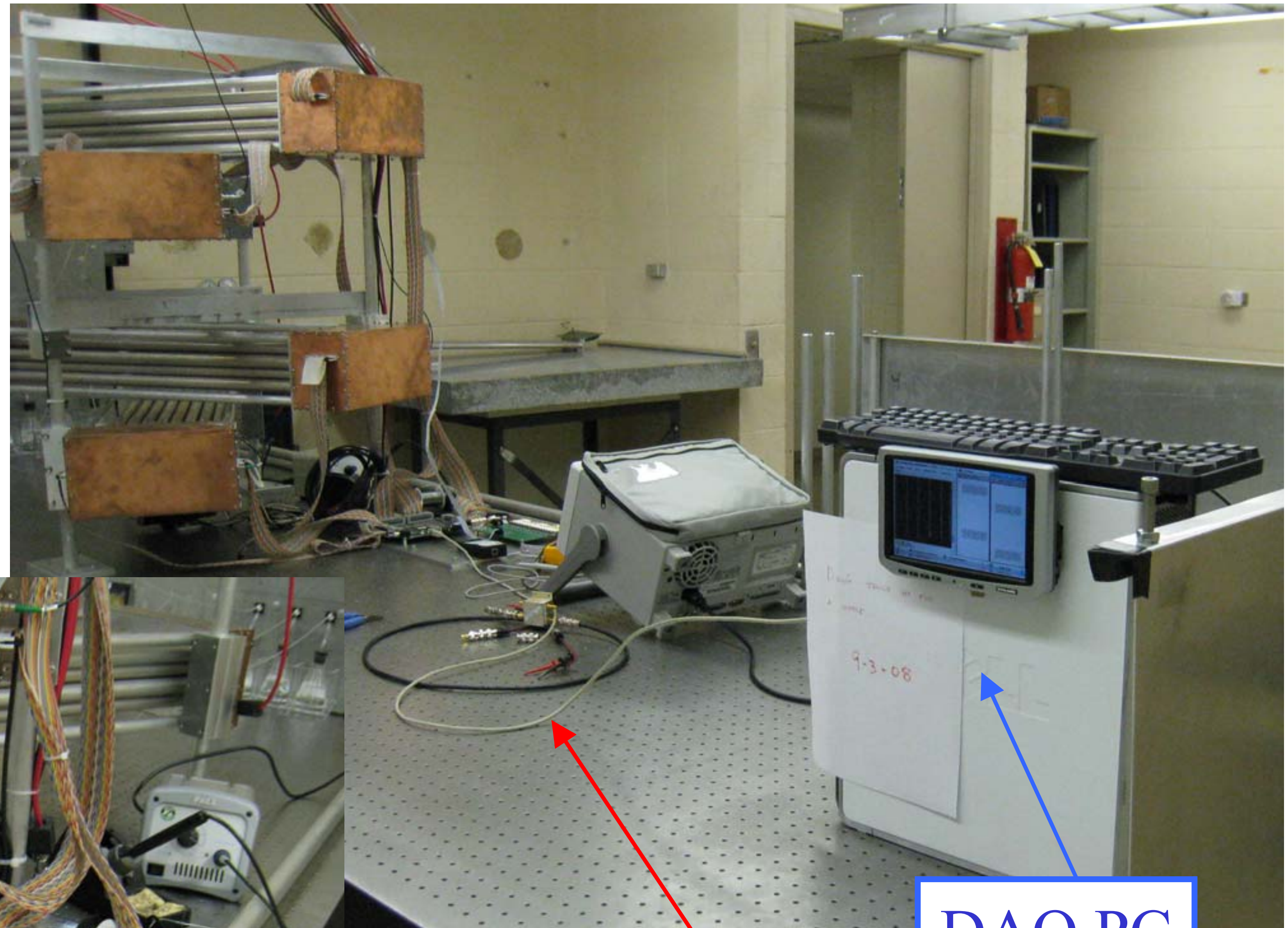


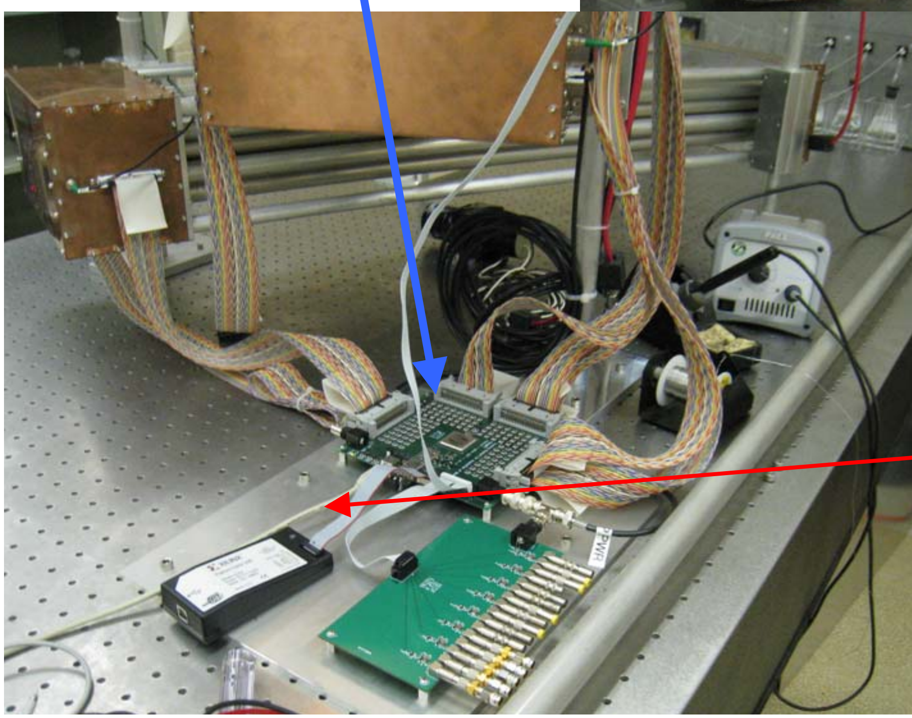


Precision Timing Block (T=0)
Radiator viewed by 2x fine-mesh PMTs

Cosmic Test Bench - Infrastructure

- 128 channel Discriminator and TDC board (TRAMP)

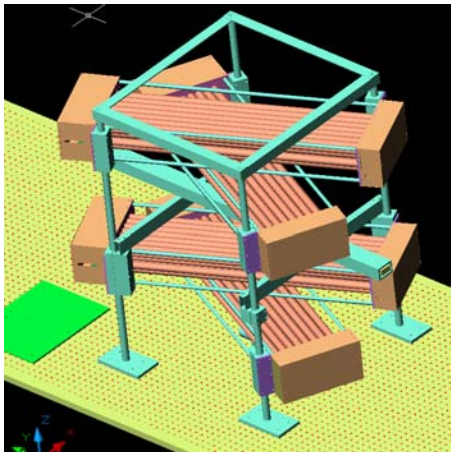


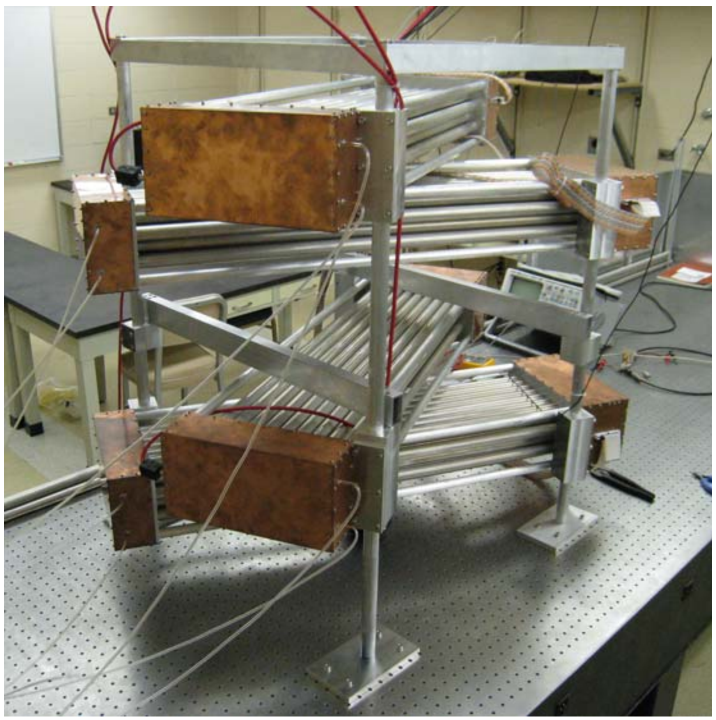


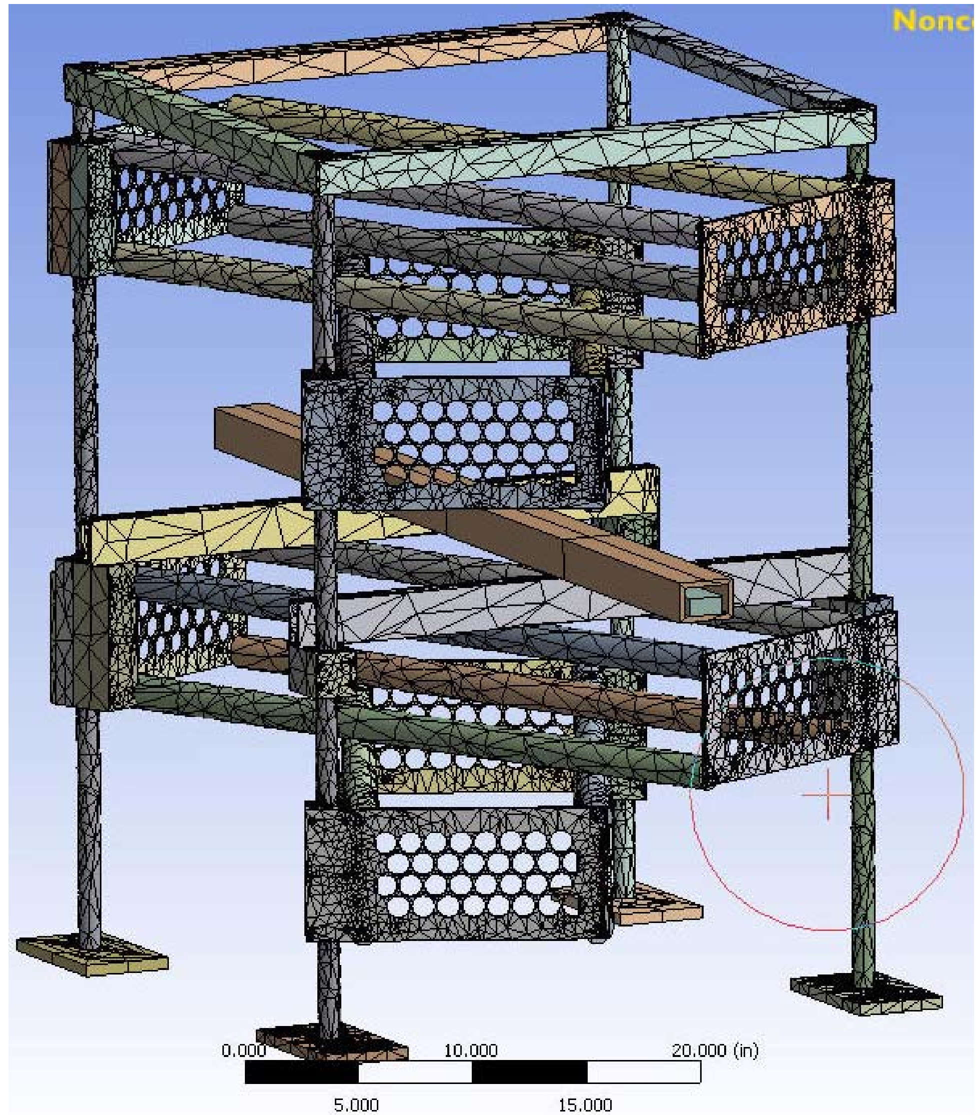
DAQ PC

USB2 link (drift-tubes)

Cosmic Test Bench – mech. Stability

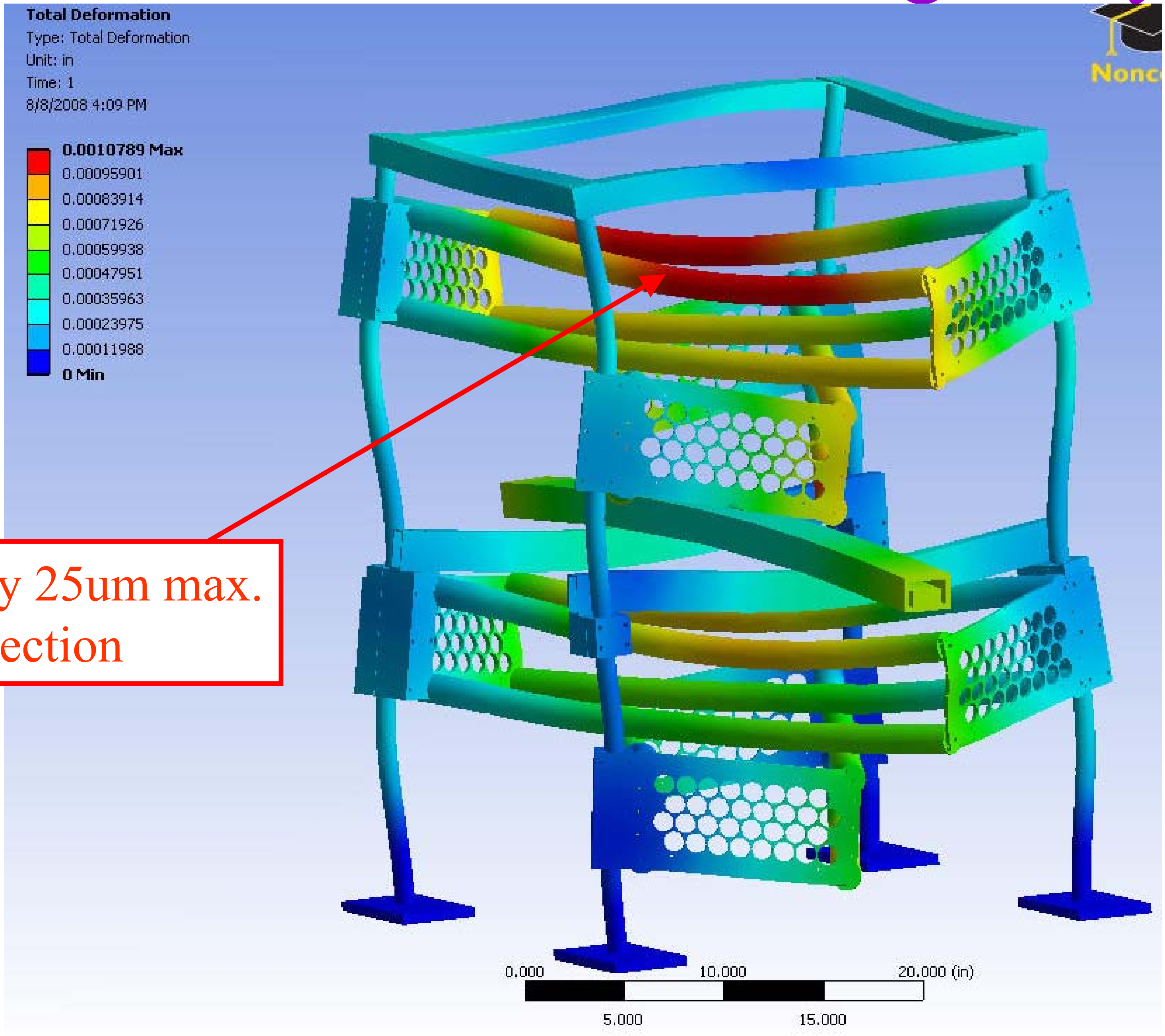






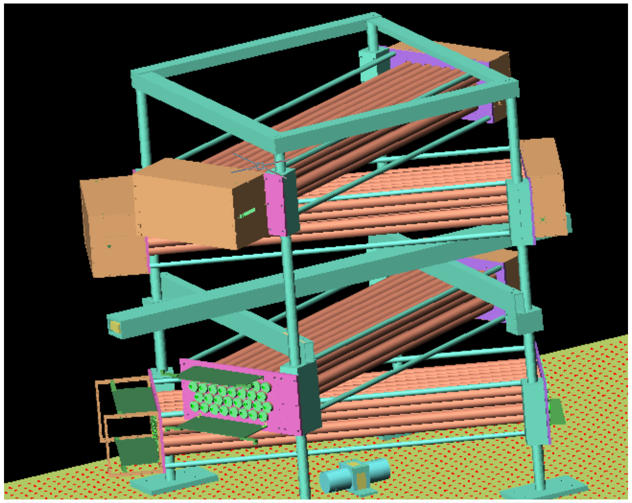
Rigidity and stability are excellent

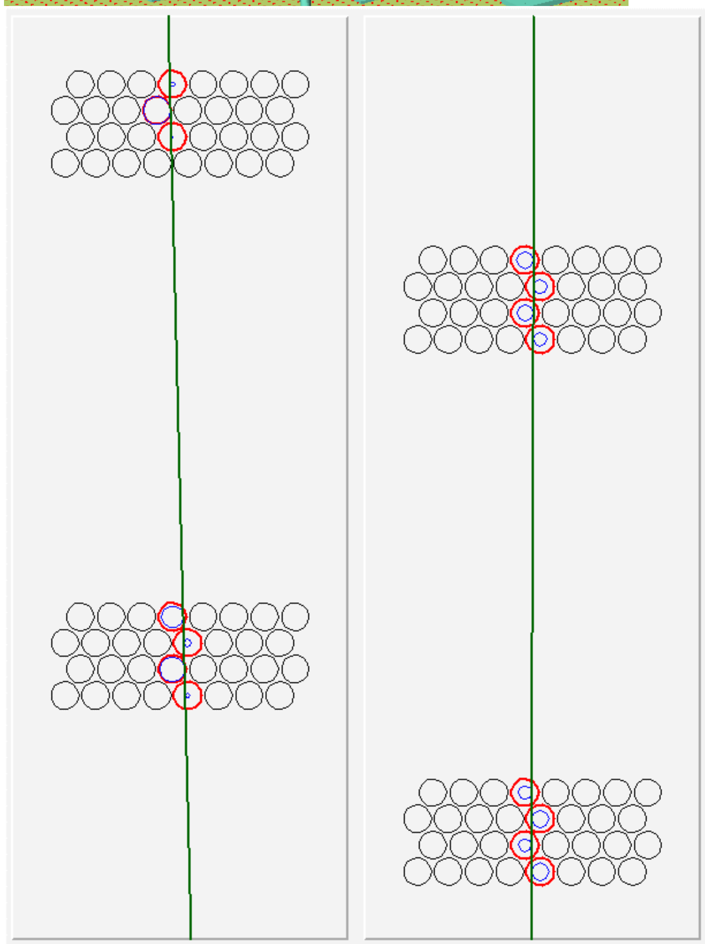
Cosmic Test Bench – Sag analysis

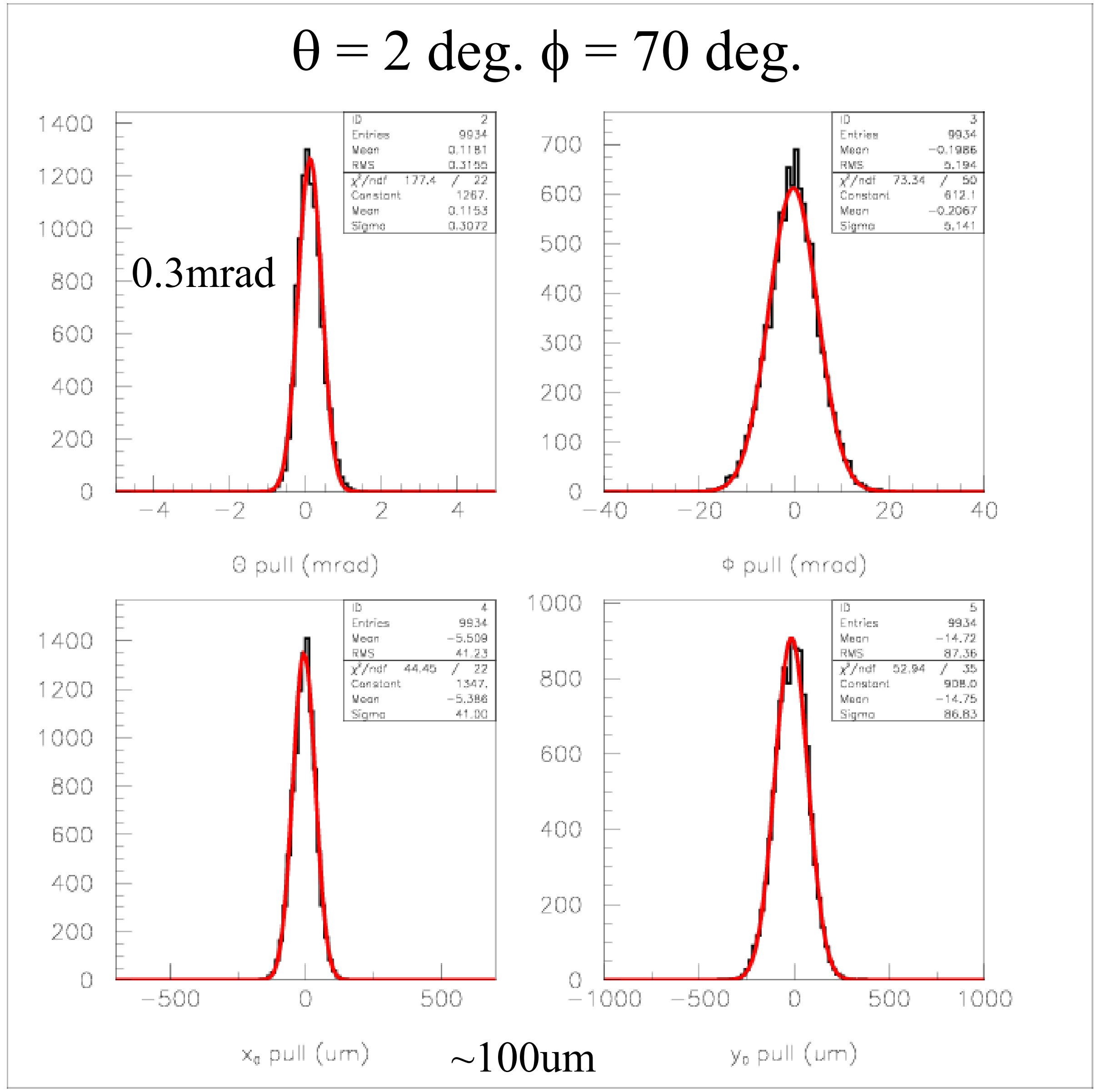


Only 25um max. deflection

Tracking Resolution Sims.

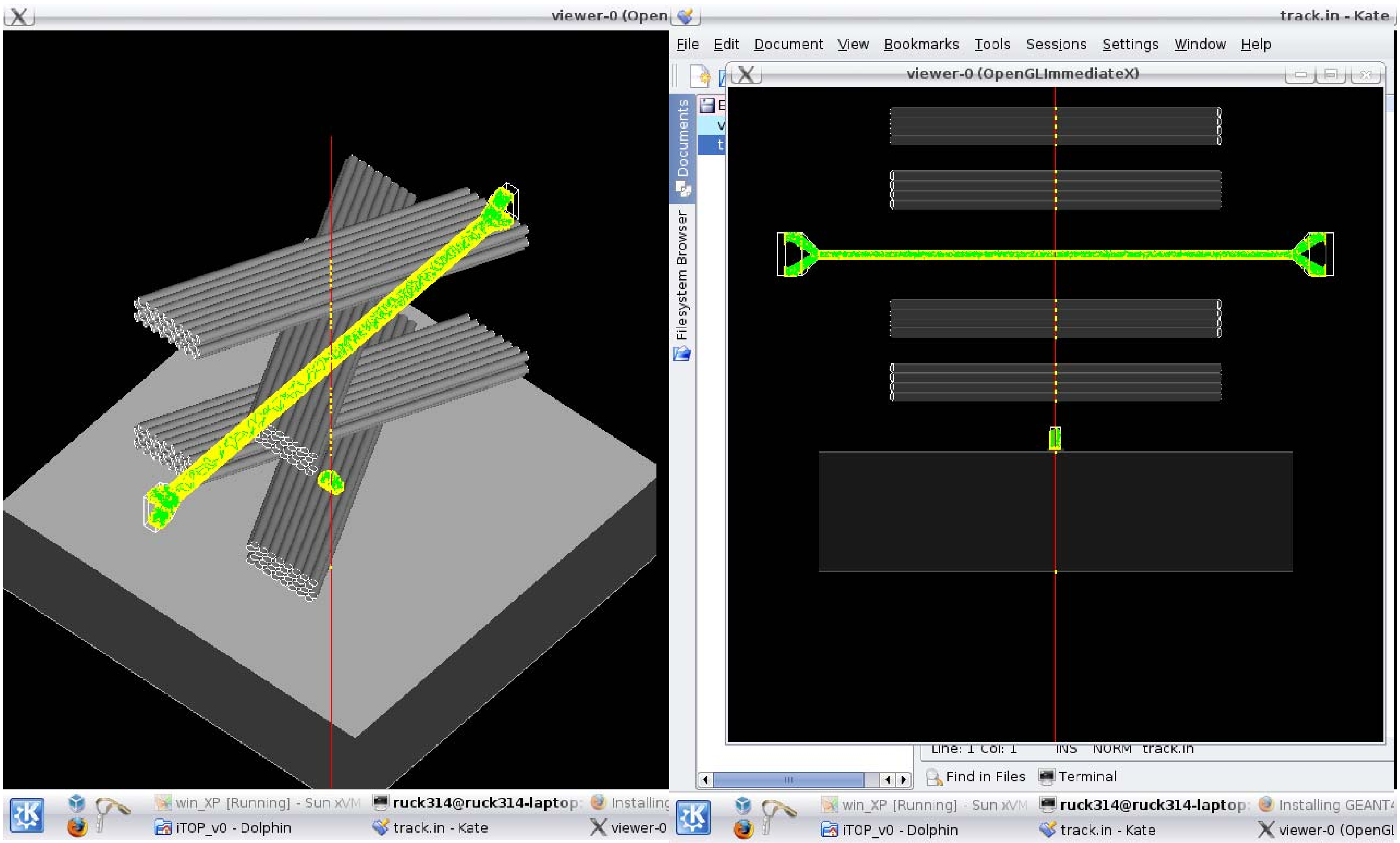






G4 Simulation

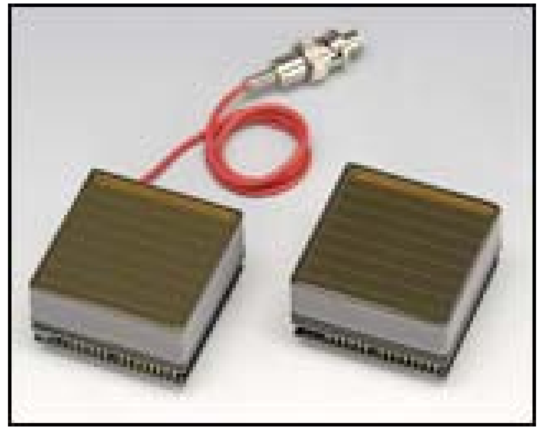
- Studying optimizations for image planes



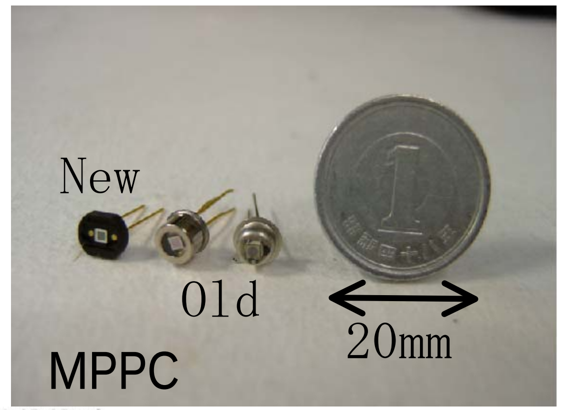
- 100% avail. beam, test different concepts – GEANT confirm

Photon detector options

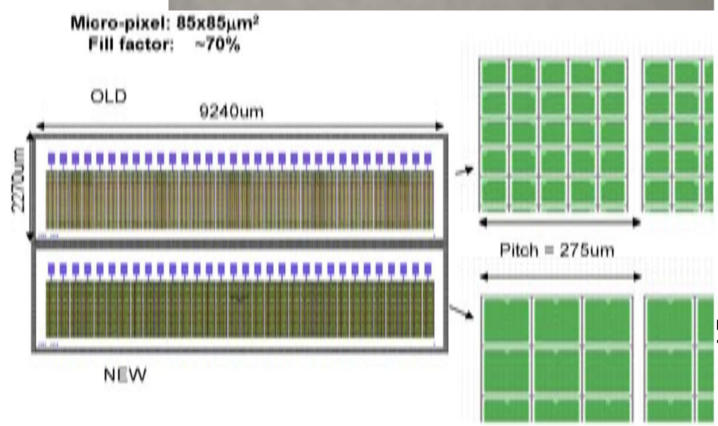
- MCP-PMT (H-8500)
  – Will use for initial testing
    - Study realistic time resolution
    - Use BLAB gain to extend lifetime
  – Demonstrate timing at lower gain



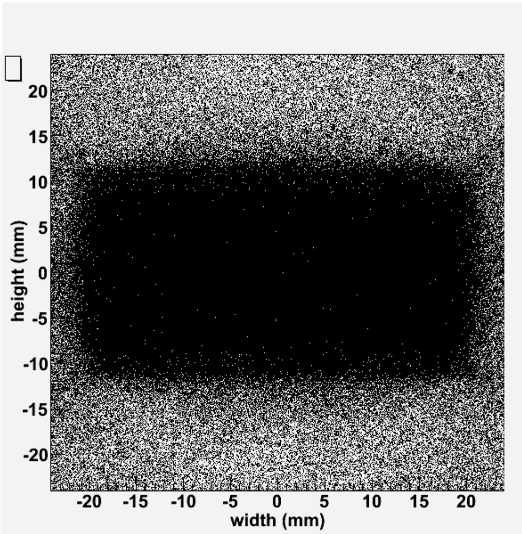
- SiPM/MPPC
  – Good stability, 100ps TTS (N=100 p.e. → 10ps)
  – Need light guide to make work
  – Radiation hardness?

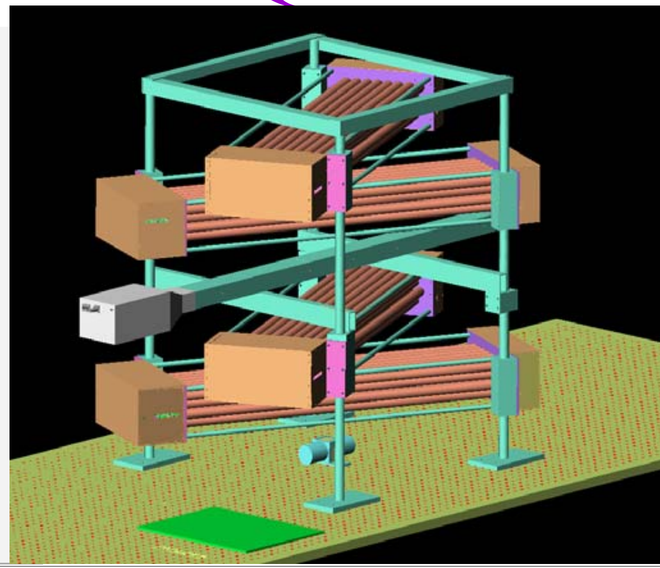


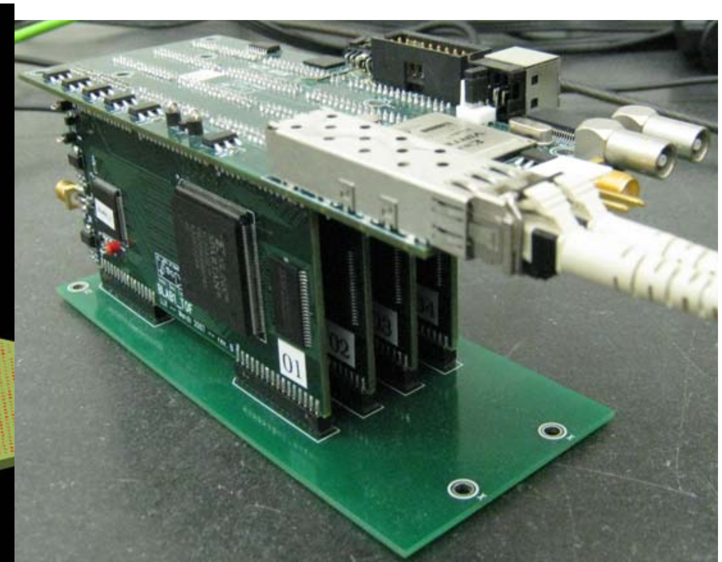
- Linear arrays
  – Started evaluating (good vertical resolution)
  – Packaging considerations



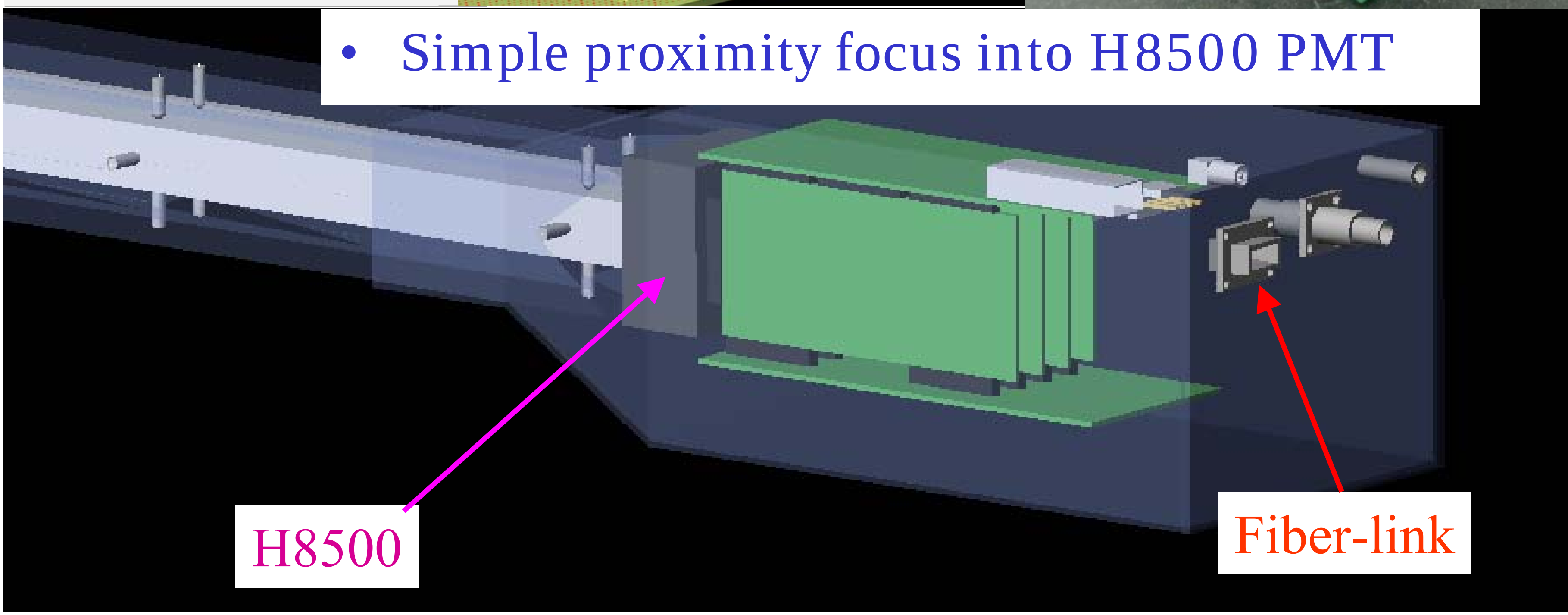
Initial Quartz bar test





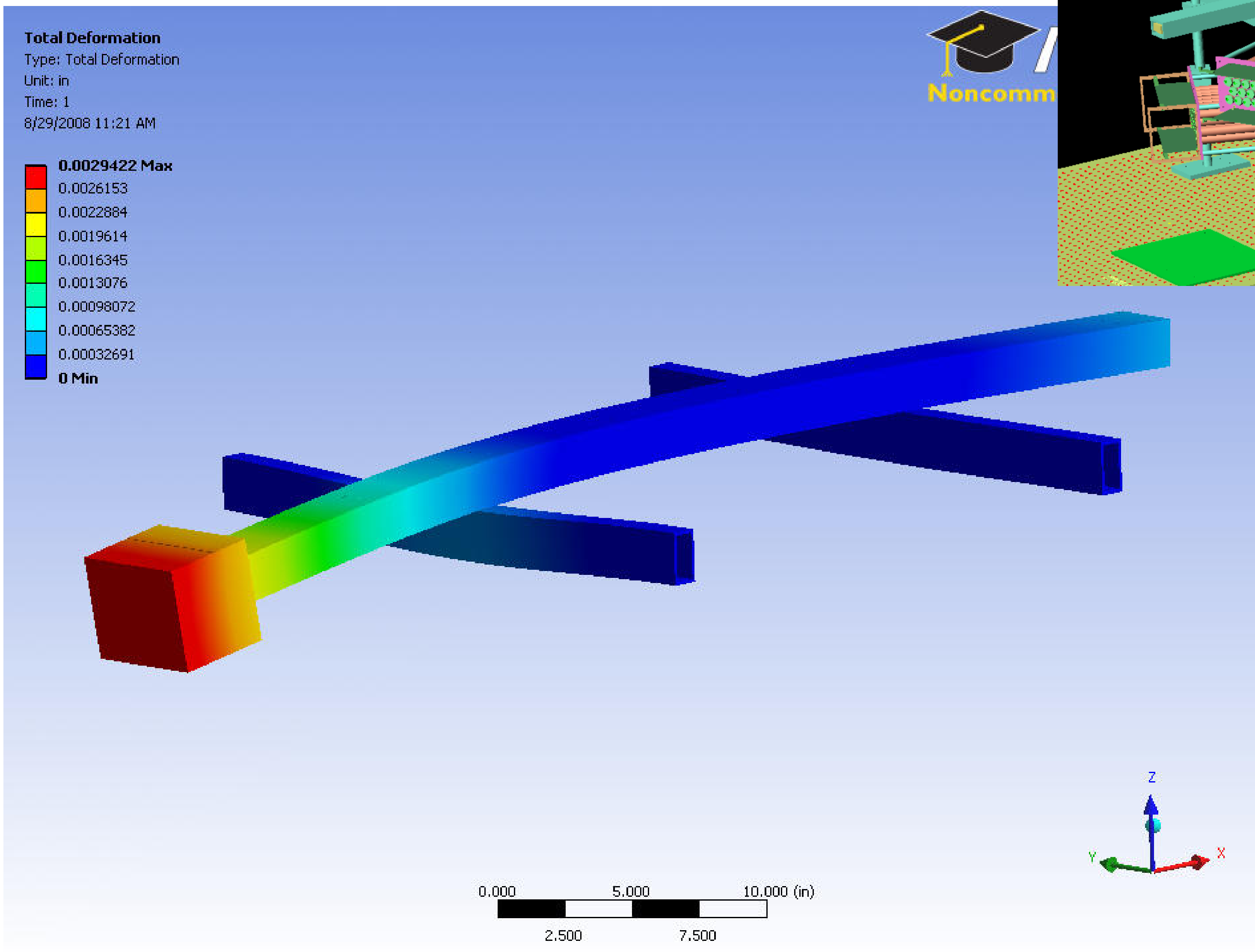


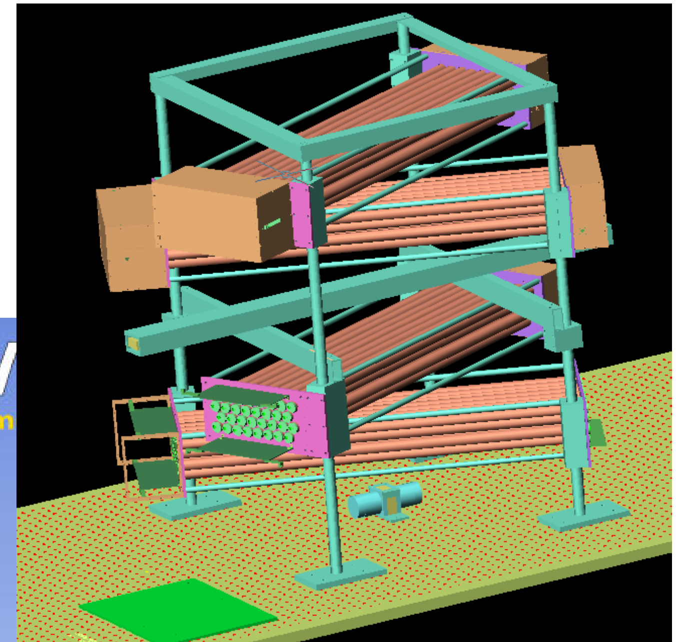
- Simple proximity focus into H8500 PMT



Cantilevered Loading

~75um max deflection (~3kg load)

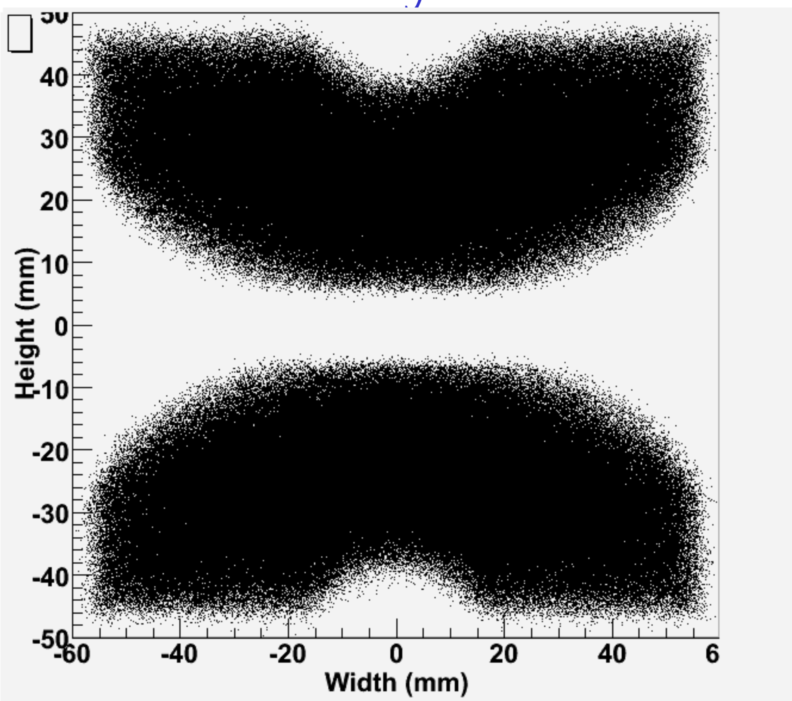


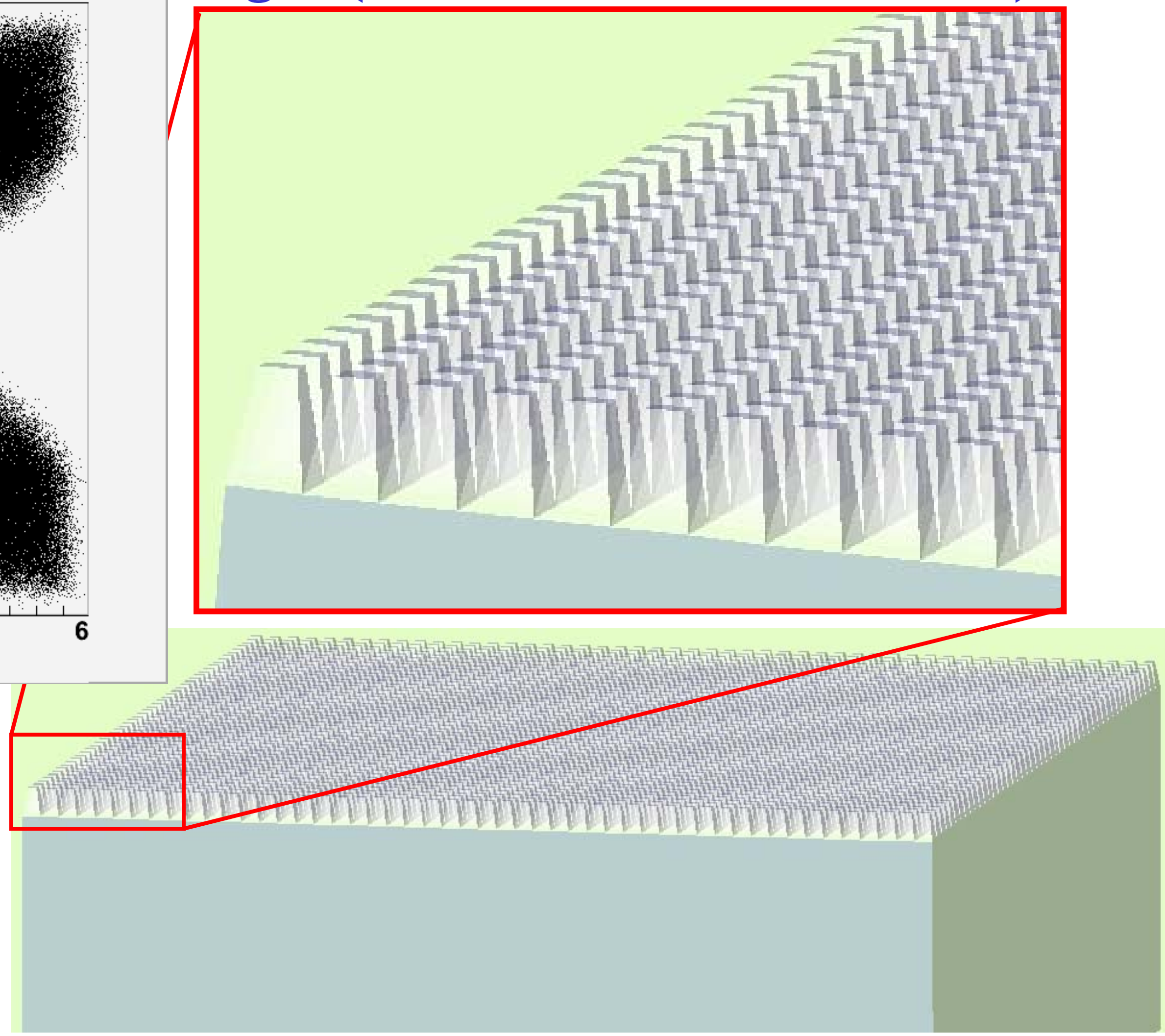


Add additional support (outrigger)

Full Image plane test (40mm SOB)

- Proximity focus initial target (100mm iTOP thickness)

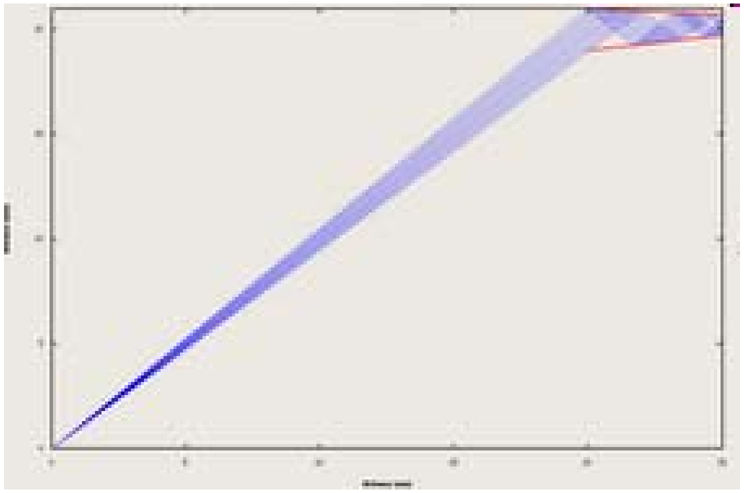




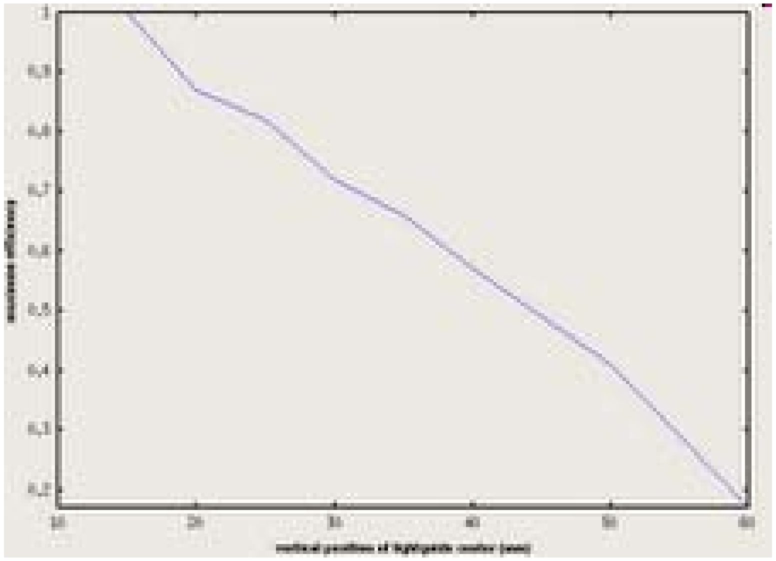
120mm (W)
x 100mm (H)
x 40mm (T)
2.4k pixels shown

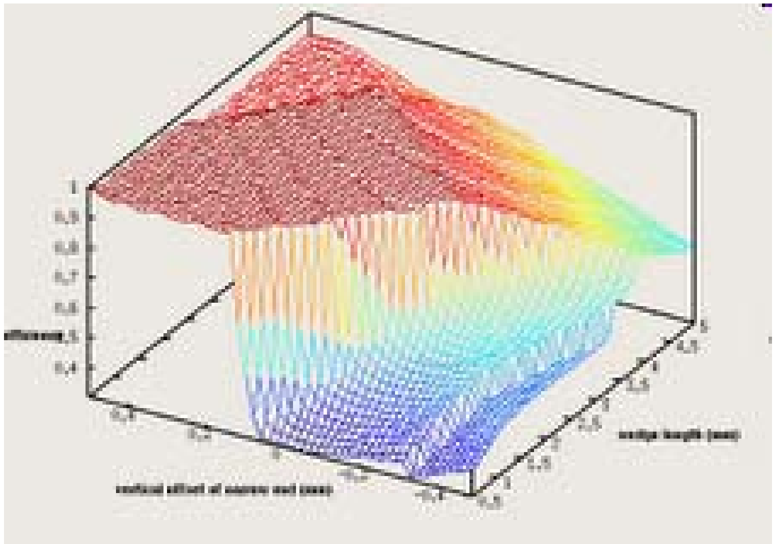
- For good coupling, proposed to taper versus position, but…

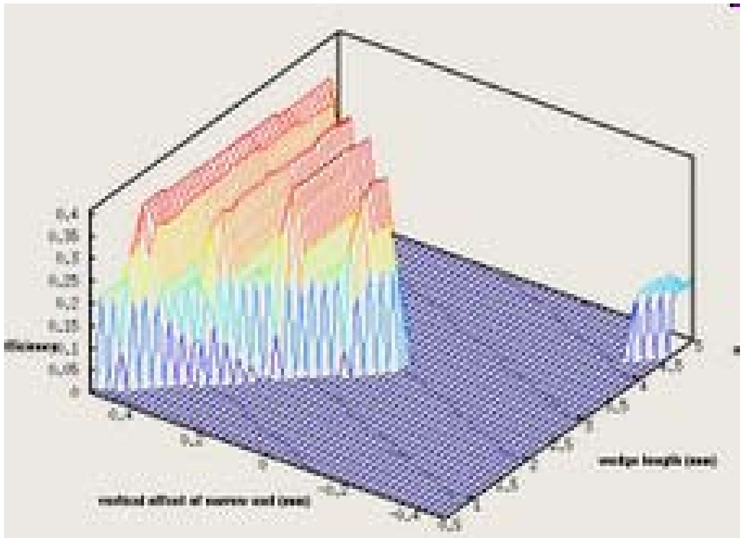
Off-axis coupling issues…



(blame octave for image quality…)

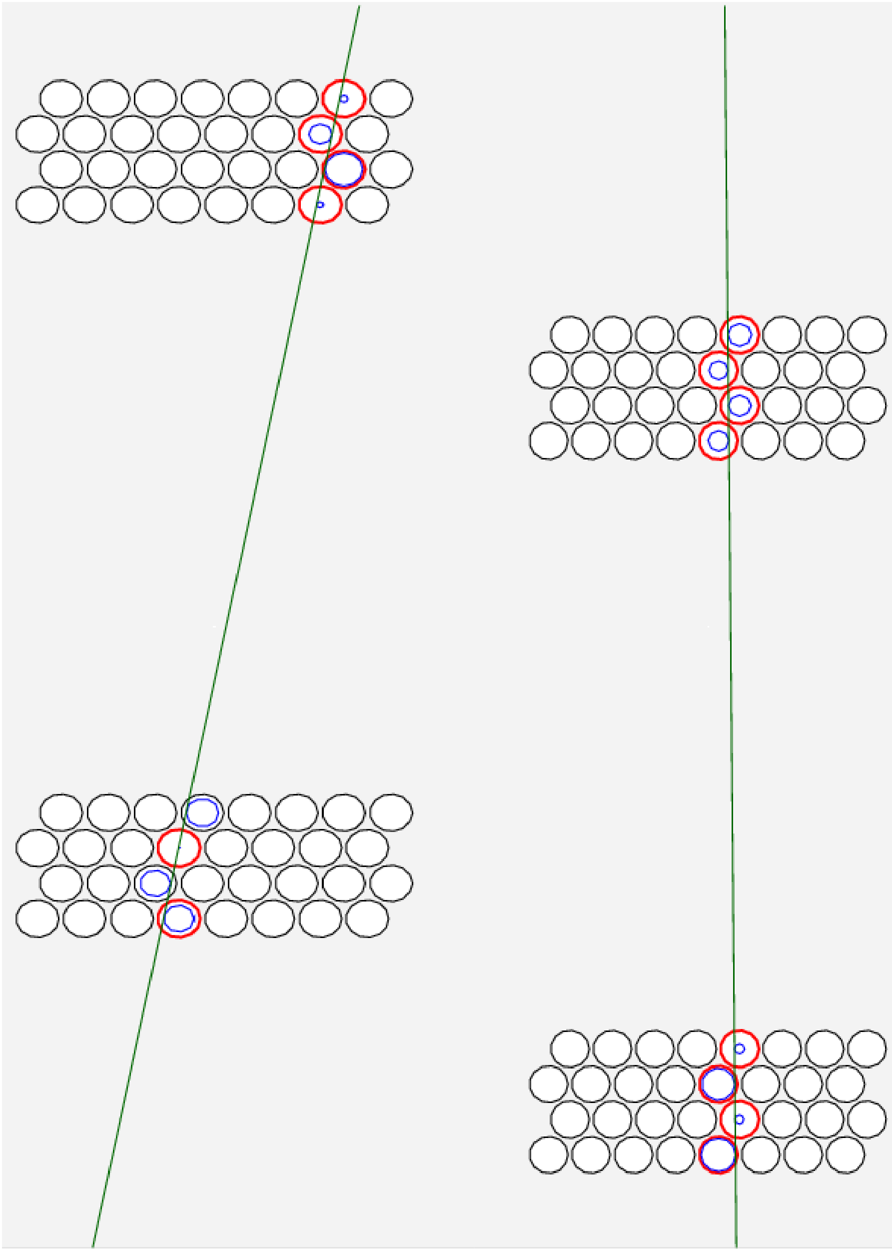






Test bench will allow study of planar arrays

First Fitted Track



Fit status was 1

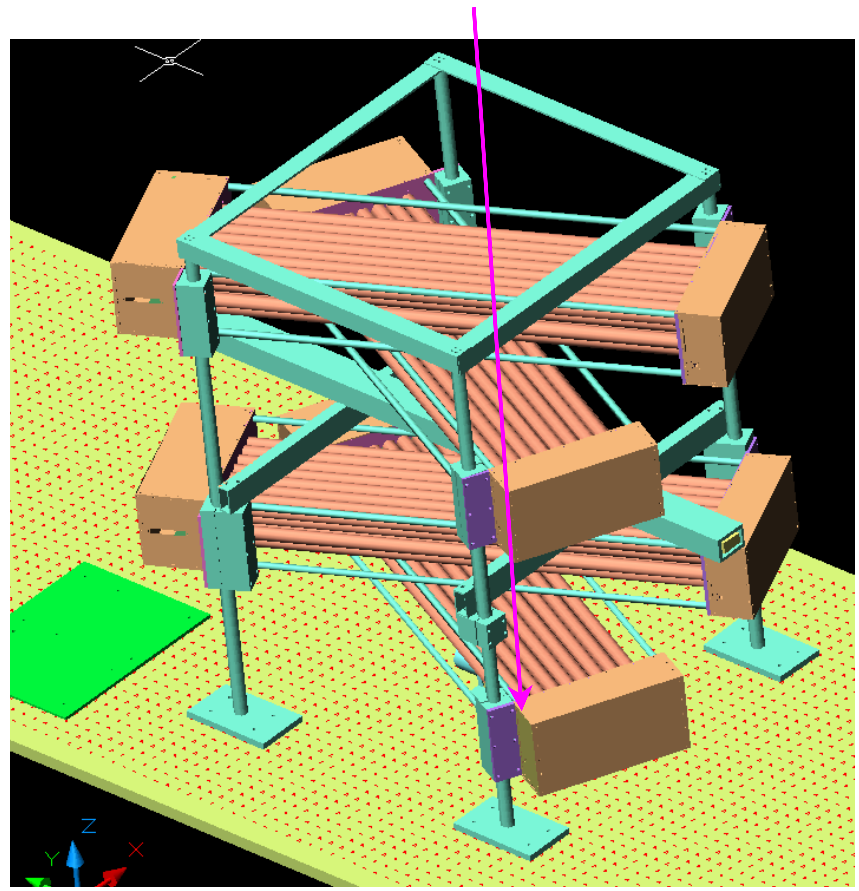
Theta = 14.1181 deg

Phi = 247.083 deg

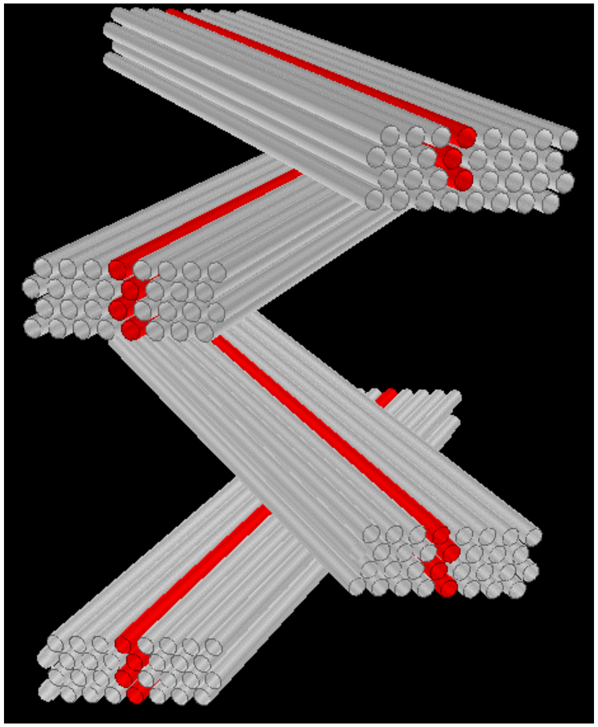
x0 = 1.2125 cm

y0 = -0.943005 cm

t0 = 177.919 ns



Test Bench Status



Cosmic Data taking
for tube alignment
in Progress

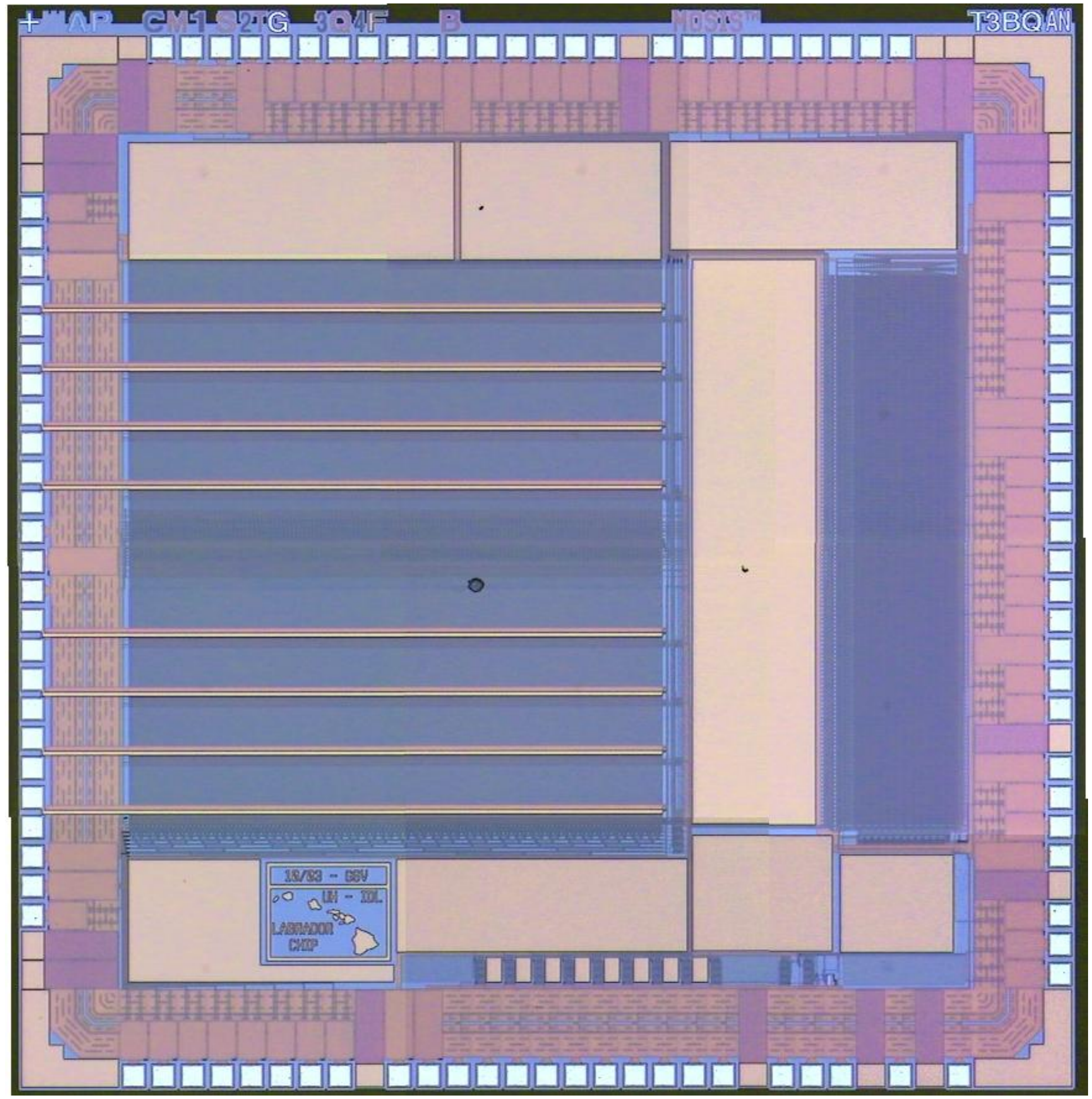
- Machining of Bar Support in progress
- First tests with H8500 thereafter (debug for f-DIRC)
- **Strategy** is to match full GEANT4 simulations to results seen (close the loop)
- In parallel develop larger image array (~2k channels)
- Add a 2^{nd} Quartz bar
- Add momentum selector (DSSDs and magnet)

Summary

Building toward large-scale prototypes

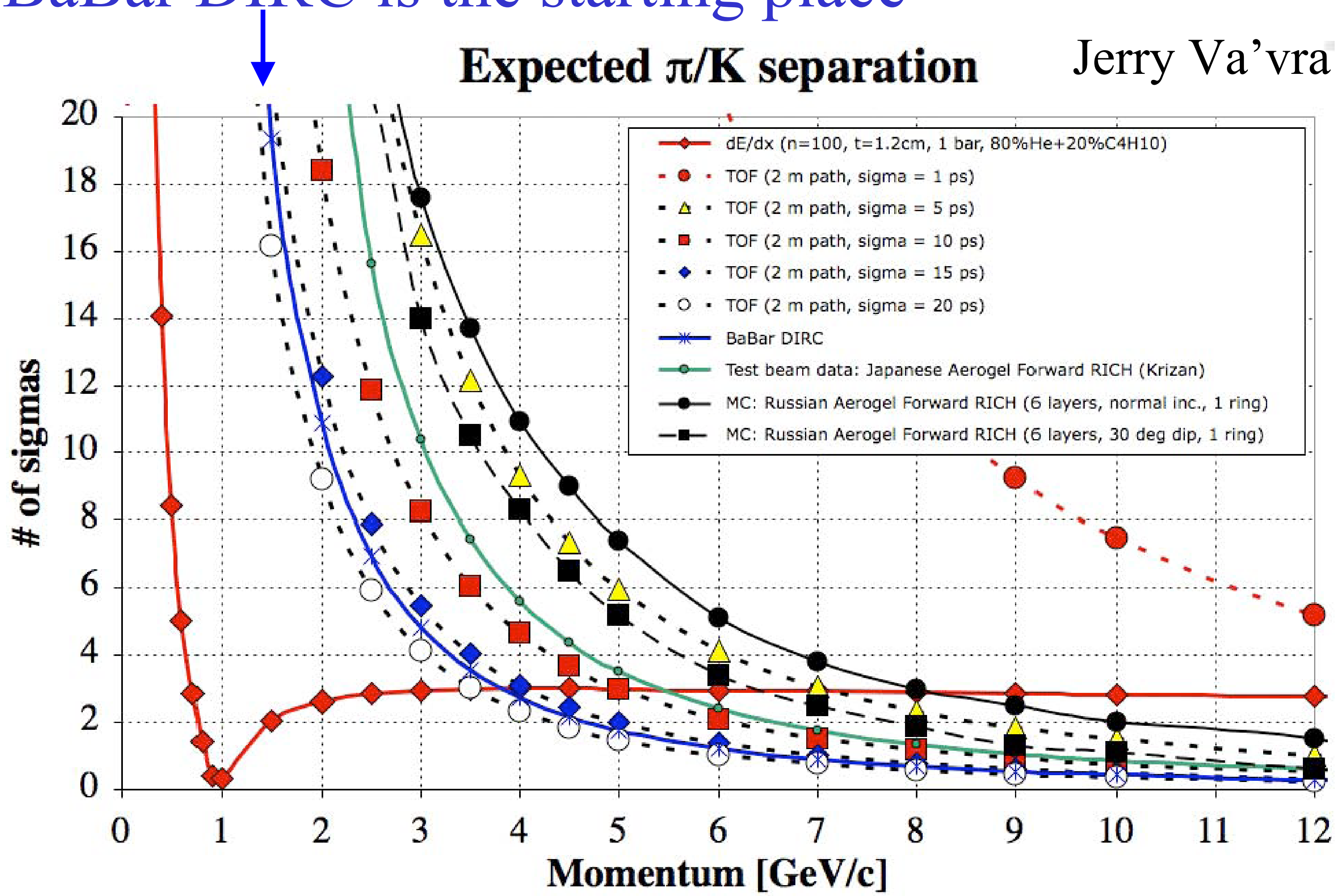
- December 2008 – 448 channel BLAB2-based readout system in Bldg 121 f-DIRC test stand
- Timing tests of semi-conductor G-APDs (continuing this autumn)
- Prototype k-Channel imaging plane (autumn)
    - Performance, cost, integration
    - Higher pixellation readout
- Close loop between GEANT4 and prototype (by year's end?)
- Define what needed for TDR input (2009)

Back-up slides

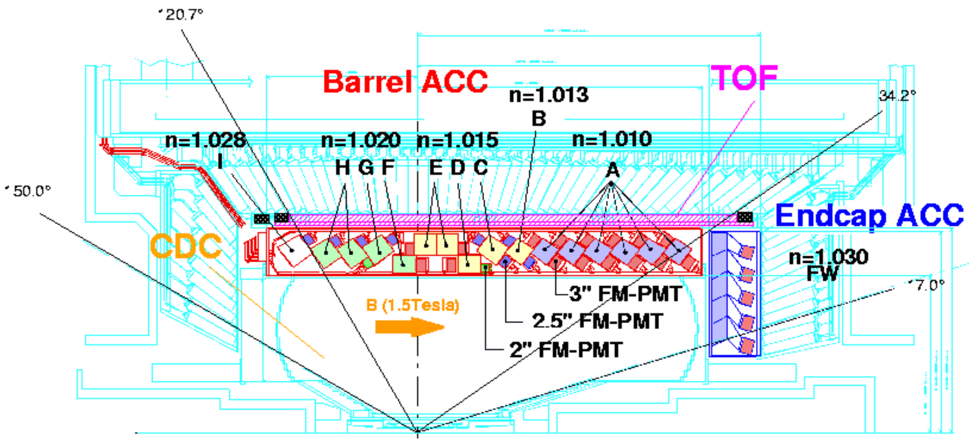


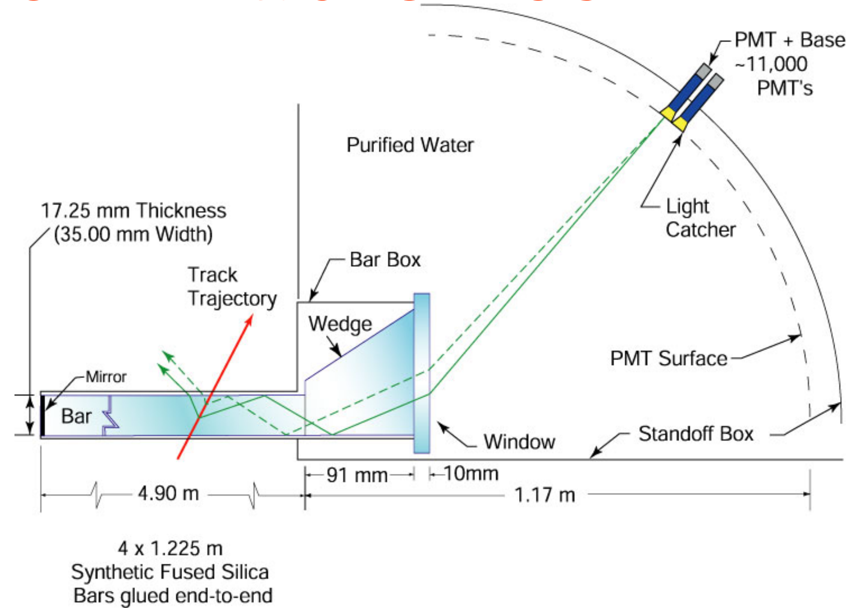
Particle ID Techniques

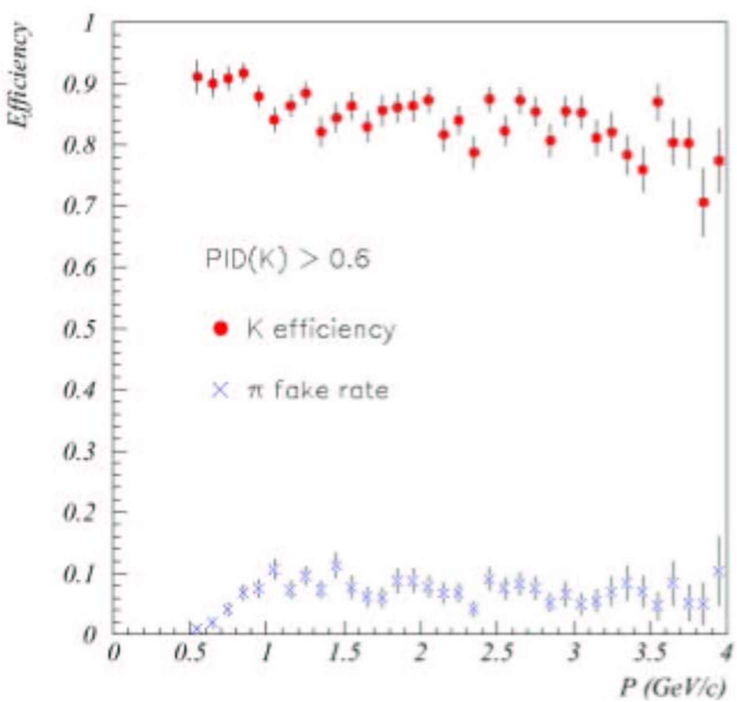
- BaBar DIRC is the starting place

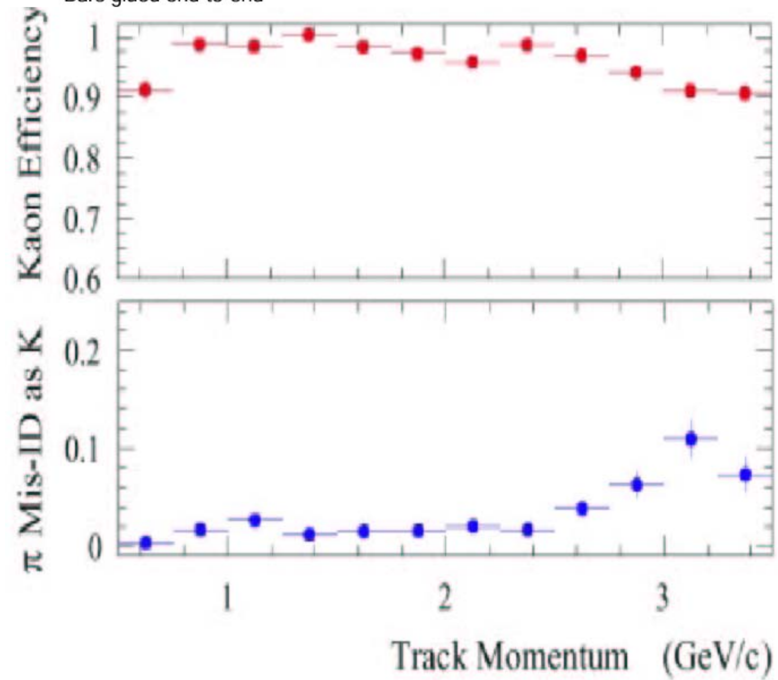


Particle ID at the B-factories

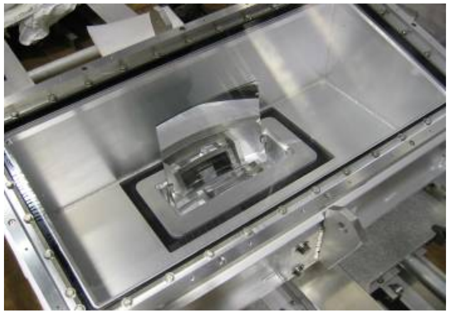


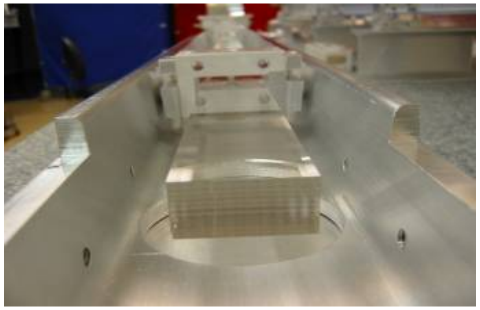


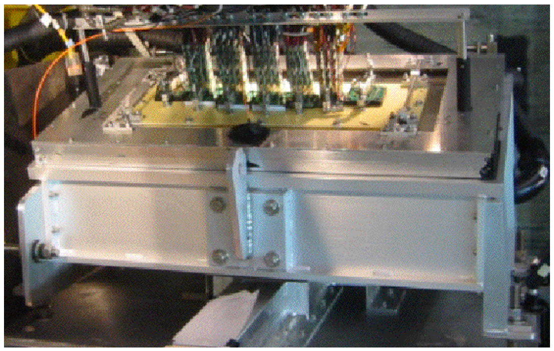


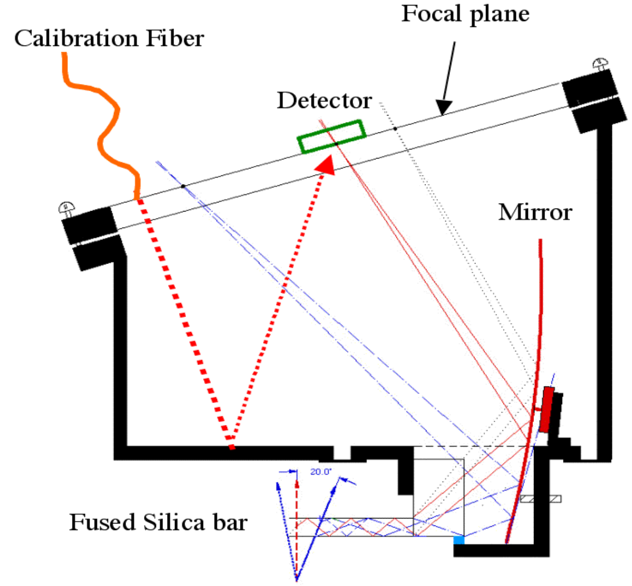


Focusing DIRC Prototype Optics









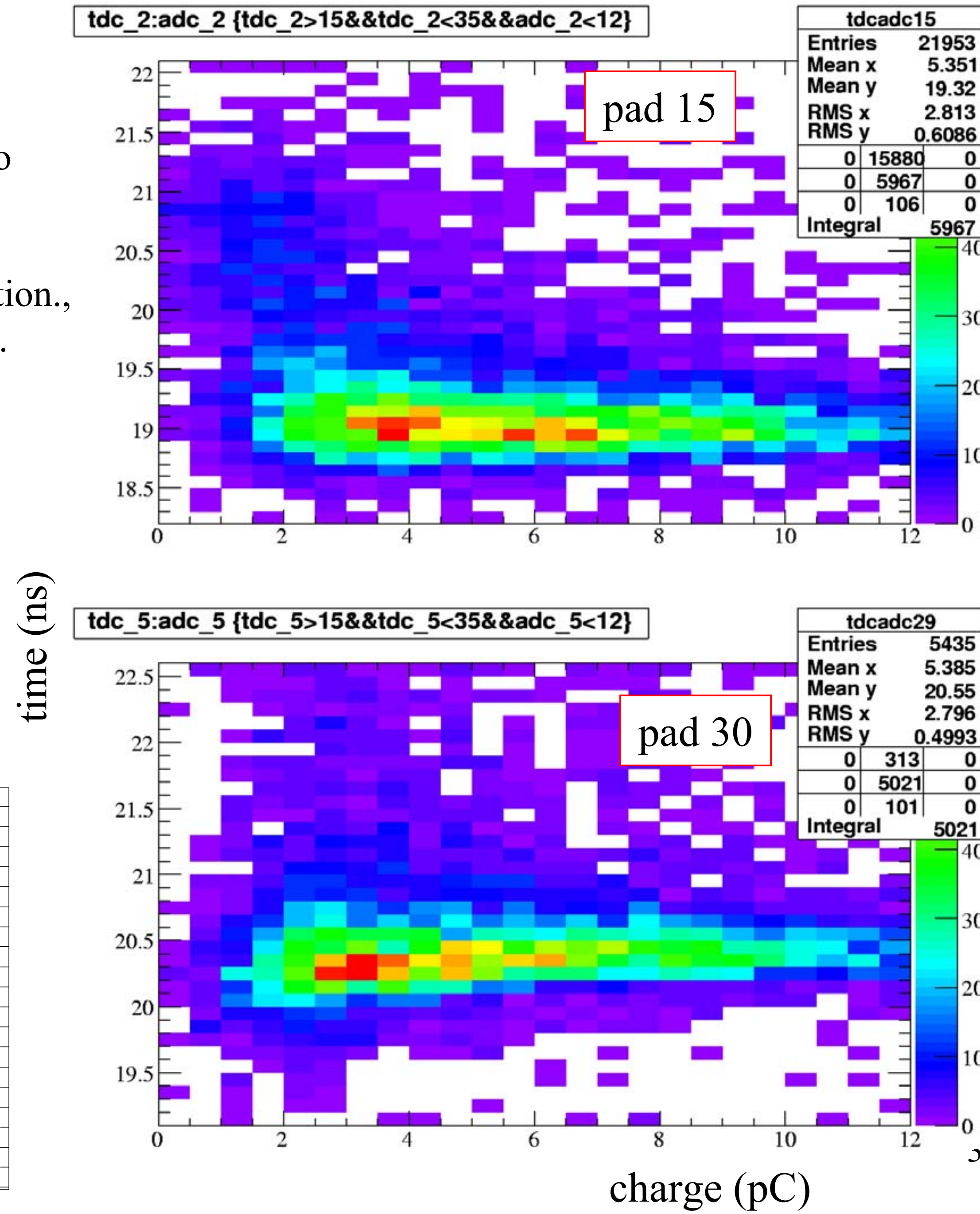
- Radiator:
  - 1.7 cm thick, 3.5 cm wide, 3.7 m long fused silica bar (spares from BABAR DIRC).
- Optical expansion region:
  - filled with a mineral oil to match the fused silica refraction index (KamLand oil).
  - include optical fiber for the electronics calibration (PiLas laser diode).
- Focusing optics:
  - a spherical mirror with 49cm focal length focuses photons onto a detector plane.

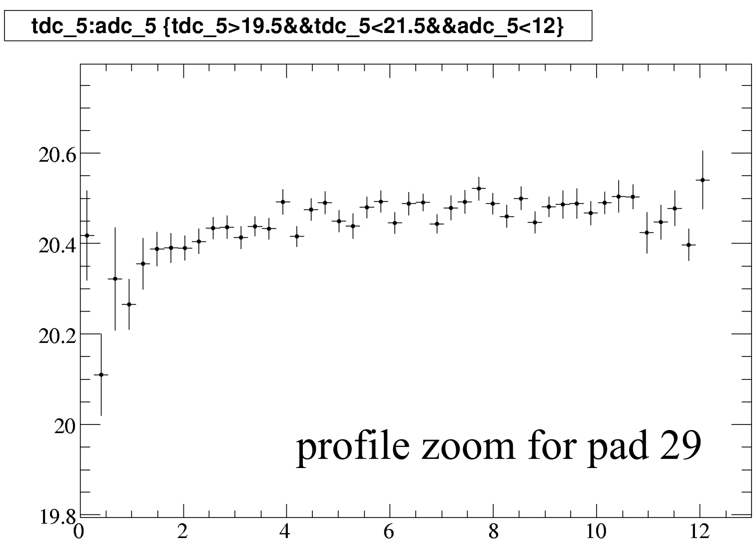
TDC vs. ADC for signal in run 27

Larry's offline correction method seems to come close to correcting time walk.

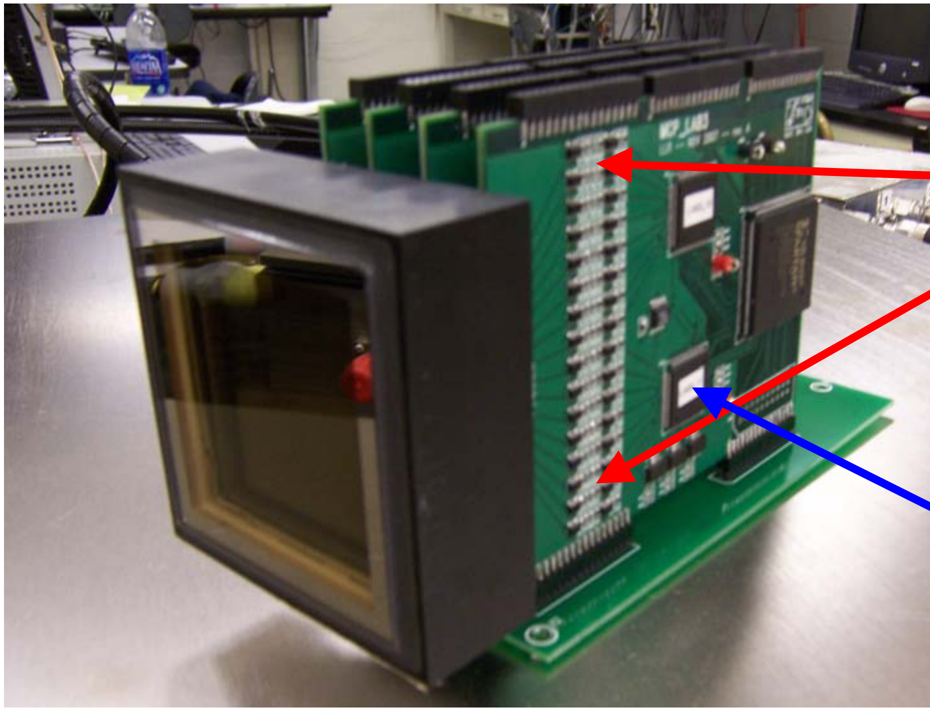
Some over-correction, some under-correction., more can be done offline with charge info.

Jochen Schwiening analysis (preliminary)





Gain Needed



Amplifiers dominate board space

Readout ASIC tiny (14x14mm for 16 channels)

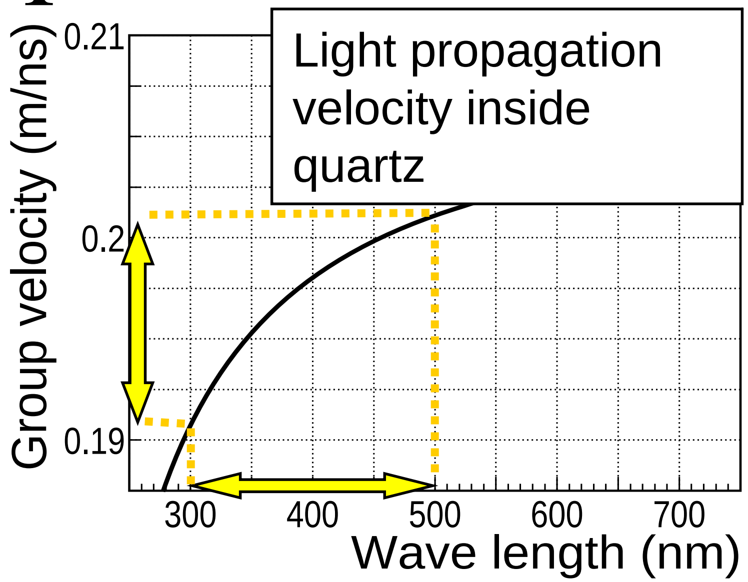
- What gain needed?
  - At 10^6 gain, each p.e. = 160 fC
  - At $2x10^5$ gain (better for aging), each p.e. = 32 fC
  - In typical ~5ns pulse, Vpeak = dQ/dt * R = 32uA * R = 32mV * R [kΩ] (6.4mV)

Gain Estimate	
Rterm	1 p.e. peak
50	1mV
1k	20mV
20k	400mV

Chromatic dispersion

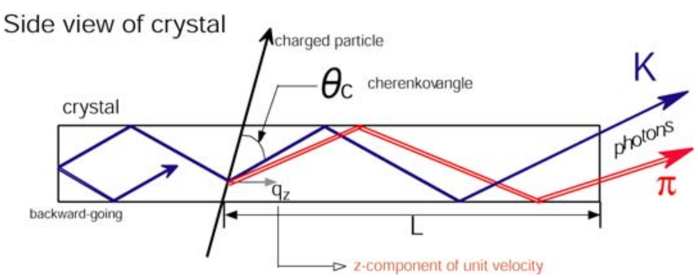
Variation of propagation velocity depending on the wavelength of Cherenkov photons

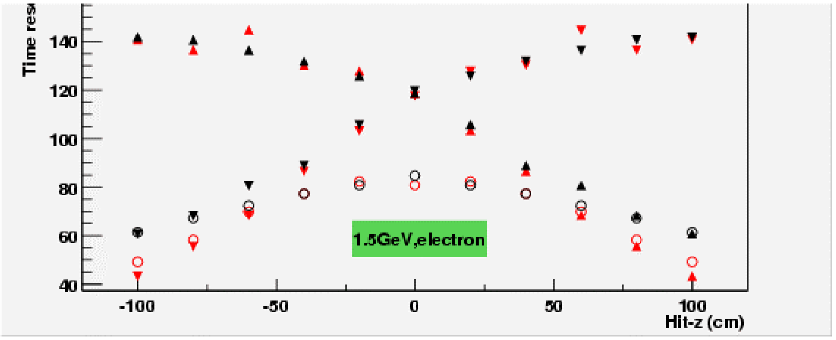
- Due to wavelength spread of detected photons
- → propagation time dispersion



- Longer propagation length

→ Improves ring image difference
But, decrease time resolution.





Techniques complement each other!

Separation Concept using Log $\mathcal{L}$

90 degrees (normal incidence)