Extraction-Line Energy Spectrometer

Energy and Polarization Workshop
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DESY - Zeuthen

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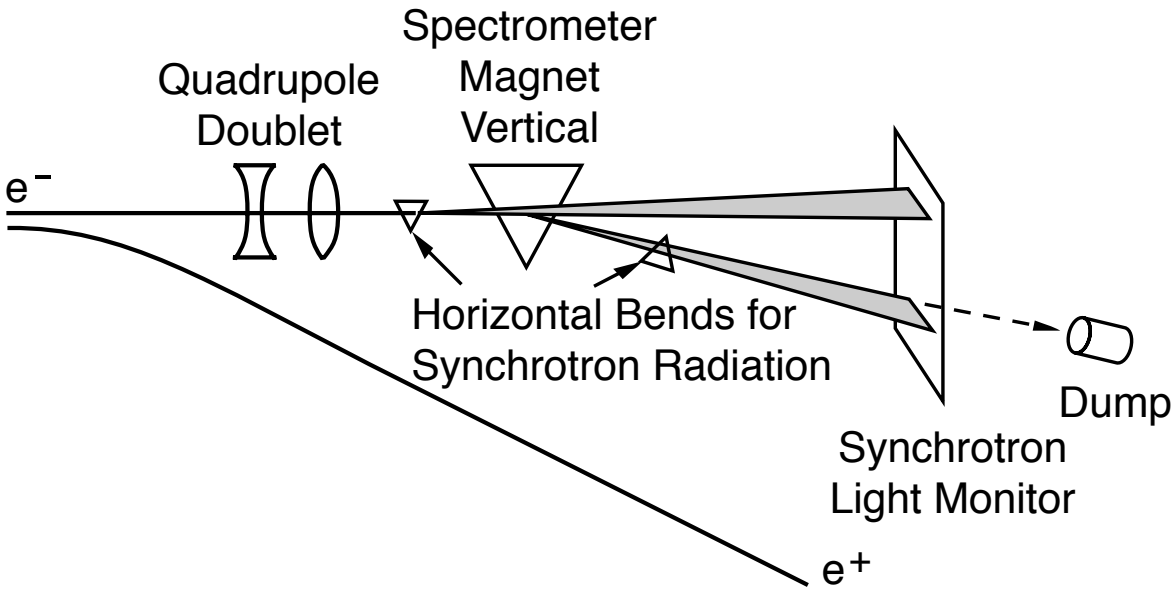
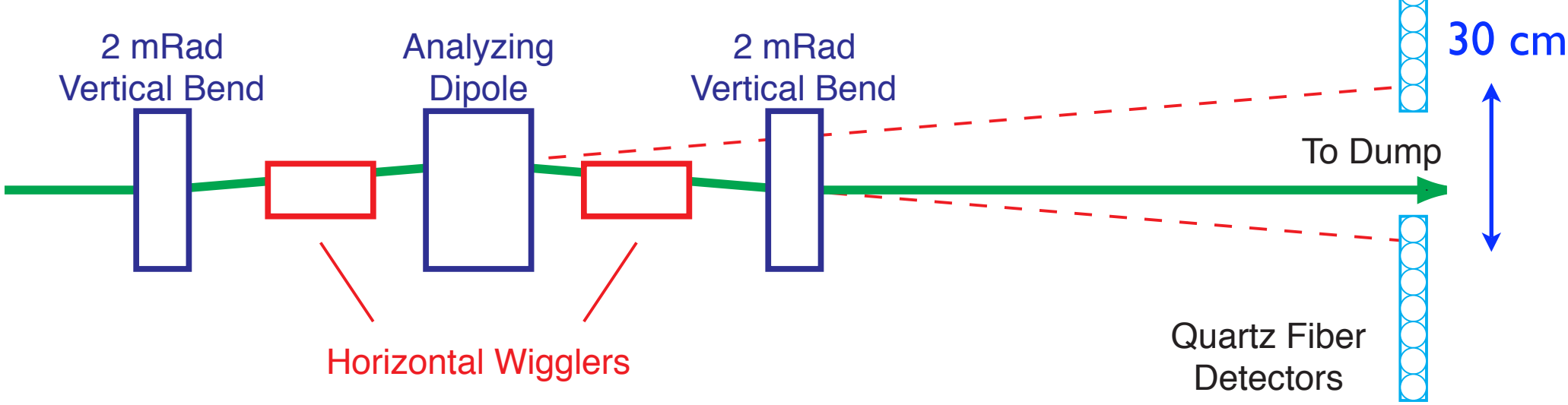
Oregon XLS Project

- Oregon has pursued a design for an extraction-line energy spectrometer similar in style to the SLC Wisrd



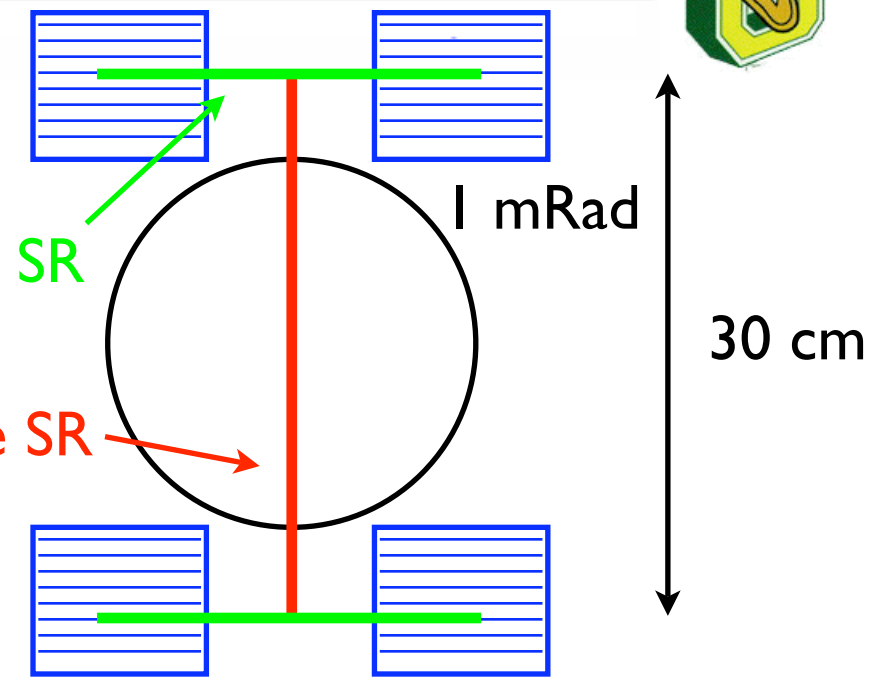
- Design and performance for ILC extraction line
- Detector test beam T-475 at SLAC ESA
- ~~Full spectrometer test w/ T-474~~

Extraction Line Spectrometer



- Secondary focus at detector plane
- Wigglers can be turned off for background measurements
- Long flight distance (~75m) to position-sensitive detector
- 30 cm separation on detector plane
- ~150 MeV / 100 microns - need O(20 micron) accuracy

Detector plane

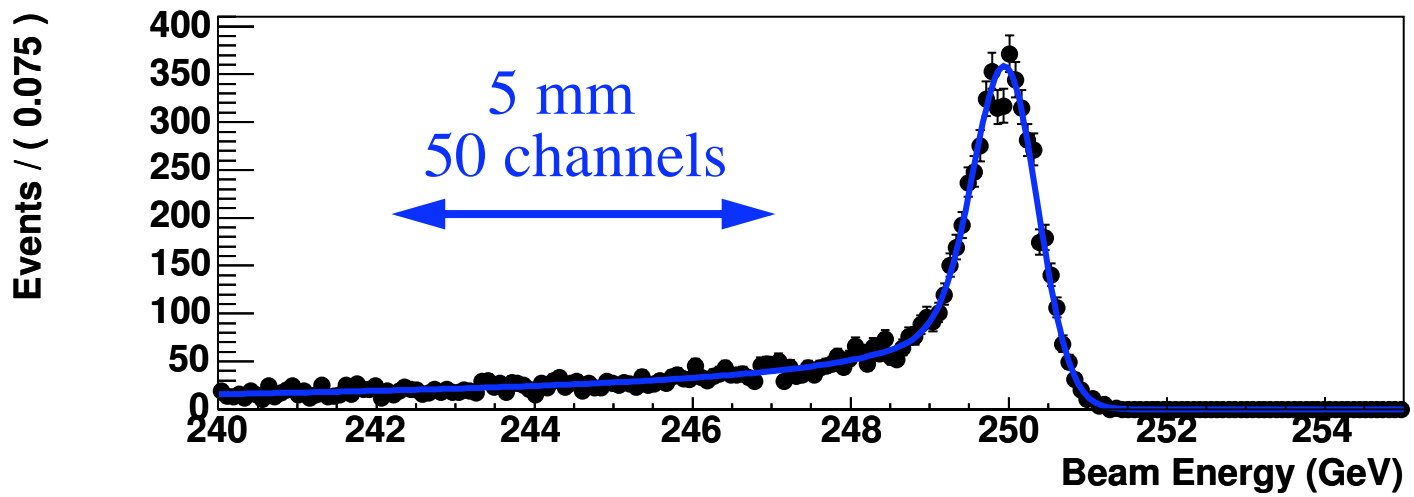


150 MeV / 100 um
for 250 GeV beam

- 4 mRad bend (+/- 2 mRad) over ~75 meters
- 20 micron accuracy for 100 ppm (optical survey OK)
- Instrument with 100 micron quartz fibers, MaPMT or SiPM?
- Double detector improves wiggler alignment tolerance

Rad hard and robust, fast and simple readout,
easy gain adjust, no RF pickup, modest cross-talk

Detector Module



- Fused silica (quartz) fibers, read out with 8x8 MaPMT
- Observe Cerenkov light from secondary electrons
- 100 micron pitch in core region (~2 cm - 128 fibers)
- 1 mm pitch (600 micron fibers) else (~26 cm - 256 fibers)

More signal/channel, lower channel count
~1600 fibers, 24 PMTs per beam
26 cm detector can see to 50% of Enom

T-475 program

Stage 1 - 2006

- Check SR detection by Cherenkov in quartz fibers
- Operational Experience

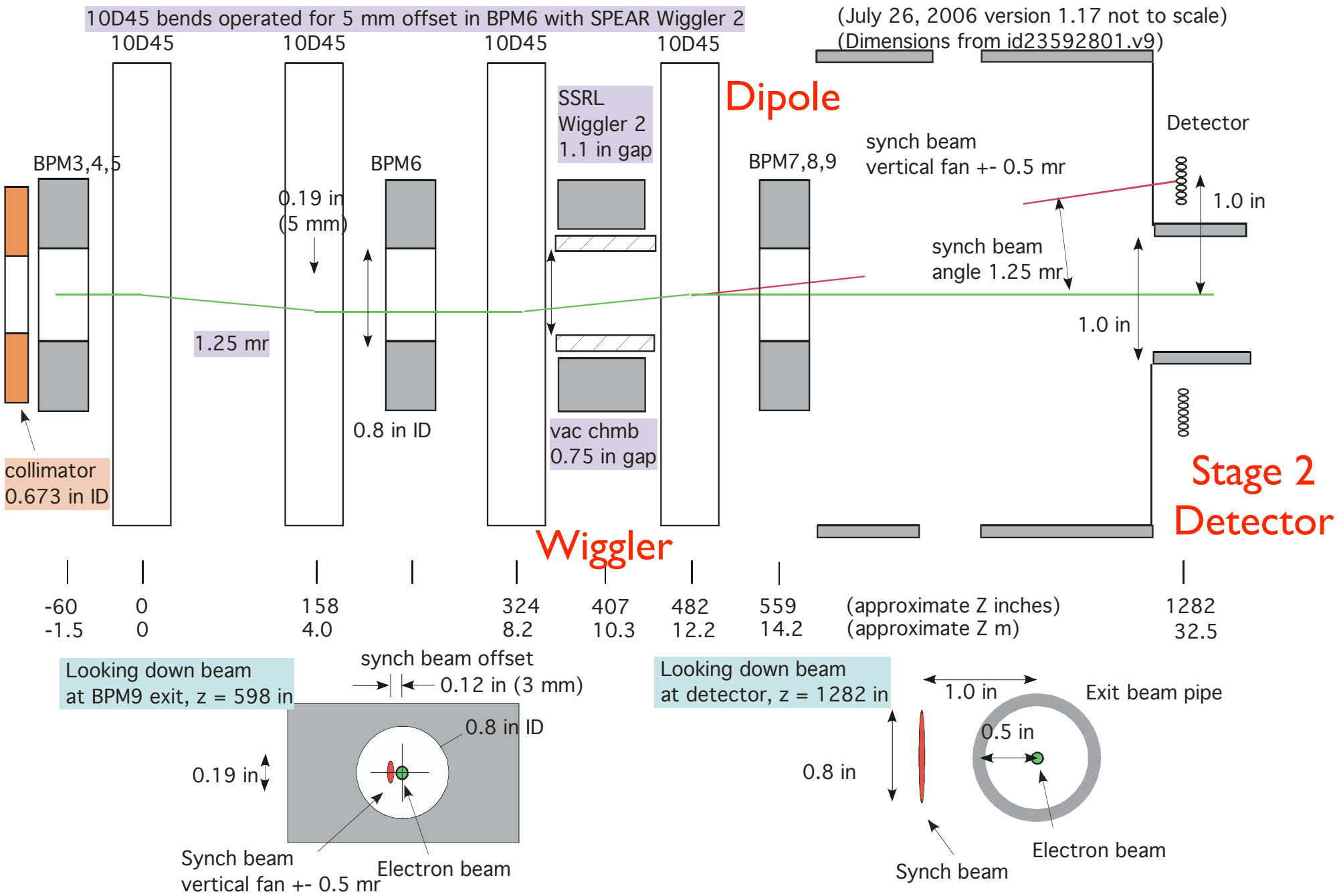
Stage 2 - 2007

- Refine design to be closer to XLS
- Demonstrate E measurement by this technique ???
- ~~Compare to BPM-based measurement~~

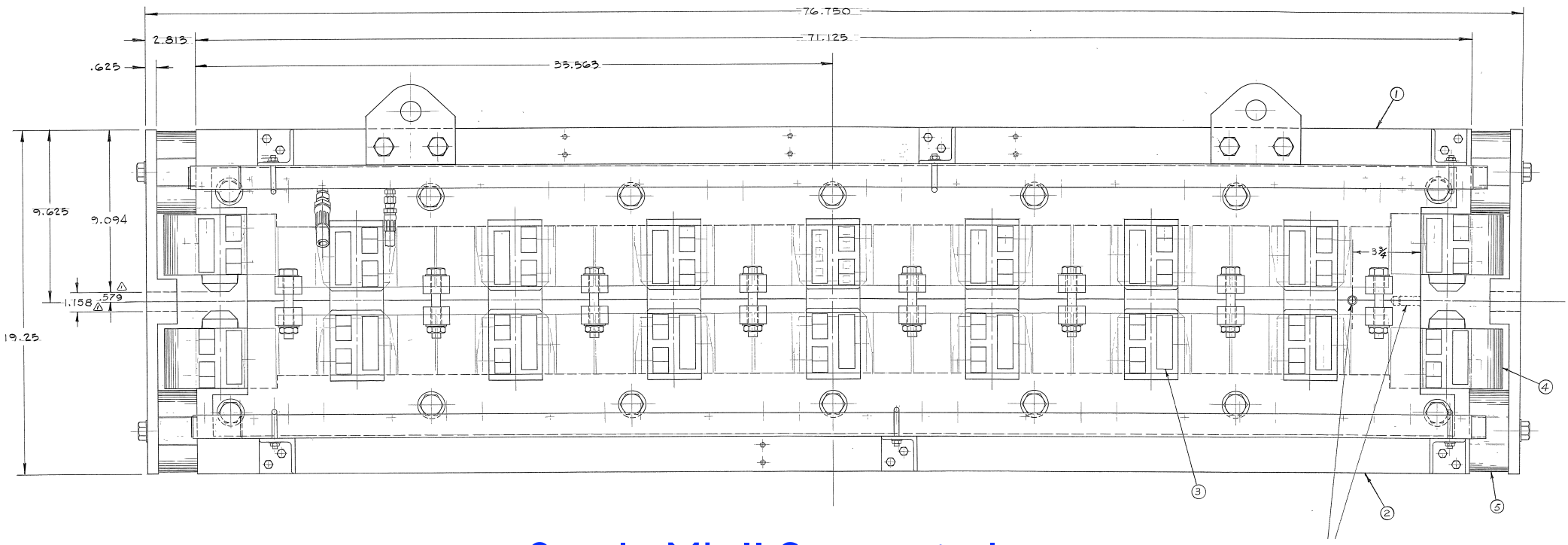
Post Stage 2 - 2008+

- Additional lab tests
- Explore other detector options

T474 BPM Spectrometer and T475 Synch Light Spectrometer Plan View



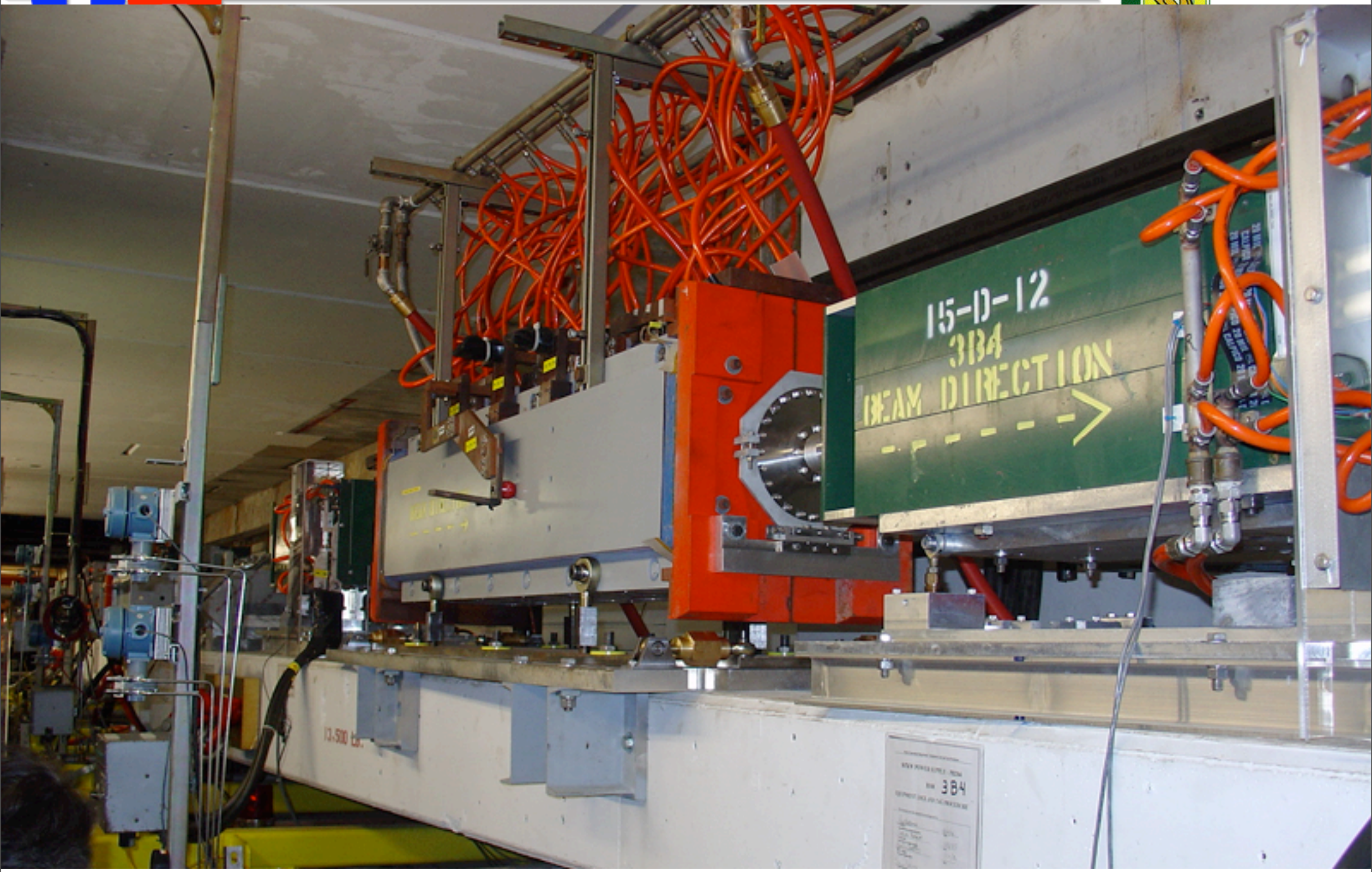
Mk-II Spear wiggler



8-pole Mk-II Spear wiggler
16 kGauss field - 1.8 meters long
+/- 0.75 mRad vertical stripe

Produces Ec ~ 1 MeV photons
+/- 1.5 cm at detector plane

Wiggler in-situ



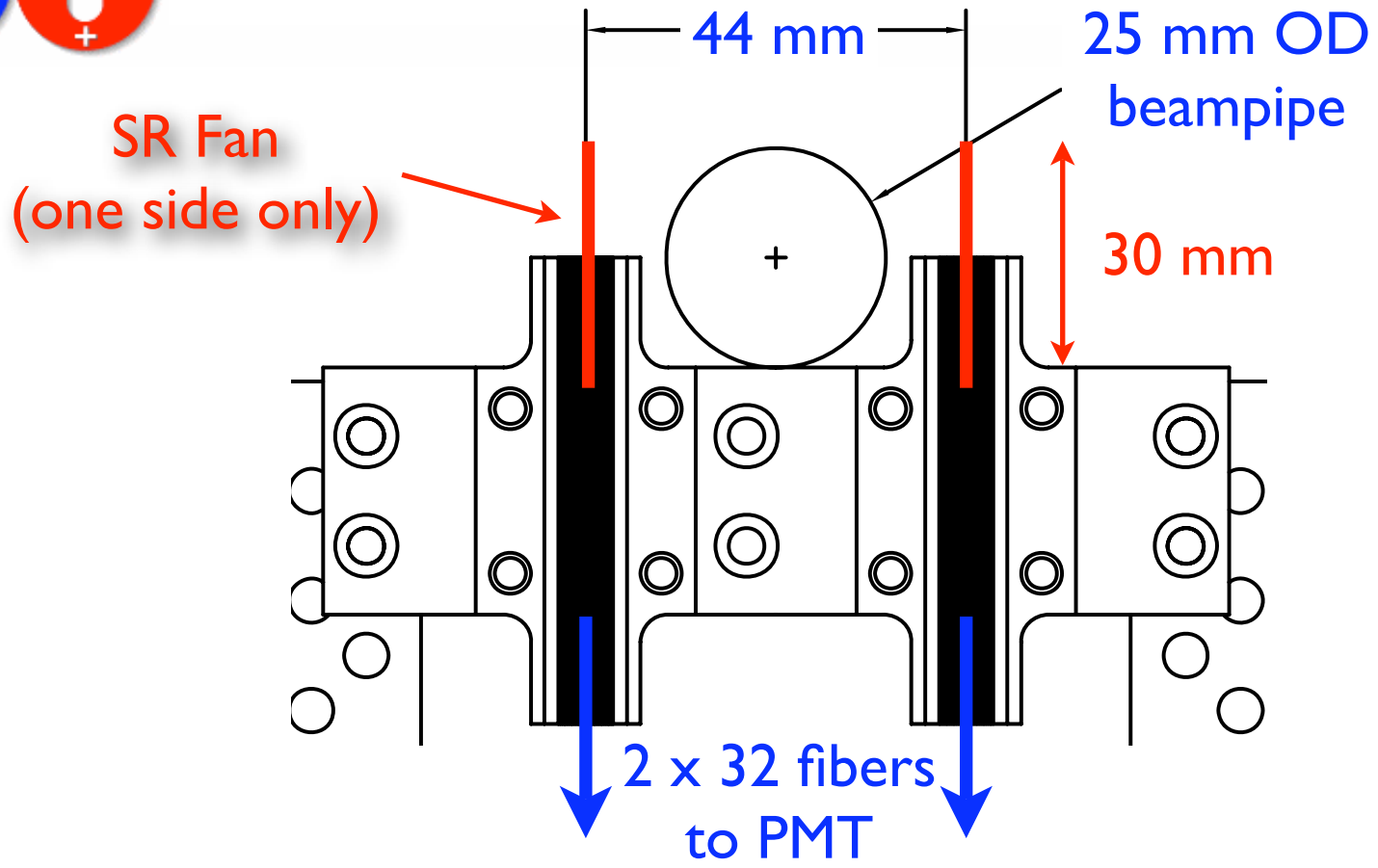
In Beamline

SR Exit Window

Detector Stand

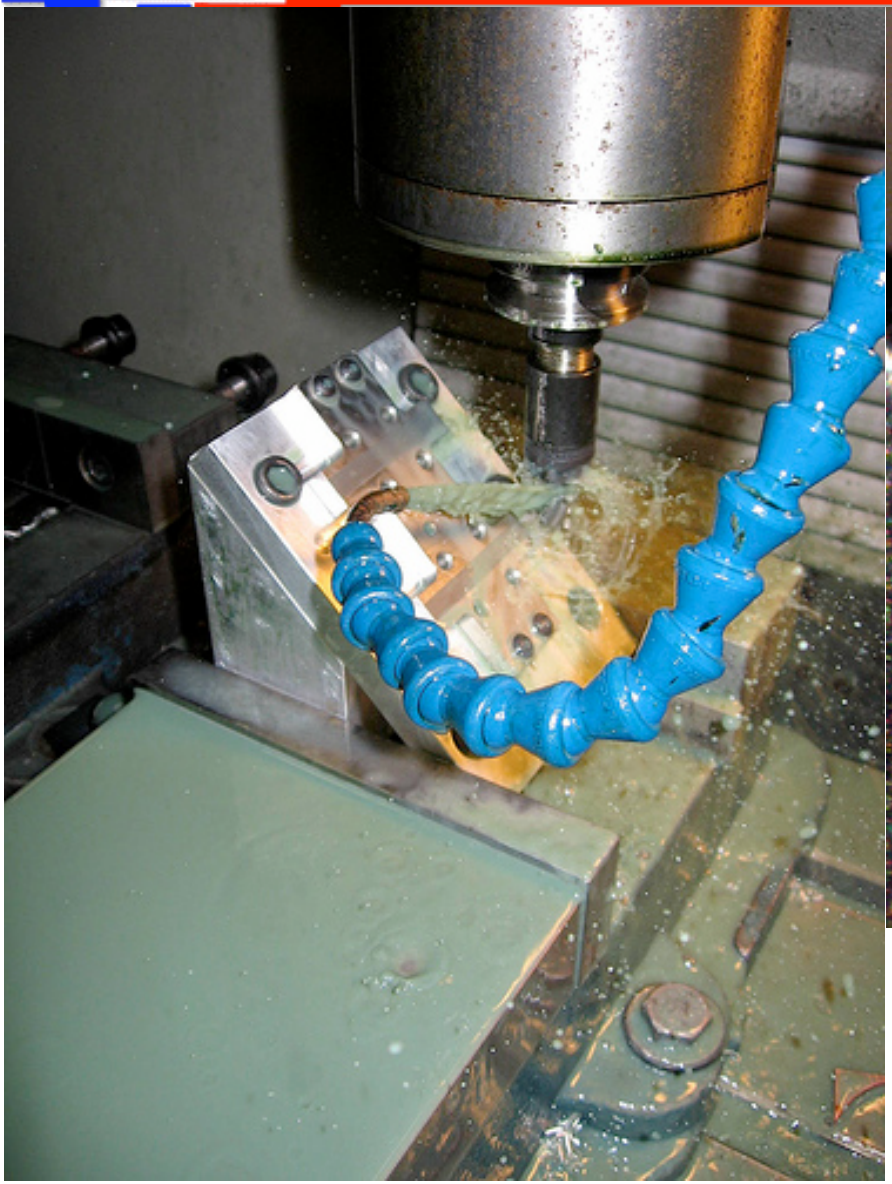
PMT Shelf

2nd prototype detector

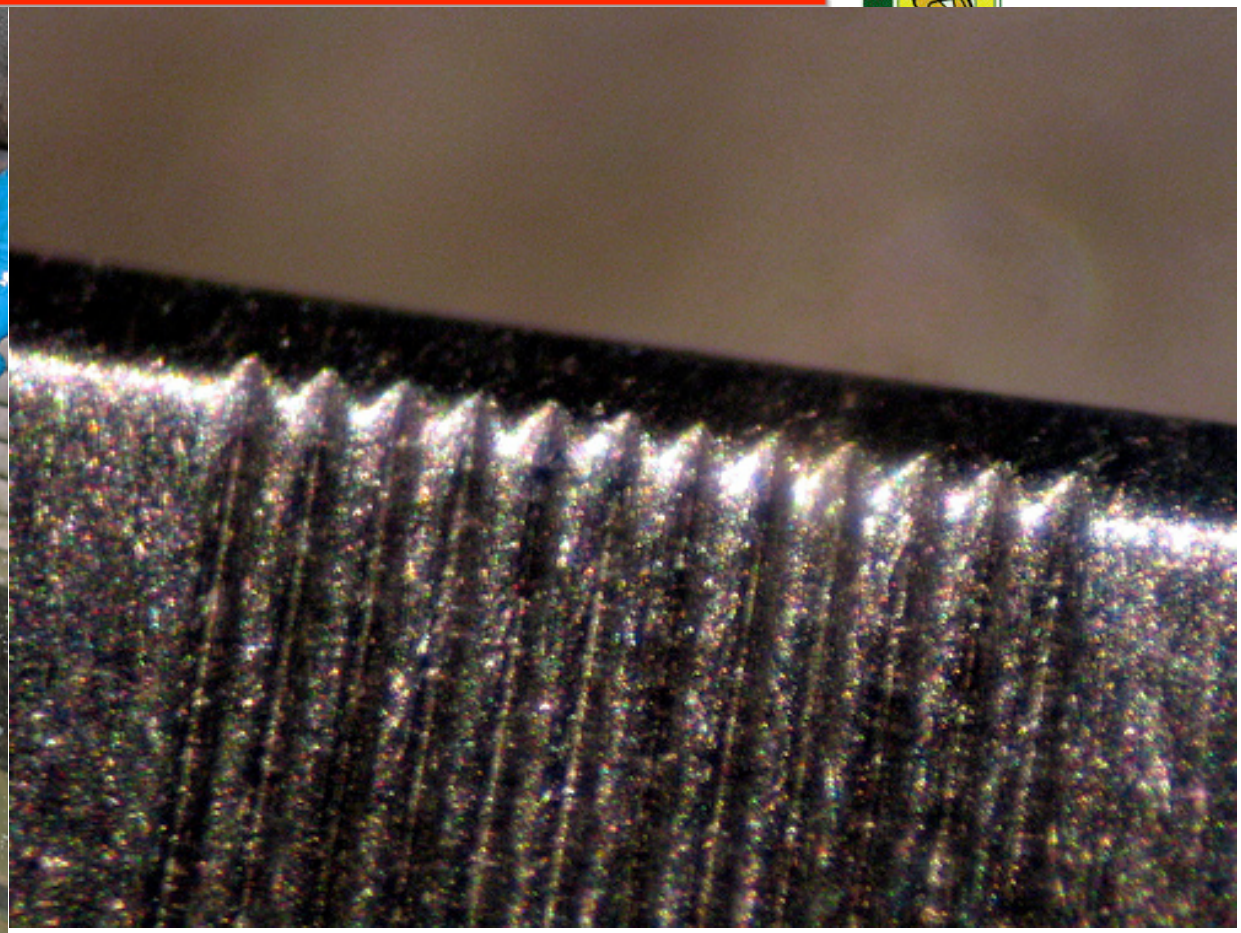


- 64 x 140 micron (100 micron active) UV fibers (Polymicro)
- Spaced on 200 micron pitch w/ grooves engraved on Invar
- Fibers held in place with Indium foil "gasket"

Construction Photos



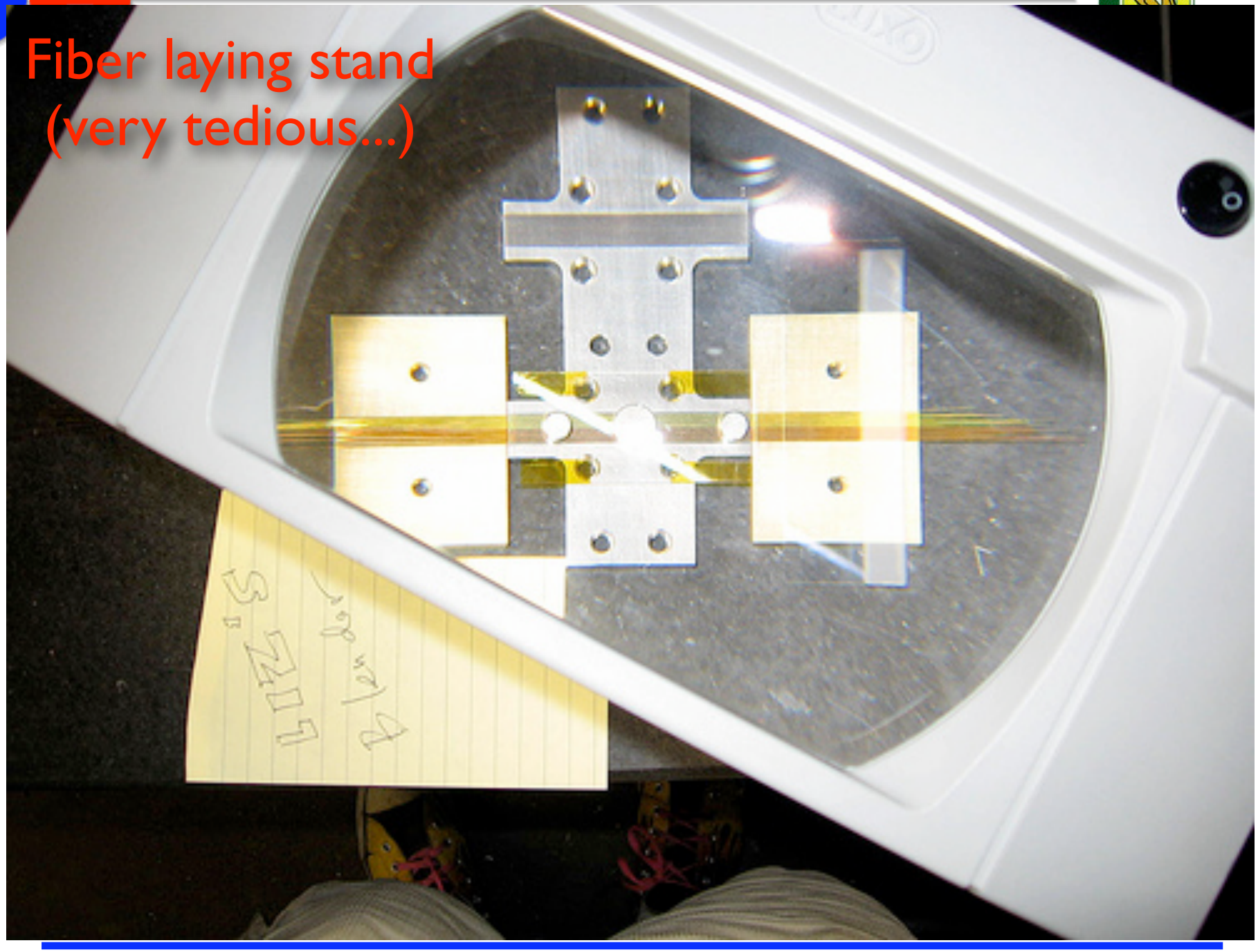
CNC Goodness



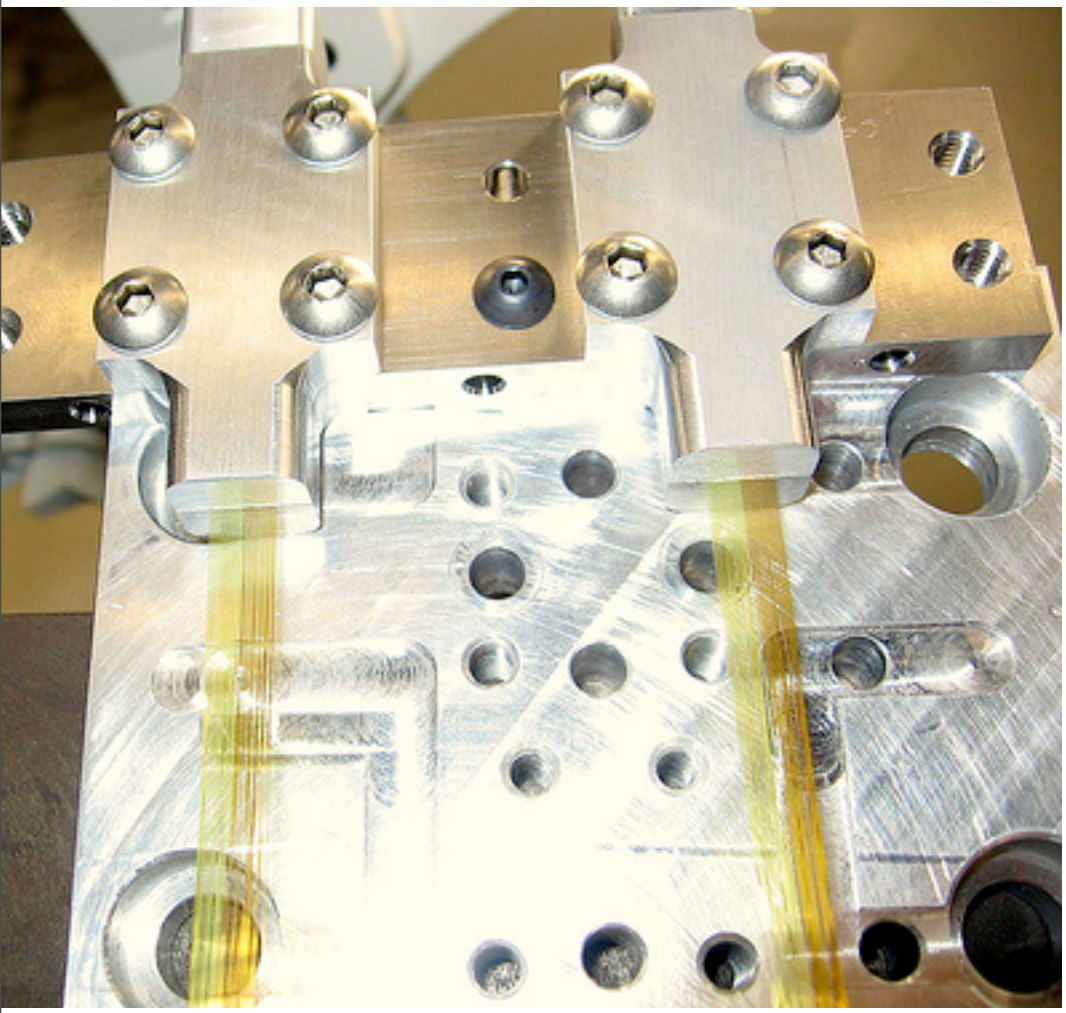
200 micron
grooves in Invar

(Photos courtesy J. Garman)

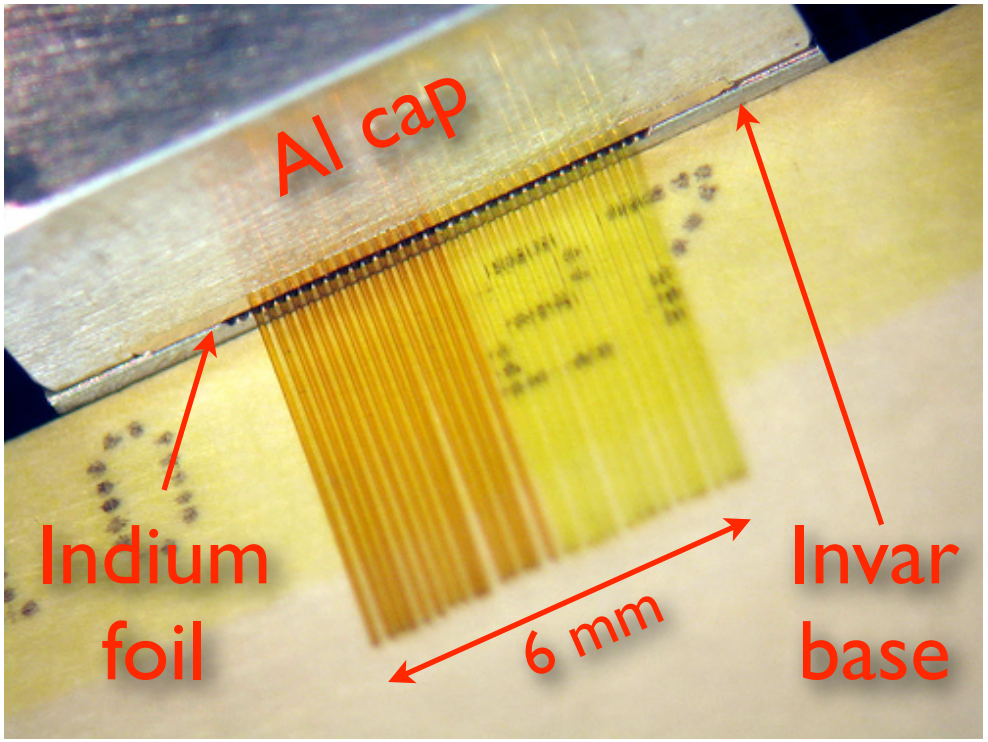
Hand Assembly



Finished Assembly

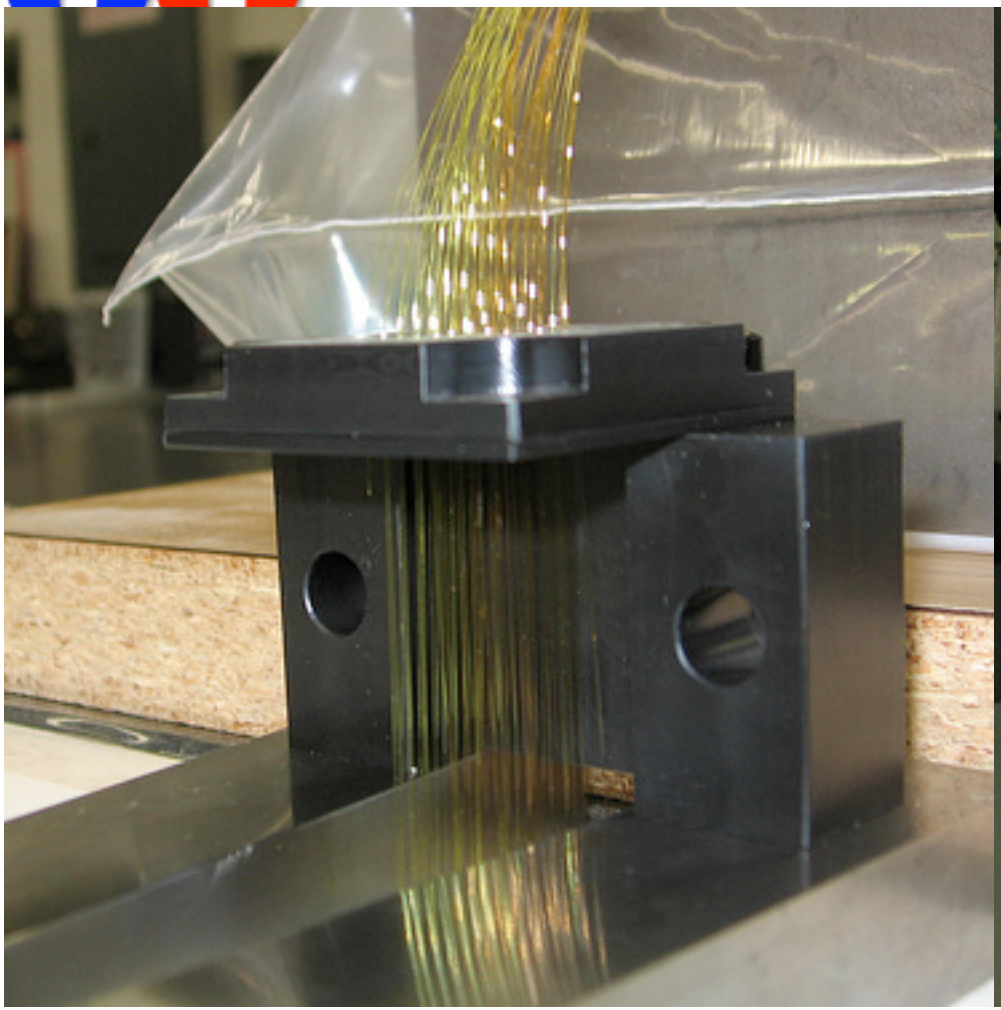


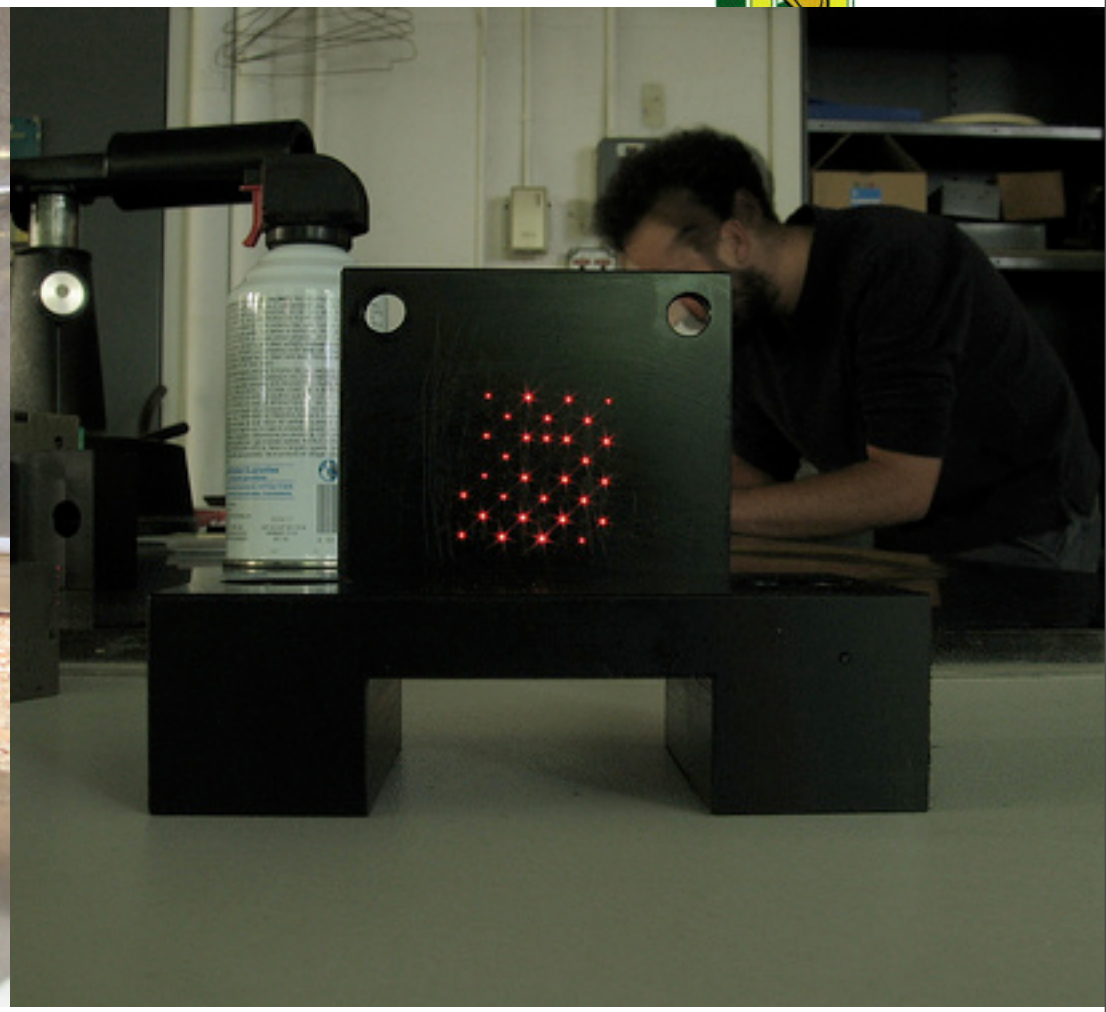
60 fibers in place
(4 background fibers)



Fiber ends
before trimming

PMT View

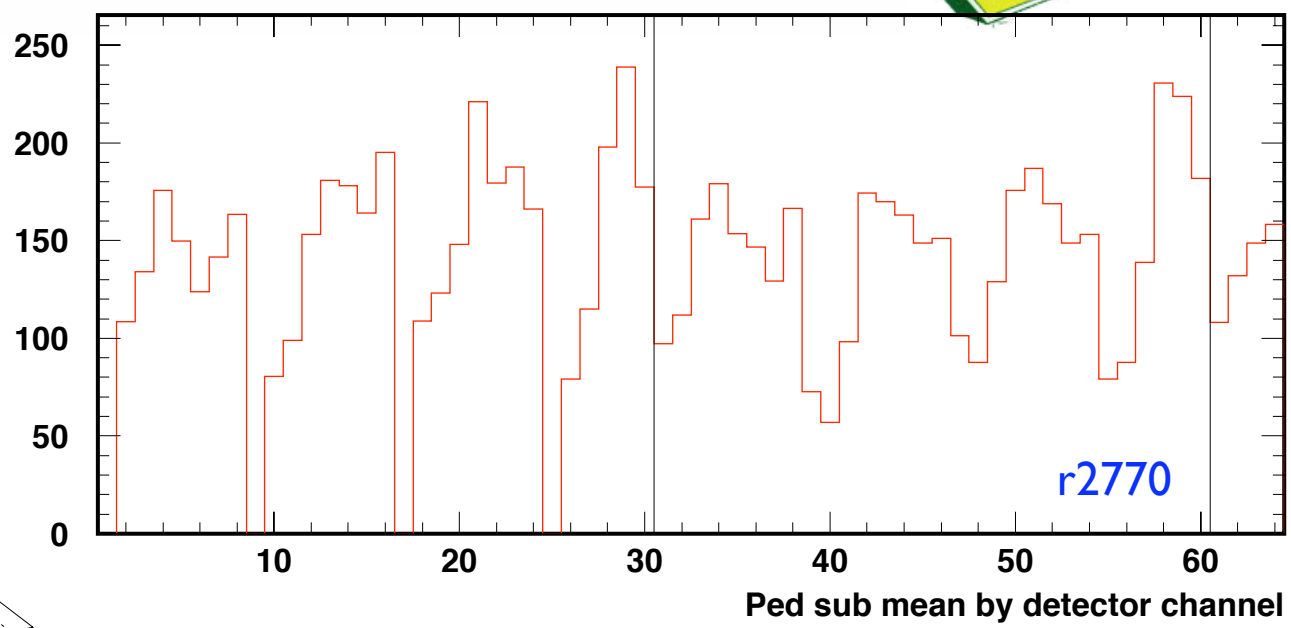


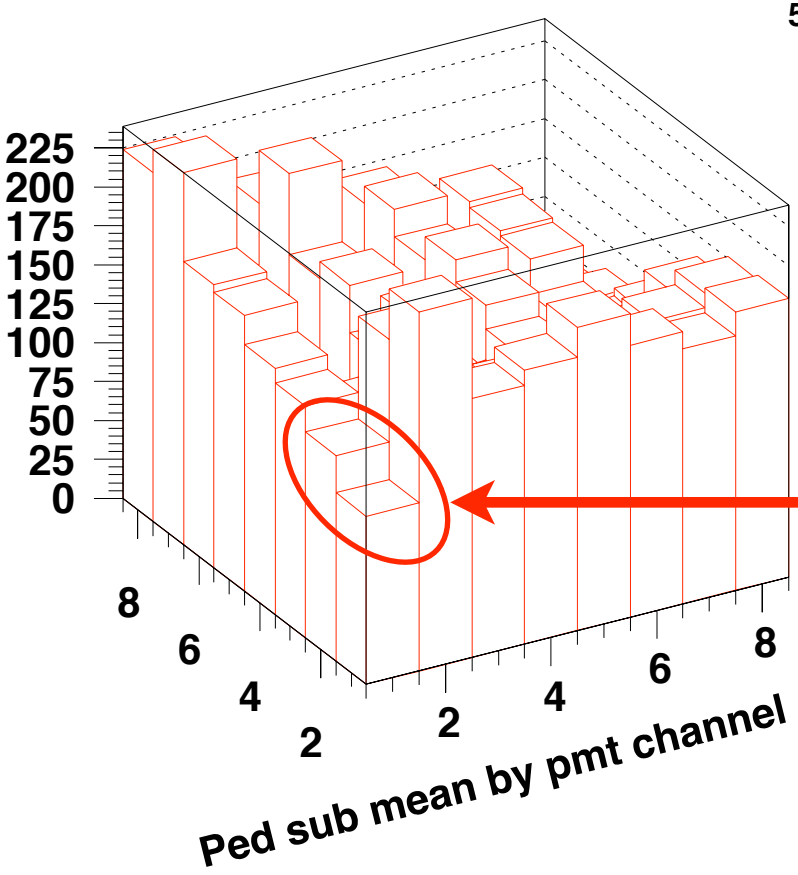


Delrin “cookie” for 64 channel PMT

July 2007 Run Data

"Dirty" conditions
PR2 in - spraying tunnel
with junk





PMT view

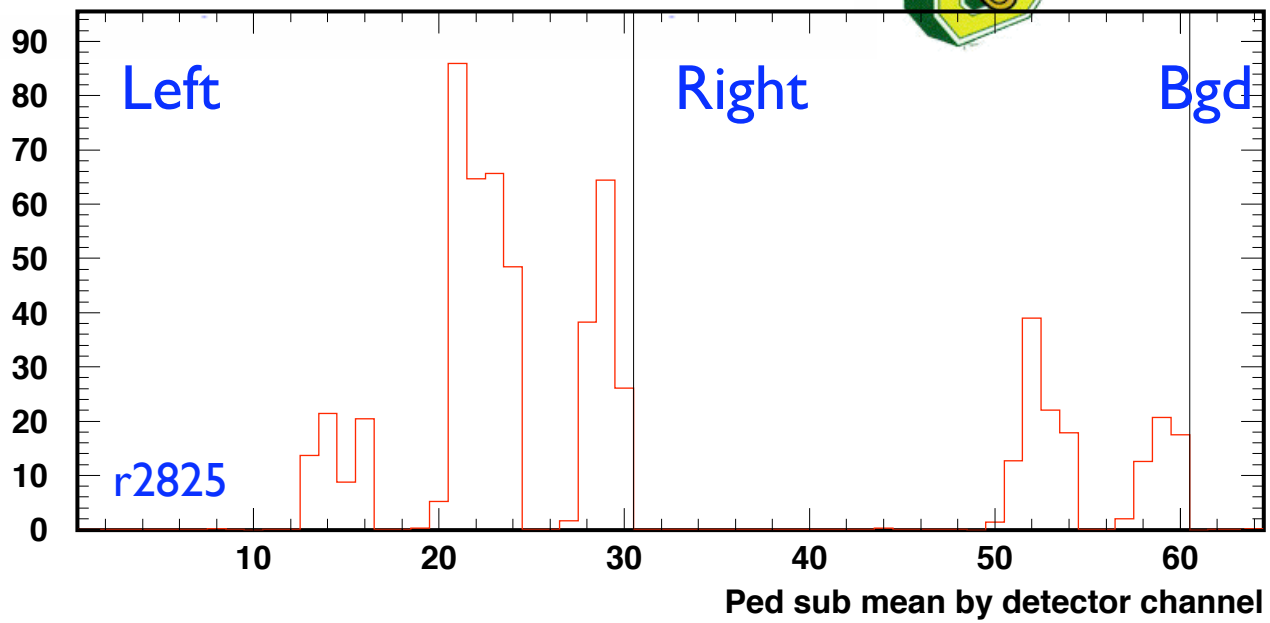
Unconnected PMT pixels show
large backgrounds
Direct PMT hits!
(or huge cross-talk at PMT)

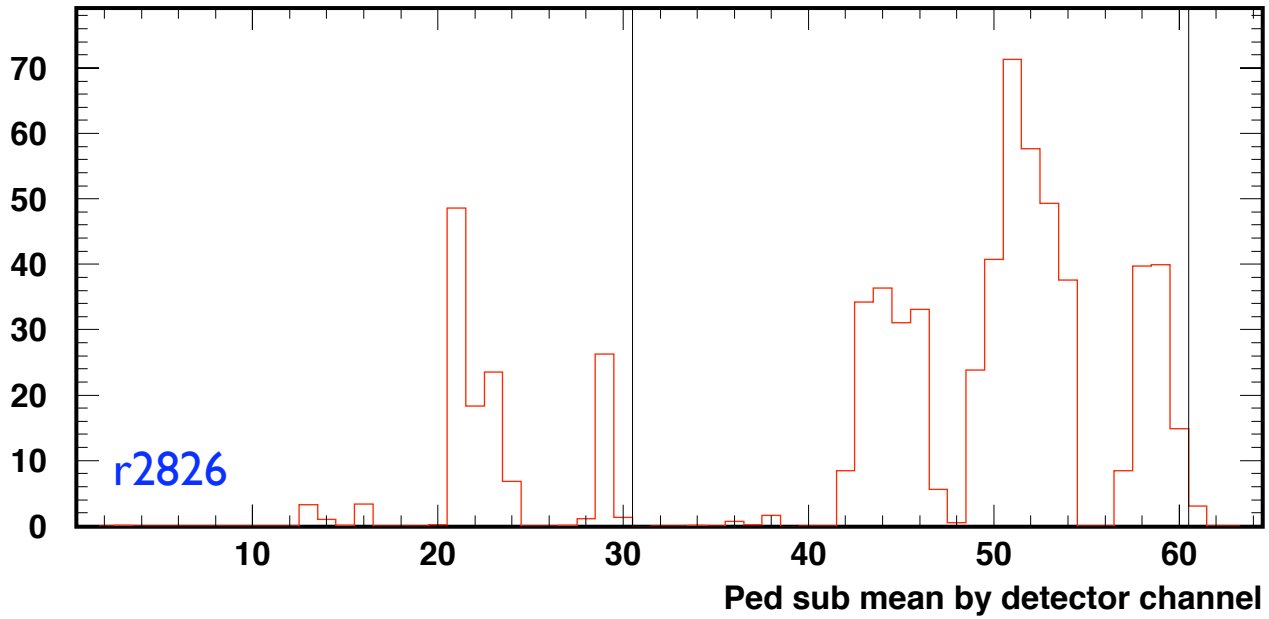
July 2007 Run Data

- Reversing chicane moves beam from Left to Right
- Good "signal" strength
- Low/zero backgrounds
- Significant crosstalk

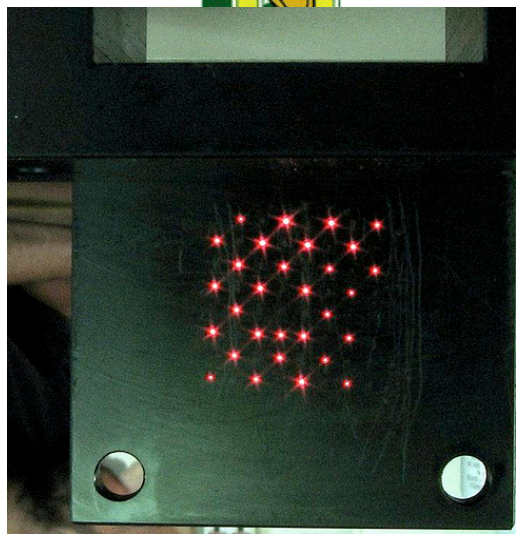
Recently verified with bench measurements ~10% for neighbors

Working now to measure more accurately in the bench setup

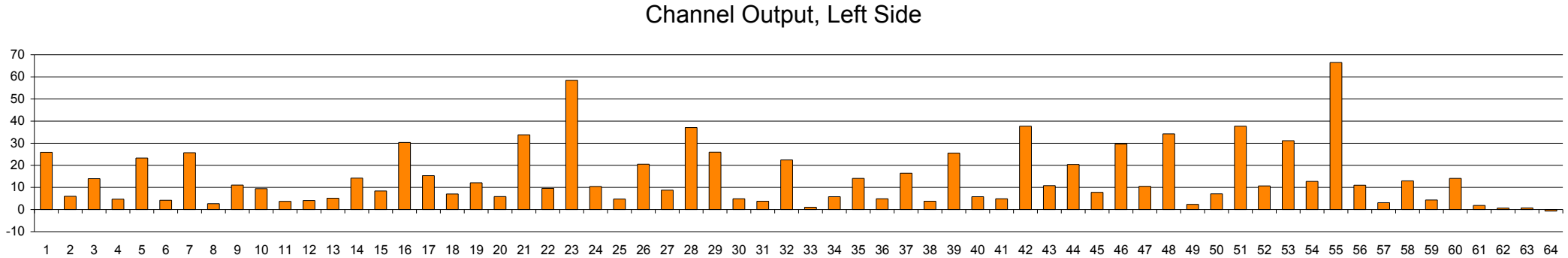


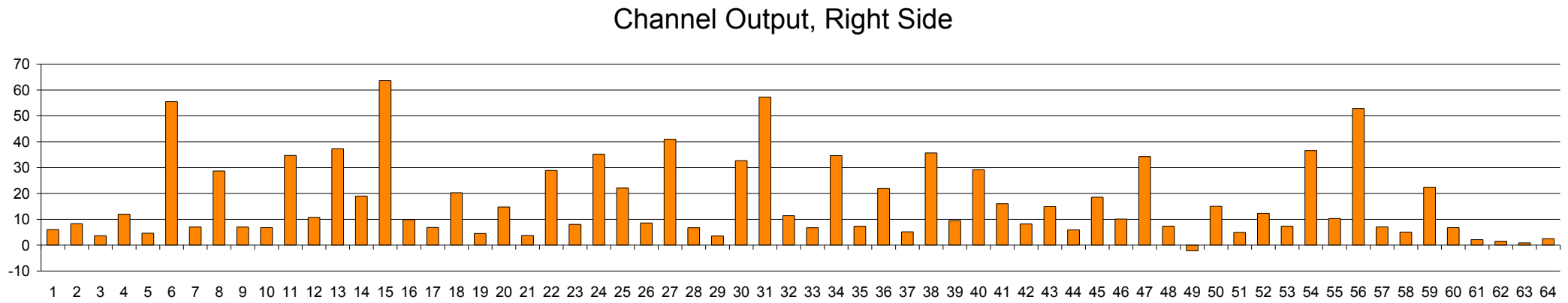


Crosstalk Take 1

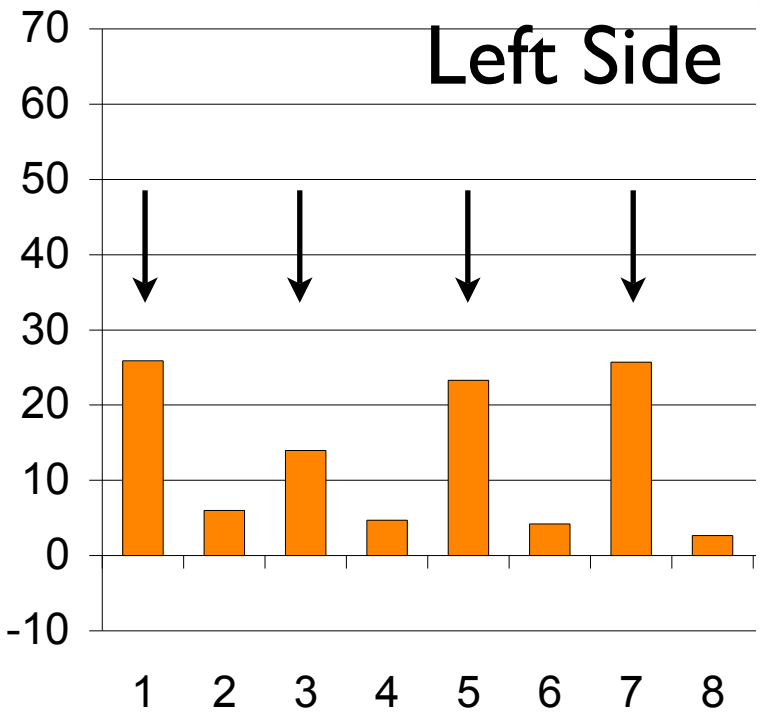


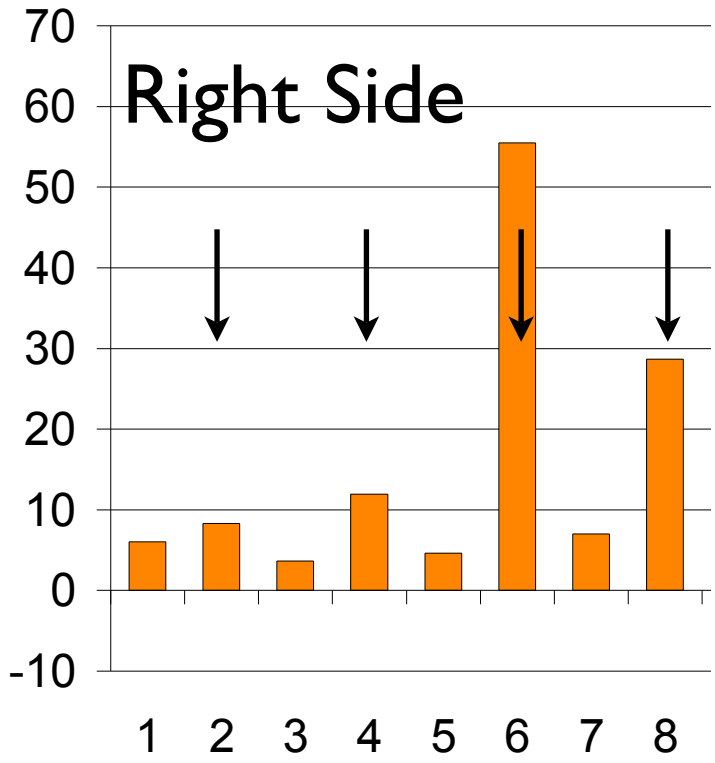
- Illuminate fibers at head with blue LED inside ping-pong ball
- Measure response from PMT for left or right
- Same readout as ESA (CAEN V792 VME ADC)





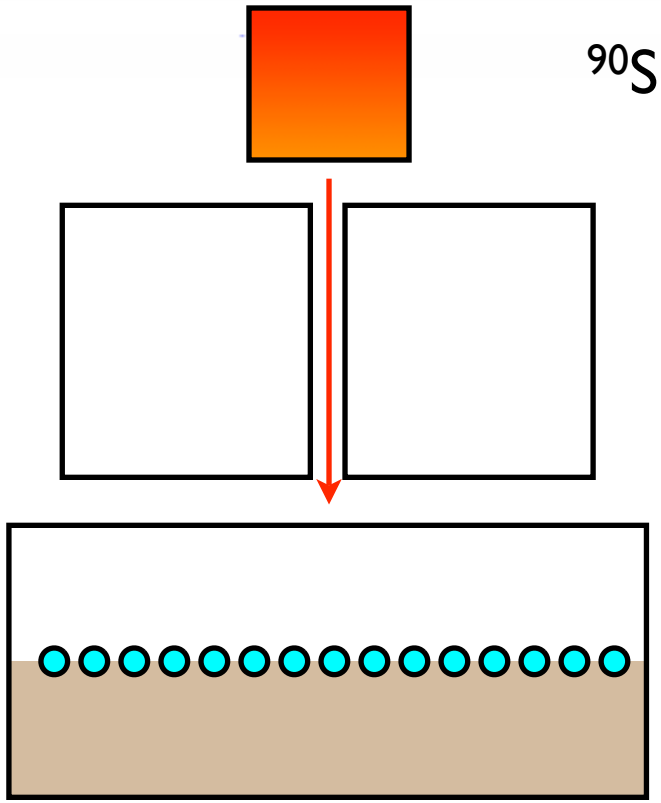
Crosstalk Take I





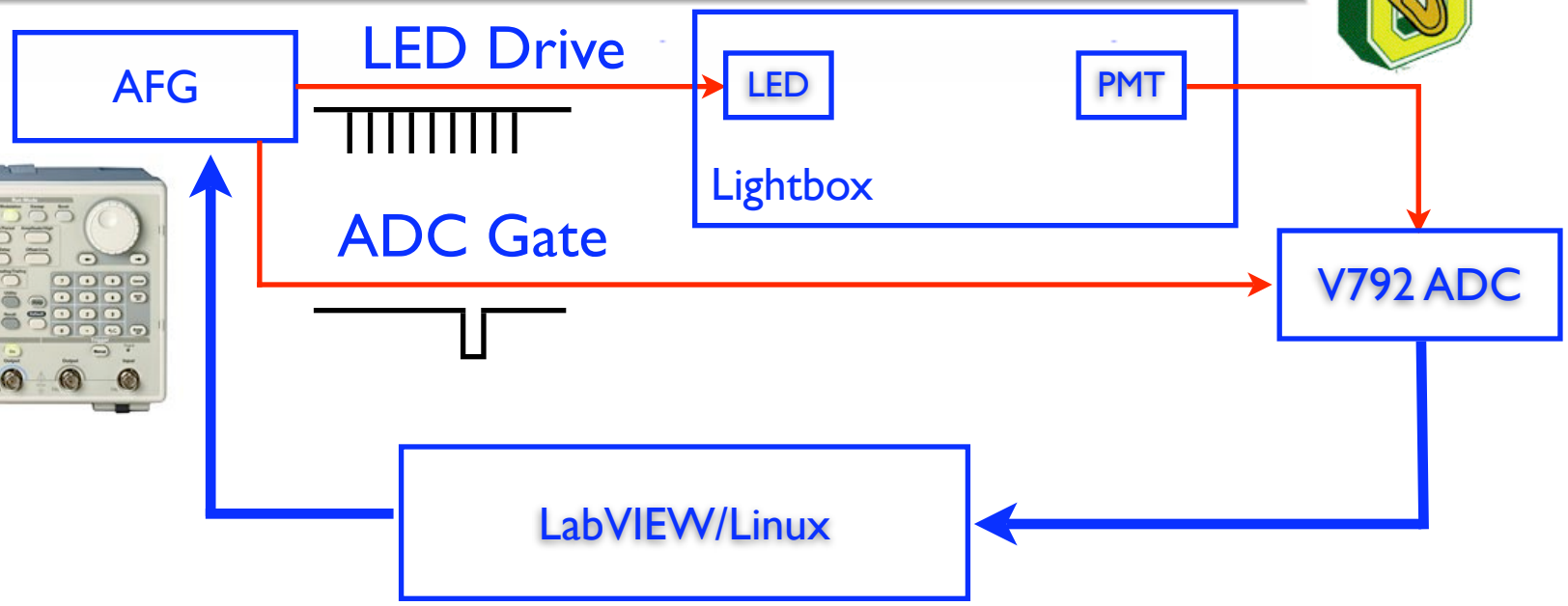
- Large variation in response (poor optical coupling)
- Clear L/R pattern seen (as expected)
- Large cross-talk (10-20%) - not understood

Crosstalk Take II



- Use electron source to apply consistent rate
- Invar backplane prevents scintilator trigger
- Need high-intensity electron/photon source
- Possibly this Summer?

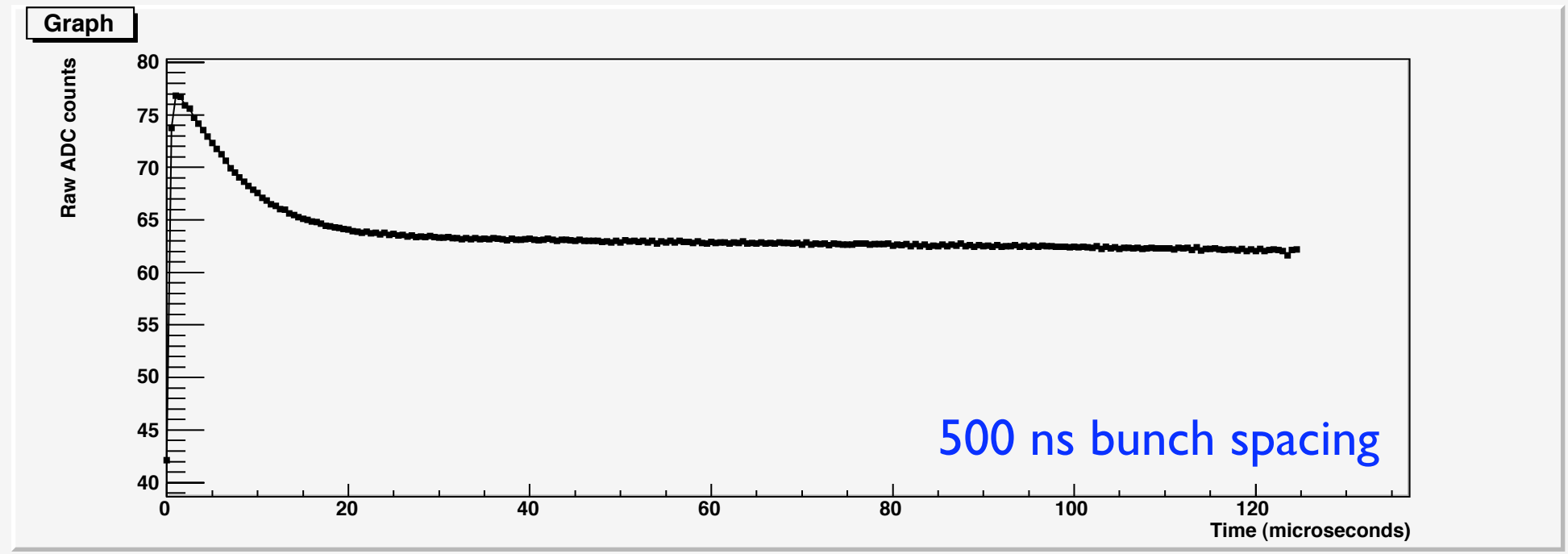
Oregon Teststand



- Use Tektronix AFG3022 to simulate ILC bunch train
- Second AFG channel produces sync. sliding gate
- UV LED (395 nm), adjustable intensity from pulse amplitude
- VME readout by CAEN V792 ADC - VME-PCI bridge

Test MaPMT gain and linearity in long ILC-like bunch train

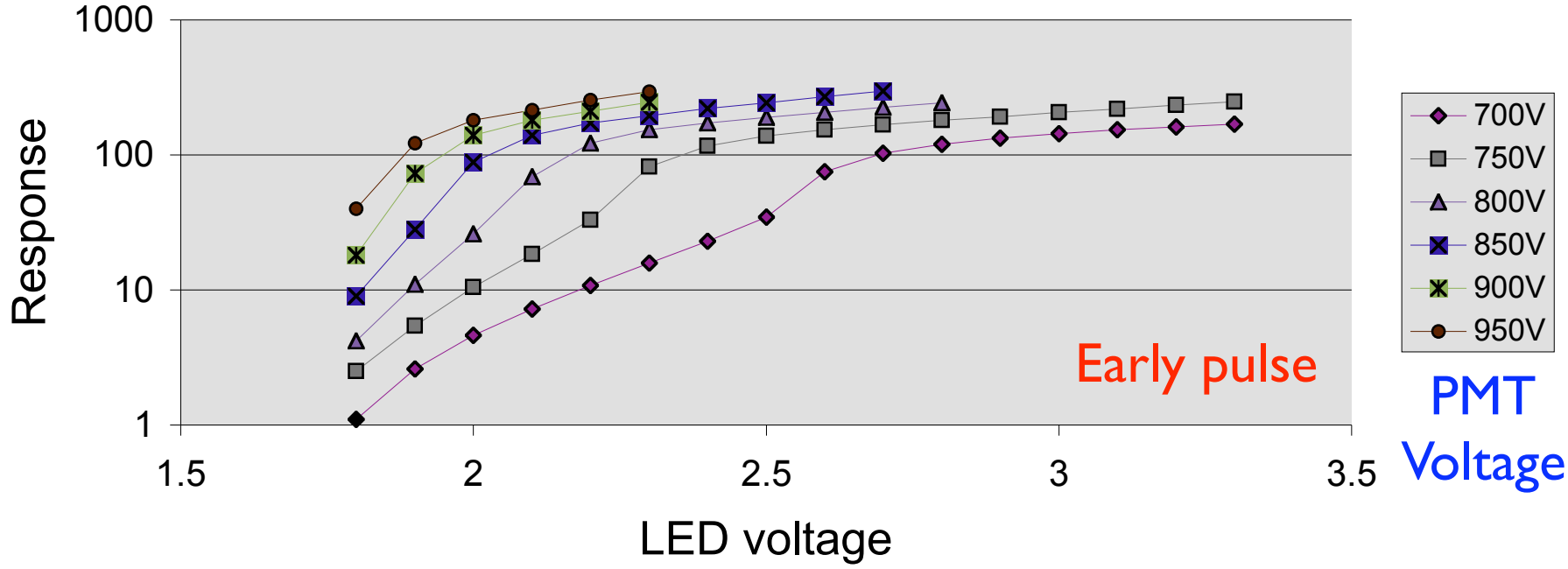
PMT Loading

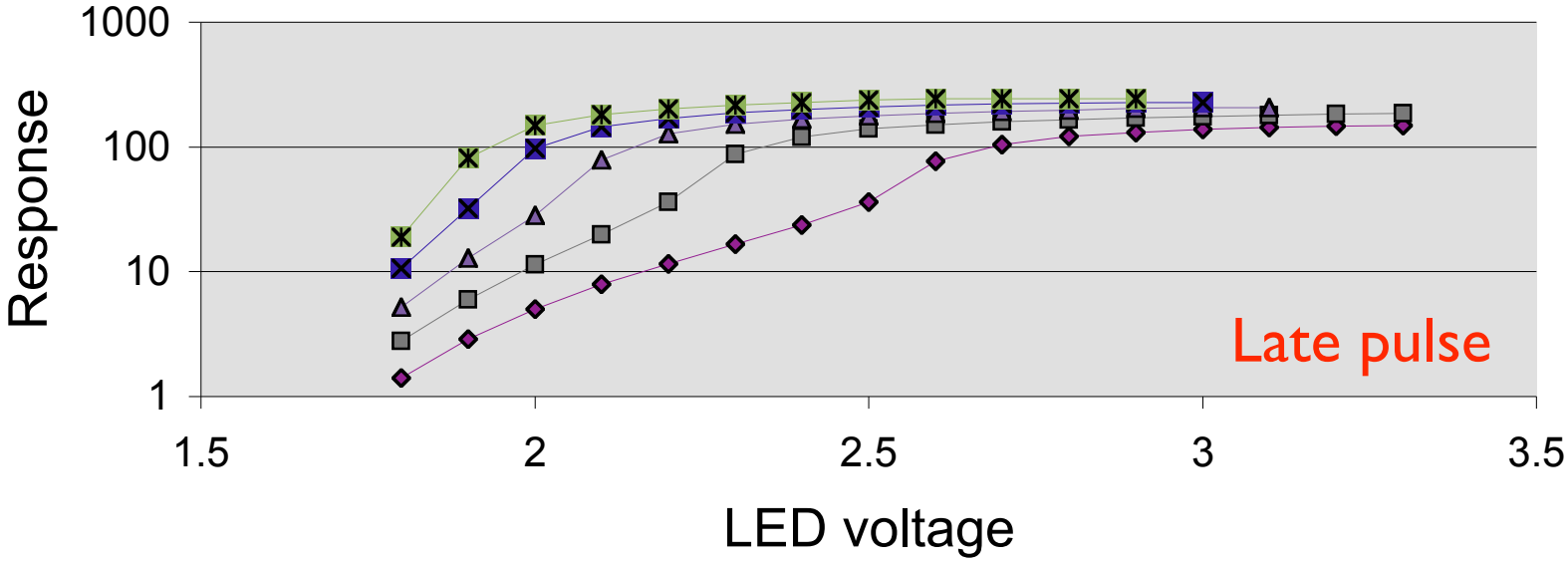


- MA-PMT response measured in individual train pulse
- Clear loading seen as pulse amplitude increases
- Relatively stable after ~ 20 microseconds

What changes? Gain, Linearity, or both?

PMT Linearity

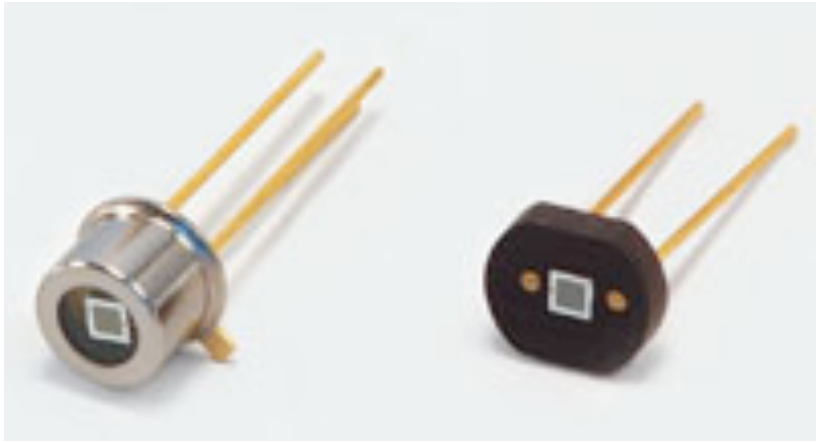




Clear "knee" independent of PMT voltage, harder cutoff

MPPC Studies

- Hamamatsu Multi-Pixel Photon Counters - aka SiPMTs



1024 (25 μm)^2 pixels

binary photon counting

- Avoid charge loading problems?
- Same readout as beamcal - KPix variant
- Highly non-linear once saturated (counts pixels hit)
- Dynamic range issues?

Tests with these devices starting

Summary

July 2007 ESA run

- Second T-475 Detector saw first and last beam
- Detailed analysis just starting - crosstalk issues

Oregon Teststand

- Other PMT, fiber, and sensor tests also ongoing
- Detailed bench measurements of detector response

Future detector activities

- Exploring other detector options
- Eventual detector post-mortem after response/crosstalk is carefully measured