

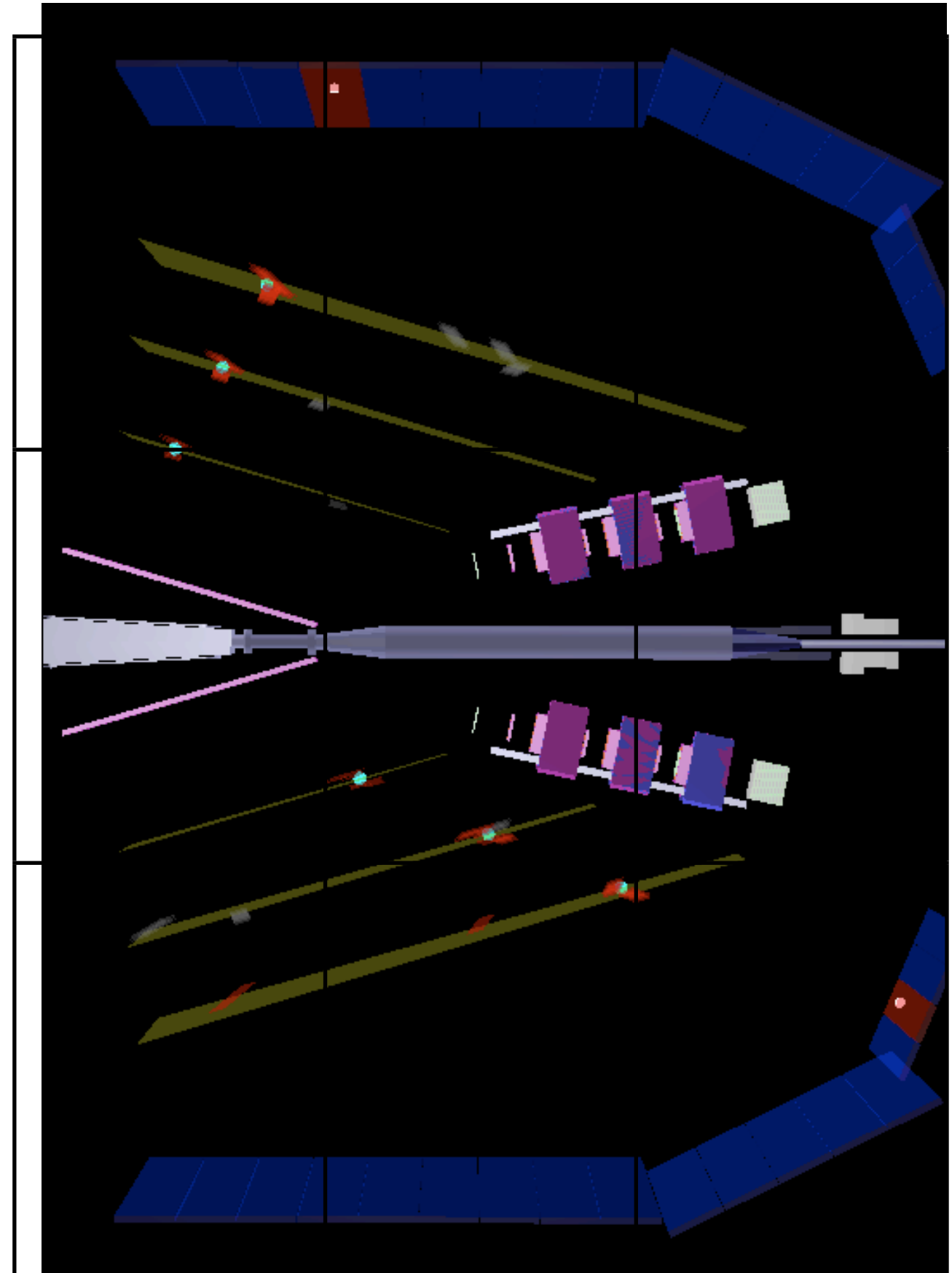
OLYMPUS Experiment

Measure two-photon contribution to electron-proton elastic scattering

- upgrade of BLAST detector
- e^- / e^+ beams at DORIS
- internal H^2 gas target

OLYMPUS experiment

- H^2 gas target, internal to ring
- toroidal magnetic field
- proposed GEM tracker upgrade
- wire chambers
- time of flight scintillator bars
- 12° GEM luminosity monitor
- 12° MWPC luminosity monitor
- symmetric Møller detector
- e^- / e^+ at 2.01 GeV from DORIS



OLYMPUS Experiment

Plan

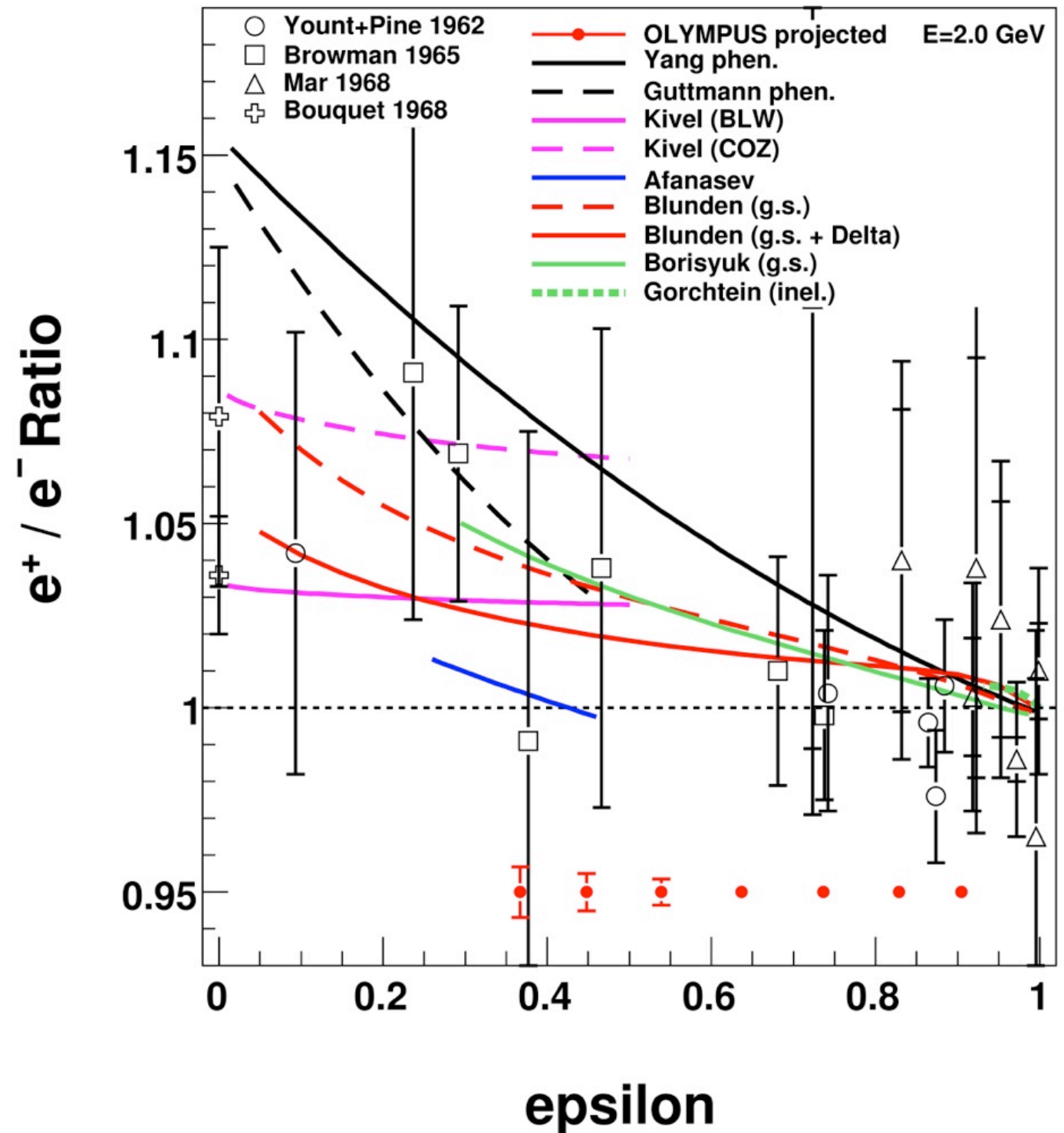
- 100 mA, 2×10^{15} atoms/cm²
- 500 h both e⁻ and e⁺ at 2 GeV
- reverse toroidal magnetic field

February, 2012 run

- ~50 mA
 - limited by deadtime in DAQ
- $\sim 5 \times 10^{14}$ atoms/cm²
 - limited by beam lifetime ~1 hr
- 80% running efficiency

October-December, 2012

- ~100 mA
 - 2nd level trigger reduces deadtime
- $\sim 5 \times 10^{14}$ atoms/cm²
 - still limited by beam lifetime
- ~4 less statistics than planned



OLYMPUS Experiment

Latest analysis suggests

- February luminosity factor 4
- not 8 !

February, 2012 run

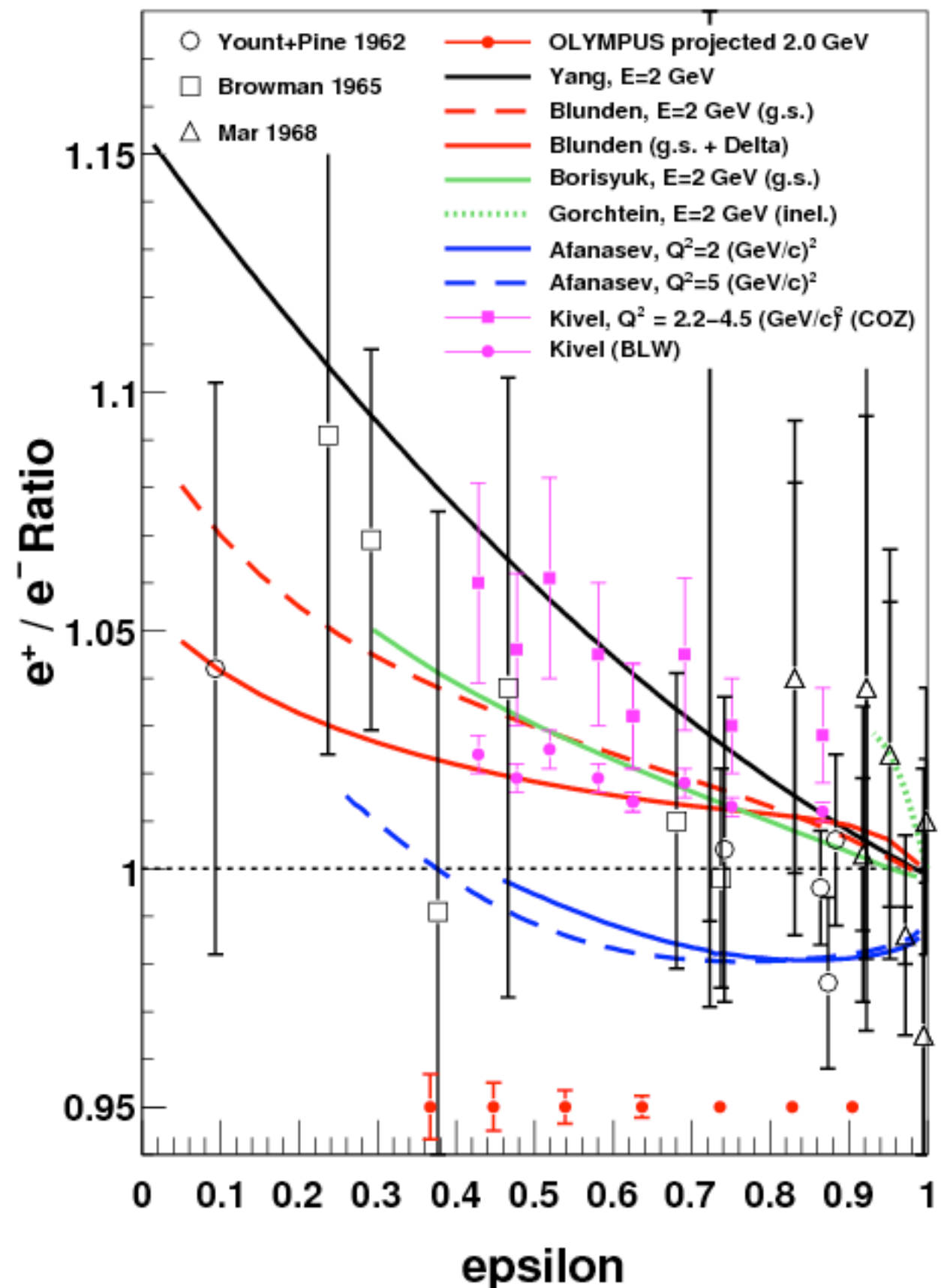
- ~50 mA
 - limited by deadtime in DAQ
- $\sim 1 \times 10^{15}$ atoms/cm²
 - limited by beam lifetime ~1 hr
- 80% running efficiency

October-December, 2012

- ~100 mA
 - 2nd level trigger reduces deadtime
- $\sim 1 \times 10^{15}$ atoms/cm²
 - still limited by beam lifetime

2 - 4 less luminosity but

- efficiency higher than 50% of plan
- gains possible (top-up, lifetime, ...)



Since February Data Run

Luminosity confusion in February run

- symmetric Møller, 12° detectors, beam current and target gas flow

Target system

- gas leak, first repair failed, second repair successful

Wire Chambers

- mostly working, difficulties in track reconstruction, missing tracks

GEM Tracker

- distracted effort from analysis
- partially successful but ran out of time - decided to shelve for now

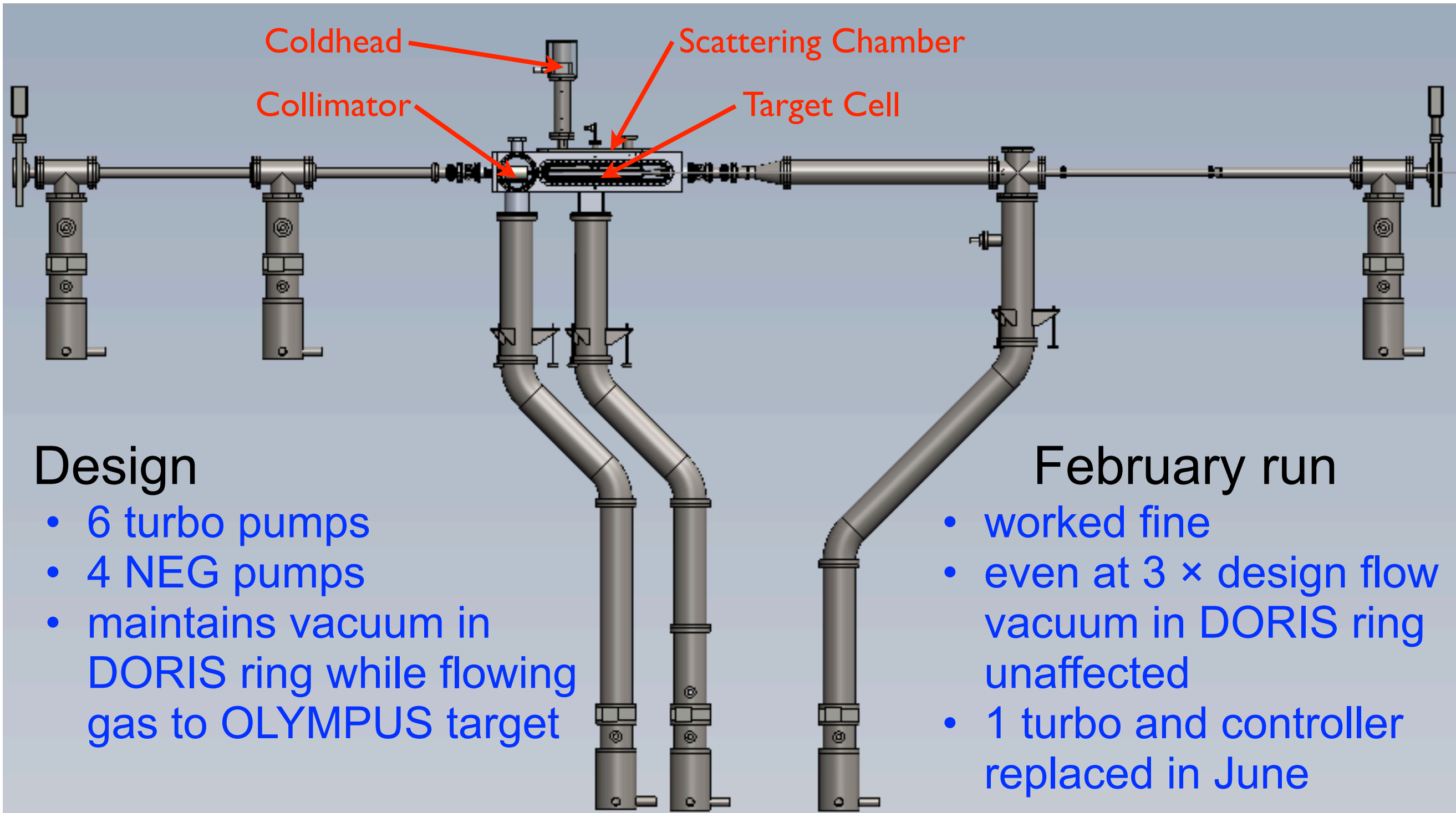
Time of Flight Detectors

- working well, need final calibration and stability checks

DAQ and Slow Control

- worked very smoothly and efficiently in February, even better in future

OLYMPUS Vacuum System



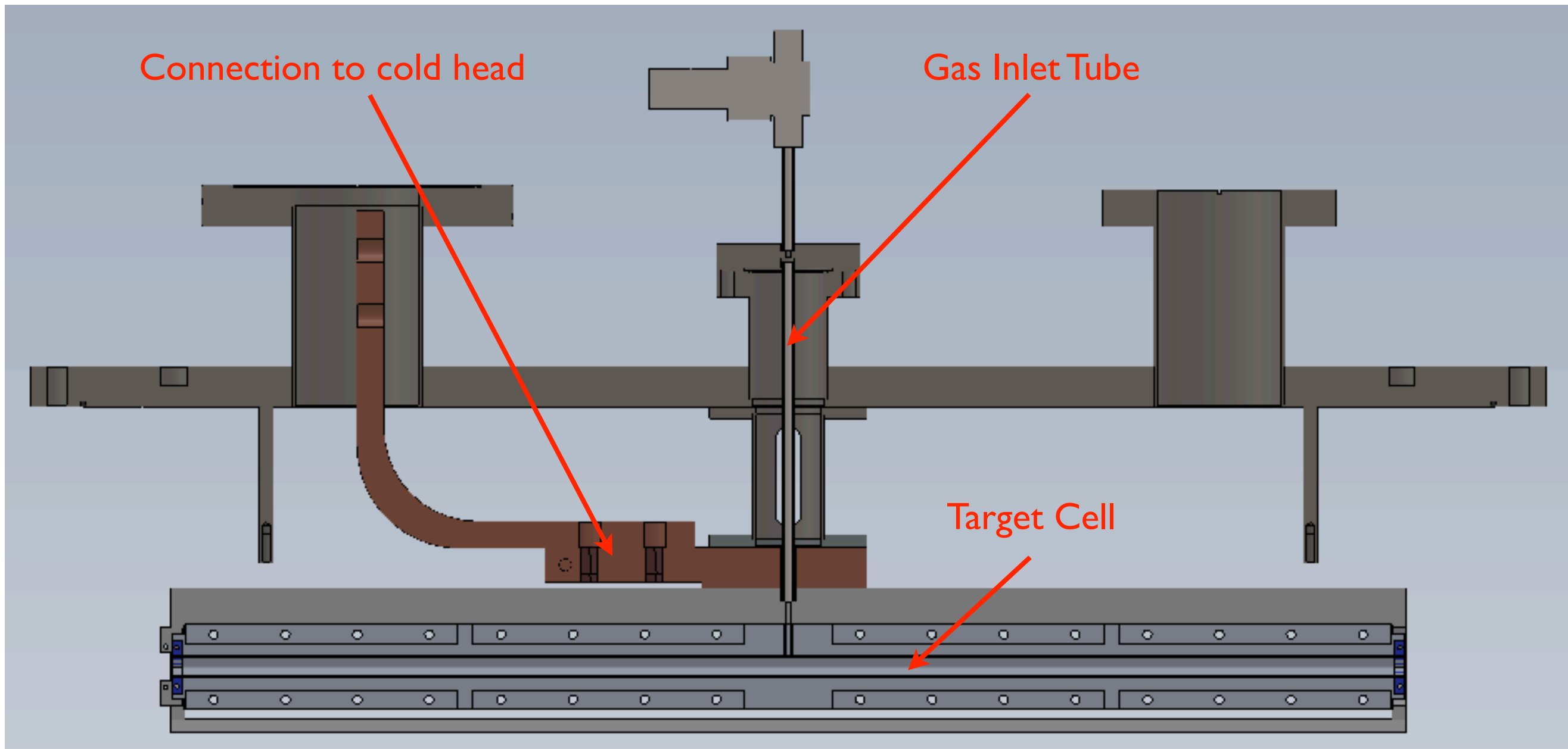
Design

- 6 turbo pumps
- 4 NEG pumps
- maintains vacuum in DORIS ring while flowing gas to OLYMPUS target

February run

- worked fine
- even at $3 \times$ design flow vacuum in DORIS ring unaffected
- 1 turbo and controller replaced in June

OLYMPUS Target System

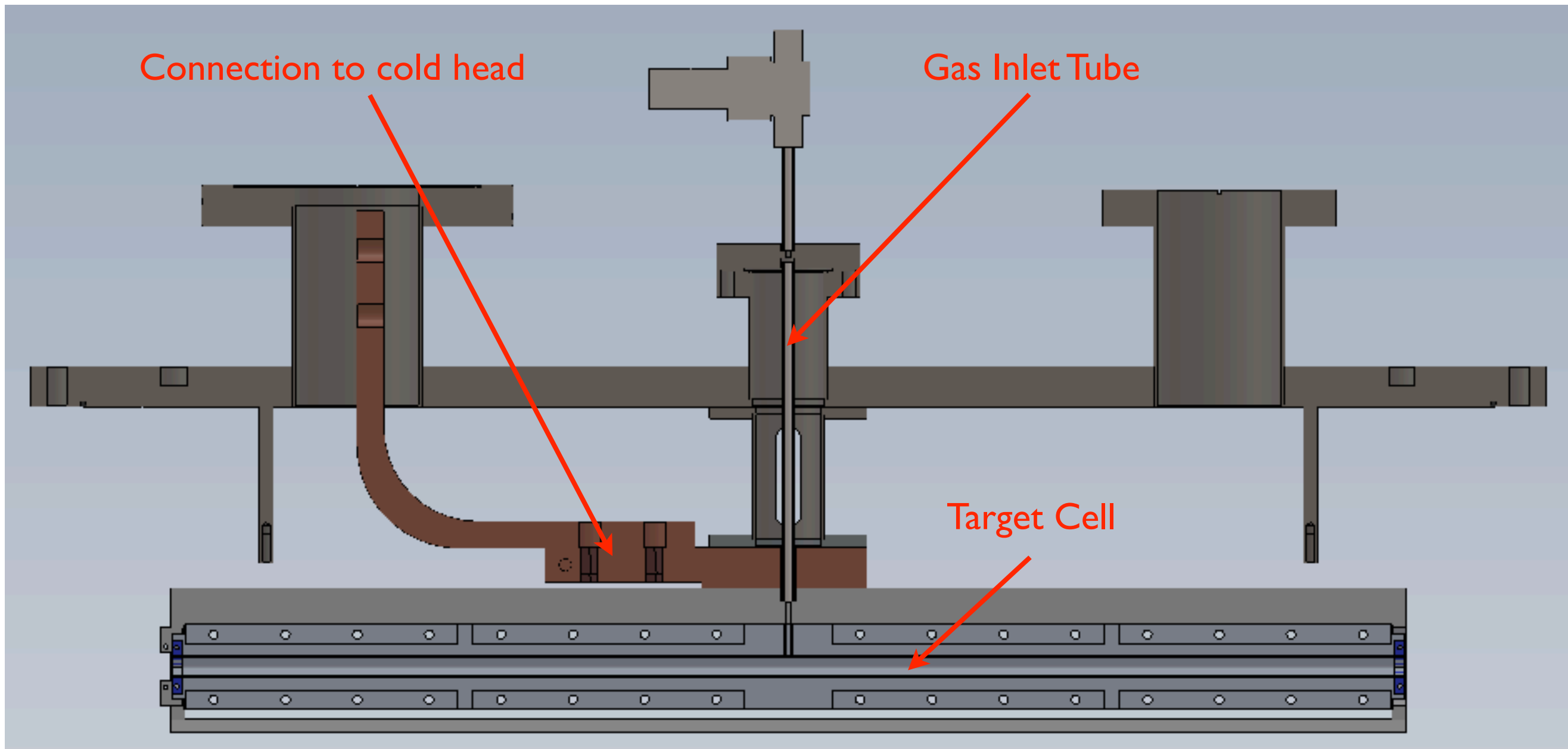


February run

- target system worked but ...
- ran with 0.8 sccm gas flow
- 2–3X higher than expected

- beam lifetime ~1 h optimal for data acquisition
- 25 – 30 % deadtime
- but luminosity $8 \times$ lower than expected

OLYMPUS Target System



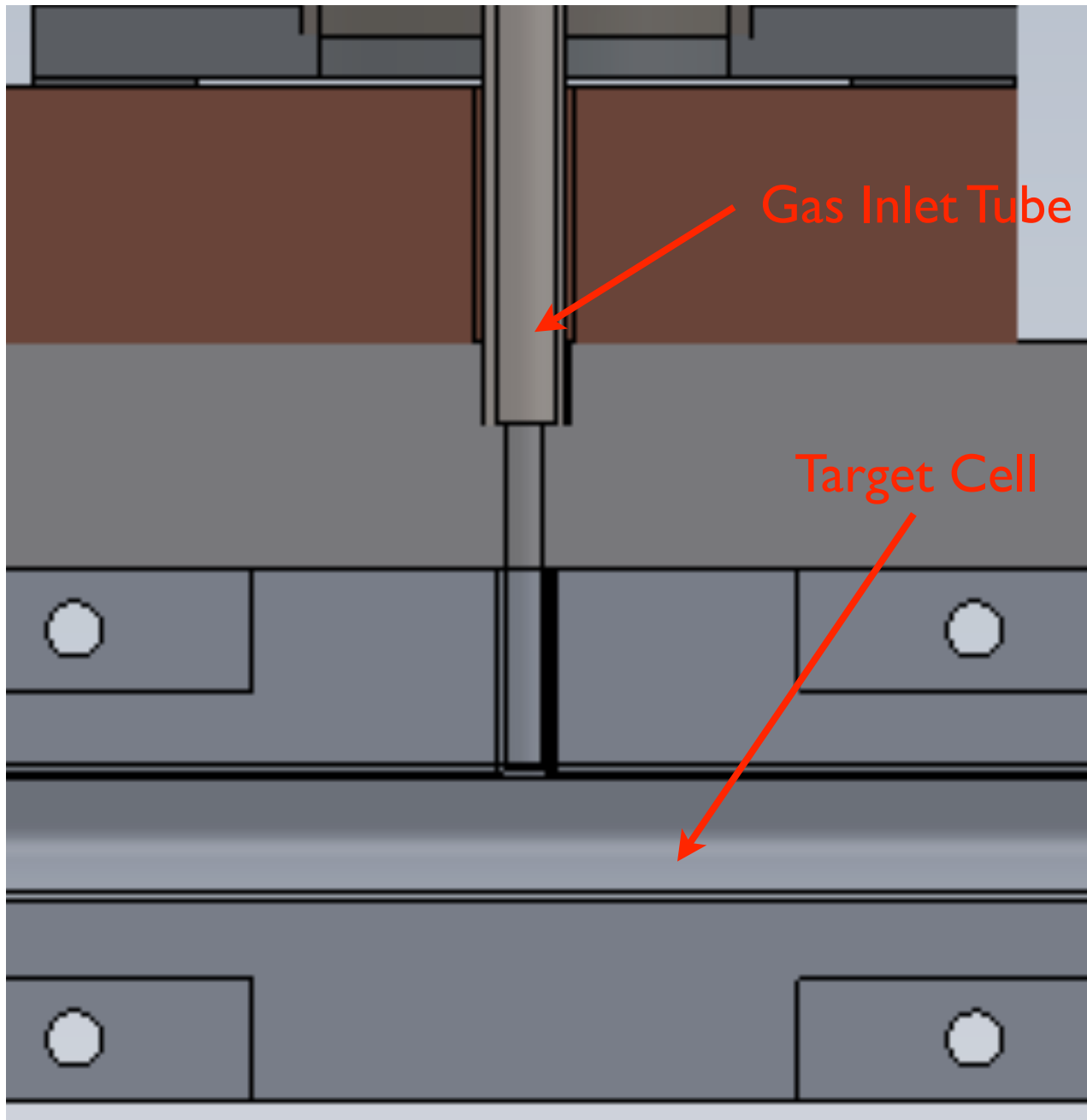
February run

- target system worked but ...
- ran with 0.8 sccm gas flow
- 2–3X higher than expected

- beam lifetime ~1 h optimal for data acquisition
- 25 – 30 % deadtime

Luminosity 4 - 8 × lower

OLYMPUS Target System



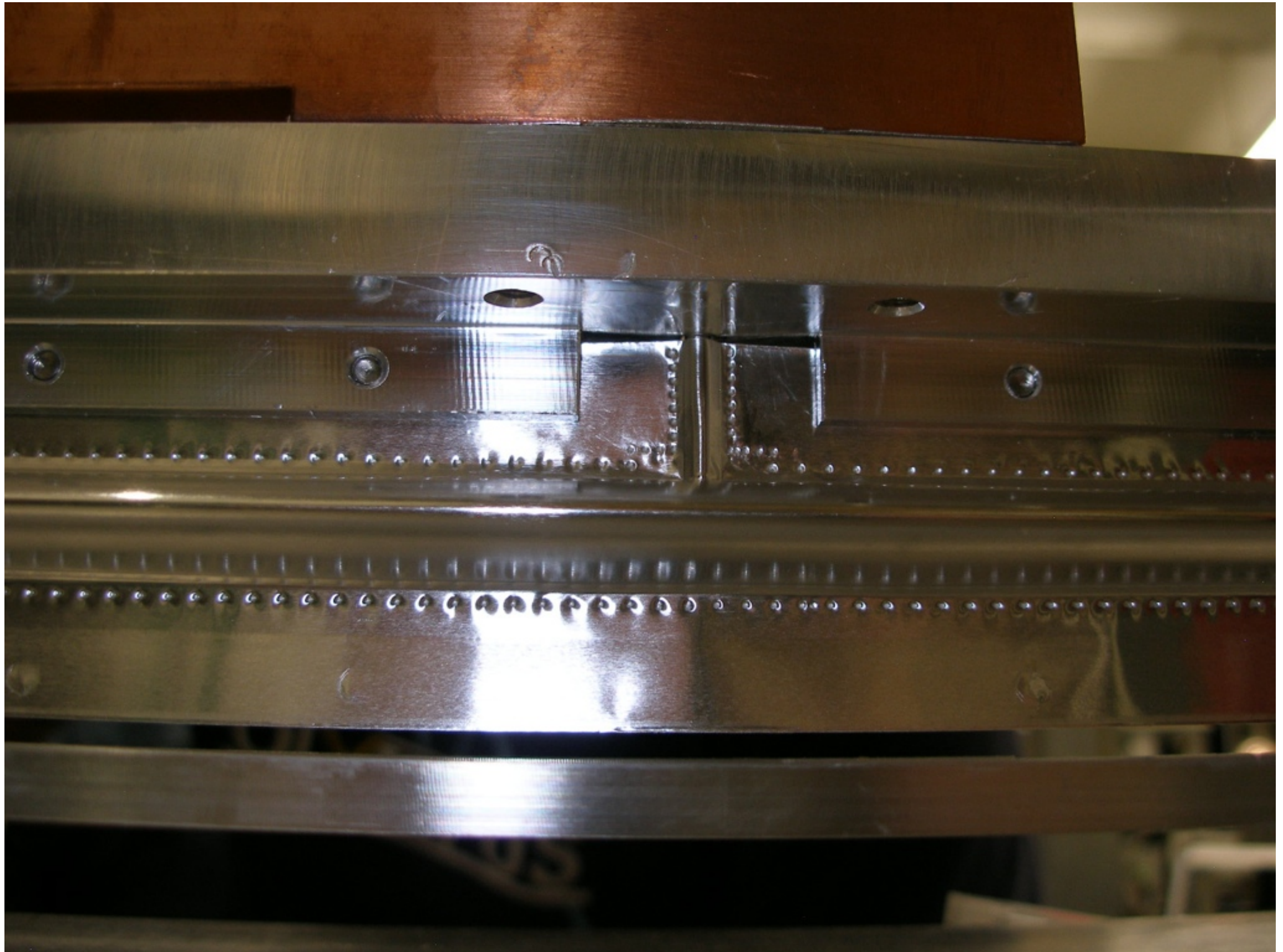
Lot of time spent studying the luminosity from:

- beam current + gas flow
- 12° GEM detector rate
- 12° MWPC detector rate
- symmetric Møller rate

Concluded that the target was leaking gas

- only ~12 % of the gas flowing to the target was getting to the target cell
- several places for small leaks
 - tight fits not seals
- few places for large leak unless there was a hole or a blockage
 - in fact there was a unexpected gap

Gap in OLYMPUS Target Cell



Solution for Gas Flow into Target Cell

Modify gas inlet tube

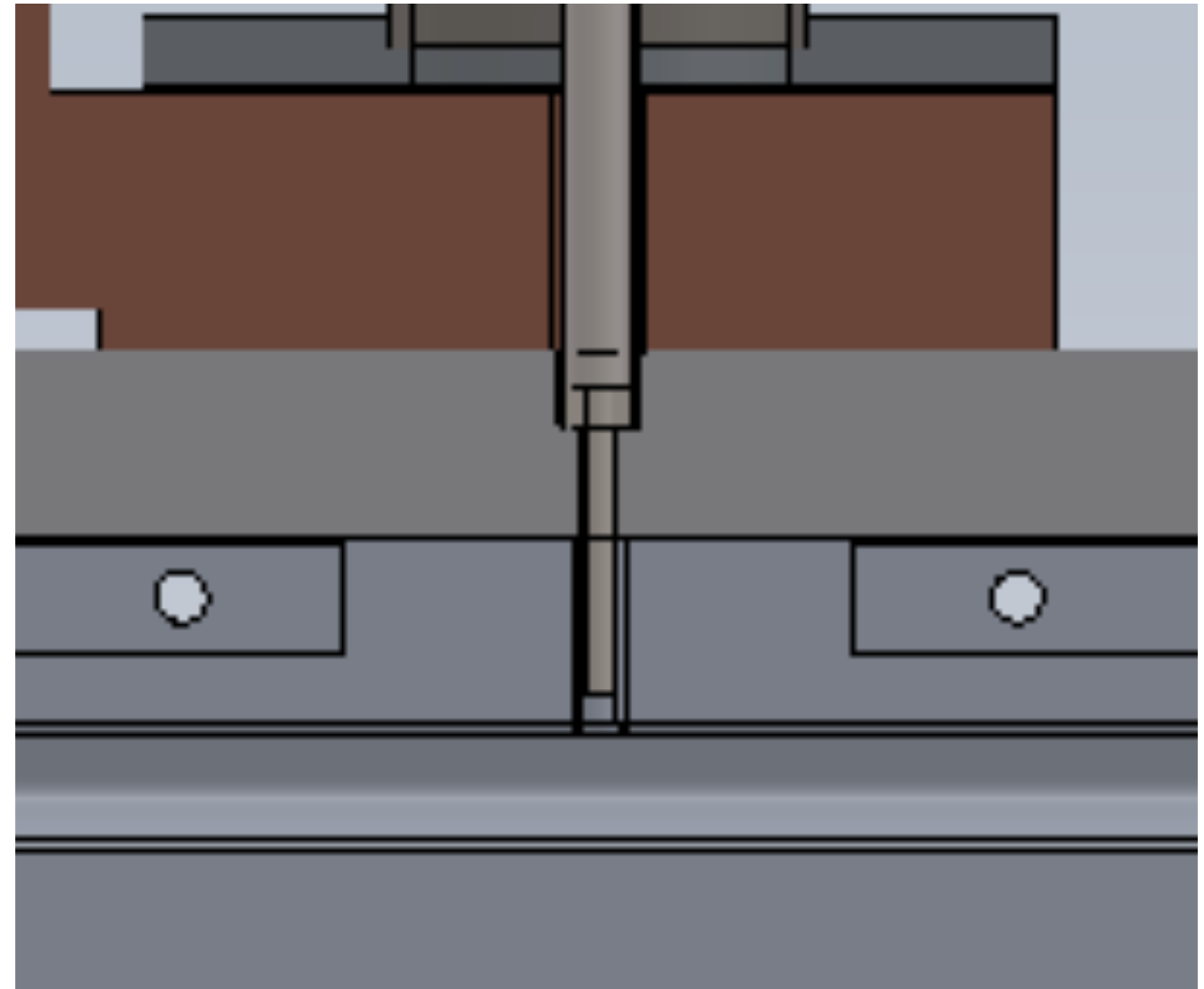
- bayonet fits into target cell inlet
- added some gas seals

First attempt in June

- installing new tube in situ failed
- endoscope and/or bayonet tore target cell inlet foil
- left pieces hanging into beam
- forced to remove scattering chamber from DORIS ring

July repair in vacuum lab

- mounted spare target cell
- installed tube with bayonet
- reinstalled scattering chamber into ring and resurveyed



Change in performance

- Feb. 0.8 sccm \Rightarrow ~1 h lifetime
- July 0.1 sccm \Rightarrow ~1 h lifetime
- working as intended !

OLYMPUS Wire Chambers

In general wire chambers appear to be working properly

- in February run 8 cells had to be disconnected for not holding HV
 - 8 in a total 318 is $< 3\%$ of cells not working
- in July repaired 7 of these 8 cells - currently 1 cell not holding HV

Good TDC distributions and efficiency

- reasonable signal / noise
- except inner chambers see lots of Møller and Bhabha events
 - at 2 GeV beam energy magnetic field insufficient to sweep these away

Reconstruction not simple

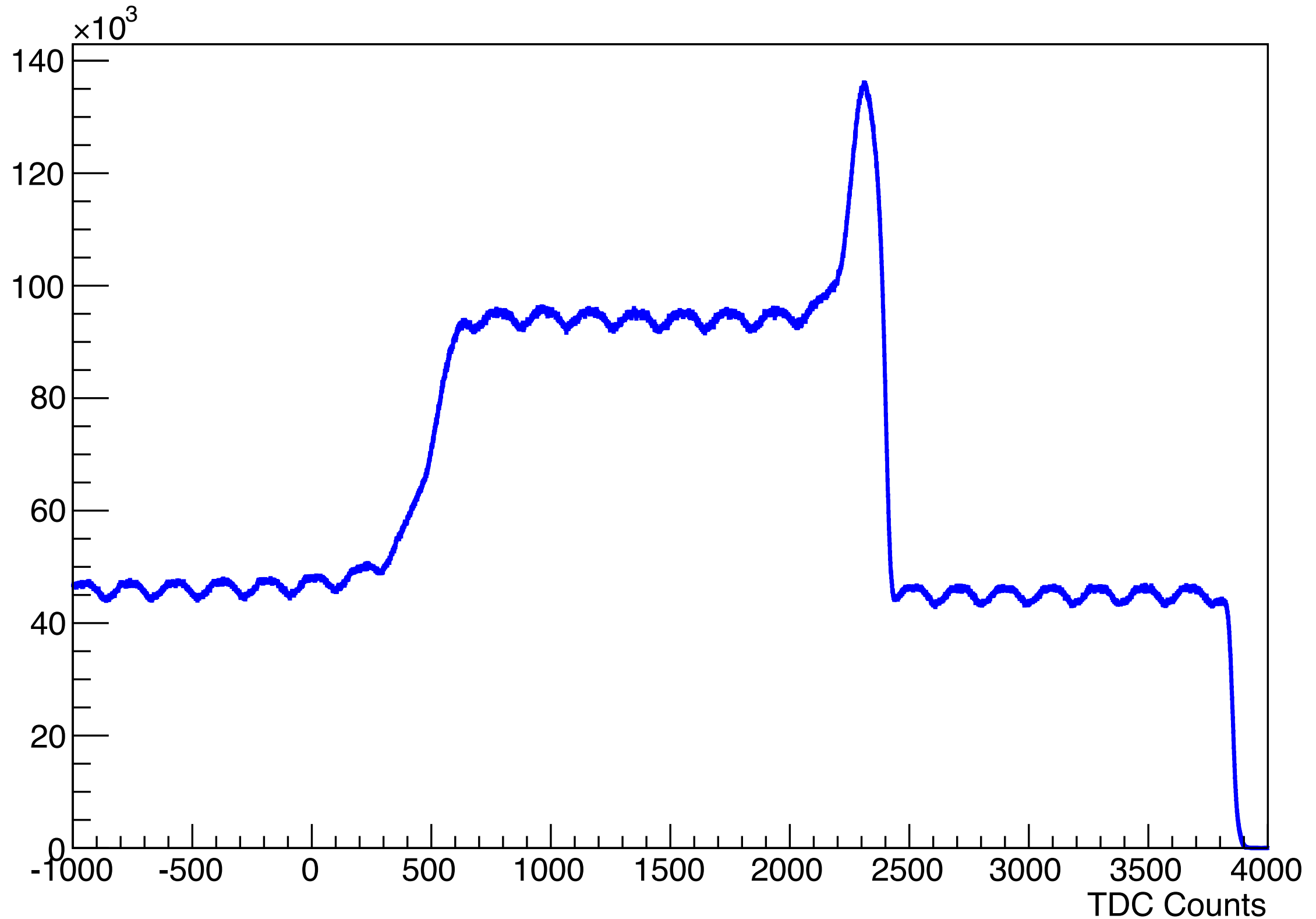
- inhomogeneous magnetic field
 - different Lorentz angle in every cell
 - reversing toroid polarity more than doubles the reconstruction problem

Missing tracks at forward angles

- initially taken as a reconstruction problem
- may also be a wire chamber efficiency problem
- likely a combination of both

WC TDC Distribution

TDC Distribution

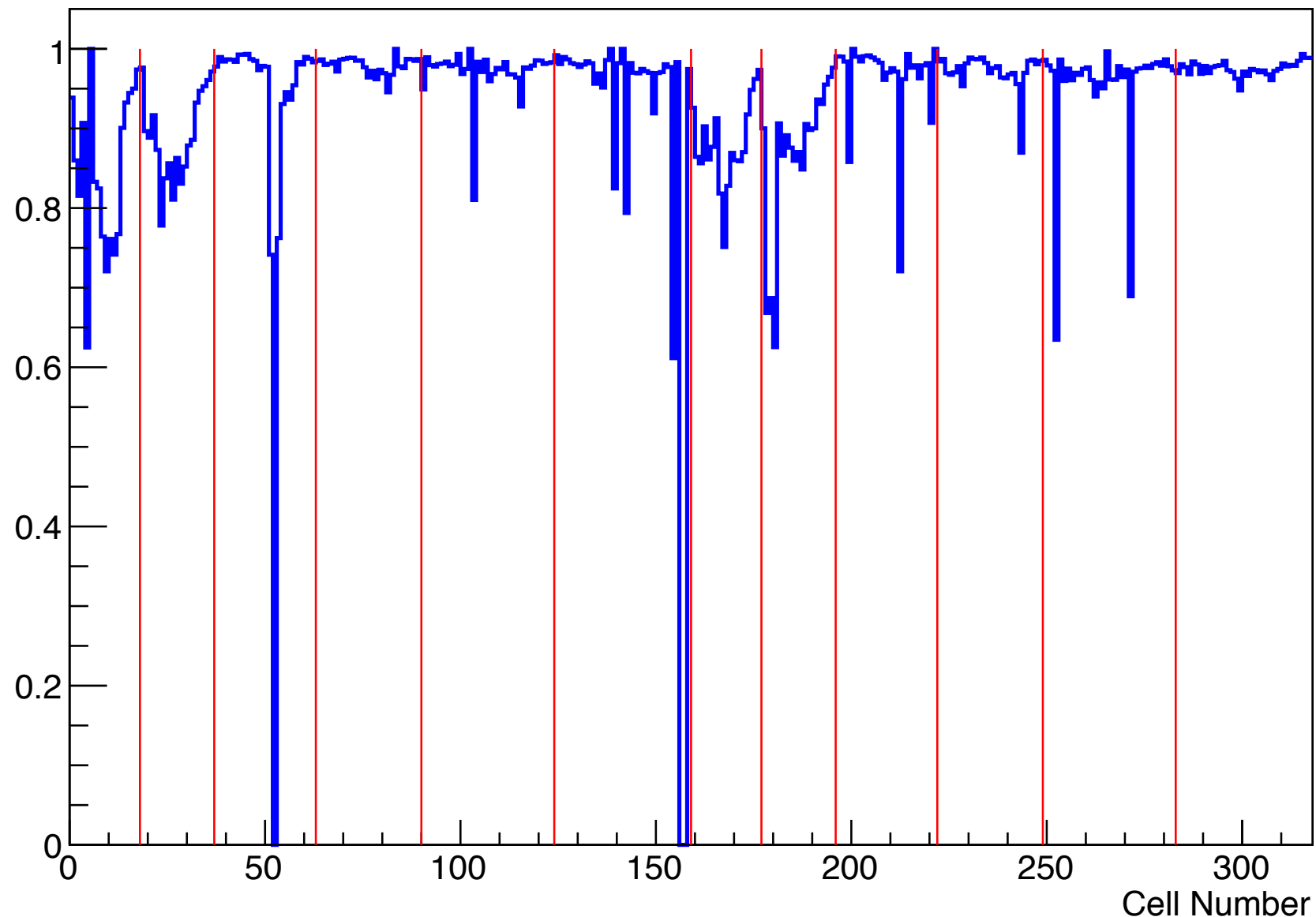


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Wire Chamber Cell “Efficiency”

Look for hits on wires 1 and 3 in the proper TDC range

- look for hit on wire 2 in the proper TDC range
 - red lines correspond to super-layers
 - inner chambers in left and right sectors noisy because of Møller / Bhabha events
 - ~98% for middle and outer chambers
 - better measure of WC efficiency would use tracks

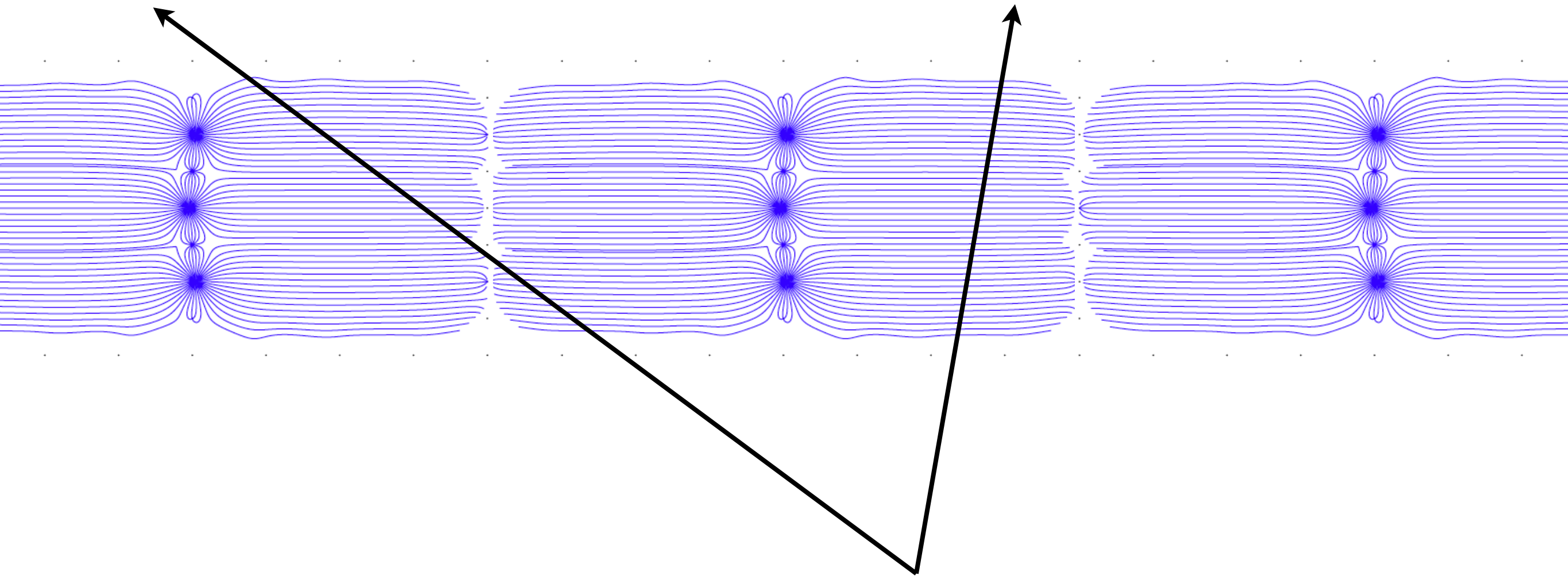


0 05 10 20 50

Lines of Electron Drift at $B = 0$ G

Single super-layer of drift cells in OLYMPUS wire chamber

- “Jet-style” drift cells \rightarrow sense wires “see” large distances left and right
- longest drift times around 1.1 micro-second (11 beam crossings)

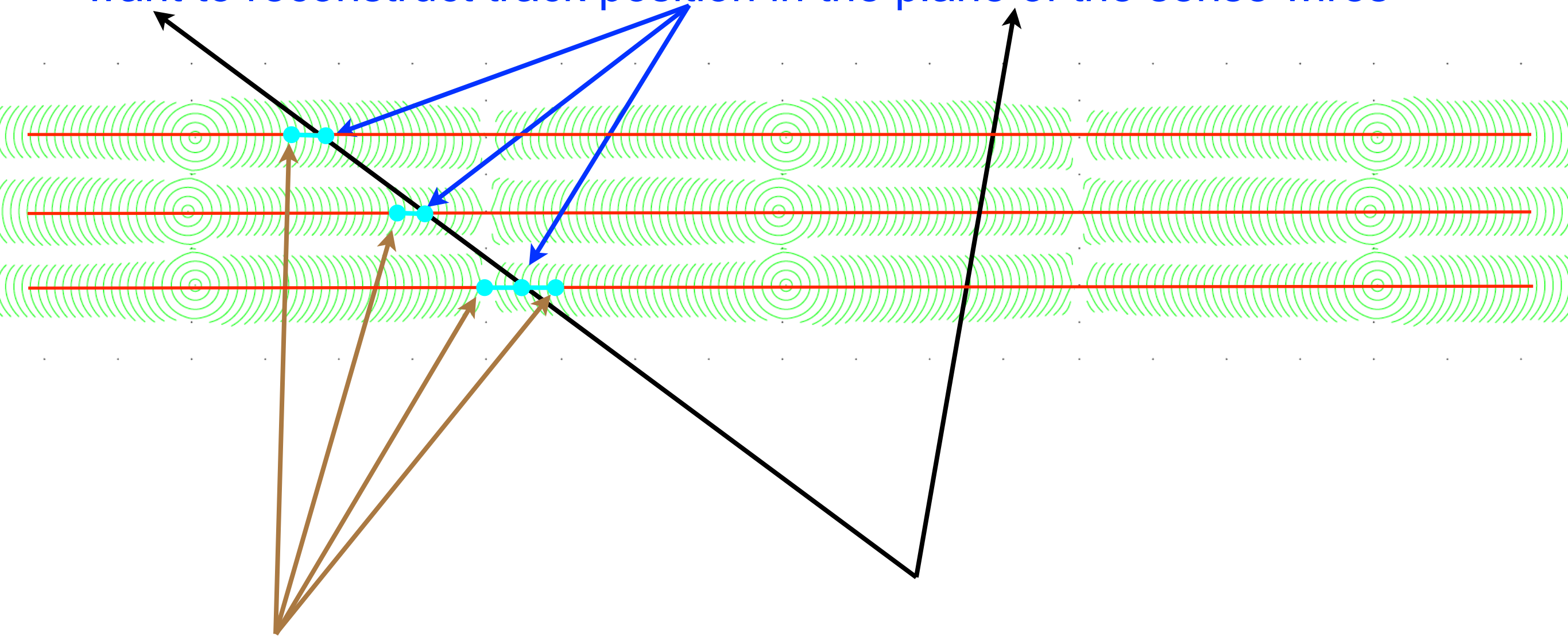


- wire chambers subtend $20^\circ - 80^\circ$ in polar angle
- chamber inclined by $16.5^\circ \Rightarrow$ tracks vary $-6.5^\circ \Leftrightarrow 53.5^\circ$ to normal

Lines of Equal Drift Time at $B = 0$ G

Charged particles ionise gas along the track

- first electrons to reach sense wire usually “fire” the TDC
- tangent of track to isochrone determines drift time
- want to reconstruct track position in the plane of the sense wires

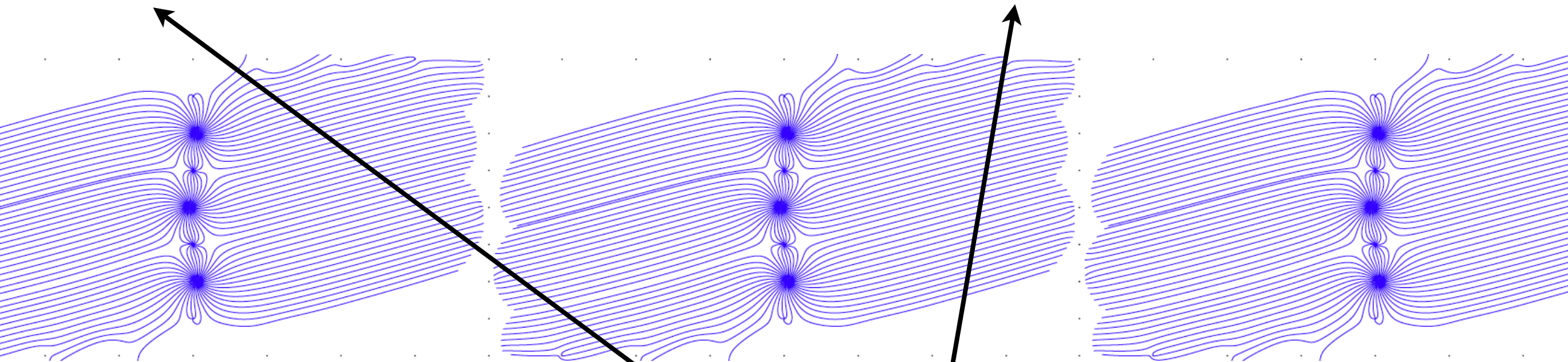


- but apparent position differs with increasing angle
 - larger angles relative to normal have larger correction

Lines of Electron Drift at $B = 3000$ G

BLAST had a fixed magnet polarity

- lines of electron drift angled because of Lorentz force
- reduced the effect for tracks at large relative angles

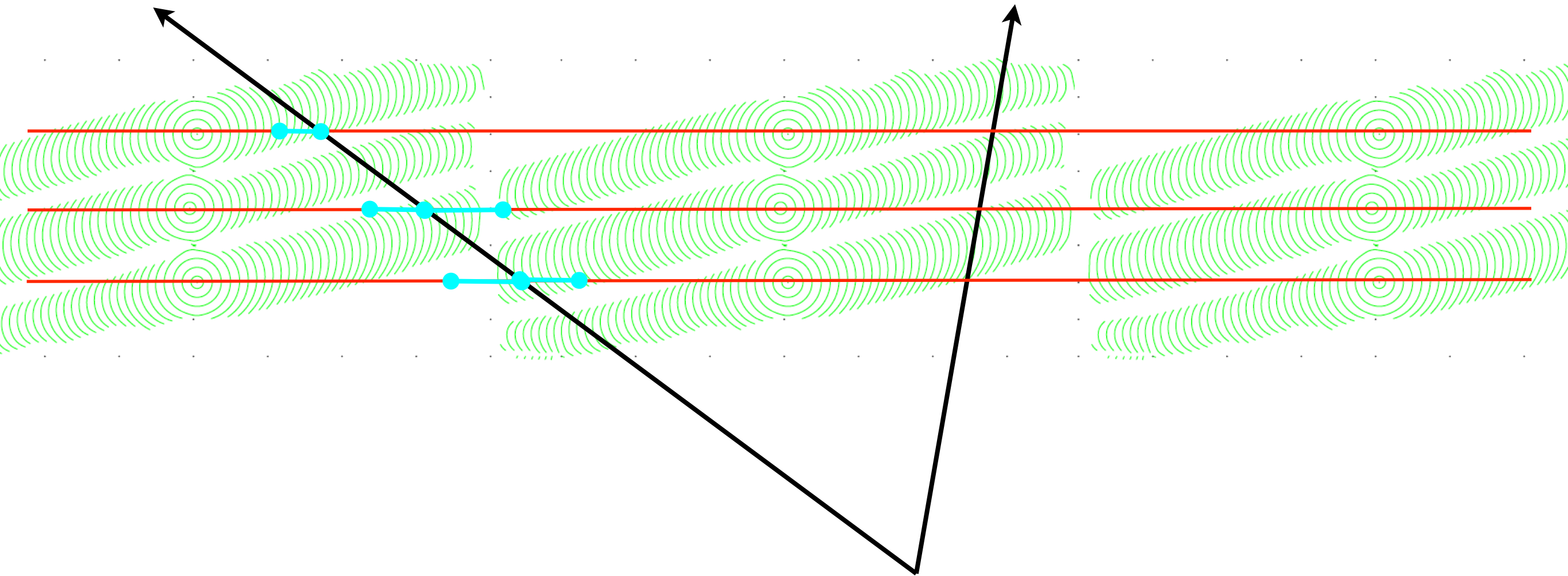


- 3000 G is the maximum field we have at OLYMPUS

Lines of Equal Drift Time at $B = 3000$ G

BLAST had a fixed magnet polarity

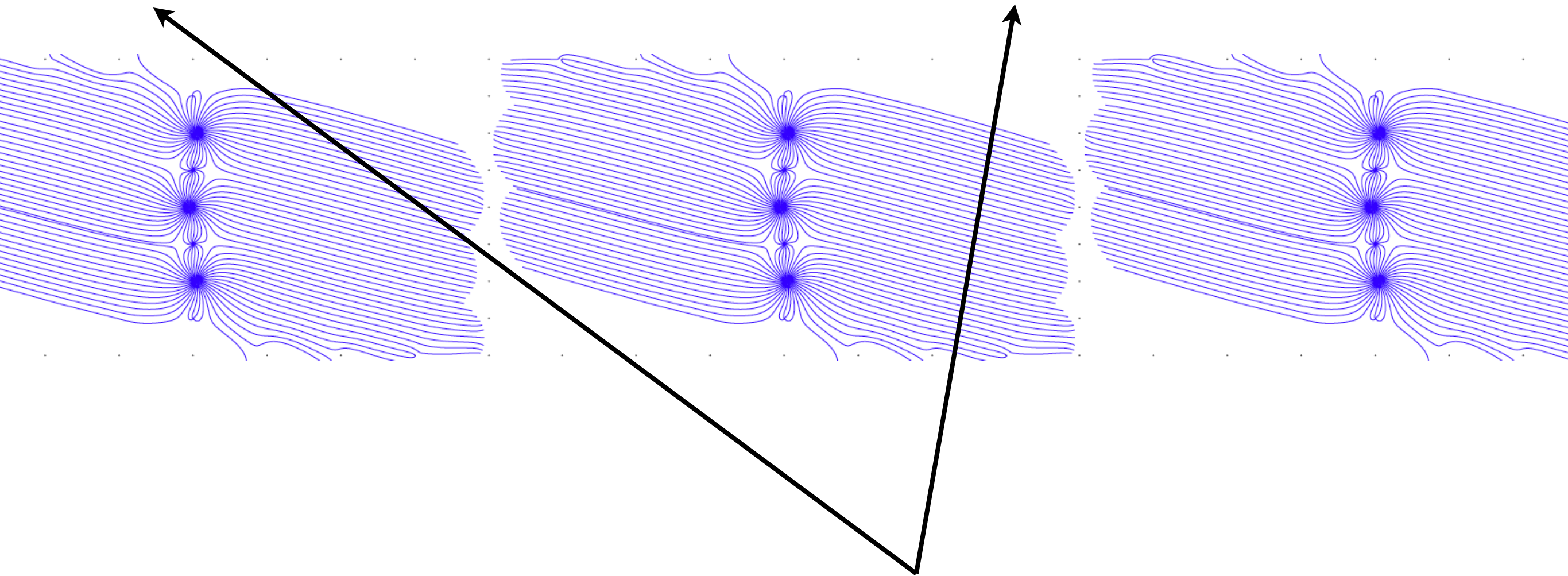
- lines of electron drift angled because of Lorentz force
- reduced the effect for tracks at large relative angles



Lines of Electron Drift at $B = -3000$ G

But OLYMPUS runs with both magnet polarities

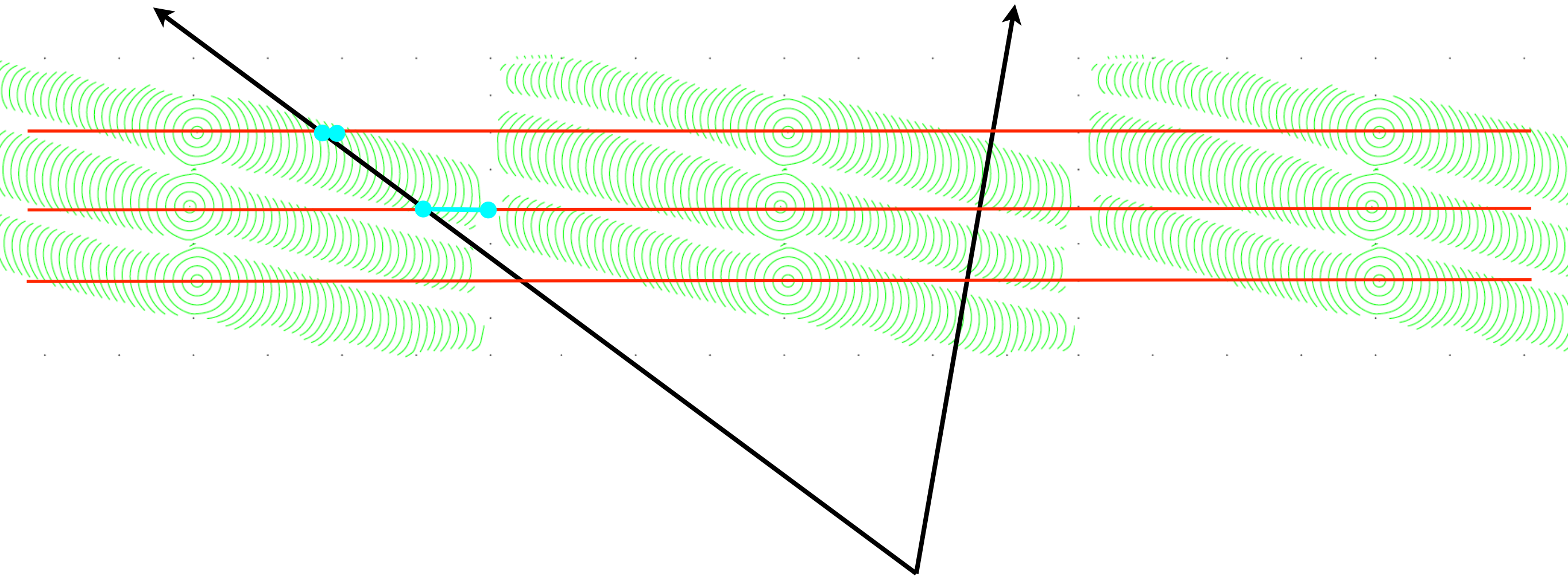
- reconstruction a bit more complicated
- deviation of apparent position from reconstructed position larger



Lines of Equal Drift Time at $B = -3000 \text{ G}$

But OLYMPUS runs with both magnet polarities

- reconstruction is more complicated
- deviation of apparent position from reconstructed position varies
- not all tracks produce 3 hits in a chamber

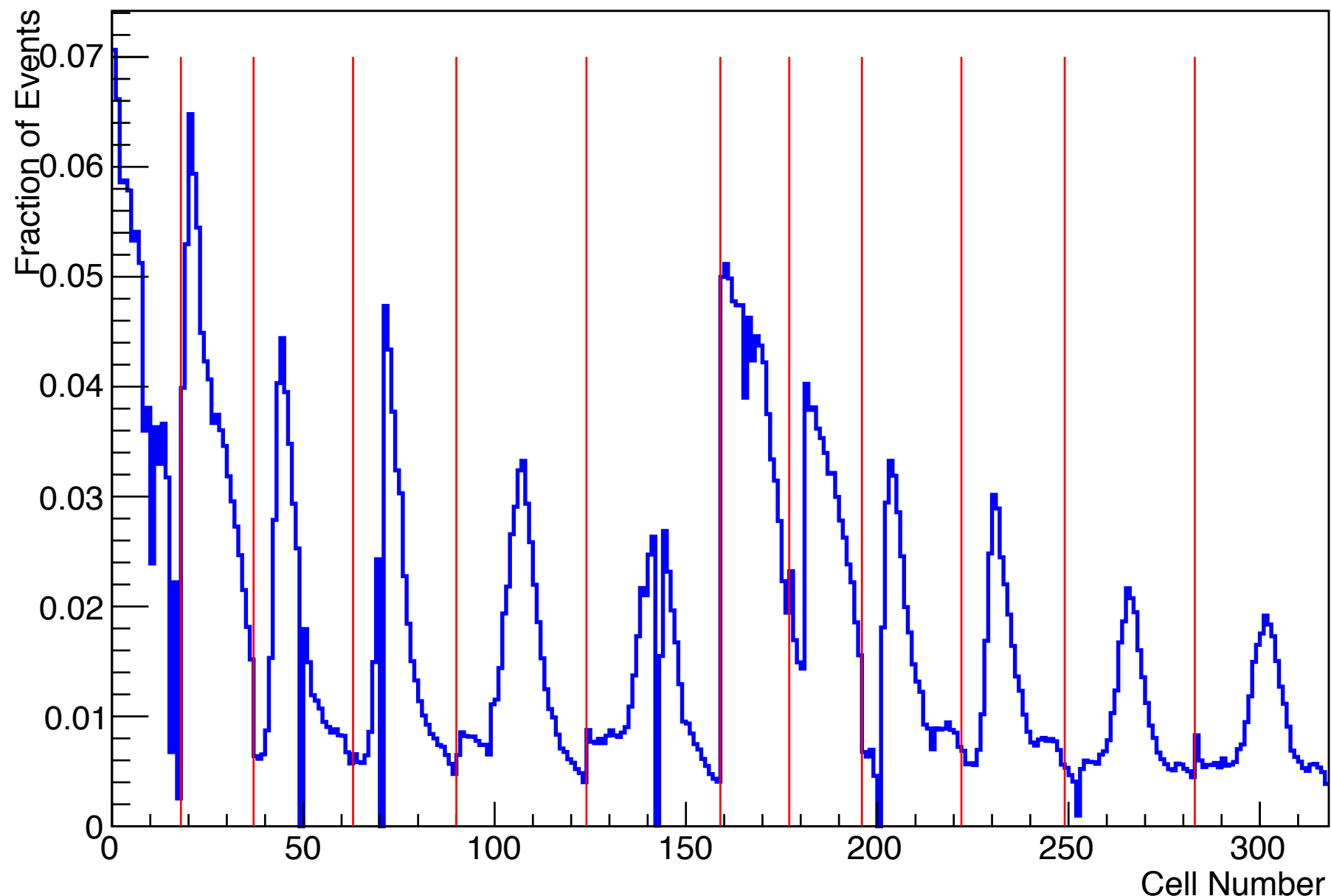


- has taken more time to solve than wished
 - need to know track angle to determine position, an iterative procedure
 - need to handle less than 3 hits in a super-layer for a track
 - need accurate time to position relationships as a function of angle, field, and wire

Missing Tracks

No electrons seen at forward angles.

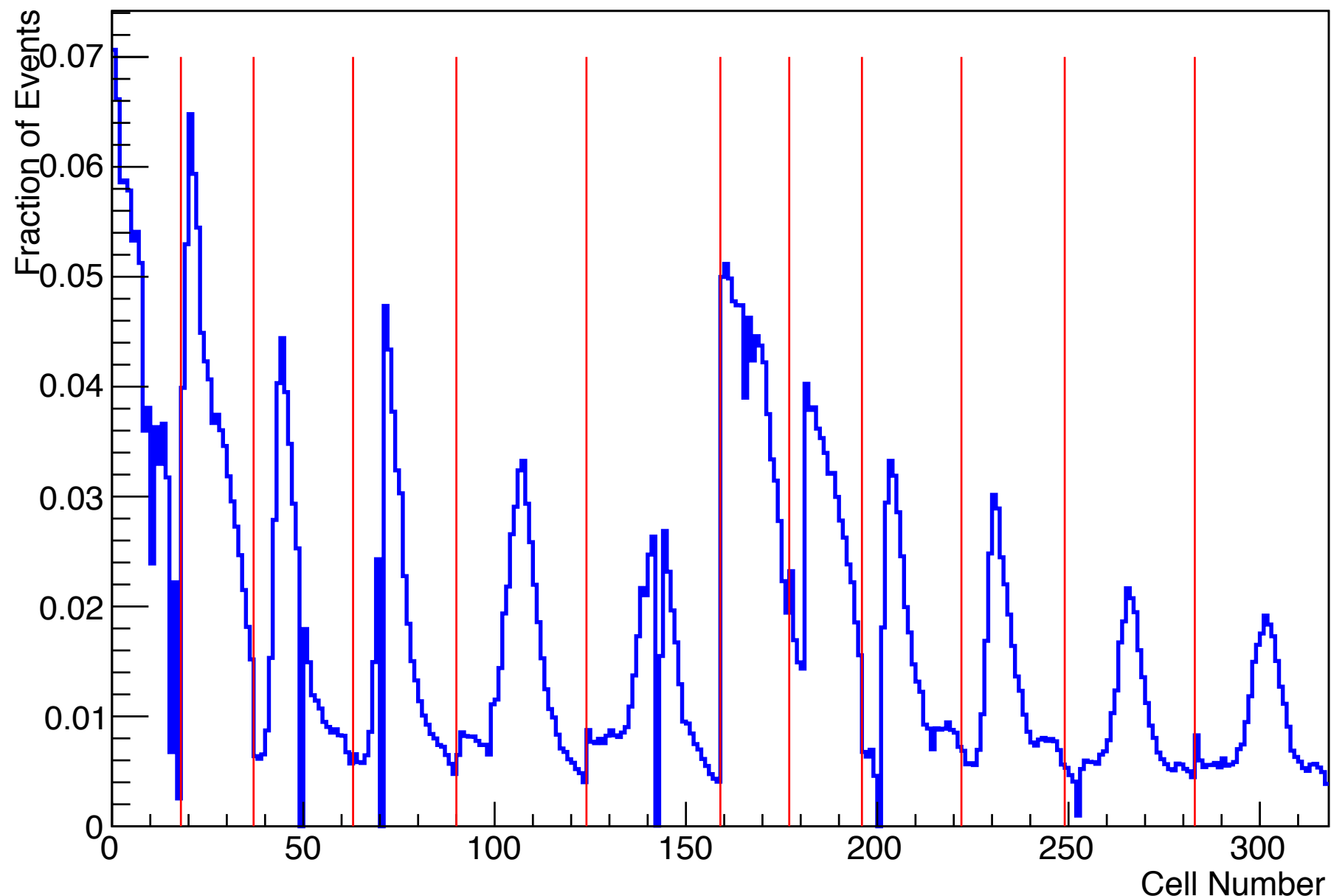
- initially thought to be a reconstruction issue
- possible problem with wire chamber efficiency
- plot rate of triple hits in each cell
 - observed peak appears to be due to showering and dominates the events



Missing Tracks

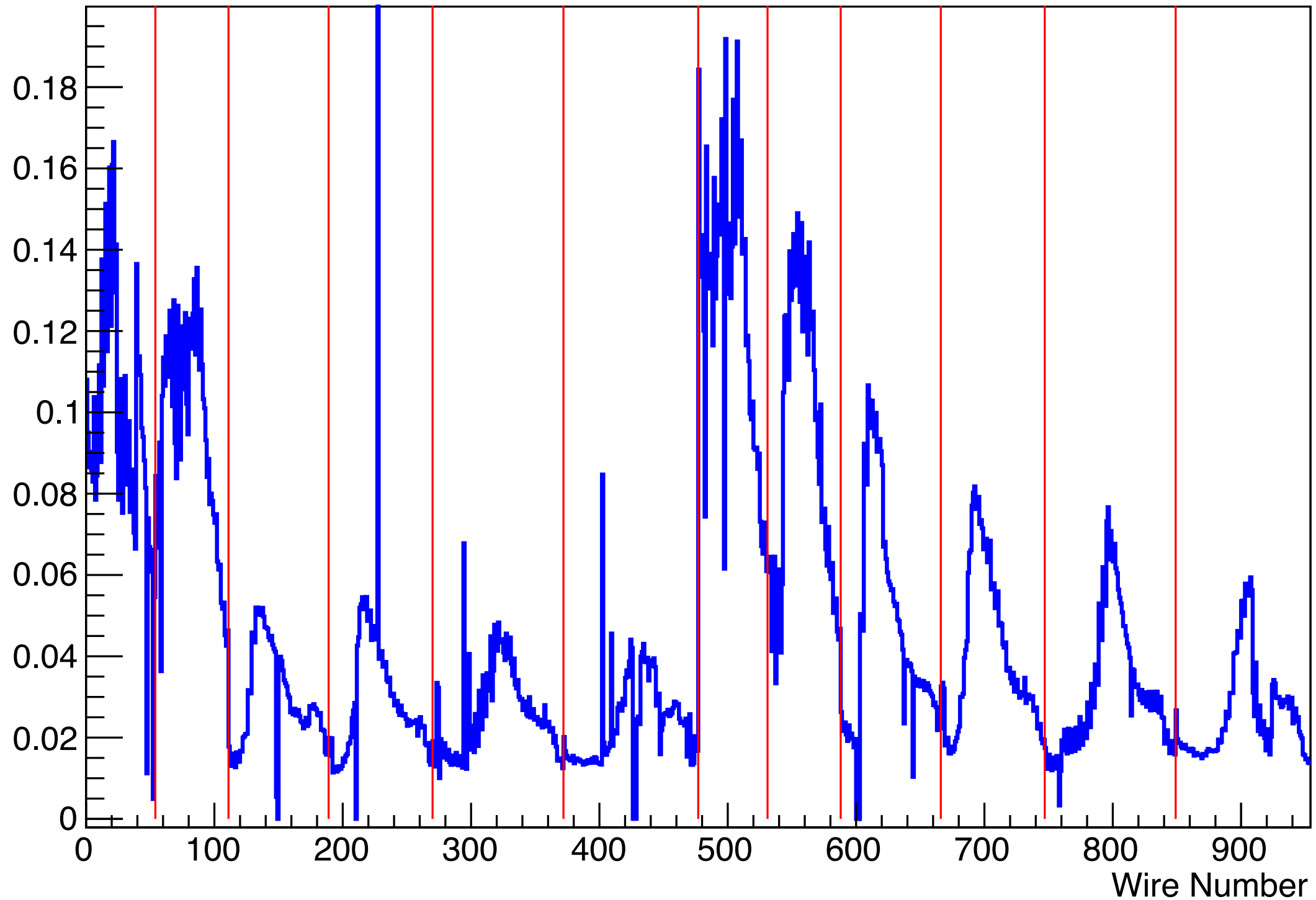
Not all electrons seen at forward angles ~50% missing

- initially thought to be a reconstruction issue
- possible problem with wire chamber efficiency
- plot rate of triple hits in each cell
 - observed peak appears to be due to showering and dominates the events



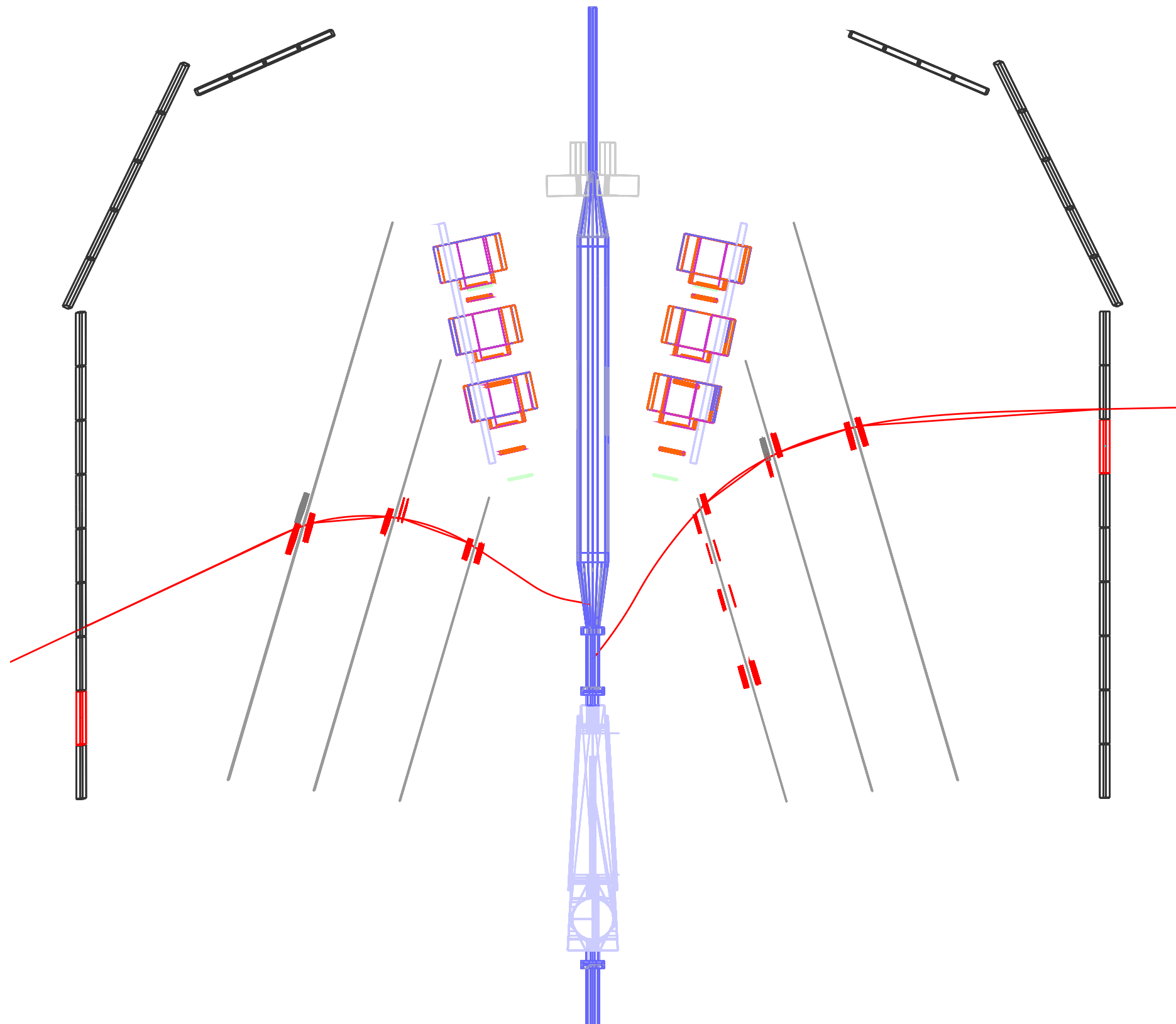
Individual Wire Rates

Wire Rate

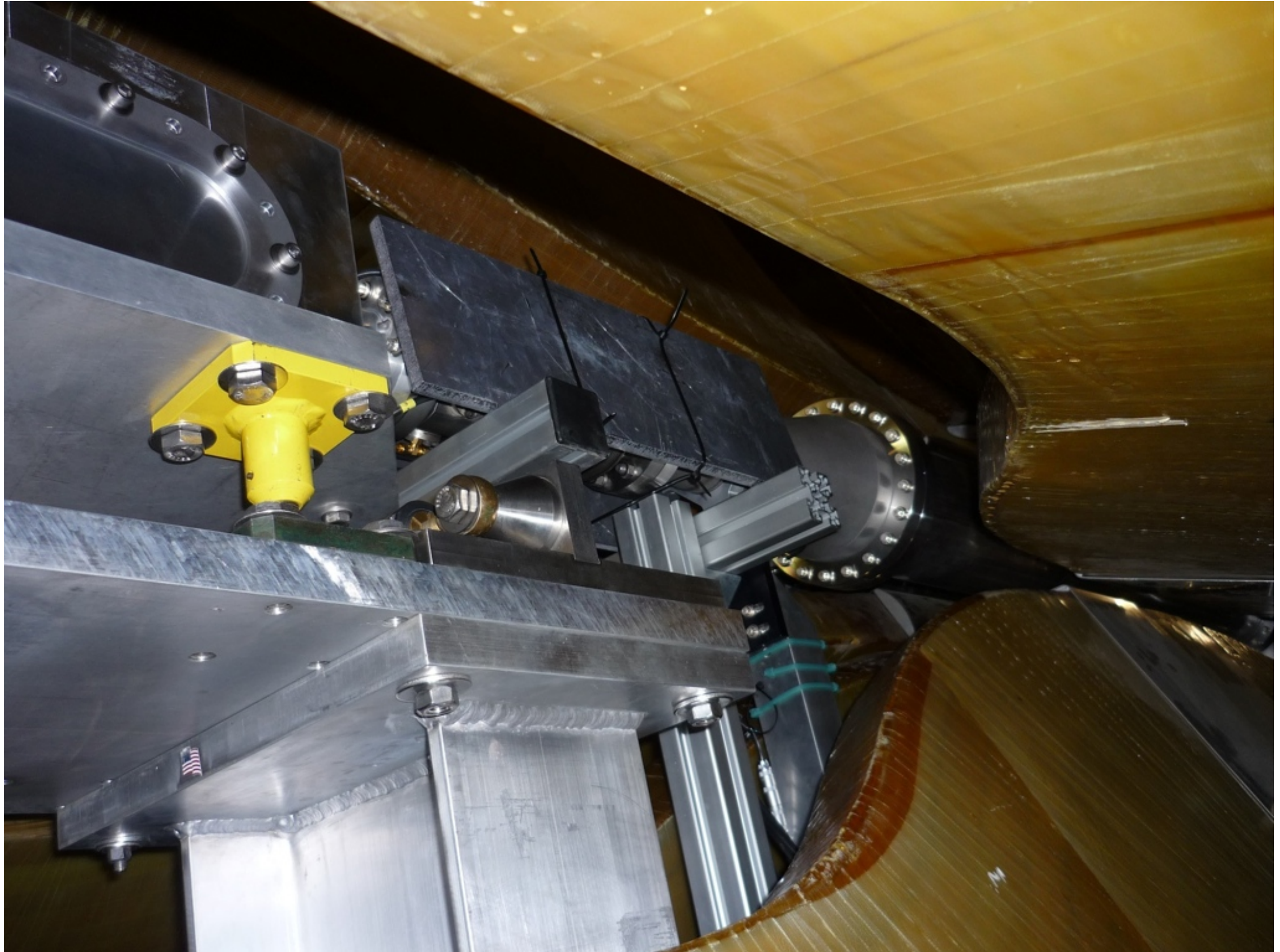


2012-09-17 09:30:51

Showering Downstream of Target Cell



Lead Shield for Downstream Showering



Missing Tracks

Not reconstructing proper rate for leptons in forward region

- reconstruction problem?
- wire chamber problem ?
 - investigated low voltage power dropping over longest lines
 - added power supplies and recabled last week
 - possible HV and/or threshold issue
 - investigated last week
 - requires further analysis

Showering from region on down stream BPM

- causes large number of low momentum tracks in wire chambers
- possibly dominating number of events
- investigated shielding with lead
 - requires further analysis

Other ideas?

GEM Tracker

GEM tracker intention

- add another space point before wire chambers to aid tracking
- 1.2 m long, requires two separate stacks of foils and readout

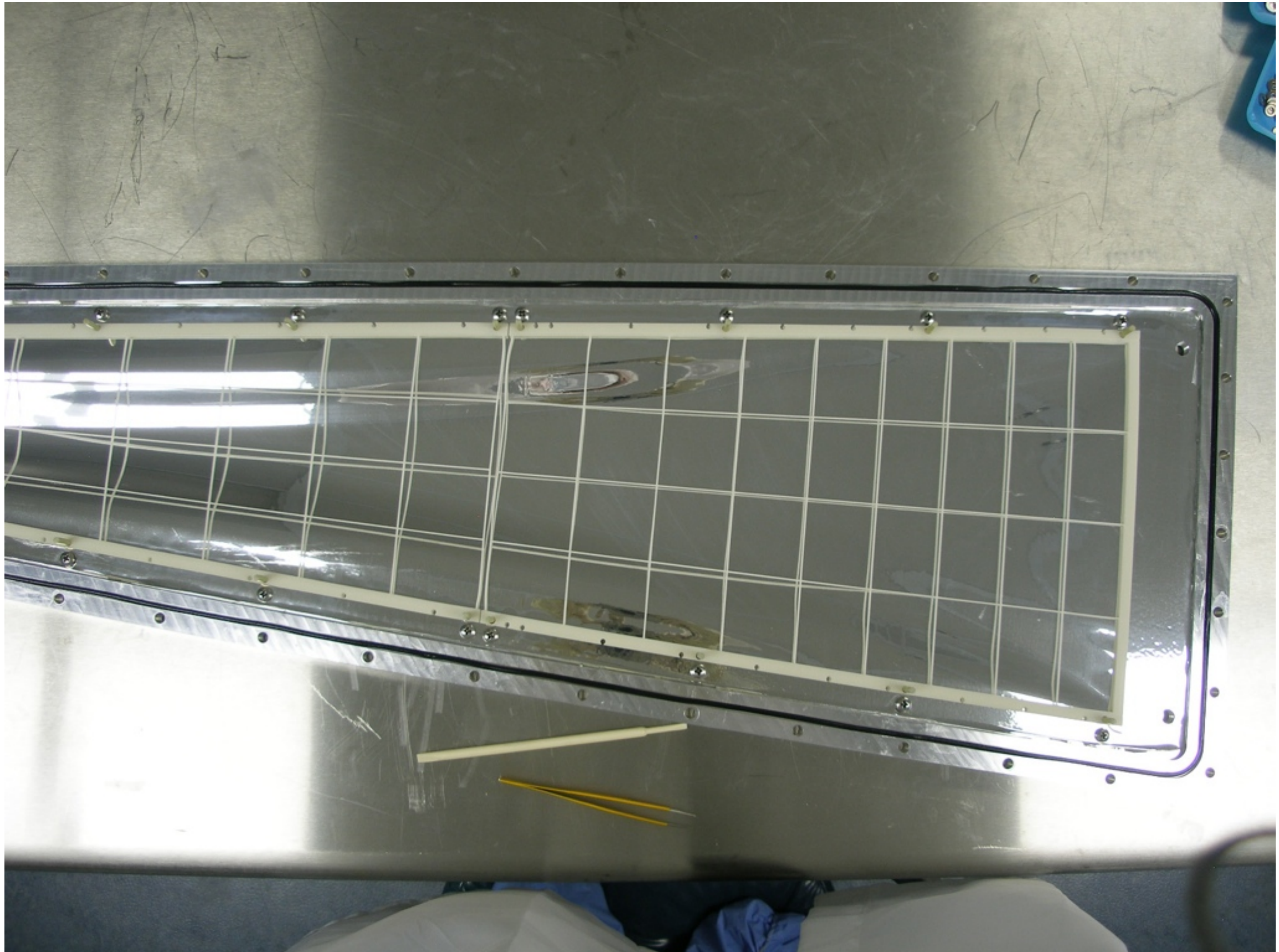
Design was innovative

- gas volume aluminium box with O-ring seals against readout boards
 - thin entrance and exit windows of aluminised mylar over active area
 - peelable shims match readout board thicknesses at ends of chamber
- stereo readout geometry with line and pad with vias
- GEM foils loose - not stretched nor attached to frames
 - each foil held in place by 8 alignment pins
- layers separated by nylon spacer grids produced by 3D printing
- HV connections using spring loaded contacts to ring terminals
 - HV lines brought in on readout board
- designed minimises handling and allows easy assembly/disassembly
 - disassemble ~1 h
 - assemble ~2 h
- empty forward region for particles to pass to 12° detectors

Top and Bottom Gas Enclosure



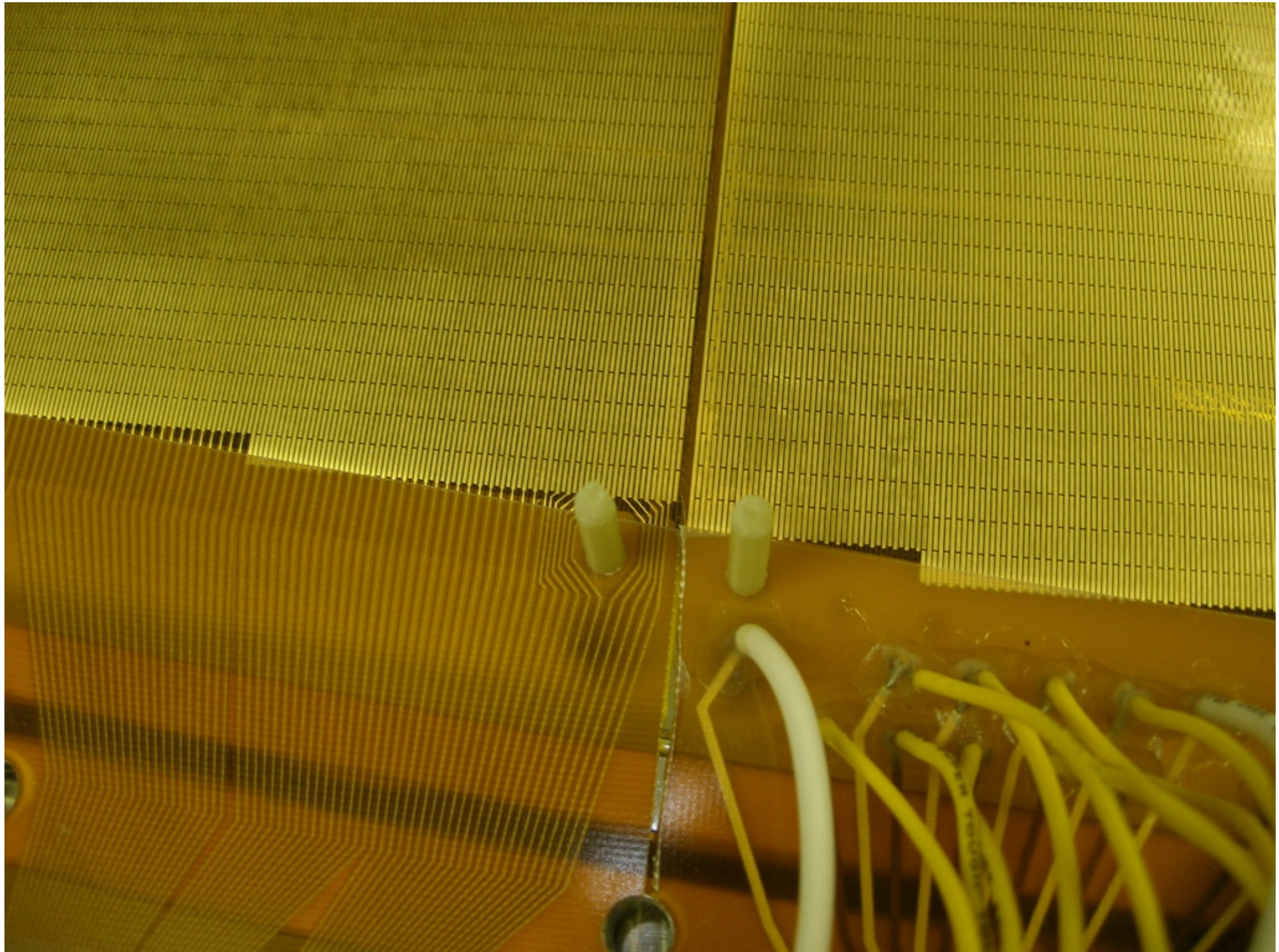
R/O Board Support Grid - 3D Printed



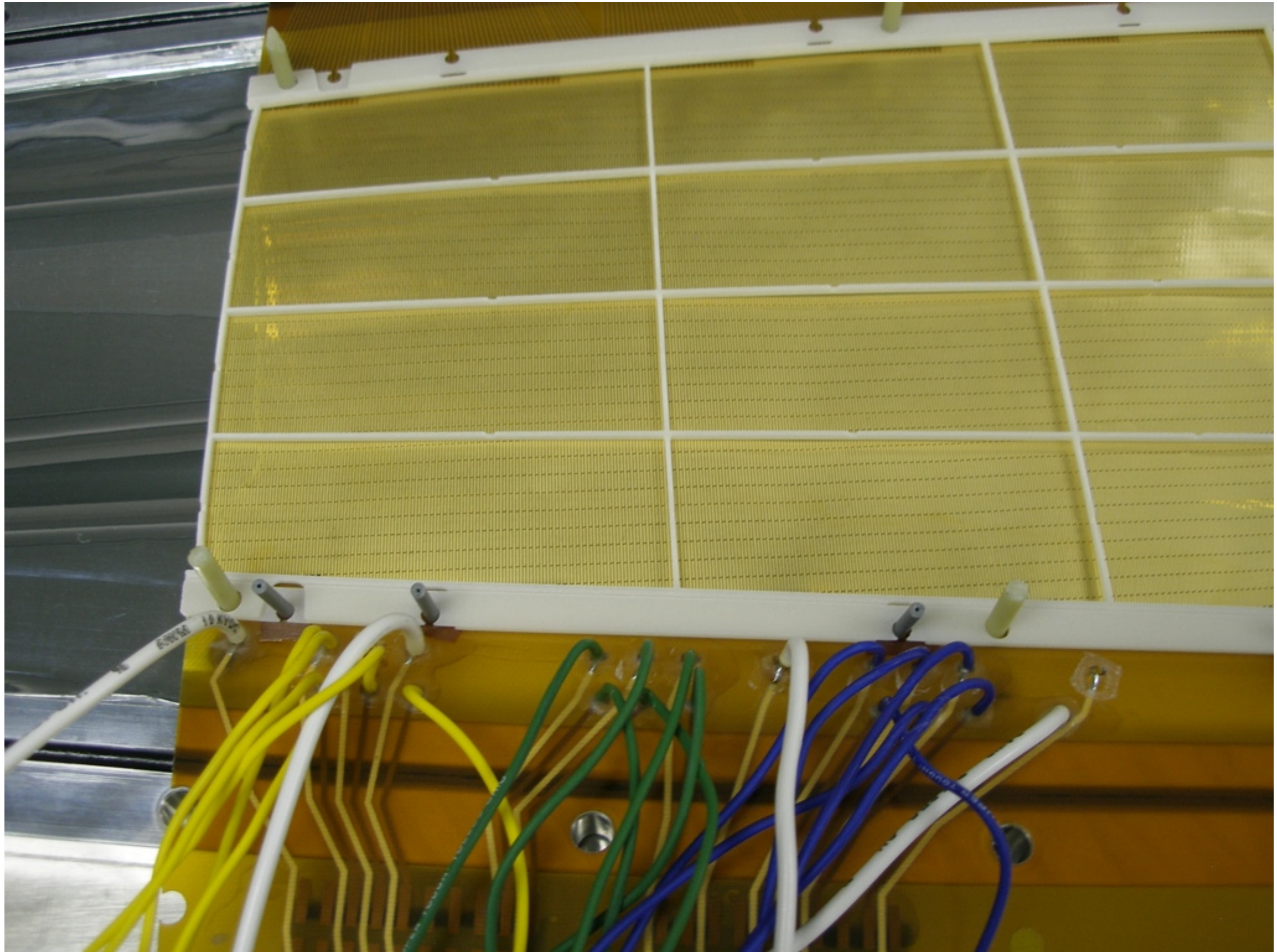
Installing Readout Boards



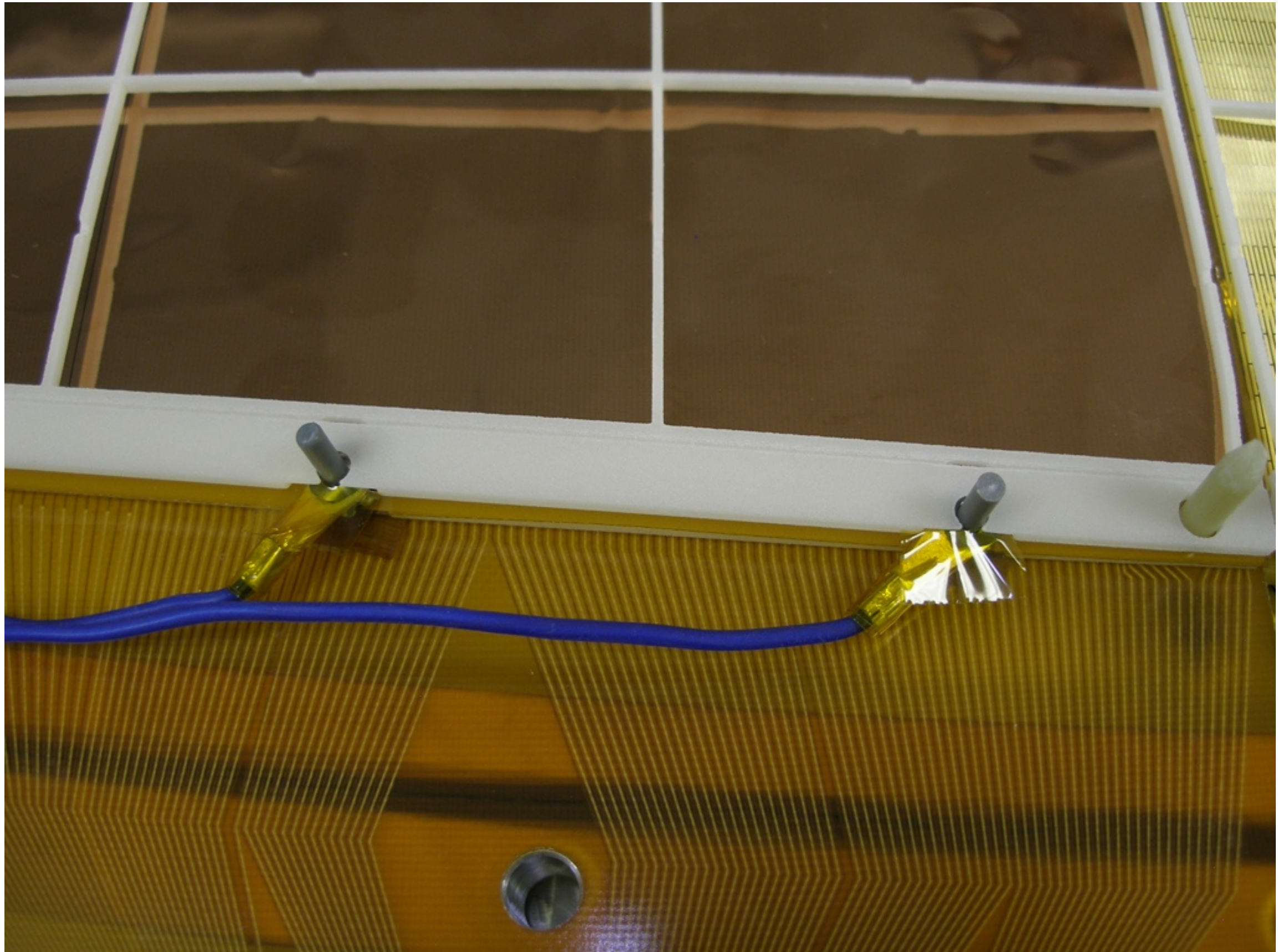
Readout Board Detail - Small meets Large



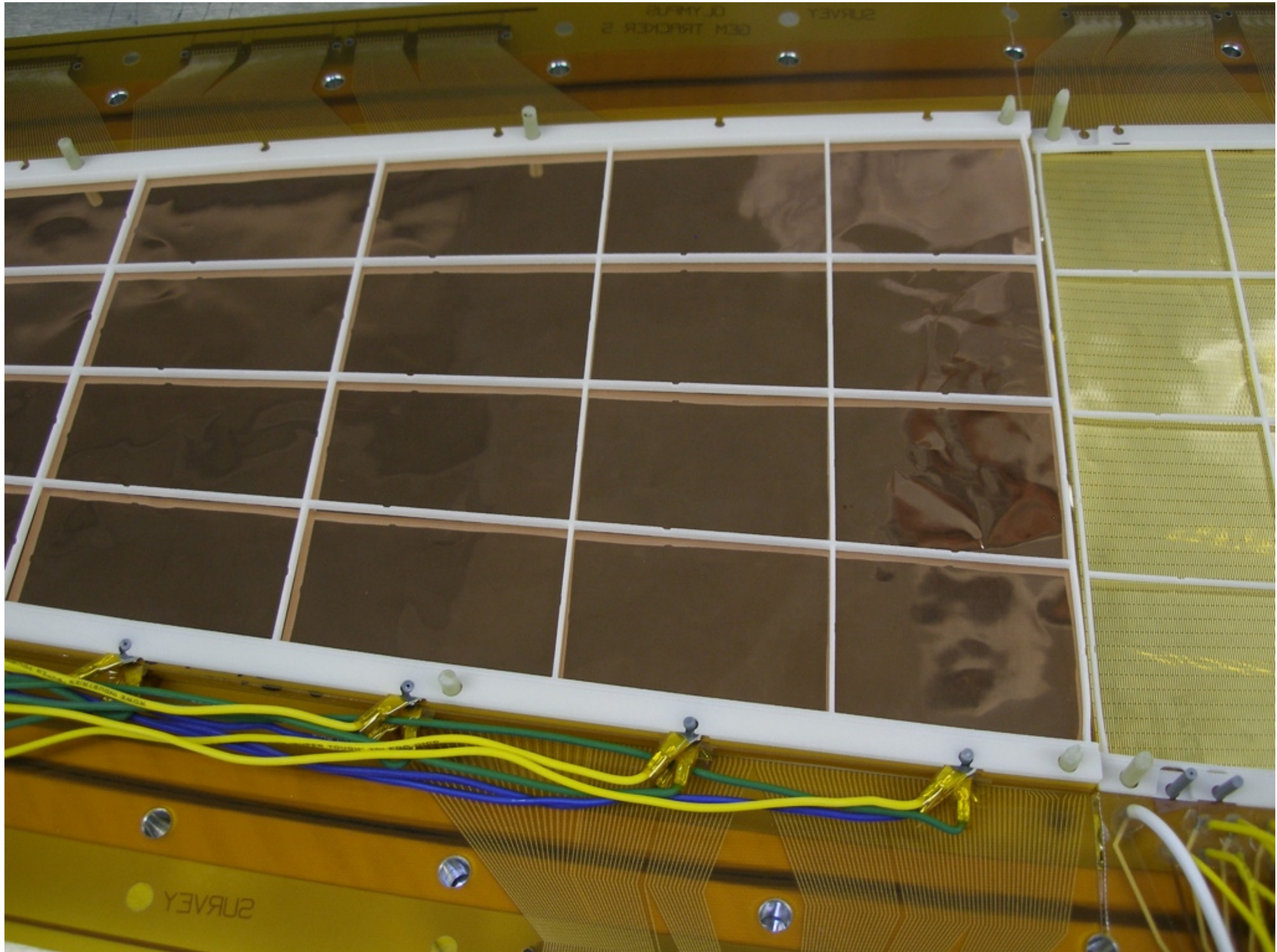
First GEM Support Grid and HV Cables



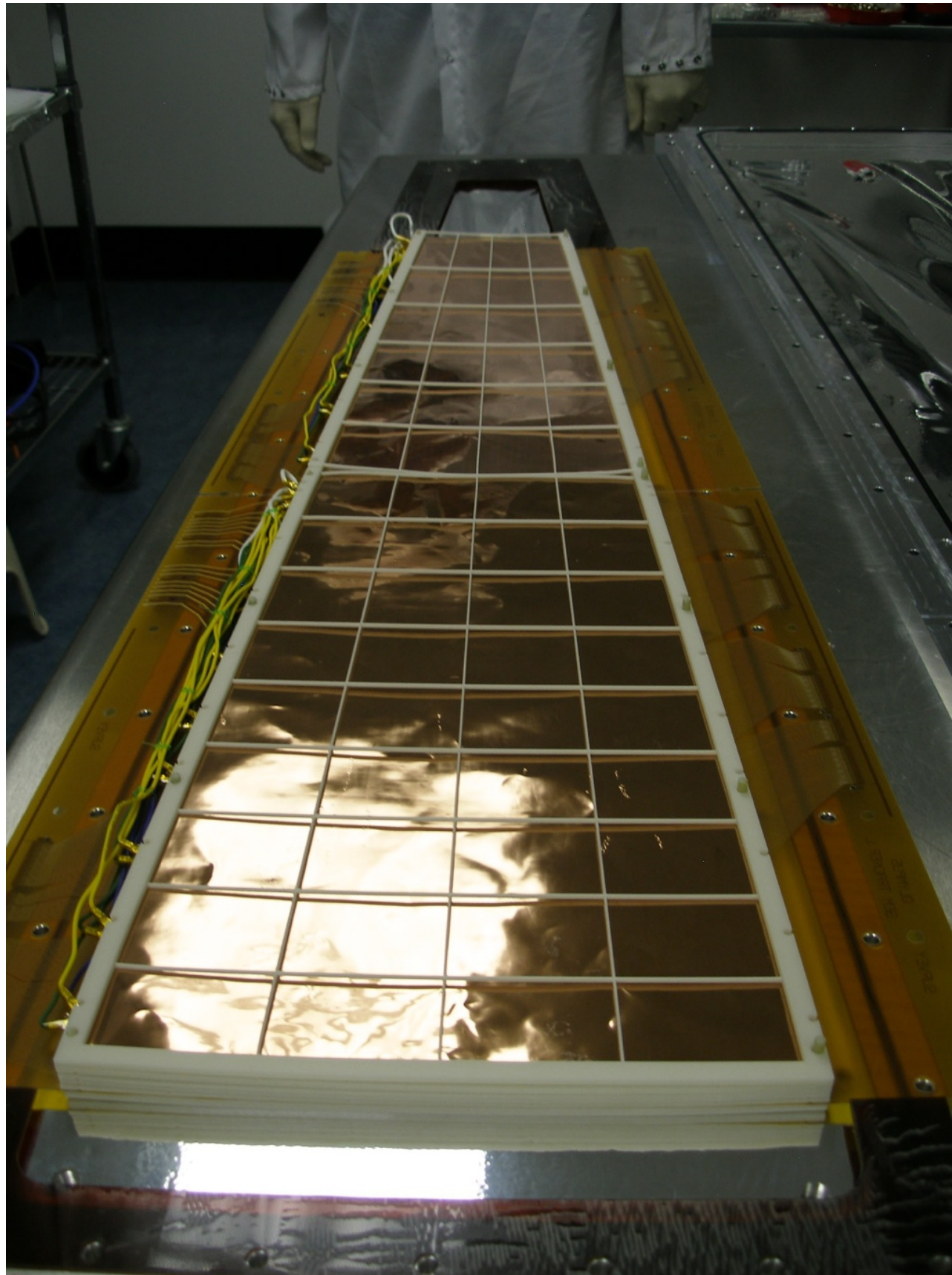
First GEM Layer and Spring Loaded HV



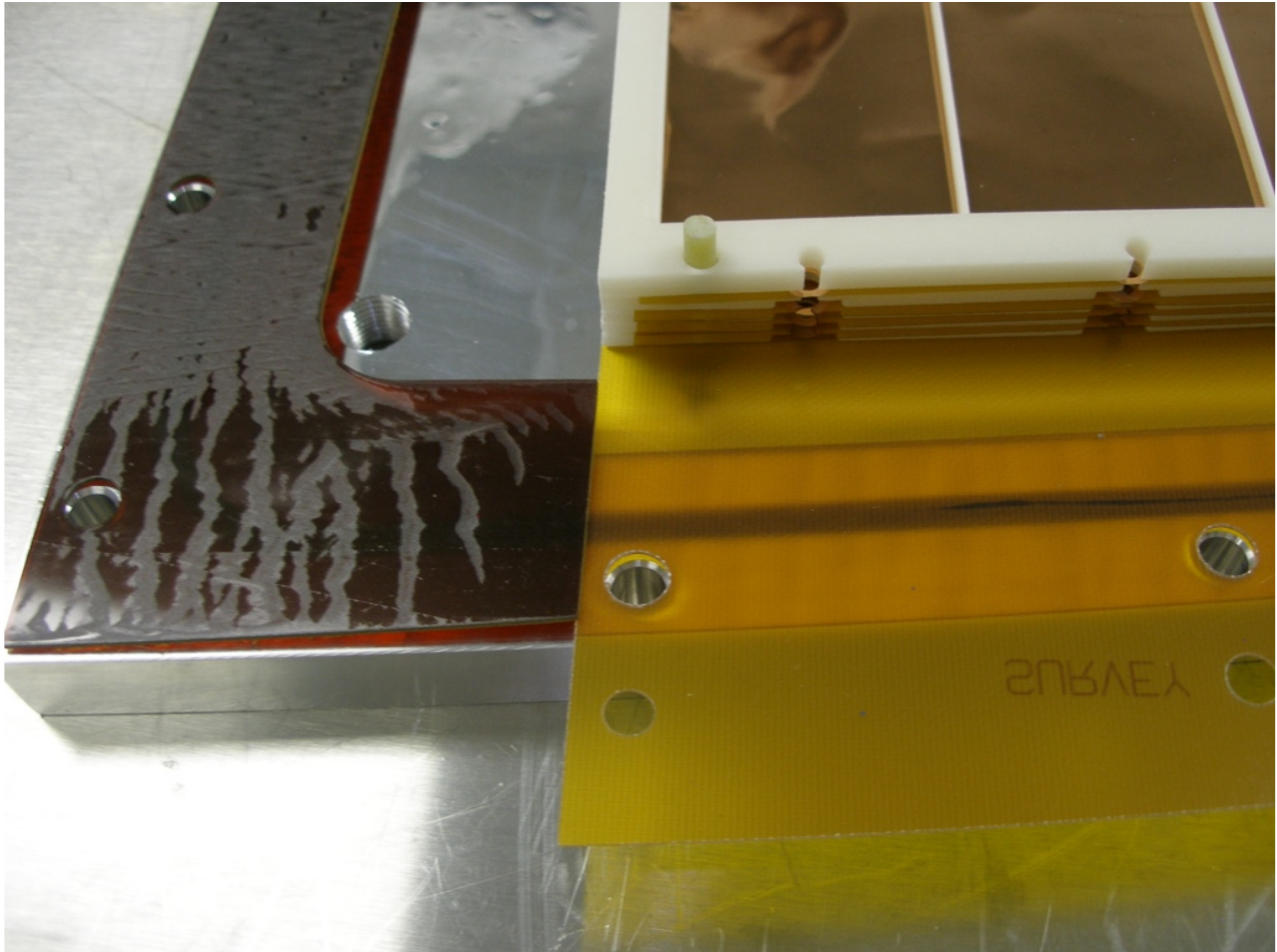
One Half Completed - R/O, 3 GEM, and HV



GEM Tracker - Fully Stacked and Cabled



Peelable Shims Match R/O for Gas Seal



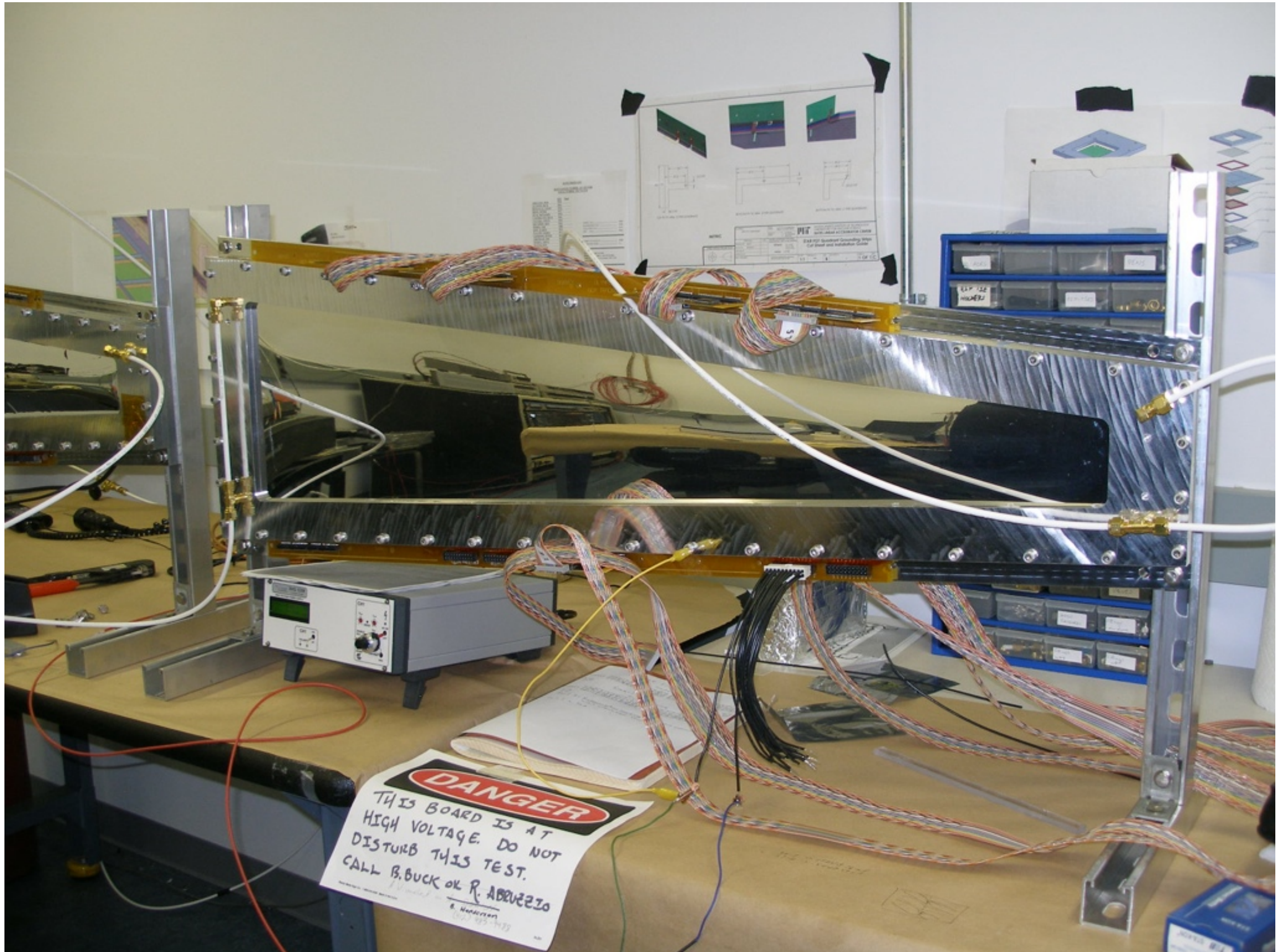
GEM Tracker - Fully Assembled



GEM Tracker - Readout and HV Electronics



2 GEM Trackers in Test Setup



GEM Tracker - Problems

Gas flow:

- GEM foils are terribly hydroscopic- cause μA leakage currents
 - need gas flowing over or through each foil
 - initial gas volume design assumed convection sufficient eventually (wasn't)
 - was able to modify gas flow which worked but only on third iteration

Handling GEM foils caused higher leakage currents

- each assembly / disassembly or exposure to atmosphere resulted in dimples or creases in GEM foil surface or added contaminants
- last assembly using all new small GEM foils held HV
- however, large GEM foils broke down at 3500 V

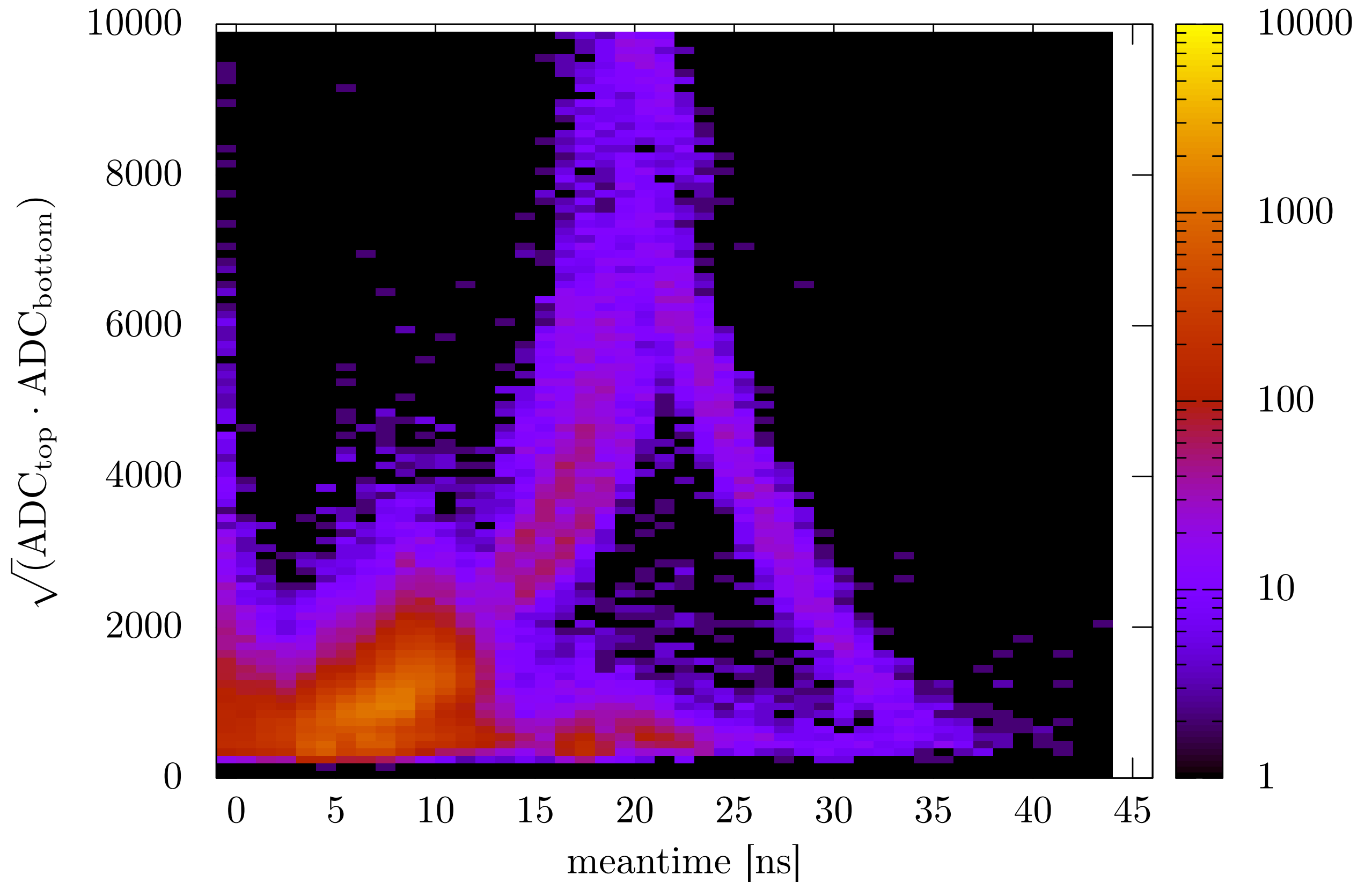
In the end ran out of time to solve for OLYMPUS installation

- could have shipped and installed in September access
 - but only half of one detector working and one month to integrate readout
 - could build second or even third detector and ship for installation in early October
 - but decided limited chance for success and other problems more pressing

Shelved GEM tracker for now

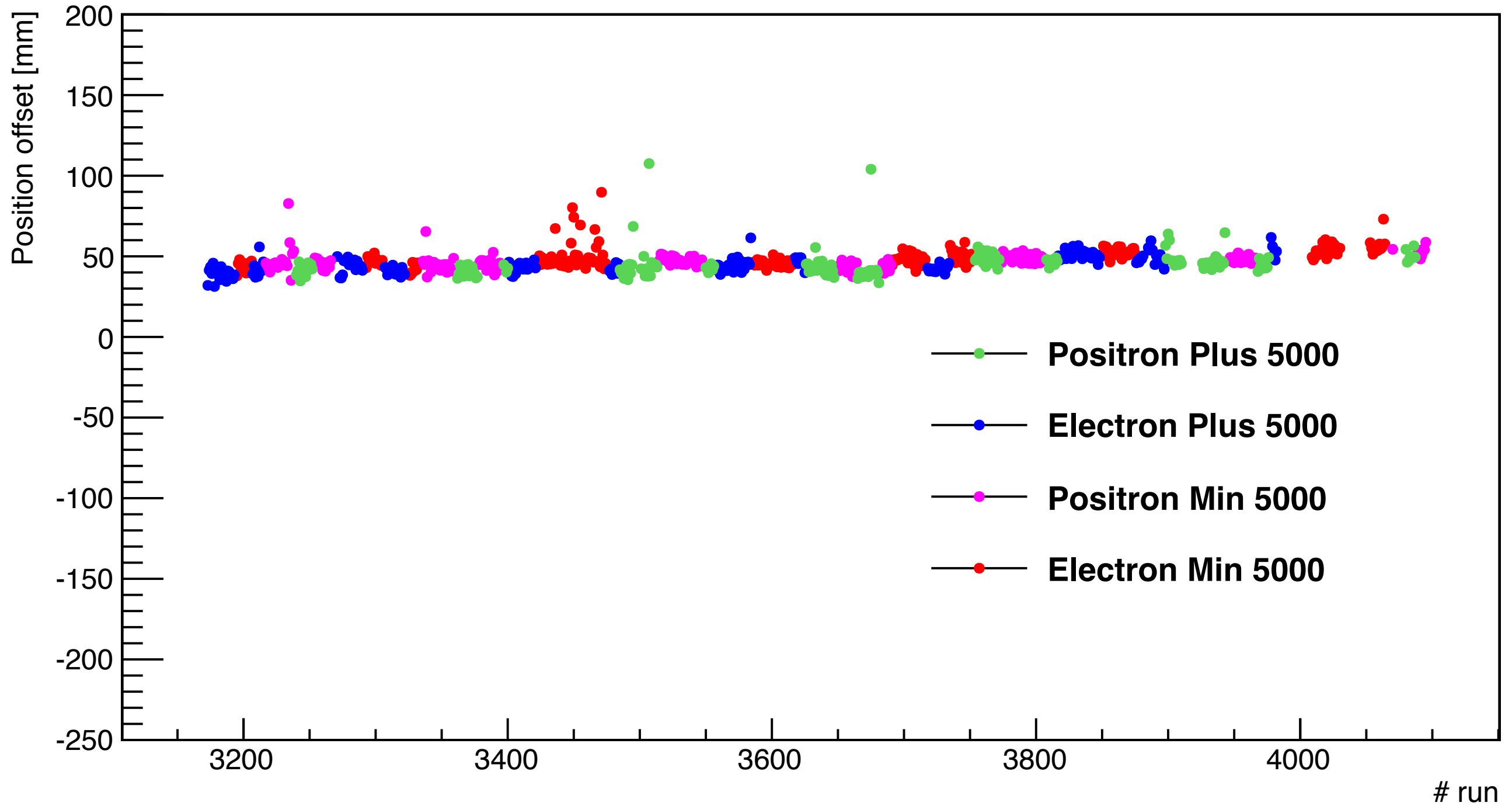
Time of Flight Scintillator Bars

ADC vs. TDC (backward bars)



TOF Calibration and Stability

tof 8

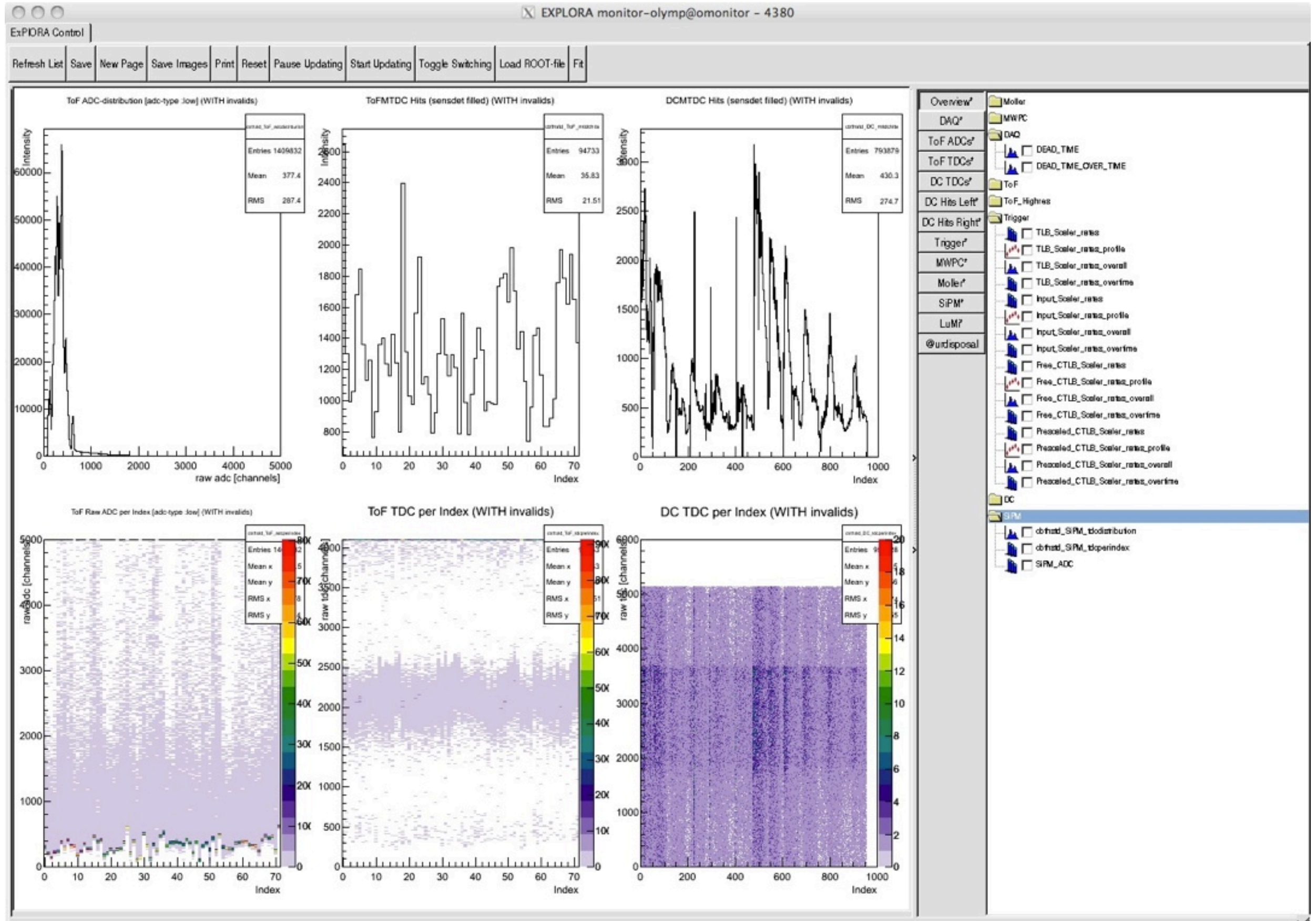


Data Acquisition System

The screenshot displays the DAQ Control software interface, which is organized into several functional panels:

- Views Panel:** Features a green status indicator, Start/Stop buttons, and checkboxes for Autopilot, dump data (/dev/null), Low Rate Warning, and Stop run on LEVB failure.
- Time Panel:** Shows Time (18:53:24), Started (18:52:33), and Runtime (00:00:51) with dropdown menus.
- Monitoring Panel:** Displays key performance indicators: Current Run # (4423), Average Readout Rate [Hz] (3047.2), Events (156845), DORIS Current [mA] (135.9), Current Readout Rate [Hz] (3141), and Data Rate [kByte/s] (3699). It also includes progress bars for Events (15%) and MBytes on Disk (8%).
- Configuration Panel:** Allows selection of Run Type (clockrun) and shows Output Filename (run 4423 clk I2.zebra) and Output Path (/data/tests/).
- Log Panel:** A central text area showing system messages such as "[18:52:28]:Preparing to start Run in Testmode (no run #) - Runtype clockrun - Triggerfile evb.xml." and "[18:52:33]:Succeeded to start run."
- Troubleshoot Panel:** Lists components like (1) Trigger, Saver, Explorad, (2) Blast1, (3) Blast2, (4) MWPC, (5) Moller, (6) Lumi, and DAQd.
- Comments Panel:** Includes a category dropdown, a text input field, a Runnumber dropdown (set to current), and buttons for Clear Comment, Commit, Add file..., and Delete Selected.

Online Data Monitoring



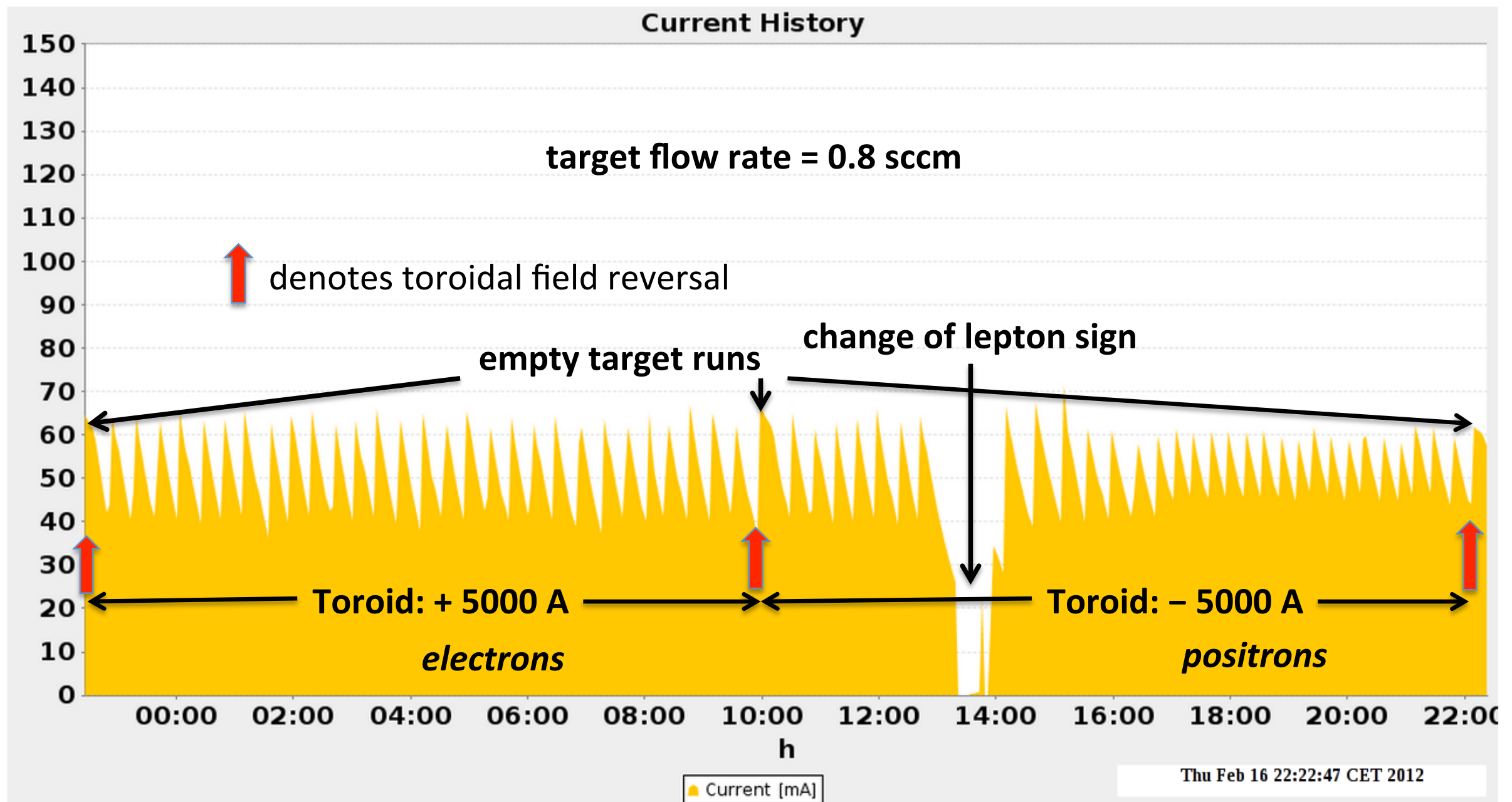
Data Acquisition and Slow Control

DAQ active 80 % of the time

- ~20 minute runs
- ~2 minutes between runs
- ~25 % deadtime in February

Shifts extremely smooth

- 2 people on shift
- 1 running the experiment
- 1 monitoring data



Slow Control System

SC:HV Overview +

Target HV Detectors Toroid Doris Alarms Processes Tools (bernauer) Log out

Overview WC ToF C5 LGEM SM MWPC Leadglass SiPM

Last update: Wed Sep 19 2012 16:14:58 GMT-0400 (EDT)

ALARM present. Click here to check alarm overview page.
Channel invalid: 164 Total: 164 Alarms present.

HV On/Off and loaded page

Crate	Status	Last page loaded
Left TOF+WC:	Off On Off Standby	Standby
Right TOF+WC,C5,LC:	Off On Off Standby	Standby
Lumi GEM:	Off On Off Standby	Standby
Symmetric Moeller:	Off On Off Standby	Standby
MWPC:	Off On Off Standby	Standby
SiPM Ch1:	Off On Off	
SiPM Ch2:	Off On Off	
SiPM Ch3:	Off On Off	
SiPM Ch4:	Off On Off	

HV Channel Enable / Untrip

ALL: Untrip / Copy Mask to Hardware

Left TOF+WC: Untrip / Copy Mask to Hardware

Right TOF+WC, C5, LC: Untrip / Copy Mask to Hardware

Lumi GEM: Untrip / Copy Mask to Hardware

Symmetric Moeller: Untrip / Copy Mask to Hardware

MWPC: Untrip / Copy Mask to Hardware

HV Load Page

All: Nominal Standby Only ToF All zero Misc 1 Misc 2

Left ToF+WC: Nominal Standby Only ToF All zero Misc 1 Misc 2

Right ToF+WC, C5, LC: Nominal Standby Only ToF All zero Misc 1 Misc 2

Lumi GEM: Nominal Standby Only ToF All zero Misc 1 Misc 2

Symmetric Moeller: Nominal Standby Only ToF All zero Misc 1 Misc 2

MWPC: Nominal Standby Only ToF All zero Misc 1 Misc 2

SiPM: Nominal Off

HV Save Page

All: Nominal Standby Only ToF All zero Misc 1 Misc 2

Left ToF + WC: Nominal Standby Only ToF All zero Misc 1 Misc 2

Right ToF + WC, C5, LC: Nominal Standby Only ToF All zero Misc 1 Misc 2

Lumi GEM: Nominal Standby Only ToF All zero Misc 1 Misc 2

Symmetric Moeller: Nominal Standby Only ToF All zero Misc 1 Misc 2

MWPC: Nominal Standby Only ToF All zero Misc 1 Misc 2

HV File I/O

Save HV settings to file

Upload Browse...

LeCroy Troubleshoot

Clear log Reconnect Left Reconnect Right

ToF Status

Type/Channel	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18
Left top	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Left bottom	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Right top	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Right bottom	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

C5 Status

Type/Channel	1	2	3	4
C5	■	■	■	■

Leadglass counter Status

Type/Channel	1	2	3
Leadglass	■	■	■

Lumi GEM Status

Type/Channel	Up	Mi	Ds
Left	■	■	■
Right	■	■	■

Symmetric Moeller Status

Type/Channel	1	2	3	4	5	6	7	8	9
Left	■	■	■	■	■	■	■	■	■
Right	■	■	■	■	■	■	■	■	■

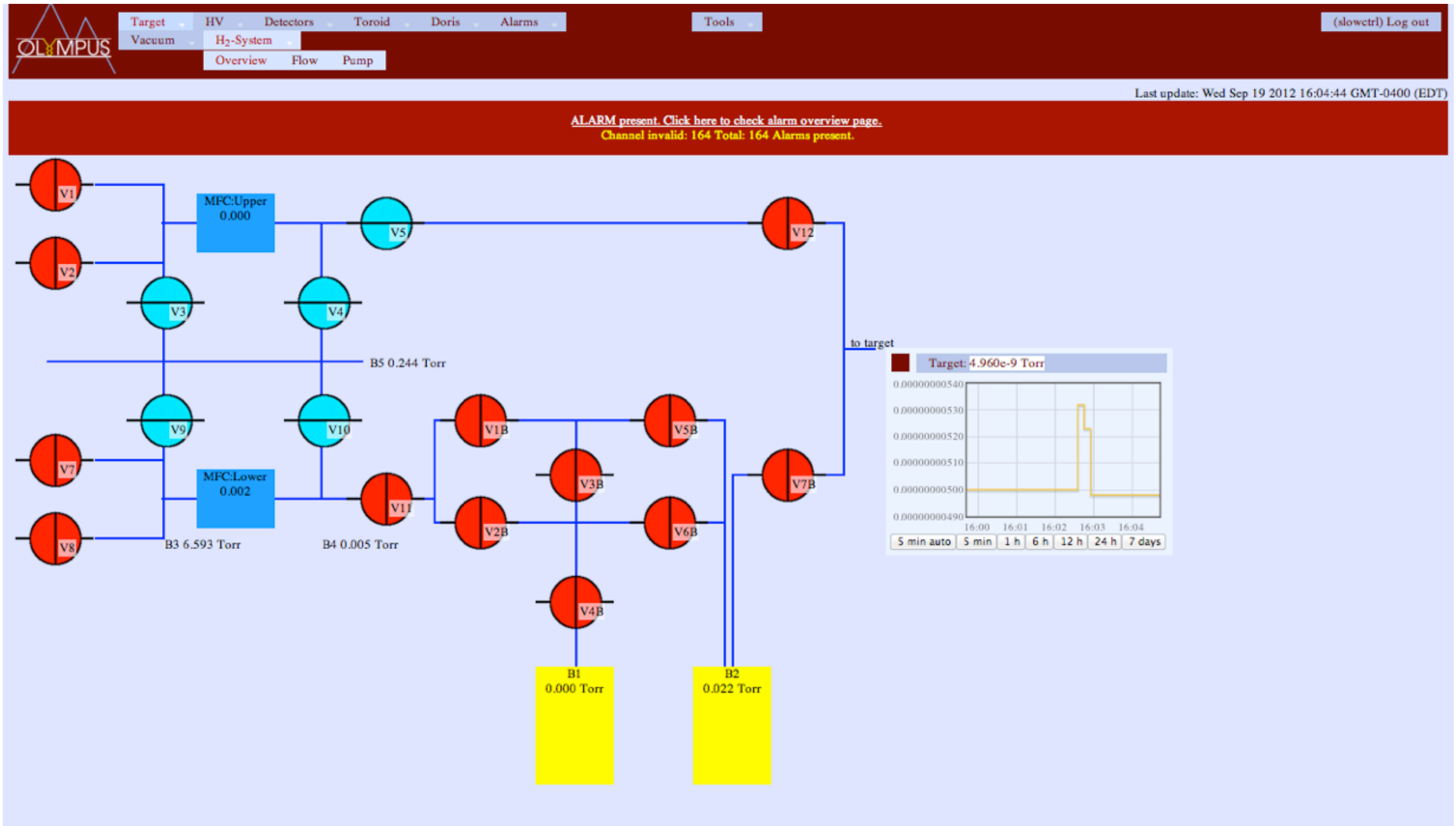
MWPC Status

Type/Channel	L1	L2	L3	R1	R2	R3
u	■	■	■	■	■	■
s	■	■	■	■	■	■
v	■	■	■	■	■	■

WC Status

Type/Channel	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	
Left sense	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Left guard	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Left field	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Right sense	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Right guard	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Right field	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

Slow Control Monitoring



Conclusions and Summary

Target and vacuum system performing as required

Luminosity may be less than planned

Detector system basically working

- reconstruction still needs work
- missing tracks have to be found
- reduce showering background and improve efficiency

GEM tracker shelved for now

Data acquisition and slow control systems all working

- operation of the experiment very smooth and easy

Ready for data run 22 October - 22 December, 2012