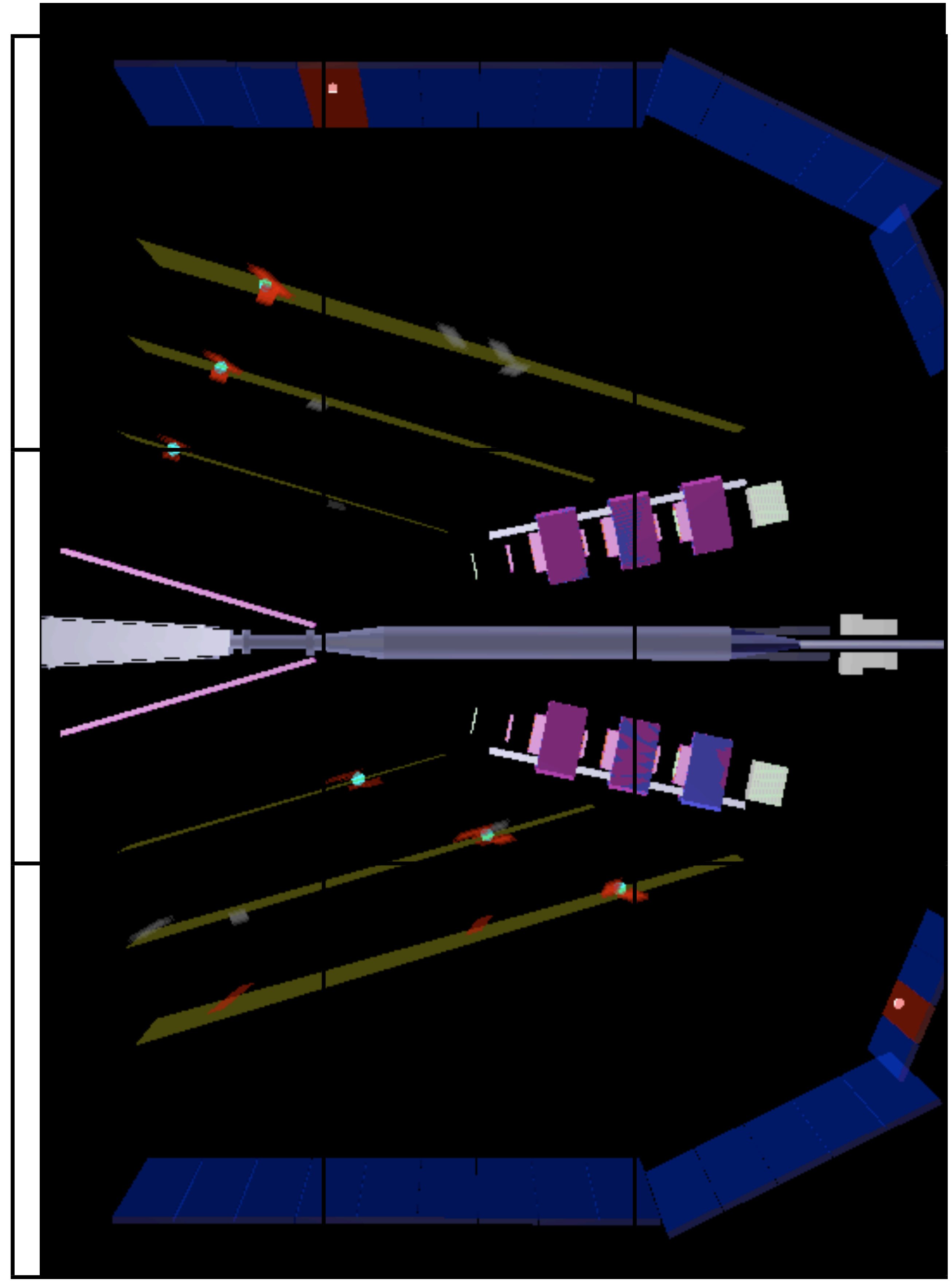
OLYMPUS Experiment

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

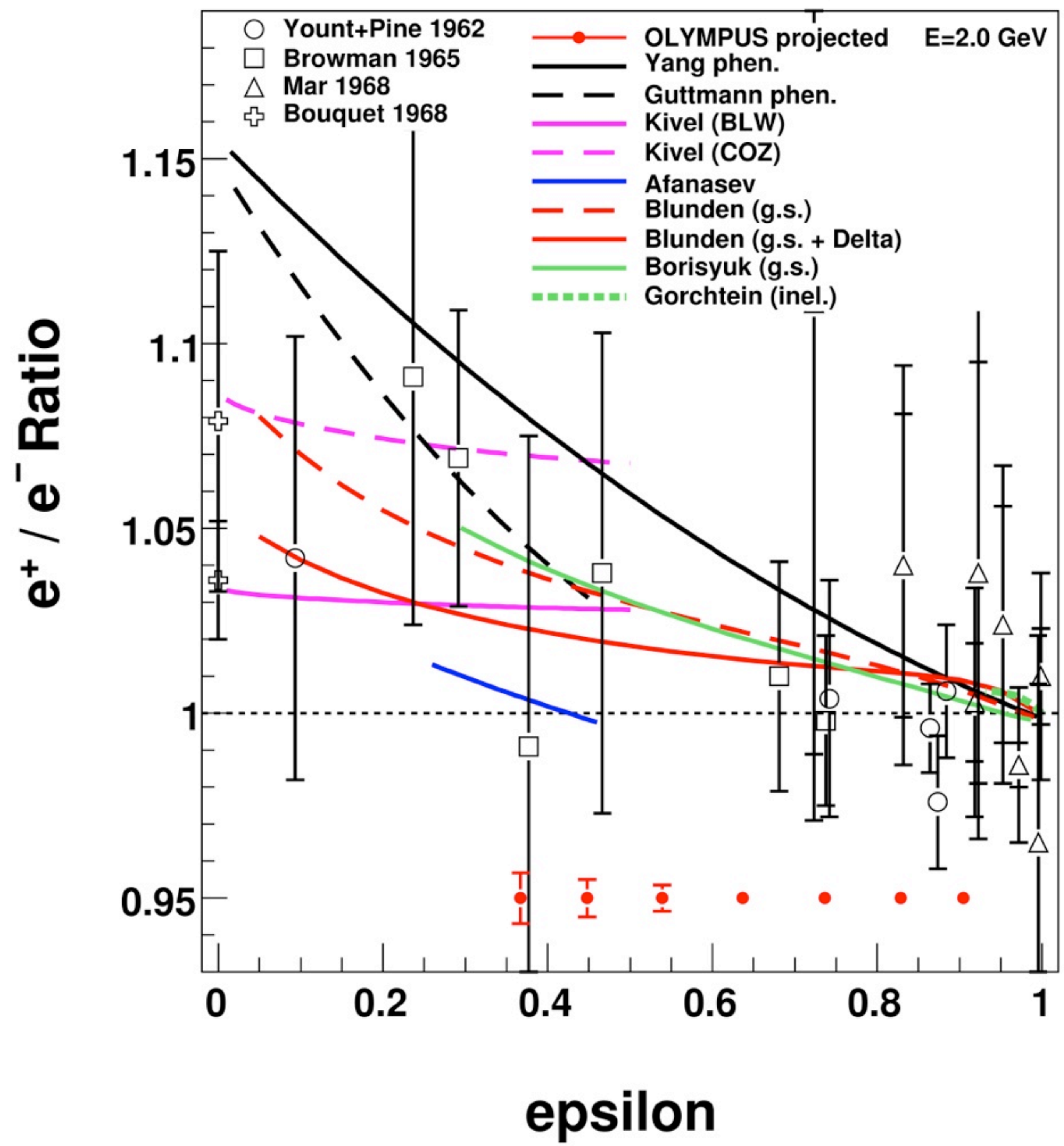


OLYMPUS Experiment

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

February, 2012 run
- ~50 mA
  - limited by deadtime in DAQ
- ~5×10^{14} atoms/cm^2
  - limited by beam lifetime ~1 hr
- 80% running efficiency

October-December, 2012
- ~100 mA
  - 2nd level trigger reduces deadtime
- ~5×10^{14} atoms/cm^2
  - still limited by beam lifetime
- ~4 less statistics than planned



OLYMPUS Experiment

Latest analysis suggests

- February luminosity factor 4
- not 8 !

February, 2012 run

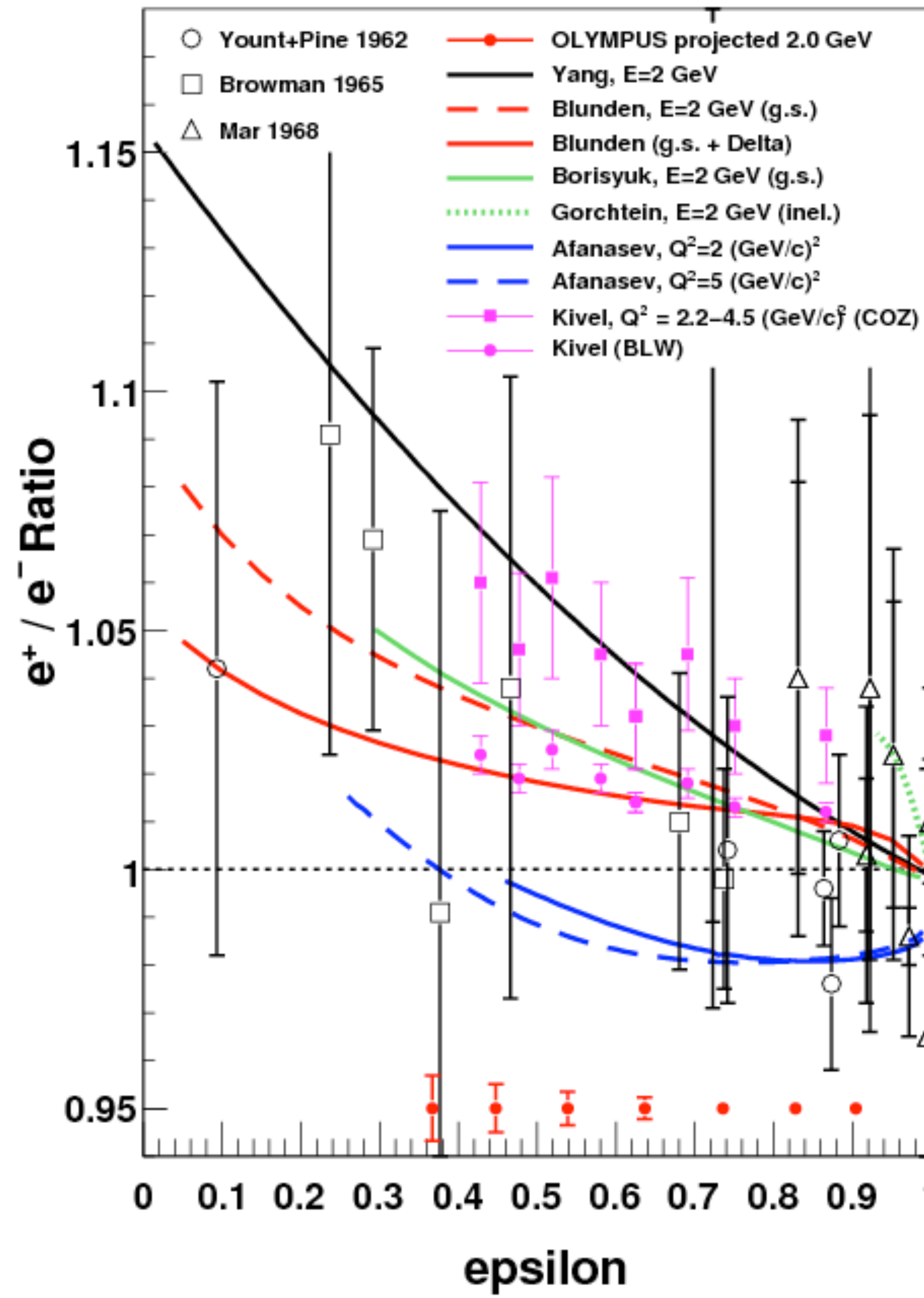
- ~50 mA
  - limited by deadtime in DAQ
- ~1×10^{15} atoms/cm^2
  - limited by beam lifetime ~1 hr
- 80% running efficiency

October-December, 2012

- ~100 mA
  - 2nd level trigger reduces deadtime
- ~1×10^{15} atoms/cm^2
  - 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

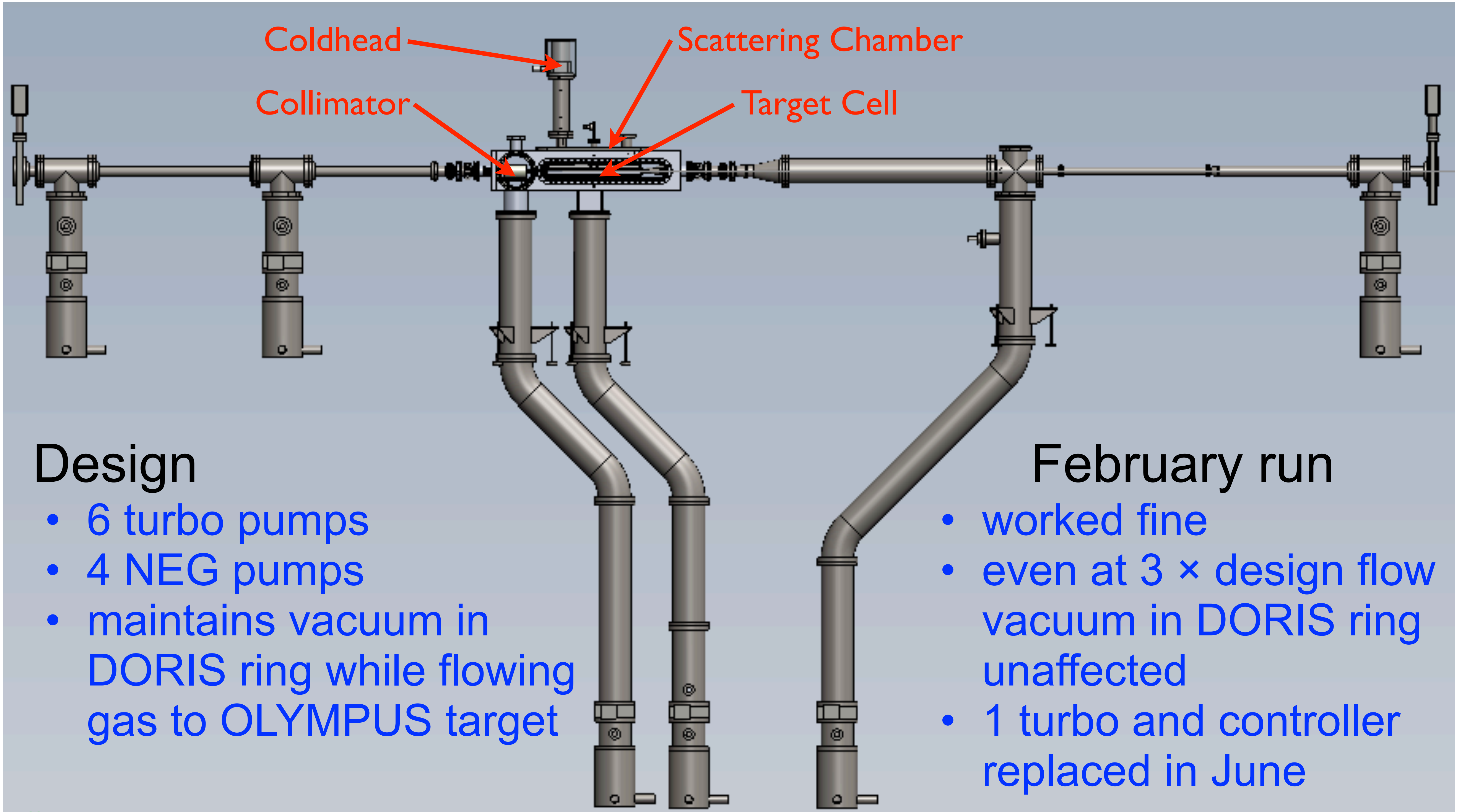
Time of Flight Detectors

- 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



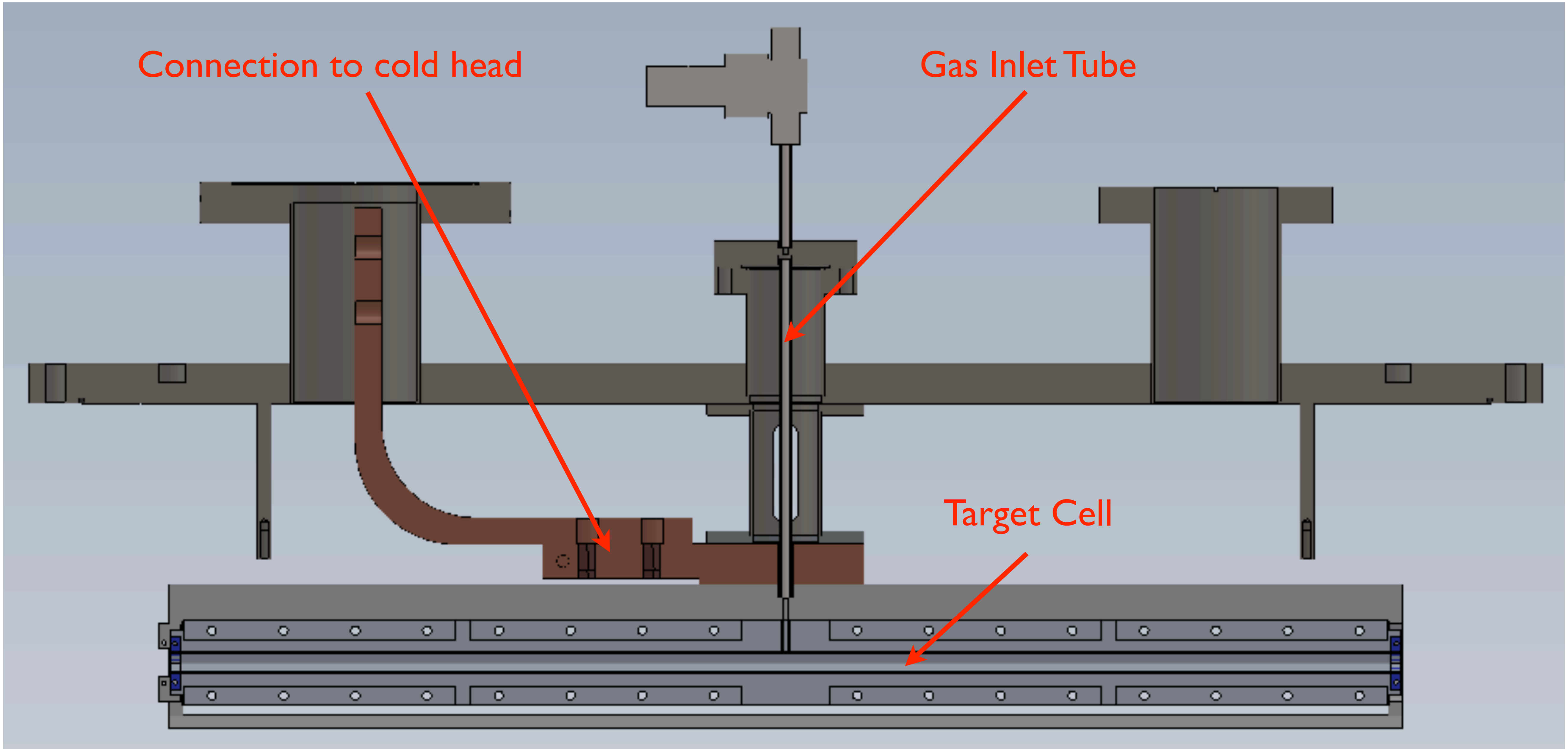
Design

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

February run

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

OLYMPUS Target System

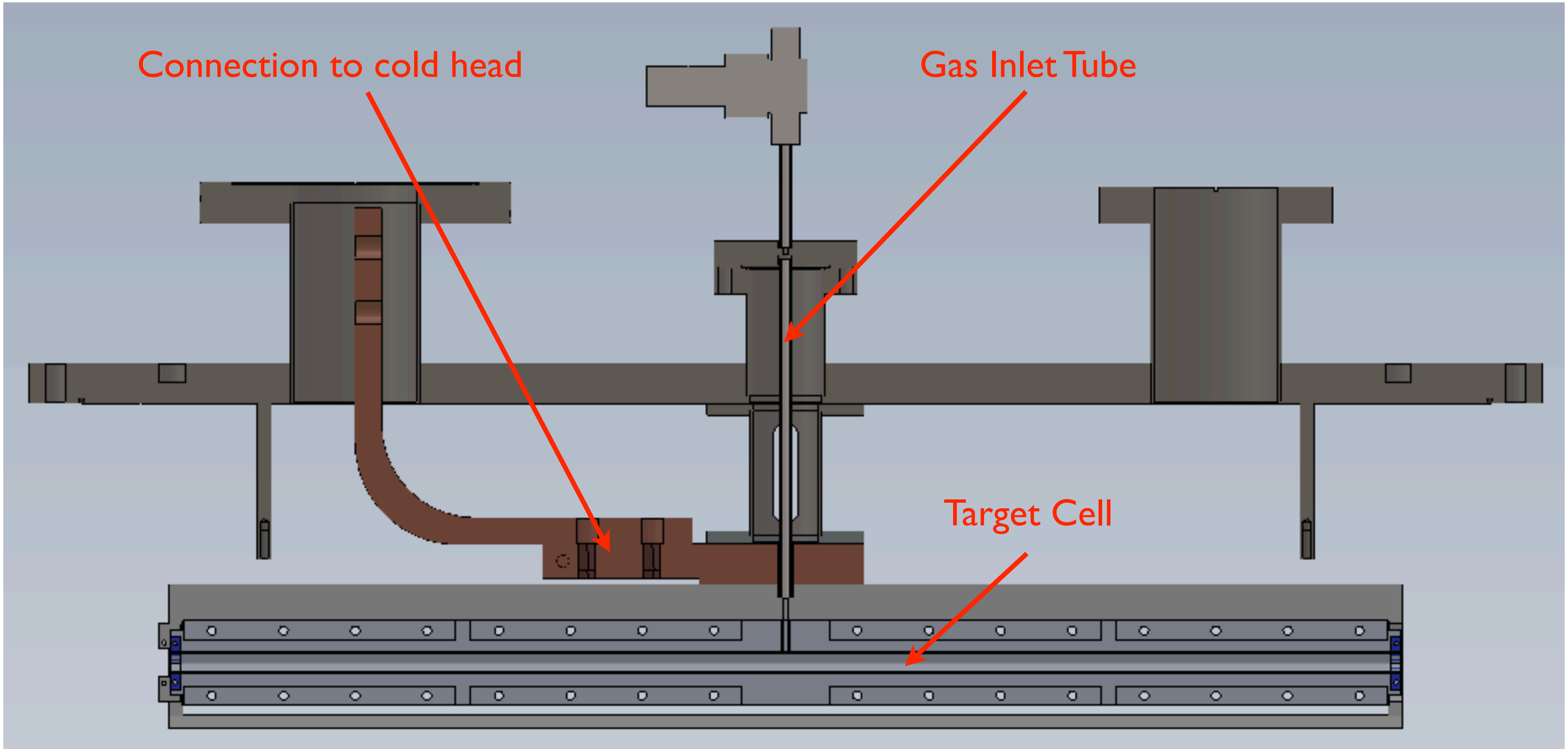


February run

- 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 × lower than expected

OLYMPUS Target System



February run

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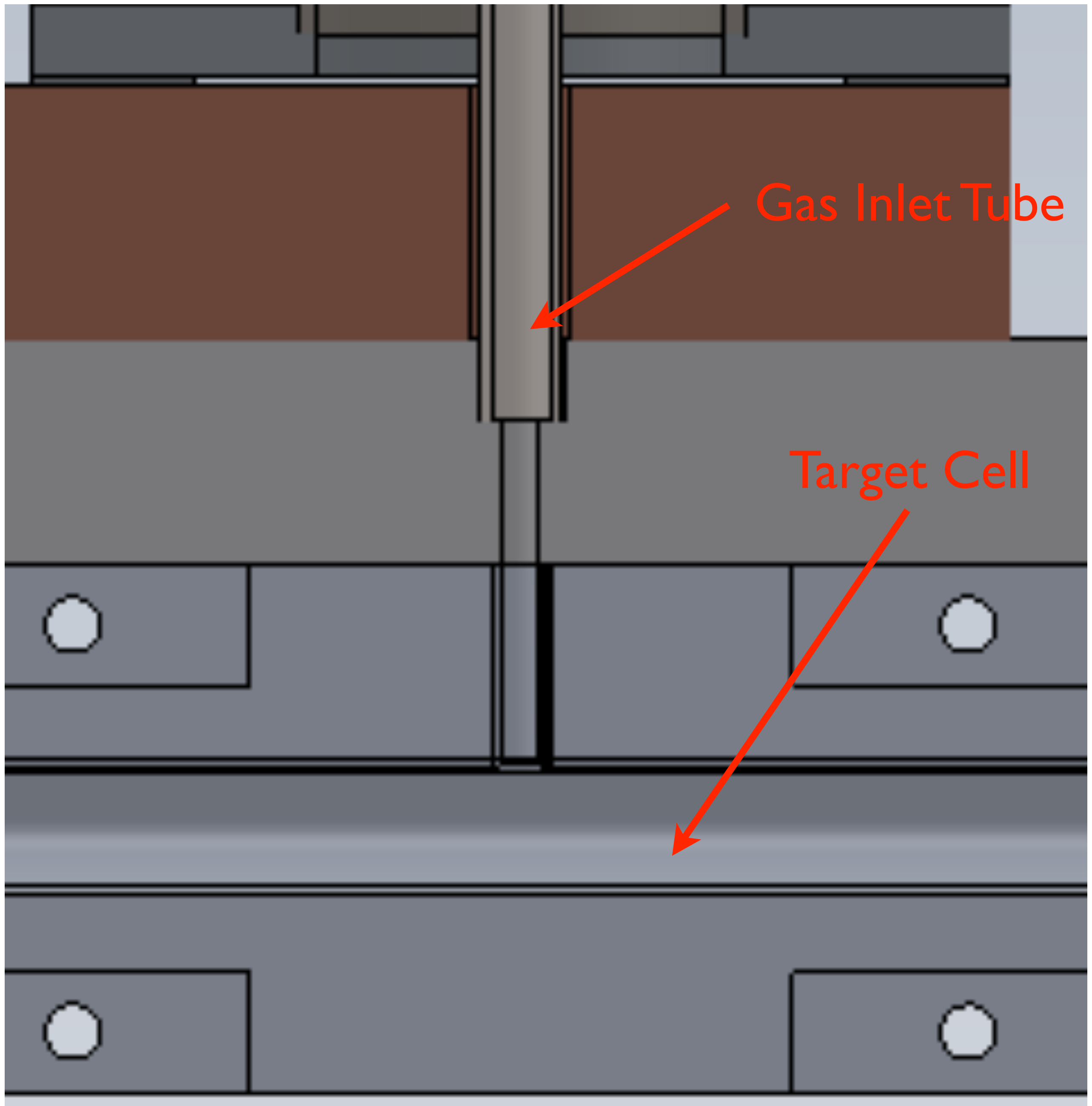
Luminosity 4 - 8 × lower

OLYMPUS Target System



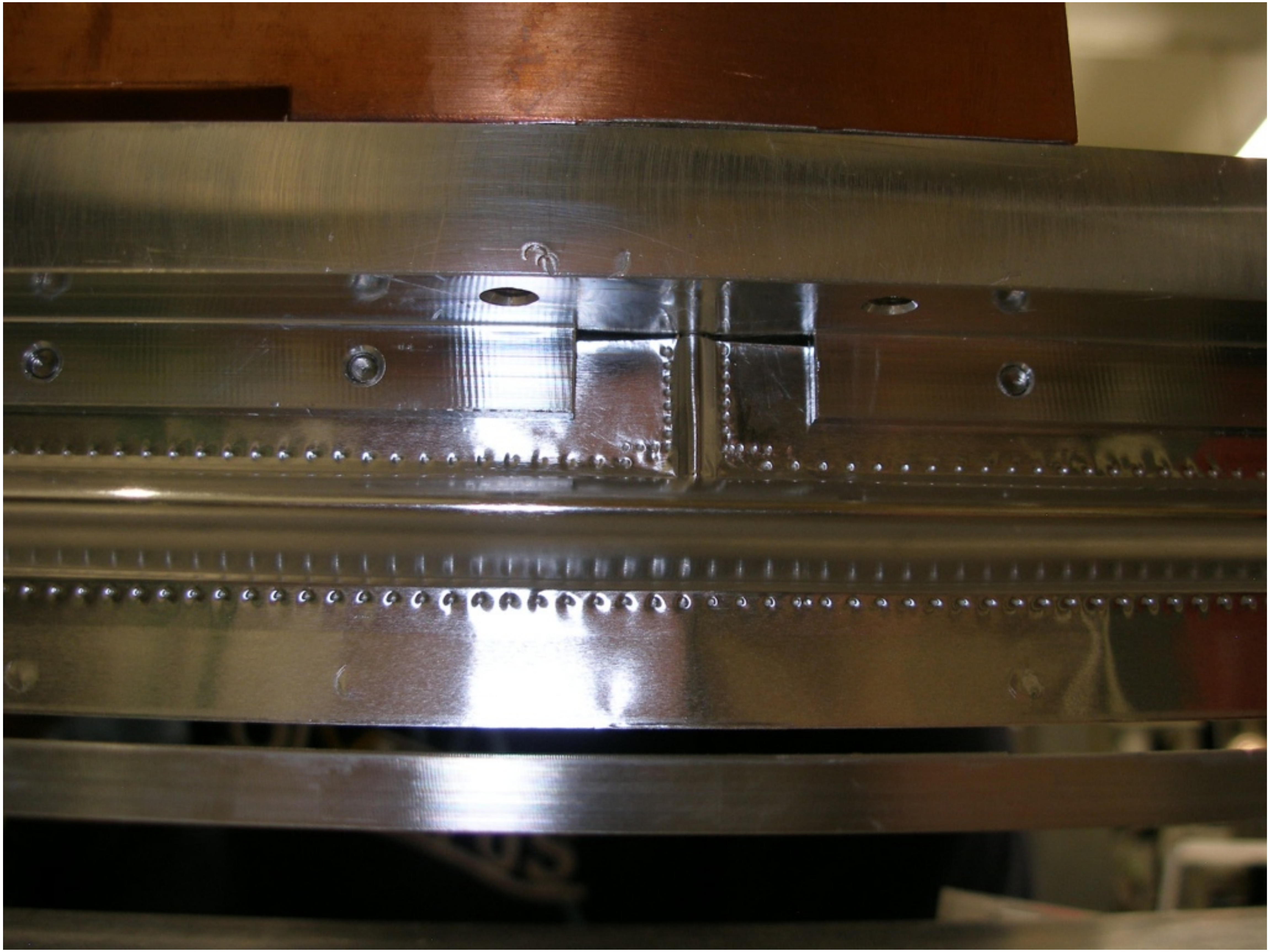
Lot of time spent studying the luminosity from:

- 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

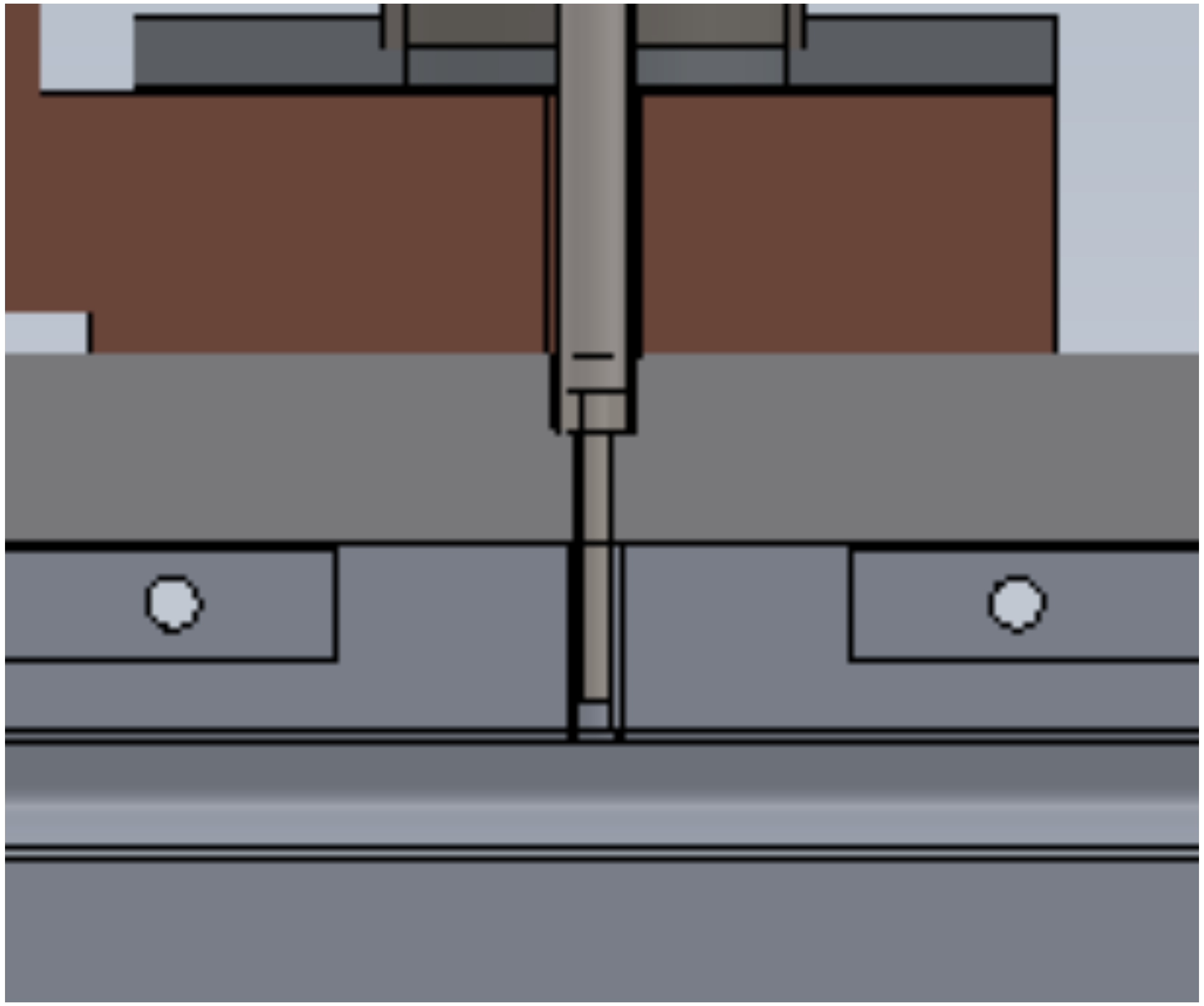
- bayonet fits into target cell inlet
- added some gas seals

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⇒~1 h lifetime
- July 0.1 sccm⇒~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

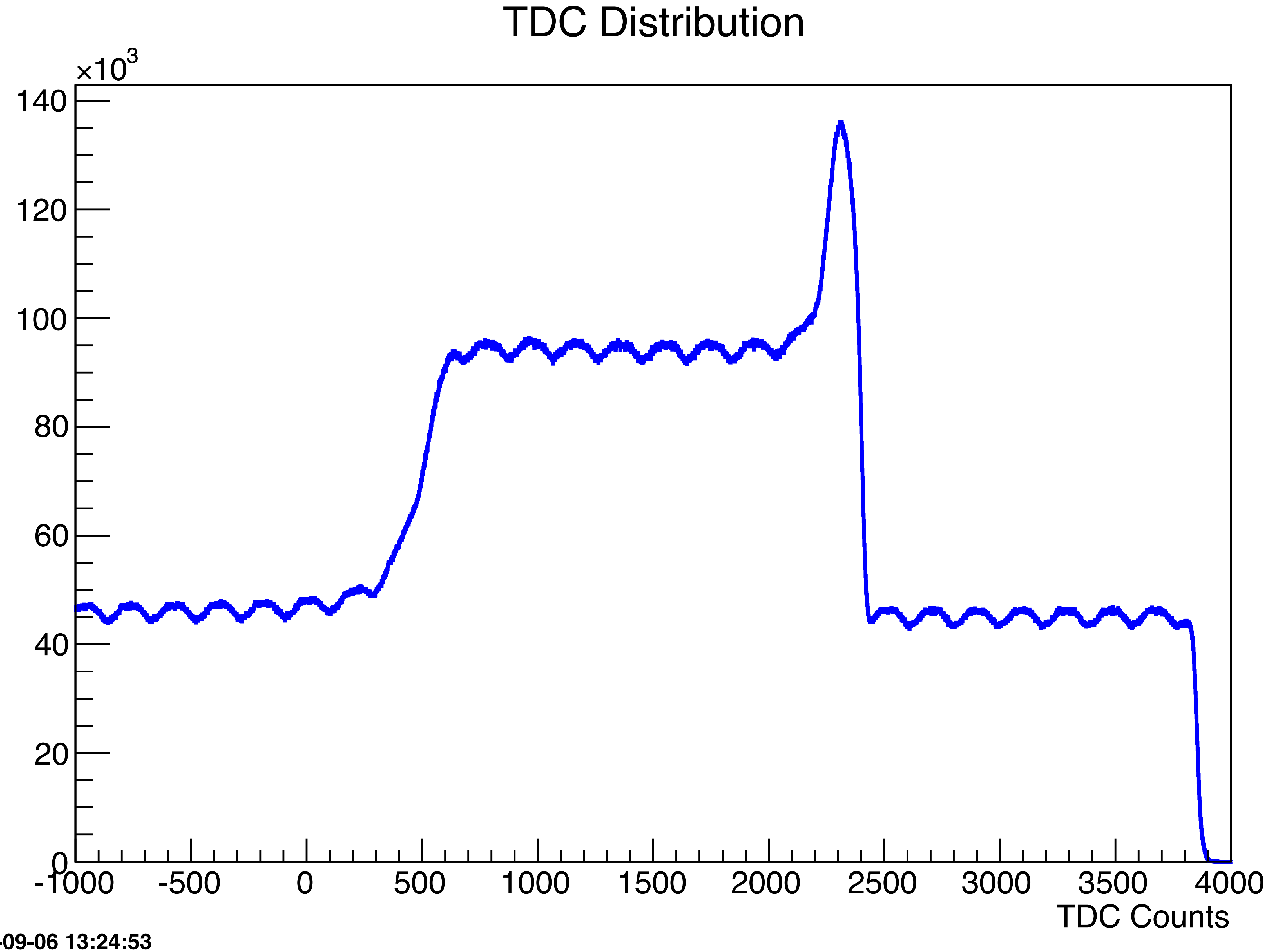
Reconstruction not simple

- 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

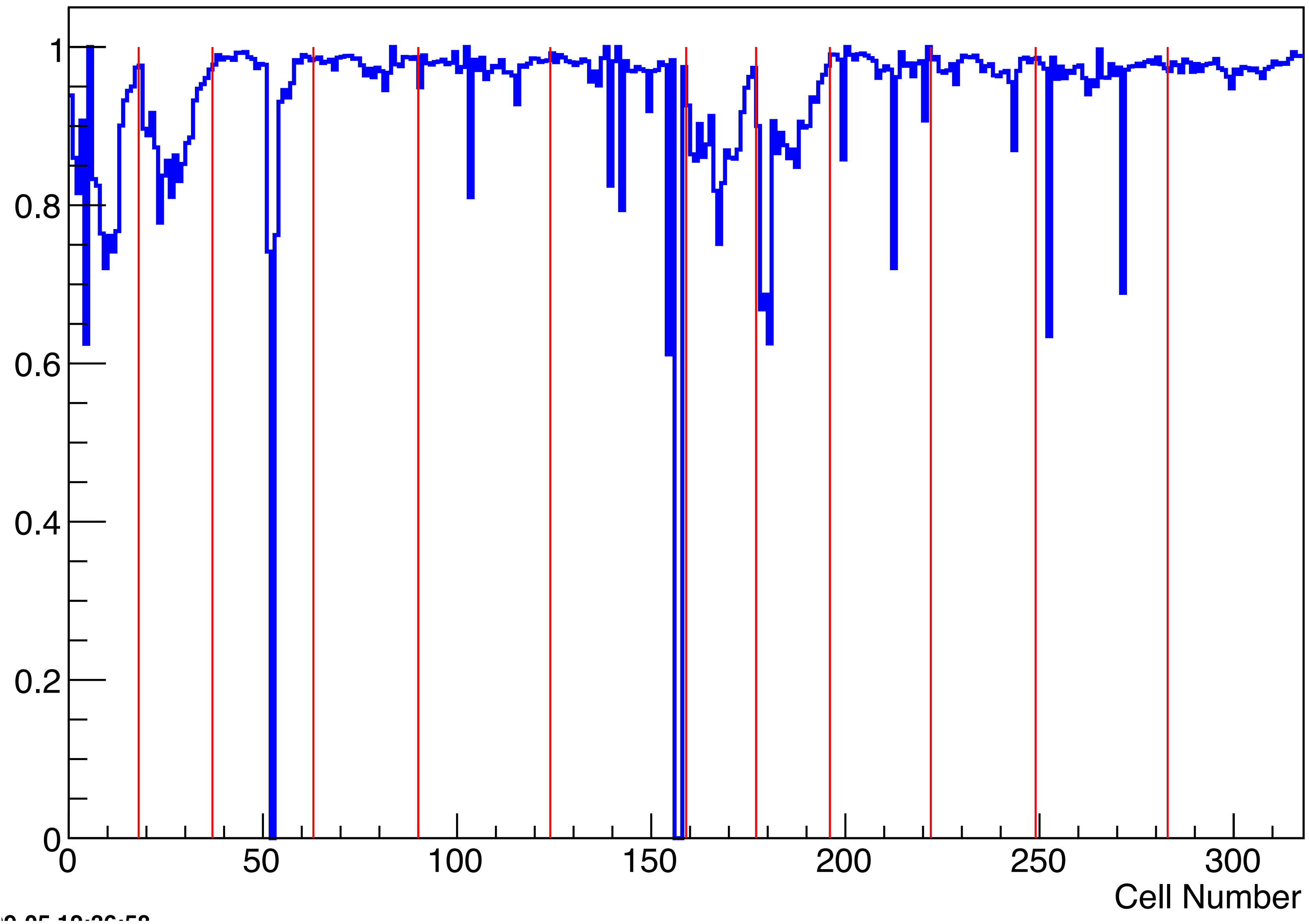
WC TDC Distribution



Wire Chamber Cell "Efficiency"

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

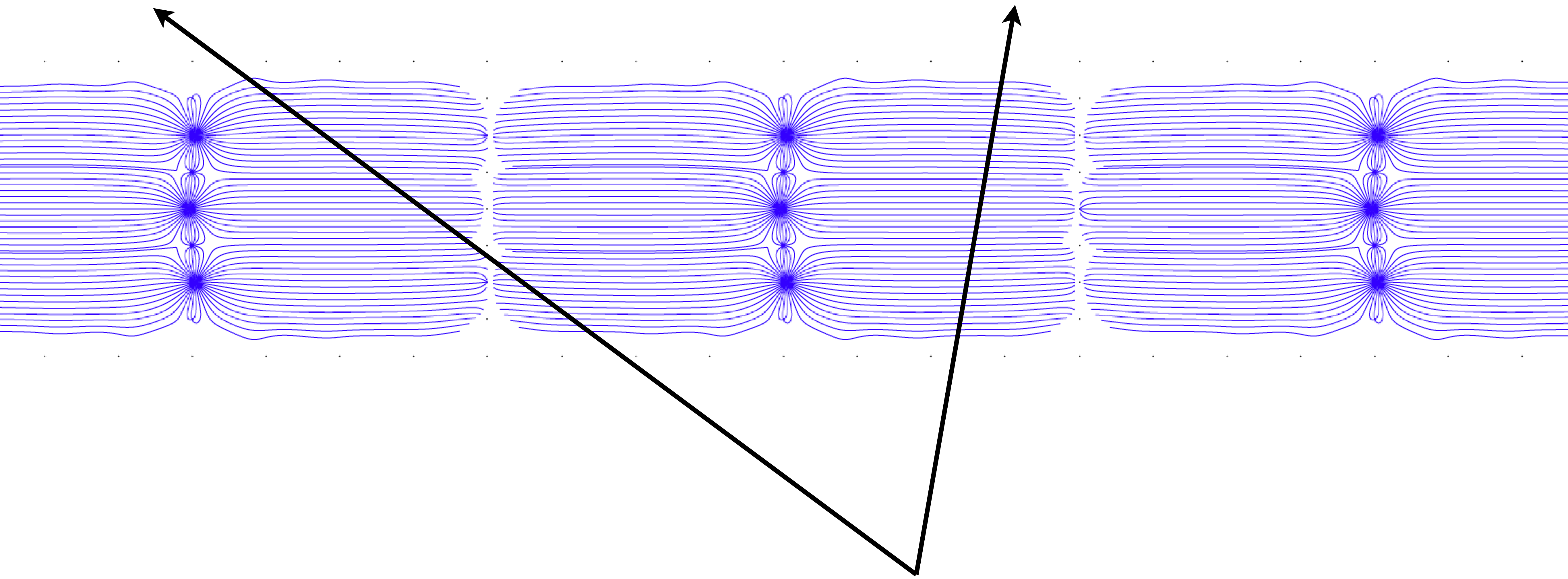
- look for hit on wire 2 in the proper TDC range
  - red lines correspond to super-layers
  - inner chambers in left and right sectors noisy because of Møller / Bhabha events
  - ~98% for middle and outer chambers
  - better measure of WC efficiency would use tracks



Lines of Electron Drift at B = 0 G

Single super-layer of drift cells in OLYMPUS wire chamber

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

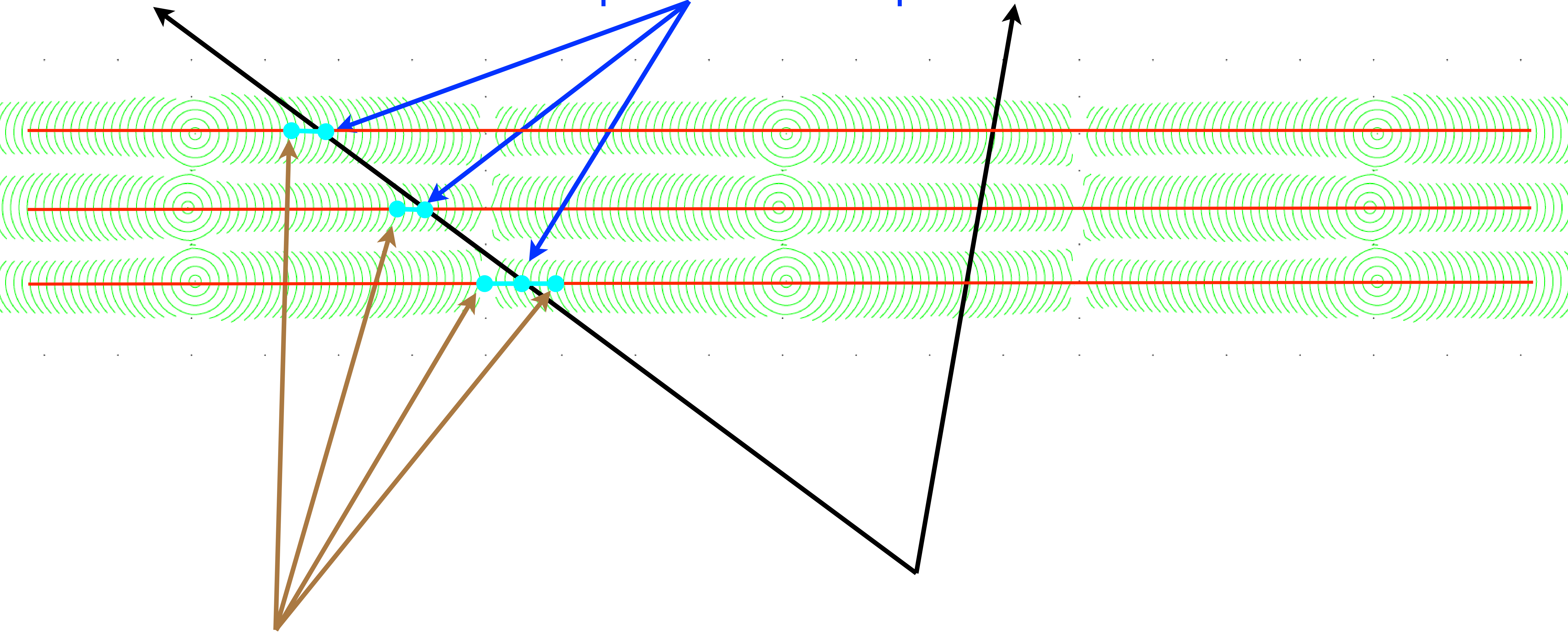


- wire chambers subtend 20° - 80° in polar angle
- chamber inclined by 16.5° ⇒ tracks vary -6.5° ⇔ 53.5° to normal

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

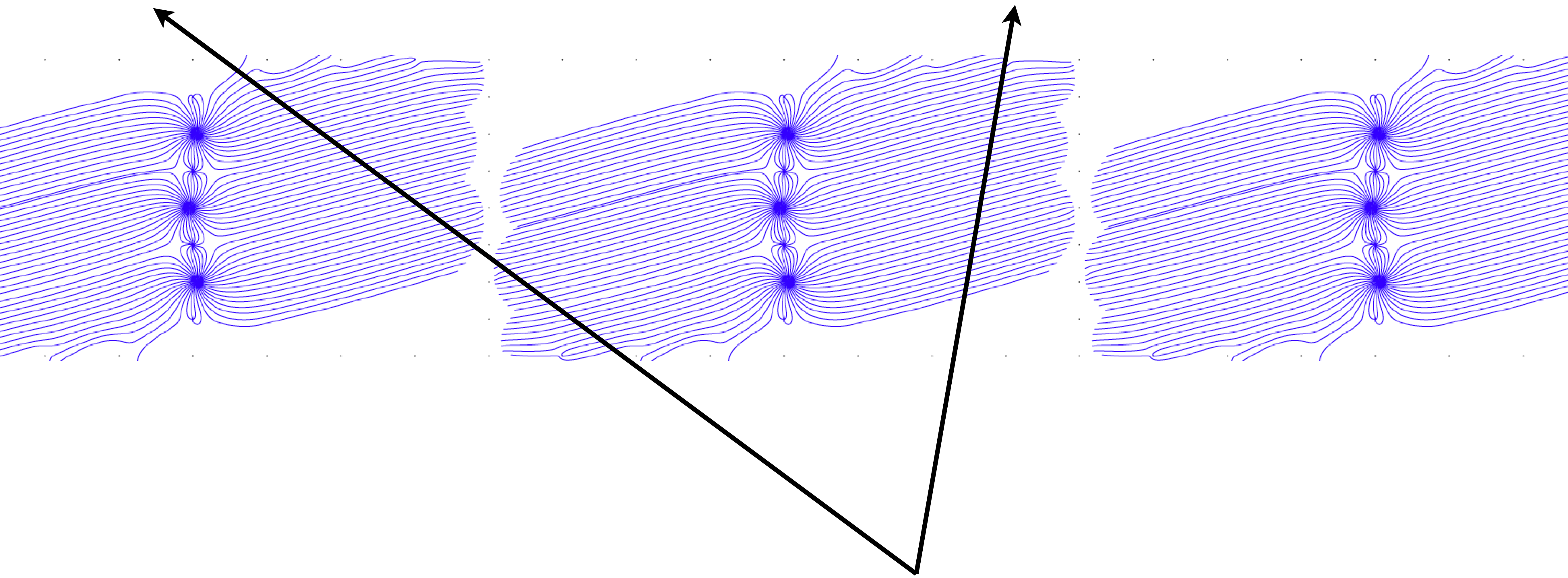


- but apparent position differs with increasing angle
  - larger angles relative to normal have larger correction

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

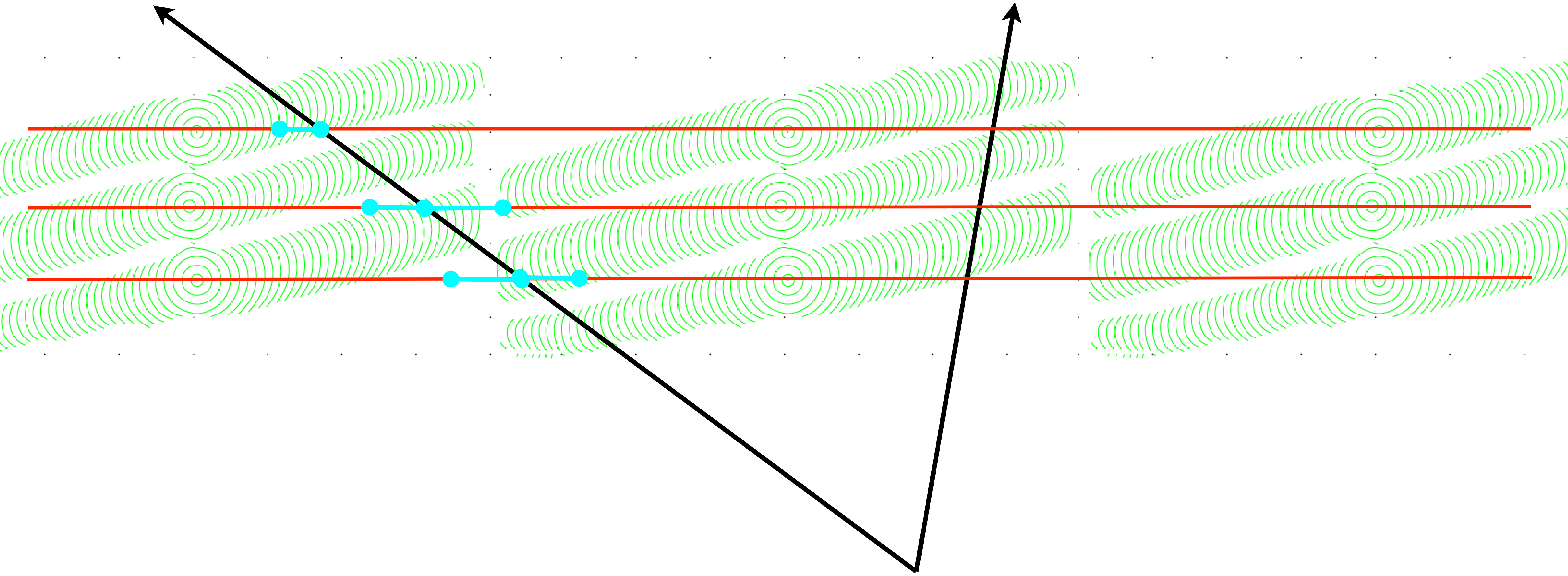


- 3000 G is the maximum field we have at OLYMPUS

Lines of Equal Drift Time at B = 3000 G

BLAST had a fixed magnet polarity

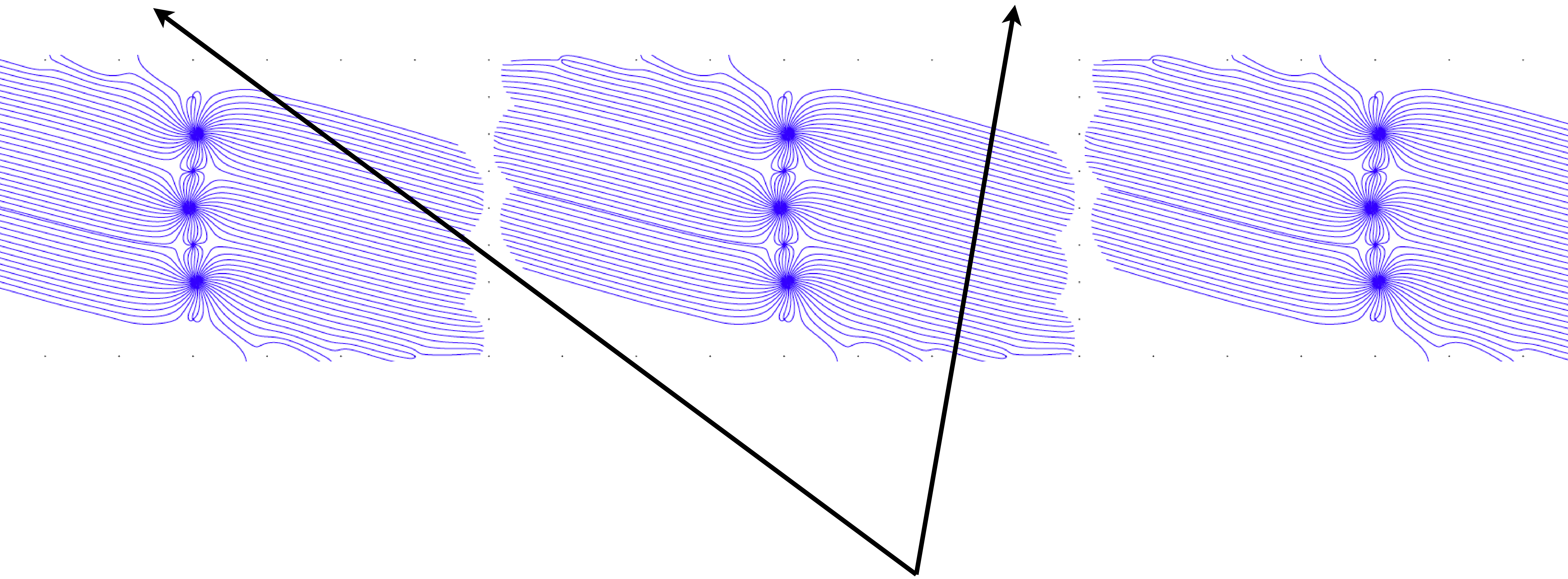
- lines of electron drift angled because of Lorentz force
- reduced the effect for tracks at large relative angles



Lines of Electron Drift at B = -3000 G

But OLYMPUS runs with both magnet polarities

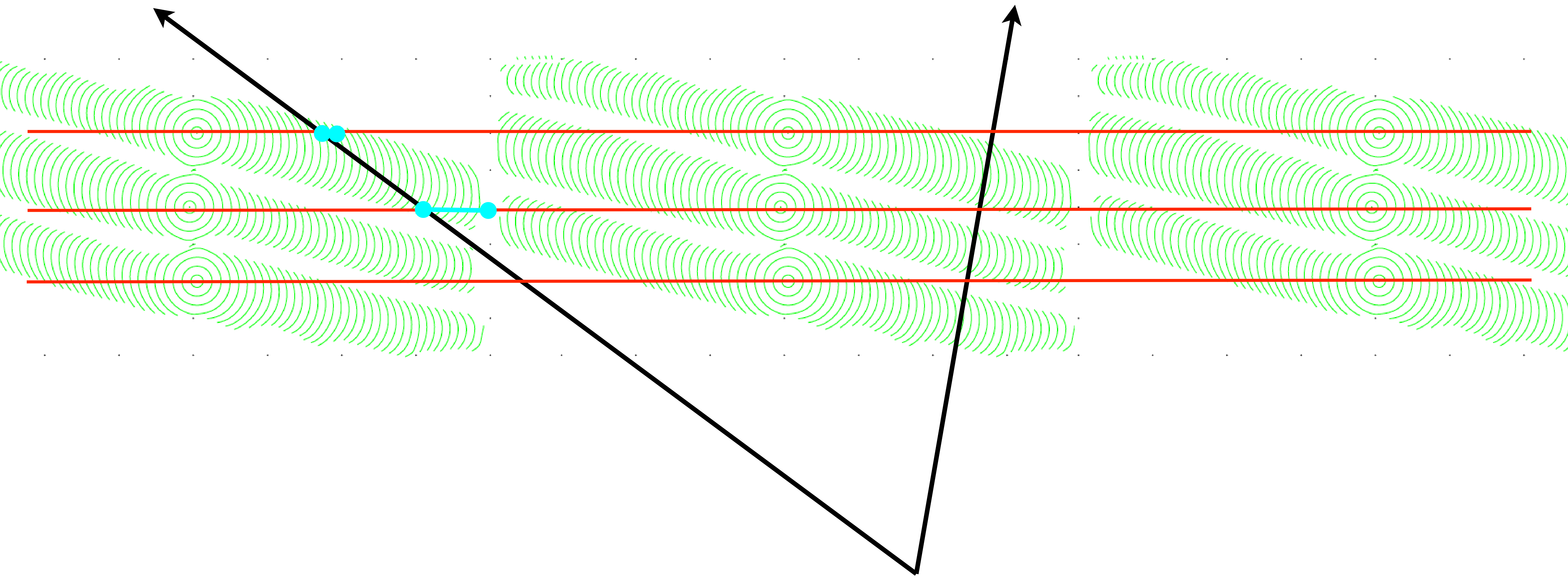
- reconstruction a bit more complicated
- deviation of apparent position from reconstructed position larger



Lines of Equal Drift Time at B = -3000 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

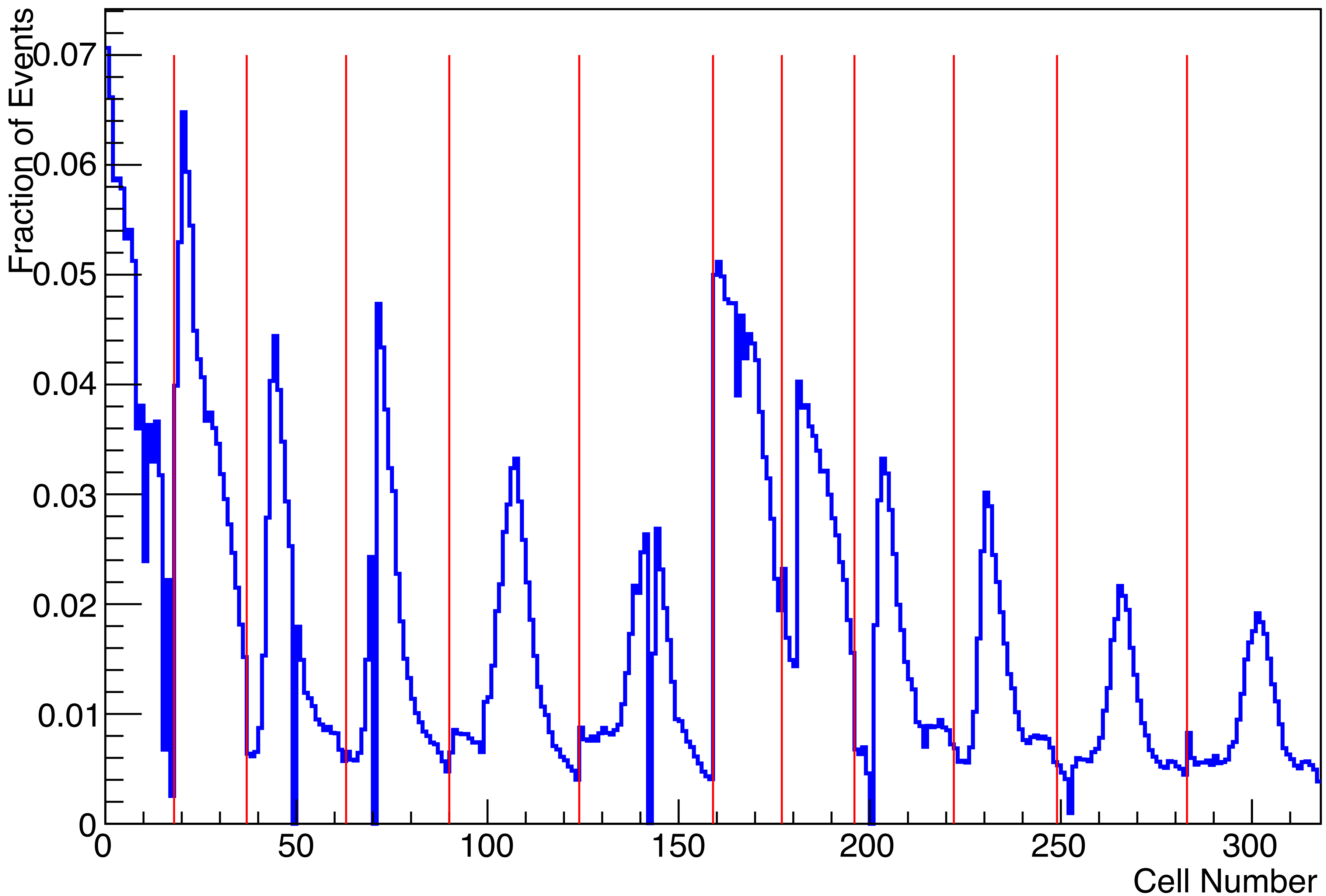


- has taken more time to solve than wished
  - need to know track angle to determine position, an iterative procedure
  - need to handle less than 3 hits in a super-layer for a track
  - need accurate time to position relationships as a function of angle, field, and wire

Missing Tracks

No electrons seen at forward angles.

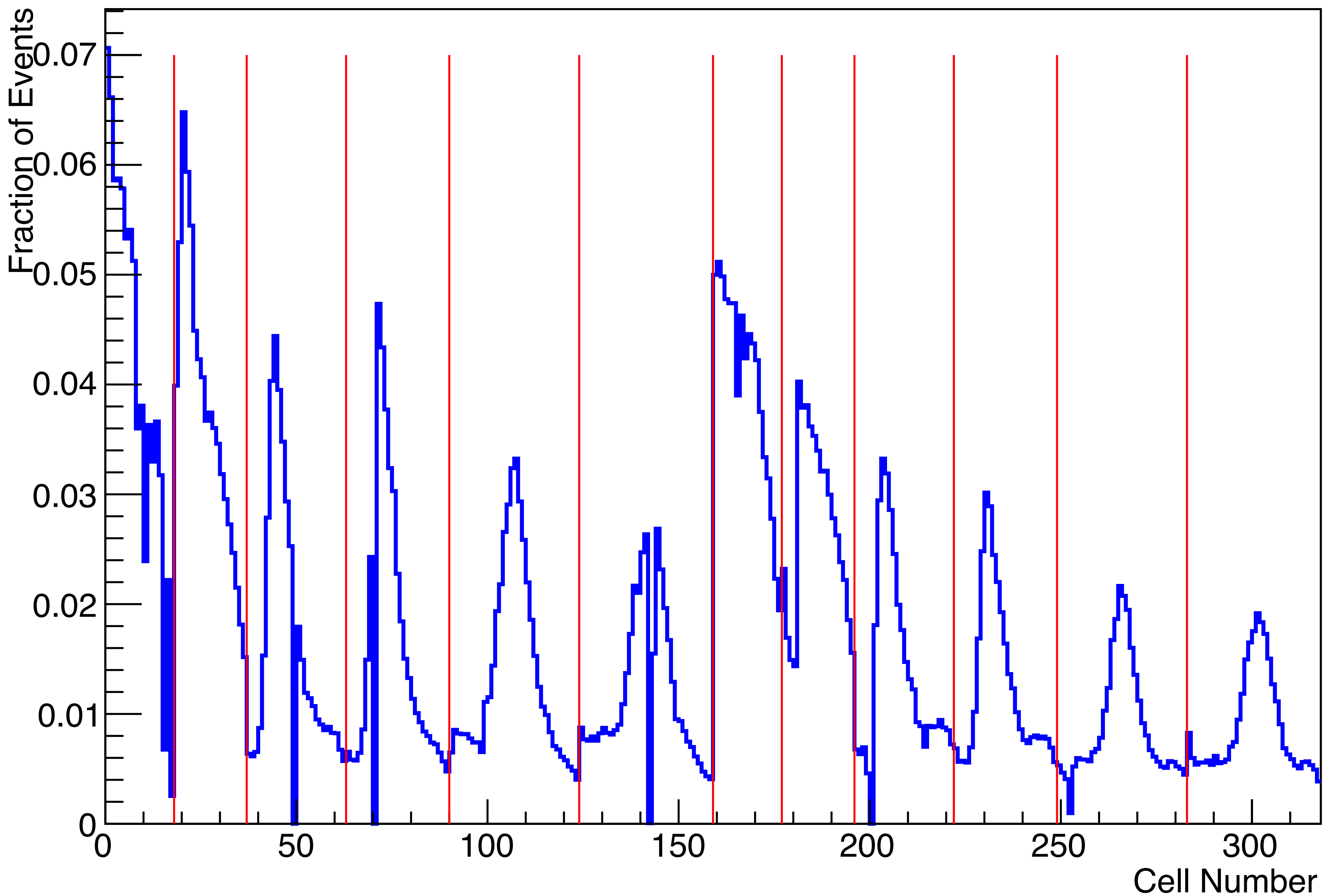
- initially thought to be a reconstruction issue
- possible problem with wire chamber efficiency
- plot rate of triple hits in each cell
  - observed peak appears to be due to showering and dominates the events



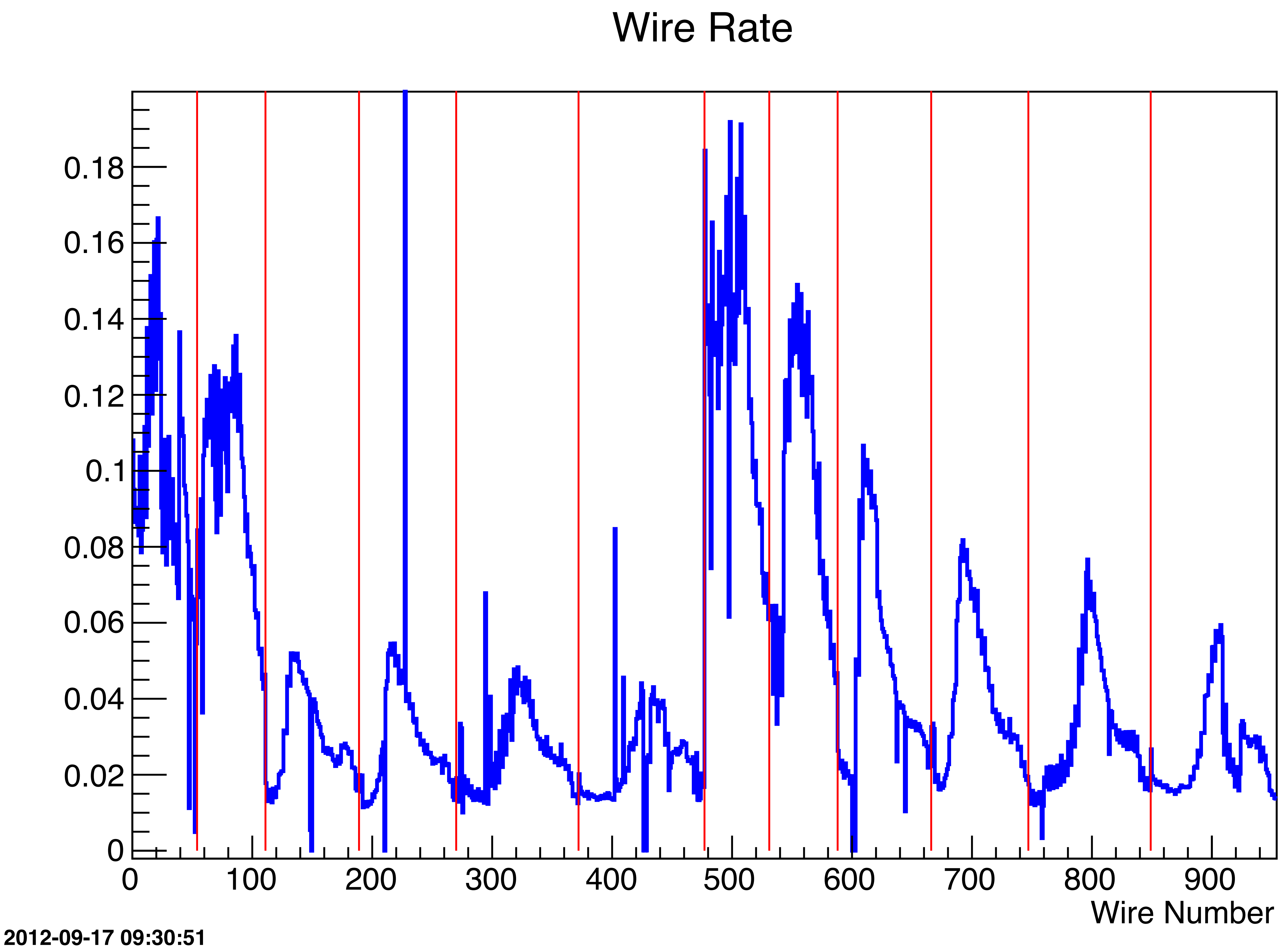
Missing Tracks

Not all electrons seen at forward angles ~50% missing

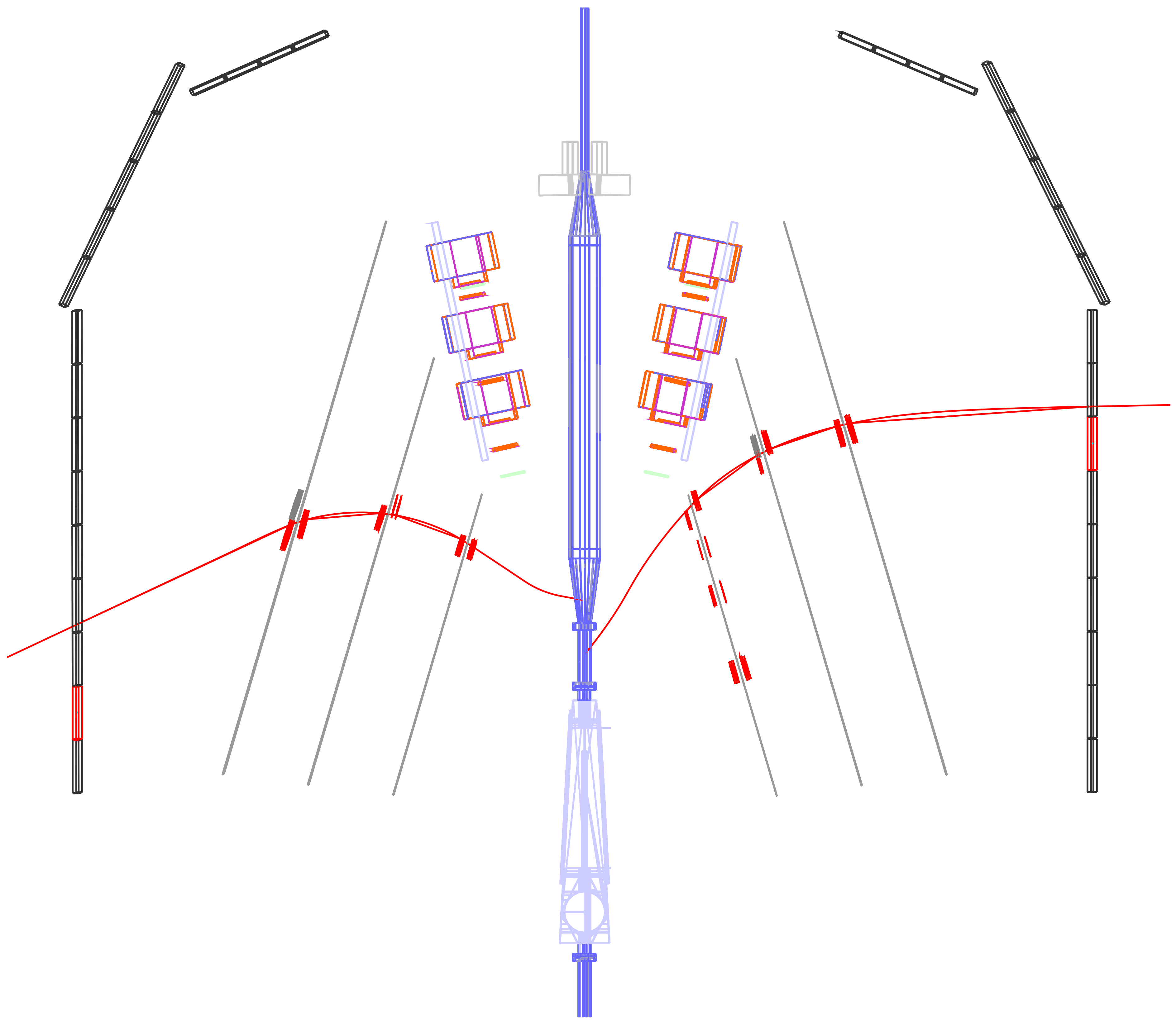
- initially thought to be a reconstruction issue
- possible problem with wire chamber efficiency
- plot rate of triple hits in each cell
    - observed peak appears to be due to showering and dominates the events



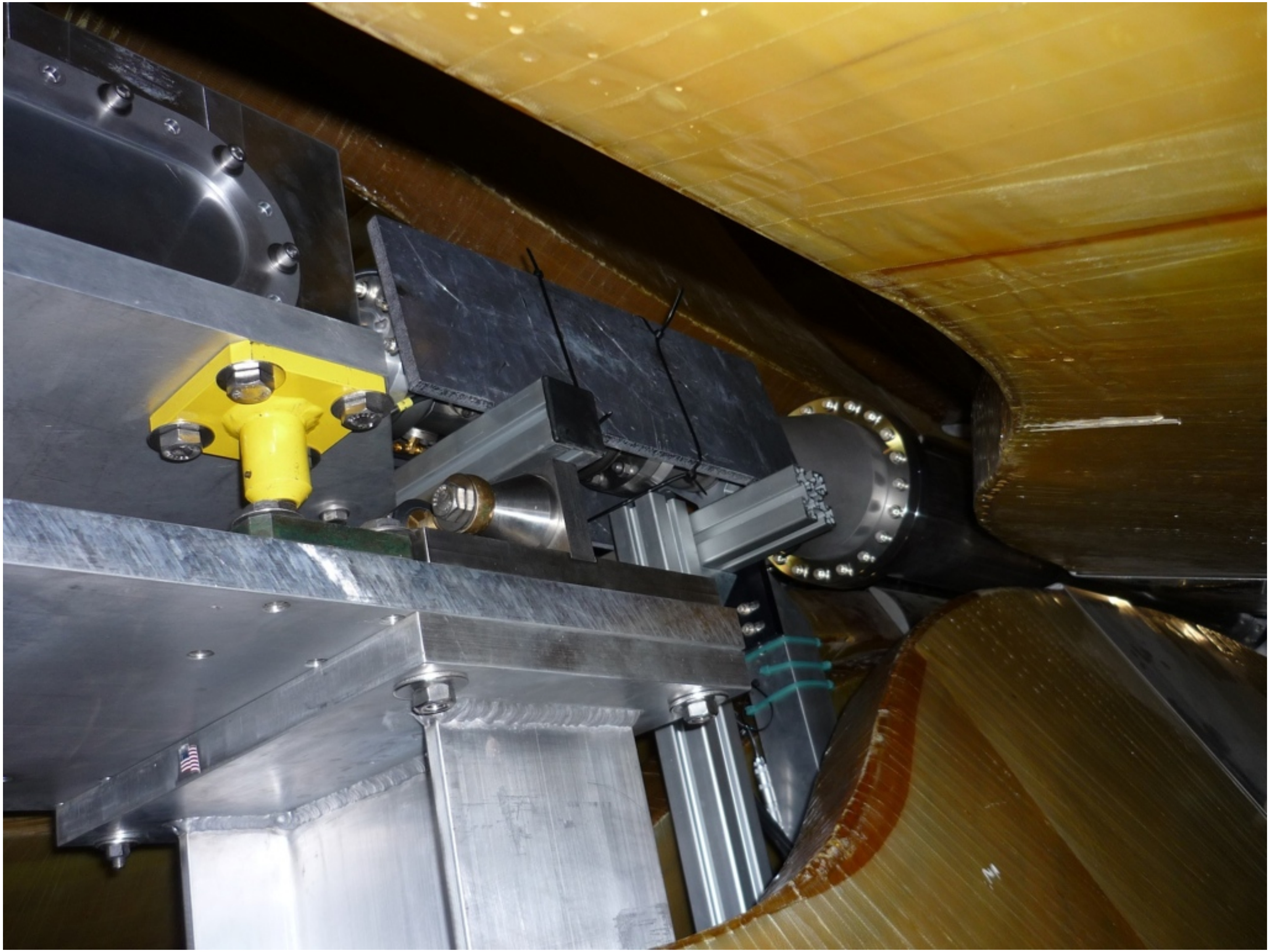
Individual Wire Rates



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

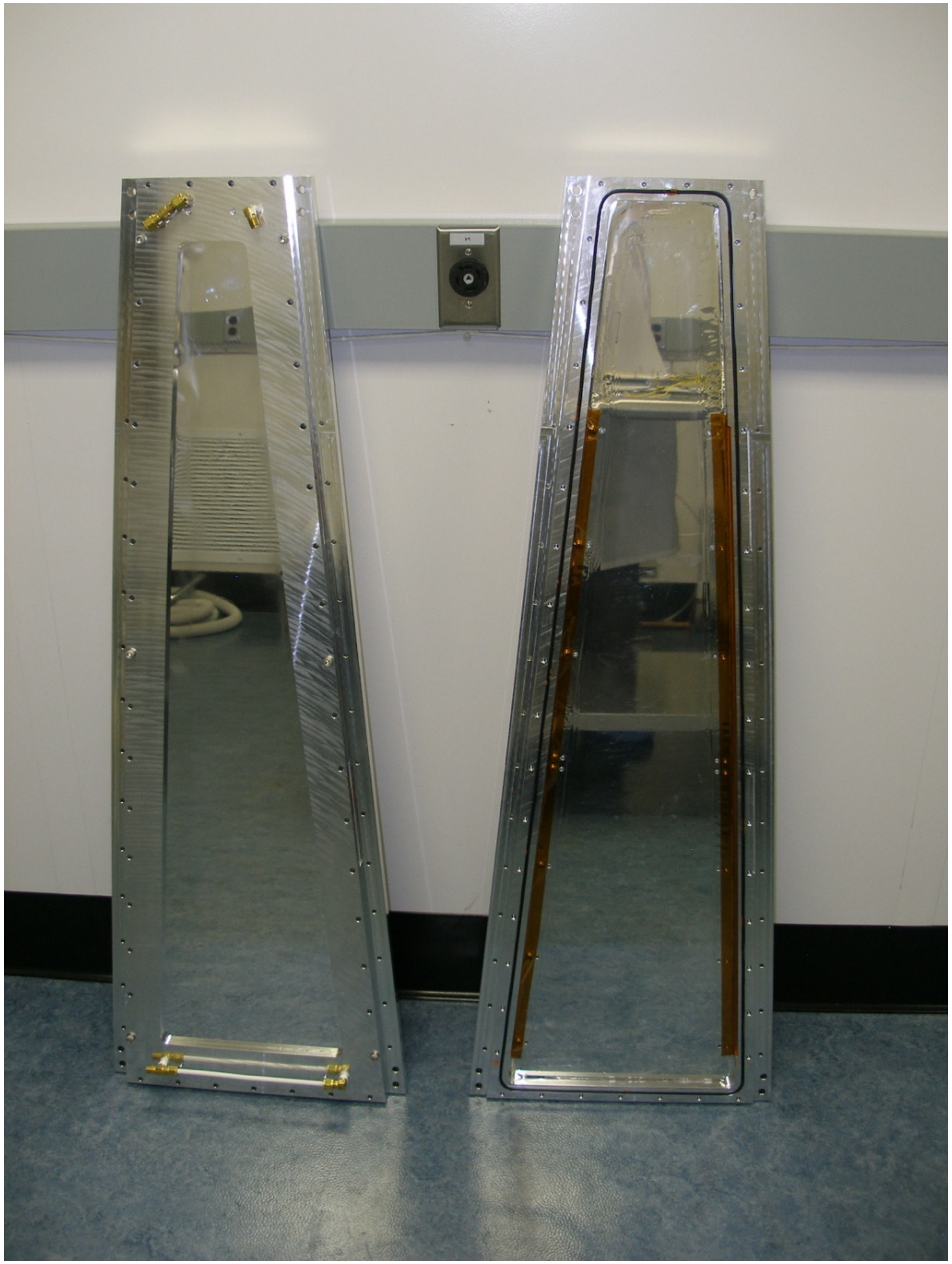
GEM tracker intention

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

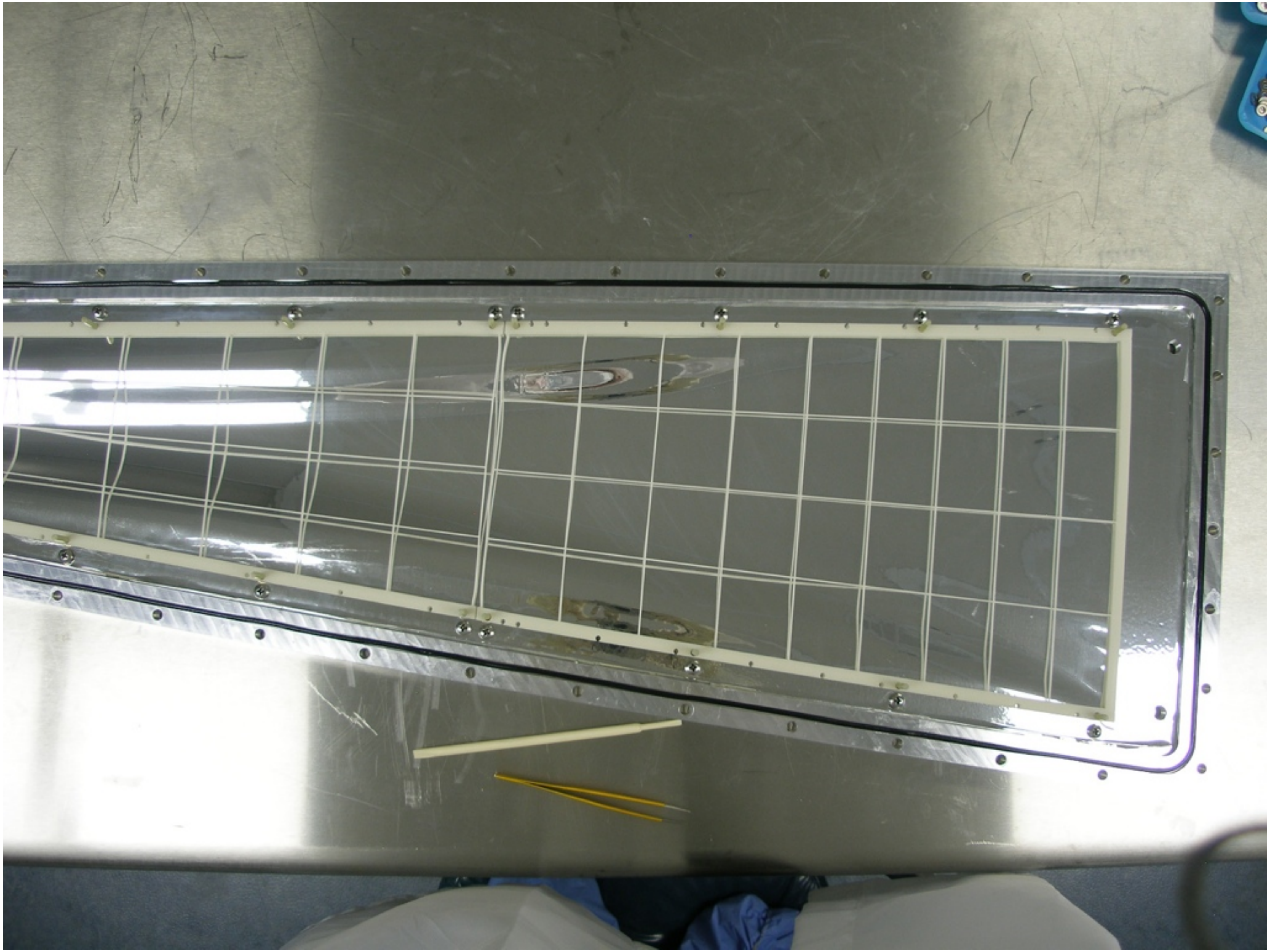
Design was innovative

- 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

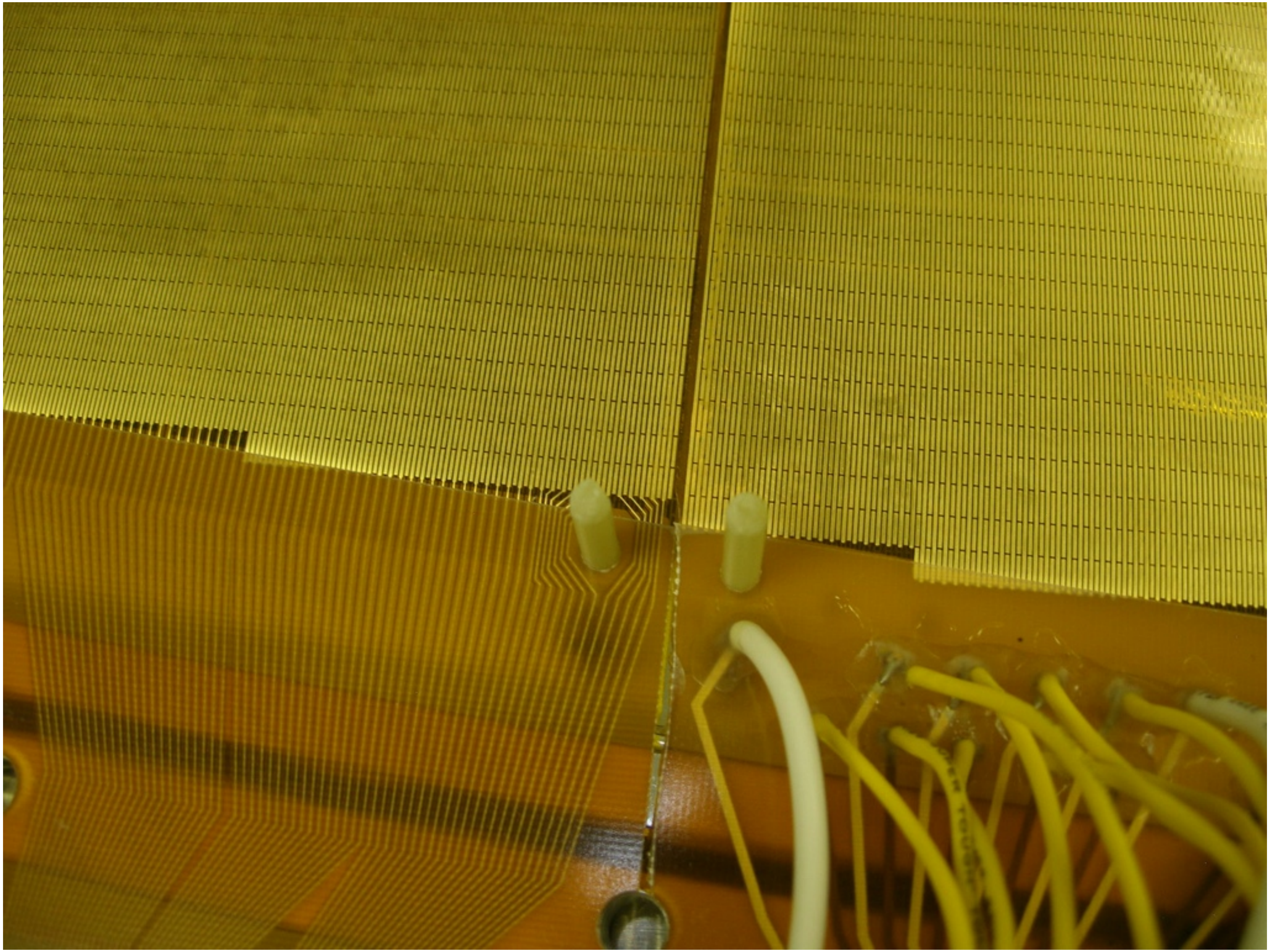


R/O Board Support Grid - 3D Printed

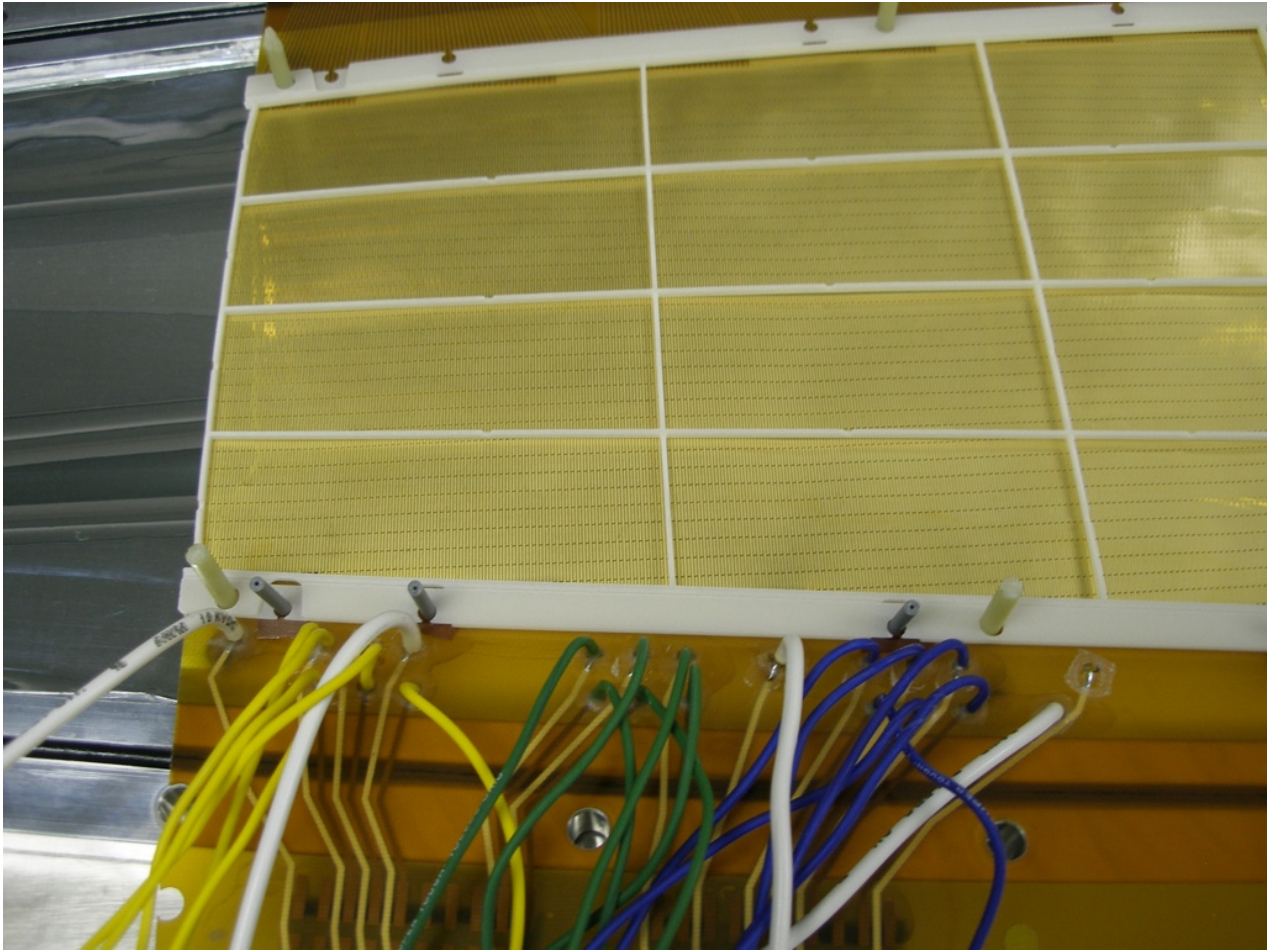


Installing Readout Boards

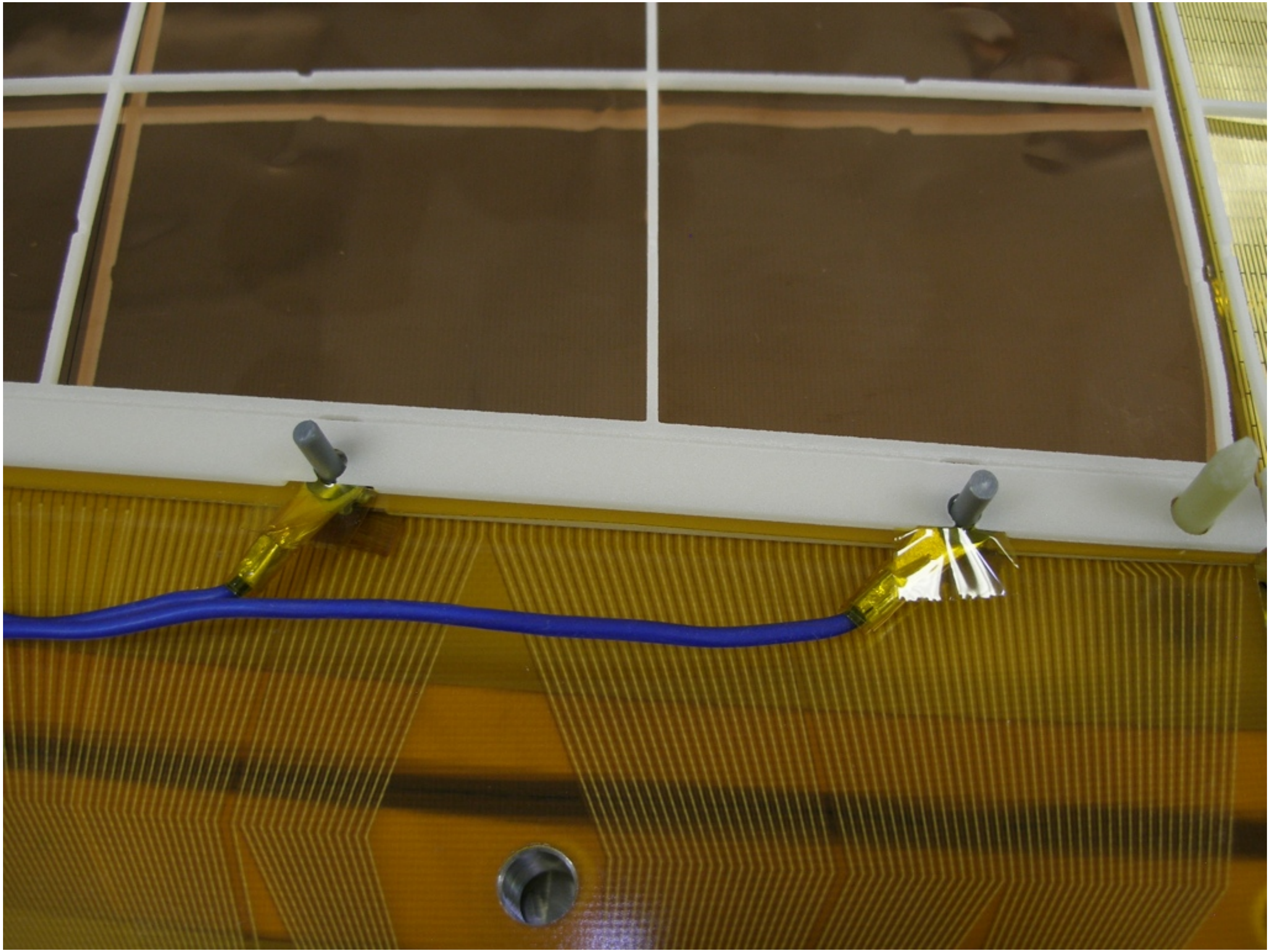
Readout Board Detail - Small meets Large



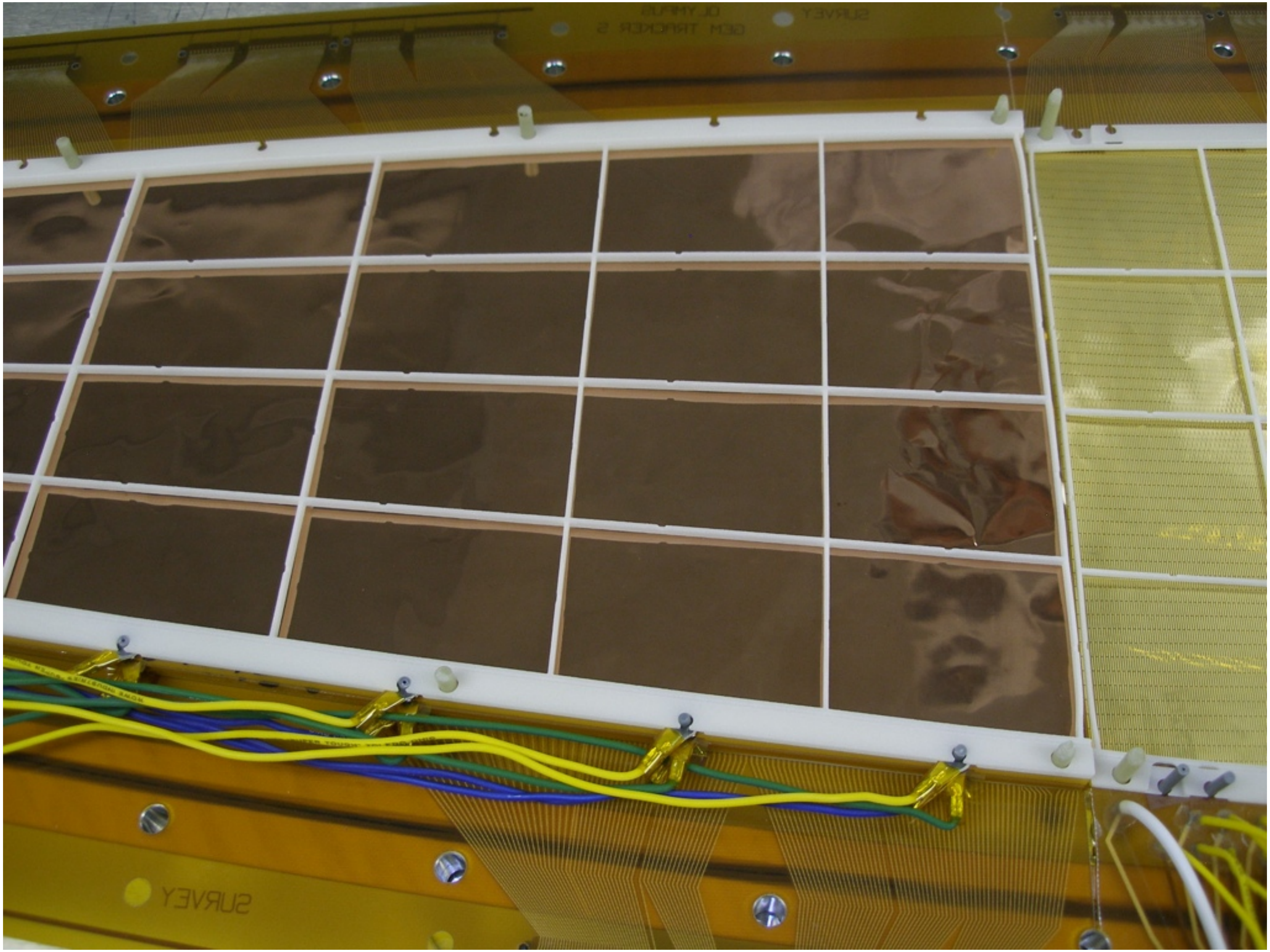
First GEM Support Grid and HV Cables



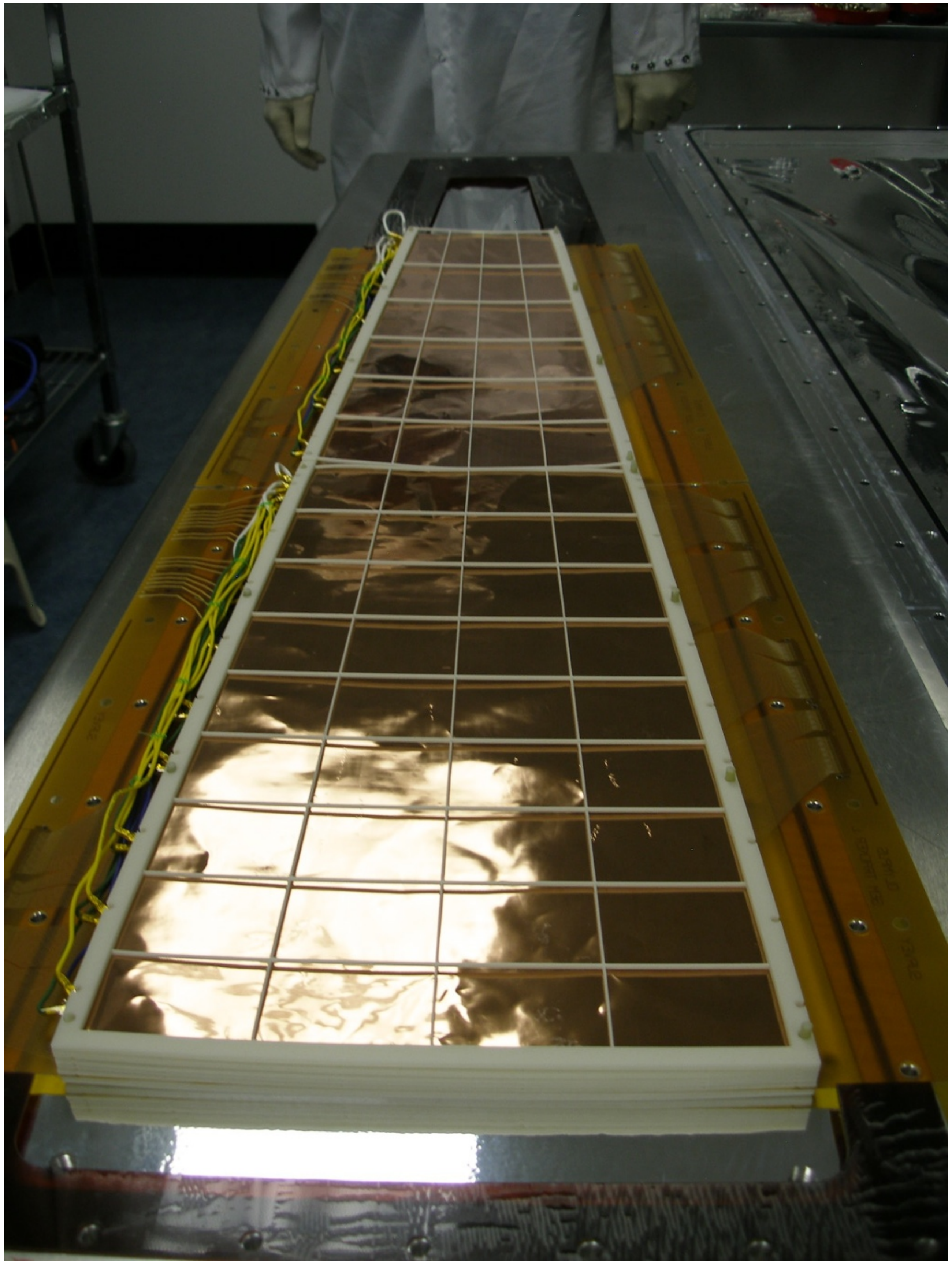
First GEM Layer and Spring Loaded HV



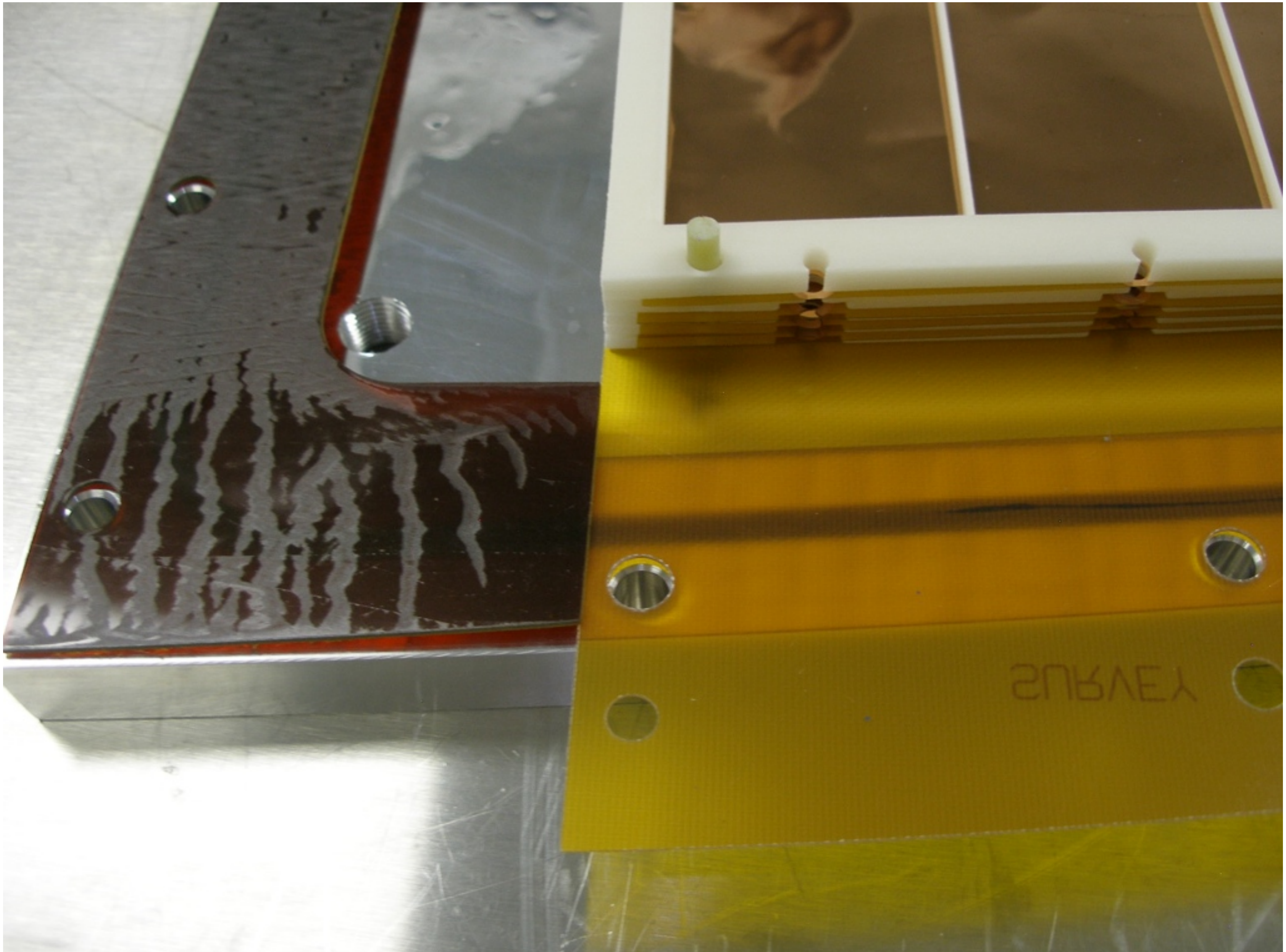
One Half Completed - R/O, 3 GEM, and HV



GEM Tracker - Fully Stacked and Cabled



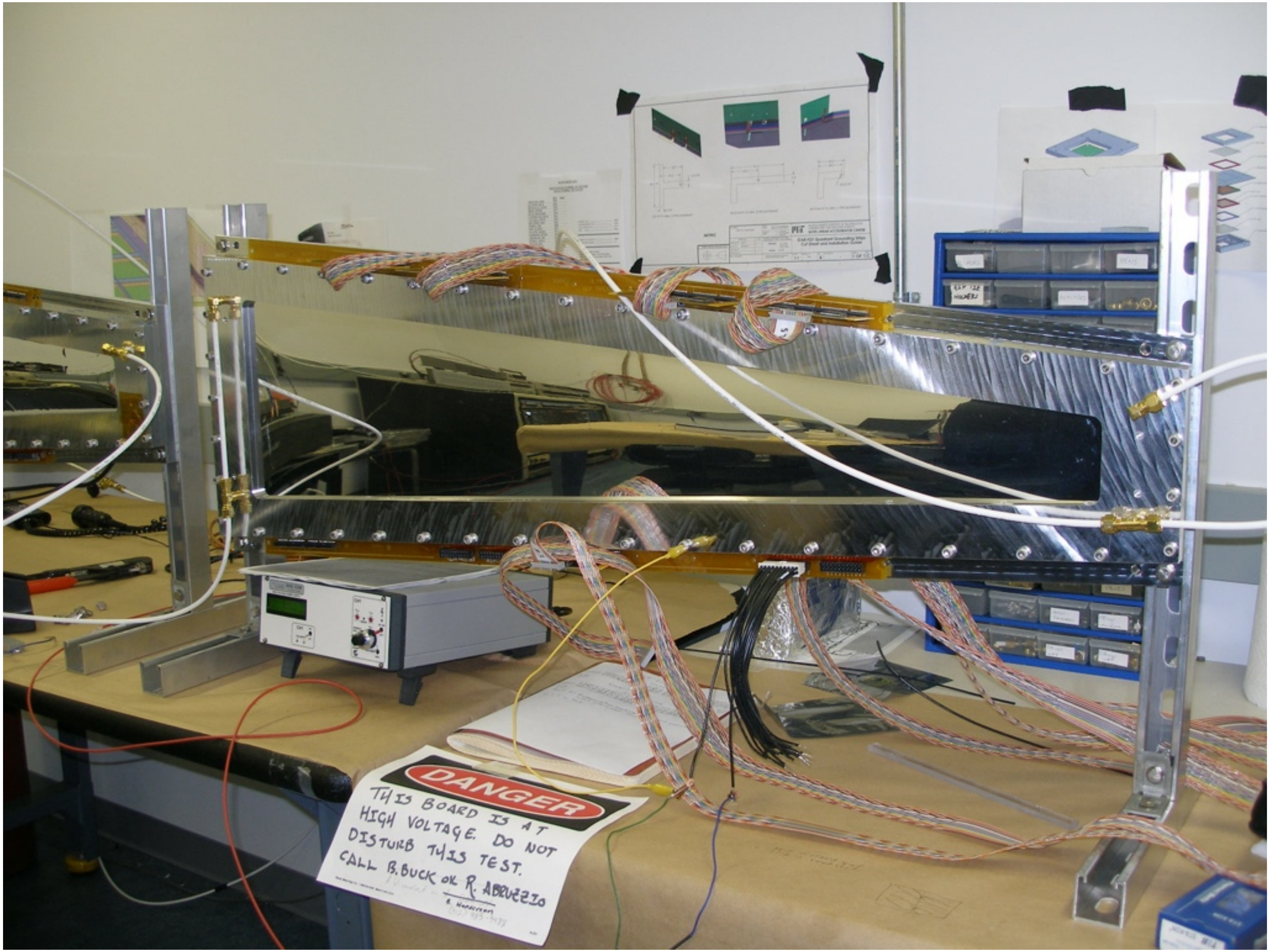
Peelable Shims Match R/O for Gas Seal



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

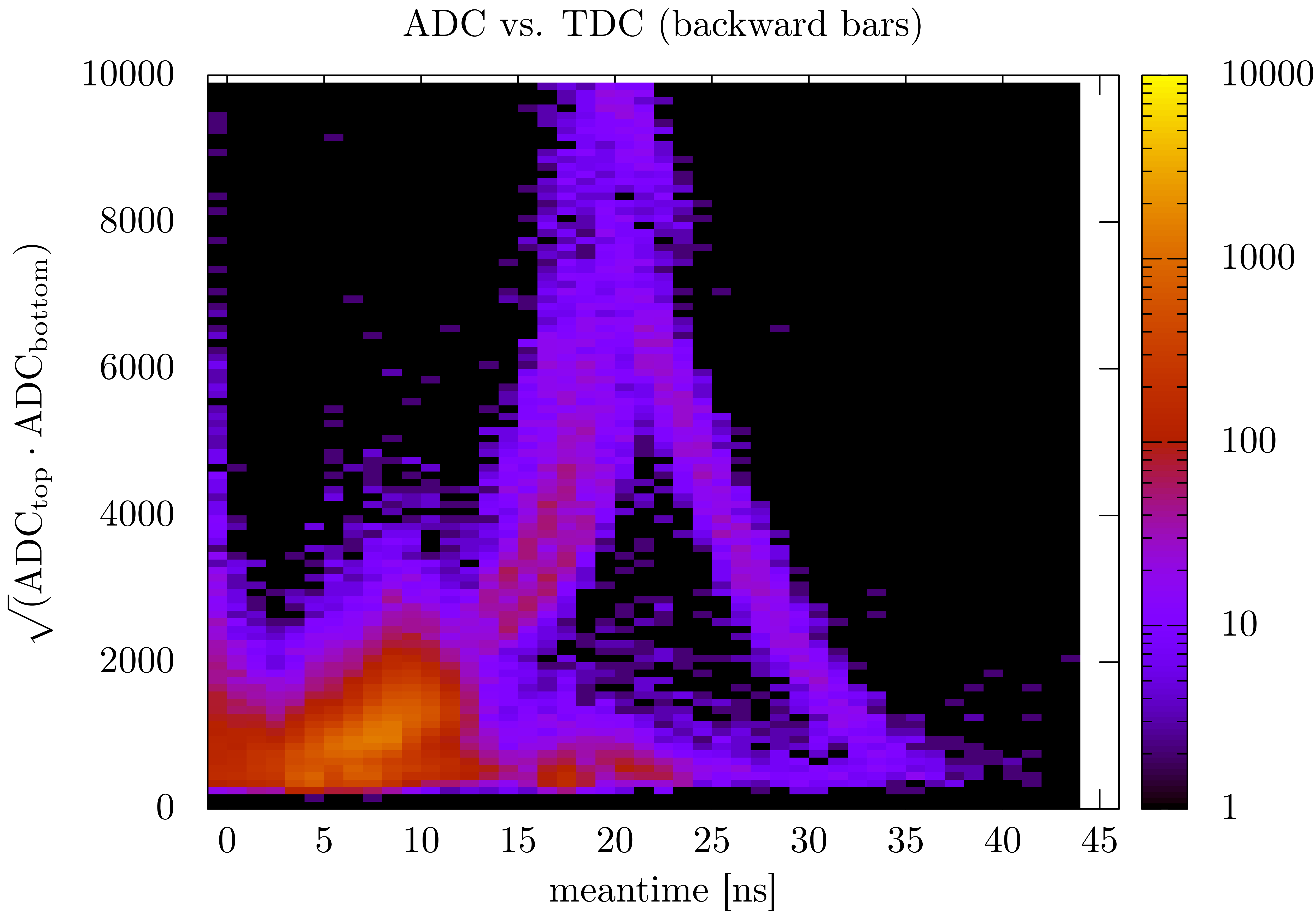
- each assembly / disassembly or exposure to atmosphere resulted in dimples or creases in GEM foil surface or added contaminants
- last assembly using all new small GEM foils held HV
- however, large GEM foils broke down at 3500 V

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

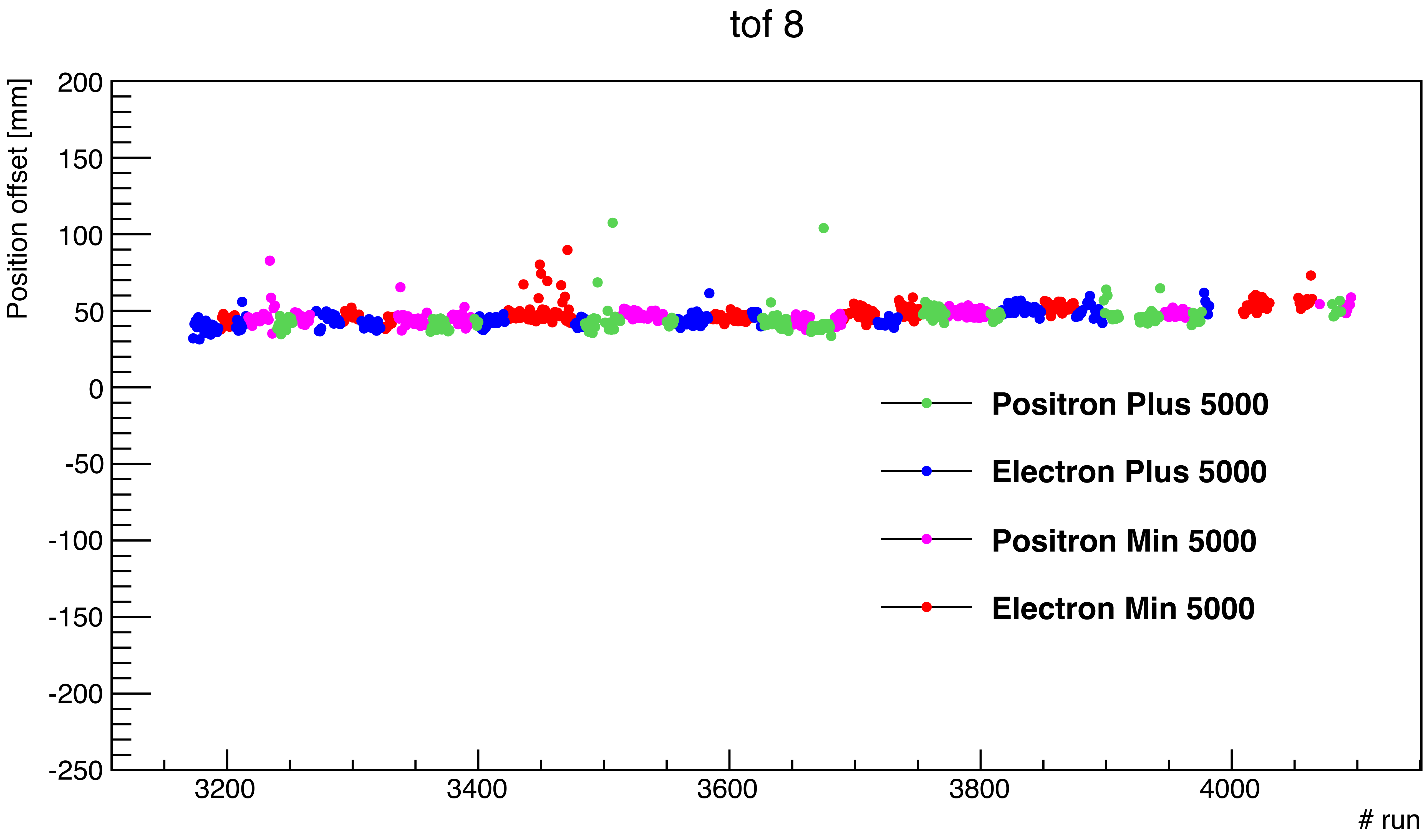
- could have shipped and installed in September access
  - but only half of one detector working and one month to integrate readout
  - could build second or even third detector and ship for installation in early October
  - but decided limited chance for success and other problems more pressing

Shelved GEM tracker for now

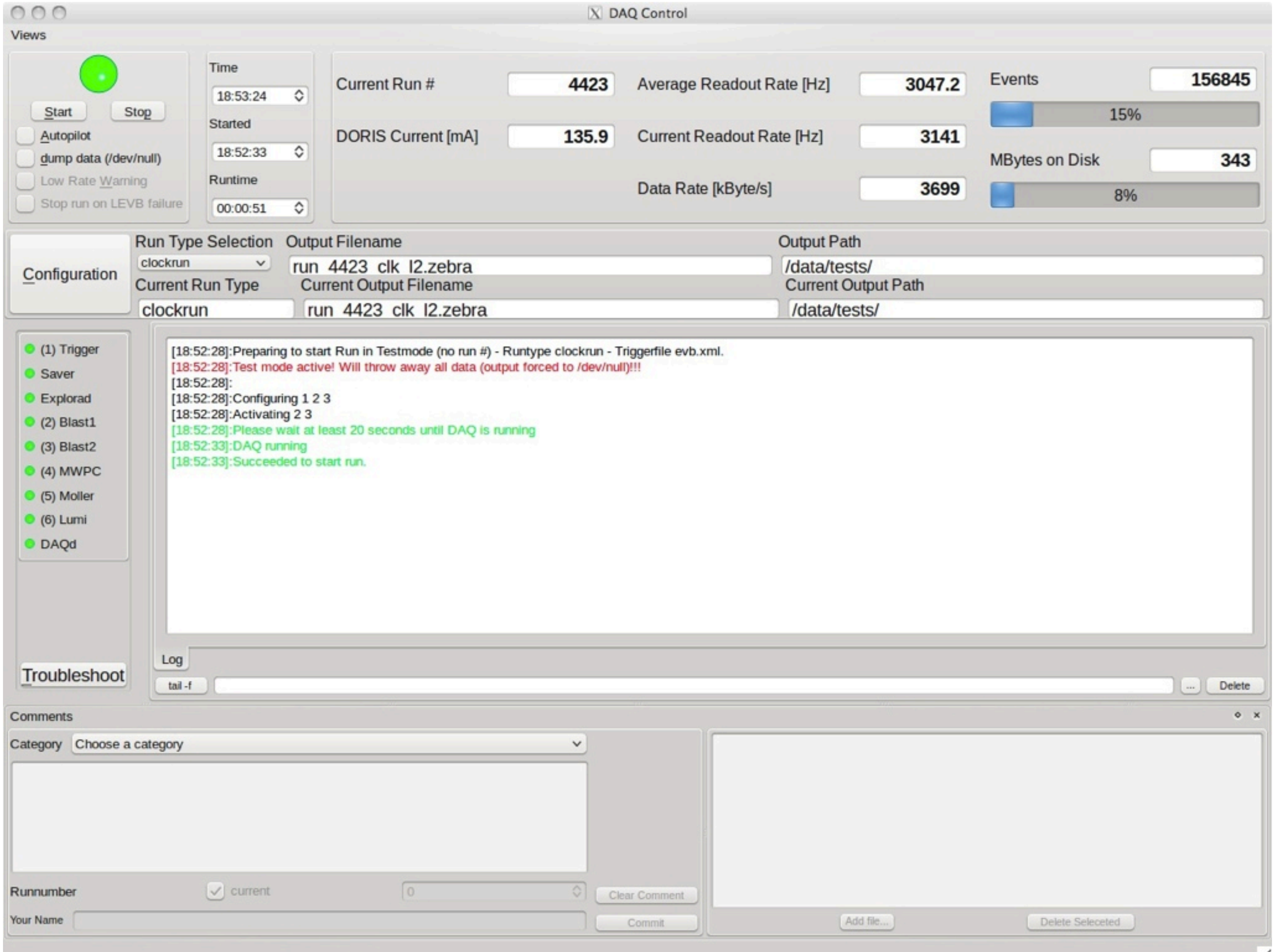
Time of Flight Scintillator Bars



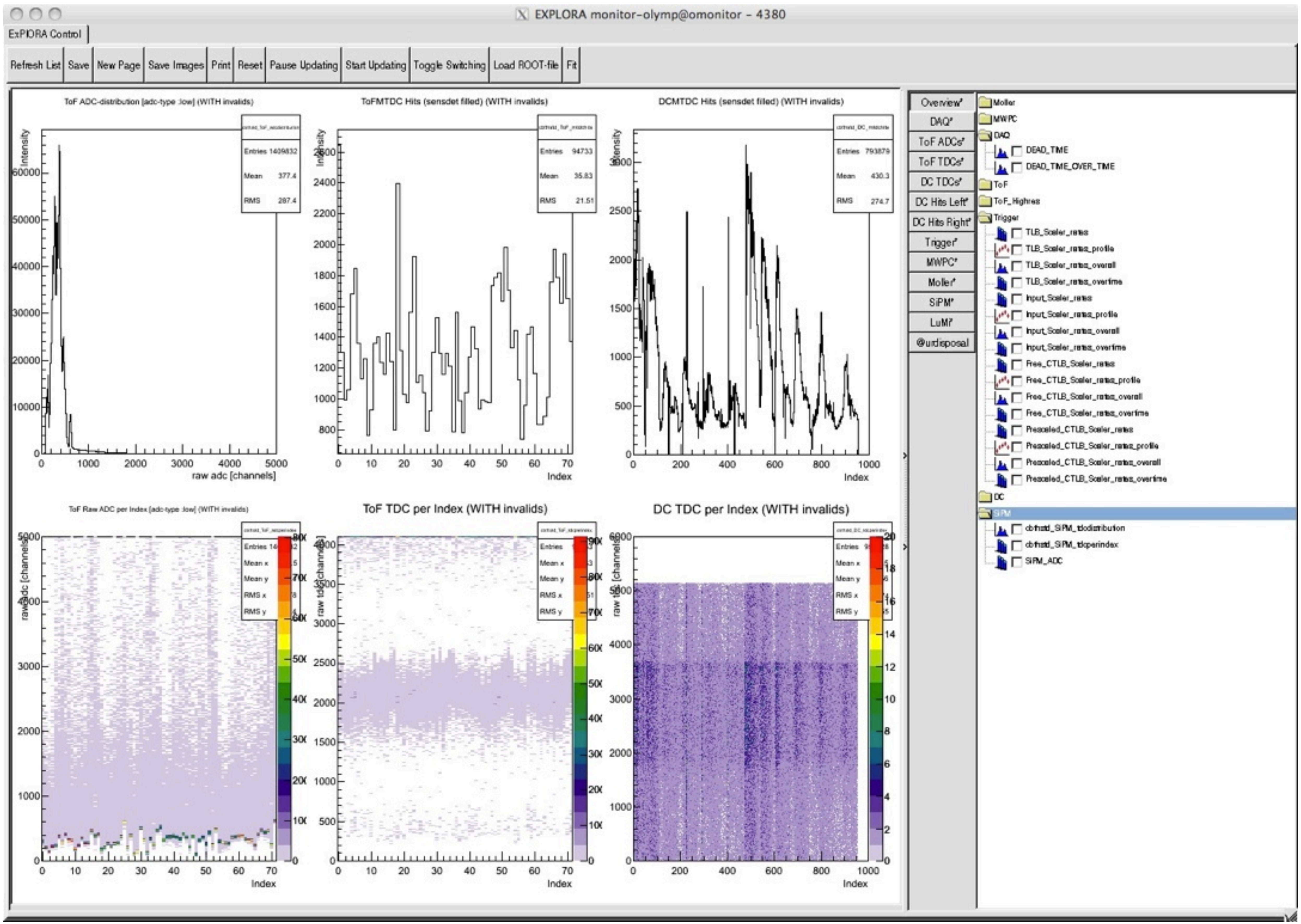
TOF Calibration and Stability



Data Acquisition System



Online Data Monitoring



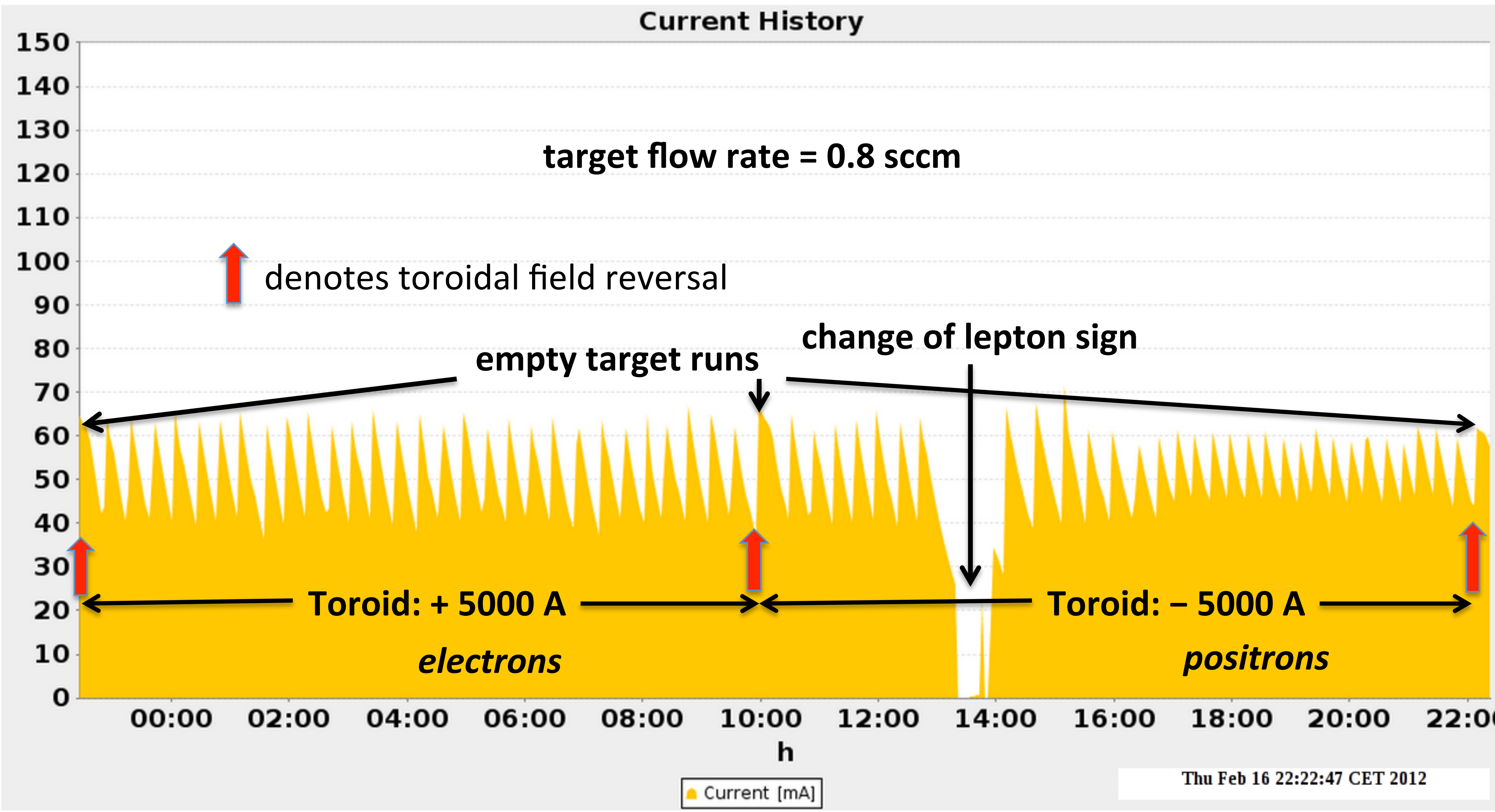
Data Acquisition and Slow Control

DAQ active 80 % of the time

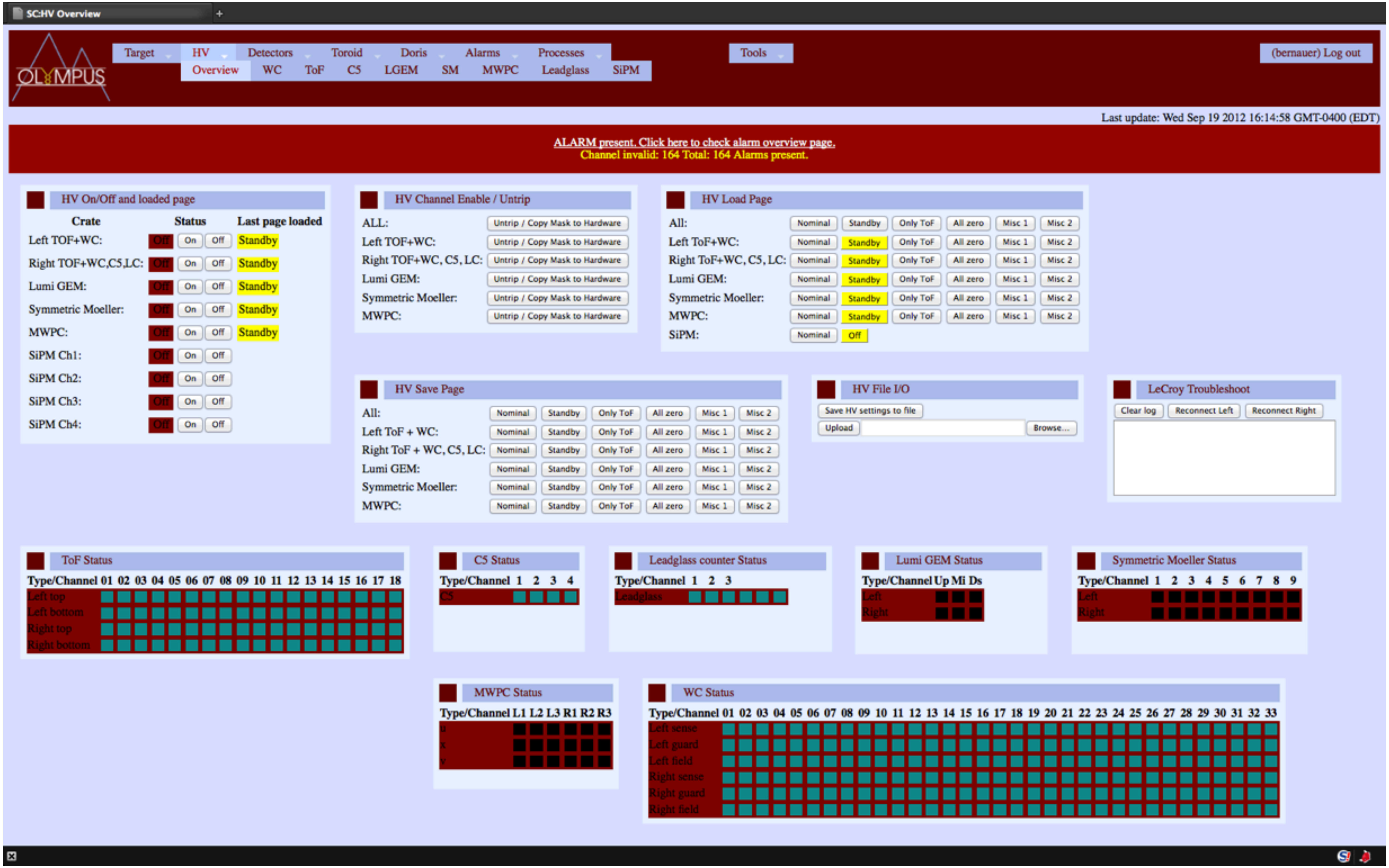
- ~20 minute runs
- ~2 minutes between runs
- ~25 % deadtime in February

Shifts extremely smooth

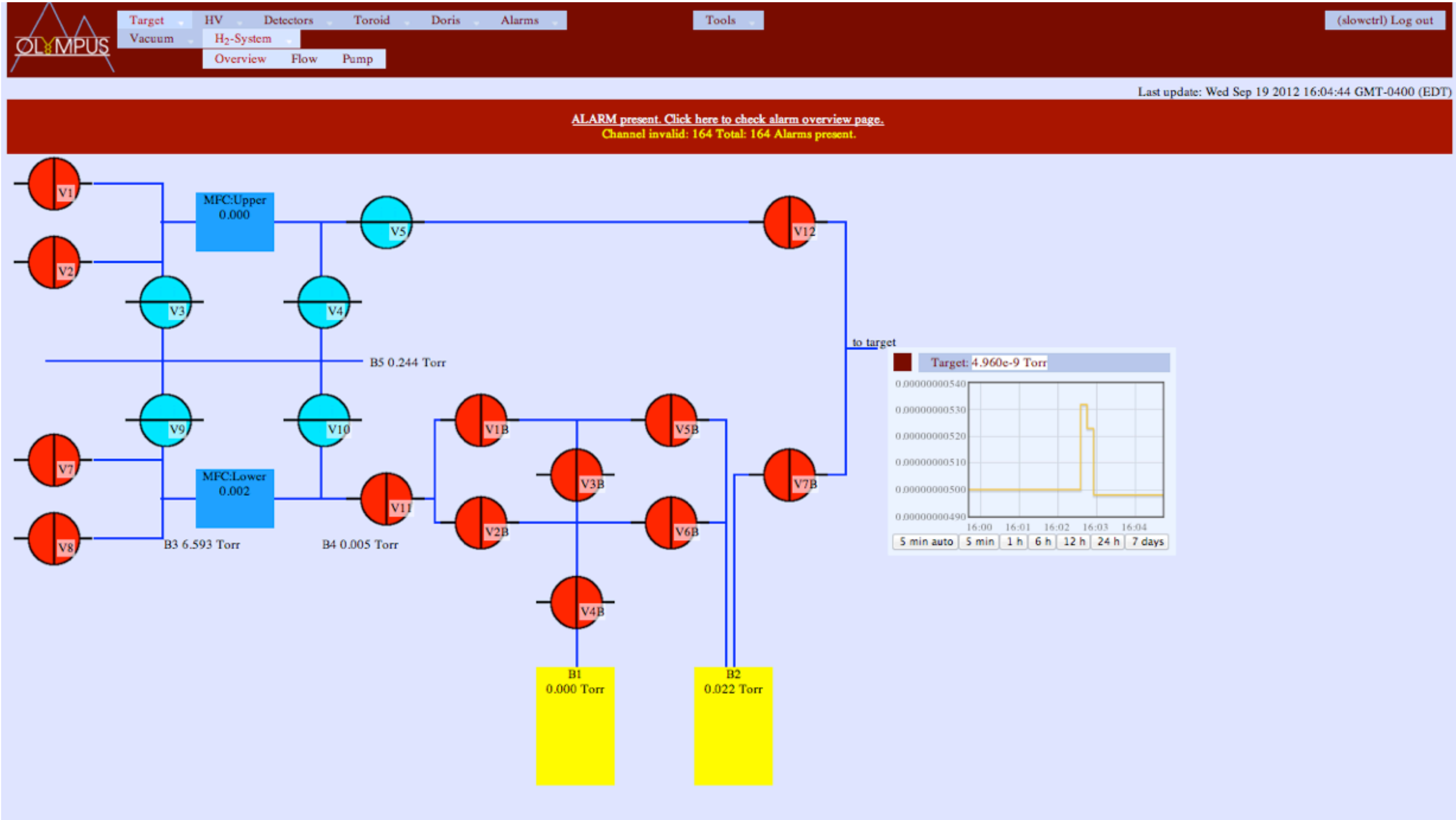
- 2 people on shift
- 1 running the experiment
- 1 monitoring data



Slow Control System



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