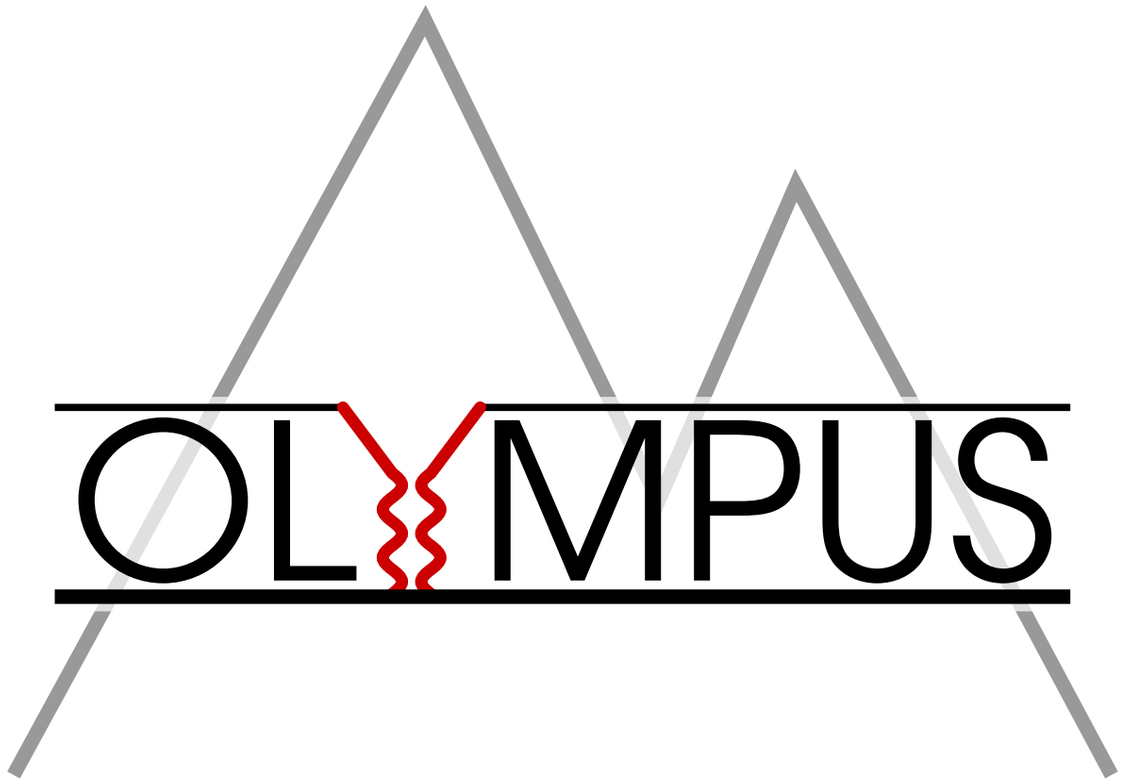
OLYMPUS



Arizona State University, USA
DESY,Hamburg, Germany
Hampton University, USA
INFN, Bari, Italy
INFN, Ferrara, Italy
INFN, Rome, Italy
Massachusetts Institute of Technology, USA
Petersburg Nuclear Physics Institute, Russia
Universität Bonn, Germany
University of Colorado, USA
University of Glasgow, United Kingdom
University of Kentucky, USA
Universität Mainz, Germany
University of New Hampshire, USA
Yerevan Physics Institute, Armenia

Outline

Physics
OLYMPUS Experiment
DORIS Ring Run
Hall 2 Test Beam
Schedule

Proton Form Factor

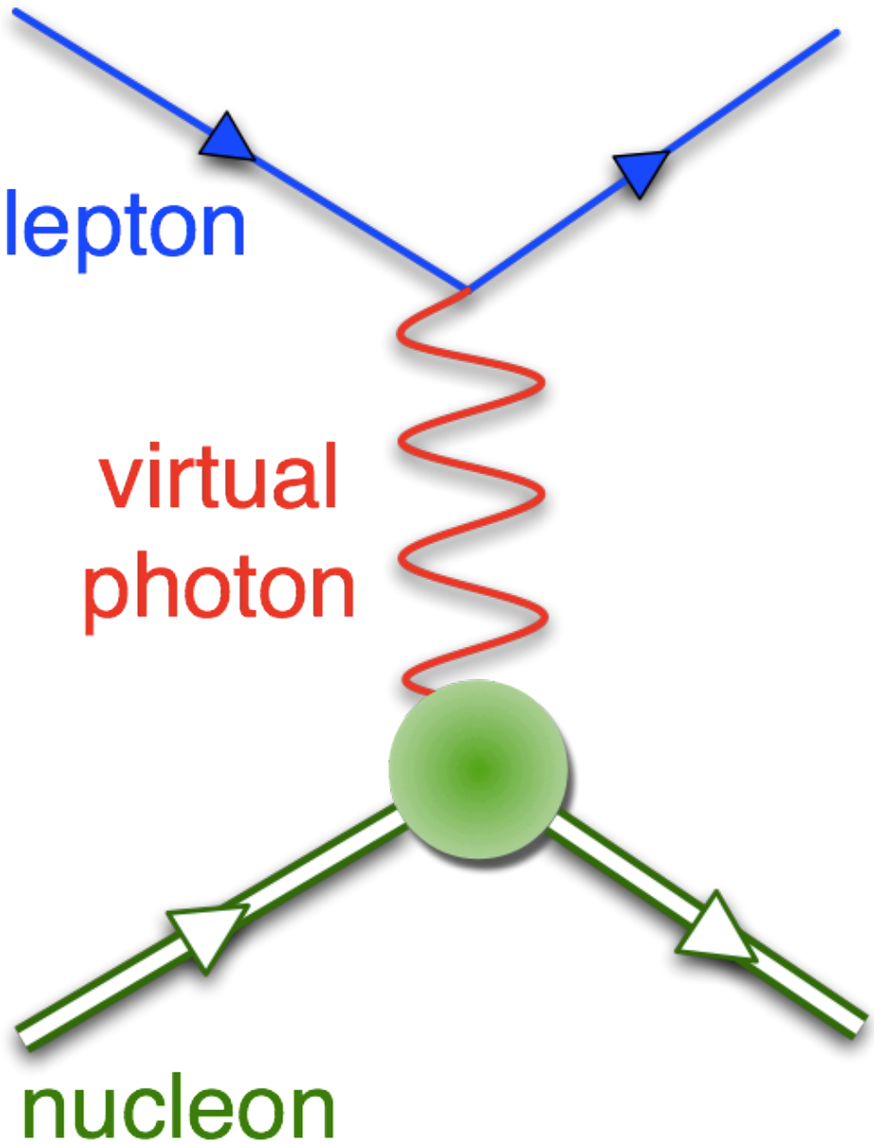
Elastic scattering (Born)

$$\langle N(P')|J^{\mu}_{EM}(0)|N(P)\rangle =$$

$$\bar{u}(P')\left[\gamma^{\mu}F_1^N(Q^2) + i\sigma^{\mu\nu}\frac{q_\nu}{2M}F_2^N(Q^2)\right]u(P)$$

Electric and magnetic form factors

$$G_E^N = F_1^N - \tau F_2^N; \qquad G_M^N = F_1^N + F_2^N$$

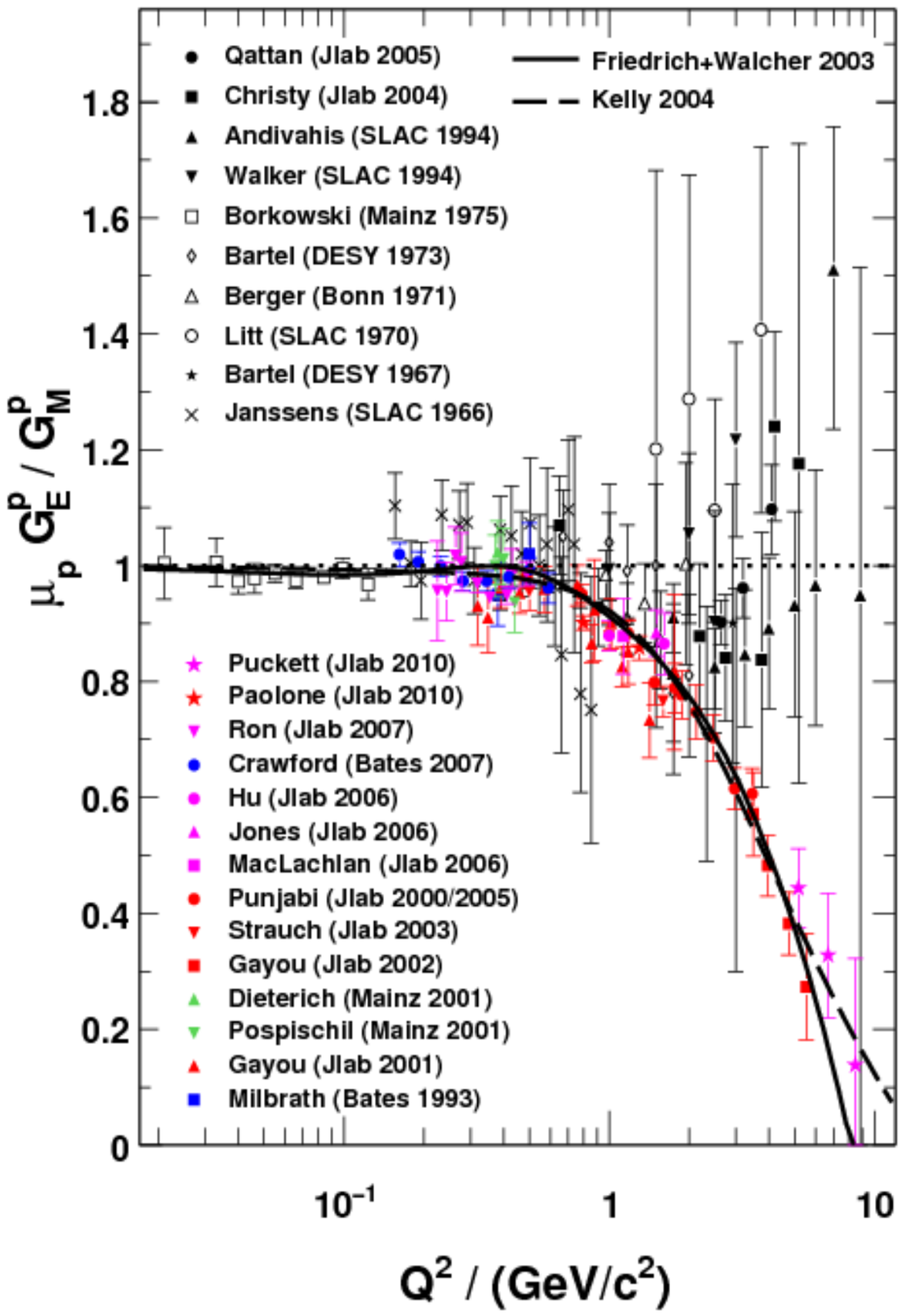


Simple (naive) approximation

$$G_D^p(Q^2) = \frac{1}{\left(1+\frac{Q^2}{0.71}\right)^2} \quad \leftrightarrow \quad \rho_D(r) = \rho_0 e^{-\sqrt{0.71}r}$$

$$G_E^p \approx G_M^p$$

Discrepancy with Polarization Results



Low Q^2 naive model worked

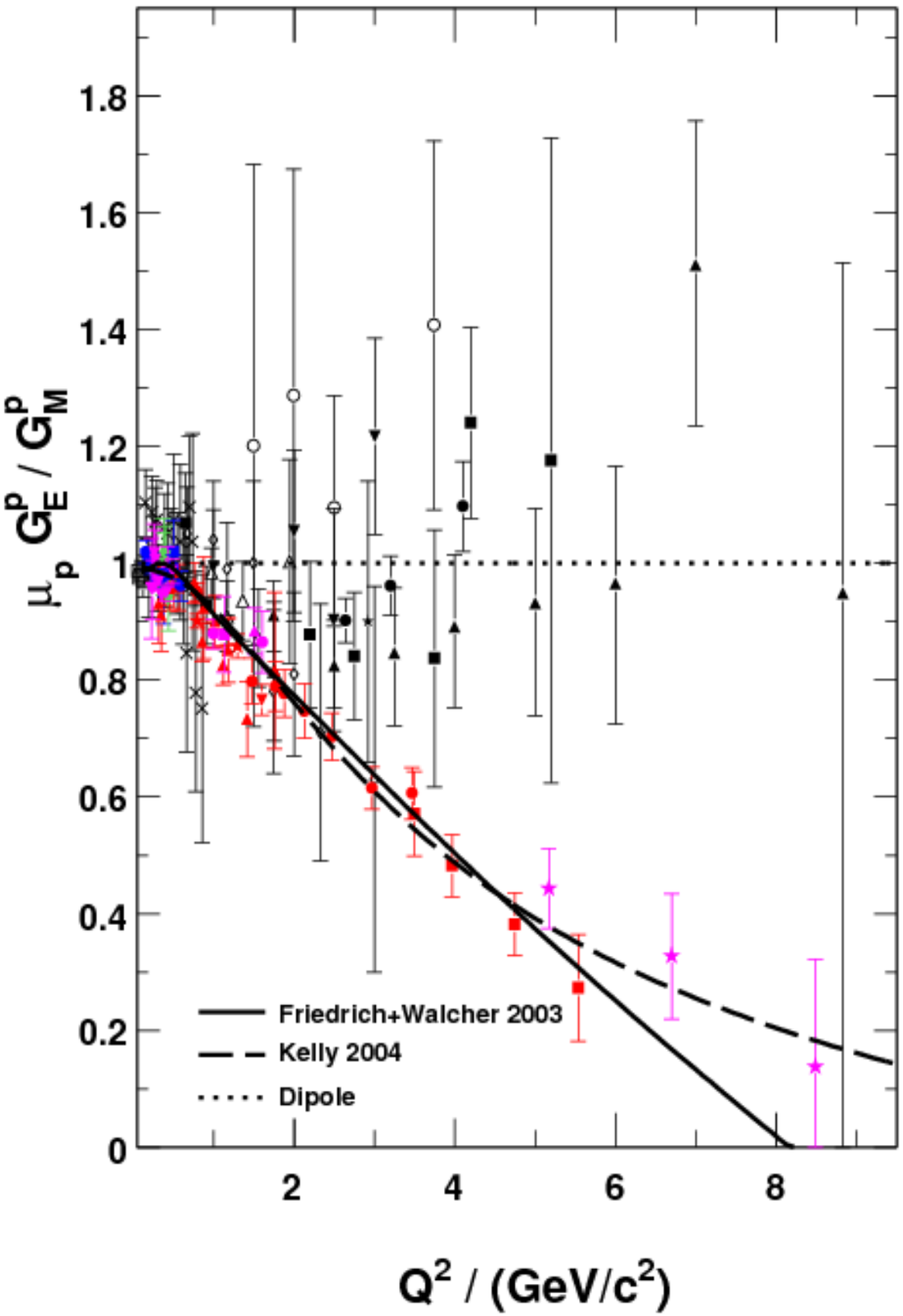
- form factor ratio ≈ 1
- Rosenbluth separation on unpolarized data
  - overlooked dominance of G_M
  - insensitive to G_E at higher Q^2

Polarization transfer measurements at JLAB

- striking discrepancy in form factor ratio with higher Q^2

Even more striking on a linear scale !

Discrepancy with Polarization Results



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Polarization transfer measurements at JLAB

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Even more striking on a linear scale !

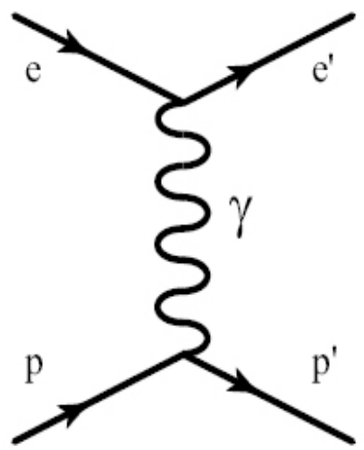
2 Photon Exchange Explaination

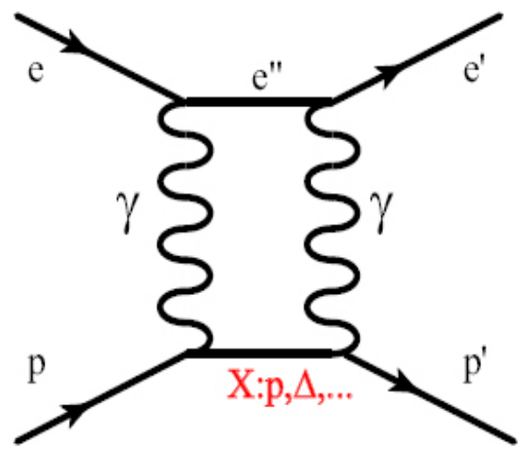
Previously dismissed as a small effect

- α^4

And/or handled by radiative (?) corrections

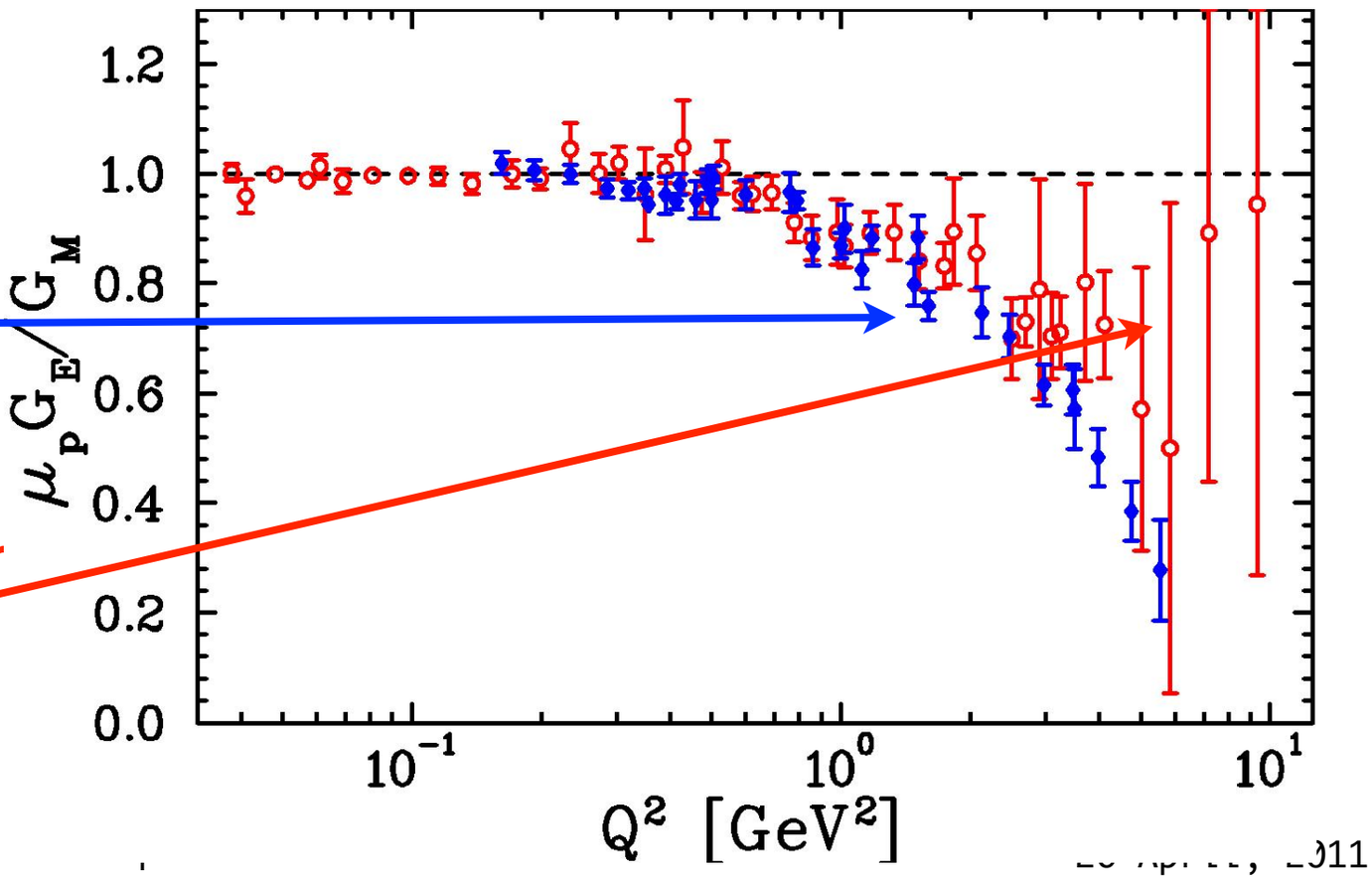
- difficult to calculate



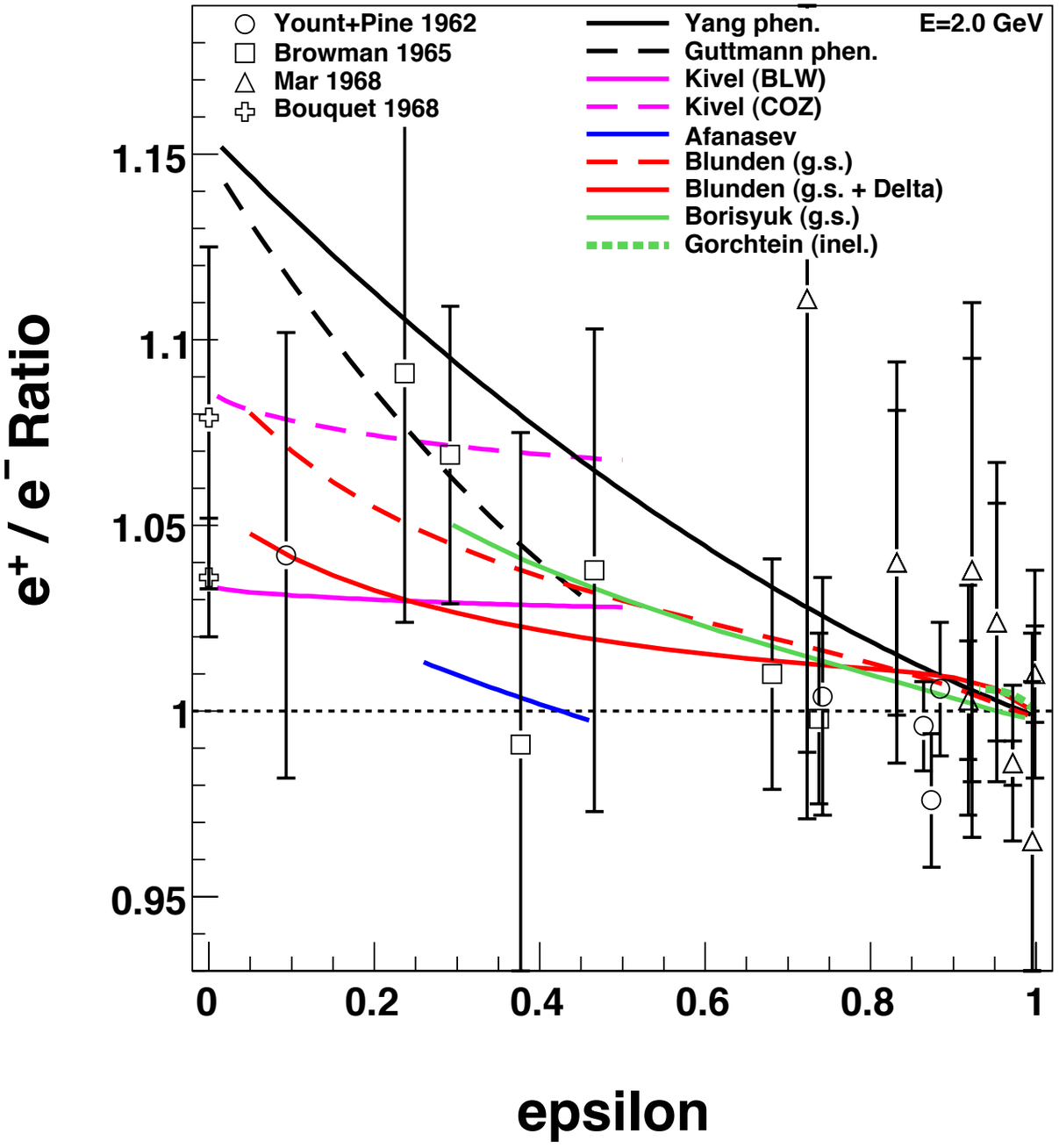


But recent calculations (in hind-sight) can possibly explain discrepancy

- polarization transfer measurements
- unpolarized Rosenbluth separation data corrected for two photon exchange



Definitive Measure of Multi-Photon Effect



Measure ratio or e^+p / e^-p cross section ratio

- interference term changes sign under $e^- \Leftrightarrow e^+$

Existing data consistent with unity

- low Q^2
- large error bars

Recent calculations not in complete agreement

- large variation in effect
  - radiative correction workshop at MIT
- lack constraint of precise data
  - need experimental measurements

Radiative Corrections Workshop @ MIT

Saturday, July 30, 2011

Kolker Room 26-414

8:30—9:00 Richard Milner MIT

Welcome and Overview

9:00—9:30 Carl Carlson Wm&Mary

Two-photon Corrections using GPDs

9:30—10:00 Nikolay Kivel Helmholtz-Institut Mainz

Phenomenological Analysis of Two-photon Exchange Amplitudes from Elastic ep Scattering

10:00—10:30 Andrei Afanasev JLab

Standard Radiative Corrections or *Single-spin Beam Asymmetry*

10:30—11:00 coffee break

11:00—11:30 Ulf Meissner (to be confirmed)

11:30—12:00 Theorist (to be confirmed)

12:00—12:30 Theorist (to be confirmed)

12:30—13:30 lunch

13:30—13:50 JLab CLAS Experiment (speaker to be confirmed)

13:50—14:10 Novosibirsk Experiment (speaker to be confirmed)

14:10—14:30 OLYMPUS Experiment (speaker to be confirmed)

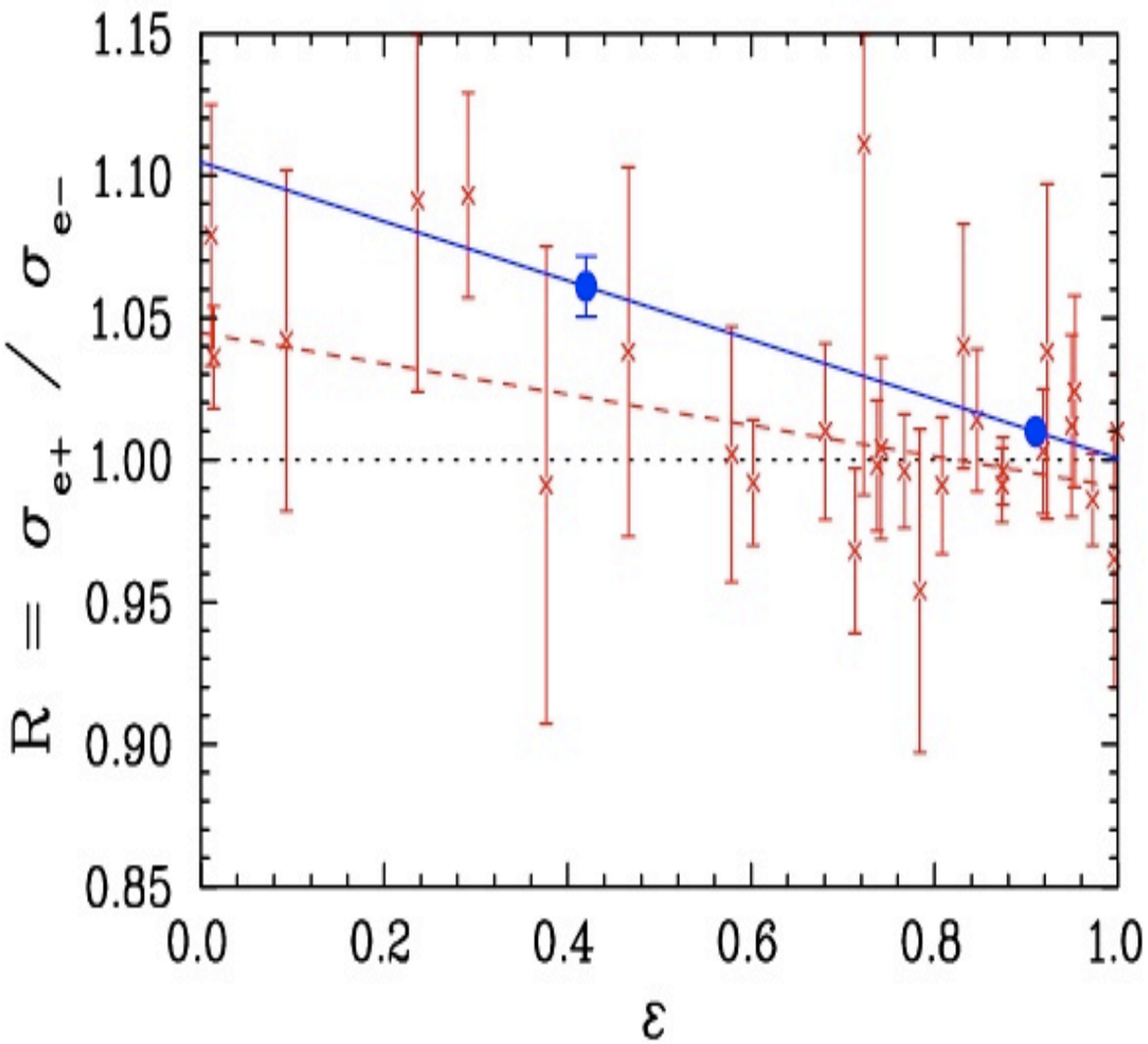
[The previous three talks should be focused on issues related to radiative corrections.

They are not intended to be general overviews of the respective experiments.]

14:30—15:00 coffee break

15:00—17:00 Discussion Moderator: Bill Donnelly

Projected Experimental Measurements

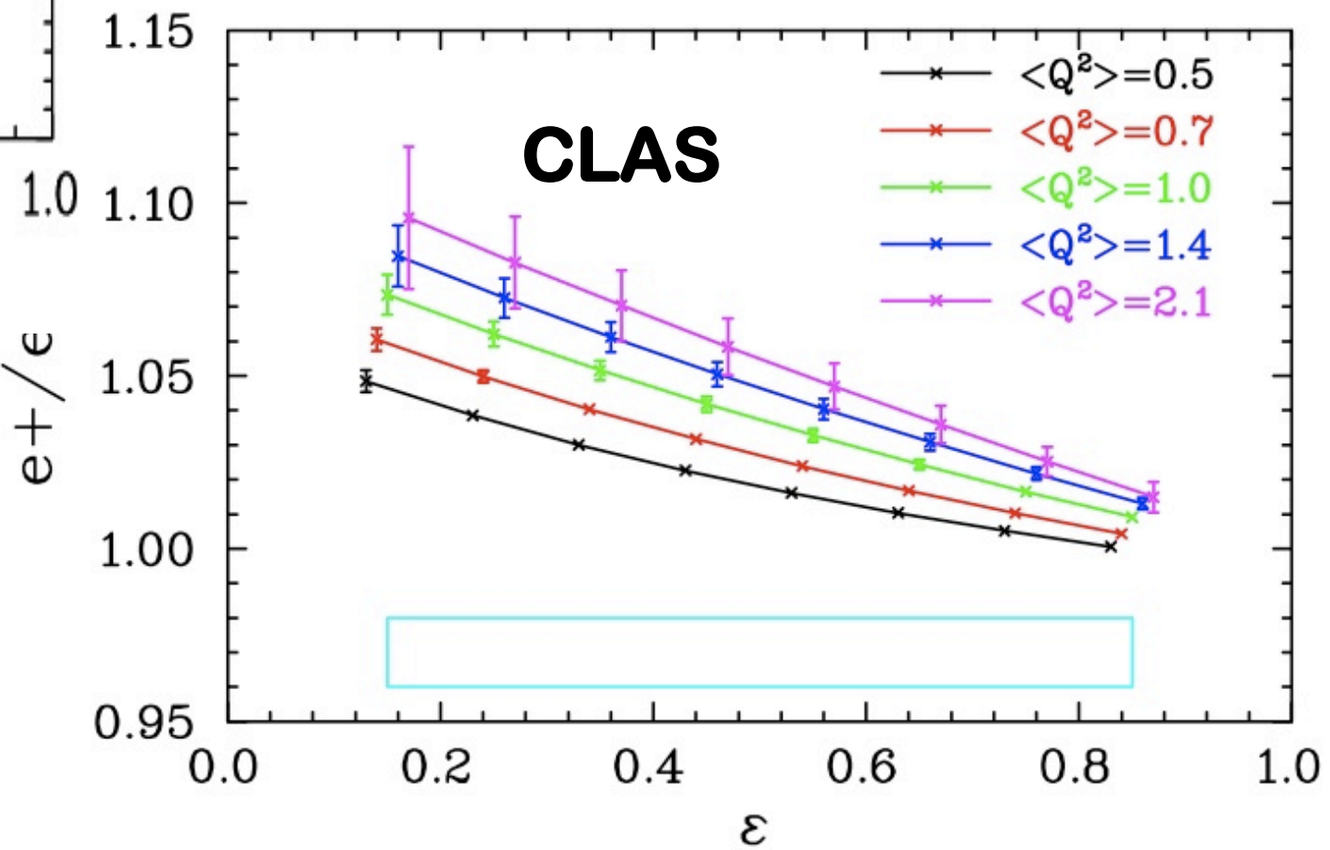


Novosibirsk

- internal target
- low statistics

CLAS

- e^- / e^+ produced by photon bremmstrahlung
- reconstruct incident energy from lepton and proton
- background ? systematics ?



OLYMPUS Projected Results

Former BLAST experiment

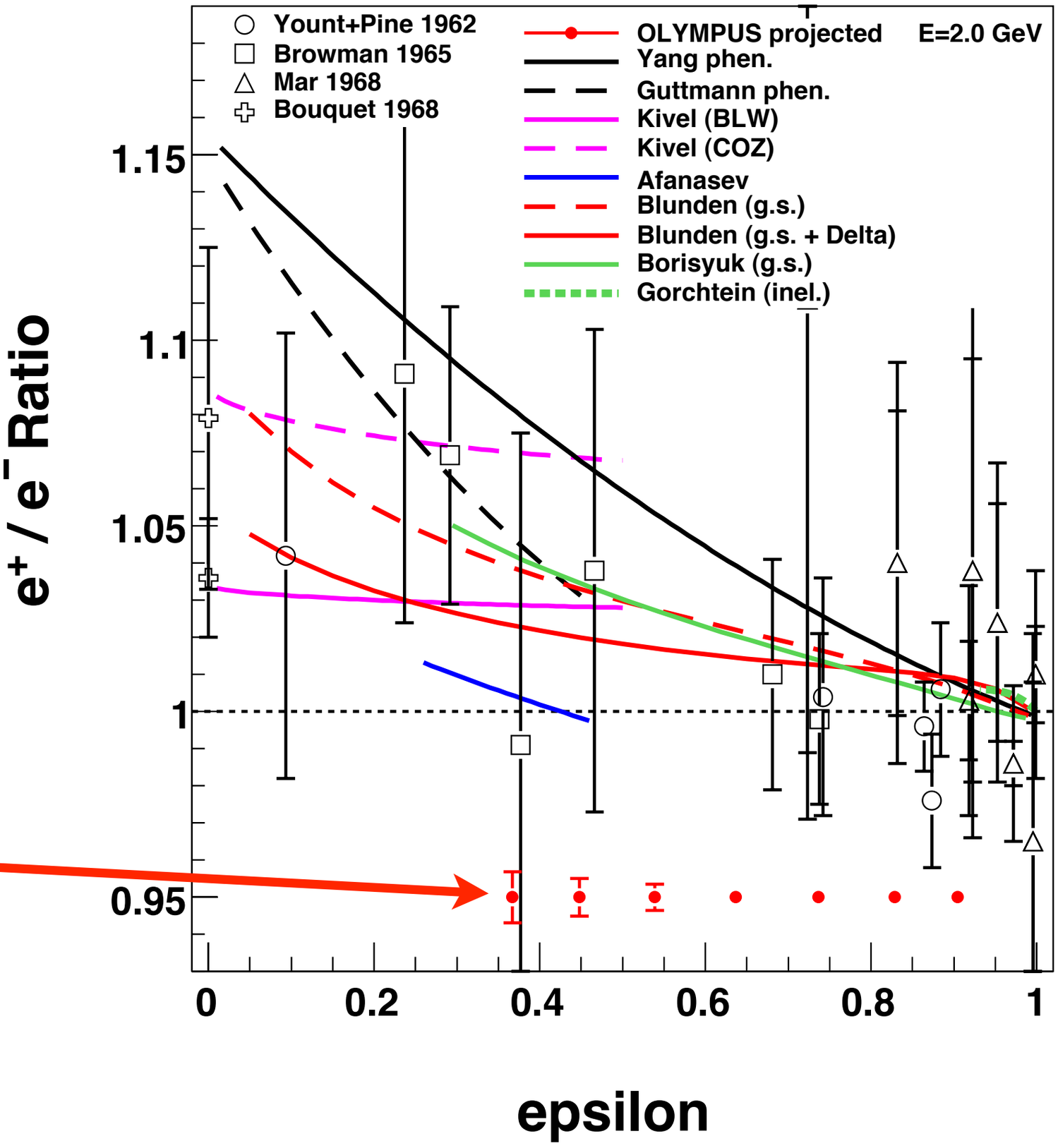
- windowless, internal gas target of pure hydrogen
- large acceptance
- left / right symmetric
- reversible magnetic field
- 1% luminosity measure

DORIS storage ring

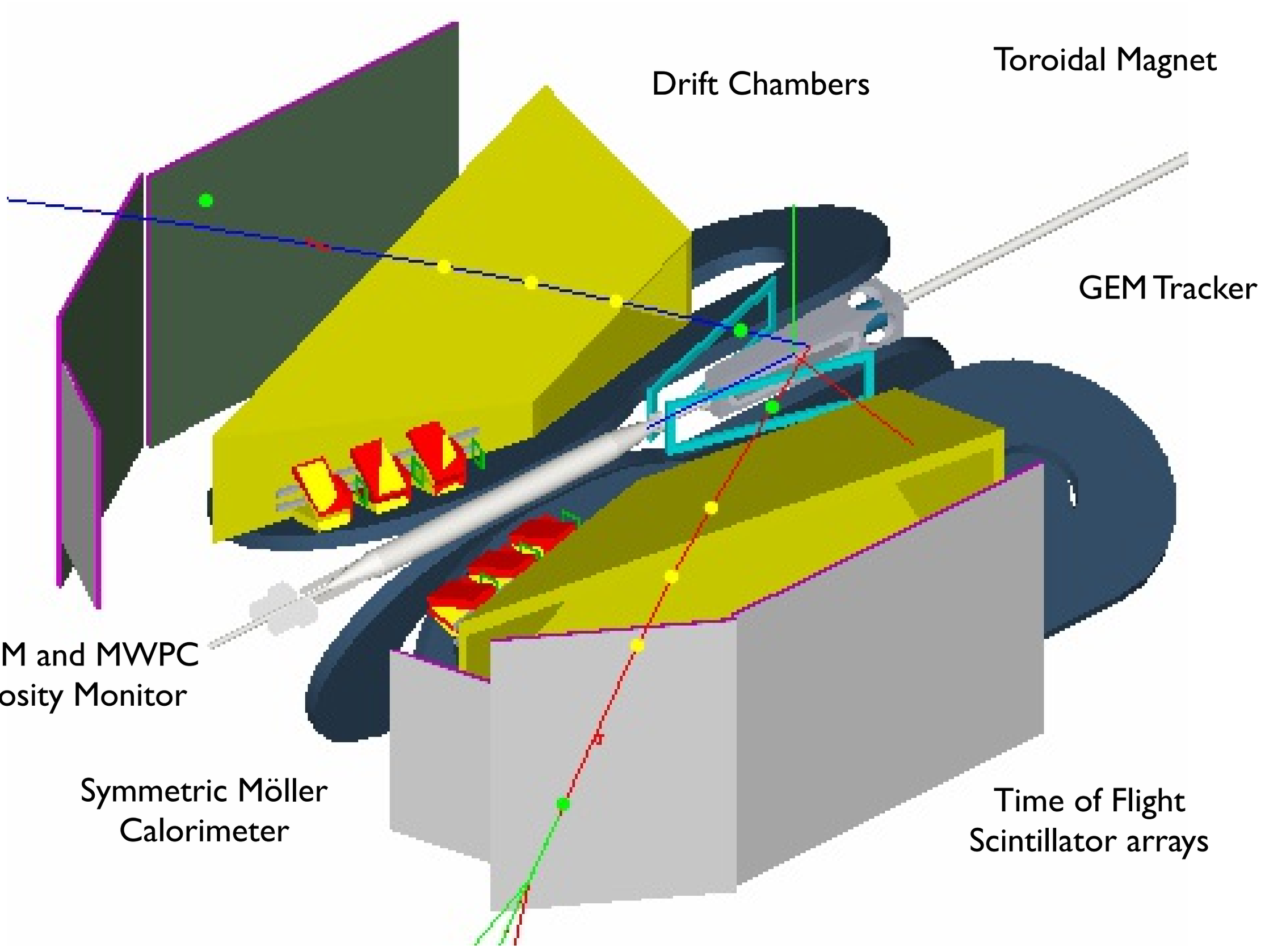
- switch e^- / e^+ frequently
- 2 GeV beam energy

Expected precision

- 2×10^{33} $cm^{-2}s^{-1}$
- 500 hours with e^+ and e^-



OLYMPUS Detector



Magnetic Toroid

Measured Magnetic Field

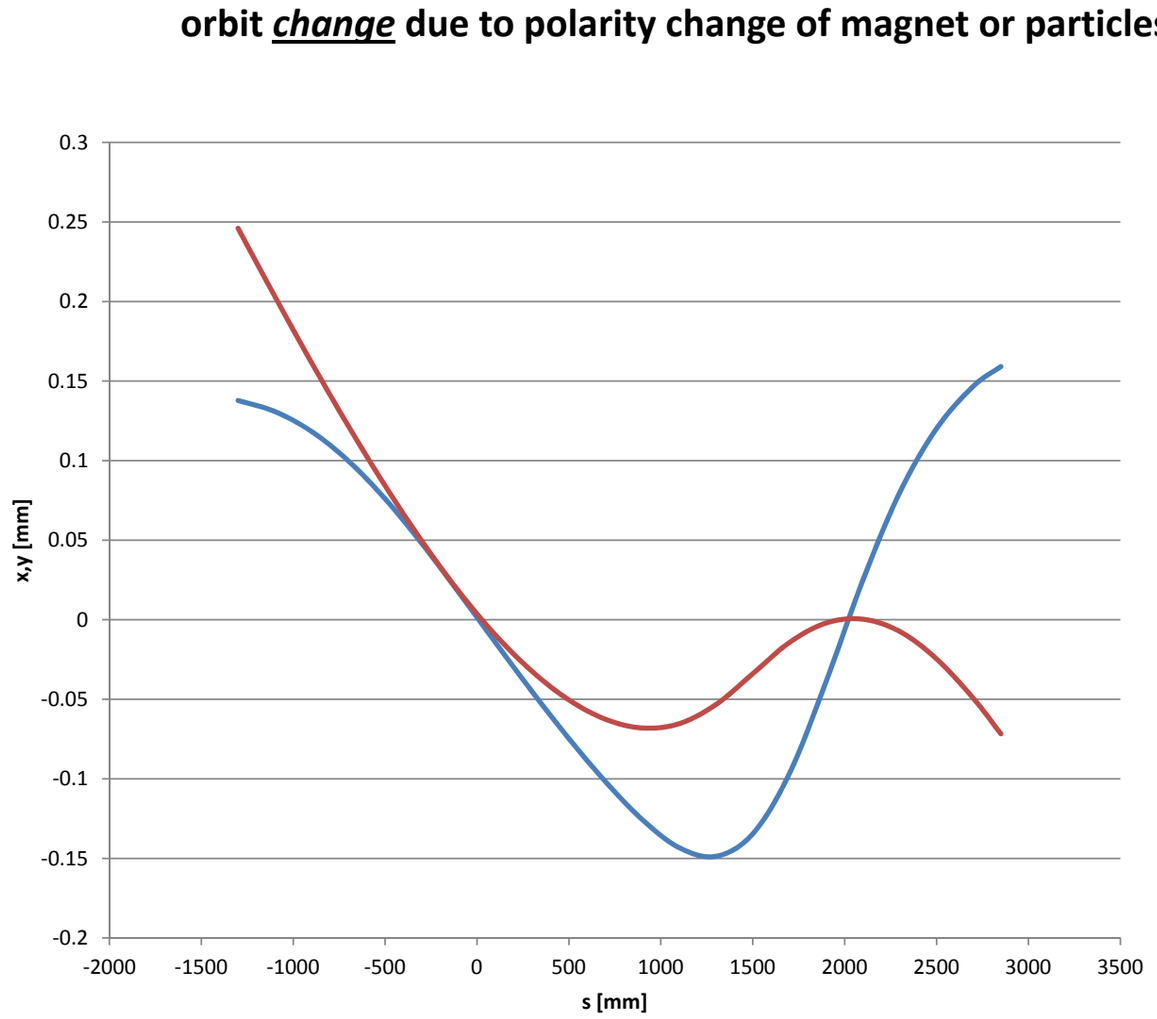
BLAST detector

- shipped from MIT-Bates last summer
- installed in park position in DORIS hall - J. Hauschildt
- cabled, powered, and water cooling installed - DESY

Magnetic field - Y. Holler

- adjusted coil positions to minimise field along beamline
- measured field on a grid in the tracking region

Effect of reversing field on beam - F. Brinker

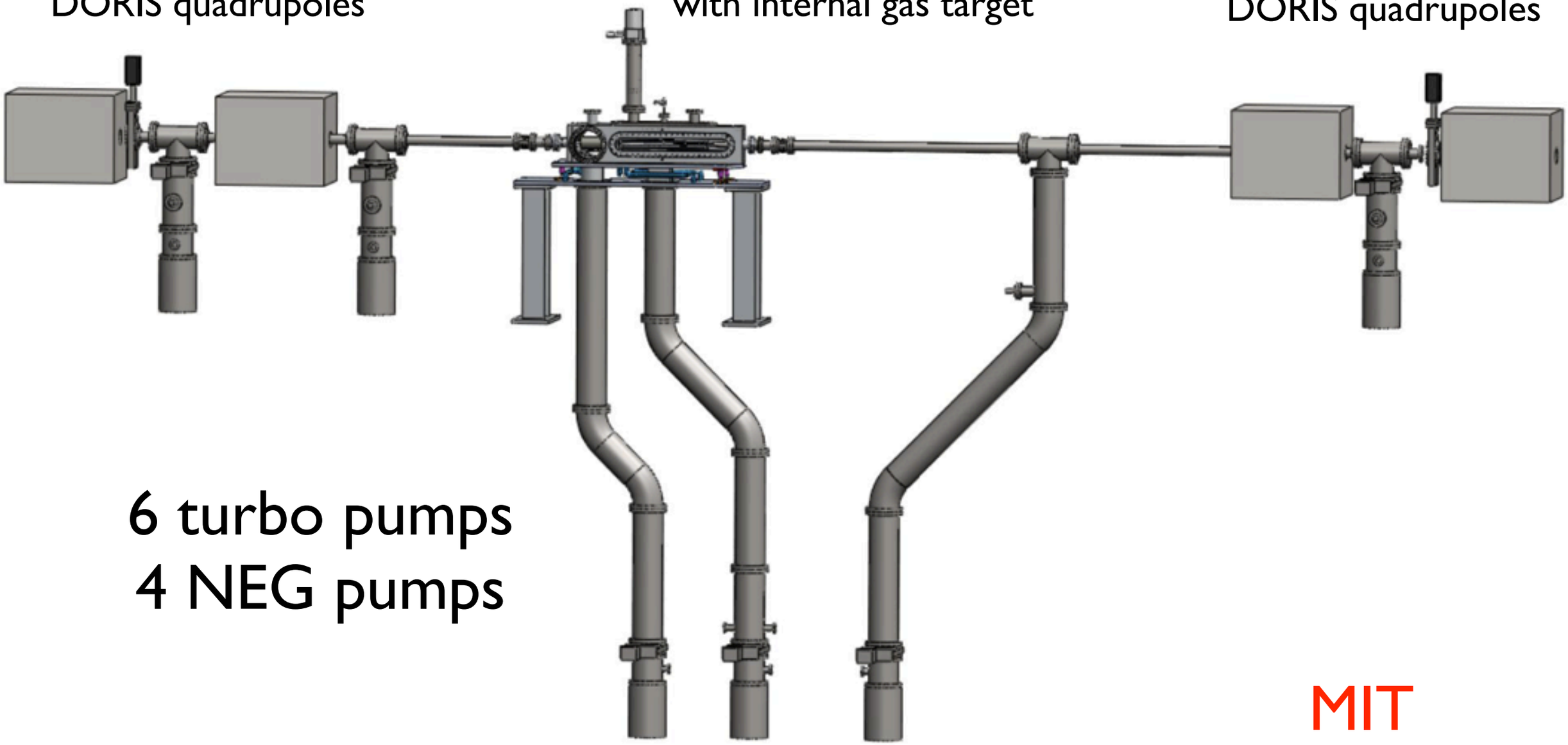


OLYMPUS Target Chamber and Vacuum

DORIS quadrupoles

Target Chamber
with internal gas target

DORIS quadrupoles



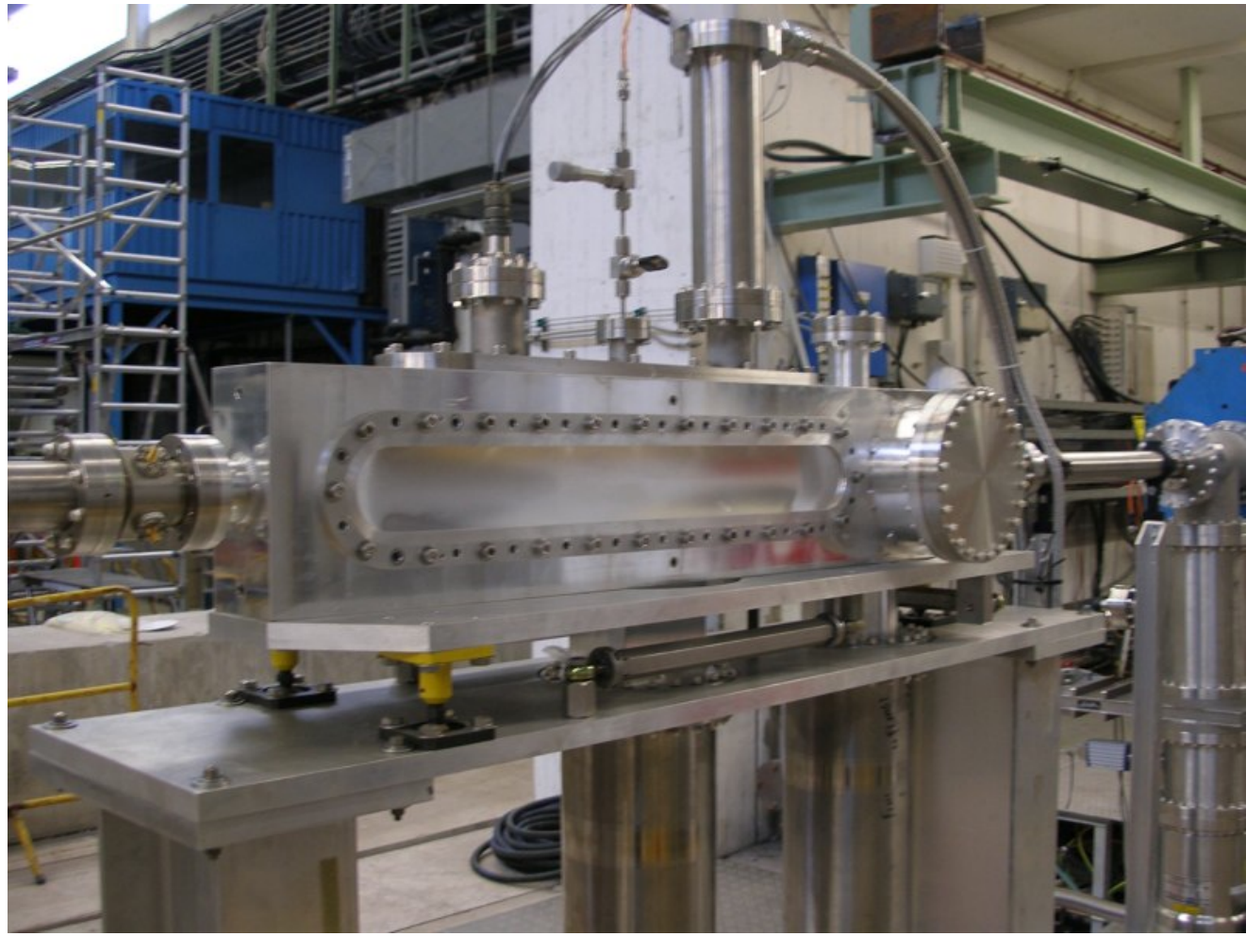
6 turbo pumps
4 NEG pumps

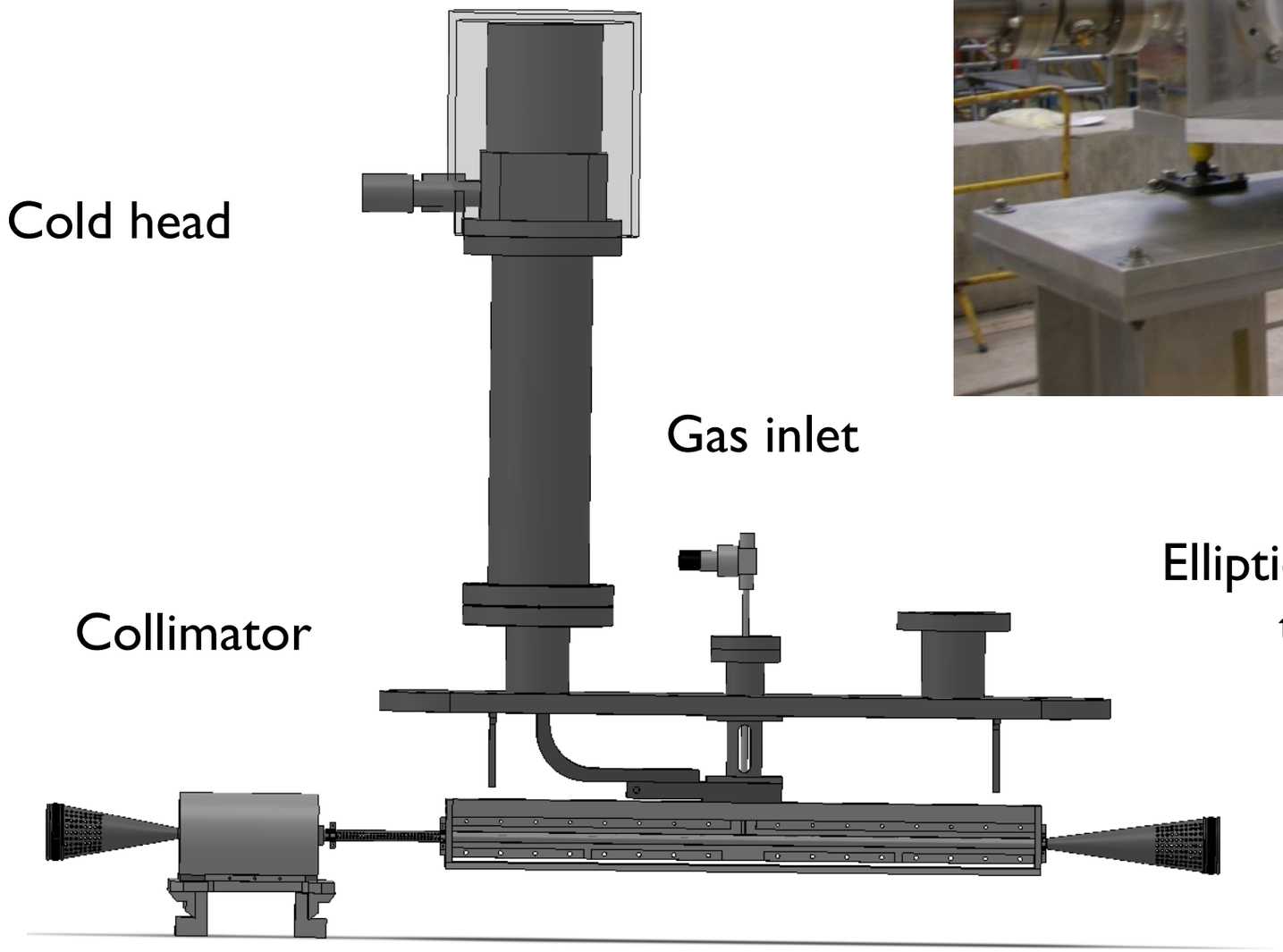
MIT

OLYMPUS Target Chamber and Vacuum

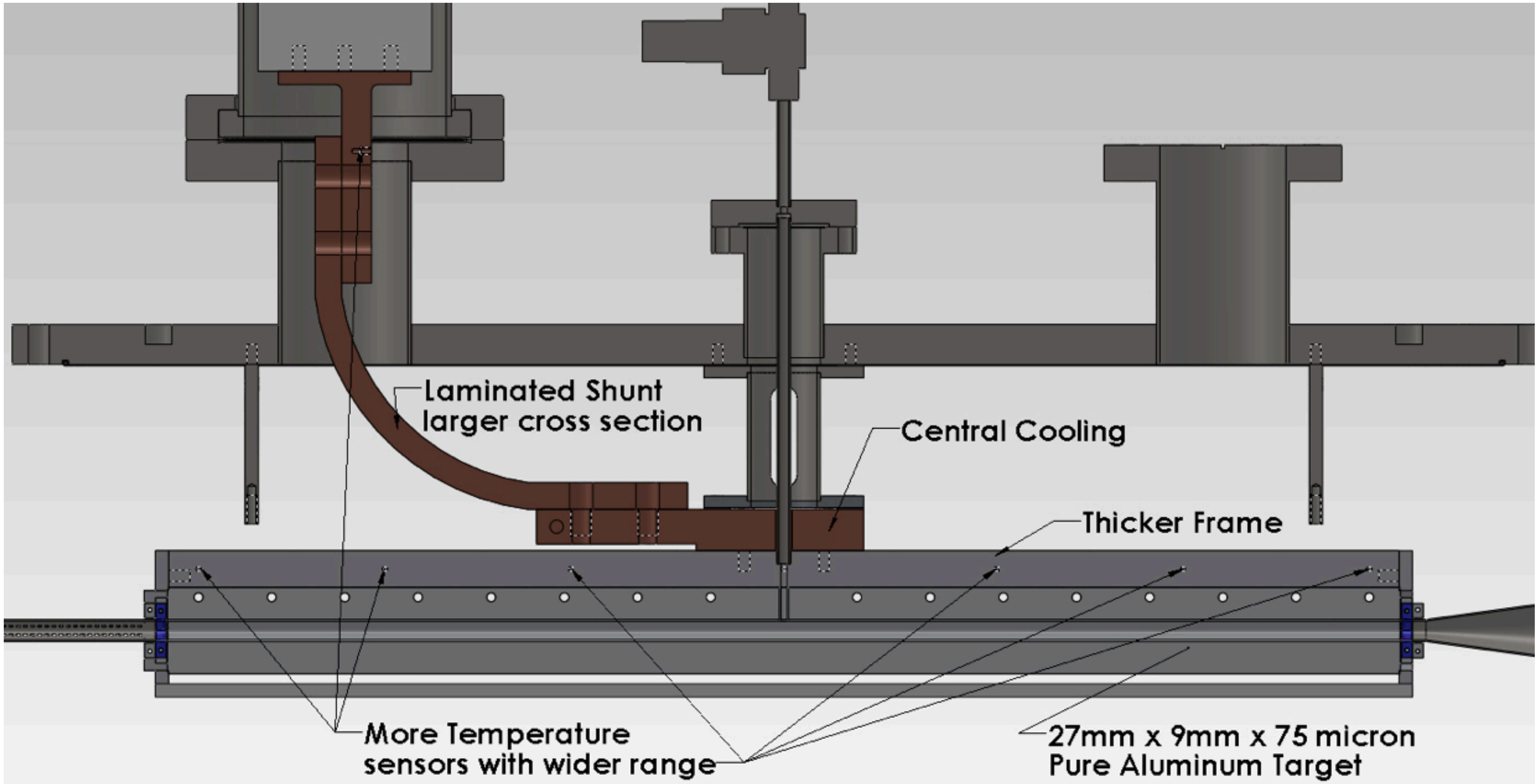
Target chamber, beamline, and vacuum system

- installed and operational January, 2011

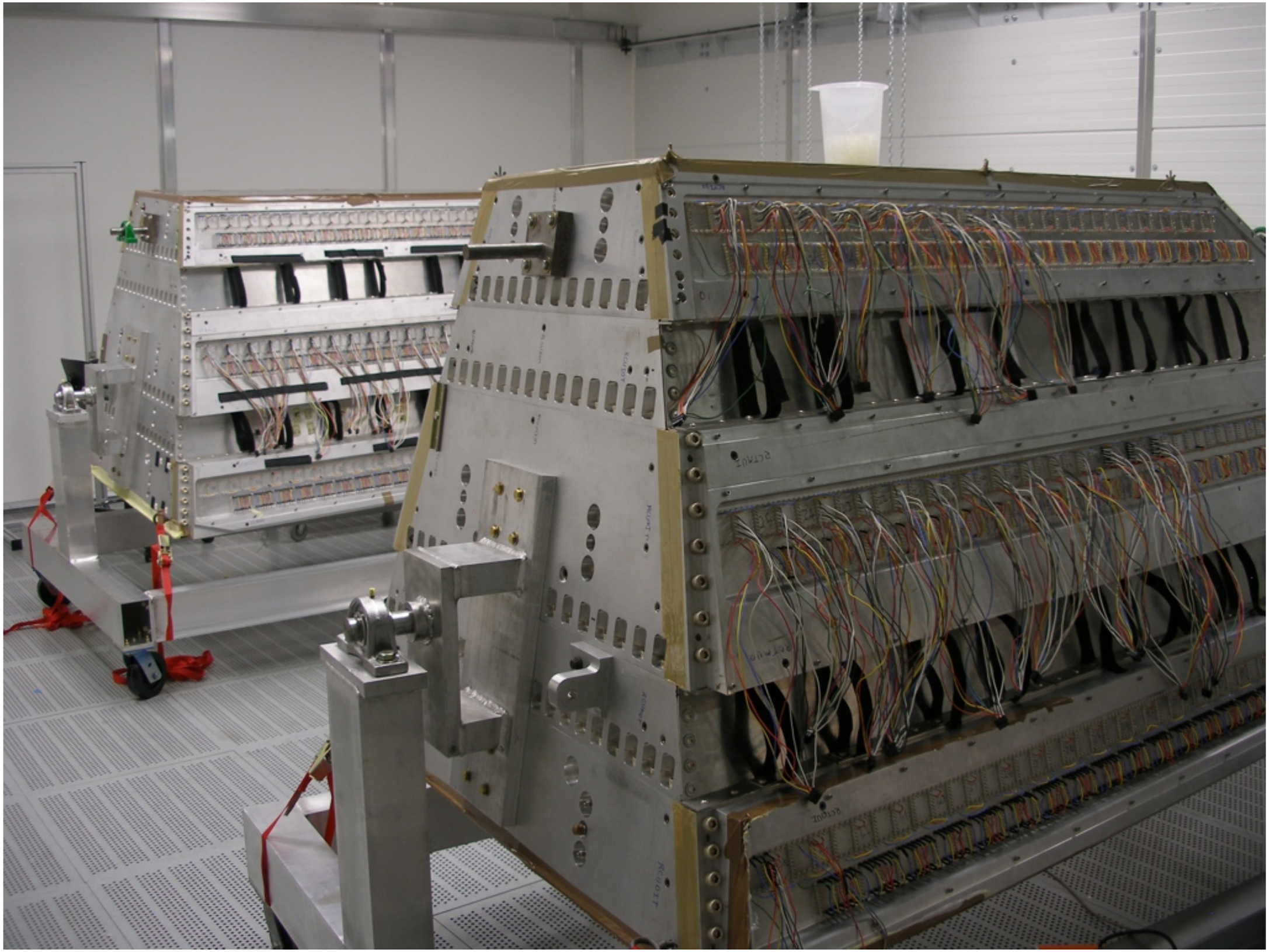




OLYMPUS Target Cell



Wire Chambers from BLAST - MIT



Wire Chamber

All chambers completely reconditioned

- shipped to DESY and fully re-wired last summer
- new windows and seals
- improved HV distribution
- better cooling for front-end electronics

First chamber moved to DORIS hall 15 April, 2011

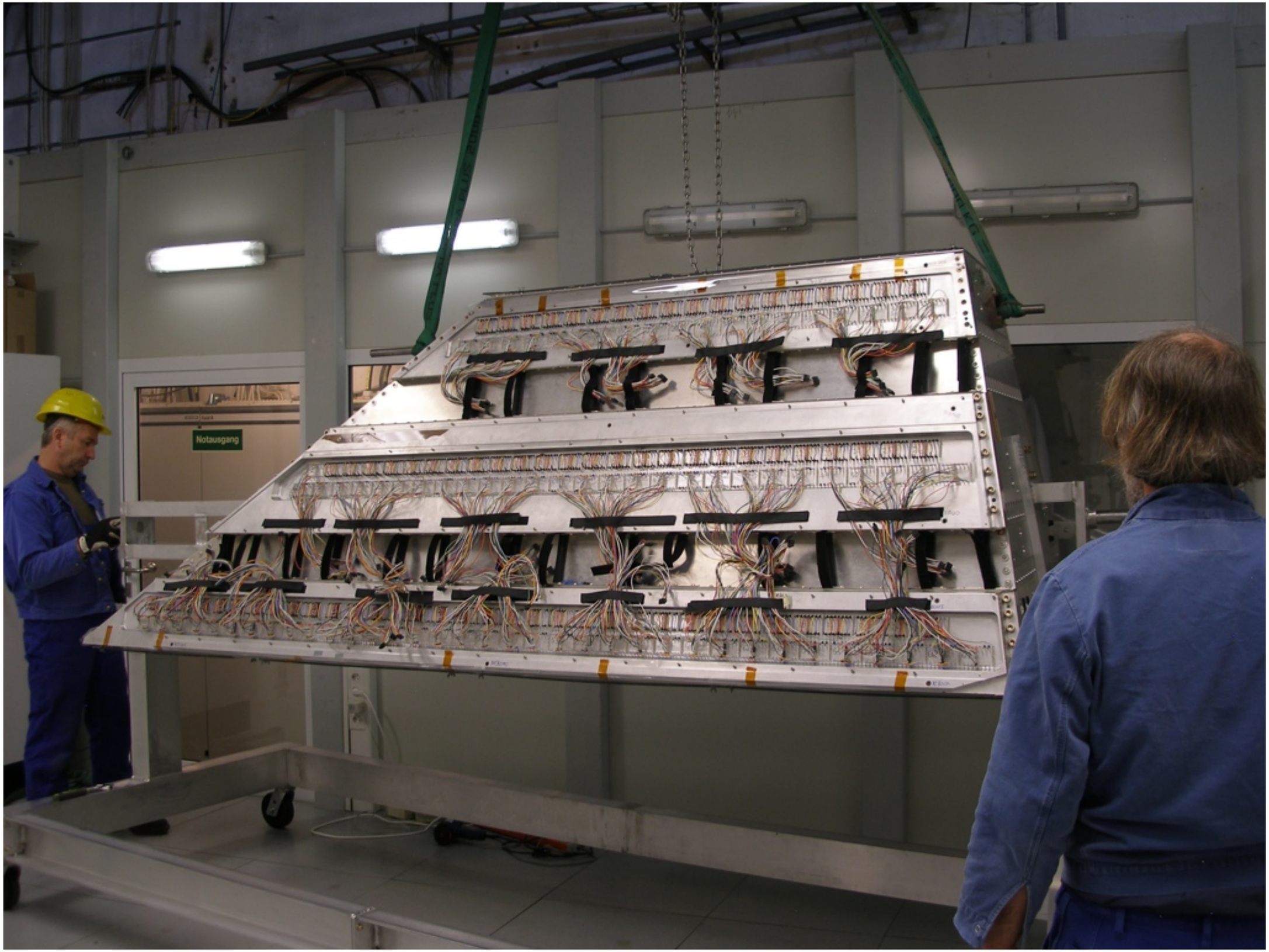
- gas now flowing, no leaks, HV conditioning underway
- signals seen

Second chamber ready and waiting in the clean room

Schedule

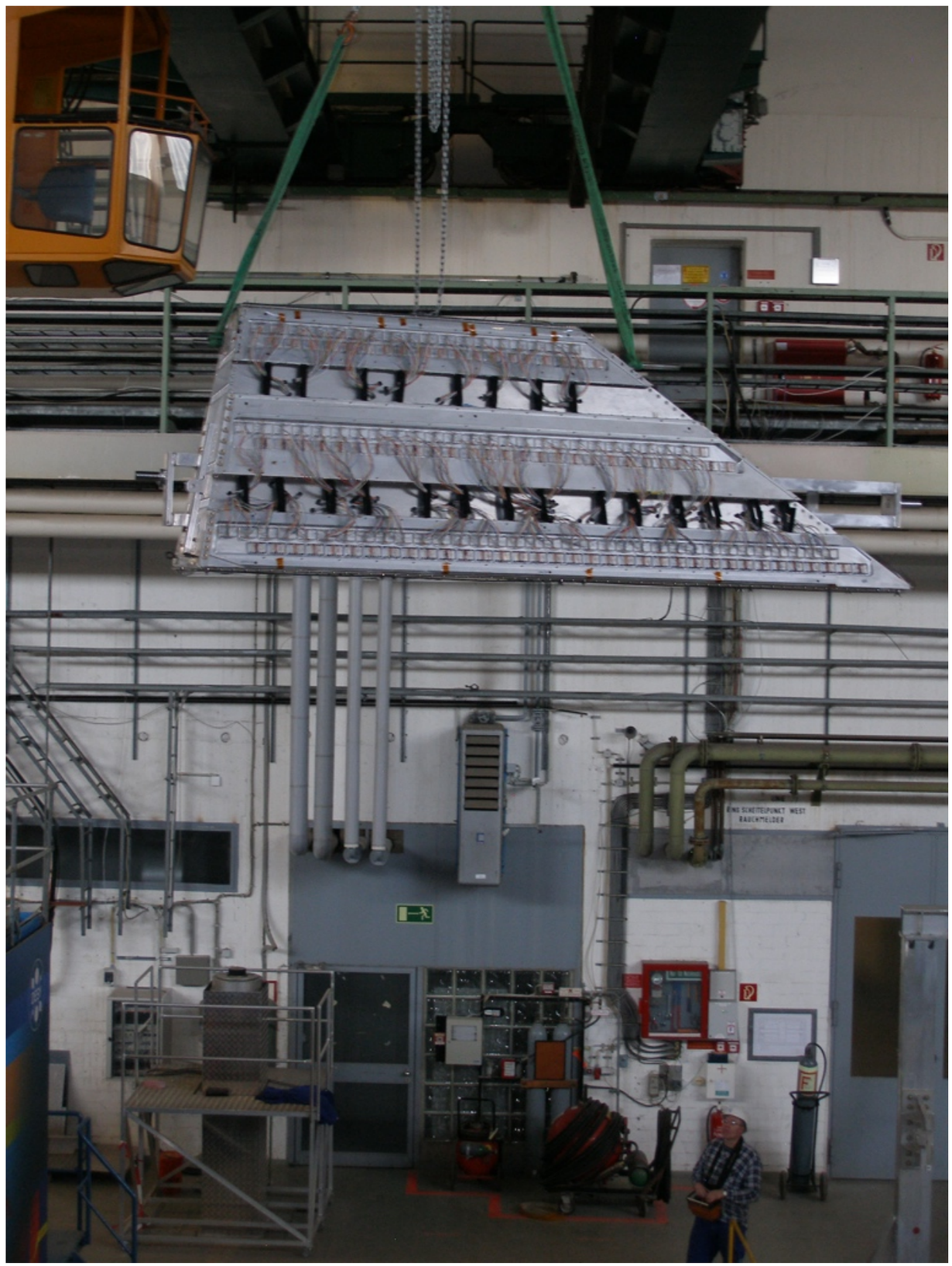
- mount both chambers into OLYMPUS middle of May
- re-connect gas and leak check
- mount front-end electronics and cable
- test and calibrate until installation
- 5 graduate students coming from mid-May until installation

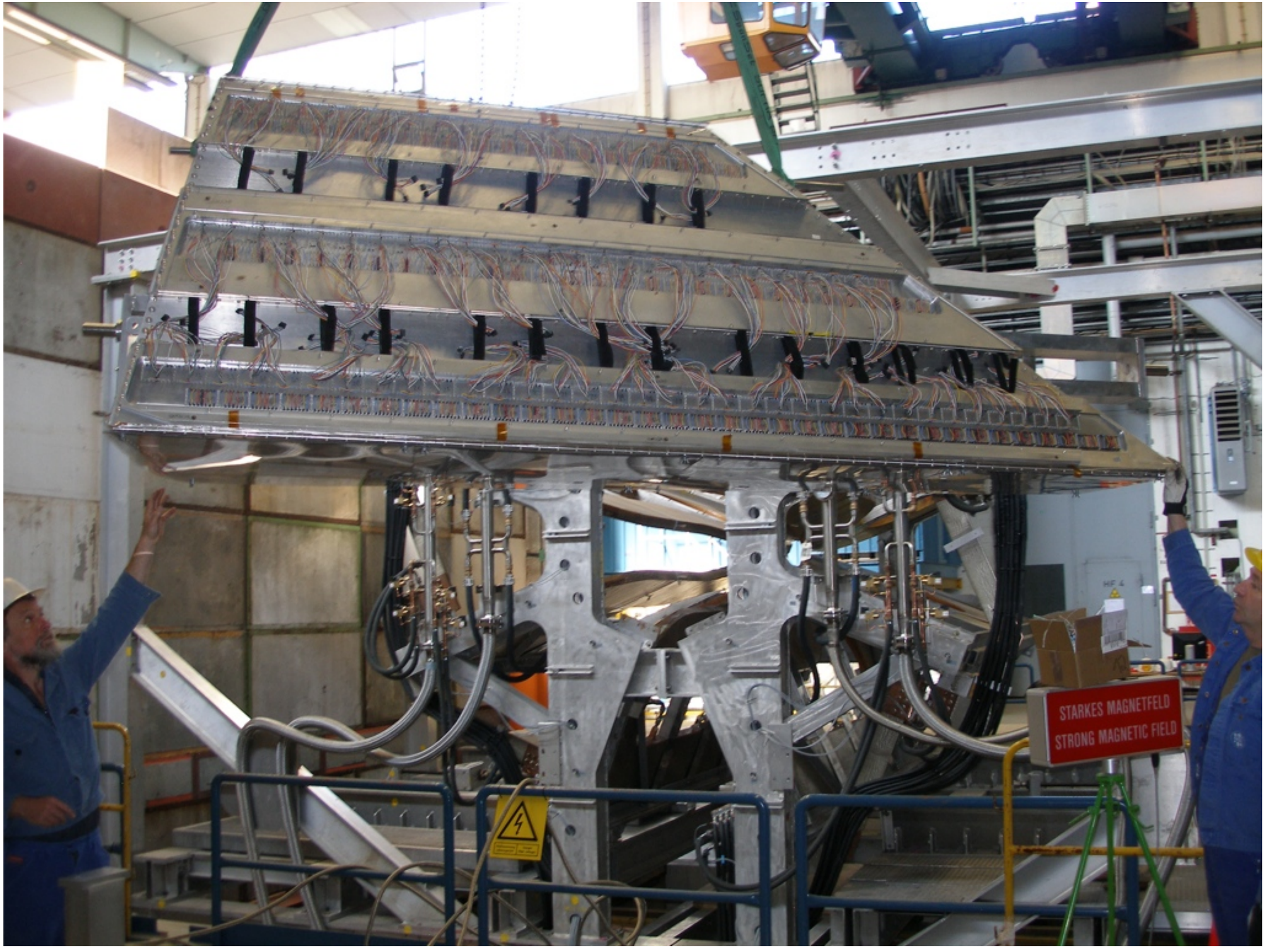
First Wire Chamber Moved to DORIS



Wire Chamber Move to DORIS

Wire Chambers in DORIS Hall




STARKES MAGNETFELD
STRONG MAGNETIC FIELD

GEM Tracker - MIT

Mechanical design started

- 90 x 30 cm^2 active area
- substantial frame to hold foils flat
  - will investigate with plain Kapton foils

Discussion with firm Tech-Etch to produce GEM foils

- largest possible 55 x 50 cm^2 probably
- not big enough, need to have gap in GEM tracker

Discussion with Tech-Etch to produce 2D readout boards

- line and pad design with vias
- stereo readout geometry

Design by June - July
Produce and test by November
Install before January run.

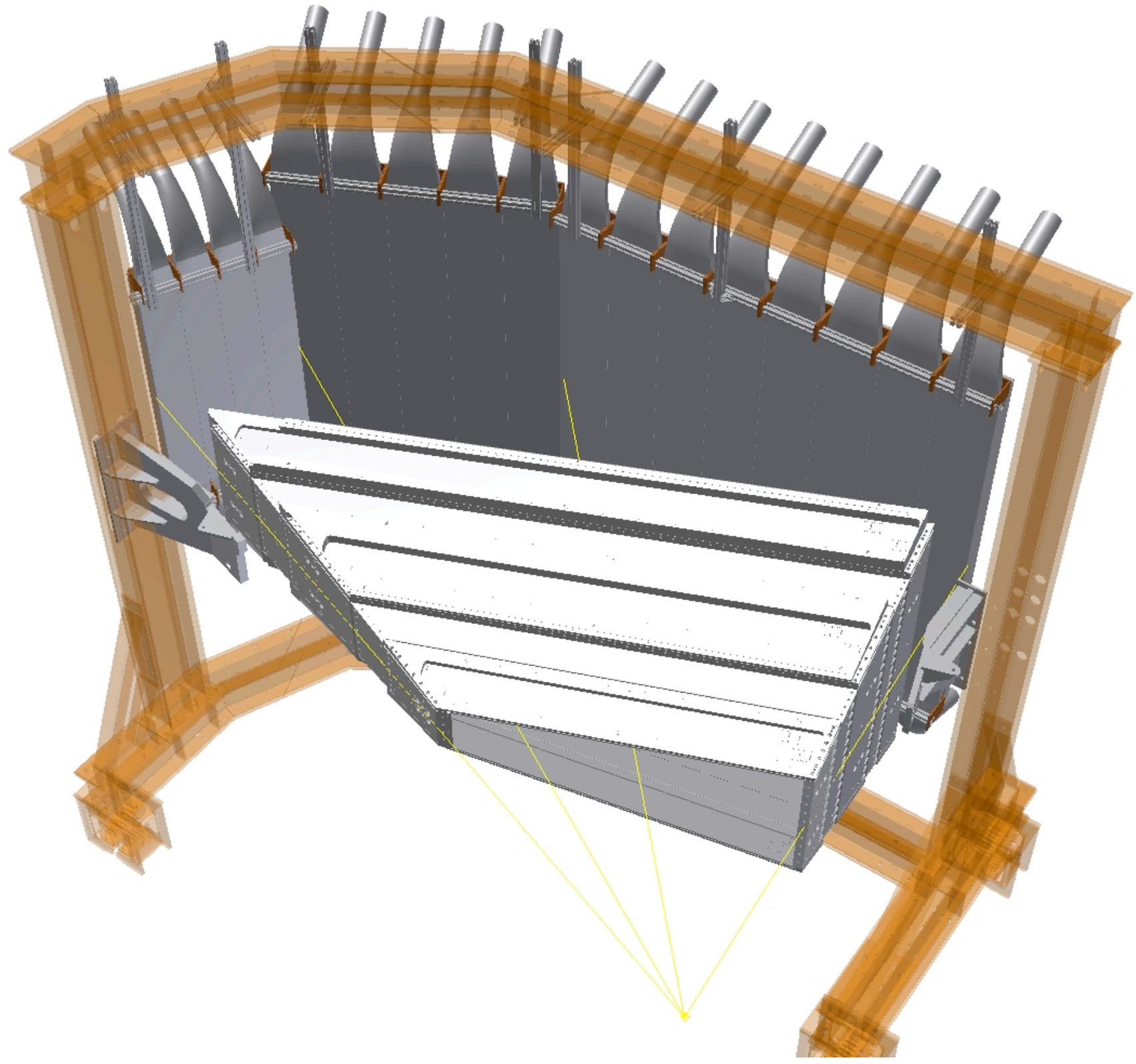
Time of Flight Scintillator Array

From BLAST detector

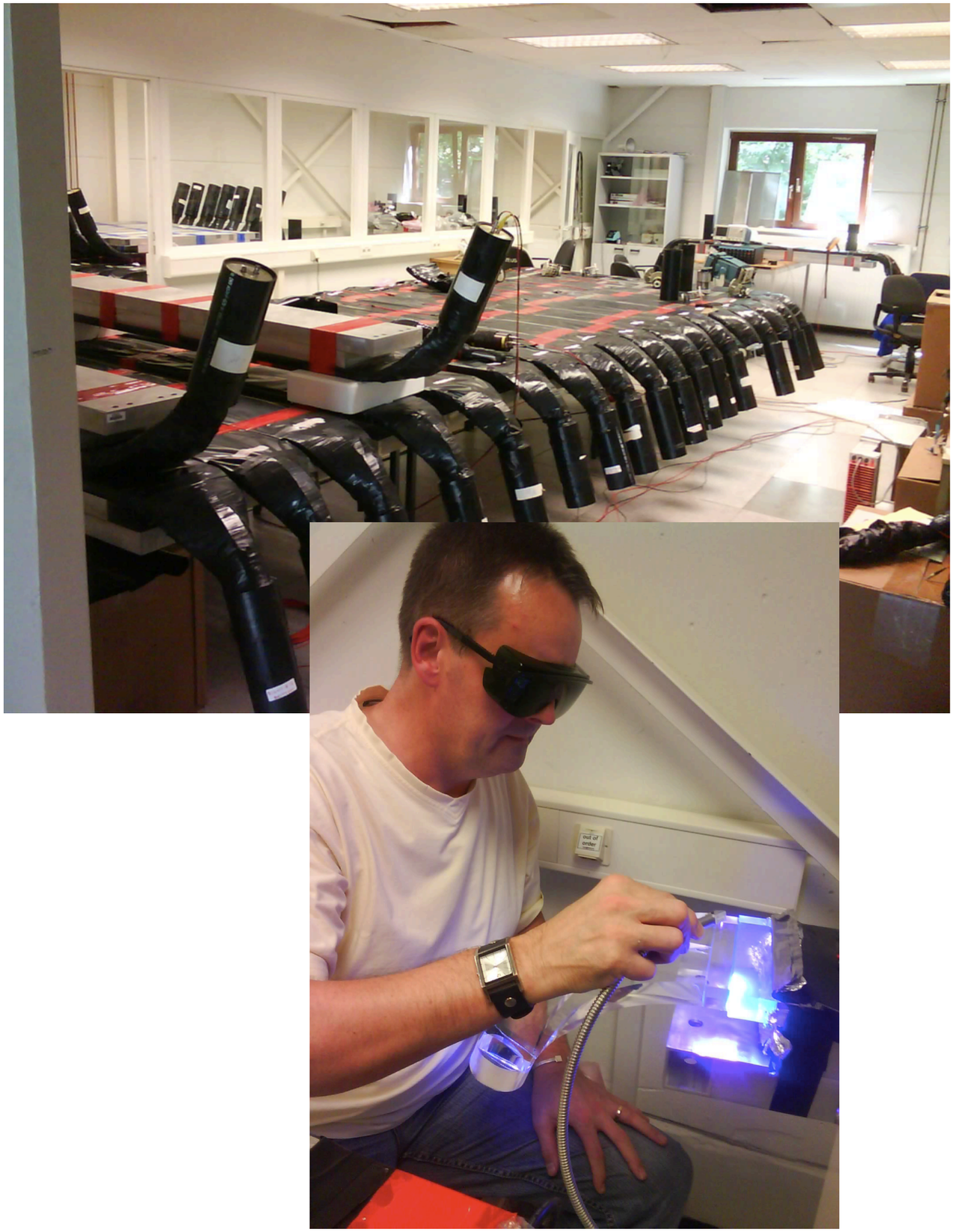
Situated behind wire chambers

Provide trigger and relative timing

Glasgow and Yerevan



Time of Flight

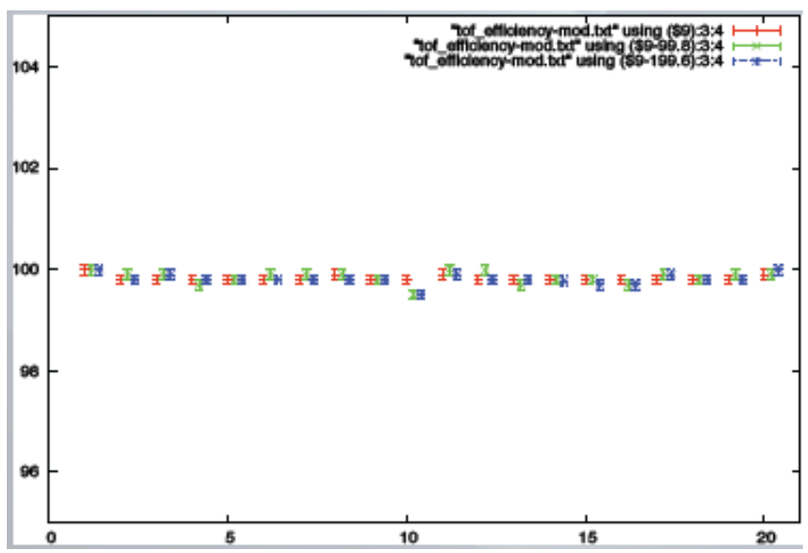


Reconditioned last summer

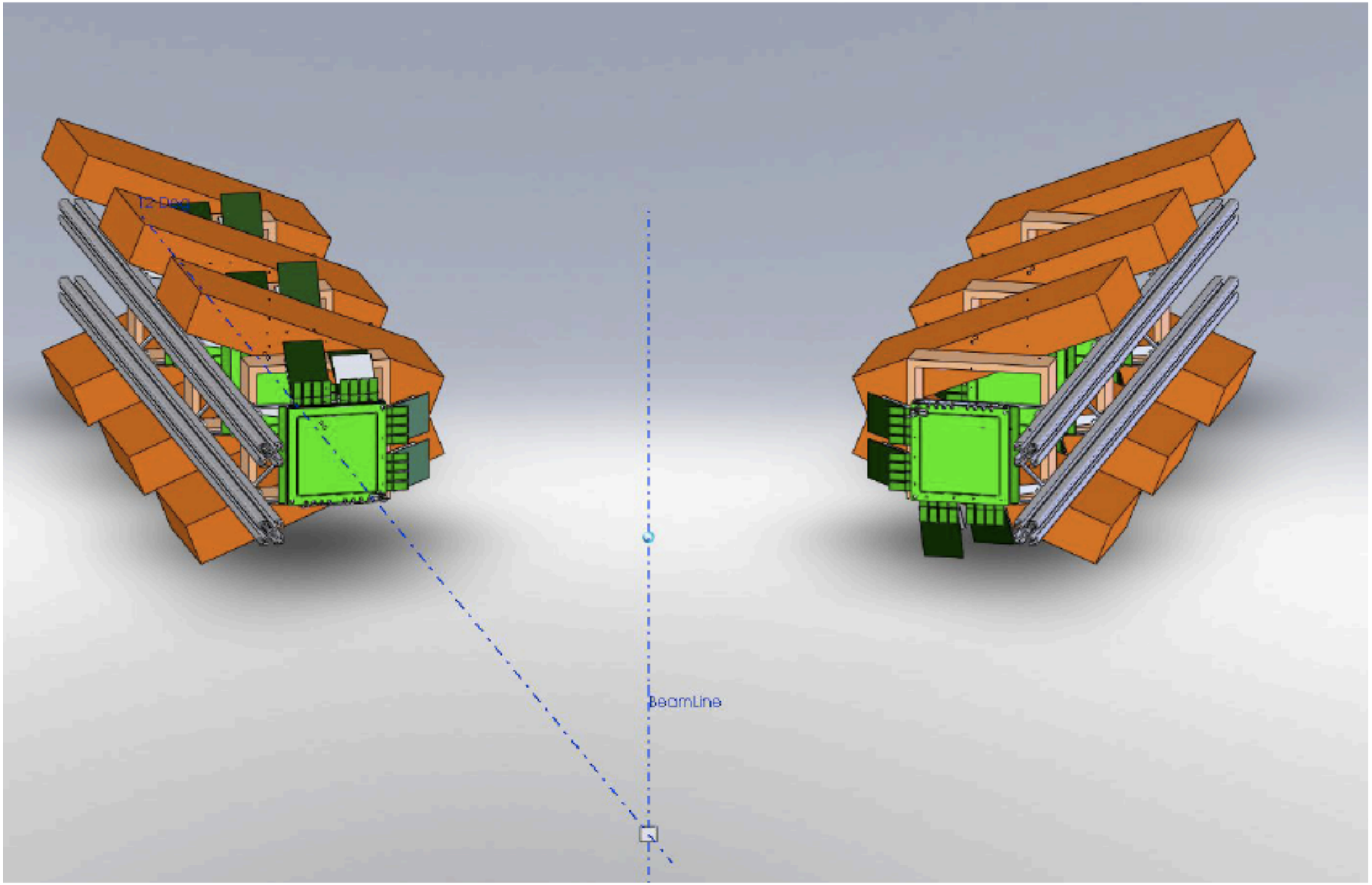
- rewrapped
- mounted PMTs
- tested with HV and measured efficiency to be >99%
- working on laser flasher system
- 39 TOF bars ready
  - 34 needed for OLYMPUS

Install in OLYMPUS detector

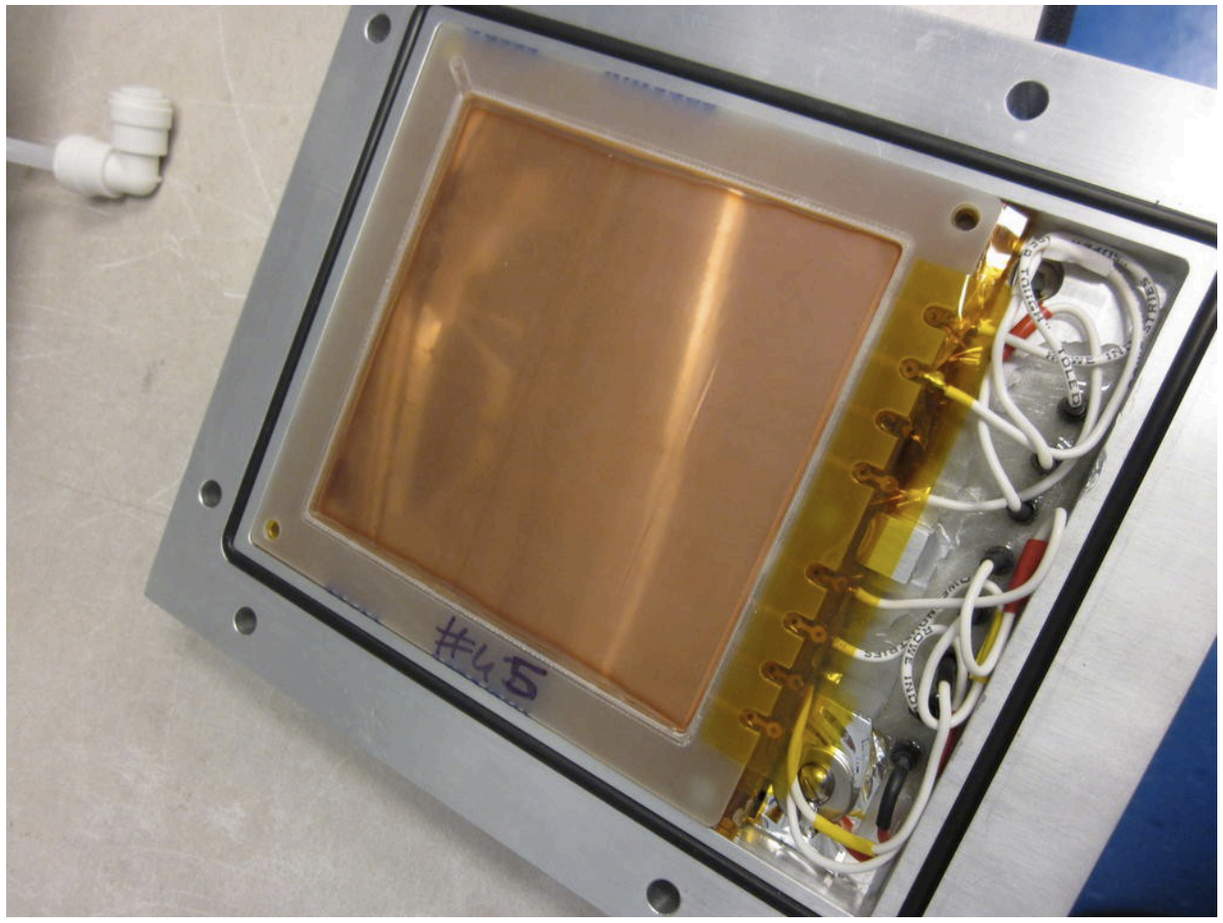
- starts next week
- finish mid-May



12° GEM and MWPC Luminosity



12° GEM Luminosity Monitor



Hampton University

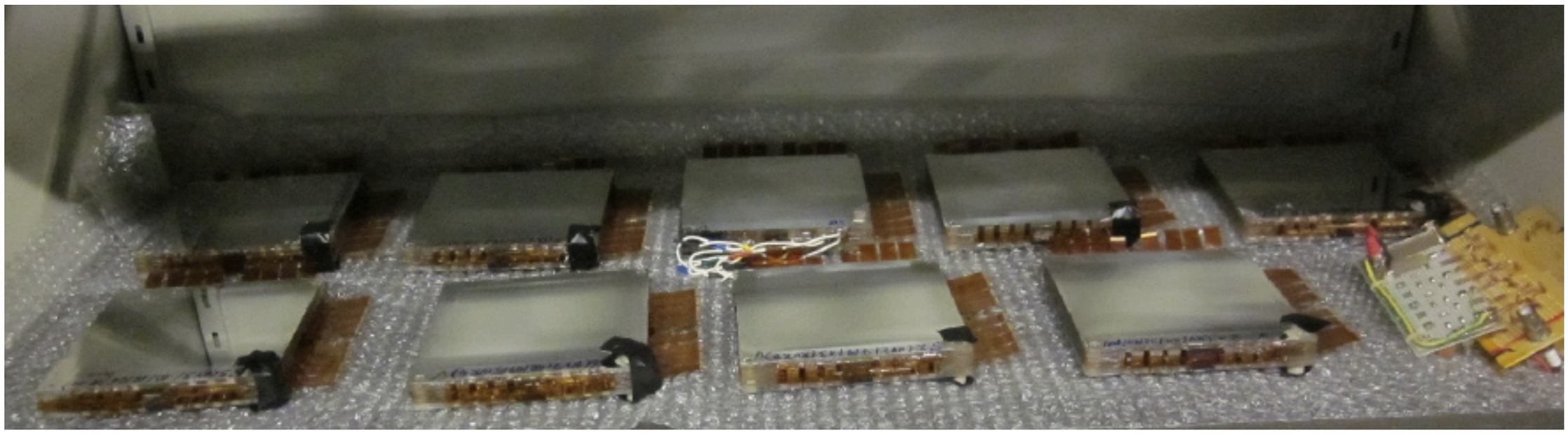
- 10 x 10 cm^2 triple GEM
- 400 micron pitch XY readout

Need 6 for OLYMPUS

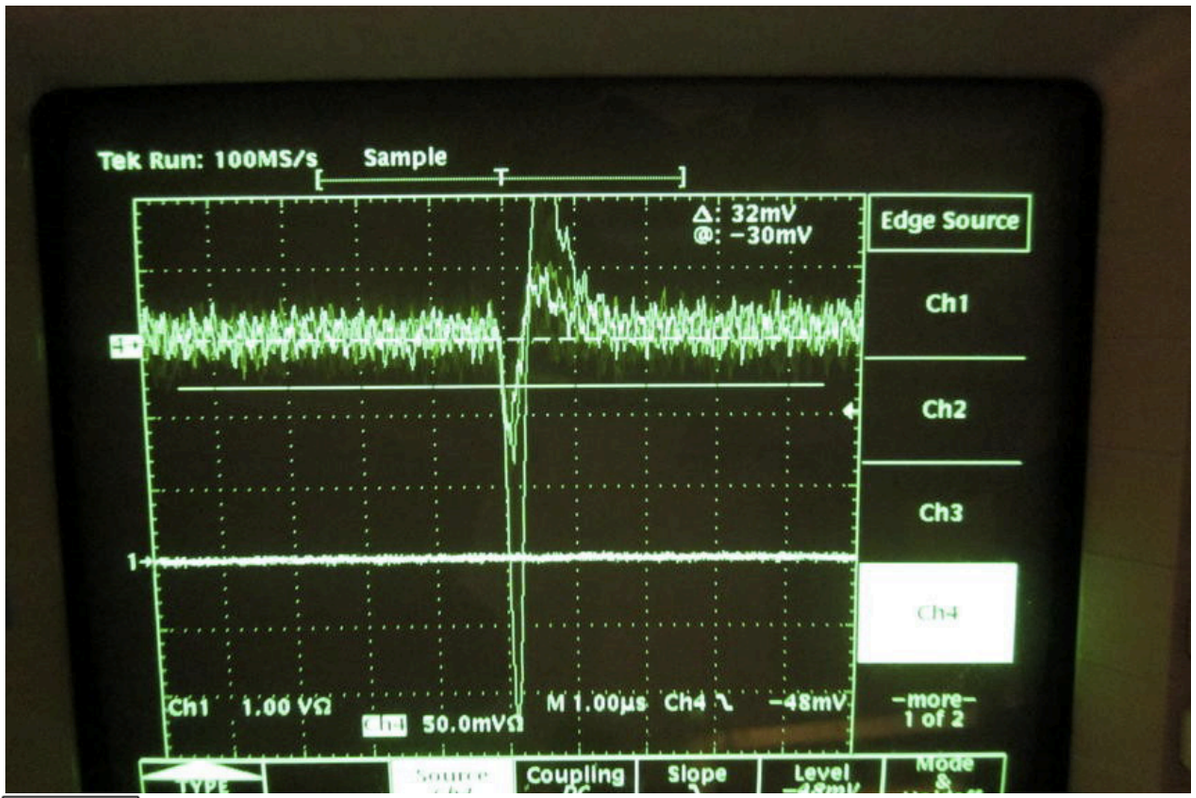
- have 9 working at DESY

Test in Hall 2 test beam

Install early July



12° GEM Luminosity Monitor

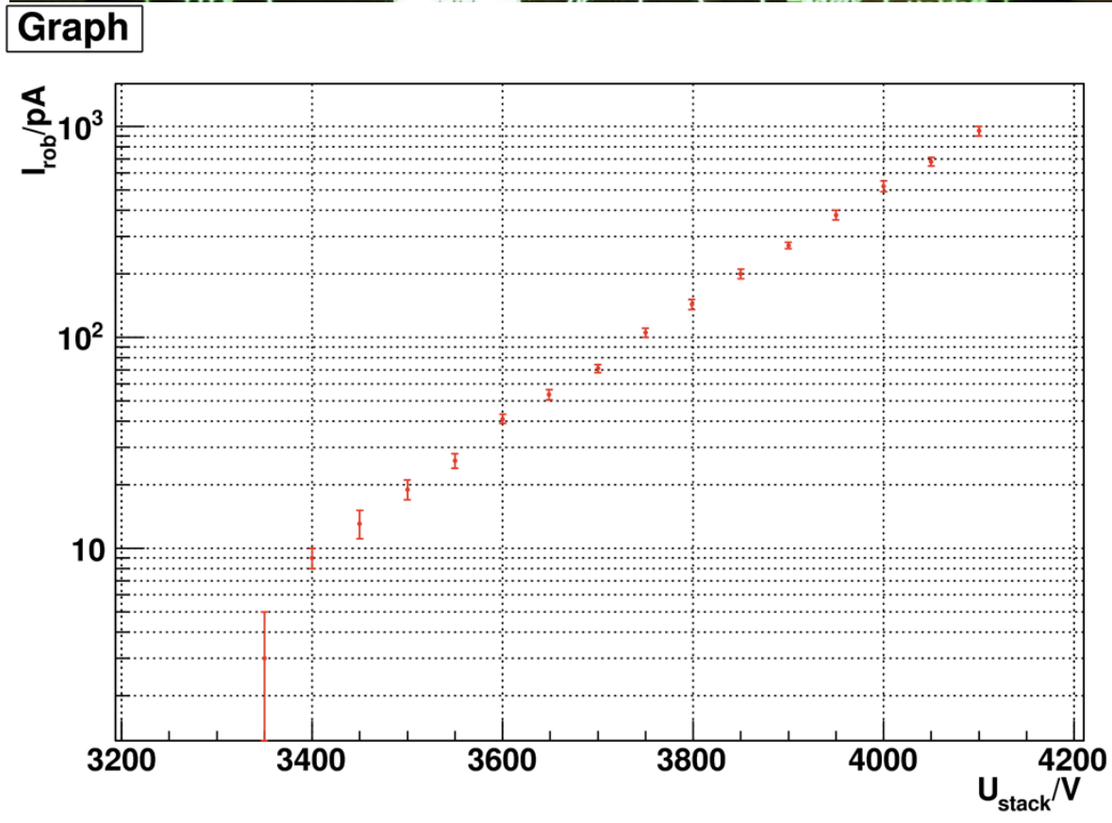


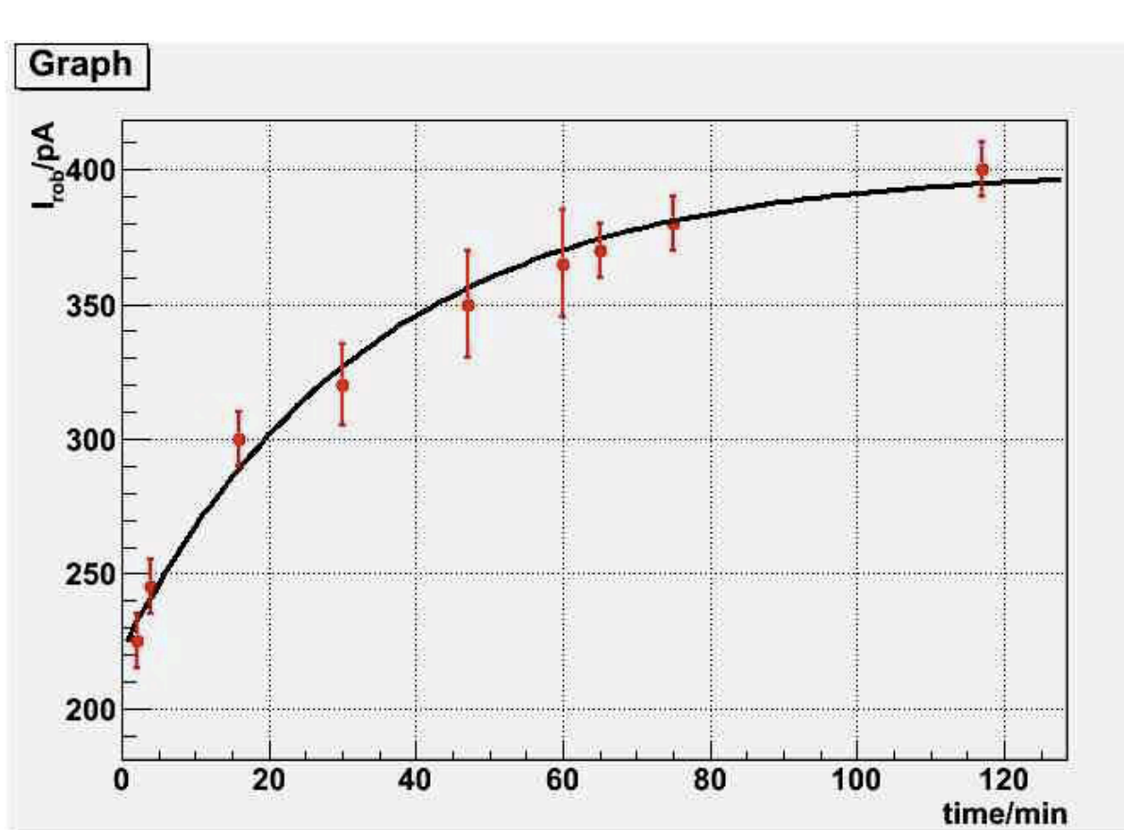
Signals seen

Gain measured versus HV

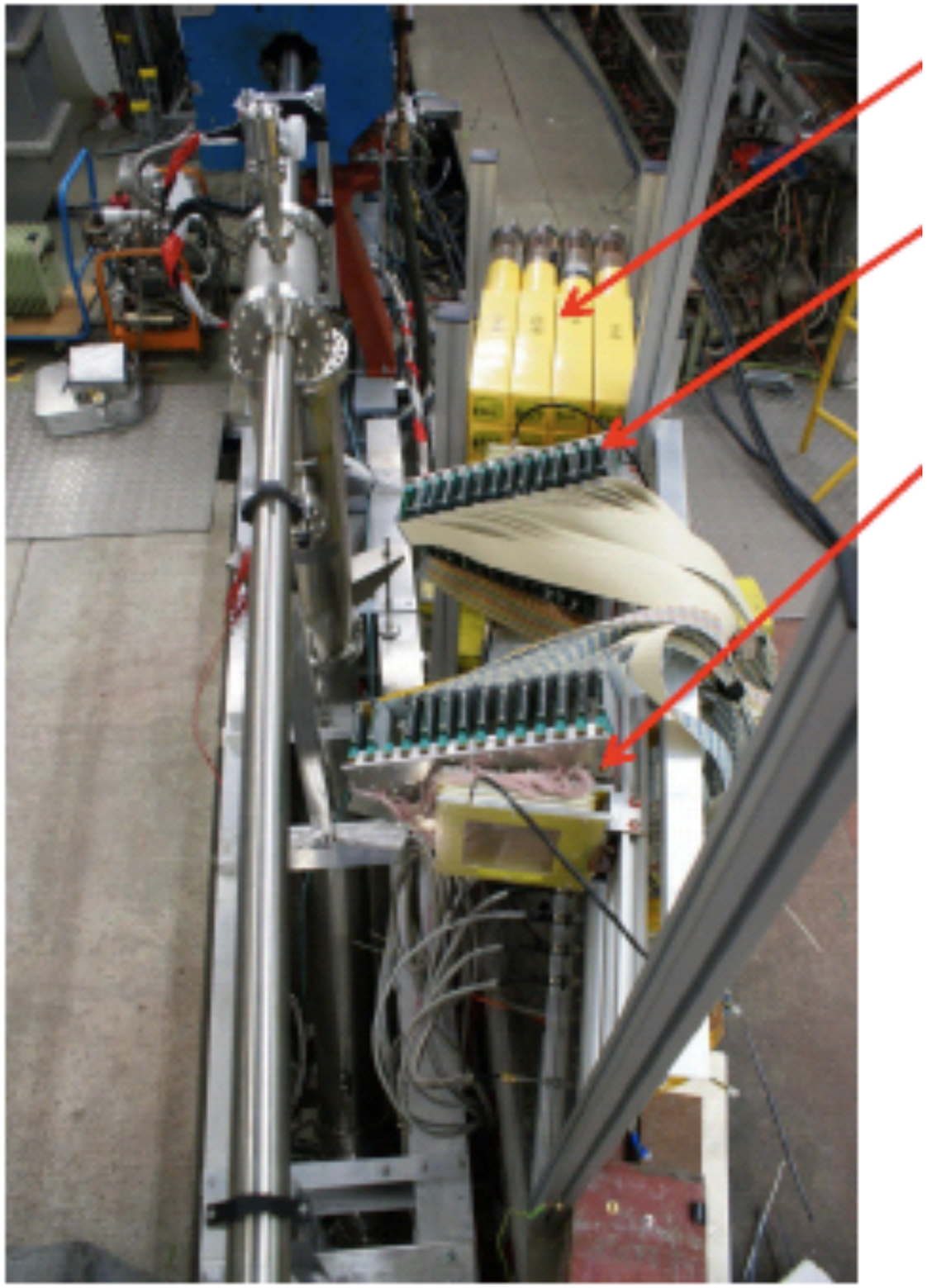
Gain increase as expected

Readout from INFN



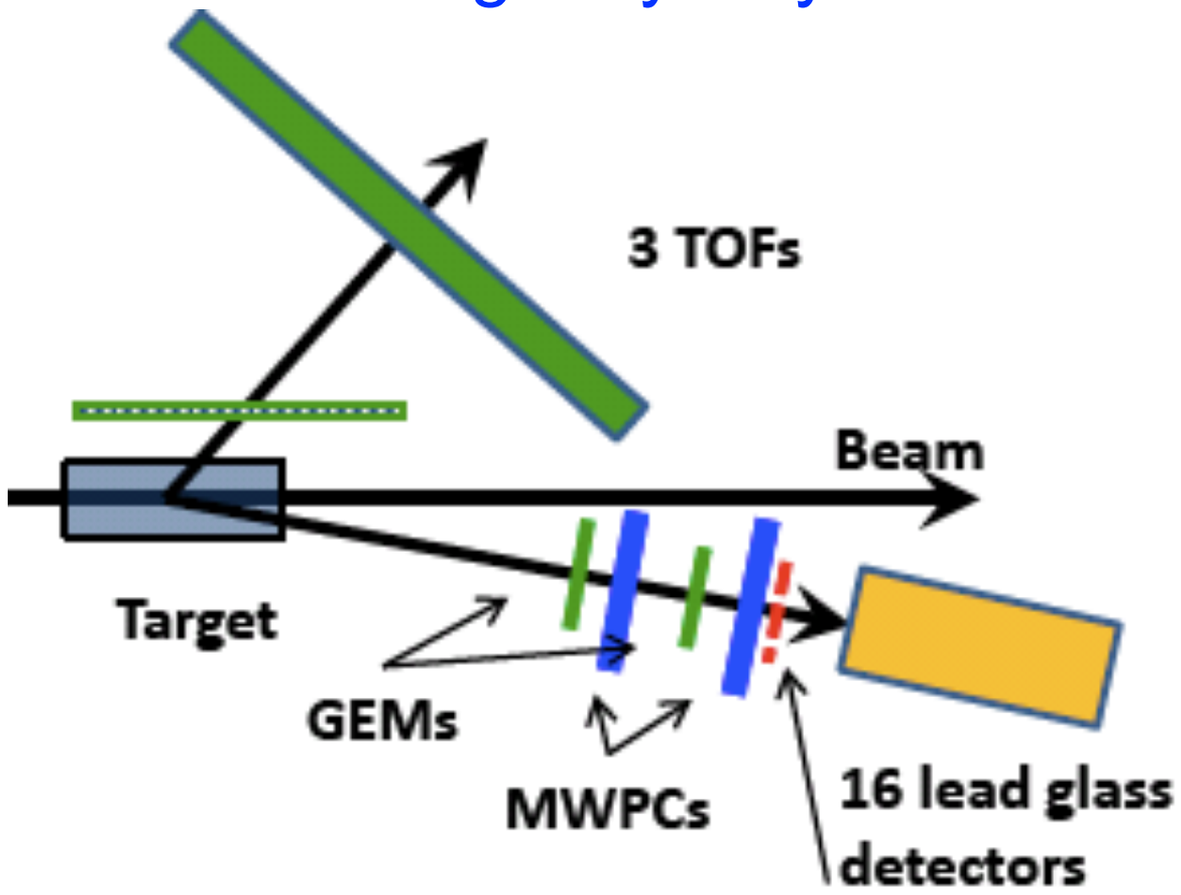


12° Multi Wire Proportional Chambers

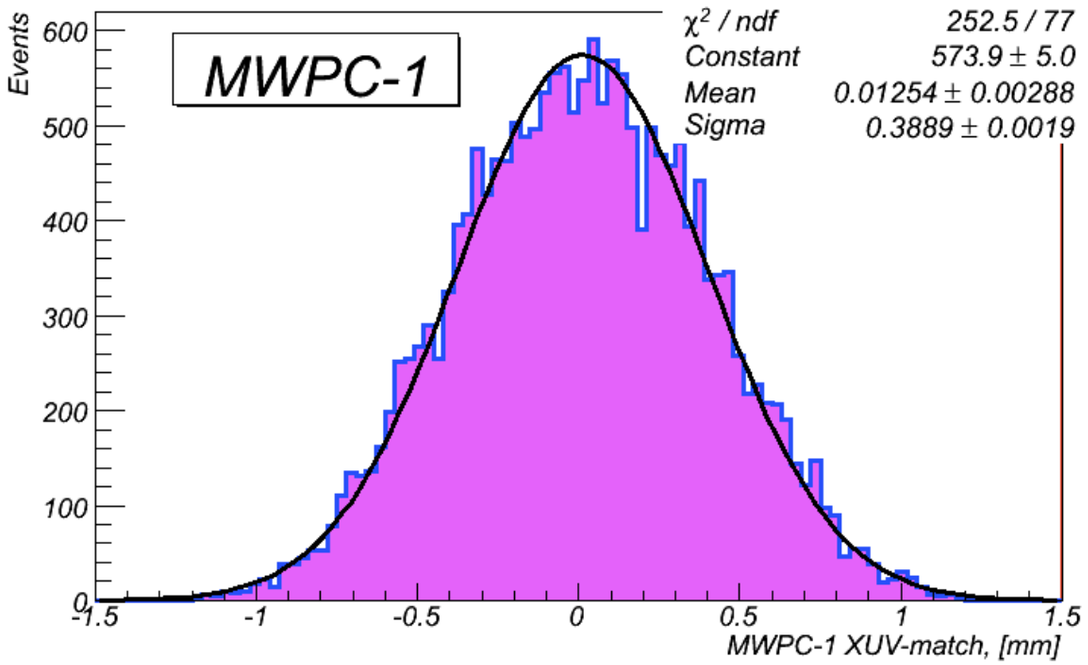


From PNPI

- X,U,V planes, 1 mm spacing
- 2 used in February ring run
- 864 channels
- CROS3 (Gatchina) readout
- 3 chambers here
- remaining 3 by July



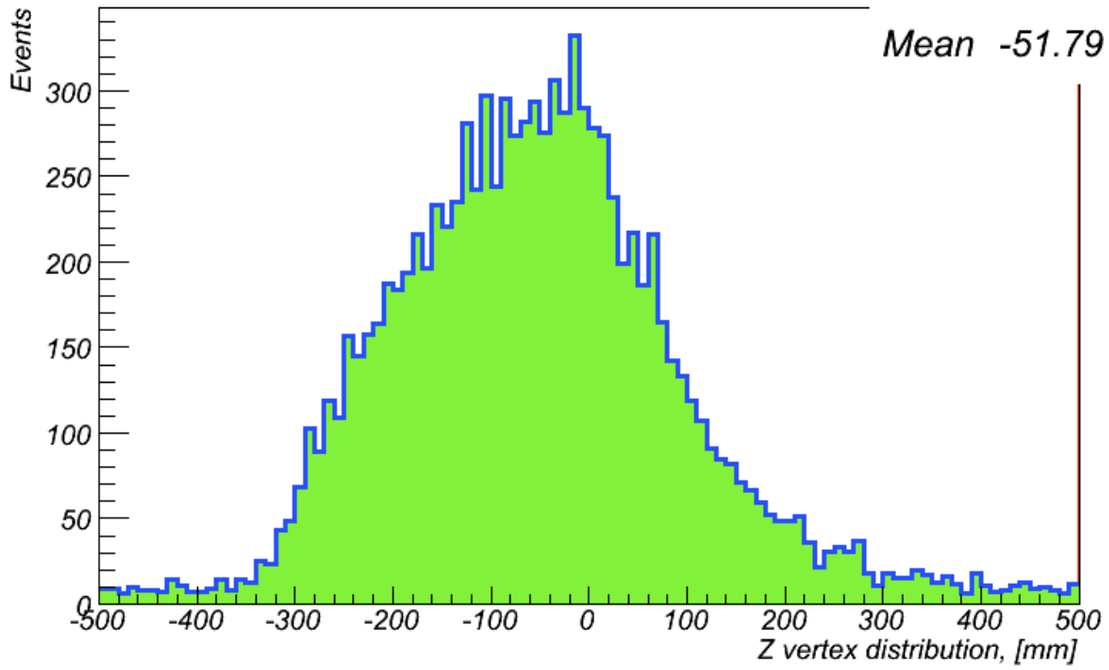
12° MWPC Luminosity Monitor



Reconstruct X from UV planes

- σ = 390 micron

Reconstruct event vertex in ring run (more later)

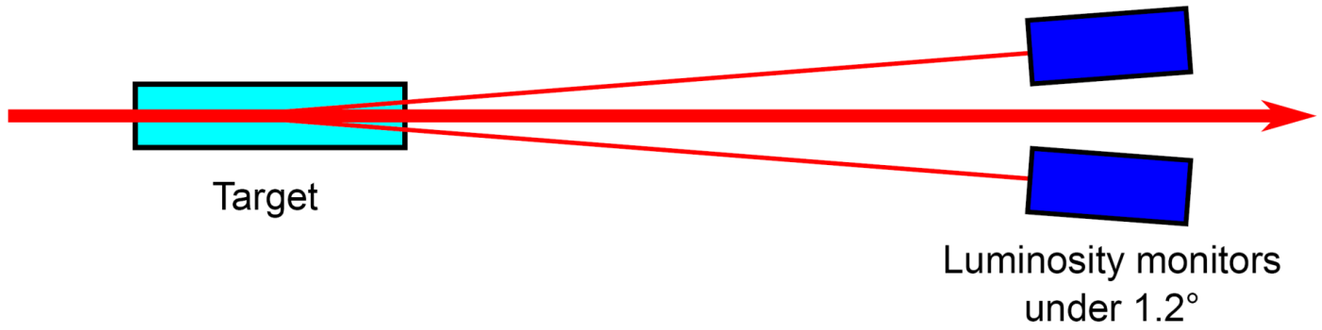


Will be studied further

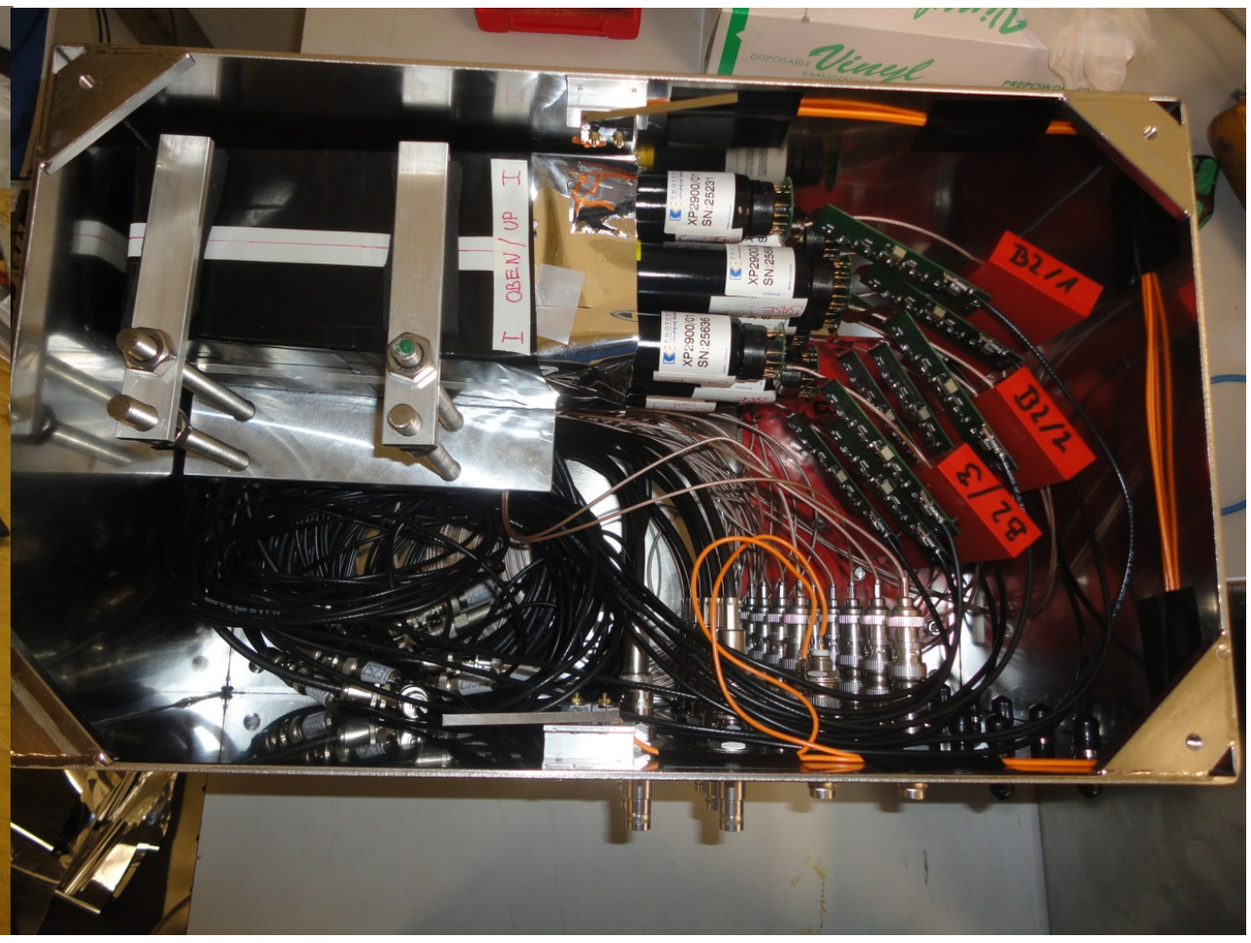
- Hall 2 test beam run in May

Install into OLYMPUS in July

Symmetric Möller Luminosity Monitor

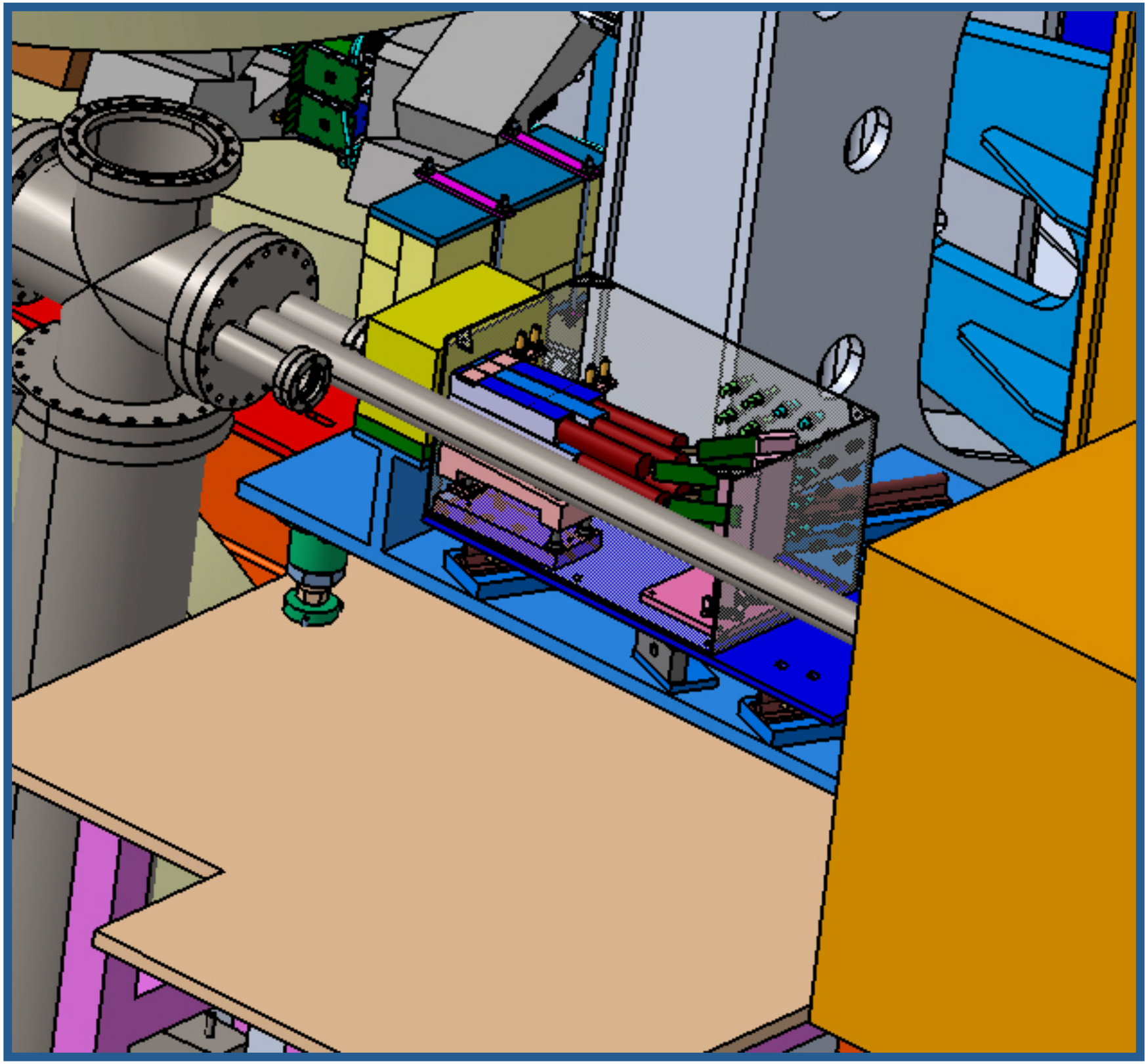


PbF_2 crystals glued to PMT



9 crystal array

Symmetric Möller Detector



Symmetric Möller Detector

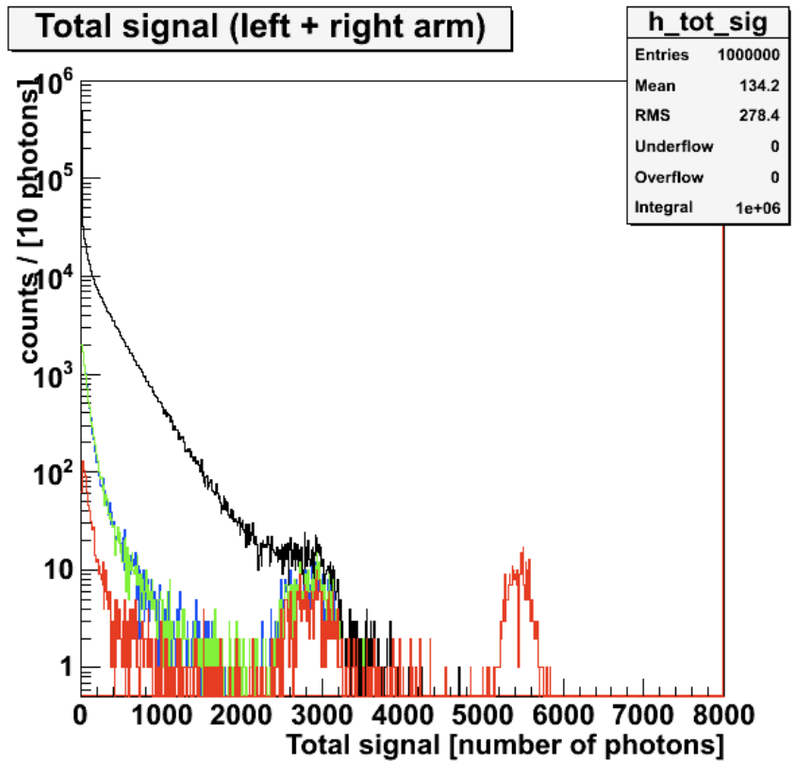
Optimised size of collimator

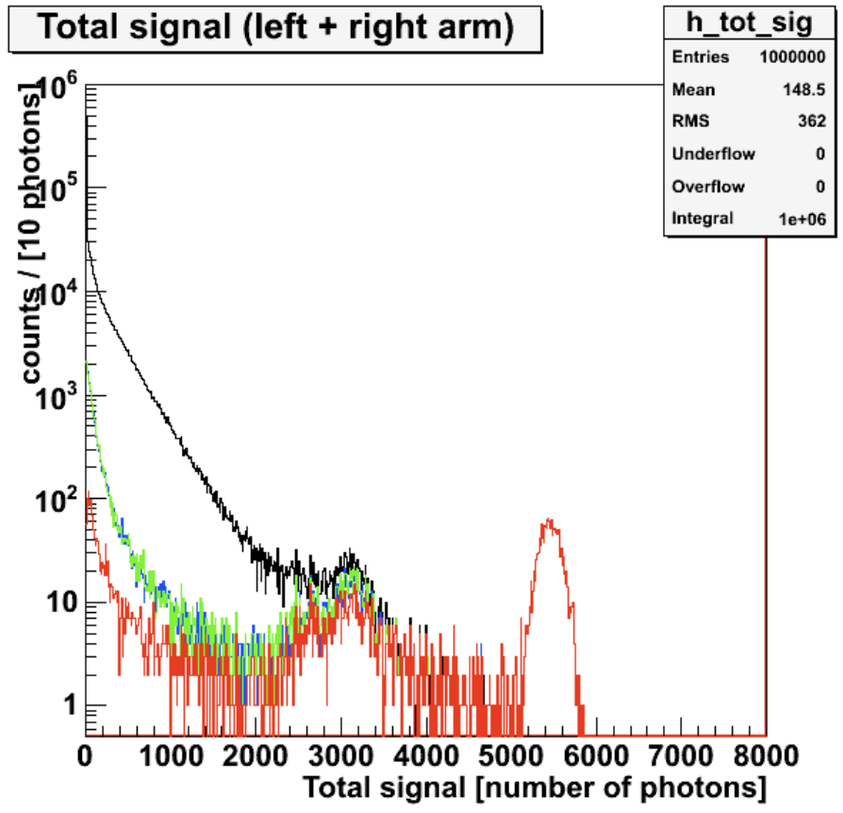
- small hole cleaner but poor statistics
- larger hole better statistics but more background
- 25 mm diameter chosen

Delivered to DESY

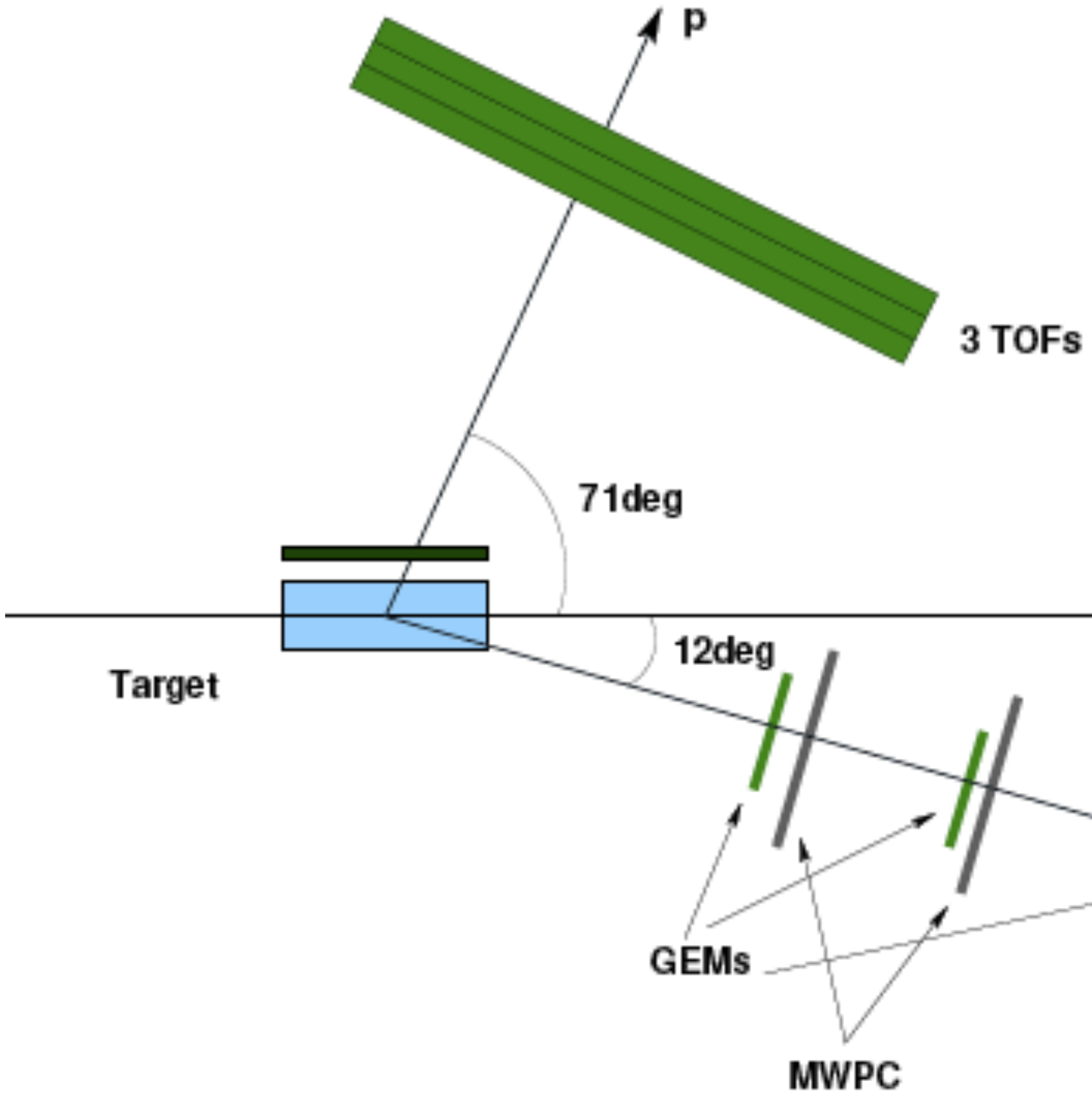
- study in Hall 2 test beam
- install in DORIS ring in July

Mainz





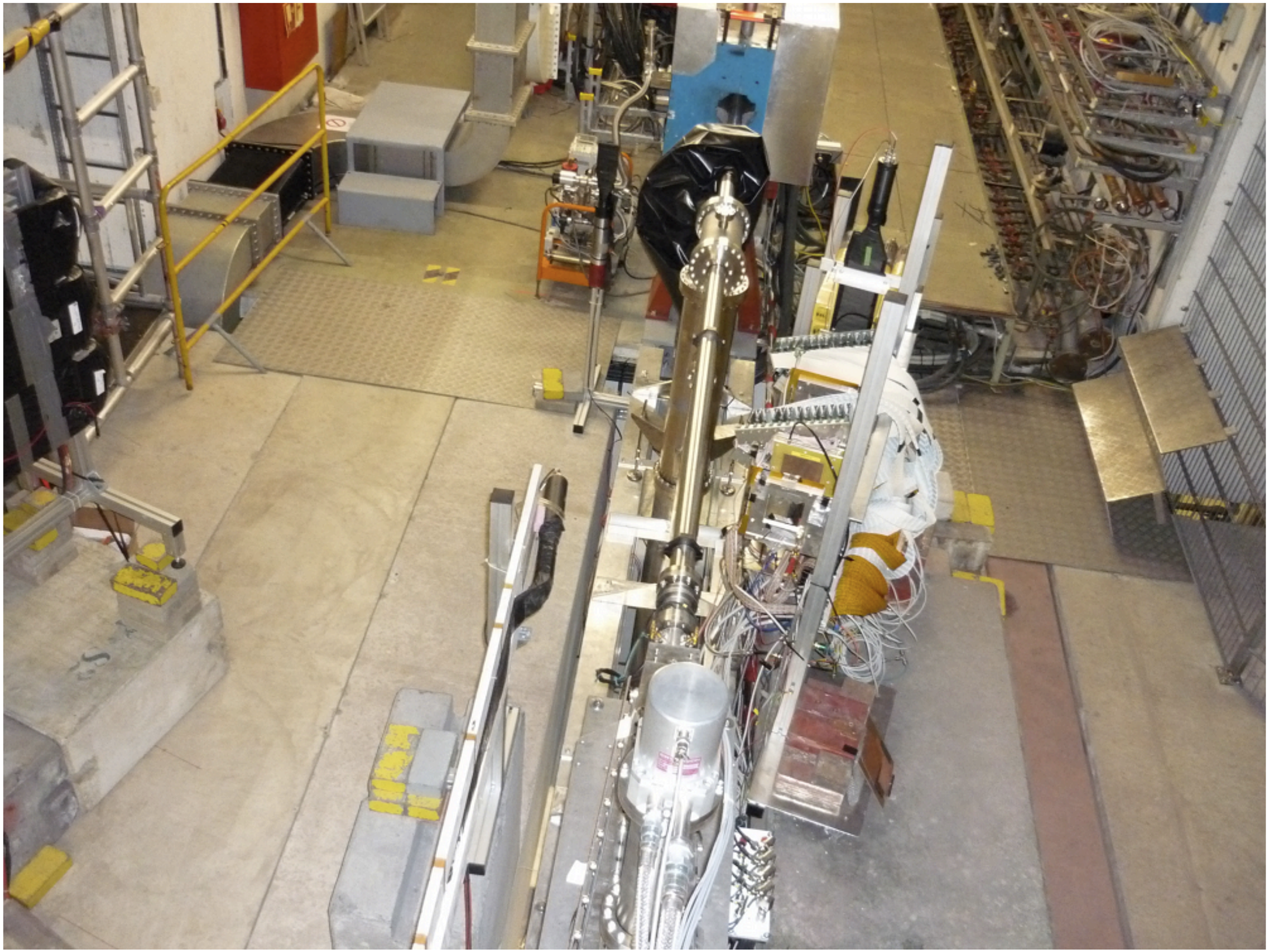
DORIS Ring Run - February, 2011



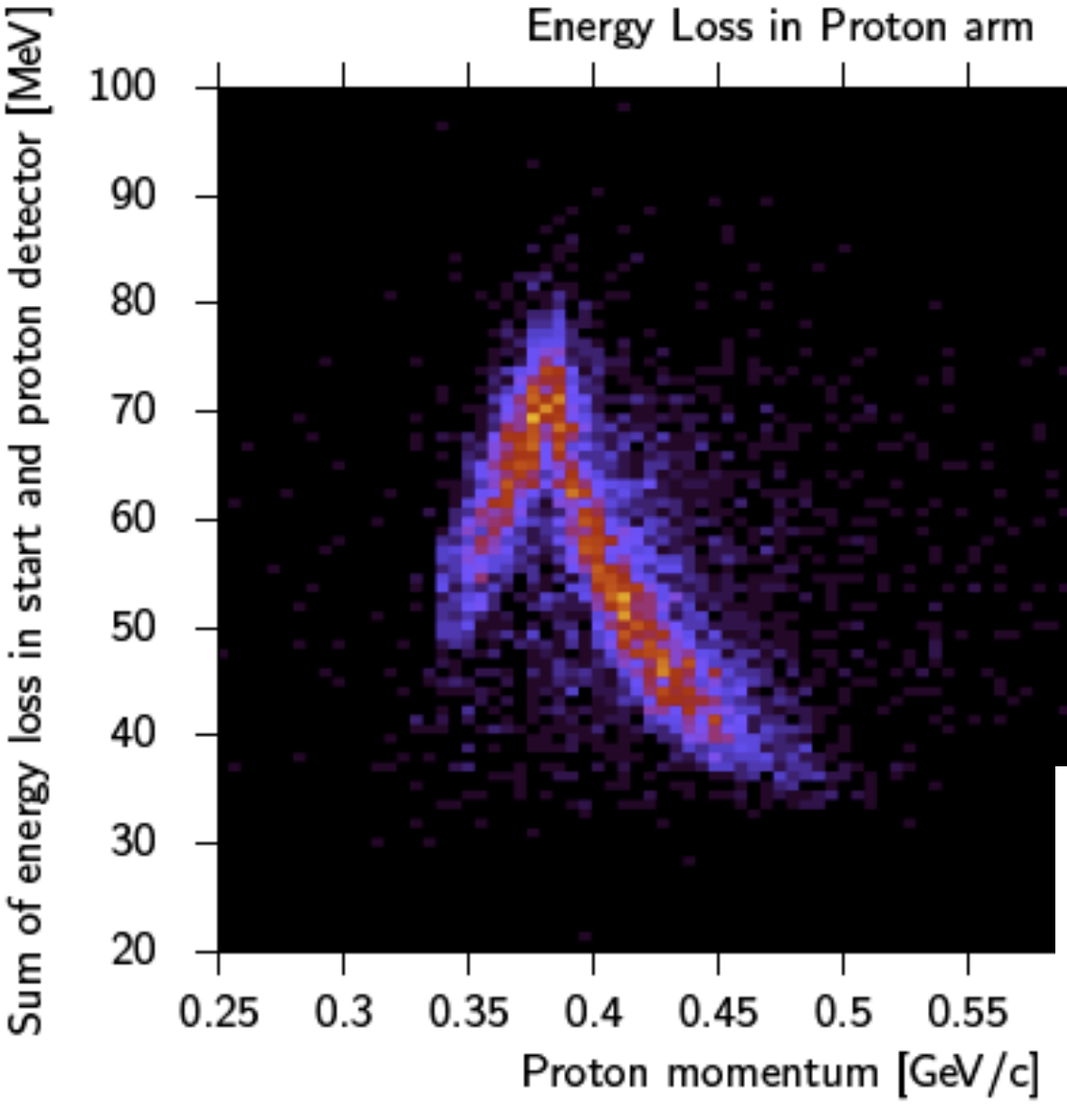
Purpose

- test target and gas system operation
- gain experience on background rates and injection flash
- test DAQ system
- 2 GeV operation of DORIS

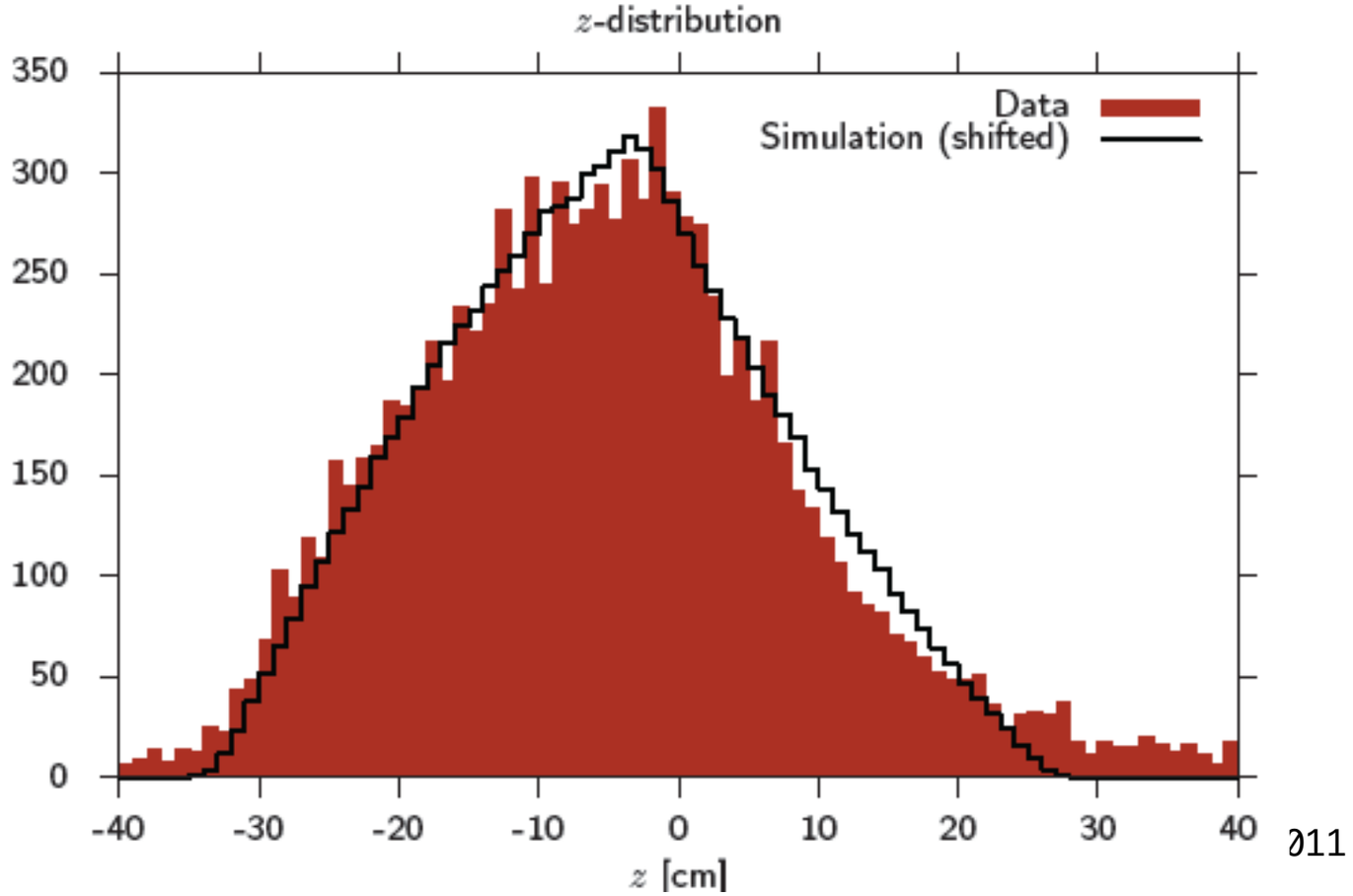
DORIS Ring Run - February, 2011



Elastic ep Scattering

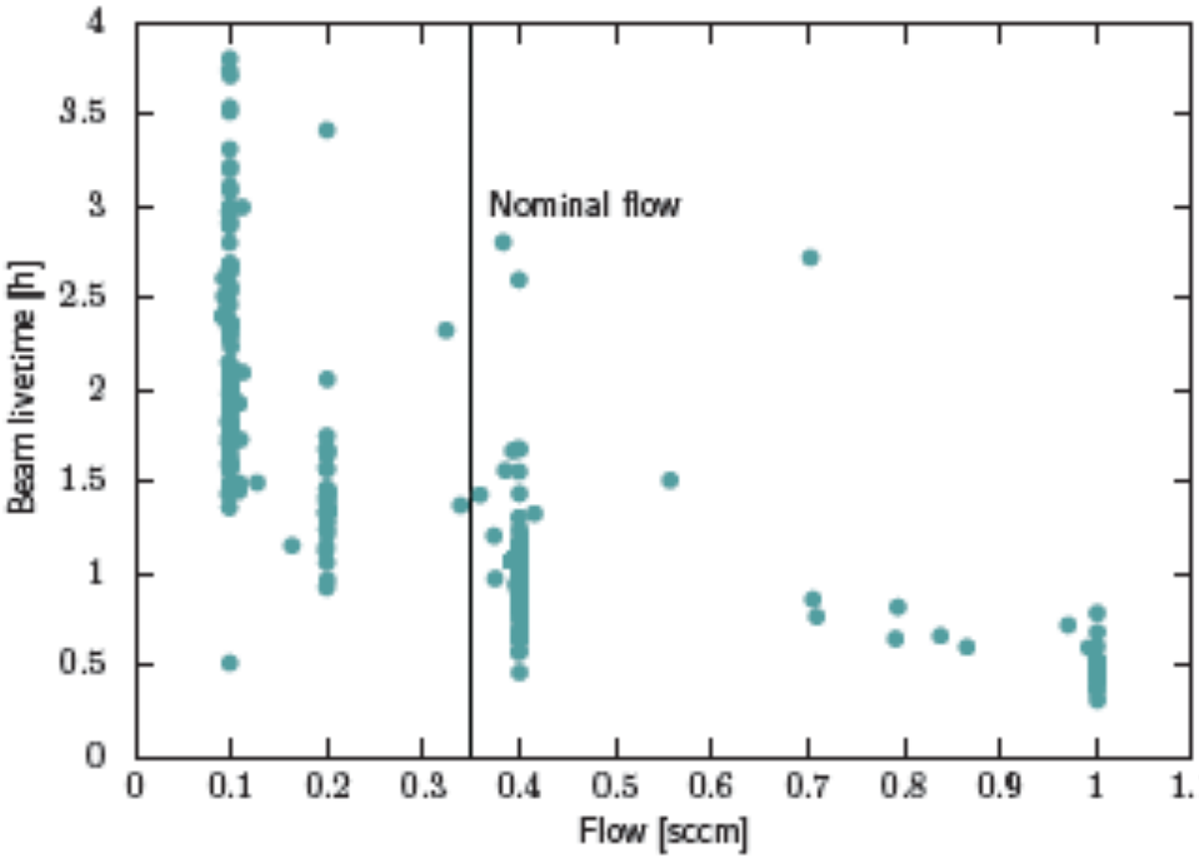


2.0 GeV, 70 mA, e^+		
Detector	w/ gas	w/o gas
LGC	16 kHz	7 kHz
PAD	420 Hz	120 Hz
SD	3 kHz	470 Hz
TC	660 kHz	55 kHz



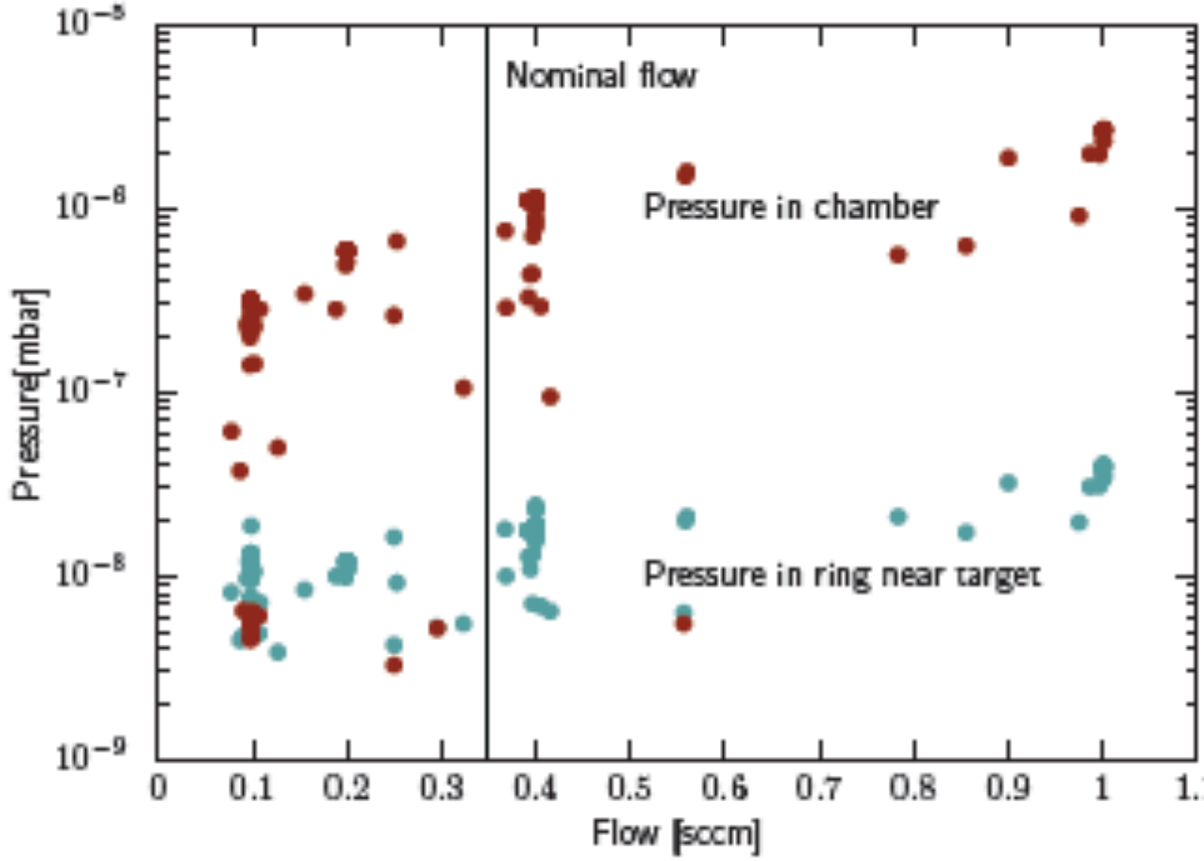
Event distribution from 60 cm long target cell

DORIS Ring Run



Target behaved as expected

- design gas flow 0.35 sccm
- ran up to 3 times gas flow
- lifetime still acceptable
  - fill time small



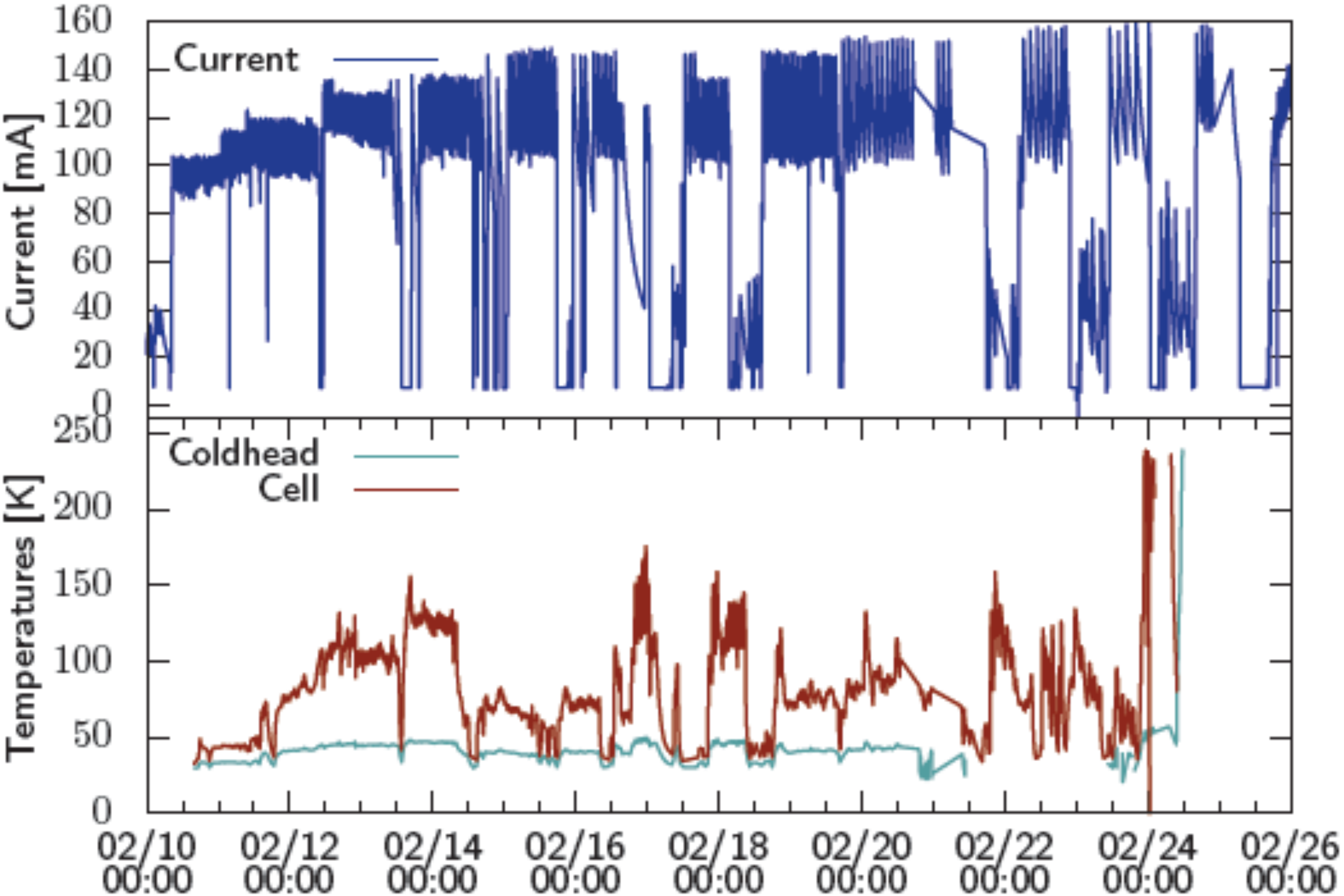
Vacuum in target chamber

- 10^{-7} - 10^{-6} mbar

Vacuum in DORIS ring near target

- 10^{-8} mbar
- largely independent of gas flow

Target Heating During Synchrotron Runs



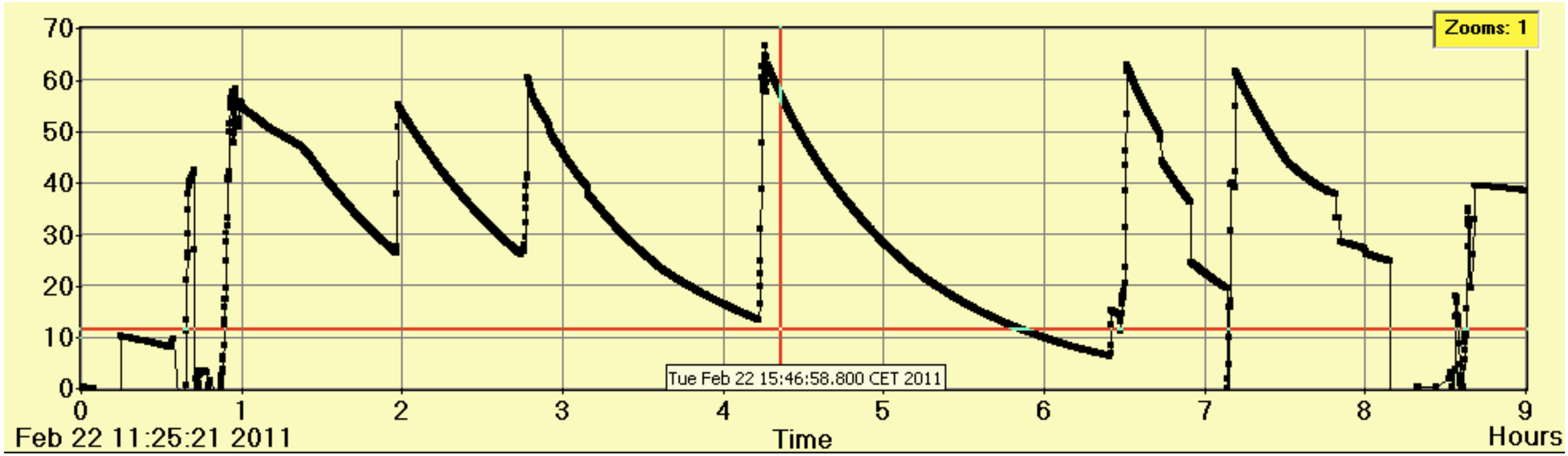
DORIS Operation

DORIS Ring Run

- OLYMPUS tests during the day shifts over 5 days at 2 GeV
- evenings 4.5 GeV
- 20’ switch between 2 and 4.5
- no “dust” events seen in electron running

2 GeV experience

- first day 38 mA with stable 3 hour lifetime
- second day ran with increasing target density
- third day 55 mA
- fourth day switched to electrons, 62 mA, 2 hr lifetime



Hall 2 Test Beam - May, 2011

DESY Hall 2 test beam

- electron and positron beams
- up to 6 GeV
- ~10^4 lepton/s at 2 GeV

Detectors

- GEM luminosity detectors
- MWPCs
- Symmetric Möller calorimeter

Plans

- installation started already this week
  - have 4 running weeks in May
- optimise detector operating paramters
- measure detector performance, resolution, calibration
- test all readout electronics
- exercise OLYMPUS data acquisition system

Schedule

OLYMPUS Detector

- major components in May
- test in park position until mid July

DORIS shutdown

- 11.7 - 15.8

OLYMPUS detector

- roll into ring 15 July
- re-install target chamber and beamline
- install symmetric Möller detector
- alignment survey
- cable and water cooling for toroid

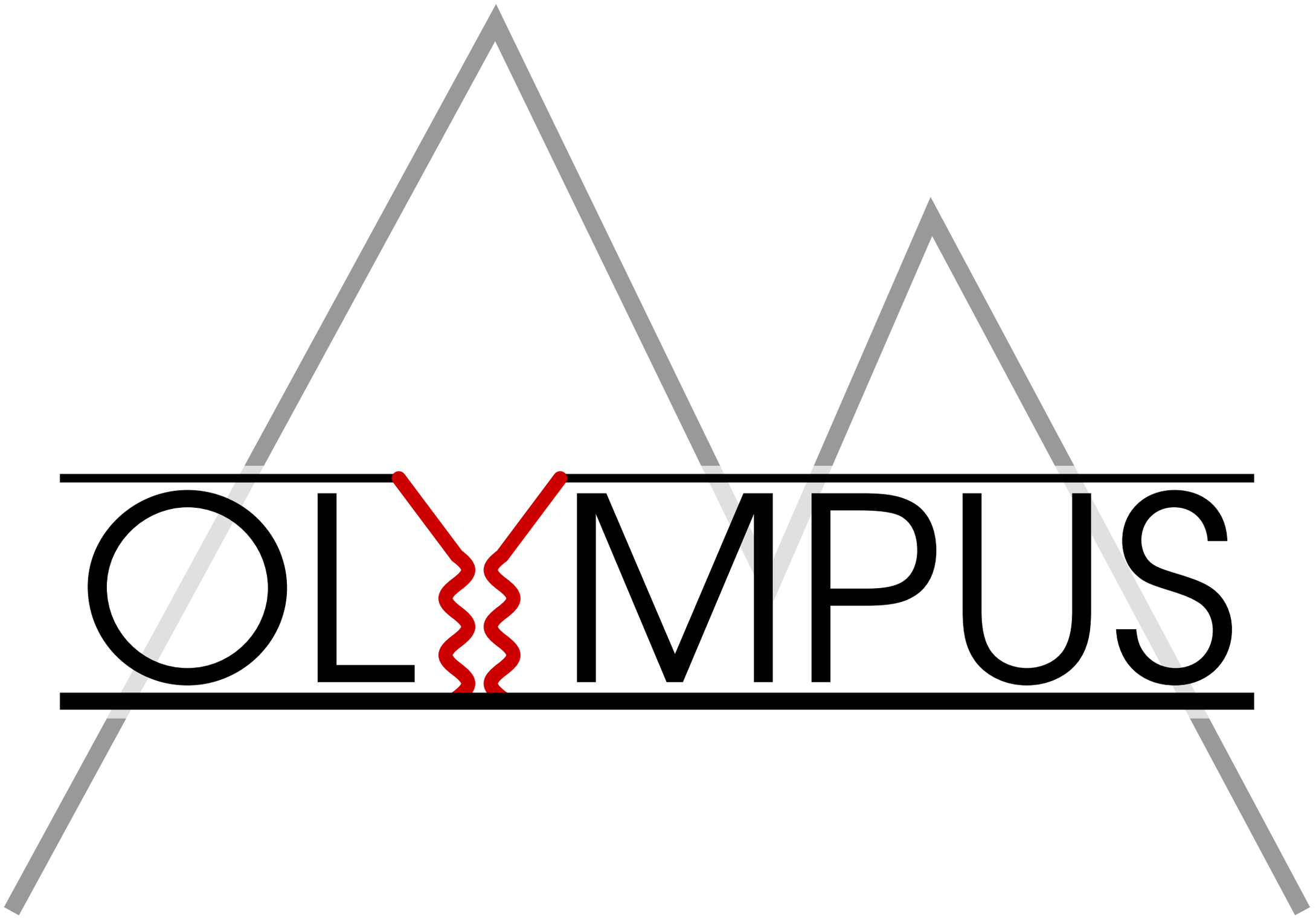
Test in ring to end of 2011

Data runs 4 weeks early 2012, 8 weeks late 2012

OLYMPUS Ready

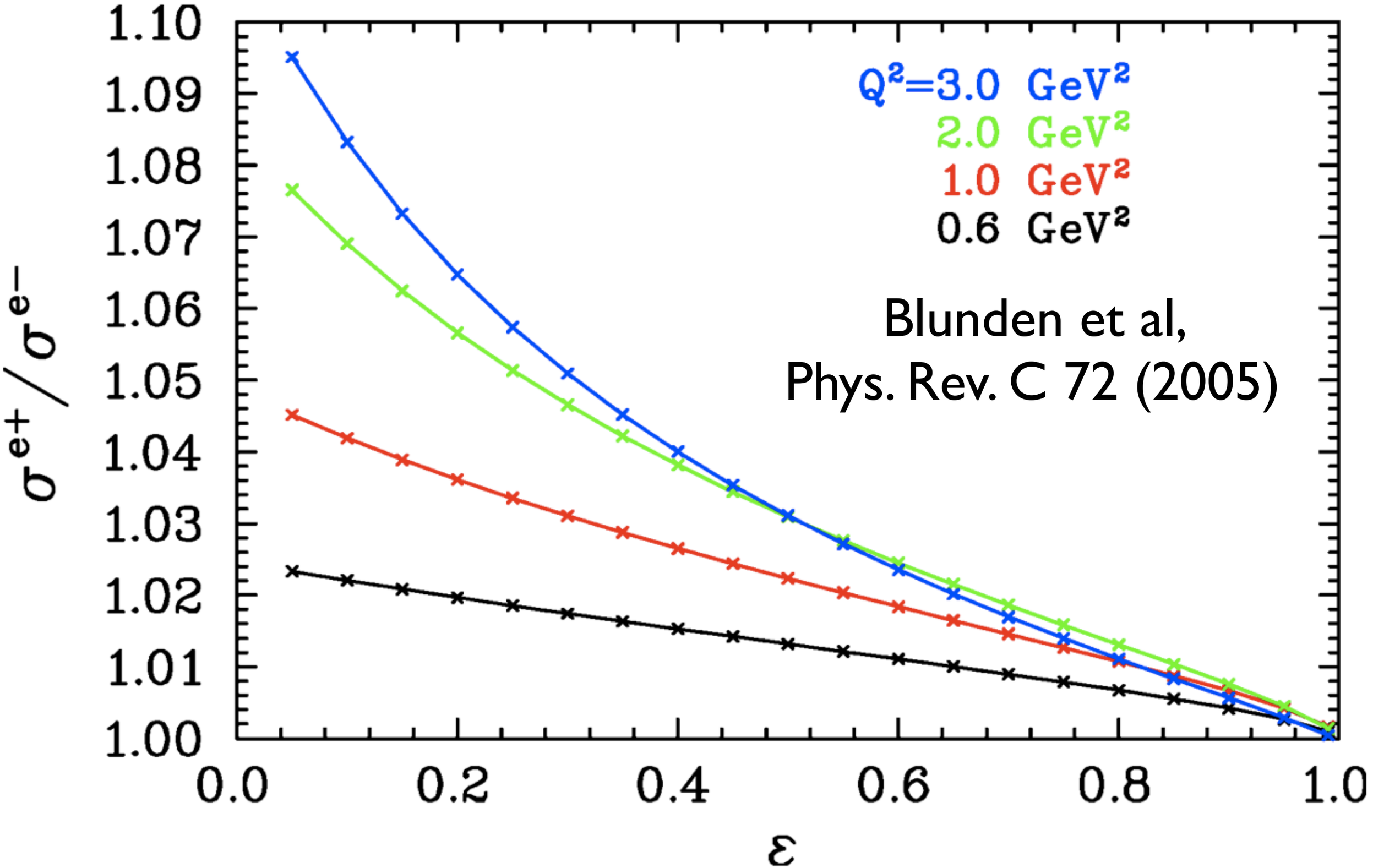
Magnet - tested and ready ✔
Target, gas system, and vacuum - fine for 2 GeV ✔
GEM Tracker - by end of year
Wire Chambers - install mid-May ✔
Time of Flight - install early May ✔
12° GEM Luminosity Monitor - test beam, install early July ✔
12° MWPC - test beam, install early July ✔
Symmetric Möller Calorimeter - test beam, install mid-July ✔
Data Acquisition System - working ✔
Slow Control System - ready ✔
DORIS - electron/positron operation, 2 GeV ✔

Thank You



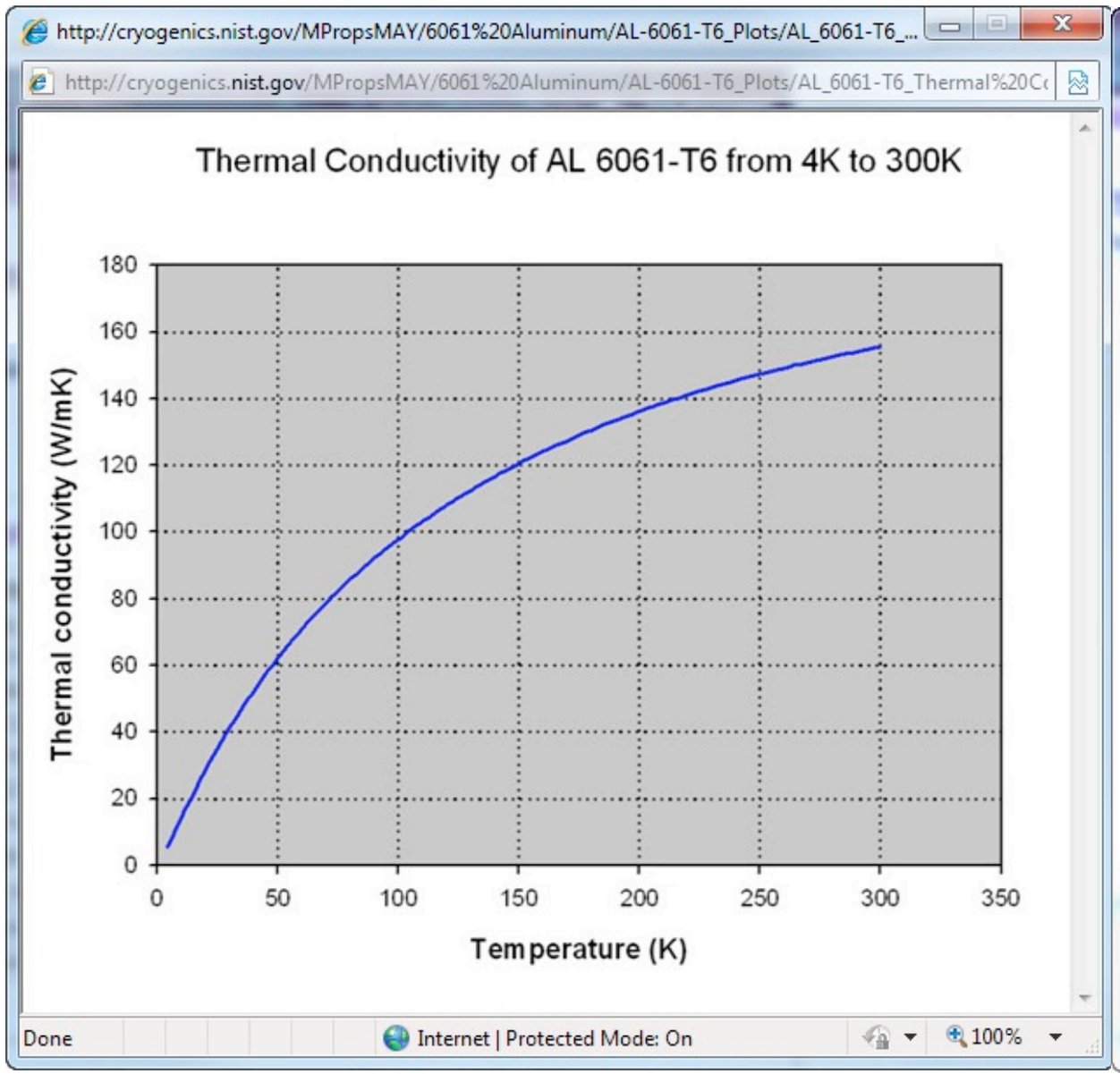
Backup Slides

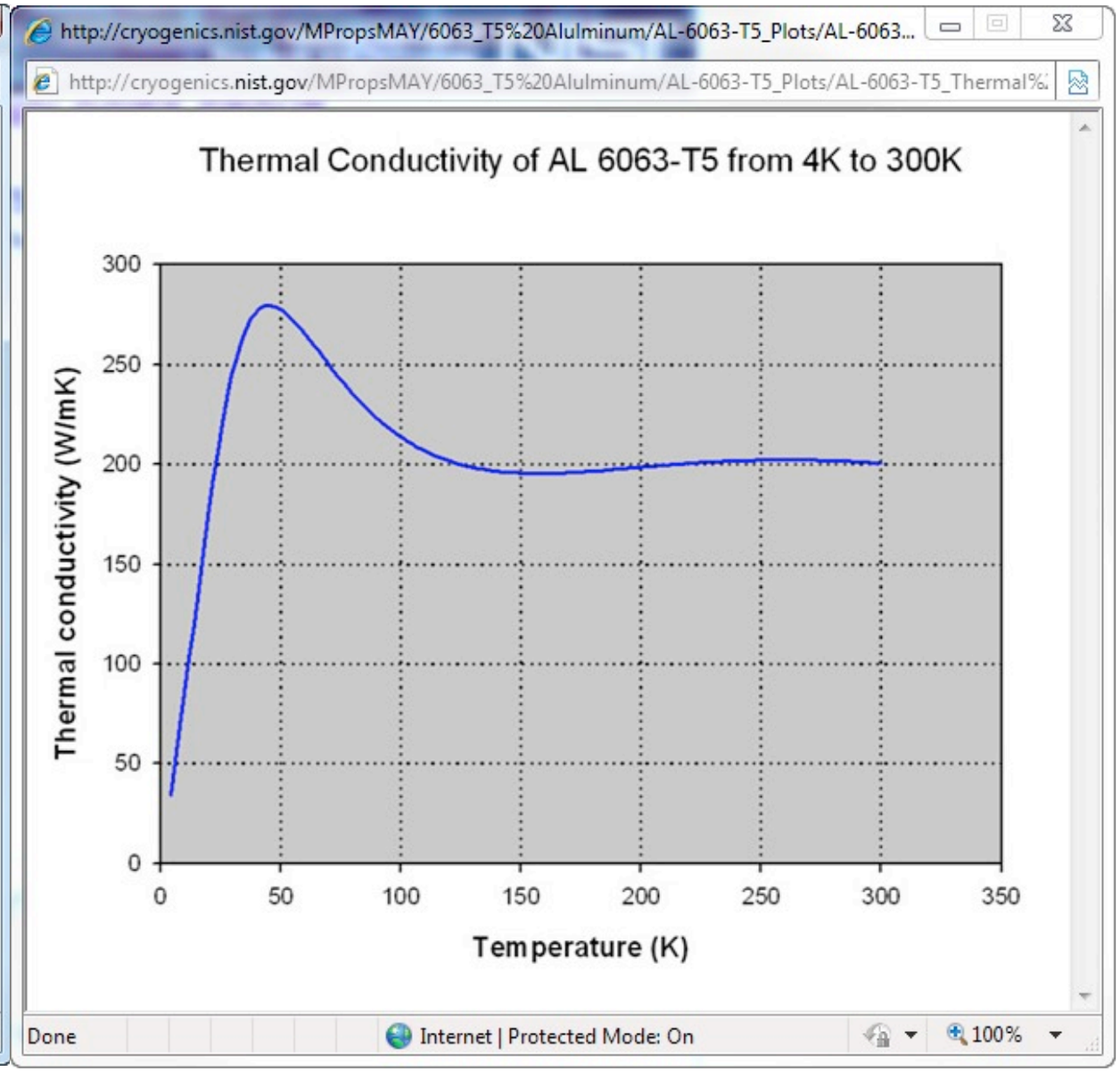
Why 2 GeV ?



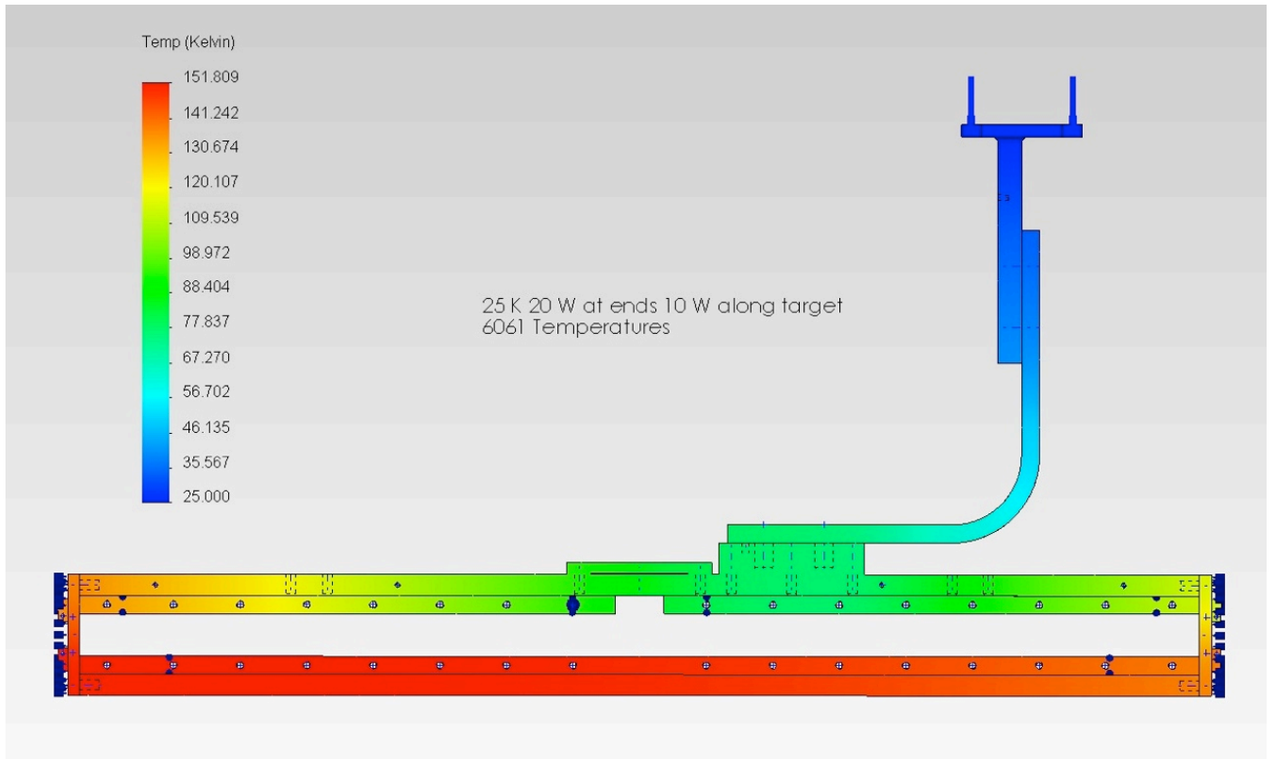
Blunden et al,
Phys. Rev. C 72 (2005)

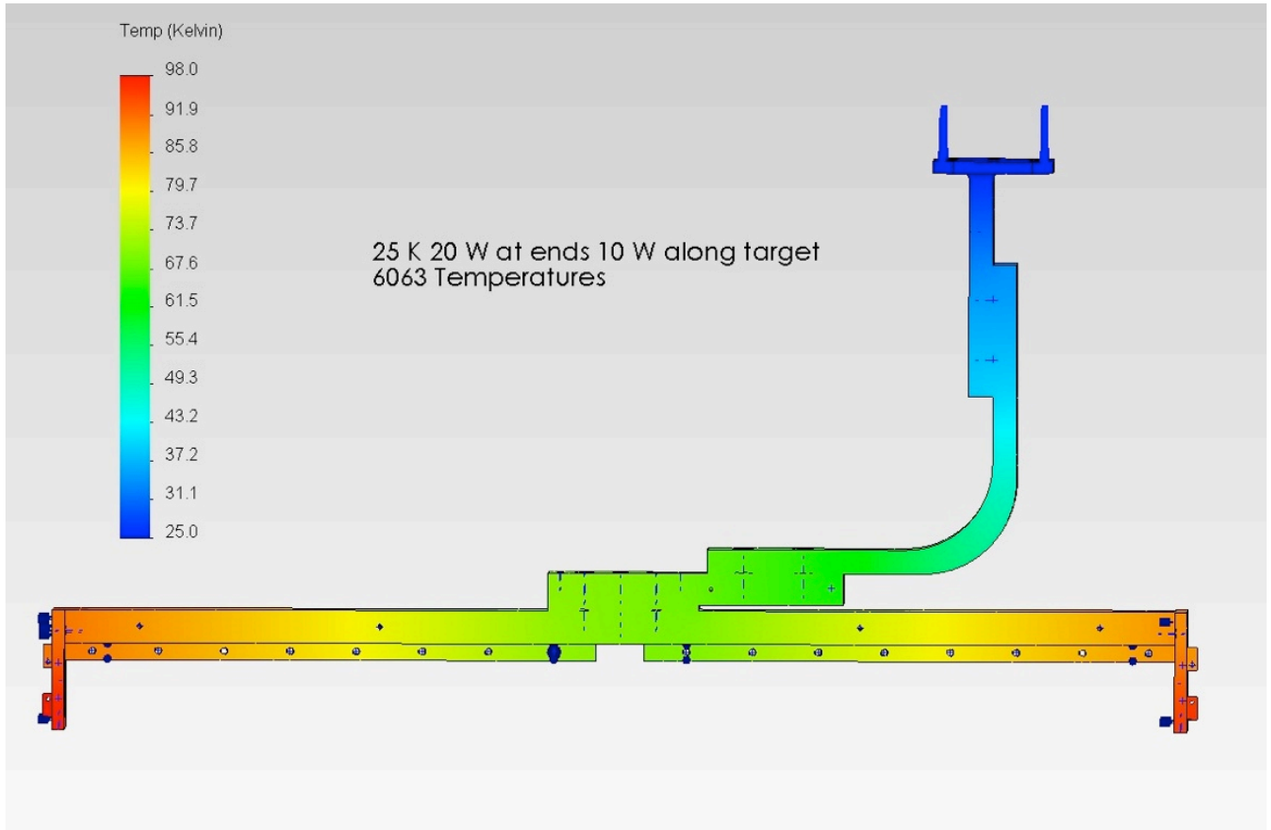
Different Thermal Conductivities



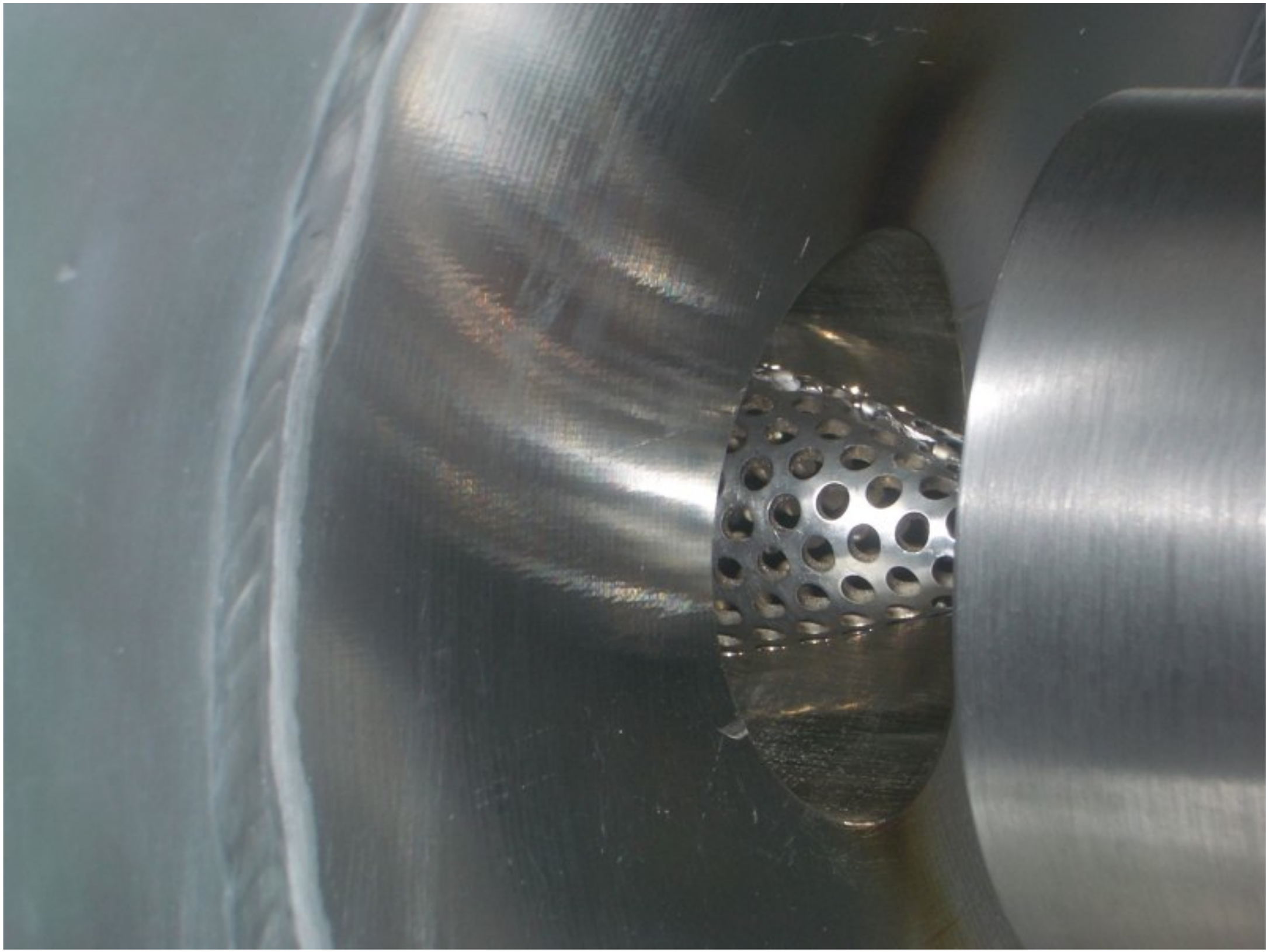


Temperature Differences

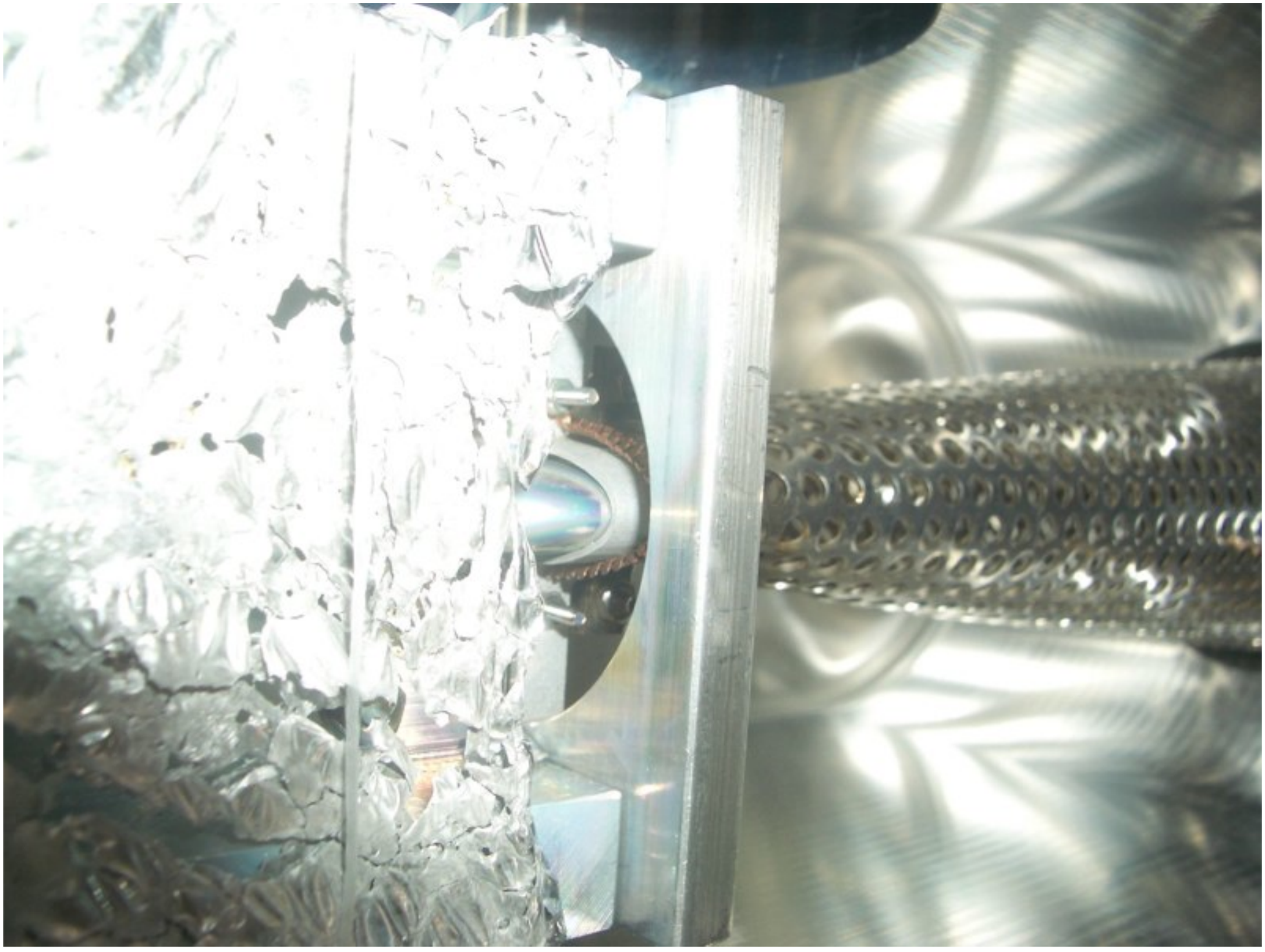




Strange Burn on Upstream End

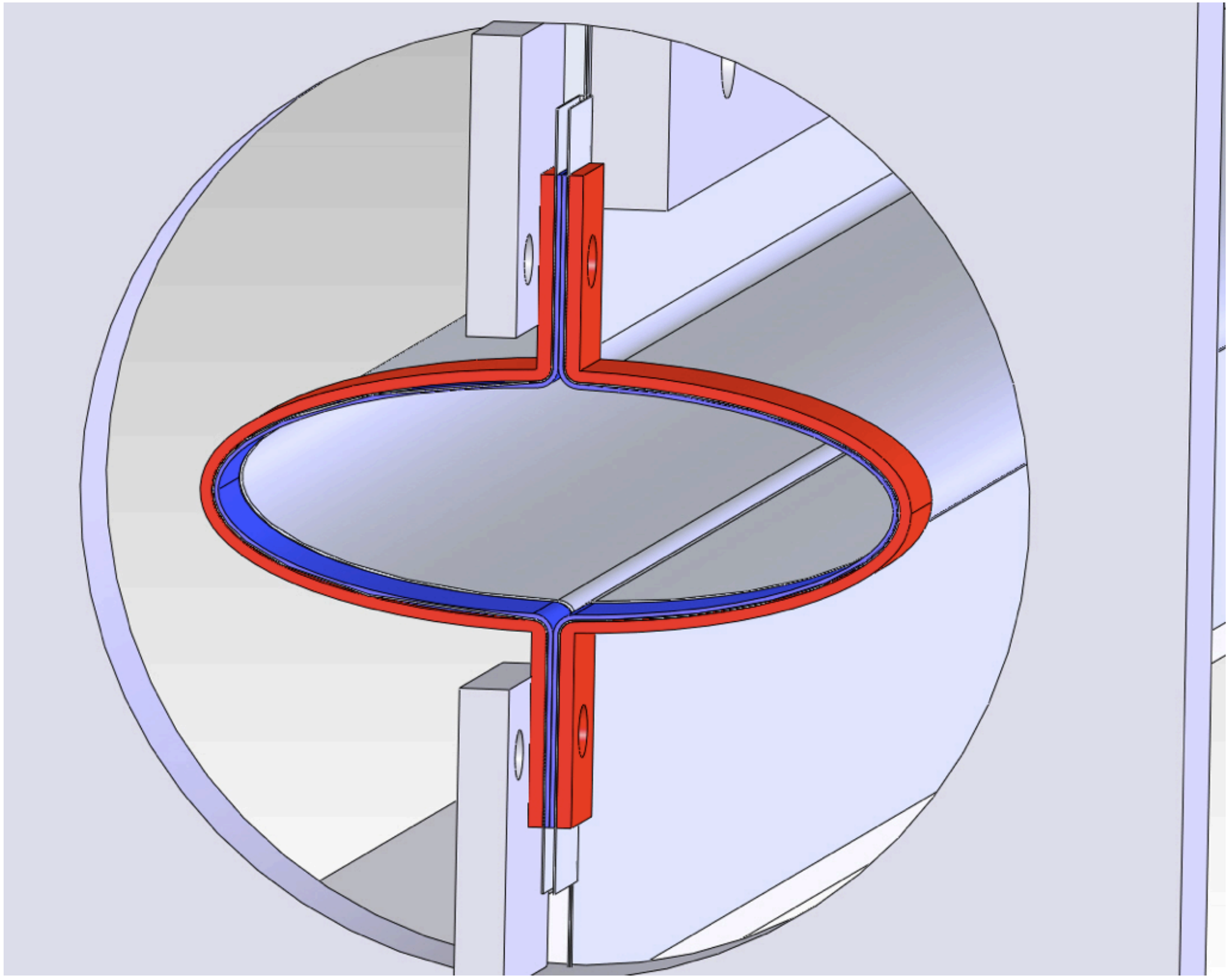


Wakefield Suppress Lost Contact

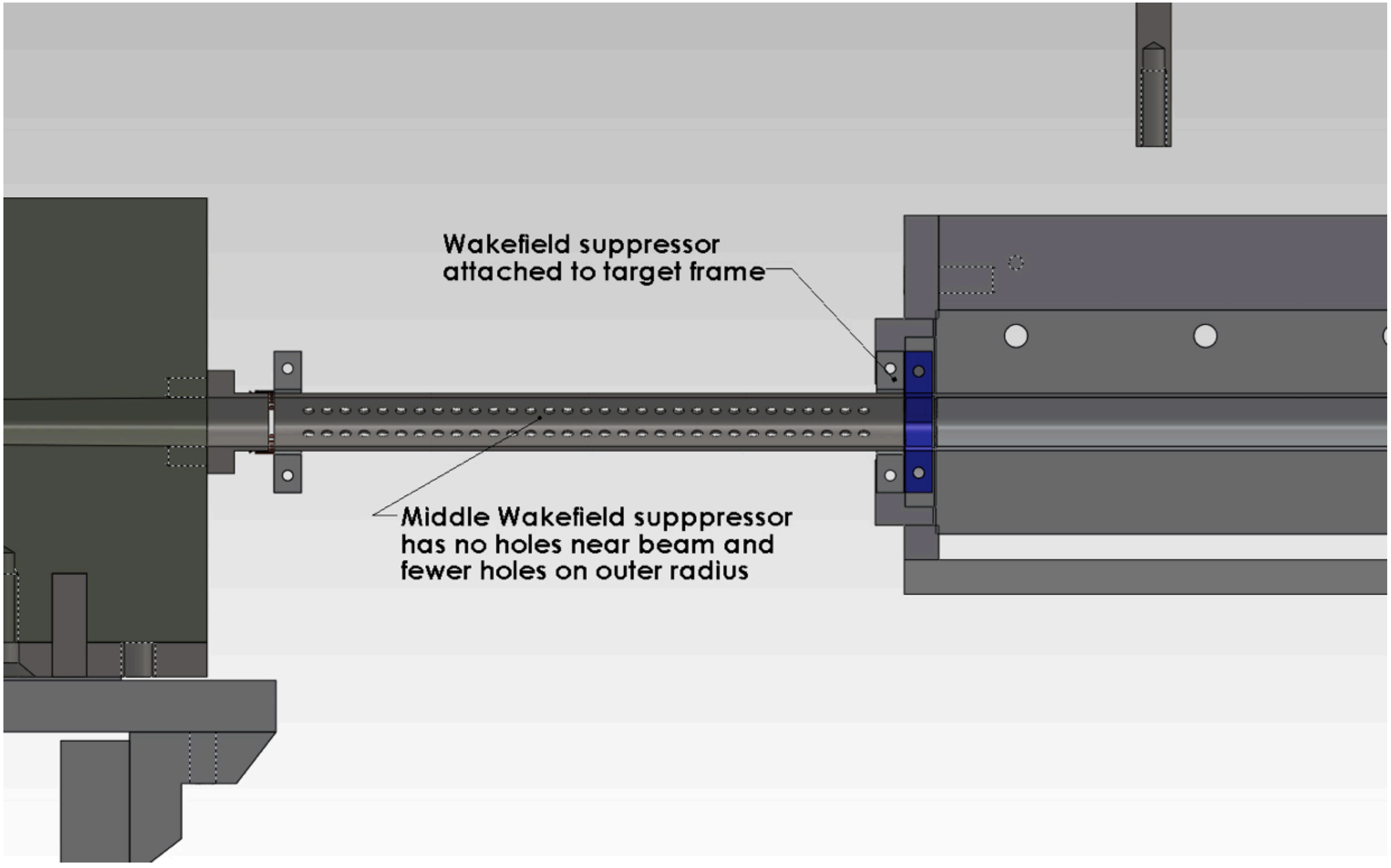


Welds of Target Cell to Ring Broken

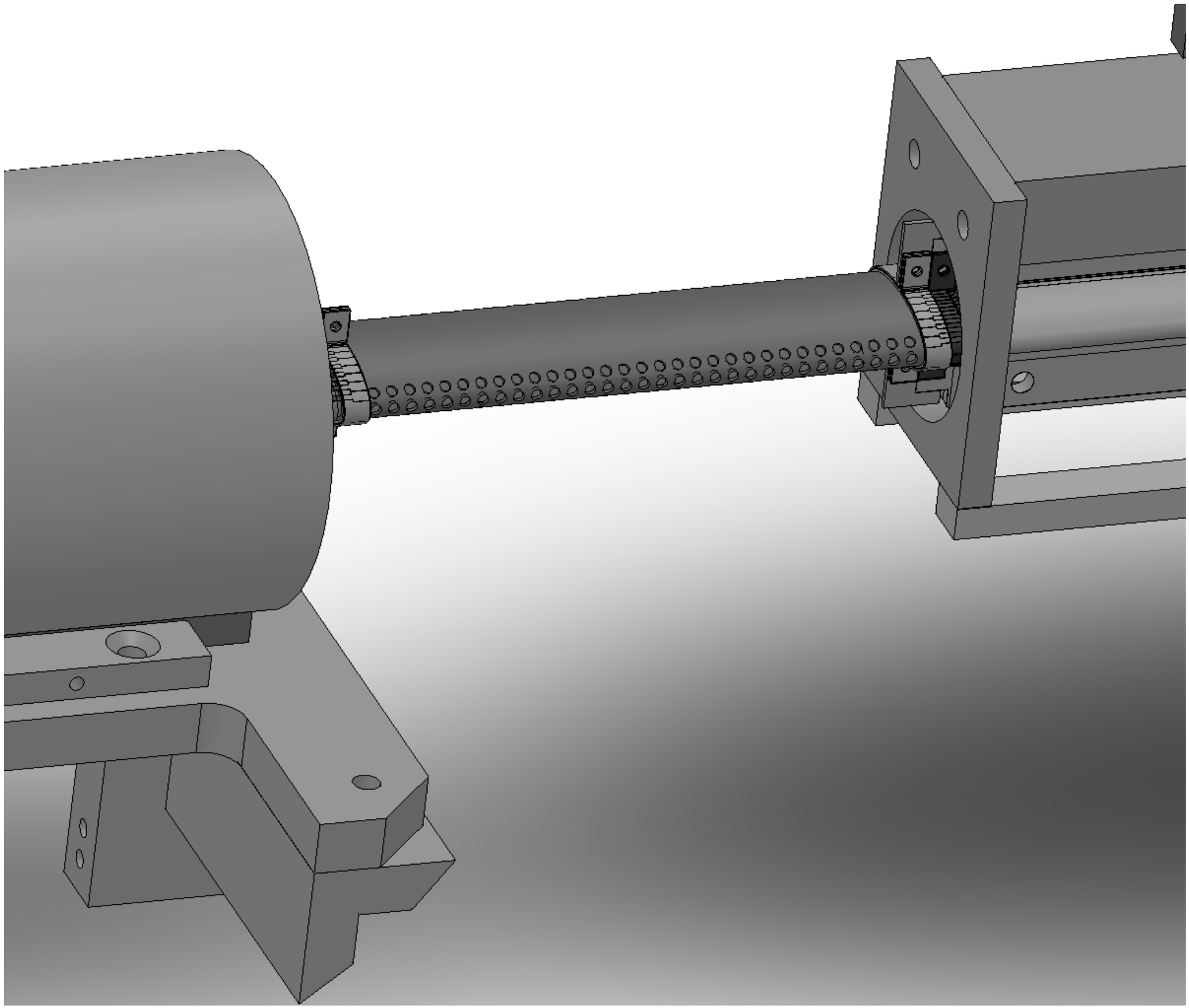
Improved Target Coupling



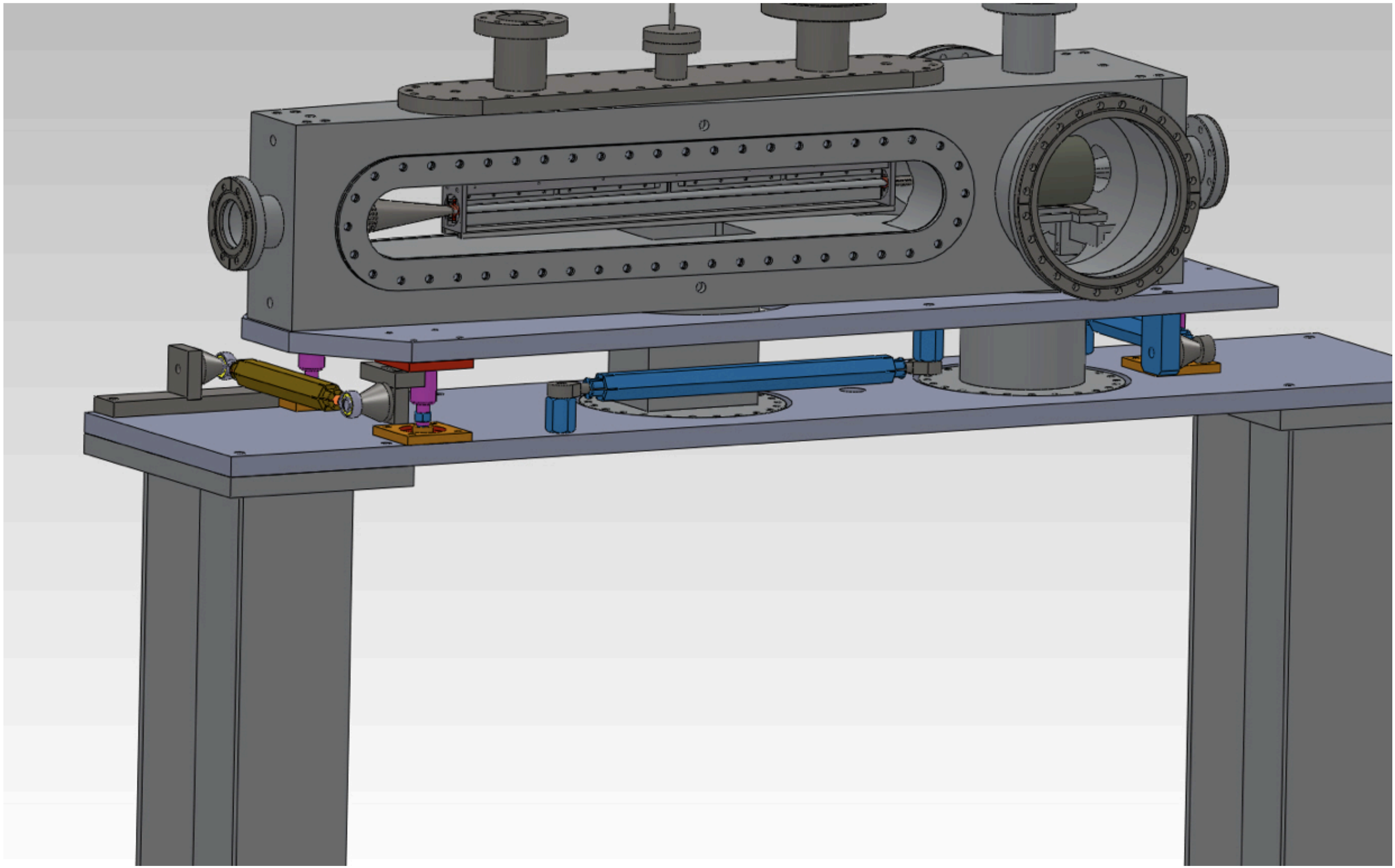
Improved Wakefield Coupling to Target



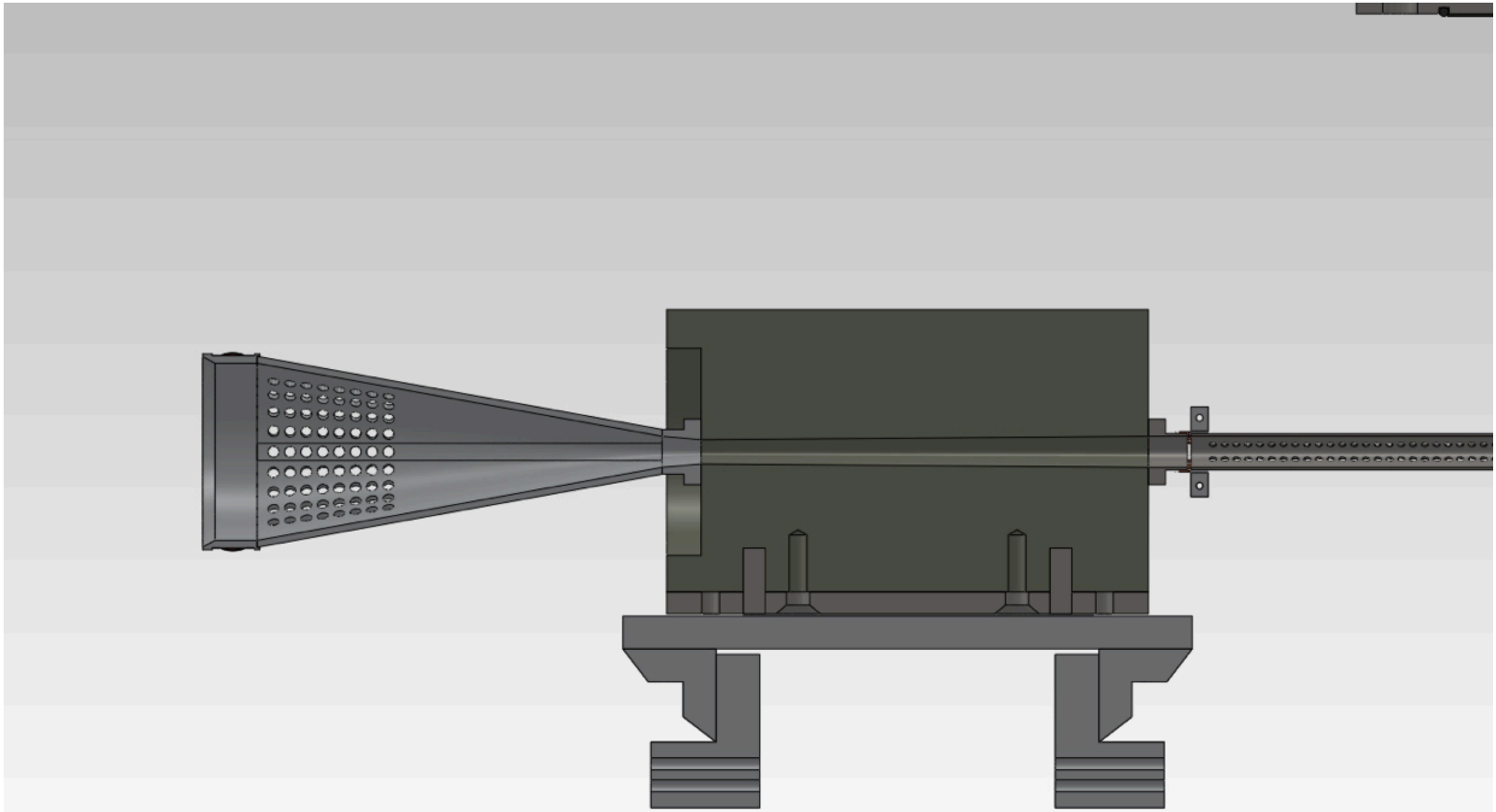
Improved Target Wakefield Suppressor



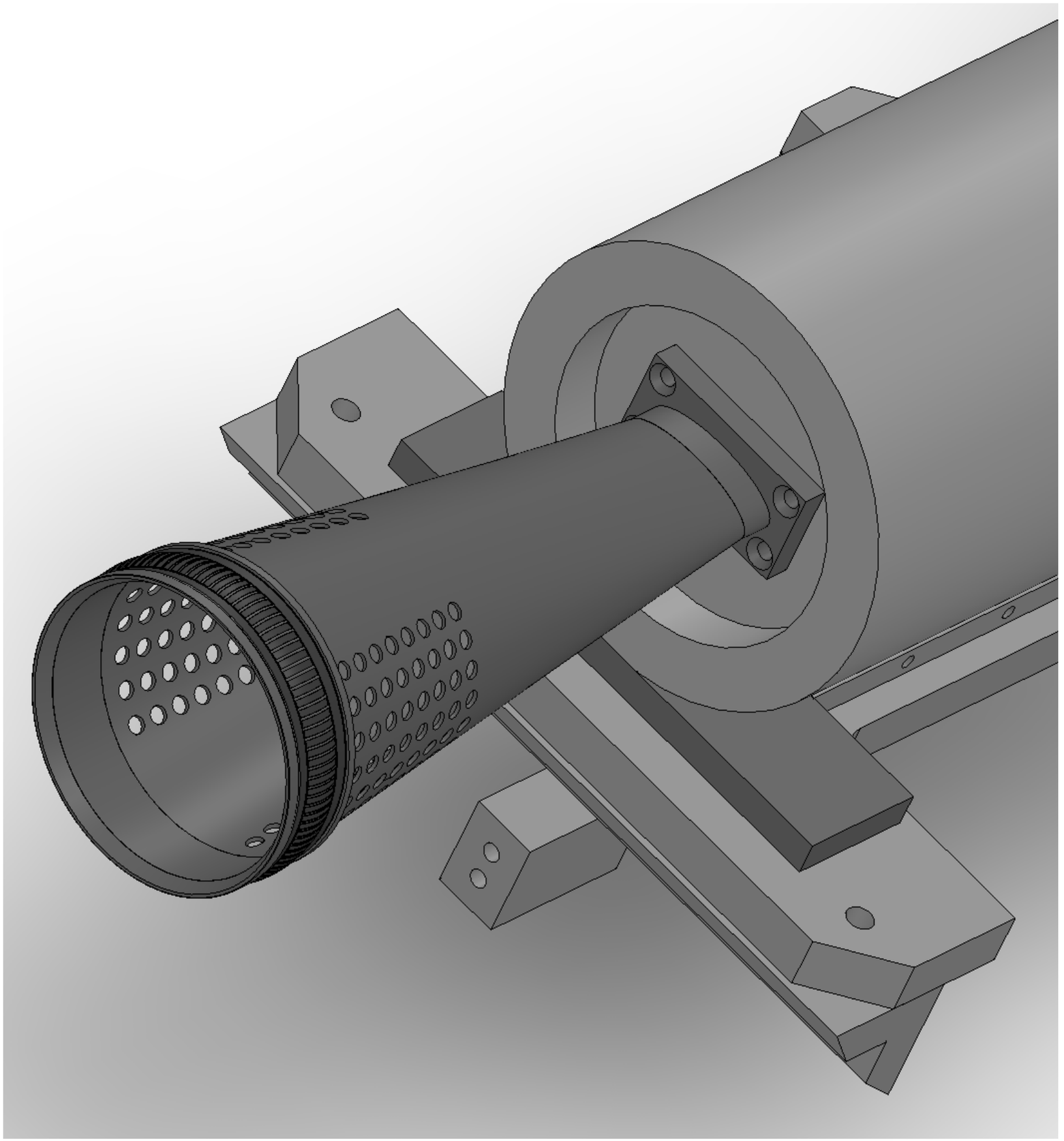
Improved Target Chamber Support



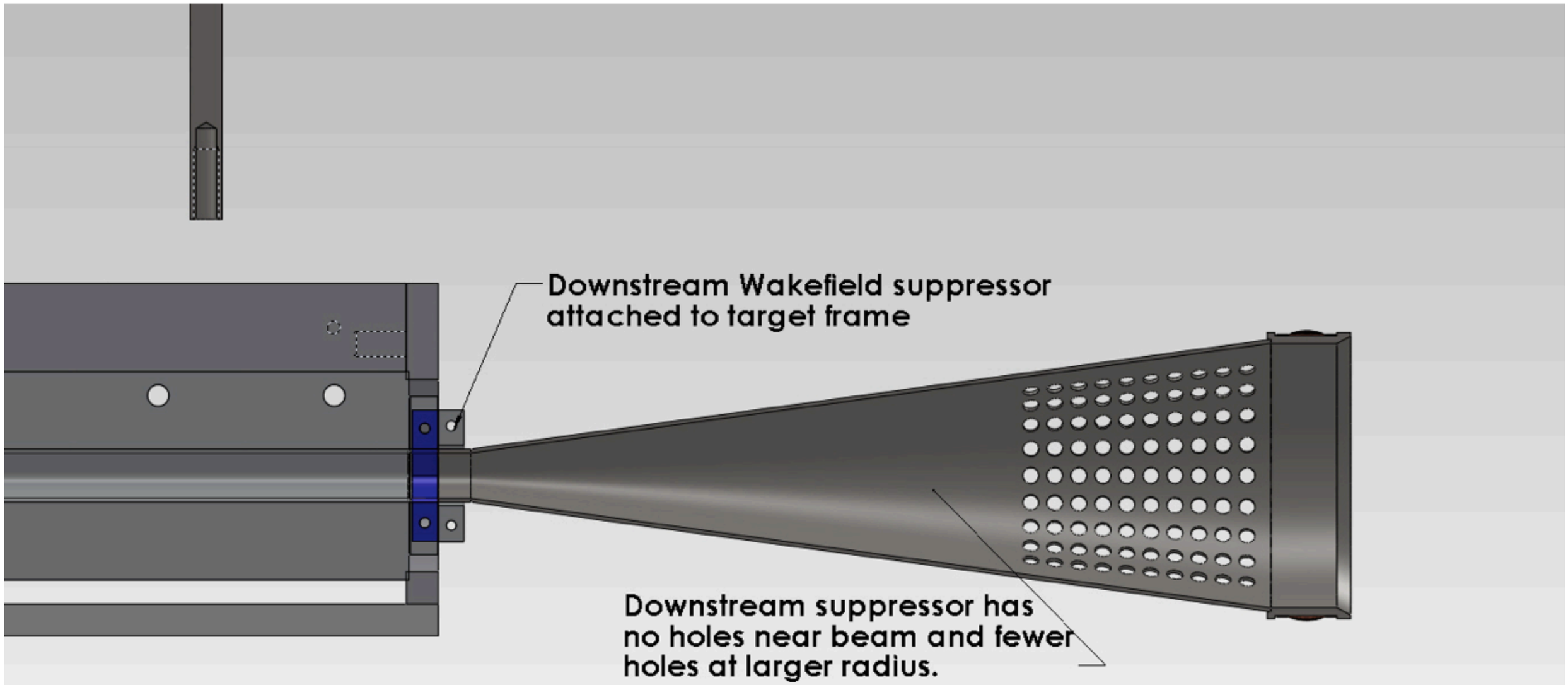
Wakefield Connected to Collimator



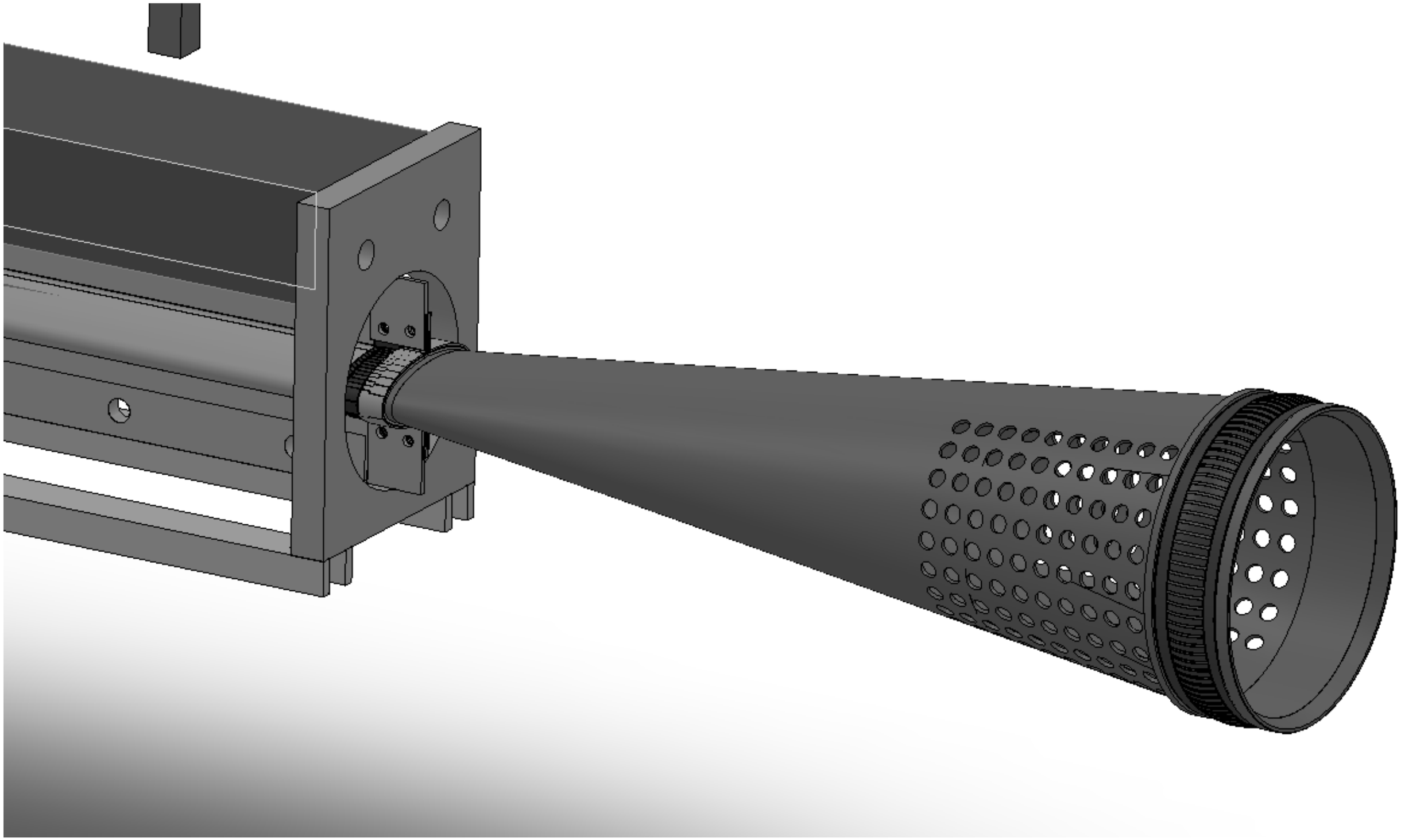
Improved Upstream Wakefield



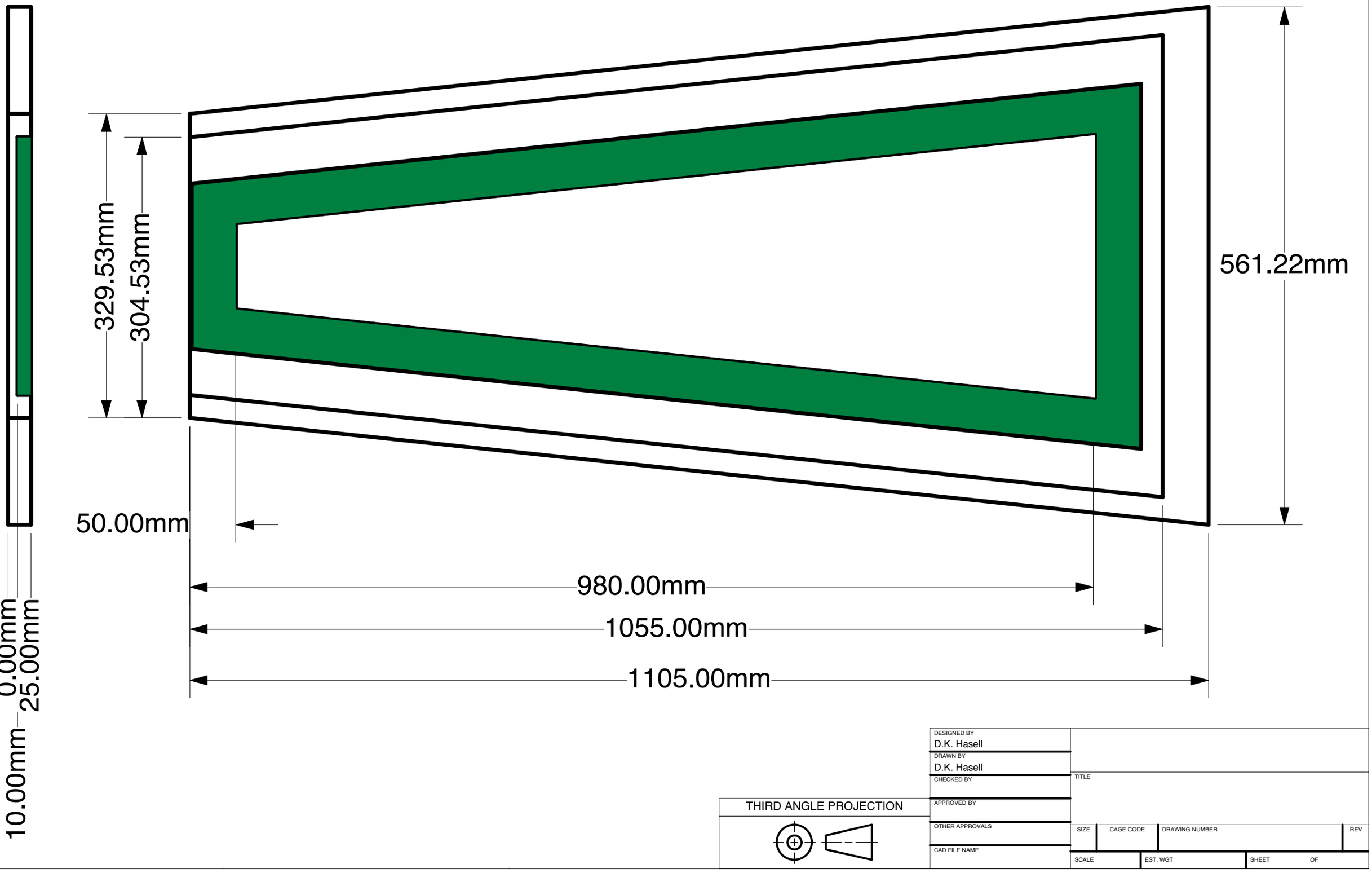
Wafefield Suppressor Downstream



Improved Downstream Wakefield



GEM Tracker Concept



DESIGNED BY	D.K. Hasell
DRAWN BY	D.K. Hasell
CHECKED BY	
APPROVED BY	
OTHER APPROVALS	
CAD FILE NAME	

THIRD ANGLE PROJECTION

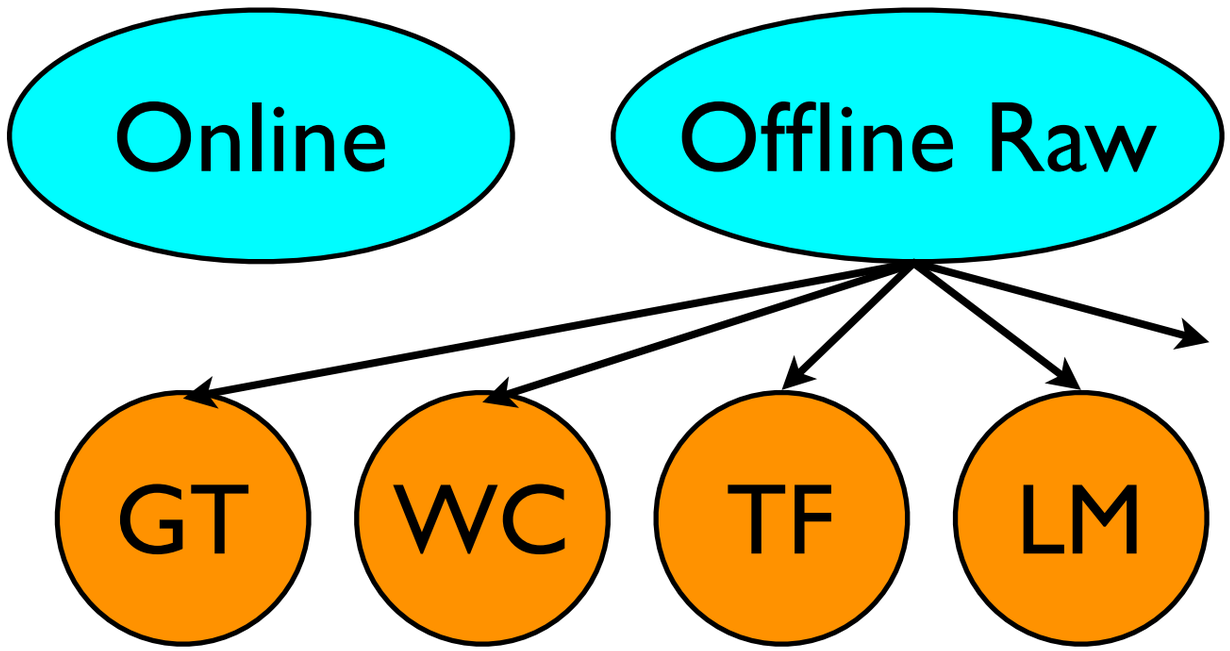
TITLE

SIZE	CAGE CODE	DRAWING NUMBER	REV
SCALE	EST. WGT	SHEET OF	

Online / Offline Analysis

Experiment

Raw Data



Experiment

- ADCs, TDCs, scalers, slow control data, trigger, DORIS parameters, etc.

Data Acquisition

- combines all data and writes to ZEBRA banks

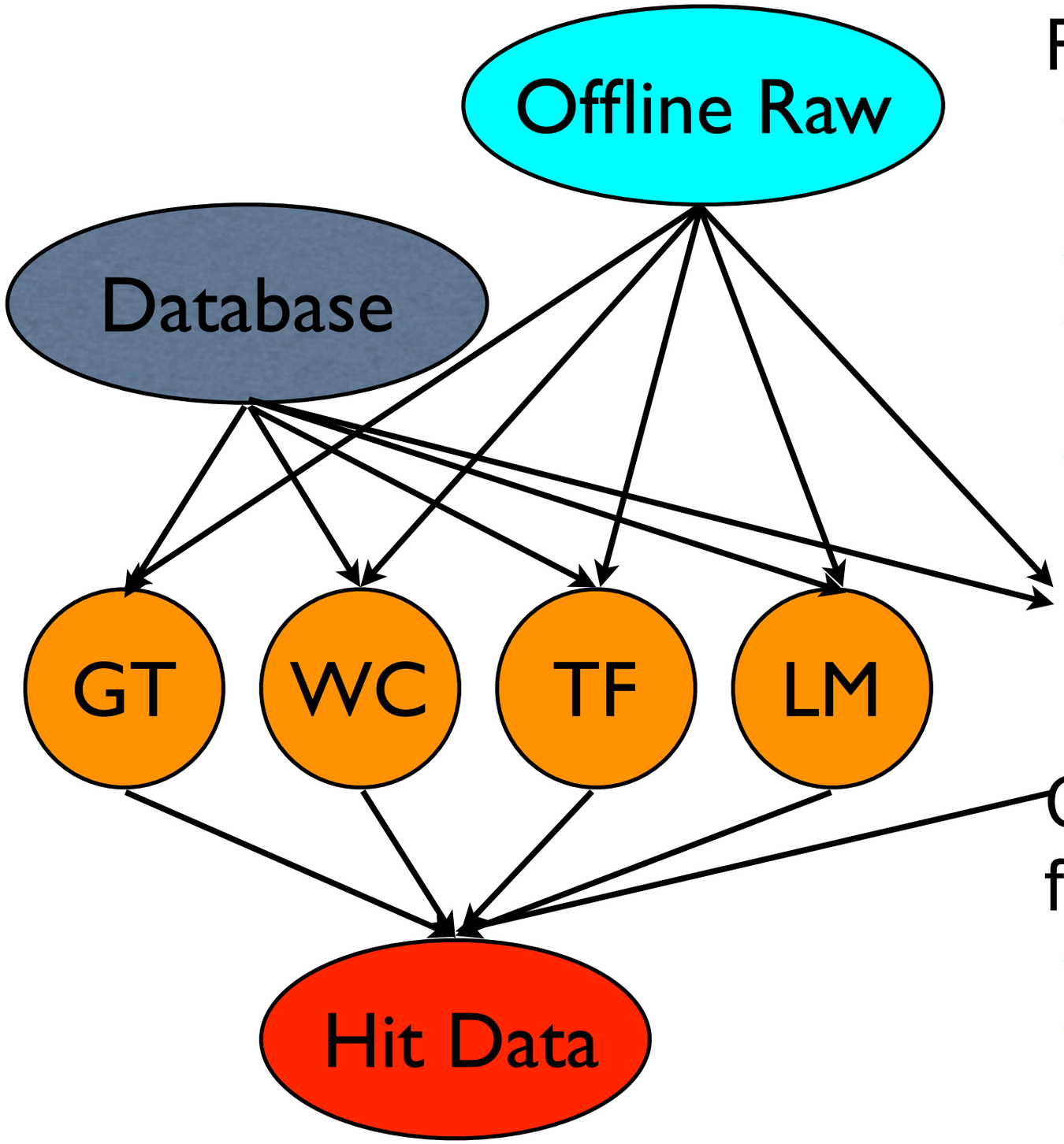
Offline raw

- re-write raw data as ROOT tree

Manage data

- pedestals, calibrations, cuts
- responsibility of each group
- run by run database

Online / Offline Analysis



Form hits in each detector

- apply cuts, pedestal subtraction, calibration
- zero suppression
- reduce raw data to collection of hits for each component
- responsibility of each group to provide this code

Combine data into ROOT file of hits

- same format as Monte Carlo
- reconstruction as MC

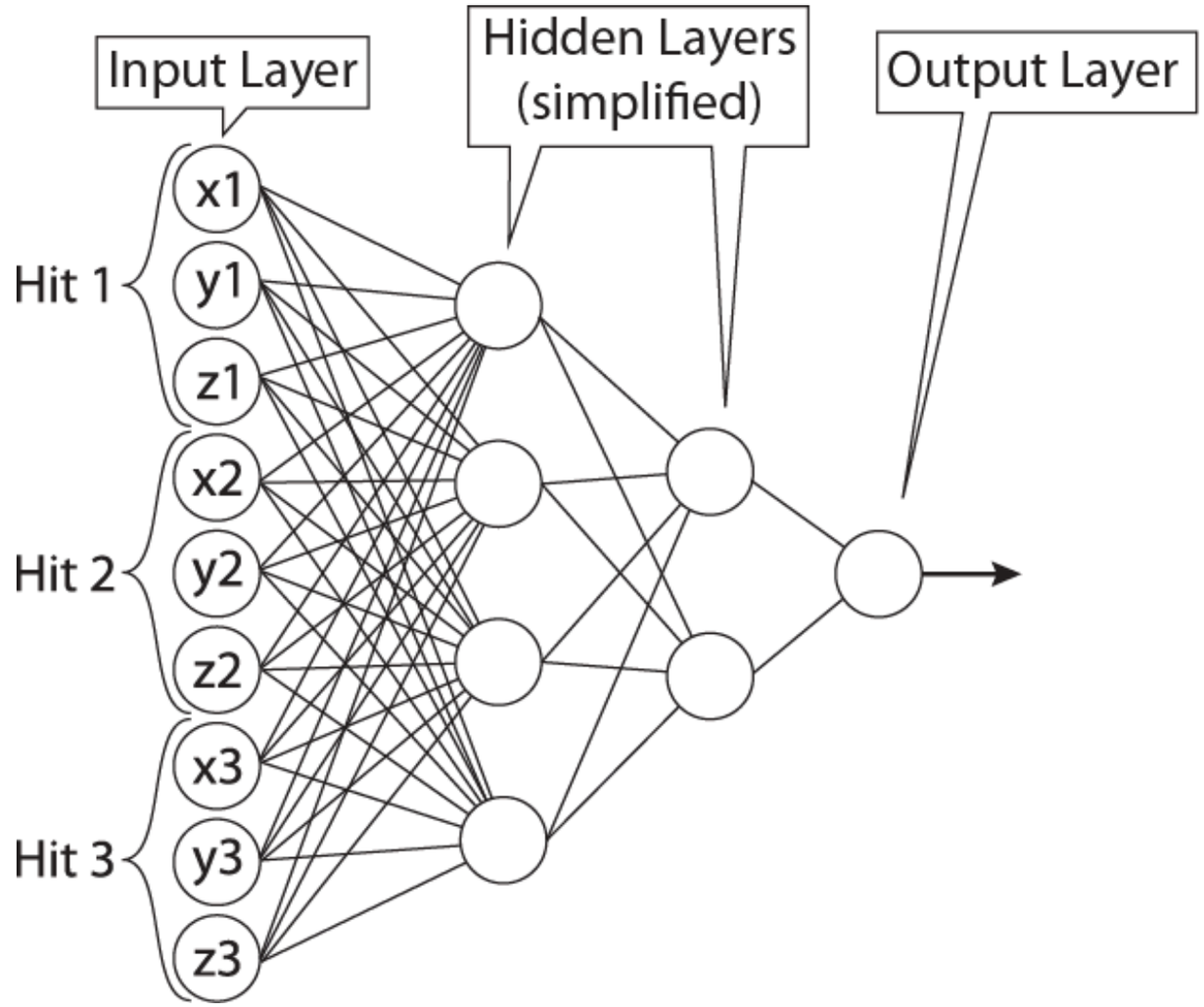
Monte Carlo

Based on GEANT4

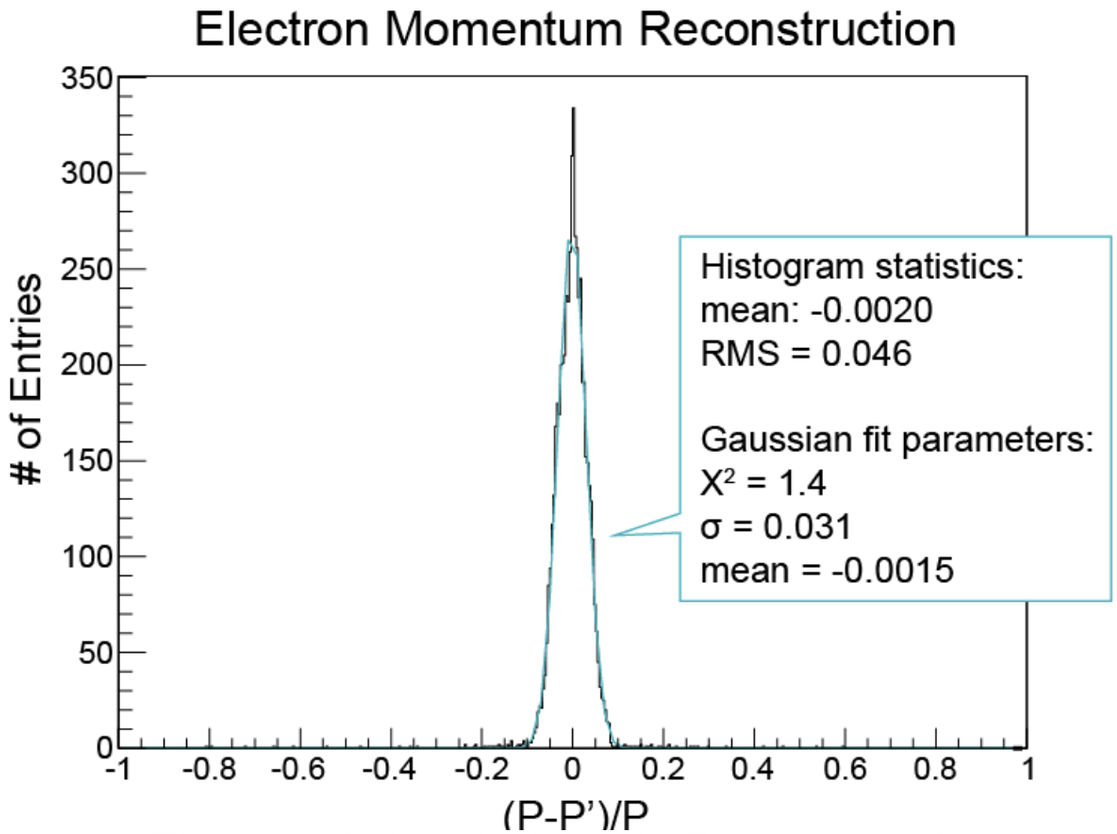
- all detectors fully simulated

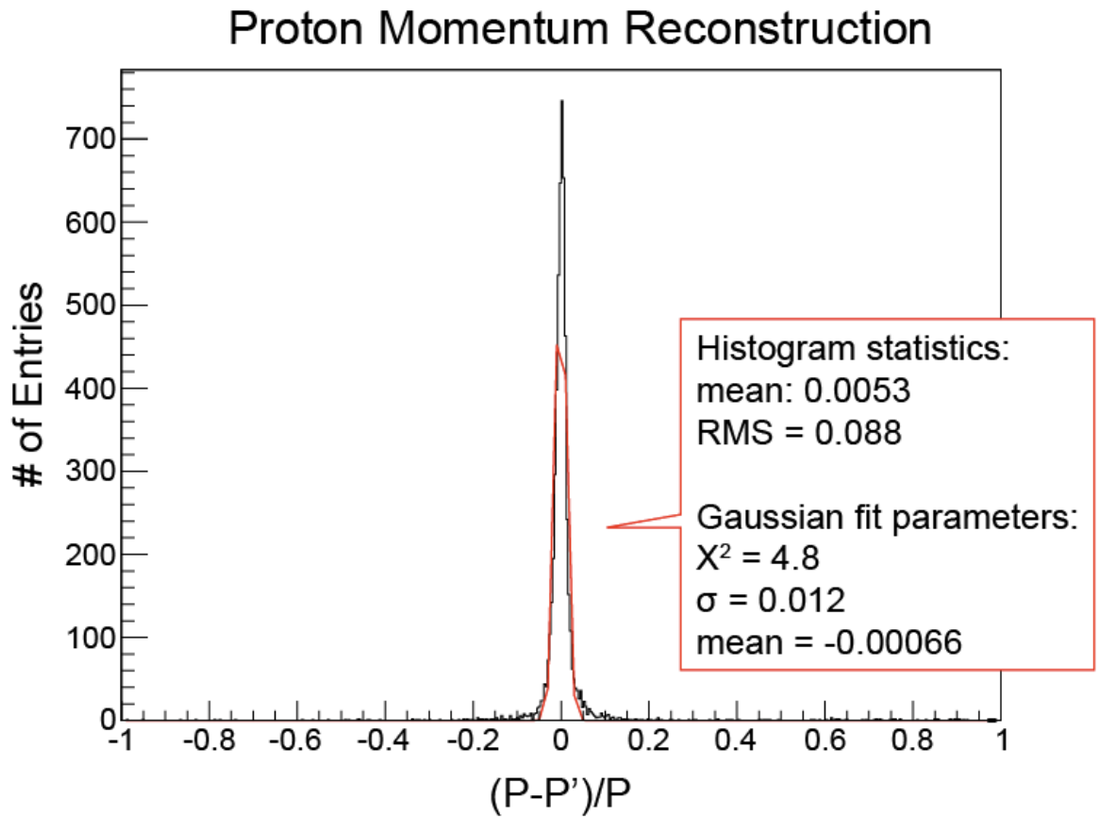
Track reconstruction

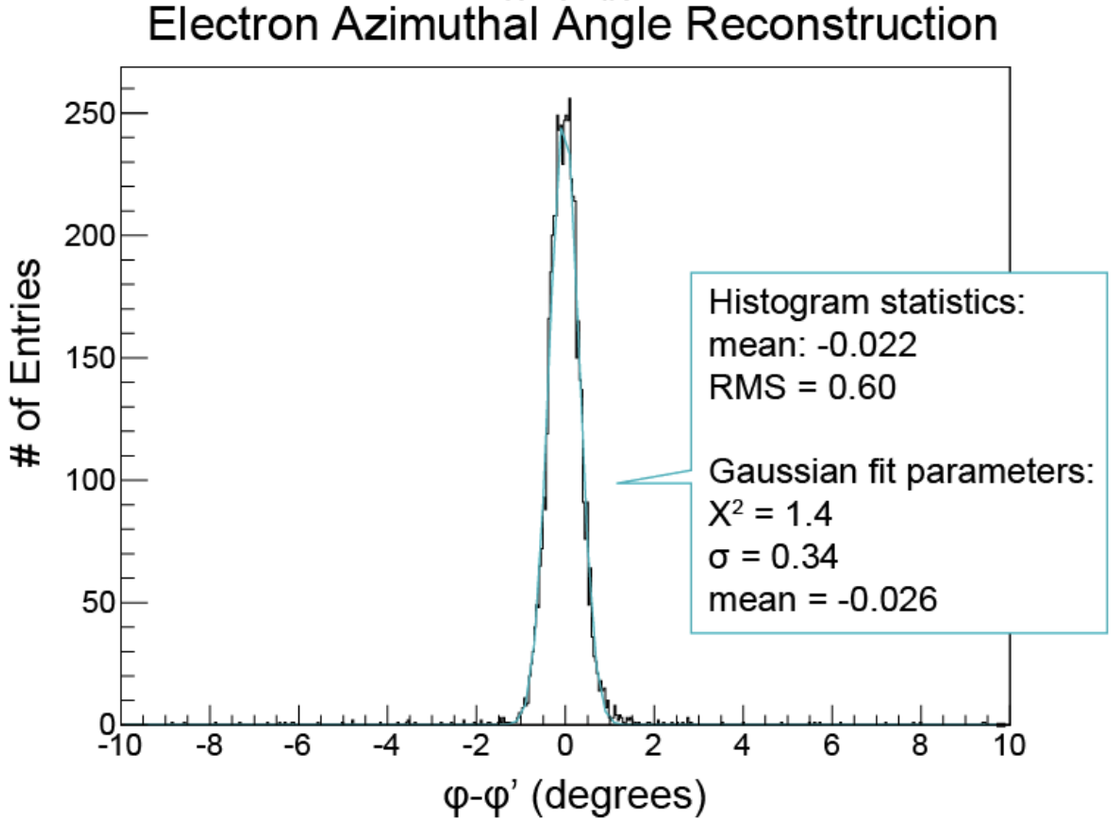
- neural network
- initial parameters for final fit

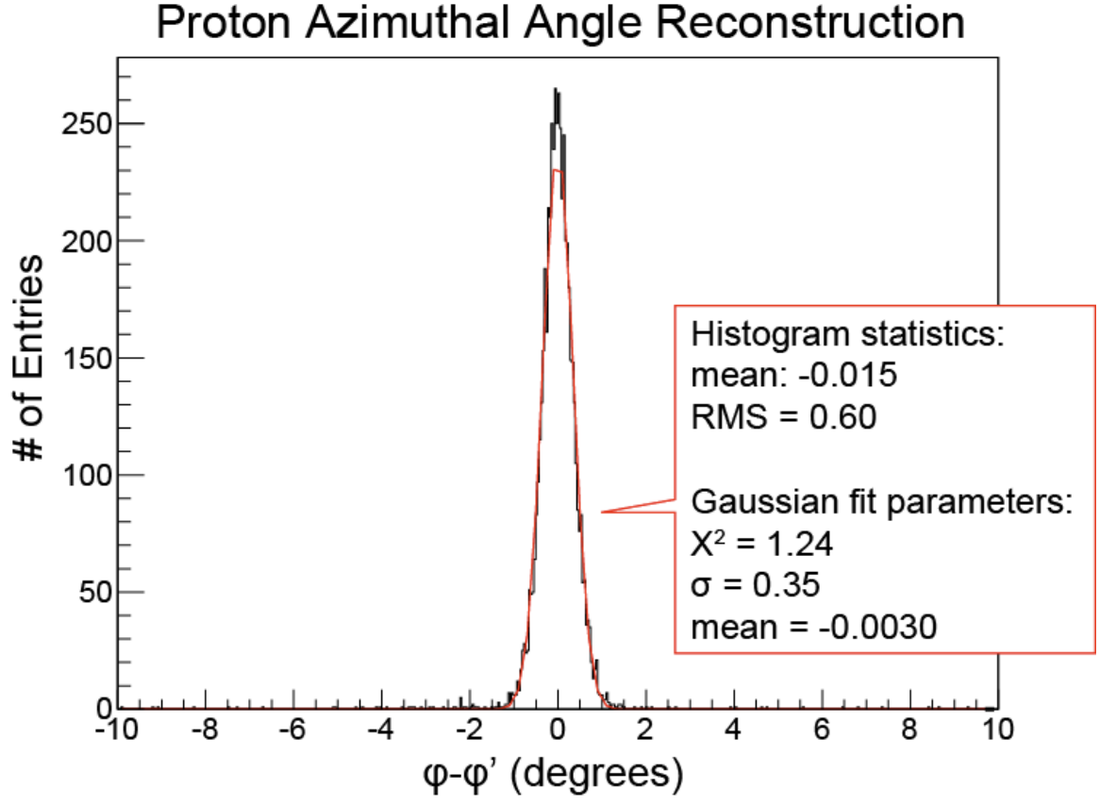


Momentum and Azimuth Resolutions

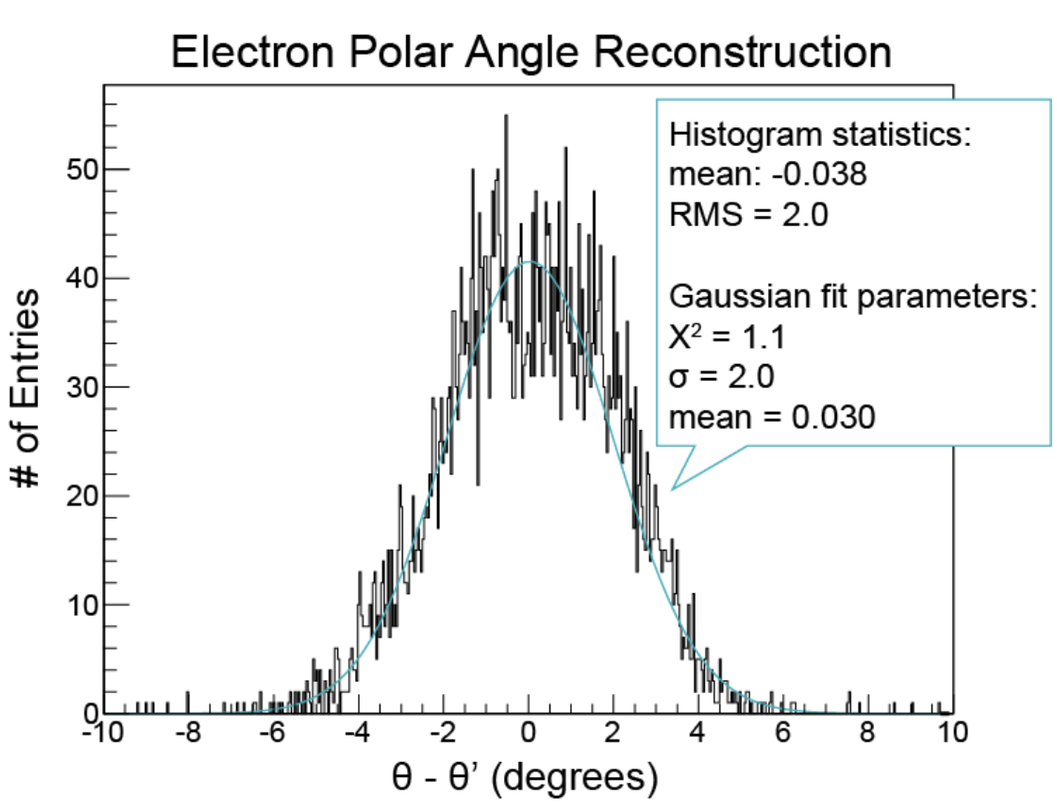


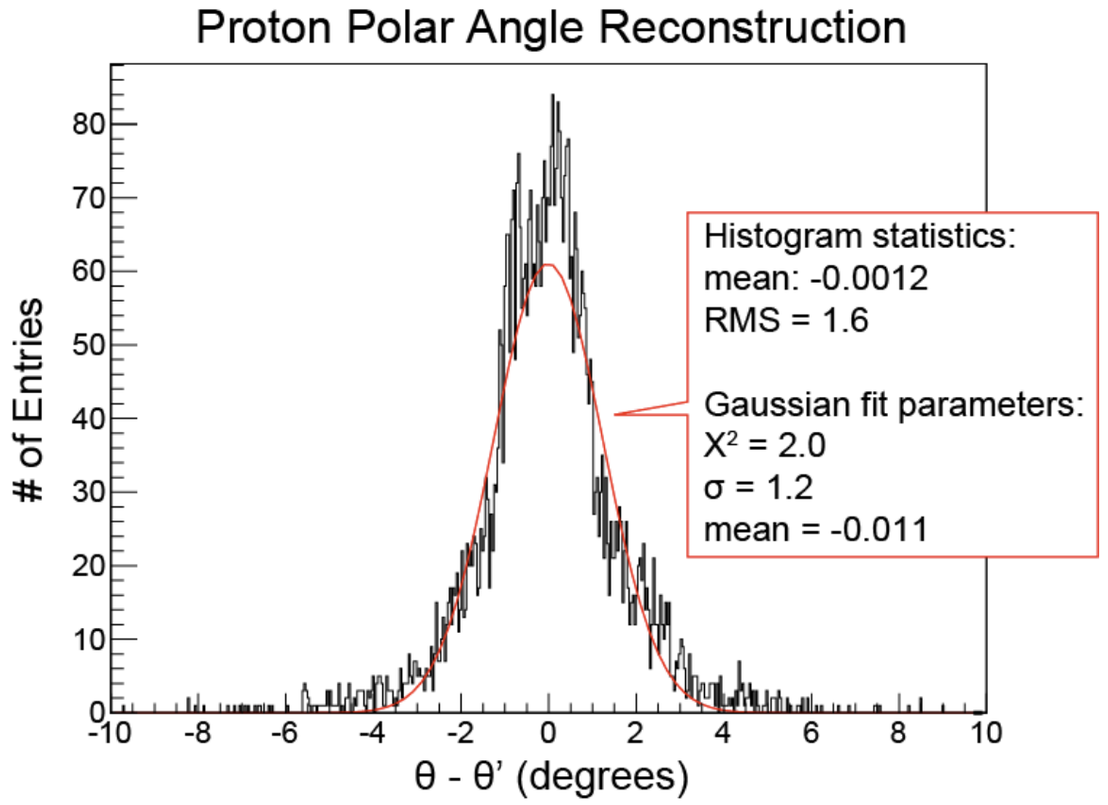


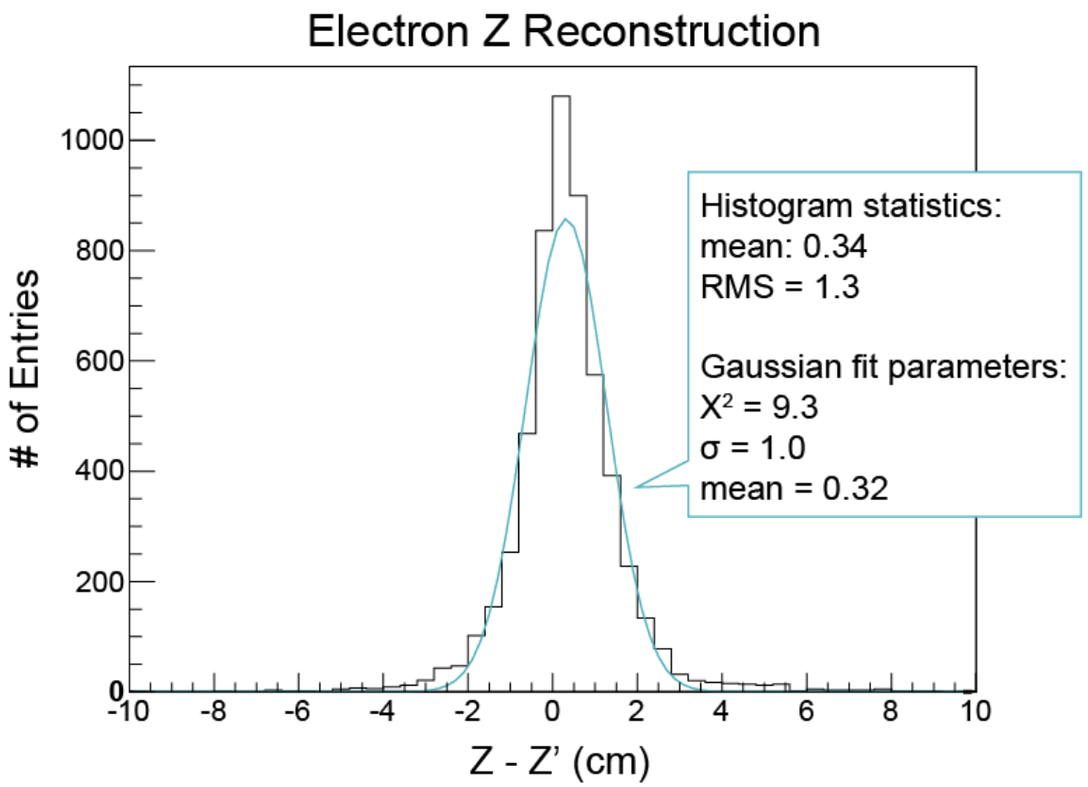


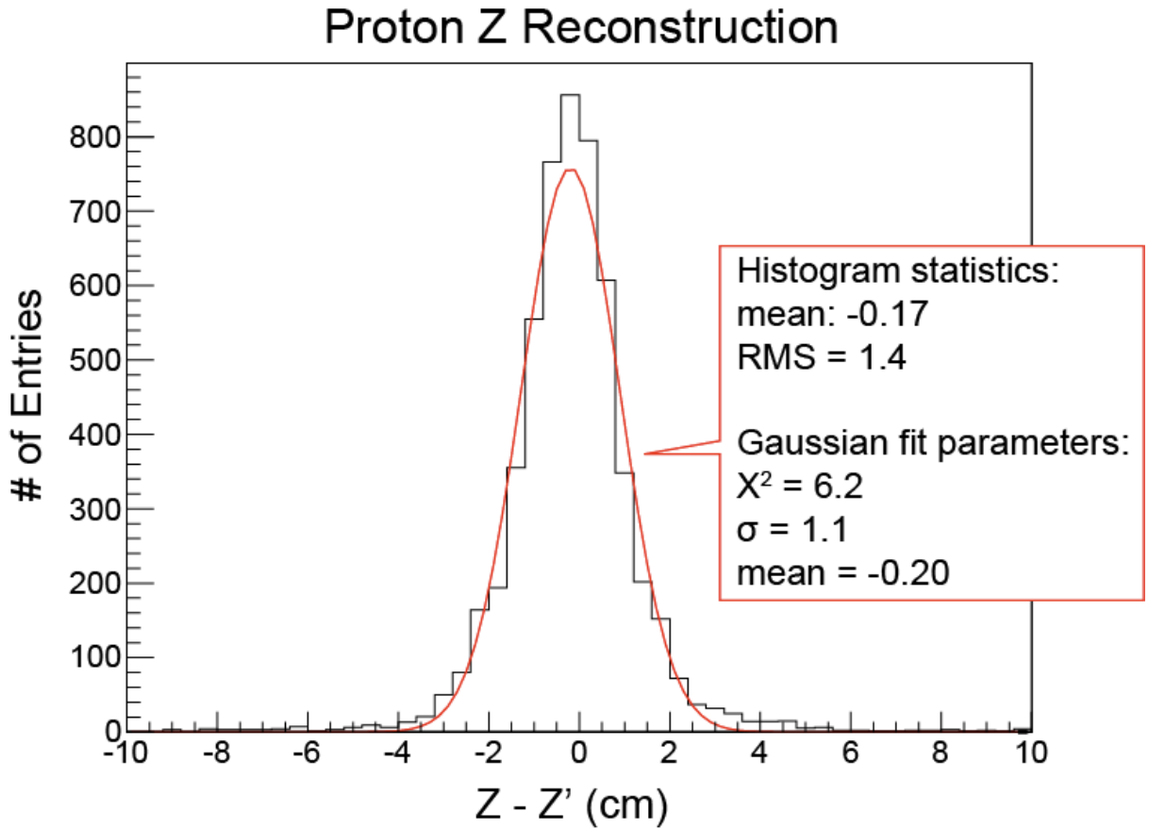


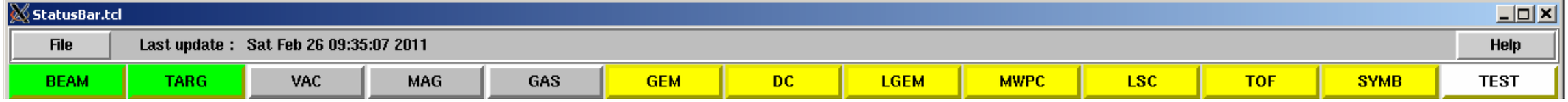
Polar and Vertex Resolutions

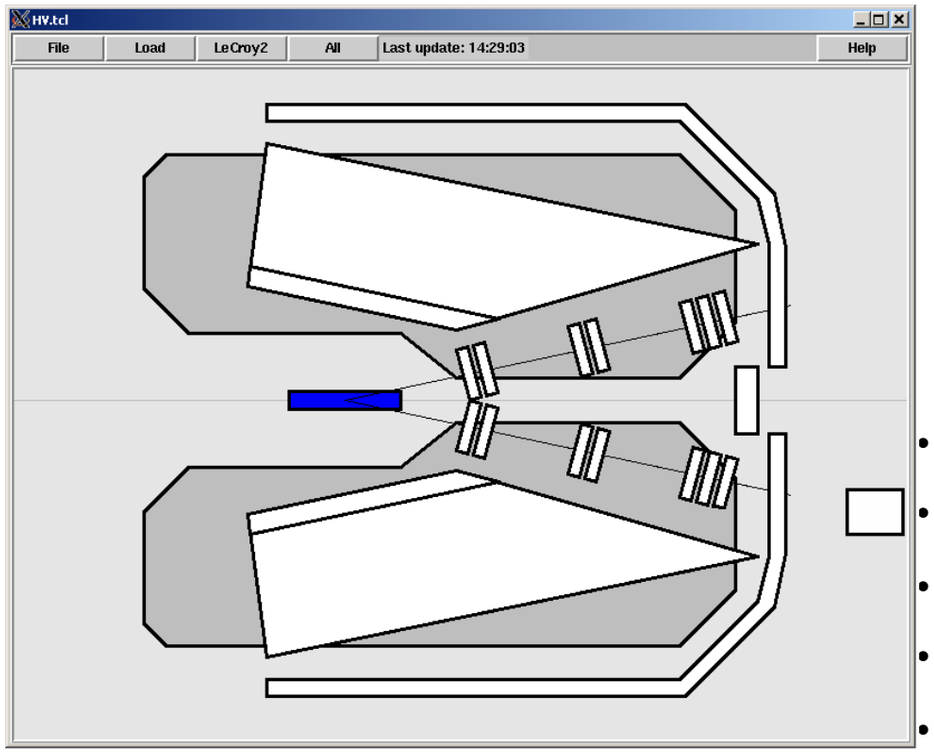






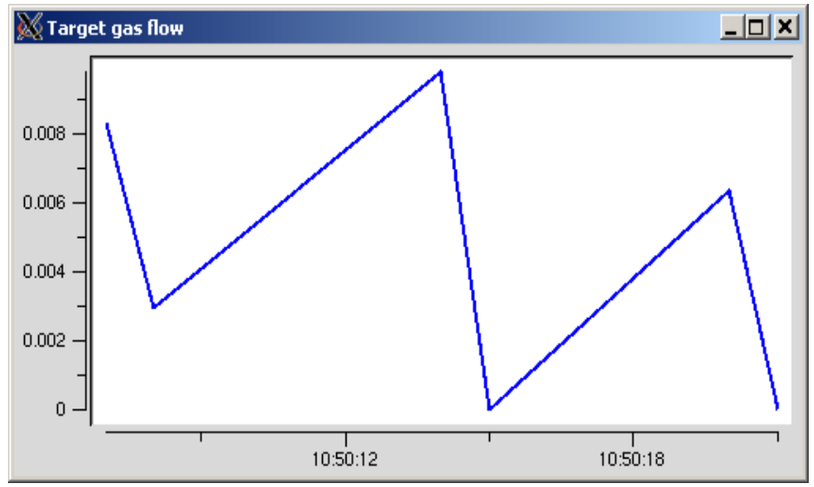


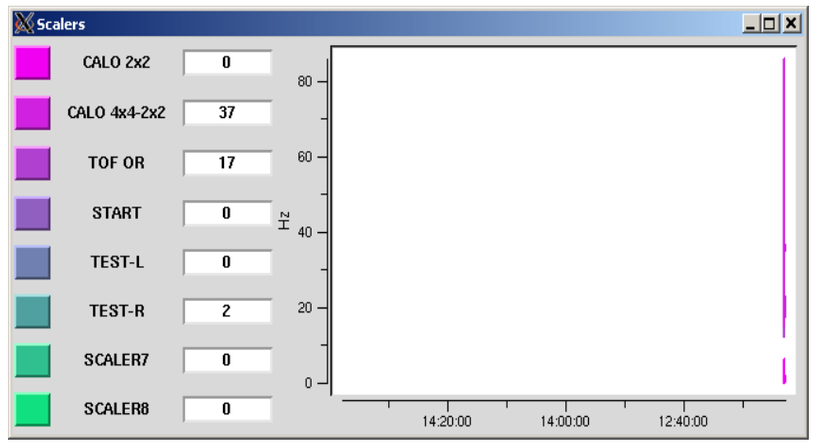


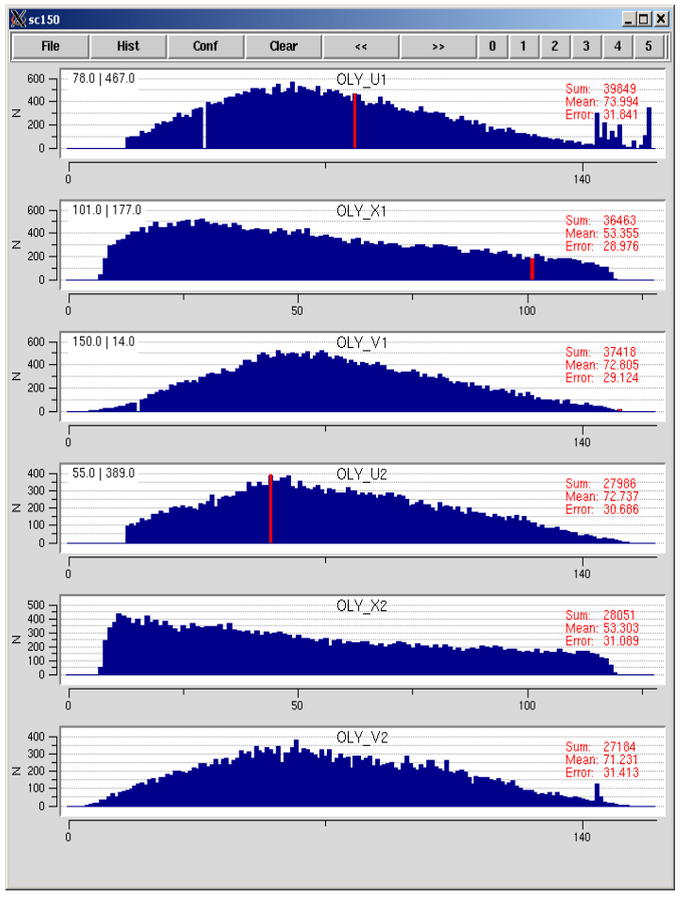


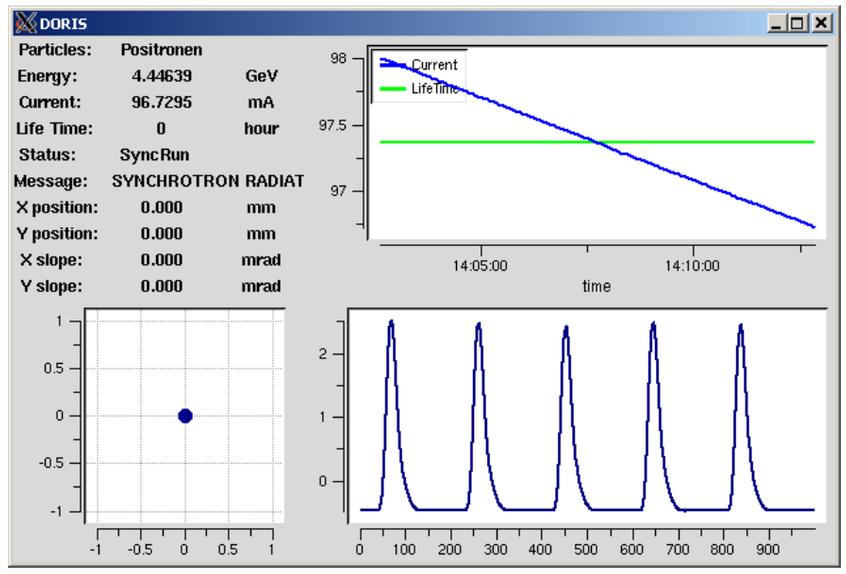
Slow Control Tasks

- **sb – Status Bar client,**
- **SB – Status Bar picture,**
- **hv – HV client for LeCroy,**
- **caen – HV client for CAEN,**
- **HV – HV picture,**
- **beam – TINE client for DORIS Globals,**
- **bunch – TINE client for beam structure,**
- **bpm – TINE client for BPM's,**
- **BEAM – beam picture,**
- **EPICS target software,**
- **targ – EPICS->StatusBar target status interface,**
- **TFLOW – Target gas flow time graph,**
- **SCAL – Scaler rates time graph,**
- **MWPC wiremaps.**





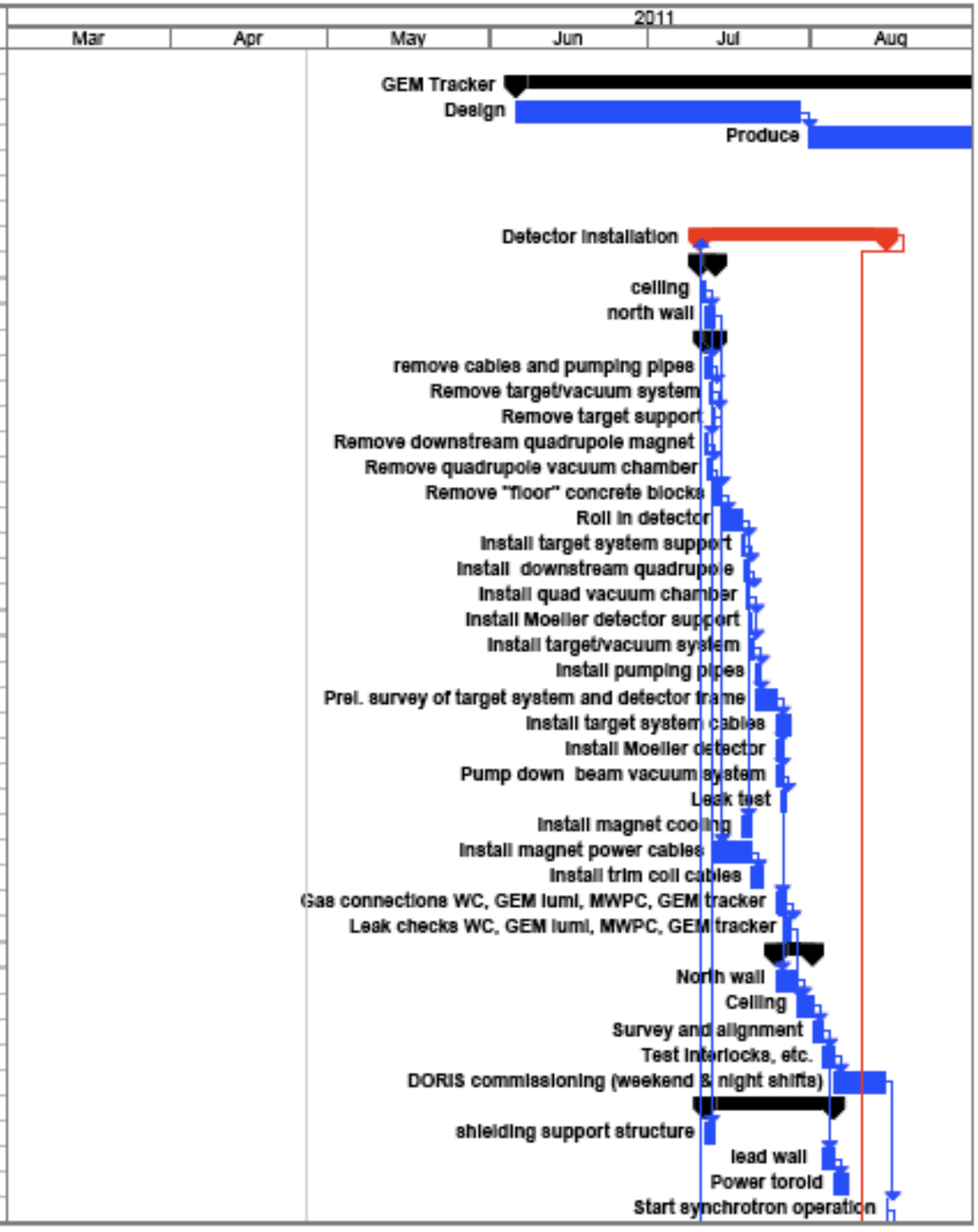




OLYMPUS Installation Schedule

OLYMPUS Schedule - Version 11
18.04.2011

ID	Task Name	Duration	Start	Finish
150				
151	GEM Tracker	140 days	Mon 06.06.11	Fri 16.12.11
152	Design	2 mons	Mon 06.06.11	Fri 29.07.11
153	Produce	3 mons	Mon 01.08.11	Fri 21.10.11
154	Test	4 wks	Mon 24.10.11	Fri 18.11.11
155	Pack and ship to DESY	4 wks	Mon 21.11.11	Fri 16.12.11
156				
157	Detector installation	25,63 days?	Mon 11.07.11	Mon 15.08.11
158	Remove shielding	3 days?	Mon 11.07.11	Wed 13.07.11
159	ceiling	1 day?	Mon 11.07.11	Mon 11.07.11
160	north wall	2 days	Tue 12.07.11	Wed 13.07.11
161	Remove OLYMPUS target/vacuum system	2 days	Tue 12.07.11	Wed 13.07.11
162	remove cables and pumping pipes	1 day	Tue 12.07.11	Tue 12.07.11
163	Remove target/vacuum system	4 hrs	Wed 13.07.11	Wed 13.07.11
164	Remove target support	4 hrs	Wed 13.07.11	Wed 13.07.11
165	Remove downstream quadrupole magnet	4 hrs	Tue 12.07.11	Tue 12.07.11
166	Remove quadrupole vacuum chamber	4 hrs	Tue 12.07.11	Tue 12.07.11
167	Remove "floor" concrete blocks	1 day?	Thu 14.07.11	Thu 14.07.11
168	Roll in detector	2 days	Fri 15.07.11	Mon 18.07.11
169	Install target system support	4 hrs	Tue 19.07.11	Tue 19.07.11
170	Install downstream quadrupole	4 hrs	Tue 19.07.11	Tue 19.07.11
171	Install quad vacuum chamber	4 hrs	Wed 20.07.11	Wed 20.07.11
172	Install Moeller detector support	4 hrs?	Wed 20.07.11	Wed 20.07.11
173	Install target/vacuum system	1 day?	Wed 20.07.11	Thu 21.07.11
174	Install pumping pipes	1 day?	Thu 21.07.11	Fri 22.07.11
175	Prel. survey of target system and detector frar	2 days	Thu 21.07.11	Mon 25.07.11
176	Install target system cables	3 days	Mon 25.07.11	Thu 28.07.11
177	Install Moeller detector	1 day?	Mon 25.07.11	Tue 26.07.11
178	Pump down beam vacuum system	1 day?	Mon 25.07.11	Tue 26.07.11
179	Leak test	1 day?	Tue 26.07.11	Wed 27.07.11
180	Install magnet cooling	2 days	Tue 19.07.11	Wed 20.07.11
181	Install magnet power cables	5 days	Thu 14.07.11	Wed 20.07.11
182	Install trim coil cables	2 days	Thu 21.07.11	Fri 22.07.11
183	Gas connections WC, GEM lumi, MWPC, GEI	2 days	Mon 25.07.11	Wed 27.07.11
184	Leak checks WC, GEM lumi, MWPC, GEM tra	1 day?	Wed 27.07.11	Thu 28.07.11
185	Setup shielding	5 days?	Mon 25.07.11	Mon 01.08.11
186	North wall	4 days	Mon 25.07.11	Fri 29.07.11
187	Ceiling	1 day?	Fri 29.07.11	Mon 01.08.11
188	Survey and alignment	2 days	Mon 01.08.11	Wed 03.08.11
189	Test interlocks, etc.	2 days	Wed 03.08.11	Fri 05.08.11
190	DORIS commissioning (weekend & night shift	6 days	Fri 05.08.11	Mon 15.08.11
191	Lead shielding wall	18,5 days	Tue 12.07.11	Fri 05.08.11
192	shielding support structure	2 days	Tue 12.07.11	Wed 13.07.11
193	lead wall	2 days	Wed 03.08.11	Fri 05.08.11
194	Power toroid	1 day?	Fri 05.08.11	Mon 08.08.11
195	Start synchrotron operation	1 hr	Mon 15.08.11	Mon 15.08.11



Project: OLYMPUS_11
Date: Wed 27.04.11

Task | Progress | Summary | External Tasks | Deadline
Split | Milestone | Project Summary | External Milestone