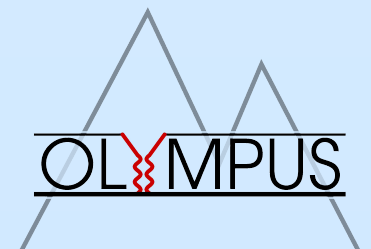


OLYMPUS Collaboration Meeting, DESY, June 27-28, 2011

GEM Luminosity Monitor

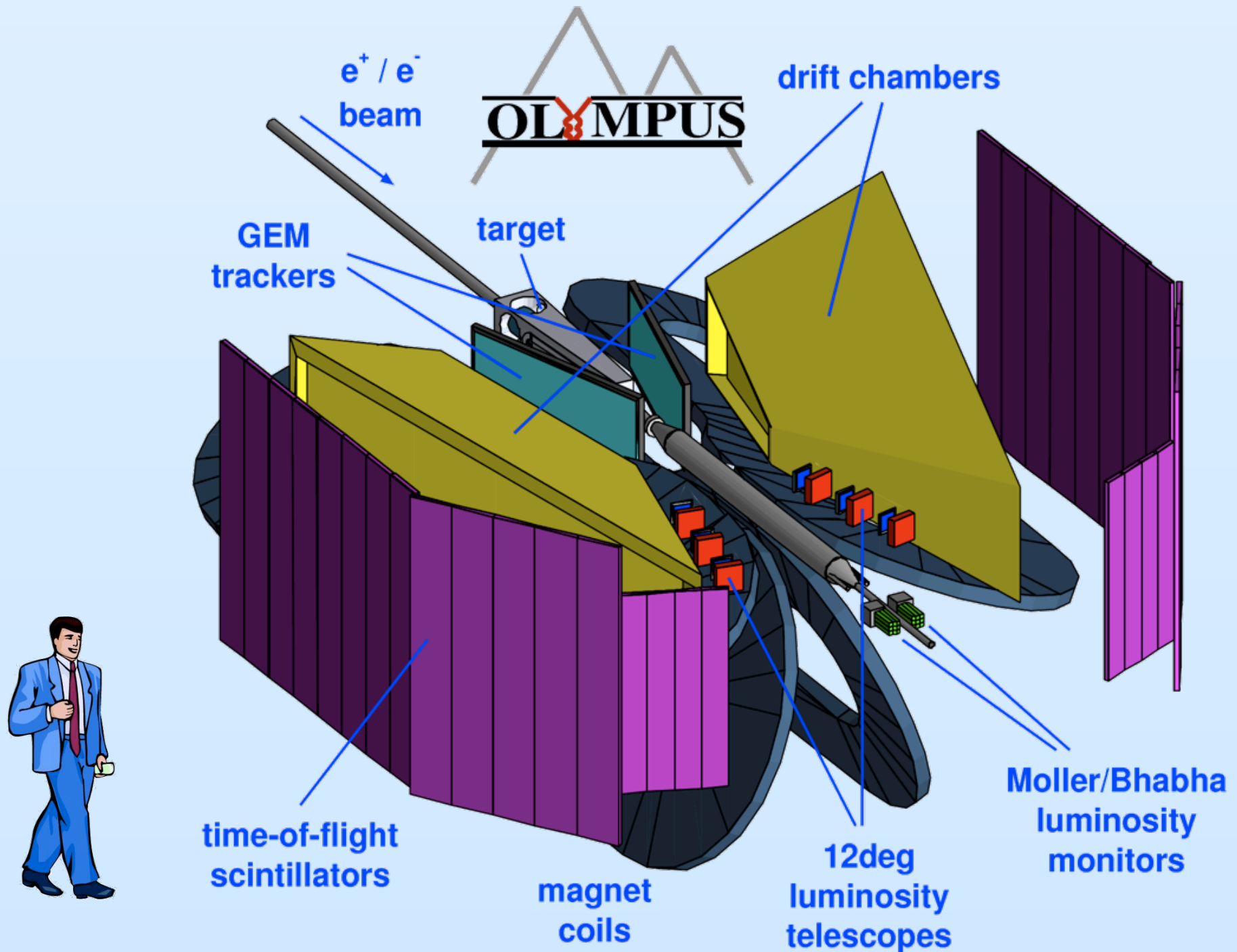
Michael Kohl

Hampton University, Hampton, VA 23668
Jefferson Laboratory, Newport News, VA 23606



* Supported by NSF grants PHY-0855473 and 0959521, and DOE Early Career Award DE-SC0003884

The OLYMPUS Detector

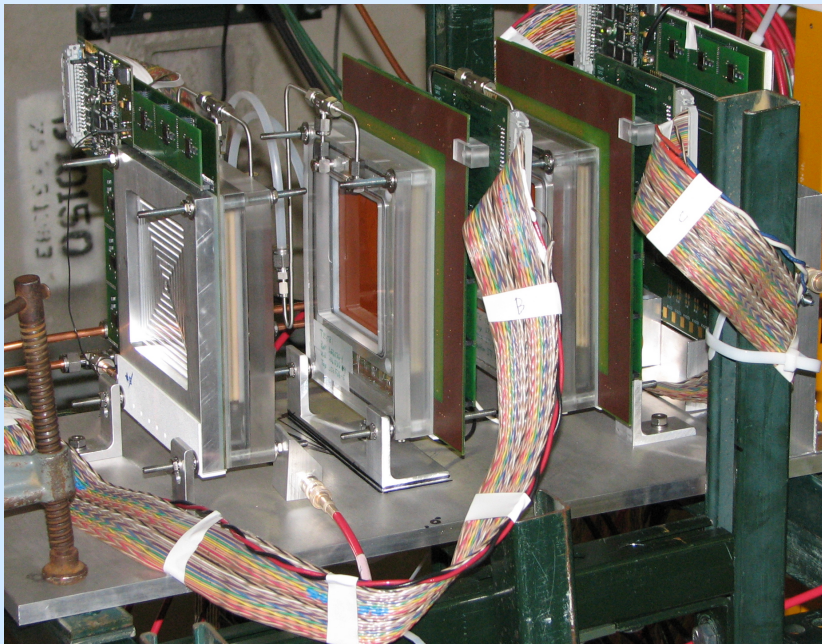
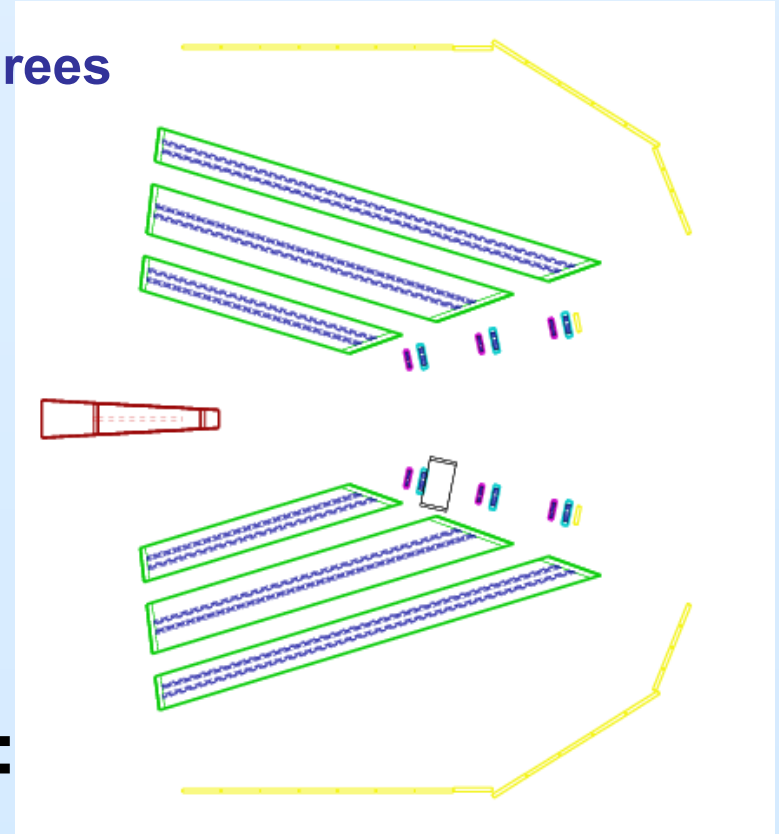


The OLYMPUS Experiment

- Electrons/positrons (100mA) in multi-GeV storage ring
DORIS at DESY, Hamburg, Germany
 - Unpolarized internal hydrogen target (buffer system)
 $3 \times 10^{15} \text{ at/cm}^2 @ 100 \text{ mA} \rightarrow L = 2 \times 10^{33} / (\text{cm}^2\text{s})$
 - Large acceptance detector for e-p in coincidence
Previous BLAST detector from MIT-Bates
 - Redundant monitoring of luminosity
Pressure, temperature, flow, current measurements
Small-angle elastic scattering at high epsilon / low Q^2
Symmetric Moller/Bhabha scattering
- **Measure ratio of positron-proton to electron-proton unpolarized elastic scattering to 1% stat.+sys.**

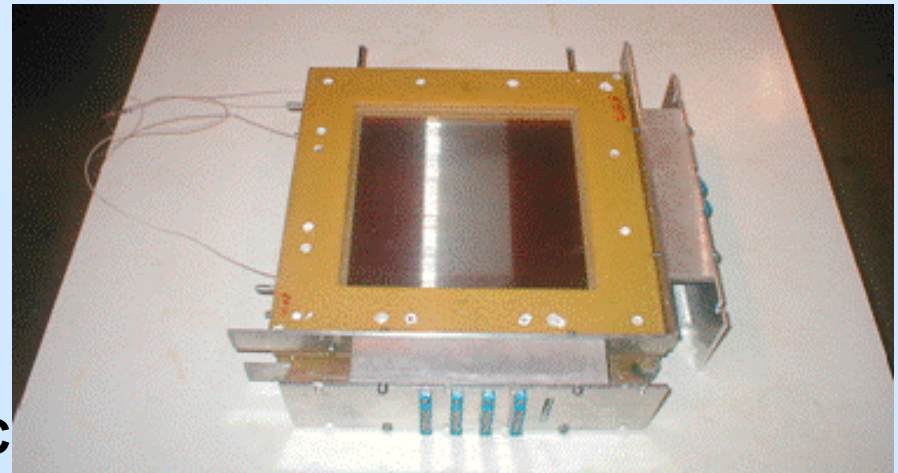
Luminosity Monitors: GEM + MWPC

- Forward elastic scattering of lepton at 12 degrees in coincidence with proton in main detector
- Two GEM + MWPC telescopes with interleaved elements operated independently
- Scintillator for triggering and timing
- High redundancy – alignment, efficiency
Two independent groups (Hampton, PNPI)



Prototypes:

GEM



MWPC

Luminosity Monitors – Basic Properties

Proposed version included in OLYMPUS TDR Sept. 2009

E_0 [GeV]	Q^2 [(GeV/c) ²]	$p_{e'}$ [GeV/c]	ϵ	θ_p	p_p [MeV/c]	Rate [h ⁻¹]
4.5	0.801	4.073	0.9736	58.7°	992	1846
2.0	0.167	1.911	0.9774	71.8°	418	49792

Table 4.1: Kinematics and count rates of the luminosity control measurement for beam energies of 2.0 and 4.5 GeV at $\theta_e = 12^\circ$. The assumed solid angle is 1.2 msr determined by the area of rearmost tracking plane farthest from the target.

- Two symmetric GEM telescopes at **12°**
- Two-photon effect negligible at high- ϵ / low- Q^2
- **Sub-percent** (relative) luminosity measurement
per hour at 2.0 GeV, per day at 4.5 GeV
- **1.2 msr** = 10 x 10 cm² at ~290 cm distance (rearmost plane)
- Three GEM layers with ~0.1 mm resolution with ~50 cm gaps

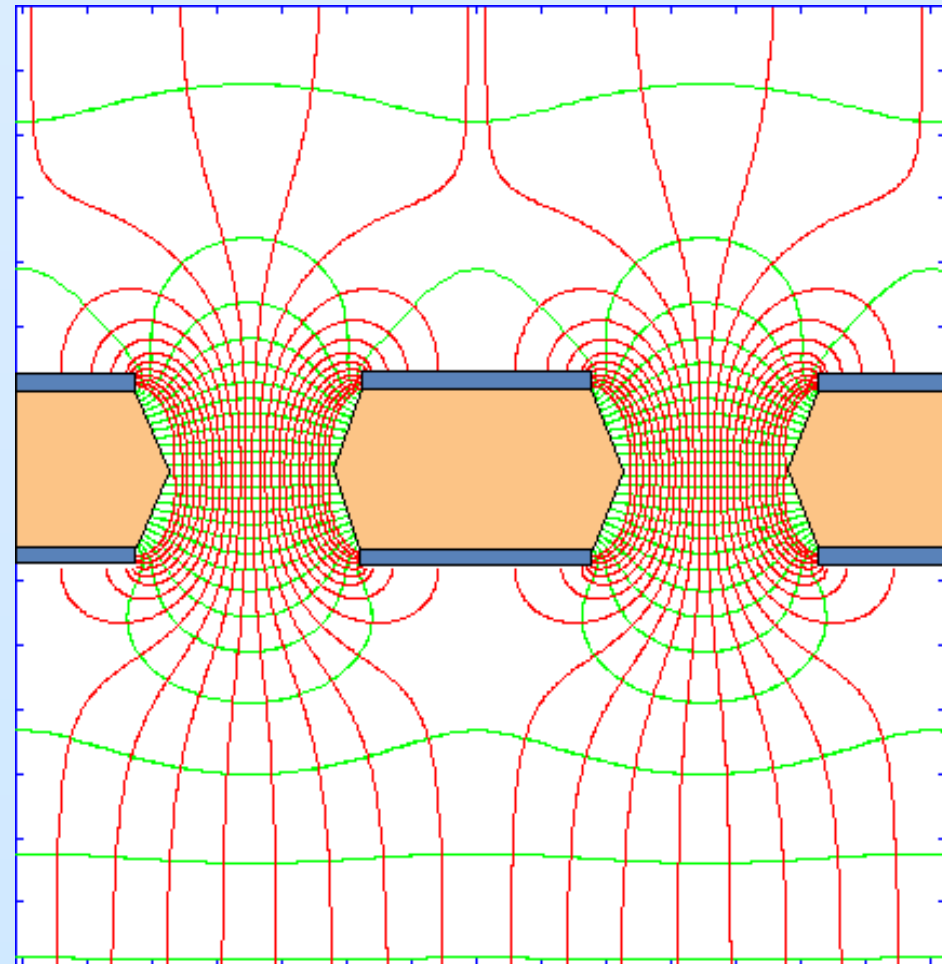
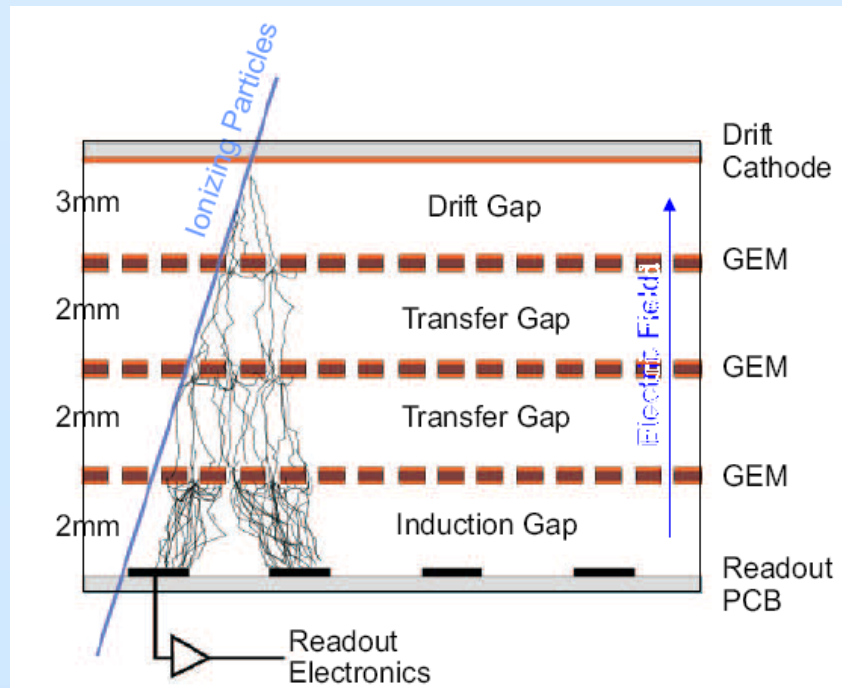
Principle of GEM Detectors

- GEM = Gas Electron Multiplier**

introduced by F. Sauli in mid 90's, [F. Sauli et al., NIMA 386 \(1997\) 531](#)

**Copper layer-sandwiched
kapton foil with chemically
etched micro-hole pattern**

➡ gas amplification in the hole



Providing GEM detectors for OLYMPUS

Collaboration HU-MIT-Rome

TechEtch/MIT to provide GEM foils

Assembly of detectors at MIT-LNS, MIT-Bates and Hampton Univ.

INFN Rome: Readout system developed for Hall A / SBS

Testing at HU and DESY

Funding

- **Secured** NSF Nuclear Physics basic research grant
(PHY-0855473: \$405k for 3 years, active since Aug. 2009)
1 postdoc; travel funds
2 undergraduate stipends for summer 2010
- **Secured** \$216k within NSF MRI-R2 for luminosity monitors
(PHY-0959521: \$216k, active since Feb. 2010)
1 grad. stipend + travel for commissioning
- **Subaward** to MIT (\$77k) established within MRI grant
for MIT-Bates engineering services and ordering of parts

The HU group at DESY (2011)



Dr. Jürgen Diefenbach
Postdoc



Ozgur Ates
PhD candidate



Miles Campbell
Sophomore



Joshua McMahon
Sophomore

Thanks to NSF and DOE!

Tasks & Timeline for LuMo Construction

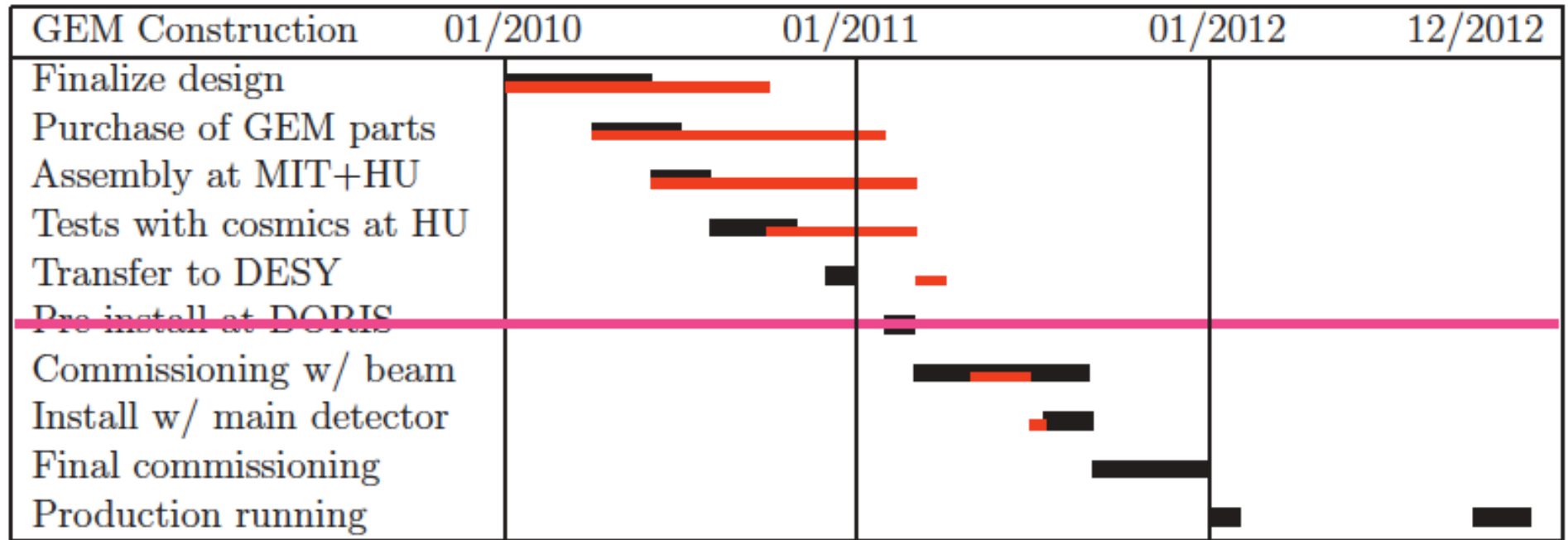


Table 2: Revised work plan for GEM luminosity monitor construction activities.

- Above original schedule from TDR (black) with June 2011 updates (red)
- Construction of GEM detectors started at MIT in summer 2010
- New research building at HU with lab space available since October 2010
- Completed assembly of GEMs at Hampton in March 2011 with partial testing
- Testing at DESY spring 2011 (DESY testbeam facility in May-June 2011)
- Final installation in OLYMPUS main detector in summer 2011

Realization of Detectors

- **Begin of 2010: Construction project fully funded (NSF/MRI-R2)**
- **Established HU-MIT subaward for Bates engineering services**
 - Drawings, direct ordering of parts, technical support for manufacturing
 - Mechanical parts designed, ordered (June 2010) and delivered by July 2010
 - Readout board designed, ordered (November 2010) and delivered by January 2011
- **GEM and HV foils from Tech Etch, Inc., 10x10 cm²**
 - Foils designed and ordered April 2010
 - 35/35 GEM foils delivered, 12/12 HV foils; 16/16 GEM foils for GEM2D by July 2010
- **HU group visited MIT and Bates from June 7 – August 8, 2010**
 - Frame preparation and cleaning
 - Testing of GEM foils (100% inspected, 30% optically scanned; 100% HV tested)
 - Stretching and gluing of PV, HV, and GEM foils on G10 frames (35% complete)

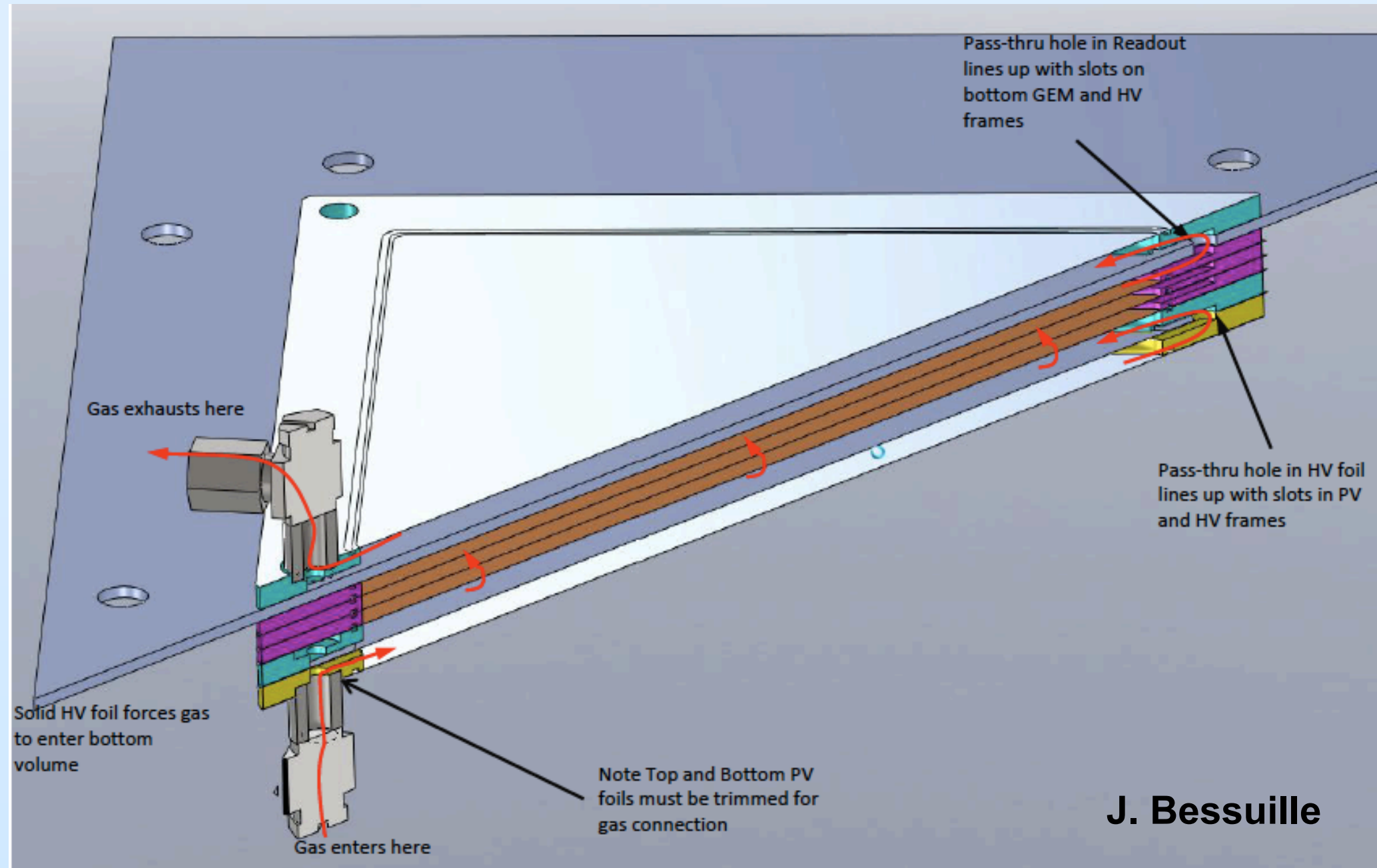
The Group at MIT (Summer 2010)



Realization of Detectors (cont'd)

- **Completed GEM assembly at HU from Sept 2010 – March 2011**
 - Preparation of new lab space
 - Gluing of foils on frames
 - HV tests repeated after gluing / leak current measurements – all GEMs still good!
 - Voltage divider and cosmic ray test setup with GEM2D chamber
 - Gain measurements with sources and picoammeter before gluing
 - Cosmic ray setup with preamplified signal
 - Tested and fixed final readout boards before gluing
 - **Glued nine (9) GEM elements by end of March (“S0 ... S8”)**
- **JD visit INFN Rome in February with HU GEM & readout board**
 - **Establish FE card functionality**, optimize for OLYMPUS GEM
 - Complete assembly and testing at HU by mid March 2011
- **Shipped detectors + electronics to DESY in April 2011**
 - Delivery of VME crate, CPU, HV modules to HU February – March 2011
 - Preparation for testing at DESY testbeam facility in May – June 2011
 - Assembly of telescopes, **install in OLYMPUS in June – July 2011**

Schematic view of a triple GEM

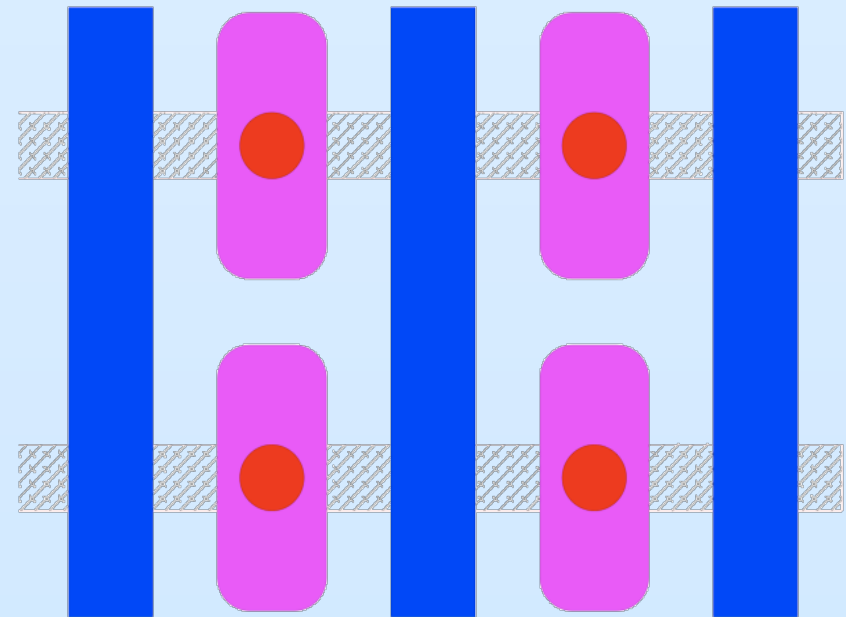


J. Bessuille

GEM Readout Board

- Want compact **12.5x12.5 cm²** total area, 10x10 cm² active area
- Straps to extend out on the sides with strips to fit into connectors on Rome APV readout cards: 4 straps/connectors per card = 128 channels;
- Pitch of 400 μm (2 cards each on 2 sides). **Designed, ordered and delivered.**

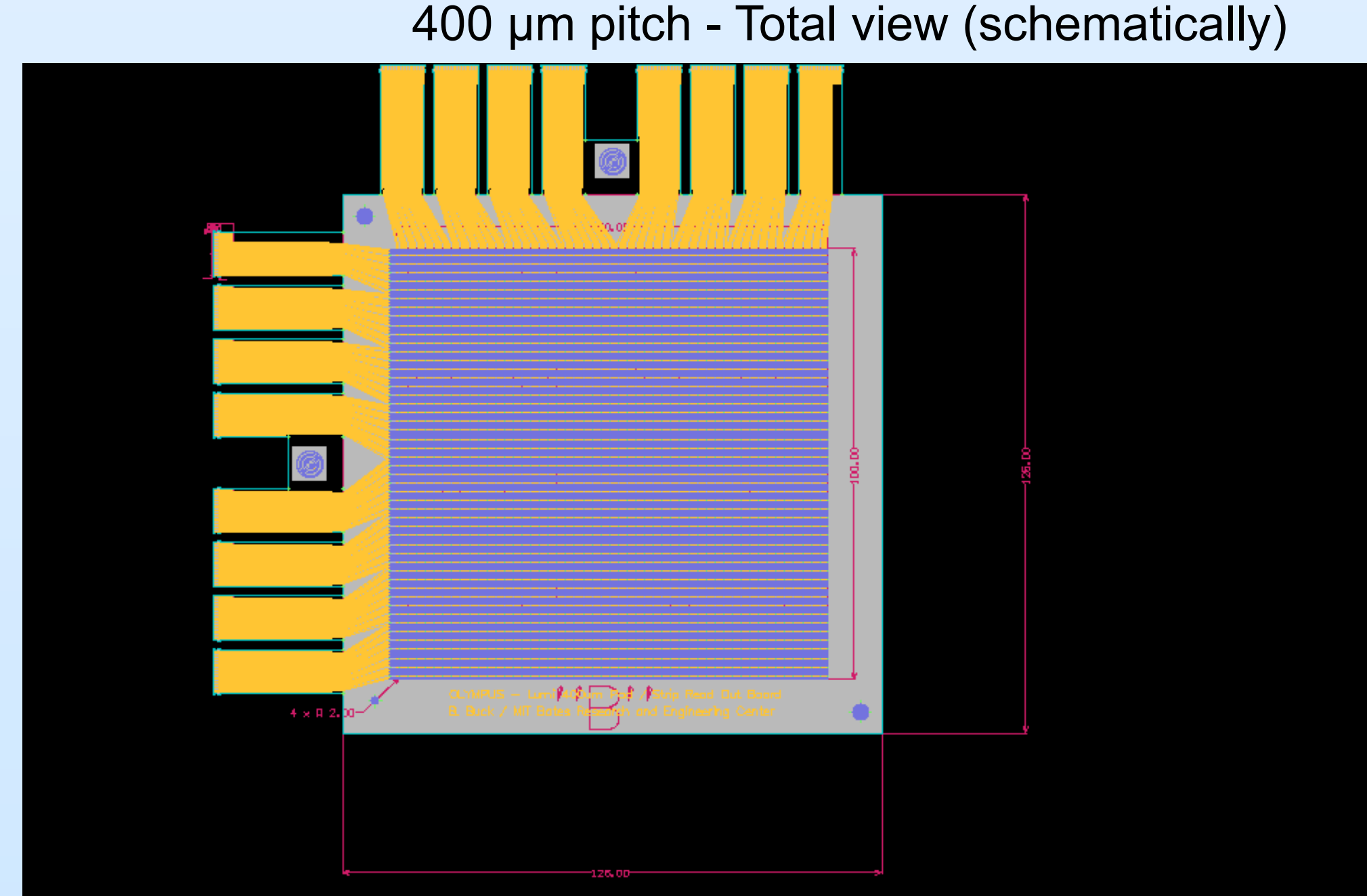
- Readout technology with strips and pads, on 2-sided foil, vias-connected on rear side
- Previous technique based on laser ablation discontinued



- Final boards had on average ~5 shorts on each, all of which were identified and repaired

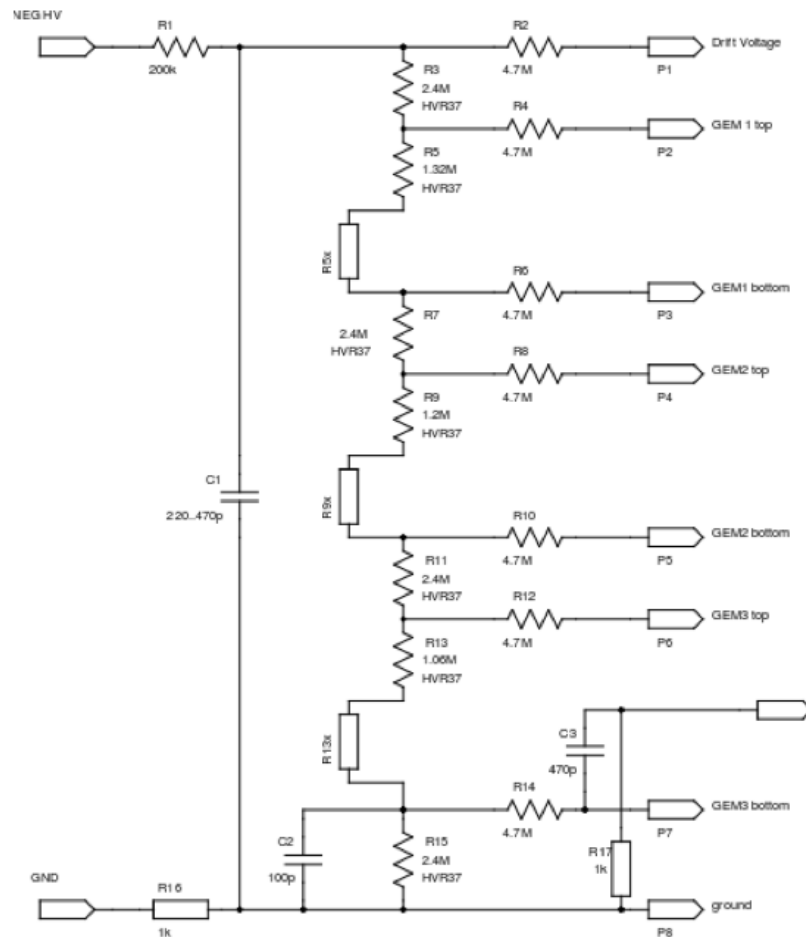
D.Hasell

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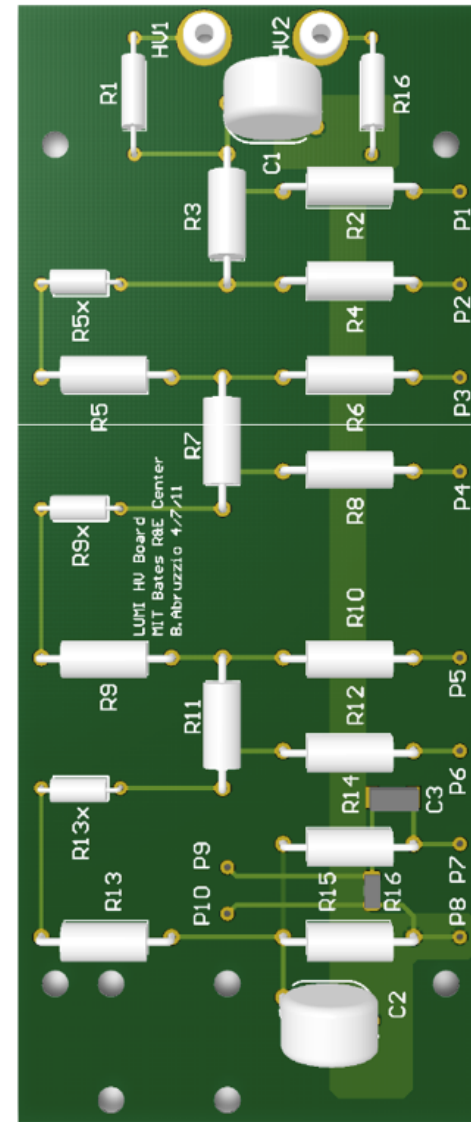


Voltage Dividers

voltage divider with fast trigger output



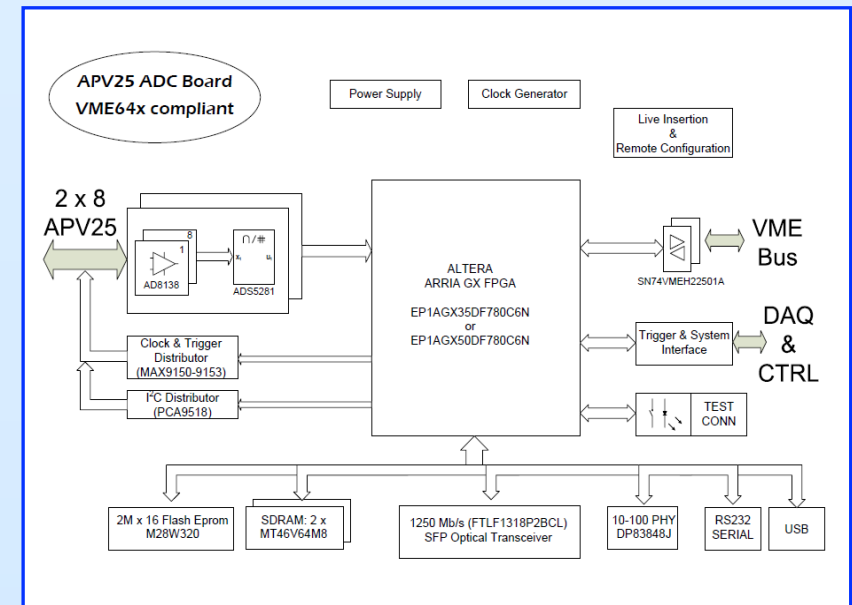
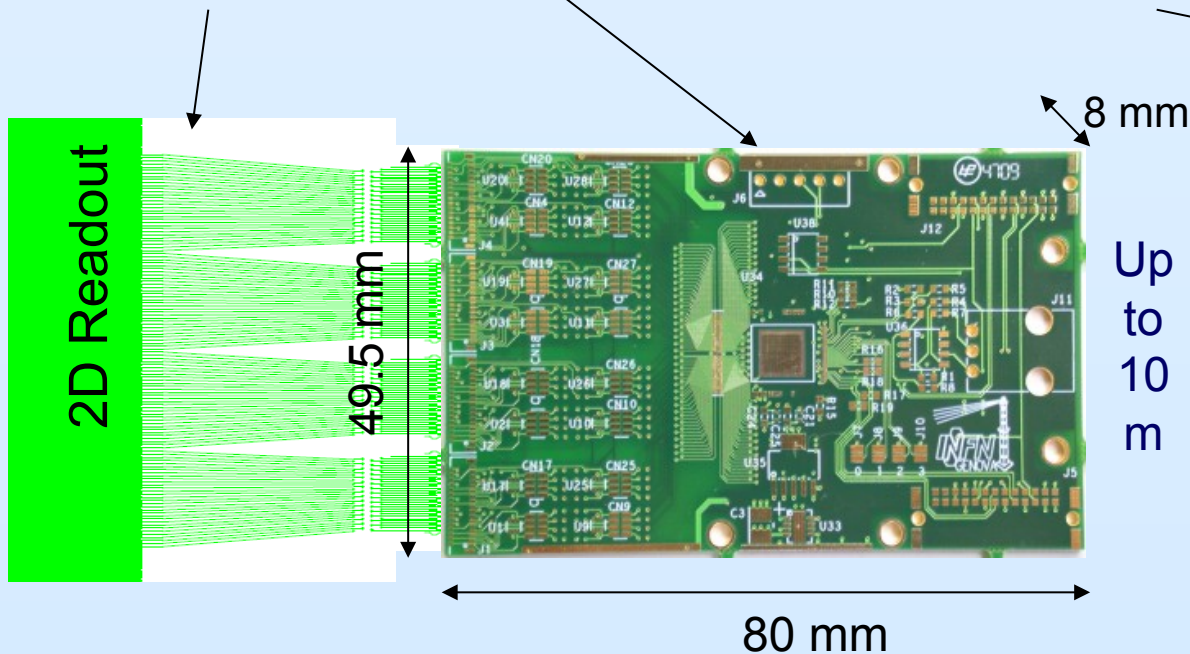
PCB layout: B. Abruzzio



Parts received at DESY end of May
9 VDs tested, cabled, still to be coated with Epoxy

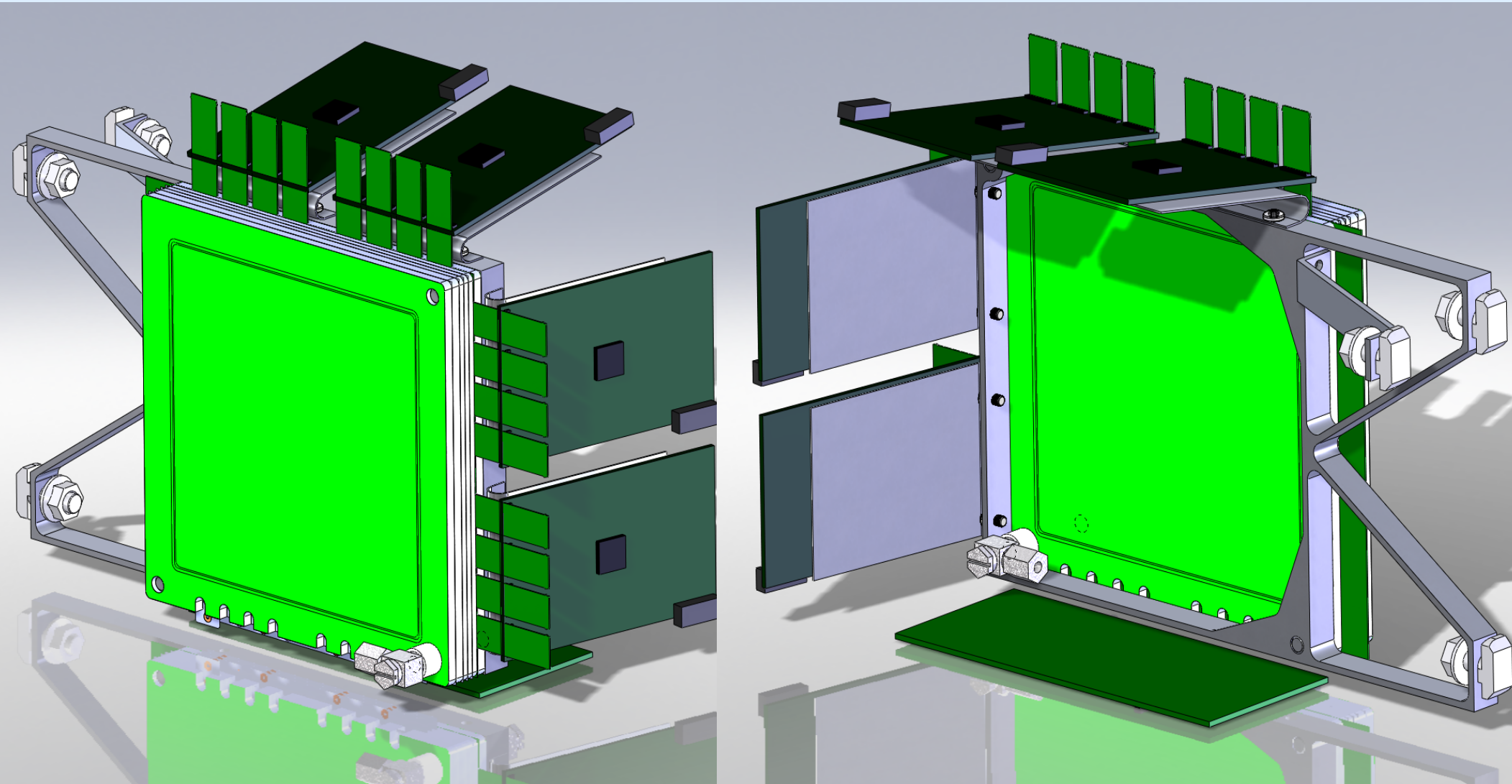
Readout Electronics (INFN Rome)

GEM \Rightarrow FEC \Rightarrow ADC+VME Controller \Rightarrow DAQ



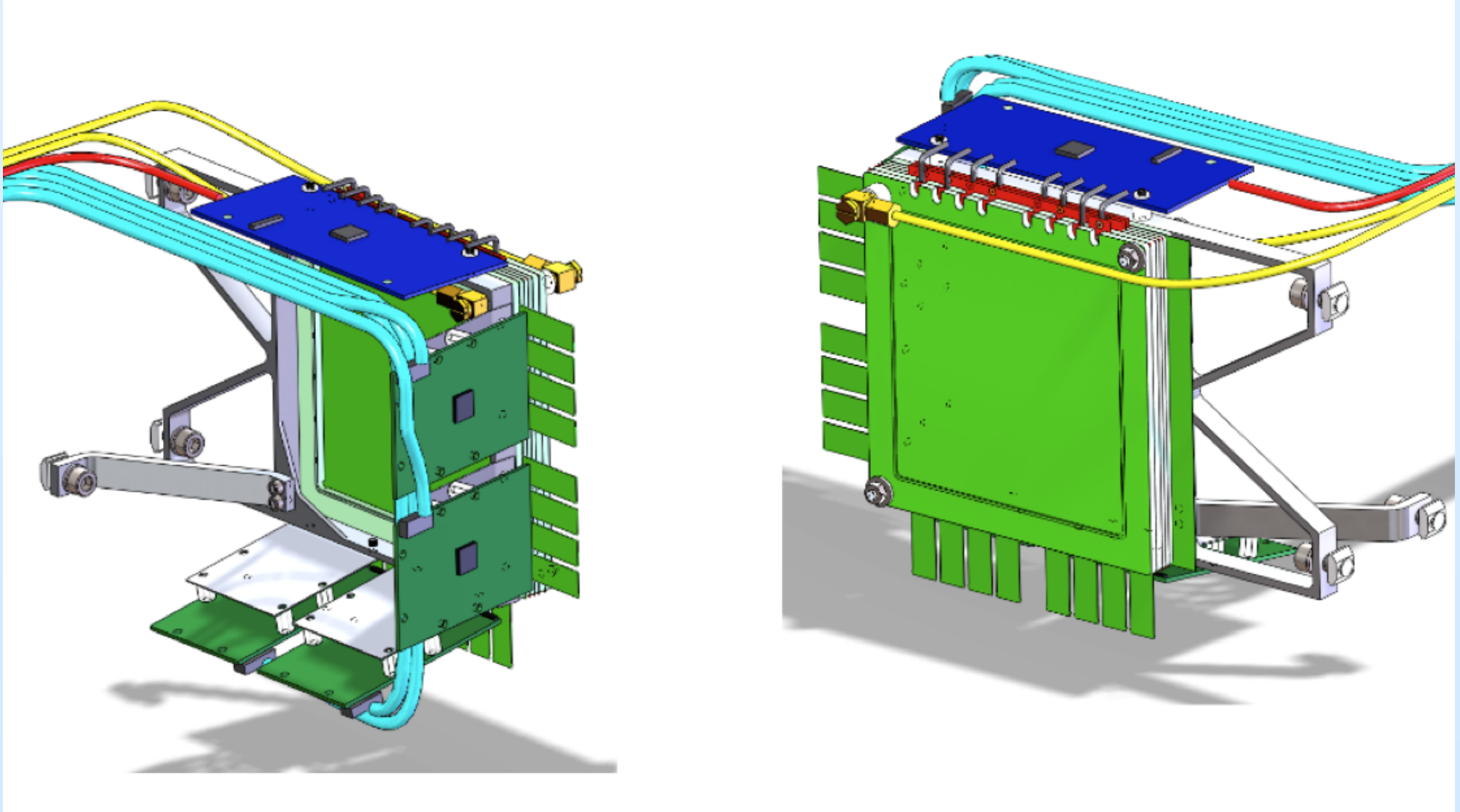
- Frontend card (APV + VME) by INFN Rome (S. Frullani)
- First test of INFN GEMs w/ new APV readout at DESY in November 2010
- JD visiting Rome with OLYMPUS GEM in February 2011 / 4 APV cards+VME
- 23 APV cards received on June 16; 2x20m HDMI cables received on June 22 another 3 APV cards expected. New batch will be produced due to issues
- 2(+1) final VME FPGA boards expected for first or second week of July

CAD model of GEM on bracket



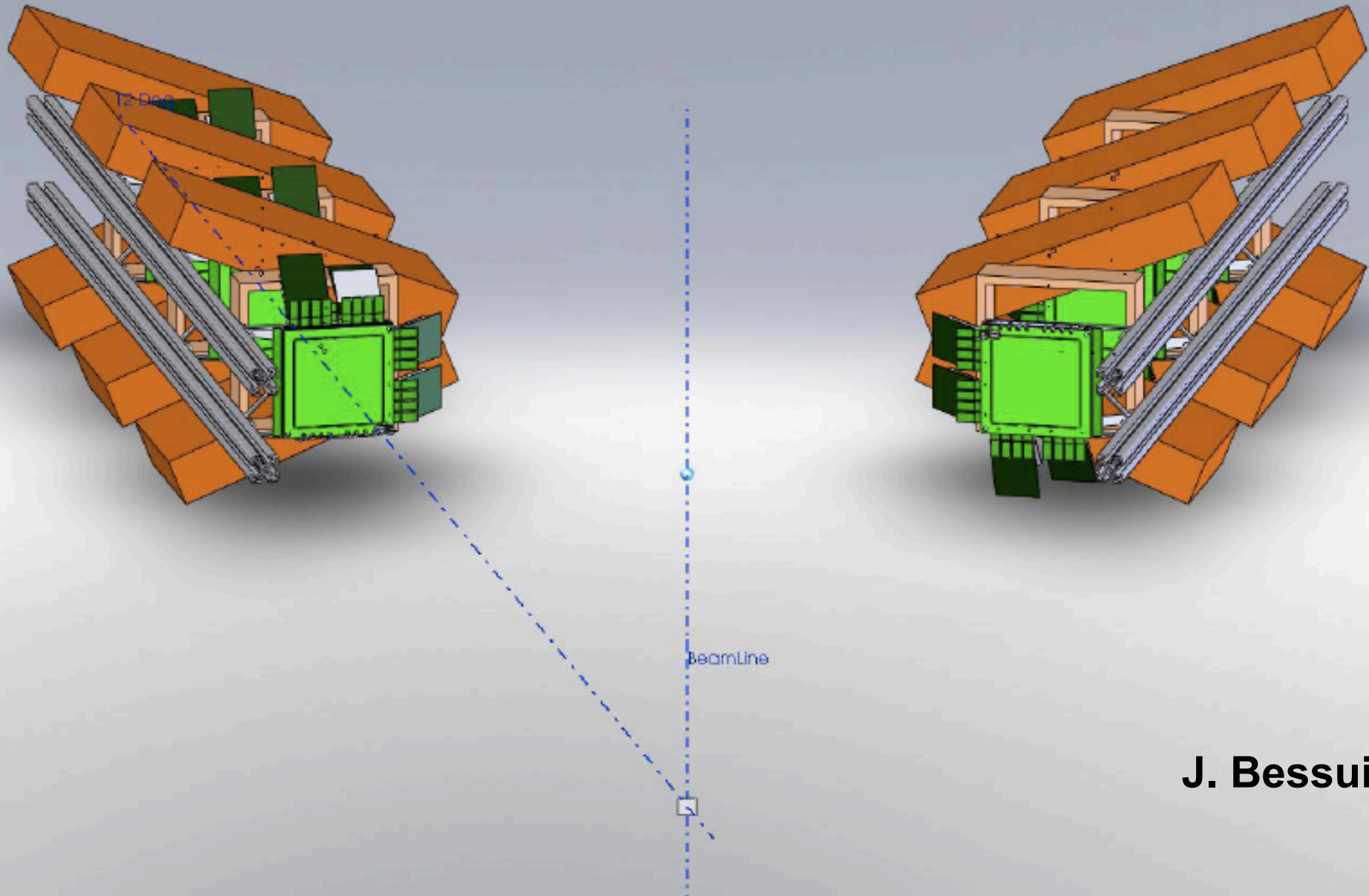
APV cards mounted on flexible plates

CAD model of GEM on bracket



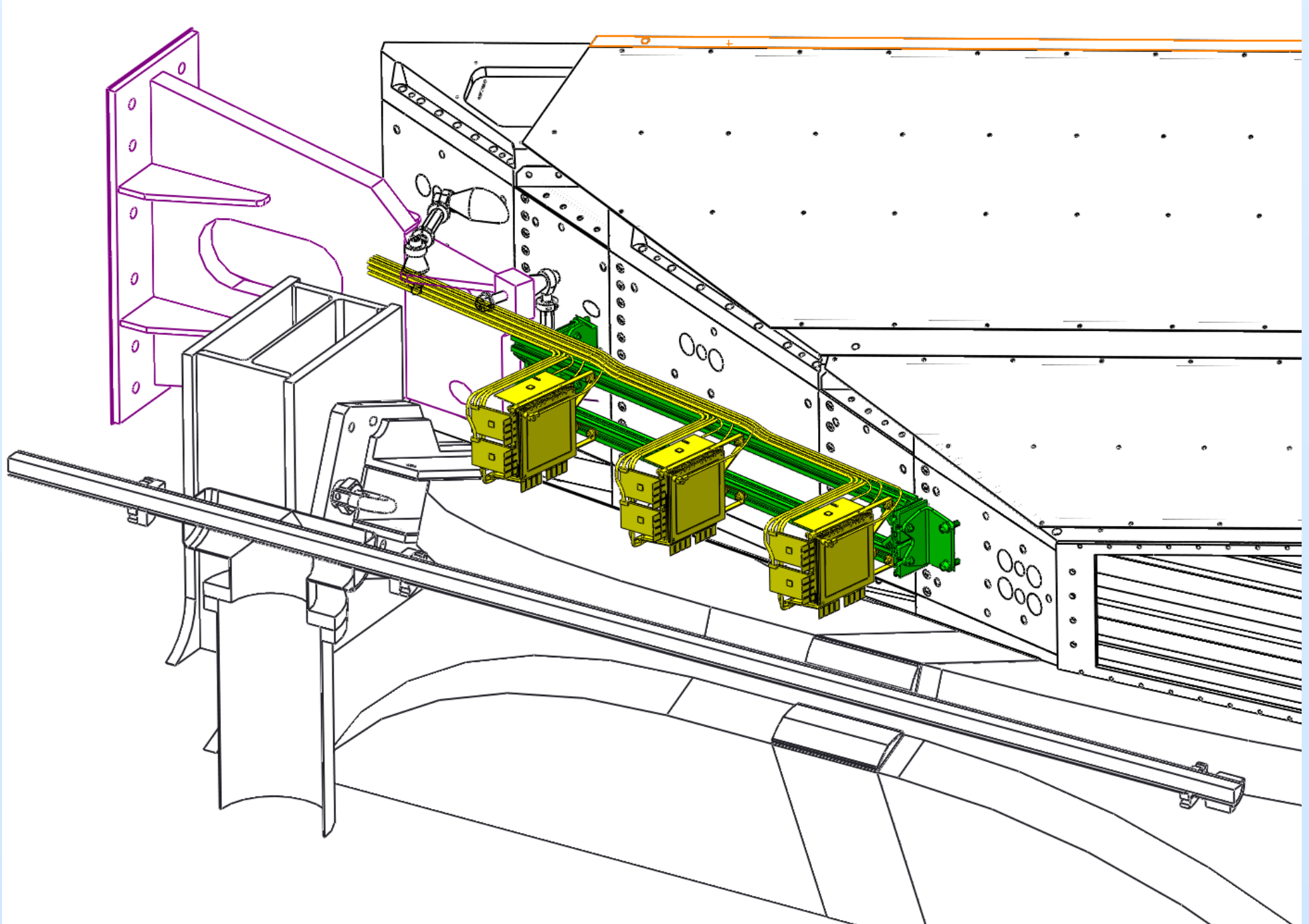
APV cards mounted on flexible plates

Lumi Telescopes (Sept 2010)

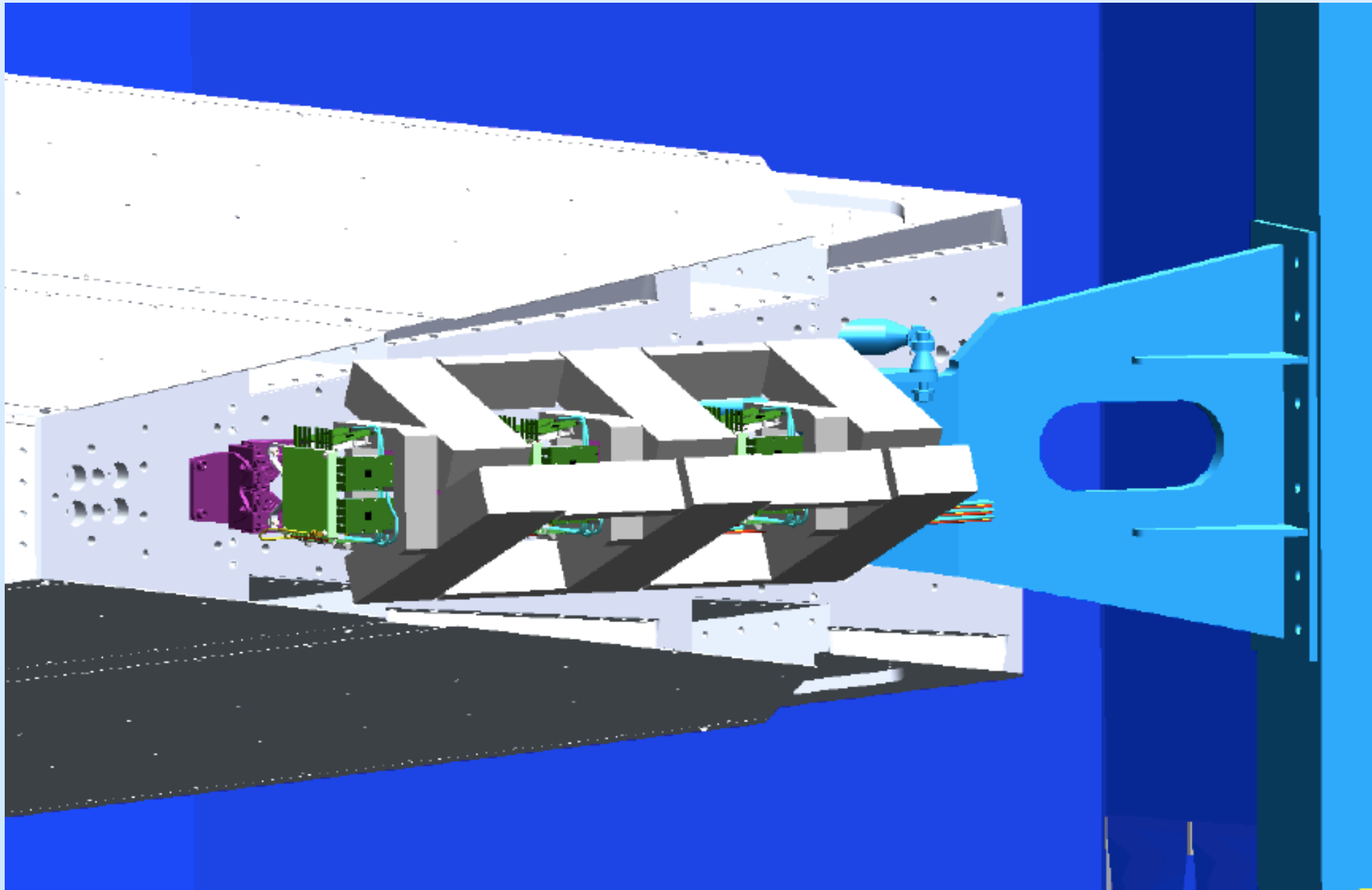


J. Bessuille

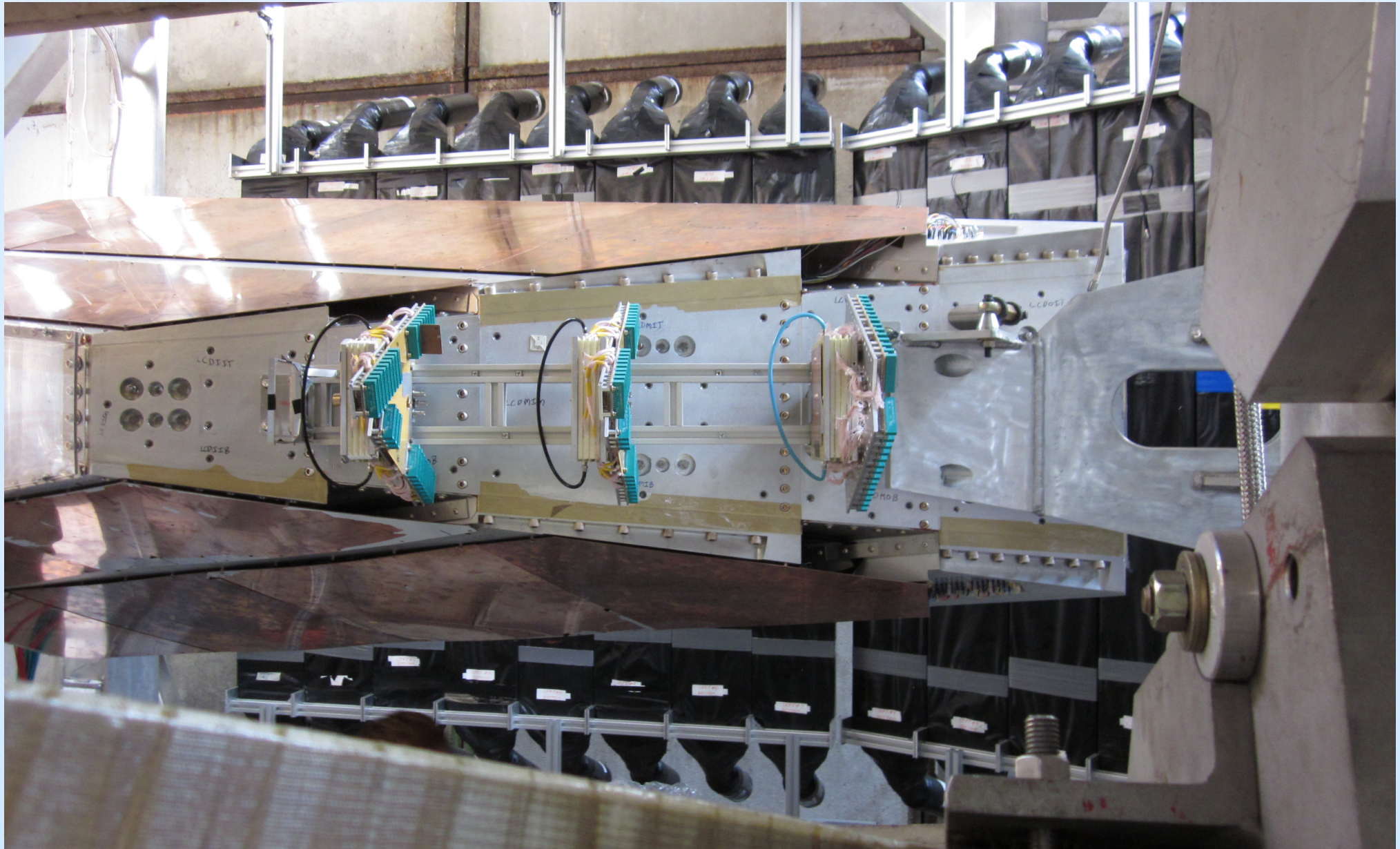
Lumi GEMs w/ services and rails



Lumi Telescopes (June 2011)

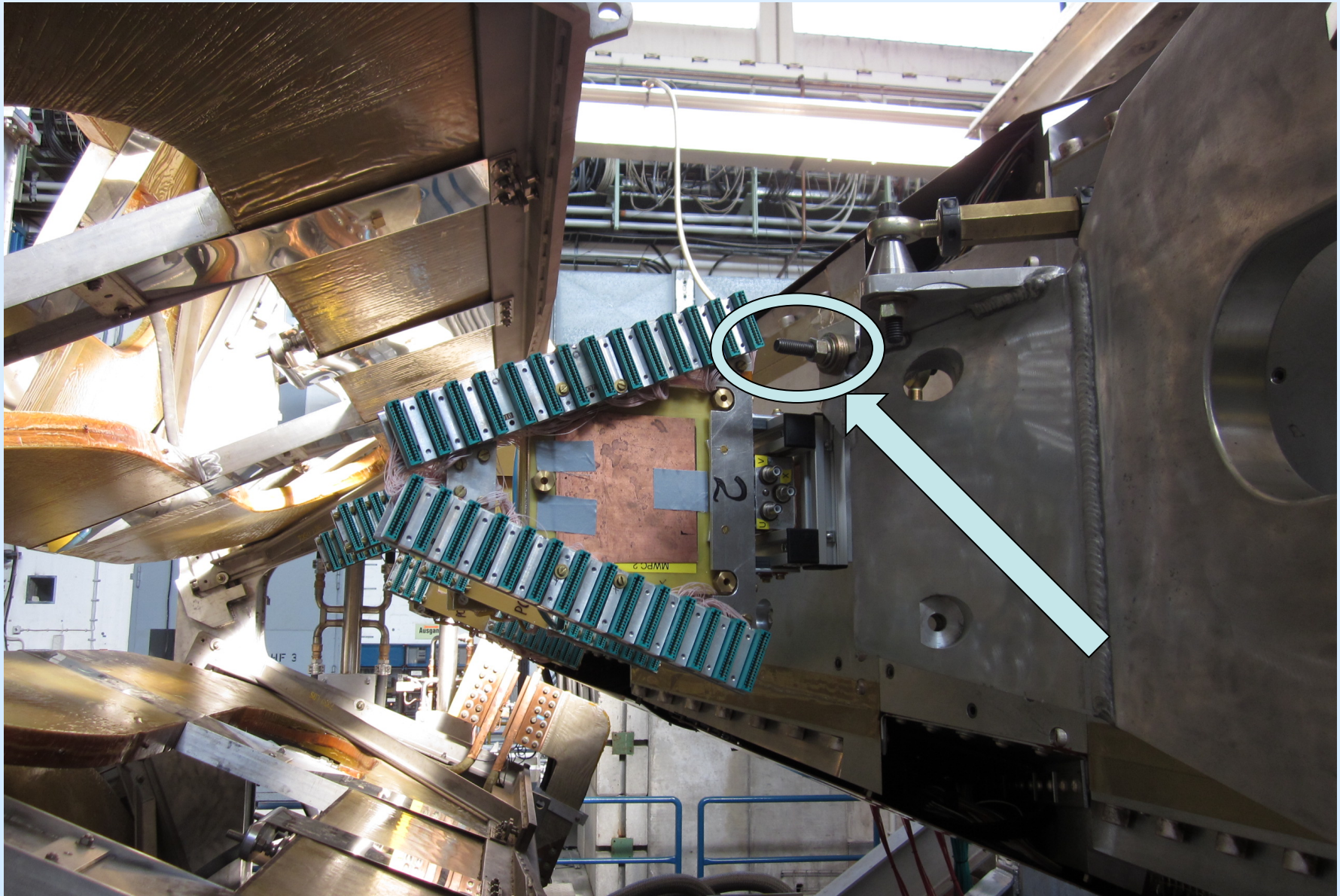


Lumi Telescopes (June 2011)



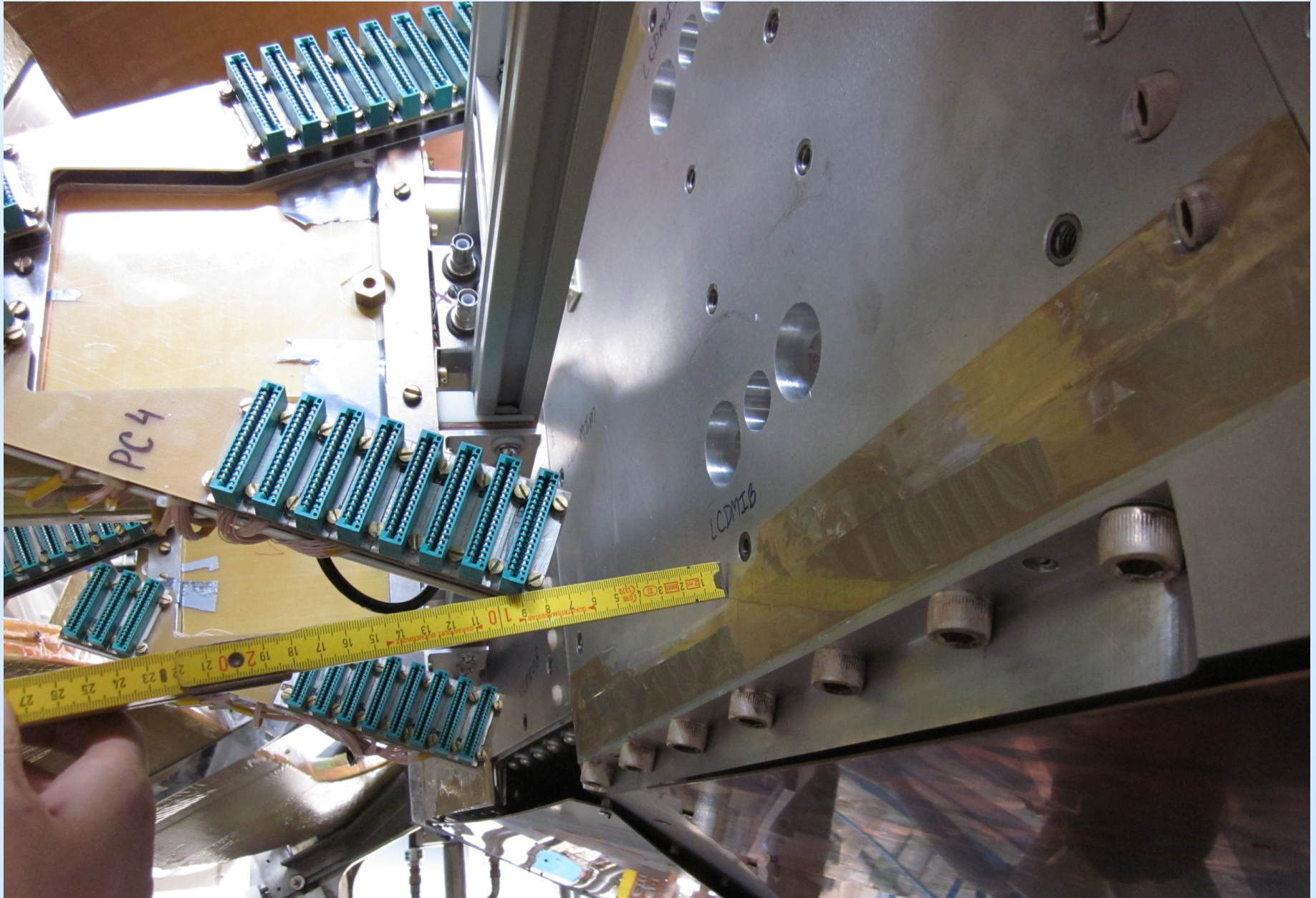
Lumi arm with MWPCs mounted on June 10, 2011

Lumi Telescopes (June 2011)



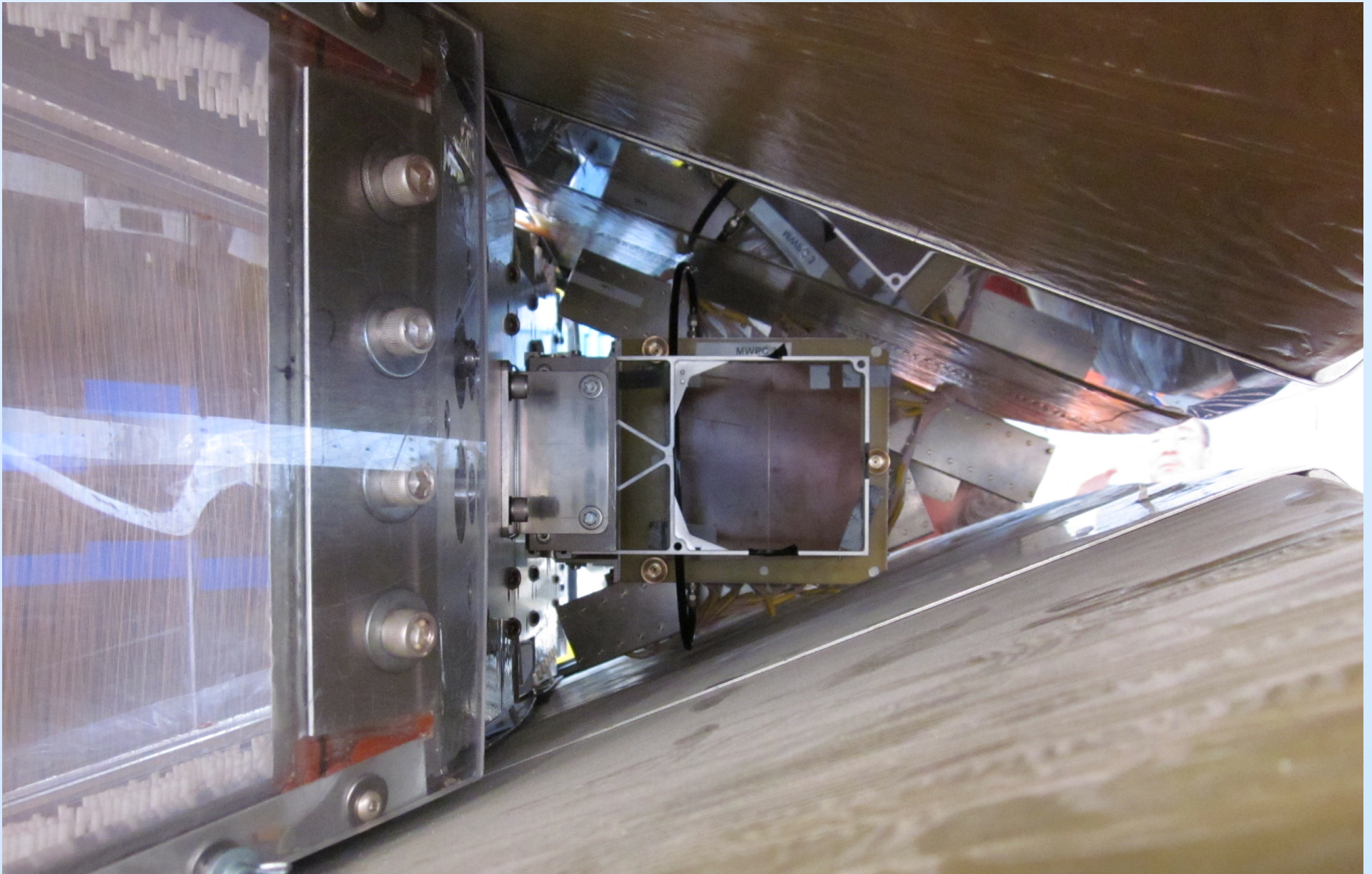
Bolt is in the way and needs to be shortened!

Lumi Telescopes (June 2011)



Clearance for gas line routing

Lumi Telescopes (June 2011)

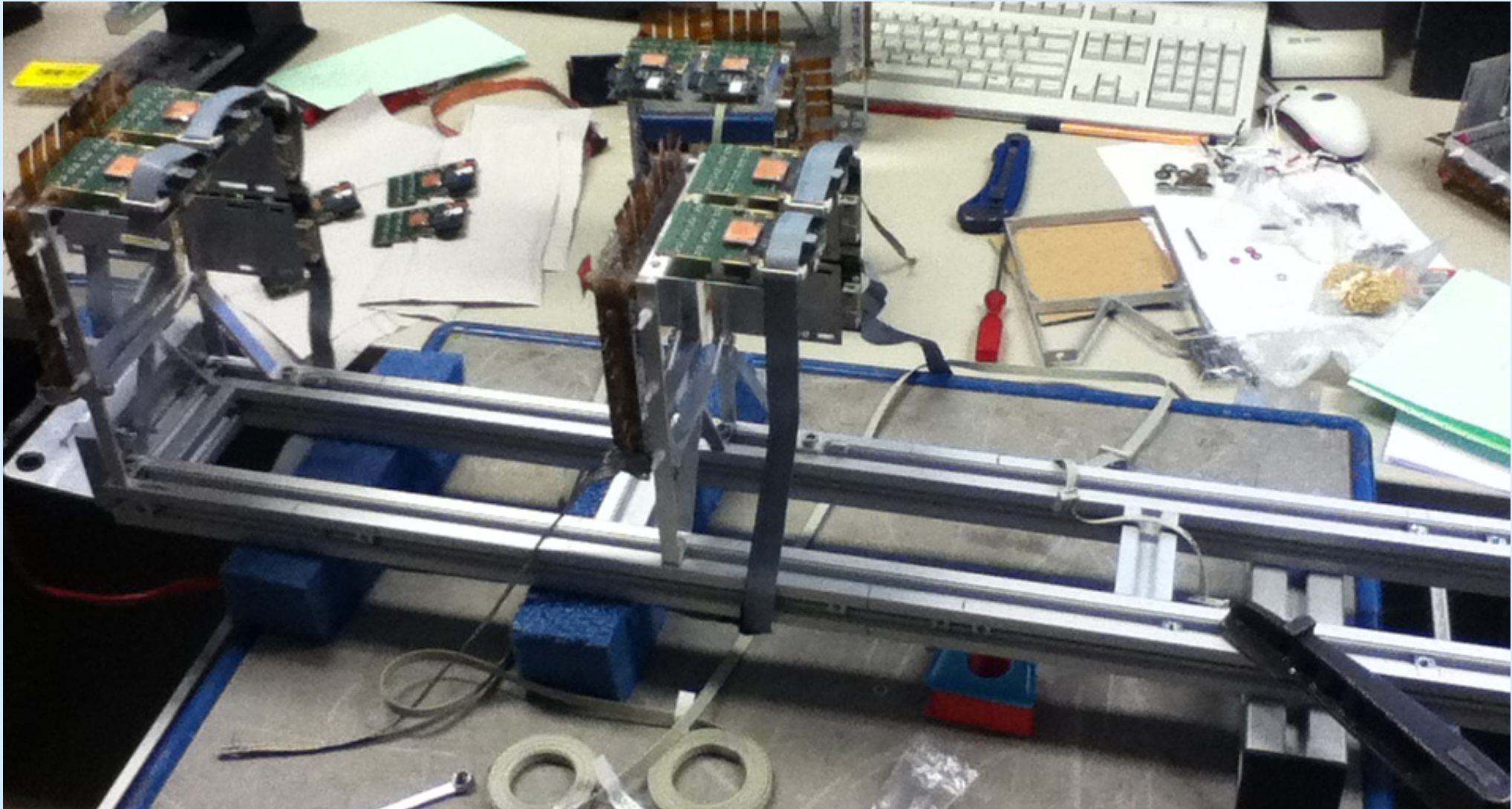


Along the 12-degree line from target

Installation Procedure

- **Wire chambers: Installed and surveyed by May 27:**
 - Assume that WC will not be moved any more (see discussion on TOF positions)
 - WC location in agreement with CAD model
 - Mount lumi telescopes and survey relative to wire chambers
- **Trial mounting of pre-assembled arm on 6/10, repeated on 6/24 in both sectors**
 - Reproduce 12 degree line within 1-2mm using two GEM brackets w/ crosshairs
 - Verify clearances of upstream element
 - Mount MWPC such that they fit
 - Assess remaining space for additional detectors (calorimeter?)
- > **Issues/observations:**
 - Bracket stability: more rigidity w/ new holes closer to the bend
 - Wire chamber mounting bolt conflicting with MWPC electronics (left sector)
 - Wire chamber gas line routing
 - First GEM could move further upstream by ~20 cm / add 4th GEM in January?
 - Downstream end: space for calorimeter (e.g. scintillator/lead sandwich) for elastic single-arm trigger
- **Assembly on bench, survey of GEMs only; mount MWPC and survey; install telescopes in OLYMPUS and survey (GEM survey impossible after MWPC)**

Lumi Telescopes (June 2011)



Assembly of first telescope in progress (6/27)

Installation Schedule

- **Mon 6/28** Continue assembly of GEM telescopes, make cables, modify APV boards
- **Tue 6/29** Silicon telescope at testbeam 22 will be re-commissioned
- **Wed 6/29** Last day of testbeam: Test with 3-GEM telescope
- **Thu 6/30** Clear testbeam 22 area, transfer to workspace in DORIS hall
- **Sun 7/03** Remaining 2 MWPCs arrive, 2 days to prepare installation
- **Tue 7/05** Finish assembling GEM-only telescopes on bench with cables, gas lines; remove cables for survey and installation
- **Wed 7/06** Survey and installation of GEM+MWPC luminosity monitor telescopes
 - Survey GEM-only telescopes on bench/wall in DORIS hall relative to RK support
 - Mount MWPCs on telescopes in predefined positions
 - Survey GEM+MWPC telescopes on bench/wall
 - Mount telescopes into OLYMPUS
 - Survey telescopes relative to wire chamber and detector
- **Thu 7/07** Cabling of GEM+MWPC telescopes
- **Fri 7/08** Routing of cables and gas; patch panels