OLYMPUS Collaboration Meeting, DESY, June 28 – 29, 2010

Status of the Forward Elastic Scattering Luminosity Monitor

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Jefferson Lab

Monitoring the Luminosities

- **Pressure, temperature, flow, current measurements**
  - limited in precision

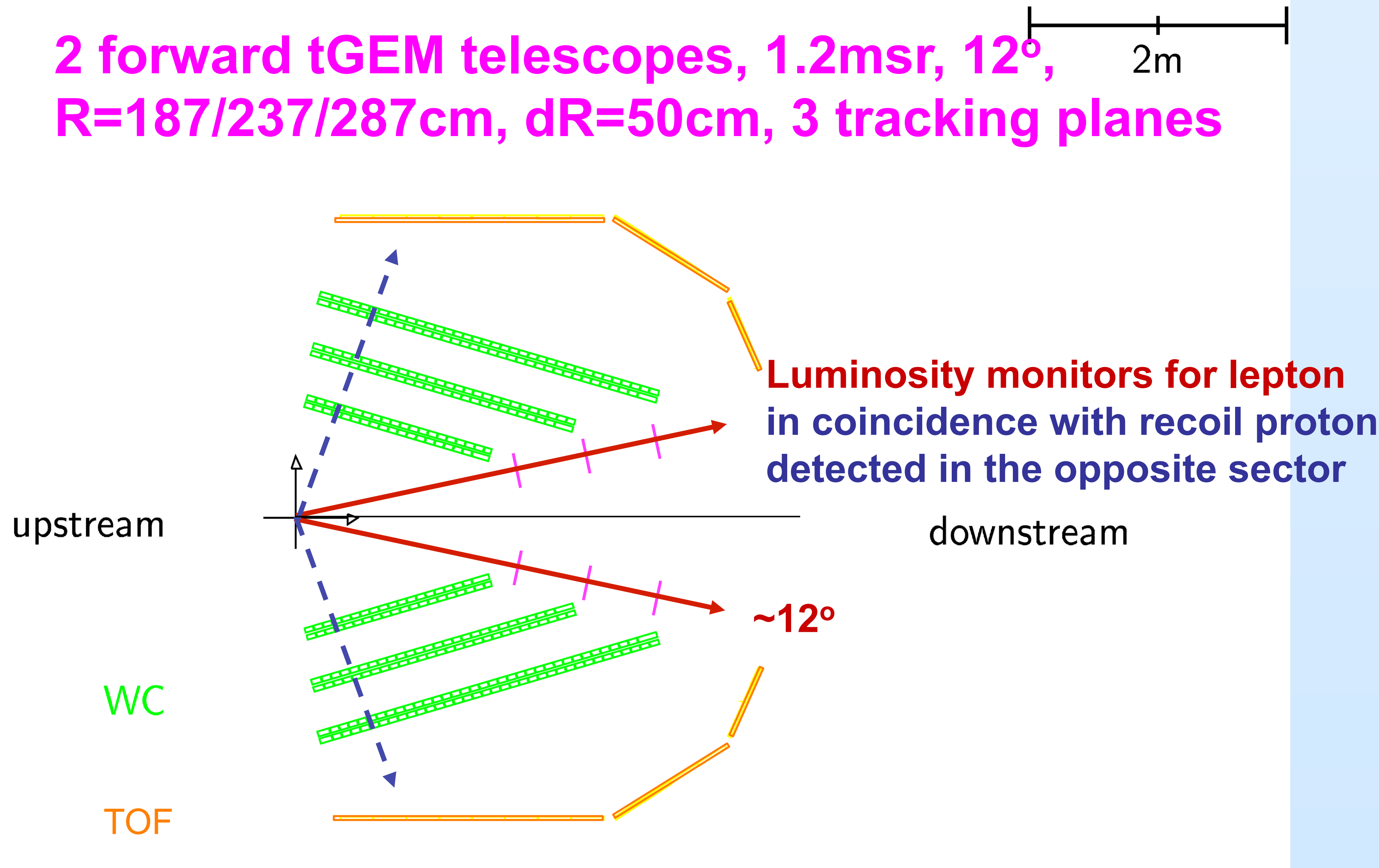
- **Moller/Bhabha scattering**
  - 1.3 degrees for symmetric Moller setup
  - requires knowledge of Moller/Bhabha cross sections

- **Small-angle elastic scattering**
  - high count rate, no TPE at high epsilon / low Q^2
  - single-arm and in coincidence with recoil proton
  - event-by-event with full track reconstruction
  - different acceptances for e^+ and e^-
  - requires knowledge of angular xsec. dependence

Luminosity Monitors: GEM Telescopes

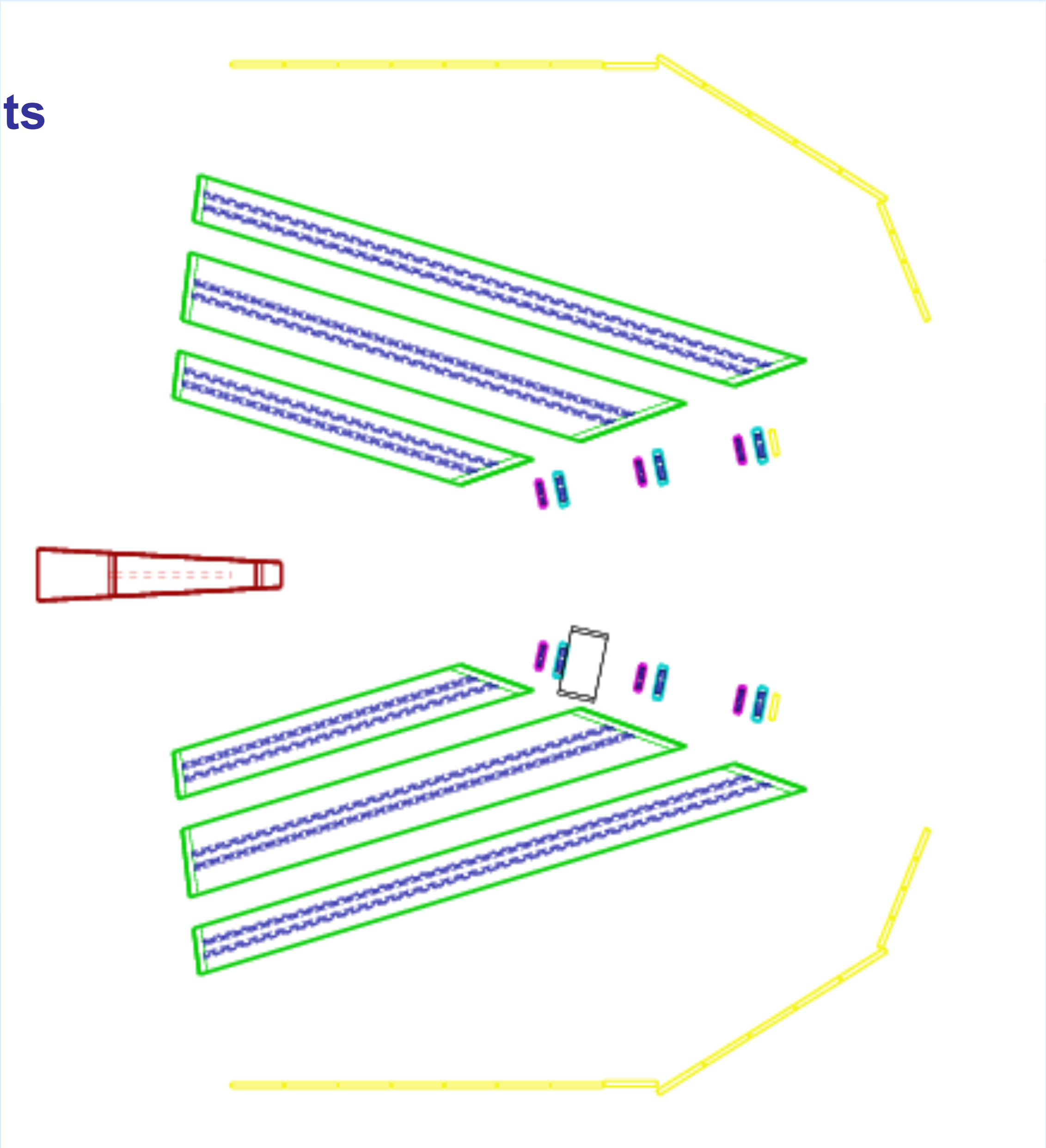
Proposed version included in OLYMPUS TDR Sept. 2009

2 forward tGEM telescopes, 1.2msr, 12°,
R=187/237/287cm, dR=50cm, 3 tracking planes



Luminosity Monitors: GEM+MWPC

- MWPC telescopes
  with 3 x/u/v elements
  interleaved with GEM elements
- Scintillator for triggering
  and timing
- High redundancy
  No interference
  Two independent groups
- Well suited for efficiency
  and alignment calibration
- Both GEM and MWPC
  telescopes can operate
  independently



Luminosity Monitors: GEM+MWPC

	δz [cm]	$\delta\theta$	$\delta\phi$	$\delta p/p$ [%]
GEMs alone	1.67	0.137°	0.301°	4.57
GEMs alone + MWPC material	1.74	0.142°	0.309°	4.86
MWPCs alone + GEM material	3.94	0.294°	0.407°	9.58
GEMs + MWPCs	1.60	0.132°	0.308°	4.43

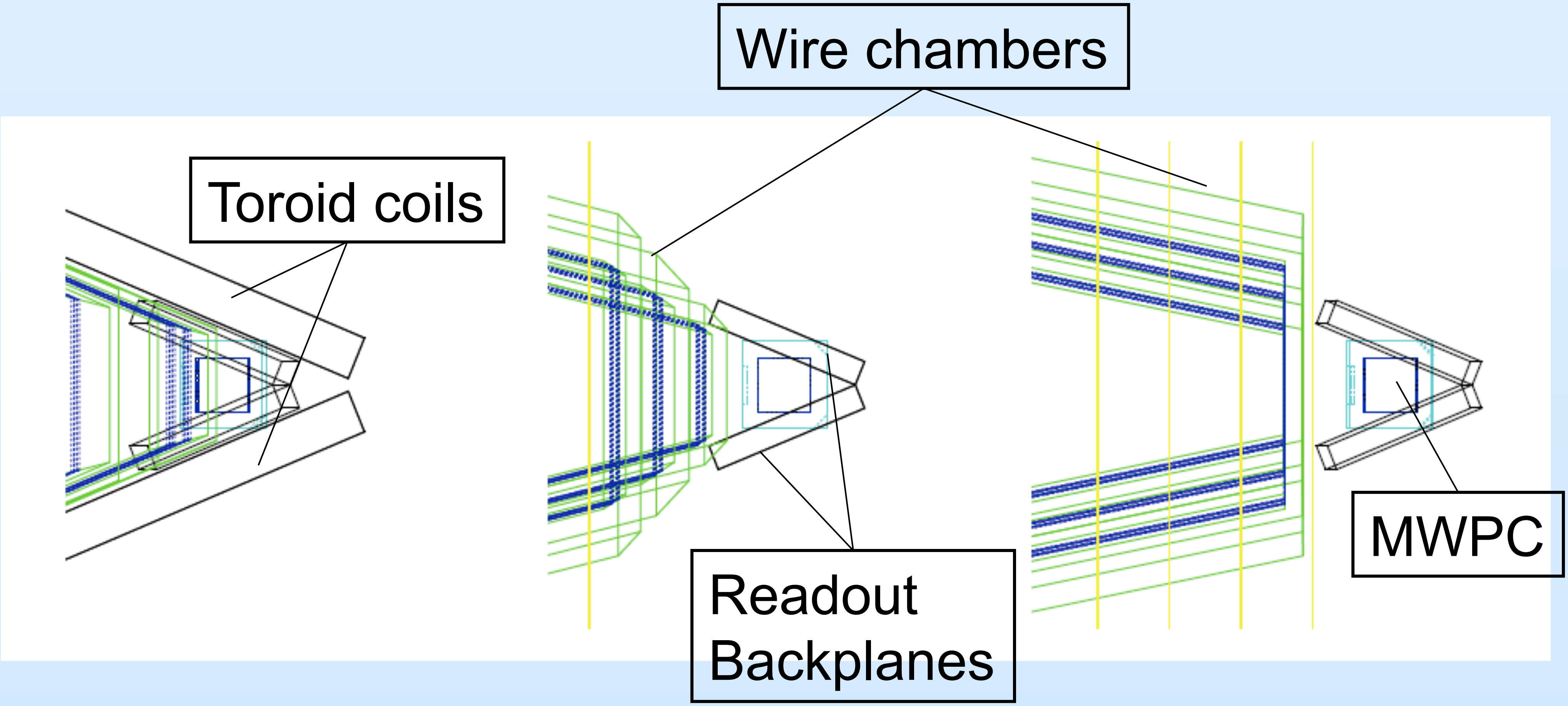
Table 1: Obtained track resolutions for various configurations of the luminosity monitor, based on a GEANT3 simulation with Kalman filter technique for reconstruction.

- **Each system alone is not deteriorated too much by the other**
- **Both systems combined give superior resolution**

- **Concept paper for TDR, Sec. 4 sent out in April, included in current version of TDR; revision/improvement still ongoing**

MWPC: Confined space … but they fit

- **MWPC closest to target at 200 cm**



0-degree view 12 degrees 19.45 degrees

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 $\boxed{\theta_e = 12^\circ.}$ 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 cm^2 at ~290 cm distance (rearmost plane)**
- **Three GEM layers with ~0.1 mm resolution with ~50 cm gaps → Match vertex resolution (z) of ~ 0.1 – 1 cm at 12° with proton in BLAST**
- **Issue of acceptance loss and different average angle due to track bending can be alleviated with reduced toroid field**

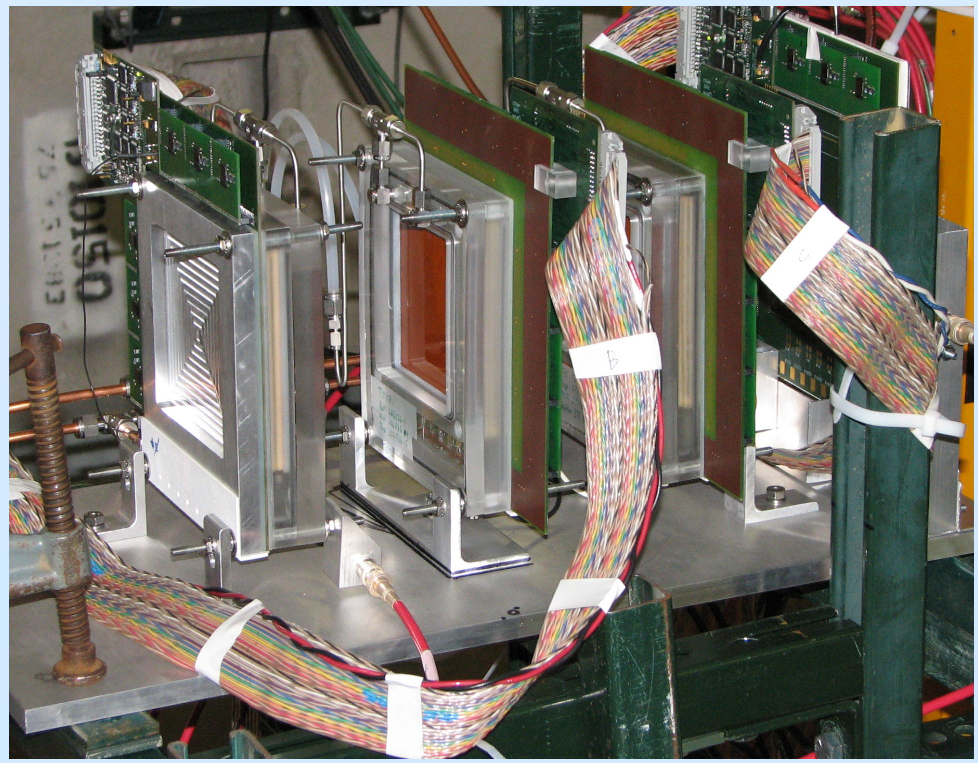
Luminosity Monitor based on GEMs

- **Forward-angle electron/positron telescopes with good angular and vertex resolution**
- **Two telescopes with 3 triple-GEM detectors, left-right symmetric**
- **Coincidence with proton in opposite sector of main detector**
- **Single-arm tracks**
- **High rate capability**
- **Readout based on APV chip**

MIT prototype:

Telescope of 3 Triple GEM prototypes (10×10 cm^2) using TechEtch foils

F. Simon et al., NIM A598 (2009) 432



Providing GEM detectors

- Collaboration HU-MIT-Rome
  - TechEtch/MIT to provide GEM foils
  - Assembly of detectors at MIT and MIT-Bates
  - Rome: Readout system developed for Hall A / SBS
  - Testing at HU and DESY

- Funding
  - Secured NSF Nuclear Physics/ARRA basic research grant ($405k) postdoc + travel; 1 graduate student supported by HU NSF group 2 undergraduate stipends for summer 2010
  - Secured $216k within NSF MRI-R2 for luminosity monitors ($125k), 1 graduate stipend + travel for commissioning
  - Subaward to MIT ($77k) within MRI grant: Permission requested from NSF for engineering services and ordering of parts, NSF approval awaited

Tasks & Timeline for LuMo Construction

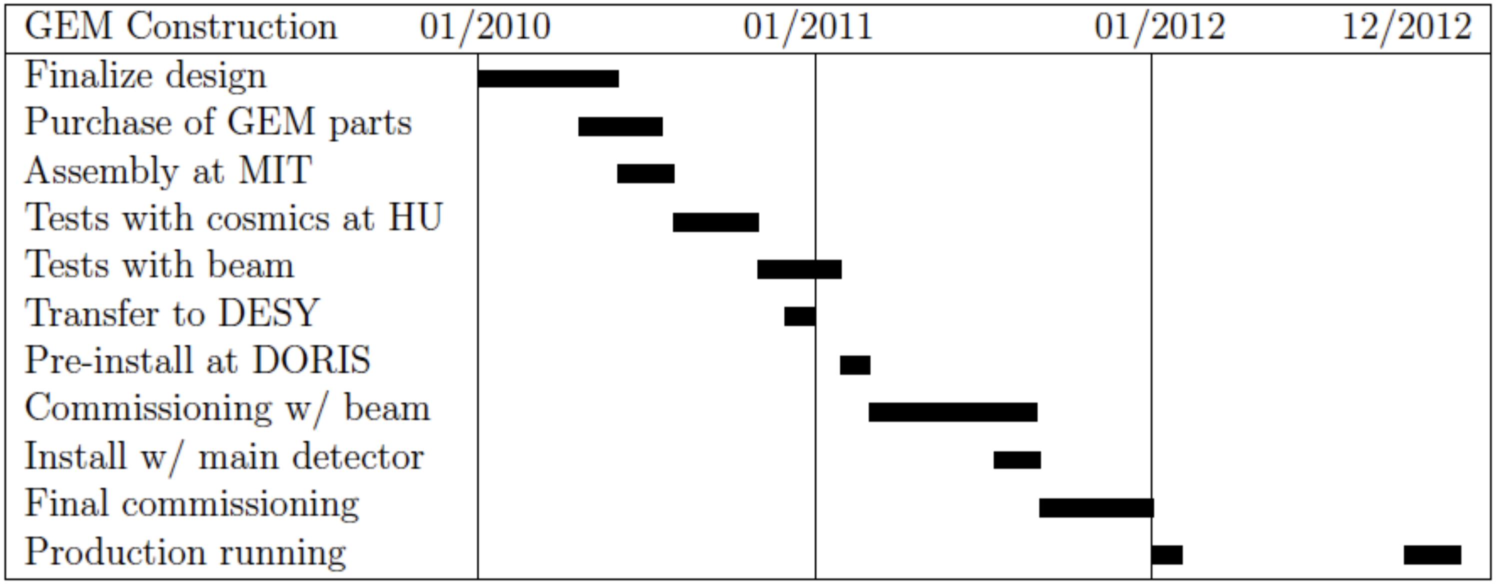


Table 4: Work plan for GEM luminosity monitor construction activities.

- **Above schedule from TDR**
- **Experiencing slight delays, yet keep goal of providing GEMs by end of 2010**
- **Assembly of GEM detectors at MIT in summer 2010 – ongoing**
- **New research building at HU with lab space available for testing in fall**
- **Extensive testing of chambers and Rome readout system at HU**
- **No beam test other than test experiment at DORIS in spring 2011**

Realization of Detectors

- Construction project fully funded (NSF, MRI-R2), grants are active
- Postdoc position filled by J. Diefenbach eff. July 1, 2010
  - Work at Mainz and DESY through mid August 2010: Readout system, DESY testrun
  - Work at HU from end of August – December 2010: Complete GEMs, testing
- HU-MIT Research Agreement (subaward) in preparation to enable Bates engineering services:
  - Drawings, direct ordering of parts, technical support for manufacturing
  - Mechanical parts to be available by ~July 20, 2010 – parts to be ordered now
  - Design of readout board ongoing – to become available ~September 2010
- Three GEM projects ongoing at MIT
  - GEM2D: O-ring sealed aluminum testbox; purpose to test readout foils
  - OLYMPUS: LuMos; glued stack, simple and compact design
  - STAR/FGT: Large, segmented GEM foils, glued stack, most sophisticated design
- Ordered 10x10 cm^2 GEM and HV foils (designed by D. Hasell) from TechEtch
  - so far 12/35 GEM foils delivered, 12/12 HV foils; 16/16 GEM foils for GEM2D

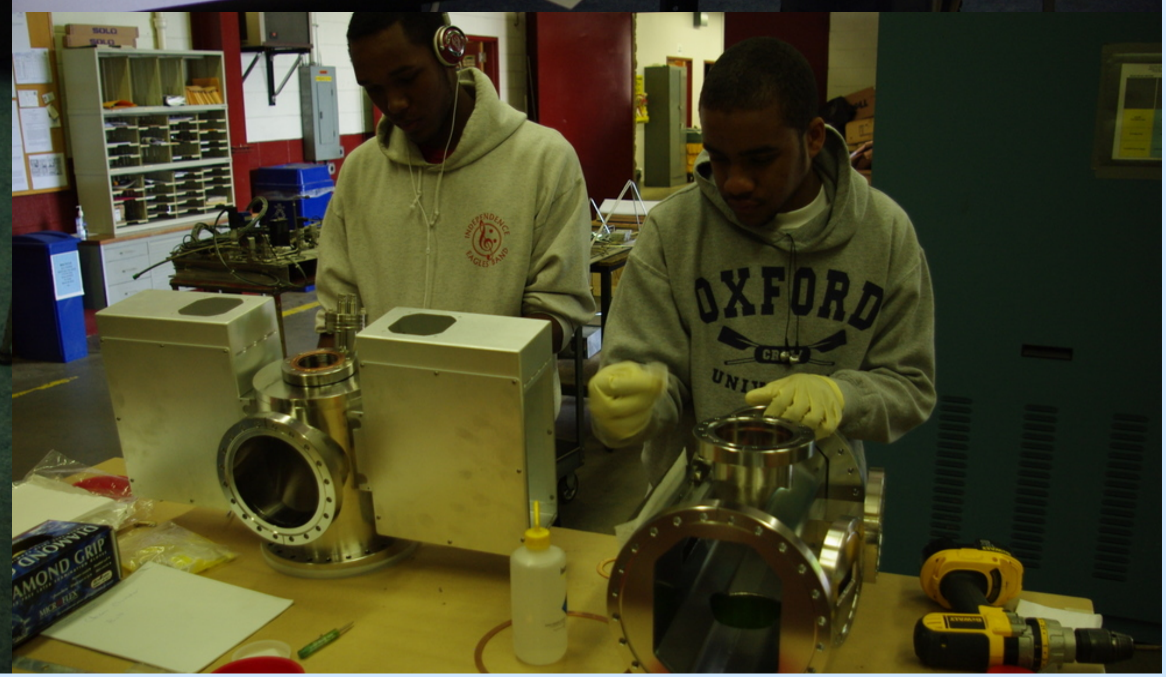
Realization of Detectors (cont'd)

- HU group currently visiting MIT and Bates from June 7 – August 8, 2010
  - Two HU undergraduate students (Miles Campbell, Joshua McMahon)
  - One HU graduate student (Ozgur Ates)
  - Three undergraduate students in MIT MSRP funded by HU/REU program (Laura Havener, Matthew Anthony, Raspberry Simpson)
  - Frame preparation and cleaning (FGT frames and GEM2D frames
  - Testing of GEM foils (Optical scanning; HV testing & conditioning)
  - Gluing of gas pressure foils, HV foils, GEM foils
- Establish one complete GEM2D box with Bonn readout system within July 2010 – need test readout board
- For OLYMPUS GEMs, prepare everything but final readout board by August 6;
  complete assembly when readout boards become available (~September 2010)

HU-MIT students …

from left: Michael Kohl, Miles Campbell, Raspberry Simpson, Joshua McMahon, Ozgur Ates, Matthew Anthony, Laura Havener, Richard Milner

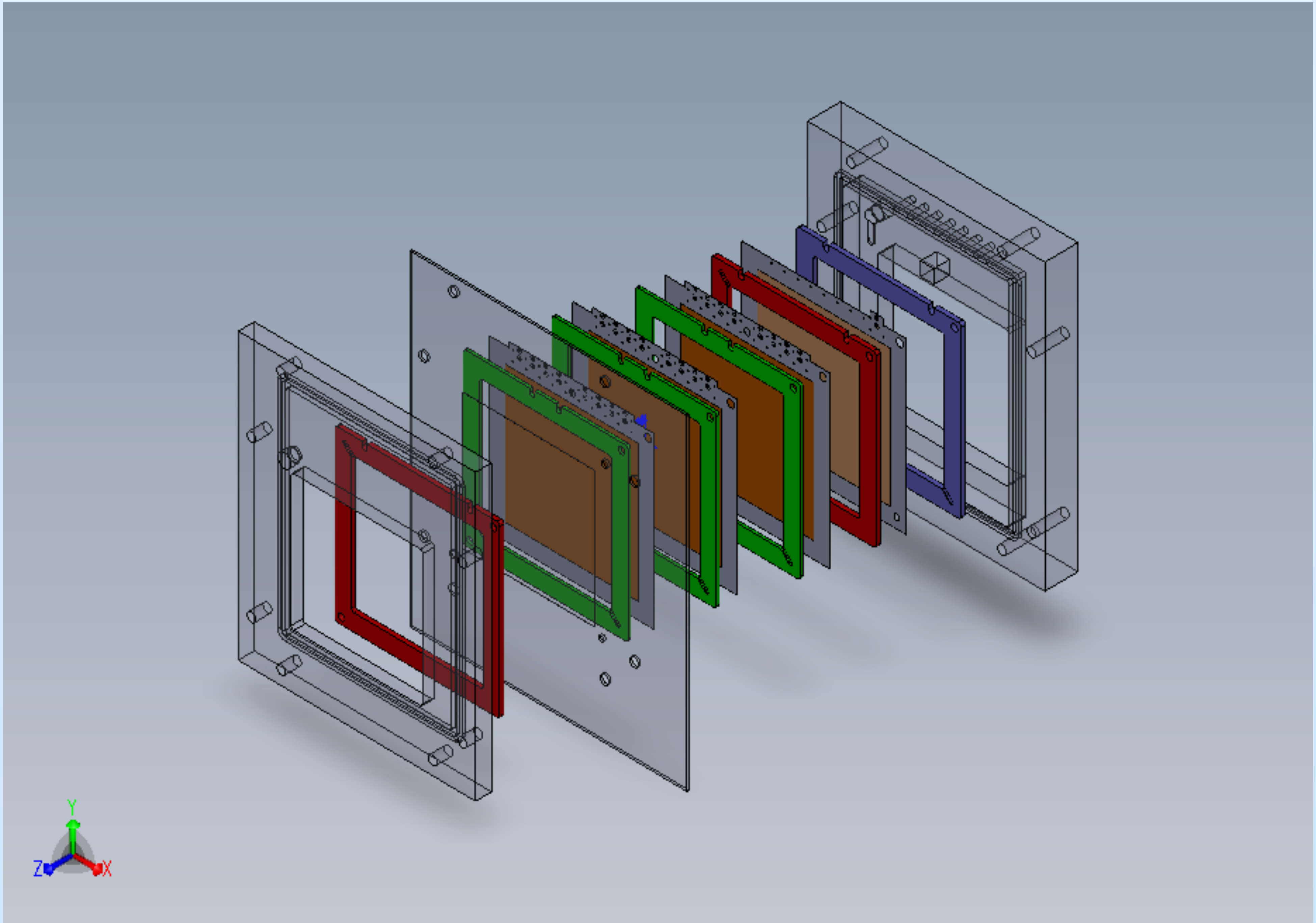
… at work



Realization of Detectors (cont'd)

- Prepare cosmic ray test stand at HU
  - Collaboration with M.E. Christy (HU)
  - Scintillators, eventually with SOS wire chambers for good track definition
- Implement test readout in September 2010 (Rome group)
  - New APV based system to be tested at DESY in July 2010
- Testing with cosmic rays / sources from September – December 2010
  - Signal to noise studies, cluster performance
  - Study gains and charge sharing
  - Operation stability, discharges
  - Efficiency versus voltage
  - Efficiency distributions versus x and y
  - Spatial resolution
- Transfer detectors to DESY by Dec. 2010
- Mount 3 GEMs in DORIS test experiment in Feb. 2011 for spring test run; replace during accesses and install in OLYMPUS

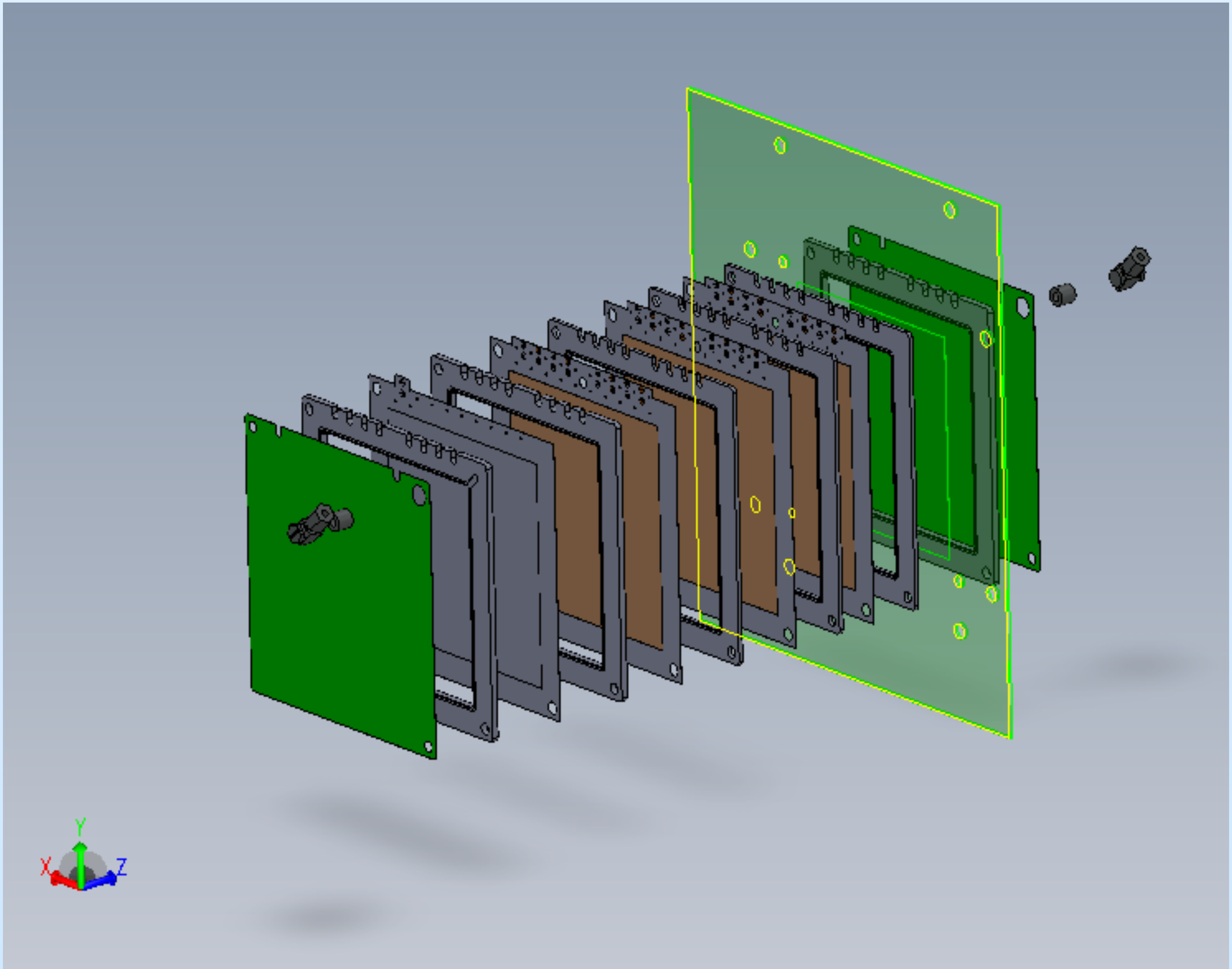
GEM2D Design of Al Testbox



GEM Design Criteria / Issues

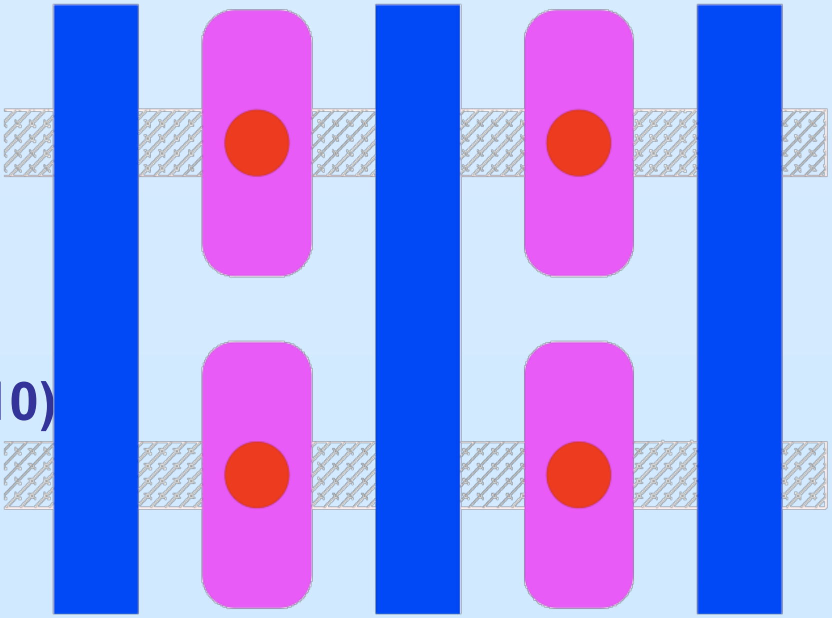
- Want 12.5x12.5 cm^2 total area – gluing instead of bolting w/ O-rings
- Identical design for all chambers preferred – easy replacements
- Can use inner frame design of new GEM2D prototype (D. Hasell) with minor modifications (like glue troughs, gas feed, HV supplying), for everything but readout
- Bob Abruzzio has produced modified drawings, ready to be ordered as soon as subaward is in place, hopefully still this week
- HV supplying: Soldering of wires to straps on GEM/HV layers located in frame cutouts, to be connected to passive voltage divider board – no “fancy” integration into frame
- Gas feeds to be glued directly onto G10 frame

Design of OLYMPUS LuMo GEMs



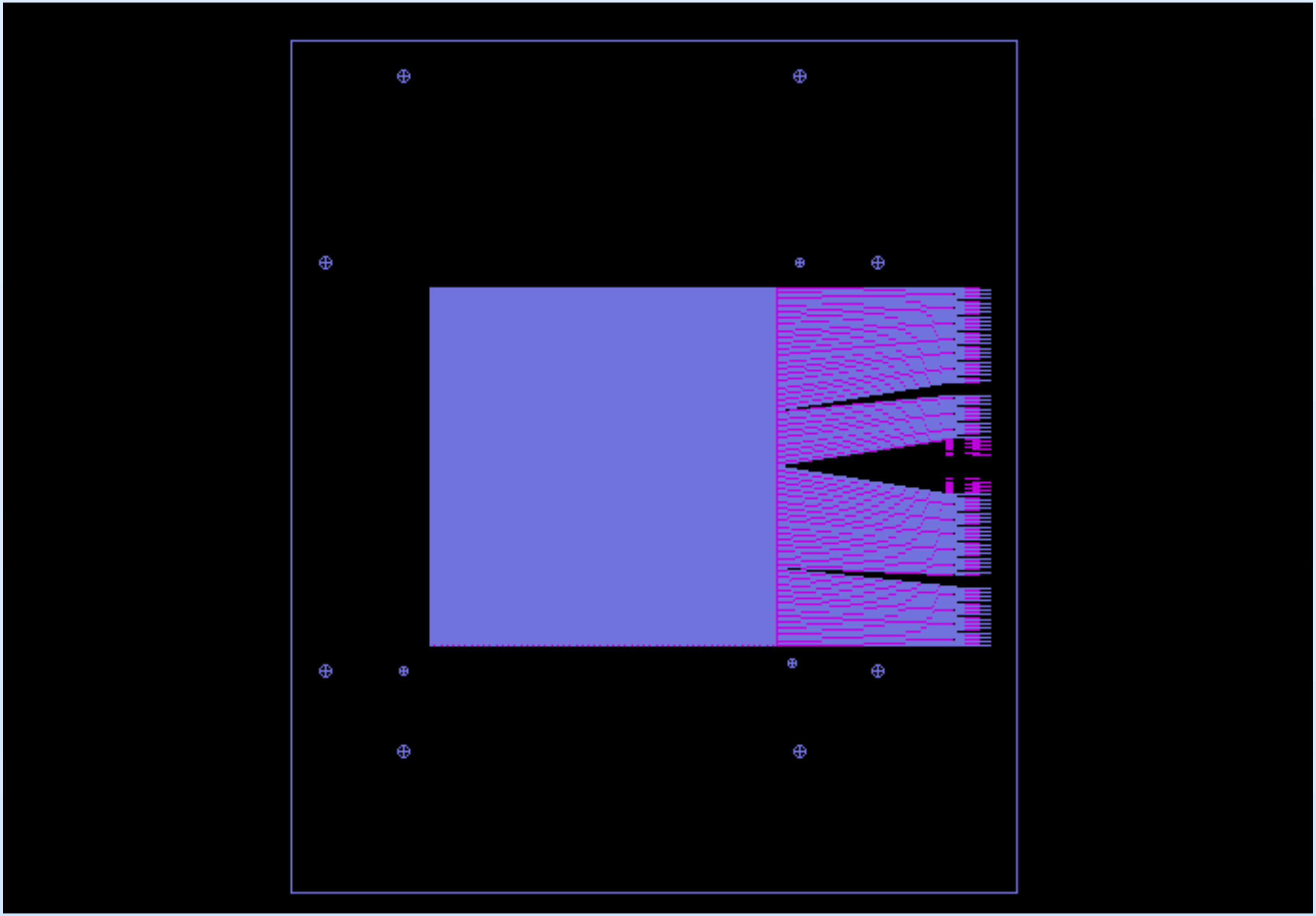
GEM Readout Board

- Readout pitch of MIT prototype: 635 μm, COMPASS: 400 μm
- Number of electronics channels per chamber: [100+100]/0.635(0.800,0.400) ~= 315 (250, 500), read out by 3(2, 4) APV chips
- Want 12.5x12.5 cm^2 total area, 10x10 cm^2 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 800 μm (2 cards on one side, design existing) and 400 μm (2 cards each on 2 sides). Design to be finalized
- Readout technology with strips and pads, on 2-sided foil, vias-connected on rear side
- Previous technique based on laser ablation discontinued
- Complete construction of GEMs when readout boards become available (~Sept. 2010)



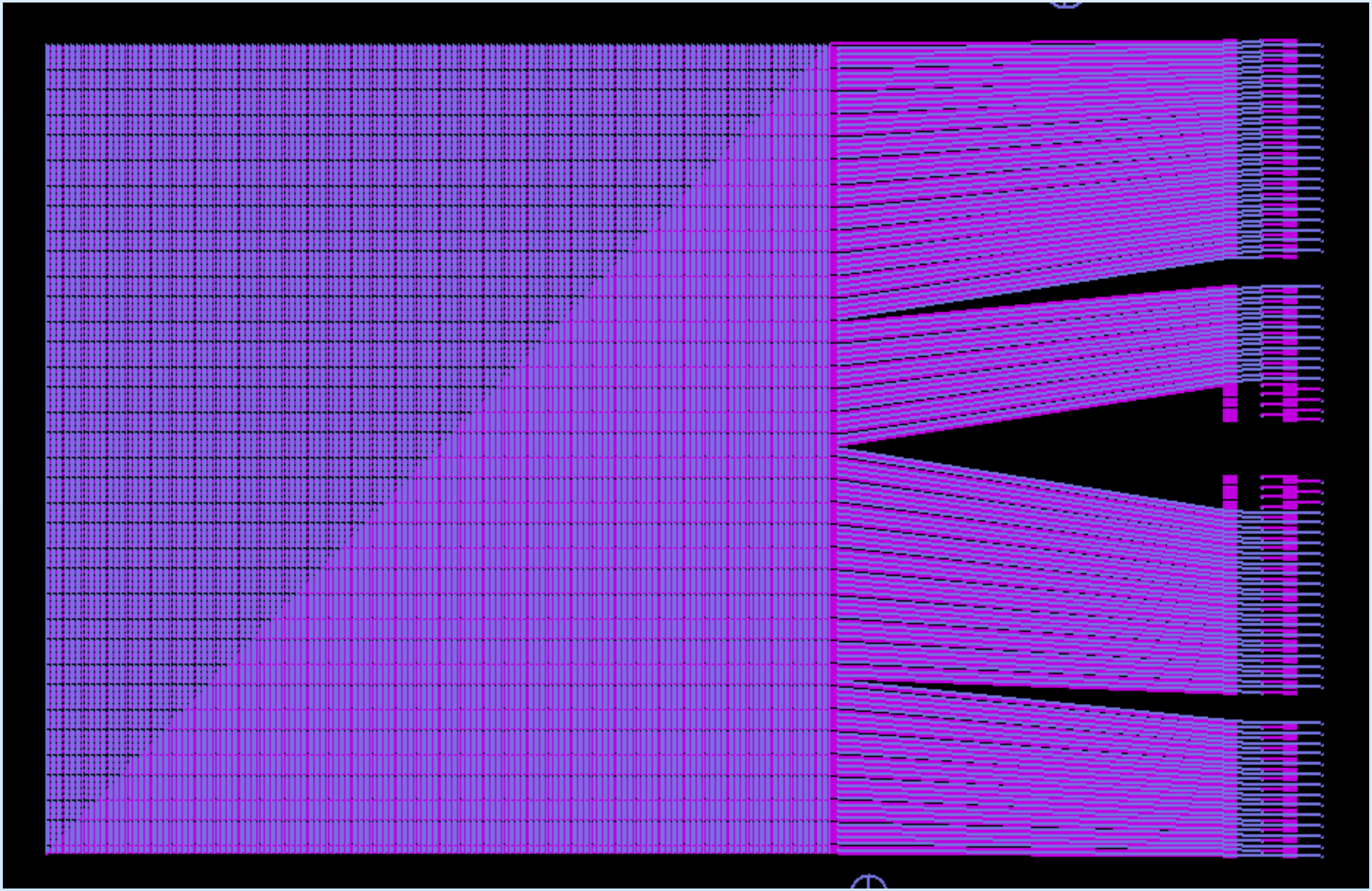
Strips & Pads Readout (D. Hasell)

800 μm pitch - Total view

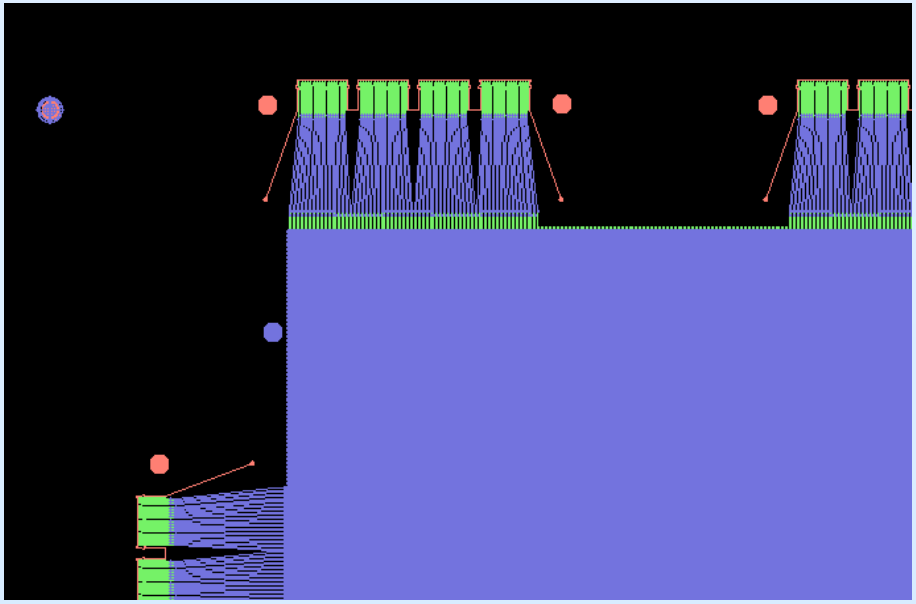


Strips & Pads Readout (D. Hasell)

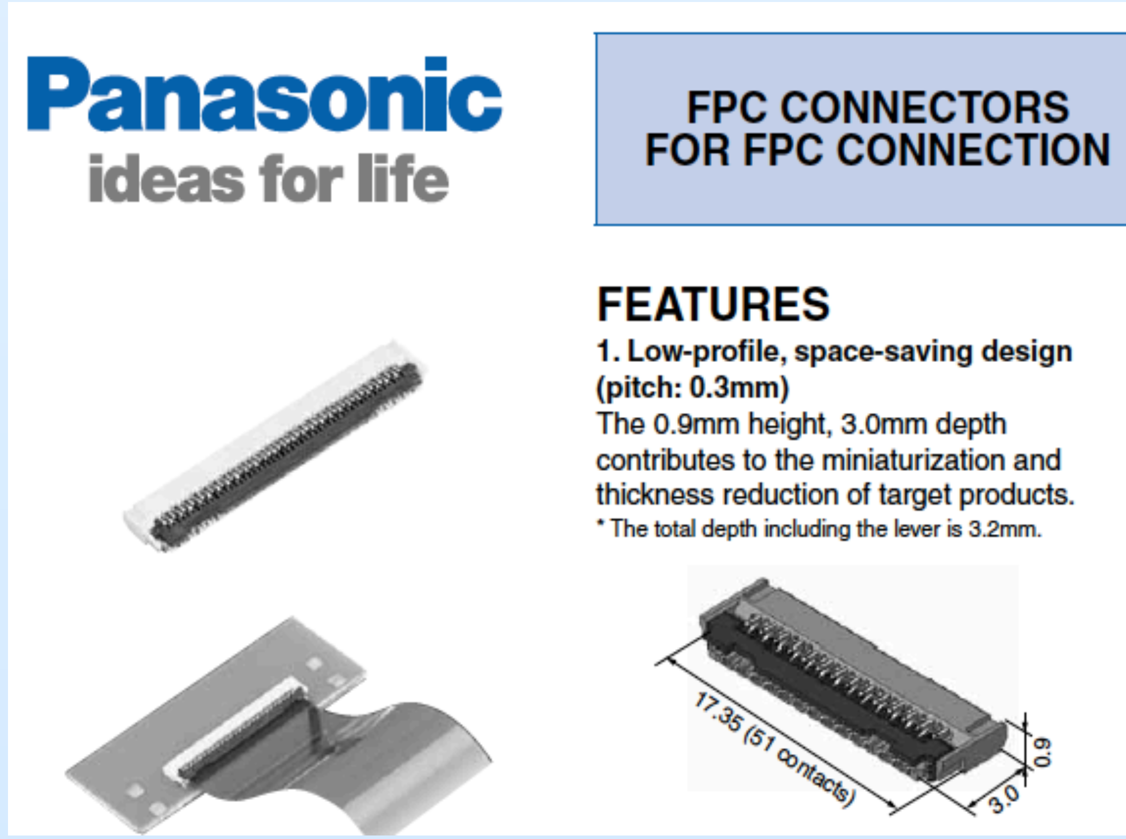
800 μm pitch - Total view

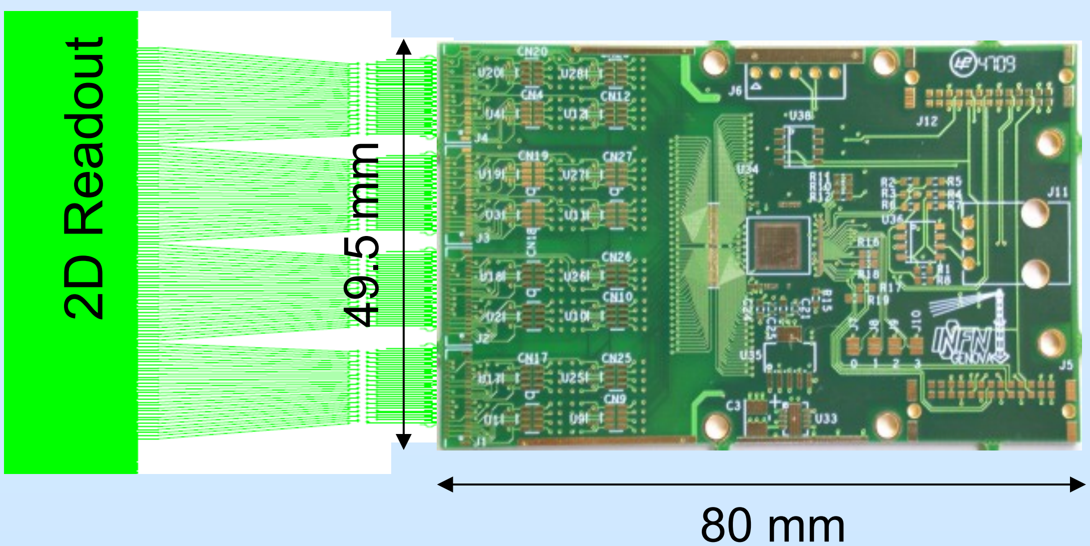


Connection to Frontend Cards (Rome)



from Rome R&D for Jlab SBS





- Use 800 or 400 μm pitch
- 2 cards – 1 side
  4 cards – 2 sides
- Use straps without any additional connectors
- Use adapter piece if any other readout system is to be used

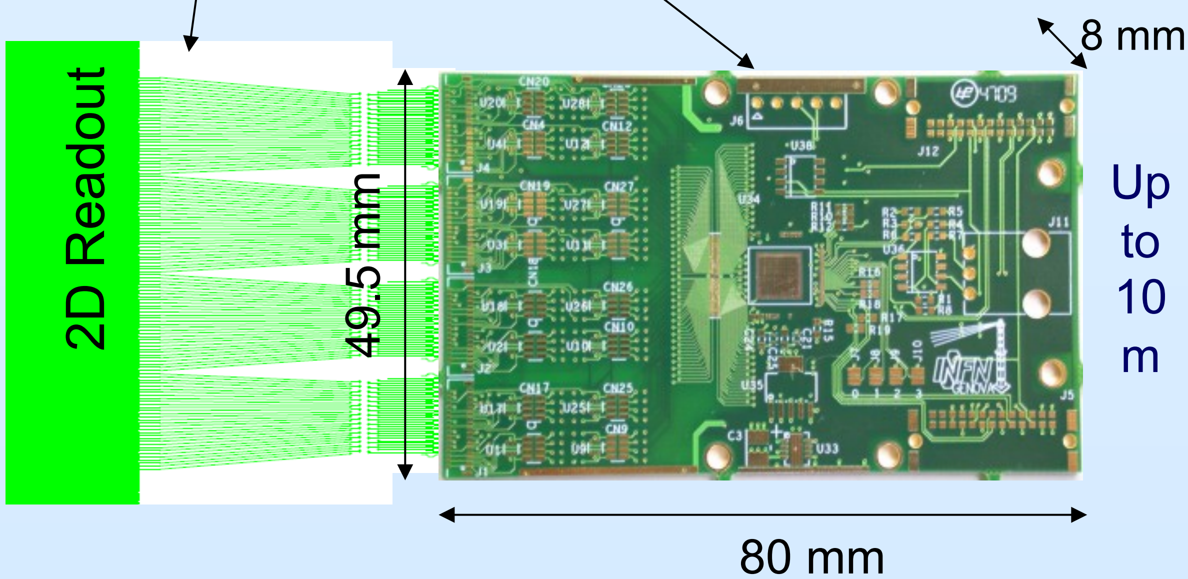
Summary

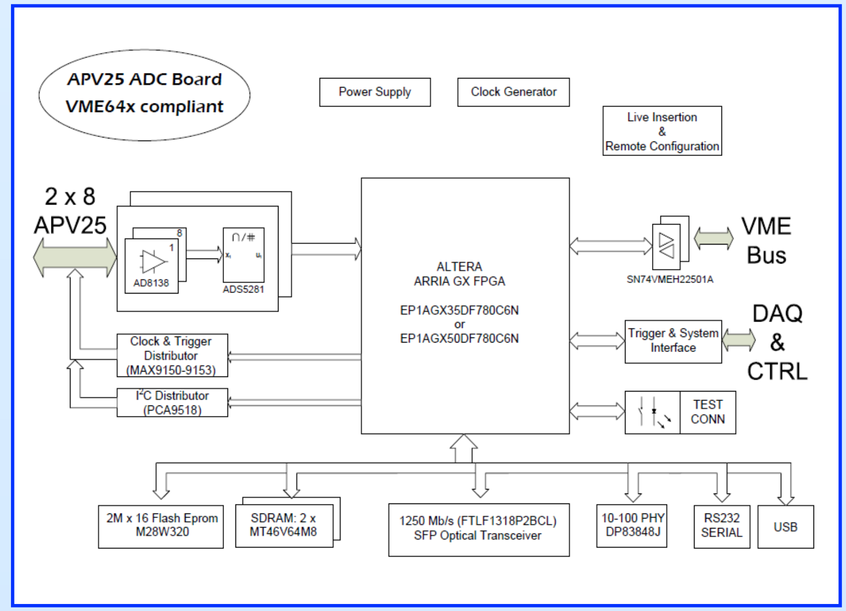
- GEM detector construction underway at MIT-Bates
- Substantial manpower with 6 students for two months available
- J. Diefenbach joining the Hampton group as postdoctoral associate
- Tight schedule for ordering of parts due to required research agreement
- Construction to be complete by September, testing by December
- Project still on track for completion by end of 2010

Backup slides

Readout Electronics

GEM ⇒ FEC ⇒ ADC+VME Controller ⇒ DAQ





- Frontend card (APV + VME) by INFN Rome ➔ see next talk, by S. Frullani
- First test of 10x10 GEMs from INFN and UVa at PREX/Hall A in March 2010
- Second test, with new APV readout toward end of PREX in May 2010
- System to become available for OLYMPUS GEMs in August 2010

Luminosity Monitor MC Tasks

- Continue to work on GEANT4 simulation
  (Ozgur Ates, HU graduate student of HU nuclear physics group)
  - use new, faster codes with better bookkeeping features
  - higher MC statistics

- Simulations of phase space integral(s) (acceptance)
  expected counts, acceptance-averaged cross section

- Study of systematic effects (beam offset, slope, width; etc.) on counts per bin

- Simulation of backgrounds (Moller/Bhabha; Inelastics)

Luminosity Monitors: Cost estimate

Proposed version included in OLYMPUS TDR Sept. 2009

Item	Amount	Cont.(%)	Total/k$	Remarks
Support frame	3	20	1.8	$500/frame (2+1 spare)
GEM chamber mechanics	9	20	10.8	$1000/chamber (6+3)
GEM foils 10×10 cm^2	40	20	9.6	$200/GEM foil (27+13)
Readout layer	9	20	21.6	$2000/board (6+3)
Hybrids	80	20	19.2	$200/hybrid (54+26)
APV25 chips	80	20	2.4	$25/chip (54+26)
Cables	18	20	2.2	Signal and HV (6+3)
FEE	2880	20	34.6	$10/channel (6+3)x320
Readout system	1		5.0	
HV distribution	9	20	0.5	$50/chamber
Power Supply		20	5.0	HV pods
Gas system	9	20	3.2	$300/line (6+3)
Misc. items			9.1	
Total			125.0	

Table 4.3: Cost estimate for the OLYMPUS luminosity monitors based on two plus one spare forward-angle GEM telescopes, each based on three triple-GEM detectors.