OLYMPUS Collaboration Meeting, DESY, April 26 – 27, 2010

Status of the Forward Elastic Scattering Luminosity Monitor

Michael Kohl

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

HAMPTON UNIVERSITY
The Standard of Excellence, An Education for Life

Jefferson Lab

Proposed Experiment

- Electrons/positrons (100mA) in multi-GeV storage ring
  DORIS at DESY, Hamburg, Germany
- Unpolarized internal hydrogen target (buffer system)
  3×10^{15} at/cm^2 @ 100 mA $\rightarrow$ L = 2×10^{33} / (cm^{2}s)
- Large acceptance detector for e-p in coincidence
  BLAST detector from MIT-Bates available
- Measure ratio of positron-proton to electron-proton unpolarized elastic scattering to 1% stat.+sys.

- Redundant monitoring of (relative) luminosity (ratios) to ~1% per hour

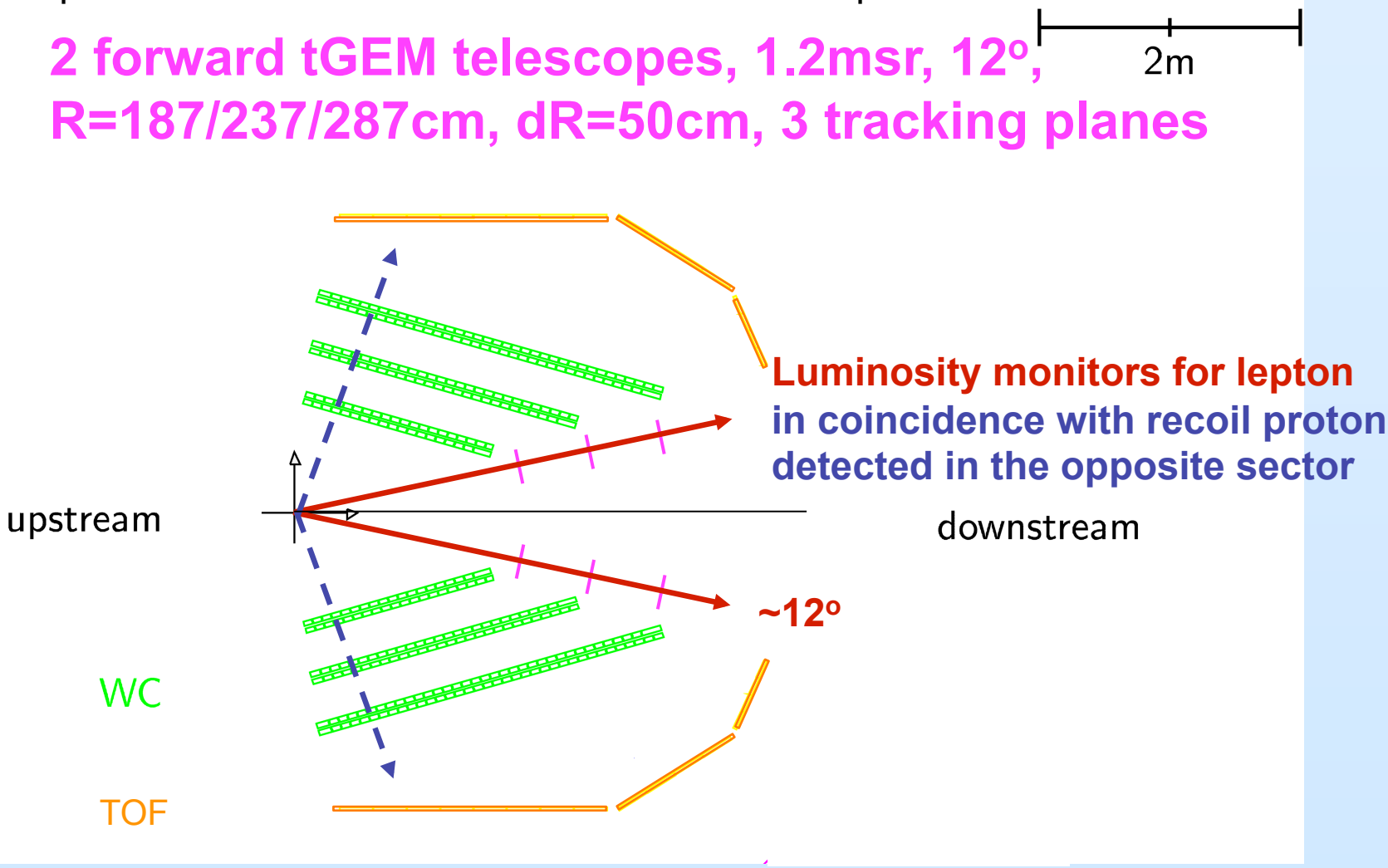
Monitoring the Luminosities

- **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

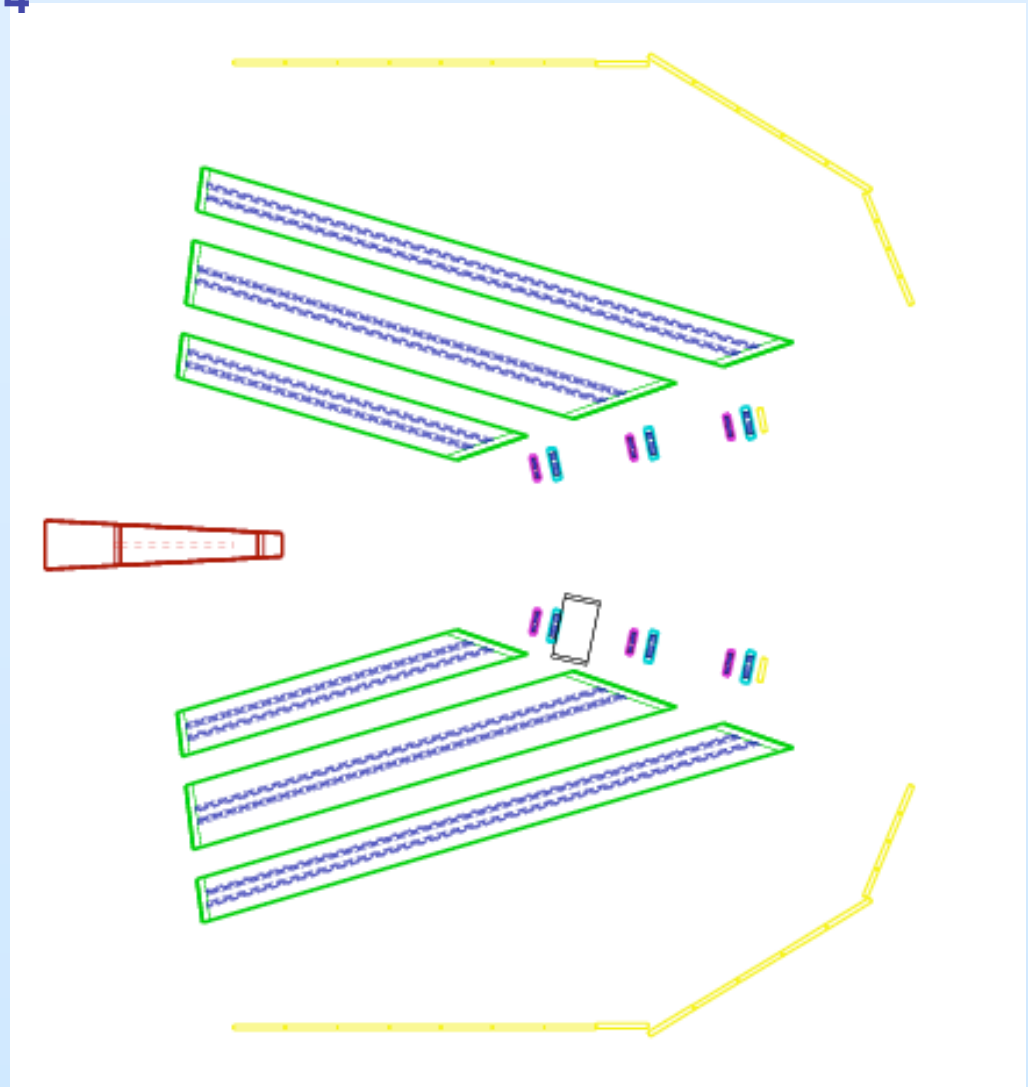
Proposed version included in OLYMPUS TDR Sept. 2009

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



Luminosity Monitors: GEM+MWPC

- Concept paper for TDR, Sec. 4 sent out to OLYMPUS collab.
- Two MWPC telescopes with 3 x/u/v elements after each GEM element
- 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

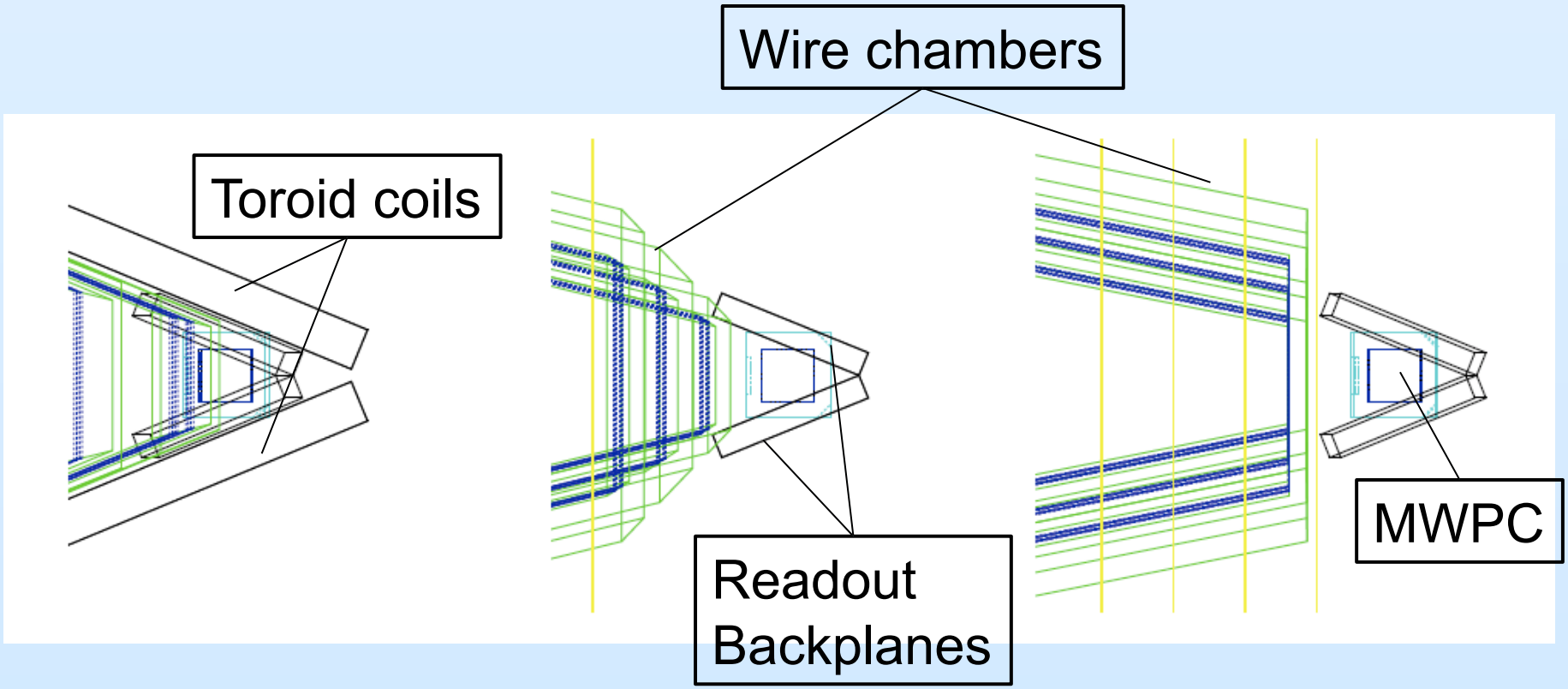
	δz [cm]	$\delta\theta$	$\delta\phi$	$\delta p/p$ [%]
GEMs alone	1.67	0.137°	0.301°	4.57
GEMs alone + MWPC material	1.74	0.142°	0.309°	4.86
MWPCs alone + GEM material	3.94	0.294°	0.407°	9.58
GEMs + MWPCs	1.60	0.132°	0.308°	4.43

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

- Concept paper for TDR, Sec. 4 sent out to OLYMPUS collaboration
- Each system alone is not deteriorated too much by the other
- Both systems combined give superior resolution

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 $\theta_e = 12°$. 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**

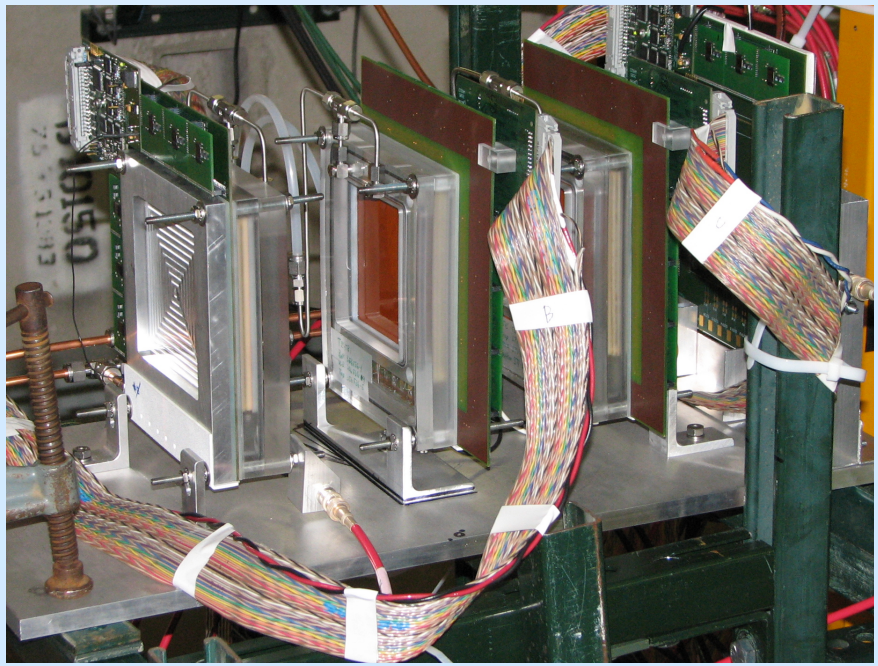
Luminosity Monitor based on GEMs

- 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 protoype:

Telescope of 3 Triple GEM prototypes (10 x 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 / HUPTI / Jlab / J-PARC or 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**

Tasks & Timeline for LuMo Construction

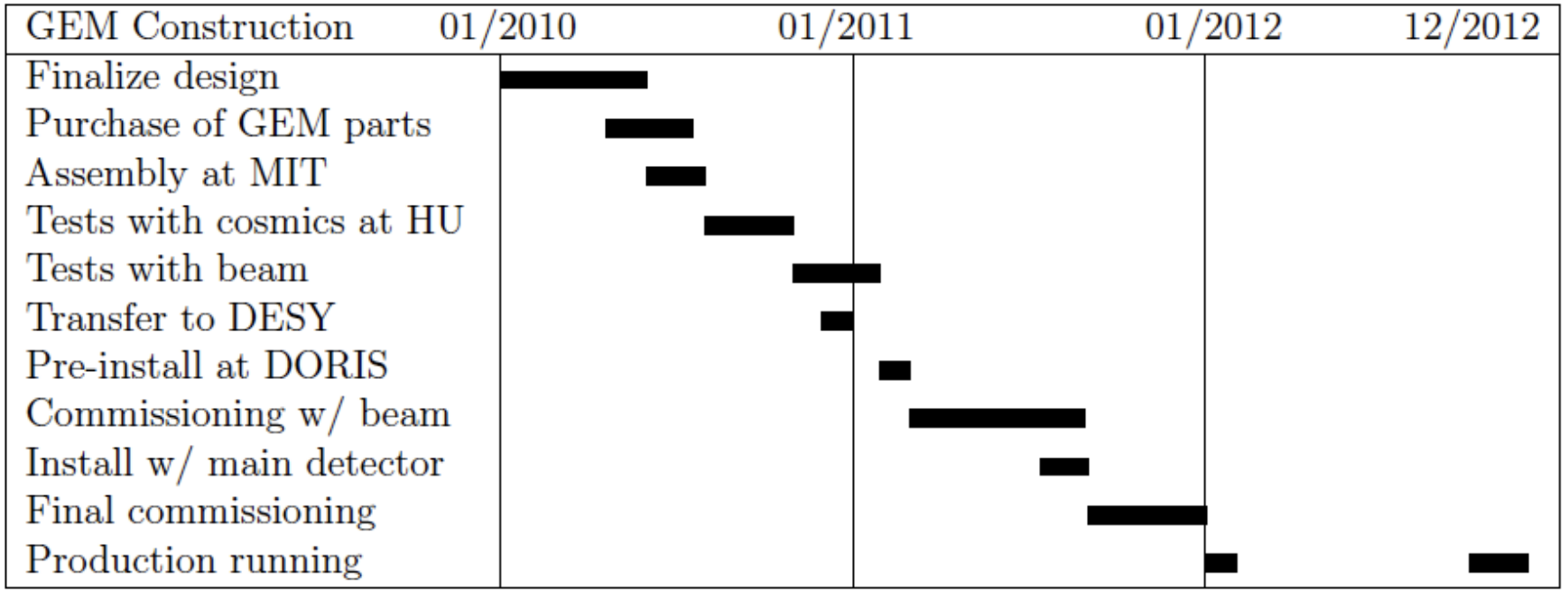


Table 4: Work plan for GEM luminosity monitor construction activities.

- **Assembly of GEM detectors at MIT in summer 2010**
- **New research building at HU with lab space available by summer 2010**
  - **Central supply of (non-flammable) gases**
  - **Clean room on HU campus from ATLAS group available if necessary**

Realization of Detectors

- Construction project fully funded (NSF, MRI-R2), grants are active
- Postdoc position possibly filled by J. Diefenbach eff. July 1, 2010
- Purchase of GEM and HV foils initiated, designed by D. Hasell, 5-6 weeks delivery (early June)
- HU-MIT Research Agreement in preparation to enable Bates engineering services:
  - Drawings, direct ordering of parts, technical support for manufacturing
  - Parts to be available by June/July
- HU group to visit MIT and Bates from June 7 – August 8, 2010
  - Two HU undergraduate students (Miles Campbell, Joshua McMahon)
  - One HU graduate student (Ozgur Ates); one postdoc (J.D., t.b.c.); and M.K.
  - Gluing and testing of GEM foils (Optical checks; HV conditioning)
  - Assembly of GEM detectors at MIT Bates
  - Some initial testing
- Have detectors constructed by August, transfer to HU

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 August 2010 (Rome group)**
  - **New APV based system if ready**
  - **"Gassiplex" system (Jlab) as fallback for cosmic ray and source tests**
- **Testing with cosmic rays / sources from August – October 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**

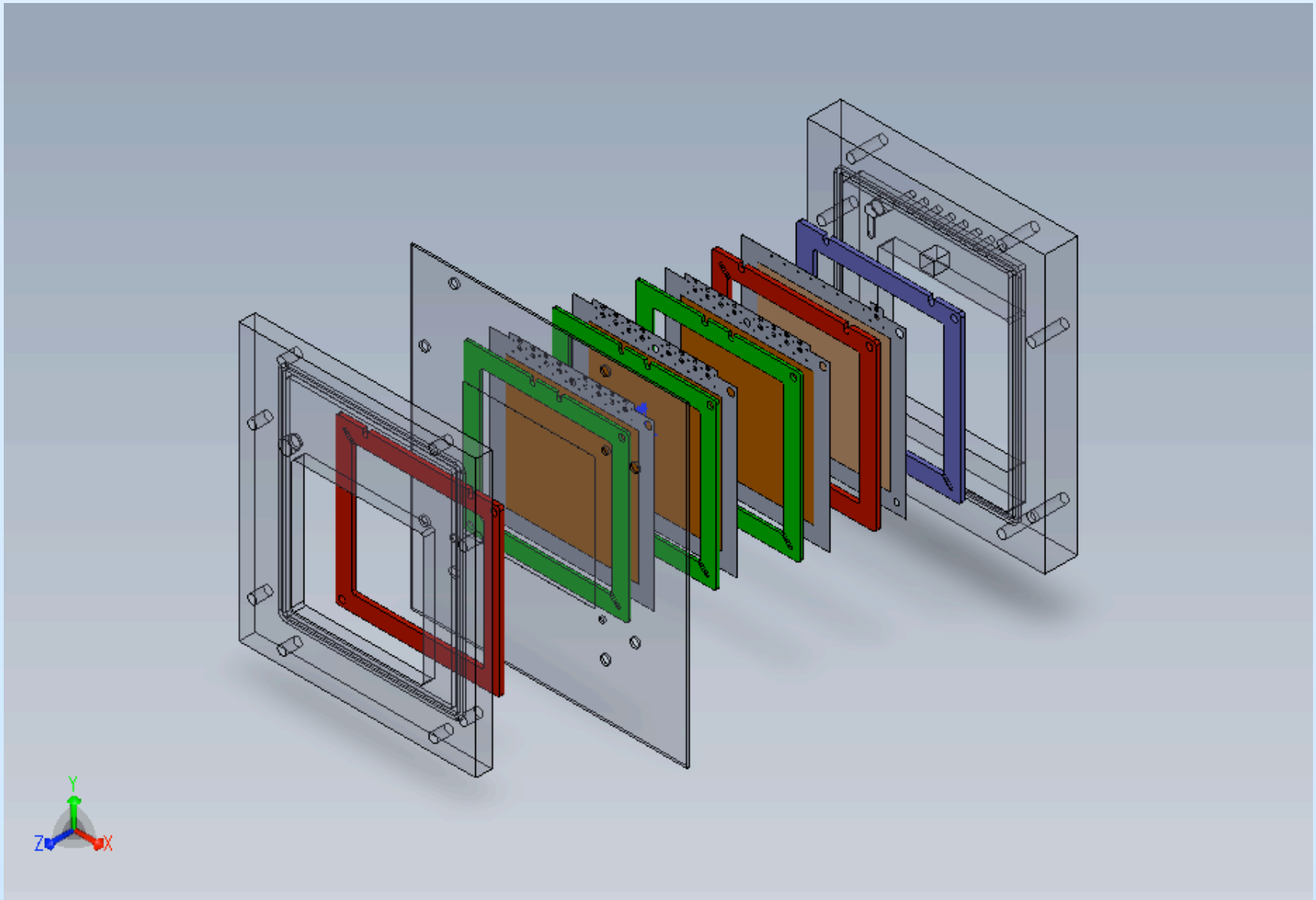
Realization of Detectors (cont'd)

- **Testing with beam between October 2010 – January 2011**
  - **HUPTI / 100 MeV protons with low intensity (initial proton track may be known)**
  - **Jlab / Qweak – parasitically (scatt. electron tracks known if comb. w. Qweak)**
  - **Kaon 1.1BR commissioning at J-PARC (Oct-Nov. 2010)**
  - **DESY testbeam (tracks well known)**
  - **Or no separate beam testing at all? – Decide by August**
- **Transfer detectors to DESY between Oct. 2010 and Jan. 2011**
- **Mount GEMs in DORIS in Feb. 2011 for spring test run**
- **Final installation in OLYMPUS in summer 2011**

GEM Design Criteria / Issues

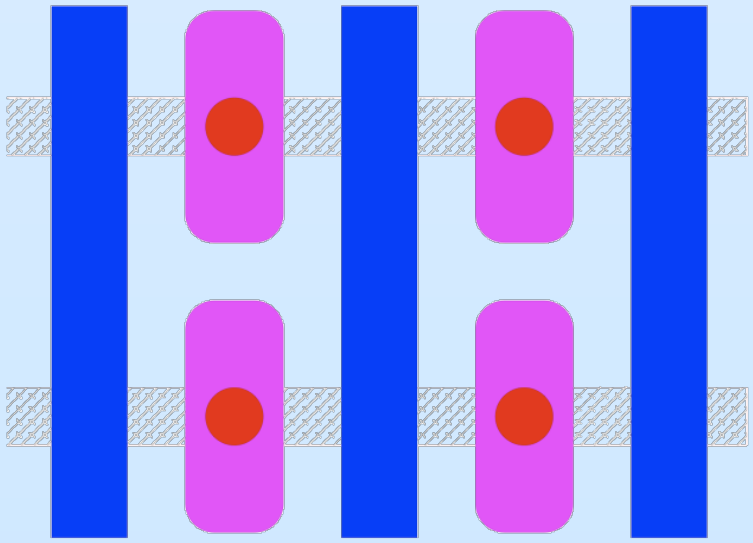
- Want 12.5x12.5 cm^2 total area – gluing instead of bolting w/ O-rings
- Identical design for all chambers preferred – easy replacements
- Can use inner frame design of new MIT prototype (D. Hasell) with minor modifications (like glue troughs), for everything but readout
- Use top and bottom spacer frames for gas pressure foils
- Access all infrastructure items – voltage supply, gas connectors, readout connectors through top frame margin

GEM Detector Design (MIT)



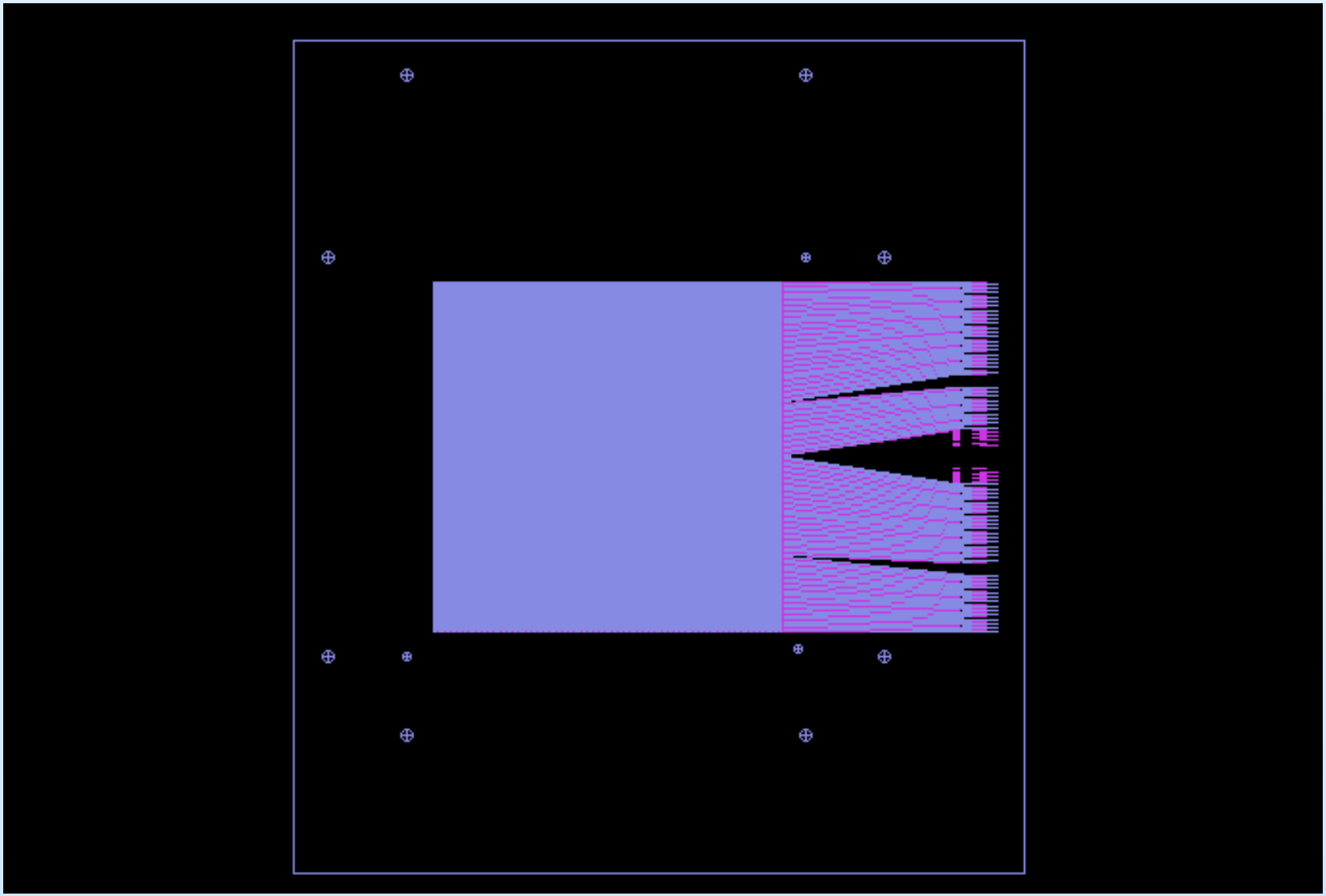
GEM Readout Board

- Readout pitch of MIT prototype: 635 (800) 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
- Issue to be decided fast: Readout board design
  - CERN design (R. de Oliveira), based on laser ablation technique, "standard" size too large (>18x18). Is used by INFN&UVA at PREX
  - CERN can produce any other design based on Gerber file
  - Laser ablation technique @ MIT (Compunetics) discontinued
  - Readout with strips and pads vias-connected on rear side
  - Is currently still in R&D phase
  - Existing design for 10x10 cm^2 with 800 μm pitch



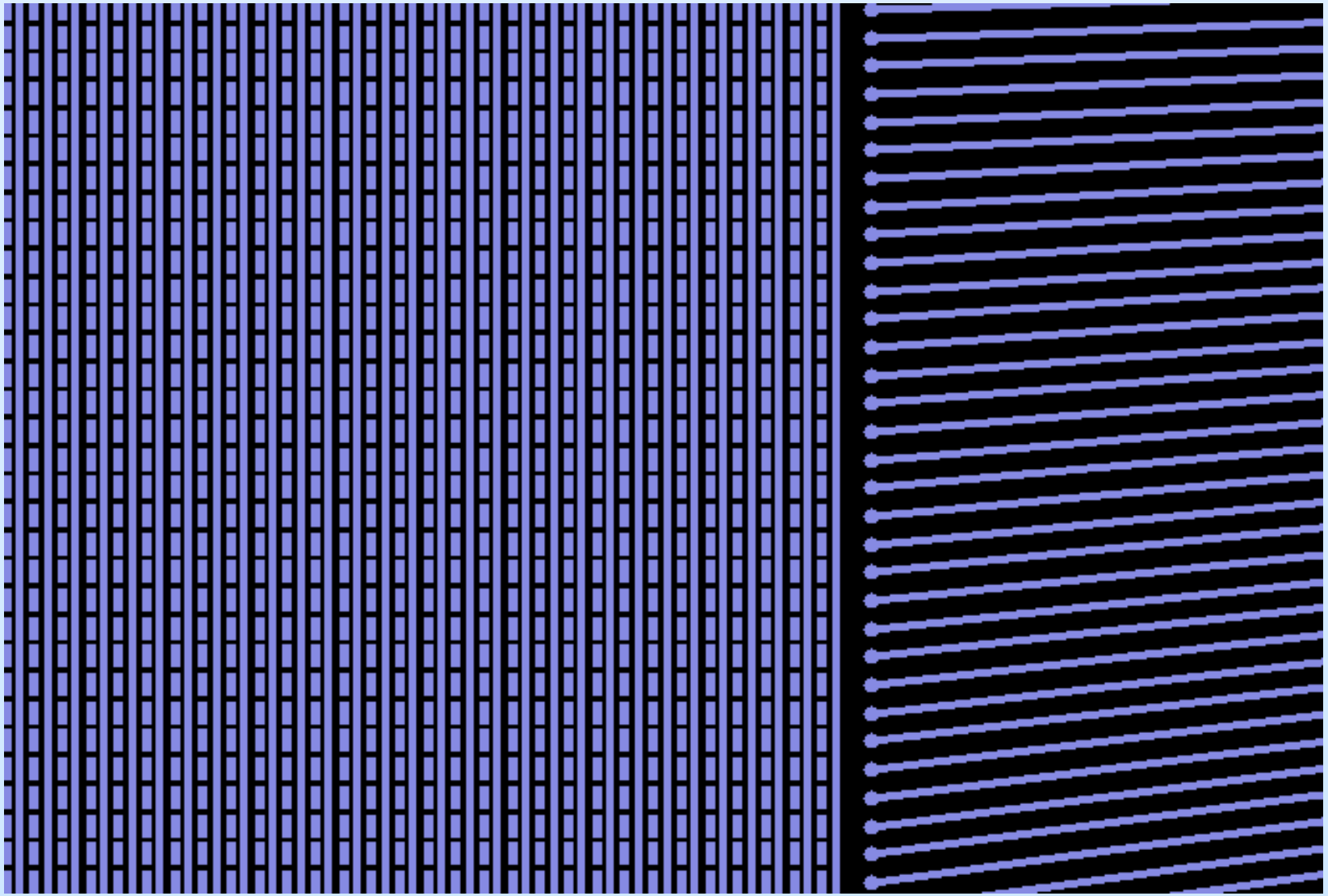
Strips & Pads Readout (D. Hasell)

800 μm pitch - Total view



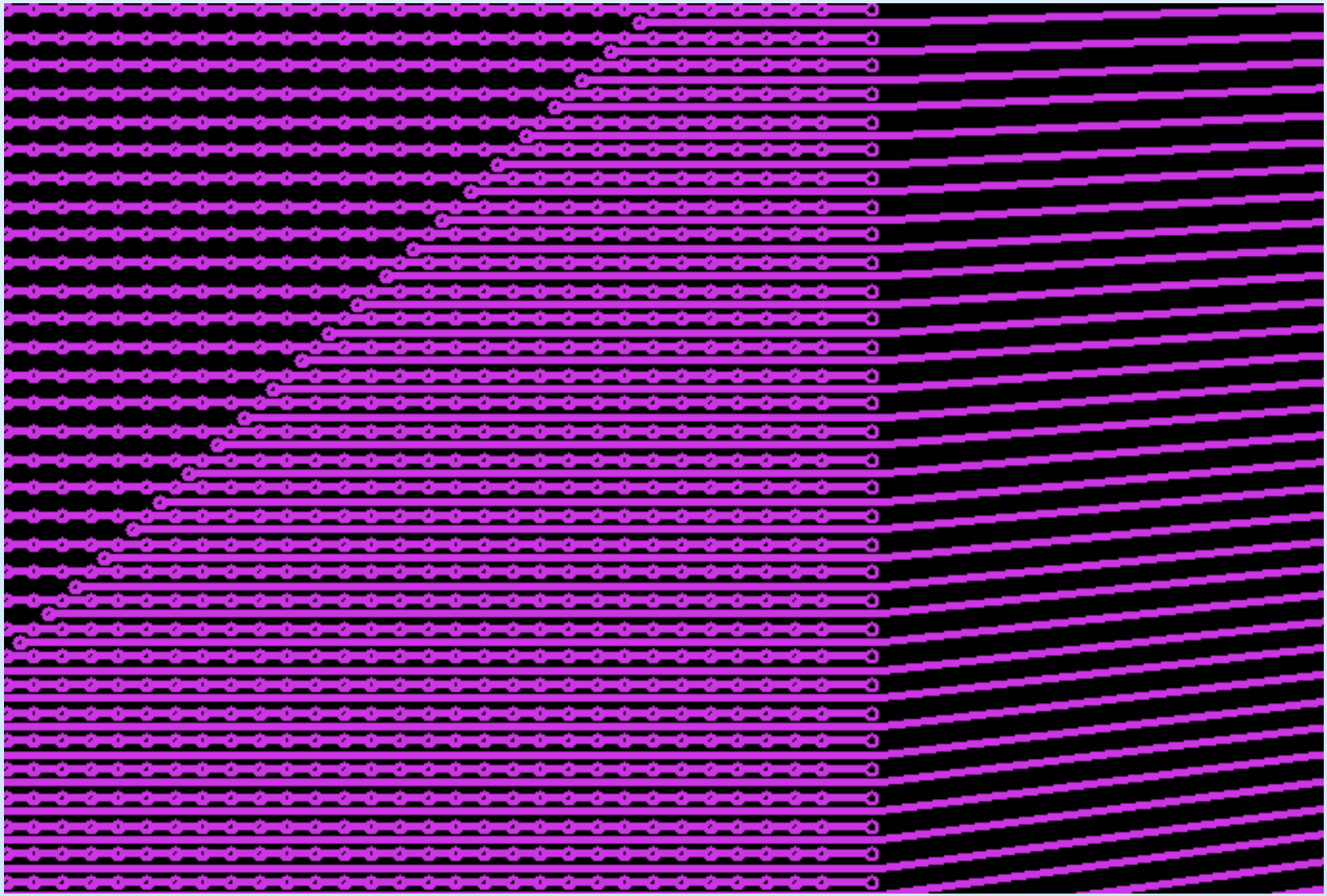
Strips & Pads Readout (D. Hasell)

800 µm pitch - Bottom side (aspect)



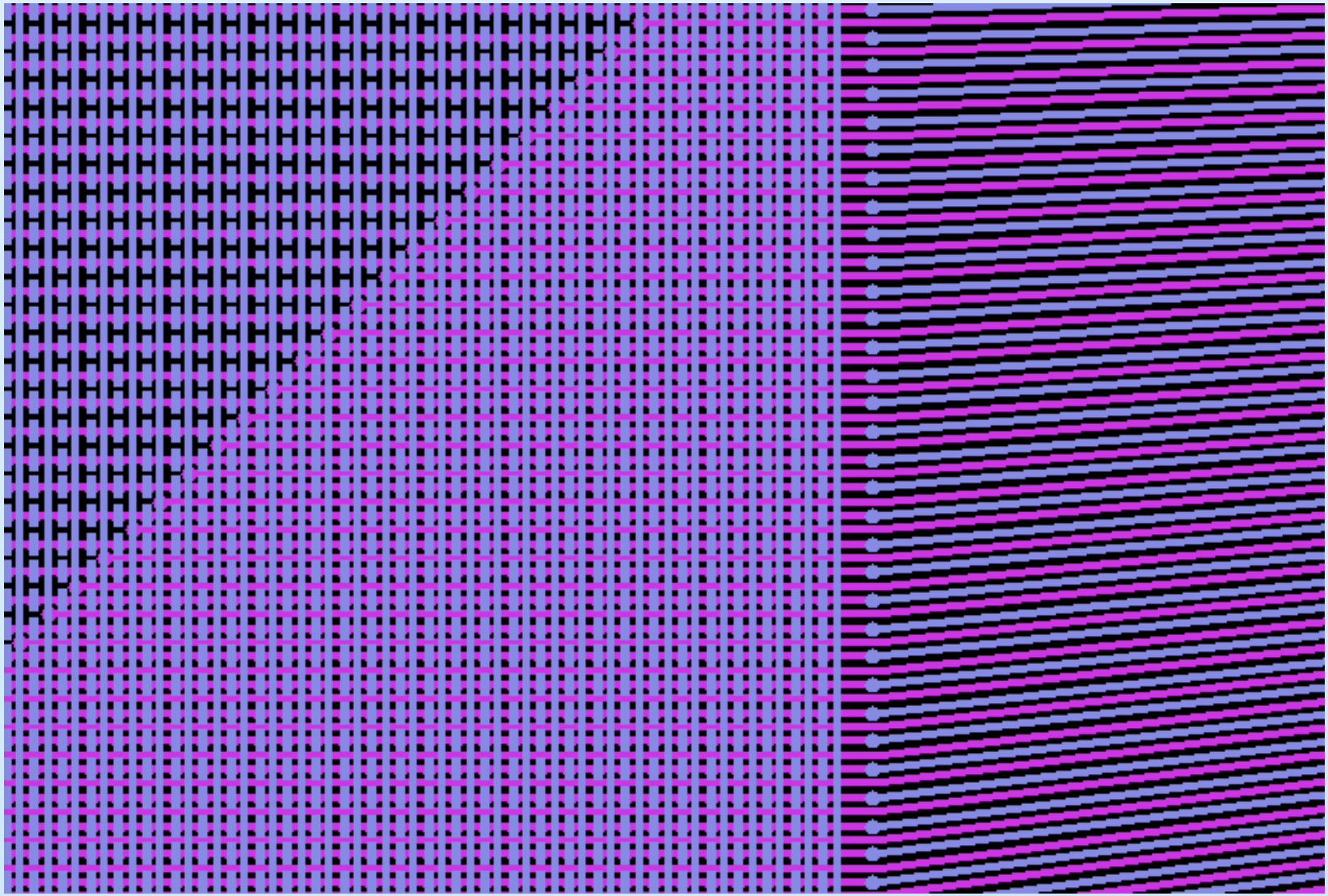
Strips & Pads Readout (D. Hasell)

800 µm pitch - Top side (aspect)



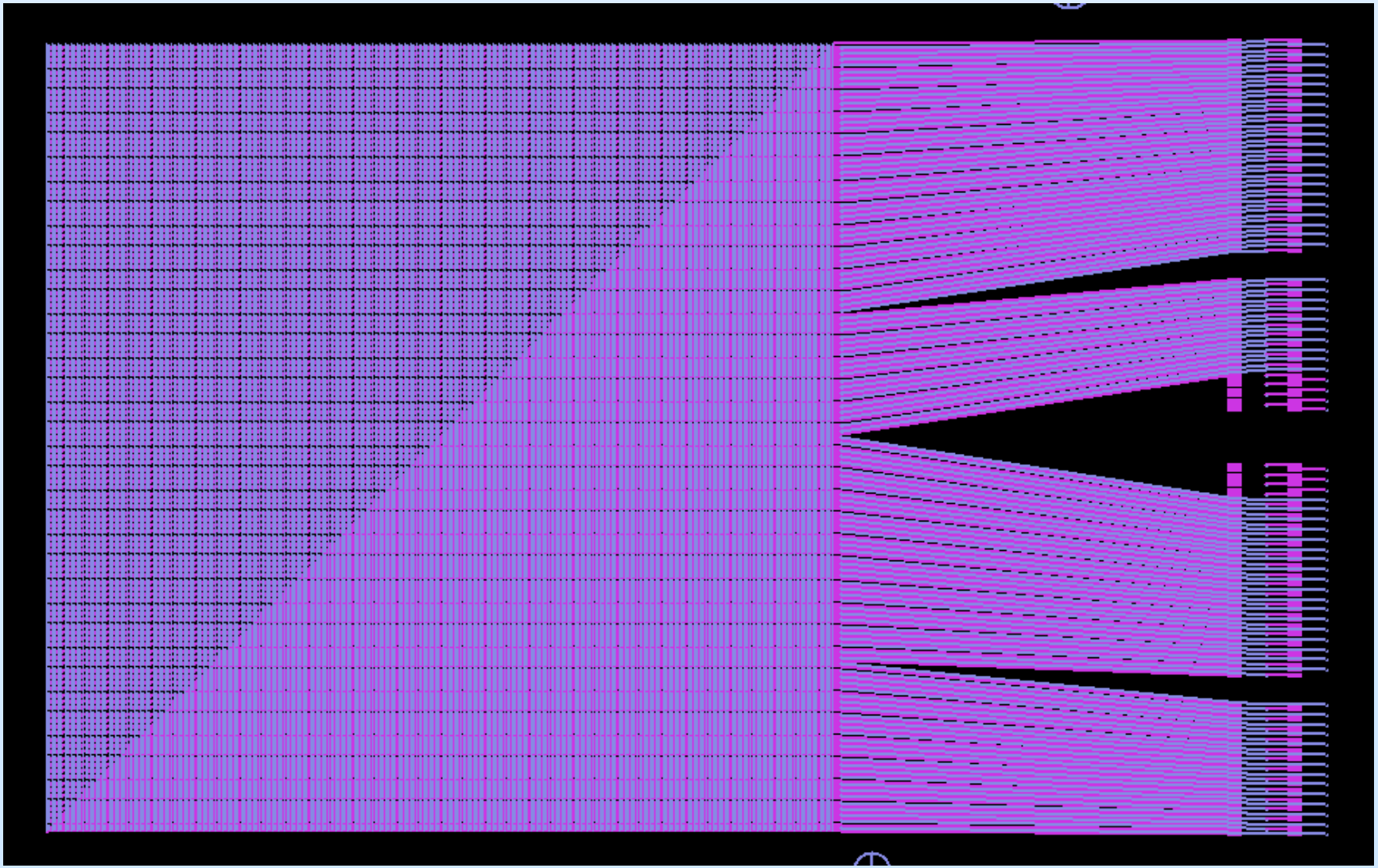
Strips & Pads Readout (D. Hasell)

800 μm pitch - Top+bottom sides (aspect)



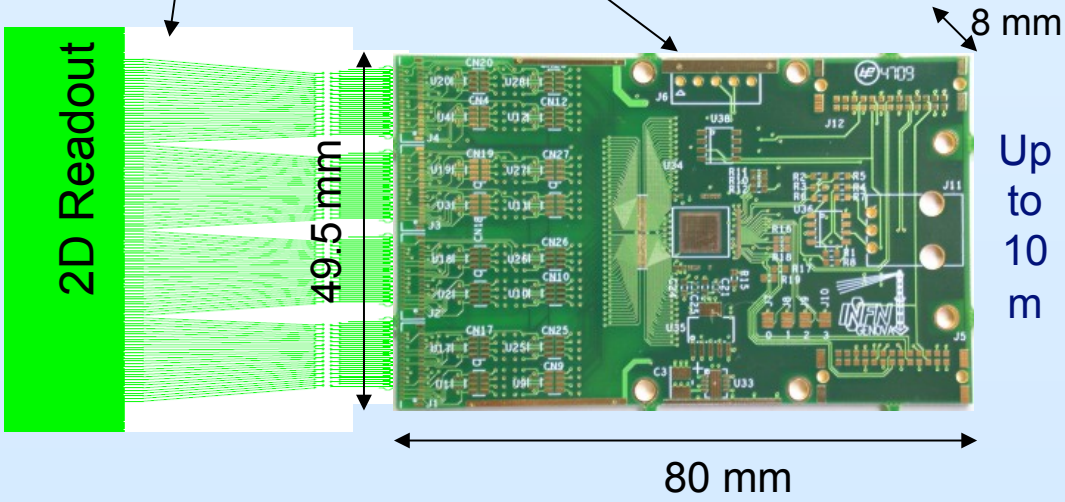
Strips & Pads Readout (D. Hasell)

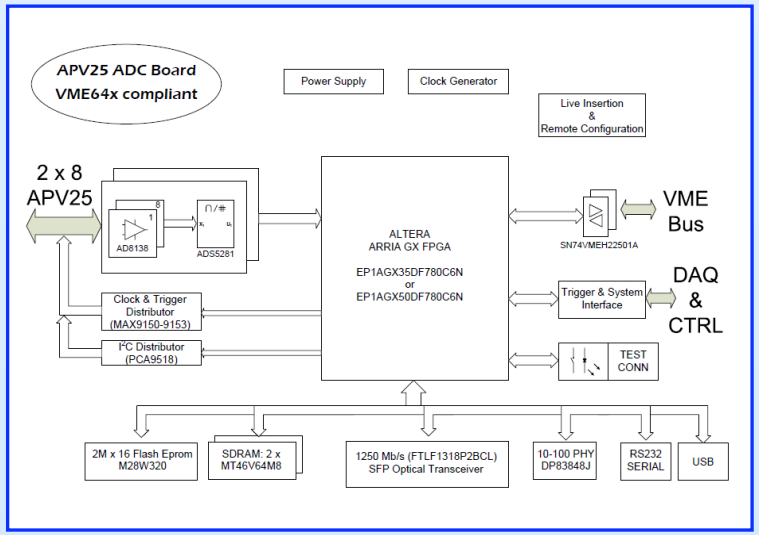
800 μm pitch - Total view



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

Backup slides

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.