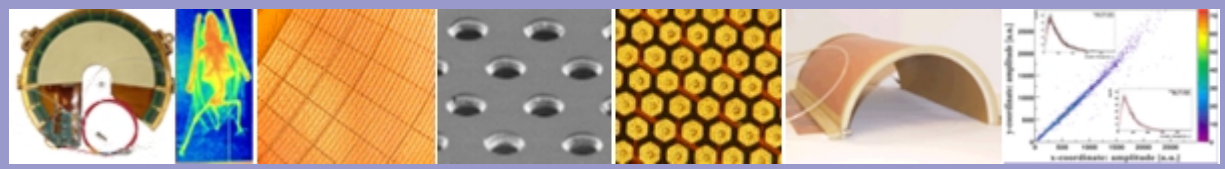
CERN

European Organization for Nuclear Research
Organisation Européenne pour la Recherche Nucléaire

GEM at CERN

Leszek Ropelewski CERN PH-DT2-ST



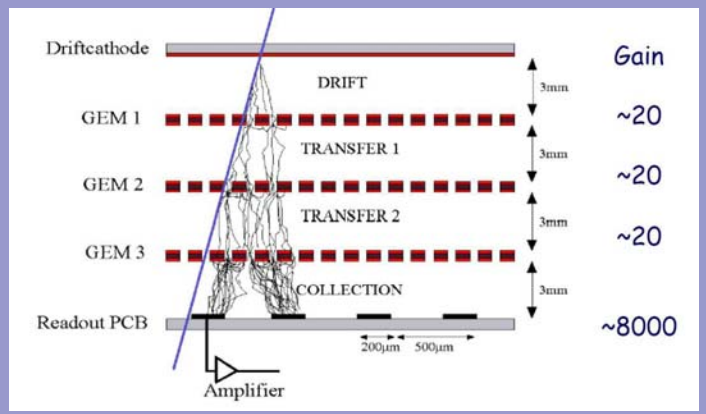
CERN Gas Detector Group Activities

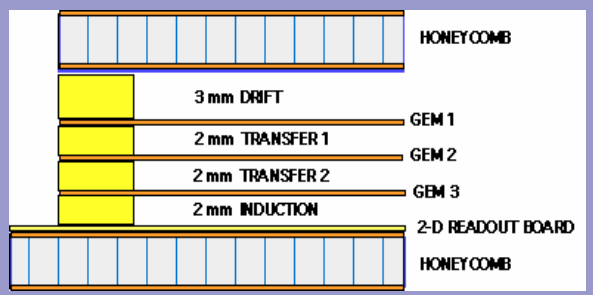
- TOTEM T2 detectors design, prototypes and integration
- Semi Cylindrical GEM detector design and prototype
- TPC gating
- Medical applications (PET)
- Large surface, light detectors
- Stability studies
- THGEM for UV light detection for RICH
- Electronics
- New gas detector lab

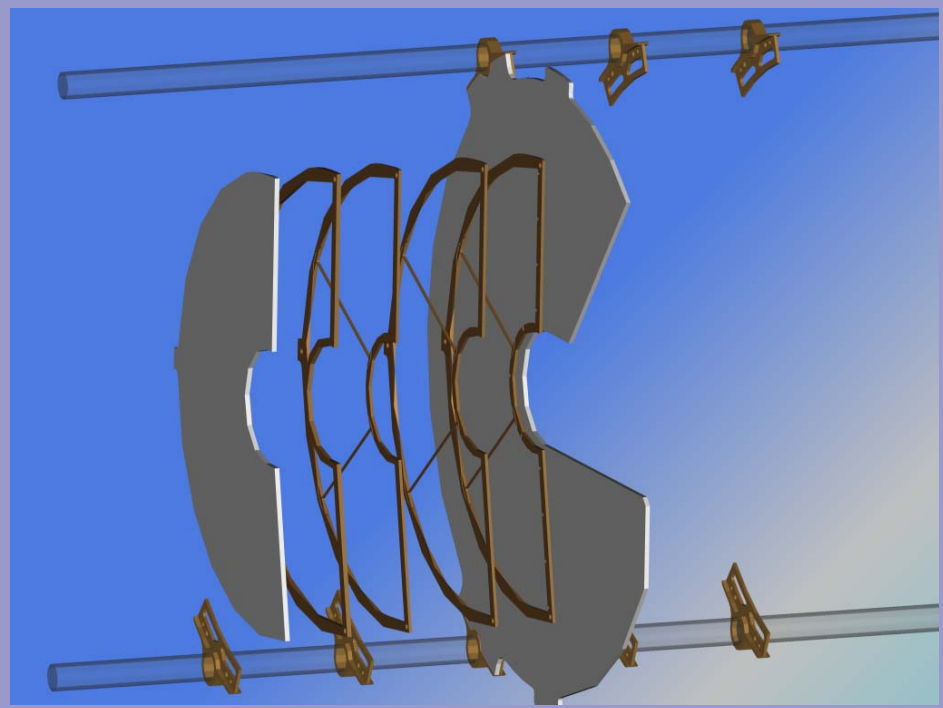
TOTEM GEM : Concept and Design

Detector requirements:

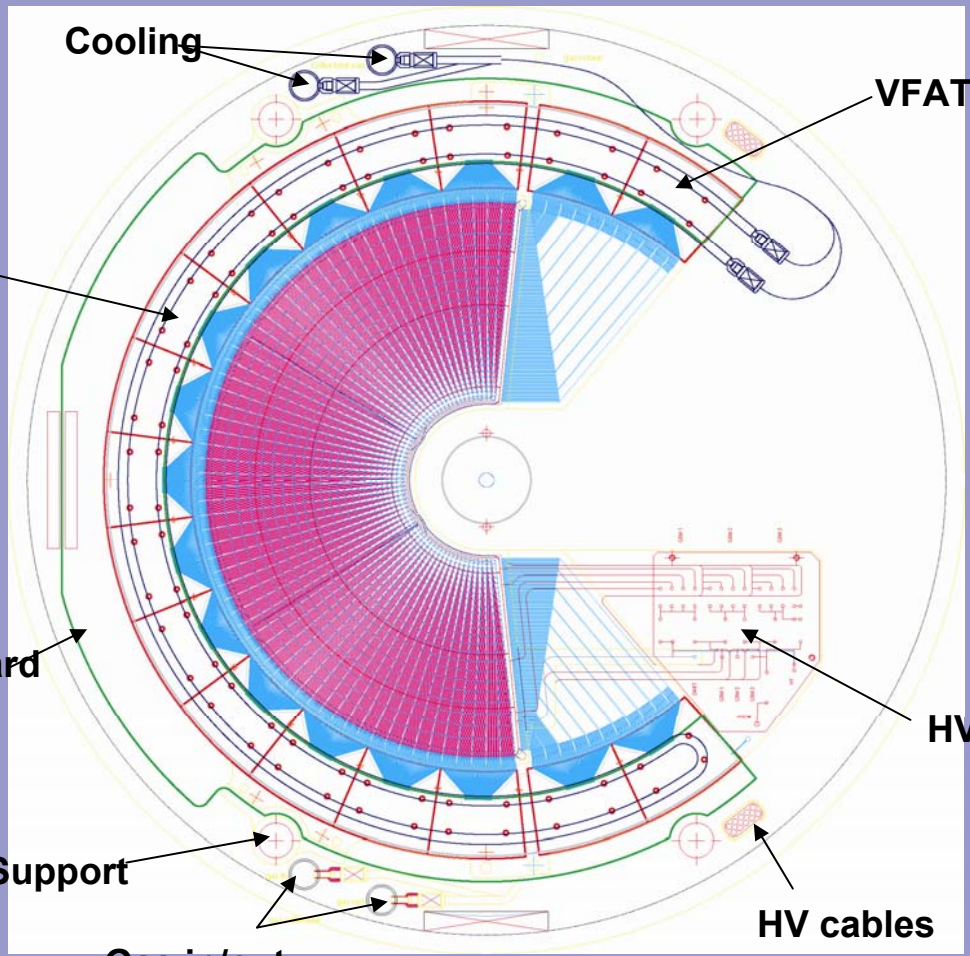
Rate Capability	- Charge particle rates 10^4 p mm^{-2}s^{-1} at L = 10^{33} cm^{-2}s^{-1}
Ageing	- 1 year of continuous operation 10^{11} p mm^{-2} -> 7 mC mm^{-2}
Discharges	- at probability of 10^{-12}/part. -> 10 disch. cm^{-2} year^{-1}
Time Resolution	- < 10 ns
Space Resolution	- < 100 µm
Efficiency	- > 97 %

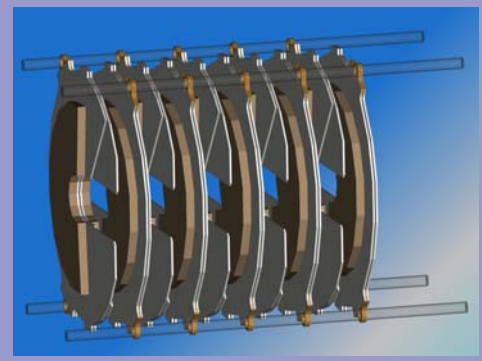


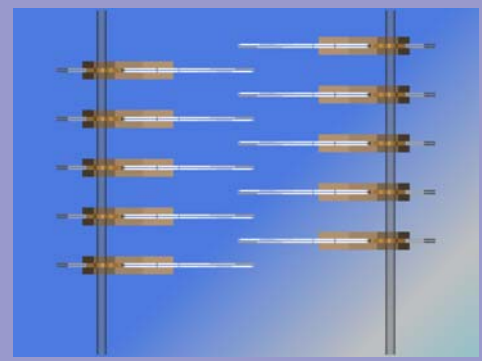


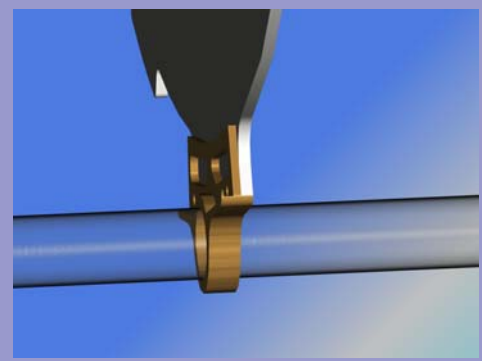


TOTEM GEM Final Detector Module

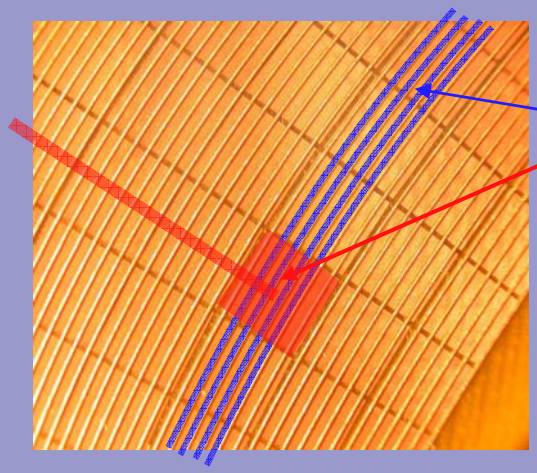




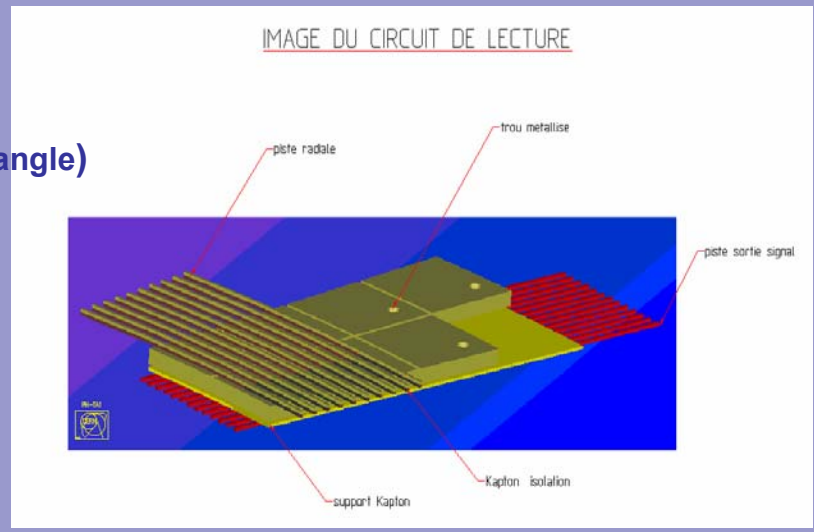


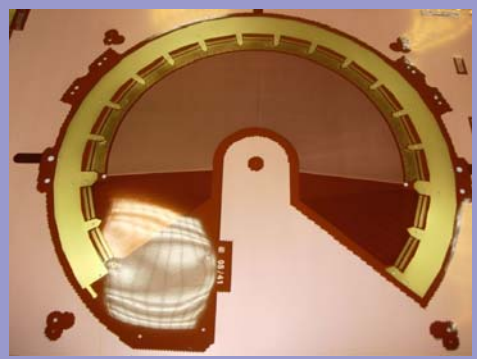


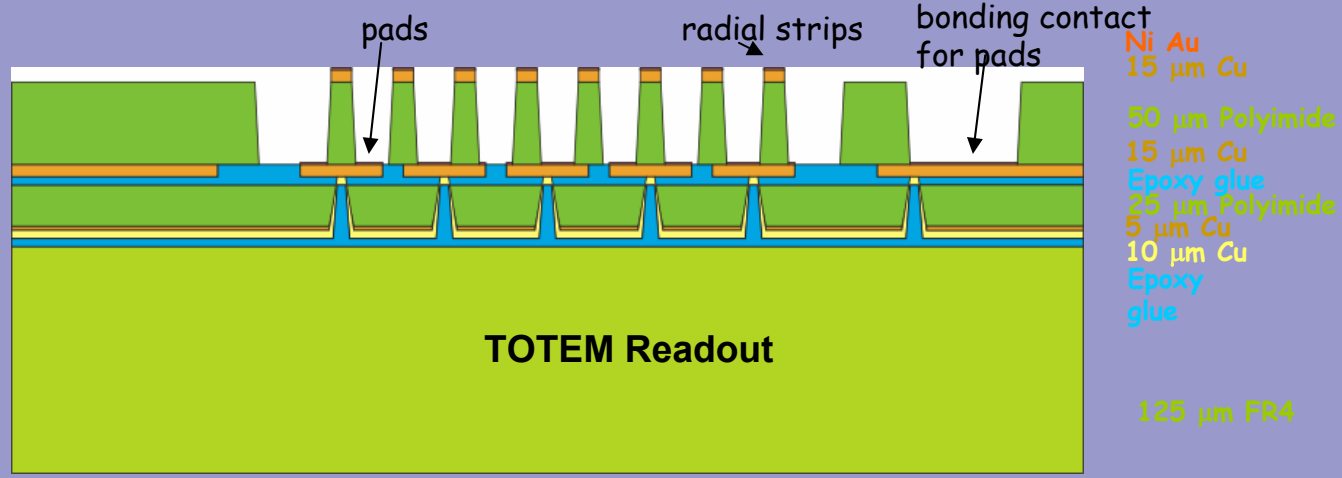
TOTEM GEM - Readout Board



TOTEM READOUT BOARD:
Radial strips (accurate track's angle)
Pad matrix (fast trigger)

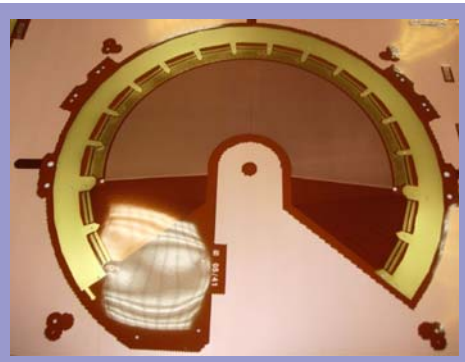


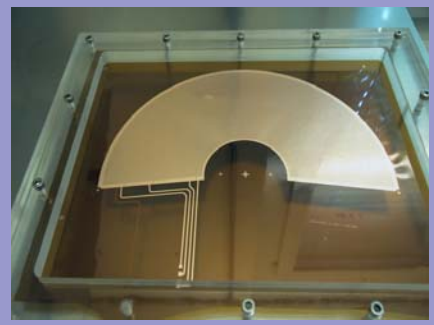




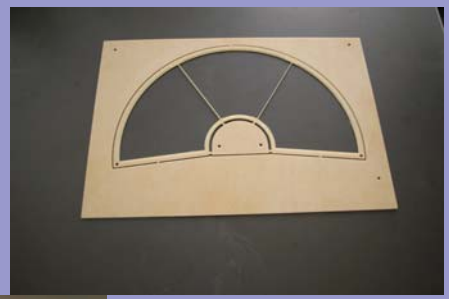
TOTEM GEM – detector components

Readout board

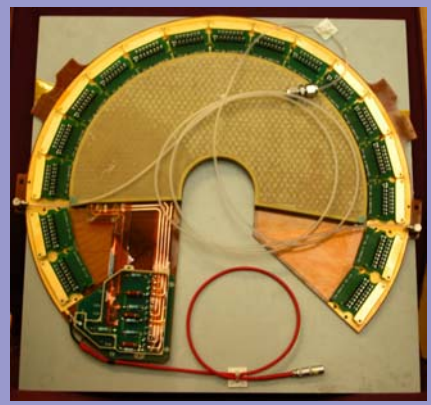




GEM foils

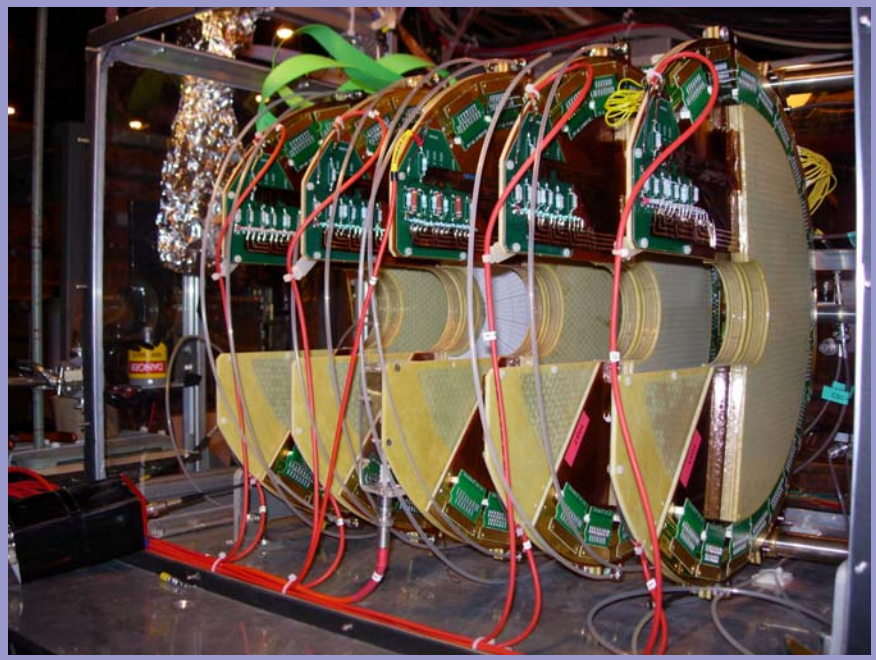


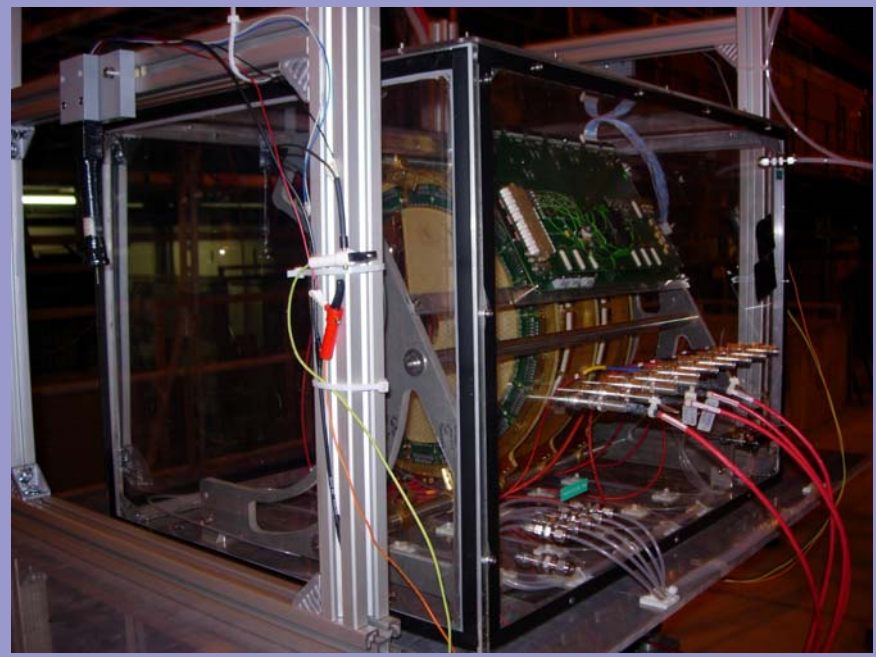
Frames, spacers and supports



HV and electronics

TOTEM GEM – test beam



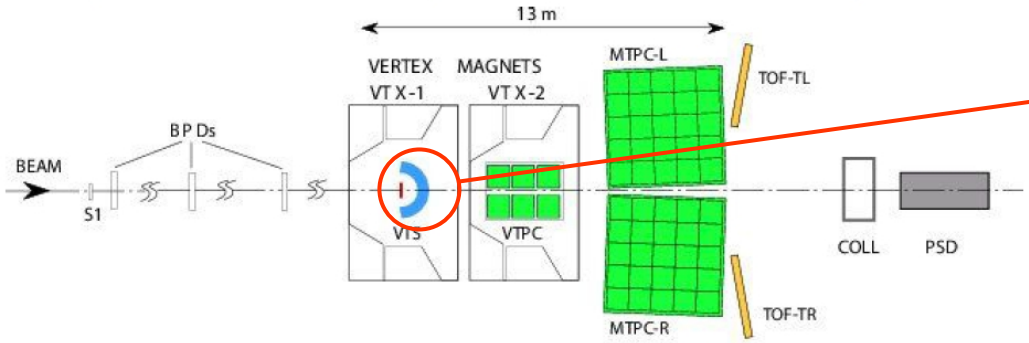


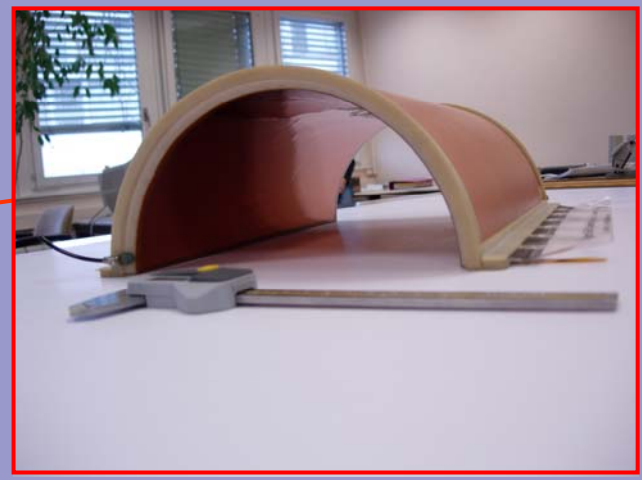
10 detectors in 5 pairs back to back
8 assembled in Helsinki
1 G&A
1 CERN

Production, components quality control → Kari Kurvinen
VFAT electronics and discharge protection chip → Walter Snoeys

Cylindrical GEM for NA49-Future

A possible "critical" experiment at the CERN SPS



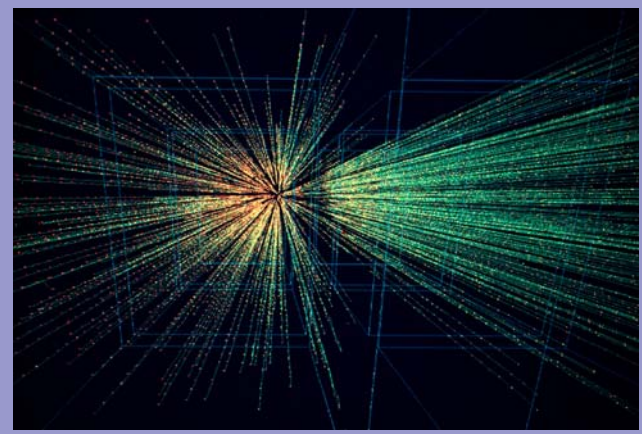


-a precise determination of an event centrality (**PSD**)

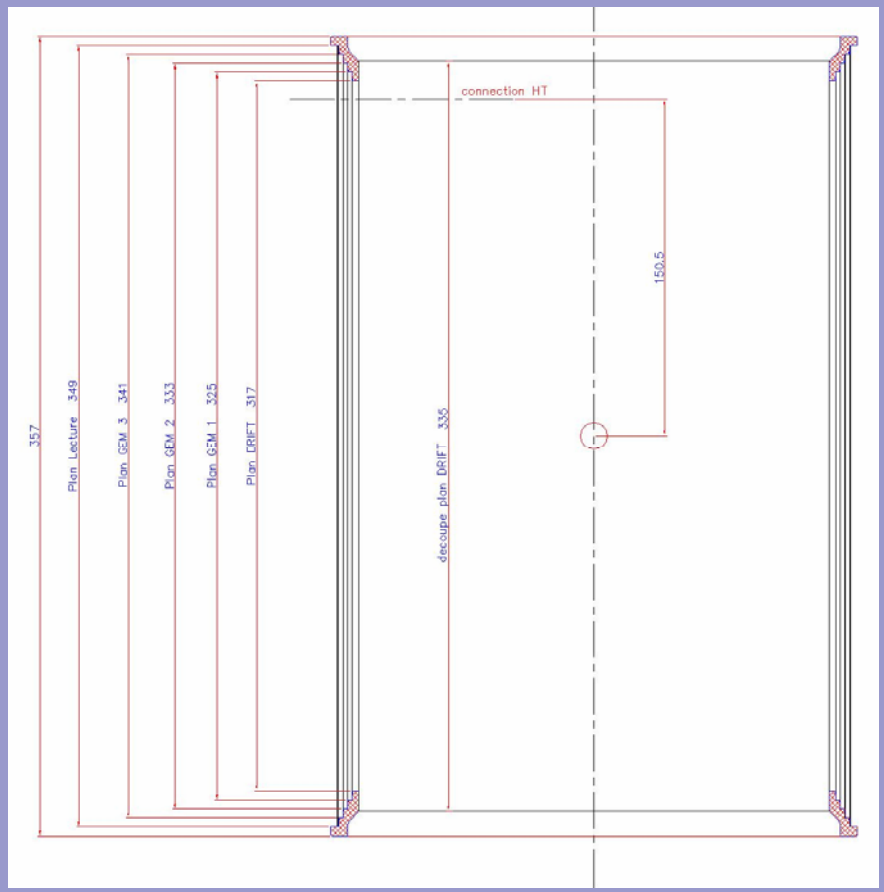
-full acceptance for charged hadrons (**VTS**)
and limited for identified hadrons (**TPCs**)

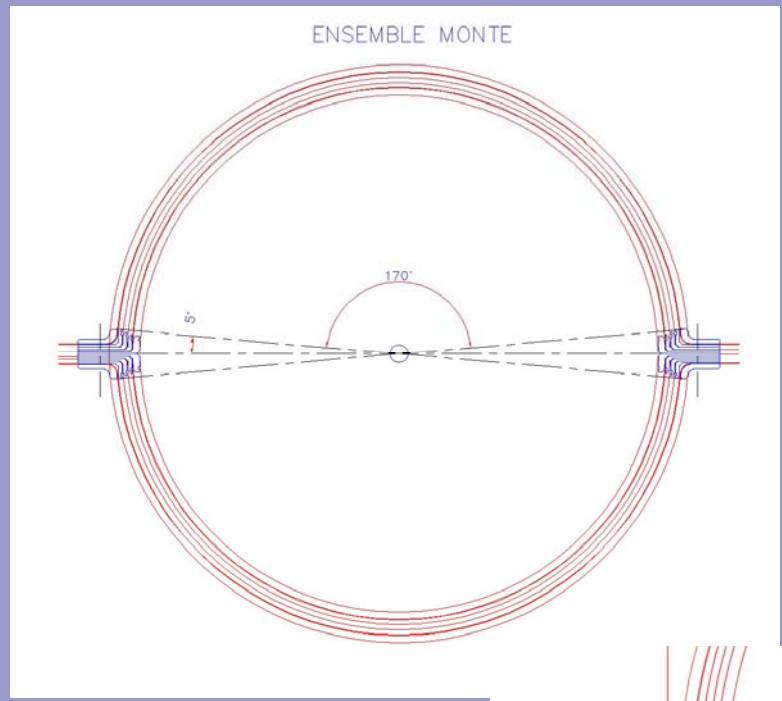
-a high event rate (**DAQ**)

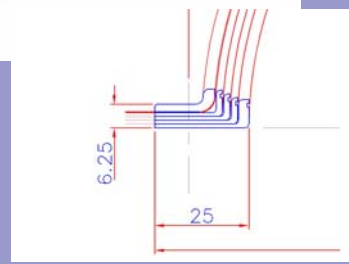
-high precision measurements of inclusive spectra
of identified hadrons (**TPCs+TOF**)



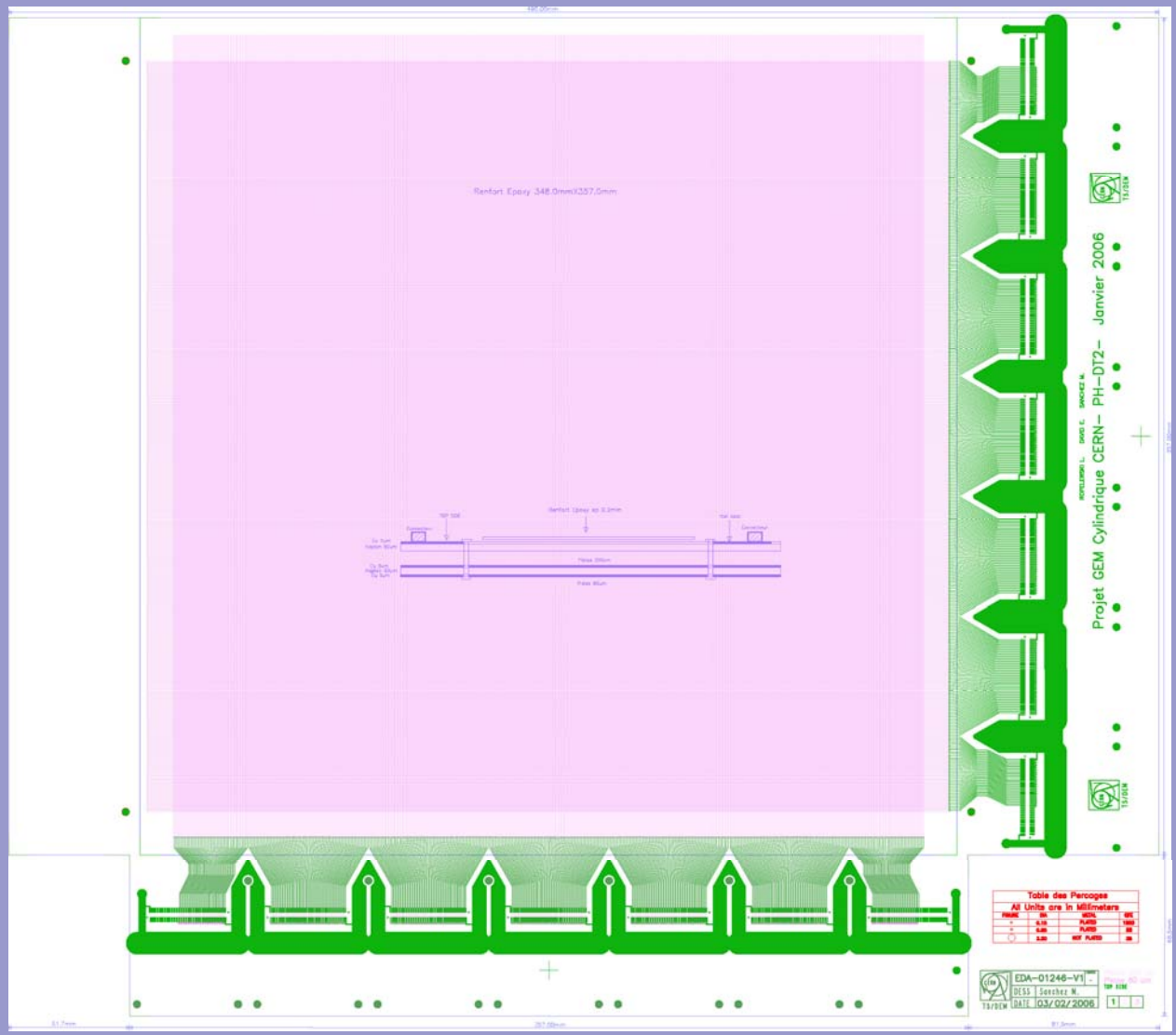
Cylindrical GEM Design

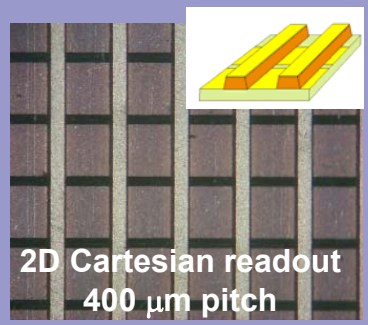


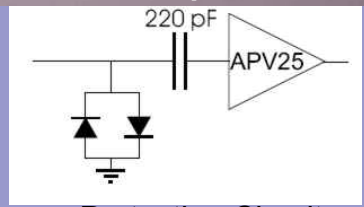




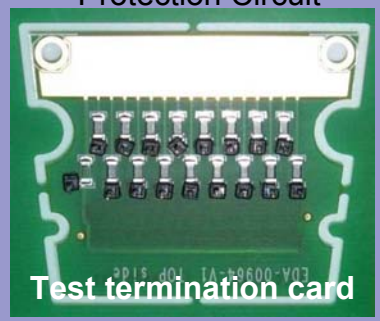
Cylindrical GEM Readout Board Design



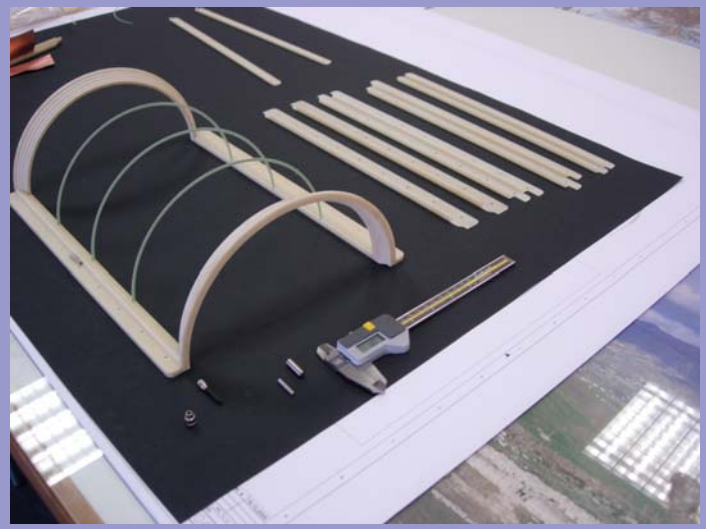


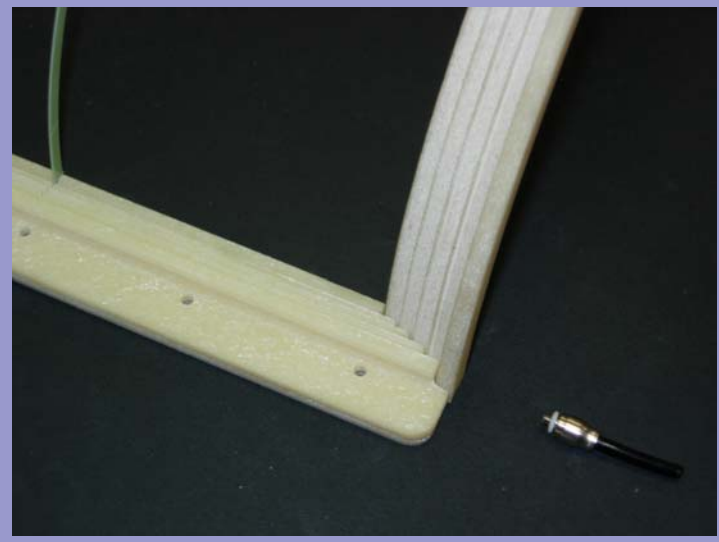


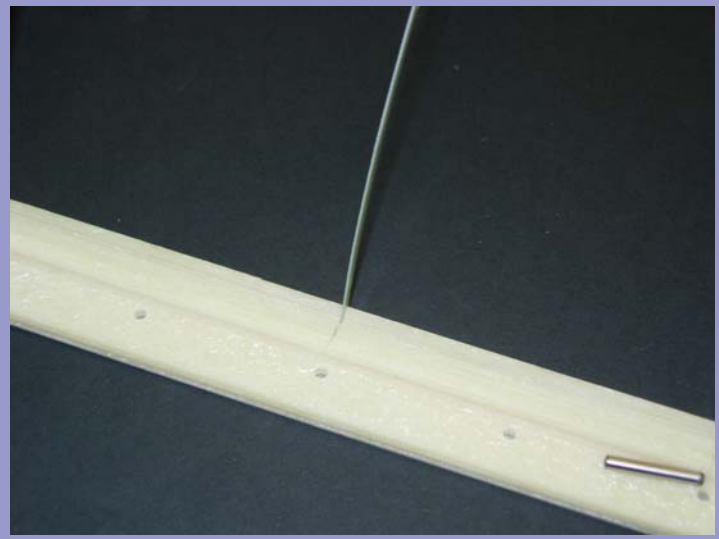
Protection Circuit



Cylindrical GEM Mechanical Parts and Tools

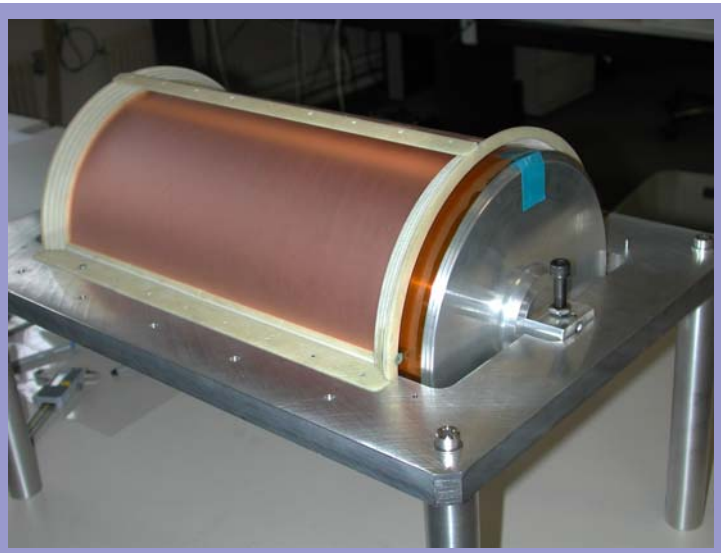


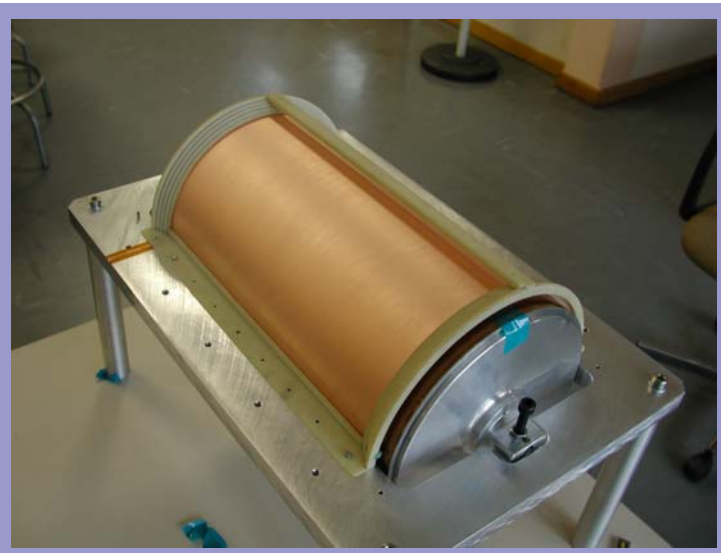


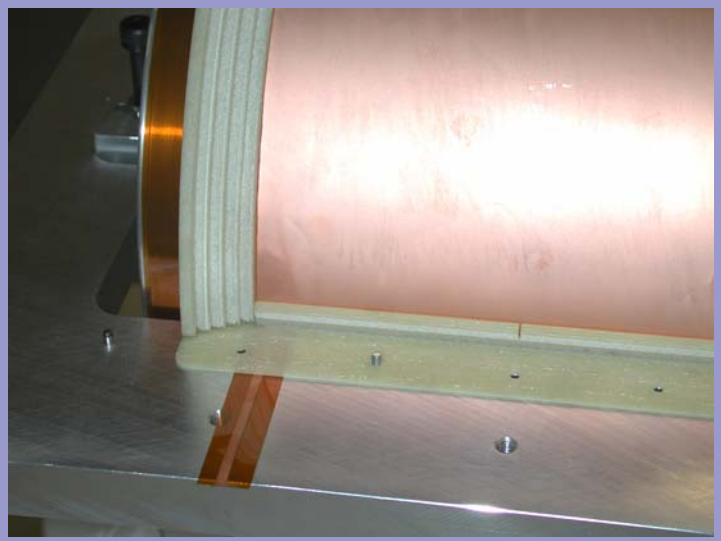


Cylindrical GEM Assembly 1

Drift Electrode

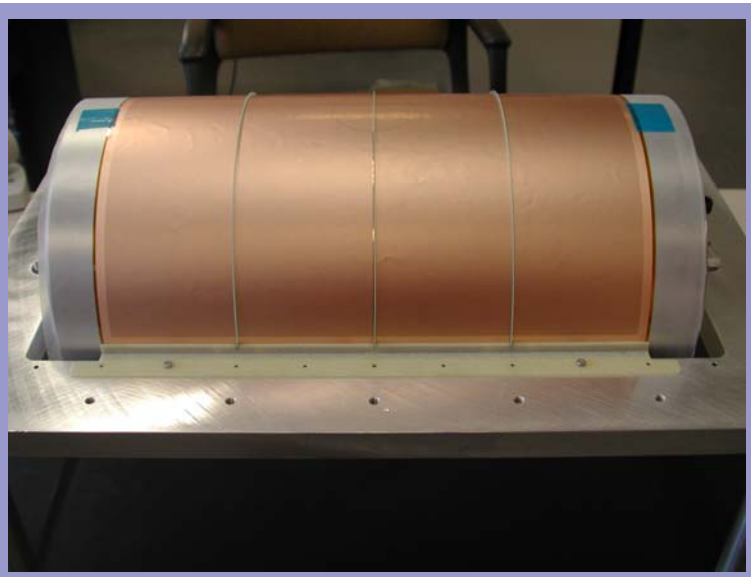


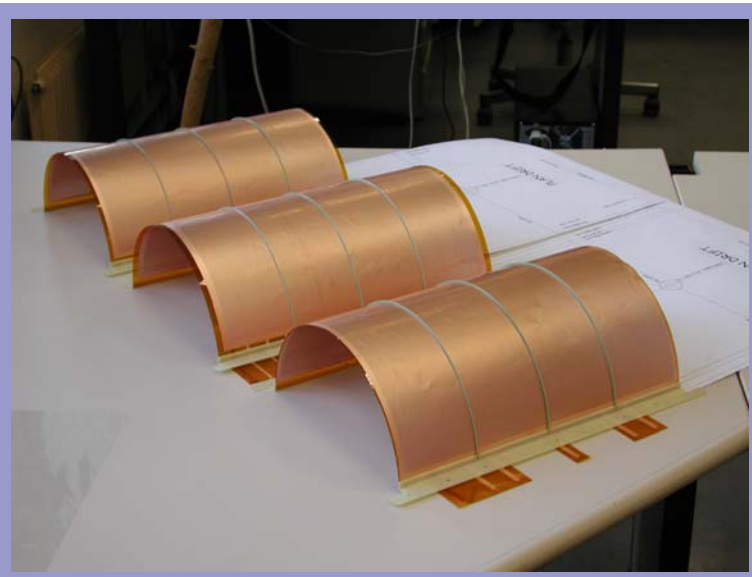


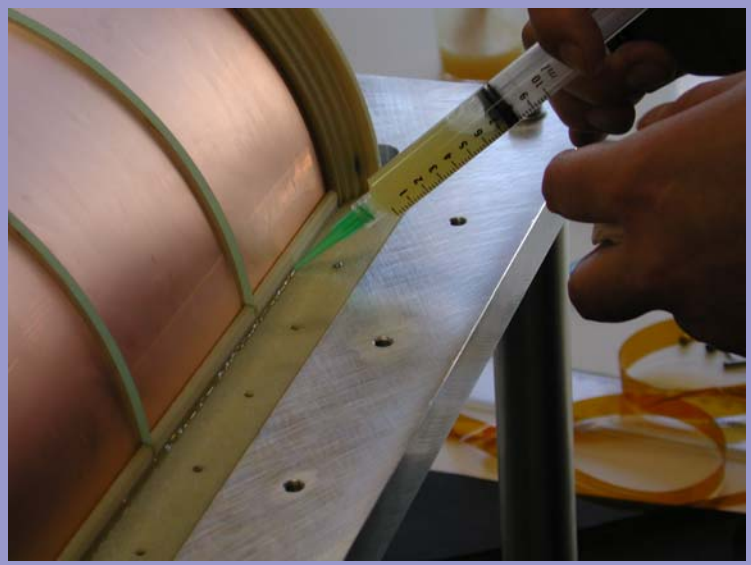


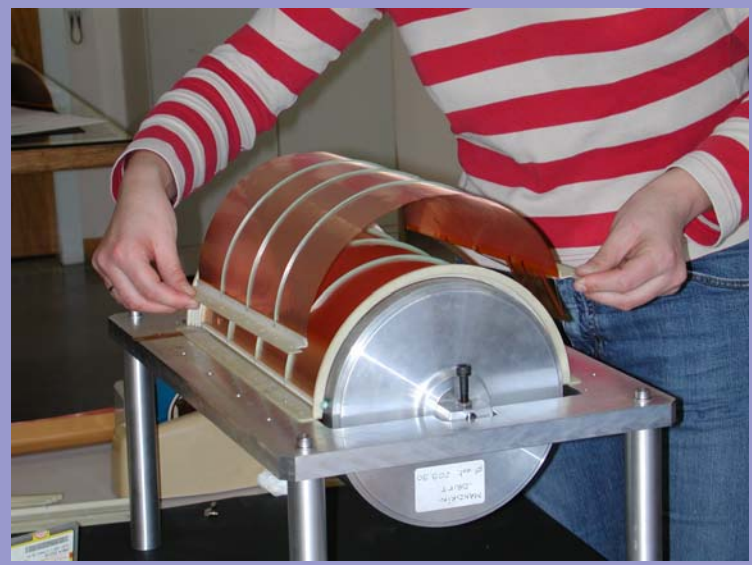
Cylindrical GEM Assembly 2

GEM foils

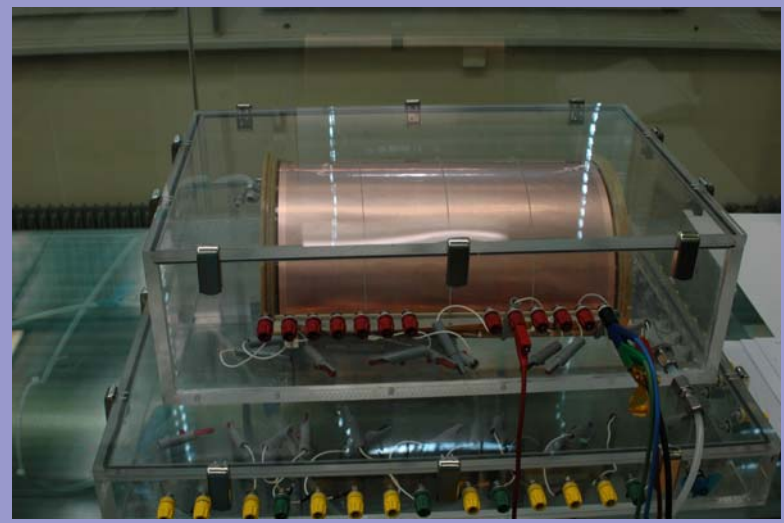


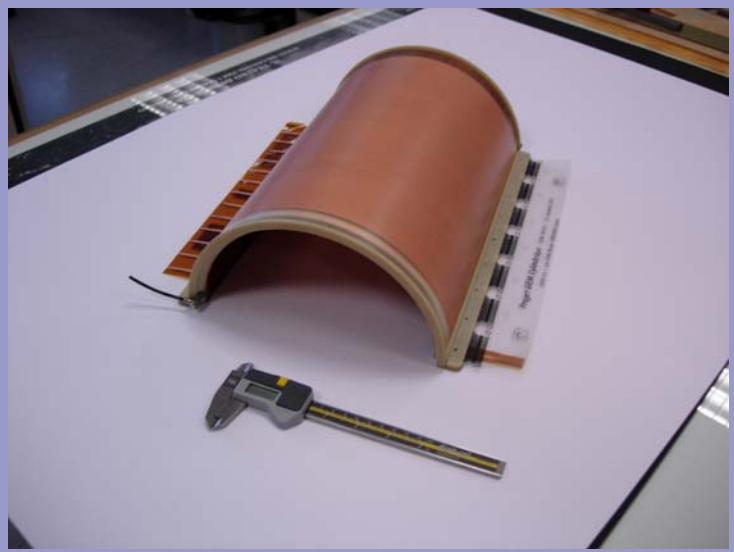






Cylindrical GEM Assembly 3





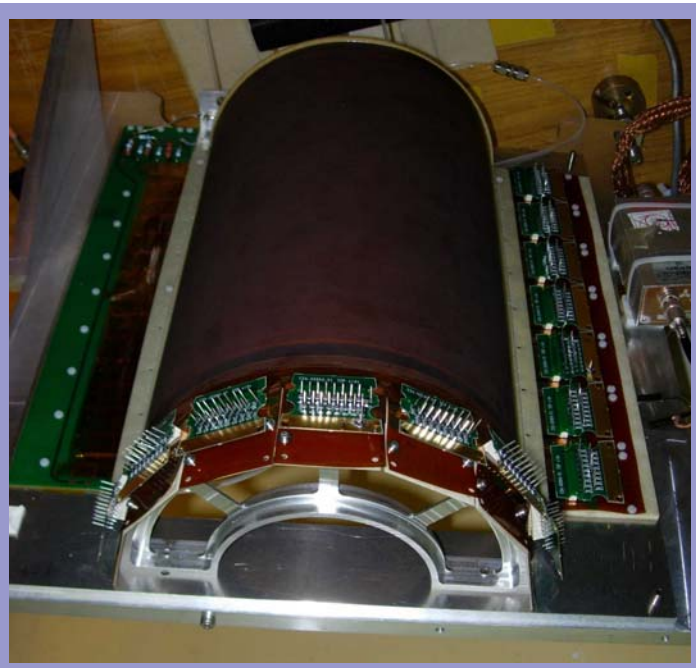
Mechanical Prototype was tested for:

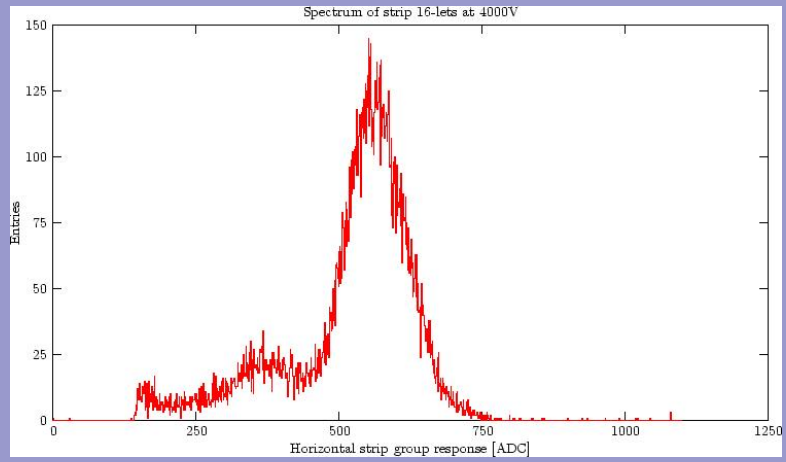
Mechanical stability
Gas tightness

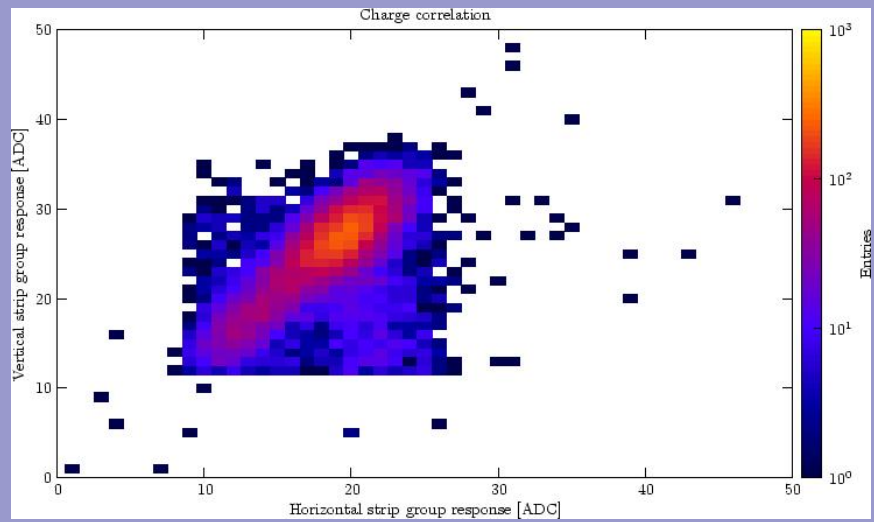
Final detector finalized:

Completed at the end of June.

Cylindrical GEM Lab Test







Lab performance as planar detector:

Gas gain

Charge sharing

Charge correlation

Energy resolution

Mechanical and electrical stability

GEM TPC gating

Ion feedback reduction:

Gas composition

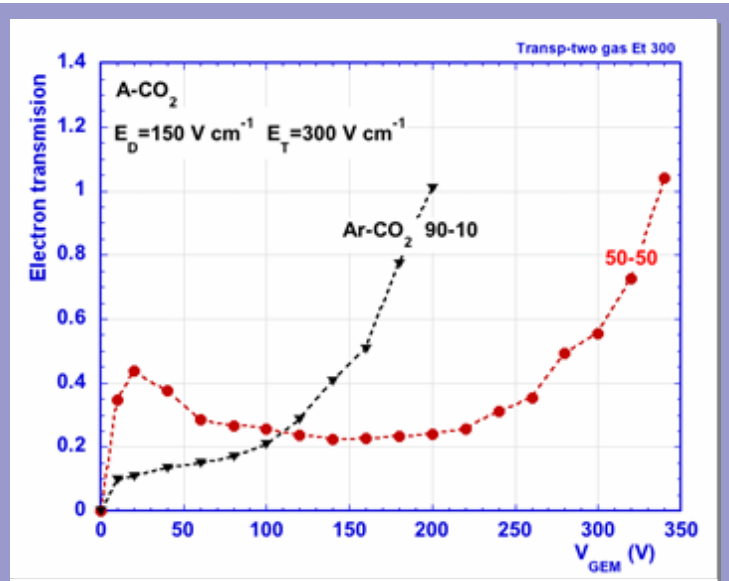
Spill structure

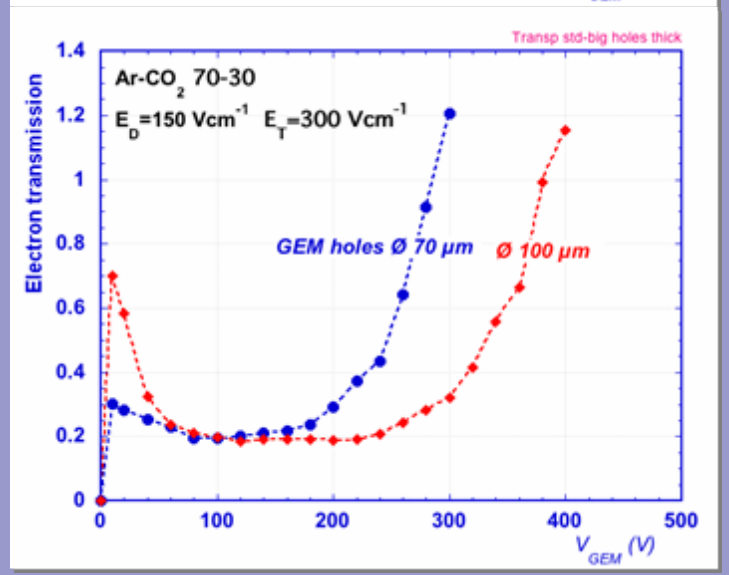
Geometry

New amplifier structures

Mesh gating

Low voltage Gem gating -->

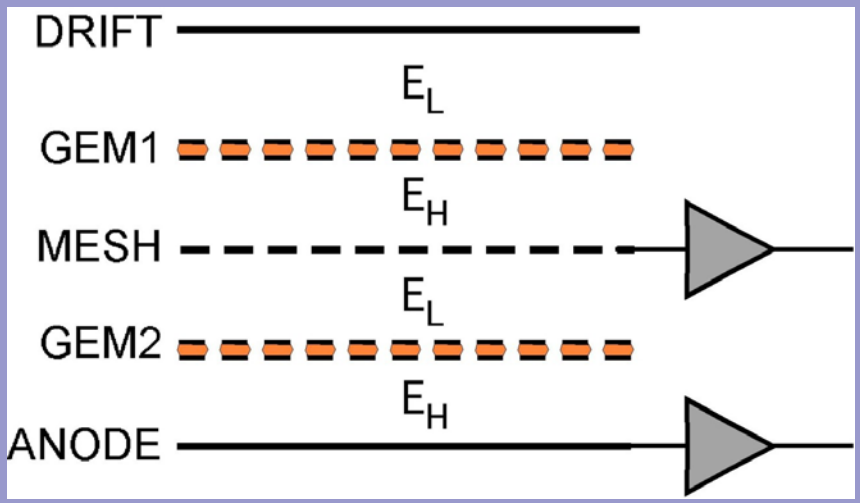


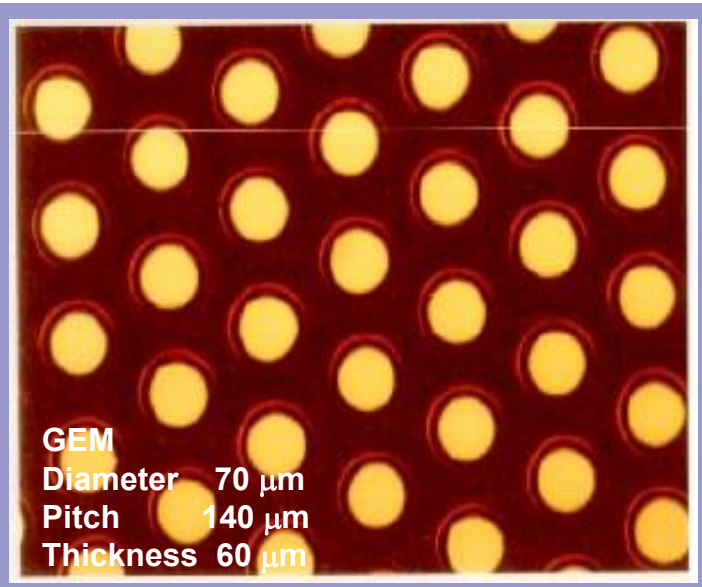


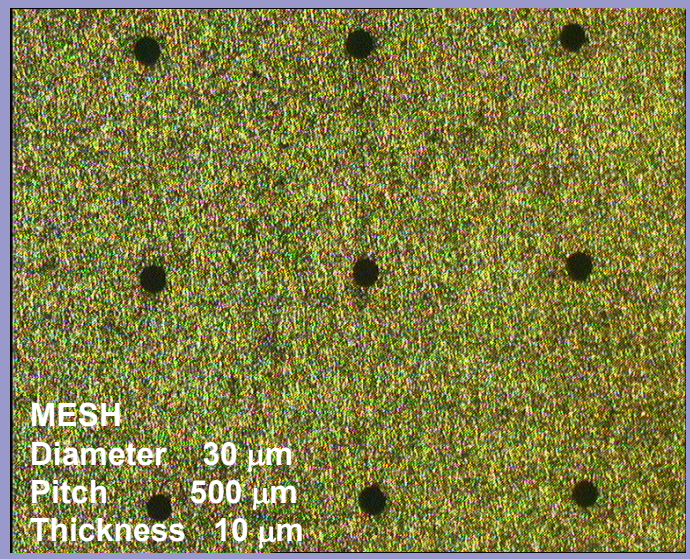
Low voltage GEM electron transmission

High energy photons detection

Detection and localization of high energy photons with high efficiency and good time resolution.



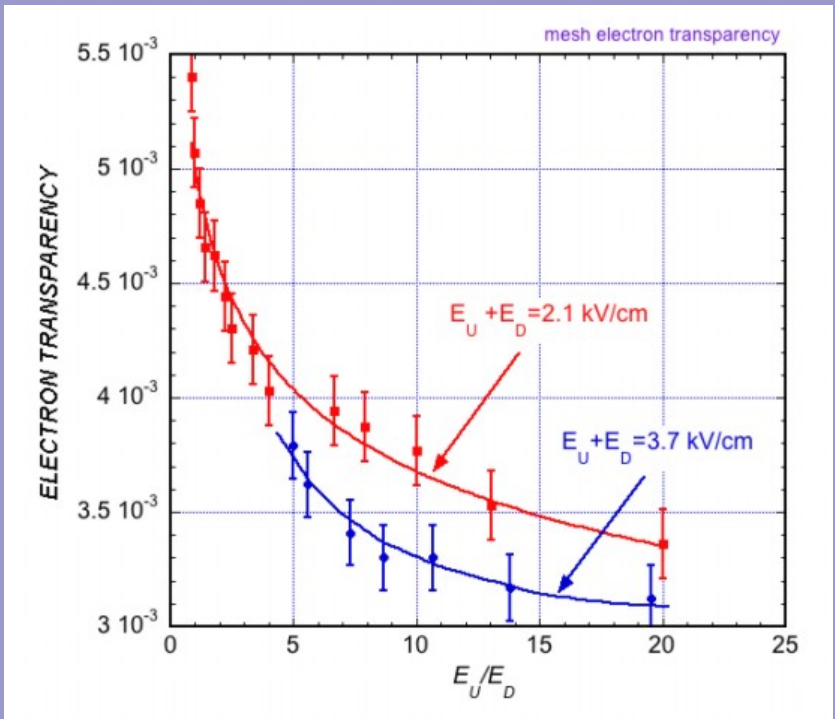


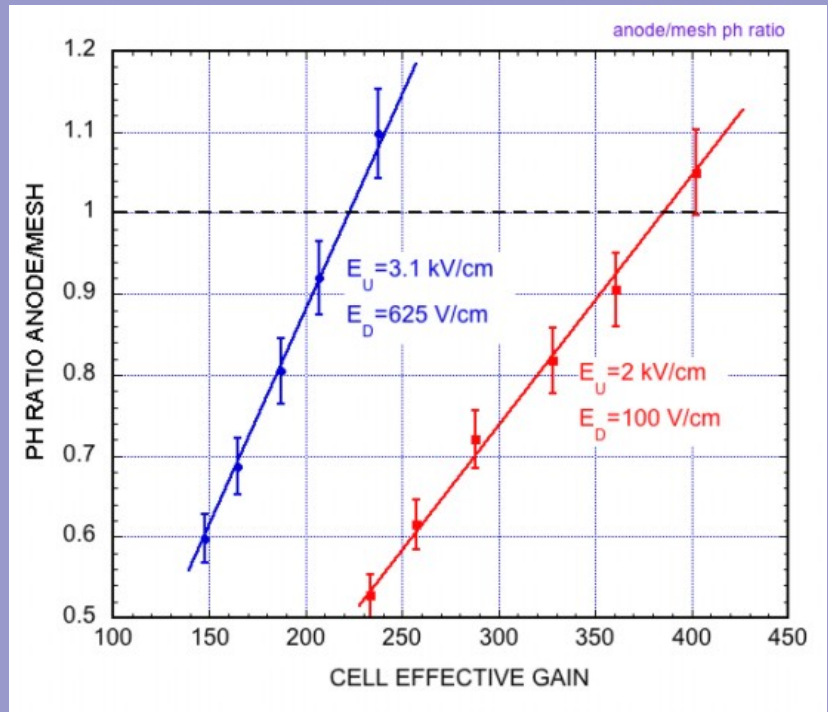


Many converters → efficiency
Signal from each mesh/converter → time
Patterned anode → localization

Condition → cell effective gas gain = 1

High energy photons detection



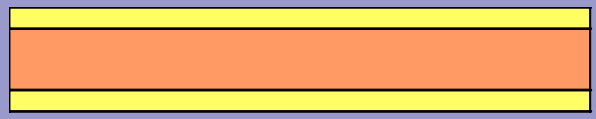


Mesh/converter electron transparency

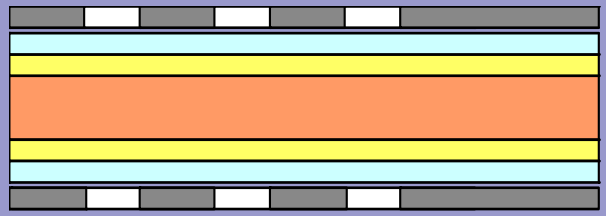
Cell effective gain

GEM Manufacturing

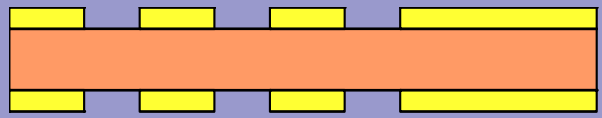
50 μm Kapton
5 μm Cu both sides



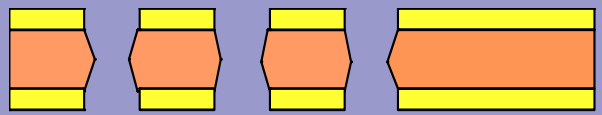
Photoresist coating,
masking and exposure
to UV light



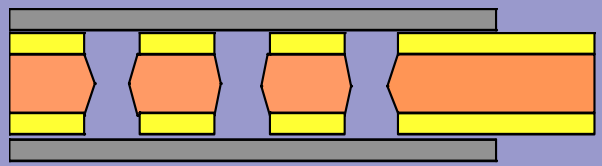
Metal etching



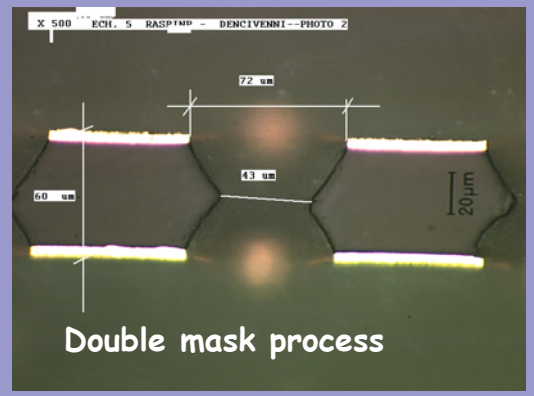
Kapton etching

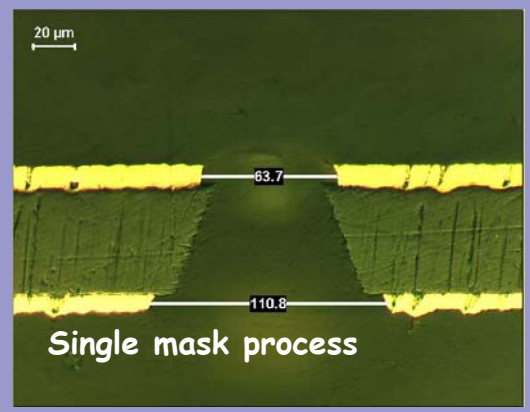


Second masking



Metal etching
and cleaning



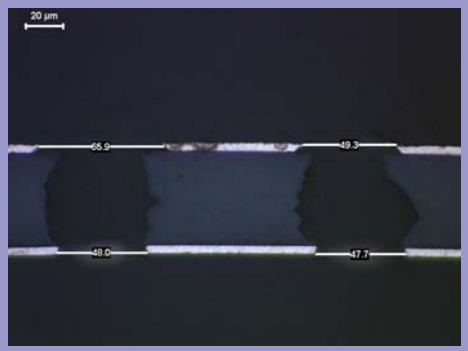


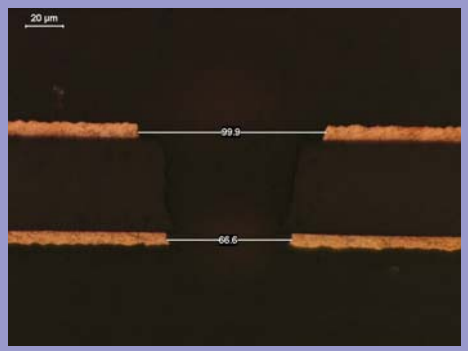
Tested for:

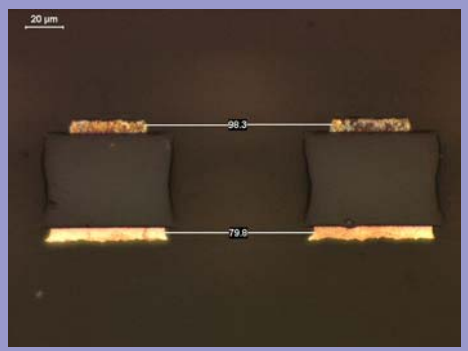
Gas gain
Charging up process (asymmetry)
Maximum gain in presence of HIPs

Large GEM foils

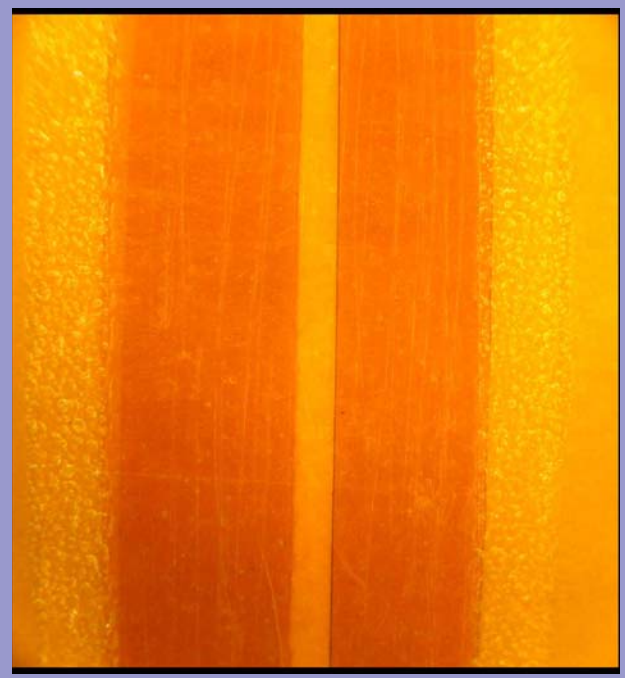
Single mask GEM foils







2 foils border

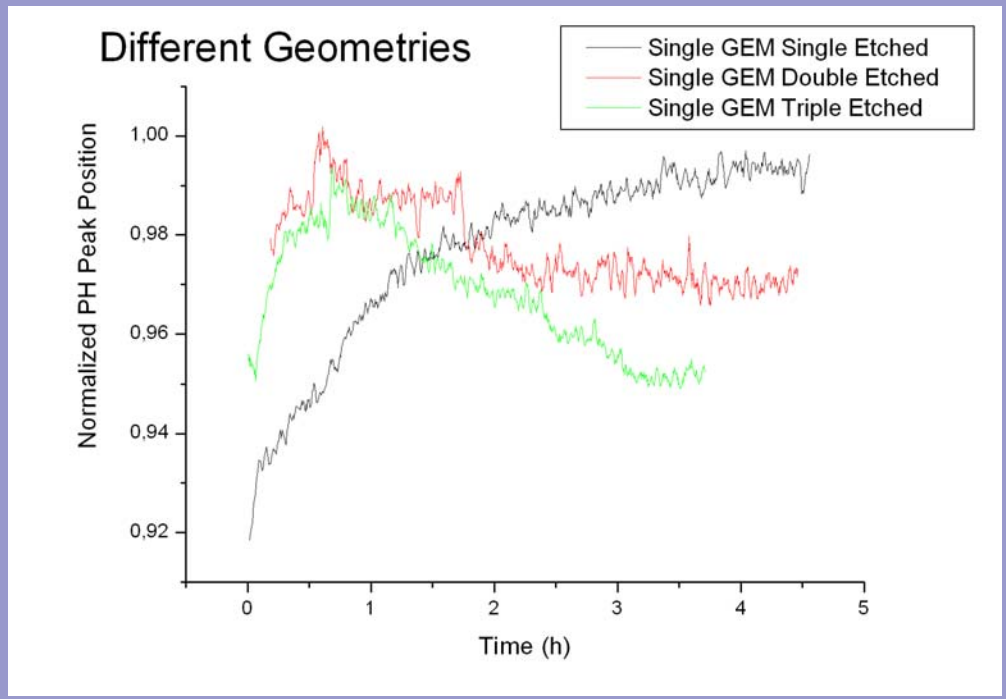


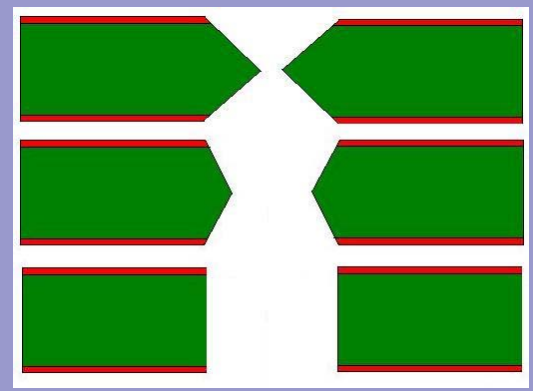
→ Rui de Oliveira
→ Serge Duarte Pinto

Stability studies

Charging up due to radiation
Kapton polarization under HV

→ E field/gain modification



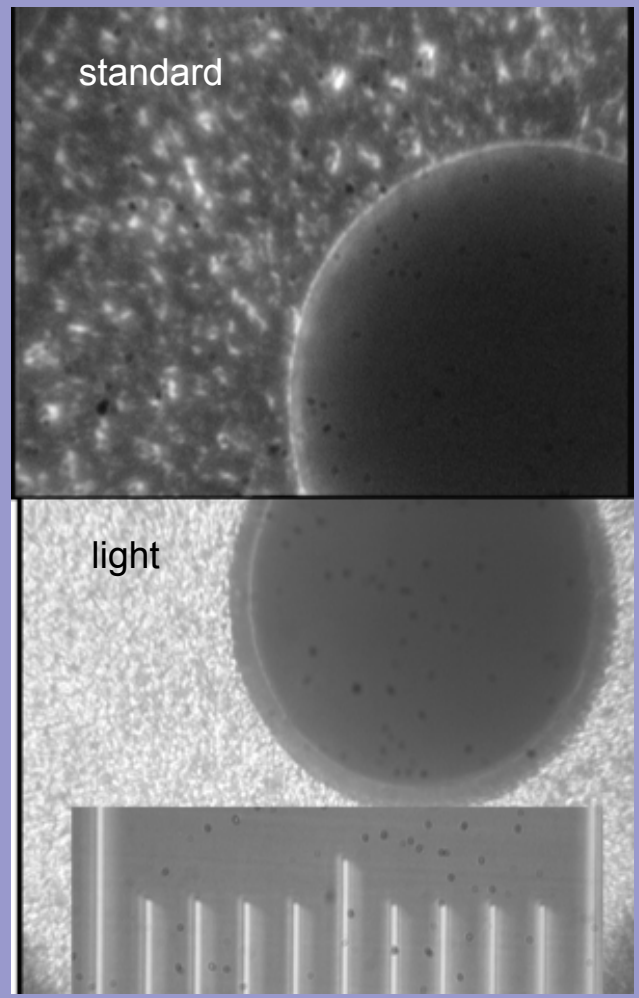


Type of Etching	Kapton Diameter	Copper Diameter
Single (standard)	50 µm	70 µm
Double	60 µm	70 µm
Triple	70 µm	70 µm

GEM Foil Material Budget Reduction

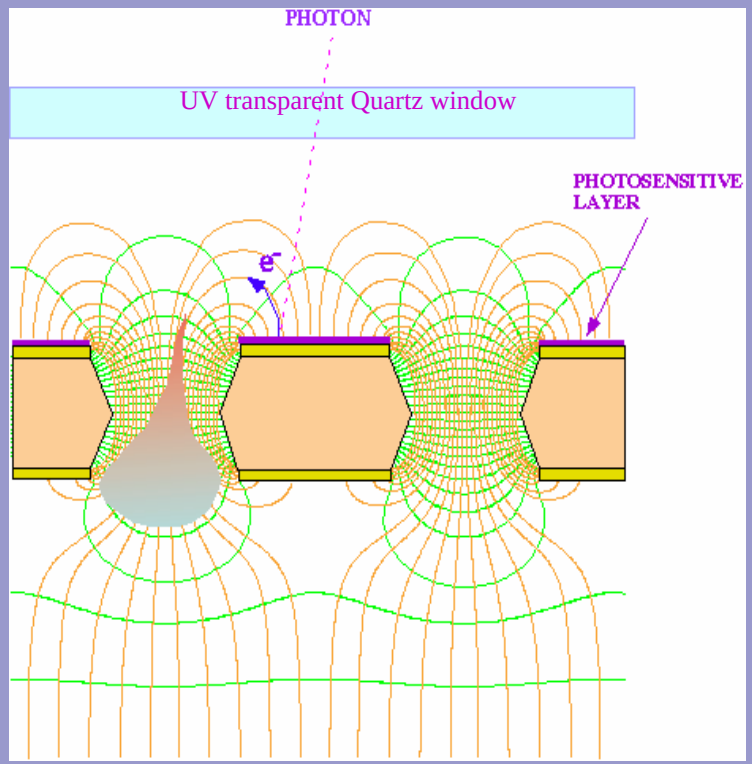
By reducing Cu layer thickness 5 μm —> 1 μm

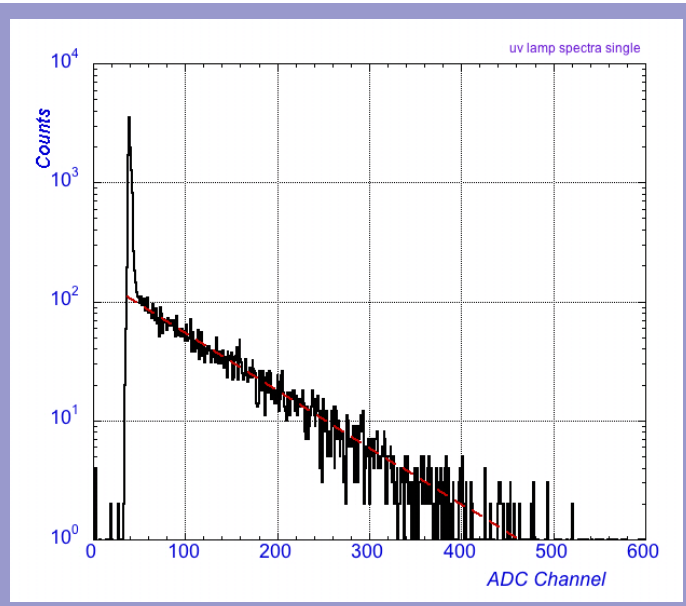
Detector element (material)	Rad. length [cm]	x/X0
Si 300 μm	9.4	$3.2\ 10^{-3}$
Cu 5 μm	1.44	$3.5\ 10^{-4}$
Kapton 50 μm	8.57	$1.8\ 10^{-4}$
Argon 1 cm	11762	$0.85\ 10^{-4}$
Triple **GEM standard**: 5 x Kapton 50 μm 7 x Cu **5 μm** Argon 7 mm		$3.4\ 10^{-3}$
Triple **GEM light**: 5 x Kapton 50 μm 7 x Cu **1 μm** Argon 7 mm		$1.5\ 10^{-3}$



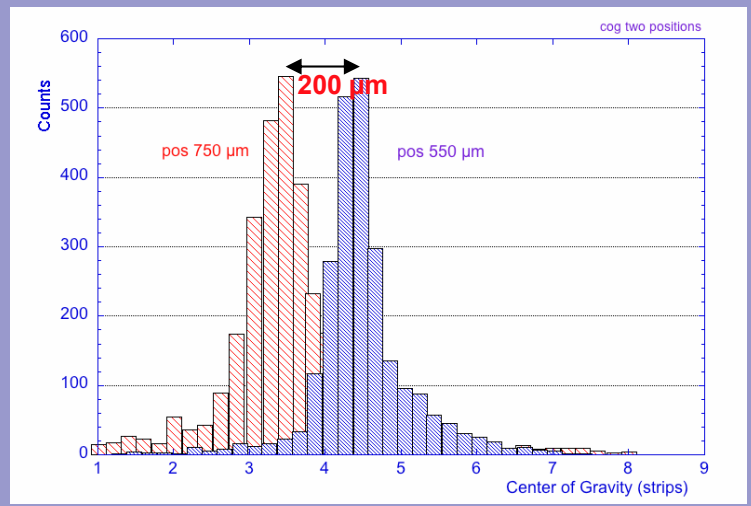
→ Lev Shekhtman

UV Light Detection (RICH)

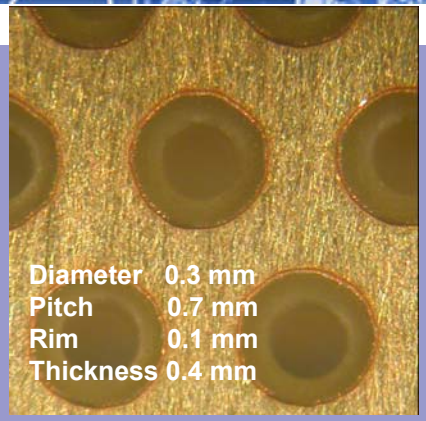


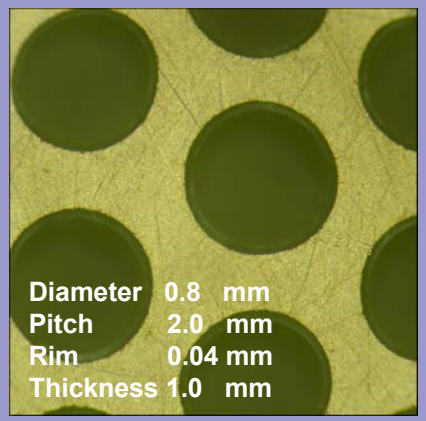


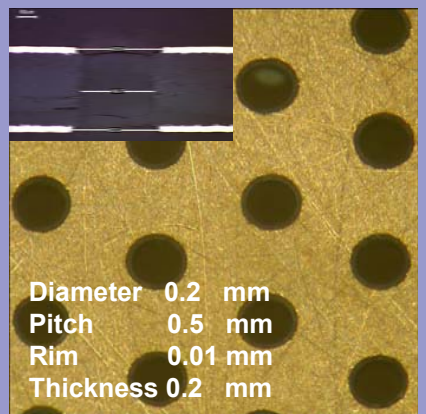
Single photoelectron p.h. spectrum

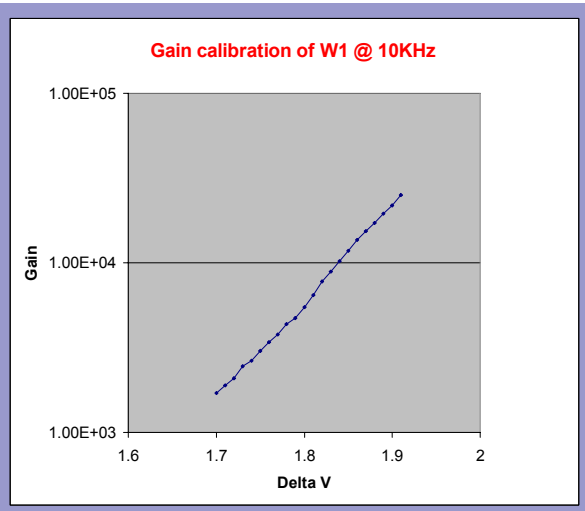


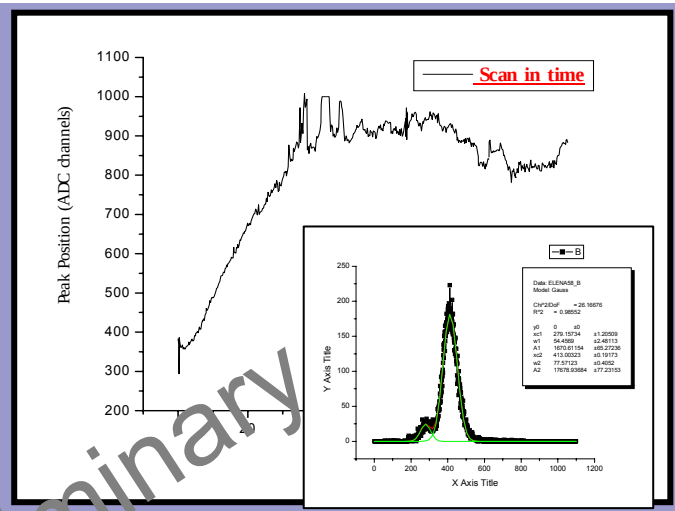
UV Light Detection for RICH with THGEM

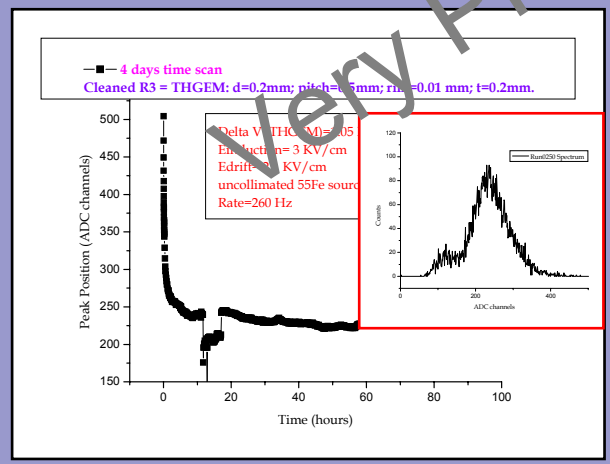


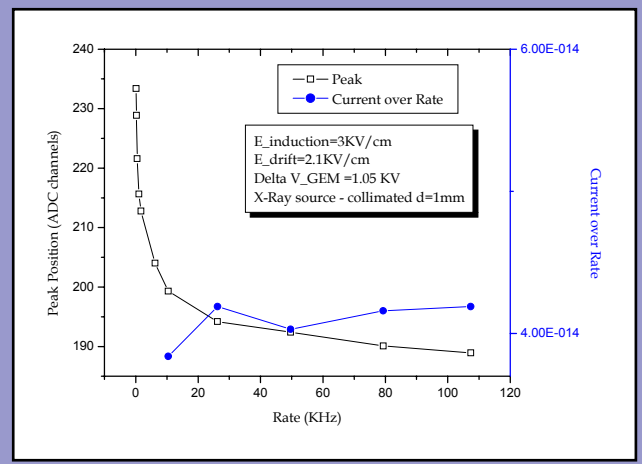




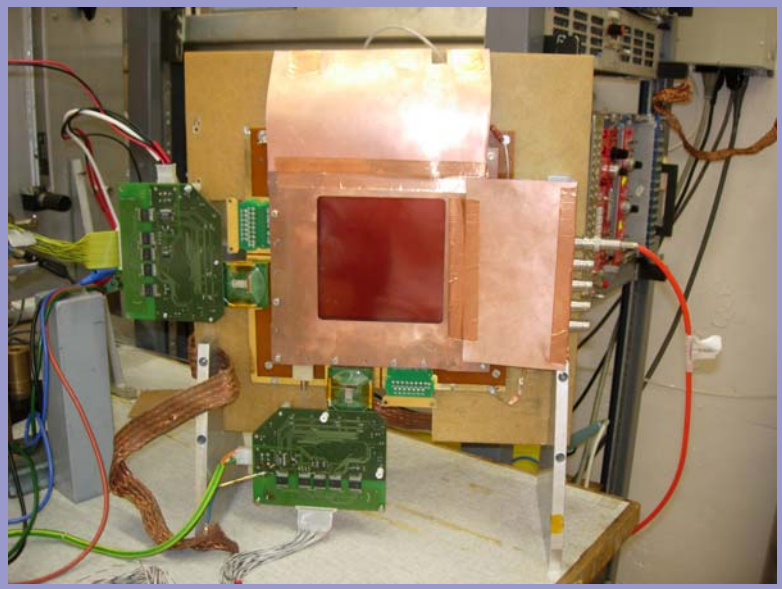


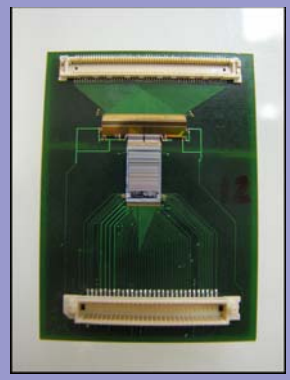


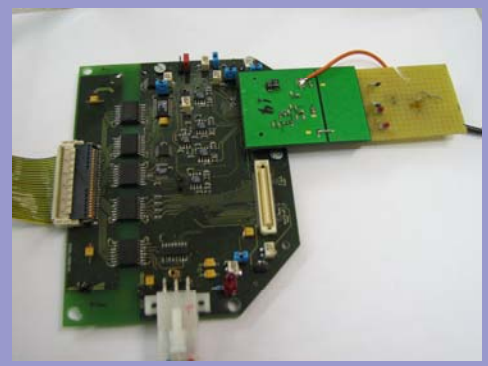


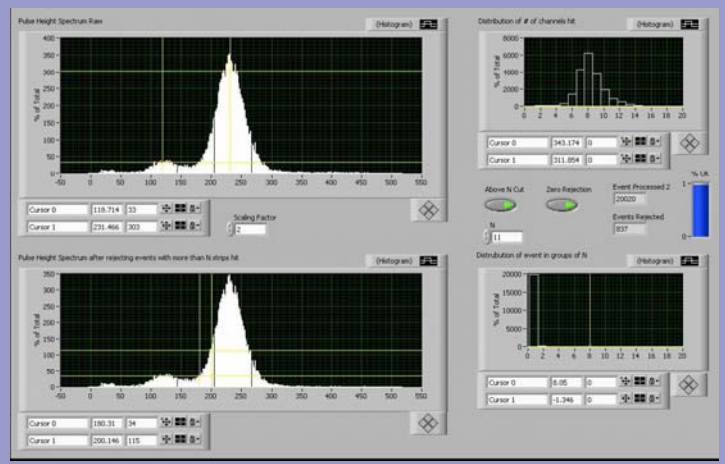


Electronics IDEAS GP5





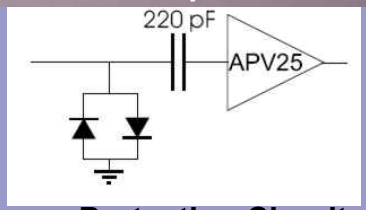




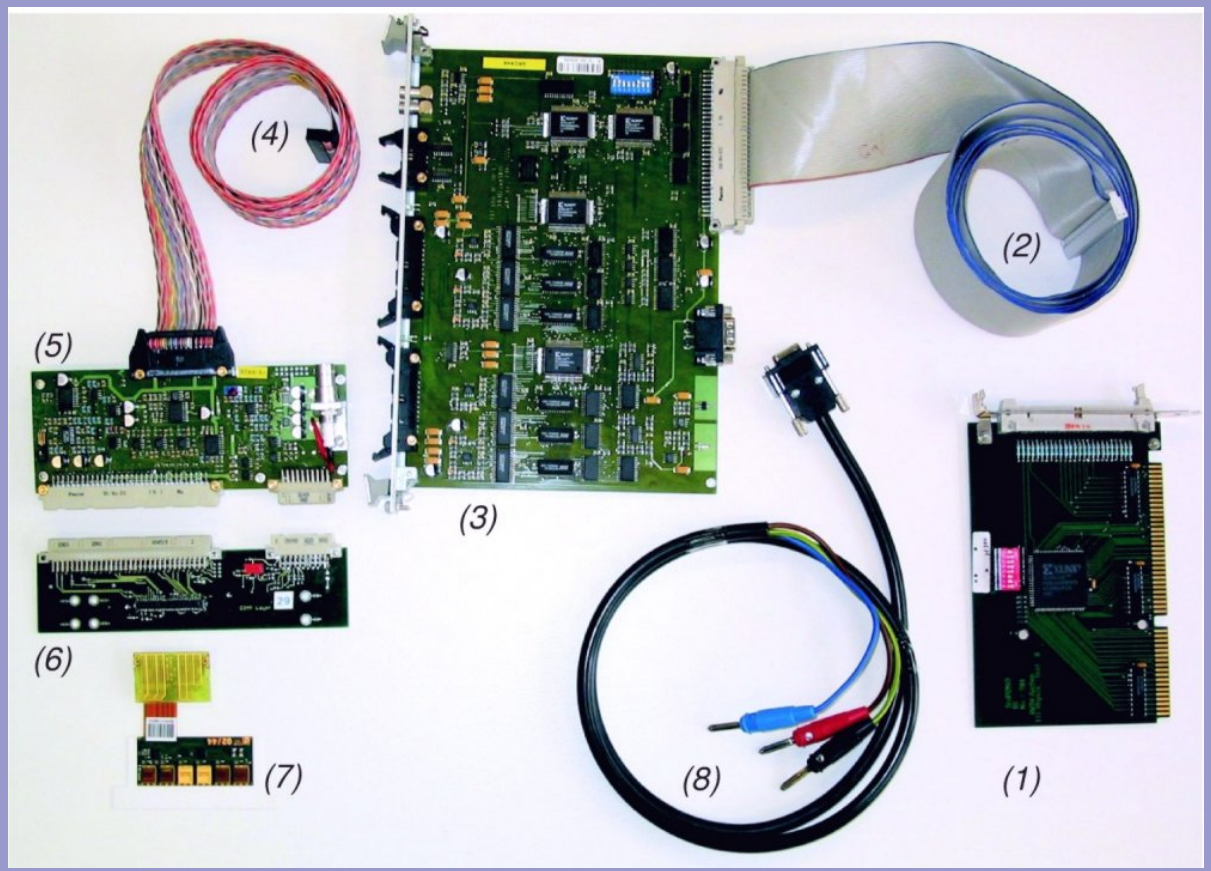
→ Nail Malakhov

APV with the ARC System

APV with protection



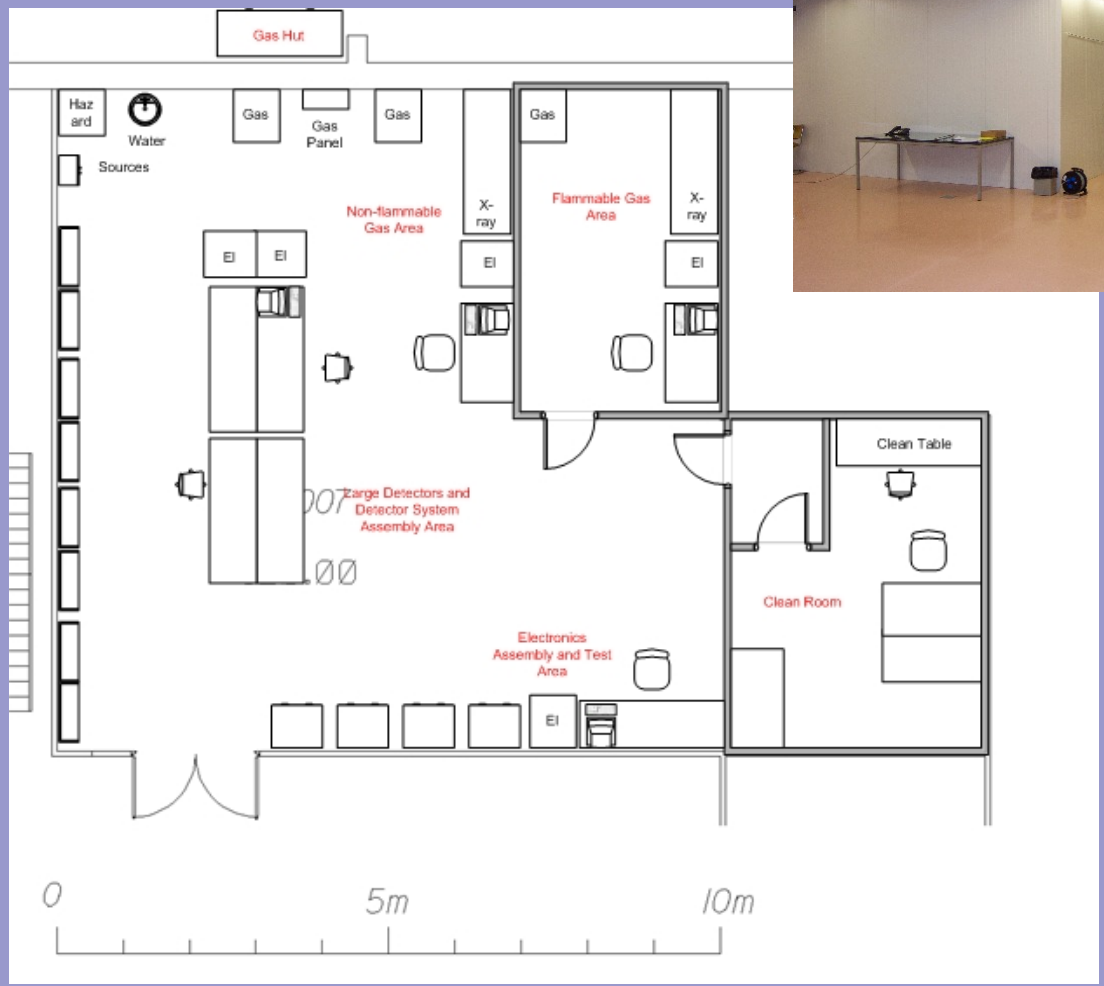
Protection Circuit



Photograph of a complete ARC setup: (1) PCMIO Interface, to be plugged into an ISA slot of the PC motherboard, (2) 50 pin flat cable, (3) ARC board, (4) 26 pin twisted pair flat cable, (5) ARC front-end adapter, (6) Hybrid-to-VUTRI adapter card, (7) front-end hybrid, (8) power supply cable for the ARC board.

1-2 128 channels APV hybrids

New Gas Detector Development Lab



Systems:
Gas System
Irradiation (X-Rays Tubes) Systems
Electrical System
Air Circulation System
Water Cooling System
Computer network

Test Areas:
Flammable Gas Test Area
Non-flammable Gas Test Area
Large Detectors and Detector Systems Assembly and Test Area
Electronics Assembly and Test Area

Support Areas:
Clean Room
Mechanical Workshop
Hazardous Chemical Materials and Radioactive Sources Storage Area
Storage (mechanical, electronics, detector components, detectors)

GEM Detectors at CERN

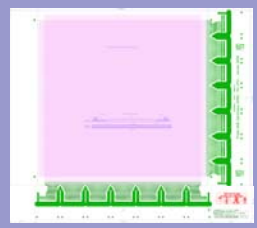
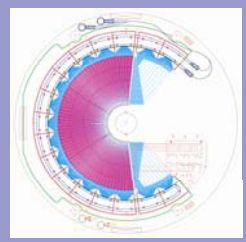
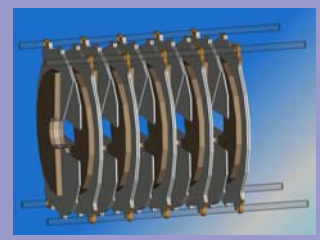
CERN is involved in all aspects of GEM detectors design, production and applications.

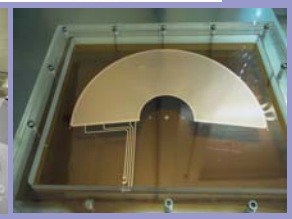
Detector Design

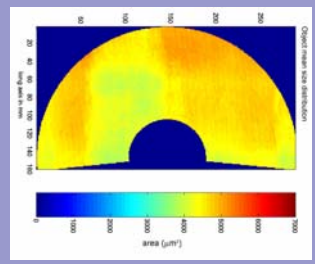
Component Production

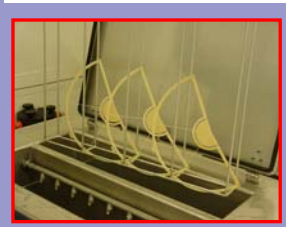
Component Quality Control

Detector Assembly





GEM Detectors at CERN

Detector Test

Readout Electronics

Detector Simulations

Technology Dissemination