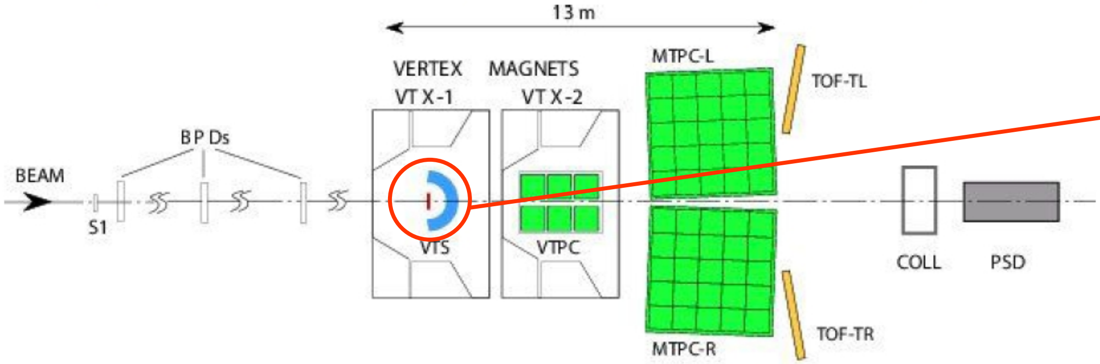
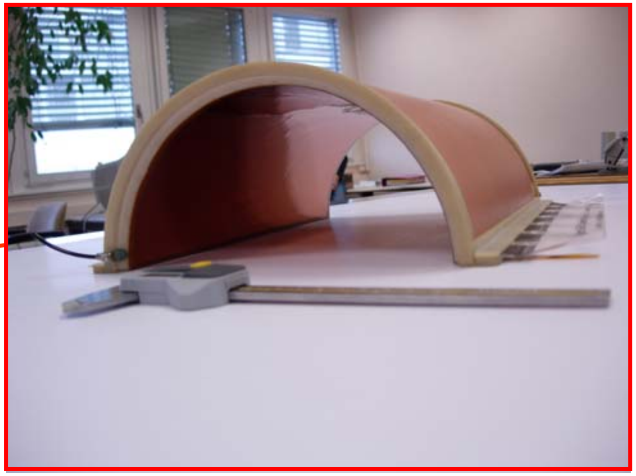
Cylindrical GEM for NA49-Future

Leszek Ropelewski
CERN PH-DT2-ST

A possible "critical" experiment at the CERN SPS



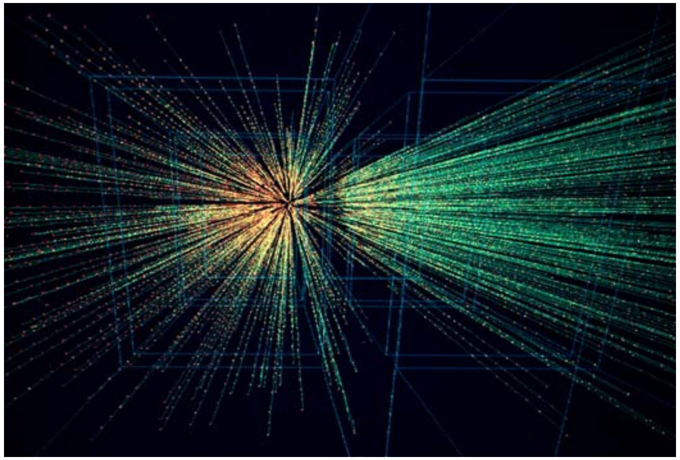


-a precise determination of an event centrality (**PSD**)

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

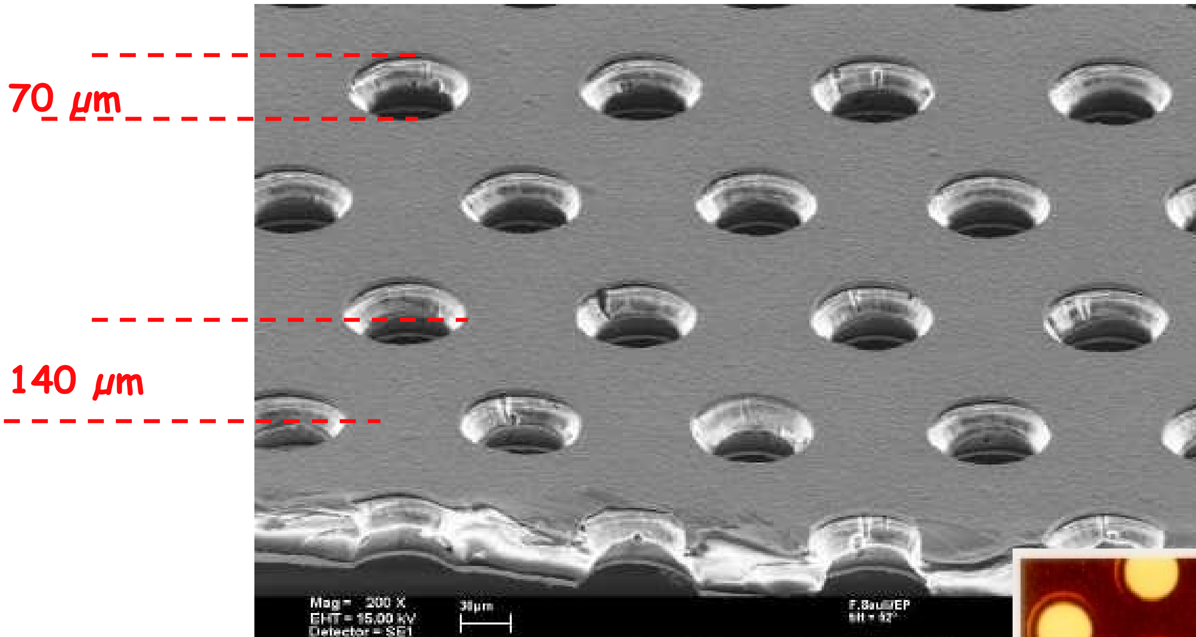
-a high event rate (**DAQ**)

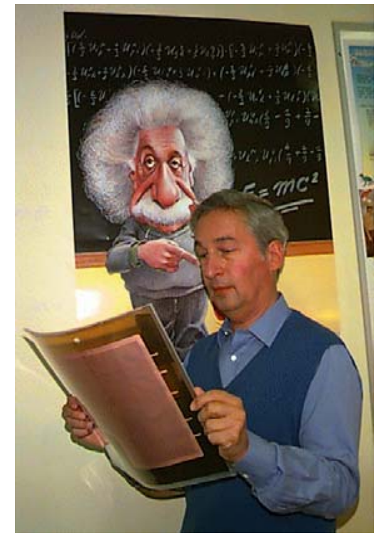
-high precision measurements of inclusive spectra
of identified hadrons (**TPCs+TOF**)



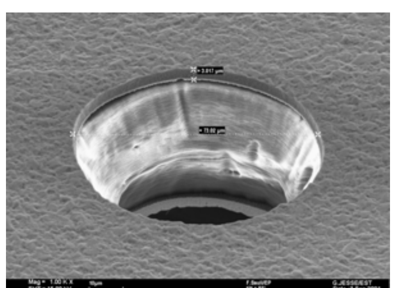
GEM: Gas Electron Multiplier

Thin metal-coated polymer foil pierced by a high density of holes (50-100/mm^2)
Typical geometry: 5 μm Cu on 50 μm Kapton, 70 μm holes at 140 μm pitch

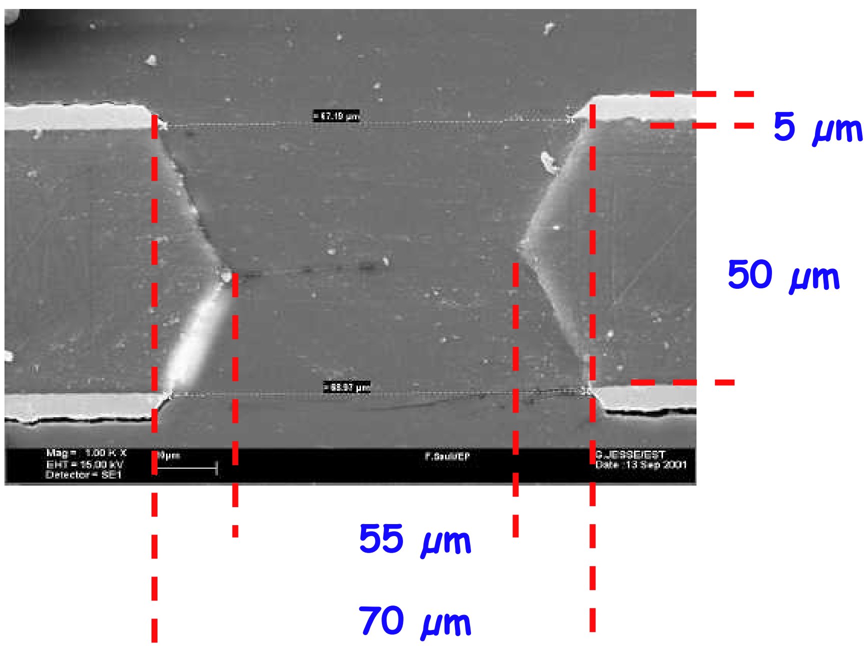




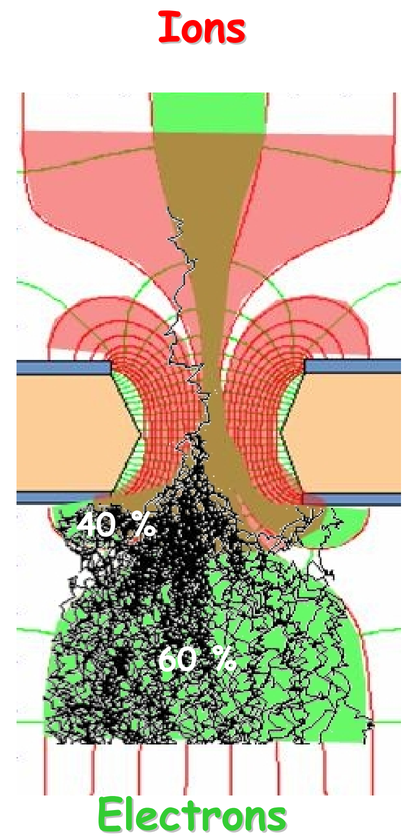
F. Sauli, Nucl. Instrum. Methods A386(1997)531



GEM Principle

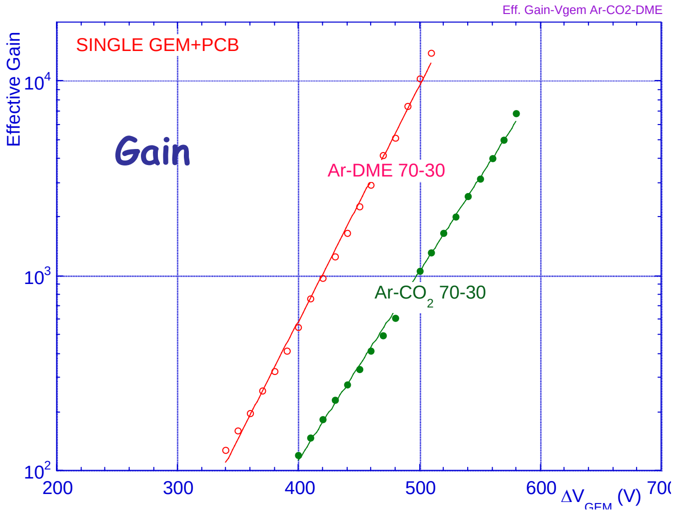


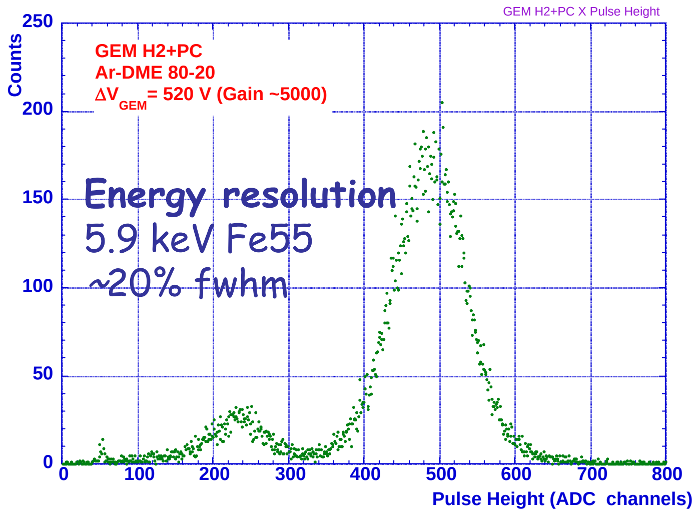
GEM hole cross section



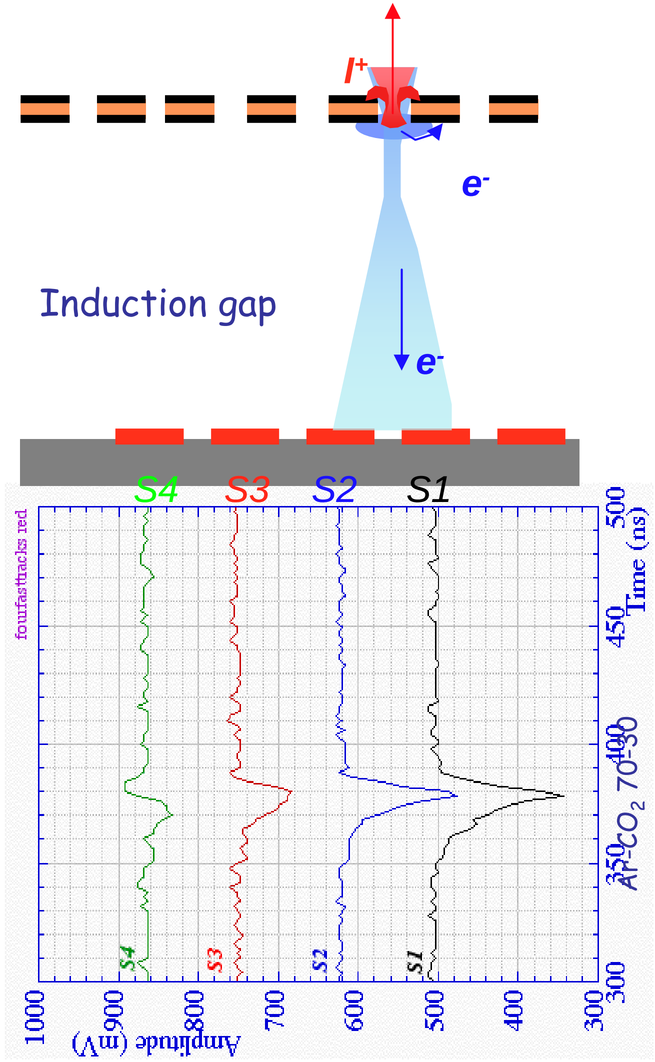
Avalanche simulation

Single GEM Performances





R. Bouclier et al NIM A 396 (1997) 50



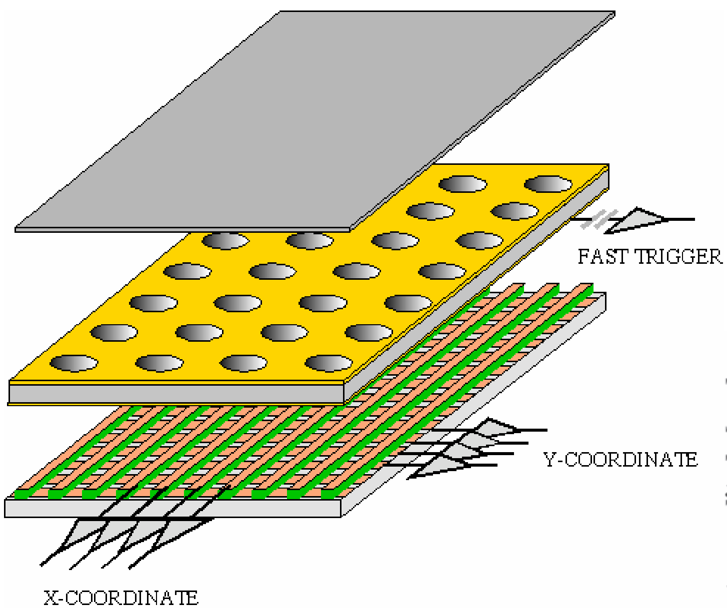
Very good multi-track resolution
Requires high density of readout channels

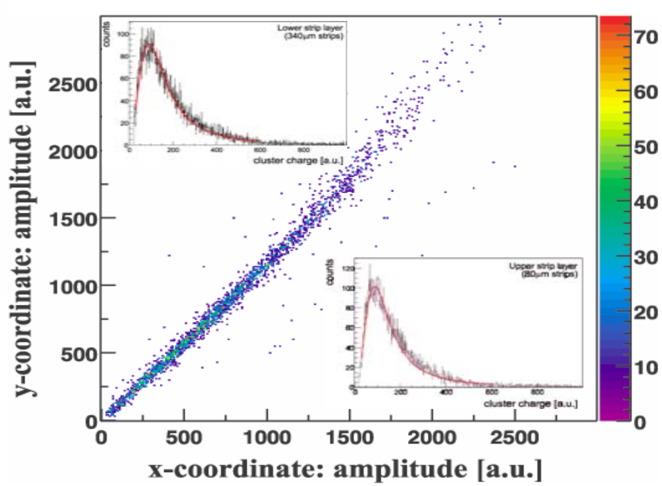
Signal Readout

Electrons are collected on patterned readout boards.
A fast signal can be detected on the lower GEM electrode for triggering or energy discrimination.
All readout electrodes are at ground potential.

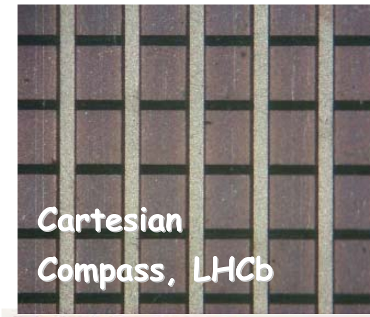
Full decoupling of the charge amplification structure from the charge collection and readout structure.

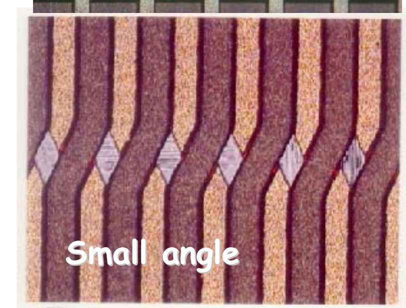
Both structures can be optimized independently !





Charge correlation (Cartesian readout)

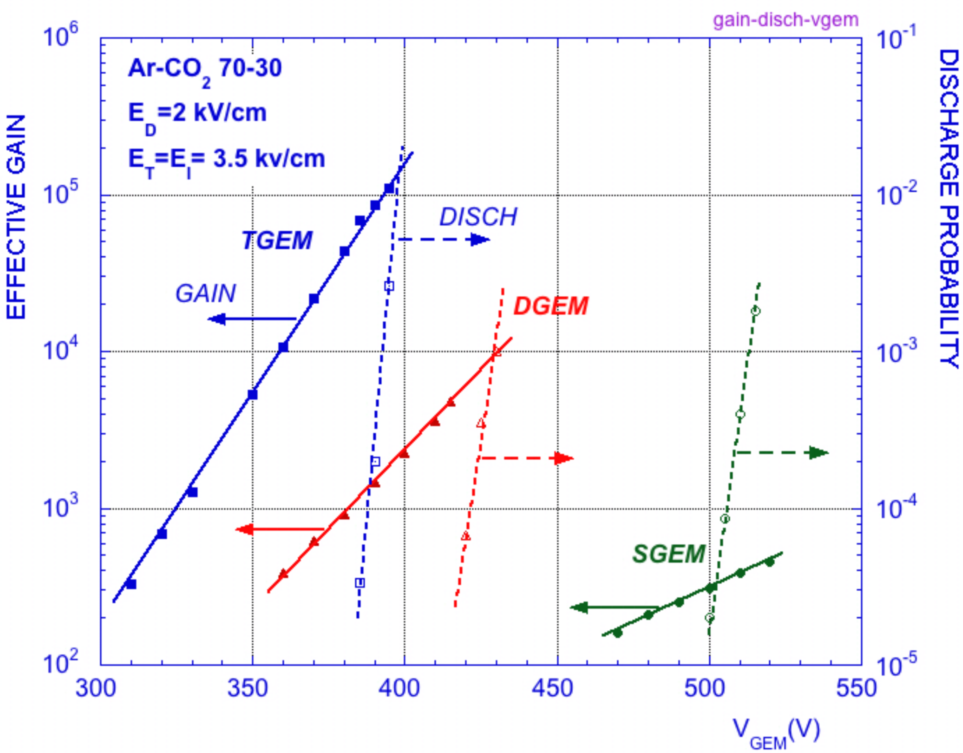




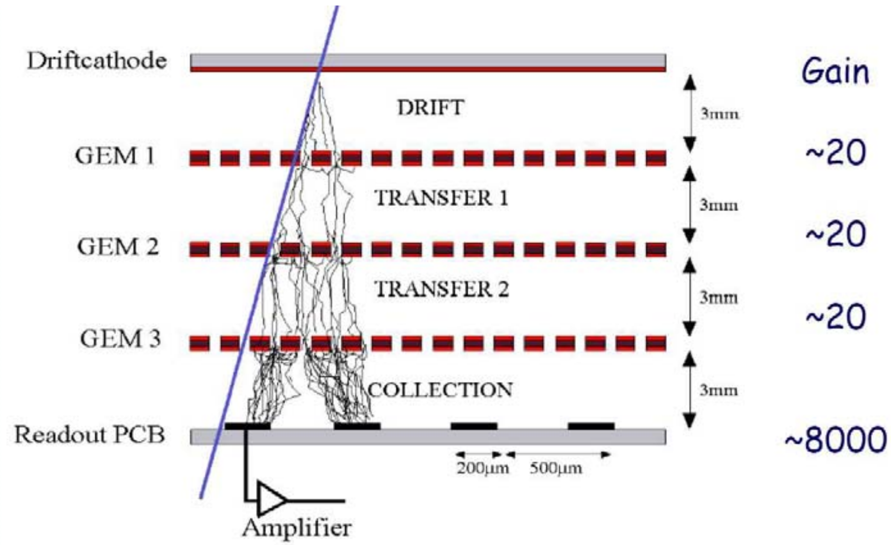
Multi-GEM Detectors

Discharge Probability on Exposure to 5 MeV Alphas

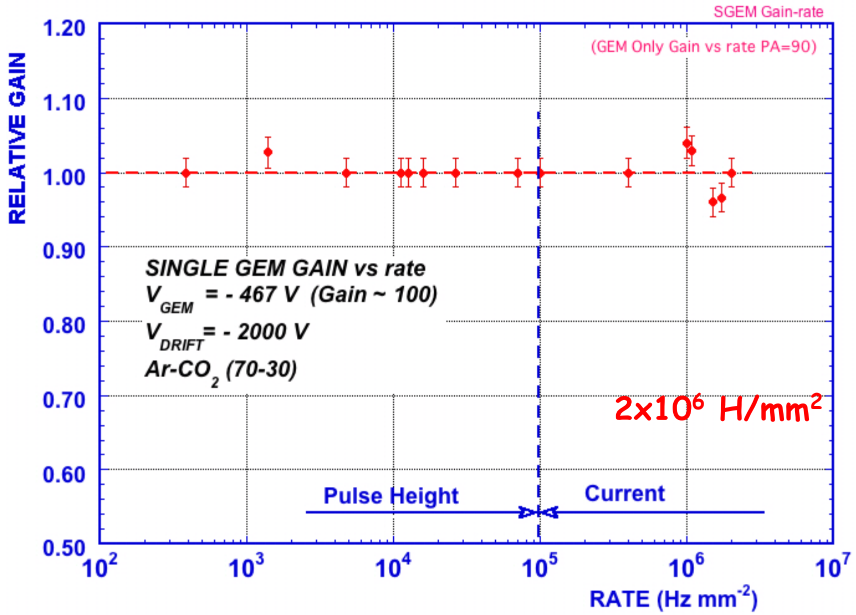
Multiple structures provide equal gain at lower voltage.
Discharge probability on exposure to α particles is strongly reduced.



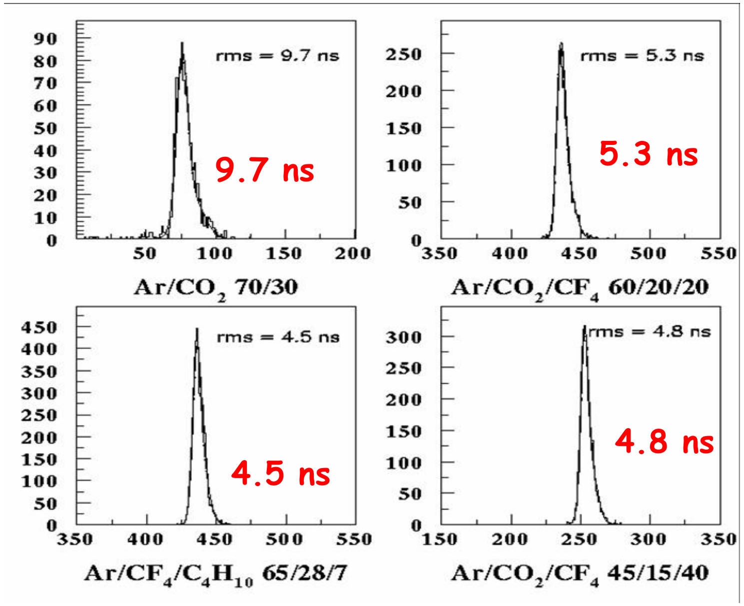
S. Bachmann et al Nucl. Instr. and Meth. A479(2002)294



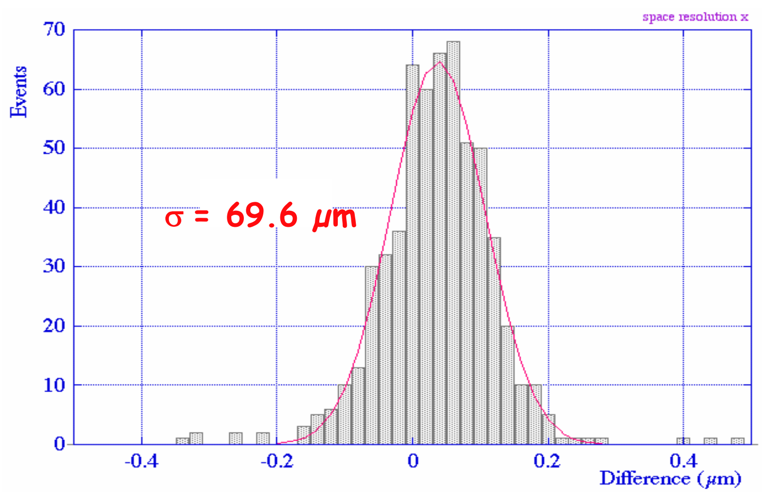
GEM – Gas Electron Multiplier



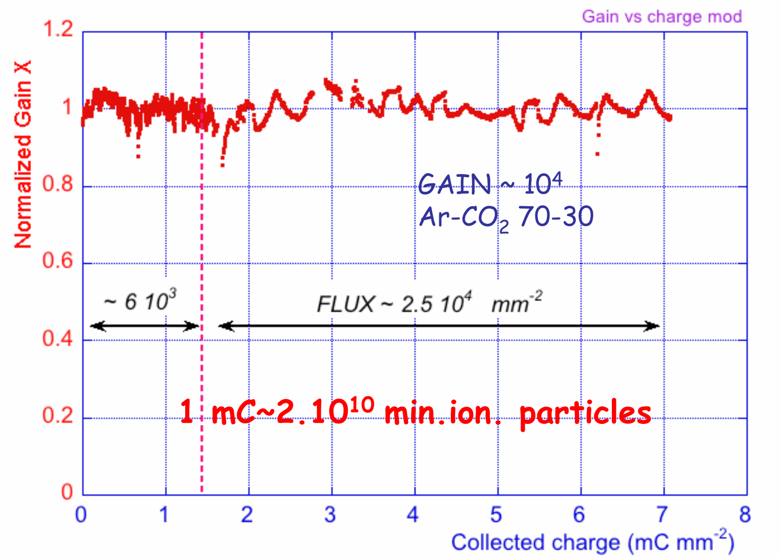
Rate capability



Time resolution

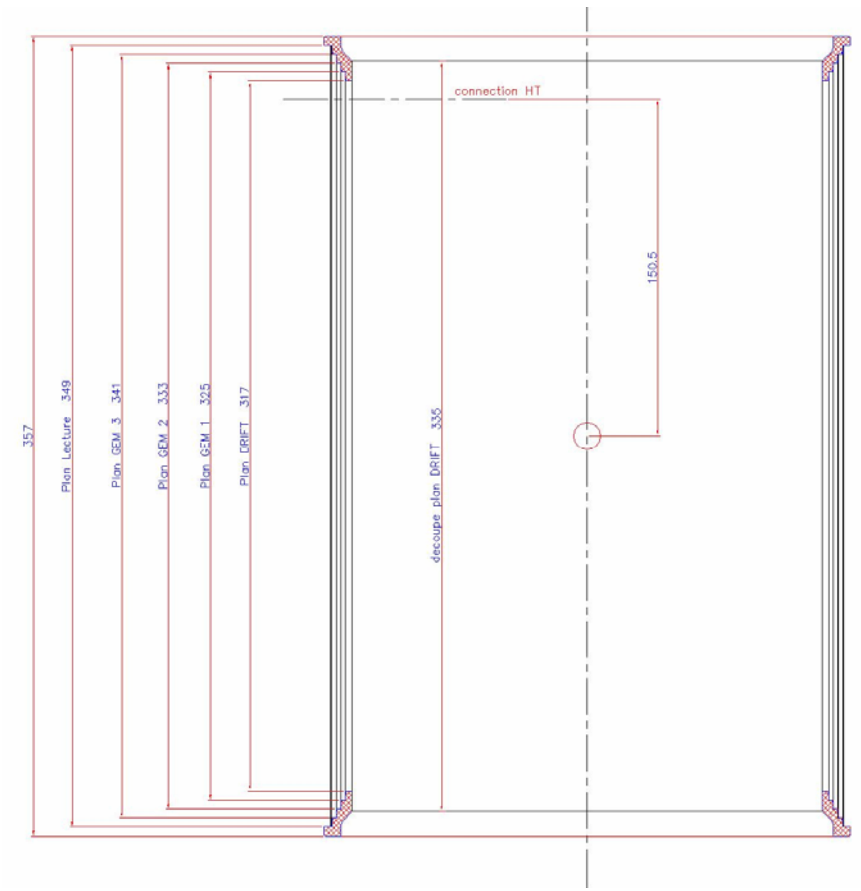


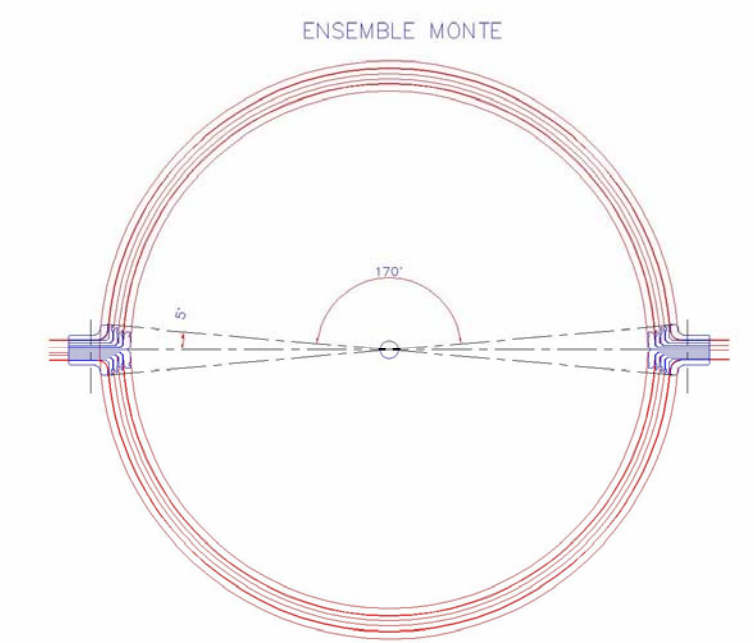
Space resolution

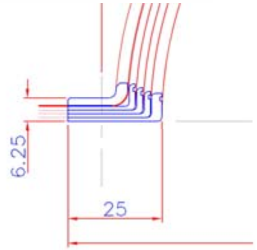


Ageing properties

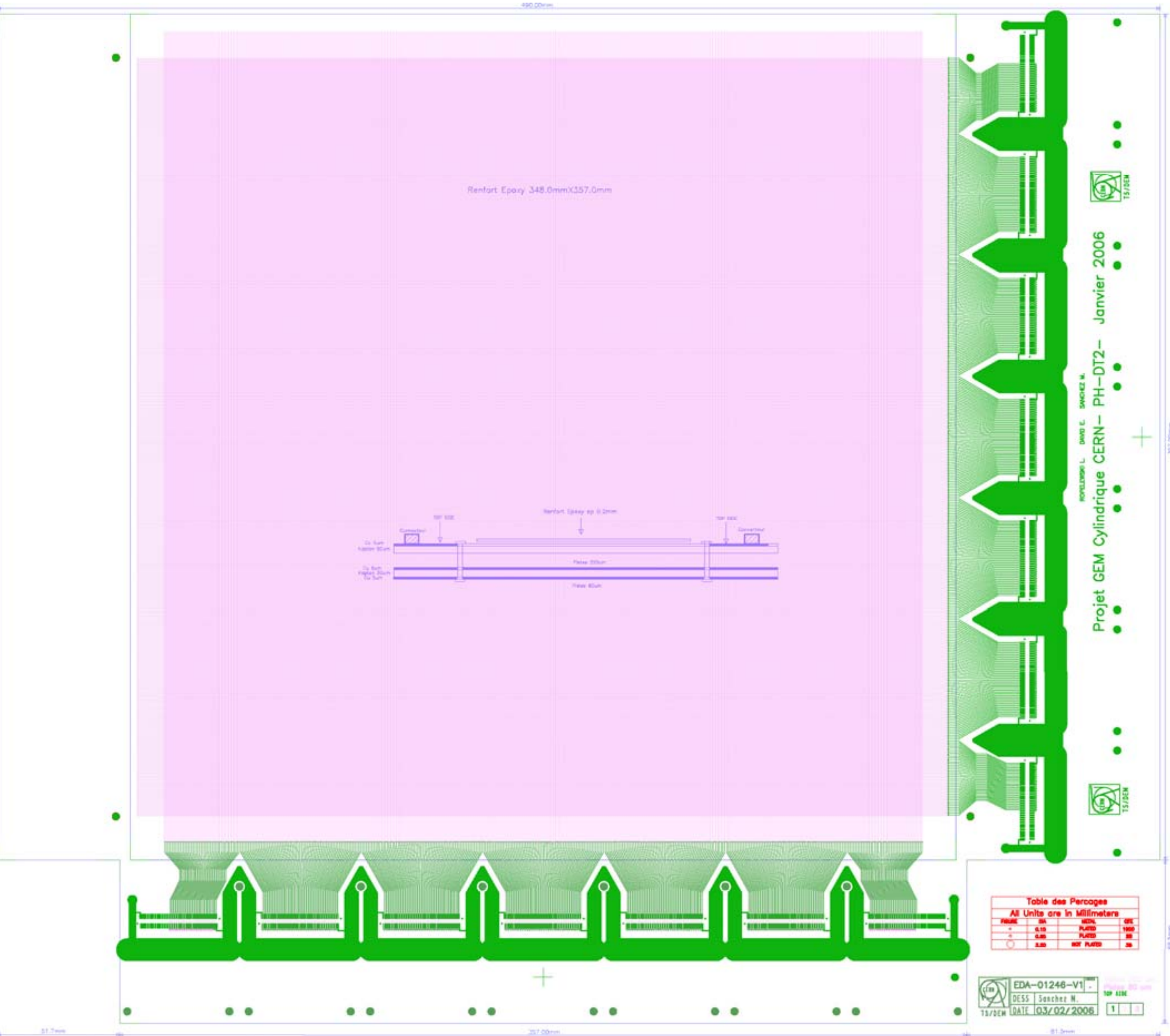
Cylindrical GEM Design

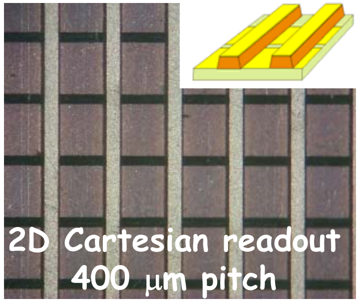


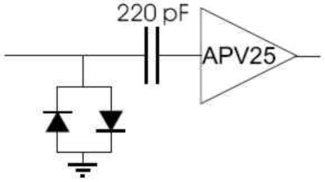




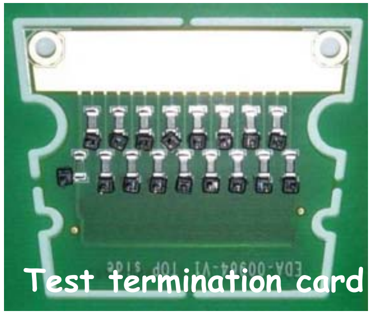
Cylindrical GEM Readout Board Design



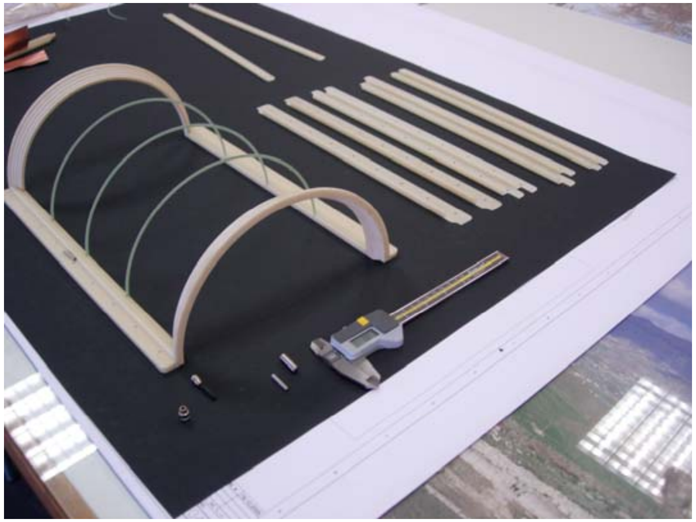
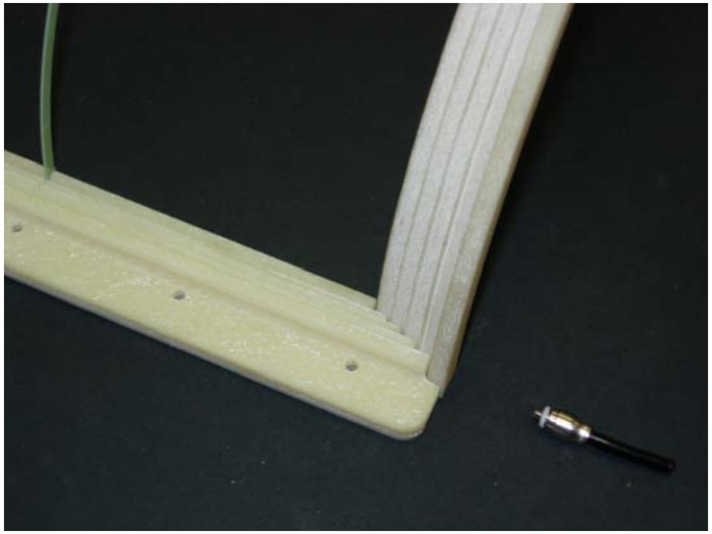
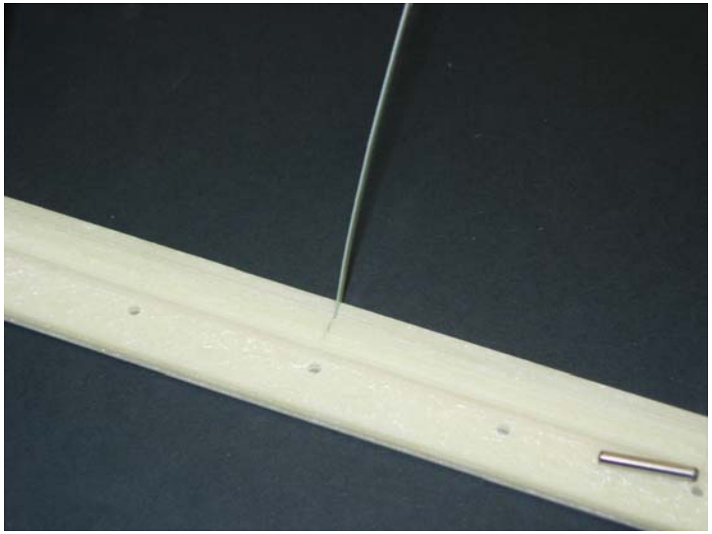




Protection Circuit

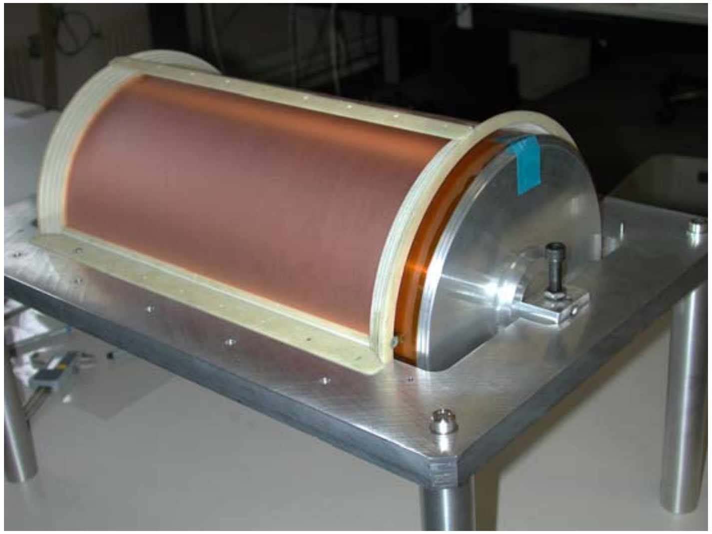


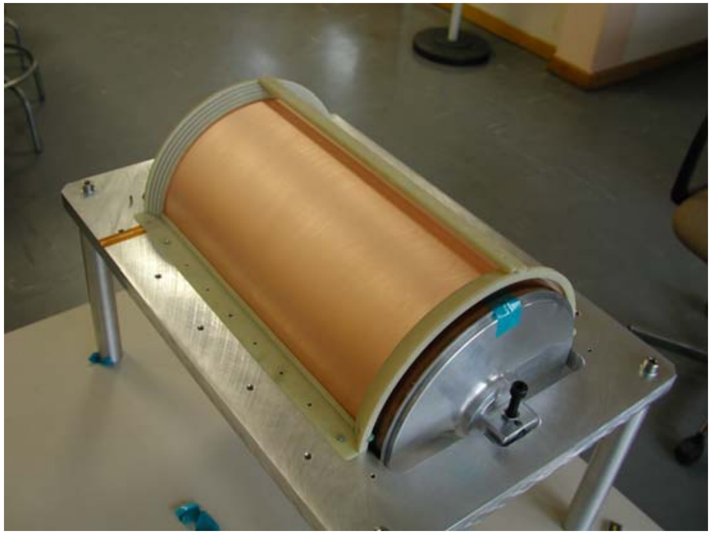
Cylindrical GEM Mechanical Parts and Tools

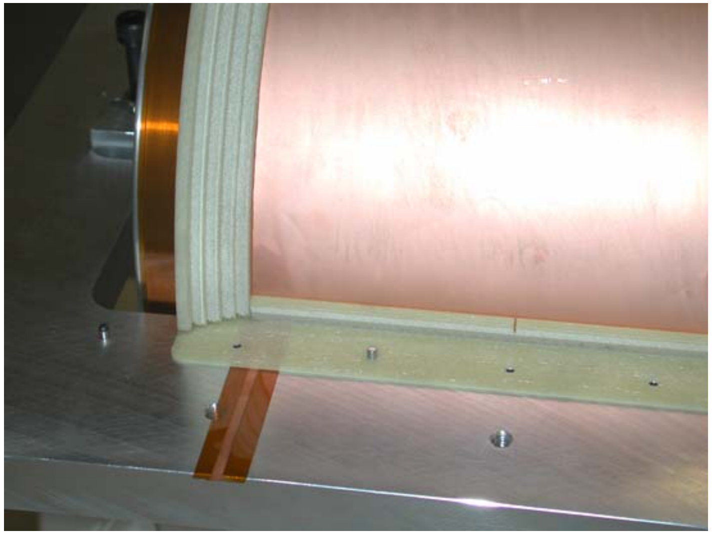




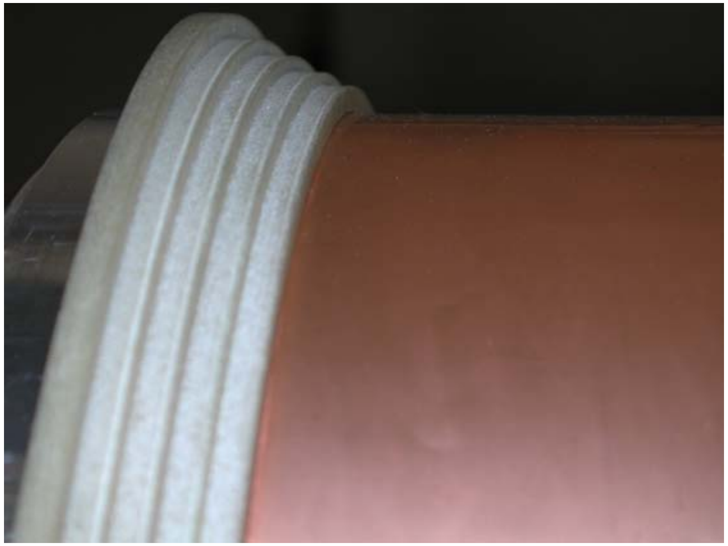

Cylindrical GEM Assembly 1

Drift Electrode



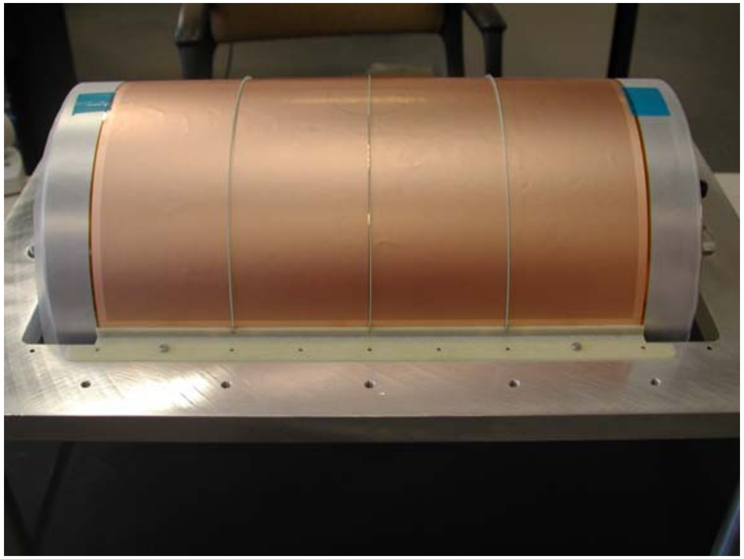


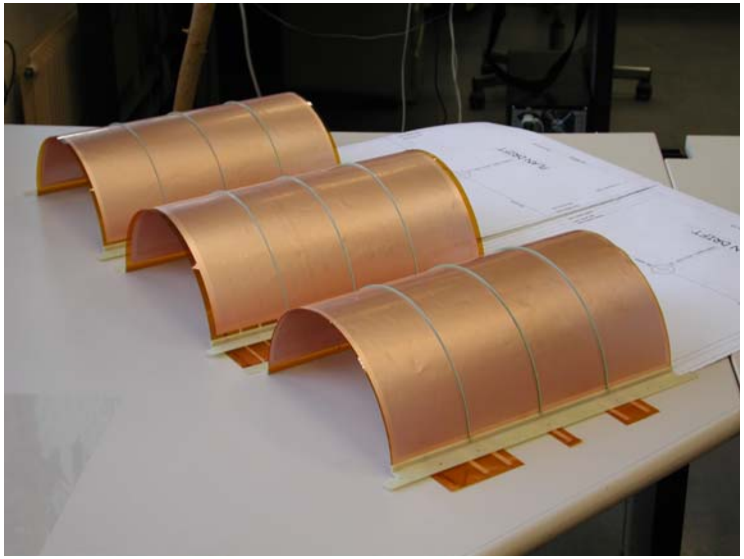


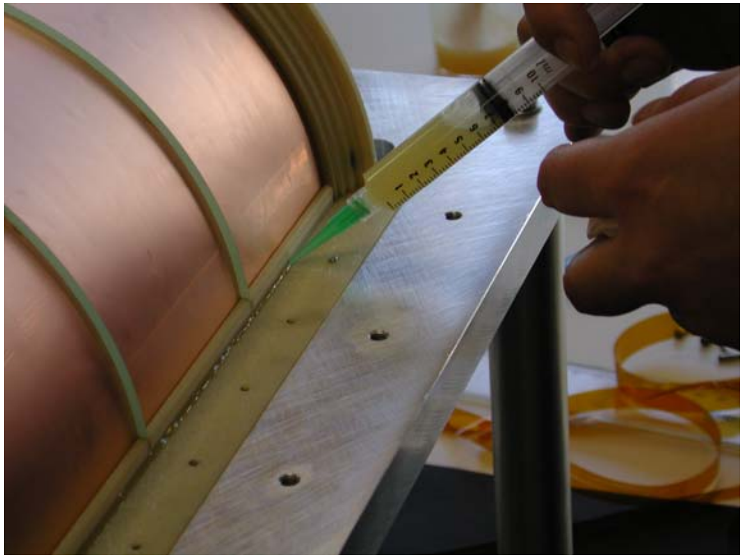


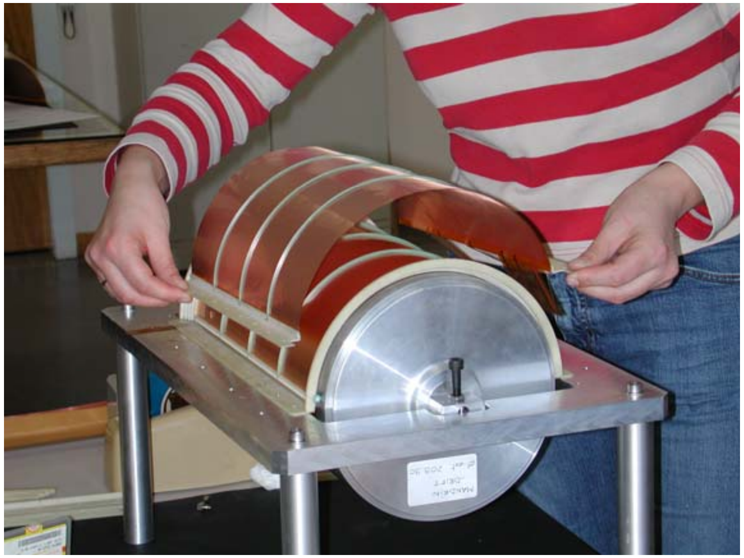
Cylindrical GEM Assembly 2

GEM foils

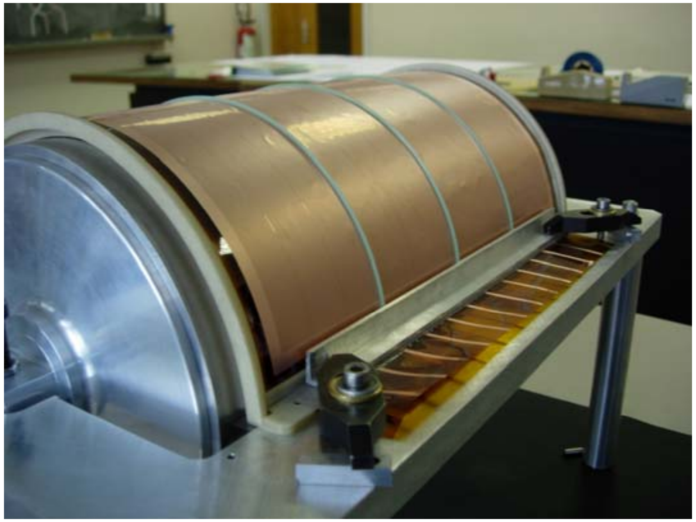


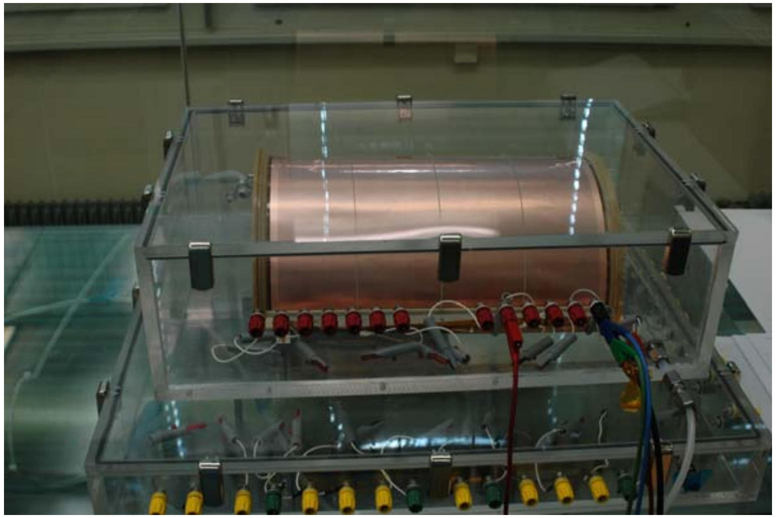


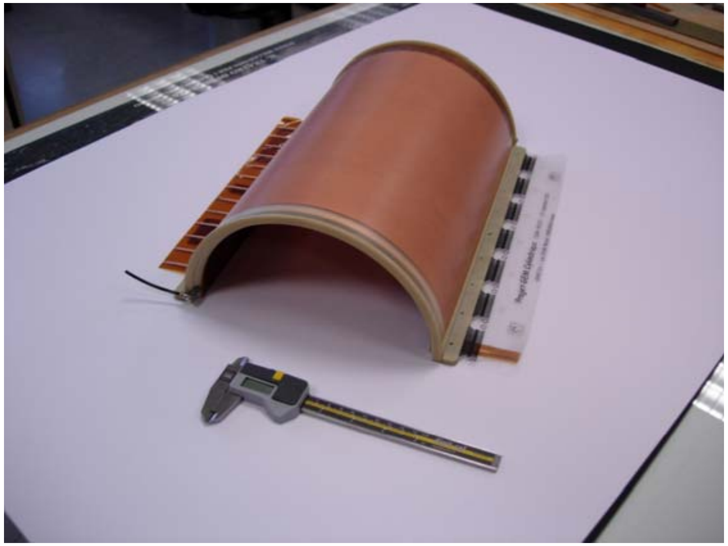




Cylindrical GEM Assembly 3







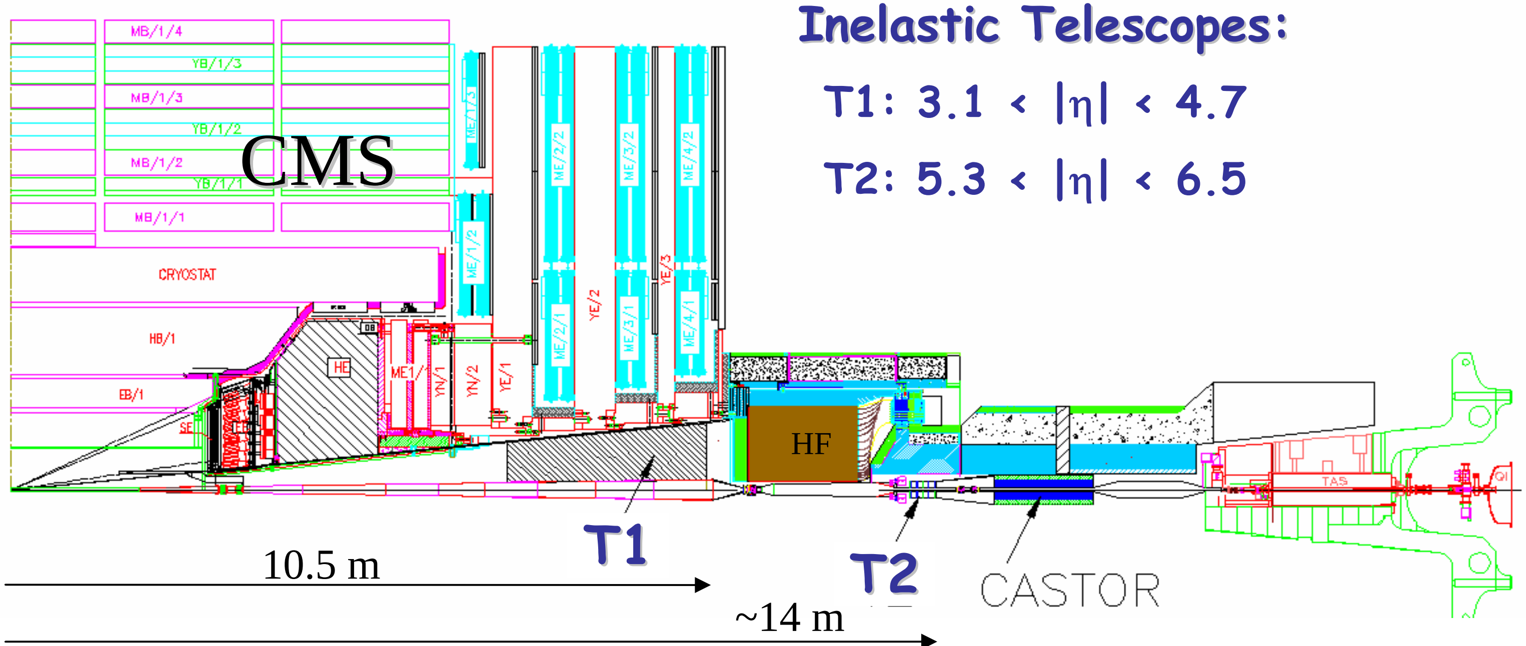
Mechanical Prototype was tested for:

Mechanical stability
Gas tightness

Final detector is being finalized:

Completed at the end of June.

TOTEM Inelastic Telescopes

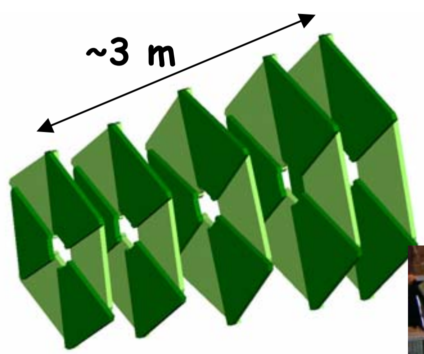


Inelastic Telescopes:

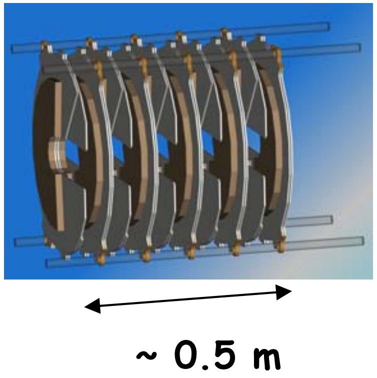
T1: $3.1 < |\eta| < 4.7$

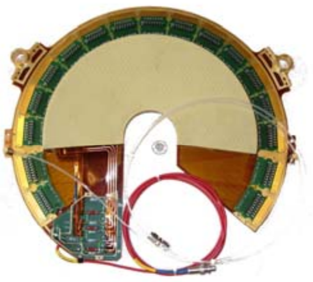
T2: $5.3 < |\eta| < 6.5$

T1: Cathode Strip Chambers



T2: GEMs



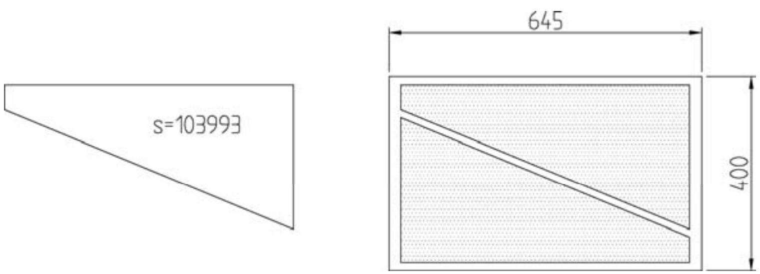


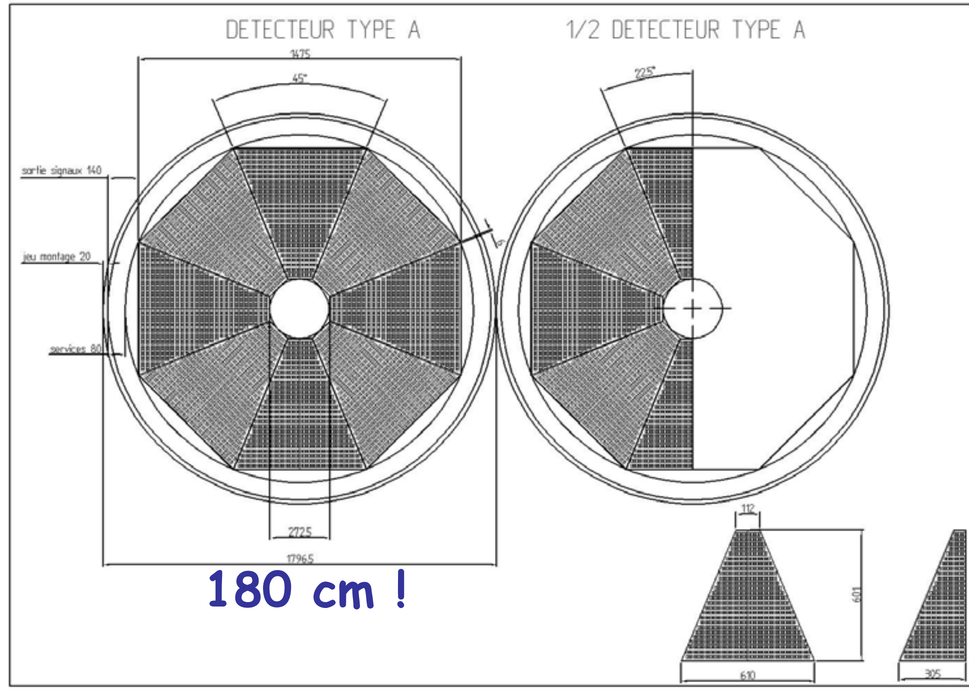
T1 Upgrade - Large GEM Detectors

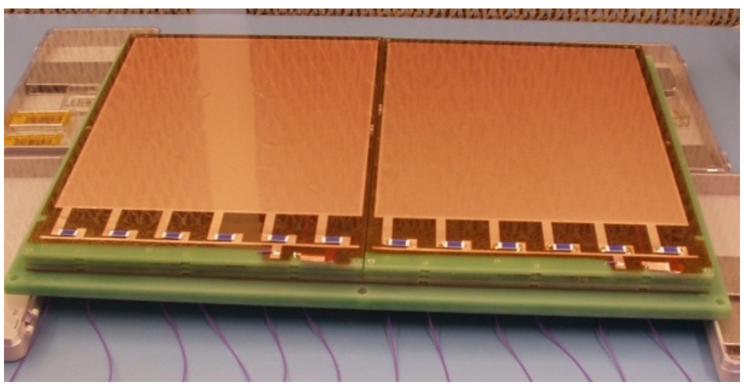
GEM foil size is limited by :

Starting raw material dimensions

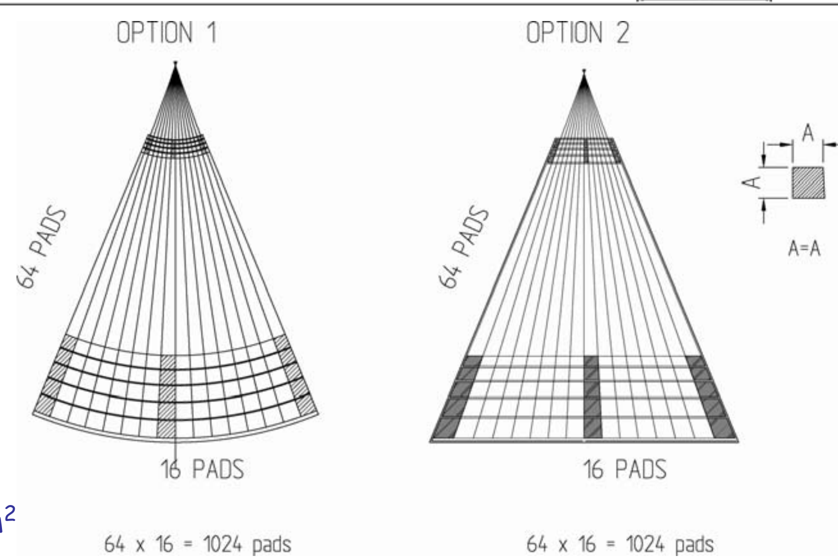
Precision of 2 masks alignment







Emilio Radicioni et al.



mean pad size ~ 2 cm^2
16x64 7x7 mm^2 —> 38x38 mm^2

GEM Manufacturing

50 µm Kapton
5 µm Cu both sides

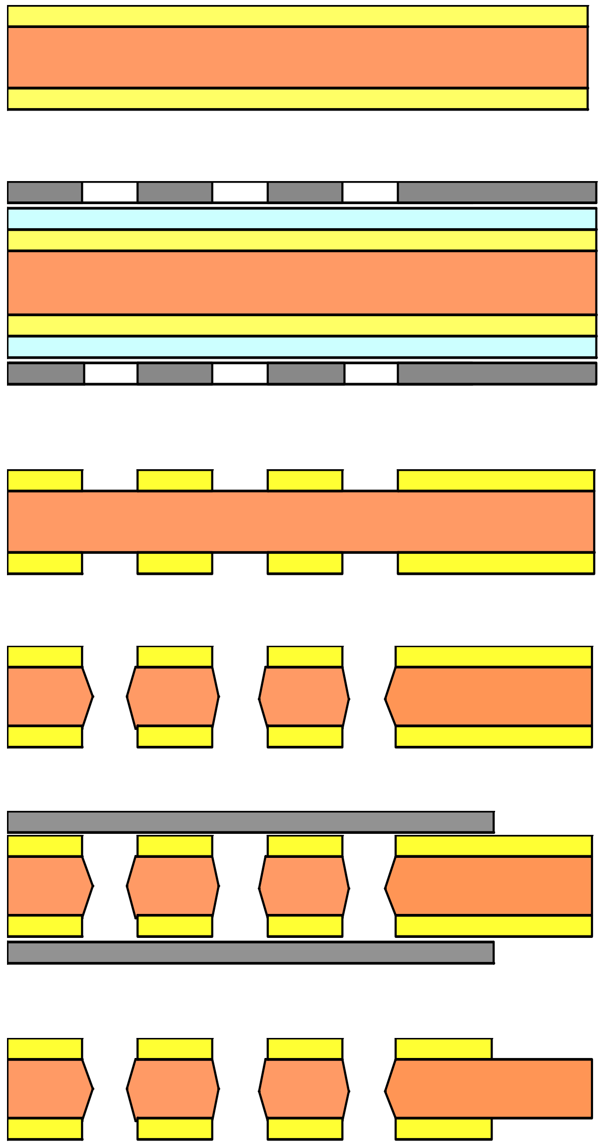
Photoresist coating,
masking and exposure
to UV light

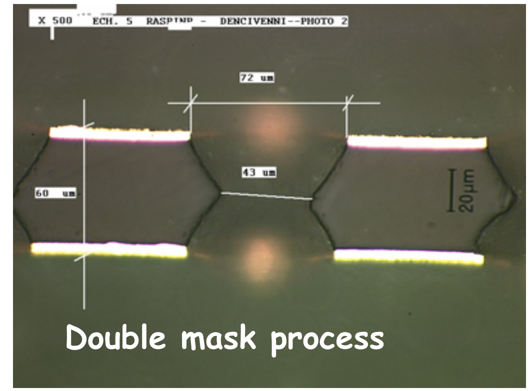
Metal etching

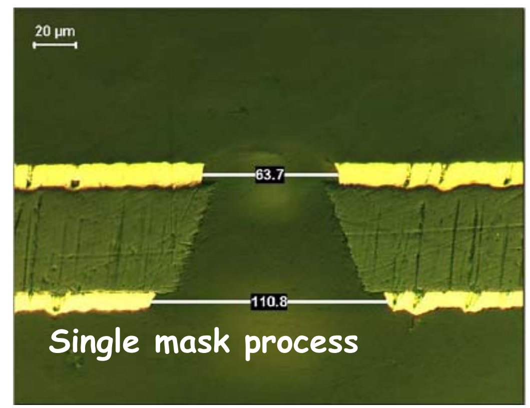
Kapton etching

Second masking

Metal etching
and cleaning







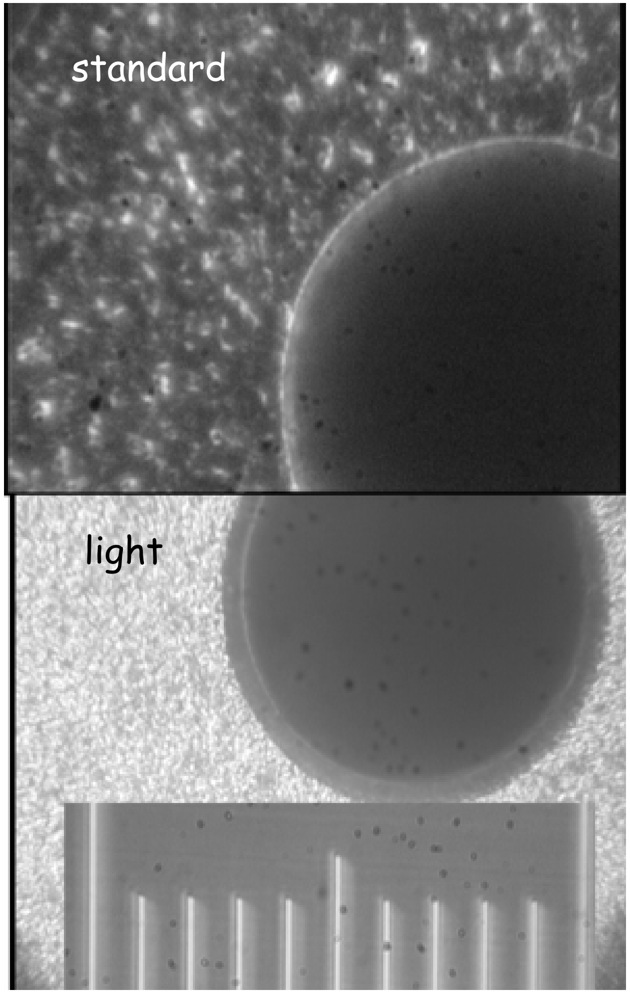
Positively tested for:

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

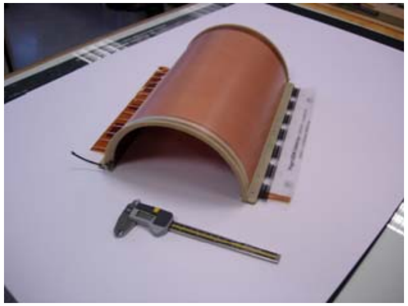
GEM Foil Material Budget Reduction

By reducing Cu layer thickness 5 μm —> 1 μm

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



Cylindrical GEM Beam Test



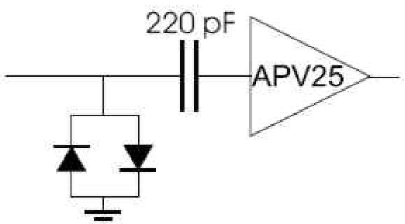
Semi-Cylindrical GEM -> 1 detector
Support structure PH-DT2

1 hv lines, hv ps
1 gas pipe, gas rack, distribution box
Electronics ? – (requirement: availability of the electronics 1 month before the beam)

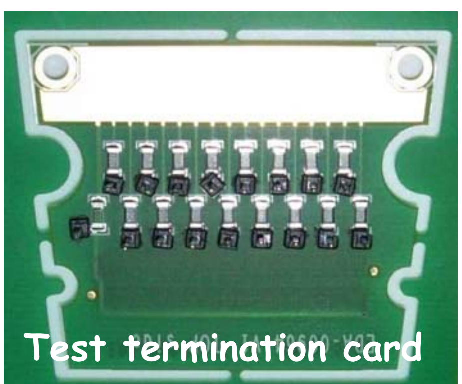
Test:
System aspects, integration of all services
Tracking
Background (heavily ionizing radiation)

Resources:
Detector : Leszek
Infrastructure: ?
Electronics : ?
DAQ: ?
Data analysis: ?

Available Test Cards

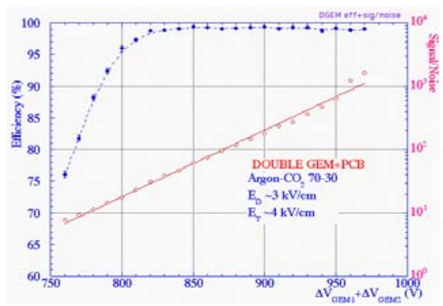


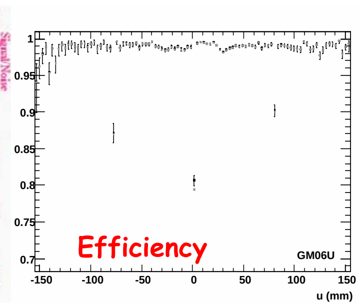
Protection Circuit

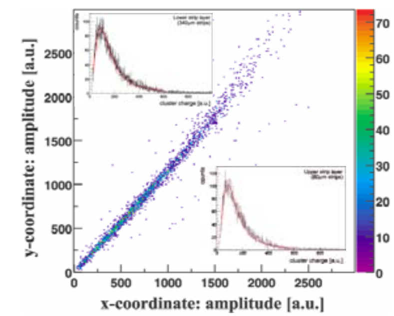


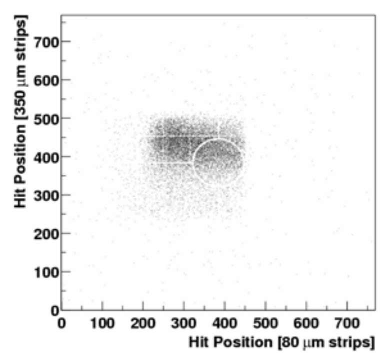
Possible tests (in the lab and beam):

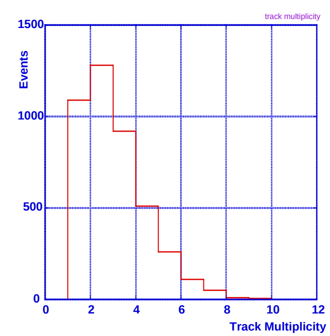
Gain Calibration (l)
Uniformity of the Response (l)
Dead Zones (b)
Efficiency (b)
Charge sharing (l)
Space resolution (with external tracker) (b)

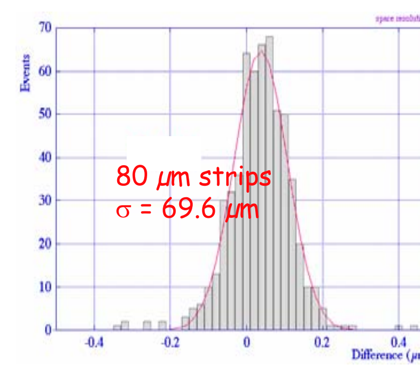




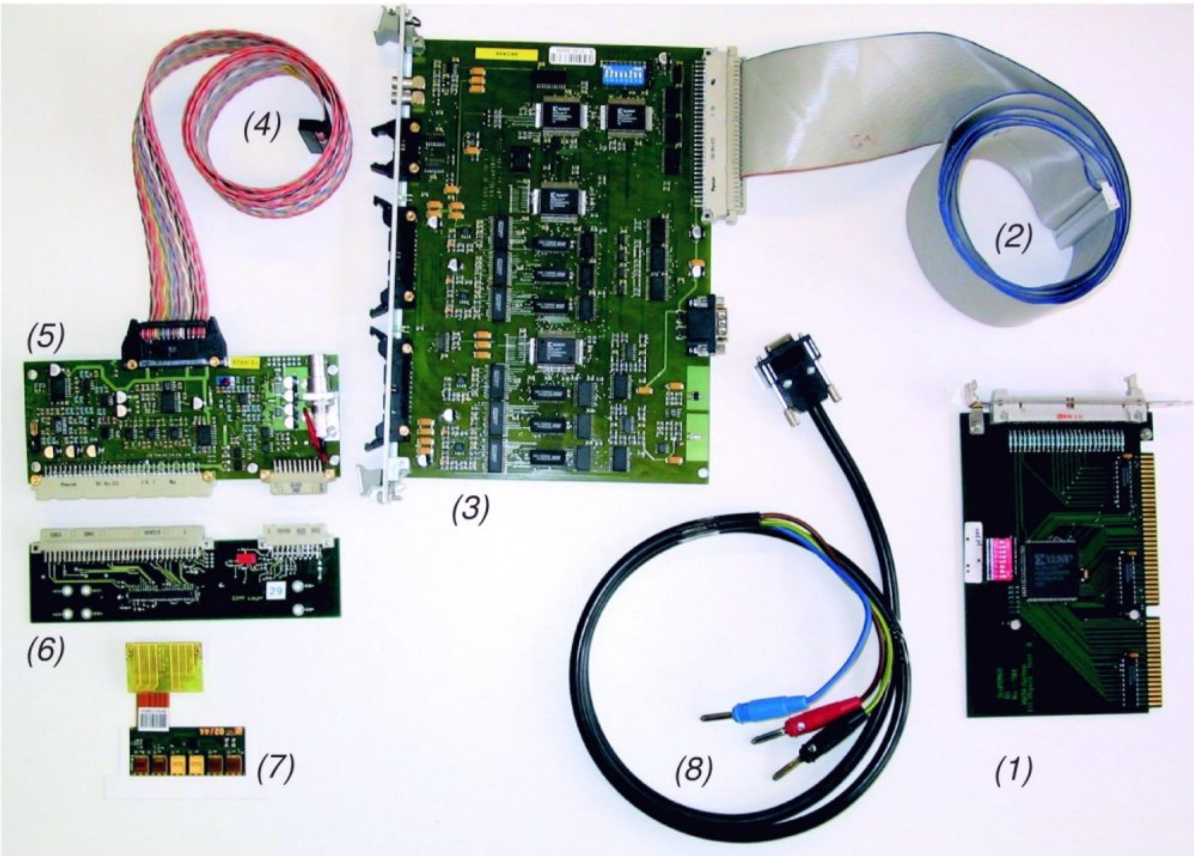








The ARC System



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 at a time