GEM chambers for SoLID

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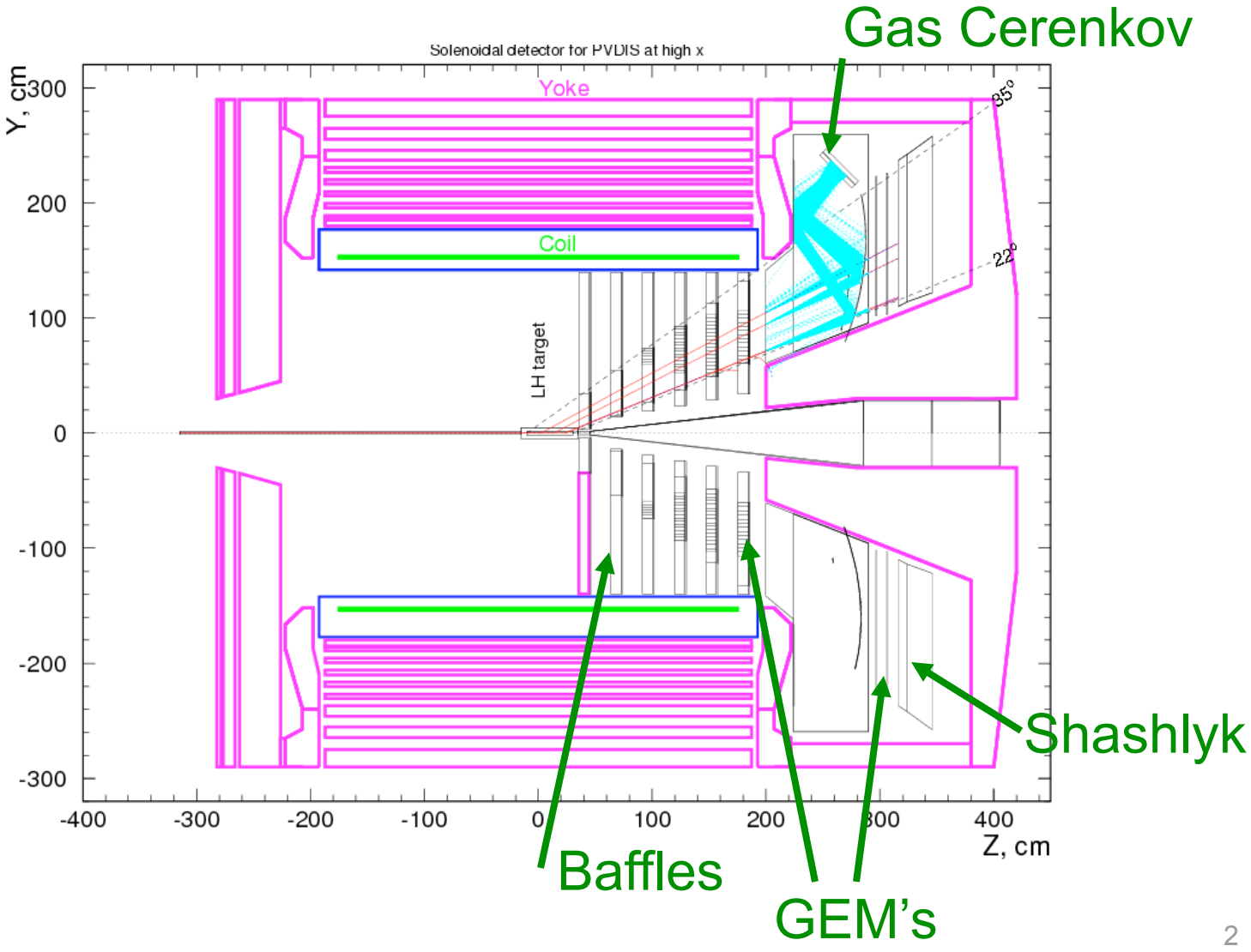
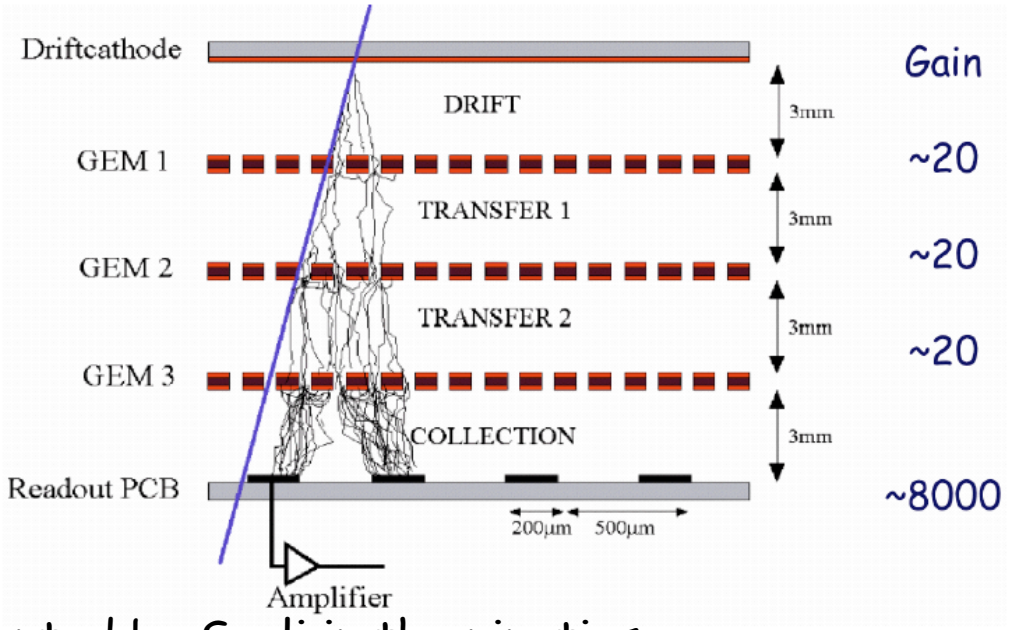
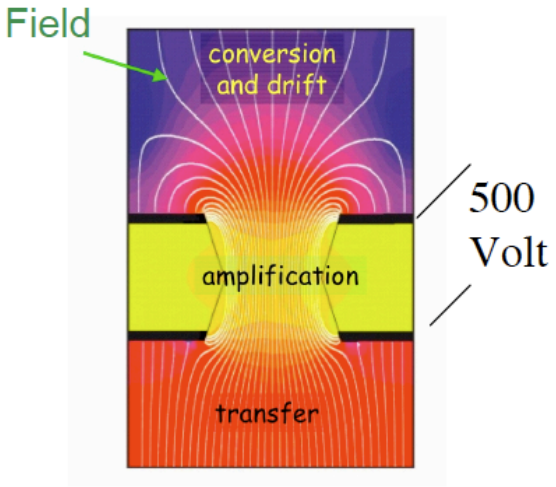
SoLID Spectrometer

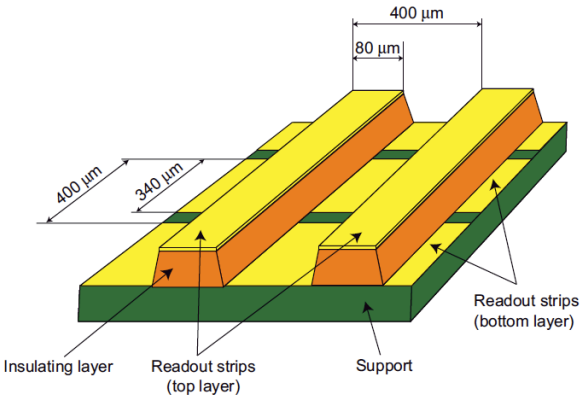


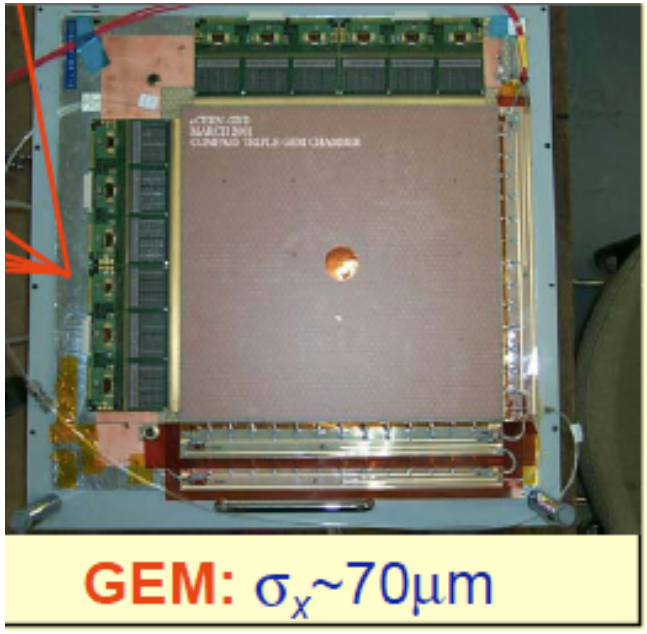
Gas Electron Multiplier- GEM: technology





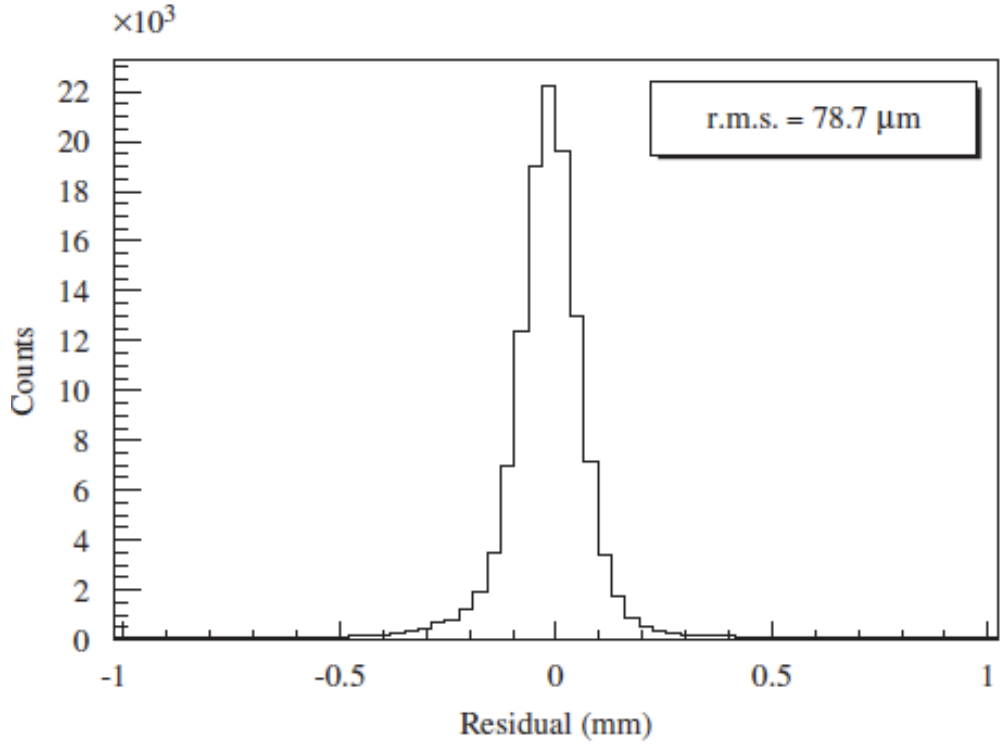
- Invented by Sauli in the nineties.
- Have been adapted for many applications since.
- Successfully used in COMPASS for a few years.





Ideal for high luminosity applications requiring high resolution: like SOLID

- Can tolerate rates up to 50 kHz/mm^2 or more: SOLID needs up to ~ 5 kHz/mm^2.
- Achieved resolutions ~ 60 – 70 μm
- Radiation hardy: no effect after many years of running at COMPASS
- No chamber aging observed up to ~ 7 mC/mm^2: this is about 10,000 hours of running for SOLID:



Main Challenge: large area

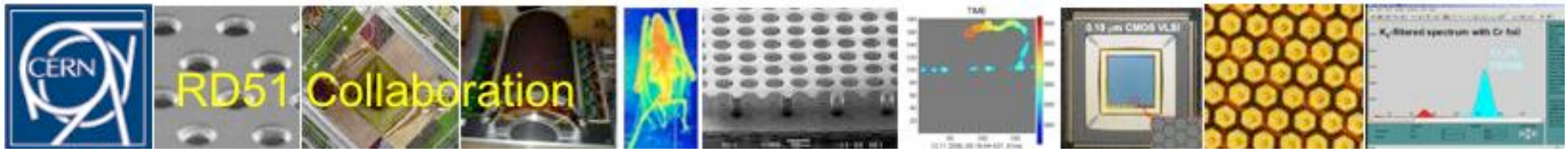
- COMPASS GEM chambers only 30 cm x 30 cm; there were total 22 chambers, total area ~ 2 m^2.
- Requirements for SOLID more than an order of magnitude larger.

Plane	Z (cm)	R_I (cm)	R_O (cm)	Total Area (m^2)	circumference (cm) Inner	outer
4	120	39.0	87.2	1.9	245	548
5	150	48.7	109.0	3.0	306	684
6	190	61.7	138.0	4.8	388	867
7	290	94.2	210.7	11.2	592	1323
8	310	100.7	225.2	12.7	633	1414
total:				33.6		

This is the bare minimum: high rates may require multiple chambers at the same location.

- Disk area larger than available GEM foil size (currently ~45 x 45 cm^2) ; need larger foil and segmentation.
- Large total area: most current GEM foil production at CERN shop: can they handle this volume ? Need new foil manufacturing

GEM Research and Development



RD51 Collaboration for the
Development of Micro-Pattern Gas Detectors Technologies

http://rd51-public.web.cern.ch/RD51%2DPublic/Welcome.html

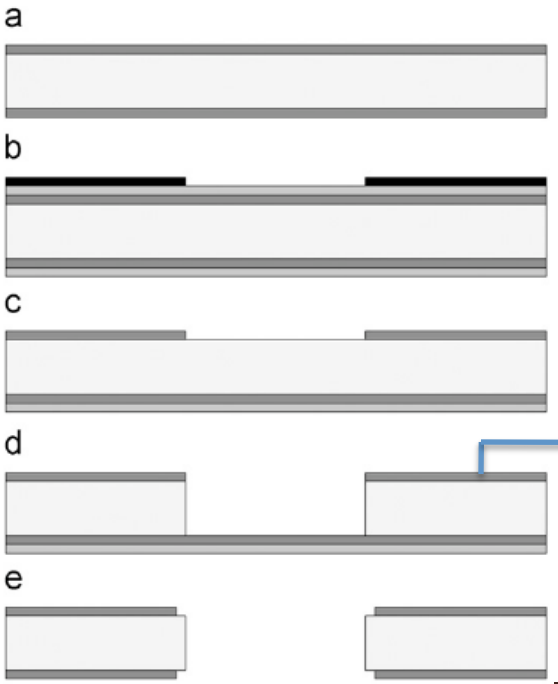
Production at CERN

- GEM size
  - With existing equipments 1.5m x 0.5m active area
  - Mid 2011: 2m x 0.5m active area
- Volumes
  - With existing equipment: 10 GEMs/month.technician
    - We can hire one more technician
  - Mid 2011: 24GEMs/month.technician (240GEM/year)
  - With some offers for large volume production we start to see the limit price of the GEMs : in the range of 600 CHF/sqr.meter

Major recent development at CERN PCB shop towards large GEM foils

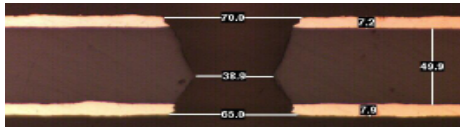
- Base material only ~ 45 cm wide roll.
- Used a double mask technique for etching: hard to the two masks accurately: Max area limited to ~ 45 cm x 45 cm previously.

Double Mask



Bias top surface to – w.r.t chemical bath

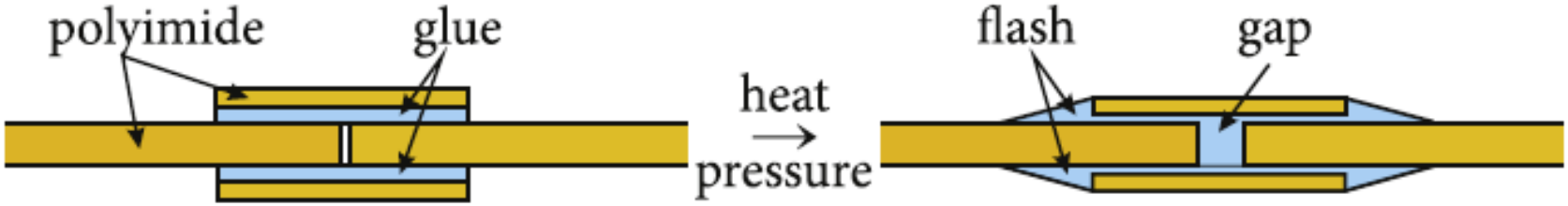
Single Mask

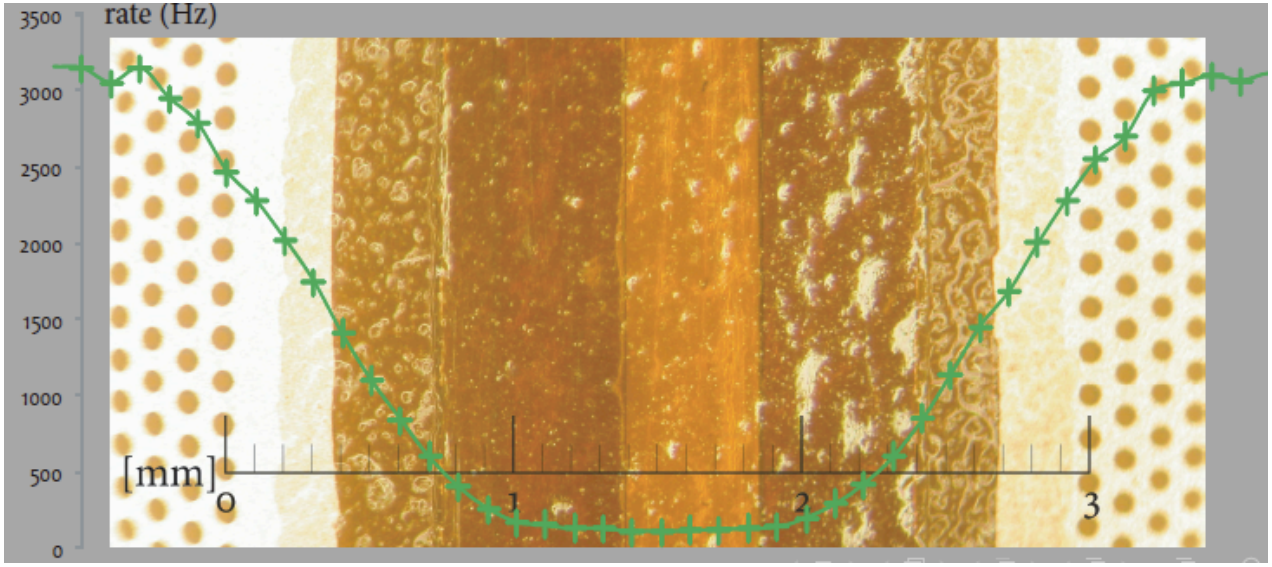


Single Mask technique allows to make GEM foils as large as 200 cm x 50 cm

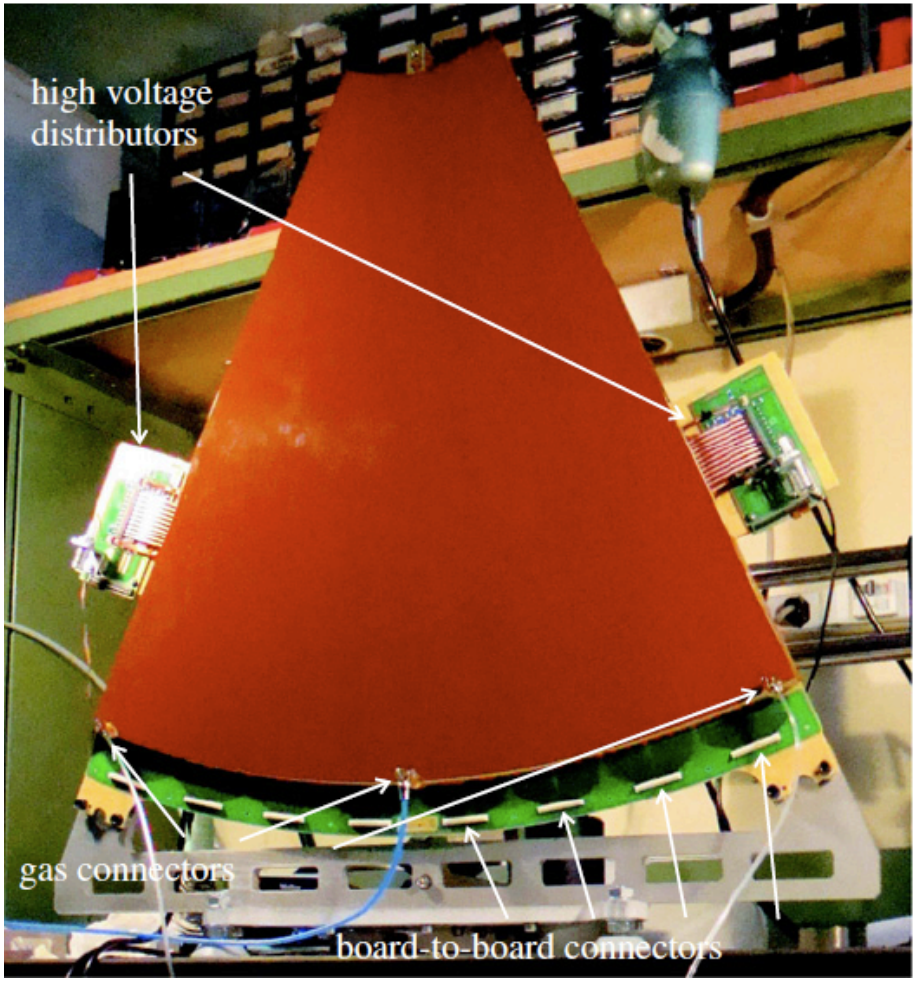
Major recent development towards large GEM foils

- Splicing GEM foils together: seam is only 2 mm wide
- Performance of the rest of the GEM foil unaffected





TOTEM T1 prototype chamber made with single mask GEM foils spliced together (33 cm x 66 cm)



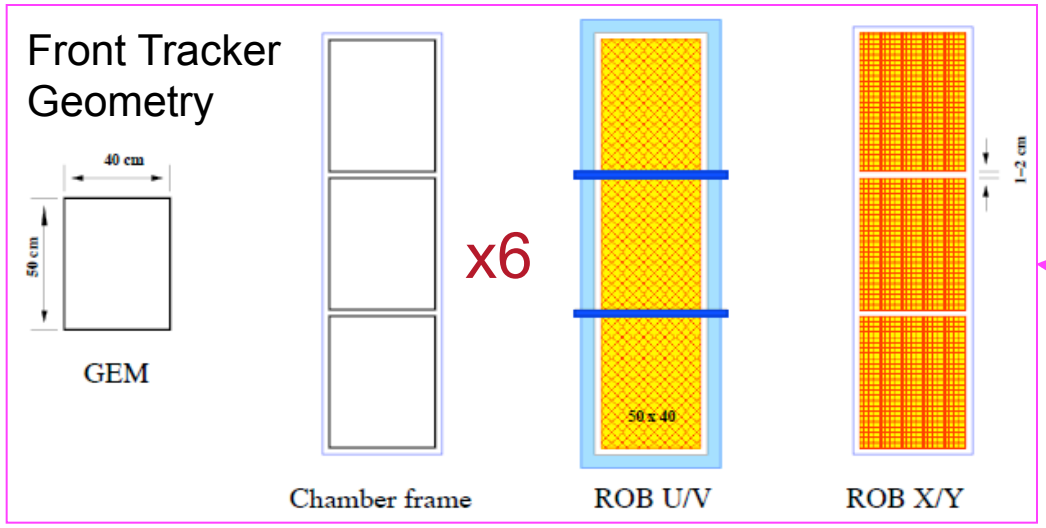
- Base material up to 51.4 cm wide now available
- CERN plans to buy equipment capable of producing 200 cm x 50 cm GEM foil.

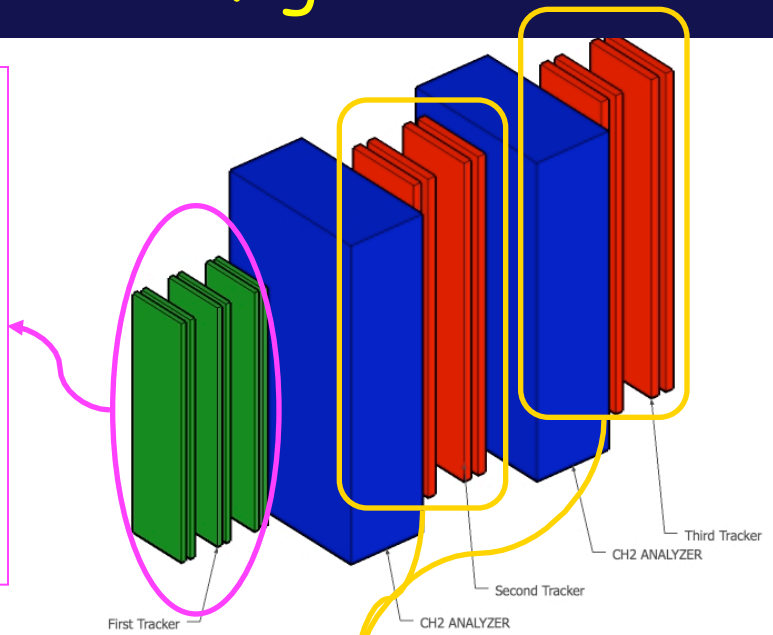
This combined with Splicing: 200 cm x 100 cm GEM foil may be possible in the next two years

M. Villa, et al., Nucl. Instr. and Meth. A (2010), doi:10.1016/j.nima.2010.06.312

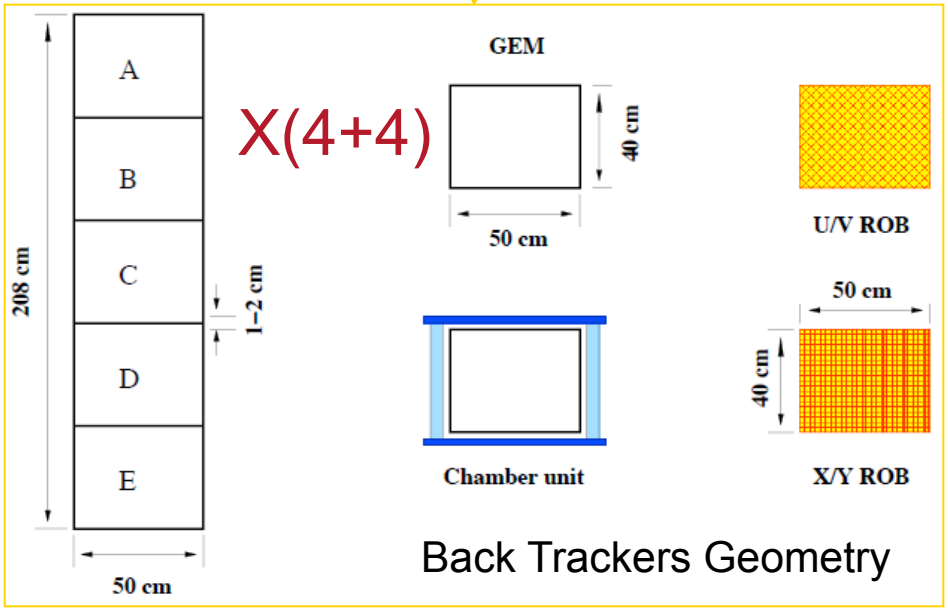
M. Alfonsi et al. / Nuclear Instruments and Methods in Physics Research A 617 (2010)

SBS Tracker Chambers configuration





- ✓ Modules are composed to form larger chambers with different sizes
- ✓ **Electronics along the borders and behind the frame (at 90°) – cyan and blue in drawing**
- ✓ **Aluminum support frame around the chamber (cyan in drawing); dedicated to each chamber configuration**



SBS Tracker Chambers configuration

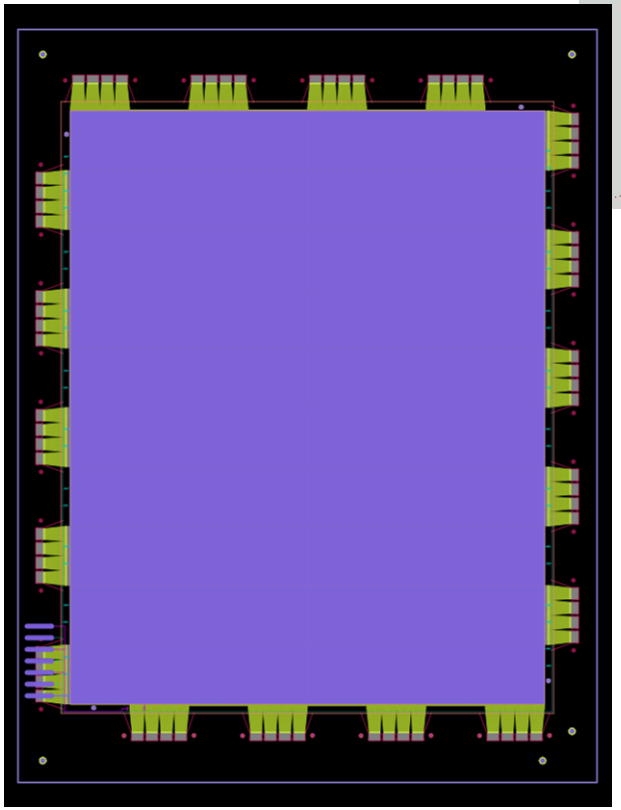
Tracker	Area (cm^2)	Number of Chambers	Readout	Pitch (mm)	Modules/ Chamber	Total Modules	Total Readout Channels
FT	40x150	6	2D 4(x/y) 2(u/v)	0.4	1×3	18	49000 + 13500
ST + TT	50x200	4 + 4	2D 2(x/y) 2(u/v)	4×0.4	1×5	20+20	13600 + 13600
CD	80x300	2	1D y+y	1.0	2×6	24	12000

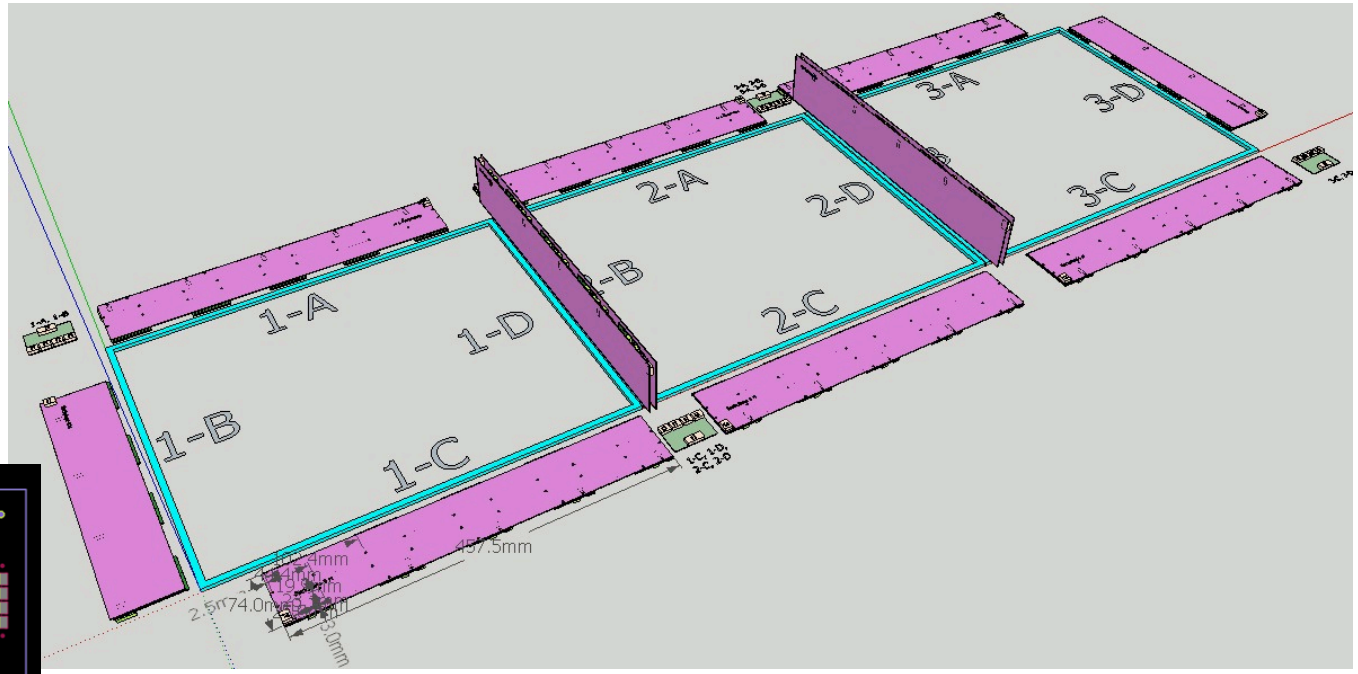
Total chs. 101700

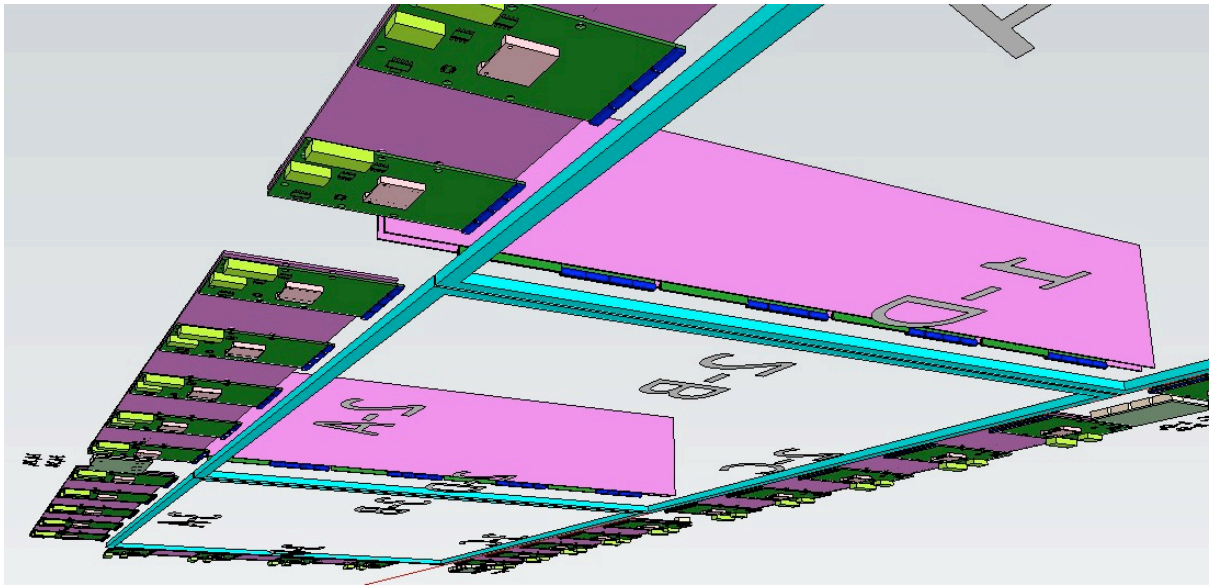
Total area ~ 16.5 m^2

Cost estimate ~ $ 3.2 M

Key to Segmentation: making dead areas as narrow as possible



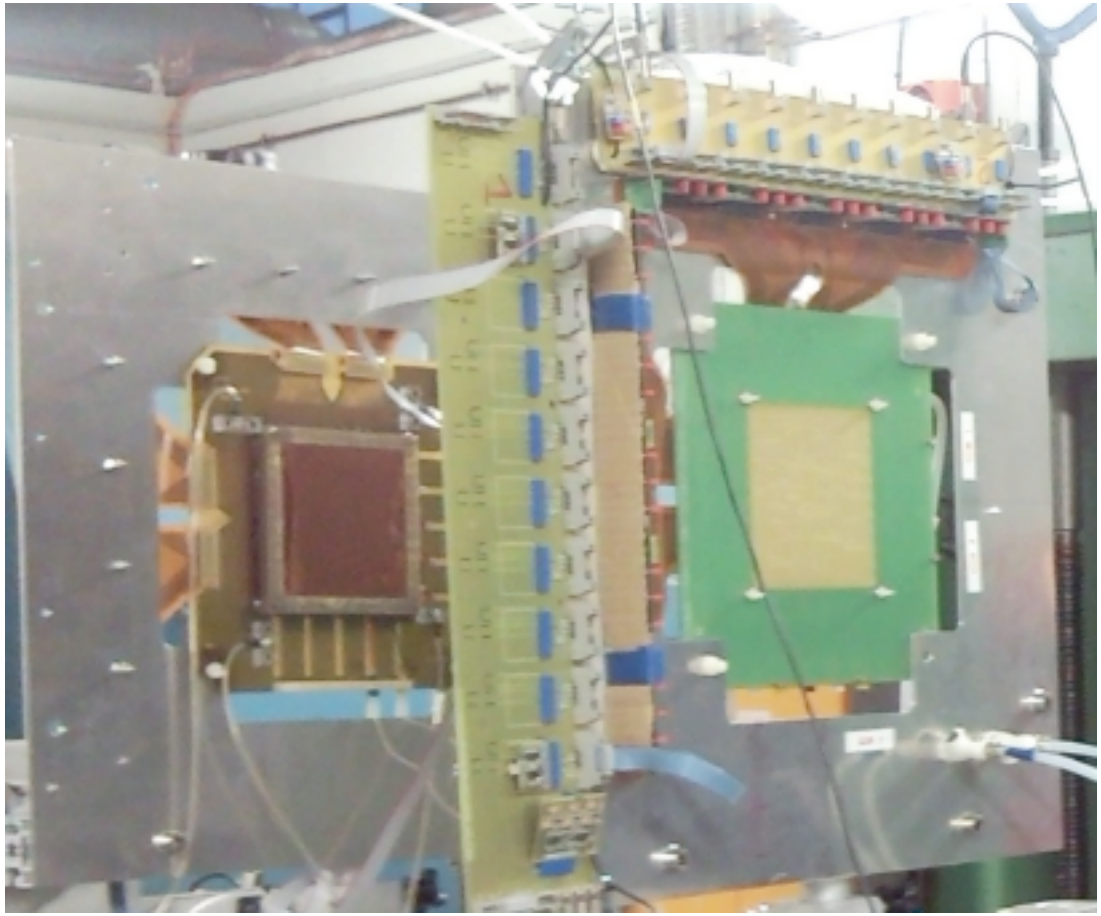




SBS GEM chamber prototyping

- Prototype GEM tracker consisting of five 10 cm x 10 cm chambers built.
- Already tested in high rate conditions during hall A PREX experiment. Data being analyzed now
- More extensive test with APV-25 electronics and under high background rates planed for this Autumn.

- A 40 cm x 40 cm prototype and APV-25 electronics under construction at INFN.



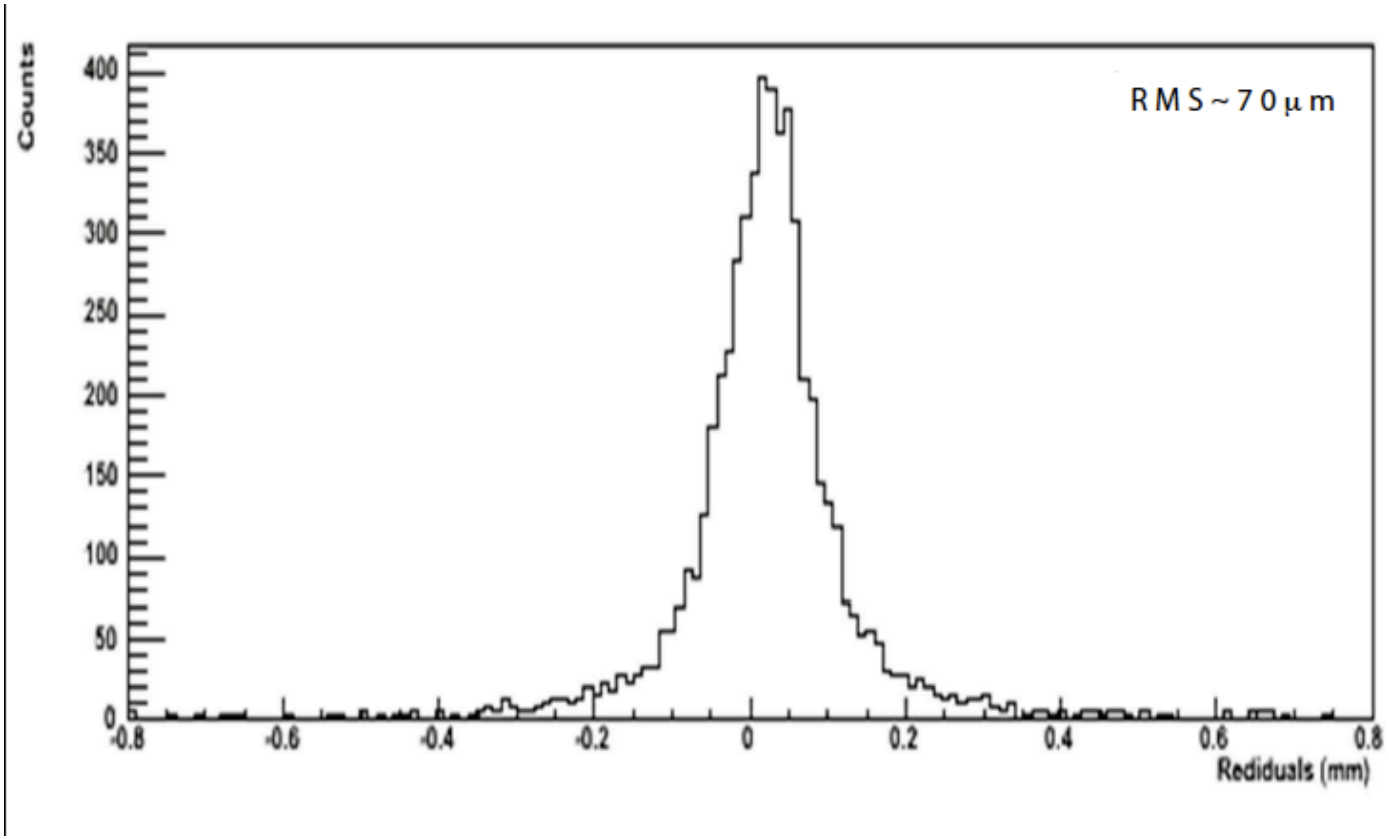
Topics to study

- Tracking under high rates
- Response to low energy photons
- Readout plane size limitations (noise pickup, capacitance etc.)
- Combining readout strips

Expect to start production early next year.

Jefferson lab prototype GEM chamber test during PREX experiment

- Good correlation between tracks projected from VDC and GEM tracks.
- Preliminary resolution (from residuals) ~ 60 microns.

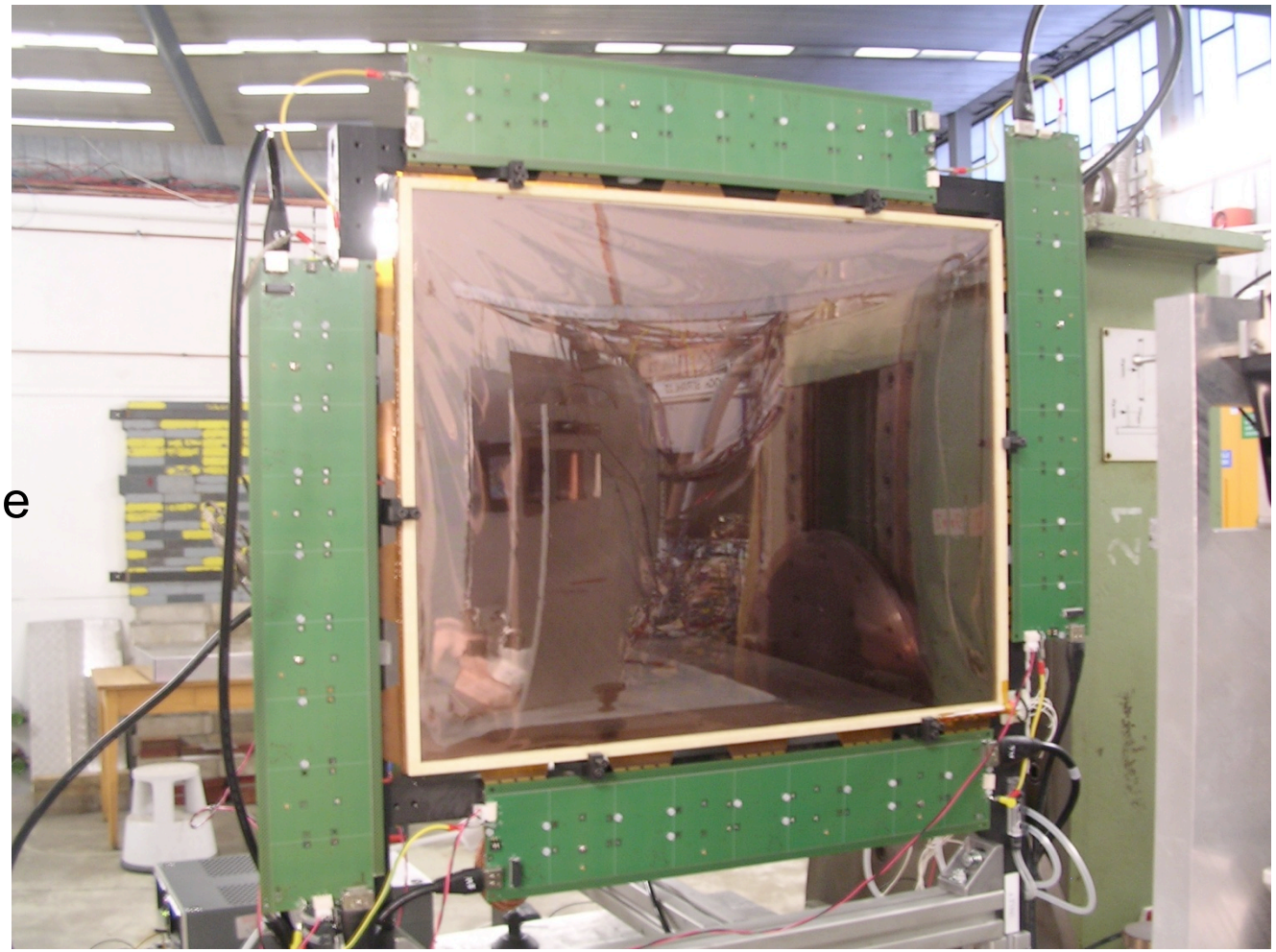


Beam test @ DESY (EUDET support)

- Fully equiped GEM module
- 18 front-end cards
- 2304 channels

(front end cards on the other side)

- 7 independente HV levels



2-6 GeV low intensity electron beam / silicon tracker available

Data taking: 28/Nov-3/Dec 2010

- Assume largest dimension of GEM foil ~150 cm x 50 cm

Plane	Z	R_I (cm)	R_O (cm)	Total Area (m^2)	inner circumference	outer circumference	Chamber segments
4	120	39.0	87.2	1.9	245	548	8
5	150	48.7	109.0	3.0	306	684	16
6	190	61.7	138.0	4.8	388	867	32
7	290	94.2	210.7	11.2	592	1323	32
8	310	100.7	225.2	12.7	633	1414	32
total:				33.6			120

rough cost estimate

Item	Quantity	Unit cost	Total cost	Material only unit cost	Material only total cost
GEM foil	~100 m^2	\$3000/m^2	0.3 M	\$3000/m^2	0.3 M
readout boards	120	\$ 2500	0.3 M	\$ 2500	0.3 M
chamber support frame	120	\$ 1500	0.2 M	\$ 1500	0.2 M
Supplies and tooling			0.1 M		0.1 M
FEE and DAQ	300 k	\$ 7.0	2.1 M	\$ 4.0	1.2 M
cables, power, etc			0.5 M		0.5 M
Gas system			0.1 M		0.1 M
Labor: Technicians	12 FTE-years	\$ 80 k	1.0 M	\$ 80 k	-
Labor: Grad students	6 student-years	\$ 50 k	0.3 M	\$ 50 k	-
support structure and integration			???		???
TOTAL:			**~ 5 M**		**~ 2.7 M**
With 33% contingency			**~6.7 M**		**~3.6 M**

R&D and prototyping expenses: ~ \$ 200 k (~ \$ 60 k year 1, ~ \$ 140 k year 2)

PVDIS with SOLID