GEM Detectors for SoLID

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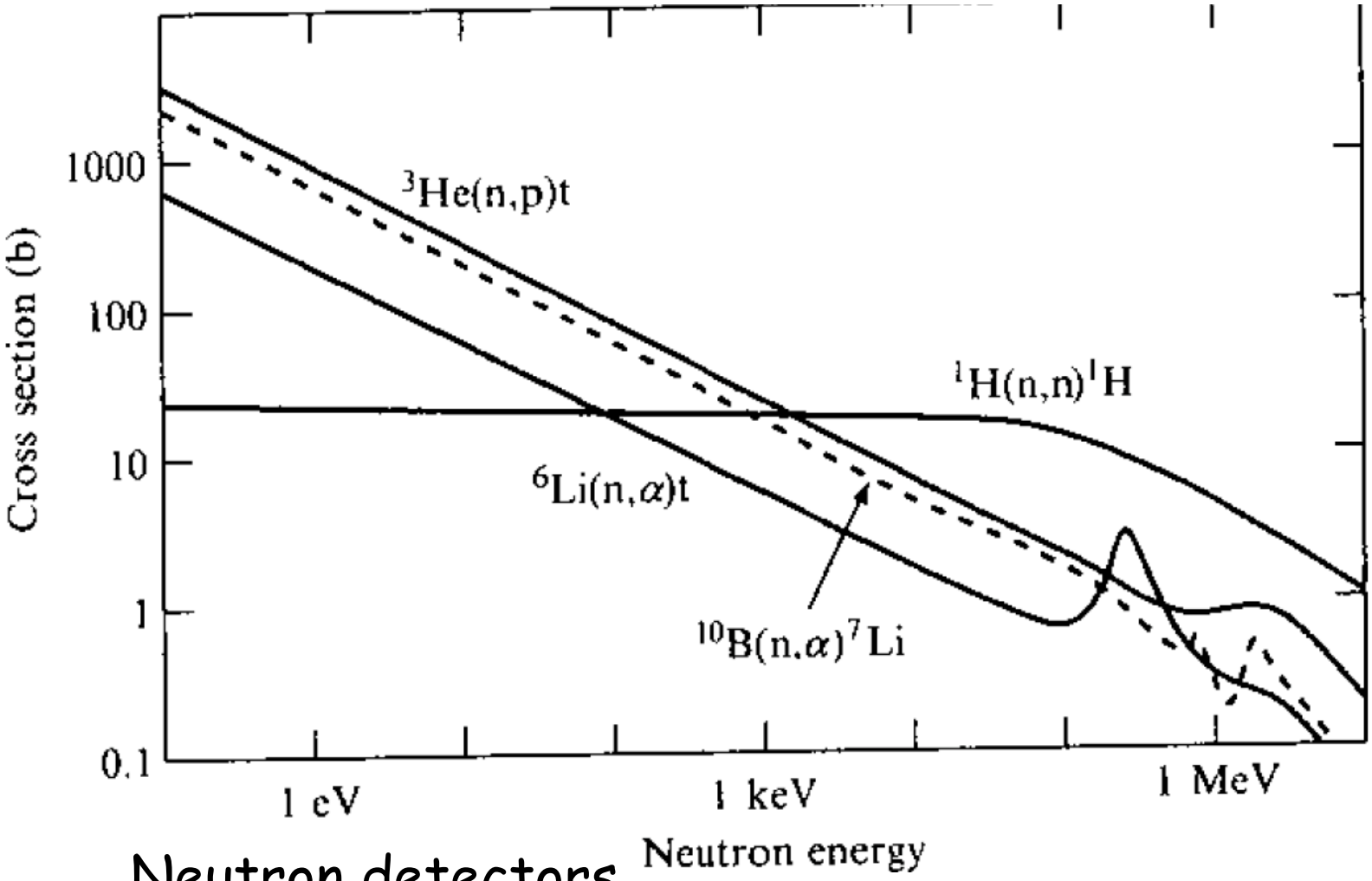
Outline

- GEM chamber concept
- Large area GEM chamber projects
- UVa GEM construction facilities
- UVa GEM construction program



Neutron detectors

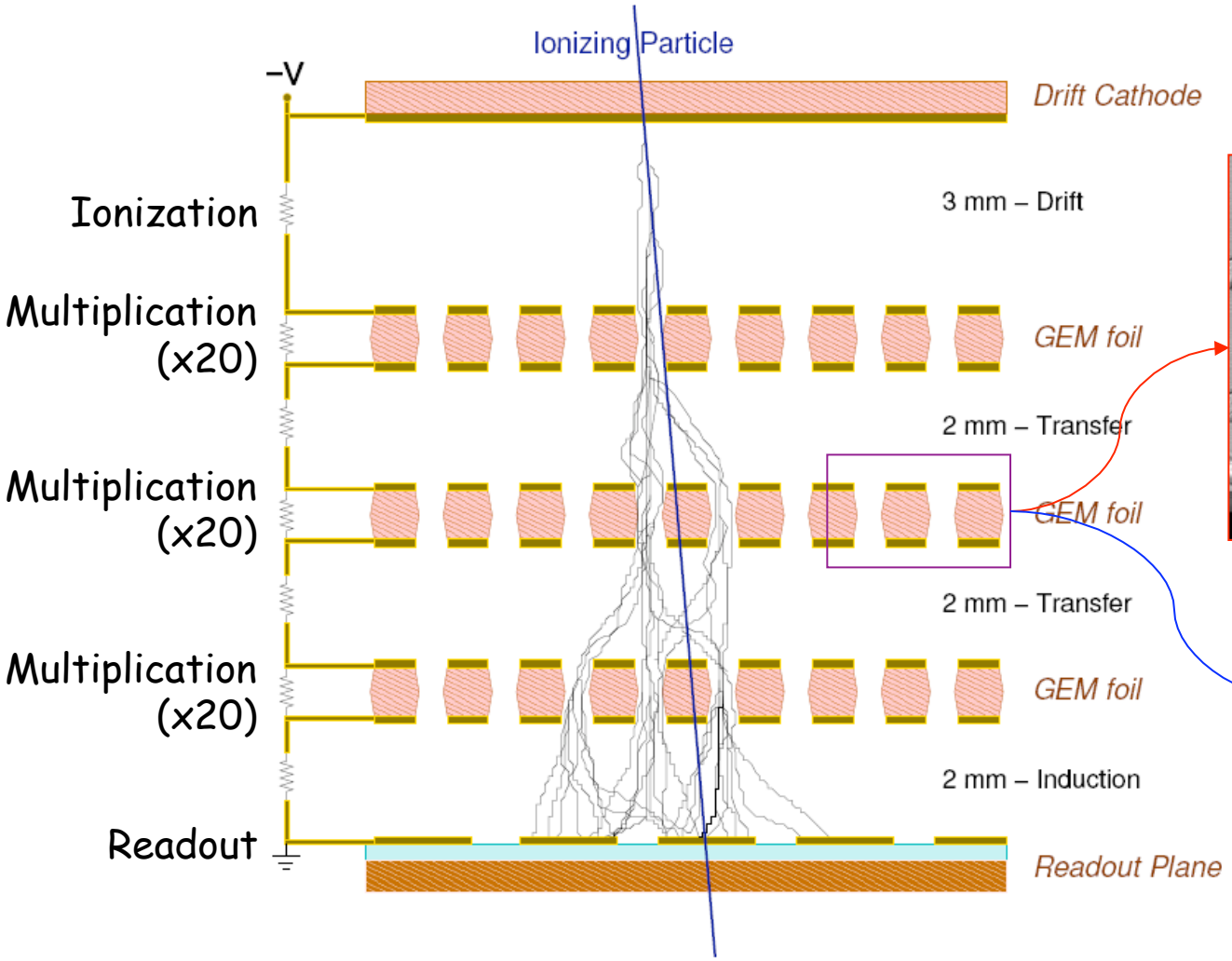
Low energy:

- BF3 gas filled proportional counter
- 3He filled proportional counter

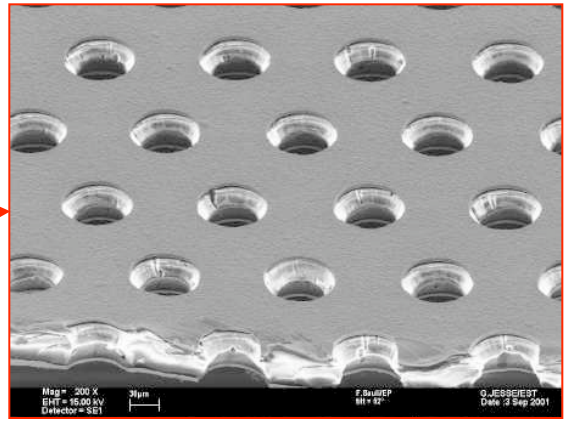
High energy:

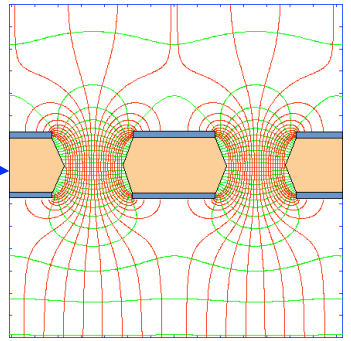
- plastic or liquid scintillators

GEM working principle



GEM foil: 50 μm Kapton + few μm copper on both sides with 70 μm holes, 140 μm pitch





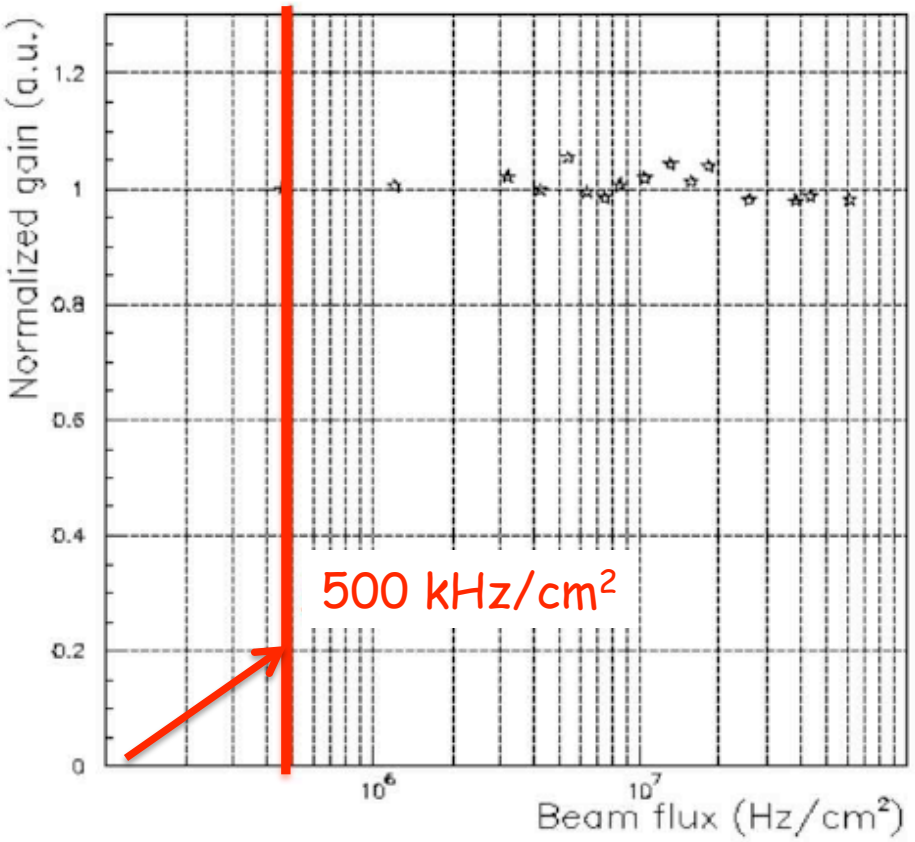
Strong electrostatic field in the GEM holes

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

GEM Rate capability

- Multiplication stages shielded from each other: much reduced feed back
- Slow moving positive ions localized to holes, away from the induction region
- Most of the created electrons contribute to signal: can operate at low gains

Much higher rates compared to wire chambers: ~ 50 MHz/cm^2



Triple GEM
Poli Lener, PhD Thesis - Rome 2005

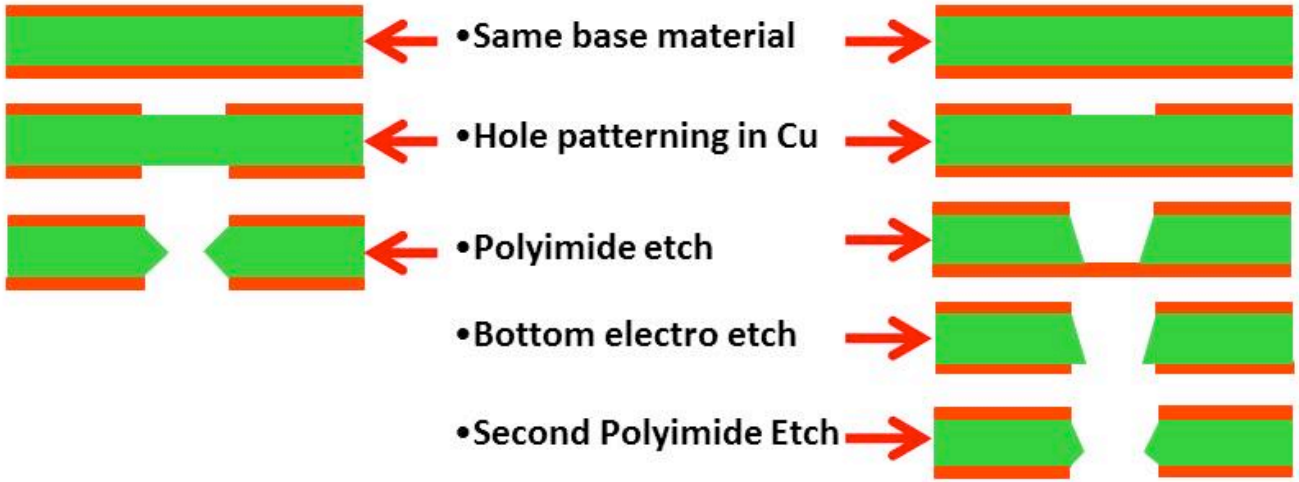
Single Mask Technology

GEM double mask Vs GEM single Mask

- Base material : Polyimide 50um + 5um on both sides
- Polyimide : Apical NP from company Kaneka (Japan)
- Supplier of the copper clad material : Nippon Mining (Japan)

Original method
- Double mask

Last few years
- Single mask



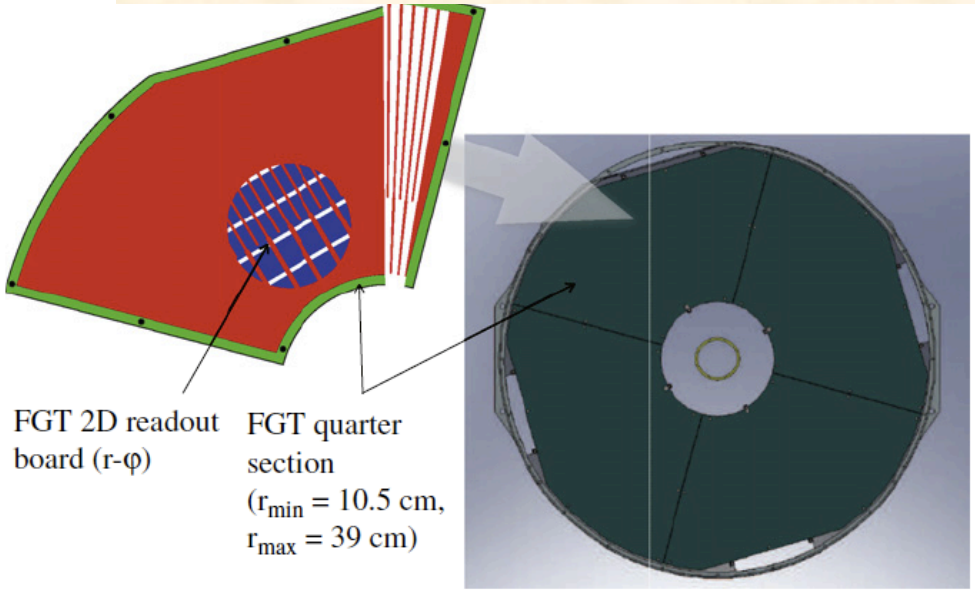
CMS Upgrade Prototype (42cm x 990 cm)

- Limited to 40cm x 40cm due to
  - Mask precision and alignment

- Limited to 2m x 60cm due to
  - Base material
  - Equipment

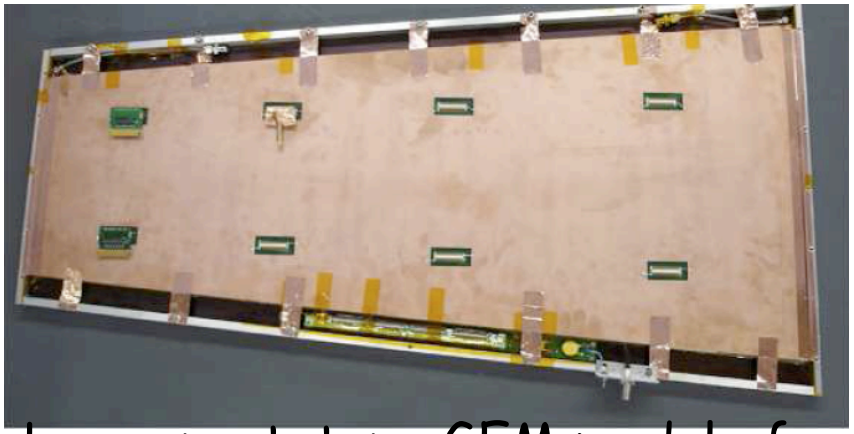
Large size available in recent years!

Large GEM chamber projects

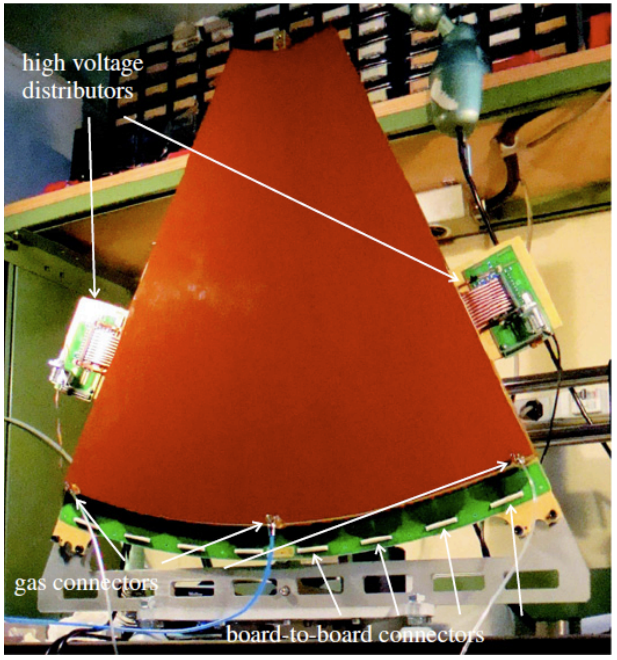


STAR Front GEM Tracker

- 6 triple-GEM disks around beam
- IR~10.5 cm, OR~39 cm
- APV25 electronics



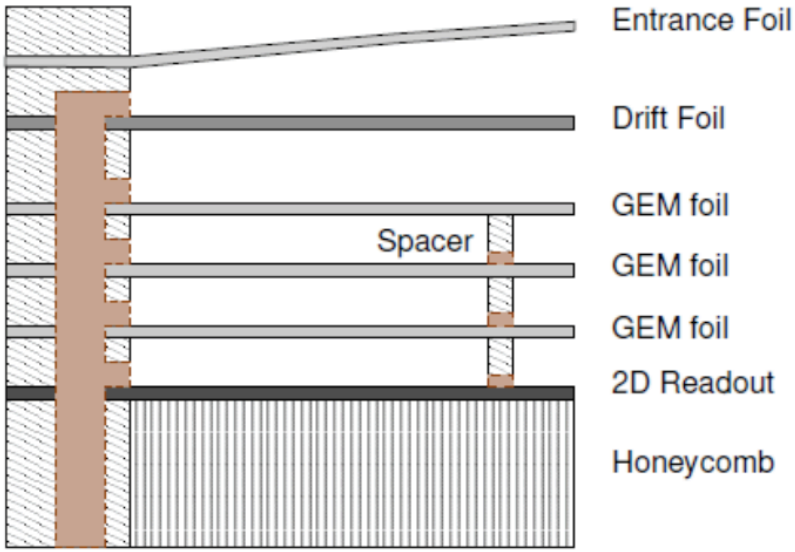
Large prototype GEM module for CMS: 99 cm x (22 – 45.5) cm

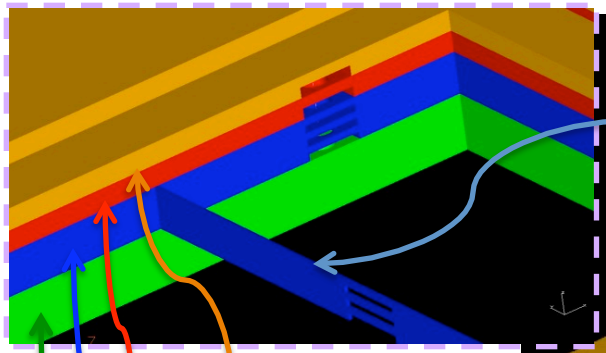


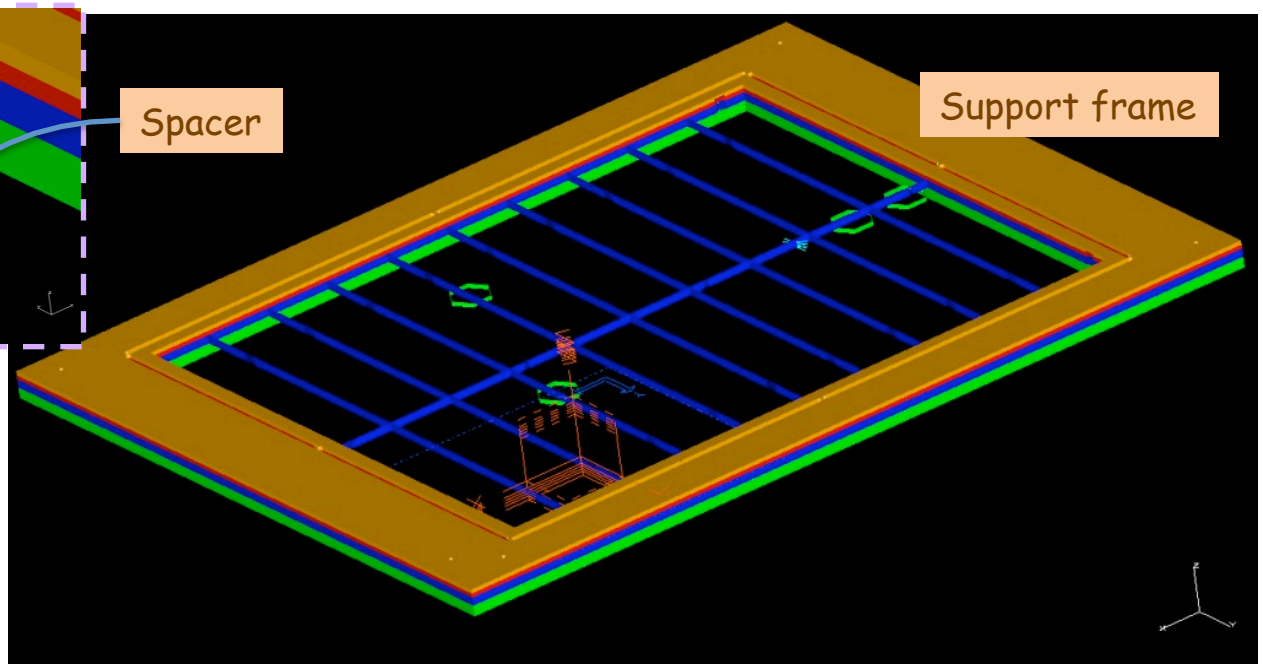
TOTEM T1 prototype made with single mask GEM foils (33 cm x 66 cm)

Basic Module of SBS Trackers

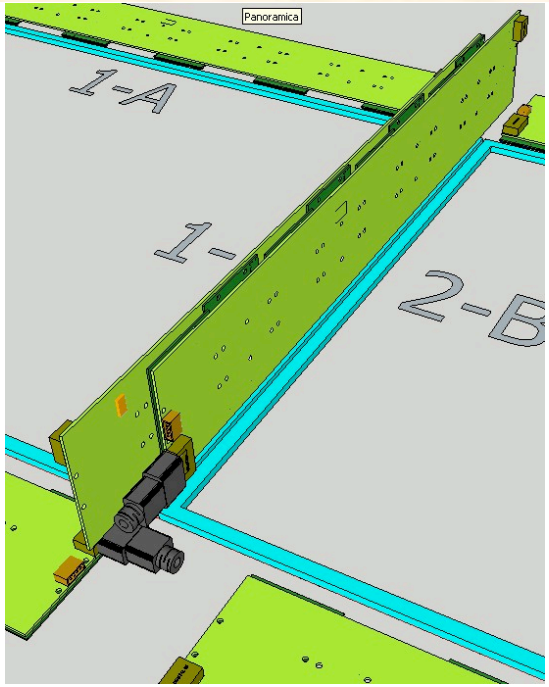
- Basic module developed in Rome used for all trackers
- Features:
  - size: 40x50 cm^2 active area
  - thin frame: only 8 mm wide
  - single mask tech. GEM foils
  - 2D strip readout (a la COMPASS) 0.4 mm pitch
  - X= 0.54%X0

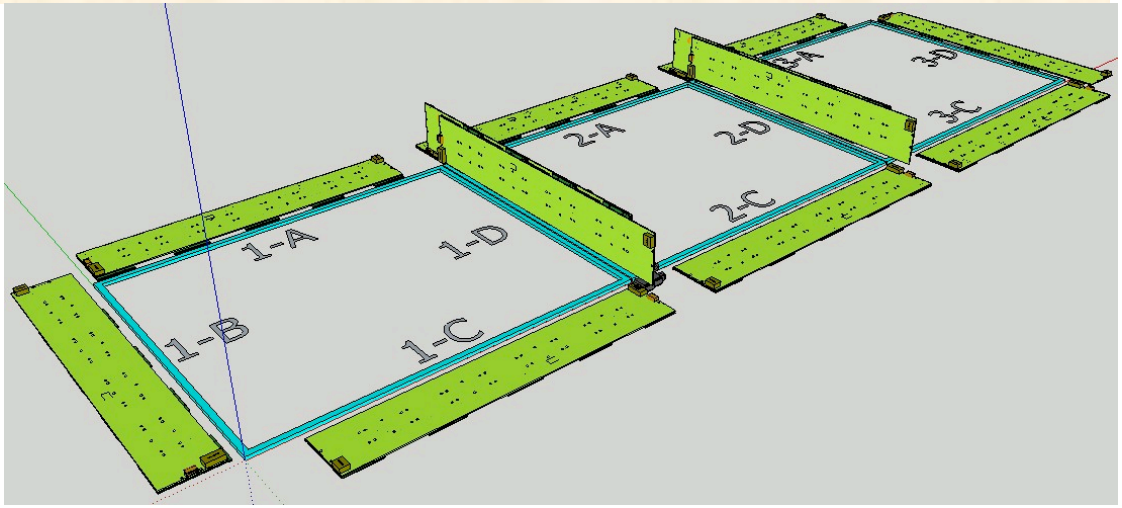


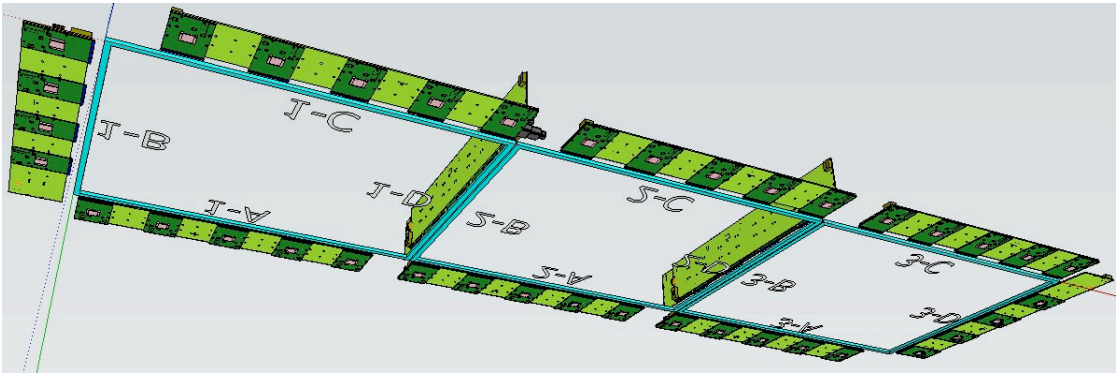




Electronics layout of one chamber



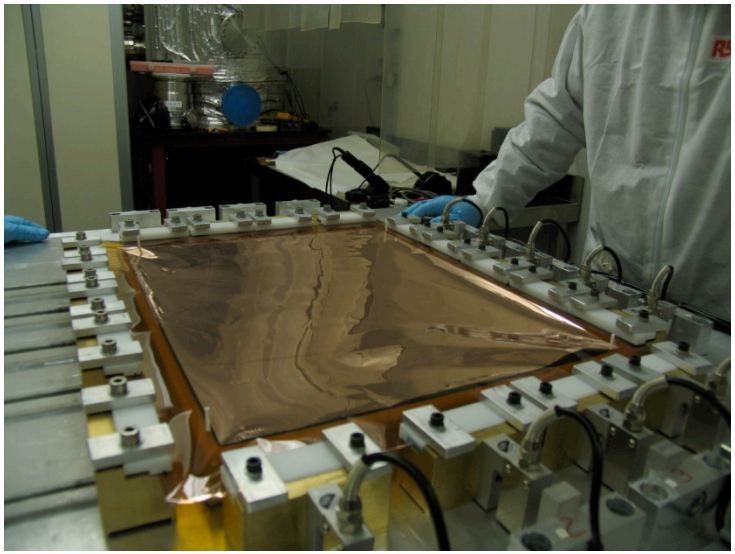




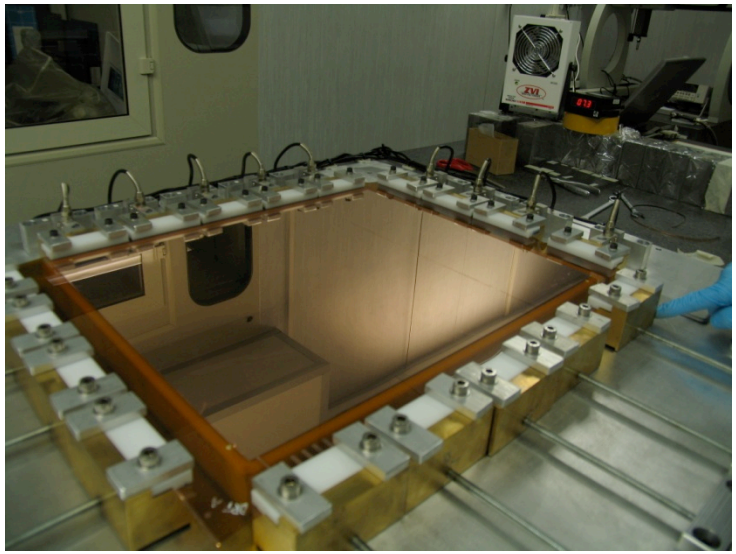
- Front End cards are connected by a passive backplane (with hard rad voltage regulators); backplane acts as a good GND connection for the cards

- Cards are electromagnetically shielded by backplane and external frame (with thin conductive tape)

Assembly of the GEM module at INFN



Stretching



Stretcher design from LNF / Bencivenni et al.

Use stretching and spacers to keep foil flat

Foil Tension: **T = 2 kg/cm**
Spacer Sector: **S = 170 cm2**
Expected maximum pressure on foil **P ~ 10 N/m2**

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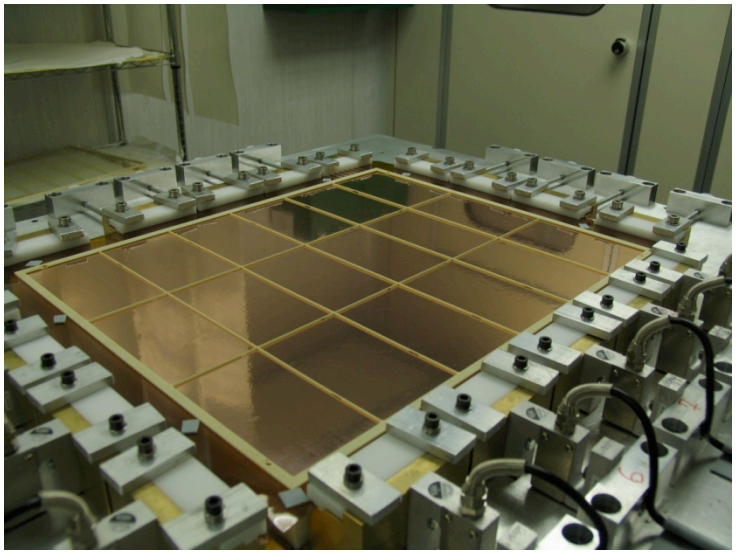
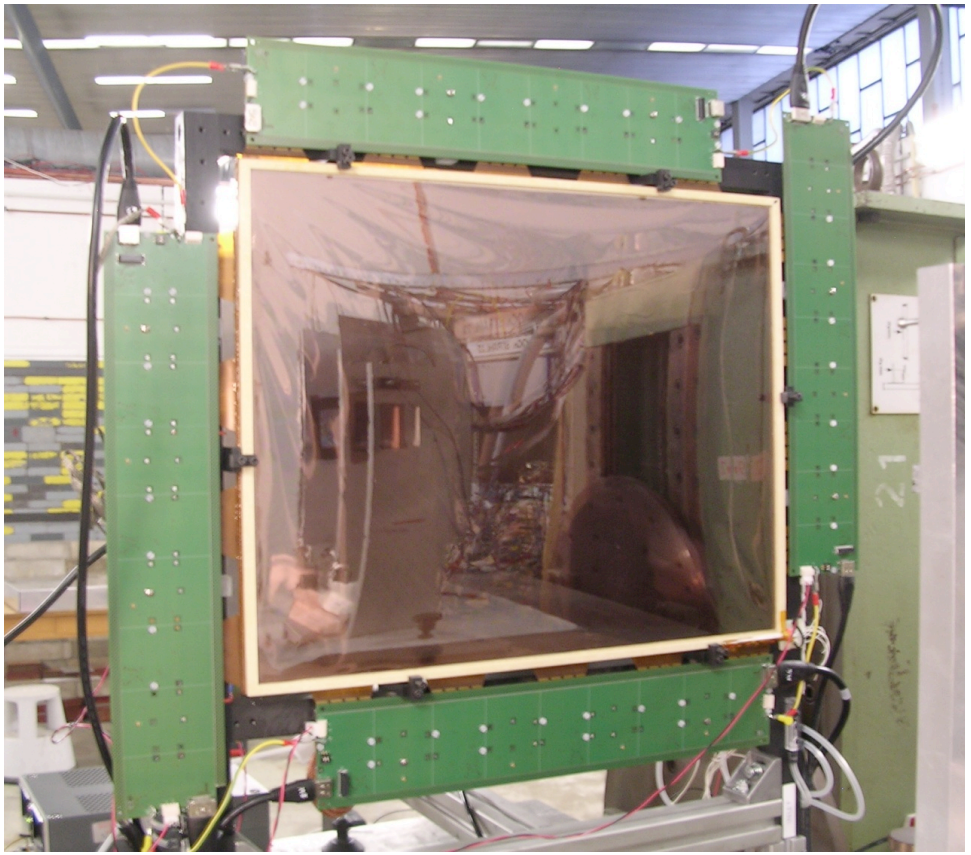
Maximum foil deformation:
u ~ 0.0074 * P * S / T = **6.4 μm**



Gluing the next frame with spacers

Completed Prototype Module and Front Tracker Production

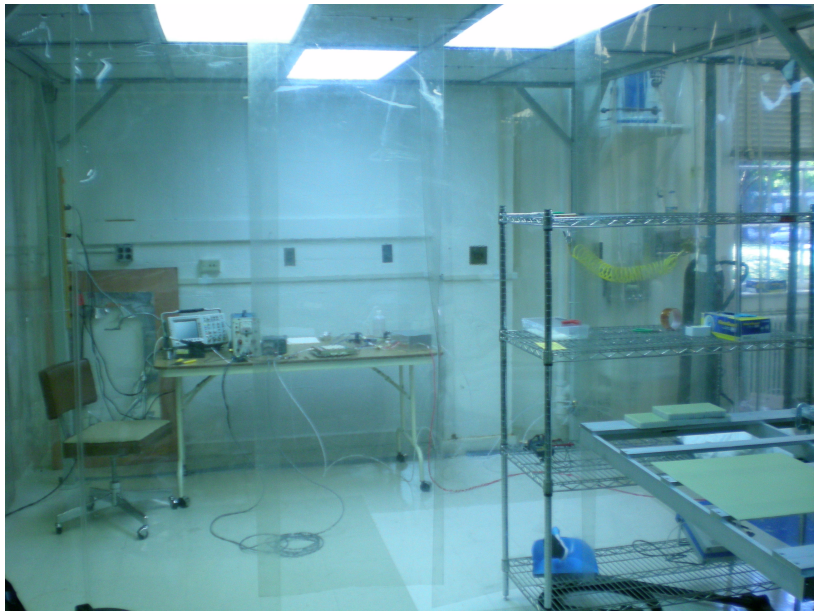
- A beam test of the completed prototype was done at DESY in Dec 2010.
  - Fully equipped 40x50 cm^2 GEM module
  - 18 APV25 front-end cards
  - 2304 channels
  - 7 independent HV levels
  - Firmware and DAQ in alpha version
- Final design now complete
- GEM and readout foils under production at CERN
- Front tracker GEM module production in Italy to start soon



Fully equipped prototype40x50 cm^2 GEM module

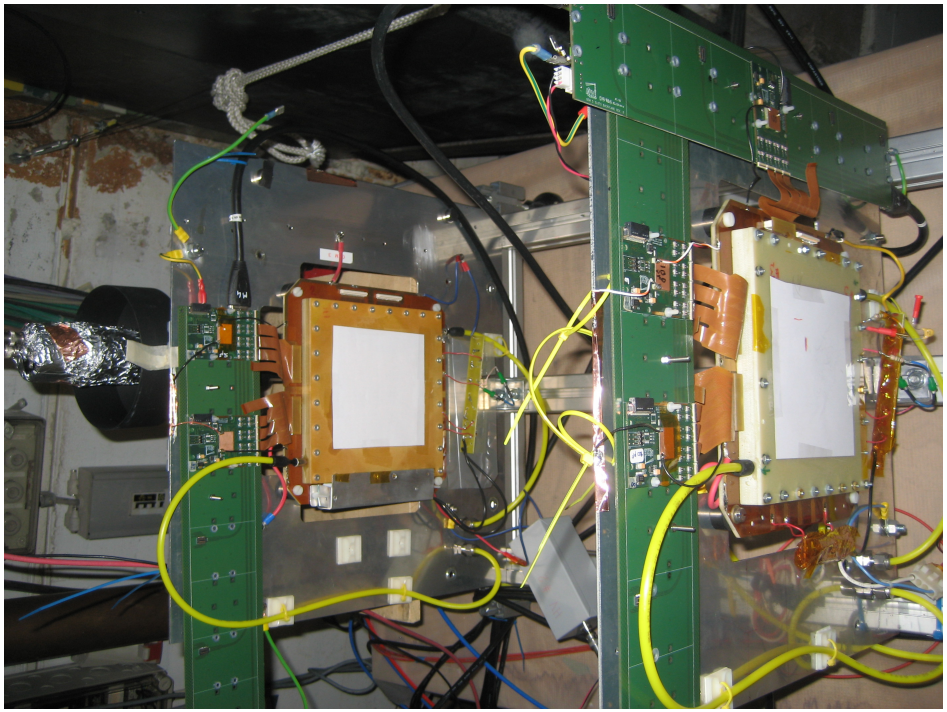
GEM construction facilities at UVa

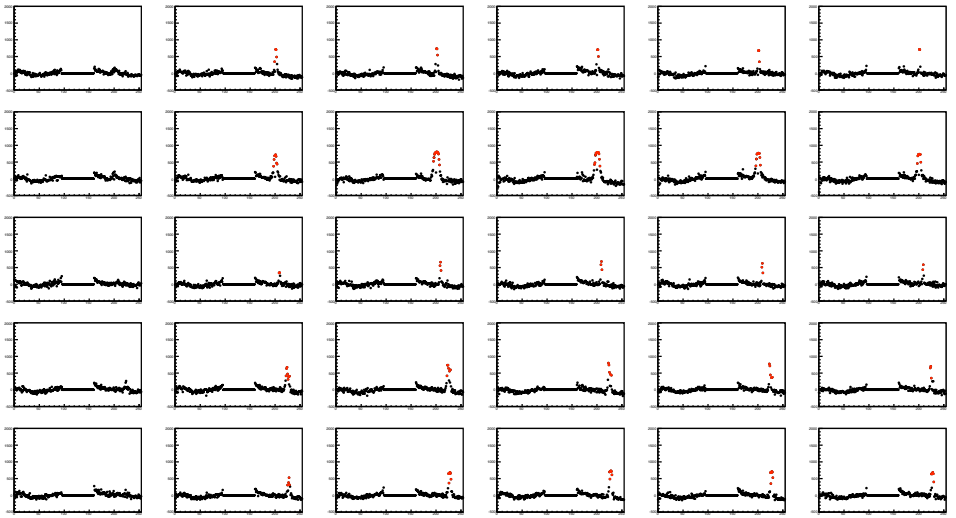
- A 3.5 m x 3 m level-1000 clean-room: this clean room was used to build
  - Drift chambers for Bigbite: 2 m x 0.5 m MWDCs.
  - Prototype GEM tracker with five 10 cm x 10 cm chambers
- Another clean room to be added early next year.
- APV25 based readout systems with 5000 channels for testing GEMs
- Wiener MPOD High Voltage system with 16 sensitive HV channels
- CODA based DAQ system
- Dry N2 storage cabinets
- Dry N2 HV box
- GEM foil stretcher



High intensity beam test at Mainz

- Recent Beam test at Mainz in September
- Demonstrate that GEMs can operate well in high rate electro-magnetic enviroements
- Rates ~ 400 kHz/cm^2
- Used 3 UVa built 10 x and APV-25 electronics.
- Data being analyzed now





Raw APV-25 ADC readout from all *x* channels from one chamber for five events (each row represents an event). Plots from left to right shows the time evolution of the signals in 25 ns intervals.

Uva GEM chamber expertise

- Liyanage and Nelyubin (Senior research scientist)
  - Built the BB MWDC together
  - Built the prototype GEM tracker
  - Few years of GEM R&D experience
- Kondo Gnanvo (Research Scientist):
  - Recognized GEM and APV electronics expert
  - Former CERN fellow working on GEM chambers with Leszek Ropelewski
  - Constructed ten 30 cm x 30 cm GEM chambers at FIT
  - development and testing of APV25 based Scalable Readout system
- Three senior graduate students
  - Students already experienced in GEM with prototype chambers.