Gas Electron Multipliers vs. Multiwire Proportional Chambers

Replacing MWPCs in de CERN experimental areas with GEMs

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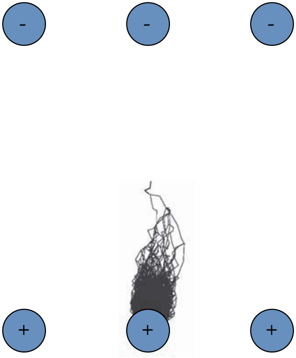
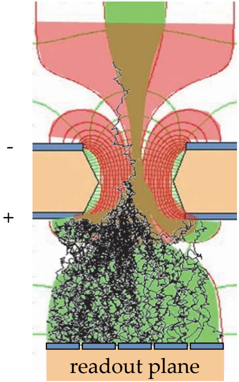
The technology

Gas detectors explained

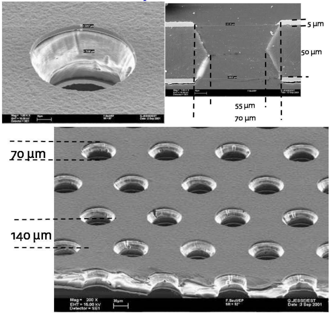




1. A fast charged particle traverses the gas, causing *ionization*.
2. Attracted by a weak electric field, the electrons *drift* to a region with a strong field.
3. There the electrons gain so much energy that they cause further ionization; a *gas avalanche* ensues.
4. Movement of all charges induces signals on the readout electrodes.

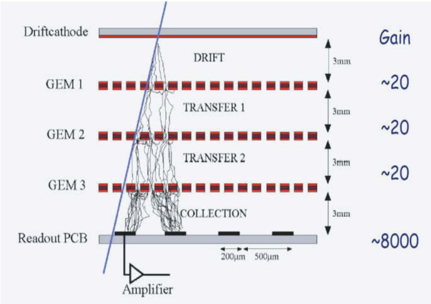
The technology

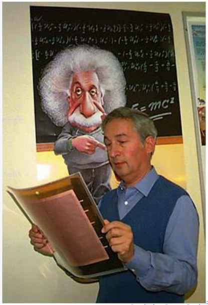
Gas Electron Multipliers

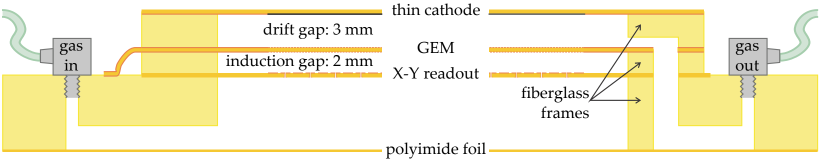


Gem properties

- Amplification structure independent from readout structure
- Fast electron signals, no ion tails
- Manufacturing based on industrial materials & procedures
- Possibility to cascade
- Flexible material, possible to change shape





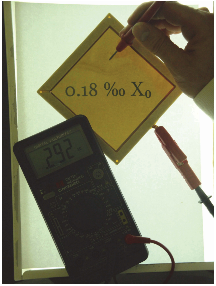


The beam

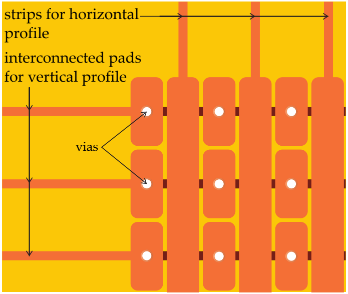
- 5.3 MeV (or 126 MeV)
- $\sim 3 \cdot 10^7$ $\bar{p}$/spill
- Spills of 100–300 ns

The detector

- Transparent cathode
- No two-chamber design
- A single GEM
- Compact model, easily fits in pendulum



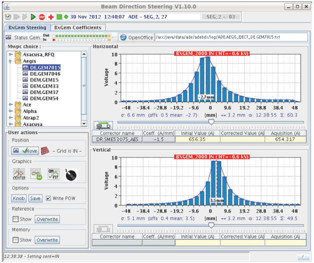
Thin metal cathode

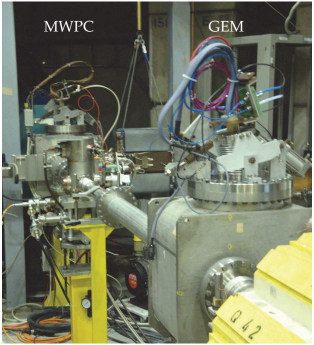


X-Y readout in one plane

Developments

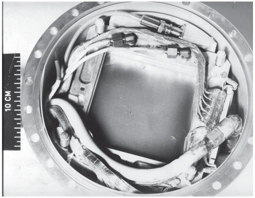
Low energy antiprotons

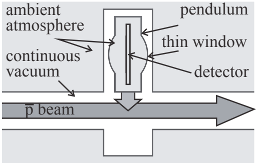


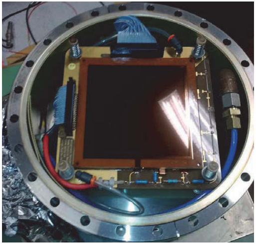


These single GEM detectors are now installed throughout the AD, where they have been giving reliable profiles ever since.

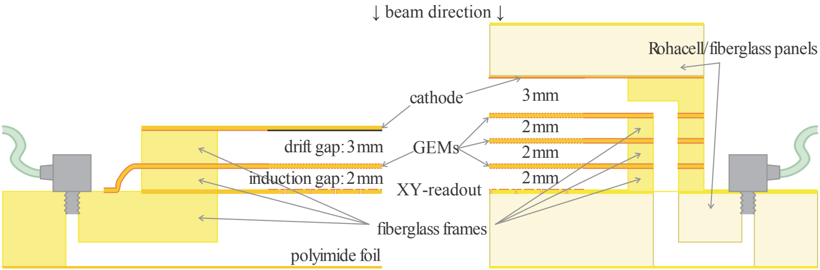
The spatial resolution can be switched between 1.6 mm and 3.2 mm by means of a pitch adapter outside the tank. This is a trade-off with active area.



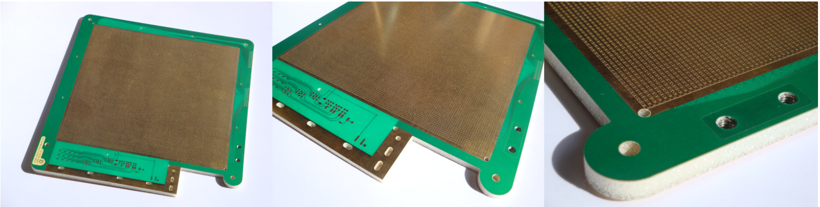




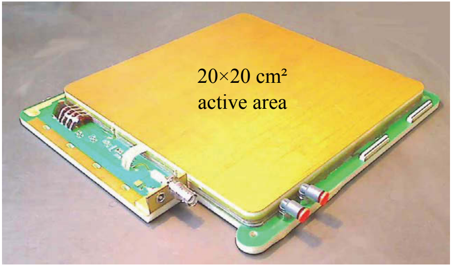
Developments
High energy beamlines

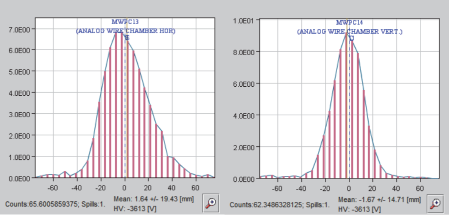


Light, stiff Rohacell foam panels on front and back of the detector. Readout and high voltage circuitry are integrated, as well as gas routing and mechanical and alignment features.



DEVELOPMENTS
High energy beamlines





- Beams of various particles and many Gev energy
- Multiple scattering less of an issue, and most monitors are motorized
- Larger area triple GEM
- Light, stiff Rohacell foam plates on front and back prevent bulging and make the detector robust

Detectors

Profile monitors in the experimental zones

Detector	Size	X/X_0	
Integrating wire chamber	$10 \times 10\ \text{cm}^2$	0.10%	
Integrating wire chamber (muon beamlines)	$20 \times 20\ \text{cm}^2$	0.06%	Very fragile
Delay wire chamber	$10 \times 10\ \text{cm}^2$	0.03%	
Single GEM	$10 \times 10\ \text{cm}^2$	0.16%	
Ionization chamber	$10 \times 10\ \text{cm}^2$	0.09%	
Triple GEM	$10 \times 10\ \text{cm}^2$	0.32%	
Triple GEM (muon beamlines)	$20 \times 20\ \text{cm}^2$	0.85%	Robust model
Scintillator, 2mm		0.60%	

All different GEM models (of the same size) are based on the same design. Which model is built is defined during assembly.

Using slimmed copper GEMS, we can make triple GEM detectors of 0.15% X_0.

Conclusions
GEMs to replace wire chambers

- The x-y readout board is successful even without GEMs
- A family of different GEM detectors was developed for the experimental areas
- These detectors perform well as beam profile monitors
- In terms of radiation length MWPCs have an edge, in other aspects of performance GEMs are more advanced
- Gem monitors are not expensive to produce, and are essentially maintenance free
- Gem properties we have not yet explored: spatial resolution ($< 50\mu$m), time resolution (< 5 ns)