



Gem-based
beam profile
monitors

Serge
Duarte Pinto

Antiproton
decelerator

Beam profiles

The detector

GEMs

Thin cathode

Xy readout

Production

Profiles

Electronics

Ionization
chamber

Conclusions

Triple GEMs

Outlook

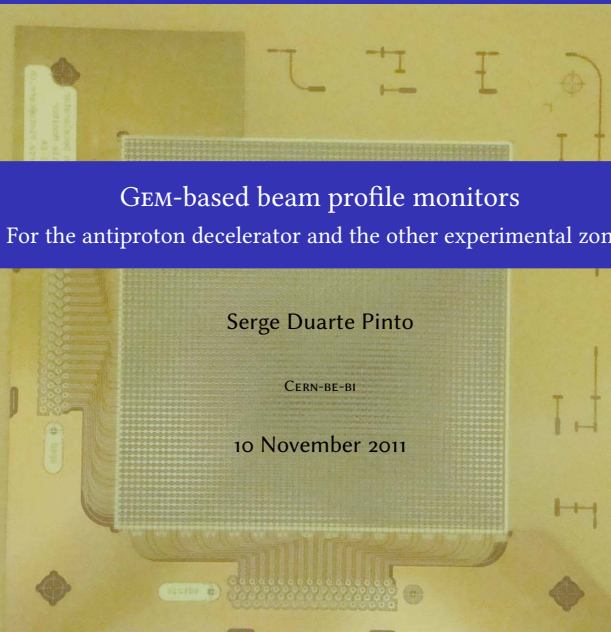
GEM-based beam profile monitors

For the antiproton decelerator and the other experimental zones

Serge Duarte Pinto

CERN-BE-BI

10 November 2011





ANTIPROTON DECELERATOR

Low energy \bar{p} beams

Grid-based
beam profile
monitors

Serge
Duarte Pinto

Antiproton
decelerator

Beam profiles

The detector

GEMs

Thin cathode

Xy readout

Production

Profiles

Electronics

Ionization
chamber

Conclusions

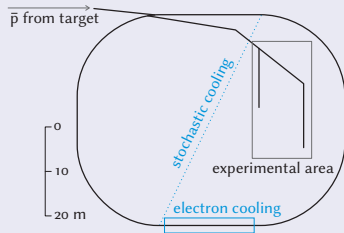
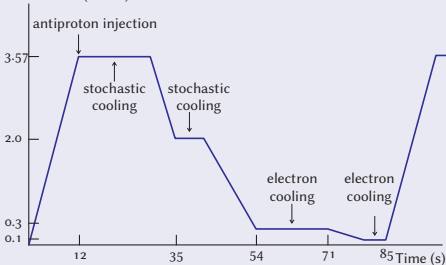
Triple GEMs

Outlook

Five experiments in AD hall

ATRAP	antihydrogen trapping & spectroscopy	5.3 MeV
ALPHA	antihydrogen trapping & spectroscopy	5.3 MeV
ASACUSA	antiprotonic helium trapping & spectroscopy	5.3 MeV
AEGIS	antihydrogen & gravity	5.3 MeV
ACE	antiproton cancer therapy	126 MeV

Momentum (GeV/c)



Short spill structure: extraction in 100–300 ns, $\sim 3.5 \cdot 10^7 \bar{p}$.



ANTI-PROTON DECELERATOR

Beam profile measurements

Grid-based
beam profile
monitors

Serge
Duarte Pinto

Antiproton
decelerator

Beam profiles

The detector

GEMs

Thin cathode

Xy readout

Production

Profiles

Electronics

Ionization
chamber

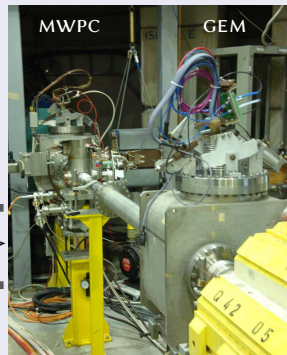
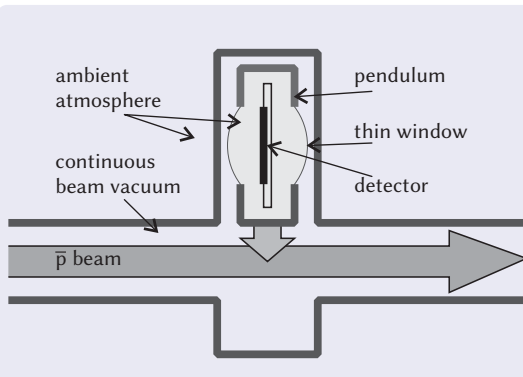
Conclusions

Triple GEMs

Outlook

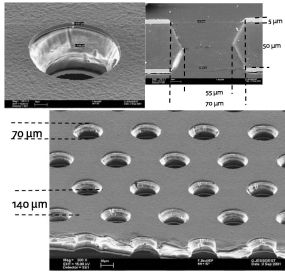
Movable detector that absorbs beam

- Due to low energy beam profile measurements are necessarily destructive.
- Detector is installed in a pendulum that can be moved in & out the beam.
- The inside of the pendulum is in contact with ambient air.
- Window of $25 \mu\text{m}$ (ss) causes energy loss and multiple scattering.

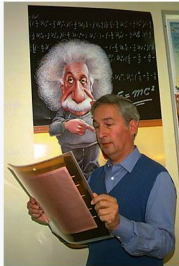
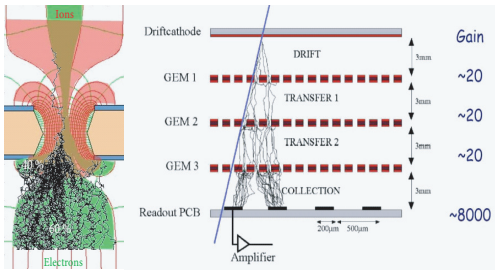




- Gas-based beam profile monitors
- Serge Duarte Pinto
- Antiproton decelerator
- Beam profiles
- The detector
- GEMs
- Thin cathode
- Xy readout
- Production
- Profiles
- Electronics
- Ionization chamber
- Conclusions
- Triple GEMs
- Outlook



- ### 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 DETECTOR

Single GEM or ionization chamber

Gas-based
beam profile
monitors

Serge
Duarte Pinto

Antiproton
decelerator

Beam profiles

The detector

GEMs

Thin cathode

Xy readout

Production

Profiles

Electronics

Ionization
chamber

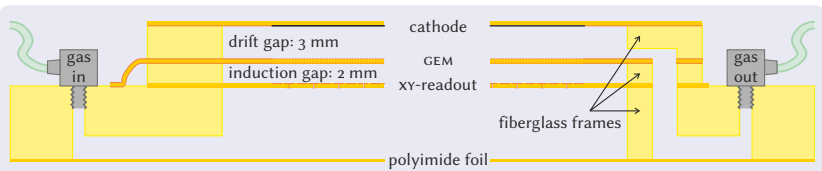
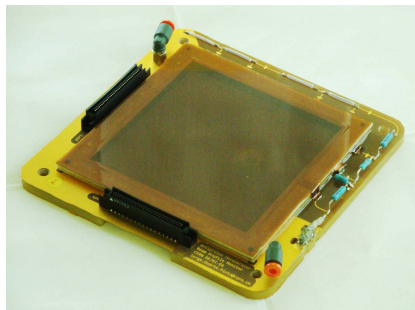
Conclusions

Triple GEMs

Outlook

Light single GEM detector

- Total material budget: 0.4 % X_0 .
- Based on $10 \times 10 \text{ cm}^2$ GEMs from CERN store.
- Gas is routed through the vias in the readout board and through the GEM holes.
- Ultra light cathode/window.
- Pads & strips xy readout.





THE DETECTOR

Ultra-light cathode

Gas-based
beam profile
monitors

Serge
Duarte Pinto

Antiproton
decelerator

Beam profiles

The detector

GEMs

Thin cathode

Xy readout

Production

Profiles

Electronics

Ionization
chamber

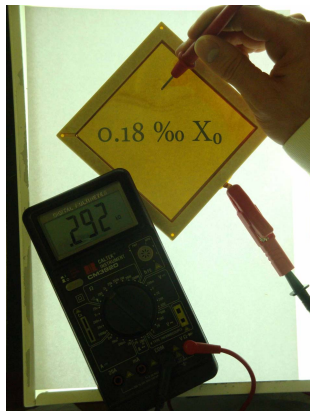
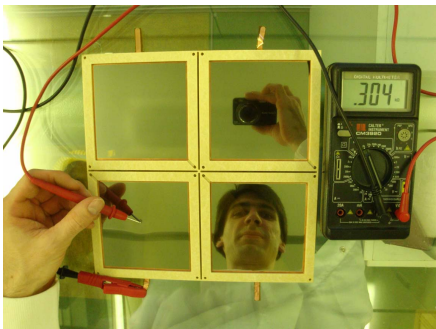
Conclusions

Triple GEMs

Outlook

Cathode & window

- Made from the base material of CERN GEMs.
- In the active area all copper is removed, but not the submicron tie-coat of chrome.
- The resistivity is reproducible from foil to foil, and does not change after stretching.
- Any surface impact must be avoided.





THE DETECTOR

Strips & pads readout board

Grid-based
beam profile
monitor

Serge
Duarte Pinto

Antiproton
decelerator

Beam profiles

The detector

GEMs

Thin cathode

Xy readout

Production

Profiles

Electronics

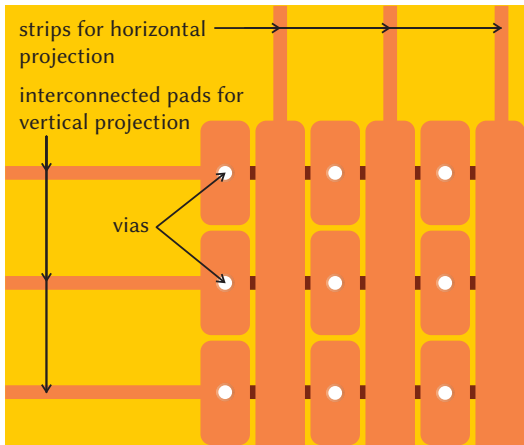
Ionization
chamber

Conclusions

Triple GEMs

Outlook

- Easy to manufacture at the wide pitch of 1.6 mm.
- Plated trough hole vias rather than microvias.
- No doubts about charge sharing.
- Works on whatever substrate, as holes are mechanically drilled.





THE DETECTOR

Strips & pads readout board

Grid-based
beam profile
monitor

Serge
Duarte Pinto

Antiproton
decelerator

Beam profiles

The detector

GEMs

Thin cathode

Xy readout

Production

Profiles

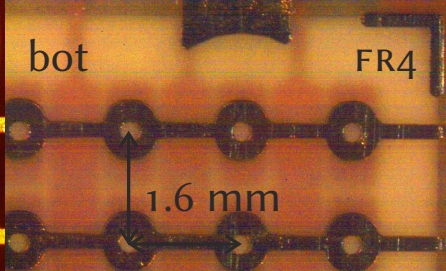
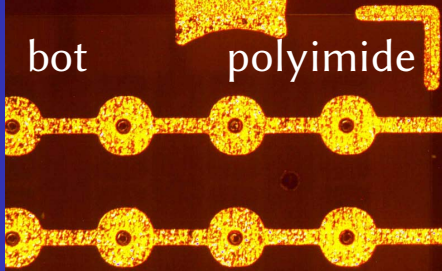
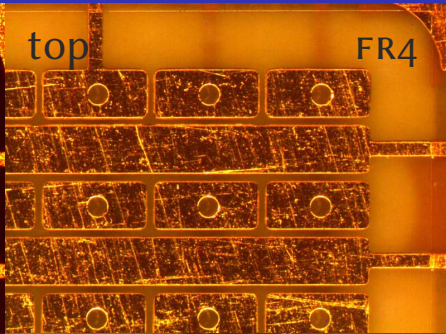
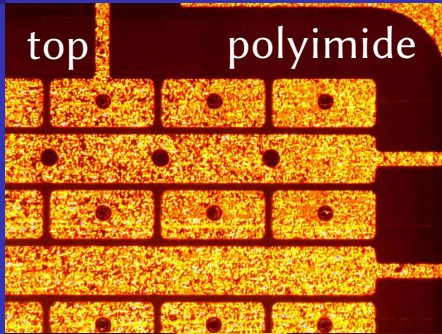
Electronics

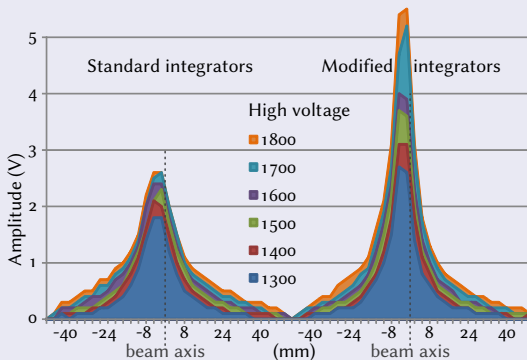
Ionization
chamber

Conclusions

Triple GEMs

Outlook



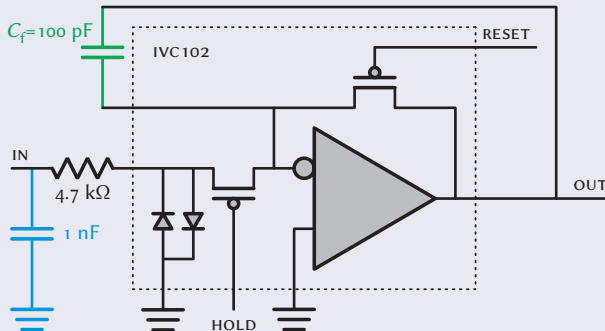


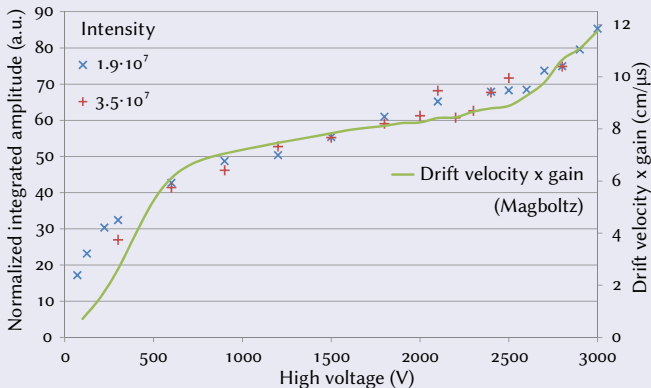
Profiles at a range of high voltage values

- GEM voltages 280–320 V. Discharges at higher voltages.
- Obviously no exponential gain. Peak is suppressed with respect to tails.
- Modification in the electronics (explained next slide) helps a lot, but still ...
- The GEM itself seems unable to deliver calibrated gain.

Tweaking electronics

- Add capacitor at input, to lower peak input current and slew rate of op-amp.
- Lower integration capacitor, lowers current and increases sensitivity.
- If you can increase sensitivity sufficiently, GEM amplification becomes superfluous (in case of 5.3 MeV beam, but how about 126 MeV?).





Micropattern ionization chamber (100 pF)

- Works fine, no distortion, proportional with beam intensity.
- Amplitude largely defined by recombination.
- Ionization density in center of the beam of order 10^{12} cm^{-3} !



CONCLUSIONS

For AD beam monitors

Gas-based
beam profile
monitors

Serge
Duarte Pinto

Antiproton
decelerator

Beam profiles

The detector

GEMs

Thin cathode

Xy readout

Production

Profiles

Electronics

Ionization
chamber

Conclusions

Triple GEMs

Outlook

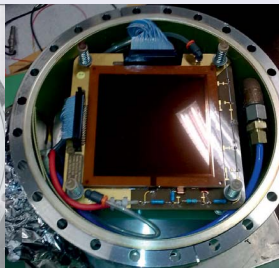
- For 5.3 MeV beams, an ionization chamber is sufficient.
- For 126 MeV beams, an additional gain of few 100 is needed.

We settle for a single GEM which can be switched between *transparent* and *multiplying* modes.

Old and new profile detectors installed in a pendulum



MWPC



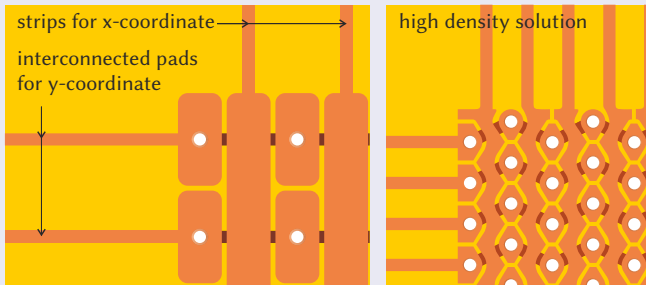
GEM



Replacement of all wire chambers

- CERN experimental areas are full of wire chambers.
- Become more & more difficult to maintain with wire experts retiring.
- We seek to develop GEM-based replacement for each type:
 - ① $10 \times 10 \text{ cm}^2$ active area, integrating electronics.
 - ② $20 \times 20 \text{ cm}^2$ active area, integrating electronics.
 - ③ $10 \times 10 \text{ cm}^2$ active area, delay line readout.

Finer-pitch xy readout



Such a layout allows pitch down to $800 \mu\text{m}$, while using FR4 & mech. drilling.





OUTLOOK

CERN switches to wireless

Wire-based
beam profile
monitors

Serge
Duarte Pinto

Antiproton
decelerator

Beam profiles

The detector

GEMs

Thin cathode

Xy readout

Production

Profiles

Electronics

Ionization
chamber

Conclusions

Triple GEMs

Outlook

- 6 detectors installed in AD so far.
- Next few months we will continue production and installation during winter shutdown.
- We already started testing triple GEMs for the other experimental areas.
- In the course of 2012 we may start production of the profile detectors (integrating electronics).
- Delay line readout could require a bit more R&D.

