R&D on a New Technology of Micro-pattern Gaseous Detectors: Fast Timing Micro-pattern Detector

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OUTLINE

- CMS Upgrade towards HL LHC
- Forward muon system challenges
- The very forward extension of ME0
- New generation of MPGD: FTM (Fast Timing Micro-pattern detector)
  - Working principle and structure
  - Results from characterization
  - Beam test and results
- Conclusion

CMS Upgrade towards HL LHC

GEM Endcap, GE2/1

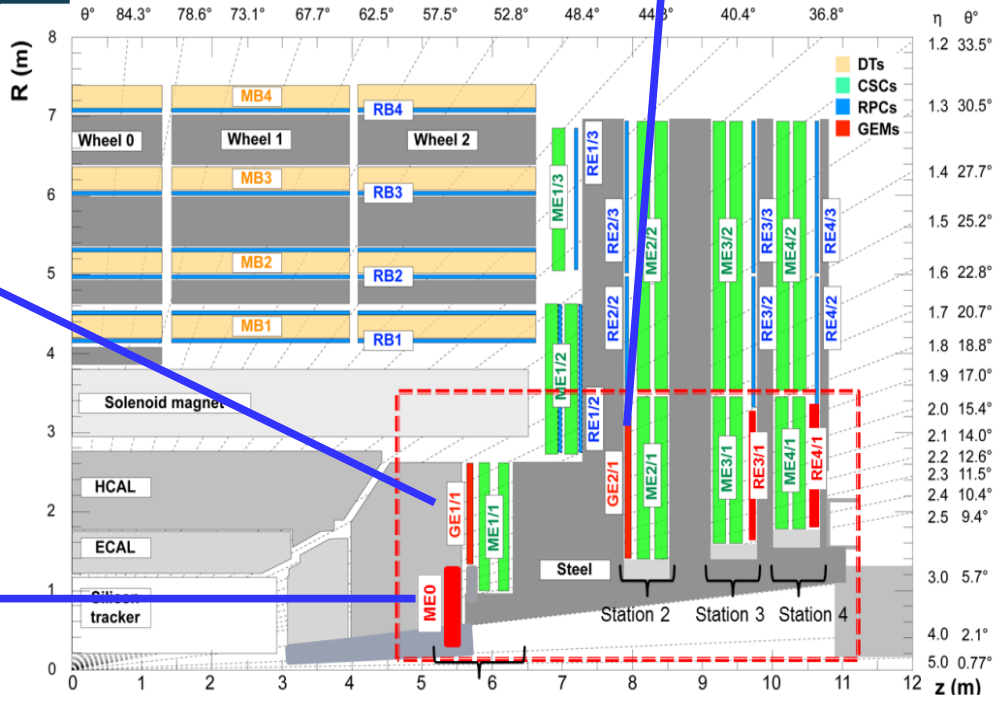
- At the region η: |η| < 2.4
- Technologies considered: GEM technology as baseline and μRWELL* as an option
- Installation proposal for LS3 (2022-24)

GEM Endcap, GE1/1

- At the region η: 1.6 < |η| < 2.2
- GEM technology
- Installation approved for LS2

Muon Endcap, ME0

- At the region η: |η| < 3.8
- Technologies considered: Back-to-back GEM detector (6 layers of triple-GEM) as baseline and new FTM detector
- Installation proposal for LS3 (2022-24)



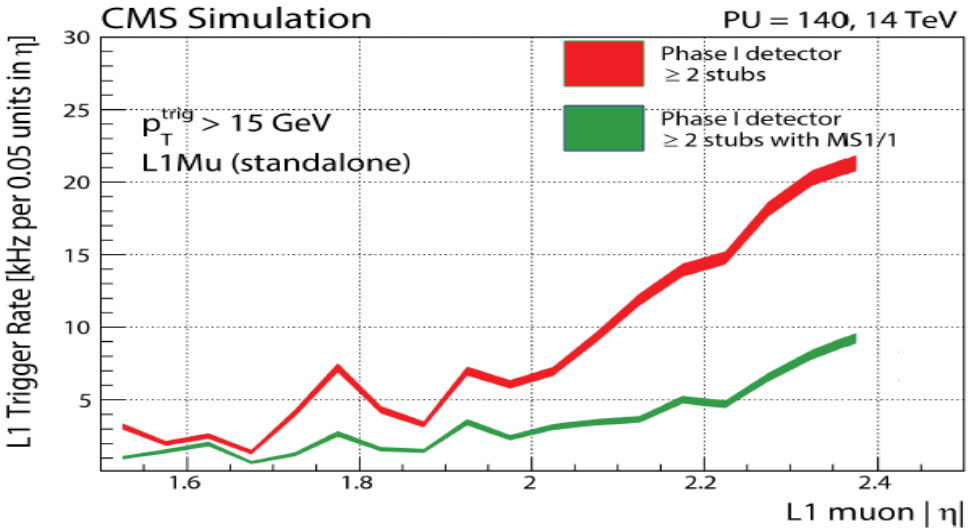
*Reference: http://iopscience.iop.org/1748-0221/10/02/P02008

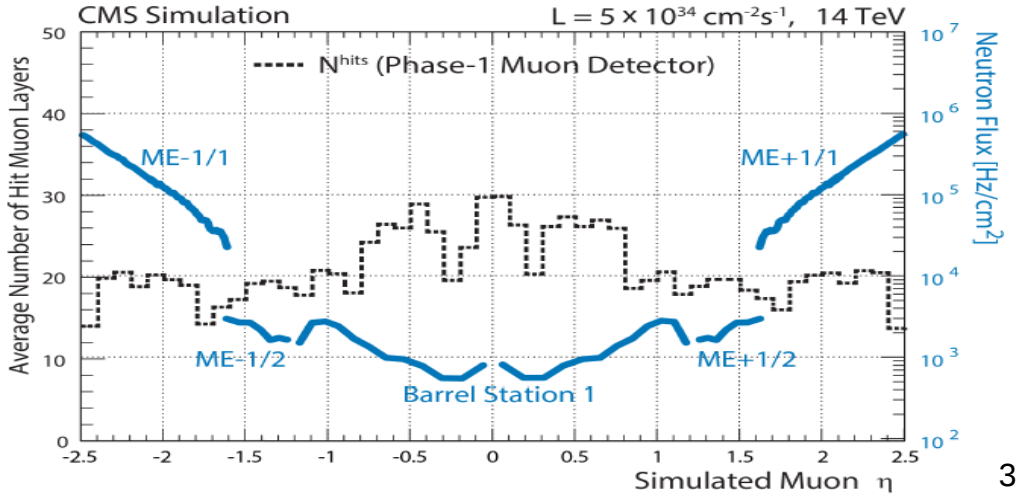
Forward muon system challenges

High luminosity can adversely affect muon system performance

The forward region is very challenging

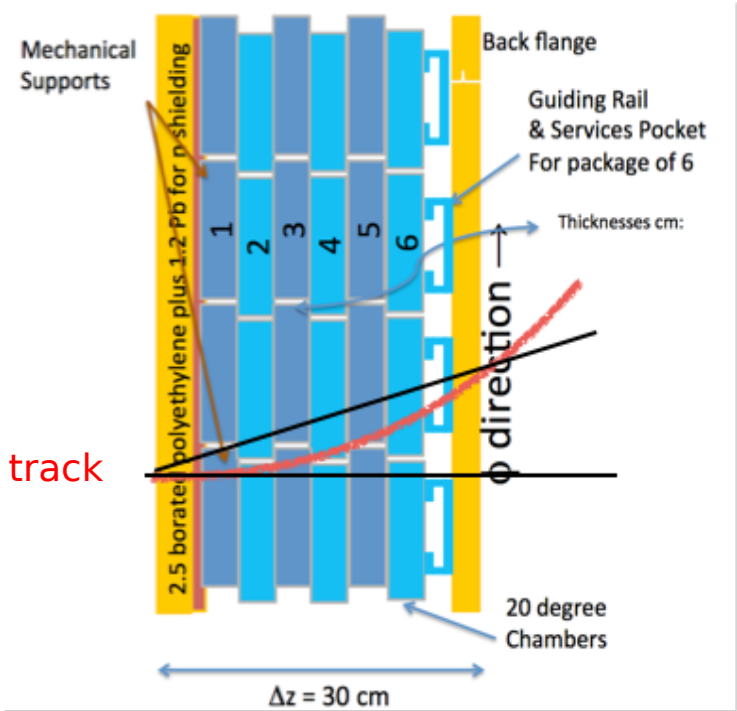
- **Redundancy**: The highest rates in the system and the fewest muon layers
- **Rate** : Very high in 10's of kHz/cm² and higher towards higher eta and worse momentum resolution
- **Longevity:** Accumulated charge after many years of LHC operation
- **Electronics:** High occupancy/rate and latency increases exceed capabilities of the existing electronics





The very forward extension: ME0

ME0 extends muon coverage behind the new endcap calorimeter to take advantage of the pixel tracking coverage extension for efficient muon ID.

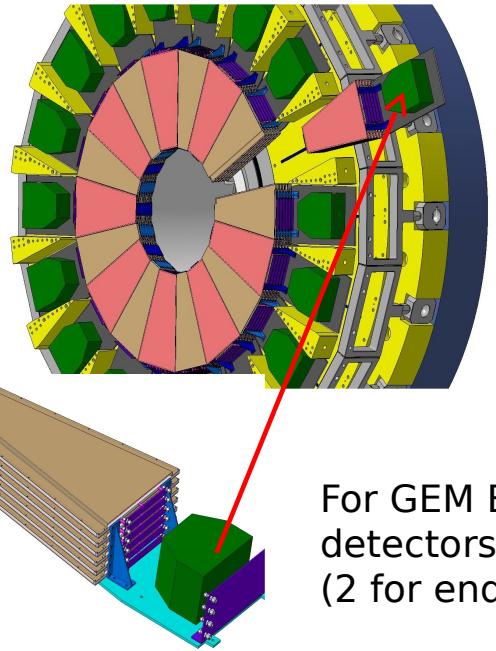


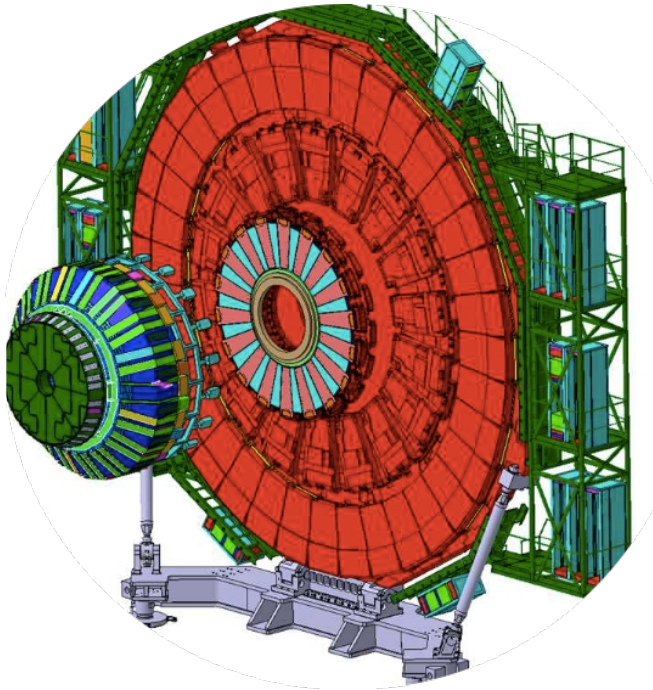
Multi-layered structure:

- Improve local muon track reconstruction, track+segment
- Spatial resolution to discriminate muon (segment) against neutrons
- Improve time resolution
  - Object reconstruction
  - Reduce in-time PU and help in vertex association

The very forward extension: ME0

Detector requirement:
- Multilayer structures
- High rate capability O(MHz/cm^2)
- Fast, so good time resolution
- No green house gases
- Good spatial resolution O(100 μm) for tracking and triggering





Baseline : Six layers of triple-GEMs

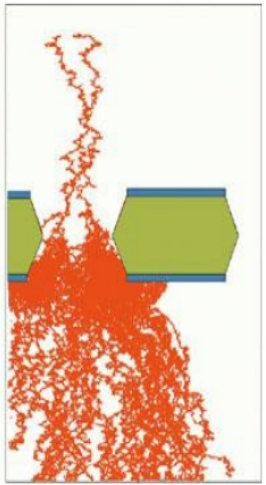
Option : Fast Timing Micropattern gas detector

For GEM Baseline proposal: 18x6x2 detectors in total
(2 for endcaps and 6 for number of layers)

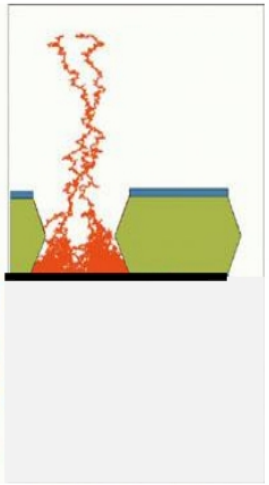
New generation of MPGD: FTM (Fast Timing Micro-pattern detector)

- A signal from every amplification stage is induced in the top and bottom readout layers.
- Time resolution improvement as a function of number of layers.
- Using two 250 μm thick drift gaps, each coupled with an amplification region composed by a fully resistive WELL.

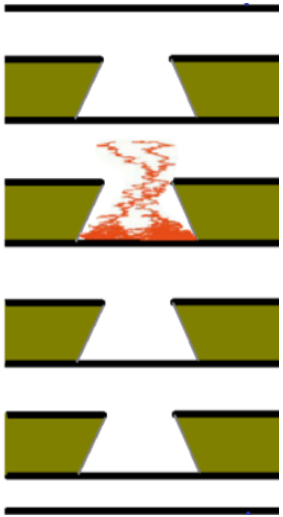
Standard MPGD



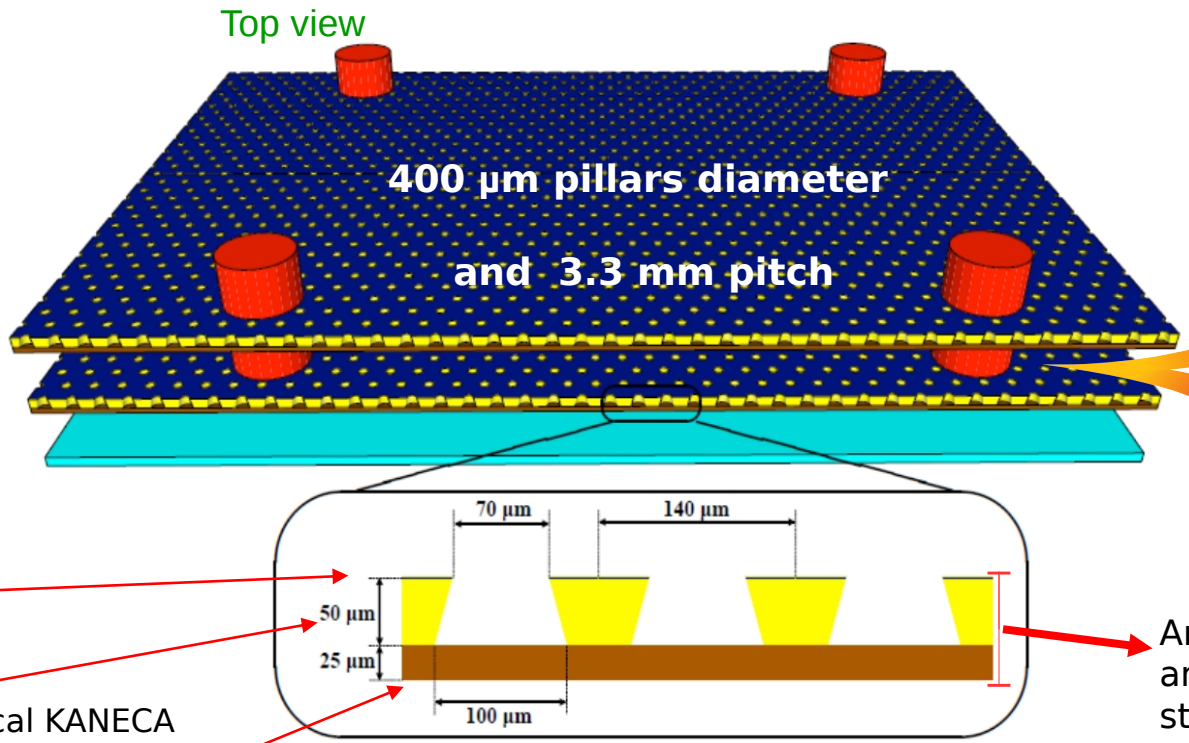
Resistive MPGD



Multi-layer Resistive MPGD



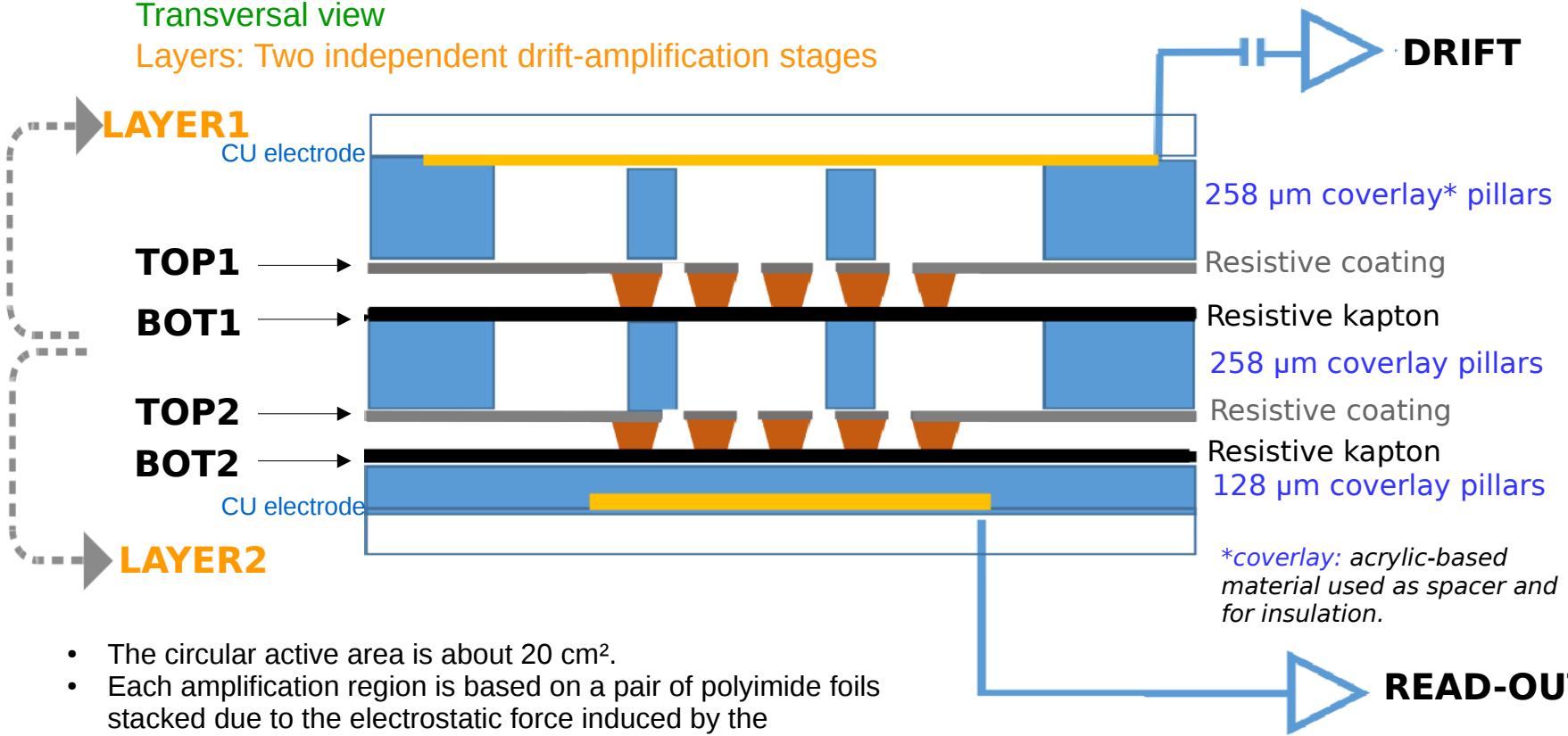
Detector layout & parameters



Structure and working principle

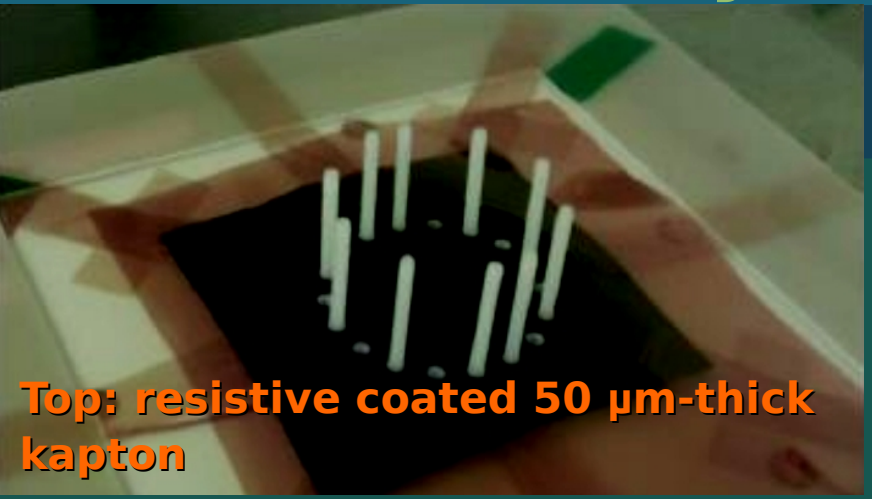
Transversal view

Layers: Two independent drift-amplification stages



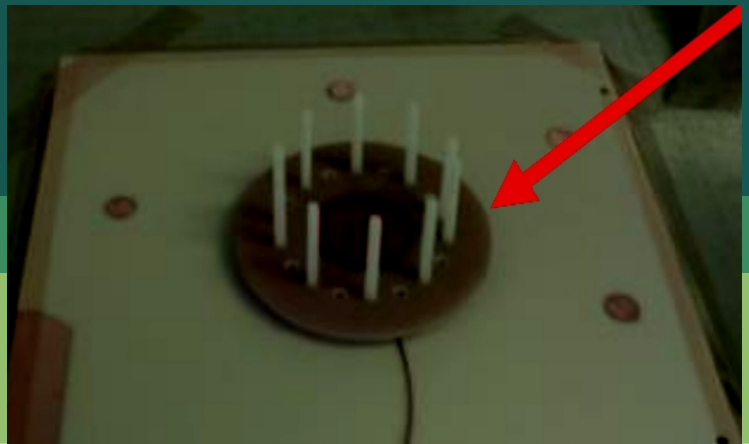
- The circular active area is about 20 cm².
- Each amplification region is based on a pair of polyimide foils stacked due to the electrostatic force induced by the polarization of the foils.

Assembly of the chamber



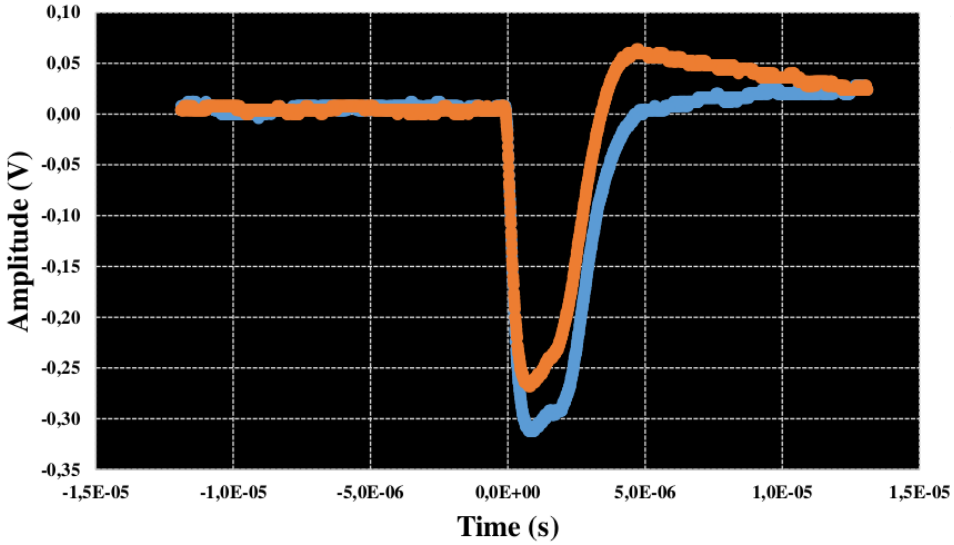
Top: resistive coated 50 μm-thick kapton

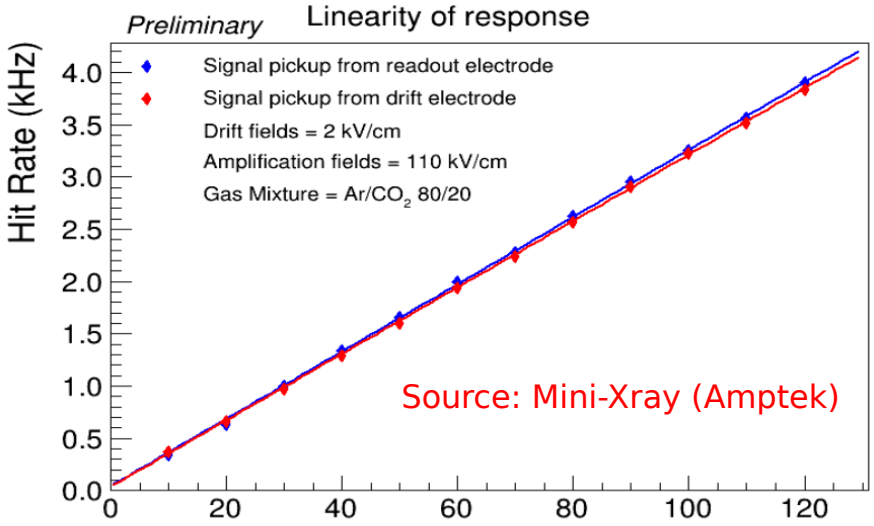
Bottom: 25 μm thick resistive kapton



Read out board
With support

Results from characterization: Electrical transparency and linearity





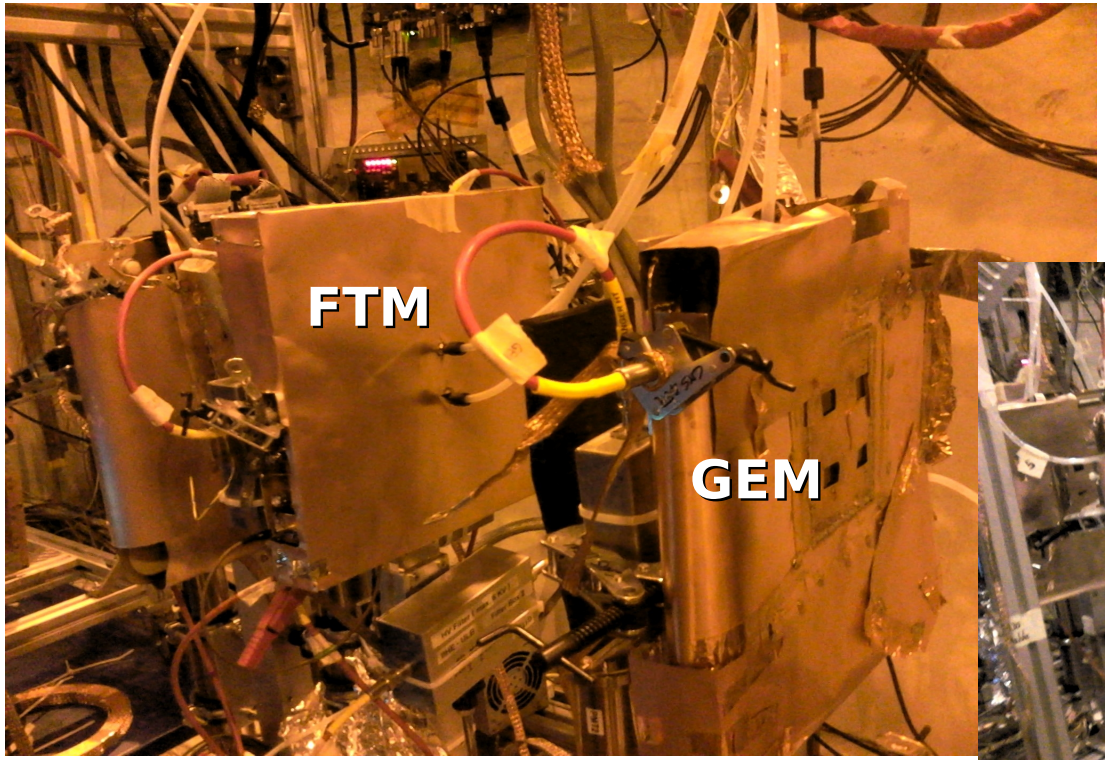
Signals from:

- Readout electrode
- Drift electrode (inverted)

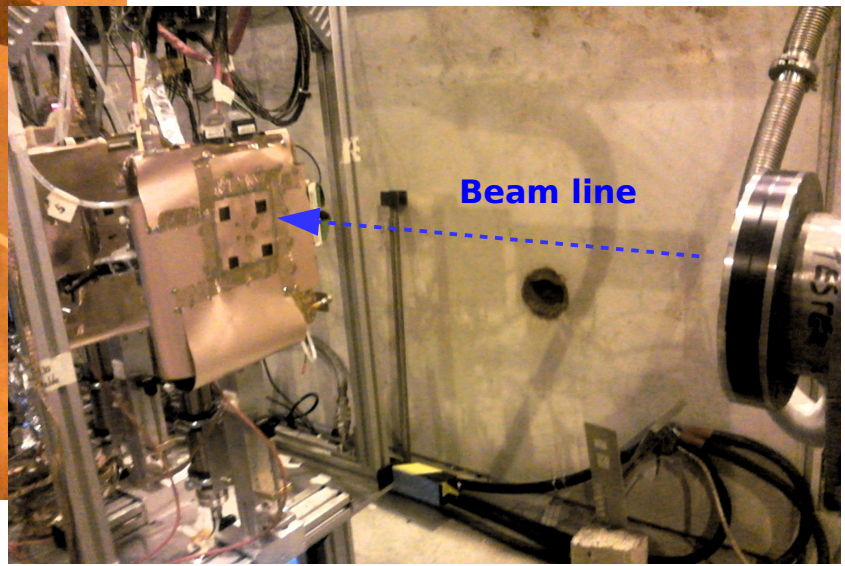
The signals are read with a preamplifier Ortec 142PC (x40000) and an amplifier Ortec 474 (x20)

- Signals are induced in the readout layers from the internal amplification layers.
- The rates measured from the readout and the drift electrodes are increasing linearly with the flux.

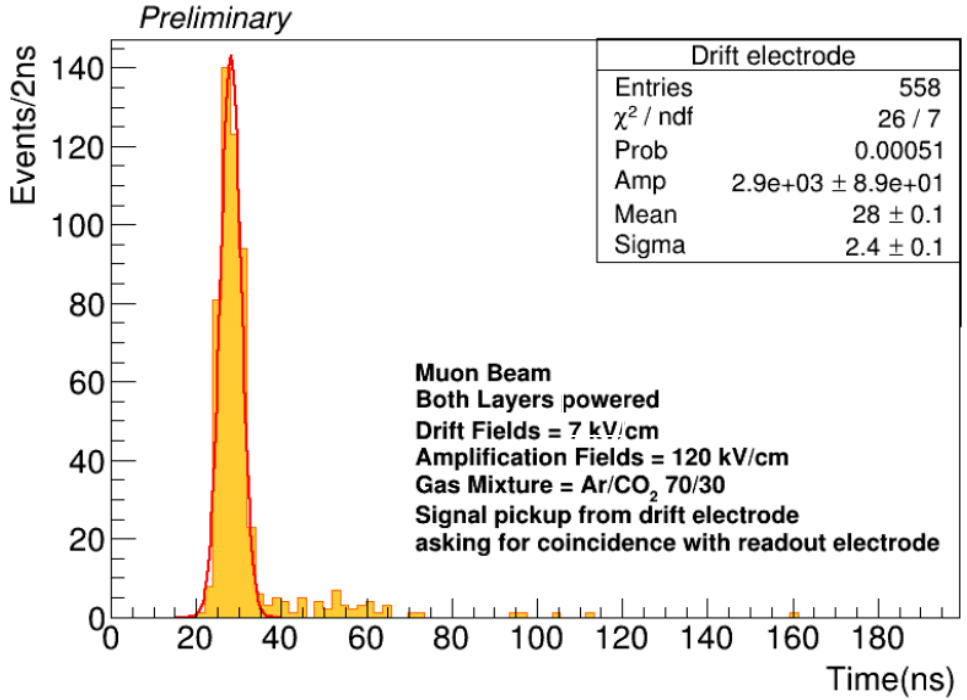
Beam Test - SETUP



- The FTM detector
- 4 scintillators, including a finger scintillator for triggering
- 3 GEMs 10x10 cm² for alignment



Results : Time Resolution



- Beam test is focused on the estimation of the time resolution.
- The time distribution of the signal got from the drift electrode with muon beam.
- The electronics chain used to readout the signals composed by a Cividec broadband amplifier (x100) and a Lecroy linear amplifier (x7.5). This chain is **faster** for timing measurement.

CONCLUSION

- The first measurements are performed on a new prototype of MPGD, Fast Timing Micro-pattern (FTM) detector.
- The results from the first prototype show linear response to the rate and electrically transparent.
- The time resolution is measured with muon beam as the first estimation of the order of 2 ns without CF_4 gas.
- The R&D is ongoing with the design of a new prototype fully PCB-based, with at least 4 independent stages.
- Additional test beams are planned to measure time resolution, efficiency and spatial resolution.

THANKS!

Any questions?

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