MPGDs for Fast Timing Applications (MPGD-FaTimA)
The Big Picture

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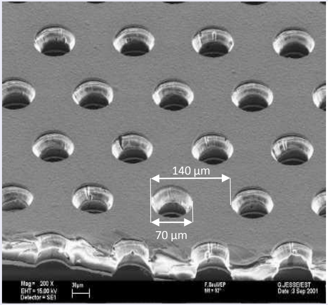
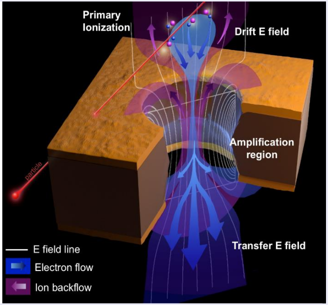
MPGD FaTimA meeting 2
December 21th 2017, Bari

Micro Pattern Gaseous Detector (MPGD)

Example: Gas Electron Multiplier (GEM)





Advantages:

- Photo-lithographic techniques allowed to produce **Micro Patterned detectors**
- Main Characteristics: High rate capability ($> 50\,\text{MHz/cm}^2$), good spatial resolution ($50\,\mu$m), high efficiency ($\geq 95\,\%$), time resolution of $\mathcal{O}$(5–10 ns)
- flexible detector structures (cfr. cylindrical trackers for KLOE and BES-III)

Micro Pattern Gaseous Detector (MPGD)

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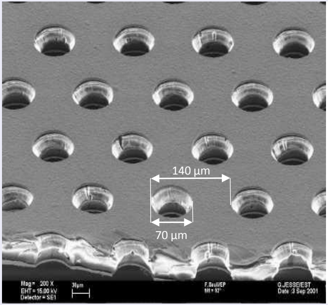
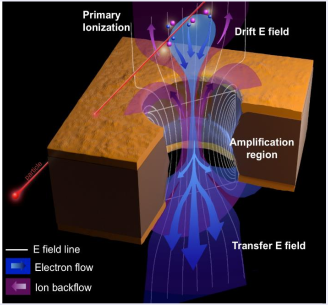


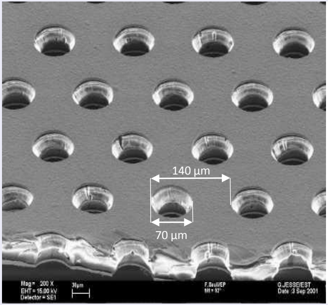


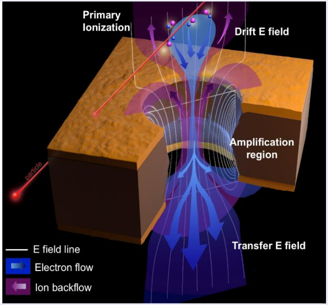
Advantages:

- Two separated regions: **drift region** (creation of electron-ion pairs) and **gain region** (multiply drifted electrons to observable electric signal)
- Rate capability is improved by fast collection of postive ions
- MPGD Time resolution driven by fluctuations in creation of electron-ion pairs

Micro Pattern Gaseous Detector (MPGD)

Example: Gas Electron Multiplier (GEM)

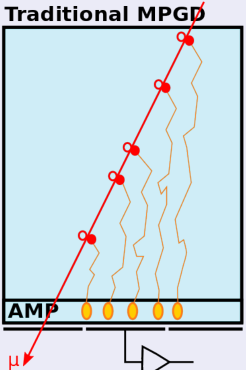




Drawbacks:

- Single Stage Gain limited to few 10^3 $\Leftrightarrow$ Wire detectors: 10^4–10^5
- Recently μ-RWELL: Gains of few 10^4 with LHCb Triple-GEM Gas (Ar:CO_2:CF_4)
- Discharges Limits Maximum Gain and provoking irriversible damage

Fast Timing MPGD Principle



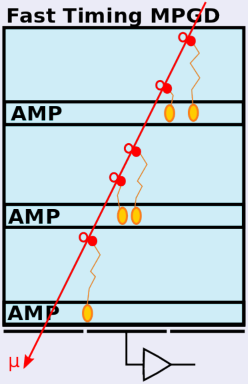
σ_t driven by distance fluct's

$$\sigma_t \propto 1/(\lambda v_{\text{drift}})$$
$$\lambda = \#\ \text{primary cls}$$

electron-ion pairs created close to amplification structure result in fast signals

Fast Timing MPGD: split drift volume in N layers, each with own amplification structure

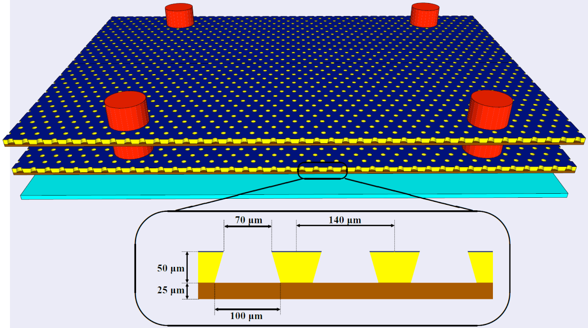
$$\sigma_t \propto 1/(\lambda v_{\text{drift}} N)$$

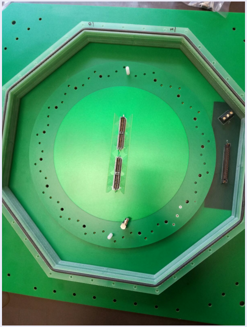


- **resistive structure $\Rightarrow$ signal from any layer induced in readout**
- **resistive structure $\Rightarrow$ limits development of discharges**
- **time resolution should improve with N = number of layers**

New FTM Prototype (FTM-v4) :: Design

4-layer prototype: (extendible to 16 layers)

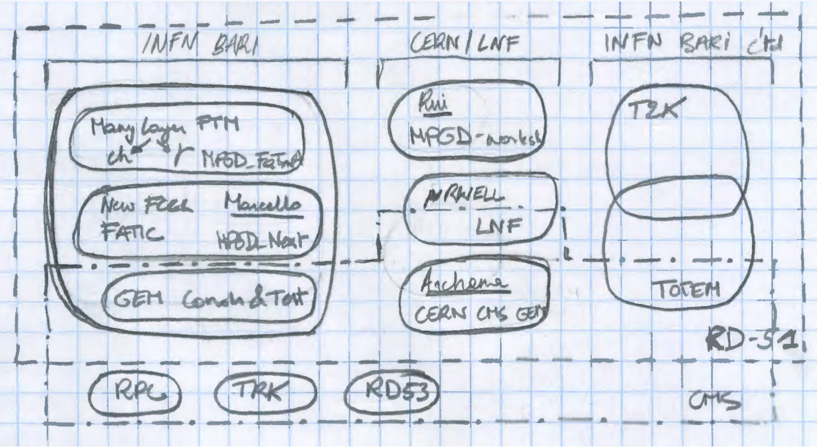




Single layer specifications:

- Drift layer: 250 μm drift layer (Red: Dupont Coverlay spacers)
- Gain layer: 50 μm kapton (Yellow: GEM foil: 70 μm hole, 140 μm pitch)
- Support Layer: 200 μm (Brown: Pre-Preg (glue) + FR4 PCB)
- Resistive coating: 10–100 nm, $\sim$ 100 M$\Omega/\square$ (Blue: Diamond Like Carbon: DLC)

Research Environment: INFN Ba, LNF, CERN



- **"Competitor": Picosec** (CERN/CEA Saclay/Greece): 100 ps (but likely *not rad-hard*, cheap and difficult to go to *large area* due to γ-cathode)

FTM Funding in CSN-V

MPGD Next (2016-2018): PI Silvia Dalla Torre

- groups INFN (Trieste, Roma, Bari, LNF) R&D on MPGDs:
  THGEM, Resistive MM, FTM, μRWELL
- **New Structures:** (*PI: Marcello Maggi*):
  R&D of new FCCL (125 μm, Cu-DLC-PI-DLC-Cu, ...), study elementary cell
- **Electronics:** (*PI: Antonio Ranieri*):
  R&D of Front-End Chip for Fast Timing MPGD
  - first submission to foundary (Dec 2016) funded by CSN-I

MPGD FaTimA (2016-2017): PI Piet Verwilligen

- development of FTM for Fast Timing Applications (FaTimA)
  - demonstrate fast timing of multi-layer FTM for charged particles (HEP)
  - adapt multi-layer FTM for 511 keV photons (TOF-PET)

FTM Challenges

FTM requirements:

- detection of single photo-e^- (closest) instead of all e- in drift
  (i.e. factor 10 reduction in charge)
- detection with single amplification layer
  (Triple GEM has amplification divided in three stages)

Therefore:

⇒ need high gain structure, with low spark/discharge rate

⇒ need low noise detector and low noise electronics

⇒ need electronics that can process pulse with low charge ($10^4 e^- = 1.6$ fC)

⇒ need electronics that can process and preserve a fast pulse

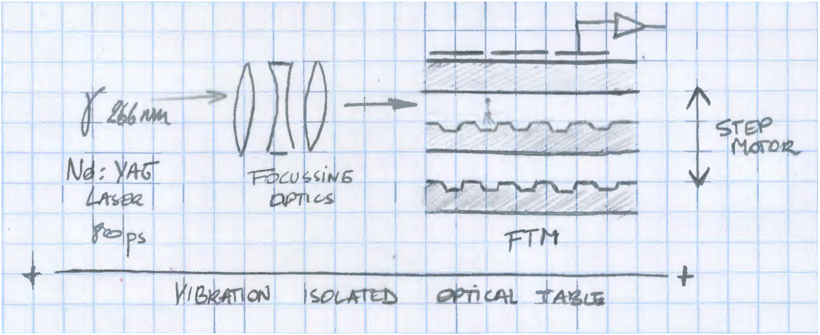
This Meeting:

- Discuss Future plans for Electronics (FATIC v2)

Expectations for 2018

1. **HV-cleaning of FTM-v4:**
   → demonstrate we reach same (high) gains in single layer as μ-RWELL
   → use $Ar:CO_2$, $Ar:CO_2:CF_4$, $Ar:iC_4H_{10}$, $Ne::iC_4H_{10}$ mixtures
2. **Test FTM with a Laser:**
   → first test: Antonio Ancona CNR (~ 335 nm)
   → later: purchase 800 ps UV (~ 265 nm) laser with μJ/pulse)
   → will be also the first test for FTM + electronics !!!
3. **Develop Test Beam Setup** and **test FTM with Beams** at CERN
   → Arrival of 2 Mosaic Boards
   → Procurement of Tracking GEM and MCP for timing reference
4. **Develop large area FTM-v5:** $30 \times 30\,\text{cm}^2$ with spacer less design
   → Discussed with Rui to make test-setup to check kapton *sag*
5. **Produce FTM with Lower Resistivity:** to study rate capability
   (funded by CSN-I RD_FA)
6. in meanwhile keep simulating and bring also the γ-FTM to a next stage
   → will have a dedicated meeting in January
7. **mid-2018: start writing proposal for ERC starting grant**

Laser Tests



γ 266 nm
Nd: YAG
LASER
80 ps
FOCUSSING
OPTICS
FTM
STEP
MOTOR
VIBRATION ISOLATED OPTICAL TABLE

Test Beam Setup