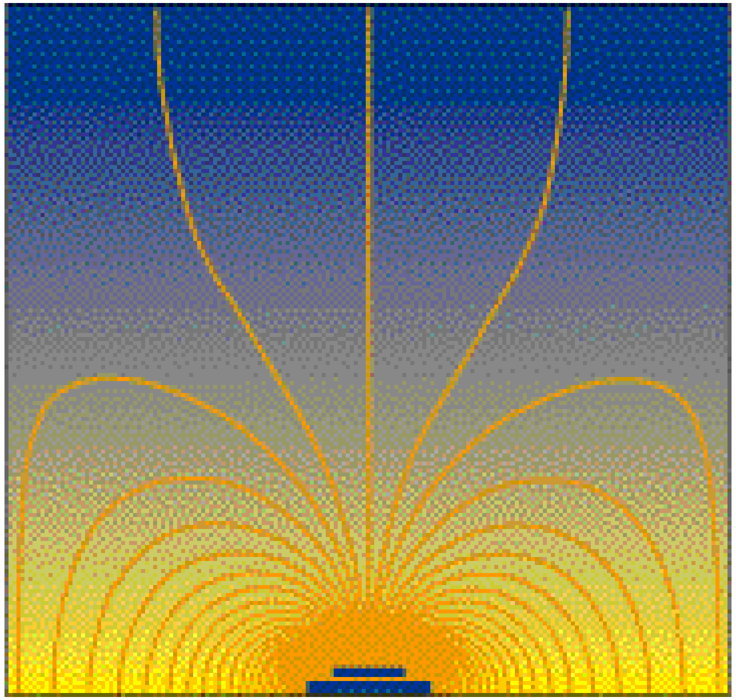
some thoughts on charging-up effects

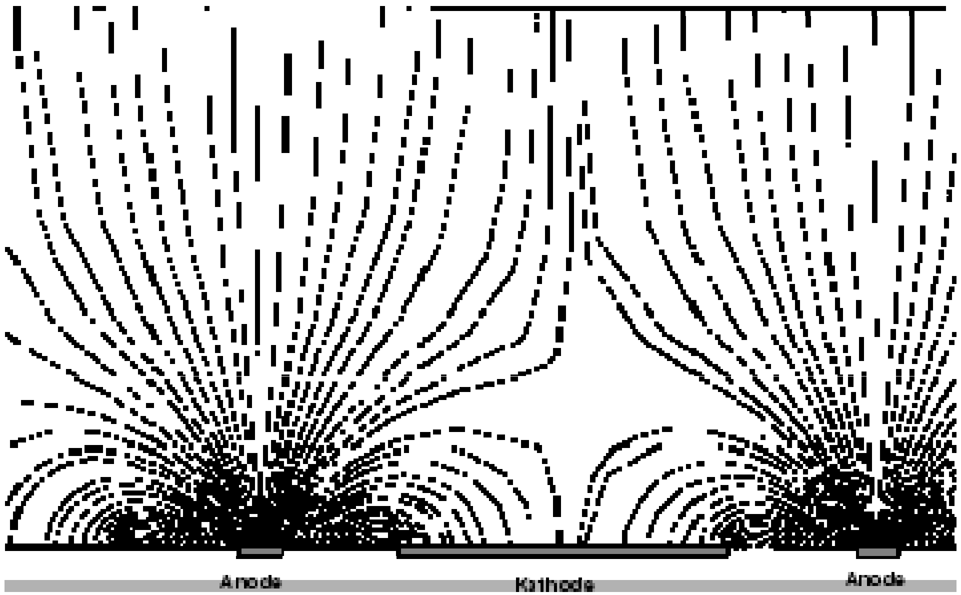
HvdG, Nikhef
RD51 Workshop, Paris, 2008

Micro Strip Gas Counters: hard to operate:

- discharges, ruining electrodes
- ageing

! Very strong electric field in insulator’s volume & surface !





GEMs:

- often cascade of 3 GEMs used to limit gain per GEM to ~40
- ‘rim’ (dia hole Cu/kapton) critical
- shape of hole wall critical
- charge up effects

Overview of MPGD development in JAPAN

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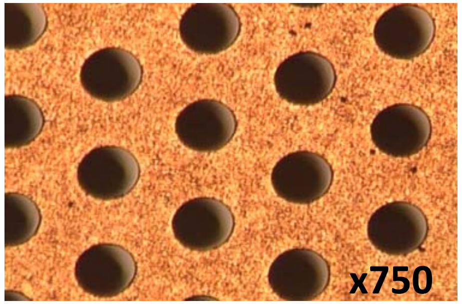
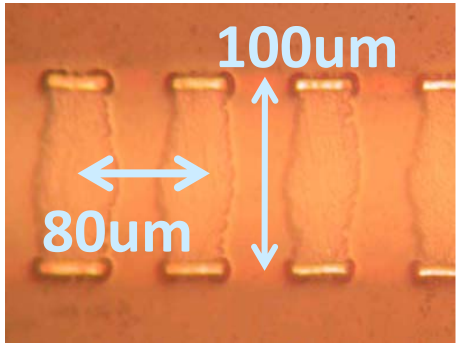
13 Oct. 2008 2nd RD51 workshop in Paris

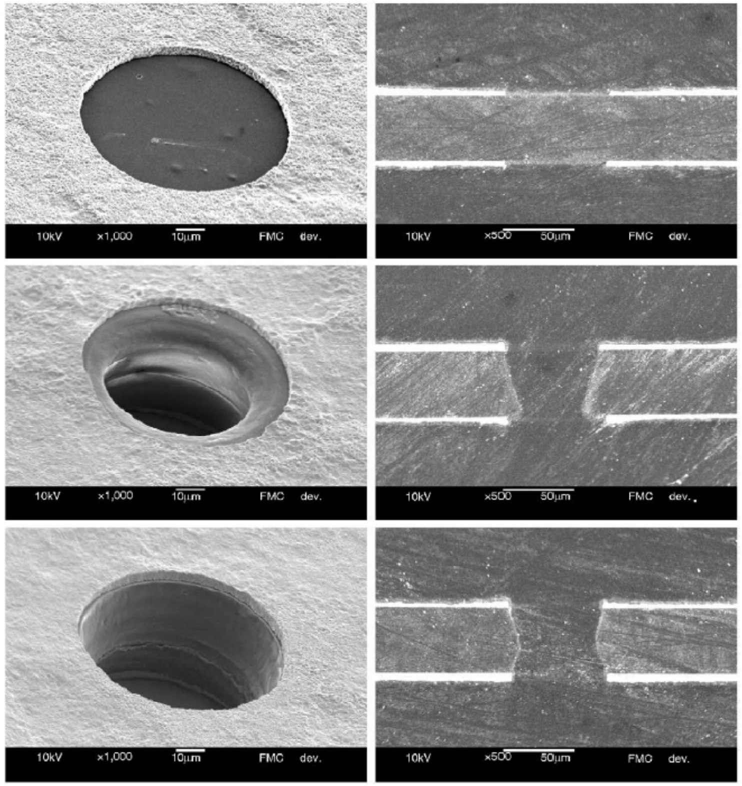
GEM Production

RIKEN/SciEnergy GEM
(thick-foil and fine-pitch)

- **pitch 80um**
- **hole 40um**
- **thickness 100um**







Remove copper by wet etching

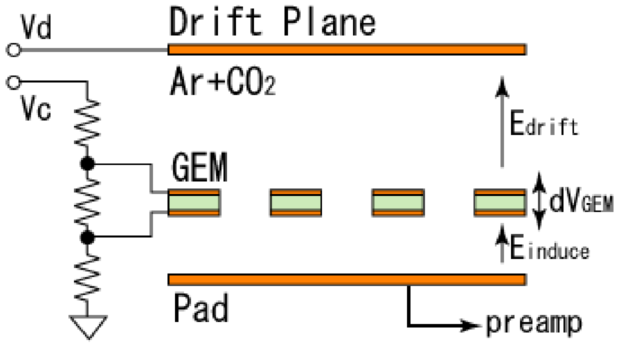
Irradiate CO_2 laser

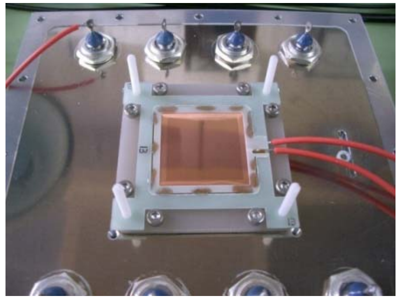
Remove remaining edge from the other side

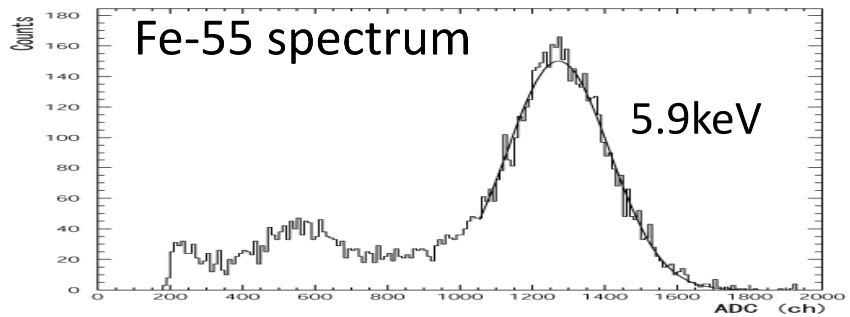
Gain Curve (RIKEN GEM)

GEM test setup and parameters

- Thick-foil and fine-pitch GEM (single layer)
- HV supplied through a resister chain
- Ed=2.5kV/cm, Ei=4~5kV/cm, ⊿V_{GEM}=300~600V
- Gas: Ar+CO_2(30%) flow
- Readout by 1cm x 1cm pad

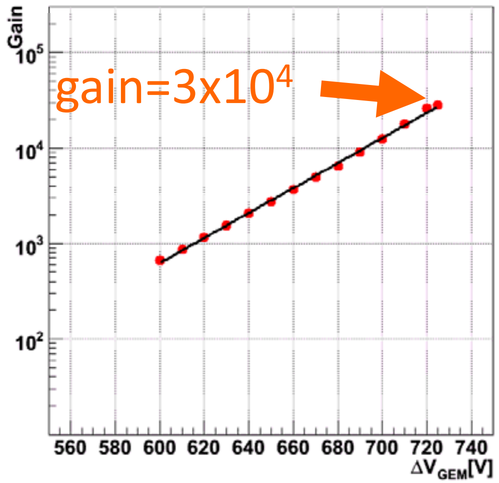






Gain measurement

- Gain vs applied voltage
- X-ray from Fe-55 (5.9keV)

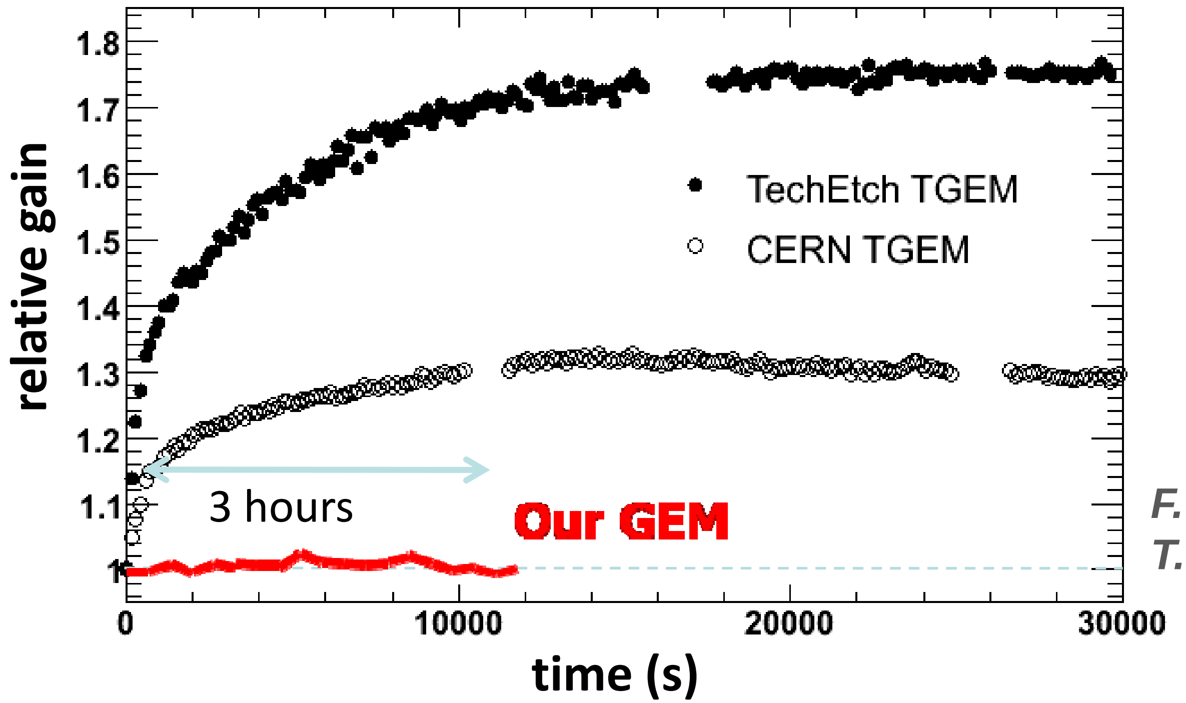


To keep good spatial resolution and keep discharge point at high gain.

Our GEM is most suitable for Cosmic X-ray Polarimeters.

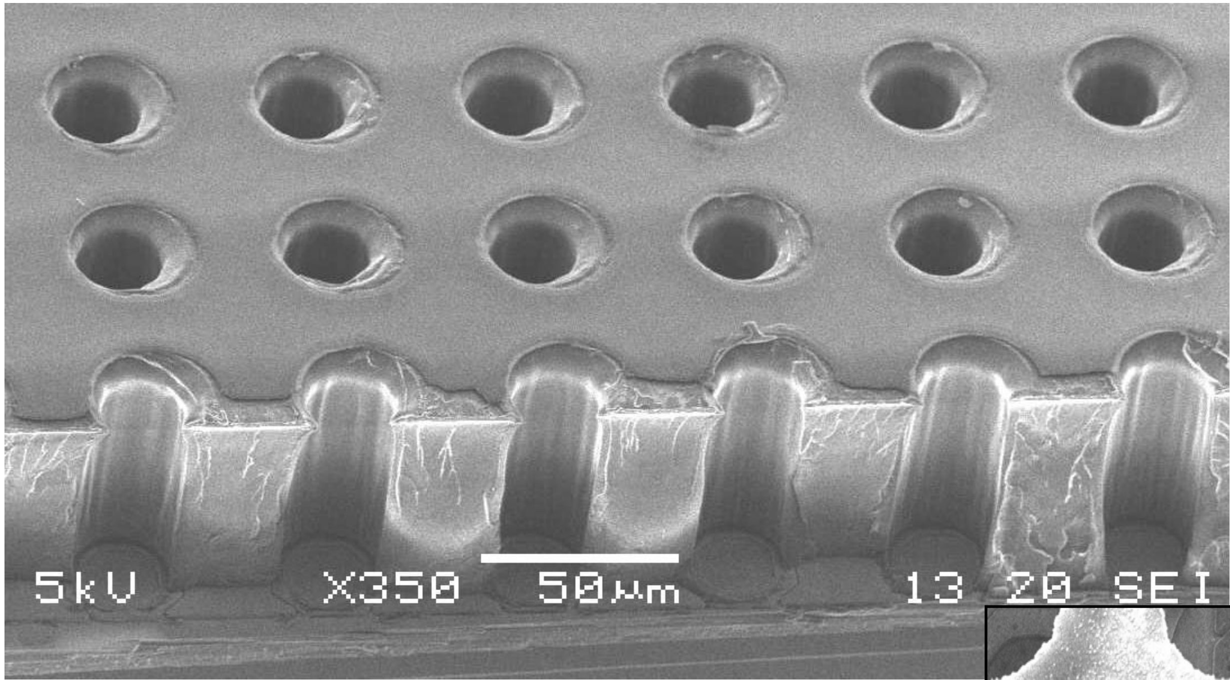
Gain instability (RIKEN GEM)

No increase and decrease just after HV on.

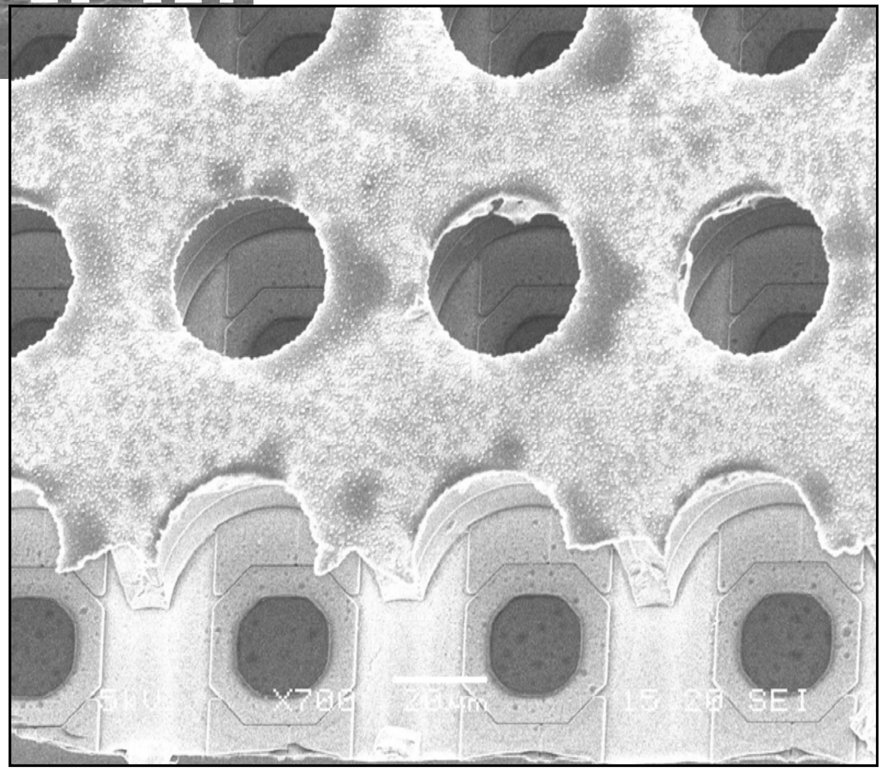


F. Simon (IEEE, 2006)
T. Tamagawa(IEEE,2007)

- **No gain increase in short measurements**
- **This is not for a special batch of GEMs but for all GEMs we produced**
- **Possible reasons;**
  - ✓**Less charging-up due to cylindrical hole shape**
  - ✓**Less polarization of Liquid Crystal Polymer**



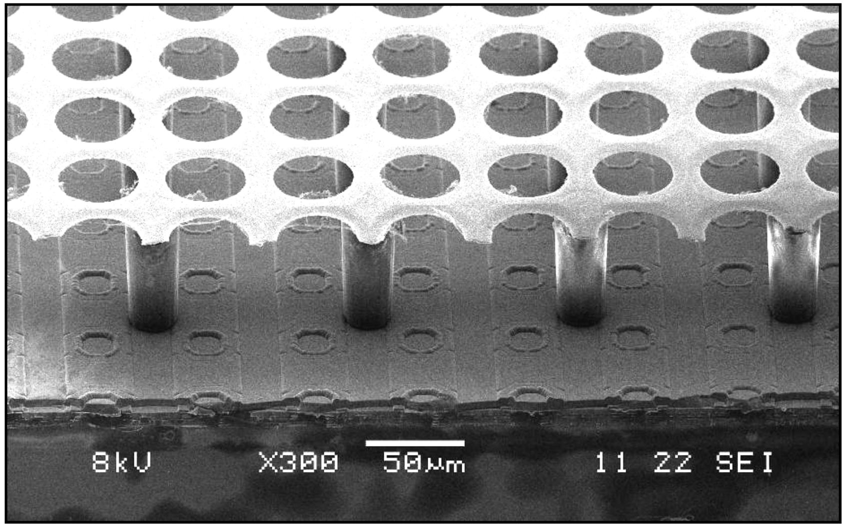
GemGrid 1



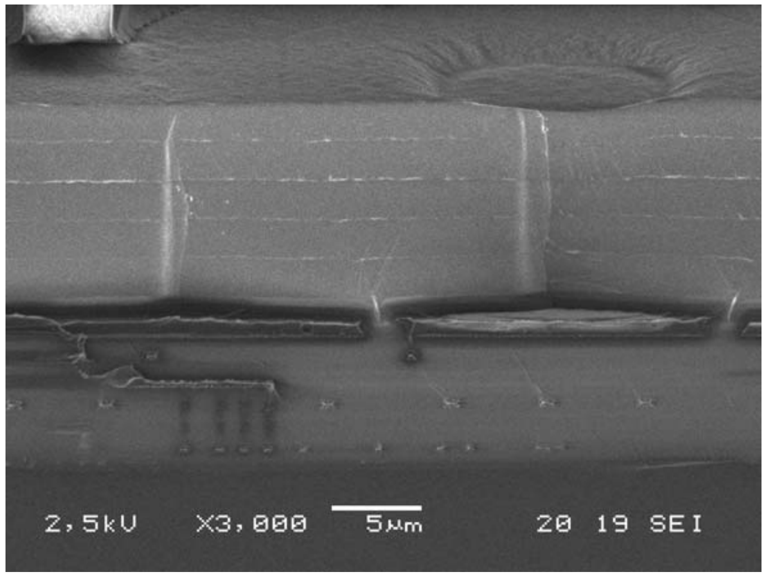
GemGrid 2

Bulk high-resistivity materials

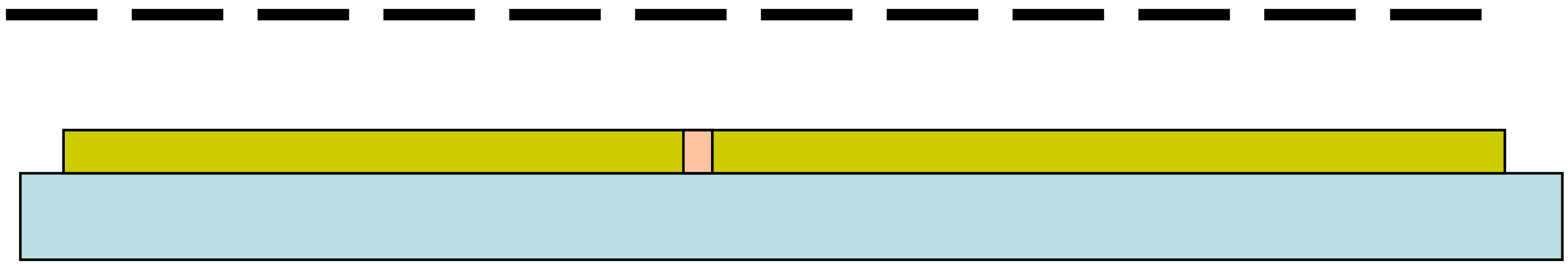
hydregenated amorphous silicon



Si rich silicon nitride (Si_3N_4)



Measurements on Si-rich Silicon Nitride (Si_3N_4)



Column resistance: ρ D/O

Potential surface measurable: gain drop factor 2 at dV = 17.5 V

With known current: bulk resistivity ρ measurable: ~ 1 – 50 10^{13} Ohm cm

Surface time constant: Column resistance x (virtual colum capacitance) =

(ρ D/O)*(ε O/D) = ρ ε   (independant of layer thickness D!)

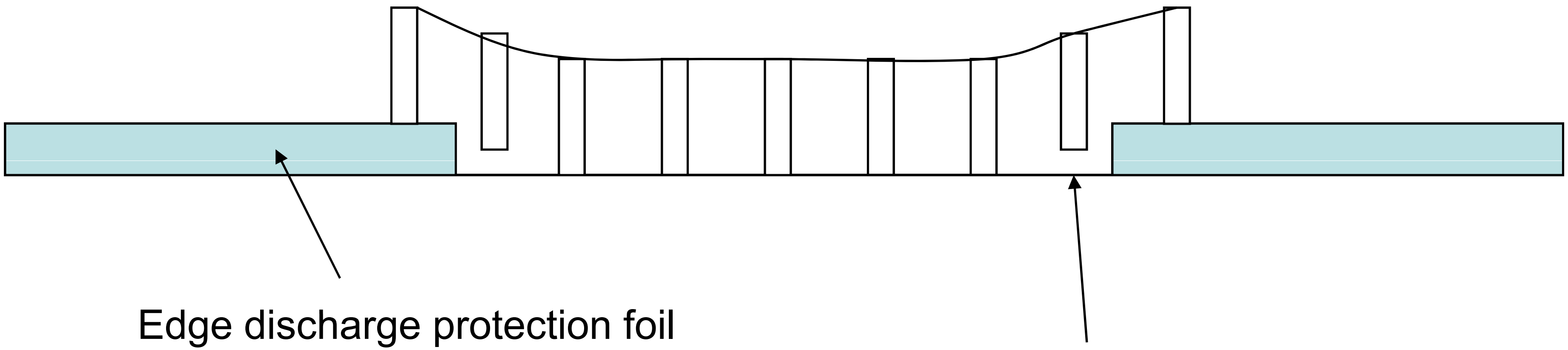
Resistive Plate Chambers (RPCs)

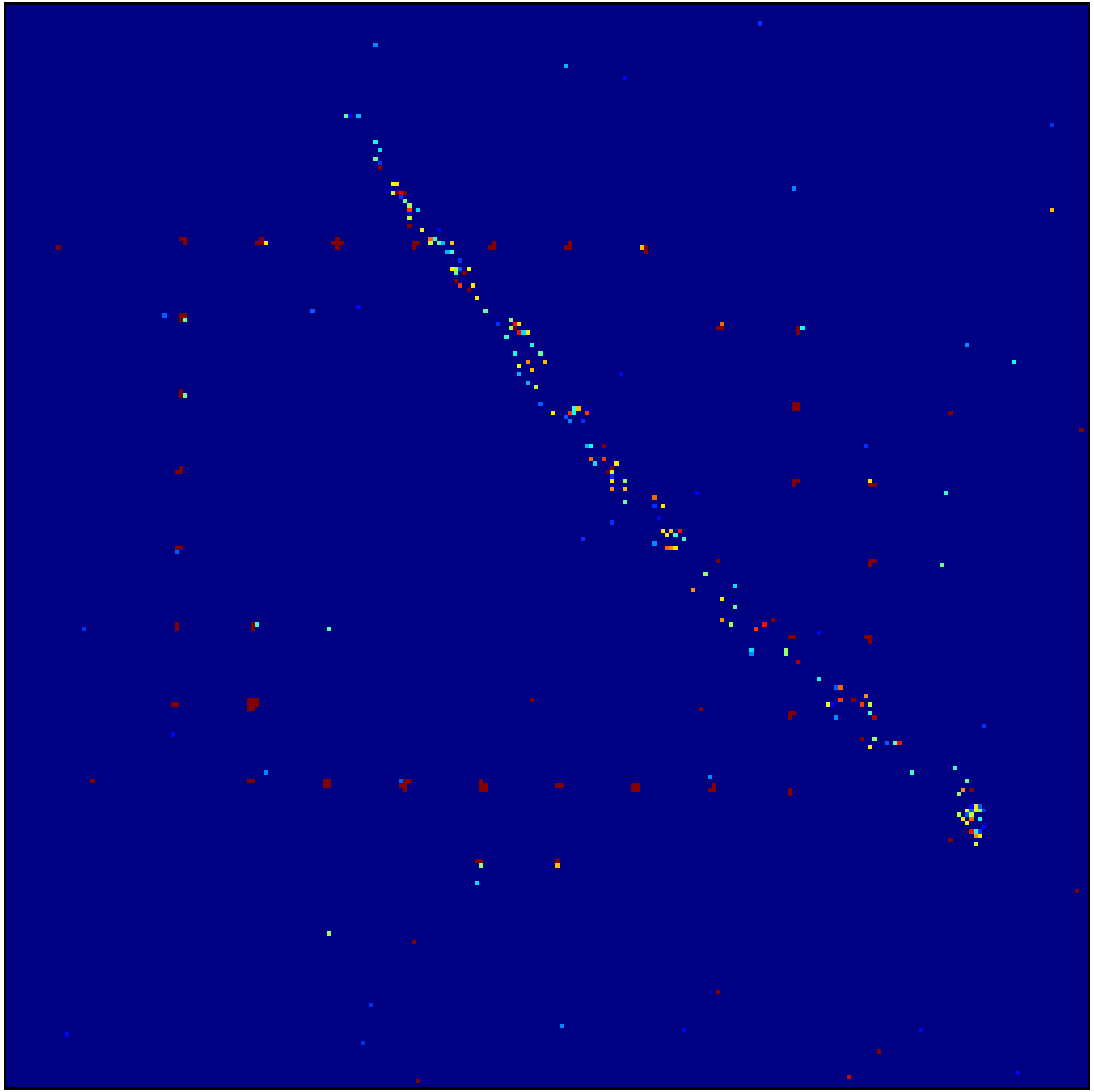
-essential: high-resistivity material
- quenches sparks
- sufficient charge compensation current

Traditional: insulator + dope (Sardinian oils…?)
New: high-resistivity bulk (ceramic) material: higher counting rates
Compare graphite covered mylar foil

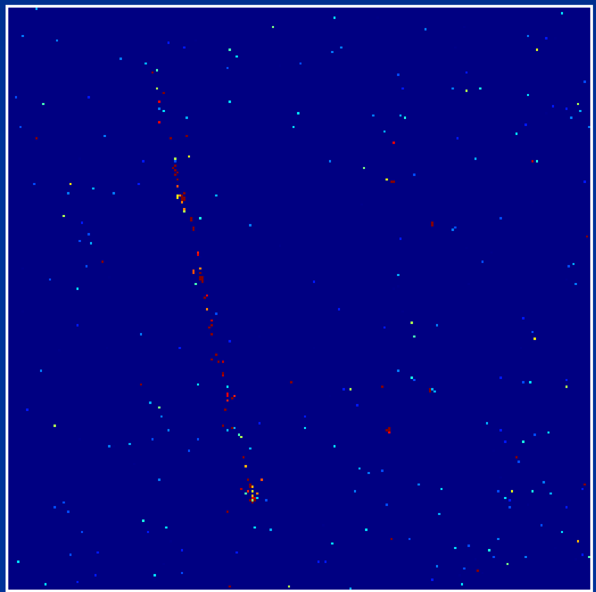
conductivity of kapton

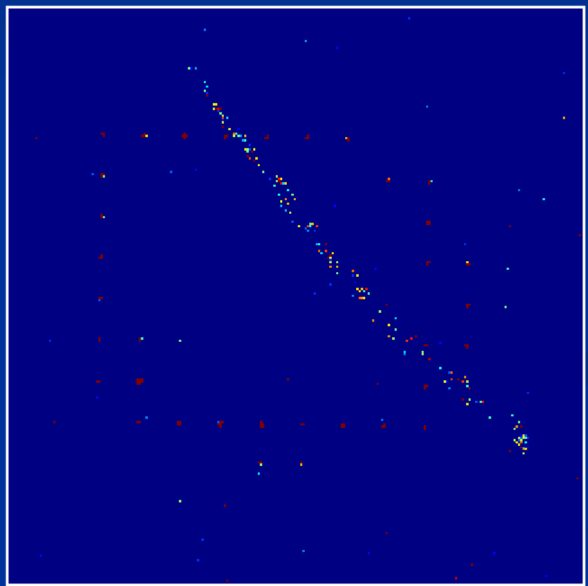
Micromegas on pillars

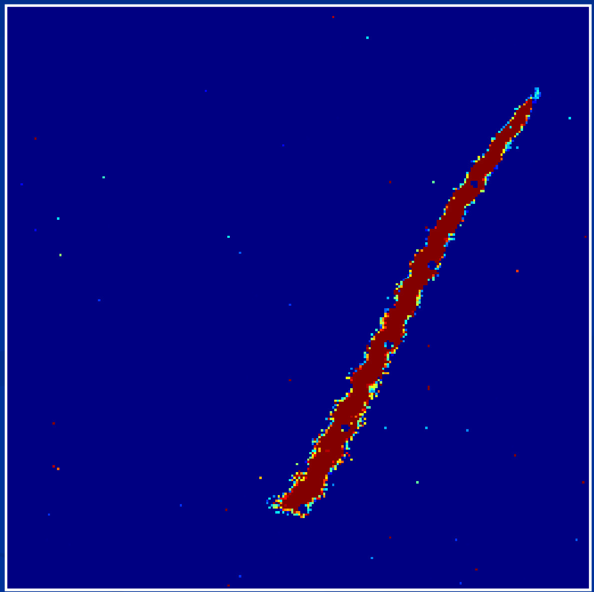




- Slow increase of grid voltage until good single electron efficiency
  - Vg = -400 V Gain ~ 8000
- Nice cosmic & alpha tracks recorded in TOT mode







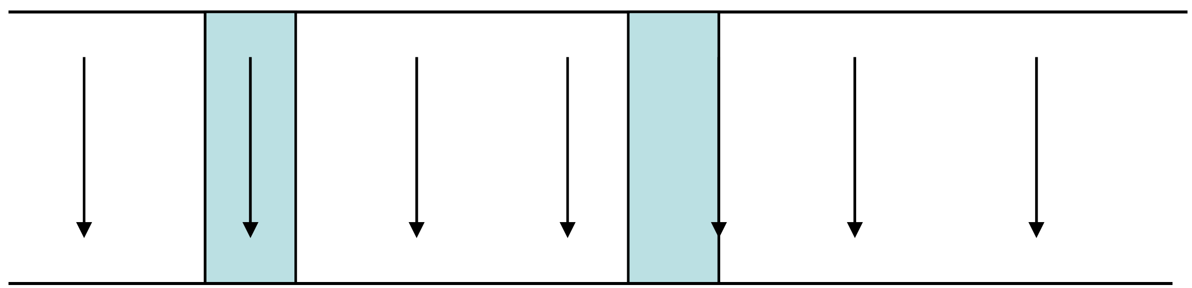
- Measure of drift time with the time mode
  - Triggered setup (3 scintillators and lead plates)
- Fill individual frames with 1000 short triggered acquisitions

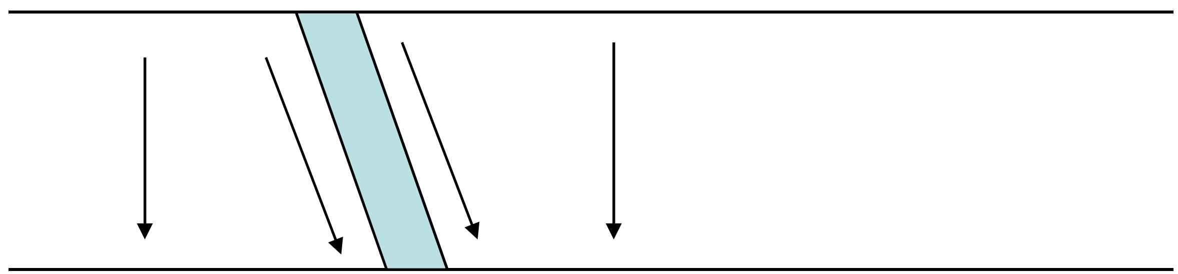
Charge-up effects

After (rapid) ramping of HV:

- polarisation: reduction of E-field in insulator (bulk) volume

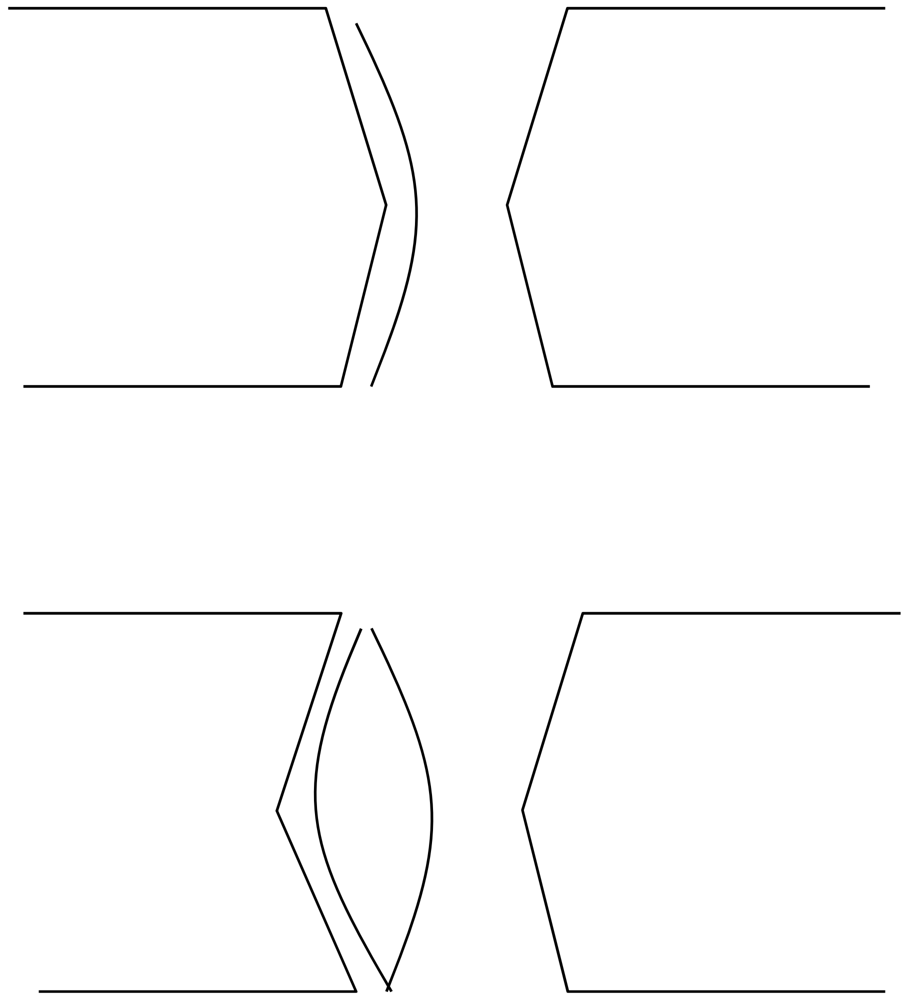
  In homogeneous field with insulator // to field: nothing

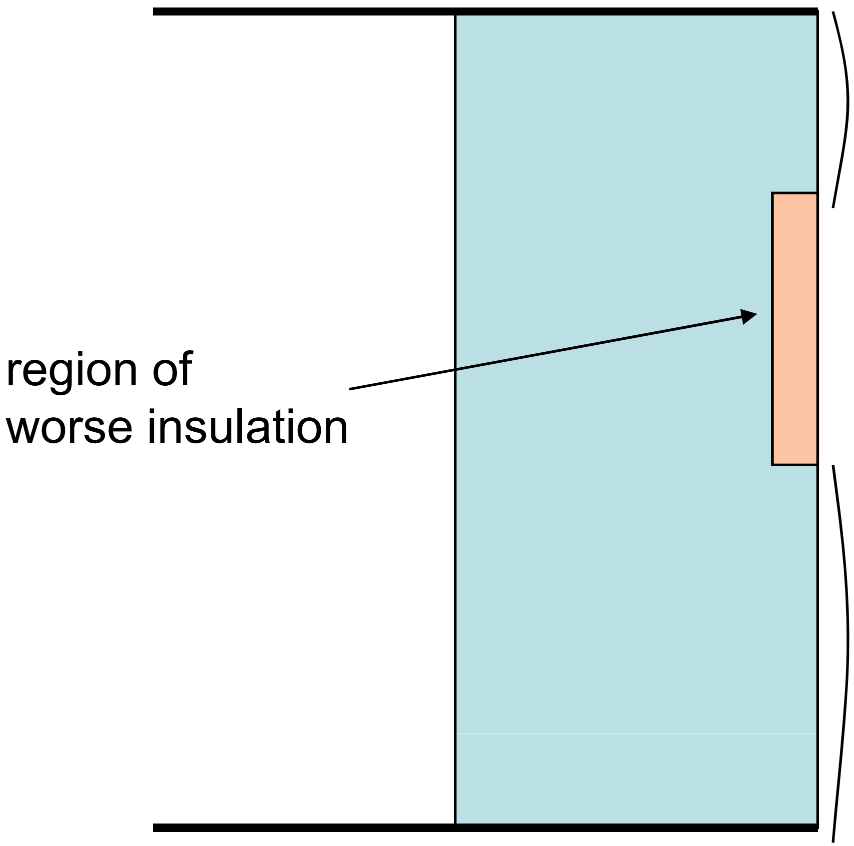




With E component perp. on insulating surface: modification of potential by hitting e- and/or ions until E // surface

GEM hole





equalizing with water

Stronger effects for good insulator

Very preliminary:

Use as little as possible insulating surfaces // strong E fields

Even more preliminary:

As for gain: GEMs perform les than (corresponding) Micromegas