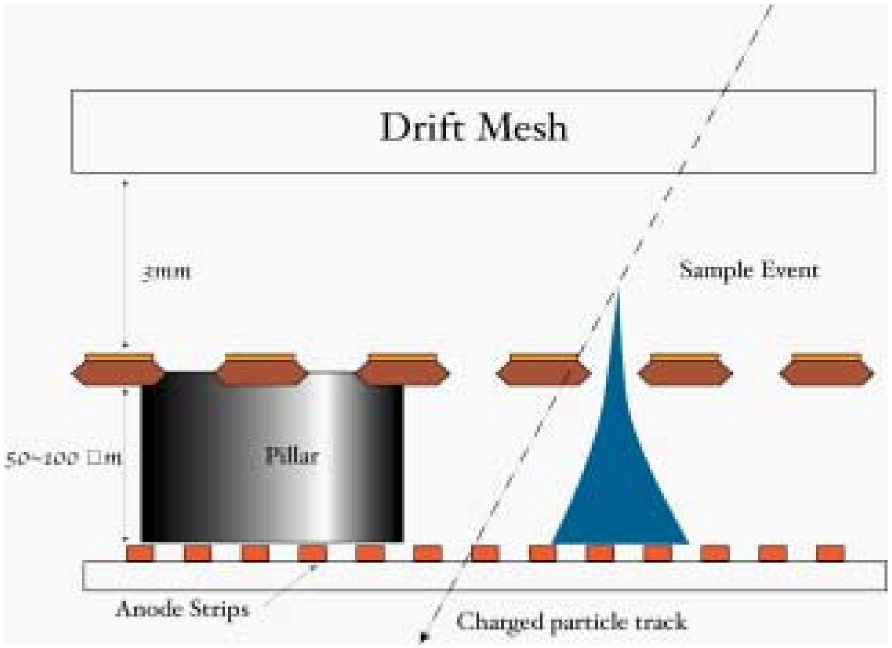
An aging study of MICROMEGAS+GEM

S. Kane, J.May, J. Miyamoto, I. Shipsey, Y, Giomataris[1]
Purdue University
[1]CEA/DSM/DAPNIA, CE-Saclay

GEM was provided by the courtesy of F. Sauli at CERN

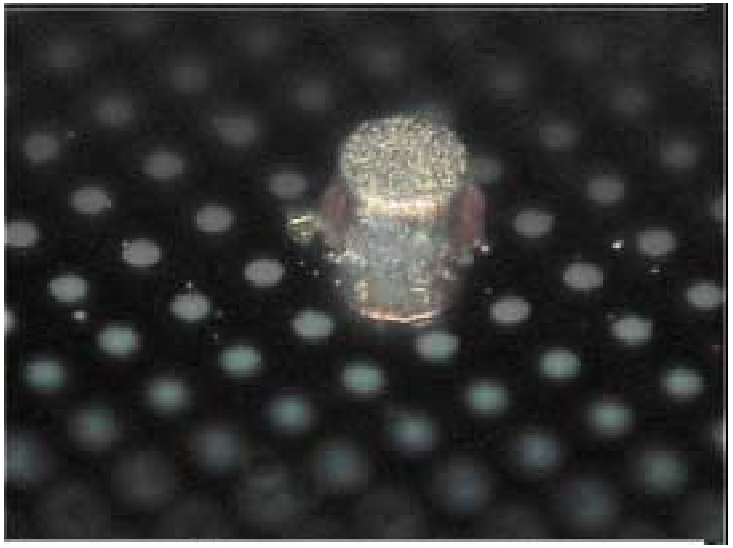
Micromegas structure

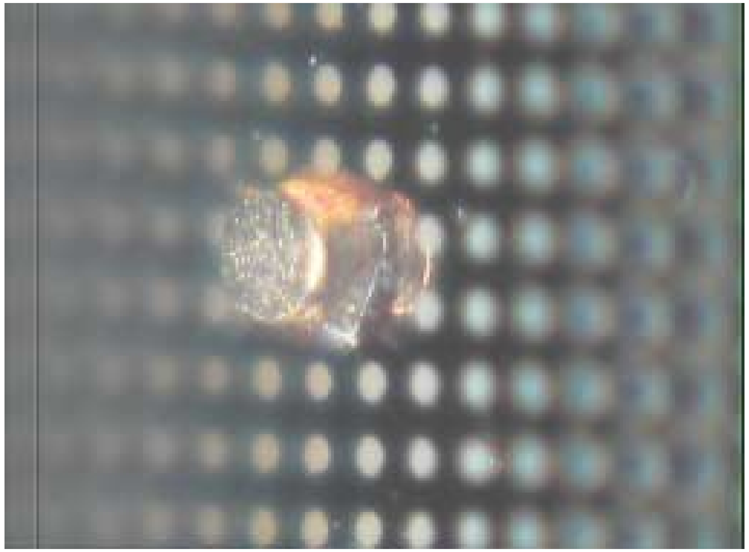
1. The micromesh resembles one-sided GEM
2. The supporting pillars (50 μ high) are separated by 1 mm (the dead areas minimal)
3. No active force is applied on the mesh and it depends on its own weight but once voltage is applied, the mesh is pulled toward the anode plane by electrostatic force



Micromesh photos

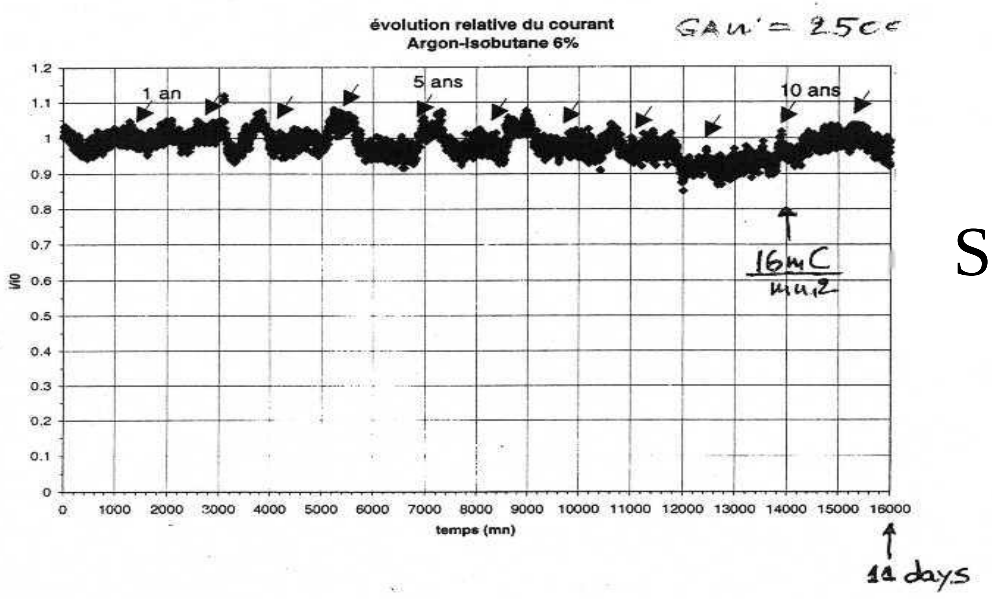
1. The pillars are insulators (kapton, polyamide. etc)
2. The pillars cover 4 holes at most to create small dead regions
3. There are enough holes for the electrons to go through (good optical and electron transparency)





Micromegas as a stand-alone device with no preamplification

1. Enough gas gain (1E+4) with conventional gas mixtures (e.g. Ar-DME, Ar-Isobutane) to detect MIPs.
2. Radiation hard up to a certain point (dark deposit seen with Ar-Isobutane mixture)
3. Can take a lot of sparks without significant damage



Saclay work

Micromegas with preamplification

Benefits

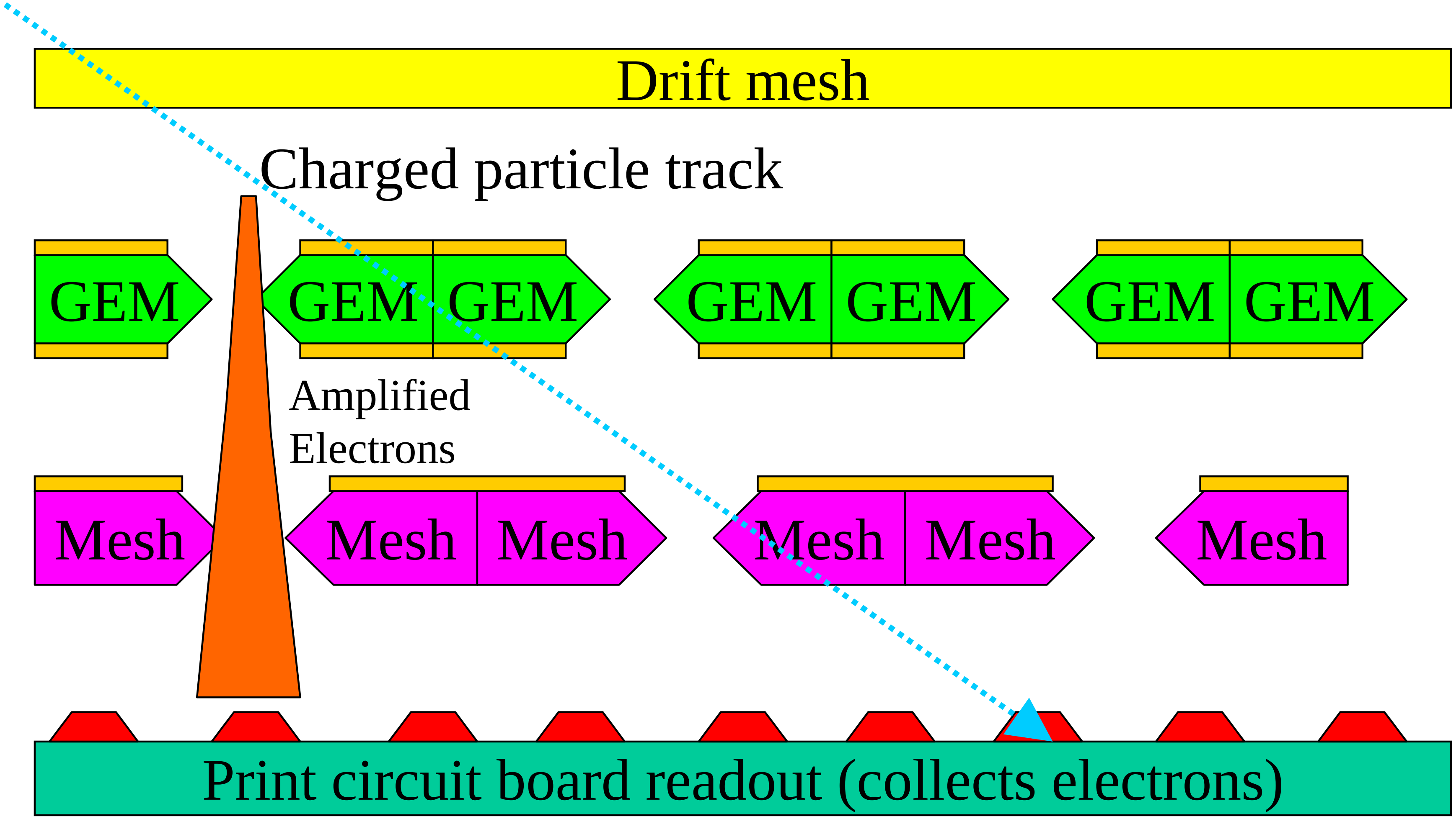
1. Allows the use of cleaner gas mixture (e.g Ar-CO_2) and can make it much radiation harder.
2. Two devices share gain and each device lives longer
3. Reduces spark rates with a high flux of MIPs

Minor disadvantages

1. More materials introduced in the chamber
2. More high voltage suppliers are needed
3. Drift voltage goes up
4. Signal slows down and more diffusion in the gas

But the benefits outweigh the disadvantages by many orders of magnitude. Why not try?

Preamplification by GEM

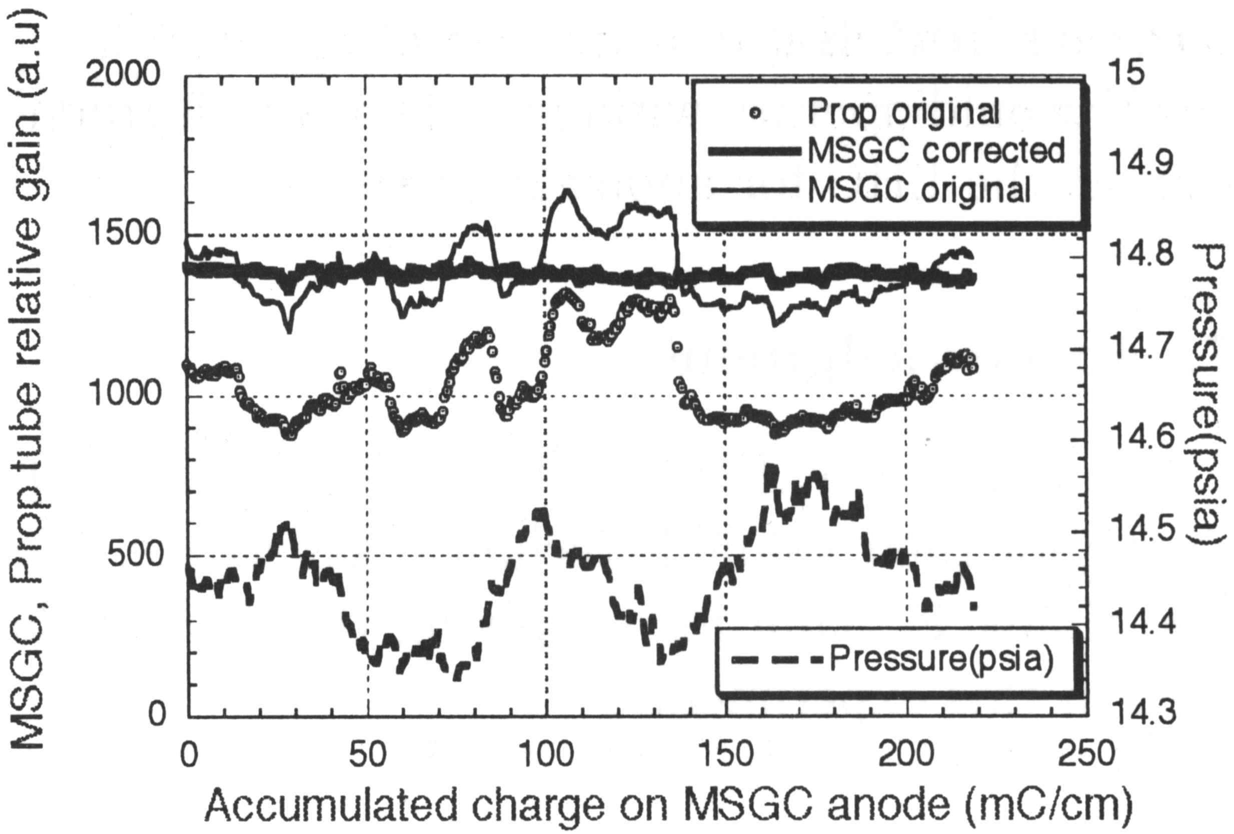


What we know about GEM+MSGC

Single GEM+MSGC (1 mm pitch) aging in Ar-DME

ref: Como 1997 Purdue work

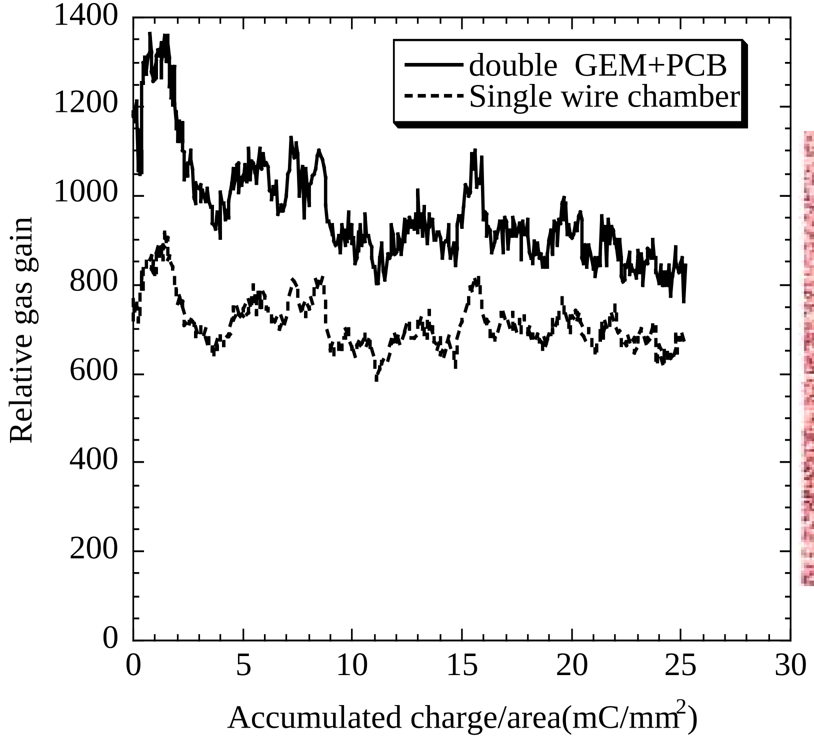
220 mC/cm and both the GEM and MSGC were clean(best result)



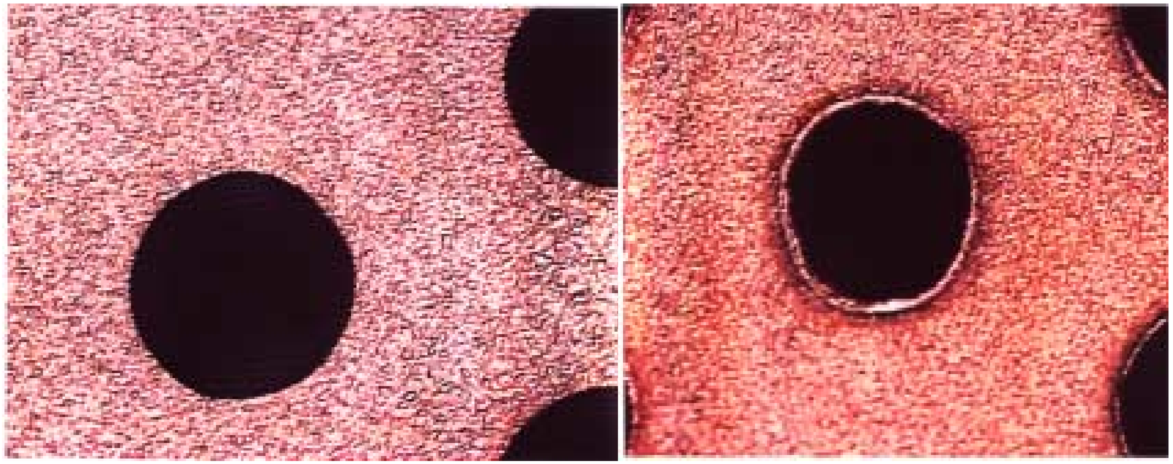
What we know about double GEM

Double GEM aging in Ar/CO_2 (ref: NSS Lyon 2000 by Purdue)

1. GEMs aged slowly after more than 25 mC/mm^2 was accumulated
2. Irradiated metals and Kapton degraded a little



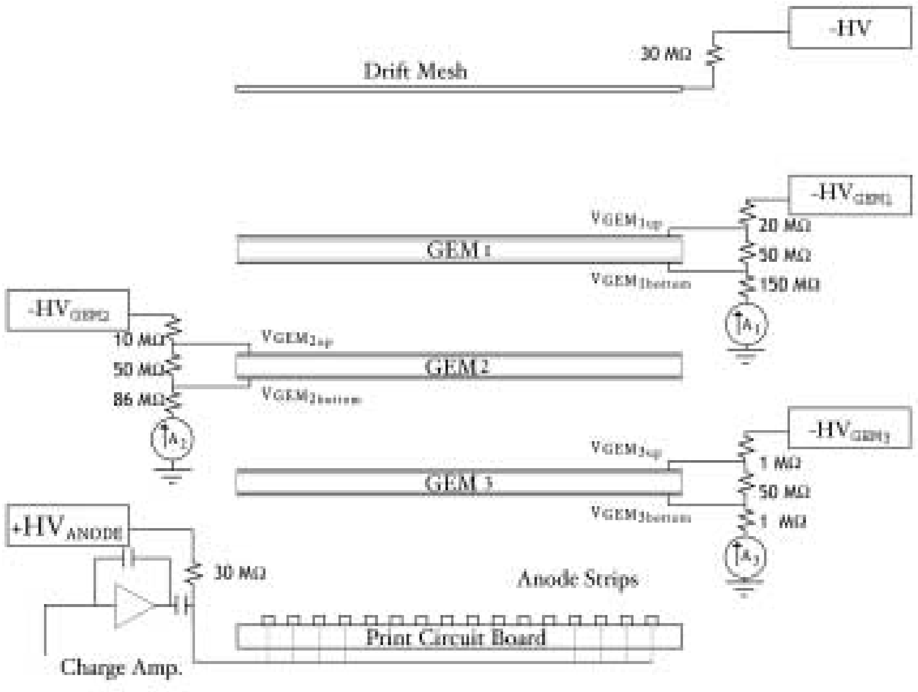
Before and After irradiation

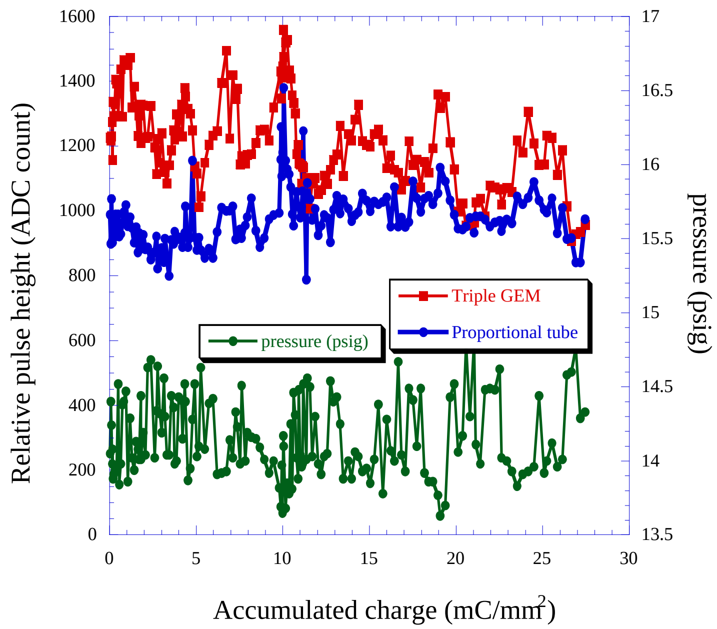


Minimal aging in triple GEM

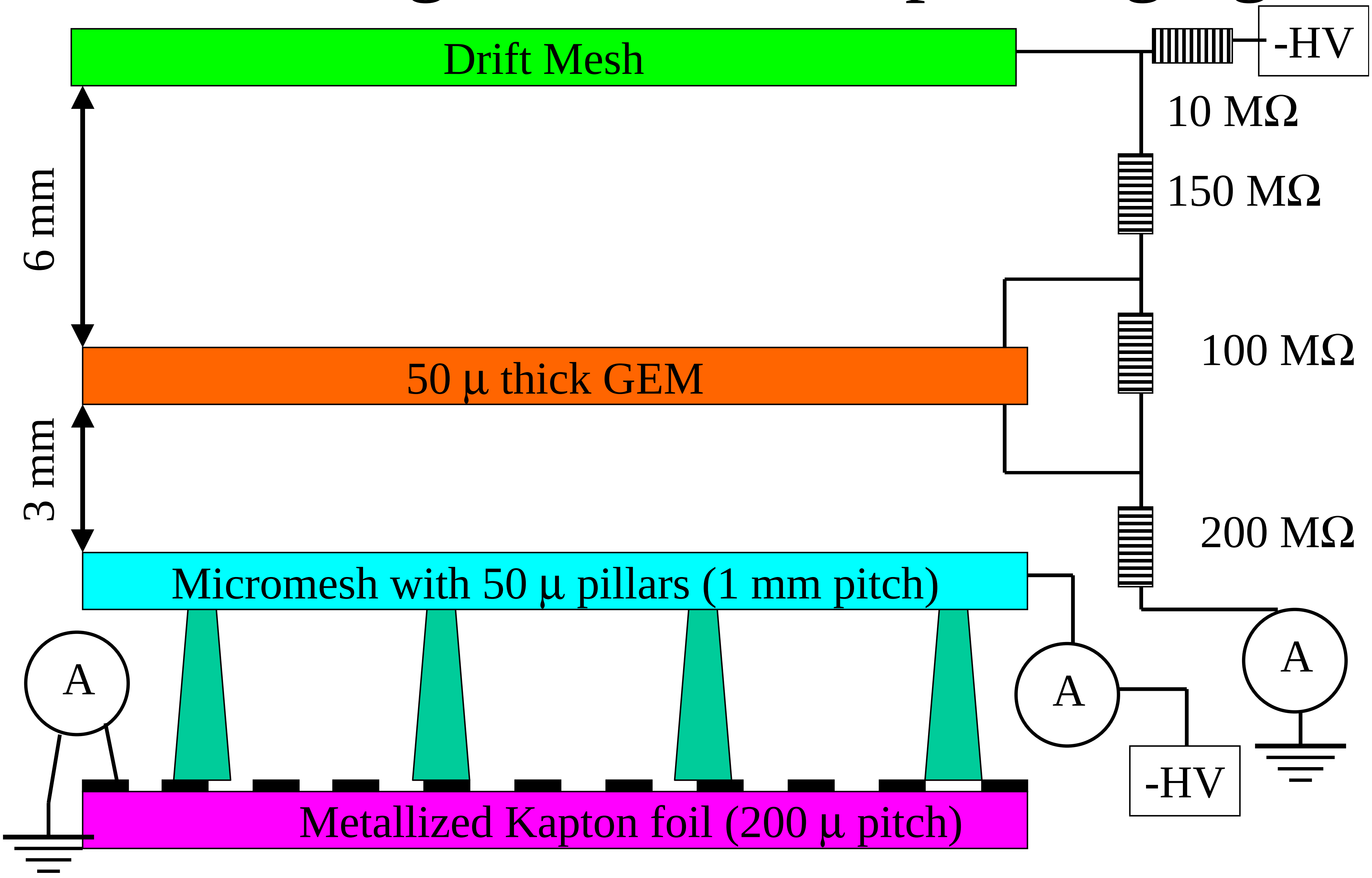
ref: Vienna 2001 Purdue work

1. The slight aging seen in double GEM was absent due to reduced gas gain in each GEM





Micromegas+GEM setup for aging

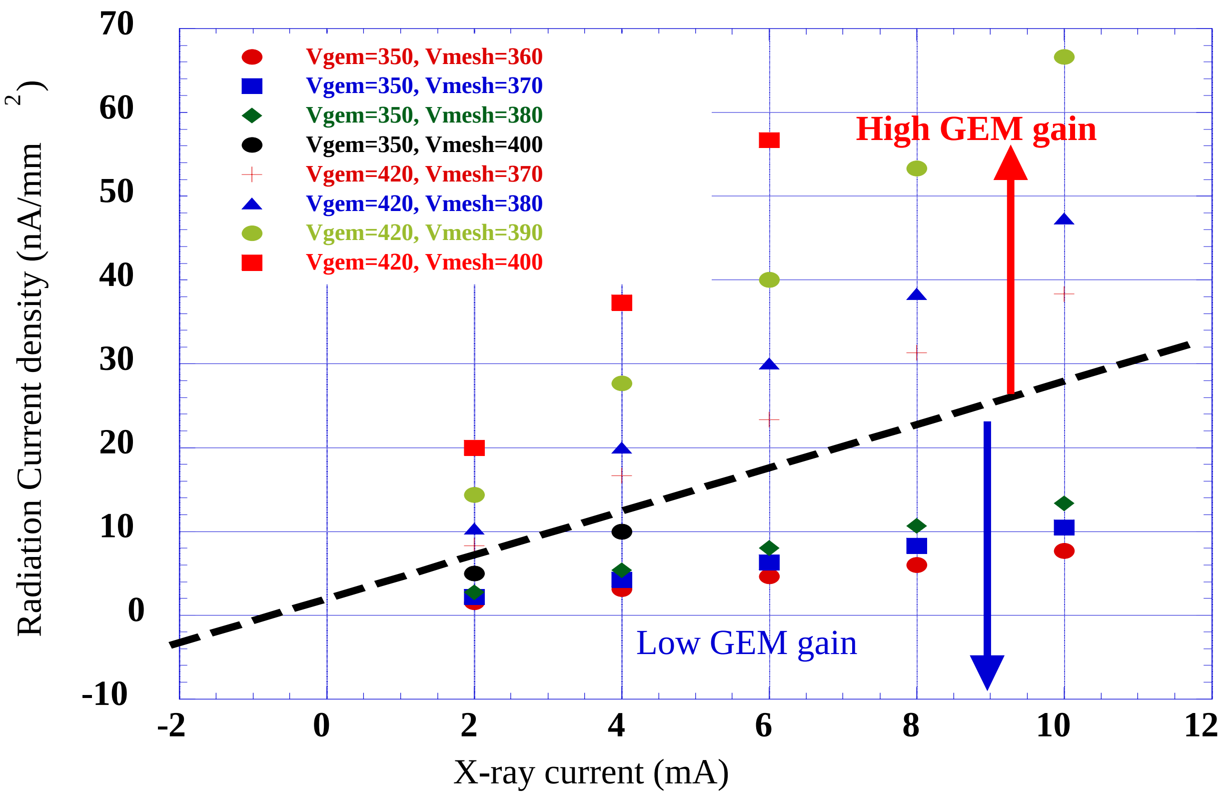


Enhanced rate capability

2 ways to split gas gain

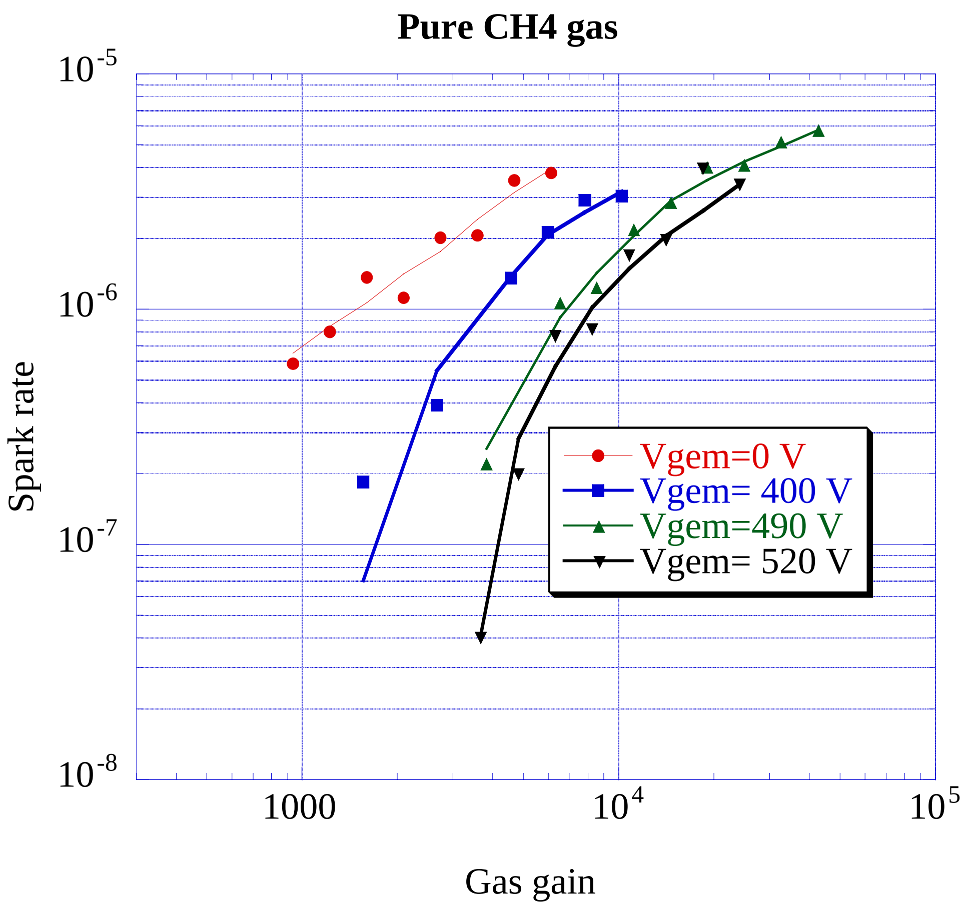
1. Small gain in the GEM+Large gain in Micromegas
2. Large gain in the GEM+Small gain in Micromegas

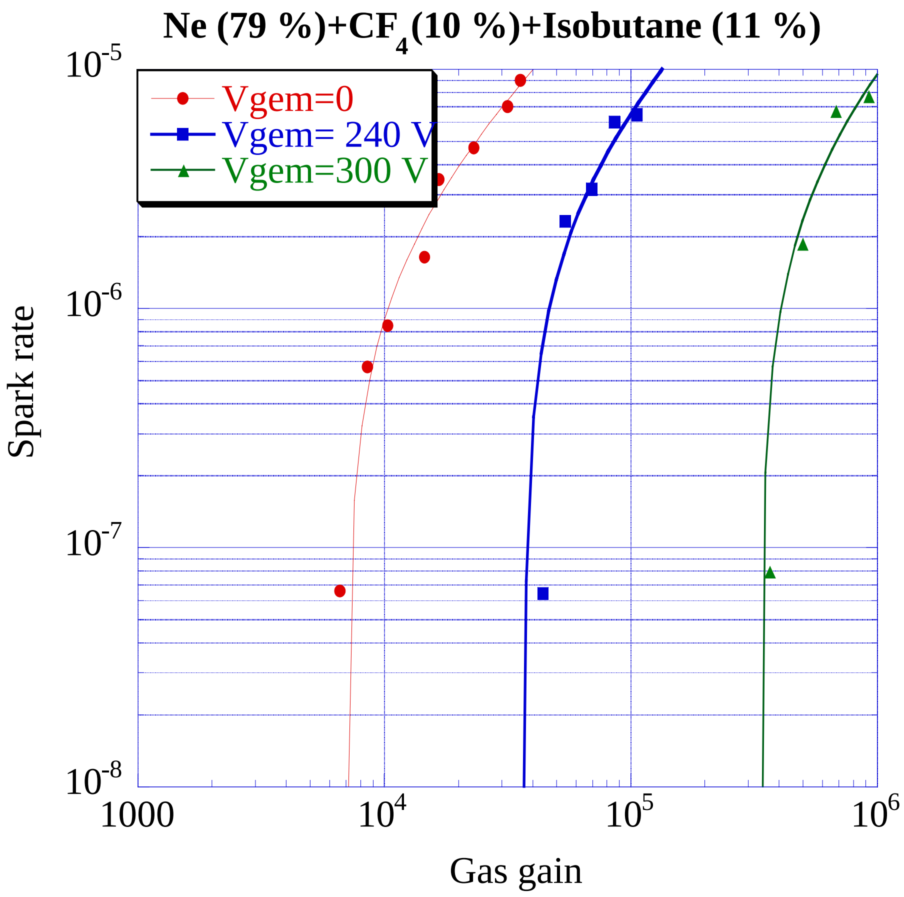
High GEM gain gives an enhanced rate capability with a less discharge probability



Low spark rate with the GEM

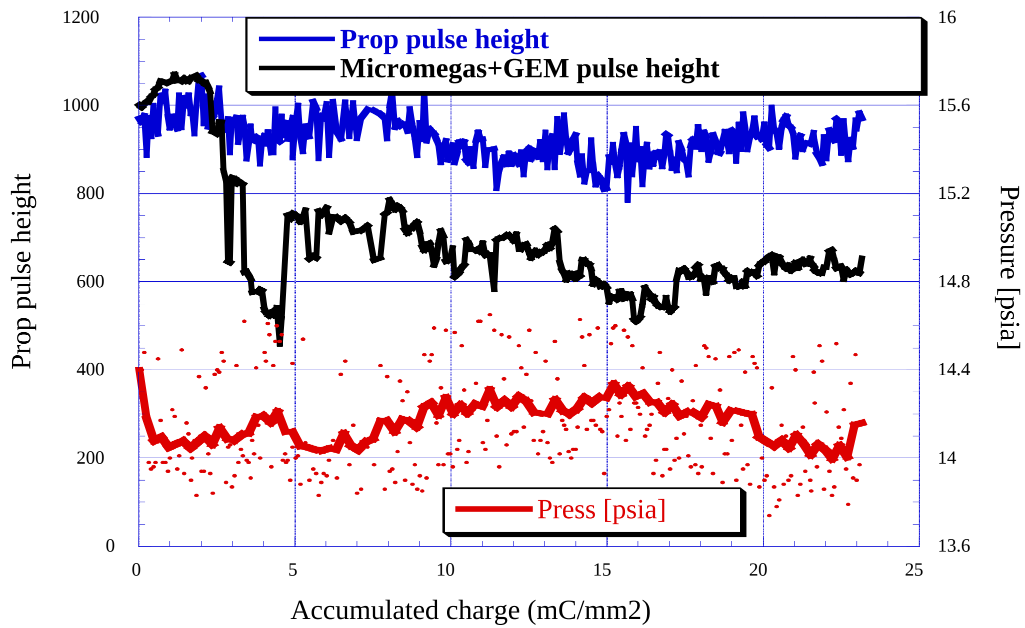
Beam test at CERN with 10 GeV/c protons (June, 2001)
With the right gas mixture 10E-8 spark rate
at gas gain of 10E-5 region
ref: Will be presented at COMO 2001 soon





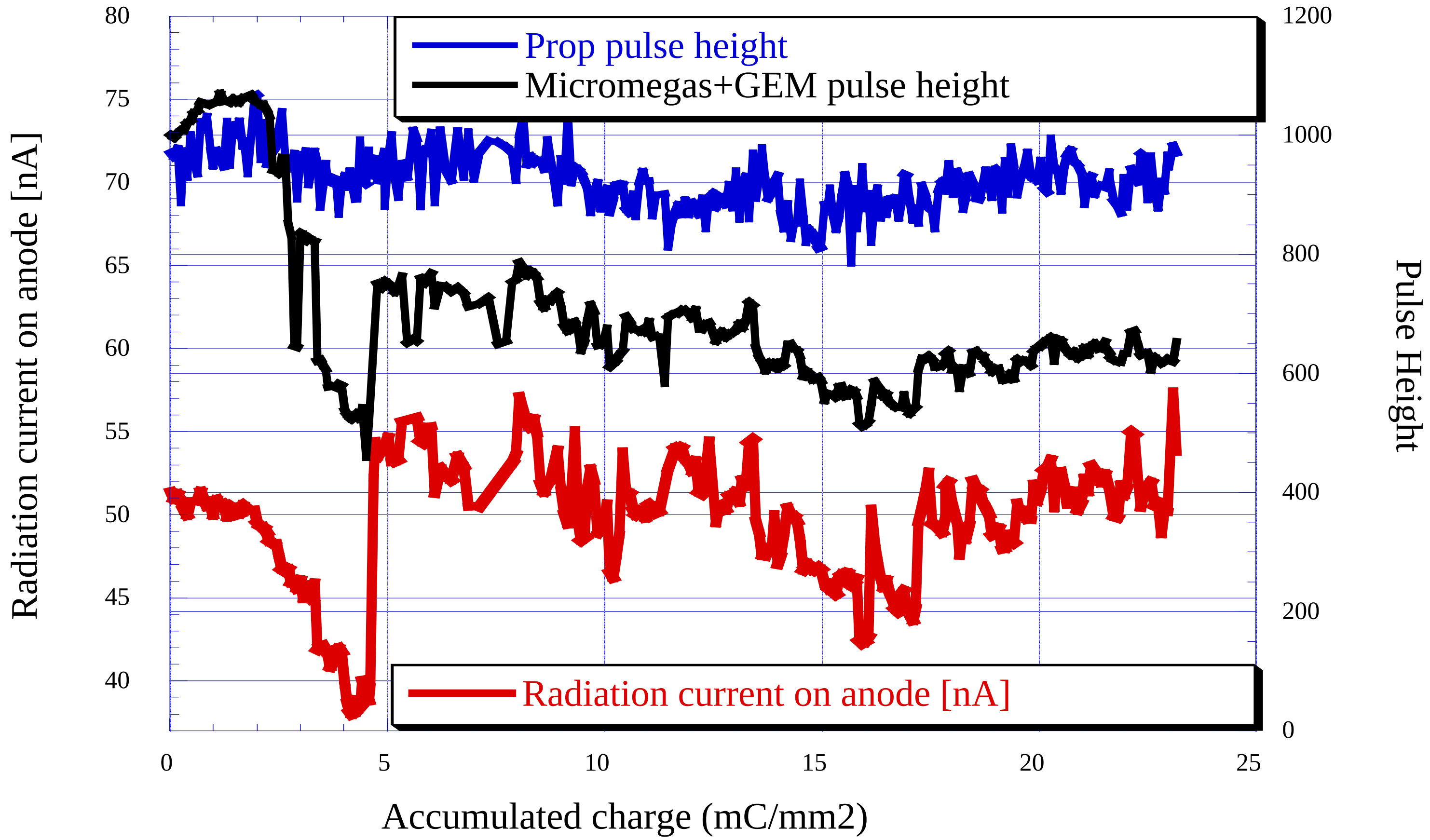
Micromegas+GEM aging

1. Clean Stainless steel chamber and tubes
2. Gas gain=3000, Current density=17 nA/mm^2
3. Irradiation time ~ 500 hours.
4. Vgem (380=>385V), Vmesh (400 =>410V) was increased slightly after 5 mC/mm^2 (100 hours) to compensate the initial gain loss but the pulse height stable remained till the end.
5. The initial gain drop is probably because the E-filed was reduced by the presence of many ions (space charge) and could have been avoided with higher mesh voltage (more gain in the micromegas)



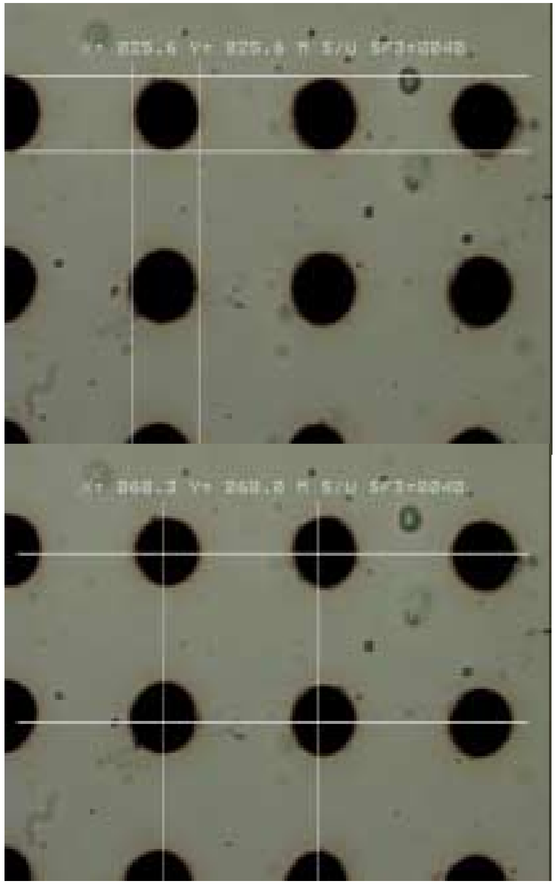
Signal current measured on the anode

1. The initial drop of the signal current was only 20% as opposed to 50 % drop in pulse height
2. Moved in tandem with the pulse height of the prop tube indicating that the traditional aging didn't occur.

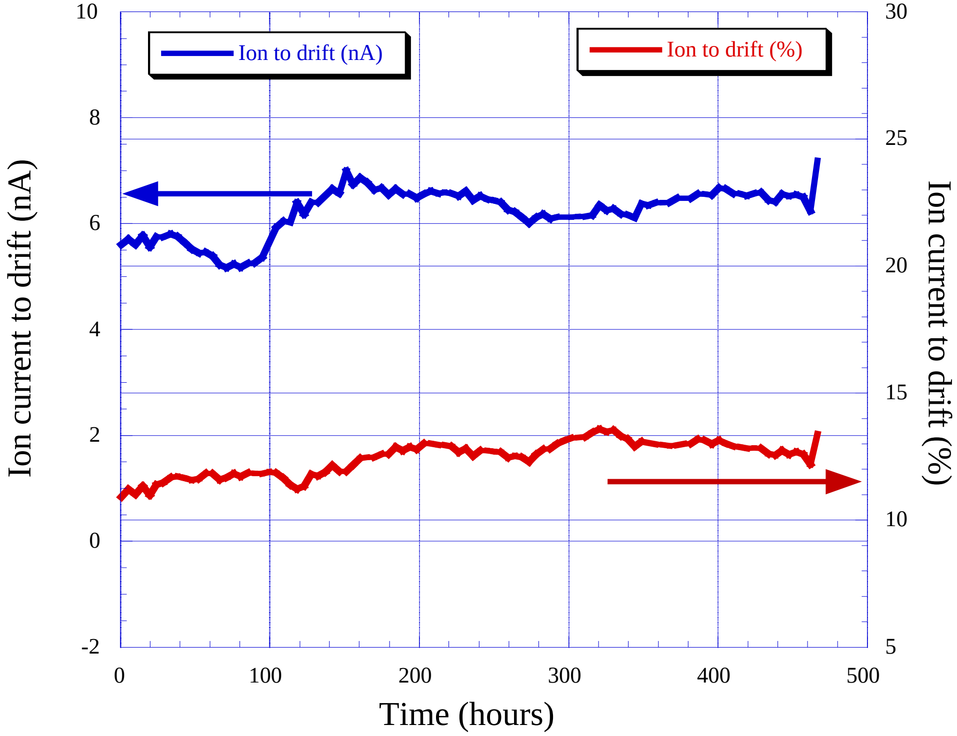


Ion feedback to the drift region

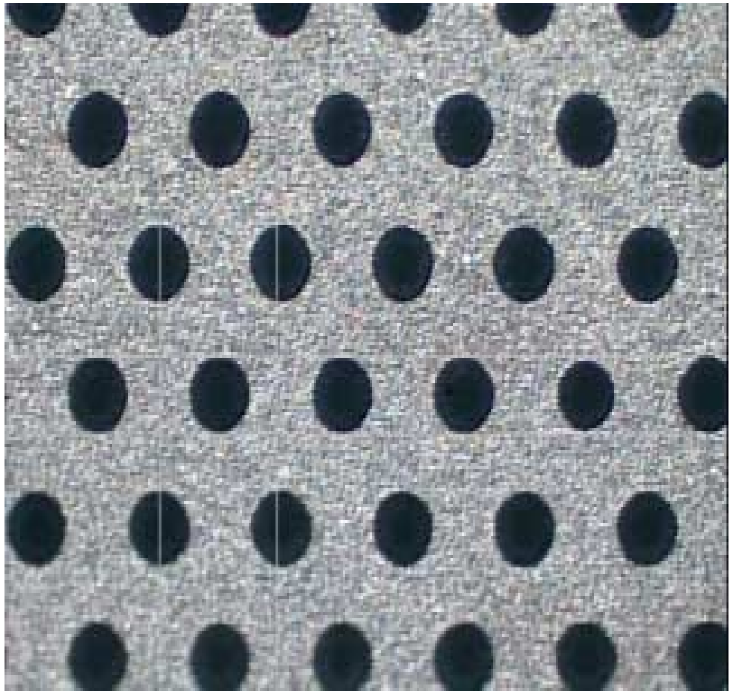
1. Ions returning to the drift region (ions not collected on the micromesh) is about 11-13 % close to the optical transparency calculated from the geometry(=14%)
2. The slight increase indicates slight aging of the mesh (inefficiency to collect ions)



=> **14 % of open areas on the mesh**



Optical inspection after irradiation



Irradiated area of the GEM after aging test

1. The irradiated spot could be located on the GEM by naked eyes and the discoloration area (whitish gray instead of black) equivalent to the collimator size.

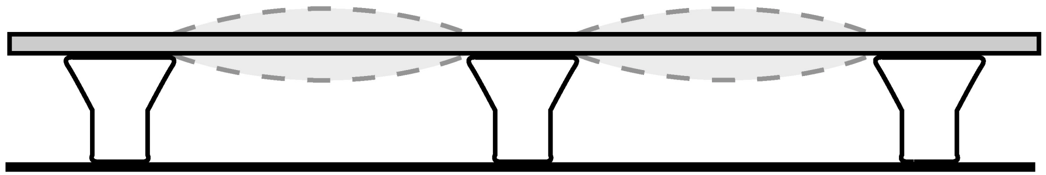
2. A close inspection under the microscope in the area did not show any sign of degradation of the GEM holes (contrast to double GEM aging)

3. Both the micromesh and the anode board stayed in good condition and the irradiated area could not be located.

Summary

1. Micromegas+GEM can take more than 23 mC/mm^2 without severe aging in $Ar\text{-}CO_2$ gas in a clean system.

2. The initial gain drop is a little concern but if the mesh is biased sufficiently, it could be prevented. The mesh oscillation below **may** have happened to change the mesh gap. A sufficient training period of micromegas **with radiation** on should be given before put into real experimental conditions.



3. Both the GEM and the micromesh were still in good condition (no deposit or shorts or severe discoloration) by optical inspection.

4. The preamplification by the GEM is a powerful tool to enhance micromegas' already excellent performance in aging and high rate capability with high gas gain.