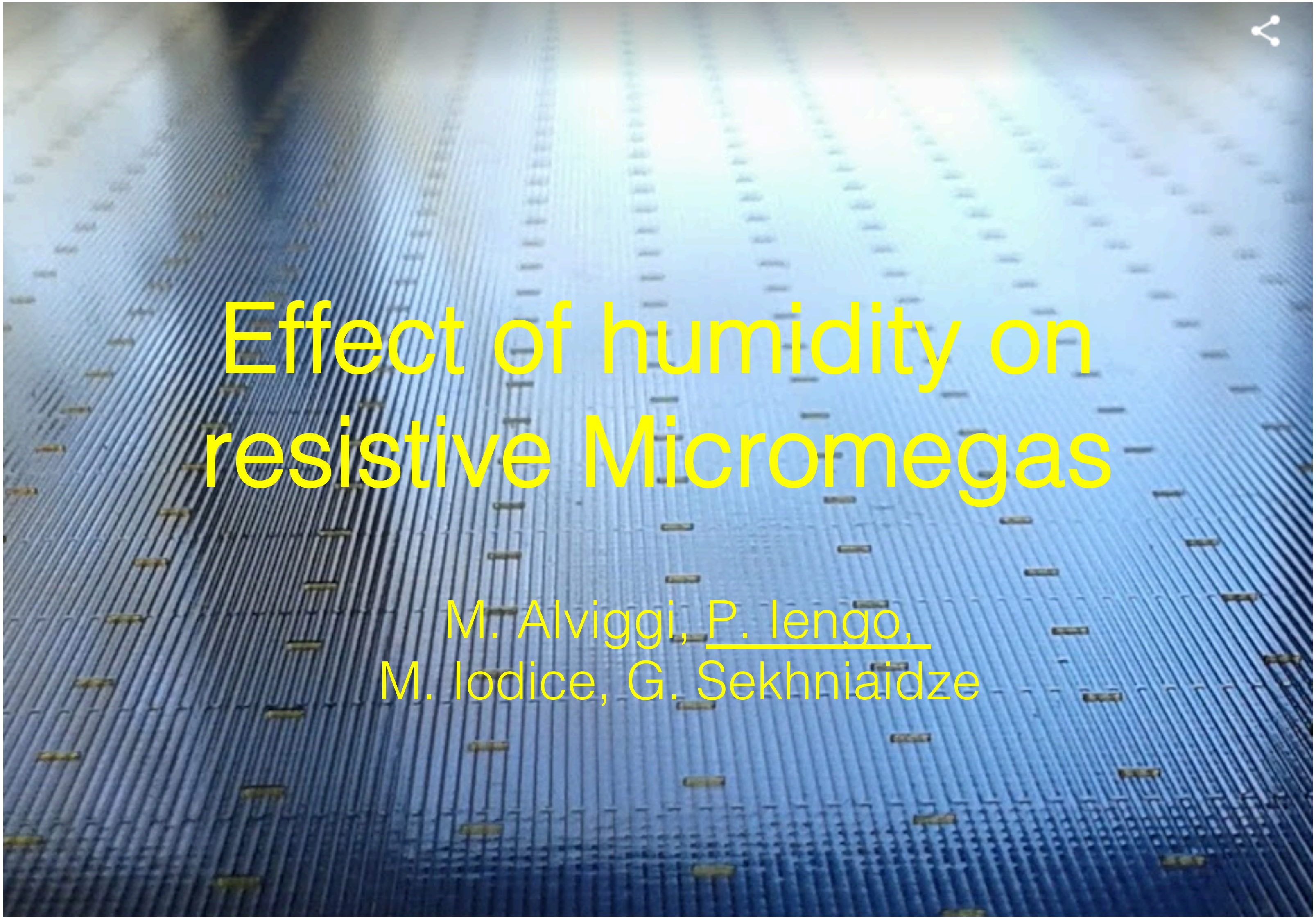


Effect of humidity on resistive Micromegas

M. Alviggi, P. Iengo,
M. Iodice, G. Sekhniaidze

Outline

- ExMe chamber
- Effect of RH on dark current at the detector closing
- Study of gain vs RH
- Effect of RH on dark current after conditioning
- Conclusions

- Previous Studies:
  - Did not find previous studies on the subject, especially regarding dark current on MM
  - Effect of water content on gain studied in other detectors…
  - Reference number: 1% RH ~ 220 ppm

F. Sauli et al
NIM A 490 (2002) 177-203

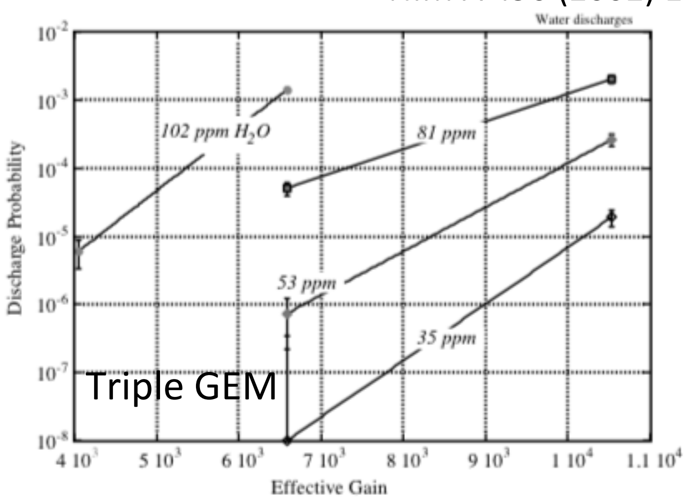
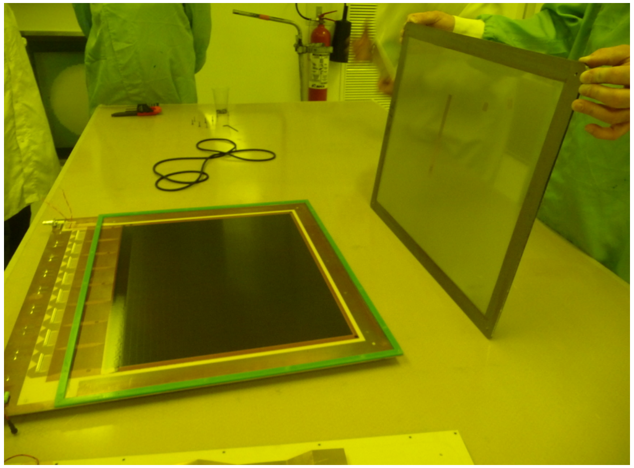
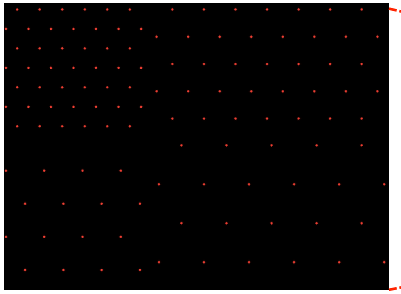


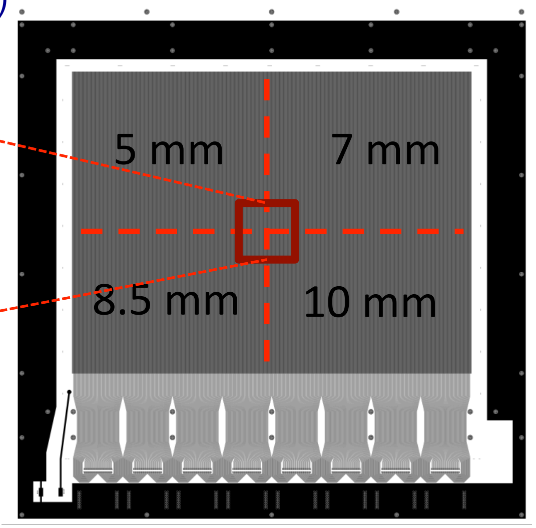
Fig. 36. Discharge probability on alphas as a function of moisture level in the gas.

Exchangeable Mesh detector (ExMe)

- ExMe (exchangeable mesh) detector
  - Designed and built at CERN in 2014 (J. Wotschack, P. Iengo, R. De Oliveira, G. Sekhniaidze) to help selection of mesh type and pillar spacing for the ATLAS NSW project
  - Mesh stretched on iron frame → easy to replace
  - 4 sectors with different pillar spacing: 5/7/8.5/10 mm
  - Circular pillars (300 um diameter) – 120 um height
  - Otherwise similar to ATLAS MM (screen-printed resistive lines on Kapton, same width/pitch as ATLAS)





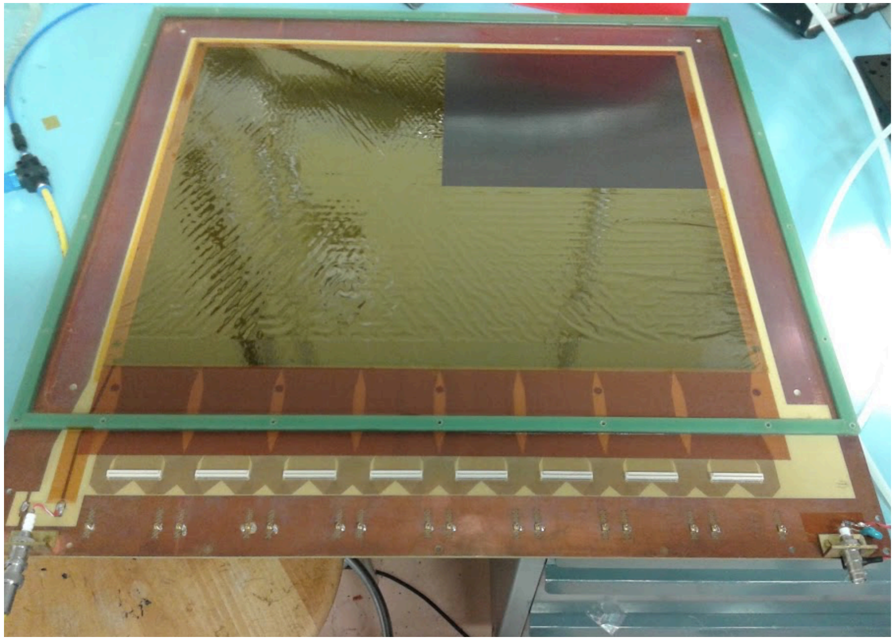


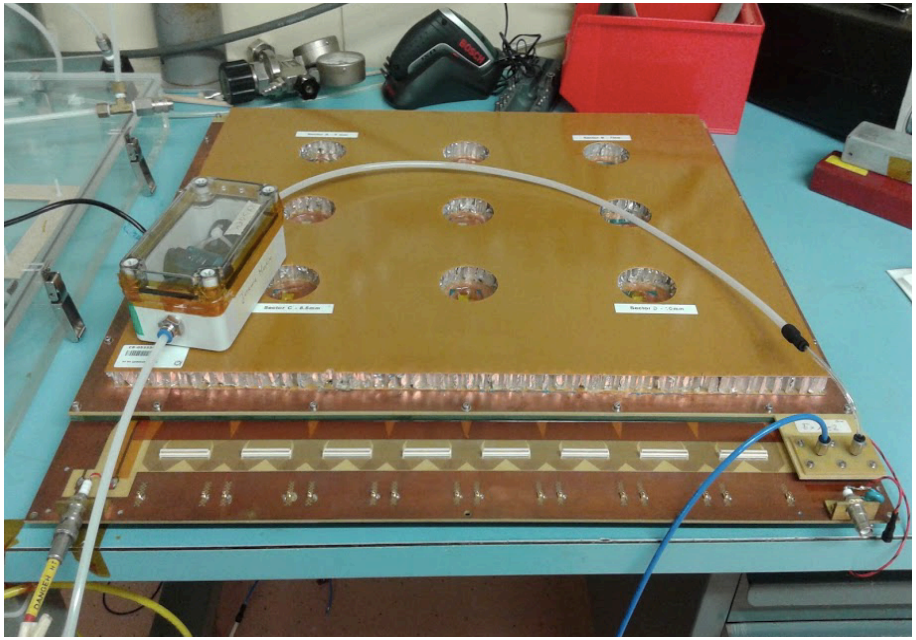
Same detector used for mesh and gas studies

(P.Iengo at RD51 Mini Week in Oct and V. D’amico in this session)

Exchangeable Mesh detector (ExMe)

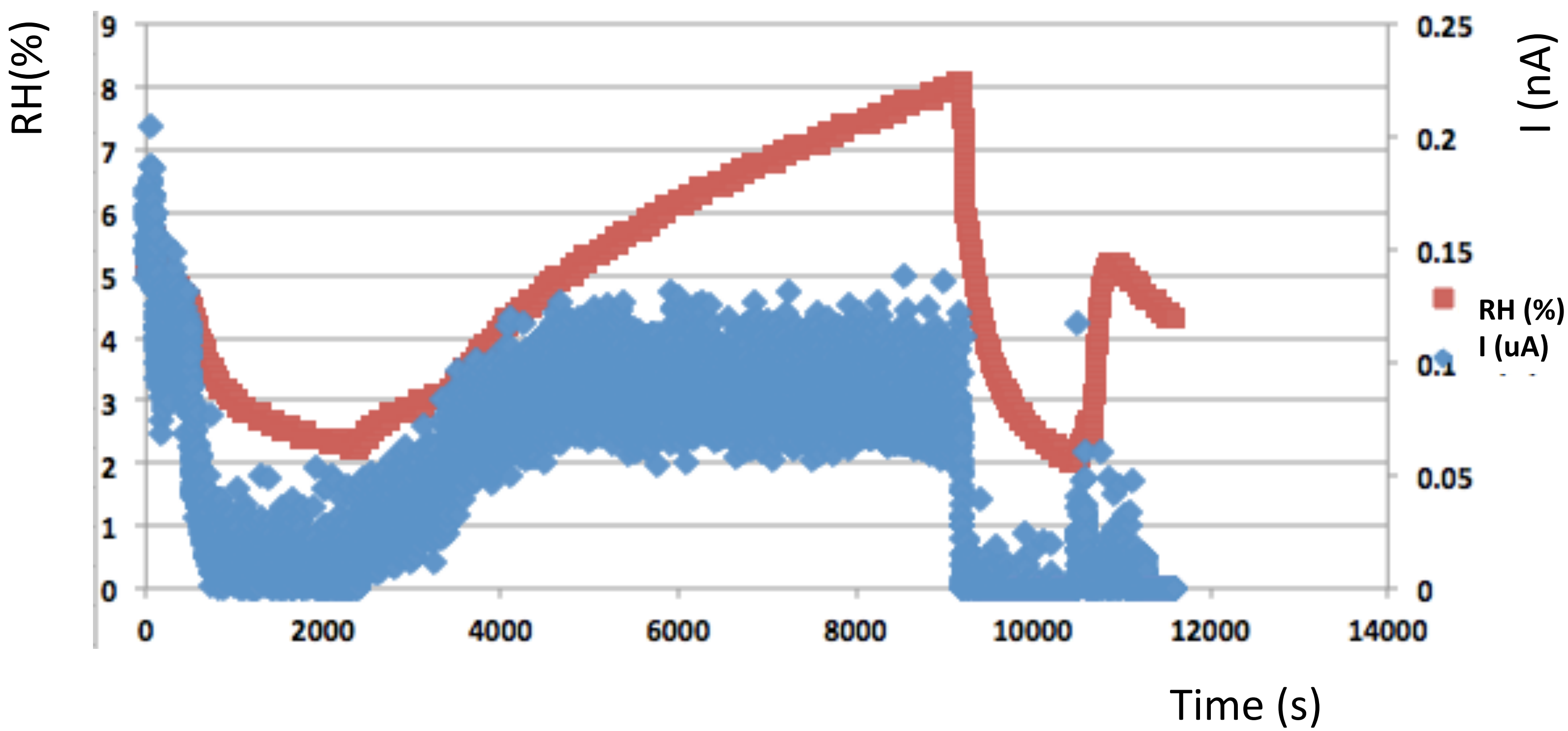
- Only sector with 7mm pillar spacing active
- Other sectors passivized with12.5 um kapton film on top of the pillars
- Mesh 18-45 Calendared
- RH measured at the output of the detector





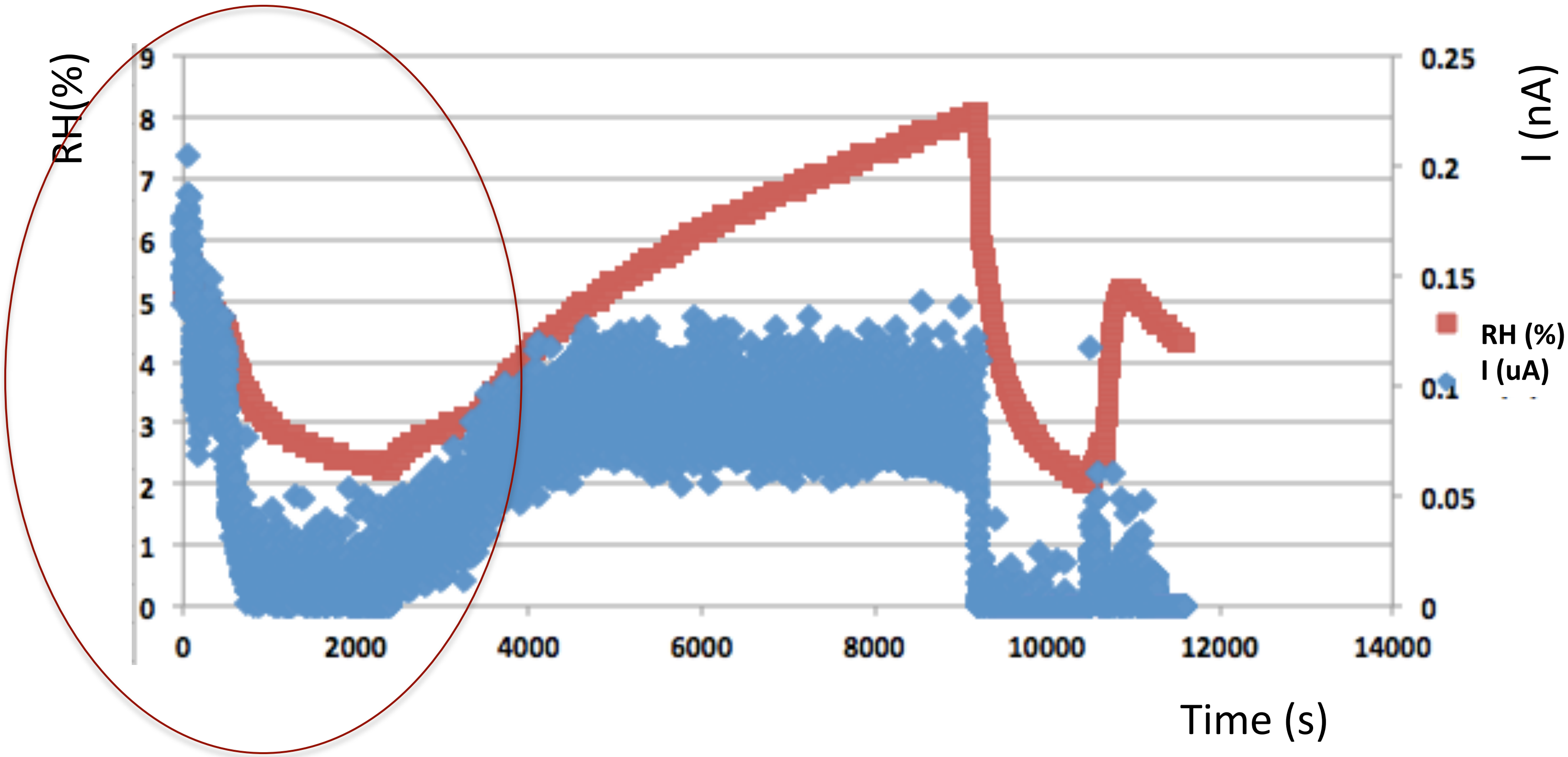
Effect of humidity on dark current

- Detector flushed with dry air immediately after closing
- Current measured every sec



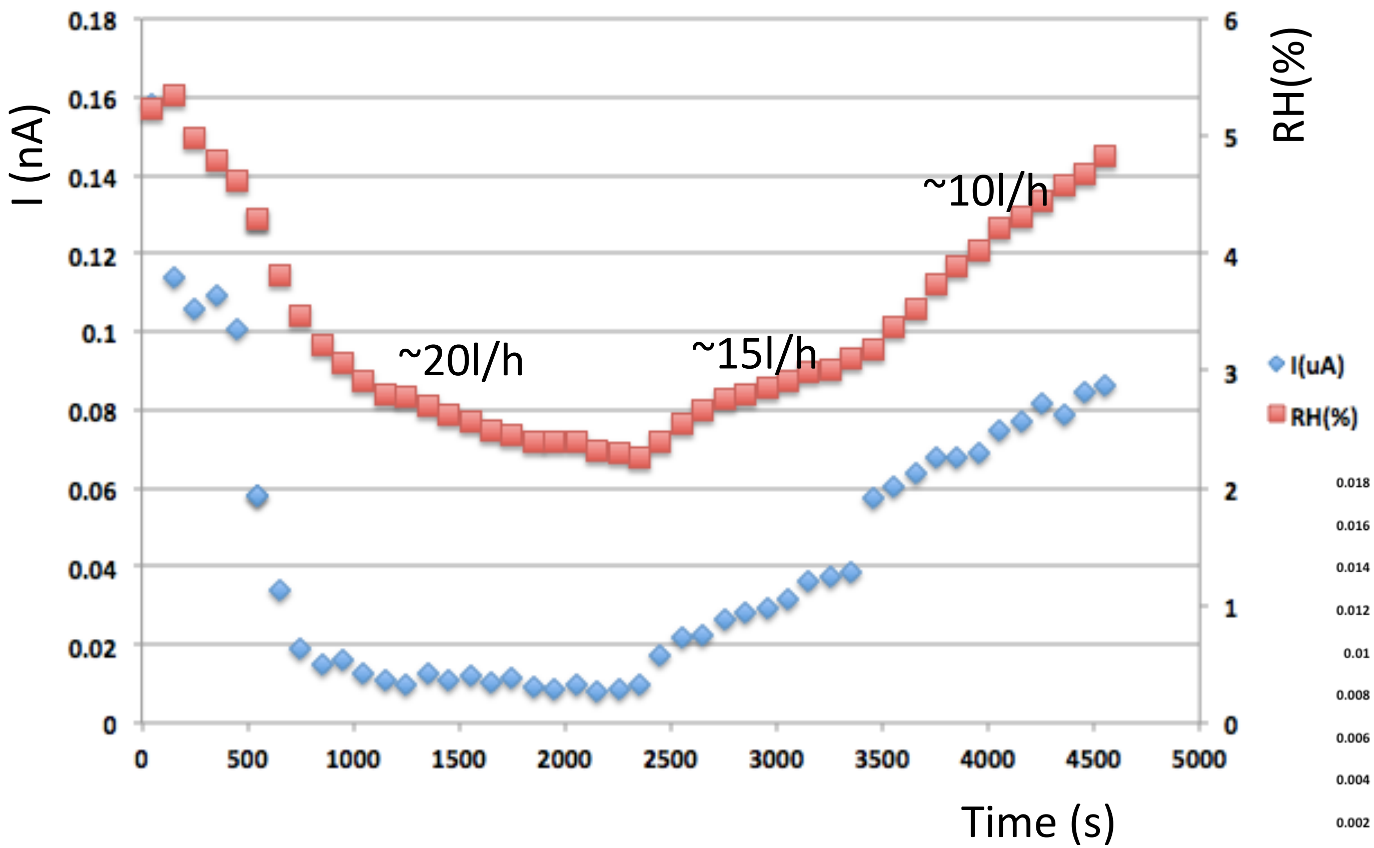
Effect of humidity on dark current

- Detector flushed with dry air immediately after closing
- Current measured every sec

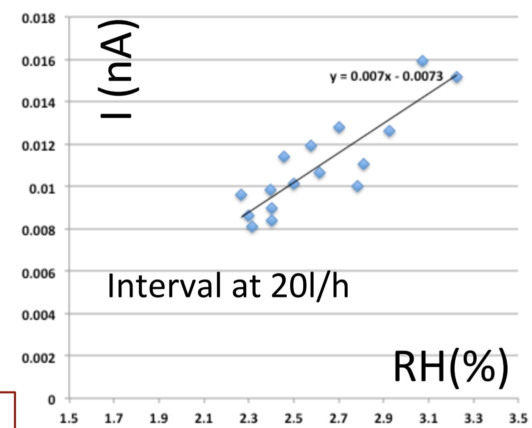


Effect of humidity on dark current

- Detector flushed with dry air immediately after closing
- Current measured every sec, average on 100 measurements



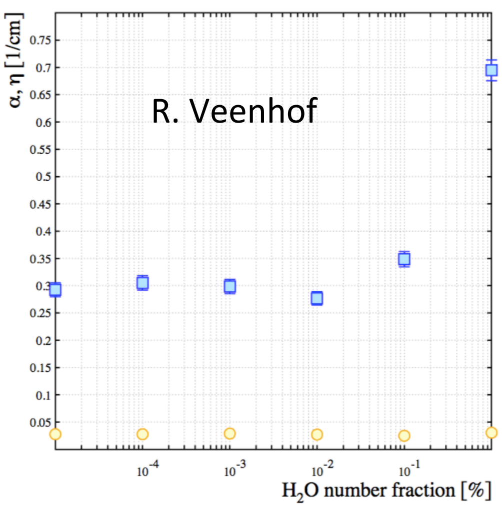
Changing the gas flow changes the pressure inside the detector as well

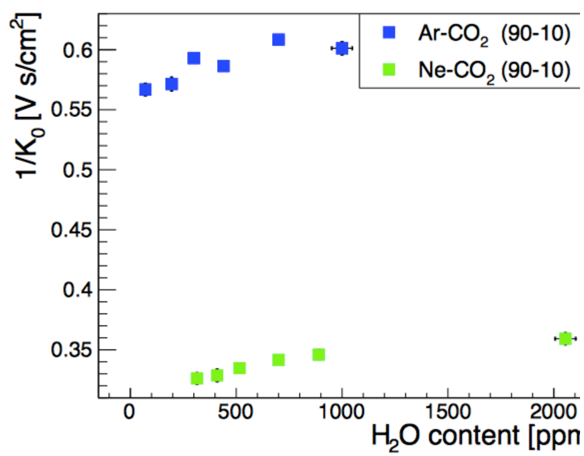


Clear correlation of dark current with RH at the detector closing

Gain vs RH

- Gain is expected to slightly decrease as water content increases as effect of electron attachment
- Very small effect for E values as in MM amplification regi ~larger in drift region (600 V/cm)





- Small effect on ion mobility (C. Garabatos et al, GEM)

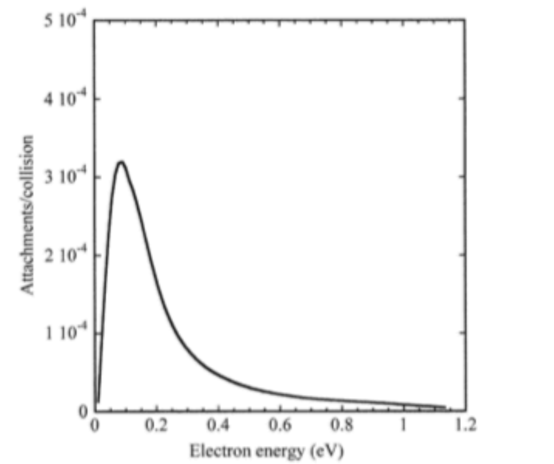


Figure 4.39 Electron attachment coefficient for oxygen (Bloch and Bradbury, 1935).

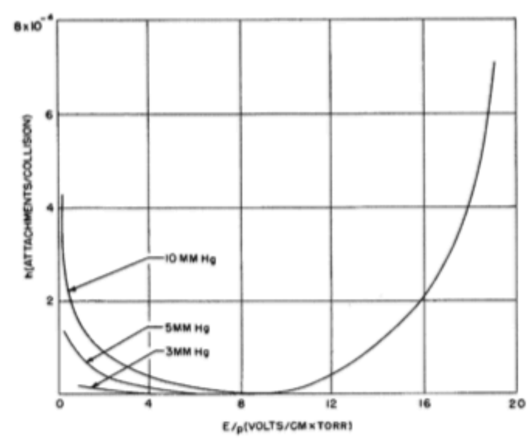
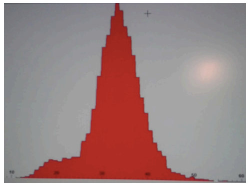


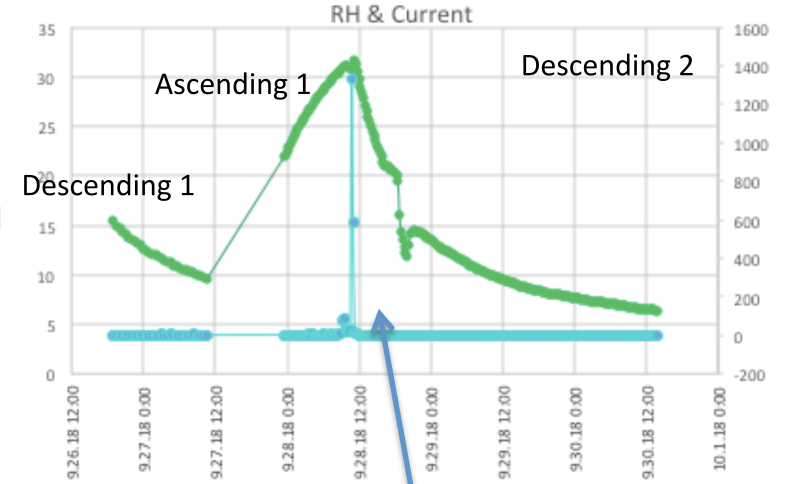
Figure 4.40 Electron capture probability in water vapours as a function of reduced field (Bradbury and Tatel, 1934).

Gain vs RH

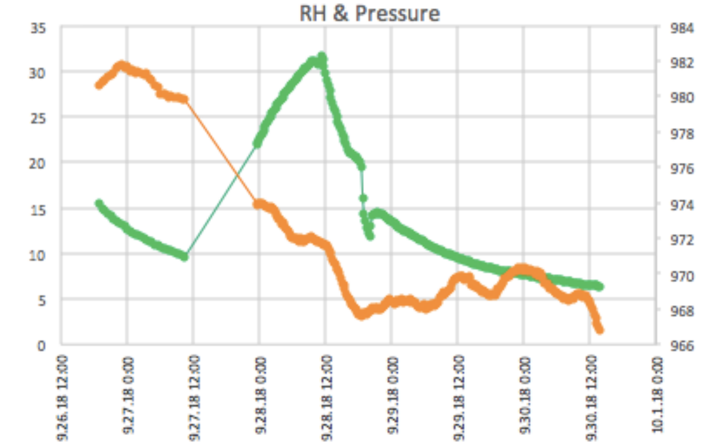
- HV_{res} = 500 V, HV_{drift} = 300 V; Ar:CO_2 93:7
- Gain (relative) measured with ^{55}Fe source and MCA

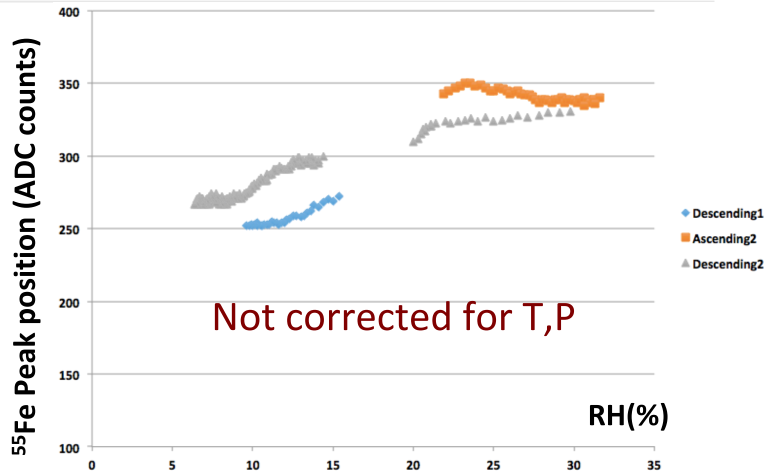


3 Periods of RH trend:
Descending 1
Ascending 1
Descending 2



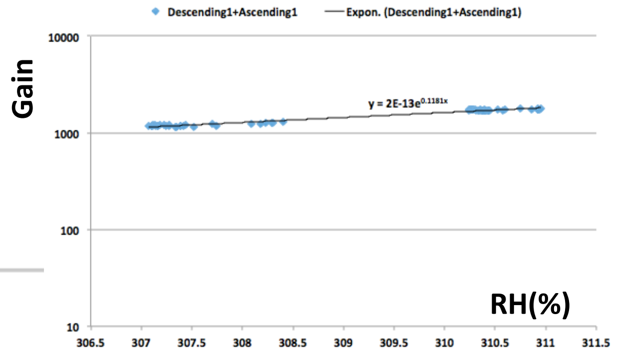
Unstable measurements removed from the analysis

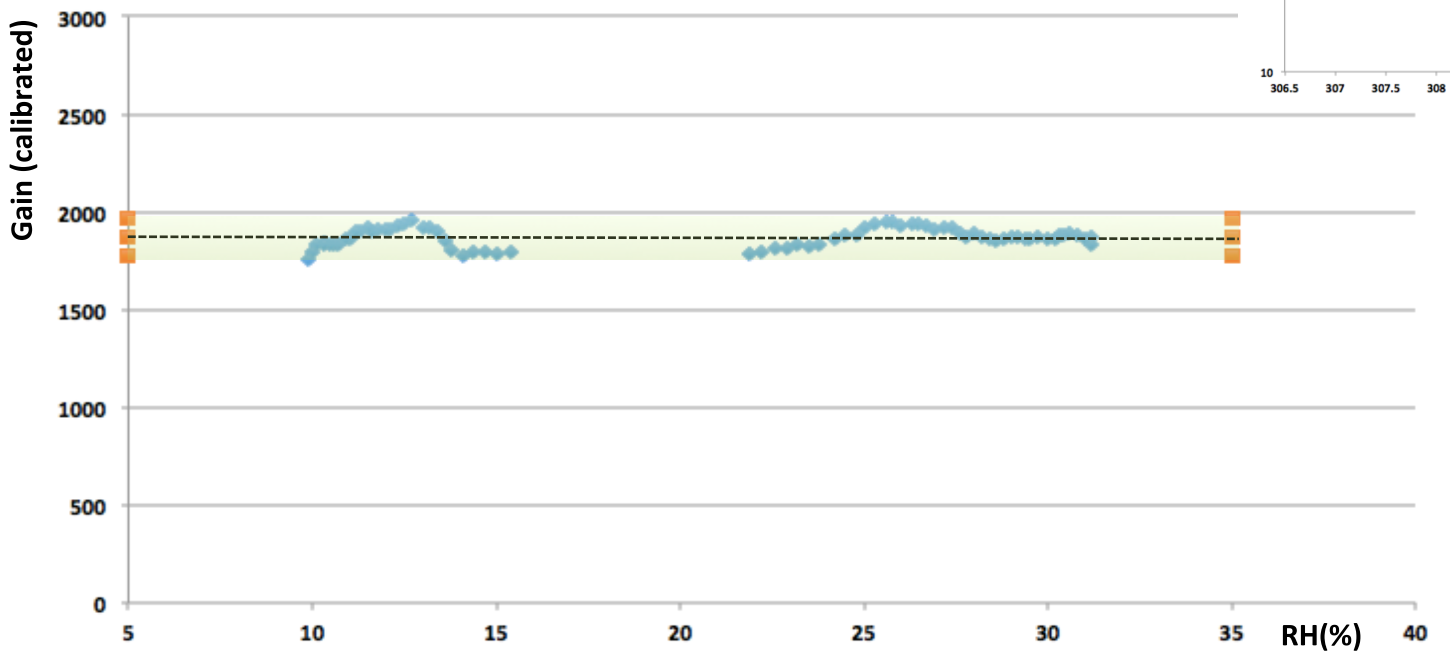




Gain vs RH after T/P correction

- After correction for T/P gain is stable with RH within +- 5% (in the interval 9-30% RH)



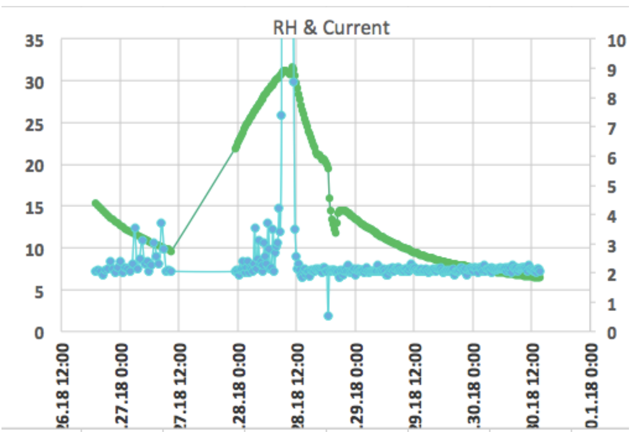


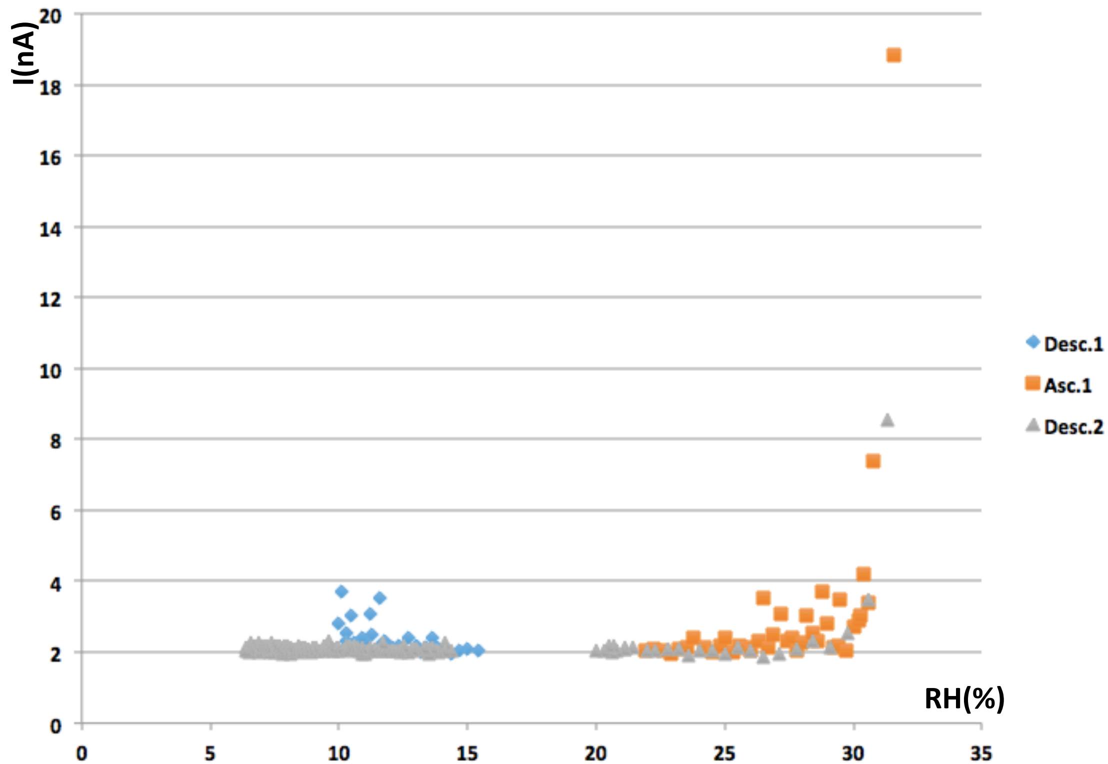
No evident trend in gain within RH=[9;30]% range

RH scan

- RH scan with Ar:CO2 93:7 with chamber already conditioned (running since several days with HV on)
  - Gas flow ~4l/h (detector volume ~1l)
  - 2 nA bias on HV channel

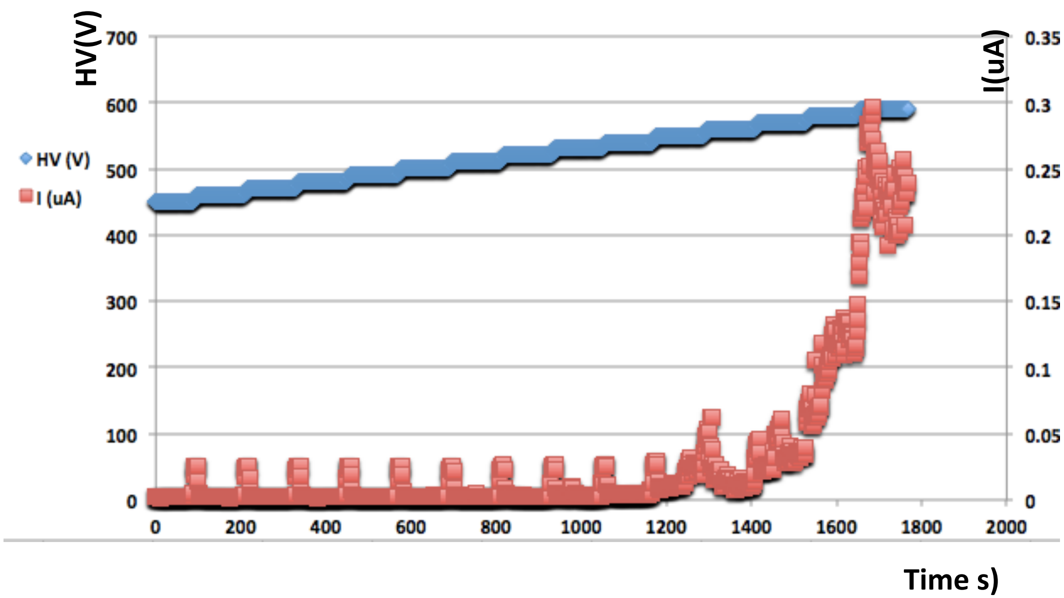
Smaller dependence from RH

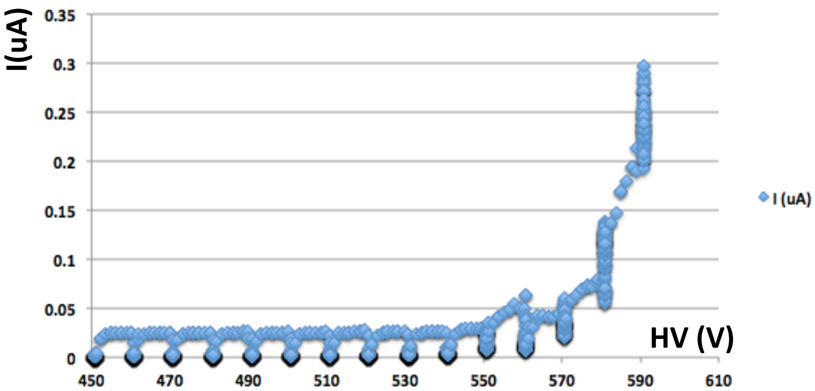


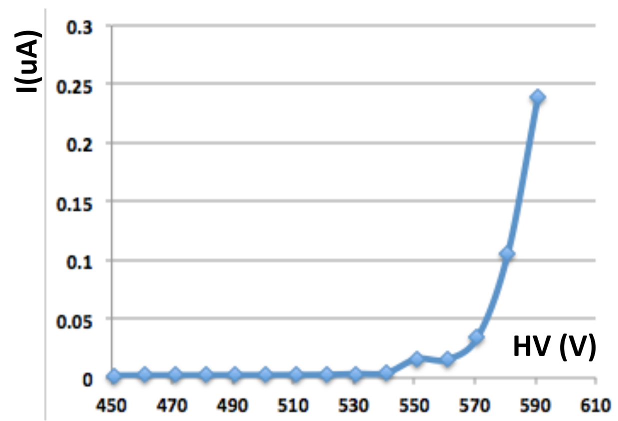


HV scan at fixed RH

- HV scans after stabilizing RH
- Current measured at 1Hz frequency → average on 100 measurements
- Example: 15.5% RH

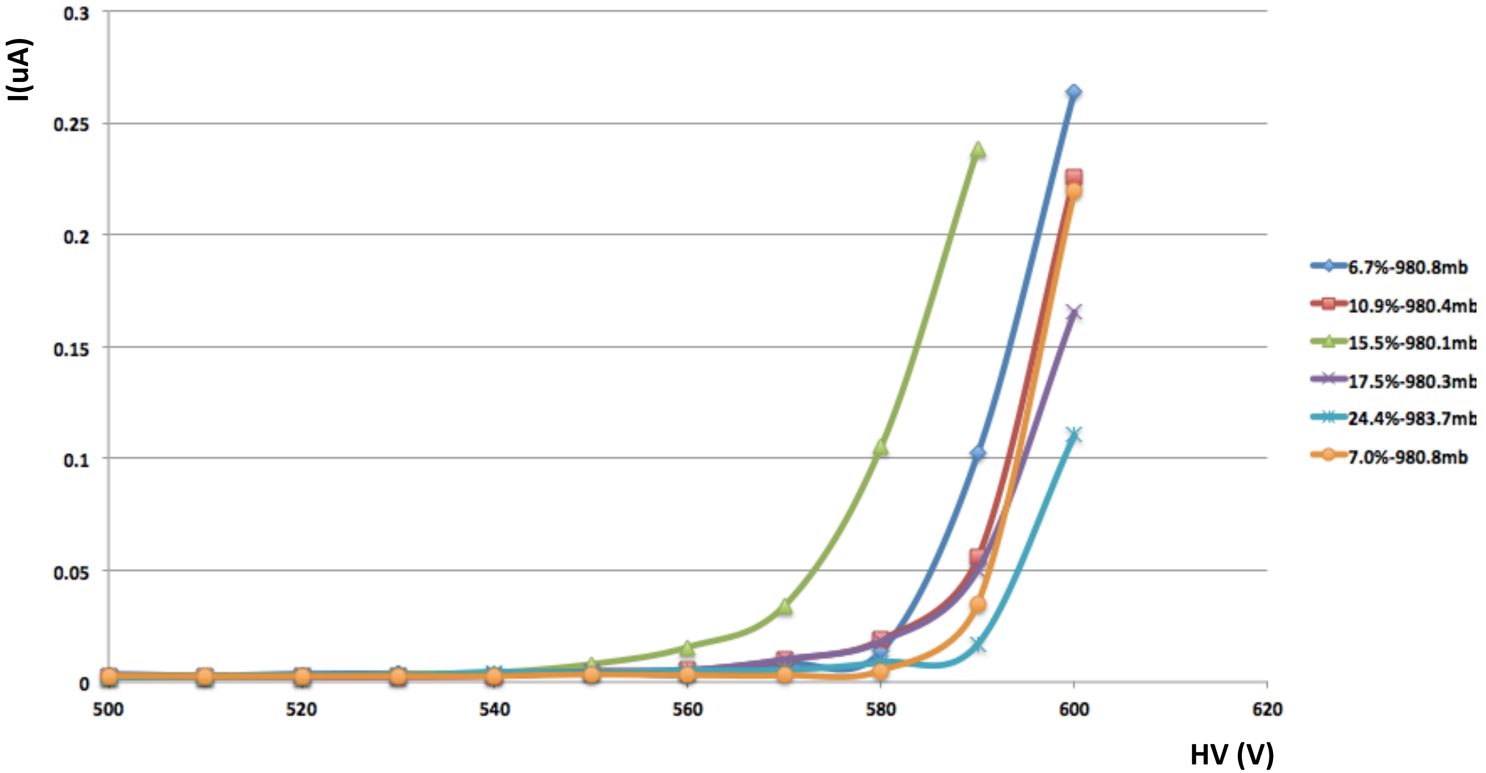






HV scan at fixed RH

- HV scans after stabilizing RH
- Current measured at 1Hz frequency → average on 100 measurements
- Currents depending on RH of gas AND history of chamber

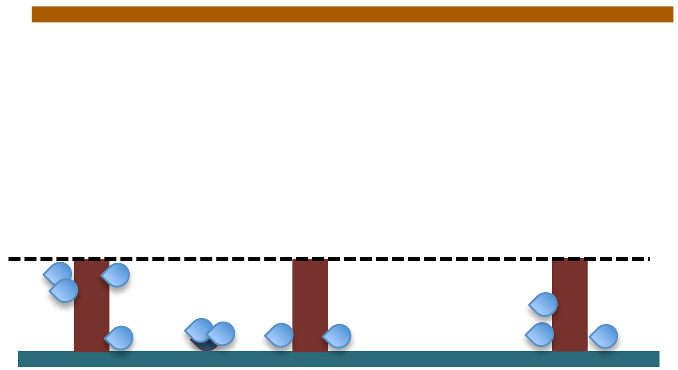


Time order
6.7%
10.9%
15.5%
7.0%
17.5%
24.4%

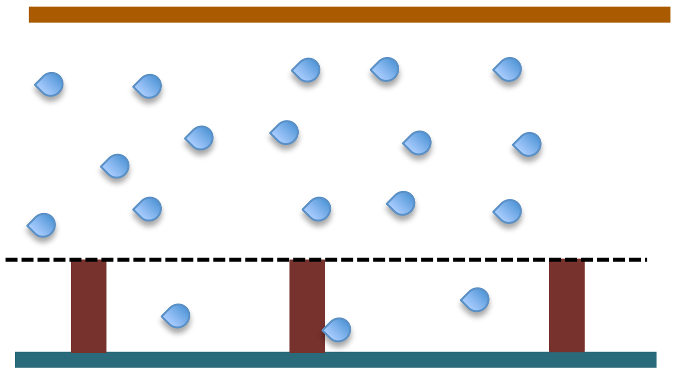
I vs V not linear
Not found the expected trend → time order matters!

Interpretation

- Observations:
  - Current 'induced' by humidity is non linear → discharges in gas
  - Two different behaviors observed: at detector closing (or after long time not being flushed) and during steady operation (after conditioning)



<u>Detector closing</u>
Water molecules trapped in detector material (pillars surfaces, local dust, etc) highly impact the dark current
Improves with time/flushing → conditioning (moisture desorption from material)



<u>Stable operation</u> (after conditioning)
Moisture entering through gas pipes and o-ring
Water molecules follows the gas path, no local accumulation on material (in short- and mid-term) → tolerable impact on currents for reasonable HR levels

Conclusions

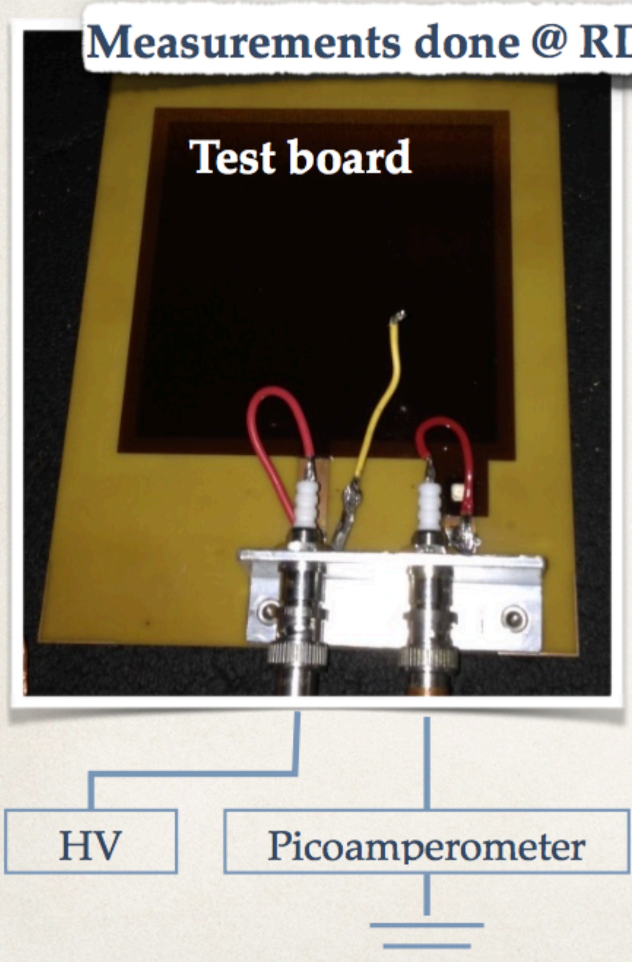
- Effect of humidity studied on resistive Micromegas
- Gas gain does not change significantly with RH (interval studied 9-30% RH)
- Large dependency of dark current vs RH at the detector closure → desorption of water content from the detector ('chamber conditioning')
- After conditioning: reduced (but still there) dependency on RH of gas
- Measurement of gas RH is not the only parameter to be accounted for: history matters

Thanks to: E. Oliveri, L. Ropelewski, F. Sauli, R. Veenhof for useful discussions

Additional Material

Study on Pyralux

Setup



10x10 cm^2 Cu area covered with 125 μm of DuPontTM Pyralux® PC1025 coverlay

Discrepancy observed between nominal and measured resistivity:

- ☑ 3.4×10^{16} Ωcm from datasheet
- ☑ 3.25×10^{14} Ωcm from measurements done at the lab temperature (≈21°C)

discrepancy ~ 2 order of magnitude

Data taking procedure:

- ☑ the test board has been cooked for 3h at 180°C to recover the nominal resistivity
- ☑ the coverlay resistivity has been measured at different temperatures

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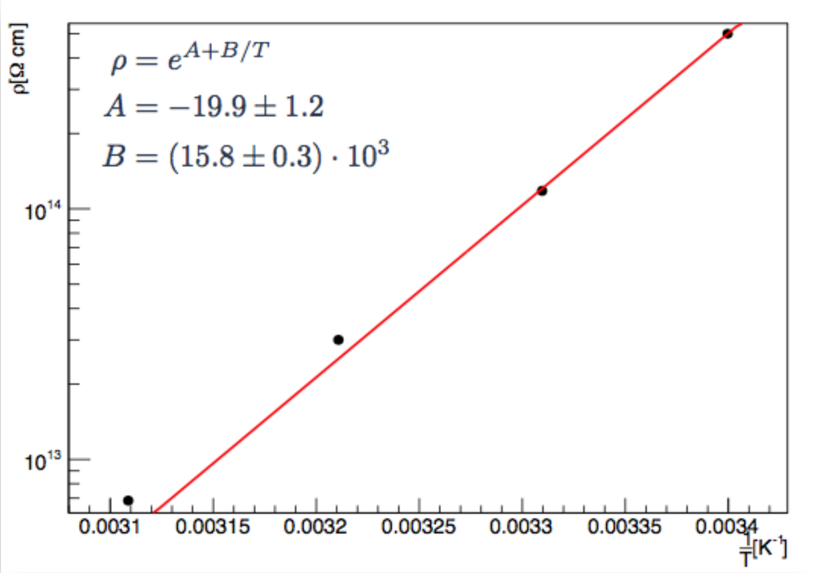
Study on Pyralux

Resistivity Vs Temperature

Before cooking ↑ (first row); After cooking ↑ (remaining rows)

T[C]	ρ[Ωcm]
Lab temperature	$\approx 3.25 \times 10^{14}$
Lab temperature	$\approx 1.37 \times 10^{15}$
≈29	$\approx 1.18 \times 10^{14}$
≈38.3	$\approx 3 \times 10^{13}$
≈48.5	$\approx 6.8 \times 10^{12}$
Lab temperature	5×10^{14}



The last four points follow $\rho = e^{A+B/T}$ relation with T expressed in Kelvin

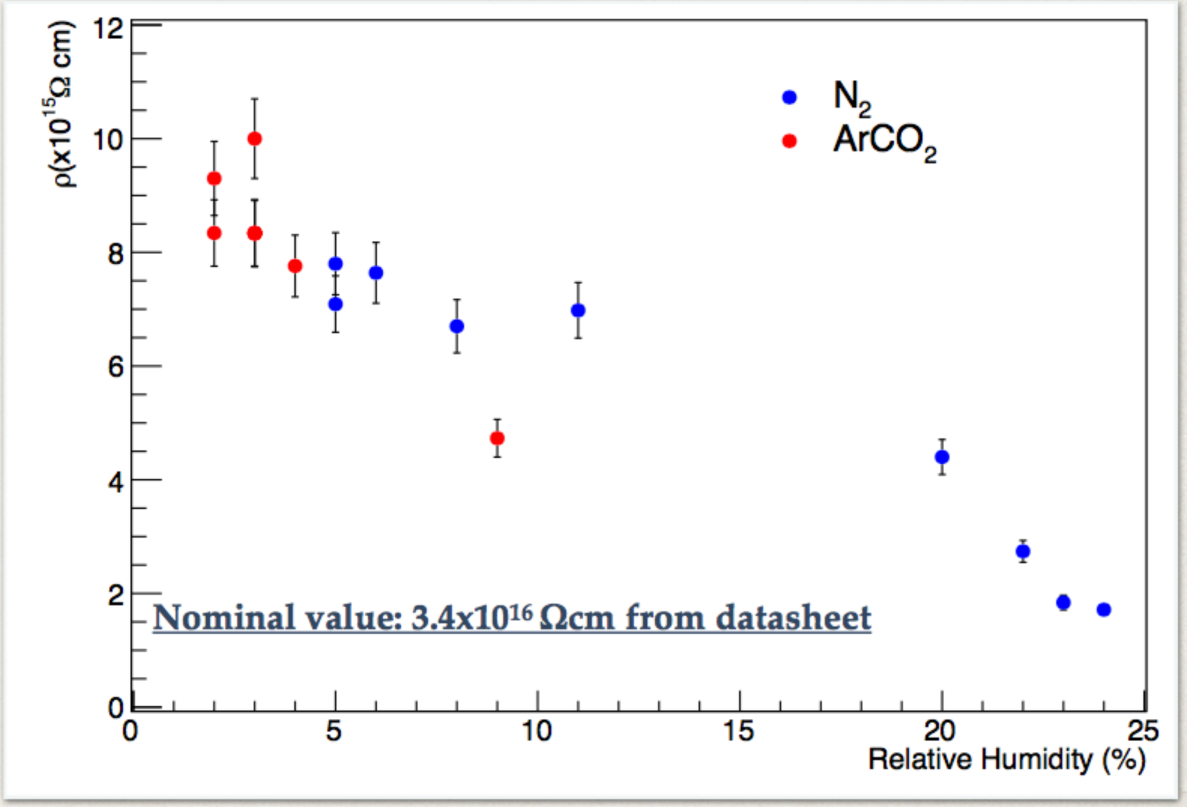
The test board has been on air for all the data-taking -> Further investigation on humidity effect needed

Study on Pyralux

Resistivity Vs Humidity

Drying the **test board** with **$ArCO_2$** or with **N_2** gives the possibility to **gain one/two order of magnitude in resistivity** with respect to the initial value

These results are coherent with what has been observed immediately after the cooking procedure



The measured lower resistivity can be explained with the absorption of humidity on part of the coverlay material