THGEMs for RICH applications

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On behalf of
Alessandria ,CERN, Freiburg, Liberec, Prague, Torino, Trieste Collaboration

Outlook

detector setup description
first results from the test beam
critical review of some detector/setup aspects
future improvements

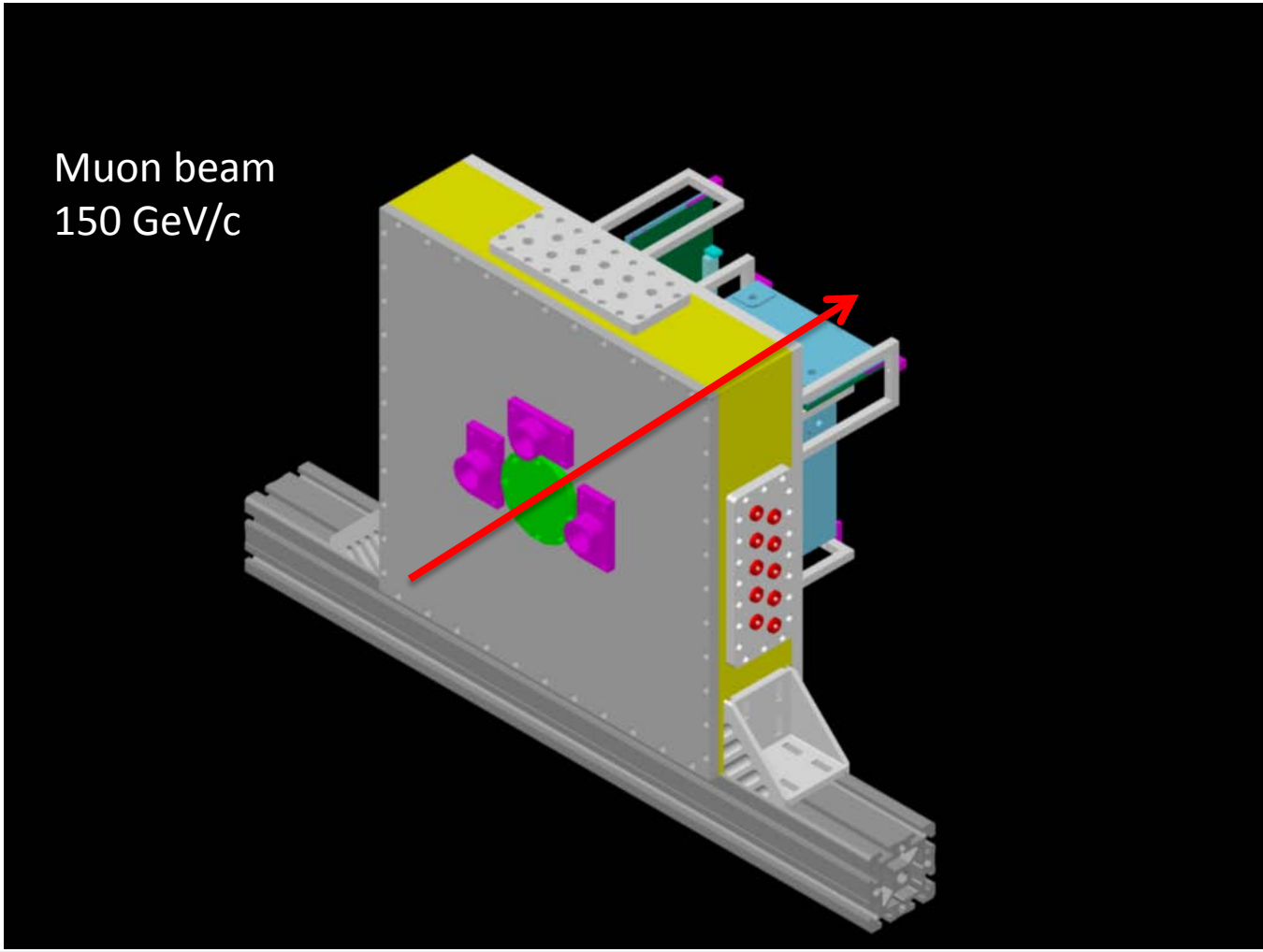
Detector installed at 887 Building CERN beam line H4 after Goliath magnet
Muon beam at 150 GeV/C
Beam dimensions:

X -> approx. 40mm @ 3σ
Y -> approx. 30mm @ 3σ

measured with wire Chamber sitting nearly1 m Before the detector

Approx 3.2E3 particles per spill (9.6seconds)

Higher intensity π beam has been used for stability test

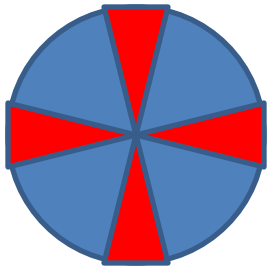


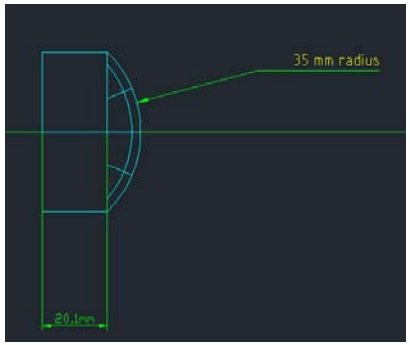
Detector characteristics

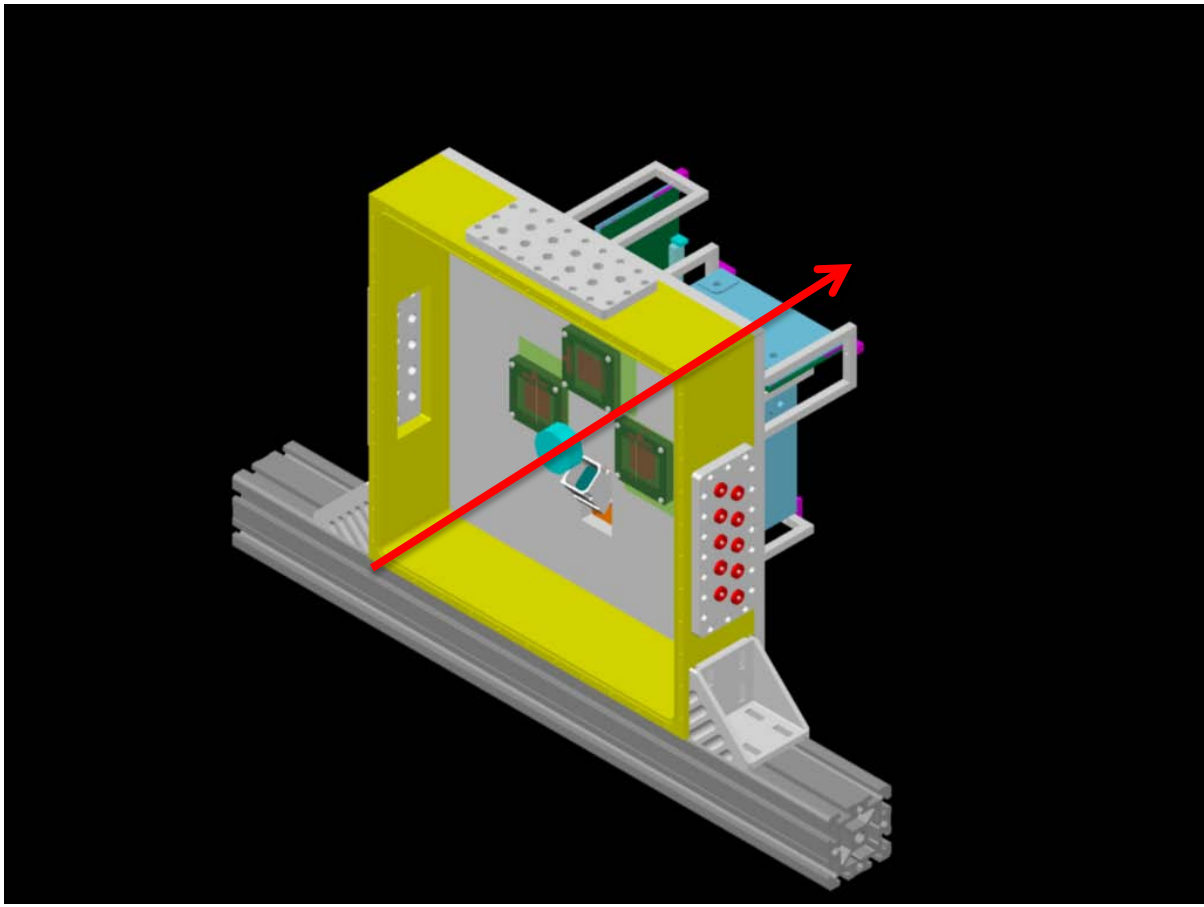
3 Triple THGEM 0.4 mm hole diameter , 0.8 mm pitch, 0.4 mm thickness (10 μm)
2 triple THGEM (Jura and Saleve) identical
1 central one equipped with grid (0.6 mm holes diameter, 0.8 pitch , 0.2 mm (fully metalised) thickness
to study ion feedback

1 MAPMT R7600 M16

Quartz radiator,
Half of the radiator is darkened at sectors of nearly 40 degrees,
45 degrees rotation allows for non single photon illumination







Cherenkov light emitted by the quartz radiator impinging on the THGEMs and on the MAPMT

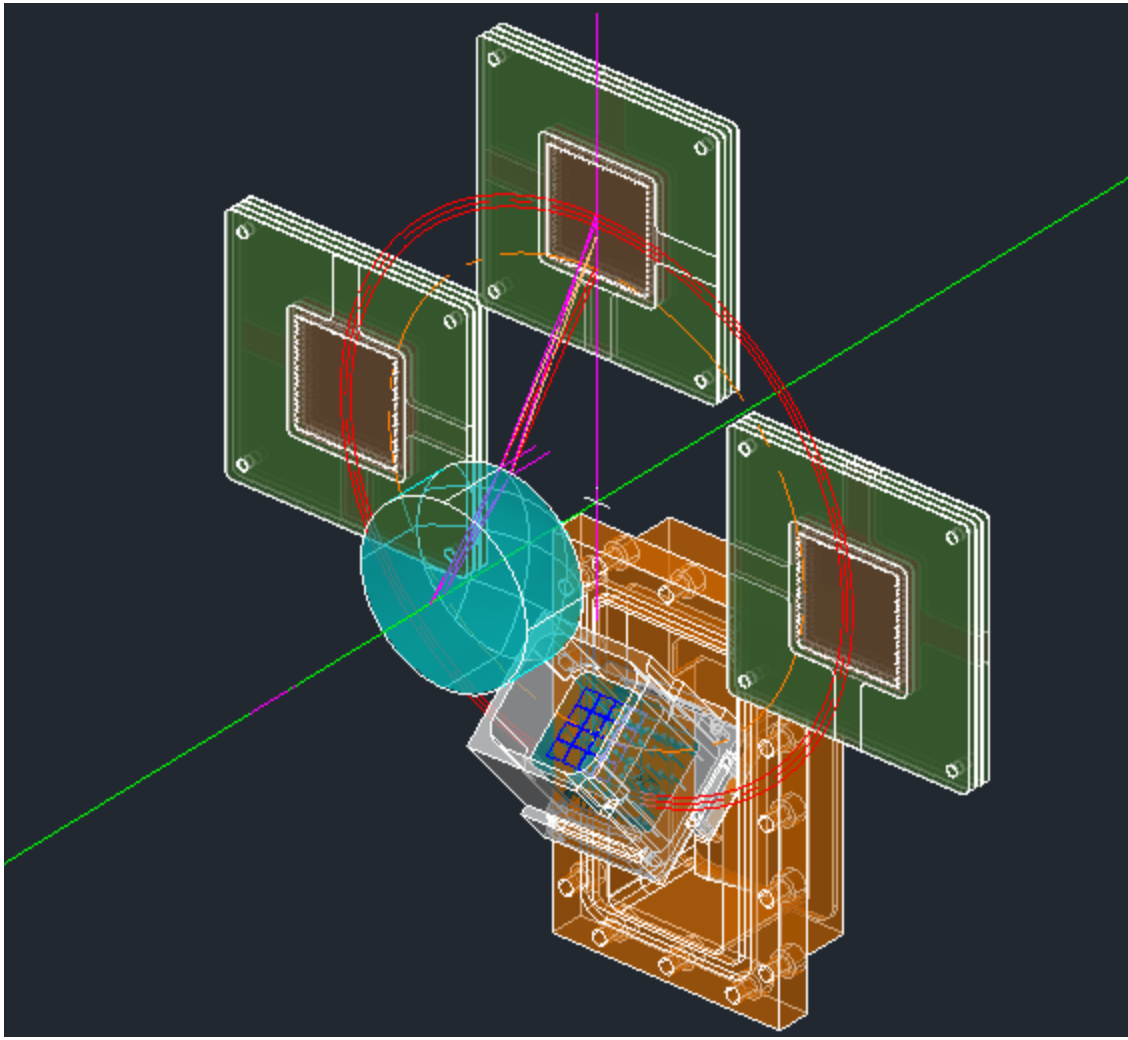
Corona of 147 mm radius ± 3 mm
6 mm transverse size onto THGEM
for wavelenght 165 195 nm

All THGEM can be tested using a UV LED placed in front of the CsI photochatode

Gas Ar/CH_4 50/50 flow rate 50 l/h

Typical gain 1-2 10^5

HV supplied from Caen N471A and one module 1471A channel remotely controlled PS
All channels indipendently or via resistive divider after operating voltage selected

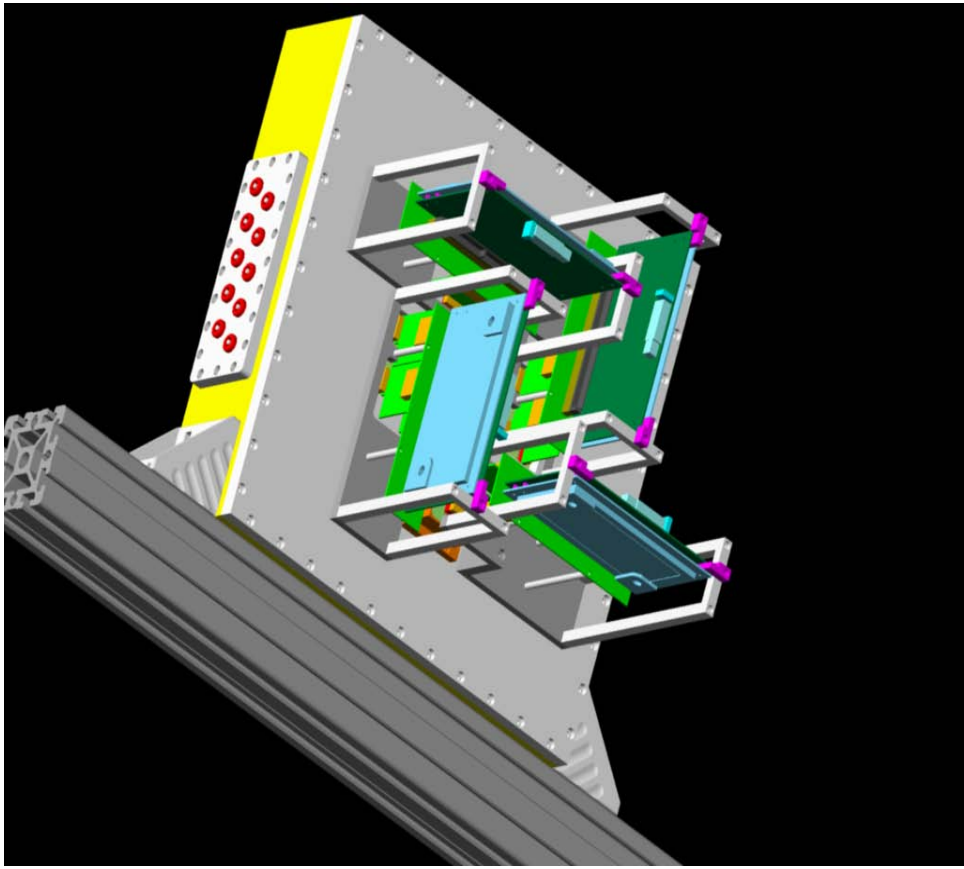


Trigger

6 scintillators

2 100 mm x 100 mm first and last intercepting the whole beam FP, RP
4 fingers 5 mm x 3 mm
2 at 90 deg each after the first FP
2 at 90 deg each before the last RP
Prealigned with the radiator/chambers

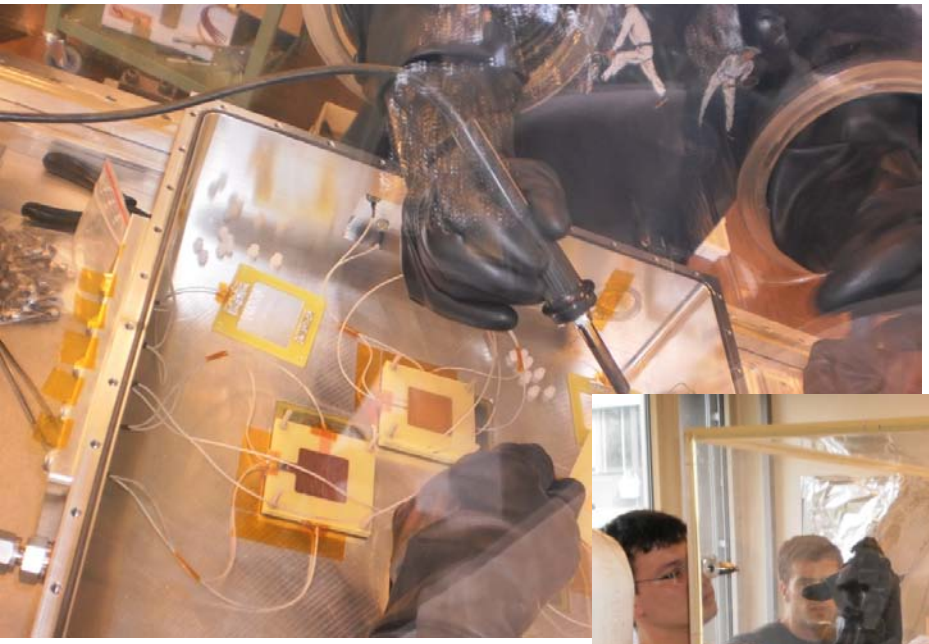
With typical beam intensity trigger rate nearly 40 Hz

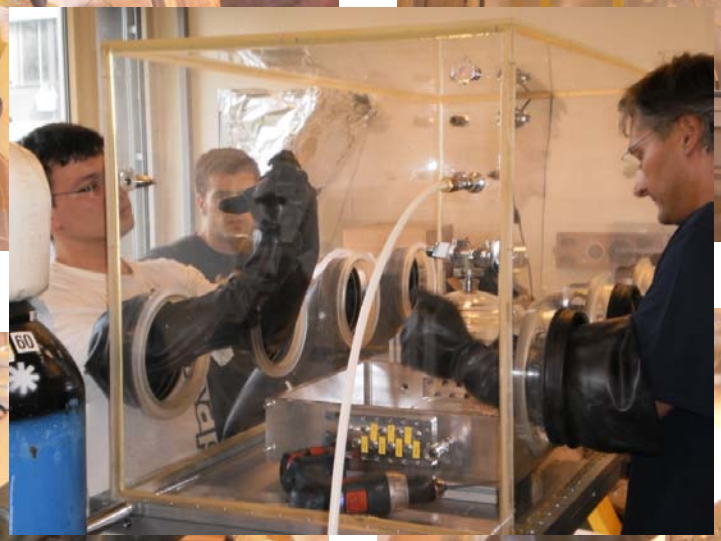
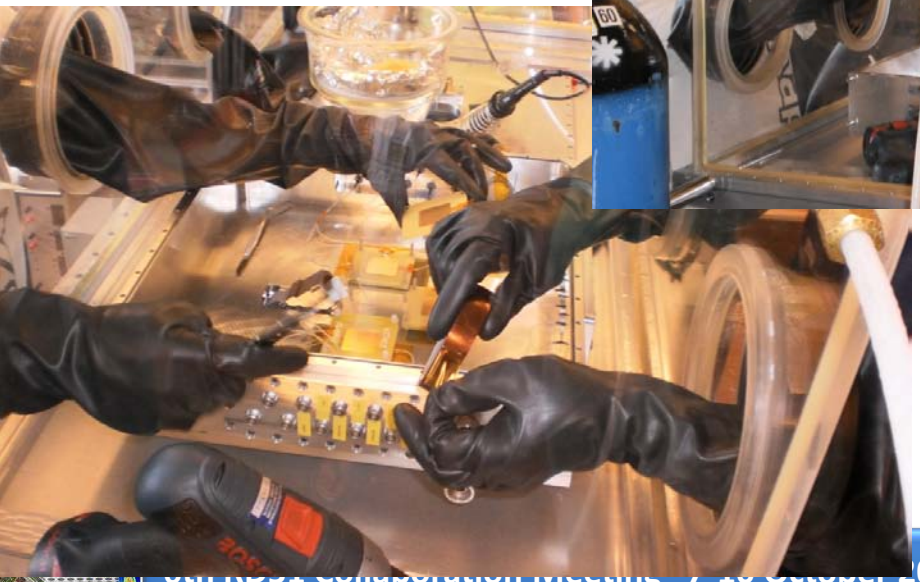
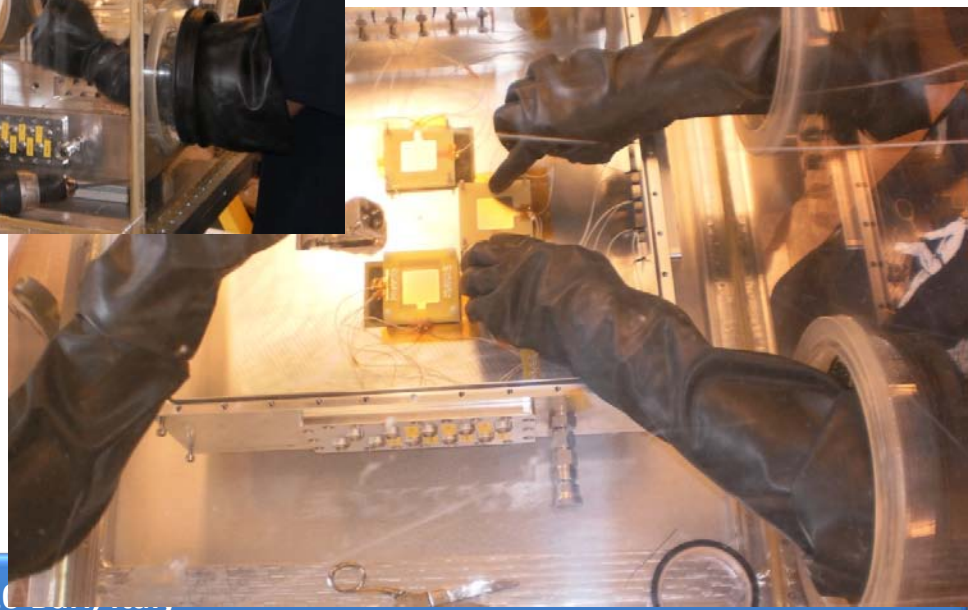


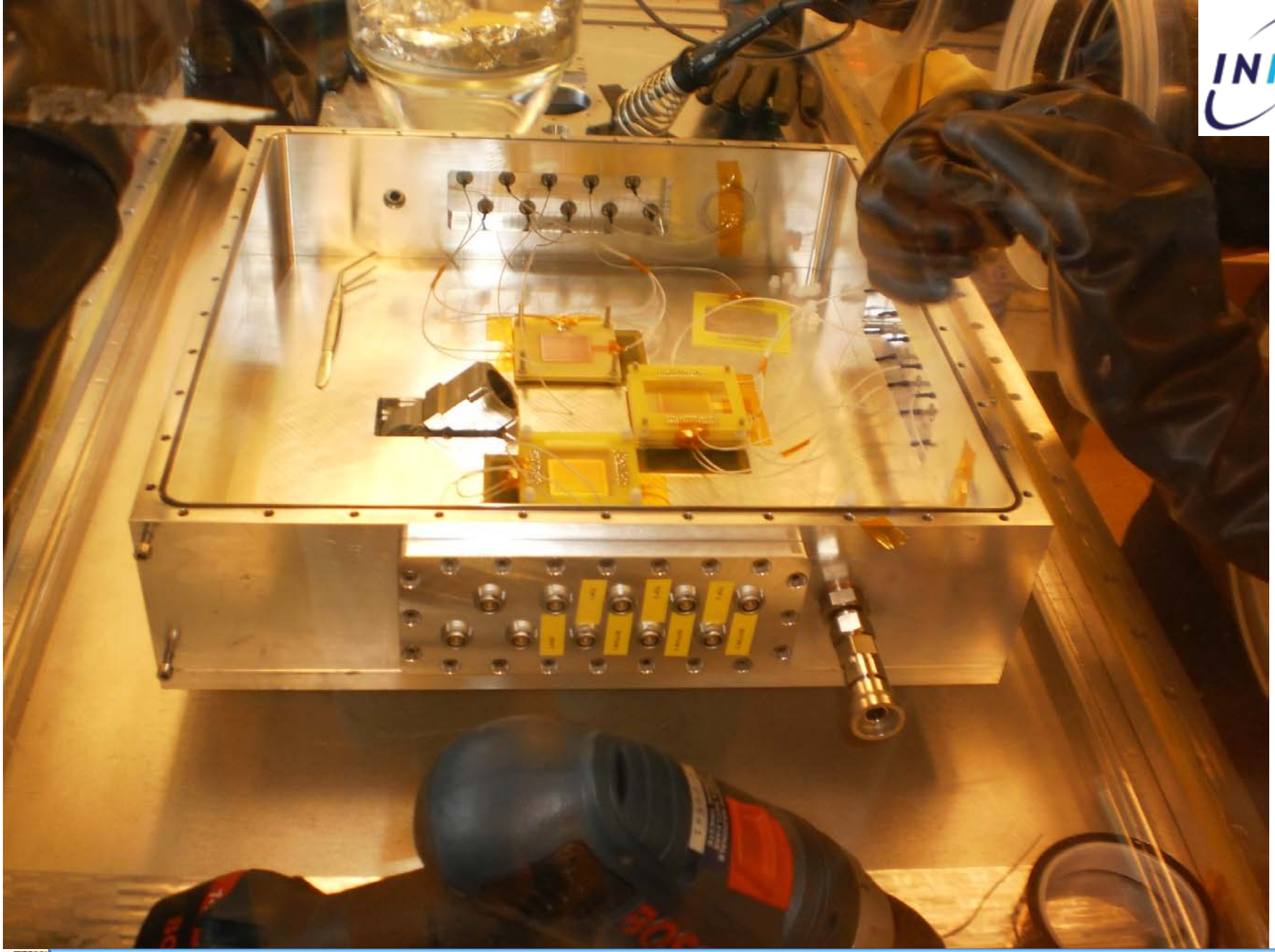
Readout:

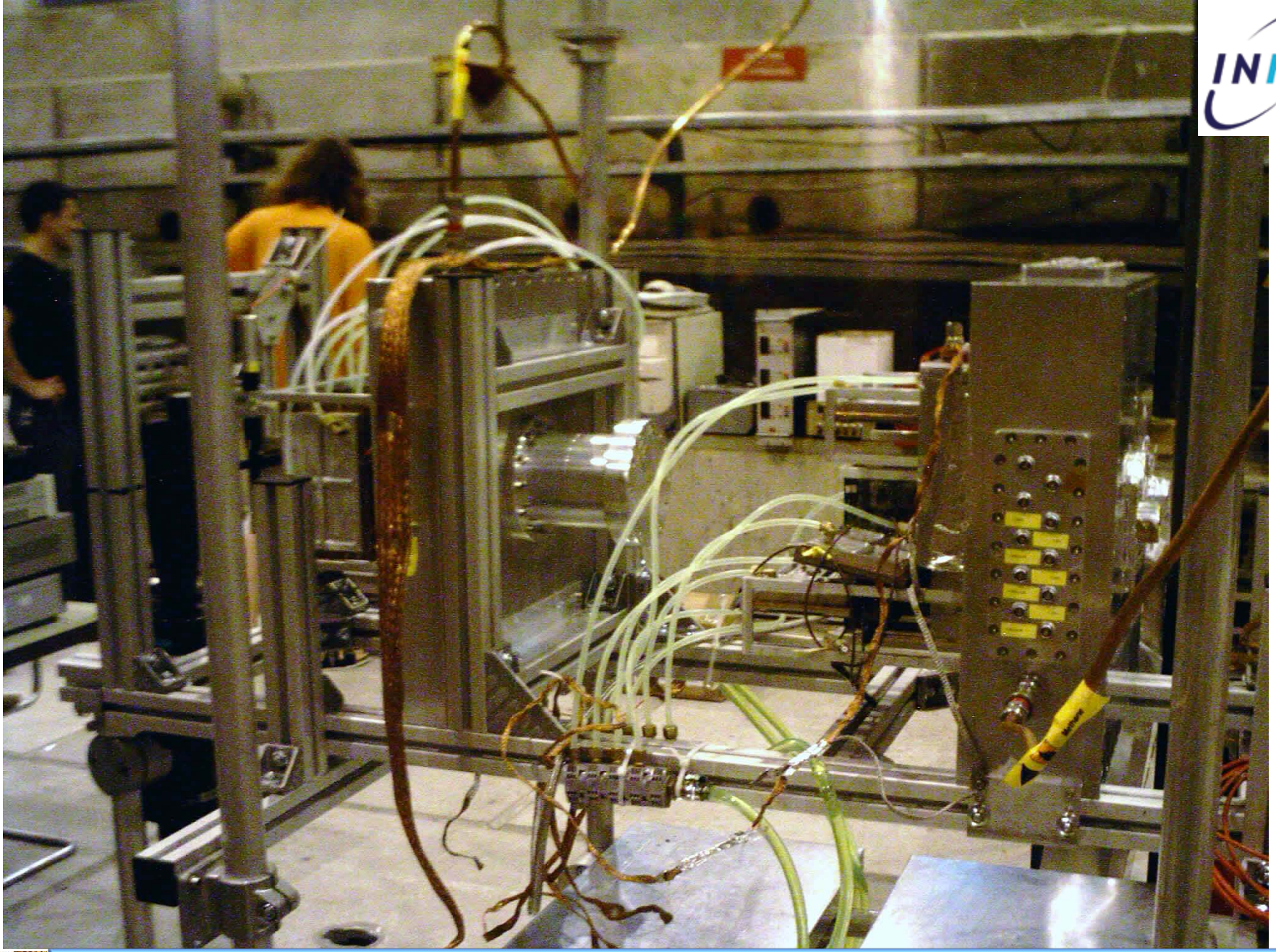
Analog readout
Electronic chain based on Cremat preamplifier + Ortec Amplifier and MCA8000A

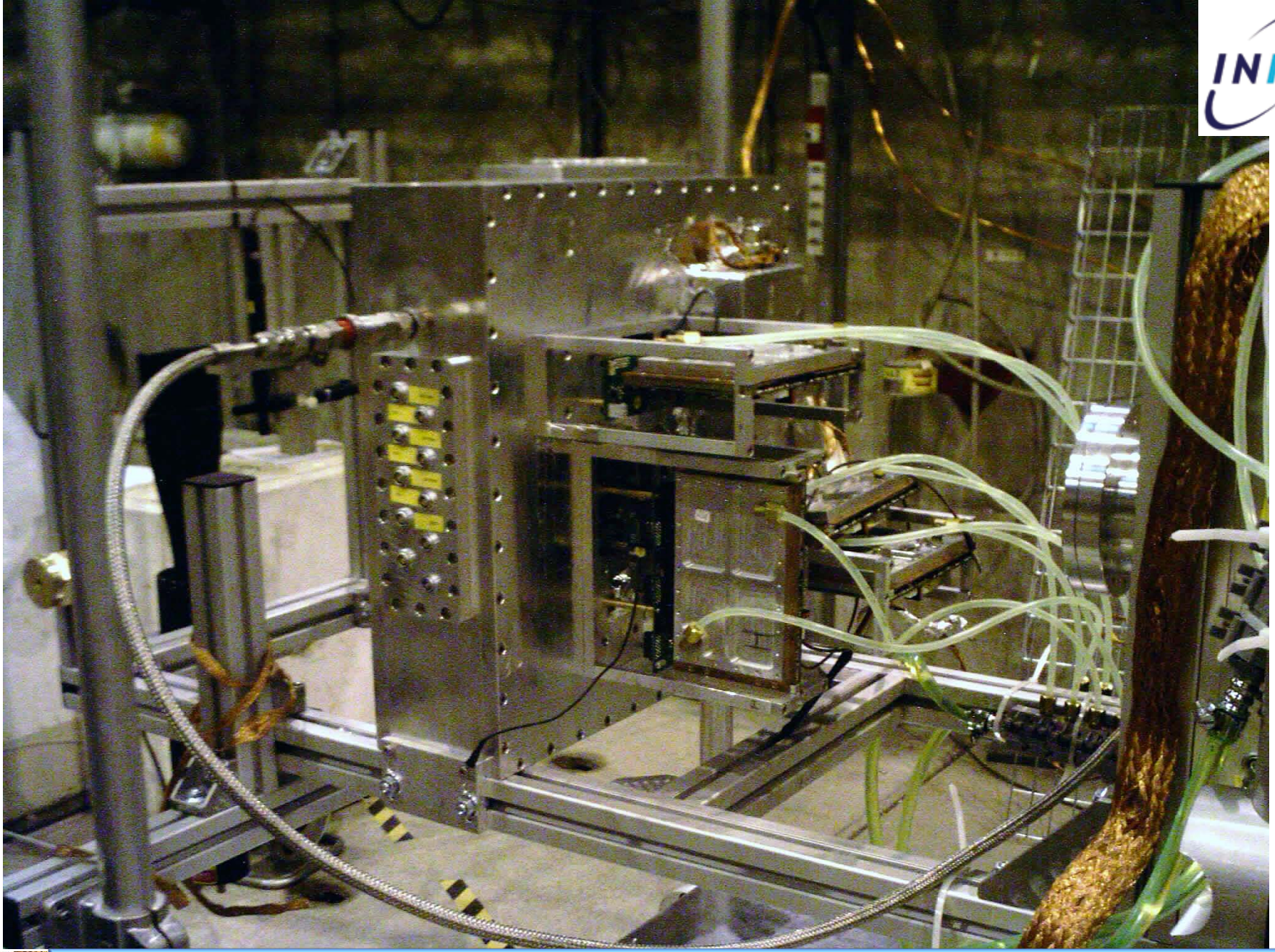
Digital readout
CMAD based front end board + F1 TDC
(Compass MAPMT readout system)





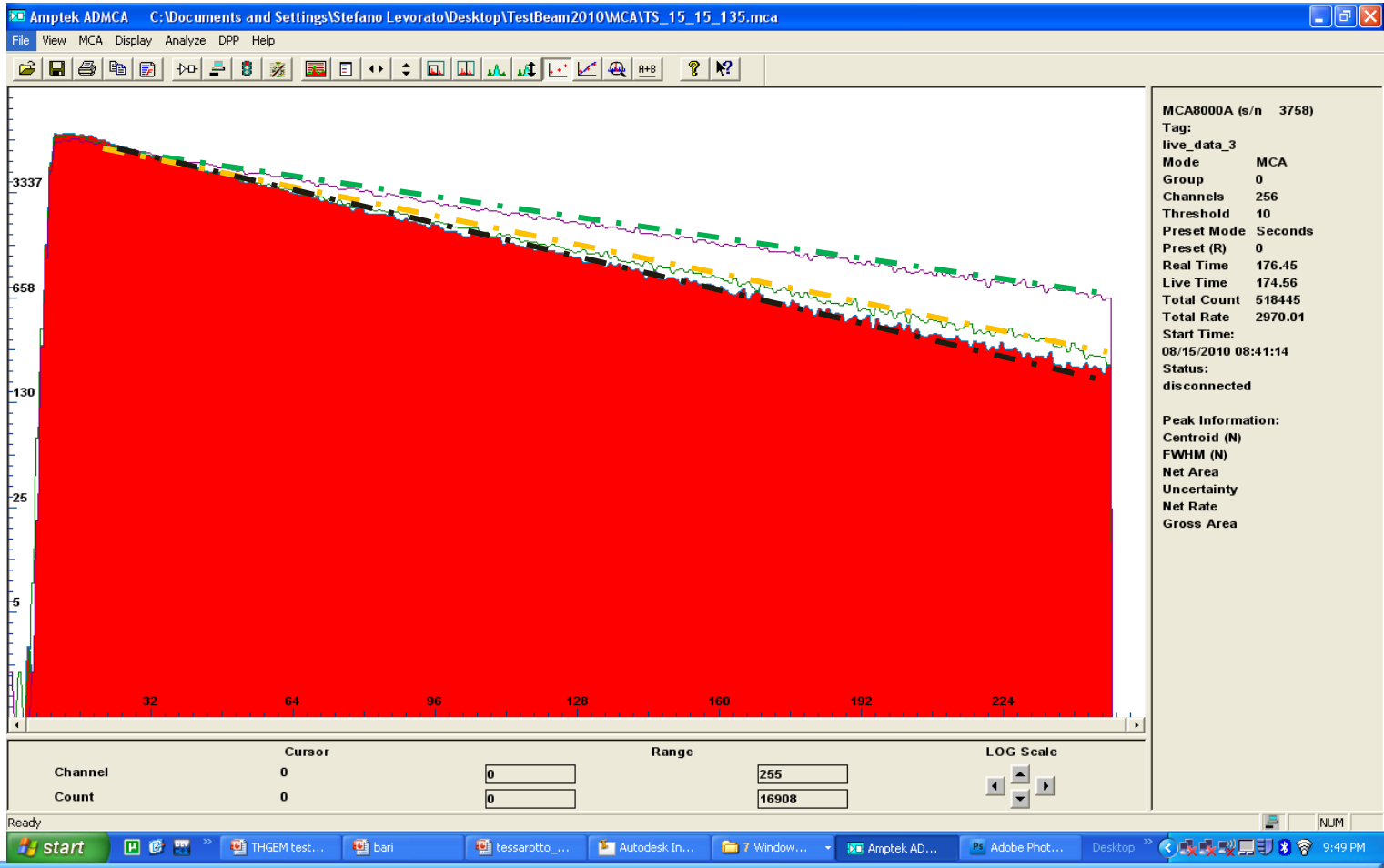




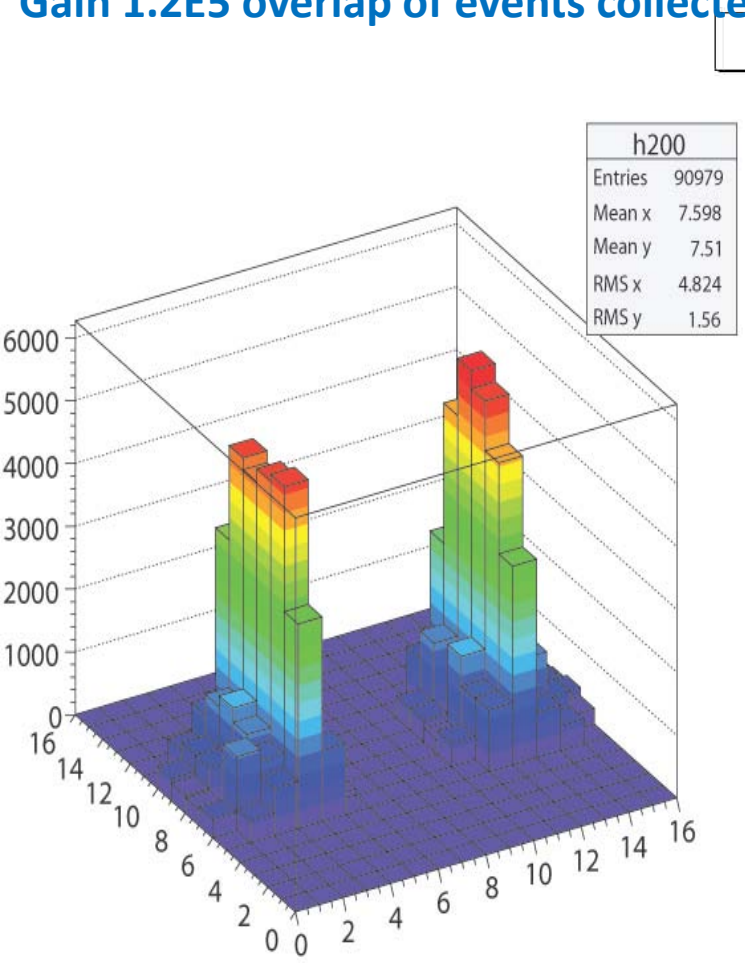
Spectra acquired with analog readout and UV LED allow for calibration and gain measurement: spectra obtained at different ΔV for the last layer

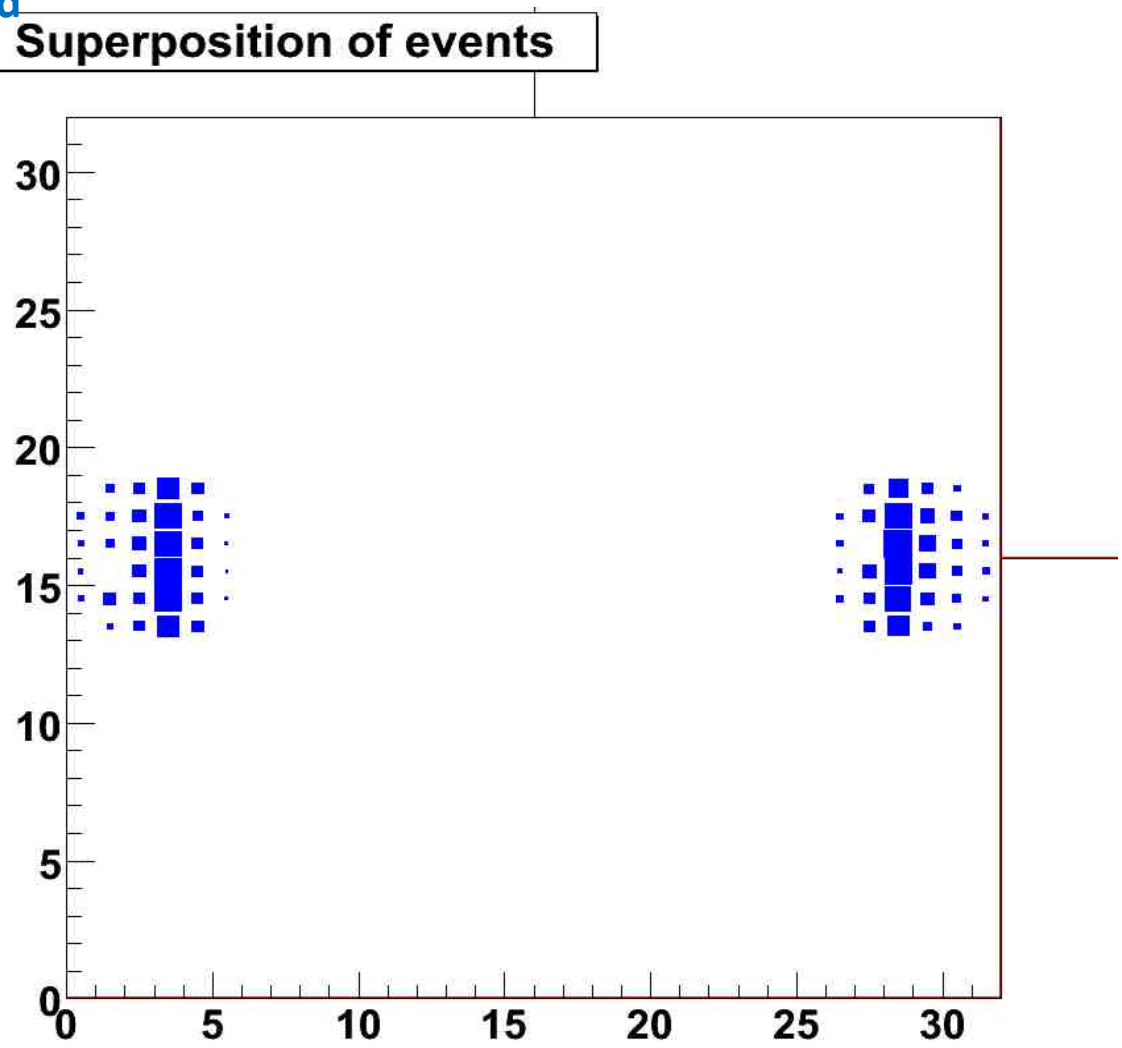
1.5 1.5 1.5 **1.5 1.5 1.45** **1.5 1.5 1.35**

Gain from slope of the fit from 3E5 1.6E5



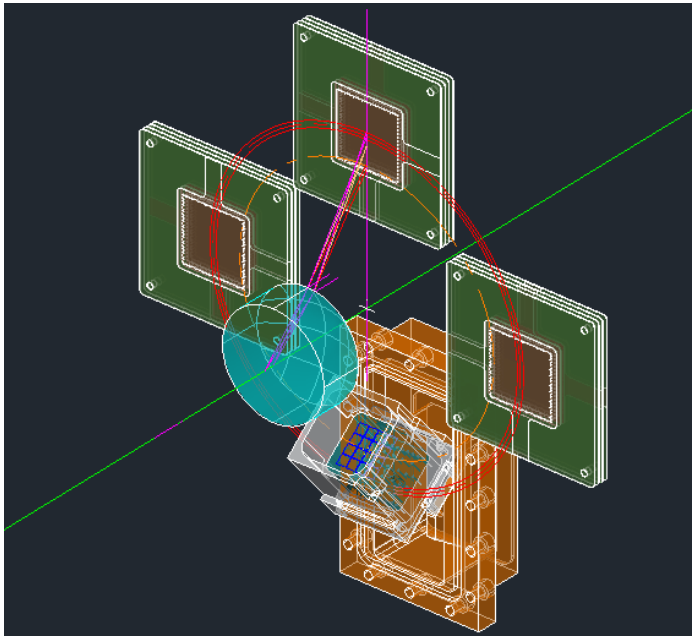
Jura and Saleve THGEM Digital Readout, Threshold set at 3fC for each of the 32 x 2 channels, Gain 1.2E5 overlap of events collected

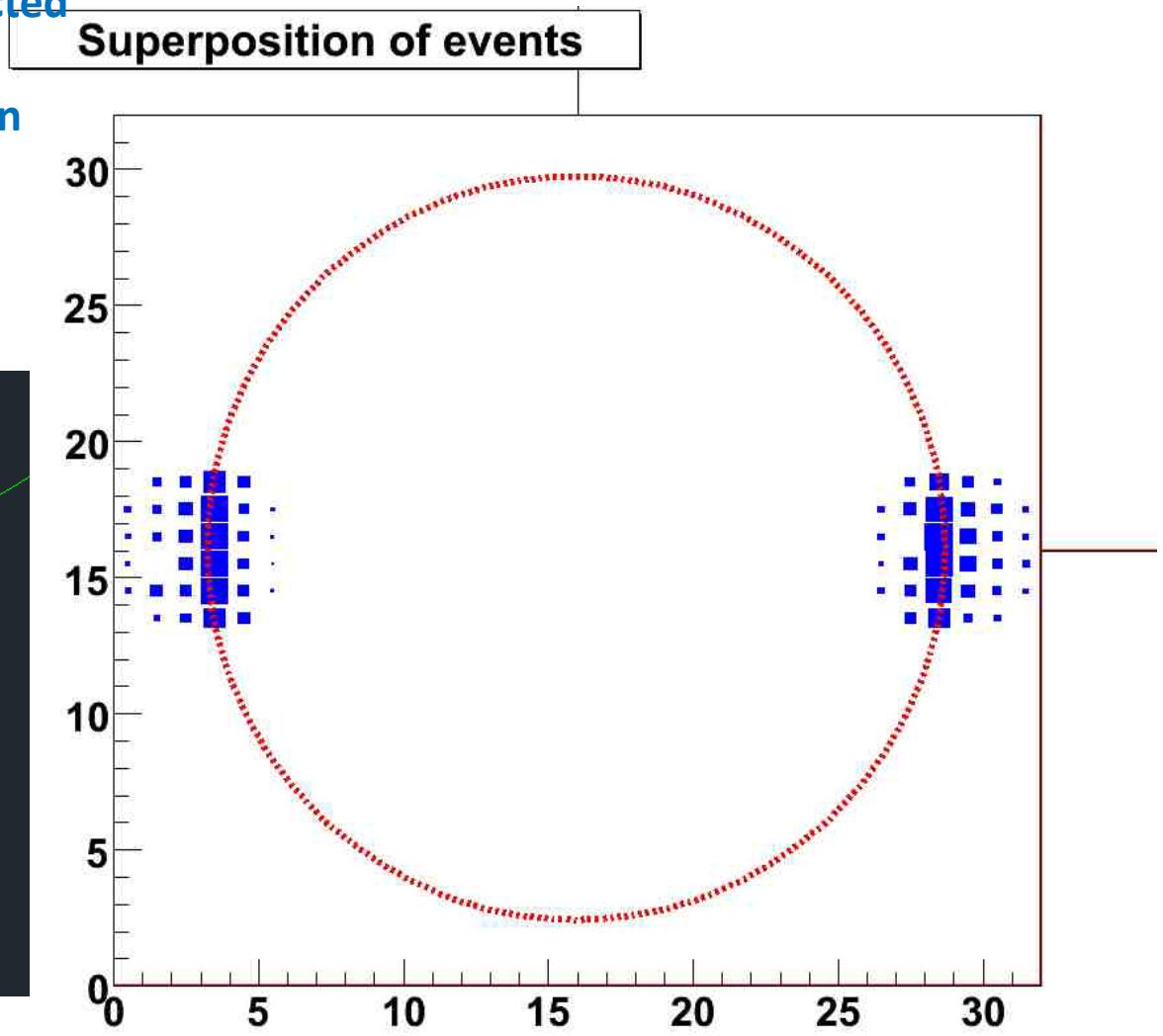




Jura and Saleve THGEM Digital Readout,
Threshold set at 3fC for each of the 32 x 2 channels,
Gain 1.2E5 overlap of events collected

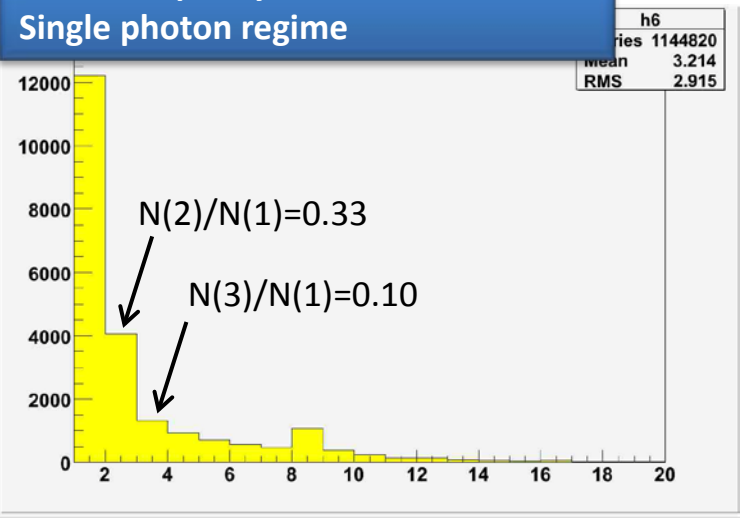
The circle is the expected corona on the THGEM surface



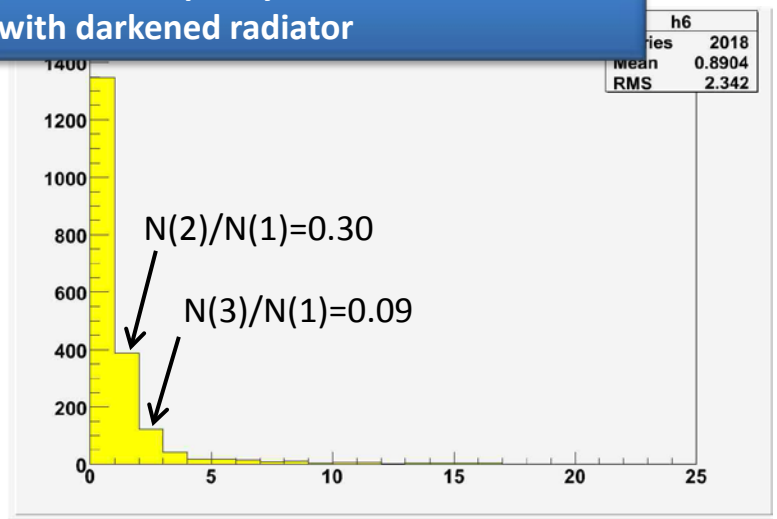


Time distribution properties of the collected events

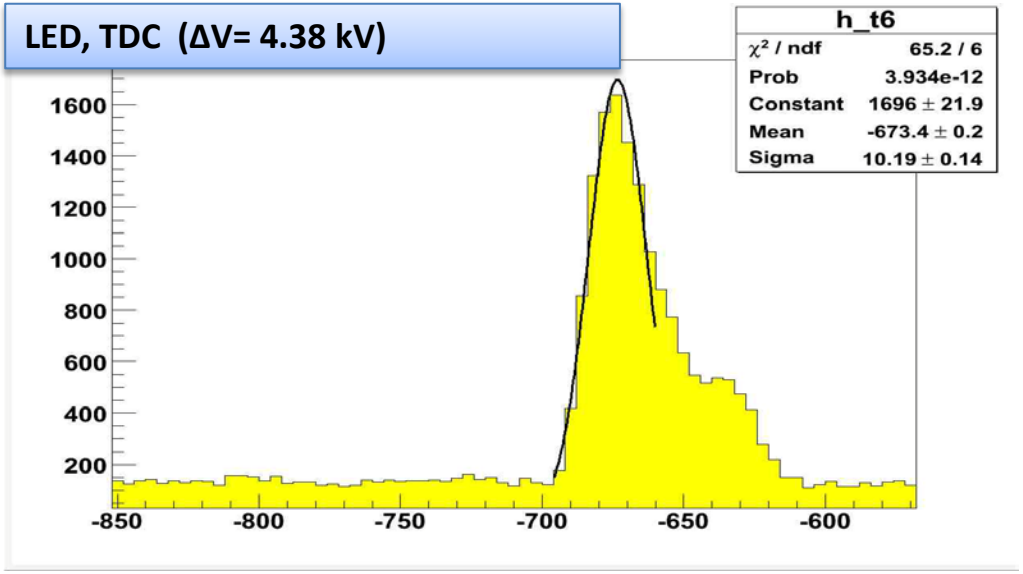
LED, multiplicity @ ΔV = 4.35 kV
Single photon regime



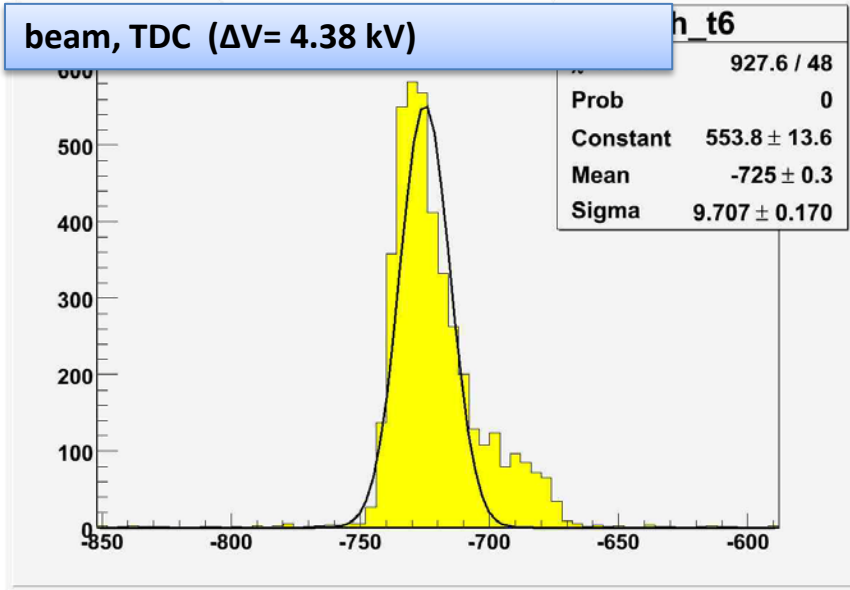
beam, multiplicity @ΔV = 4.35 kV
with darkened radiator



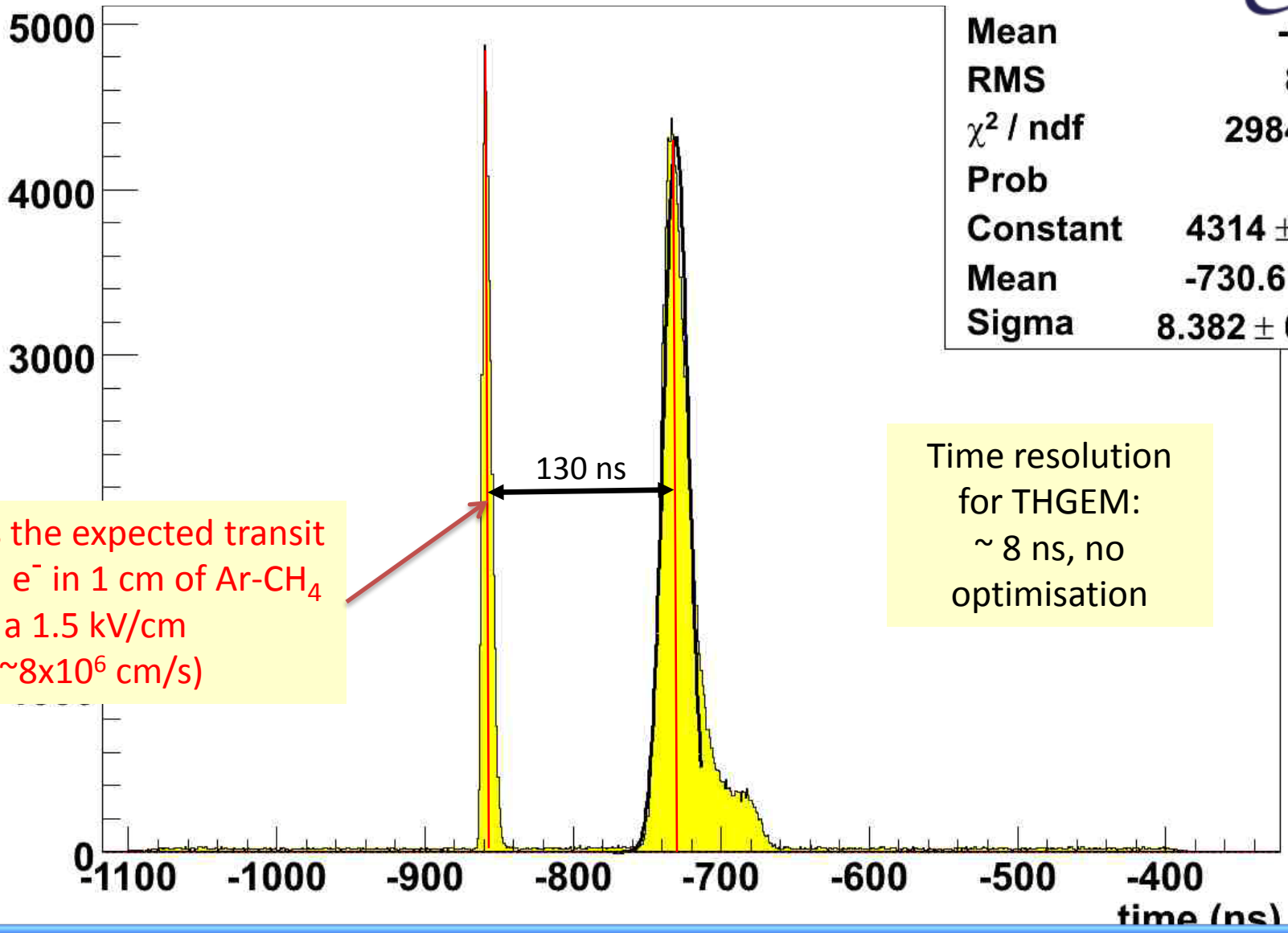
LED, TDC (ΔV= 4.38 kV)



beam, TDC (ΔV= 4.38 kV)



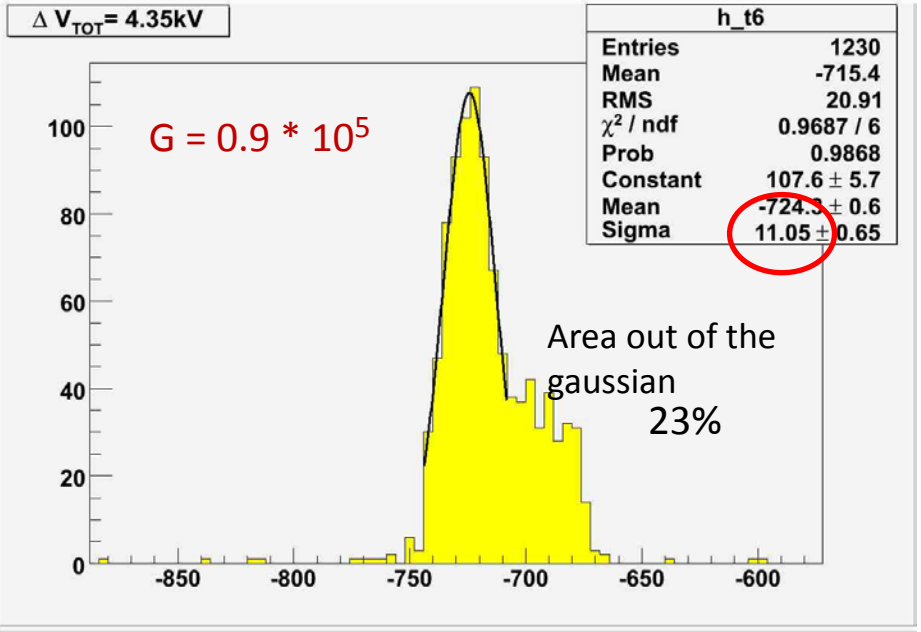
Time formation of the signal for triple THGEM detectors

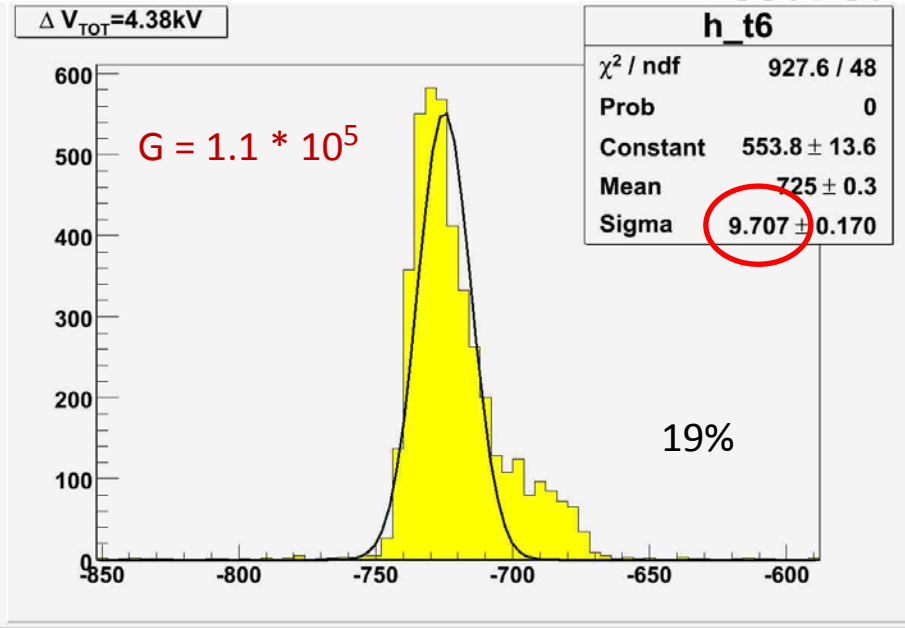


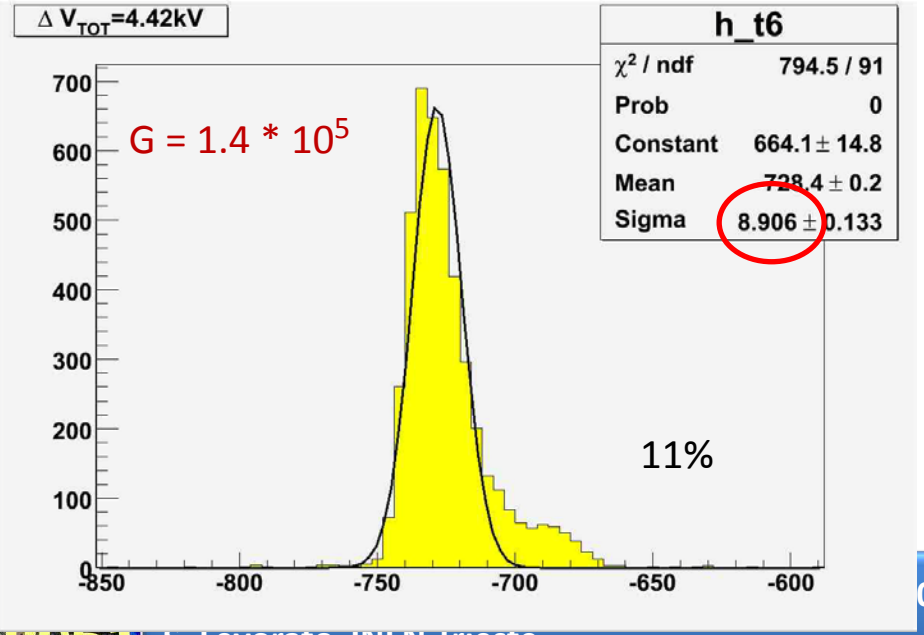
125 ns is the expected transit time for e^- in 1 cm of Ar-CH_4 a 1.5 kV/cm (~8×10^6 cm/s)

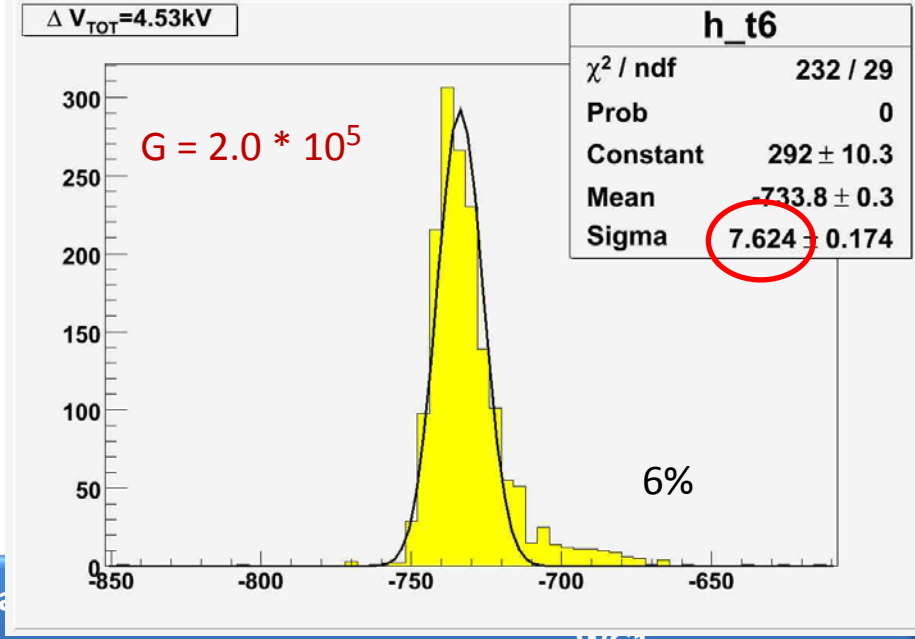
Time resolution for THGEM: ~ 8 ns, no optimisation

Time formation of the signal for triple THGEM detectors (powered via R-divider)







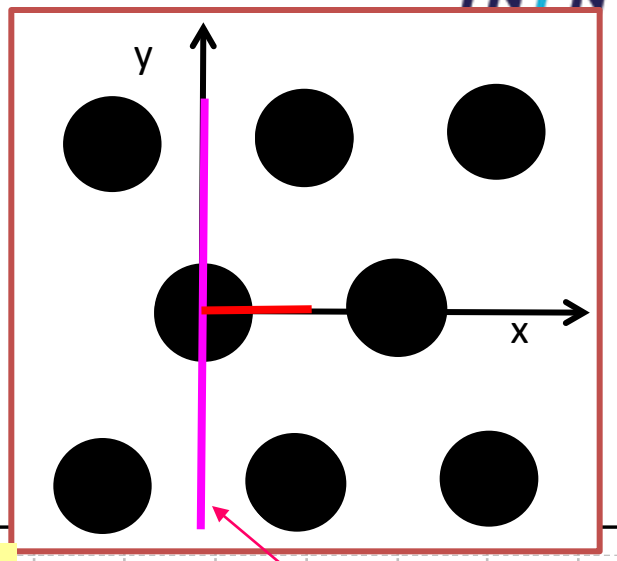


Time formation of the signal for triple THGEM detectors simulation of photoelectron extraction, E_{drift}=0

photoelectron trajectories from a THGEM photocathode, multiplication switched off

thickness 0.6 mm, diam. 0.4 mm, pitch: 0.8 mm, ΔV = 1500 V

external field above the THGEM : 0



all e^- enter the holes

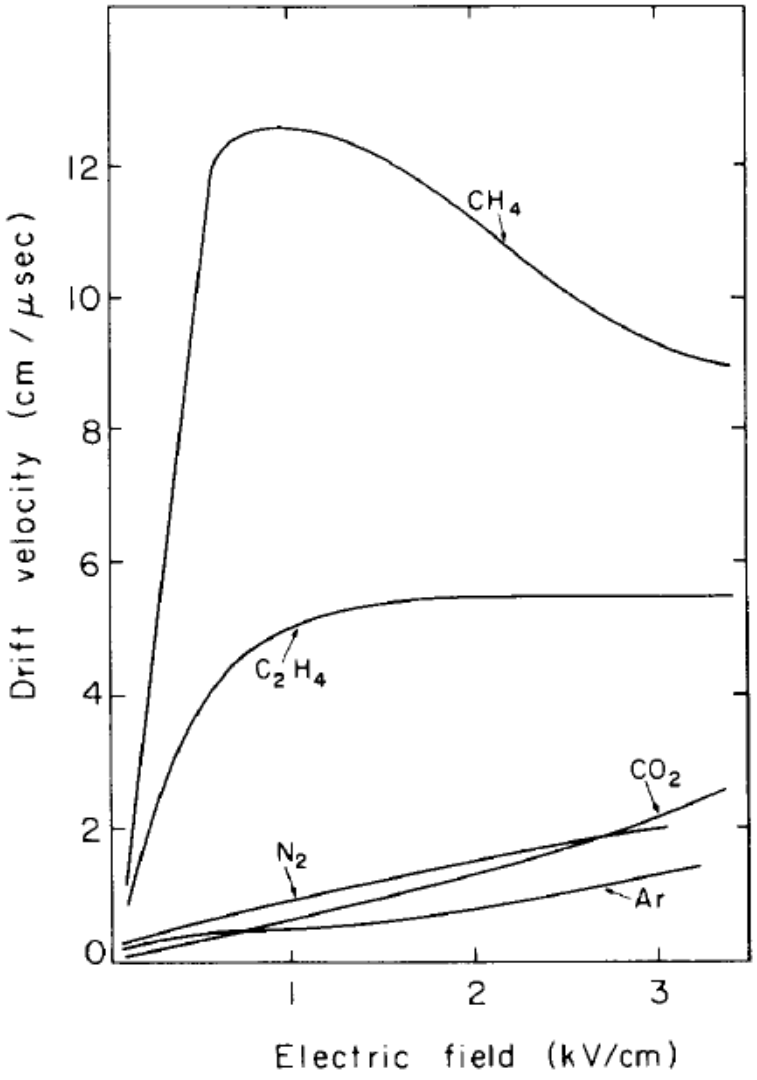
e^- projected trajectories

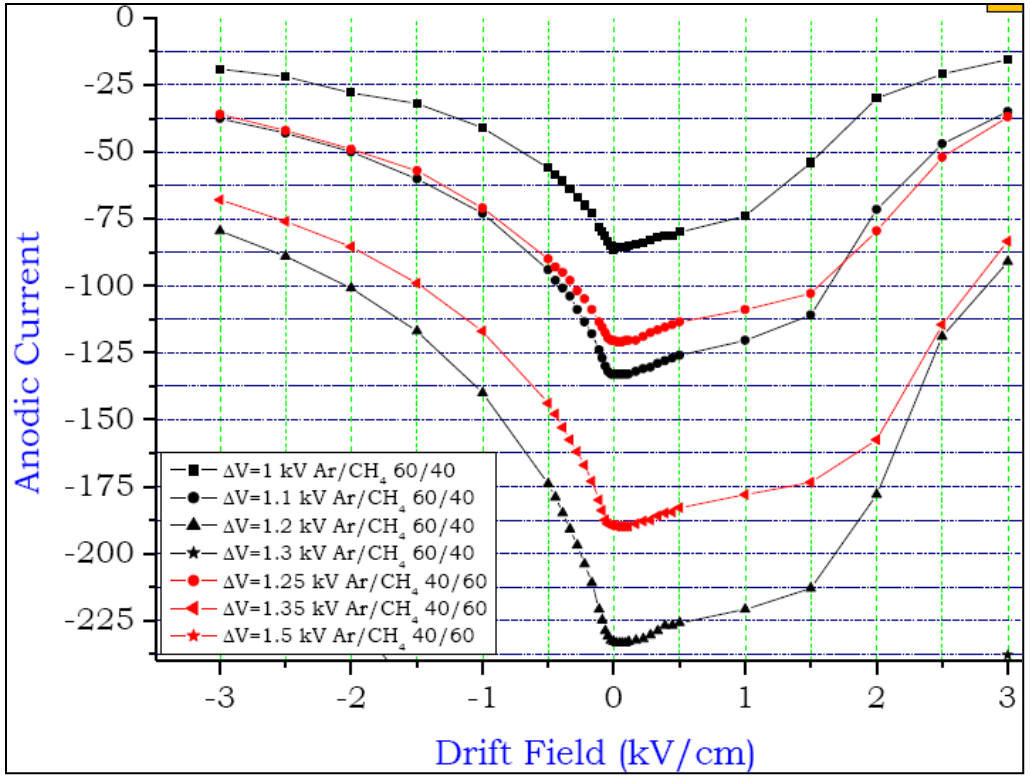
x cross-section

y cross-section

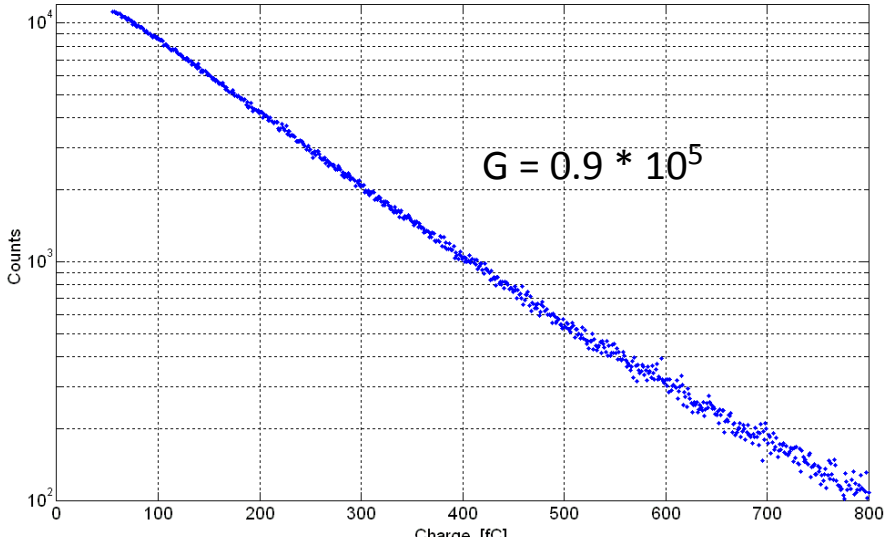
line of e^- generation

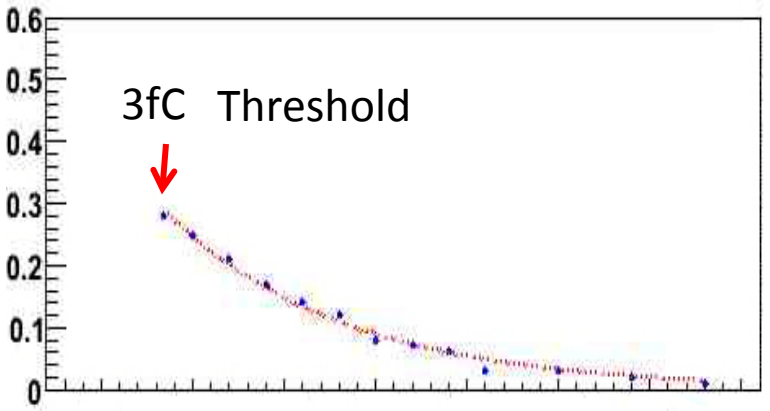
Possibile correlation between the tail of the time distribution and the reduction of extraction and collection efficiency of electrons for too feeble E field. The effect is expected as it was reported by Amos this morning.



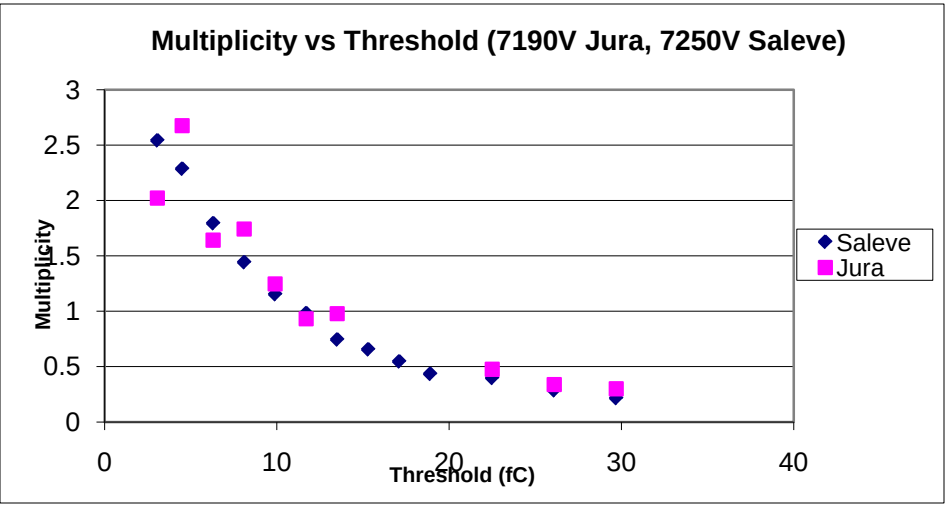


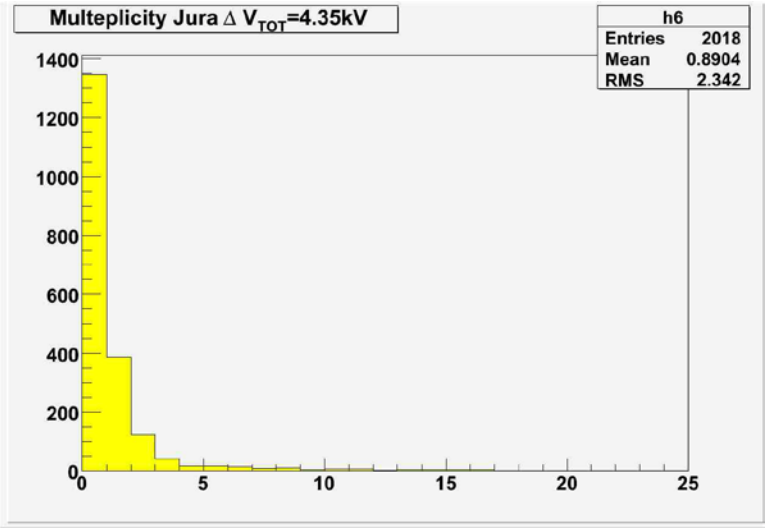
Digital and analog readout consistency check





From the threshold curve extraction of the gain of the THGEM detector (+ multiplicity spectrum) Consistent with the value expected from the fit of the analog spectrum





Time stability studies:
Performed looking at picoammeters connected to T1,B1 and T3 Resistive divirer powered

2.2E4 muon spill different voltages/gain of the THGEM

Filename	B3	B1	T1	G
jura_22_08_10_beam_muons_pico_729kV	-200pA	30pA	170pA	G = 1.5 * 10^5
jura_22_08_10_beam_muons_pico_737kV	-345pA	-40pA	260pA	G = 2.0 * 10^5
jura_22_08_10_beam_muons_pico_719kV	-100pA	-10pA	70pA	G = 0.9 * 10^5

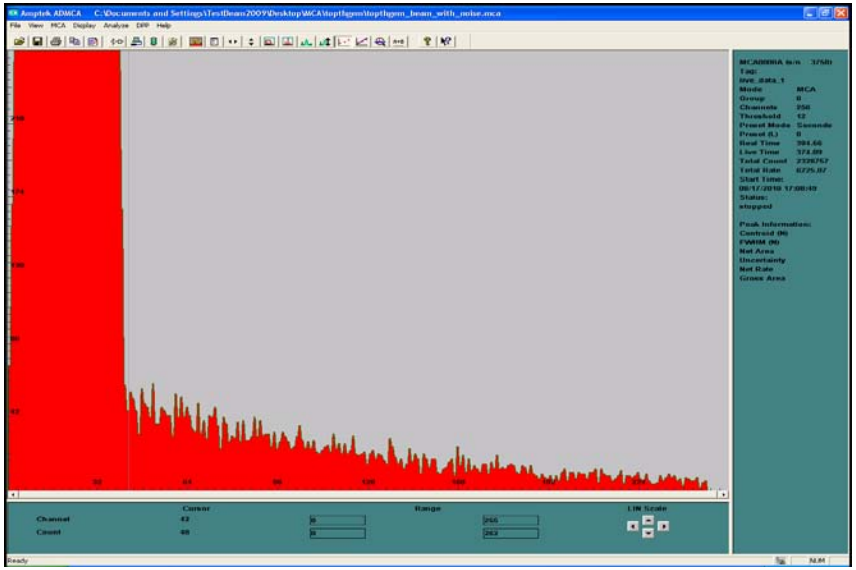
We have observed at G 0.9E5 stable detector operation with 8E4 hadrons spill @ trigger rate 5.200 KHz.

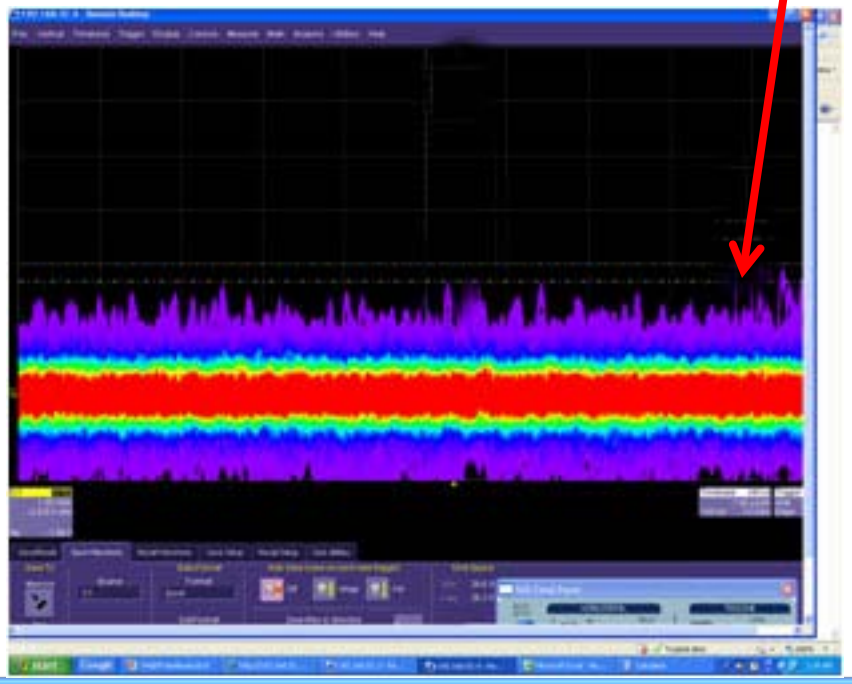
Concerning the TOP THGEM

We faced some problem with the HV power supply :
The max current setting drifted so while tryng to optimise the HV on the layers a spark damaged one layer (hypotesys to be confirmed) one THGEM detector could not be used

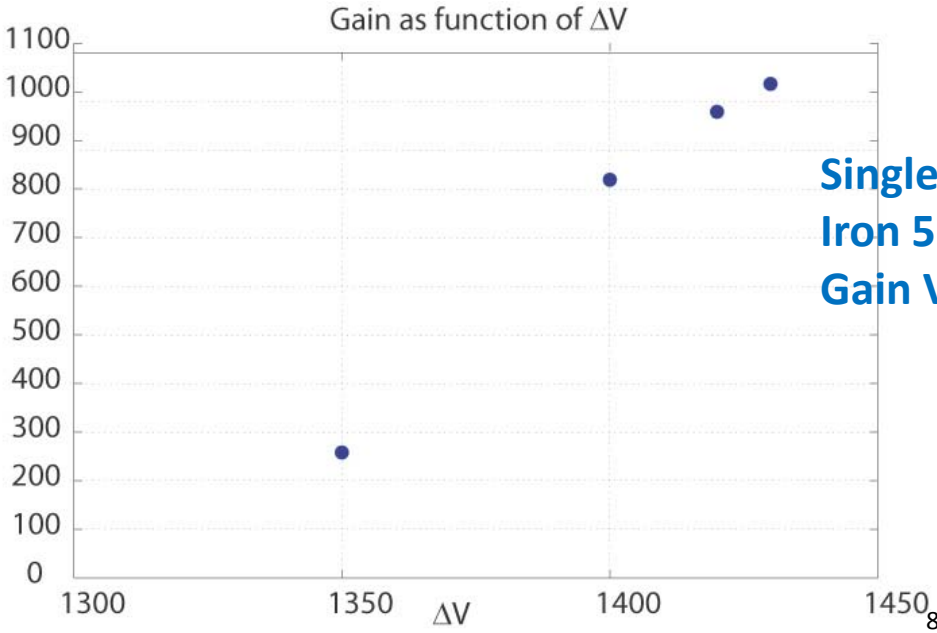
Concerning the noise level

When we tried to operate the Big (100x100 mm2) detector we had to face with hige noise problems. Example in the picture below : to get rid of the noise threshold must be set >45 fC. Some shielding done on the fly improved the situation but still prevented to acquire data. Brough back to the lab we could achieve a 3 fC noise (with less than half fC sigma) and we could acquire data.



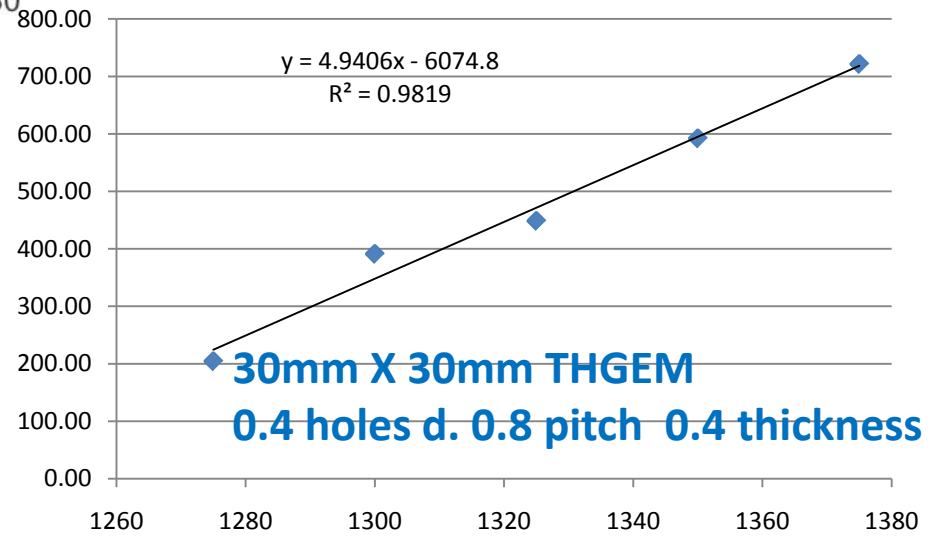


Single THGEM 100x100 behaves in the same way as small one:

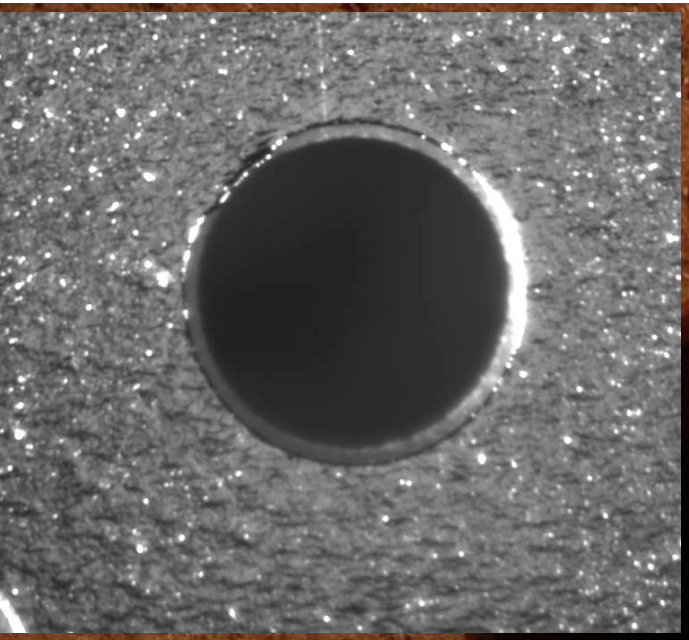


Single layer THGEM
Iron 55 source Ar/CO_2 70/30
Gain Vs/ΔV

100mmX100mm THGEM
0.4 holes d. 0.8 pitch 0.4 thickness



30mm X 30mm THGEM
0.4 holes d. 0.8 pitch 0.4 thickness



This problem was encountered also by at least by (at least) another group…
As reported this morning by Amos

It seems coming from the residual of the production procedure:

The effect is a redcution of the maximum ΔV that can be applied to the THGEM-> not enough gain!

We tried a cleaning procedure, Pure Alchool + Demineralised water @ 45 C with ultrasonic bath

We saw an improvement and we could reach the same gain values of small THGEM

BUT

Cleaning procedure exists, (RUI magic bath) which seems to work nicely and we would like to try/learn about!

OUTLOOK

Data (a lot)collected with THGEMs during the August test beam started to be analyzed

We are investigating the extraction of the Effective Quantum Efficiency (not trivial) comparing with pmt data (not completely satisfied by its illumination)

Concerning the time development of the THGEM signal it will be investigated in the next future (the effect is there with the beam as well as the UV LED)
Digital red out will be available in our lab next week.

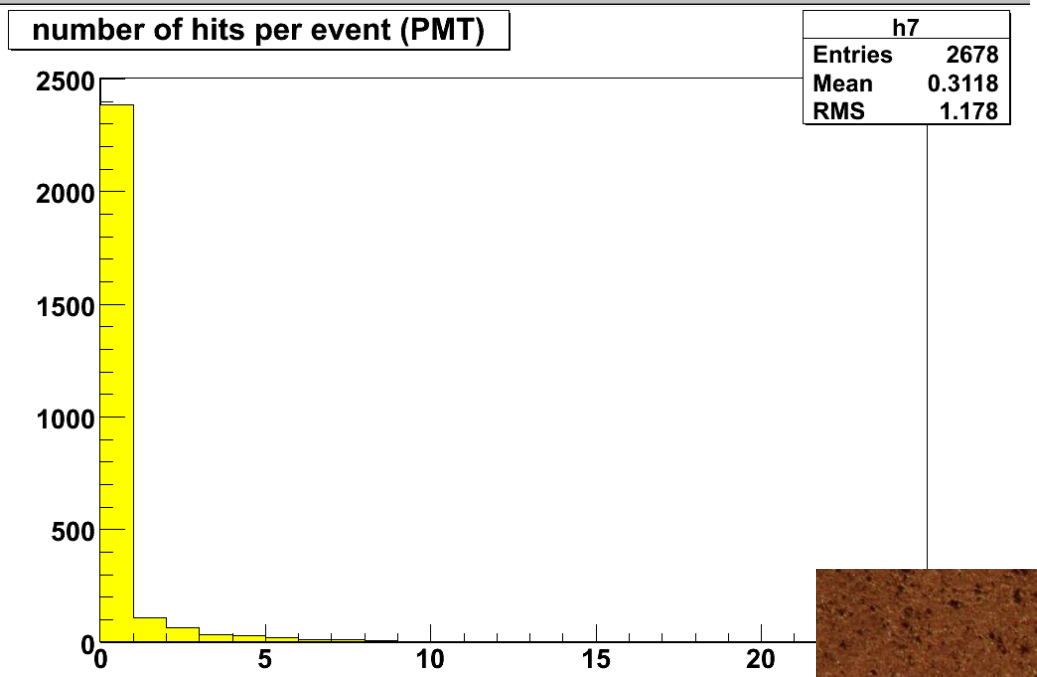
Large size detector: the noise problem has been under evaluated for our large size detector. By the way it can be cured (work in progress)

Front Electronic protection system protection (resistive protaction pads a la RUI (R11))→ studies needed

SIMULATION work, it will start soon we will have a AC/DC license for COMSOL and start the comparison with Ansys/neBem/ result

Larger size detector 300 mm x 400 mm to be tested next year

THANK YOU Very much!


number of hits per event (PMT)
h7
Entries 2678
Mean 0.3118
RMS 1.178
2500
2000
1500
1000
500
0
0
5
10
15
20