Development and tests of a large area CsI-TGEM-based RICH prototype

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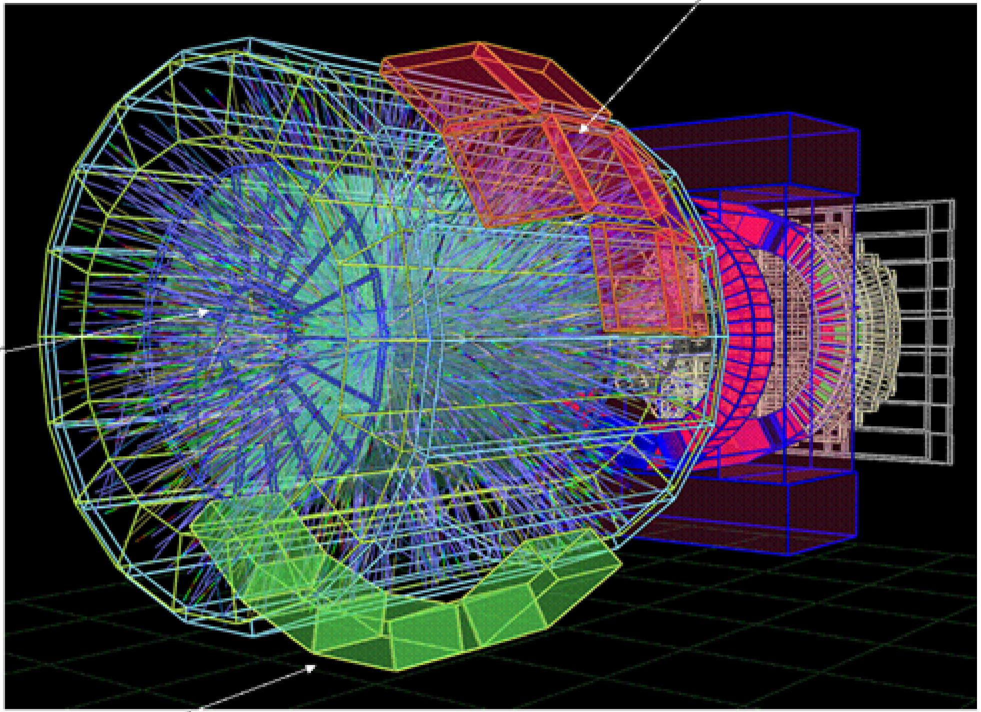
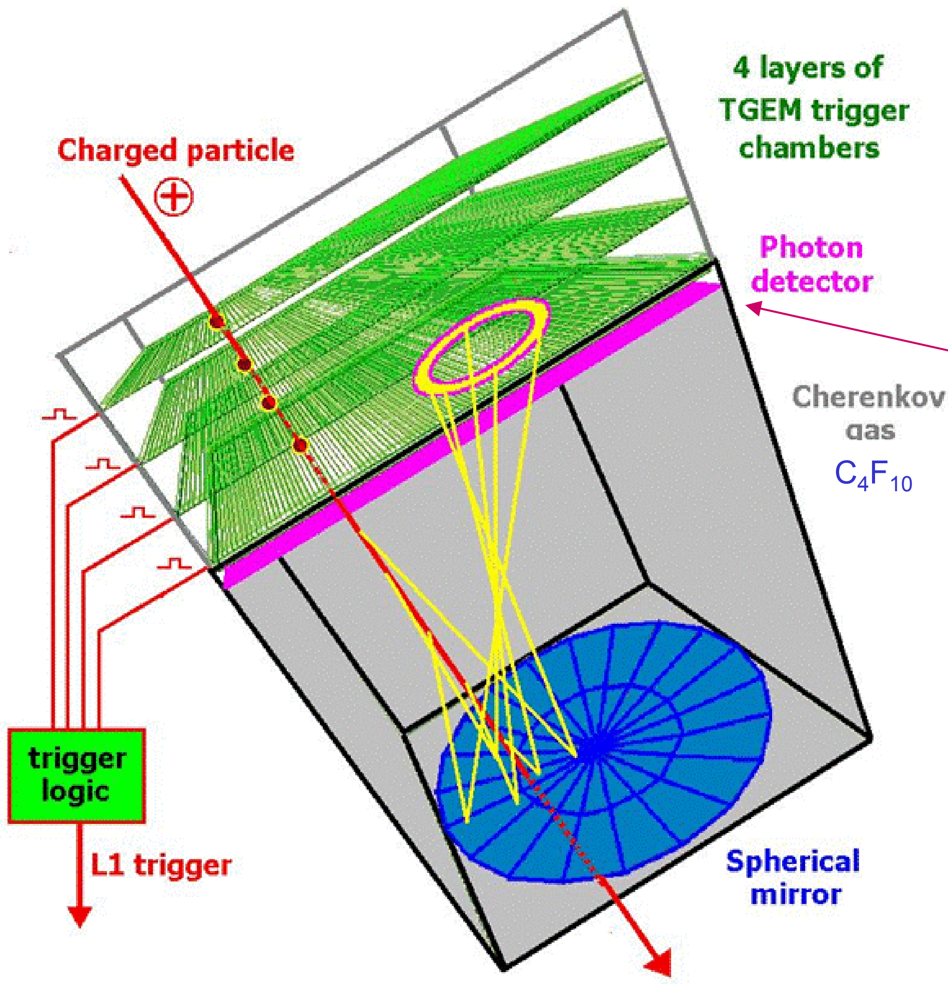
In the framework of the ALICE upgrade program we are investigating the possibility to build a new RICH detector allowing to extend the particle identification for hadrons up to 30GeV/c .**It is called VHMPID.**



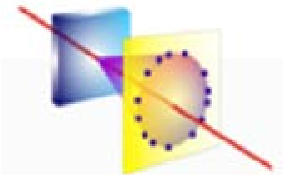
The **VHMPID** should be able to identify, on a track-by- track basis, protons enabling to study the leading particles composition in jets (correlated with the $\pi 0$ and /or γ energies deposited in the electromagnetic calorimeter).

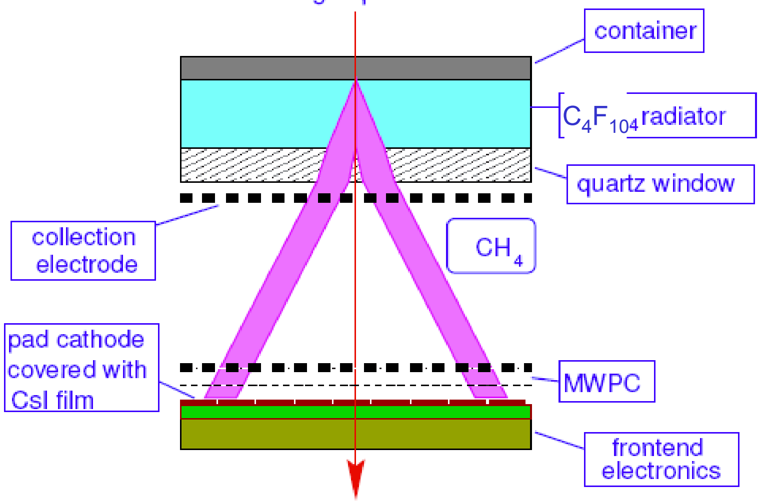
The suggested detector will consist of a gaseous radiator (for example, CF_4 or C_4F_{10}) and a planar gaseous photodetector



The key element of the VHMPID is a planar photodetector

There are **two** options for planar photodetectors which are currently under evaluation:



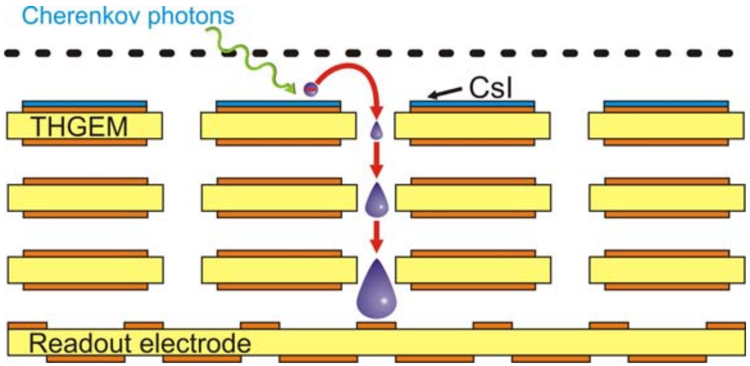


MWPC

(similar to one used in ALICE RICH)

or

TGEMs/RETGEMs



For TGEM see : *L. Periale et al., NIM A478,2002,377, S. Chalem et al., NIM A558, 2006, 475*

The aim of this work is to build a CsI-TGEM based RICH prototype, perform it beam test and compare to the MWPC approach

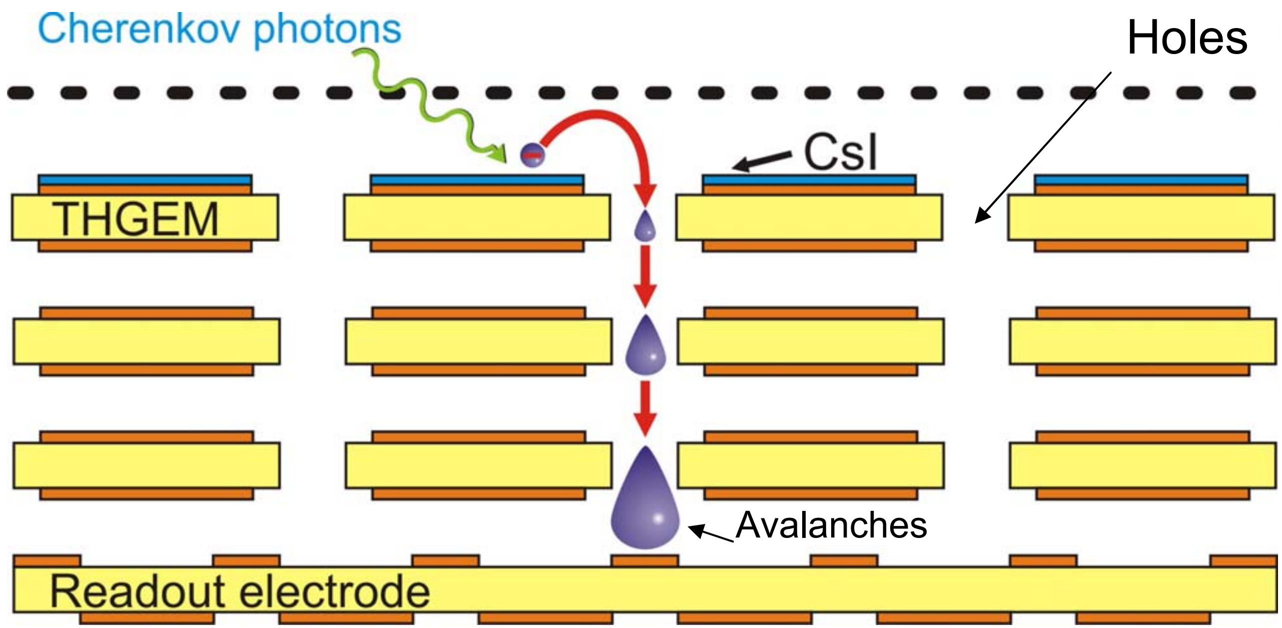
TGEM

TGEM is a hole-type gaseous multiplier based on standard printed circuit boards featuring a combination of mechanical drilling (by a CNC drilling machine) and etching techniques.

Thickness: 0.45 mm
Hole d: 0.4 mm
Rims: 10 μm
Pitch: 0.8 mm
Active area: 77%

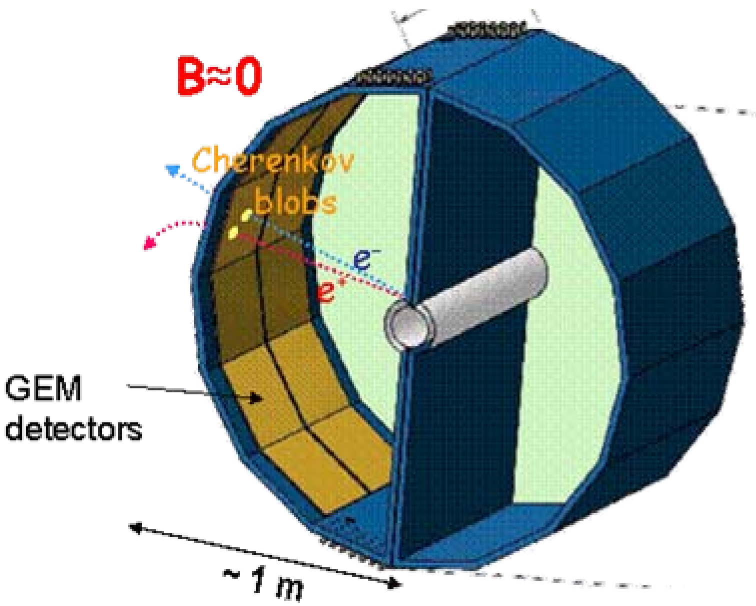
100mm

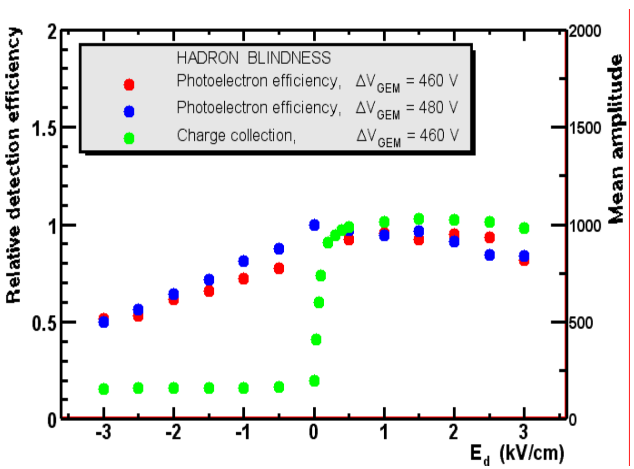
The operation principle of the CsI coated triple TGEM (CsI -TGEM)



TGEMs have several attractive features compared to ordinary GEMs:

1) ~10 times higher gains
2) robustness- capability to withstand sparks without being destroyed
3) it is a self- supporting mechanical structure making their use convenient in large detectors

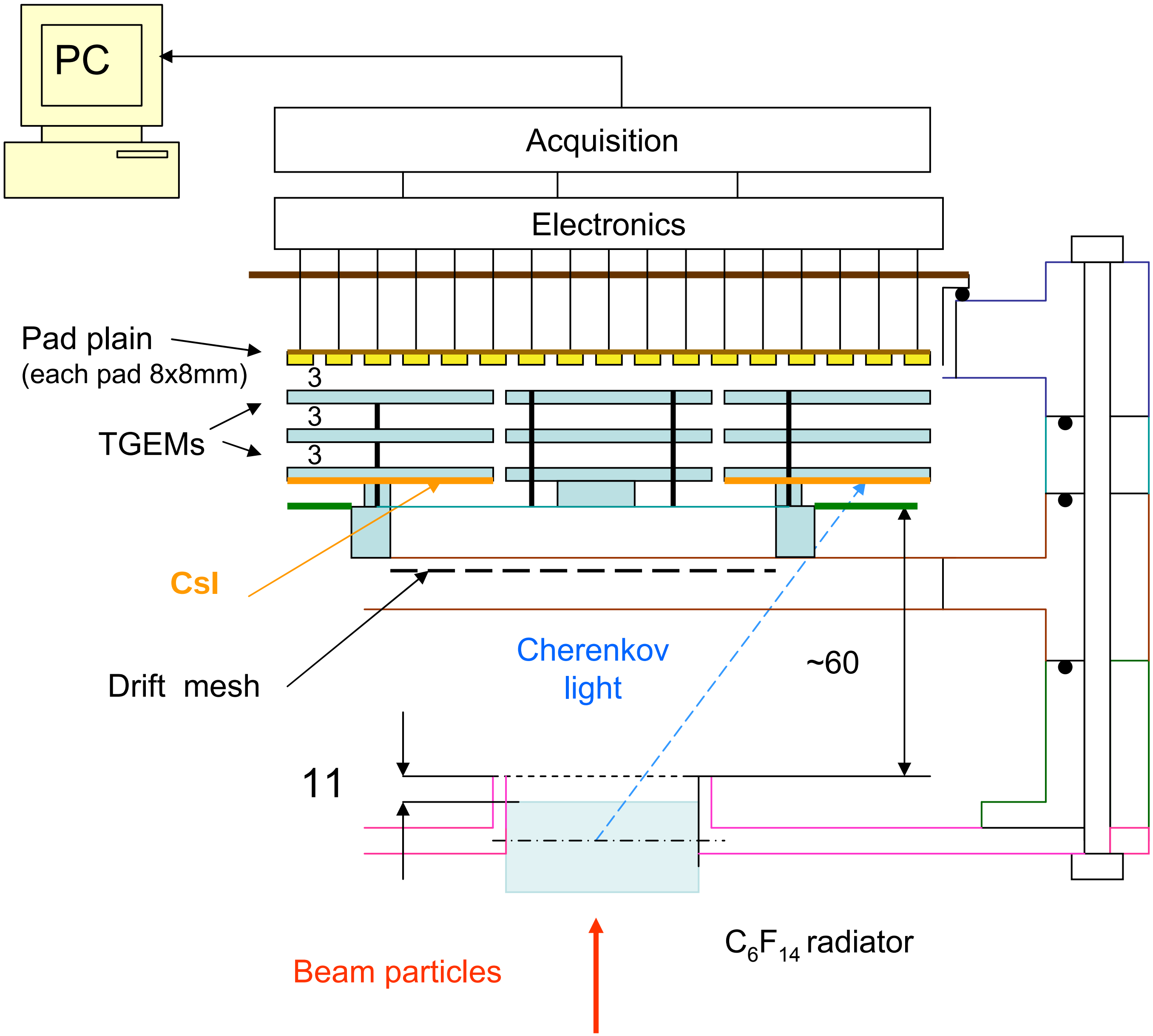




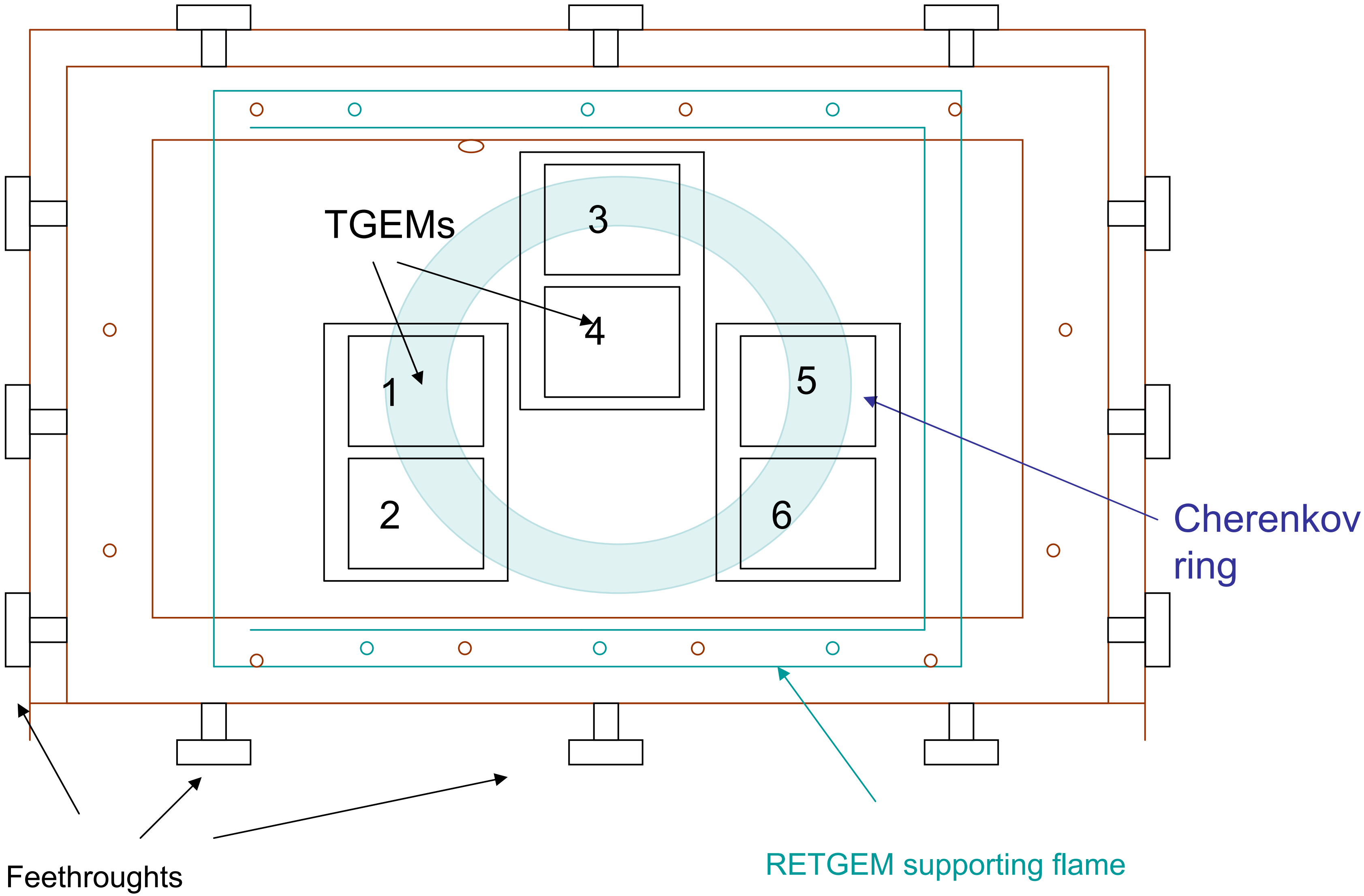
CsI-TGEMs, have some advantages, over MWPC for example:

- CsI-TGEM can operate in badly quenched gases as well as in gases in which are strong UV emitters. This allows to achieve high gains without feedback problems. This also opens a possibility to use them in unflammable gases or if necessary using windowless detectors (as in PHENIX)
- In some experiments, if necessary CsI-TGEMs, can operate in "handron blind mode" with zero and even reversed electric field in the drift region which allows strongly suppress the ionization signal from charged particles (PHENIX)

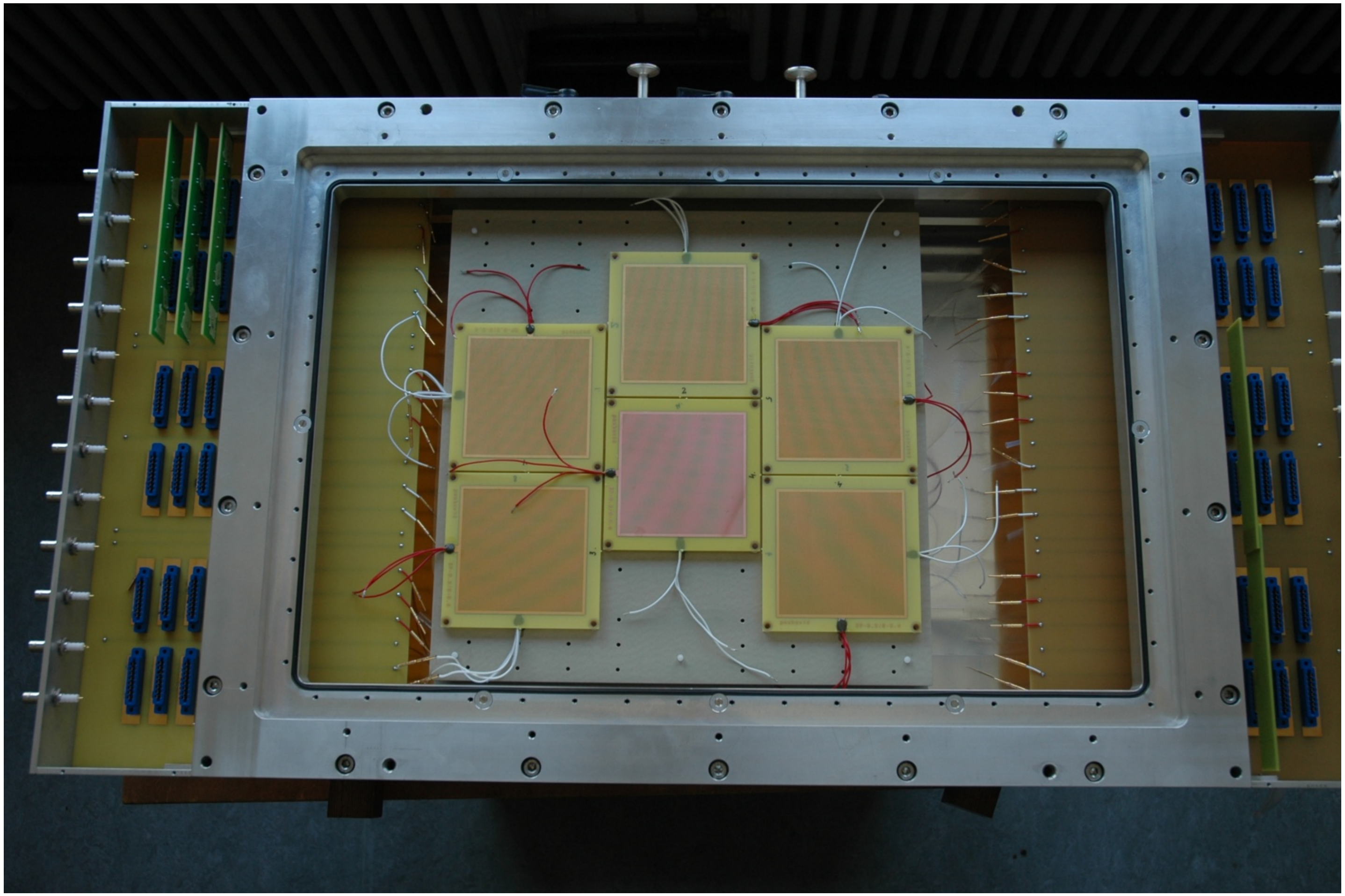
Design of the CsI-TGEM based RICH prototype


PC
Acquisition
Electronics
Pad plain
(each pad 8x8mm)
3
3
3
TGEMs
CsI
Drift mesh
Cherenkov
light
~60
11
C_6F_{14} radiator
Beam particles

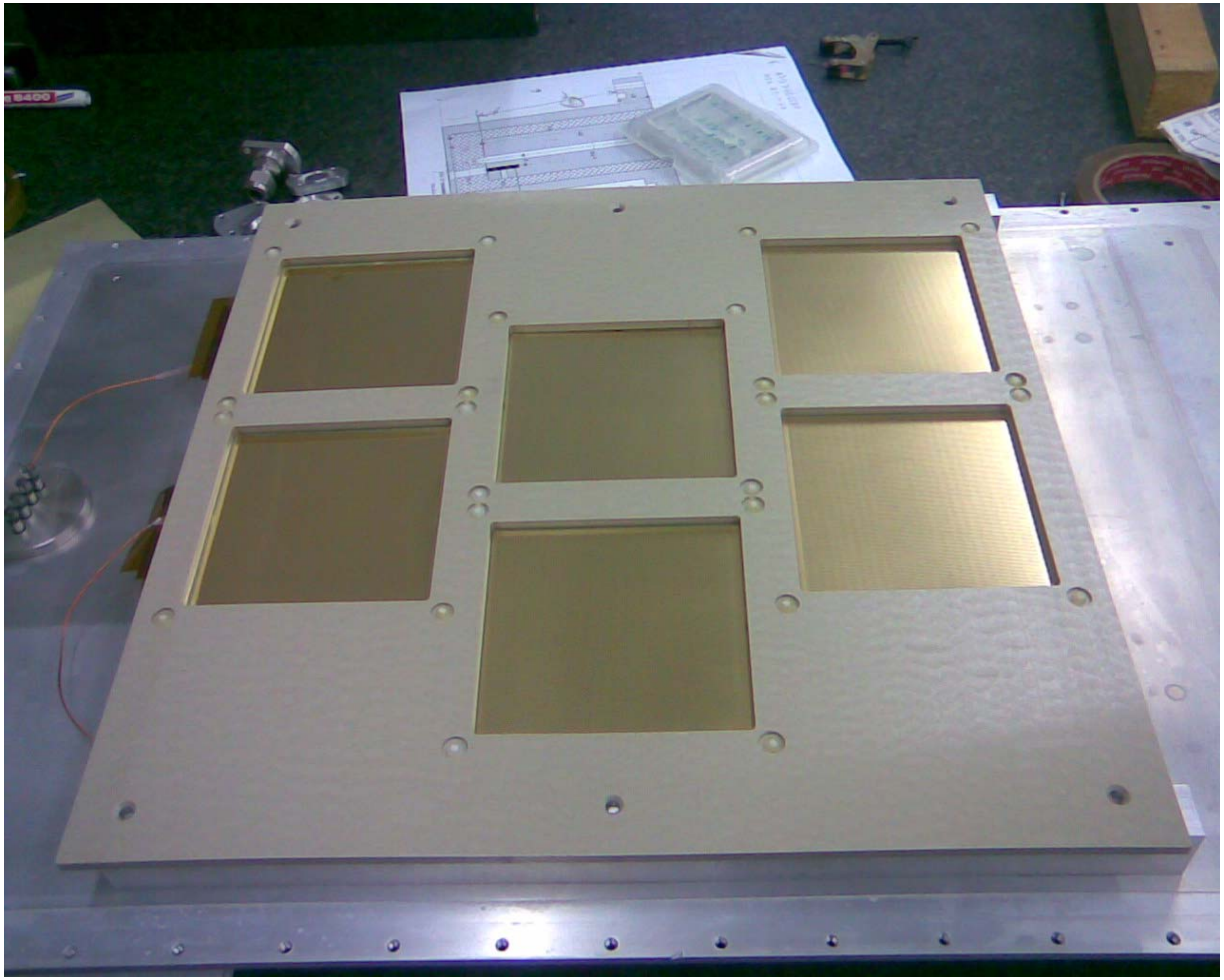
The top view of the RICH prototype (from the electronics side)



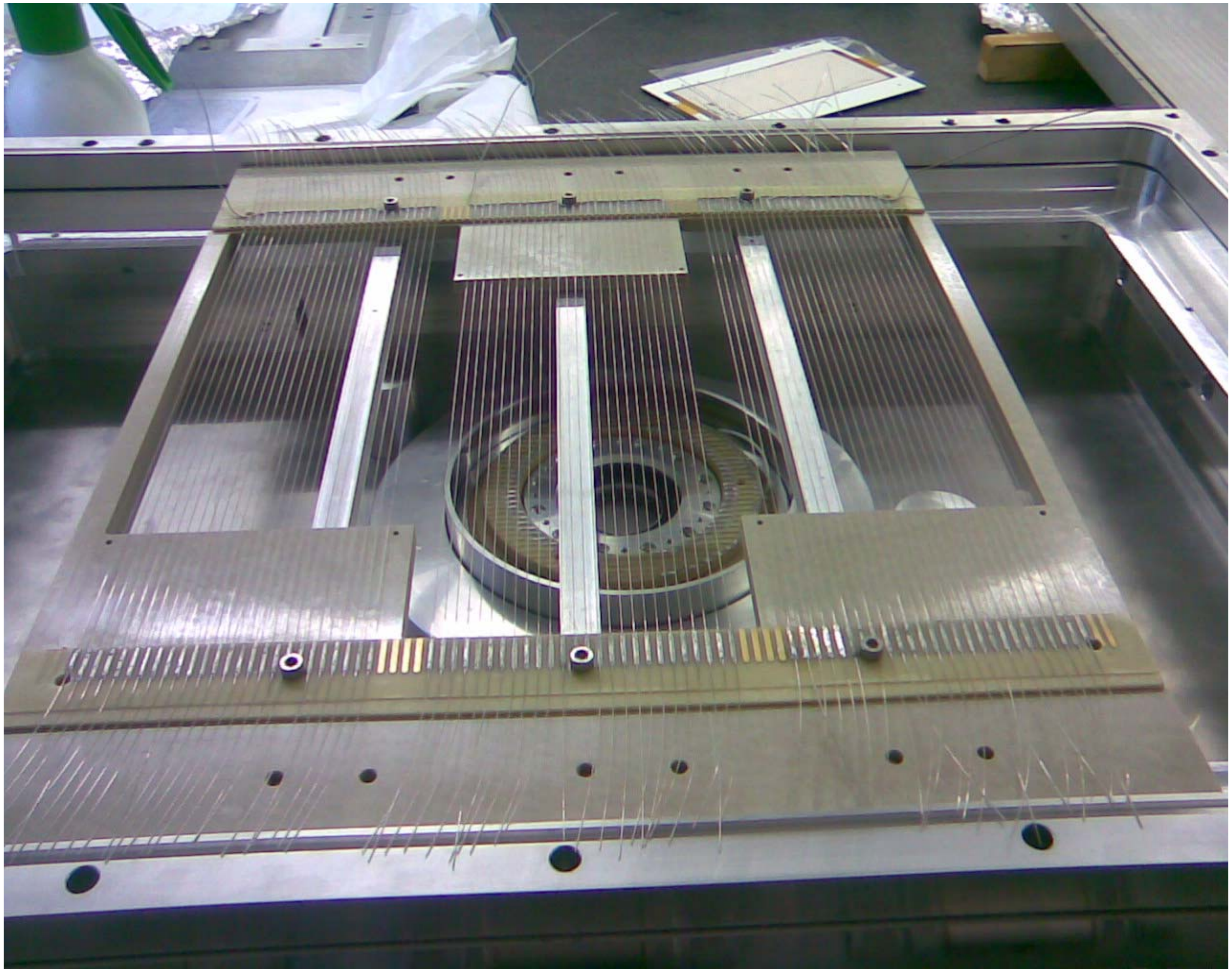
View from the back plane



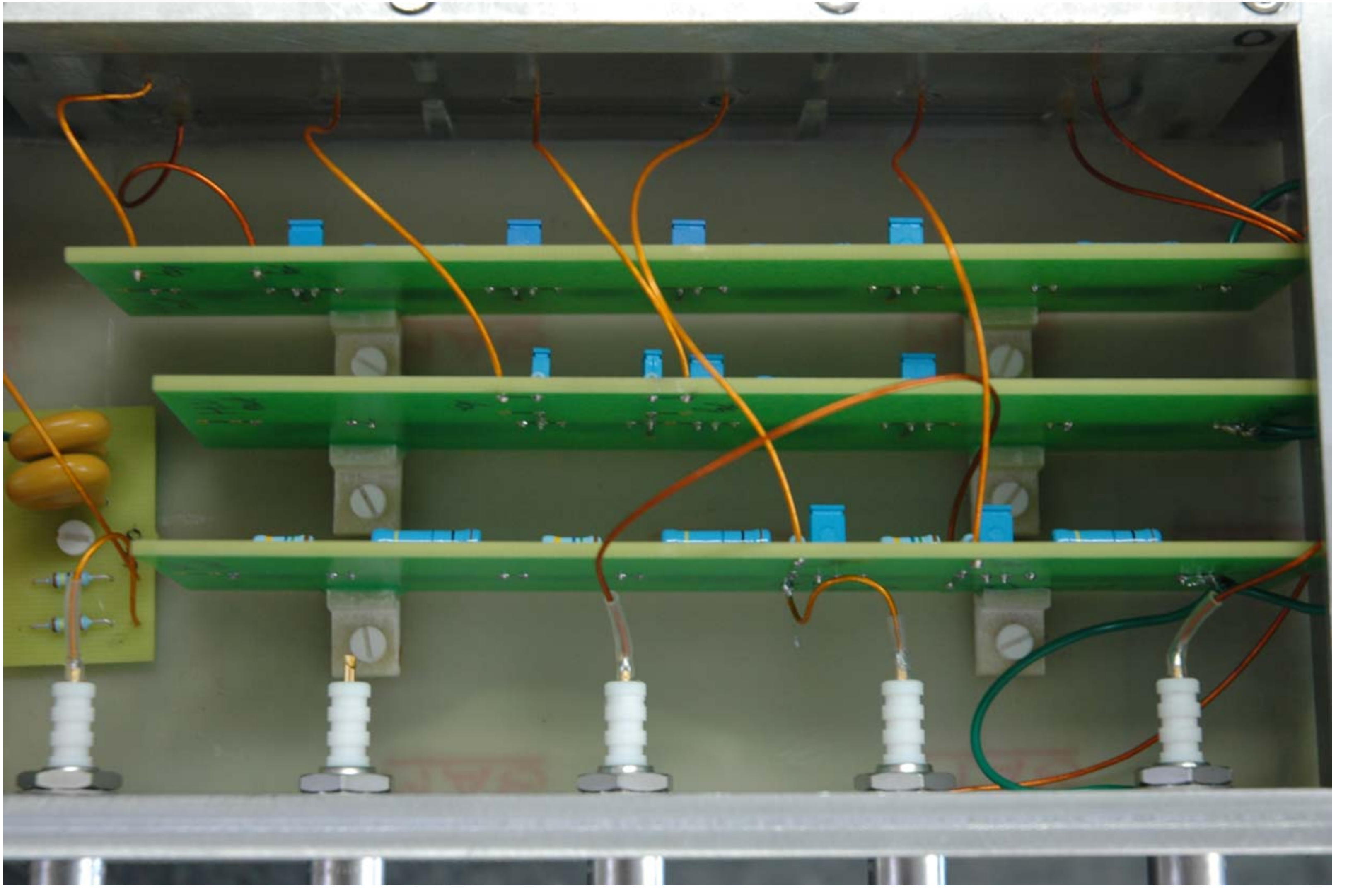
CsI side



Drift meshes (three independent grids)



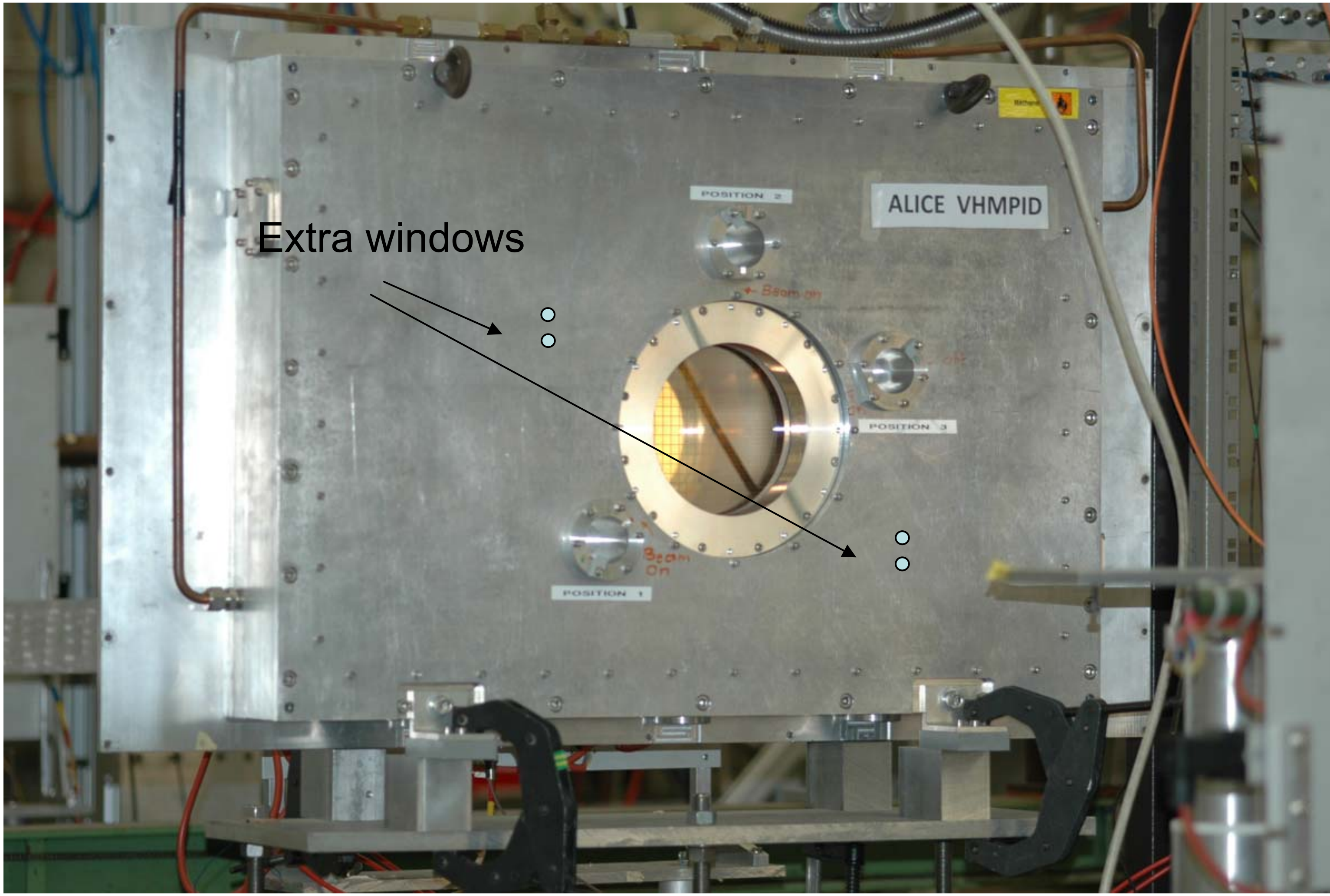
Voltage dividers



There was a possibility to independently observe analog signals from any of electrodes of any TGEM and if necessary individually optimize voltages on any TGEM

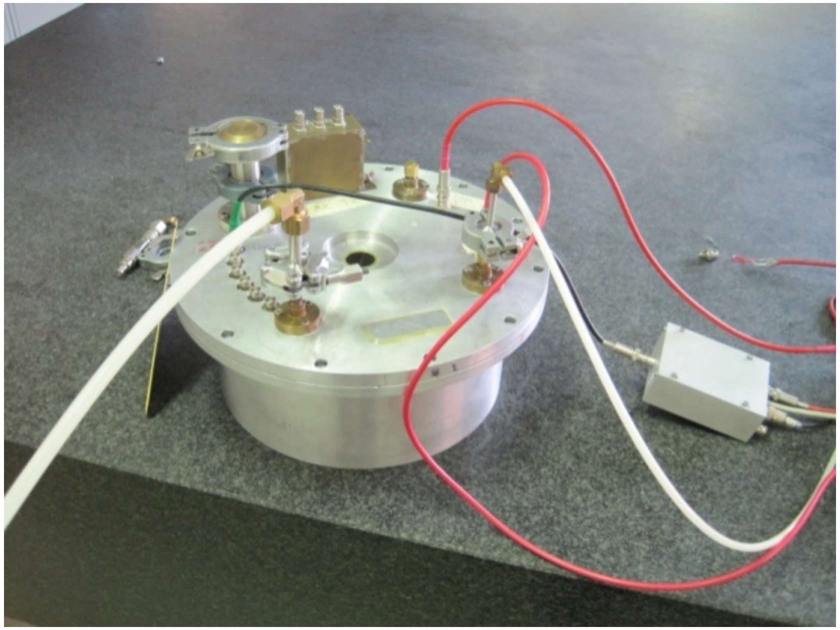
Six triple TGEMs were assembled using a glow box inside the RICH prototypes gas chamber.

Front view



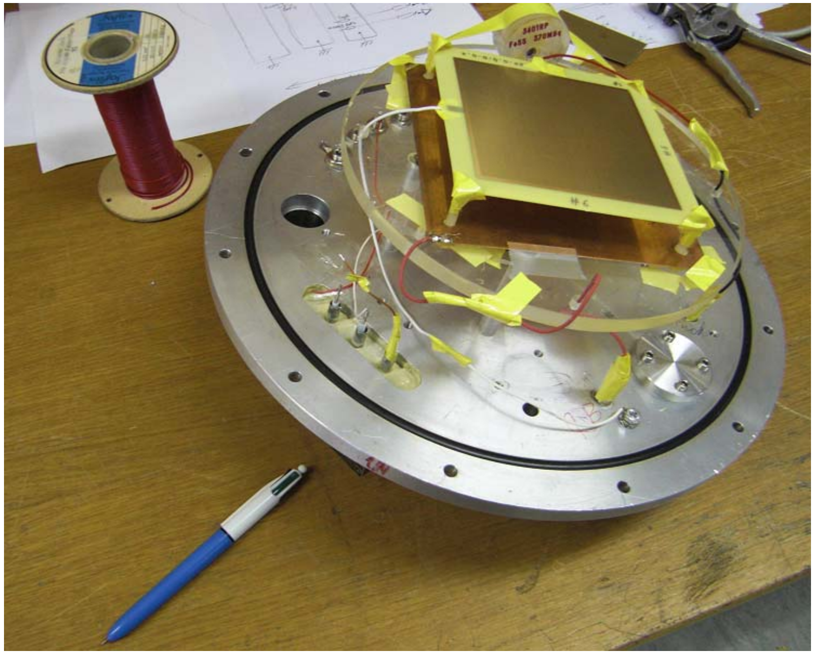
The RICH prototype has windows in front of each triple TGEM allowing to irradiate the detectors ether with the radioactive sources such as ^{55}Fe or ^{90}Sr or with he UV light from a Hg lamp

Laboratory tests

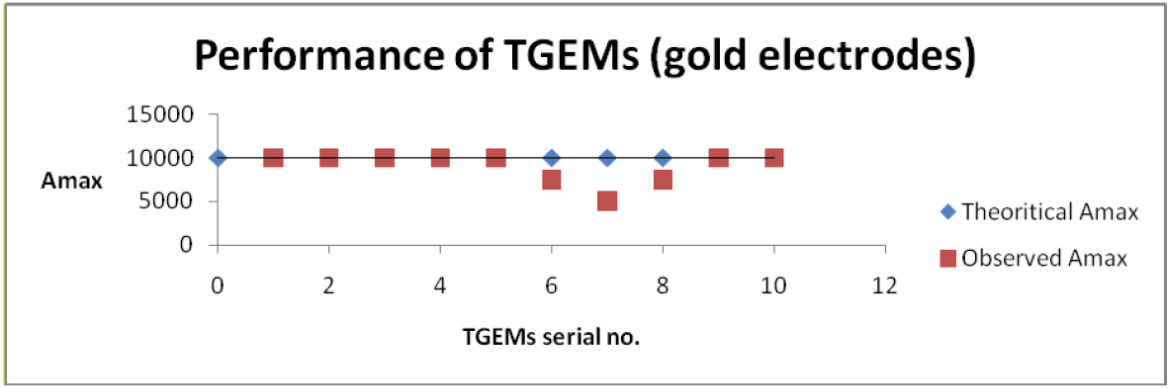


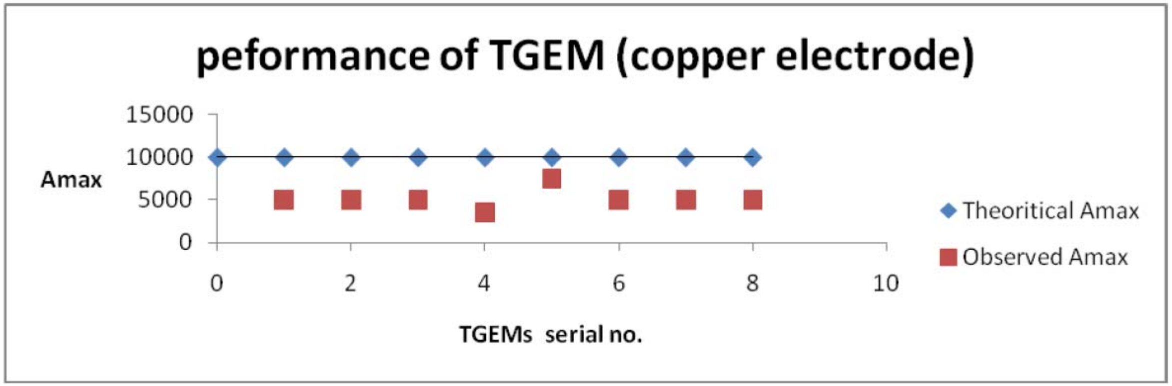
Before the installation to the RICH detector, each TGEM was individually tested in a separate small gas chamber.

In these tests we mainly identified the maximum achievable gains when the detectors were irradiated with the ^{55}Fe source and with the UV light.

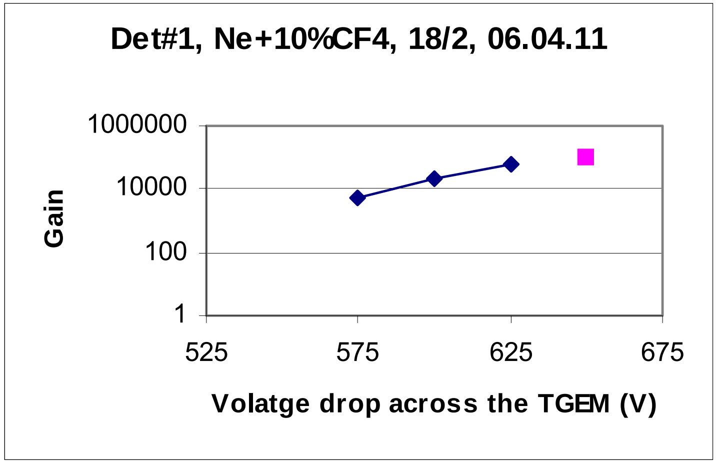


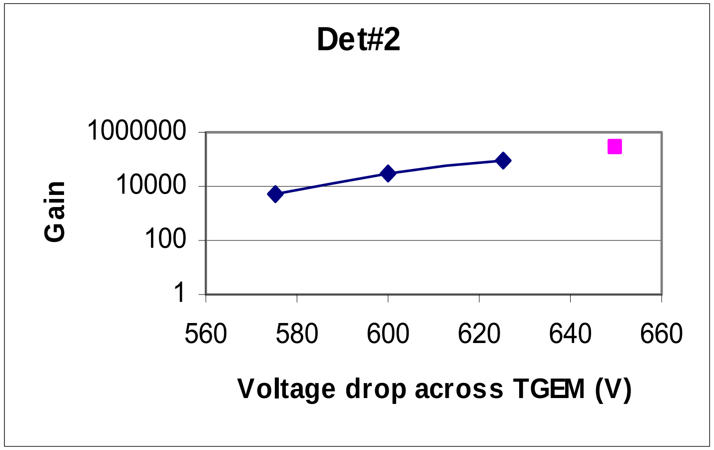
Summary of single TGEMs performance



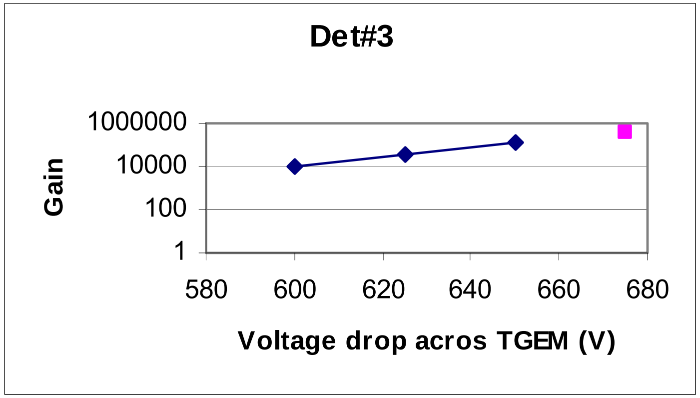


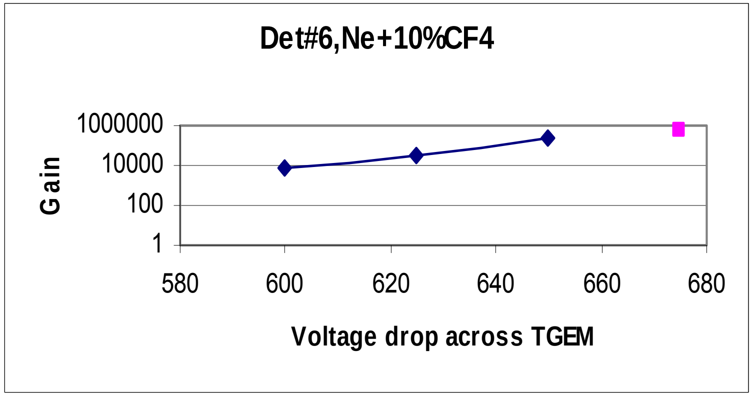
Typical results of gas gain measurements <u>for triple</u> CsI-TGEMs





Gains in the range $3 10^5$-10^6 were achieved





Measurements were performed when the detectors were simultaneously irradiated with ^{55}Fe and UV light and ^{90}Sr source

Stability?

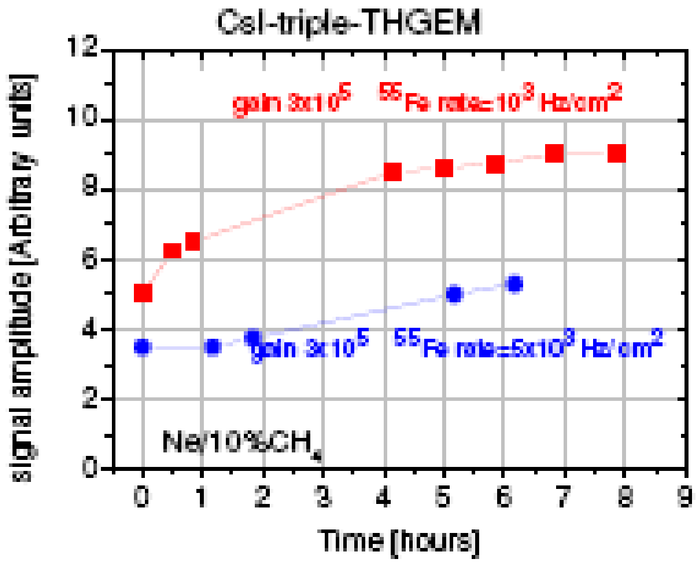
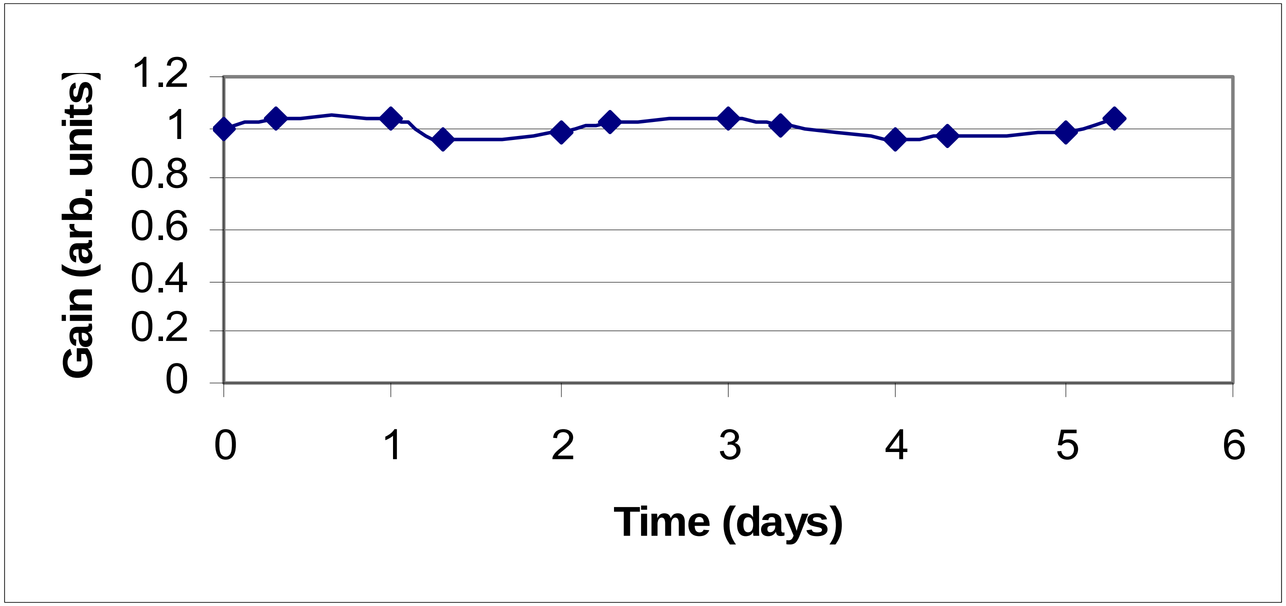


Figure 15. Short-term stability of a triple-THGEM (rim 0.1 mm) with CsI photocathode measured in Ne+10%CH_4 at a) at overall gain of 3×10^5 and counting rate of $\sim$ 1 kHz/cm^2 and b) an overall gain of 3×10^5 and counting rate of $\sim$ 5 kHz/cm^2.

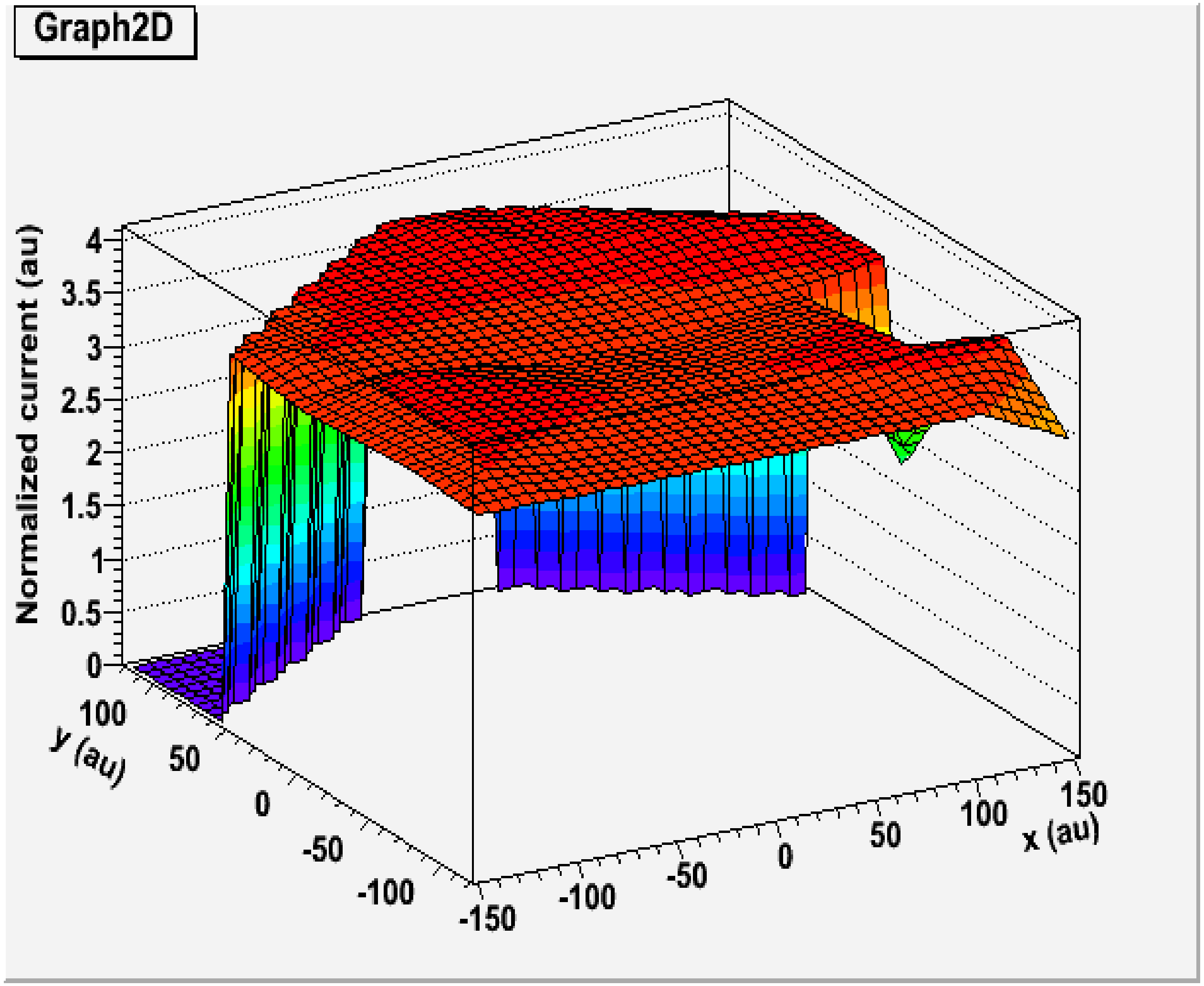
See, for example:V. Peskov et al ., JINST 5 P11004, 2010

We have <u>solved</u> the stability problems by constantly keeping some voltages over TGEMs



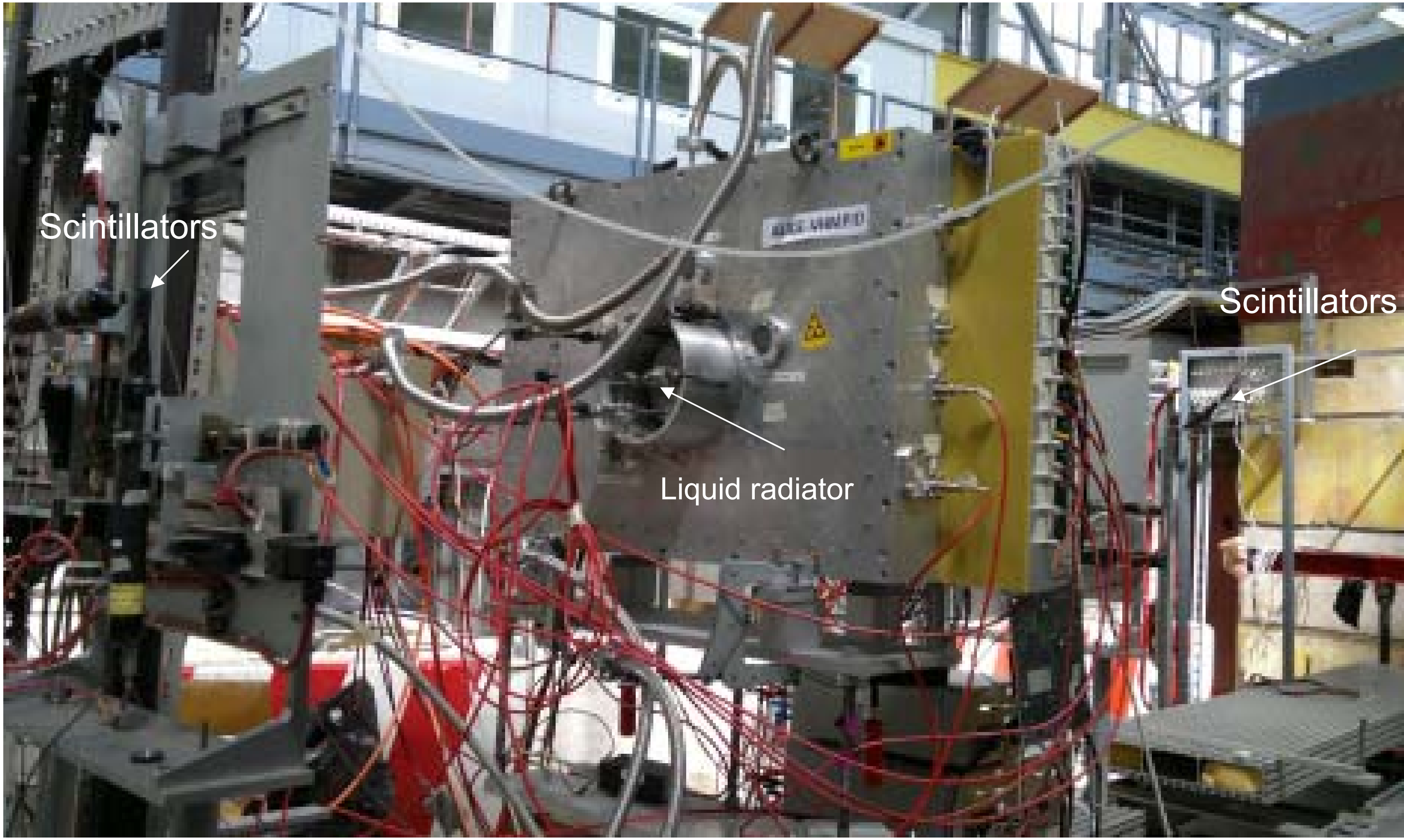
PS. The variations above correlated to the atmospheric pressure changes

QE measurements before CsI-TGEM installation into the RICH prototype

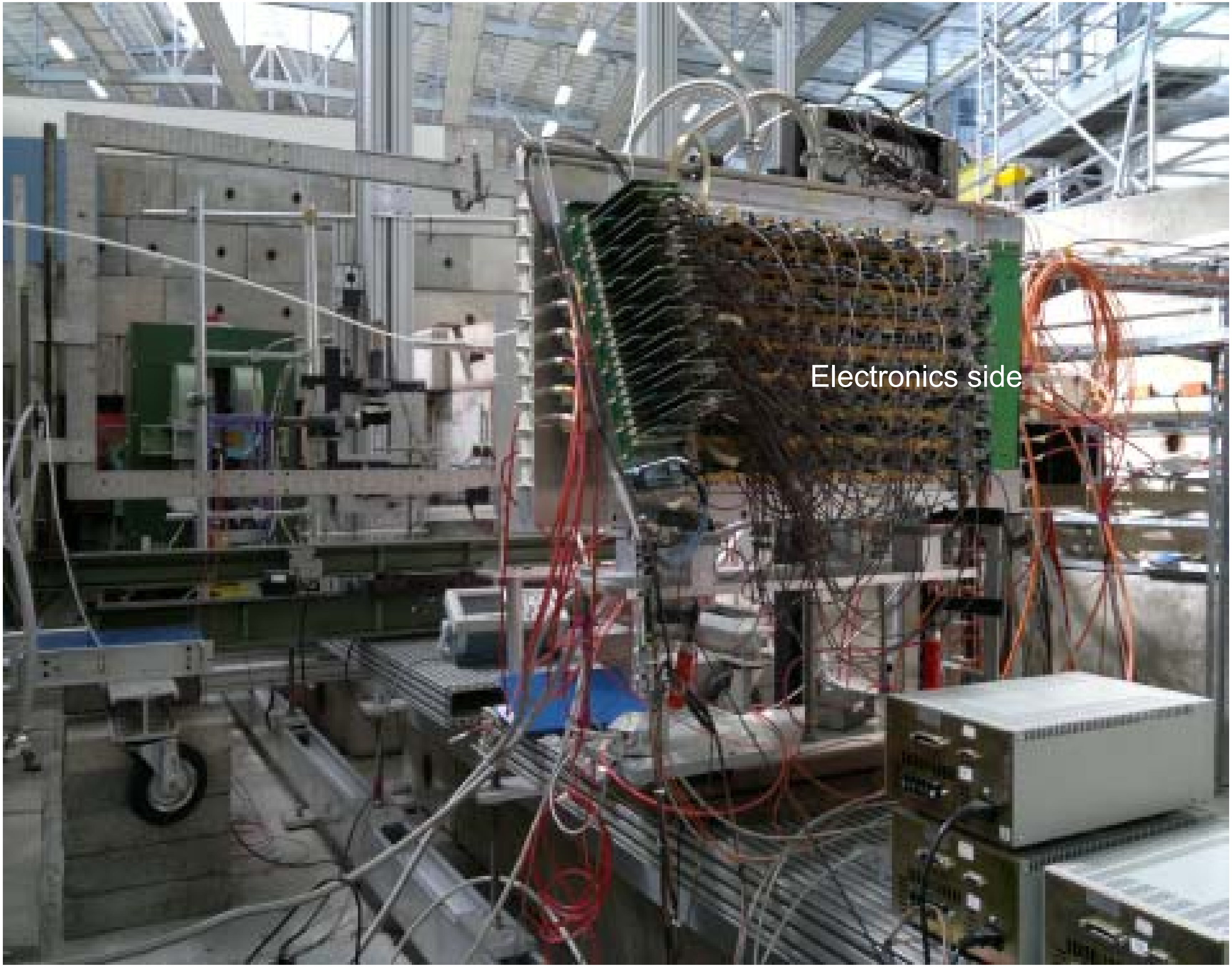


The QE value is about 16% less than in the case of the best CsI-MWPC

Beam test

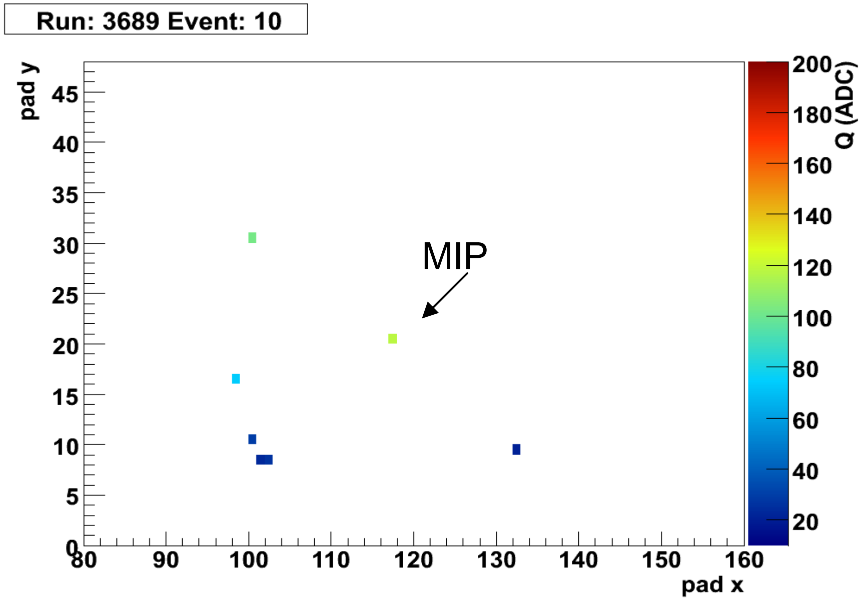


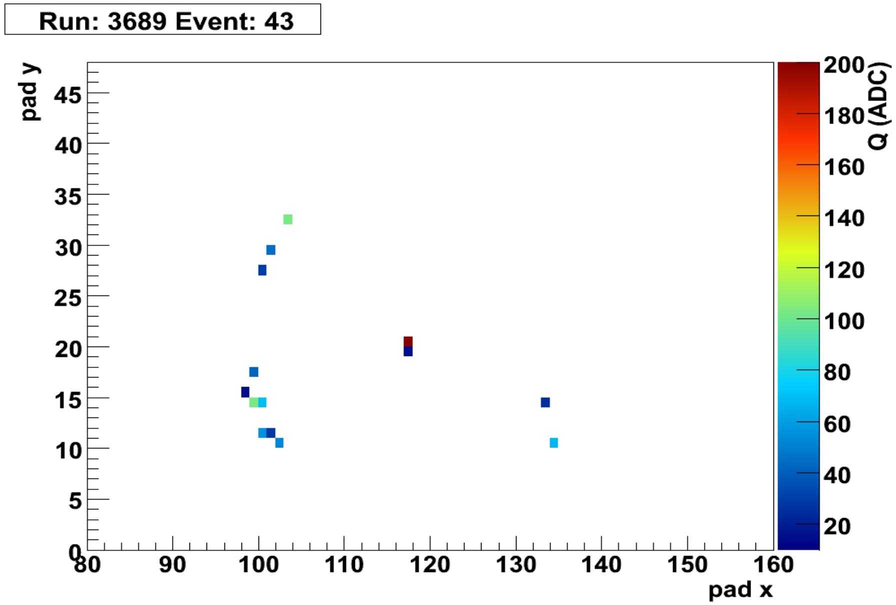
Our proximity focusing TGEM-based RICH prototype installed at CERN T10 beam test facility (mostly ~6 GeV/c pions)

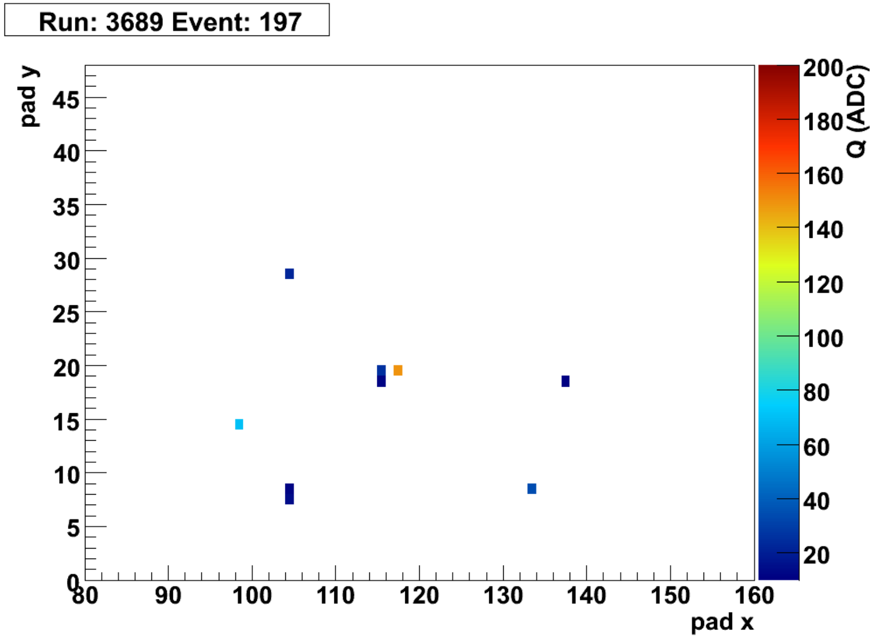

Electronics side

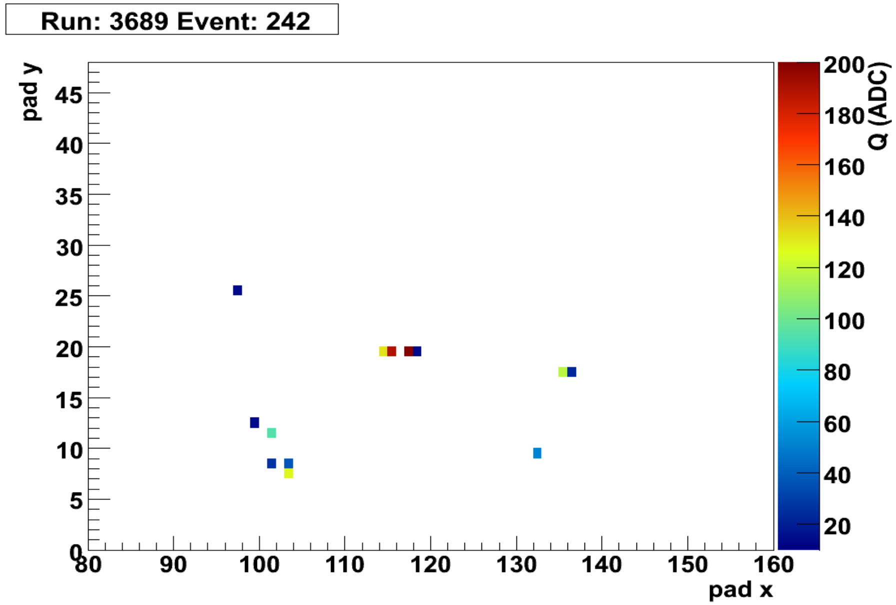
Some results

Single events display



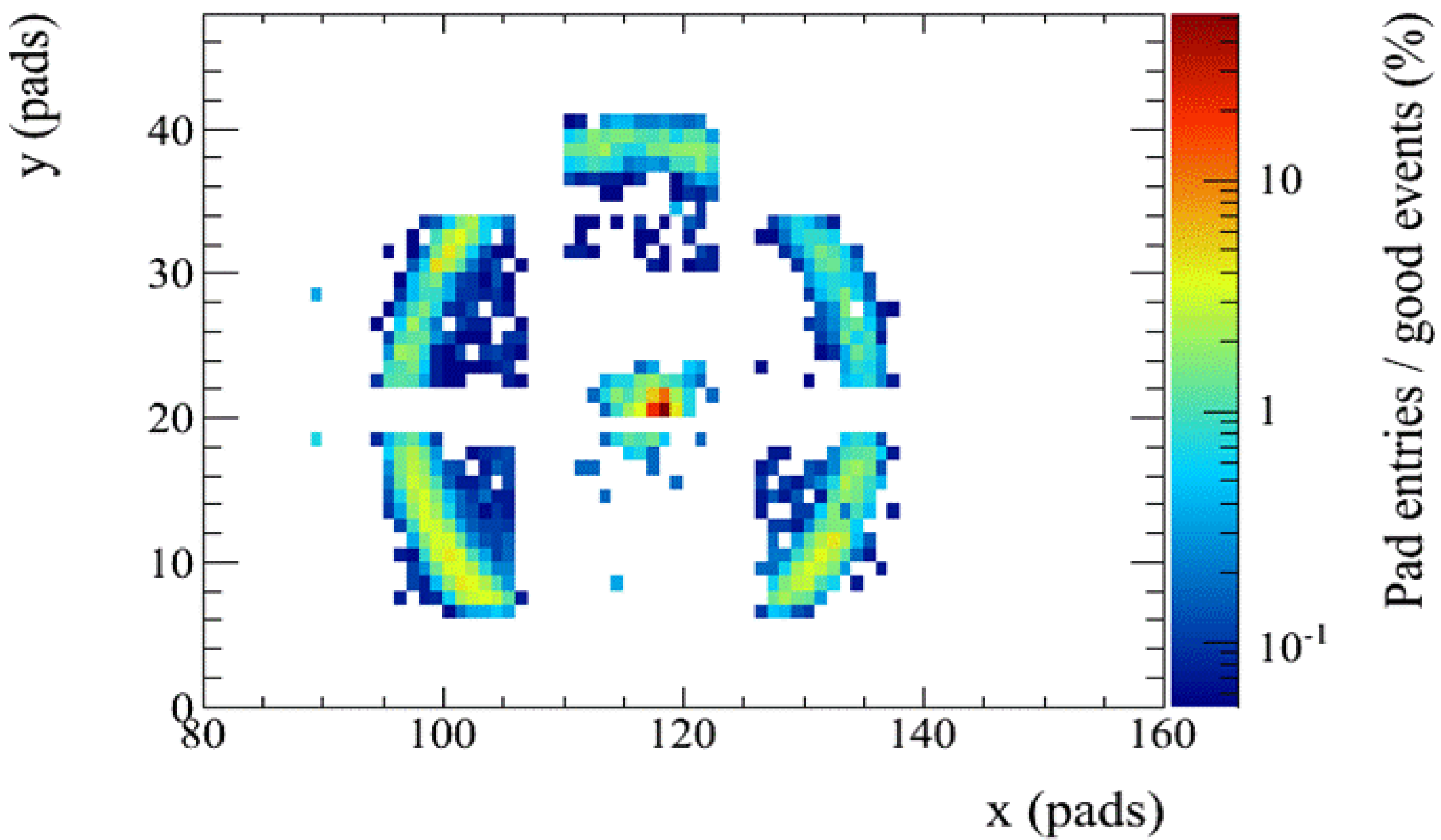






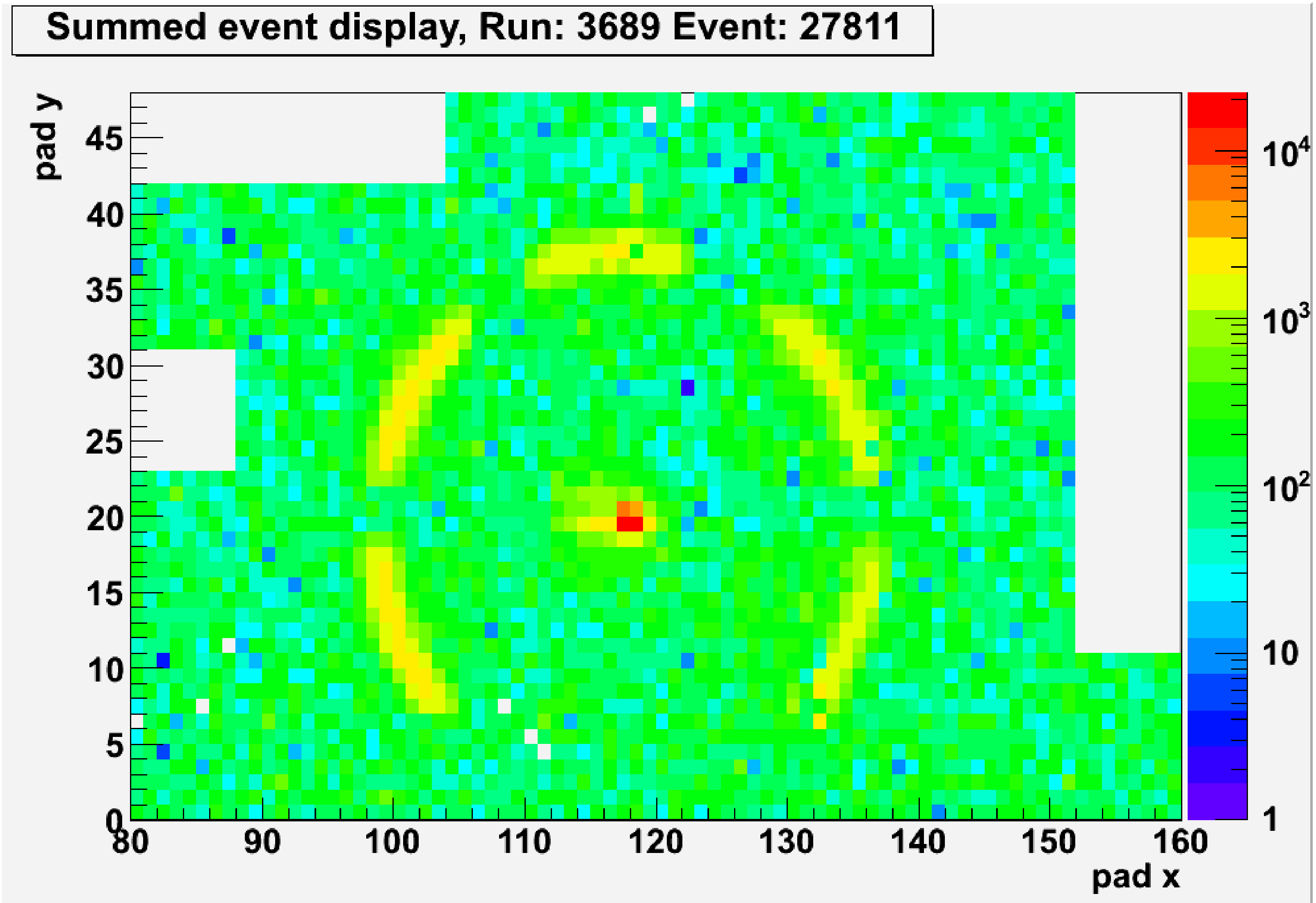
Ne+10%CH_4

(Overlapping events, radiator thickness 10mm)



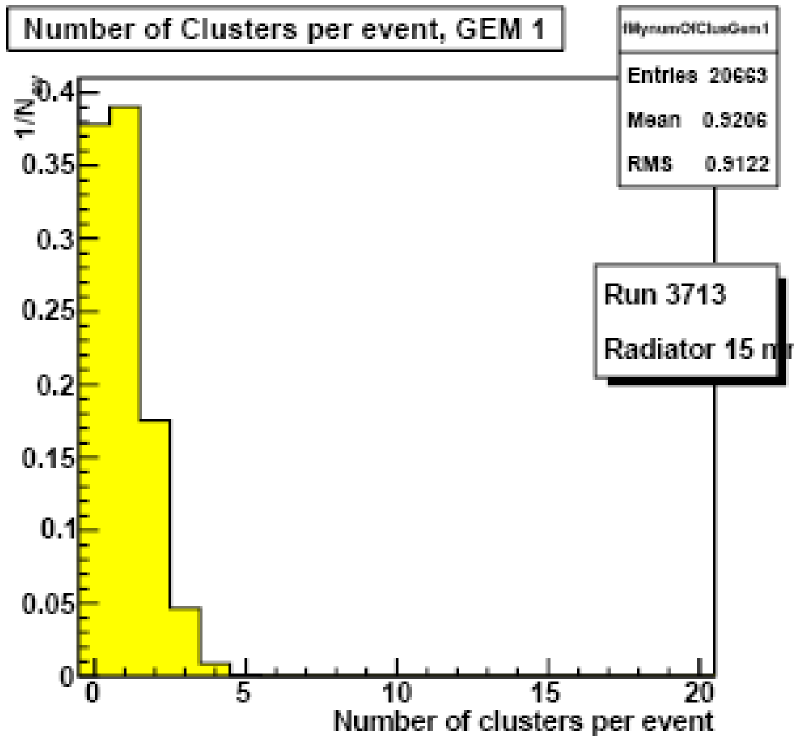
November 2010 beam test. Noise was removed offline

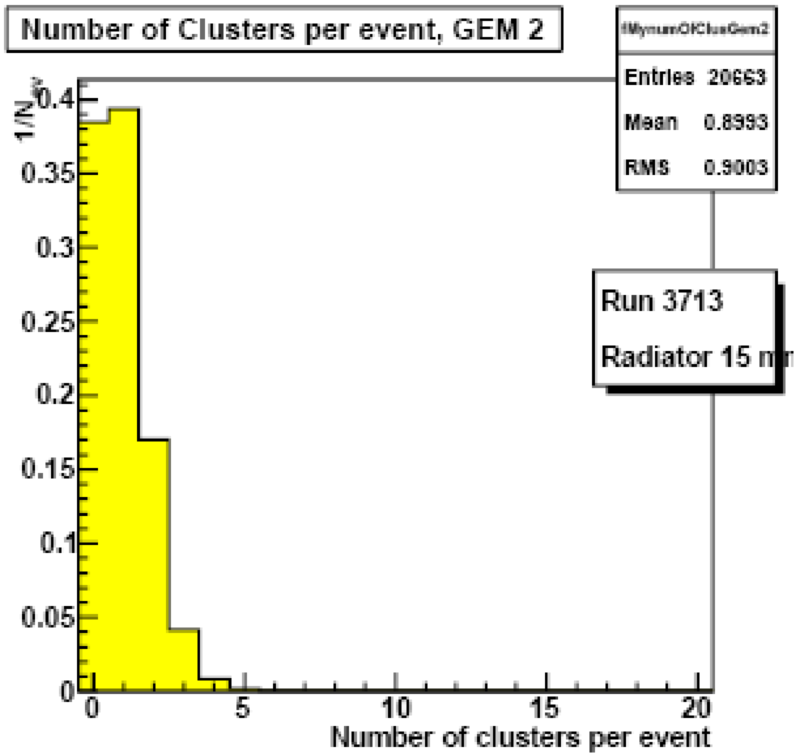
Ne+10%CF_4 (overlapping events, rad. thickness 15 mm)



May 2011 beam test. Raw data, no noise removal

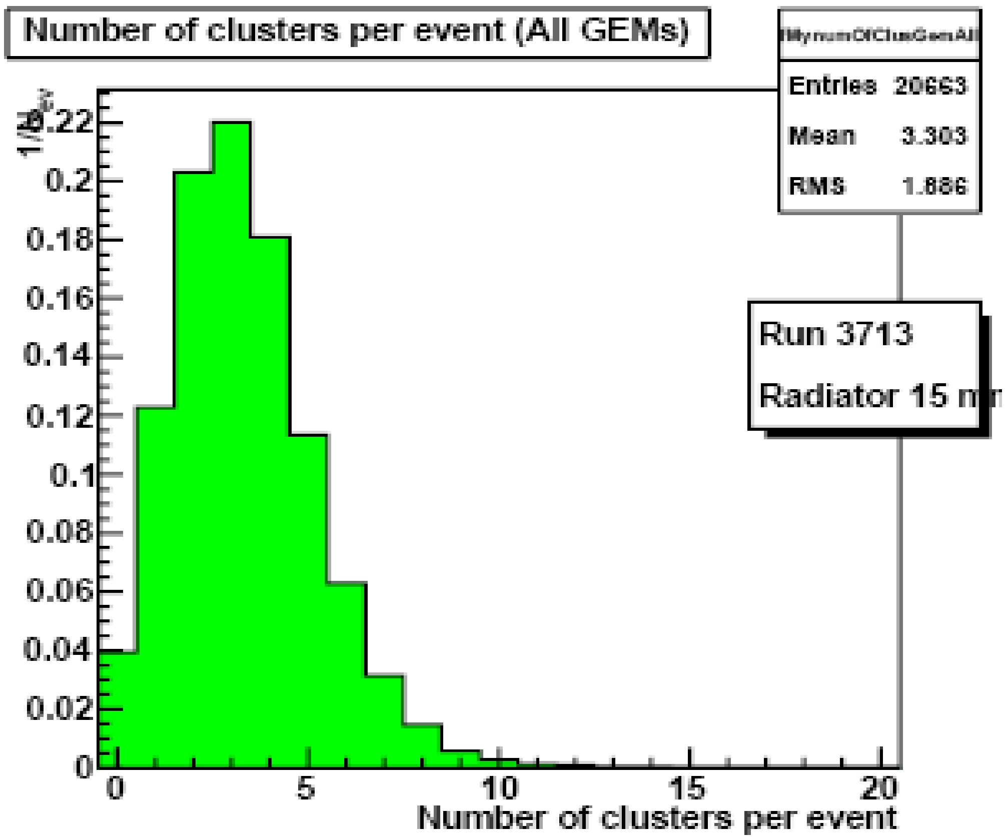
Some examples of data



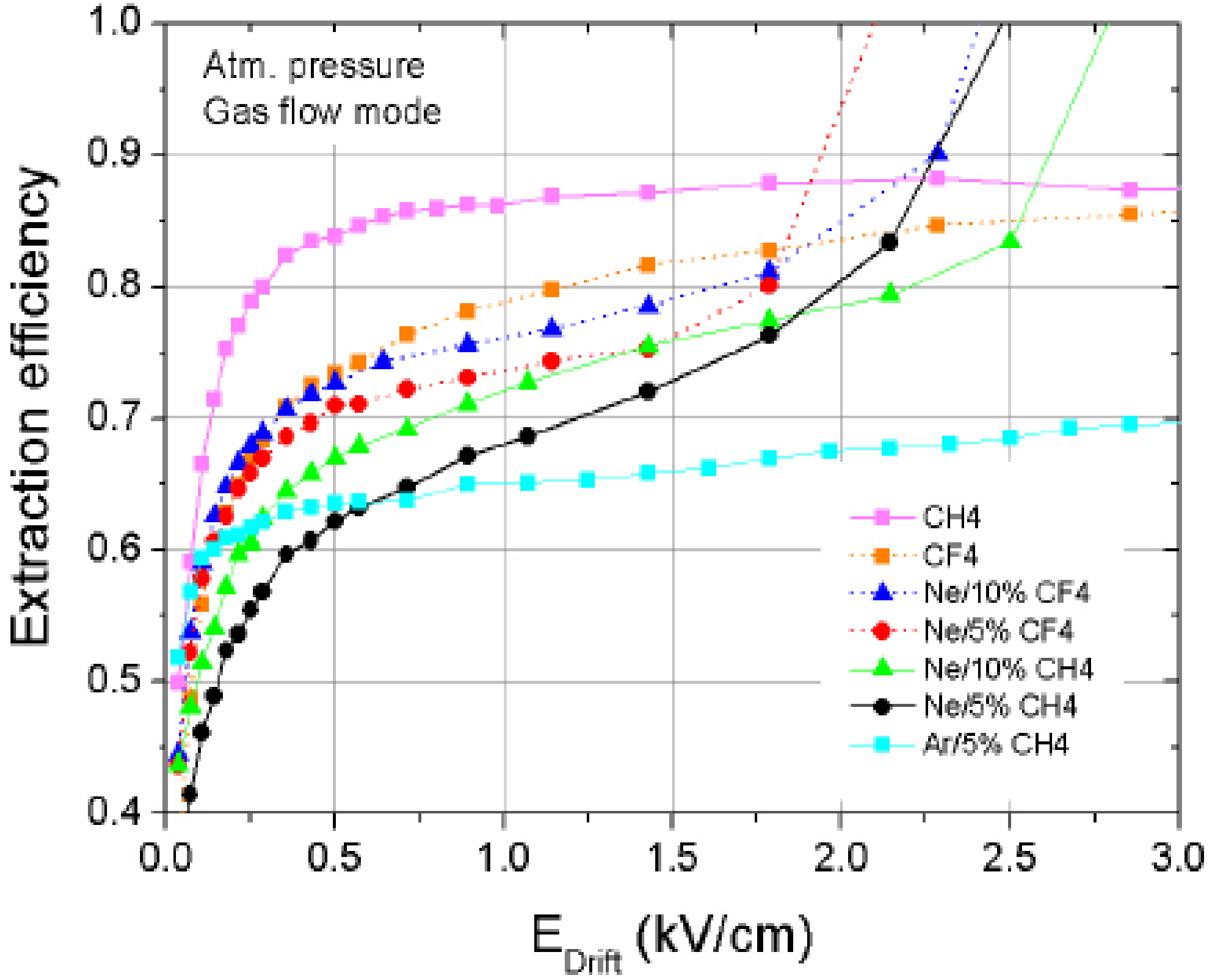


Main conclusion : ~<u>1p.e. per TGEM</u>

Four triple TGEMs together



After corrections on geometry and nonuniformity of the detector response the estimated mean total number of photoelectrons per event is about **10.2**



How much p.e one can expect in "ideal conditions": full surface (without holes) and CH_4 gas:

Corrections: 0.9 (extraction)x0.75=0.68

10p.e/0.68~ **15pe**

What was achieved in the past with the CsI-MWPC (radiator 15mm)?

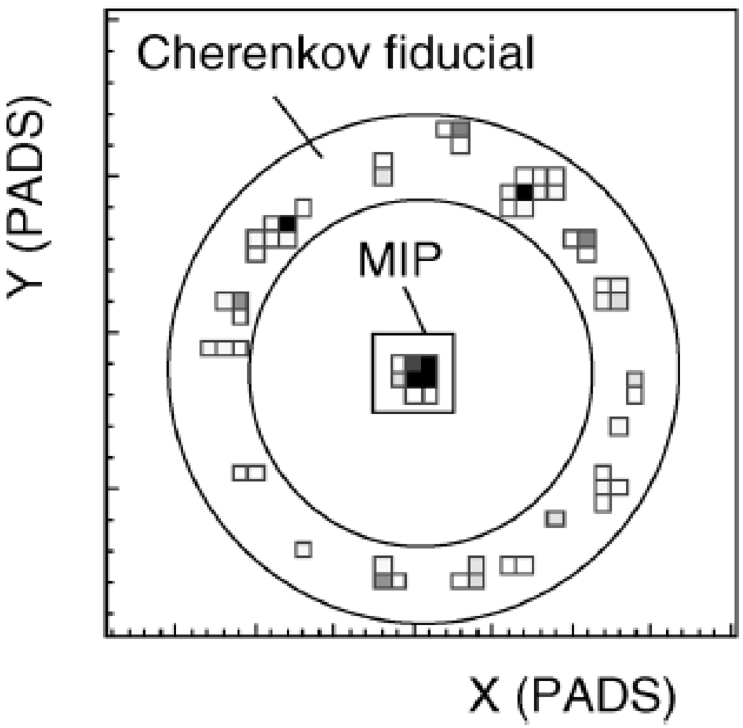
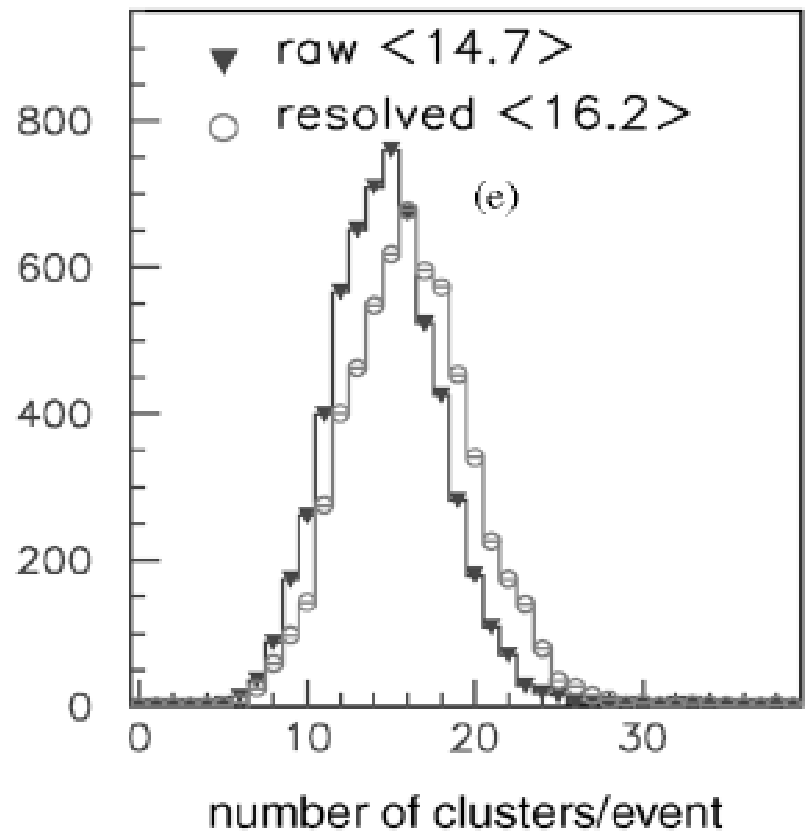
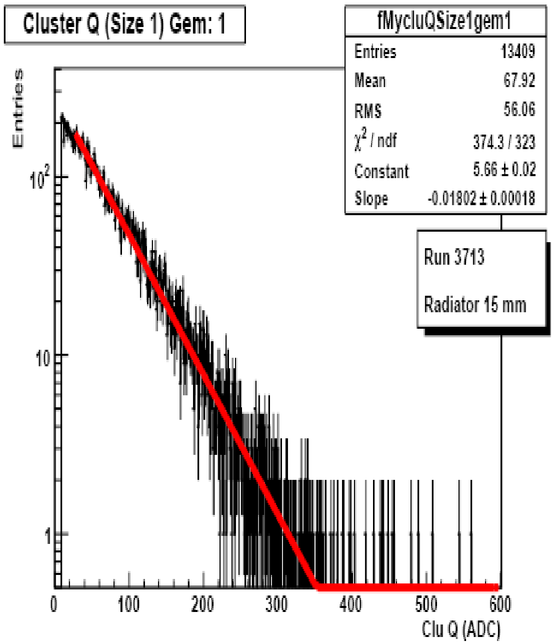
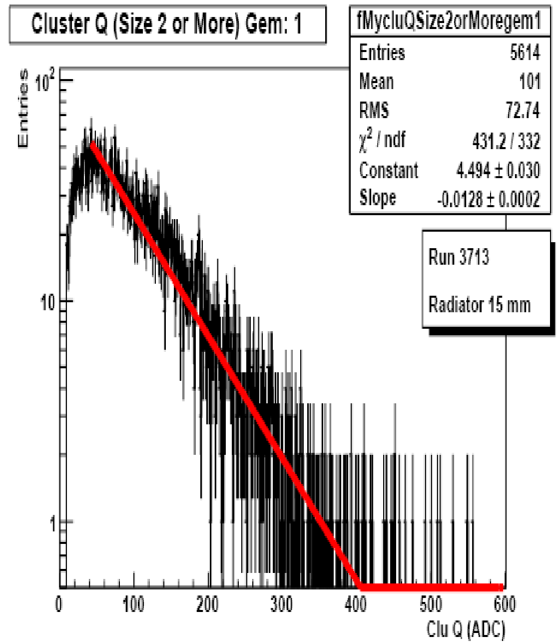


Fig. 3. Single Cherenkov ring event with the three zones used for cluster finding. A pad unit is $8 \times 8\ \mathrm{mm}^2$.

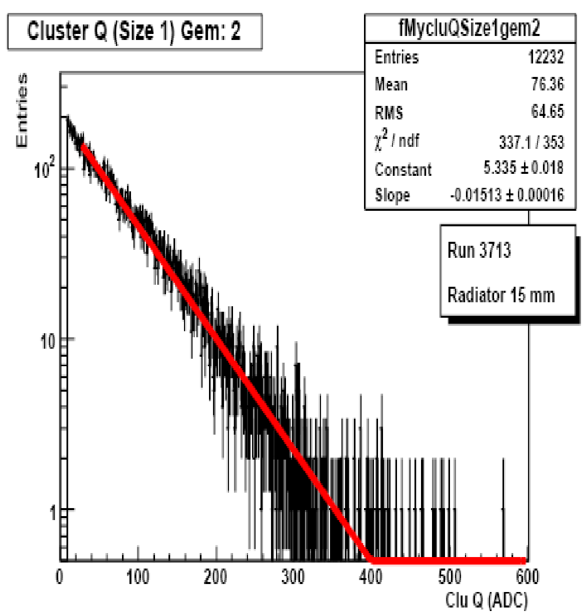


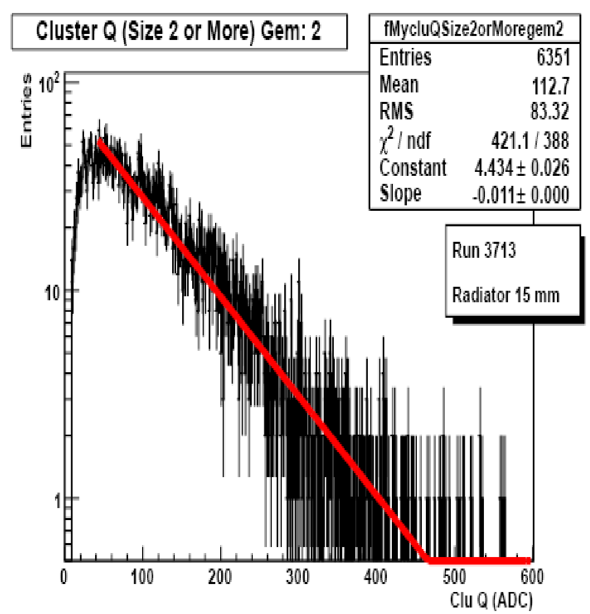
F. Piuz et al., NIM A433,1999, 178





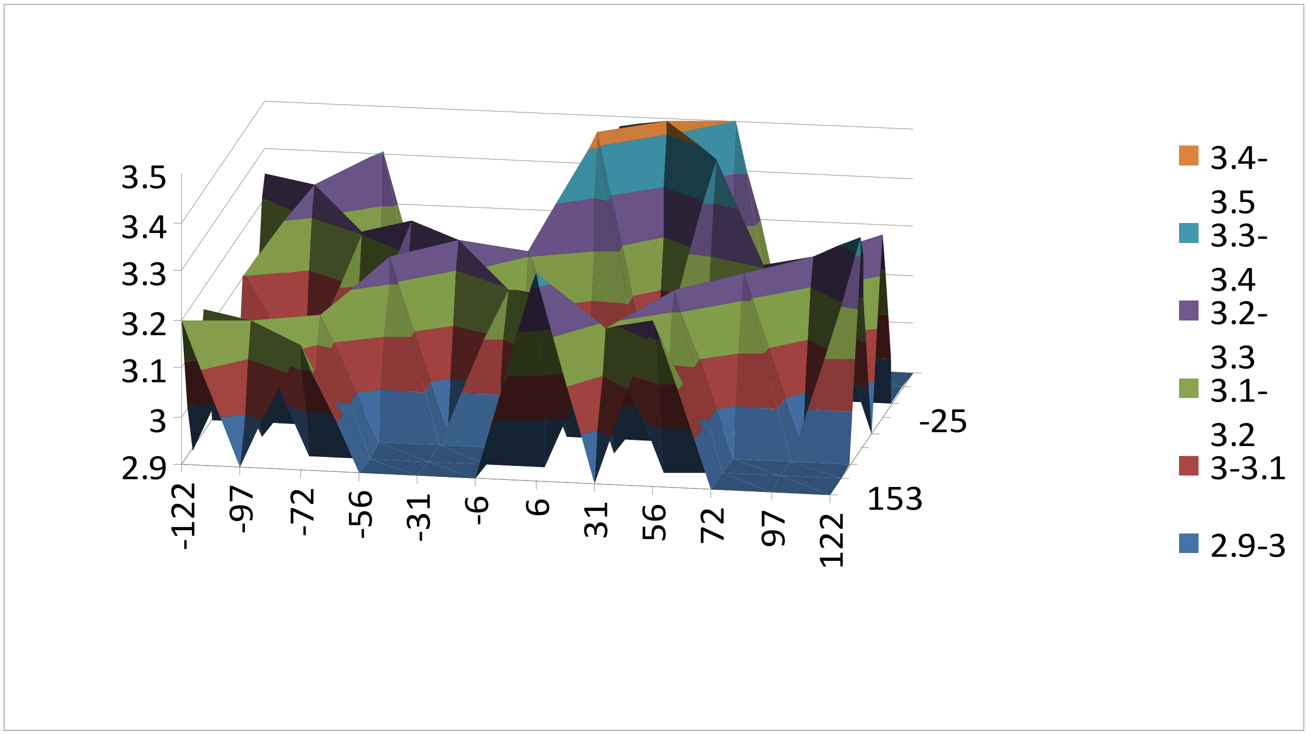
Overall TGEM gas gain ~1,4 x10^5





Radiator 15mm

QE scan after the beam test



Conclusion from the scan: the QE of the CsI layer on the top of TGEMs is practically the same as before our tests - about 16% less than in the case of good MWPC - so corrected on this the total number of expected p.e. will be around **16-17**-close enough to the MWPC data

Developing the simulation program

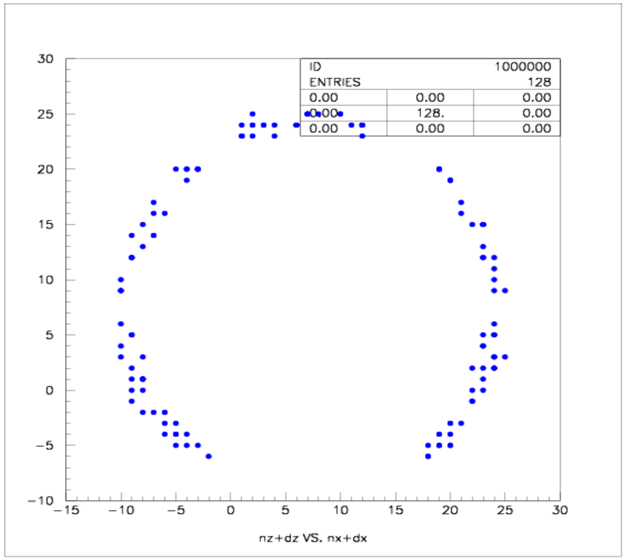
Some details, how simulation was done.

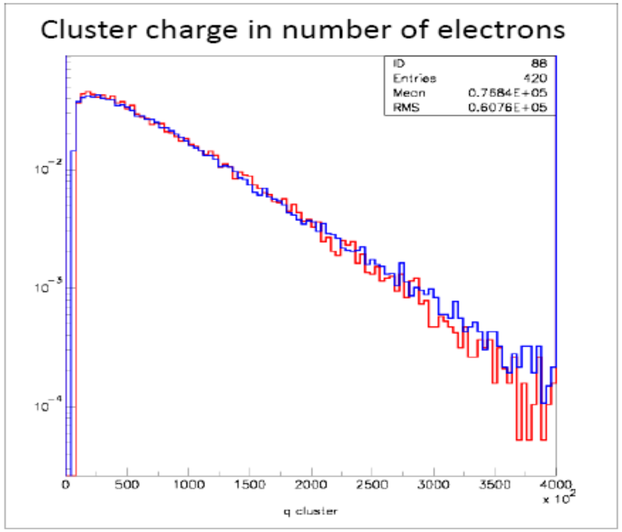
Input parameters: geometry, n-index, gas (ionization, diffusion), E-field, Average Gas Amplification, FEE parameters,…

- Primary ionization: track, Fe55 (position in a space of each e-), single photo-electron from CsI on a top of a first foil (GEANT-3 for UV production, transport and CsI QE)
- Transport of each e- to nearest hole in first foil (probability and position in a hole)
- Gas amplification; Polya distribution and "some special parameters".
- Transfer of each e- after gas amplification step to next foil (hole selection)
- Repeat GA and Transport steps for second and third foil.
- Collect electrons on pad (strip) structure
- Add FEE noise and response for each ("active") pad
- Threshold to select "active" pads.
- Cluster finding and reconstruction.

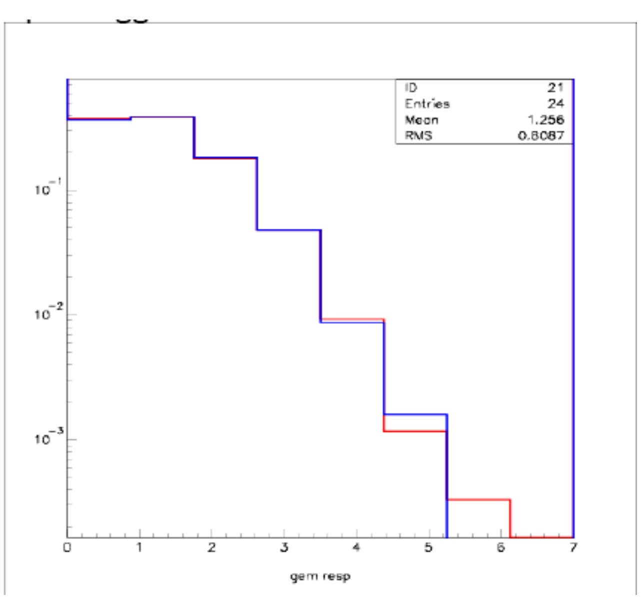
- NO Background (for the moment)

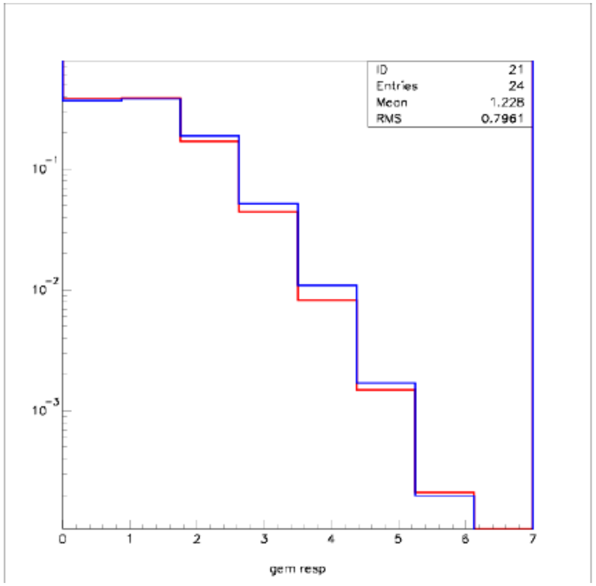
Some preliminary results of the simulation



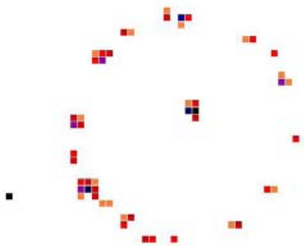


Red-experimental data
Blue-calculations





Number of reconstructed clusters per trigger (assumption QE=0.66QE in CH_4), so ~35% accuracy



Conclusions:

● **For the first time** Cherenkov rings were detected with CsI-TGEMs

●The mean number of detected photoelectrons is the same as expected from estimations

● Thus, preliminary It looks that TGEM is an attractive option for the ALICE VHMPID: it can operate in inflammable gases with a relatively high QE, it has a fast signals and cetera

●Of course, the final choice of the photodetector for VHMPID will be based on many considerations, for example MWPC approach has its own strong advantage: it is a well proven technology

Aknowledgments:

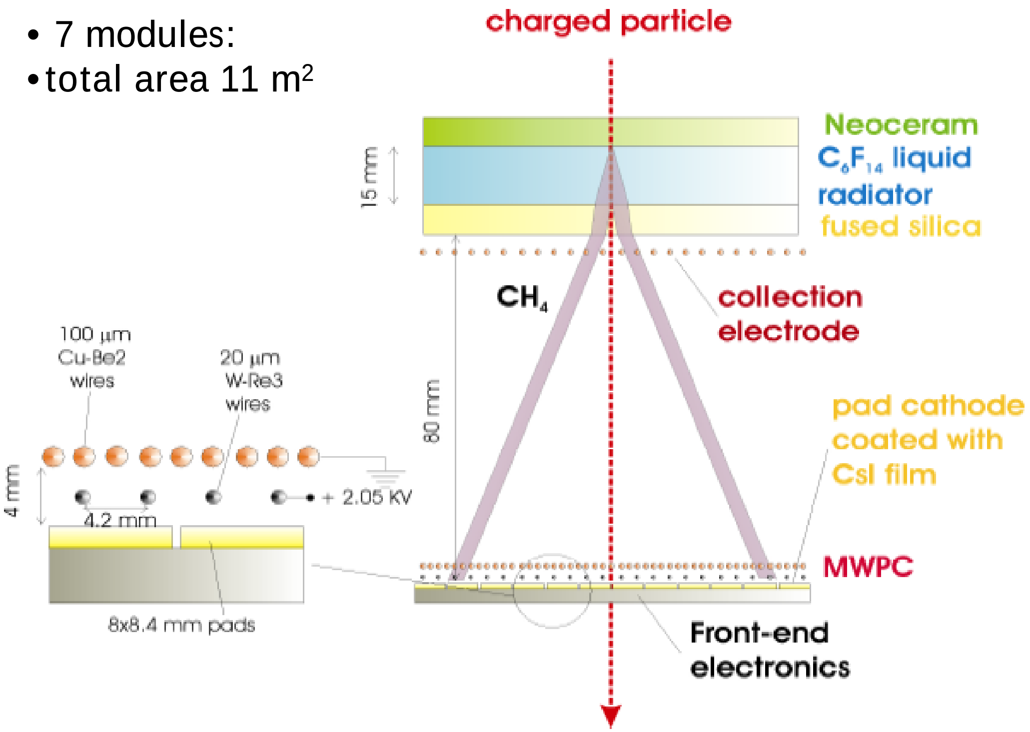
Author would like to thank J. Van Beelen, M. Van Stenis and M. Webber for their help throughout this work

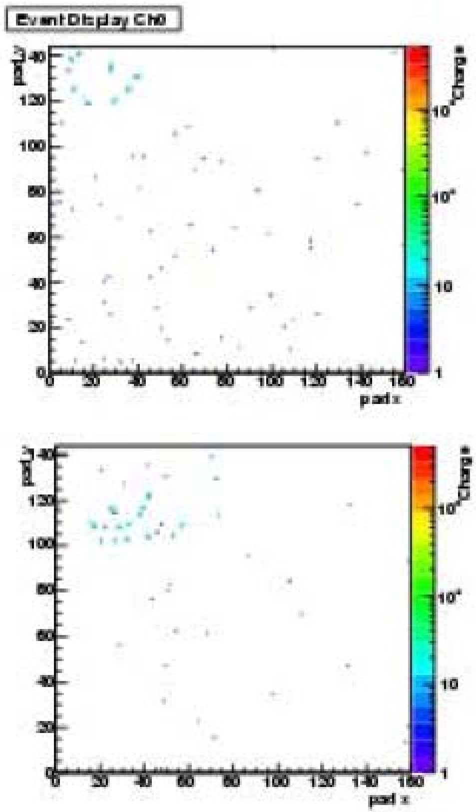
Spare

The main advantages of MWPC- it is a proven technology

The current ALICE/HMPID Detector

- 7 modules:
- total area 11 m^2

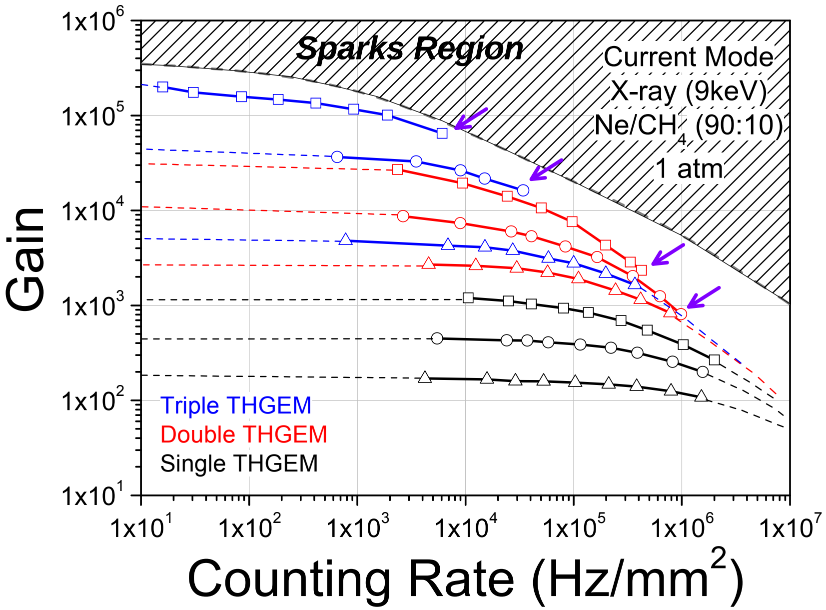


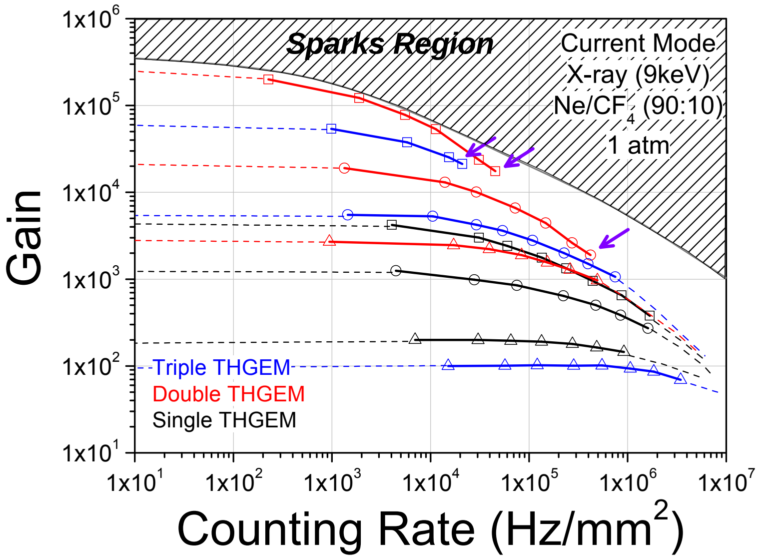


First Cherenkov rings candidates at 7TeV proton-proton collisions at LHC

See A. Di Mauro talk at his Conference

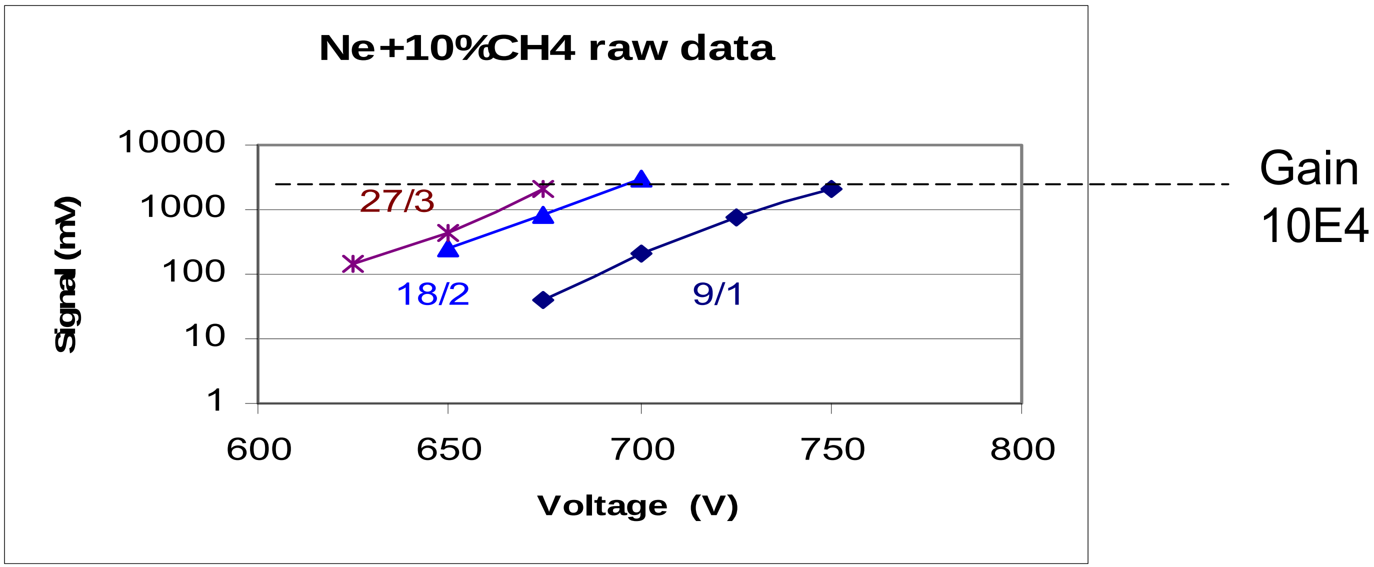
Rate dependance





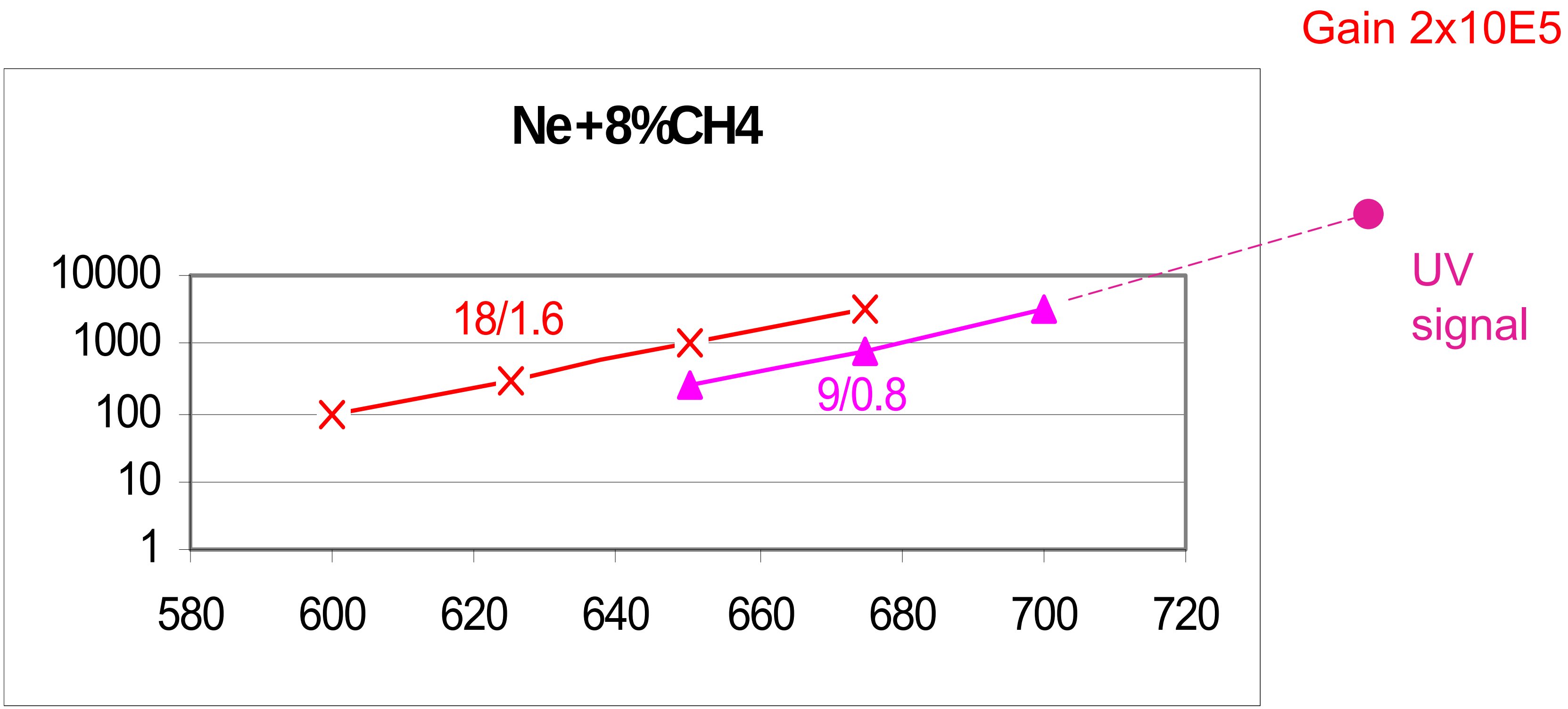
Triple TGEM is inside this general limit!.. So at the beam test we should not expect an unlimited gain

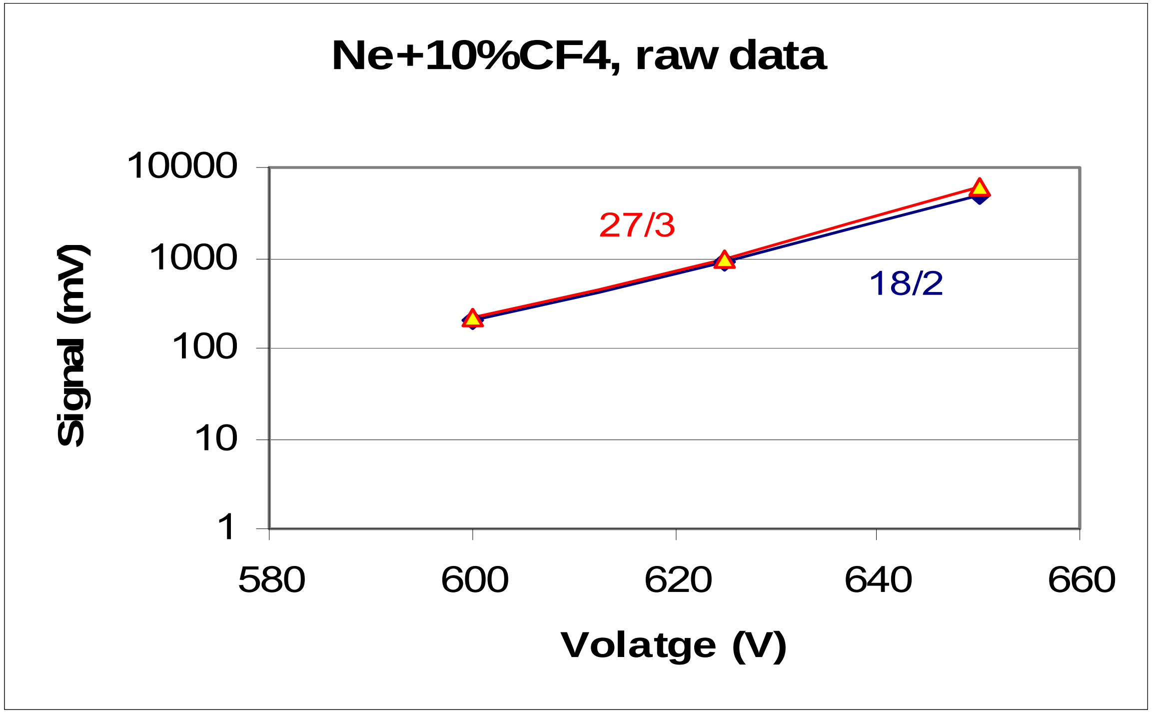
Measurements with 55Fe



The gas flow at the beam test was 27/3

Measurements with 55Fe





No flow dependence in the given region