Portability and policapillary for X ray imaging

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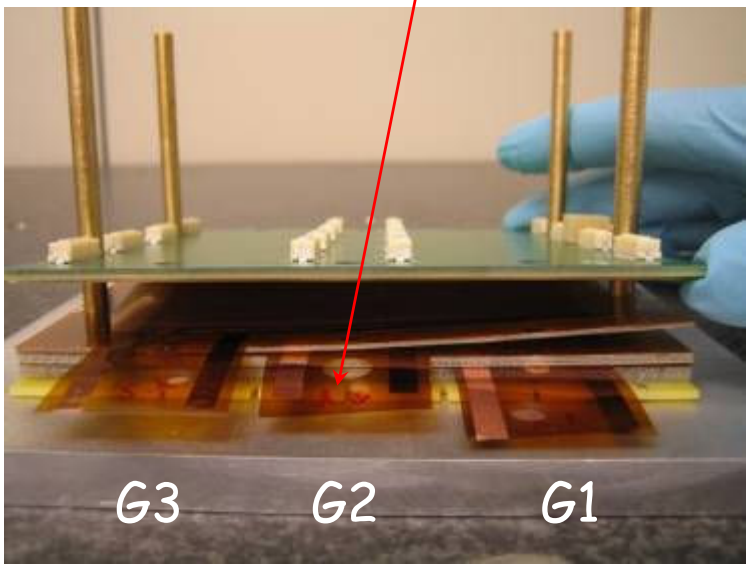
- Construction of a standard triple GEM detector
- Triple GEM detector as beam monitor
- Monitors for UA9 crystal channeling experiment at SPS
- Neutron flux monitor for Tokamak
- A compact Time Projection Chamber with GEM
- First measurements with 3GEM and policapillary
- Conclusions

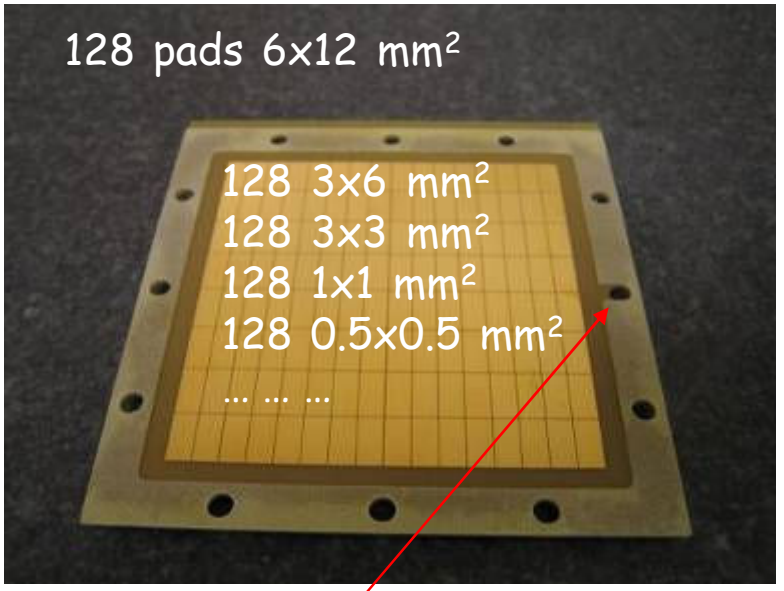
IMAGEM http://www.lnf.infn.it/esperimenti/imagem/

A Standard Triple GEM construction

The detectors described in this talk are built starting form the standard 10x10cm^2 produced by CERN :
only one GEM foil has been modified to have central electrodes.



The GEM are stretched and a G10 frame is glued on top

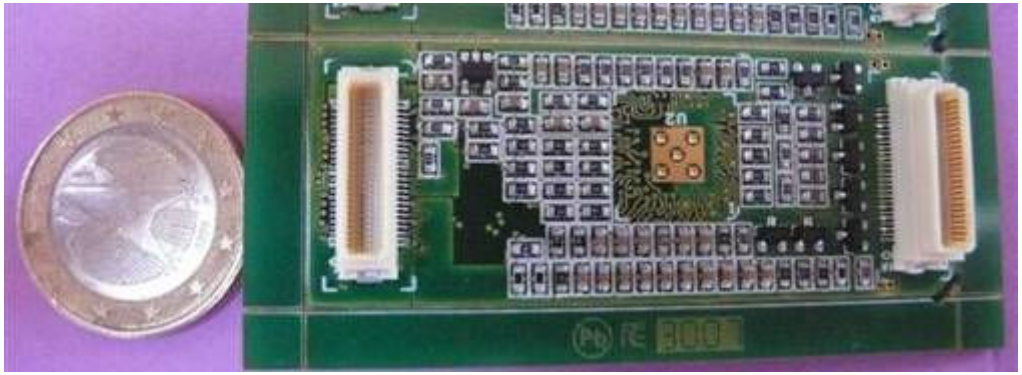


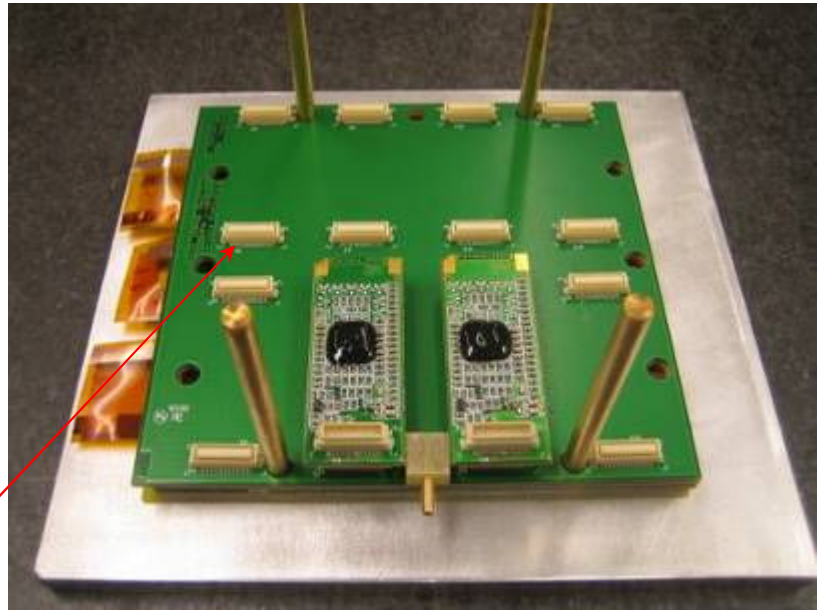
The frame for the G3 foil has been modified for the gas inlet

The FEE board used

The card is based on *Carioca Chip and has been designed and realized in Frascati by Gianni Corradi ; Total dimension : 3x6 cm^2

16 channels for each card: channel density of 1 ch/cm^2
Sensitivity of 2-3 fC; LVDS output (25 ns); Radhard;
Extremely modular and usable for GEM applications

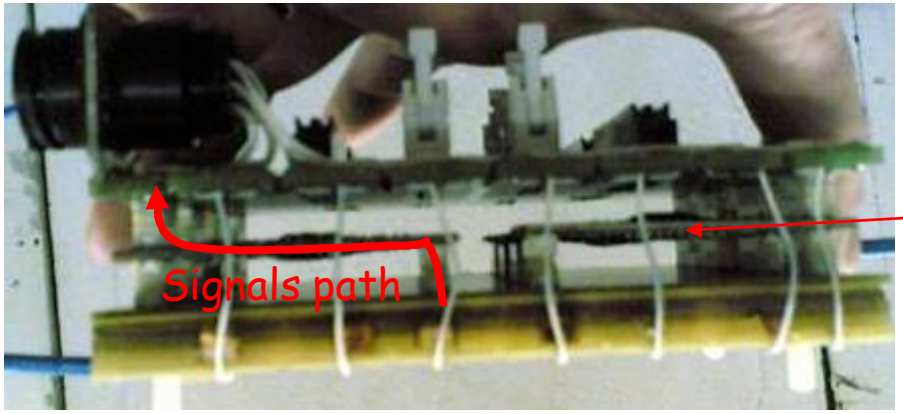




All the anode PCB have been designed with the same connector layout for a total of 128 channels

* Development of the CARIOCA front-end chip for the LHCb muon detector. W. Bonivento, et al NIM A491:233-243,2002

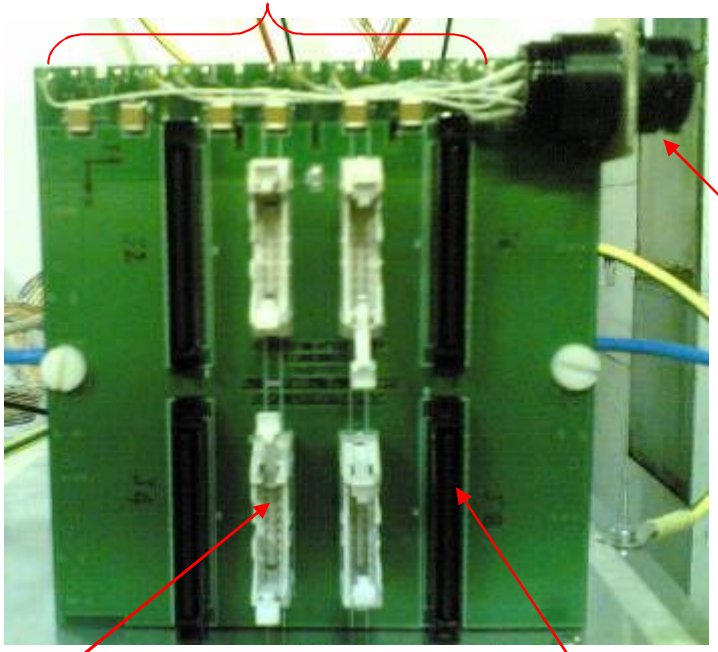
The mother board



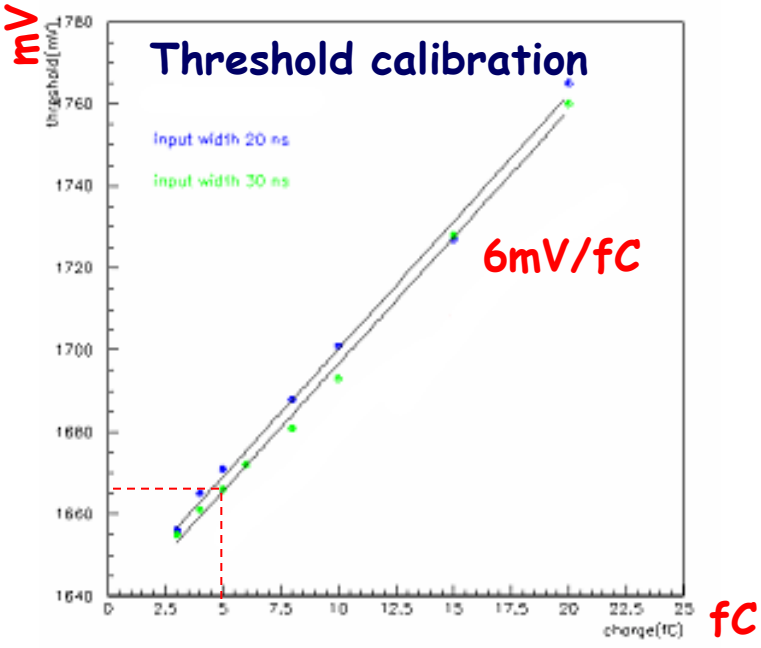
On this mother board
HV and LV ground are connected
each other through a 10 KΩ resistor

CARIOCA readout electronics

HV filters



HV in



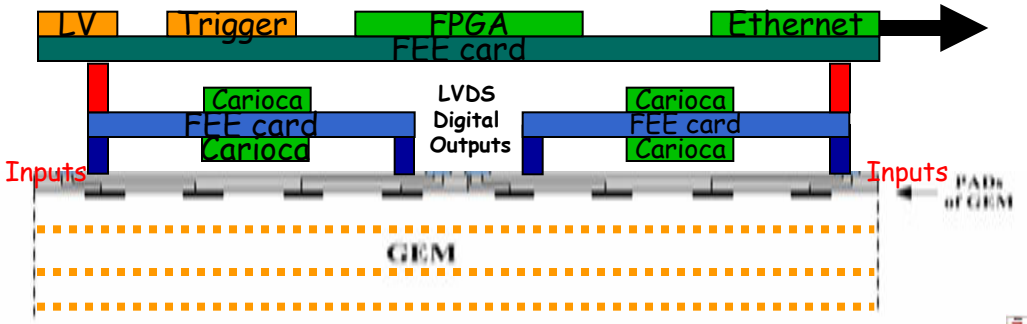
Threshold & LV in

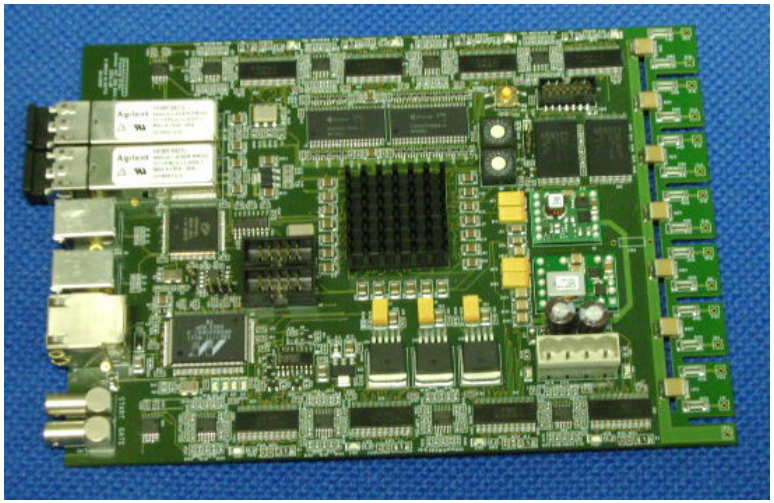
4×32 LVDS signals out

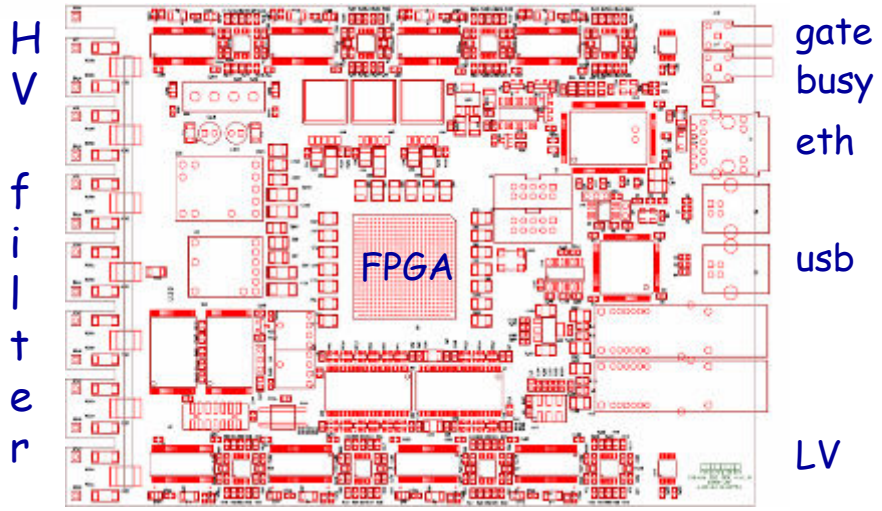
"Intelligent" Mother Board

We have now an Intelligent Mother Board with an FPGA on board able to count the 128 channel hits and/or measure the time respect to a trigger (1 ns) ; the data are readable through an Ethernet connection.

(LNF A.Balla, P.Ciambrone, M.Gatta)



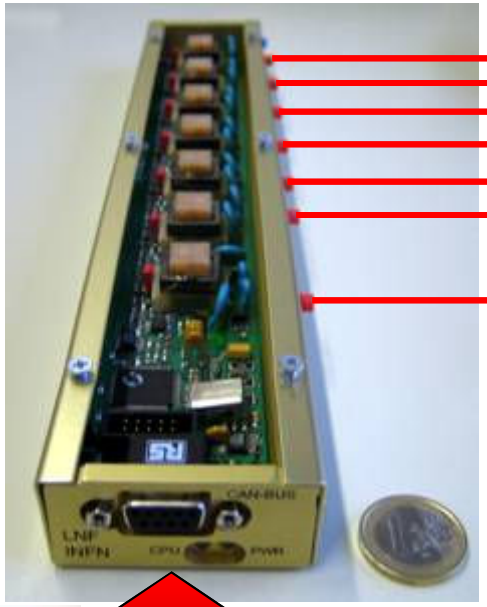




HV supply for GEM detectors

HVGEM is a new device designed and realized at Frascati specifically for the HV power supply of 3GEM detectors.

Controlled via Canbus



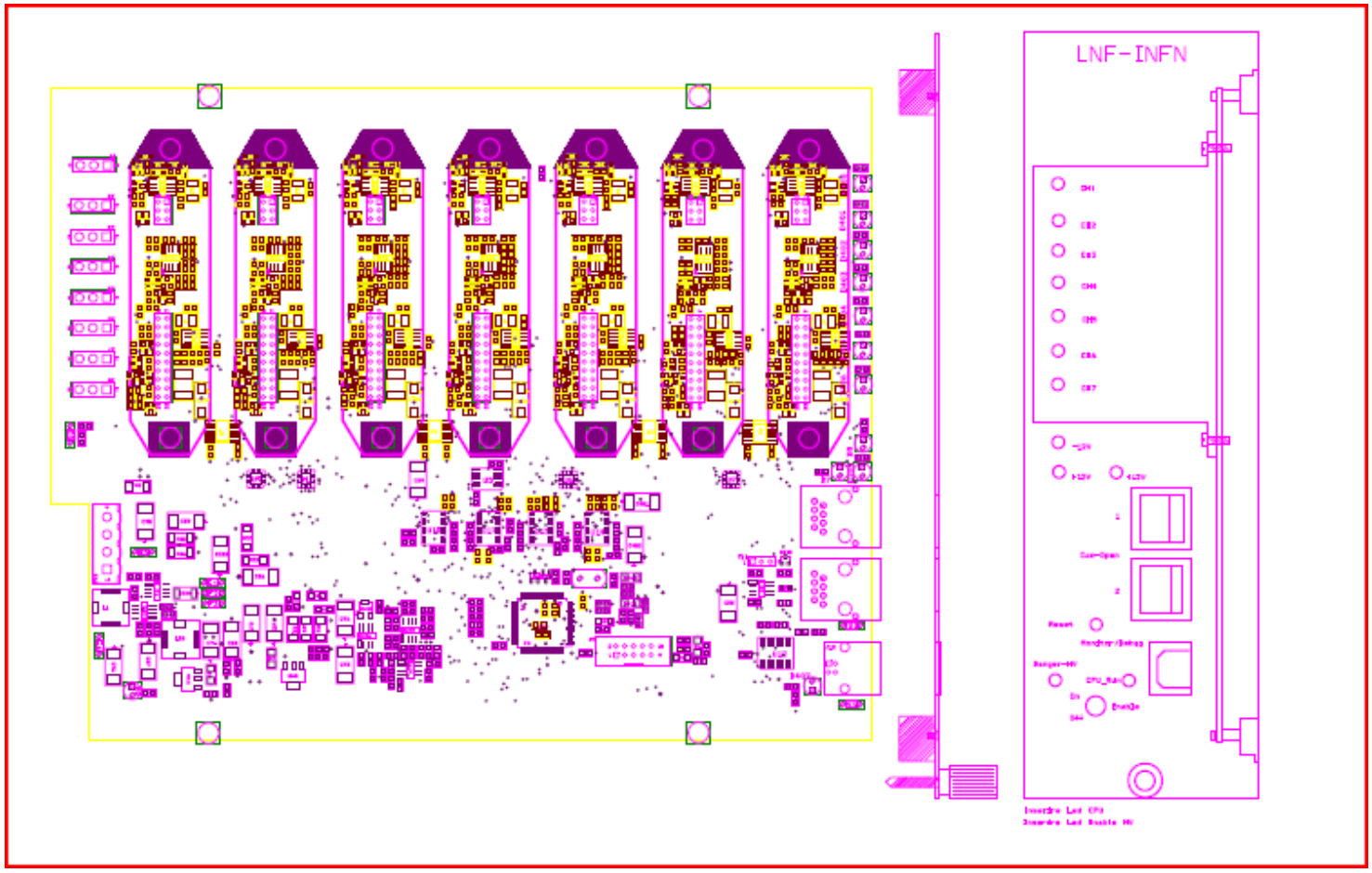
12 V

G. Corradi, F. Murtas and D.Tagnani
A novel HighVoltage System for a triple GEM detector
Reference: NIM A46 128

All the detectors for beam diagnostic described here have been powered with this new device

A new version with 7 nano-ammeters,
one for each generator element,
is in construction and ready at beginning 2010

New HVGEM module



Powered with 12 Volts

It's a NIM standard module (2 slots) : in production (4 modules)
7 HV channels AND 7 nanoammeters

HV Online monitor and control

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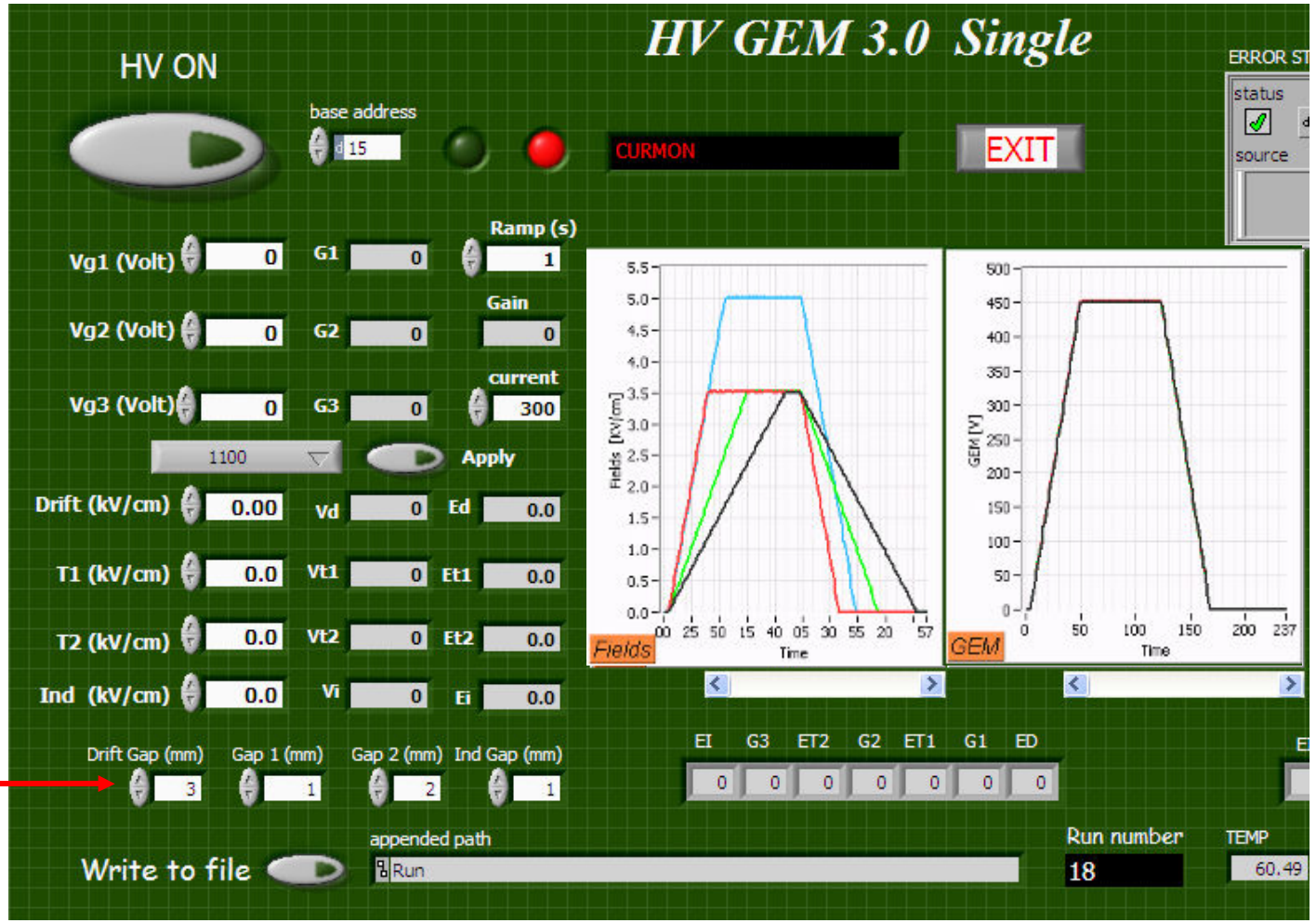
It gives the possibility to set and control directly the 4 fields and the total gain of our triple GEM chambers

Labview and PVSS programs

GEM Voltage (gain)

Fields

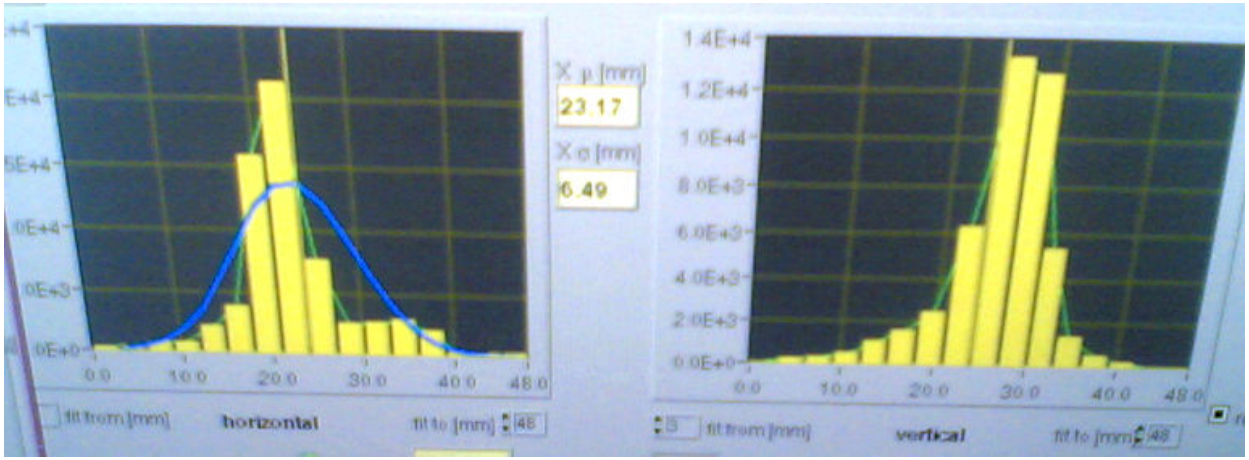
Gap dimension

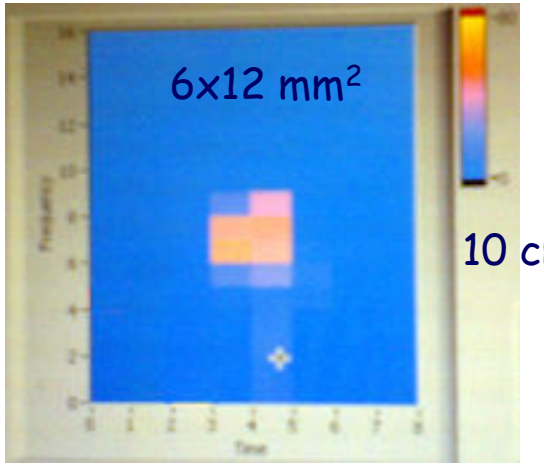


Beam monitors for Frascati Test Beam and UA9 experiment at SPS (CERN)

Beam monitor at BTF Frascati

Beam profile at BTF in two configuration : narrow and wide beam

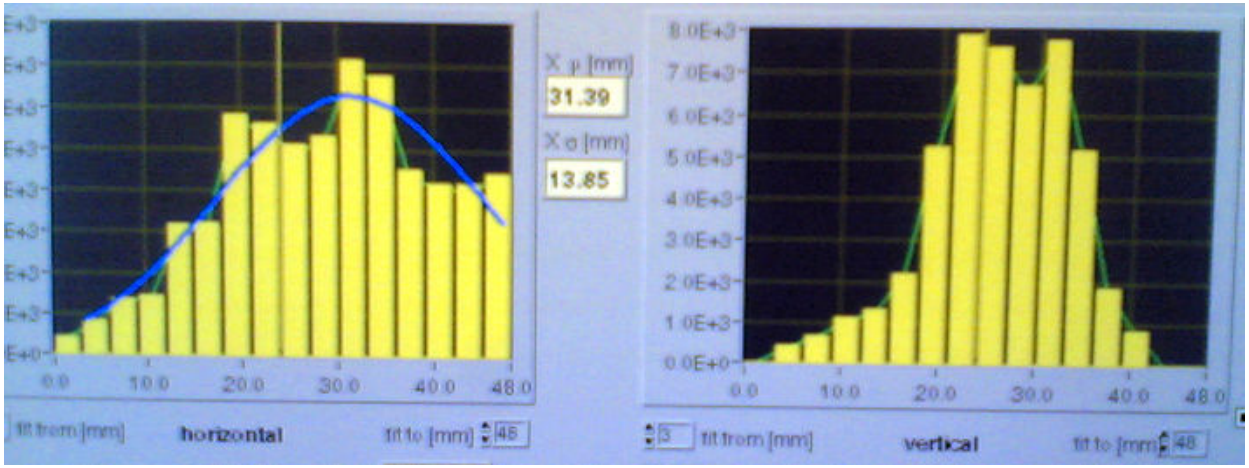


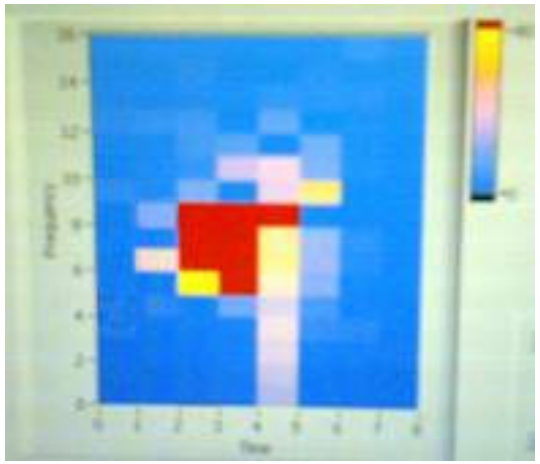


10 cm

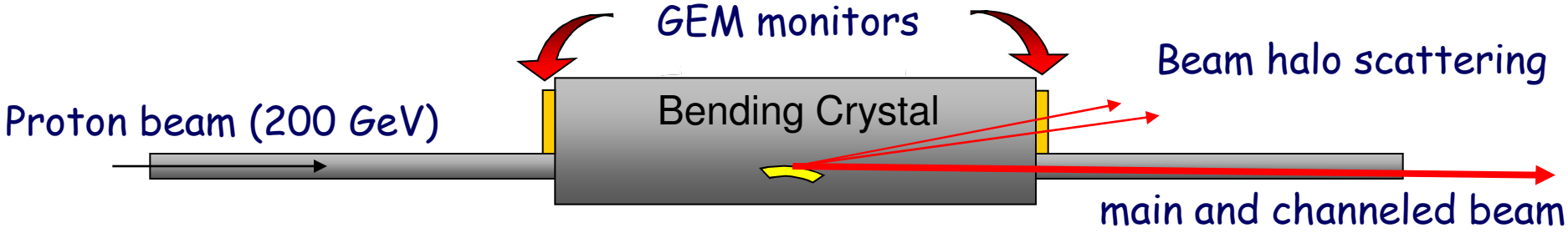
10 cm

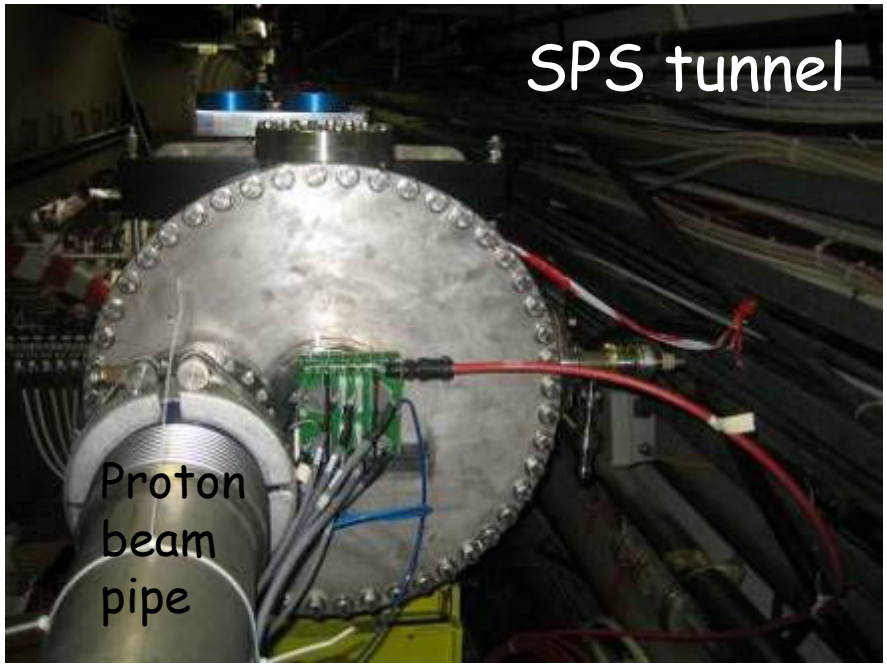
Standard diagnostic with scintillating fibers

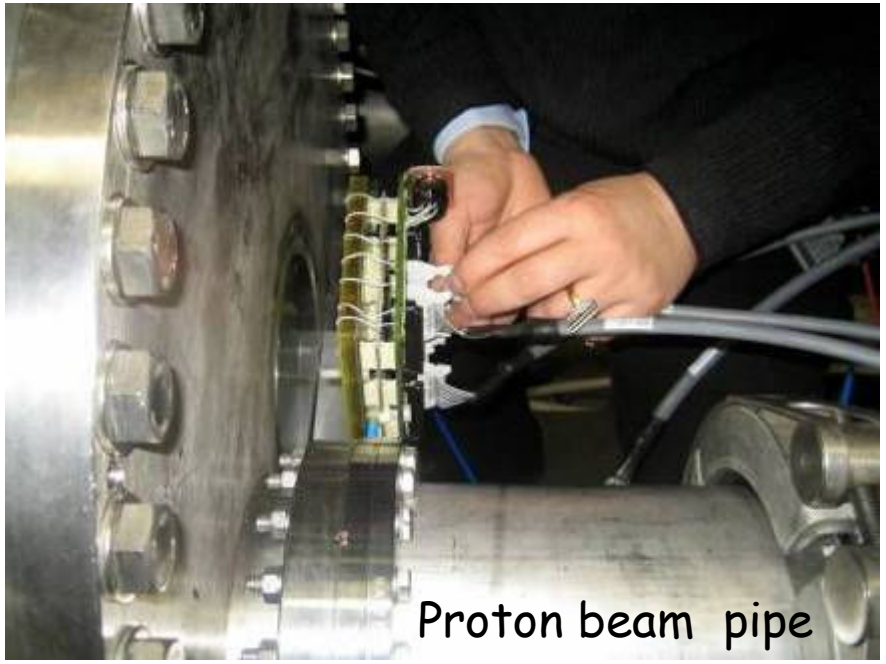




GEM monitor on UA9 Experiment at CERN



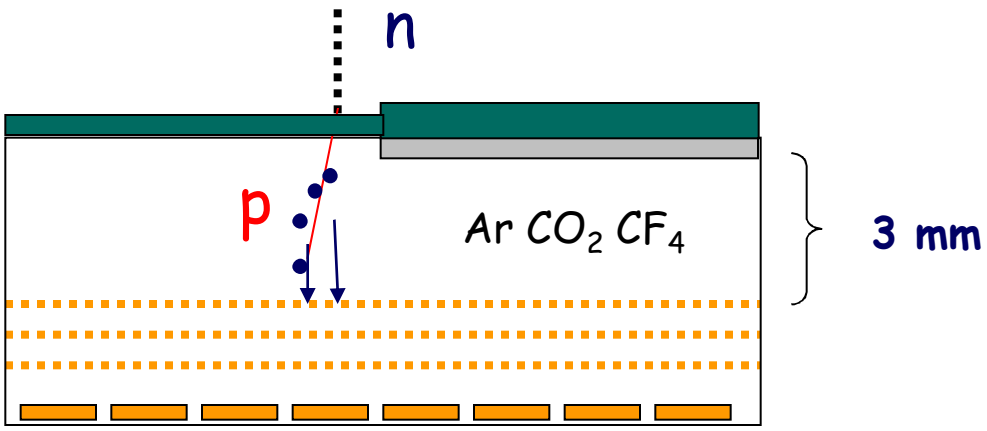




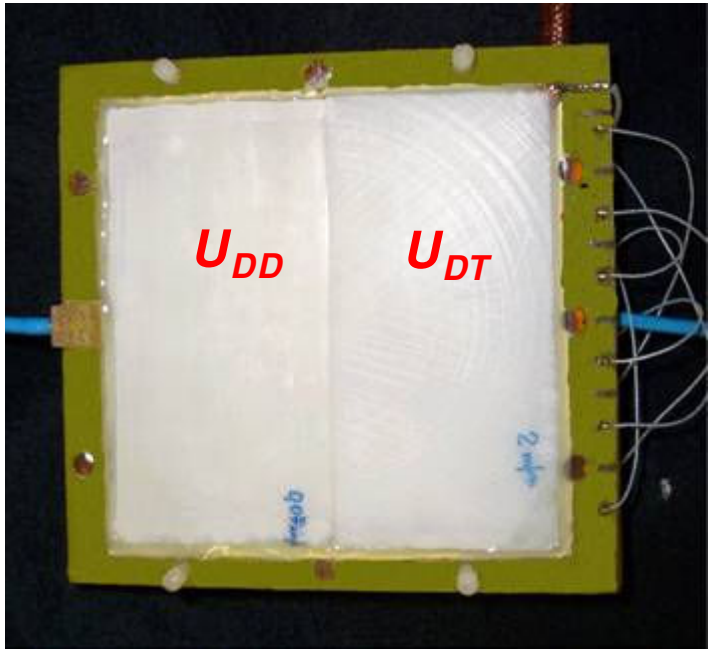
The installation just two months after the collaboration request

Neutron Flux Monitor for fusion reactors

Neutron flux from fusion plasma



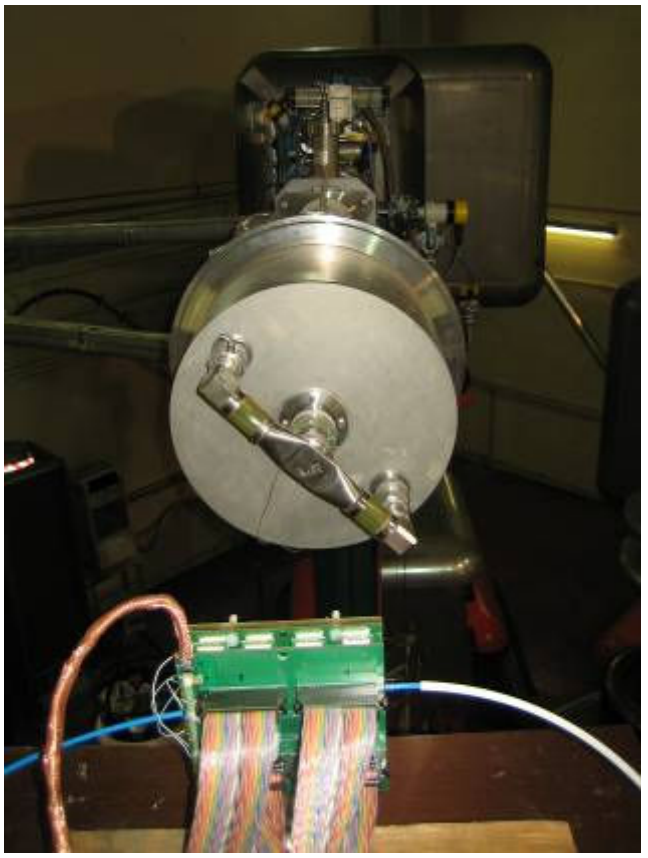
Frascati Neutron Generator at Enea Frascati :
2.5 (DD) and 14 (DT) MeV



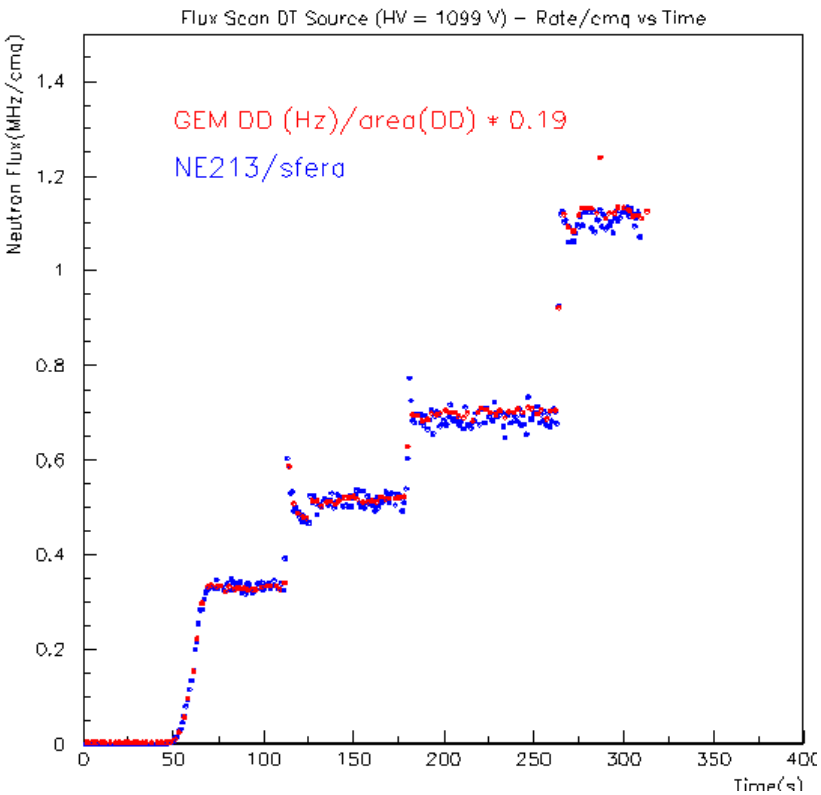
Detector divided in two zone :

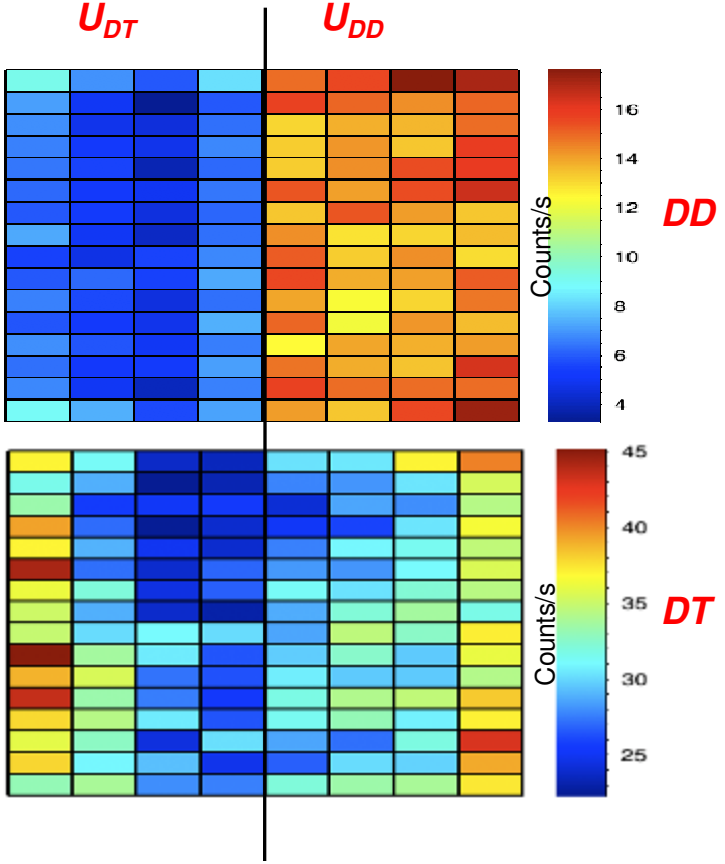
U_{DD} 700 μm Polyeth.
5 μm Al.

U_{DT} 2 mm Polyeth.
0.2 mm Al.



Flux vs time and discrimination



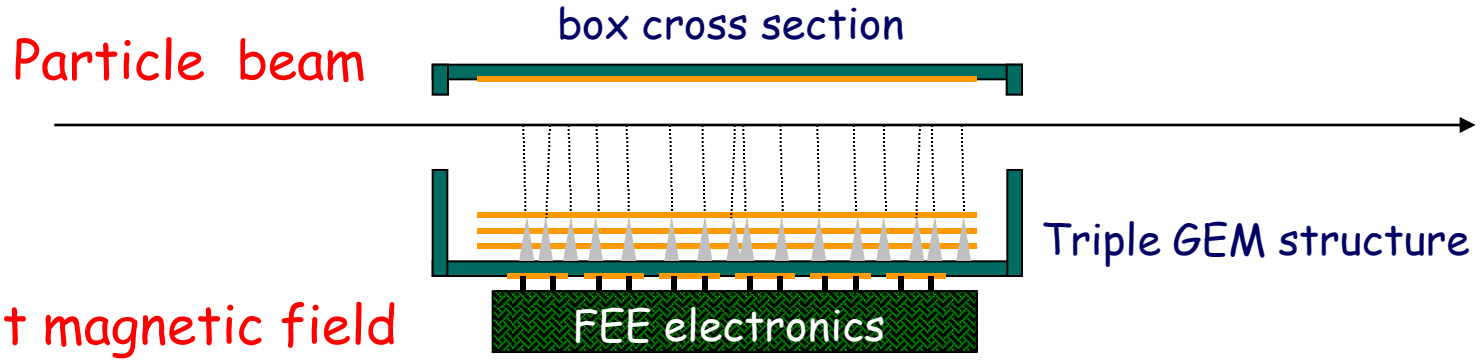


More studies on cathode materials are needed to improve discrimination
Installaed at Frascati Tokamak Upgrade : measurements in progress

Compact TPC with GEM readout for high intensity beam and ion beam

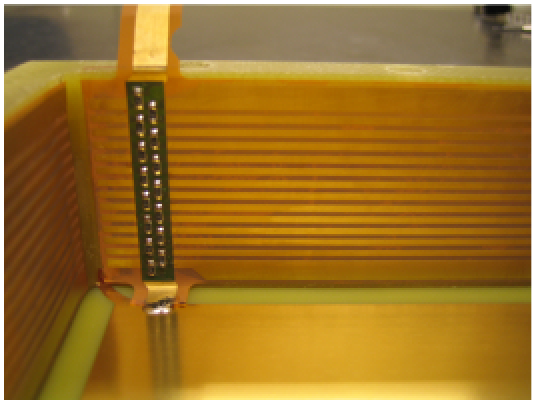
TPG for beam diagnostic

It's essentially a small TPC with a 4 cm drift and readout with triple GEM
In this way also high current beam can be monitored in position

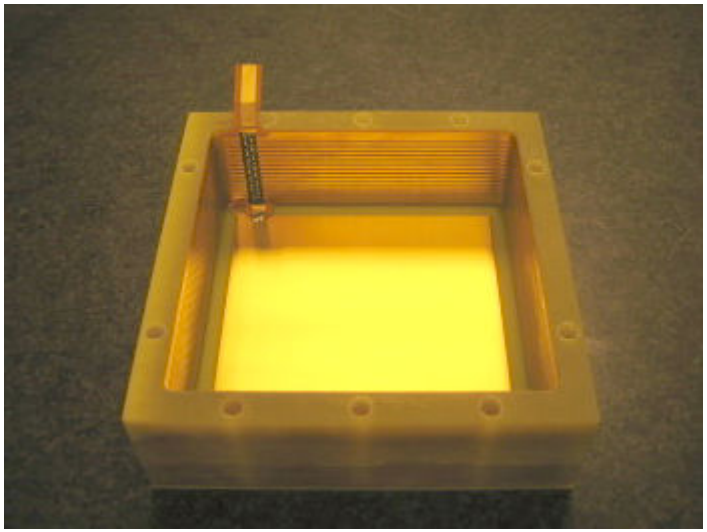


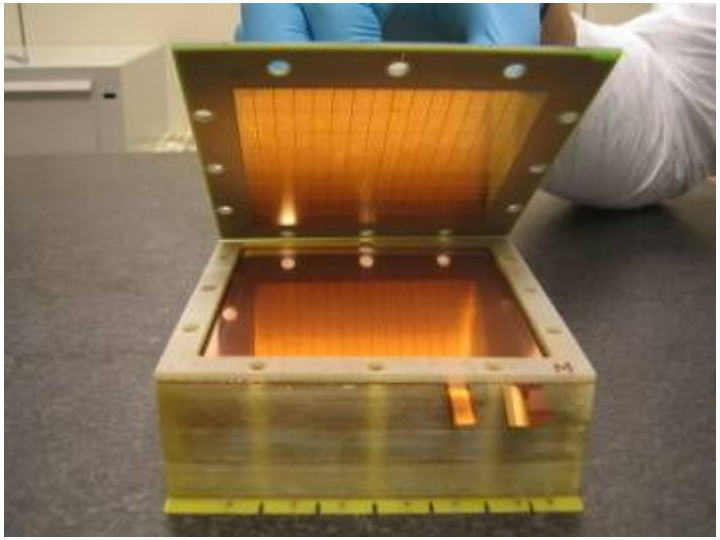
The material budget crossed by a particle is only two kapton foils (<0.2%X_0) used for the field cage necessary for the drift field uniformity

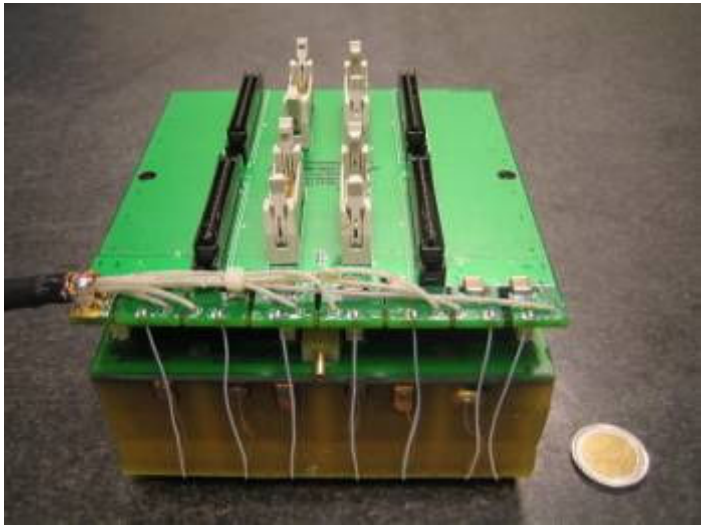
14 strips with 15 resistors (10 MΩ) for a total field cage current of 1 μA



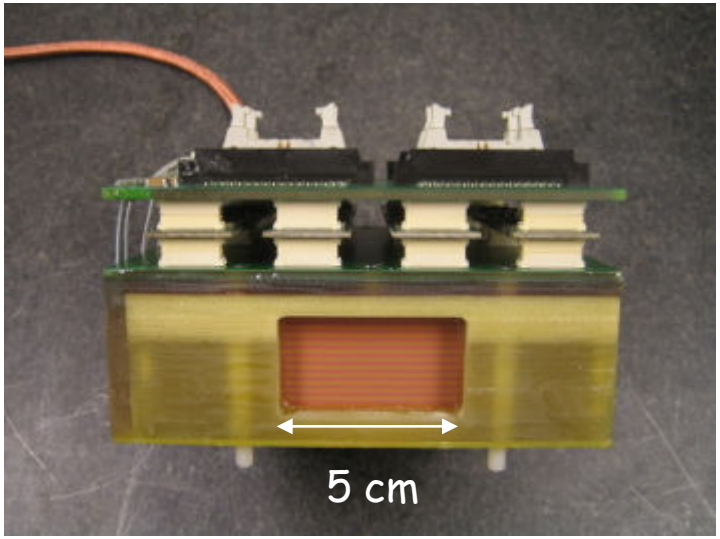
Assembling the TPG chamber







(M. Pistilli)

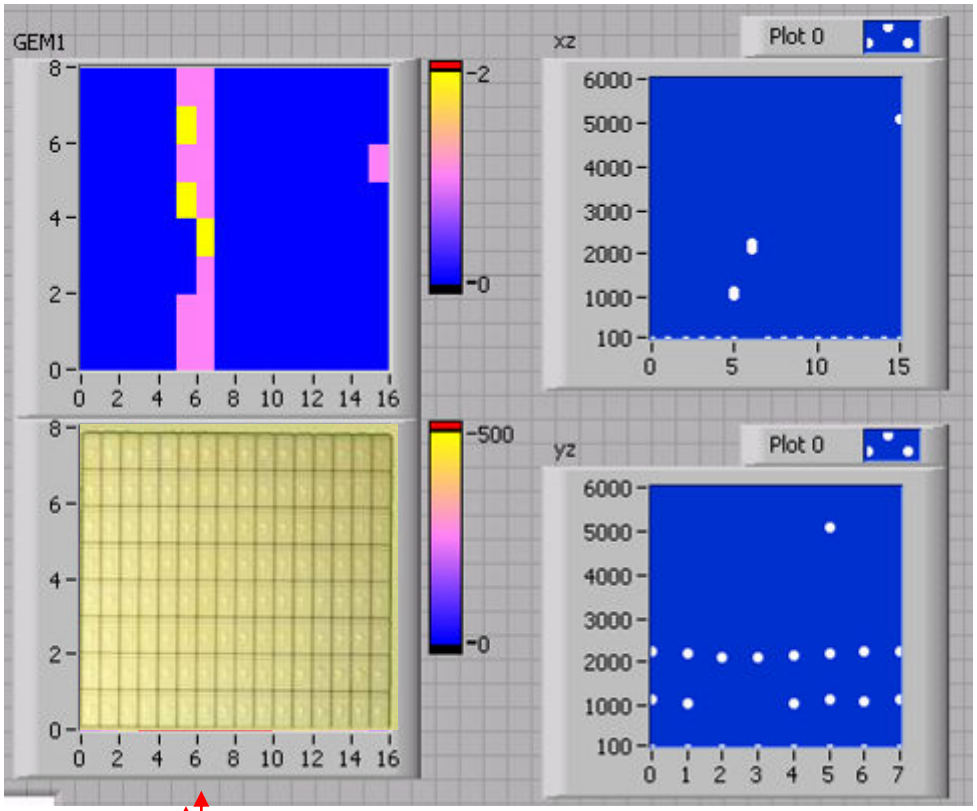


Low intensity beam

Top view

Two electrons in 10 ns

Last event



Front view

Pad layout

Side view

particles

particles

High Intensity beam 4400 e⁻

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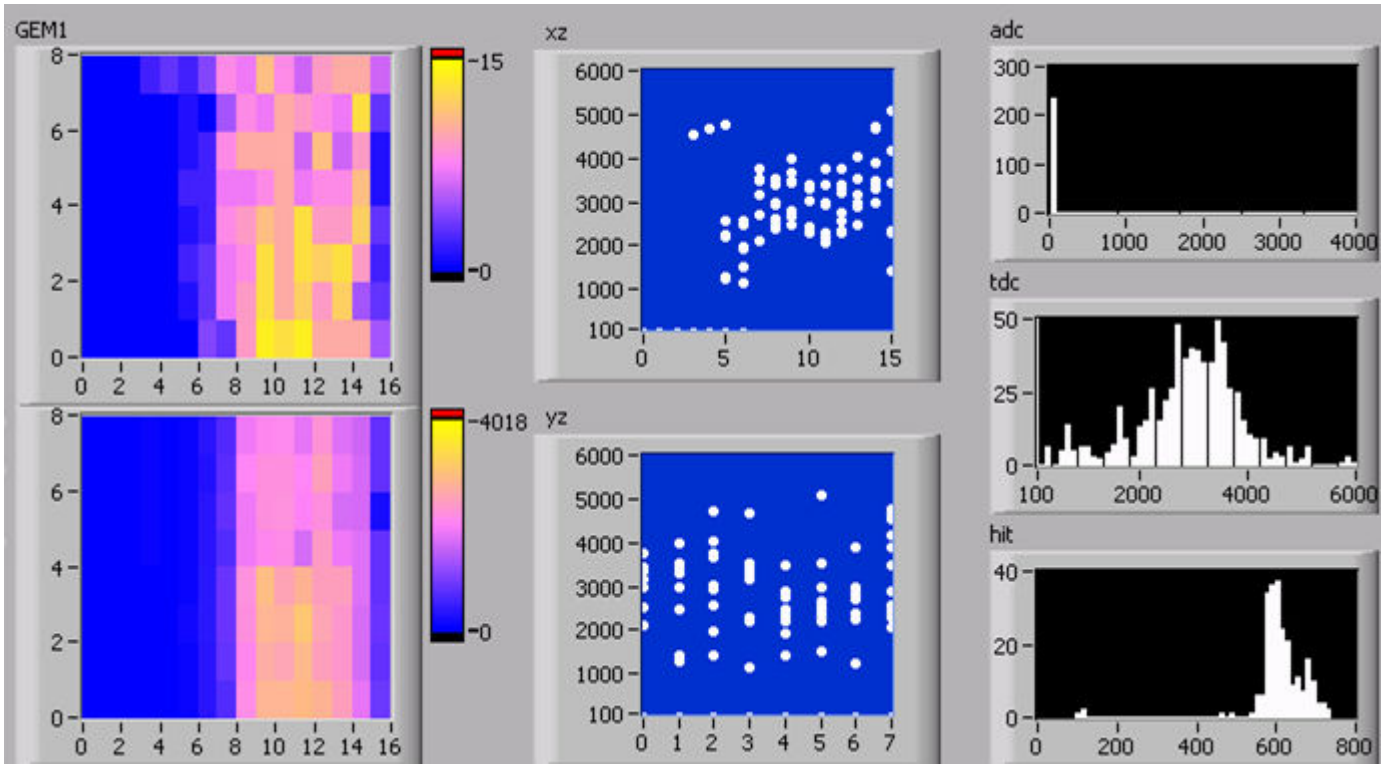
The time length of a single bunch was 10 ns

Top view

Side view



z distrib.

hits

History view

Test for beam channeling at CERN

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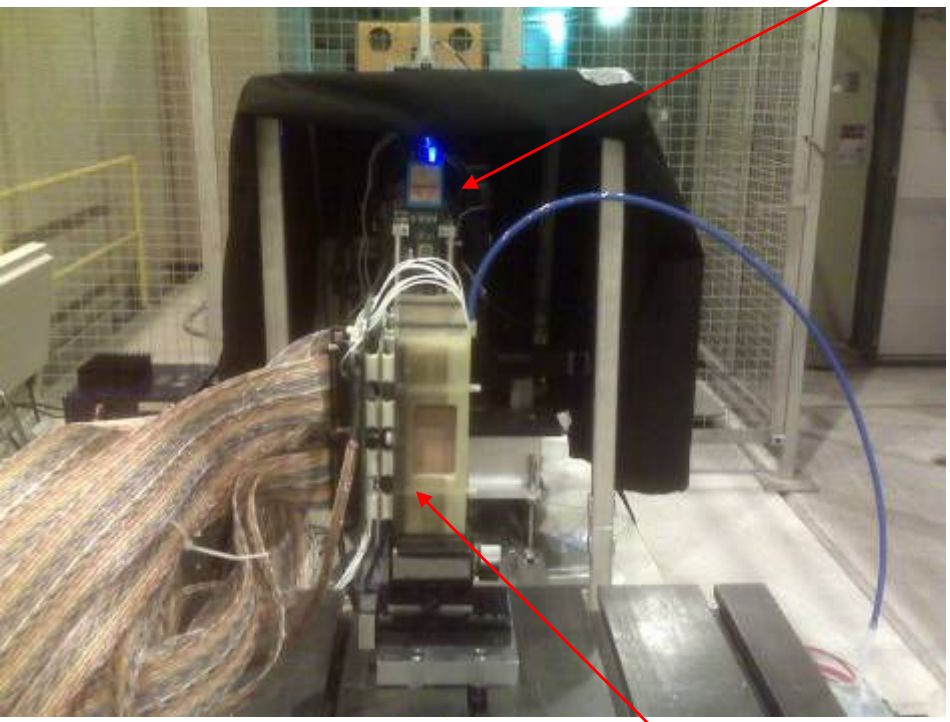
Medipix array

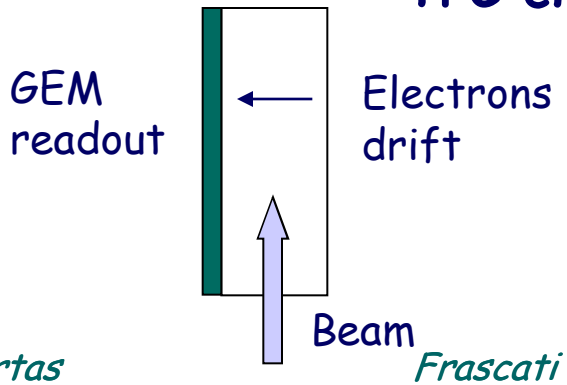


8 columns

16 rows

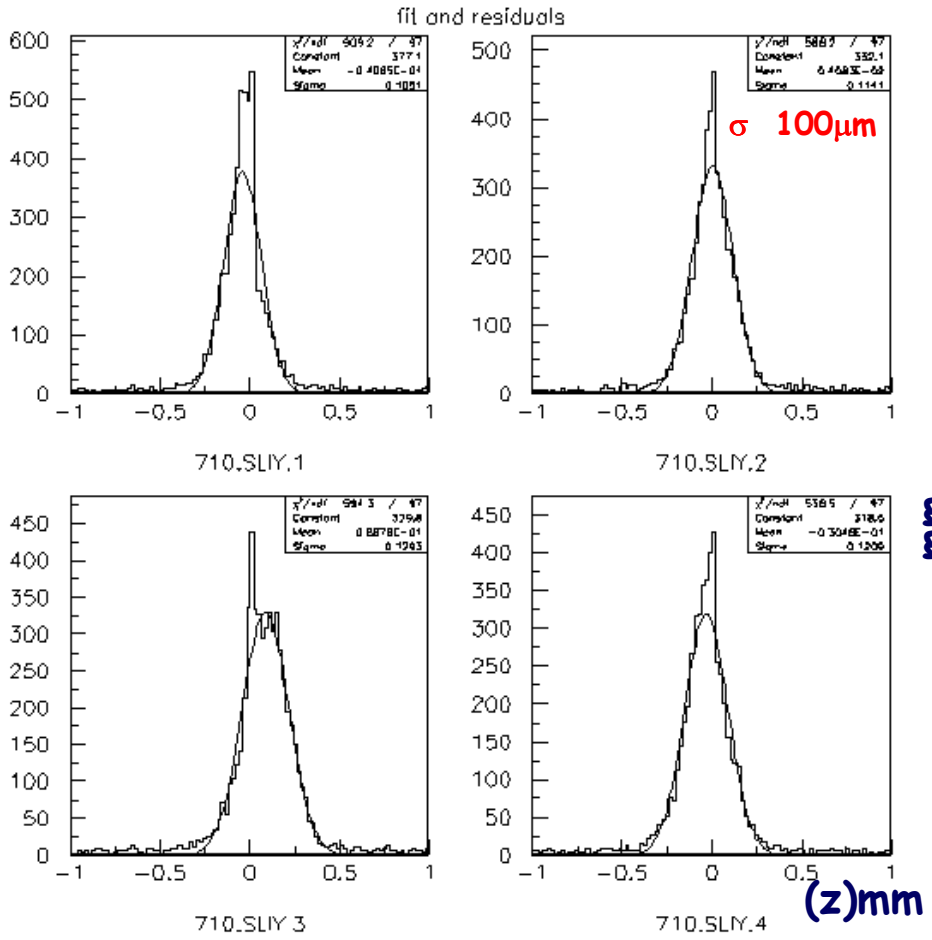
particles

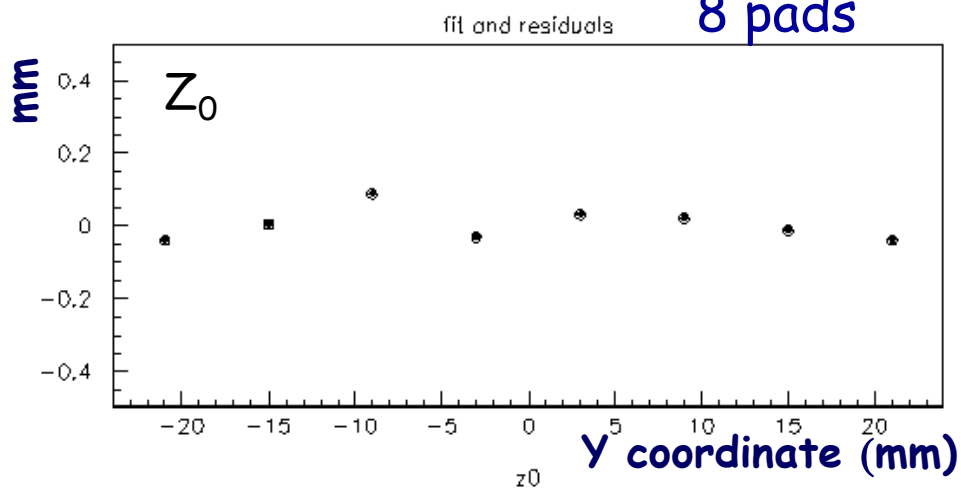
TPC chamber

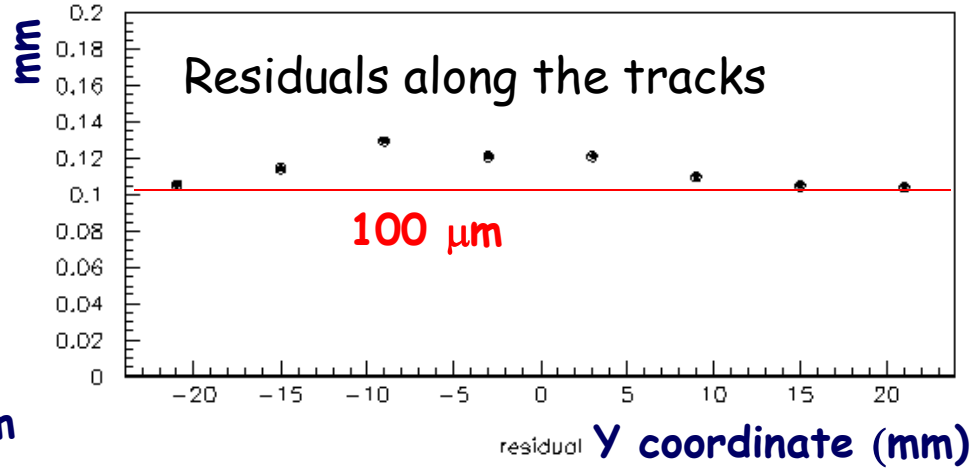


Track reconstruction

Residual measured by each pad

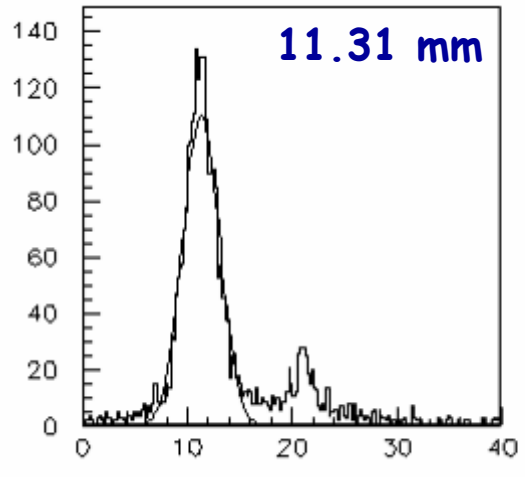


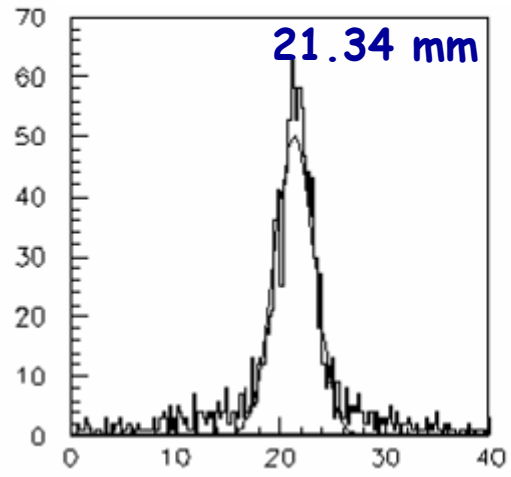




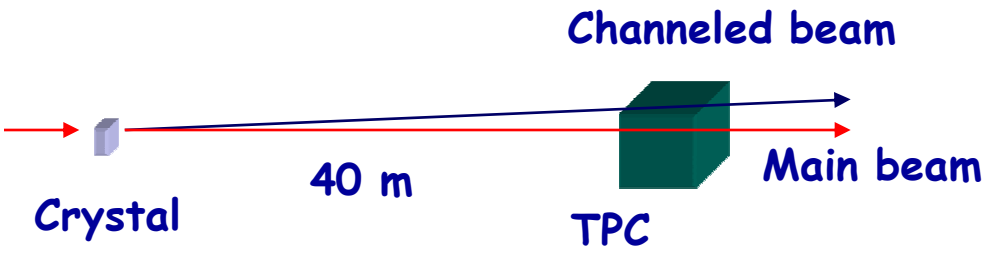
50 μm resolution in track position

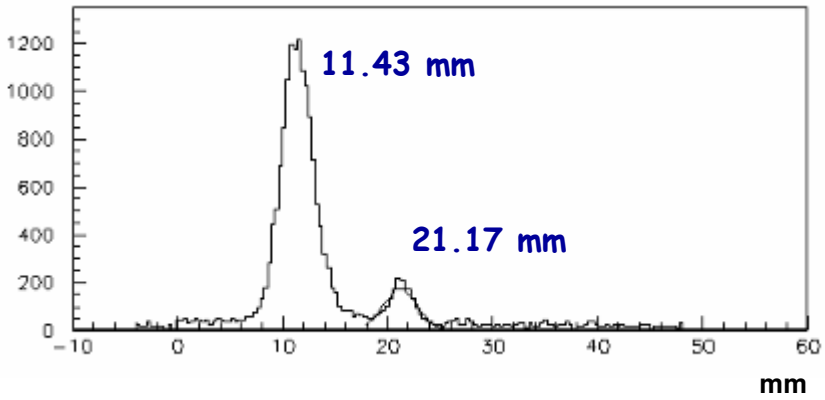
Chamber calibration



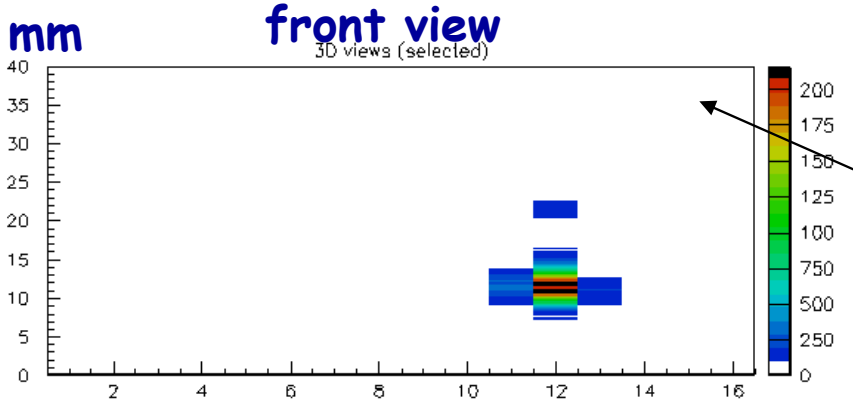


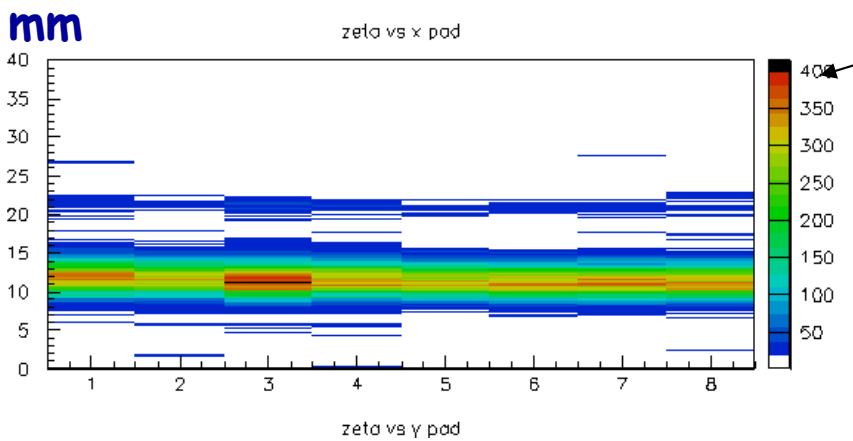
Beam position with a chamber displacement of 1 cm





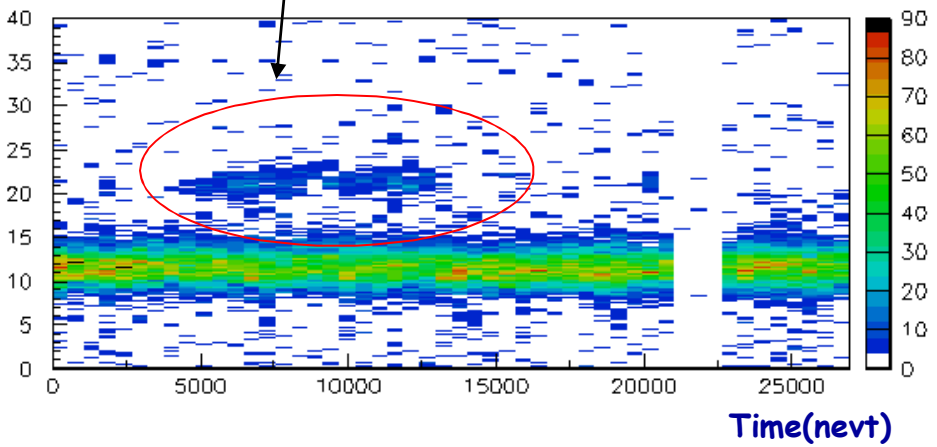
Proton Channeling at CERN test





top view

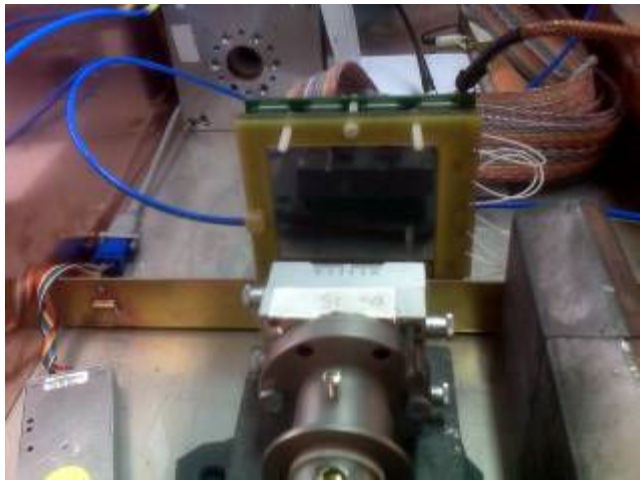
Channeled beam

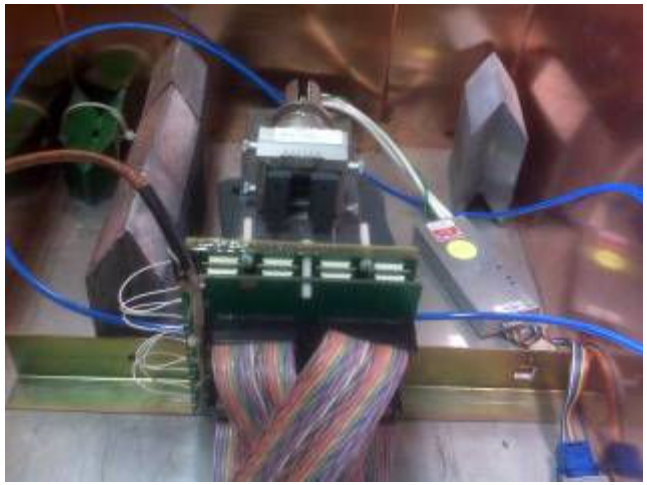


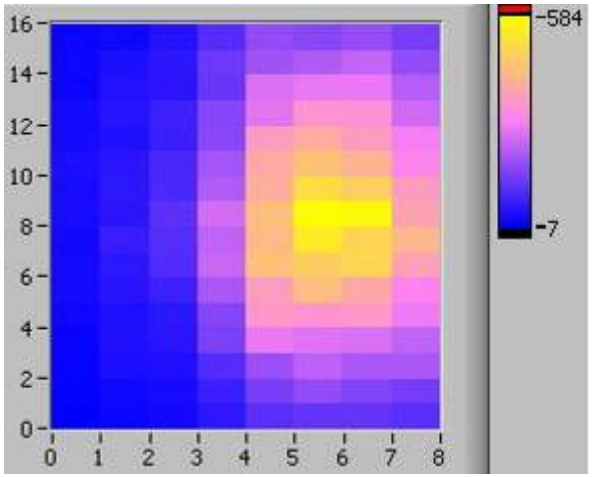
TripleGEM and policapillary for X ray monitor

3GEM detector for Xray

A collaboration between CEA ENEA INFN has been started to develop diagnostic for burning plasma with soft Xray. A GEM detector with a cathode maylar window has been installed in Cadarache laboratory







This is an image of the spot produced by the X ray source.
The DAQ is realized with a general purpose CAEN VME module (FPGA) able to produce also prompt control signals for feedback systems.

Polycapillary for Xray focusing

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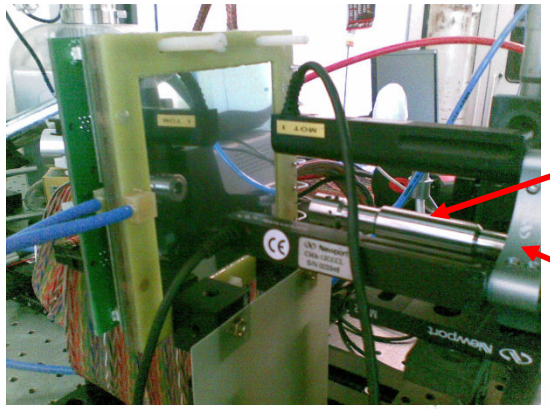
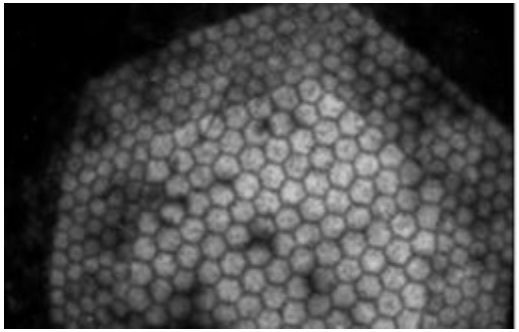
Generation	Kind of optics	Sizes: length	channel	energy
1st	Assembled lens made of single capillaries	1 m	1 mm	≤ 10 keV
2nd	Monolithic lens made of single capillaries	10-30 cm	0.1-1 mm	≤ 10 keV
3rd	Assembled lens made of polycapillaries	10 cm	10-50 μm	≤ 20 keV
4th	Monolihic lens made of polycapillaries	4-10 cm	1-10 μm	≤ 50 keV
5th	Monolithic integral micro lens	1-3 cm	0.3-1 μm	≤ 100 keV

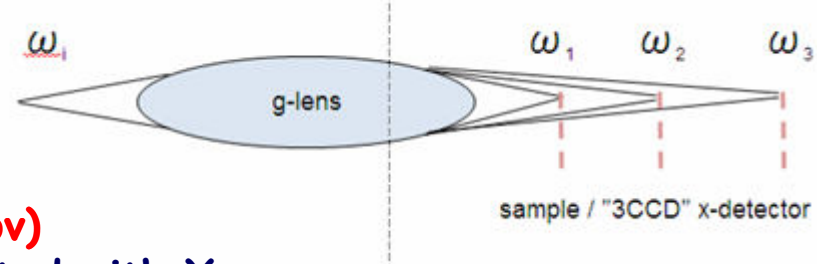
Frascati Lab



Polycapillary lens or half lens

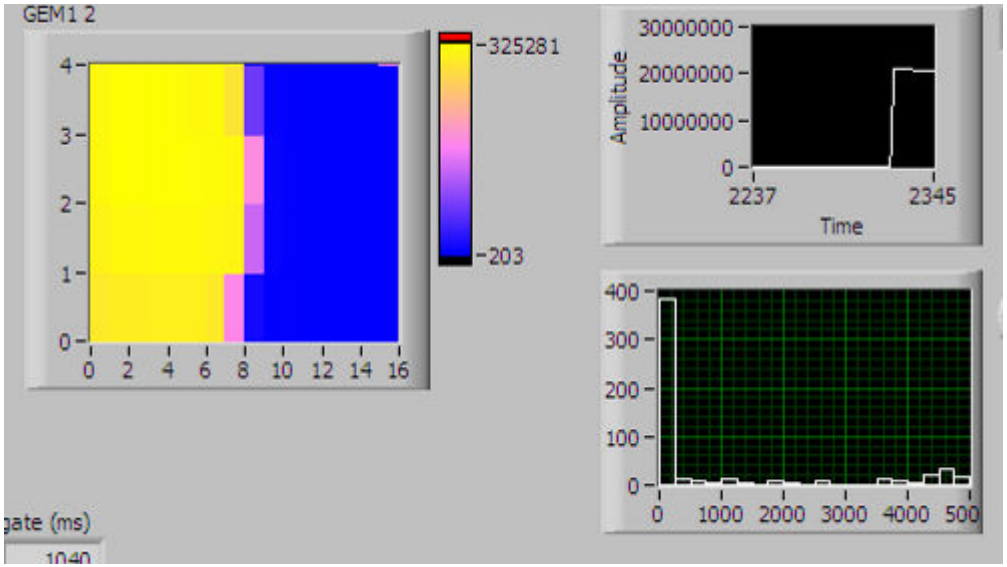
Xray source



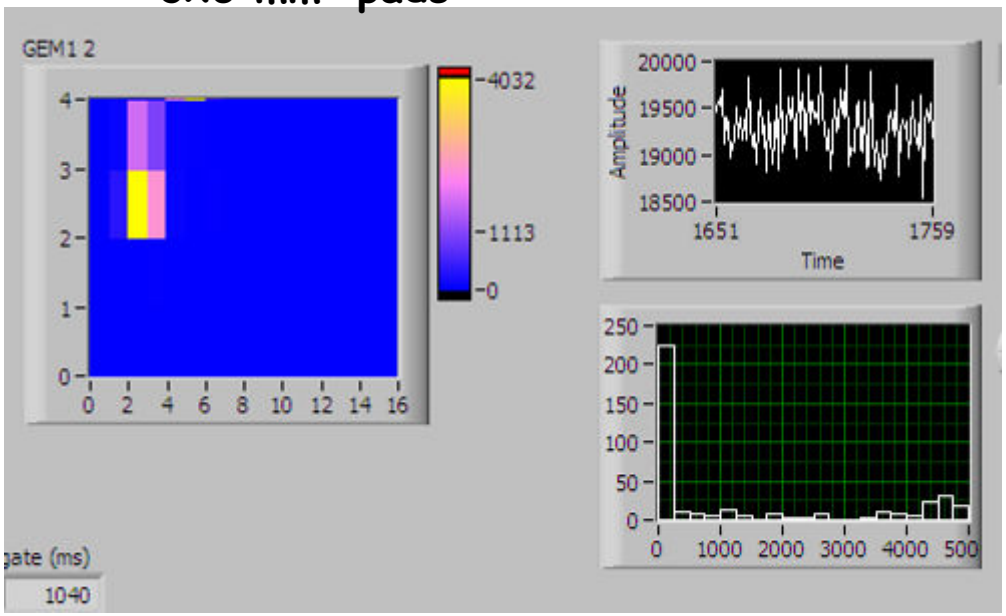


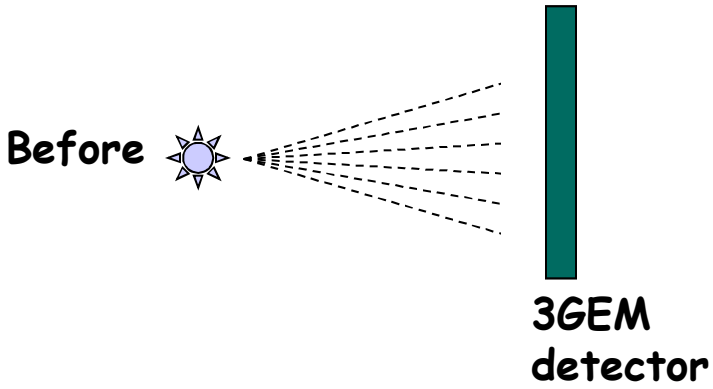
G-Lens (by S. Dabagov)
Focusing point correlated with X ray energy

X Ray spot with polycapillary

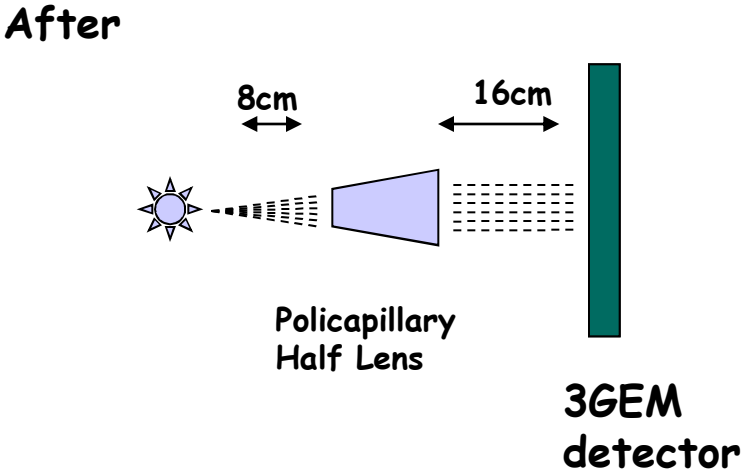


3x6 mm^2 pads

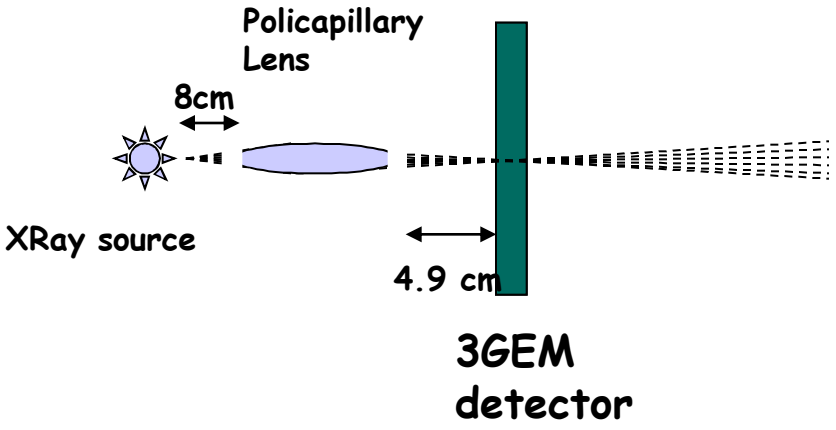




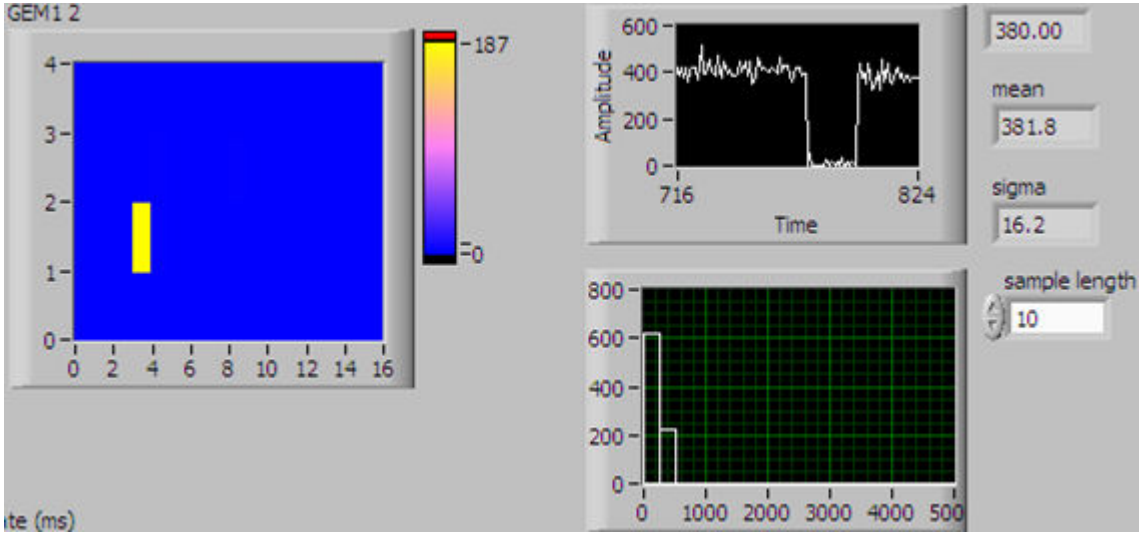
First measurements with polycapillary and GEM detector

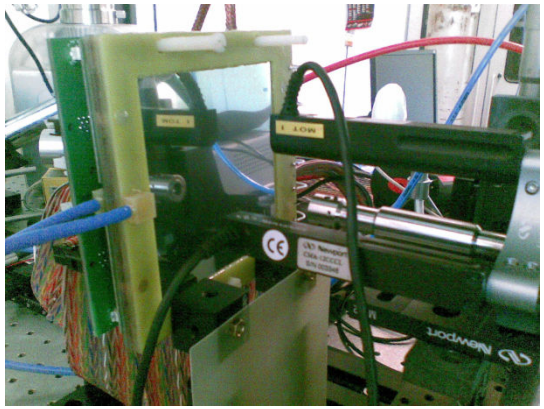


3GEM and Policapillary

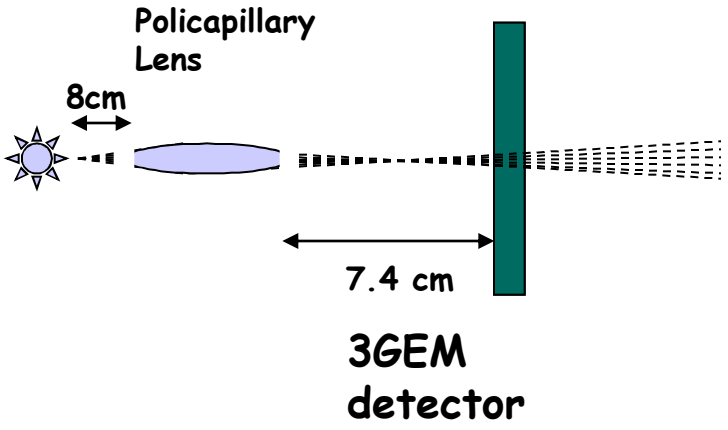


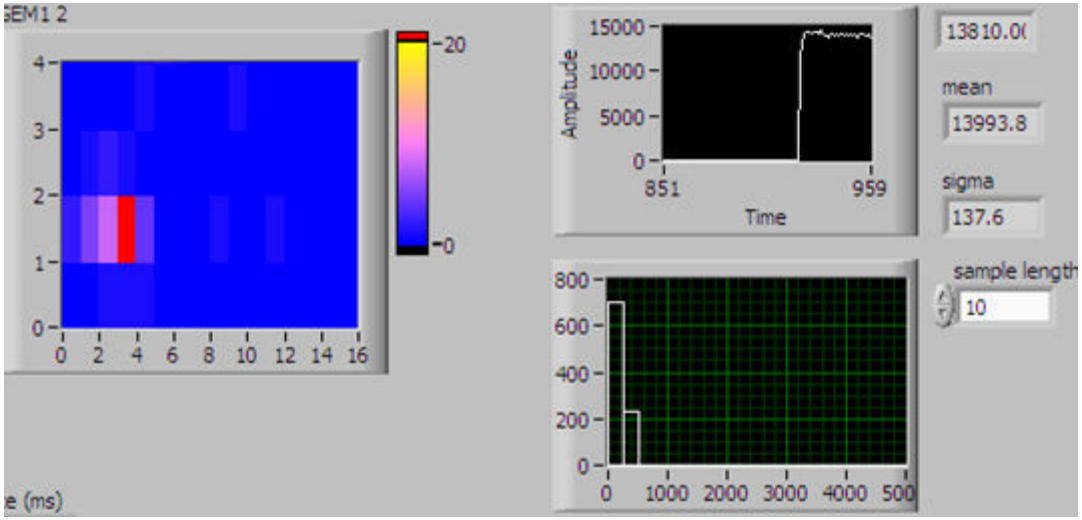
X Ray Energy 10.6 kV
Current 0.01 mA Power 0.1 Watt
3GEM Pateau @ 980 Volt (AR CO_2 CF_4)
GEM spot counting rate 380 Hz
Efficiency X Ray detection 7 %

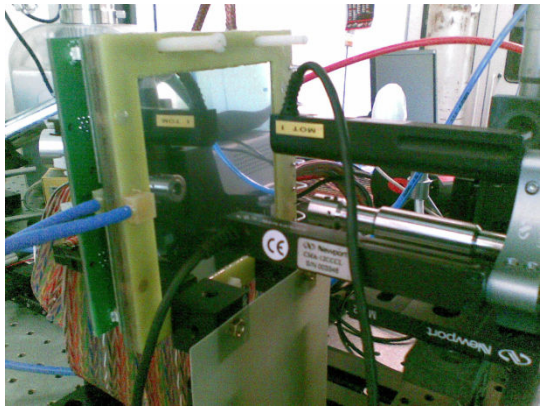




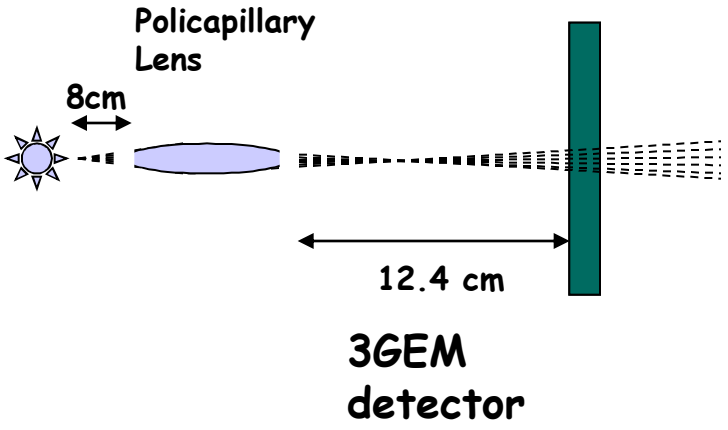
Measurements with 3GEM

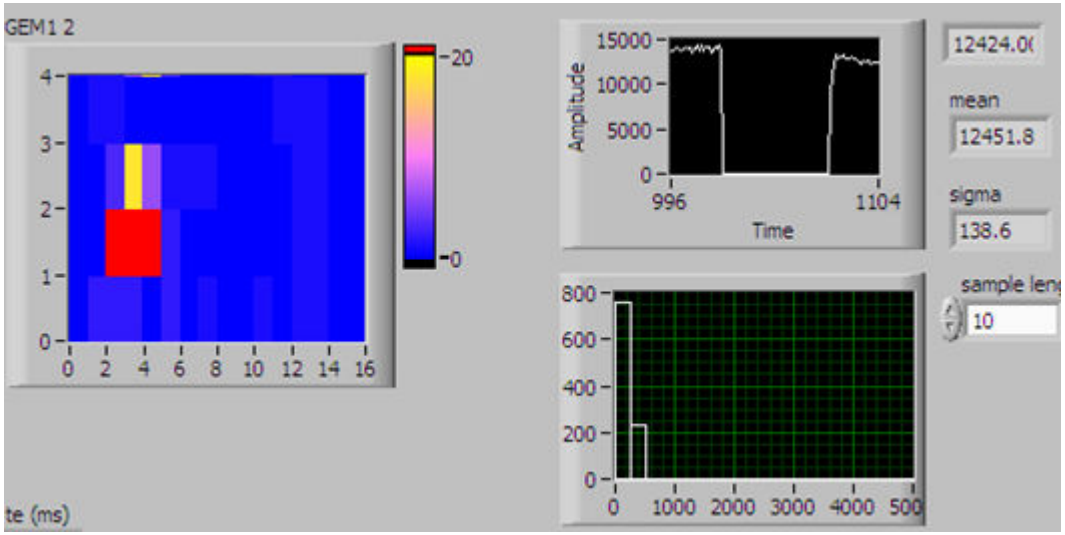


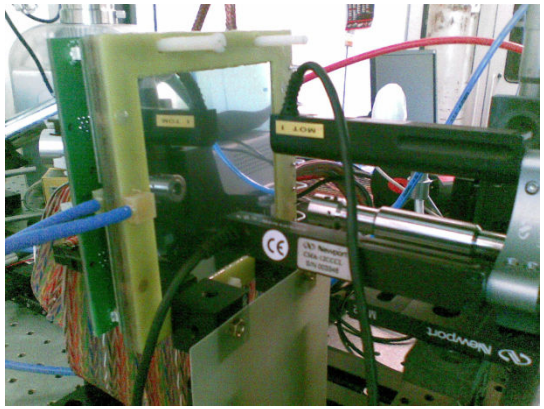




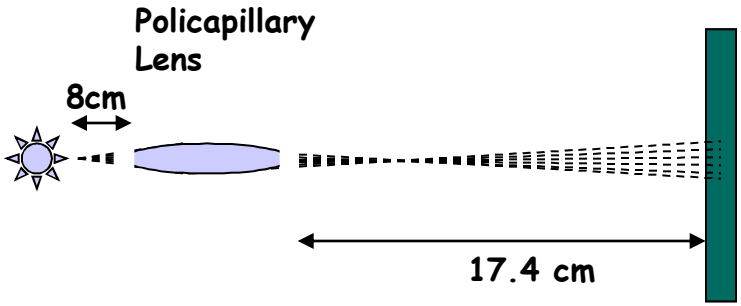
Measurements with 3GEM

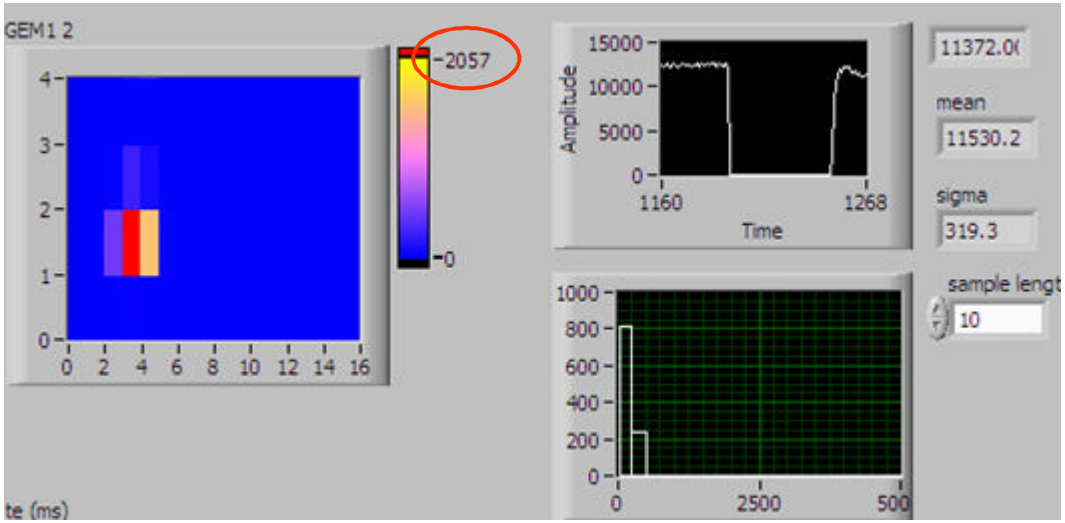


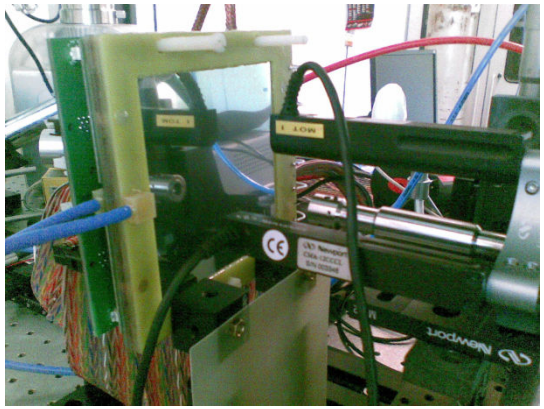




Measurements with 3GEM







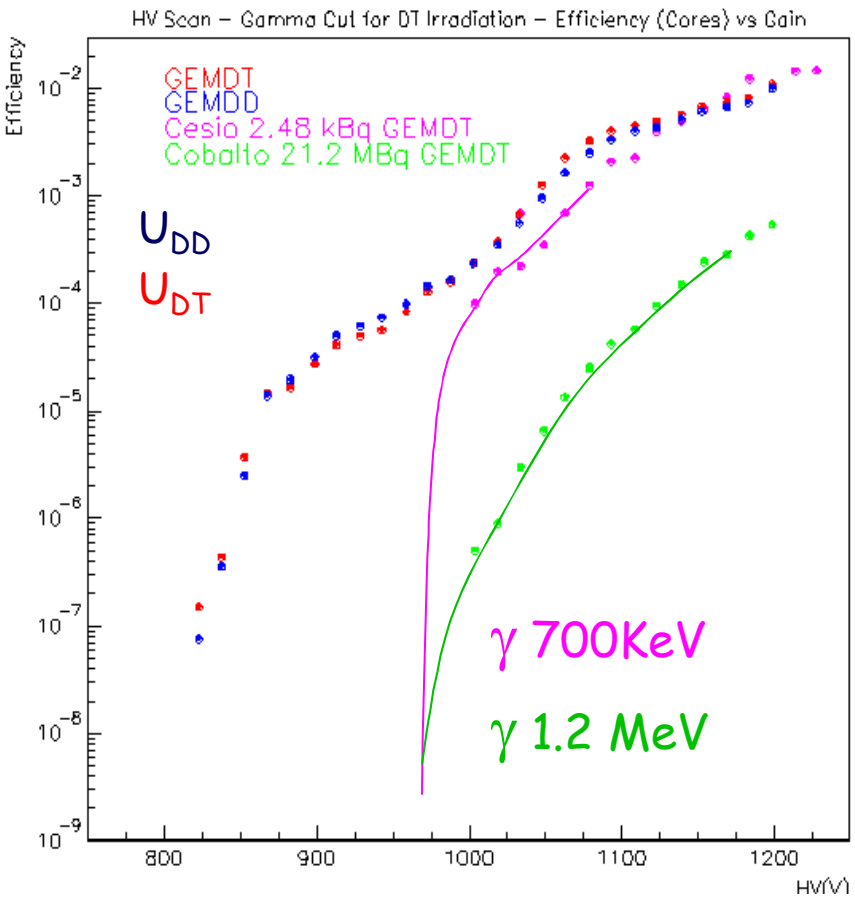
Conclusions

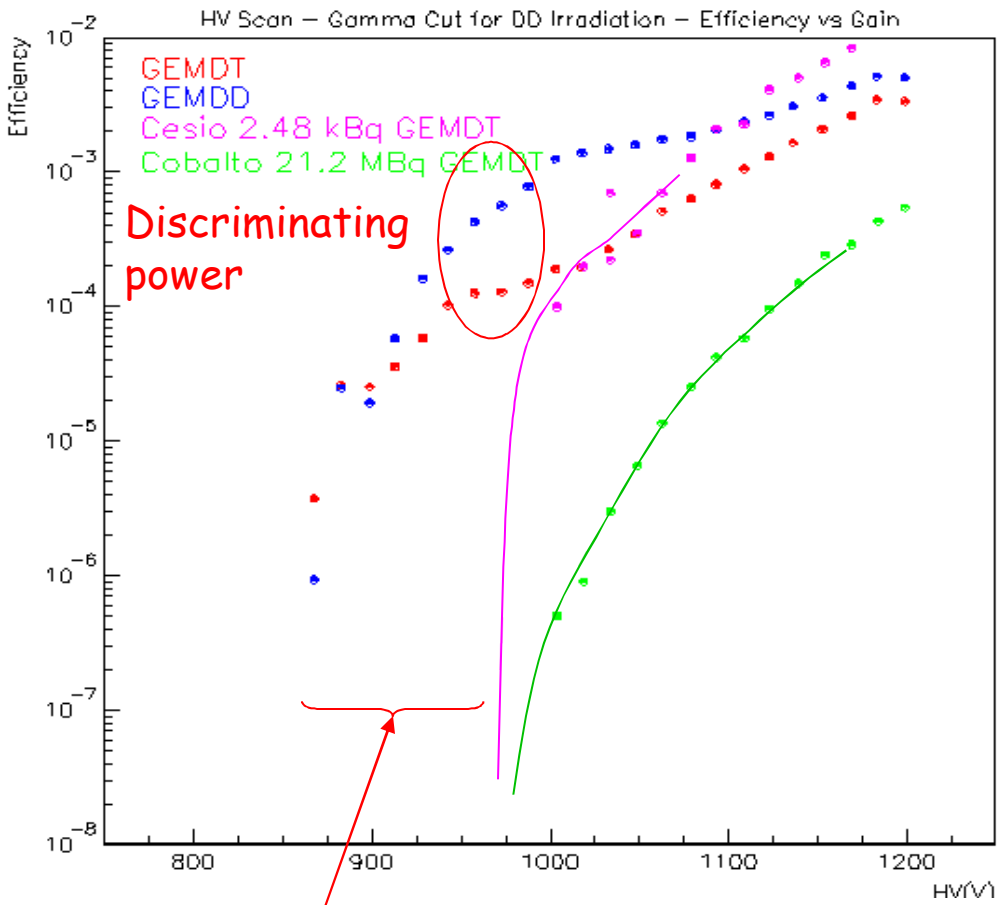
- Several portable detectors based on triple GEM technology have been built in Frascati for several purpose : Luminosity monitor, Neutron flux monitor, Xray monitors, Beam position monitors, …
- In all of these sectors they show good performances and confirm good radiation hardness
- These R&D are producing a rapid fall-out inside and outside INFN (ENEA, CEA, ISIS, Politecnico di Milano…).
- Particular interest inside EFDA for burning plasma diagnos.
- Using the polycapillary technology, we proposed a new R&D for Xrays monitor and imaging for high fluxes region (Nuclear Fusion Reactors) in collaboration with ENEA and CEA.

Efficiency vs GEM gain

14 MeV Neutron

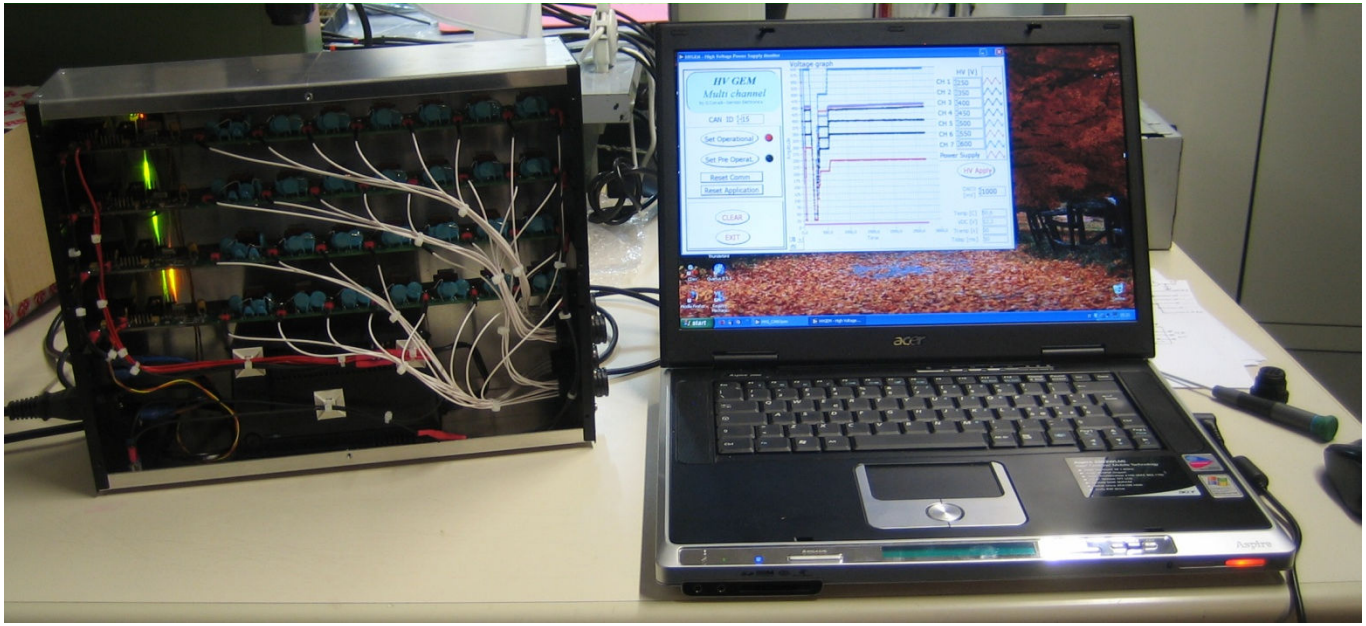
2.5 MeV Neutron





There is a working region without photon contamination with eff = 10^{-4}

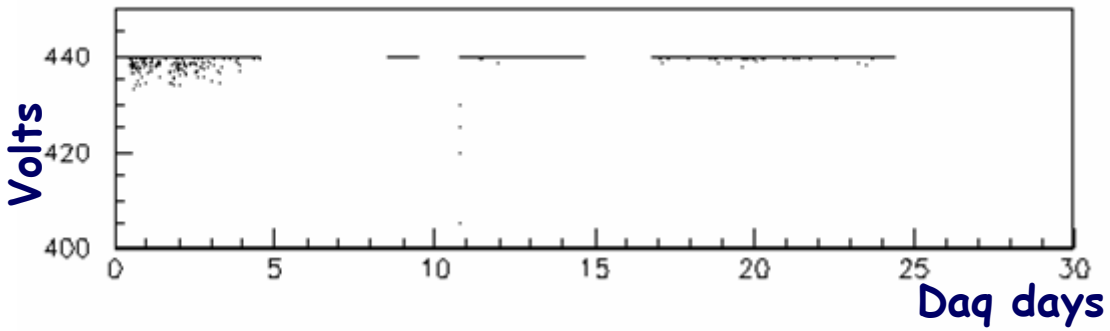
New system with 4 modules



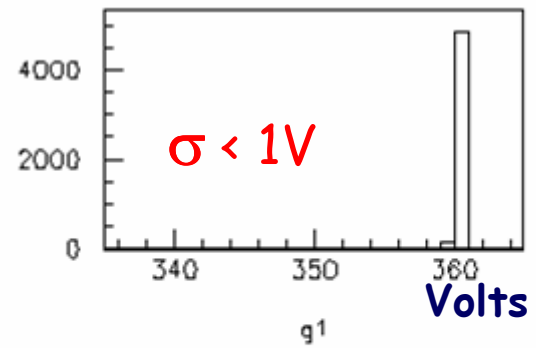
Recently a new system with 4 modules has been made for the luminometer power supply. This system is actually working near the Dafne IP

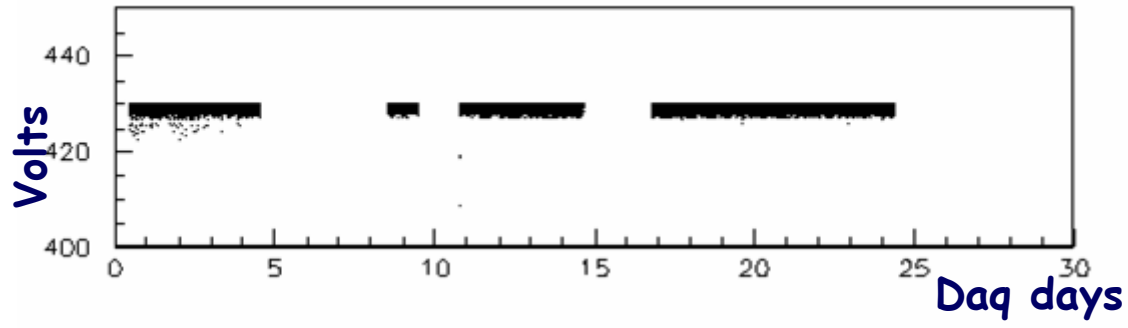
A detail of 4 HV connectors

HVGEM prototype stability

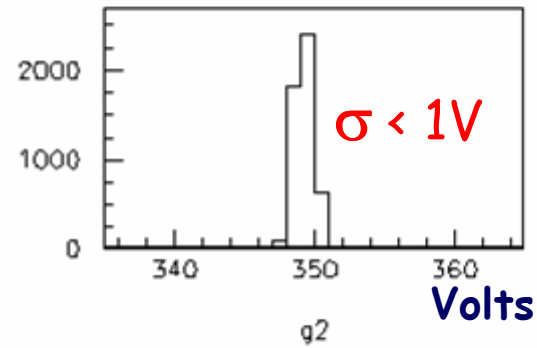


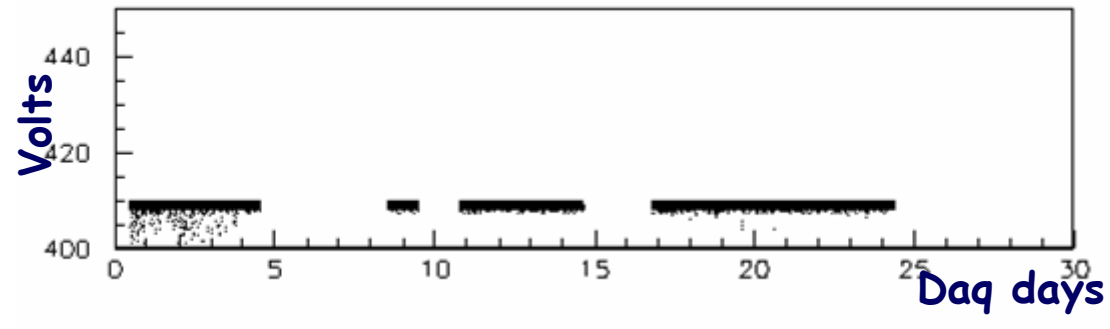
g1



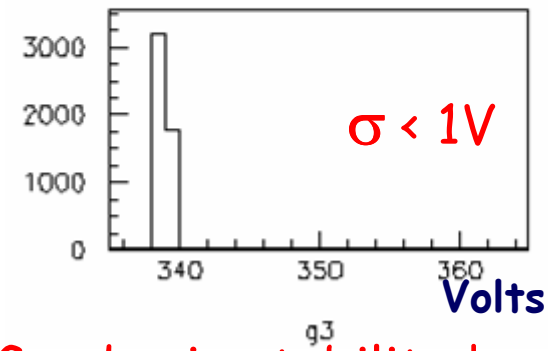


g2





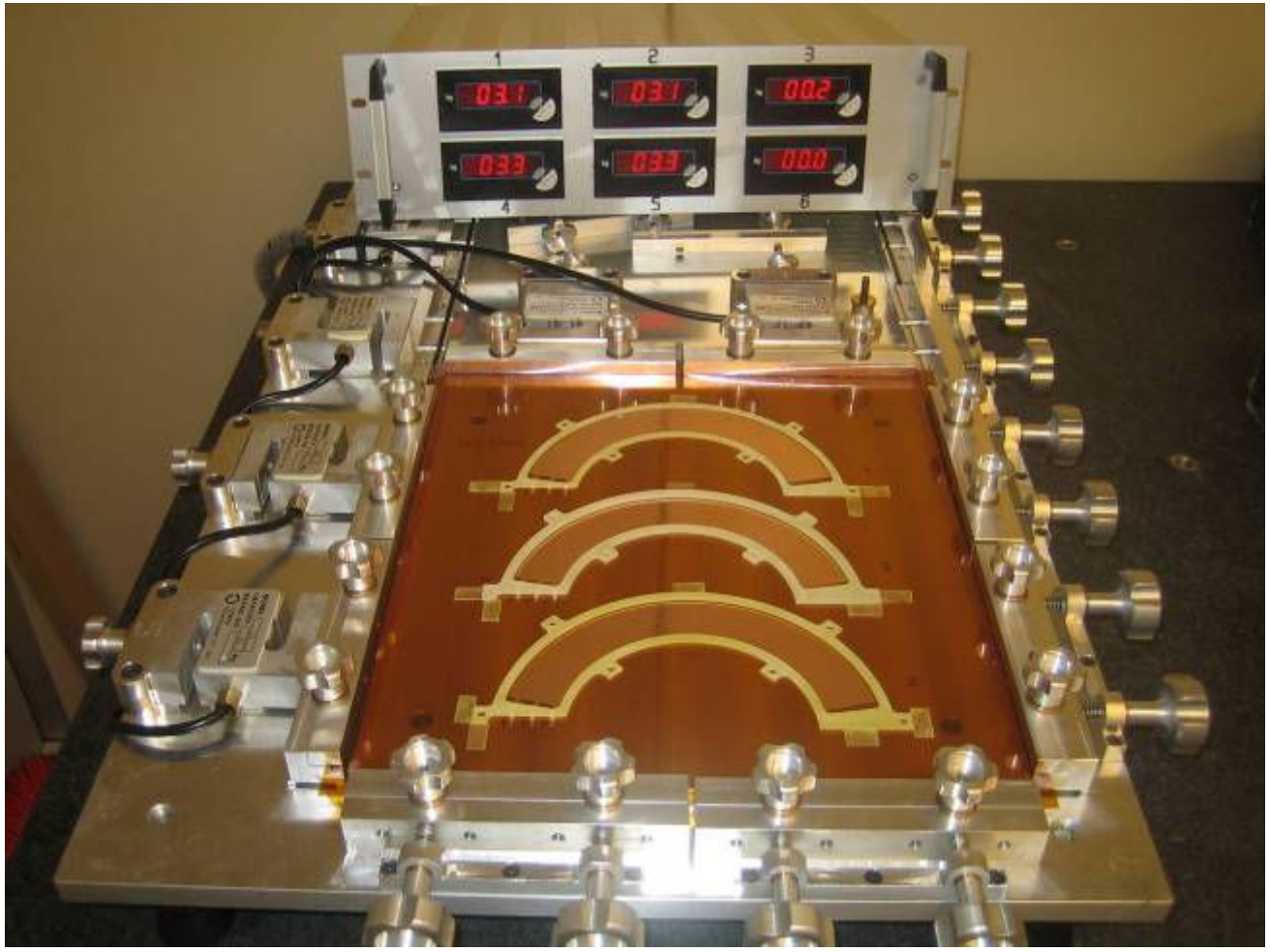
g3



Good gain stability !

Kapton foil with 3 lumi GEM

The construction of this type of detector has required a new GEM design (same kapton and holes structure but different electrodes shapes)

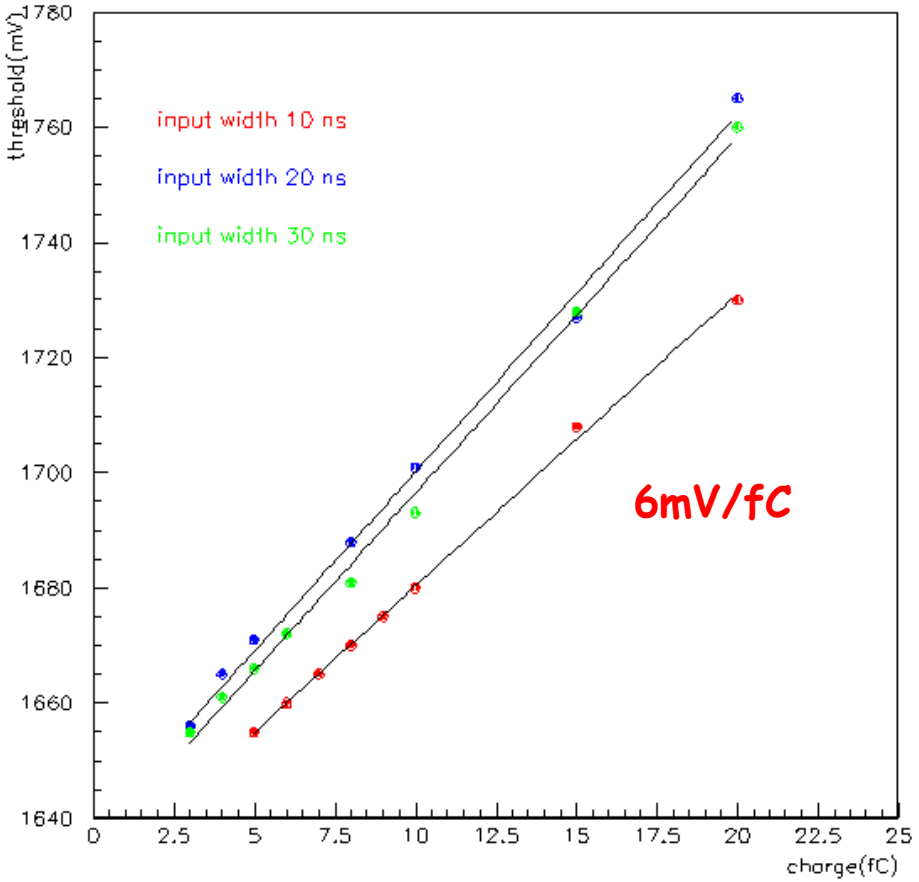


One GEM foil with the three annular structure during the stratching phase for the prototype construction

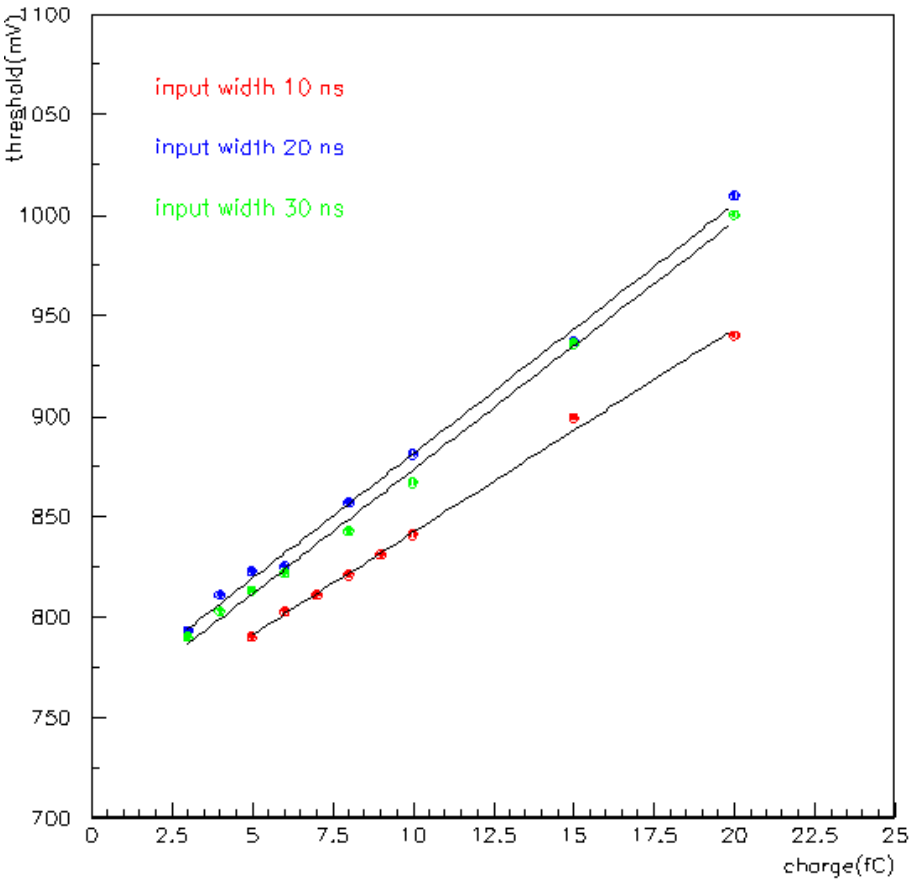
Carioca Card Sensitivity

The sensitivity is measured vs two different thresholds

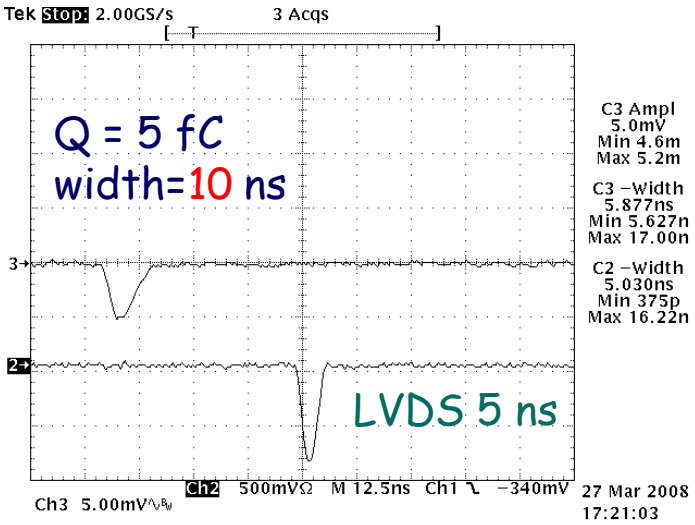
DAC Threshold on power supply

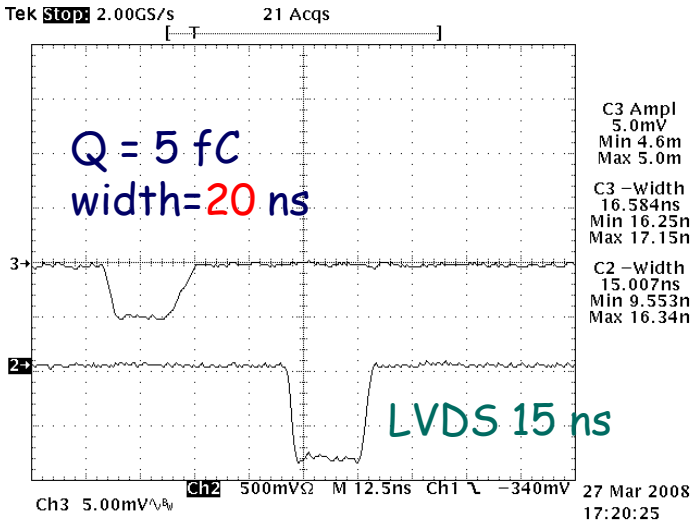


Threshold on Carioca



Carioca Card Sensitivity





The sensitivity has been measured injecting a charge between 5 and 20 fC with different width