Applications with Triple GEM Detector

B.Buonomo, G.Corradi, F.Murtas, G.Mazzitelli, M.Pistilli, M.Poli Lener, D.Tagnani
Laboratori Nazionali di Frascati INFN

P.Valente
Sezione Roma INFN

- Triple GEM detector as beam monitor
- Monitors for Crystal experiment at SPS
- A compact Time Projection chamber with GEM

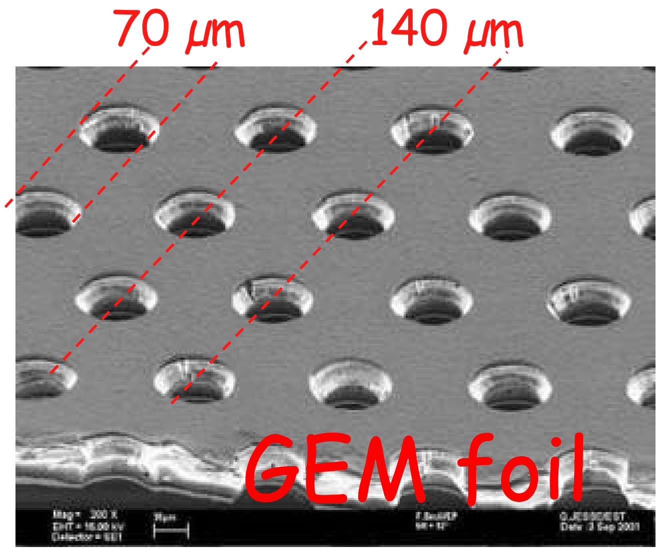
An INFN R&D project : IMAGEM

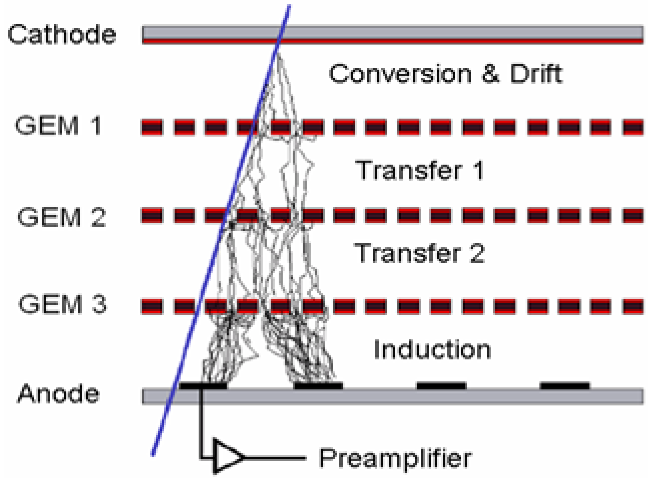
http://www.lnf.infn.it/esperimenti/imagem/

A triple GEM Chamber

A Gas Electron Multiplier (F.Sauli, NIM A386 531) is made by 50 μm thick kapton foil, copper clad on each side and perforated by an high surface-density of bi-conical channels;

Several triple GEM chambers have been built in Frascati in the LHCb Muon Chamber framework*





* **M.Alfonsi et al., The Triple-GEM detector for the M1R1 muon station at LHCb, N14-182, 2005 IEEE NSS Conference, Puerto Rico**

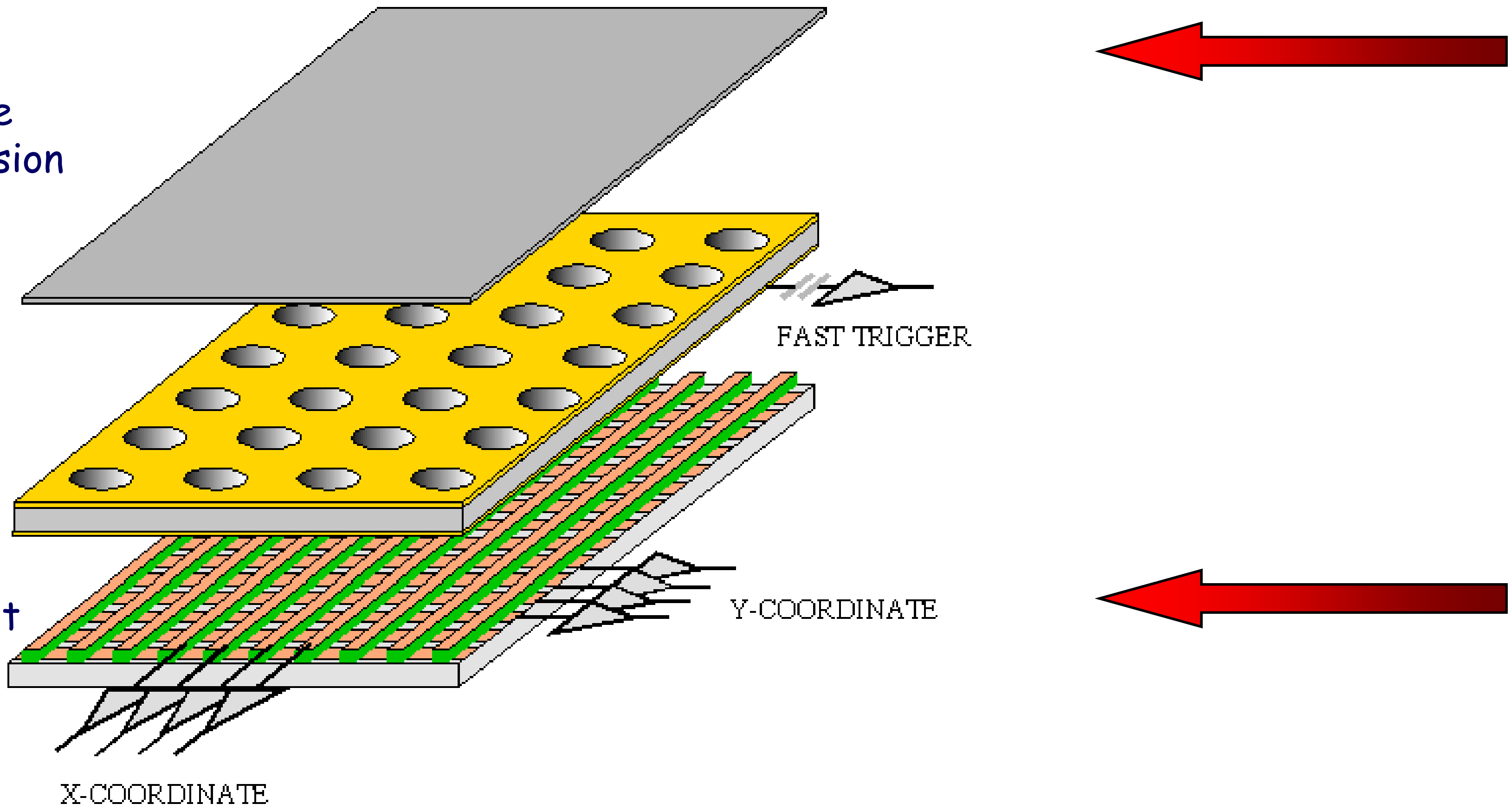
Where we are working now

- Gain and readout functions on separate electrodes
- Fast electron charge collected on patterned anode
- High rate capability and radiation tolerant

Particle conversion

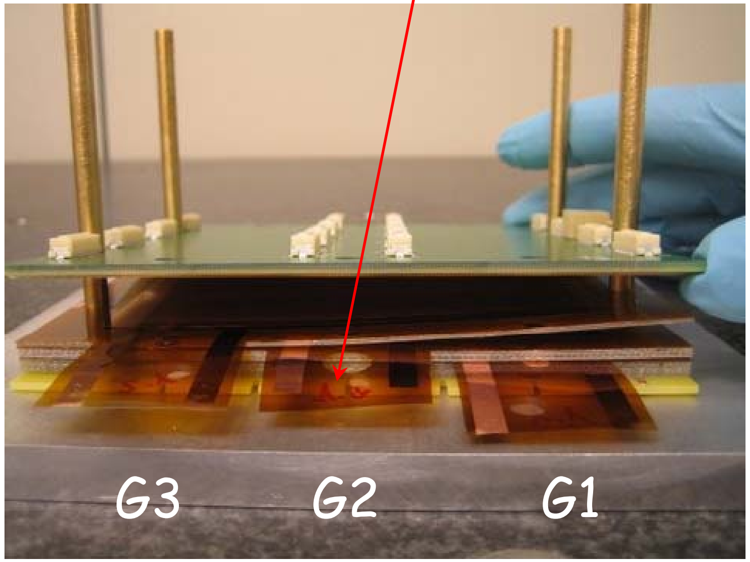
Gain

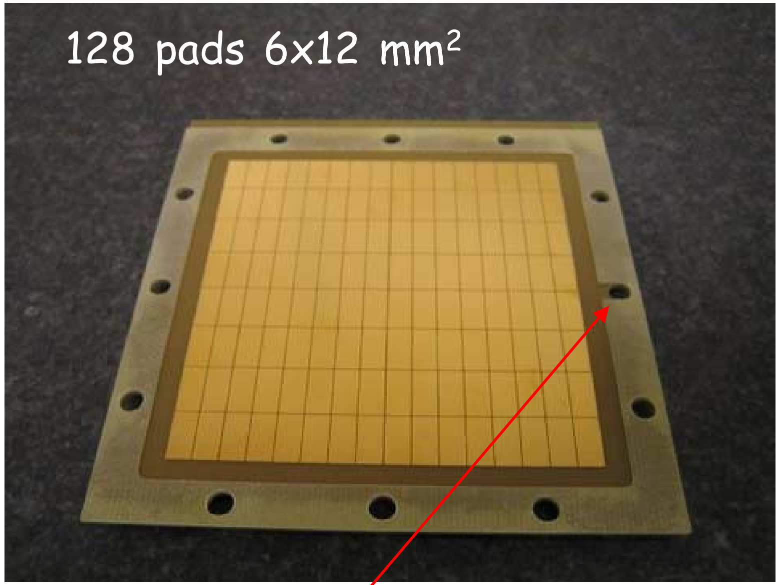
Readout



A Standard Triple GEM construction

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





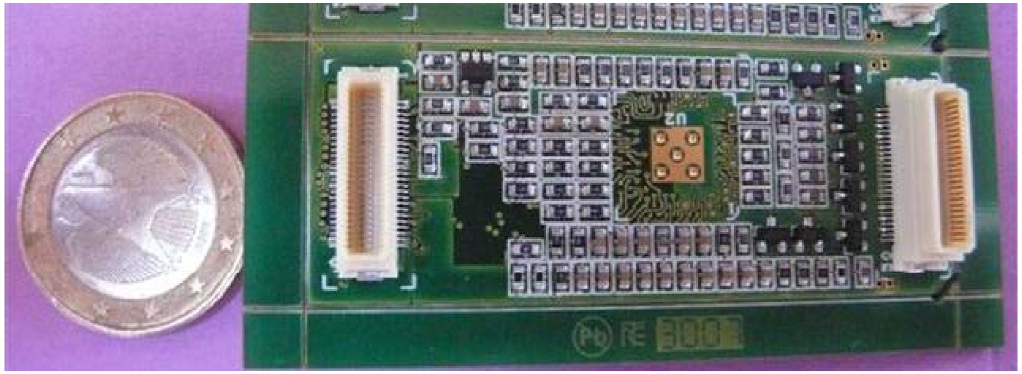
The GEM are stretched and a G10 frame is glued on top

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

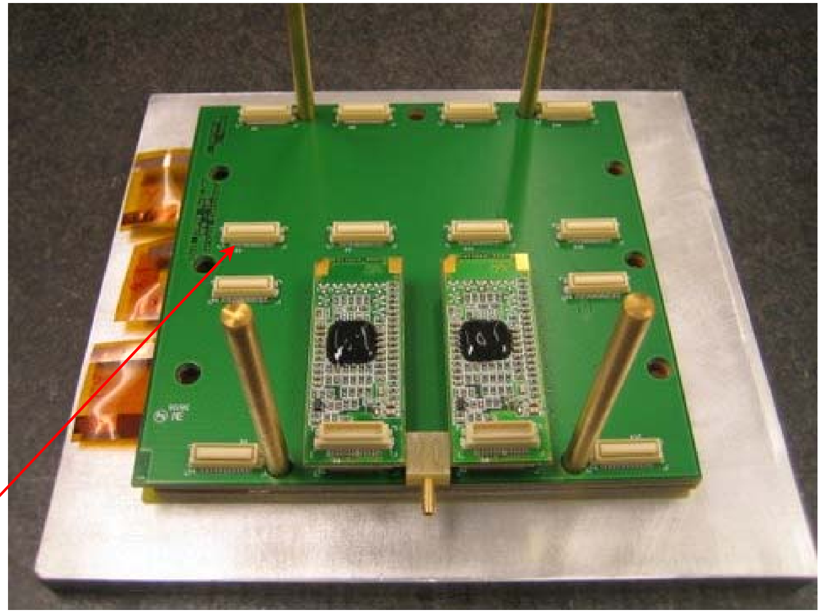
The FEE board used

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



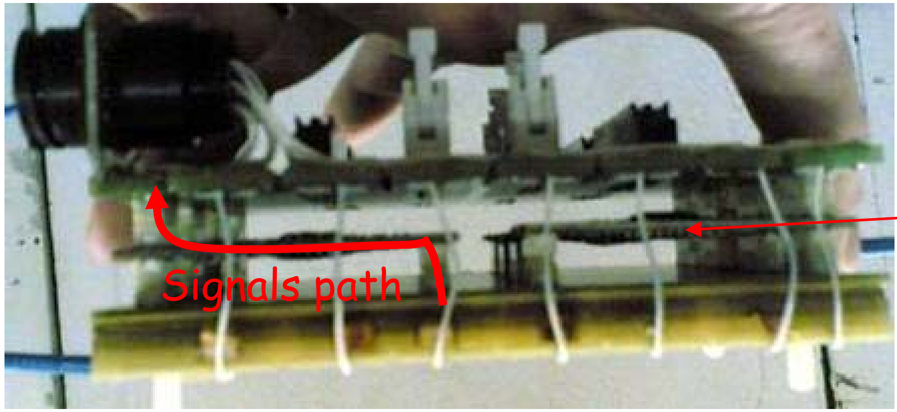
All the anode PCB have been designed with the same connector layout for a total of 128 channels



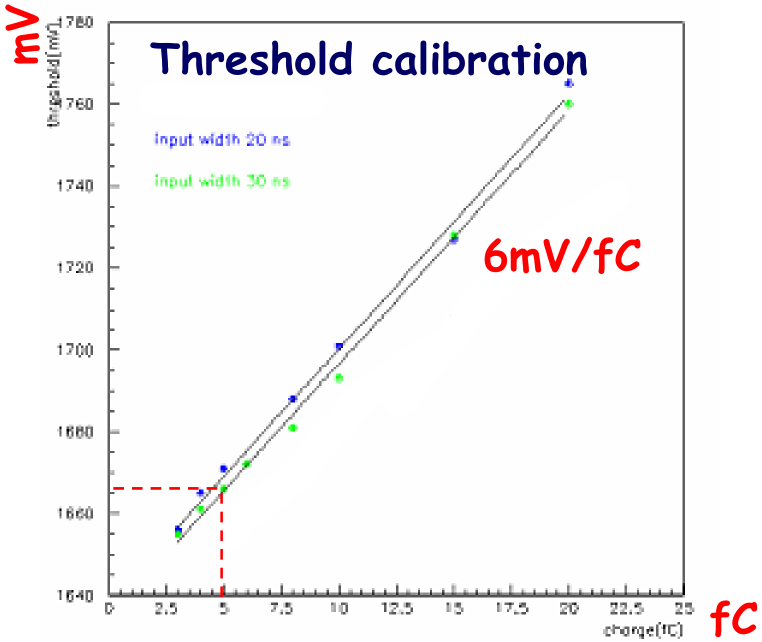
* Development of the CARIOCA front-end chip for the LHCb muon detector. W. Bonivento, et al NIM A491:233-243,2002

The mother board

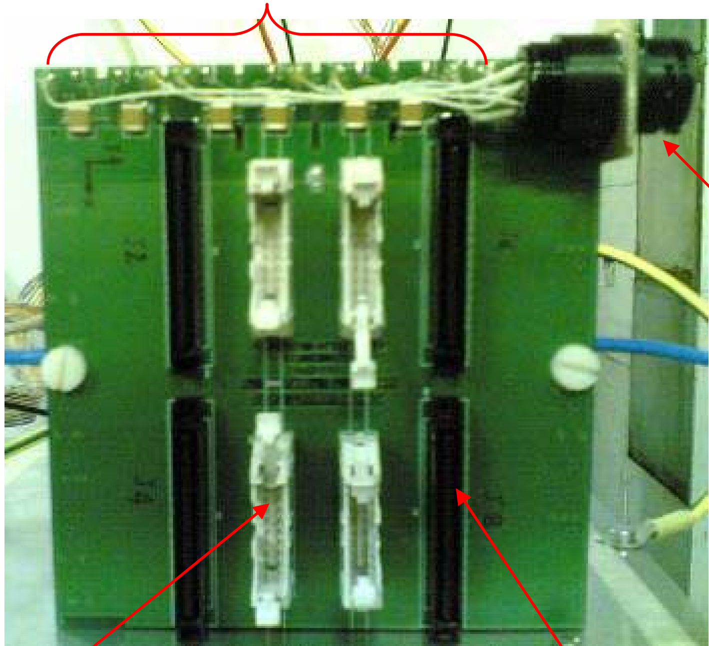
On this mother board
HV and LV ground are connected each other through a 10 KΩ resistor



CARIOCA readout electronics



HV filters



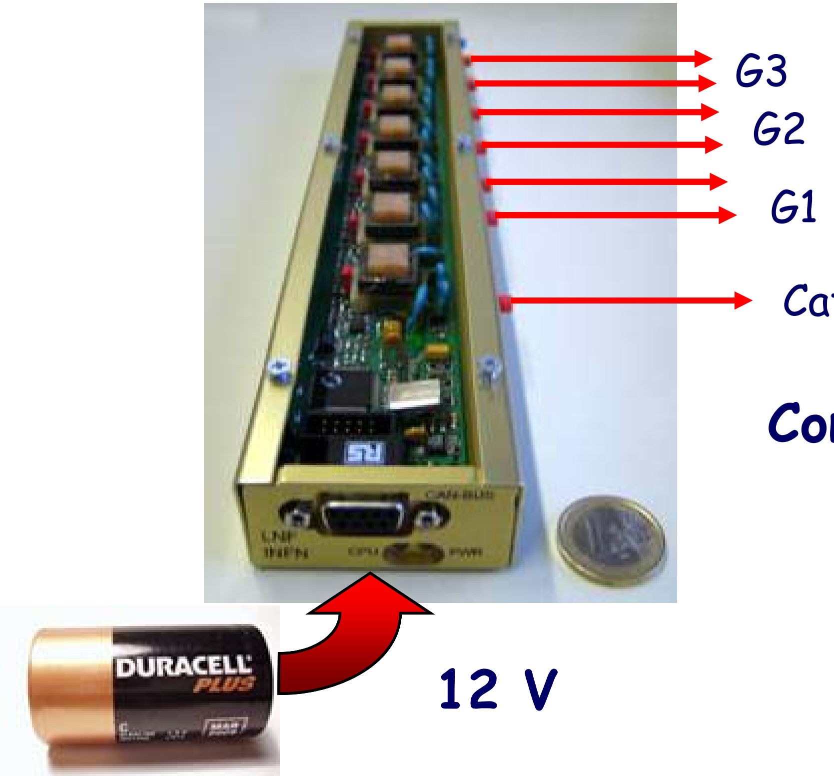
HV in

Threshold & LV in

4×32 LVDS signals out

HV supply for GEM detectors

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



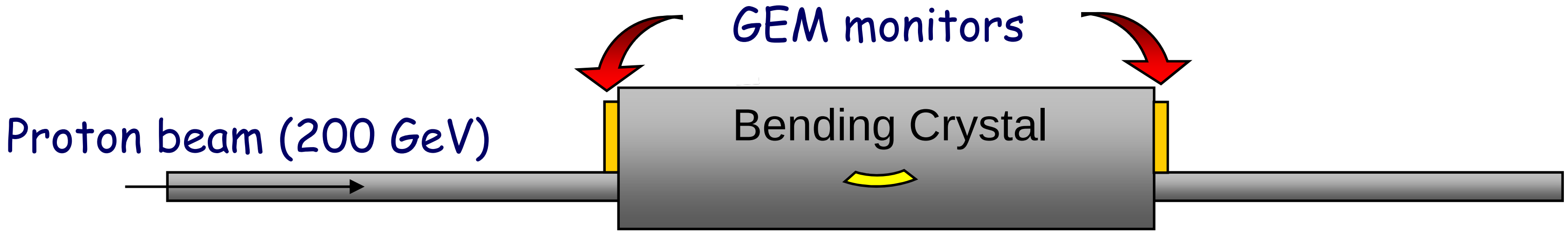
All the detector for beam diagnostic has been power up with this new device

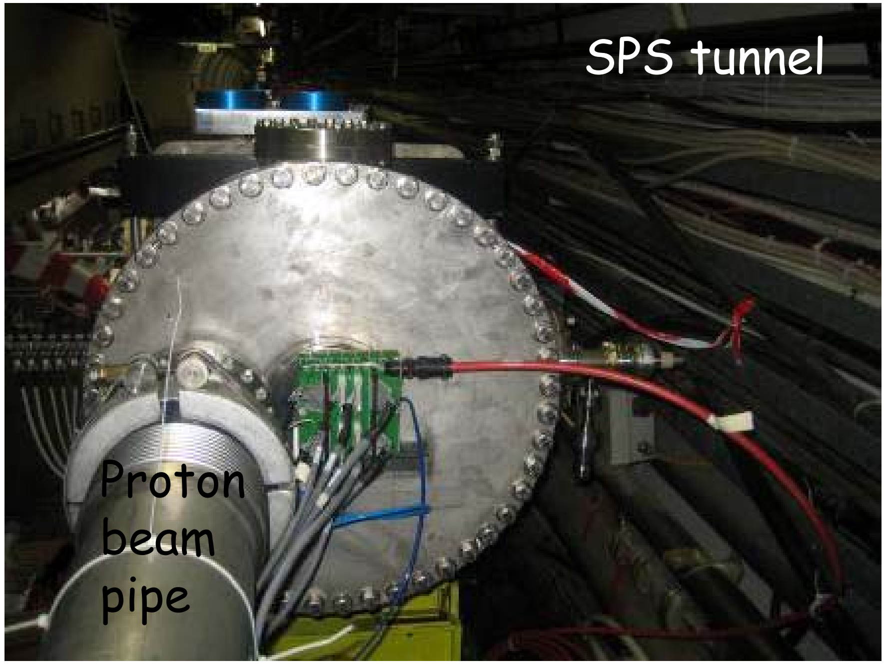
Controlled via Canbus

A Corradi, F. Murtas and D.Tagnani
A novel HighVoltage System for a triple GEM detector
Nuclear Inst. and Methods in Physics Research, A
Reference: NIM A46 128

Beam monitors on Crystal experiment at SPS

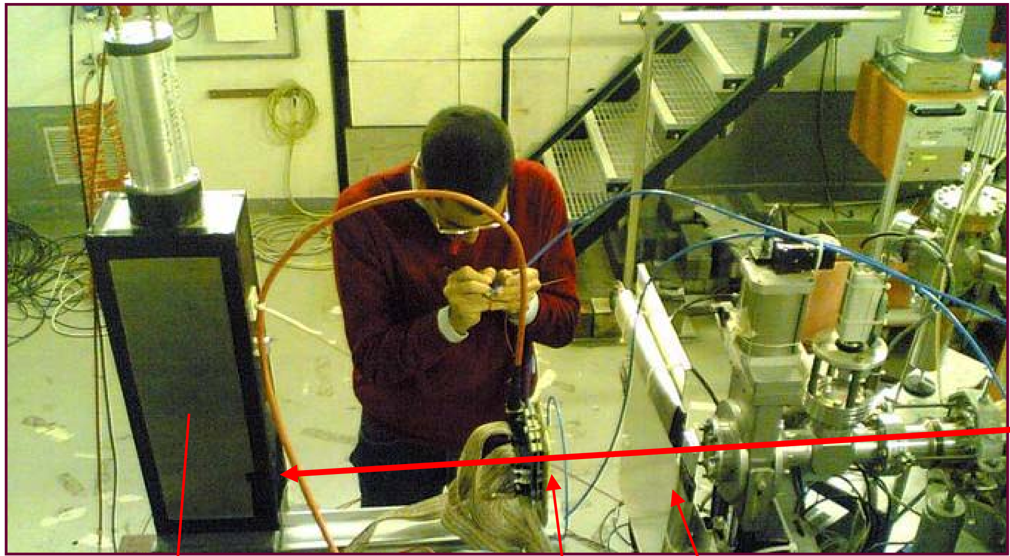
Installation on Crystal Tank at SPS





The first RUN foreseen on next June 18th … in the meanwhile

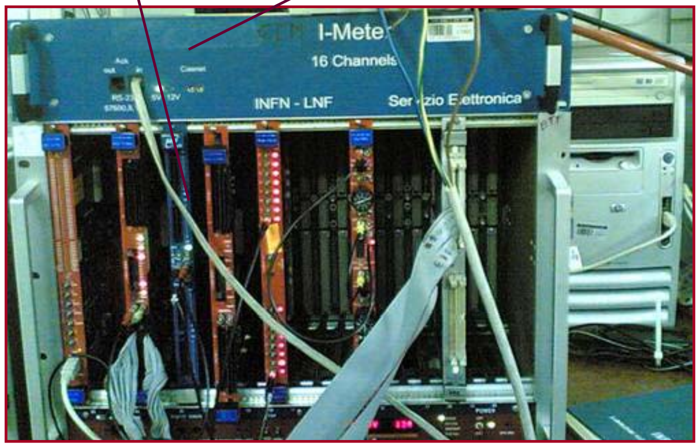
Beam Test at BTF Frascati



500 MeV e^-

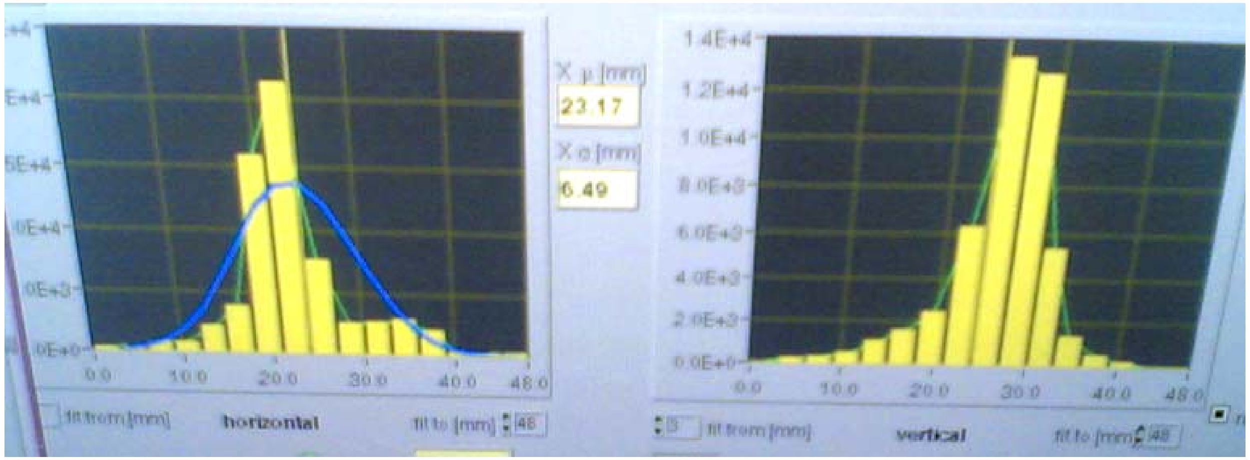
Calorimeter GEM Fiber detectors

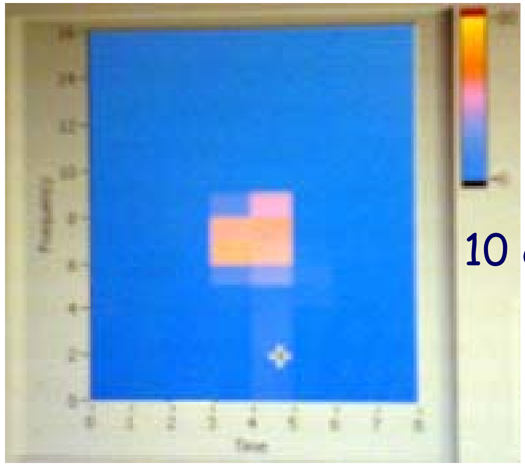
Scaler Nanoammeter



Beam monitor at BTF Frascati

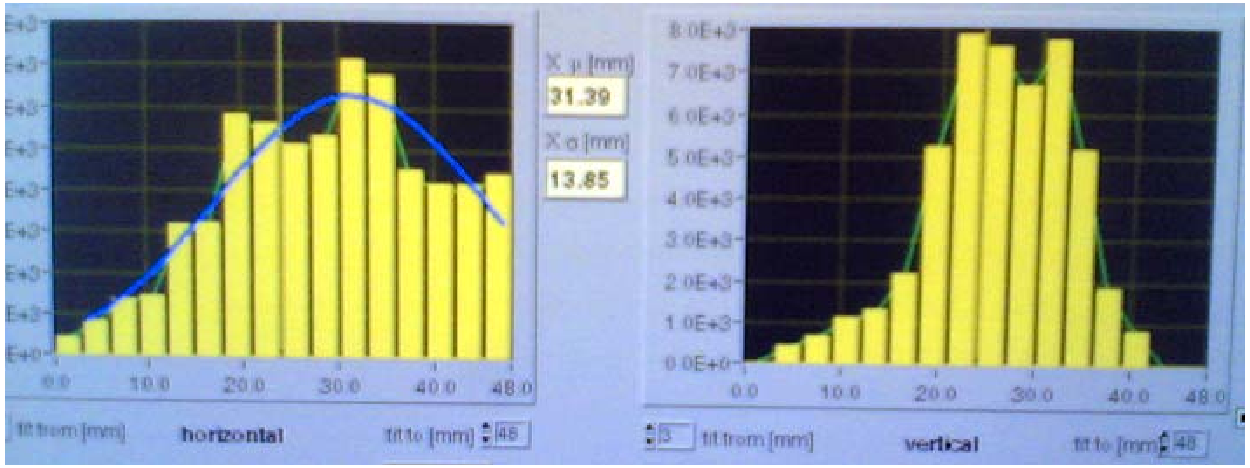
Beam profile at BTF in two configuration : narrow and wide beam

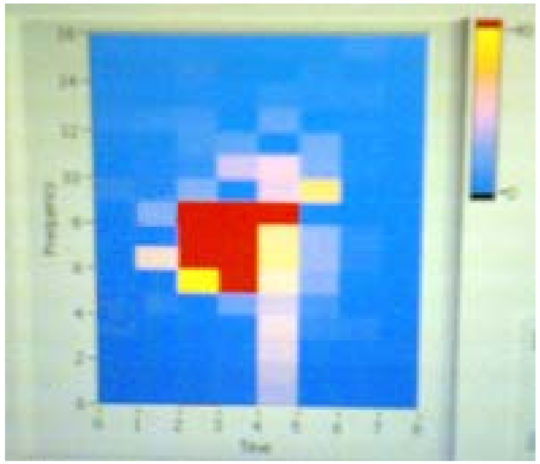




10 cm

10 cm

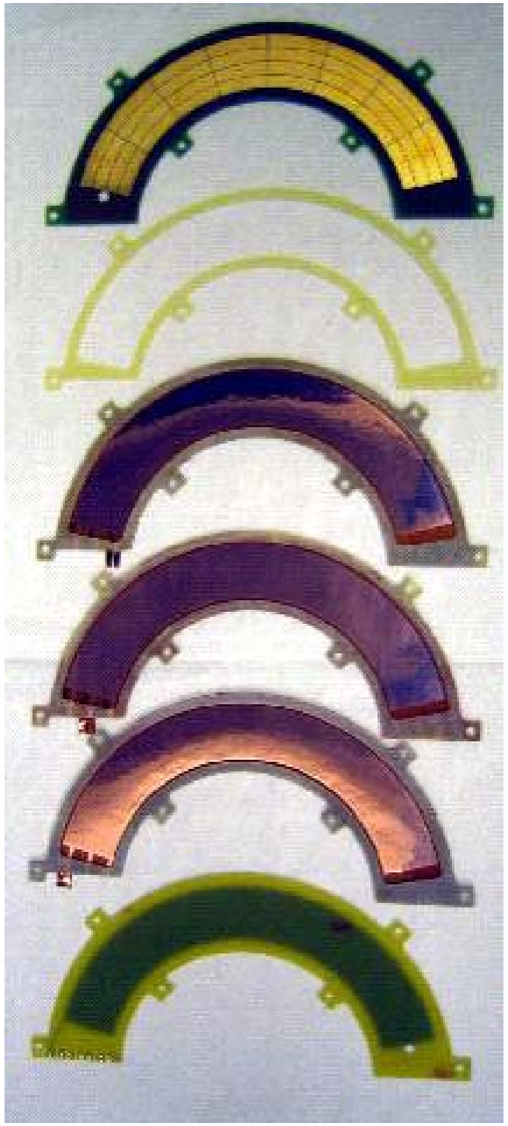




If some other shapes are needed …

LUMI GEM Assembling

Pads : 6 x 24/32 mm^2



pads

induction gap

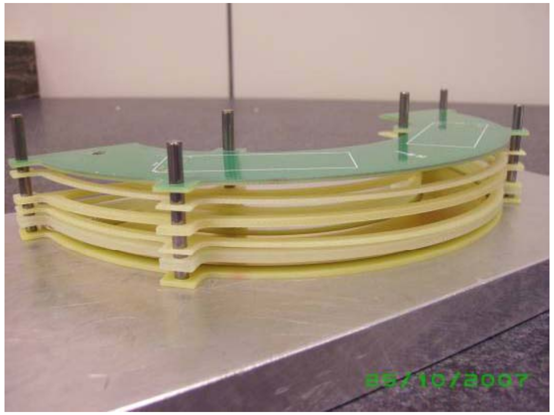
GEM 3

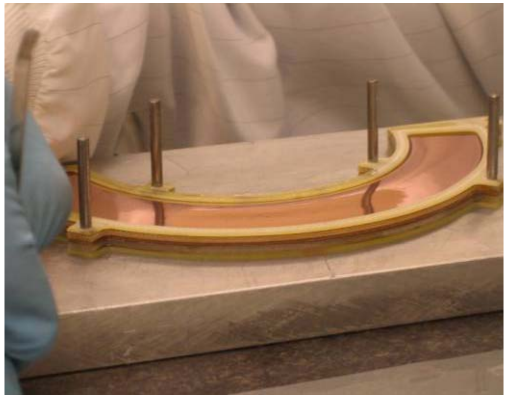
GEM 2

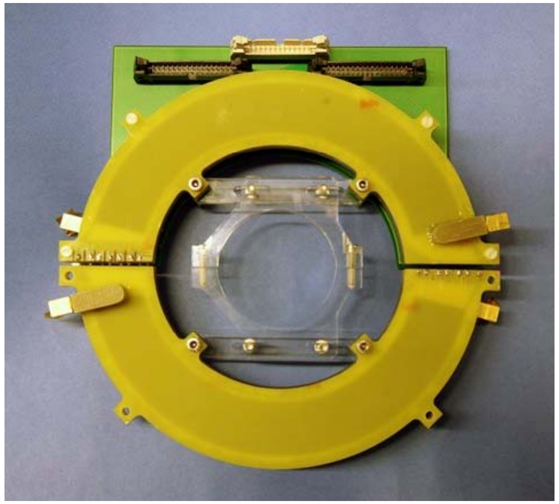
GEM 1

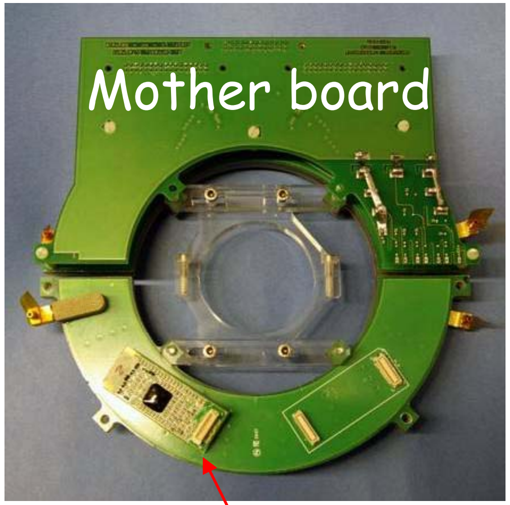
Cathode

Seven detectors have been built





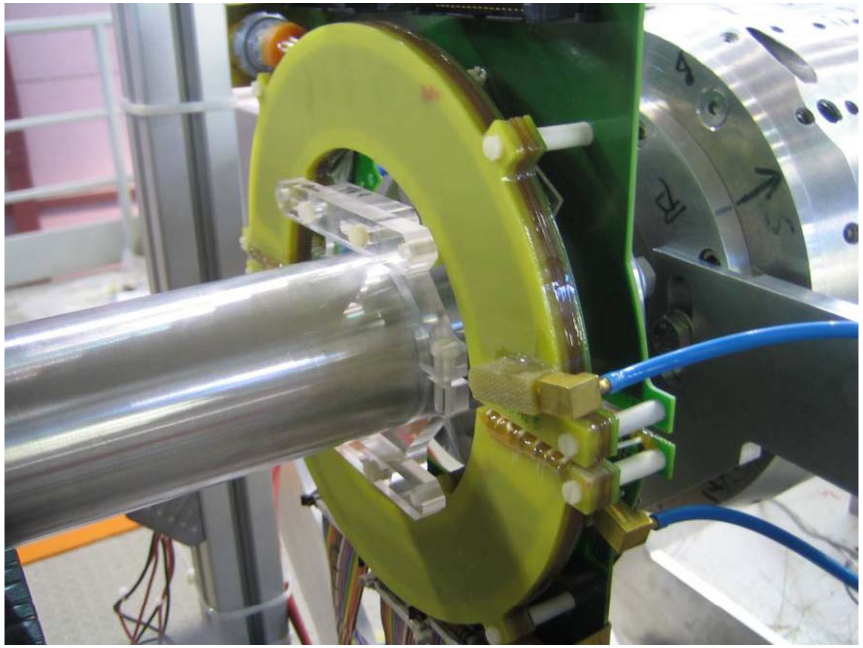




Final luminometers with Carioca FEE

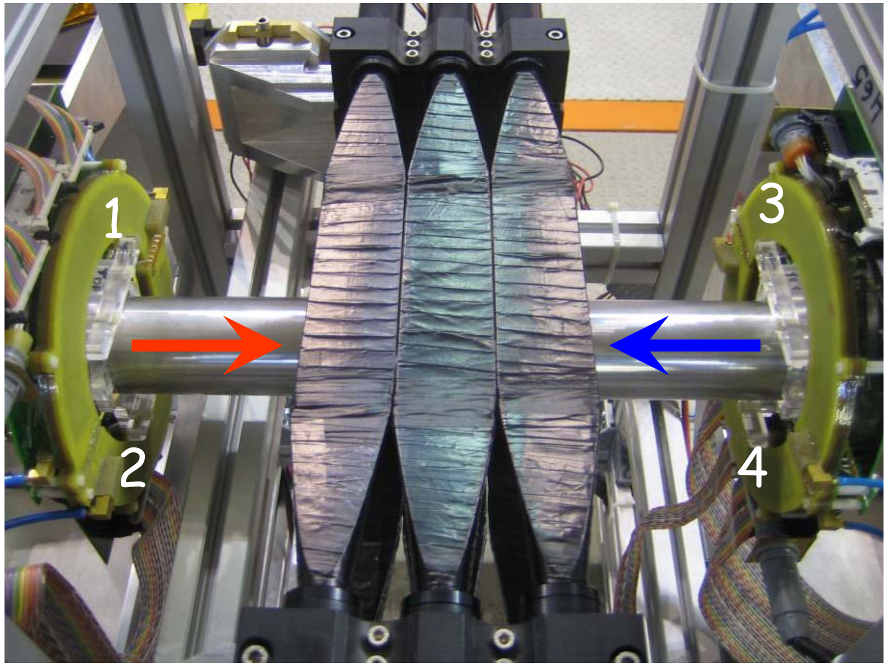
Design by D.Tagnani

GEM luminometer mounted on Dafne



Electron monitor

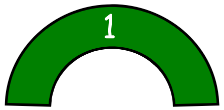
Positron Monitor



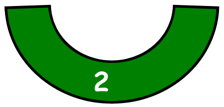
See the Paolo Valente talk on Luminosity measurements at Dafne

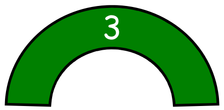
Background monitor

Readout every second with VME scalers

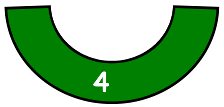


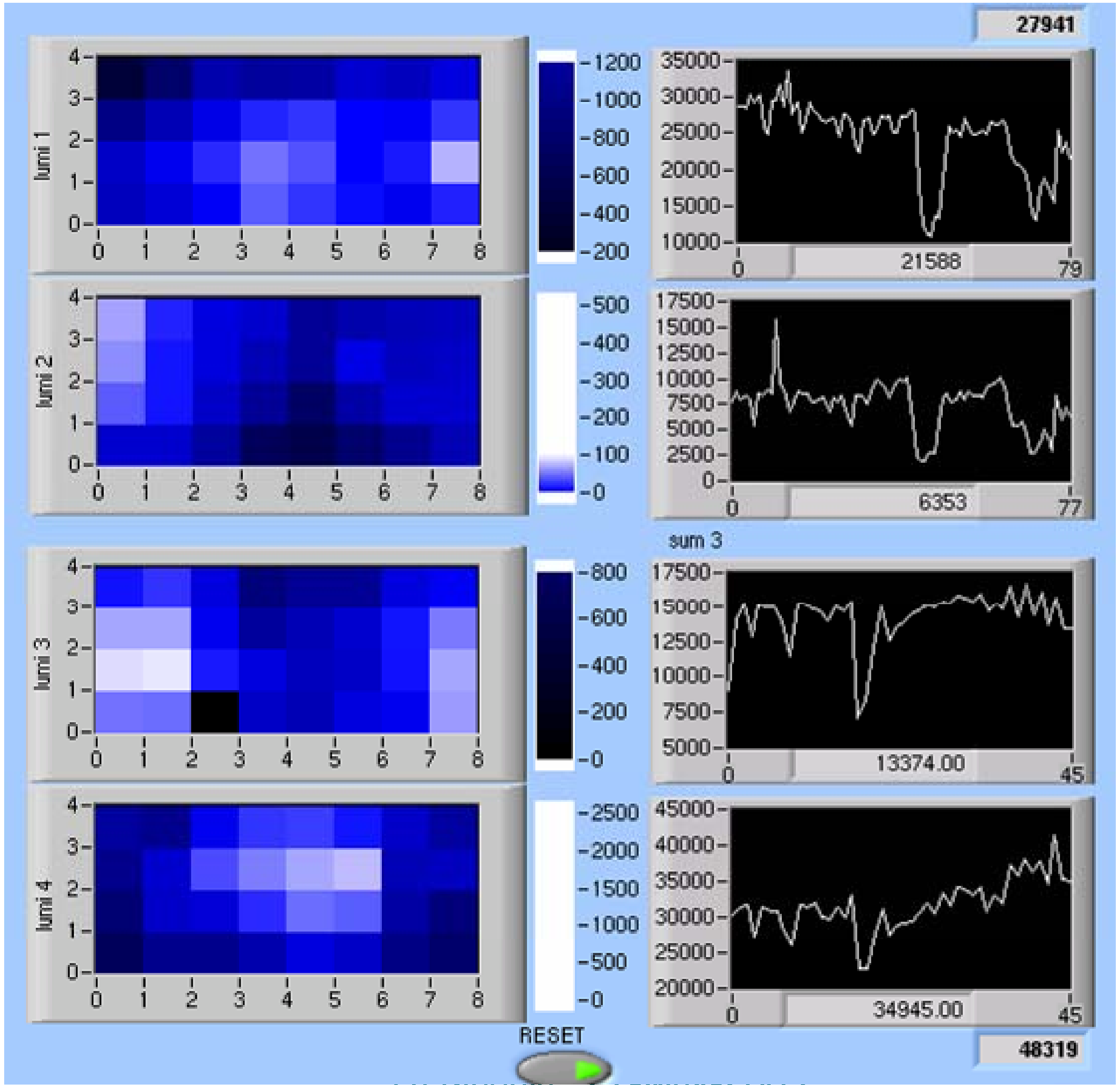
Electron monitor





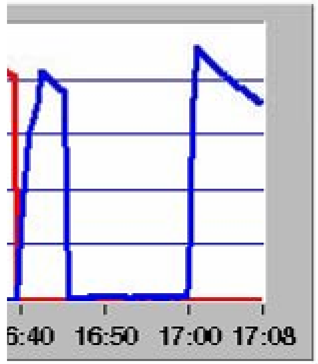
Positron Monitor





28 KHz

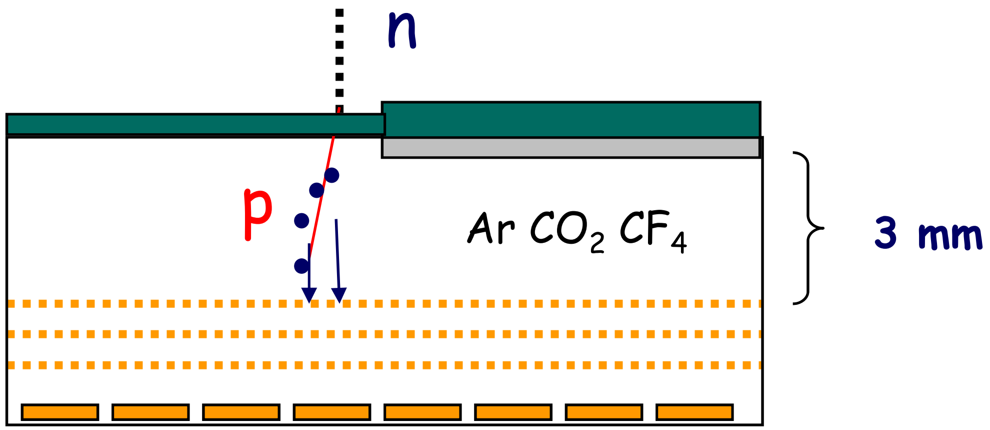
Only Electron Beam



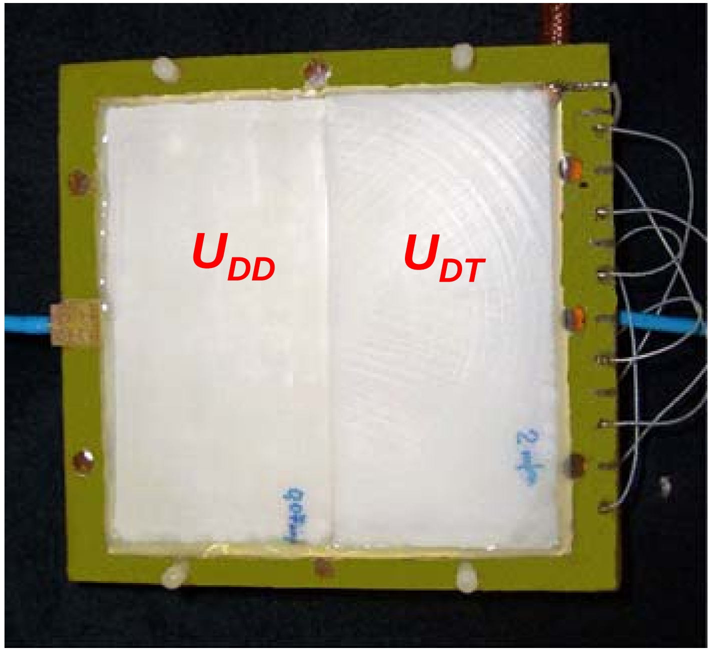
48 KHz

Neutron Flux Monitor for fusion reactors

Neutron flux from fusion plasma



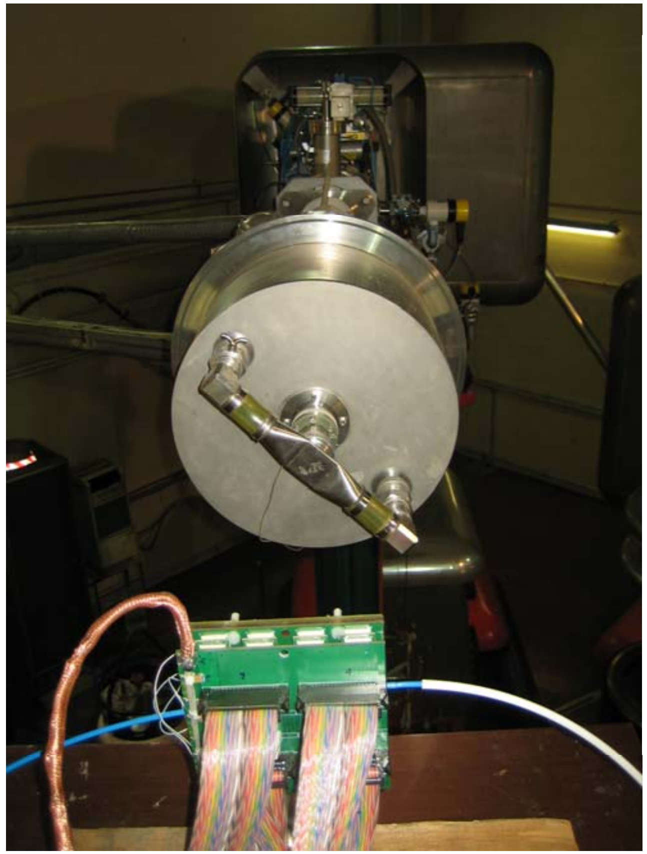
Frascati Neutron Generator
At Enea Frascati :
2.5 (DD) and 14 (DT) MeV



Detector divided
in two zone :

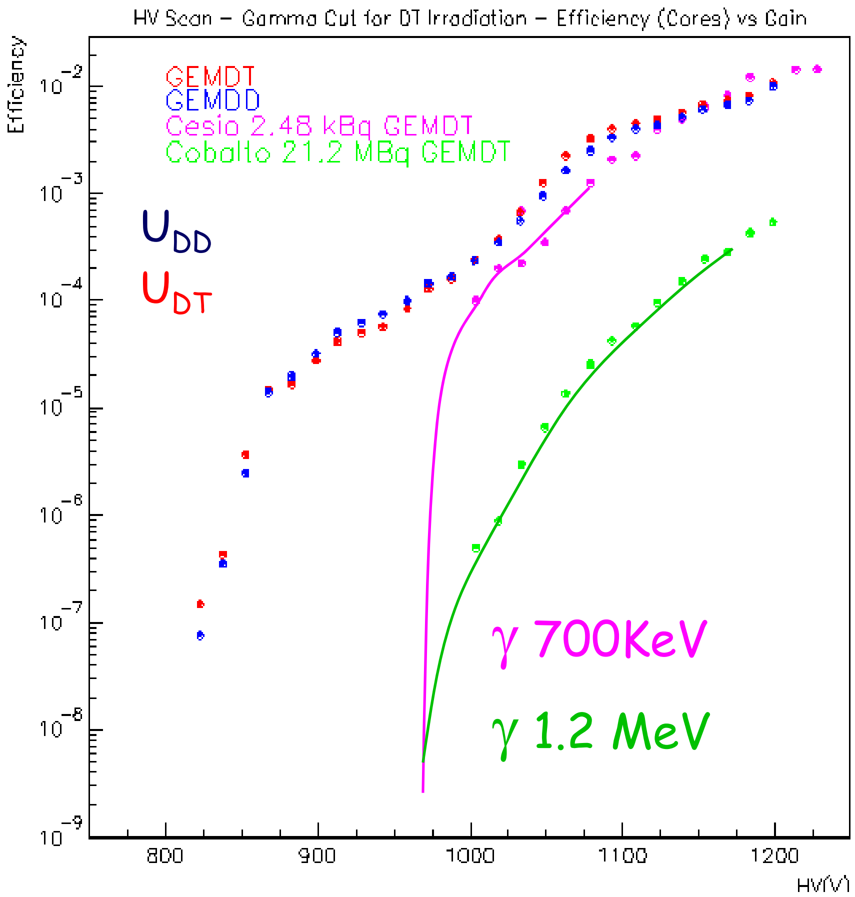
U_{DD} 700 μm Polyeth.
5 μm Al.

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

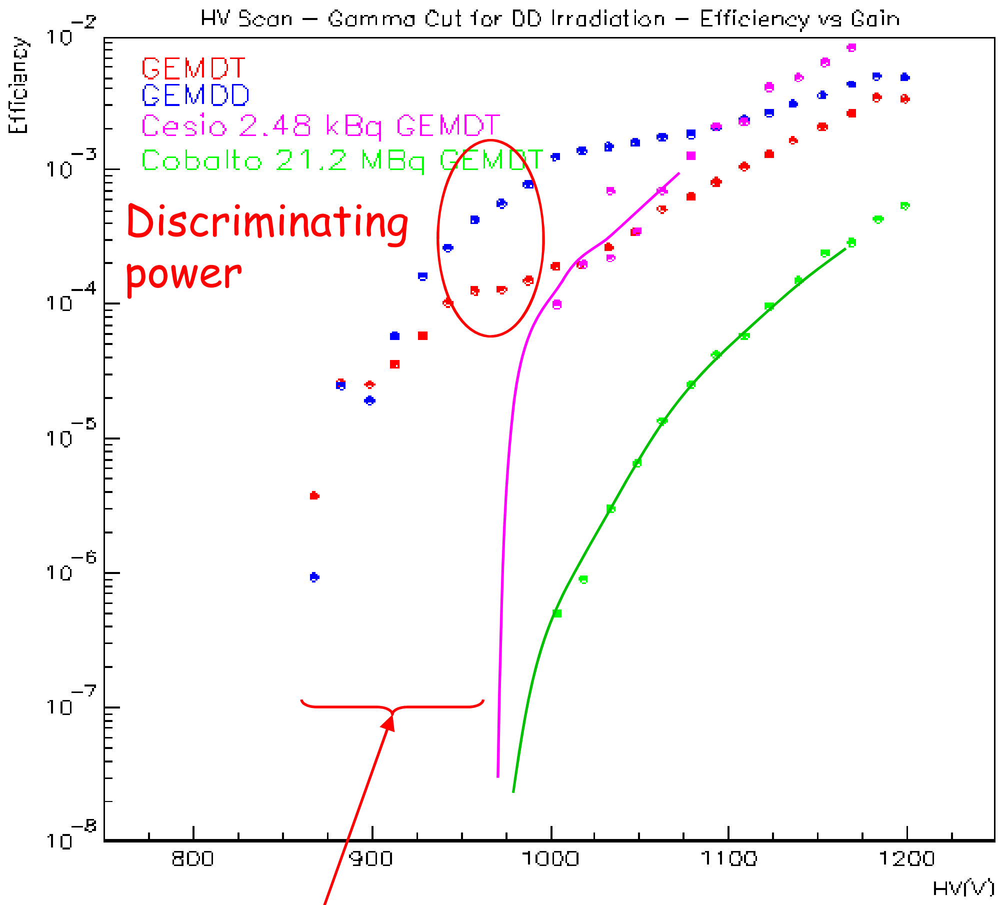


Efficiency vs GEM gain

14 MeV Neutron



2.5 MeV Neutron

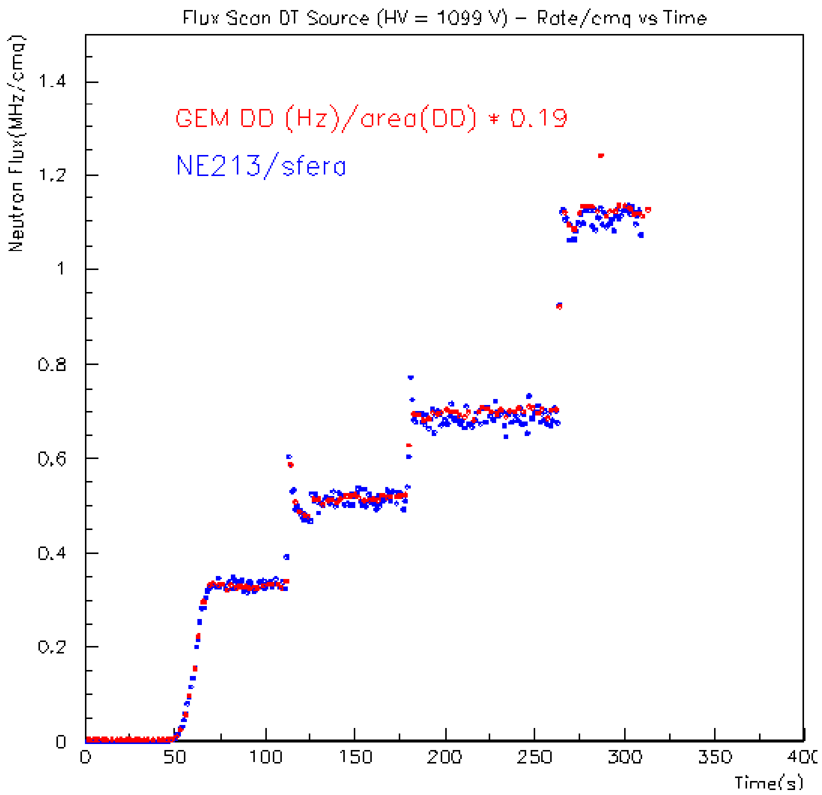


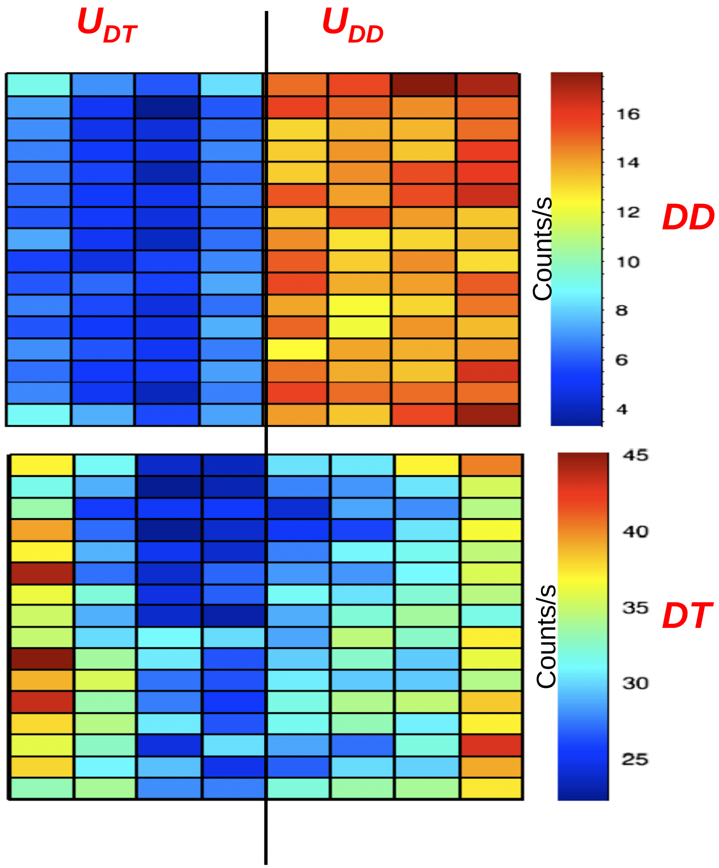
There is a working region without photon contamination with eff = 10^{-4}

See Basilio Esposito Poster

Flux vs time and discrimination

INFN Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati





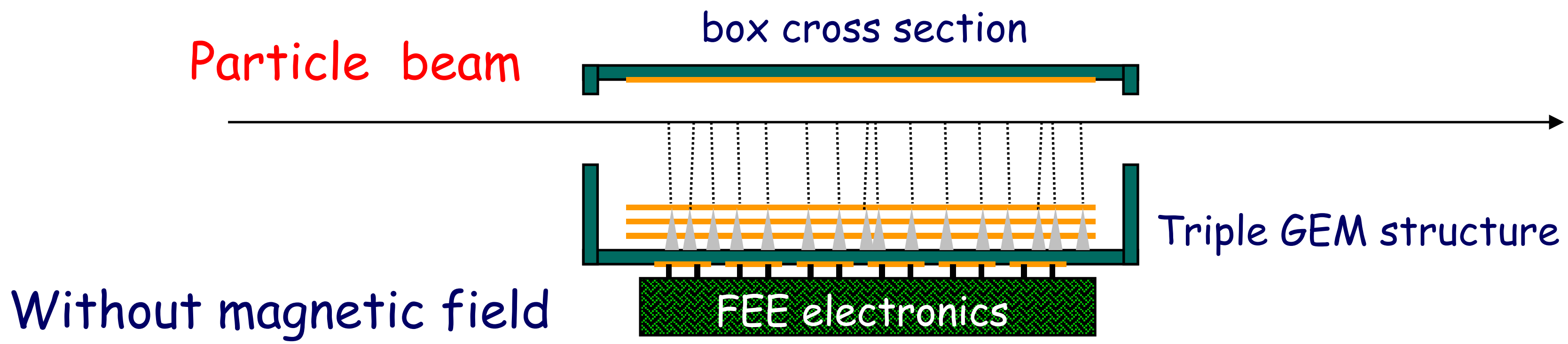
More studies on cathode materials to improve discrimination in prgress

Starting ENEA INFN CEA collaboration for the use of these monitors at Tokamak (Cadarache and Frascati) and Ignitor Project

Small TPG for high intensity beam and ion beam

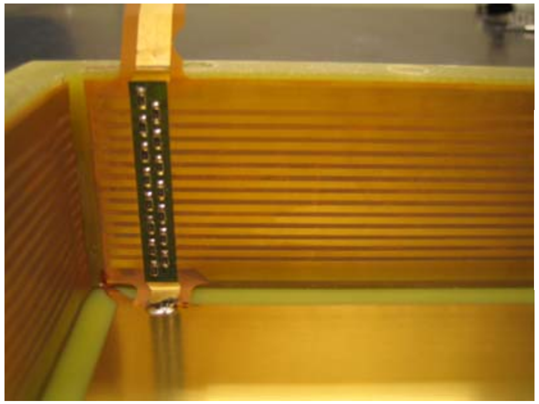
TPG for beam diagnostic

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

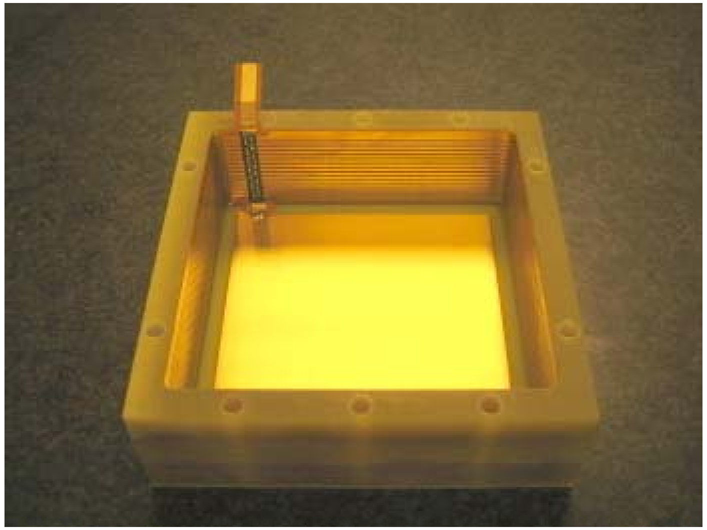


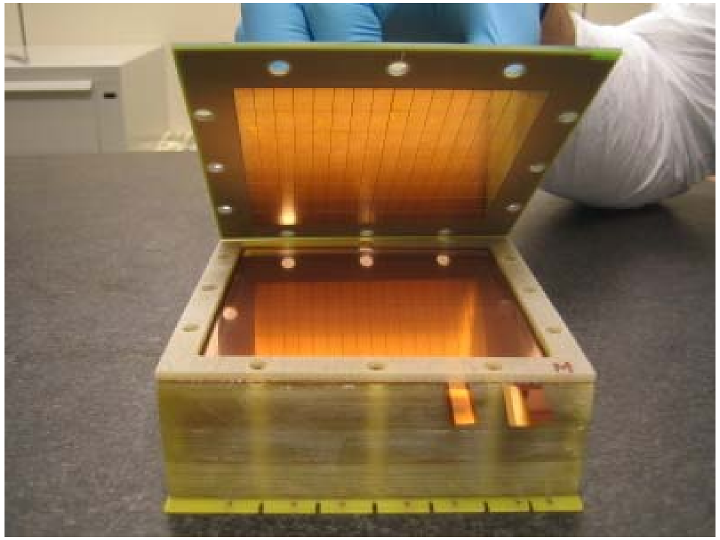
The material budget crossed by a particle is only two kapton foils (<0.2%X_0) used for the field cage necessary for the drift field uniformity

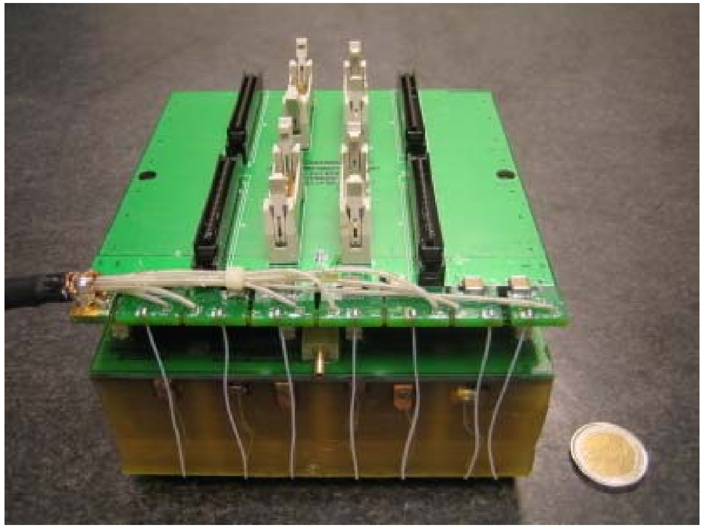
14 strips with 15 resistors (10 MΩ) for a total field cage current of 1 μA

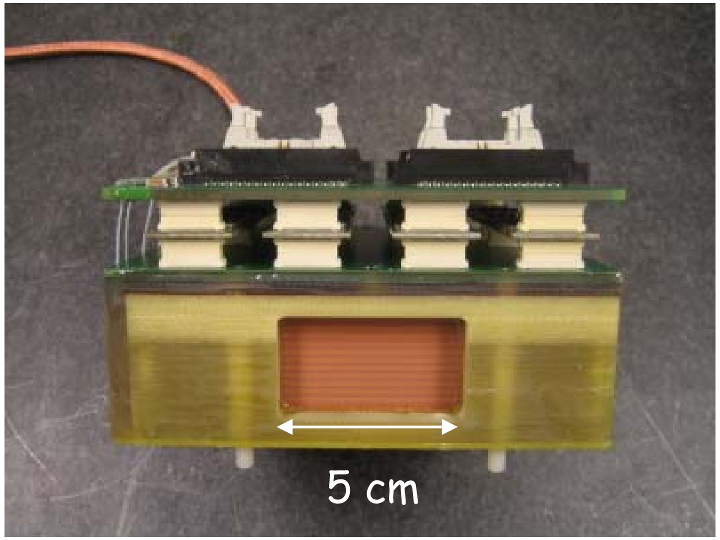


Assembling the TPG chamber



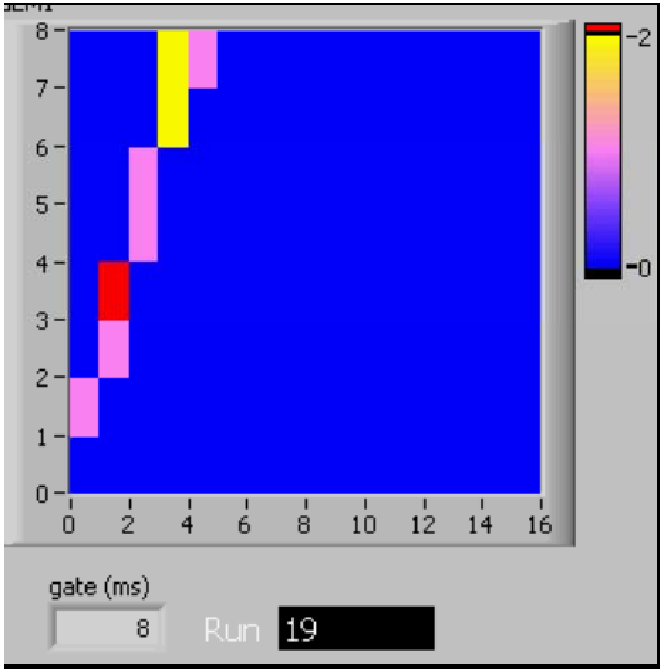


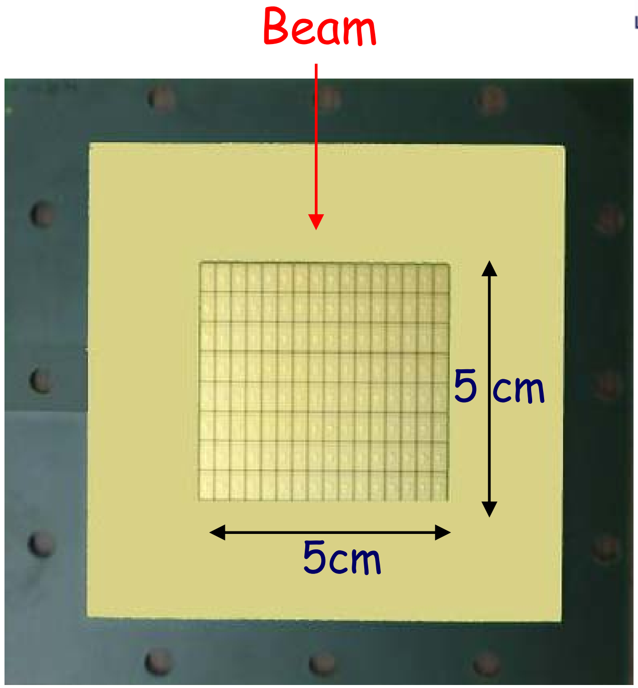




(M. Pistilli)

Cosmic rays in free running



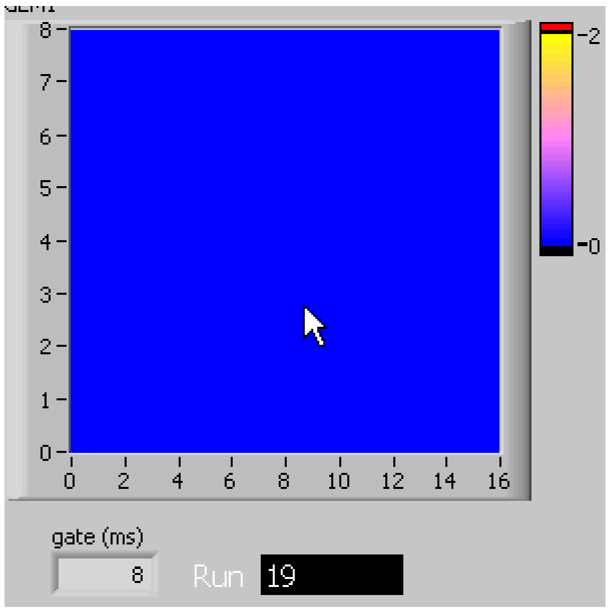


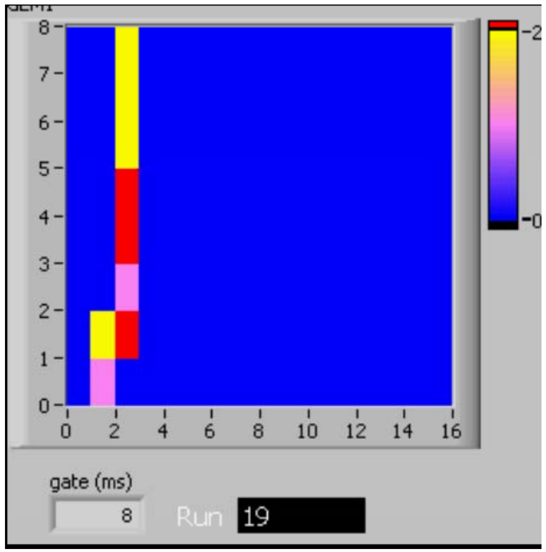
A gate of 8ms is open randomly without an external trigger

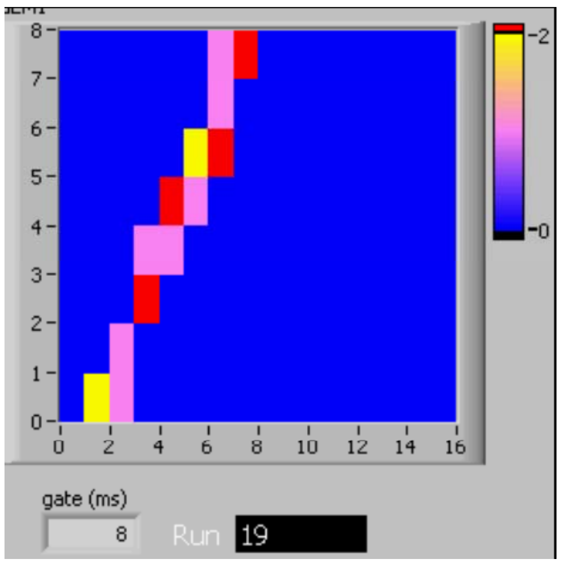
Threshold set at about 7 fC
Gas mixture Ar CO_2 (70-30)
Triple GEM Gain at about 10^4

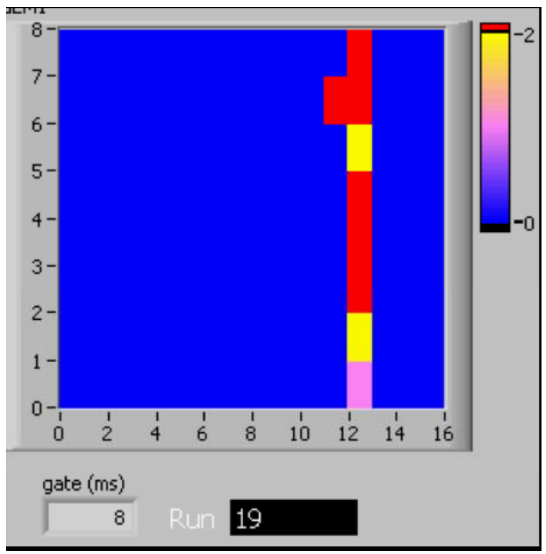
For this type of monitor a new layout has been designed for an active volume of 5x5x4 cm^3
Pad dimension 3x6 mm^2
Threshold set at 7 fC
Gas mixture Ar CO_2 (70-30)
Triple GEM Gain at about 10^4
Sub-millimetric precision

Some other events





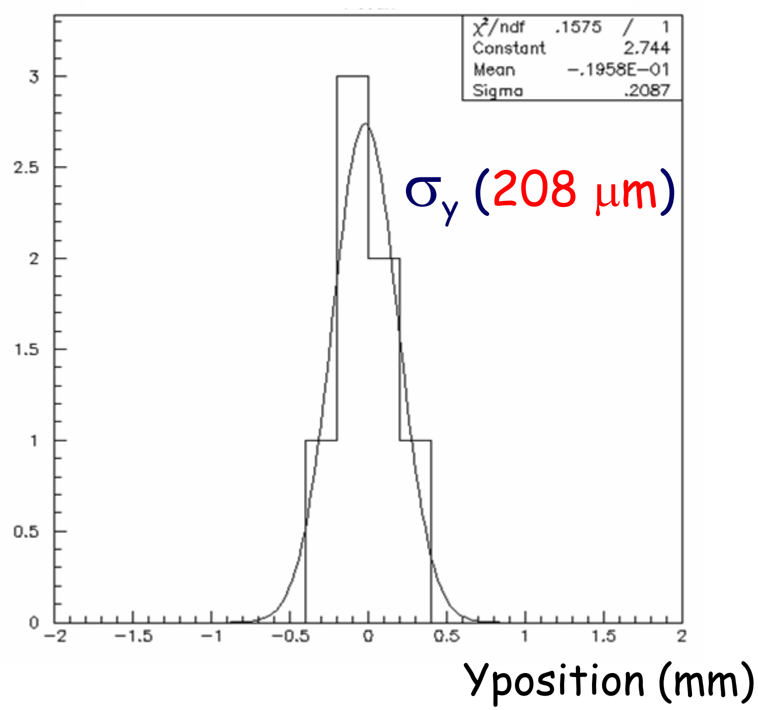




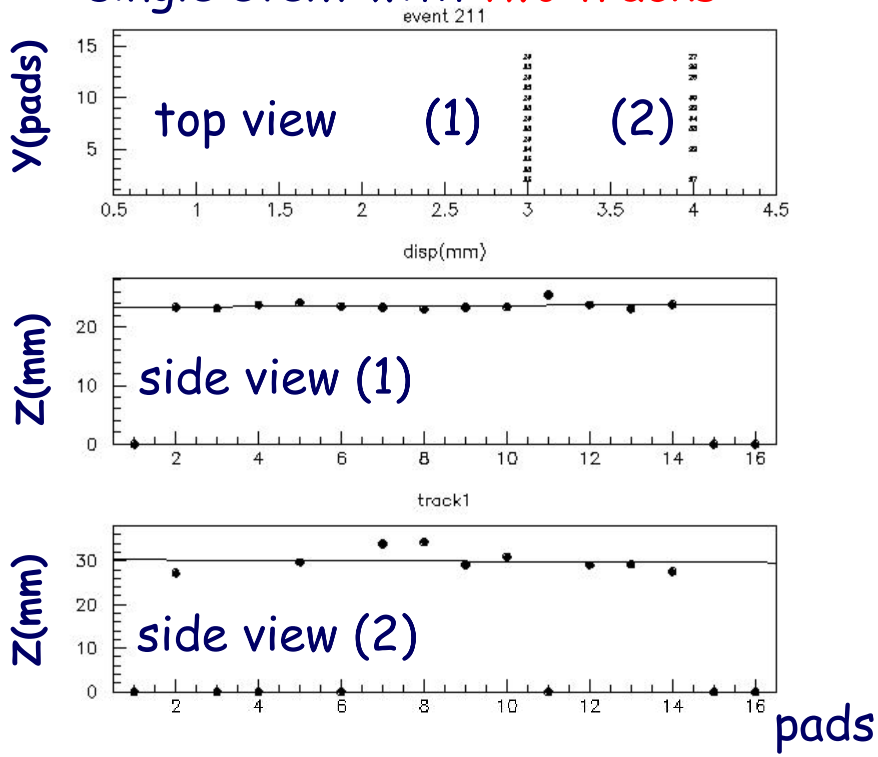
TPG performance

The track is reconstructed using the space time relation

residual distribution



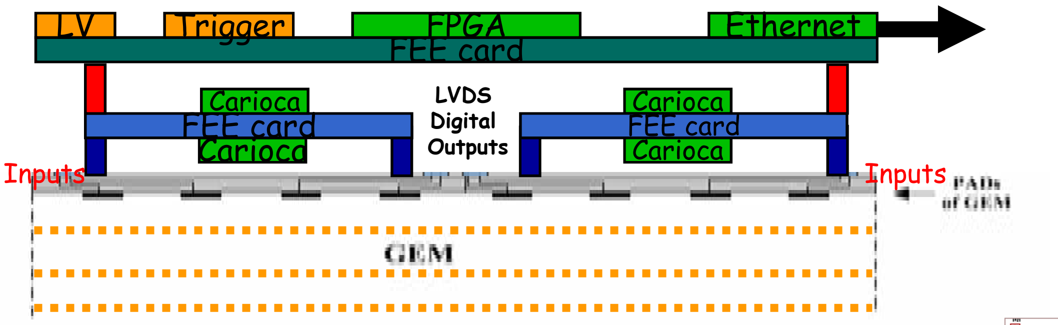
single event with two tracks



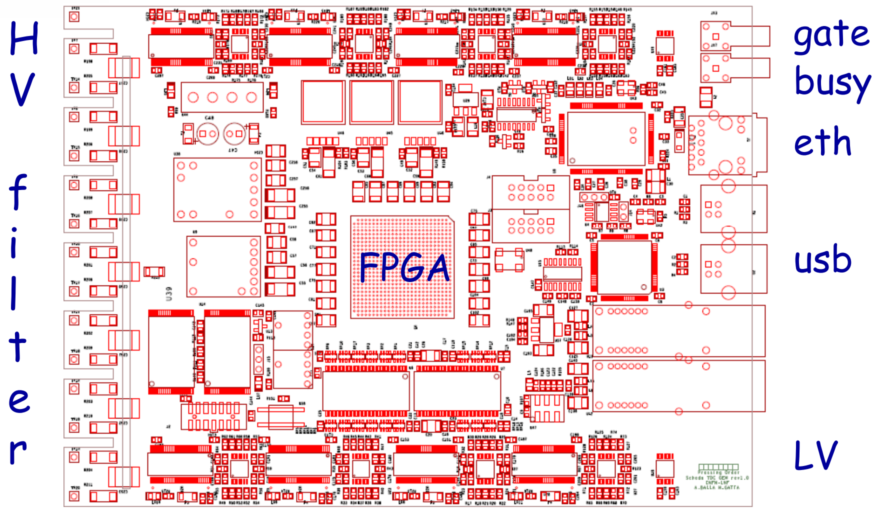
Characterization with different gas mixture is in progress
Next beam test at BTF (e^-) and ion beam facilities (C^+)

"Intelligent" Mother Board

We are working on a 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 readble through an ethernet connection.



Design done (A.Balla, M.Gatta);
Ready in few weeks



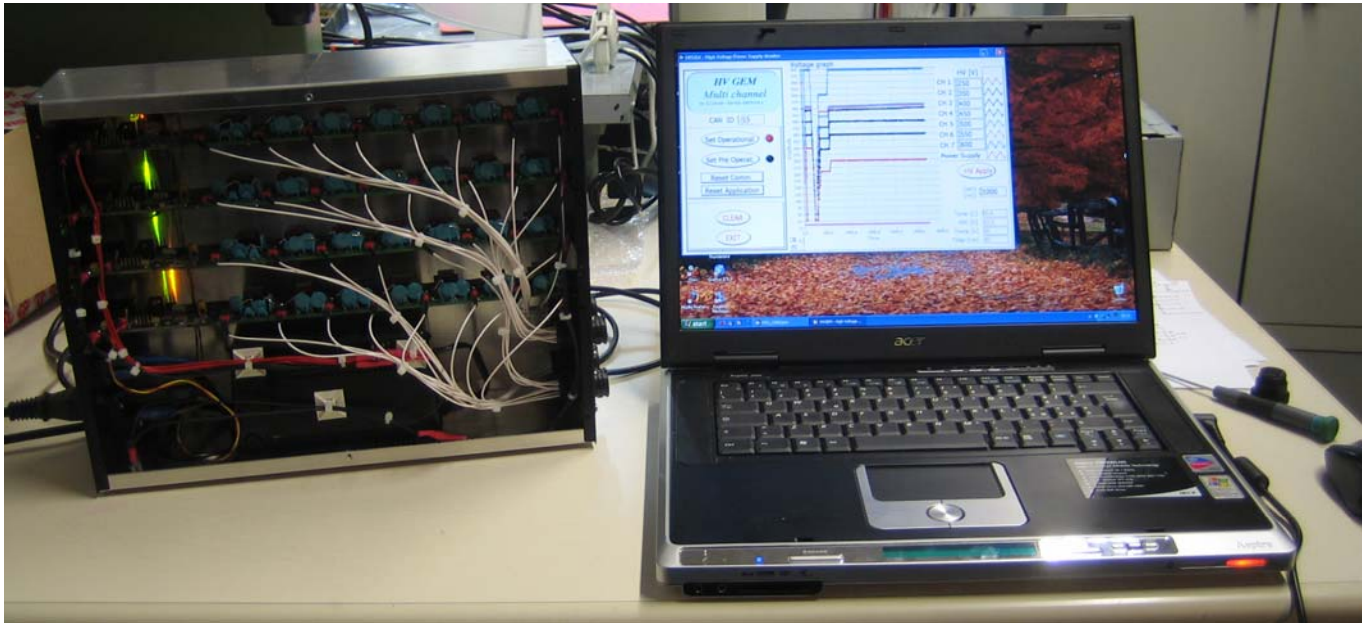
Conclusions

Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

- Several portable detectors based on triple GEM technology have been built in Frascati for several purpose :
  Bhabha track position, Neutron monitor, Beam monitors, Xray, Gamma ray …
- In all of these sectors they show good performances and confirm good radiation hardness
- These R&D brought us to develop new HV systems,
  new front end electronics based on well known ASIC chips,
  new electronics for "on board DAQ" based on FPGA
- Future R&D on neutron and Xrays detection for high fluxes (Nuclear Fusion Reactors) for ITER and IGNITOR
- Future R&D on beam monitor for high intensity beams and ions beam for hadrotherapy

New system with 4 modules

Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati



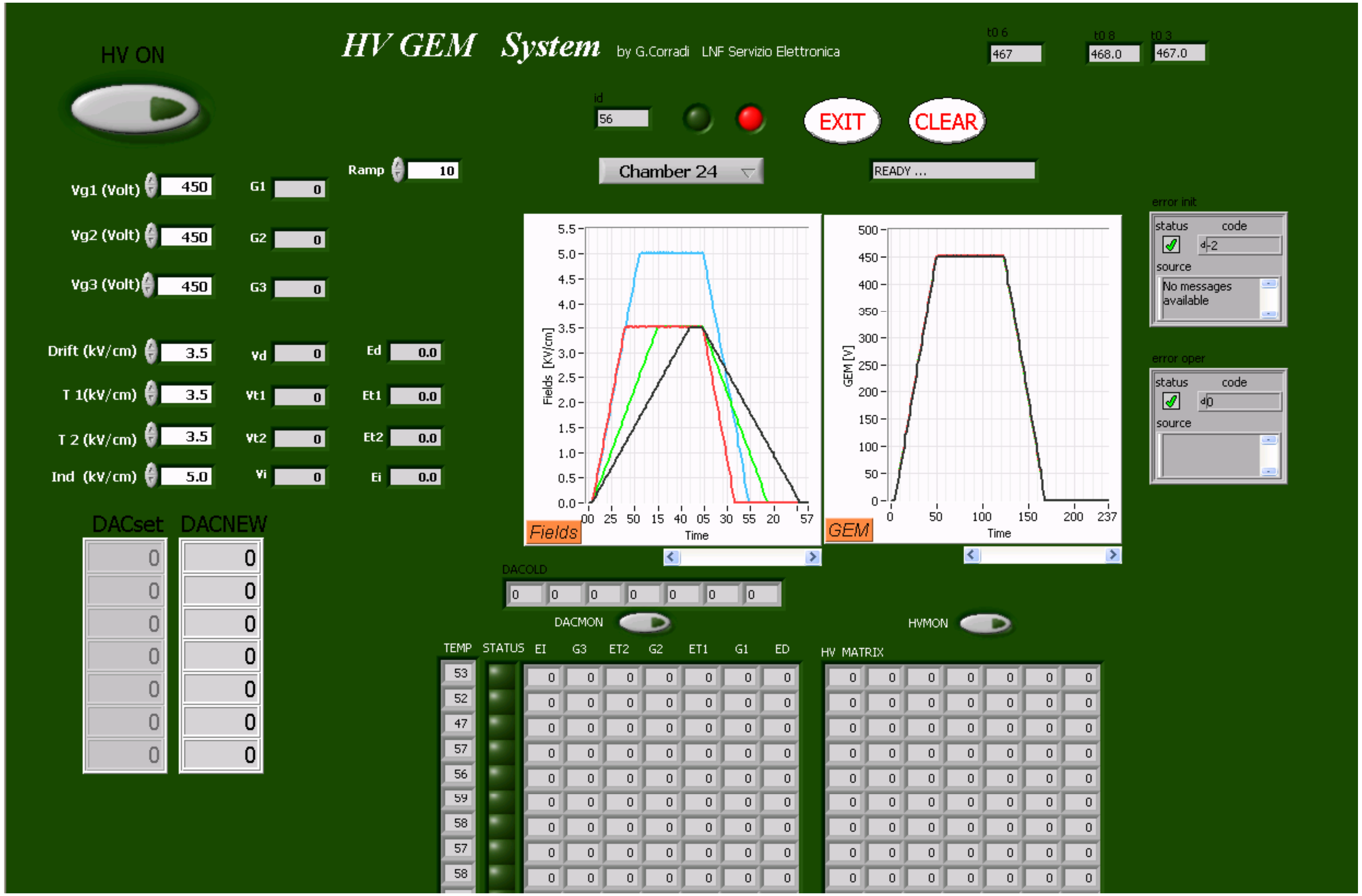
Recently a new system with 4 modules has been made for the luminometer power supply.
This system is actually working near the Dafne IP

A detail of 4 HV connectors

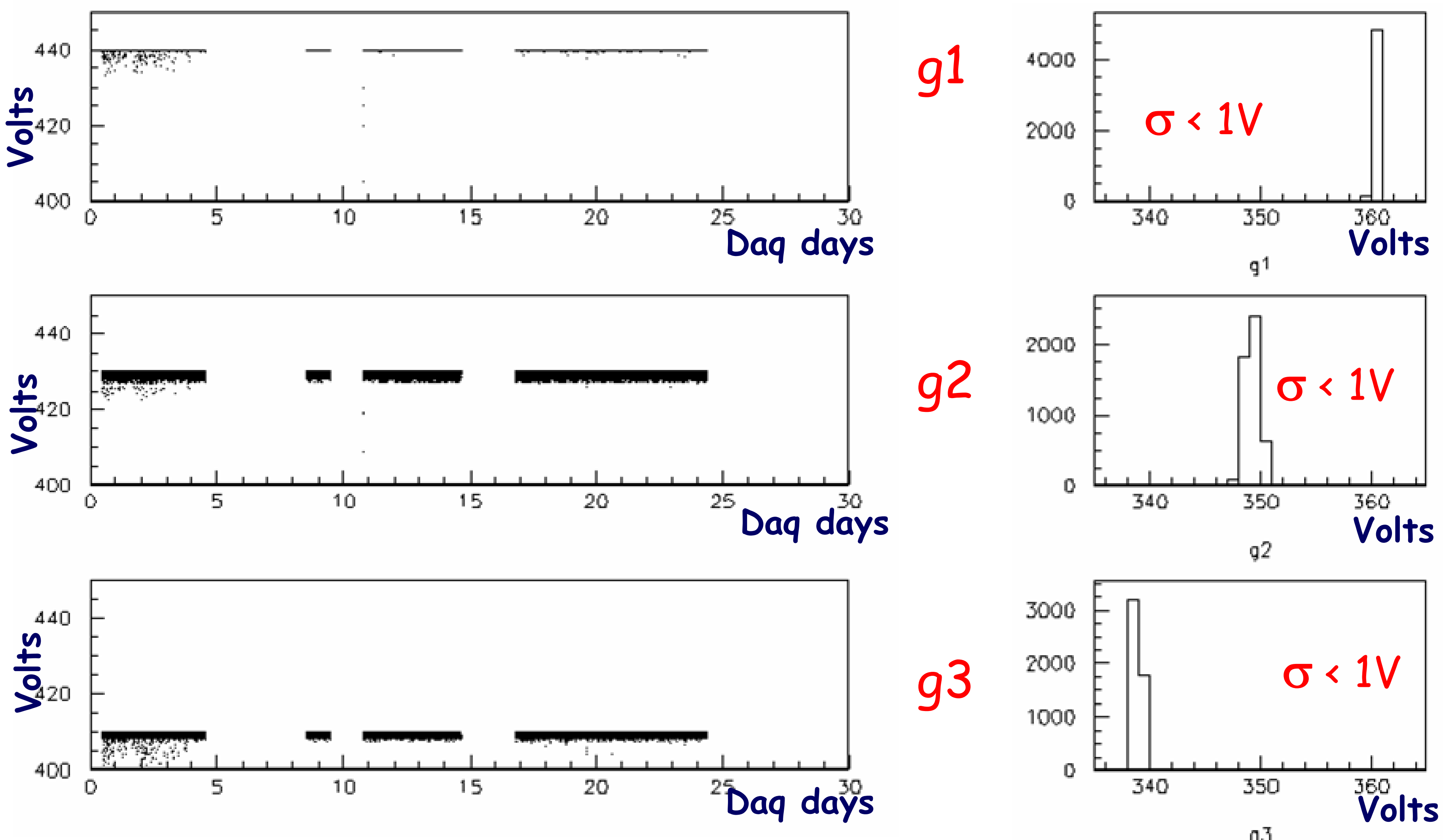
HV Online monitor and control

INFN Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

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



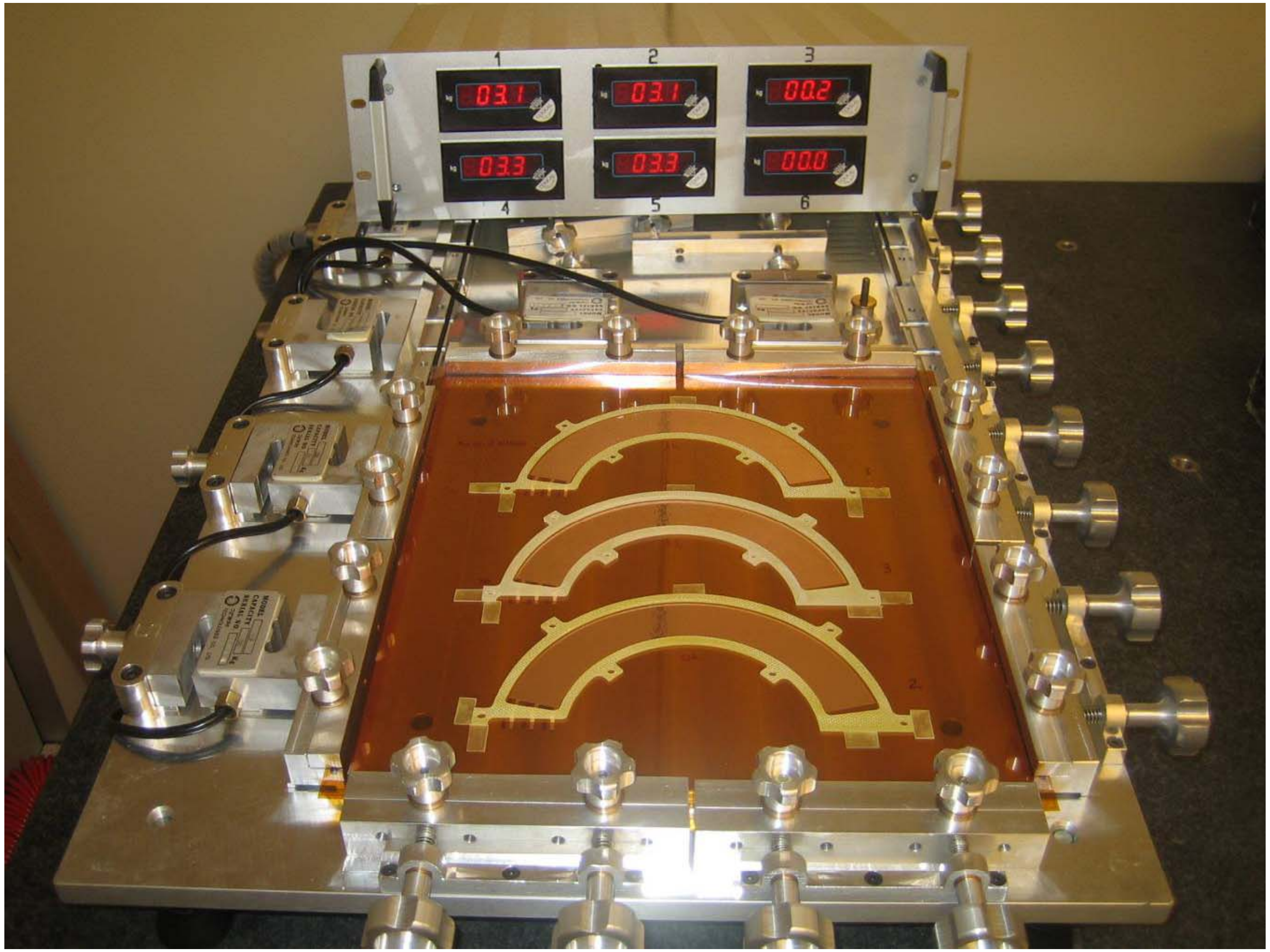
HVGEM prototype stability



Good gain stability !

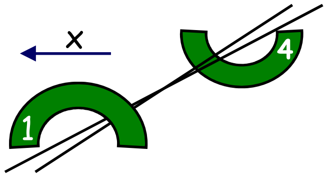
Kapton foil with 3 lumi GEM

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

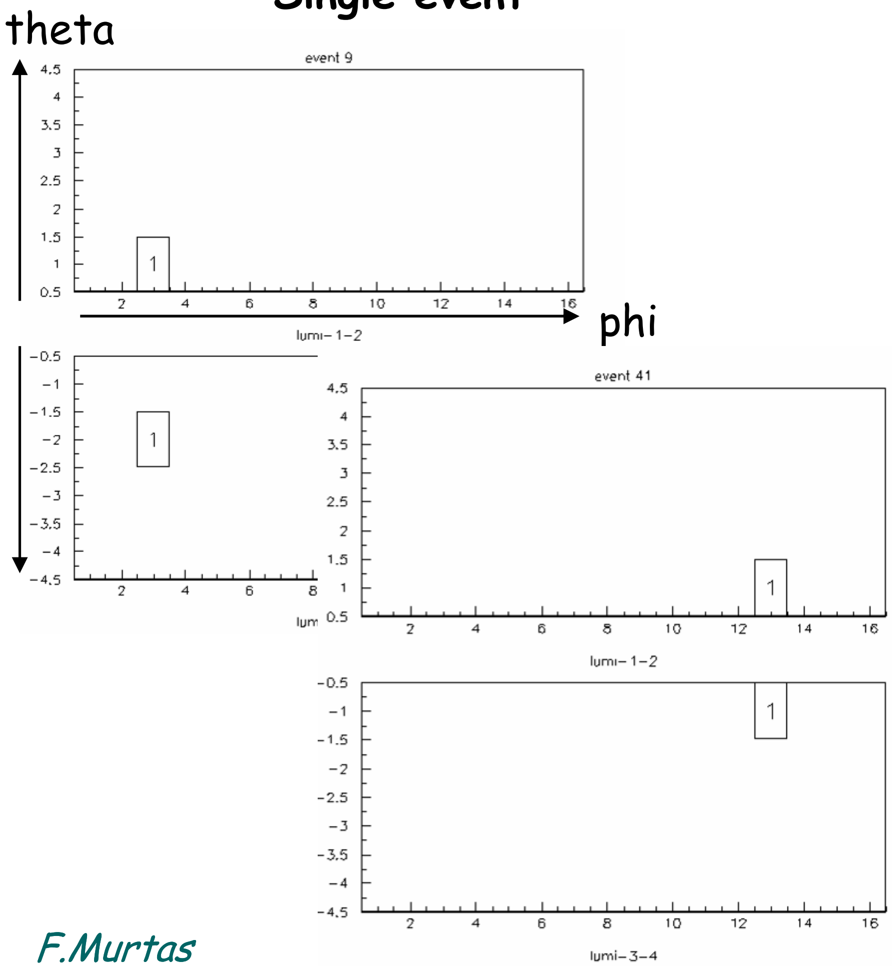


One GEM foil with the three annular structure during the stratching phase for the prototype construction

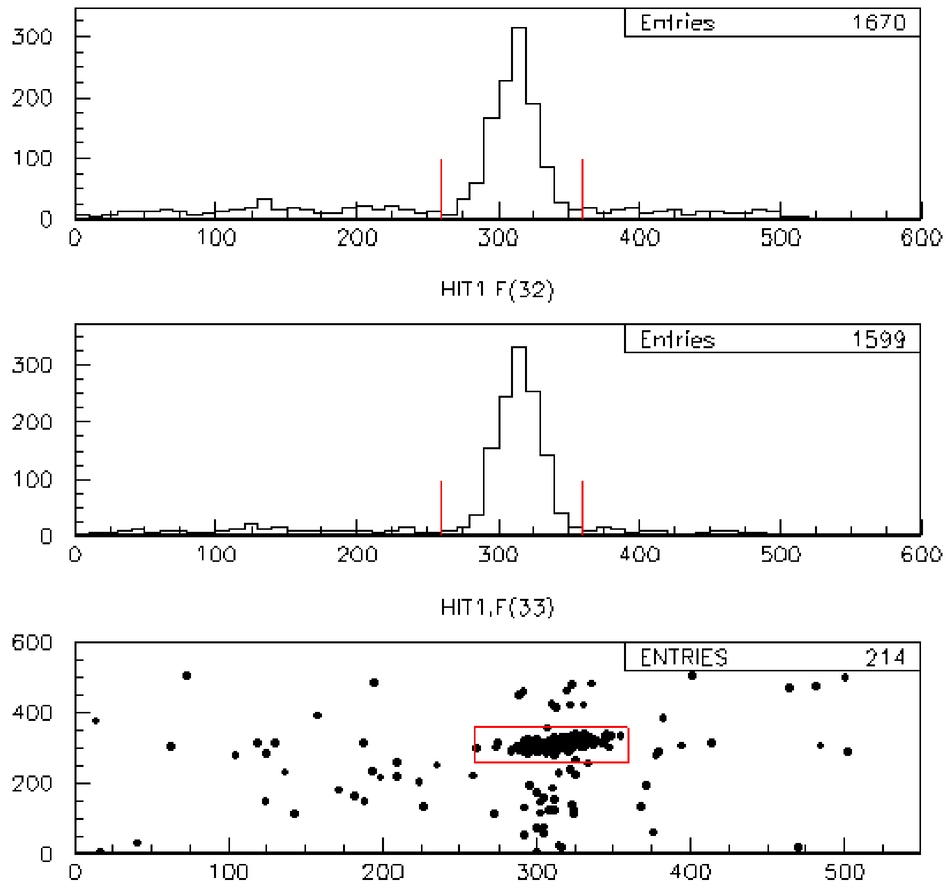
Bhabha time correlation



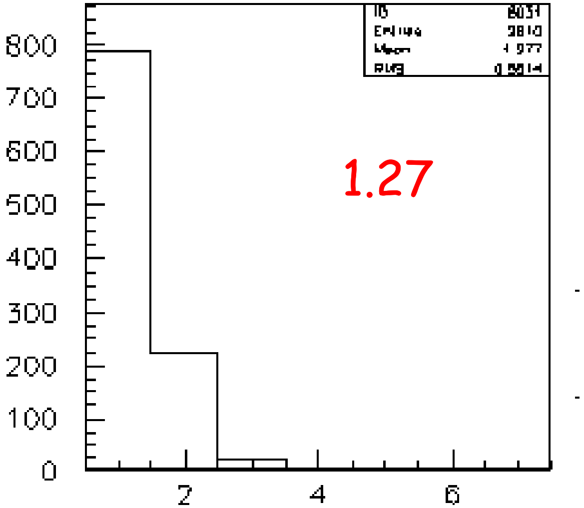
Single event



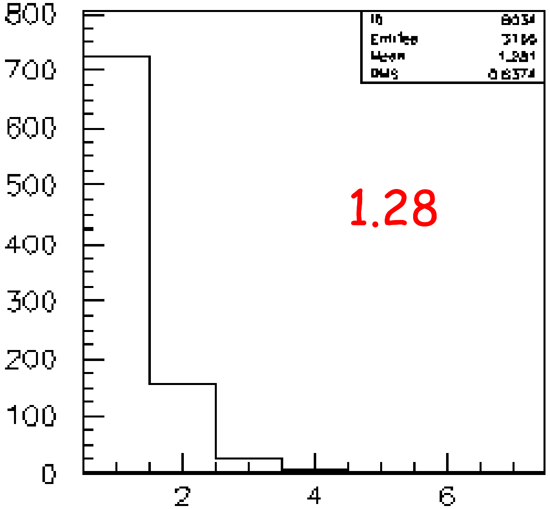
Readout multihit TDC



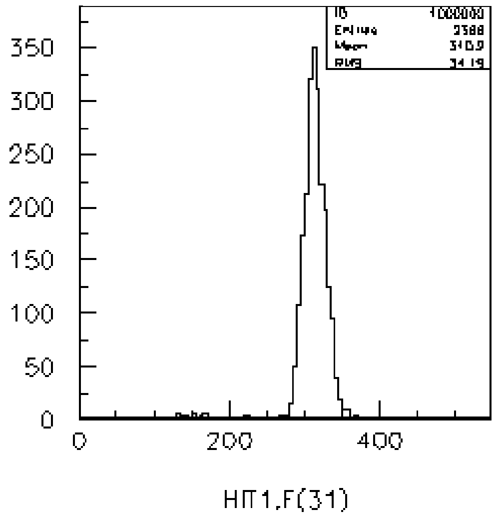
Hit molteplicity and timing

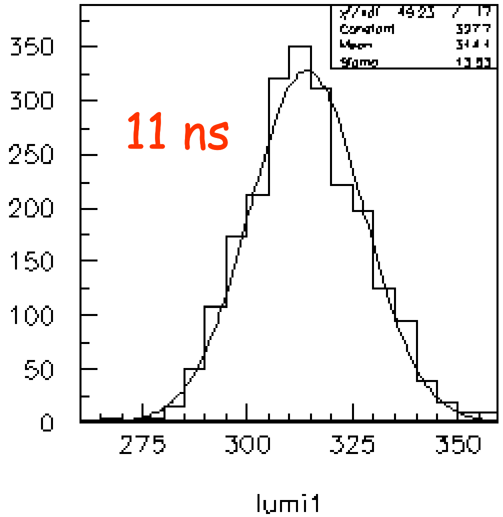


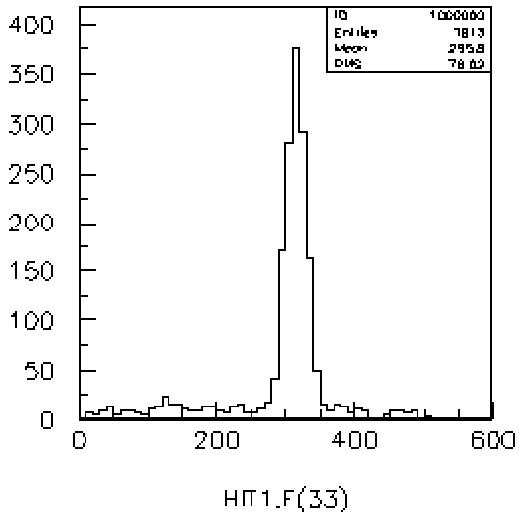
Molteplicity

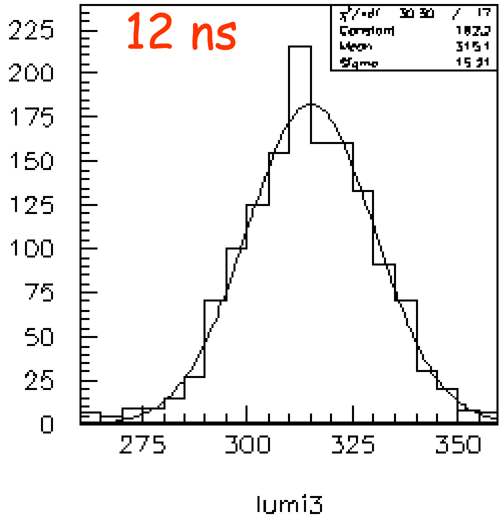


Without T0 subtraction Over 32 channels

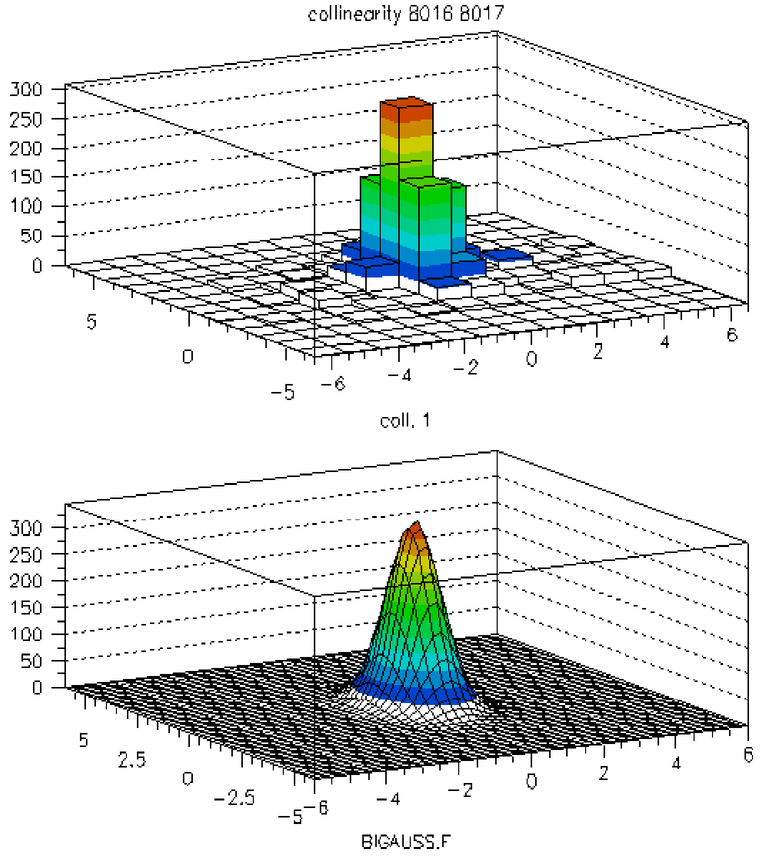








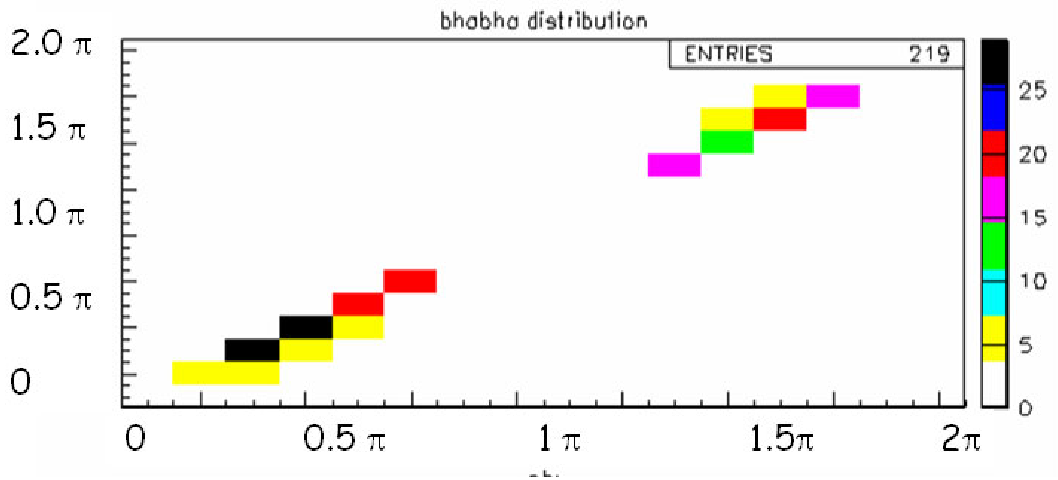
Bhabha Correlation



The correlation in phi of bhabha events is clear

More precise analysis is in progress

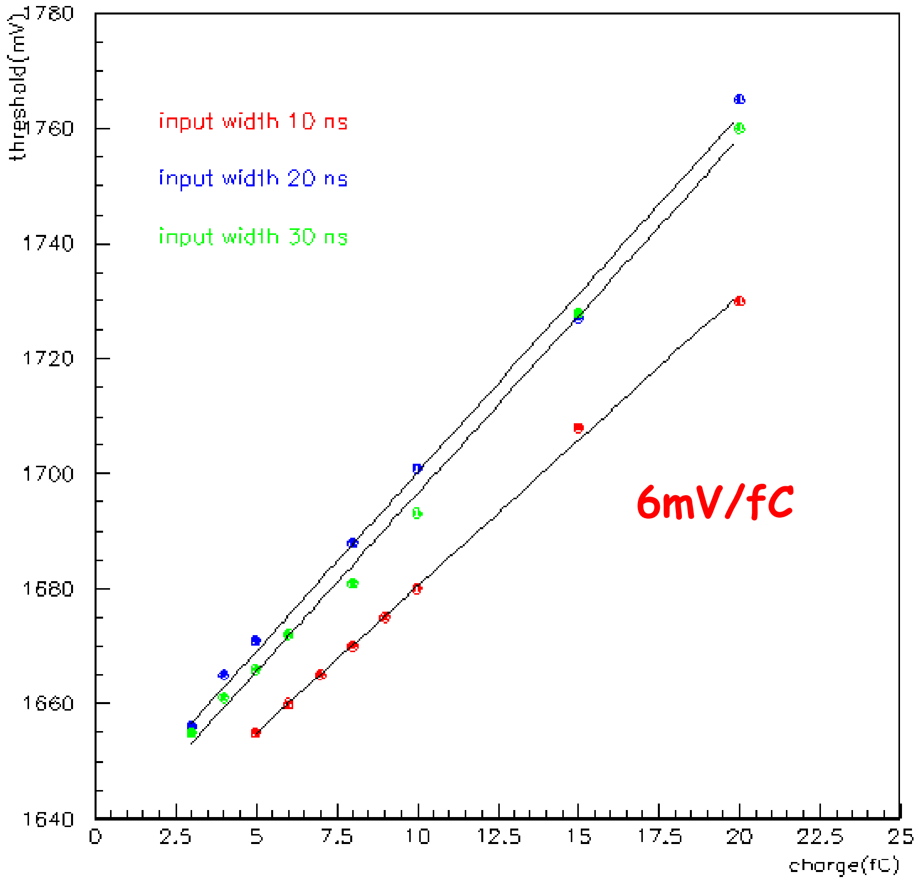
The system is able to measure the particle impact point with a precision of 8 mm in theta



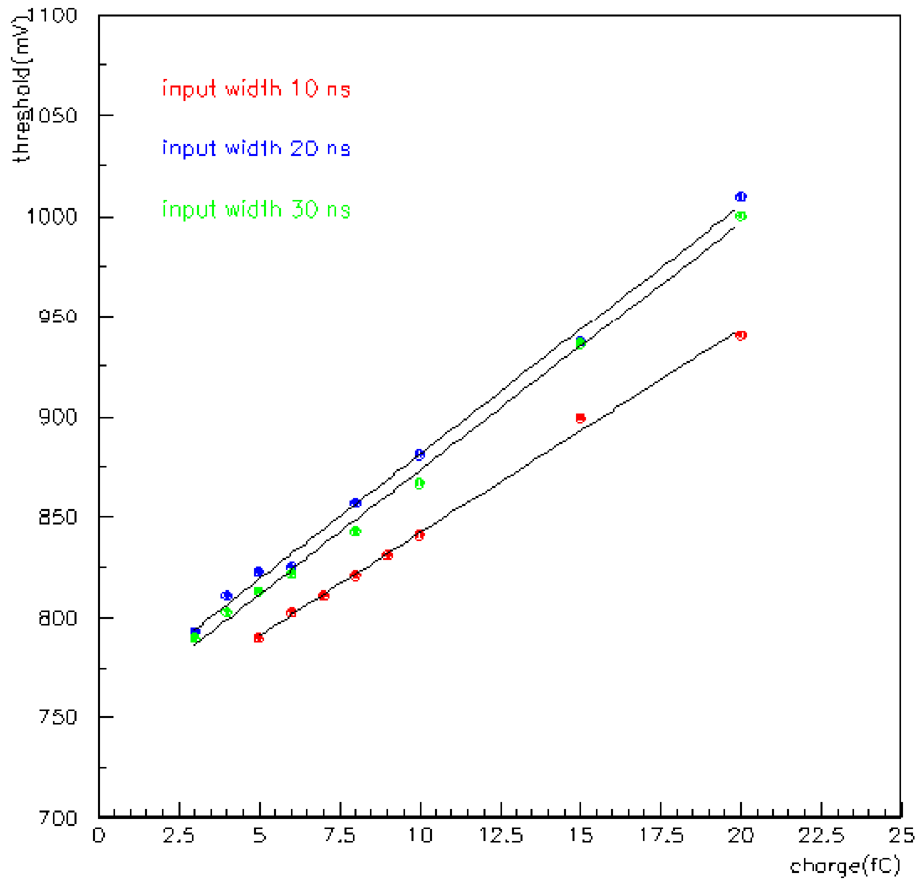
Carioca Card Sensitivity

The sensitivity is measured vs two different thresholds

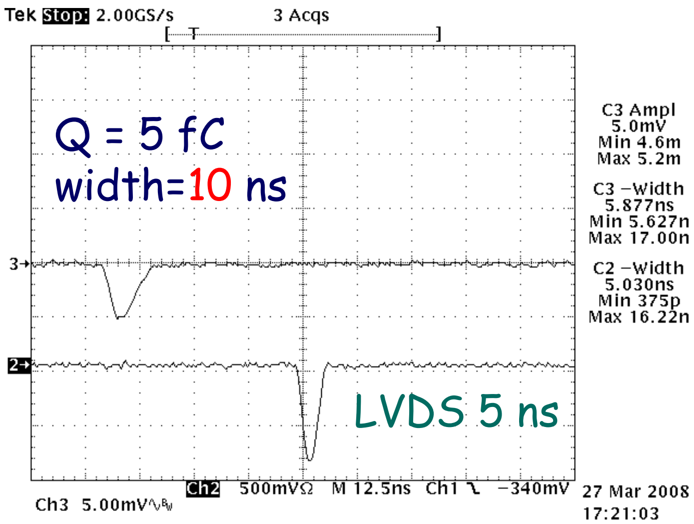
DAC Threshold on power supply

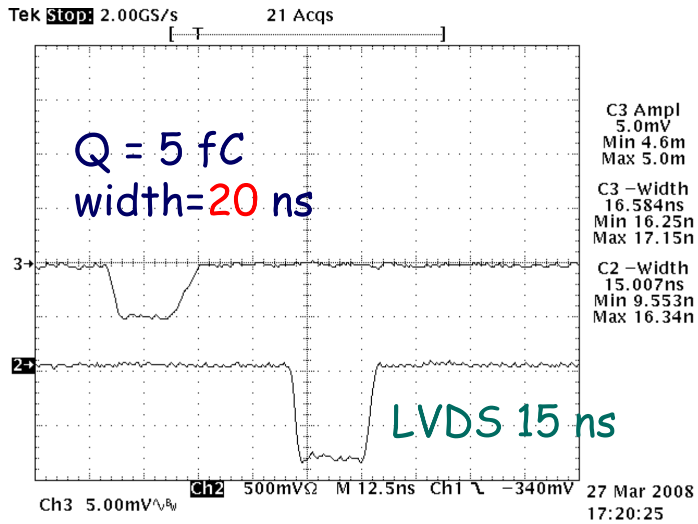


Threshold on Carioca



Carioca Card Sensitivity





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