

A compact triple GEM-TPC as beam tracker

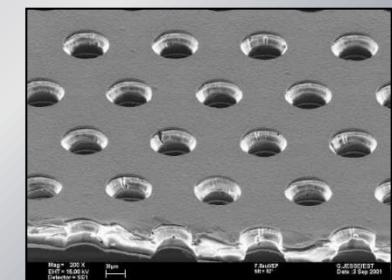
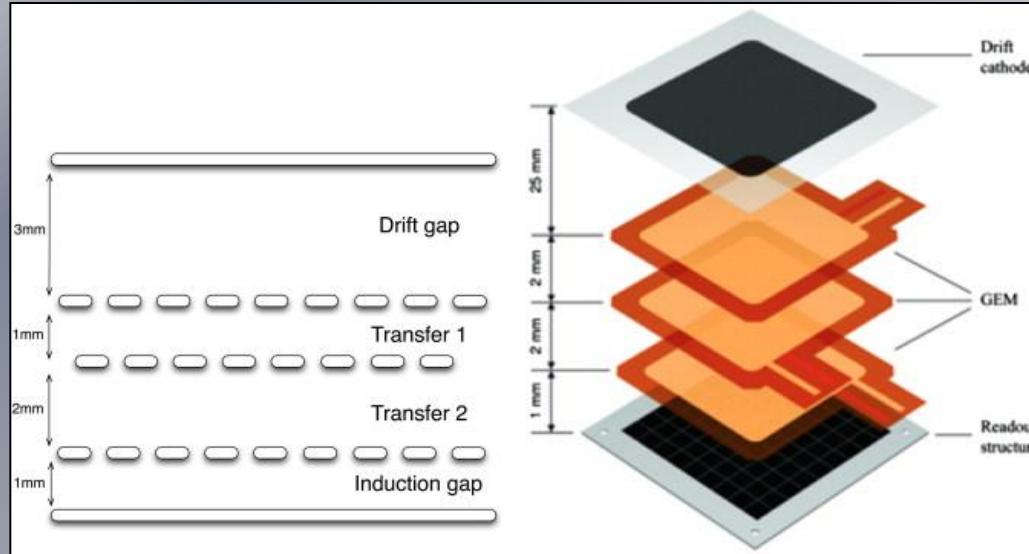
How it works and some results

Gerardo Claps

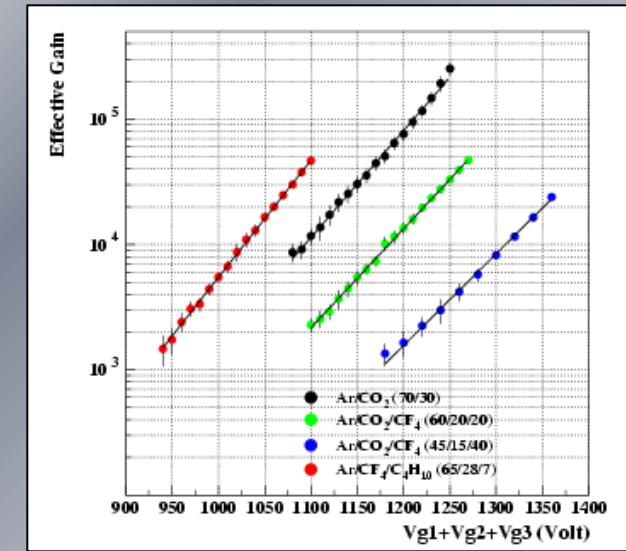
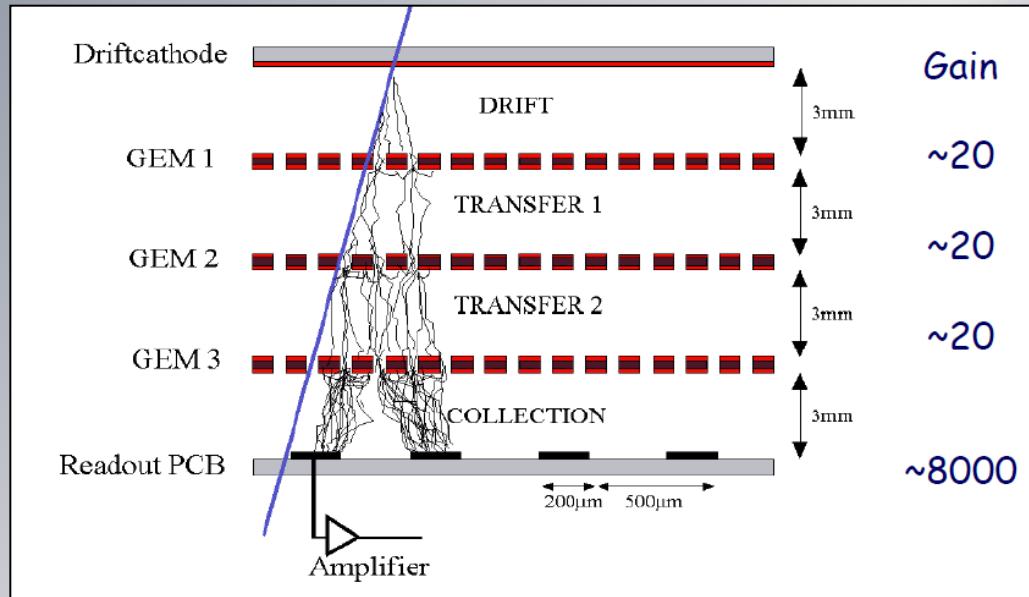
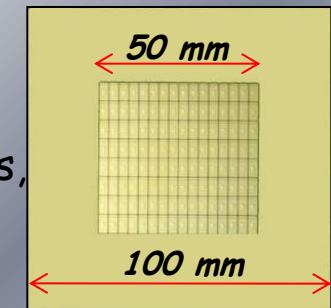
INFN - Laboratori Nazionali di Frascati

Triple-GEM detectors

Layout of a typical Triple GEM detector constructed with standard $10 \times 10 \text{ cm}^2$.

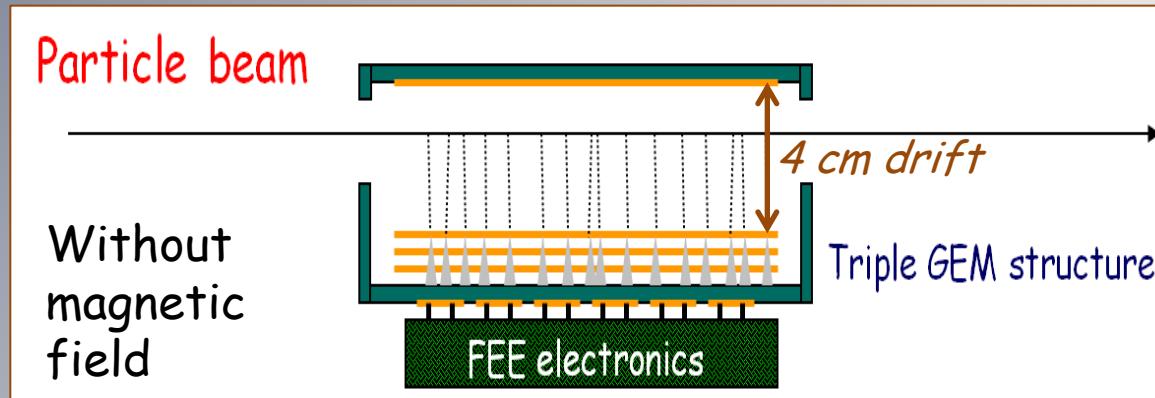


A GEM foil and the anode with 128 pads, each pad is $3 \times 6 \text{ mm}^2$ wide.

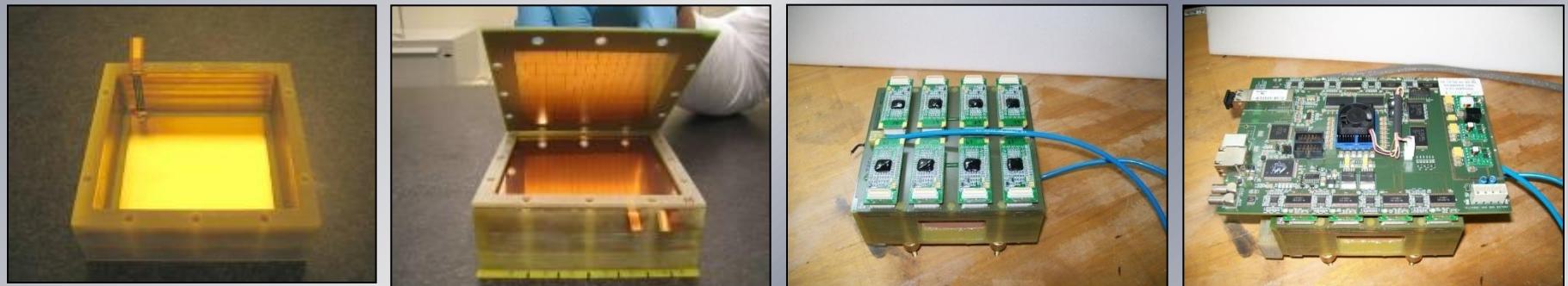


The compact Triple-GEM TPC

It's essentially a small TPC with a 4 cm drift and readout with triple GEM.

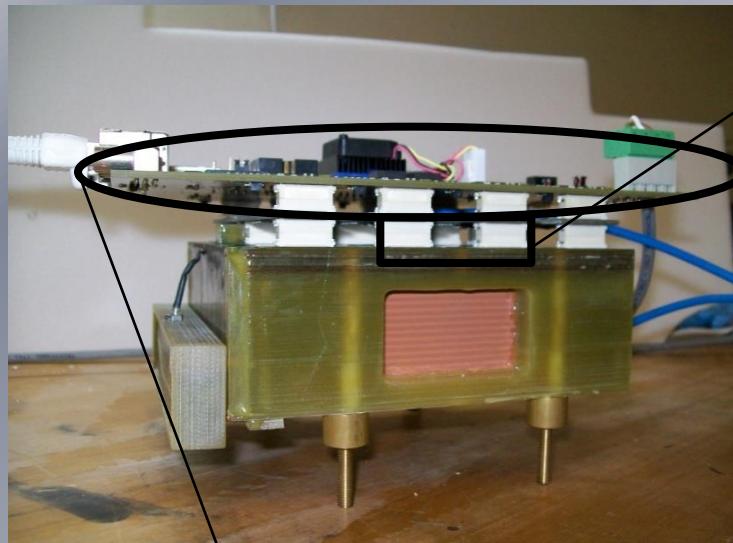


Material budget crossed by a particle is only two kapton foils ($<0.2\%X_0$) used for the field cage necessary for the drift field uniformity

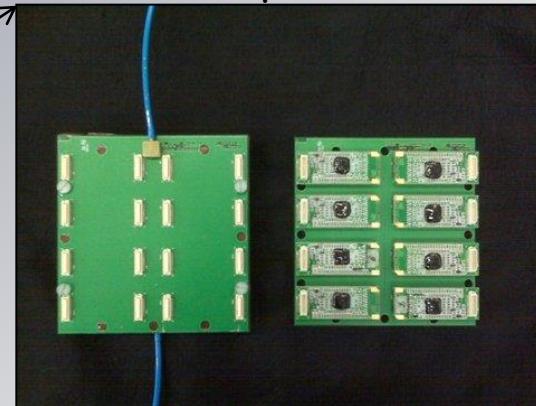


It has been used to monitor different kind of beam particles. With this detector also high current beam can be monitored in position.

FEE: CARIOCA cards and FPGA Mother Board

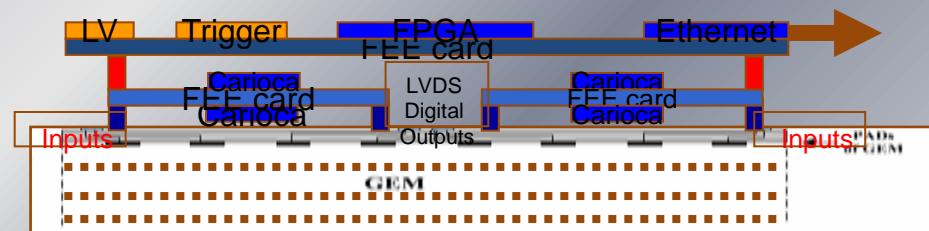


CARIOCA chip cards



The card is based on Carioca Chip and has been designed and realized in Frascati (G. Corradi);
 Total dimension : $3 \times 6 \text{ cm}^2$

16 channels for each card: channel density of 1 ch/cm^2
 Sensitivity of $2\text{-}3 \text{ fC}$, LVDS output (25 ns), Radhard.



We have an Intelligent Mother Board with an **FPGA** (Field Programmable Gate Array) 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
 (A.Balla, P.Ciambrone, M.Gatta)

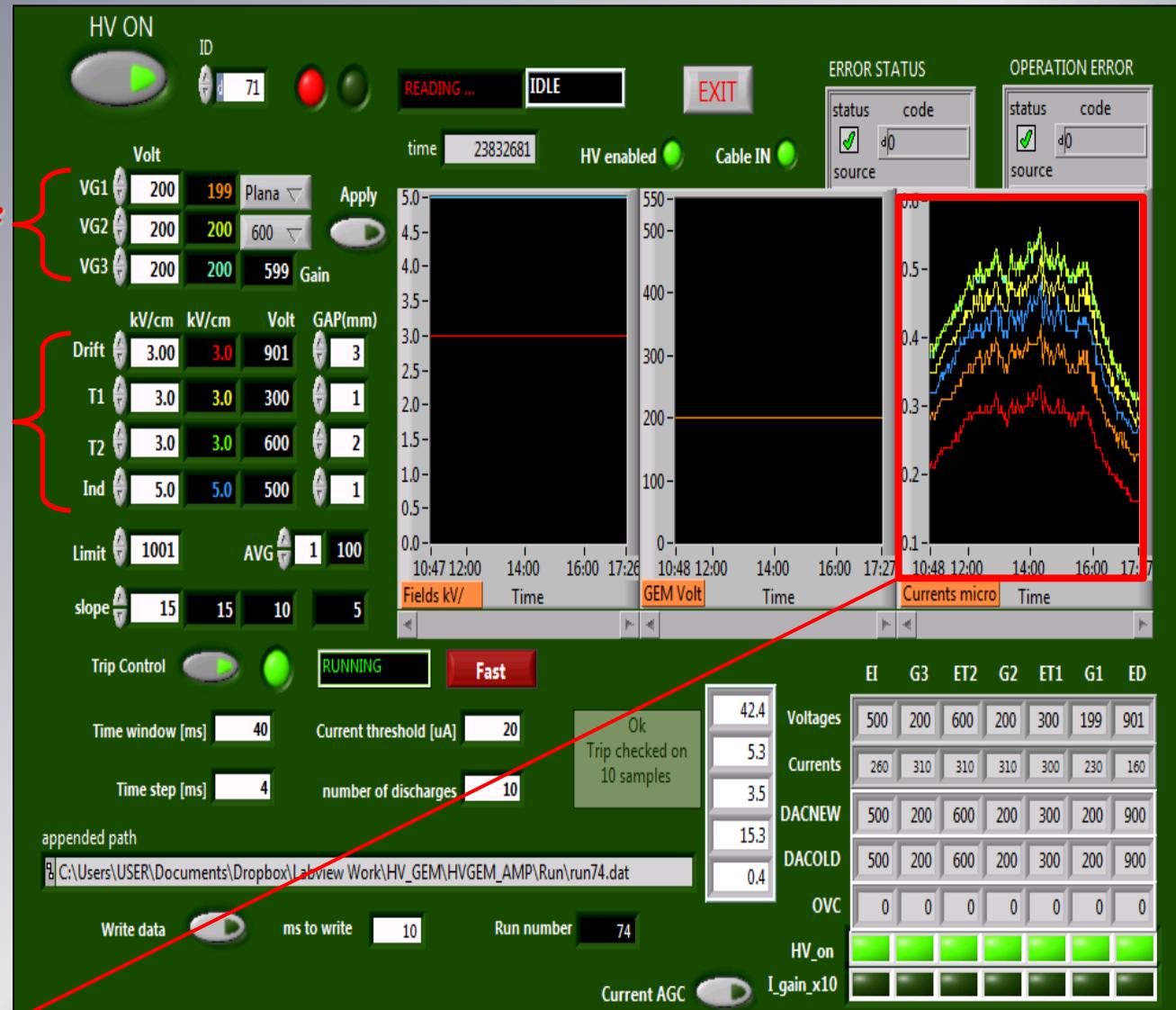
High Voltages: NIM standard HVGEM module

Labview Control Panel
for the High Voltage

GEM Voltage
(gain)

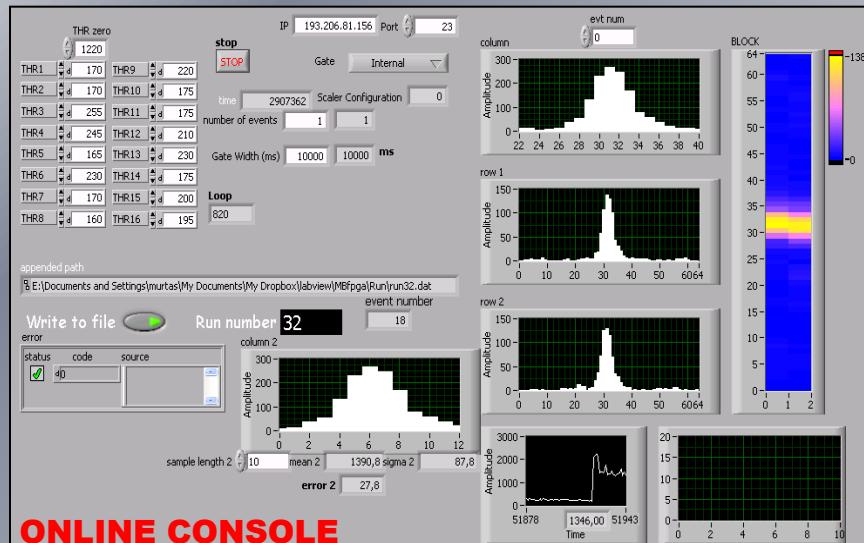
Fields

High Voltage Module for
triple-GEM detector



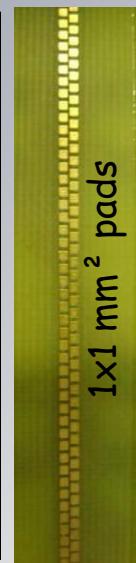
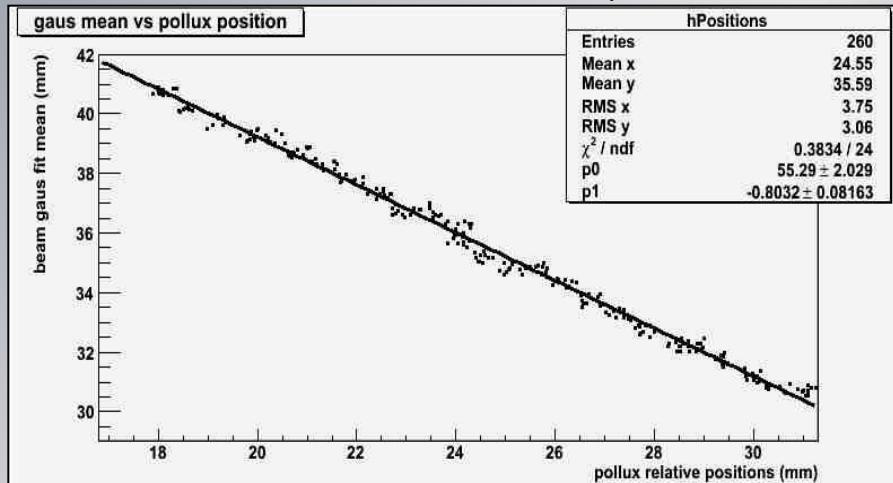
Real-time electrodes current measurements: each channel has a nano-Ammeter which measures the current with a sensitivity of 10 nA.

Scaler mode: beam profile and position

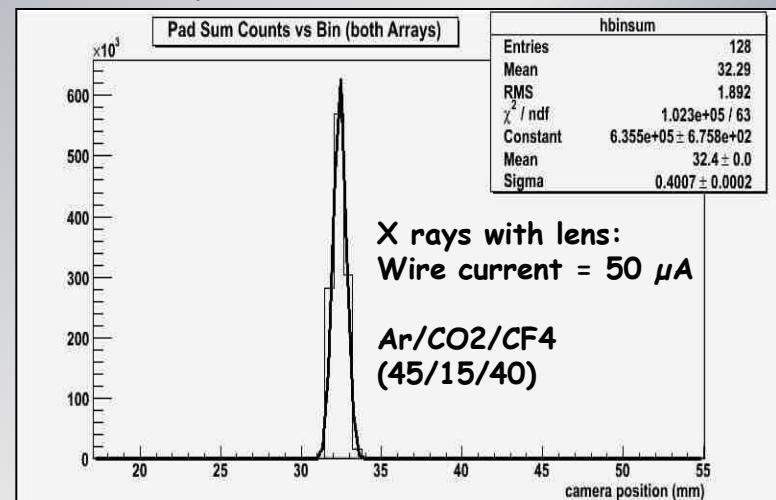


ONLINE CONSOLE

The Chamber is mounted on a mobile support. Moving it at regular steps of 0.50 mm, the event is detected at each position.

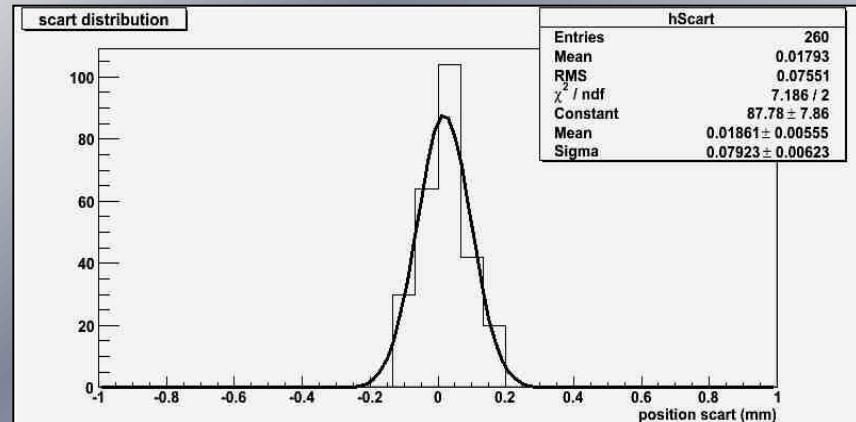


Beam position measurements



X rays with lens:
Wire current = 50 μA
Ar/CO₂/CF₄
(45/15/40)

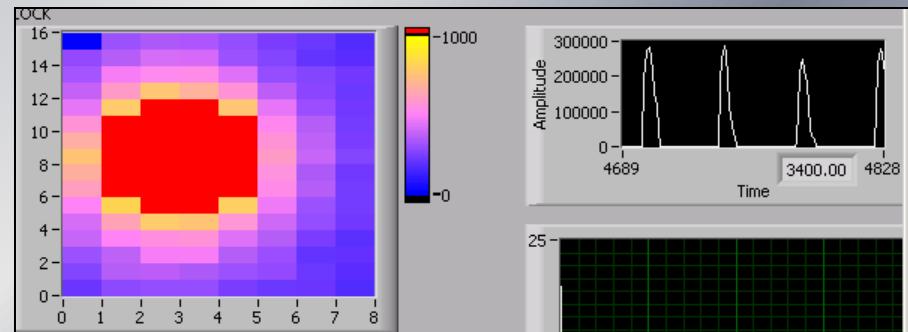
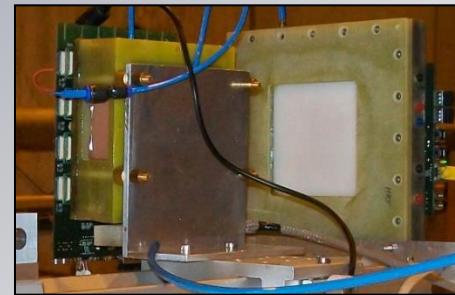
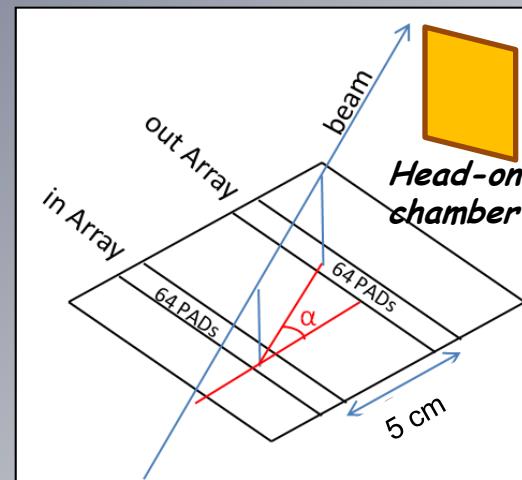
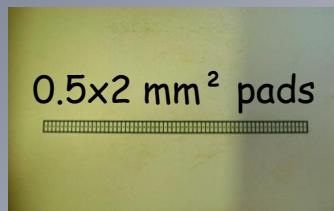
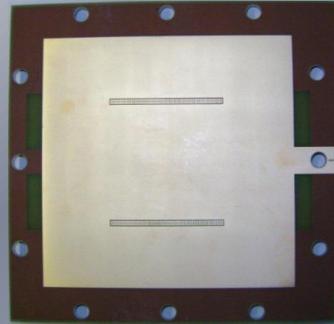
The distributions of the difference between the detected position and theoretical position resulting from the linear fit.



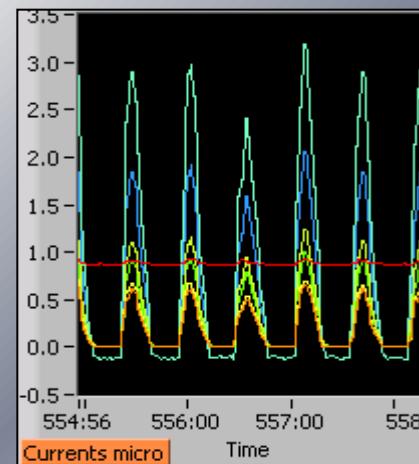
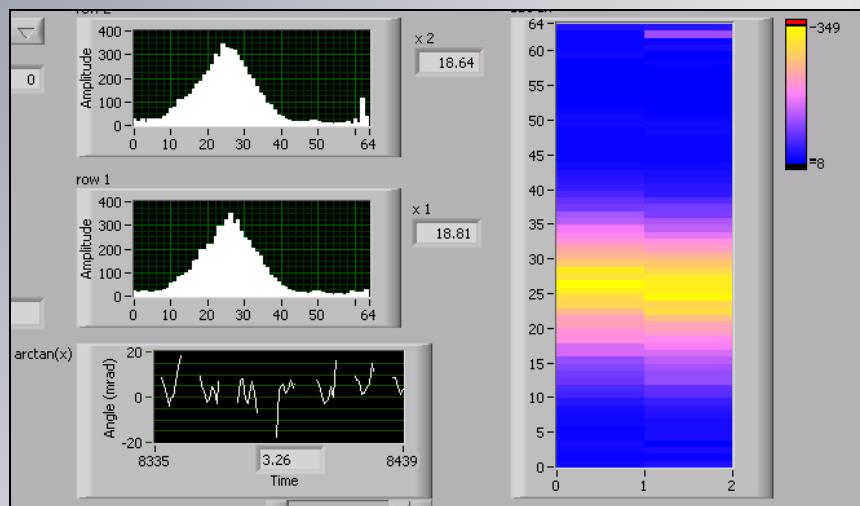
We obtain a spatial resolution of about 80 μm .

Scaler mode: beam profile and angle

This anode configuration permit us to measure the angle α for thin particle beams (res ~ 15 mrad).



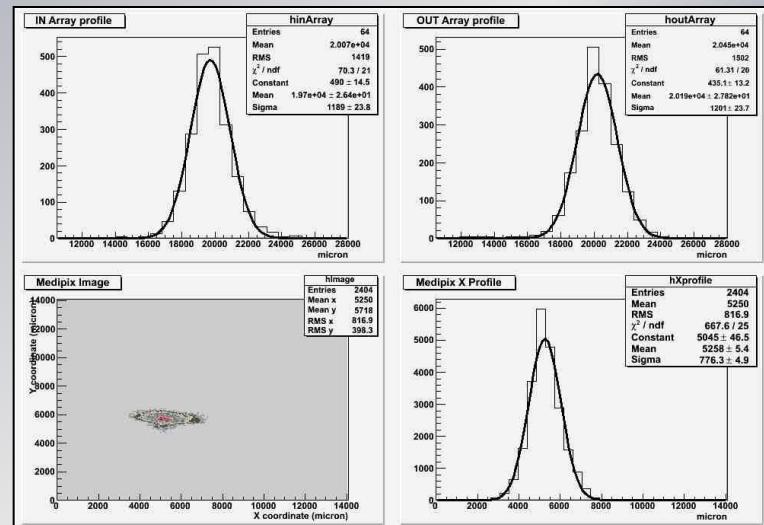
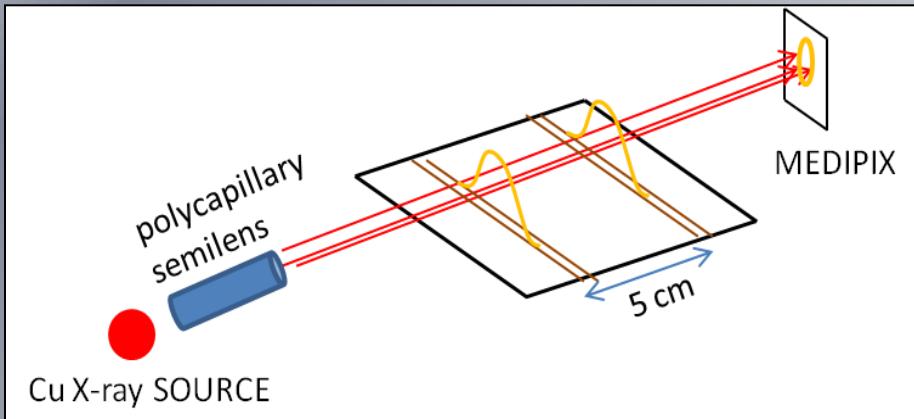
Lead ions beam at CERN (80 MeV/n)



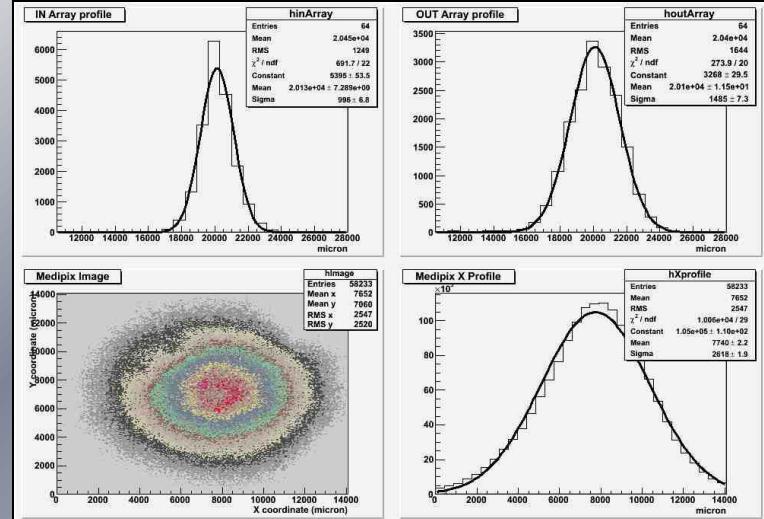
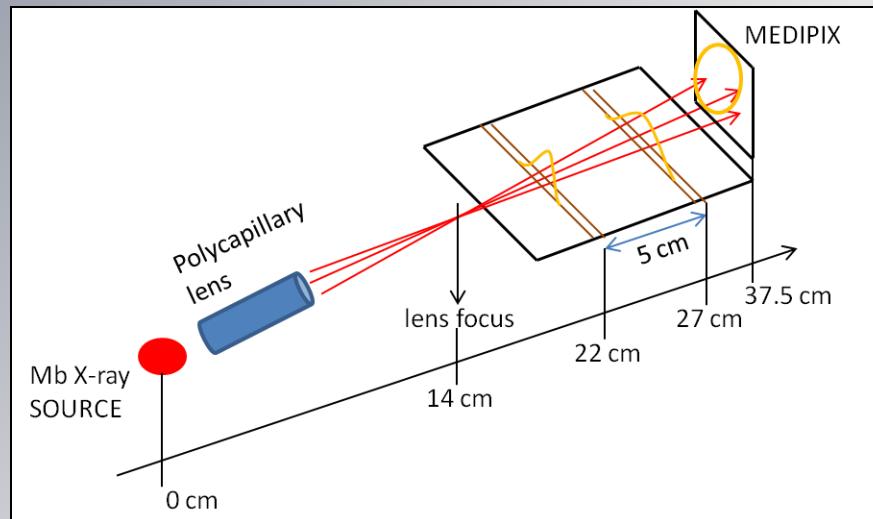
Current peaks are observed the pulsed ion beam passes through the chamber.

Scaler mode: X-ray beam profile and angle

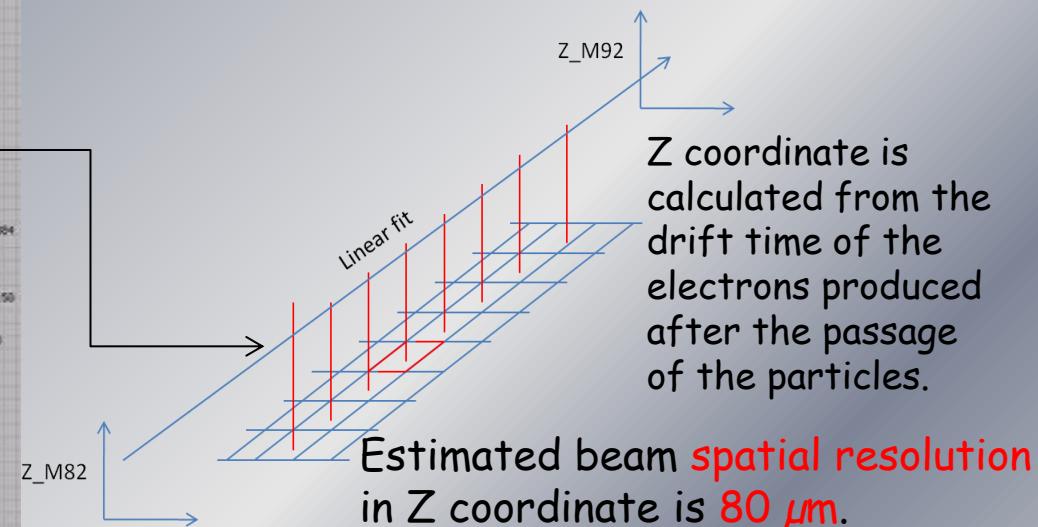
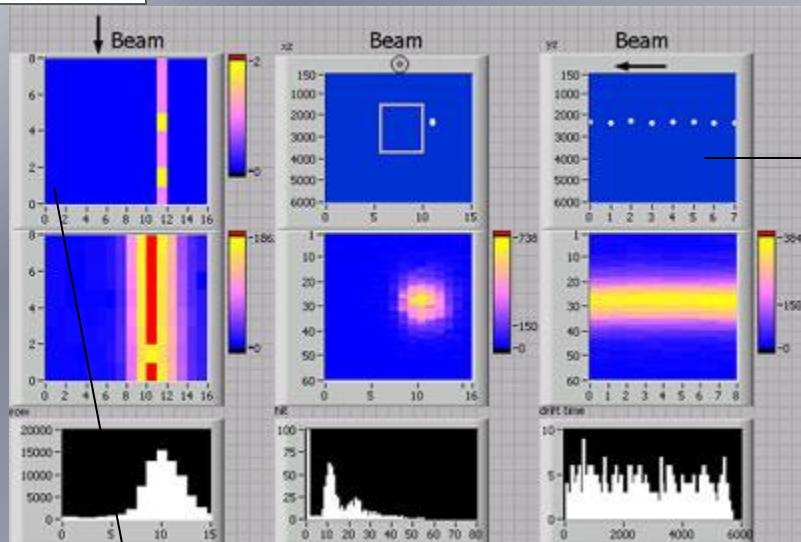
Beam profile measurements for an X-rays beam passing through a polycapillary semilens.



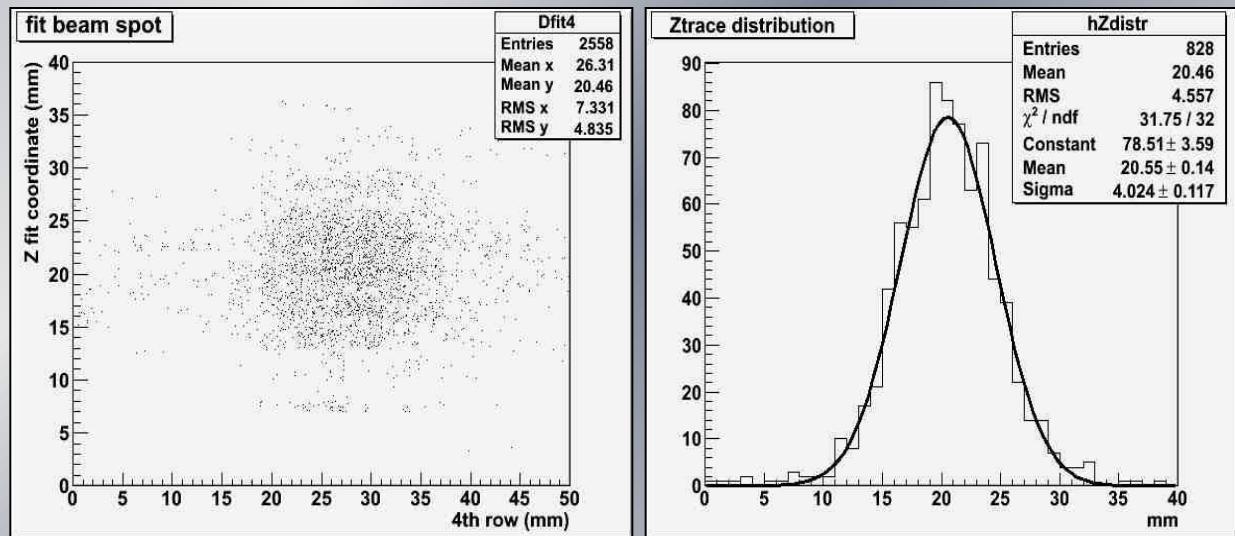
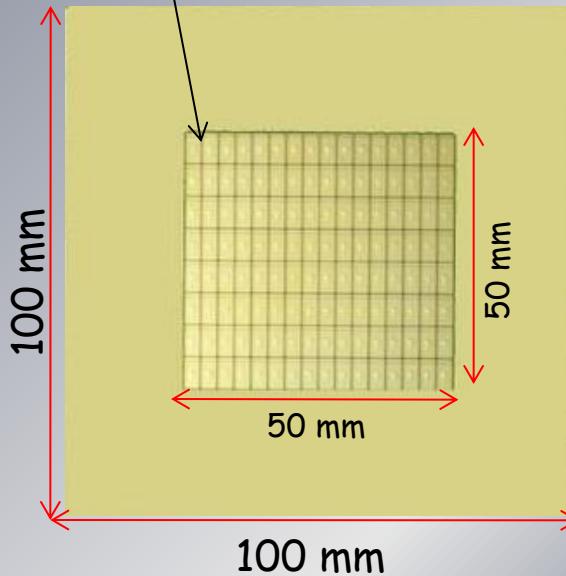
Beam profile measurements for an X-rays beam passing through a polycapillary lens.



TPC mode: 3D beam reconstruction



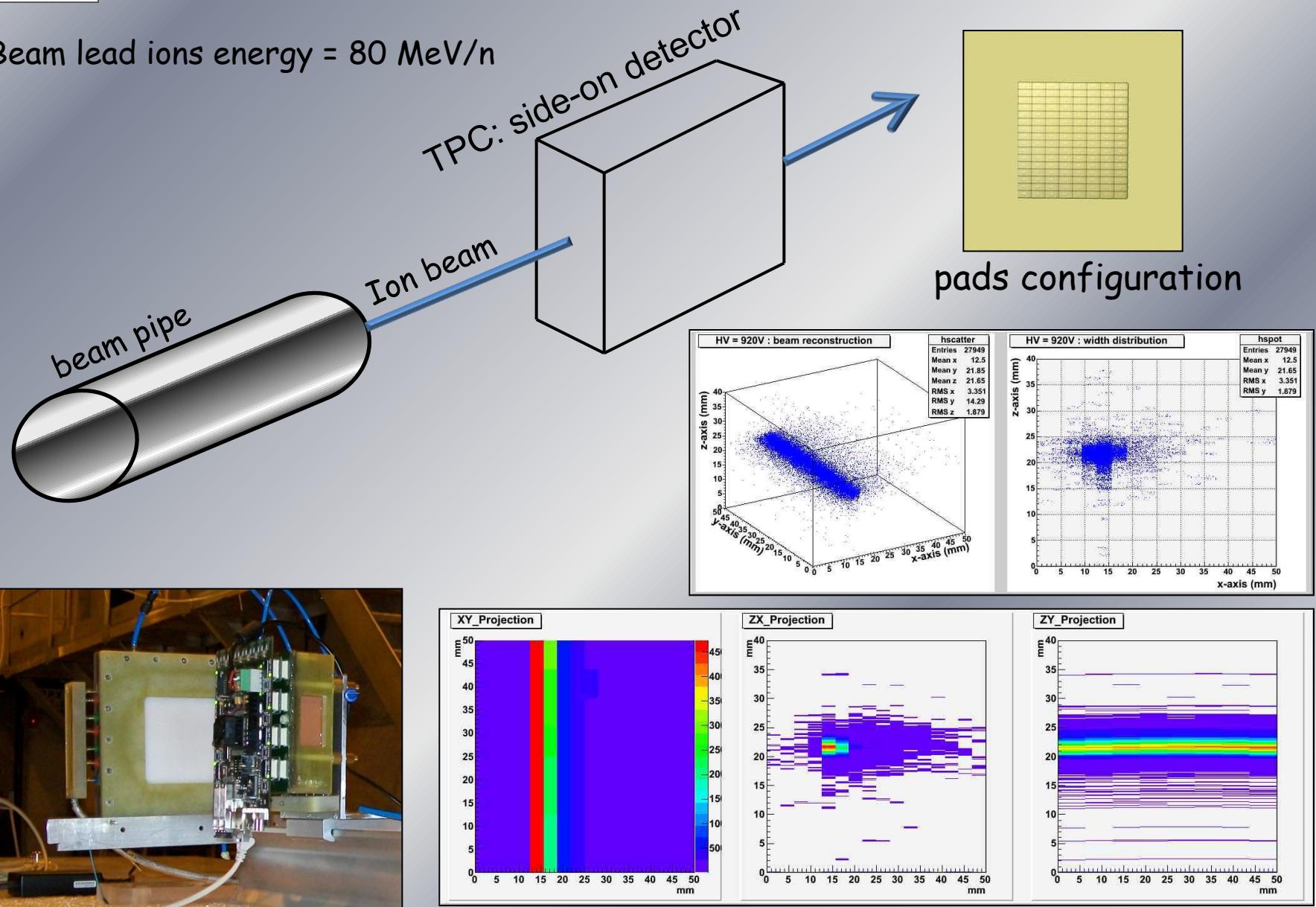
We fit the 8 points of the Chamber trace with a line. Considering the values of this line, we can reconstruct the beam spot at the center of the Chamber



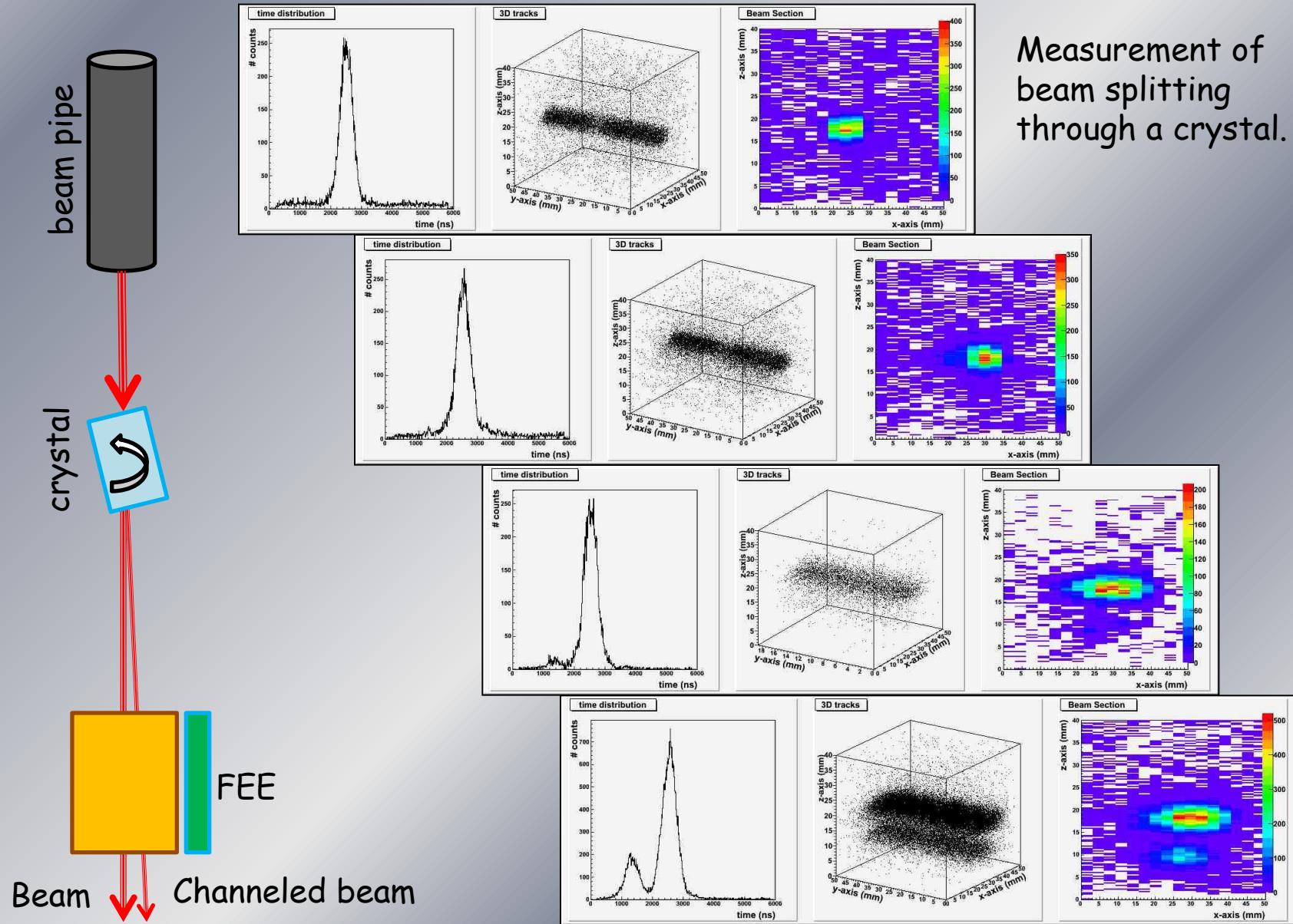
Beam Z profile

TPC mode: lead ion measurements at CERN

Beam lead ions energy = 80 MeV/n



TPC mode: positron beam at BTF



Conclusions

- ✓ TPC GEM is a versatile compact detector with negligible effects on detected beam (**only 0.2% X_0**);
- ✓ read-out electronics shows a **low Carioca Card sensitivity (< 10 mV/fC)**;
- ✓ the **FPGA based Mather Board** simplifies the Data Acquisition and its power supply can be provided by a simple portable switch power pack with a noise lower than the linear power supplier;
- ✓ with **2x64 PADs row lines**, it is possible to reconstruct a continuous beam profile, determine the position with **80 μm resolution** and **14 mrad angular resolution**;
- ✓ with the new pad layout it possible to measure the beam direction with **an angular resolution of about 15 mrad**;
- ✓ with a **16x8 PADs matrix**, in bunched beam it is possible a 3D track reconstruction with **80 μm resolution** in Z coordinate.