Readout studies with planar GEM

TEST BEAM results

SPS North Area H4 beam line
CERN PREVESSIN

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Overview

The test is part of development of a Cylindrical GEM for KLOE-2. A prototype with 1D readout was realized and tested last year.

Final design includes 2-D readout (XV with 40^o angle)

We need to fully characterize 2-D readout (charge sharing, grounding, crosstalk, magnetic field etc)

We built a planar triple GEM's telescope ($10x10\ cm^2$) tested at the H4 SPS beam line at CERN; all the GEM are double masked.

The test has been done in magnetic field with range 0T-1.3T

This study has been done in the framework of the R&D for KLOE-2 experiment

The project for KLOE-2 Inner Tracker has been approved by INFN

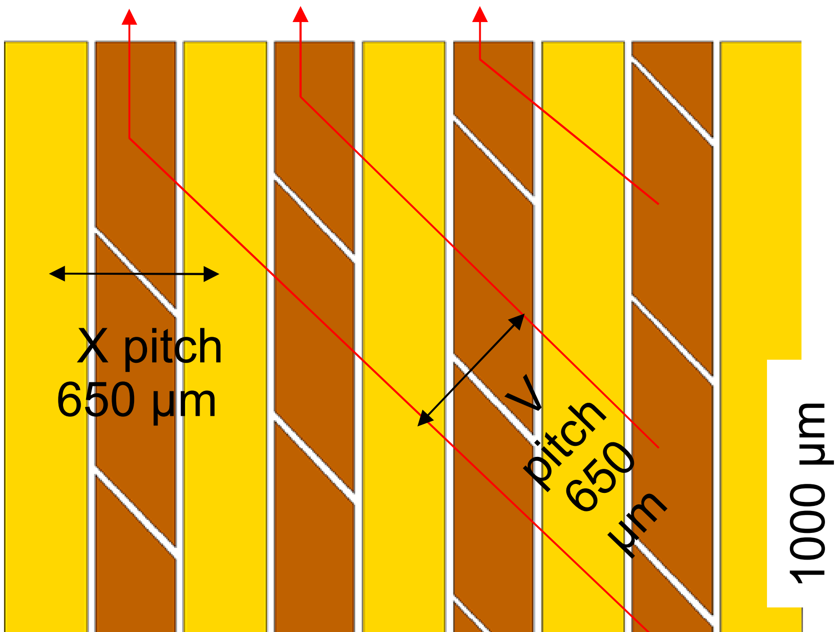
Tracking telescope:

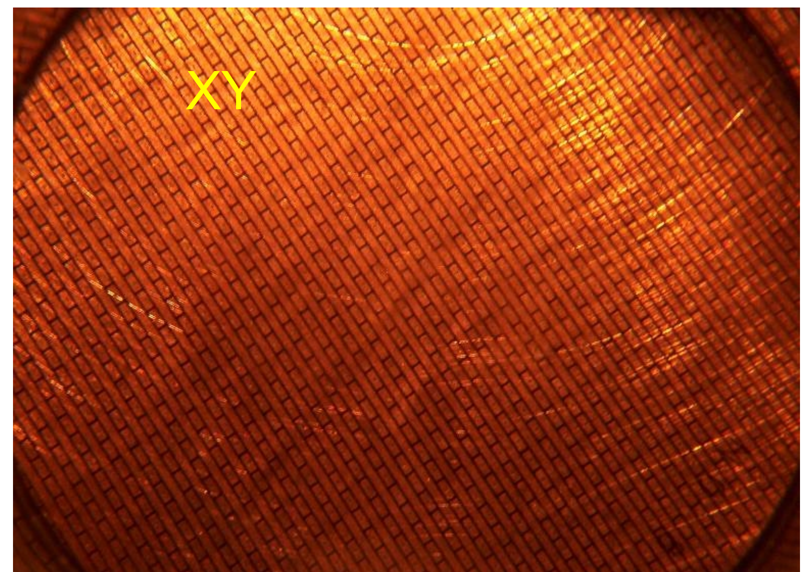
4 GEMs with XY (used as *external trackers*)

Chamber under investigation:

1 GEM with XV readout strips (*the 2-D pattern we will used for the IT*)

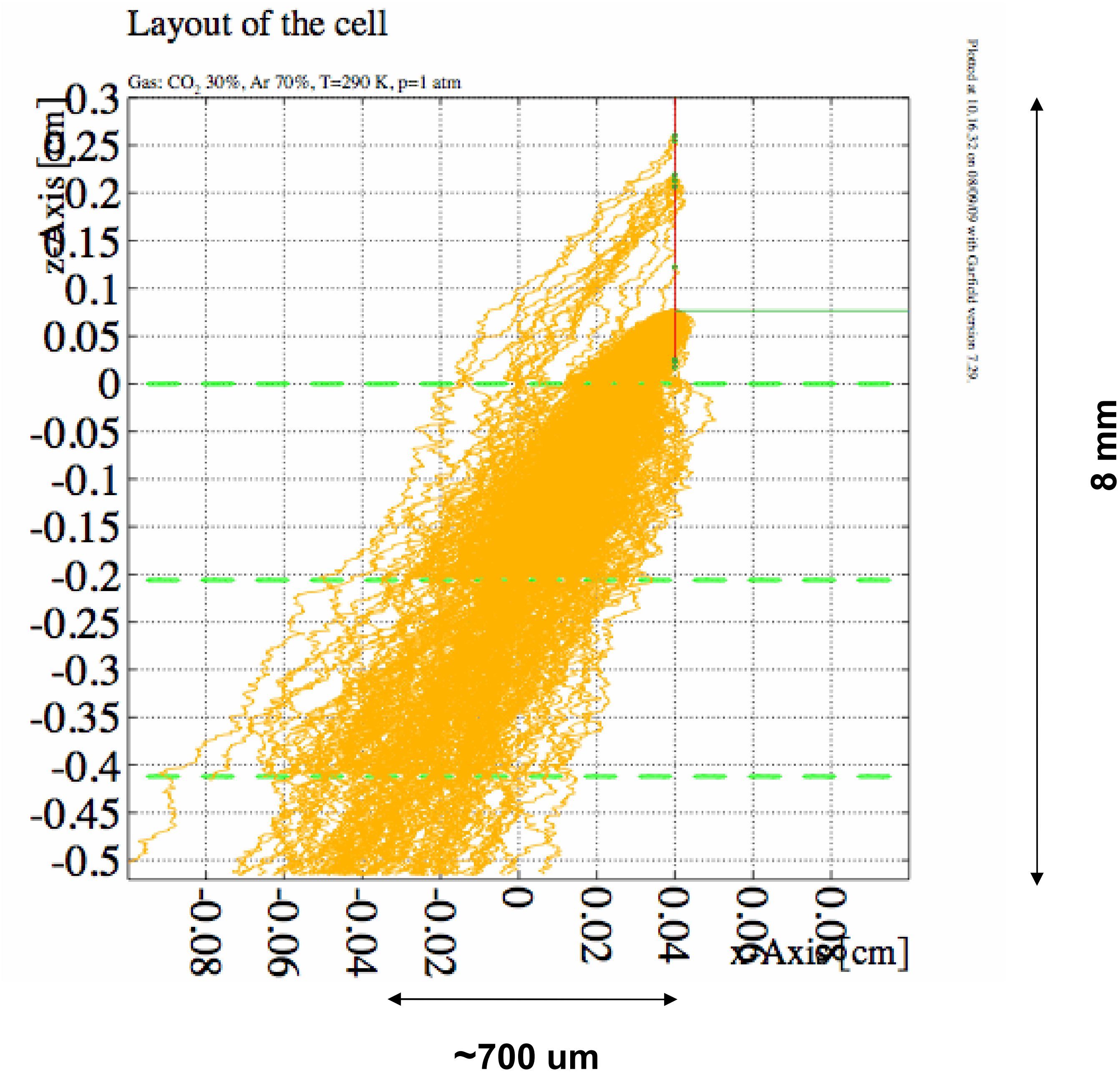
650 µm pitch, with digital readout (GASTONE: an ASIC chip realized for this project).





Effect of magnetic field

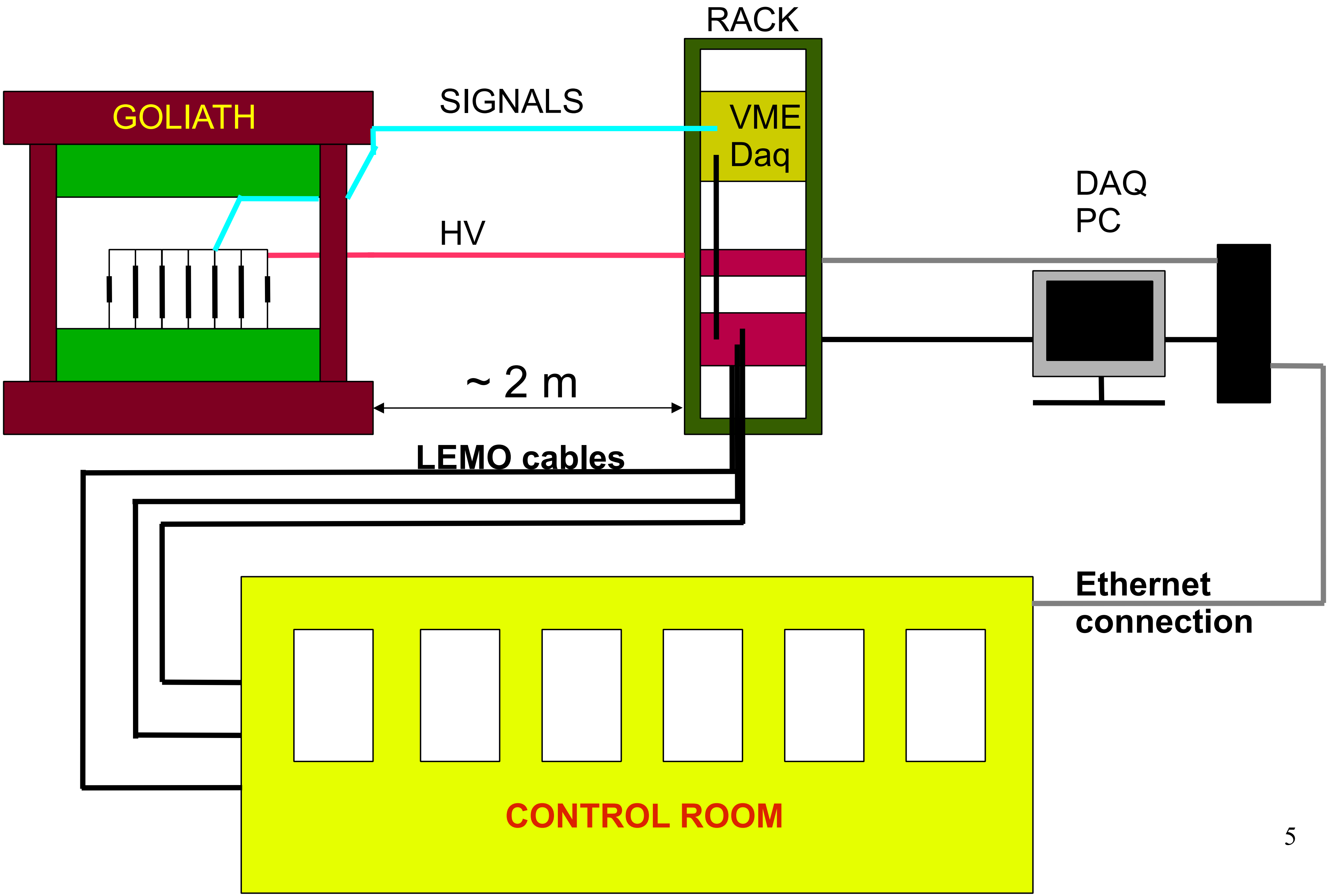
At test beam we used Goliath magnet, B field up to 1.5 T
The chambers were filled with **Ar/CO2**



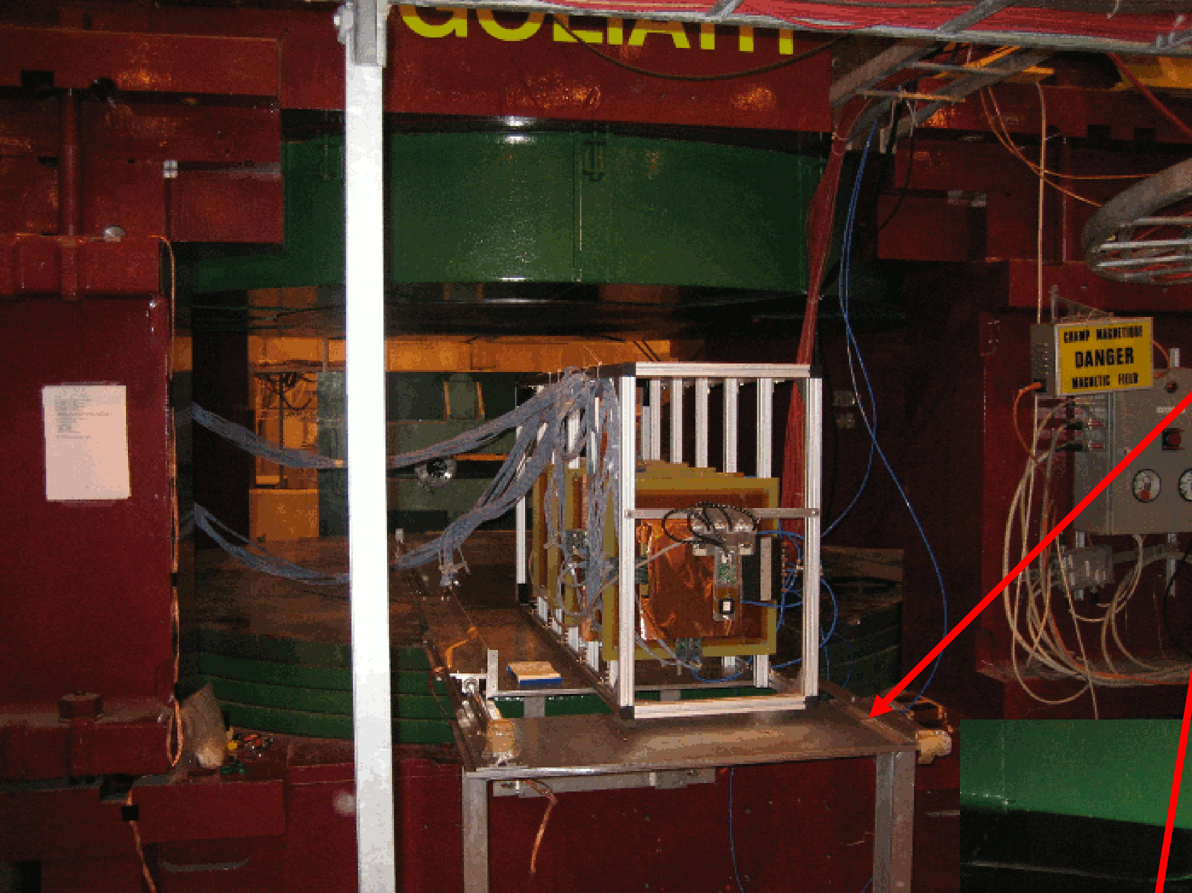
A triple GEM (3/2/2/1) was built with ANSYS and simulation of electrons drift motion with 0.5 T (the foreseen KLOE-2 magnetic field) was done with GARFIELD

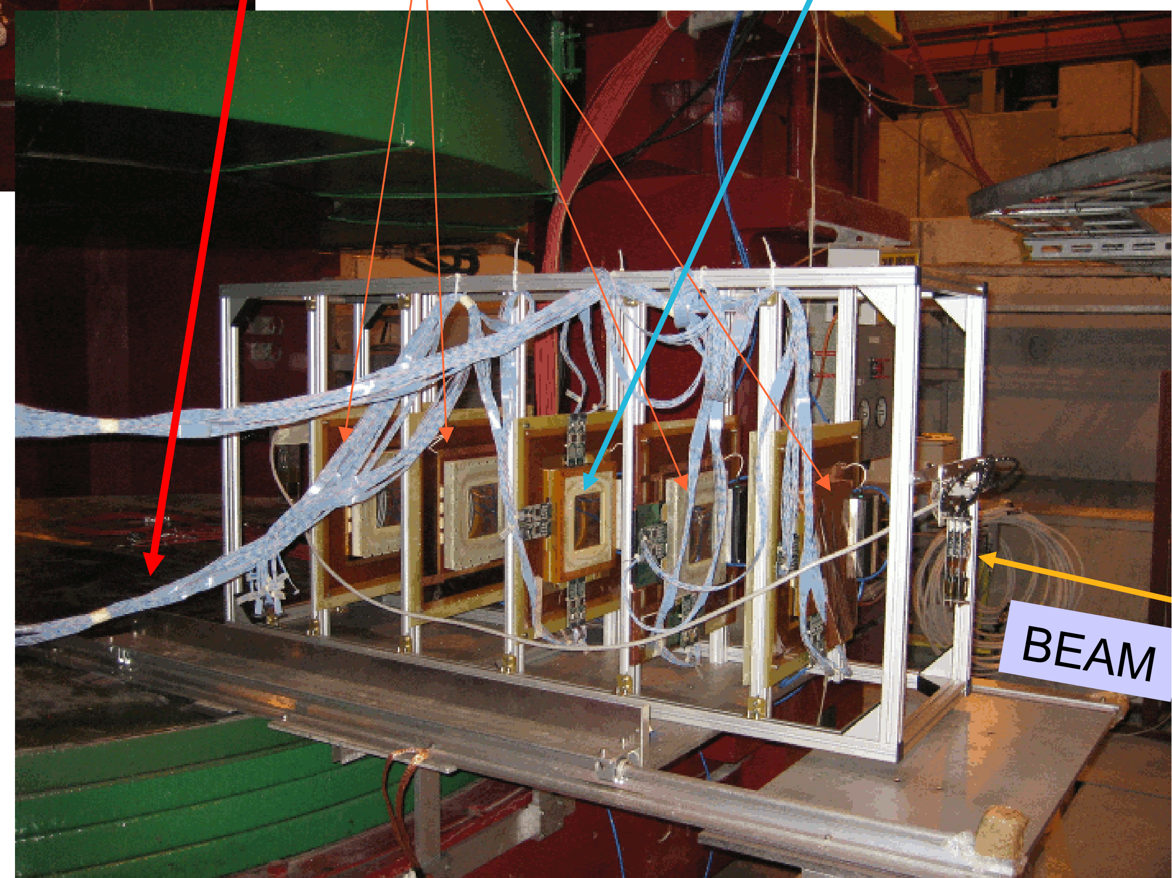
Ar/CO_2=70/30
B=0.5 T
Mean Lorentz angle ($<\alpha_L>$) ~ 8°-9°

The experimental layout



SPS North Area H4 beam:
π 150 GeV/c





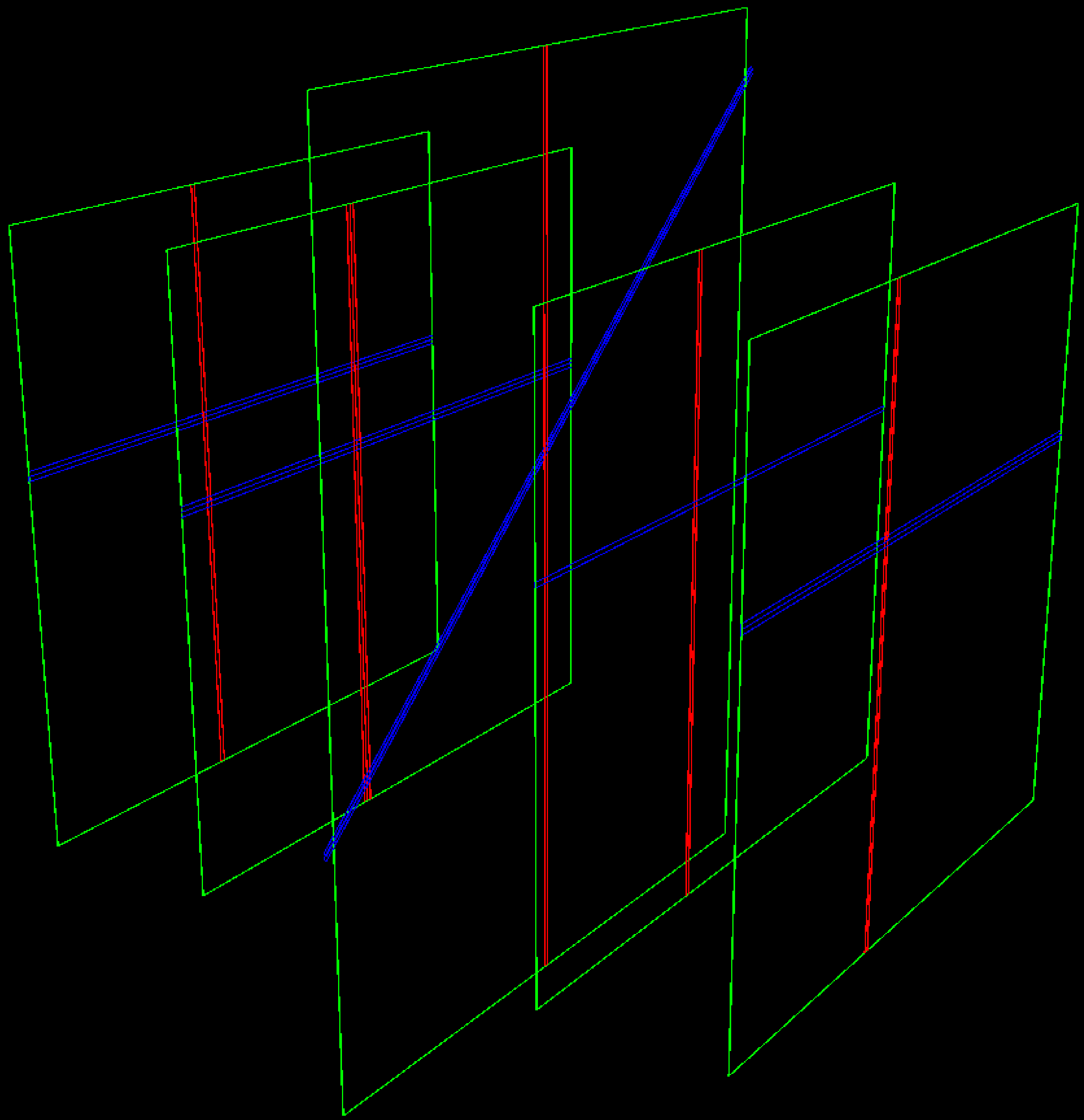
Gas: Ar-CO_2 70-30

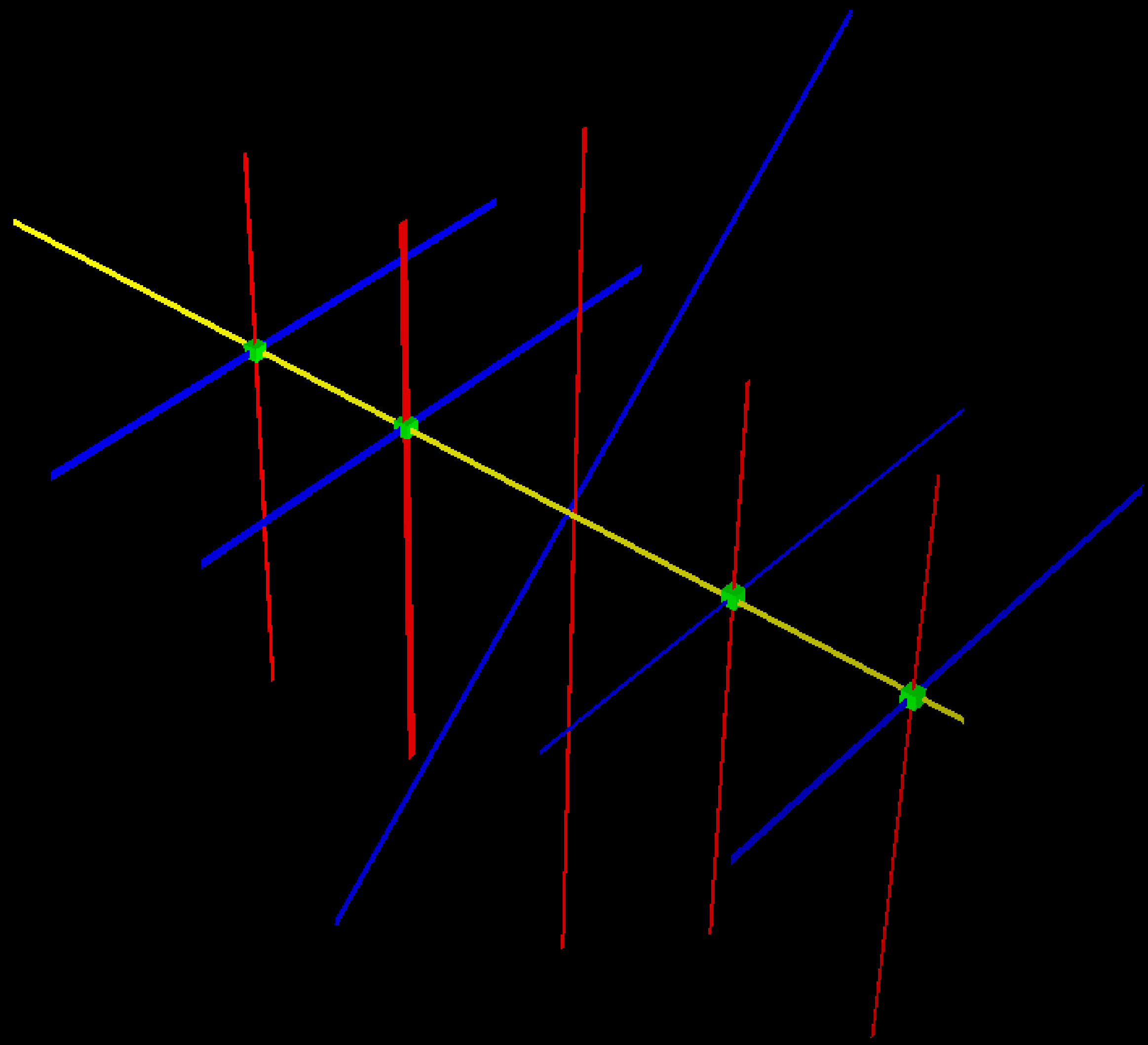
Fields: 1.5 - 3.0 - 3.0 - 5.0 kV/cm

V_{GEM}: 390-380-370 =1140V, gain~$2 \cdot 10^4$

FEE:
GEMs partially equipped with 22 GASTONE boards

trigger:
6 scintillators with SiPM



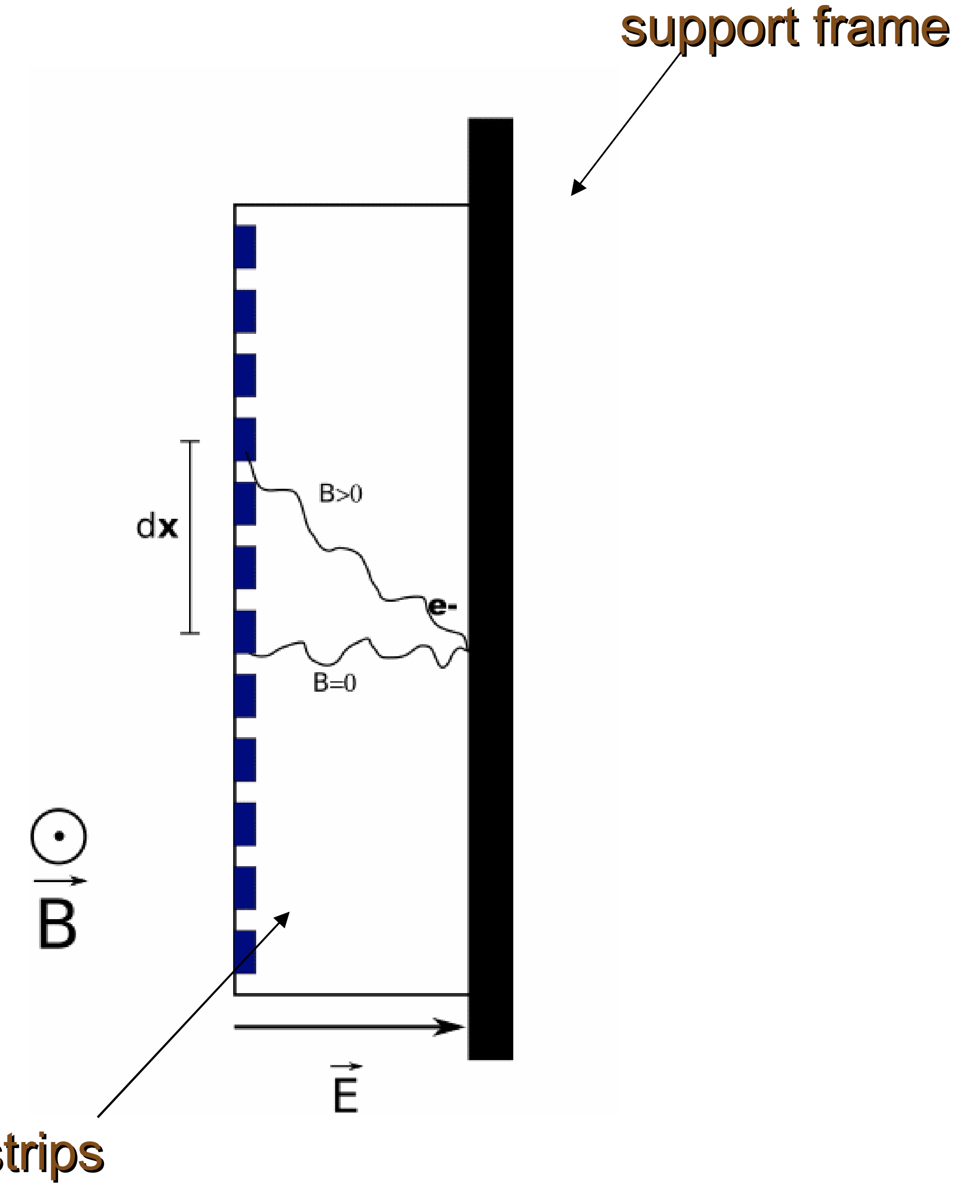


What we measured

- The displacement of electrons due to the Lorentz strength
- The spatial resolution depending on magnetic field
- Reconstruction efficiency and cluster size in function of ΔV and B

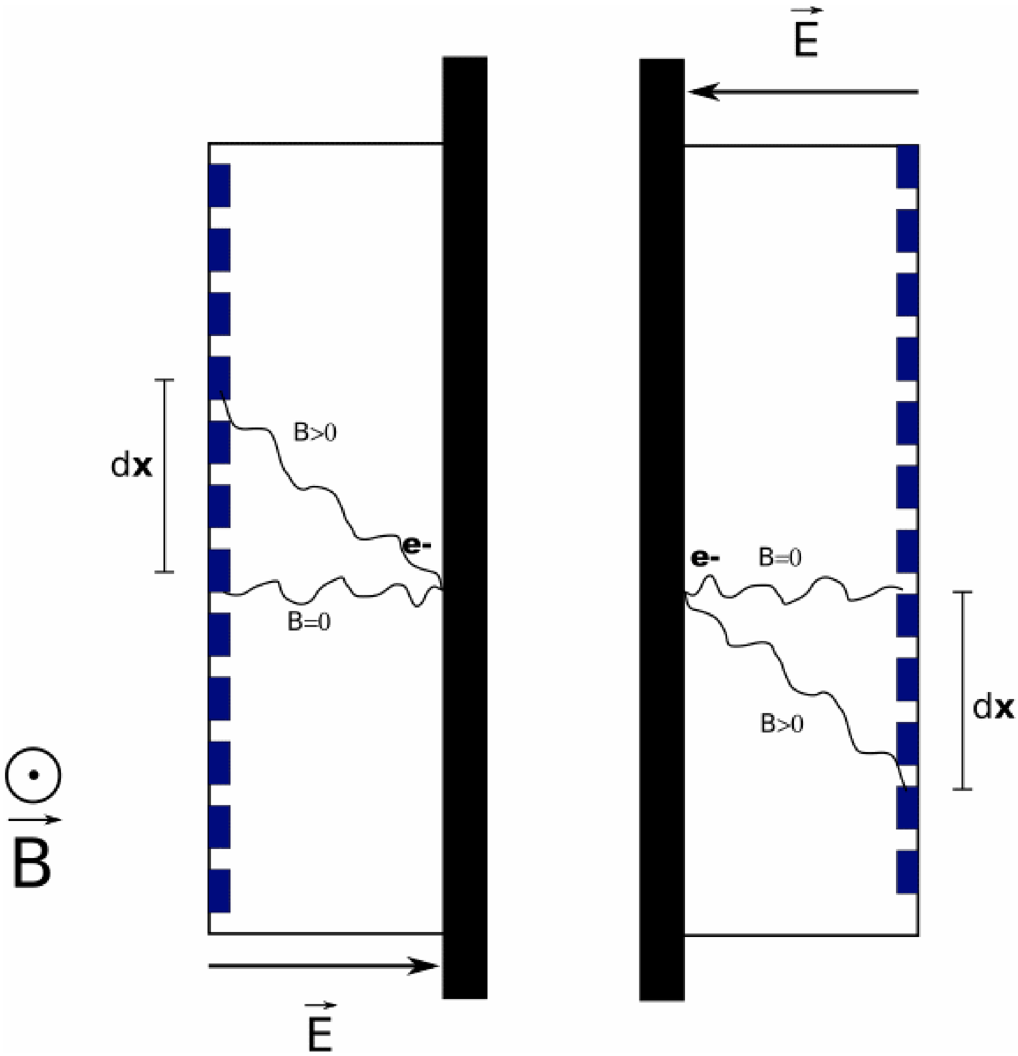
Lorentz angle

- **dx -** displacement on the readout plane due to effect of the magnetic field

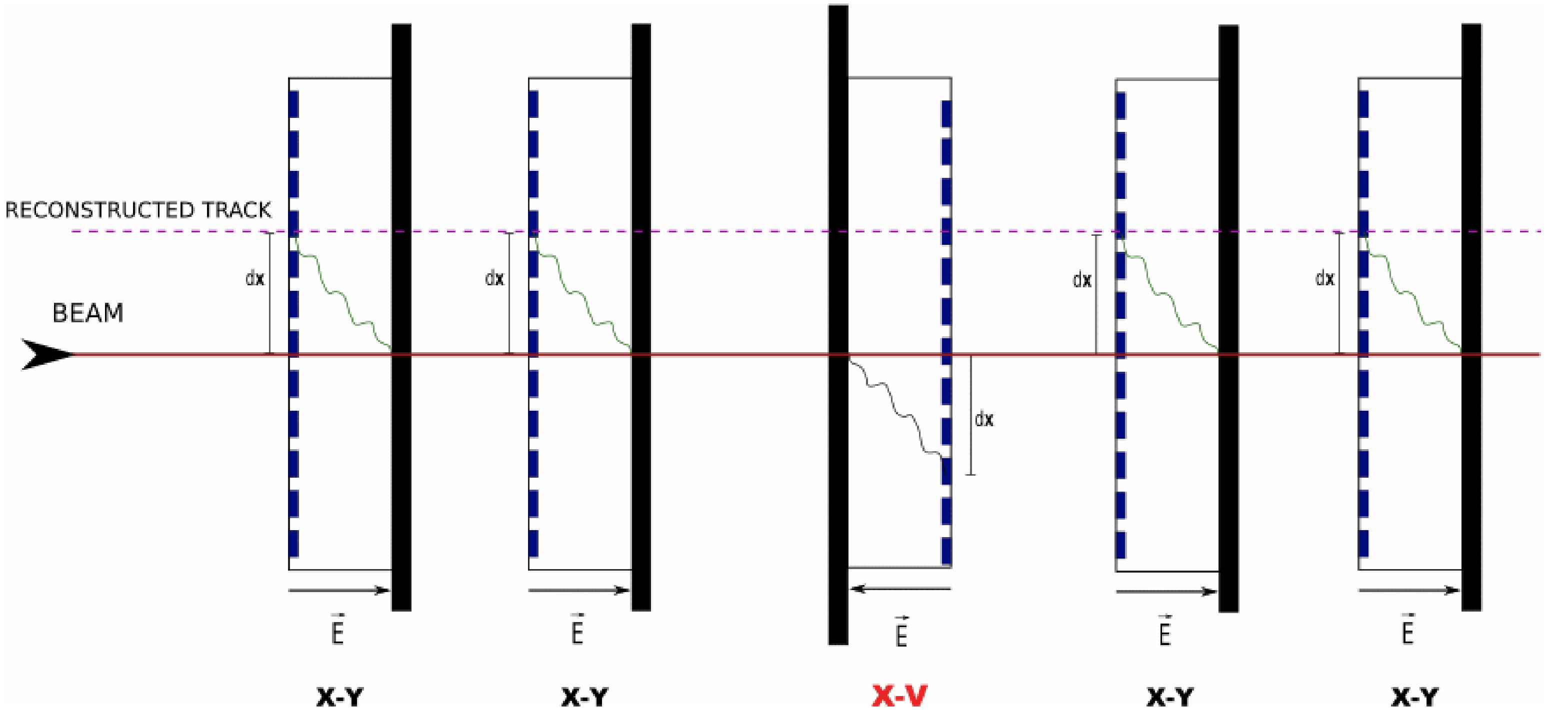


Lorentz angle

- **dx** - displacement on the readout plane due to effect of the magnetic field
- after rotation the electric field changes direction and the displacement will be reversed



Lorentz angle

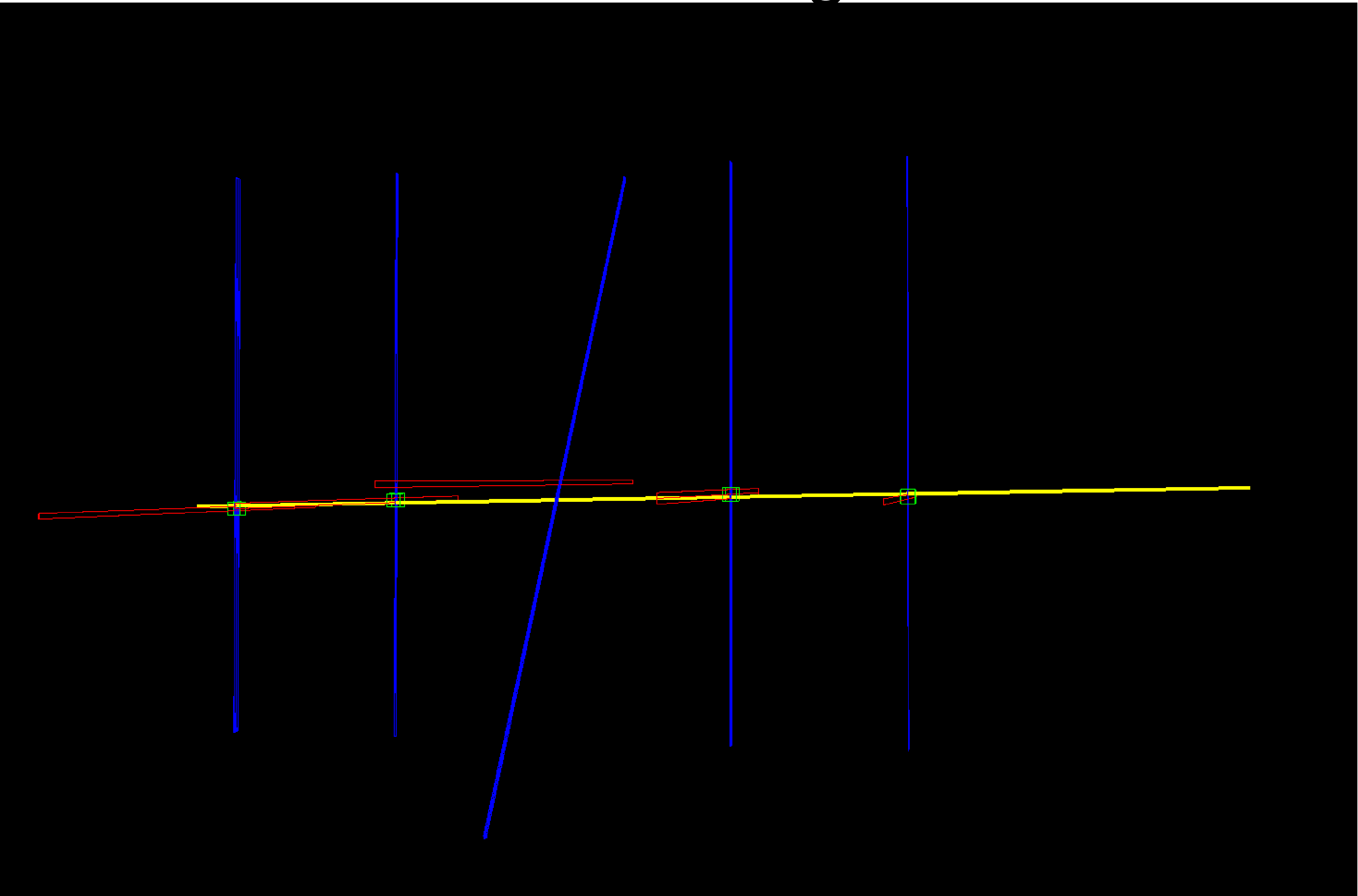


- we align the setup with B = 0
- turn on B field
- we reconstruct the track using only 4 X-Y planes
- we measure the displacement on X-V plane

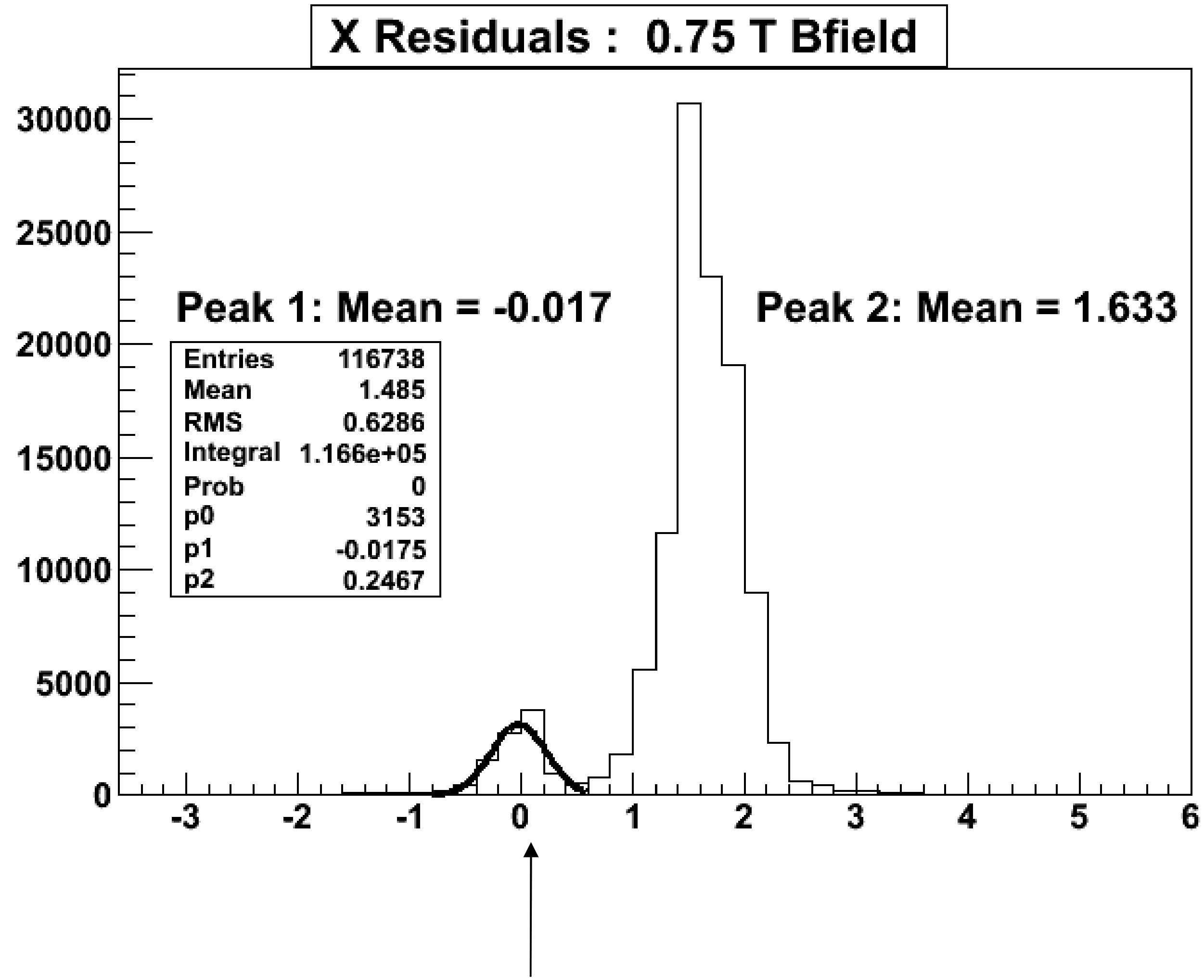
measured displacement $D = 2 \cdot \boldsymbol{r} \cdot \tan \alpha_L$

(where ***r*** is effective thickness of the detector)

Lorentz angle



Displacement

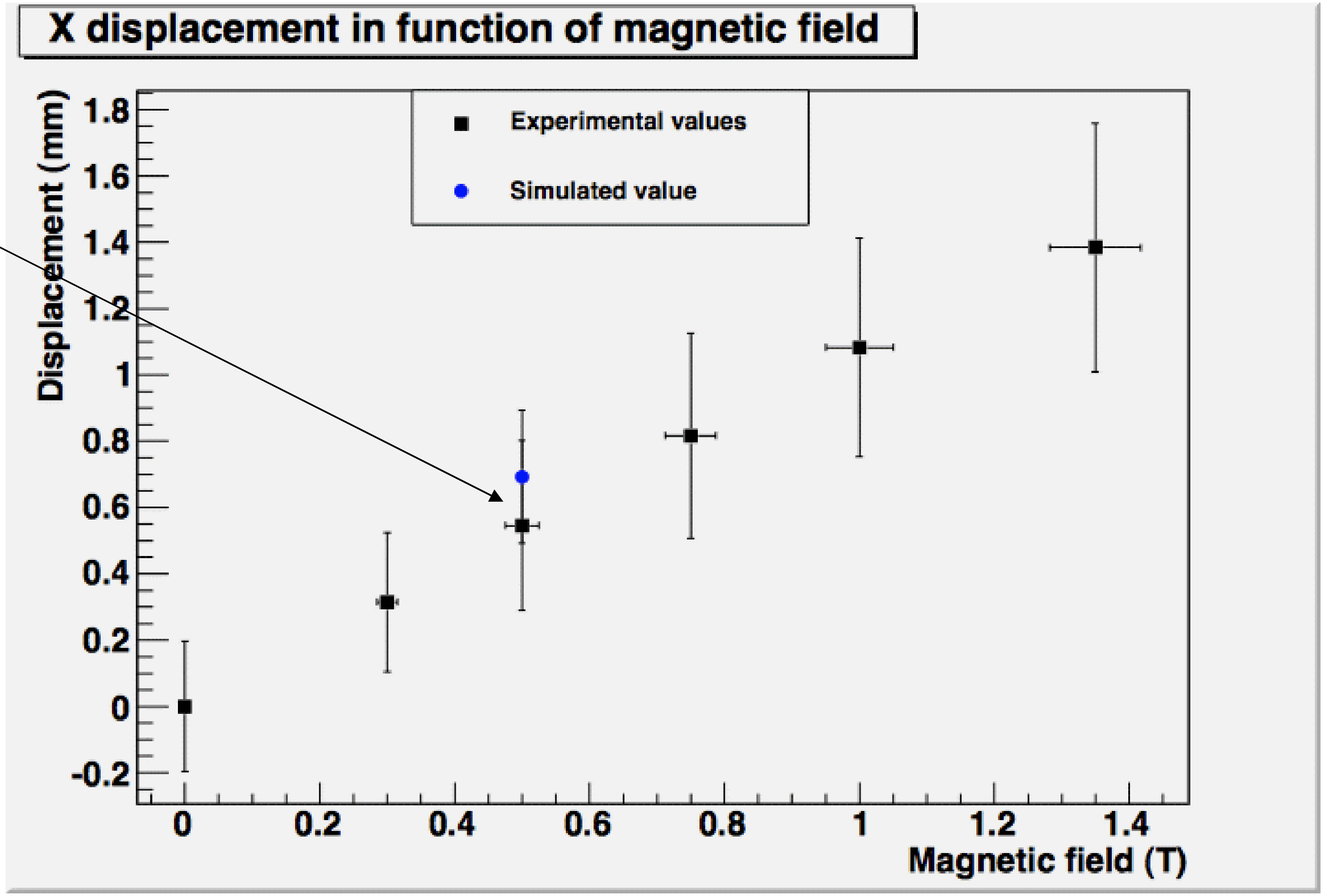


THE MAGNET ACCIDENTALLY TRIPPED DURING THE RUN

Lorentz angle measurement

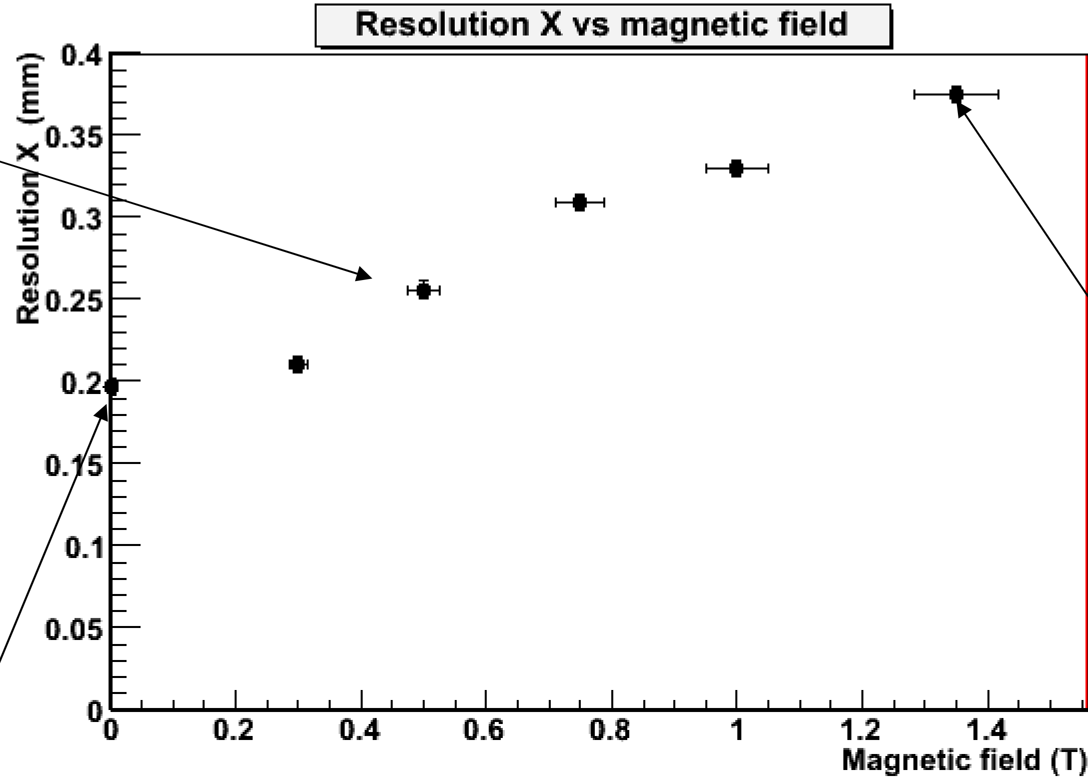
Blue point from very preliminary GARFIELD simulation
The point fits roughly calculated (factor 0.5 included) measured offset at 0.5 T

KLOE
B field

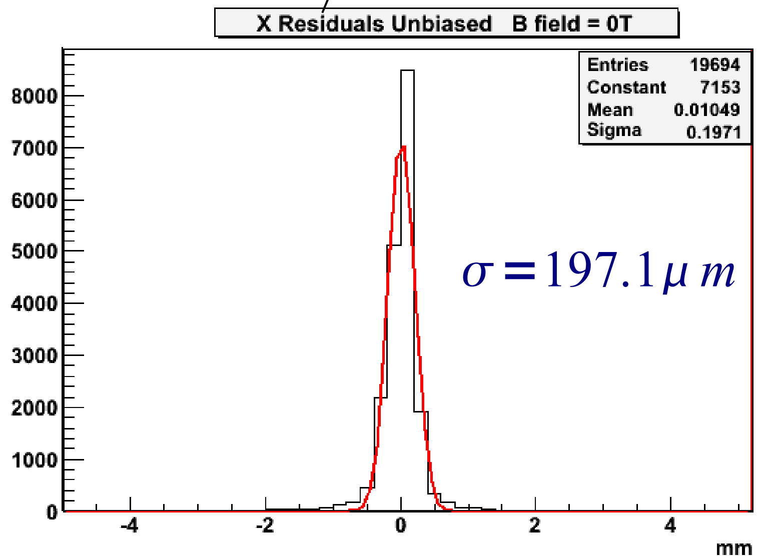


Resolution in X plane (bending plane)

KLOE B field

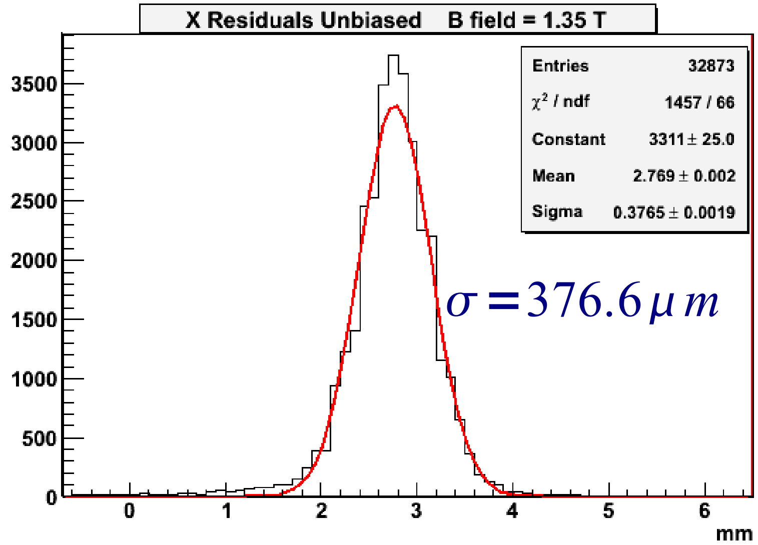


V_{GEM}: 390-380-370 =1140V, gain~$2 \cdot 10^4$



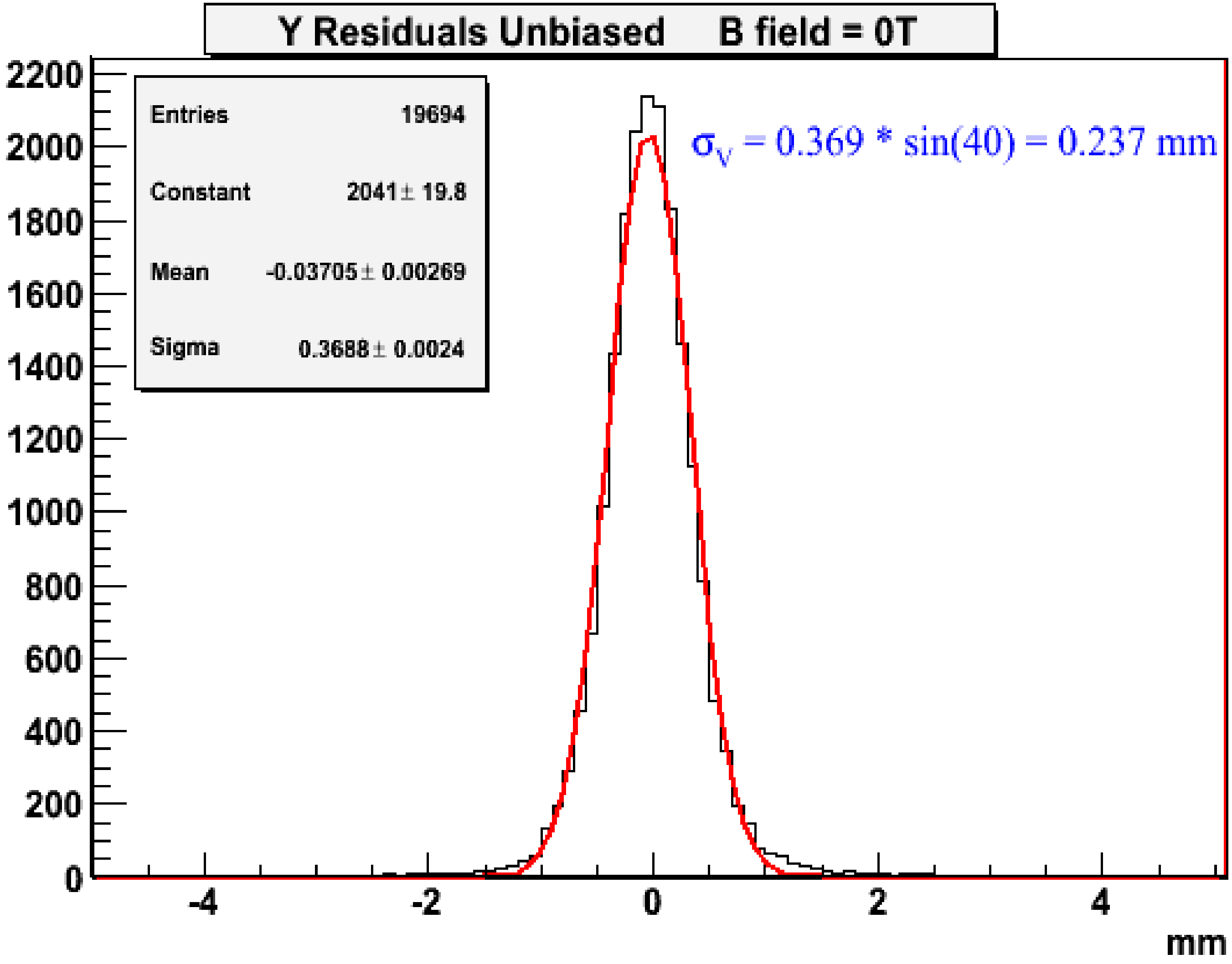
$\sigma = 197.1 \mu m$

The magnetic field increases the spread of the electrons



$\sigma = 376.6 \mu m$

Y resolution

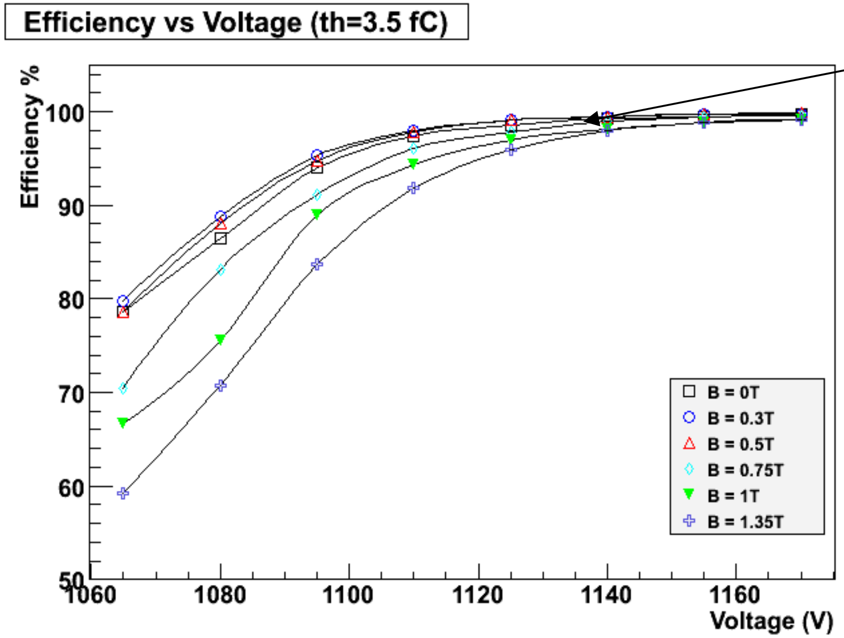


40° is the angle between the V strips and the y coordinate

Efficiency measuments

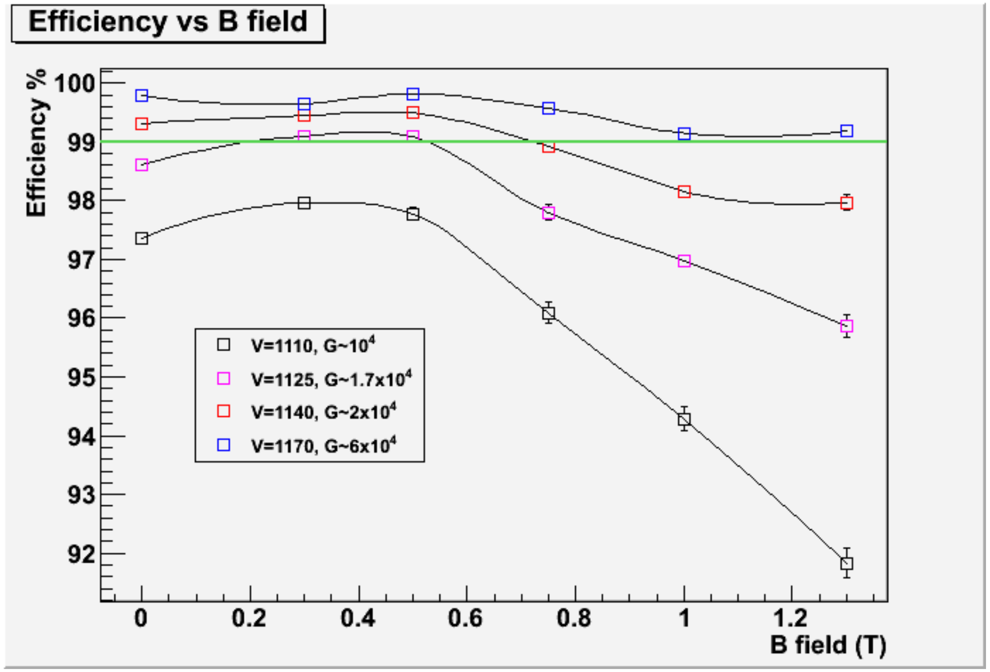
No significative variations among the curves of 0T, 0.3T and 0.5T

Working point: G~2·10^4

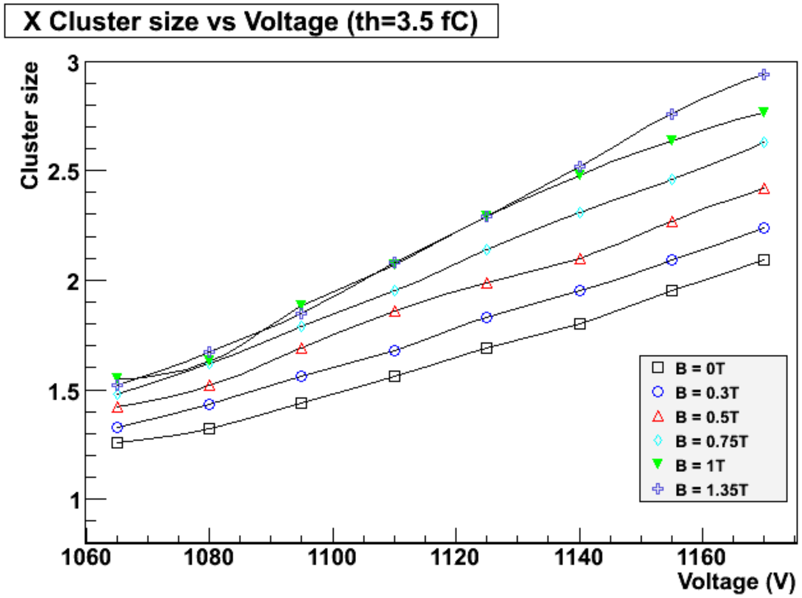


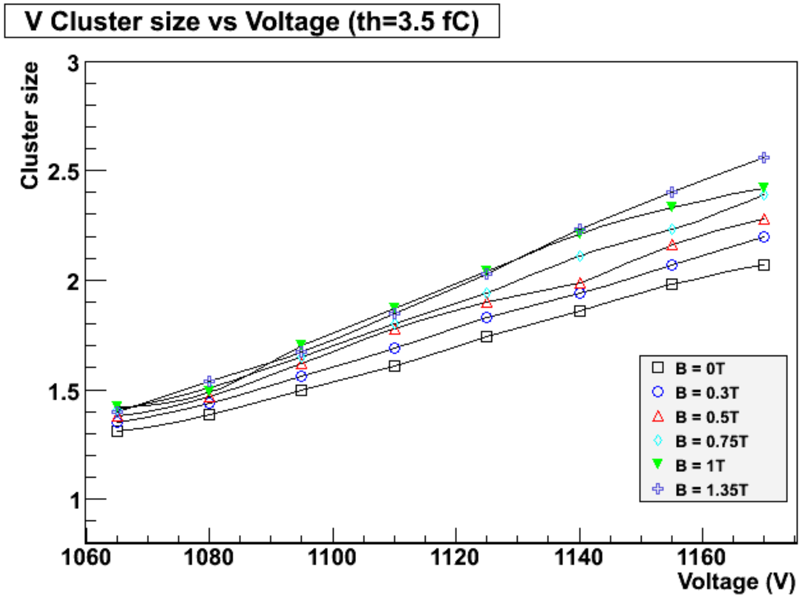
In the electron drift motion the diffusion adds to Lorentz strength, increasing their spread. The bending plane is the x-z: for this reasons the effect is greater for x strips than for the v ones.

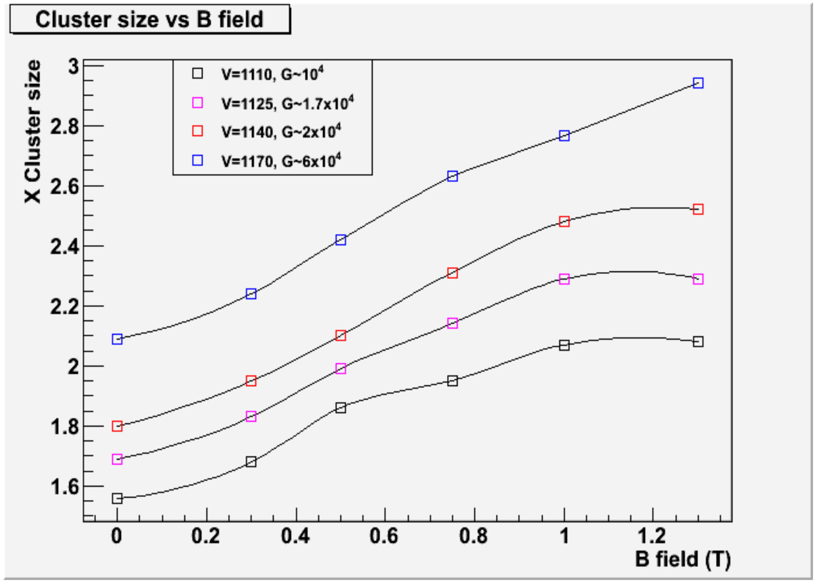
A good efficiency in presence of magnetic field can be reached working at higher gain



Cluster size measurements







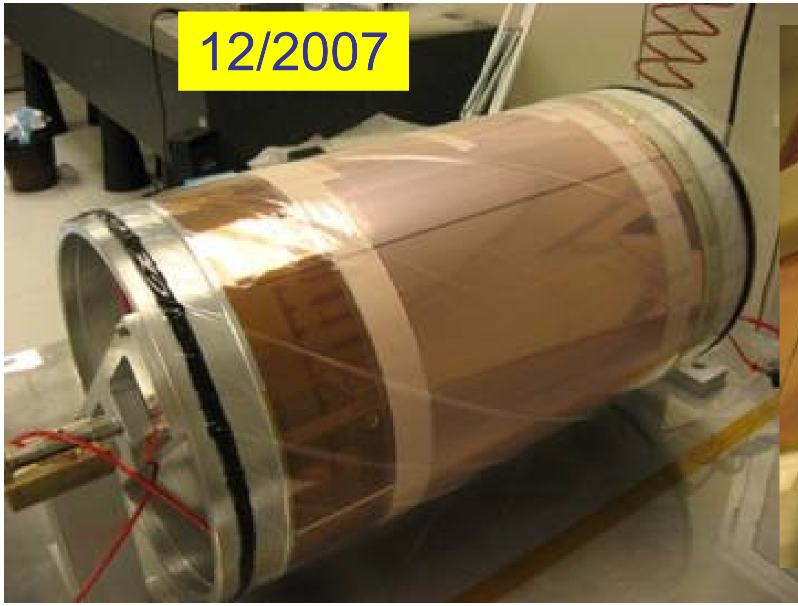
The cluster size gets worse as magnetic field increases because of a larger spread of electrons in the gas gaps

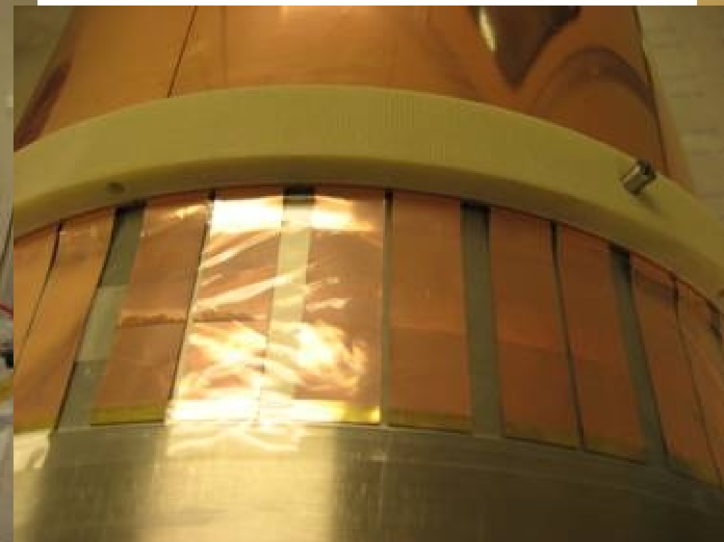
Conclusions

- The XV readout system for the IT with CGEM of KLOE-2 experiment works as expected
- Magnetic field up to 0.5 T doesn't significantly affect recostruction efficiency and the spatial resolution of the detector
- Simulation studies are in progress

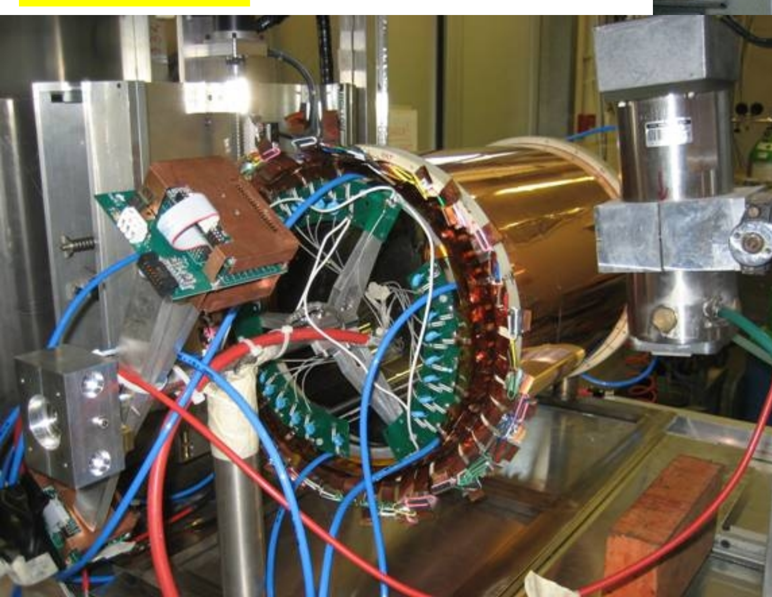
Construction of the CGEM proto & test

12/2007

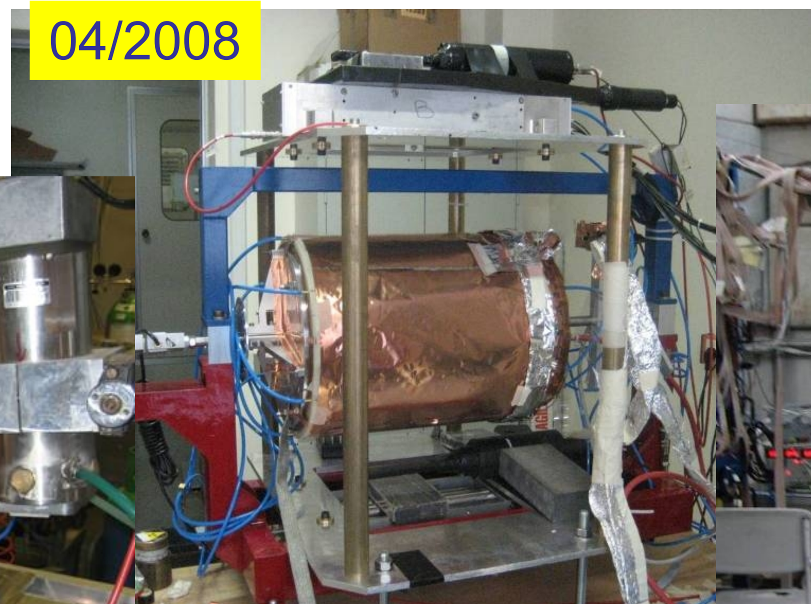




02/2008

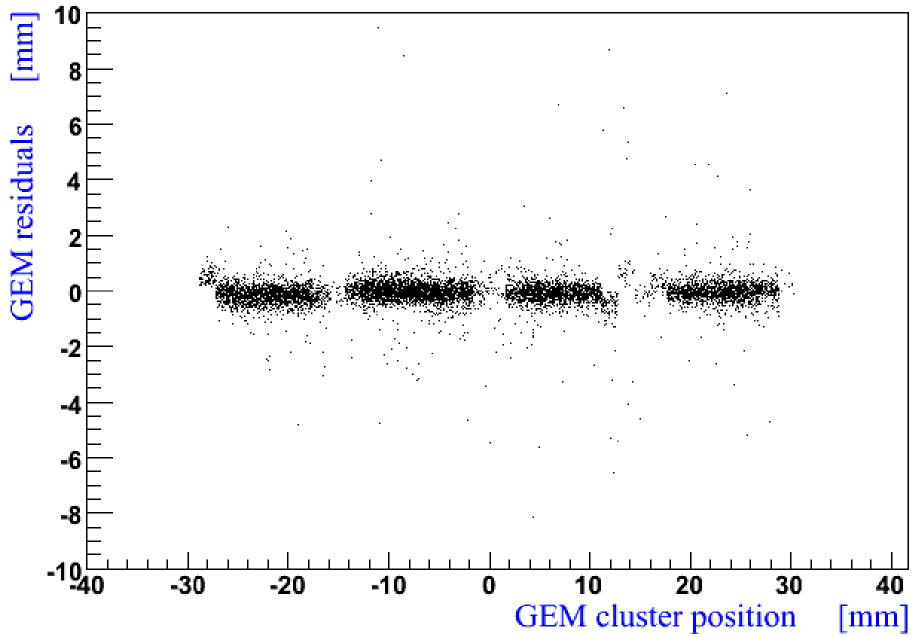


04/2008

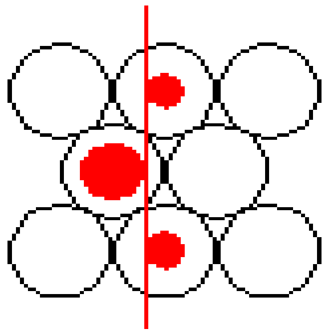


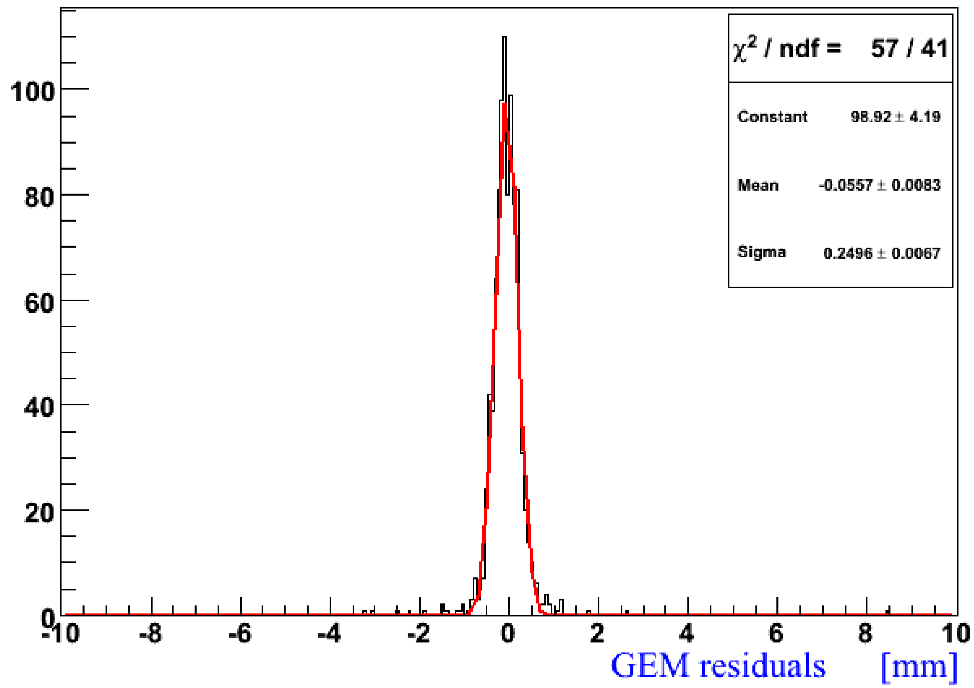
07/2008

CGEM TB-2008 results: 1-D strips (650 μm pitch)



GEM residuals with respect to the track reconstructed by the external drift tubes





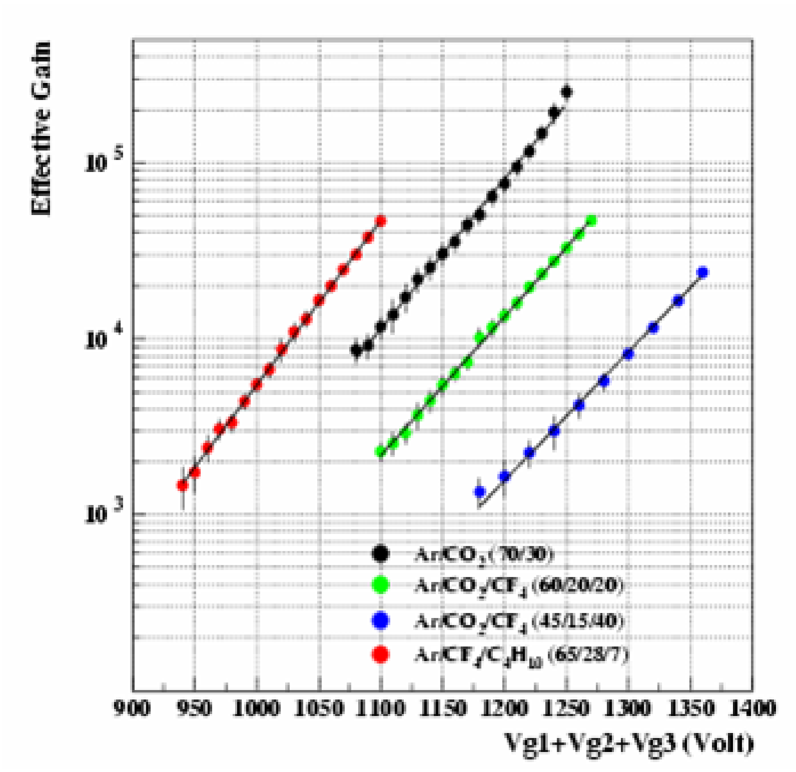
$$\sigma^2_{global} = \sigma^2_{GEM} + \sigma^2_{tracker}$$

$$\sigma_{GEM} = \sqrt{(250\,\mu m)^2 - (140\,\mu m)^2} \simeq 200\,\mu m$$

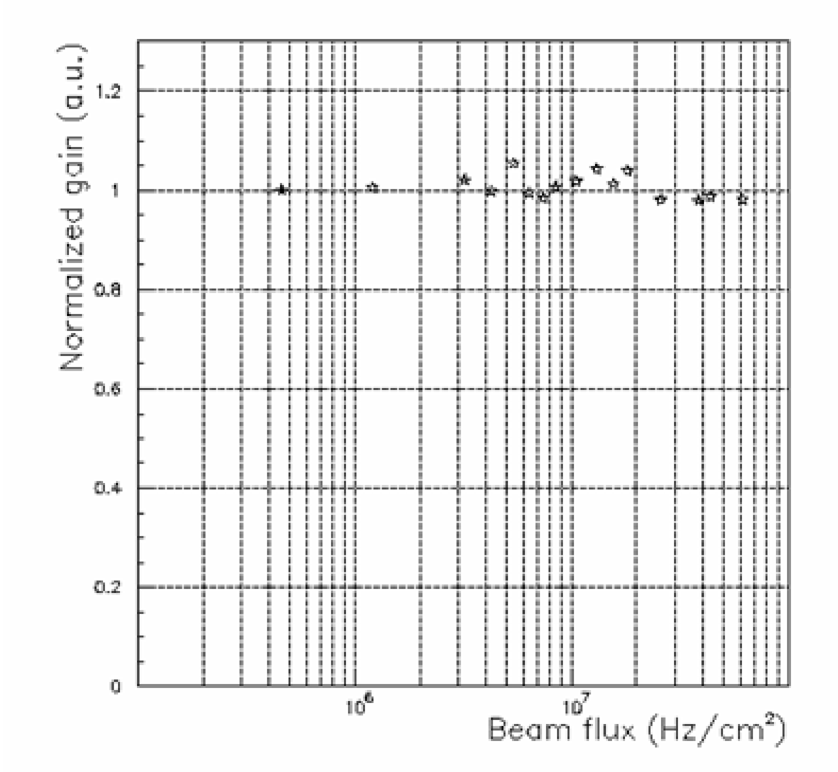
compatible with <pitch>/√12 (with digital readout)

Operation of a GEM detector

Gas Gain

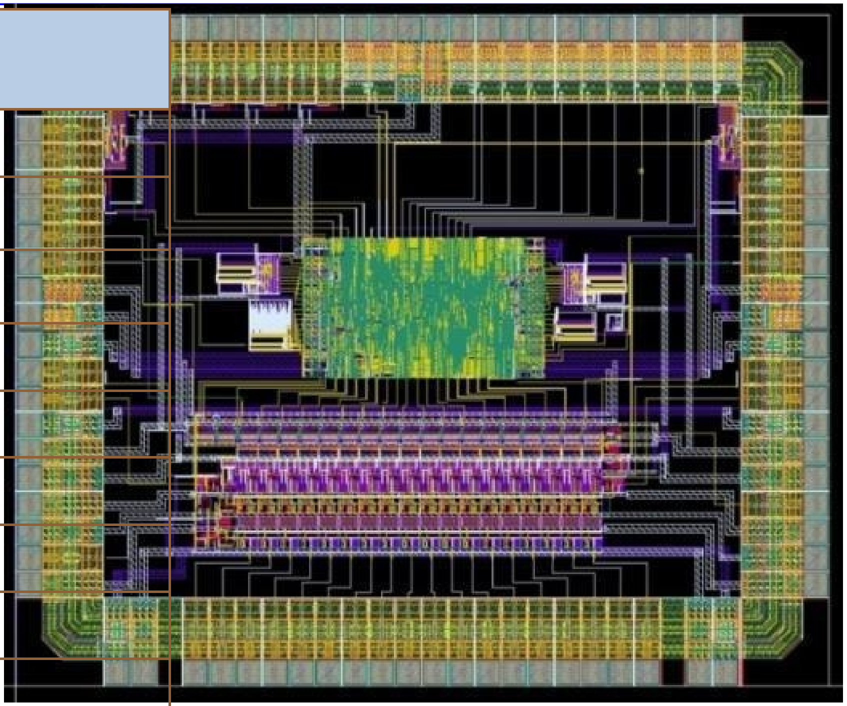


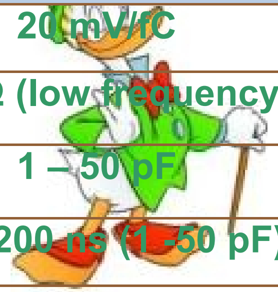
Rate Capability



GASTONE (Gem Amplifier Shaper Tracking ON Events) ASIC

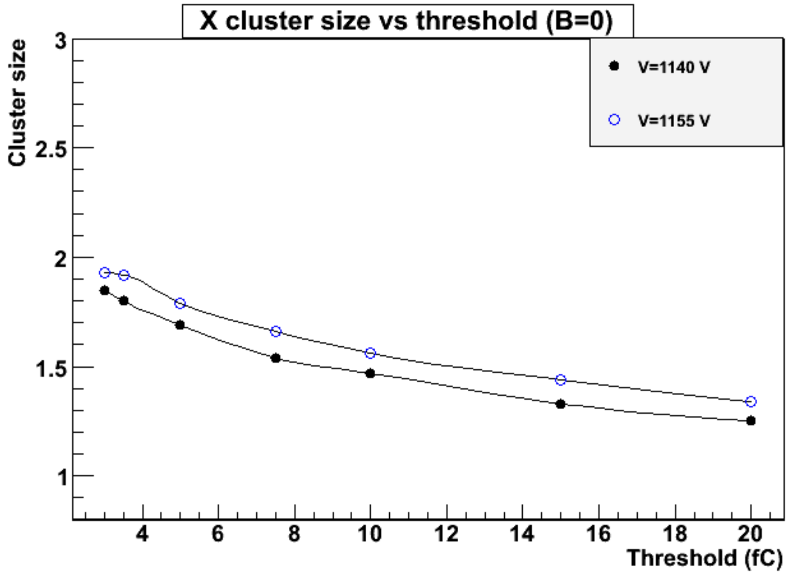
	GASTONE
Sensitivity (pF)	20 mV/fC
Z_{IN}	400 Ω (low frequency)
C_{DET}	1 – 50 pF
Peaking time	90 – 200 ns (1-50 pF)
Noise (erms)	$974\ e^- + 59\ e^-/pF$
Baseline restorer	yes*
Channels/chip	64*
Readout	LVDS/Serial
Power consum.	≈ 0.6 mA/ch

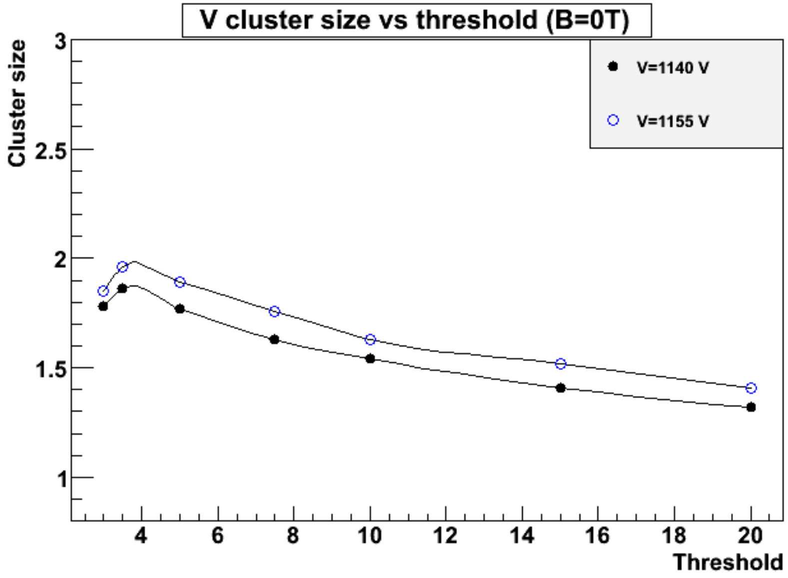


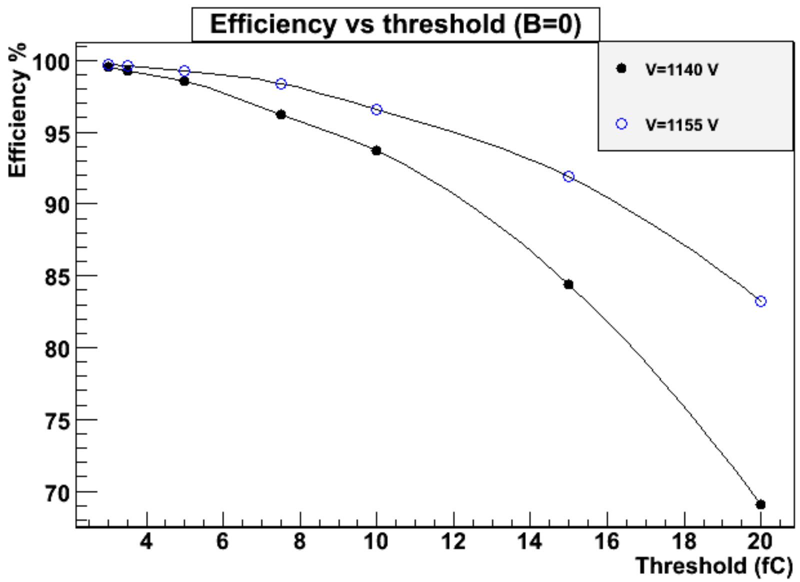


- **Low power consumption** and **high integration** chip needed to satisfy IT requirements
- Time and noise characteristics to be adapted to large spread of C_{DET} due to XV readout
- 4 different blocks:
  - charge sensitive preamplifier
  - shaper
  - leading-edge discriminator (with programmable thr.)
  - monostable to stretch the digital signal, waiting for L1 trigger
- 16 channel release with protection network inside the chip and BLR already tested
- 64 channels release for the end of 2008

Threshold scan on GASTONE chip



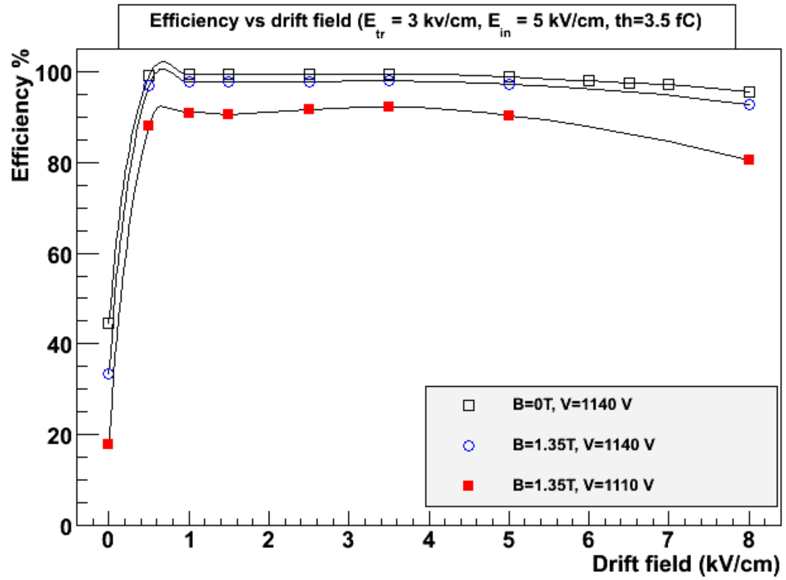


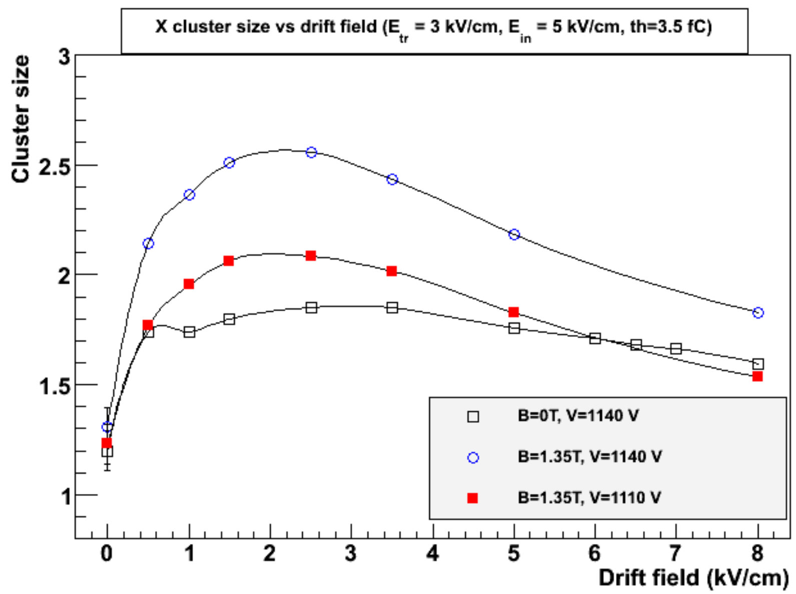


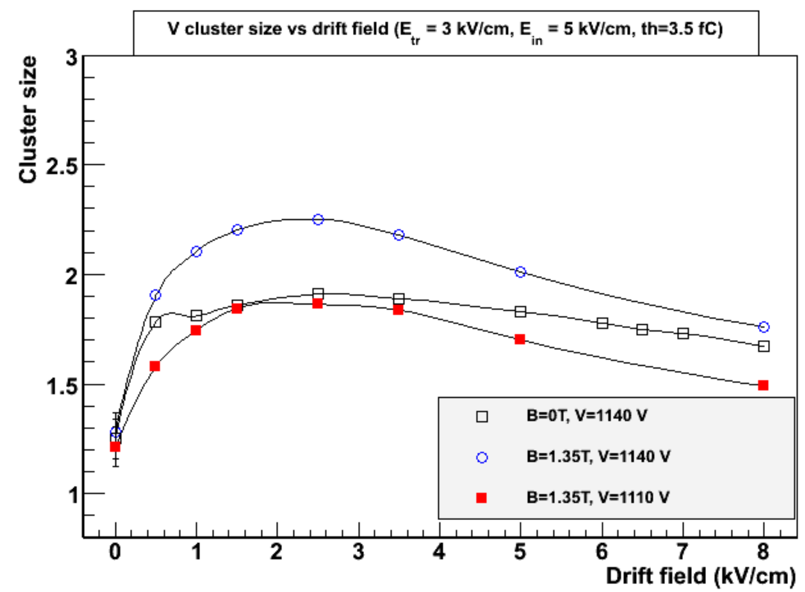
GASTONE charge sensitivity = 25 mV/fC

Reference threshold = 3.5 fC

Drift field scan







Transfer field scan