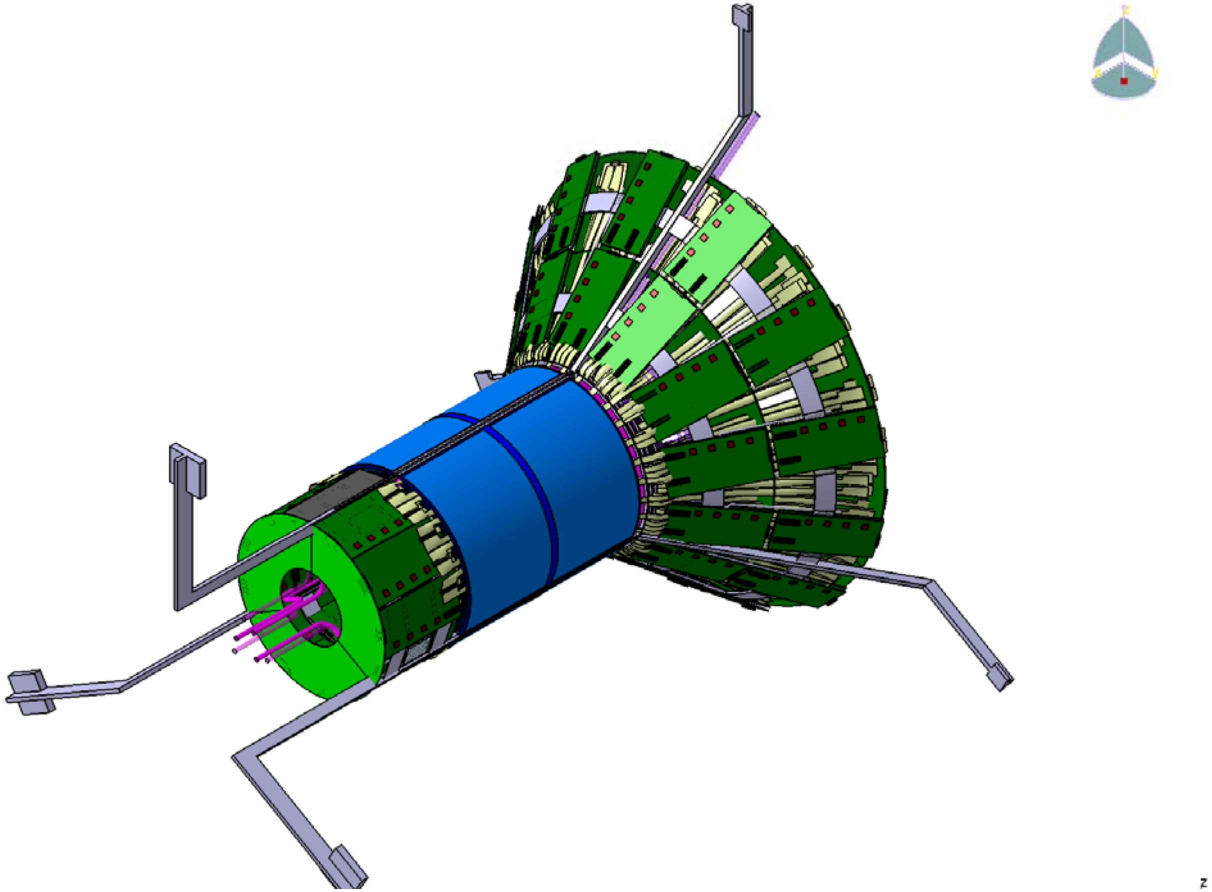
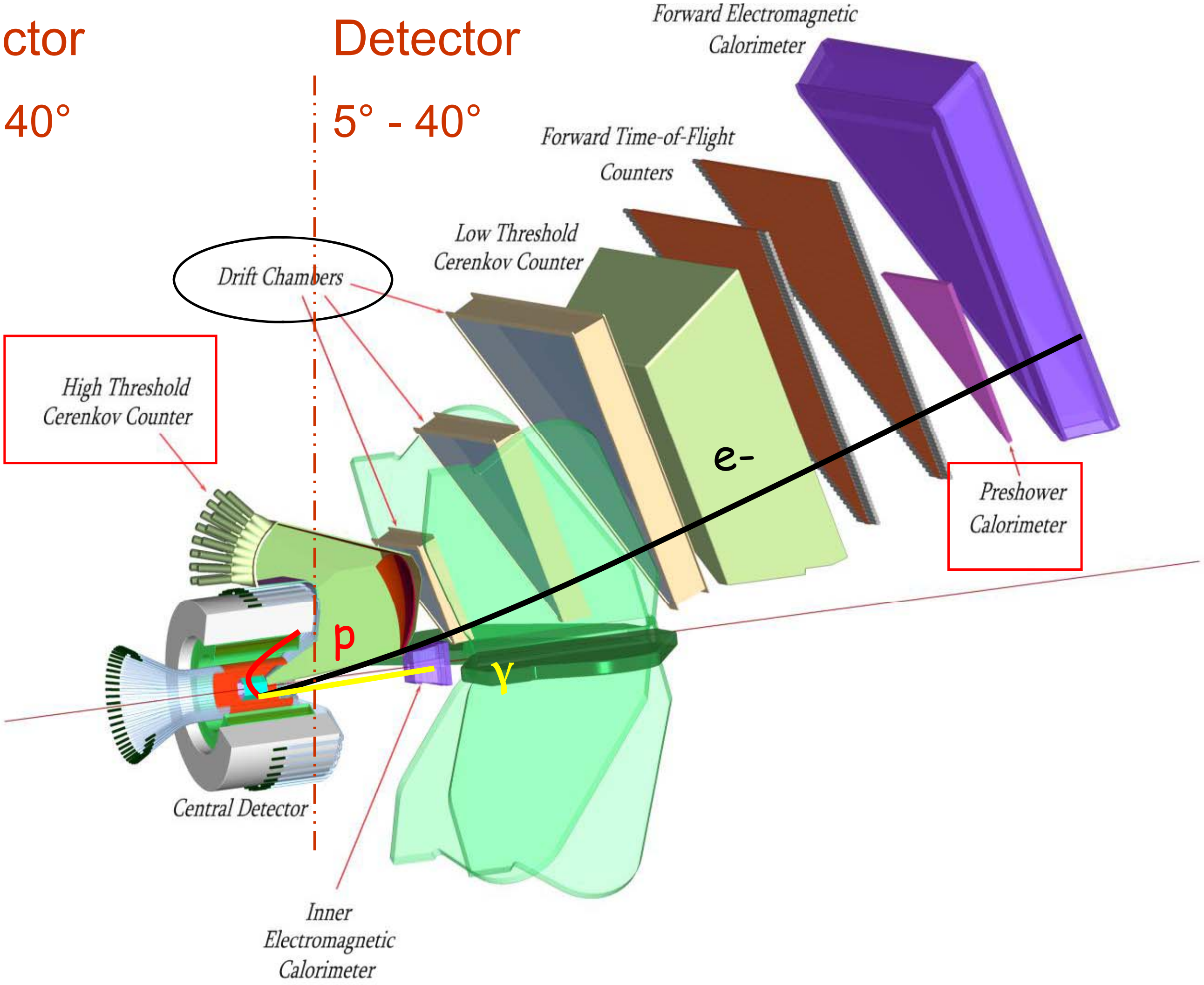
Micromegas Tracker Project for CLAS12

- Context
- Central tracker
- Bulk MM
- Simulations
- Tests



CLAS UPGRADE = CLAS12



CLAS upgrade for 11 GeV

Physics constraints:

- higher momentum tracks, smaller cross sections

- **Detector goals:**

- 1% momentum resolution at 5 GeV/c
- capability to run at L= 10^{35} $cm^{-2}s^{-1}$, good vertex resolution, reliability.

- **Detector designs:**

Forward detector: (electrons, forward mesons)

- Addition of high threshold Č counters to improve e^- and π id.
- Preshower to increase granularity of the calorimeter and discriminate π^0 and γ.
- Revamping of regular equipment, DCs cells reduced, Torus modified to handle angular range from 5 to 40° (was 8 to 142°)

CENTRAL DETECTOR

5 T Solenoid

Central Vertex Tracker

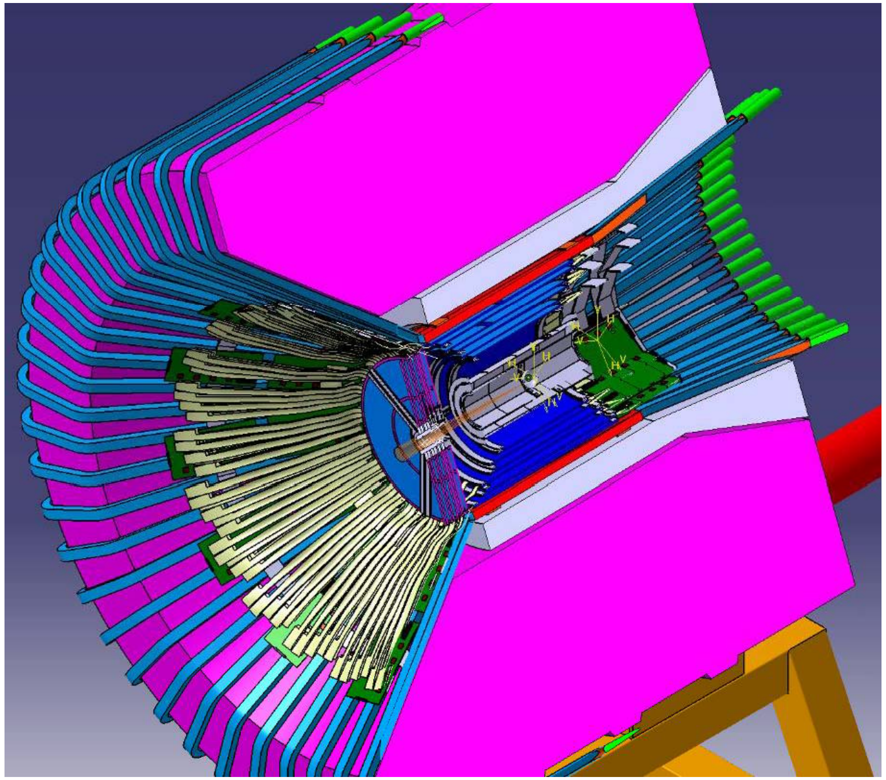
Forward vertex Tracker

Central Time of Flight

Neutron counter

Trigger rate : 10 kHz

Singles rate : 2 – 20 MHz

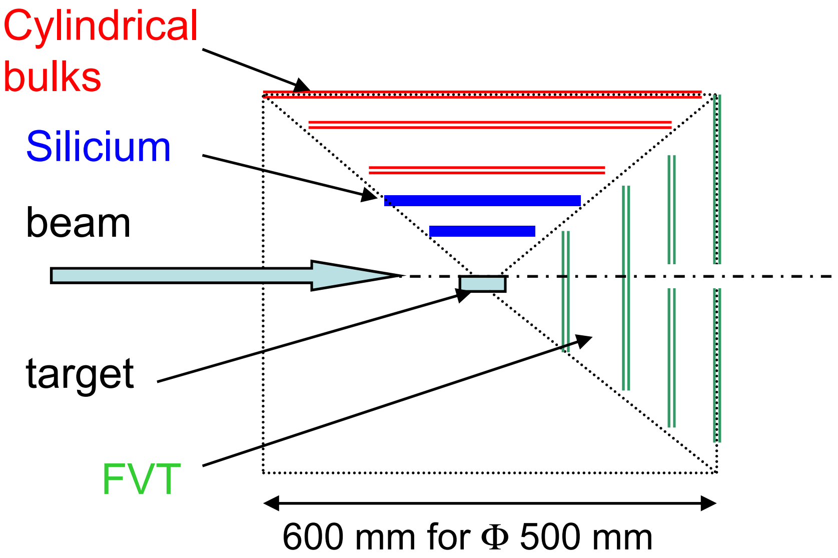


Bulk MM tracker Project

Mixed solution: Silicium + Micromegas bulk

- Central detector
  - 2 planes of Silicium (X,Y)
  - 3 cylindrical bulks (XY): 3m^2, pitch 0.6 mm ,10k channels.

- Forward detector
  - 4 plane bulks (XY): 1 m^2, 3k channels.



Cylindrical bulks

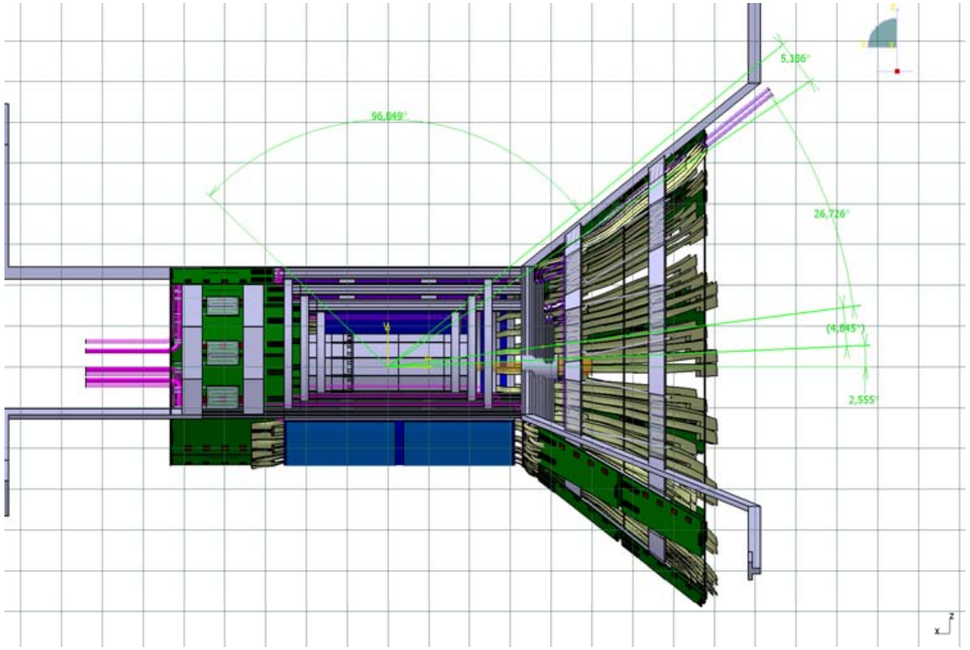
Silicium

beam

target

FVT

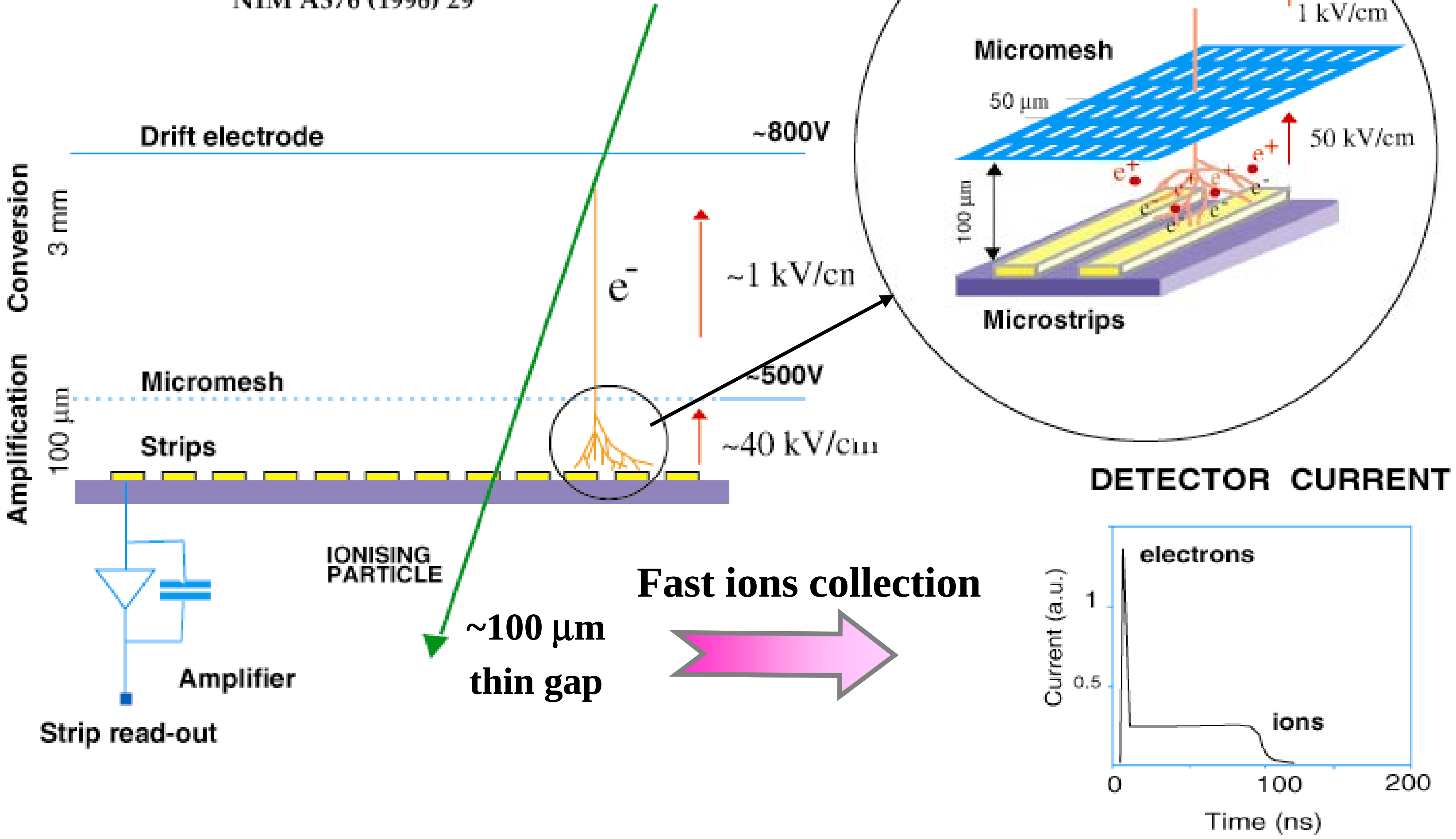
600 mm for Φ 500 mm



What is a MicroMégas ?

MICROMEGAS
Micro Mesh Gaseous Structure

Y.Giomataris, Ph. Rebourgeard, J.P Robert and G. Charpak
NIM A376 (1996) 29

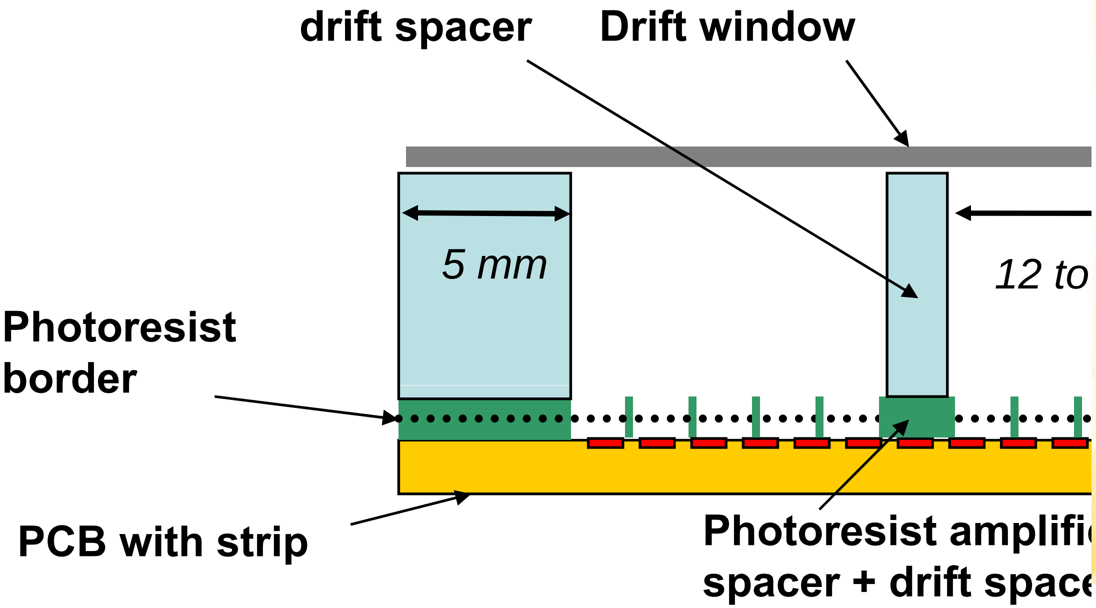


~100 µm
thin gap

Fast ions collection

What is a bulk Micromegas ?

The basic idea is to build the whole detector in one process:
the anode plane with the copper strips,
a photo resistive film having the right thickness, and the cloth mesh
are laminated together at high temperature, forming a single object.
By photolithographic method then the photo resistive material is etched producing the pillars.



Resolutions comparison

(Sébastien Procureur)

(for π @ 0.6 GeV/c , $\theta = 90°$)

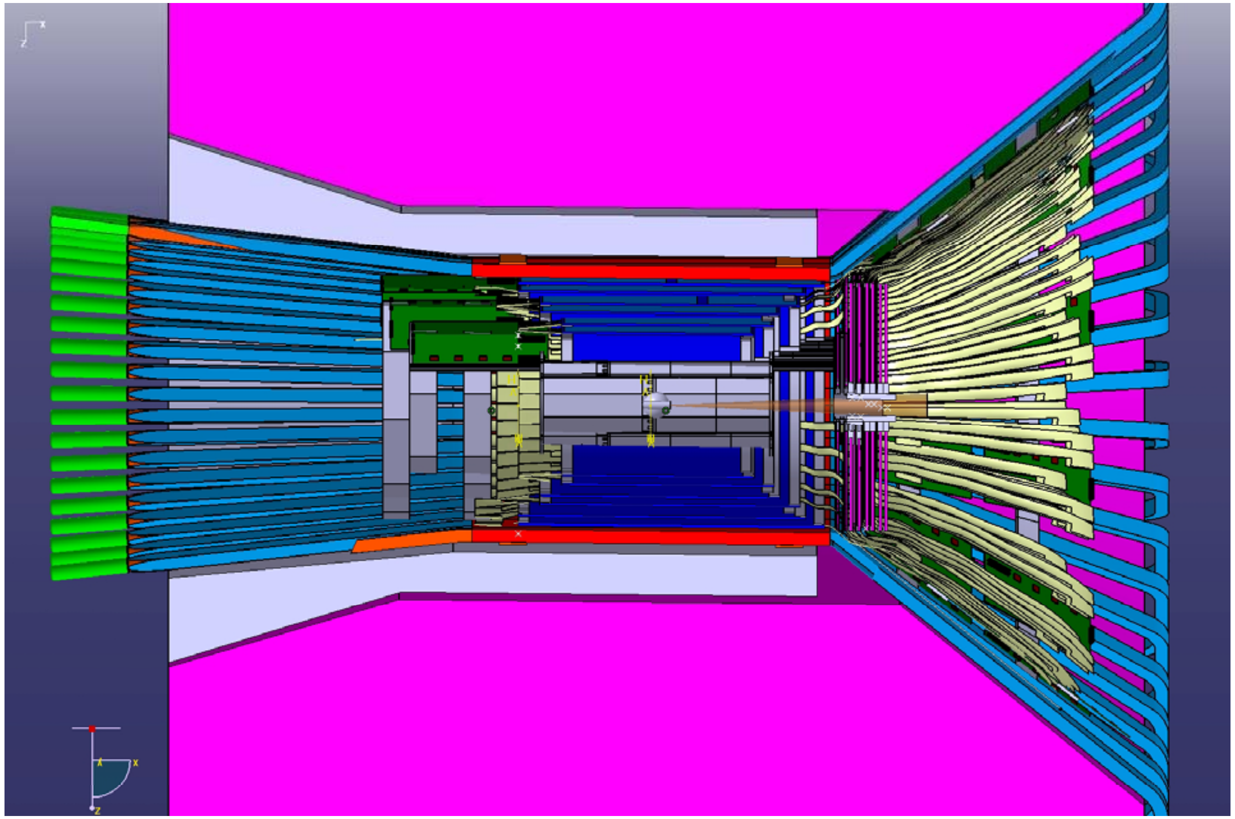
	4 x 2MM	**4 x 2SI**	**2 x 2SI + 3 x 2MM**	**Specs.**
σ_{p_T}/p_T (%)	2.9	2.1	1.6	5
σ_θ (mrad)	1.3	15.1	1.4	10
σ_φ (mrad)	10.9	2.9	2.6	5
σ_z (µm)	212	1522	267	tbd.

→ The mixed solution benefits of advantages from both SI and MM!

→ The « Si only » solution is never the best…

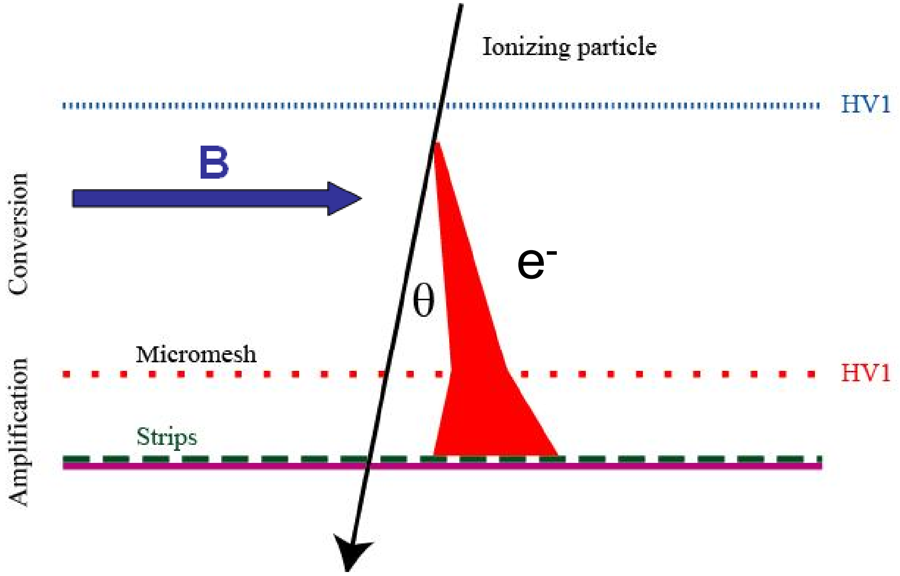
MM tracker project Design

- Drawings to show difficulties and help to find solutions
- Mechanical structure, electronics integration



Main issues to deal with ..

- Full characterization of a bulk cylindrical detector under different gas mixtures, with different radii.
- Magnetic environment to deal with : 5 T orthogonal to the detector !



$\tan\theta = v \times B / E$

Standard conditions :

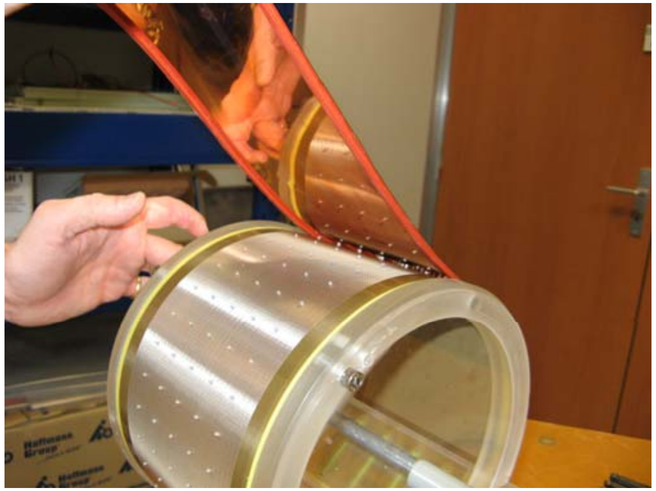
E= 1 kV/cm, v= 8 cm/µsec

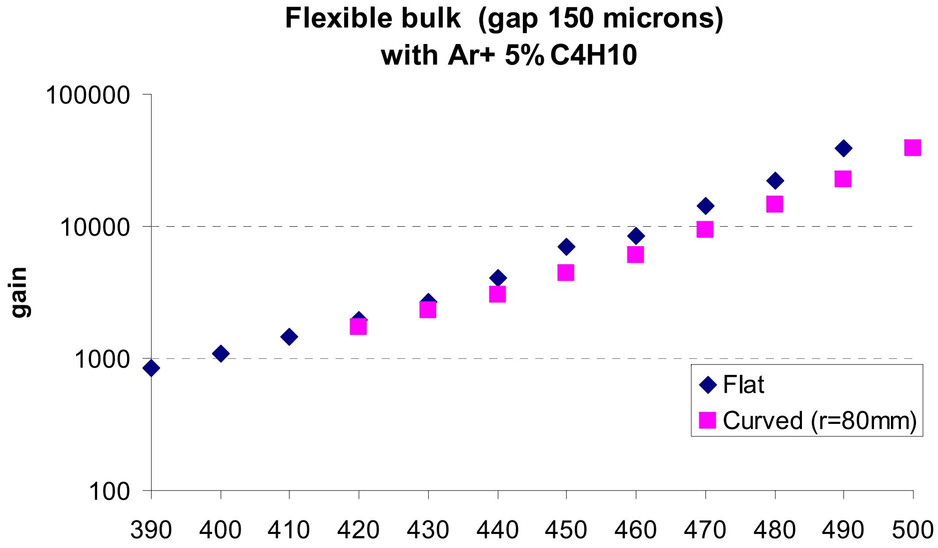
$\theta = 75°$

Adapted conditions:
E= 10 kV/cm,
v= 5 cm/µsec

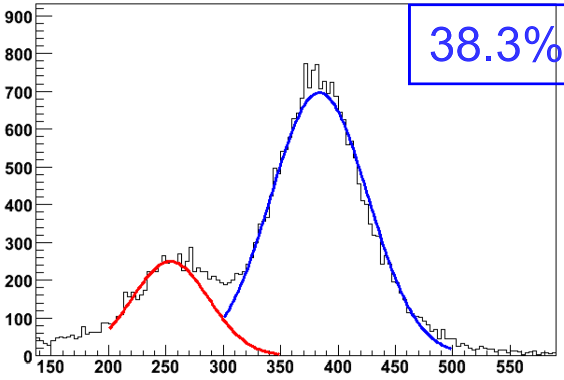
$\theta = 14°$

Cylindrical prototypes tests

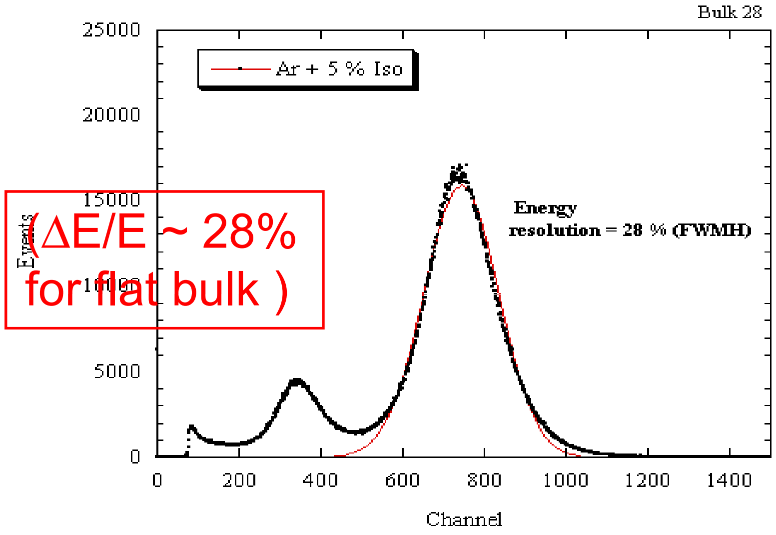




1st Fe^{55} observed on a **curved bulk**



38.3% FWHM



(ΔE/E ~ 28% for flat bulk)

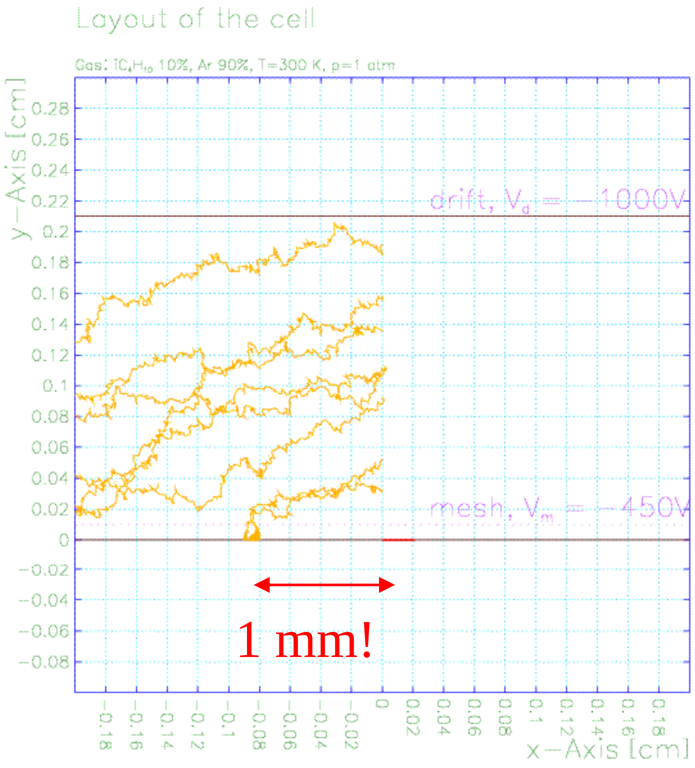
B- Simulations (S. Procureur)

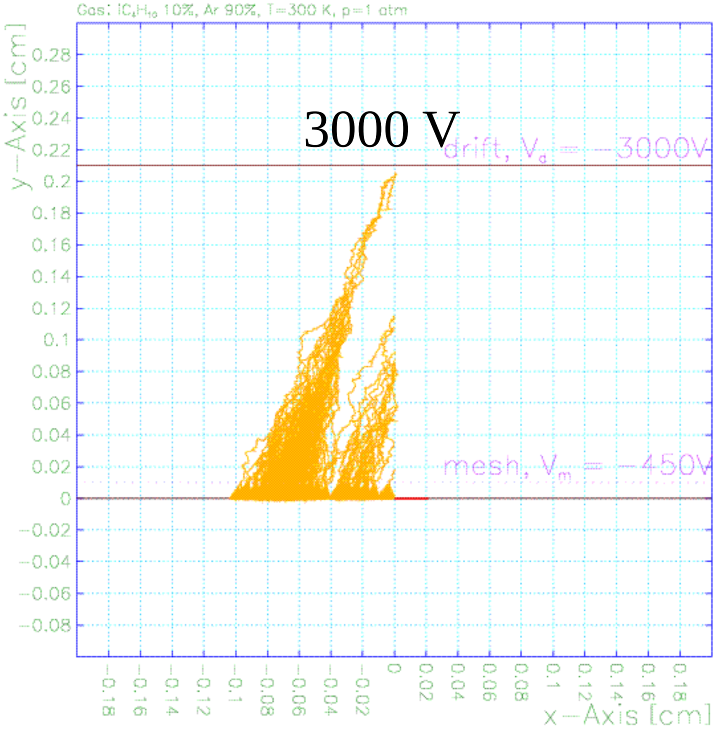
→ GARFIELD code (CERN)

Large Lorentz angle (~ 75º)

- higher drift field
- reduce conversion gap

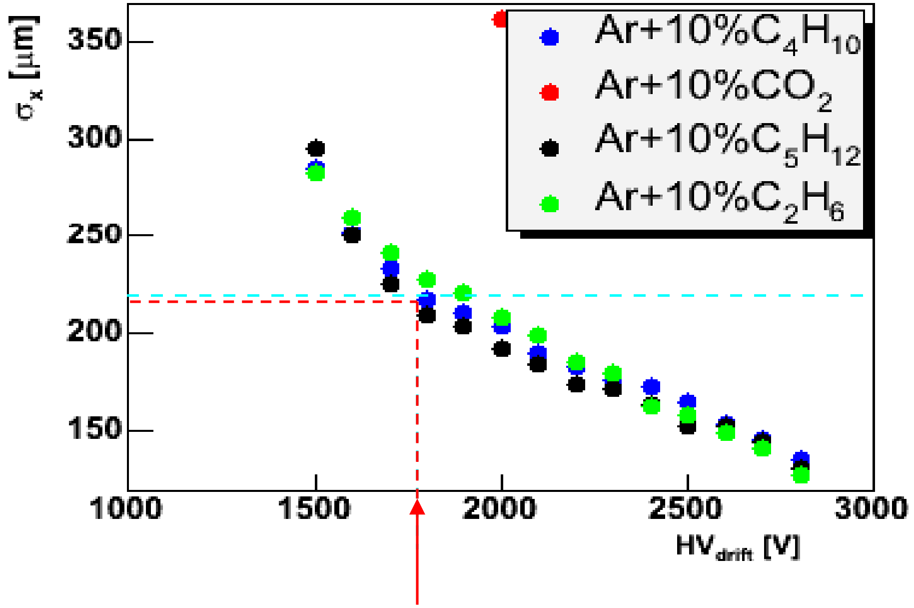
Regular electric field configuration :





Why we need tests in B-field

Space resolution

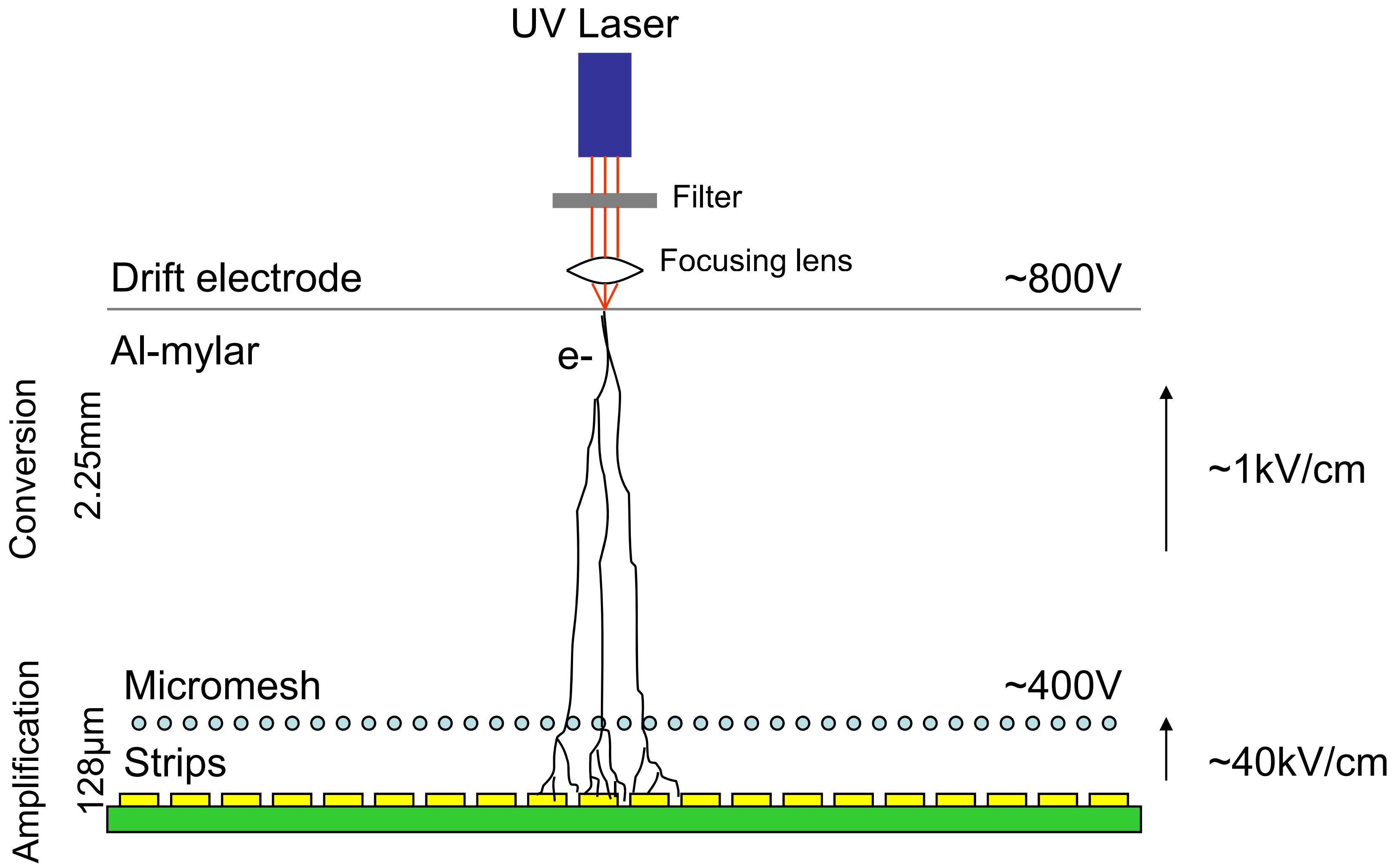


Argon gas - Vmesh = 450V - pitch = 600 μm - gaps = (2.0mm;100 μm) - π @ 1 GeV & 90°

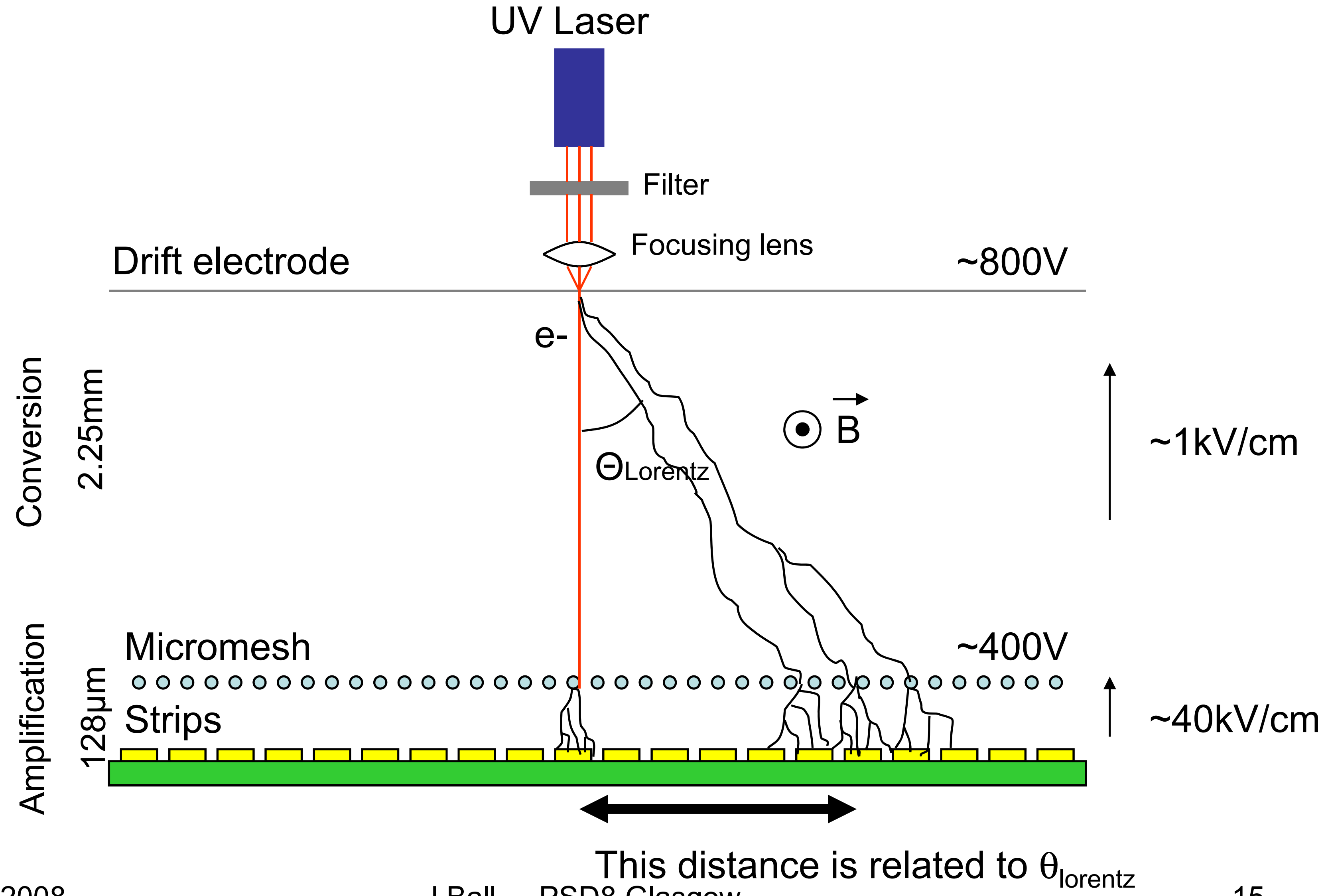
But we need to check:

1. how realistic GARFIELD simulation is
2. can we reach a satisfactory voltage setup with a thin cylindrical Micromegas detector.

Experimental principle



With a magnetic field



This distance is related to $\theta_{lorentz}$

Experimental setup

Magnet refurbishing: Fall 2007

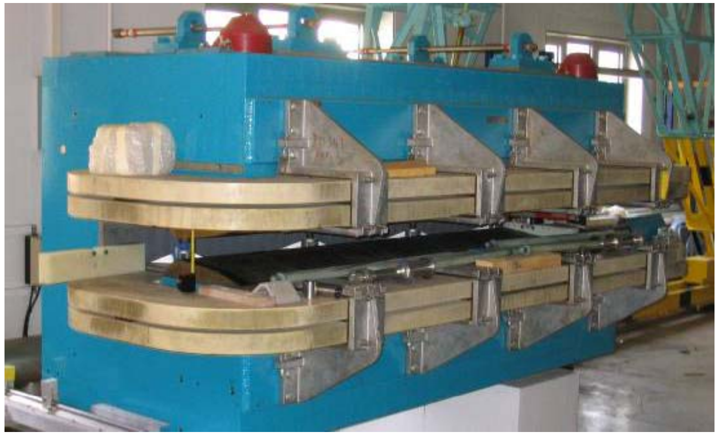
Tests started: February 2008

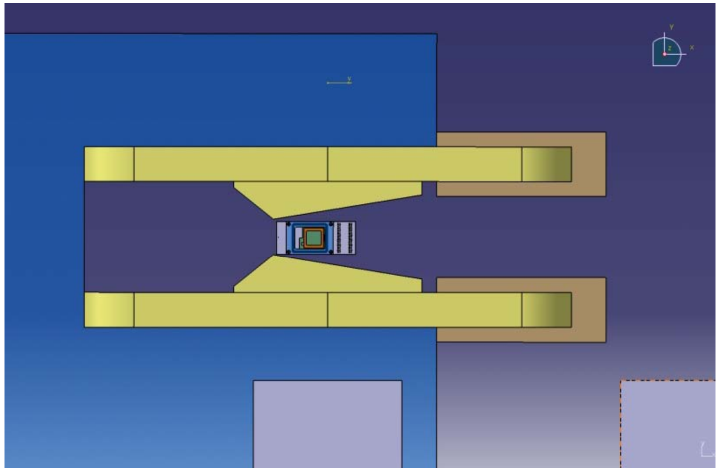
Magnetic field: 0 to 1.5 T

Laser: UV 355nm + neutral filters
<50µJ/pulse, 2ns pulse, very good beam size and divergence

Detector: MM prototype V3
Bulk MM detector equipped with Gassiplex Board (96 channels)

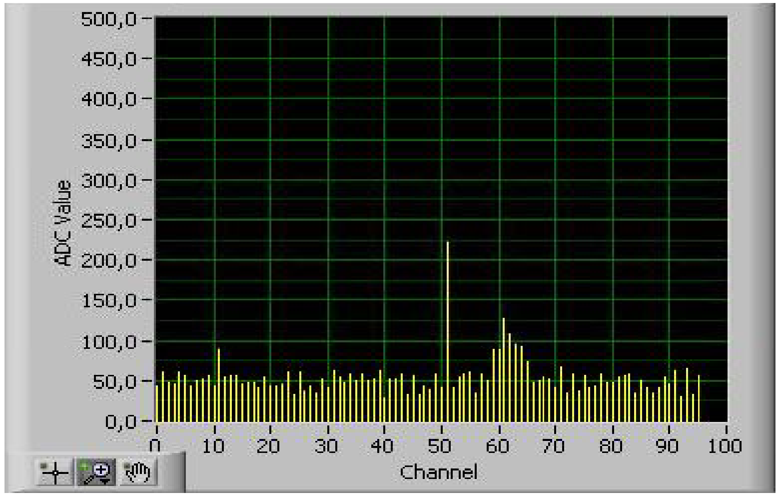
Active area 30x30 mm^2, pitch 300 µm
2.25mm Drift-Mesh, 128µm Mesh-Strips
Gas: 5% iC4H10 + 95% Ar



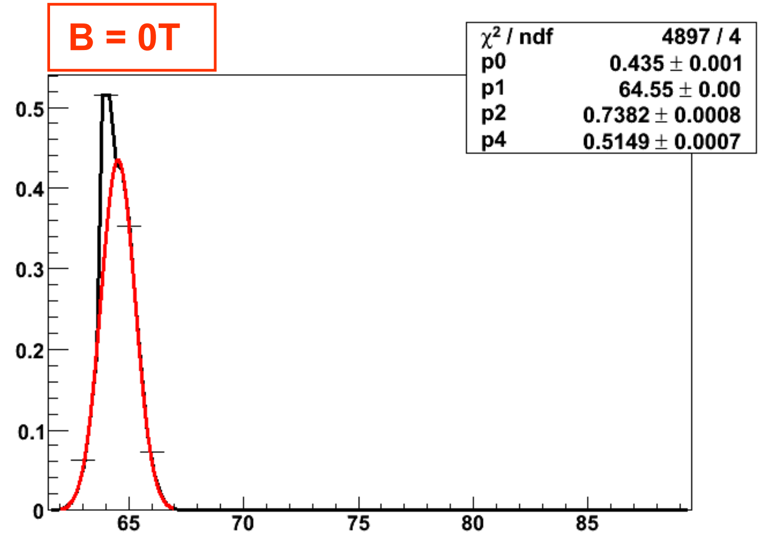


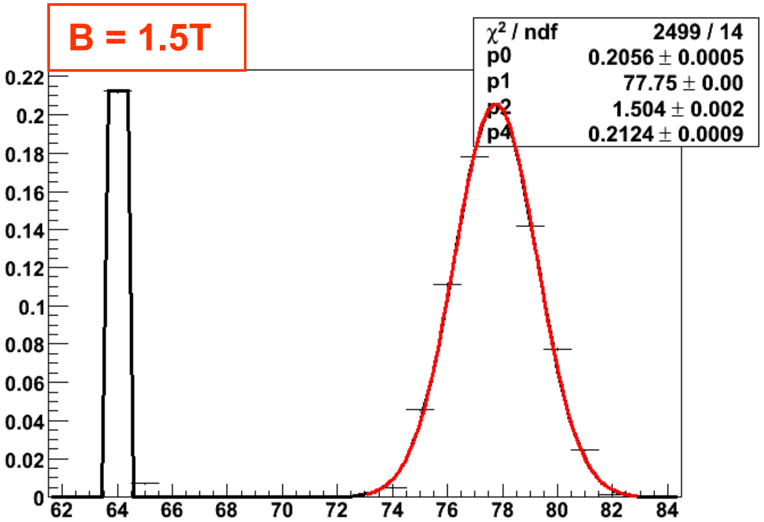
Lorentz angle behaviour with the magnetic field

- Lorentz angle mesured from the deviation of the B=0T peak
- Drift distance: 2.25mm
- The signal spreads out with the Lorentz deviation → increase the resolution

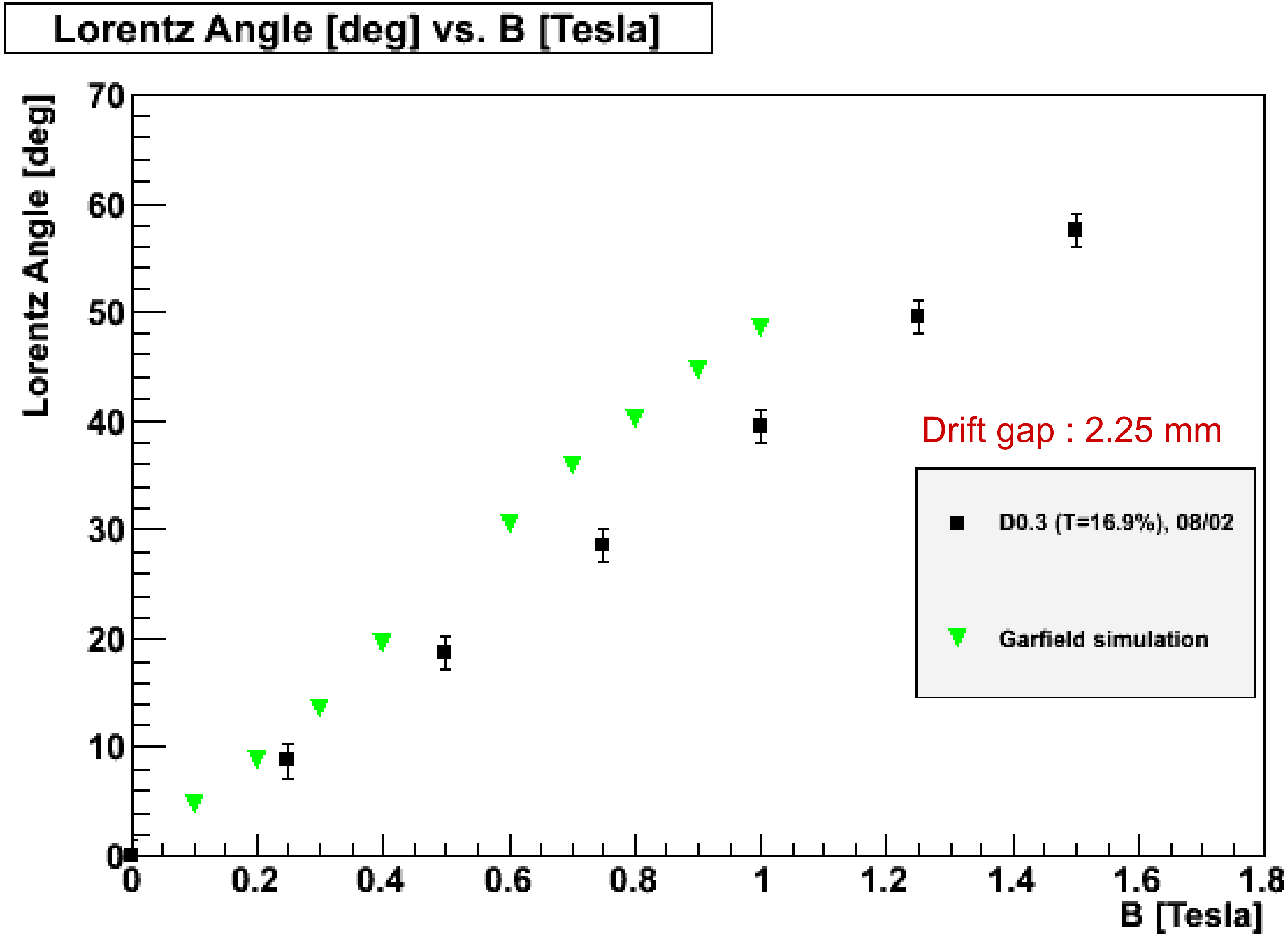


Labview DAQ



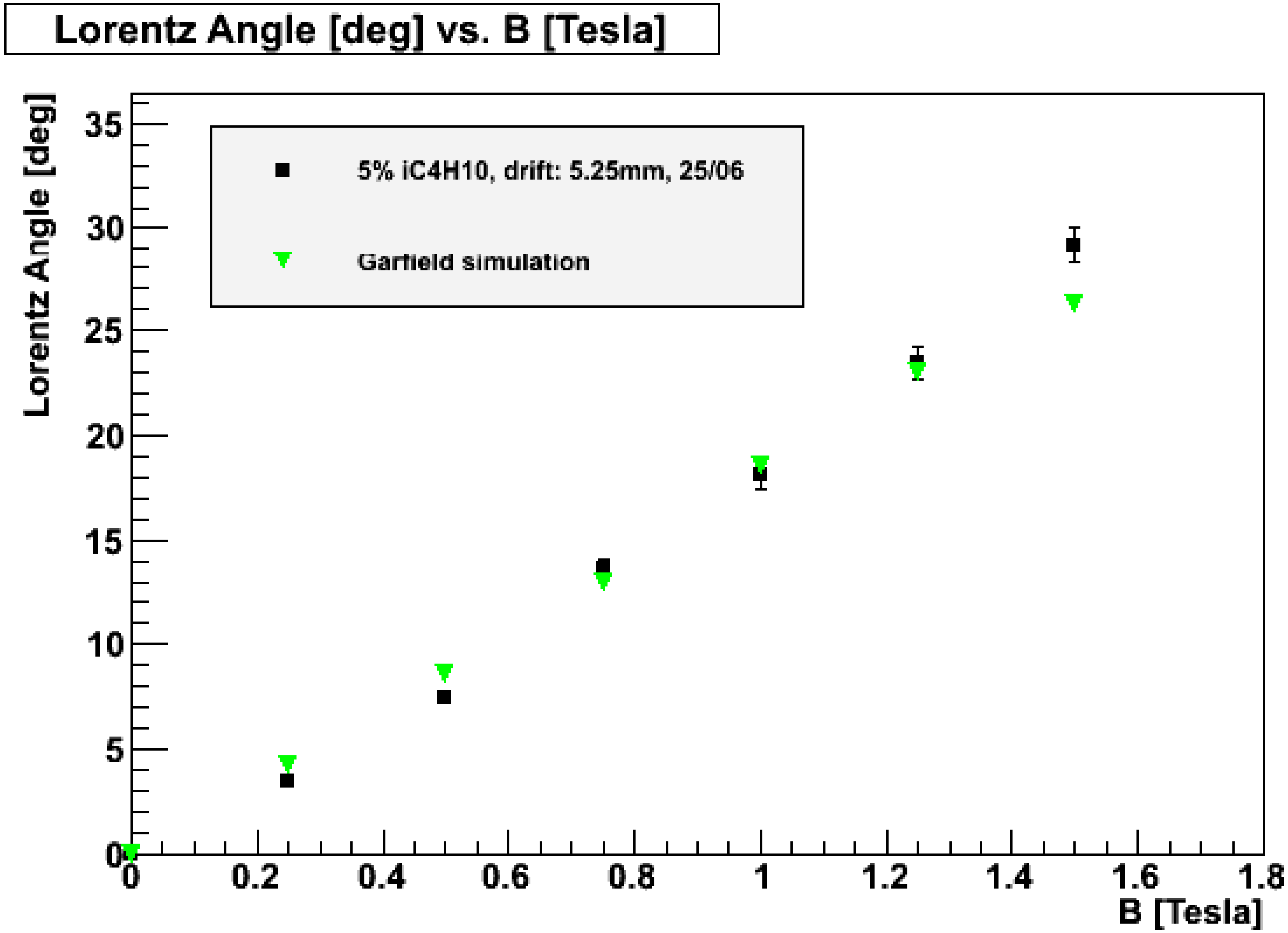


Lorentz angle behaviour (1)

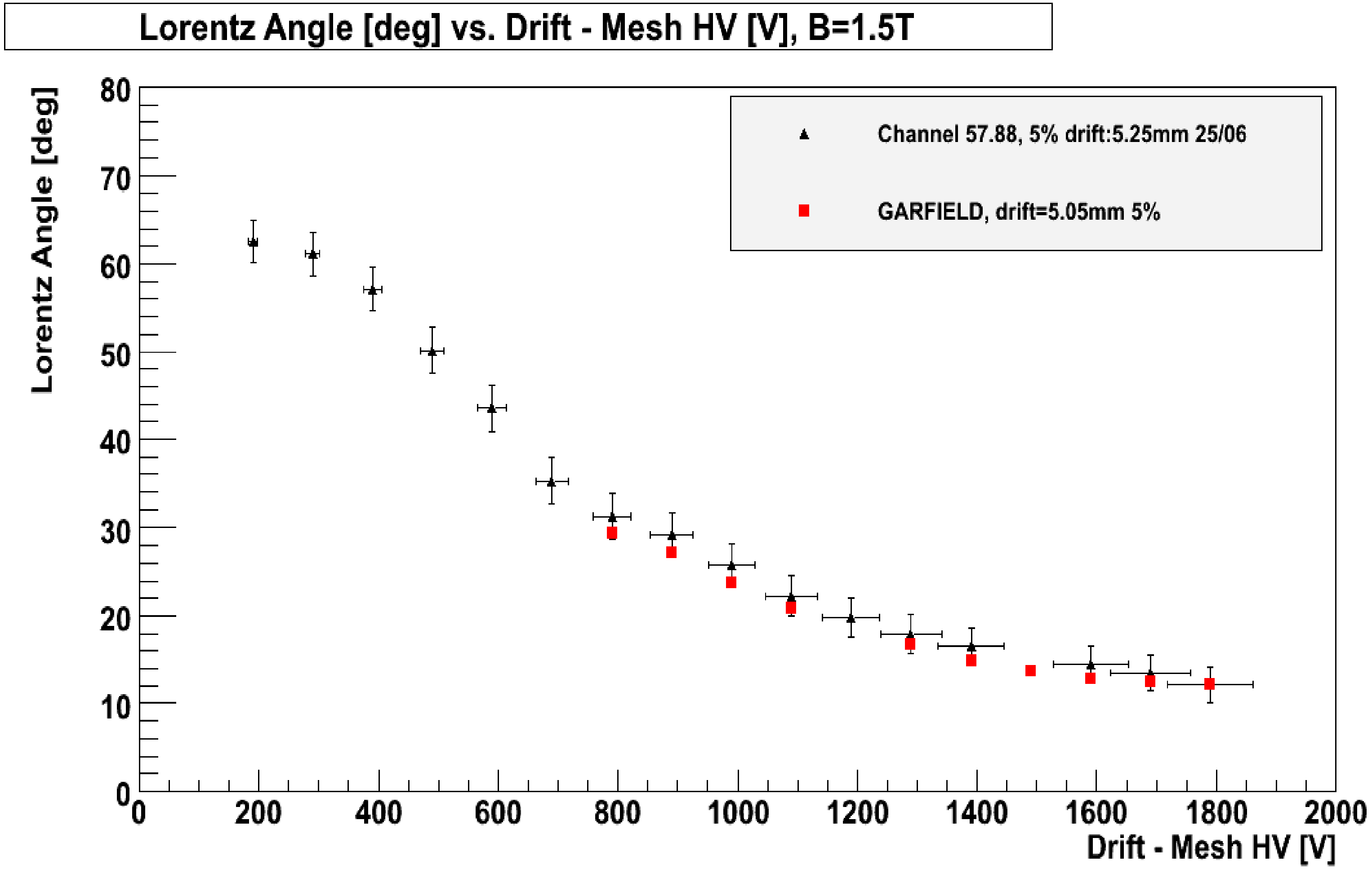


Drift gap : 2.25 mm

Lorentz angle behaviour with the magnetic field (2)



Lorentz angle behaviour with the drift HV

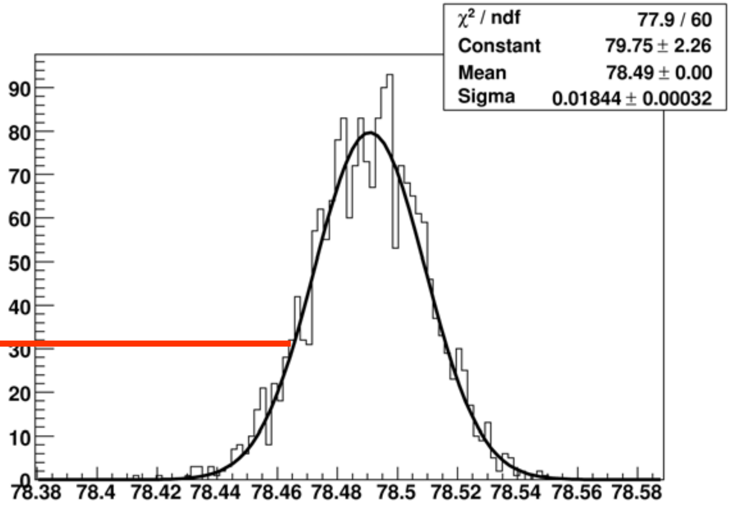


« Spatial resolution »

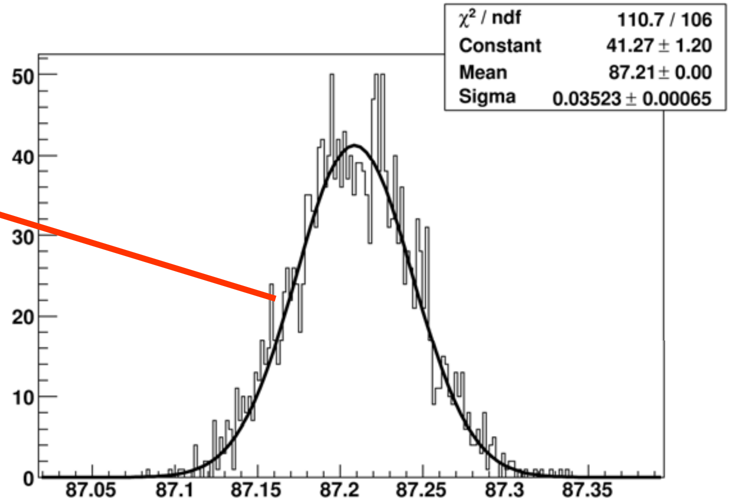
- Sigma of the average position calculated event by event
- $\sigma^2_{exp}=(\sigma^2_{laser+}\sigma^2_{det})/N$
- When the magnetic field increases → the resolution increases
- Test the detector homogeneity

	B0 (T)	B0.5 (T)	B1 (T)	B1.5 (T)
exp	5.53 μm	6.84 μm	8.46 μm	10.04 μm

B = 0T



B = 1.5T



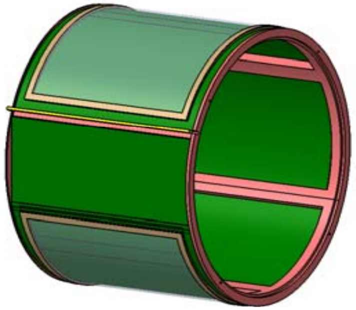
CLAS12 Micromegas Bulk Demonstrator

One type of Bulk:

Active area; 115 mm for 288 strips, 500 mm long
Material: 100 µm PCB, 5 µm Cu, 18µm mesh, 20µm Mylar

Two type of structure, X and Y, for Bulk integration:

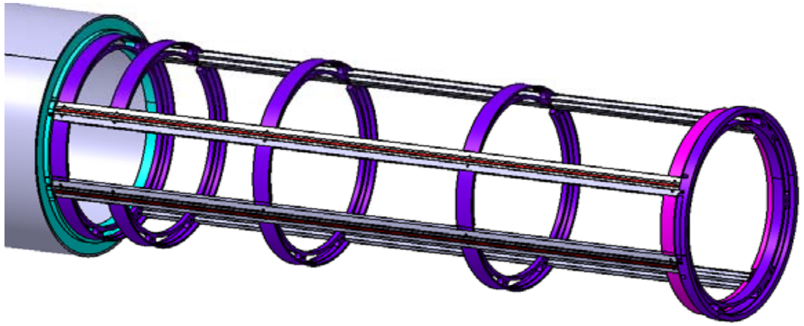
Cylindrical for Y: ϕ ext: 220 mm
Tile for X: ϕ int 180 mm



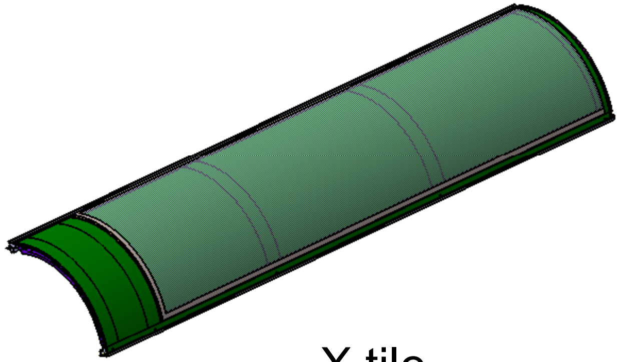
Y cylinder

One support for up to 3 X tiles and 3 Y cylinders:

Channels: 1728 read by AFTER ASIC (T2K)
Active area: 0.34 m²
Dead zone between detectors not optimized on the prototype !!!



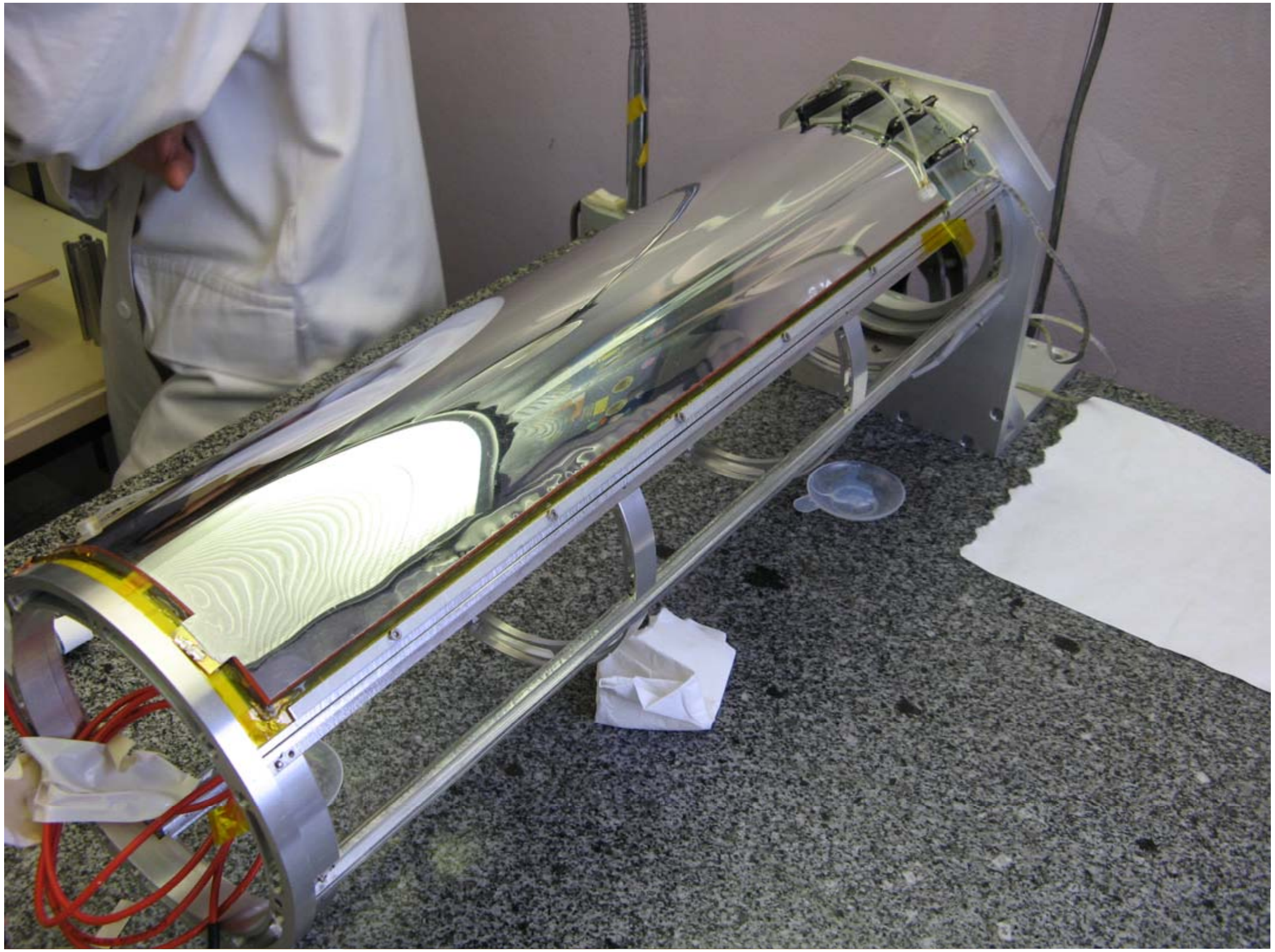
Support structure



X tile

Cylindrical Prototype

Length:
600 mm
Diameter:
180 / 220 mm



Bulk MM traker project schedule

SPhN: J.Ball, M. El Yakoubi, P. Konczykowski, S. Procureur, F. Sabatié

SEDI: S. Aune, M. Combet, C. Lahonde-Hamdoun, O. Meunier

I. Giomataris

October – December 2008 :

- High magnetic field tests at JLab (DVCS magnet: 4.7 T)

- Tests and validation of X and Y tiles

1st semester 2009 :

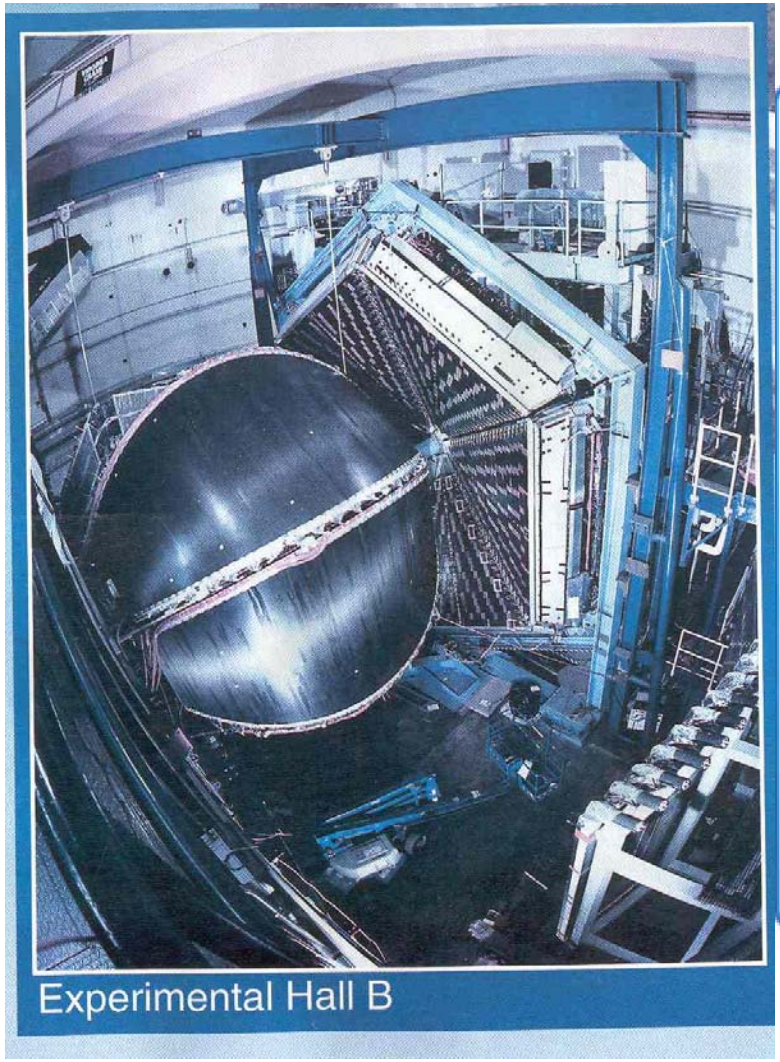
- Prototype test with beam at Jlab

- Front End electronics Definition and Design studies

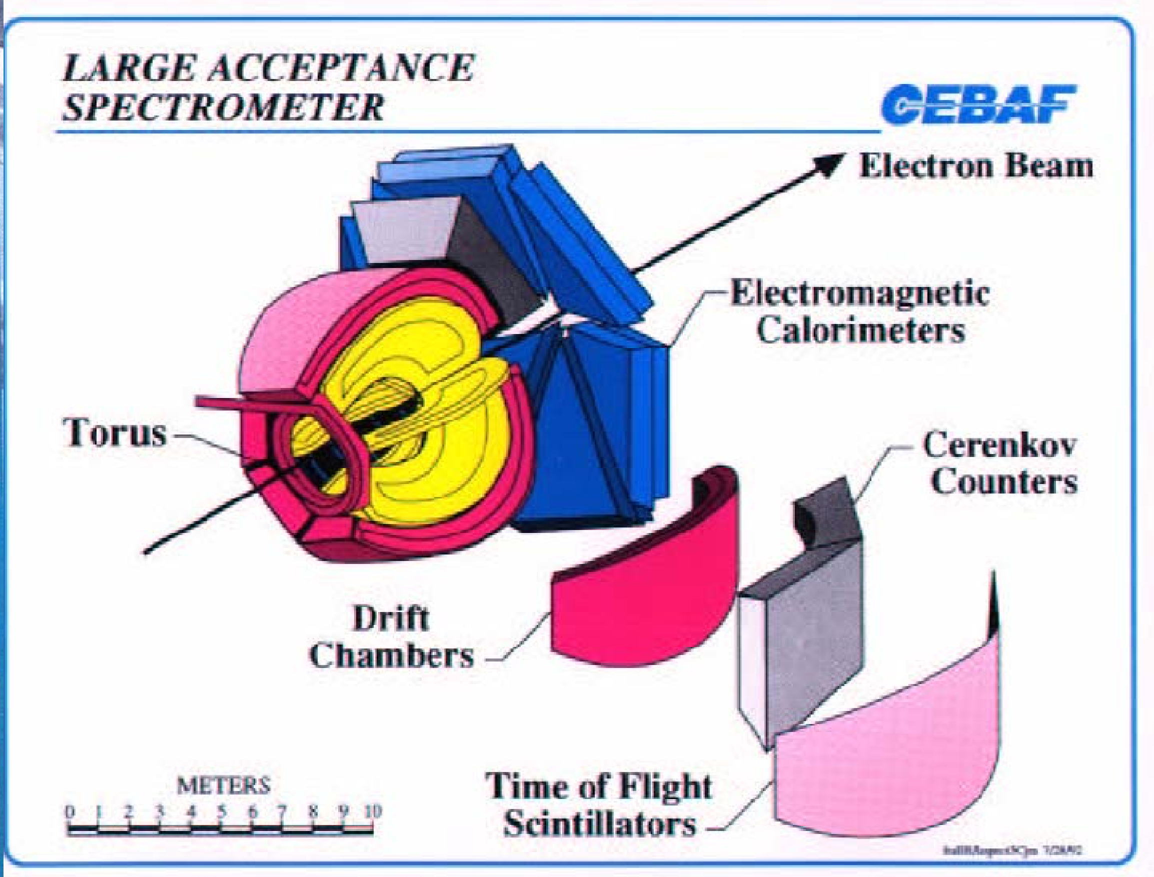
→ Decision about Central Tracker in 2009…

- Additional slides

CLAS



Experimental Hall B



Material thickness budget:

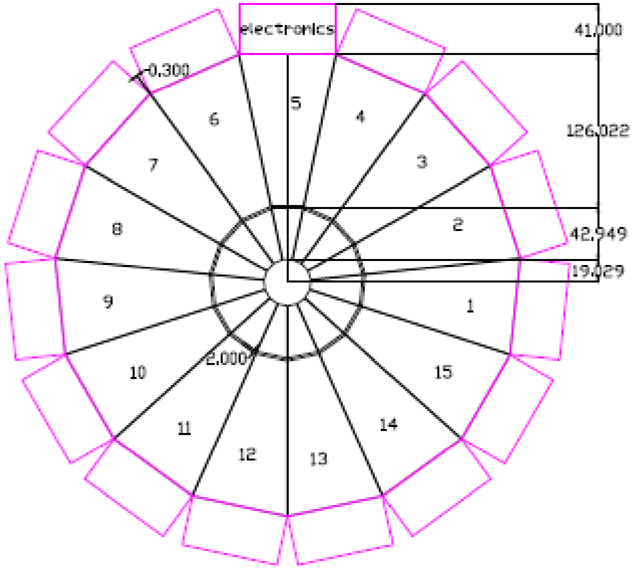
Units: 10^{-4} x L_R	Minimum	Maximum	Weighted average
Drift : 100 µm Mylar foil	3.5	3.5	3.5
PCB : 50µm Kapton	1.7	1.7	1.7
Cu strips : 5µm (88% filling)	0	3.5	3.1
Mesh :15µm Fe (20% filling)	0	8.5	1.7
95% Ar 5% Isobutane 3mm	0.27	0.27	0.27
Drift spacers 3mm (0.8%)	0	100 (?)	0.8 (?)
Mesh spacers 200µm (1%)	0	7 (?)	0.7 (?)
TOTAL	9	-	11.4

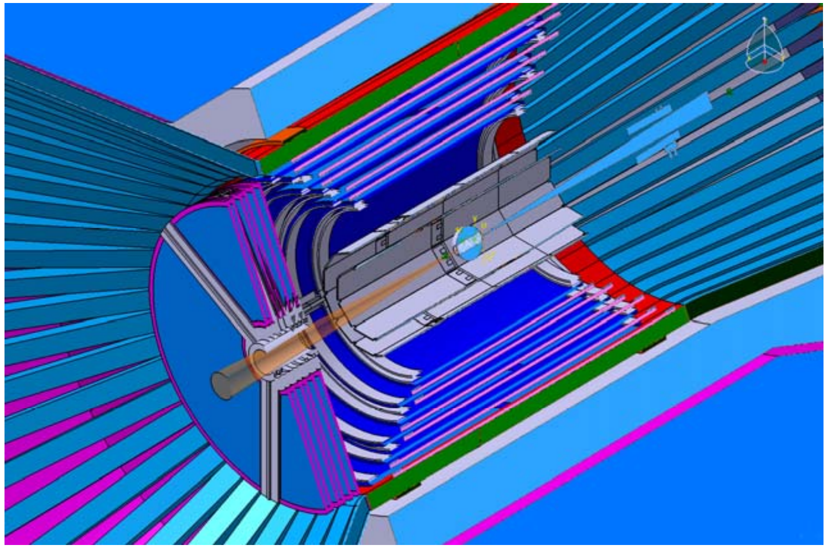
Pure Si 300 µm = 32 x 10^{-4} L_R

Forward Tracker

Considered options :

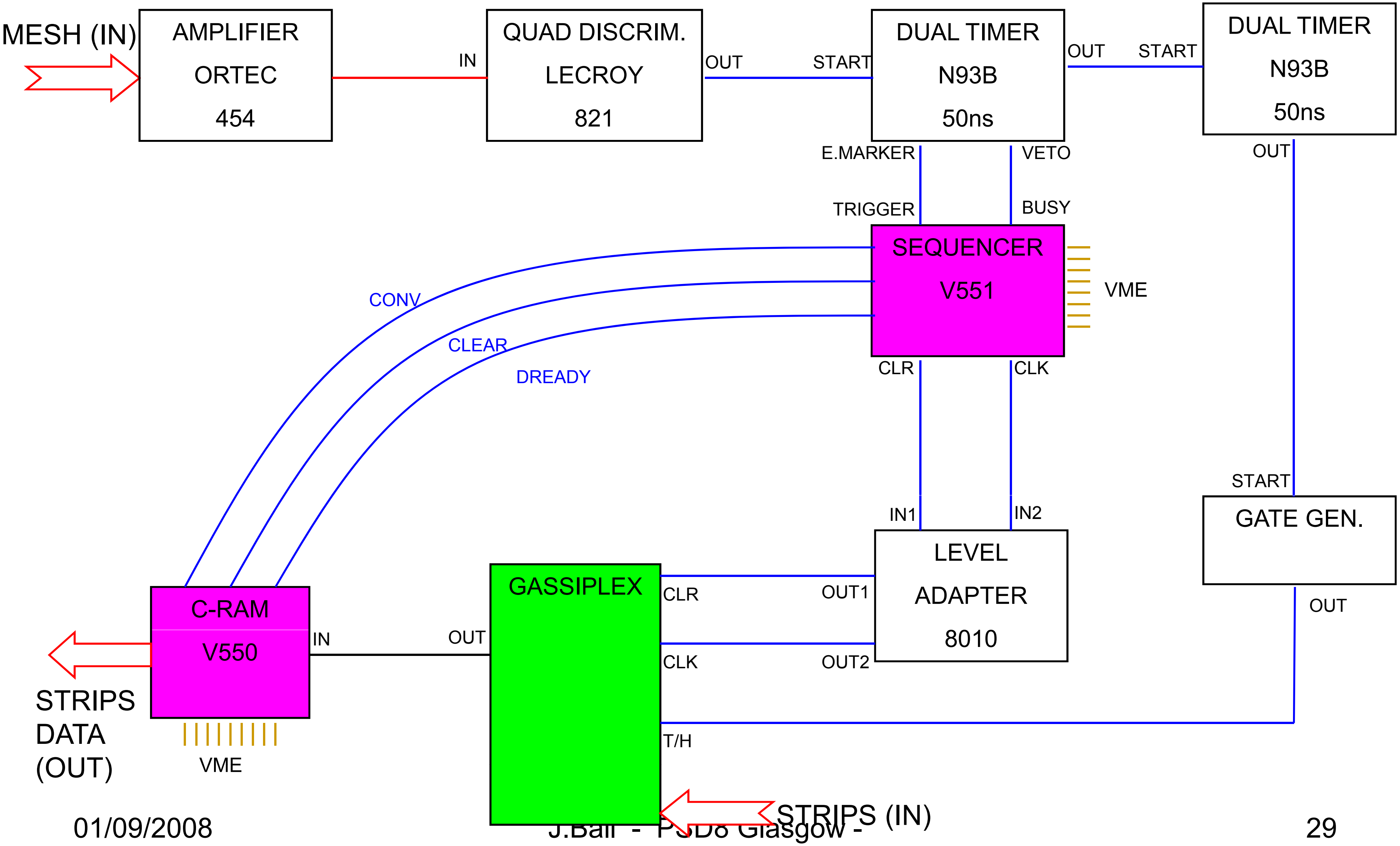
- Silicium
- Micromegas

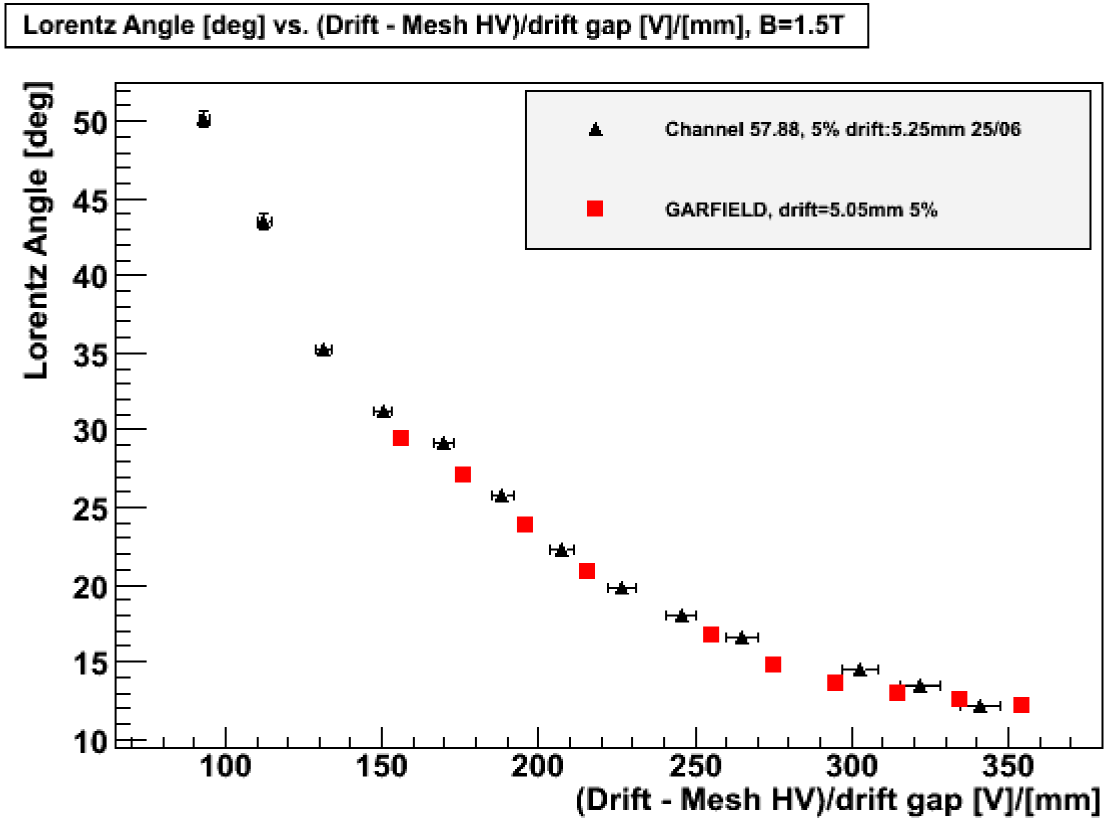




Issue : Interference with HTČC

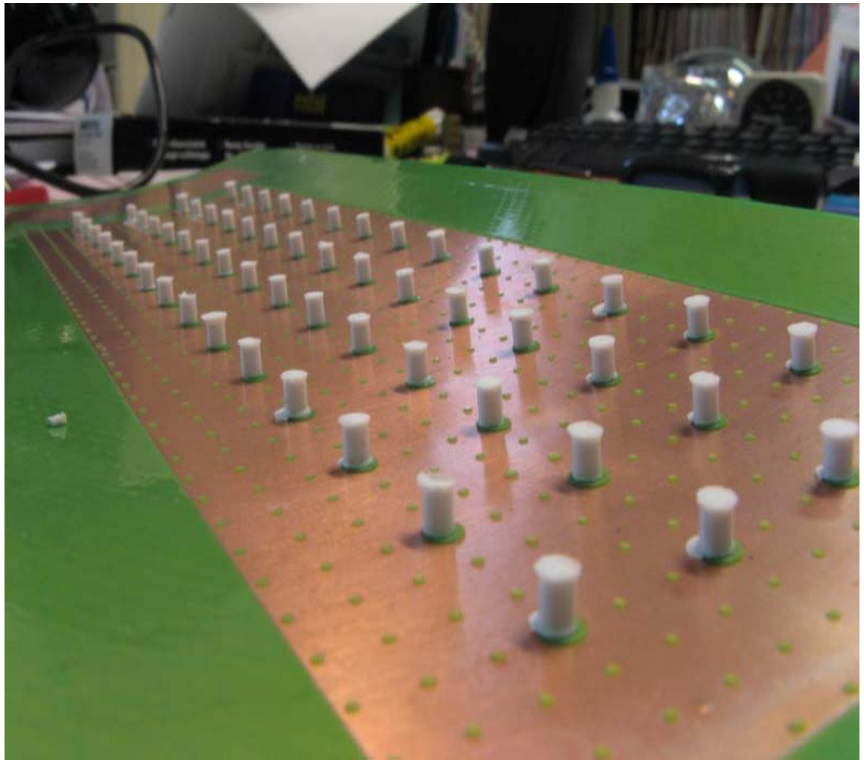
Electronics schematic




Lorentz Angle [deg] vs. (Drift - Mesh HV)/drift gap [V]/[mm], B=1.5T
Lorentz Angle [deg]
50
45
40
35
30
25
20
15
10
100
150
200
250
300
350
(Drift - Mesh HV)/drift gap [V]/[mm]
▲ Channel 57.88, 5% drift:5.25mm 25/06
🟥 GARFIELD, drift=5.05mm 5%

Drift Electrode integration

→ Drift plane set on silicon pillars, gas leak proof



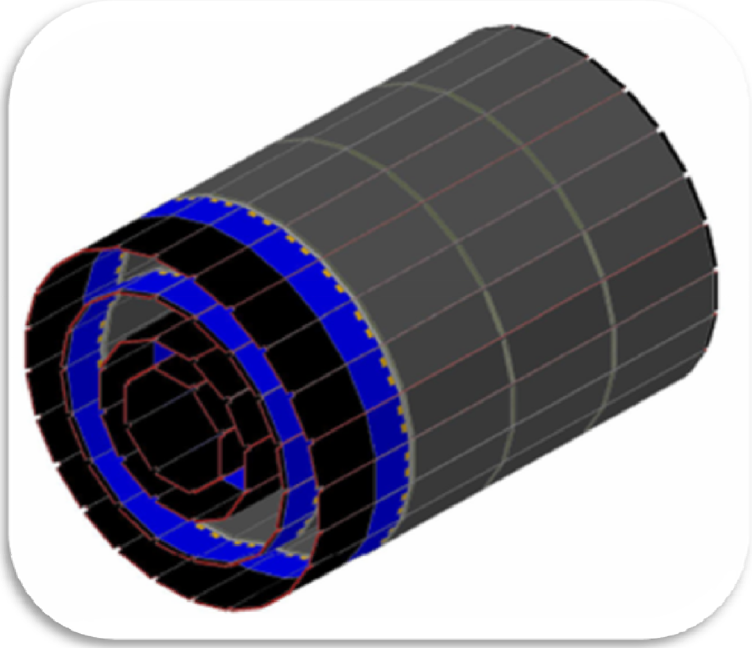
→ pillar spacing ? Sag < 0.1 mm from simul.

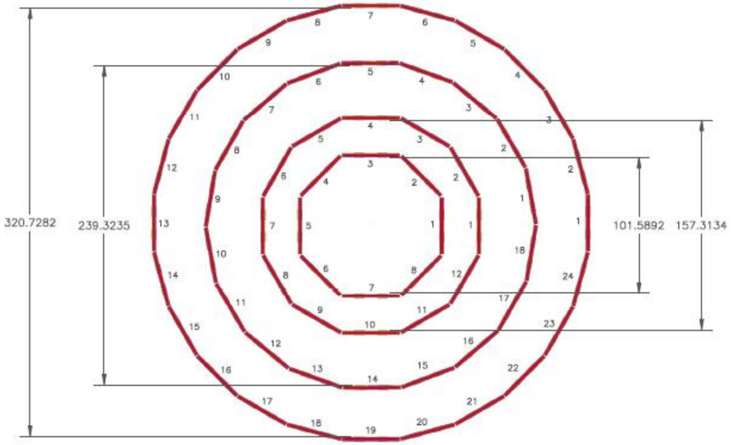
Central Tracker

Two options considered : SVT, Hybrid Bulk MM + SVT

SVT : a barrel silicon tracker (BST) and a forward silicon tracker (FST). The BST has four regions with eight, twelve, eighteen, and twenty-four sectors respectively,

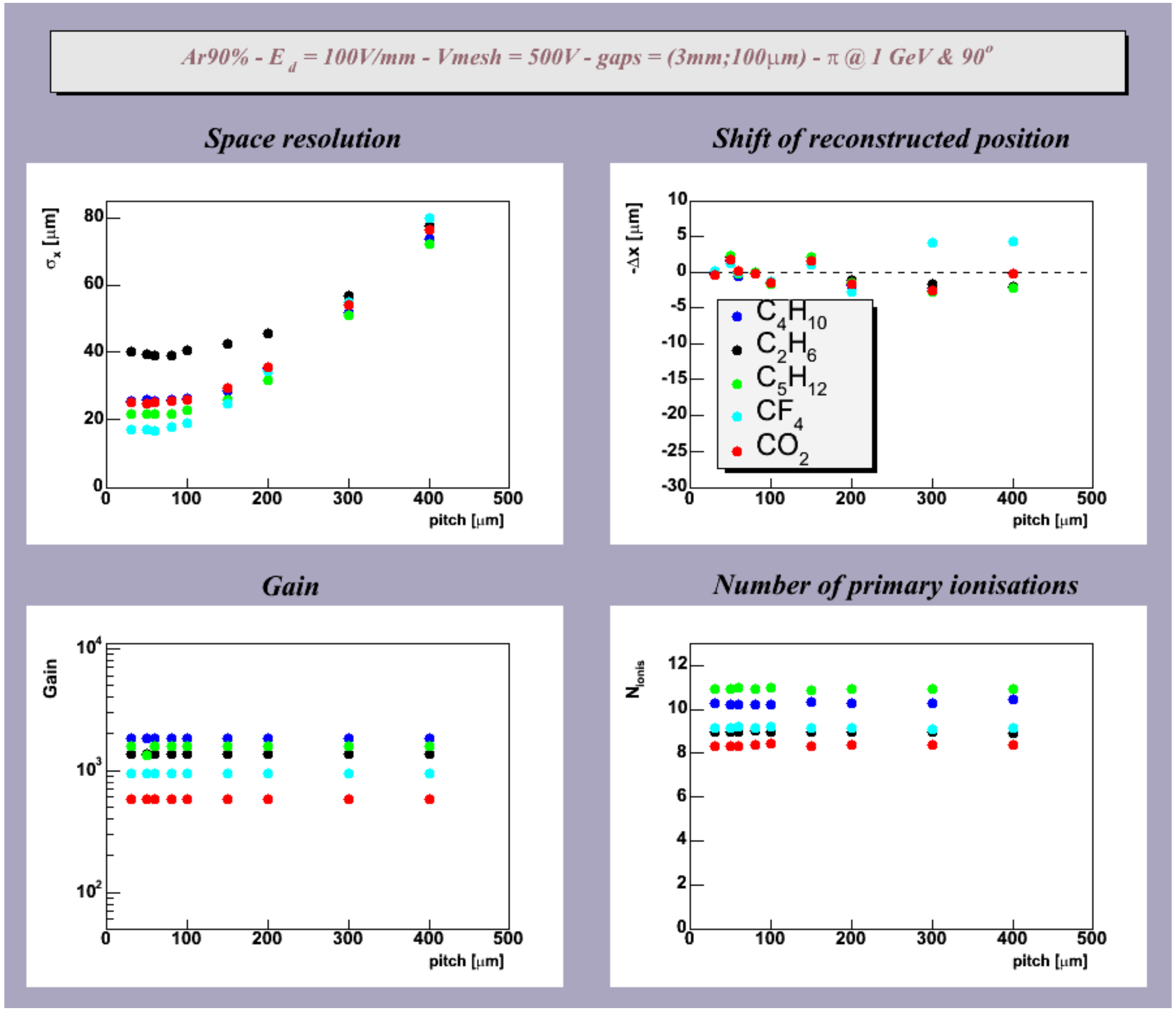
The FST has three regions, FR1–FR3, each consisting of fifteen sectors,





Simulation of FVT with Garfield

In the FVT configuration, the space resolution is better, if the pitch is small enough



→ Systematics studies with different pitches, gas mixtures, resistive film, etc…

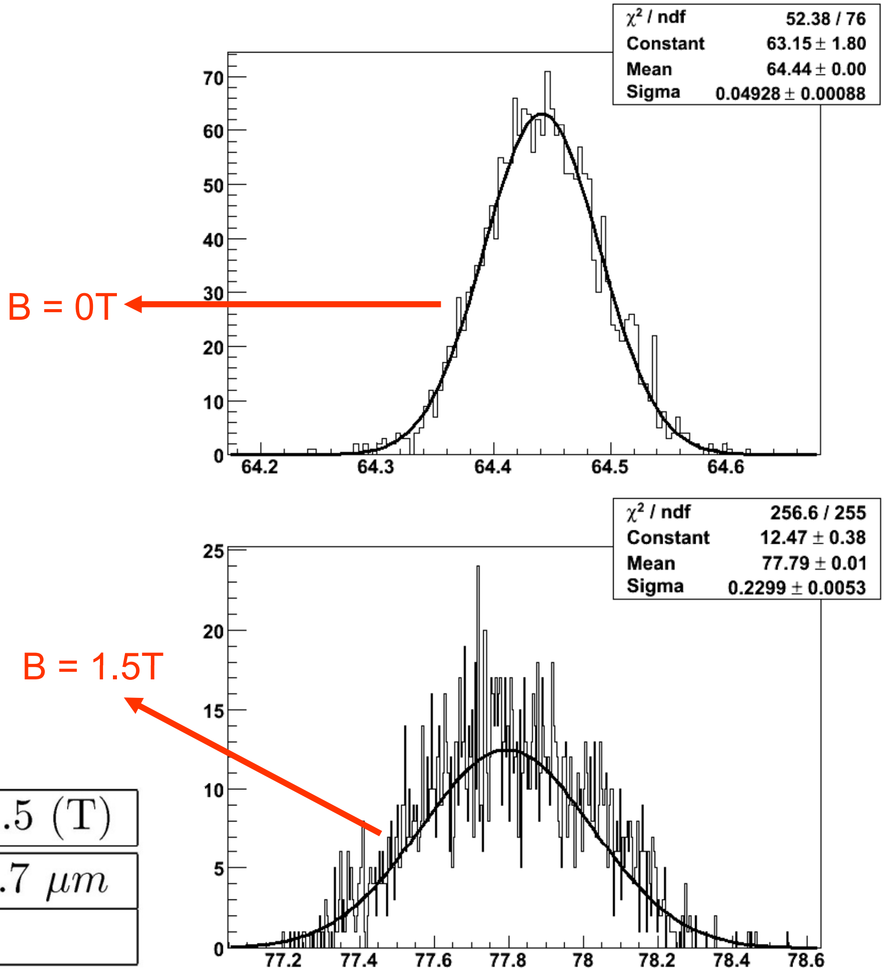
Resistive film will give a smaller "effective" pitch but a larger Time resolution, unlikely wrt background.

if resistive film possible (low transverse diffusion)(Ar+CF_4);
⇒σ = 20 µm

⇒if not, σ = 80 µm increase transverse diffusion (Ne+C_2H_6)

Spatial resolution

- Sigma of the average position calculated event by event
- $\sigma^2=(\sigma^2(\text{laser})+\sigma^2(x))/N$
- When the magnetic field increases → the resolution increases
- Test the detector homogeneity

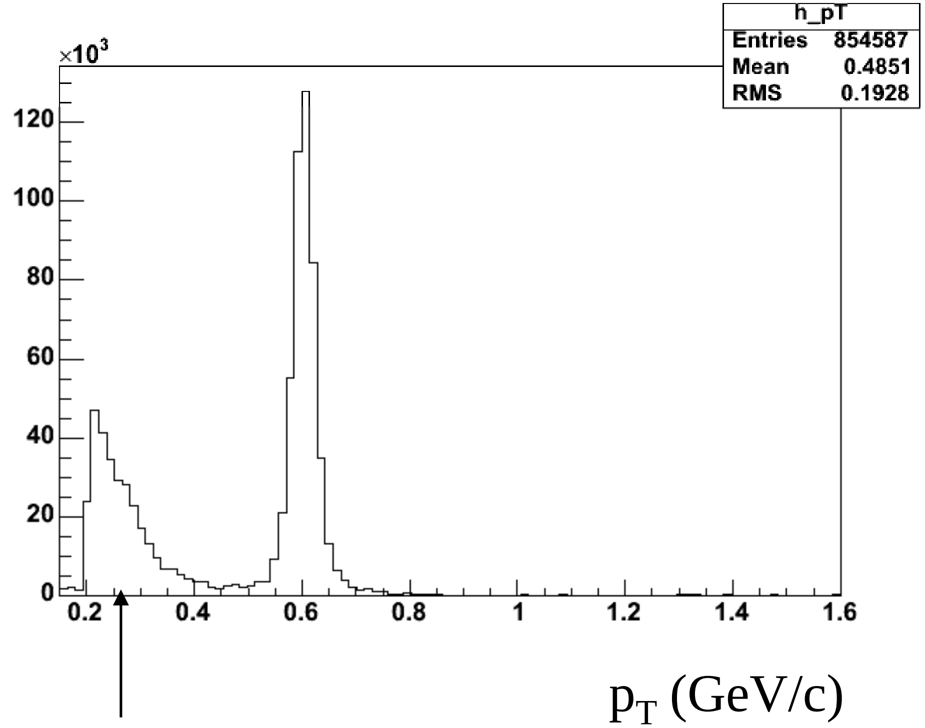


	B0 (T)	B0.5 (T)	B1 (T)	B1.5 (T)
exp	13.9 μm		26.5 μm	53.7 μm
sim	22 μm	38 μm	102 μm	

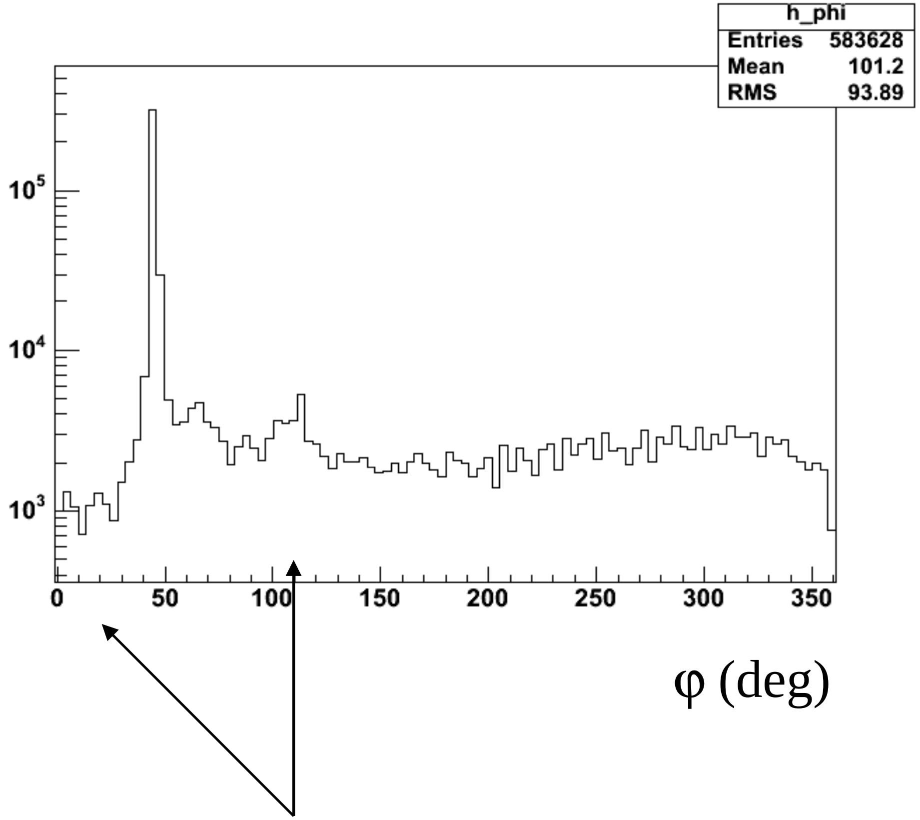
TAB. 1 – Spatial resolution at different magnetic fields

Status of the central tracking

→ Track finder algorithm with 150 MHz background (now parameterized via Geant4 simul.).
KF algorithm



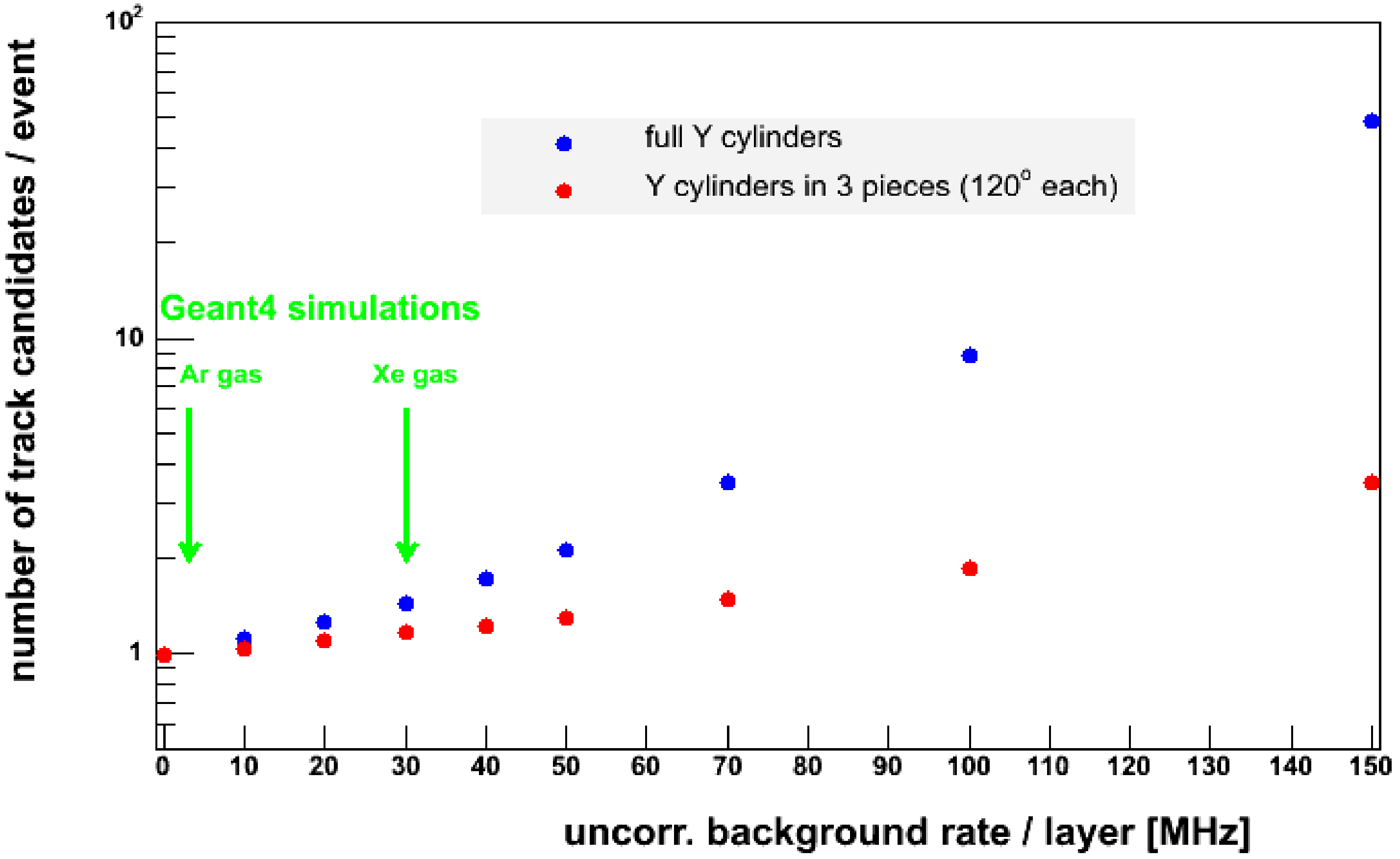
Fake tracks (small momentum, small θ.



Bugs (fixed)

Status of the central tracking

→ Effect of (uncorrelated) background on the number of reconstructed tracks (assuming a time window of 100 ns)

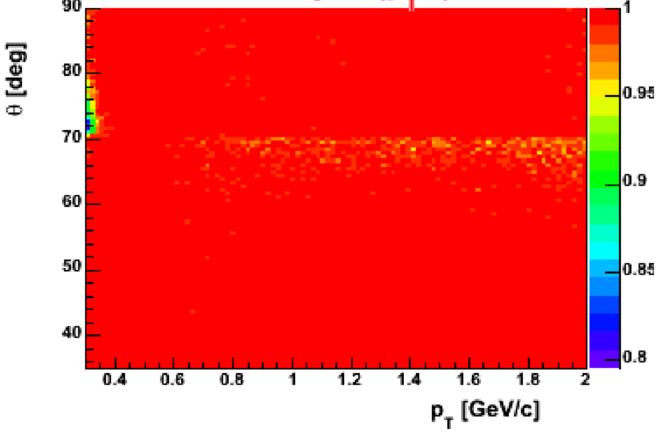


⇒ Can handle much more than what is expected by Geant4 simulations!

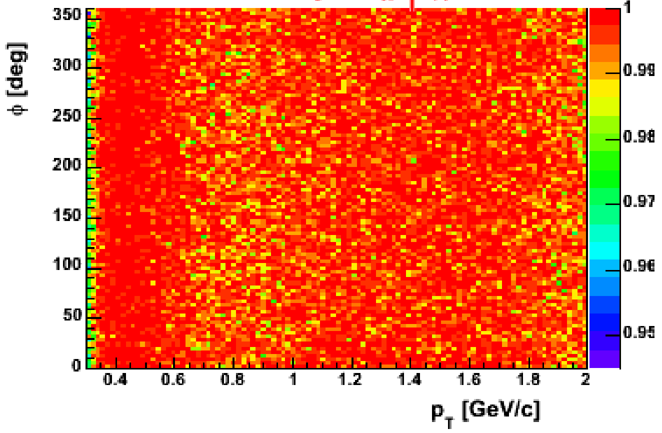
Status of the central tracking

→ Reconstruction: efficiency and performances

efficiency in (p_T,θ)



efficiency in (p_T,ϕ)

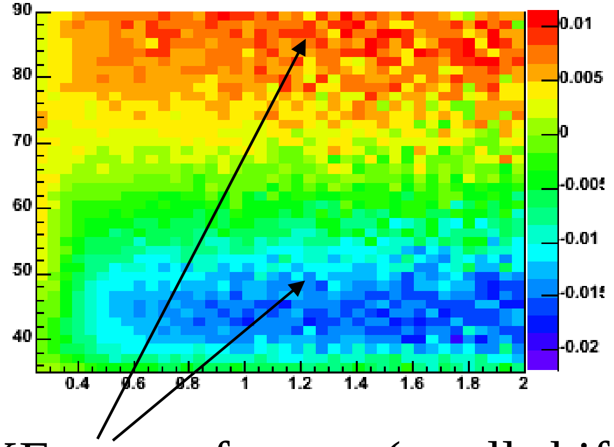


$\Rightarrow \varepsilon = 99.0\%$

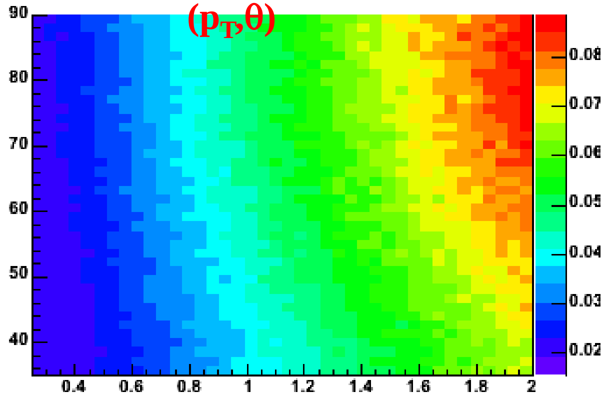
$0.25 < p_T < 2.0$ GeV/c

$35° < \theta < 90°$

$\Delta p_T/p_T$ in (p_T,θ)



σ_{pT}/p_T in (p_T,θ)



KF not perfect yet (small shift of the reconstructed momentum, depending on θ)