SHIP Test Beam Oct-Nov 2015

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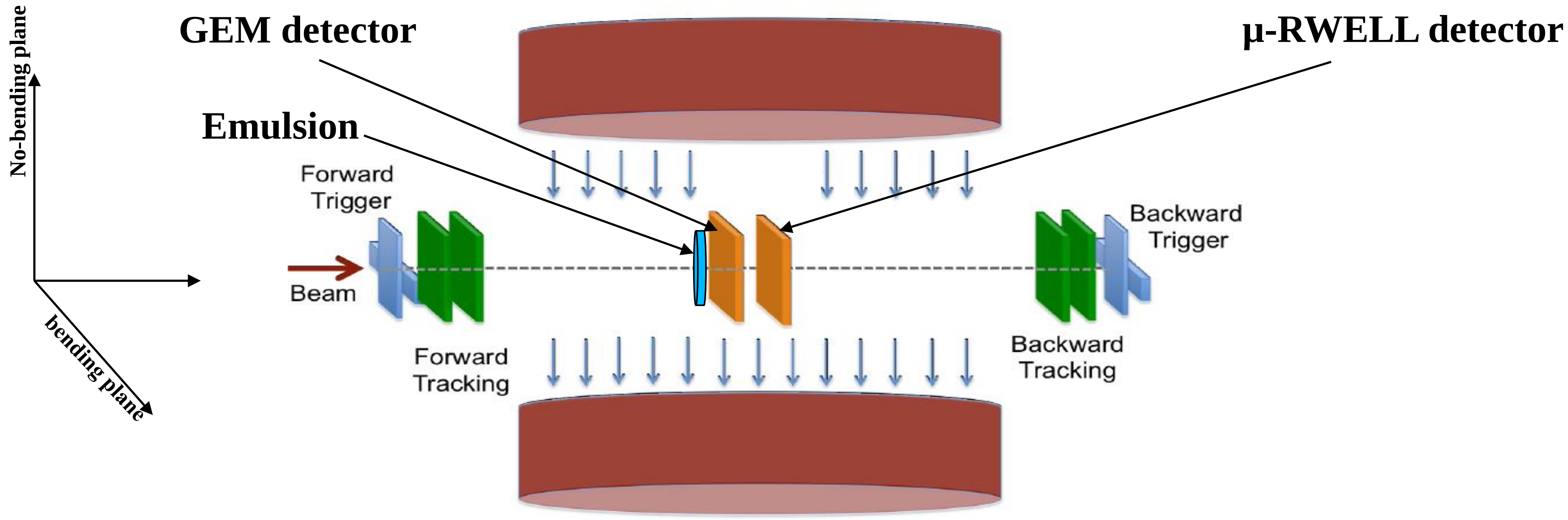
Beam Test Setup



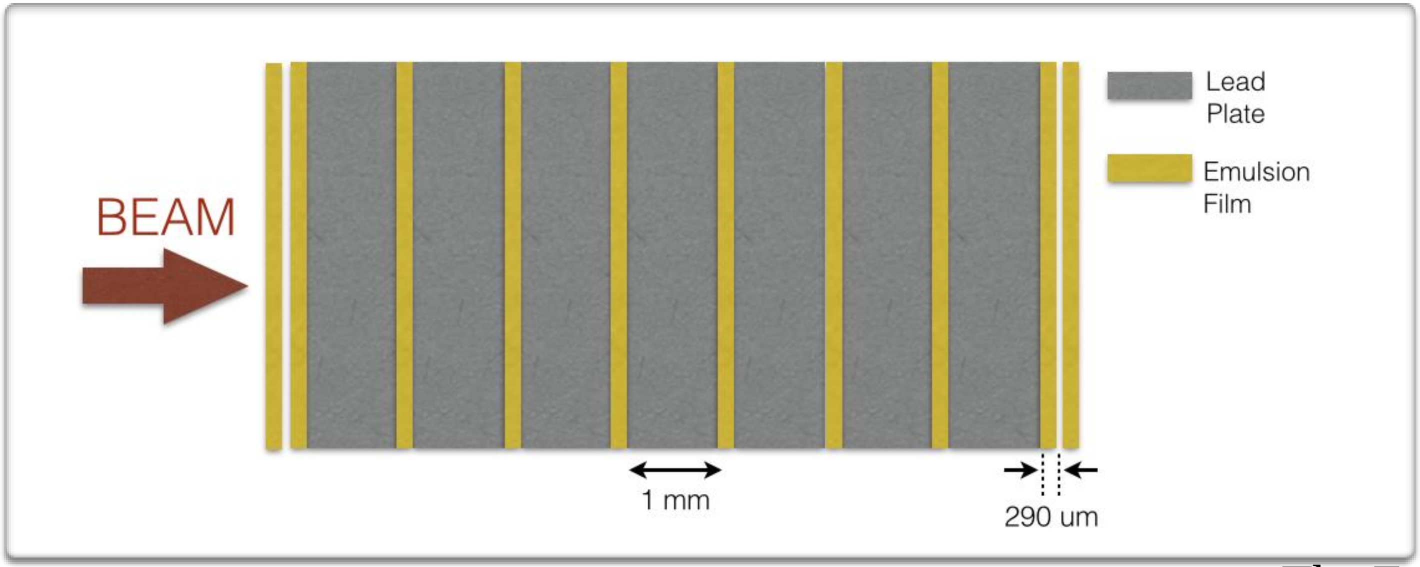
GOAL: study of the matching between emulsion and electronic tracker

- trigger scintillators and GEM trackers outside Goliath
- setup was foreseen two kind of electronic detectors, both independently coupled with emulsion set-up:
  - a large drift gap XY GEM
  - ~~two 1-D μ-RWELL coupled at 90° to supply XY info~~ not delivered
  - beam set-up displaced wrt the beam axis of ~10 cm in order to reduce the irradiation of the emulsion units

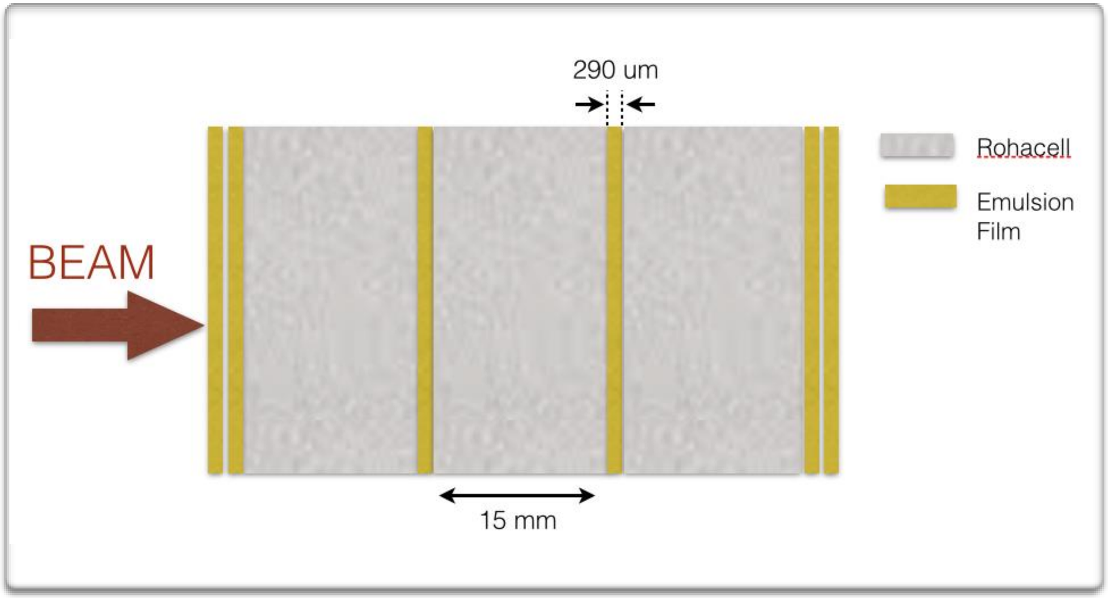
- tracking with linear fit
- track residual w/COG
- analysis code by INFN - Ferrara

Emulsion Target Units

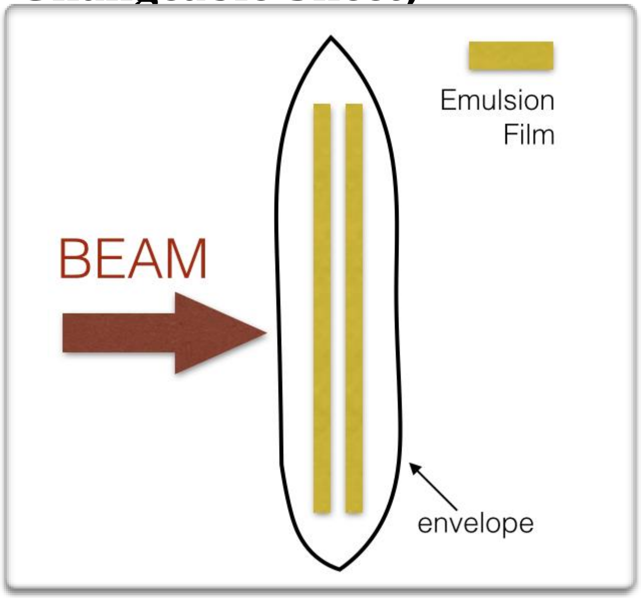
- The Emulsion Cloud Chamber **(ECC)**



- The Compact Emulsion Spectrometer **(CES)**

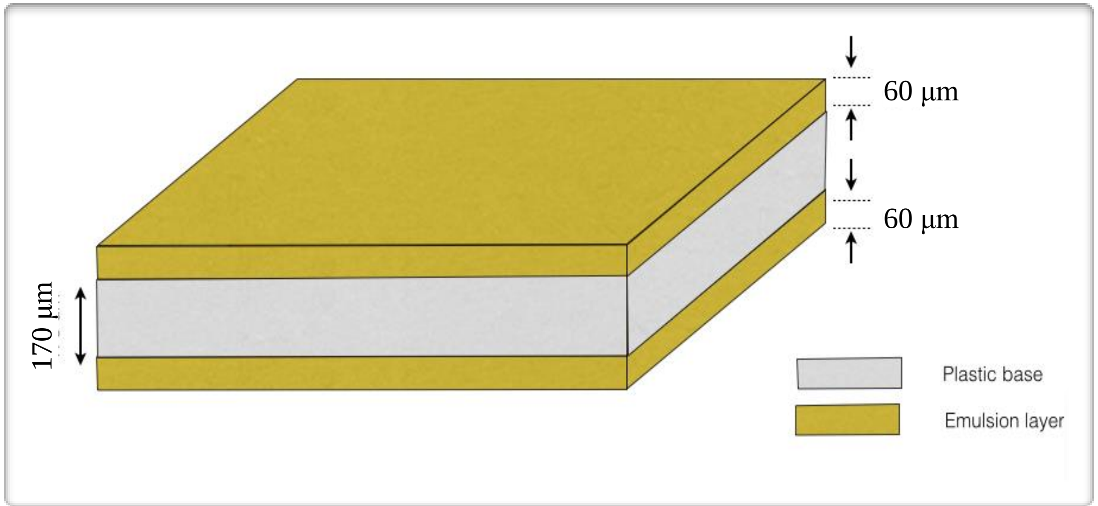


- The Emulsion Doublet **(CS – Changeable Sheet)**



Emulsion Films

- Emulsion films produced in Nagoya University



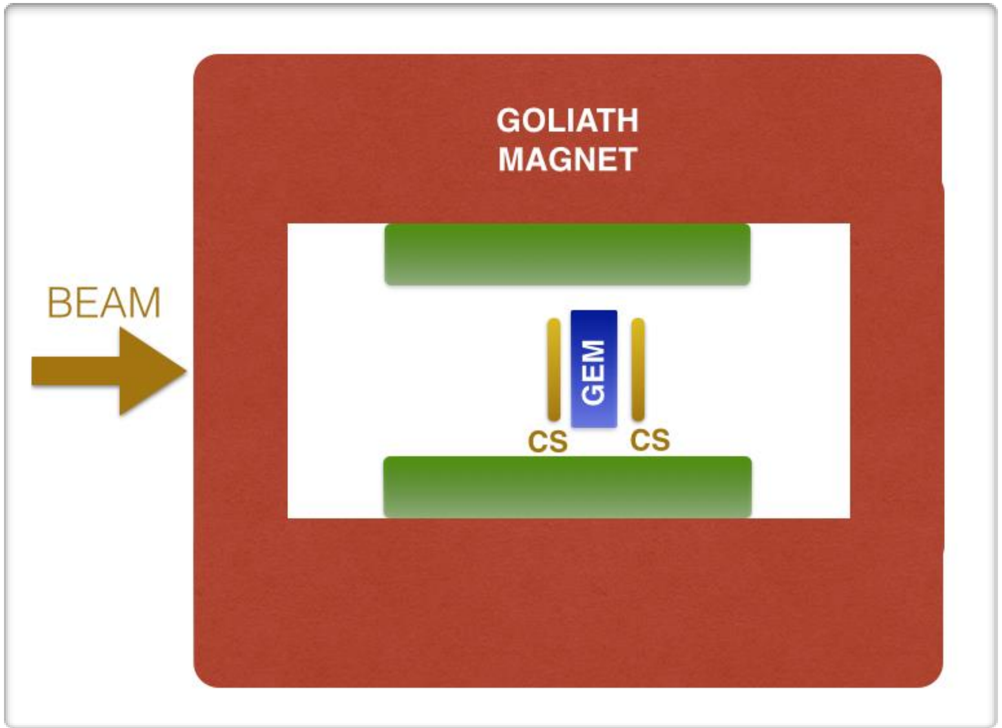
- Film dimensions
    - Surface: 125 mm x 100 mm
    - Total thickness: 290 μm

- New emulsion gel developed in Nagoya University
    - Grain density: 50 grains/100 μm (higher than OPERA films)

- Emulsion production
    - Emulsion poured in middle August 2015 and cut by hand
    - Shipped to CERN by plane
    - Total amount of emulsion films produced: 120
    - Emulsion films used in the Emu+GEM test beam: 30

CS exposure

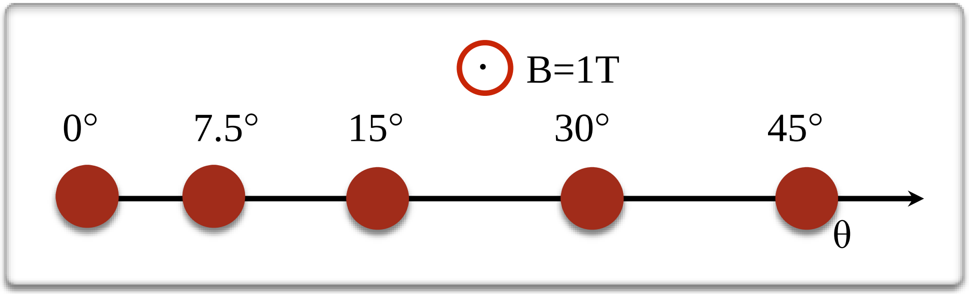
- Aim: study of the GEM space resolution with external track point (coming from the two CS) reconstructed with precision at level of few μm



- Experimental setup: #2 CS attached on GEM upstream and downstream surfaces
- Low density: 50 tracks/cm^2/angle
- 5 exposure angles

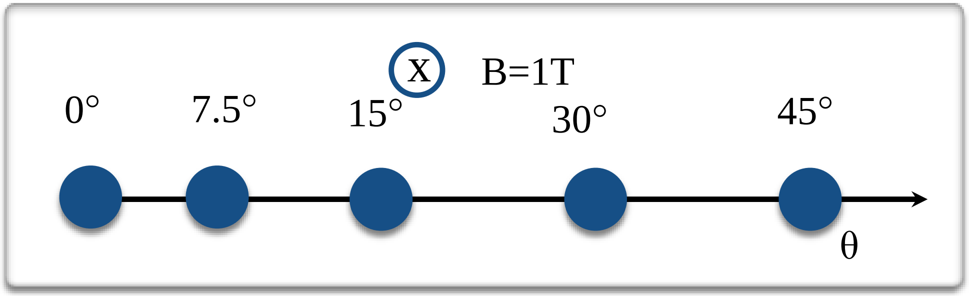
Exposure 1

- Target: 2 x CS
- Magnetic Field: + 1T



Exposure 2

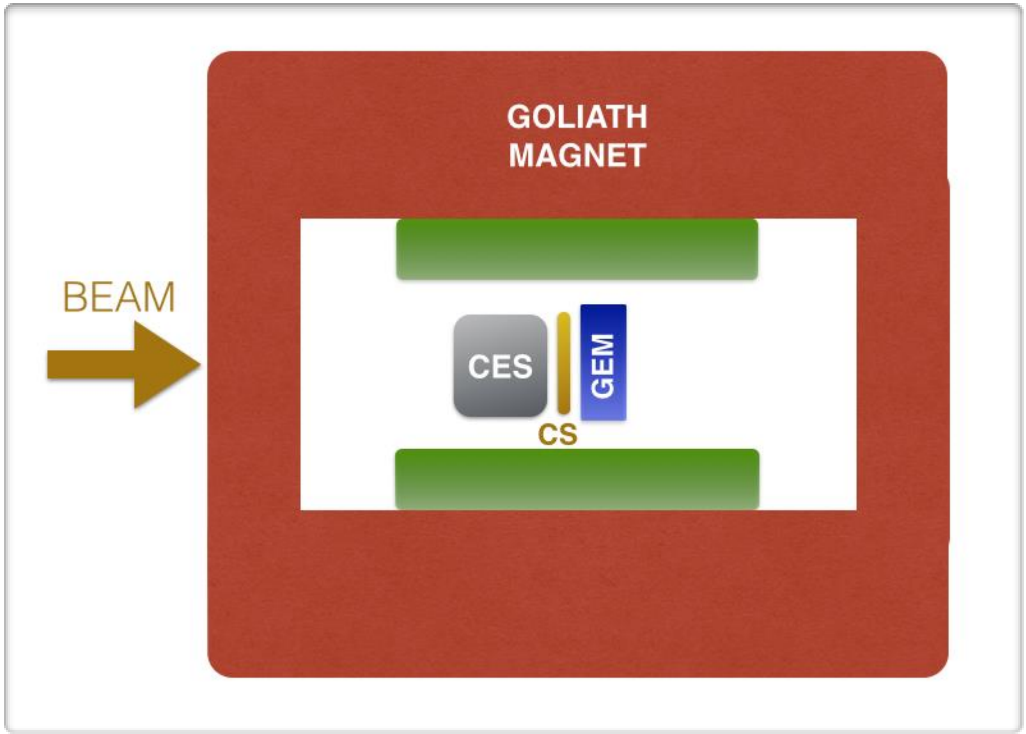
- Target: 2 x CS
- Magnetic Field: - 1T

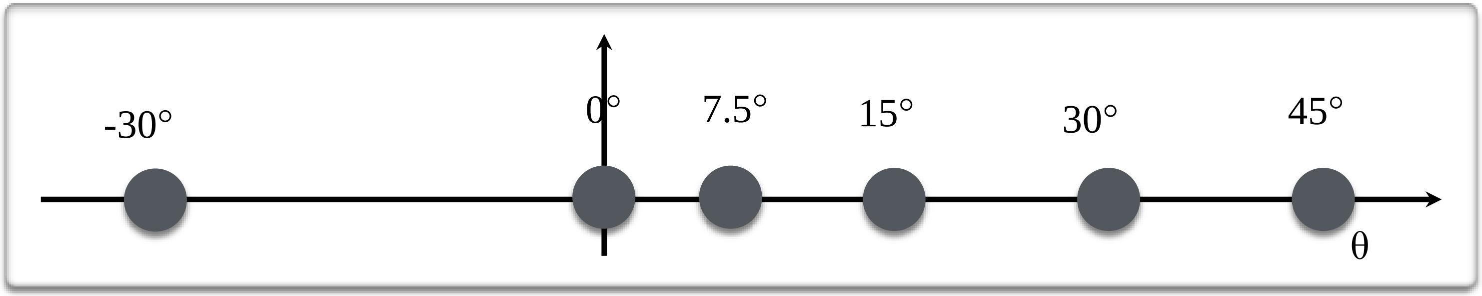


CES exposure

- Aim: track matching between GEM and CES (Emulsions interleaved with Rohacell)

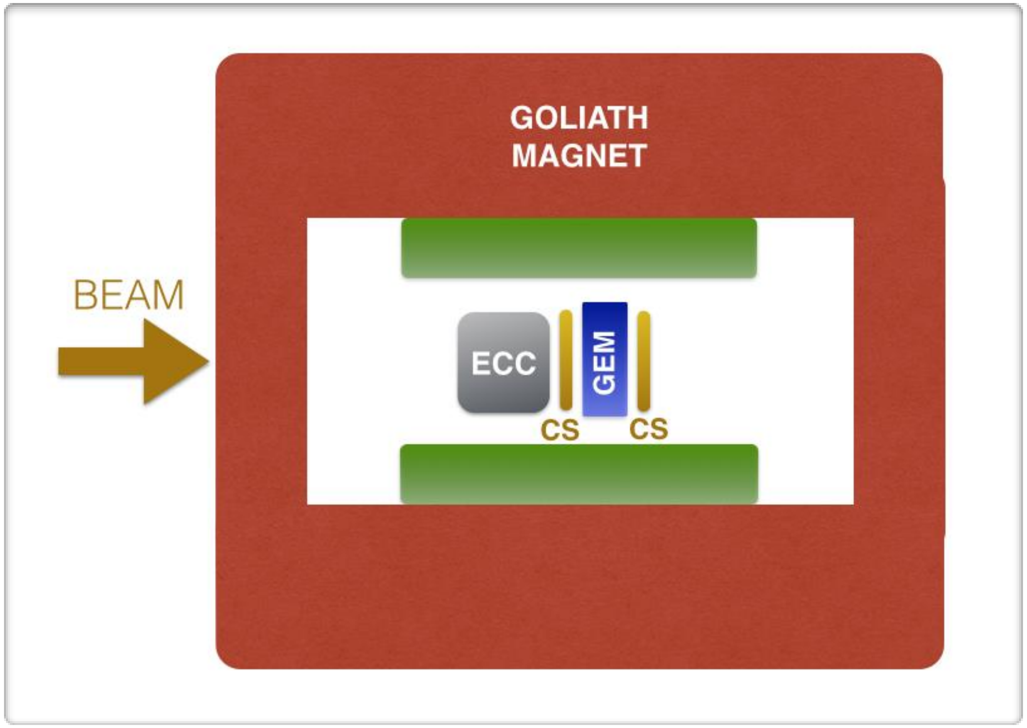
- Target: 1 CES + 1 CS (Emulsion doublet)
- Low density: 100 tracks/cm^2/angle
- 6 exposure angles
- No magnetic field



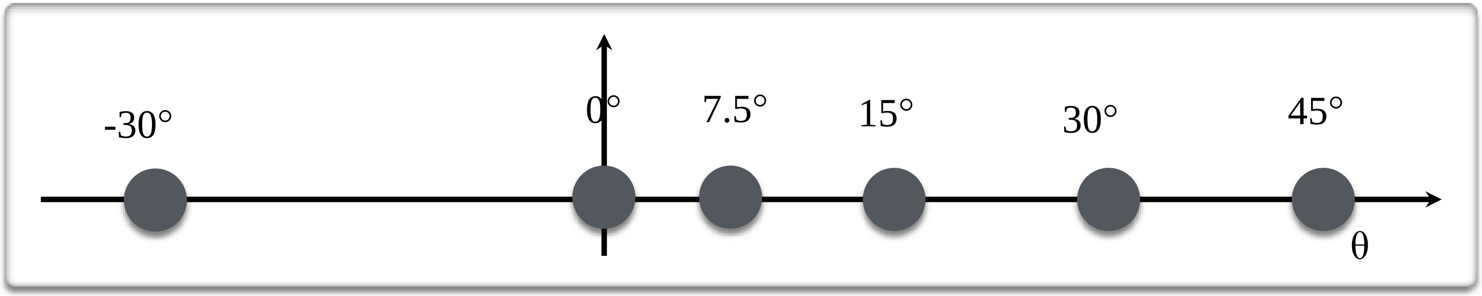


ECC exposure

- Aim: track matching between GEM and ECC (Emulsions interleaved with Lead)

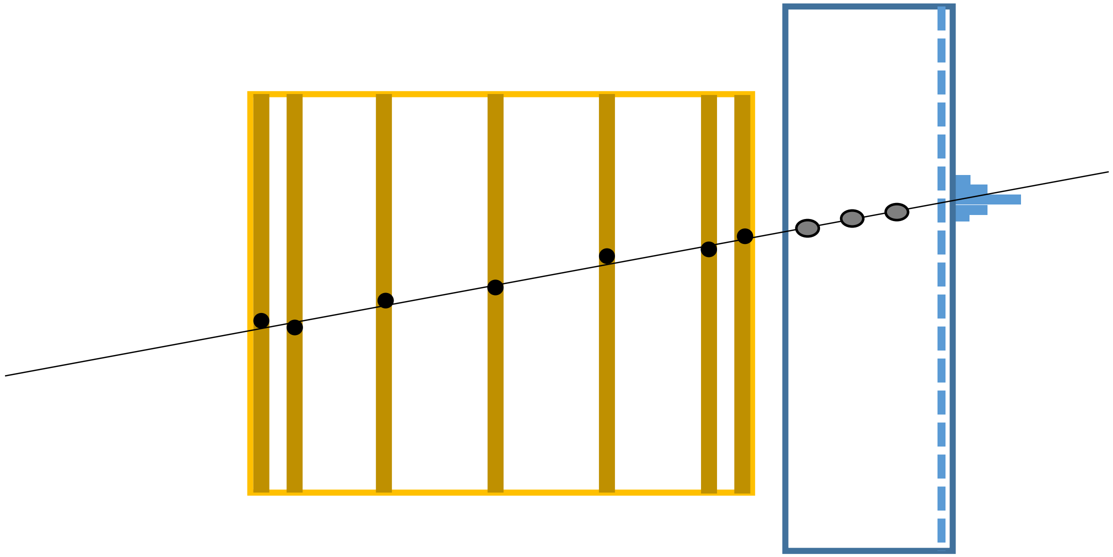


- Target: 1 ECC + 2 CS (Emulsion doublet)
- Low density: 100 tracks/cm^2/angle
- 6 exposure angles
- No magnetic field



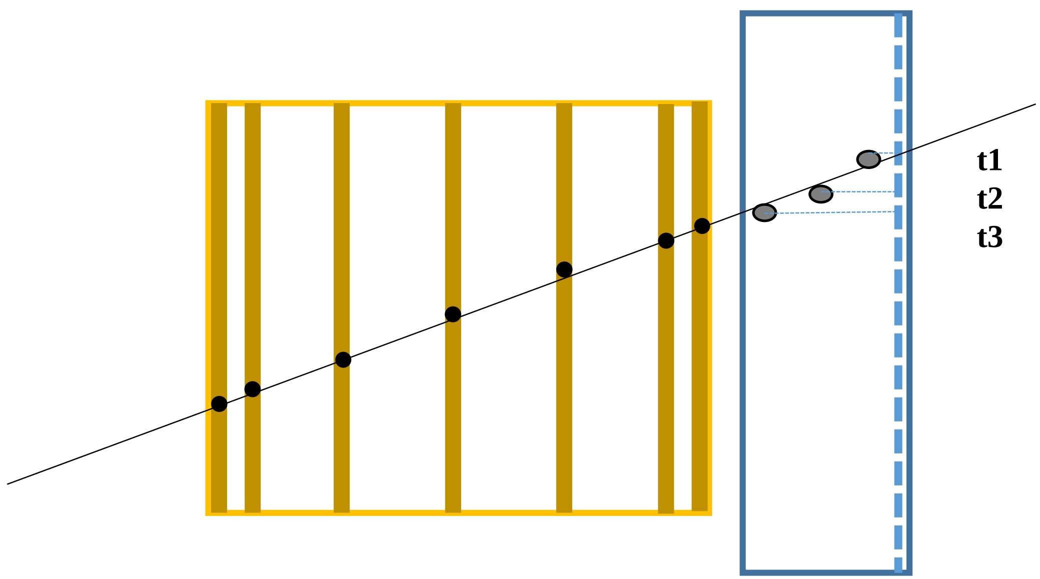
Electronic tracker & Emulsion matching

The electronic tracker should provide the time stamp to the event reconstructed by the emulsion unit



COG method:
XY(elect) position from electronic detector is compared/matched with the XY(emu) by the emulsion unit.

It works only with small angle & low B field.

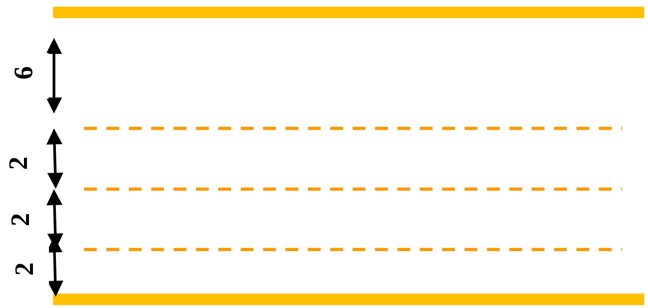


Micro-TPC mode:
direct comparison/matching between the track_segment (elect) reconstructed by the electronic detector and the track_segment (emu) finely reconstructed by the emulsion unit.

It works well also at large angle & high B field

Electronic Detectors layout

Triple-GEM detector:
6/2/2/2 gap geometry



X-Y r/o (650 μm strip pitch)

GEM operated in Ar/CO_2=70/30

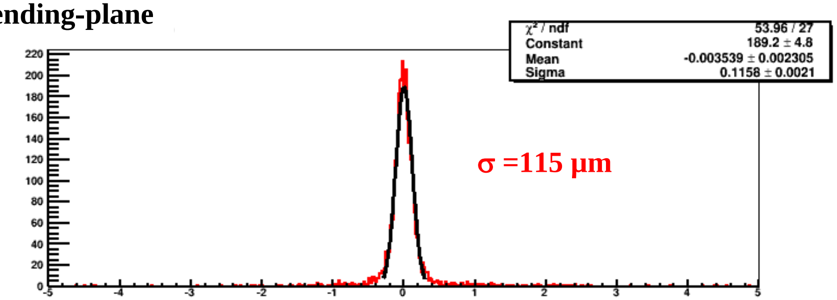
μ-RWELL detector:
4 mm drift gap & resistivity ~1MΩ/□
USE ONLY AS SW-TRIGGER TO CLEAN THE EVENT SAMPLE

1 D r/o (400 μm strip pitch)

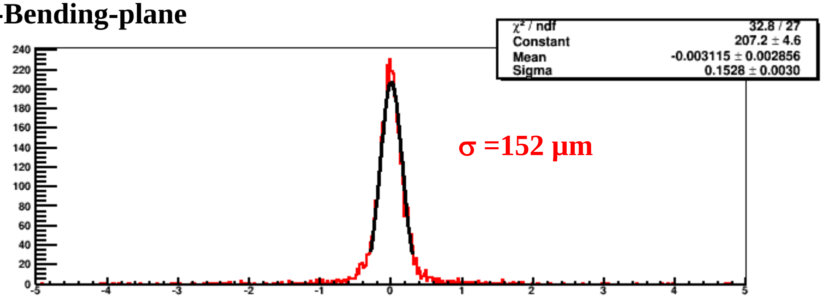
μ-RWELL operated in Ar/ISO=90/10

Center of Gravity (COG) method

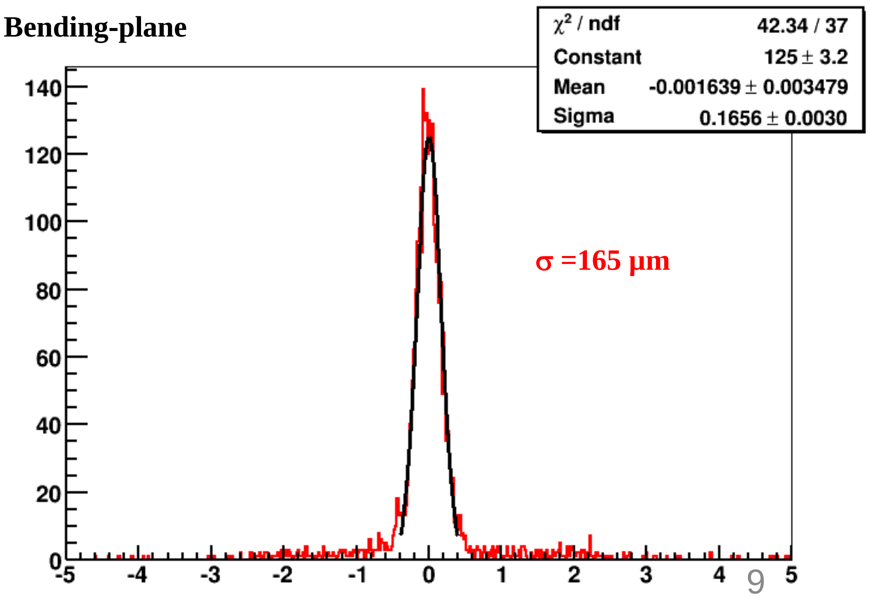
Bending-plane



No-Bending-plane



Bending-plane



RUN conditions

Calibration RUN (upstream – downstream trigger):

- Scan in drift field with orthogonal tracks & B=0 T (7 runs)
- Scan in HV with orthogonal tracks & B=0, -1 T (18 runs)
- Scan in angle (0,7.5,15,30,45) & B= 0, ± 1 T & 2 GEM Gain (30 runs)

Run with emulsion setup (trigger w/forward scintillators + SW trigger based on forward trackers + μ-RWELL):

- Scan with CS emulsion: angle (0,7.5,15,30,45) & B= 0, ± 1T (10 runs)
- Scan with CES & ECC emulsion: tilt angle (0,7.5,15,30,45) & B= 0 T (10 runs)

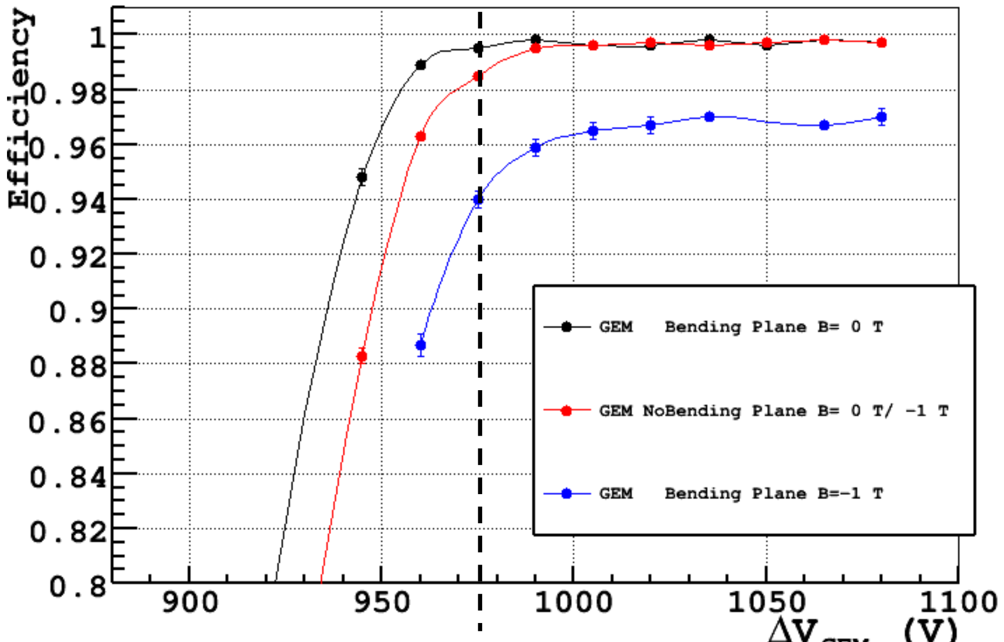
We present preliminary results based on (COG) method for the Calibration runs

NO micro-TPC MODE ANALYSIS (the code is under development by INFN-FE)

NO COMBINED RESULTS BETWEEN GEM & EMULSIONS SETUP

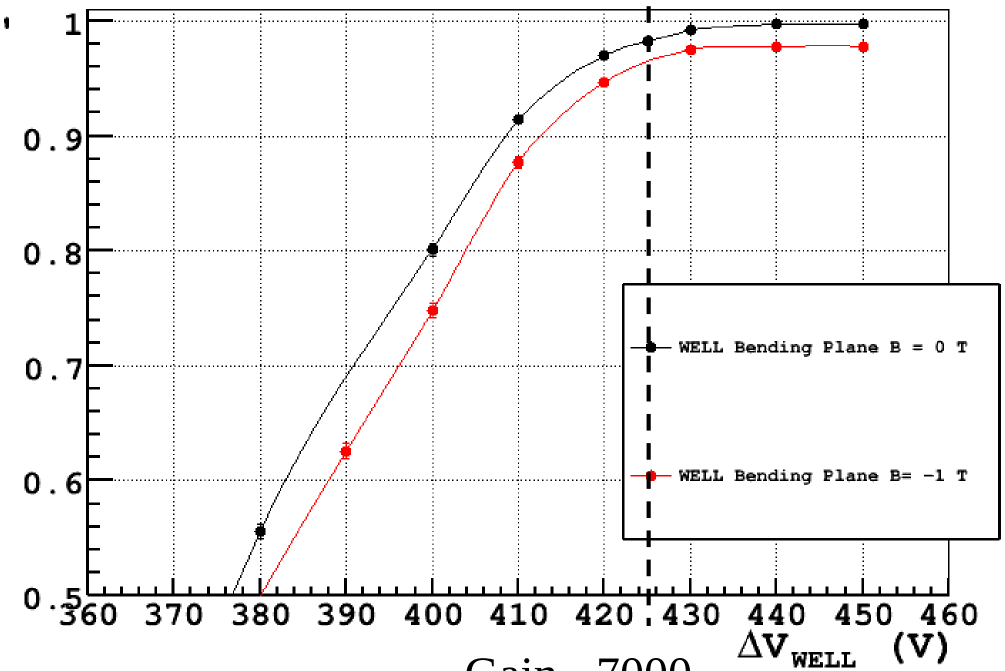
Efficiency vs HV with orthogonal tracks

GEM detector



Gain~ 2000

μ-RWELL detector

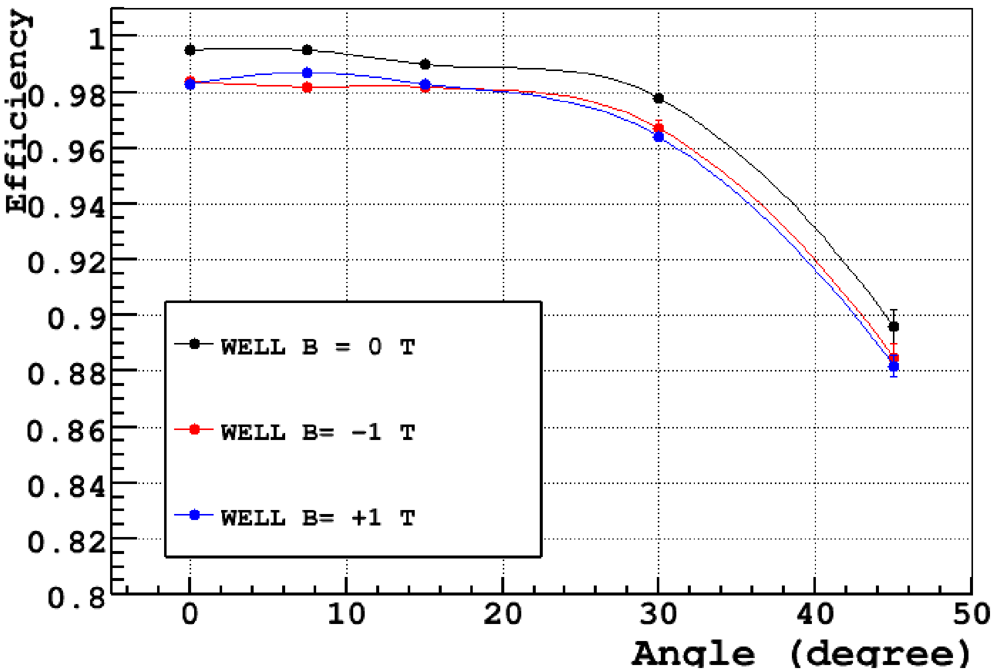


Gain~ 7000

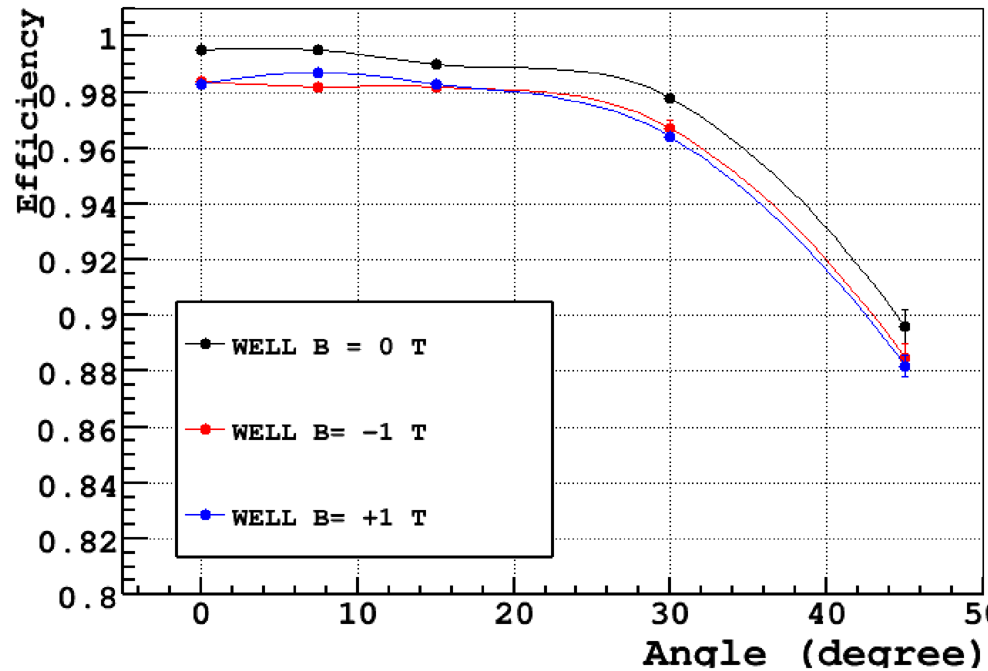
The efficiency decrease with B

Efficiency vs tilt angle
w & w/out magnetic field

GEM detector - Gain~ 4000



μ-RWELL detector - Gain~ 8000

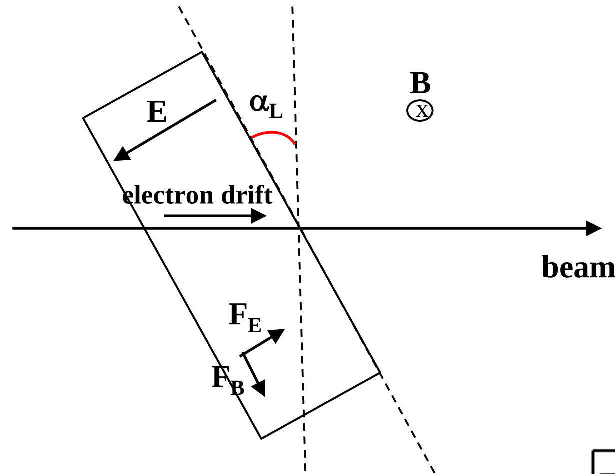


- Larger the incidence angle
- Larger the spread of the charge over the readout strips
- Smaller the charge collected by the strips
- Smaller the efficiency

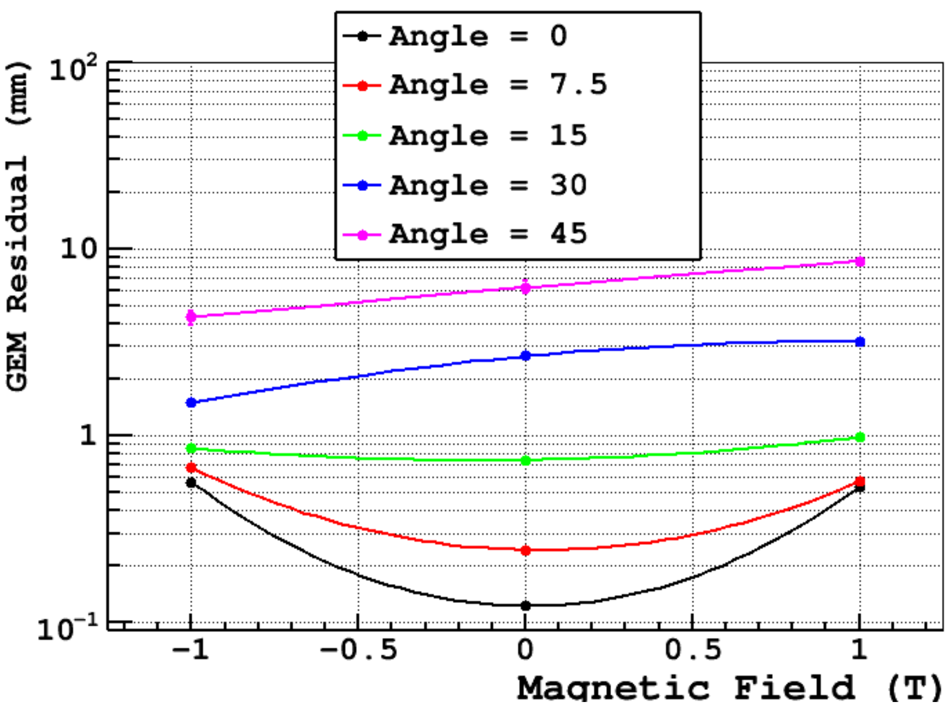
The effect is larger w/B

Track residual vs magnetic field for different tilt angle

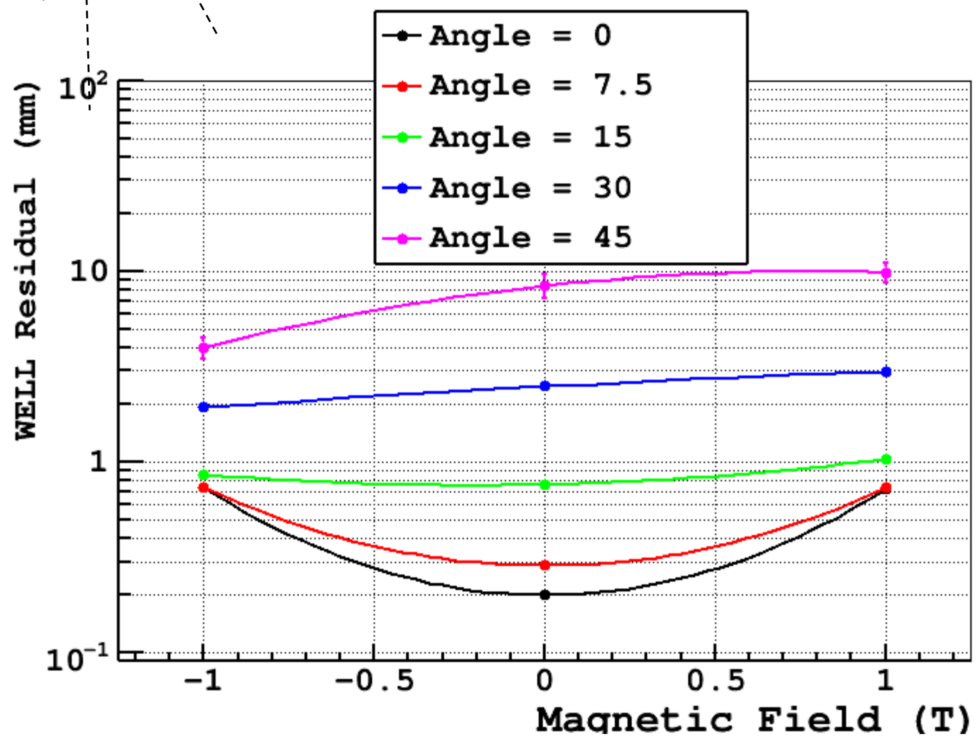
The track reconstruction based on COG methode make sense only at small incidence angle and low B field.



GEM detector



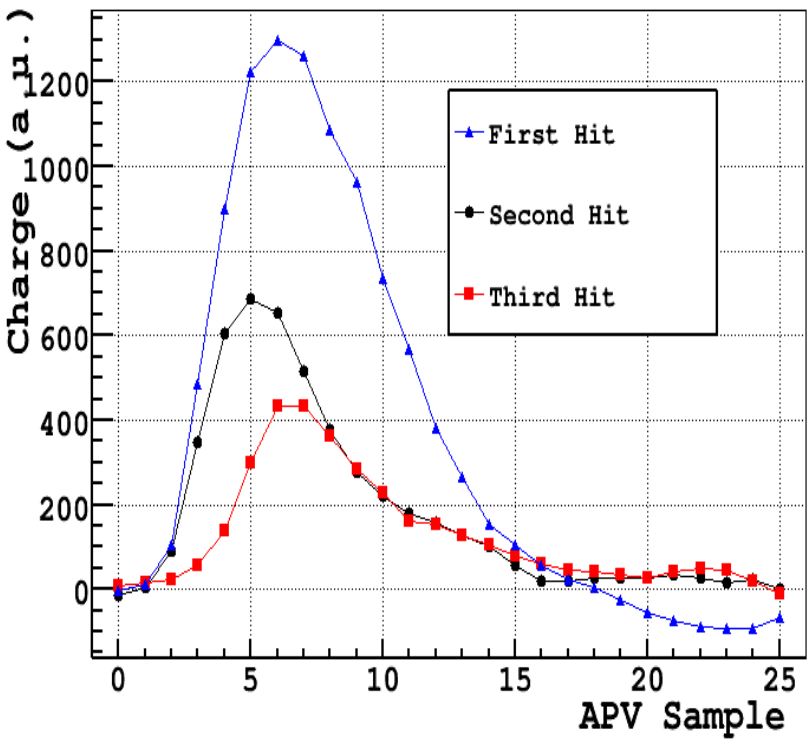
µRWELL detector



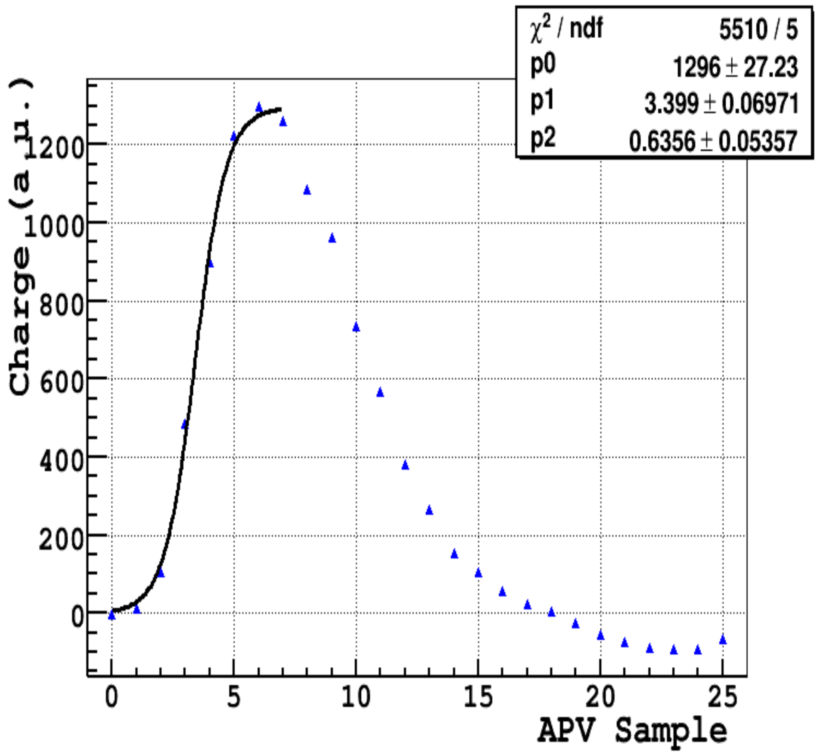
μ-TCP mode (I)
orthogonal tracks & B = 1T

work in progress

Event with 3 hits



$$FD(t) = \frac{p0}{1 + exp^{\frac{-(t-p1)}{p2}}}$$

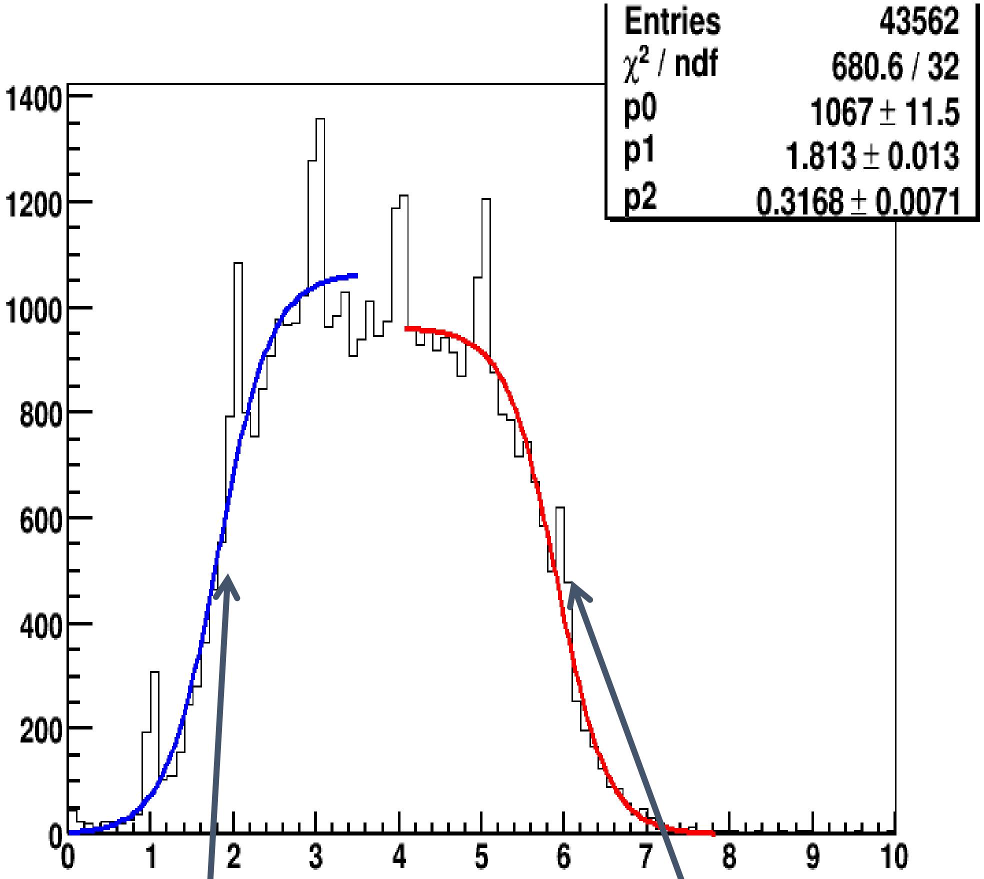


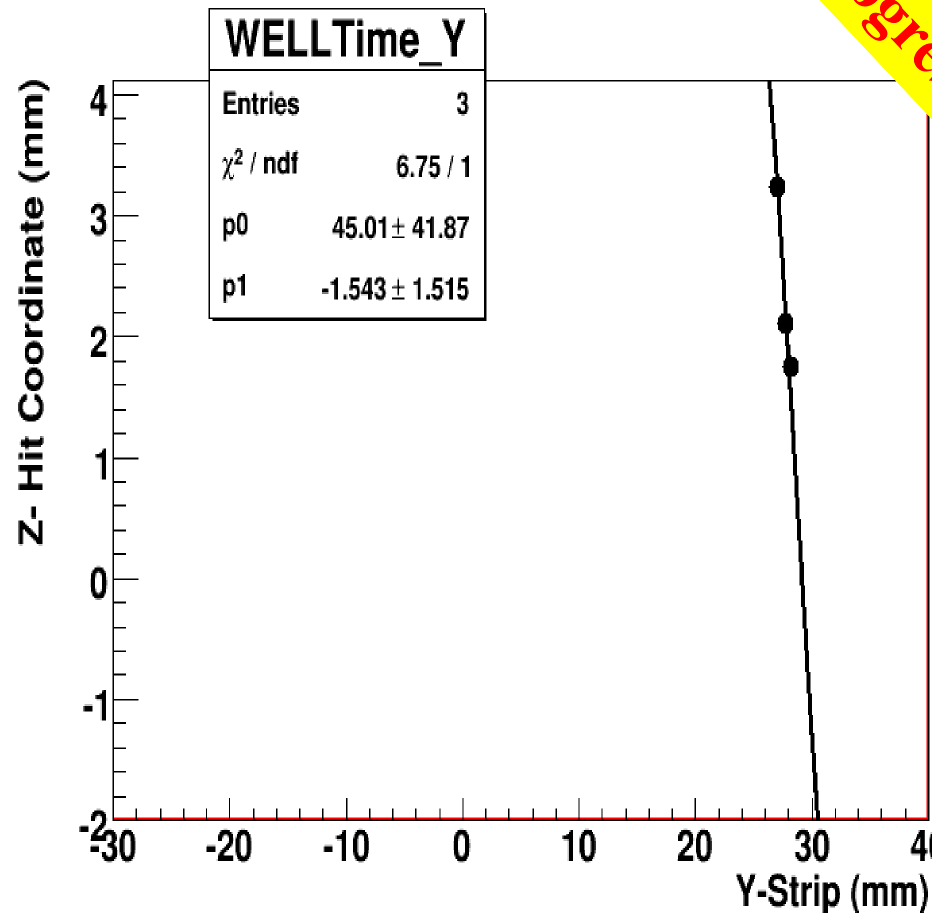
Charge distribution fitted with a Fermi-Dirac:
p1 is the time at half-maximum of the charge distribution

μ-TCP mode (II)
orthogonal tracks & B = 1T

work in progress

The Fermi-Dirac's parameter p1 for all events





T0 = 1.81 APV Sample →
(45.323 +- 0.003) ns

Tmax = 5.91 APV Sample →
(147.657 +- 0.004) ns

Double Fermi-Dirac Fit

ΔT = 102.3 +- 0.1 ns
Drift Gap = 4 mm
Drift Velocity = (3.9 +- 0.1) cm/μs
Drift Velocity (Garfield) = (3.5+-0.1) cm/ μs

Summary

The analysis of the SHIP TB data is still at an early stage:

- the study of the GEM space resolution vs angle and B requires for more sophisticated analysis than usual COG (at least for $\alpha > 15°$)

- the code for micro-TPC mode (by Ferrara group) is under development

- combined analysis between GEM and emulsion target units (CS, CES, ECC) still to be started (delay on the emulsion chemical development)

At the moment it’s difficult to foresee for other TB with emulsions in 2016

2016 Beam Time request

In the framework of μ-RWELL R&D we are collaborating with the CMS – phase2 upgrade group for the design & construction of a first prototype of **large area μ-RWELL** with the so called LR resistive scheme (see Morello presentation of today).

The goal is to have a dedicated TB of such a proto by the **end of the 2016 (last H4 TB time slot).**

In parallel we also aim to test some **small (10x10 cm^2) μ-RWELL protos** with other features (such as HR resistive scheme and thicker WELL amplification stage – 125μm)

SPARES

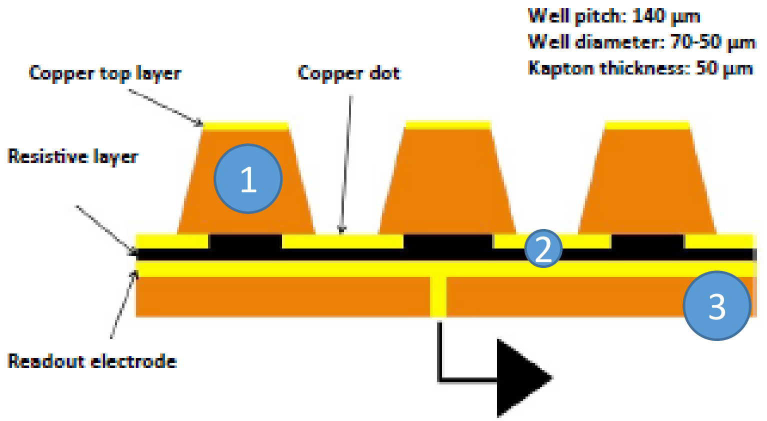
The μ-RWELL architecture

The **μ-RWELL[(*)] PCB** is realized by coupling:

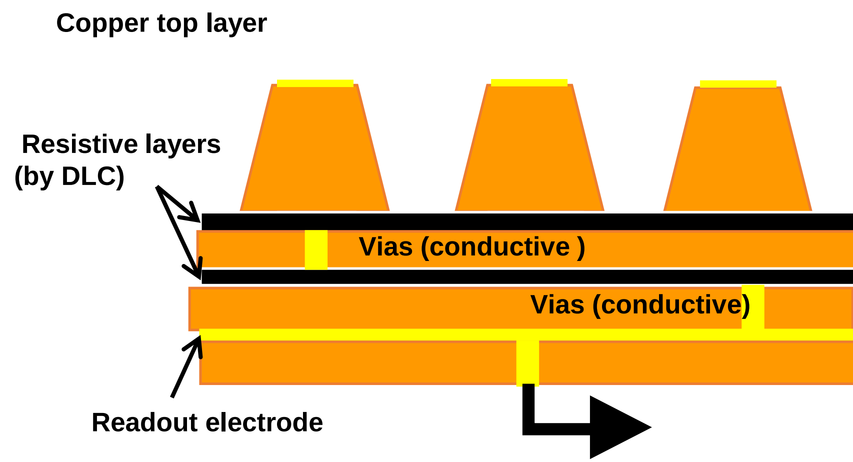
1. a "**suitable patterned GEM foil**" for the "amplification stage"

2. a **"resistive stage"** for the discharge suppression & current evacuation
   - **i. "Low particle rate" (LR)** << 100kHz/cm^2**:** single resistive layer → surface resistivity (~100 MΩ/□)
   - **ii. "High particle rate" (HR**)** >> 100kHz/cm^2: more sophisticated resistive scheme must be implemented (*performed by MPDG_NEXT- LNF financed by GR5-INFN*)

3. a **simple readout PCB** board → OK



The simplest scheme of μ-RWELL detector

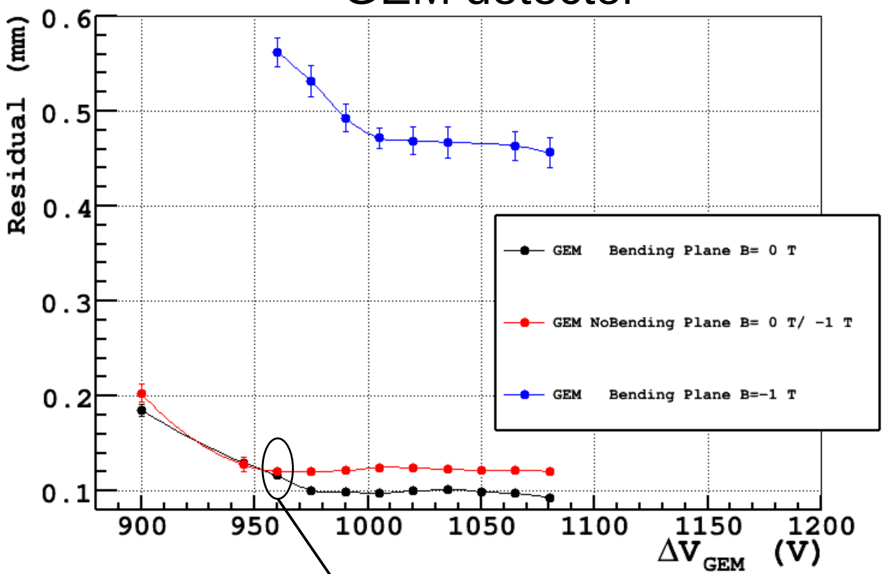


(**) the final goal being O(1 MHz/cm^2)

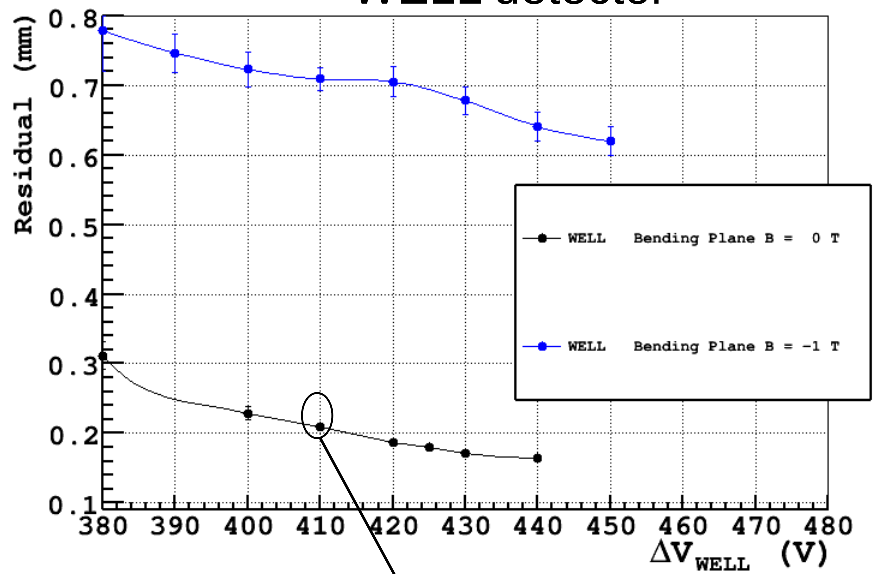
(*) the first prototype of such a type of detector (at that time called *Blind-GEM* detector) has been proposed in the 2009 by the author.

Track residual vs HV with orthogonal tracks

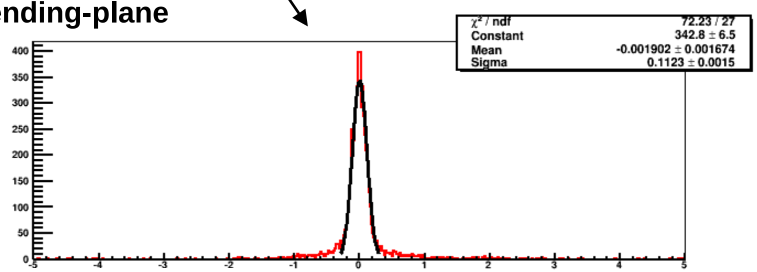
GEM detector



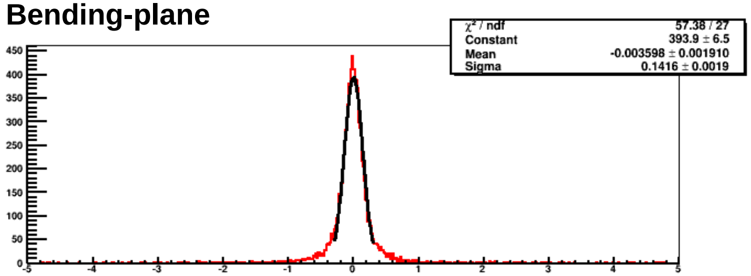
WELL detector



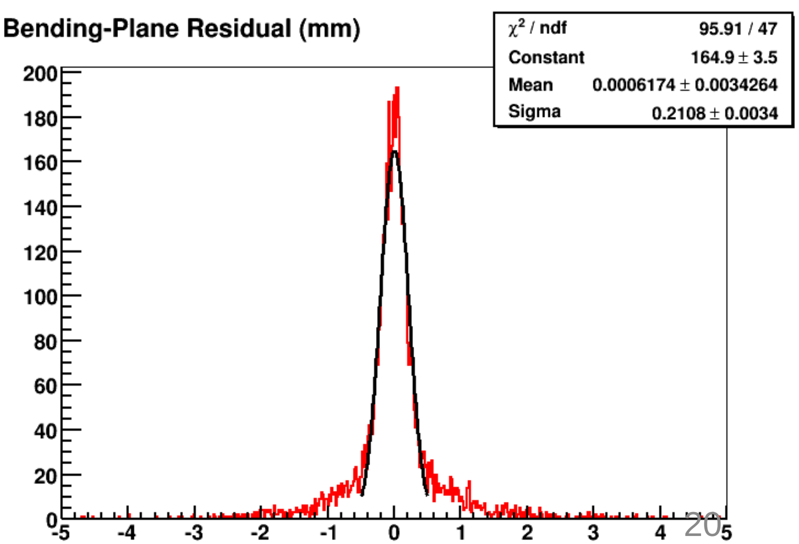
Bending-plane



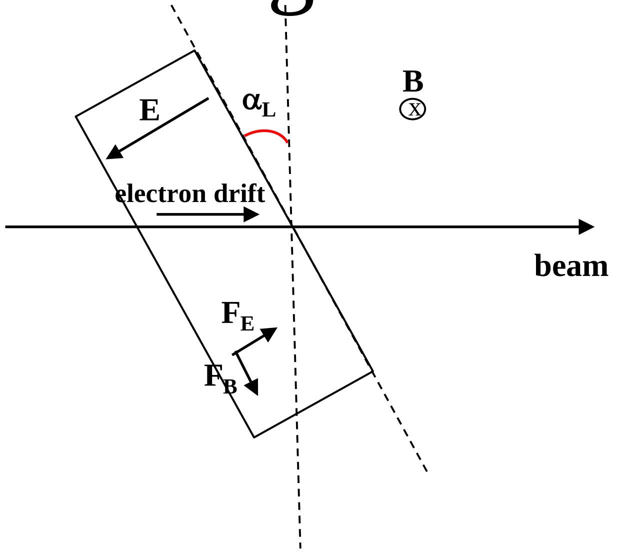
No Bending-plane



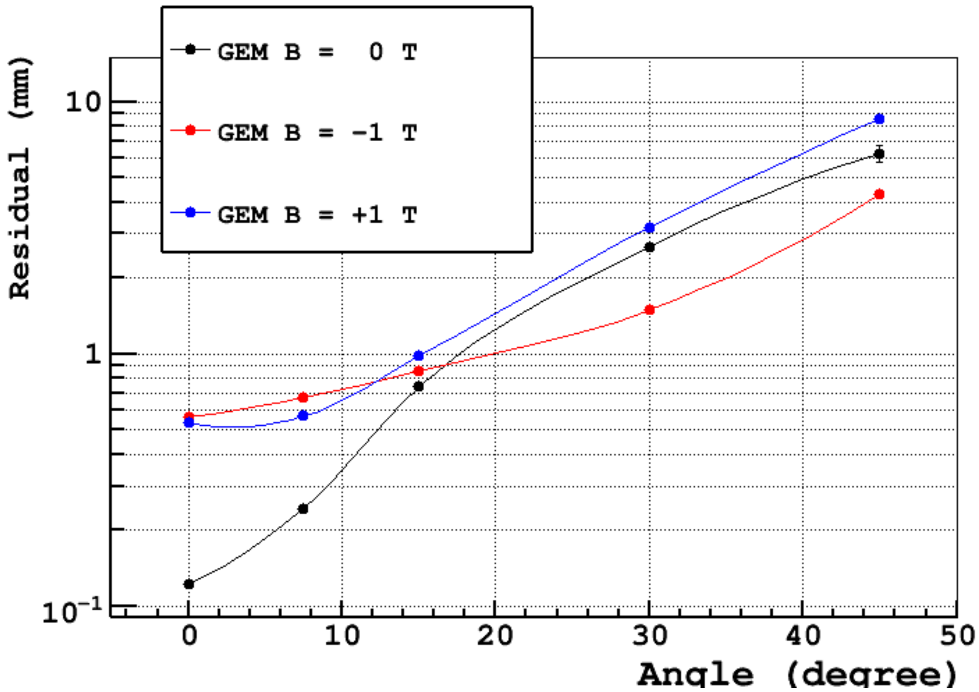
Bending-Plane Residual (mm)



Track residual vs tilt angle w & w/out magnetic field



GEM detector



μ-RWELL detector