Status and Plans for Data Analysis

MAIN OBJECTIVES OF THIS PRESENTATION

- Start a review of *established results*, *results needing further studies*, *planned analyses*
- Input for coordination of analyses, document results and prepare a list of "approved plots"
- Lots of test-beam done, Many many analyses carried out and already documented, as well as work on simulations

→ Apology :

-- Very hard to consider all analyses done;
-- I could have overlooked important analyses;
-- Some analyses/results I consider not fully understood could instead have been already discussed at length and simply I am not aware.

THE TEST BEAM CAMPAIGNS

Performance of MM studied during several test beam campaigns with high energy particle beams at CERN (until 2012) and with 5 GeV e^- beam at DESY (June 2013)

- Up to 8 MM Test chambers aligned along the beam line (plus reference chambers)
- Test Chambers: Resistive strips, Active area of 10x10 cm^2,
- Strip pitch of **0.25 and 0.4 mm**, drift gap of **5 mm and 10 mm**, Amplif. Gap 128 μm
- Oriented in back-to-back configuration forming doublets
- operated with Ar:CO_2 gas mixture (93:7).
- Our "nominal" HV configuration (mesh at ground) was:
  - -- E_{drift} = 600 V/cm; vdrift = 47mm/ns
  - -- Amplification Voltage 450 -- 550 V (Gain ~10^4)

FE and DAQ :

- APV25 operated at 40 MHz – 27 samples – tot time window of 675 ns
- SRS (RD51) Read-Out system adopted
- Tests of new FE chip, first version of VMM, were also carried out.

WHERE WE STAND (BY EXAMPLES)

List of studies/measurements usually shown at Meetings and Conferences

Chamber Response

- Signal shape → Charge and Time
- Timing (first hit and total drift time)

Tracking

- Pattern recognition
- Spatial Resolutions (spread)
- Position accuracy (bias)
- Efficiencies

  All above measurements for
  - Straigh tracks
  - Inclined tracks
  - Magnetic Field
  - Low Vs High Background

Ageing

- Ageing

Vs

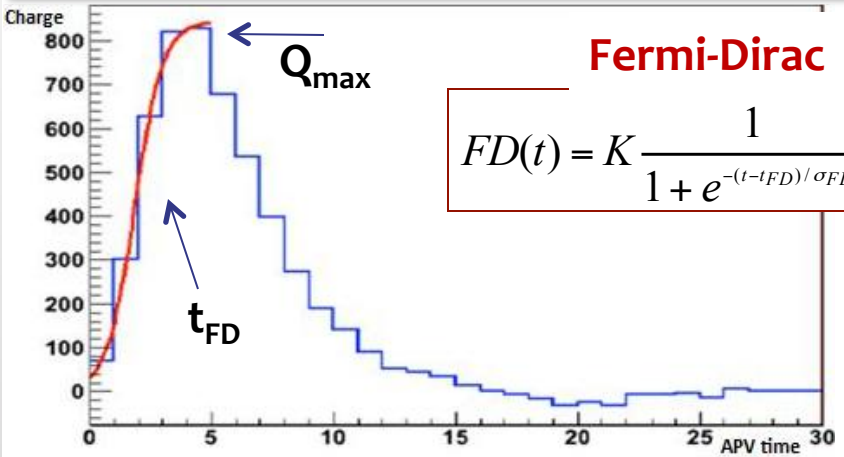
- Operating Conditions
- FE elx (APV, VMM)
- Chamber Prototype
  - Mechanical Properties (size, pitch, gap)

Vs

SIMULATION

SIGNAL SHAPES -- TIMING

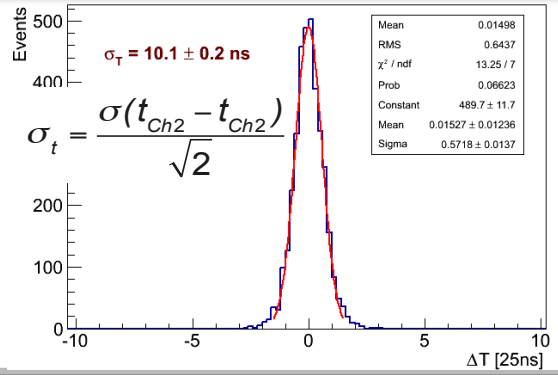
- APV signal shape fit to obtain charge and time
- So far **best results** with FD fit:



Fermi-Dirac

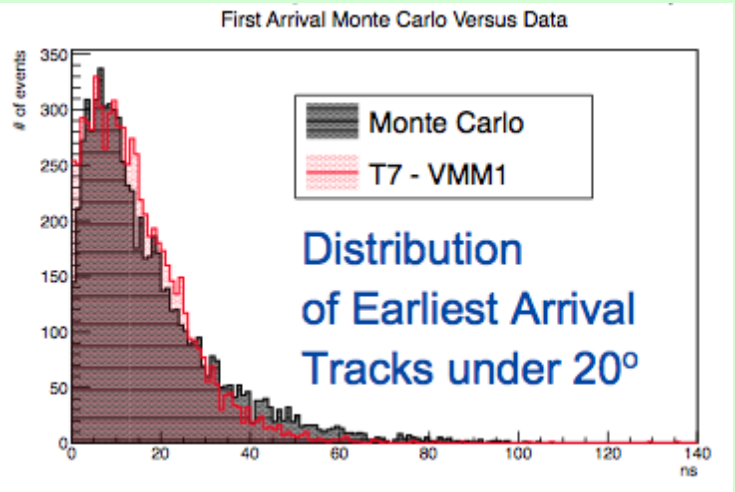
$$FD(t) = K\frac{1}{1+e^{-(t-t_{FD})/\sigma_{FD}}} + B$$

- Measured Time resolution ~10 ns:
  ~5 ns intrinsic + contributions by ?



Fit Method?
elx chain?

- VMM first tests: preliminay results
-- good agreement with simulations

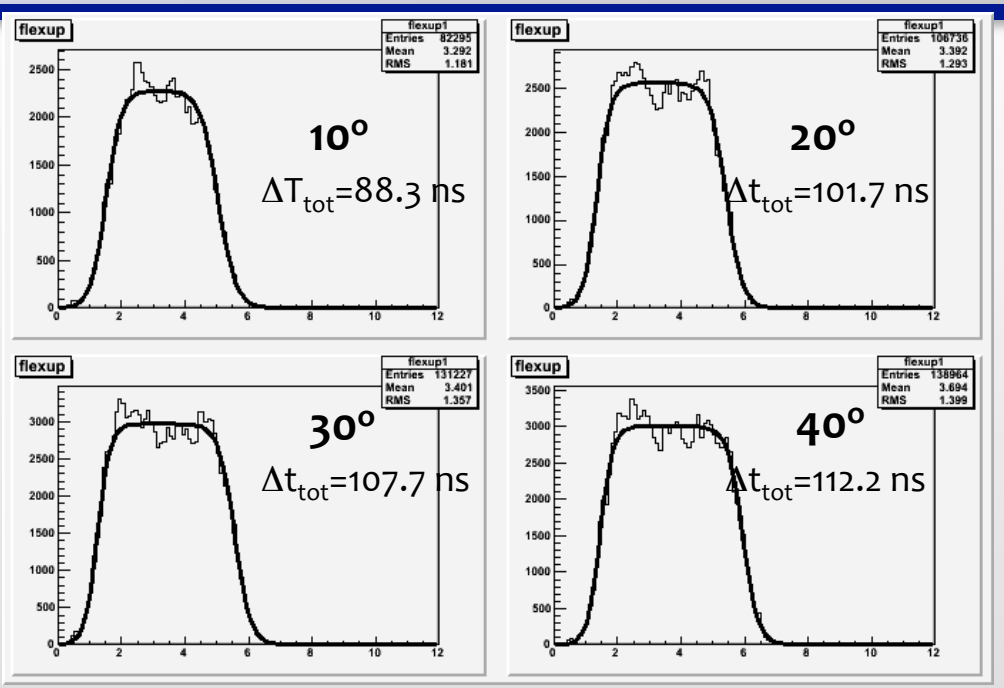


NEED further study for VMM-APV comparison also aiming at disentangling contributions (intrinsic given by primary emission spatial spread, FE elx, full read-out chain)

SIGNAL SHAPES – TOTAL DRIFT TIME

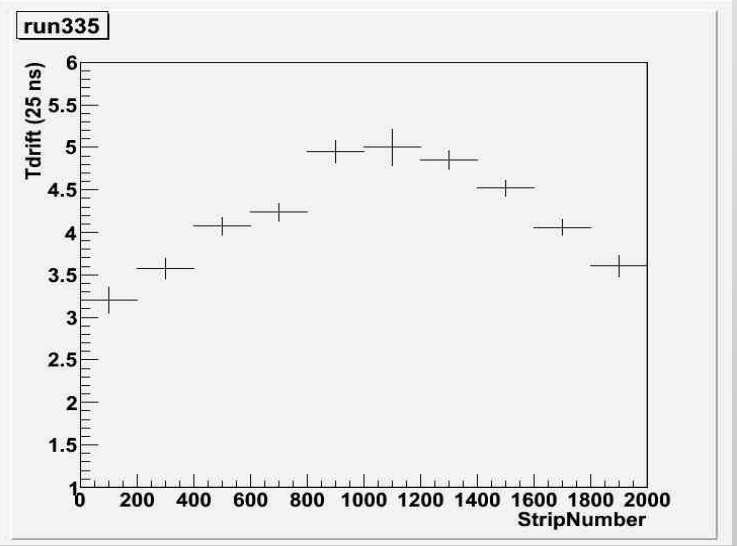
The total Drift Time distribution

- Further studies needed to establish uncertainties and systematics and **dependence from track angle**



- Given the drift velocity the tot_Time provides measurements of gap uniformity/deformation
- Can be used for QA/QC and calibrations (e.g. knowing the gap → measure v_{drift})

L3 chamber deformation gap (swelling) as measure by TotDriftTime Vs position across the chamber



SPATIAL RESOLUTION FOR PERPENDICULAR TRACKS

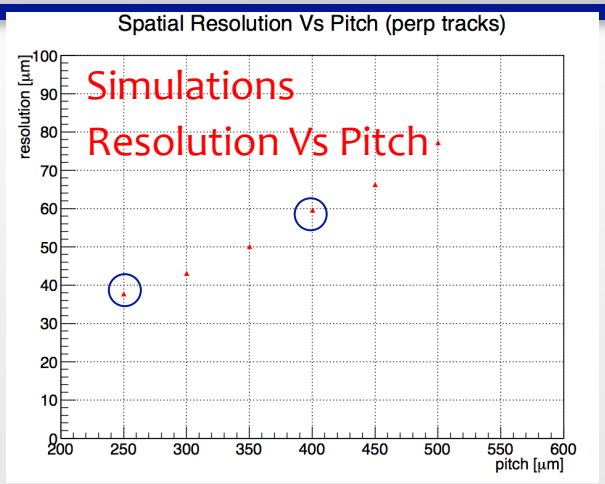
Cluster Charge Weighted Centroid for straight tracks

- Centroid definition
- Eta corrections (R.Turchetta NIMA335(1993)44-58)

Two methods used to measure the spatial resolution

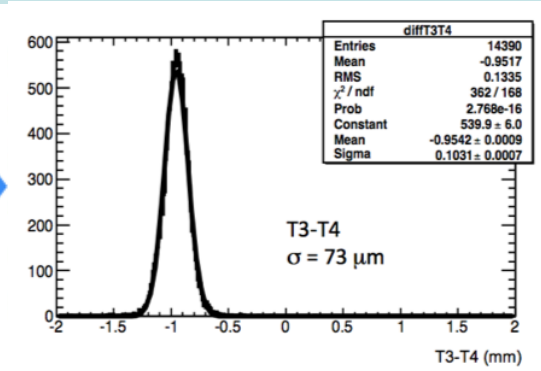
- Cluster position DIFFERENCE between two chambers
- Residuals from full tracking

→ Good agreement among the two methods

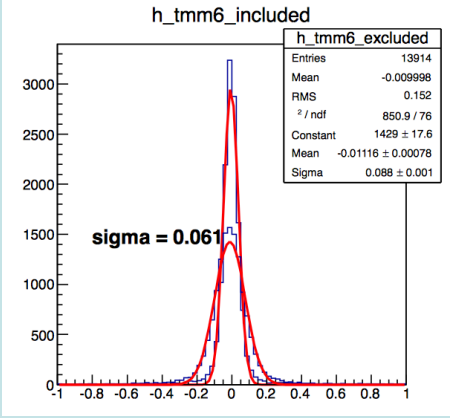


Results for 400 μm pitch (from Chamber differences):

Spatial Resolution for perpendicular tracks with APV25 Chip



Results for 250 μm pitch (full tracking):

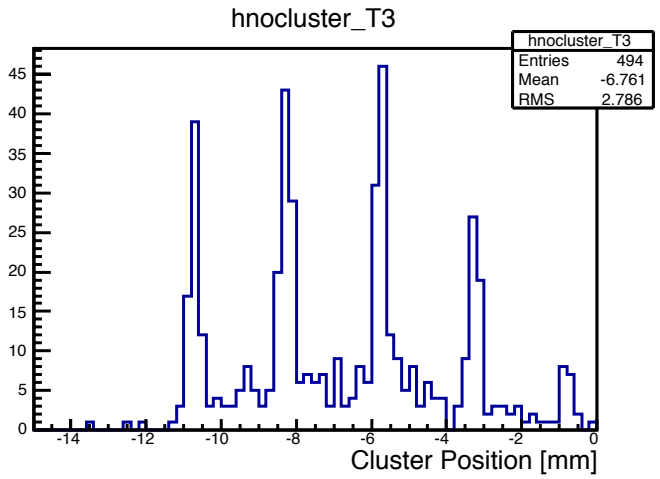


Simulated resolutions significantly better than data:

- Some missing contribution in the MC ?
- "extra"-contributions to data: e.g. from Multiple Scattering. Beam angular spread, …
- Analyses of residuals with external tracking (Silicon teslescope) give better results (K.Ntekas thesis)

EFFICIENCIES

Distribution of local inefficiencies as measured from the missing hits on one chamber corresponding to a reconstructed track from the other chambers



Global inefficiencies in the range 1 to 2% consistent with the partially dead area due to the presence of 300μm diameter pillars separated by 2.5 mm.

- Establish single plane track efficiency for tracks not passing on pillars
- (we have numbers – just cross-check)
- and for track passing on pillars (diffusion should partially recover inefficiencies)

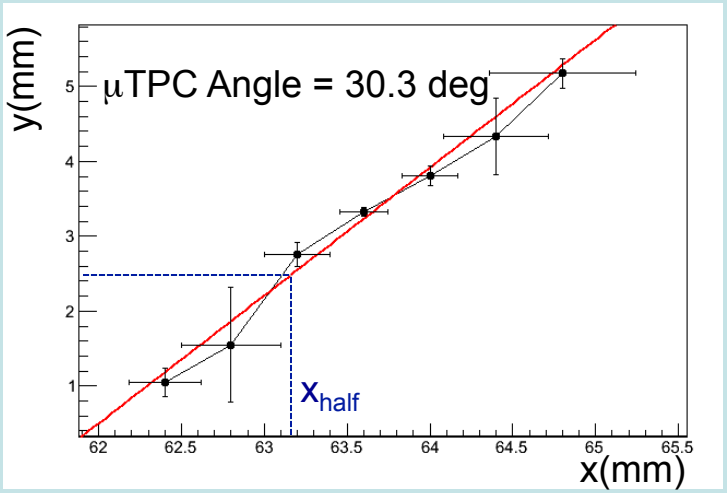
- Correlation between cluster definition (n_{strip}>1 ?) and efficiency

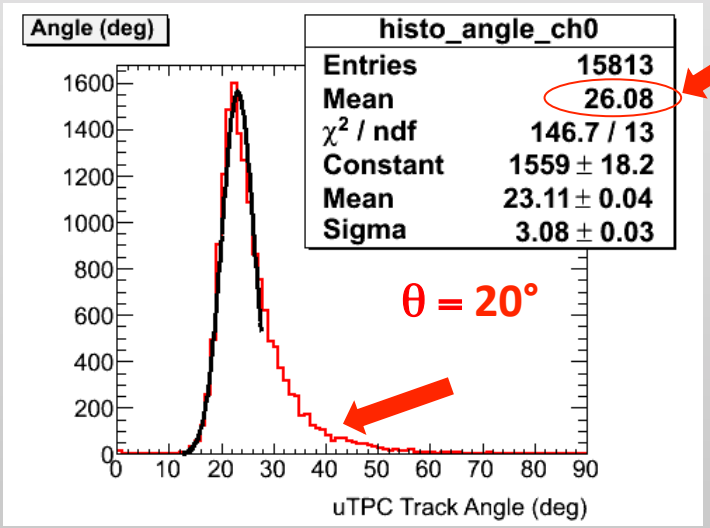
INCLINED TRACKS -- MICROTPC METHOD

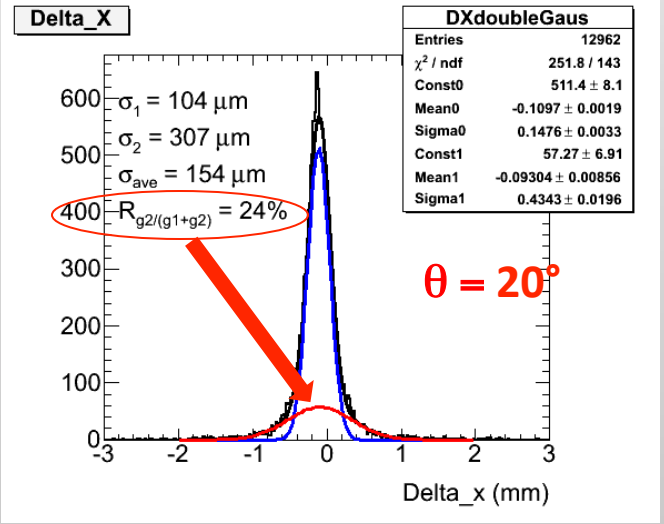
Tracklet Reconstruction

- **Tracklet Reconstruction Efficiency**
- Angle bias
- Tails in the Angle reconstruction
- Optimal position ("xhalf" ?)
- SPATIAL RESOLUTION AND TAILS
- **Position bias ?**
- CENTROID + μTPC Combination

(recovery of μTPC tracklet reco inefficiencies)







TRACK RECONSTRUCTION IN MAGNETIC FIELD

Some established results and procedures
Lots of work still to be done

Established Results from TDR:

- Resolution is not degraded :

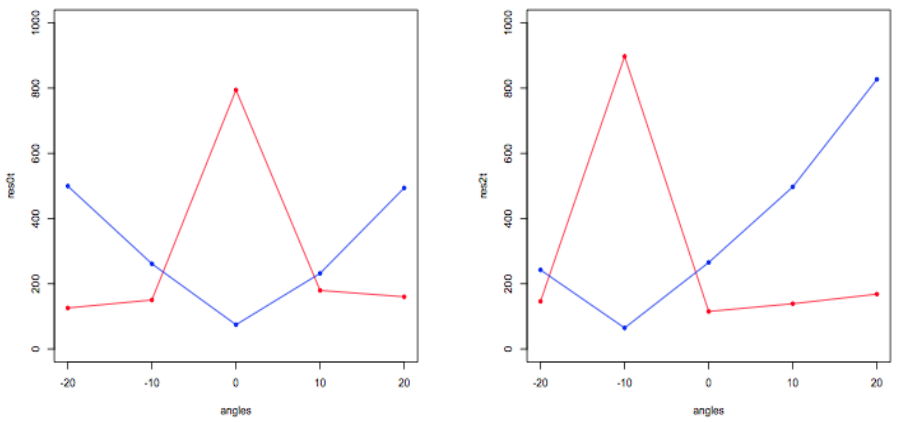


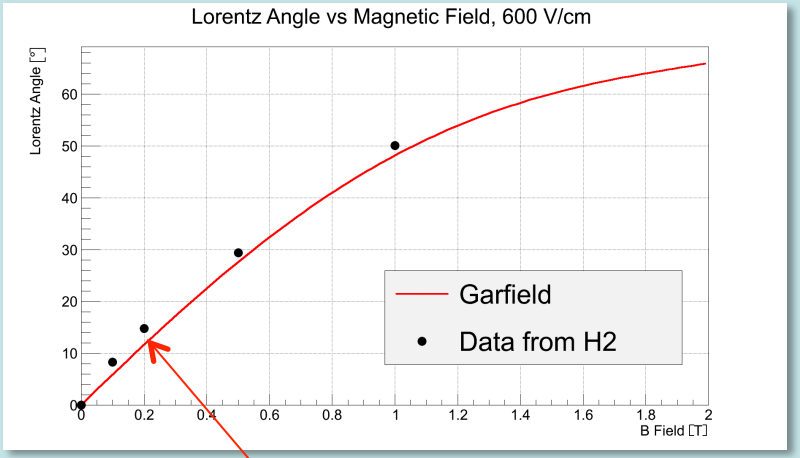
Figure 20: Comparison of space resolutions obtained in the H2 test-beam using the centroid (red) and the μTPC (blue) methods.

As expected, bad resolution at $\theta_{track} \sim \theta_{Lorentz} \sim 10°$ at B=0.2 T (need further analysis at all angles)

Need further investigation

- Lorentz angle reconstruction:

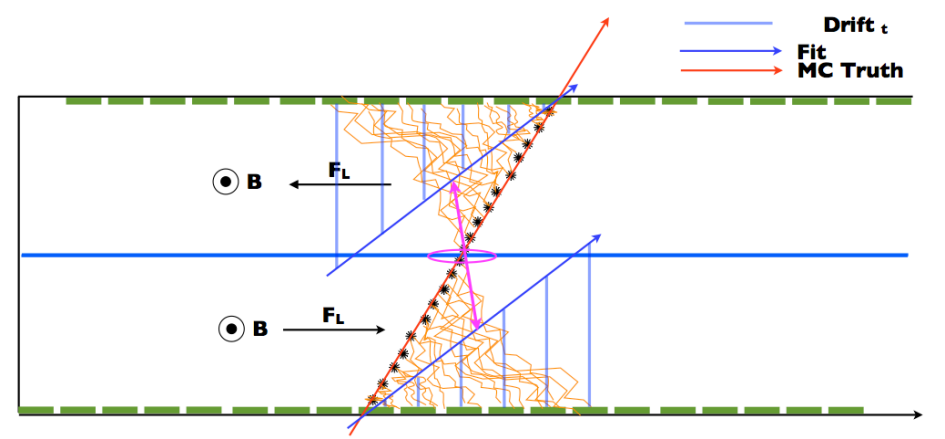
Lorentz angle from perpendicular tracks;
E_{drift} 600V/cm



Understand >10% discrepancies

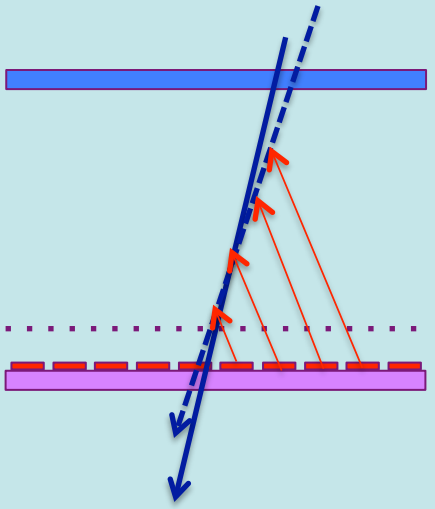
TRACK RECONSTRUCTION IN MAGNETIC FIELD - POSITION BIAS

DEMONSTRATE Bias Cancellation through back to back "average"



KNOWLEDGE of Magnetic Field

(B-field corrections)



$$x_i = strip_i \cdot PITCH - v_{B,x} \cdot t_i$$

$$y_i = -v_{B,y} \cdot t_i$$

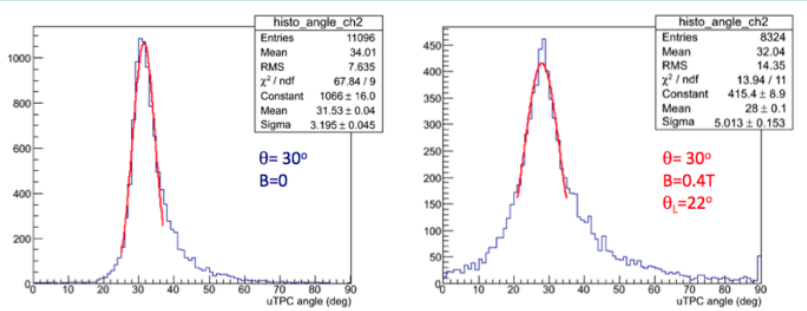


Figure 19: Track angle reconstruction in μTPC mode for tracks at 30° with magnetic field corrections. Left: B=0; $v_{drift} = 47\mu$m/ns (no corrections applied); Right: B=0.4T; Lorentz Angle $\theta_L = 22°$; $v_{drift} = 43\mu$m/ns

- Preliminary results from **June 2013 DESY test-beam**
- Angular reconstruction shape differ in the cases of B=0 and B=0.4T ; some systematics still there (beam deflection should be accounted for)

June 2013 DESY Test Beam Data

Lots of effort and Analyses done

Recap from M.Biglietti Sept. Muon Week

https://indico.cern.ch/getFile.py/access?contribId=3&resId=0&materialId=slides&confId=272889

Outline

2

- Testbeam setup and experimental conditions
- Electron beam property measurements
- Micromegas spatial resolutions with no B field
  - straight tracks → cluster centroids
  - inclined tracks → uTPC technique
  - several methods for cross checks
- First results with magnetic field
- Disclaimer : data analysis in progress, in particular for what concerns the performance in the magnetic field

DESY TEST BEAM DATA ANALYSIS SHOULD BE FINALIZED

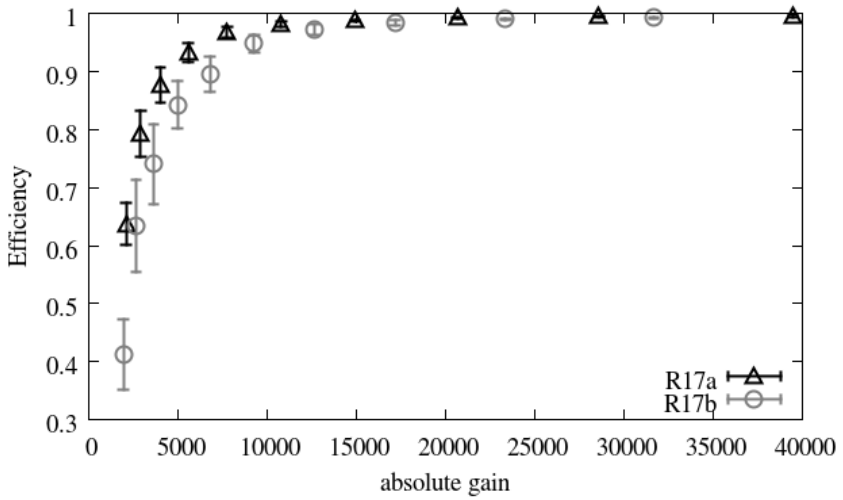
AGEING

No ageing effects measured after irradiation with X-ray, cold neutron, gamma and alpha sources with equivalent dose from 5 to 10 HL-LHC years

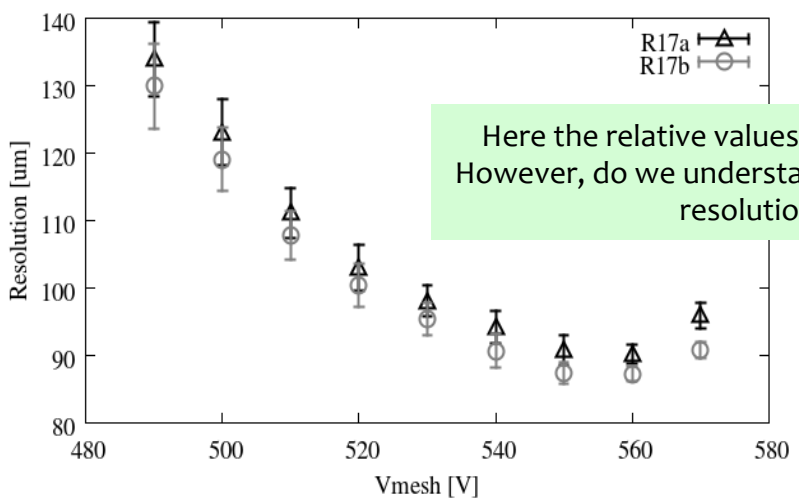
This is an example of established results … possibly with minor pending issues

The two R17 prototypes were taken to the H6 SPS CERN pion beam to perform a **comparative study between both prototypes**, **irradiated** and **non-irradiated** one.

Performance evaluated in terms of **efficiency** and **spatial resolution**



Both detectors reach efficiencies of about 99.5% for the highest values of the gain, proving that there is no visible degradation effect in these measurements



Here the relative values matters. However, do we understand these resolution values?

Irradiated and non-irradiated detectors show same performance in terms of efficiency and Spatial Resolution

CONCLUSIONS

- Examples have been provided to initiate a process of MM Performance Review
- Many results exists, in some cases needing further investigation, as well as methods/procedures, sometimes not fully exploited
- Should be the task of the *Analysis Coordinator* to further develop the analysis strategy, establish priorities, provide fully understood results (as well as pointing to not understood results and critical issues)
- In the process of evaluating new methods and algorithms, many lines of code will be written → **Software** maintenance and distribution
- In the process of reviewing data, more **simulation** studies will be required (or retrieved), the simulations playing a crucial role for deep understanding of the MM performance in association with FE-elx and Read-out chain.