Mini TPC update

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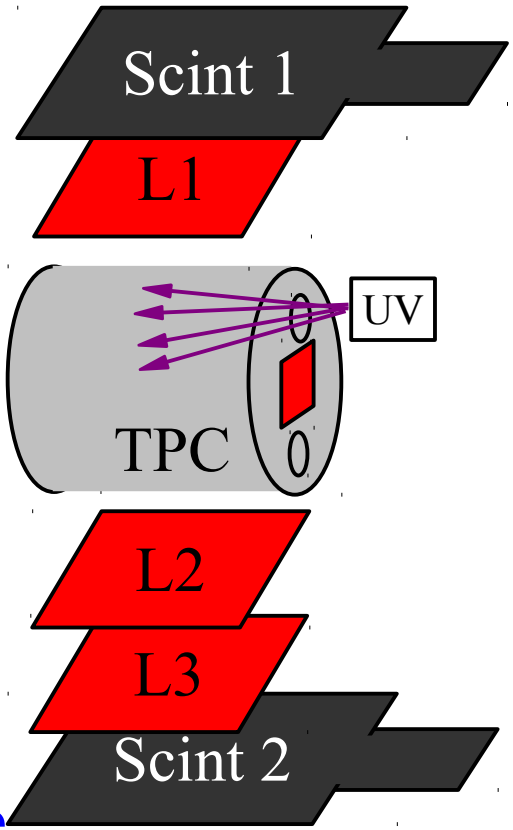
Outline

- Introduction/Reminder
- Recent events
  - Tomography tests
  - Stability of voltage/gain/gas/etc

Mini-TPC project

Goal: test TPC tracking performance in the presence of space charge to check/tune simulation of space charge effect

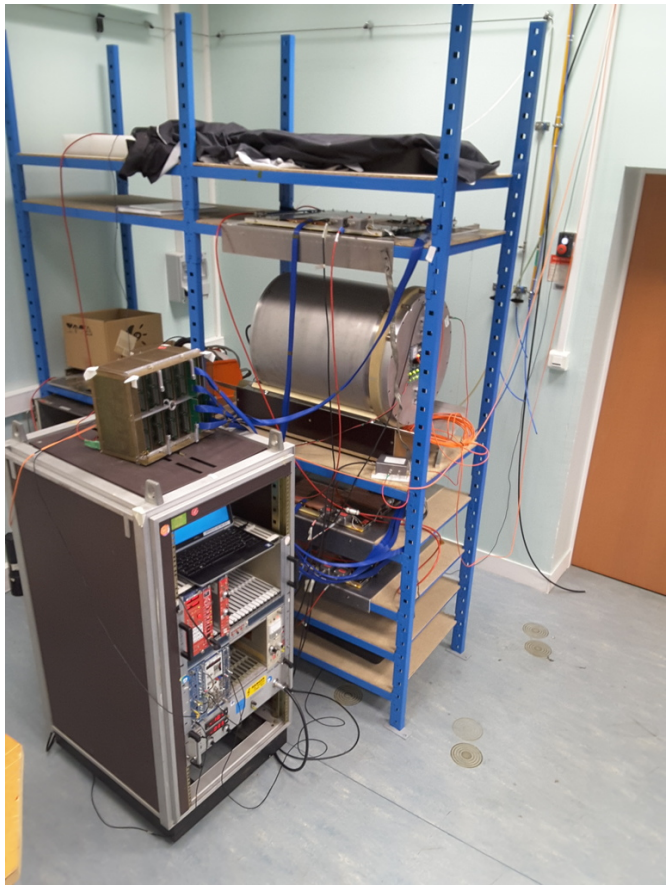
- Recycle existing chamber present at Saclay
- Use micromegas resistive module as TPC pads
  - Existing detector+electronics (AFTER)+DAQ developed for T2K and ILD R&D
  - New TPC end-plate to plug the micromegas device
- Transparent windows to send UV-rays through the chamber
  - UV rays yield photo-electrons at the cathod level
  - Photo-electrons drift toward micromegas
  - Micromegas amplification yields ion back-flow in drift space
- Measure tracking performance with cosmic muons
  - Trigger with 2 scintillators
  - Use 3 large area micromegas chambers as hodoscope.



TPC+Multigen data

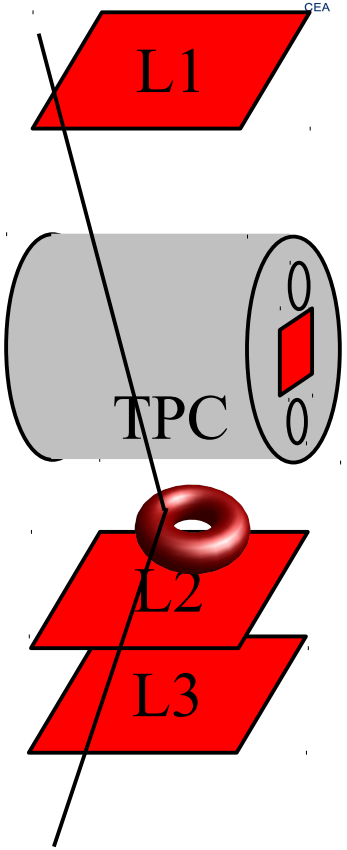
- Start steady data acquisition in January 2017
  - Required amount of data for a proper tracking performance study was not known
  - Goal to collect as much data as possible in steady state
    - Typical trigger rate ~ 1 Hz
    - Typical rate for good events in 3 Multigen and TPC volume ~ 0.3 Hz

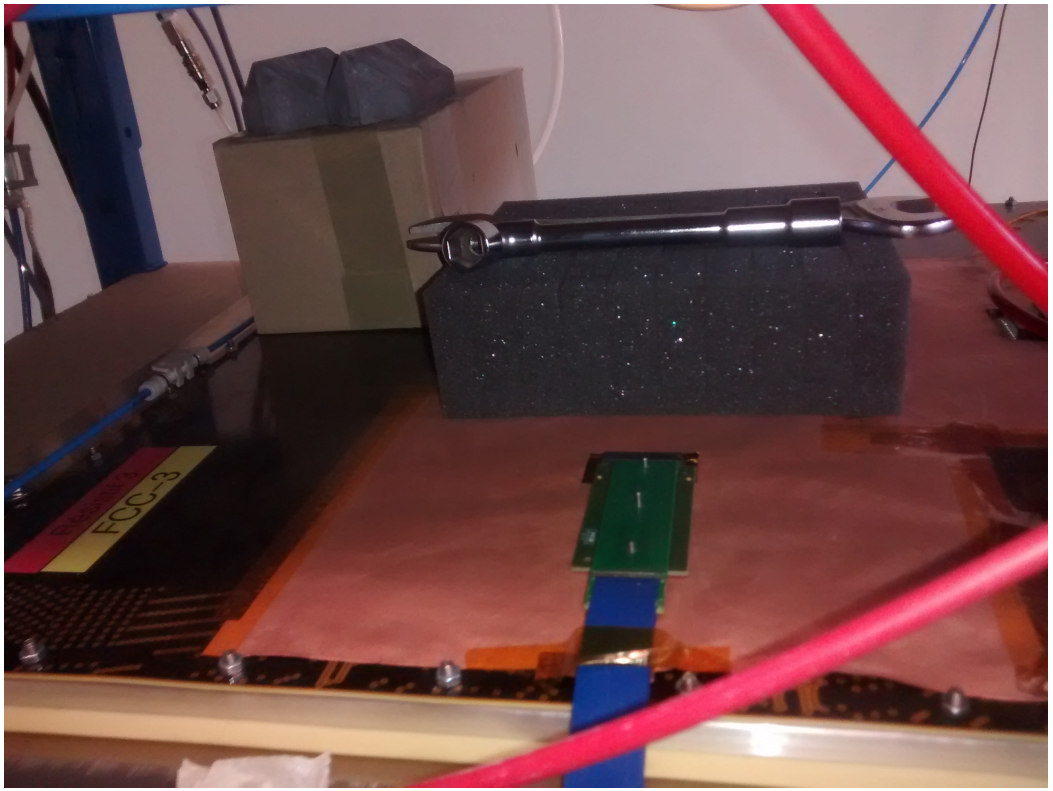
- Data acquisition in 2017
  - Use 95% Argon + 5% Isobutane
  - TPC
    - Mesh at -430 V (128 µm GAP)
    - Drift -10 kV / 48 cm → ~200 V/cm
  - Multigen (v1)
    - ~ 480 V



Tomography tests

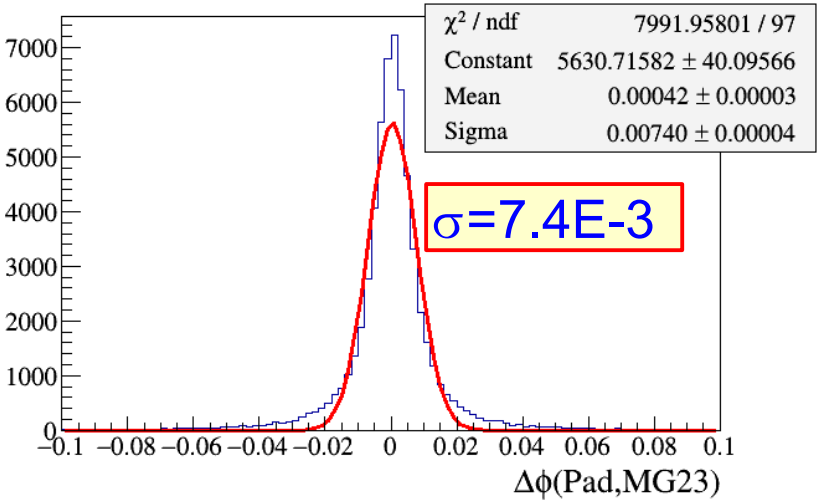
- Insert object between L2 and TPC
  - Try to observe overdensities by looking at deviation due to multiple scattering
  - Roy inserted wrenches on 06/04
    - ~ 0.5 cm thickness of iron
  - I added chevron-shapped lead tile on 06/05
    - ~ 3.5 cm thickness of lead at max

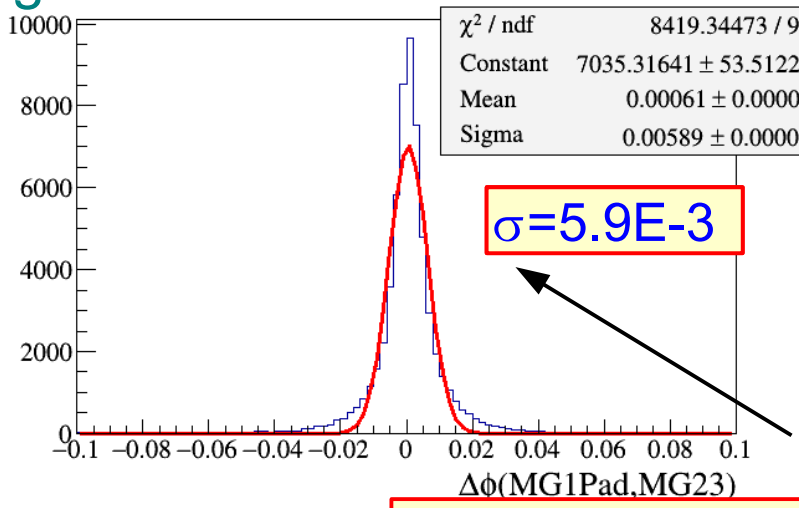


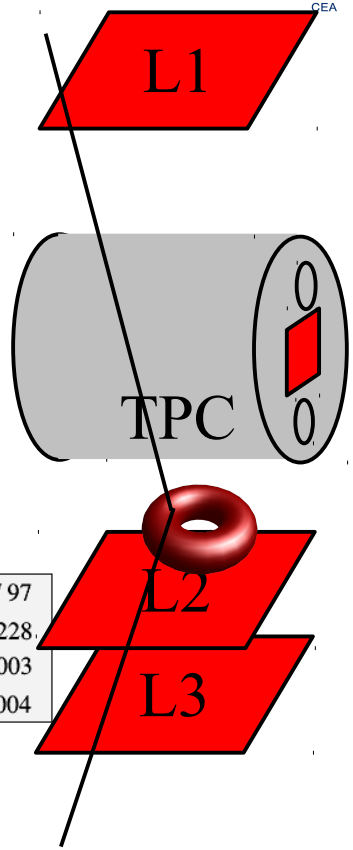


Tomography tests

- Multiple scattering expectations $\sigma(\theta) = \frac{0.0136}{\beta p}\sqrt{\frac{L}{X_0}}\left[1 + 0.038\ln\left(\frac{L}{X_0}\right)\right]$
  - 2d RMS angle for 1 GeV muon in 0.5cm iron: 7 E-3 rad
  - 2d RMS angle for 1 GeV muon in 3.5cm lead: 3 E-2 rad
- 3 ways to reconstruct cosmic muon track segments
  - use Multigen L2L3
  - use TPC only (no PRF)
  - use TPC+Multigen L1
- "Resolution" between track segments in Φ







  - Here, data taken in runs without object
  - See non-Gaussian tail
    - Multiple scattering of low momentum muons ?
    - Tail of resolution in detectors

  (NB I see ~ same resolution in θ)

Numbers here are comparable to multiple scattering angle
However :
-lots of muon below 1 GeV
-non-gaussian tail of resolution

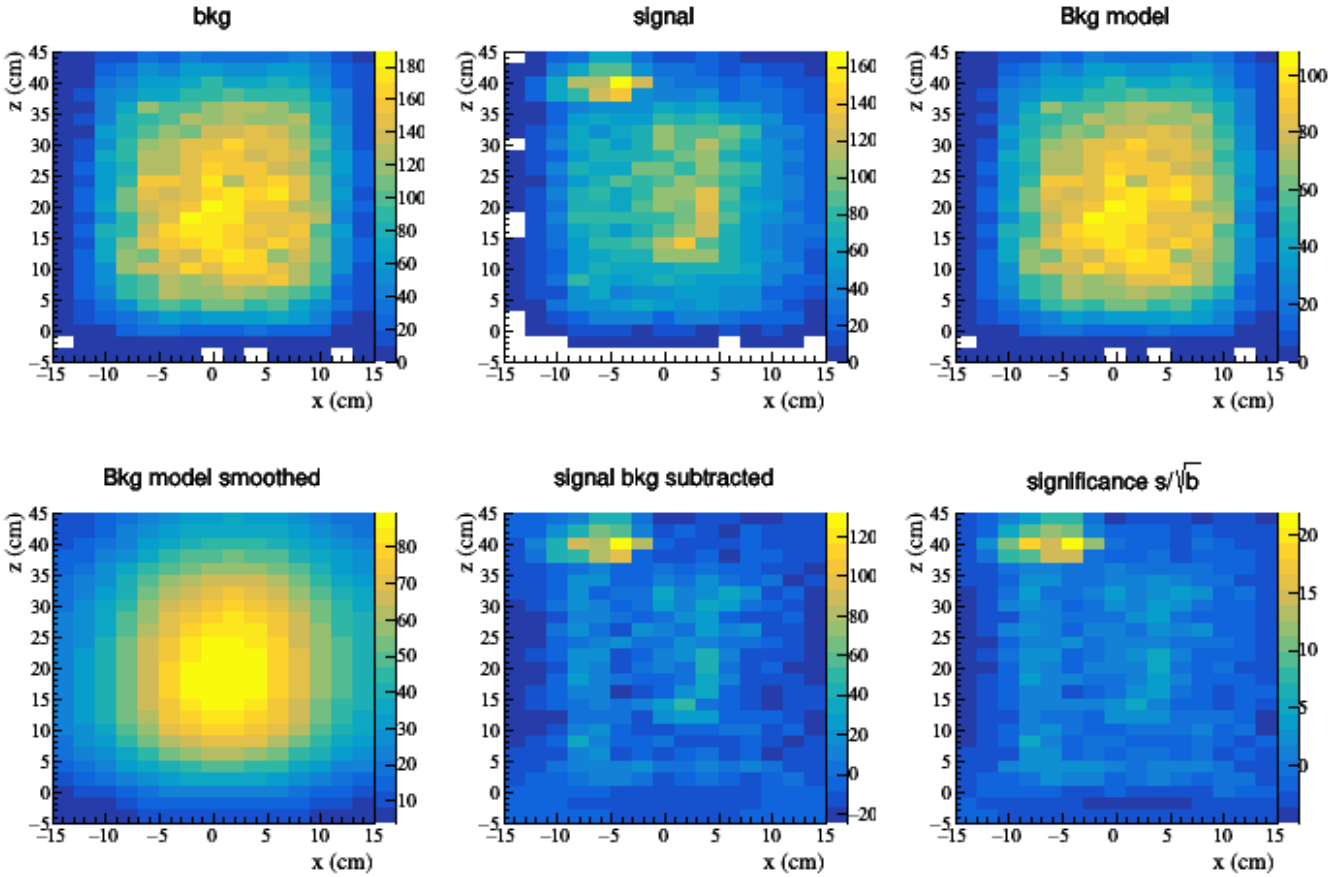
Tomography results

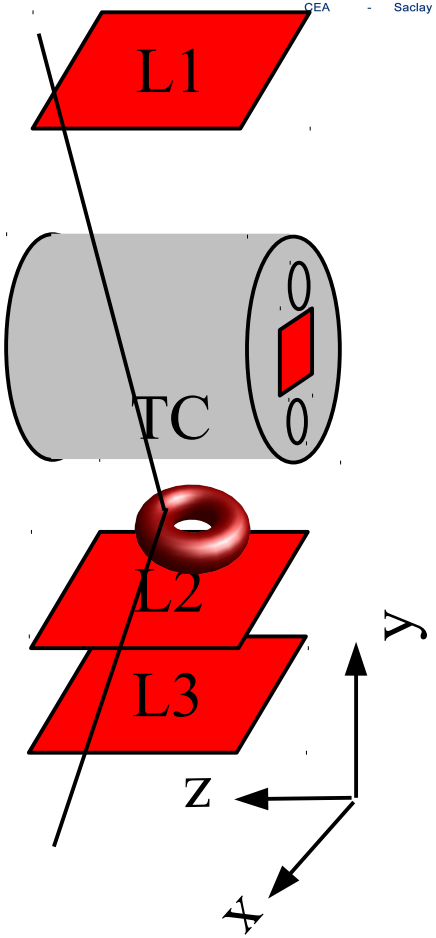
Signal, using L2L3, and TPC+L1I

- Require large deviation angle between segments
  - $\alpha=\sqrt{\Delta\theta^2+\Delta\Phi^2}>0.02$
- Require segments to point to same vertex in x,z ~1cm

Background

- Reverse angle cut $\alpha=\sqrt{\Delta\theta^2+\Delta\Phi^2}<0.01$
  - Also similar results using “blank” events taken in March





1 month of data, coarse picture, 2cm x 2cm

Tomography results (2)

Signal, using L2L3, and TPC+L1I

- Require large deviation angle between segments
  - $\alpha=\sqrt{\Delta\theta^2+\Delta\Phi^2}>0.02$
- Require segments to point to same vertex in x,z ~1cm

Background

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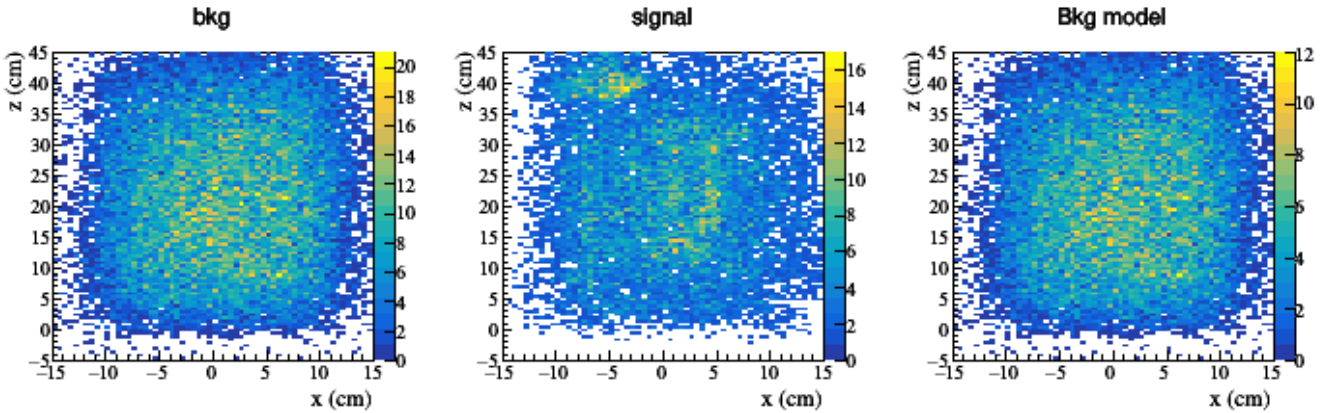
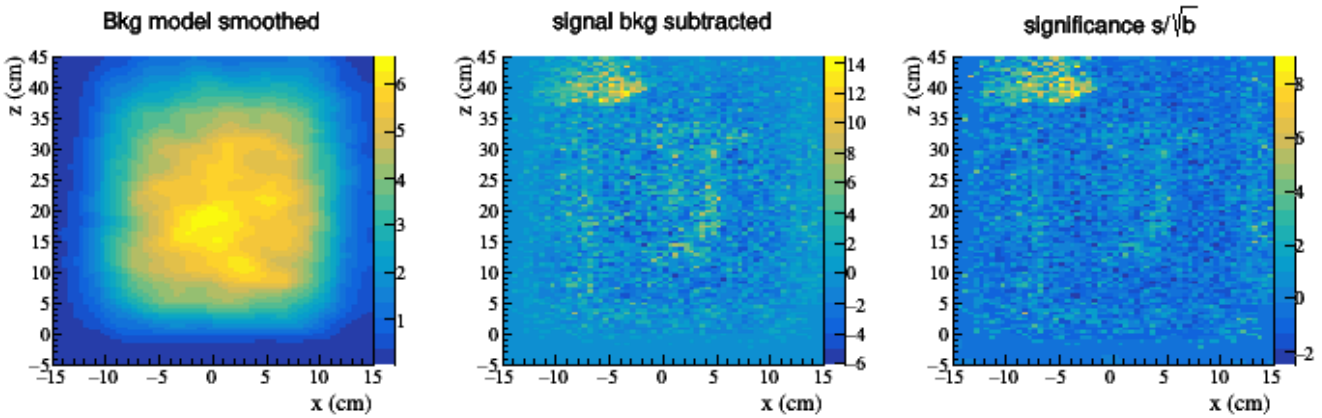
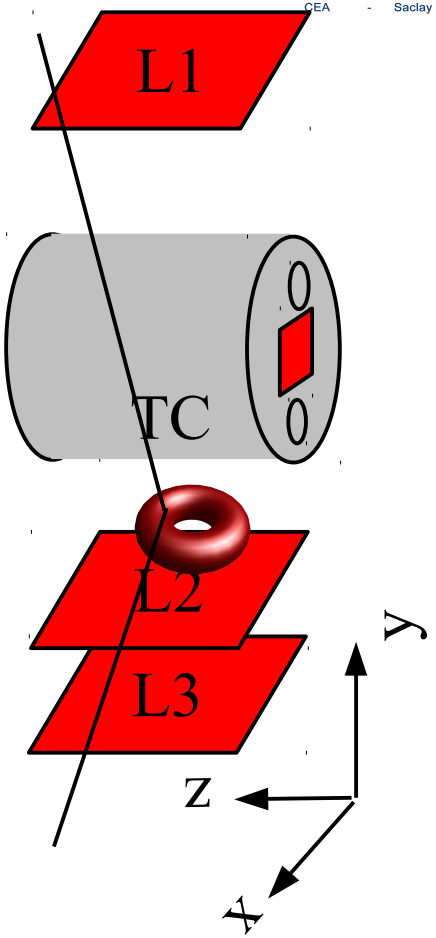


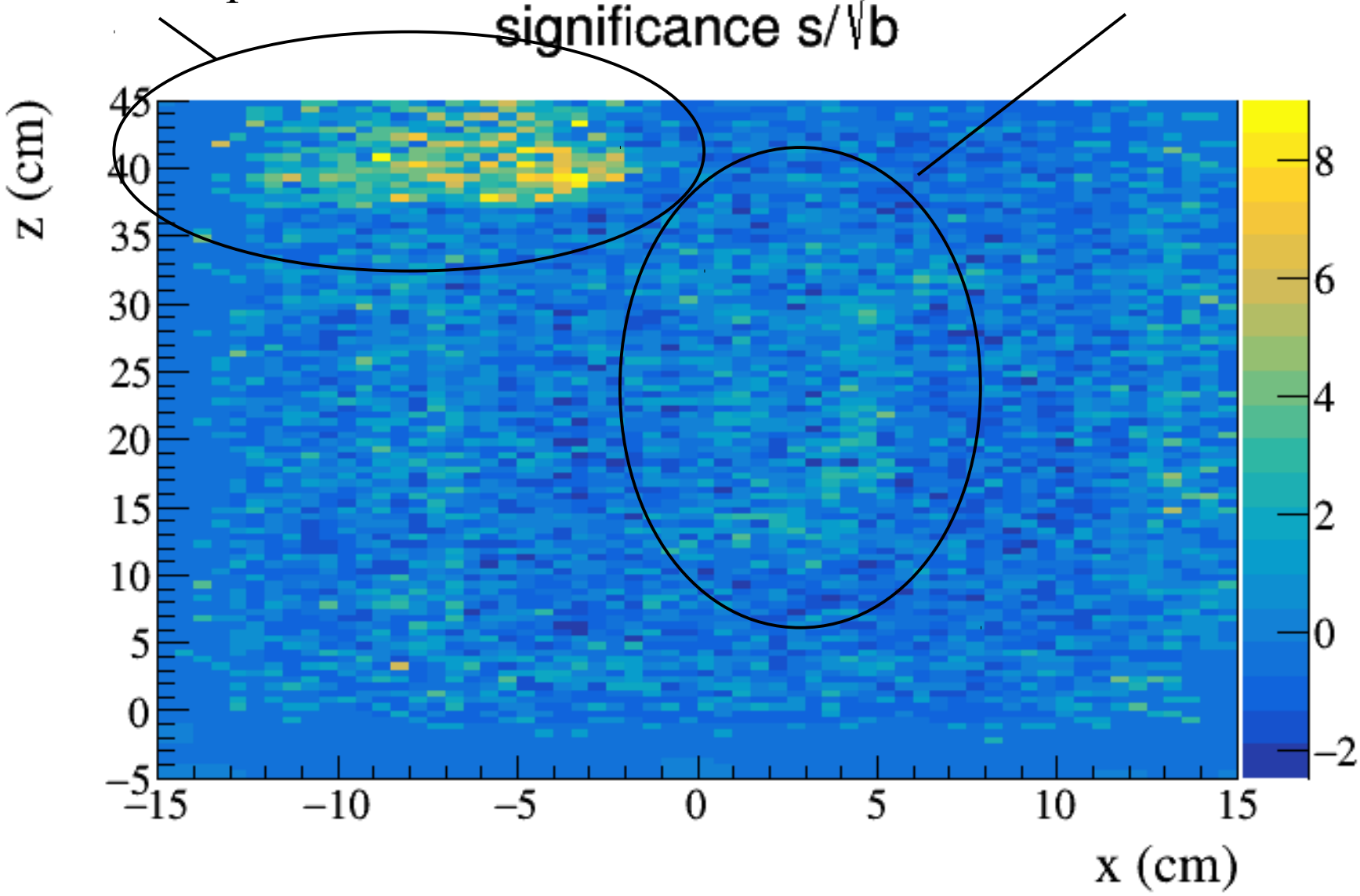




Tomography

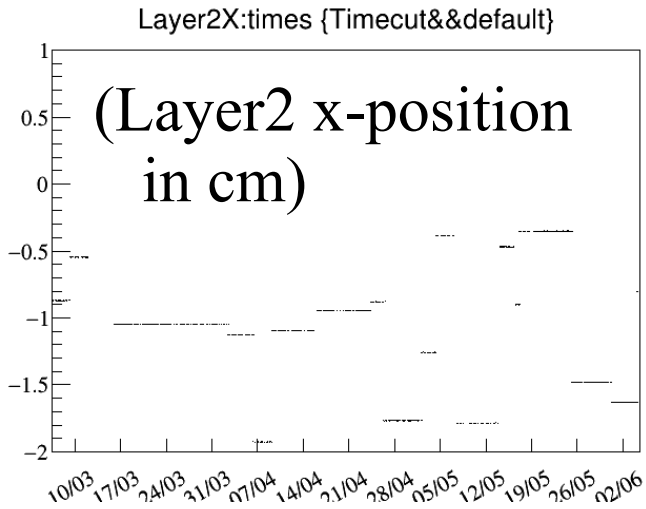
observe V-shape of chevron ?

ghost due to wrenches ?



Tomography todo list for improvments

- Resolution of the “picture” affected by alignment which is not so stable in time
  - Alignment constants are computed regularly
    - They should be equal over a short period
    - They are not
  - Working on improving alignment procedures

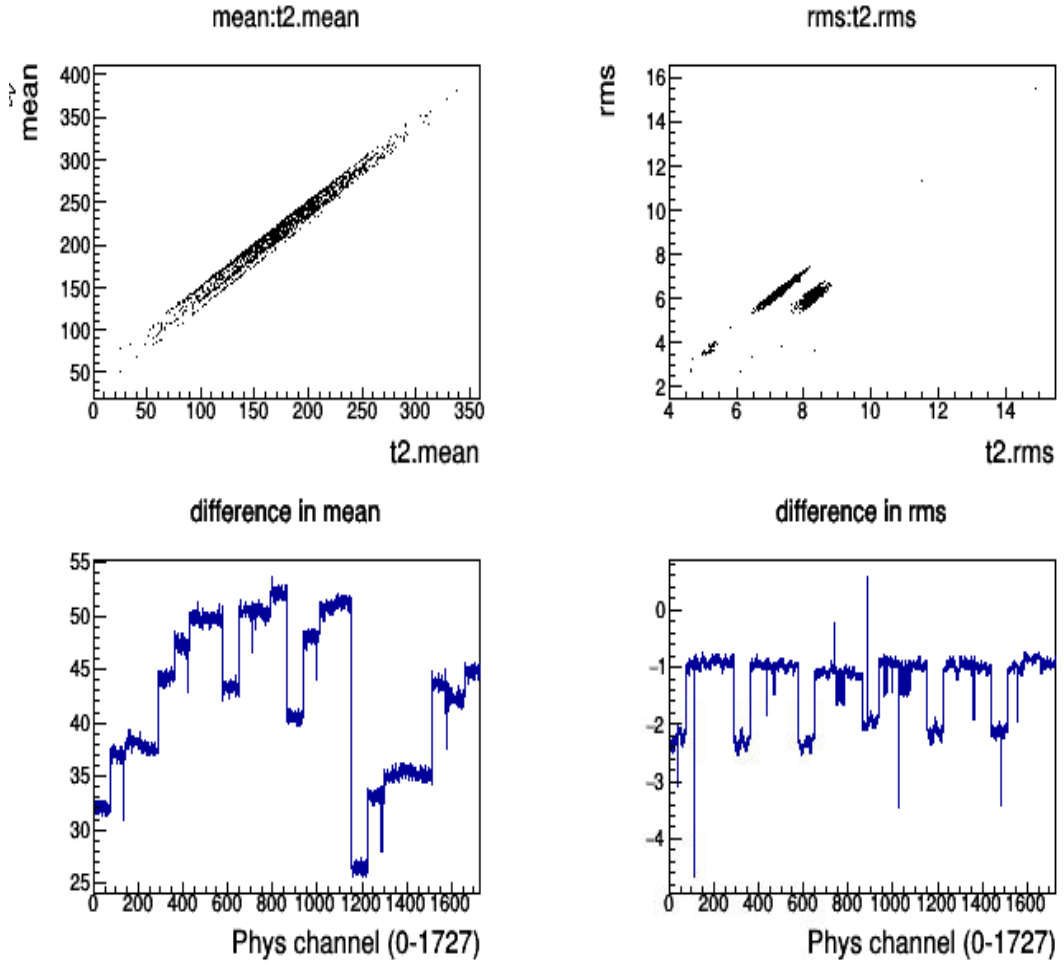


- Improve resolution in tracking
  - Use PRF ?
  - Remove region with dead channels in TPC affecting track resolution
- Optimize data analyzes
- Improve detector stability
  - Mostly multigen noise vs efficiency vs trip (in particular Layer 1)
  - May was not a good month regarding data taking.
    - Usable statistics for a given period of time could be increased by ~2

Data quality

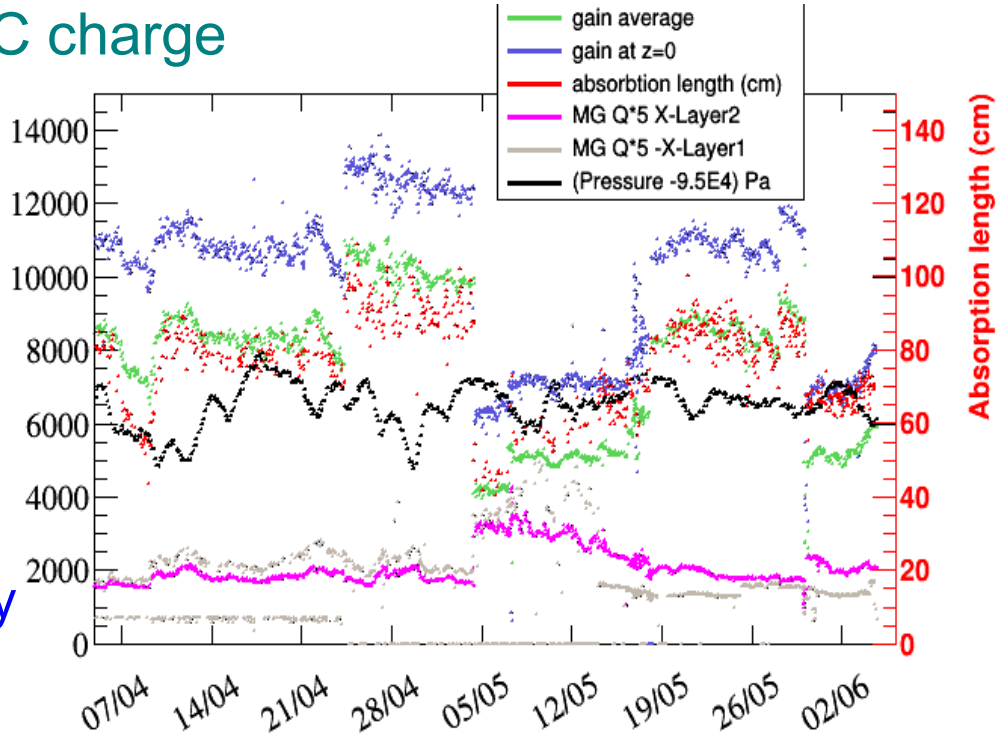
- For long time, observed instability in TPC pedestals
  - Eg comparison of pedestals determined 24/04 15h26 then 24/04 16:11
  - Here units are ADC counts
    - (Typically ADC=200 – 1000 for a good track)
    - zero suppression = cut at Pedestal + 4.5* RMS

- Instability affects charges measured in TPC



Data quality

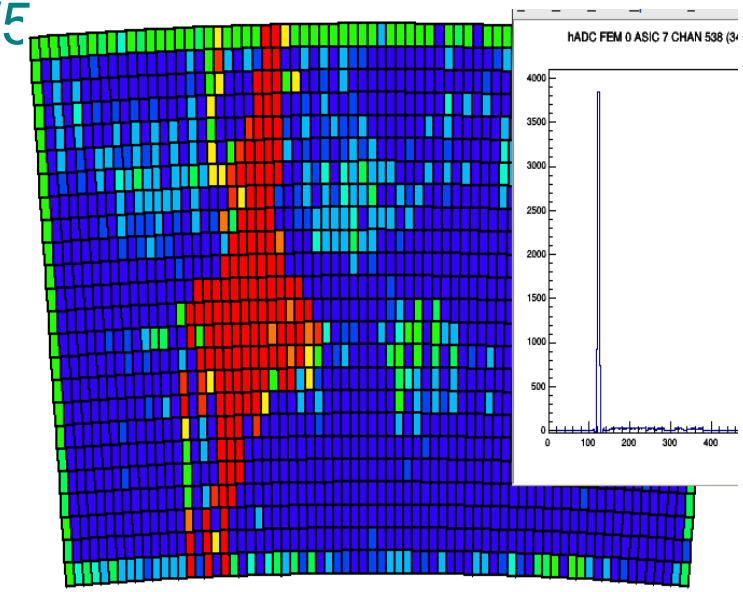
- For long time, observed instability in TPC pedestals
  - eg redetermine pedestals on 24/04
- On 5/5 unexplained
  - drops in charge observed in TPC
  - increase in charge observed in Multigen layers
  - At the same time electric noise conditions worsen in the building
- On 18/5 unexplained increase in TPC charge



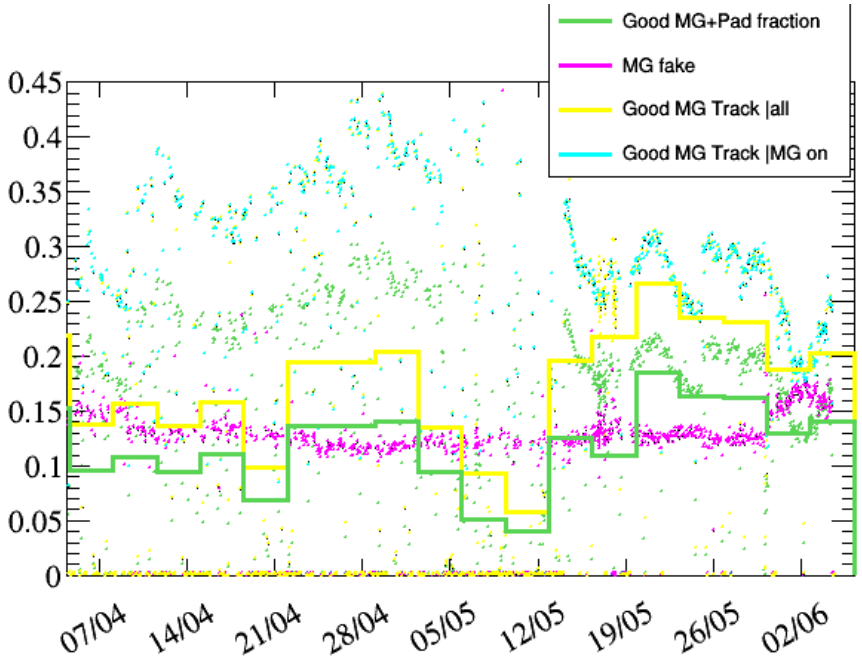
- Suggestions by experts
  - one power supply is not enough for MG and TPC electronics
  - Electronics may not function properly
    - May yield noise, pedestals instability and wrong readout of charge !!
  - → use two power supplies
- Two power supplies on 30/5

Two power supplies

- Two separate electronic power supplies on 30/5
- First effect:
  - Increase in TPC gain → saturation
  - So the gain we had before was wrong (?)
  - Needed to decrease TPC HV 430V → 400V



- Second effet
  - Signal/noise worsen in Multigens → MG tracks dropped to ~0
  - needed to increase HV to recover
  - Also improved a bit grounding
    - Some evidence that with a common power supply the TPC electronics was grounding the MG electronics
- Still trying to improve MG situation
  - overall efficiency issue since early May
  - Currently having 50% less good events than we could hope
  - Need to further play with HV and grounding



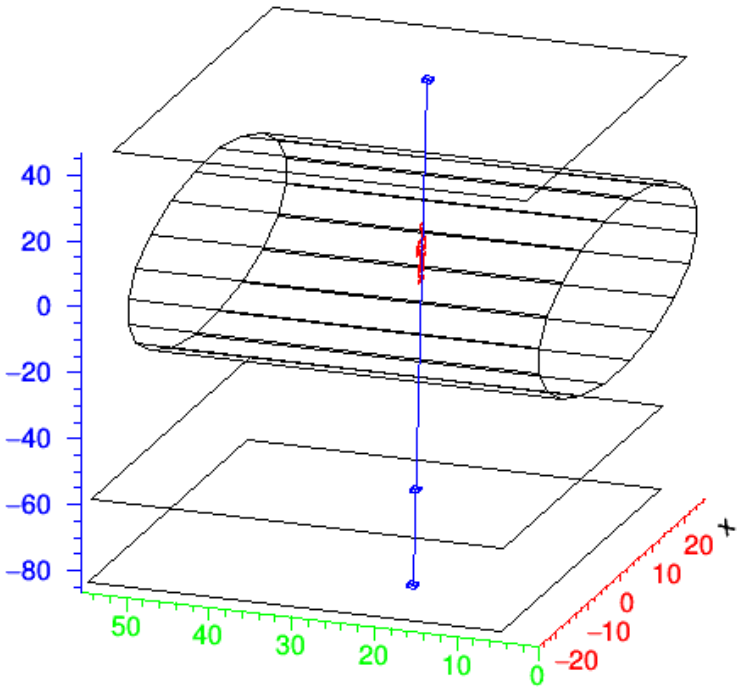
Summary

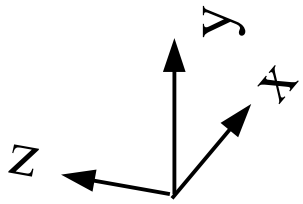
- First results of TPC + Multigen tomography
  - We see piece of lead, but just hint of iron wrenches
  - Was taken with far from best Multigen conditions
- Data quality
  - Evidence that we had issues running with one power supply for both electronics
  - This had to be solved, as all monitoring quantities (eg: absorbtion in gas, or gain) rely on stable and good electronic readout.
  - Now that electronic are separated, need a bit of work for proper and stable running conditions
-

Support

Alignment

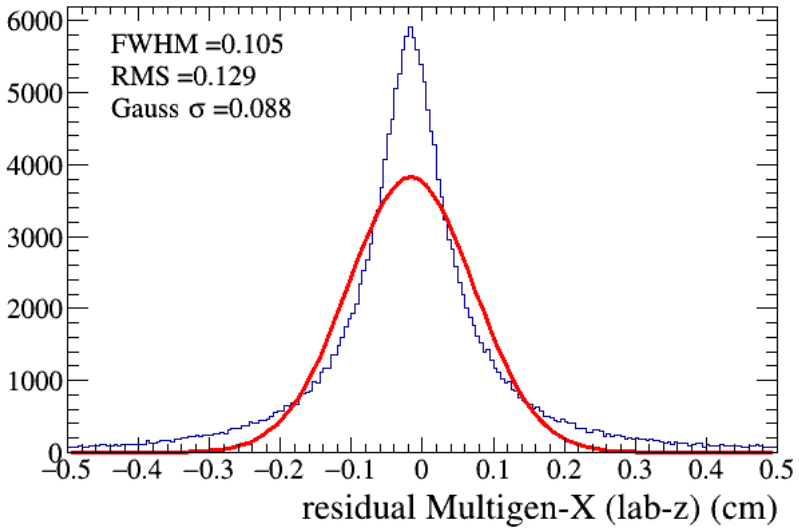
- Perform alignment using as input lengths
  - Multigen pitch = 486.26 microns
  - Pad geometry (over?) simplified
  - T0 of TPC fixed
- Quick fit
  - Define track from 2 hits from outermost Multigen (Layer 1 and 3)
  - Compute residuals for the hits in TPC and MG Layer 2
  - Fit (z,x,y) of 3 Multigens
  - Fit 3 rotations (X,Y,Z) of TPC relative to Multigens
  - Fit drift velocity

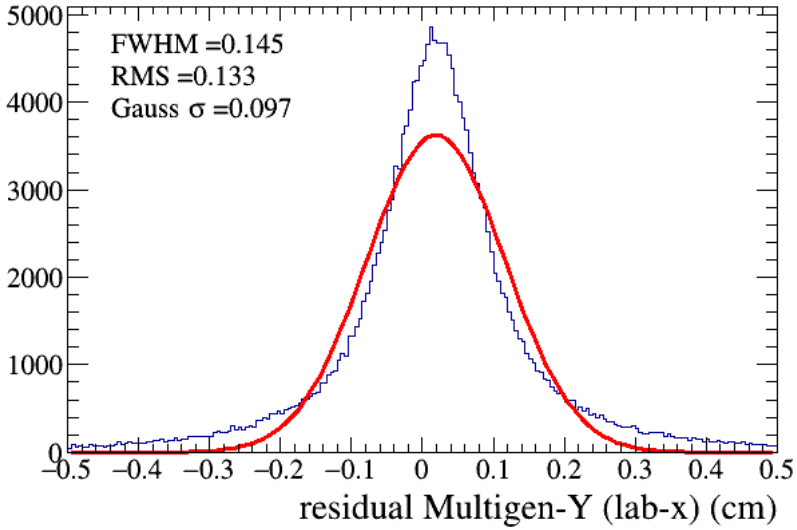


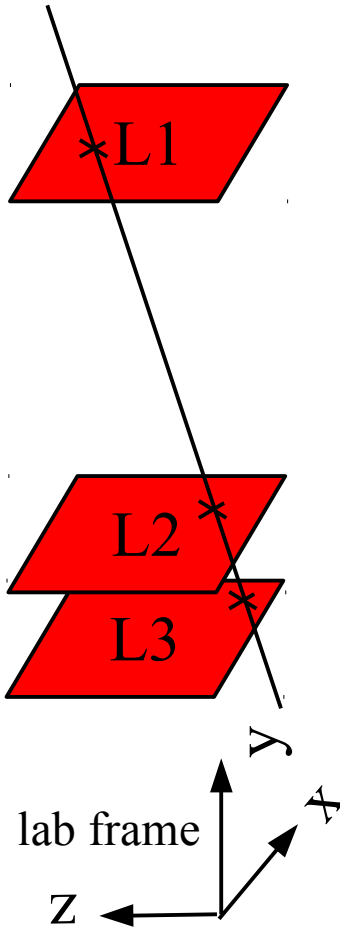


Multigen resolution

- Residual: Layer 2 vs extrapolation from (Layer1,Layer3)
- Here we see convoluted resolution between L1,L2,L3





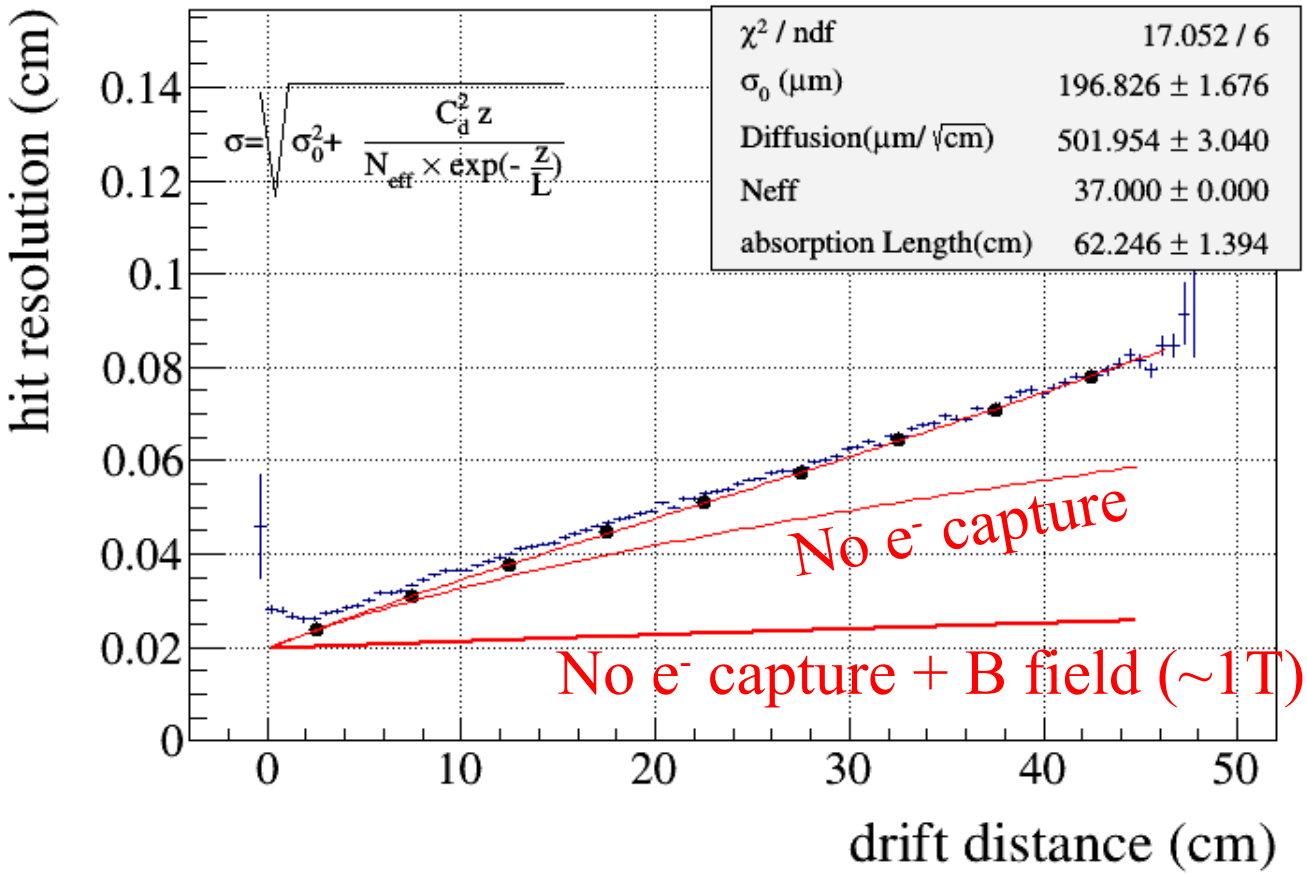


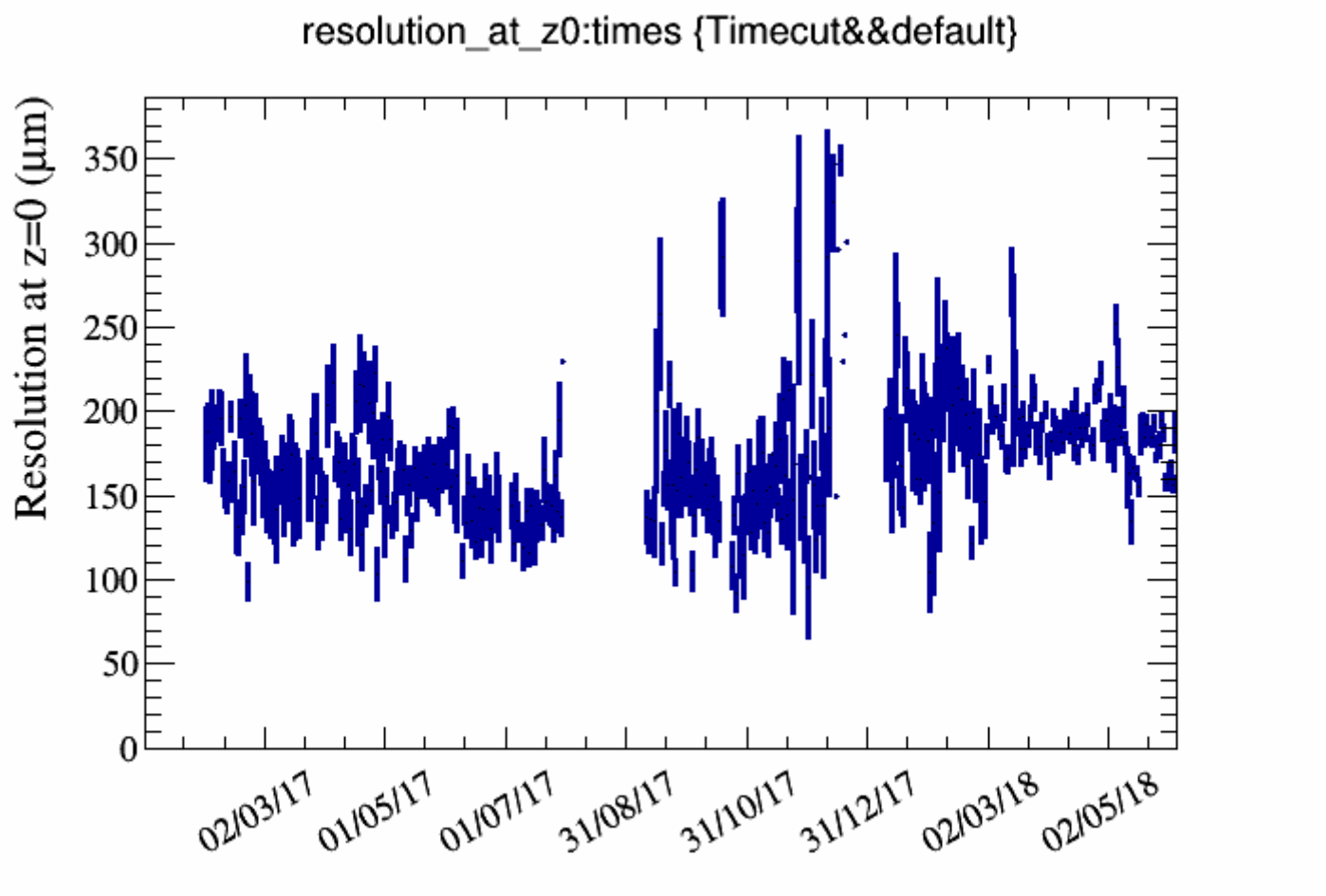
- Important Non Gaussian tail
- Individual Multigen FWHM
  - ~ 800 µm in X
  - ~ 1100 µm in Y

Pad resolution with double diff method

- Resolution vs z
  - Fit with standard form but adding an absorption (e- capture) term
  - Find similar absorption length as when studying charge vs time
- Resolution at z=0 ~ 200 µm.
  - Worse than ~ 60 µm obtained with state of the art hit reconstruction (based on pad response function) on test beam data by Colas et al.
- Extrapolate resolution function
  - No more e⁻ capture
  - In B field
- More recent data:
  - higher gaz flow
  - better gaz (?)
  - smaller dependence of resolution vs drift

March 18 data




resolution_at_z0:times {Timecut&&default}
Resolution at z=0 (µm)
350
300
250
200
150
100
50
0
02/03/17
01/05/17
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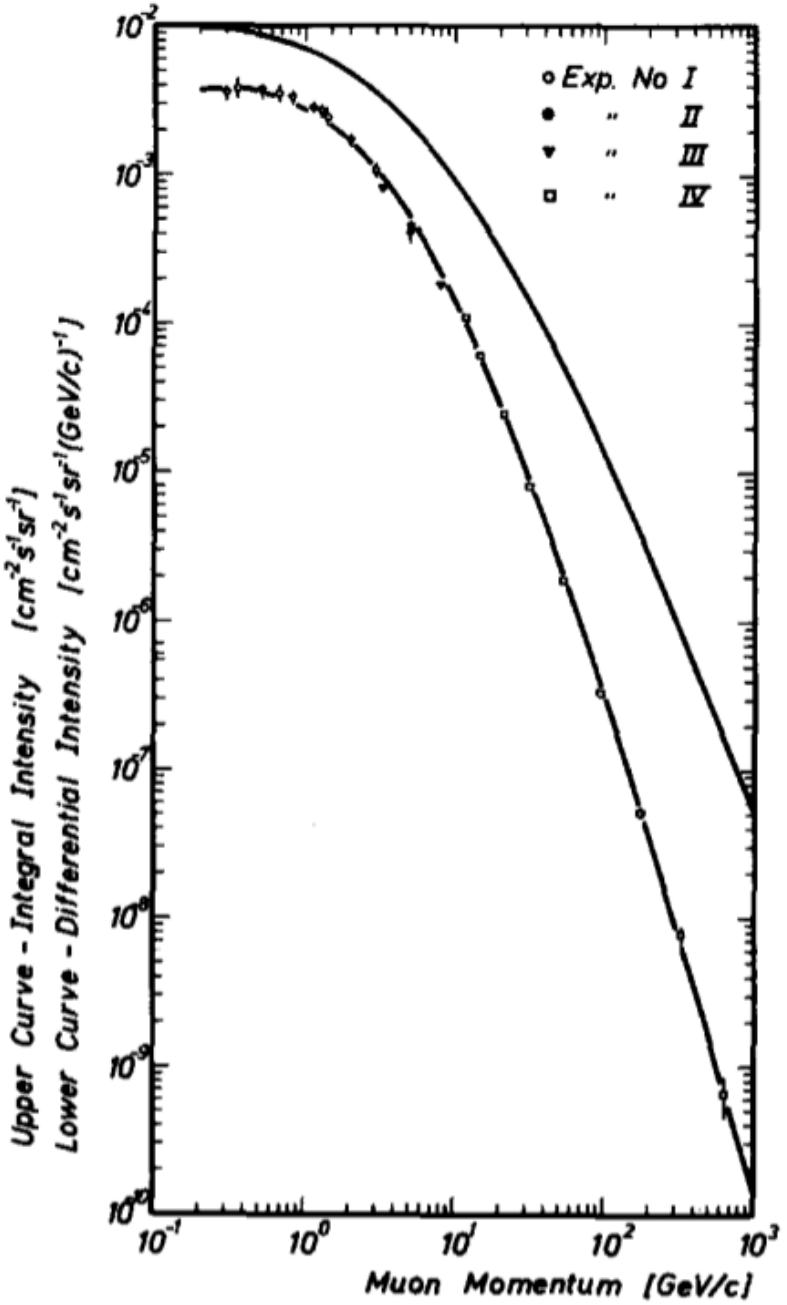
31/08/17
31/10/17
31/12/17
02/03/18
02/05/18


Exp. No I
" II
" III
" IV
Upper Curve - Integral Intensity [cm⁻²s⁻¹sr⁻¹]
Lower Curve - Differential Intensity [cm⁻²s⁻¹sr⁻¹(GeV/c)⁻¹]
Muon Momentum [GeV/c]