Mini TPC at Saclay : update

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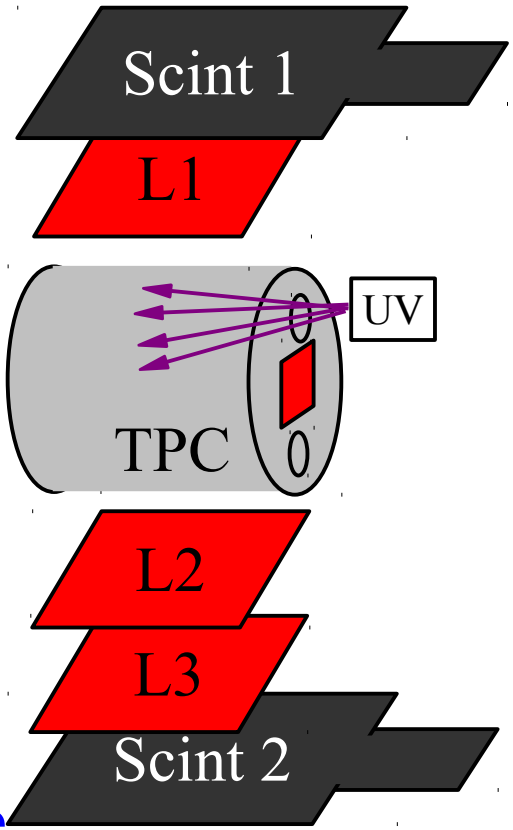
Outline

- Introduction/Reminder
- Recent events
  - Alignment
  - Tomography tests
  - Stability of voltage/gain//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.

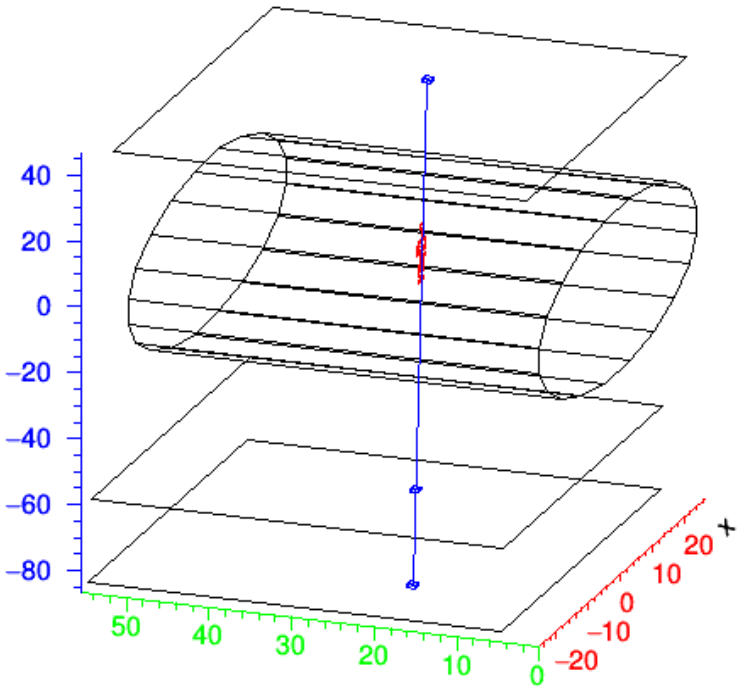


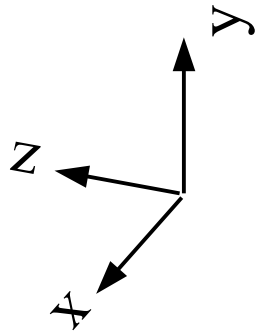
TPC+Multigen data

- 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 - 2018
  - Use 95% Argon + 5% Isobutane
  - TPC Mesh at -430 V (128 µm GAP)
    TPC Drift -10 kV / 48 cm → ~200 V/cm
  - Multigen (v1) anod at +480 V
- Issues to be solved before turning UV on
  - Quality:
    - Large e- capture rate in TPC
    - Sometimes poor S/B in multigen
    - Track resolution not as good as expected
      - need to improve tracking
  - Stability
    - Gain in TPC not stable in time
    - S/B in multigen not stable in time
    - Track resolution varying with time

Alignment procedure

- 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 relative to (X,Y,Z) axes for TPC
  - Fit drift velocity



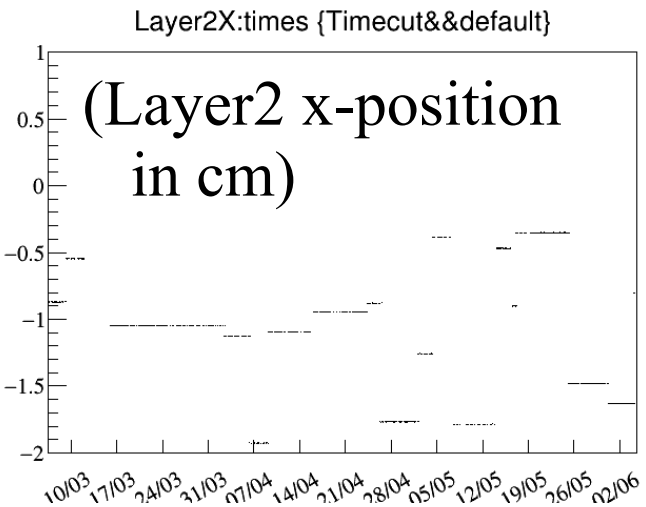


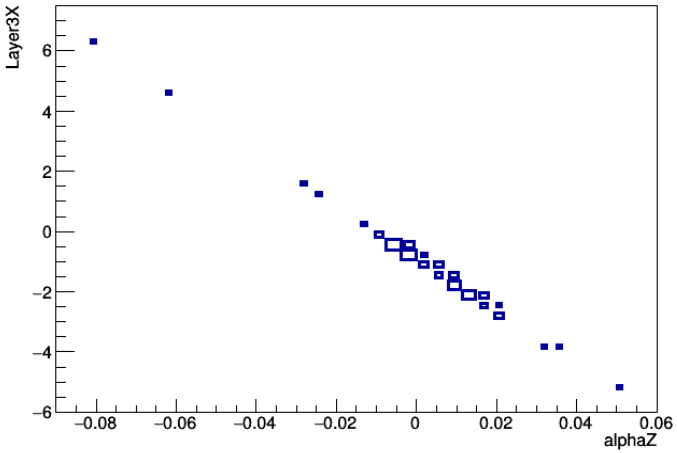
Alignment issue

Alignment constants are computed regularly

- They should be equal over a short period as we don't move the detectors
- They are not

- Reason for instability
  - Evidence of degeneracy in fit outputs:
    Not enough sensitivity to disentangle a rotation of TPC from a translation of Multigen ?
  - Note: this does not affect resolution I computed so far.
  - This is a problem when you compare an absolute (x,y,z) coordinate between different runs (eg for Tomography)
- Recent attempt to improve alignment by changing reference track
  - Instead of computing hit residuals relative to MG L1-L3 track I tried computing residuals relative to global MG L1-L2-L3+TPC fit
    - No improvement in degeneracy so far



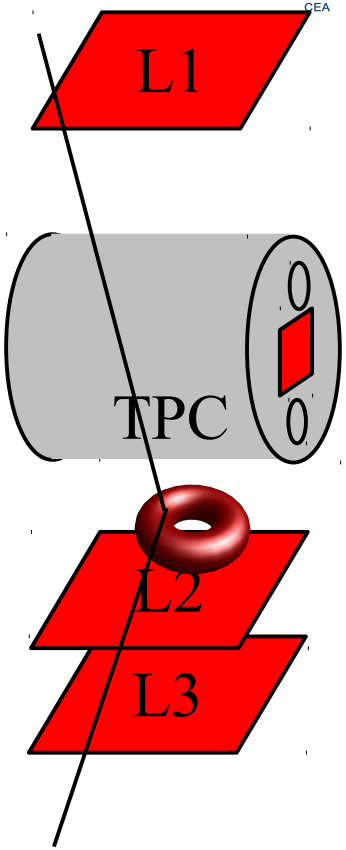


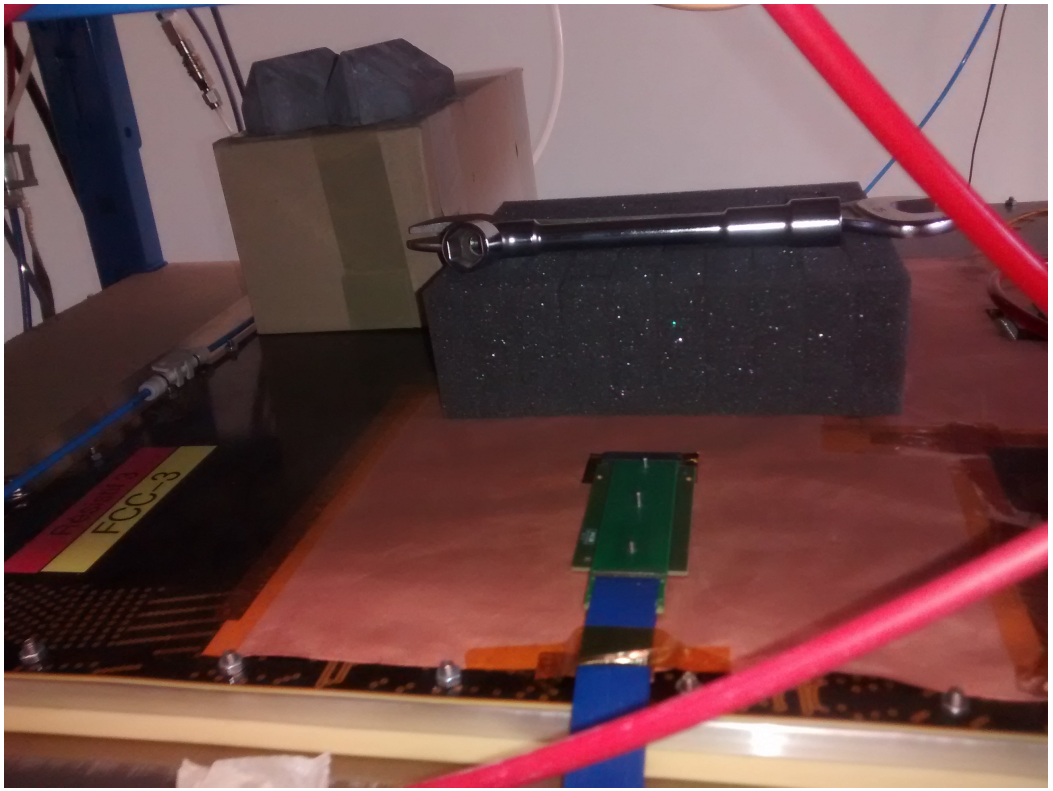
Layer3x- vs rotation around Z-axis, in different runs

- Issue still to be settled
  - May be we should just reduce the number of degrees of freedom

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





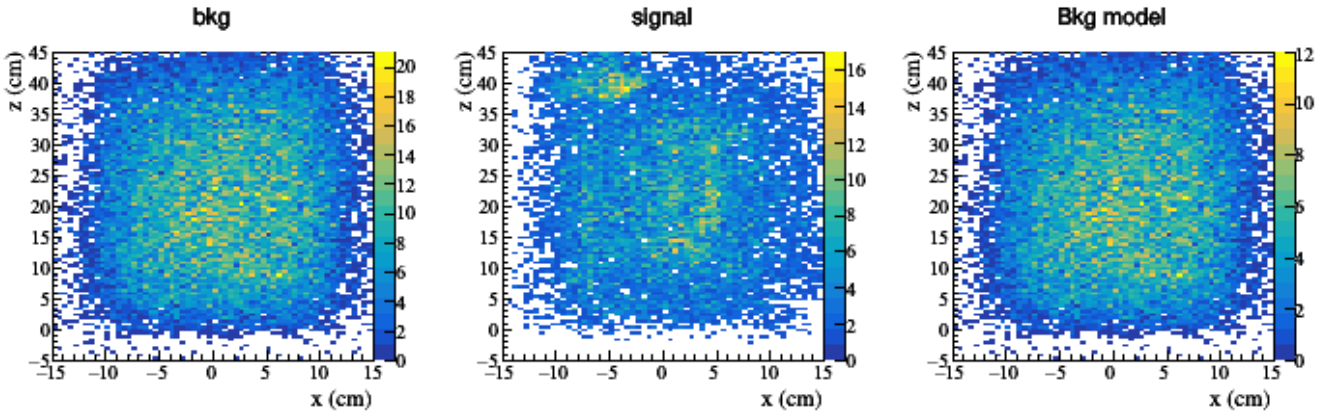
Tomography results presented June 6

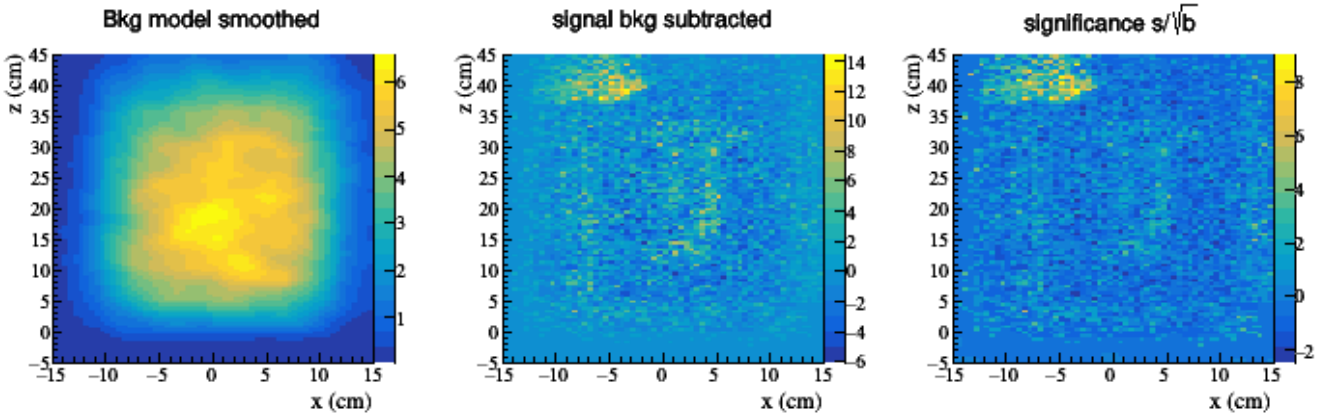
Signal, using L2L3, and TPC+L1I

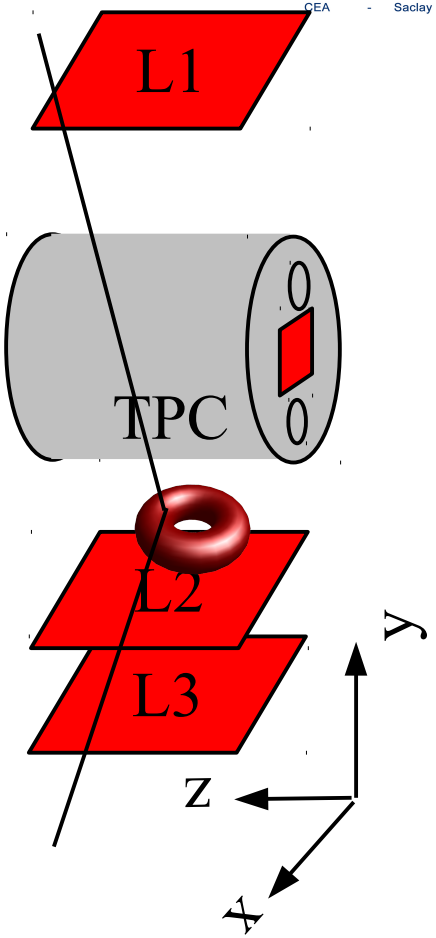
- Require large deviation angle between segments
  - $\alpha=\sqrt{\Delta\theta^2+\Delta\Phi^2}>0.02$
- Require segments to point to same vertex in x,z ~1cm

Background

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



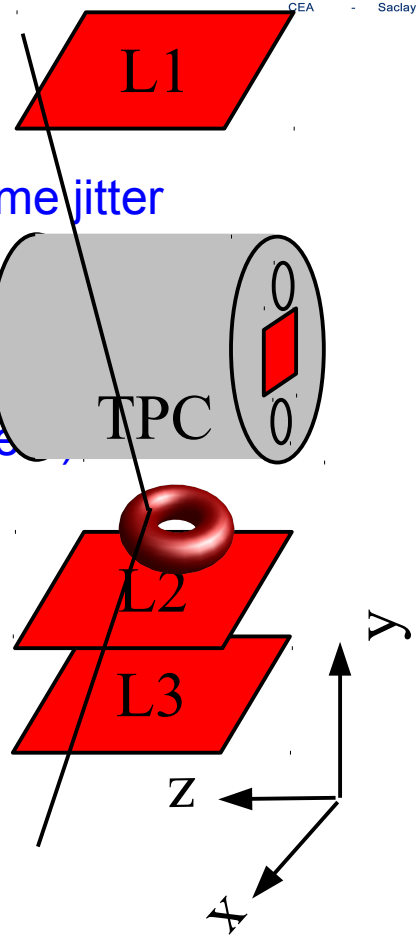


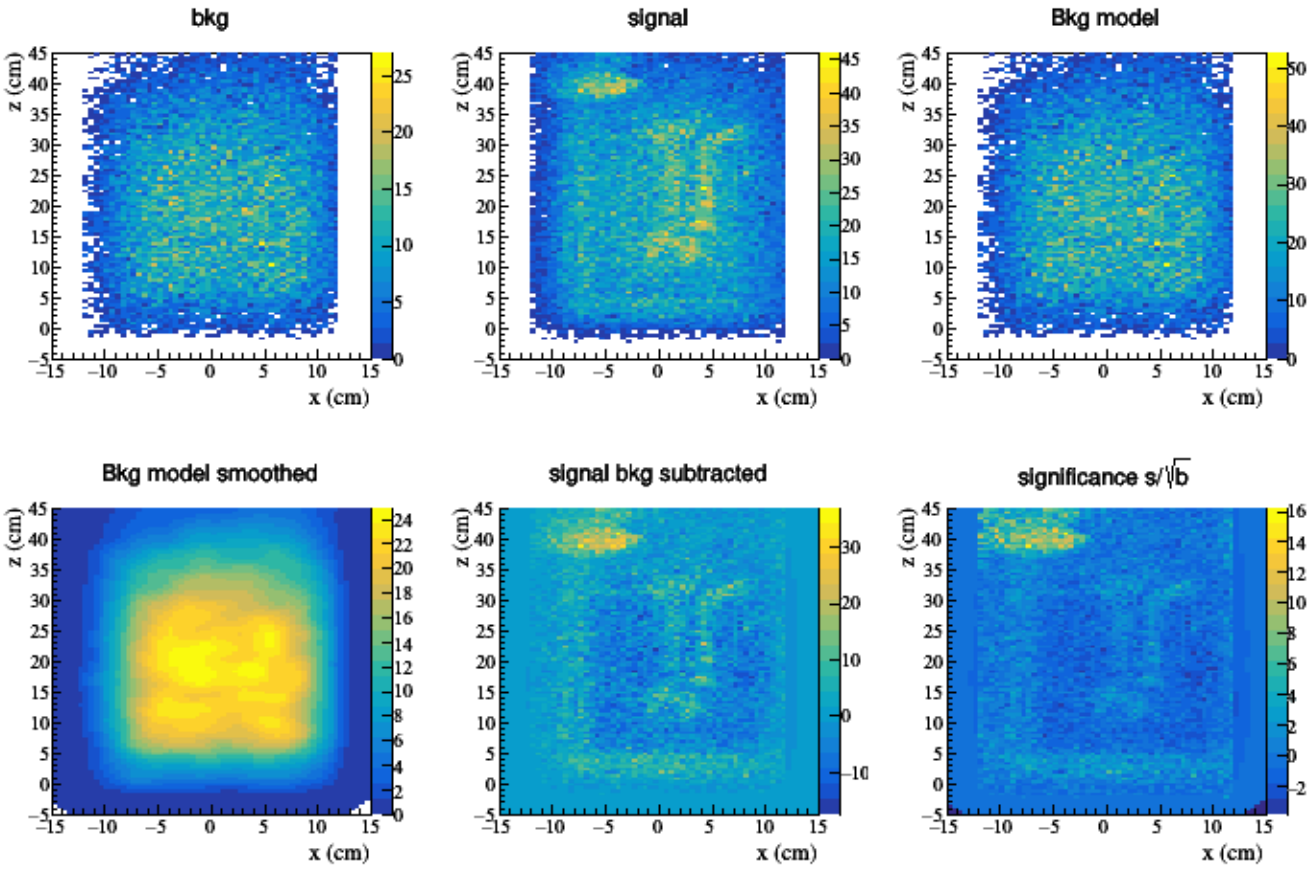


Updated plot

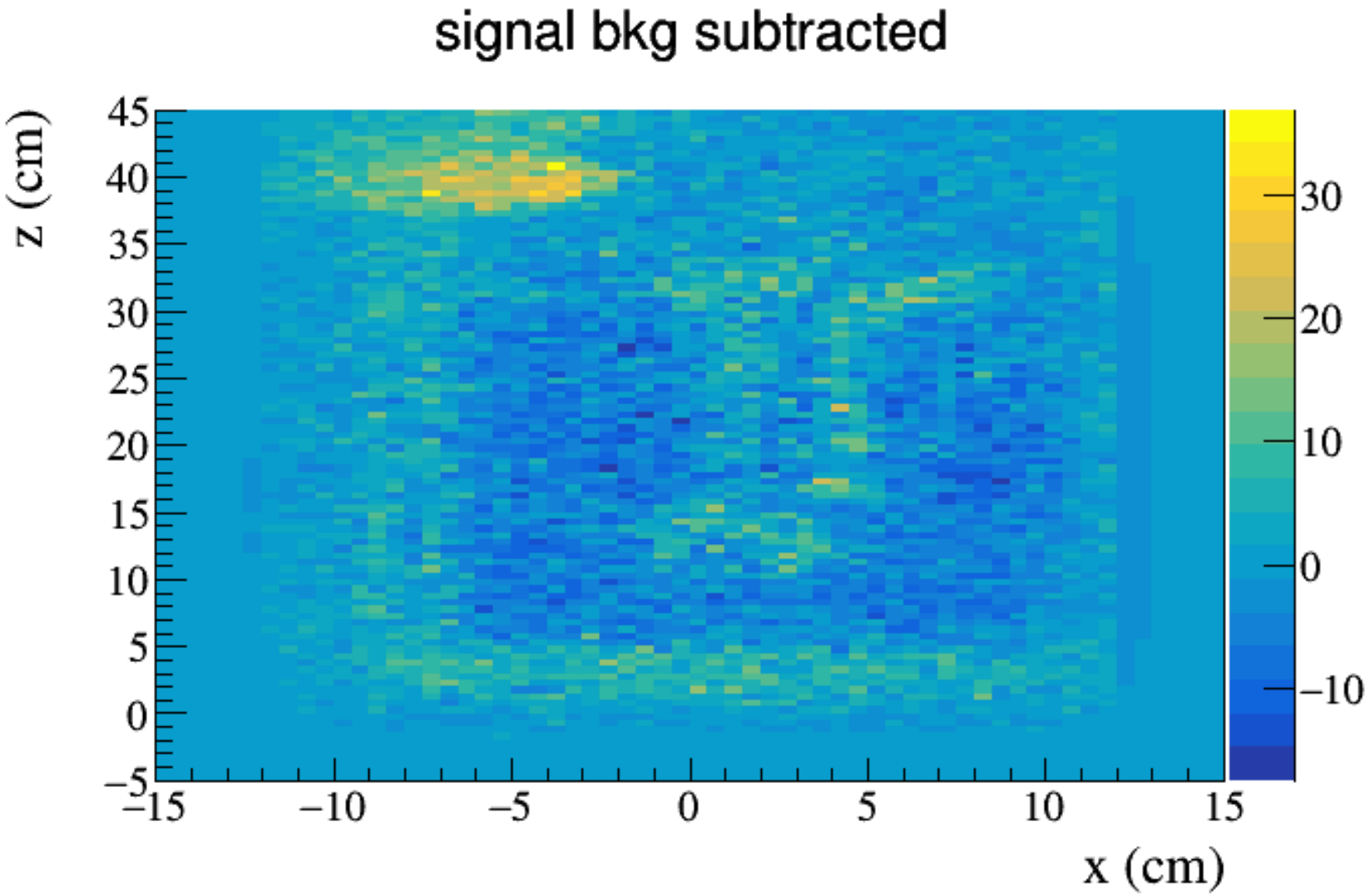
Main Changes:

- Process data using one single alignment geometry file
  - avoid issue with on-the-fly alignment procedure that yields some jitter ~ +/-1cm
- Include April (without lead) and June data
- Do not use Layer1 info, which is often missing due to trip.
  - Deviation angles computed as Δ(MG23 segment, TPC segme





Wrenches


signal bkg subtracted
z (cm)
45
40
35
30
25
20
15
10
5
0
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−10
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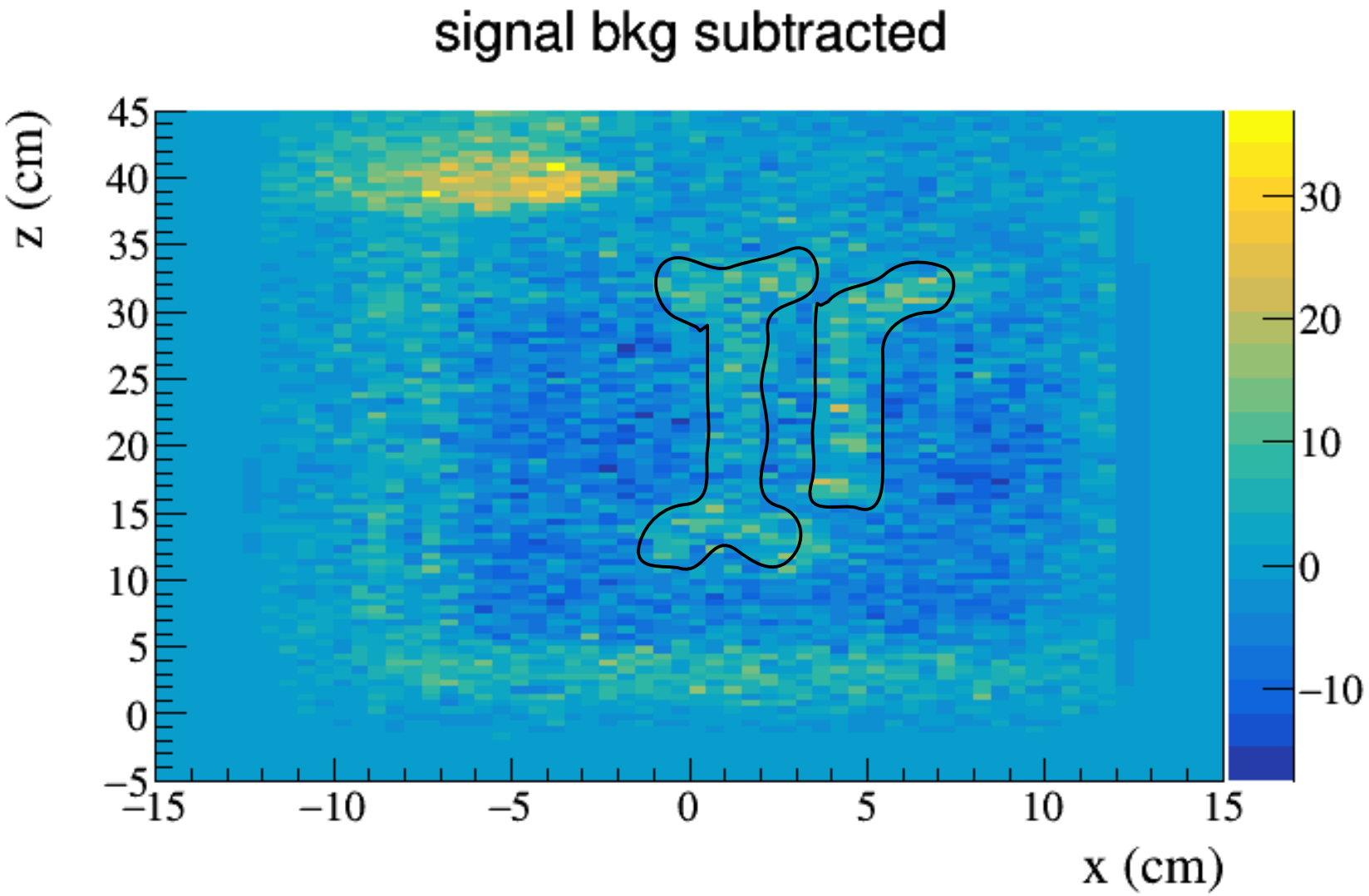
0
5
10
15
x (cm)
30
20
10
0
−10

Wrenches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10
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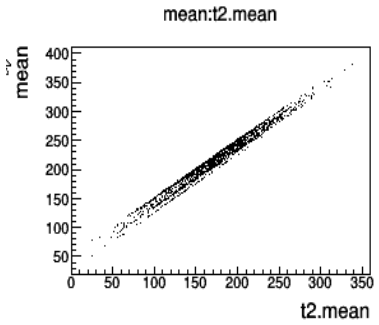
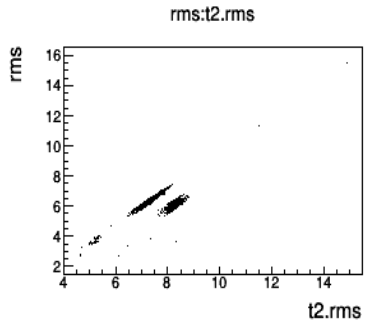
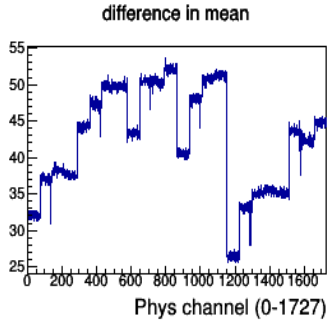
30
20
10
0
−10

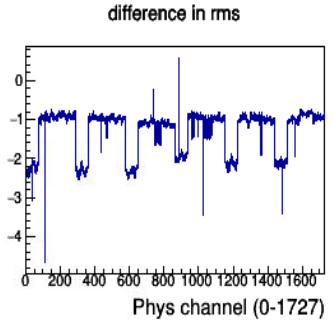
Data quality

- For long time, observed instability in TPC pedestals
  - Eg comparison of pedestals determined 24/04 15h26 then 24/04 16:11

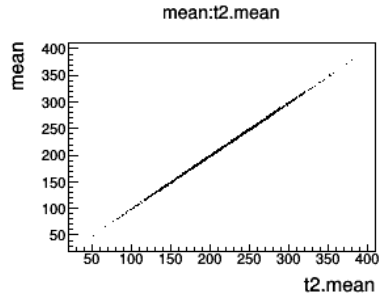


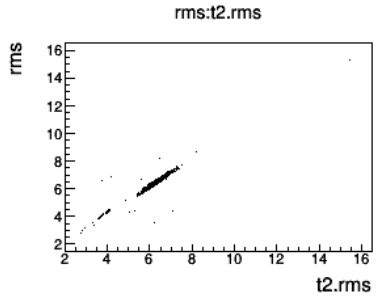


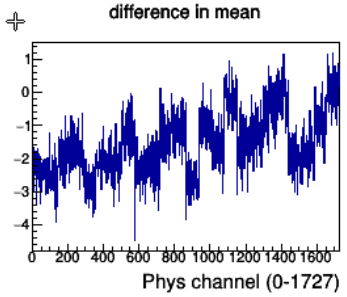


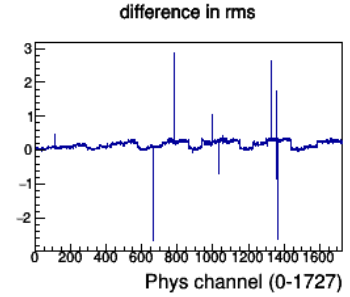


- Now using two 5V power supplies for MG and TPC
- TPC pedestal seem more stable
  - Eg comparison 30/05/3018 vs 20/06/2018
- To be confirmed with time
  - also see next slides









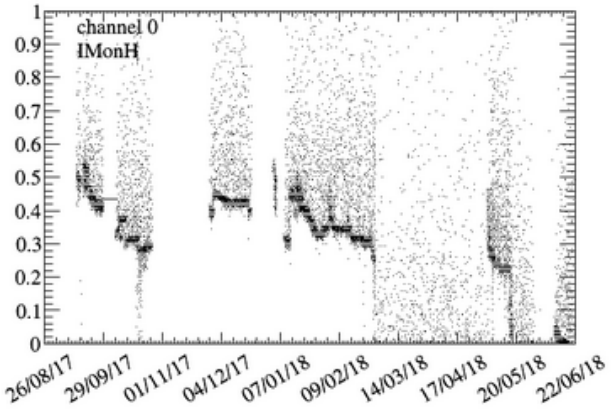
Issue with electronics/power supply

- Many strange issues in the last couple of months
  - TPC “gain” (actually charge collected) sudden increases/drops by a factor of x2
  - Multigen gain and signal/bkg sudden changes
- Occurrences of the changes
  - Sometime with no apparent reason
  - When separating the two electronics low voltage power supply
  - When playing with grounding of detectors

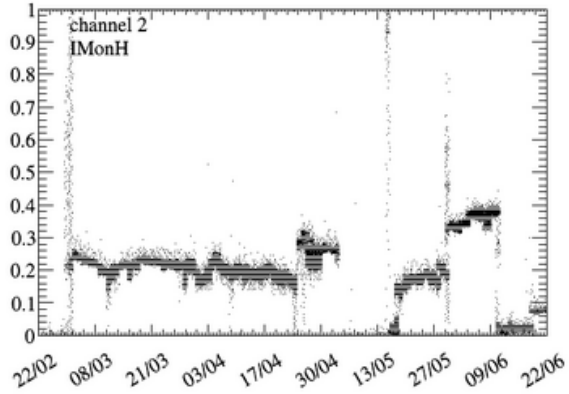
Issue with electronics/power supply

- Looked at High Voltage power supply log over last year
  - Sizable current is being seen by power-supply when the “gain” is low
    - Note that this current is +/- independent of the High voltage setting
    - Charge build-up (??) between micromegas mesh and anods that changes the gain ?
  - I Worked on grounding with grounding strip in June. This seems to improved things now. Got stable gain in July

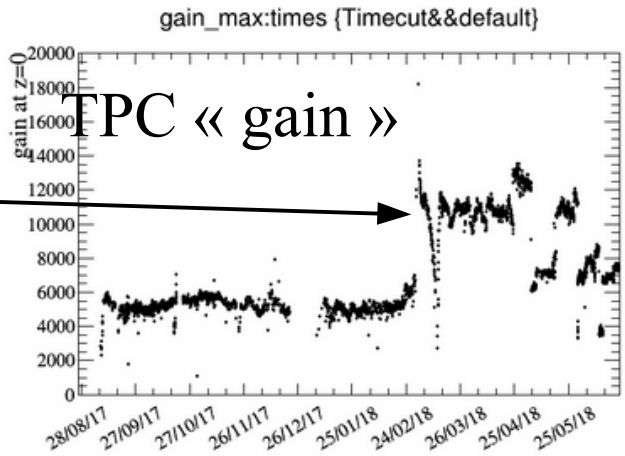
TPC -HV current

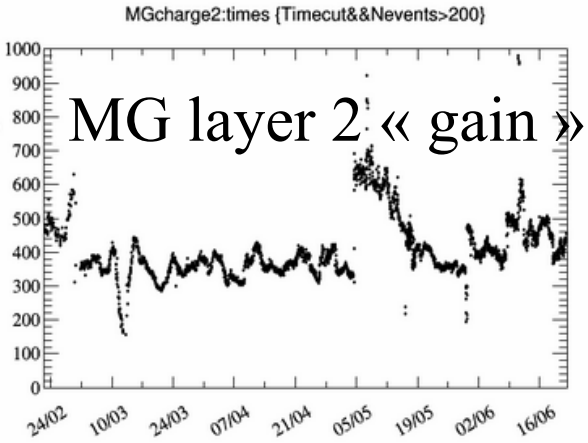


MGL2 HV - current



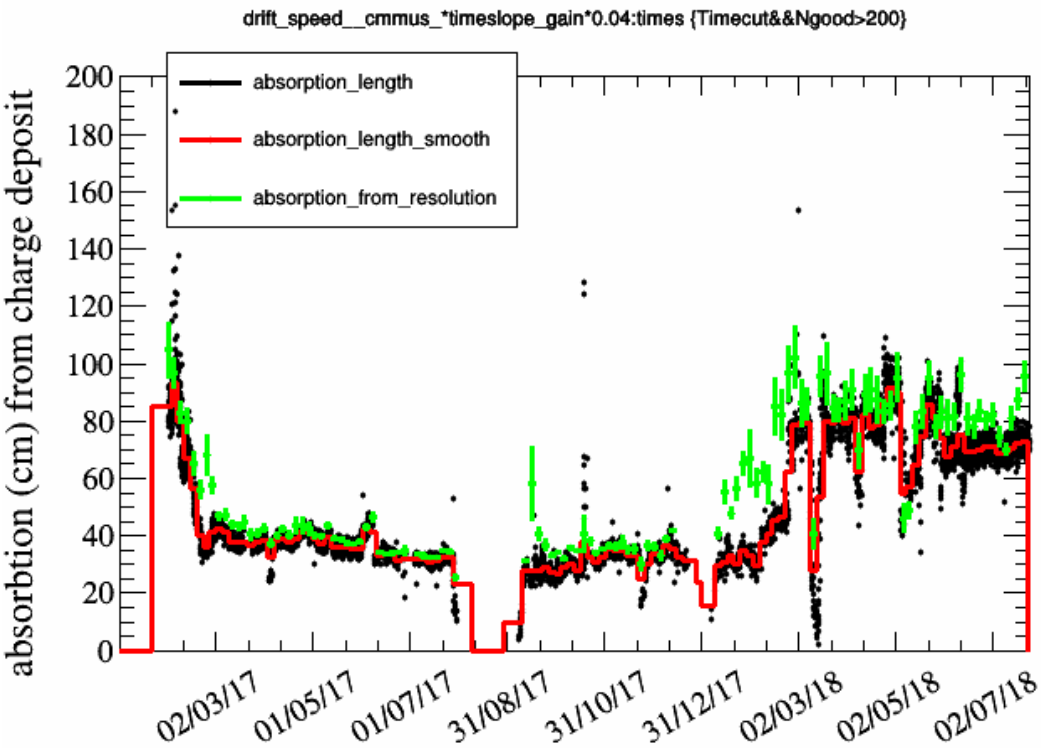
I initially claimed this jump in gain was due to change of bottle of Isobutane, looks like this is related to the current



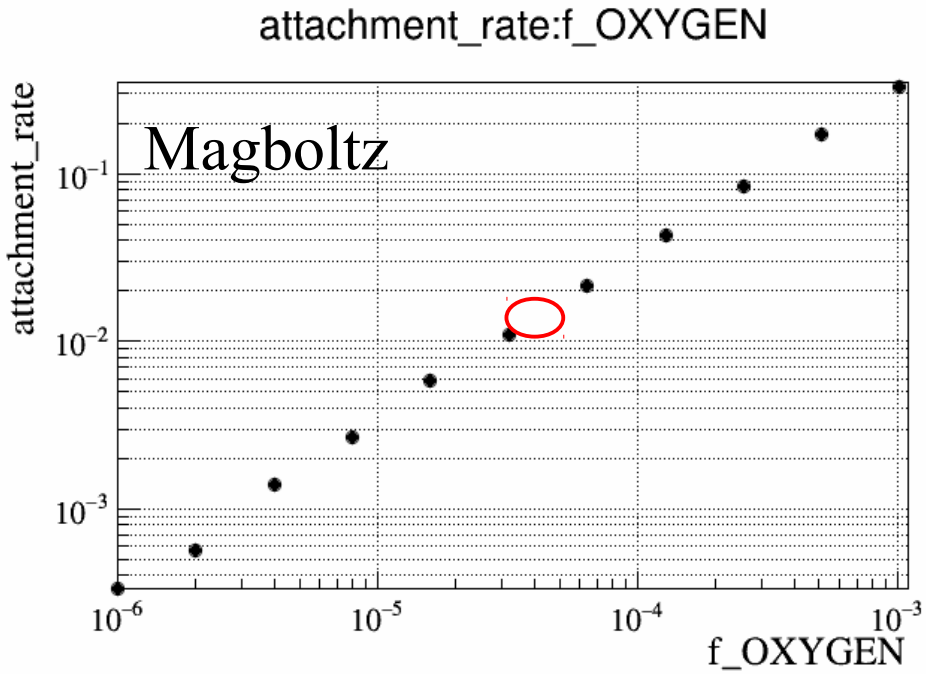


Issue with gas

- Too large absorption in gas (electron capture) affecting resolution.
- Presumably O2 outgasing or leakage.
  - Suspected something wrong in gas.
  - In July, changed 10 m of gas pipe. Was nylon, now aluminum coated pipe.
  - No visible change. Now suspect a leakage in some pipe connector, or O2 in the Argon bottle



green: e- capture determined from resolution vs z
red e- capture determined from charge vs z



Attachment ~ 1/80 cm-1 ↔ f_{O2} ~ 3E-5

Expected contaminent fraction in Argon 4.6 : 4E-5

Summary

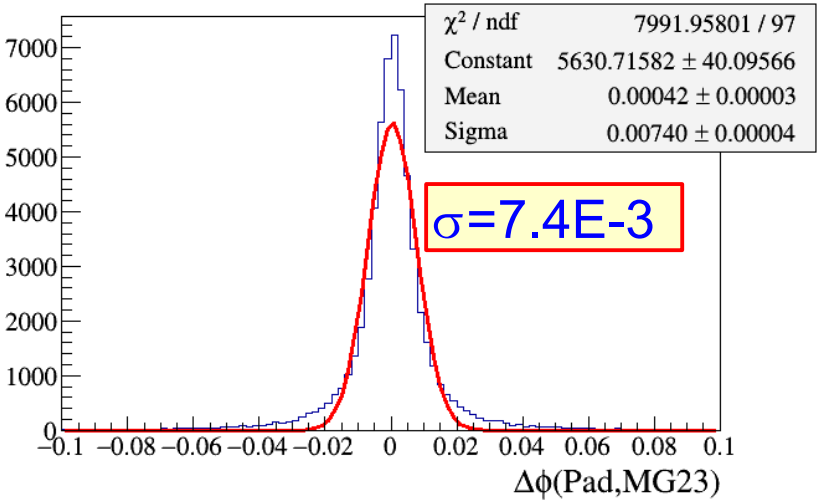
- Detector alignment to be improved
  - May be too many degrees of freedom
- TPC + Multigen tomography
  - We see piece of lead, and also iron wrenches
  - Still to be improved with better analysis and better data quality

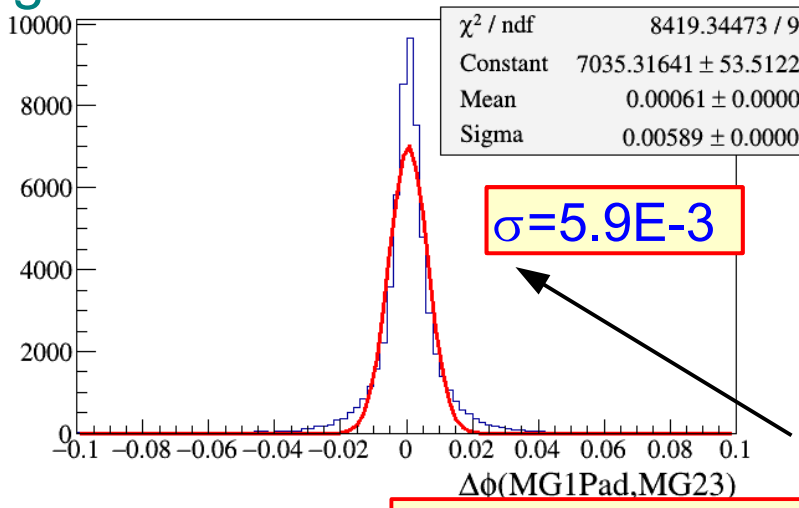
- Data quality
  - Electronic
    - Evidence that something is wrong in between HV/LV and electronics
      - a sort of current leakage affecting gains in multigen and TPC
    - Hopefully now solved
  - Gas quality:
    - Evidence for presence of contaminant (O2 ?)
    - Should test O2 absorber.

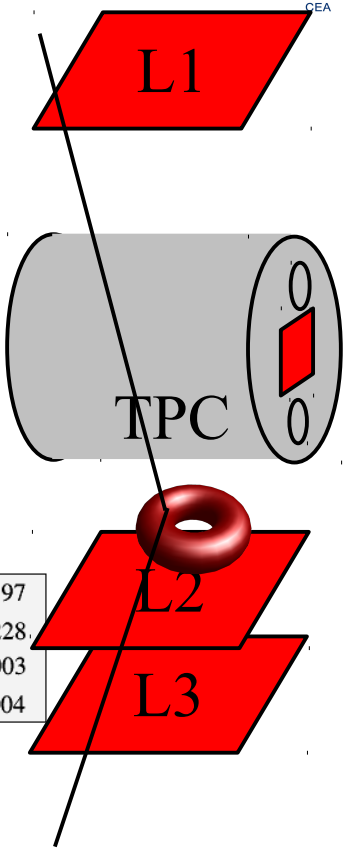
Support

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







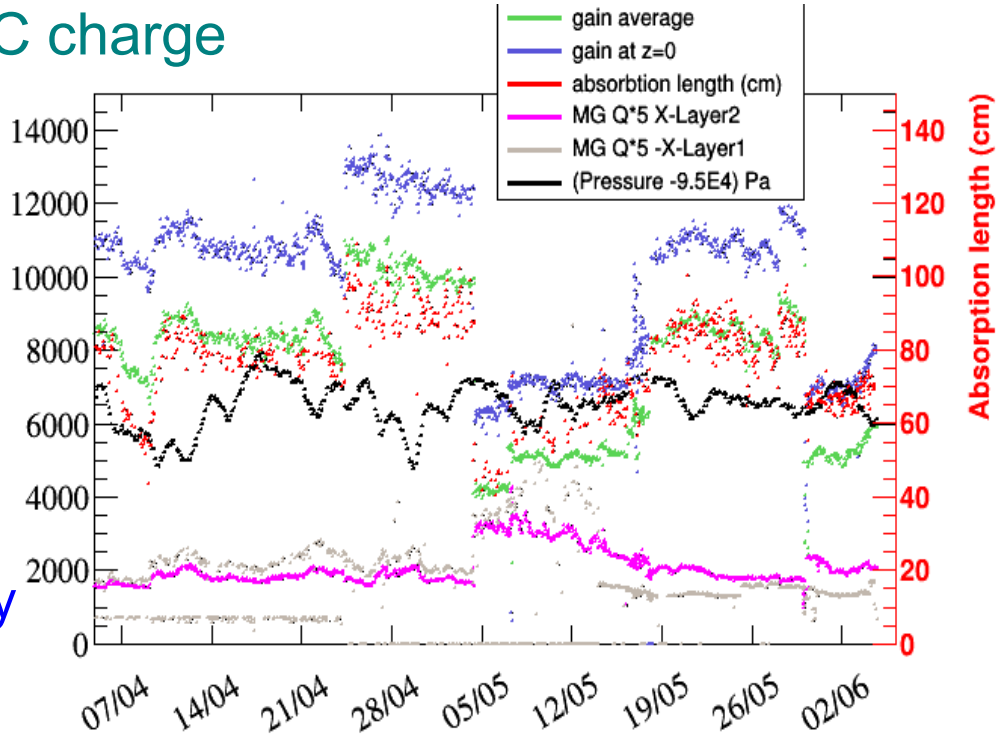
  - Here, data taken in runs without object
  - See non-Gaussian tail
    - Multiple scattering of low momentum muons ?
    - Tail of resolution in detectors

  (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

Data quality

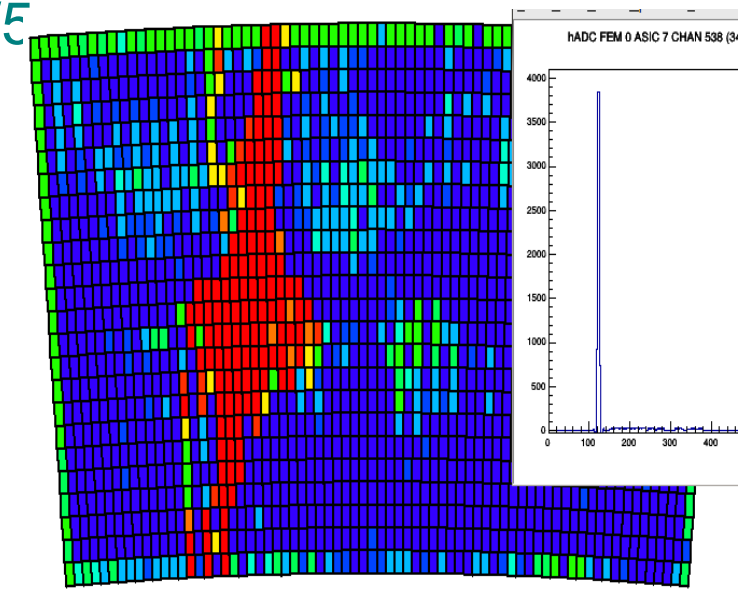
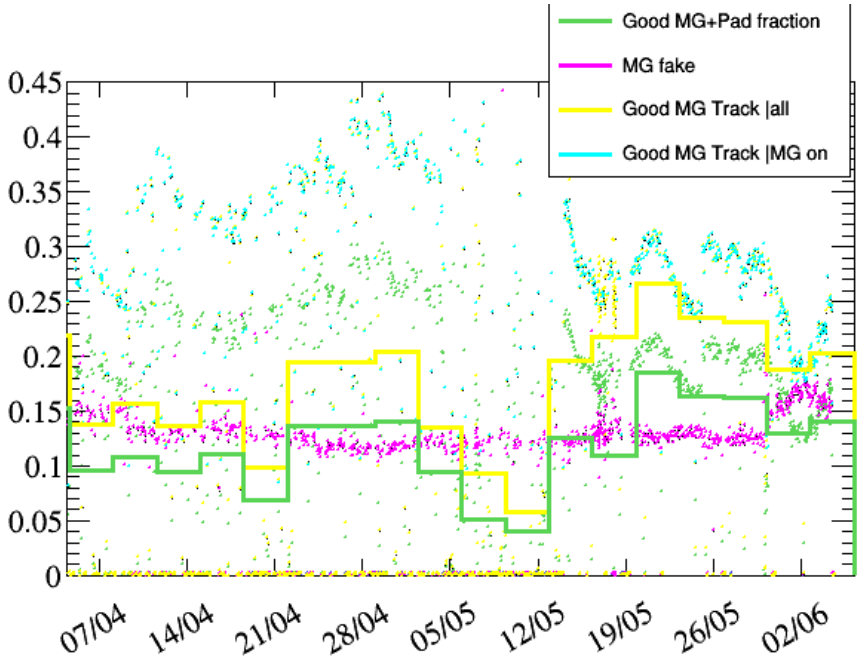
- For long time, observed instability in TPC pedestals
  - eg redetermine pedestals on 24/04
- On 5/5 unexplained
  - drops in charge observed in TPC
  - increase in charge observed in Multigen layers
  - At the same time electric noise conditions worsen in the building
- On 18/5 unexplained increase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