Mini TPC @ Saclay

Roy Aleksan, David Attie, Paul Colas, Fabrice Couderc, Sergei Ganjour, Marc Riallot, Philippe Schwemling, Boris Tuchming

Charge space at FCC-ee

Study to estimate (primary) space charge at FCC-ee

Main source identified as hadronic Z at L=10 ^{36} cm^{2}s^{-1}

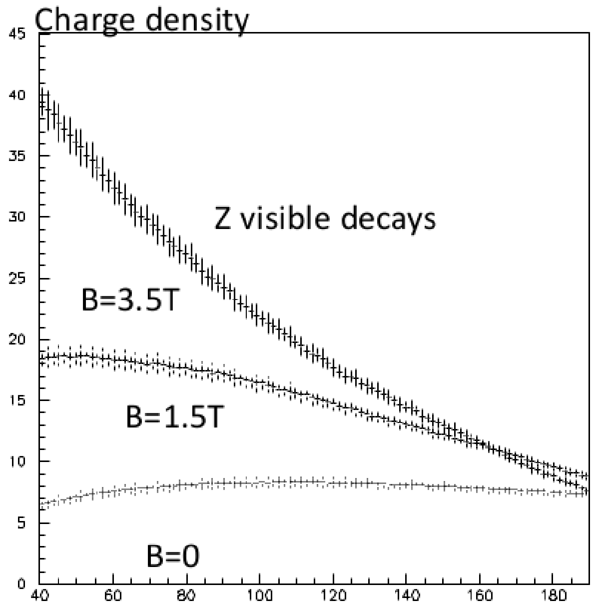
- primary ions
- secondary (amplification) ions back-flow
  - Here assume (agressive) 1 electron → 1 ion back flow

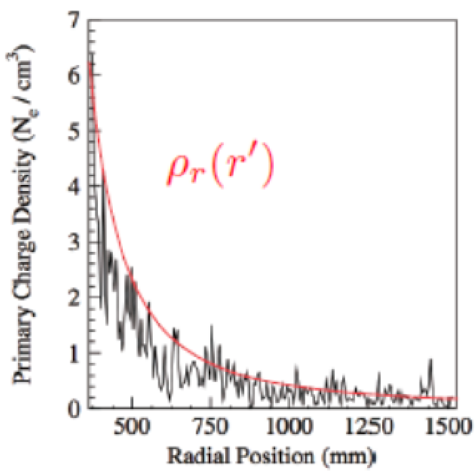
Qualitative comparison Tlep/ILC

X 2 to account for ion backflow

for Fcc-ee

Sergei Ganjour
Philippe Schwemling
(Feb 2014)





Charge Density (per 100 bunches

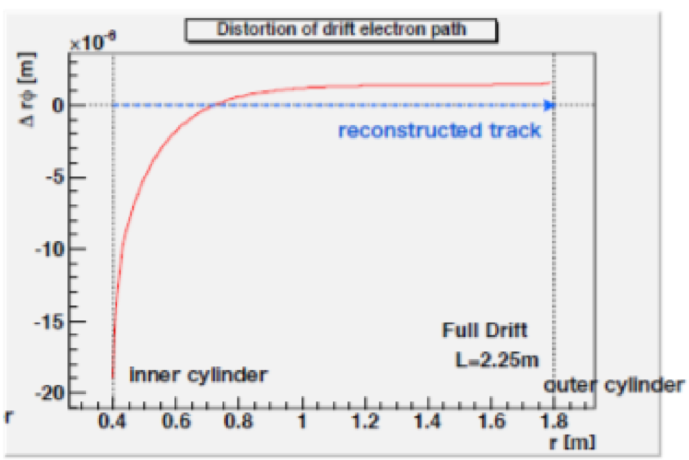
Charge distributions quite different,
ILC simulation more peaked at low radius : Inclusion of low Pt backgd ?

Charge space at FCC-ee

MC-based estimate of distortions

- Space charge induced by
  - primary ions
  - secondary (amplification) ions back-flow
    - Here assume (agressive) 1 electron → 1 ion back flow

for ILC

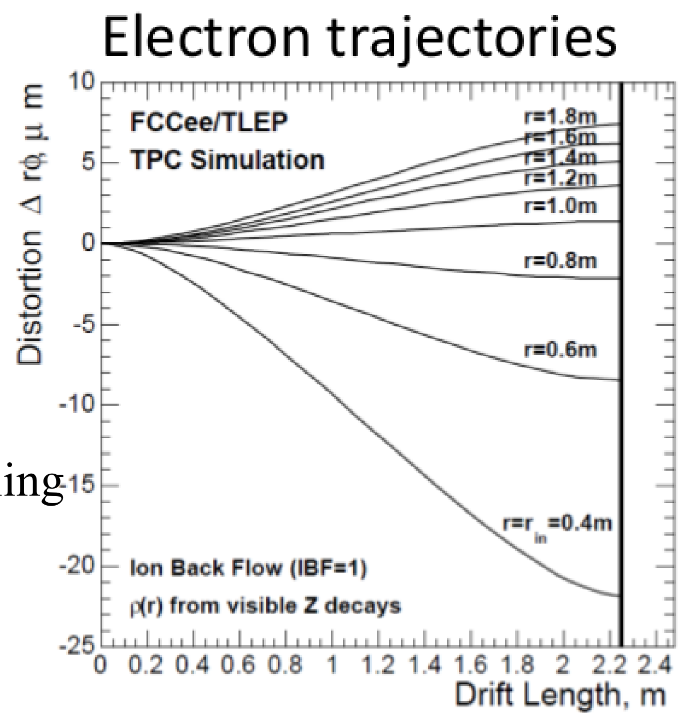


Distortion of drift electron path (Full drift)

Arai Daisuke
2012/February/23 @ WP meeting

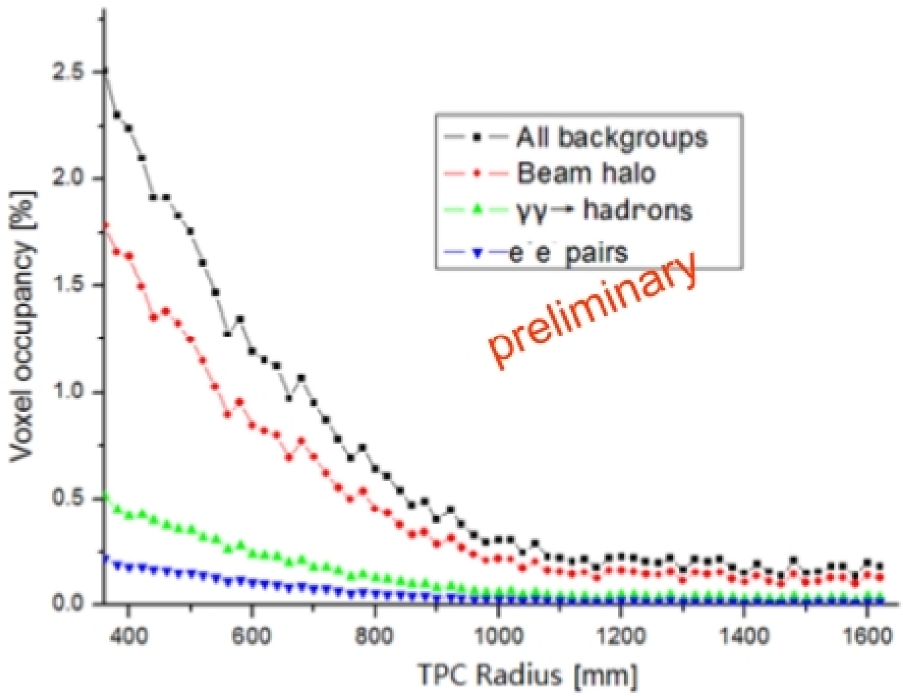
for Fcc-ee

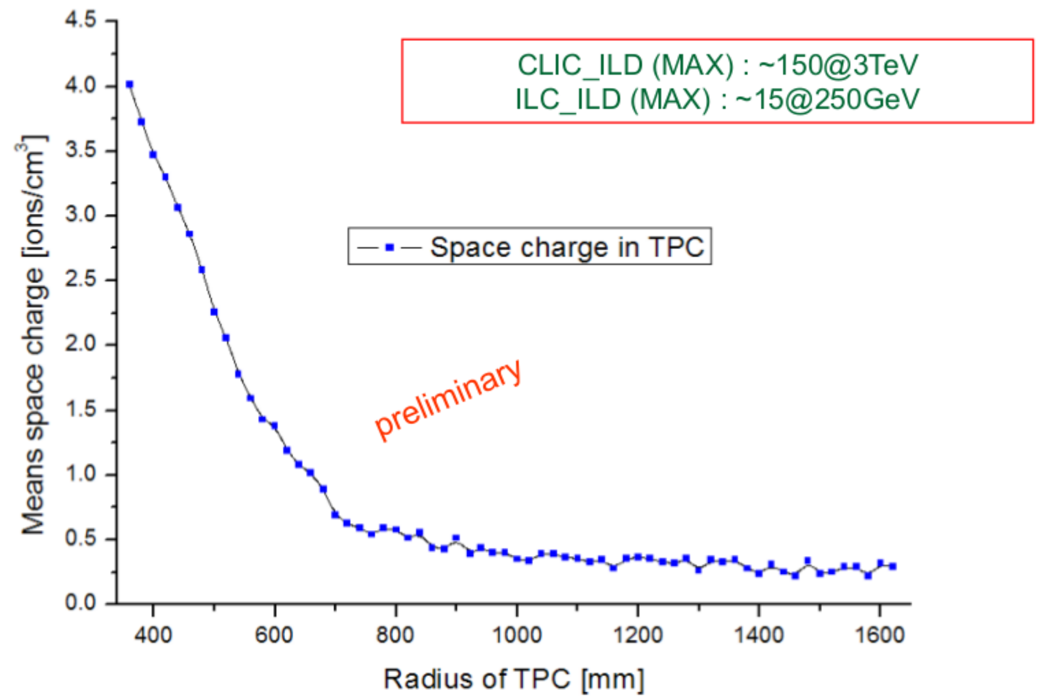
Sergei Ganjour
Philippe Schwemling



Recent studies from CEPC

- Had meeting last week with IHEP/Tsinghua people, studying effects of space charge for CEPC (L = 2 .10 ^{34} cm^{2} s^{-1})



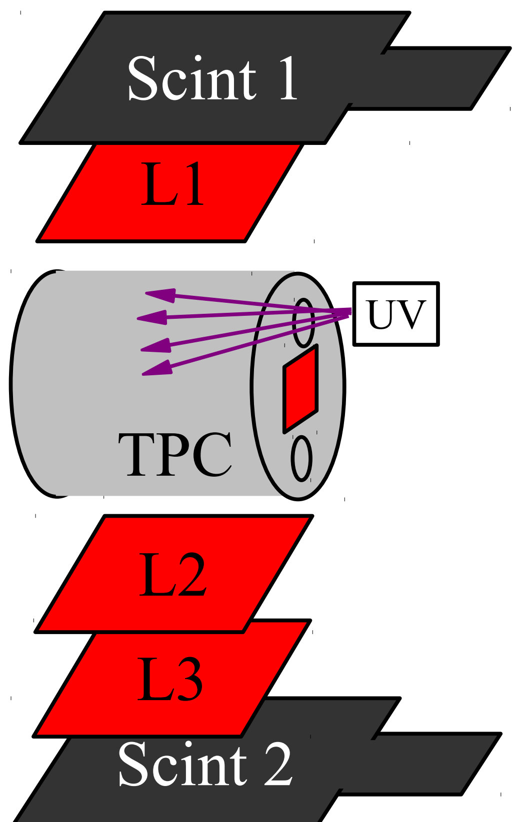


NB : not sure if they studied $Z \rightarrow$ hadrons

Mini-TPC project

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

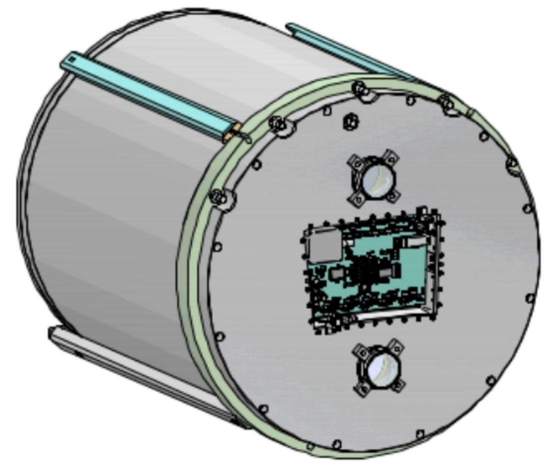
- Recycle existing chamber present at Saclay
- Use micromegas resistive module as TPC pads
  - Existing detector+electronics+DAQ developed for T2K and ILD R&D
  - New TPC end-plate to plug the micromegas device
- Transparent windows to send UV-rays through the chamber
  - UV rays yield photo-electrons 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.

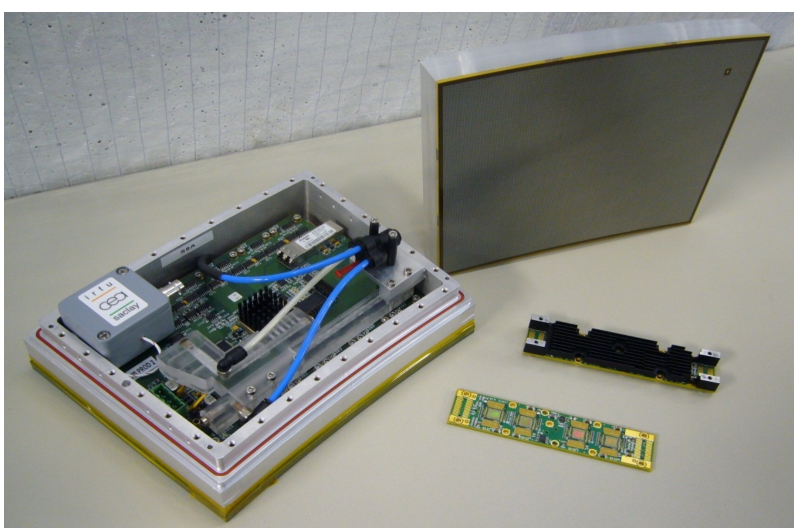


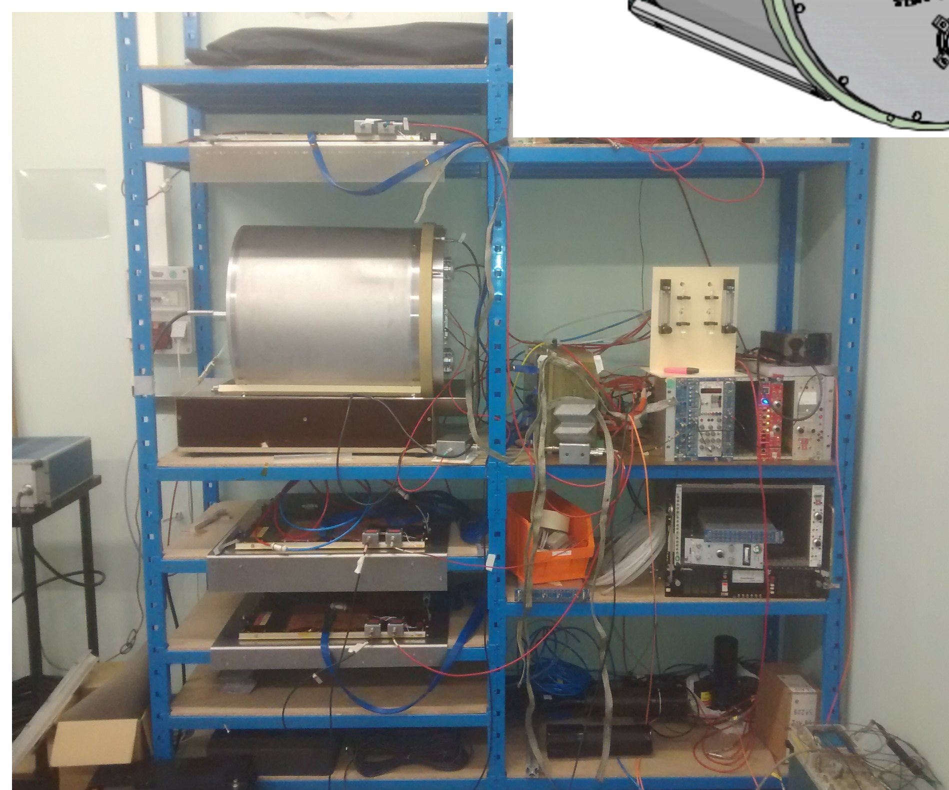
Mini-TPC project

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

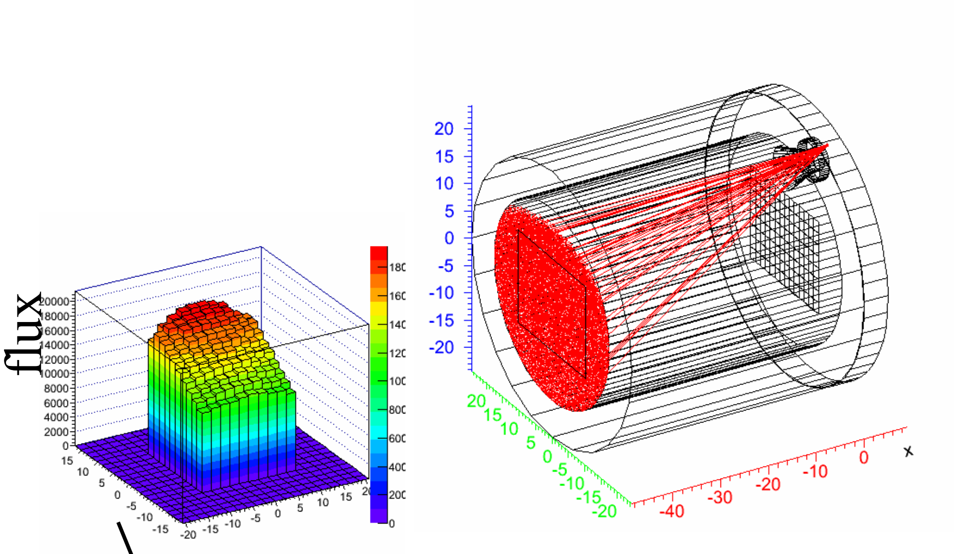
- TPC:
  - Δz TPC =48cm
  - D = 50 cm
- Micromegas modules:
  - 17cm * 23 cm
  - 1748 (36*48) channels

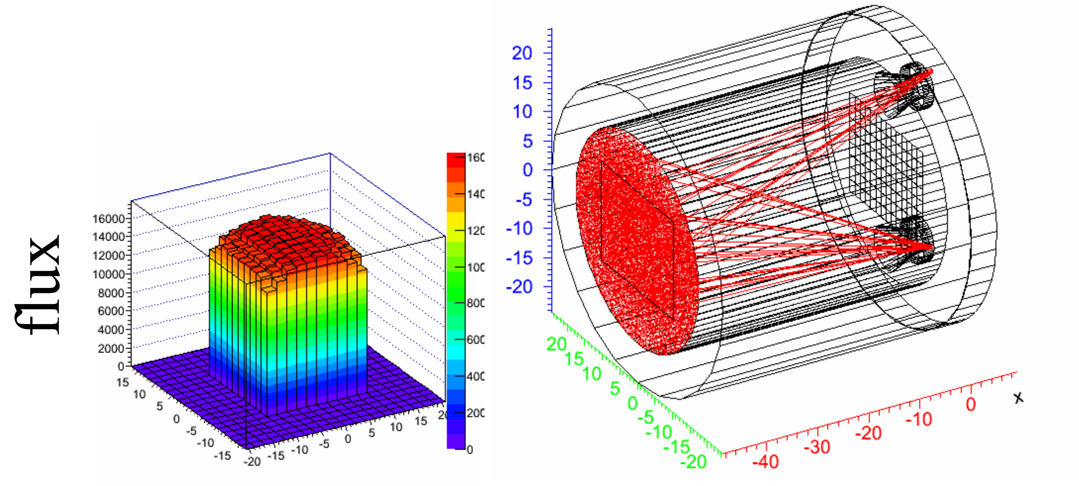






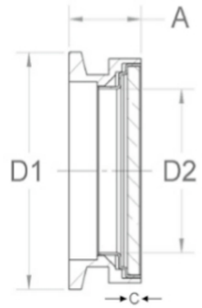
Two Viewports





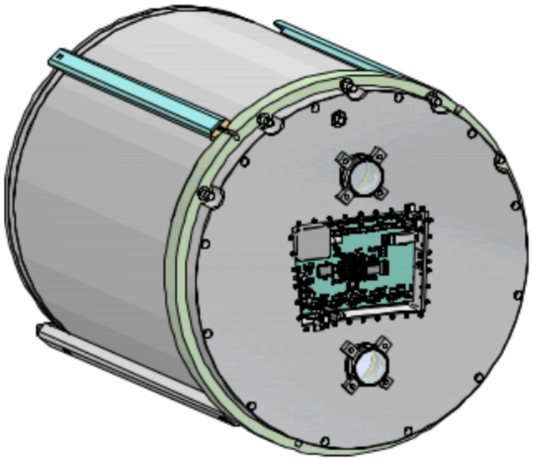
Solid angle effect+UV absorption+ Quantum efficiency= non homogeneous photo-electrons yield

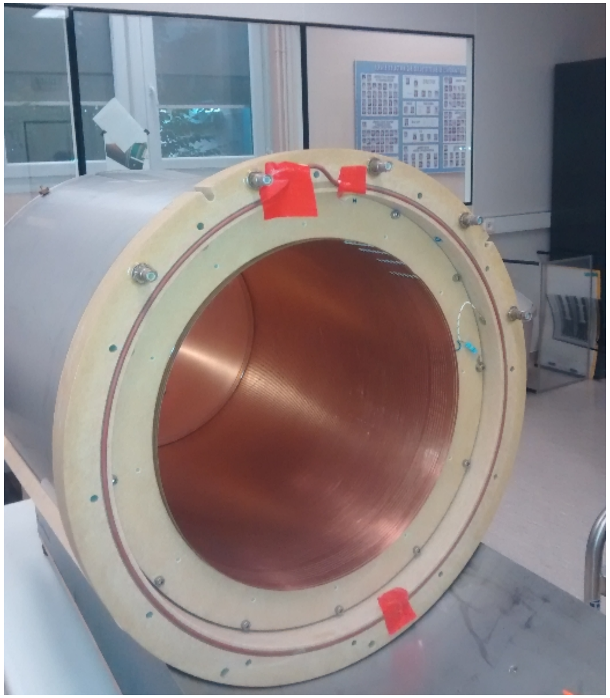
- Two viewports for better control on photon-electron yield homogeneity
- Will use CaF_2 viewport of diameter 3.8cm

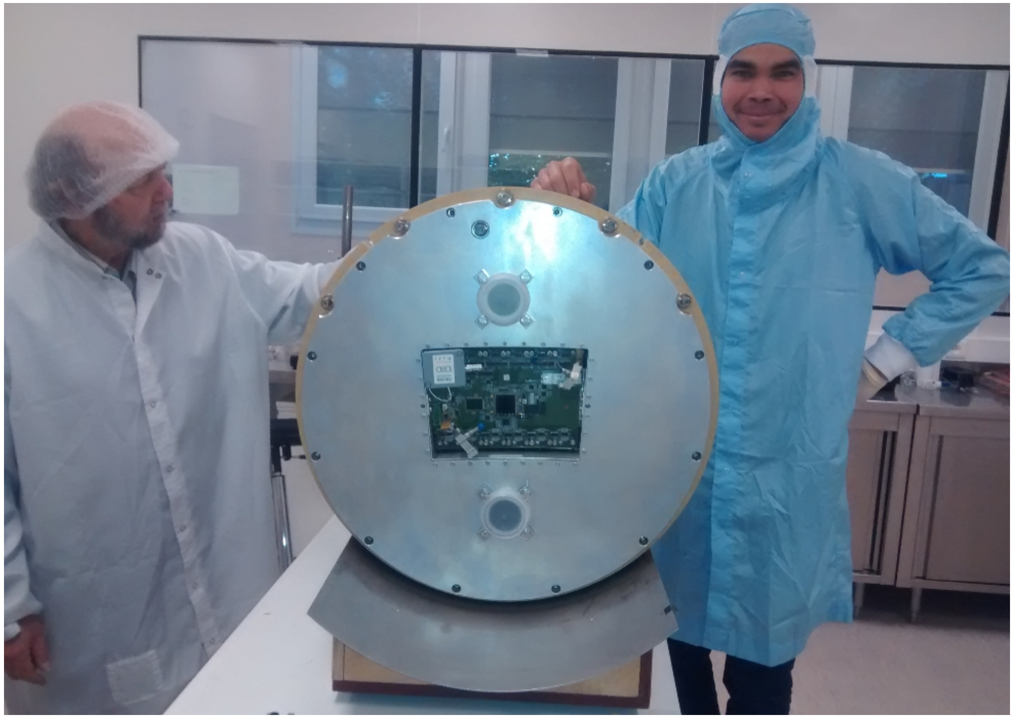


TPC assembly

- Endplate designed with two CaF_2 viewport of diameter 3.8cm
- Assembled last Winter
- Re-opened last month

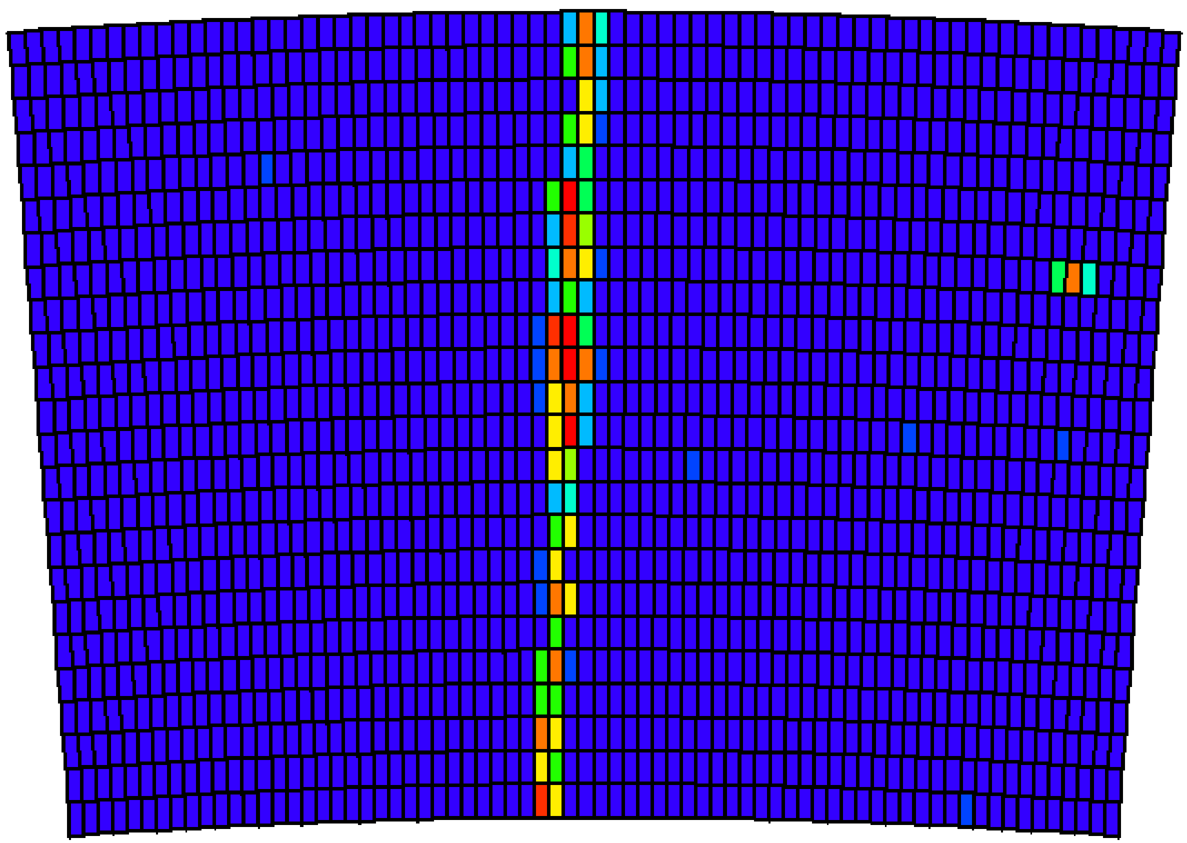


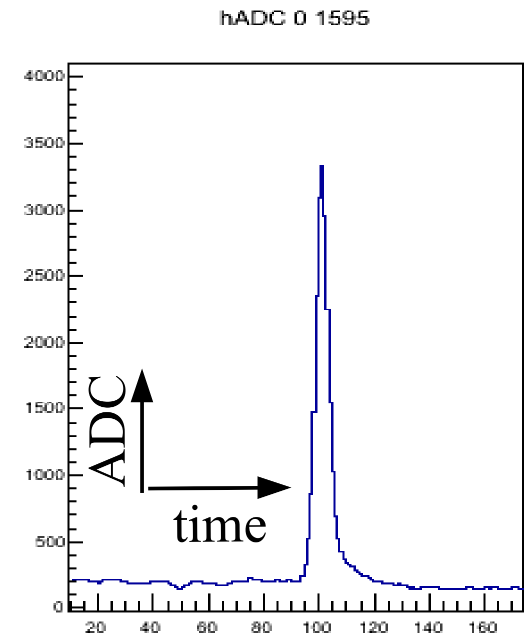




Running TPC

- Many issues with gas and gas lines prevented to run smoothly.
- Managed to take first cosmic data last month
  - 95% Argon + 5% Iso-C_4H_{10}
  - Drift field of 100 V/cm



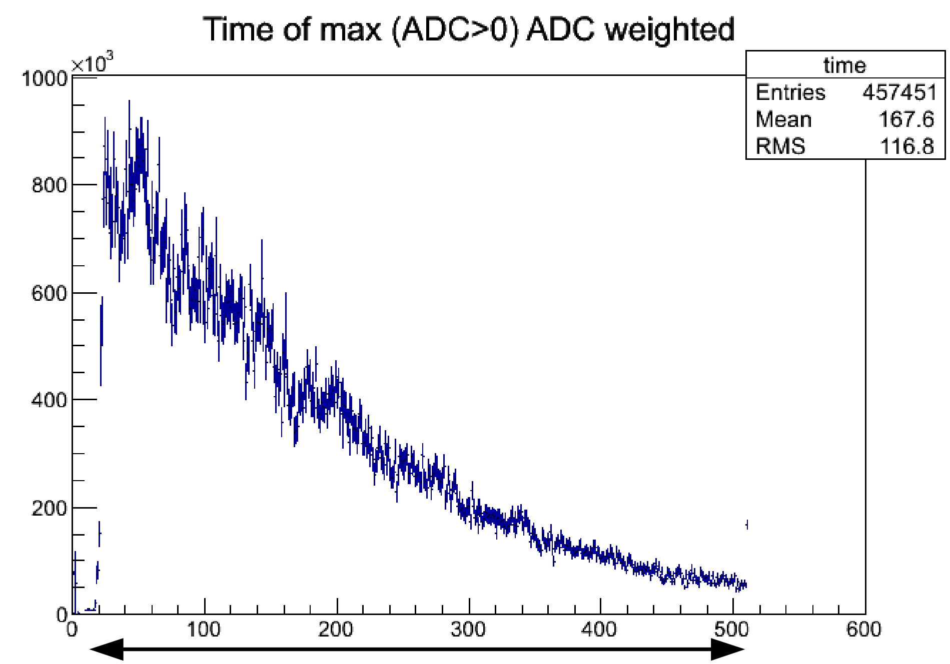


very clean signal

1728 channels
~20x20 cm^2

Gas in TPC (3)

- Energy deposit vs z shows absorption of primary electrons along z axis.
- Gas not as pure as needed
  - After ~ 6days of gaz circulating (~ 10 times the TPC volume)
  - presumably O2 or H2O contamination
- Need to improve procedure to get clean gaz in TPC volume..
  - Change pipes yesterday, polyurethan → polyamid
  - Increase gas flow ?
  - Use Nitrogen flow to clean the TPC ?

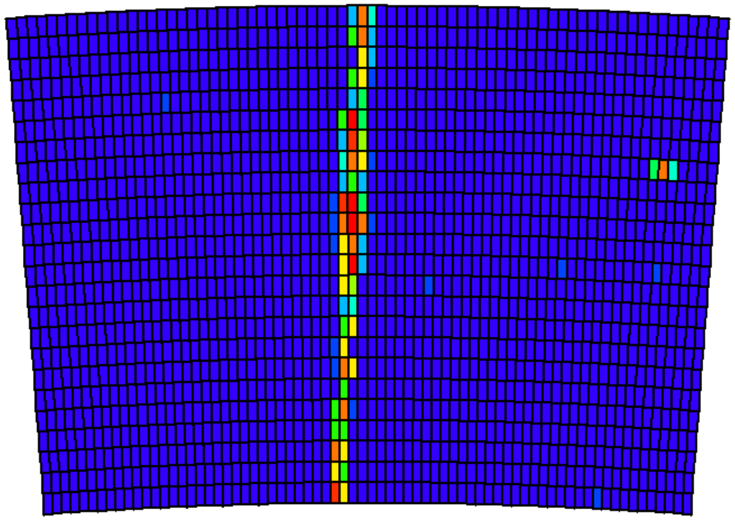


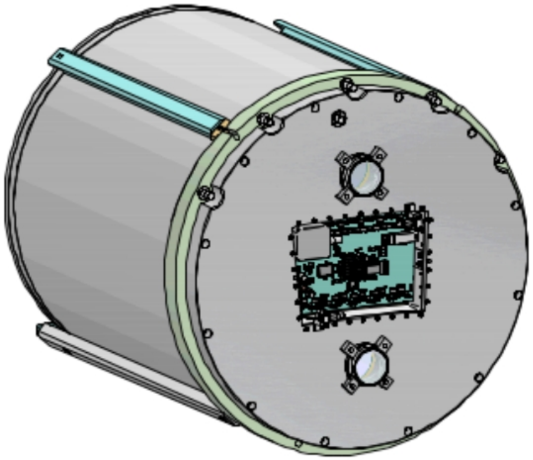
$\Delta T = 20\ \mu s$, $\Delta Z \sim 40cm$

(drift speed ~ 2cm/µs for 100 V/cm)

Conclusion TPC

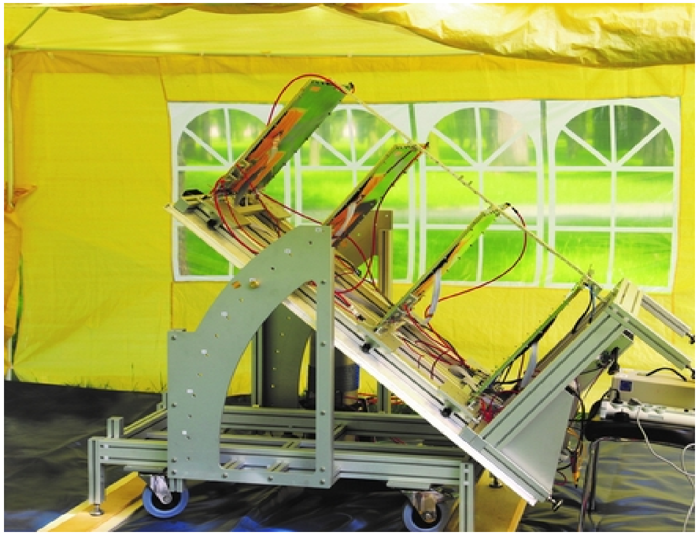
- We are able to make it run.
- However some work needed for steady clean gas operation
- Need also to define working points (HV/gain settings)
- Then need reconstruct tracks
  - account for individual « pad response functions»

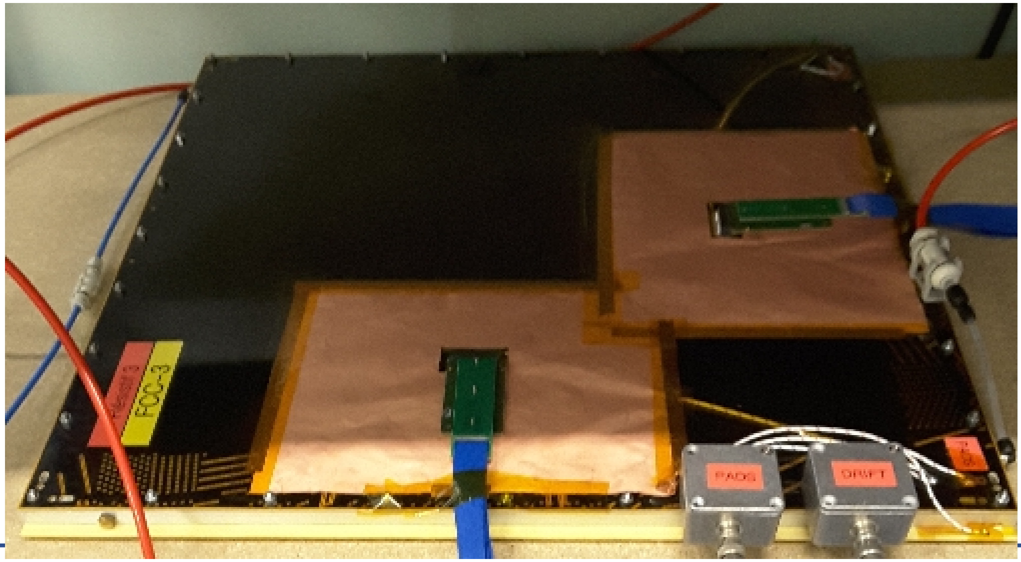




Hodoscope « Multigen » chambers

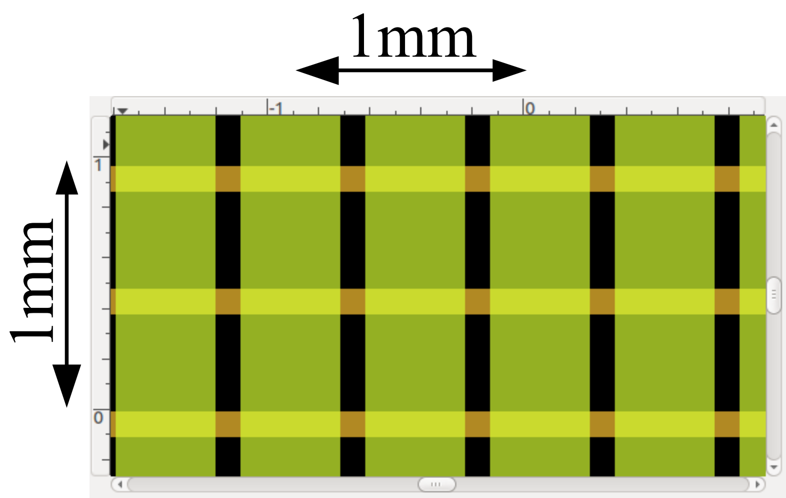
- Use three micromegas chambers as developed for M-Cube project or Class12 tracker= large area micromegas
  - 50 x 50 cm^2 coverage.
  - Two layers of orthogonal read-out strips
  - Pitch: 486 μm.
  - 1024 strip x 1024 strip → X x Y reconstruction.
  - Expect ~200 μm resolution ?

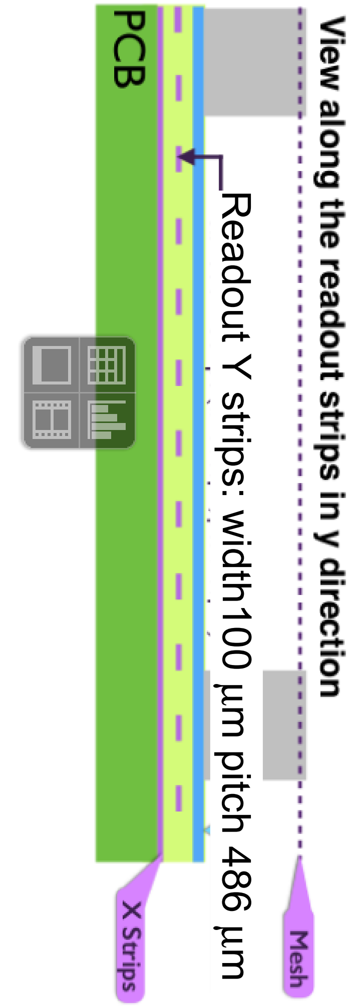




Geometry

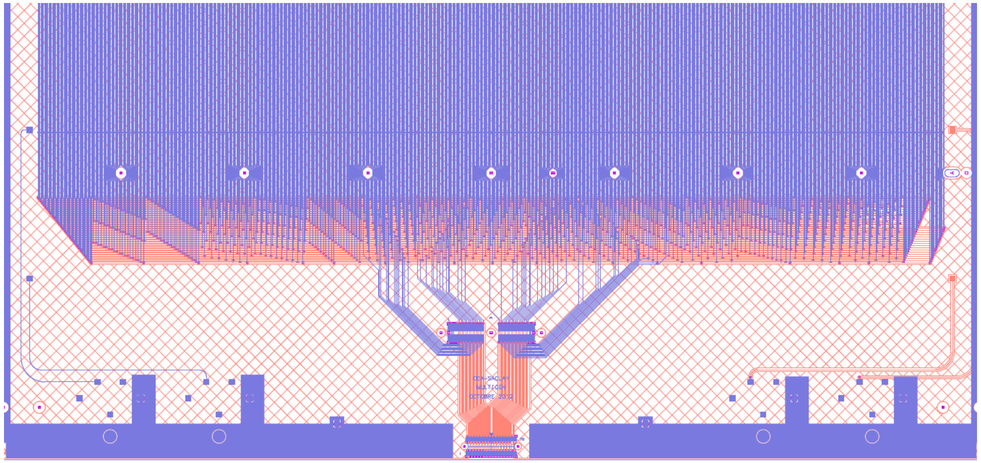
- 386 µm wide resistive strips (1MΩ/□) along Y





Multigen detector

- Genetic “multiplexling”
  - (Procureur et al, NIM A 729 (2013) 888)
  - 1024 strip → 61 readout channels
    - ~17 strips connected together.
    - 50 x 50 cm^2 coverage with 122 channels !



However

- Very large capacitance
  - Sensitive to outside noise
  - Cross-talks between channels
  - “Common noise subtraction” needed
- Somewhat complicate pattern recognition
  - Connections are optimized so that three fired channels uniquely defines three possible adjacent strips.
  - Need to test all possibilities to find physical clusters of hits
  - Any mistake in channel mapping kills reconstruction

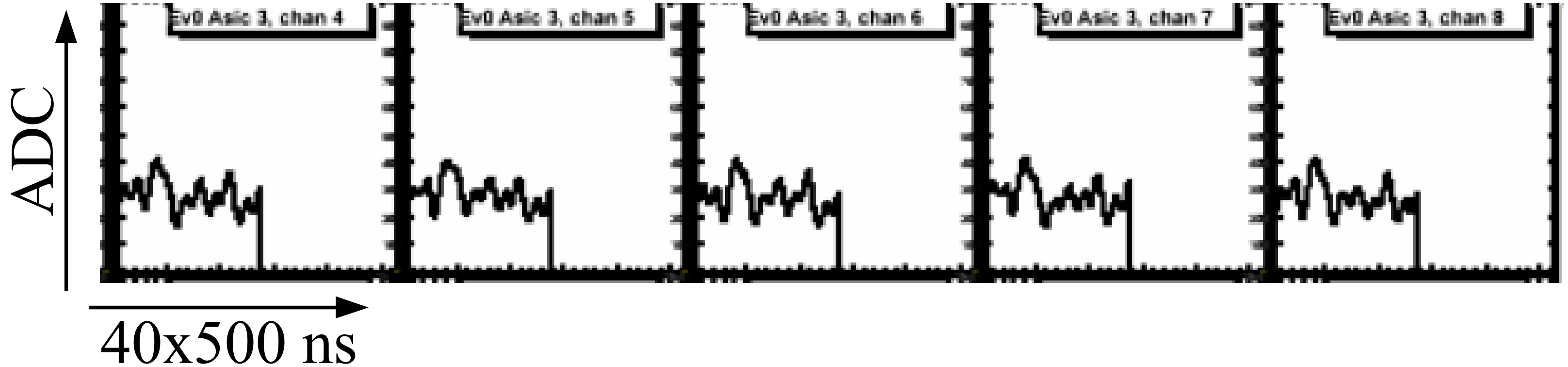
We had to fight against the two difficulties in the last months to be able to see muon tracks

Noise in Hodoscope

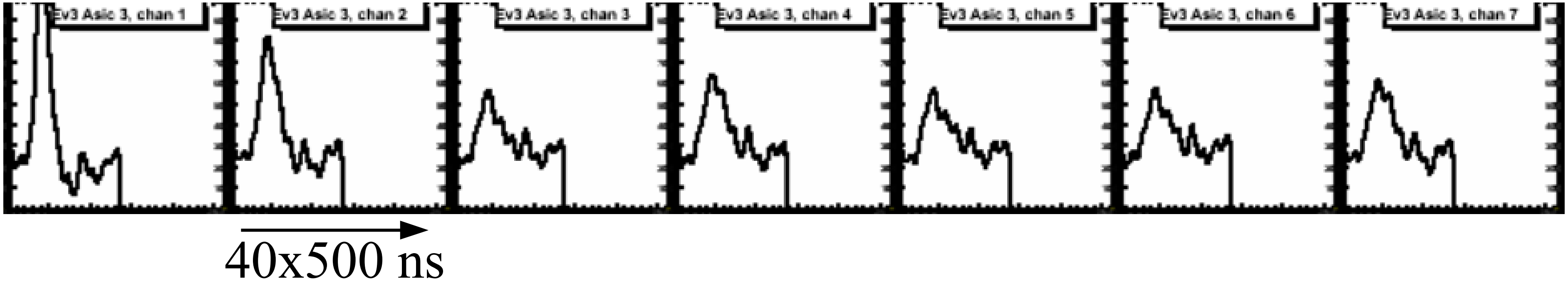
Struggled against noise in Hodoscope for a while

Two kind of noises:

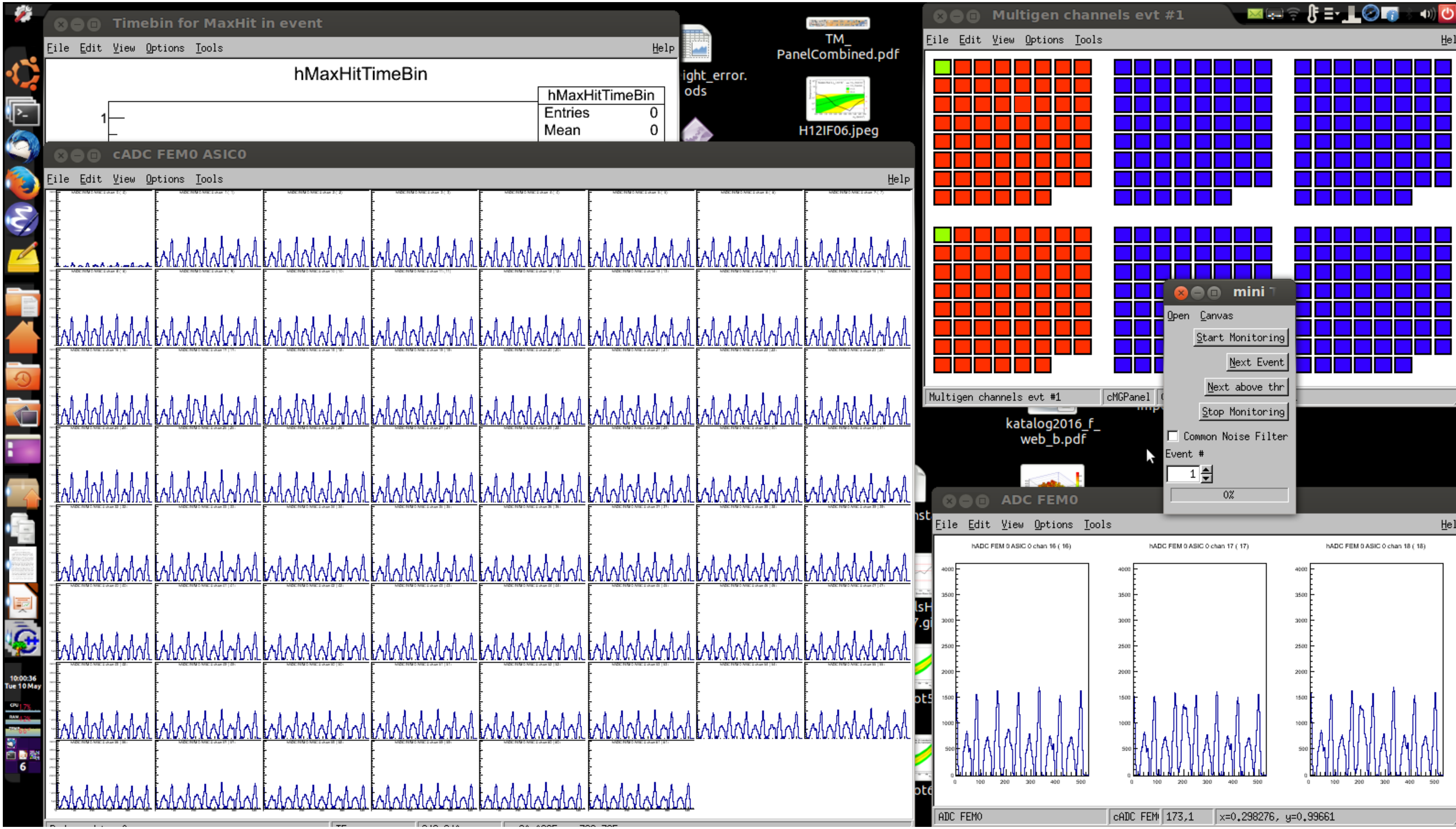
- Common noise due to external source
  - Seen in all strips of a given ASIC
  - Reduced with proper grounding.



- Auto-correlated noise due to the signal itself = cross-talk
  - Seen in all strips of a given ASIC

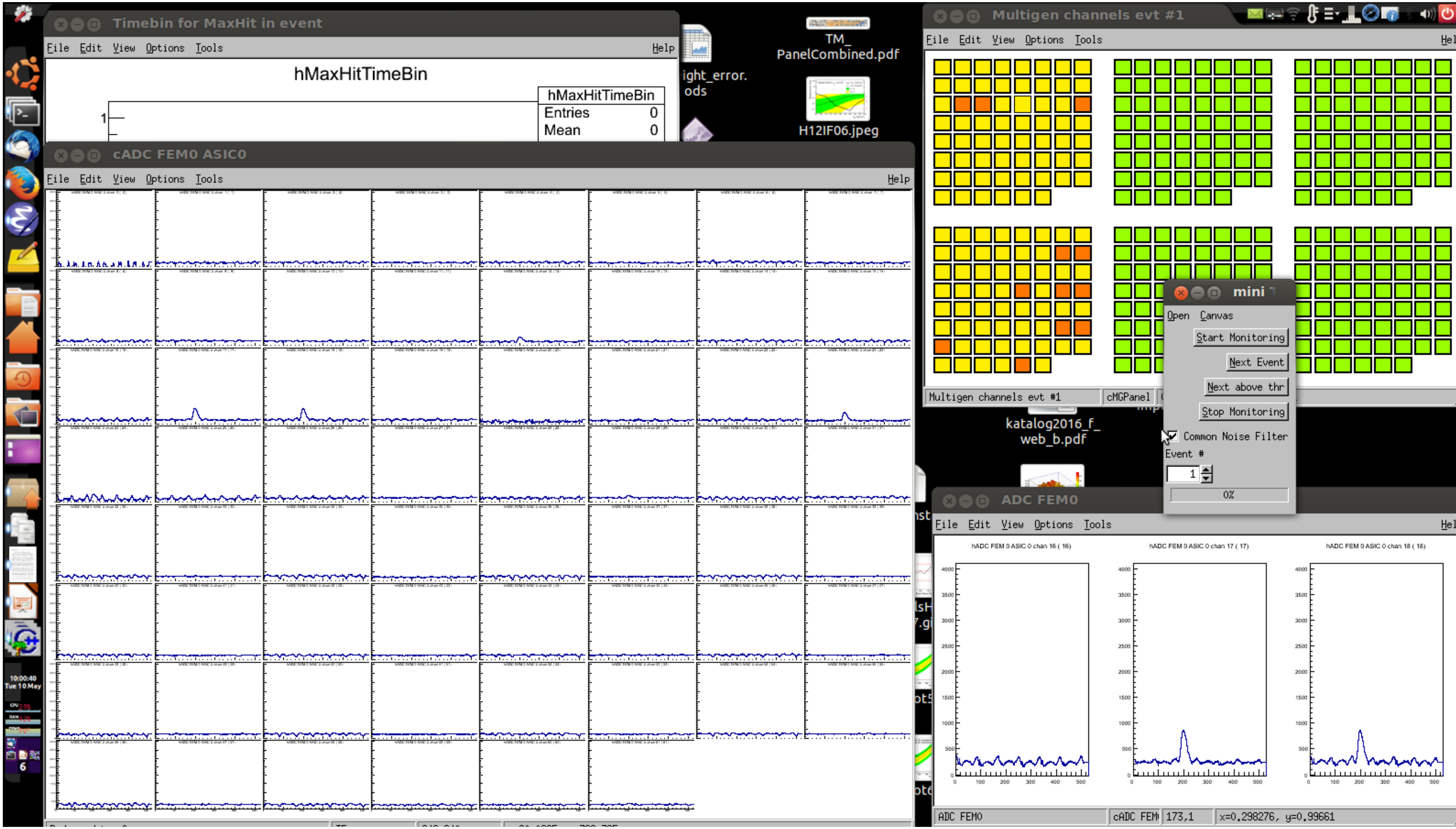


Display of some Nov15 data (very noisy) 1/2



61 histograms corresponding to top left red squares (click with middle button)
3 histograms of selected channels (left button click on selected channel)

Display of some Nov15 data (very noisy) 2/2



61 histograms corresponding to top left group of yellow&orange squares
Now we see the physical muon hits, using common noise subtraction

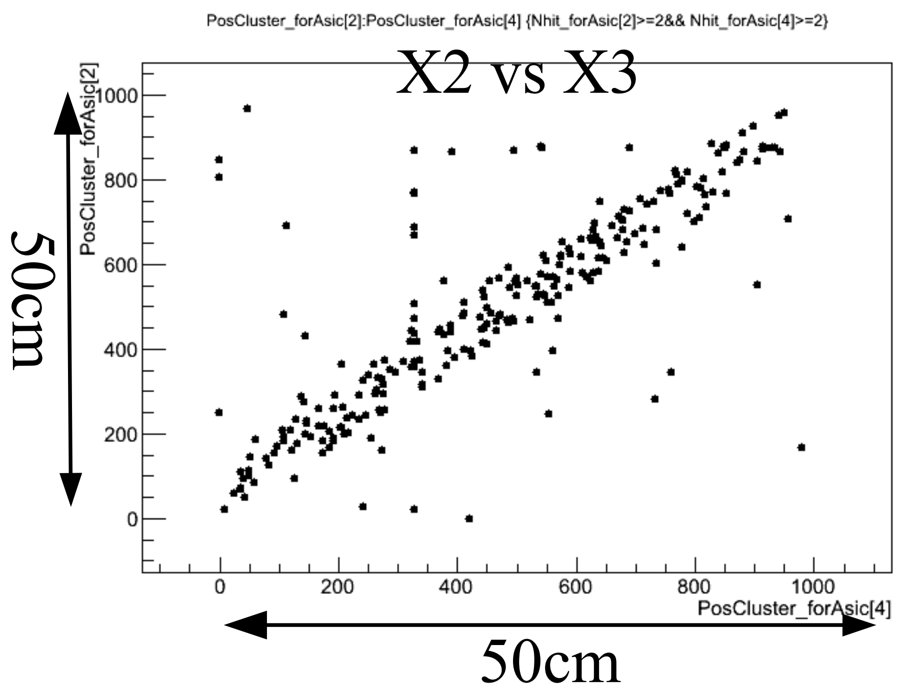
Cluster positions using correct mapping

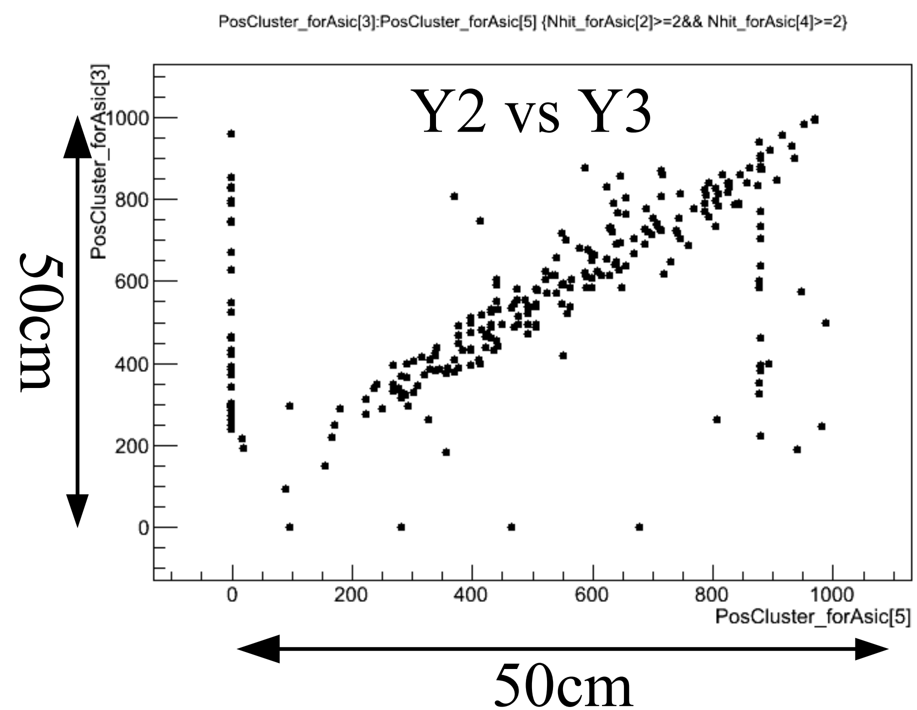
- Cluster size:
  - ~5 hits layer X
  - ~10 hits layer Y (due to resistive strip)
- Layer 2 and 3 are very close (~20cm)
  - So X at layer 2 ("X2") and X at layer 3 ("X3") should be within ~10cm
  - Y2 and Y3 should be within 10cm as well
  - NB: chambers aligned at the ~5cm level here !!

Layer 1

Layer 2

Layer 3



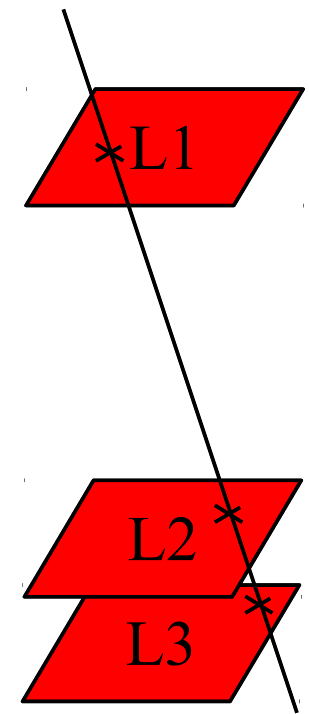


Dec15 data

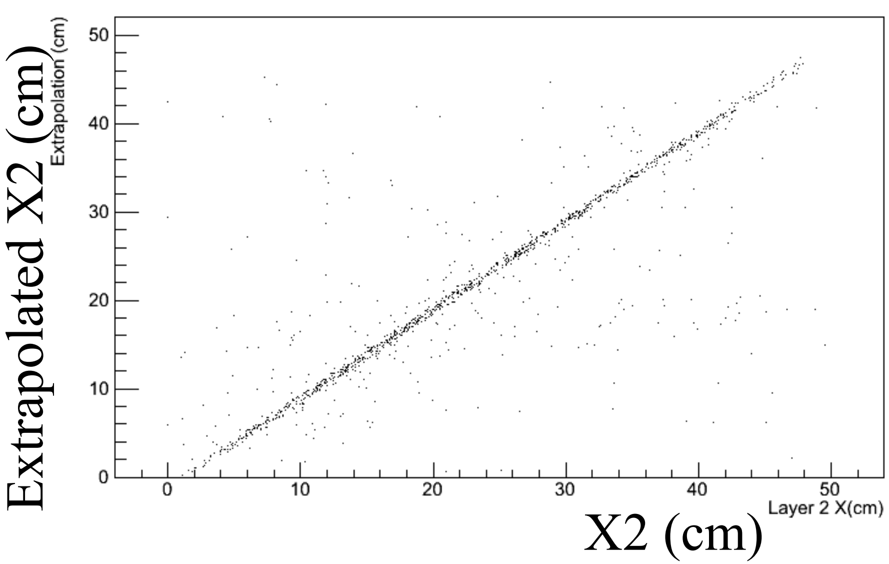
Alignment with tracks(1/2)

- Use position of hits reconstructed at Layer 1 and 3.
- Extrapolate to Layer 2, Compare with hits at Layer 2
- Build chi2

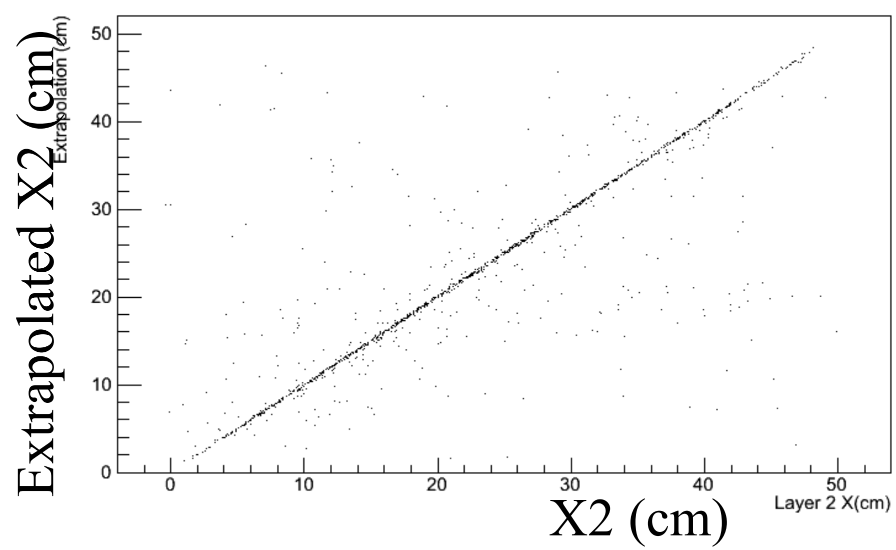
  Chi2 minimization with seven parameters:
  - rotation of L2 and L3 relative to vertical axis
  - translation in X,Y of L2, L3
  - relative position along vertical axis, of L2



Before aligment



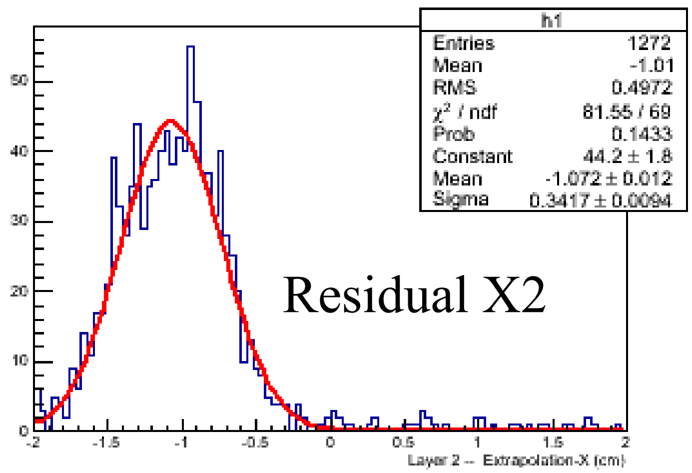
After alignment

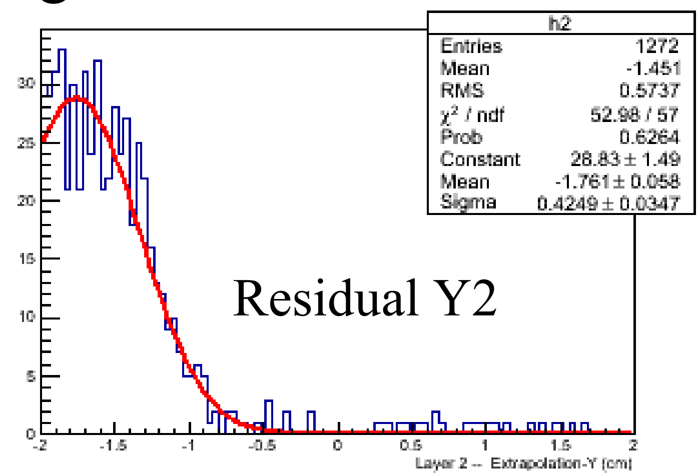


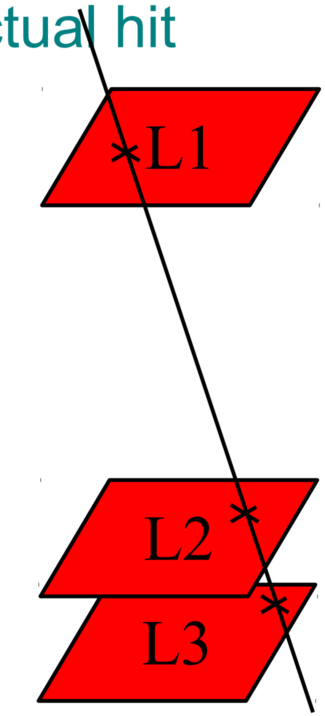
Alignment with tracks(2/2)

- Look at residuals (difference between extrapolation and actual hit position)

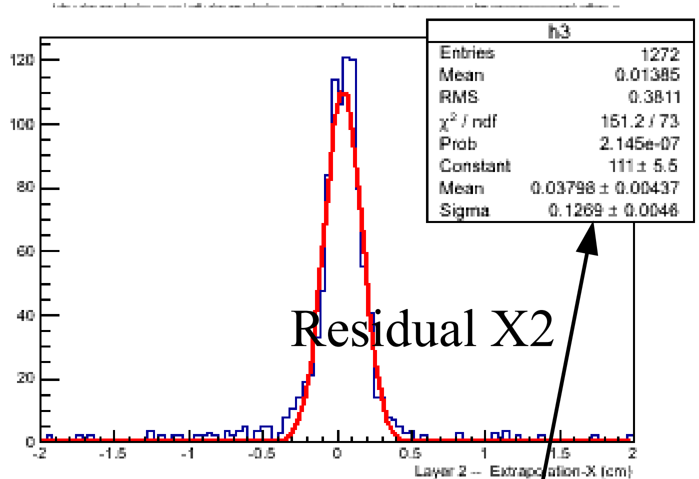
Before aligment

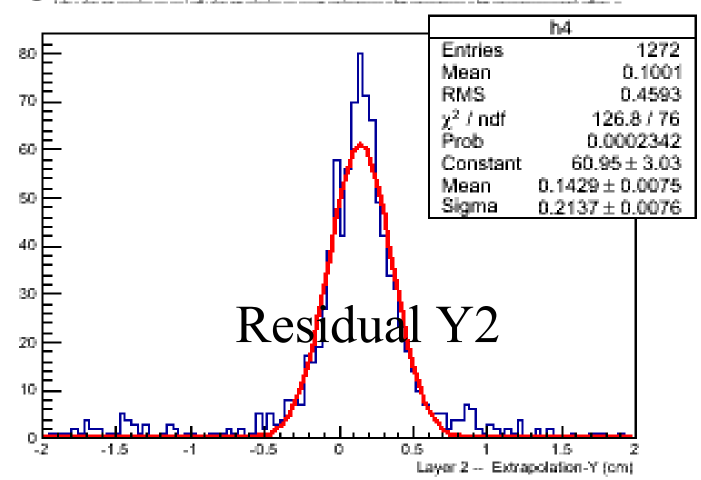






After aligment



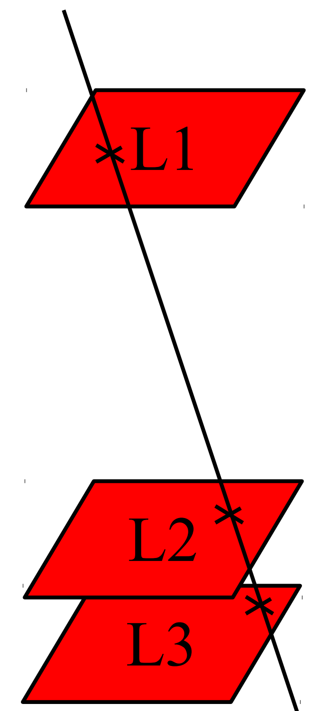


X2 (cm)

Individual hit resolution ~950 μm
(should be angle dependent)

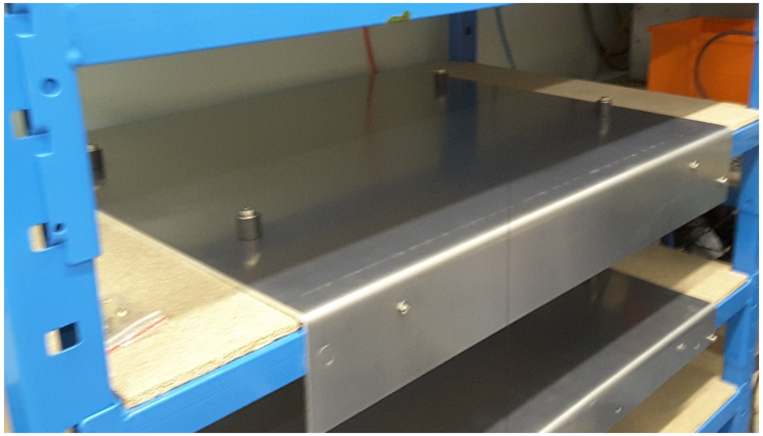
Conclusion hodoscope

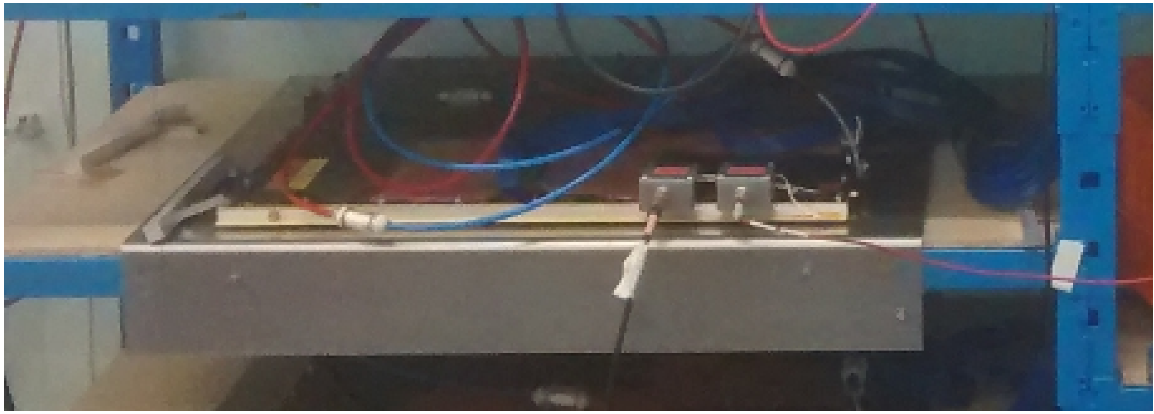
- With noise filtering, right mapping and cluster finding, we are able to reconstruct muon tracks
- Need to study resolution, efficiency, artifacts, noise, etc....
- Need now to optimize definition of hit, threshold, etc.. and also the cluster reconstruction algorithm.



Recent improvements (Oct 16)

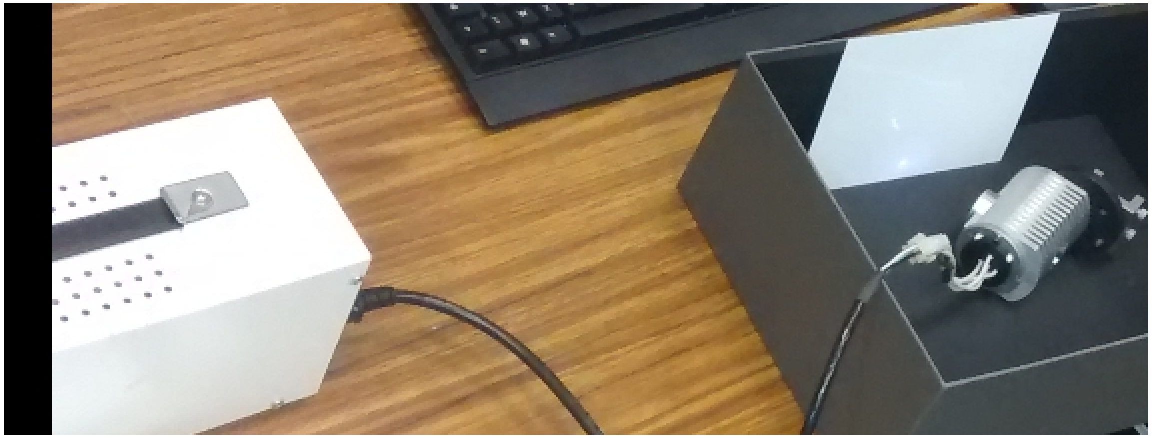
- Multigen modules are now fixed on the rack, and aligned at the millimeter level.

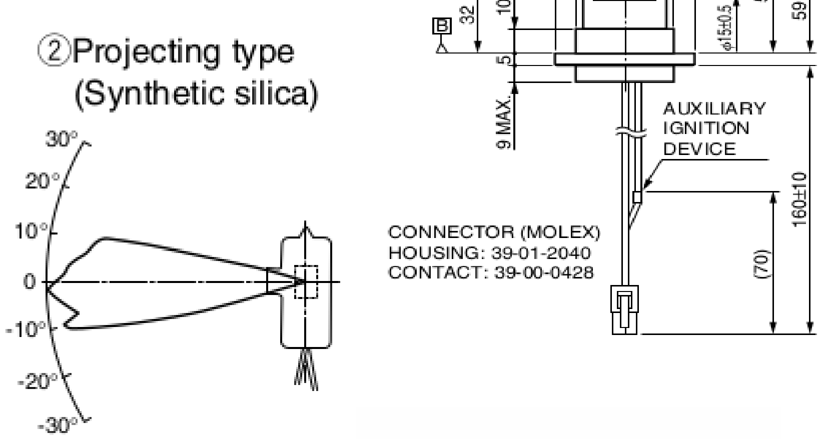




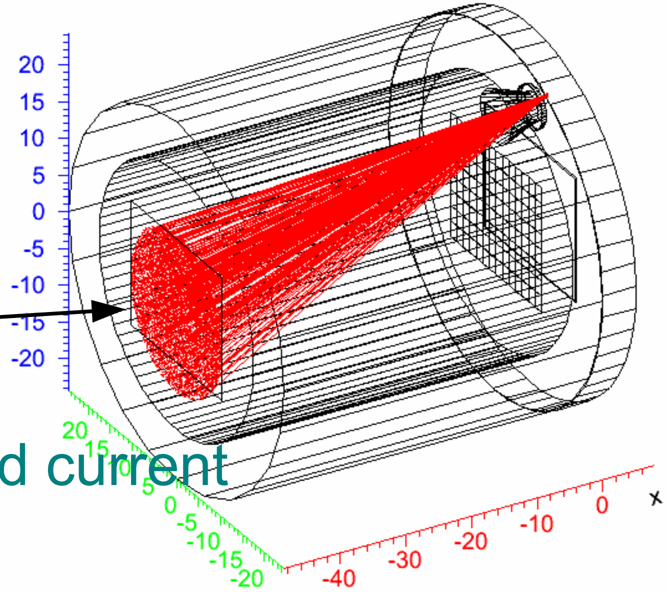
UV lamp

Tested UV lamps borrowed to Alan Peyaud
Hamamatsu X2D2 Hamamatsu L10904
http://www.hamamatsu.com/jp/en/L10904.html





- Paul had a look at the lamp
  - His idea: no blinking shutter required
  - Continuous (attenuated mode should be ok)
- First tests: UV beam seem to be narrow
  - 20° cone if specs correctly understood
  - 20° starts beeing small
  - To be confirmed.
- Now should send light in TPC and see induced current



Status and todo (1/2)

Many things to develop and test

- TPC
  - Improve gas cleaning
  - Optimize working point (Micromegas gain, gas mixture)
- Multigen Hodoscope
  - Optimize working point (gain) and reduce external noise level
  - Need to study resolution, efficiency, artifacts, noise, etc....
  - Optimize definition of hit, threshold, etc.. and also the cluster reconstruction algorithm.
- UV light
  - Need to be commissioned and tested
  - Design system to control flux

Status and todo (2/2)

- DAQ, read-out, slow control
    - DAQ monitoring recently improved to include Hodoscope and noise suppression
        - Still need a few improvements (eg add Hodoscope track reconstruction)
    - Need to solve issue with backend electronics to read-out TPC pads and hodoscope simultaneously. Right now, DAQ software randomly crashes freezes after ~100 events.
    - May need to make HV dependent upon (temperature, pressure) for constant gain
    - Philippe wants to also record trigger signal
- Software
    - Software development to integrate hodoscope+TPC.
    - Software for optimized track reconstruction in TPC
        - account for individual « pad response function »
- Manpower
    - Trying to hire Post-doc and Students for 2017

Old and backup

Common noise subtraction

- Common noise subtraction technique seems to work to remove signal-induced noise. X-layer

before subtraction
after