The Carleton EUDET Telescope: Cosmic Ray Studies and Fermilab Testbeam Experiences

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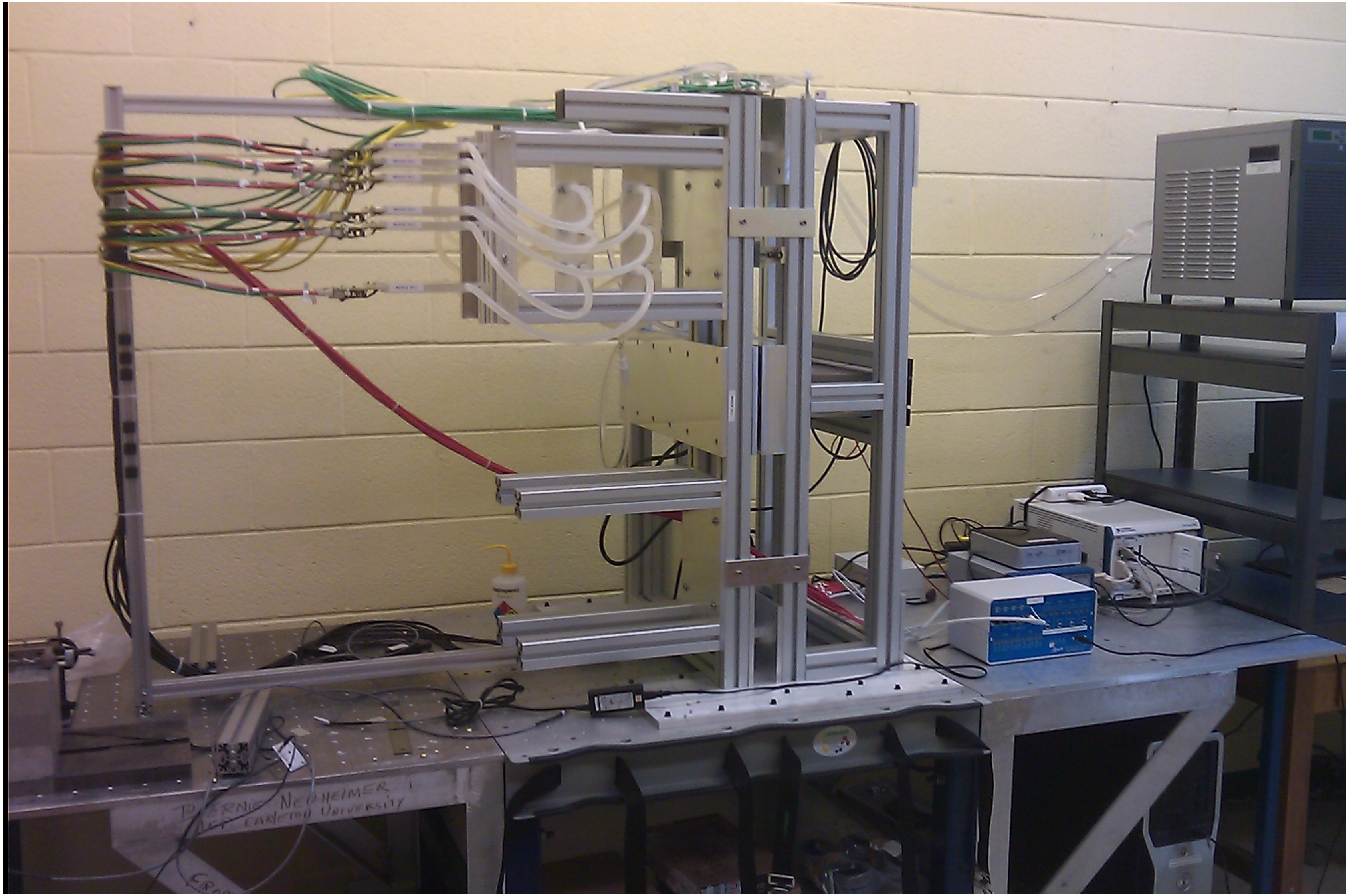
Talk ToC

- Changes required for use at Carleton
- Learning curve with cosmic ray muons
- ATLAS sTGC DAQ integration
- Fermilab test beam, May 2014
- Ongoing analysis tools development
- Upcoming applications
- Remaining questions

The Caladium Installation

- Basic setup and test went smoothly with the help of Hanno Perry on site
- Carleton does not have an accelerator
  - Telescope was remounted vertically to be used with cosmic ray muons (4GeV avg)
  - Planes mounted as close as possible and 15mm x 25mm scintillators were used to maximize solid acceptance angle
  - Intention to be used as integration platform in advance of a testbeam

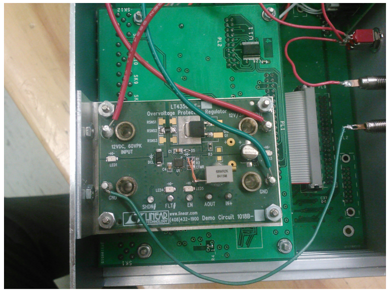
Initial Configuration

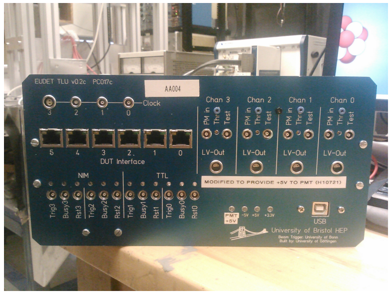


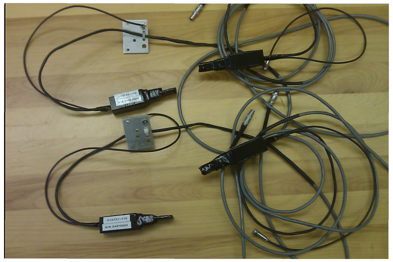
Commissioning Issues

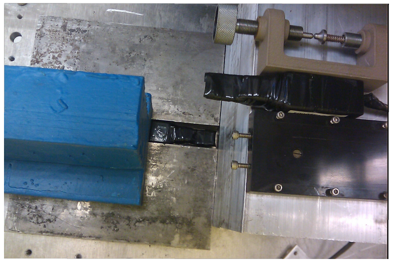
- Many TLU and EUDAQ mods were needed to use available PMTs
- Cooling system flow resistance issues
- Lack of HW and SW docs, simulations?
- Isolation from EUDET community has made it difficult to get answers
- Evolving EUDAQ frameworks have made it difficult to coordinate changes
- EUTelescope cannot use muon data?

TLU Modifications







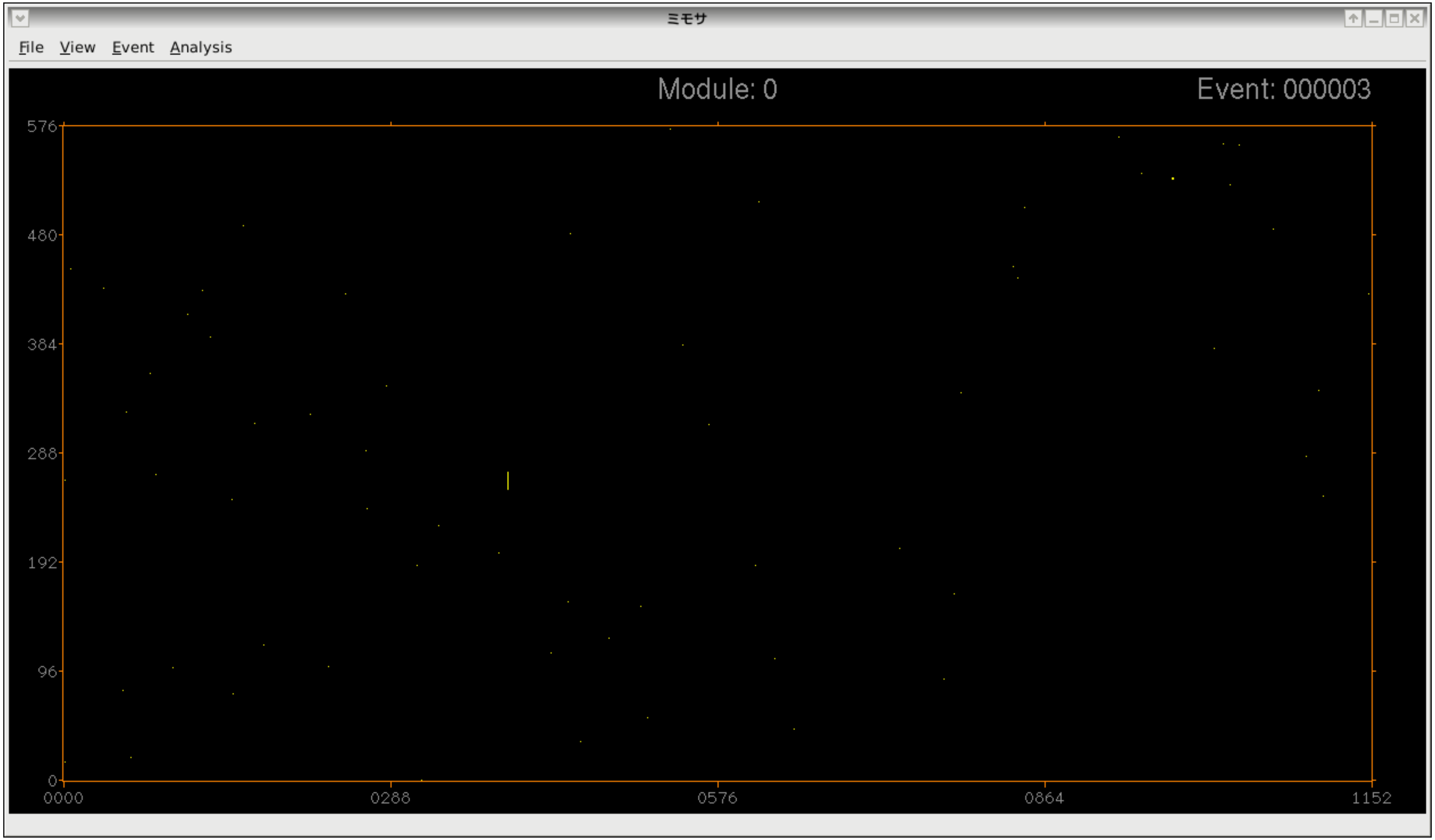


- PMT Power Supply: Modified to step +3.3V to +5V instead of +15V for Hamamatsu model H10721-110
- Added PMT Power overvoltage/current protection circuit (LT4356-3 using DC1018B-C circuit) after report of destroyed PMTs on Aconite (root cause unknown)
- Aconite issue also prompted us to add an external PSU input for PMT Power: internal/external switchable
- PMT Control Voltage: 0.0V to +2.0V (vs. 0.0V to +1.0V) – internal switch selectable
- Added support in EUDAQ to allow the control voltages to be set independently for each PMT (and for +1.0V vs. +2.0V max. operation) rather than all set to 0.8V
- Added gain and offset error compensation for control voltage DACs (provided spreadsheet to calculate)
- Added support to ramp up control voltages to prevent triggering of overcurrent protection circuit (not yet folded into latest EUDAQ)
- Added external monitoring pins to allow the thresholds of the four individual discriminators in the TLU to be measured without having to remove the unit’s cover
- Added straps to secure TLU power brick cable to TLU power input connector (could be pulled out)

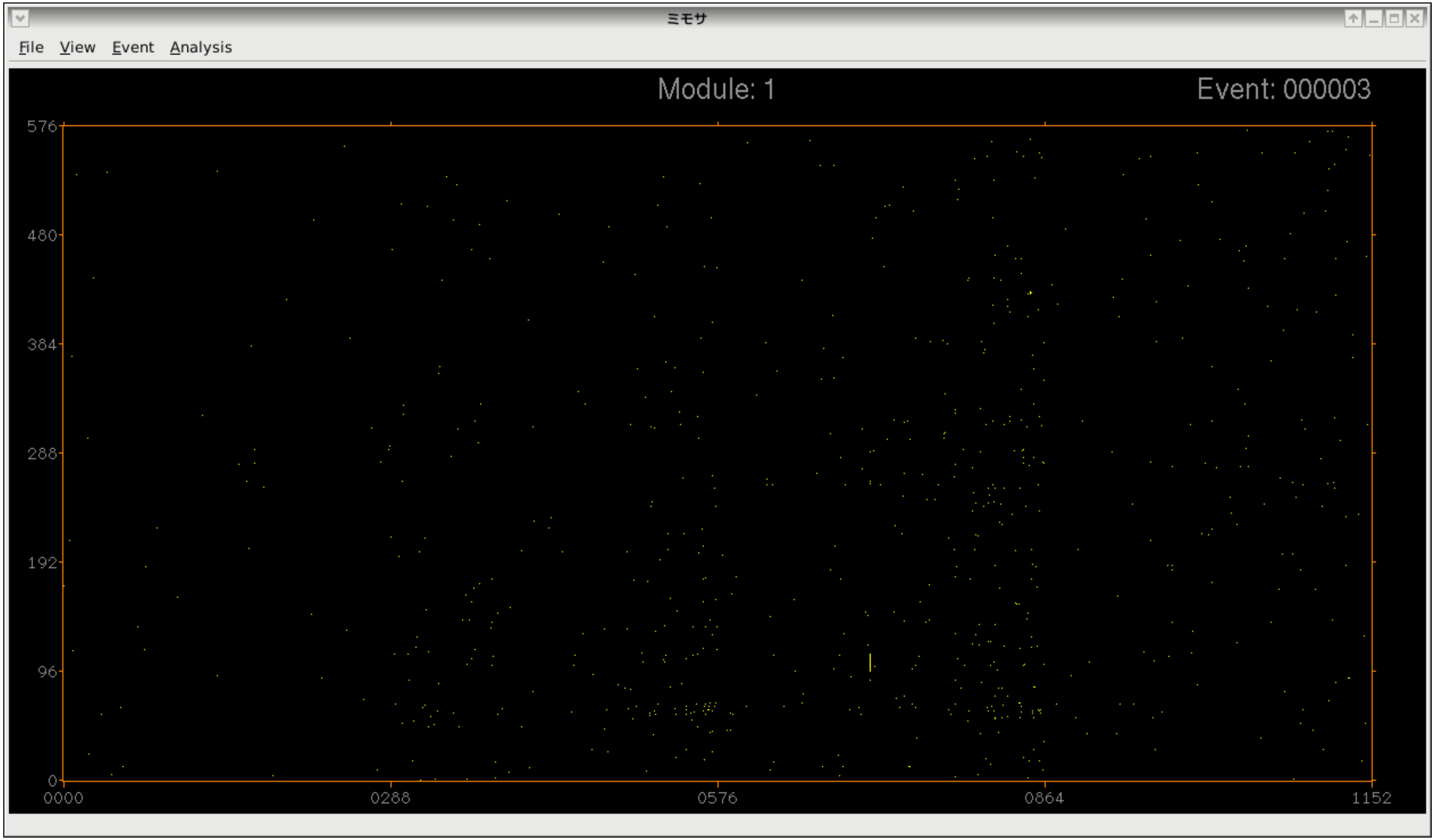
The Mystery of the Invisible Muons

- Verified we were triggering PMTs on cosmic ray muons, and could "see" Co-60 sources using autotrigger, but we "saw" no muons
- Conclusion (in MIMOSA): $-\Delta E$ (4GeV e^-) ≈ 563keV, and $-\Delta E$ (4GeV μ) ≈ 6.7keV
- We lowered discriminator thresholds considerably (noisy!), but using Mikhail's new visualization tool: muons for the first time!
- *Bonus:* Ru-106 sources can be used as "muon analogues" for single planes: $-\Delta E$ (3.5MeV e^-) ≈ 5.0keV, and $-\Delta E$ (1.44MeV e^-) ≈ 4.8keV
- Critical learning step leading up to Fermilab!

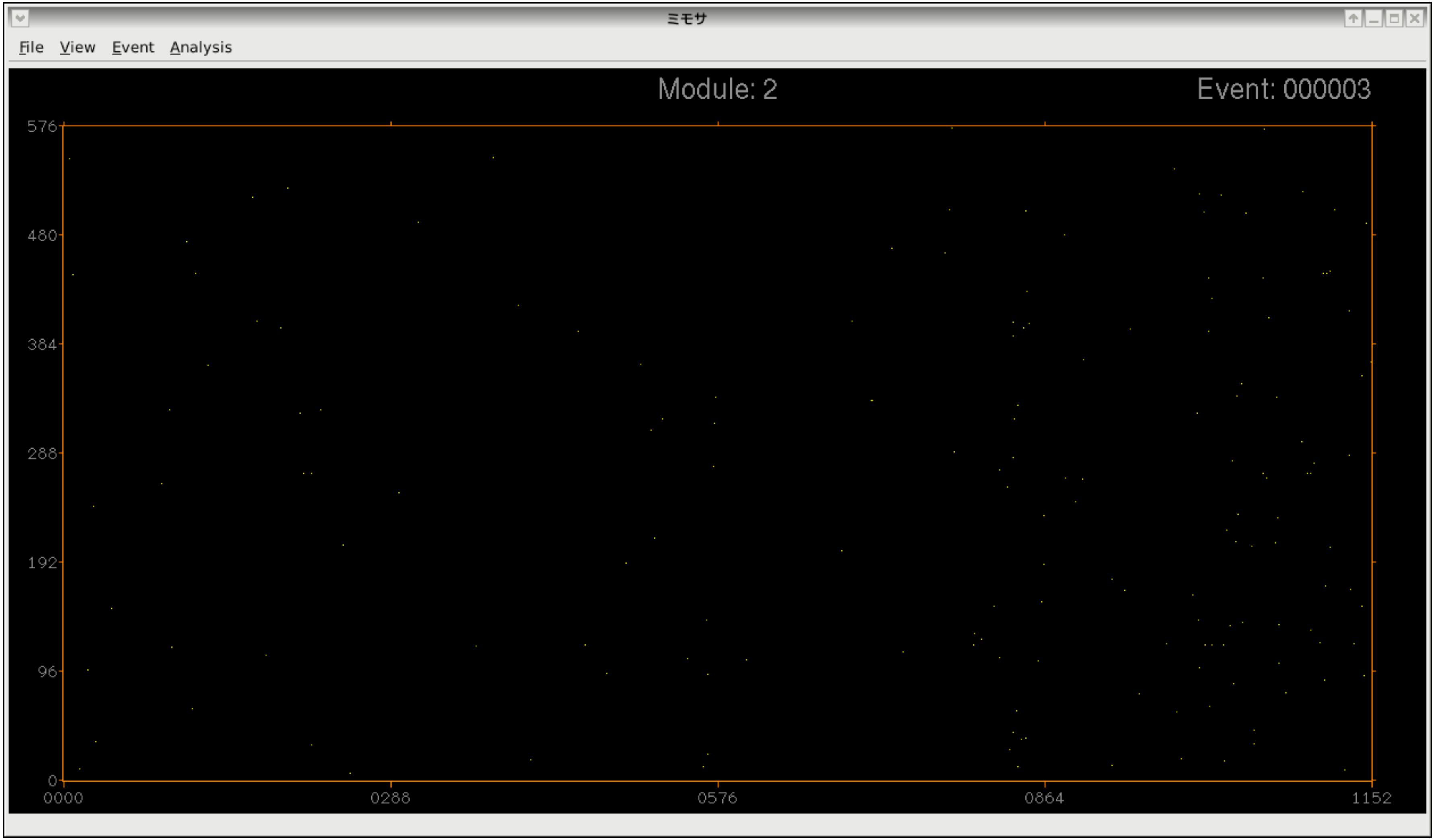
Spot The Muon? Plane 0



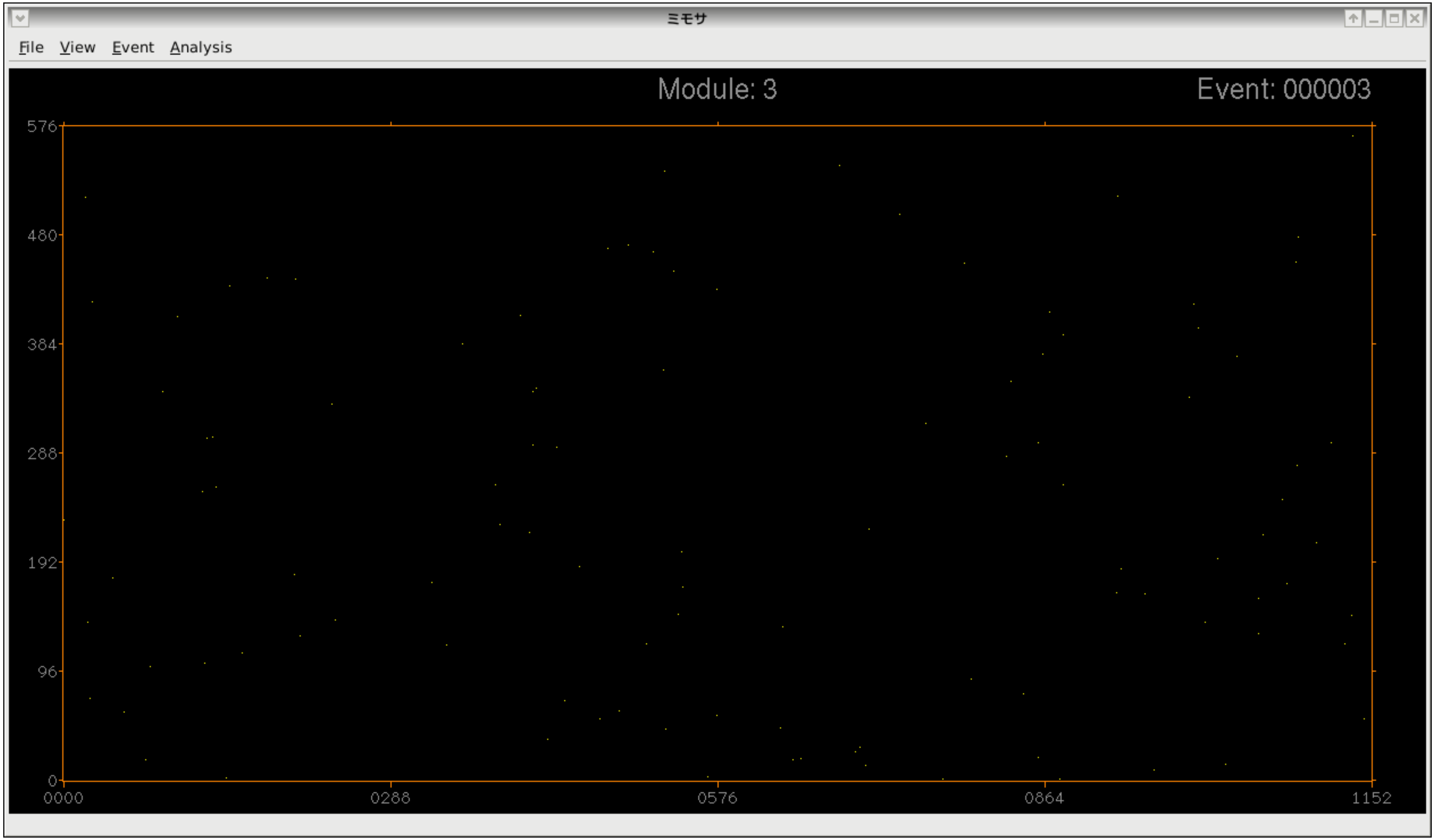
Spot The Muon? Plane 1



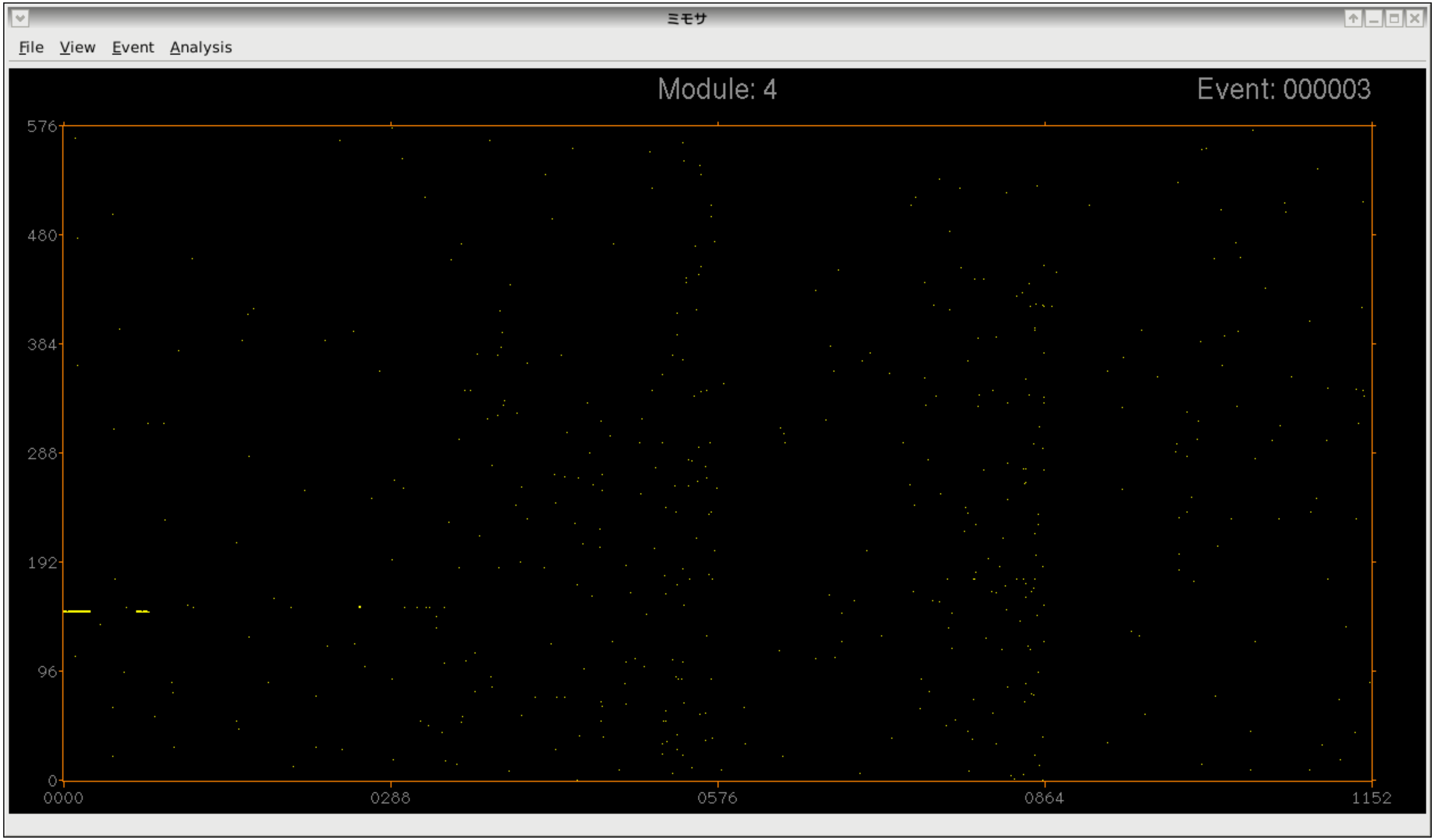
Spot The Muon? Plane 2



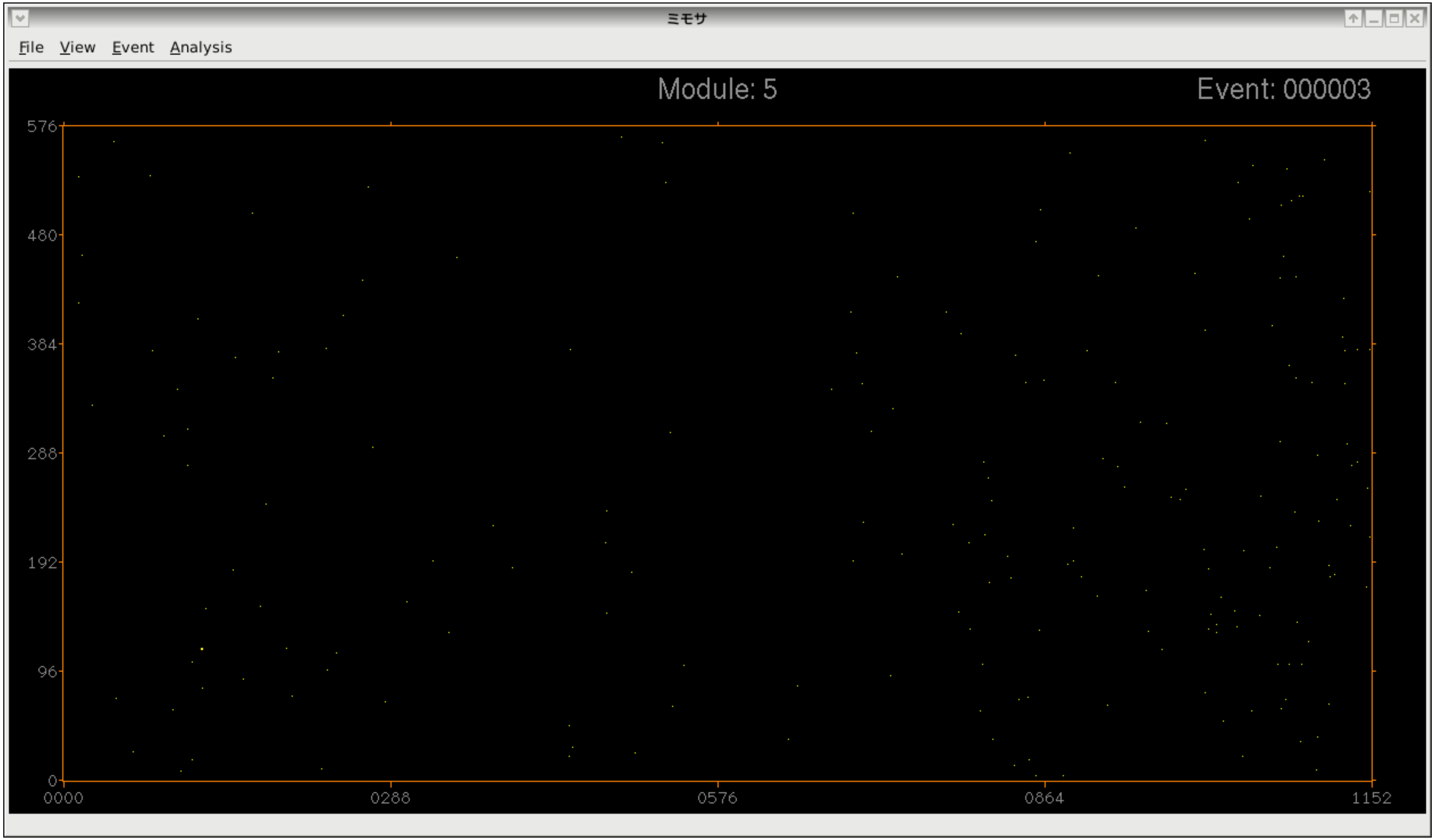
Spot The Muon? Plane 3



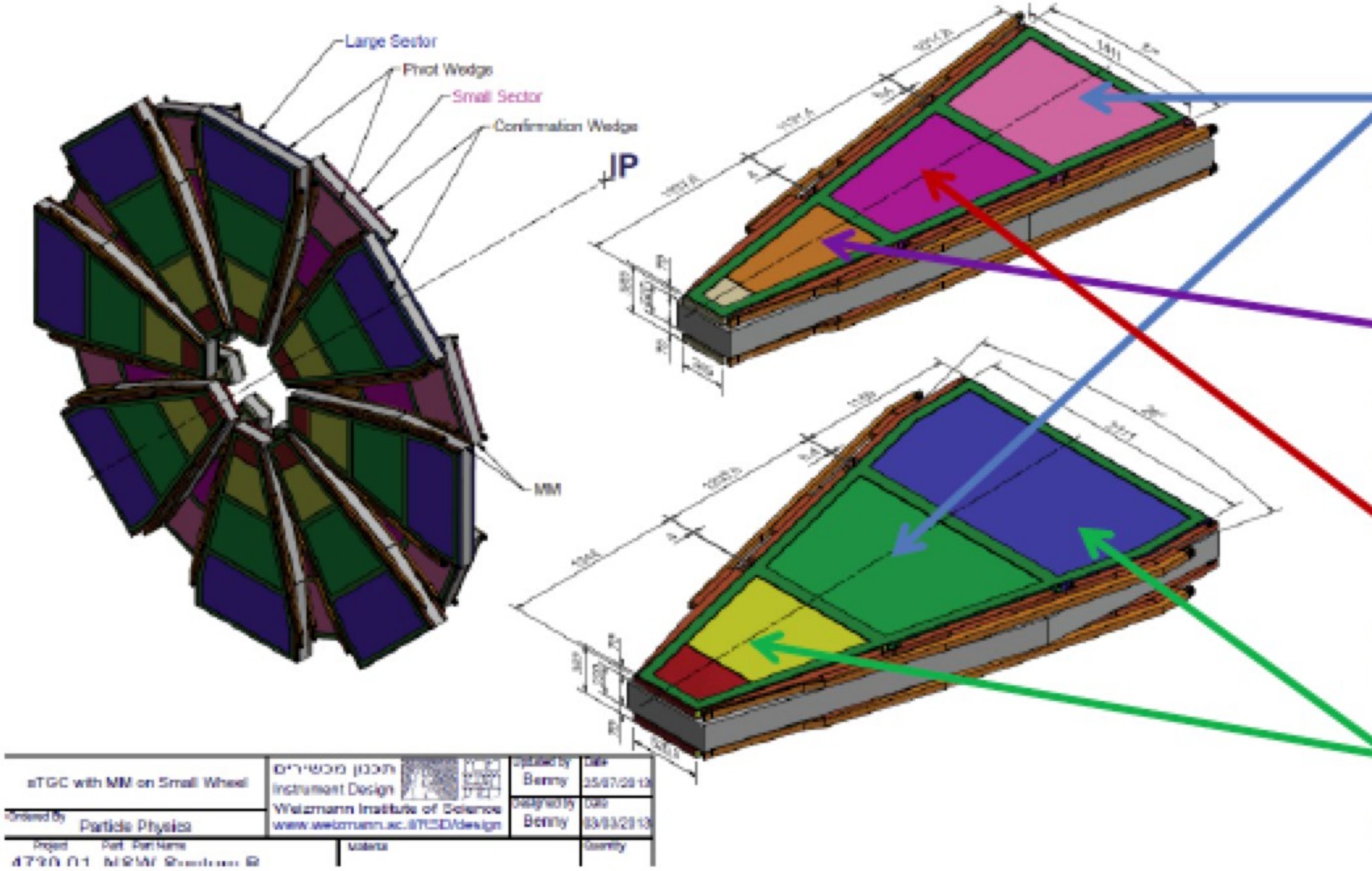
Spot The Muon? Plane 4



Spot The Muon? Plane 5



sTGC for ATLAS New Small Wheel



- Canada

64 quadruplets +
6 spares

- Chile

32 quadruplets +
3 spares

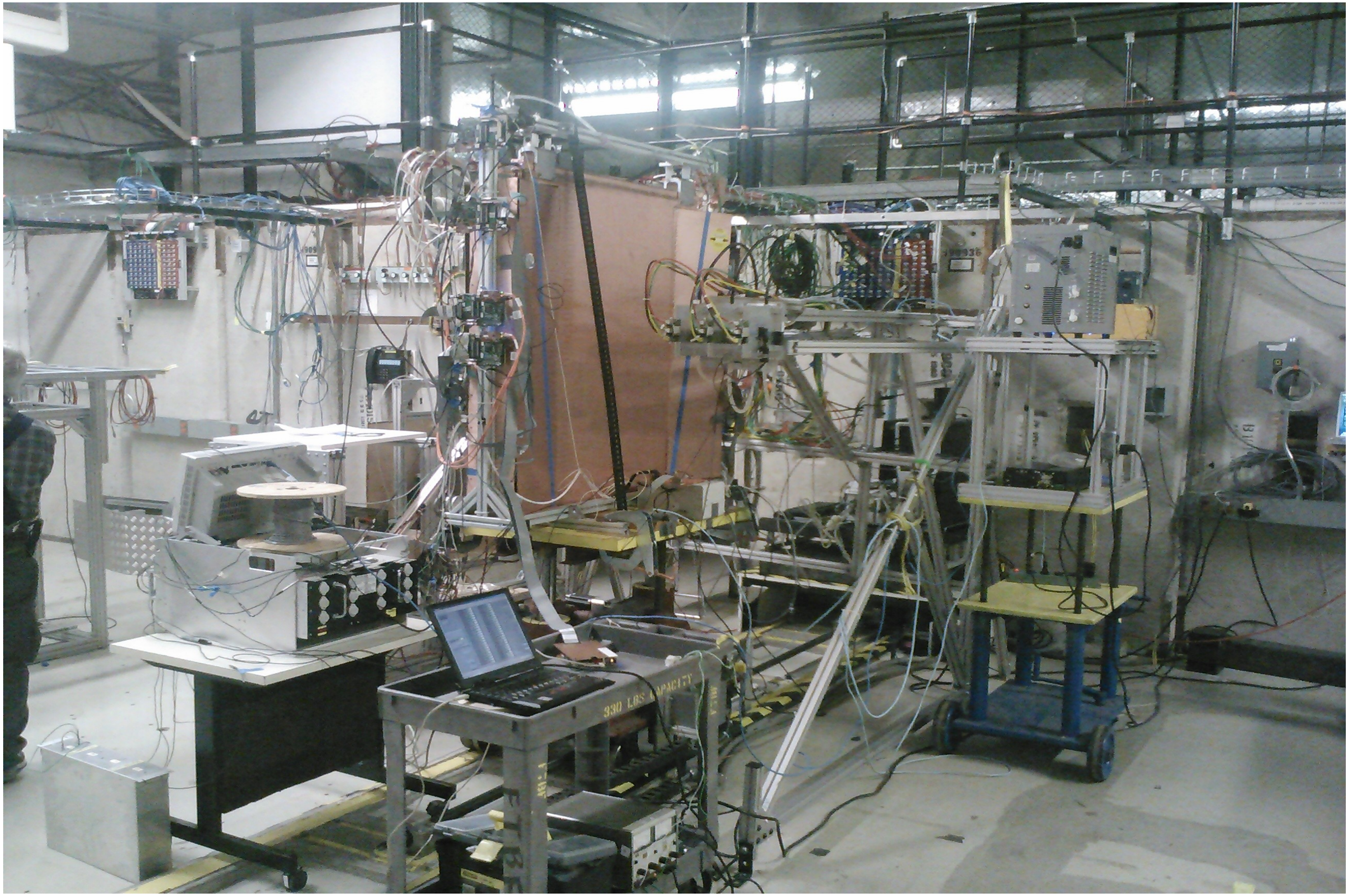
- China

32 quadruplets +
3 spares

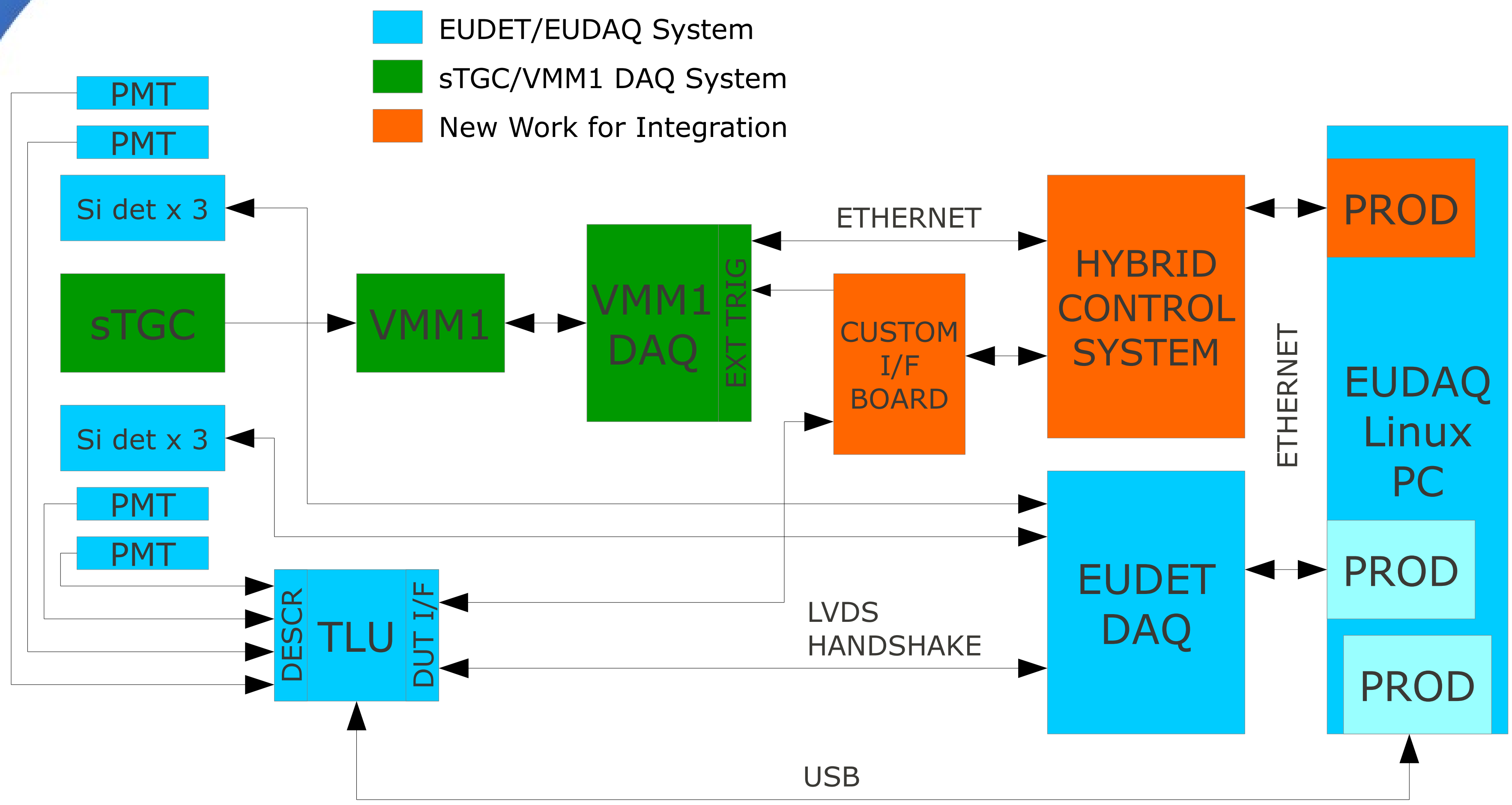
- Israel

64 quadruplets +
6 spares

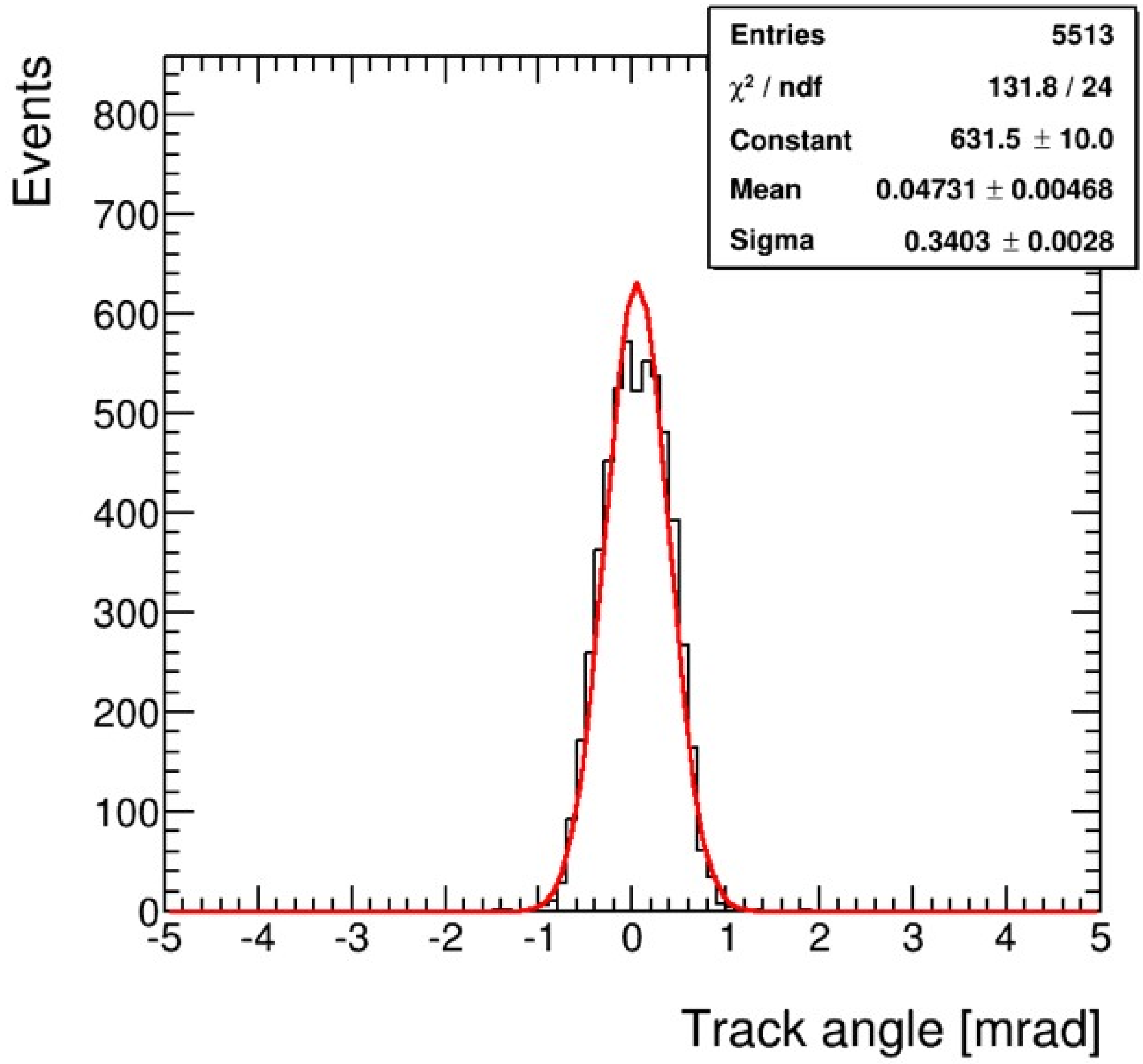
Fermilab Configuration



Integrating the sTGC Electronics

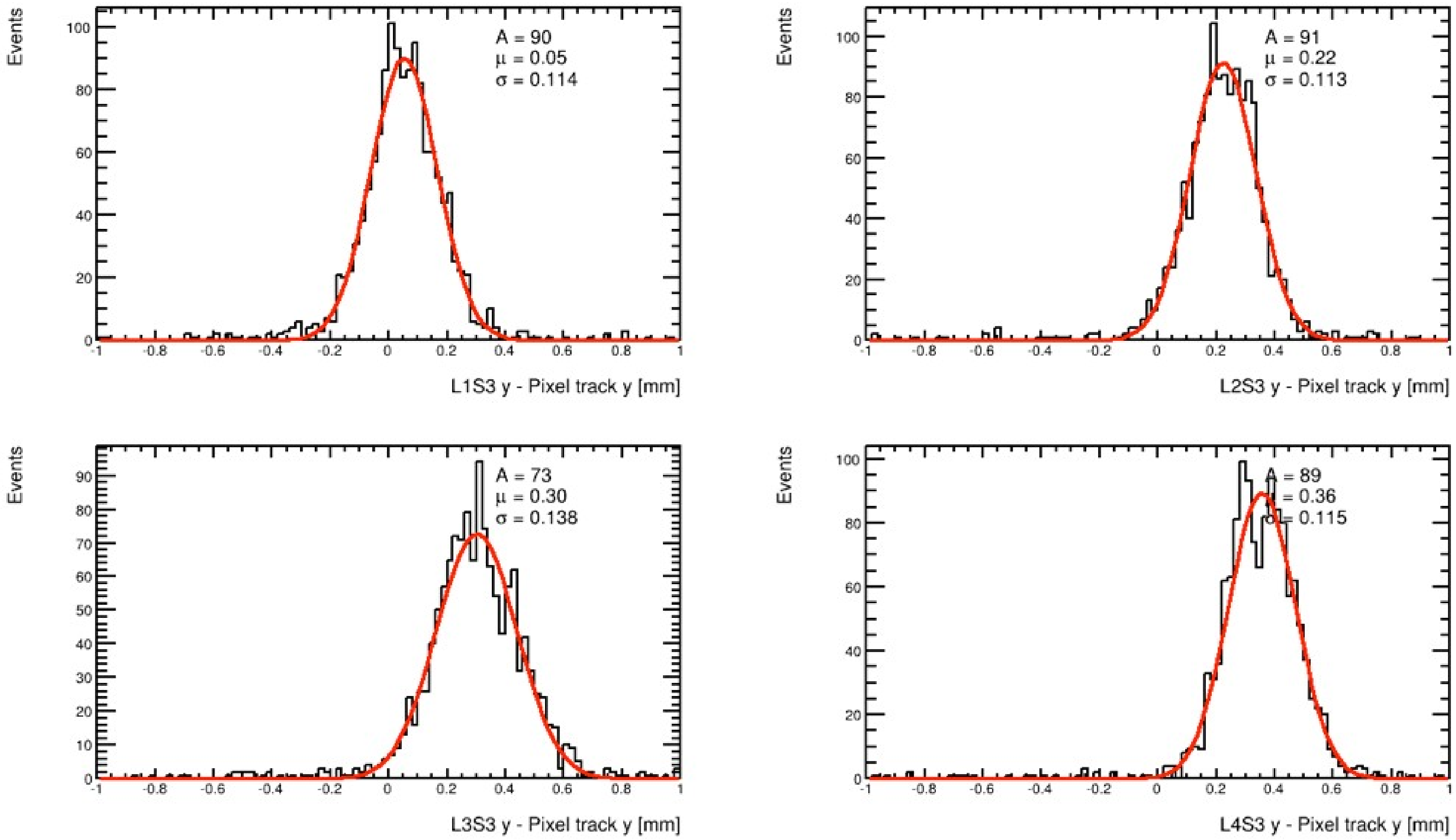


Multiple Scattering in sTGC



EUDET + sTGC Data Analysis

Not corrected for multiple scattering and relative alignment of the EUDET wrt sTGC!



Mikhail Batygov: Toolsmith

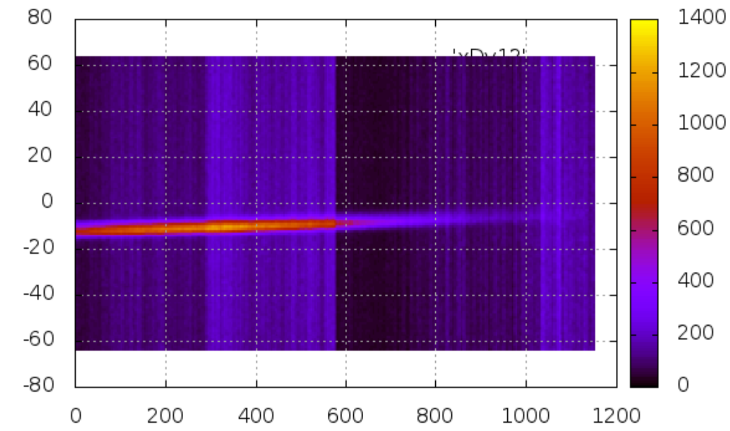
- Prompted by issues with detecting muons, he developed a package that allows raw events to be viewed
- A new fast standalone clusterizer was written for muons – critical at Fermilab when a large fraction of isolated pixels were legitimate single clusters
- An integrated standalone analysis package was then built after Fermilab to validate alignment and to plot beam

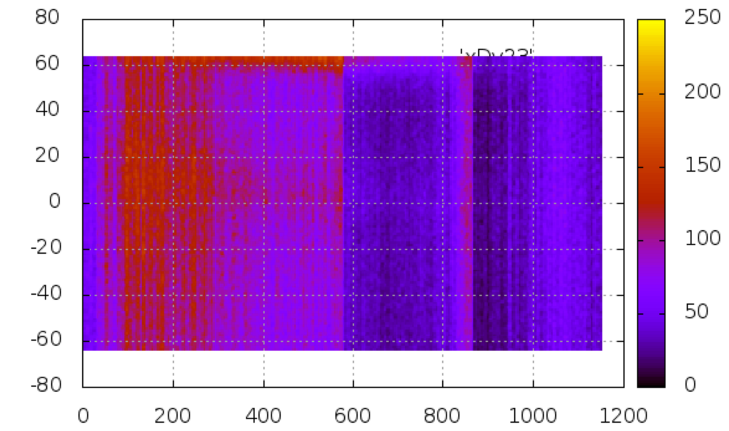
Clusterizer

- Easily switched between “cross-only" (4 neighbours), “full square" (8 neighbours), and more permissive or exotic selection criteria
- “Breadth-First" exhaustive active pixel search
- Non-recursive for robustness in worst-case
- Assigns “Cluster Number" to each active pixel
- Every isolated pixel makes a unique “cluster"
- 153370 events, 4σ thresholds (noisy!), EUtel: 4m49.3s, Carleton’s: (full square): 3.4s

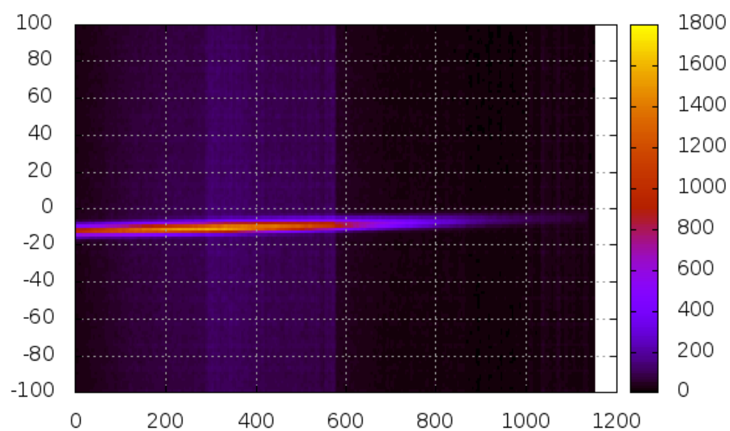
Noisy Plots to Useful Plots

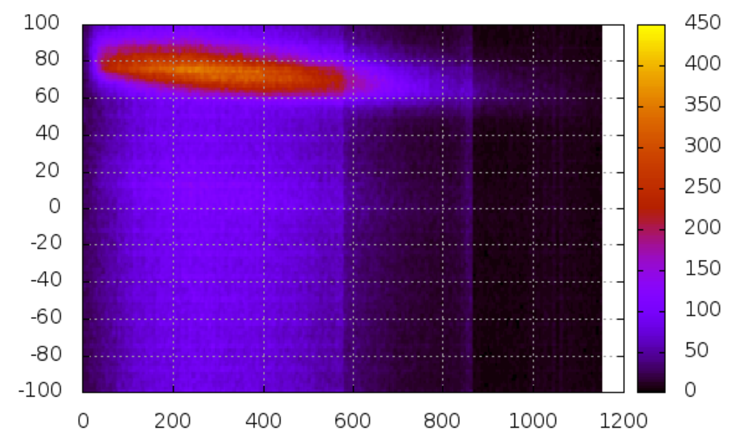
- Plots of X vs. ΔY, planes 1/2; 2/3 (1.0% noise cutoff)





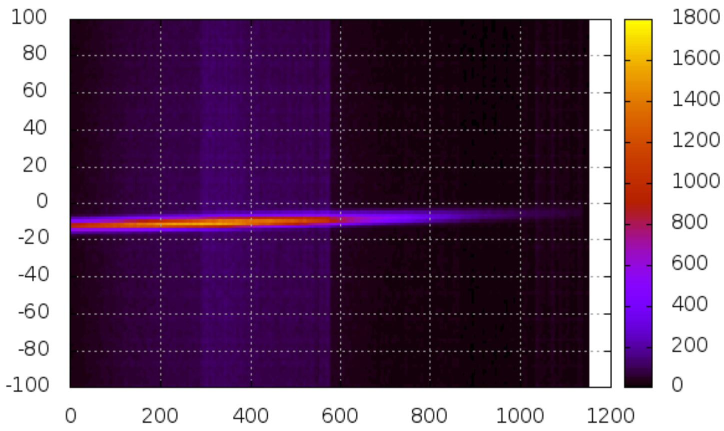
- Plots of X vs. ΔY, planes 1/2; 2/3 (0.1% noise cutoff)

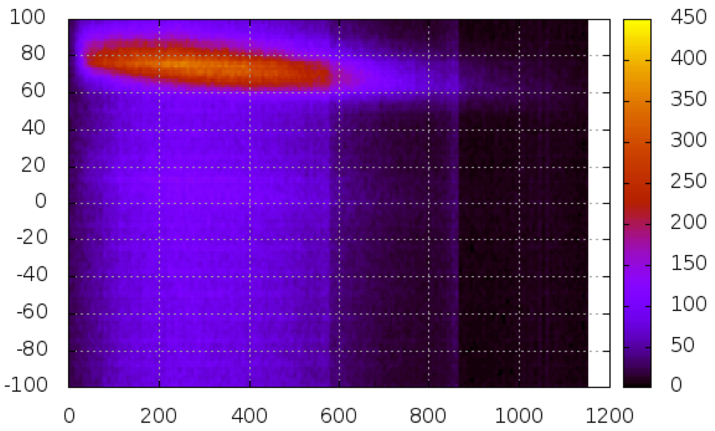




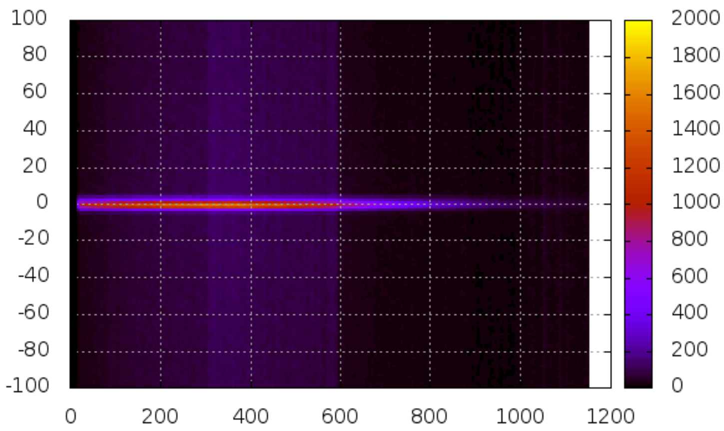
Pre vs. Post Alignment Plots

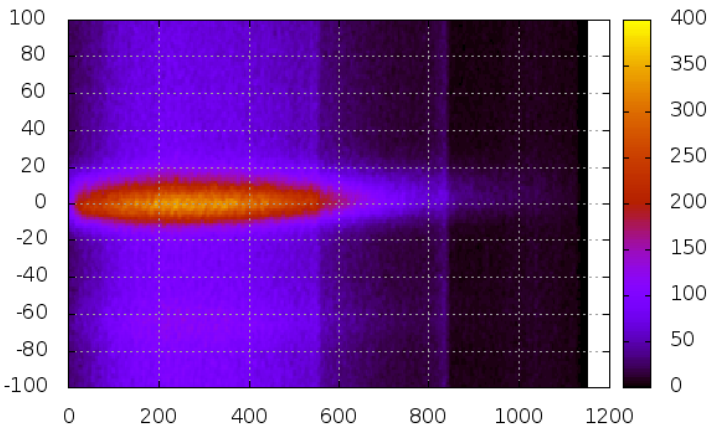
- Plots of X vs. ΔY, planes 1/2; 2/3 (pre-alignment)





- Plots of X vs. ΔY, planes 123; 2/3 (post-alignment)





Ongoing Work and Future Plans

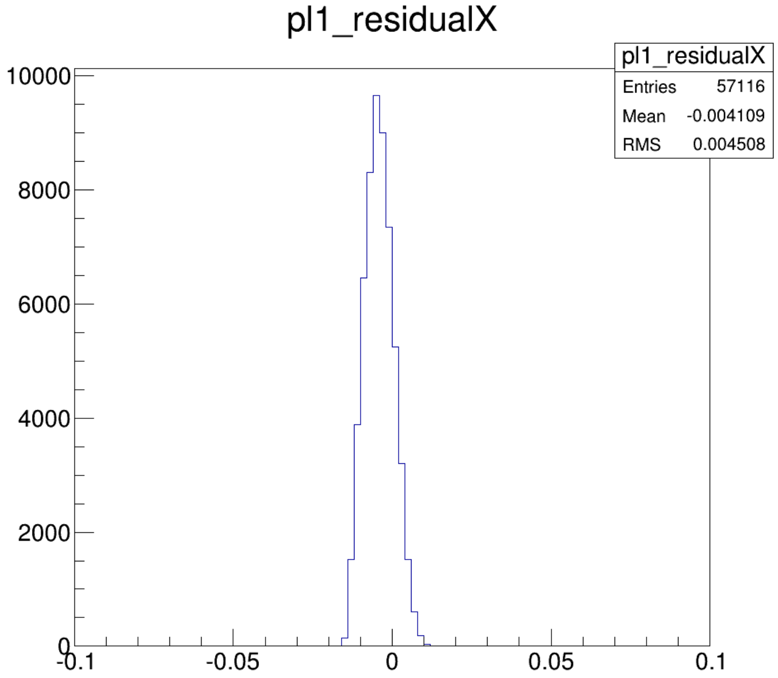
- Work will continue over the summer on incorporating a track fitter into the standalone analysis package
- Intention is to develop a tool for analyzing muon data and also a fast tool that can be used for data quality analysis at test beams or for quick
- Thomas Koffas is in discussions with SLAC to station Caladium there for a period of time for our joint use

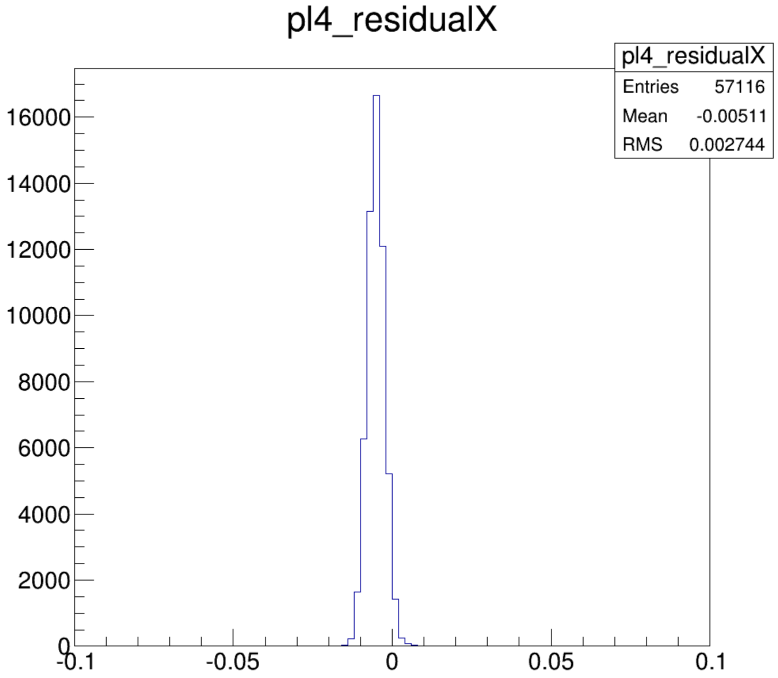
Our Remaining Questions...

- Do the TLU discriminators actually work? We have been unable to get them to function correctly (used NIM)
- Raw data format for EUDAQ docs?
- Can EUTelescope be configured to process cosmic ray muon data?
- Noisy sensors (one in particular) is giving us grief, does anyone else have this problem?
- We need to use low thresholds for all our work, how do we generate optimal threshold settings for the MIMOSA-26 chips?

And... can someone answer this?

- Given the small size of the 32GeV pion clusters (<2x2) we would expect the lower limit of the residuals to be 18µm/√12/√2 = 3.7µm
- For our noisy plane (regardless of which other plane chosen as DUT), EUTelescope says residuals is 2.7µm!





Conclusion

- Carleton is learning how to use Caladium with low ionization particles (e.g. 32GeV pions) and naturally occurring cosmic ray muons
- The software infrastructure is designed and tested with an electron or high energy test beam in mind and is not as well suited to other applications
- We are developing new tools to complement the existing frameworks

Your Questions?