G-2 tracker test beam T1042

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Abstract

The Muon g-2 experiment is on the frontier of Particle Physics. Its tracker system is based on Straw Detectors. A prototype of these has been successfully tested in Fermilab's Mtest Facility during June 2015. During this test, a High Voltage (HV) supply powered the straws and was operated at different voltages. During the offline analysis of this data, variation of parameters as Threshold, HV, beam rate and type of gas were subject of study. An inverse proportion relation was found between threshold and noise (higher threshold, lower noise) but more detailed analysis is needed for more conclusive results.

The Muon μ

- Same charge as the electron
- 200 times heavier ➡ More sensitive to new physics
- Intrinsic magnetic moment, g Information about $\begin{cases} Momentum \\ Spin \end{cases}$
- Dirac predicted $g = 2$. But experiment has differ.
- Corrections with the Standard Model
- Anomalous magnetic moment $a_\mu = \frac{g-2}{2}$
- Standard Model prediction: $a_\mu^{SM} = a_\mu^{QED} + a_\mu^{had} + a_\mu^{EW}$

Muon G-2

- G-2 aims to measure g of the muon with better precision (140 ppb) than the previous Brookhaven's E821 (0.7ppb)
- Big Collaboration

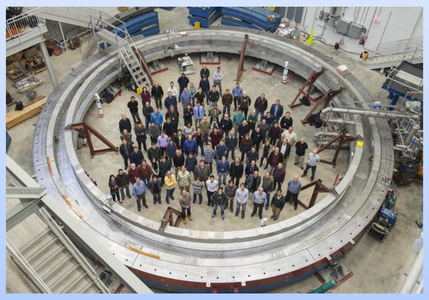


Image 1 – G-2 Collaboration in the storage ring – July 2015

- Get clues about physics *Beyond the Standard Model.*

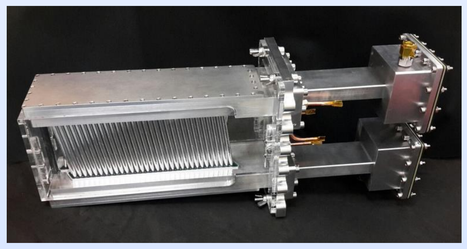


Image 2 - Straw tracker – Summer 2015

Tracker

- Straw trackers measure the beam profile as a function of time
- 3 stations located at 15°, 180° and 270° from injection point.
- 8 modules per station.
- 1 module 4 layers of straws
- 1 layer 32 straws wide
- U V layers

Straw parameters	
Wall Material	Aluminized Mylar
Wall thickness	15μm
Wire Material	Gold plated Tungsten
Wire diameter	25 μm
Straw length	10 cm
Stereo angle	$\pm$7,5° from vertical
Operating Voltage	1800 V

Table 1 – Straw Parameters

Test Beam June 2015

- MTest (FNAL)
- 2 weeks
- 120 GeV protons
- Tracker module
- Ar-CO2 & Ar-Ethane

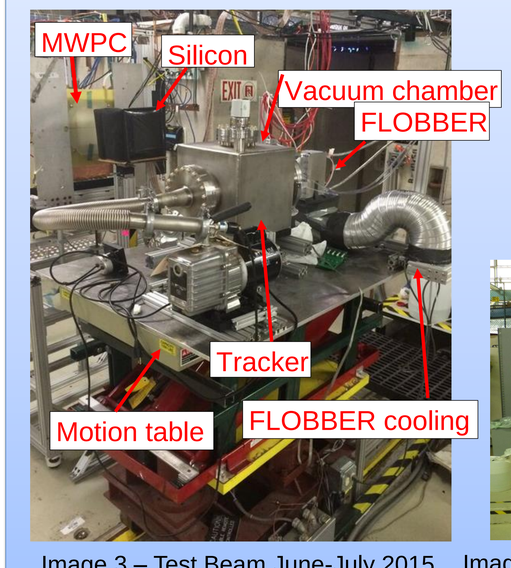


Image 3 – Test Beam June-July 2015

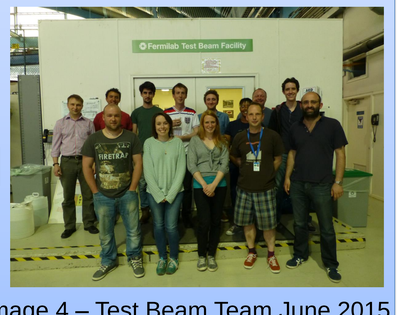


Image 4 – Test Beam Team June 2015

High Voltage

- Iseg EHS 8220p-F
- Switched Mode Power Supply (Supply)
- Low ripple and noise
- Resolution few pA
- Remotely controllable via SNMP
- Friendly GUI
- Operated at 1400-1500-1600-1700-1800 V
- Ramp speed of 5%
- Current trip of 20 μA

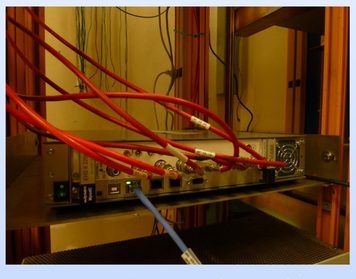


Image 5 – HV plugged in

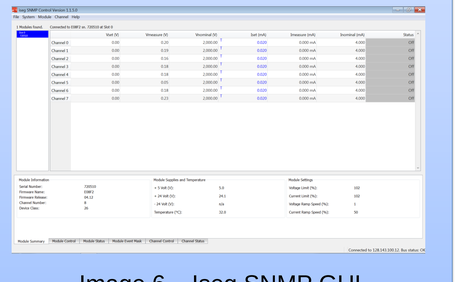


Image 6 – Iseg SNMP GUI

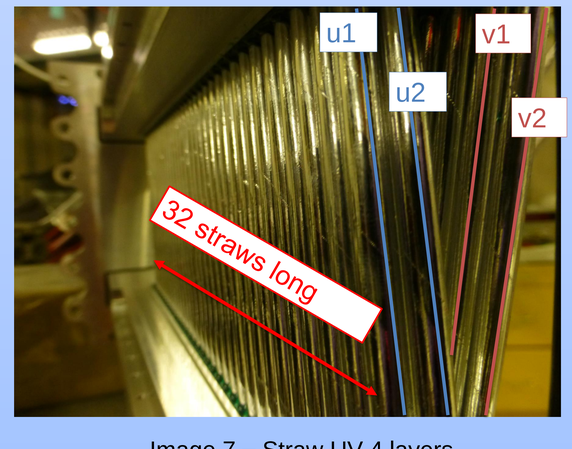
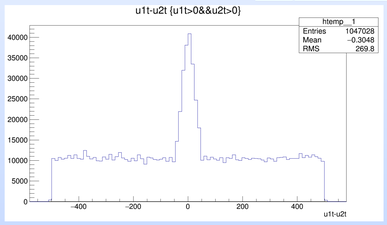


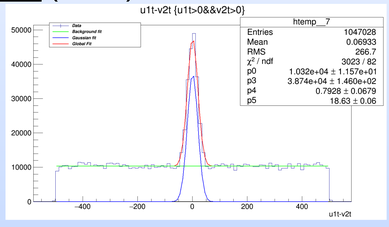
Image 7 – Straw UV 4 layers

Test Beam Data Analysis

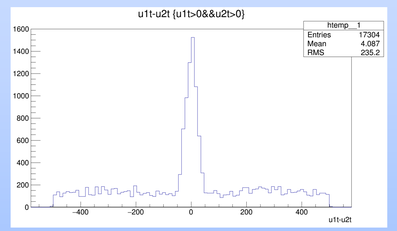
- Existing gm2 simulation and analysis software (Geant4/Art, C++, Root)
- Straw digits hits per layer
- Time Differences between hits by layer
- Hits which are less than 500 ns apart
- Looping for hits in 4 layers

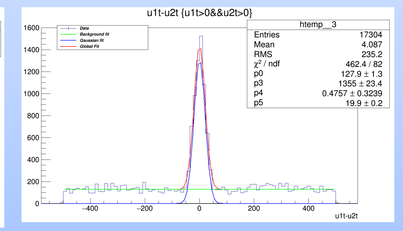
Argon:Ethane (50:50)





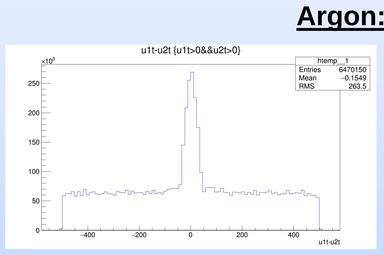
Run 405 – Threshold* 400mV – HV 1800 V – Beam Rate 100k

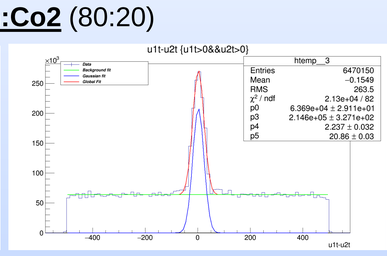




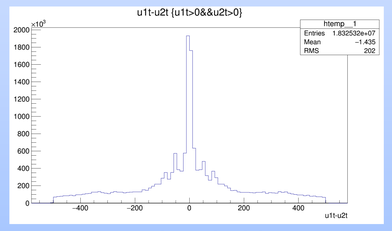
Run 413 – Threshold* 1000mV – HV 1800 V – Beam Rate 100k

Argon:Co2 (80:20)





Run 314 – Threshold* 300mV – HV 1500 V – Beam Rate 10k



Run 340 – Threshold* 1200mV – HV 1600 V – Beam Rate 10k

Results

- $\Delta t \approx 0$ ➡ Hits are correct.
- Gaussian and flat noise fit
- Most are beneath the Gaussian.
- Higher Threshold – Less noise
- Differences between gas unclear
- Still more analysis to do looking more into detail in all the parameters.

*Readout Electronics Threshold

Conclusions

- Experiment in the frontier of the Standard Model
- Test beam was an opportunity to see collaboration happen
- Operated the HV module and gained knowledge about it.
- The time differences between straw layers ≈ 0. The hits registered by the straws represent the reality.
- The higher threshold, the less noise.
- There is still analysis to be done.

References

- "Muon G – 2 Technical Design Report." Fermi National Accelerator Laboratory, 15 June 2015. Web. 26 June 2015.
- Li, Liang. "Muon G-2 Experiment at Fermilab." Shanghai Jiao Tong University, 5 June 2013. Web. 15 June 2015.

Acknowledgments

- Brendan C Casey – Fermi National Laboratory
- Thomas Stuttard – University College of London
- Tammy Walton – Fermi National Laboratory
- Brendan Kiburg - Fermi National Laboratory

August 2015

Universidad de los Andes

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