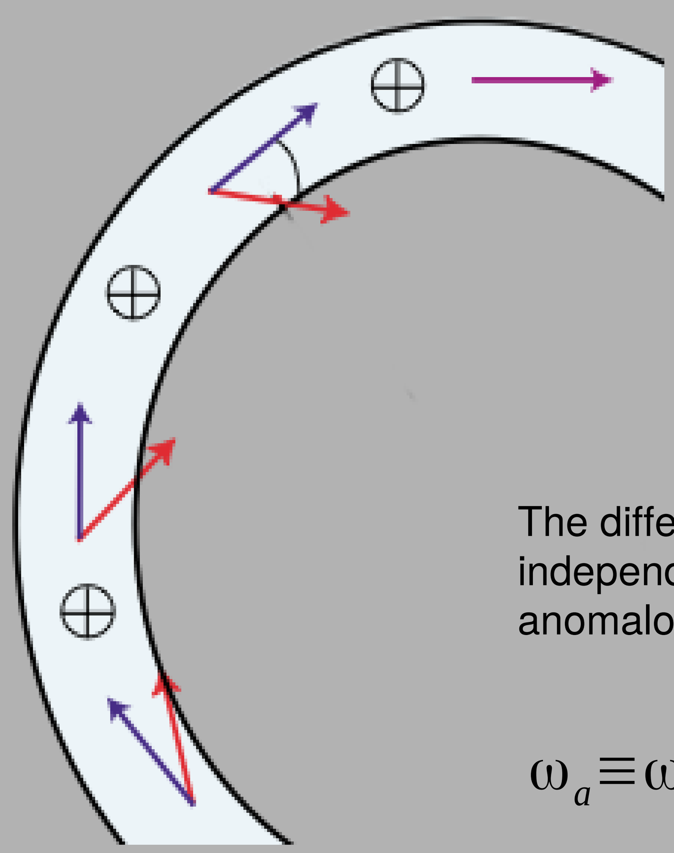
Construction and Commisioning of the Beam delivery, storage ring and g-2 detectors at FNAL

A.Gioiosa on behalf of the g-2 Collaboration

Principle of the Muon g-2 experiment

A tale of two frequencies

Polarized muons are injected into the *(g-2)*$_\mu$ storage ring where a strong (1.45T) magnetic field both traps the muons and causes their spin vector to precess. The momentum turns at the cyclotron frequency ω_c while the spin rotates due to the combination of Larmor and Thomas precession ω_s.



momentum rotation $\omega_c = \frac{eB}{\gamma m}$

spin rotation $\omega_s = \frac{geB}{2m} + (1-\gamma)\frac{eB}{\gamma m}$

The difference of these frequencies is independent of γ and proportional to the anomalous magnetic moment

$$\omega_a \equiv \omega_s - \omega_c = \frac{a_\mu eB}{m}$$

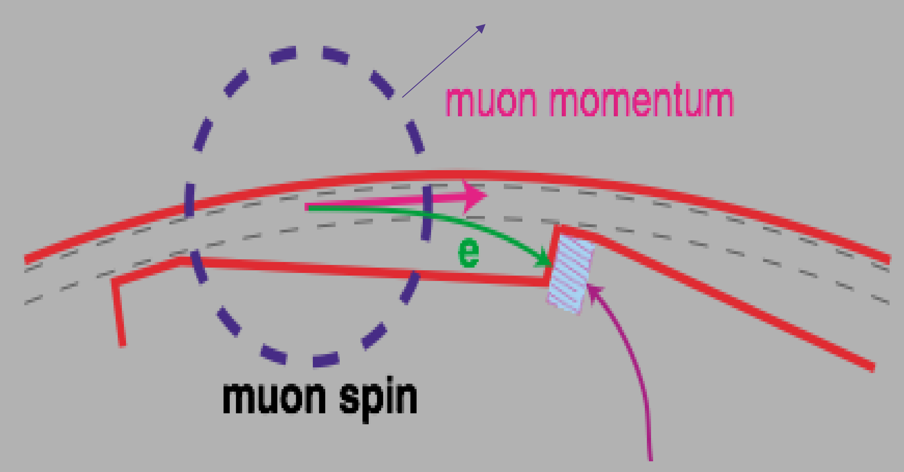
The quantity a_μ, is obtained by measuring the frequency **ωₐ** and the magnetic field *B*, which can be absolutely tied to the precession frequency of free protons **ωₚ**.

Measuring ωₐ

The parity-violating weak decay of the muon leads to a strong correlation between the direction of the spin and the high energy decay positron

24 calorimeter stations symmetrical around the storage ring measure the time and energy of accepted positrons to observe ωₐ over 10 muon lifetimes.

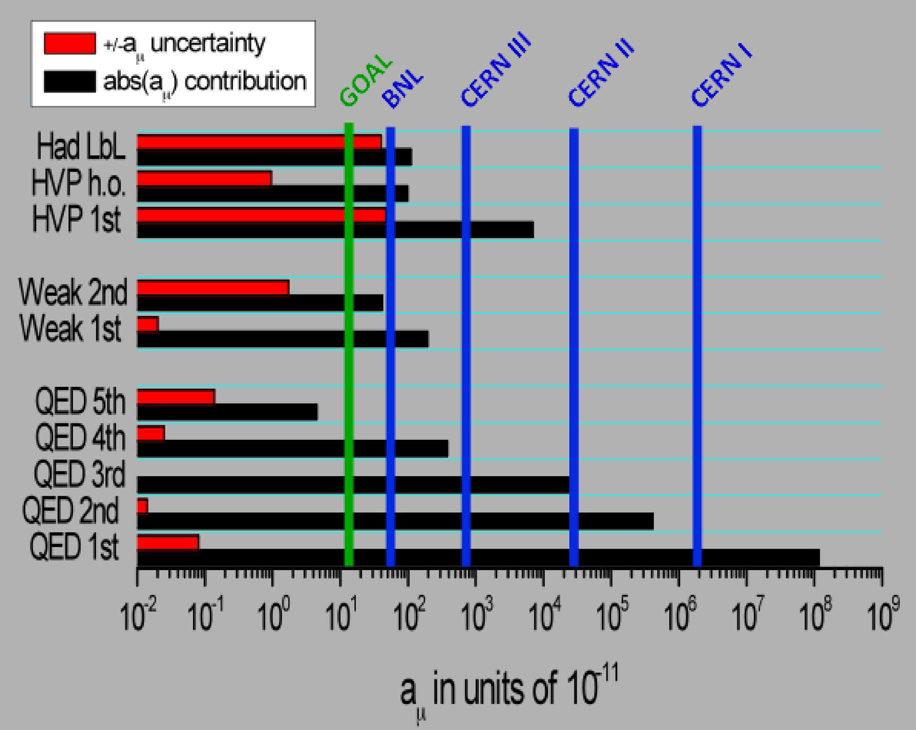
$$\mu^+ \to e^+ + \nu_e + \bar{\nu}_\mu$$

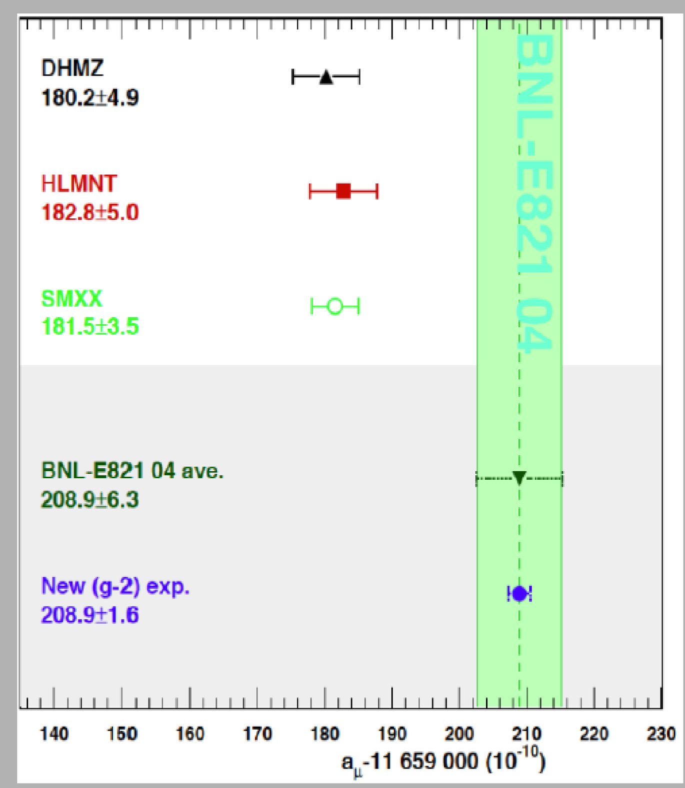


Measuring ωₚ

Precise knowledge of the magnetic field measured by Nuclear Magnetic Resonance (NMR) probes can be related to the absolute field experienced by the muons through the precession frequency of free protons ωₚ.

New Physics?

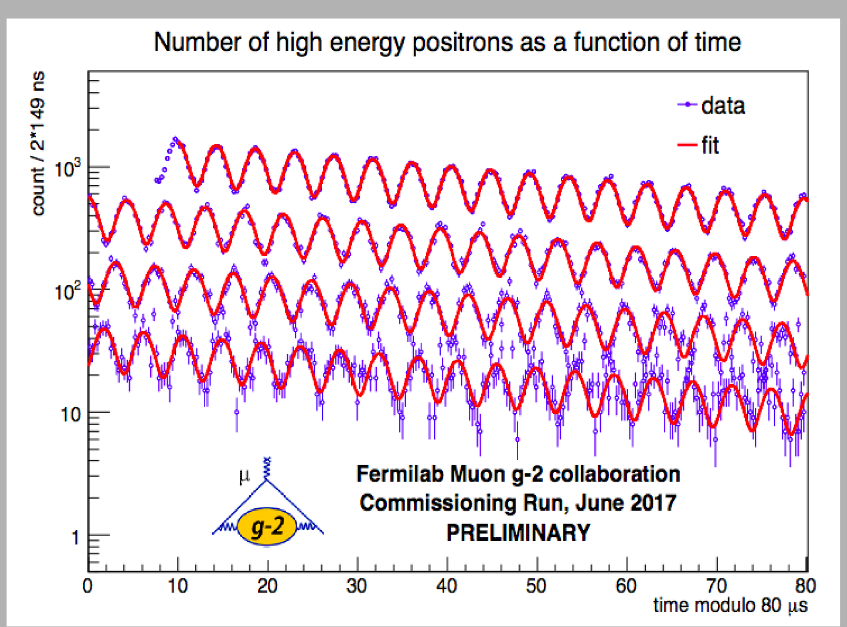




Calorimeter

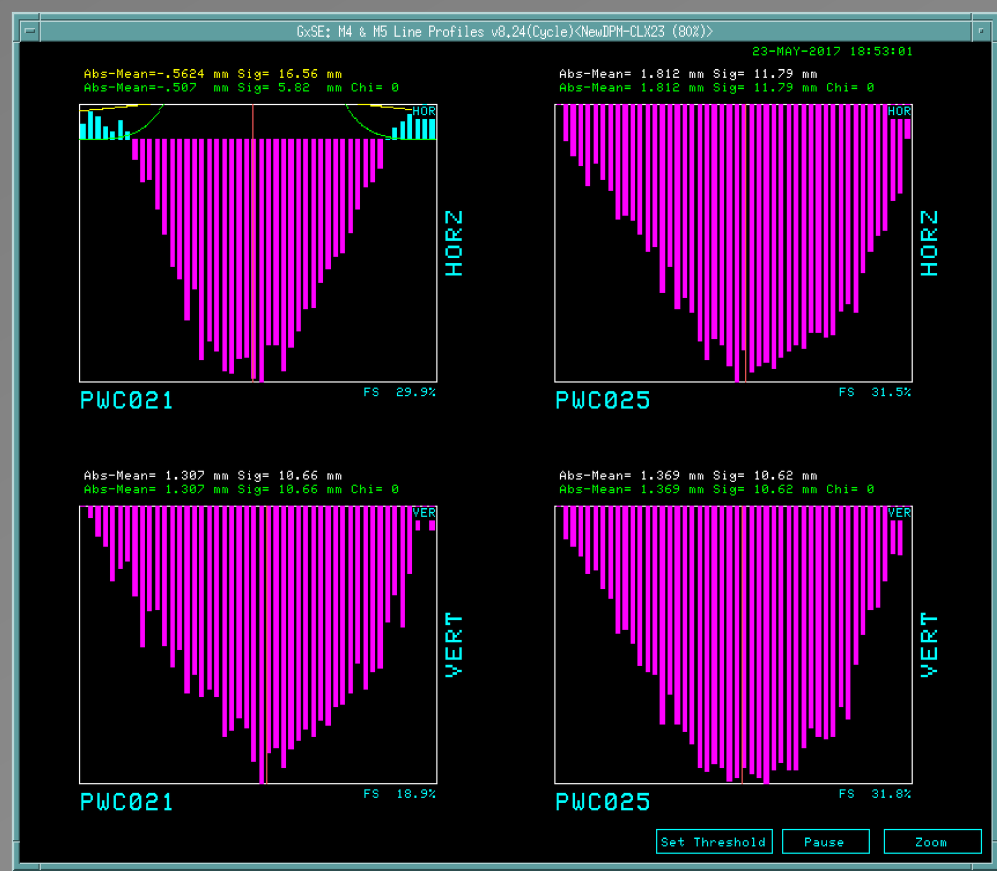
The calorimeter is composed by an array of 54 Pure PbF_2 Cherenkov crystals readout by large area SiPM

The pure nature of the Cherenkov crystal permits to have an almost immediate signal whene a positron strikes the calorimeter reducing the chance of pile up events.



This figure was accumulated from two weeks of data accumulated in June 2017 and has approximately 700k positrons. The number of wiggles is somewhere between that achieved by CERN-II and CERN-III.

http://www.nature.com/news/muons-big-moment-could-fuel-new-physics-1.21811



Ring

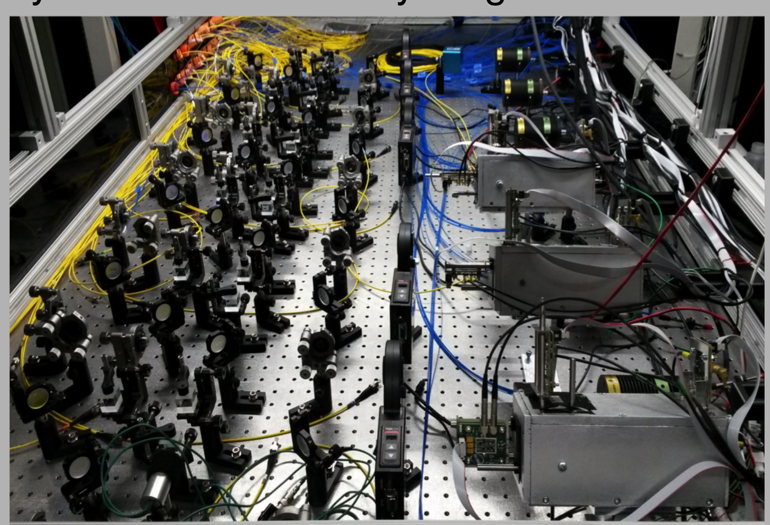
BNL storage ring moved to FNAL. Magnet is fully operational and almost all the detectors are installed.

Beam

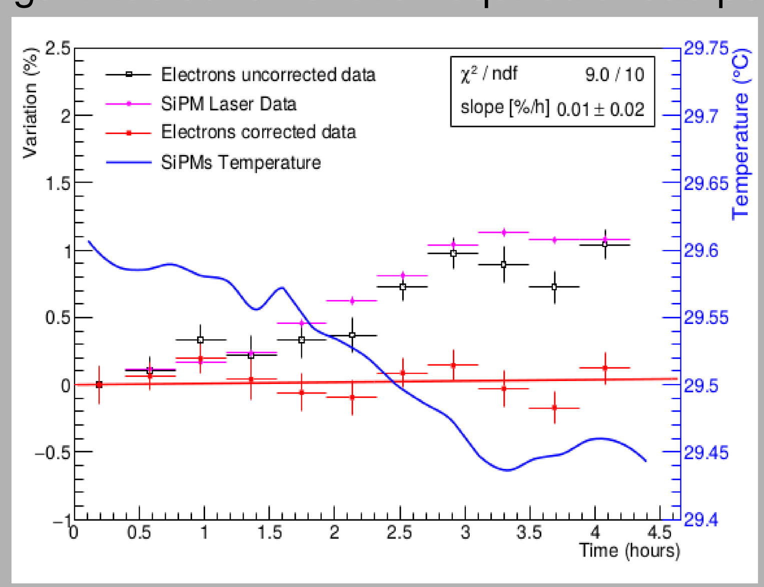
FNAL accelerator complex ready. First Beam in the storage ring in June!

Laser Calibration System

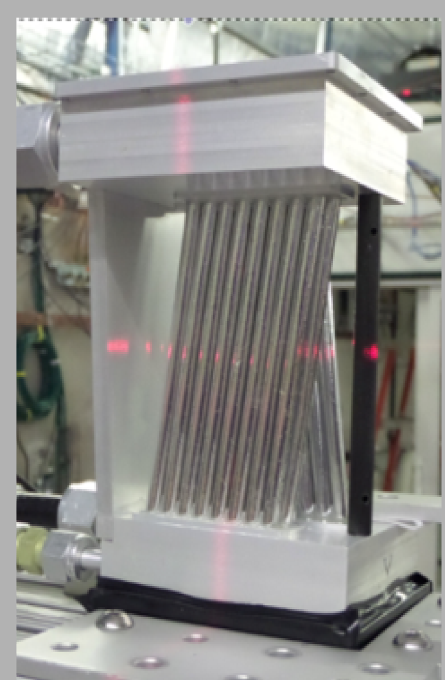
State of art laser calibration system is needed to maintain the systematic uncertainty on gain fluctuation at the 0.02 ppm level.



Several test beam were performed to test all the performance of the system. The final result show a system able to correct for gain fluctuation e level required.at sub per mil level.



Tracking System



A tracking system has been developed to reduce systematc error due to beam dynamics inside the storage ring.

3 detectors will be installed in the ring along the ring.

Laboratory test confirmed high level efficiency of 99.2% for a single module.

Is necessary to modify the vacuum chamber to house the tracker.

All the 8 modules of the first tracker detector efficiently installed in the storage ring and ready for beam commisioning.

Papers

A. T. Fienberg *et al.*, 'Studies of an array of PbF_2 Cherenkov crystals with large area SiPM read-out", **Nucl. Instrum. Meth A783 12-21 (2015).**
A. Anastasi *et al.*, "Test of candidate light distributors for the muon (g-2) experiment", **Nucl. Instrum. Meth. A788 43-48 (2015).**
A. Anastasi *et al.*,'Electron beam test of key elements of the laser-based calibration system for the muon g-2 experiment", **sub. Nucl. Instrum Meth. A (2016).**