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The (g-2) Experiment:
Exploring the Muon's Anomalous Magnetic Dipole Moment

Last Time

- "Is a new theory of light and matter needed at the highest energies?"[1]
- Looking for polarized x-rays
- Testing QED in high B fields

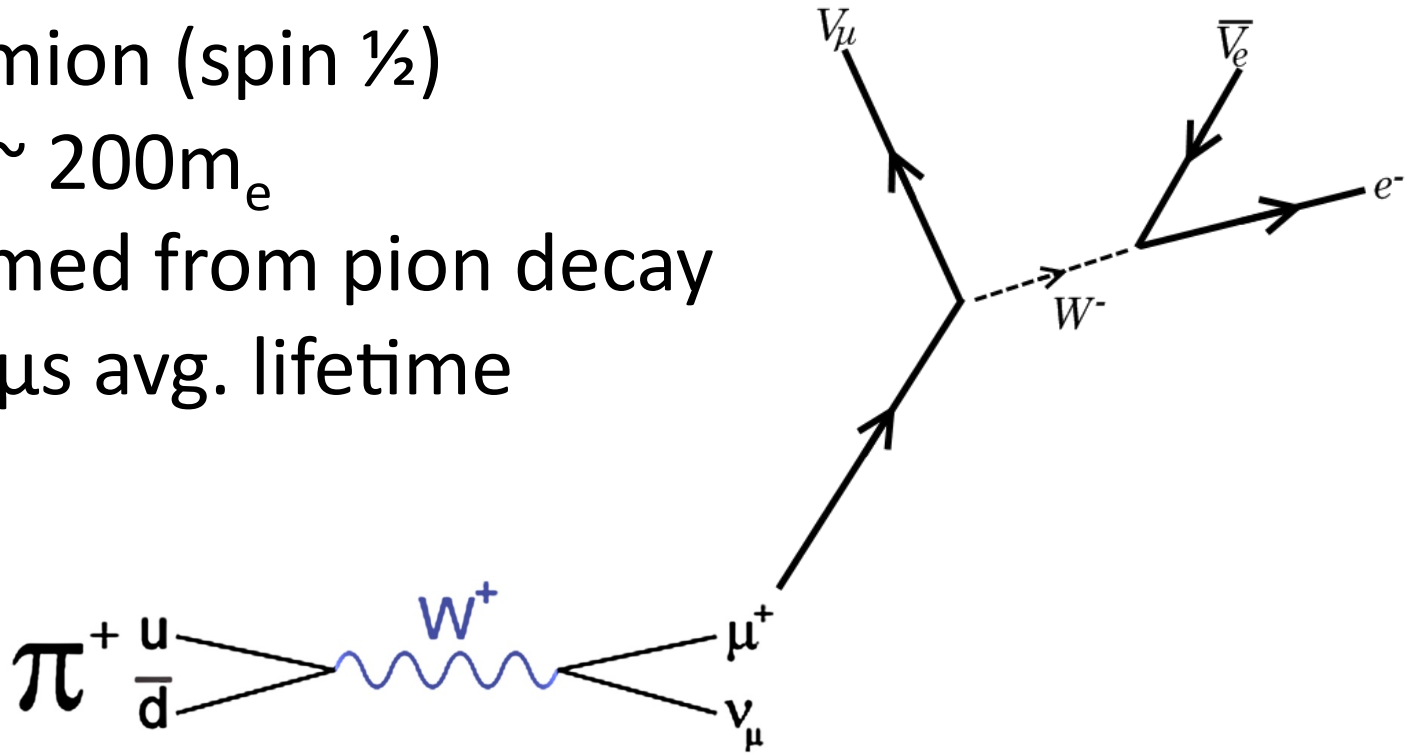
[1]Connecting Quarks With the Cosmos, Natonal Research Council, ©2003 Natonal Academy of Sciences

Overview

- A New Focus
- Background
- (g-2) Experiment
- Future
- Images courtesy http://www.g-2.bnl.gov/

Muons

- Negative charge
- Fermion (spin ½)
- $m_\mu \sim 200 m_e$
- Formed from pion decay
- 2.2 μs avg. lifetime



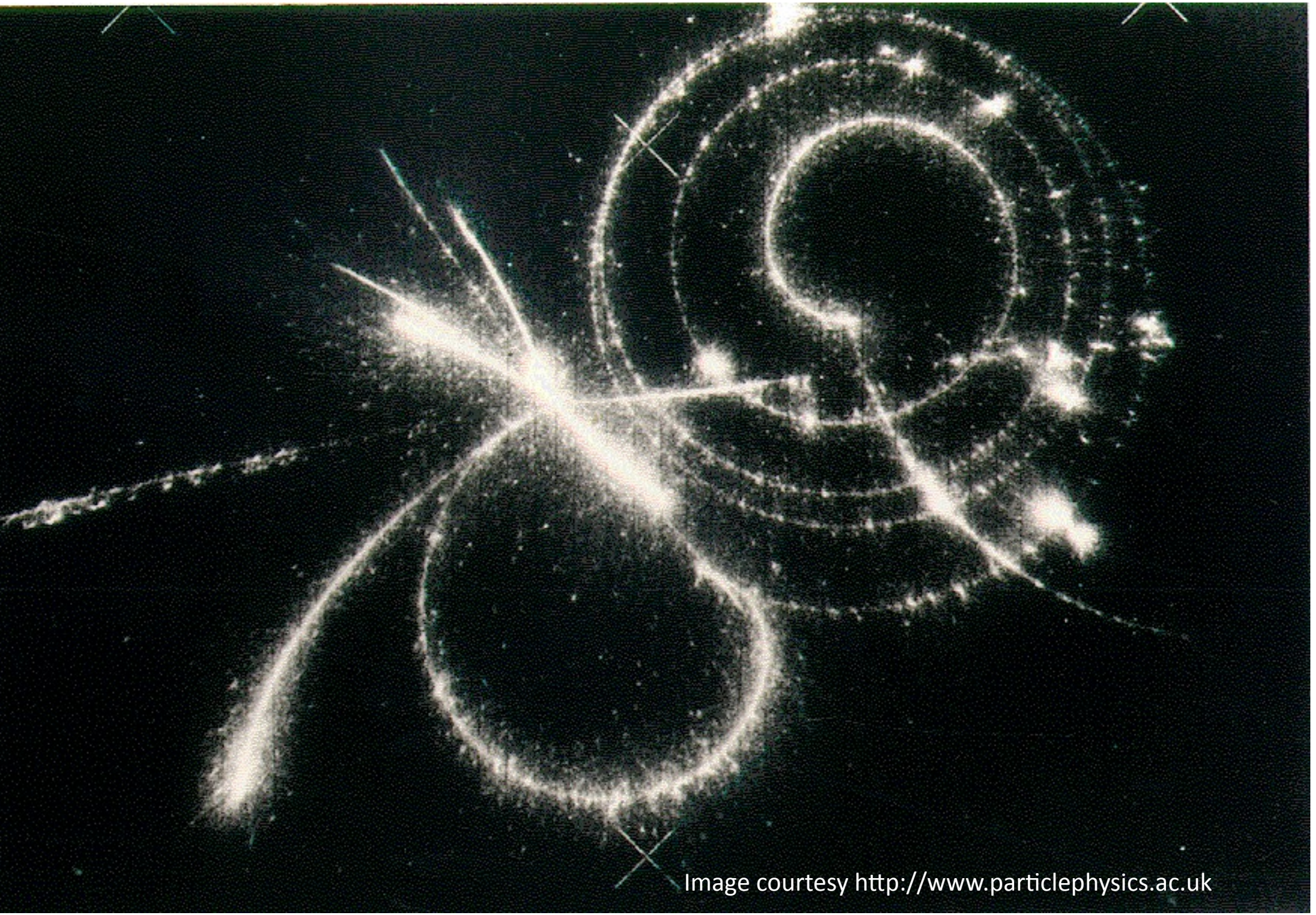
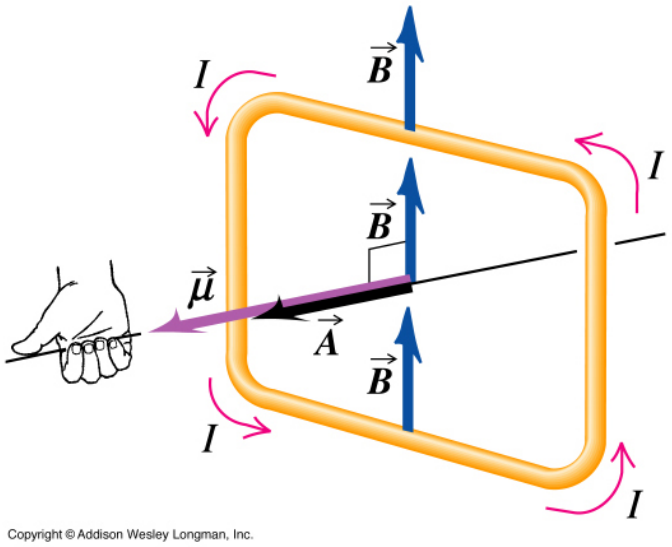


Image courtesy http://www.particlephysics.ac.uk

g – factor

- relates the observed magnetic moment μ of a particle to the angular momentum quantum number



$$\mu_{muon} = g \frac{e\hbar}{2m_\mu} \frac{S}{\hbar}$$

Anomalous Magnetic Dipole Moment

- Dirac equation describes elementary spin ½ particles (predicts g =2)
- a_μ is difference between g derived from Dirac Equation and observed g

$$a_\mu = \frac{g - 2}{2}$$

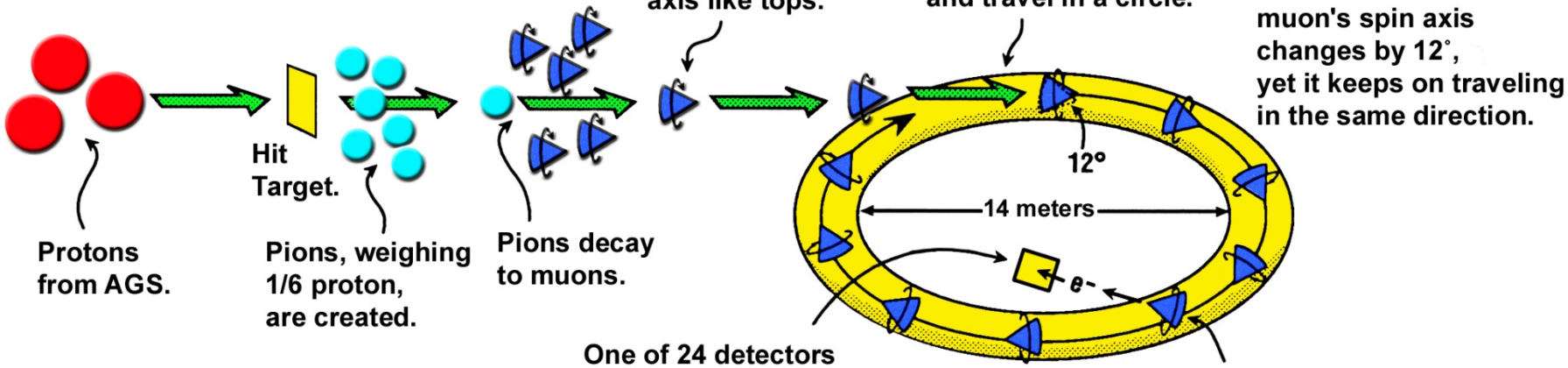
a_μ of the electron

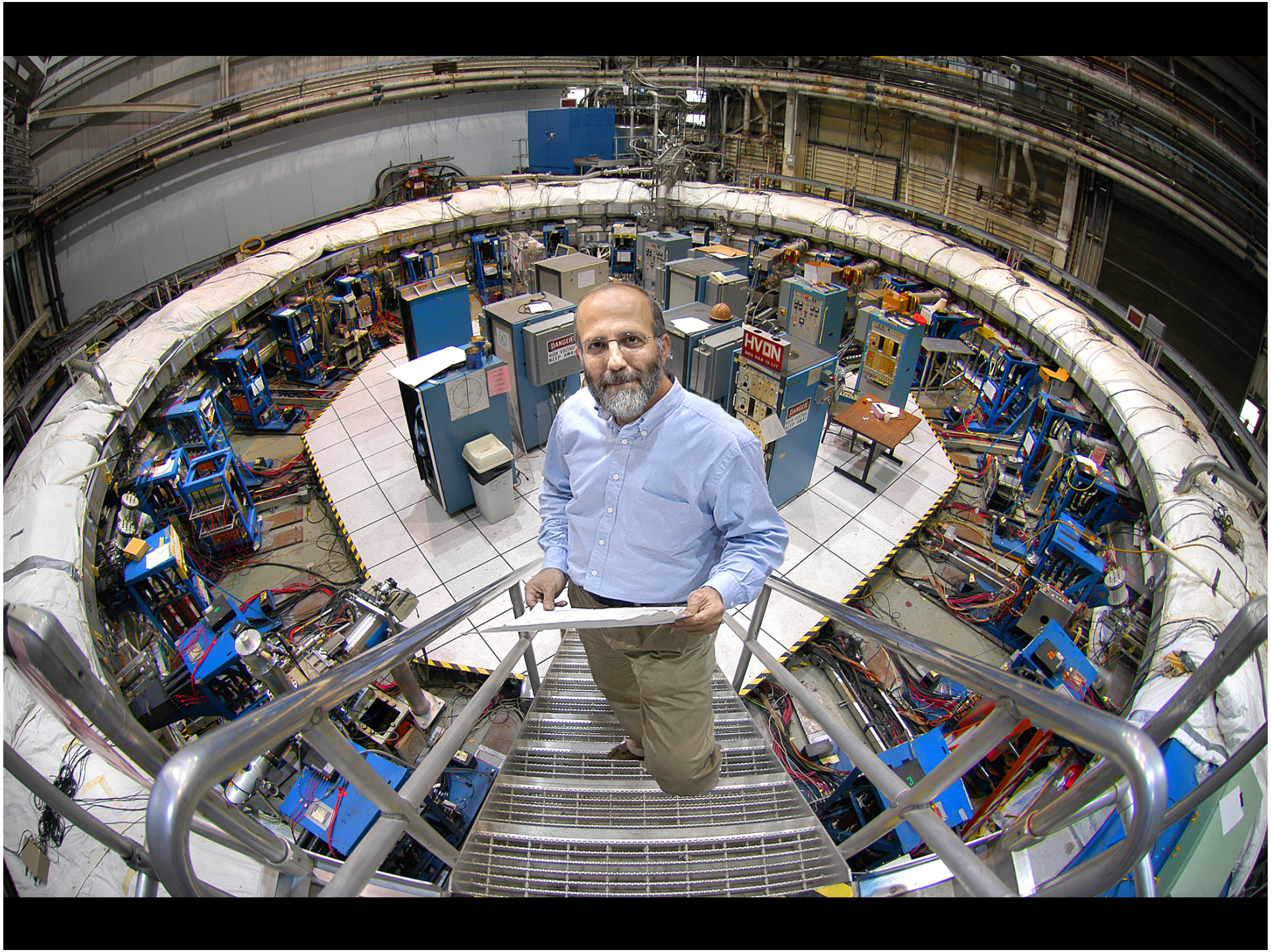
- most accurately verified prediction in physics (>10 sig figs)
- A huge success of QED
- But predicted value for muons doesn't match experiment!

Recap

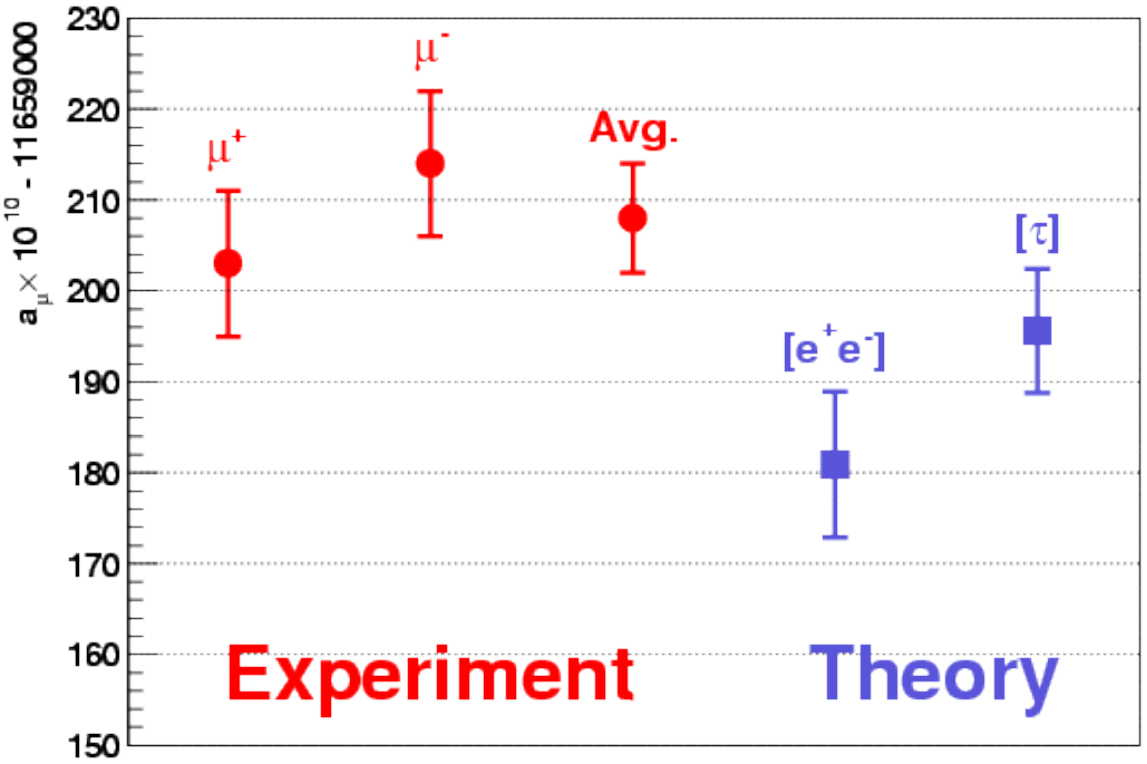
- Muons are heavier cousins of electrons
- g-factor relates μ to S
- a_μ is difference between Dirac and observed g
- QED explains a_μ for e^- but not $\mu^{+/-}$

LIFE OF A MUON:
THE g-2 EXPERIMENT




DANGER
HVON
DANGER

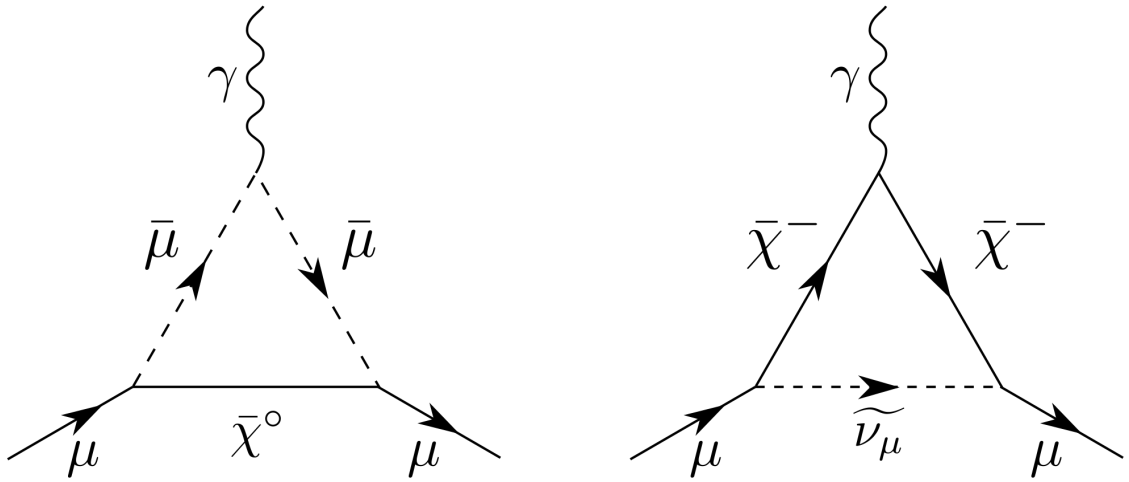
Muon (g-2) Results



Bennet et al., Measurement of the Negative Muon Anomalous Magnetic Moment to 0.7 ppm, Phys. Rev. Lett. 92, 161802 (2004)

Conclusions

- Result differs by 2.7 (1.4) std dev from SM
- Beyond standard model?
- Internal structure? Supersymmetry?



Future

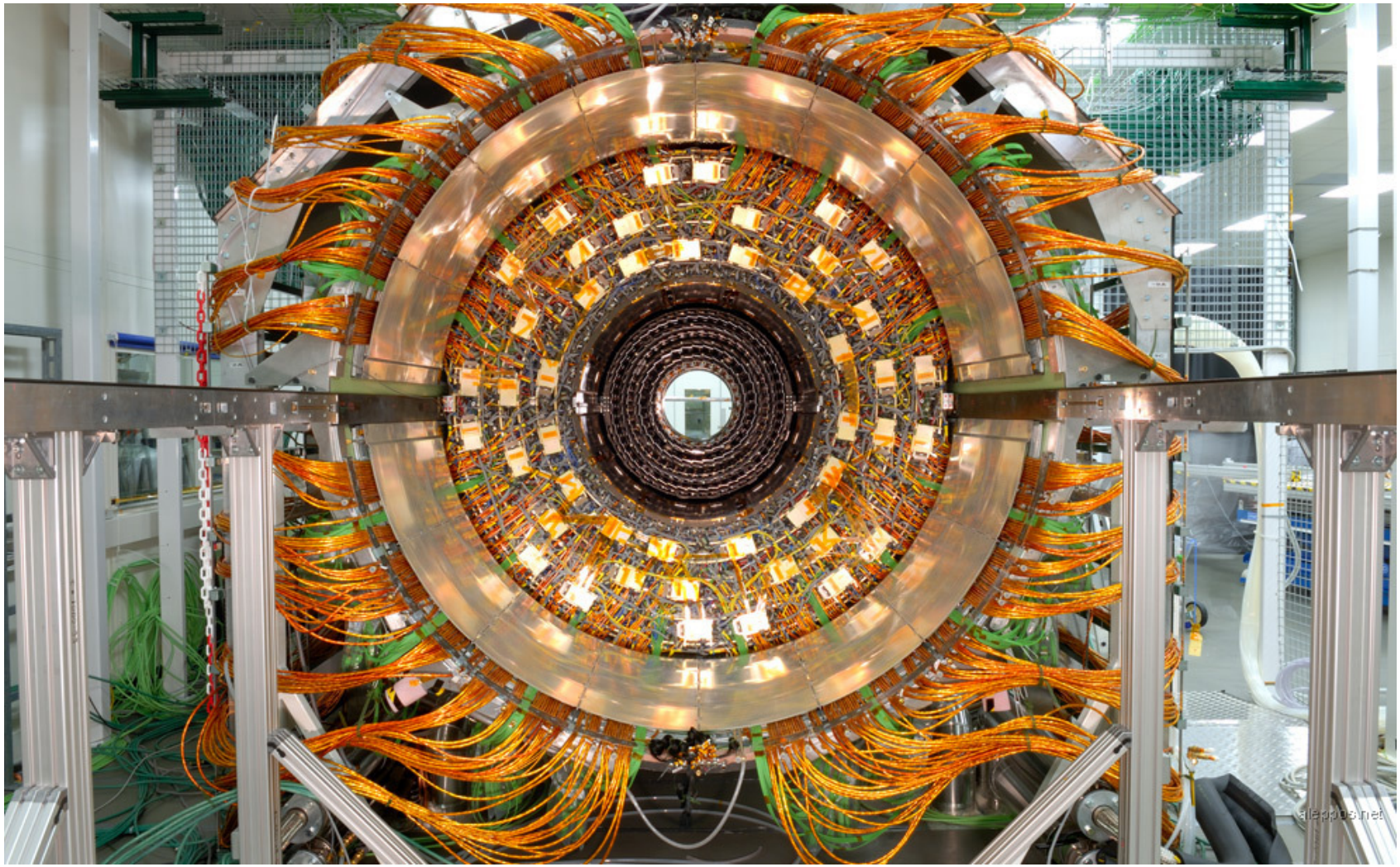


Image courtesy Maximilien Brice, © CERN

Muon Collider Conceptual Layout

Project X
Accelerate hydrogen ions to 8 GeV using SRF technology.

Compressor Ring
Reduce size of beam.

Target
Collisions lead to muons with energy of about 200 MeV.

Muon Capture and Cooling
Capture, bunch and cool muons to create a tight beam.

Initial Acceleration
In a dozen turns, accelerate muons to 20 GeV.

Recirculating Linear Accelerator
In a number of turns, accelerate muons up to 2 TeV using SRF technology.

Collider Ring
Bring positive and negative muons into collision at two locations 100 meters underground.

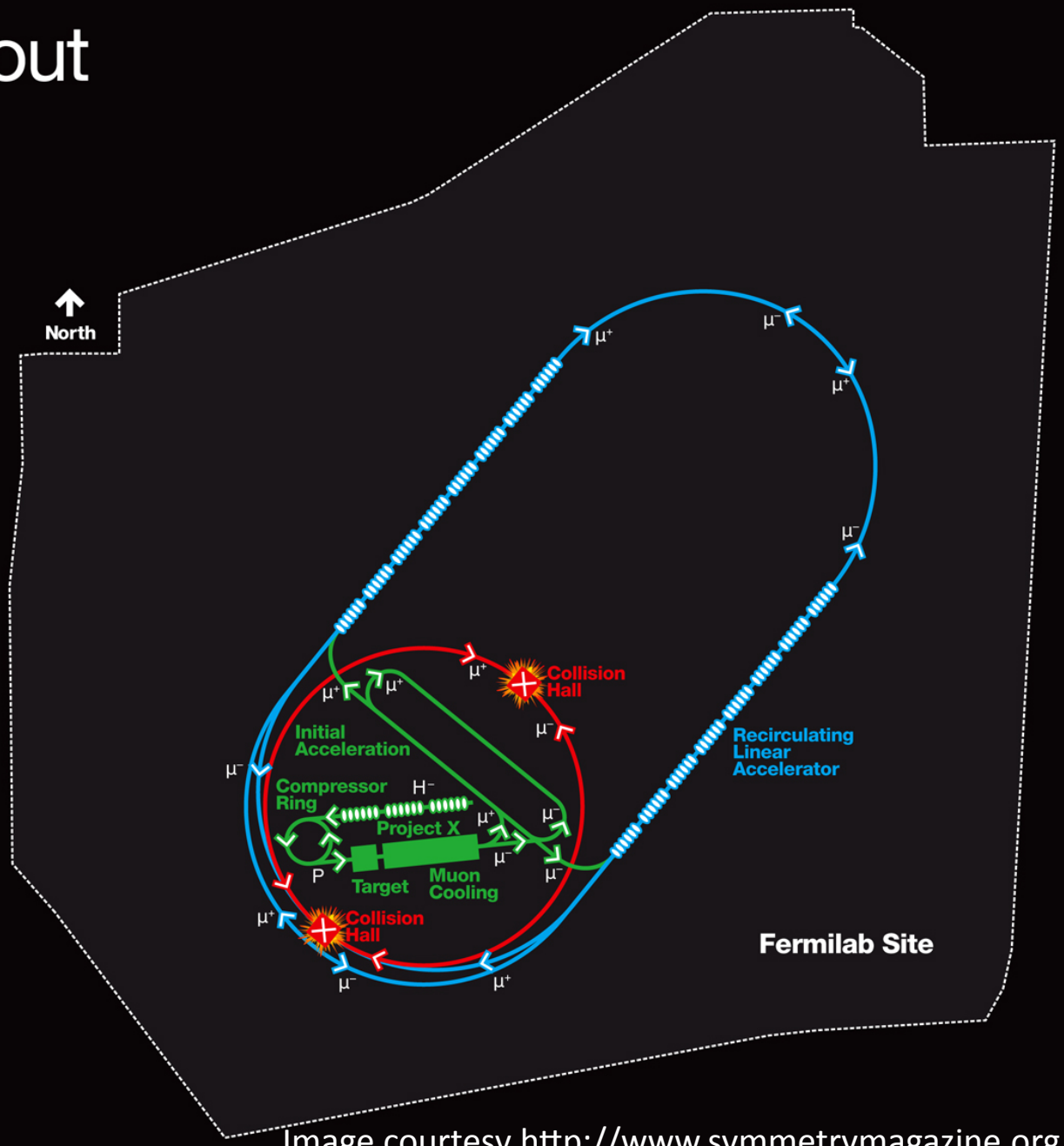


Image courtesy http://www.symmetrymagazine.org

Works Cited

- The Muon g-2 Experiment Homepage, http://www.g-2.bnl.gov/
- The Brookhaven Muon Anomalous Magnetic Moment Experiment, Hertzog, David W., Morse, William M., Annual Review of Nuclear and Particle Science. Volume 54, Page 141-174, Dec 2004
- Muons Continue to Defy Standard Model, Dumé, Belle, PhysicsWorld.com, Jan. 8, 2004
- The Pion-Muon Death Cycle - a Double Anniversary, http://www.particlephysics.ac.uk/, Oct. 15, 1997
- Measurement of the Negative Muon Anomalous Magnetic Moment to 0.7 ppm, Bennett et al., Phys. Rev. Lett. 92, 161802, 2004

History

- Muon discovered 1936
- QED predicts corrections to g factor for e^-
- Precession of $\mu_{electron}$ confirms
- First muon tests at CERN 1980's
- (g-2) experiment result Jan 8, 2004