Muon Campus at Fermilab & …Muon g-2...Mu2e Experiments

Community Advisory Board
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U.S. DEPARTMENT OF ENERGY | Office of Science

Muon Campus Vision, circa 2012

- Convert the anti-proton source into a customizable muon beam source
- Build a new beamline and two experimental halls for new experiments

Muon Campus Reality

- New beamline in place, both buildings constructed, first experiment installed and ready to start beam commissioning next month

Muons as probes for new physics

Muons can be extremely good probes of the Standard Model
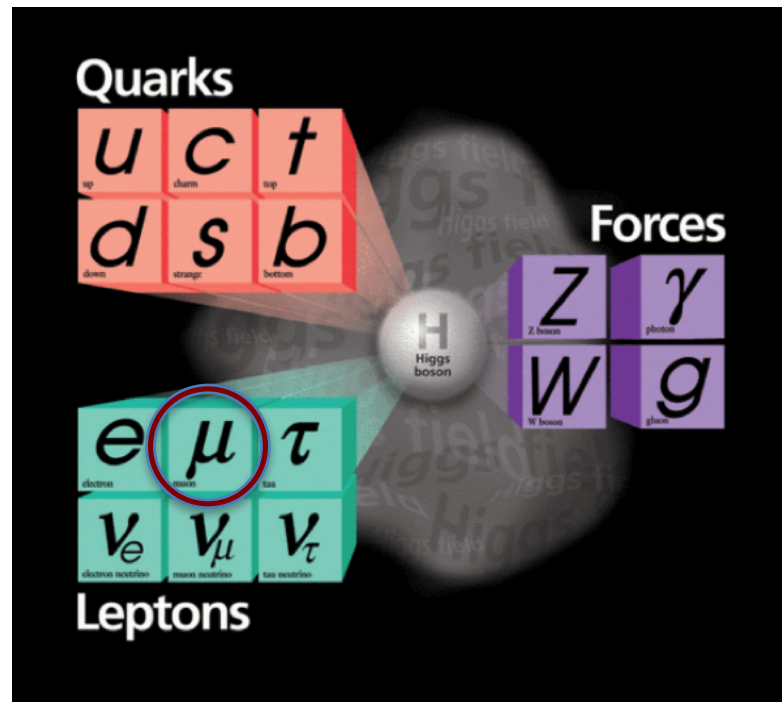
- Can be produced copiously

$$BR(\pi^\pm \to \mu^\pm \nu) = 99.9877\%$$

- Don't get ensnared by the strong force
- Relatively long life time 2.2 μs
- Relatively heavy $(m_\mu/m_e)^2 = 40000$

Developing a program at Fermilab based on using muons as tools

- Muon g-2 experiment (data 2017)
- Mu2e experiment (data 2021)
- Future possibilities for other muon-based experiments, e.g. muon EDM, other CLFV channels

The Standard Model

The Muon g-2 Experiment

- Think of muons as little spinning tops, in a magnetic field and they revolve like a gyroscope
- The rate of that revolution changes due to particles that spontaneously flash into existance
- Goal is to make an intense muon source, inject into a storage ring, measure frequency to look for the influence of unknown particles or forces
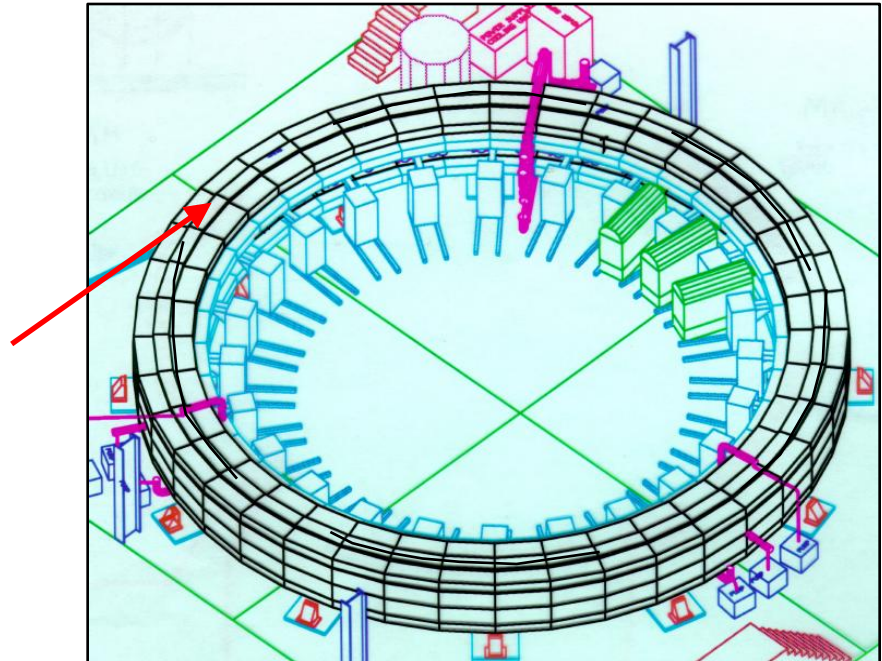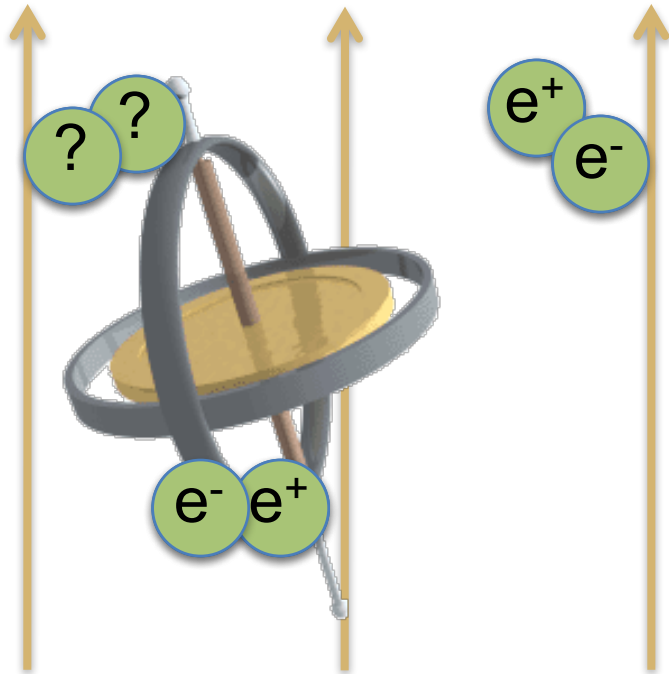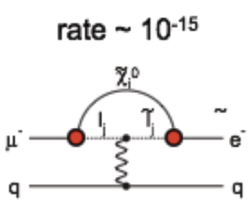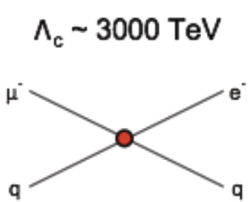
The Mu2e Experiment

- Mu2e also uses muons to look for new physics
- They are trying to determine if muons ever spontaneously convert to an electron w/out neutrinos
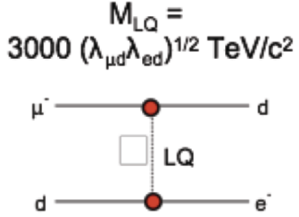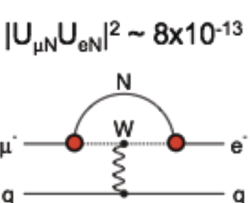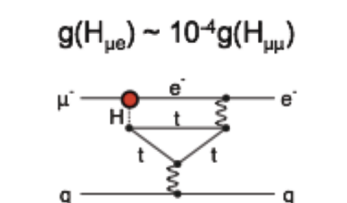- Discovery of even 1 muon that turns into an electron → Nobel prize

Supersymmetry
rate ~ 10^{-15}

Compositeness
$\Lambda_c \sim 3000$ TeV

Leptoquark
$M_{LQ} = 3000\,(\lambda_{\mu d}\lambda_{ed})^{1/2}$ TeV/c^2

Heavy Neutrinos
$|U_{\mu N}U_{eN}|^2 \sim 8\times10^{-13}$

Second Higgs Doublet
$g(H_{\mu e}) \sim 10^{-4}g(H_{\mu\mu})$

Heavy Z'
Anomal. Z Coupling
$M_{Z'} = 3000$ TeV/c^2
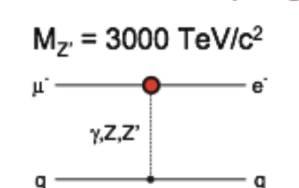
A System of superconducting solenoids and an intense muon beam

Production Solenoid (PS)   *Transport Solenoid (TS)*   *Detector Solenoid (DS)*

2.5T

4.6T

2.0T

μ e

1.0T

~25 meters

The Mu2e Experiment

Stopping Target   Straw Tracker   Crystal Calorimeter

Simulated microbunch (670 – 1695 ns) including signal electron plus full occupancy overlay
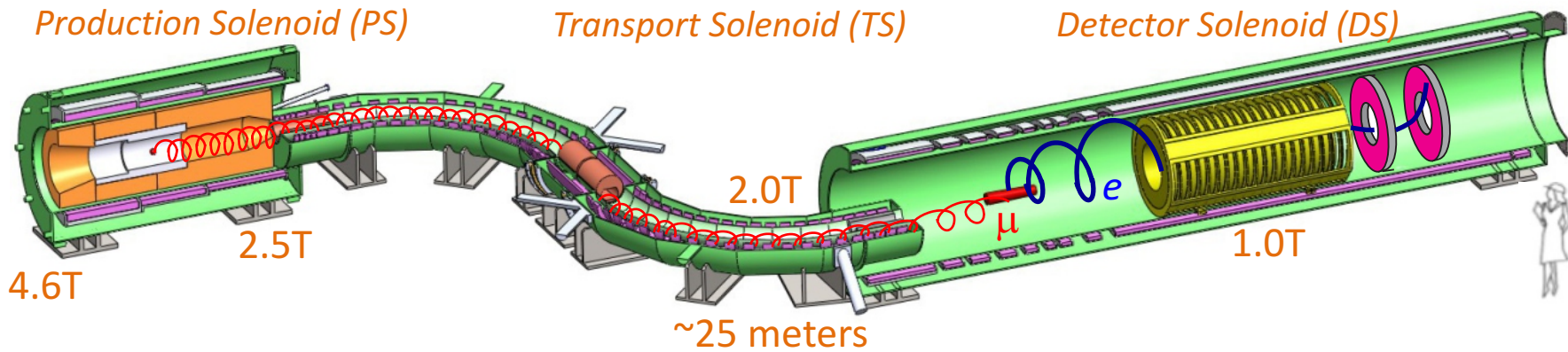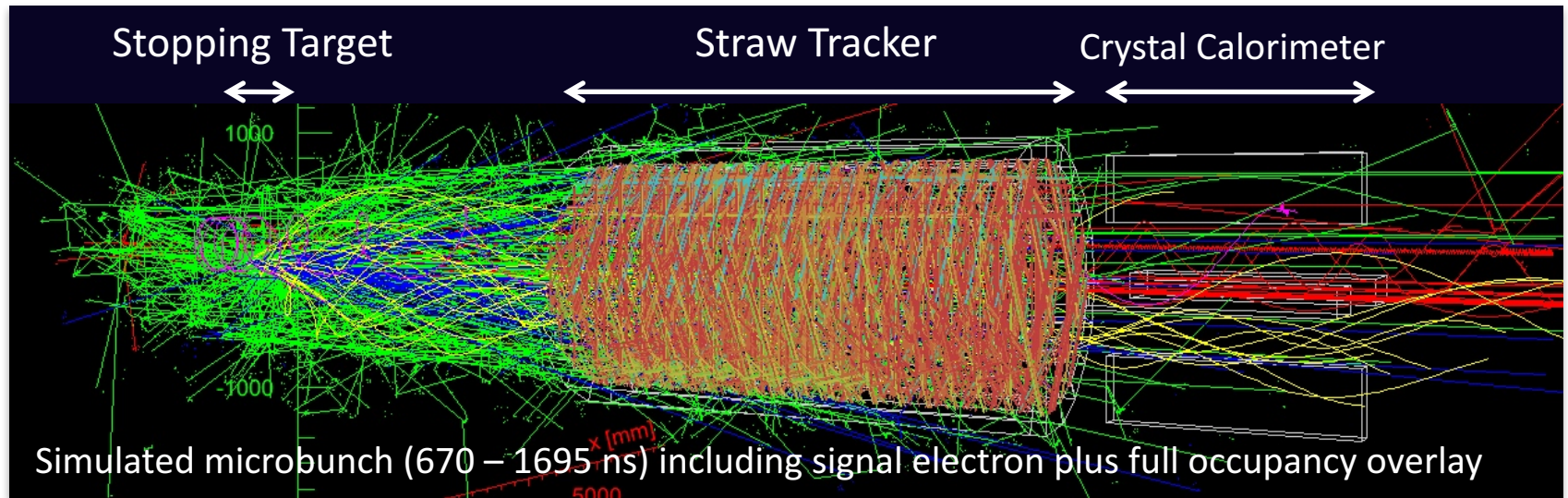
Find 1 in 10,000,000,000,000,000!

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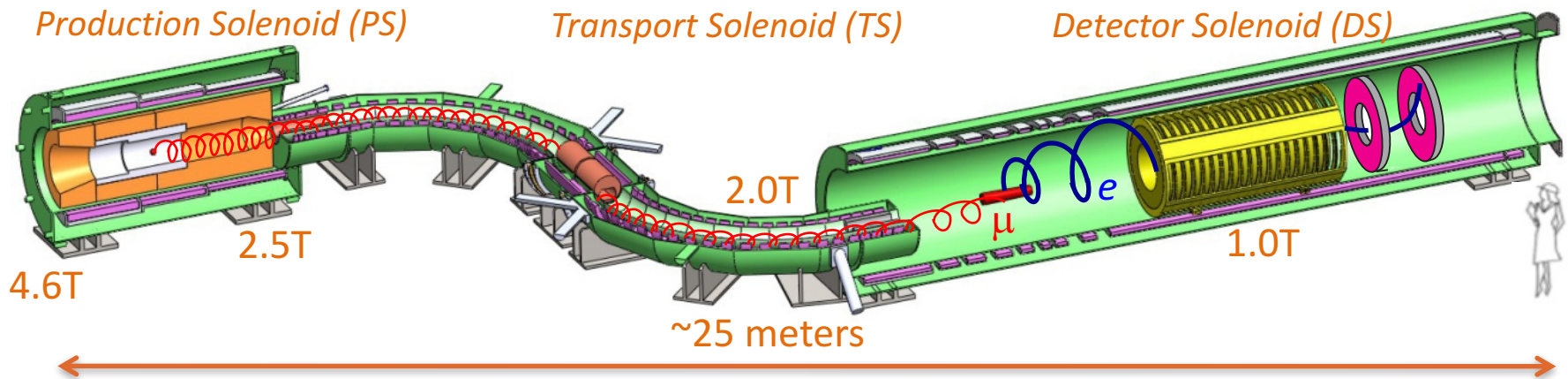
Moving the storage ring…

Our local brewery, Two Brothers, created a special beer for the occasion