Mu2e Target in 10 min

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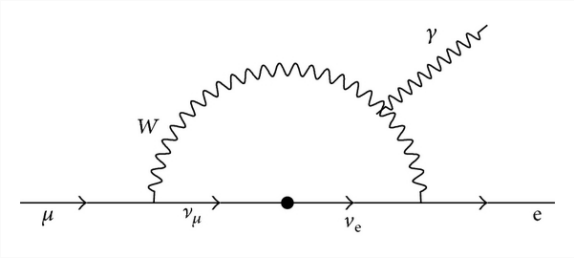
Charged Lepton Flavor Violation

Charged leptons are only fermions without observation of flavor violation

- Quarks mix (CKM)
- Neutrinos oscillate

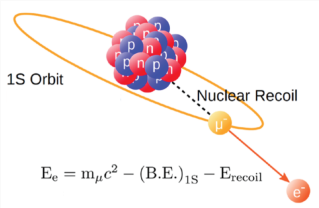
CLFV is allowed in νSM, but ludicrously suppressed

- $Br(\mu \to e\gamma) \propto (\frac{\Delta m_\nu^2}{M_W^2})^2 < 10^{-52}$

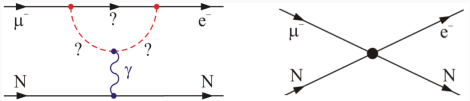


Any experimental observation would unambiguously indicate New Physics

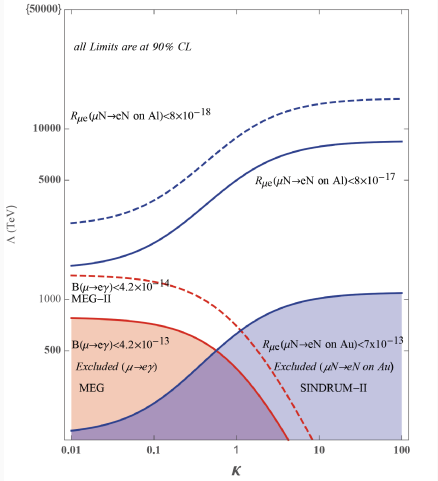
CLFV: $\mu \to e$ conversion



- Monoenergetic $\sim$105 MeV/c conversion-electron (CE)
- Sensitive to energy scales $\mathcal{O}(1000)$ TeV



Adapted from A. de Gouvea and P. Vogel,
Progress in Particle and Nuclear Physics 71, 75–92 (2013)

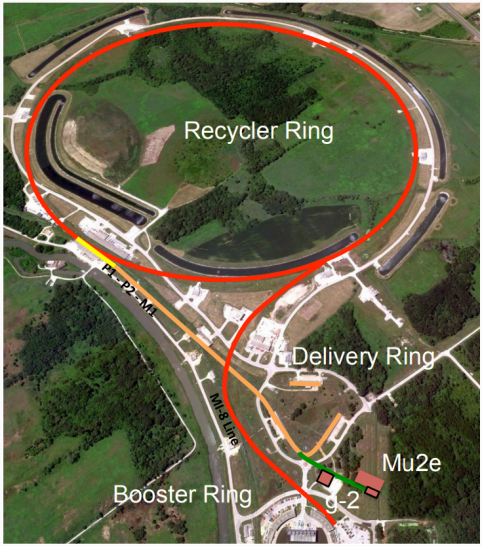


$$\mathcal{L}_{\text{CLFV}} = \frac{m_\mu}{(\kappa+1)\Lambda^2}\bar{\mu}_R\sigma_{\mu\nu}e_L F^{\mu\nu} + \frac{\kappa}{(\kappa+1)\Lambda^2}\bar{\mu}_L\gamma_\mu e_L(\bar{u}_L\gamma^\mu u_L + \bar{d}_L\gamma^\mu d_L)$$

Challenge 1: μ^- beam from FNAL protons

Resonant extraction @ FNAL:

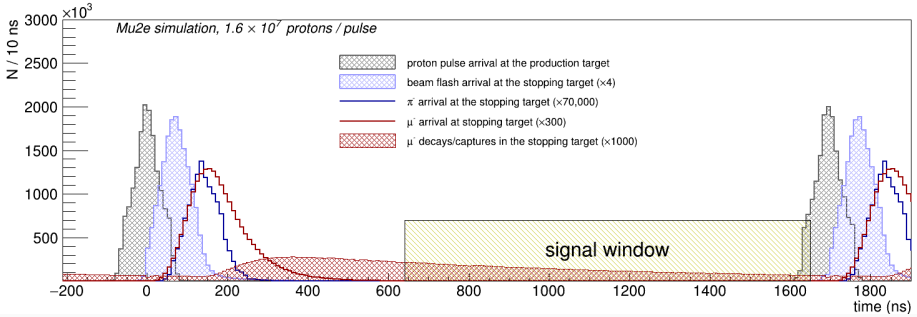
- $\sim 3 \times 10^7$ protons @ 8 GeV
- $\sim$ 1 mm gaussian beam radius
- 250 ns pulses
- 1.7 μs pulse period
- At 2.5 MHz



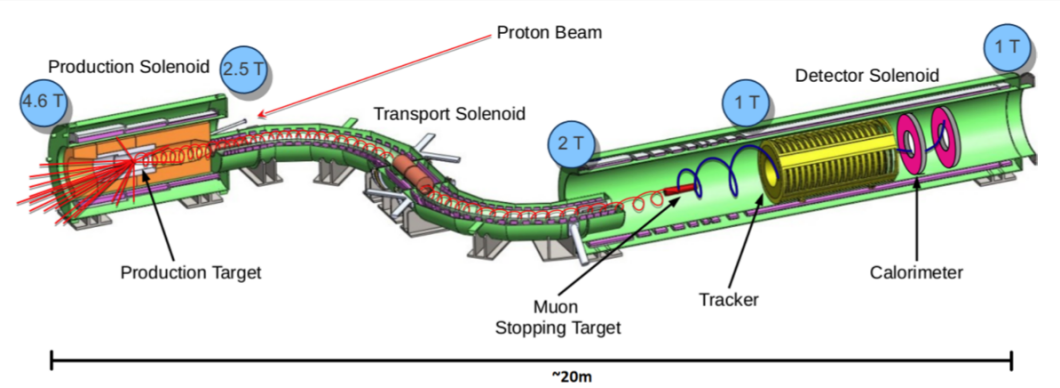
Challenge 2: Ideal Mu2e conditions

Mu2e needs:

- High yield of *stoppable* muons $\Rightarrow$ low momentum μ^- beam
- Minimal beam-induced backgrounds (i.e. radiative pion capture)
- Low radiation environment



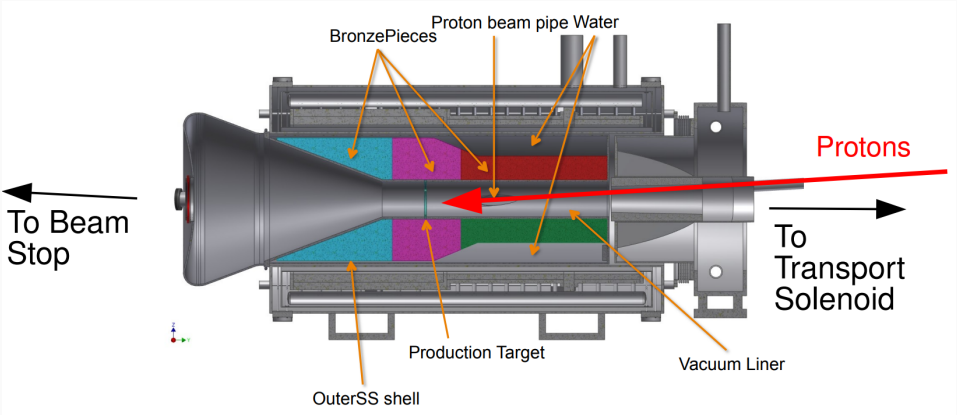
Mu2e



Discovery potential of $R_{\mu e} = \frac{\Gamma(\mu^- + N(Z,A) \rightarrow e^- + N(Z,A))}{\Gamma(\mu^- + N(Z,A) \rightarrow \nu_\mu + N(Z-1,A))} > 2 \times 10^{-16}$ (5σ)

- $R_{\mu e} < 8 \times 10^{-17}$ (90% CL)
- $\mathcal{O}(10^4)$ improvement of previous result (SINDRUM-II)

Production Solenoid (PS)



Compact, high-Z pion-production target in high B-field with backwards extraction

Production Target

LaO_2-doped Tungsten, core EDMed from single rod

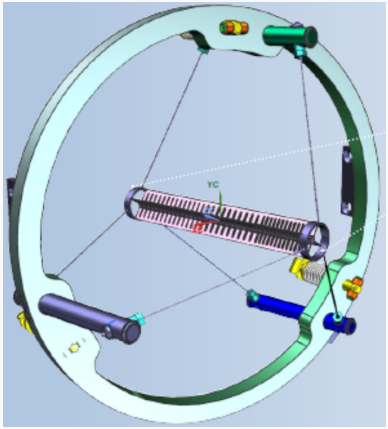
Longitudinally segmented cylinder
$\Rightarrow$ stress management

Longitudinal fins
$\Rightarrow$ thermal and structural management

1mm tungsten spokes

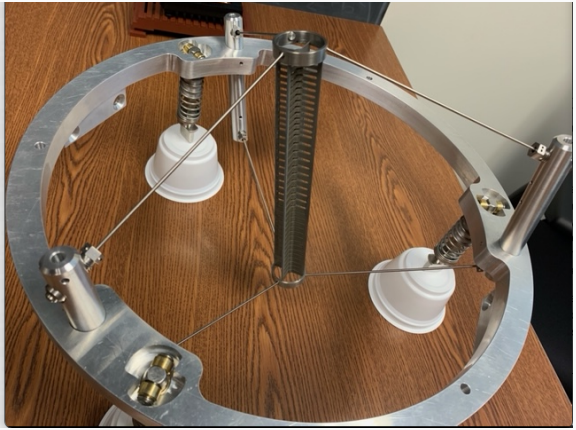
$\sim$700 W power absorbtion $\Rightarrow$ $\sim$1500 K

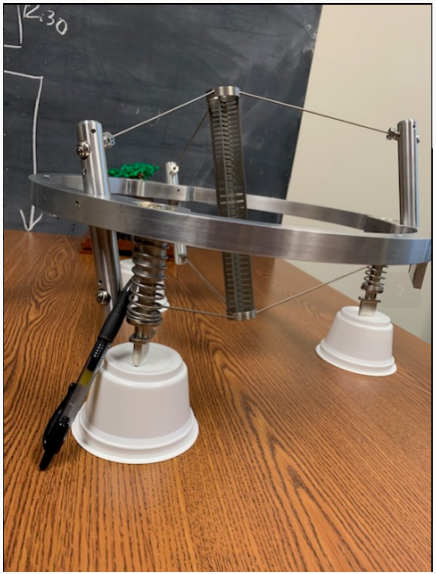
- Radiatively cooled



Expect target lifetime of $\sim$1 year: $\Rightarrow$ replace during summer shutdowns

Production Target





Future work and remaining questions

First target is in-hand

- Mu2e Run 1 scheduled for ∼2026 ($\leq$ 1 year long, ∼0.5x beam intensity)

First-of-its-kind target: fully simulation-driven optimization and stress analysis

- Designed with nominal beam intensity @ 1 year: $\Rightarrow$ Run 1 should not be a concern
- Target failure and replacement outside of shutdown window slows experiment

What can we test and how?

- Are expected performance degradations (e.g. thermal stresses, oxidation, creep) within tolerances?

Can we setup Mu2e target testing at FNAL?