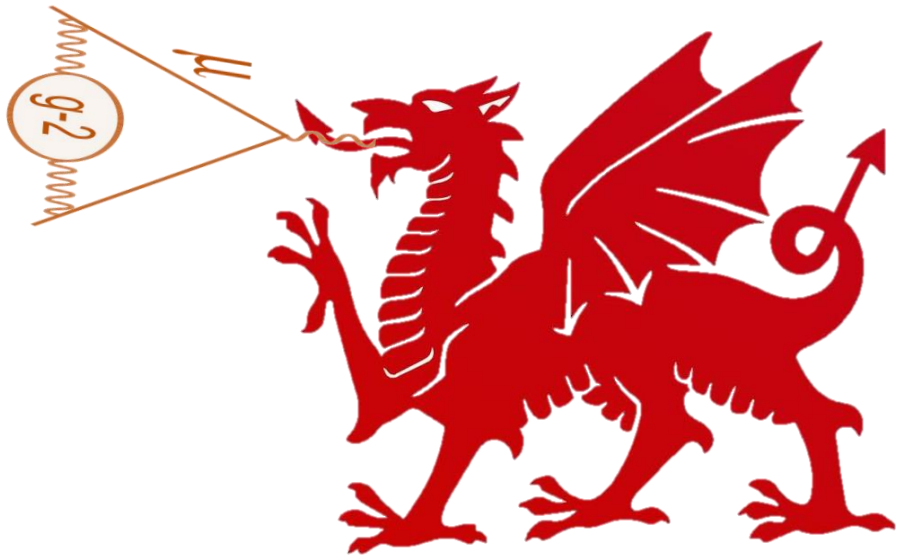


Physics retreat flash talk

Leverhulme physics retreat

Dominika Vasilkova

The muon EDM: why should you care?

- Analogous to the magnetic dipole moment (MDM), charged particles might also have an intrinsic electric dipole moment (EDM):

$$H = -\vec{\mu} \cdot \vec{B} + \vec{d} \cdot \vec{E}$$

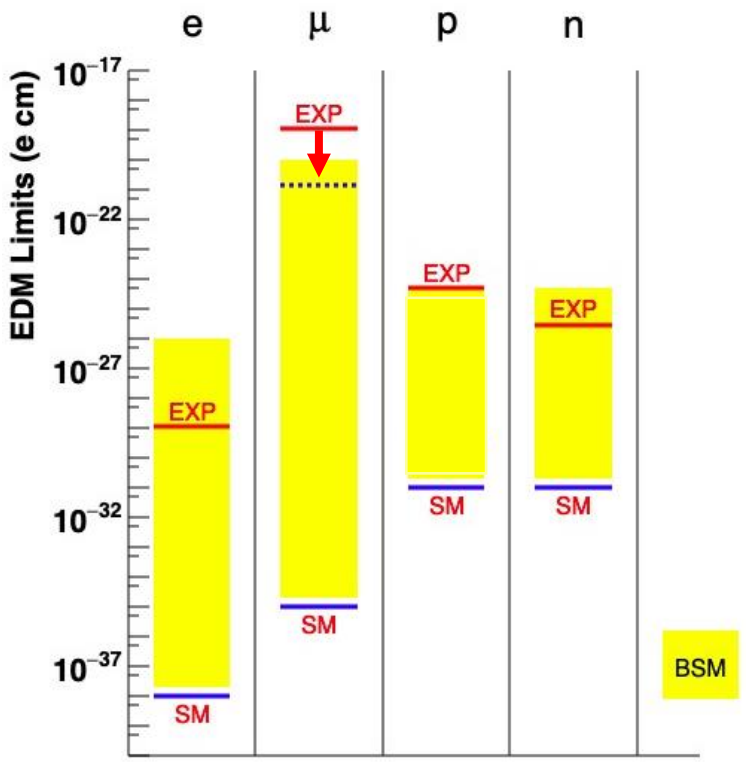
MDM:

$$\vec{\mu} = g\frac{e}{2m}\vec{S}$$

EDM:

$$\vec{d} = \eta\frac{Qe}{2mc}\vec{S}$$

- Why muon EDM?
  - SM muon EDM well below the range of current experiments.
  - **d**.**E** is CP-odd, so observation gives a **new source of CP violation** in the lepton sector.



- Previous best direct limit was set at Brookhaven National Laboratory (BNL): **1.9 × 10^{-19}** $e \cdot cm$.
- **Target at FNAL: set a ~ 10x better limit!**

The past ~2 years: progress and updates

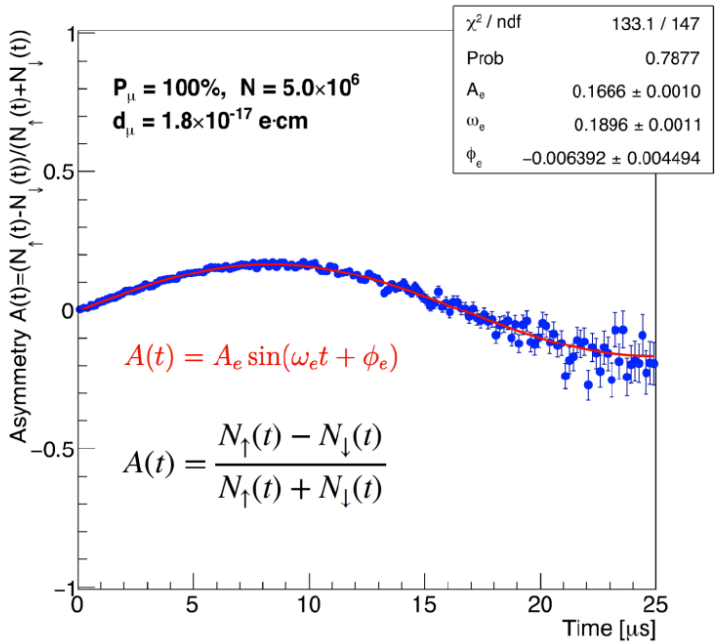
- **Muon g-2:** Electric Dipole Moment (EDM) search, straw tracking detector work, operations
- EDM:
  - New gas gun MC defined and run (~8.5b decays) for EDM tracker acceptance
  - Work done to improve data/MC matching for increased accuracy of corrections
  - Revamped tracker alignment systematic + reconstruction uncertainties
  - Discovered + fixed closure issue with acceptance correction (new extra correction + systematic)
  - Studies on impact of CBO
  - Completion of Run 2/3 EDM analysis, writing of EDM note + responses to reviewer comments
- Straw trackers:
  - Post-running checks to check for signs of aging + overall resolution/efficiency studies to check for any variation at ~ g-2 period scale. Confirmed no degradation of trackers over g-2's run time!
- Operations:
  - RunCo-ed through the end of Run 6 + some post-running systematic studies (mainly calorimeter acceptance studies and tracker scattering target work).

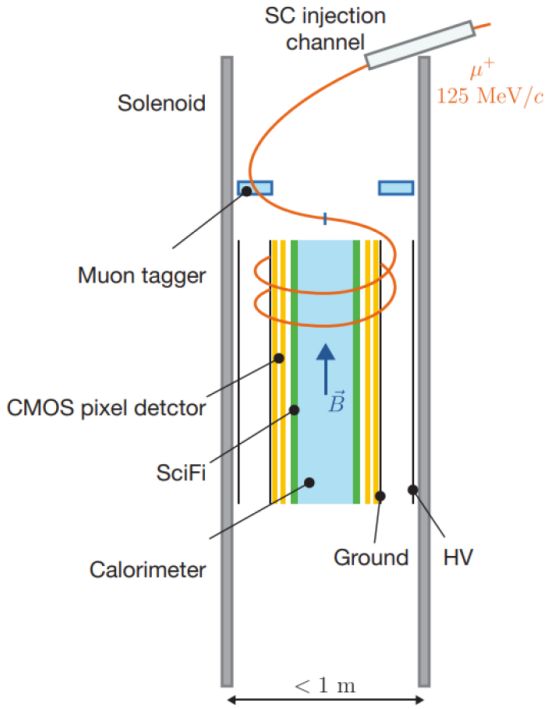
The past ~2 years: progress and updates

- **MuEDM:** a future dedicated muon EDM experiment @ PSI
  - Frozen spin method gives large improvements to sensitivity!

$$\vec{\omega} = -\frac{q}{m}\left[a_\mu \vec{B} + \left(\frac{1}{1-\gamma^2} - a_\mu\right)\frac{\vec{\beta}\times\vec{E}}{c} + \frac{2d_\mu mc}{q\hbar}\left(\frac{\vec{E}}{c} + \vec{\beta}\times\vec{B}\right)\right]$$

g-2 precession $\vec{\omega}_a$ EDM precession $\vec{\omega}_\eta$





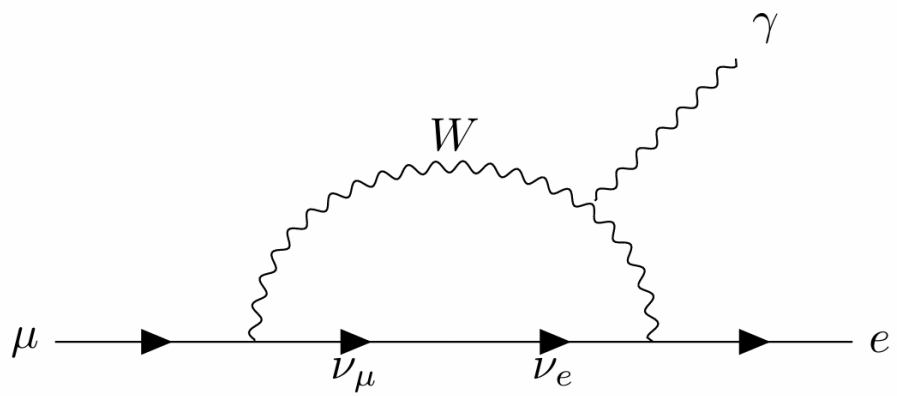
- **MuEDM at PSI:** simulations
  - Setting up early simulation frameworks for muEDM simulation work + 'production-style' scripts to allow non-PSI people to run muEDM code.
  - We also hosted the collaboration meeting earlier this year!

The past ~2 years: progress and updates

- Charged leptons (e, mu, tau) all conserve flavour, but quarks and neutrinos do not.
- Can have CLFV in the SM with neutrino masses (via oscillations) but is heavily suppressed…
- So, search for BSM physics by looking for enhanced CLFV rates!

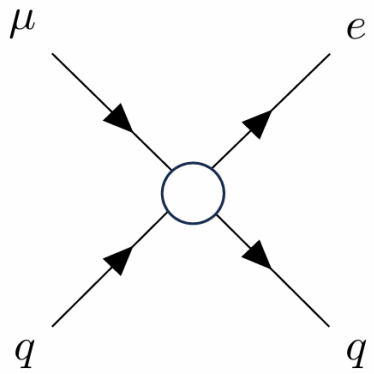
SM (not measurable)

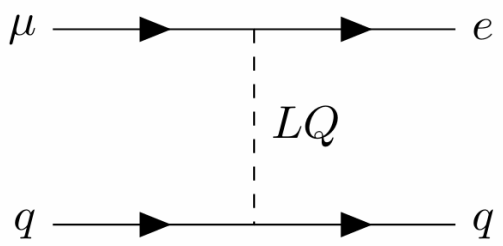
$R(\mu \to e) \propto (\Delta {m_\nu}^2 / {M_W}^2)^2 < 10^{-50}$! [2]



BSM (measurable)

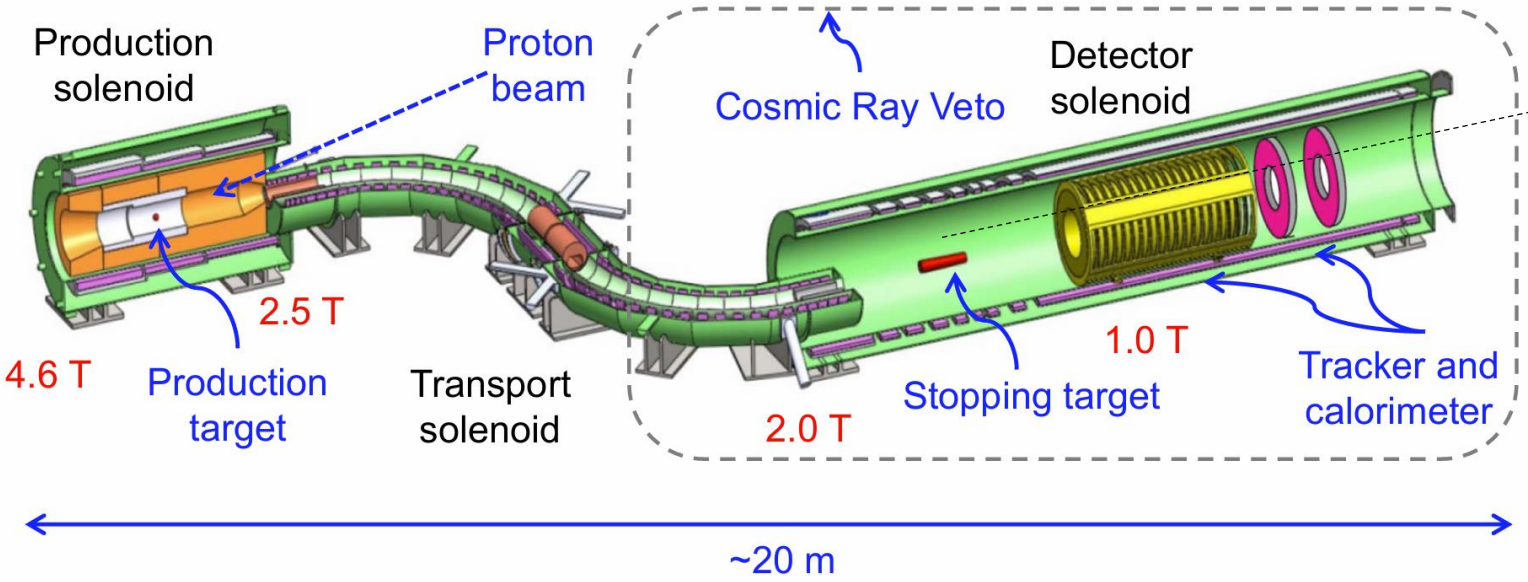
$R(\mu \to e) \sim 10^{-15} - 10^{-17}$ [3]

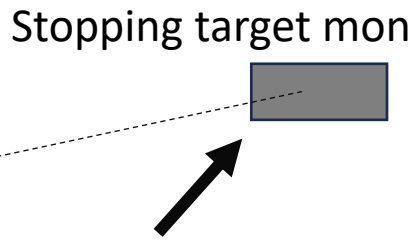




The past ~2 years: progress and updates

- Mu2e experiment searches for muon to electron conversion in Al:
  - Aiming for 4 orders of magnitude better limit vs old measurement (@ SINDRUM)





- UK contribution: the STM, which measures the total # of muons on target
- HPGe detector + $LaBr_3$ detector for complementarity.
- Essential for the signal rate measurement (sets the denominator!)

- **Mu2e:** STM DAQ/hardware work + simulations
  - Only joined this ~ two months ago so not much here!
  - Simulations of multiple scattering peaks in the STM + impact on energy resolution
  - DAQ code to implement efficient data flow with headers (still something of a WIP…)

Future plans

- Muon g-2:
  - Wrapping up leftover bits from Run 2/3 EDM: investigations of alignment, potential fake EDM signal sources, and a high-stats new MC for studying the impact of CBO.

- MuEDM at PSI:
  - Currently unable to access work here, but we have a test beam in Dec + hopefully lots more beam time next year, so planning to go out to help with that!
  - Possible that Liverpool could contribute detectors to Phase 2, dependent on STFC choosing to fund it…

- Mu2e:
  - Continue DAQ/hardware work as needed (lots to do here before it's ready for actual experiment data!) and continue developing/integrating STM simulation into DAQ.

- Outreach:
  - Trying to get something in for the ESF: not sure this'll be successful, but will need volunteers to help run it if it is! Proposal submitted for some combination of talks/exhibitions/activities.