

MuEDM

For all projects :

Key physics deliverables (name up to 5). Be quantitative where relevant/possible.

Please quote the datasets and running/exposure time required for the numbers above.

Environmental cost of construction (in units of tonnes of CO₂ equivalent)

Environmental cost of operation per year (in units of tonnes of CO₂ equivalent)

Estimate of financial costs (provide separate numbers for R+D phase, construction phase and operations phase)

Does your project plan dedicated submission(s) for the ESPPU (if so, give details).

Physics reach in context

EDMs are ~ 0 in the Standard Model. Violate CP \rightarrow can be connected to matter/antimatter asymmetry.

- Appear through new complex parameters in many BSM theories
- Complementary to rest of muon program (g-2 tests chirality flipping interactions, Mu2e/Mu3e/COMET/MEG test flavour violation)

Indirect constraint from scaling the electron EDM limit: $|d_e| < 4.1 \times 10^{-30}$ e.cm: indirect muon limit of $|d_\mu| < 6 \times 10^{-28}$

- BUT assumes minimal flavour violation, which is also not present in many BSM theories

Current *direct* limit on muon EDM: $|d_\mu| < 1.8 \times 10^{-19}$ e.cm (Brookhaven g-2)

- FNAL g-2 should improve this by $\sim x10$, to around $|d_\mu| < \sim 10^{-20}$ e.cm by 2025/6
- JPARC g-2/EDM: targeting $x100$, to $|d_\mu| < 1.5 \times 10^{-21}$ e.cm,
 - Aim to begin data taking before 2030.

The region beyond 10^{-21} e.cm is compelling in terms of sensitivity to BSM

- MuEDM Phase 2 is the only experiment to probe this region,
- reaching $|d_\mu| < 6 \times 10^{-23}$ e.cm ($x3000$ on current limit)

Any EDM induces spin precession parallel to magnetic field

- Sensitivity jump with MuEDM due to first to use “frozen spin” to remove g-2 precession
- High rate of single muons captured in storage magnet

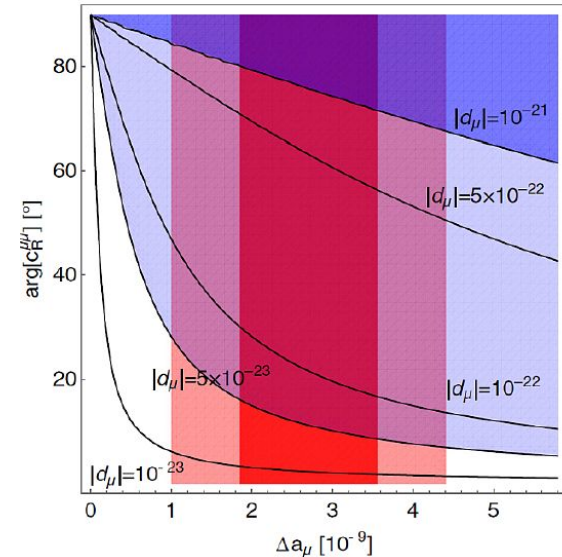


Figure: Contours of d_μ as a function of the anomalous momentum Δa_μ and the phase of the associated Wilson coefficient, from arXiv:2102.08838.

MuEDM Phase 1 (“Demonstrator”)

At PSI, on the piE1 beamline

- 4×10^6 muons / s @ 28 MeV

Physics deliverables:

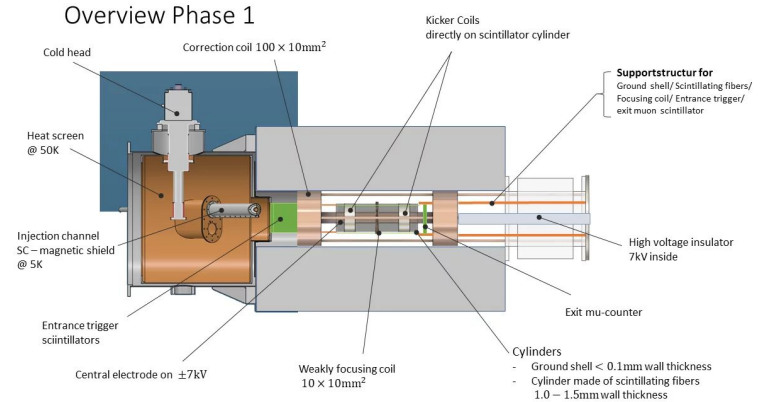
- Proof of frozen spin technique for EDM search
- Could reach sensitivity comparable to FNAL g-2 aim ($\sim 10^{-20}$ e.cm)

Aim to run before HIMB shutdown at PSI (which is 2027/28)

- Redeploy on the Phase-2 beamline after HIMB (2029) to characterise beam
- Not using HIMB beamlines, but cannot run during shutdown

UK involvement

- Simulation work through Leverhulme Professorship & existing CG.
- Solenoid correction coils at the Cockcroft Institute



MuEDM Phase 2

At PSI, on the muE1 beamline

- 1.2×10^8 muons / s @ 125 MeV
- Larger bore storage magnet & new detectors w.r.t. Phase 1

Physics deliverables:

- Sensitivity to muon EDM $|d_\mu| < 6 \times 10^{-23}$ e.cm
- Based on 1 year of physics-quality run time
- Expect to start ~2032

Planned UK involvement:

- HV-MAPS silicon positron tracker + DAQ
- Solenoid / coil work at Cockcroft Institute
- Estimate ~£2M, using synergy with Mu3e Phase-2 work.

