Proton and muon EDM Experiments

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EDM Measurements

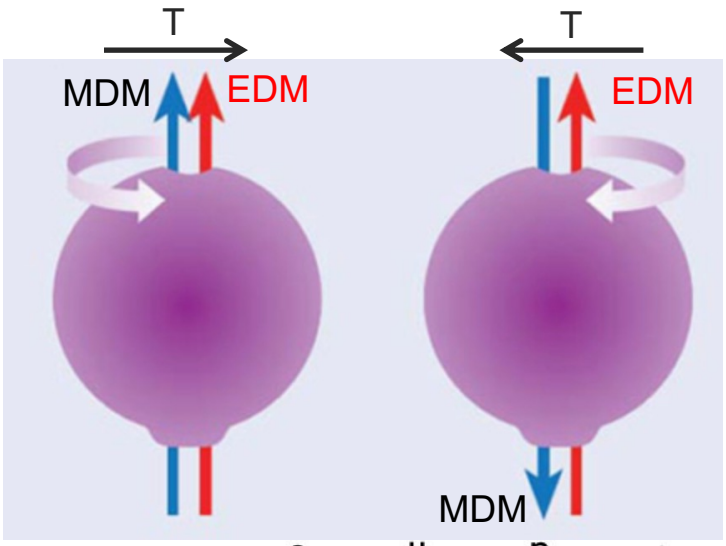
Fundamental particles can have an Electric Dipole Moment

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

EDM

$$\vec{\mu} = g \frac{e}{2mc} \vec{s}$$

MDM



Additional source of **CP violation** (assuming CPT invariance)

Muon EDM:

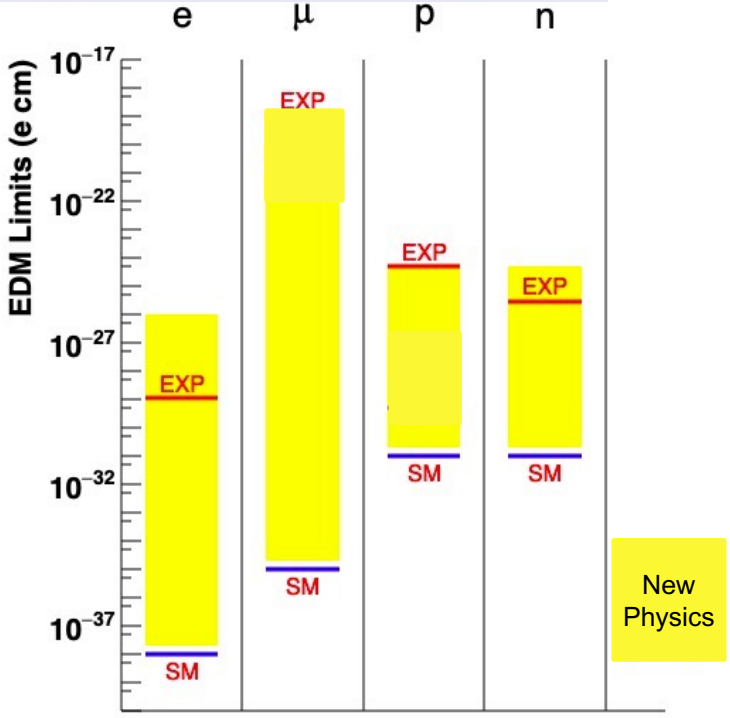
Sensitivity at FNAL $\sim 1\times10^{-20} e.cm$

Sensitivity at PSI $\sim 1\times10^{-24} e.cm$

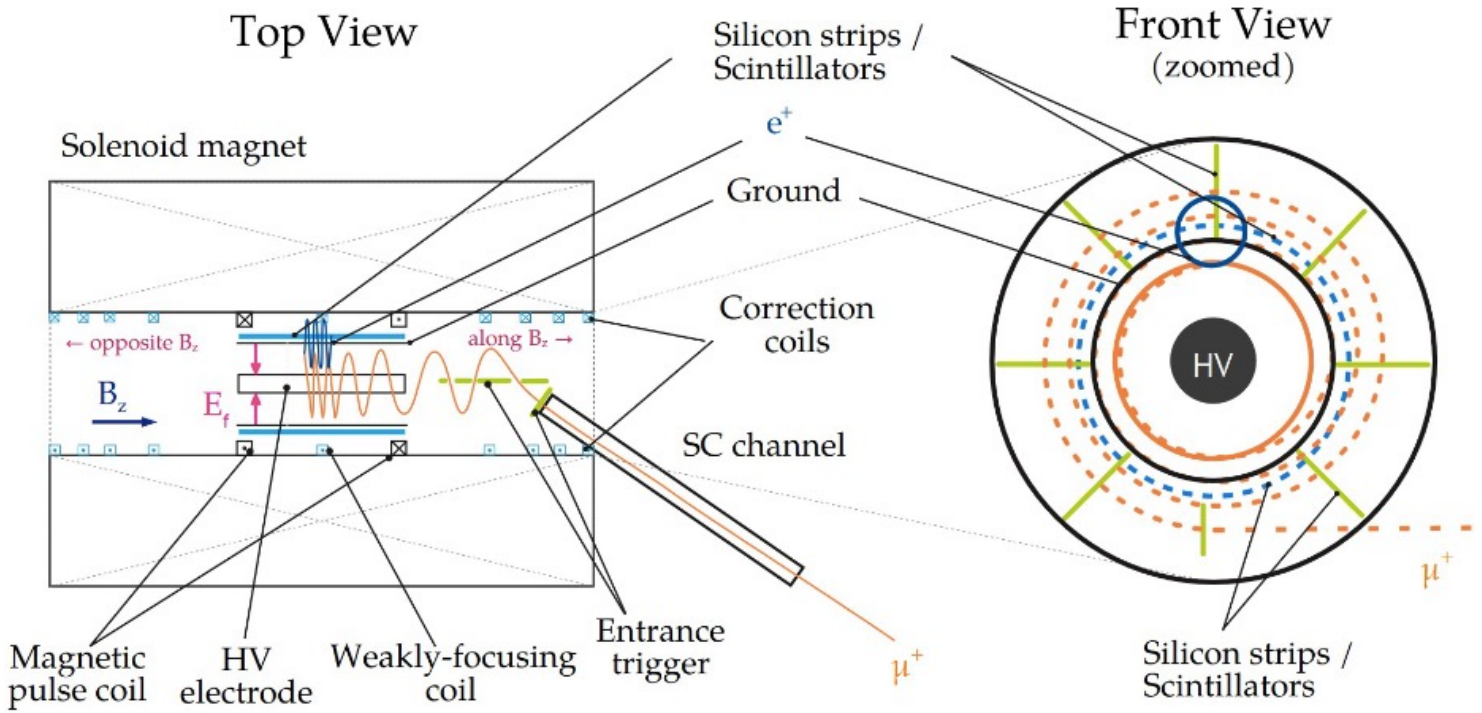
Proton EDM:

Sensitivity at BNL $\sim 1\times10^{-29} e.cm$

Amongst the worlds most precise measurements



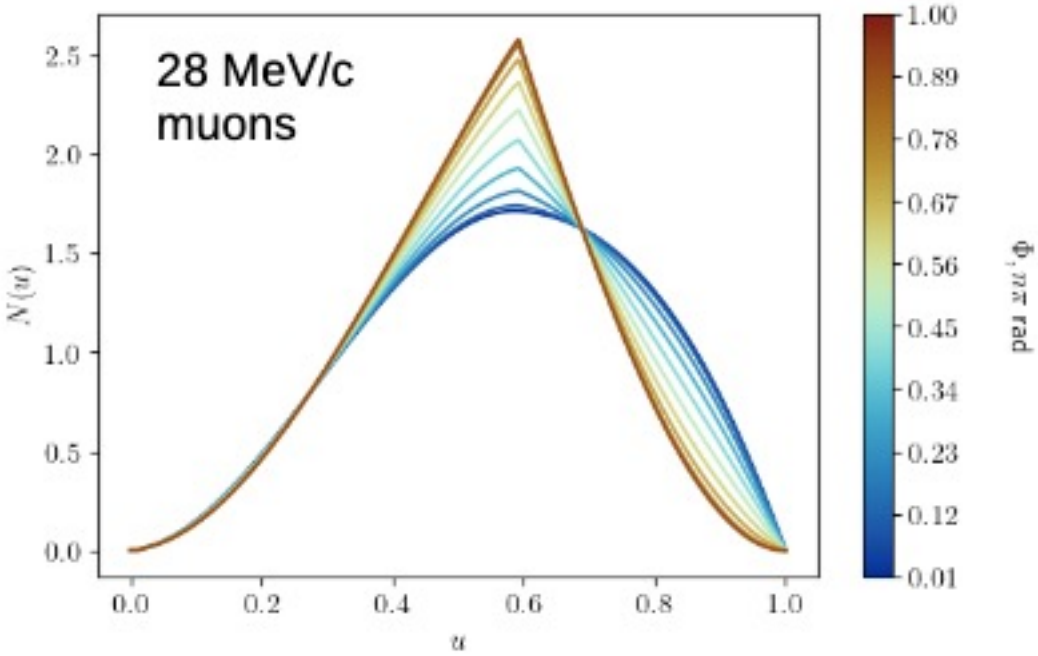
Muon EDM

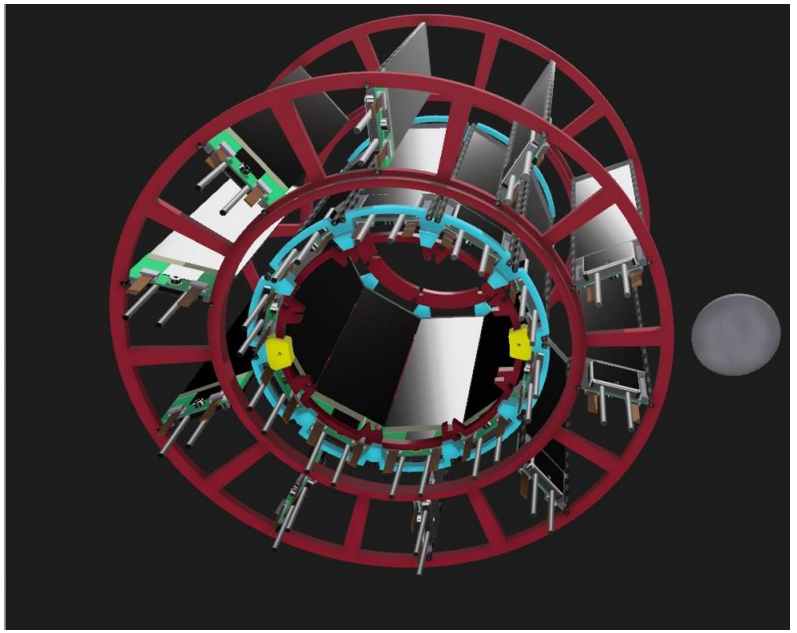


PSI experiment will run in 2 phases
Phase I – demonstrate frozen spin method
Phase II – dedicated muon EDM measurement

Design and build the positron detectors at Liverpool

Positron Measurement @ muEDM



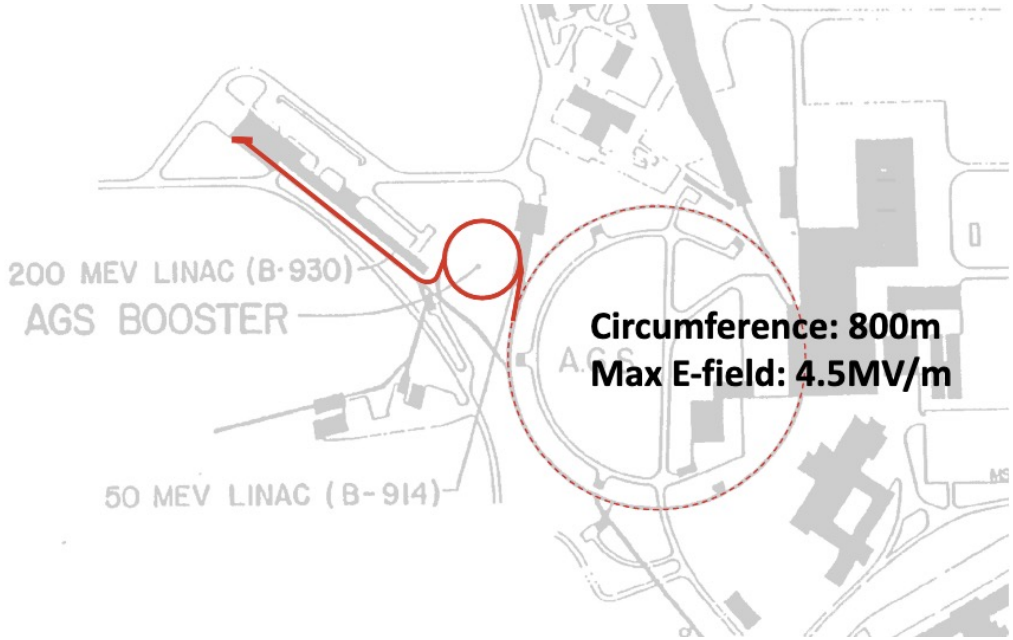


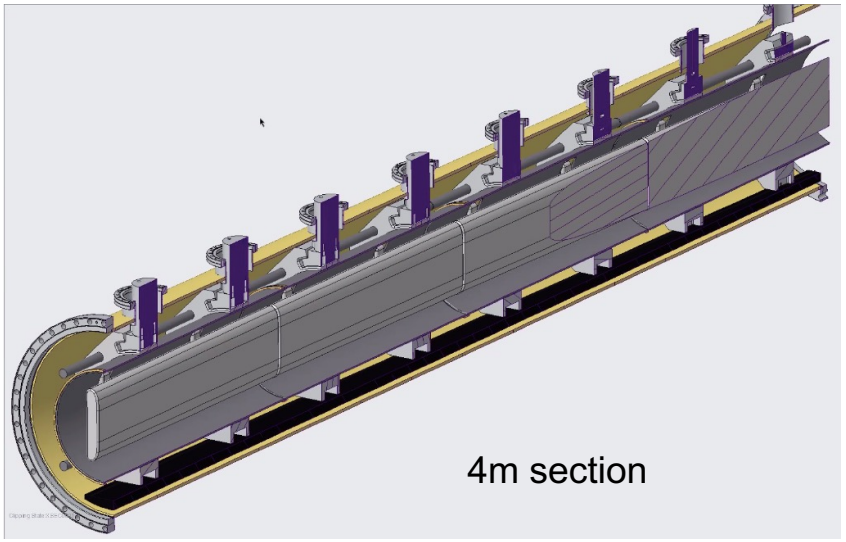
- Need low mass, high precision detectors for momentum and longitudinal angle measurement of decaying positron – use expertise at Liverpool from g-2/Mu3e/LHCb…

- Longitudinal angle tells us about the EDM, and sets the ultimate sensitivity of the experiment

Proton EDM

- **800m** storage ring with simultaneous CW and CCW 0.7GeV proton beams
- Waiting for December 7th for announcement from American funding agency
- E-fields of 4.4 MV/m needed, with extremely challenging uniformity (<10μm tolerances).
- Just signing **$300k** contract with Brookhaven National Laboratory to develop and manufacture electrostatic deflectors.





Proton EDM at Brookhaven National Lab

Statement from BNL management

“University of Liverpool's (UoL) is internationally recognized for its precision mechanics in particle and nuclear physics experiments.”

“UoL excels in machining aluminium and understands how to cut and apply cryo/heat treatment to mitigate mechanical distortions during vacuum bakeout.”

Conclusions

Muon EDM:

- Experiment is approved at PSI, with test beam measurements taking place in 2024

- In process of seeking funding in the UK

Proton EDM:

- If a positive outcome from P5 in the US this week we expect a 10 year development programme towards physics operation at Brookhaven

Backups

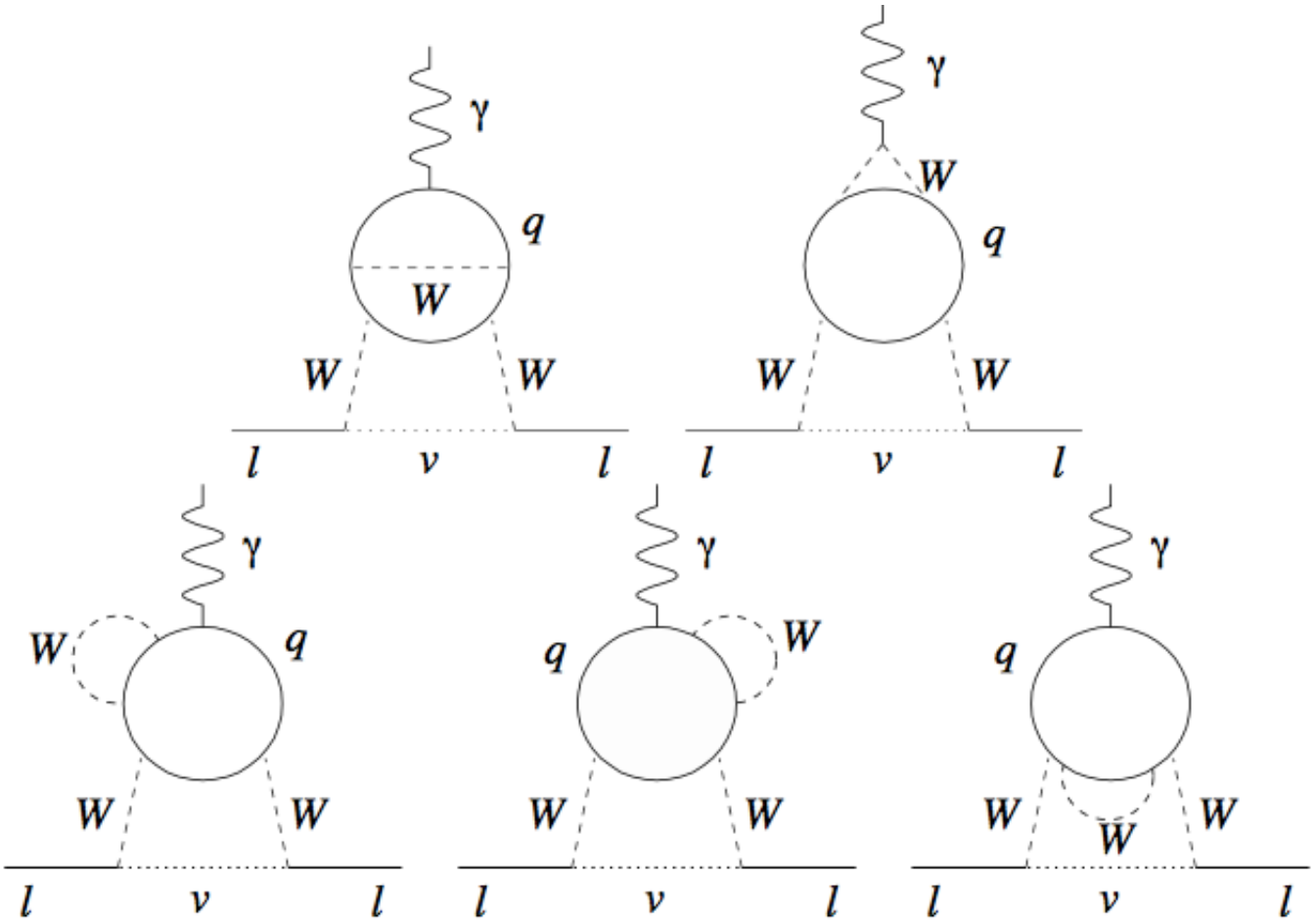
Current limits

	Current Limit on $\|d\|$ (e·cm) (95% C.L.)	Standard Model Value (e·cm)	Highest Limits Interesting In Other Models (e·cm)
e	$1.8(1.2)(1.0)\cdot 10^{-27}$	10^{-38}	$\lesssim 10^{-27}$
μ	$< 1.05 \cdot 10^{-18}$	$\lesssim 10^{-35}$	$\lesssim 2 \cdot 10^{-25} \cdot \left(\frac{m_\mu}{m_e}\right)^2$
τ	$< 3.1 \cdot 10^{-16}$	$\lesssim 10^{-34}$	$\lesssim 1.7 \cdot 10^{-24} \cdot \left(\frac{m_\tau}{m_e}\right)^2$
p	$-3.7(6.3) \cdot 10^{-23}$	$\sim 10^{-31}$	$\lesssim 6 \cdot 10^{-26}$
n	$< 6.3 \cdot 10^{-26}$	$\sim 10^{-31}$	$\lesssim 6 \cdot 10^{-26}$

Table 1.1: Current limits and Standard Model predictions for $|d|$ of electrons (e) [1], muons (μ) [2], taus (τ) [3], protons (p) [4] and neutrons (n) [5].

From Sossong's thesis, page 2 (28 in document)

SM Contributions



From Sossong's thesis, page 5 (31 in document)
SM contribution all 3r ~10^{-35} e.cm