Proton EDM Storage Ring Experiment

William Morse

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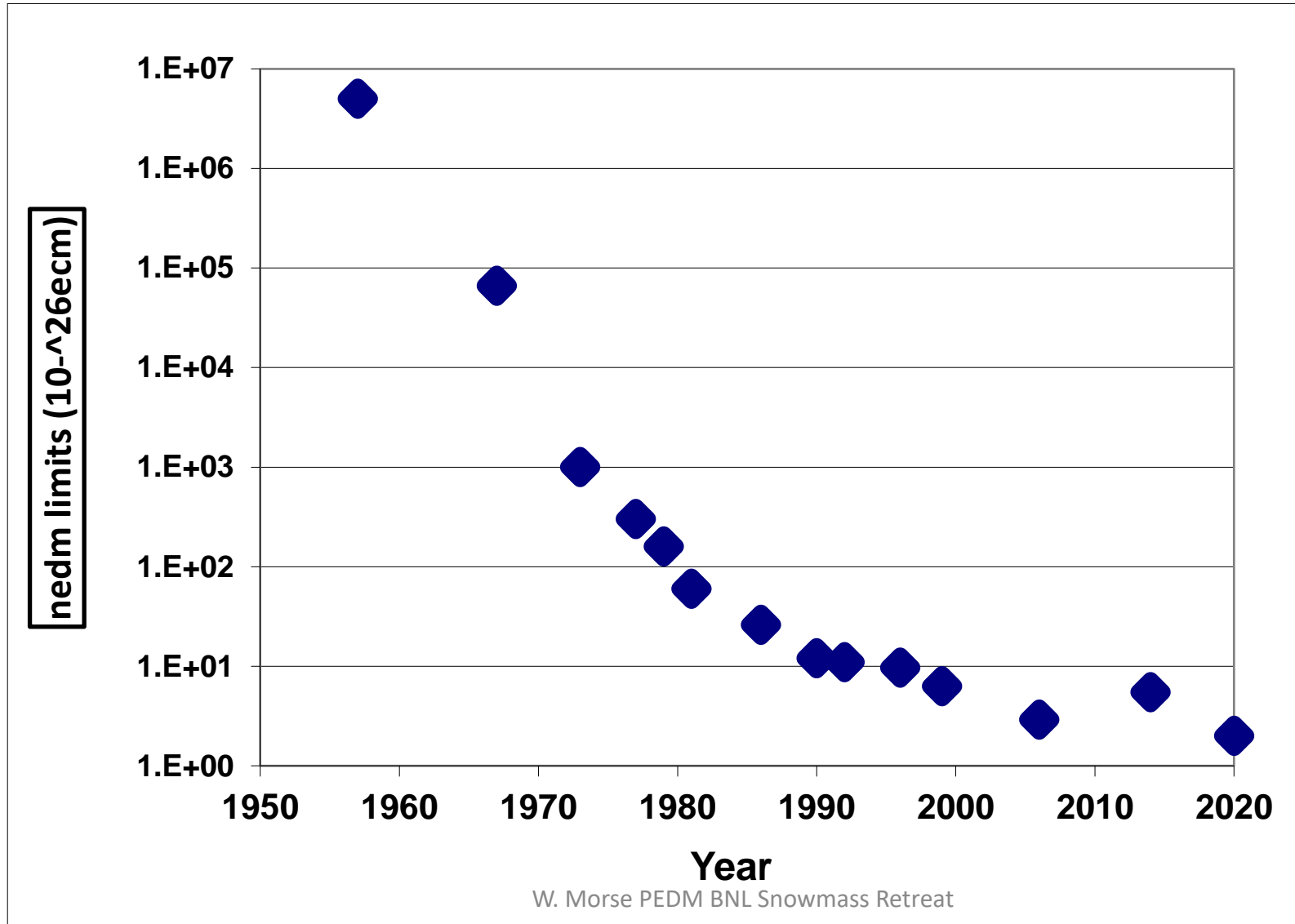
Proton EDM Storage Ring Experiment

- Neutron edm experiment sensitivity has been stuck at $10^{-26} e \cdot cm$.

- Due to statistics, not systematics.

- We can get 10^{11} polarized protons from the LINAC/Booster.

- Our requirement is 2×10^{10} polarized protons.

- Magic momentum = 0.7 GeV/c (233 MeV kinetic energy).

- Excellent polarimeter analyzing power at this energy.

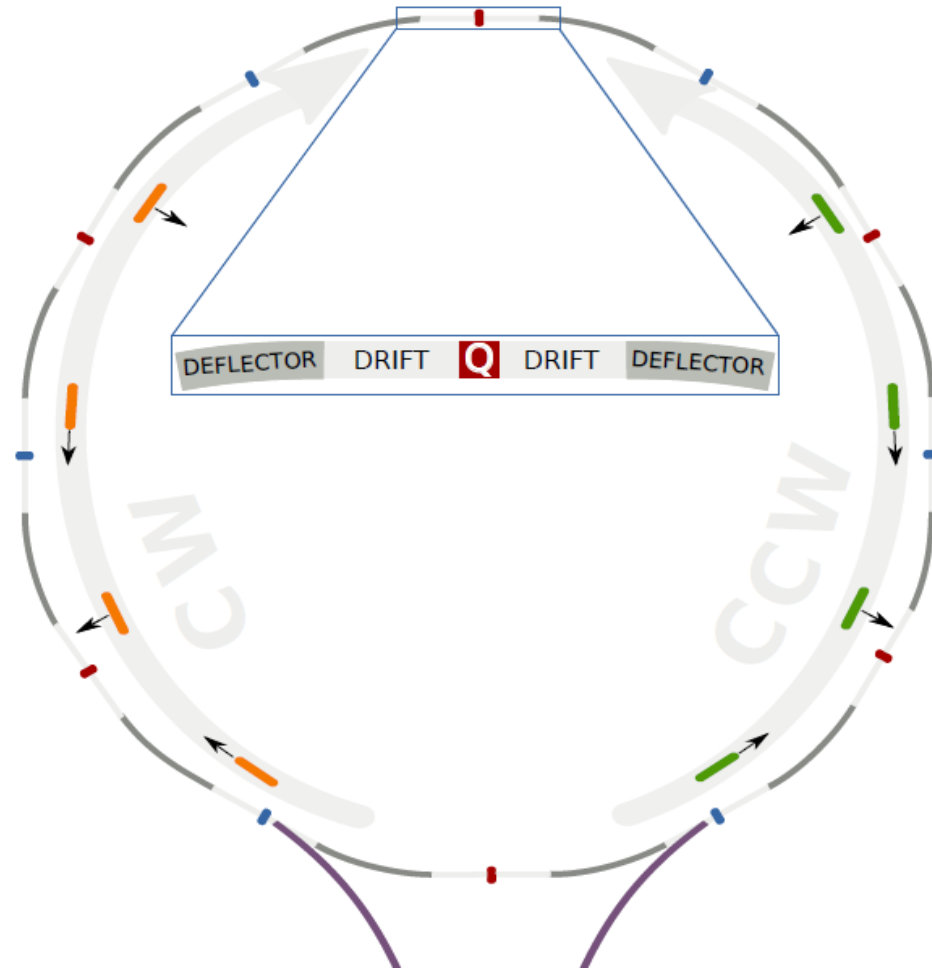- Our proton edm experiment targeted sensitivity is $10^{-29} e \cdot cm$.

Magic Momentum

- Muon 3.1 GeV/c, Proton 0.7GeV/c
- No spin precession due to MDM in electric fields
- $\beta = \sqrt{\dfrac{2}{g}}$

$$\frac{d\hat{\beta} \cdot \vec{s}}{dt} = -\frac{e}{m}\vec{s}_P \cdot \left[G\hat{\beta} \times \vec{B} + \left(\frac{g\beta}{2} - \frac{1}{\beta} \right) \frac{\vec{E}}{c} \right]$$

Neutron edm exps are at $10^{-26} e \cdot cm$.

PEDM

DEFLECTOR   DRIFT   Q   DRIFT   DEFLECTOR

PEDM

- Proton edm sensitivity $10^{-29} \mathrm{e} \cdot \mathrm{cm}$.
- Improves the sensitivity to θ_{QCD} by three orders of magnitude, a critical parameter related to axion physics. Combination of ARIADNE and hadronic EDM exps can exclude axions from a large frequency range; critical to axion dark matter searches.
- New Physics reach at 10^3 TeV mass scale.
- Probes CP-violation in the Higgs sector with best sensitivity: $30 \times$ more sensitive compared to eEDM; spin flip proportional to mass. W. Marciano Feb. 24, 2020 talk at BNL.

PEDM

- Highly symmetric, magic momentum storage ring lattice in order to control systematics.
  - Proton "magic momentum" = 0.7 GeV/c. Muon "magic momentum" = 3.1 GeV/c.
  - Proton polarimetry peak sensitivity at the magic momentum.
  - Electric bending, magnetic focusing is optimal.
  - Stores simultaneously CW and CCW bunches.
  - Stores simultaneously longitudinally and radially polarized bunches.
  - 24-fold symmetric storage ring.
  - Alternating focusing and de-focusing elements fill to fill.

PEDM

- Circumference = 800m.
  - $E = 4.4$ MV/m.
  - Conservative electric field.
- 10 years to first physics publication.
- Sensitive to vector dark matter/dark energy models [1].
  - VDM/DE signal proportional to $\beta = v/c$. Magic momentum pEDM ring $\beta = 0.6$.
- PEDM experiment is highly complementary with molecule edm experiments [2].
- Molecule edm: many different effects, "sole source analysis", unknown cancellations [3].
- After proton edm, add magnetic bending and do Deuteron/He3 edm measurements.
- Deuteron and He3 edm measurements have complementary physics to proton edm.

PEDM

1. P.W. Graham *et al., Storage ring Probes for Dark Matter and Dark Energy, PRD103, 055010, 2021.

2. N. Hutzler, Developing New Directions in Fundamental Physics 2020, 4-6 Nov. 2020.

3. T. Chupp, Developing New Directions in Fundamental Physics 2020, 4-6 Nov. 2020; T. Chupp et al., Rev. Mod. Phys. 91, 015001 (2019).