

Test of Standard Model and Search for Physics Beyond Opportunities for Fundamental Physics using Small-scale Storage Ring Exp'ts

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The physics / basic idea of the LOI¹

Goal:

Investigation of **symmetries** of SM & Cosmology (P, T and CP; PQ (Peccei-Quinn)), using **polarized charged particles** and precision **storage rings**:

- ▶ P-V and T-V (CP-V): Electric Dipole Moments of particles (p , d , ^3He) \Leftrightarrow Baryon asymmetric Universe
- ▶ PQ: Oscillating EDMs \Leftrightarrow Axion/ALP \Leftrightarrow Dark Matter
- ▶ T-V and P-C: microscopic T-violation

Communities:

- ▶ **nuclear/hadron** (polarized beams, targets, polarimetry, ...)
- ▶ **particle and astroparticle physics** (particle property, beyond SM particles, baryogenesis, ...)
- ▶ **accelerator** (precision storage rings, ...)

Frontiers:

- ▶ Rare Precision and Accelerator Physics

¹see https://www.snowmass21.org/docs/files/summaries/RF/SNOWMASS21-RF3_RF0_Frank_Rathmann-008.pdf

What is required for the LOI to succeed?

Proton EDM: goal sensitivity: 1×10^{-29} e cm

- ▶ **All-electric storage ring** with polarized CW and CCW beams:
 - ▶ ≈ 700 MeV/c (*magic momentum*, frozen spin)
 - ▶ spin-coherence time > 1000 s
 - ▶ *non-destructive* sampling polarimetry, ...
- ▶ Also used for axion/ALP search (oscillating EDM)
- ▶ **Strategy:** staged approach

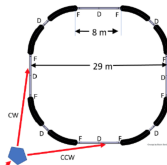
Stage 1

- ▶ precursor exp't



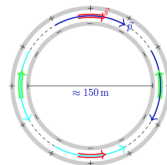
Stage 2

- ▶ prototype ring



Stage 3

- ▶ dedicated ring



Deuteron EDM:

- ▶ Storage ring with combined E - and B -fields required

What do you plan to do during Snowmass?

Submission of contributed paper based on CERN Yellow Report²:

- ▶ *Storage Ring to Search for Electric Dipole Moments of Charged Particles – Feasibility Study*

Continuation of work on design of prototype ring:

- ▶ **All-electric (non-magic momentum):** 1st stage \Rightarrow R&D
- ▶ **combined E/B :** 2nd stage \Rightarrow science
- ▶ Host site independent

Timeline:

- ▶ **now (COSY) + 5 yrs (prototype) + 10 yrs (final ring)**

²F. Abusaif et al., <https://arxiv.org/abs/1912.07881> (2019).

What do you hope to get out of Snowmass?

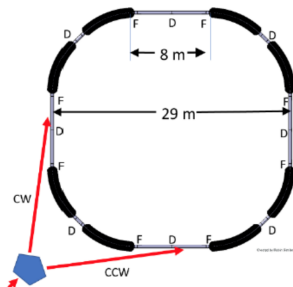
- ▶ **Strong endorsement of science case**
 - ▶ like in Update of European Strategy for Particle Physics (ESPP), June 2020³
- ▶ **Support toward unification of international efforts**

³see Deliberation Document on 2020 Update of ESPP, The European Strategy Group,
<http://cds.cern.ch/record/2721371/files/CERN-ESU-016-2020%20Deliberation%20Document%20European%20Strategy.pdf>

Challenges

Prototype ring (Stage 2):

- ▶ All-electric ring (high field, field homogeneity and stability)
- ▶ E/B combined bending
- ▶ Storage time
- ▶ CW-CCW injection and operation
- ▶ Spin-coherence time in electric machine
- ▶ Polarimetry (efficient, sampling, *non-destructive*)
- ▶ Optimum orbit control
- ▶ Systematic effects from magnetic moments
- ▶ Multi-bunch approach to co-magnetometry
- ▶ Stochastic cooling



Conclusion

Test of Standard Model and Search for Physics Beyond

- ▶ Excellent perspectives for nuclear/hadron, astroparticle physics and accelerator technology
- ▶ **Search for static charged particle EDMs** (p , d , ^3He)
 - ▶ EDMs \rightarrow probes of CP-violating interactions
 - ▶ Matter-antimatter asymmetry of the Universe
- ▶ **Search for oscillating EDMs**
 - ▶ Axion-gluon coupling
 - ▶ Dark matter search
- ▶ **Staged approach** with prototype EDM storage ring to face challenges in accelerator technology:
 - ▶ **Primary purpose of PTR**
 - ▶ Resolve open issues before precision EDM ring is targeted in Stage 3
 - ▶ host sites considered: CERN or COSY