





Simulations of Beam Dynamics of Prototype EDM Storage Ring

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Physics Case:

- Matter antimatter asymmetry can be explained by CP- violation
- Permanent electric dipóle moment (EDM) is fundamental property of particles (like mass, charge, magnetic moment) **Existence of EDM only possible if violation** of time reversal and parity symmetry.



Strategy:

1. Precursor Experiment @ COSY Storage Ring Forschungszentrum Jülich Germany

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Prototype proton EDM Storage Ring (PTR)

3. All electric Storage ring

Prototype EDM Storage Ring:

Ring will be operated in two modes:

- Electrostatic bendings (at T=30 MeV)
- Electromagnetic bendings (at T=45 MeV)

Goals

- Beam injection with multiple polarization states and for longer time. (> 1000 sec)
- Develop key technologies beam cooling, deflector, beam position monitors, magnetic shielding....
- Perform EDM measurement

 D_X

 D_{X}

Simulations :

(a) Strong lattice

(b) Medium lattice

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Four Lattice with different focusing strength generated by MADX.

Estimation of Beam Loss Rates:

1.Hadronic Interactions (HI) 2.Coulomb Scatterings (CS) 3.Energy Loss straggling (ELS) 4.Intrabeam Scatterings (IBS)

Residual Gas & Target:

Gases composition $H_2: N_2$ with 80:20 • Nitrogen equivalent pressure $P_{eq} = 2.8 \times 10^{-11} torr$



Rest Gas density Carbon target density $n_{rg} = 5.30 \times 10^5 \ atoms/cm^3$ $n_t \sim 2 \times 10^{12}$ atoms /cm²

Results :

Total beam loss rates $\left(\frac{1}{\tau}\right)_{Tot} = \left(\frac{1}{\tau}\right)_{HI} + \left(\frac{1}{\tau}\right)_{CS} + \left(\frac{1}{\tau}\right)_{ES} + \left(\frac{1}{\tau}\right)_{IBS}$

Beam loss rates for residual and target for all four lattices

Energy loss straggling isn't contributing theoretically in beam loss rates



Lattice	HI $(10^{-6}s^{-1})$	$\frac{\text{CS}}{(10^{-4}s^{-1})}$	$(10^{-4}s^{-1})$	$(1/\tau)_{tot}(10^{-4}s^{-1})$	$ au_{tot}(s)$
Strong	2.14	6.46	2.34	8.82	1133
Medium		20.21	2.10	22.34	447
Weak		57.48	1.99	59.49	168
Weaker		115.87	1.90	117.79	85

Summary:

- Preliminary design of prototype EDM ring
- Most dominating effect is Single Coulomb
- Scatterings
- Lattice with $\beta_{y-max} \leq 100 m$ is preferable for longer beam lifetime.

References:

- 1. F. Hinterberger. Beam-Target Interaction and Intrabeam Scattering in the HESR Ring.Technical Report JUEL- 4206, Forschungszentrum Jülich GmbH (Germany), Feb 2006.
- 2. F. Abusaif et al., Storage ring to search for electric dipole moments of charged particles.Feasibility Study. CERN Yellow Reports: Monographs, Geneva. Geneva: CERN. CERN, Jan 2019

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