Search for Electric Dipole Moments at COSY in Jülich

Closed-Orbit and Spin Tracking Simulations

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Motivation

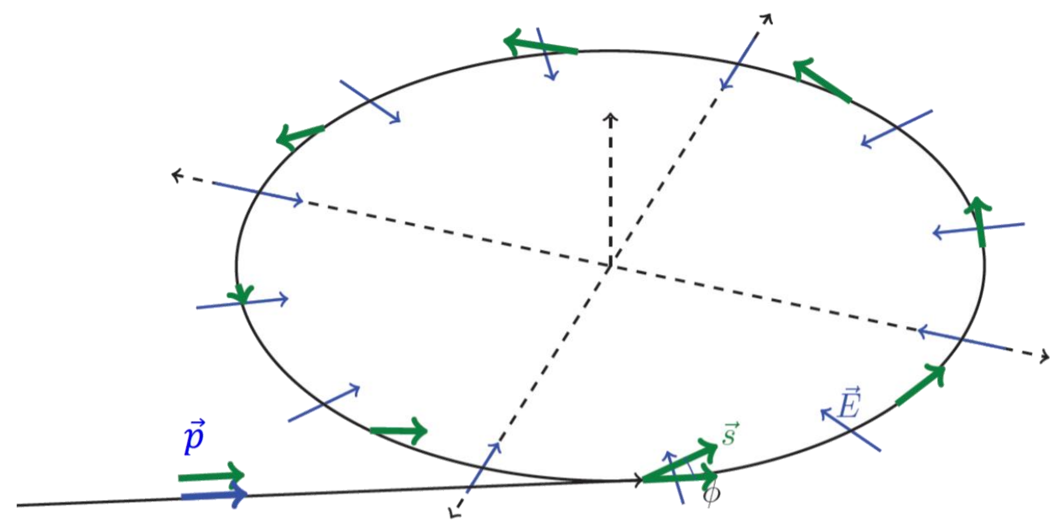
Basic idea of measuring an EDM:

- Inject particles with $\vec{p} \parallel \vec{S}$
- Apply radial electric field
- For $\vec{d} \neq 0$: spin rotates out of horizontal plane
- Measure: build-up of vertical polarization ($\phi \propto |\vec{d}|$)

$$\frac{d\vec{S}}{dt} = \vec{S} \times \vec{\Omega}_{MDM} + \vec{S} \times \vec{\Omega}_{EDM}$$

$$\vec{\mu} = 2(G+1) \cdot \frac{e}{2m} \vec{S}$$

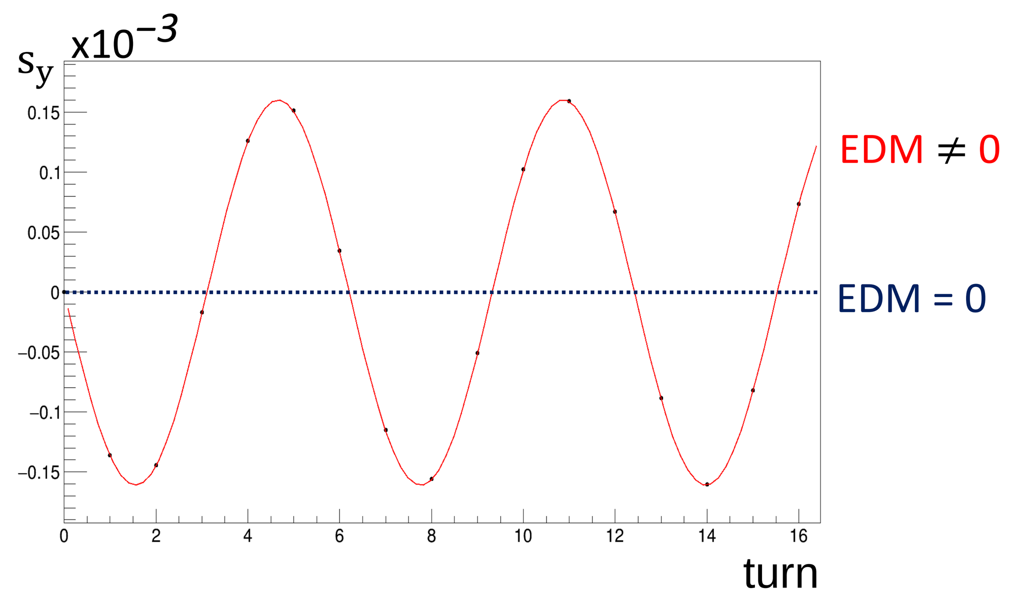
$$\vec{d} = \eta \cdot \frac{e}{2mc} \vec{S}$$

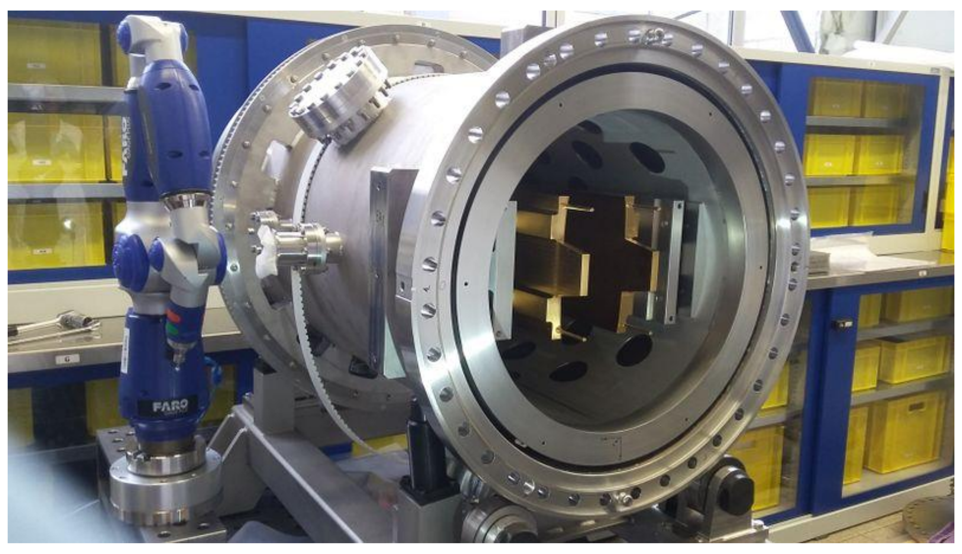


Wien filter method

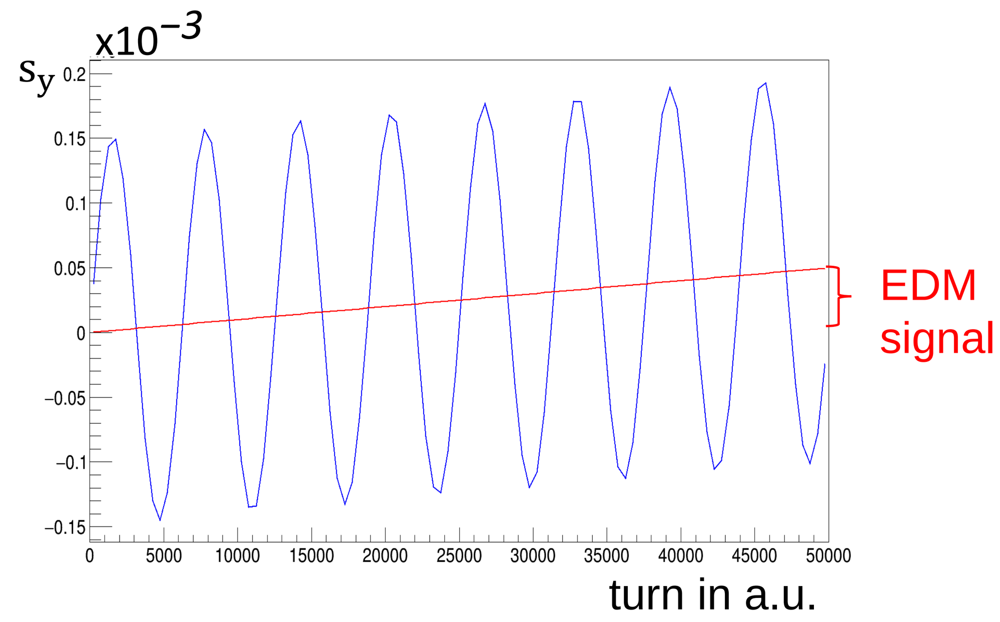
- Vertical fields
- $\vec{S} \parallel \vec{p}$
- Spin rotates in horizontal plane
- $\vec{d} \neq 0$: vertical spin build-up

without Wien filter: No net EDM effect



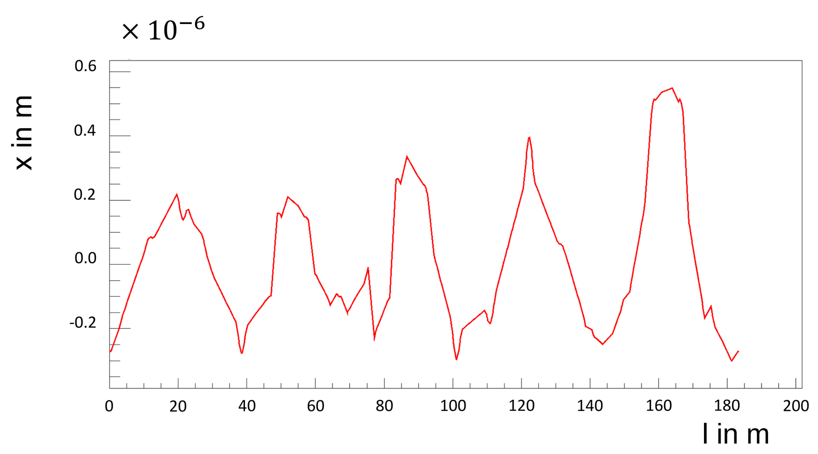


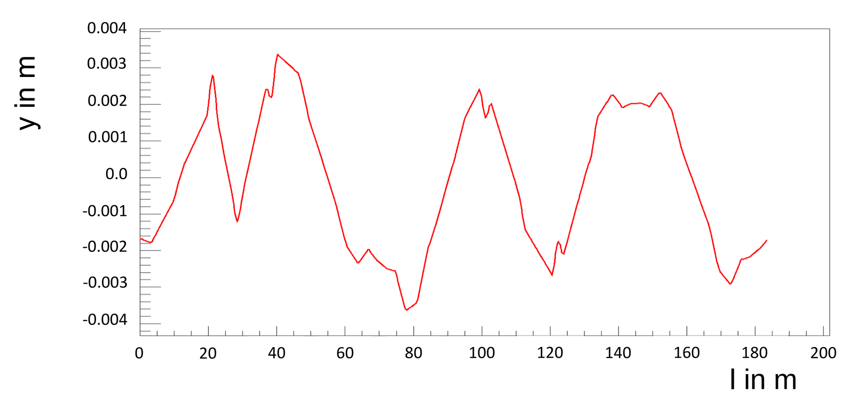
with Wien filter: Net EDM effect

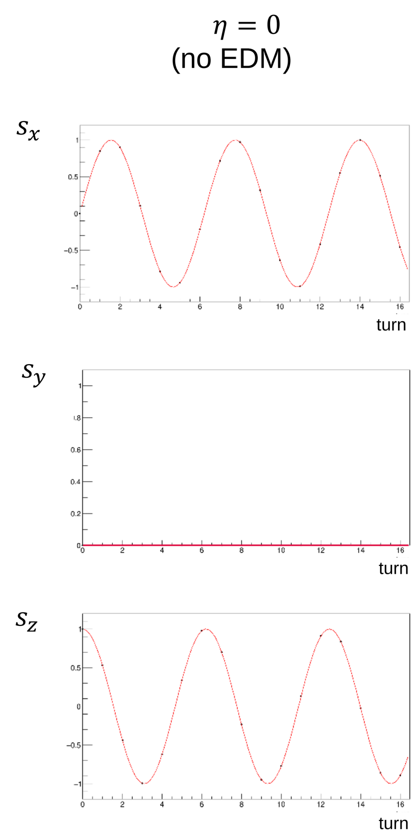


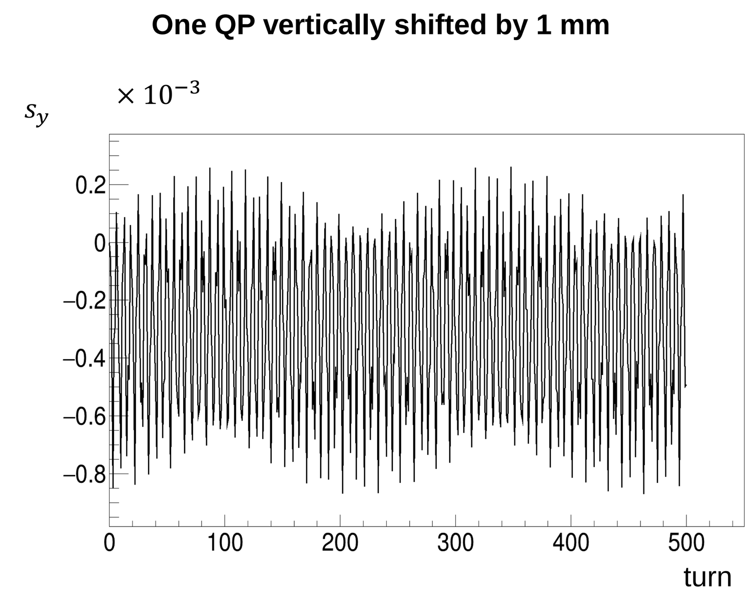
Misalignment of quadrupoles

- Disturbed closed-orbit due to QP misalignment
- Spin sees radial magnetic field
- Radial magnetic fields lead to vertical spin build-up

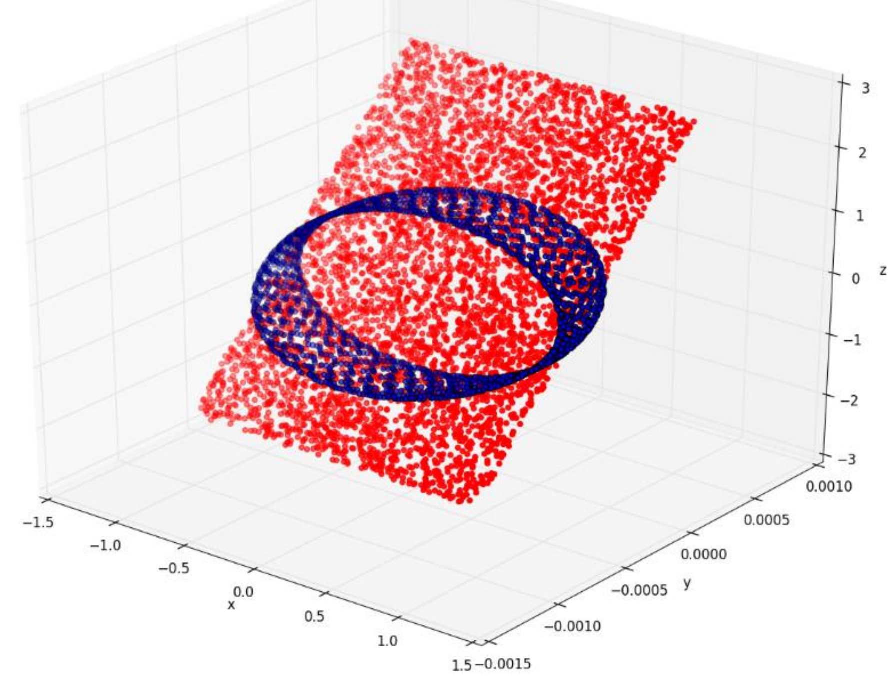






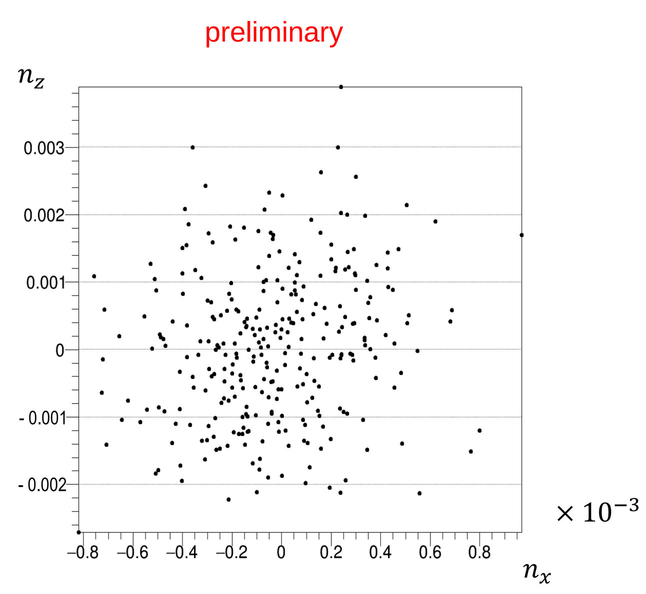


Invariant spin axis



Determine **best-fit plane** and find **average spin rotation axis**

- 300 sets of random quadrupole misalignments
- Calculate invariant spin axis for each setting
- $RMS_{n_z} \approx 0.001$
  $\rightarrow \sigma_{EDM} = 3 \cdot 10^{-18}\ e \cdot cm$



- Horizontal projection of invariant spin vectors
- Vertical component close to 1.0
- Small deviations in horizontal plane