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 \( (\phi \propto |\vec{d}|) \)

\[
\frac{d\vec{S}}{dt} = \vec{S} \times \vec{H}_{\text{MDM}} + \vec{S} \times \vec{H}_{\text{EDM}}
\]
\[
\vec{\mu} = 2(G + 1) \cdot \frac{e}{2m} \vec{S}
\]
\[
\vec{d} = n \cdot \frac{e}{2mc} \vec{S}
\]

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
- \( \text{RMS}_{xz} \approx 0.001 \)
  \( \Rightarrow \sigma_{\text{EDM}} = 3 \cdot 10^{-18} \text{ e } \cdot \text{cm} \)
- Horizontal projection of invariant spin vectors
- Vertical component close to 1.0
- Small deviations in horizontal plane