Magnetic Field/Spin Transport Q&A

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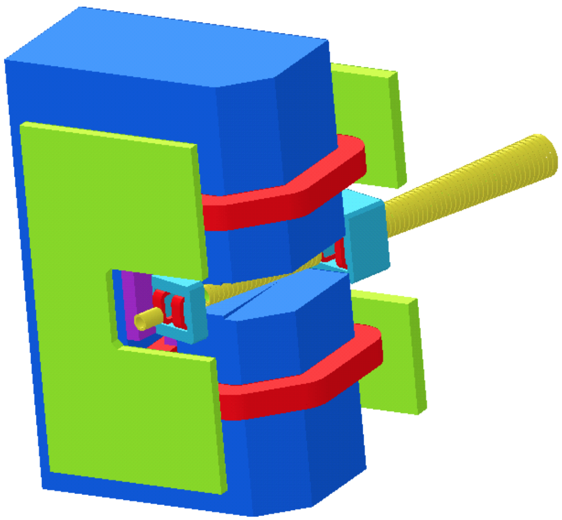
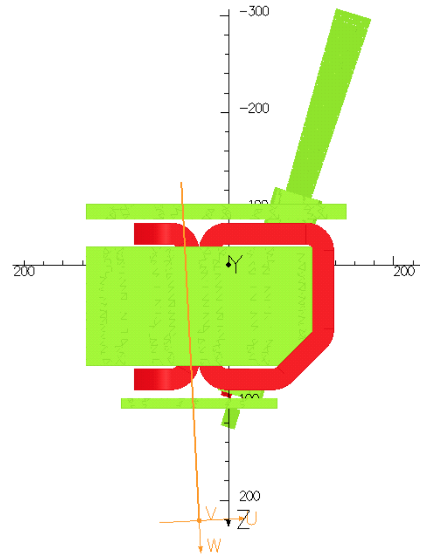
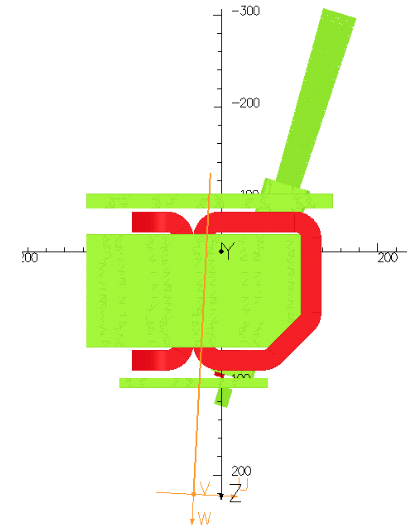


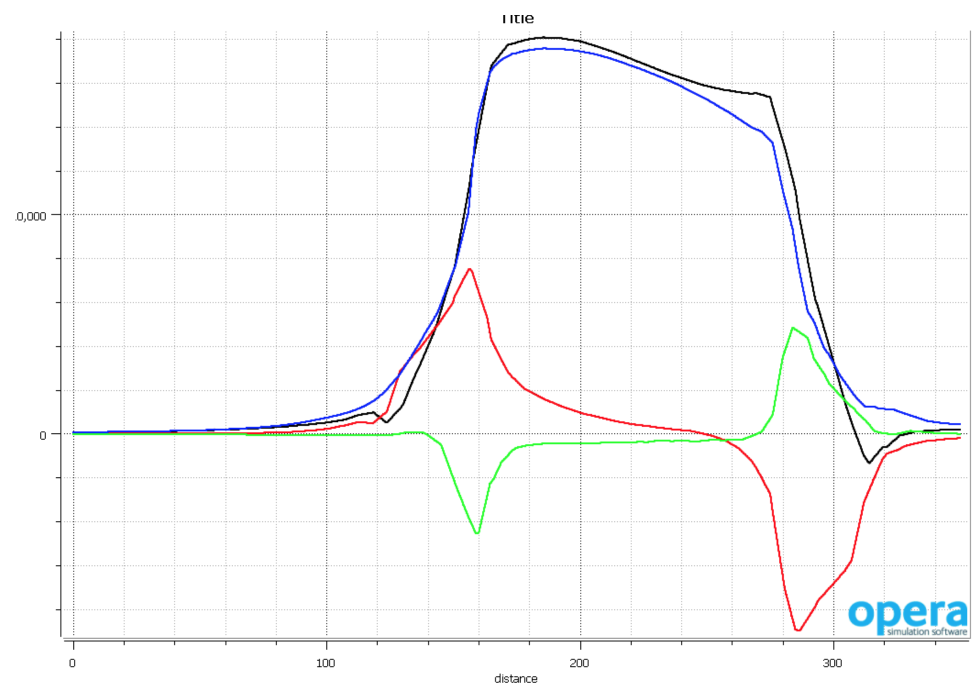




$$\int B_{\perp} dL = 2.39\ T \cdot m$$

$$\int B_{||} dL = 2500\ G \cdot cm(+3^{\circ})$$

$$\int B_{||} dL = -7500\ G \cdot cm(-3^{\circ})$$



Spin Transport

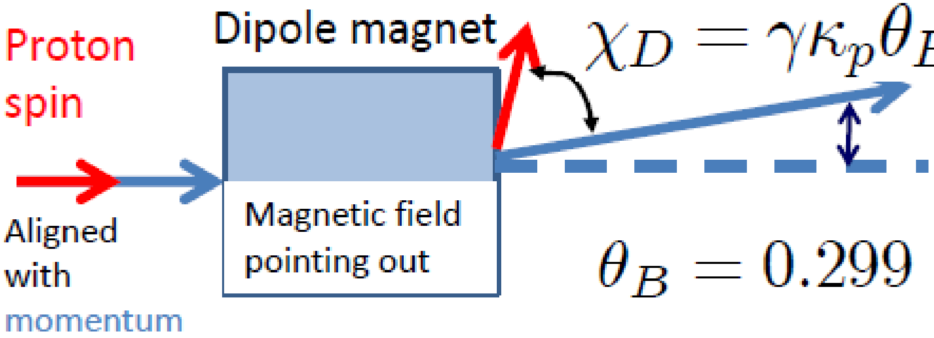
$$\frac{d\mathbf{S}}{dt} = \frac{e}{m\gamma}\mathbf{S} \times \left[\frac{g}{2}\mathbf{B}_{\|} + \left(1 + \gamma\left(\frac{g}{2} - 1\right)\right)\mathbf{B}_{\perp}\right]$$

Note: Precession angle relative to trajectory for B_perp is

$$\chi_{\perp} = \gamma\kappa\theta$$

For a longitudinal component of field, trajectory does not precess, but spin precesses by angle proportional to kappa

Systematic for bend angles



$$\chi_D = \gamma \kappa_p \theta_B$$

$$\theta_B = 0.299 \times \frac{\int B \cdot dl}{\mathrm{p}}$$

$P_y^{pp} = P_t$

$P_x^{pp} = P_l \sin\chi_D$

Ideally χ_D =90 deg, for Q^2 = 12 need $\int Bdl = 2.7\mathrm{Tm}$

Spin transport is more complicated due to fringe fields.
Good approximation for spin precession is geometric model:

Dispersive plane (out-of_plane angle)

$$\chi_D = \gamma \kappa_p (\theta_B + \theta_{tar} - \theta_{fp})$$

Non-Dispersive plane (in-plane angle)

$$\chi_{ND} = \gamma \kappa_p (\phi_{tar} - \phi_{fp})$$

$$P_x^{pp} = P_t \cos \chi_{ND} + P_l \sin \chi_{ND}$$

$$P_y^{pp} = (P_t \sin \chi_{ND} - P_l \cos \chi_{ND}) \sin \chi D$$

$$\frac{P_t}{P_l} = \frac{1+\frac{P_x^{pp}}{P_y^{pp}} \sin\chi_D \cot\chi_{ND}}{1-\frac{P_x^{pp}}{P_y^{pp}} \sin\chi_D \tan\chi_{ND}} \tan\chi_{ND}$$

D << 1 then $$\frac{P_t}{P_l} = \chi_{ND} + \sin\chi_D \frac{P_x^{pp}}{P_y^{pp}}$$

minant systematic error from χ_{ND}

$$\Delta(\frac{P_t}{P_l}) = \gamma\kappa_p \Delta(\phi_{tar} - \phi_{fp})$$

Q^2 = 12 $$\Delta(\mu_p \frac{G_E}{G_M}) = 80 \times \Delta(\phi_{tar} - \phi_{fp})$$

Systematic from ϕ_{pp}

Know ledge of the ϕ_{pp} = 0 plane relative to the elastic reaction plane is one of the leading systematics.

$$\Delta\phi_{pp} = \frac{1}{\sin\theta_{pp}}\sqrt{\Delta\theta_x^2 + \Delta\theta_y^2}$$

For Q^2 = 12 the FOM peaks at θ_{pp} = 3 deg

$$\Delta\theta_x = \Delta\theta_y = 0.1\text{mr then } \Delta\phi_{pp} = 0.0026$$

$$f^+ - f^- = \sqrt{(P_t^{pp})^2 + (P_l^{pp})^2}\,\sin(\phi_{pp} + \frac{P_t^{pp}}{P_l^{pp}})$$

So shift in ϕ_{pp} leads to a shift in the ratio which is magnified by the kinematic factors

$$\Delta\mu_p \frac{G_E}{G_M} = 6 \times \Delta\phi_{pp}$$

For resolution, we would like the angular resolution to be the same as for the Coulomb scattering. With 50cm CH analyzer it is 2mr for Q^2 = 12
So at θ_{pp} = 1 deg then $\Delta\phi_{pp}$ = 9.5 deg

Strategy for magnetic field/spin transport calibration

- Optics calibration using sieve slit
- Partial mapping of SBS field at boundaries, check on TOSCA calculations
  - Full mapping if significant discrepancies found
- Zero-field, low-current, thin-target runs for absolute alignment and positioning of SBS front and polarimeter trackers
- Different methods for spin transport calculation as systematic checks:
  - GEANT4 spin-tracking with TOSCA-generated field map
  - COSY
  - “Geometric approximation”

Systematic and statistical errors on $\mu G_E^p/G_M^P$

Q^2	5	8	12
Stat. error	0.023	0.032	0.074
Total systematic error	0.010	0.013	0.019
Non-Dispersive Bend Angle Absolute Error (0.1mr)	0.0024	0.0045	0.0082
Dispersive Bend Angle Absolute Error (0.1mr)	0.0002	0.0003	0.0002
Polarimeter Azim. Angle Absolute Error (0.1mr)	0.0046	0.0087	0.0157
Background fraction Error $P_t^{inel} = 0.2$ $f = 0.1$ $\Delta f/f = 0.05$	0.0080	0.0080	0.0080