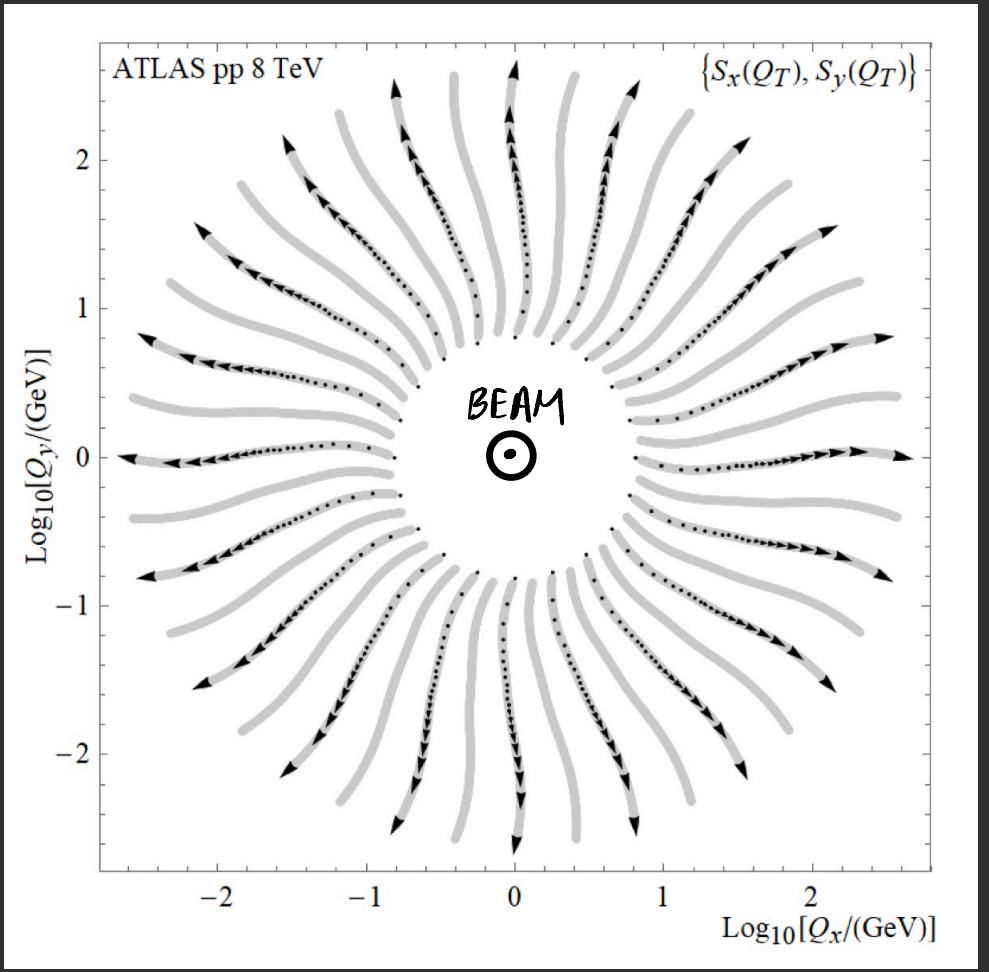
Hello!


ATLAS pp 8 TeV
$\{S_x(Q_T), S_y(Q_T)\}$
BEAM
$\mathrm{Log}_{10}[Q_y/(\mathrm{GeV})]$
$\mathrm{Log}_{10}[Q_x/(\mathrm{GeV})]$
2
1
0
−1
−2
−2
−1
0
1
2

Our paper!

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High Energy Physics - Phenomenology

[Submitted on 5 May 2026]

Mirror Quantum Tomography Finds Unexpected Polarization Phenomena in Z Boson Production in pp Collisions at the LHC

A. Gautam, J. C. Martens, J. P. Ralston, G. Stejskal, J. D. Tapia Takaki

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Thanks!

The spin vector $\vec{S}$ of a Z-boson is:

$$\vec{S} = \langle \vec{J} \rangle = Tr[\vec{J}\,\rho_x(z)]$$

Born's Rule

ρ_x is an unknown polarization density matrix

QUANTUM TOMOGRAPHY

Reconstructs a density matrix

$$\rho = \sum_i \langle \sigma_i \rangle \sigma_i$$

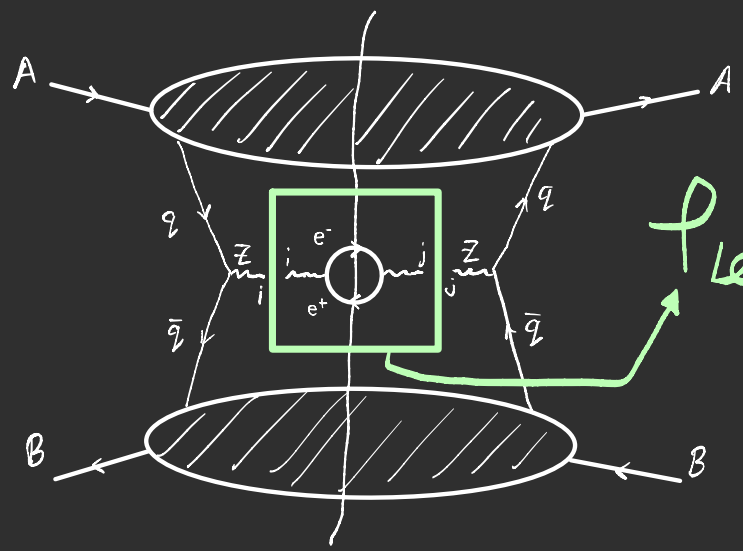
$$\langle \sigma_i \rangle = Tr[\sigma_i \rho]$$

σ_i probes ρ

$$tr[\sigma_i \sigma_j] = \delta_{ij}$$

To probe $f_x(z)$

Choose ρ_{lep} → dilepton density matrix



$$\rho_{lep\,ij} = \frac{1}{3}\delta_{ij} + \sin^2\theta_W \vec{J}_{ij}\cdot\hat{\ell} + \frac{1}{2}U_{ij}$$

$$J_{ijk} = -i\varepsilon_{ijk}$$

$$\hat{\ell}_i = (k^+ - k^-)_i$$

$$U_{ij} = \frac{1}{3}\delta_{ij} - \hat{\ell}_i\hat{\ell}_j$$

An experiment measures

$$\frac{dN}{d\Omega_\ell}(Z \to e^+e^-) \propto \mathrm{Tr}\left[\rho^{\ell}_{lep}\,\rho_x(z)\right] = P(\Omega_\ell | \rho_x)$$

$$\hookrightarrow d\Omega_\ell = d\cos\theta_\ell\, d\phi_\ell$$

Reconstruct ρ_x by mirror method

$$\rho_{x\,ij}(z) = \frac{\delta_{ij}}{3} - \frac{\vec{\bar{J}}_{ij}\cdot\vec{s}}{2} + U_{ij}$$