E03-104: Experiment Status Report

$^4\mathrm{He}(\vec{e},e'\vec{p})^3\mathrm{H}$ at $Q^2 = 0.8$ GeV^2 and 1.3 GeV^2

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Polarization-Transfer Technique

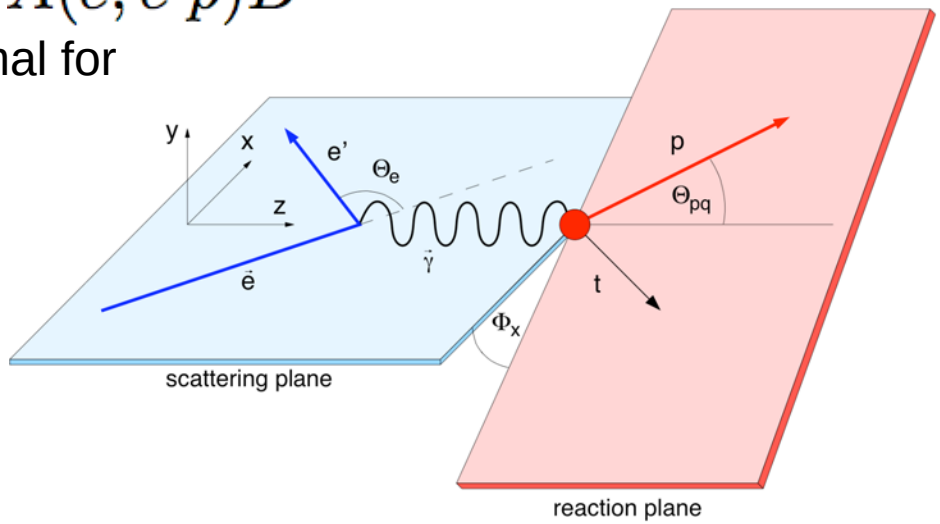
- Free electron-nucleon scattering

$$\frac{G_E}{G_M} = -\frac{P'_x}{P'_z} \cdot \frac{(E_i + E_f)}{2m} \tan\left(\frac{\theta_e}{2}\right)$$

- Bound nucleons → evaluation within model

Reaction-mechanism effects in $A(\vec{e}, e'\vec{p})B$ predicted to be small and minimal for

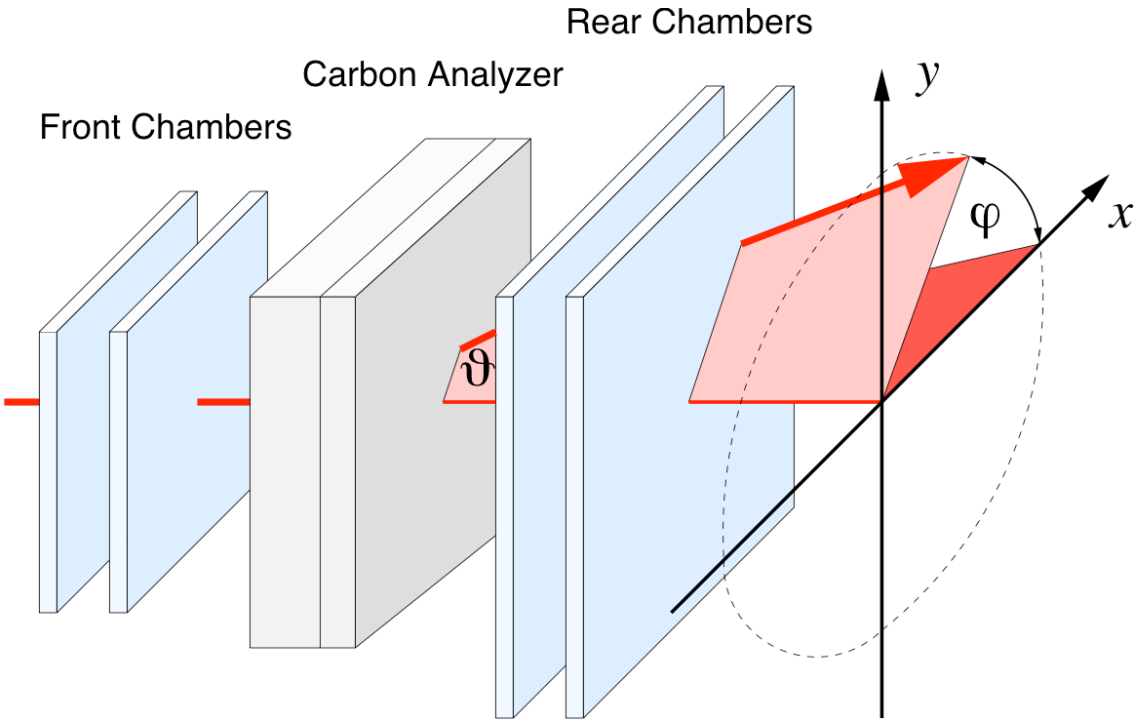
- Quasielastic scattering
- Low missing momentum
- Symmetry about $\boldsymbol{p}_m = 0$



R. Arnold, C. Carlson, and F. Gross, Phys. Rev. C **23**, 363 (1981); for reaction-mechanism effects, *e.g.*, J.M. Laget, Nucl. Phys. A **579**, 333 (1994), J.J. Kelly, Phys. Rev. C **59**, 3256 (1999), A. Meucci, C. Guisti, and F.D. Pacati, Phys. Rev. C **66**, 034610 (2002).

Polarization Measurement

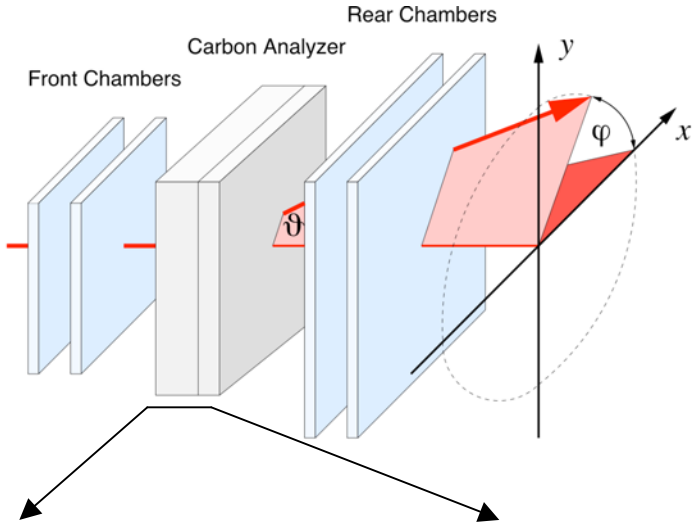
Focal-Plane Polarimeter



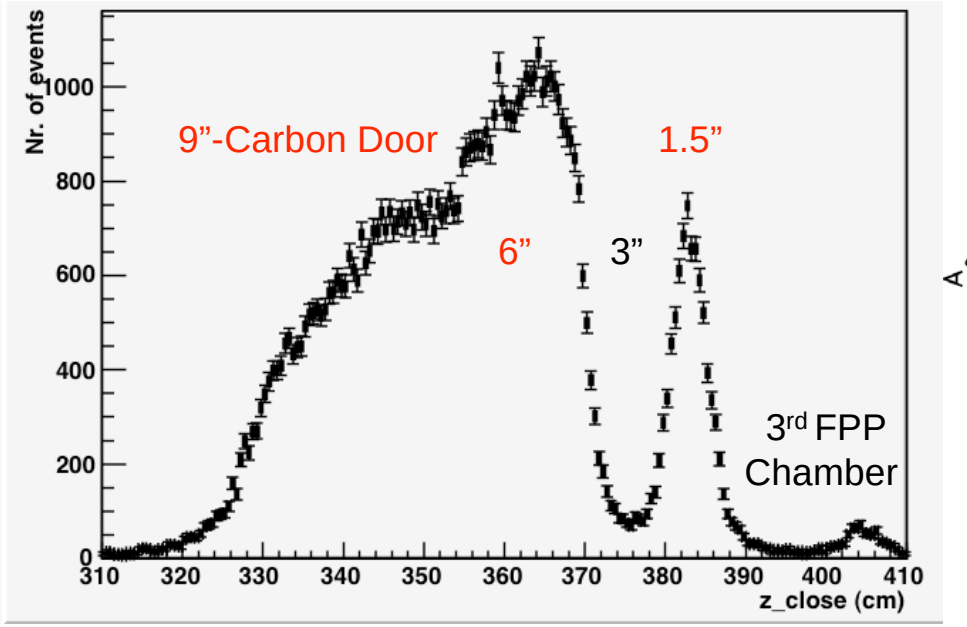
Observed angular distribution

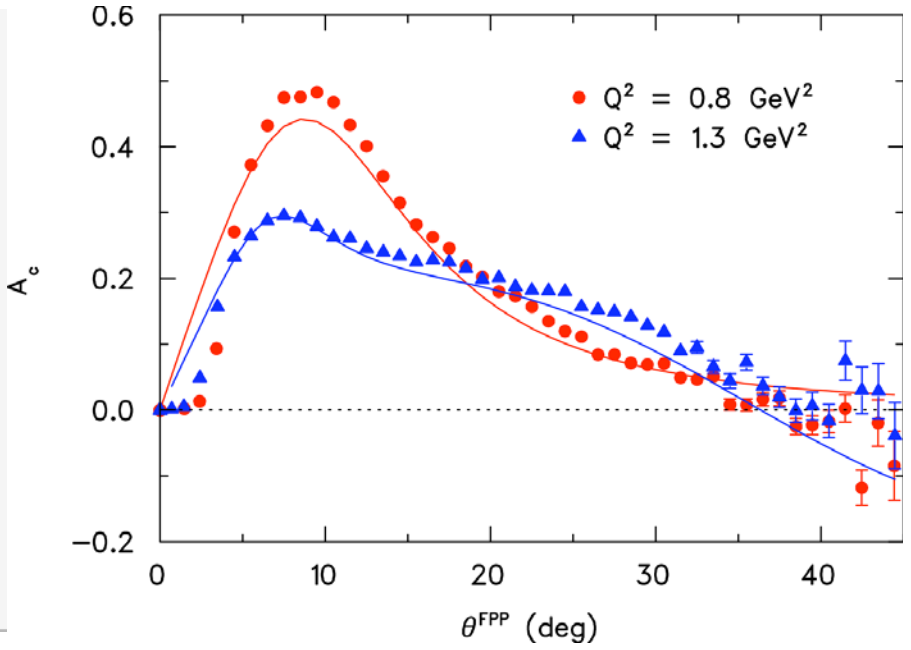
$$
\begin{aligned}
I(\vartheta,\varphi) &= I_0(\vartheta)\,(1+\epsilon_y\cos\varphi+\epsilon_x\sin\varphi) \\
&= I_0(\vartheta)\,[1+A_C(P_y\cos\varphi-P_x\sin\varphi)]
\end{aligned}
$$

FPP Alignment and Calibration

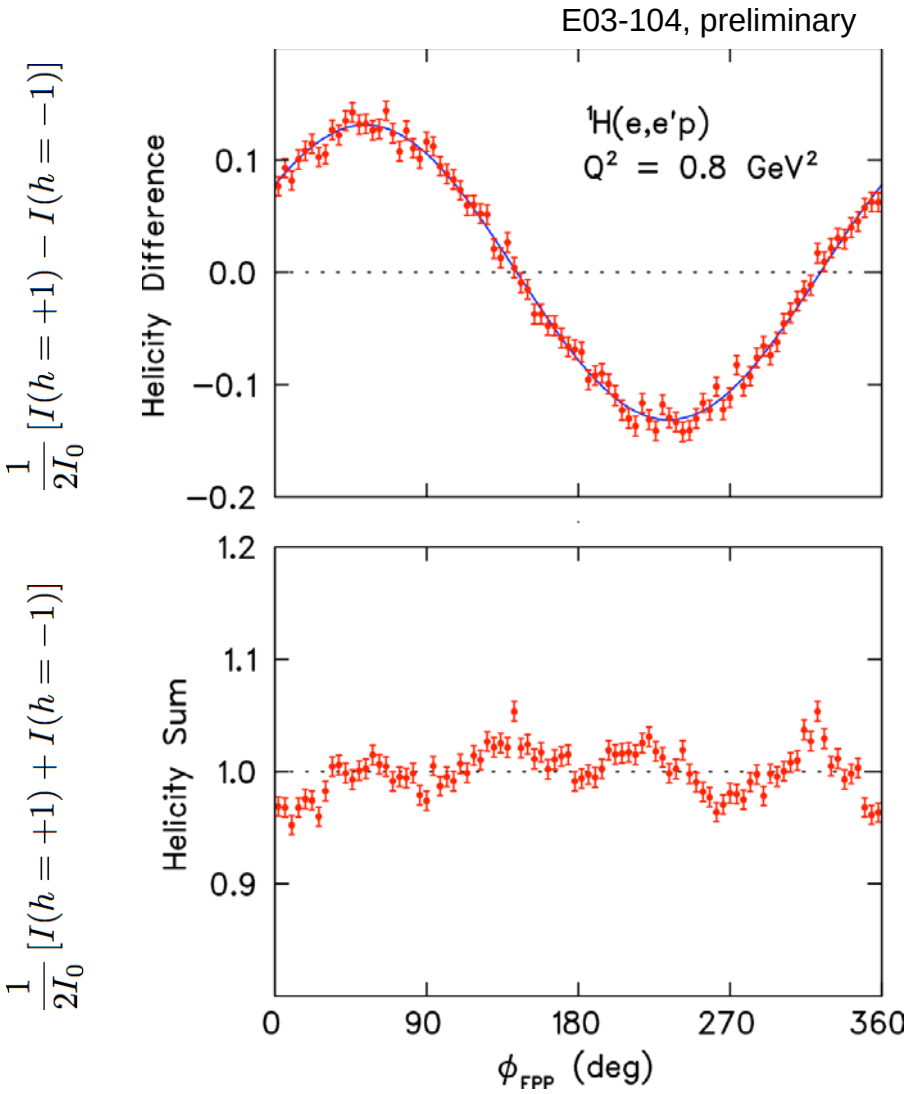


- Good reconstruction of the pC reaction vertex after alignment
- Carbon analyzing power from ep data
- Spin transport





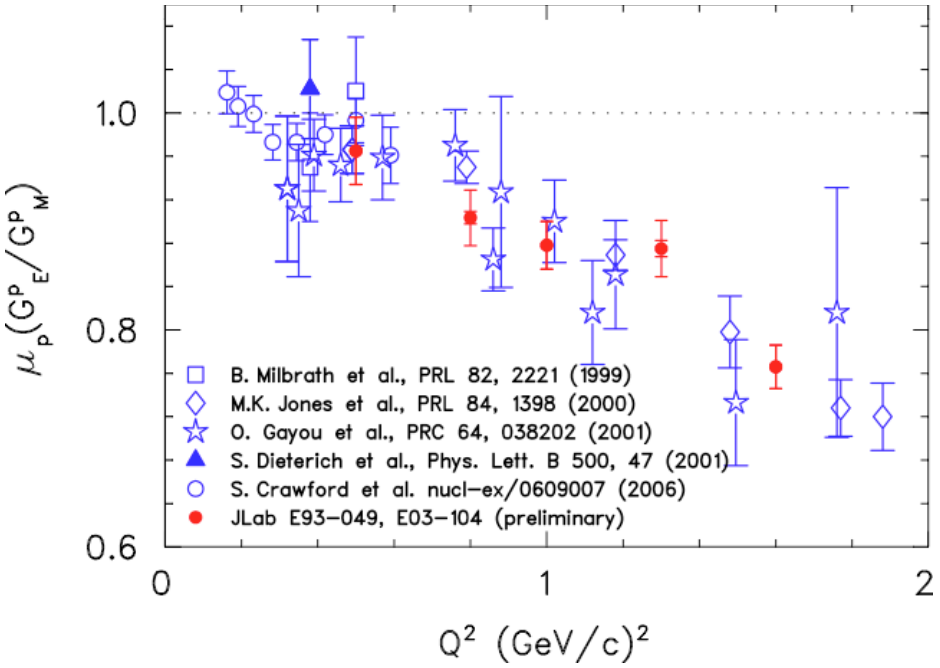
Observed Angular Distribution

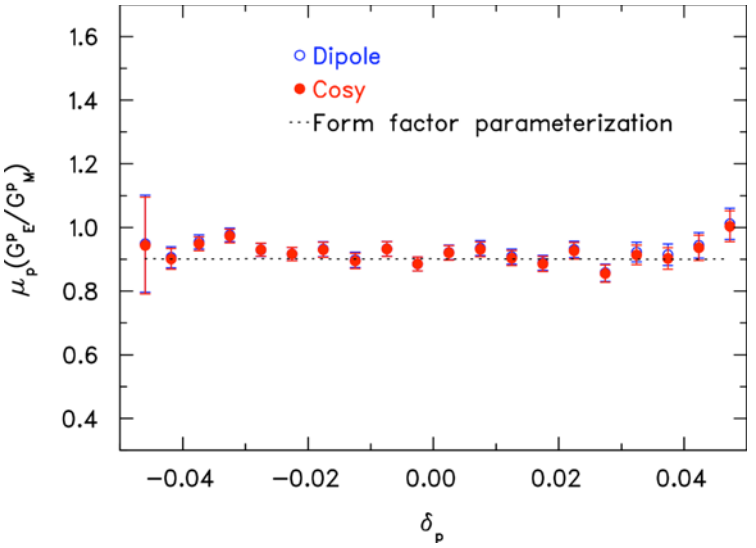


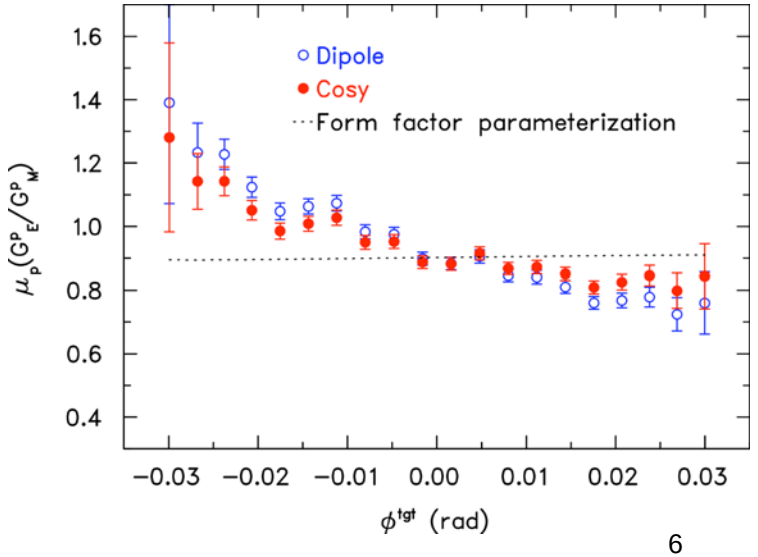
- Excellent control of systematic uncertainties for polarization transfer

- Instrumental asymmetries complicate the extraction of induced polarization
  - Detector misalignment
  - Detector inefficiencies
  - Tracking problems

Free Proton Form-Factor Ratio G_E/G_M



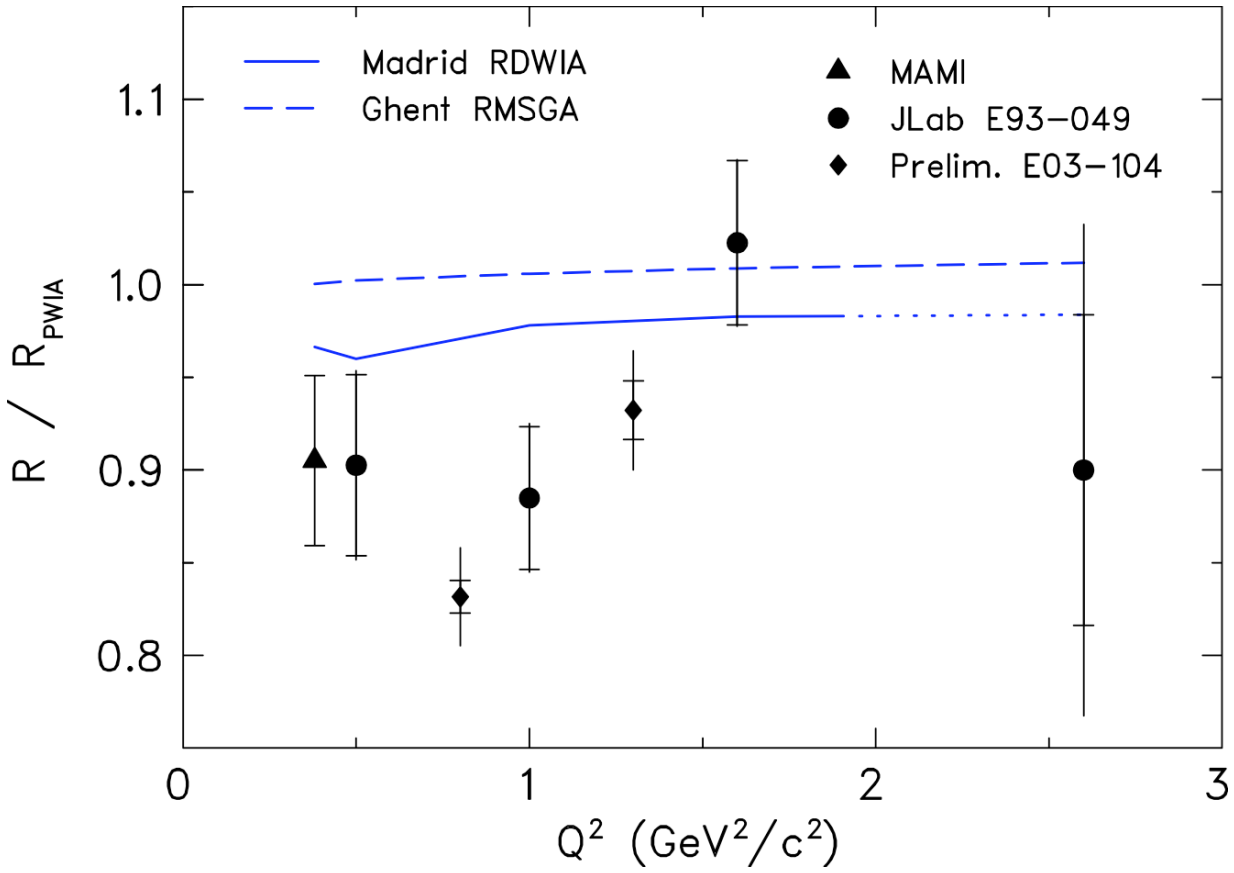




- Preliminary results from E03-104 with small statistical uncertainties $\delta(P'x/P'z) \approx 0.7$ %
- High statistics allows for systematic study of spin transport

^{4}He$(\vec{e},e'\vec{p})$ - Polarization-Transfer Ratio

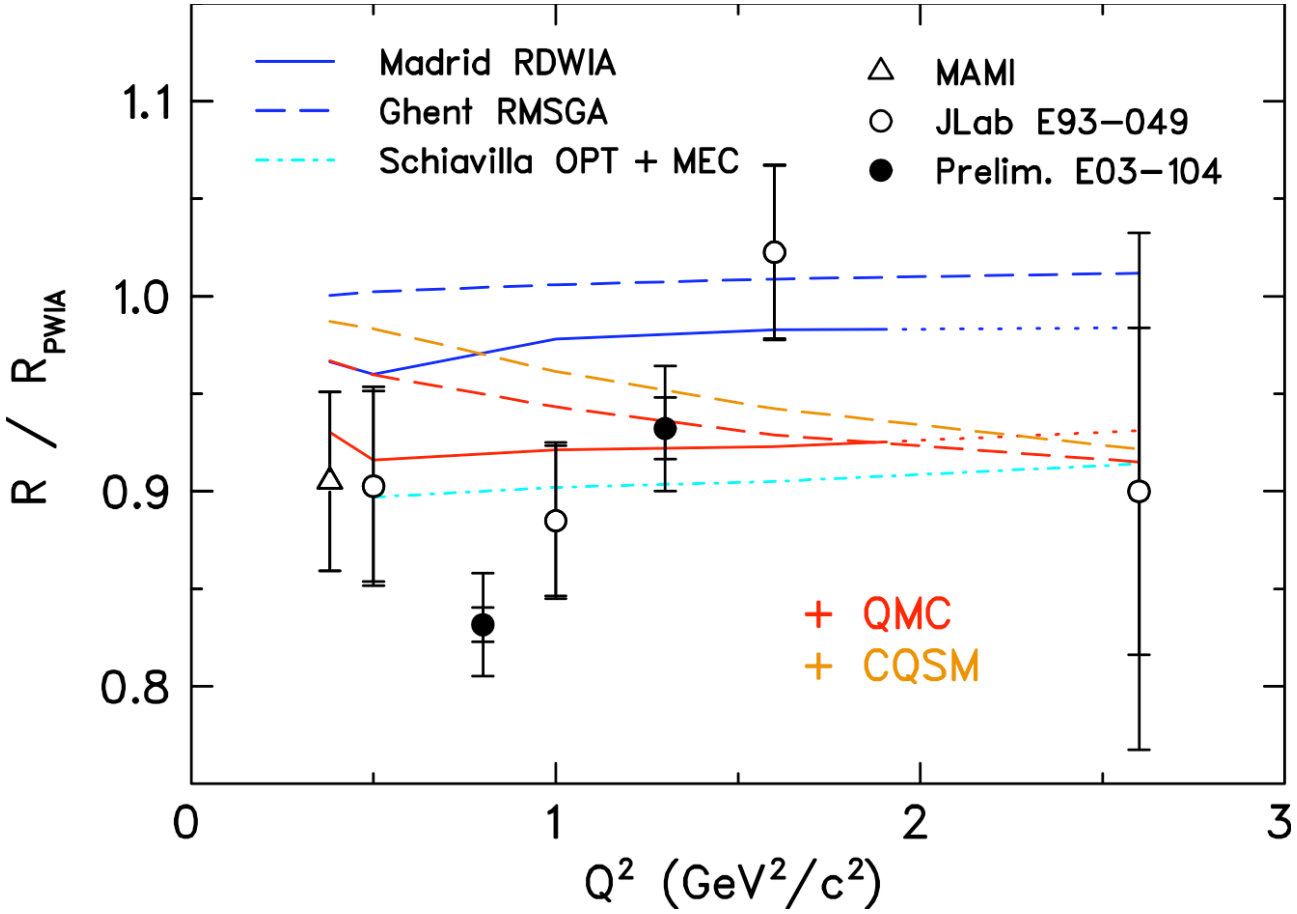
$$R = P'_x/P'_z(^4\mathrm{He})\,/\,P'_x/P'_z(^1\mathrm{H})$$



- RDWIA and RMSGA models can not describe the data.
- New data will set tight constraints, and possibly hint at an unexpected trend in Q^2

RDWIA: J.M. Udias *et al.*, Phys. Rev. Lett. **83**, 5451 (1999);
RMSGA: P. Lava *et al.*, Phys. Rev. C **71**, 014605 (2005), D. Debruyne *et al.*, Phys. Rev. C **62**, 024611 (2000)

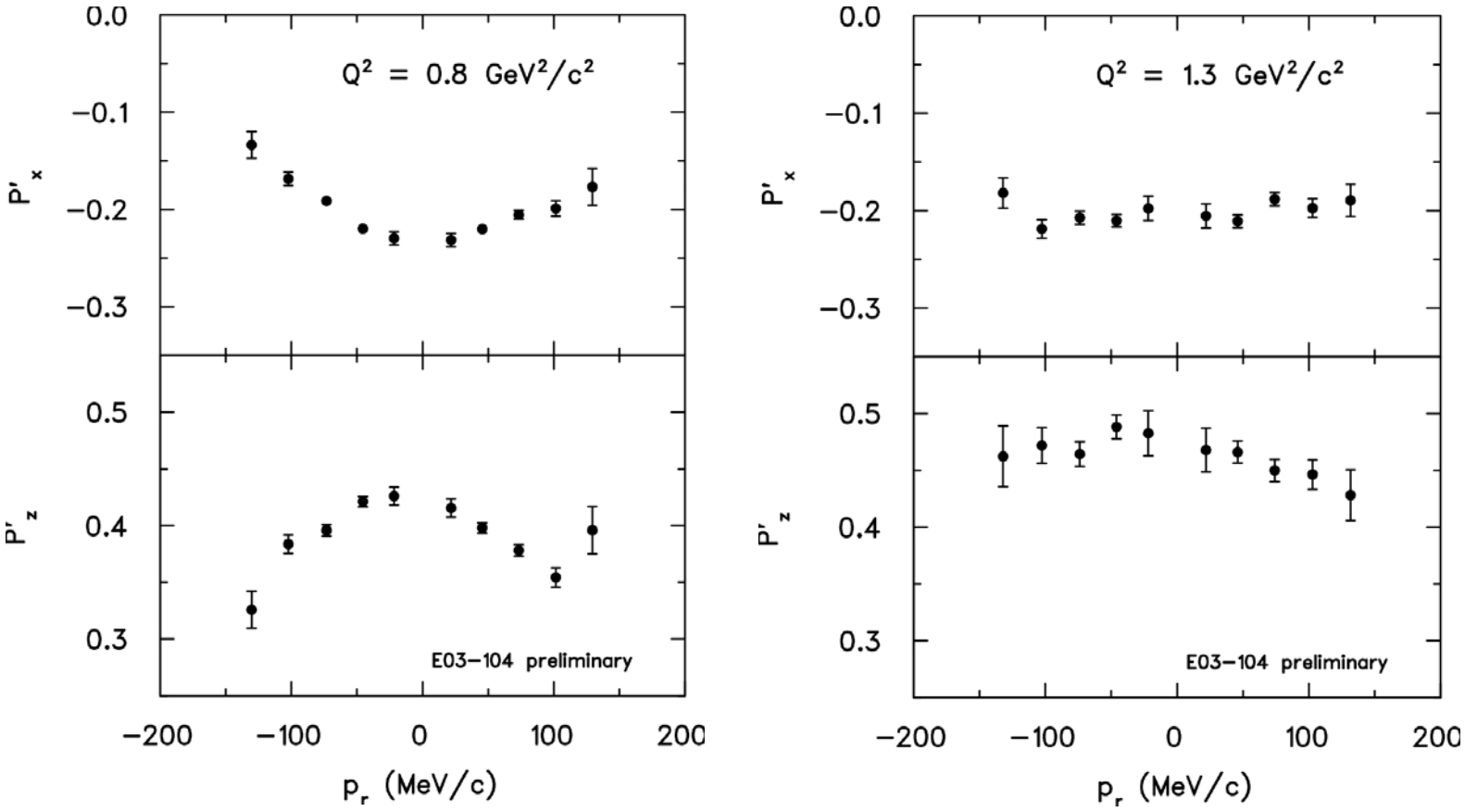
Two Competing Interpretations



1. Previous data effectively described by proton medium modified form factors
2. Alternative explanation given by spin-dependent charge exchange FSI

- No model accounts for preliminary $Q^2 = 0.8$ GeV^2 data
- E03-104 will provide for improved P'_x, P'_z, and P_y data

$^4\mathrm{He}(\vec{e},e'\vec{p})$ - Polarization-Transfer

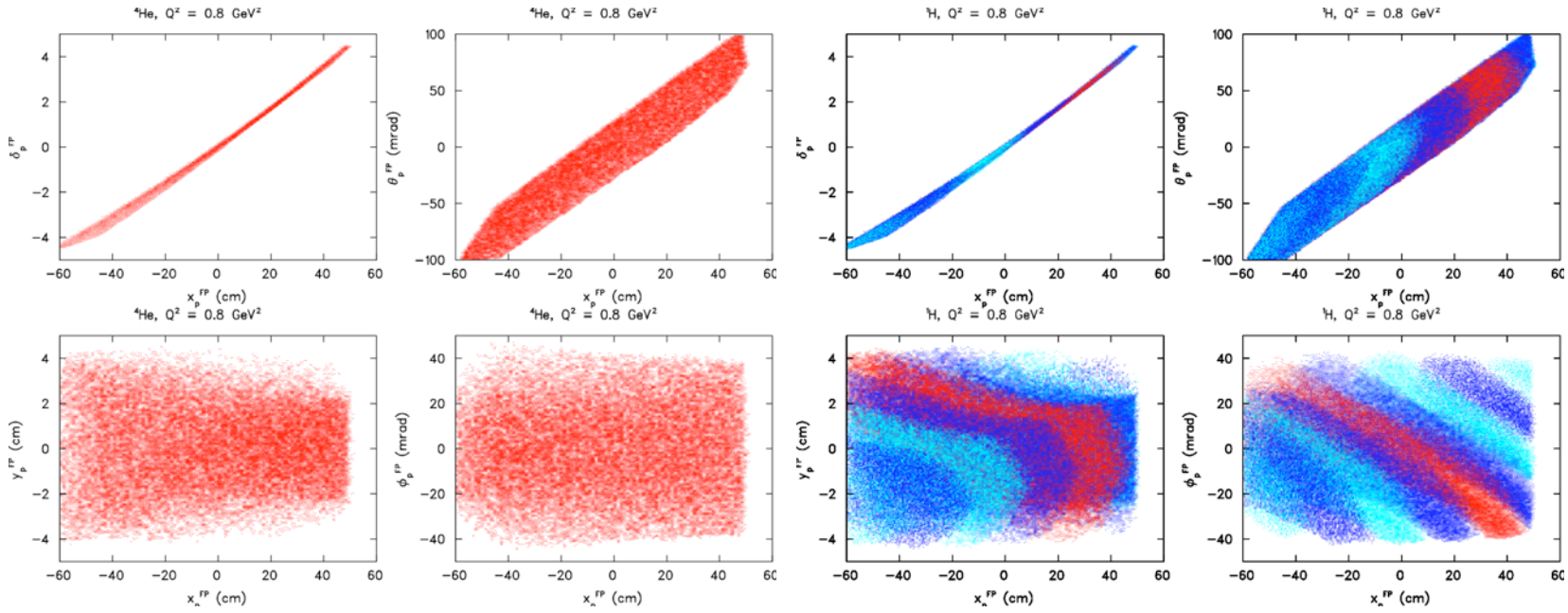


- Considerable missing momentum dependence of P'_x and P'_z for $Q^2 = 0.8$ GeV^2; much less for $Q^2 = 1.3$ GeV^2
- E03-104 will allow for more detailed study of polarization transfer

E03-104: Proton Focal-Plane Coverage

Helium Data

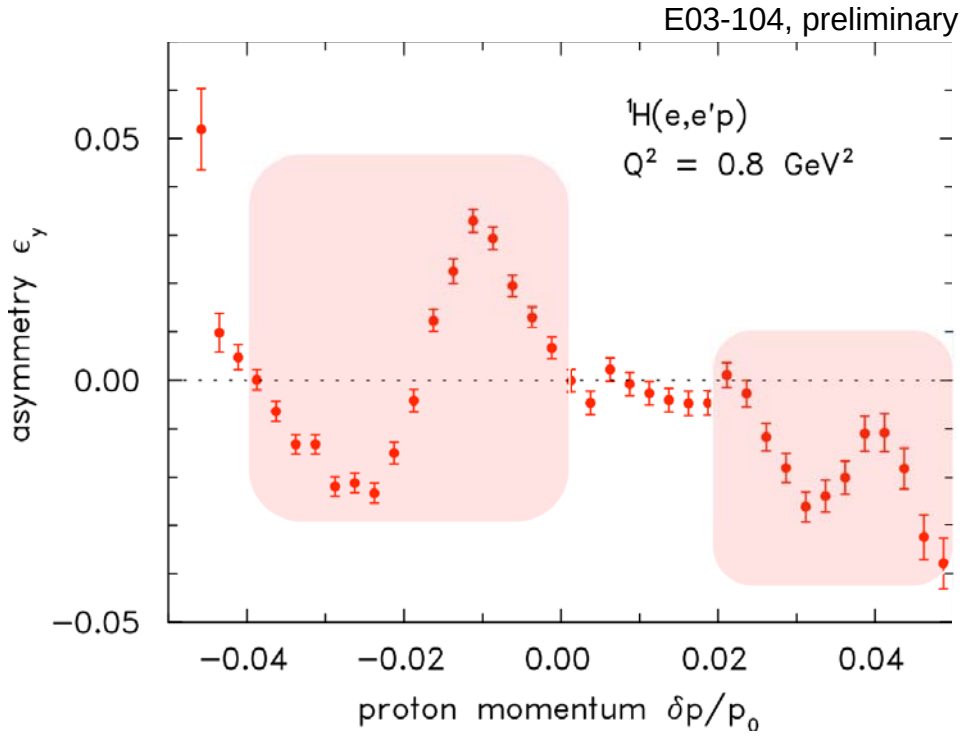
Hydrogen Data

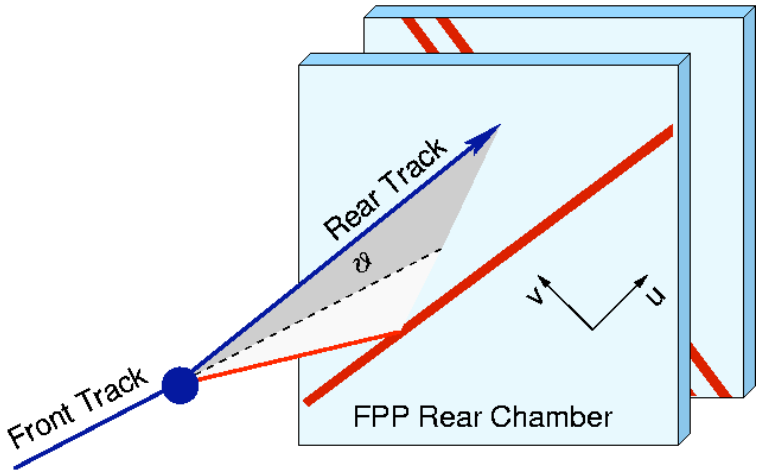


MCEEP Simulations

- "Unpolarized" protons from ^{1}H(e,e'**p**) in 9 momentum settings
- Full focal-plane coverage; similar to that of ^{4}He(e,e'**p**)
  - Study of instrumental asymmetries
  - Measure and subtract instrumental asymmetries

Extraction of Induced Polarization





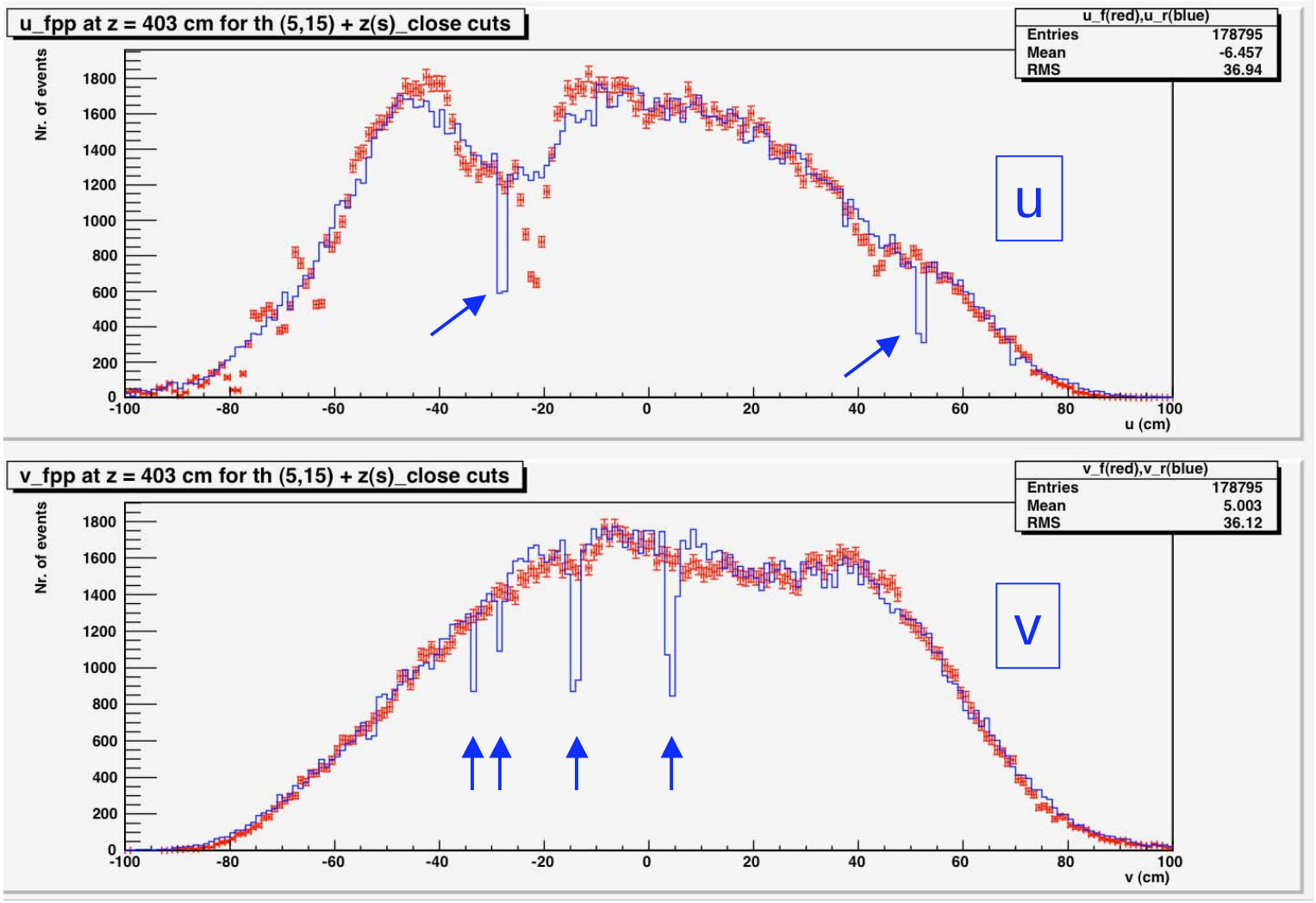
"mirror" test

- Instrumental asymmetries do not cancel, unless we have for the FPP acceptance and efficiency:

$$A(\varphi) = A(\varphi + \pi)$$

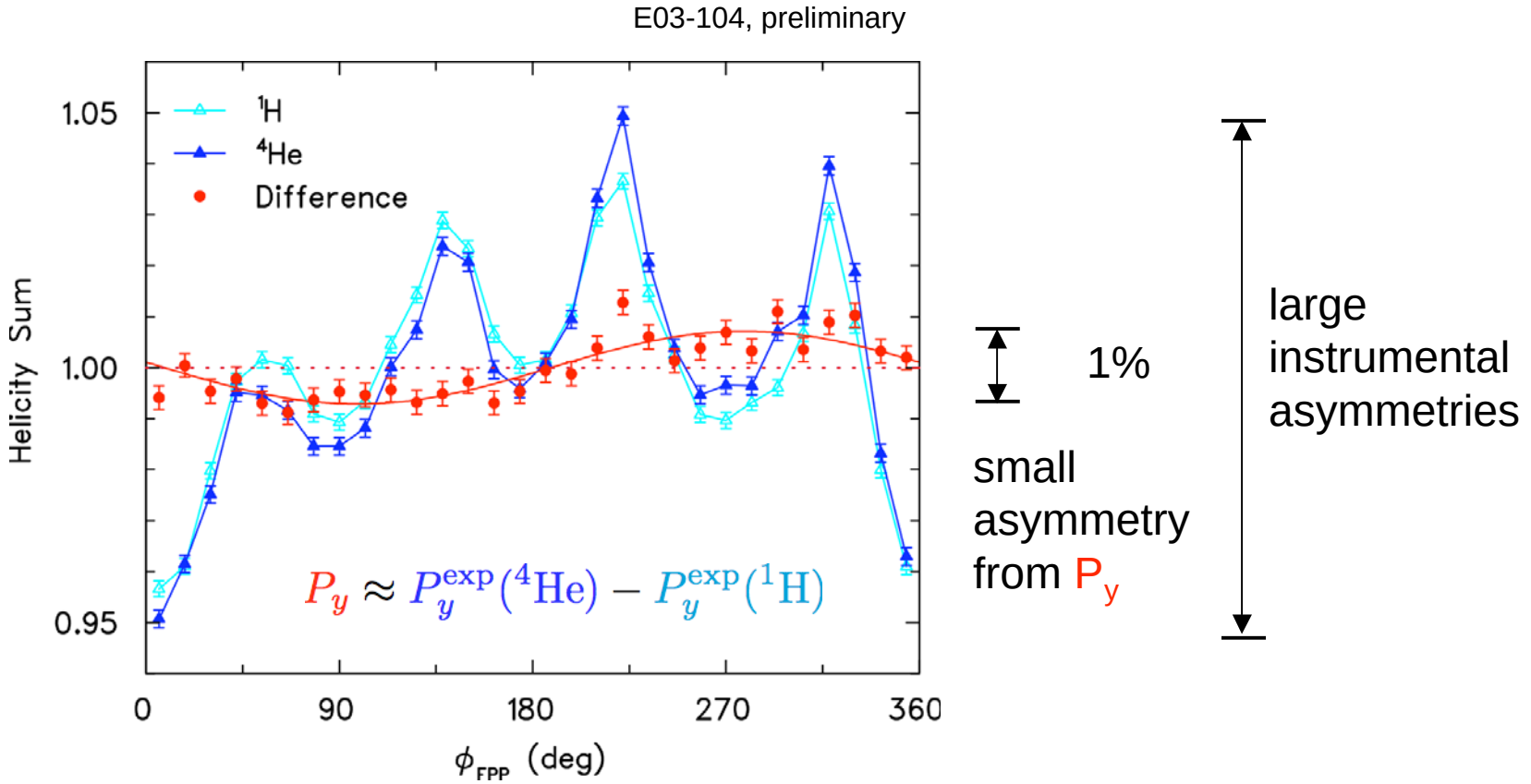
- Implementation of "mirror" test to ensure symmetry in A

FPP Rear Chamber Performance

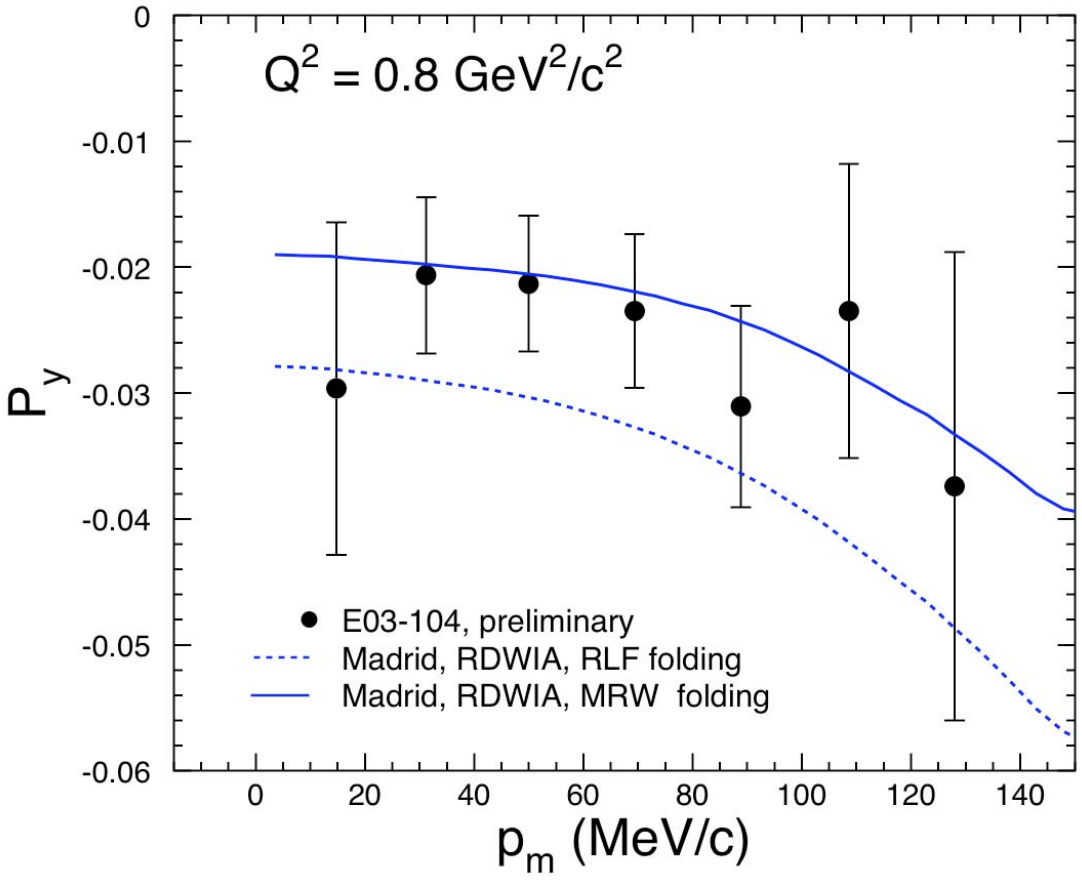


Measure and Subtract Instrumental Asymmetries

- Extract P_y for ^{4}He(e,e'**p**) from ^{4}He and ^{1}H angular distributions



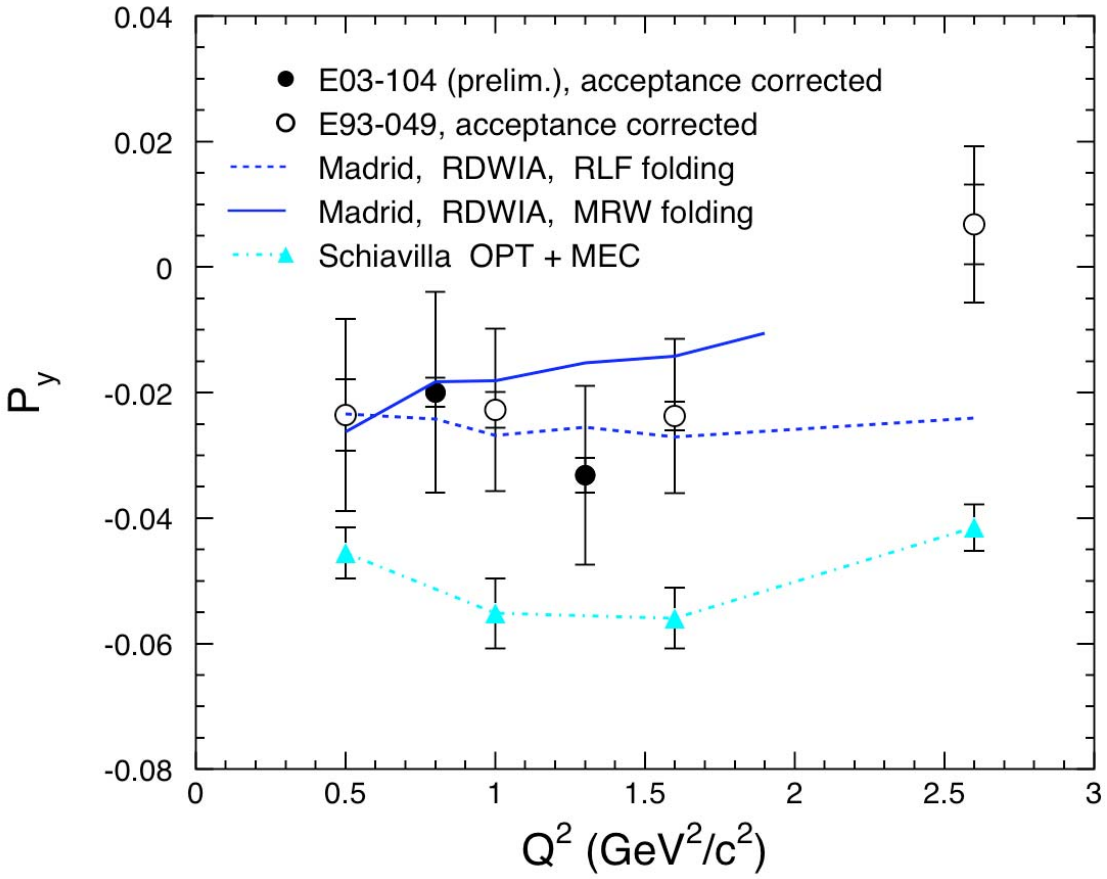
Induced Polarization in ^{4}He$(e,e'\vec{p})$



- P_y is a measure of final-state interactions
- Observed final-state interactions small and increase with missing momentum
- RDWIA results consistent with data
- RDWIA can be used to correct data for HRS acceptance (30% - 40% effect)

E03-104 induced polarization still very preliminary.
Uncertainties are statistical only; systematic uncertainties < 0.02

Induced Polarization in ^{4}He$(\vec{e},e'\vec{p})$



- Observed final-state interaction small and with only very weak Q^2 dependence
- RDWIA results consistent with data
- Spin-dependent charge exchange terms not constrained by N-N scattering and possibly overestimated
- E03-104 took specific data that will set tight constraints on FSI

Inner uncertainties are statistical only;
full analysis of E03-104 will have reduced systematic uncertainties

Summary

- **E93-049: Polarization transfer in ^{4}He(e,e'p)**
  - Significant deviation from RDWIA results; data effectively described by proton medium modifications
  - Alternative interpretation in terms of strong charge-exchange FSI; possibly inconsistent with P_y

- **E03-104**
  - High statistics data at Q^2 = 0.8 GeV^2 and 1.3 GeV^2
  - Polarization transfer can be studied in detail
  - Much improved induced polarization data will be crucial to better constrain FSI
  - Preliminary results from E03-104 already challenge available models