E03-104: Experiment Status Report

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Motivation

A(e,e'p)B reactions

Conventional Nuclear Physics:
- we probe "point-like" nucleons + form-factors
- reaction mechanisms: theoretically parameterized ignoring that the nucleon's inner structure may be changed in the nuclear medium

QCD:
- nucleons: composite objects of quarks and gluons

? Are the experimental results described by conventional nuclear physics theories?

If not…

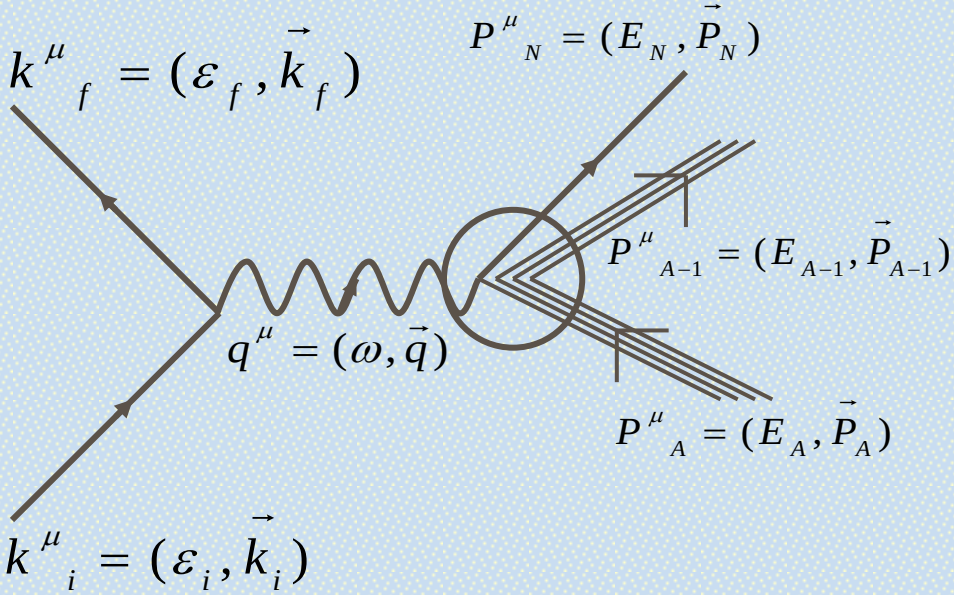
? ***Is it because there are not enough higher order corrections to the Born+IA ?***

? ***Is it because the possible medium modification of the nucleons structure is ignored in the conventional nuclear physics theories*** ?

? **Which approach would be more economical ?**

Theory: Overview

Born + Impulse Approximation(PWIA)



$$W_{if} = \int dx \int dy \int \frac{dq}{(2\pi)^2} j_{\mu}{}^{e}(x) e^{-iq(x-y)} \frac{(-1)}{q_{\mu}{}^{2}} J_{N}{}^{\mu}(y)$$

$$j_{\mu}{}^{e}(r) = \bar{\psi}_{f}{}^{e}(r)\gamma^{\mu}\psi_{i}{}^{e}(r) \qquad J_{N}{}^{\mu}(r) = \bar{\psi}_{F}{}^{N}(r)\hat{J}_{N}{}^{\mu}\psi_{B}{}^{N}(r)$$

- Theoretical calculations have to take into account the presence of the nuclear medium.

In-Medium Effects

Electron-photon vertex current:

- Coulomb distortion of the electron wave function.

Photon-nucleon vertex current:

- Off-shell effects (no unambiguous treatment): various prescriptions to impose current conservation. =>
  - T. De Forest, Jr. Nucl. Phys. A392, 232 (1983)

- Many-body currents: IA = "zero order approximation" but realistically we need higher-order corrections to IA. =>
  - A. Meucci *et al.*, Phys. Rev. C 66, 034610 (2002)
  - R. Schiavilla *et al.*, Phys. Rev. Lett. 94, 072303 (2005)

- Final-State Interactions: the nucleon can interact with its neighbors after being struck by the photon. =>
  - J. Udias *et al.*, Phys. Rev. Lett. 83, 5451 (1999)
  - R. Schiavilla *et al.*, Phys. Rev. Lett. 94, 072303 (2005)

- **In**-medium form-factors: free or medium modified form-factors in the electromagnetic current operator? =>
  - D.H. Lu *et al.*, Phys. Rev. C 60, 068201 (1999)
  - J. R. Smith and G. Miller, Phys. Rev. Lett. 91, 212301 (2003)
  - T. Horikawa, W. Bentz, Nucl. Phys. A762, 102 (2005)
  - S. Liuti, hep-ph/0608251, hep-ph/0601125

E03-104 in Hall A

Targets:

^{4}He:

- High density nucleus => any possible medium effects are enhanced.
- Its relative simplicity allows realistic microscopic calculations.
- Variety of calculations show that polarization-transfer observables in ^{4}He(e,e'p)^{3}H are influenced little by FSI, MEC…

^{1}H:

- ^{1}H is baseline when estimating the effect of the medium on the polarization-transfer ratio in ^{4}He(e,e'p)^{3}H .

Kinematics:

- Quasielastic scattering + low p_m + symmetry about p_m=0; Q^2 = 0.8, 1.3 GeV^2 .

Beam:

- Longitudinally polarized electron beam; incoming electron helicity flipped to access both the transfer and induced polarization.

Detection system:

- Hall A High Resolution Spectrometers (HRS): FPP used to determine the polarization of the recoiling protons.

Analysis Status

Mike Paolone

Polarization transfer.

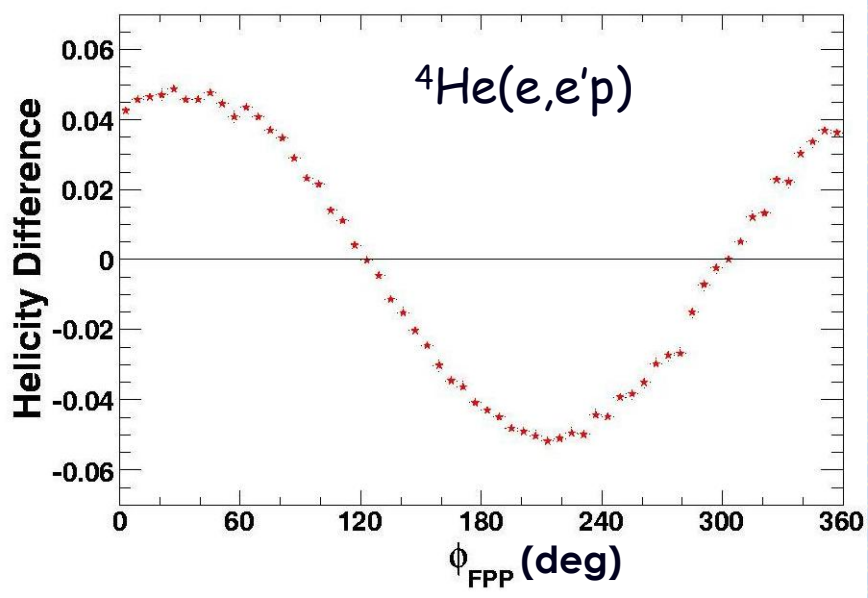
✓ - spectrometer pointing and kinematics

✓ - maintenance of analysis code

✓ - implementation of COSY spin transport into PALMETTO code

- verification of COSY transport model

- study of systematic uncertainties



S. Malace

Induced polarization.

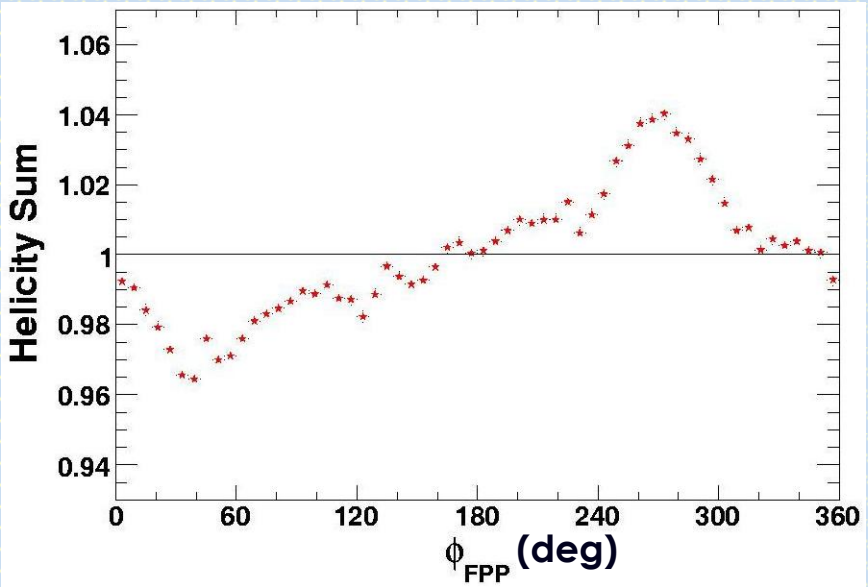
Instrumental asymmetries complicate the extraction of induced polarization and are typically caused by:

✓ - detector misalignment

✓ - detector inefficiencies

✓ - tracking issues

- detector acceptance (cone test)



Instrumental Asymmetries

Drift Chamber Inefficiencies

- FPP chambers performance: inefficient regions cause instrumental asymmetries.

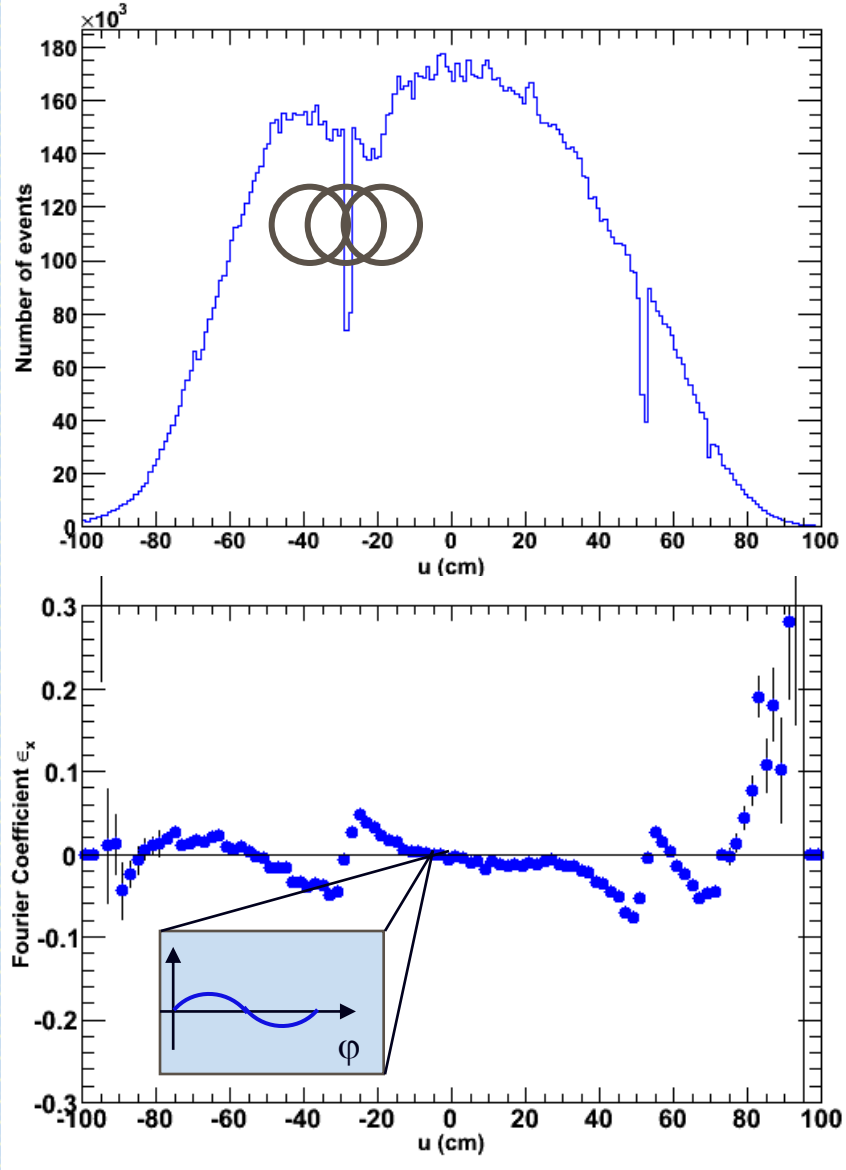
- Instrumental asymmetries do not cancel, unless we have for the FPP acceptance and efficiency:

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

- Because of dead wires, in some regions of the chambers (CHs), the strict requirements of the <u>standard tracking algorithm</u> cannot be met => holes in the event distribution.

- Plan of attack: accept poorer tracking resolution in order to fill the holes => <u>relaxed tracking algorithm</u>.

- But for that we need, first of all, very good calibrations…

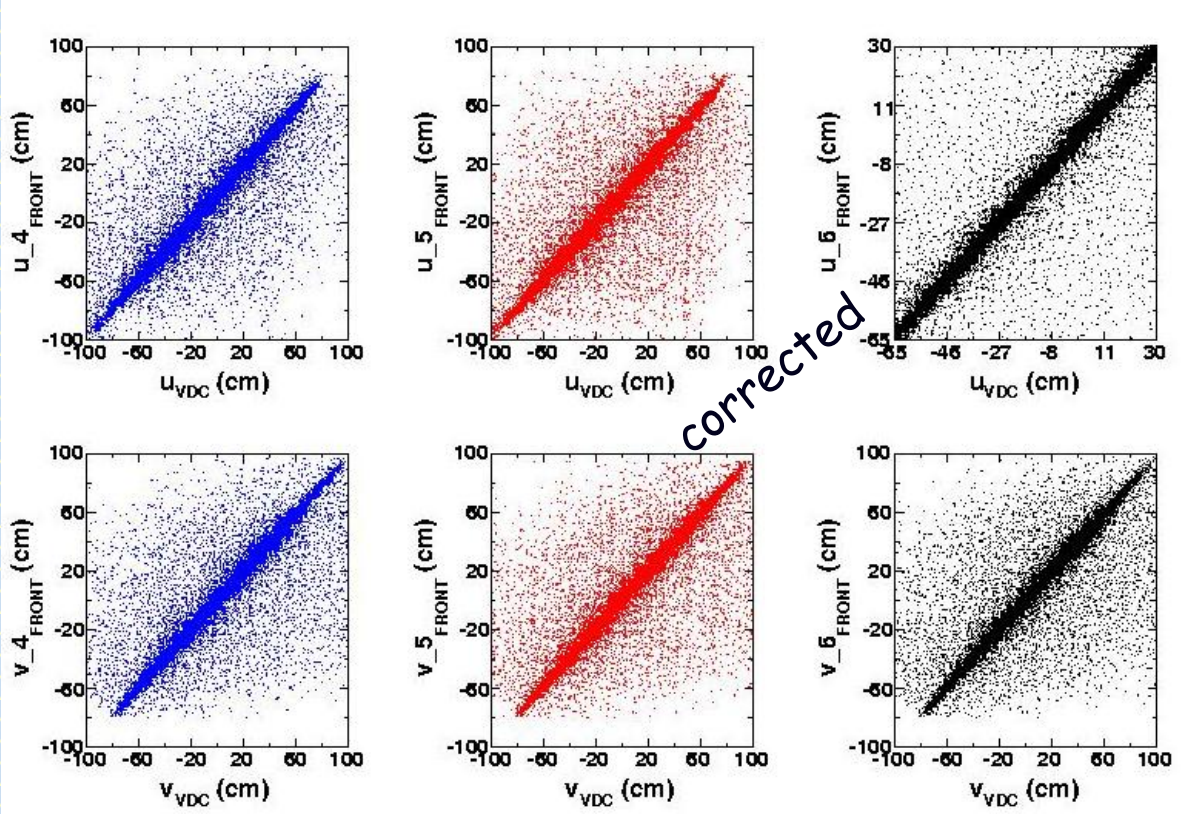


Instrumental Asymmetries

Drift Chamber Calibrations

- Reasonable looking wire maps (demultiplexing cuts set right, no hot wires…).

- Check for interchanged wire groups: for last u plane of CH2 wiregroups 10 and 11 interchanged.



- When all calibrations done, we can "relax" the standard tracking algorithm.

Instrumental Asymmetries

Tracking algorithm

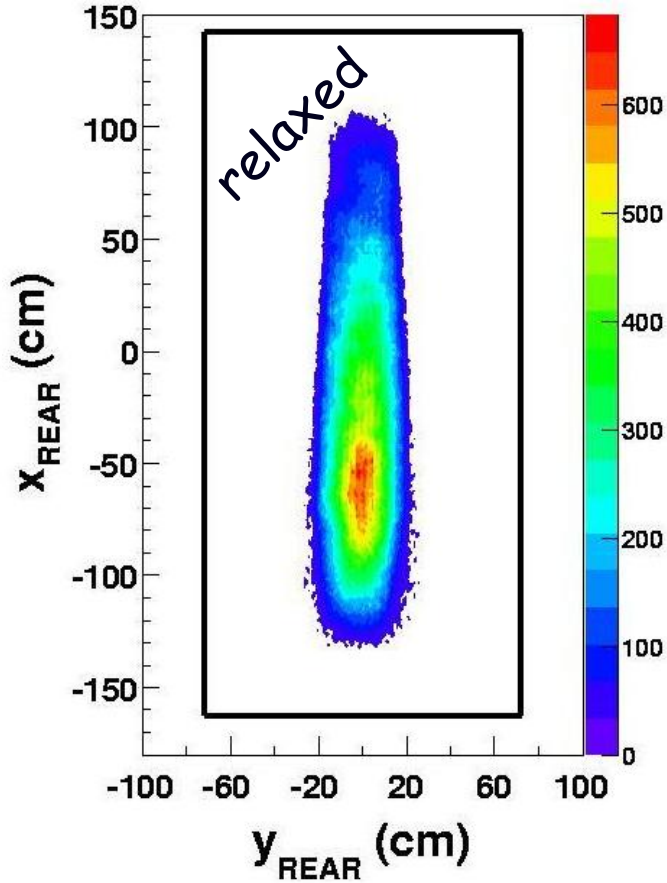
Standard tracking:
- at least 1 hit in CH3/CH4 & at least 3 hits in total
- tries to resolve the left-right ambiguities

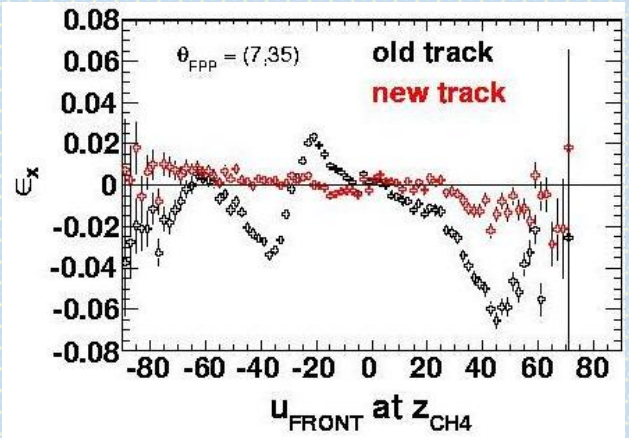
•Standard tracking algorithm ***too restrictive*** if CHs planes have dead wires => "holes" in the event distribution.

Relaxed tracking:
-at least 1 hit in CH3 or CH4

To reconstruct a "relaxed" track:
- if 1 hit in each chamber => track
- if 1 hit just in one of the chambers => hit + pC vertex = track

•With the relaxed tracking algorithm local false asymmetries are gone.



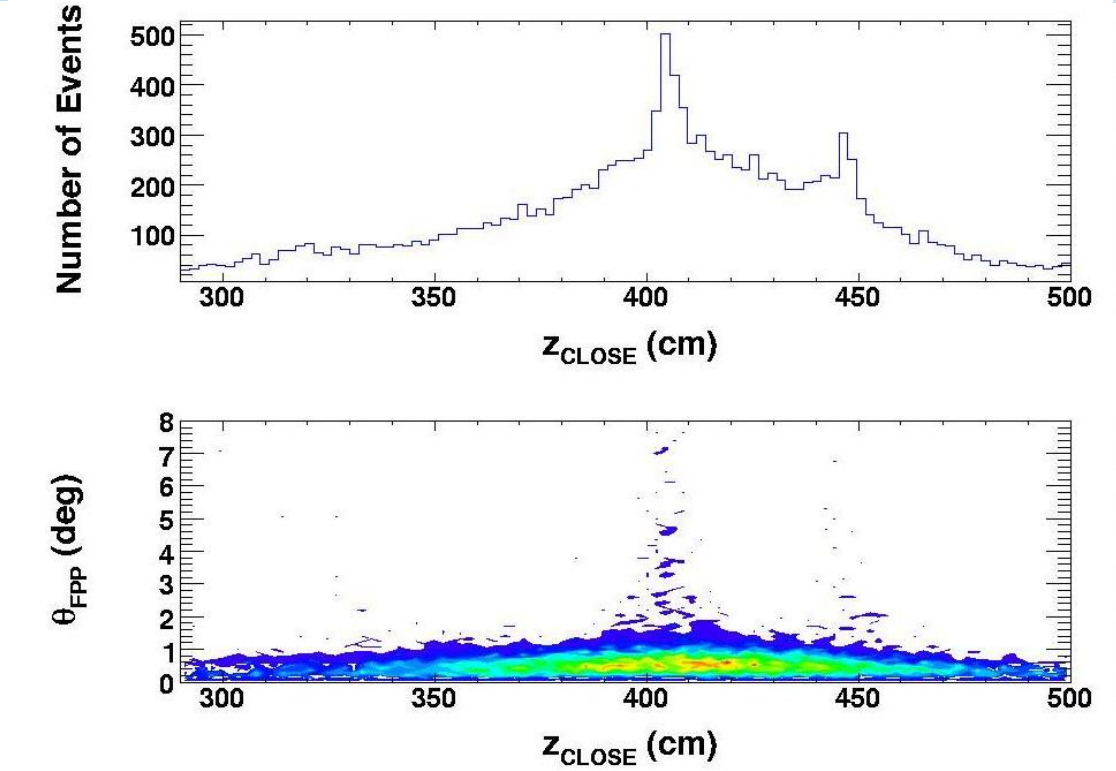


Instrumental Asymmetries

Detector Misalignment:

- Detector misalignment source of false asymmetries (can lead to a wrong reconstruction of φ_{Fpp} and θ_{Fpp}).

- Special runs ("straight-through" runs) taken to correct the reconstructed tracks for a possible misalignment of the detector.

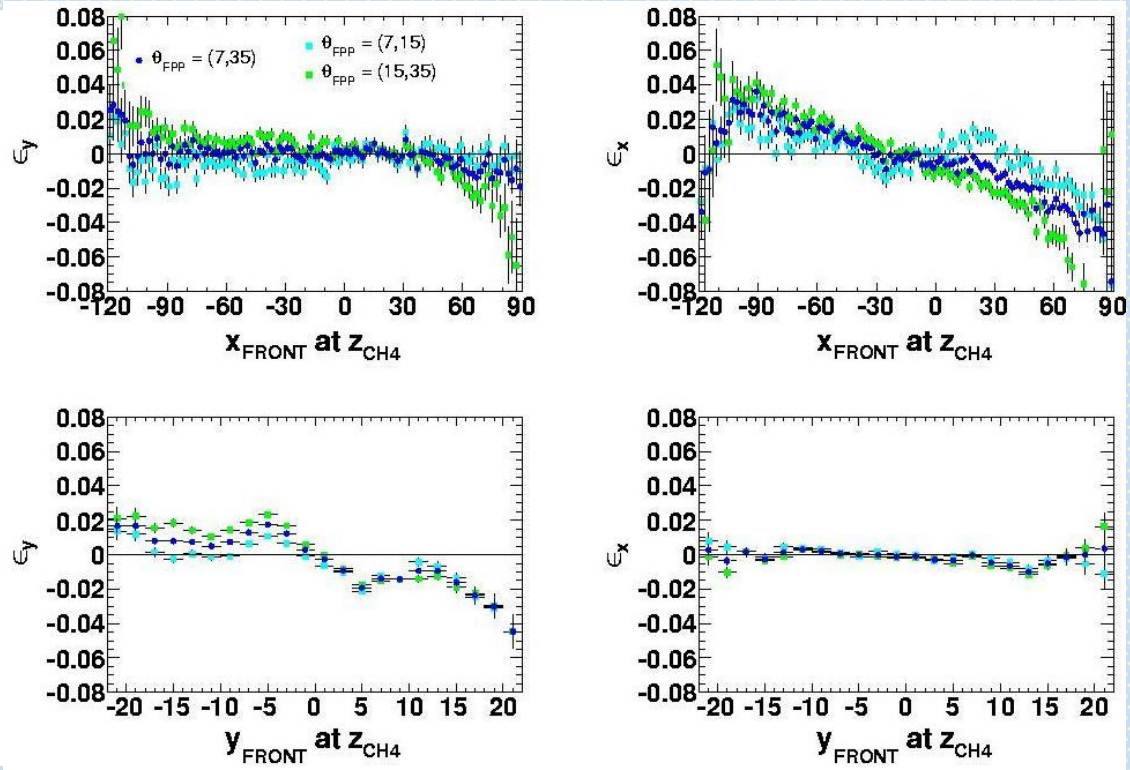


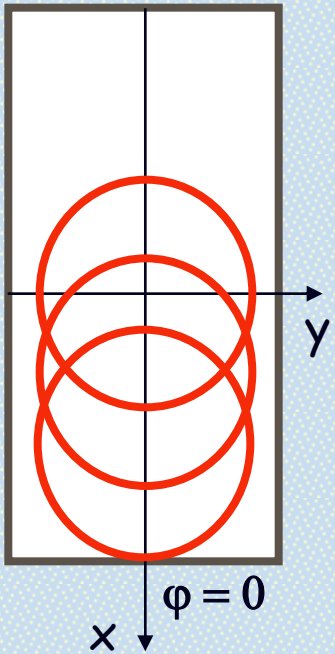
- The quality of the alignment is limited by the resolution of the detector, multiple scattering and limited y coverage for straight-through runs.

Instrumental Asymmetries

Results:

- First order false asymmetries greatly reduced – by a factor of ~4.
- The Fourier coefficients behavior shows small residual false asymmetries which may be related to the cone test quality.

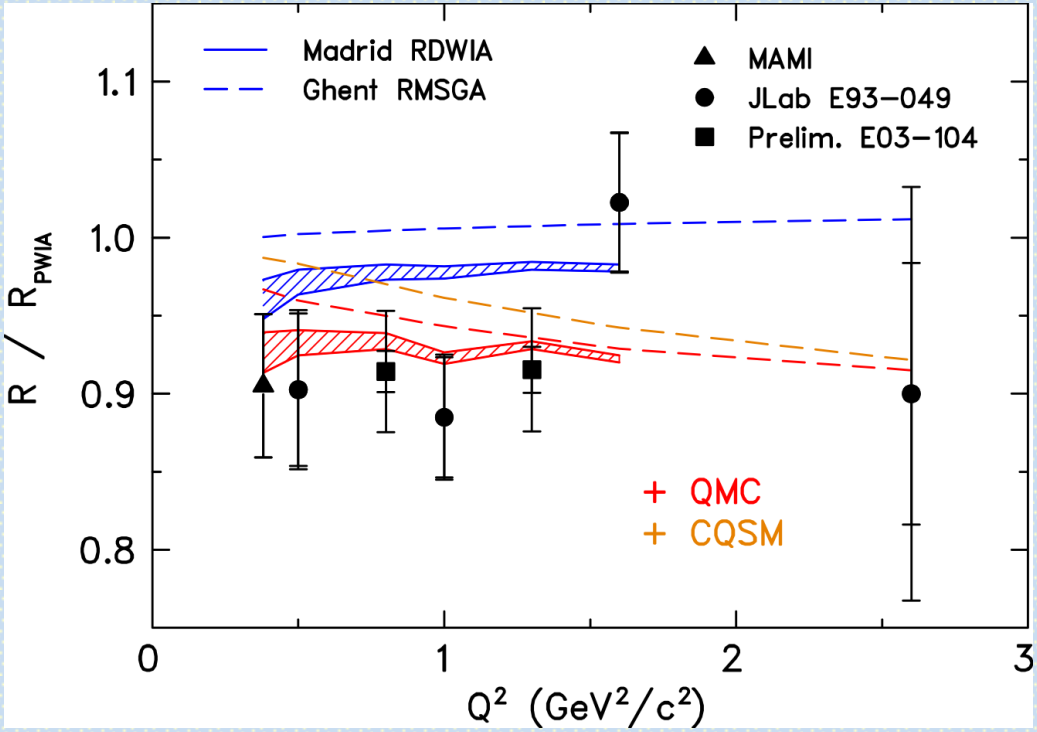




- Work in progress: improve the cone test and the chambers alignment.

Polarization-Transfer in $^4He(e,e'p)^3H$

- RDWIA calculation: no MEC and no charge-exchange FSI terms.
- Study shows: effect of MEC ~ 3-4%.
- RMSGA calculation: similar procedure as RDWIA but different treatment of FSI => FSI underestimated.

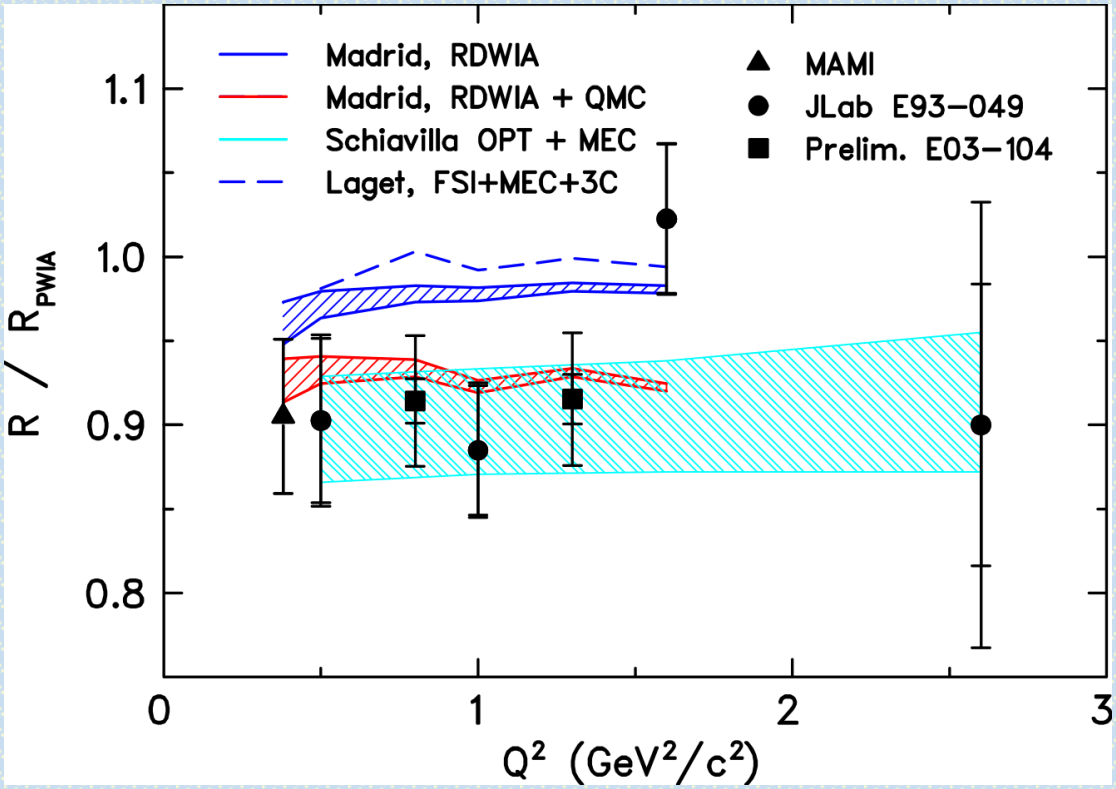


- **RDWIA and RMSGA models cannot describe the data.**
- **Data effectively described by medium modified form factors.**

Polarization-Transfer in $^4He(e,e'p)^3H$

Schiavilla *et al.* calculation provides for alternative explanation:

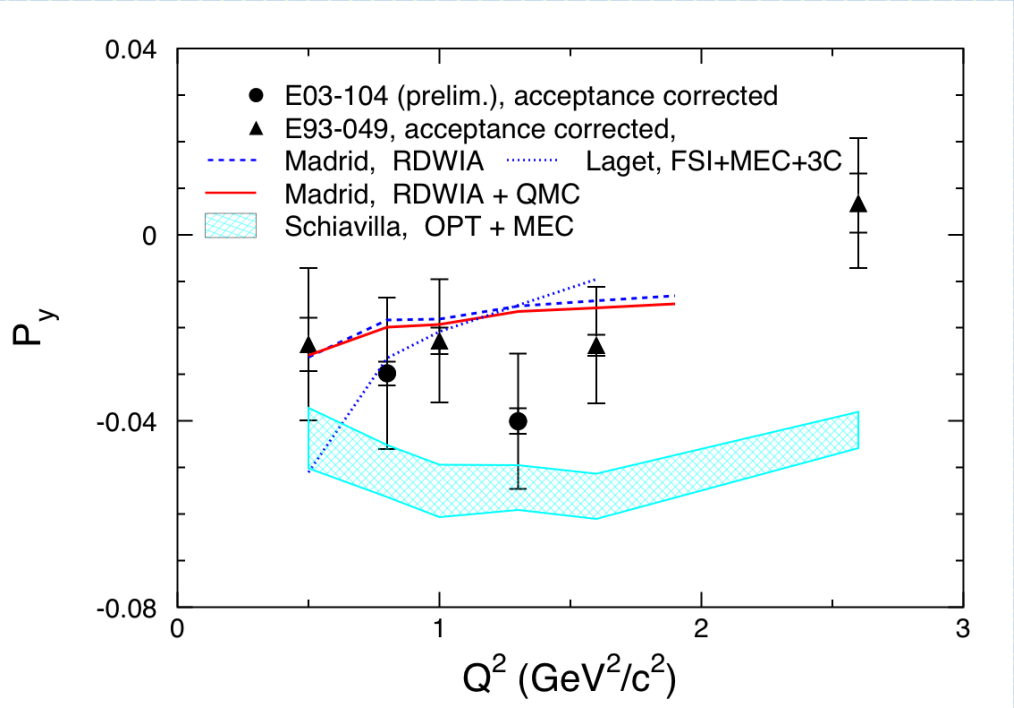
- R is suppressed ~ 4% from MEC.
- FSI suppresses R ~ 6% - significant contribution from spin-dependent charge-exchange .



- **Charge-exchange term not well constrained => need precise P_y data.**

Induced Polarization

- RDWIA used to correct data for HRS acceptance (30% - 40% effect).
- P_y (measure of FSI) small and with only very weak Q^2 dependence.



- Spin-dependent charge-exchange terms not well constrained by N-N scattering and possibly overestimated.
- RDWIA results consistent with data.
- E03-104 data will set tight constraints on FSI.

Summary

Previous data on polarization transfer in ^{4}He(e,e'p) – E93-094

- 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
- final results this Summer