Understanding the ^{3}He Nuclei: Asymmetry Measurements in Quasi-Elastic $\overrightarrow{^3\mathrm{He}}(\vec{e},e'd)$ and $\overrightarrow{^3\mathrm{He}}(\vec{e},e'p)$

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Outline

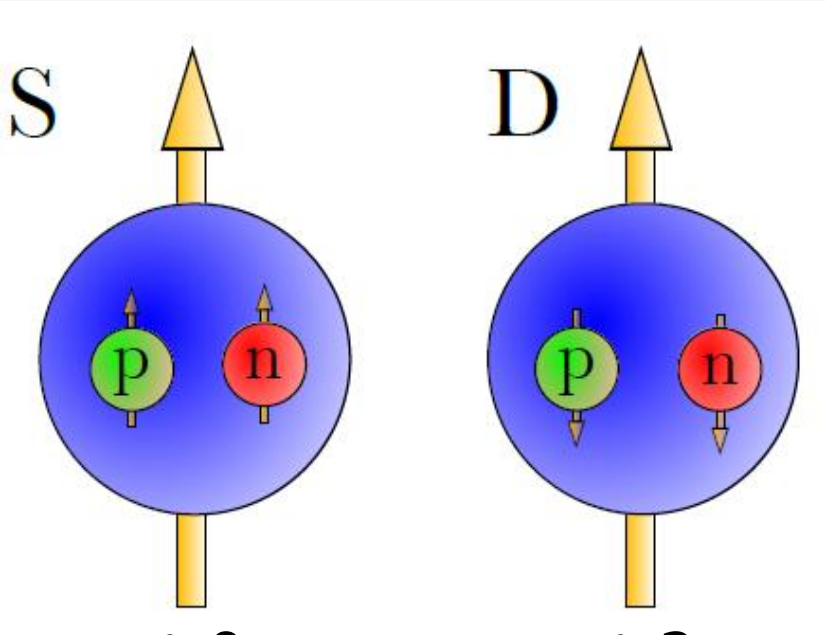
- Physics Motivation
- Experimental Setup
- Detector Calibration: High Resolution Spectrometer (HRS) and BigBite
- Summary and Outlook

Physics motivation

- Practically: understanding ^{3}He ground-state spin structure helps in a variety of experiments that try to extract neutron information from ^{3}He
- Theoretically: nucleon-nucleon potential theory predicts three components in the ^{3}He ground-state wave-function. Understanding the role of the S’ and D states helps us understand the “standard model” of few-body system
- Double polarization measurements have large sensitivities to both S’ and D components

Deuterium Spin Structure

- Spin-1 Particle, 2 spin-$^1/_2$ Nucleons (Proton and Neutron)

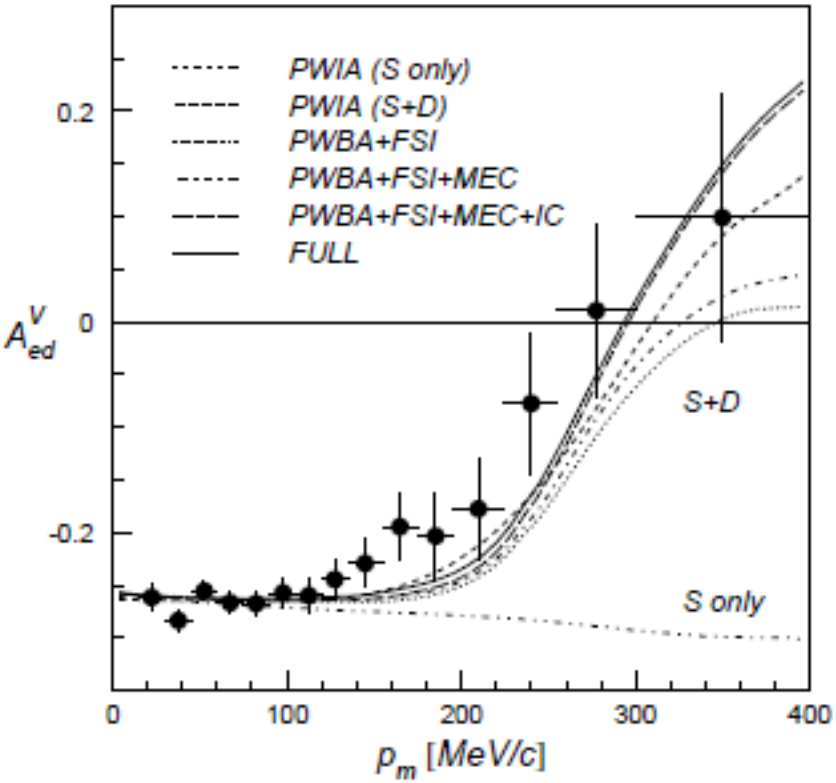


Angular Momentum $\ell=0$ $\ell=2$

~90% ~10%

$\vec{D}(\vec{e},e'p)n$ Asymmetry Measurements at NIKHEF

- A sign flip of asymmetry with the increase of missing momentum gave an indication of the existence of D state
- Sign flip happened at around Fermi momentum of deuterium nucleus

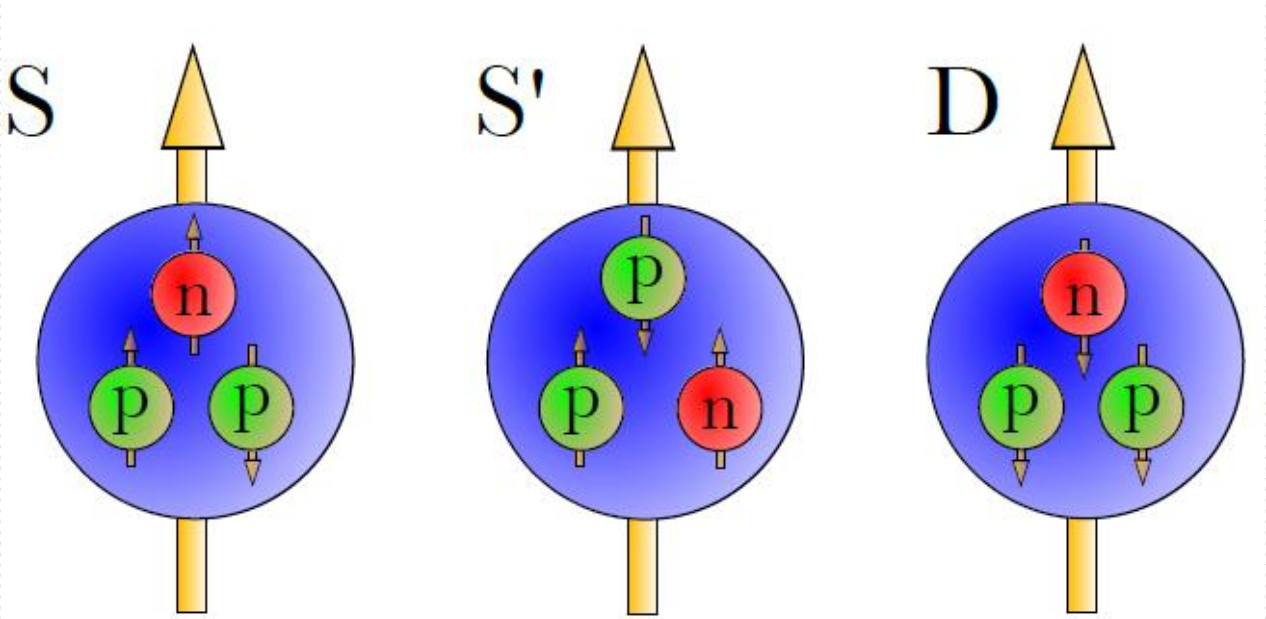


I. Passchier *et al.*, Phys. Rev. Lett. **88** (2002) 102302.

^{3}He spin structure

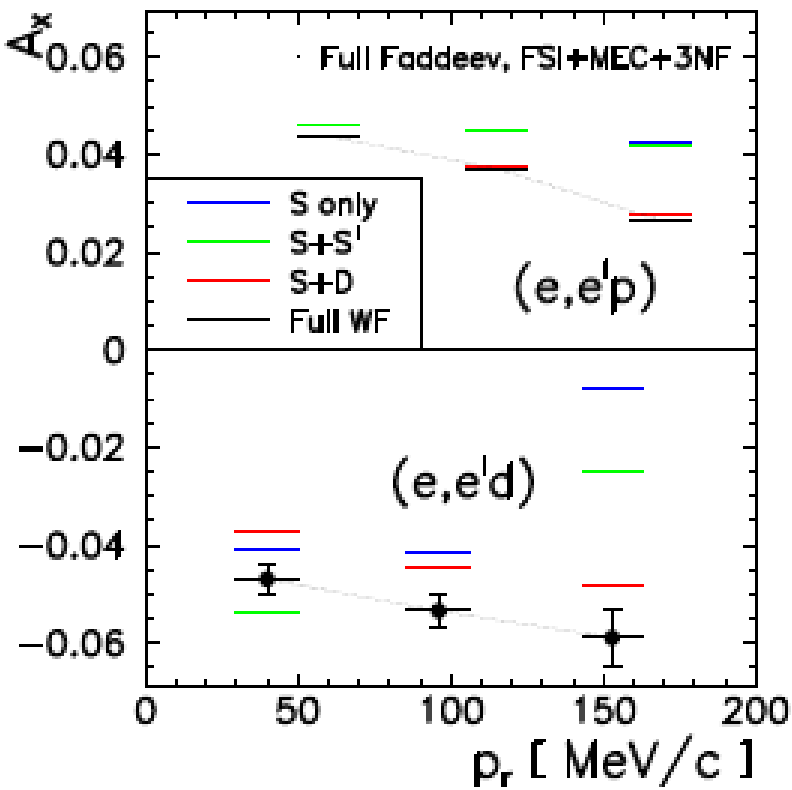
- Spin-1/2 Particle, 3 spin-1/2 Nucleons (Proton and Neutron)

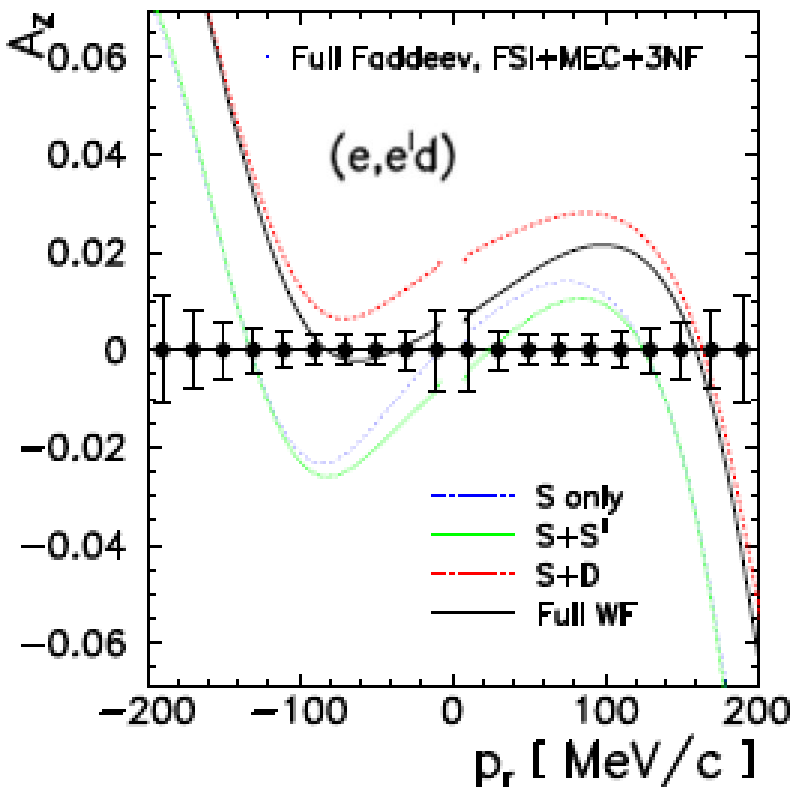
Effective Neutron Target



	S	S'	D
Angular Momentum	ℓ=0	ℓ=0	ℓ=2
	~90%	~1-2%	~8%

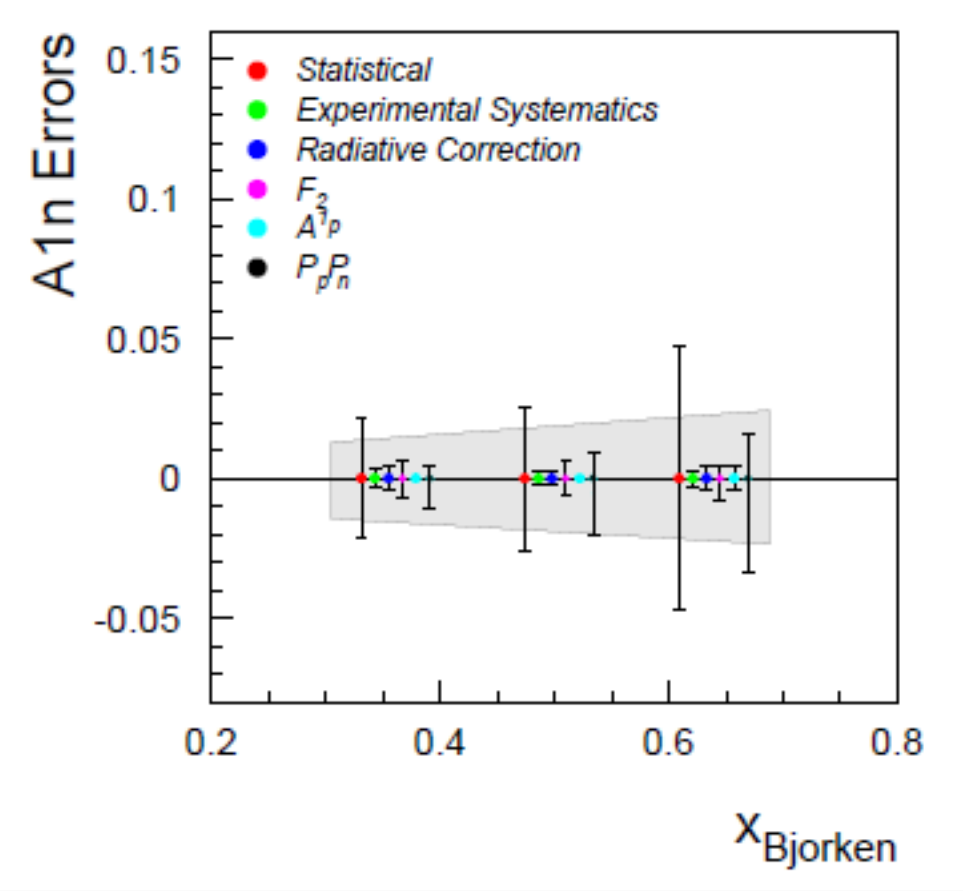
Theoretical asymmetry from Faddeev Calculation





^{3}He based experiments

- JLab experiment E99-117 measured neutron asymmetry A^1_n in DIS region, the leading error other than statistical is caused by uncertainty in the effective proton and neutron polarization in ^{3}He



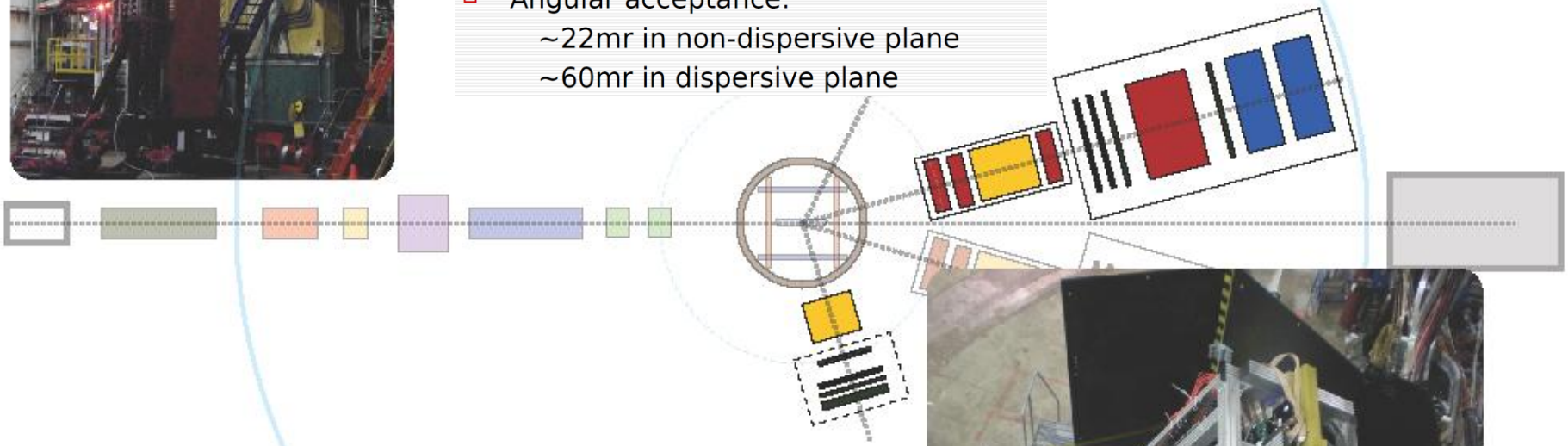
X. Zheng *et al.*, Phys. Rev. C 70, 065207(2004)

JLab E05-102: Experimental Setup

- Beam energy 2.4 GeV, helicity fast-flipped (30Hz)
- LHRS angle 12.5 and 14.5 degrees
- BigBite angle 75 and 82 degrees
- ^{3}He target polarization ~60%

High-resolution spectrometers (HRS)

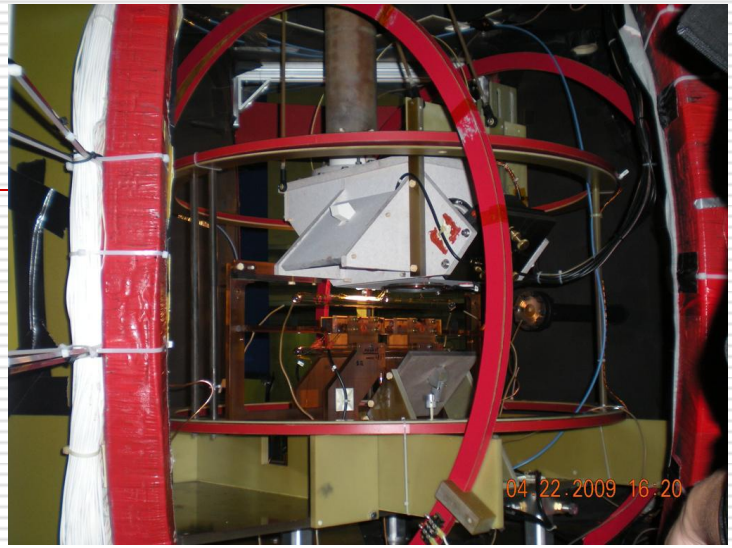
- Detects scattering electrons with high resolution
- Angular resolution:
  - ~0.6mr in non-dispersive plane
  - ~0.2mr in dispersive plane
- Momentum acceptance: ±4.5%
- Angular acceptance:
  - ~22mr in non-dispersive plane
  - ~60mr in dispersive plane



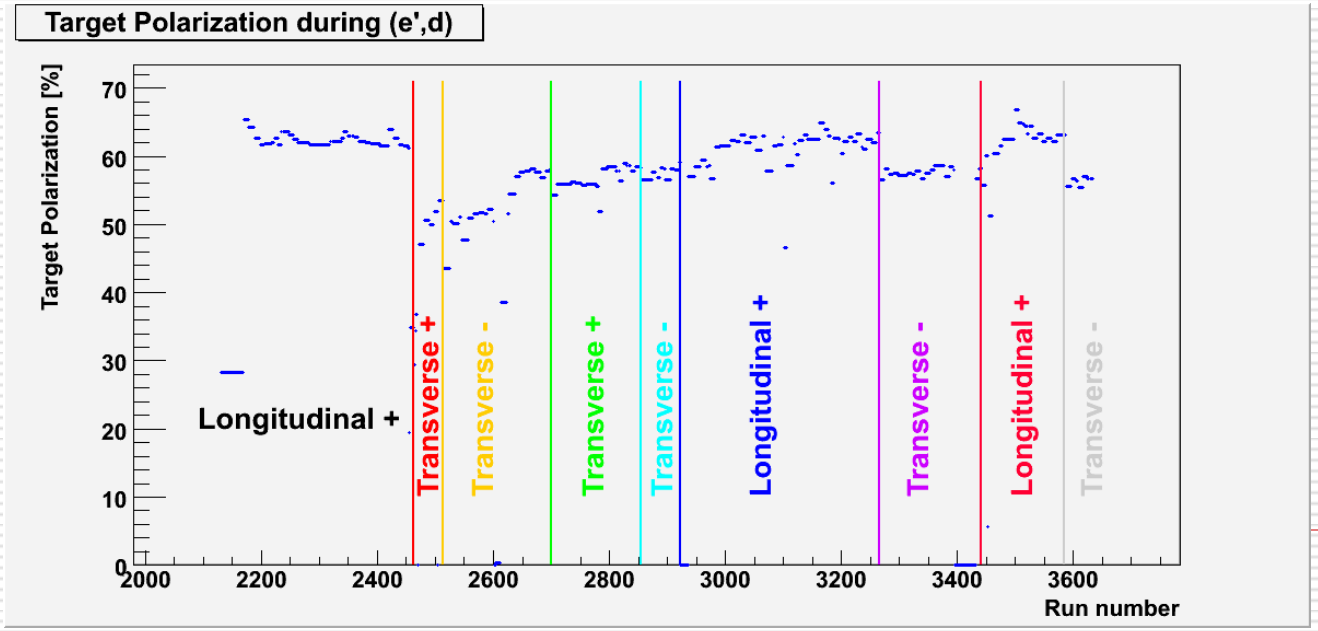
BigBite spectrometer

- Detects protons and deuterons with large acceptance and relatively low resolution
- Solid angle of 96 msr
- Momentum acceptance: 200-900MeV/c
- Two wire chambers and two scintillator planes (3 mm and 30 mm thick each)

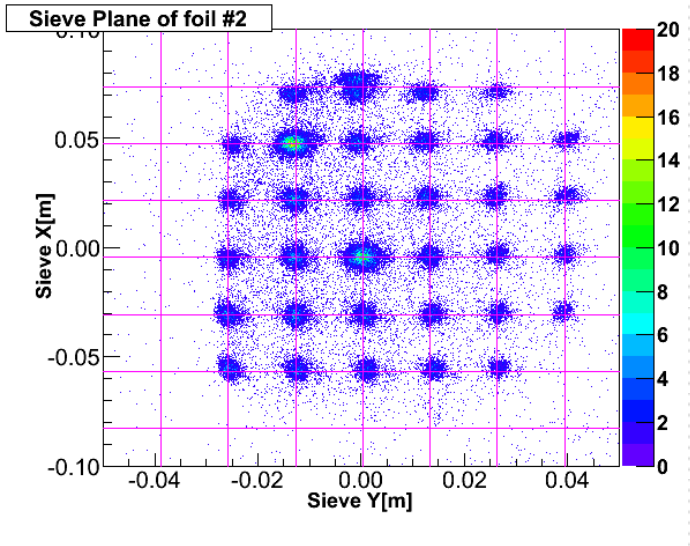
^{3}He Target

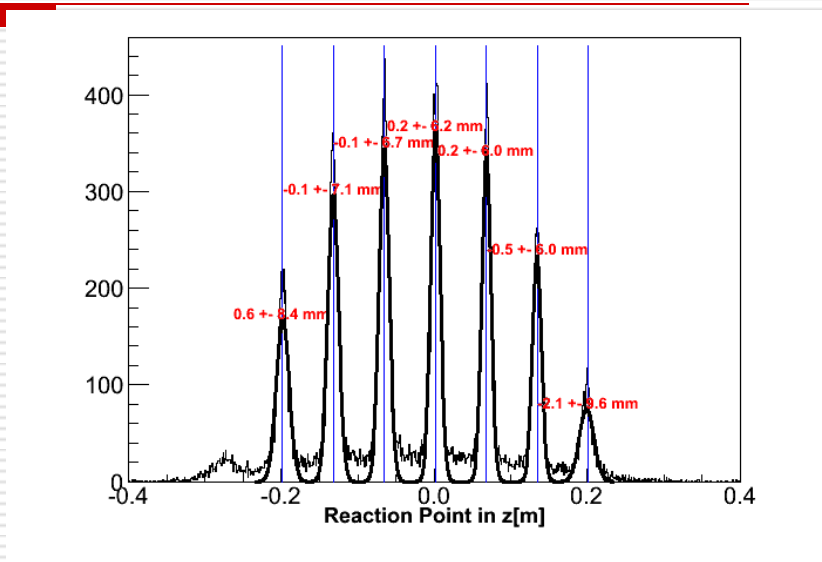


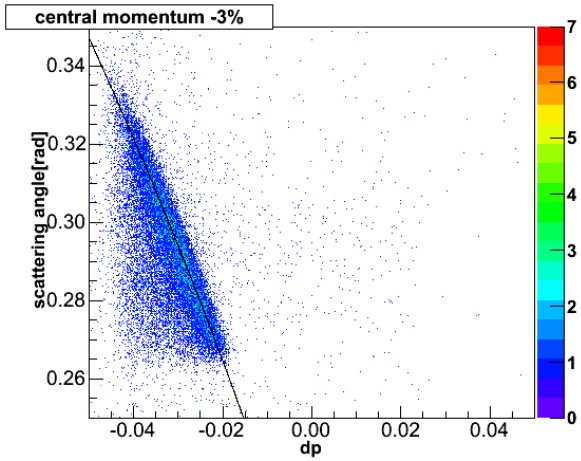
- Hybrid K-Rb spin exchange optical pumping
- High in-beam polarization ~60%
- Narrow band-width laser

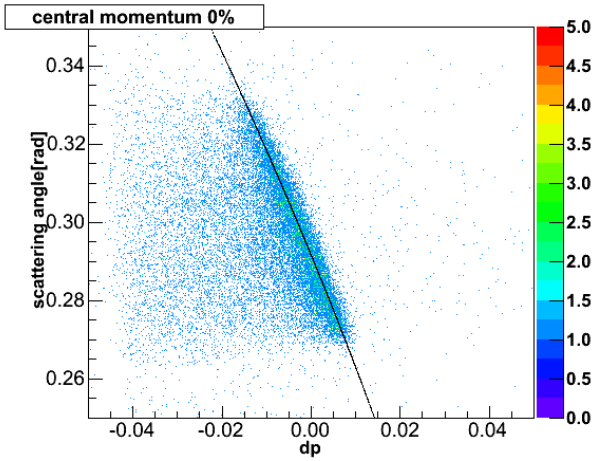


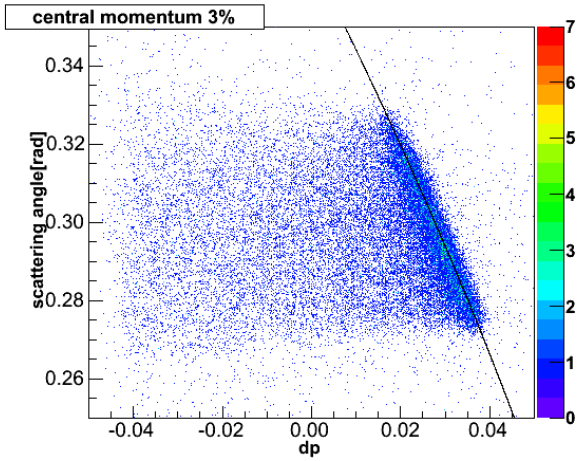
Calibration: High Resolution Spectrometer (HRS) Optics





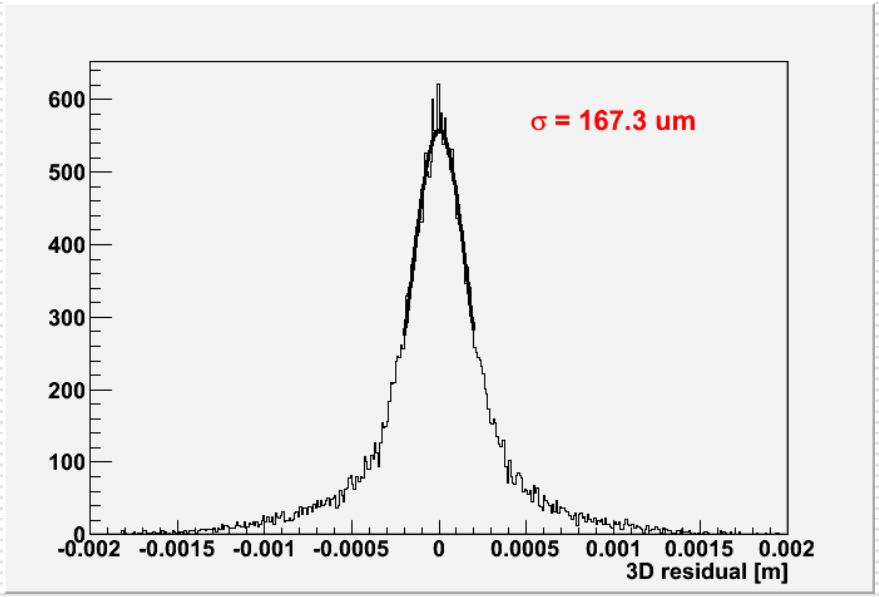




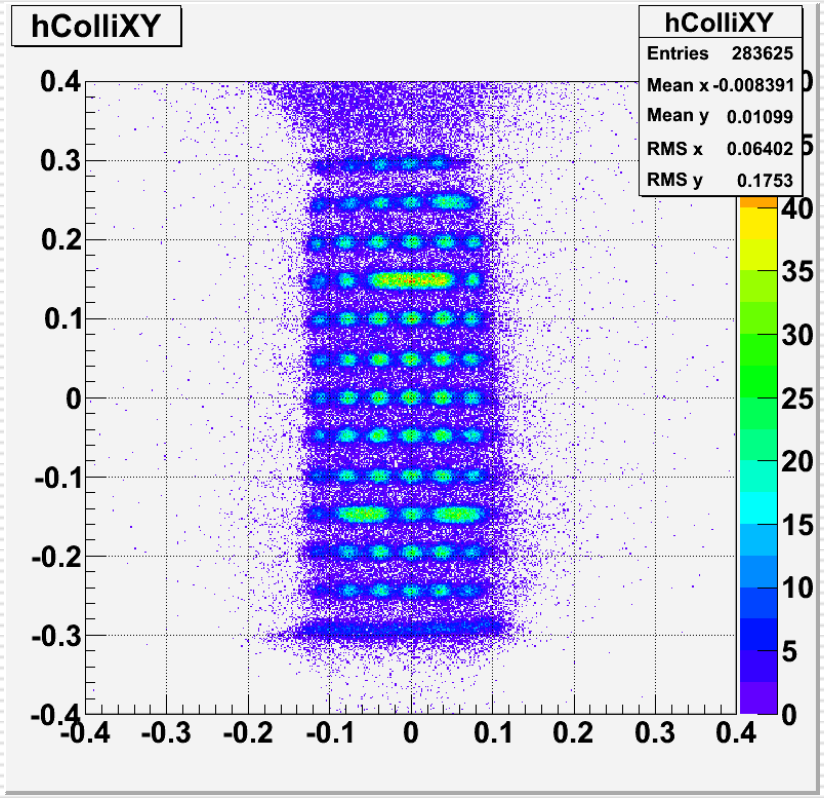


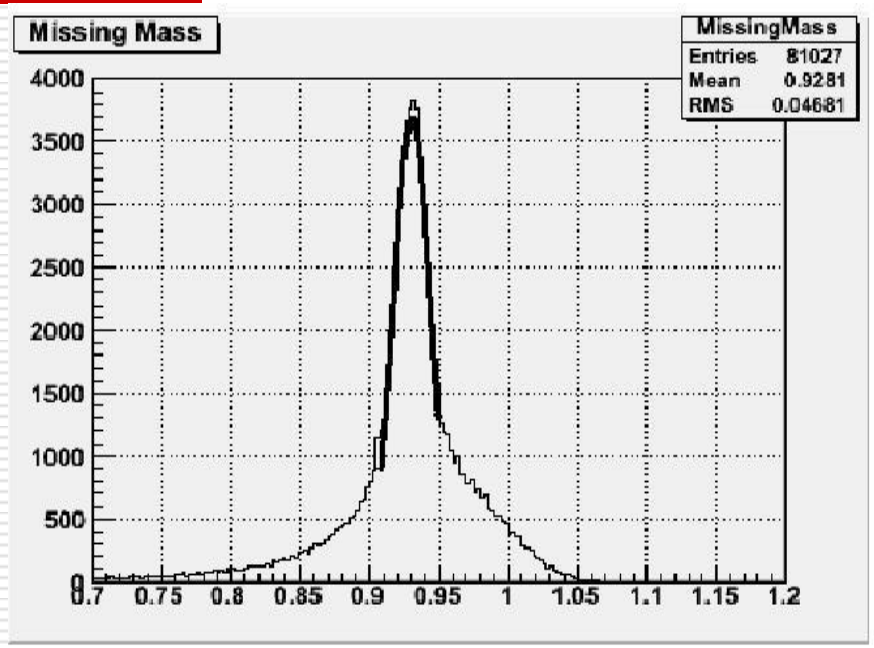
BigBite Spectrometer Wire Chamber Tracking

- Track resolution σ∼180 um
- Tracking hit efficiency ~98.3%

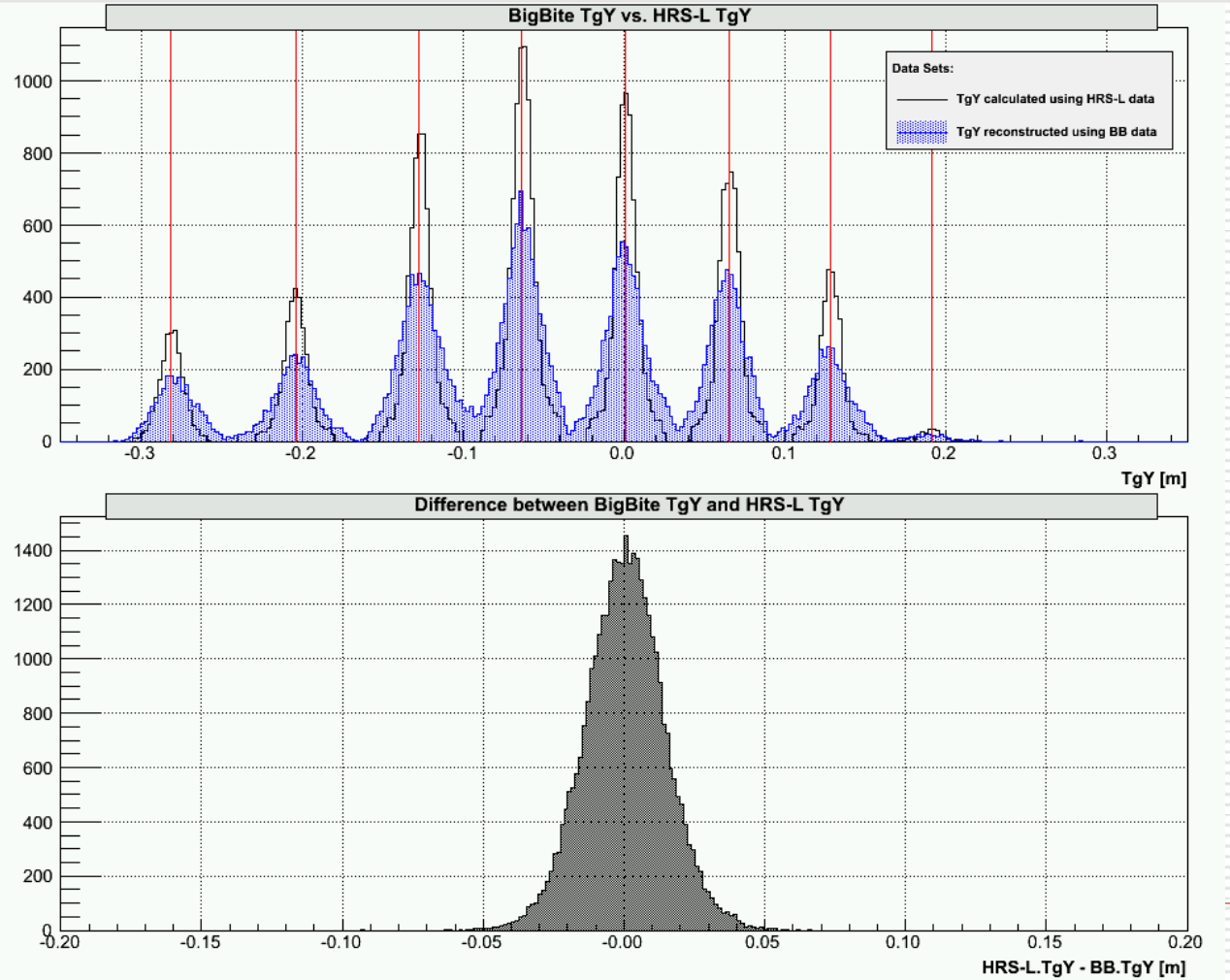


BigBite optics: sieve and momentum





BB optics: reaction point z



Summary and outlook

- Finished:
  - HRS optics
  - BigBite optics
- Ongoing and to-be-done
  - Target
  - Asymmetry

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E05-015,
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BigBite optics: target y

- 7-foil carbon target
- Comparing BB reconstruction (blue) with LHRS reconstruction (black)