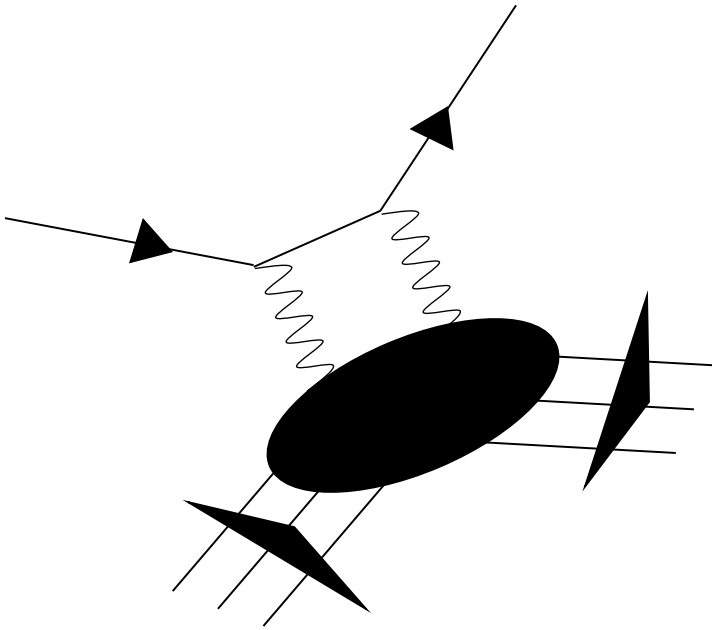
Measurement of the Target Single-Spin Asymmetry in Quasi-Elastic $^3He^{\uparrow}(e, e')$



Yawei Zhang

Rutgers University

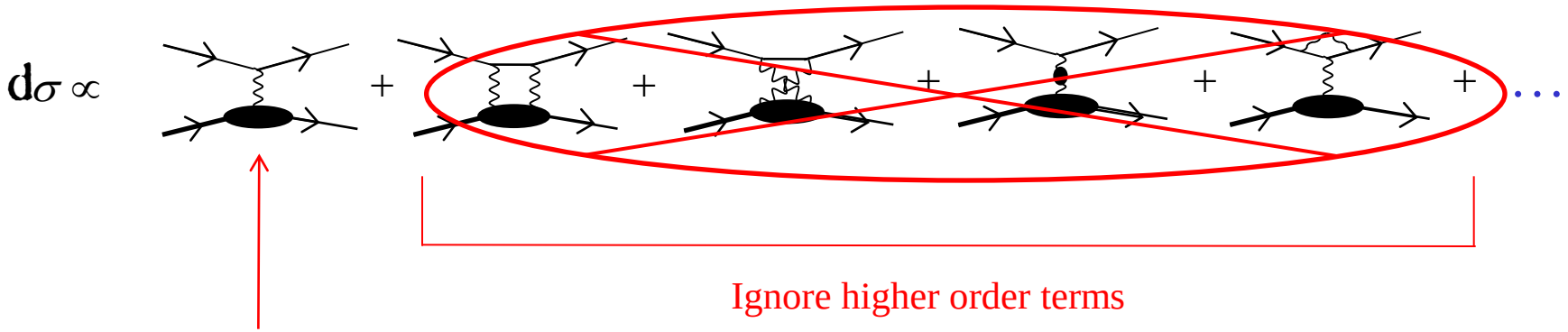
For the Hall-A Quasi-Elastic Collaboration at Jefferson Lab

Outline

- Physics Motivation
- Experiment Setup
- Data Analysis
- Preliminary Results
- Summary

Physics Motivation

Born Approximation:



OK Either higher order contributions lost in experimental error bars;

or Born Approximation could predict experimental outcome within error bars.

Physics Motivation

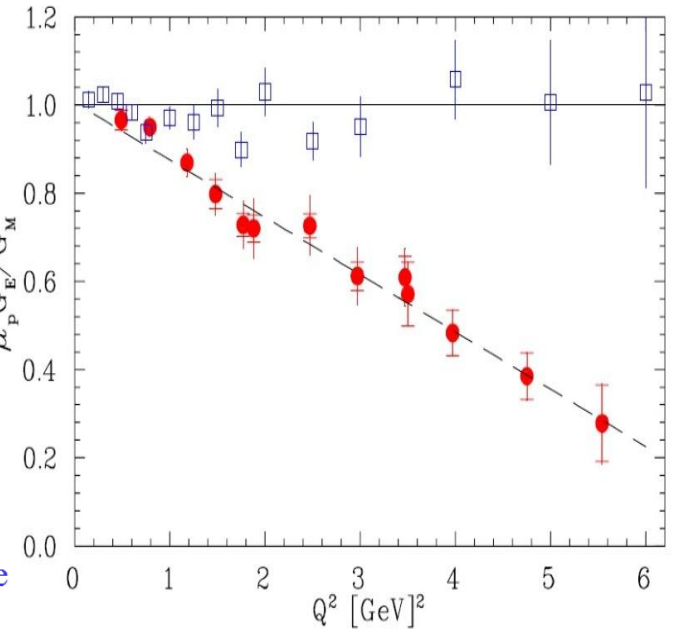
Rosenbluth Method

Measures unpolarized cross-sections, elastic electron-proton scattering

$$\frac{d\sigma}{d\Omega} = \sigma_{mott}\frac{E'_e}{E_e}\left\{\frac{G_E^2+\tau G_M^2}{1+\tau} + 2\tau G_M^2 \tan^2(\theta_e/2)\right\}$$

where $\tau = \frac{Q^2}{4M_p^2}$

Separate G_E and G_M by varying incident electron energy (E_e) and scattering angle (θ_e) at fixed Q^2



Recoil Polarization

A longitudinally polarized electron transfers its polarization to recoil proton.

Measures the ratio of the transverse (P_t) and longitudinal (P_l)polarization of the recoiled proton.

$$\frac{P_t}{P_l} = -\frac{G_E}{G_M}\frac{2M_p}{E_e+E_{e'}}\tan^{-1}(\theta_e/2)$$

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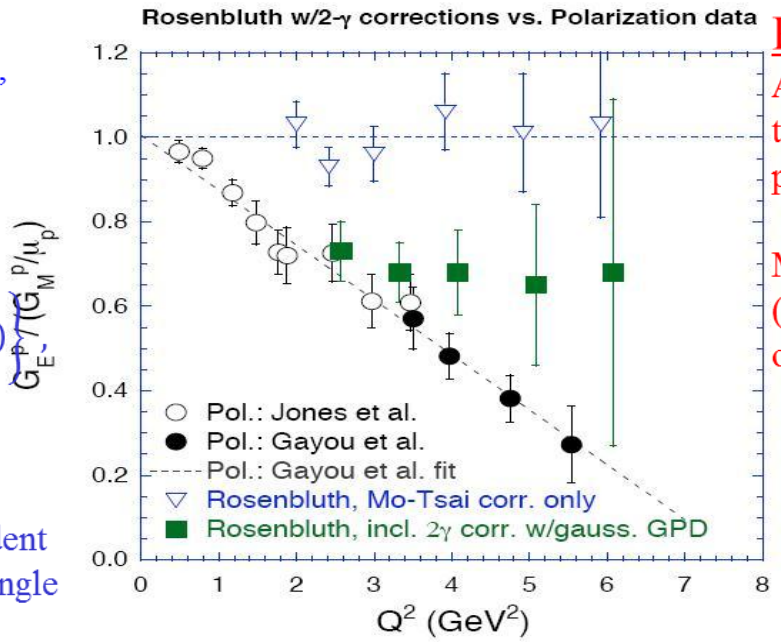

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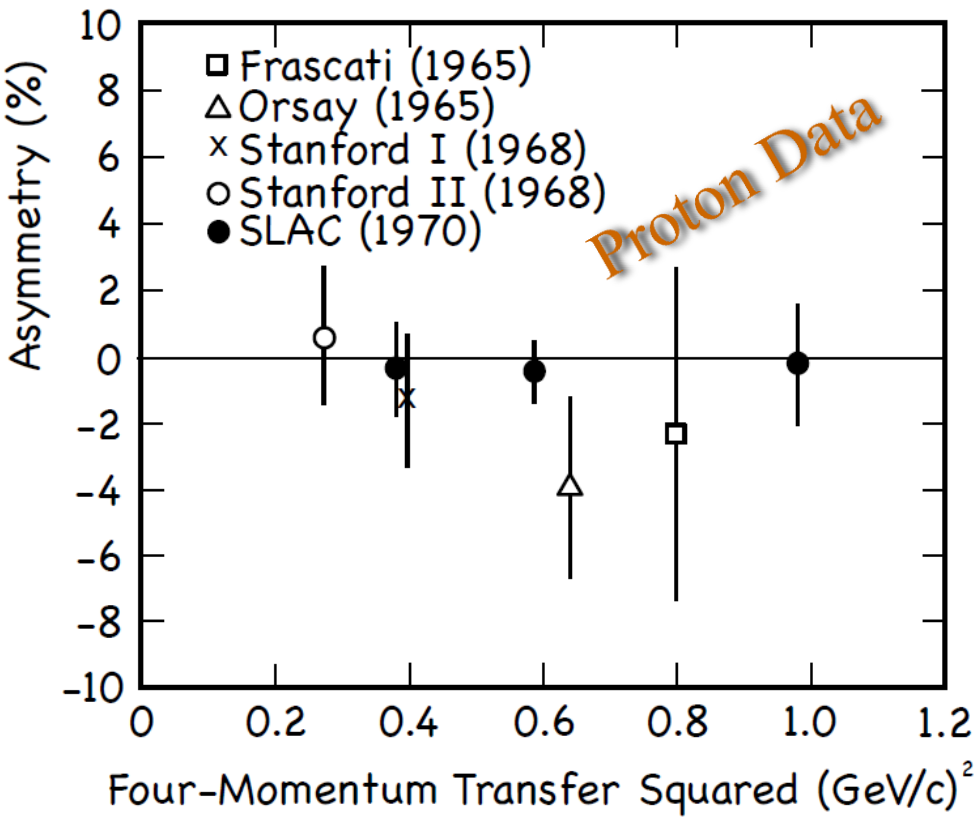
Rosenbluth Method with 2γ exchange

Carlson et. al. calculation including 2γ exchange correction using Generalized Parton Distribution functions (GPD's)

Existing Data

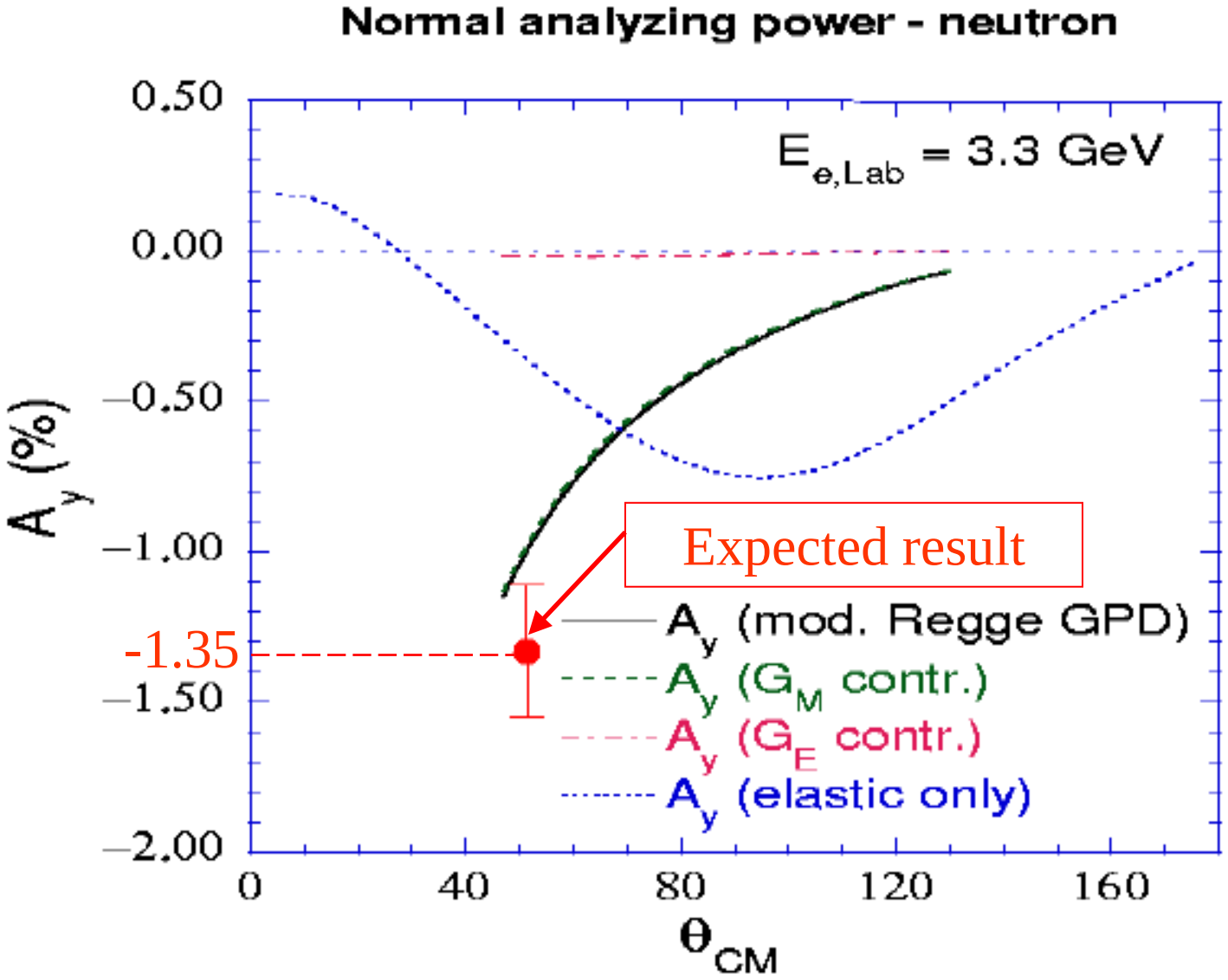


- $A_y^{Born} = 0$ using Time-Reversal Invariance
- $A_y \neq 0$ due to imaginary part of interference

- A non-zero A_y never measured!
- A high-enough precision measurement does not exist!

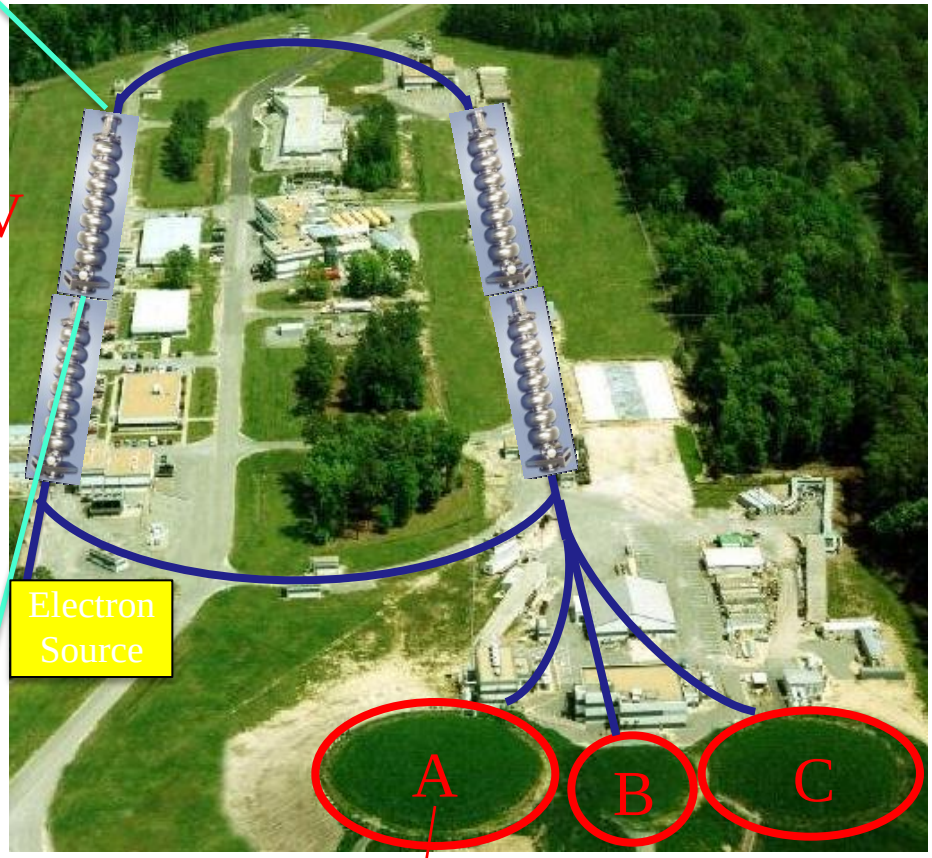
- Make a precise non-zero measurement of Ay
- Provide a new experimental constraint on GPD Models
- Provide quantitative information about the imaginary part of the two-photon exchange process

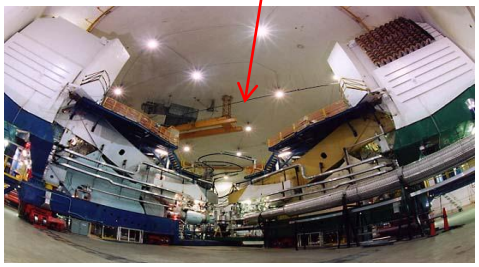
Theoretical prediction



Jefferson Lab

E_{beam} up to 6 GeV



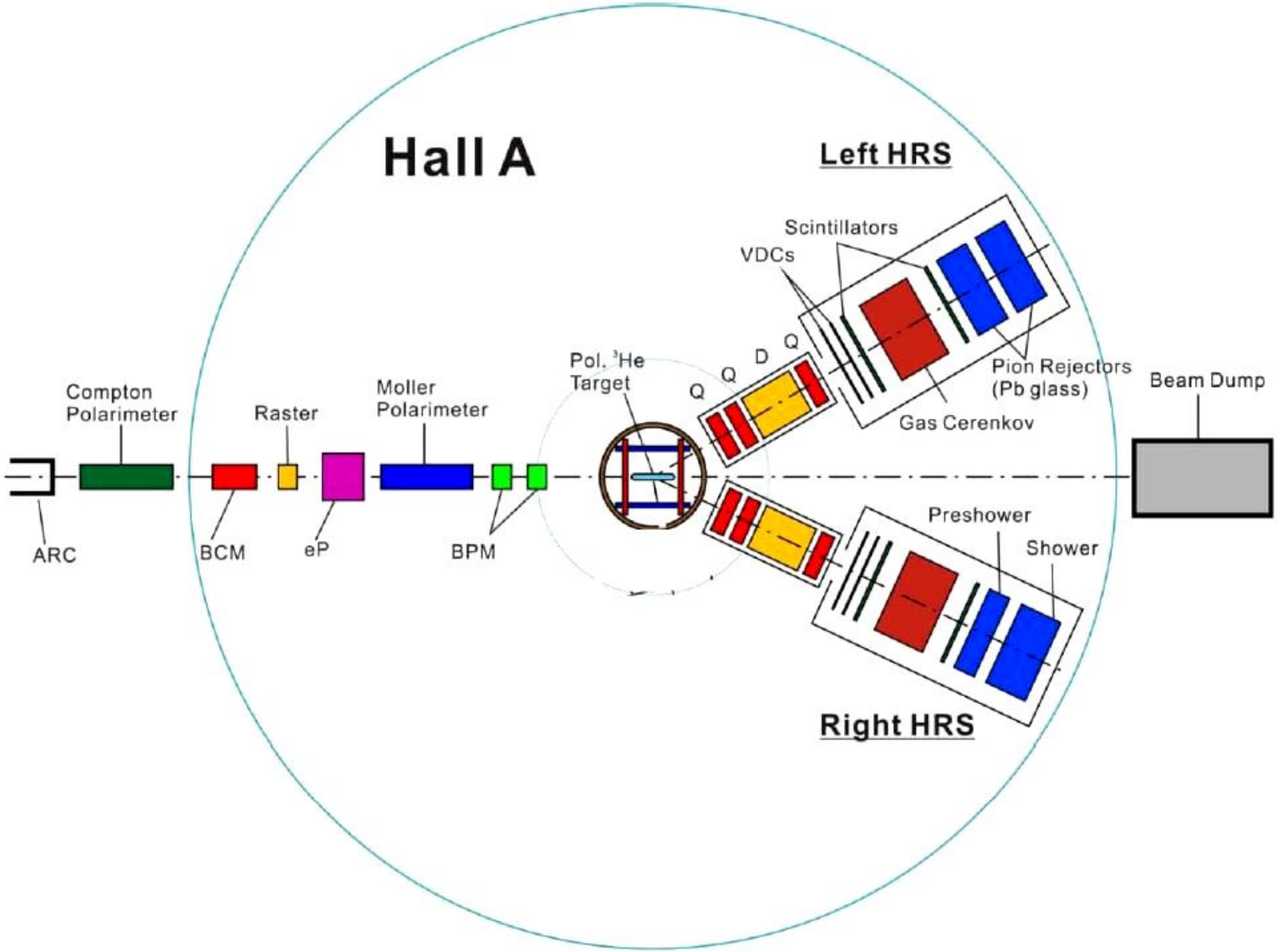


Kinematics of A_y

QE A_y experiment (E05-015) was run from April 26th to May 12th in 2009

E_0 [GeV]	E' [GeV]	θ_{lab} [Deg]	Q^2 [GeV]^2	$\|q\|$ [GeV]	θ_q [Deg]
1.25	1.22	17	0.13	0.359	71
2.43	2.18	17	0.46	0.681	62
3.61	3.09	17	0.98	0.988	54

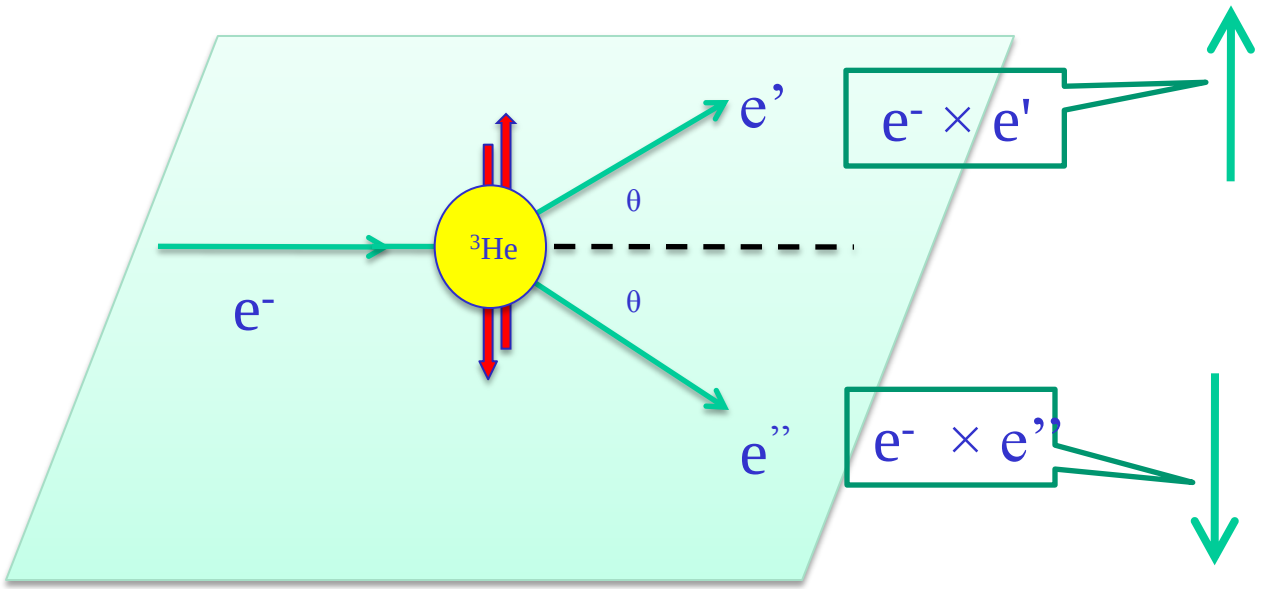
Experiment Setup



Experiment Setup

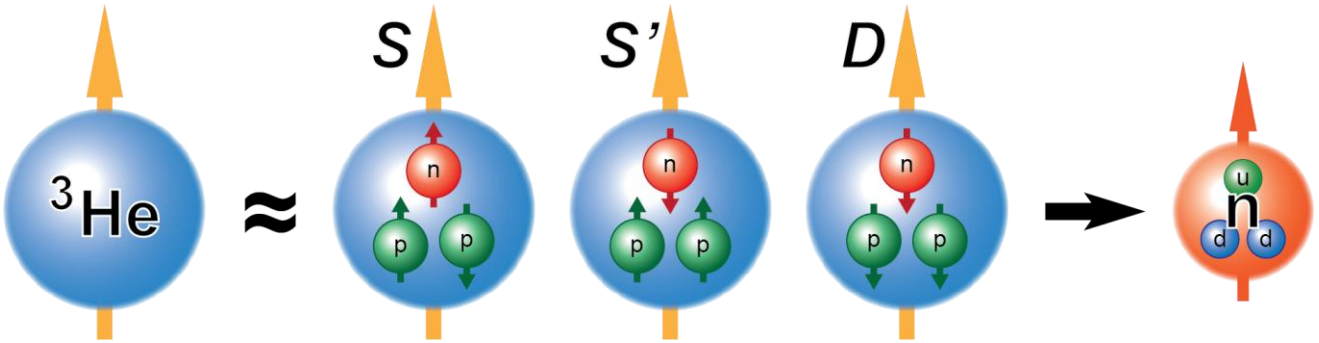
$$A_y = \frac{\sigma^{\uparrow} - \sigma^{\downarrow}}{\sigma^{\uparrow} + \sigma^{\downarrow}}$$

$$\vec{s} \cdot (\vec{k} \times \vec{k}')$$



$$A_y(-\theta) = -A_y(\theta)$$

Polarized ^{3}He Target



88% 1.5% 8%

F. R. P. Bissey, A. W. Thomas, and I. R. Afnan, Phys. Rev. C64, 024004 (2001)

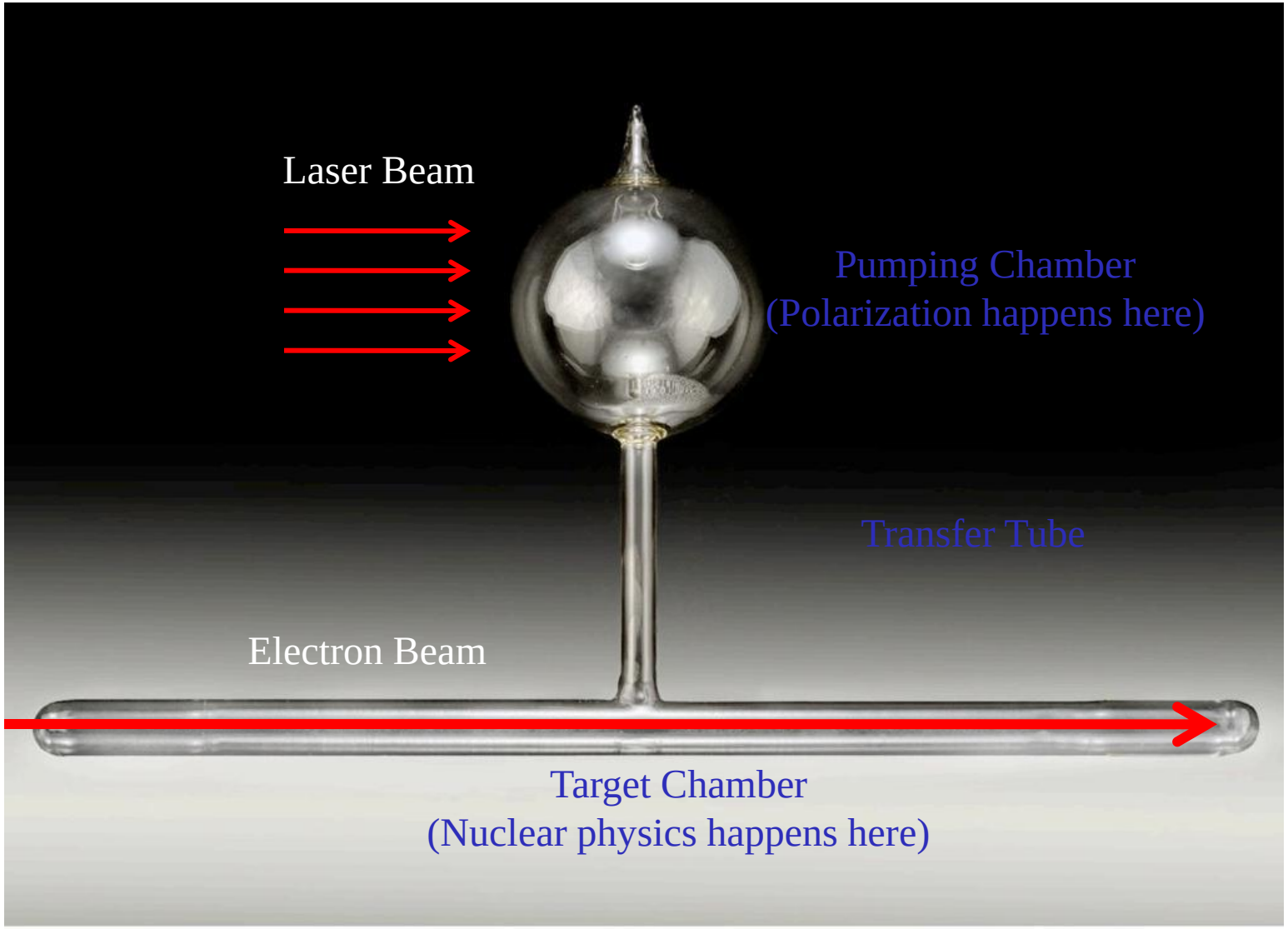
Why ^{3}He?

No free neutrons – they decay in less than 15 minutes!

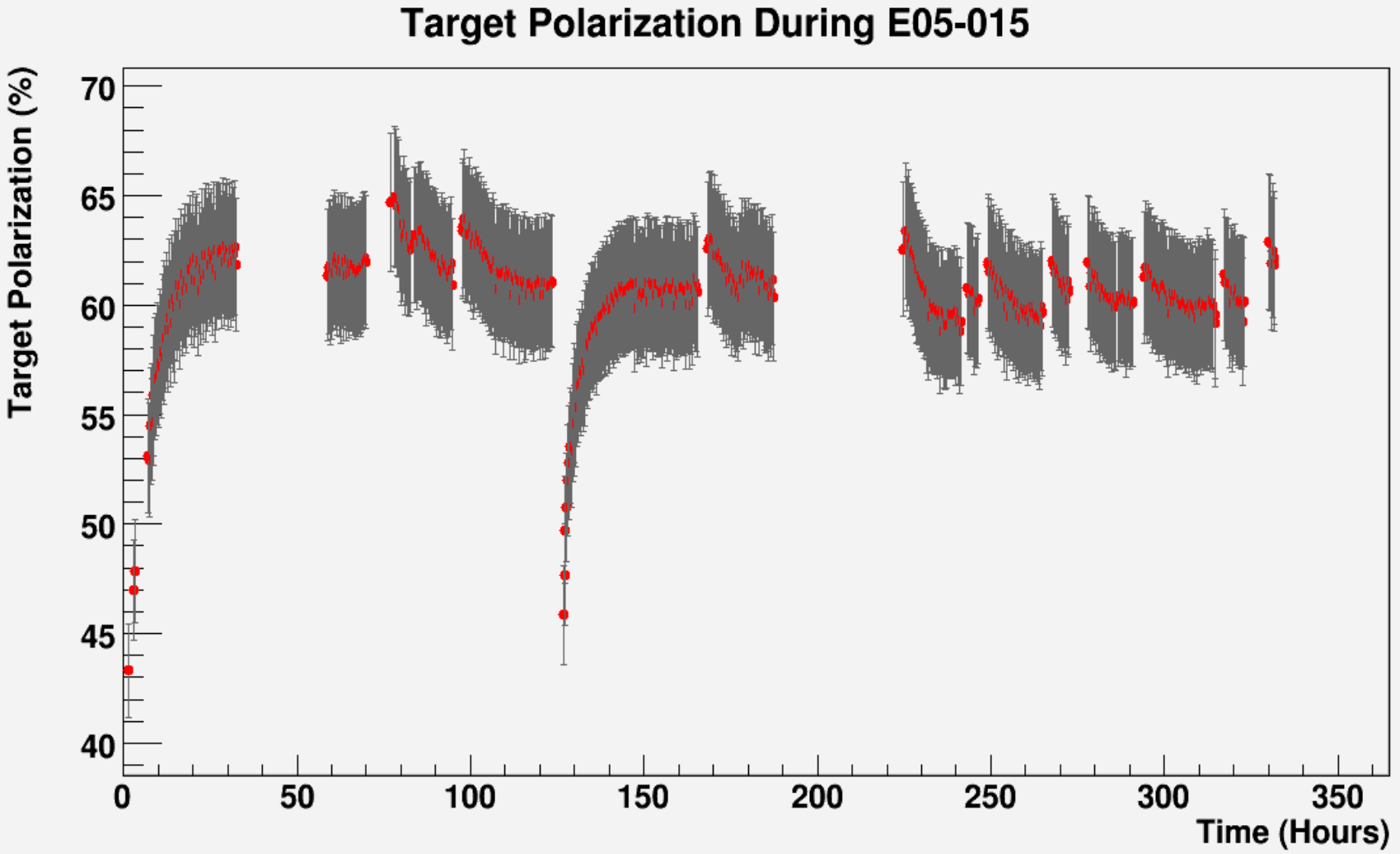
^{3}He and Deuteron are two good candidates for a neutron target.

100% polarized ^{3}He atom ⟶ 88% polarized neutron

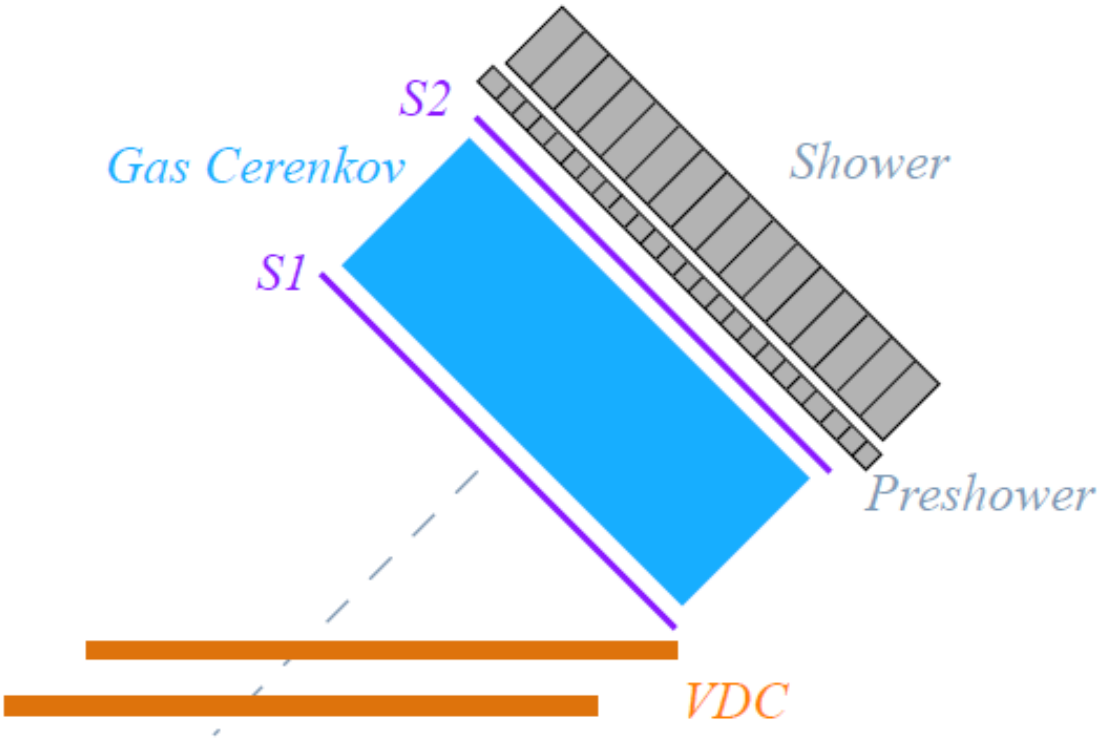
Polarized ^{3}He Target



Target Performance



Detectors



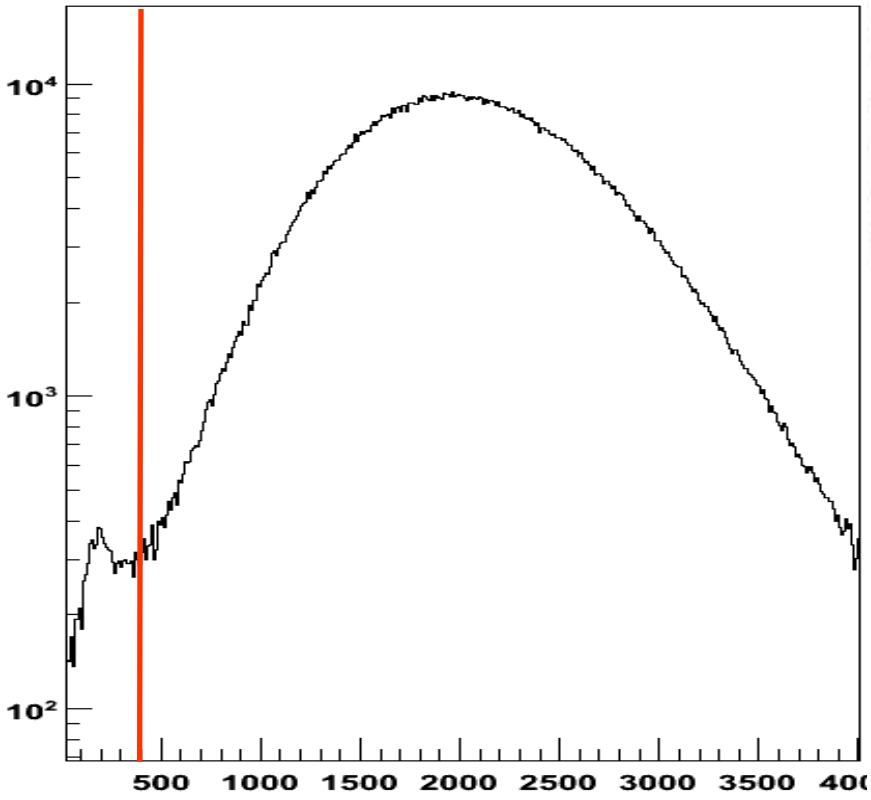
1). A pair of Vertical Drift Chambers (VDCs) to determine the trajectory of a particle;

2). Two scintillator planes (S1 and S2) to generate the trigger and the time-of-flight information;

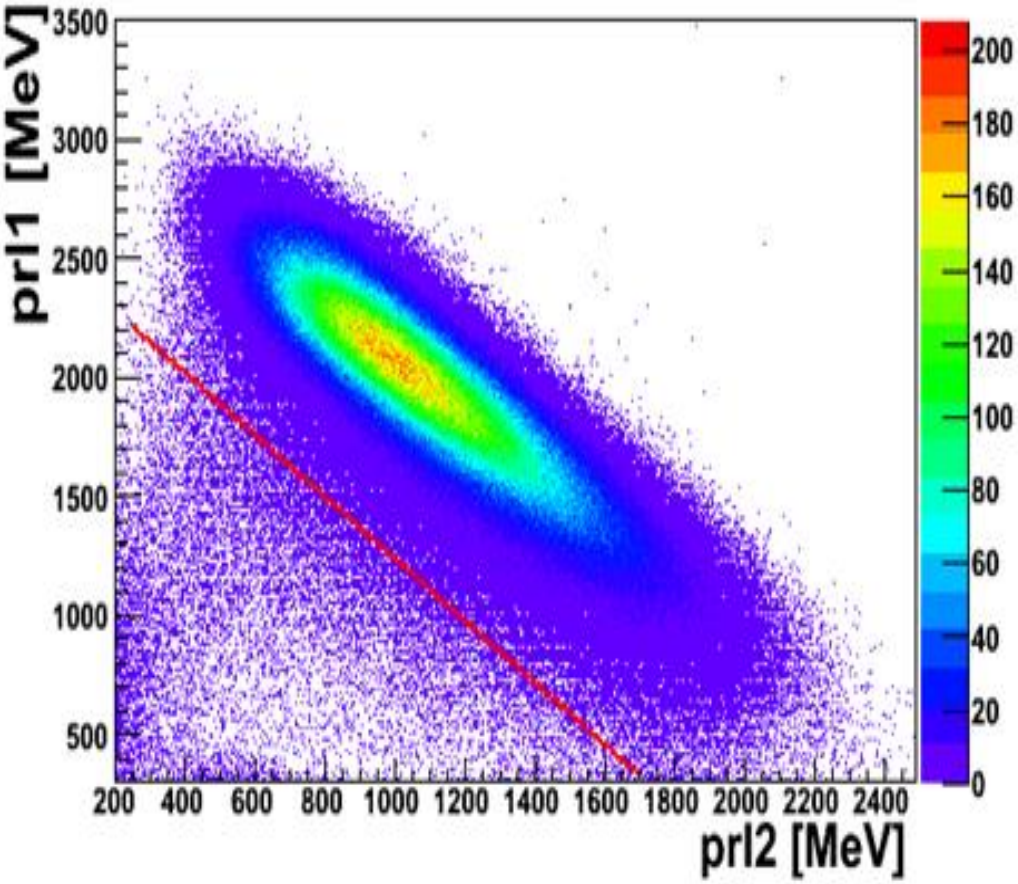
3). A Gas Cerenkov detector for e^-/π^- sepration;

4). A preshower and a shower for additional e^-/π^- sepration;

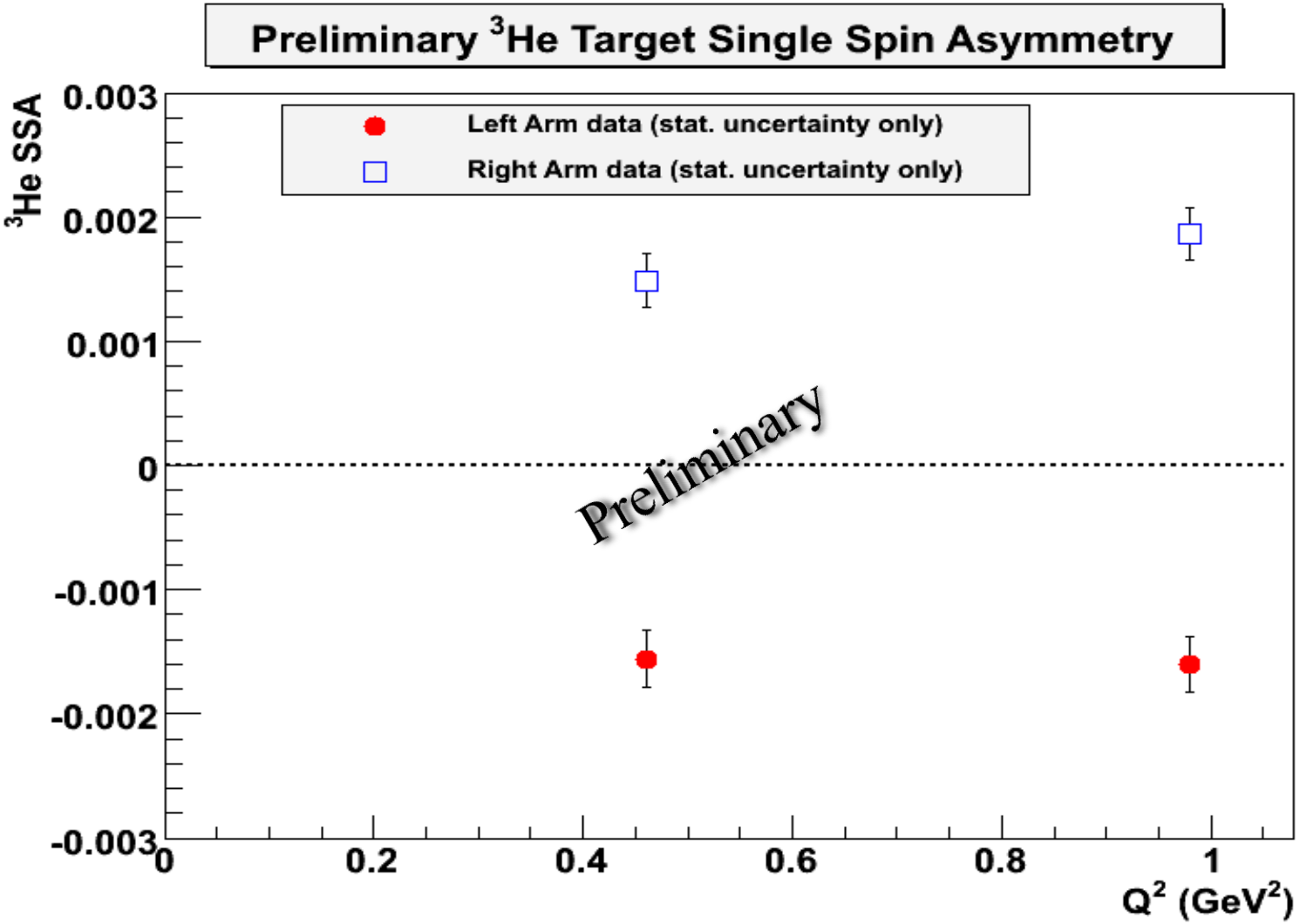
Good Events



Gas Cerenkov ADCs



Preliminary Results



Summary

- First time to measure the target SSA, A_y^n, was performed in Jefferson Lab's Hall A.
- Use both hybrid spin exchange optical pumping (SEOP) and narrow-band lasers, leading to record polarized ^{3}He target performance: $P_T > 60\%$.
- From the preliminary result, the asymmetry is clearly non-zero.
- Uncertainty is several times better than previous proton data.

Preliminary Result