

Proton and Deuteron Spin Structure Function Measurements in the Resonance Region

Frank R. Wesselmann
University of Virginia

for the RSS Collaboration

Outline

- Overview
- Setup
- Results

Overview

Jlab Experiment E01-006 (RSS):

- * nucleon spin structure measurement
 A_{\parallel} and A_{\perp} , proton and deuteron
- * scattered polarized e^- beam off polarized, solid target
- * inclusive measurement
- * Resonance Region ($0.8 < W < 1.9 \text{ GeV}$)
 $E_0 = 5.76 \text{ GeV}$, $p = 4.09 \text{ GeV}$ and 4.7 GeV
- * ran January – March 2002
in Hall C at Jefferson Lab
Newport News, Virginia
- * $\mathcal{P}_{ND_3} \approx 15\%$ and $\mathcal{P}_{NH_3} \approx 70\%$
 $20 - 40 \text{ mC per target, orientation}$

RSS Collaboration

Aram Aghalaryan, Abdellah Ahmidouch, Razmik Asaturyan,
Hu Bitao, Frederic Bloch, Werner Boeglin, Peter Bosted,
Roger Carlini, Jinseok Cha, Jian-Ping Chen, Eric Christy,
Leon Cole, Luminita Coman, Marius Coman, Donald Crabb,
Sam Danagoulian, Donal Day, Jim Dunne, Mostafa Elaasar,
Rolf Ent, Howard Fenker, Emil Frlez, Lipin Gan, Javier Gomez,
Mark Jones, Chris Keith, Cynthia Keppel, Mahbub Khandaker,
Andi Klein, Yongguang Liang, Jechiel Lichtenstadt,
Richard Lindgren, Dave Mack, Paul McKee, Dustin McNulty,
Hamlet Mkrtchyan, Rakhsha Nasseripour,
Maria-Ioana Niculescu, Kristoff Normand, Blaine Norum,
Dinko Pocanic, Yelena Prok, Brian Raue, Joerg Reinhold,
Julie Roche, Daniela Rohe, **Oscar Rondon**, Nikolai Savvinov,
Brad Sawatzky, Ingo Sick, Cole Smith, Greg Smith,
Sam Stepanyan, Liguang Tang, Giuseppe Testa, Bill Vulcan,
Kebin Wang, Glen Warren, Frank R. Wesselmann, Steve Wood,
Chen Yan, Lulin Yuan, Junho Yun, Marko Zeier-Koch,
Hongguo Zhu

*Universität Basel, Florida International University,
Hampton University, North Carolina A&T University,
Norfolk State University, Old Dominion University,
Southern University at New Orleans, Tel Aviv University,
Thomas Jefferson National Accelerator Facility,
University of Massachusetts, University of Maryland,
Mississippi State University,
University of North Carolina at Wilmington,
University of Virginia,
Virginia Polytechnic Institute & State University,
Yerevan Physics Institute*

Motivation

Resonance Region Spin Structure Function Data:

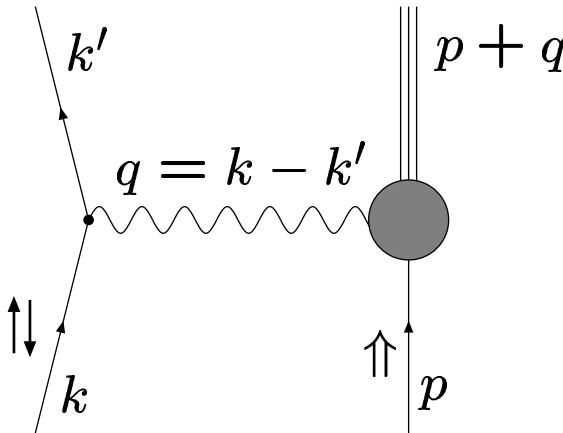
- * W dependence of A_1 , A_2
- * (polarized) local duality
- * GDH sum rule
- * higher twist effects

RSS in particular:

- * p and d
- * A_{\parallel} and A_{\perp}
- * consistent setup
 - same kinematics, systematics*

⇒ model-free extraction of A_1 and A_2

Polarized Scattering



$$A_{||} = \frac{\sigma_{\downarrow\uparrow}^{\uparrow\uparrow} - \sigma_{\uparrow\uparrow}^{\uparrow\uparrow}}{\sigma_{\downarrow\uparrow}^{\uparrow\uparrow} + \sigma_{\uparrow\uparrow}^{\uparrow\uparrow}}$$

$$A_{\perp} = \frac{\sigma_{\uparrow\leftarrow}^{\uparrow\leftarrow} - \sigma_{\downarrow\leftarrow}^{\downarrow\leftarrow}}{\sigma_{\uparrow\leftarrow}^{\uparrow\leftarrow} + \sigma_{\downarrow\leftarrow}^{\downarrow\leftarrow}}$$

$$A_1 = \frac{\sigma_{1/2}^T - \sigma_{3/2}^T}{\sigma_{1/2}^T + \sigma_{3/2}^T} \quad A_{||} = D (A_1 + \eta A_2)$$

$$A_2 = \frac{\sigma_{1/2}^{TL}}{\sigma_{1/2}^T + \sigma_{3/2}^T} \quad A_{\perp} = d (A_2 - \zeta A_1)$$

$$g_1 = \frac{F_1}{1+\gamma^2} (A_1 + \gamma A_2) \quad g_2 = \frac{F_1}{1+\gamma^2} (A_2/\gamma - A_1)$$

$$D = \frac{1 - E'\epsilon/E}{1 + \epsilon R} \quad d = D \sqrt{\frac{2\epsilon}{1 + \epsilon}} \quad \eta = \frac{\epsilon \sqrt{Q^2}}{E - E'\epsilon} \quad \zeta = \frac{\eta(1 + \epsilon)}{2\epsilon}$$

$$Q^2 = -q^2 \quad \gamma^2 = \frac{Q^2}{\nu^2} \quad \epsilon^{-1} = 1 + 2(1 + \frac{\nu^2}{Q^2}) \tan^2(\frac{\theta}{2})$$

From Experimental to Physical Asymmetry (simplified)

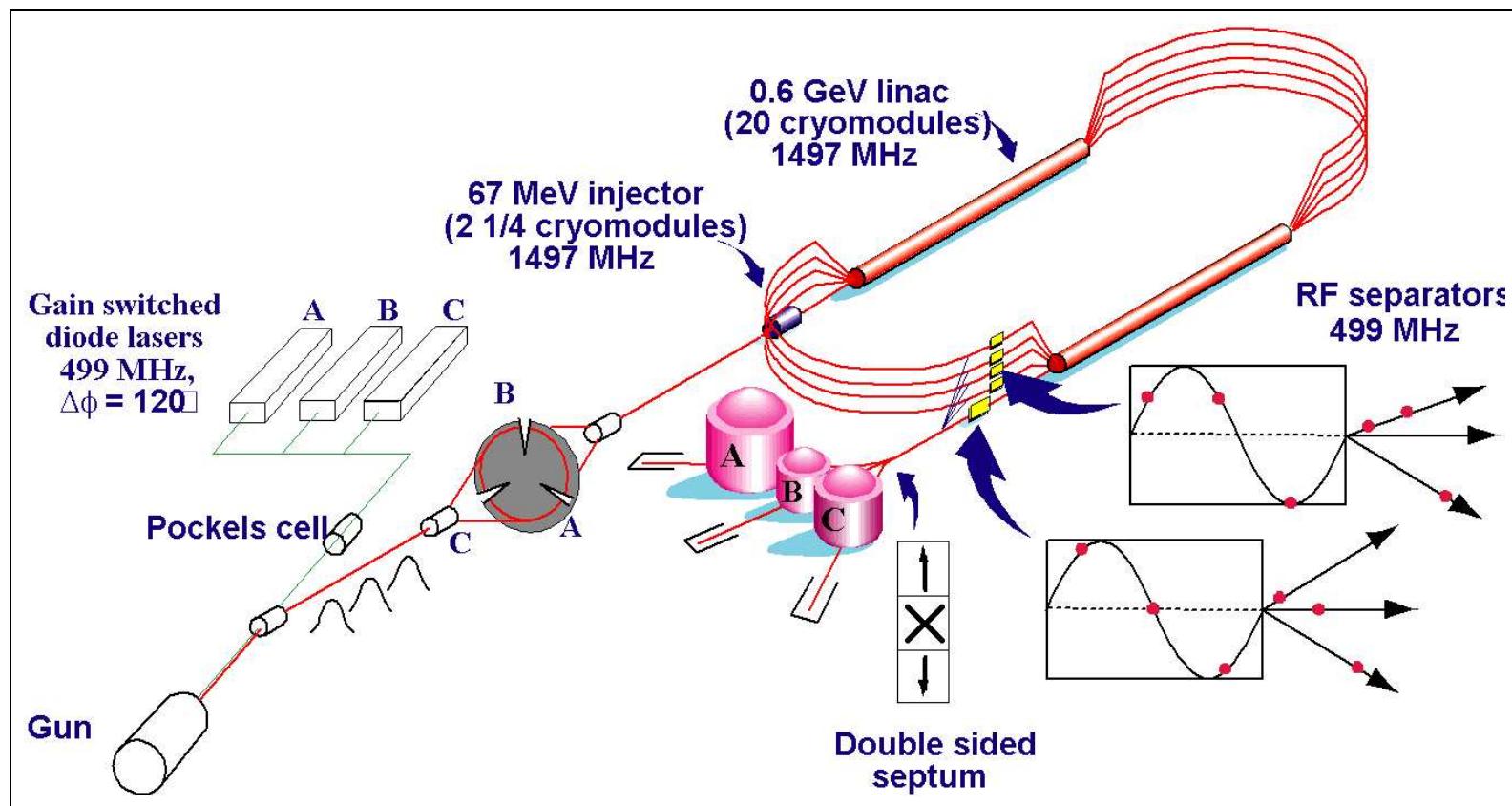
$$A_{raw} = \frac{N^{\downarrow\uparrow} - N^{\uparrow\uparrow}}{N^{\downarrow\uparrow} + N^{\uparrow\uparrow}}$$

charge normalized: $N^i \rightarrow N^i/Q_i$

$$A_{\parallel}, A_{\perp} = \frac{A^{raw}}{f \mathcal{P}_{beam} \mathcal{P}_{target}} + A_{RC}$$

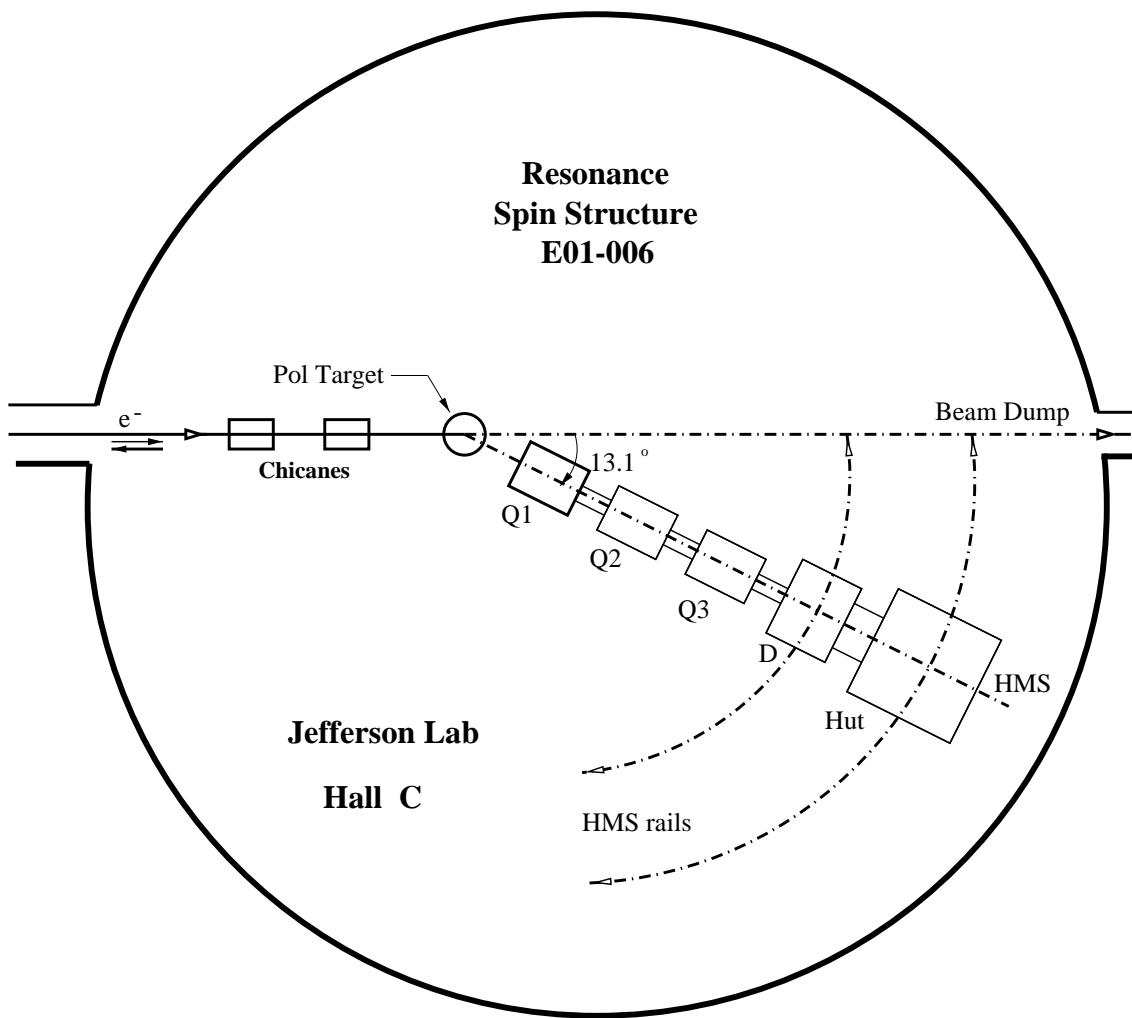
\mathcal{P}_{beam}	Beam Polarization
\mathcal{P}_{target}	Target Polarization
f	Dilution Factor
A_{RC}	Radiative Corrections

Experimental Setup



Thomas Jefferson National Accelerator Facility

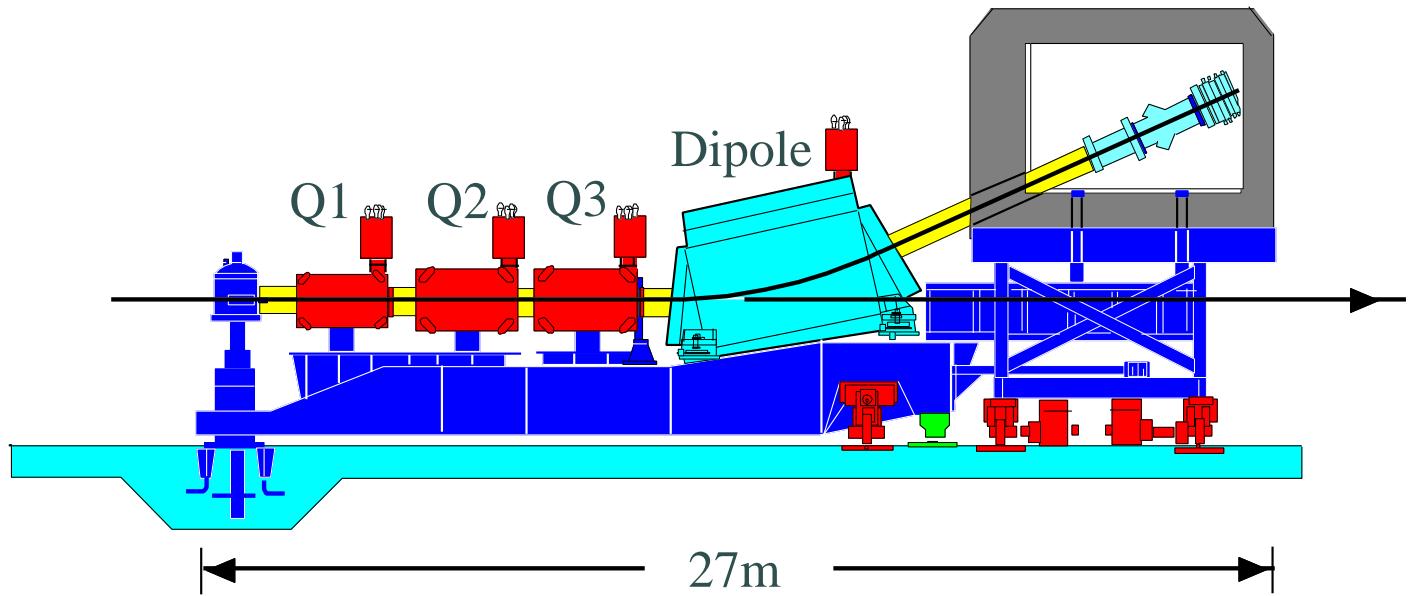
Jefferson Lab's Hall C



Not Shown:

- * Moller Polarimeter
- * Short Orbit Spectrometer
- * recent G0 installations

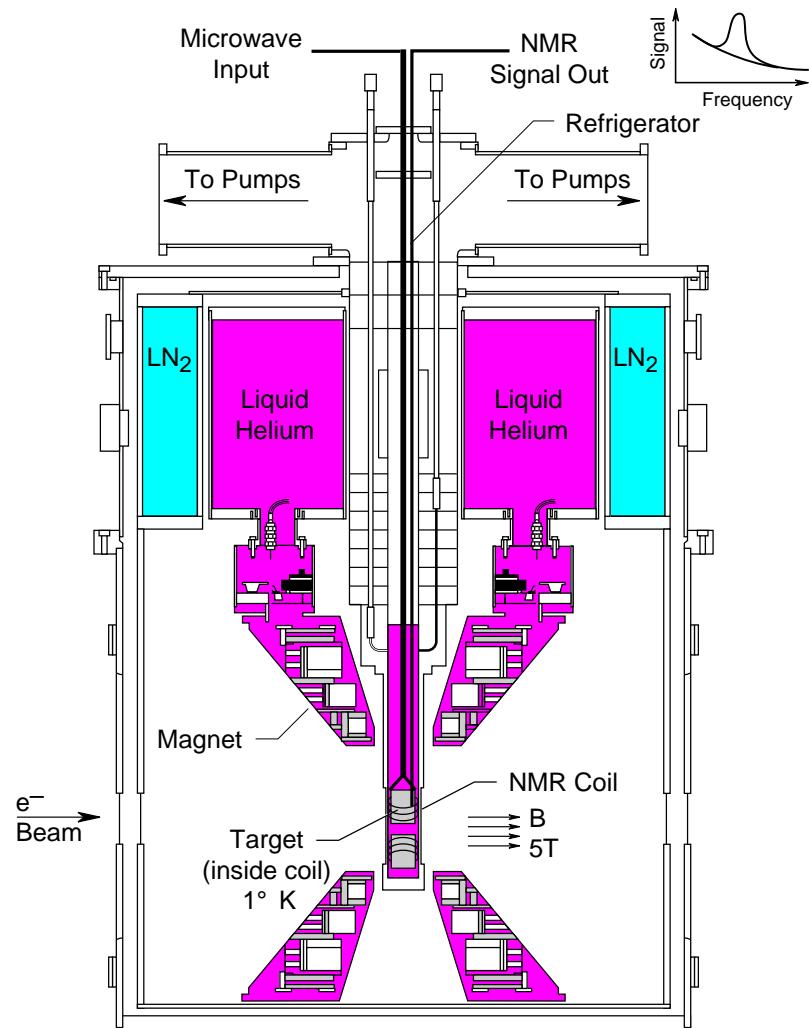
High Momentum Spectrometer



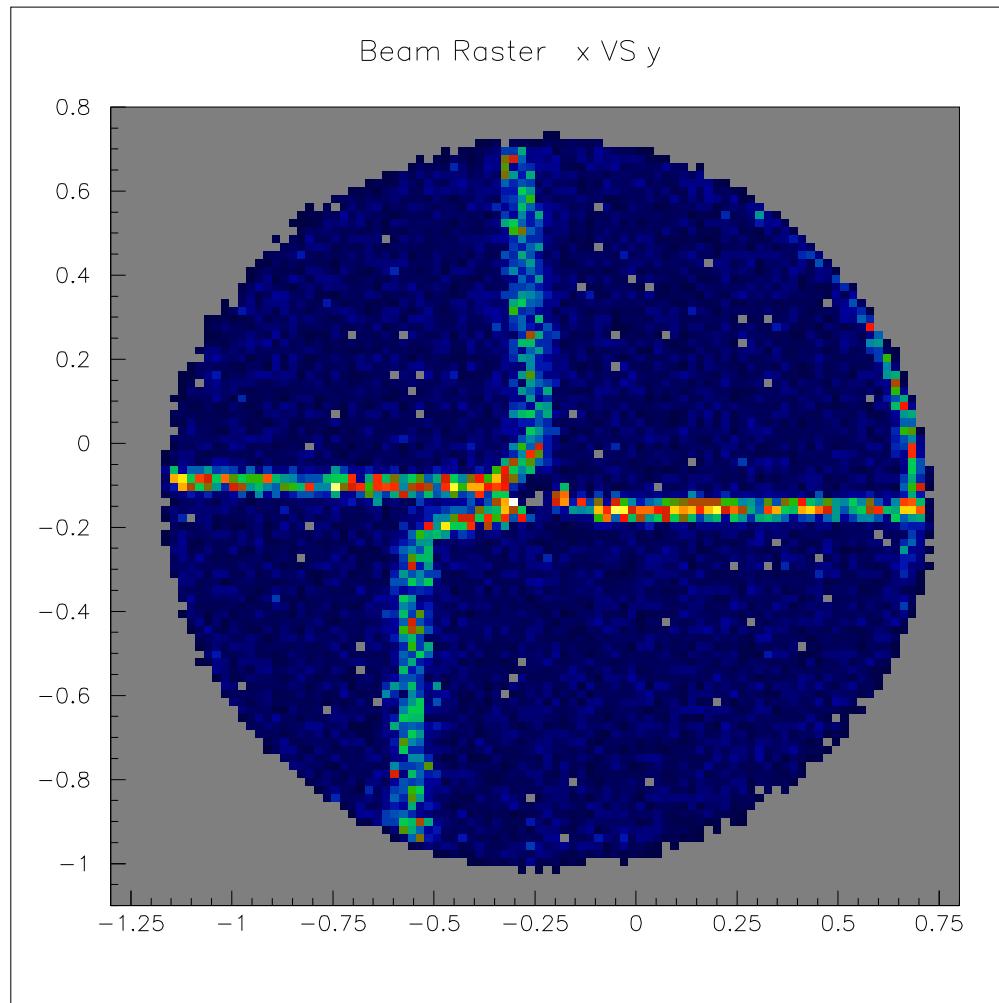
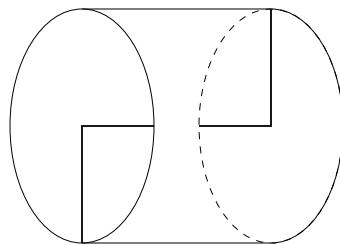
- * 1 dipole magnet, 3 quadrupoles
4.1 and 4.7 GeV, $\pm 9\%$ acceptance
- * shielded detector package
*segmented Pb glass calorimeter,
gas Cherenkov, scintillator hodoscopes,
wire drift chambers*
- * well-studied tracking, reconstruction

Target

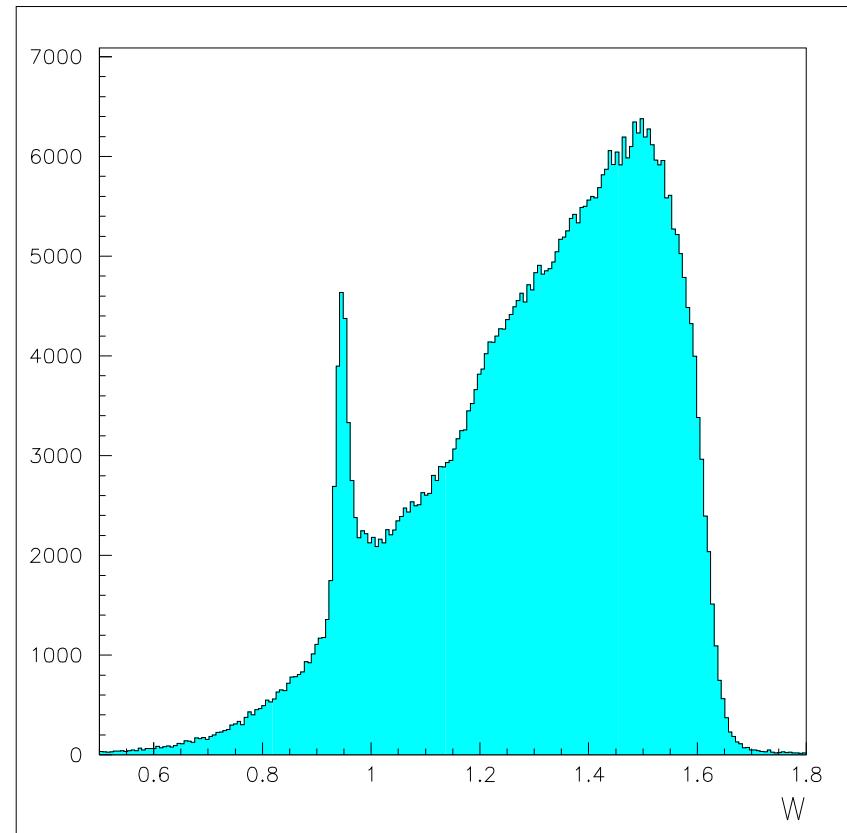
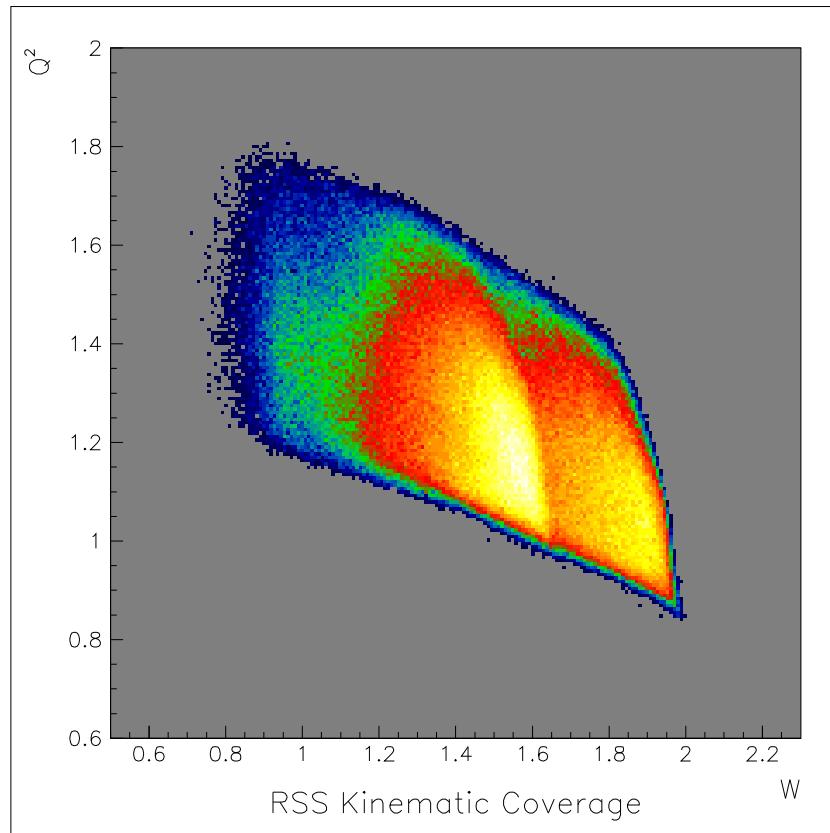
- * frozen NH₃ & ND₃
- * ⁴He evaporation refrigerator
- * 5T polarizing field
- * dynamic nuclear polarization driven by microwaves
- * NMR system for polarization measurement
- * remotely movable insert



Beam Rastering



Kinematics



Example: longitudinal NH_3

Preliminary Results

