Measurement of g_2^p and the Longitudinal - Transverse Spin Polarizability

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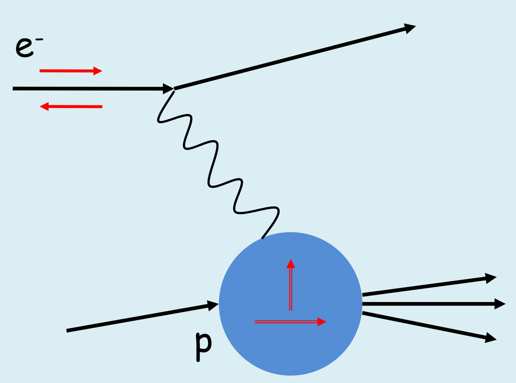
Jefferson Lab

What is g_2?



In inclusive scattering, the structure functions F1, F2, g1 and g2 together provide information about proton structure. The inclusive polarized cross section can be expressed as:

$$\frac{d^2\sigma}{d\Omega dE'} = \sigma_{Mott}[\frac{1}{\nu}F_2(x,Q^2) + \frac{2}{M}F_1(x,Q^2)\tan^2\frac{\theta}{2} + \gamma g_1(x,Q^2) + \delta g_2(x,Q^2)]$$

How to get g_2^p?

The structure functions g_1^p and g_2^p can be expressed in terms of the longitudinal and transverse polarized cross section differences $\Delta\sigma_{//}$ and $\Delta\sigma_{\perp}$:

$$g_1 = \frac{MQ^2}{4\alpha_e^2}\frac{y}{(1-y)(2-y)}[\Delta\sigma_\parallel + \tan\frac{\theta}{2}\Delta\sigma_\perp]$$

$$g_2 = \frac{MQ^2}{4\alpha_e^2}\frac{y}{(1-y)(2-y)}[-\Delta\sigma_\parallel + \frac{1+(1-y)\cos\theta}{(1-y)\sin\theta}\Delta\sigma_\perp]$$

where y=ν/E.

The structure function g_1^p has been measured with high precision by the EG4 collaboration. g_2^p can be obtained from the g_1^p data and the transverse polarized cross section difference $\Delta\sigma_{\perp}$.

Introduction

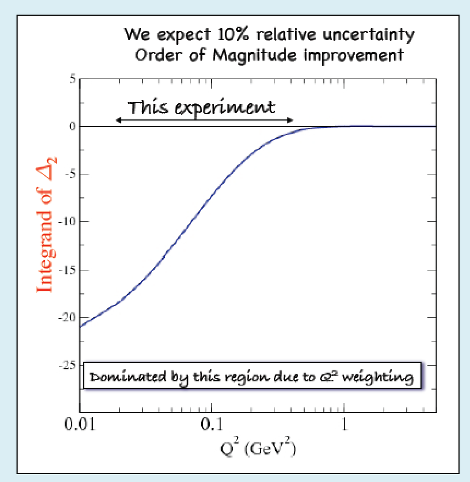
A precision measurement of the nucleon spin structure functions is one of the key goals of hadronic physics. Moments of these quantities are powerful tools to test QCD sum rules and provide benchmark tests of Lattice QCD and Chiral Perturbation Theory. JLab Hall A experiment **g2p** will measure the proton structure function g_2 in a low Q^2 region, which has never been explored.

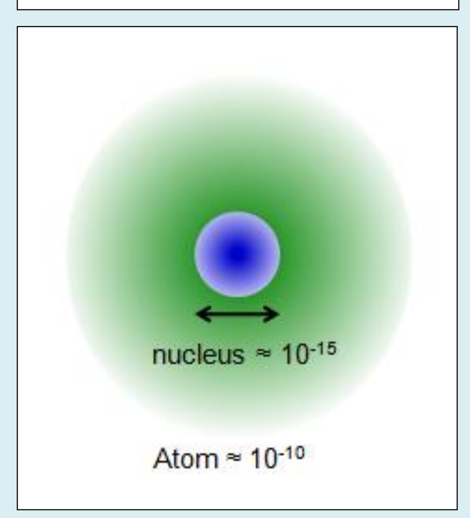
Goal

To measure g2p in a low Q^2 region ($0.02<Q^2<0.4$ GeV^2) with a precision of 5~7%

-- Measure asymmetries and cross sections to 4-5%

Why g_2^p?





Hydrogen Hyperfine Structure

- Lack of knowledge of g_2 at low Q^2 is one of the leading uncertainties
- Will provide first real constraint on Δ_2, part of the Hydrogen hyperfine energy corrections (due to g_2 Structure).

Proton Charge Radius

- Significant difference between the extraction from μ-H Lamb shift and from eP scattering
- Increased knowledge of g2p will reduce the uncertainty

g_2^p

Burkhardt-Cottingham SUM Rules

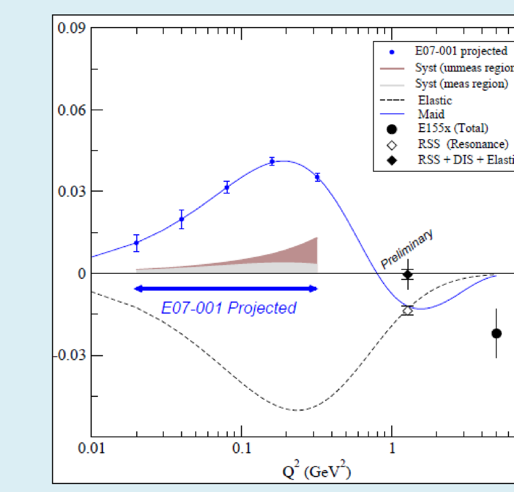
- $\Gamma_2(Q^2) = \int g_2(x,Q^2)\,dx$

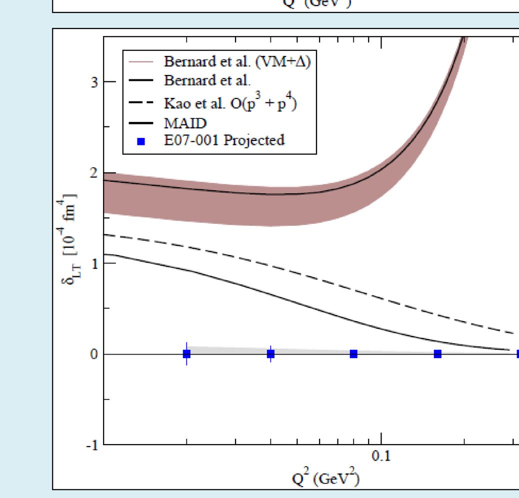
Predicted to vanish for all Q^2

- Violation suggested for proton at large Q^2

Spin Polarizability $\delta_{LT}(Q^2)$

- Ideal place to test χPT

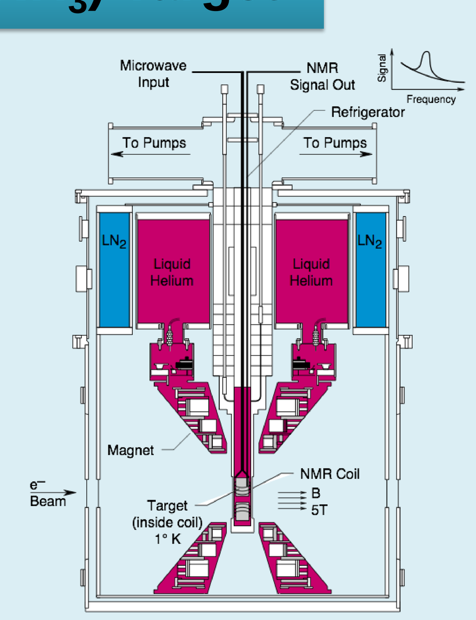




Experimental Setup

Polarized Ammonia ($^{14}NH_3$) Target

- Dynamic nuclear polarization
- Three in-plane directions of target polarization for g2p/GEp: 0°, 20° and 90°
- NMR to measure the target polarization
- 5 T / Polarization > 90%
- 2.5 T/ Polarization ~40%
- Used at SLAC and Jlab for nearly 20 years



Minimize the target depolarization due to beam

- Low beam current (50~150nA)

→New Beamline diagnosis

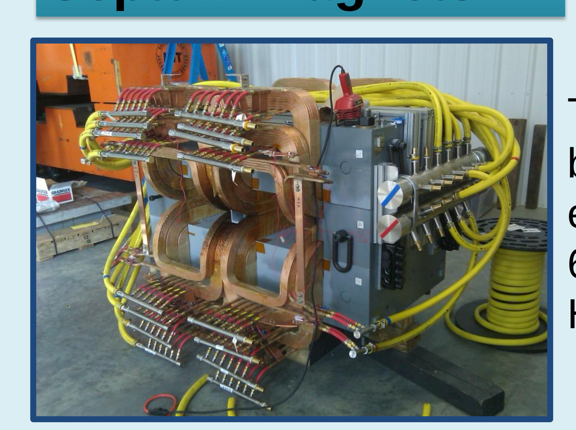
- New readout electronics for BPM, BCM
- New Harp
- Refurbished Tungsten Calorimeter to calibrate the BCM
- Slow raster

Target field effect

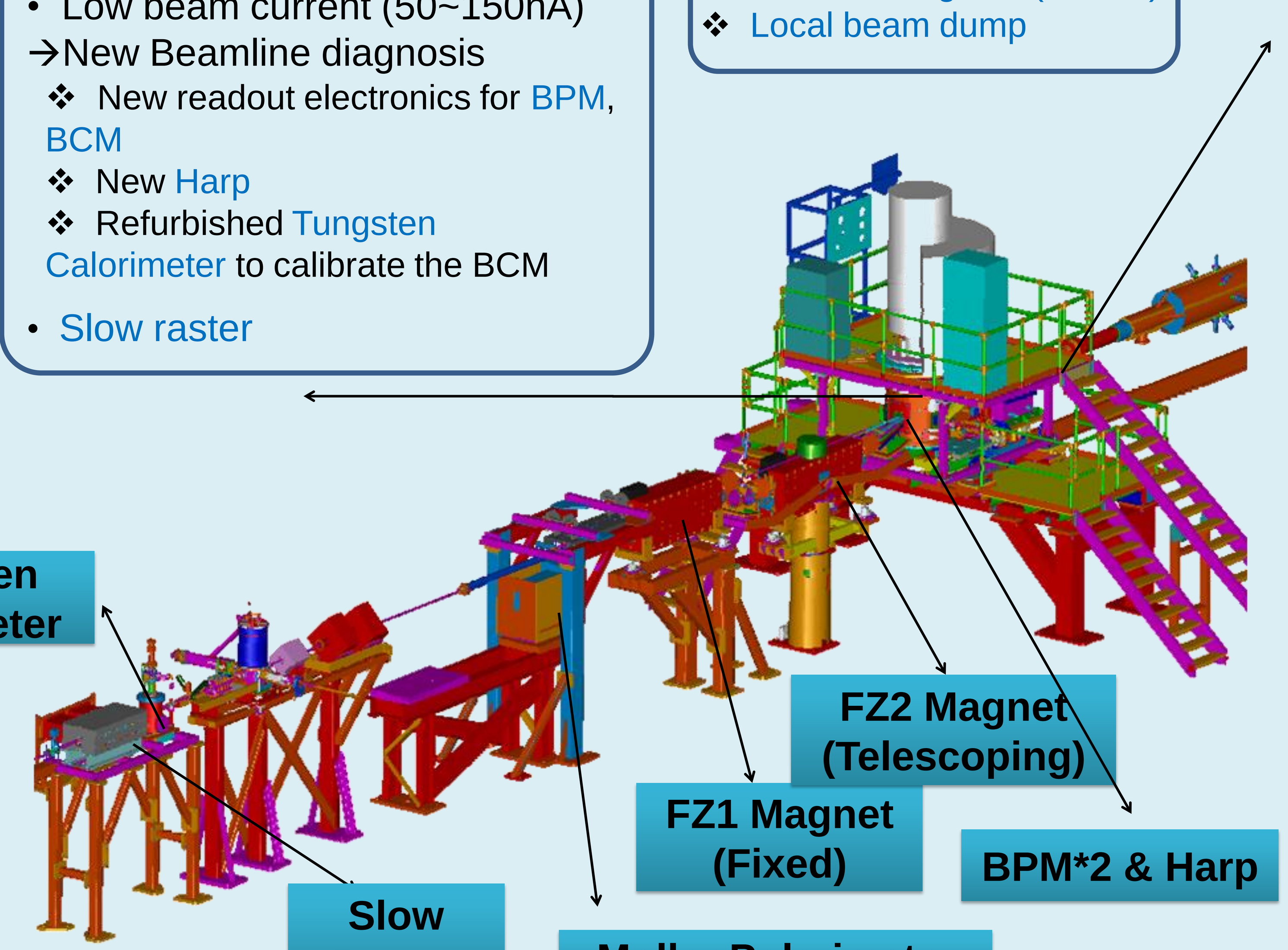
→Electron beam bending

- Chicane Magnets (FZ1&2)
- Local beam dump

Room Temperature Septum Magnets



To horizontally bend scattered electrons from 6° to 12.5° into HRS



Detectors

Left & right HRS:

- VDCs, S1/S2, Gas Cherenkov and Lead-glass Shower/Pre-shower

3rd arm:

- Online monitoring of beam & target polarization by measuring the elastic asymmetries (Moller & NMR)
- Detect protons at 72 degrees

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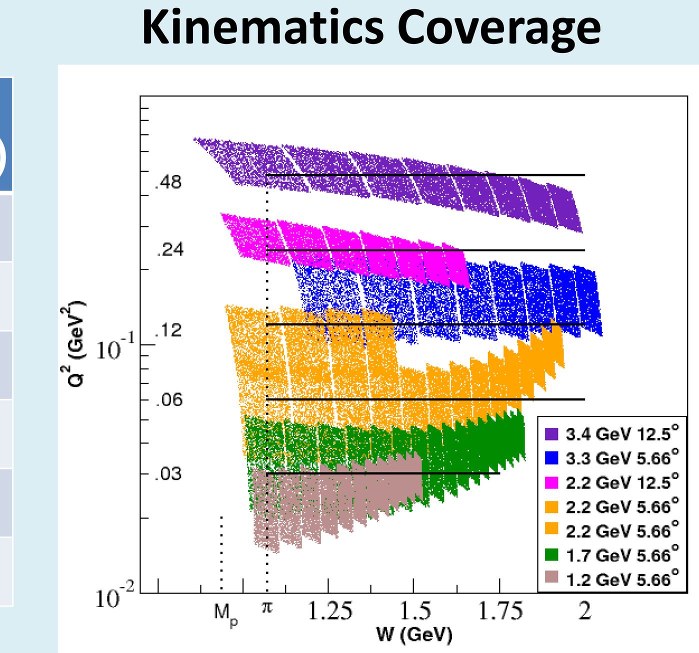
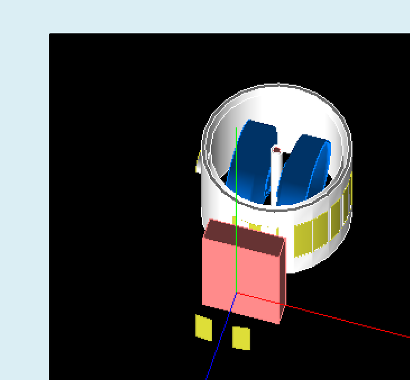
Progress

Kinematics Coverage

E (GeV)	θ (deg)	Target Field(T)
2.2	5.7	5.0
1.2	5.7	2.5
1.7	5.7	2.5
3.4	5.7	5.0
2.2	12.5	5.0
3.4	12.5	5.0



- Run plan optimization
- Target field effect on kinematics
- Geant4 simulation primarily developed
- SNAKE acceptance study
- Optics study
- 3rd arm design



G4 simulation of the scattering chamber, local dump & septum