Understanding the Structure of the Proton: Gep-III in Hall C at Jefferson Lab

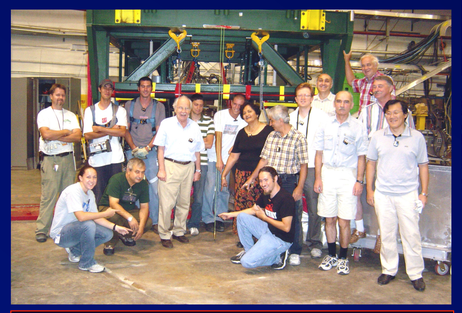
A collaboration involving over 20 institutions from the U.S., Armenia, Canada, France, Italy and Russia

Led by the College of William & Mary, JLab, Norfolk State University and Christopher Newport University

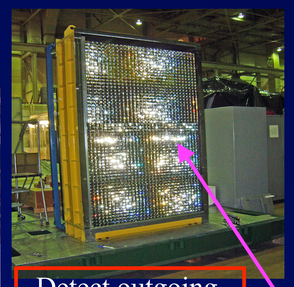
Elastic Electron Scattering and Proton Form Factors

BigCal

- Select elastic scattering events by detecting scattered electron in BigCal in coincidence with proton in HMS
- Timing and kinematic cuts eliminate most accidentals



Hall C technicians, undergraduate and graduate students, postdocs and professors are all smiling after the 12 ton BigCal was positioned to within 0.1 inches of desired position using a plumb bob, crane and some elbow grease.

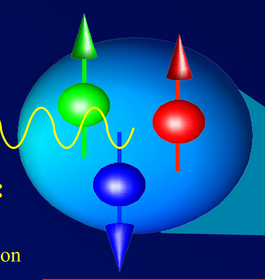


Detect outgoing electron in BigCal

BigCal assembly and testing led by College of William and Mary and Institute of High Energy Physics, Protvino, Russia

Electron scatters via a virtual photon with the proton in the liquid hydrogen target and knocks the proton out. The magnetic field of the High Momentum Spectrometer sweeps the proton to detectors which measure the spin of the proton.

The ratio of the electric to magnetic form factors is determined, by measuring the spin of the scattered proton.



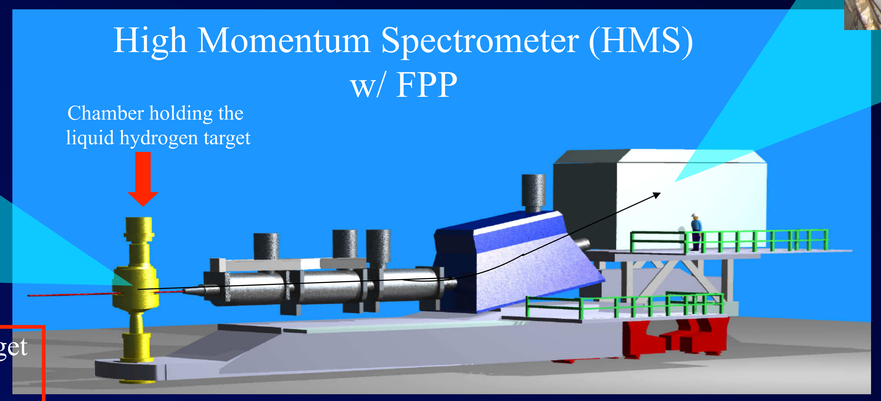
γ^*

Virtual photon

Incoming *polarized* electron produced by 6 GeV accelerator

Unpolarized proton target

Quarks inside proton represented by red, blue and green spinning balls



Scattered *polarized* proton detected in HMS, measure proton spin with FPP

Focal Plane Polarimeter (FPP)

HMS drift chambers define incident track, FPP measures tracks of protons scattered in CH_2 analyzer blocks. With this information, the spin of the proton is determined.

FPP drift chambers: built at JINR, Dubna, Russia. Commissioned by Norfolk State University

Form Factors and proton structure

- The proton is composed of quarks and gluons.
- The charged quarks move inside the proton and produce electric and magnetic fields.
- The proton has an intrinsic spin magnetic moment.
- The charge and current distributions are probed using virtual photons from Electron Scattering.
- Measured "form factors" give direct information on the spatial distribution of the charge and current inside the proton.

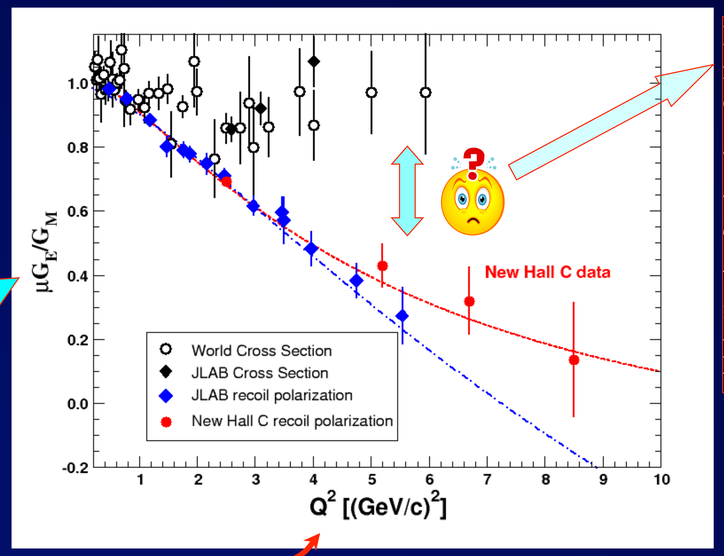
G_E is the Electric Form Factor and is related to the charge distribution.

G_M is the Magnetic Form Factor and is related to the current distribution.

Gep-III measured the ratio G_E/G_M

As Q^2 increases the wavelength of the virtual photon decreases. Similar to using a microscope to see finer details inside the proton.

Final Results



Discrepancy between two methods for measuring G_E/G_M:

- cross section
- recoil polarization

This has led to new theoretical work which indicates that recoil polarization is the better way to measure G_E/G_M