E93-026: Measuring the Electric Form Factor of the Neutron

Spokespersons: D.Day, J.Mitchell, G.Warren, M.Zeier

Collaborating Institutions: Duke University, Florida International University, Hampton University, Jefferson Lab, Louisiana Tech University, Mississippi State University, Norfolk State University, North Carolina A&T State University, Old Dominion University, Ohio University, Southern University at New Orleans, Tel Aviv University, University of Basel, University of Maryland at College Park, University of Virginia, Virginia Polytechnic Institute & State University, Vrije Universiteit of Amsterdam, Yerevan Physics Institute

The electric form factor of the neutron G_{En} is related to the distribution of charge inside the neutron. While the total charge of the neutron is zero, the charge at some point within the neutron does not have to be zero. Understanding the distribution of the charge within the nucleus allows us to study how the building blocks of the neutron, quarks and gluons, form the neutron. We measured G_{En} using spin observables, i.e. we must known in which direction points the spin of the electron and the spin of the neutron.

Cartoon showing the charge structure of the neutron.

As the neutrons carry no net charge, it is difficult to detect them. Thus we need a thick detector, such as the one shown in this picture. Even though this detector is about 3 feet thick, it will only detect about 60% of the neutrons.

Cartoon of setup used to measure G_{En}. On the right side is the HMS, on the left side is the neutron detector and shielding house and in the middle are the gray cylinders representing the polarized target.

Plot of World's data for G_{En} showing the our published results from the 1998 running as well as preliminary results for the data collected in 2001.

Deuteron Form Factor
^{3}He($\vec{e}$,en)
$\vec{D}$(e,en)
Our 1998 Results
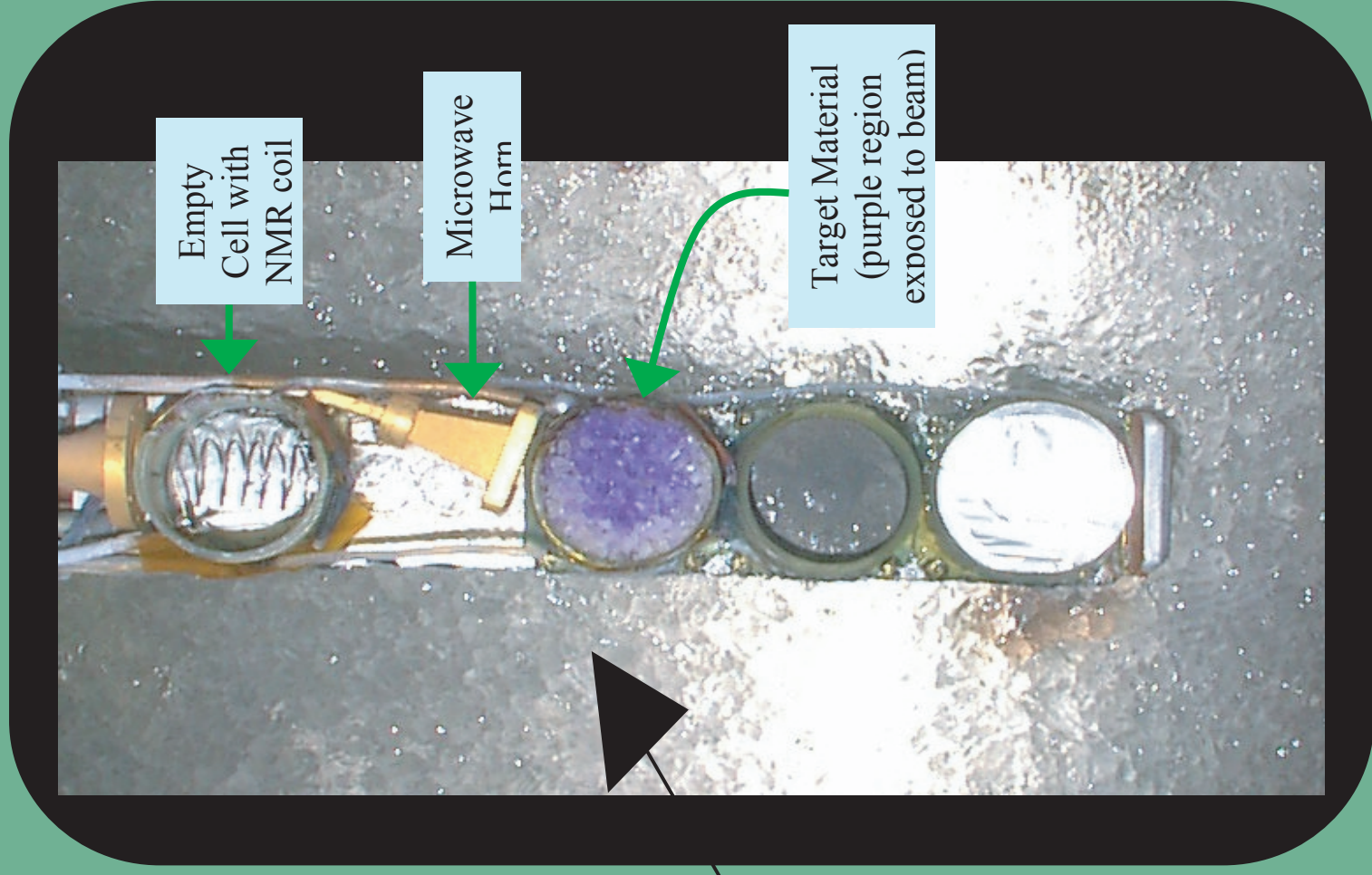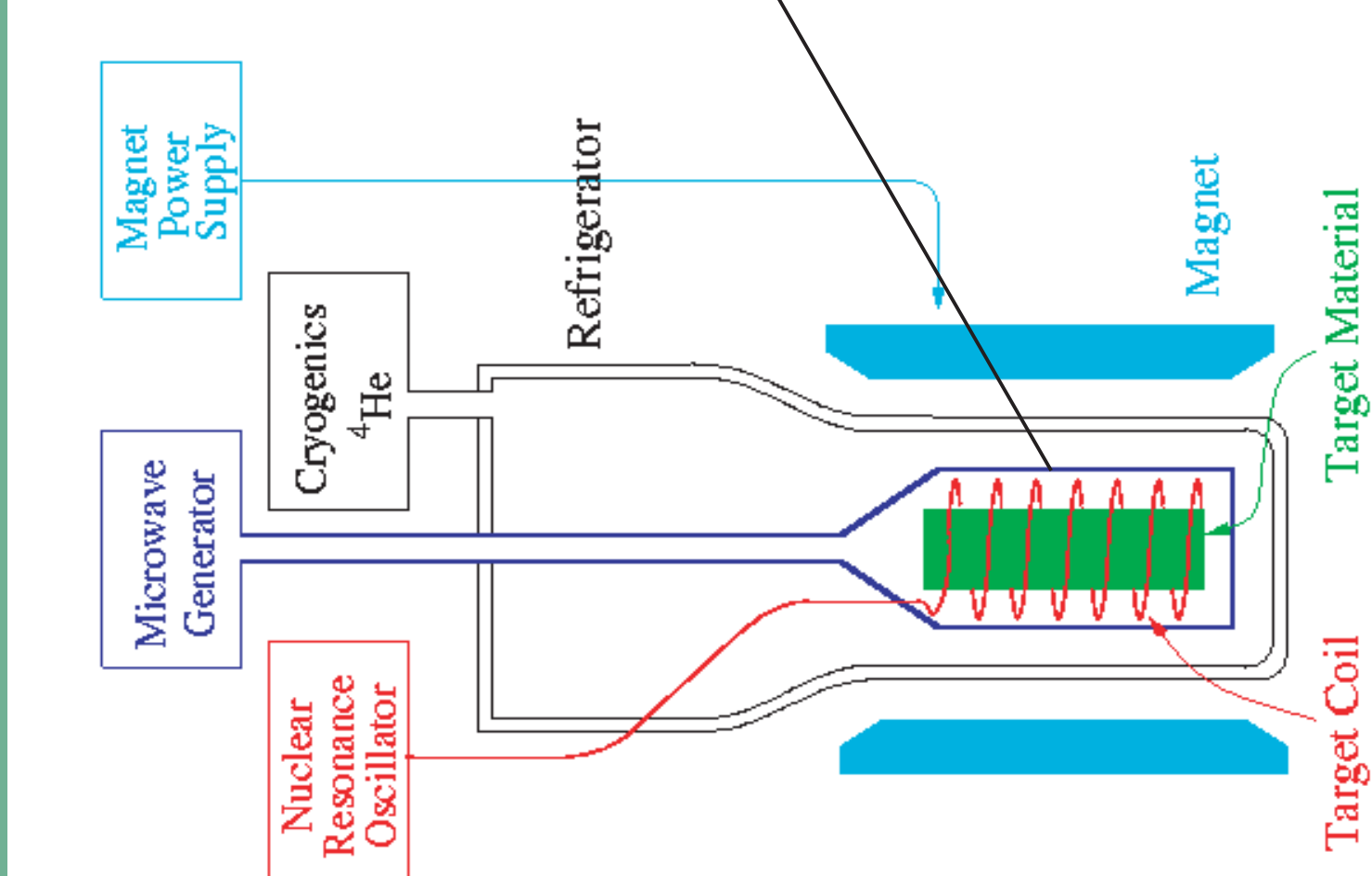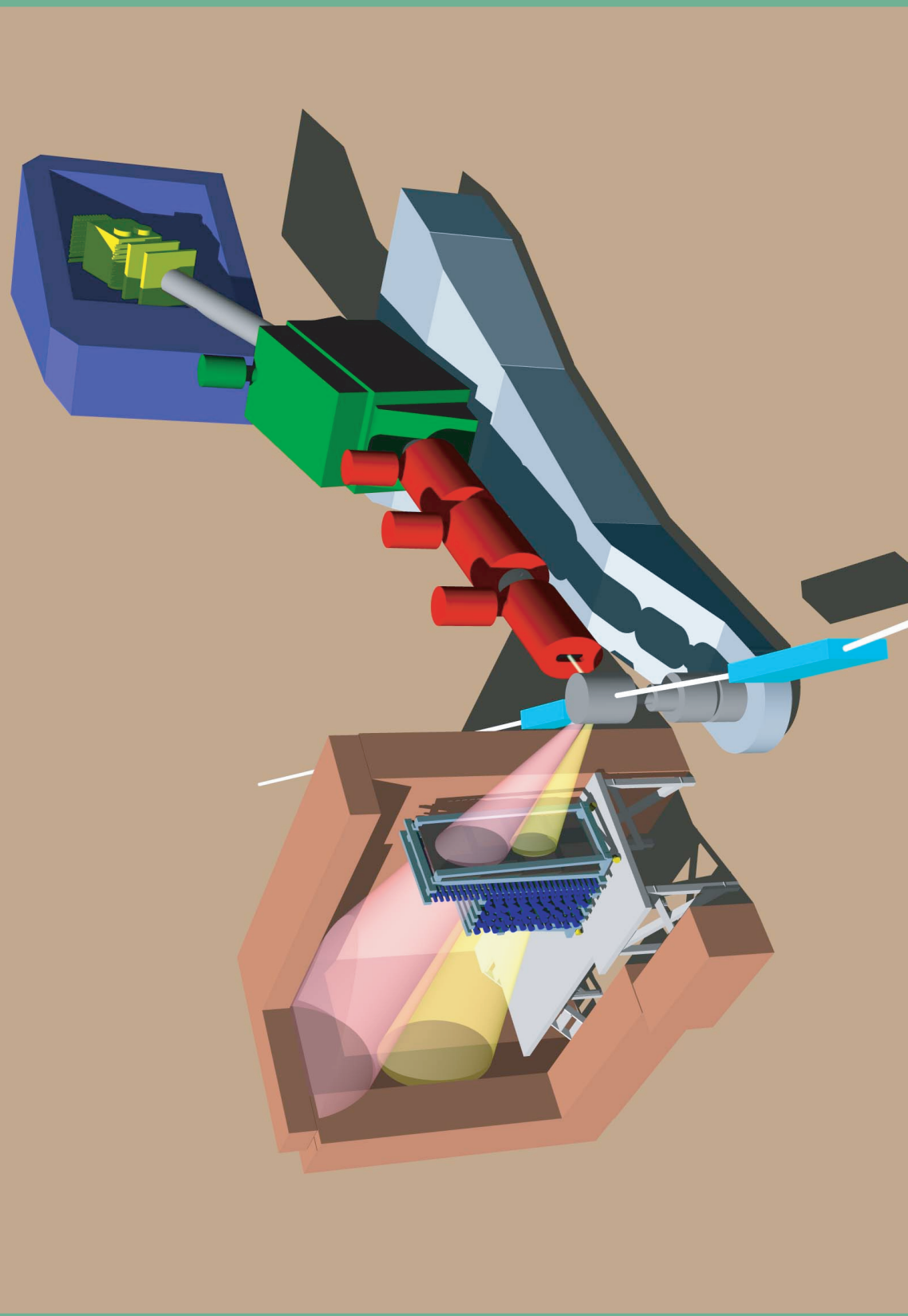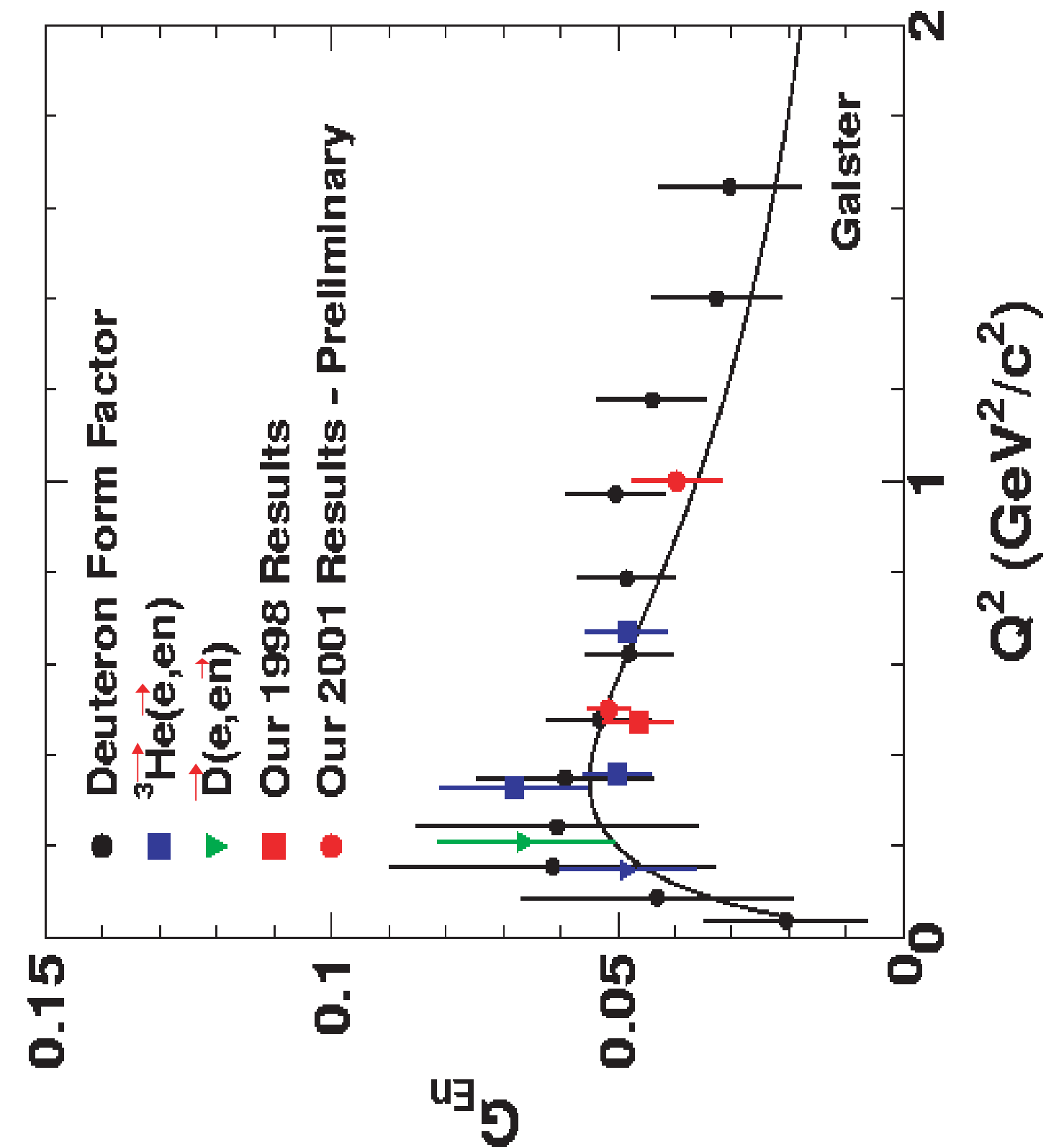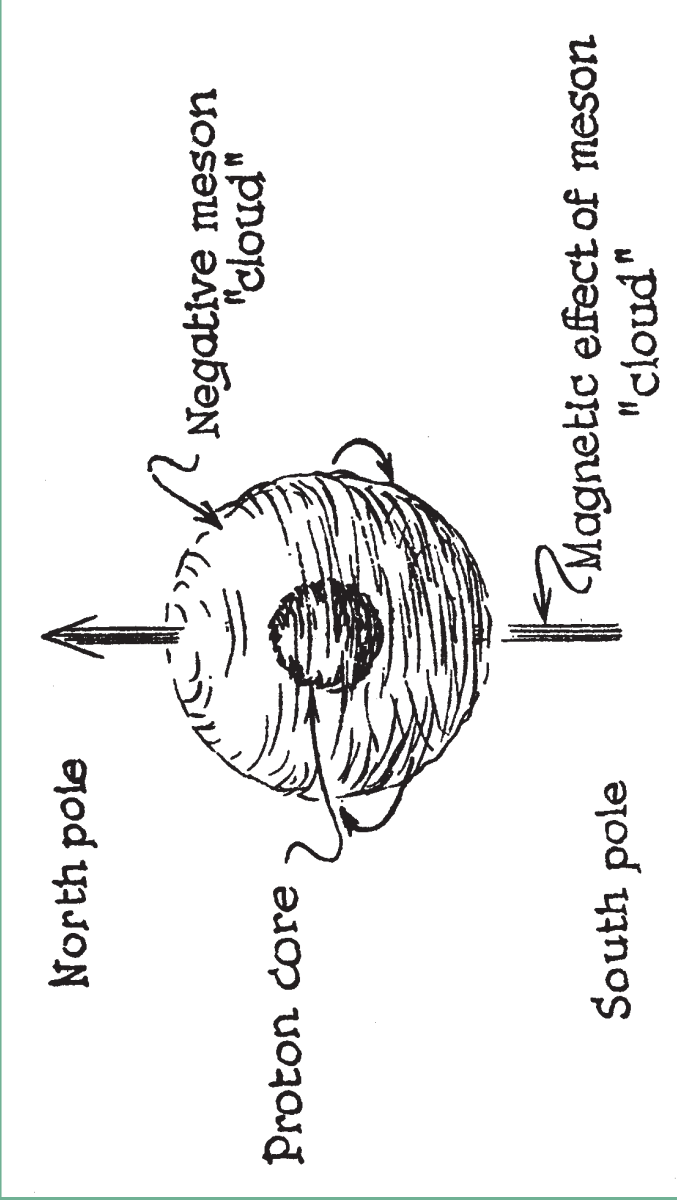Our 2001 Results - Preliminary

Galster

G_{En}
Q^2 (GeV^2/c^2)

Electron:
Charge = -1
Mass = 4.1 10^{-31} lb
Spin Magnitude = 1/2

Spin is a fundamental property of elementary particles, like mass and charge, but is also has a direction. The classical analogue of spin is the rotation of a body around an axis.

Spin Observable = LARGE x small

Spin Observables are a powerful tool to investigate physics. Typically they are sensitive to a LARGE well known quantity times a small lesser known quantity, thus magnifying the sensitivity to the smaller term.

The left picture shows the principle ingredients necessary for a polarized target. The right picture shows the target stick in a liquid nitrogen bath. The target stick holds the material that is placed i the beam.

Microwave Generator
Magnet Power Supply
Nuclear Resonance Oscillator
Cryogenics ^{4}He
Refrigerator
Target Coil
Target Material
Magnet

Empty Cell with NMR Coil
Microwave Horn
Target Material (purple region exposed to beam)