The GDH Sum Rule of the neutron using nearly real photons

Patricia Solvignon

Thesis Progress Report

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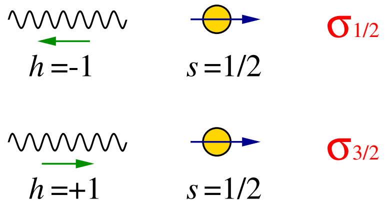
Theoretical Background

- GDH Sum Rule (real photon)

$$\int_{thr}^{\infty} \frac{d\nu}{\nu}\left[\sigma_{\frac{1}{2}} - \sigma_{\frac{3}{2}}\right] = -\frac{2\pi^2\alpha}{M_N^2}\kappa^2$$



- Extended GDH Sum Rule (virtual photon)

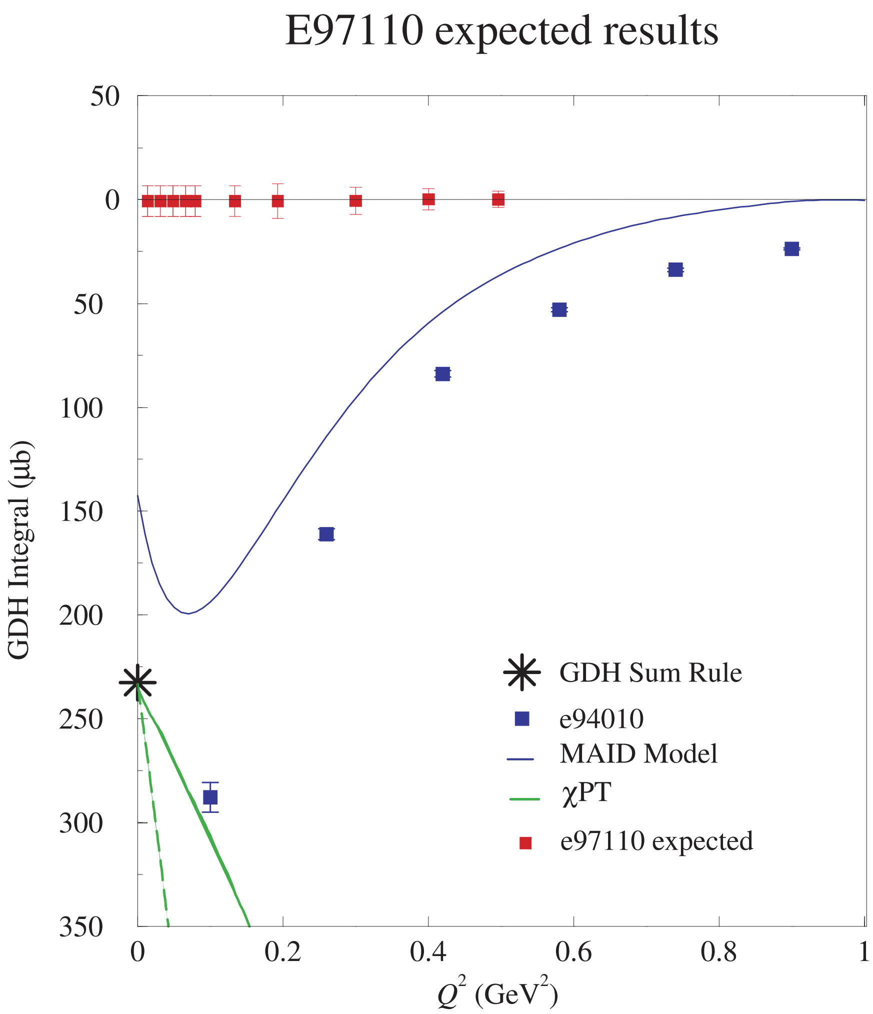
$$S_1(0,Q^2) = 4\int_{Q^2/2M}^{\infty} \frac{d\nu}{\nu} G_1(\nu,Q^2)$$

→ applicable for any Q^2

→ at the limit Q^2=0, reduces to the GDH sum rule

→ For $Q^2 < 0.2$ GeV^2: χPT prediction

The E97-110 experiment

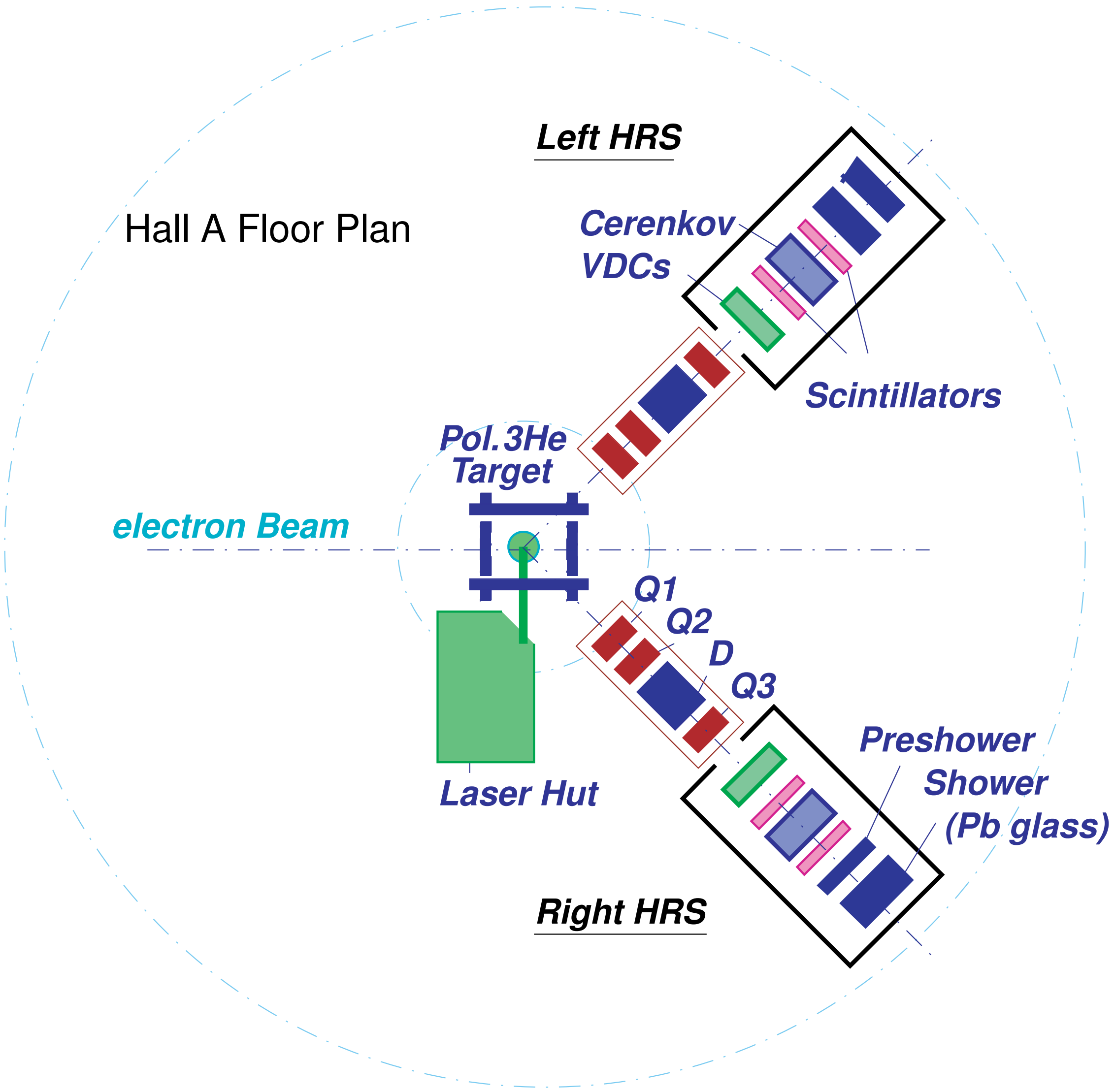


- $\longrightarrow$ Kinematic coverage: $0.02 < \mathrm{Q}^2 < 0.5\ (\mathrm{GeV/c})^2$
- $\longrightarrow$ Measurement of the slope of the GDH sum rule at Q^2 near zero predicted by χPT
- $\longrightarrow$ reasonable extrapolation to the real photon point can be obtained

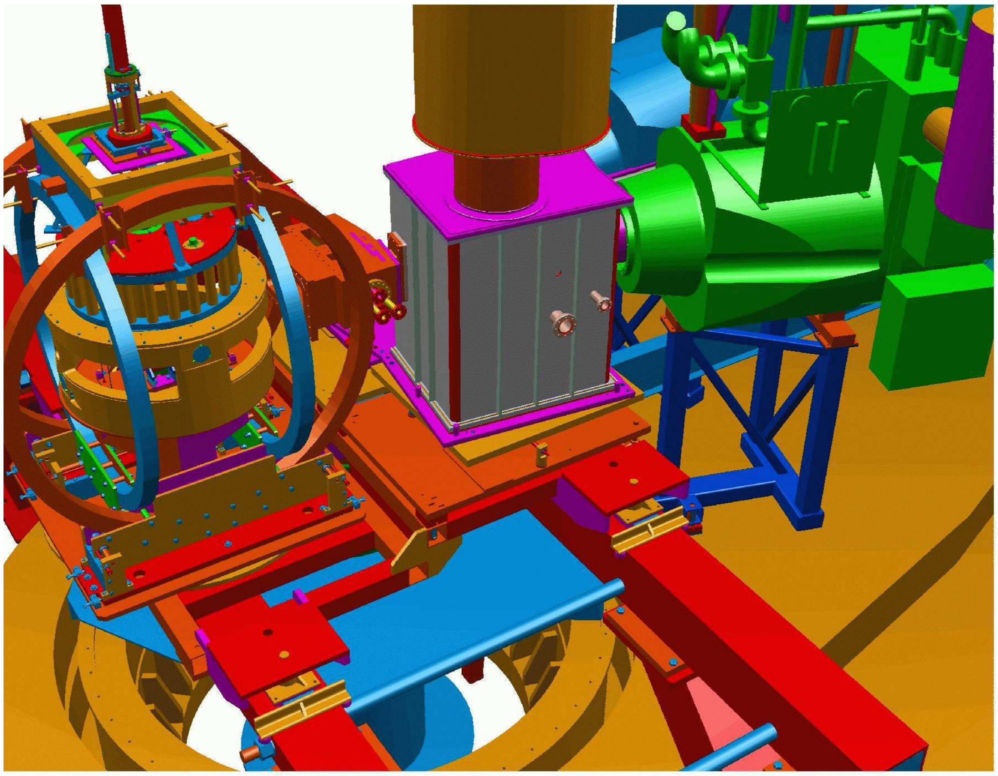
The Experimental setup

- Jefferson Lab polarized e$^-$ beam

- High Resolution Spectrometers

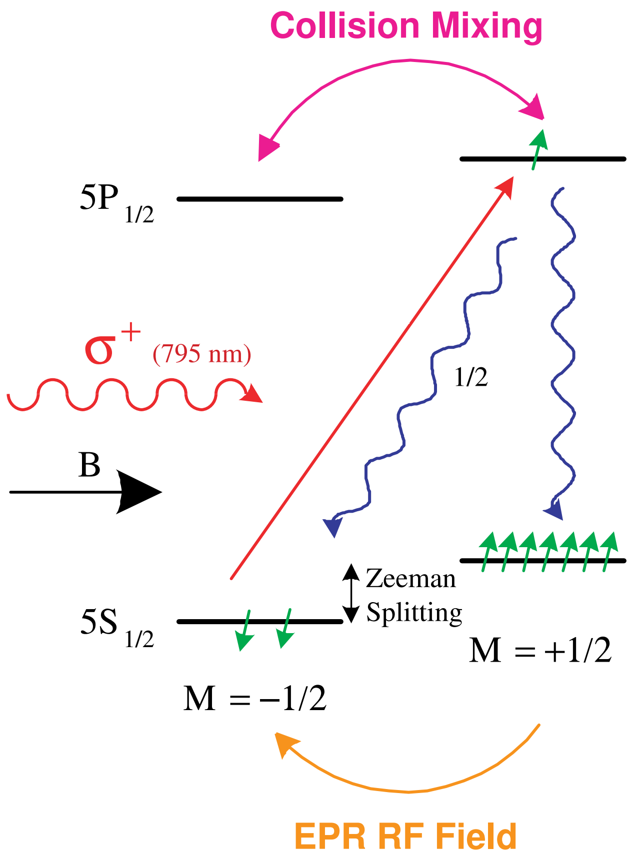


- Septum Magnets



→ measurements at forward scattering angles (6° to 12.5°) to access the low Q^2 region

Optical Pumping of the Rubidium

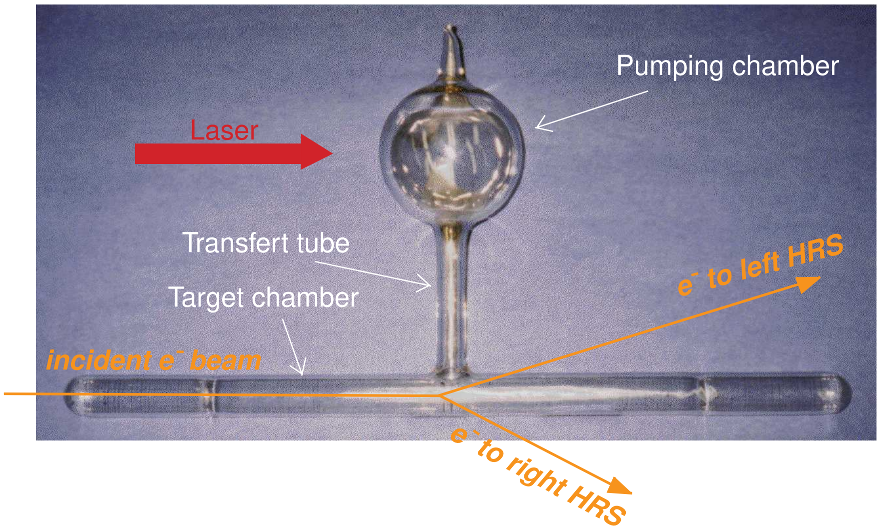


Two step process:

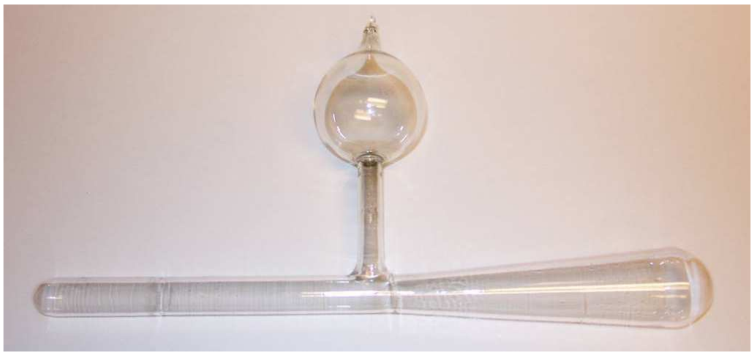
1. **Rb vapor is polarized by optical pumping** with circularly polarized light.
2. **Rb e^- polarization is transferred to ^{3}He nucleus** by spin-exchange interaction.

The ^{3}He target cells

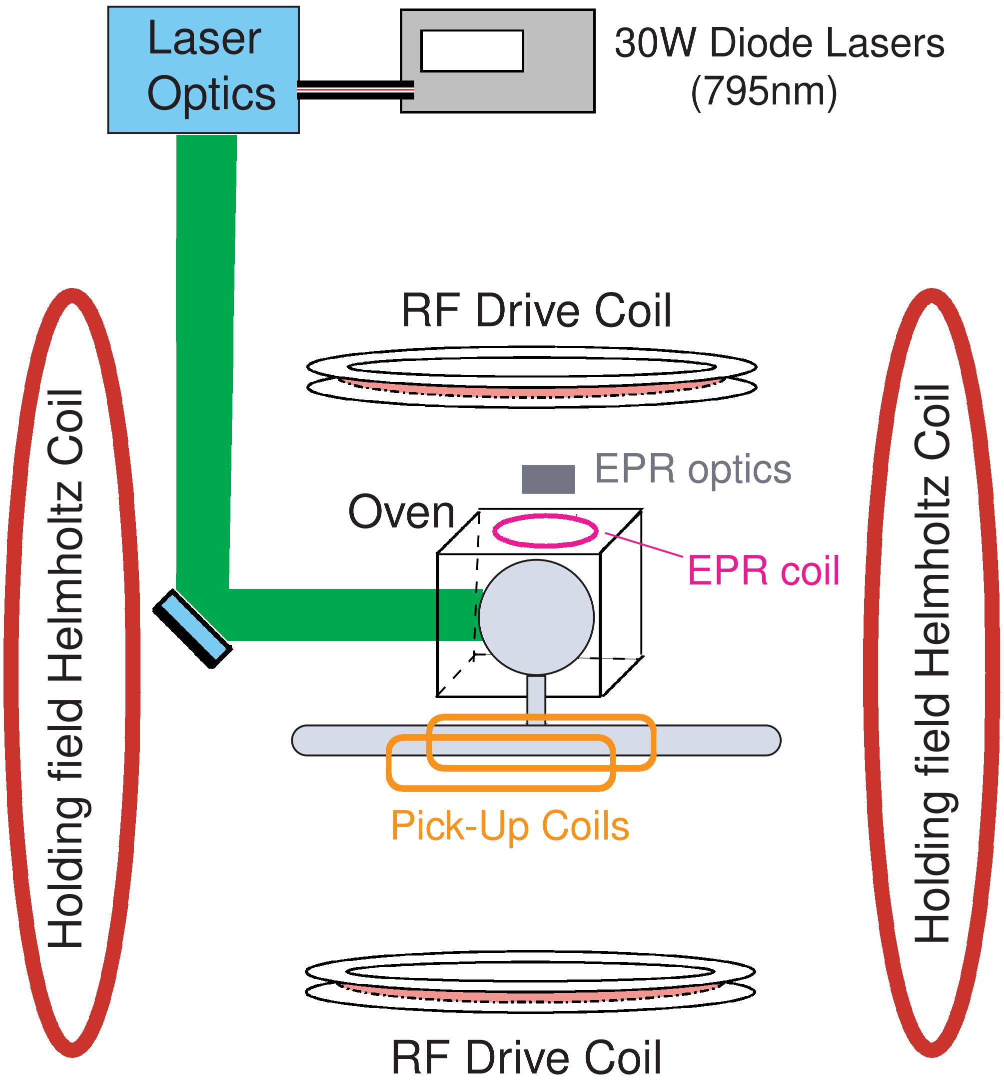
→ Standard cell: length: 40cm, density ∼ 10 atm



→ Ice-cone cell: length: 34cm, density ∼ 7 atm



The polarized ^{3}He target system

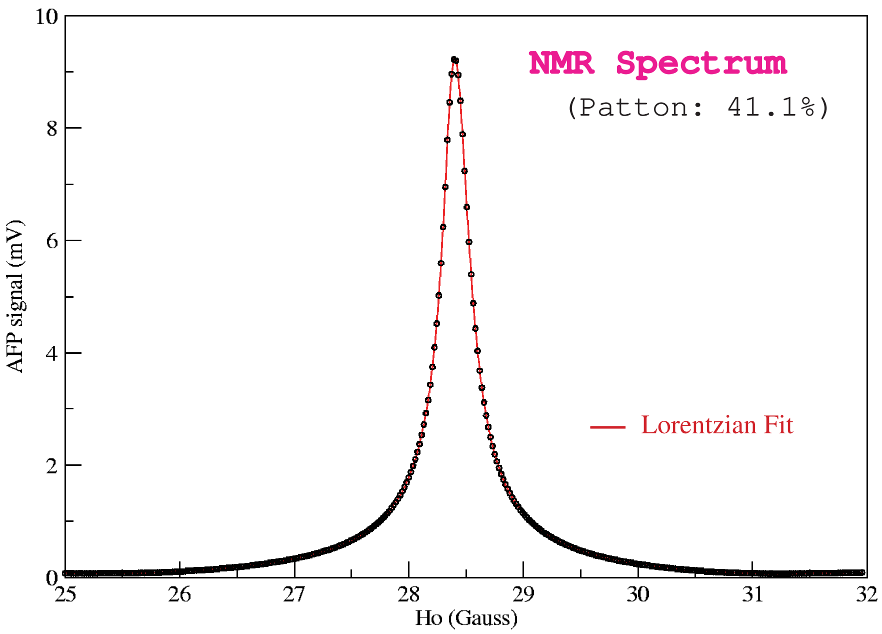


→ Two independent polarimetries: NMR and EPR

→ Longitudinal and transverse orientations

Polarimetries

- NMR



→ When no field: $|\uparrow>$ and $|\downarrow>$ are degenerate

→ external field H_0: degeneracy is removed and the two states are separated by $\Delta E = \gamma\hbar H_0$

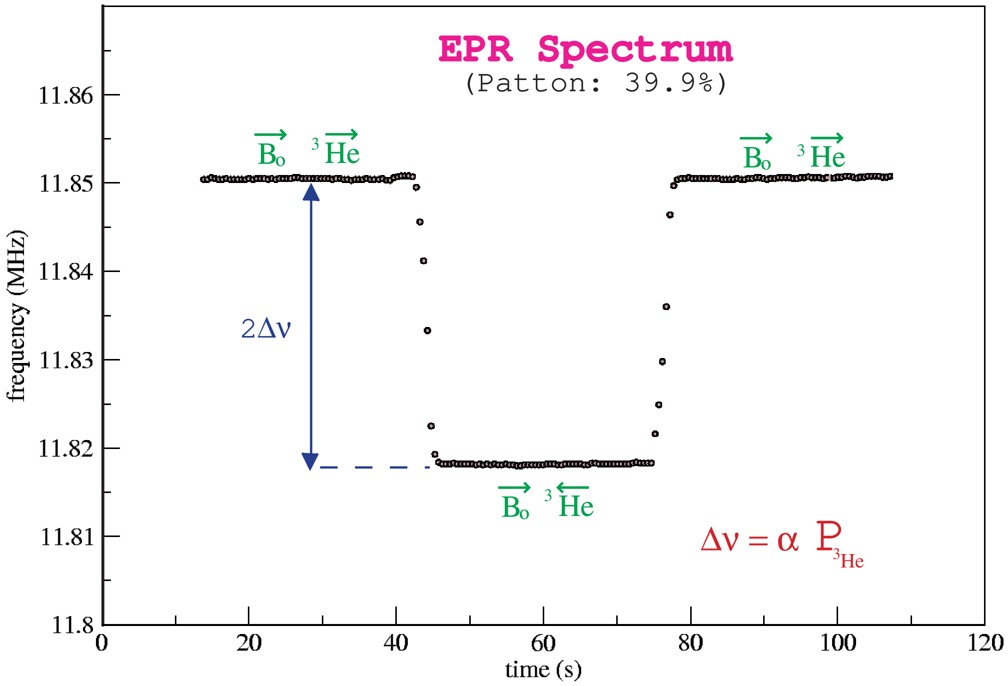
→ An RF field $H_1(\omega)$ induces the transition between the two states

→ The resonance occurs when $\omega = \omega_0$ where $\omega_0 = \gamma H_0 = \frac{E(\uparrow)-E(\downarrow)}{\hbar}$

$$P_{^3He} = \kappa.S$$

→ Calibration with a identical target cell filled with water

- EPR



→ Polarized ^{3}He creates an extra magnetic field: $B_{^3He}$

→ The frequency of the m_F = -3 → -2 transition is proportional to the holding field $B_0 + B_{^3He}$

→ We measure the Zeeman splitting with B_0 and $B_{^3He}$ aligned and anti-aligned (by flipping the spins: AFP process)

$$\Delta\nu = \kappa_{epr}.P_{^3He}$$

Conclusion

- Principally worked on the polarized target for the past year
- The polarized ^{3}He system is ready for the experiment
- Now focusing on the online data analysis
- E97-110 will run in January-February 2003