BigBite Analysis

Water Cell Calibration: Bloch Equations (Numerical Solution),Pion Asymmetry

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03/14/2012

Outline

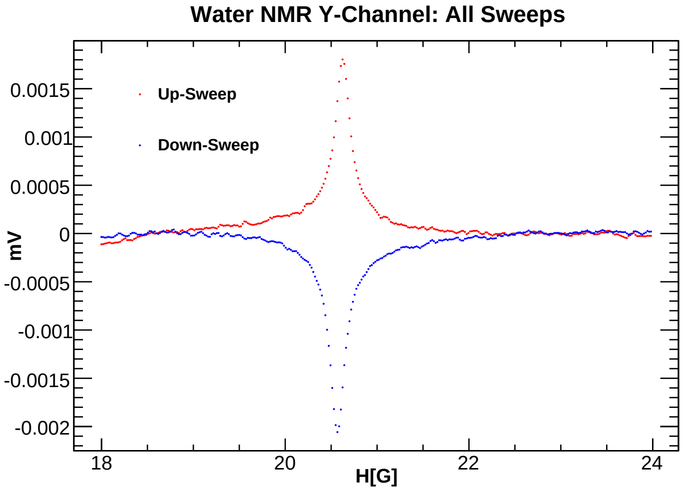
1. Water Calibration
   - Procedure
   - Bloch Equations
2. Pion Asymmetry
3. What’s Next

Water Calibration Procedure

- Information on water calibration posted on d2n wiki page
- Fit Water Data
  - Numerical Solution using Bloch equations (T1 = T2)
  - Analytic Solution using Bloch equations (T1 = T2)
  - Use Numerical Solution to correct for (T1 != T2)
- Apply Water Signal Corrections
  - Q-Curve: response of pick up coils change over time
  - Holding field drift: field may drift with time
- Cell Corrections (Water and ^{3}He cells are different)
  - Flux
  - Gains

Average Water Signal

6,197 NMR Sweeps



Bloch Equations (1)

- Bloch equations describe time evolution of the water polarization

$$\frac{dP_x(t)}{dt} = -\frac{1}{T_2}P_x(t) + \gamma\left(H(t) - H_0\right)P_y(t) + \frac{1}{T_2}\chi H_1 \qquad (1)$$

$$\frac{dP_y(t)}{dt} = -\gamma\left(H(t) - H_0\right)P_x(t) - \frac{1}{T_2}P_y(t) + \gamma H_1 P_z(t) \qquad (2)$$

$$\frac{dP_z(t)}{dt} = -\gamma H_1 P_y(t) - \frac{1}{T_1}P_z(t) + \frac{1}{T_1}\chi H(t) \qquad (3)$$

Bloch Equations (2)

- T_1: Longitudinal relax time
- T_2: Transverse relax time
- H_0: Resonance field
- H_1: Transverse field component
- $H(t) = H_0 + \alpha t$: field component along z axis (α = 1.2 G/s)
- γ: gyro-magnetic ratio of the proton
- $\chi = \frac{\mu_{p,H_2O}}{kT}$
- μ_{p,H_2O}: magnetic moment of proton in water
- k: Boltzmann constant
- T: Temperature of target chamber

Numerical Solution (1)

- To solve numerically we set (values from Sebastien Incerti Tech Note 10):
    - T_1 = T_2 = 2s
    - H_1 = 72.83 mG
- Use initial conditions:
    - $\frac{dP_x(t_i)}{dt} = 0$
    - $\frac{dP_y(t_i)}{dt} = 0$
    - $\frac{dP_z(t_i)}{dt} = 0$
- $P_x(t_i) = -1.287 \times 10^{-10}$
- $P_y(t_i) = 8.218 \times 10^{-16}$
- $P_z(t_i) = 6.184 \times 10^{-9}$

Numerical Solution (1): $P_x(t)$

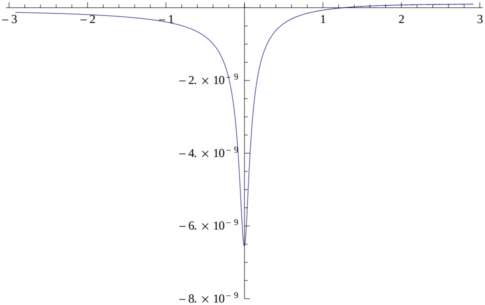


Figure: Component P_x of the polarization P as a function of time. This curve is the shape of the water signal detected by the pick-up coils.

Numerical Solution (1): $P_y(t)$

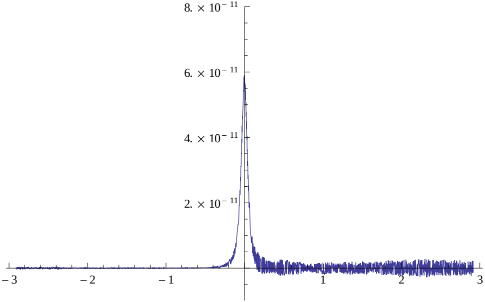


Figure: Component P_y of the polarization P as a function of time. The y component is much smaller than the other two components P_x and P_z.

Numerical Solution (1): $P_z(t)$

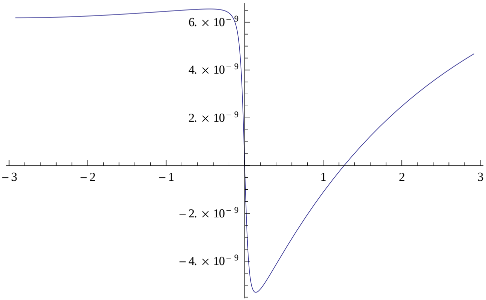


Figure: Component P_z of the polarization P as a function of time. When the sweep starts, the magnetization of the water is directed toward the positive direction of the z-axis. The z component is zero at the resonance and is flipped shortly after. The spins are in the high energy state, then they immediately start to flip back to the low energy state. At the end of the sweep, their orientation is close to the one they had before the sweep.

Numerical Solution (2)

- Using (from Ioannis Kominis E94-010)
  - T_1 = T_2 = 3s
  - H_1 = 90.80 mG
- $P_x(t_i) = -1.604 \times 10^{-10}$
- $P_y(t_i) = 6.829 \times 10^{-16}$
- $P_z(t_i) = 6.182 \times 10^{-9}$

Numerical Solution (2): $P_x(t)$

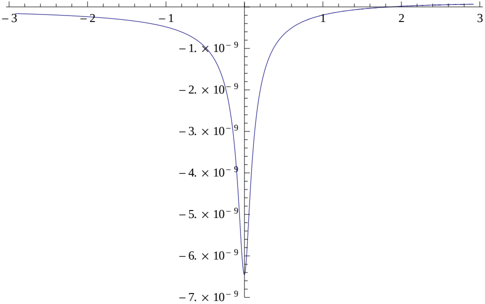


Figure: Component P_x of the polarization P as a function of time. This curve is the shape of the water signal detected by the pick-up coils.

Numerical Solution (2): $P_y(t)$

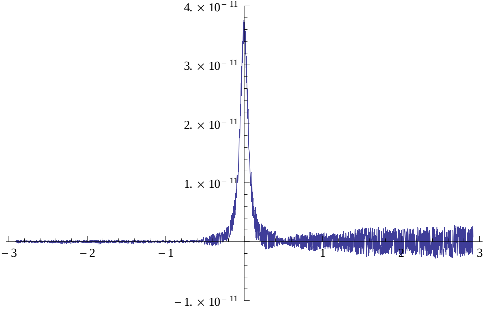


Figure: Component P_y of the polarization P as a function of time. The y component is much smaller than the other two components P_x and P_z.

Numerical Solution (2): $P_z(t)$

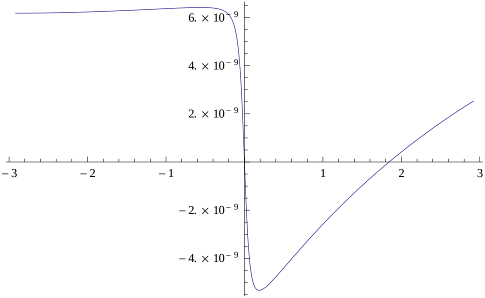


Figure: Component P_z of the polarization P as a function of time. When the sweep starts, the magnetization of the water is directed toward the positive direction of the z-axis. The z component is zero at the resonance and is flipped shortly after. The spins are in the high energy state, then they immediately start to flip back to the low energy state. At the end of the sweep, their orientation is close to the one they had before the sweep.

Raw Pion Asymmetry

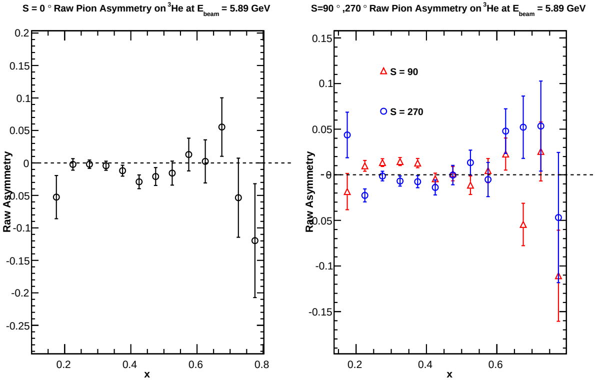


Figure: Used PID cuts to select pions and computed the raw asymmetry for each target orientation.

Physics Pion Asymmetry

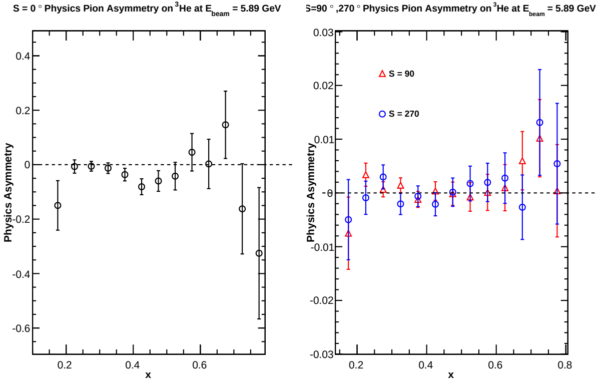


Figure: Used PID cuts to select pions and computed the physics asymmetry for each target orientation.

What’s Next

- Look more into in-plane angle shift
- Finish live time calculations
- Implement live-times and new densities into 5-pass N2 runs for dilution correction
- Need to get T_1,T_2 and H_1 for our experiment
- Compute the analytic solution to Bloch equations