Improving the Determination of RHIC Beam Polarization

Summary: At the last RSC meeting, I concluded that the beam polarization uncertainty at full RHIC energy was about 20%, much of which came from the uncertainty in the analyzing power used to calibrate the beam polarization used in E950. This could be improved in a new experiment where a p+C CNI polarimeter was set up in conjunction with a polarized solid target in an AGS fixed target line. With the CNI polarimeter set up in a fixed target line, you could get approximately 1M events in 30 shifts. During the discussion it seemed perhaps a better idea to leave the CNI polarimeter in the AGS ring, with a foil or wide ribbon target, so that statistics would not be a problem, although one would have to rely on the spin tracking to make sure that the polarization in the AGS and the polarization at the solid target experiment were understood. There were questions about the ability of the solid target experiment to determine the beam polarization to better than 5%. Several issues were brought up including whether or not the spin direction could be flipped with the holding magnetic field unchanged. This can, in fact be done. Also, the field can be flipped to check systematic uncertainties. Also, I misspoke during the presentation referring to ^{3}He recirculation rather than ^{4}He. For the 5T field, cheaper ^{4}He is sufficiently cold to maintain the polarization, and depending upon the length of the run needed, could just be vented or captured.

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Improving the Determination of RHIC Beam Polarization

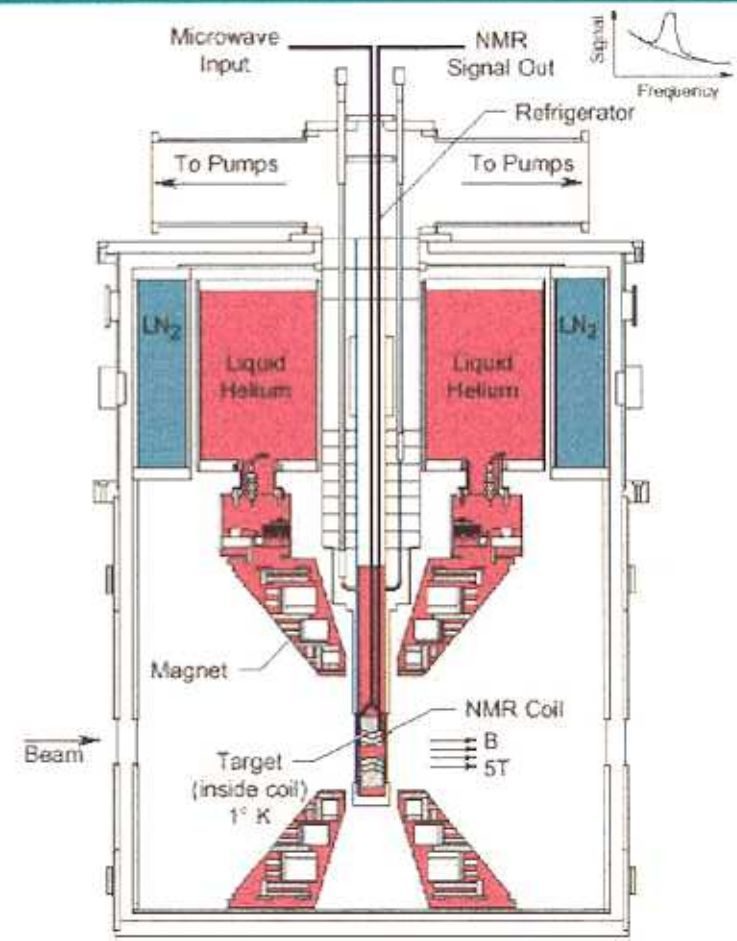
- Get physics analyzing power from E950 asymmetry measurement, needs beam polarization from E925.
  - E925 determines beam polarization with total uncertainty ~15%.
  - The systematic uncertainty (12%) is dominated by the determination of the analyzing power calculated from other measurements.
- E950 has statistical uncertainties ~10% in low –t region.
  - The value of the asymmetry at low –t is very stable with even gross changes in the analyzing procedure, and therefore has systematic uncertainty ~5%.
- Needs extrapolation from E950 energy to RHIC injection energy.
- Statistical uncertainties expected to be ~1% during upcoming run.
  - Uncertainty in the theoretical energy dependence of asymmetry ~5% (from fits to E950 data using range of real part of μ_P extrapolated to injection energy).

Calibrating the RHIC Polarimeter at Injection Energy

- New calibration experiment at injection energy.
  - "RHIC polarimeter" in an AGS fixed target line.
  - Followed by a solid polarized target experiment to determine the beam polarization to <5%.
- Proposed gains:
  - Measurement at injection energy – no extrapolation uncertainty.
  - Better statistics and systematics and lower threshold (not in the AGS ring, longer run)
  - Much improved beam polarization measurement using the polarized target.
  - Better determination of the hadronic spin-flip term helps to understand energy dependence of asymmetry.

Calibrating the RHIC Polarimeter at Injection Energy

- Polarized Target:
  - Solid target.
  - 5T field.
  - Longitudinal polarization can be modified to give sideways (and possibly transverse).
  - Can be ready by summer 2002 at BNL (given appropriate services).



Calibrating the RHIC Polarimeter at Injection Energy

- Previous experiment (Crabb et al., '76):
  - Measured pp elastic from $0.1 \leq |t| \leq 0.9$.
    - 0.8 – 2.5 degrees lab angle.
    - Recoil energy 55 – 480MeV.
  - Coincident detection of recoil and scattered protons.
  - Luminosity monitors.
  - Fairly simple TOF setup.
- Could re-use E925 detectors?
  - Forward counters
  - Recoil detectors

Calibrating the RHIC Polarimeter at Injection Energy

- Problems:
  - Sideways polarization (?).
  - Opening in coils for recoil proton detection.

    AND/OR
  - Small angle scattered proton detection.
  - ^{4}He recirculation.
  - Beam scanning of target or defocusing.
  - Need good CNI statistics – next slide.

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Calibrating the RHIC Polarimeter at Injection Energy

- CNI statistics:
  - Could use carbon foil instead of ribbon (5μg/cm^2).
    - Cover entire beam spot.
    - Beam focused on target.
  - Assume beam of 1x10^{11}protons/bunch.
    - Gives Luminosity of 1x10^{28}cm^{-2}sec^{-1}.
    - 5x10^2 lower than E950.
  - Increased detector acceptance x3.
    - 14 events/sec (28 per bunch).
  - Increased running time x10 (30 shifts).
    - 1.3 million events (50% duty factor).
  - E950 had 20 million events.

Calibrating the RHIC Polarimeter at Injection Energy

- CNI systematics:
  - Bunched beam.
    - Gives much better TOF.
    - -t calculation improves.
  - External beam line.
    - Reduced noise.
    - Can go to much lower –t (higher asymmetry).
  - Improved energy calibration.
    - Have learned much since E950.
  - Beam polarization determined using same sample of beam.

Estimate of Improved Beam Polarization Uncertainty

- Injection Energy:
  - From this proposal. (~5%)
- Full energy:
  - From Acceleration/Deceleration. (Statistics dominated, ~1.4%)
- From Theory:
- Overall double spin asymmetry scale uncertainty from beam polarization <15%