Determination of RHIC Beam Polarization

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Determination of RHIC Beam Polarization

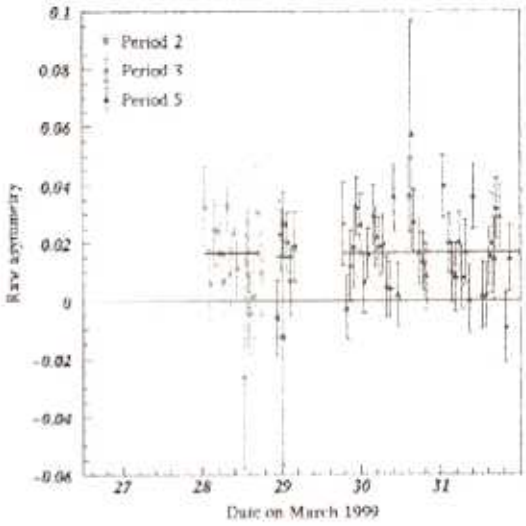
- Results from E950 – Junji Tojo.
  - Determination of A_N using $\mathbf{P}_B$ from E925.
- Results from RHIC Polarimeter – Osamu Jinnouchi.
  - Expected uncertainties from RHIC polarimeter.
- How do we use these to determine beam polarization at full energy?
  - How to determine polarization at injection energy without an absolute polarimeter.
  - How to determine polarization after acceleration.

General Process at Injection Energy

- Use RHIC p+C CNI polarimeters to measure beam polarization at injection energy. Need physics analyzing power.
- Get physics analyzing power from E950 asymmetry measurement. E950 needs beam polarization from E925.
- E925 determines the beam polarization from pp elastic measurement. Needs pp elastic analyzing power from fits to previous calibrated data. Weak link.

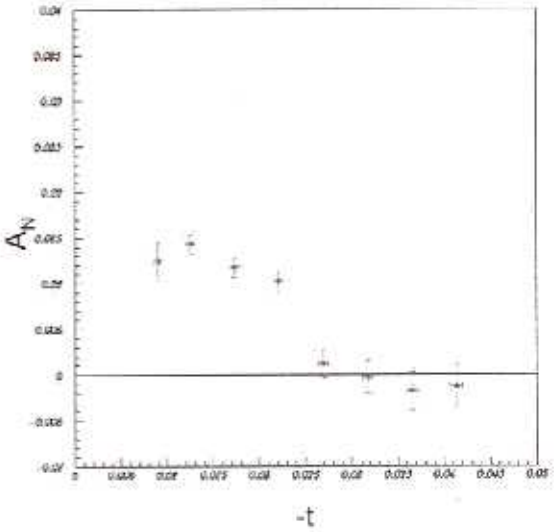
Results from E925

- E925 determines beam polarization to be 0.407±0.035(stat) ±0.048 (syst) during E950 running (total uncertainty ~15%).
- The systematic uncertainty (12%) is dominated by the determination of the analyzing power calculated from other measurements (at different energies) to be A_N=0.0400±0.0048.



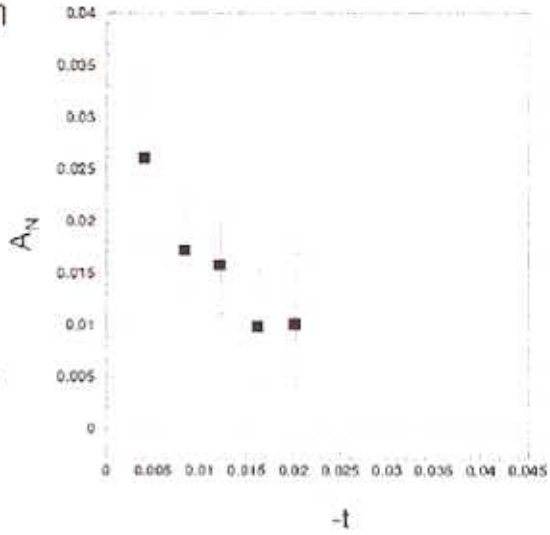
Results from E950

- E950 has very small 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 small systematic uncertainty (~5%).



Results from RHIC Polarimeter

- Needs extrapolation from E950 energy to RHIC injection energy.
- Statistical uncertainties expected to be ~1% during upcoming run.
- Well understood systematic uncertainties.
- Match to E950 shape in very good agreement.



Calibrating the RHIC Polarimeter at Injection Energy Using E950

- Energy differences.
  - E950 was at $\sqrt{s} = 24.7 GeV$
  - RHIC injection is at $\sqrt{s} = 25.9 GeV$
  - AGS internal polarimeter during RHIC polarimeter run has large systematic uncertainties.
  - 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).
- No shape differences, only scale uncertainty.

Theoretical Determination of Energy-Dependence of Analyzing Power

- E950 does not fix the determination of the hadronic spin-flip amplitude to a high enough degree to be able to say the even what sign of the energy dependence of the asymmetry will be at full energy.

Method of Accelerating and Decelerating Beam

- E950 Energy is too low for injection (~transition).
- Injection energy at $G\gamma$=46.6, E = 24.3GeV.
- Plan to make asymmetry measurements at "stepping stones" along the way, or also possibly during the ramp (ramp time vs. measurement time!).
- Then plan to decelerate and make measurements, although beam loss back at injection energy may *require* measurements during ramp down.
- Scenario #1: Asymmetry is the same at low and high energies and is the same upon return to low energy.
- Scenario #2: Asymmetry is different at low and high energies, but is the same upon return to low energy.
- Scenario #3: Asymmetry is different at low and high energies, and is also different upon return to low energy.

Method of Accelerating and Decelerating Beam

- Scenario #1:
  - Analyzing power is the same at injection and full energy, and there is no polarization loss.
- Scenario #2:
  - Analyzing power is different at injection and full energy, and there is no polarization loss.
- Scenario #3:
  - Difference upon return to injection energy is due to polarization loss, equally distributed between ramp up and ramp down (?).
  - Difference between injection and full energy due to energy dependence of analyzing power.
    - Consistency check with E950 hadron spin-flip measurement.

Estimate of Beam Polarization Uncertainty

- Injection Energy:
  - From E950. (~19%)
- Full energy:
  - From Acceleration/Deceleration. (Statistics dominated, ~1.4%)
- From Theory:
- Overall double spin asymmetry scale uncertainty from beam polarization <50%