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Thoughts on Polarimetry for ^{3}He Beams at RHIC

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Abstract

The Relativistic Heavy Ions Collider (RHIC) has accelerated polarized proton beams for physics since 2001. As part of the future eRHIC program and in order to enhance access to the down quark, a program to accelerate polarized ^{3}He in the AGS and RHIC is envisioned. To that end, a polarized ^{3}He source is being built at MIT. This will be installed on the BNL EBIS source in preparation for injection into the booster and AGS. As an early exercise, in June 2012, unpolarized ^{3}He beams have been accelerated in the AGS. This paper will peruse some potential ideas for ^{3}He polarimetry and calibration that could be utilized at the AGS as well as RHIC. The current proton polarimetry program serves as a guide.

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1 Introduction

The task of selecting potential high energy polarized proton beam polarimeters was made relatively easy by the preponderance of transverse single spin processes such as inclusive pion production, primakoff production, and Coulomb Nuclear Interference production at energies as high as 120 GeV for experiment E704 at Fermilab. In comparison, the experience with polarized ^{3}He beams is at the few hundred MeV level and the respective polarimetery was carried out with double scattering experiments that are not suitable for high energies in the GeV range. Thus the new effort at BNL represents a new challenge of finding suitable physics processes with high enough analyzing power and cross section

to use in polarimetry and, of course, we need to find suitable means of calibrating such polarimeters similar to what was done for polarized proton beams at RHIC.

For the AGS and RHIC polarized proton polarimeters we utilized the p-Carbon elastic scattering process in the Coulomb Nuclear Interference region to serve multiple purposes, fast beam polarization measurements on the order of a few minutes, beam polarization profile measurements, and beam emittance measurments. This was done using thin carbon targets that traverse the beam vertically or horizontally as needed. Elastically scattered recoil carbon is detected using silicon detectors positioned at angles around close to 90^0 in the lab system.

The RHIC polarimeters were calibrated using the pp elastic scattering process in the Coulomb Nuclear Interference region. This utilized a polarized hydrogen jet target the polarization of which was measured using an independent Breit Rabi polarimeter. This, used the identical particle concept where the analyzing power is the same whether the beam of the target is polarized. Thus the beam polarization was inferred from the beam left-right scattering asymmetry and the polarization level of the jet target, which was measured continuously. The Coulomb Nuclear Interference process for polarimetery served us well for RHIC. The asymmetries [1] seemed to change little, within a few percent, over the wide RHIC energy range Figure 1. This should serve as a potential guide for our pursuit of ^{3}He polarimetry.

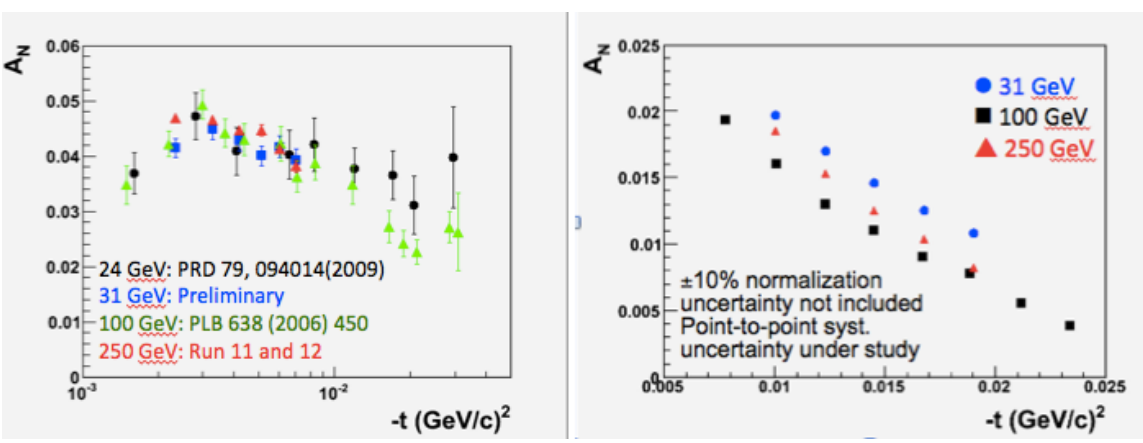

FIG. 1: The measured analyzing power A_N in pp and p-Carbon elastic scattering respectively at RHIC energies.

2 Helium polarimetry

Based on the above experience with proton beams, it seemed prudent to utilize a similar concept for helium polarimetry, namely asymmetries in the CNI domain. To that end some theoretical work has started to explore this possibility and what lies ahead. Some estimates of the analyzing power for p-^{3}He CNI seem give asymmetries comparable to those from p-Carbon CNI with zero hadronic spin flip amplitudes. The distibution changes considerably with inclusion of a non-zero hadronic spin flip component [2].

Buttimore [3], on the otherhand, derived an estimate of the ^{3}He-Carbon analyzing power ~ -0.780 $\sqrt{[2\sigma^P/\sigma^{He}]}$ where the σ's are the realtive total cross sections. In June 2012 we had a chance to inject and accelerate an unpolarized ^{3}He beam in the AGS to 33.3 GeV the RHIC injection energy [4]. The AGS CNI polarimeter carbon target was inserted to: a) assert that we can measure the receoil carbon from ^{3}He-Carbon elastic scattering, Figure 2, and b) compare rate seen by the silicon detectors to that from p-Carbon as an indicator of the total cross section, and c) measure a zero beam polarization.

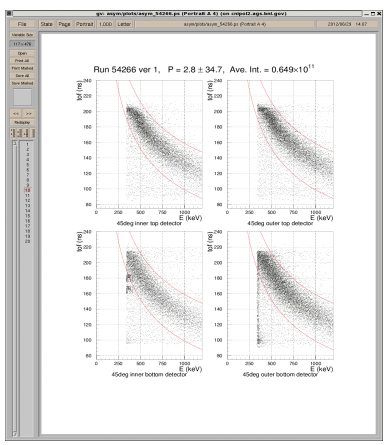

FIG. 2: The Time Vs Energy plot of the recoil carbon from the ^{3}He-Carbon elastic scattering as detected by silicon strip detectors. A clean banana structure is observed.

While these are indeed slow carbons, a quick kinematics estimate indicated that the 1mm detectors were seeing only elastics and the 2mm silicon detectors acceptance could see some ^{3}He breakup scatters. The measured polarization was consistent with zero. In addition the observed total rate compared to that from protons was about a factor of 2. The above estimate, implies the ^{3}He-Carbon asymmetry at ¾ that in p-Carbon

scattering. Another piece of good news is the possibility of using the same polarimeters in the AGS and RHIC for beam polarization measurement. Another option is to use the ^{3}He-p elastic scattering process using the polarized hydrogen jet target at RHIC.

While this is encouraging, we still have to secure a calibration system at any energy similar to what we currently do at RHIC. This requires a polarized ^{3}He jet to utilize the identical particle principle in ^{3}He - ^{3}He elastic scattering where either the beam or the target are polarized. This requires that we measure the ^{3}He jet polarization by some independent method similar to what is currently employed with polarized helium targets.

3 The path forward

I have desribed a potential approach towards ^{3}He polarimetry for RHIC. This will require theoretical support to estimate the asymmetry in ^{3}He-^{3}He elastic scattering in the Coulomb Nuclear Interference region, and a design of a good intensity polarized ^{3}He jet target probably utilizing concepts similar to those for Hermes or Meinz.

For the accelerator end, the MIT polarized ^{3}He source is expected to come to BNL at the end of 2013 to be installed on the BNL EBIS source which will take a good portion of a year. That done, we can then inject into the Booster and AGS and intiate the studies necessary to preserve and measure the ^{3}He beam polarization. For ^{3}He polarized beams at the highest energies, additional snakes will needed in RHIC.

References

[1] Makdisi Y. et al. // PSTP 2011 proceedings St. Petersburgh, Russia Grigoryev, Kravtsov, and Vasilyev eds pp 47

[2] Trueman L. // arXiv:0710.3380v1 [hep-ph]

[3] Buttimore N. H. // Polarizing Helium-3 for down quark spin enrichment, Proceedings of Diffraction 2012 to be published.

[4] Huang H. // Private communications and internal BNL report

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