The submitted manuscript has been authored by a contractor of the U. S. Government under contract No. W-31-109-ENG-38. Accordingly, the U. S. Government retains a nonexclusive, royalty-free license to publish or reproduce the published form of this contribution, or allow others to do so, for U. S. Government purposes.

FERMILAB
APR 22 1997

ANL-HEP-CP-96-101
For the Proceedings of the 12th International Symposium on High-Energy Spin Physics
10-14 September 1996, Amsterdam, The Netherlands

Some Issues in Polarimetry at RHIC

Presented by D. Underwood

High Energy Physics Argonne National Laboratory USA

ANL-HEP-CP-96-101
Fermilab Library
0 1160 0044514 2

ABSTRACT

This talk was given in conjunction with a talk by F. Mariam on the toroidal magnet design for a pion inclusive polarimeter. Here we describe several issues including the 200 GeV pion inclusive asymmetry data from Fermilab E704, the possible use of a calorimeter with the Toroidal Magnet polarimeter design, and some aspects of polarization Luminosity measurements.

Pion Inclusive Polarimeter

In order for spin experiments to succeed at RHIC, solutions to a number of issues related to polarimetry must be implemented. To tune the RHIC machine to accelerate polarized protons from 23 GeV to 250 GeV, a polarimeter with fast feedback is needed, preferably on timescales of a few minutes. Perhaps the tuning could be done with a relative polarimeter if the energy dependence of the process used in the polarimeter were not too great, and the polarization loss in the machine were to occur at only a few discrete energies. An absolute polarimeter with essentially no energy dependence would avoid the need for such assumptions.

The inclusive pion asymmetry seen at 200 GeV [1] and at 11.75 GeV [2] may provide both an absolute and almost energy dependent measurement. The asymmetries for Pt > 0.7 are in the region of 20 to 25% for Xf around 0.5 to 0.6. The absolute beam polarization used to normalize the 200 GeV data is belived to be known to +- 6%. The data at 11.5 GeV has asymmetries of similar size in similar kinematic regions. In order to clearify the situation, a measurement will be made at 23 GeV using polarized beam at the AGS in the next year or so. [3]

As described in the talk by Mariam, we have proposed a toroidal magnet system for the polarimeter. The magnets have radial openings in 4 directions, horizontal and vertical. The horizontal slots allow a two-arm measurement to help control systematics in the absence of being able to count the beam. The vertical slots can be used for luminosity measurements for the horizontal arms, or possibly to check for horizintal spin components in the beam.

It is difficult to provide adaquate selectivity in xf and pt to utilize the polarimeter in essentially a scaler mode with no event reconstruction. The kick provided by the magnets is not large compared to the particle momentum, and the hodoscopes cannot be used upstream of the magnets with a carbon fiber target because of the

multiplicity of interactions from each bunch. We are therefore studying a combination of magnetic bending and high resolution hadronic calorimeter to select the pions of interest. A very simple calorimeter with hadronic energy resolution of about 40% /root(E) is described in the literature.[4]

Polarization and Luminosity

The physics experiments need to know the absolute polarization of each beam to an accuracy approaching 5%, depending on the physics of interest and the statistics available. Some experiments require transverse polarization of both beams, but most require longitudinal lolarization of both beams. Spin rotators will be used to provide longitudinal polarization at two experiments while the polarization is vertical in the rest of the machine (spin tune 1/2) to prevent depolarization. The experiments need to know the direction of longitudinal polarization relative to beam momentum for each beam to do the physics with various parity violating and parity conserving combinations. If we label the two beams as yellow and blue to simplify discussion, then the experiments need all 9 of the possible combinations of helicity and empty bunches, namely blue (plus, minus ,empty) intersecting with yellow (plus, minus, empty). The combinations containing empty bunches are needed to control beam-gas systematics and effects of wakefields.

The experiments also need to know the relative luminosity of each combination of polarization direction and beam momentum, to very high accuracy. Some of the approved experiments expect raw spin asymmetries of about 2 x $10^{-}3$. It would be good to make the systematic errors due to knowledge of relative spin luminosity much smaller than this. The luminosity should be measured by each experiment, at each experiment, for it's own particular set of bunch combinations and quadrupole settings. The density distribution in bunches and the overlap of the bunches and the polarization within bunches may change with time during a beam store.

It is also possible that the polarization in the core of the beam could evolve differently during a store than the polarization at the edge where there are larger betatron oscillations. Thus, it is desirable to for the polarimeter to measure polarization as a function of position in the beam. The use of a carbon fiber target in the pion inclusive polarimeter could provide this.

Bunch Patterns

We give an existence proof for providing reasonable numbers of intersections fo each spin combination at each interaction region. We assume the following constraints in searching for an appropriate pattern of +,- and empty bunches. First, we assume 60 RF buckets around the ring, with at least 3 in a row empty to allow

for the rise time of abort magnets, etc. We then want the interaction regions in use to get each of the 9 combinations. We want the non-empty combinations to occur in roughly equal numbers and more often than the empty combinations. The 9 combinations are (+,empty,-)blue X (+,empty,-)yellow. We were led to consider a hybrid of pre-determined pattern and random generation in order to find a solution.

Note that the relative location of the successive empty buckets may not have the relative position for aborts if there is some constraint relating the two beams. This will be studied in the future.

bunch patterns of the two beams

blue

- + - + - + - E E + - E E E - + - + - + - + - + - + - + - +

E + - + - + - + - + - + - + - + - + - + - + - + - + - E - +

yellow

E E E + + - E + + - - E + - - + + - - + + - E + + - - + + -

- + E - - + + - - + + E - + + - - + + - - E + - - + + - - +

At 6 int. regions:

notation: + is positive helicity bunch, e is empty bunch location

1 number ++,–,+-,-+ 11 12 11 12 number +e,-e,e+,e-,ee 4 3 3 2 2

2 number ++,–,+-,-+ 11 12 11 12 number +e,-e,e+,e-,ee 4 3 3 2 2

3 number ++,–,+-,-+ 11 12 12 12 number +e,-e,e+,e-,ee 3 3 3 1 3

4 number ++,–,+-,-+ 12 11 11 12 number +e,-e,e+,e-,ee 3 4 2 3 2

5 number ++,–,+-,-+ 12 12 10 11 number +e,-e,e+,e-,ee 4 4 3 3 1

6 number ++,–,+-,-+ 11 12 10 12 number +e,-e,e+,e-,ee 5 3 3 3 1

References

1. Analyzing Power in Inclusive pi+ and pi- at high Xf with a 200 GeV Polarized proton beam, E704 Collaboration, D.L.Adams et al, PL264B, 462 (1991)

2. W.H.Dragoset et al., PRD 18,(1978) 3939
R.D. Klem et al, PRL 36, (1976) 929

3. Asymmetries in Inclusive Pion Production at Large Xf=(0.5 to 0.8) and Pt >0.8 GeV/c with a Polarized Beam for a RHIC Polarimeter AGS Experiment E925

4. Performance of a Compensating Lead-Scintillator Hadronic Calorimeter E. Bernardi, et al, NIM A262 (1987) 229

* *Work supported in part by the U.S. Department of Energy, Division of High Energy Physics, Contract W-31-109-ENG-38.*