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SOME POSSIBILITIES FOR DOING POLARIZED p,p̄ EXPERIMENTS AT THE SSC

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Summary

While there has been a previous study of accelerating polarized beam at the SSC, we have looked at several alternative approaches, including polarizing stored beam, using polarized gas jets, and using secondary polarized beams. We also point out some physics possibilities and give references to physics reviews.

We have considered several alternate methods of obtaining polarized proton interactions, other than producing a polarized external beam from the parity-violating decay of lambdas:

1. Polarized protons can be injected into the collider and accelerated to full energy. This technique received some attention at the Ann Arbor workshop.[1] Severe problems arise in such matters as crossing many strong depolarizing resonances.

   This method cannot be used to provide polarized anti-protons.

2. Two ideas were considered to polarize the beams after they have been accelerated to full energy. In both these methods, Compton scattering by polarized photons is used to selectively scatter protons of one sign of polarization; the remaining beam, now polarized, is used for internal interactions.

   One method[2] involves the use of lasers in the optical or near-infrared range. The scattered, polarized protons remain in the beam and get re-accelerated to full energy. The effect is cumulative and adds to the r.f. energy requirements of the accelerator.

   The other method involves the use of intense polarized x-ray beams, in the kilovolt range, which one presumes will become available in the time scale of building the SSC. The scattered protons are now lost from the beam and the remaining beam becomes polarized. The large loss in beam intensity would have to be replenished. (The ejected protons would also be polarized and, perhaps, can be collected to form an external polarized beam.)

   Retaining the polarization of internal beams polarized by either of these methods, or by accelerating injected polarized beams, would seem to require the presence of snake magnets in the ring. The purpose of the snakes is to make the spin tune energy independent and this can be accomplished with only two snakes, each of which rotates polarization 180° about orthogonal axes. There may be advantages to distributing the snake functions and combining snakes with rotators at the interaction regions as described in Reference 3.

   The fundamental problem with polarization in the SSC ring is alignment errors, as pointed out in References 4-7. Terrain following can be compensated for with a few extra magnets to line up polarization with the field in terrain following bends, as described in Reference 5. The spin precession due to expected magnet misalignments could be larger than 90° in even a fraction of the ring so that two snakes might not work at all, and the precessions in segments of the machine would be uncorrelated so that multiple snakes would appear not to do any better.

3. An internal gas jet target[8] can be constructed from a source of atomic polarized hydrogen.[9] It seems likely that the density of the jet is controllable to yield any luminosity that is acceptable in terms of counting rate, beam depletion, heating and radiation damage, and other limiting factors. The center-of-mass energy is lower than when two beams collide, but higher than in the lambda decay beam.

   Collisions in which only one of the interactants is polarized can be used to look for parity- and time-reversal violating effects. When two spins are measured, one of which may be in the final state, we can determine spin-dependent structure functions using a reaction such as

$$p \text{ (or } \bar{p}) + p\uparrow \rightarrow l^+l^-X$$

   Rates for such reactions have been studied[10] for fixed targets. We intend to make Monte Carlo estimates of the rates in the geometry of an internal target, at the energy of the SSC.

If polarized circulating beam is not available at the SSC, many kinds of experiments can still be done with a secondary polarized beam similar to one being built at Fermilab.[11] The beam obtains both polarized p,p̄ from decays of Λ^0 and $\bar{\Lambda}^0$, where the Λ^0 is produced at low t and the polarization comes from weak decay. The polarization can be reversed and aligned to any direction with a snake.[12]

One can do two-spin experiments with polarized beam and polarized target with both p and p̄. This kind of beamline scales in length with energy, due to the lambda decay length, whereas the magnets and apertures remain constant. The polarized beam intensity is about 10^{-5} of the number of interactions of the primary beam, and this factor is about the same as for the photon and neutrino beams discussed at this workshop.

At the SSC, one could use a gas jet as the primary production target for such a beam. With 10^8 interactions/sec., the polarized beam intensity would be 10^3/sec. As an example, one could measure a raw asymmetry of 5×10^{-6} in the total cross section in 100 hours, which corresponds to about .3 mb when target dilution of about .2 and beam polarization of about .5 are taken into account.

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A detailed review of physics possibilities with polarization is given in Reference 13.

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