Summary of the 70 GeV Booster Group*†

Y. Makdisi, Coordinator
Brookhaven National Laboratory, Upton, NY 11973

F. Khiari, Scientific Secretary
University of Michigan, Ann Arbor, MI 48109

This group and that involved with the demonstration snake overlapped completely. This summary relates the chronology of the discussions during the week. In addition, the results of calculations, pertinent to the booster, that were carried out after the workshop appear here and elsewhere in these proceedings.

The Booster I lattice was taken from the SSC Reference Design Study of May 8, 1984. Table I summarizes the features that are of interest to this work.

Table I.

Energy range	1 - 70 GeV
No. of bending magnets	30
No. of straight sections	6
Length of straight sections (m)	2 x 16
Periodicity	6
Vertical tune ν_y	9.37
$\Delta\gamma$/turn	1.5×10^{-4}

The energy range of this Booster (1-70 GeV) makes it difficult to employ a single technique for preserving the beam polarization. The conventional resonance jumping method, fast quadrupoles and correction dipoles, require uncomfortably high currents when the beam energy exceeds 25 GeV. Similarly, solenoid-equipped Siberian snakes require excessively high fields that scale linearly with γ. In addition, solenoids tend to rotate the horizontal and vertical beam ellipses. Thus quadrupole correction is needed to preserve beam dynamics. On the other hand, snakes using bending magnets have the advantage of working at constant excitation, depending on the spin precession per magnet, independent of γ. This constant field causes large beam excursions at low γ requiring large aperture power hungry magnets. These constraints made it clear that two techniques will be used: the conventional approach up to 20 GeV, and Siberian snakes from 20 to 70 Gev.

The results of the DEPOL calculation by E. Courant, S. Y. Lee, and S. Tepikian (Fig. 1) show the expected resonance strengths $|\varepsilon|$ for γ < 20 GeV to be below the $.5 \times 10^{-1}$ level which poses no problems for resonance jumping if our experience at the AGS is to serve as a guide. The resonance strength above 20 GeV grows with γ but is

*Work performed under the auspices of the U. S. Department of Energy.

still below the 10^{-1} level which should be well accommodated by one or two Siberian snakes.

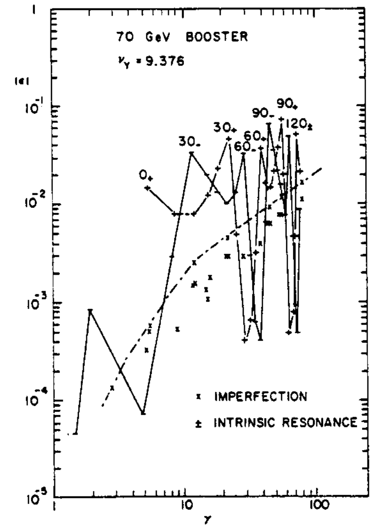

Fig. 1. Resonance strength $|\varepsilon|V_s\gamma$ for the 70 GeV Booster as predicted by the DEPOL program.

Various schemes were presented to bridge these two resonance jumping techniques during the acceleration cycle. One possibility is a bypass in which the snakes could reside, another would be a flattop at 20 GeV during which the snakes are energized to full power. Both are awkward and present logistical problems.

By mid-week the first piece of good news arrived--that being a single adiabatically energized snake will not significantly depolarize the beam (see note on Turning on a Siberian Snake in the 1-70 GeV SSC Booster by K. Steffen, these proceedings).

This provided one good solution to the mixing problem namely, the snake magnets will be energized during the acceleration cycle reaching maximum operating value at 20 GeV where they will take over the resonance jumping role (Fig. 2). The use of a single snake requires the polarization spin vector to be longitudinal along the direction of motion. This demands an additional spin precessor before the snake and after extraction for the planned vertical spin injection into the 1 TeV booster.

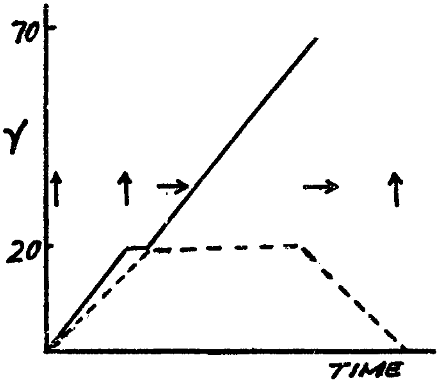

Fig. 2. A one-snake system. Arrows denote spin vectors; the dashed lines snake excitation.

Towards the later part of the week, the possibility of adiabatically energizing two snakes became feasible (see J. Buon, Depolarization Effects in a Ring Equipped with Snakes, these proceedings). The study finds that the spin tune of 1/2 is preserved as long as the intrinsic resonances strengths are below 1.8×10^{-1}. This condition is satisfied in the machine. No depolarizing effects were anticipated from crossing imperfection resonances.

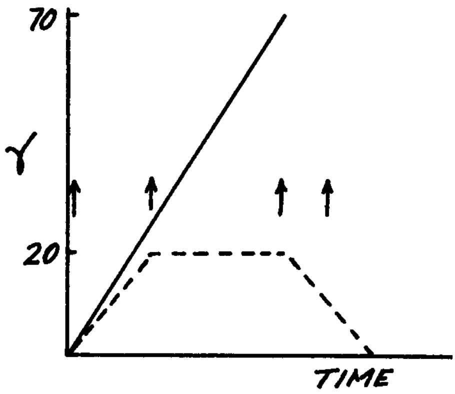

Fig. 3. A two-snake system. Arrows denote spin vectors and the dashed lines snake excitation.

This solution (Fig. 3) made it possible to use one ring and employ both the conventional (tune-shifting quads) and the new (snakes) techniques simultaneously with the following provisions:

a. Spin injected vertically at a half integer tune $G\gamma = n + 1/2$ gives a linac injection energy of ~ 900 MeV.

b. The two snakes will be energized slowly, reaching maximum current at 20 GeV.

c. Use transverse snakes (Type II) with 8 alternating horizontal and vertical bending magnets per snake each rotating the spin by $\pi/2$.

d. Magnet excitation of ~ 27 kG-m will be needed. At 1.5 meters/magnet, a string of eight magnets fits easily in one straight section.

e. Since slow excitation is possible, the beam kick by each magnet is reduced; thus relatively small magnet apertures (10-15 cm) can be used to save power.

f. Space should be provided for the fast tune-shifting quadrupoles.

It should be emphasized that all this depends on the success of an adiabatic turn on. The demonstration snake group will test that concept, it is therefore essential that this demonstration be carried out.

There is always the fallback position where two rings could be built, each employing one resonance jumping technique. The choice of energy range should be mandated by the spin preservation requirement as well as other physics considerations in case extraction to experimental areas is contemplated when the boosters are not injecting for the SSC.

While polarized H^- ion sources are expected to improve their output to the mA range, one should keep open the possibility of using one of these boosters as an accumulator ring to increase the intensity, if needed.

† Group participants

G. Danby, F. Khiari, Y. Y. Lee, J. Norem, Y. Makdisi, D. Peaslee, L. Ratner, R. Raylman