Fermilab

UPC 129

April 14, 1980

NOTES ON A STUDY WEEK
ON BEAM STORAGE IN THE TEVATRON
April 7-11, 1980

1. Lattice The lattice designers (D. Johnson, S. Krinsky, A. Garren) do not consider the low-β sections optimized. Garren believes that it would be possible to achieve lower η^* with a more symmetric lattice. It is understood by the designers that changes are possible only in straight sections.

   Garren presented several lattices. The first was one he worked out a year ago. It has $\beta_x^* = \beta_y^* = 1.5$ m, $\eta^* = 6$ cm, $\beta_{x\ max} = 565$ m, $\beta_{y\ max} = 323$ m, $\xi = 39$ (±?). The changes are all in insertion quads and the added cost is in adding 4 independent power supplies. The drift space is 40 m long.

   Another lattice, done this week, also made some changes in the bends. Everything between the two D's at the ends of the straight section is replaced by a totally symmetric lattice. This did not seem to have a good drift space.

   Another suggestion of Garren's was to reverse the quad polarity in half the superperiods, giving a periodicity of 3 with symmetry.

   Comments from various people

   (i) Field error harmonics will possibly make it impossible to achieve low η. We may need harmonic quad corrections to get low η.

   (ii) The lattices discussed did not treat the question of high-β straight sections. These and the low-β could probably be achieved more flexibly if changes in power-supply hookups were allowed during changes between fixed-target and colliding-beams modes.

   Topics for Study: Criteria on η^*, ξ_x, and ξ_y are needed.

2. Magnets and Corrections: Don Edwards reviewed the correction-magnet criterion and sizes. Information on magnet quality was made available.

   The question of corrections was discussed very little and no new thoughts were offered on correction-magnet sizes (See the suggestion on harmonic correction under "Lattice" above).

Parzen discussed the ISABELLE magnets. The dipoles have b_2, b_3, and b_4 correction coils; the quads have b_1, b_5, b_o, and a_o. All are powered together on the zeroth harmonic. The insertion quads have b_1, all separately powered.

Systematic error tolerances (all in cm^{-n})

b_2: 0.35×10^{-6}
b_4: 43×10^{-9}
b_6: 6×10^{-9}
b_8: 1×10^{-9}

These are derived from the "allowable" curvature of the "working line" (the range of tune variation with $\Delta p/p$, as estimated from ISR experience):

Random tolerances (cm^{-n})

b_0: 2×10^{-4}
b_1: 6×10^{-5}
b_2: 7×10^{-6}

The uncorrectable minimum closed-orbit error arising from the large radial size of their stack and the field fall-off at the edge is 1.3 mm rms. They lose 5 mm aperture with 90% probability from errors.

There is a random error in vertical dispersion from a_1. There is a 25% increase in beam size at injection and a 10% increase at 400 GeV. This gives a 25% luminosity loss and a 25% variation in beam-beam tune shift. There is a random error of 5% rms, 10% peak in β_y at crossing points.

They set a requirement of $\Delta\nu \leqslant 0.001$, derived from ISR, and this gives tolerances on the 25 individual correction power supplies.

For the main power supply, they have set tolerances of:

Ripple: $\Delta I/I < 10^{-7}$
Short-term changes: $\Delta I/I < 10^{-6}$
Long-term drists: $\Delta I/I < 5.10^{-6}$

Parzen commented that the Tevatron magnet is rich in higher multipoles compared with ISABELLE and that he considers this to arise from our having only two shells in our coil. This also gives us, he claims, only a small useful aperture compared with inner coil radius.

<u>Topics for Study</u>:

(i) Need for harmonic corrections
(ii) Connection between magnet quality achieved and correction sizes.

3. Magnet Power Supply Dan Wolff and Bob Shafer reviewed power-supply ripple and fluctuations. Jim MacLachlan reviewed Main Ring storage studies.

The ripple and fluctuation criterion is ±40 mA at 4300 A. The voltage regulator should reduce variations by a factor 500 and the current regulator should reduce variations by a factor 500. These are dominated by component stability.

The long-term drift from 5% line-voltage variations should be

$$\frac{\Delta I}{I} = \frac{5\%}{500.5000} = 2x10^{-5}.$$

The field variation on flat-top should be less than 10^{-8}.

Different firing angles of supplies could make an effective frequency shift at 720 Hz that might not be totally covered by the separate 720-Hz trap. There might also be some effects from the cap tree.

The Tevatron system is not a learning system like the Main Ring. It is possible that a learning system might help to overcome line variations or Main-Ring ramps.

Topics for Study

(i) Orbit effects of expected field errors from propagation characteristics.
(ii) Main-Ring studies on effect of ripple on stored beam.

4. Vacuum Vacuum was reviewed by Sandro Ruggiero and Hans Jöstlein. There is no change from the conclusions of Mizuno, Ohnuma and Ruggiero of UPC-119. Neutralization and pressure bumps are not considered problems, The largest loss of luminosity comes from nuclear scattering.

5. RF Quentin Kerns reviewed the rf system. Very little attention has been paid to the effects of amplitude and phase noise on orbits and Kerns hopes for guidance. Some concern was also expressed that the system as designed might have problems from errors in gain in the feedback amplifiers generating synchrotron oscillations. Thus the beam may induce phase noise.

Topics of Study:

(i) Need to estimate effects of noise on orbits.

6. Orbits No attention was paid to intrabeam scattering.

There was little discussion of beam-beam interactions, which had been the subject of a separate study week. Most participants believe that beam-beam effects are a combination of nonlinear interactions and noise. The noise can drive motion into stochastic regions and perhaps into instability. Some possible noise sources are intrabeam scattering, phase noise in bunched beams, or Schottky noise in colliding beams.

There is also a separate question of multiple resonance crossing from modulation by synchrotron oscillations (so-called "thick-layer diffusion").

Topics for Study

(i) Multiple resonance crossing from synchrotron modulation with real magnetic fields. What are the effects of multipoles?

(ii) Effects of rf waveform. The nonlinearities near the edge of buckets could be a problem in SPS. We have longer, more linear buckets.

(iii) Need to know more about resolution of pickup electrodes, to know how much multipole fields are induced by closed-orbit errors.

(iv) Beam-beam interaction.

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