C0 IR Review

Review Panel

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The C0 IR design was presented by John Johnstone for review by the panel On February 14, 2001. Comments and recommendations on the design follow.

Linear optics design

Designs were presented for three different operational scenarios at top energy:

1. Full luminosity at B0, D0 and separated beams at C0 ($\beta^*(C0) = 2.6$ m)
2. Full luminosity at B0, D0, collisions at C0 with smaller than design luminosity ($\beta^*(C0) = 2.6$ m).
3. No collisions at B0, D0, design luminosity at C0 ($\beta^*(C0) = 0.5$ m)

Constraints

Under ideal conditions the optics conditions are well matched to the boundaries of the insertion. The additional chromaticity generated by the insertion is small in the first two cases (about 4 units). In the third case the additional chromaticity of C0 (about 20 units) will be more than compensated by the lower chromaticity of the insertions at B0 and D0. The linear optics design should therefore have minimal impact on the rest of the ring in each of the three scenarios and meets the constraints imposed on it.

Flexibility

The design was demonstrated to be flexible enough to match the boundary conditions as they change during the β squeeze at B0 and D0. The C0 insertion should stay transparent (or nearly so) to the rest of the ring under these conditions.

Lower β^*

The BTeV experiment has indicated that the maximum usable luminosity at B0 will be $2{\times}10^{32}$ cm^{-2} sec^{-1}. Nevertheless, it would be desirable to design the insertion to provide a β^* lower than 0.5 m in the event that intensities and emittances are not at their design values. The design is apparently capable of lowering $\beta*$ to 0.35 m at C0 provided that the Q4 quadrupoles can be made about 75 mm longer. Small modifications (such as in the lengths of the magnet ends) should be sufficient to create this additional space and it would increase the flexibility of the design. The better field quality of the LHC style quadrupoles in the C0 insertion should allow at least as low (if not lower) a β^* at C0 as at B0 and D0.

Robustness

Gradient errors of up to 0.25% in the quadrupoles Q1 to Q5 can apparently be compensated by the rest of the quadrupoles in the insertion to prevent optics mismatches from propagating into the rest of the ring. If this is indeed true for a random distrbution of such errors, the design is robust against likely magnet errors. A similar study should be done (if not done already) to determine that alignment errors can be similarly compensated by the orbit correctors in the insertion.

Overall the linear optics design is sound and there are no obvious design deficiencies.

Engineering Design Issues

Trim power supplies on the inner triplet

Placing trim power supplies on the inner triplets Q1, Q2 and Q3 could be a useful option. The buswork exists in the Tevatron ring for this to be feasible. These power supplies might remove the need for a separate trim quadrupole QT as in the present design and create space which could be used for additional correctors. This requires a more detailed study which would examine the accuracy required of the trim supplies. Regulation of the fields of Q1, Q2, Q3 by better than 0.01% would be difficult particulary at low field, due to persistent current magnetization effects, which can certainly be several times larger than 1 part in 10^4. If, on the other hand, cruder accuracy is all that is required or if the trim supply is used only to, effectively, program a slightly different ramp for the Q2 than the Q1 and Q3 (such that one does not go around any hysteresis loops), then substituting a trim supply across Q2 would be acceptable. If greater accuracy is required, the use of trim quadrupoles will work while use of trim supplies will require some study. The burden of proof would have to be to demonstrate that the latter is acceptable.

Magnets with shorter ends.

In the present design the length of the inter-connects between quadrupoles may have been over-estimated by about 200mm. In addition there is potential to shorten these inter-connect lengths to about 950mm with some additional work. By comparison, the length of a full interconnect between, for example, the Q1 and Q2 equivalents in B0 is 875 mm. This is certainly shorter than is possible for an LHC style quadrupole but not by enough to overcome the advantage of the higher gradient in the LHC quad. The panel recommends that these issues be resolved by discussions between John Johnstone and Jim Kerby, Tom Nicol and Jim Strait in the Technical Division.

Future Work

The design should proceed to the next stage where outstanding accelerator physics issues can be examined, perhaps by a small group of people. Some of these are:

- Linear decoupling within the insertion with suitably placed skew quadrupole correctors.
- Optics at injection energy, specifically matching the separation helix with the available separators.
- Inclusion of the beam-beam induced orbit shifts in setting separator strengths
- Beam-beam induced tune footprints and dynamic aperture calculations, specially in scenario (2) when beams collide at all three IPs. Without such calculations, it is not clear whether the beams (particularly the anti-protons) will be sufficiently stable in the presence of the additional beam-beam interactions at C0. Scenario (2) may then only be possible with reduced luminosities at all three IPs.
- Are nonlinear correctors required within the C0 insertion to correct for the field quality of the insertion quadrupoles in any of the three scenarios?
- Is nonlinear chromaticity correction of the C0 insertion required in any of the three scenarios?

While these issues should be addressed as the design of the C0 IR develops from the current conceptual stage to the real engineering design that will be built, none are likely to invalidate the overall concept of the design. Modifications to make room for additional correctors will be the most likely result.