Single Particle Issues in the VLHC

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The major issues discussed in this working group were:

- High and low field magnets
  - Field quality
  - Required aperture
  - Scaling of the Cell length
- Lattice design
  - 3 TeV Low field lattice
  - IR design for a 50TeV high field lattice
- Correction Schemes
  - Orbit correction in LEP
  - “Sparse” Correctors
  - Nonlinear global correction
- Uses of synchrotron radiation
- Beam experiments with an AC dipole

Very brief descriptions of the talks:

High field magnets

Field quality with Nb-Ti coils has improved significantly in the last few years due to improvements in manufacturing, changes in design and reduction of measurement errors. Random errors can be controlled much better so systematic errors may be dominant in the present generation of superconducting magnets. Harmonics due to persistent currents in magnets with Nb_3-Sn coils have to lowered significantly before they can be considered acceptable.

Low field magnets

Combined function transmission line magnets with the necessary aperture can be built for a 3TeV ring. Issues that need to be addressed are field quality and dynamic range.

Errors and Cell Length

Neglecting the effects of synchrotron radiation, the optimal cell length depends on the balance of systematic and random errors. If random errors dominate, shorter cell lengths would be preferred while the opposite would be true if systematic errors were dominant.

3TeV low field lattice

A lattice with combined function transmission line magnets operating at 3TeV has been designed. Correctors (for each plane) are placed every other cell. This spacing of correctors has been shown to be adequate to correct for orbit errors resulting from expected transverse displacement and roll errors of the magnets.

IR design for a high field 50TeV lattice

A first attempt has been made at an IR design with quadrupole gradients of about 350T/m or pole tip fields of 9.25T with an aperture of 50mm. This can be used for energy deposition studies.

Orbit correction in LEP

Vertical motion of IR quadrupoles in LEP by a few microns lead to large vertical orbit excursions. These quadrupoles were placed on cantilevered support structures and heating of the supports when the ring was energized to top energy lead to the quadrupole motion. Closed orbit correctors placed in the vicinity of these quadrupoles were used to reduce the orbit distortion.

Sparse correctors

In order to save on correctors and cable costs, one could envisage placing correctors only near access shafts. In the SSC these were 4km apart. It was shown that with correctors this far apart, orbit distortions in the SSC ring due to random misalignments of quadrupoles would grow to as much as 14mm before they would be corrected. It is an important issue to determine how the minimal distance between correctors scale with the parameters of the ring such as the energy, circumference, cell length, phase advance per cell etc.

Nonlinear global correction

It was demonstrated that in the LHC lattice, correction of sextupolar and octupolar fields due to localized sources such as IR quadrupoles can be achieved with nonlinear correctors placed at well chosen locations in the arcs. For this method to be effective, an experimental method of measuring the one turn return map is required.

Uses of synchrotron radiation

At injection, synchrotron radiation is minimal and the beam should be injected with the equilibrium emittances expected at top energy. This would also have the effect of reducing the magnet aperture requirements. The beneficial effects of damping due to synchrotron radiation should not be relied upon to relax the requirements on the error fields at injection.

Beam experiments with an AC dipole

An example of a non-destructive diagnostic method to measure nonlinarities was presented. This relies on using an AC dipole excited at close to the betatron frequency to cause reversible orbit excursions. An experiment has been done at AGS with this technique with the AC dipole turned on and off adiabatically and no emittance growth was found to result. The aim is to use this technique to set the strengths of nonlinear correctors.

Future Projects

SHORT TERM - ($\sim$6months-1year)

- Measure the field quality in low-field magnets
- Measure persistent current b_2 in Nb_3-Sn superconducting magnets
- Feedback into error harmonic tables for low and high field magnets.
- Long term dynamic aperture calculations.
- How sparse can correctors be?
- Cost comparison of magnets with the same good field region.
- Measurement of ground motion.
- Ideas for beam experiments. Use machine studies fully.

LONG TERM

- **Proposals for beam experiments.**
- Lattice design with self-consistent principles for both low and high field rings.
- IR designs for both options.
- Nonlinear dynamics with new tools, e.g AC dipoles, frequency map analysis.
- Beam based alignment.
- Cooling?