LHC upgrade IR optics web repository

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Abstract

Many alternative IR optics have been proposed for the LHC upgrade. A web repository has been created with the main goal of hosting all these optics options but also to help in the comparison of the different options via standardization of the lattice descriptions and the parameters used for their evaluation. It is also thought that this web repository will become a useful tool for the IR designers by providing information and computer scripts.

THE WEB REPOSITORY

The web repository is located at:
http://care-hhh.web.cern.ch/care-hhh/SuperLHC_IRoptics/IRoptics.html
It aims to accomplish the following goals:

- Provide all the IR optics options. Obviously, prior to this we need the designer or responsible of the IR option to send us the appropriate files.
- Standardization:
  - Format: MADX. This format has been chosen since the support for MAD-8 has been stopped. If a format conversion is required this would normally be done by us.
  - Get the IRs in the full LHC lattice. Total matching of the IR to the rest of the LHC is fundamental to assess every option. A lot of help can be provided by us in carrying out this task.
  - Parameter choice: L*, β^*, θ, TAS, etc. Certain parameters have to be common to the IR options for useful comparisons.
- Provide MADX routines for usual jobs: slicing, IR errors, tune and chromaticity matching, etc.
- Provide standardized IR option information: optics, chromaticities, apertures, responsible, etc.
- Provide general information.

The repository already contains ten entries. Three dipole first options and seven quadrupole first. Two of the dipole first options are based on triplet focusing differing mostly on the distance between the IP and the first dipole. The remaining dipole first option uses doublet focussing. There is a larger variety within the quadrupole first options. The LHC nominal optics is included to allow comparison with this basic configuration. The option of using flat beams in the nominal LHC is also included to show the 20% luminosity gain. Below we list the remaining options in order of appearance with the responsible person and a brief description:

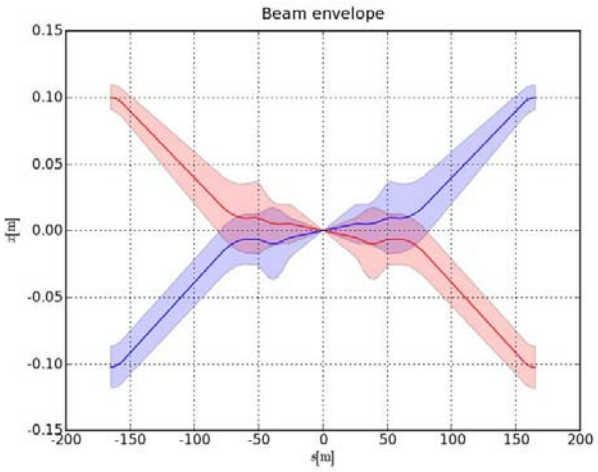

Figure 1: Beam envelopes for the baseline quadrupole first option.

- Low gradient (O. Bruning and R. de Maria). Features long quadrupoles with a low gradient.
- Baseline upgrade (T. Sen). Shares the layout with the nominal LHC but neets larger aperture quadrupoles.
- D0 (J.P. Koutchouk). Features small dipoles between the triplet and the IP.
- Q0 (E. Laface). Uses small quadrupoles between the triplet and the IP.
- Crab cavity (R. Tomás). Large crossing angle with crab cavities at both sides of the IP right after the triplet.

SOME ADVANTAGES OF THE WEB REPOSITORY

Figure 1 shows how the beam envelope is plotted for a particular IR option (quadrupole first). The main advantage of this feature is the standardization of the algorithms to compute apertures.

Figs. 2 and 3 show summaries of the natural first and second order chromaticities of the different IR optics options (in the full LHC) versus beta peak. So far a linear dependency is found for the first order natural chromaticity, while the second order chromaticity seems to have an exponential rise after 18km beta peak.

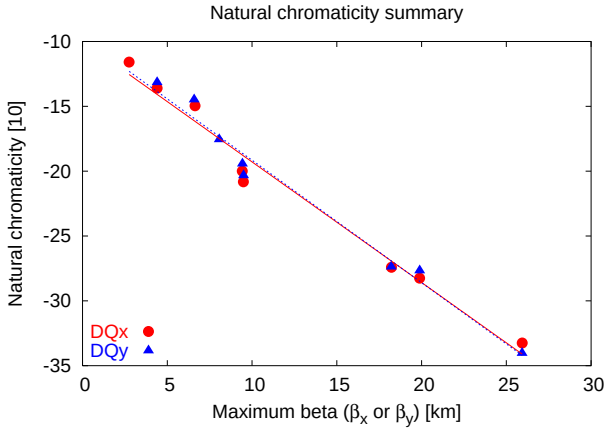

Figure 2: Summary of natural first order chromaticities of the different options versus beta peak.

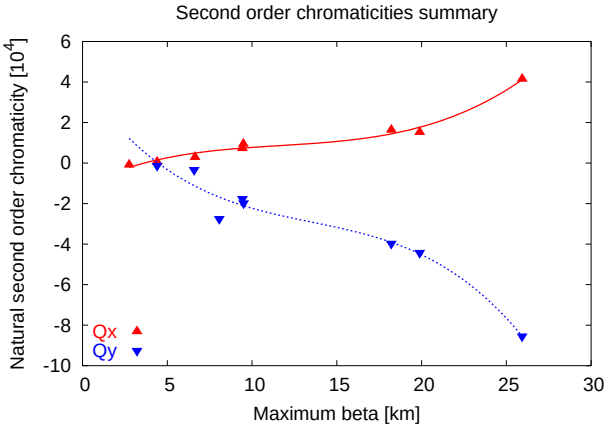

Figure 3: Summary of natural second order chromaticities of the different options versus beta peak.

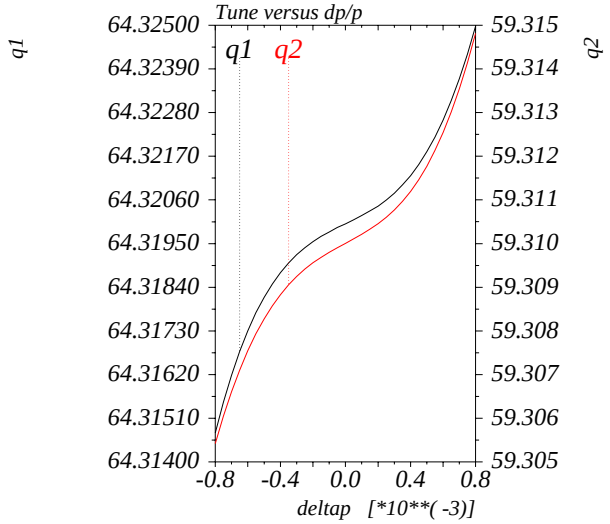

Figure 4: Tunes versus relative momentum deviation after correction of the first two orders of chromaticity for the baseline quadrupole first option.

Case	DA
R. de Maria dipole first	6.0
R. de Maria 'old' low gradient	7.0
Crab cavity	12.5
T. Sen Quad first	14.0

Table 1: Summary of dynamic apertures

The correction of chromaticity can be performed in various ways since there are a large number of independent sextupolar families in the LHC. There are two options to correct chromaticity within the web repository MADX jobs: correction of the first order chromaticity and simultaneous correction of the two first orders. We strongly suggest the use of the latter. Figure 4 shows the tunes versus relative momentum deviation after correction of the first two orders of chromaticity for the baseline quadrupole first option. A large third order chromaticity remains uncorrected. This is a common feature of all the 'standard' LHC upgrade options and could limit the energy acceptance and make machine operation difficult. Various attempts have been carried out to develop a scheme for local chromaticity correction. None of them have succeeded in compensating chromaticity without spoiling dynamic aperture [1, 2].

Probably one of the most important advantages of the web repository is the possibility of computing the dynamic aperture of all the options in a standardized way, using the same algorithm for the chromaticity correction and the same multipolar errors. Table 1 shows the dynamic aperture for some cases. The field quality of the IR magnets has been taken from the existing LHC magnet errors and scaled down by a factor of ten. We immediately recognize the more favorable options concerning particle stability. However it has to be mentioned that none of these options has a reasonable dynamic aperture when considering the LHC magnetic errors without any scaling. It is therefore necessary to develop means to improve the magnetic quality of the IR magnets and/or to find efficient correction schemes using dedicated multipole coils for the LHC IR upgrade.

CONCLUSION

A web repository of the LHC IR upgrade options has been constructed. It has proven useful in many different aspects thanks to the effort put in standardization of formats and calculations. We encourage the IR designers or responsibles to keep updating the repository with the latest versions of the IR optics and possibly with new IR designs.

ACKNOWLEDGMENTS

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REFERENCES

[1] R. de Maria et al, "Dipole first with chromaticity issues" these proceedings.

[2] R. Tomás et al, "Crab cavity IR optics design with $\theta = 8$mrad" these proceedings.