Update on MERLIN-SixTrack comparison and ATS optics

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Summary

- Introduction
- Collimation setup
- Simulation setup and main parameters
- Comparison between MADX and Merlin optics calculation for nominal (7TeV) LHC
- Input distribution at TCP.C6L7 for MERLIN and SixTrack
- Loss maps comparison between Merlin and Sixtrack for nominal optics at 7 TeV
- Impact distribution on the main collimators
- New SD and elastic scattering routines
- ATS optics problem
Introduction

- Setup a detailed benchmarking between MERLIN and SixTrack to ensure that MERLIN is ready to produce realistic physical results.
- The next step is to introduce the new improved SD and elastic scattering routines in MERLIN, check the effects of the interactions in the collimation jaws (also with the new mixed materials).
- Produce the firsts reliable loss maps for the 3.5, 4 TeV and the nominal case, and compare them with SixTrack and measurements.
- Apply this tool to ATS and other HiLumi ideas: hollow lens, crystal collimation and so on..
- Release a well documented and stable version for the accelerator community (Haroon PhD)
### LHC Collimation Setup

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<th>Nom</th>
<th>IR6</th>
<th>Nom</th>
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<tbody>
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<td>TCL</td>
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Differences with SixTrack:

- Different location and type of collimators in IR2 and IR8: from TCTVB to TCTVA and gap from 8.3 to 30 sigma
- TCDQA are two sides in the following simulation
Simulations setup

- Energy: 7TeV, nominal emittance, no dp/p, no beam length
- Nominal optics: beta_star = 55 cm
- 6.4M particles tracked for 200 turns
- Horizontal Halo: 6σ
- Impact parameter: 1µm; Bin: 10cm
- First collimator beam 1: TCP.C6L7
- MADX repository for nominal LHCb1: V6.503
- Note(Nominal): crossing and separation applied
- The separation is off in Sixtrack simulation
MADX vs. Merlin beta functions

- MADX input V6.503 for nominal case at 7TeV
- Both thick optics: beta_star = 55cm in IR1-5, 10m in IR2-8
- Note: log scale in y and the curves are superimposed
MADX vs. Merlin dispersion functions

- MADX input V6.503 nominal case
- Both thick optics
MERLIN-MADX optics differences

Abs_Error = |value(MADX) - value(MERLIN)|
The SixTrack plots are in the normalized space. CUT in y in SixTrack?
The MERLIN phase space is filtered in x at 6 sigma, i.e. we generate particles only in front of the jaws in order to reduce the computational time.

PLOTS MADE WITH ROOT SCRIPT BY CLAUDIA TAMBASCO
MERLIN-SixTrack initial distribution

X-Y Projections

X'-Y' Projections

# of particles

Note: log scale in MERLIN plot
Particles simulated: 6.4M - Particles absorbed: Merlin 5.55M, SixTrack 6.1M

The different values of the inefficiencies in IR2-8 are due to the different gap setting
Transverse losses in the TCP

SixTrack

MERLIN
Transverse losses in the TCP

**SixTrack**

**MERLIN**
Angles projection in the TCP

Note: Different x range in TCP.D histogram in MERLIN
Transverse losses in Sixtrack

Transverse distribution impacts_real TCP.C L=0.60 cm

Transverse distribution impacts_real TCP.D L=0.60 cm

Transverse distribution impacts_real TCP.B L=0.60 cm

SixTrack
Transverse losses in losses in MERLIN
Merlin and SixTrack longitudinal losses histogram
Improved Single Diffractive Scattering (Preliminary results)

The main idea is to model the single diffraction and elastic scattering with the Regge theory and get the parameters of the model from a fit from all the existing data for p-p and p-pbar scattering.

In the plot is shown the double differential cross section for the exchanged momentum $t = -0.05$. The blue line is the fit of the Regge model (the plot goes up to 0.12) and the red one is the contribution from the resonances at low missing mass $M_X$.

Sixtrack SD function:

$$\frac{d^2\sigma}{dM_X^2 dt} \propto e^{-b(M_X)t} \frac{M_X^2}{M_X^2}$$

$$\xi = \frac{M_X^2}{s}$$
Problem with ATS dispersion calculation

- Optics repository for ATS beam 1: SLHCV3.1b
- The interesting case is with crossing on and dispersion corrected: flag on_x and on Disp in job.sample.madx file
Problem with ATS dispersion calculation

- We get a perfect matching of the Twiss parameters and the dispersions for only crossing on or dispersion correction on, but MERLIN fail when both of them are on.

- Some tests to find the problem are in progress.

Red: MADX - Green: MERLIN
Conclusions

MERLIN is ready to produce a quantitative comparison with SixTrack (few things to check and fix):
- Change the optics to crossing on and separation off
- Move and change the collimator in IR2-8
- TCDQA one side (easy just forgot to do in the last simulations)
- Check the aperture along the ring in Sixtrack and MERLIN
- Check the scattering routines
- Define some standard values to calculate like percentage of the cold losses and warm losses, protons lost in the dispersion suppressor etc.

The new Single Diffractive and Elastic scattering routines are almost ready, at the moment the routines are in a testing status: Montecarlo generations and integrated cross sections calculation

THANKS FOR YOUR ATTENTION AND HOSPITALITY!