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 comunity (Haroon PhD)

LHC Collimation Setup

IR1	Nom	IR6	Nom
TCL	8	TCDQA	8
IR2		TCSG	7.5
TCT	8.3		
TCTVB	8.3	IR7	
IR3		TCP	6
TCP	15	TCSG	7
TCSG	18	TCLA	10
TCLA	20	IR8	
IR5		TCT	8.3
TCTH	8.3	TCTVB	8.3
TCL	10		

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
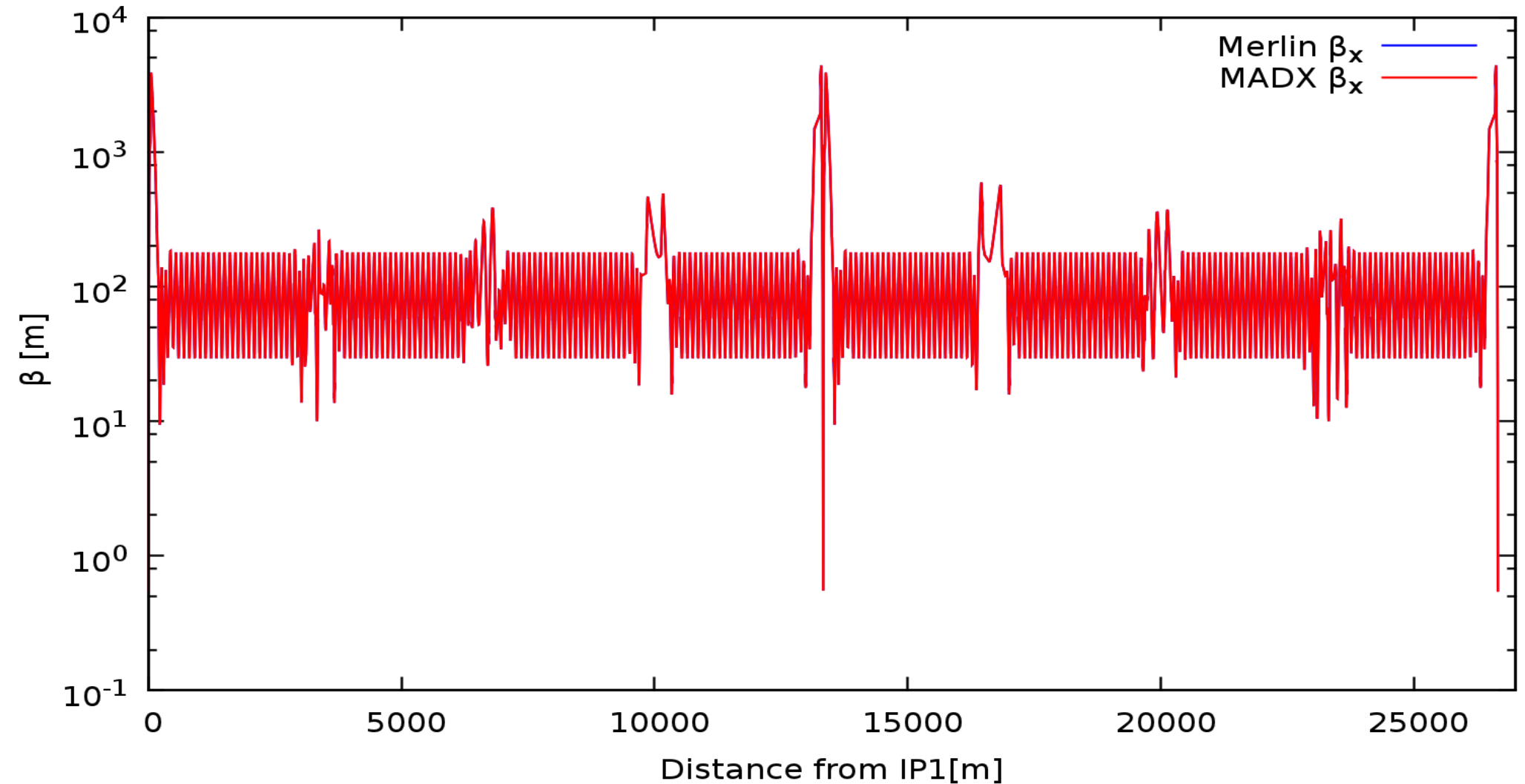
MADX vs. Merlin dispersion functions

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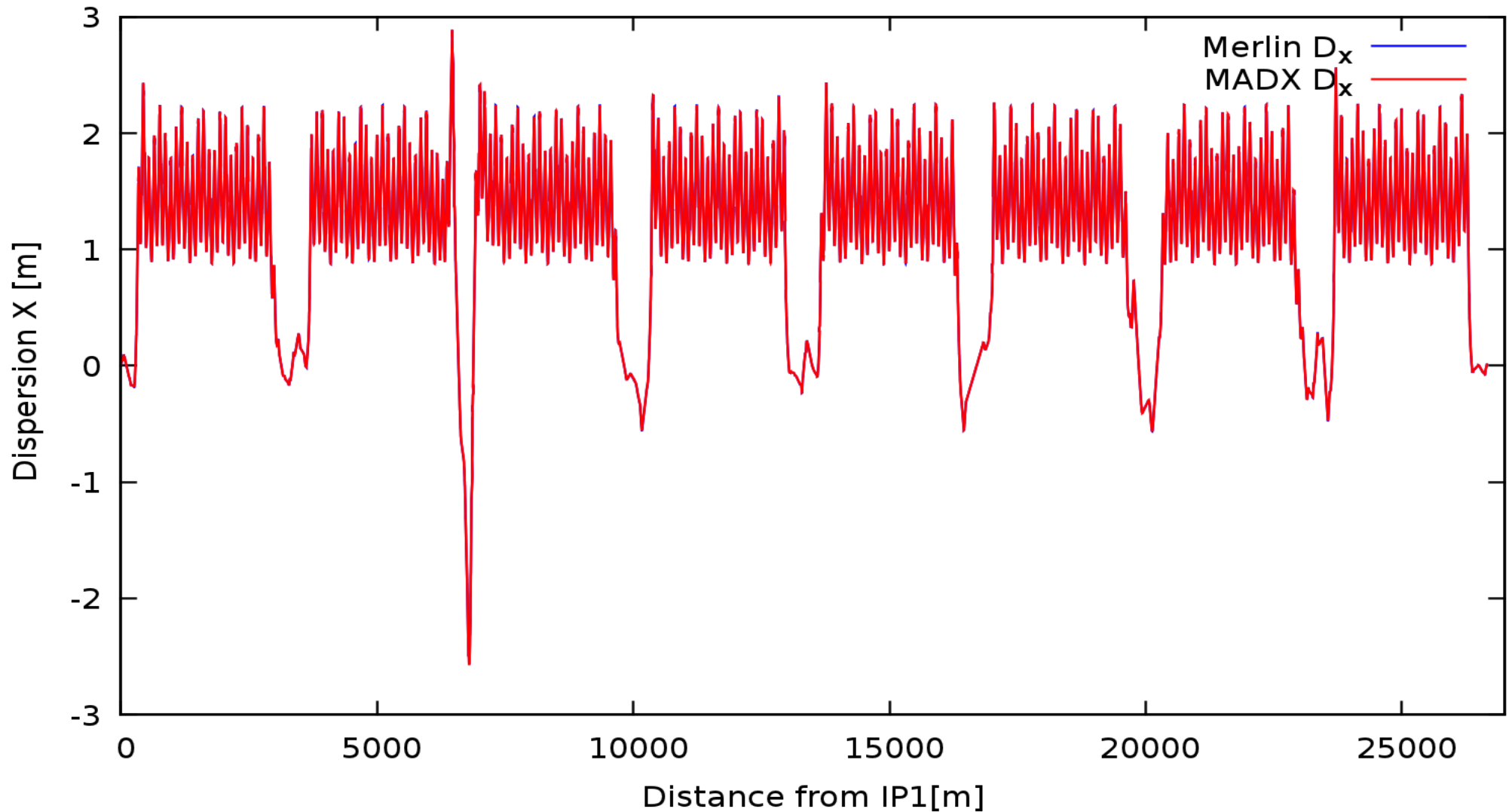
MERLIN-MADX optics differences

MAD-X – Merlin Optics abs differences (nominal)
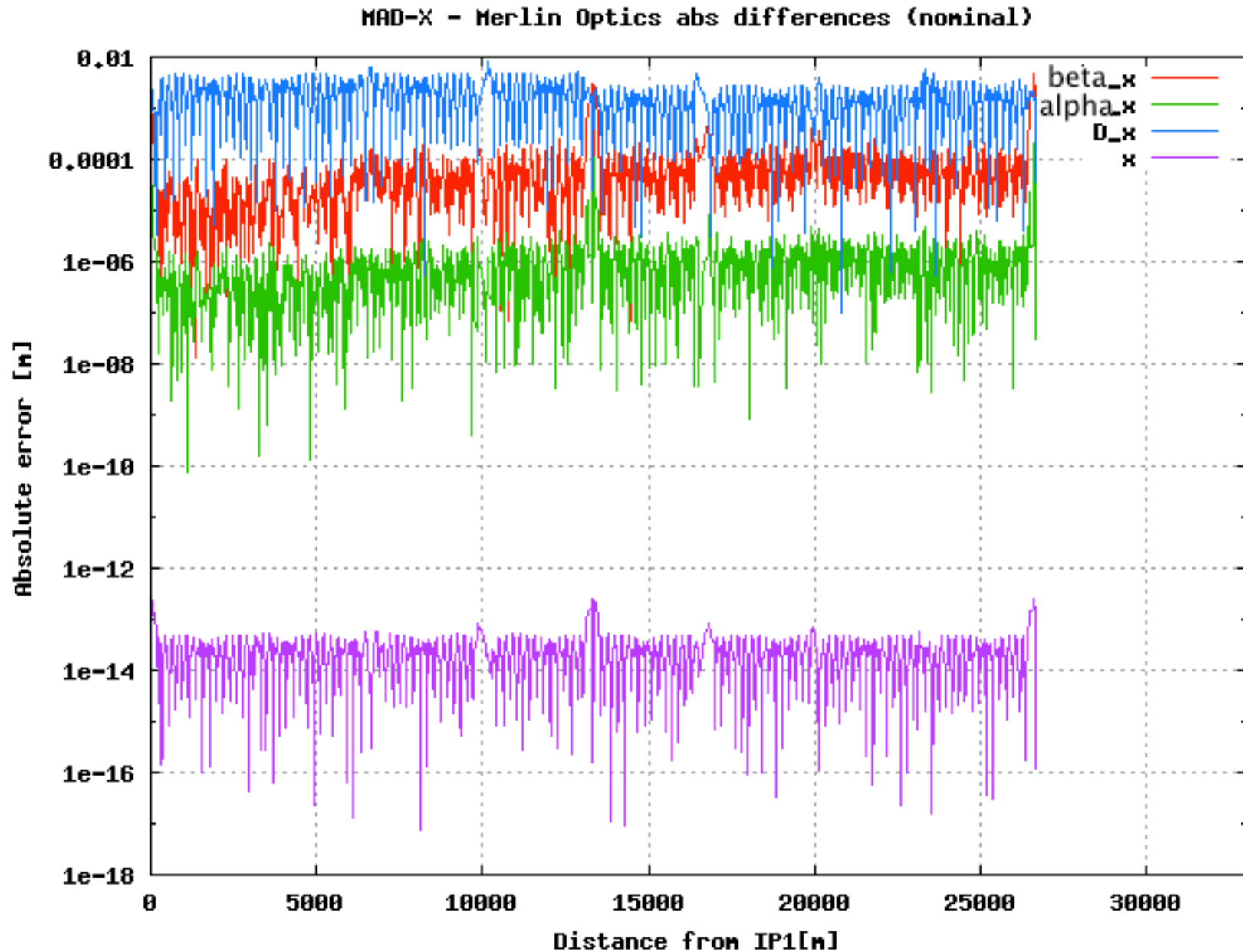
$Abs\_Error = |value(MADX) - value(MERLIN)|$

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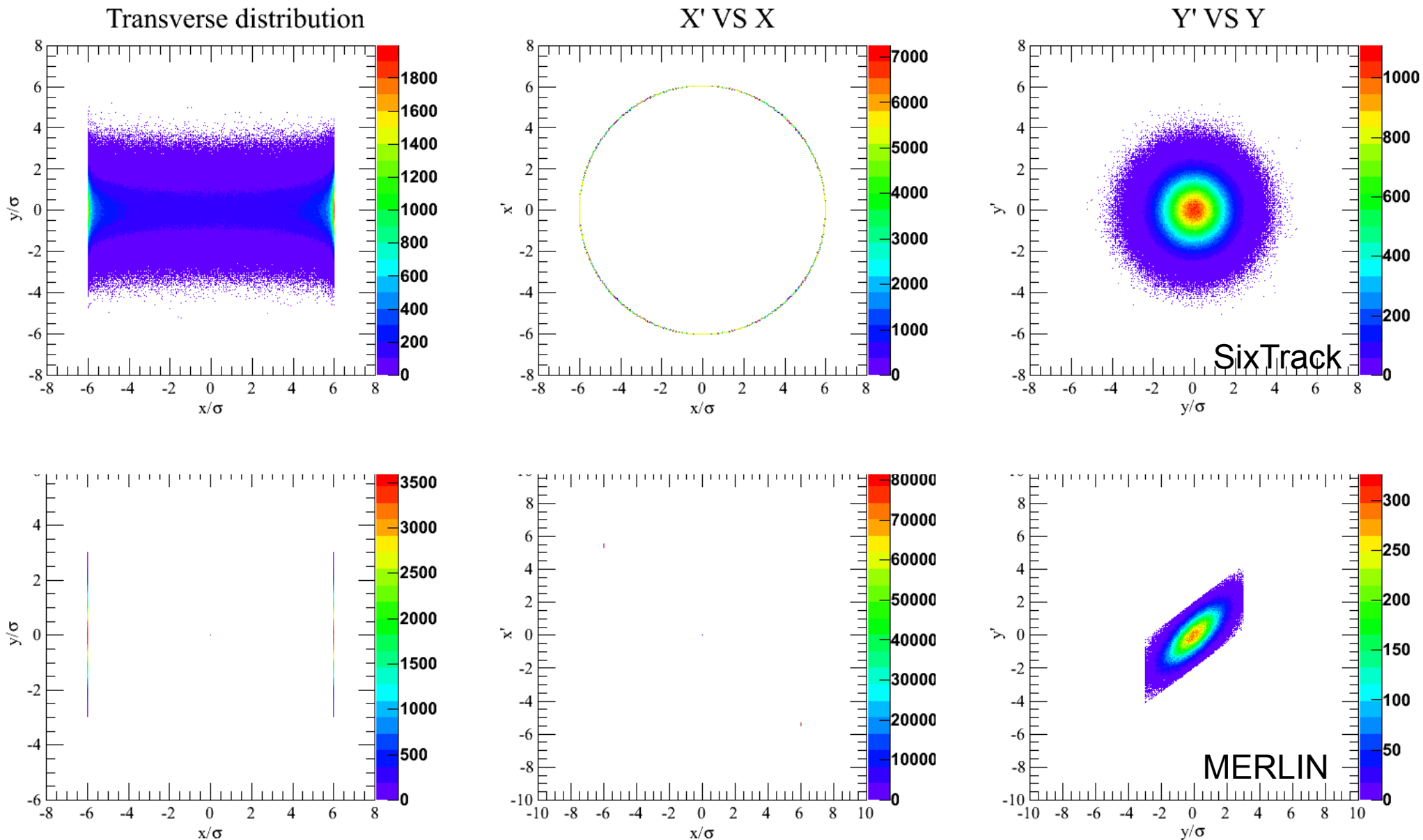
The SixTrack plots are in the normalized space. CUT in y in SixTrack ?
The MERLIN phase space is filtered in x at 6 sigma, i.e. we generate particles only in front of the jaws in order to reduce the computational time.

PLOTS MADE WITH ROOT SCRIPT BY CLAUDIA TAMBASCO

MERLIN-SixTrack initial distribution
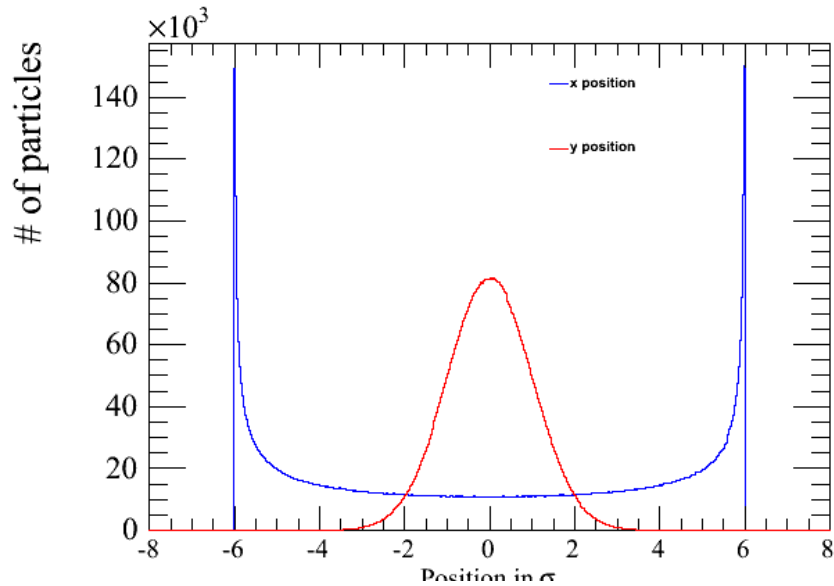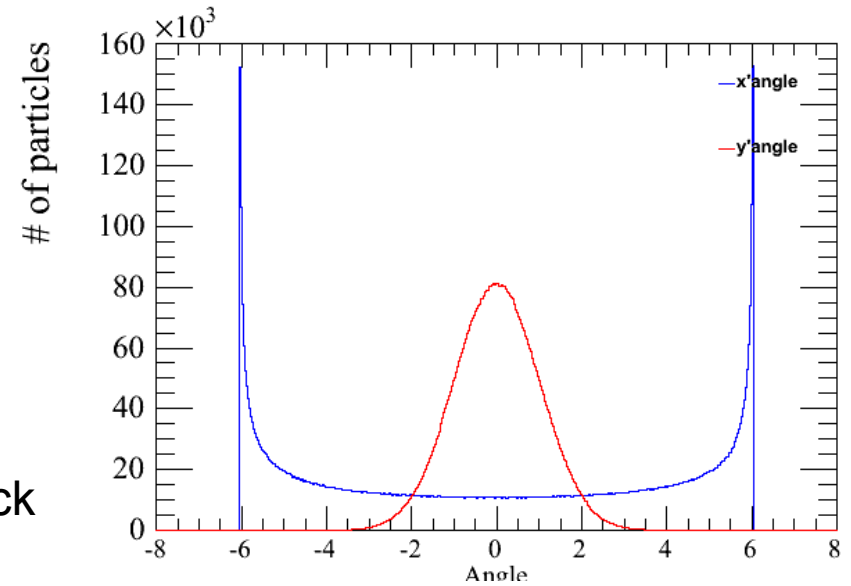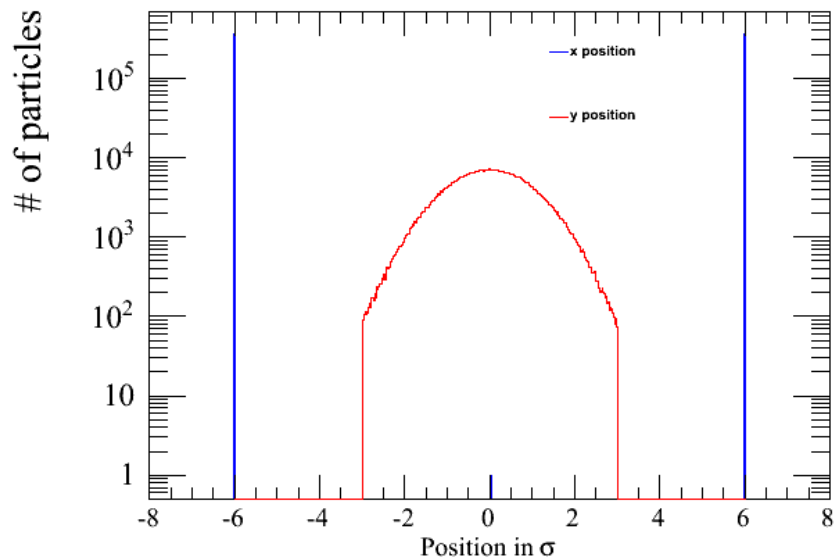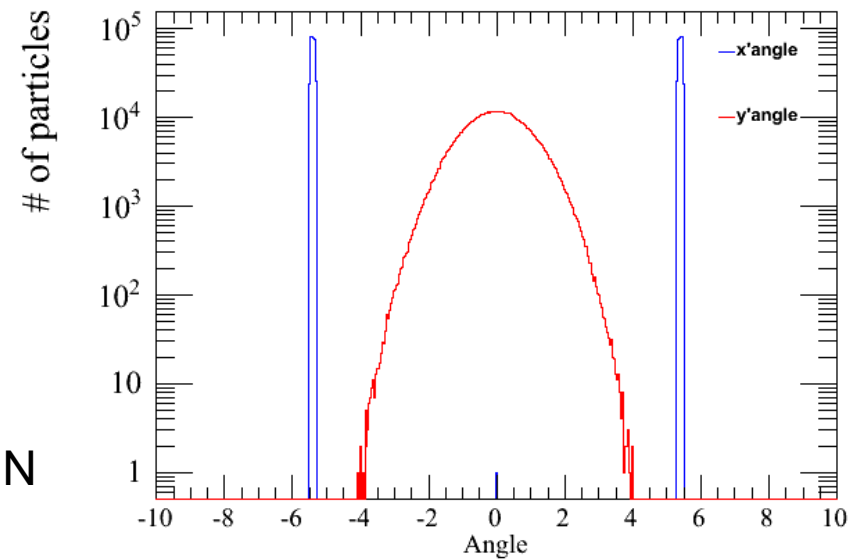
Note: log scale in MERLIN plot

B1 HORIZONTAL
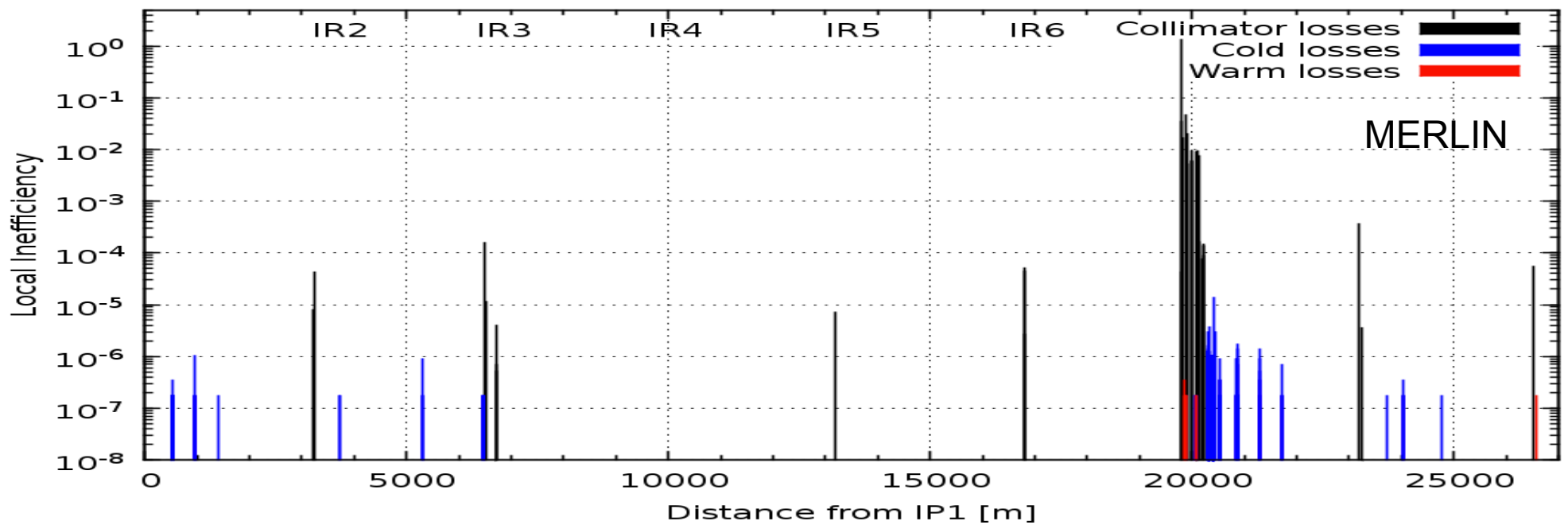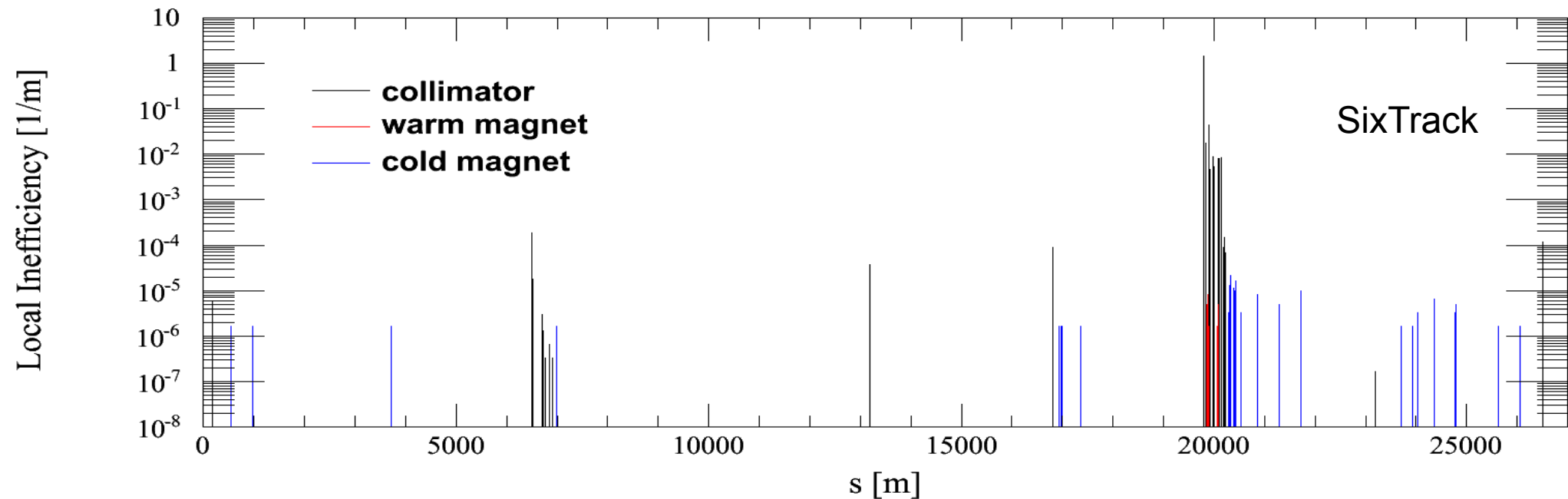
SixTrack

MERLIN

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

B1 HORIZONTAL
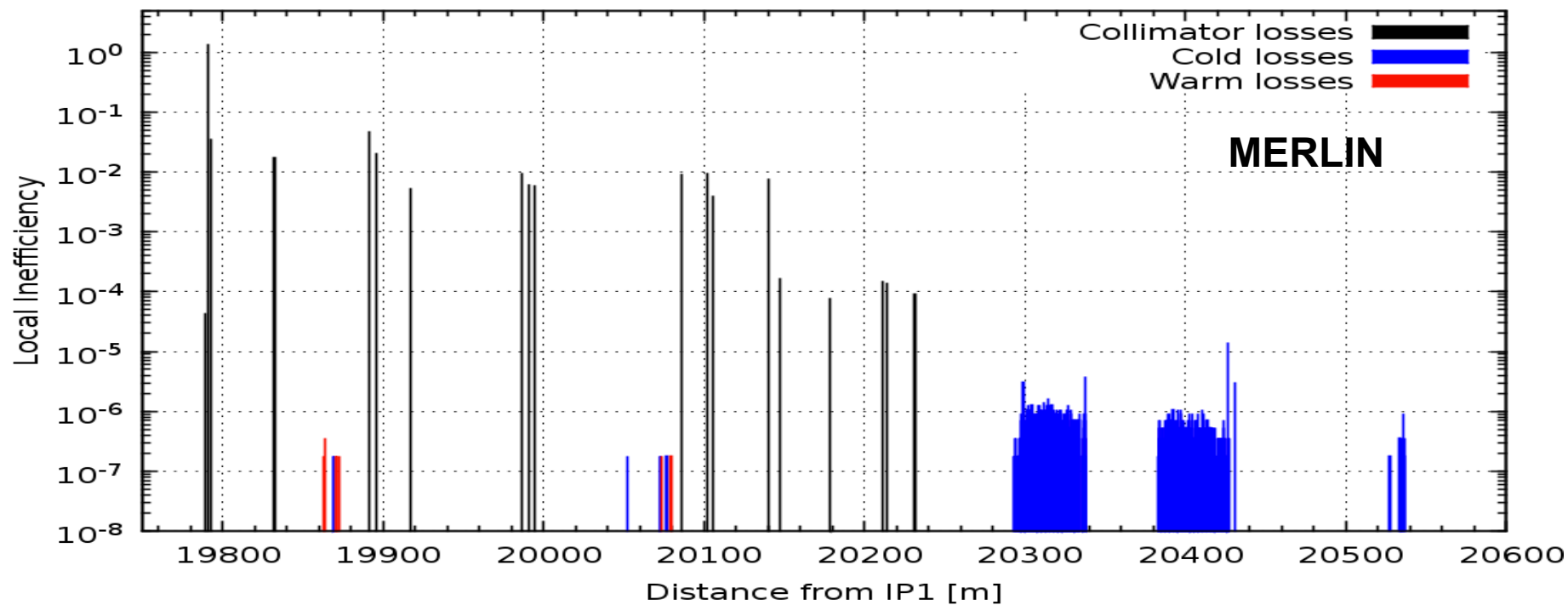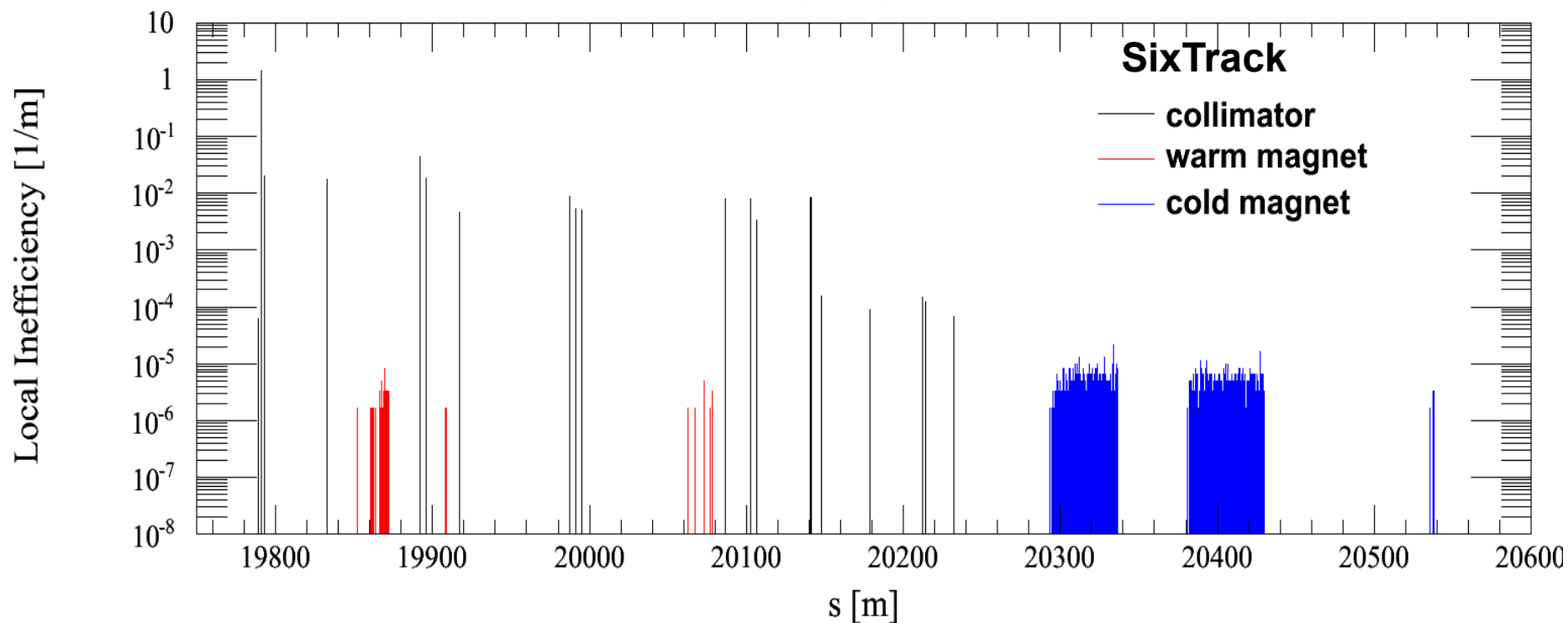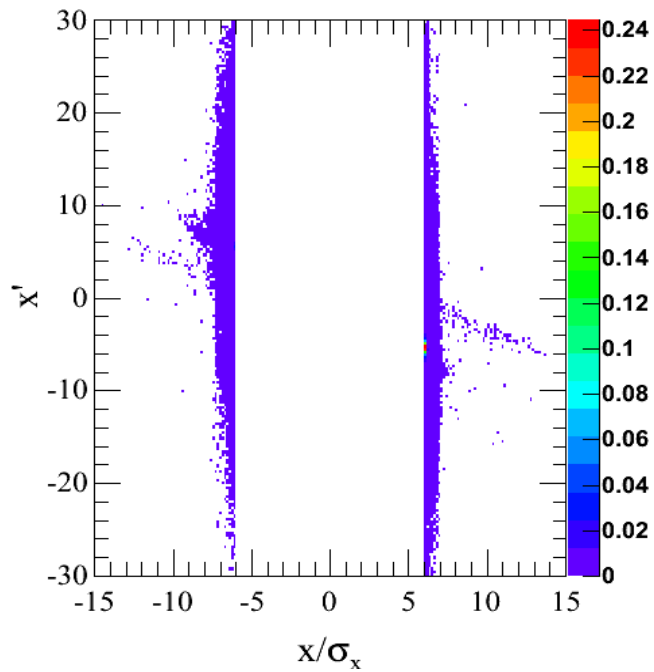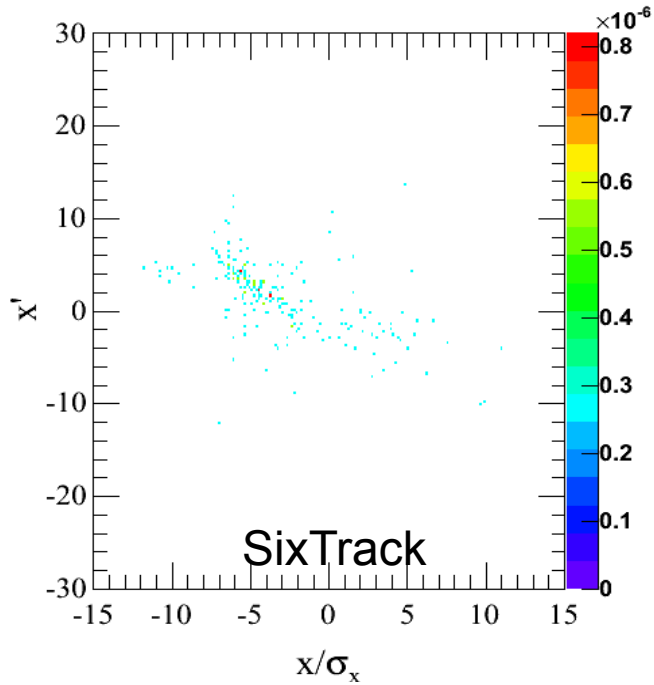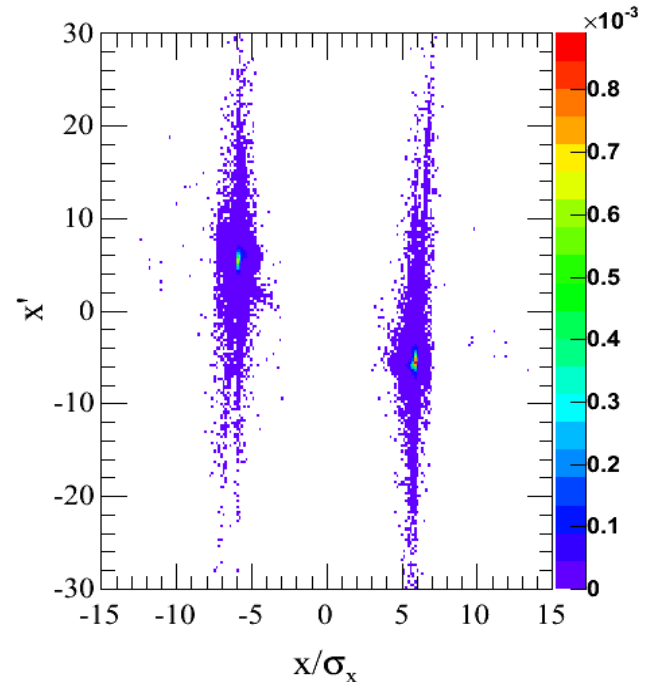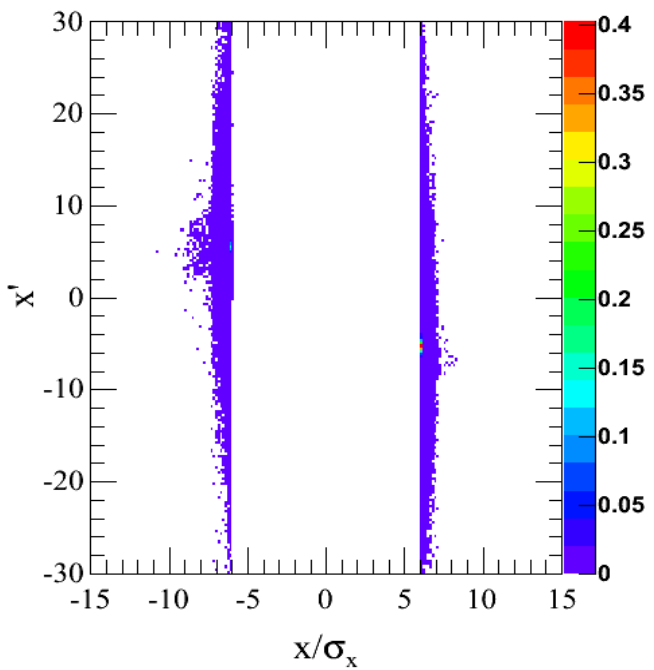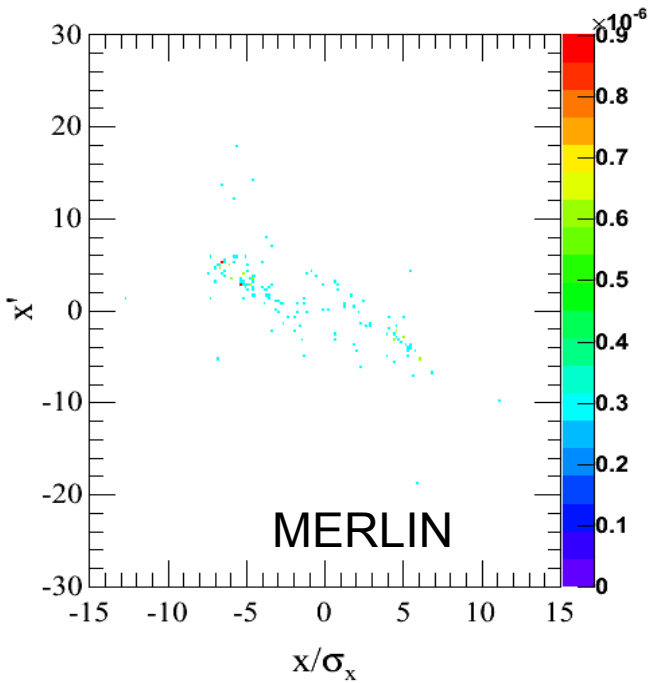
SixTrack
— collimator
— warm magnet
— cold magnet

MERLIN

Collimator losses
Cold losses
Warm losses
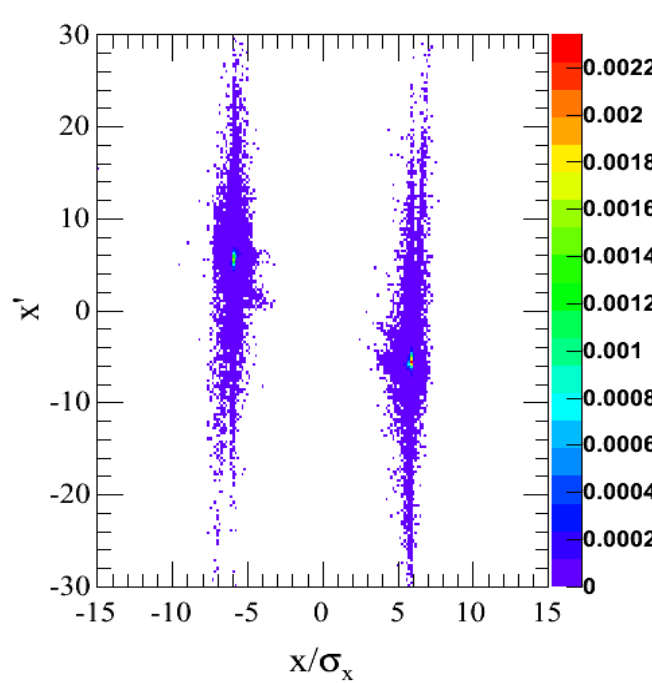
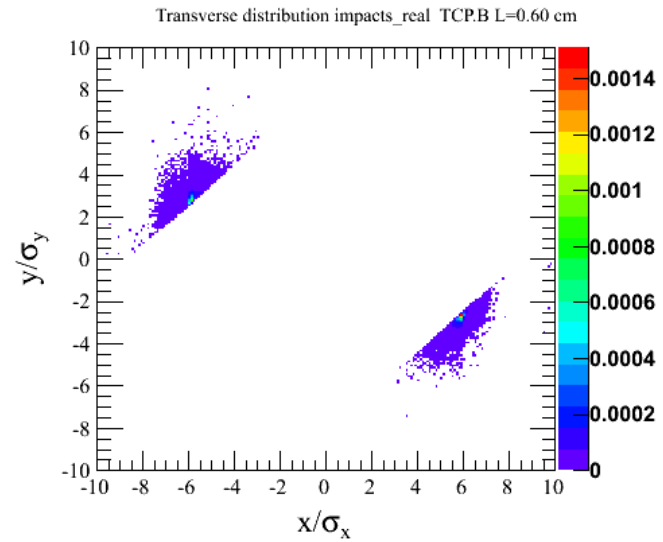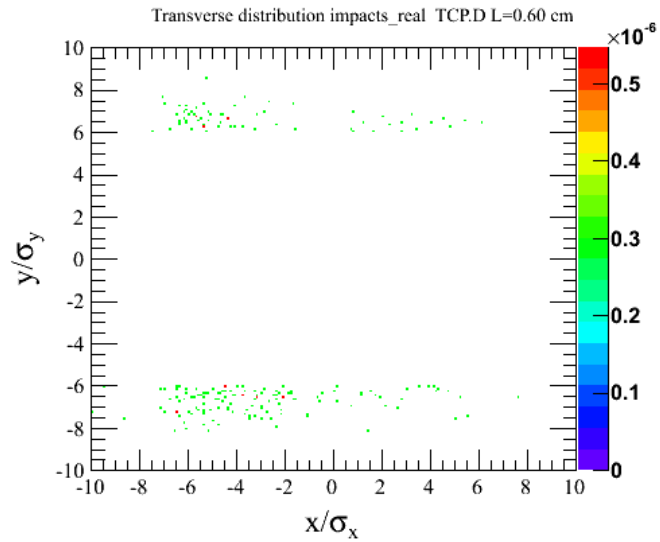# Transverse losses in the TCP

Transverse losses in the TCP
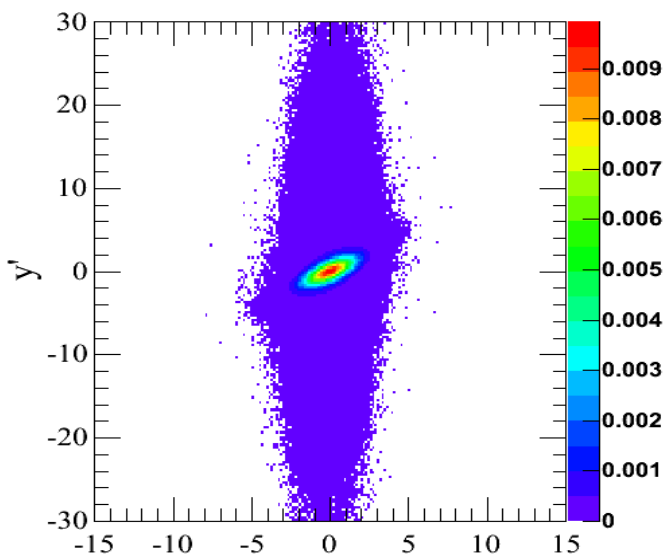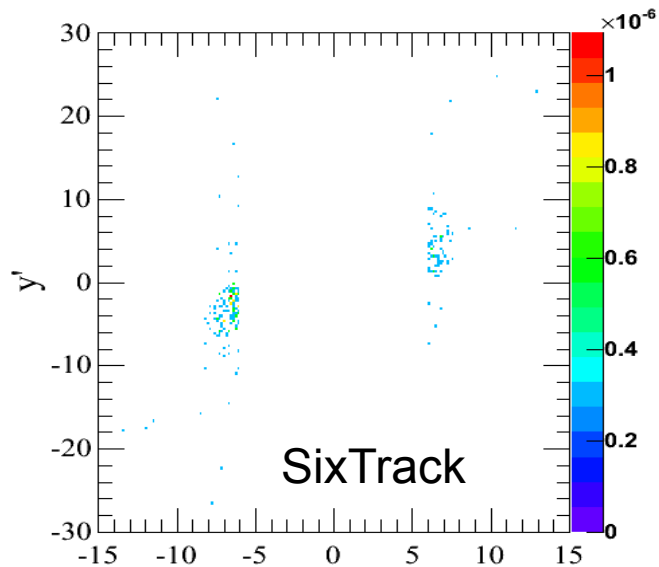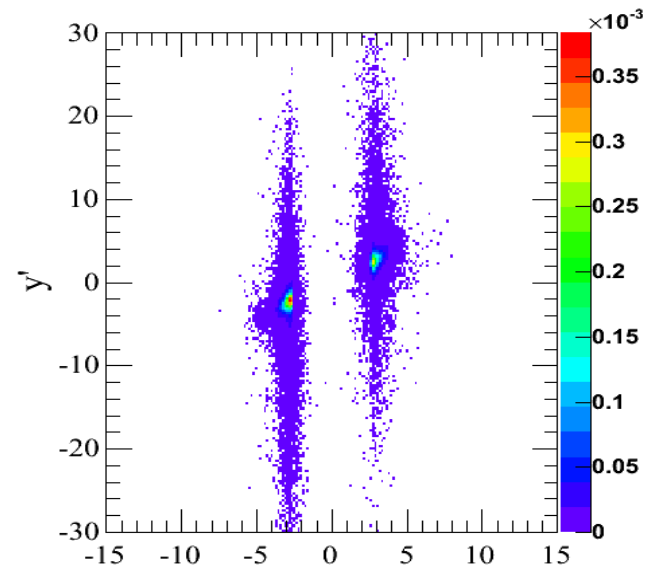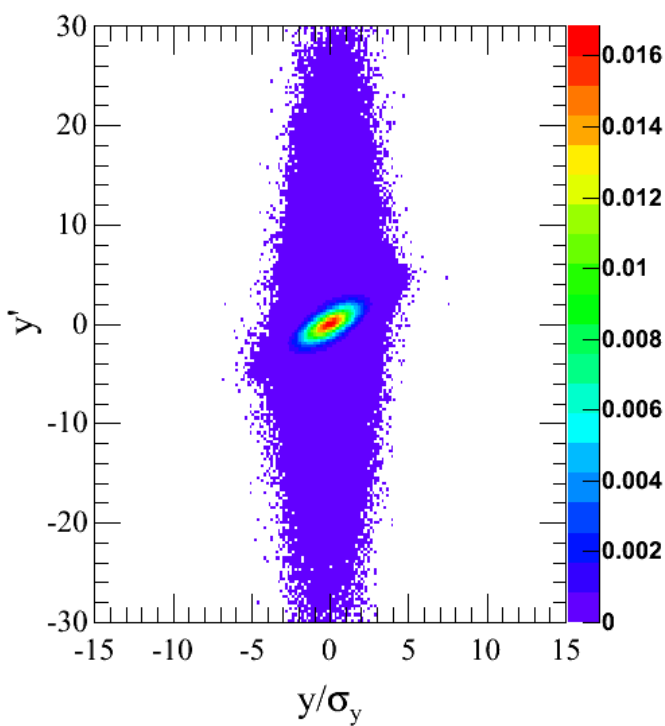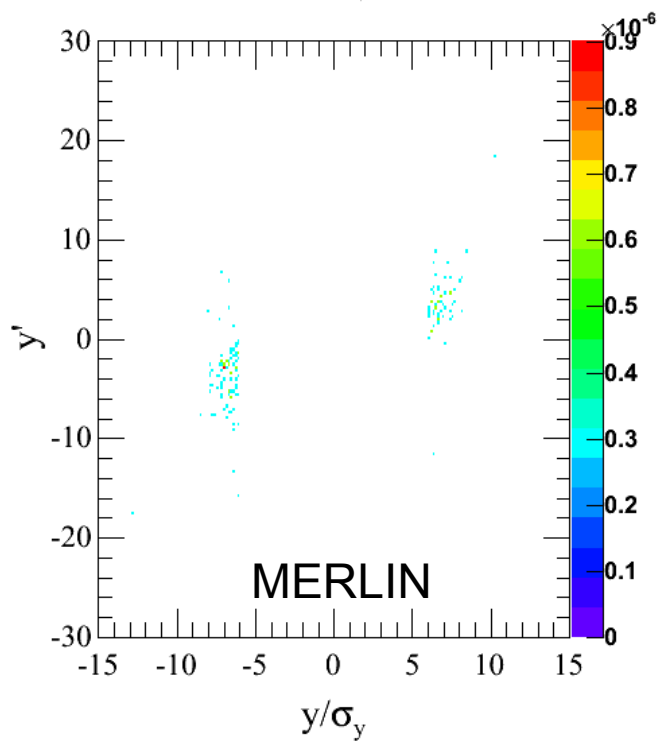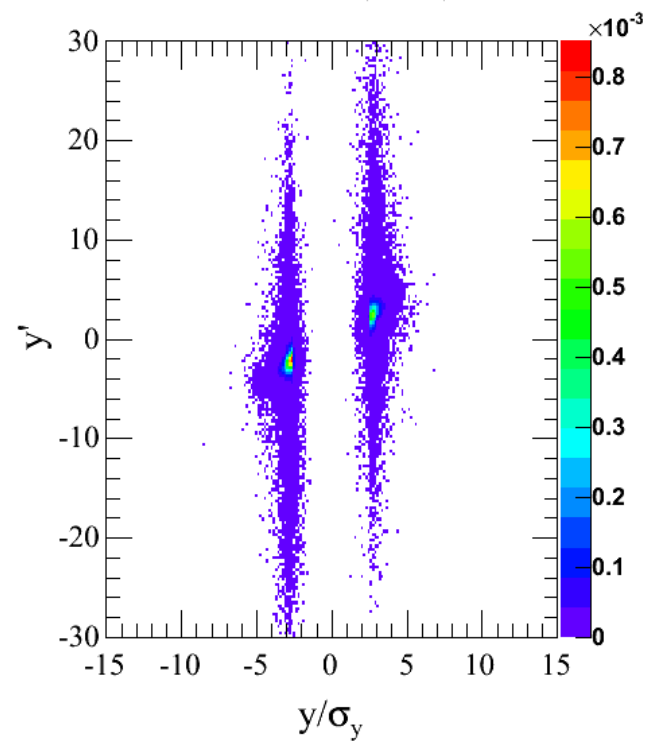
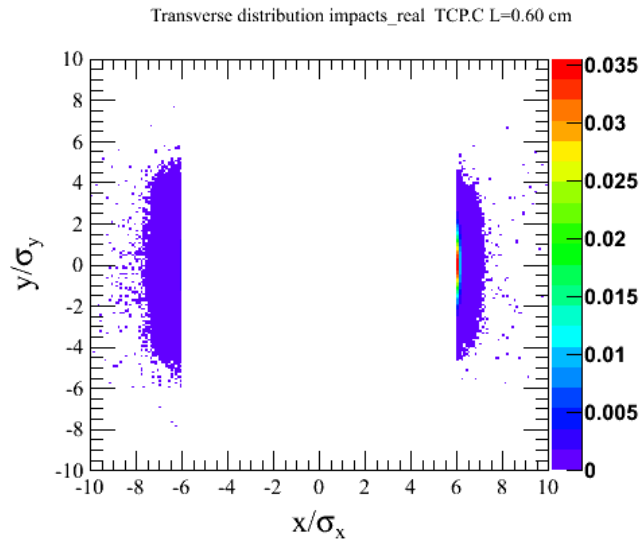# Angles projection in the TCP
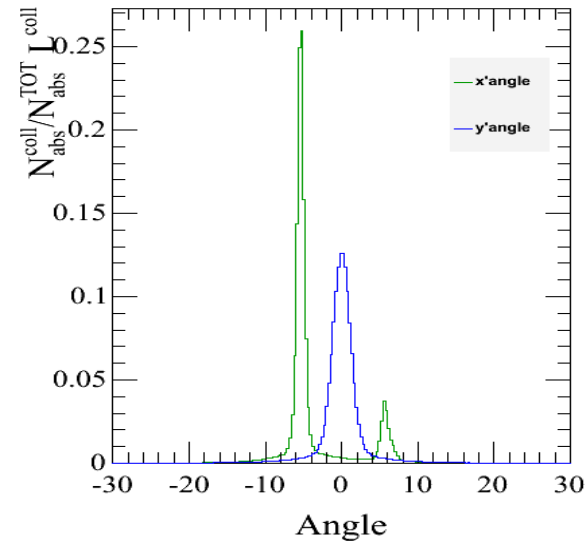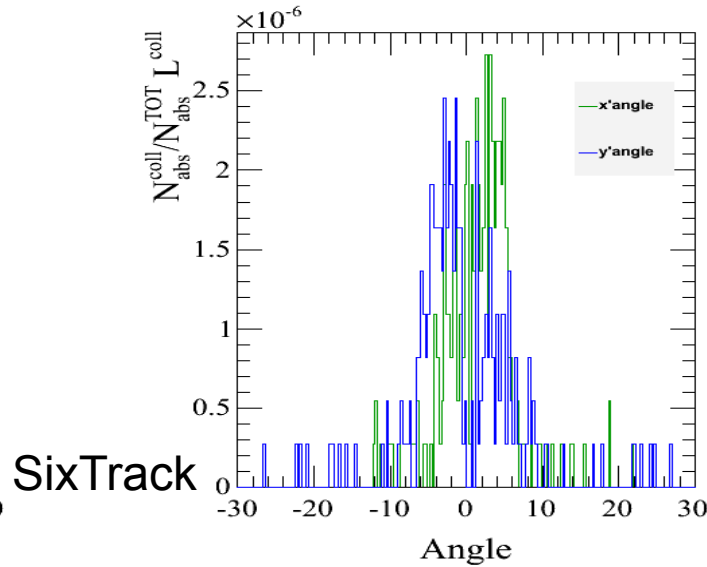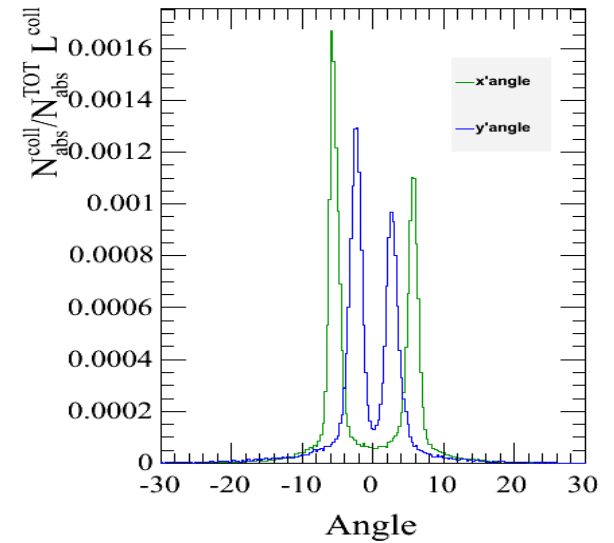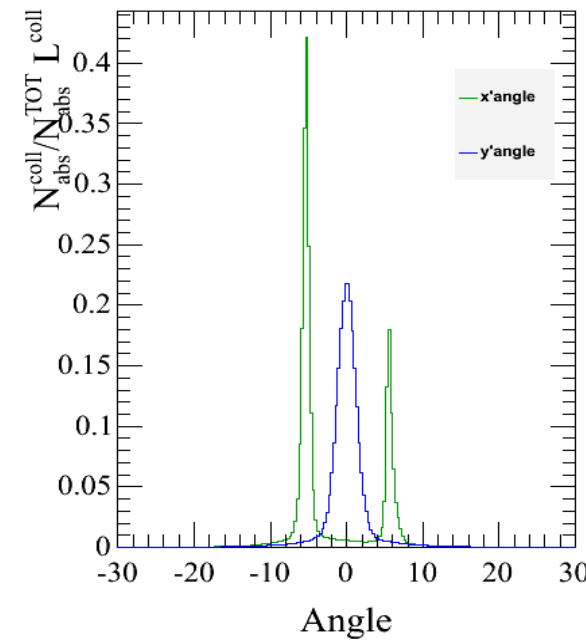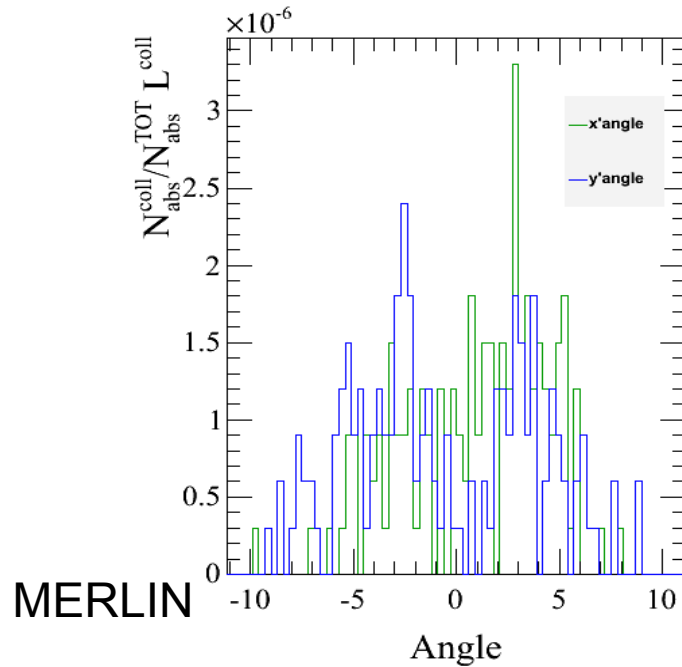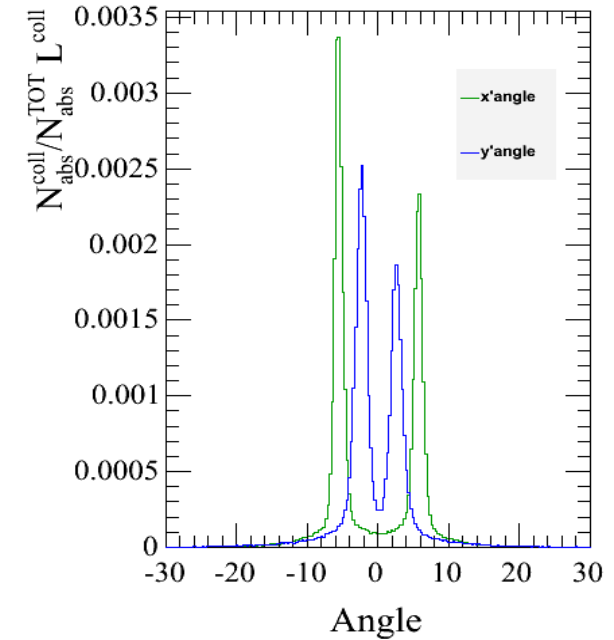
Note: Different x range in TCP.D histogram in MERLIN

Transverse losses in Sixtrack
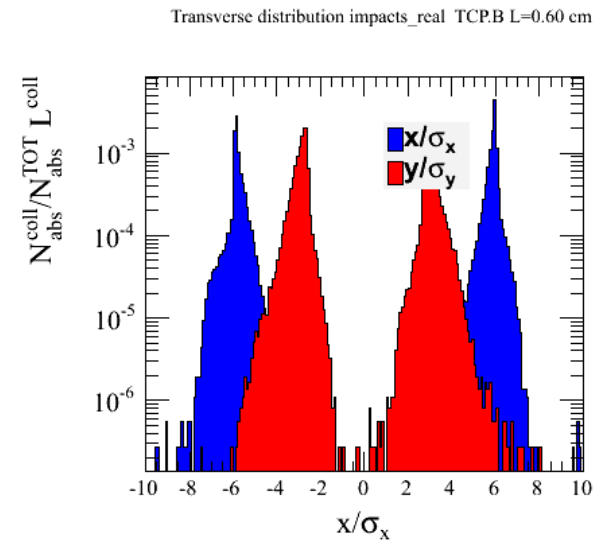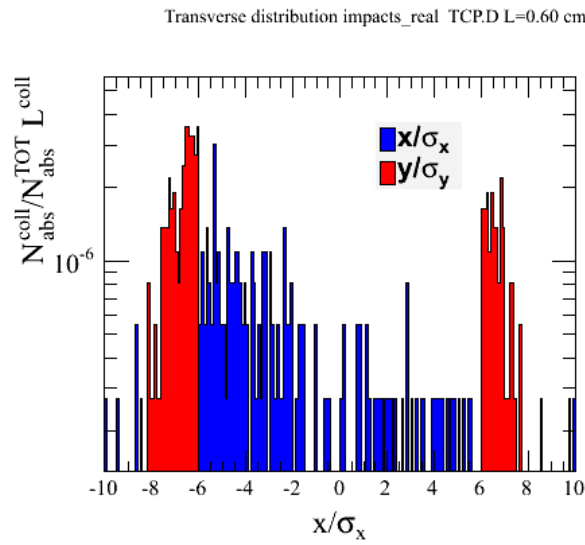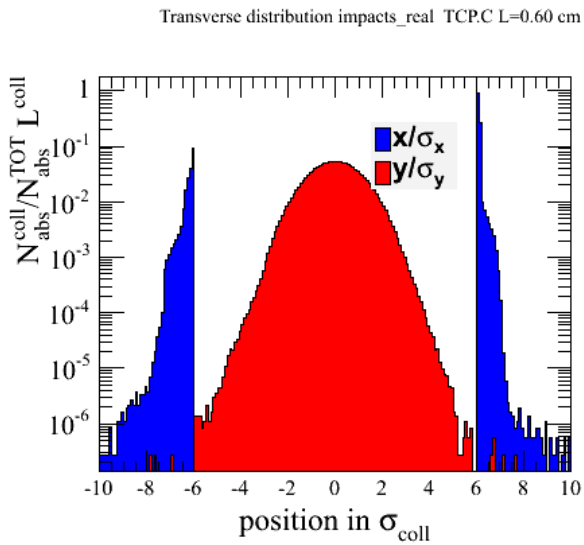
SixTrack

Transverse losses in losses in MERLIN
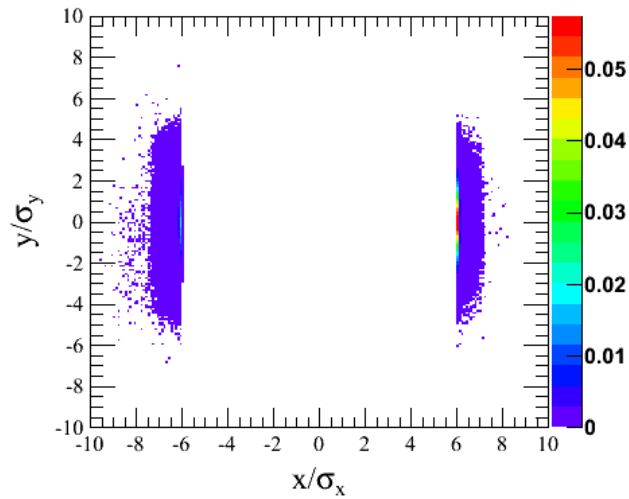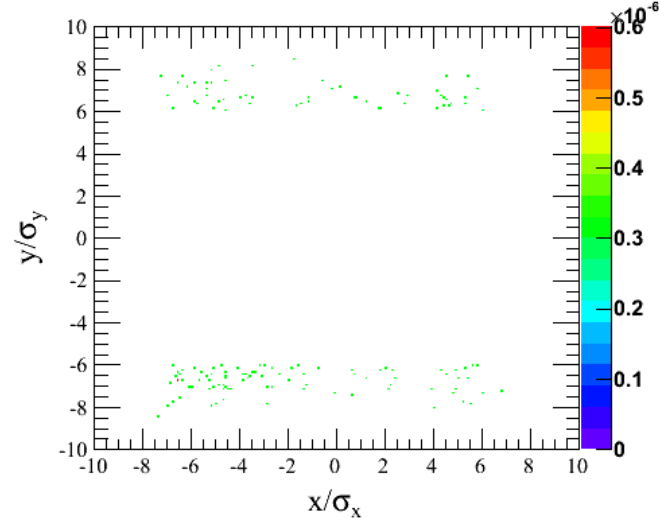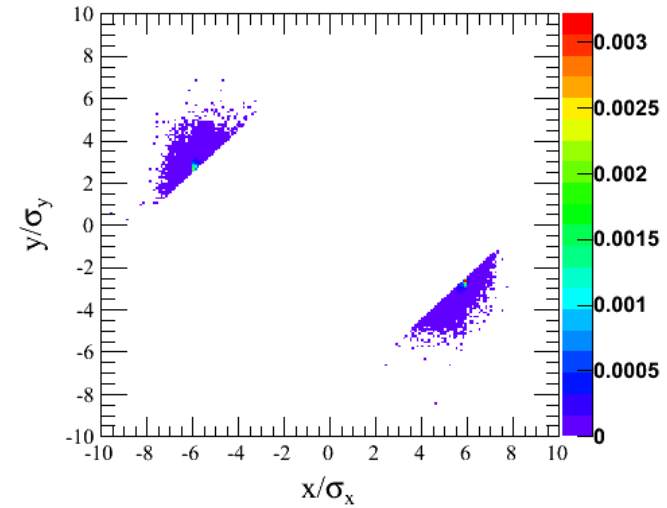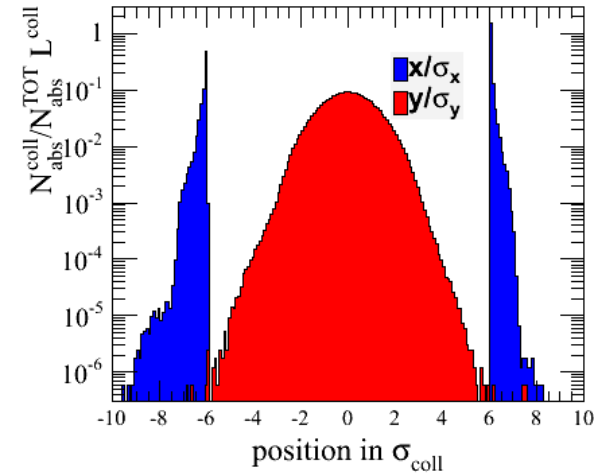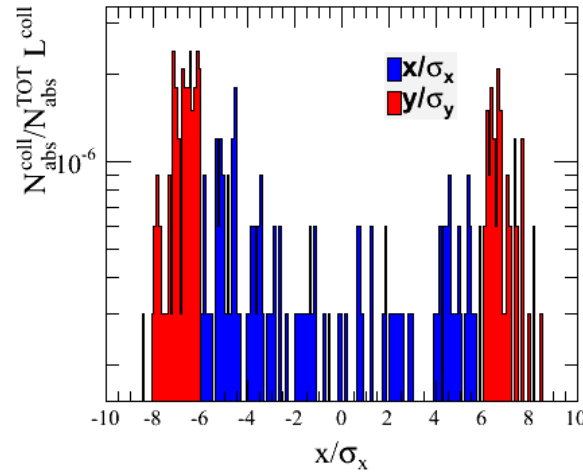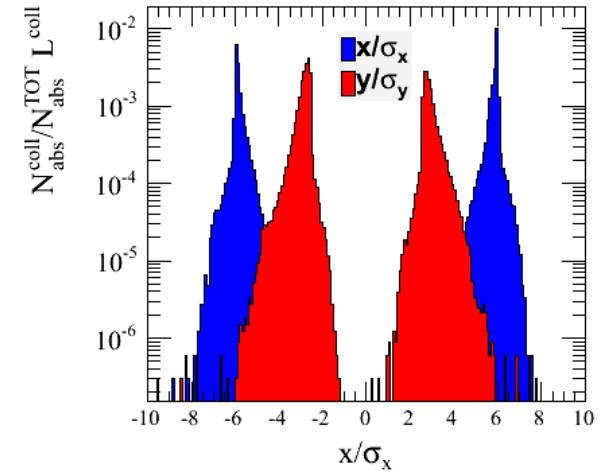

MERLIN

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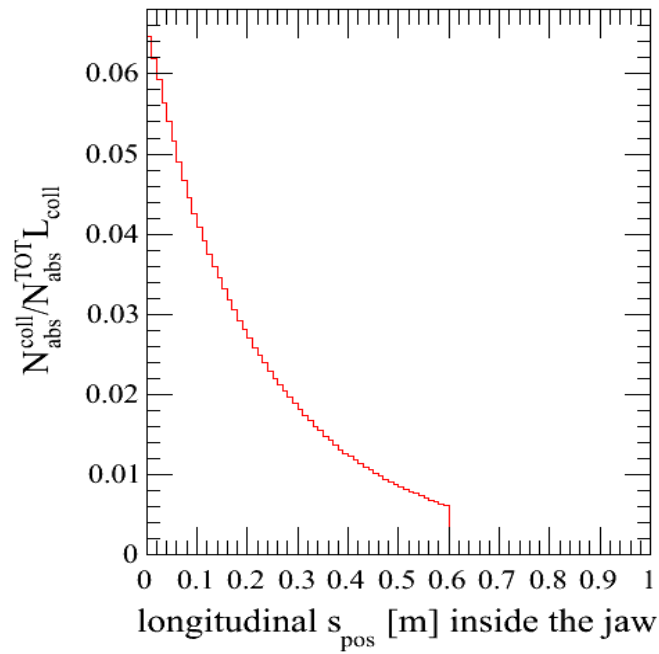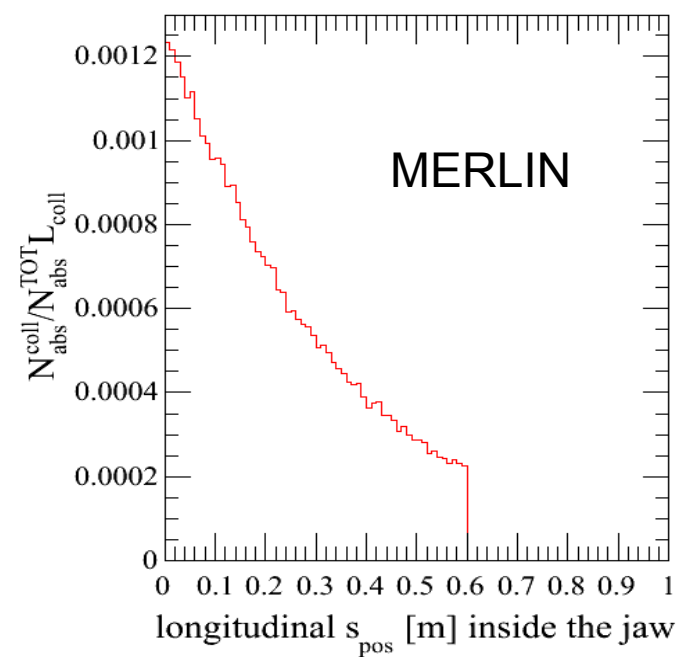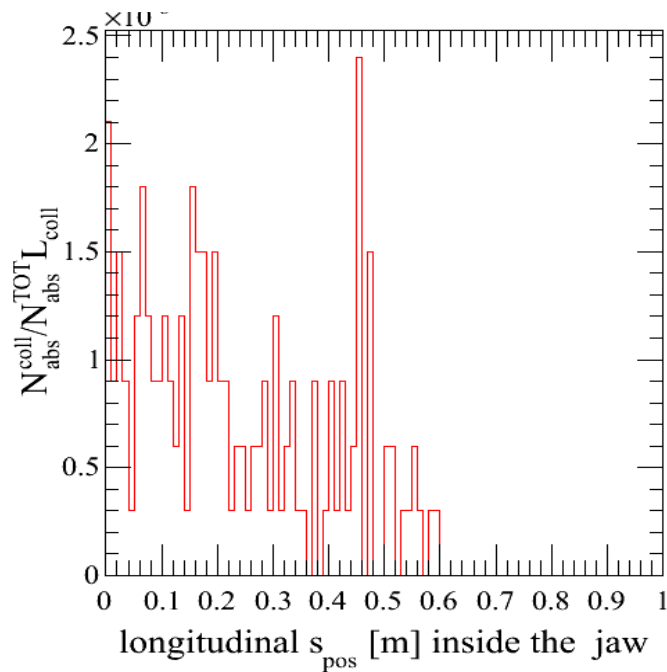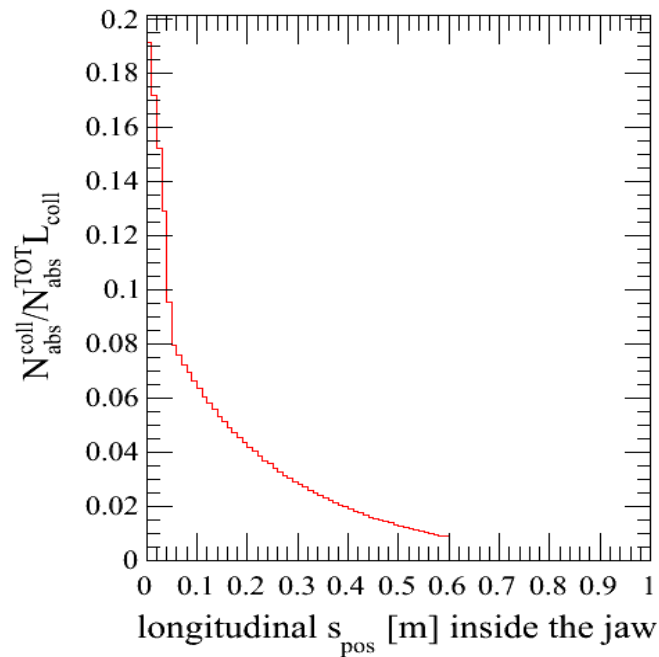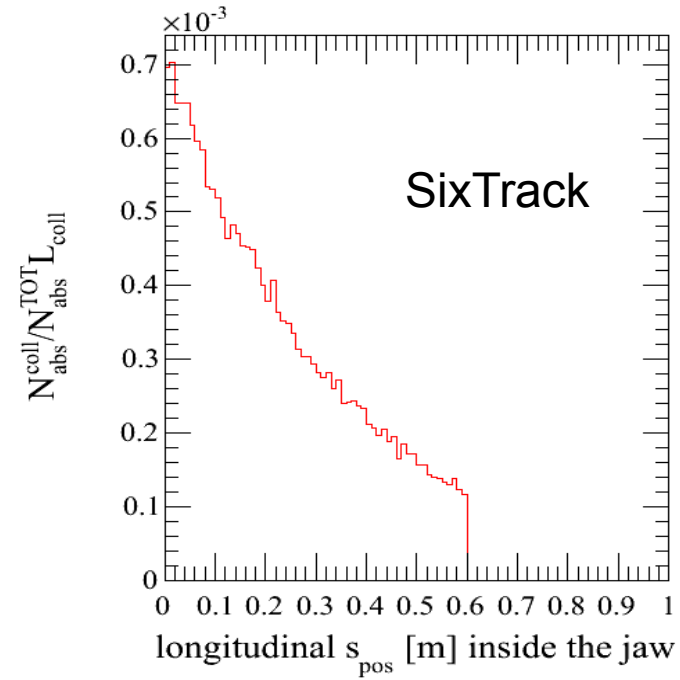
Improved Single Diffractive Scattering (Preliminary results)

p ⟶ p

R_i

● ═══ X

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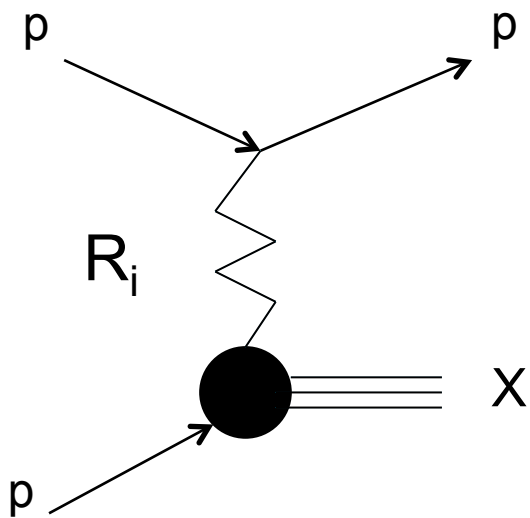
The main idea is to model the single diffraction and elastic scattering with the Regge theory and get the parameters of the model from a fit from all the existing data for p-p and p-pbar scattering.

$$\xi = \frac{M_X^2}{s}$$

Sixtrack SD function:

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

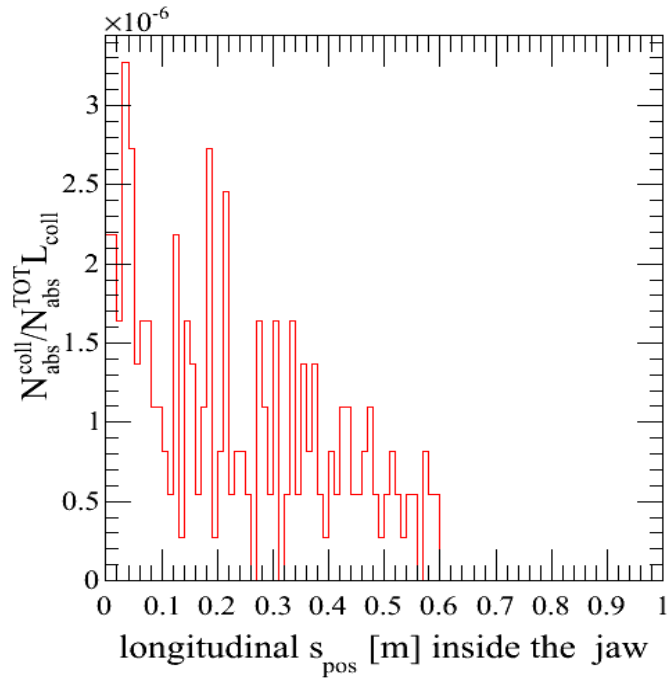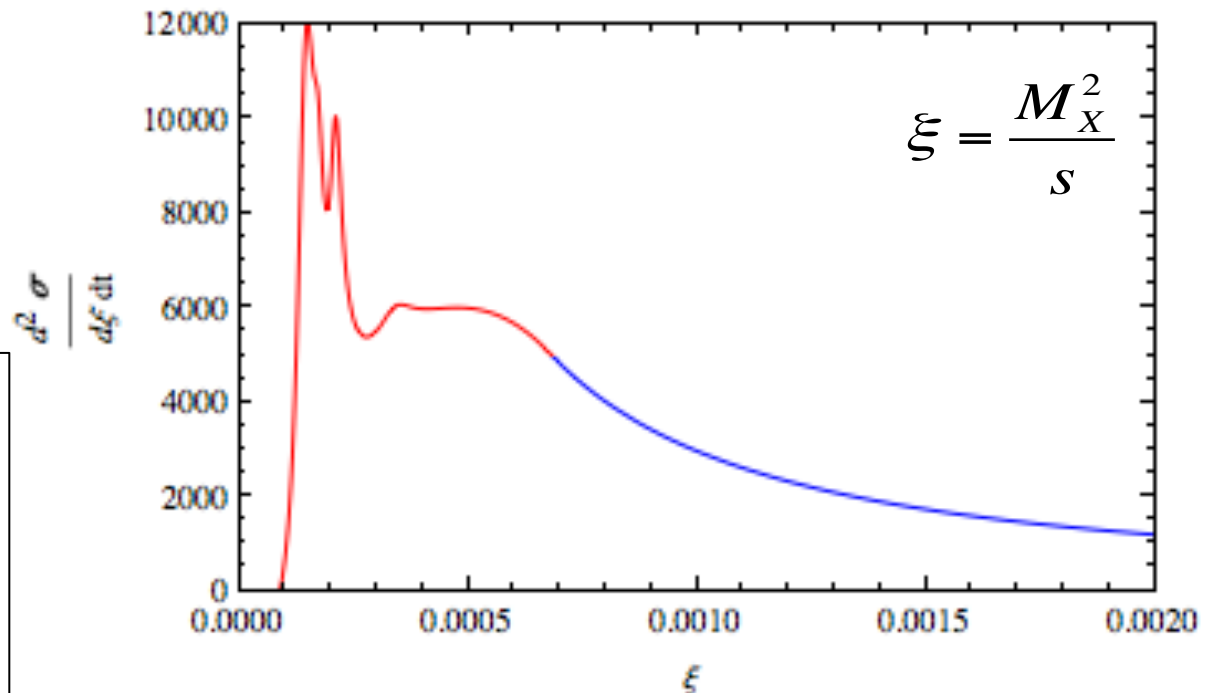In the plot is shown the double differential cross section for the exchanged momentum t = - 0.05. The blue line is the fit of the Regge model (the plot goes up to 0.12) and the red one is the contribution from the resonances at low missing mass Mx.

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
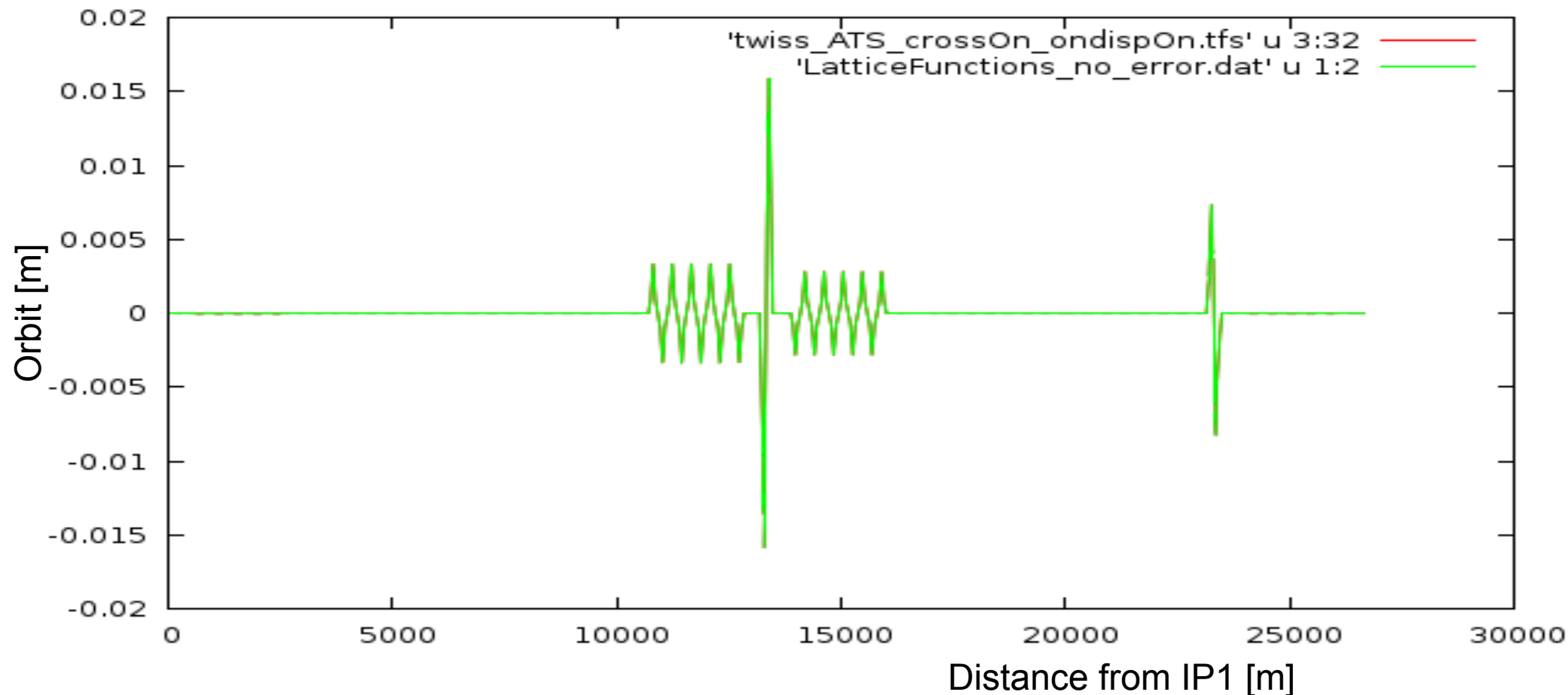
Problem with ATS dispersion calculation

- 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
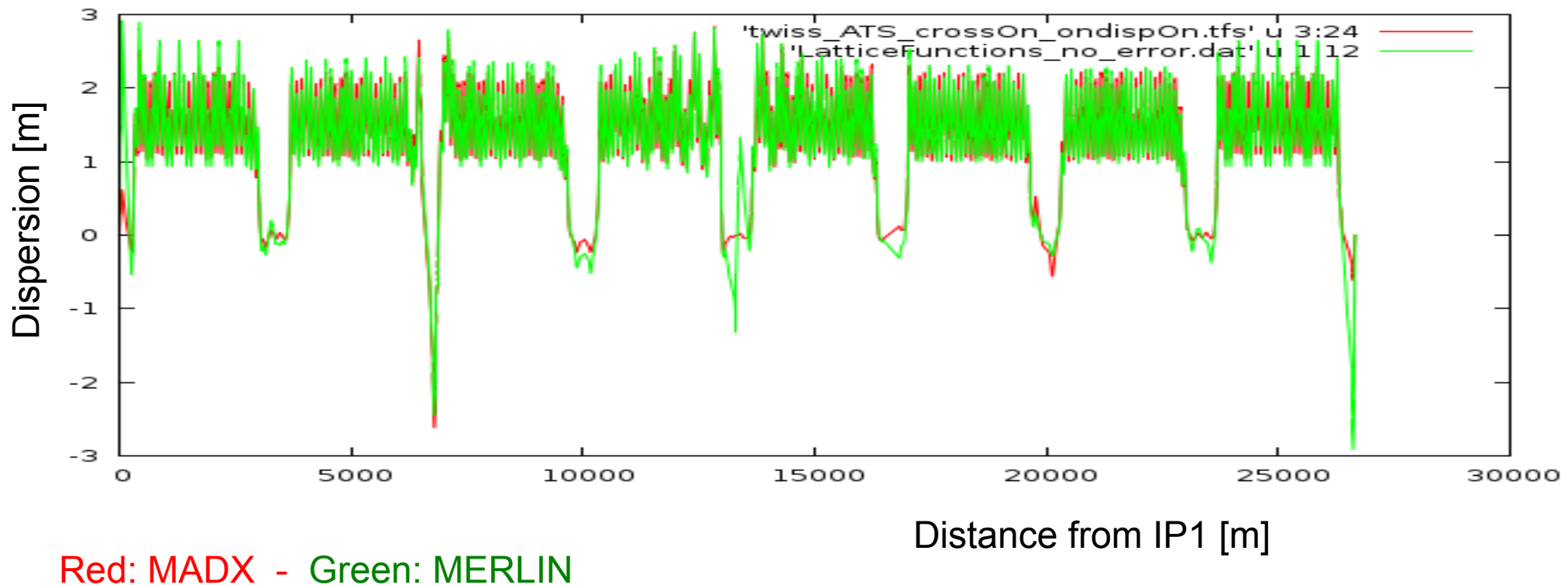
Conclusions

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!