Follow up on post LS1 IR7 optics

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Introduction

Re-cabling of IR7 and possibility to power down an MQW lead to a new proposed LHC optics for the post-LS1 restart of the machine

Studies of the influence of this new possible optics on the LHC Collimation cleaning required to validate the new solution

Conclusions of previous study:

Beam 1:

- ✓ Horizontal plane: similar results with respect to previous optics
- ✓ Vertical plane: Dangerous loss peak (higher than IR7 DS) expected in IR8
  - New optics modified to bring back the IR7 local dispersion to previous value
    - Still present a new peak higher than IR7 DS, but moved on Q19 of IR7

Beam 2:

- ✓ Safe loss maps obtained with the new optics, in both collimation planes

Previous & present study

Main hypothesis on appearance of dangerous loss peak in IR8 based on periodical dispersion:

- Modified momentum cut performed by IR7 collimators

Since that peak is due to protons which experienced single diffractive interaction in vertical IR7-TCP, and lost at the first passage through that s location:

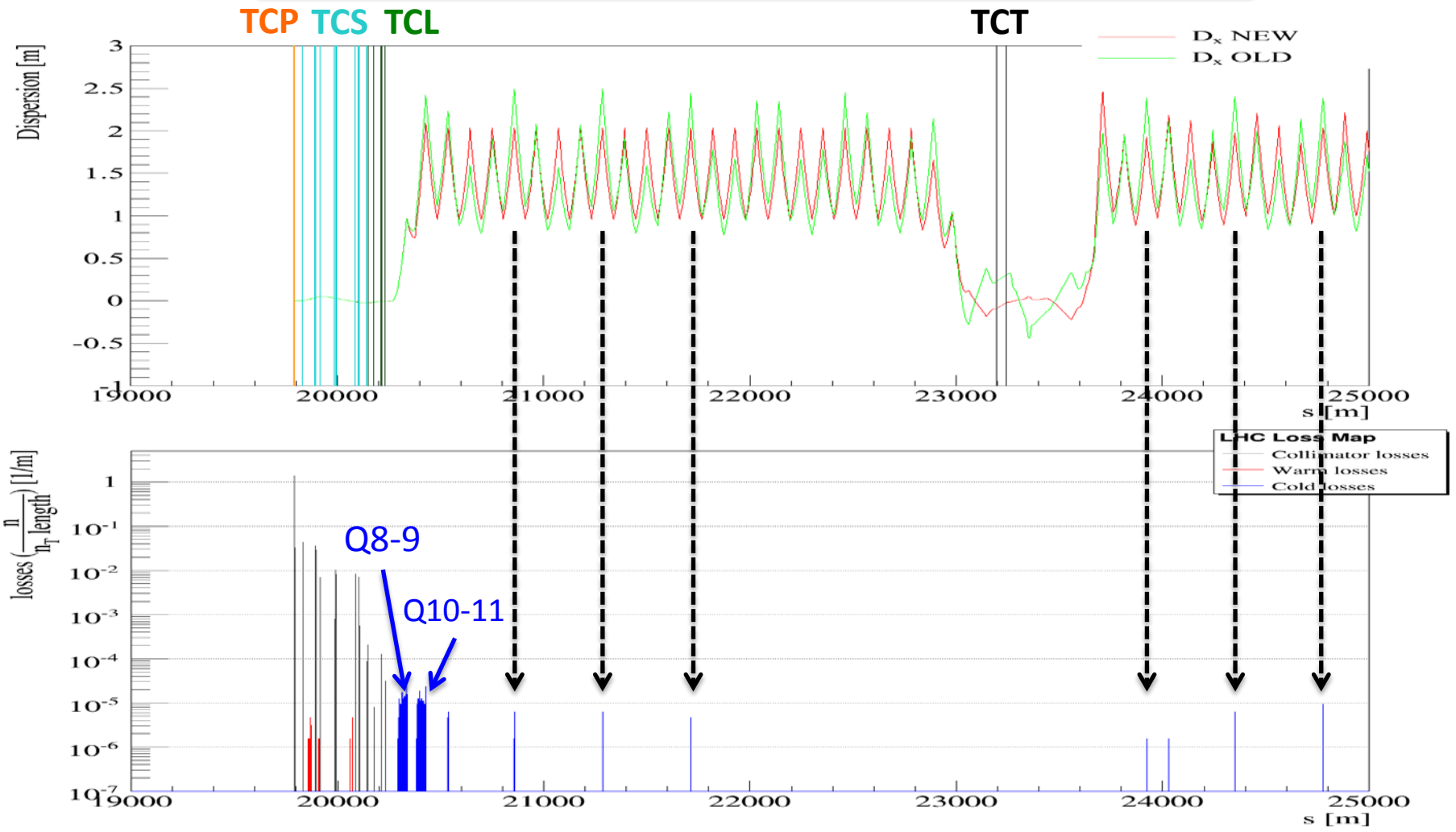
- New study focused on non-periodic dispersion

Starting condition imposed on MADX to start the lattice at the vertical IR7-TCP with $D_x=0$, $D_y=0$

- Not a proper tracking based on MADX
- Key point: to get a feeling of how much the trajectory is shifted, for a particle which acquired a not-negligible $\delta p/p$ interacting with the collimator jaw

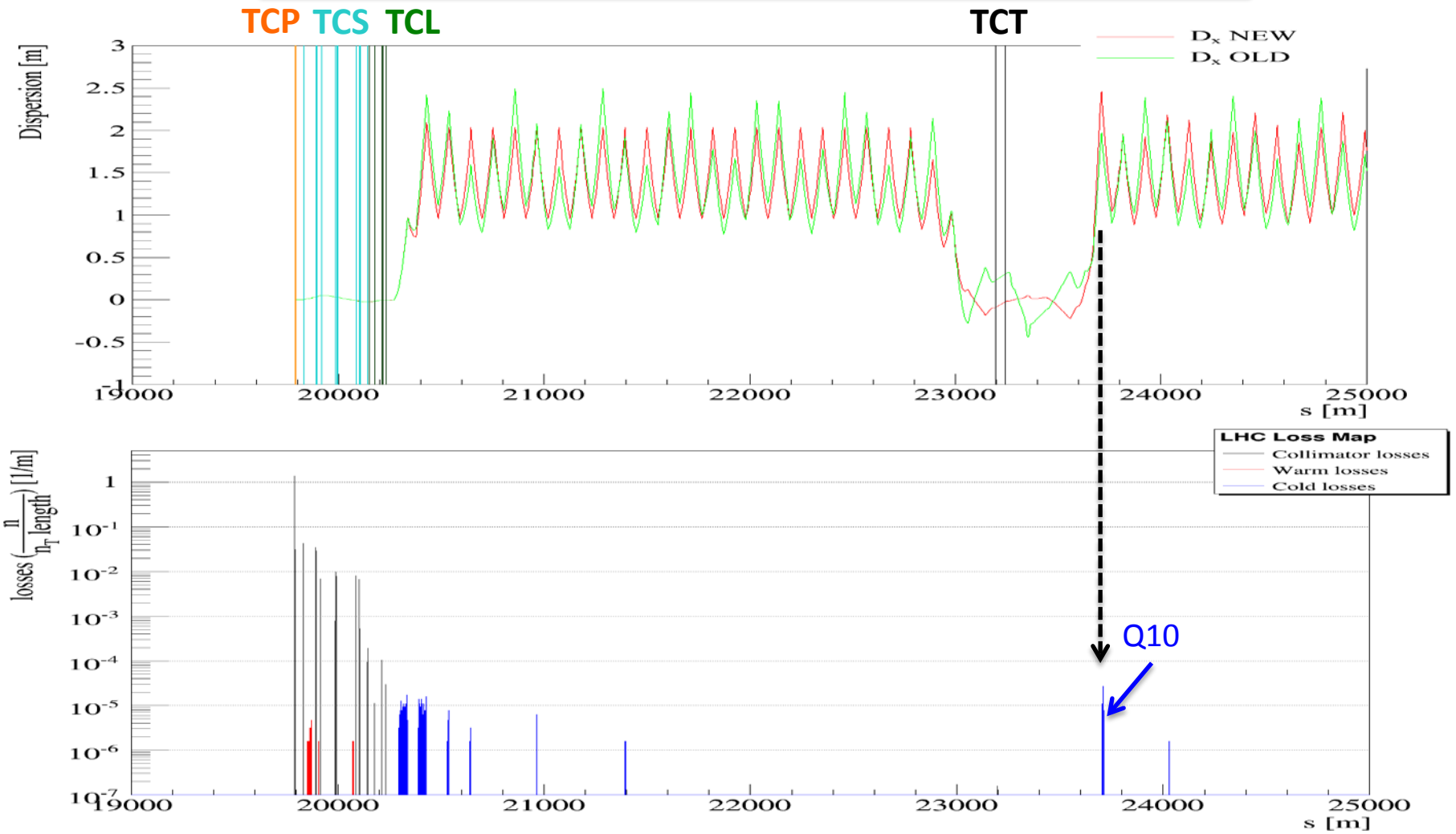
NB: all simulations have been performed with MADX 5.02.00

Influence of **old** dispersion



Most of the off-momentum particles due to diffractive events are scraped in the DS, then:
Strong correlation is seen between peaks in non-periodic dispersion and beam loss

Influence of **new** dispersion

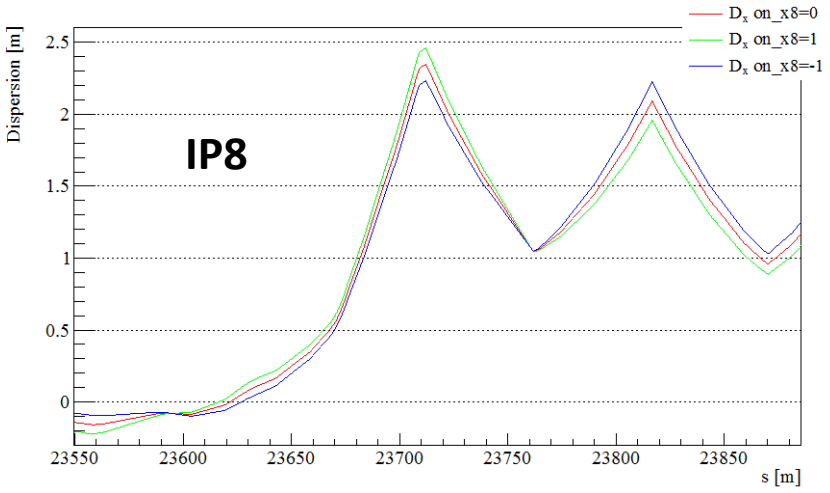


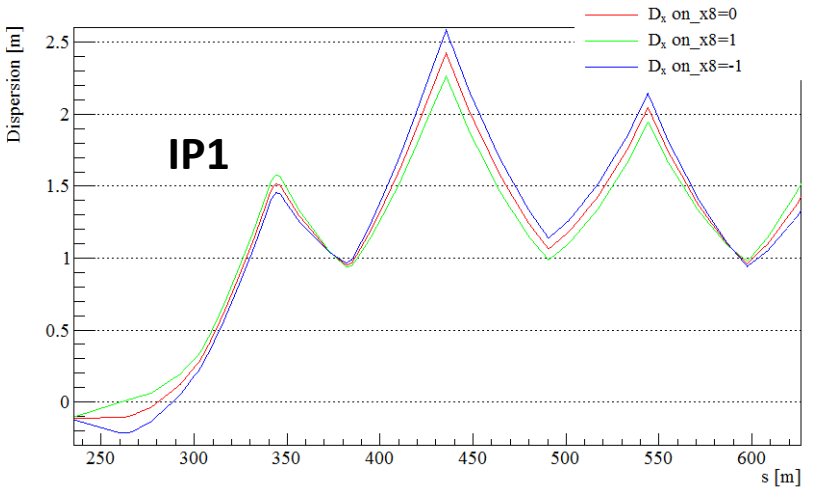
Mismatch due to crossing-scheme induces dispersive peak ~50cm higher than with old optics!

Crossing scheme

Effect on dispersion have been studied:

- ✓ Tested any permutation of crossing, separatrix and compensator (i.e. -1, 0, 1 in MADX)
  - ↳ *Only crossing plays a not-negligible role*





Possible to gain of ~30cm in dispersion at IP8 playing with crossing scheme

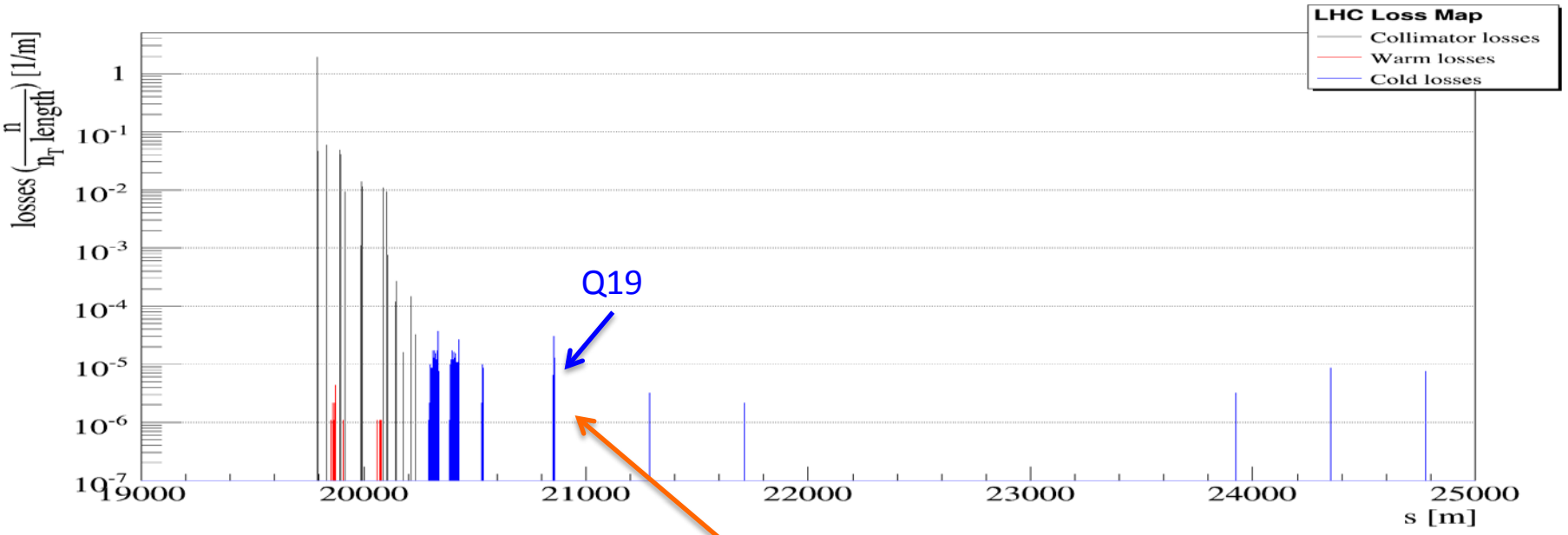
↳ However, what we gain at IP8, we lose at IP1

↳ It would mean just to move the location of the dangerous peak

First optics modification

First step taken to overcome the appearance on the new dangerous peak in IR8:

- Dispersion function brought back to the old values, without changing anything else



Previous dangerous peak in IR8 disappeared but we got a new one!

Found to be correlated with the combination of old dispersion and new phase advance between vertical TCP and s location of this peak (see next slide)

Φ+D_x influence on modified opt.

Looking at the trajectory followed by particles kicked from the vertical TCP:

$$y_{Loss} = \sqrt{\frac{\beta_{Loss}}{\beta_{TCP}}}\cos(\phi)\, y_{TCP} + \Theta\sqrt{\beta_{Loss}\beta_{TCP}}\sin(\phi)$$

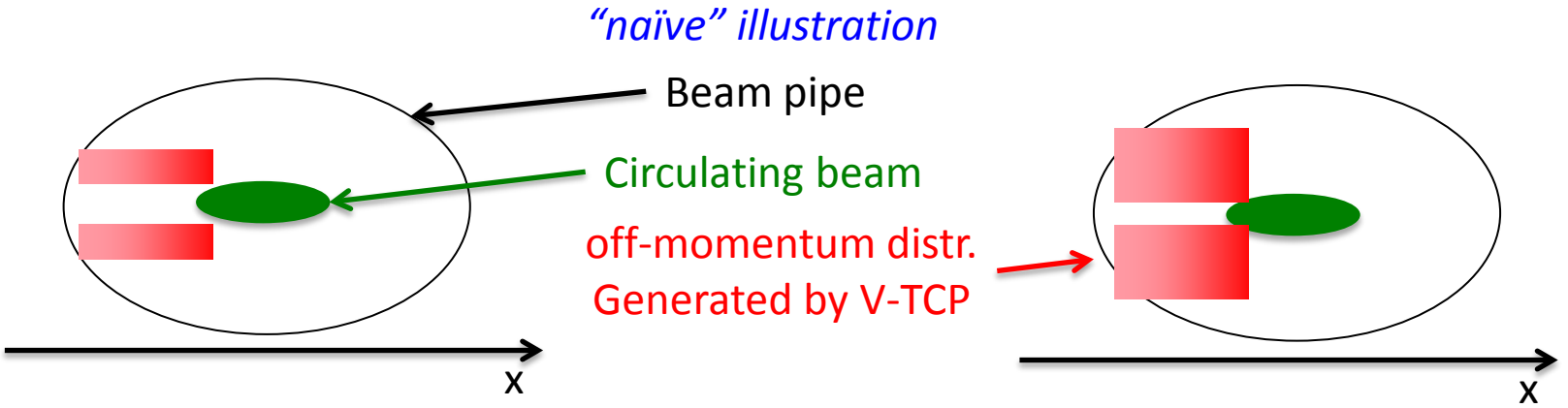
Where y_{TCP} is the vertical TCP half-gap (i.e. 1.2mm)

With the old phase advance we get:

$$y_{Loss} = 7.4 \cdot 10^{-4} + \Theta(-13.2)$$

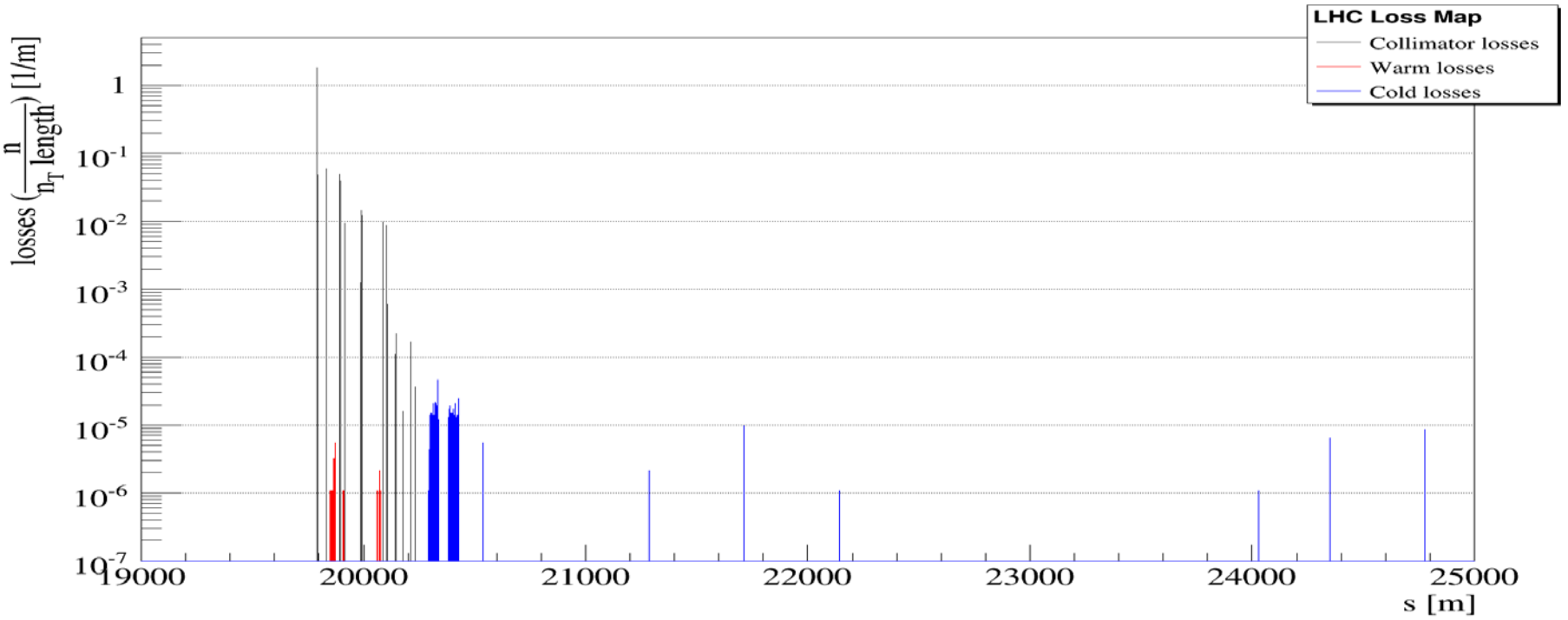
With the new one:

$$y_{Loss} = 7.6 \cdot 10^{-4} + \Theta(-6.1)$$



Second optics modification

Dispersion function and phase advance brought back to the old values



Finally IR7-DS is again the limiting location of the whole LHC!

Integrated losses

Quadrupole		Optics			
Name	IR	Old	New	1st Mod.	2nd Mod.
Q8-9	7	1.5e-3	1.2e-3	1.8e-3	2.2e-3
Q10-11	7	1.6e-3	9.4e-4	1.7e-3	2.3e-3
Q19	7	2.8e-5	-	2.4e-4	-
Q10	8	-	2.1e-4	-	-

Conclusion

Appearance of dangerous peak in IR8 using the proposed post-LS1 optics was seen:

- Only vertical plane of beam 1 was affected
- Correlation with mismatch in dispersion due to crossing scheme was found

Restoring only the old dispersion function, a new dangerous peak raised

- Correlation with convolution of old dispersion and new phase advance was found

Restoring both old dispersion and phase advance IR7 DS become again the limiting location of the whole LHC

- Study on integrated losses show slightly higher level of loss in IR7 DS, but still within safe margins.
- Minor aperture limitation at injection are expected (R. De Maria can comment better)