CERN-ACC-NOTE-2016-0011

19 January 2016
hector.garcia.morales@cern.ch

Off-momentum loss maps with one beam

H. Garcia-Morales, Royal Holloway University of London, United Kingdom
R. Bruce, CERN, Geneva, Switzerland
B. Salvachua Ferrando, CERN, Geneva, Switzerland

Keywords: LHC, collimation, off-momentum loss maps

Summary

The aim of this MD is the benchmarking of simulation of off-momentum loss maps. During the MD we performed standard off-momentum loss maps but with just one beam in the machine in order to separate contributions from both beams. This will help us to further understand the dynamics of the off-momentum collimation cleaning and give input to the determination of the operational settings of collimators of the off-momentum cleaning insertion. The MD was carried out during different end-of-fills of other MDs. In this note we summarize the procedures and the measurements taken during the MD week.

Contents

1 Introduction

The dynamics of how particles with large enough energy error hit the momentum collimator in IR3 and a fraction of outscattered particles is eventually lost in the cold aperture, has been studied in the past but just for some particular cases. In order to get a deeper understanding of the dynamics of such particles a new set of simulations that recreates the off-momentum loss map acquisition has been created. In these simulations an RF frequency trim is performed and the hits in the collimators and aperture are recorded in a similar way it is done for the regular betatron cleaning [1]. These simulations give us an idea of the off-momentum halo distribution.

The merit of this MD consists of the benchmarking of simulations which will help us to further understand the dynamics of the off-momentum collimation cleaning and give input to the determination of the operational settings of the off-momentum cleaning insertion.

2 MD overview

For optimal efficiency and use of the beam time, it was decided to carry out the off-momentum loss maps as end-of-fill studies. Before the beginning of the MD week, four different MDs were selected to perform off-momentum loss maps at the end of the fill. A low intensity was required and the collimator settings in the standard configuration (Tab. 1). The initial idea was to perform these studies in as many machine configurations as possible. Unfortunately, due to a variety of issues during the host MDs, we could carry on only two off-momentum loss maps.

2.1 MD procedure

The MD follows a few regular steps. First, we need to get rid of one beam using collimator scraping. Then, standard off-momentum loss maps are performed via an RF frequency shift in order to make the beam go off-momentum until particles are lost in IR3. At the end of the trim the beam is completely gone. Both loss maps were obtained at collision optics configuration at $\beta^\star = 80$ cm at 6.5 TeV and a single nominal bunch. After one beam was extracted, an RF frequency trim of +500 Hz was applied in both cases. The frequency shift

Table 1: Settings of different collimator families for 6.5 TeV physics operation in beam size units

Collimator	Aperture (σ)
TCP IR3	14.0
TCS IR3	18.0
TCLA IR3	20.0
TCP IR7	5.5
TCS IR7	8.0
TCLA IR7	10.6
TCT	13.7

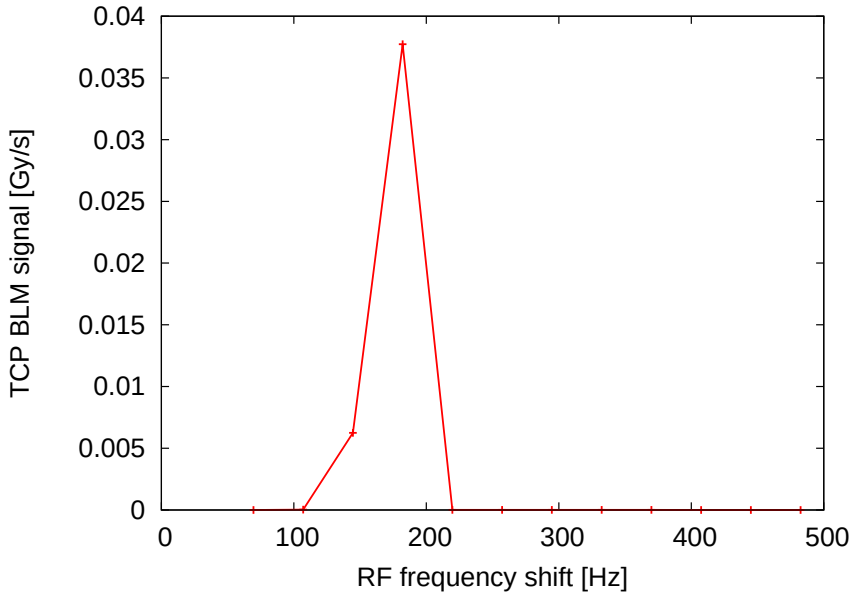

Figure 1: Beam loss monitor signal in TCP IR3 as a function of RF frequency trim with B2 present in the machine. In this case the maximum losses occur at a frequency shift of 184 Hz

was increased from 0 to 500 Hz linearly in about 15 seconds. As expected, the beam was dumped before reaching the final frequency shift.

3 Measured off-momentum loss maps

In this section we summarize the two measured loss maps and give a preliminary analysis of the data.

3.1 Measurement 2015-10-29: B2 $\Delta f = +500$ Hz

The first measured off-momentum loss map with one beam was performed the 29th of October during the last physics runs and before the start of the MD week, when a preparation fill for the proton collimator quench was carried out. The loss map was taken in B2 after dumping B1. A positive RF frequency trim of $\Delta f = +500$ Hz was applied. Maximum losses occur at frequency shift of about 184 Hz and after 250 Hz the beam is gone (Fig. 1).

In Fig. 2 and Fig. 3 the obtained off-momentum loss map is shown. The beam is circulating from the right to the left. As expected, most of the losses occur in the primary collimator in IR3. Significant losses are observed on TCTs in IR1. These losses may generate important beam induced background in the ATLAS detector. In IR5, such losses are an order of magnitude lower. Similarly, in IR6, a large number of losses not only in the collimator but also in cold and warm regions are observed.

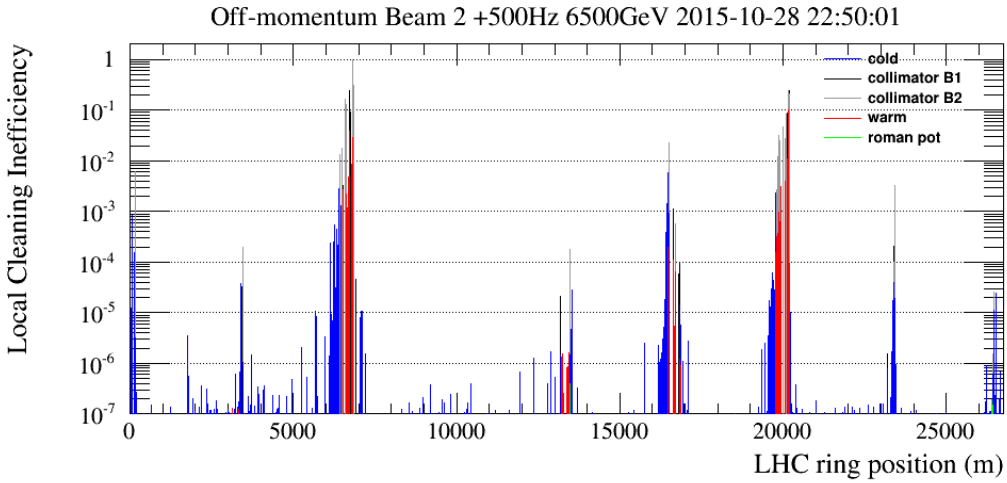

Figure 2: Off-momentum loss map performed in B2 and a frequency trim of +500 Hz for collision optics with $\beta^\star = 80$ cm at 6.5 TeV. The data represents the BLM signals all around the ring and they are normalized to the highest BLM signal.

3.2 Measurement 2015-11-04: B1 $\Delta f = +500$ Hz

The second measured off-momentum loss map with one beam was performed the 4th of November at the end of the fill of the MD284 devoted to beam tail population measurement. The loss map was taken in B1 after dumping B2. A positive RF frequency trim of $\Delta f = +500$ Hz was applied. Maximum losses occur at a frequency shift of about 220 Hz and after 300 Hz the beam is gone (Fig. 4).

In Fig. 5 and Fig. 6 the obtained off-momentum loss map is shown. In this case the beam is circulating from the left to the right. Again, the peak losses occur in TCP in IR3 but now the ratio between these losses and the peak losses in IR7 is lower with respect to the previous case with beam 2. Now, TCT losses in IR5 are much higher than those in IR1. In comparison with the standard betatron loss maps, we observe much higher losses in cold regions in new locations, such as IR3.

4 Conclusions

Off-momentum loss maps with just one beam have been measured at 6.5 TeV, $\beta^\star = 80$ cm and the 2015 standard collimation settings as end-of-fill-studies. Because of issues in the host MDs we could not perform the whole planned program (both beams for positive and negative frequency shifts). Two off-momentum loss maps were performed, for positive frequency shift and for the two beams. These data are very valuable for benchmarking simulations and further studies will be done to obtain a reliable simulation tool and a good model of the LHC off-momentum beam halo. In order to complete the set of data, it would be very beneficial to repeat the measurements during the next recommissioning phase for negative RF frequency trim.

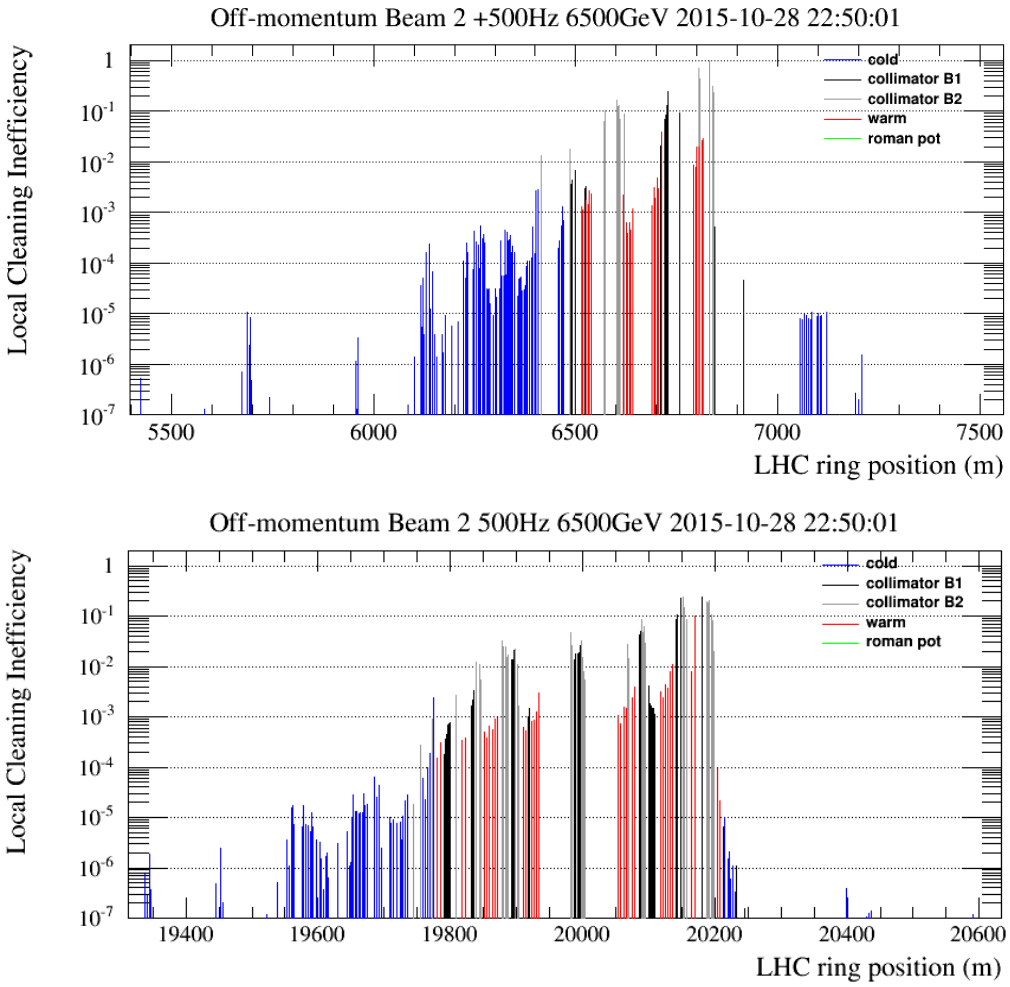

Figure 3: Zoom on the IR3 (top) and IR7 (bottom) of the off-momentum loss map performed in B2 at 6.5 TeV, $\beta^* = 80$ cm and a frequency trim of +500 Hz.

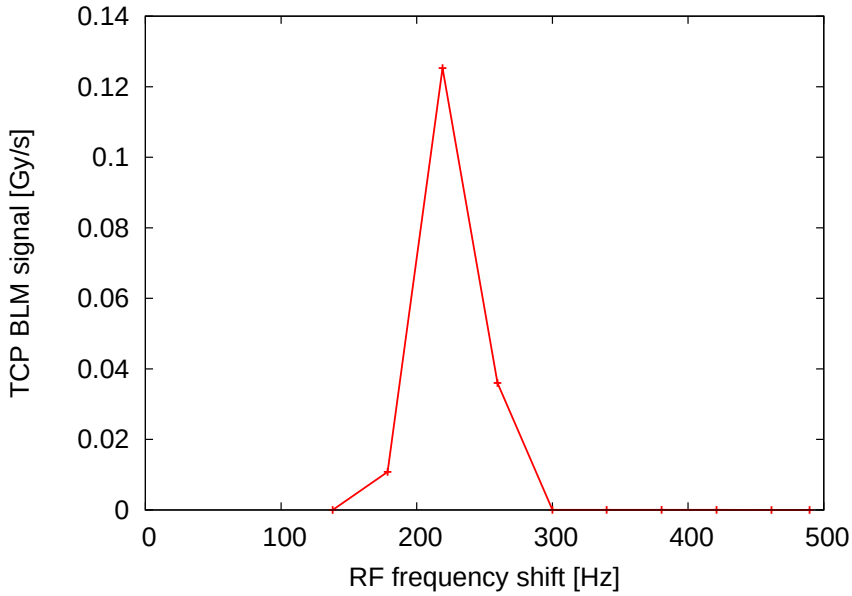

Figure 4: Beam loss monitor signal in TCP IR3 as a function of RF frequency trim with B1 present in the machine. In this case the maximum losses occur at a frequency shift of about 220 Hz

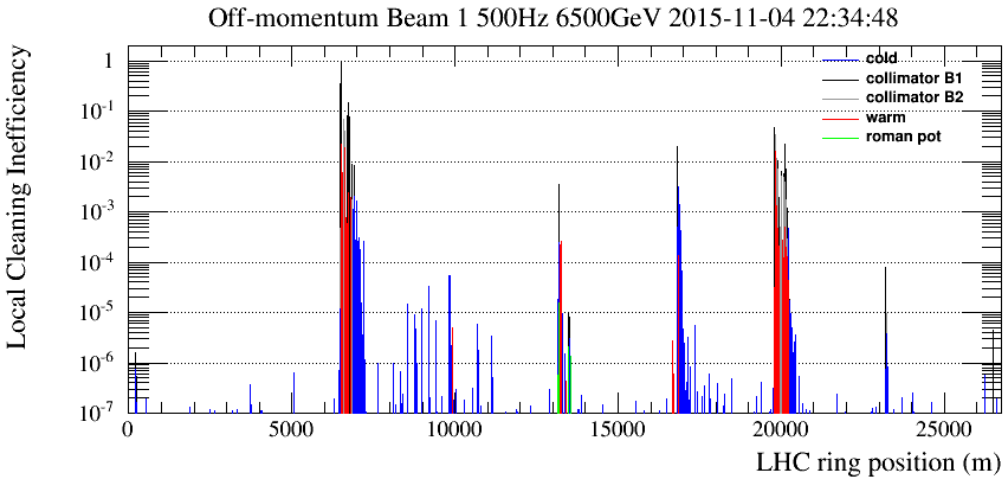

Figure 5: Off-momentum loss map performed in B1 and a frequency trim of +500 Hz for collision optics with $\beta^\star = 80$ cm at 6.5 TeV. The data represents the BLM signals all around the ring and they are normalized to the highest BLM signal.

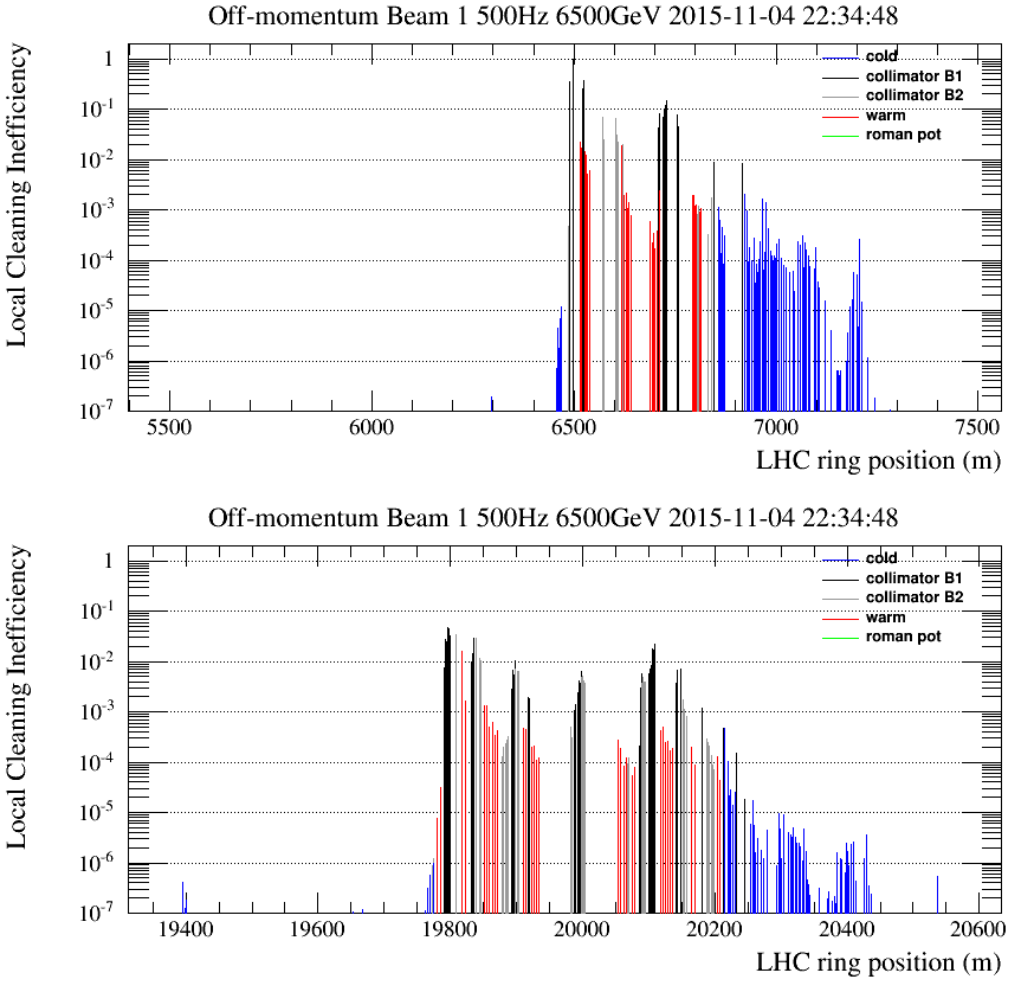

Figure 6: Zoom on the IR3 (top) and IR7 (bottom) of the off-momentum loss map performed in B1 at 6.5 TeV, $\beta^* = 80$ cm and a frequency trim of +500 Hz.

References

[1] R.Bruce et al., "Simulations and measurements of beam loss patterns at the CERN Large Hadron Collider", Phys. Rev. STAB **17**, 081004 (2014).