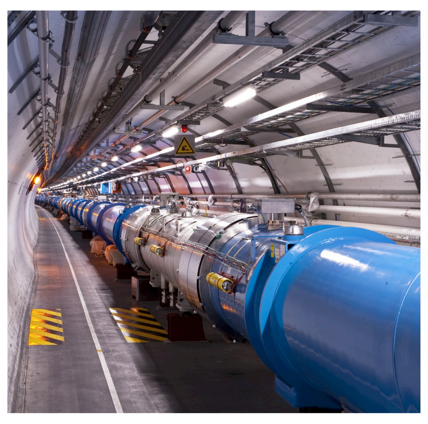

CLEANING PERFORMANCE OF THE LHC COLLIMATION SYSTEM UP TO 4 TeV*

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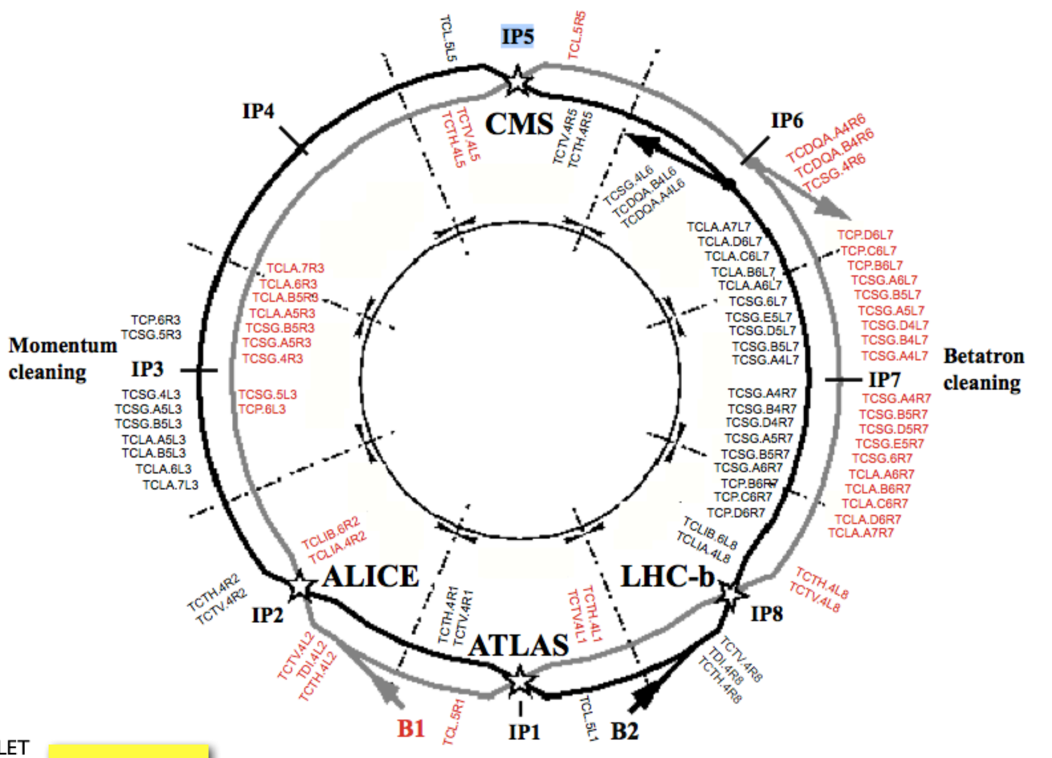
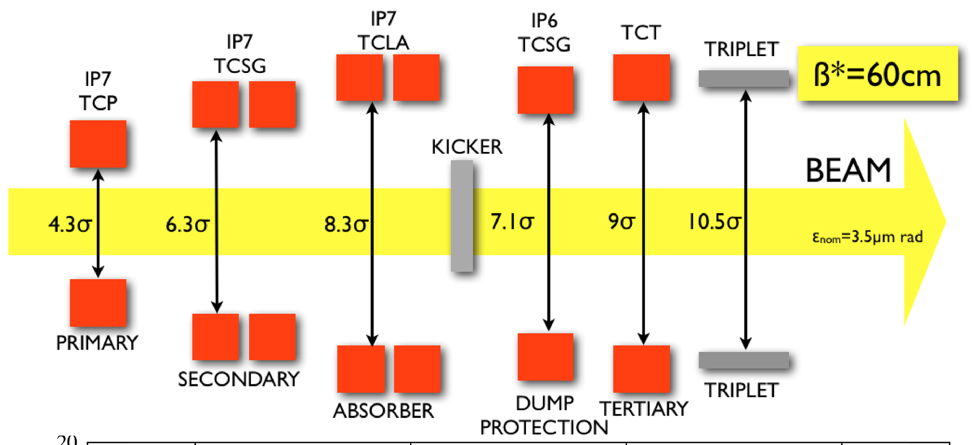
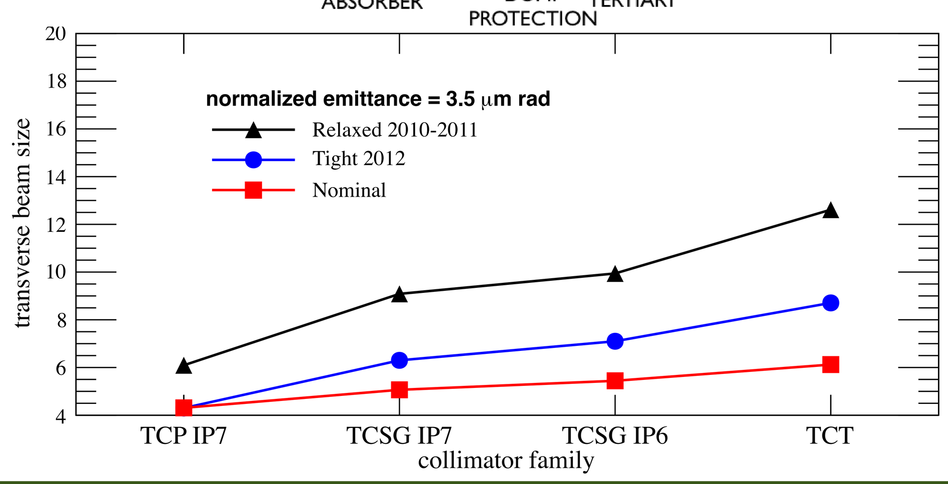
We review the performance of the LHC collimation system during 2012 and compare it with previous years. During 2012, the so-called tight settings were deployed for a better cleaning and improved β* reach. As a result, a record cleaning efficiency below a few 10^{-4} was achieved in the cold regions where the highest beam losses occur. The cleaning in other cold locations is typically a factor of 10 better. No quenches were observed during regular operation with up to 140 MJ stored beam energy. The system stability during the year, monitored regularly to ensure the system functionality for all machine configurations, and the performance of the alignment tools are also reviewed.

The LHC collimation system provides a multi-stage cleaning in two main cleaning insertions, IR3 for momentum cleaning and IR7 for betatron cleaning. A total of 108 collimators, hundred of them movable that need to be aligned within 10 – 50 μm precision to achieve the required cleaning.

During the 2012 running period with 4TeV beam energy the collimator system was setup with the so-called "tight" collimator settings. This settings were necessary to achieve smaller β* down to 0.6cm at 4TeV providing more luminosity to the experiments.



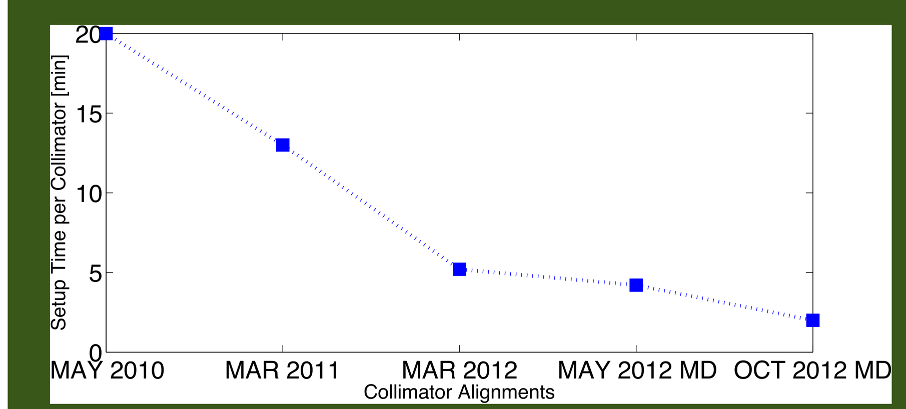


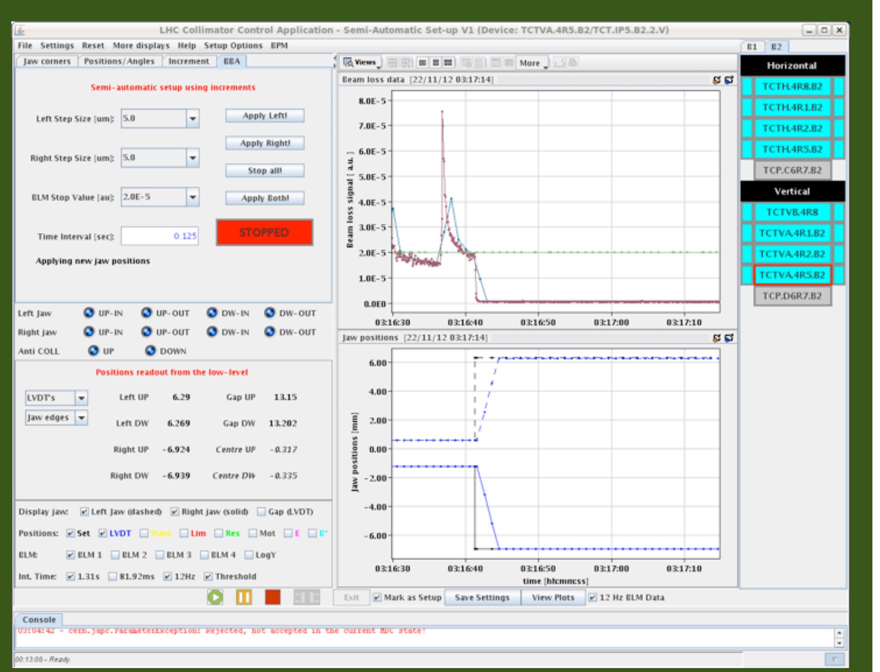


The plot on the left shows the evolution of the collimator settings since 2010, from "relaxed" to "tight" and the nominal collimator settings (black, blue and red line respectively). The "tight" settings used in 2012 were validated during MD's in 2011. In particular, it was verified that the proposed hierarchy could be achieved without additional alignment campaigns, indicating that the orbit and collimator settings are stable enough to ensure a good hierarchy with 2 σ retraction between TCSGs and TCLAs with 1 single alignment per year. The nominal settings are even "tighter" and have been tested during several MD's but up to date they were not used in regular operation.

COLLIMATION ALIGNMENT

All collimators are setup symmetrically around the beam orbit for each machine configuration (i.e. injection, flat top, squeeze and collisions). The alignment procedure is used to set each collimator jaw independently around the beam orbit based on the beam loss monitor (BLM) spike observed when touching the beam halo with the primary collimators. This is done only in dedicated low intensity fills.

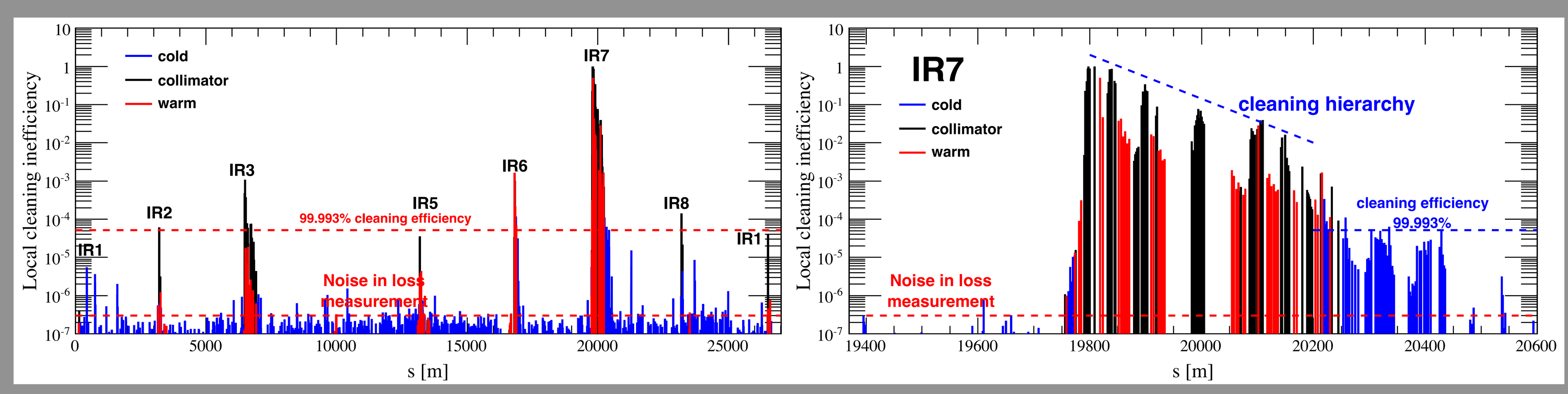




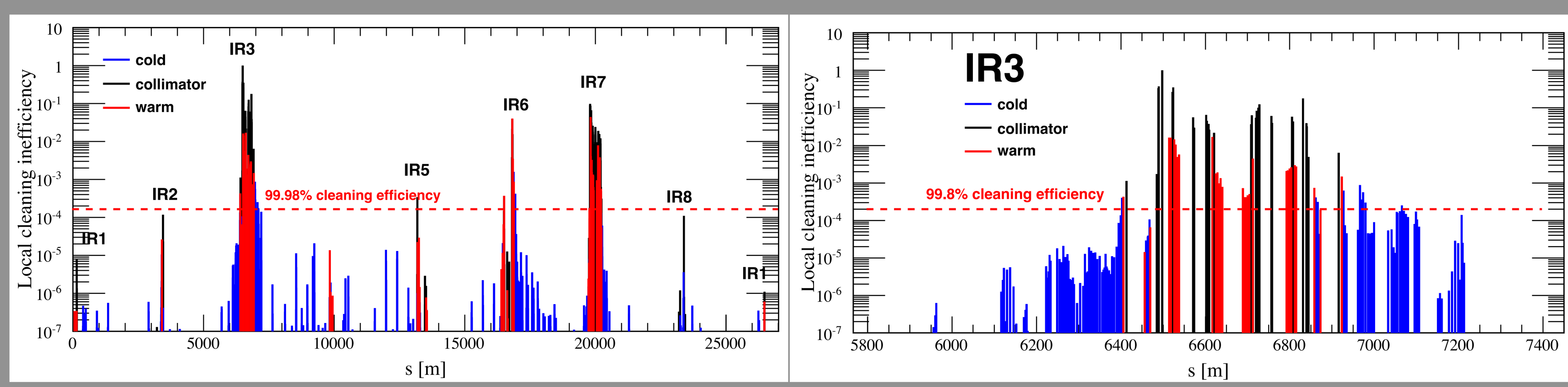
Since 2010 several improvements have been implemented in the alignment software towards a faster, more reproducible and human-error proof alignment. The main improvement on the alignment speed was the use of the 12.5 Hz BLM data, available from the start of 2012 run.

SYSTEM PERFORMANCE

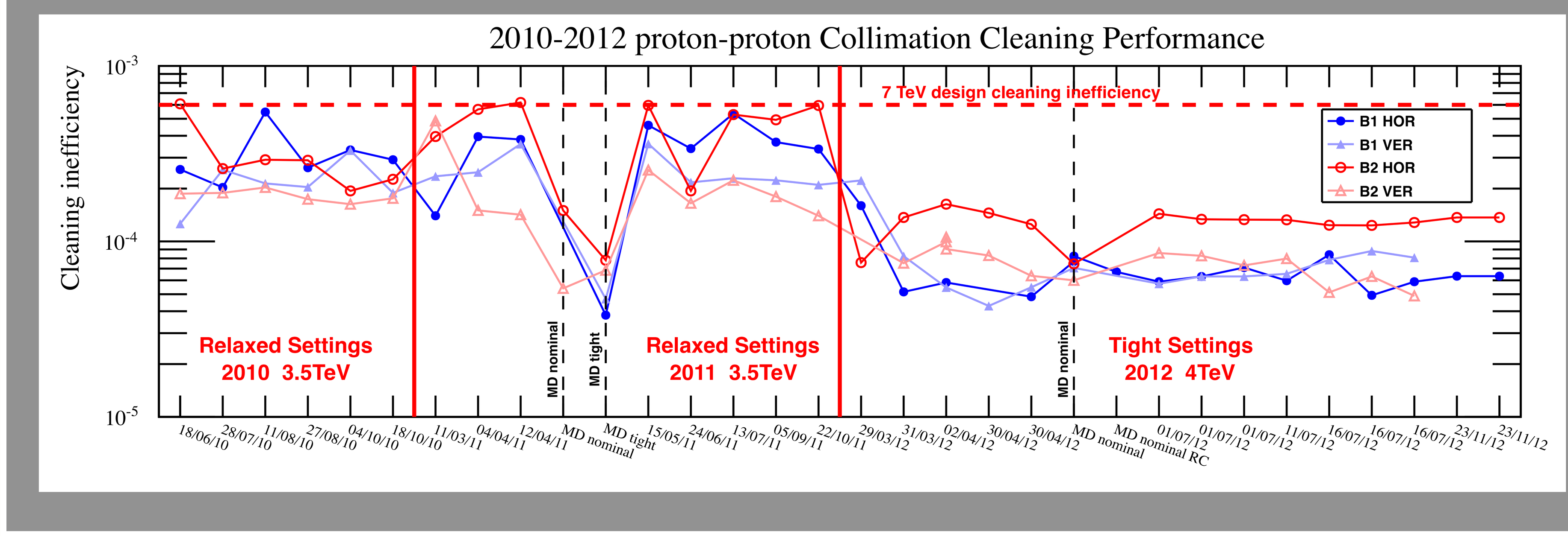
In order to validate the cleaning hierarchy and study the performance of the collimator system, loss maps are performed. Beam losses are recorded along the ring while exciting the beam with the transverse damper (ADT) and are compared with the peak losses at the primary collimators to compute the cleaning inefficiency. The ADT introduces white noise in vertical or horizontal plane that can be gated to selected bunches. When the ADT is working on this mode the excited bunch is blown up with a controlled speed and interacts with the collimators producing beam losses along the ring that simulate what would happen in case of instabilities.



Off-momentum cleaning in IR3 is also validated by looking at losses artificially generated by changing the LHC radio frequency (RF) by ±500 Hz in order to generate an off-momentum shift big enough to measure the cleaning inefficiency in IR3. The highest loss occurs now in IR3 as opposed to the betatron losses were the peak appears in IR7.



In 2010 and 2011 the beam energy was 3.5 TeV and the relaxed collimator settings were used while in 2012 the beam energy was increased to 4 TeV and the tighter collimators settings described in previous section were used. The figure shows an excellent stability of the cleaning performance which was achieved with only one alignment campaign per year at the beginning of each run period. In 2012, with the "tight" settings the average cleaning improved from 99.97% to 99.993% with small dependence on the beam energy.



CONCLUSIONS

The performance of the collimation system was discussed. The improvements on the alignment tool decreased the collimation setup time from 20 min to few minutes per collimator. The cleaning stability in the dispersion suppressor region of IR7 along the LHC running periods was analyzed and was shown to be excellent. In 2012, with the "tight" collimator settings the average cleaning inefficiency (ηc) at Q8 in IR7 was about ηc = 7·10–5 for Beam 1 (both horizontal and vertical halo cleaning) and Beam 2 vertical and around ηc = 10–4 for Beam 2 horizontal. Even though not required for cleaning, this improvement was crucial to push for β· = 0.6 cm. No quenches with circulating beamswere experienced with up to 140 MJ at 4 TeV.

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