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Notes for the meeting on settings of LHC collimators and protection devices

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The meeting was called to discuss a coherent view on settings of collimators and absorbers in the LHC ring and the transfer lines. The discussion and conclusions are summarized.

Aperture assumptions:

It was agreed that an available aperture of 1.2 · n1 should be used in the horizontal and vertical planes, while the available aperture is 1.4 · n1 in the 45 degree direction (radial).

Plane	Available aperture [n1]	Avail. aperture [σ] with n1=7
x, y	1.2	**8.4**
skew	1.4	**9.8**

Previously, some settings of protection devices assumed 9.8σ available aperture in the arc or at the triplet. As beam perturbations occur in the horizontal or vertical planes for most failures, the settings of protection devices must be adjusted to an available aperture of 8.4σ instead.

It was agreed to specify the n1 of the aperture independently for x, y, and skew in order to identify the type of local bottlenecks in aperture. This will be done by S. Redaelli in collaboration with J.B. Jeanneret and R. Assmann.

Settings of ring devices:

The following settings were defined for consistent collimation and protection in the LHC ring:

Elements	Real depth [σ] (n1=7)	Nominal setting [σ] (n1=7)
Primary collimators	≤ 6	**5.9**
Secondary collimators	≤ 7	**6.9**
Tertiary collimators	≤ 8.3	**8.1** *(to be confirmed*
Protection devices	≤ 8.3	**7.7** *(to be confirmed)*

In order to guarantee a real depth of collimators or absorbers, the setting must be deeper in order to take into account various possible errors and operational scenarios. These uncertainties are especially important for the protection devices and much smaller for the precise and constantly monitored collimators. Settings apply both to injection and physics for the same n1=7 (it is noted that of course special injection protection is open at top energy).

Protection devices that are relevant in this context include TDI, TCDQ, TCDD, and TCLI (the replacement of TCDD and some TCLI by tertiary collimators is under study). The settings with an available aperture of 8.4 σ have been studied for the TDI (B. Goddard et al) and the required nominal settings of protection devices refer to this study. Details remain to be worked out.

Settings and configurations for transfer line collimators TCDI

The transfer line collimators fulfill two main duties duties:

1. Protection of the transfer line and the LHC injection septa.

2. Protection of the LHC equipment during first turn of the LHC, especially the arcs between injection and ring collimator systems in IR3 and IR7.

Assuming the absence of any beam halo above 3σ (after beam scraping in the SPS), quenches should be avoided in the ring for injection oscillations below 3σ and LHC primary collimators at 6σ. However, for larger injection oscillations or inefficient scraping quenches could be expected: the secondary collimators can then intercept significant beam population and act as primary collimators with bad cleaning efficiency.

The second protection goal of the TCDI depends on the available aperture in the LHC arcs. The betatron protection provided by the TCDI is a function of the number of components:

Configuration	Real depth [σ]	x/y protection [σ]	x/y aperture [σ]	Skew protection [σ]	Skew aperture [σ]
x at 0º/90º y at 0º/90º	5.0	**7.1**	8.4	**10.0**	9.8
x at 0º/45º/90º/135º y at 0º/45º/90º/135º	5.0	**5.4**	8.4	**7.7**	9.8

The protection is given in horizontal (x) and vertical (y) directions, and separately in the skew direction. As flat collimators are used in the transfer line, the protection in skew direction is less good than in transverse direction (a factor √2 is assumed). It is seen that the margin between the provided protection and the available aperture is quite limited for the reduced system. Errors and imperfections must still be folded in (e.g. injection ripple from the LHC injection kickers, injection mismatch, …) and it is not guaranteed that the reduced system will provide the required protection. A full system performs much better. The following conclusion was agreed on:

- In view of the much improved protection, a full system for transfer line collimators is considered as the baseline solution.

- The baseline system for TCDI collimators does then include 16 instead of 8 betatron collimators for the two injection lines (for momentum collimation 2 more components are added in either configuration).

- This will be presented at Chamonix.

- The protection with errors will be studied in detail over the next months. In case that it can be shown that sufficient protection is provided with a reduced system, then the system will be scaled back.

It was pointed out that not all ideal 45º locations are available in the present transfer line layout. Further studies will be done by H. Burkhardt and V. Kain in collaboration with B. Goddard et al.