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Damage Limits for LHC Collimators

Each collimator has 2 BLM's installed directly downstream, one ion chamber and one CCD based device. The two BLM's combined cover a very large dynamical range in beam loss measurements.

A machine protection threshold for the BLM's will be set to prevent local beam losses above the damage limits of the collimators and surrounding accelerator equipment. The damage limits for collimators are summarized in this note. Beam shall be aborted if beam loss exceeds one of these limits. Note that limits for quenching downstream magnets are for some collimators much lower. It is assumed that the machine protection limits for BLM's at collimators are only set to prevent damage.

The following assumptions have been made:

1. Robustness limits for TCSG's are reduced by a factor 10 if compared to the limits at primary collimators, as heating of downstream equipment was not studied in detail. Primary losses should always occur at primary collimators.
2. Robustness of Cu jaws for slow losses is about 200 times below robustness of CFC jaws.
3. Robustness of W jaws for slow losses is about 2000 times below robustness of CFC jaws.
4. Damage limits have been assigned to all collimators even for modes when objects are assumed to be out of the beam (this affects TCLIA, TCLIB, TCL, TCLP).
5. Injection and dump protection devices are assumed to take the same maximum beam load before damage as the secondary collimators in the cleaning insertions with the same or similar design (any constraints from neighboring equipment?).

It is noted that the damage limits will be adjusted with operational experience, taking into account the measured temperature in the collimator jaw during losses of protons, vacuum behavior, etc. In particular, the thresholds might be adjusted to also abort beam before development of vacuum spikes and closure of vacuum valves.

Table 1: Estimated settings of "damage" interlock limits for various collimator types in the cleaning insertions. Power refers to nominal intensity.

Device	Location	Energy	Condition 1	Condition 2	Condition 3
TCP	IR3	450 GeV	dN/dt > 1.2e12 p/s for T > 10 s (87 kW)	dN/dt > 6e12 p/s for 1 s < T < 10 s (430 kW)	dN/dt > 1.5e13 p/s for T < 1 s (1.1 MW)
TCP	IR7	450 GeV	dN/dt > 1.2e12 p/s for T > 10 s (87 kW)	dN/dt > 6e12 p/s for T < 10 s (430 kW)	
TCP	IR3, IR7	7 TeV	dN/dt > 0.8e11 p/s for T > 10 s (90 kW)	dN/dt > 4e11 p/s for T < 10 s (449 kW)	
TCSG	IR3	450 GeV	dN/dt > 1.2e11 p/s for T > 10 s (9 kW)	dN/dt > 6e11 p/s for 1 s < T < 10 s (43 kW)	dN/dt > 1.5e12 p/s for T < 1 s (110 kW)
TCSG	IR7	450 GeV	dN/dt > 1.2e11 p/s for T > 10 s (9 kW)	dN/dt > 6e11 p/s for T < 10 s (43 kW)	
TCSG	IR3, IR7	7 TeV	dN/dt > 0.8e10 p/s for T > 10 s (9 kW)	dN/dt > 4e10 p/s for T < 10 s (45 kW)	
TCLA	IR3	450 GeV	dN/dt > 6e8 p/s for T > 10 s (45 W)	dN/dt > 3e9 p/s for 1 s < T < 10 s (215 W)	dN/dt > 7.5e9 p/s for T < 1 s (550 W)
TCLA	IR7	450 GeV	dN/dt > 6e8 p/s for T > 10 s (45 W)	dN/dt > 3e9 p/s for T < 10 s (215 W)	
TCLA	IR3, IR7	7 TeV	dN/dt > 4e7 p/s for T > 10 s (45 W)	dN/dt > 2e8 p/s for T < 10 s (225 W)	

Table 2: Estimated settings of "damage" interlock limits for various collimator types outside of cleaning insertions. Power refers to nominal intensity.

Device	Location	Energy	Condition 1	Condition 2	Condition 3
TCTH, TCTVA, TCTVB	IR1, IR2, IR5, IR8	450 GeV	dN/dt > 6e8 p/s for T > 10 s (45 W)	dN/dt > 3e9 p/s for T < 10 s (215 W)	
TCTH, TCTVA, TCTVB	IR1, IR2, IR5, IR8	7 TeV	dN/dt > 4e7 p/s for T > 10 s (45 W)	dN/dt > 2e8 p/s for T < 10 s (225 W)	
TCL, TCLP	IR1, IR5	450 GeV	dN/dt > 6e9 p/s for T > 10 s (450 W)	dN/dt > 3e10 p/s for T < 10 s (2.2 kW)	
TCL, TCLP	IR1, IR5	7 TeV	dN/dt > 4e8 p/s for T > 10 s (450 W)	dN/dt > 2e9 p/s for T < 10 s (2.2 kW)	
TCLIA, TCLIB, TCSG	IR2, IR6, IR8	450 GeV	dN/dt > 1.2e11 p/s for T > 10 s (9 kW)	dN/dt > 6e11 p/s for T < 10 s (43 kW)	
TCLIA, TCLIB, TCSG	IR2, IR6, IR8	7 TeV	dN/dt > 0.8e10 p/s for T > 10 s (9 kW)	dN/dt > 4e10 p/s for T < 10 s (45 kW)	