LHC Collimation Review 2011

main focus:

evaluate necessity of planned upgrades of the LHC collimation system

Review Committee:

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charge for committee

1. Are collimation performance and limitations properly analyzed and adequately addressed by upgrade plans?

2. **Can the collimation upgrade in the IR3 dispersion suppressors, presently foreseen for the 2013/4 shutdown, be delayed by three years without limiting LHC performance at 7 TeV?**

3. Have any issues or risks been overlooked that should be addressed in the collimation upgrade plan?

$\rightarrow$ ignore cost and manpower effort

general comments

- the general progress with LHC, and particularly performance and understanding of the collimation system are impressive
- the committee is impressed by the quality of design- and preperatory technical work done on the proposed collimators in the dispersion suppressor regions
- the agreement between simulations and observations regarding collimation efficiency and loss distribution is excellent in most cases
- nevertheless the prediction of intensity limits at 7TeV remains a difficult problem

intensity limit 3.5TeV

results from 2011 establish intensity margins for 3.5TeV well beyond the requirements

scaling to 7TeV predicts a margin of **four times the nominal intensity**

	3.5 TeV						
	η_{lineff}	Efficiency	$R_q L_{dil}$ [p/s]	τ_{min} [h]	N_{max} [p]	N_{lim} @BLM [p]	N_{lim}/N_{nom}
2010	5.20E-04	99.95%	8.40E+07	0.6	3.7E+14	1.2E+14	41%
MD	1.56E-04	99.98%	1.22E+09	1.0	2.8E+16	0.94E+16	2900%

Cleaning efficiency: Gain factor 3.3 (MD on collimation settings)

Quench limit times dilution length: Gain factor 14.5 (MD on DS quench)

Min. lifetime: Gain factor 1.7 (2011 operation)

assumptions for scaling to 7TeV

- minimum beam lifetime stays constant
  - but many operating conditions change (bunch spacing, bunch charge, emittance, collimator settings…)
- scaling of cleaning efficiency is 0.4 from simulations
  - experiment provoking losses artificially on 1/3 resonance might not reproduce real situation
- scaling of quench limit times dilution length: 0.29
- locations of peak losses stay the same

concerns for operation without DS collimators

- with nominal intensity/emittance the impedance limit for pp is reached
- performance reach will be determined by the ability to maintain the demanding collimator hirarchy during operation
  - integrated collimator BPM's would help a lot

concerns for heavy ion operation

- predicted intensity limit from IR3 is ¼..½ of nominal intensity, based on conservative assumptions
- the luminosity will be limited to 50% of the nominal by the lack of local collimators next to detectors in IR's 1,2,5
- predictions are less certain than for protons

R2E concerns

- 4 failures observed, without mitigation actions factor 75 expected at nominal LHC parameters
- mitigating actions against radiation damage of electronics in IR 7 may not be sufficient
- carbon secondary collimators with integrated BPM's will be produced in any case for phase 2; if R2E problems arise in IR7 these can be installed in IR3 readily

further findings 1

- increased activation does not prevent upgrade work in LS2 2017 if work postponed, although ALARA favors LS1 2013 (factor 4)
- the planning of the collimator installation already in LS1 2013 is challenging and presents risks
- however the advantages of upgrading IR3 in 2013 are:
  - gain experience prior to upgrading all IR's at once
  - staging the DS collimation upgrades reduces peak workload

further findings 2

- the committee acknowledges study on time dependent MB quench stability
- operational experience with present system at 3.5 TeV is good; few dumps from "cleaning losses“; margins are comfortable
- rad damage to magnets: expect about 2.4 MGy/y if magnets run at 1/3 of quench limit; onset of problems above 10 MGy!; needs realistic FLUKA simulations
- possible 'operational' mitigation measures if DS collimators NOT installed and problems seen: buttons in collimators, 50ns, improve on lifetime dips

committee's conclusions

- on the basis of the evidence presented, the committee concludes that the nominal proton intensity of LHC at 7TeV can be achieved without the installation of additional collimators in the IR3 dispersion suppression region in LS1
- however, the eventual installation of the DS collimators will increase operational margins and flexibility significantly

recommendations 1

- mechanism for lifetime dips at 3.5 TeV should be better understood and how this scales with energy; perform studies to evaluate effects of varying operational parameters on lifetime dips
- consider mitigation measures against lifetime dips, e.g. collide before squeeze
- estimate radiation damage to stabilizing material of superconducting cable at cryogenic temperatures

recommendations 2

- quench limit studies, including provoking quenches, should be continued to
  - benchmark simulation predictions
  - gain data for heavy ion operation
  - establish a link to 1D beam loss model used throughout the collimation project, particularly in IR3
  - increase confidence concerning 7TeV predictions
- FLUKA uncertainties concerning single diffractive cross sections should be reduced by comparison to pPb data

recommendations 3

- investigate other upgrade options (postponing work on DS collimators until LS2)
  - fixed masks inside large aperture dipole magnets
  - possibility of 11 T magnet to replace main dipole, to make space
  - thin Tungsten primary collimators
  - hollow e-beam
- evaluate risk level with present tolerances and 0.55 m β^*
- impedance: 7 TeV settings on the edge for stability for headtail modes and TMC; Investigate feedback?
- addition of combined cleaning will maybe double the total impedance coming from the collimators due to smaller gaps...this should be properly evaluated.

summary on charge

1. Are collimation performance and limitations properly analyzed and adequately addressed by upgrade plans?

yes

2. **Can the collimation upgrade in the IR3 dispersion suppressors, presently foreseen for the 2013/4 shutdown, be delayed by three years without limiting LHC performance at 7 TeV?**

yes for protons, possibly not for ions

3. Have any issues or risks been overlooked that should be addressed in the collimation upgrade plan?

no