Status of LHC Collimation

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HWC: EN/STI, BE/OP, BE/ABP ➔ not reported here in detail

Collimation beam commissioning team:
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plus common activities with TE/ABT (Brennan et al), BE/BI (Bernd et al), ...
Hardware Status

• System frozen since start of September (only required improvements agreed).
• All **100 LHC collimators fully operational**.
• No problems so far: not a single access required since start of beam operation. **Good sign for collimator reliability**.
• Collimators moved as required for splash events and then for collimation setup.
First Multi-Stage Betatron and Momentum Collimation

21/100 coll. beam-based aligned to nominal settings for trial ramp 24.11.2009 (others coarse).

<table>
<thead>
<tr>
<th>IR7</th>
<th>Primary: 5.7 σ</th>
<th>Secondary: ~10 σ</th>
<th>Tungsten absorber: 10 σ</th>
</tr>
</thead>
<tbody>
<tr>
<td>IR3</td>
<td>Primary: 8.0 σ</td>
<td>Secondary: ~10 σ</td>
<td>Tungsten absorber: 10 σ</td>
</tr>
<tr>
<td>IR6</td>
<td>TCS: ~7.0 σ</td>
<td>TCDQ: ~8.0 σ</td>
<td></td>
</tr>
</tbody>
</table>

- No unexpected losses in arcs, experimental insertions, ...
- Initial cleaning efficiency: > 99 %
First Ramp with Rough Collimator Settings

Losses during first ramp: beam energy = 0.447 [TeV], time 1351.0 [s]
Then Full Collimation Set-Up Last Sunday

• **Both beams in parallel (2 teams of 2 persons each) for 1 shift.** Carefully prepared by the team...

• Setting up to *injection settings* (expressed in nominal emittance):
  – Primary betatron collimators: 5.7 \( \sigma \)
  – Primary momentum collimators: 8.0 \( \sigma \)
  – and the full multi-stage hierarchy (see our papers)

• Achieved **60 collimators (120 jaws) in \(~7\) hours**: \(~10\) min per collimator.

• Principle: **Created halo edge at assumed 5.7 \( \sigma \) and move all jaws to the edge.** Accuracy: 200-300 \( \mu \text{m} \)
Beam-Based Jaw Alignment

Set increments of jaw positions/angles
- Left POSIT [mm]: -0.05
- Right POSIT [mm]: +0.05
- Left ANGLE [mrad]: 0.0
- Right ANGLE [mrad]: 0.0

Applying new jaw positions
- Left jaw: UP, IN, UP-OUT, DW, DW-OUT
- Right jaw: UP, IN, UP-OUT, DW, DW-OUT
- Anti COLL: UP, DOWN

Positions readout from the low-level
- LVDT's
  - Left POSIT: 4.172
  - Right POSIT: -3.758
  - Left ANGLE: -0.008
  - Right ANGLE: -0.02
- Gap UF: 7.825
- Gap Dw: 7.874
- Centre UF: 0.204
- Centre Dw: 0.21

Display jaw: Left jaw (dashed), Right jaw (solid)

Positions:
- Set, LVDT, Warn, Lim, Res, Motor

BLM:
- BLM 1, BLM 2, BLM 3, BLM 4, LogY

Console
09:32:33 - Ready
  --> BLYNcli, 0312, 10, TCLA.A7L7.B2
  --> BLYNcli, 0312, 10, TCLA.A7L7.B2
09:32:33 - Ready
1st Beam-Based Collimation Set-Up for Beam 1 (29.11.2009)

Calibrated Full Gap [mm]

Collimator Number

Gap Size @ 5.7σ
Collimator Scans (beam size and centre)

TCLA.C6R7.B1
(Vertical)
Beam centre ~ 2.2 mm
Beam size ~1.3 mm

Beam size
Fit: 1.3 mm
Expected: 1.1 mm
Observations

• Worked very well. Accuracy: ~0.2 mm
• Gap centre offsets between -1.0mm and +1.5mm.
• Most results nicely compatible with expected gaps. We follow the expected variation!
• Some larger deviations in IR6 (high beta) and IR1 (experimental area) to be followed.
• Collimator jaws were then retracted from their calibrated 5.7σ settings to nominal gap values to establish multi-stage collimation (secondaries to 6.7 σ, absorbers to 10σ, ...).
Peak loss first ramp to 1.18 TeV

Subtract constant offsets (no beam)
November 29, 21:55:51 - First ramp to 1.18 TeV - Beam 1 - Highest loss in 1.3 s integral

Efficiency: > 99.9%
LHC Operation with Collimation

• Cleaning and collimation so far looking highly efficient, no hole (loss at unexpected location) shown yet.

• Price to pay? Reduction of beam lifetime $\sim 50h \rightarrow \sim 3h$ with collimators in place.

• Not a total surprise: Lifetime and background issues for collimation below 5$\sigma$ observed at many places!

• Reason: Likely slow diffusion process much more visible with tight aperture than loose aperture. Too early for predicted impedance issues!?

• Needs beam optimization (diffusion), collimator experiments and/or higher intensity to analyze.

• Risk: OK for pilot injection but what happens for higher intensities? When do we need transverse damper?
Collimation Machine Protection Aspects

• Collimator position and gap interlocks passed full qualification (except TDI). Fully documented in MTF collimator database. MPP can check...

• Thresholds only active for tertiary collimators (TCT’s). Can be put elsewhere, once decided.

• Issues for BLM thresholds at tungsten resolved with BLM team. Created known beam loss at collimators and calibrated BLM signal in power loss at collimators. Can relax collimator thresholds (factor 100?) and unmask. ➔ BLM team.

• System can be declared safe (except TDI issue).
Conclusion

• Very happy to see the system working with beam after 7 very busy years.

• Already >99.9% of cleaning efficiency is visible after 10 hours of beam time for optimization. Thanks to the very efficient young collimation team members (C. Bracco, D. Wollmann) and BE/Bl for excellent diagnostics (BLM’s).

• See first signs of interesting halo dynamics (lifetime). Must follow up, especially for higher intensity! We need low diffusion beam.

• System is safe (documented), with triple redundancy. Not a single failure yet (HW and beam).

• Next steps: Put thresholds active, better accuracy setup, injection protection, closing jaws during ramp (intermediate).

• From collimation, we feel so far confident for increasing beam intensity (2010 goal is 40 MJ stored energy). Looks like simulated.