LHC quench limit with adjusted collimator jaws

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LCC 19/6/02
Quench limits at injection


Pilot with 5e9 p does not quench if losses are diluted over ~ 5 m.
quench levels for LHC at 450 GeV and 7 TeV

Without collimation and dilution

\[(\Delta N/\Delta t) = N_0 / \tau\]

Loss rates for 1 min lifetime

Nominal beam

Nominal batch

3 \cdot 10^{10} \text{p}

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Reminder

Collimation inefficiency = \frac{\text{Number of protons above } 10 \sigma}{\text{Number of protons hitting the collimator at } 6 \sigma}

Phase space tertiary halo:

Not all protons above 10 \sigma are lost in the same place:

Local inefficiency [1/m]:

Integrate halos above 10\sigma

Divide by dilution length (\sim 50 m)
Collimation efficiency

Ideal design: $10^{-3}$
Dilution length: 50 m
Local cleaning inefficiency: $2 \cdot 10^{-5}$

Tolerances for each 50% increase in inefficiency (preliminary):

<table>
<thead>
<tr>
<th>Error</th>
<th>Tolerance</th>
<th>Preliminary estimates:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orbit</td>
<td>0.6 $\sigma$</td>
<td>Combined effect can make tolerances more severe!</td>
</tr>
<tr>
<td>Beta beat</td>
<td>8%</td>
<td></td>
</tr>
<tr>
<td>Longitudinal angle</td>
<td>50 $\mu$m</td>
<td></td>
</tr>
<tr>
<td>$\Delta L/L$ (prim)</td>
<td>75%</td>
<td></td>
</tr>
<tr>
<td>Surface flatness (prim)</td>
<td>10 $\mu$m</td>
<td></td>
</tr>
<tr>
<td>$\Delta L/L$ (sec)</td>
<td>20%</td>
<td></td>
</tr>
<tr>
<td>Surface flatness (sec)</td>
<td>25 $\mu$m</td>
<td></td>
</tr>
<tr>
<td>Setting accuracy (prim)</td>
<td>-1.0/+0.5 $\sigma$</td>
<td>Estimate:</td>
</tr>
<tr>
<td>Setting accuracy (sec)</td>
<td>$\geq \pm 0.5 \sigma$</td>
<td>Loose factor 10, dilution 10 m</td>
</tr>
</tbody>
</table>

Local cleaning inefficiency $10^{-3}$
With collimation and dilution

Local loss rates for 1 min lifetime

Nominal beam

Nominal batch

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Conclusion

1 turn loss of pilot bunch:

Pilot \( (5 \cdot 10^9 \text{ p}) \) is above fast transient quench limit at injection.

No quench if losses are distributed over 5-10 m.

Consider **1 min beam lifetime**:

Without collimation and dilution: \( \text{up to } 3 \cdot 10^{10} \text{ p} \)

Roughly set collimation: nominal LHC batch
(assume factor 50 loss in local cleaning inefficiency)

All depends on assumptions on efficiency and beam lifetime!

Note: Efficiency must be optimized to top energy requirement before ramp!