LHC Injectors Upgrade Project

R. Garoby
OUTLINE

1. Organization

2. Strategy

3. Goals (first approach)
1. Organization
Objectives

• **Mandate**

“The LHC Injectors Upgrade should plan for delivering reliably to the LHC the beams required for reaching the goals of the HL-LHC. This includes LINAC4, the PS booster, the PS, the SPS, as well as the heavy ion chain.”

• **Implementation**

The LIU Project will:

– Analyse the status of the injectors and the HL-LHC requirements,
– Propose an upgrade path for the injectors, exploiting the work done by the Task Forces on the „PSB energy upgrade“ and „SPS upgrade“ and by the Working Group on the SPS upgrade,
– Organize the upgrades (WBS with resources and planning) and take care of their implementation,
– Take care of hardware and beam commissioning.
Organization

• **Project team**

LIU Project Leader: R. Garoby – Deputy: M. Meddahi

<table>
<thead>
<tr>
<th>Linac4 Project Leader</th>
<th>M. Vretenar</th>
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<tbody>
<tr>
<td>PSB Upgrade Coordinator</td>
<td>K. Hanke</td>
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<td>PS Upgrade Coordinator</td>
<td>S. Gilardoni</td>
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<tr>
<td>SPS Upgrade Coordinator</td>
<td>B. Goddard</td>
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• **Communication**

• Weekly meetings of the Project Team (Thursday – 9h00)
2. Strategy
Preliminary Comment

Although the work done prior to the LIU Project will be fully exploited, the upgrade path recommended for the LIU Project may differ from the conclusions of the TFs because:

• Options are still open or not precisely defined (e.g.: e-clouds in the SPS, collimation and scraping, ...)
• The PS, which was not in the mandates of the Task Forces, deserves analysis and certainly needs action
• Results from recent MDs in the injectors have to be taken into account
• Experience operating the LHC will influence the requirements
• The rate of implementation has to correspond to an acceptable spending profile for the organization.
Request to HL-LHC

Beyond the detailed beam characteristics (distance between bunches, number of bunches, intensity per bunch, emittances etc.), the technical goal (beam specifications at the entrance of LHC) has to include:

• Margin in the LHC (beam loss, emittance blow-up in LHC itself)
• Tolerance for imperfection (equality between bunches in intensity and emittances)
• List of beam types (distance between bunches, number of bunches etc.)
• List of ions to consider with their specific list of parameters

Preliminary commitment of HL-LHC => official parameter list by end of 2011

=> Need for a draft parameter list before!
LIU rules

LIU looks after the needs of the LHC, assuming that performance for the other users has to be kept unchanged:

• If performance is improved without any additional action, this shall be announced,
• If performance could be increased with additional action(s), this will be documented separately for separate financing
Planning

• 1\textsuperscript{st} December: „LIU day“
  – Descriptions of the present ideas for the upgrades,
  – Discussion with collection of reactions and suggestions.

• Chamonix 2011
  – Presentation of procedure followed by the LIU Project
  – Synthesis of open questions
  – List of required studies at the beginning of 2011 (short talk at the beginning of discussion after the last presentation in the LIU session)

• April 2011 (for the MTP 2011)
  – Recommended baseline solution for the upgrade and possible options (technical proposal)
  – Detailed work plan for 2011 and 2012 with resources
  – Baseline work plan for 2013 till 2016 with resources
3. Goals
Draft beam specifications

*Scenario for increasing the LHC luminosity*

*(private and preliminary!)*

- Nominal luminosity \(10^{34} \text{ cm}^{-2}\text{s}^{-1}\) reached with:
  - 75 ns spacing, \(1.7 \times 10^{11}\) p/b, emittances \(= 2.7 \mu\text{rad}\), \(\beta^\ast = 0.55 \text{ m}\)
  - or 50 ns spacing, \(1.7 \times 10^{11}\) p/b, nominal emittances \(= 3.75 \mu\text{rad}\), \(\beta^\ast = 0.55 \text{ m}\)
- 2 x nominal luminosity reached with:
  - 50 ns spacing, \(2.3 \times 10^{11}\) p/b, nominal emittances, \(\beta^\ast = 0.55 \text{ m}\)
  - or 25 ns spacing, \(1.15 \times 10^{11}\) p/b, emittances \(= 1.9 \mu\text{rad}\), \(\beta^\ast = 0.55 \text{ m}\)
- 3 x nominal luminosity reached with:
  - 25 ns spacing, \(1.7 \times 10^{11}\) p/b, emittances \(= 2.7 \mu\text{rad}\), \(\beta^\ast = 0.55 \text{ m}\)
- 6 x nominal luminosity reached with:
  - 25 ns spacing, \(1.7 \times 10^{11}\) p/b, emittances \(= 1.9 \mu\text{rad}\), \(\beta^\ast = 0.3 \text{ m}\)
### Assumption:

- With Linac2, the PSB can deliver $1.63 \times 10^{12}$ protons per ring within 2.5 mm.mrad and 1 eVs.
- With Linac4, the PSB will be able to provide $3.26 \times 10^{12}$ protons per ring in the same transverse emittances and 1.2 eVs.
- $\Delta Q$ at 1.4 GeV injection of 1 eVs bunch with $1.7 \times 10^{11}$ p in the PS on $h=7$ is taken as 0.25.

### Double batch from the PSB – 2 GeV – 25 ns bunch spacing

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<thead>
<tr>
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<th>6 x 1</th>
<th>8 x 1</th>
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<tbody>
<tr>
<td>Nb. of bunches from the PSB</td>
<td>6 x 1</td>
<td>8 x 1</td>
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<tr>
<td>Max. long. emittance / ring</td>
<td>4.2</td>
<td>2.8</td>
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<tr>
<td>$h(PS)$ at injection</td>
<td>7</td>
<td>9</td>
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<tr>
<td>$\Delta Q(PS)$ at injection</td>
<td>0.27</td>
<td>0.315</td>
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<tr>
<td>PS gymnastics at intermediate energy</td>
<td>Splitting $h=7$ -&gt; $h=21$</td>
<td>Splitting $h=9$ -&gt; $h=18$ Batch compression $h=18$ -&gt; $h=21$</td>
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<tr>
<td>Bunch at transition</td>
<td>$10.9 \times 10^{11}$ p /b $&lt;1.4$ eVs / $h=21$</td>
<td>$16.3 \times 10^{11}$ p /b $&lt;1.4$ eVs / $h=21$</td>
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<tr>
<td>PS gymnastics at high energy</td>
<td>Splitting $h=21$ -&gt; $h=42$ -&gt; $h=84$</td>
<td>Splitting $h=21$ -&gt; $h=42$ -&gt; $h=84$</td>
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<td>Nb of bunches at ejection</td>
<td>72</td>
<td>64</td>
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<td>Intensity per bunch (x $10^{11}$) at PS injection with nominal emittance</td>
<td>2.72</td>
<td>4.08</td>
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<tr>
<td>Intensity per bunch (x $10^{11}$) at PS ejection with nominal emittance</td>
<td>2.58</td>
<td>3.88</td>
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<td>Intensity per bunch (x $10^{11}$) at PS ejection within 2.7 mm.mrad</td>
<td>2.17</td>
<td>3.25</td>
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<tr>
<td>Intensity per bunch (x $10^{11}$) at PS ejection within 1.9 mm.mrad</td>
<td>1.5</td>
<td>2.25</td>
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