The LIU Project

Apparently single and simple goal:
To prepare the proton beam for HL-LHC after LS2 (~2021)
… it concerns also the Lead beam
+ progressive improvement of beam characteristics is important…
+ other users should not suffer and preferably benefit…

Very large extension:
- Most accelerators at CERN are concerned
- Many groups & teams are involved
- Roles overlap (close interconnection OP-LIU)
- Material resources are from multiple origins (exploitation, consolidation, LIU…)

Today’s meeting is a unique opportunity to get a snapshot at what is happening in the context of LIU
Outstanding LHC performance
LHC performance with protons in 2012

Proton-Proton: $\sqrt{s} = 8$ TeV

All Experiments $L_{Del} = 48.74$ fb$^{-1}$

Overall Performance exceeds prediction by $\sim 1.3$ fb$^{-1}$
Proton injectors’ performance for LHC in 2012

It would have been impossible without the regular and excellent proton beam delivered by the injectors...

Defined Characteristics 2004 (Source: LHC-OP-ES-0002 rev 1.0, EDMS: 487892)

<table>
<thead>
<tr>
<th></th>
<th>PSB extraction</th>
<th>PS extraction</th>
<th>SPS extraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ip / ring [x10^{11}]</td>
<td>LHC25 2.4 - 13.8</td>
<td>LHC50 1.2 - 6.9</td>
<td>LHC25 16</td>
</tr>
<tr>
<td>ε_{h} and ε_{v} [mm ∙ mrad] 1σ, norm.</td>
<td>≤ 2.5</td>
<td>≤ 2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>nb bunches</td>
<td>4 + 2</td>
<td>4 + 2</td>
<td>2.5</td>
</tr>
<tr>
<td>Ip / bunch [x10^{11}]</td>
<td>0.2 - 1.15</td>
<td>0.2 - 1.15</td>
<td>0.2 - 1.15</td>
</tr>
<tr>
<td>nb bunches</td>
<td>72</td>
<td>36</td>
<td>72</td>
</tr>
</tbody>
</table>

Expected in 2012 (Chamonix 2012)

Tentative Operational Characteristics 2012

<table>
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<tr>
<td>Ip / ring [x10^{11}]</td>
<td>LHC25 16</td>
<td>LHC50 11</td>
<td>LHC25 1.15</td>
</tr>
<tr>
<td>ε_{h} and ε_{v} [mm ∙ mrad] 1σ, norm.</td>
<td>2.5</td>
<td>1.9</td>
<td>3.5</td>
</tr>
<tr>
<td>nb bunches</td>
<td>2</td>
<td>2</td>
<td>72</td>
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</table>

Achieved in 2012

Achieved Operational Characteristics 2012

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<td>LHC25 16</td>
<td>LHC50 12</td>
<td>LHC25 1.35</td>
</tr>
<tr>
<td>ε_{h} and ε_{v} [mm ∙ mrad] 1σ, norm.</td>
<td>2.3</td>
<td>1.35</td>
<td>2.4</td>
</tr>
<tr>
<td>nb bunches</td>
<td>2</td>
<td>2</td>
<td>2</td>
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</table>

Nominal specs’
LHC performance for p-Pb in 2013

- Full instantaneous luminosity $1 \times 10^{29} \text{ cm}^{-2}\text{s}^{-1}$ already reached with the first fill with full filling scheme
- Levelling in ALICE at $1 \times 10^{29} \text{ cm}^{-2}\text{s}^{-1}$ in almost all standard fills
- Two fills were done with IP1 and 5 separated, allowing ALICE to catch up after initial minimum-bias
- Van der Meer scans done in both configurations
- Final integrated luminosity above experiments’ request of 30 nb$^{-1}$
- The run ended with record peak luminosity of $1.15 \times 10^{29} \text{ cm}^{-2}\text{s}^{-1}$, record turn around of 2.37 h

R. Versteegen
Injectors provided very good quality Pb beams: average number of ions per bunch was $1.44 \times 10^8$ at start of stable beams (mean over the run), i.e. almost twice the nominal.

Most fills were dumped by the BPMSs thresholds in IR6 due to misreading for low intensity Pb bunches.

BPMSs' limit was reached faster with B1 (Pb-p) than with B2 (p-Pb),

Durations of more than 10h were reached with intermediate filling schemes and special fills colliding only in ALICE (and LHCb).

**Result of the combined efforts of OP and LIU project teams!**
Remarkable progress of LIU developments
Beams expected @ SPS extraction after LS1

<table>
<thead>
<tr>
<th>Baseline for physics</th>
<th>Bunch intensity ([10^{11} \text{ p/b}])</th>
<th>Transv. Emittance** ([1 \sigma \text{ norm, mm.mrad}])</th>
<th>Bunches per batch (@ SPS inj.)</th>
<th>PSB rings</th>
<th>Harm. @PS inj.</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 ns****</td>
<td>1.15</td>
<td>2.8</td>
<td>72</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>25 ns BCMS</td>
<td>1.15</td>
<td>1.4</td>
<td>48***</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>Eventually for startup</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50 ns</td>
<td>1.65</td>
<td>1.7</td>
<td>36</td>
<td></td>
<td>7</td>
</tr>
<tr>
<td>50 ns</td>
<td>1.6</td>
<td>1.2</td>
<td>24</td>
<td></td>
<td>9</td>
</tr>
</tbody>
</table>

** Transverse Emittance = \((\varepsilon_h + \varepsilon_v)/2\)

Beam are produced approx. round: linear coupling in PS used to avoid Head-tail instability

*** Filling scheme with batches of 48 bunches exists giving a reduction of 8% in Luminosity compared to the same scheme with 72 bunches

**** Better performances measured during scrubbing run: 1.15 \(10^{11}\) p/b, 2.4 - 2.5 mm.mrad

1.4 \(10^{11}\) p/b produced but no emittance measurements available @SPS

Combined effects of progresses in PSB (refined adjustments), PS (BCMS...) and SPS (Q20...)
Progress in beam studies

- Progress in the PSB (Low emittance, space charge...) – E. Benedetto
- Progress in the PS (Xverse damper, resonance compensation, impedance...) – G. Sterbini
- Progress in the SPS (transfer efficiency, beam instabilities, ...) – T. Argyropoulos
- BCMS beam results (up to LHC...) – S. Hancock
- Q20 in SPS – H. Bartosik
- Progress on e-clouds (PS and SPS) – G. Iadarola
- Results and plans for Lead ions – D. Manglunki
Progress in hardware development

- Linac4 construction status and plans – M. Vretenar
- Latest results in the 3 MeV test place (RFQ, ion source, chopper...) – G. Bellodi
- H⁻ injection system in the PSB – W. Weterings
- Finemet cavities: status and plan for PSB RF and PS damper during LS1 – M. Paoluzzi
- Digital LLRF – M.E. Angoletta
- Potential of the wide band transverse damper – G. Kotzian

Planned changes during LS1

- PSB (new dump, new PCs for multipoles,...) – K. Hanke
- PS (shielding, long, damper,...) – S. Gilardoni
- SPS (new BWS, 800 MHz upgrade...) – B. Goddard
LET’S LISTEN TO THE ACTORS...
AND CELEBRATE!

[16h20 – Salle des pas perdus]