**READINESS OF AND PLANS FOR THE INJECTORS FOR 2009**

E. Métral (15 + 5 min, 13 slides)  
*(for the Injectors Complex Team)*

- **PROTONS: news in 2008**
  - Rephasing SPS-LHC ➔ Possibility to extract p beams to LHC
  - Low intensity probe beam: 2E9 p/b (instead of 5E9)
  - 25 ns (LHC25) and 75 ns (LHC75) beams with intermediate intensities
  - Controlled transverse emittance blow-up in SPS
  - 2 requests from the LHCCWG held on 13/02/08
    - 1 LHCINDIV + 1 LHCPILOT (at the same time) in SPS
    - 50 ns beam (LHC50)
  - Production of the LHC75(50) in 1 batch (instead of 2) into PS

- **IONS: news in 2007 and 2008**
  - Early beam ➔ SPS commissioning in 2007
  - New 18 GHz source in 2008 (instead of 14.5 GHz)

- **CONCLUSION AND PLANS FOR 2009**
Rephasing SPS-LHC ➔ Possibility to extract p beams to LHC

- 2-step process:
  - Frequency matching: lock SPS RF onto LHC RF/2
  - Phase matching: align SPS bunches with LHC buckets
- Rephasing fully qualified on 08/08/2008

**PROTONS: NEWS IN 2008**

Courtesy of P. Baudrenghien
Low intensity probe beam: 2E9 p/b (instead of 5E9)

- LHCPROBE with new definition (following 1st LHC injection tests of 09-10/08/08): 2E9 p/b

- Discussions (and actions) to see whether the intensity should be reduced in PSB, PS or SPS

- Finally, it was decided to do it in the PS
  - Longitudinal shaving at the start of the ramp
  - Possibility to scan from 2E9 to 5E9 p/b with only 1 Timing

Example of ~2.5E9 p/b in the SPS (on LHCFAST)
25 ns and 75 ns beams with intermediate intensities

- Intermediate intensities created (archives made for LHC25) in the PSB: 1/10, 1/5, 1/3, 1/2, 2/3, WITHOUT taking care of the transverse emittances (it was decided that the controlled transverse emittance blow-up will be done, if needed, in the SPS). Longitudinal parameters are preserved.

SPS BCT

Example of ~ 1/10 for LHC25 in the SPS (on LHCFAST)

SPS FBCT

at inj.
Controlled transverse emittance blow-up in the SPS

- Goals were reached for both single-bunch and multi-bunch beams ➔ From ~1 µm to ~3-3.5 µm (rms. norm.), with good reproducibility
- Case of the previous beam (LHC25, 1/10) on LHCFAST cycle shown below

**BWSH51995**

<table>
<thead>
<tr>
<th>WITHOUT</th>
<th>WITH</th>
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<tr>
<td>$\sigma_x = 0.37 \text{ mm}$</td>
<td>$\sigma_x = 0.74 \text{ mm}$</td>
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<td>$\varepsilon_x = 0.8 \mu\text{m}$</td>
<td>$\varepsilon_x = 3.2 \mu\text{m}$</td>
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**BWSV51995**

<table>
<thead>
<tr>
<th>WITHOUT</th>
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<tr>
<td>$\sigma_y = 0.20 \text{ mm}$</td>
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<tr>
<td>$\varepsilon_y = 0.7 \mu\text{m}$</td>
<td>$\varepsilon_y = 3.0 \mu\text{m}$</td>
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Different acceleration between LHC NOMINAL and LHCFAST cycles: 4320 (or 15120) vs. 7590 (or 18390)

Elias Métal, LHC Performance Workshop, Chamonix 2009, 02-06/02/2009
2 REQUESTS FROM THE LHCCWG (held on 13/02/2008)

- (a) 1st priority: Check what happens in the SPS if we inject 2 bunches, 1 with high intensity (LHCINDIV in the PS) and 1 with low (LHCPILLOT in the PS)
  - Contact person: E. Métal

- (b) 2nd priority: Check that we can still produce the 50 ns beam in the PS and see what happens in the SPS
  - Motivation: This 50 ns option is interesting again to try and satisfy the need of low luminosity in IP2

Discussion with W. Herr (14/02/08): With the 50 ns beam (without changing anything) the luminosity is reduced by a factor 2 (2 times less bunches) and the long range effects are also reduced by a factor 2. If in addition, the transverse emittances are 10-15% smaller then one can almost completely forget about long-range beam-beam effects!
1 LHCINDIV + 1 LHCPILOT (at the same time) in SPS

→ On Nominal cycle

- Bunch length measured just before extraction
  - LHCINDIV → 1.2 ns (4σ)
  - LHCPILOT → 0.8 ns (4σ)
- Measured transverse emittances: ~ 2.5 µm
50 ns beam

- “Nominal” LHC50 in the PSB = LHC25 $\frac{1}{2}$ (No user in the PSB)
- Reminder: The batch spacing for LHC50 should be 9 (25 ns) empty buckets, i.e. 250 ns (instead of 225 ns for LHC25 and LHC75)
- Issues with SPS interlocks (outgassing): ZS ion trap and MKDV1

- ~ 80% of nominal intensity shown below
- Total intensity increased to ~ 1650E10 p (~ nom. int.) at 19:59 on TU 07/10/08

TIME [ms]
Production of the LHC75(50) in 1 batch (instead of 2) into PS

- Very promising results for LHC75_1b in PSB and PS (as well as with LHC50_1b in PSB)
- No major difficulties found in PSB: 3 rings on h2 at extraction + h1 (to match h7 in the PS) + synchro h1
- LHC75_1b should be OK in the PS ➔ Trade-off between longitudinal emittance and PSB extraction kicker rise-time (106 ns)
- LHC25/50_1b are excluded in the PS without lengthening the injection plateau by ~ 40 ms for longitudinal blow-up before 3-splitting

Courtesy of S. Hancock

LHC75 injected in 1 batch into PS

- 6 bunches measured in PS.
  - Small oscillations might be reducible with better energy matching, but are comparable with the ‘every day’ situation
  - PSB-to-PS transfer line steering not optimal due to lack of time (ring2 intensity loss)
IONS: NEWS IN 2007 AND 2008

Early beam → SPS commissioning in 2007

- **Intensity**
  - Design: $2.952 \times 10^8$ charges
  - Achieved: 10% smaller than design

- **Transverse emittances (rms, norm)**
  - Design: $1.2 \, \mu$m
  - Achieved: 25% smaller than design

- **Tunes optimization**: 26.13 / 26.25

4 bunches of $9 \times 10^7$ ions ($\text{Pb}^{82+}$)

~ 7 s long injection plateau instead of ~ 40 s in the nominal scheme

No synchronization with LHC!

Beam seen at the beginning of one of the extraction lines towards LHC (TT60/TI2)
New 18 GHz source in 2008 (instead of 14.5 GHz)

- **Scaling law:** $I \propto f^2 \Rightarrow$ Going to 18 GHz “should” increase the ion current by $\sim 50\%$ (giving more margin for nominal LHC beam)

- **Results in 2008:**
  - Source works with 18 GHz (as stable as with 14.5 GHz)
  - No performance increase (yet) with 18 GHz at the end of the linac, but the performance with 14.5 GHz was the result of several years of tuning
CONCLUSION AND PLANS FOR 2009: PROTONS

- Several “new” LHC beams/flavours have been produced in 2008 and are ready for the LHC in 2009

- A particular attention was paid to low-intensity beams (with good reproducibility) in 2008 to be ready for the LHC’s (first) requests

- Production of the LHC75 in 1 batch (instead of 2) into PS
  - MDs will be planned asap to check all open issues in detail
  - Once it is OK it should become the baseline (after approval by relevant committee)

- Production of the LHC25/50 in 1 batch (instead of 2) into PS
  - Injection plateau has to be increased by ~ 40 ms for longitudinal blow-up before 3-splitting
  - MDs needed to study trans. emittance conservation vs. intensity
CONCLUSION AND PLANS FOR 2009: IONS

◆ EARLY BEAM: Several weeks of setting-up and MD time are necessary to make a first LHC ion run possible (~ end of September)

◆ NOMINAL BEAM
- Only LEIR made some progress in 2007
- PS HW needs rebuilding, testing, setting up
- Alternative filling schemes (to minimize IBS and SC) need to be tested in SPS
- LHC crystal collimation studies ➔ Many MDs foreseen in 2009

◆ No ions in rings since November 2007 ➔ Recommissioning needed (controls, RF, power supplies, etc.)

ACK: P. Baudrenghien, C. Carli, S. Hancock, K. Hanke, D. Küchler, D. Manglunki, S. Maury, G. Rumolo, R. Steerenberg…
Reminder: key parameters for Nominal beam (same bunch for Early)

<table>
<thead>
<tr>
<th></th>
<th>ECR Source</th>
<th>Linac 3</th>
<th>LEIR</th>
<th>PS</th>
<th>SPS</th>
<th>LHC</th>
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<td>2.5 KeV/u</td>
<td>4.2 MeV/u</td>
<td>72.2 MeV/u</td>
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<td>177 GeV/u</td>
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<tr>
<td>(^{208}\text{Pb}) charge state</td>
<td>29+</td>
<td>29+ (\rightarrow) 54+</td>
<td>54+</td>
<td>54+ (\rightarrow) 82+</td>
<td>82+</td>
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<tr>
<td>Output B(_{p}) [Tm]</td>
<td>2.12 (\rightarrow) 1.14</td>
<td>4.80</td>
<td>86.7 (\rightarrow) 57.3</td>
<td>1500</td>
<td>23350</td>
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<tr>
<td>bunches/ring</td>
<td>2 (1/8 of PS)</td>
<td>4</td>
<td>52</td>
<td>592</td>
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<tr>
<td>ions/pulse</td>
<td>(9 \times 10^9)</td>
<td>(1.15 \times 10^9)</td>
<td>(9 \times 10^8)</td>
<td>(4.8 \times 10^8)</td>
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<tr>
<td>ions/LHC bunch</td>
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<td>(2.25 \times 10^8)</td>
<td>(1.2 \times 10^8)</td>
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<td>bunch spacing [ns]</td>
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<tr>
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<td>2.6</td>
<td>1.75</td>
<td>0.14</td>
<td>0.0063</td>
<td>0.0005</td>
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</table>
| Repetition time [s]     | 0.2-0.4    | 0.2-0.4  | 3.6     | 3.6      | \(\sim\)50 | \(\sim\)10\text{fill/}

LHC Performance Committee, Oct 22\textsuperscript{nd} 2008
Conclusions

• The instantaneous pressure rises in MKDV kickers shows a clear threshold effect with intensity.
• There is a relative fast conditioning effect.
• Phenomena is present for 50nsec and 75nsec spacing.
• Depends on bunch length
• Depends on batch spacing
• Time behaviour of MKDV1 and MKDV2 different

*Courtesy of K. Cornelis (SPSU meeting, 18/11/08)*