Chamonix14
Session 3: 2015 commissioning with beam

Mike Lamont and Giulia Papotti

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Situation

• The LHC has been pulled apart and put back together again
• There have been major system consolidation and upgrades including significant control system upgrades at all levels
• Operationally not a new machine, carry forward considerable experience – however will face familiar and new challenges
## 2015 – Energy

<table>
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<th>Issue</th>
<th>Possible effects</th>
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<tr>
<td>Higher stored beam energy</td>
<td>Even bigger disaster if things go wrong</td>
</tr>
<tr>
<td>Lower tolerance to beam loss, lower quench margins</td>
<td>Premature beam dumps&lt;br&gt;Tighter parameter control required</td>
</tr>
<tr>
<td>More energy dumped in triplets and collimator regions</td>
<td>Beam loss, heat load</td>
</tr>
<tr>
<td>Lower intensity set-up beams</td>
<td>Commissioning efficiency</td>
</tr>
<tr>
<td>Systems closer to maximum (RF, converters, beam dump...)</td>
<td>Premature dumps, asynchronous dumps</td>
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2015 – 25 ns

<table>
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<tr>
<th>Issue</th>
<th>Possible effects</th>
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<tbody>
<tr>
<td>Injection of 25 ns beams</td>
<td>Bigger beam size, higher intensity per injection</td>
</tr>
<tr>
<td>Electron cloud</td>
<td>Instabilities, emittance growth, desorption, heat-load</td>
</tr>
<tr>
<td>UFOs+</td>
<td>Premature dumps</td>
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<tr>
<td>Long range beam-beam</td>
<td>Poor lifetime, larger crossing angle</td>
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Scrubbing will be one of the main drivers of commissioning 2015
Experiments

• See 2015 as a commissioning year and an investment
  – 25 ns very strongly favored
  – It is accepted that running at 25 ns could result in lower delivered luminosity
  – Will accept up to 1 fb\(^{-1}\) @ 50 ns
• Target energy taken to be 6.5 TeV
• Peak mean pile-up of around 50 “is considered to be acceptable” – un-levelled
Special runs

• 5 days initially:
  – Low pileup and un-squeezed optics for LHCf and VdM

• Later:
  – High $\beta^*$ (90m) for TOTEM/ALFA (pilot or extended)
  – Precision VdM
  – Intermediate proton-proton run

• Ions (baseline - 5.1 TeV)
  – Peak luminosity: $3$ to $4 \times 10^{27}$ cm$^{-2}$s$^{-1}$
  – Estimate around $0.8$ nb$^{-1}$ (John Jowett)
2015 proton run outline

50 ns commissioning and scrubbing

50 ns intensity ramp-up + physics run

Use same parameters as for 25 ns relaxed

25 ns commissioning and scrubbing, relaxed scenario

25 ns intensity ramp-up + physics run, relaxed

Main focus in this talk

25 ns commissioning, pushed scenario

25 ns intensity ramp-up + physics run, pushed

Parameters depend on experience with beam

R. Bruce, 2014.09.23
Collimation/beta*

• **Run 2:** Many things have changed - **start carefully**...

• For initial 50 ns run, use same settings as for 25 ns

• **Collimator settings:** 2012 settings in mm

• **11 σ** beam-beam separation

• **$\beta^* = 80\text{cm}$** at startup to allow relaxed margins
  – Establish limits (aperture, stability...)
  – Push performance later when limits are better known
  – Ultimate 2015 around $\beta^* = 40\text{ cm}$
How can the gain in aperture be used?

- Gain in aperture margin
- Gain in MP margin – move out TCTs
- Gain in impedance – move out all collimators
- OR: increase crossing angle and $\beta^*$ – plot doesn’t change
Optics - options

• **MINIMUM**: no optics change w.r.t. 2012
  – Except those necessary for 25 ns, 6.5 TeV

• **MEDIUM**: same as MINIMUMUM, with
  – New IR4 optics.
  – Tweaked IR6 optics (MKD-TCDQ phase)
  – IR1/2/3/5/6/7 same optics as MINIMUMUM

• **MAXIMUM**: overall new injection and collision optics, and crossing scheme, **ATS-compatible**
Optics - status

• **MAXIMUM:** ATS compatible optics studied in depth
  – potential issues found
  – felt prudent to stay with something more familiar initially
  – to be developed and deployed in Run 2

• **MEDIUM:**
  – Improvements for BI and ADT enumerated
  – In the process of validation...
    • Performance in terms of DA. It is closer to option-min and no surprises are expected.
    • Performance in terms of cleaning efficiency.
## Nominal cycle

<table>
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<tr>
<th>Phase</th>
<th>Minimum Time [mins]</th>
<th>Details</th>
</tr>
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<tbody>
<tr>
<td>Pre-cycle/ramp-down</td>
<td>85 pre-cycle, 65 ramp-down</td>
<td>Work on ramp-down times during hardware commissioning (QF/QD/QX)</td>
</tr>
<tr>
<td>Pre-injection set-up</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Set-up with beam</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Injection</td>
<td>30</td>
<td>24*SPS@40s/cycle, better orbit control in the SPS, stability of extraction power supplies, LICs, transverse damper - defensive cleaning</td>
</tr>
<tr>
<td>Prepare ramp</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Ramp</td>
<td>20.5</td>
<td>Re-measure snapback, Q’ etc. FiDel in good shape</td>
</tr>
<tr>
<td>Flat-top</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Squeeze</td>
<td>12.5</td>
<td></td>
</tr>
<tr>
<td>Collide</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>3h full precycle 2h45m rampdown</td>
<td>More exotics options – test/deploy later in run</td>
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Matteo Solfaroli
Experience in Run 1 showed that the electron cloud can limit the achievable performance with 25 ns beams mainly through beam degradation at low energy and high heat load at high energy.

To cope with nominal number of bunches more scrubbing is necessary.

→ Main goal: e-cloud suppression in the dipole magnets (all along the fill)

- It would bring the arc heat loads well within cooling capacity
- It would significantly improve beam quality preservation

G. Iadarola and G. Rumolo
Buildup simulations show **a substantial enhancement of the e-cloud** with the “doublet” bunch pattern.
“Doublet” scrubbing beam: PyECLoUD simulation results

Buildup simulations show a substantial enhancement of the e-cloud with the “doublet” bunch pattern.

PyECLoUD simulations for the LHC arc dipoles

- **50 ns beam**: 
  - ~1400 bunches
  - $1.7 \times 10^{11}$ p/b

- **25 ns beam**: 
  - ~2800 bunches
  - $1.15 \times 10^{11}$ p/b

- **Doublet beam**: 
  - ~2800 doublets
  - $0.7 \times 10^{11}$ p/b
"Doublet" scrubbing beam: PyECLoUD simulation results

Buildup simulations show a substantial enhancement of the e-cloud with the "doublet" bunch pattern.
### “Doublet” scrubbing beam: PyECloud simulation results

Buildup simulations show a **substantial enhancement of the e-cloud** with the “doublet” bunch pattern.

For example if: \( \text{SEY}_{\text{dip}} = \text{SEY}_{\text{quad}} = 1.45 \):

<table>
<thead>
<tr>
<th></th>
<th>( N_{\text{bunches}} )</th>
<th>Bunch int.</th>
<th>Total int.</th>
<th>Heat load</th>
<th>( P_{\text{dip}} )</th>
<th>( P_{\text{quad}} )</th>
<th>( P_{\text{TDI}} ) *</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Std. 25 ns beam</strong></td>
<td>~2800</td>
<td>1.15 ( x 10^{11} ) p/b</td>
<td>3.2 ( x 10^{14} ) p/beam</td>
<td>71 W/hc/beam</td>
<td>1 W/m</td>
<td>9.2 W/m</td>
<td>415 W</td>
</tr>
<tr>
<td><strong>Doublet beam</strong></td>
<td>~900</td>
<td>0.7 ( x 10^{11} ) p/b</td>
<td>1.2 ( x 10^{14} ) p/beam</td>
<td>125 W/hc/beam</td>
<td>2.6 W/m</td>
<td>3.2 W/m</td>
<td>107 W</td>
</tr>
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</table>

With the doublet beam:
- Arc beam screen **cooling capacity fully exploited**
- Stronger EC with significantly **lower total intensity**
- Scrubbing power much **better distributed along the arc**
- Lower intensity have a **positive impact on impedance heating** on sensitive elements (e.g. TDI)

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**Plan B**: If scrubbing insufficient even with scrubbing beam, the **8b+4e scheme** could provide a significant e-cloud mitigation with 50% more bunches compared to 50 ns beam

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Giovanni Iadarola and Giovanni Rumolo
Conclusions

• 2015 should be interesting
  – Lots of experience but new challenges

• Collimation, beta*, optics, other parameters:
  – Settling to a consensus
  – Conservative choices - better to deal with the known unknowns

• Scrubbing
  – Will be critical
  – Doublet beam attractive – development in SPS and early tests in LHC – priority
  – Two stage scrubbing strategy is proposed...

Many thanks to the speakers!