Experiments desiderata

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on behalf of the LHC Experiments

- where we stand, what we wish
- luminosity / pile-up requirements, other parameters
- projections
- special physics requests
One of these silly slides shown at Chamonix 2011

ProJECTION

- Suppose: $L_{\text{start}} = 4.5 \times 10^{32}$, $L_{\text{yeah}} \approx 1.2 \times 10^{33}$, $L_{\text{yeswecan}} = 2 \times 10^{33}$
- 124 days high lumi physics days
  - 35% of that in stable beams, decay factor 0.7

144 high lumi physics days

SM Higgs is discovered
or
SM Higgs is history

Going to $L_{\text{yeah}}$ asap can make quite a difference at the end

(This was the aggressive projection)
And now it looks like this

- Suppose: $L_{\text{start}} = 4.5 \times 10^{32}$ \hspace{1cm} $L_{\text{yeah}} = \sim 1.2 \times 10^{33}$ \hspace{1cm} $L_{\text{yeswecan!}} = 2 \times 10^{33}$

- 124 days high lumi physics days
  - 35% of that in stable beams, decay factor 0.7

144 high lumi physics days

- ATLAS/CMS
  - $\sim 1.3 \text{fb}^{-1}$ at $\sim 25 \text{pb}^{-1}$/day

I choose $t=0$ is Apr 13 (after scrubbing)

80 more days?

28 pb$^{-1}$ collected before the scrubbing, 2 weeks at 75ns
Physics Reach

**LHCb will probe the standard model range with 1 fb⁻¹ in Bₛ → μ⁺μ⁻.**

<table>
<thead>
<tr>
<th>ATLAS + CMS</th>
<th>95% CL exclusion</th>
<th>3σ sensitivity</th>
<th>5σ sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 fb⁻¹</td>
<td>120 - 530</td>
<td>135 - 475</td>
<td>152 - 175</td>
</tr>
<tr>
<td>2 fb⁻¹</td>
<td>114 - 585</td>
<td>120 - 545</td>
<td>140 - 200</td>
</tr>
<tr>
<td>5 fb⁻¹</td>
<td>114 - 600</td>
<td>114 - 600</td>
<td>128 - 482</td>
</tr>
<tr>
<td>10 fb⁻¹</td>
<td>114 - 600</td>
<td>114 - 600</td>
<td>117 - 535</td>
</tr>
</tbody>
</table>

**LHCb projection from 37 pb⁻¹ √s = 7 TeV**

37 pb⁻¹  500 pb⁻¹  1 fb⁻¹
- Leveling is a success: gives an extra factor 1.4 on integrated lumi
- LHCb working hard to push upward the working point
  - Operated at 3e32Hz/cm² in June, tested up to 4e32Hz/cm² and will run at 3.5e32Hz/cm² this summer
  - NEED LARGEST POSSIBLE NR OF COLLIDING PAIRS
    (to keep pile-up under control)
  - NEED LARGEST NR OF HOURS
- Status: ~0.4 fb⁻¹, 9 pb⁻¹ / day
- Exceeding the 2011 target of 1 fb⁻¹ remains a challenge, though a sensible one.
The rule of thumb

The chart shows the time in stable beams (2011) with different time values per day:

- 9.3h/day
- 8.2h/day
- 7.8h/day

The graph represents the integrated time in stable beams over weeks, with specific sections marked for TS1, Scrub, MD1, and TS2.

The chart is generated on 2011-06-30 08:07 including fill 1901.

1 day of physics operation for 8h of stable beams
From the previous slide, everybody think now that
(with 90 more days of high luminosity physics, see later)

4 fb\(^{-1}\) delivered to IP1 and IP5 each

1 fb\(^{-1}\) delivered to IP8

are realistic wishes (and even more seems achievable!).

Thus, any change (improvement) of LHC operation should be considered in the light of these (now realistic) integrated luminosity expectations for 2011.

Setup time to be balanced with gain in integrated lumi.
- pp physics operation: 101 days
- Post-TS ramp up: 2 x 2.5 days
- Special physics: 6 days?

90 days of high lumi operation

-2 days of floating MD?
Wishes from experiments: luminosity / pile-up

- In general:
  - Maximum integrated luminosity $L_{\text{int}}$
  - For same integrated luminosity, prefer less pile-up

- ATLAS / CMS:
  - Main aim: maximize $L_{\text{int}}$, push instantaneous luminosity, but without compromising high machine efficiency
  - An extended physics period up to $3 \times 10^{33}$ before further increase seems like a reasonable strategy
  - Pile-up: might become a challenge when $\mu > 25$
    - Want to explore highest possible PU at end of run

- LHCb:
  - Maximize $L_{\text{int}}$, i.e. maximize running time
  - Instantaneous luminosity: run at fixed value, $\sim 3.5 \times 10^{32}$ Hz/cm$^2$
    - no luminosity decay, continue with leveling (great, so far!)
  - Pile-up: $\mu < 2.5$

- ALICE:
  - Maximize $L_{\text{int}}$, i.e. maximize running time
  - Instantaneous luminosity: $5 \times 10^{29}...5 \times 10^{30}$ Hz/cm$^2$, but
  - Pile-up: $\mu < 0.05$

$\mu = \text{average number of inelastic interactions per bunch crossing (now = } \sim 7 \text{ in IP1/5)}$
Special physics activities

- 90m third fill => around Sep TS4/MD3
- 90m n x physics fill => TBD
- TOTEM/RPs 147m => not before Sep TS4
- ALICE field reversal => not before Sep TS4
- precise lumi calib => not before Sep TS4
- 25ns physics fill => not before end of Sep

Remember the rule of thumb: 8h of m.a.time = 1 real day of operation

Some of these will have to be dropped / reduced

machine-available time

~8h
n x ~8h
will be discussed with the experiments early Sep

~8h
~16h
2 x ~8h
~8h
Integrated luminosity: what will you push?

- Physics time and $k_b$: these do not increase pile-up
- While $N$, $\beta^*$ and $\varepsilon_T$ all do increase pile-up
- Increasing $N$: fairly small setup time? (adiabatic changes)
- Reducing $\varepsilon_T$: fairly small setup time? (adiabatic changes)
- Reducing $\beta^*$: how much setup time?
  - Gain in peak lumi to be balanced with commissioning time $\Rightarrow$ intLumi $L$
  - Perhaps profitable for next year's planning and perhaps for 2011 ion run
  - For LHCb: no gain from smaller $\beta^*$, can only give a loss $\Rightarrow$ 1 fb$^{-1}$ in danger?
- $k_b \Rightarrow$ 25ns: how much setup time?
  - 25ns operation is profitable for all expts, if can achieve same $L$
  - Lumi production at 25ns for this year seems inadequate
    - estimate for scrubbing time? some experiments might need time to adapt?
  - Expts wish for at least one stable beams fill, but toward end of run
    - prepare for possible use of 25ns during next year's physics production
In Summary

- LHC routinely operated at $>1\times10^{33}$ machine since mid May
  - 2011 goals for IP1/5 already achieved!
  - 8h stable beams per day (room for improvement?)
- Prospects for $>1\text{ fb}^{-1}$ at IP8 and $>4\text{ fb}^{-1}$ at IP1/5 look very good
- The experiments would favour increasing the luminosity by those means which have the least cost in hours of stable beams

This probably means:
- Maximize physics operation time (machine availability)
- Reduce $\varepsilon_T$ (50ns double batch...)
- Increase bunch charge

Reducing $\beta^*$ and increasing $k_b$ (25ns): keep it "exploratory" in view of 2012 and ion run, to be carefully balanced with impact on integrated luminosity
Possible benefits for machine performance:
- less resistive losses (cryo, kicker, collimators ?)
- less intra-bunch scattering (compensate for decrease in $\varepsilon_T$)

For the experiments?
- reduction in acceptance ?
- better separation of vertices ?
Ions in 2011

**Pb run: Goals for 2011**

- Had no time to discuss
- Will pick this up at mid August

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30 \( \mu \text{b}^{-1} \) delivered to each of IP1, IP2 and IP5 at 3.5 TeV (or higher energy) sounds like a reasonable p-A test in 2011 is much welcome (for physics in subsequent ion run)

- quadruple statistics
- \( \beta^* = 1.5 \text{ m or smaller} \) ? \( L \times 2.3 \)
- nominal scheme \( L \times 2-5 ? \, N/\varepsilon_N \) loss ?

LHCb is discussing presently to run during ions (few colliding pairs).
How will the LHC reach previously established maximum luminosity after a technical stop?

From rMPP 28.06.2011:

- test ramp with a pilot
- physics fill with 2x2 nominal bunches
  - also loss maps?
- physics fill with ~50 nominal bunches
- physics fill with ~260 nominal bunches
- physics fill with ~850 nominal bunches
- back to 1380 bunches

Total: ~4x5h of machine-available time, i.e. 2.5 days of operation

These can all be short (1-3h stable beams for the expts to collect some data and check out the detectors?)