Summary – what we discussed and learned (accelerator)

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(Starting from a personal perspective to trigger discussions)
Starting considerations

Improving the present performance of the VdM scans is very challenging and call for (even closer) collaboration between experiments and machine in a series of subjects.

Depending of the experiments, among the contributions to the systematic errors possibly related to the machine we have:

- scan-to-scan variation,
- x-y non-factorization,
- orbit stability,
- beam current-calibration,
- beam-beam effect,
- …

In this context, the present understanding of the luminosity and emittance evolution can be improved by a closer collaboration with the experiment.

e.g., uncertain breakdown from R. Hawksings (ATLAS)
VdM Bunch from Injectors

- General consensus on improved quality of the beam form the Injector Chain after 2012, but this did not solved the non-factorization.
- For Run3, the strategy in the PSB may change due to the improved LINAC4 emittances, but clear commitment in producing the VdM beam during Run3 first year.

Single bunch beam parameters requested by LHC

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>Intensity</td>
<td>0.7-0.9x10^{11} p/b</td>
</tr>
<tr>
<td>Transverse emittance (norm.)</td>
<td>≥ 2.5 μm</td>
</tr>
<tr>
<td>Transverse distribution</td>
<td>Gaussian</td>
</tr>
</tbody>
</table>
Difficulties to measure the optics for VdM scan \((\beta^* = 19/24 \text{ m}, \text{ Q1 k-mod})\). In principle an optics with \(\beta^* = 17 \text{ m}\) can be easier to measure.

Can a \(\beta^* = 17 \text{ m}\) optics be considered for VdM Run3?

### 2016 MD on VdM: \(\beta^*\) measurement

#### Uncertainties
- Magnet misalignment of 6 mm rms.
- Magnet strength error: \(\Delta K/K = 10^{-3}\).
- Tune uncertainty: \(\delta Q = 5.0 \cdot 10^{-5}\).

<table>
<thead>
<tr>
<th>Beam 1</th>
<th>Beam 2</th>
</tr>
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<tbody>
<tr>
<td>IP</td>
<td>(\beta_x^*)</td>
</tr>
<tr>
<td>IP1</td>
<td>17.4 ± 0.02</td>
</tr>
<tr>
<td>IP5</td>
<td>33.06 ± 24.17</td>
</tr>
<tr>
<td>IP8</td>
<td>21.52 ± 0.03</td>
</tr>
</tbody>
</table>

- Reasonable for IP1.
- Very bad measurement for \(\beta_x^*\) in IP5 and \(\beta_y^*\) in IP8.
Protocol for the VdM scans

Beam displacement sequence controlled by experiment-provided files: pre-programmed scan are less error prone approach!

Clear non-factorization observed from the experiments...

LHCb is performing a 2D scan aiming to relax the hypothesis of the x-y factorization. Can a similar approach be considered in the other experiment?
VdM BB simulations

- The linear approach used until now should be improved → from single particle parameters to distributions.
- To find optimal agreement between the COMBI/Balagura results.
- Find a parametrization to apply this correction in the VdM scan (complex BB schedule...)

![Graph](image-url)
Effect along the train

- Patterns with trains emerged: are they related to BB?

- Luminosity monitoring with emittance scans
  
  Define figure of merit \( F_{oM} = \frac{L_{spec,0}}{L_{spec,beam}} \)

- Observe bunch dependence and global downwards trend → Cause is not clear yet (also see next slide)
Instrument calibration and precision

- Important to track and document the performance of the beam instrumentation (legacy data).
- **Synergy with LHCb** for measuring the ghost bunches.
- **DOROS performance** good for the (limited) intensity drop observed during the VdM scan.
Instrument calibration and precision

- Important to track and document the performance of the beam instrumentation.
- Synergy with LHCb for measuring the ghost bunches (limit in the BSRL).
- DOROS performance very good for the (small) intensity drop observed during the VdM scan.
VdM scan and crossing angle

- Currently unused, Q1 BPMs could be made available during VdM scans to quantify any drifts from zero crossing angle.
- Same BPM, same cables, same electronics are used to acquire both beams which eliminates many systematics.
Orbit stability and Corrector Hysteresis

- Orbit feedback is off during the VdM.
- Orbit drift has to be taken into account during the scan: more automatic approach to monitor the orbit drift?
- ATLAS observed hysteresis effect → systematic characterization during Run 3? can leap-frog scan help?

*Tides in November 2016 (4 TeV p-Pb)*

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**Tides in November 2016 (4 TeV p-Pb)**

![Graph showing tides in November 2016 for 4 TeV p-Pb collisions. The graph depicts fluctuations in Δp/p (ppm) over the days of November 2016.](image)
Despite the efforts with WS and BSRT] “Emittance from luminosity not self consistent”.

Significant (and appreciated) efforts from CMS in the emittance scans.

Transverse and longitudinal emittance is a very important input for the luminosity model.
Bunch-by-bunch luminosity

- First results of the bunch-by-bunch fluctuation presented.
- It seems the effect is enhanced in 2018 with the BCMS beams, therefore the interest to further understand it as may affect the machine/experiment performance in Run 3 or HL-LHC.