Buch-by-bunch Luminosity Variations in LHC Run 2

Short Update - summary?

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..selected slides with key results shown in LPC, HSI and WP2 meetings, plus few slides on losers from G. Iadarola
Bunch Luminosity Fluctuations

The issue: bunch to bunch fluctuations in Lumi increase with time during stable beams

RMS change from ~12% to ~25% in 14h

RMS increase driven by mainly due to intensity variations (losses)

Separate by bunch families:
- bunches colliding in IP1/IP5 only
- 1st in injection (no e-cloud, low BBLR)
- leading bunch in each train (low e-cloud, low BBLR)
- 12th bunch in train (max e-cloud, max BBLR)
Bunch Luminosity Fluctuations

- Effect of x-sing angle change clearly visible for the bunches that have max e-cloud and BBLR contributions

- No RMS increase for a non-colliding train
- ~same e-cloud as normal trains that showed the same increase as in other fills
Test fill with constant crossing angle

Crossing angle anti-leveling

Constant crossing angle

G. Iadarola - HSI Meeting 04.09.2019
Test fill with constant crossing angle

2018, T = 7h (135 urad)

Loss rate [10^9 p/h]

2018, T = 7h (160 urad)

Loss rate [10^9 p/h]
**Situation in 2017 (25 ns)**

2018

β* = 30 cm

2017

β* = 40 cm

25 ns

In 2017:

- LR-BB pattern visible on the transient happening at each angle step
Test fill with constant crossing angle

Crossing angle anti-levelling

Constant crossing angle
In 2017:
- With the 8b+4e beam losses were extremely small

2017
\[ \beta^* = 30 \text{ cm} \]
25 ns

2017
\[ \beta^* = 40 \text{ cm} \]
25 ns
Summary

• Shown highlights of BbyB Luminosity fluctuation observations and beam loss patterns in Run 2

• A general growth of up to **20% RMS** observed for the BCMS fills of 2018, with the maximum up to 60% for a sizeable fraction of the bunches. This is mainly due to fluctuations in the bunch intensities, caused by *losses above burn-off*.

• Studies on the beam losses indicate correlations with the beam type (BCMS or 8b4e) and collision scheme (crossing angle, beta*) impacting different the **e-cloud** and **BBLR effects** that produce the losses.

• In **Run 2** the focus was to optimise the integrated luminosity as BtB fluctuations were not impacting the performance of the experiments
  • Choose to define a collision scheme at constant DA of ~5σ (without e-cloud considerations) with pushed x-sing angle and beta* to maximise the integrated luminosity
  • The luminosity decay was giving margin to experiments to absorb any fluctuations

• For **Run 3** with levelling, would be possible to optimise the collision scheme to minimise the fluctuations to the levels acceptable by the experiments
  • Seem up to **10-15% fluctuations** would have minimal impact to the experiments (tbc)
  • Backup option to operate with **mixed BCMS + 8b4e beams**

• For HL-LHC the situation would be largely different: β* levelling would allow larger DA configuration plus the e-cloud in the triplets would be largely suppressed by the coating with amorphous carbon. Also, the burn-off rate would be much faster, minimising the impact of the losses (above e-cloud)