Flat top halo scraping campaigns 2017
Status and outlook

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ColUSM 03/11/2017
Motivation

- Measuring the time evolution of the losses during a collimator scan – **halo diffusion and its population**
  - *With dBLM (diamond loss detectors) measuring bunch by bunch / train by train*
- **Beam halo reconstruction** along the collimator scan.
- In 2017 first measurements (among some others) with:
  - 2550b in the machine (regular fill) **220MJ** at the scraping start
  - With HLLHC like bunches (dedicated MD, **20MJ** beam)
Outline

1. Experiments setup and data collected
2. Frequency analysis of losses
3. Particle Diffusion coefficient
   1. Whole beam (100Hz IC loss data)
   2. Bunch by bunch (dBLM data)
4. Halo reconstruction
5. Conclusions
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The setup and the data

- All the tests were performed as an **EoF excursion**.
  - *Reduced initial beam intensity!*
- We have performed various tests
  - **Both beams and planes**
  - **Various beam intensities** and number of bunches, including **high intensity 8b4e** HLLHC like beams.

<table>
<thead>
<tr>
<th>Fill nb.</th>
<th>date</th>
<th>n</th>
<th>Beam1</th>
<th>Beam2</th>
<th>scans performed</th>
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<tr>
<td>5834</td>
<td>2017-06-15</td>
<td>900</td>
<td>8.8e13</td>
<td>8.9e13</td>
<td>B1/ B2 H/V</td>
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<tr>
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<td>B1/ B2 H</td>
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<tr>
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<td>2029</td>
<td>1.3e14</td>
<td>1.36e14</td>
<td>B1H B2 V</td>
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<tr>
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<td>2017-08-06</td>
<td>2550</td>
<td>1.9e14</td>
<td>2.1e14</td>
<td>B1/B2 H/V</td>
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<tr>
<td>6194</td>
<td>2017-09-13</td>
<td>224</td>
<td>2.7e13</td>
<td>2.7e13</td>
<td>B1/B2 H/V</td>
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<tr>
<td>6199</td>
<td>2017-09-14</td>
<td>n/a</td>
<td>n/a</td>
<td>1e13 (36%)</td>
<td>B2 H/V</td>
</tr>
</tbody>
</table>

*Table 1:* Summary of the End of fill scraping MD performed in June and August of 2017. Where \( n \) is the number of bunches, \( I_{st} \) is the total intensity at the the start of the scraping, and \( I_s \) is the total scraped intensity.
Scan sequence

- Before the actual collimator movement (in a given plane) a manual centering was performed.
- Consecutive steps of 5μm for $2\sigma$ (0.2mm in H or 0.28mm in V) of the scan span were performed:
  - Every ~20s for the INWARD steps.
  - Every ~60s for the OUTWARD case.

A typical scan overview:
- One plane for both beams (red/blue).
- And jaw movement along the test (other colors).
Step analysis

- Extraction details of the collimator jaw movement at $t_0$
  - $5\mu m$ step is normally resolved within less than 1s
- Loss data (IC 100Hz) selection for $t_0 - 2s$ and $t_0 + 15s$
- Data fix (corrupted data, missing data)
- FFT of the step data
  - Available spectra for 0-50Hz
- Fit for the decay part
  - Diffusion speed
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Step analysis – FFT of the loss data

- Beam losses have oscilatory character

Many frequencies visible in the spectrum:
- **4.4Hz**, mechanical IT vibrations
- **Strong peaks at**
  - **21.9Hz** and **46.2Hz**
  - **9Hz, 18Hz** and **24.8Hz**
FFT of the scraping steps (0-10Hz)

- Beam losses have oscillatory character

**Many frequencies visible in the spectrum:**

- **4.4Hz, 6.7Hz**
- **~1Hz for Beam 2**
Diffusion (100Hz data)

- Perform a fit for each step (action $J_c = \frac{x^2}{2\beta}$) and extract diffusion rate $D$ from:

$$\partial t F_t(J_c, t) = -A_i + (2A_i - A_c)P\left(\frac{-J_c}{w}\right) - \frac{2A_i(J_{ci} - J_c)}{\sqrt{2\pi w}} + \frac{2(A_iJ_{ci} - A_cJ_c)}{\sqrt{2\pi w}} \exp\left(-\frac{1}{2}\left(\frac{J_c}{w}\right)^2\right)$$

$$w = \sqrt{2Dt}$$

$$\partial t F_0(J_c, t) = -A_i P\left(\frac{(J_{ci} - J_c)}{w}\right) + (2A_i - A_c)P\left(\frac{-J_c}{w}\right) + \frac{2(A_iJ_{ci} - A_cJ_c)}{\sqrt{2\pi w}} \exp\left(-\frac{1}{2}\left(\frac{J_c}{w}\right)^2\right)$$

- Fitting and error estimation
  - Just the decay part that $\frac{1}{\sqrt{t}}$
  - Bootstrapping fit results for subsets (~30) of the main selection, their spread gives an error on the estimated parameter
Diffusion (100Hz data) (2)

- Observed discrepancy wrt to the 2016 results
  - 1-2 orders of magnitude Higher -> still under study
  - Big variation in the J=0.0035 -> To be understood
  - Outward steps similar discrepancies
Diffusion bbb data

- Consistent with 100Hz data results
- order of magnitude
- Estimated rates for non colliding bunches slightly higher than the others

In order to profit from the raw diamond signals (waveform) – additional time synchronisation is needed!
Halo reconstruction

- Estimations done for the first scraped plane in each case
  - *From the BLM (100Hz) signal /step*
  - *From the FBCT / step*
- **Not for every scan** a collimator alignment was performed,
  - *Resulting in out of date centre positions*
Halo reconstruction (2)

- In all cases an over population (1 order of magnitude) is present.
- Initial parameters (i.e. center) plays the main fiddle in the magnitude of the overpopulation.

Fill 6052, 2550b, 220MJ

Corrected for burnoff!

Fill 6194, 224b, 30MJ

From the FBCT

From the BLM (100Hz)
Conclusions

- A set of scraping ranging with many beam intensities
  - Including a scan with a beam of \(220\,\text{MJ}\)
- Diffusion coefficients obtained still differ with few orders of magnitude wrt to 2016/2012.
  - Still work in progress!
- Successful use of dBLMs for bbb estimations
  - Improvement in timing detector – collimator needed for more!
- Reconstructed Halo again shows over population
  - reaching slightly above one order of magnitude