Physics of interest:

- Diffractive processes – proton(s) remaining intact.
- Color-singlet exchange (photon, Pomeron).

Signatures of diffractive event:

- Rapidity gap.
- Forward protons.

Low pile-up conditions for studies of diffractive physics:

- High cross-section processes.
- Clean environment, largely reduced background.
- Soft single and central diffraction ($\mu \sim 0.01$).
- Single diffractive jet, jet-gap-jet, $\gamma$-jet ($\mu \sim 1$).

Pile-up background:

Protons from pile-up events may be misidentified as originating from hard diffractive event.

<table>
<thead>
<tr>
<th>Date (2017)</th>
<th>LHC fill</th>
<th>Run</th>
<th>Pile-up $\mu$</th>
<th>Integrated luminosity</th>
</tr>
</thead>
<tbody>
<tr>
<td>29/07</td>
<td>6019</td>
<td>331020</td>
<td>$\approx 1$</td>
<td>14.6 pb$^{-1}$</td>
</tr>
<tr>
<td>23/09</td>
<td>6238</td>
<td>336505</td>
<td>$\approx 0.05$</td>
<td>17.5 pb$^{-1}$</td>
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<tr>
<td>21/11</td>
<td>6405</td>
<td>341312</td>
<td>$\approx 2$</td>
<td>27.9 pb$^{-1}$</td>
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<tr>
<td>22/11</td>
<td>6411</td>
<td>341419</td>
<td>$\approx 2$</td>
<td>36.2 pb$^{-1}$</td>
</tr>
<tr>
<td>23/11</td>
<td>6413</td>
<td>341534</td>
<td>$\approx 2$</td>
<td>56.6 pb$^{-1}$</td>
</tr>
<tr>
<td>25/11</td>
<td>6415</td>
<td>341615</td>
<td>$\approx 2$</td>
<td>35.2 pb$^{-1}$</td>
</tr>
<tr>
<td>26/11</td>
<td>6417</td>
<td>341649</td>
<td>$\approx 2, \approx 1$</td>
<td>15.6 pb$^{-1}$</td>
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</table>
The ATLAS Forward Proton (AFP) detector

Two Roman Pot stations (NEAR and FAR) on each side; each consists of four Silicon Tracker (SiT) planes. FAR stations also equipped with the Time of Flight (ToF) detectors.

- Measures protons scattered at very small angles (∼100 µrad).

- SiT plane: 336×80 pixels, 50×250 µm², 230 µm thick.
- SiT resolution: $\sigma_x=6$ µm at 14° plane tilt.
- Typical acceptance: $0.02 < \xi < 0.12$, $p_T \lesssim 3$ GeV/c.
- Trigger: majority vote, 2 out of 3 planes.
  Rate of recorded events triggered by the C-side: The changes of trigger rate follow the changes of $\mu$.
  Lower rates at the beginning of the run are due to change of prescale factor (2→1).
AFP SiT Trigger Efficiency

Hit signal duration causes trigger **dead time**, i.e. no new trigger can be given while the signal is still high from a previous hit.

With a peak at 8 clock cycles of 25 ns, a typical dead-time of \( \approx 200 \text{ ns} \) is expected. The sketch below shows schematically how the trigger event is missed.

**Bunch structure**

- filled bunch
- signal, trigger fired
- dead time
- empty bunch
- signal, trigger not fired

(bunch duration – 25 ns)

**Trigger:**

\[
L1_{\text{AFP\_A\_OR\_C}} = (A-\text{NEAR} \& A-\text{FAR}) \mid (C-\text{NEAR} \& C-\text{FAR})
\]

Relative trigger efficiency dependence on bunch structure:

**SiT trigger efficiency** drops due to dead-time

- Normalized to the highest recorded efficiency (first point).
- Efficiency decreases for consecutively filled bunches (shaded regions) due to dead time.
- Filled bunches (8) are separated by empty bunches (4-8), during which the SiT trigger is able to partially recover and thus an increase in efficiency is recorded.
Particle showers created in SiT planes?

Diffractive protons registered in AFP might interact (electromagnetically and strongly) with either silicon tracker, or the Roman Pot floor. This leads to particles showers, propagating downstream and leaving following traces:

- Each consecutive pixel layer registers on average larger number of hits.
- Similarly, farther layers frequently register higher charge.

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