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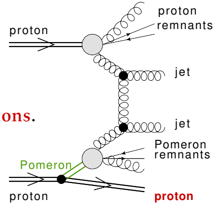
LHCP 2021 **ATLAS AFP – Special Low Pile-up Runs (2017)**

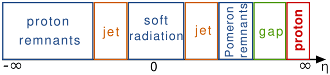
Physics of interest:

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

Signatures of diffractive event:

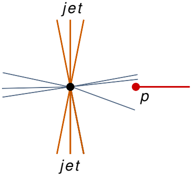
- Rapidity gap.
- **Forward protons.**





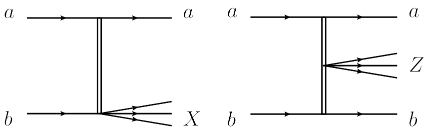
Pile-up **background**:

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



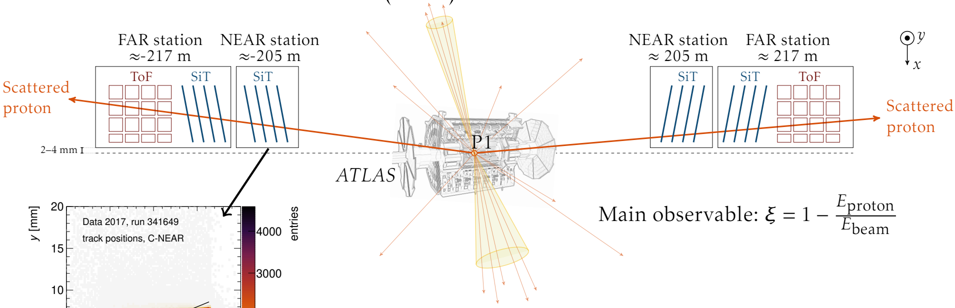
Low pile-up conditions for studies of diffractive physics:

- High cross-section processes.
- Clean environment, largely reduced background.
- Soft single and central diffraction (μ~0.01).
- Single diffractive jet, jet-gap-jet, γ-jet (μ~1).

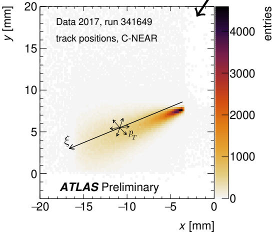


Date (2017)	LHC fill	Run	Pile-up μ	Integrated luminosity
29/07	6019	331020	≈ 1	14.6 pb^{-1}
23/09	6238	336505	≈ 0.05	17.5 pb^{-1}
21/11	6405	341312	≈ 2	27.9 pb^{-1}
22/11	6411	341419	≈ 2	36.2 pb^{-1}
23/11	6413	341534	≈ 2	56.6 pb^{-1}
25/11	6415	341615	≈ 2	35.2 pb^{-1}
26/11	6417	341649	$\approx 2, \approx 1$	15.6 pb^{-1}

The ATLAS Forward Proton (AFP) detector

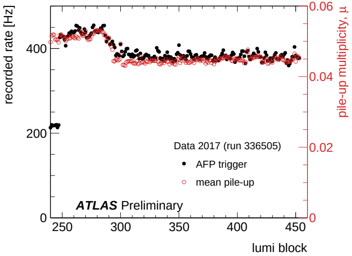


Main observable: $\xi = 1 - \frac{E_{\text{proton}}}{E_{\text{beam}}}$



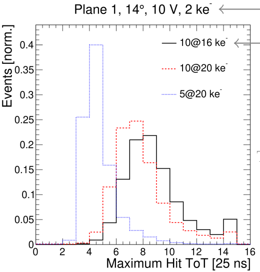
- Two Roman Pot stations (NEAR and FAR) on each side; each consists of four Silicon Tracker (SiT) planes. FAR stations also equipped with the Time of Flight (ToF) detectors.
- Measures protons scattered at very small angles (~100 μrad).

- SiT plane: 336×80 pixels, 50×250 μm^2, 230 μm thick.
- SiT **resolution**: σ_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 μ.
  Lower rates a 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.



10 V bias voltage, 2ke⁻ threshold

tuned to ToT at 10 for 16 ke⁻ injected charge

ToT ≡ time over threshold

ToT of pixel with highest signal in event

With a peak at 8 clock cycles of 25 ns, a typical dead-time of ≈200 ns is expected. The sketch below shows schematically how the trigger event is missed.

Bunch structure

- filled bunch

- empty bunch

- dead time

- signal, trigger fired

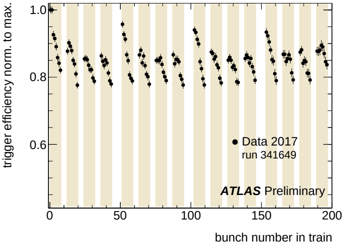
- signal, trigger not fired

(bunch duration – 25 ns)

Trigger:

`L1_AFP_A_OR_C = (A-NEAR & A-FAR) | (C-NEAR & C-FAR)`

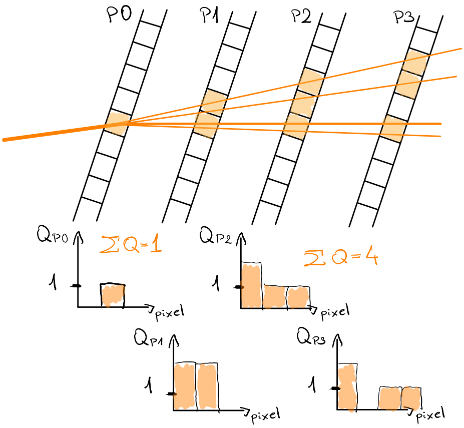
Relative trigger efficiency dependence on bunch structure:



SiT trigger efficiency drops due to dead-time

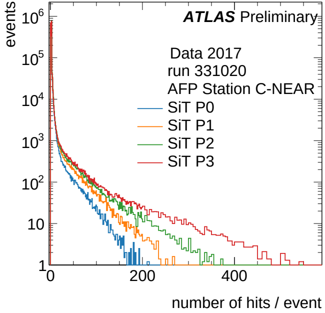
- Normalized to the highest recorded efficiency (first point).
- Efficiency decreases for consecutively filled bunches (shaded regions) due to dead time.
- Filled bunches (8) are separated by empty bunches (4-8), during which the SiT trigger is able to partially recover and thus an increase in efficiency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

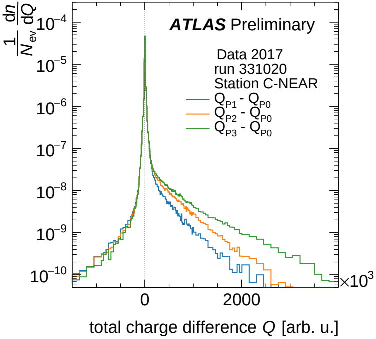
Particle showers created in SiT planes?



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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