ATLAS Roman Pots at LHC Run 3 Detector Status

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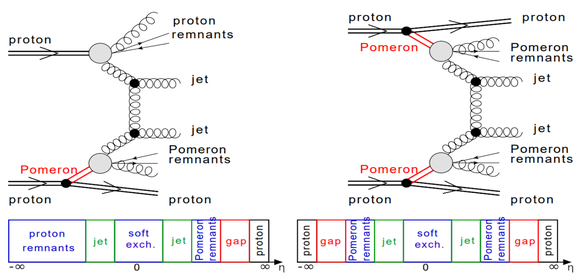
on behalf of ATLAS Forward Detectors

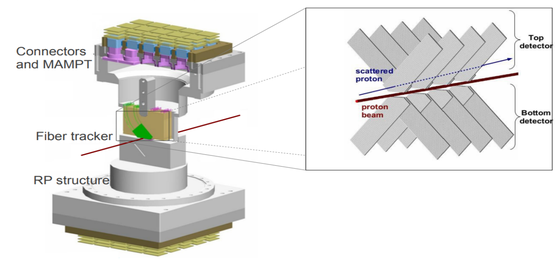
Introduction

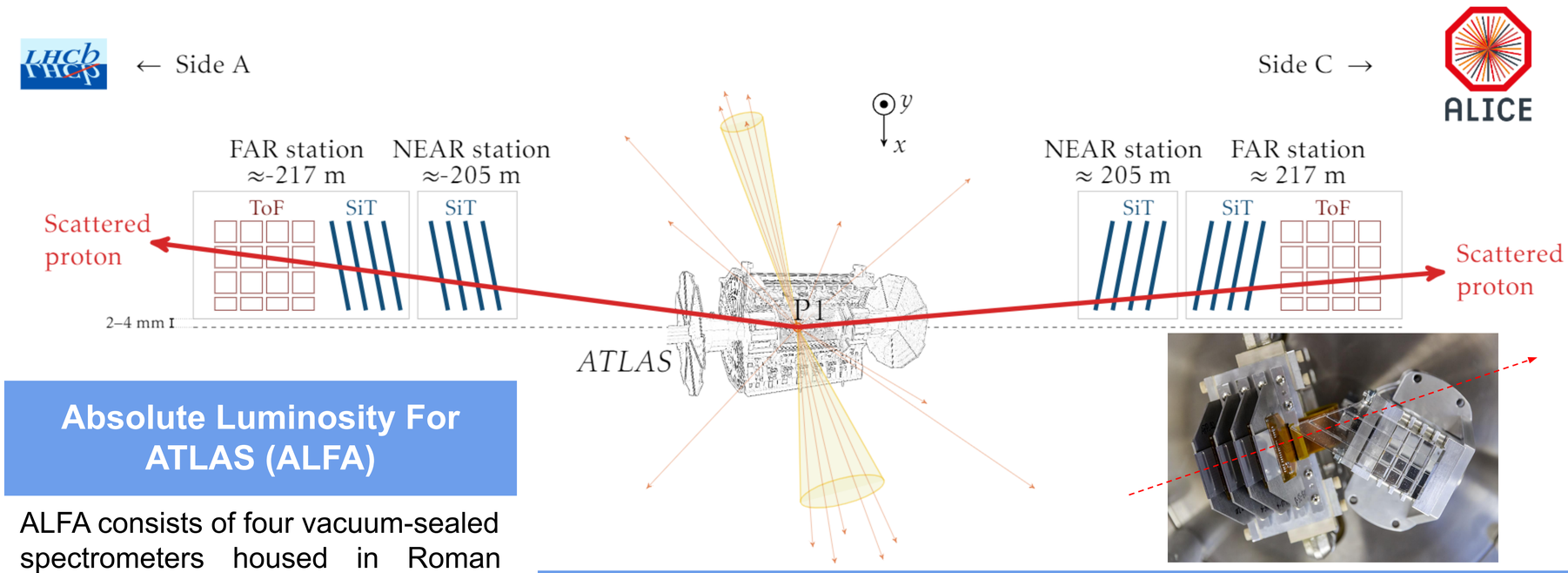
The physics motivation for the ATLAS Roman Pots (ARP) project is based on investigating diffractive and photon-induced processes by tagging one or both "*forward*" protons with AFP and ALFA detectors. **Diffractive** interactions occur due to exchange of colorless object: photon in case of electromagnetic and *Pomeron* in case of strong interactions. This exchange does not alter the quantum numbers of the interacting particle thus one or both colliding proton may remain intact and scattered at very small angles (few micro-radians) thus called "*forward*" protons. In addition, there will be a rapidity gap, which is a space in rapidity devoid of particles.



Absolute Luminosity For ATLAS (ALFA)

ALFA consists of four vacuum-sealed spectrometers housed in Roman Pots, which are inserted vertically into the beam line and are installed on both sides of ATLAS at approximately **237 m (NEAR station)** and **241 (Run 1)/ 245 m (Run 2) FAR station**. Each station houses a multilayer scintillating fibre (SciFi) detectors for alignment and tracking, allowing resolution of $\sigma_x = \sigma_y = 30$ **µm**, ALFA goal is to perform measurements of elastic scattering and soft diffraction.



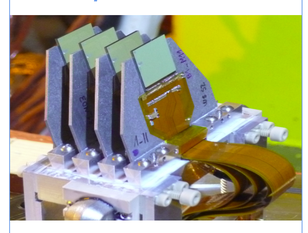


ATLAS Forward Proton (AFP)

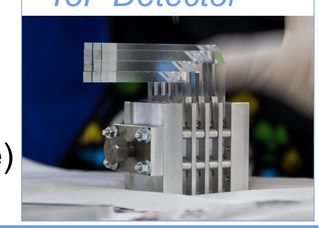
AFP consists of four stations installed on both sides of ATLAS at approximately **205 m (NEAR station)** and **217 m (FAR station)**. Each station is made of a single horizontal Roman pot housing the AFP detectors:

- 4 Silicon Tracker (SiT) planes are present in each RP station to measure proton position:
  - 50 × 250 µm^2 pixel size
  - resolution: $\sigma_x \approx 5$ **µm**, $\sigma_y \approx 30$ **µm** [Ref. 1]
- The Time-of-Flight (ToF) detectors are designed to measure the primary vertex z-position which can be compared to position reconstructed by the ATLAS tracker to help reduce the background.
  - present only in FAR stations
  - 4 × 4 matrix of quartz bars, L-shaped and rotated 48° w.r.t. LHC beam (Cherenkov angle)

SiT planes



ToF Detector



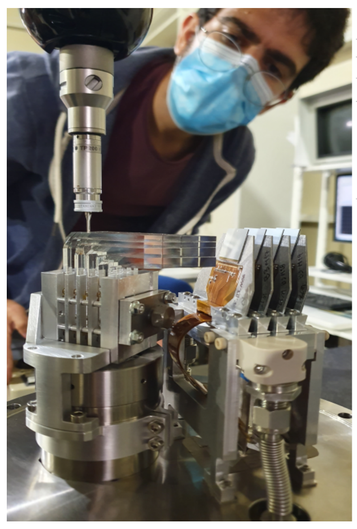
ARP Upgrades for RUN 3

AFP:

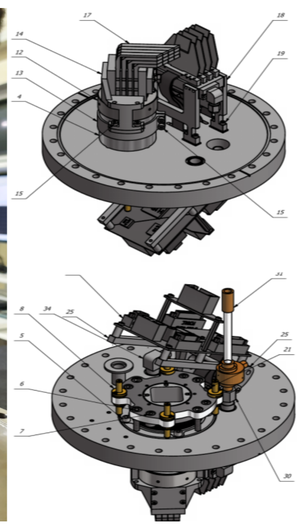
- A redesign of the AFP ToF detector: keeping the Micro-Channel Plate PhotoMulTipliers (MCP-PMTs) outside vacuum in order to reduce the risk of electric arcs [Ref. 2].
- New MCP-PMT and its back-end electronics designs to address Run 2 inefficiencies from and to suppress cross-talk.
- **Timing resolution for ToF**: **20 ± 4 ps (side A) and 26 ± 5 ps (side C)** [Ref. 3], 20 ps → spatial resolution of 4.24 mm.
- New SiT tracking modules installed on new heat exchangers, enhanced cooling capabilities.
- New Versatile Link Demonstrator Board (VLDB).

ALFA: Minor refurbishment → one more data-taking in Run 3.

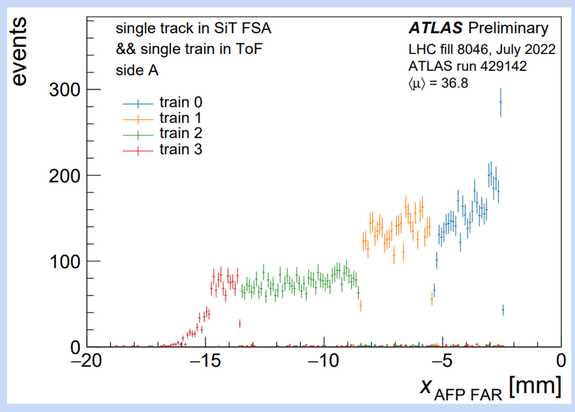
Alignment during installation



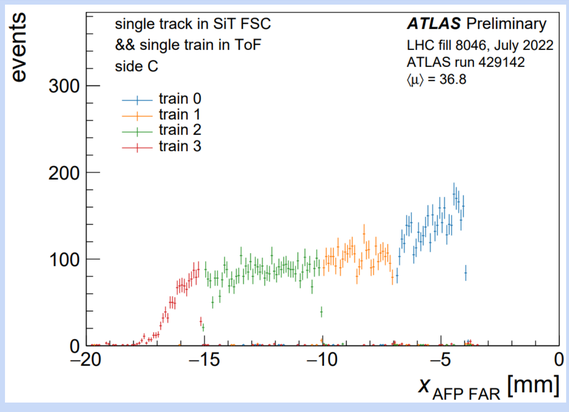
Out-of-Vacuum solution

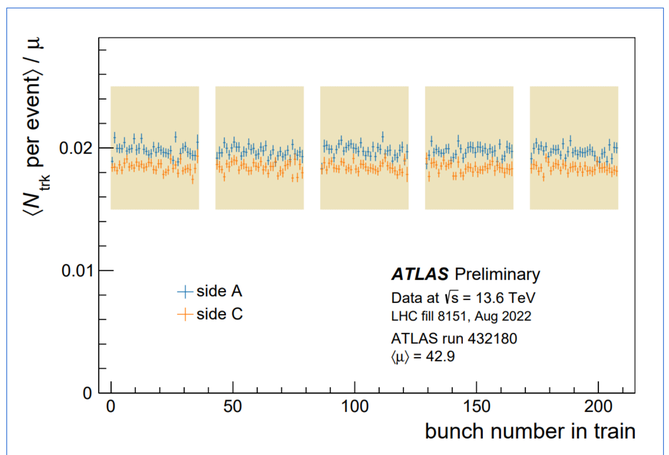


AFP Performance in RUN 3

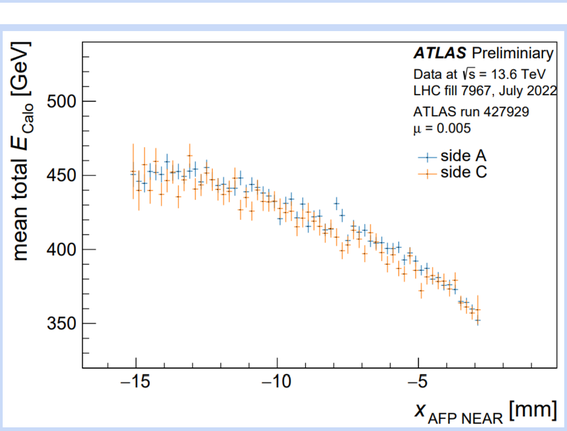


The x position of the track reconstructed in AFP SiT (FAR station) in events in which a single-train signal in ToF detector was observed for side A (left plot) and side C (right plot). The differences in the $x_{AFP\ FAR}$ between sides are due to global alignment corrections not being applied).

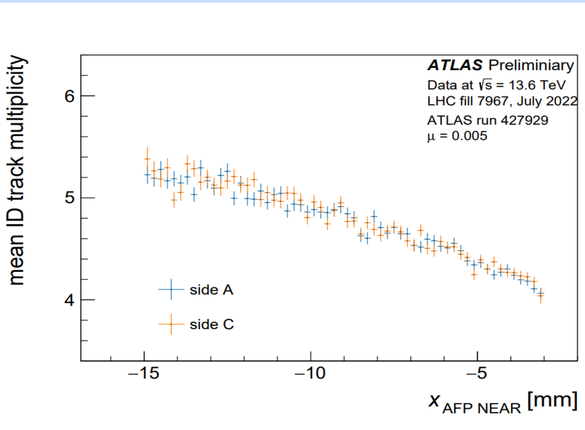




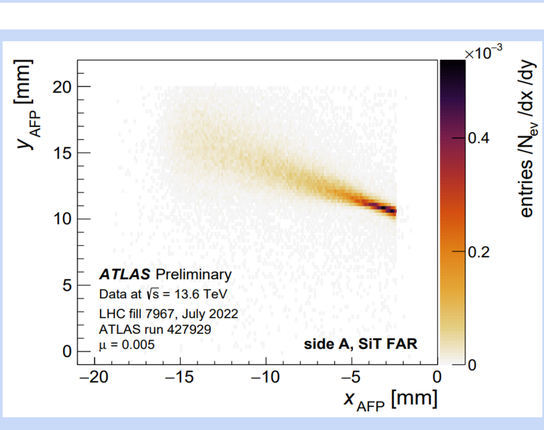
Average track multiplicity on the given side in dependence on the bunch number in train weighted by pile-up at that train. No dependence on bunch number in train is visible which indicates none or very small dead-time effect.
More performance plots in ref. 4.



Correlation between the x position of reconstructed tracks in AFP NEAR stations and the total energy measured by the ATLAS Calorimeters for side A and C.



Correlation between the x position of reconstructed tracks in AFP NEAR stations and the charged track multiplicity in the ATLAS Inner Detector for Side A and C.



Positions of tracks reconstructed in AFP. Coordinate system: center of the beampipe at (x, y) = (0, 10 mm)

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1. Beam tests of an integrated prototype of the ATLAS Forward Proton detector, JINST 11(09), P09005 (2016), doi:10.1088/1748-0221/11/09/P09005, 1608.01485
2. L. Nozka et al., Performance studies of new optics for the time-of-flight detector of the AFP project, Opt. Express 28(13), 19783 (2020), doi:10.1364/OE.394582.
3. Timing resolution studies of the optical part of the AFP Time-of-flight detector, Opt. Express (2018), doi:10.1364/OE.26.008028
4. https://cds.cern.ch/record/2826256/