

ATLAS FORWARD PROTON DETECTOR

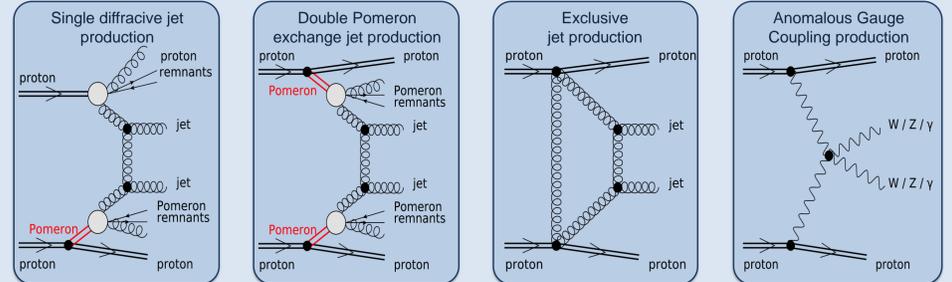
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On behalf of the ATLAS Collaboration



Physics Motivation

The ATLAS Forward Proton (AFP) is a system for the measurement of protons scattered at small angles. Such protons are predominantly produced when a colourless object – photon (in case of electromagnetic process) or Pomeron (strong interaction) – is exchanged. The AFP physics programme is focused on processes in which interacting protons stay intact – i.e. diffractive physics.

Examples of diffractive processes, described within the Standard Model, are: single diffractive, double Pomeron exchange and exclusive jet production. A precise measurement of the exclusive jet cross section will set constraints for other exclusive processes including the exclusive production of the Higgs boson. AFP can also be used as an effective tool for Beyond Standard Model studies, for example searches for Anomalous Quartic Gauge Couplings. Tagging the scattered protons with AFP provides a powerful way to reduce backgrounds based on energy-momentum conservation in exclusive processes and energy-momentum conservation.



Detector System

- Detectors are installed in Roman pots in a secondary vacuum (20 mbar).
- This technology allows movement w.r.t. the proton beam.
- Precise movement system permits positioning of the pot ~2 mm from the beam centre (depending on LHC beam conditions).
- Two Roman Pot stations are installed on each side of the ATLAS Interaction Point (IP).
- NEAR stations: ~205 m away from the IP, contain four layers of tracking detectors.
- FAR stations: ~217 m away from the IP, contain four layers of tracking detectors and will contain a Time-of-Flight system.

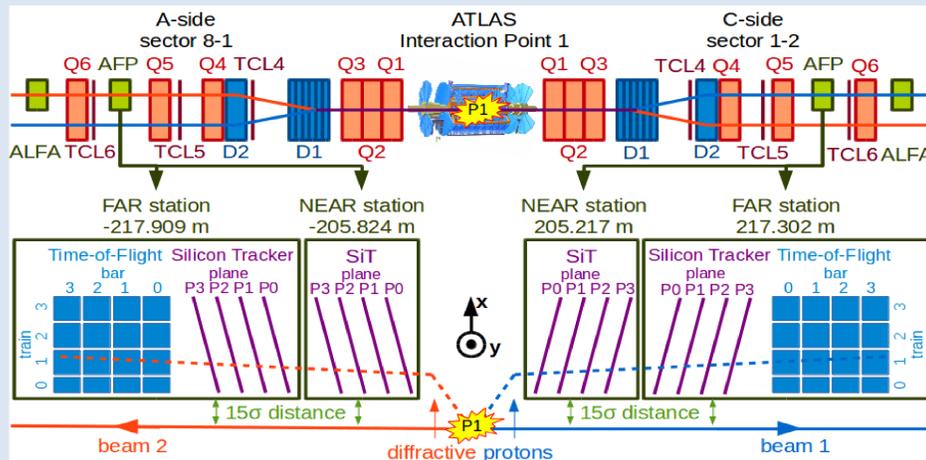


Figure: Position of AFP stations w.r.t. ATLAS detector.

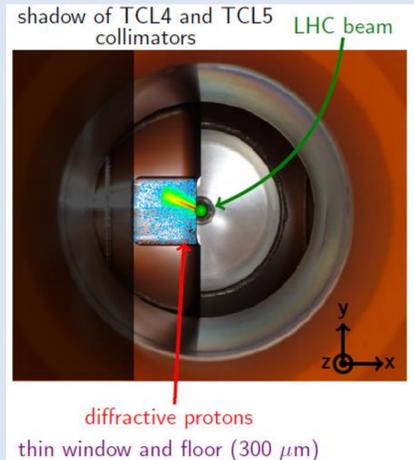


Figure: Diffractive protons as "seen" by AFP when pots are in data-taking position.

Silicon Tracker (SiT)

- Technology: 3D Silicon sensors (same as the ATLAS Insertable B-Layer).
- Each sensor consists of 336 x 80 pixels of 50 x 250 μm².
- Overall chip size is 16.8 x 20 mm², read out by the ATLAS FE-14 ASIC.
- Each station contains four sensors tilted by 14° to reach 100% efficiency, and best reconstruction resolution in the short pixel direction..
- Further resolution improvements are done by staggering sensors by ±60 μm relatively each others.
- Expected overall resolution: 6 μm along short and 70 μm along the long pixel direction
- The sensor edge facing the LHC beam is cut away to minimize the intensive area to 180 μm or smaller ("edgeless" sensors).
- Provides tracking information in high and low pile-up conditions and trigger for low pile-up runs.

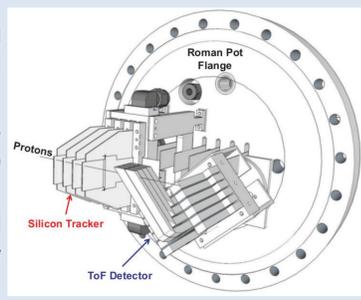


Figure: Sketch of Tracker and Time-of-Flight detectors mounted on Roman pots flange.

Time-of-Flight (ToF)

- Matrix of 4 x 4 quartz bars mounted at the Cherenkov angle with respect to the diffractive proton direction.
- Ultrafast photomultipliers (MCP-PMT) convert light into electric pulses which are further amplified and readout.
- Expected resolution (from test beam and early analysis): 25-30 ps per quartz bar.
- Provides proton Time-of-Flight and proton trigger for low and high pile-up standard luminosity runs.

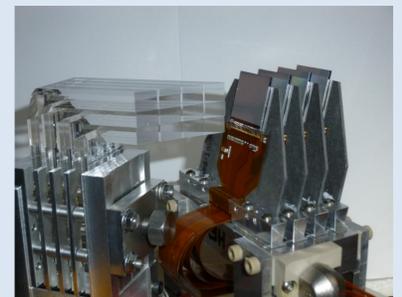
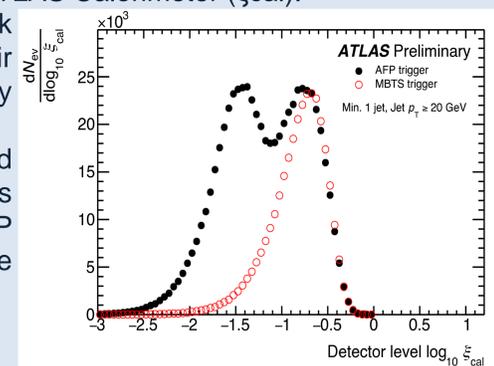


Figure: Time-of-Flight (left) and Silicon Tracker (right) detectors mounted on the AFP flange.

AFP Performance 2016 ATLAS-PHYS-PUB-2017-012

A first performance study with a very low-μ (μ~0,3) data sample:

- Took data triggering with the AFP SiT and Minimum Bias Trigger Scintillator.
- Measure proton relative energy loss using ATLAS Calorimeter (ξ_{cal}).
- MBTS triggered data exhibits a single peak at high ξ_{cal} → events that have most of their energy lost in the calorimeter (dominated by non-diffractive events).
- The AFP triggered data exhibits a second peak at lower ξ_{cal} → most of the energy is carried away by the proton measured in AFP (diffractive events as well as non-diffractive events with pile-up).

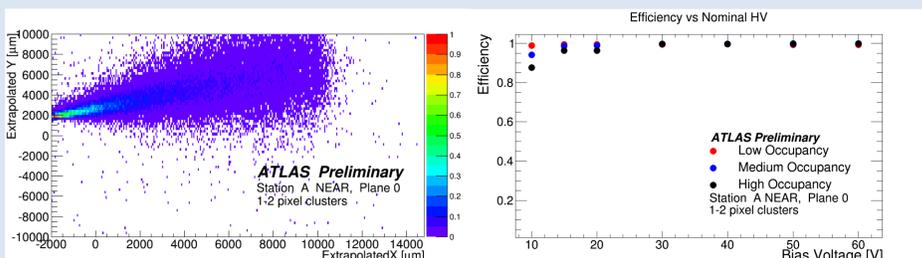


AFP is able to tag diffractive events efficiently.

SiT Performance in 2017

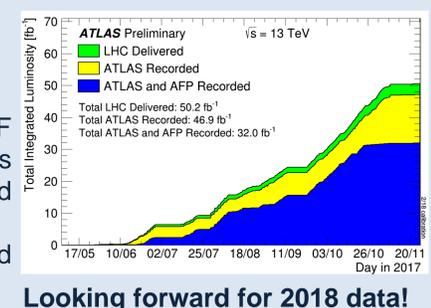
To monitor the SiT performance, data is taken at different bias voltages. For these studies Tracks are reconstructed using 3 planes and extrapolated to the fourth plane. The extrapolated track position (X,Y) in Station A NEAR, Plane 0 is shown in the left figure.

The efficiency is determined by matching the position of clusters to the extrapolated tracks within a window of one pixel, and normalizing by the total number of tracks. The efficiency as a function of the voltage is shown in the right figure. Full efficiency is recovered for all the regions for bias voltages larger than 40V.



Outlook

- 2016:**
 - Only one arm with two tracker stations.
 - Data taken during special, low pile-up (μ) runs.
- 2017:**
 - Full system: two arms with two stations each. (ToF installed but troubled data taking some problems occurred: very low efficiency due to PMT exceeded lifetime and too low HV).
 - 32 fb⁻¹ of data taken during special and standard runs.
- 2018:**
 - Due to ToF low efficiency, only silicon tracker were installed during YETS, plan to install improved ToF in June.



Looking forward for 2018 data!