The ATLAS Forward Proton Time-of-Flight detector: use and projected performance for LHC Run3

12th International Conference on Position Sensitive Detectors

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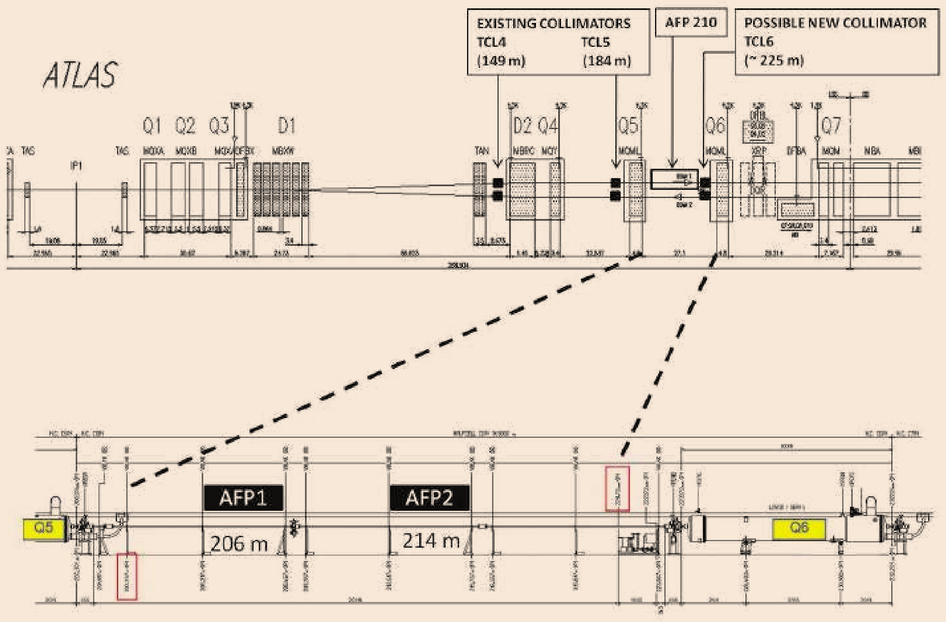
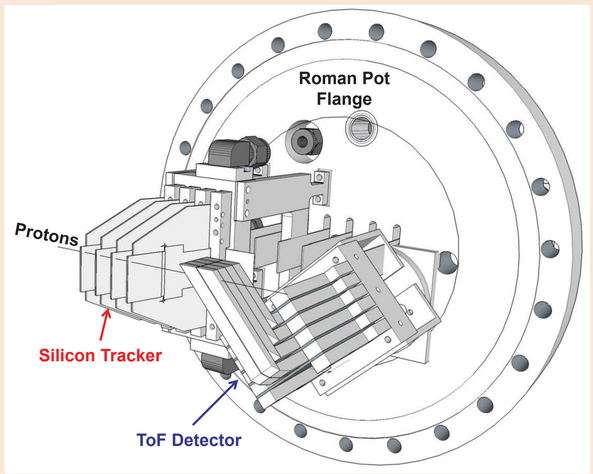
AFP stations

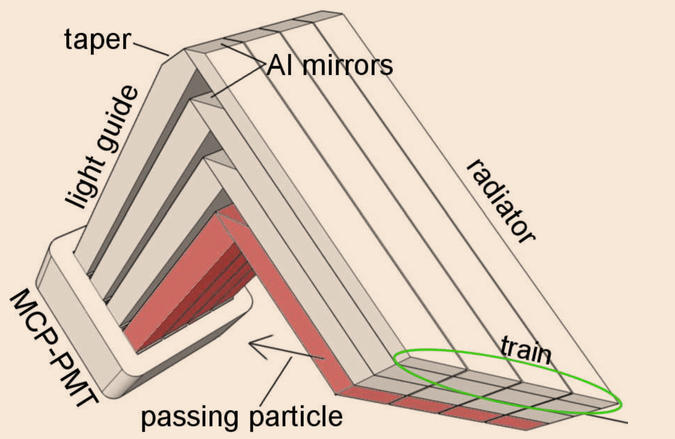
- **A**TLAS **F**orward **P**roton
- Forward detector focused on diffractive protons
- Detector packages placed in four Roman Pot stations located on both sides, $\sim 210\,\mathrm{m}$ from ATLAS collision point
- 3D silicon tracker + ToF (only far stations)

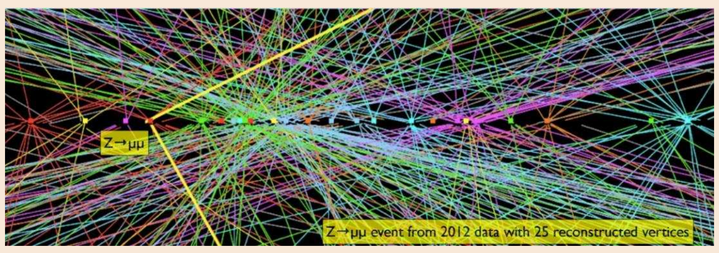




ToF detector

- A fast Cherenkov timing detector
- 4x4 channel matrix, 4 bars form a train
- Purpose:
  - reduce background by mathing vertex reconstructed by central ATLAS detector with one computed from proton arrival time difference
  - provide fast trigger

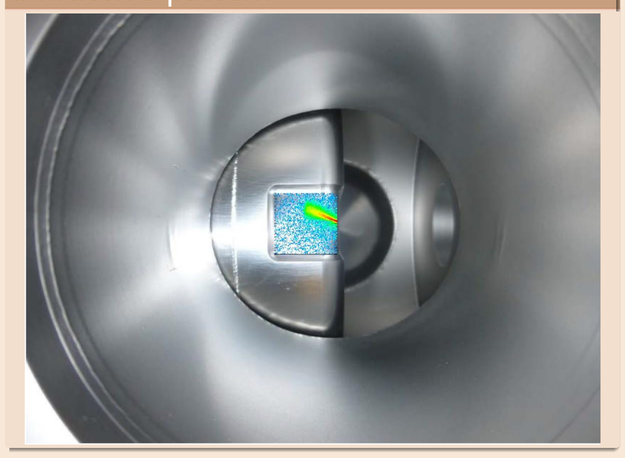




- Expected background reduction: factor of 10 for $20\,\mathrm{ps}$ detector.

AFP – how the real thing looks like

Roman Pot as seen by the beam, with diffractive pattern



AFP detector package ready for installation

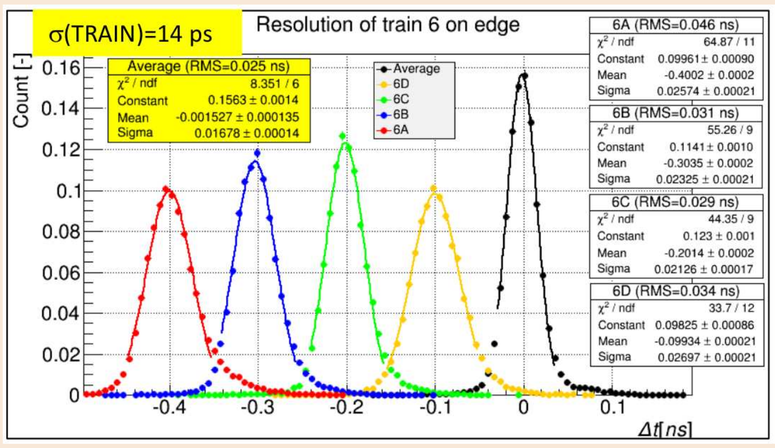
Performance: Beam test

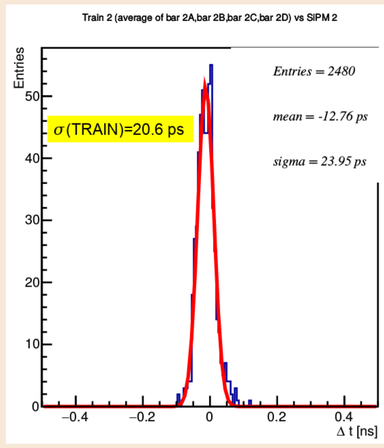
Results obtained at SPS NA beam test (140 GeV pions)

Raw PMT signal (oscilloscope):
20 ps single channel, 14 ps train combined

After passing High Performance Time to Digital Converter (HPTDC):
20.6 ps train combined

Timing resolution distributions (raw left, HPTDC right)



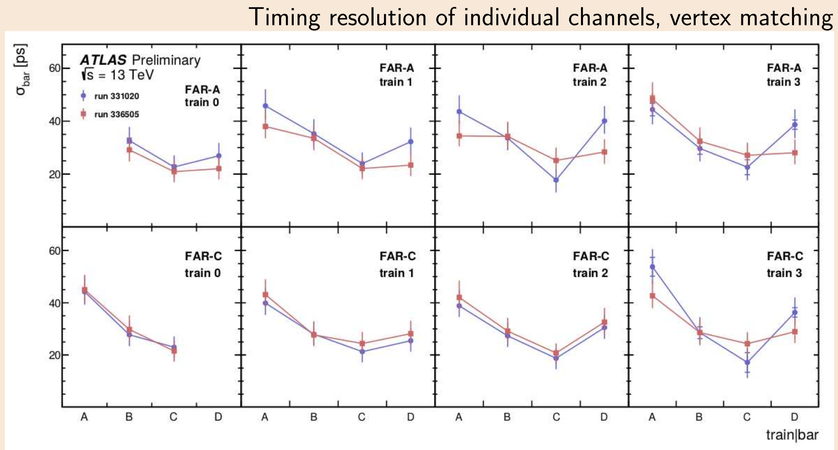


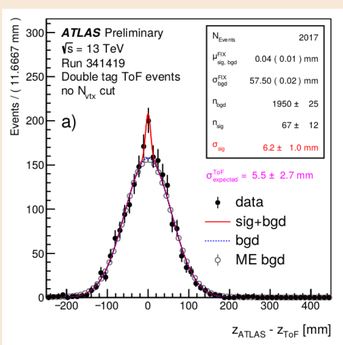
Note: fits in raw plots without timing reference resolution subtraction (9 ps)

Performance analysis of 2017 data

- Poor efficiency of few percent (PMT degraded fast)
- Good timing resolution (21 ps) nonetheless!

Timing resolution of individual channels, vertex matching distribution

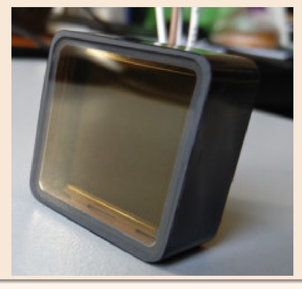


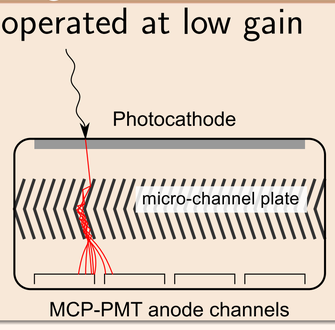


Performance of the ATLAS Forward Proton Time-of-Flight Detector in 2017, ATL-FWD-PUB-2021-002

Upgrades – Photomultipliers optimized for high rates

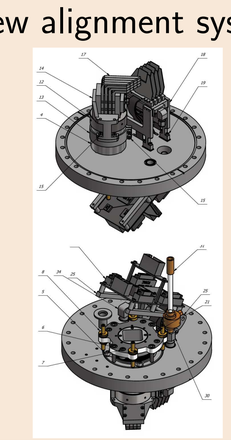
Long life tubes with low MCP resistance, operated at low gain

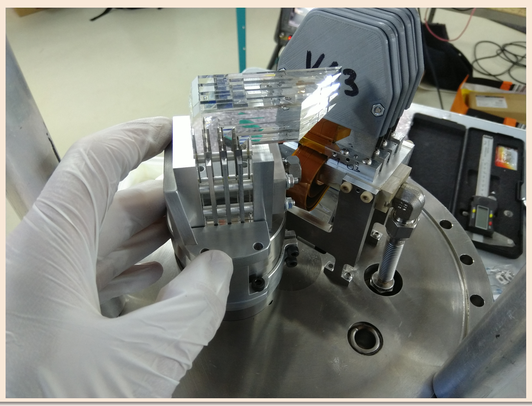




Upgrades – Out of Vacuum solution

Out of vacuum redesign – PMT moved out of the pot → easier access to electronics, new alignment system





Upgrades – Glueless ToF bars

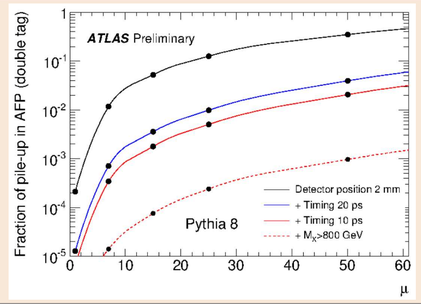
Glue absorbed some deeper UV signal, was a radiation hardness weak point

Upgrades – Electronics

- Faster read-out: PicoTDC instead of HPTDC
- Remotely controlled amplifiers
- Better PMT interference shielding
- Modified HV divider – improved timing and efficiency at low PMT gain

Expected timing and background suppression

- 25 – 30 ps single bar
- 20 – 25 ps train combined
- Without PicoTDC a bit worse (∼ 16 ps HPTDC contribution)



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