ATLAS Forward Proton Time-of-Flight Detector

Status & Performance in Run 2

Varsiha Sothilingam (KIP, Heidelberg University)
On behalf of the ATLAS Forward Detectors

UNIVERSITÄT HEIDELBERG ZUKUNFT SEIT 1386

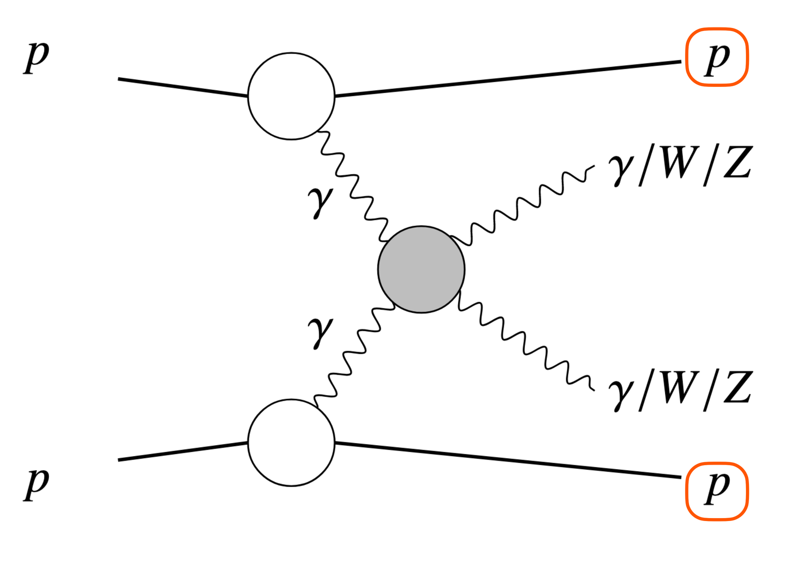
Forward Physics Interest

Beyond Standard Model:

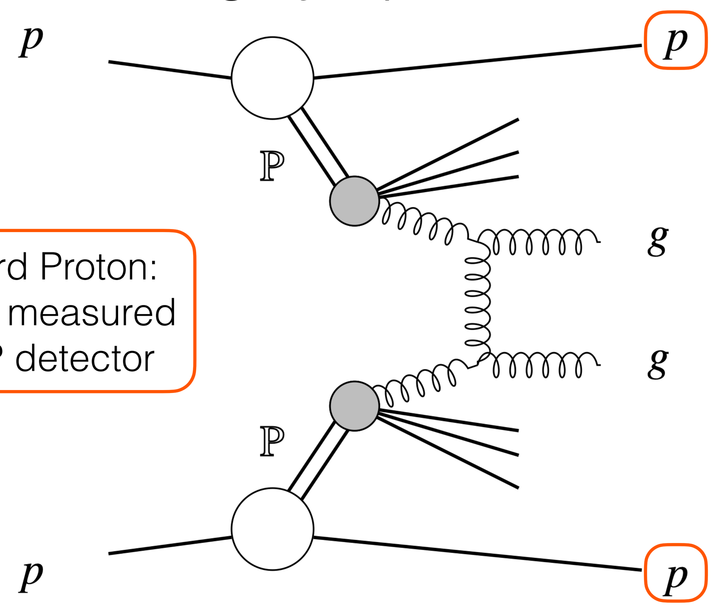
- Photon induced processes
- Both intact forward protons
- Example: anomalous gauge couplings

Hard Diffractive Processes:

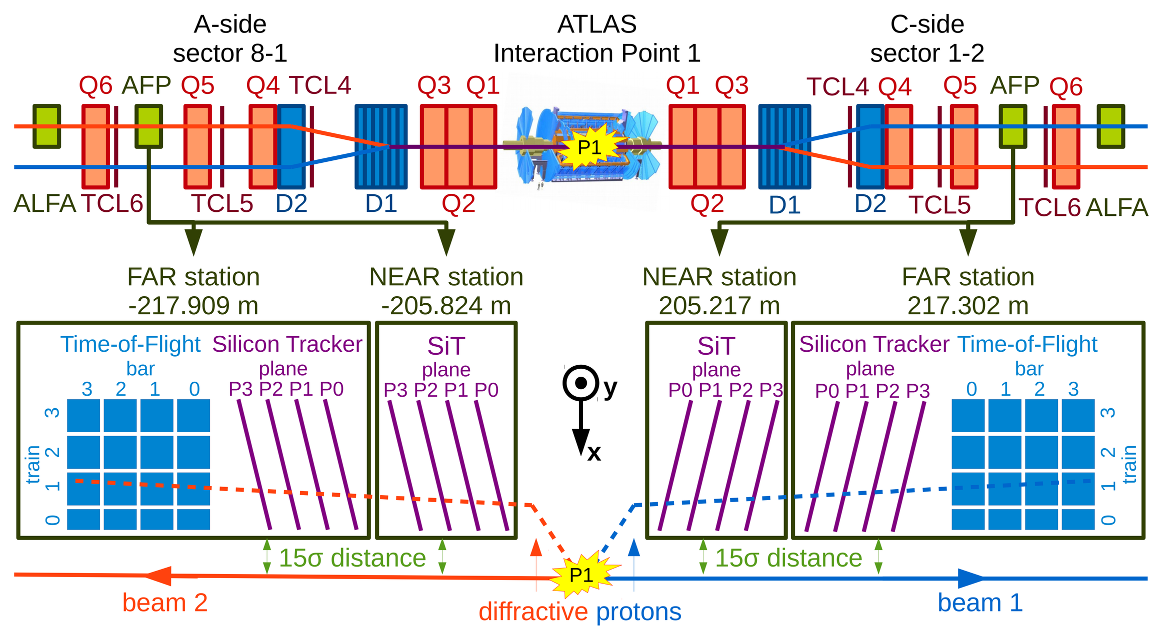
- Verify Standard Model predictions
- One or both protons intact
- Example: double Pomeron exchange jet production



Forward Proton: Can be measured in AFP detector



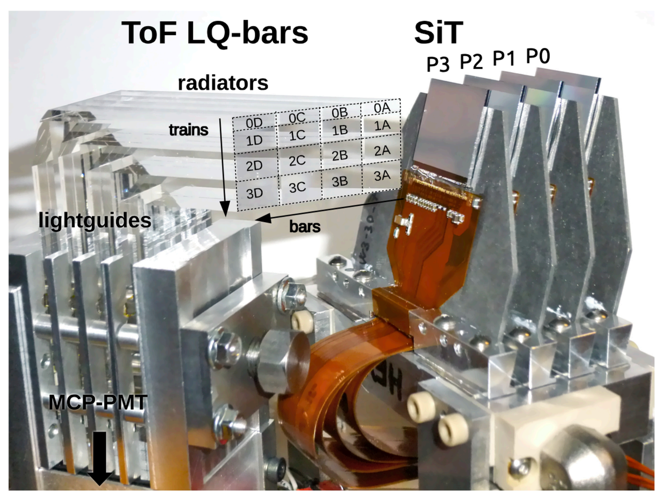
ATLAS Forward Proton Detector



- Located on each side (A/C) of the ATLAS Detector
- ~210 m from the Interaction Point
- Each side has two stations, NEAR: containing tracker, FAR: containing tracker and Time-of-Flight

Roman Pot Detector: allows AFP to be very close to the LHC beam during stable collisions → detect forward scattered protons

Silicon Trackers (SiT)



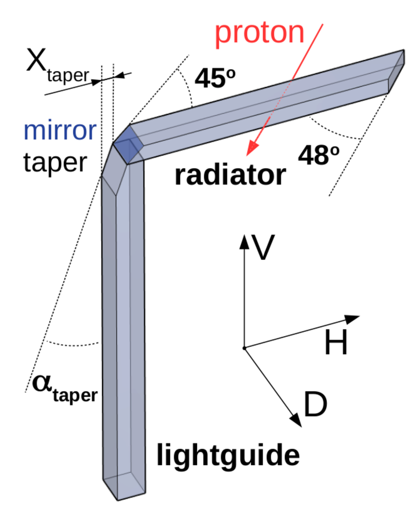
AFP Far Station Setup

- 4 Silicon Pixel sensor planes (16 x 20 mm[2]) per station
- Tilt (14°) to increase reconstruction precision
- Proton trajectory reconstructed with precision of 6 (30) μm in x (y)

Advantage: full 4-momentum reconstruction of central detector objects

Time-of-Flight System (ToF)

- Cherenkov light produced in and guided by LQ bars
- Signal amplified, processed and delivered to ATLAS
- Timing measurements on both sides used to reconstruct primary vertex of protons in ATLAS detector
- Trains are formed of 4 bars in the same plane



AFP ToF L-shaped Quartz (LQ) bars

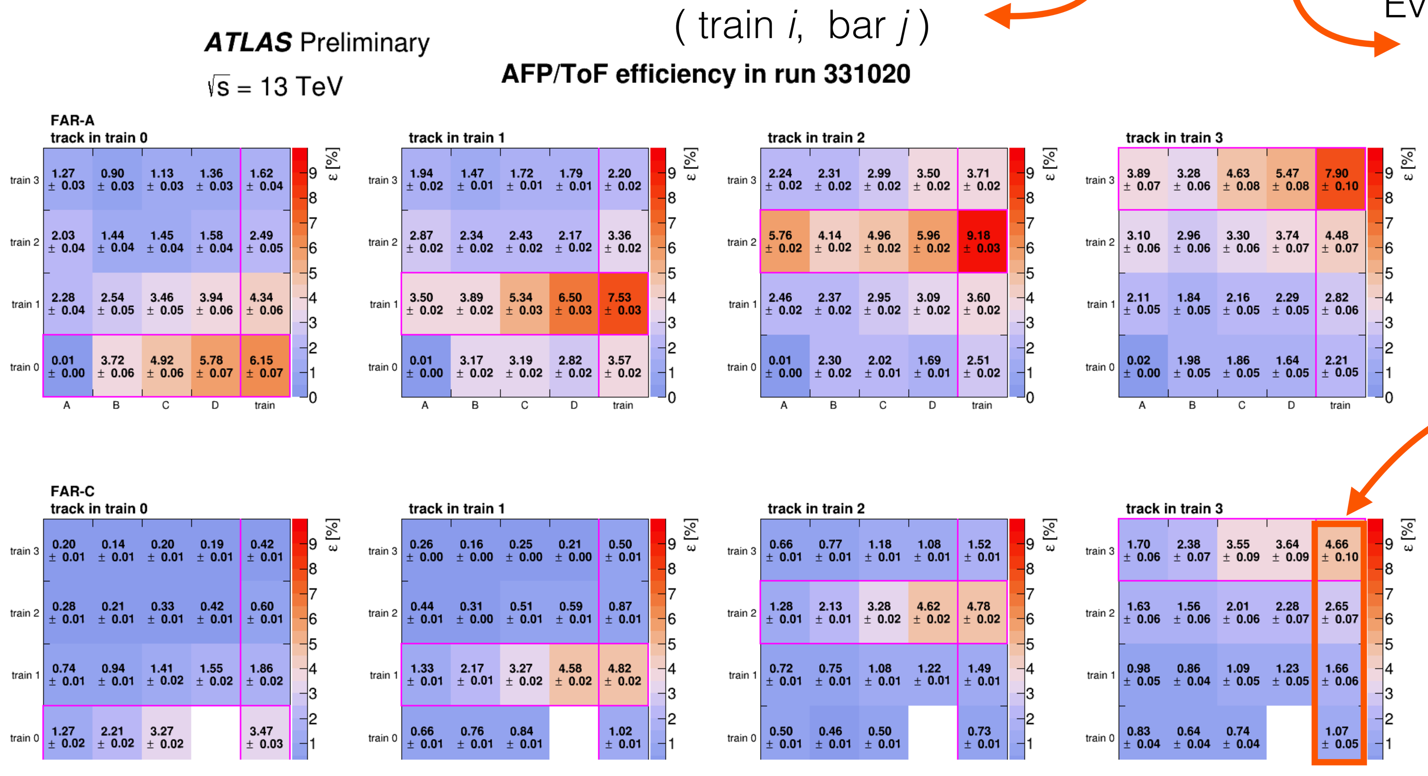
Advantage: reduce combinatorial background events due to high pileup effects.

ToF Efficiency

$$\varepsilon_{ij} = \mathrm{N}(\mathrm{Bar}_{ij} \cap \mathrm{Track}_k)/\mathrm{N}(\mathrm{Track}_k)$$

Events in a given channel (train i, bar j)

Events with reconstructed SiT tracks physically pointing to train k

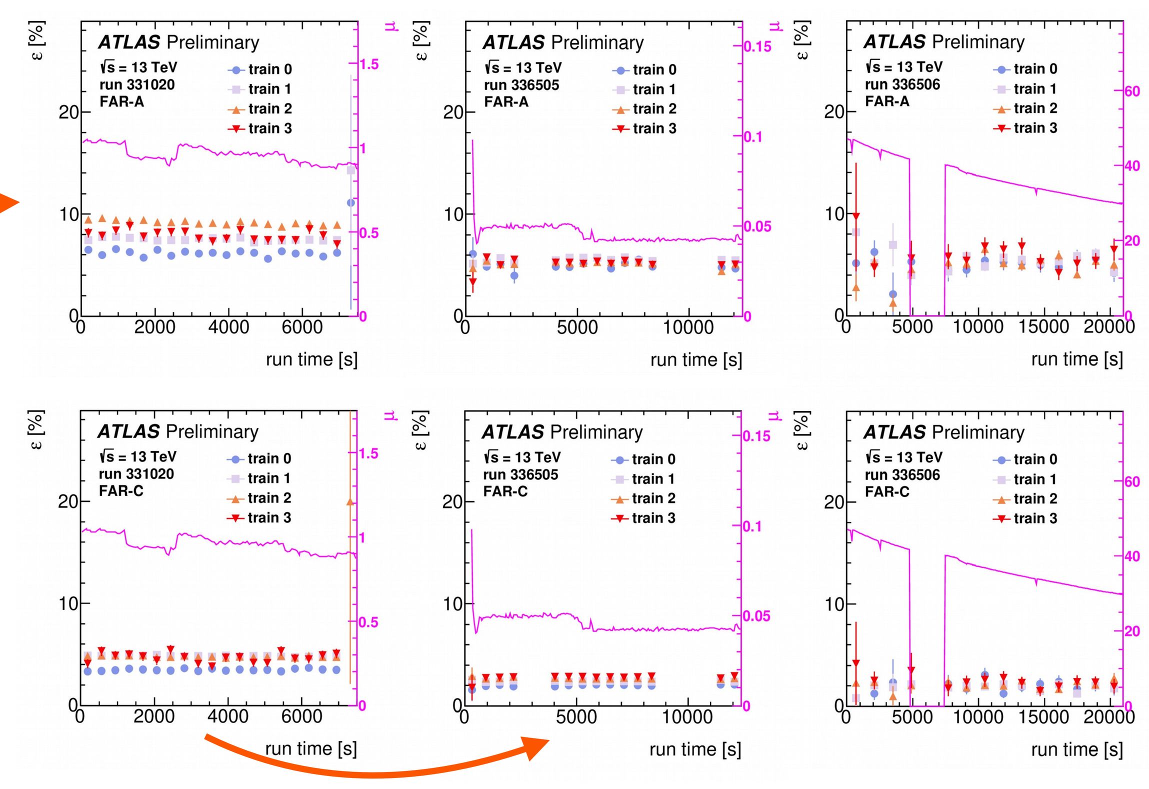


Efficiencies of full train calculated with channel values

Single train requirement here

Data taken in 2017, in low μ conditions

- Over time, efficiency lowers due degradation of PMTs.
- Efficiencies are independent of pile-up conditions



Data taken two months later

Time Resolution

- Time measurement of a single ToF channel:

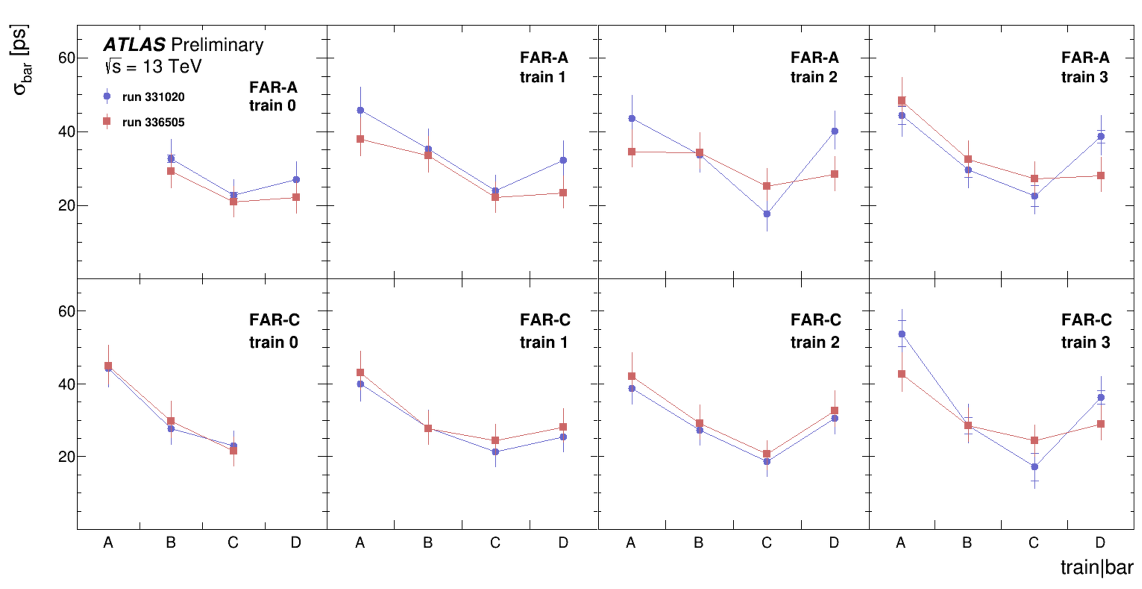
$$t_i = t_{proton} + t_{i,delay} + t_{i,smear} - t_{clock}$$

True proton arrival time; Constant time offset of a given channel; Contribution smeared by stochastic effects; Reference clock signal

- Channel resolution

$$\sigma_i = \sqrt{Var(t_{i,smear})}$$

calculated from time distributions between different channels of a given train.



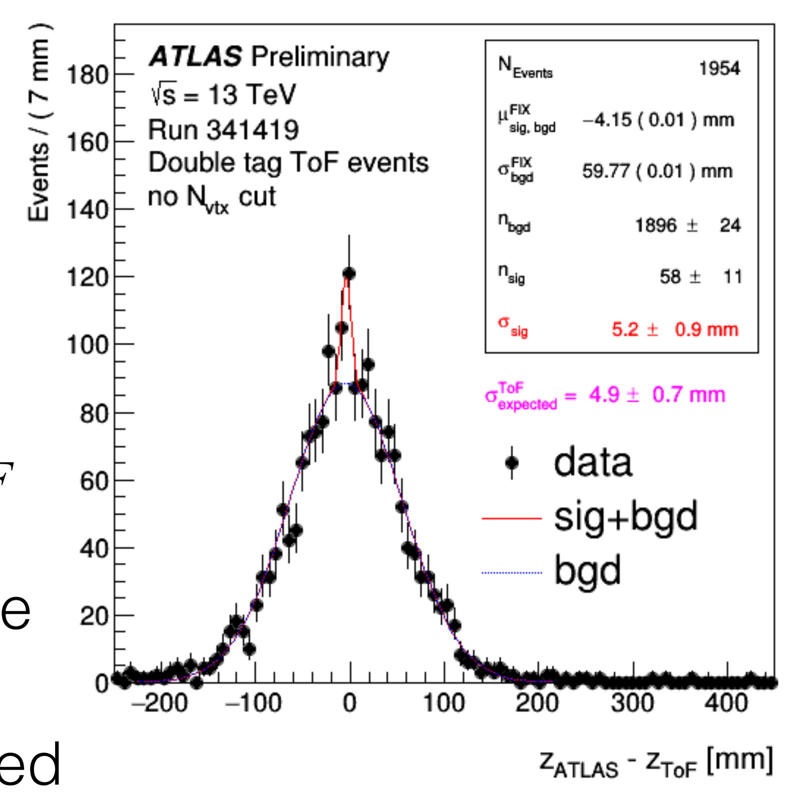
The overall time resolution of each ToF detector: 20 (26) ± 4 (5) ps for side A (C).

Vertex Matching

- Timing values from both diffractive protons provide vertex position of scattered protons:

$$z_{ToF} = \frac{c}{2}(t_{FAR-C} - t_{FAR-A})$$

- The z-resolution: $\Delta z = z_{ATLAS} - z_{ToF}$
- Signal: z_{ATLAS} from central diffractive objects and z_{ToF} from ToF Station
- Background: hard vertex reconstructed in ATLAS + random (pile-up) protons in AFP



Vertex position resolution measured for ATLAS AFP ToF Detector: 5.2 ± 0.9mm

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