Trigger development for the ATLAS Forward Proton Detector (AFP)

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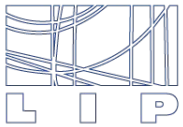
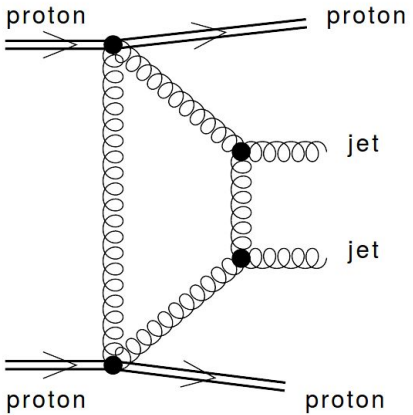
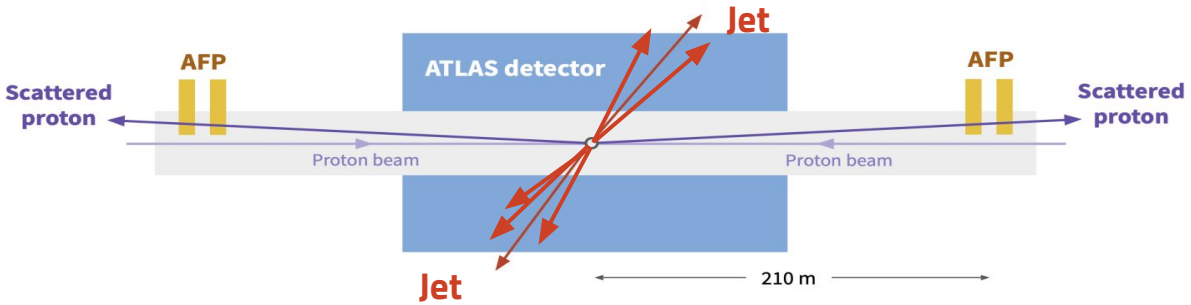


ATLAS Forward Proton Detector (AFP) | Motivation and overview

- Identify protons that emerge intact from the collision at very low angles
- **Both protons remain intact** and all the energy lost is used to produce the central system (central exclusive production - **CEP**)
- CEP of jet pairs provides insight into QCD interactions and allows to set limits on exclusive Higgs boson production
    - Cannot be studied without dedicated trigger
- Demonstrate AFP capabilities and set the foundation for the search of new physics in diffractive processes
- Trigger strategy: tag protons (AFP) and combine with information from jets in the central detector

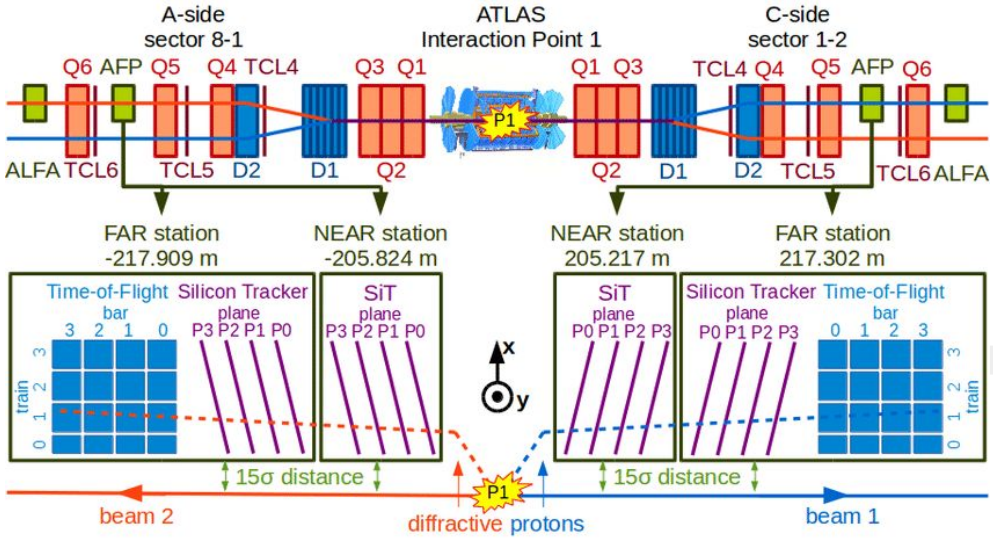


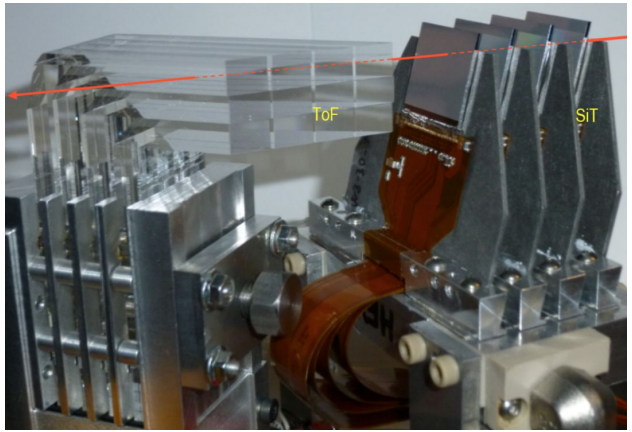
σ = 0.5 pb @ 14 TeV
(pT leading jet > 150 GeV)



ATLAS Forward Proton Detector (AFP) | Stations and sub detectors

- Composed of a **silicon tracker** and a **time-of-flight** detector (ToF)
  - **Tracker** provides position measurement
  - **ToF** allows the identification of protons coming from the same interaction point (crucial for operation at high pileup)



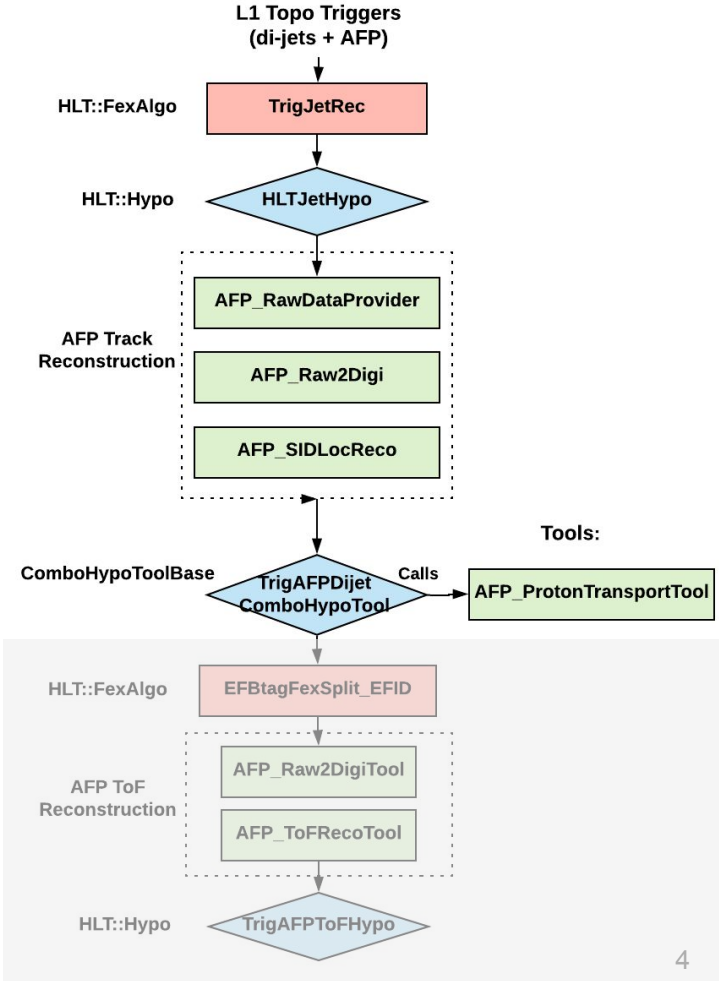


Dijet central exclusive production trigger

- L1 topological trigger requiring a jet pair and CEP specific cuts
- Request ≥2 jets in the central detector
- Kinematic properties of dijet pair ⇒ proton's energy loss
- Protons energy loss ⇒ expected positions at both AFP stations
- From the list of tracks reconstructed by AFP choose the one closest to each proton
  - Apply geometric selection cut
- Accept events for which both protons have matched tracks

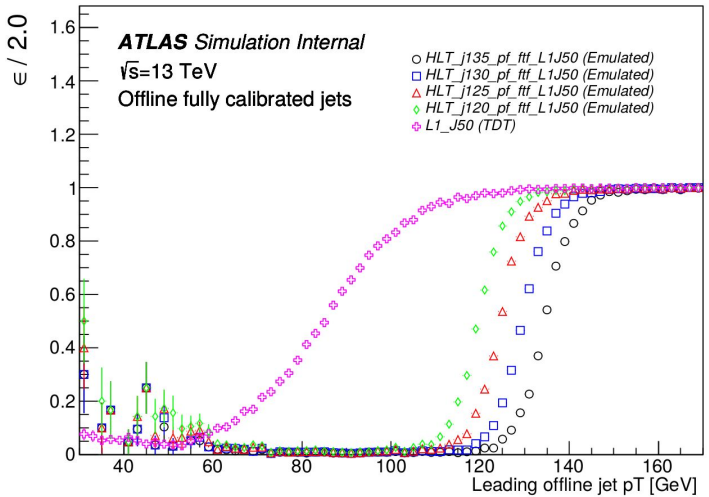
- In technical notation, an example trigger chain would be HLT_2j120_mb_afprec_afpdijet_L1CEP-CJ50

≥2 jets with pT>120 GeV
Tracks reconstructed in AFP
Algorithm that combines dijet+AFP
L1 trigger item



Dijet central exclusive production trigger | L1 items

- Suitable L1 jet trigger thresholds that ensure maximum efficiency at HLT?
- AFP geometric acceptance ⇒ Jet $p_T \geq 150$ GeV
- L1 jet trigger threshold such that the HLT trigger is fully efficient for a jet offline $p_T = 150$ GeV
- Can be achieved using L1_J50 (≥1 jet, pT ≥ 50 GeV)
    - To ensure that the rate is manageable, dedicated central exclusive selection are applied using the L1 topological trigger
    - Kinematic properties of two leading jets ⇒ Estimate if protons will be within AFP acceptance

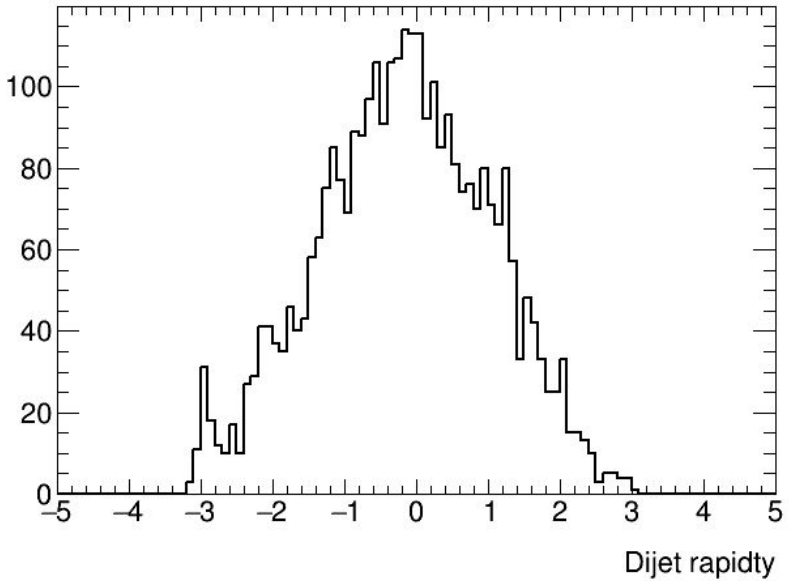


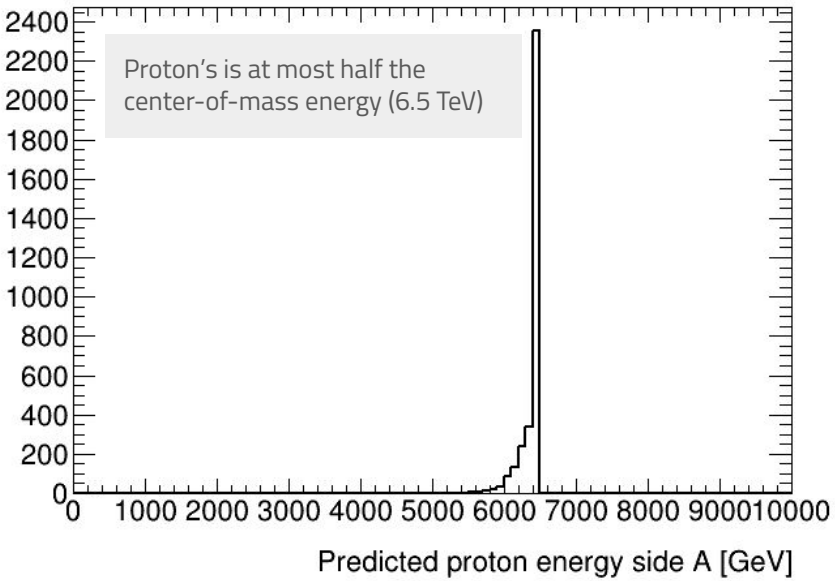
Plot by Ricardo Barrué

- Trigger chains with different L1 pT thresholds have been added to the menu
- Algorithm is working as expected ⇒ Validation plots next

Hypothesis algorithm monitoring plots

- Plots produced based on a data sample from 2018 and with no L1 requirement (to increase statistics)





Proton's is at most half the center-of-mass energy (6.5 TeV)

Relative energy loss

$$\xi_{j1/j2} = \exp(\pm\eta_{jj}) * (M_{jj}/E_{CM})$$

Proton energy

$$E_{p1/p2} = E_{beam} * (1 - \xi_{j1/j2})$$

Conclusions

- Studying CEP of jets is crucial to further our understanding of QCD interactions
- Demonstrating AFP triggering capabilities will open the door to the use of these triggers in searches for new physics in diffractive processes

- Trigger chains combining jet reconstruction in the central detector and track reconstruction in AFP implemented in the ATLAS trigger software framework with different L1 trigger requirements
    - Needed to properly study the trigger performance
- Algorithm for ToF selections still to be implemented ⇒ Allow AFP operation at high pileup

Backup

Dijet hypothesis algorithm | Implementation details

- Use the kinematic properties of the dijet system (measured by the central detector) to calculate the protons' energy

Relative energy loss

$$\xi_{j1/j2} = \exp(\pm\eta_{jj}) * (M_{jj}/E_{CM})$$

Proton energy

$$E_{p1/p2} = E_{beam} * (1 - \xi_{j1/j2})$$

- Based on the protons' energy calculate their expected positions in AFP stations
- Find nearest AFP track to each of the protons based on distance: $d = \sqrt{(\Delta x^2 + \Delta y^2)}$
- Accept as matched tracks that fulfil (current default values, can be configured)
  - $d < 2.0$
  - $\Delta x < 2.5$ and $\Delta y < 2.5$
- Event accepted if both protons are matched to tracks

AFP track reconstruction monitoring

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