Turning Noise Into Data: Using Pileup for Extraction of the Jet Energy Resolution

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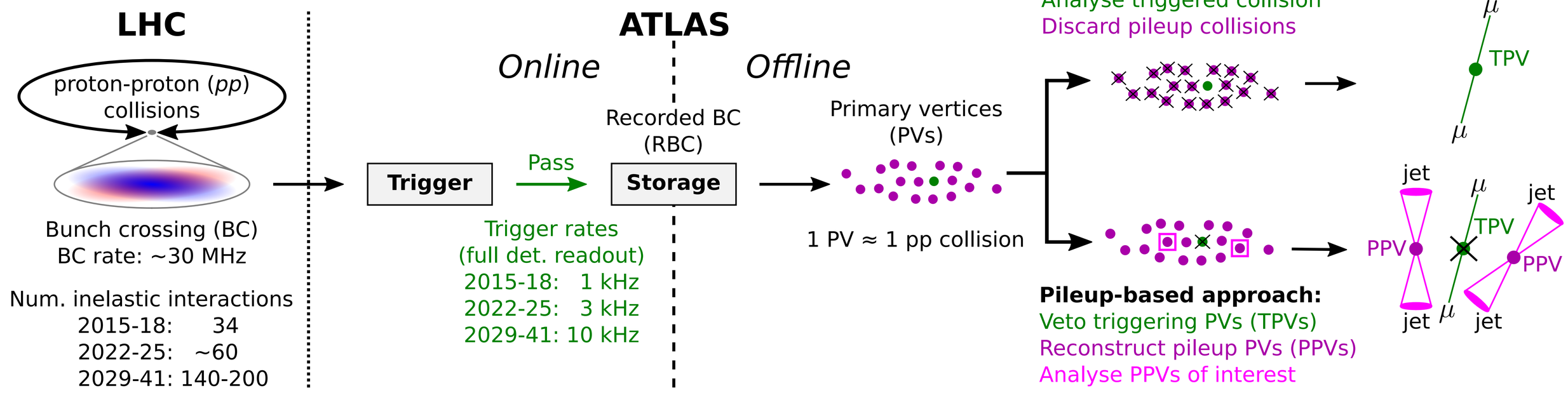
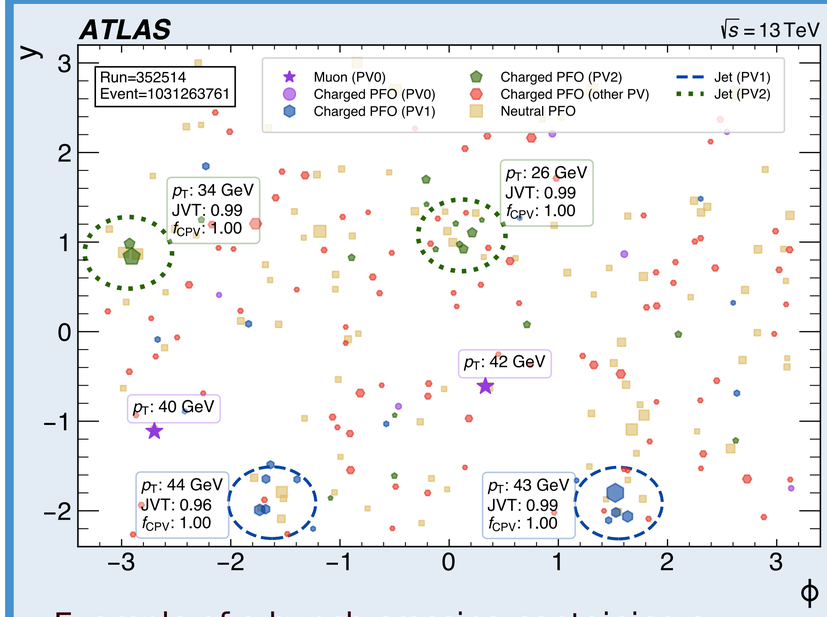
The ATLAS detector observes **multiple proton-proton (*pp*) collisions simultaneously** in each bunch crossing. The typical physics analysis only considers a single *pp* collision selected by the trigger system, while the rest of the collisions are referred to as **pileup**. They add noise to the physics process under study. However, by independently reconstructing these pileup collisions, it is possible to access **an enormous dataset of lower-energy hadronic physics processes**. In this approach, the triggering collision is vetoed, leaving the remaining pileup dataset **trigger unbiased**. The potential benefits of using pileup for physics are shown through the evaluation of the **Jet Energy Resolution (JER)**, comparing single-jet-trigger-based and pileup-based datasets.

Interactive 3D event display showing a bunch crossing containing a muon-triggered collision and two distinct dijet pileup collisions. Displays the same bunch crossing as the 2D display below in the section "Visualising a Bunch Crossing".

Using Pileup Collisions for Physics



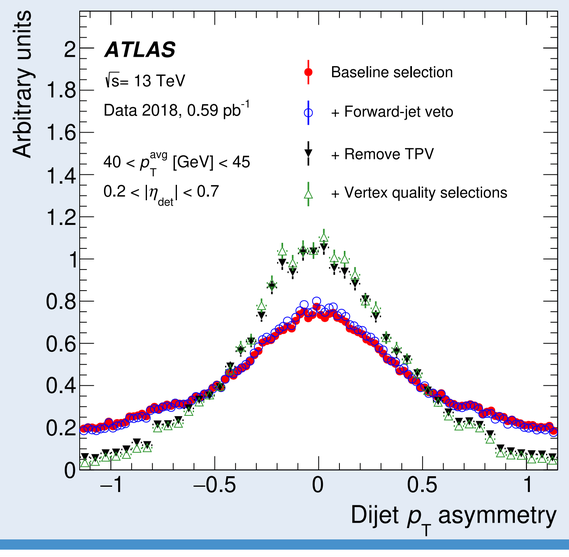
Visualising a Bunch Crossing



Example of a bunch crossing containing a muon-triggered collision (PV0) and two distinct dijet pileup collisions (PV1 and PV2)

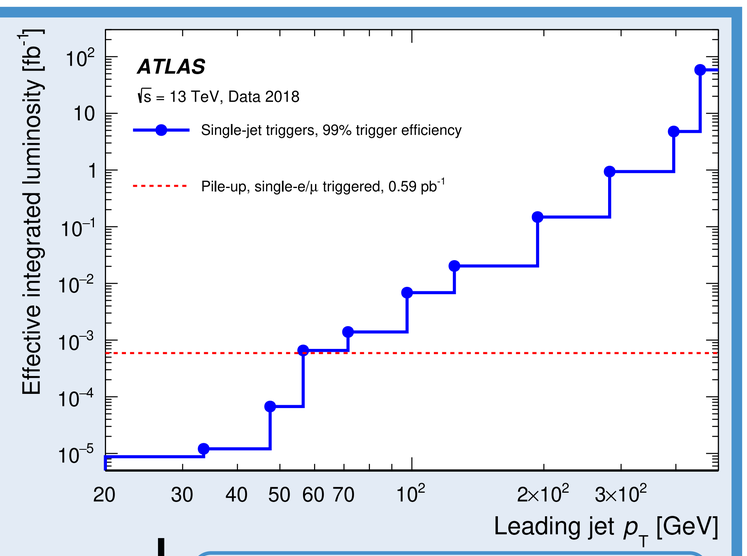
Pileup Dataset Selection

- Use only well-understood jets within the **tracker acceptance region**
- Remove **out-of-time jets** from other bunch crossings
- Remove the triggering vertex (currently only considering **electron and muon triggers**)
- Veto pileup collisions that are **closer than 2 mm** to triggering vertex to ensure being unbiased by trigger
- Select only events where the jets clearly originate from the same collision, removing events where collisions overlap

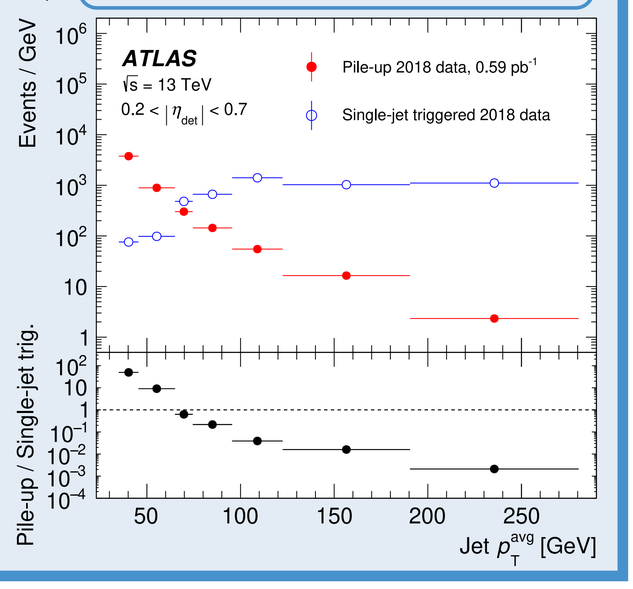


Benefits of Pileup Dataset

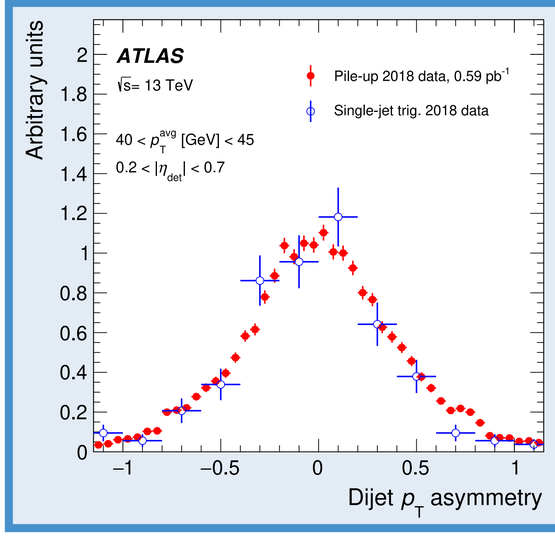
- A novel way of using already recorded data without additional cost or requirements on the trigger system, readout or storage
- Low energy single-jet triggers record only fraction of all the events (prescaling)
  - → No such limitation with pileup data
  - → Mostly depend on ATLAS trigger rate
- **More data with pileup approach** compared to single-jet triggers when **leading jet p_T < 65 GeV**



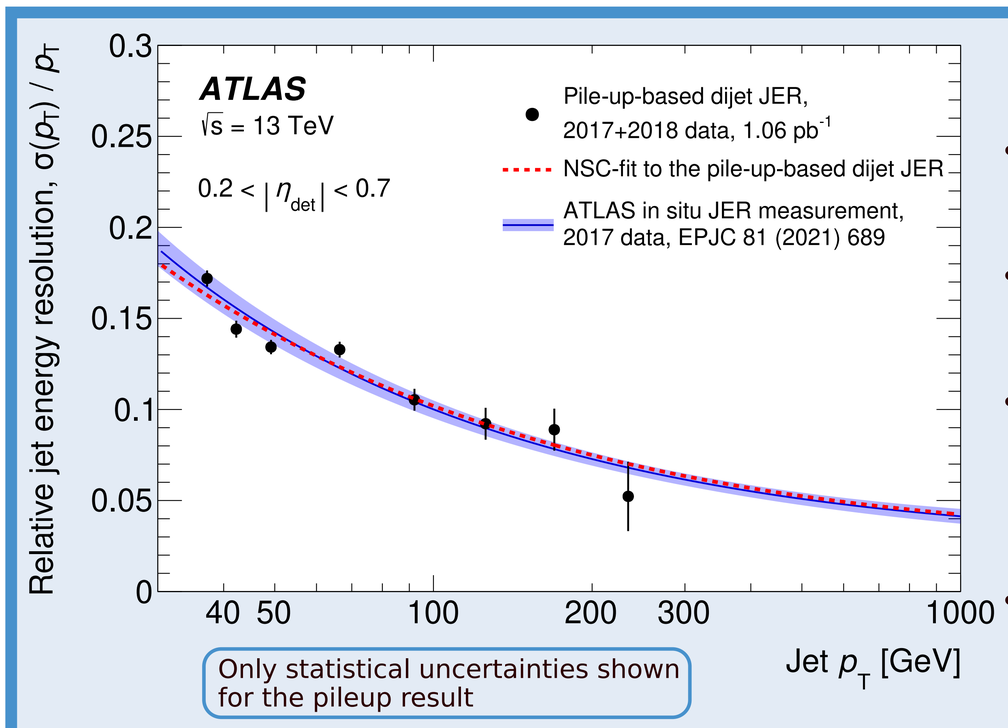
After analysis selections, 50x more data for JER measurement at very low p_T



Jet Energy Resolution



- The JER measures the precision with which the energy of the hadronic showers can be known
- Important quantity in many Standard Model measurements and searches for new physics
- Derived by measuring p_T imbalance of pair of jets (**asymmetry**) and width of this distribution in multiple p_T bins



Results and Outlook

- **Excellent agreement** with the official ATLAS JER single-jet triggered measurement
- Provides strong evidence that pileup dataset is **unbiased** as results are compatible with the normal approach
- The pileup JER measurement has much **higher sensitivity** than triggered dijet JER measurements at low p_T, and will help in the in situ combination
- The pileup dataset offers many interesting potential applications for low-energy hadronic physics analyses

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