# Using pileup in search of new physics

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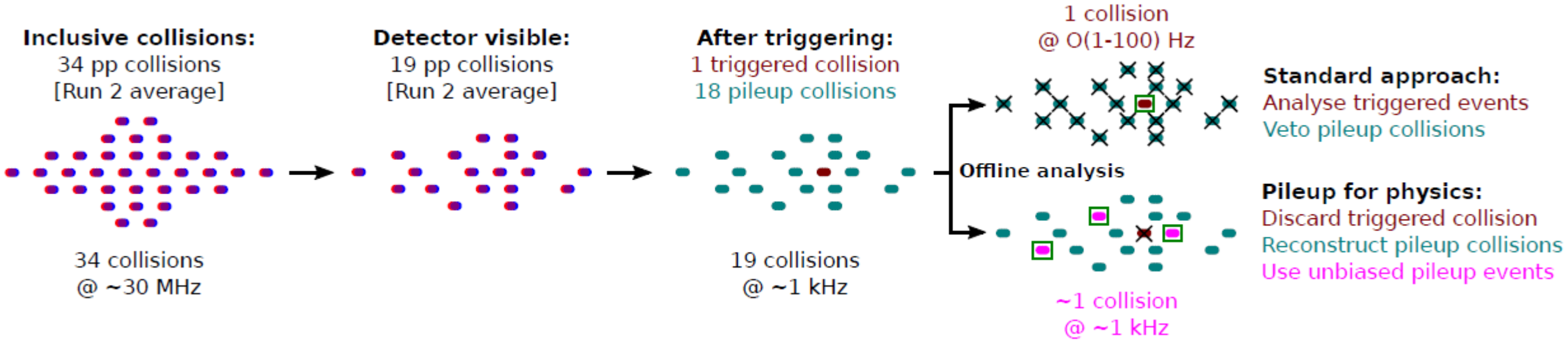
# Turning noise into data: pileup collisions

- **Standard:** one collision of “interest” and 18 pileup collisions (seen as noise to be rejected).
- Each proton-proton collision is independent.
  - If we are able to reconstruct the pileup collisions separately, we can build trigger-unbiased data.
- Pileup can then be used as a minimum bias dataset.
  - This is useful when the pileup dataset is larger than the triggered dataset.

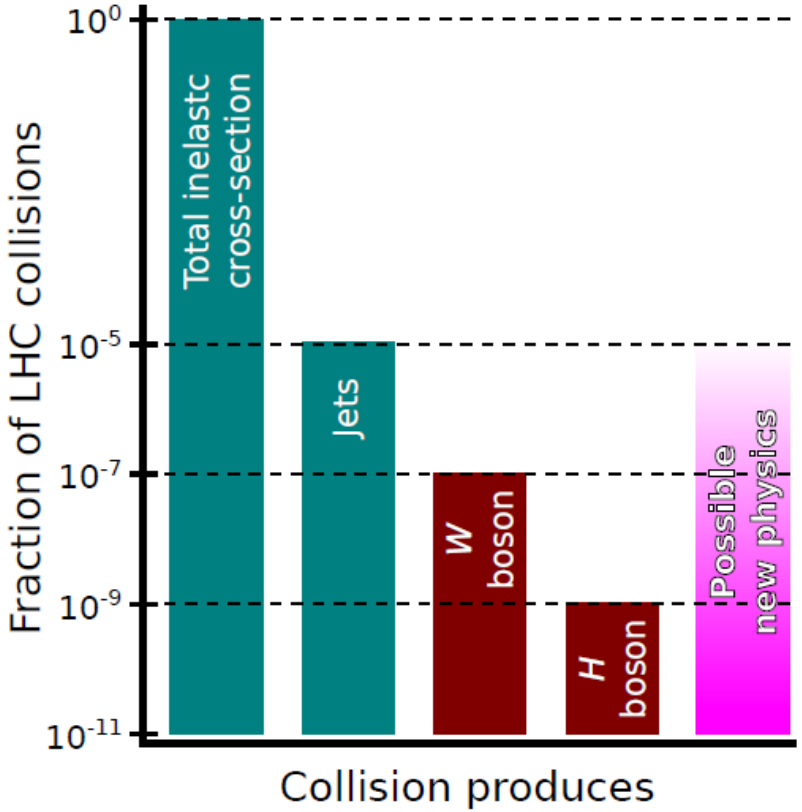


# Amount of data to expect from using pileup

- $\mathcal{L}_{\text{int}}^{\text{pileup}} \approx \mathcal{L}_{\text{int}}^{\text{LHC}} \times \frac{\text{data recording rate}}{\text{LHC collision rate}}$
  - Run 2 data recording rate ≈ 1 kHz
  - LHC collision rate ≈ 30 MHz
  - → Run 2 $\mathcal{L}_{\text{int}}^{\text{pileup}}$ ≈ 5 $pb^{-1}$
- Small compared to 140 $pb^{-1}$ .
  - However, it still amounts to a lot of data:

    $\sigma(W^{\pm}) \approx 10^4\,\text{pb} \implies 5 \times 10^4\ W^{\pm}$

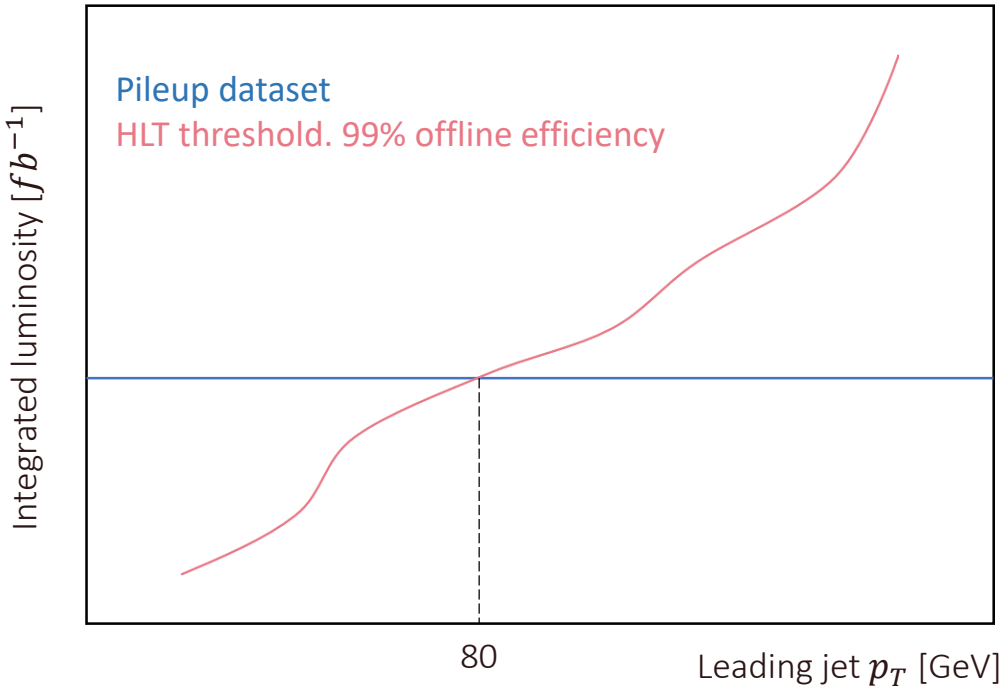
  - Competing constraints: physics of interest must have a very low trigger acceptance, but must have a large cross-section, to be seen in pileup.




Cross-sections from SM summary plot

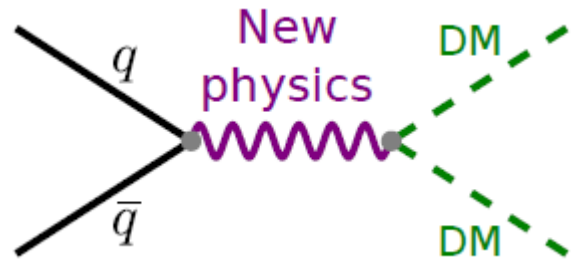
# Where can we use this pileup dataset?

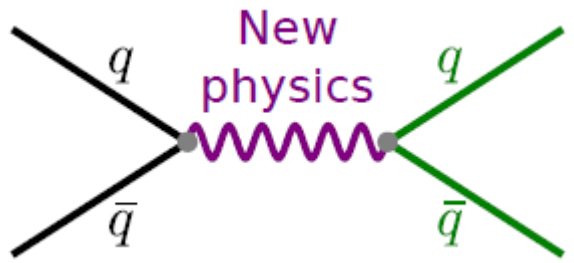
- First we need to consider the acceptance of the relevant trigger (for us is the HLT single-jet).
- For single-jet trigger users, pileup dataset is best for $p_T \lesssim 80\ GeV$.
  - Comparable to using triggers for $80\ GeV \lesssim p_T \lesssim 110\ GeV$.
- Triggered searches have to consider efficiency.
  - No such constraints in pileup.
  - The pileup scales linear with luminosity. Relevance grows with pileup.

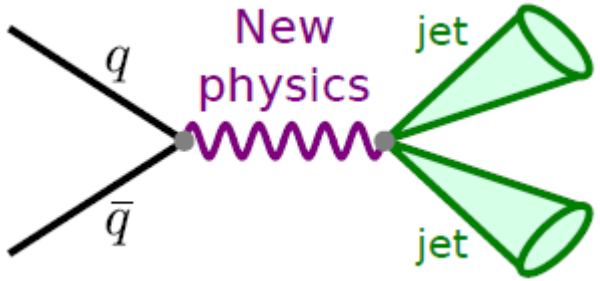


# What can we use pileup for?

- Jet calibrations
- Dijet resonance searches
- Much more!
- However, first we need to reconstruct the data!



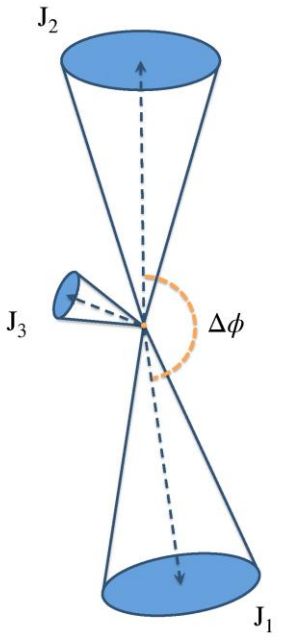



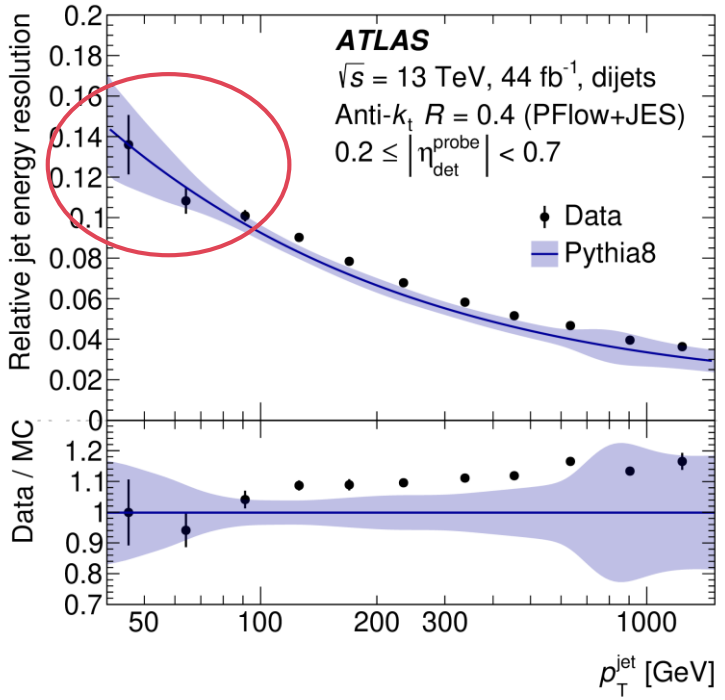
# Creating the dataset

- New analysis strategy due to huge increase in statistics compared to standard approach.
  - This is possible due to increased LHC pileup levels and advanced understanding of jet reconstruction.
- Need of planning new reconstruction approaches.
- New nomenclature.
- Checking the non-bias between proton-proton collisions.
  - Each proton-proton collision may be independent, but we need to make sure the trigger decision comes from a single collision, and remove that one.

# Jet calibrations

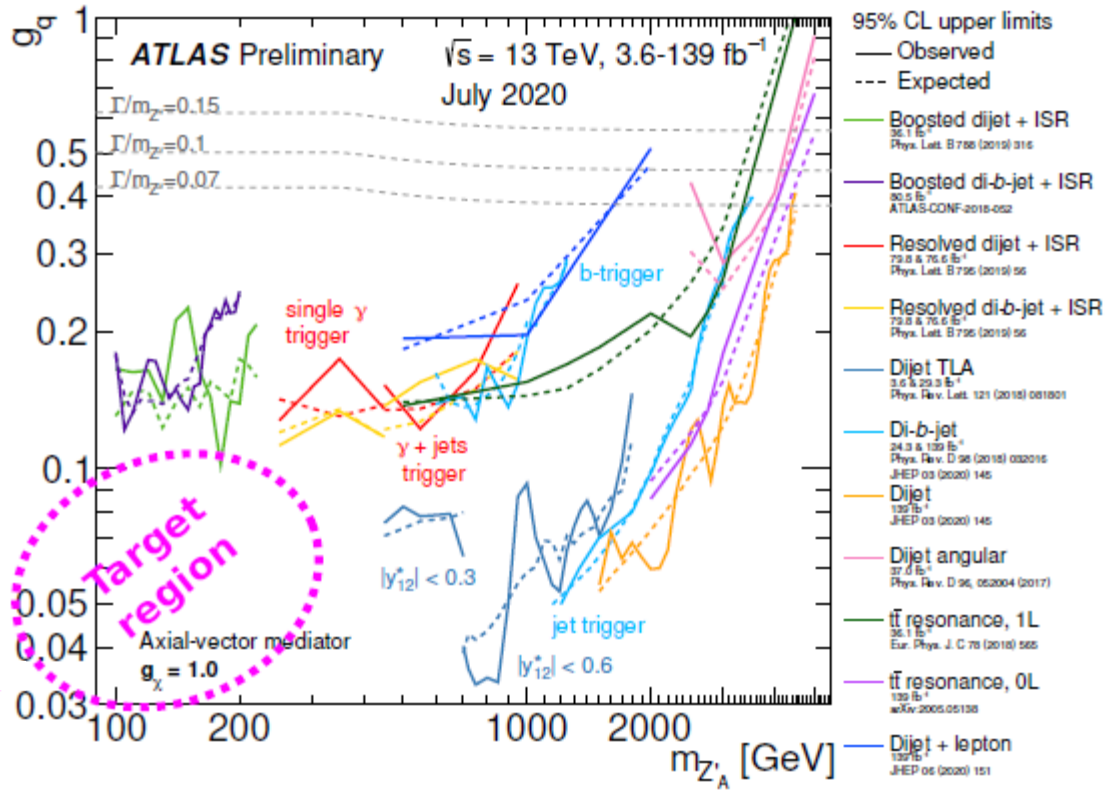
- At the low $p_T$ region we have a lack of statistics.
  - This is where our pileup data will be able to help us!
  - We get more sensitivity for the low-energy regime compared to complementary searches.



# Dijet resonance searches

- Using pileup collisions gives a big increase in the available statistics at low-energy and is competitive for DM mediators up to 200 GeV.
    - In this region is where we have the W/Z boson, so we are able to validate our technique.
- Beyond dijet resonances, can consider higher multiplicity final states: a lot of new physics models (Composite Higgs model, Strongly coupled dark matter, …).



# Summary

- Most of ATLAS reconstruction is oriented around the single PV mentality
  - We present an alternative: using pileup collisions to create a minimum bias dataset.
  - For this we need a new event reconstruction strategies: vertex-by-vertex reconstruction.
- The project focus on:
  - Searches for weakly-interacting low-energy hadronic physics
    - Linking to Dark Matter, Higgs mass and more generic searches.
  - High-statistics data analysis.
  - Machine learning applications.

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