

Looking at trigger efficiencies and statistical errors for inclusive jet measurement using data from 2018

Laura Martikainen

October 25, 2022

Contents

Measurement of inclusive jet production

Triggers for inclusive jets

Statistical errors vs. trigger efficiencies

Summary

Measurement of inclusive jet production ($pp \rightarrow jet(s) + X$)

Double differential inclusive cross section is defined as

$$\frac{d^2\sigma}{dp_T dy} = \frac{N_{\text{jets}}}{\epsilon \cdot \mathcal{L}_{\text{int}} \cdot \Delta p_T \Delta y} \cdot C_{\text{smear}} \quad \text{vs.} \quad p_T \cdot \text{JEC}$$

N_{jets} : number of jets

ϵ : jet and event efficiency

\mathcal{L}_{int} : integrated luminosity

$\Delta p_T, \Delta y$: bins of traverse momentum¹ and rapidity²

C_{smear} : smearing from jet energy resolution

JEC: Jet Energy Corrections

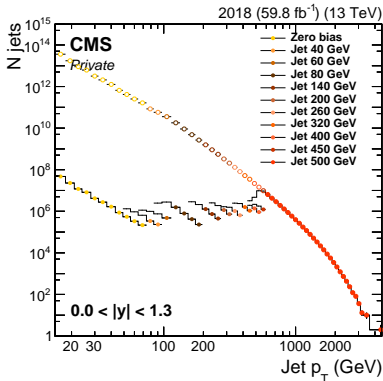
¹Using same bins as earlier CMS analyses

²Default in this analysis: 0.0-0.5, 0.5-1.0, 1.0-1.5, 1.5-2.0, 2.0-2.5, 2.5-3.0, 3.2-4.7

It's a precision analysis

- One of the staple QCD measurements
- Important input for QCD analyses, as fits for α_S and proton PDFs
- Theory calculations getting more precise, so should the measurement
- We also try to get smooth spectra

Trigger strategy



- Measure spectra different prescaled HLT_PFJet_XX paths (+ Zero Bias), combine as slices of offline p_T
- Threshold offline jet p_{TS} (aka *trigger turn ons*) for using the different paths need to be determined

Measuring trigger efficiency for two purposes

- Correct measurement for trigger efficiency
- Determine trigger turn ons as offline p_T where the efficiency is high enough
 - ▶ Typical efficiency requirement for trigger turn on is 99%, however the latest inclusive jet measurement from CMS used 99.5%
- Two alternative methods used: emulation and tag and probe

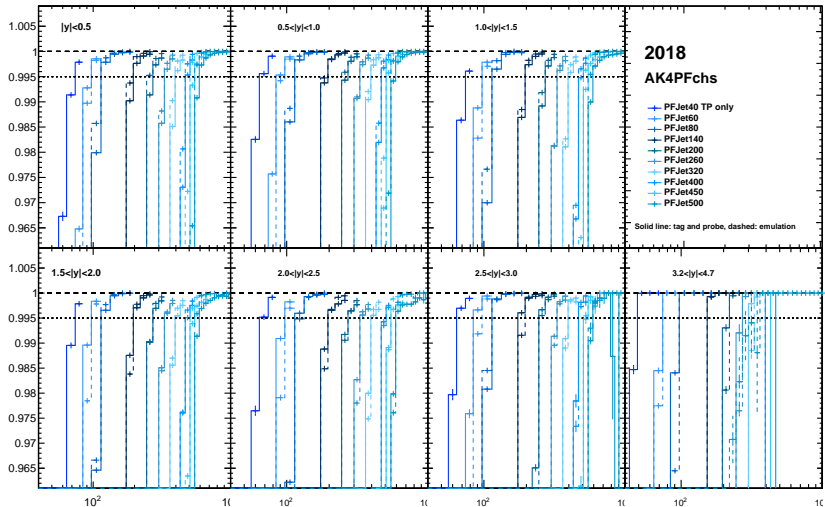
Emulation for trigger efficiency

- Using measurement from n th HLT path to study $n + 1$:th path
 - ▶ eg. PFJet40 trigger used for PFJet60 → cannot use method for PFJet40 (ZB has no trigger objects saved)
- Use HLT level jet p_T info to study the trigger: find the hardest HLT jet
- The event obviously fired the n :th trigger (reference): check if the HLT hardest p_T could have fired also the next trigger (emulation)
- Efficiency: $\varepsilon = N_{\text{emulated}}/N_{\text{reference}}$

Tag and probe for trigger efficiency

- Choose dijet system: back-to-back condition: $\Delta\phi > 2.7$ and p_T limit for soft jets: $p_{T,3} < 0.3 \times p_{T,avg}$
- Use both jets as tag in turn
- Try matching offline jets to HLT jets
 - ▶ The HLT jet needs to have p_T high enough to fire the studied trigger
 - ▶ Match first the tag jet
 - ▶ If tag matched, try probe jet
 - ▶ Efficiency: $\varepsilon = N_{\text{tag and probe fired}}/N_{\text{tag fired}}$

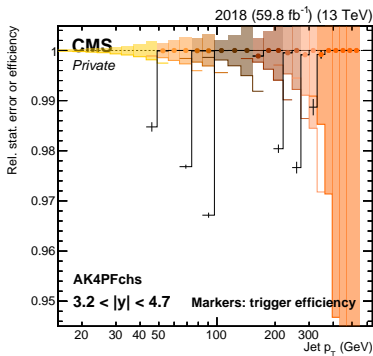
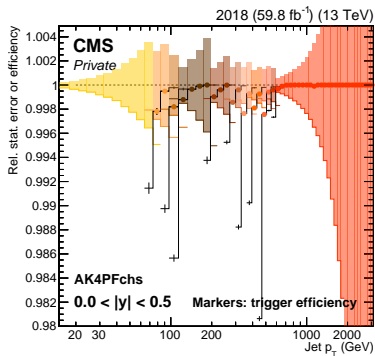
Trigger turn-ons curves, AK4



Comparing efficiency to statistical error

- The inclusive jet spectrum is steeply falling
 - ▶ ...and that's basically why we use trigger prescales in the first hand
- Also means that the statistical error of the measurement increases with increasing p_T
 - ▶ So maybe one should use as low p_T threshold as somewhat reasonable?
 - ▶ But how reliable is our efficiency measurement? Should we require $\varepsilon \approx 100\%$ to not worry about efficiency correction?
- Run 2 statistics should be quite good though
- Maybe let's look at how the statistical errors actually compare to the trigger efficiency?

Trigger efficiency vs. relative statistical error

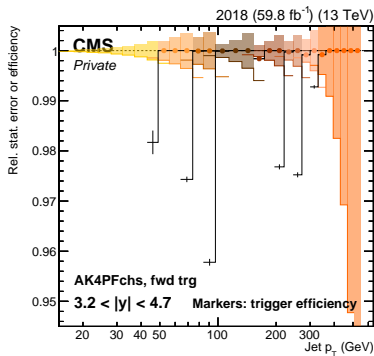
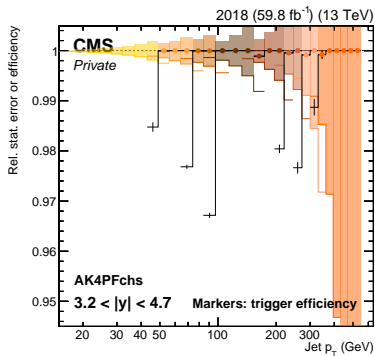


- Markers: measurement from emulation, expect PFJet40 from t&g
- Note: different p_T thresholds for measurements in barrel and HF

Bonus: how about the forward jet triggers?

- Since 2017 a different version of the PFJet triggers have existed: in addition to the specific p_T , require $2.7 < \eta_{\text{jet}} < 5.0$
- Goal is to obtain the best statistic at the HF
- So let's compare

Standard HLT jet paths vs. the fwd paths



- Note: prescale choices might not been optimal?

Summary

- Inclusive jet measurement combines measurement using different HLT paths requiring presence of a jet with different minimum transverse momenta
- For combining measurements from different triggers and for efficiency corrections, the trigger efficiencies need to be measured
- Ended up going possibly a bit overboard with optimizing the trigger strategy by comparing to statistical errors
 - ▶ Maybe most useful for optimizing measurement of high y jets
 - ▶ ...but maybe this is some useful information also for future measurements (or at least students trying to understand jet measurements)