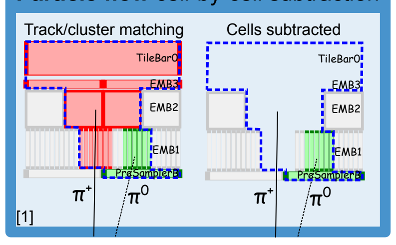
# IN SITU MEASUREMENTS OF THE ATLAS JET ENERGY RESOLUTION USING 13 TeV PP DATA

LHCC Poster Session - CERN, 27 February 2019

**Particle flow** cell-by-cell subtraction




## JER Parametrization

$$\frac{\sigma_{p_T}}{p_T} = \frac{N}{p_T} \oplus \frac{S}{\sqrt{p_T}} \oplus C$$

**N: noise term** → pile-up and electronics noise

**S: stochastic term** → sampling calorimeter

**C: constant term** → passive material

The abundance of jets in proton-proton collisions makes it very important to understand the typical range of energy values a given jet can deposit in the detector. This quantifies the Jet Energy Resolution (JER) and is studied *in situ* by two analyses which are then inputs to a ***statistical combination***. The first analysis measures the effect of ***pile-up and detector noise*** on the JER, the second measures the JER of anti-$k_t$ $R = 0.4$ jets with $p_T$ up to 1.5 TeV by using ***well-balanced dijet systems***. This poster focuses on the JER measurement of **particle flow jets** that are reconstructed by combining information from topological clusters and tracks.

## Noise Term Measurement

$$N_{\text{full}} = N_{\text{pile-up}} \oplus N_{\mu=0}$$

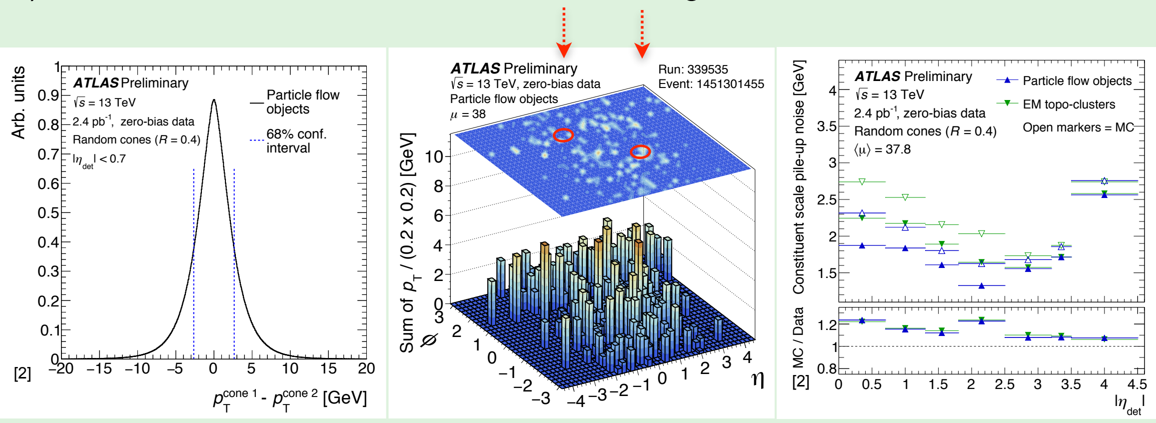
**Noise from electronics**

Extracted from JER of MC with no pile-up

**Noise from pile-up**

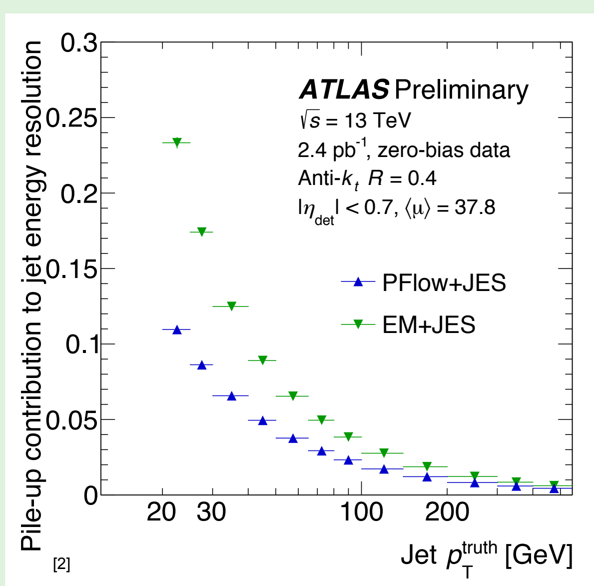
**Random cones method:**

1) Sum energies within randomly distributed and non-overlapping pairs of cones ($R = 0.4$) in **zero-bias data**
2) Width of momentum difference of two cones gives **noise at constituent scale**




### Extraction of $N_{\text{full}}$

The random cones noise is scaled to JES in bins of particle-level jet $p_T$. **The pile-up noise term** is extracted from a fit to the pile-up resolution and added in quadrature to the noise from electronics.




## Dijet Direct Balance

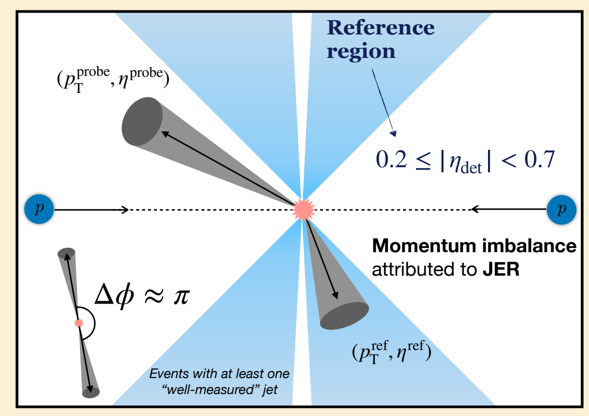
Resolution of probe jet studied from **momentum balance** with well-measured reference jet

$$A = \frac{p_T^{\text{ref}} - p_T^{\text{probe}}}{\left(p_T^{\text{ref}} + p_T^{\text{probe}}\right)/2}$$

Studied across $\eta$ with the **central reference method**:

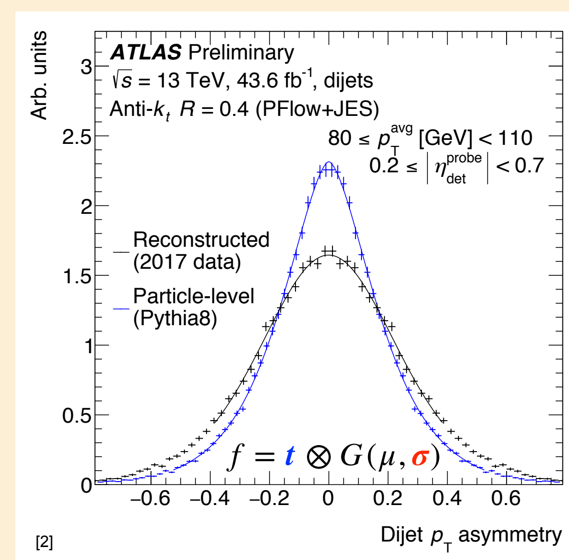
$$\left(\frac{\sigma_{p_T}}{p_T}\right)^{\text{ref}} = \frac{\sigma_A^{\text{det}}}{\sqrt{2}}, \quad \text{for } 0.2 \le |\eta_{\text{det}}^{\text{probe}}| < 0.7$$

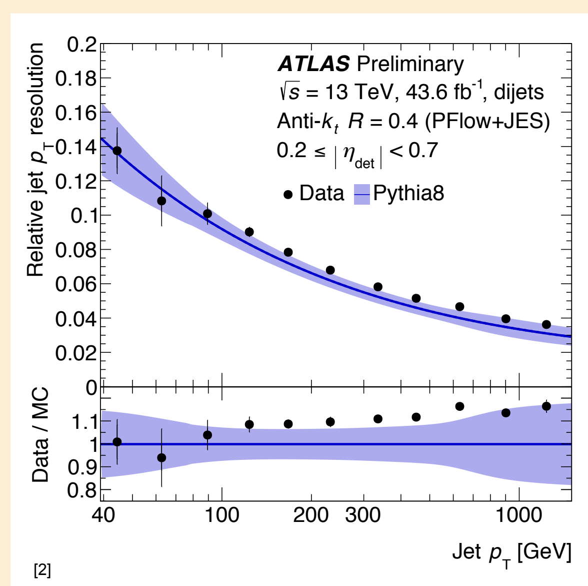
$$\left(\frac{\sigma_{p_T}}{p_T}\right)^{\text{probe}} = \sigma_A^{\text{det}} \ominus \left(\frac{\sigma_{p_T}}{p_T}\right)^{\text{ref}}, \quad \text{else}$$




### Fit Convolution

The **particle-level asymmetry** (ISR, jet out-of-cone radiation) is modelled with an *ad-hoc* function $t$. Fitting the convolution with a **Gaussian** provides a measure of the detector JER $\sigma$.



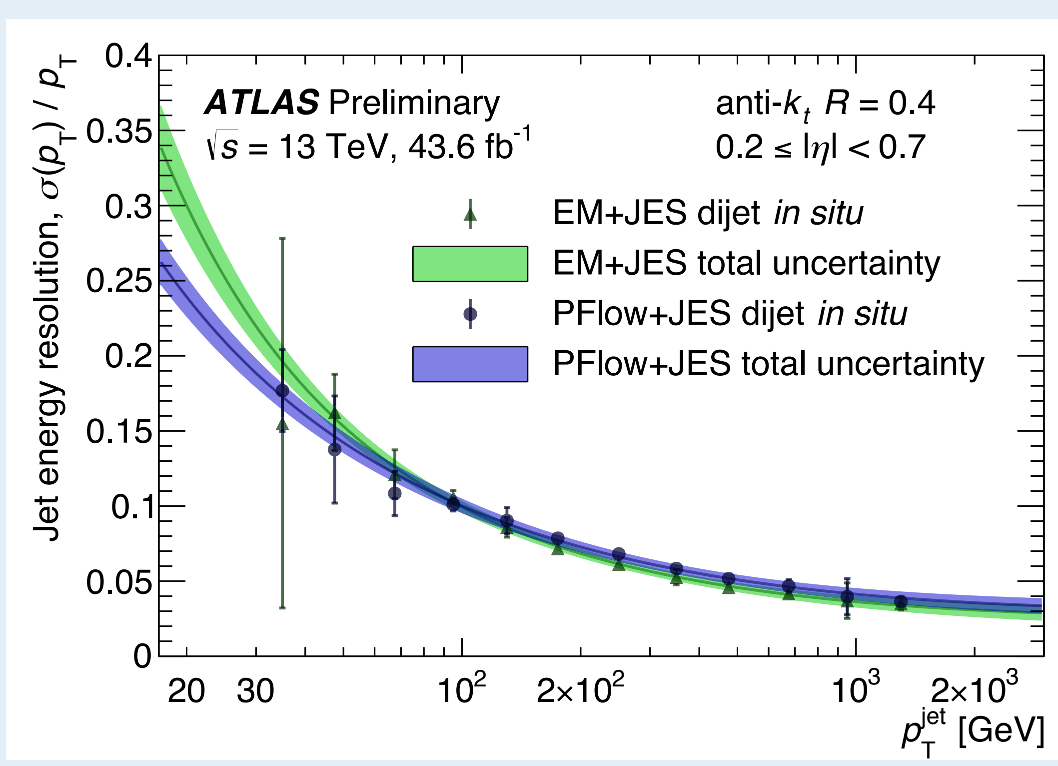

### Comparison to MC

The Monte Carlo JER predictions are extracted from $\sigma\left(p_T^{\text{reco}}/p_T^{\text{truth}}\right)$ and compared to the dijet results. After the combination, the average JER in MC is smeared to match data.

## JER Combination

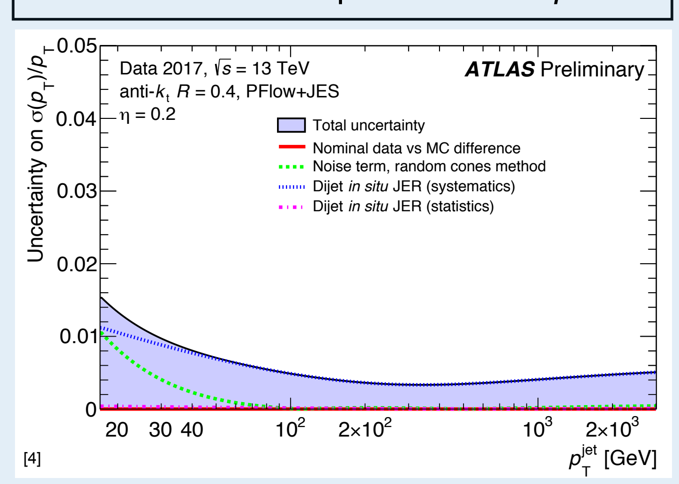
### Combined fit

Dijet results fitted with N, S, C parametrization with fixed noise term from the random cones measurement. Particle flow jets show lower JER and smaller uncertainties at low $p_T$, which is driven by the noise term.




### Uncertainties

The main systematic uncertainties arise from method non-closure, jet energy scale uncertainty, and the modelling of dijet events. The noise term uncertainties are important at low $p_T$.

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References: [1] CERN-EP-2017-024, https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/PLOTS/… [2] …= JETM-2019-01, [3] … = JETM-2019-04, [4] … = JETM-2018-005

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