In–Situ Jet Energy Scale Calibration of Large–Radius Jets

Matthew Epland

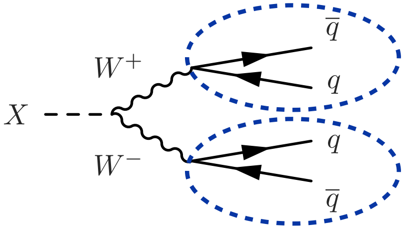
Duke University

Nov. 3, 2016

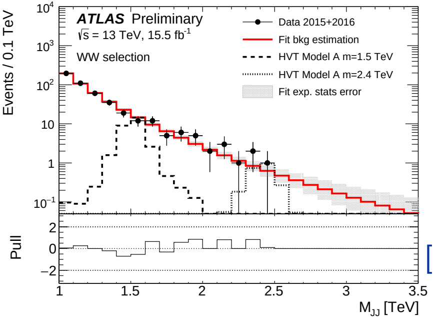
US LUA, LBNL

Why Calibrate Large–Radius Jets?

- Heavy objects decaying to multiple quarks are conveniently reconstructed as large–radius jets
  - Substructure tagging opens a window on processes like $X \to t\bar{t},\ VV,\ HH$
- Without a calibrated Jet Energy Scale (JES) discoverable features would be smeared and measurements would be off



Large–Radius Jets



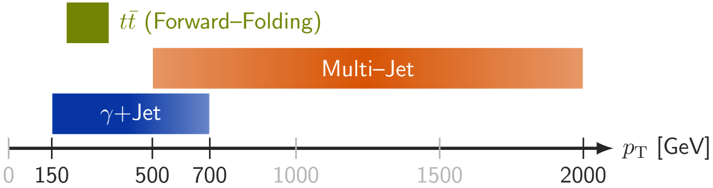
[1]

- Begin by calibrating JES from Monte Carlo (MC) simulations:

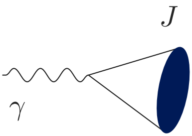
MC Calibration $= \left\langle p_{\mathrm{T}}^{\mathrm{MC,\ Reco}} / p_{\mathrm{T}}^{\mathrm{MC,\ Truth}} \right\rangle$

In–Situ Calibration Methods

After initial MC calibration, derive additional in–situ calibrations from data

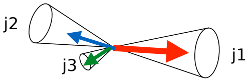


γ+Jet



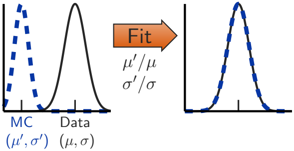
$\sim$2% uncertainty

Multi–Jet



$\sim$2% uncertainty

Forward–Folding

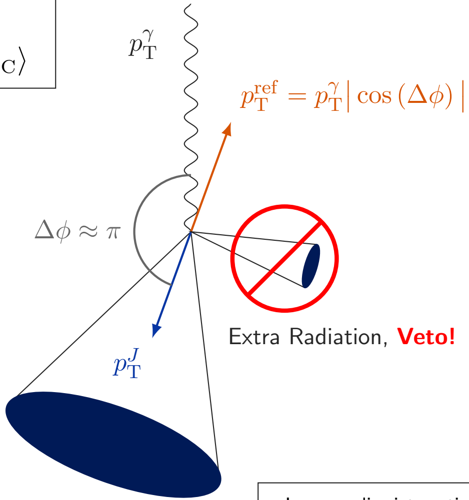


Valid on 200–350 GeV

$\sim$2.1% uncertainty

γ+Jet Direct Balance Method

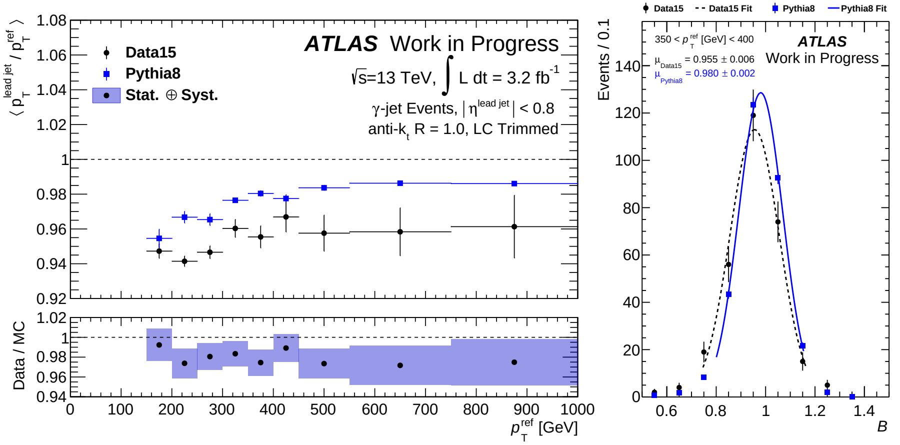
$$B = p_{\mathrm{T}}^{J} / p_{\mathrm{T}}^{\mathrm{ref}}$$
$$\mathcal{R}\left(p_{\mathrm{T}}^{J}\right) = \langle B_{\mathrm{Data}} / B_{\mathrm{MC}} \rangle$$



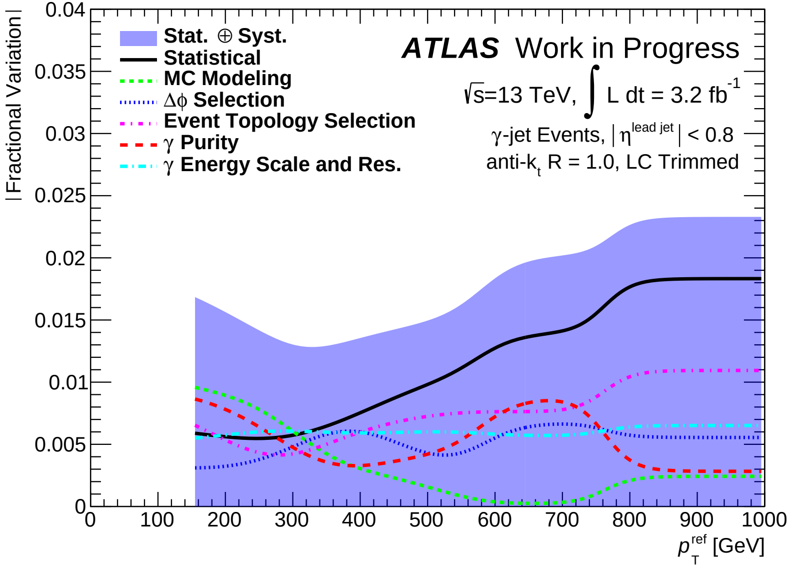
Large–radius jet: anti–$\mathrm{k_t}$ $R = 1.0$, trimmed

Extra radiation: anti–$\mathrm{k_t}$ $R = 0.4$

γ+Jet Balance



γ+Jet Systematics



Summary

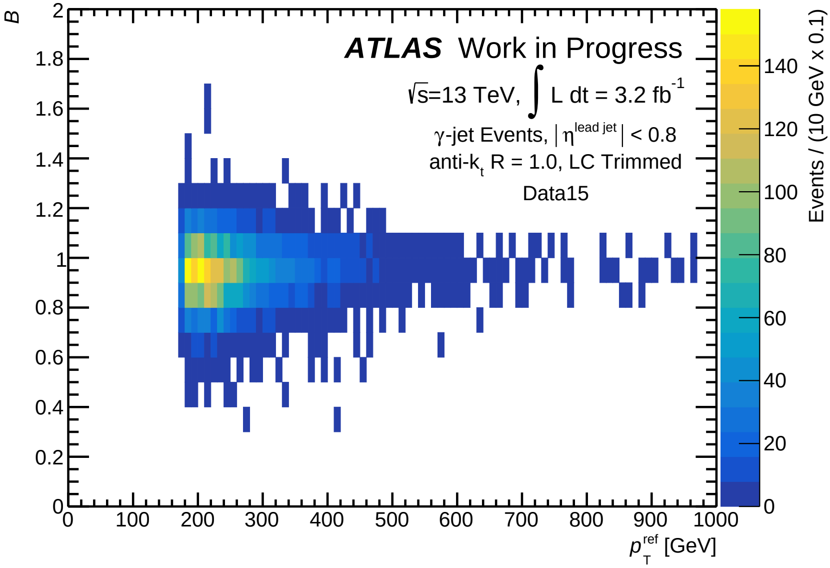
- Uncertainty in the JES calibration is a major systematic for many large–radius jet analyses, such as diboson resonance searches
- Combining the in–situ methods should produce a calibration with $\sim$2% uncertainty
- The new in–situ calibration will be approximately a factor of two improvement over the current calibration

Backup

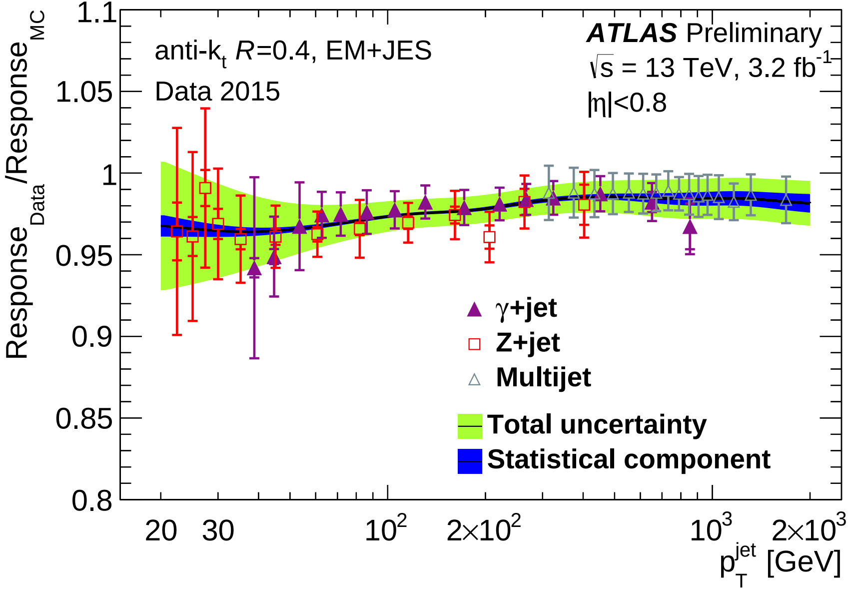
γ+Jet Event Selection

- Photons
  - $p_{\mathrm{T}}^{\gamma} > 180$ GeV
  - $|\eta^{\gamma}| < 1.37$
  - Tight identification and isolation ($E_{\mathrm{T}}^{40} < 0.022 p_{\mathrm{T}} + 2.45$ GeV)
- Large–Radius Jets (J_1)
  - $p_{\mathrm{T}}^{J_1} > 20$ GeV
  - $\left|\eta^{J_1}\right| < 0.8$
  - Overlap removal: $\Delta R_{\gamma,\, J_1} > 0.2$
- Small–Radius Jets (j_2)
  - Cleaned + JVT $\geq$ 0.59
  - Overlap removal: $\Delta R_{\gamma,\, j_2} > 0.4$, $\Delta R_{J_1,\, j_2} > 1.0$
- Topological Selections
  - $\Delta\phi > 2.8$
  - $p_{\mathrm{T}}^{j_2} < \max\left(15 \text{ GeV},\ 0.1\ p_{\mathrm{T}}^{\mathrm{ref}}\right)$

γ+**Jet** B **vs** $p_{\mathrm{T}}^{\mathrm{ref}}$



Small–Radius In-Situ JES



[2]

References

[1] Search for resonances with boson-tagged jets in 15.5 fb^{-1} of pp collisions at $\sqrt{s} = 13$ TeV collected with the ATLAS detector, Tech. Rep. ATLAS-CONF-2016-055, CERN, Geneva, Aug, 2016.
http://cds.cern.ch/record/2206137.

[2] Public plots: Jet energy scale uncertainties updated for ICHEP 2016 using full 13 TeV 2015 dataset, Aug, 2016.
https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/PLOTS/JETM-2016-010/.