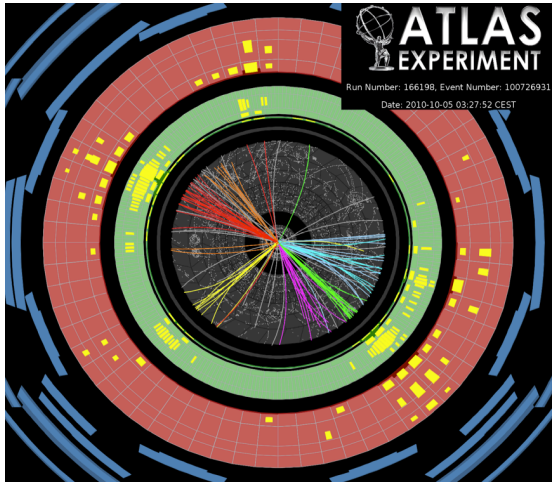
Performance of Jets and Missing ET in ATLAS



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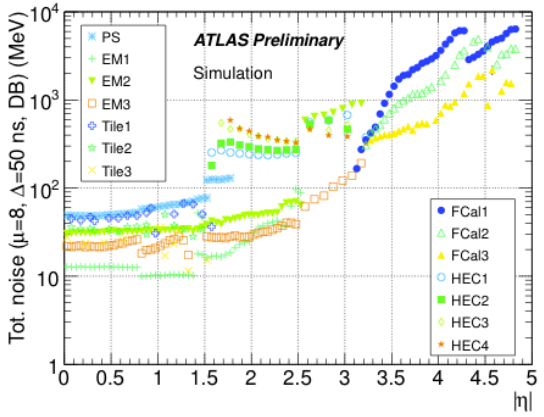
05-Jul-2012

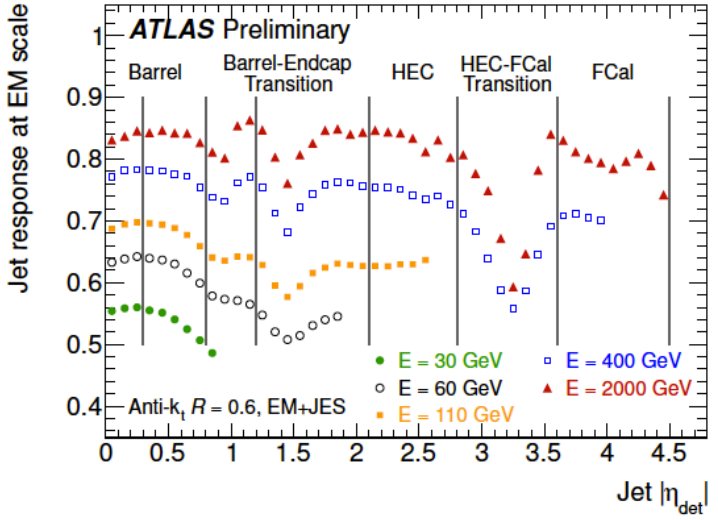
Outline

- **Jet reconstruction and calibration**
  - Inputs to jet reconstruction and calibration schemes
  - Pile-up subtraction and suppression
  - Jet energy scale uncertainty
- **Jet resolution improvement using tracks**
- **Jet substructure**
- **Missing ET performance**
  - Pile-up corrections

Jet reconstruction and calibration

- **Inputs to jet reconstruction:**
  - 3-dimensional calorimeter topological clusters:
    - Follow shower development
    - Pile-up + electronic noise suppression
    - Local hadron calibration (EM/HAD weights) derived from single pion simulations
  - Tracks
    - Independent from calorimeter
    - Additional z-vertex information
- **Jet algorithms: anti-k_t R=0.4, 0.6**
  - anti-k_t R=1.0, C/A R=1.2
- **Factorized jet energy calibration**
  - Pile-up, non-compensation, inactive material, shower leakage
  - Residual insitu calibration

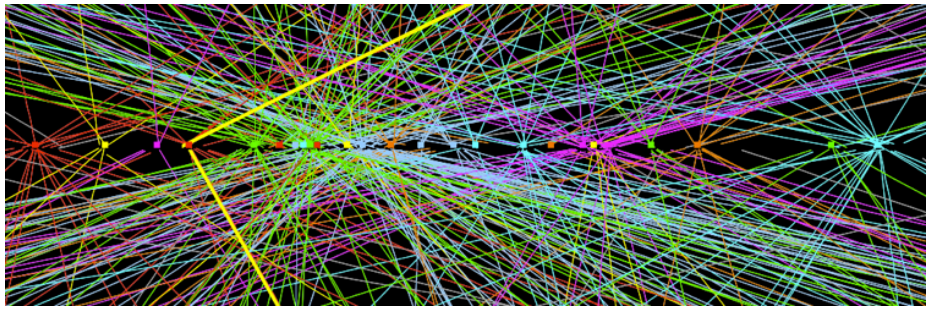




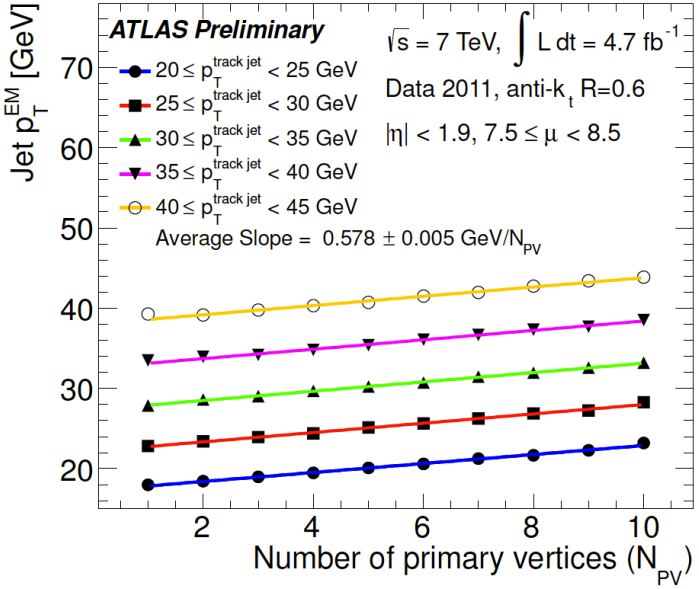
Pile-up subtraction → Monte Carlo JES calibration → Jet-by-jet Post-calibration corrections → In-situ residual calibration

Pile-up subtraction and uncertainty

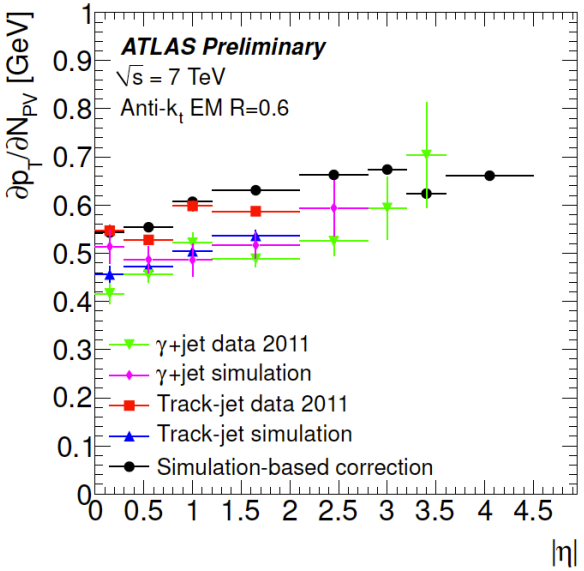
- Offset correction to account for **in-time** and **out-of-time** pile-up
- Determined from Monte Carlo
- Uncertainty from data/MC differences in dijet and γ+jet insitu offset measurements



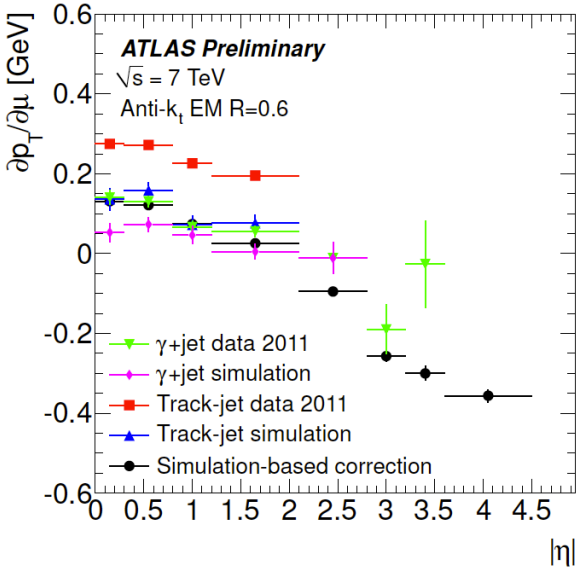
$$\mathcal{O}(N_{\mathrm{PV}},\mu,\eta_{\mathrm{det}}) = \frac{\partial p_{\mathrm{T}}}{\partial N_{\mathrm{PV}}}(\eta_{\mathrm{det}})\left(N_{\mathrm{PV}} - N_{\mathrm{PV}}^{\mathrm{ref}}\right) + \frac{\partial p_{\mathrm{T}}}{\partial \mu}(\eta_{\mathrm{det}})\left(\mu - \mu^{\mathrm{ref}}\right)$$



In-time

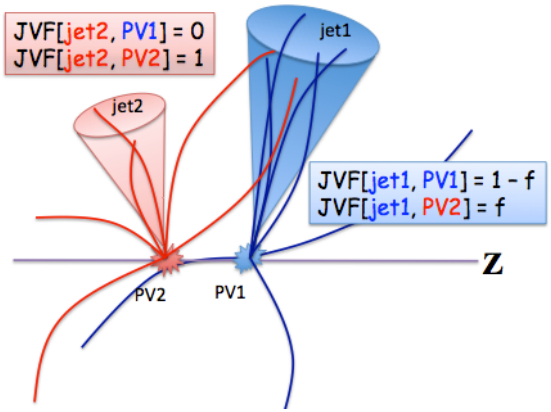


Out-of-time



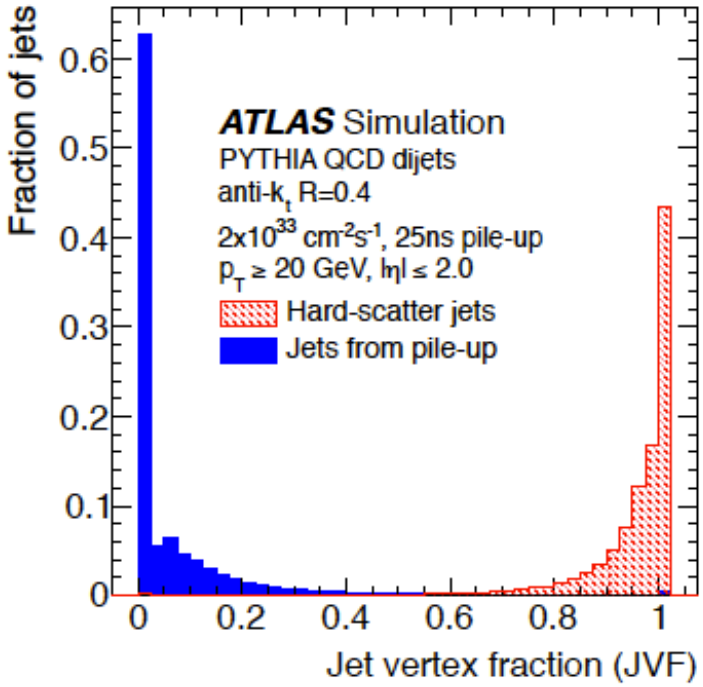
Total pile-up uncertainty <1%/vertex

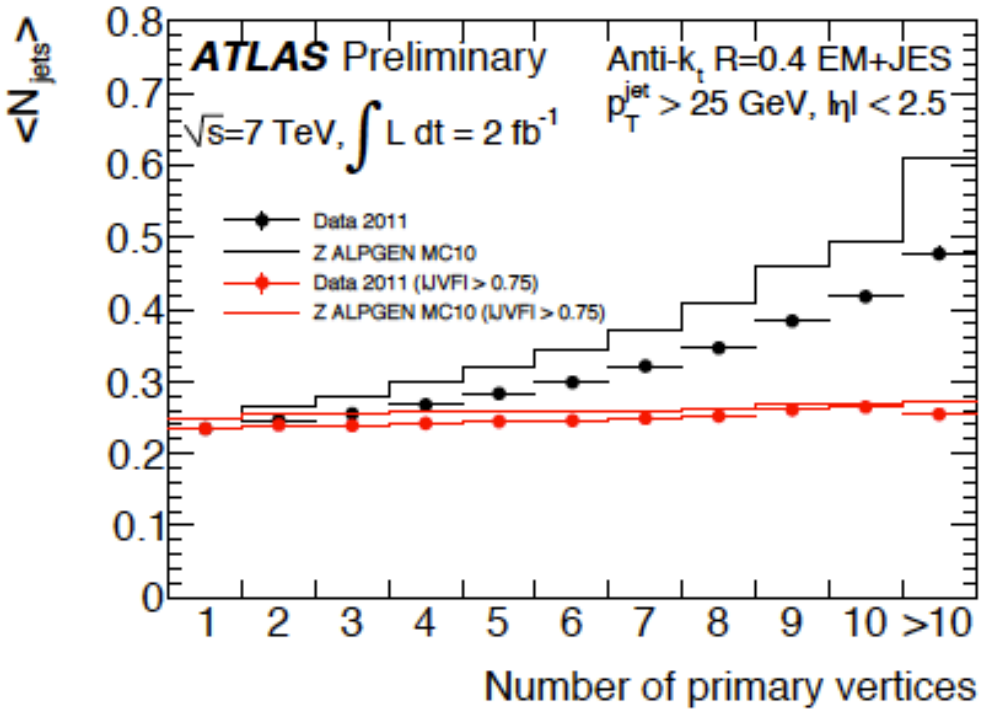
Pile-up suppression



Jet Vertex Fraction (JVF)

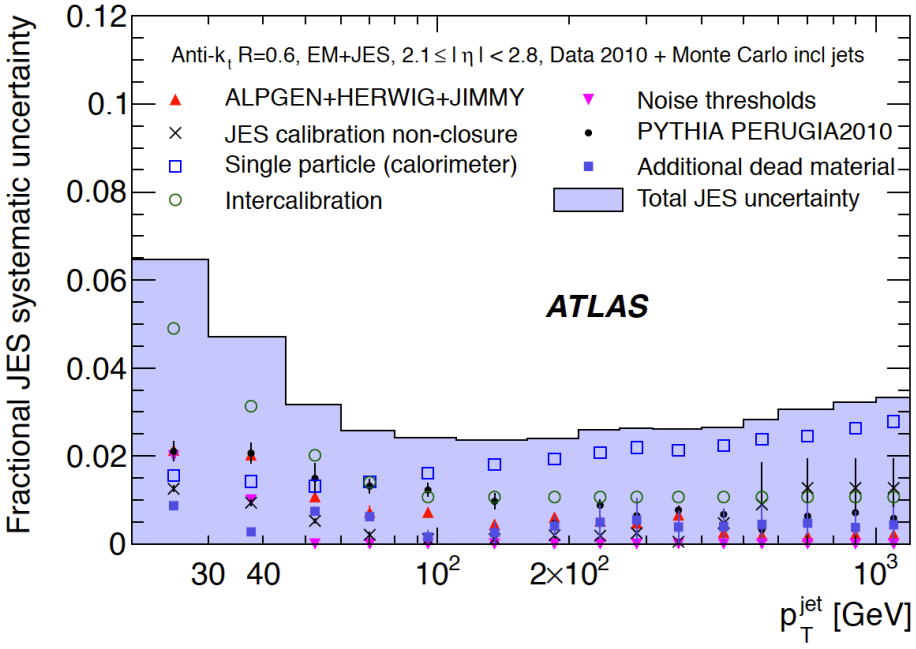
- Reject fake jets from pile-up fluctuations using jet-vertex association
- Similar technique used to suppress pile-up on missing ET



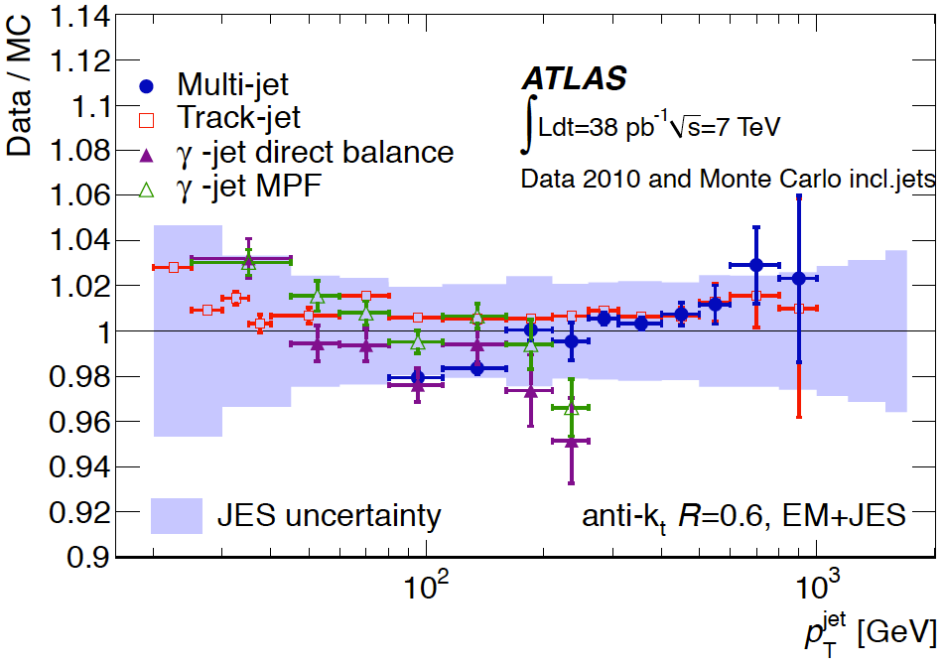


Jet energy scale uncertainty

- Single particle response (test beam / insitu)
- Monte Carlo samples with different physics modeling and detector configurations
- Relative p_T balance in dijet events



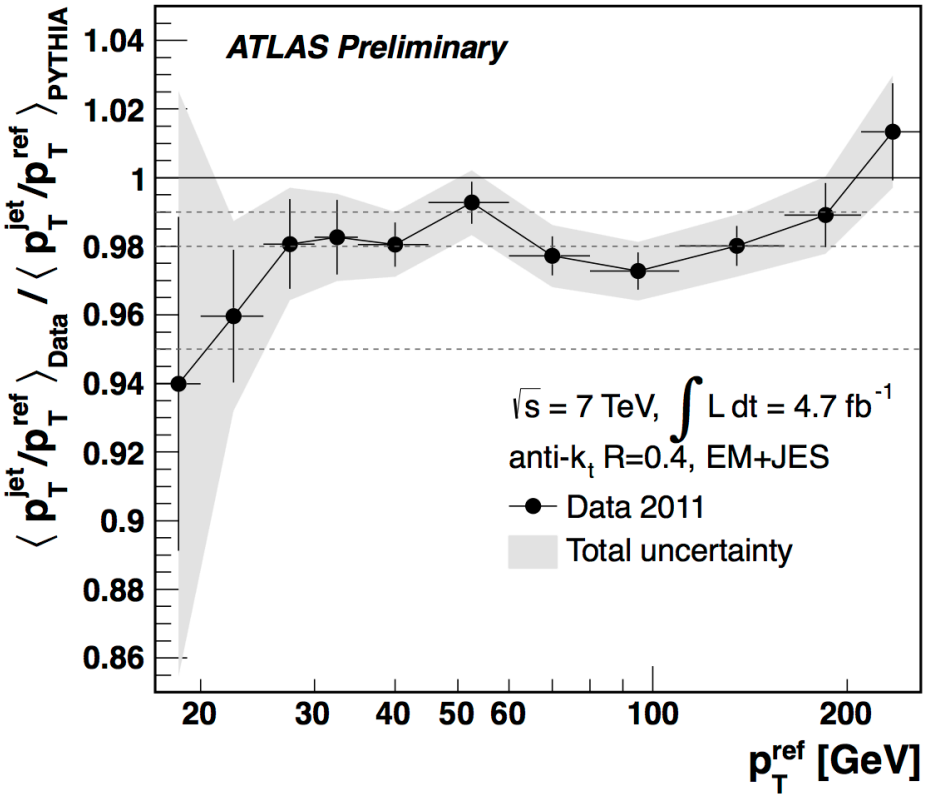
< 2.5% for central jets, p_T>100 GeV
< 7 (14)% for endcap (forward) jets

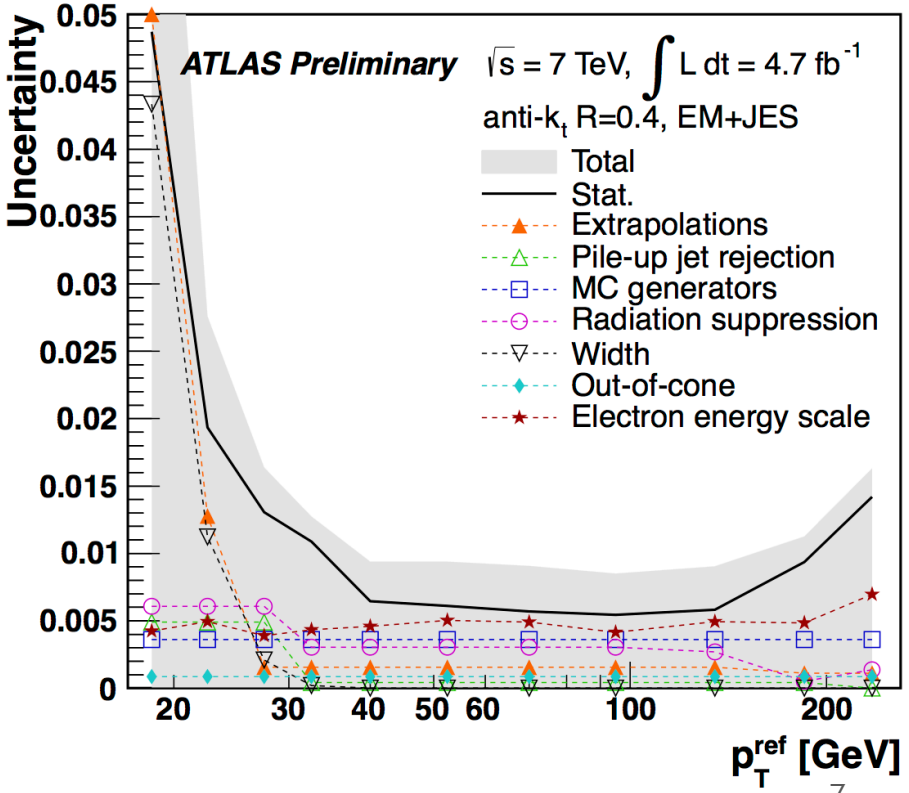


- **Insitu tests of the jet energy scale:**
  - γ +jets (MPF and direct balance)
  - track/calorimeter jet ratio
  - Multi-jet balance

Insitu jet energy scale: Z+jets

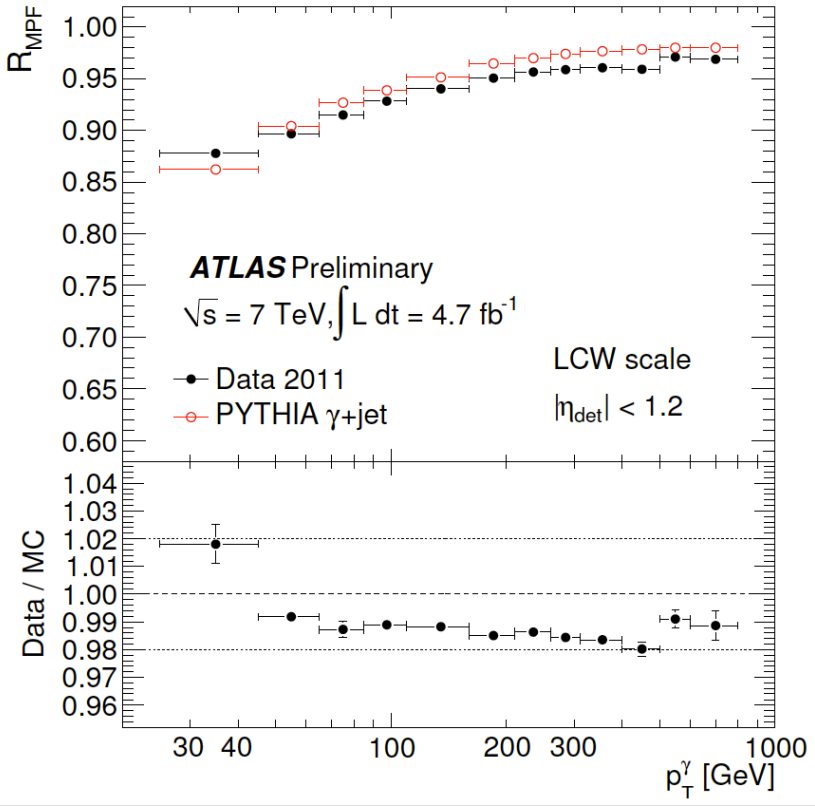
- Use large 2011 datasets to improve the precision of the jet energy scale and to adjust the jet calibration using insitu techniques
- Z+jet balance probes the jet response at low p_T (low background, and low p_T thresholds)
- **Total uncertainty 1% to 2% for jet p_T > 30 GeV**

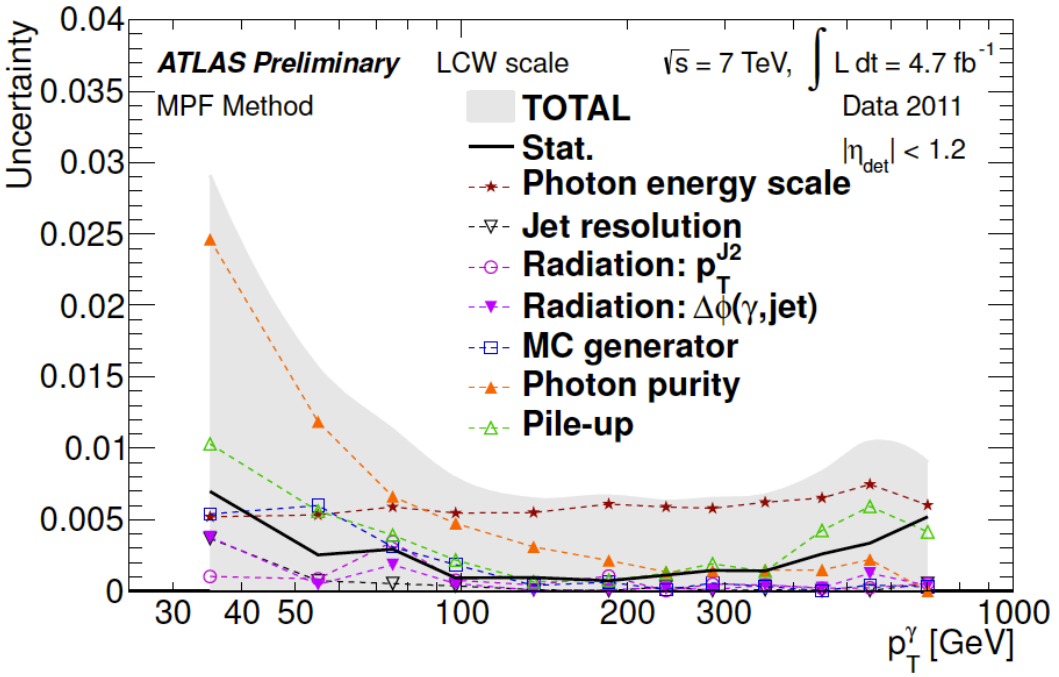




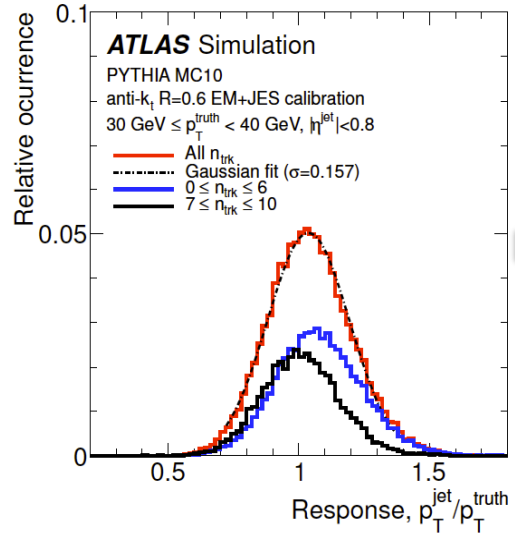
Insitu jet energy scale: γ+jets

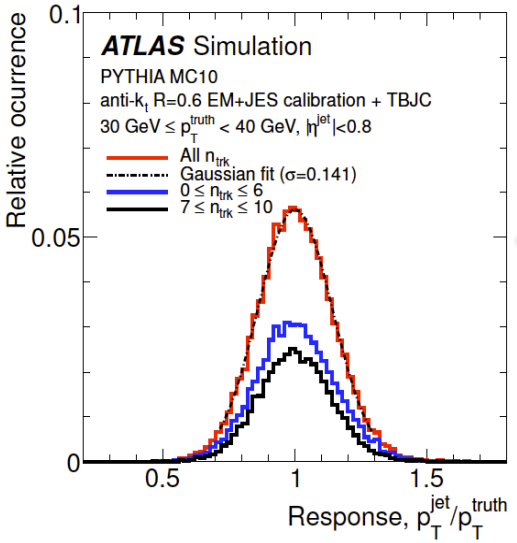
- Two techniques: direct photon-jet balance and MPF
- Jet p_T in data is ~2% smaller then in the simulation
- **Total uncertainty <1% for jet 100 < p_T < 500 GeV**



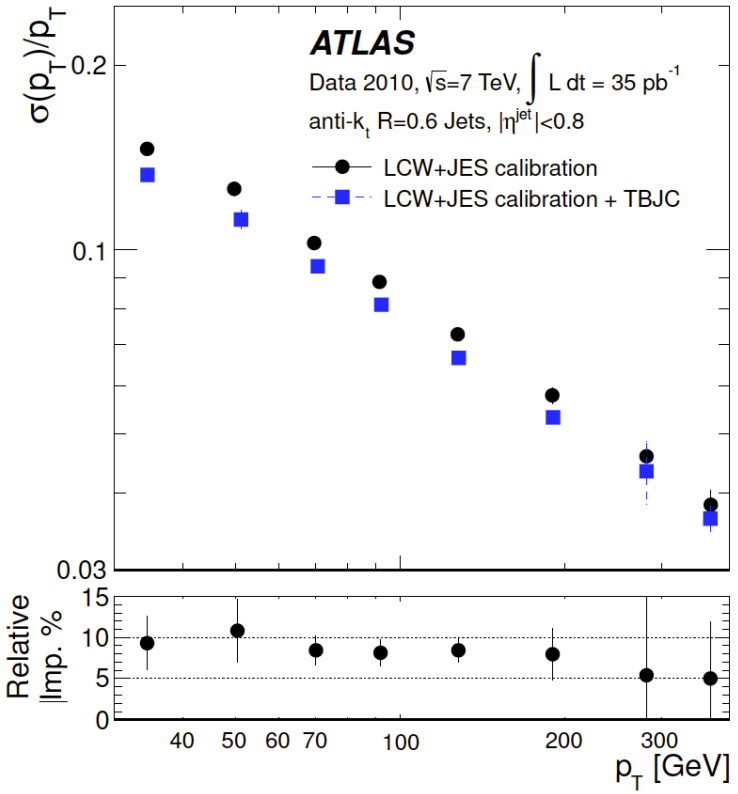


Jet resolution improvement using tracks



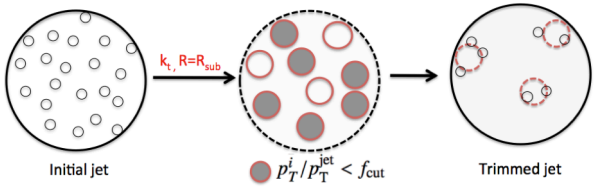


- Use tracks and jet properties to refine the jet calibration ***after*** the JES
  - Improved jet energy scale resolution
  - Reduced flavor dependence of the jet response

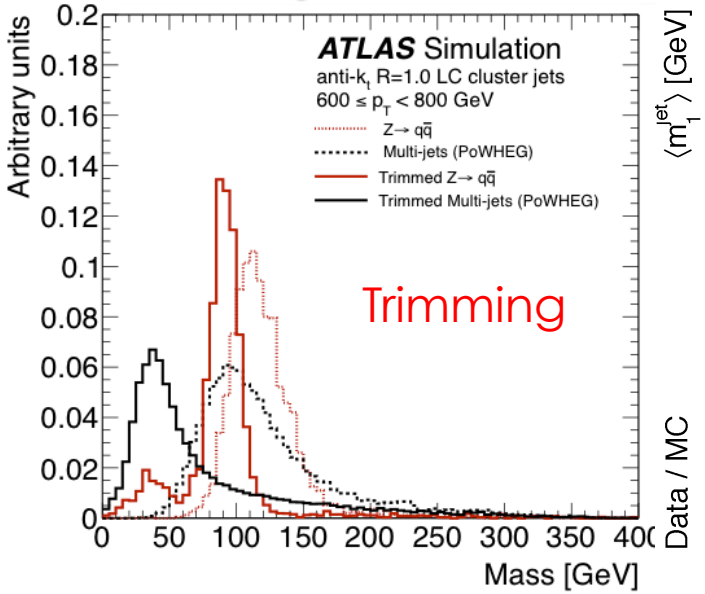


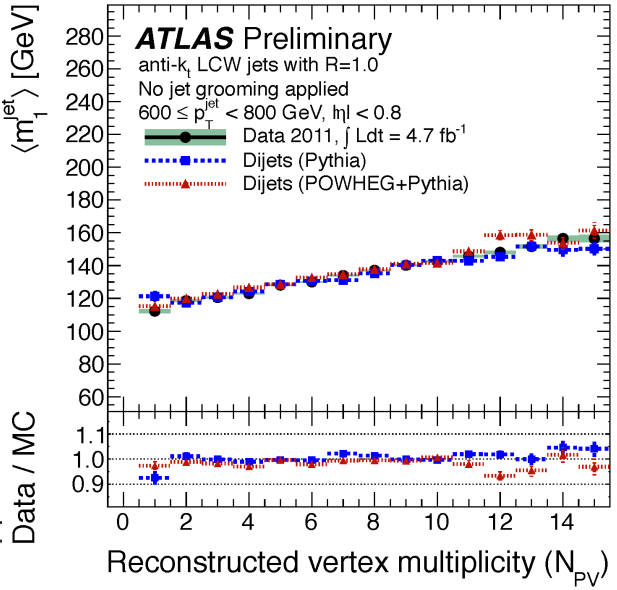
Jet grooming

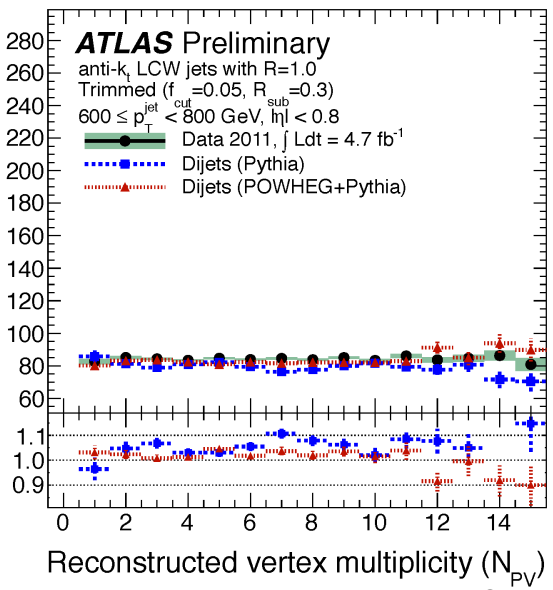
- **Distinguish jets from the decay of massive objects from massive QCD jets by removing soft wide angle radiation**:
  - Improve large-R jet mass resolution
  - Increase S/B
  - Remove pile-up effects on jet mass (reduced area)



- ATLAS has commissioned three grooming algorithms: **trimming, pruning, filtering**





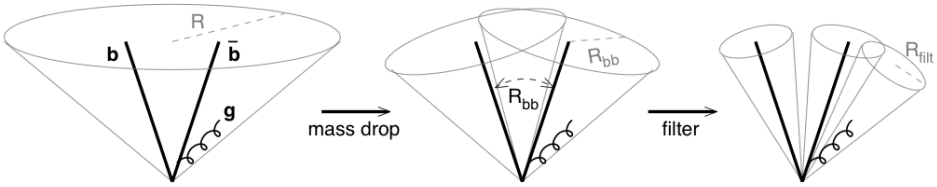


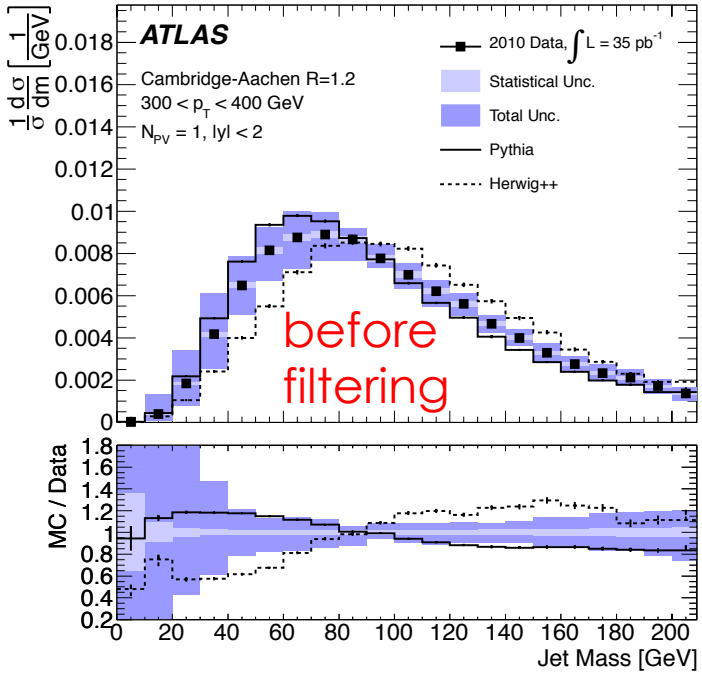
Jet mass and substructure

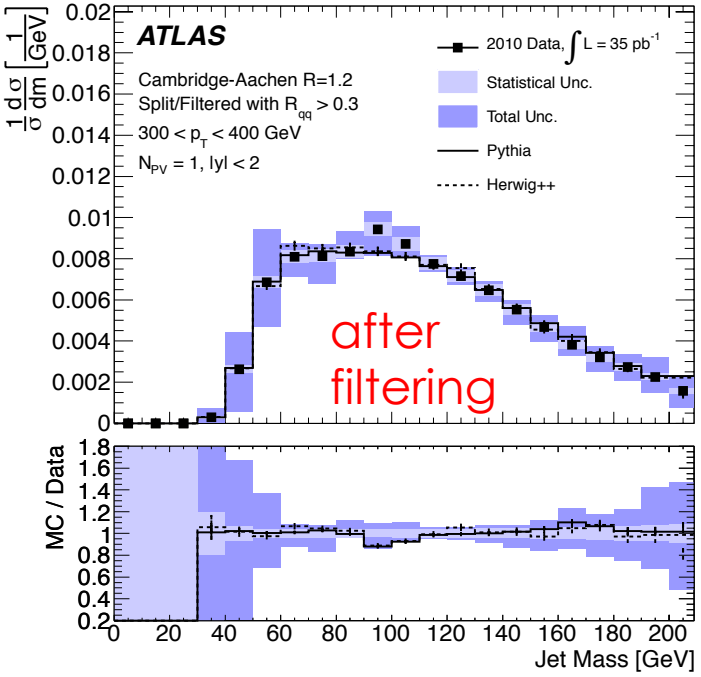
- Powerful new techniques for the identification of boosted heavy particles with large p_T

arXiv:1203.4606

- Test internal structure of QCD jets using large-R jet algorithms:
  - C/A R=1.2 + filtering
  - anti-k_t R=1.0 + trimming





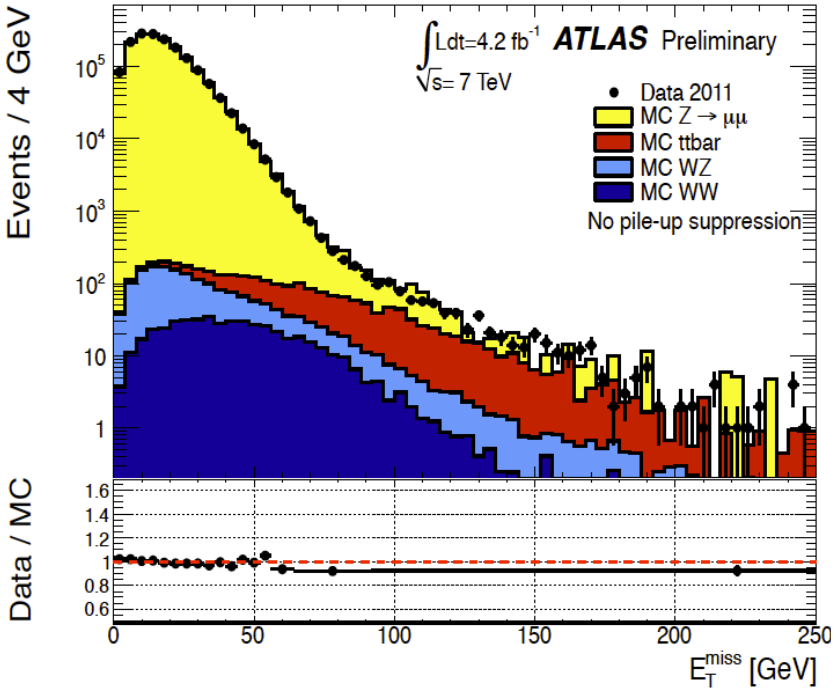


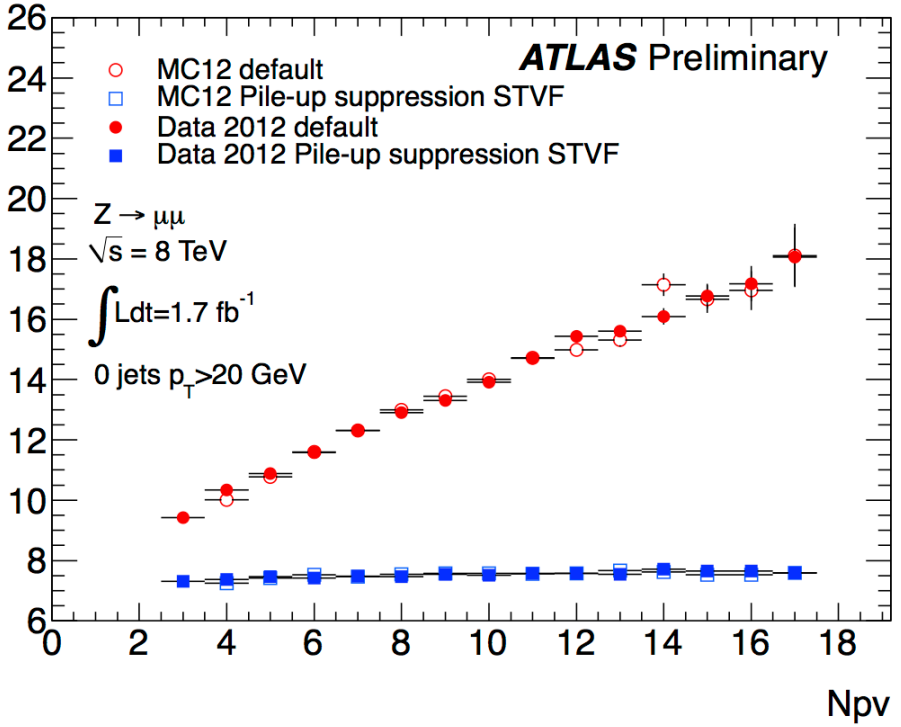
Missing ET performance

- Missing ET performance in Z→*ll* and W→e ν events
- Systematic uncertainty from data/MC differences

- Pile-up suppression using tracks (soft MET term)

$$STVF = \sum_{\substack{trackPV \\ (no-in-jets)}} p_T \Big/ \sum_{\substack{track \\ (no-in-jets)}} p_T$$





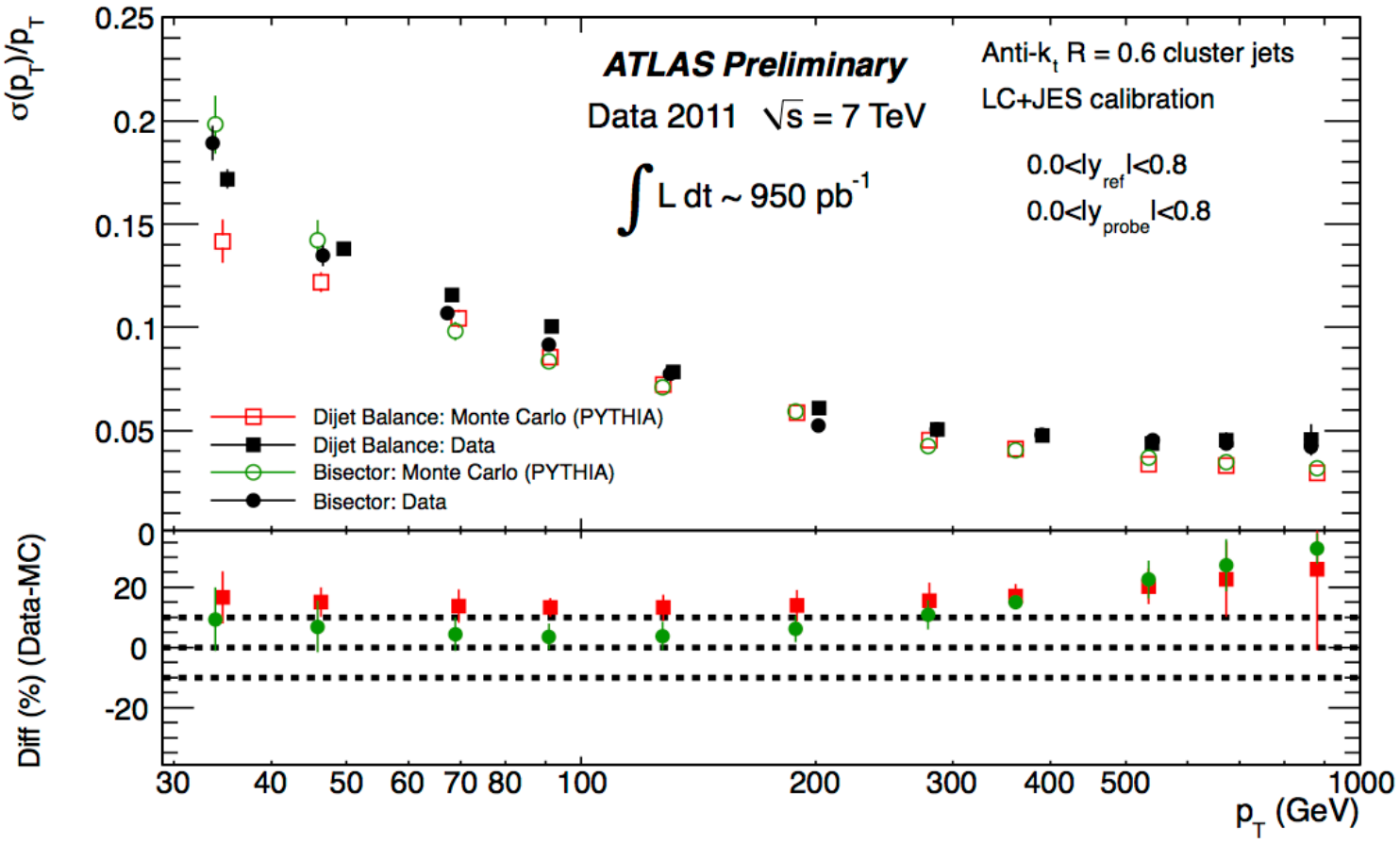
Summary

- **ATLAS has achieved a ~1% precision on the absolute energy scale uncertainty for jets with 100 GeV < p_T < 500 GeV**
  - Sophisticated topological clustering local hadron calibration
  - Pile-up subtraction and suppression
  - Insitu techniques to correct the residual jet response difference between data and Monte Carlo
  - Additional physics sample dependent uncertainties (flavor, close-by jets, pile-up)
- **Use of tracks to improve jet energy resolution and uncertainty**
- **Jet mass, jet substructure, and new jet algorithms**
  - New tools to enhance the LHC physics potential for boosted signatures
- **Missing ET performance**
  - Powerful pile-up suppression based on tracks

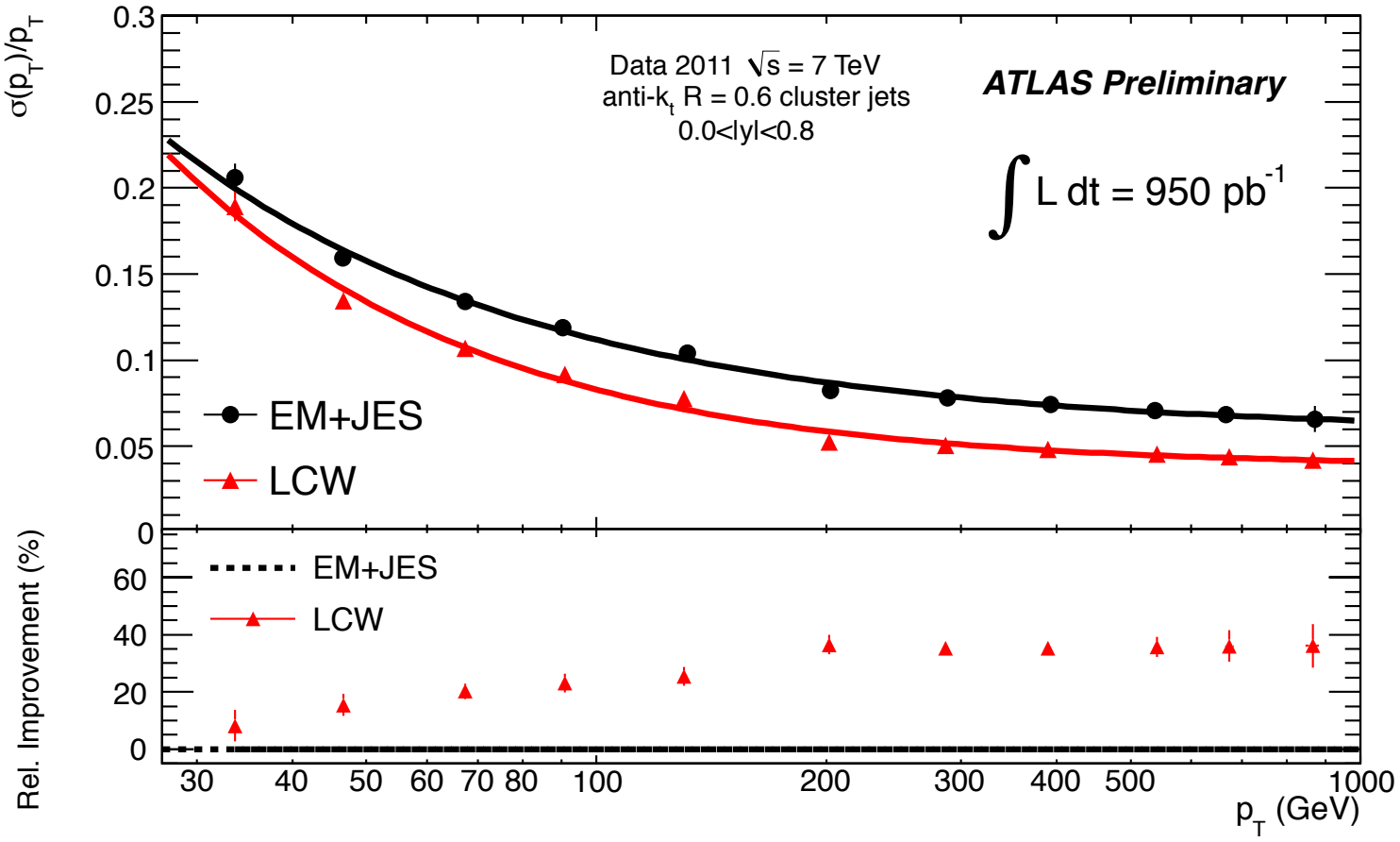
Backup slides

Jet energy resolution

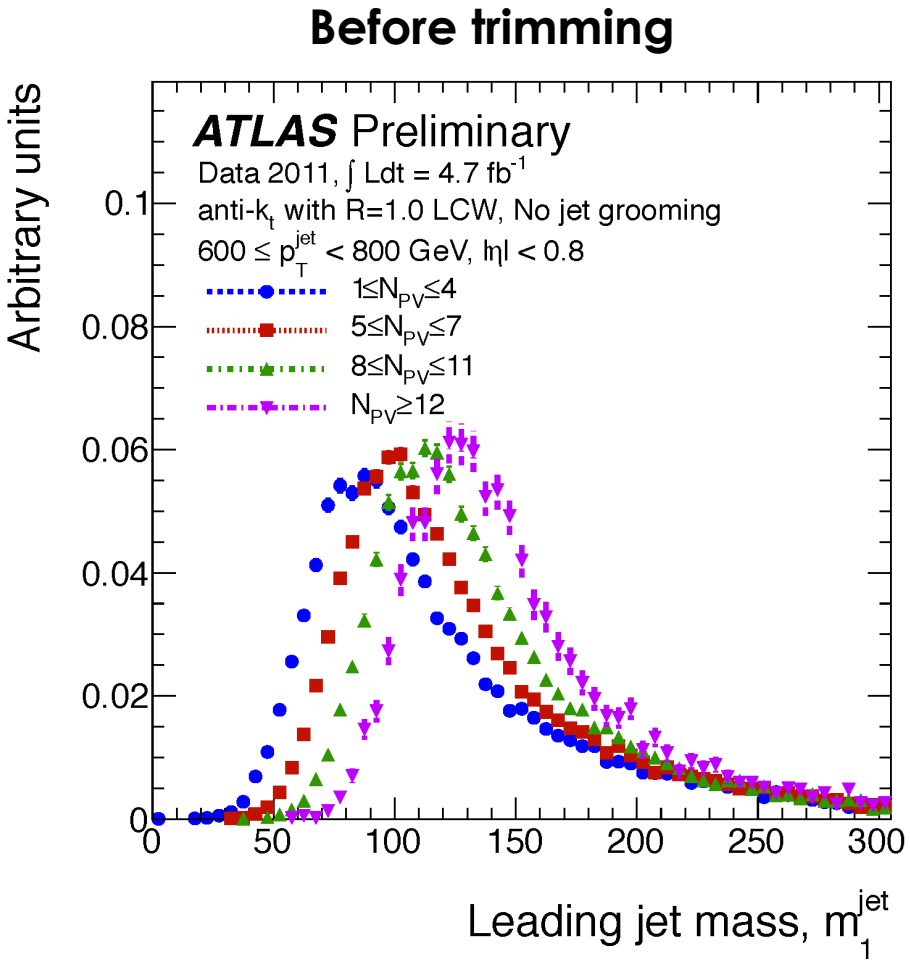
- Measured insitu using dijet balance and bisector techniques

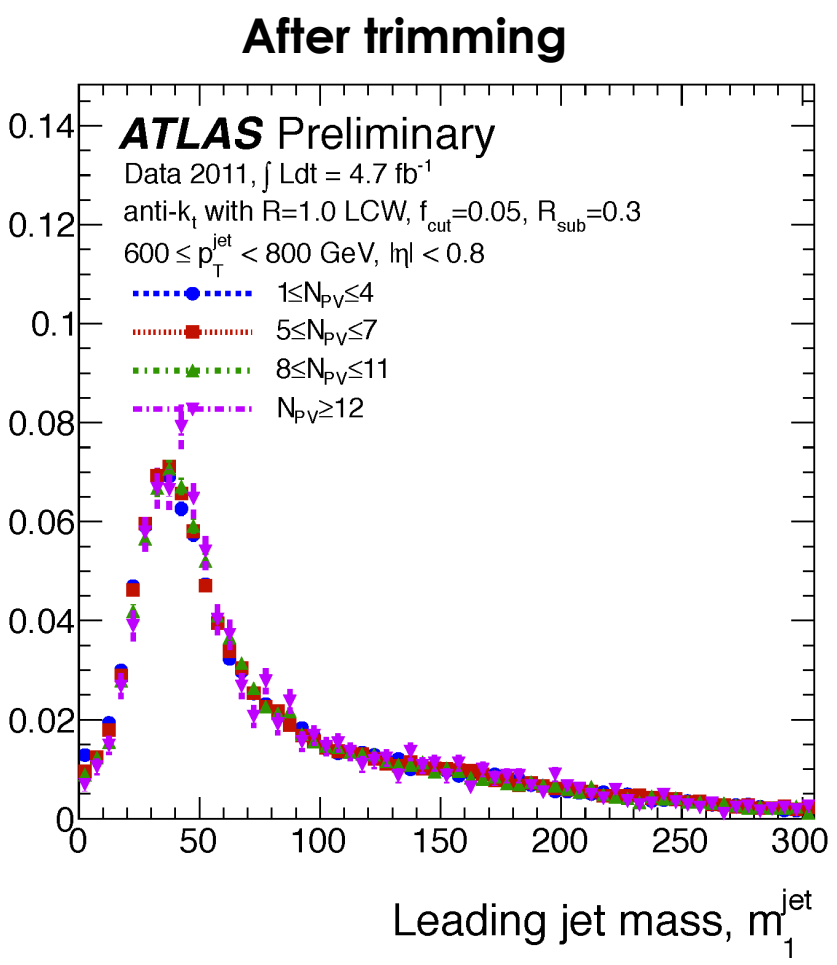


Jet energy improvement from local cluster weighting

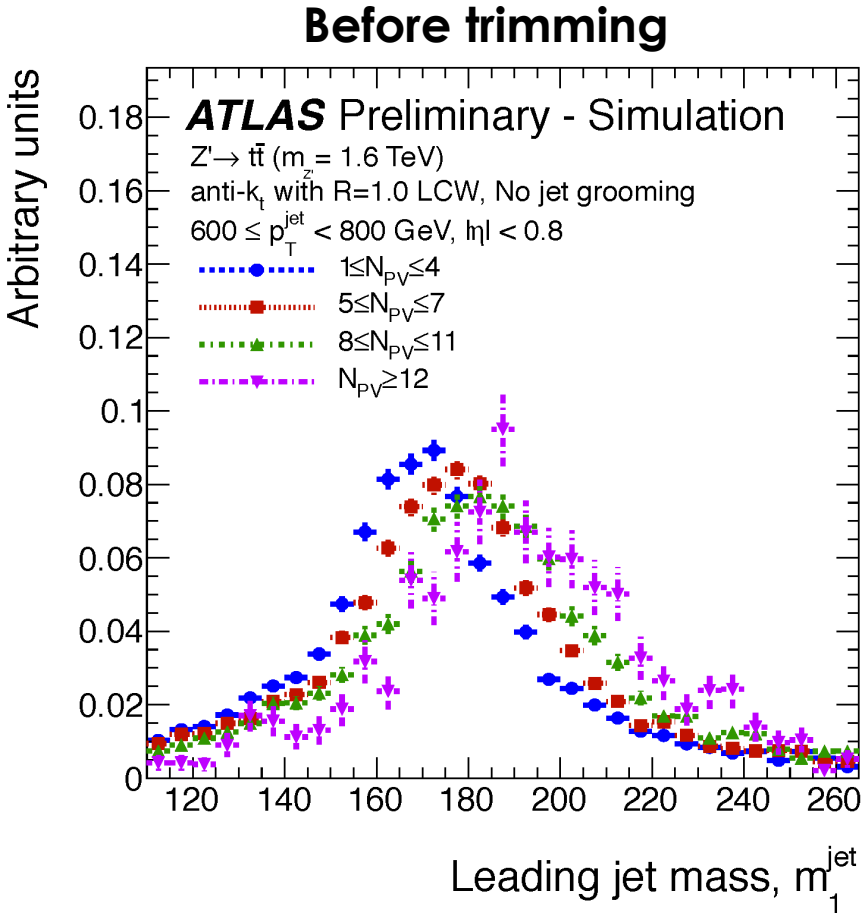


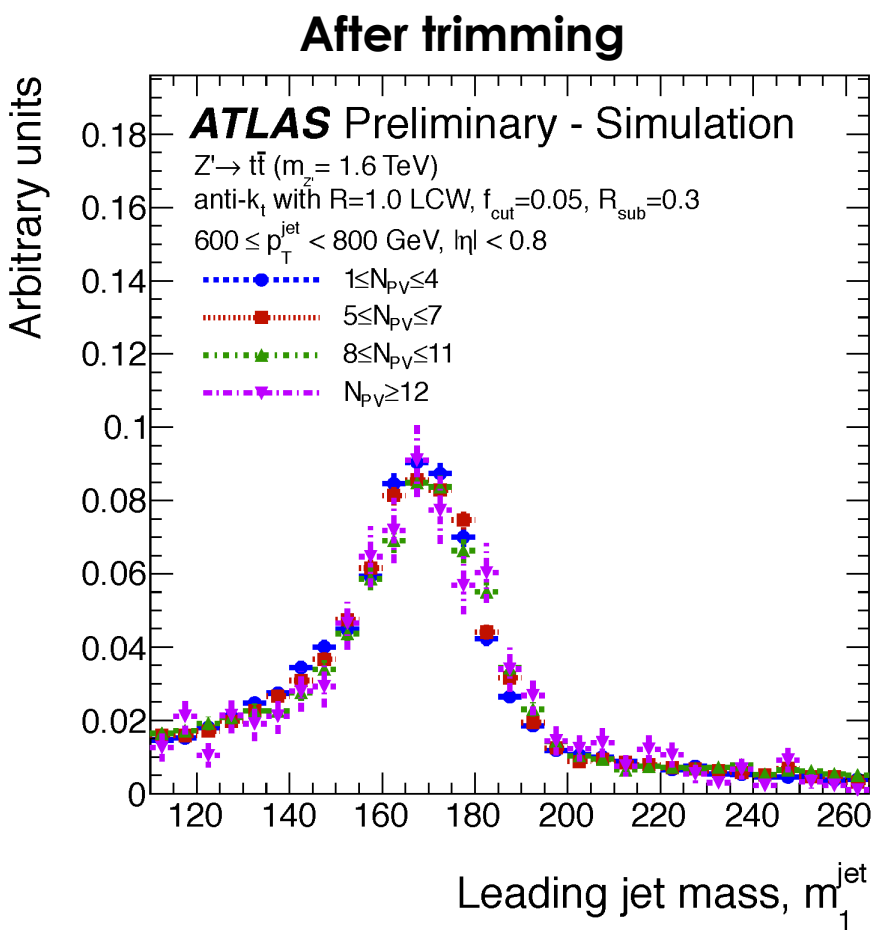
Jet mass (QCD jets)





Jet mass (boosted Z'→tt̄)





Effect of pile-up on Missing ET resolution