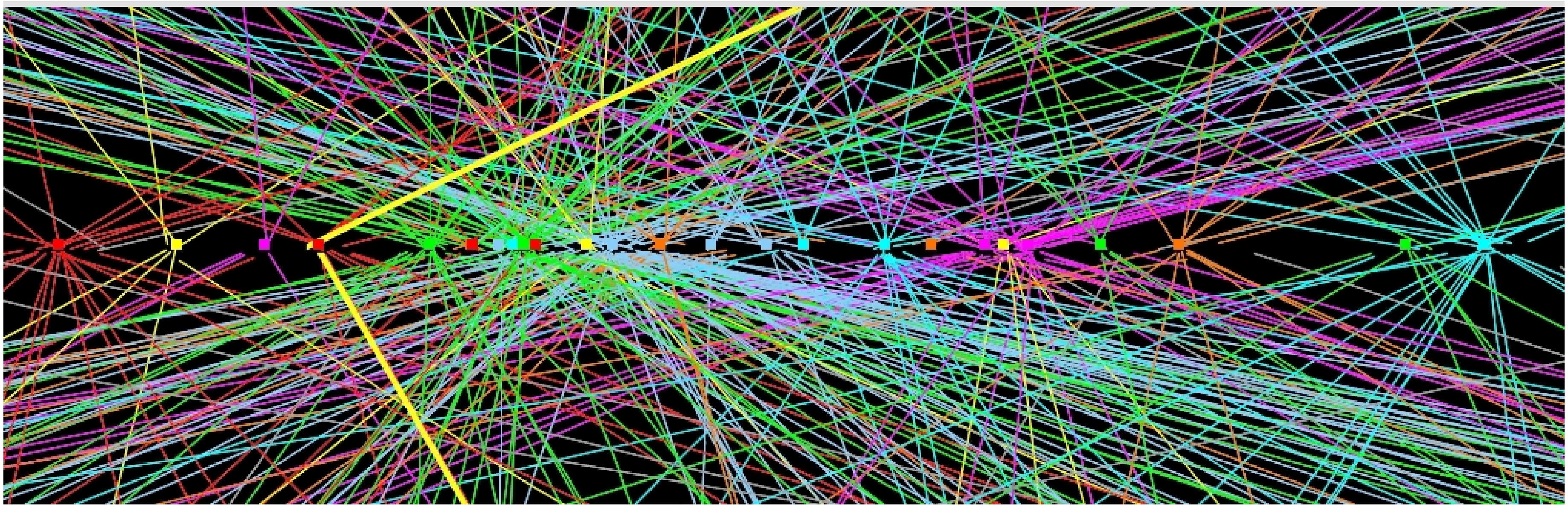
ATLAS Jet Performance at High Instantaneous Luminosity



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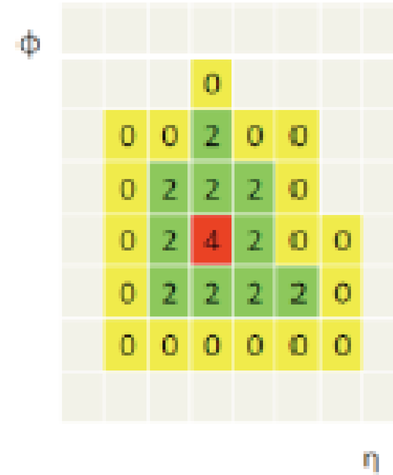
Outline

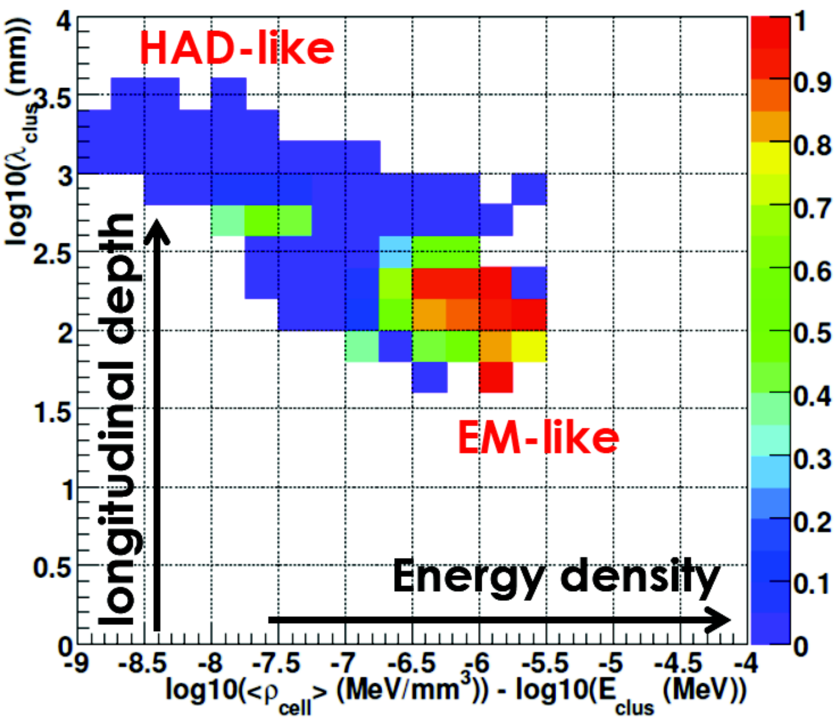
- Jet reconstruction in ATLAS
- Jets in pile-up enviroment
- Pile-up suppression tecniques

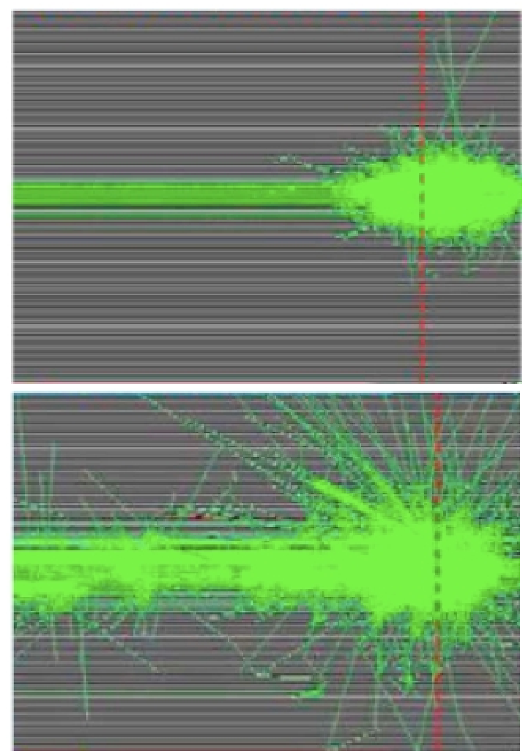
Jet recostruction in ATLAS

- 3-dimensional topological clustering optimized to follow shower development in calorimeter
- Electronic + pileup noise suppression
- Em/had local calibration to correct for calorimeter non-compensation, energy losses in dead material, and out-of-cluster energy



Seed:
$|E_{cell}|>4\sigma$
Neighbors:
$|E_{cell}|>2\sigma$
Nearest neighbors:
$|E_{cell}|>0\sigma$



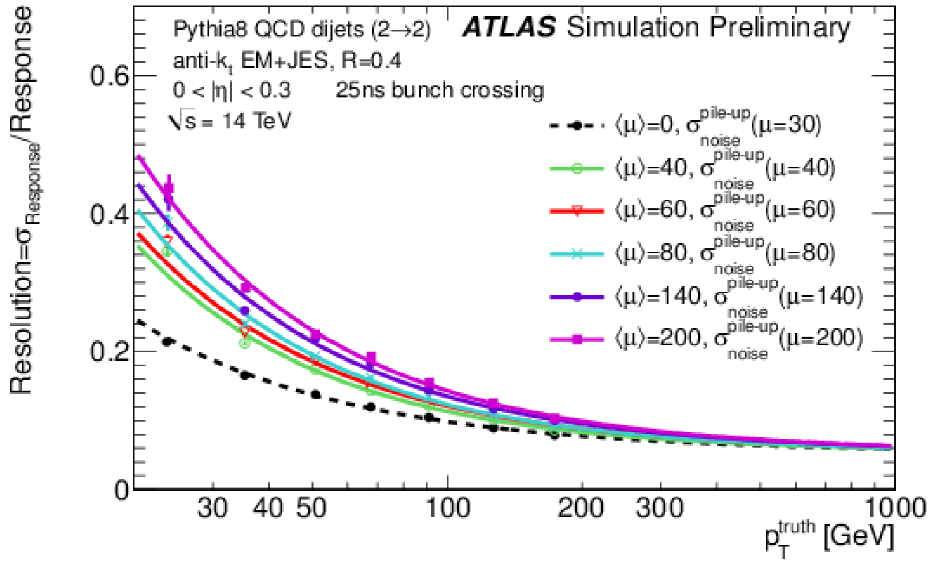


π^0

$\pi^\pm$

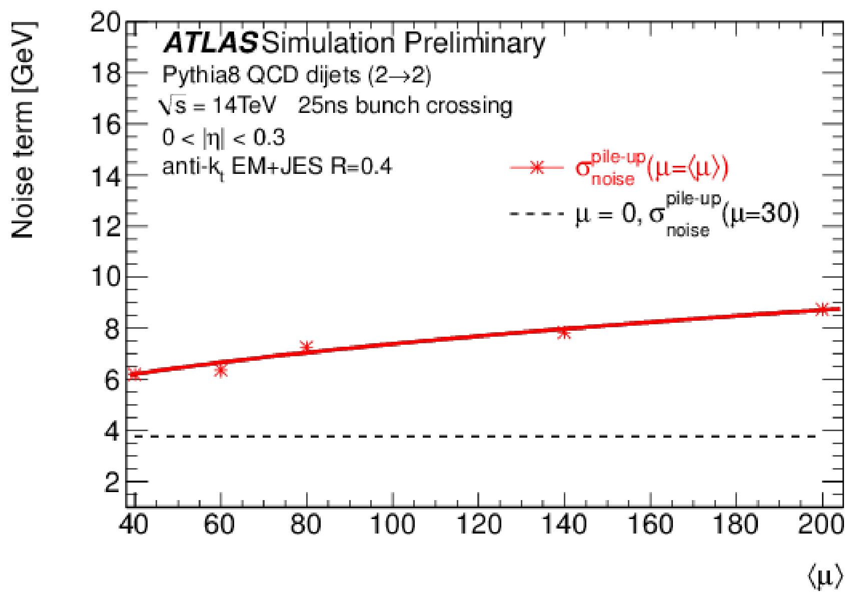
How does pile-up affect jets?

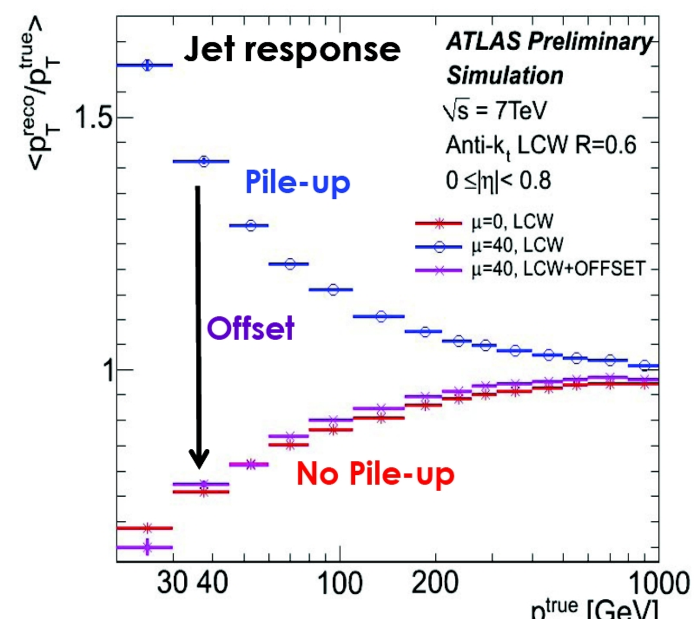
One of main challenges of the upcoming LHC run will be the anticipated high instantaneous luminosity, which will result in a large number (up to ~140) of additional proton-proton collisions in each event ("pile-up")



Effect of the pile-up on jets:

- Additional energy (offset)
- Pile-up fluctuations:
  - increase the noise term of the jet energy resolution (event-by-event fluctuations)
  - additional fake jets (local fluctuations)
- Large effect on jet mass and properties

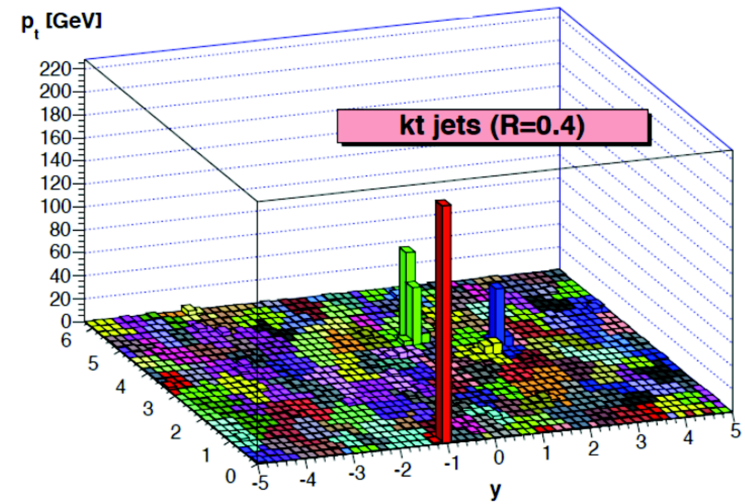




Pile-up suppression:Jet Area Method

Pile-up corrections are a key component of the jet calibration strategy at the LHC:

- Restores the jet response shape to NPV=1 and μ= 0, and make jet performance independent of varying pile-up conditions
- Reduce (event-by-event) fluctuations
- Reject pile-up jets (pile-up suppression)



Jet-by-jet correction

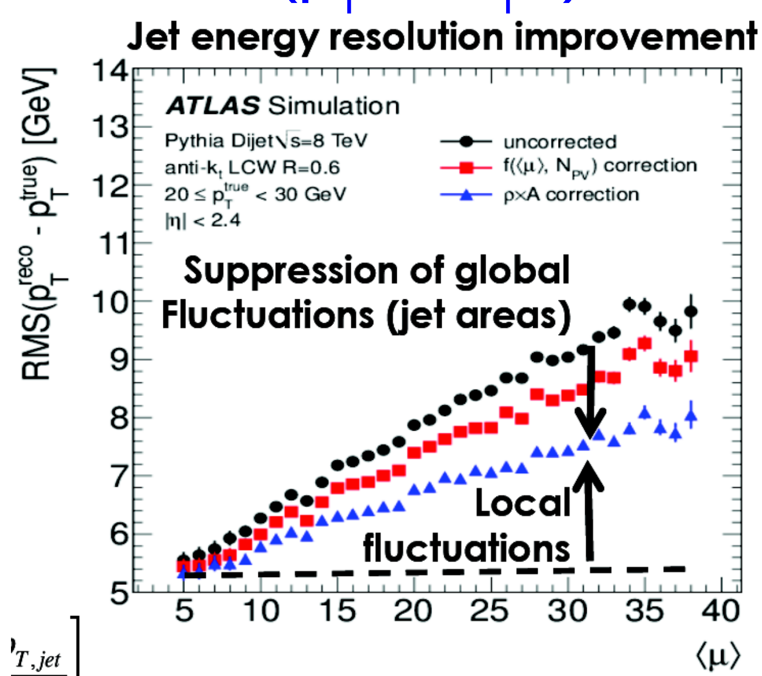
$$p_T^{jet,corr} = p_T^{jet} - \rho \times A_T^{jet}$$

Event-by-event correction

$$\rho = \text{median}\ (p_T^{jet} / A_T^{jet})$$

Estimate, event-by-event, the pile-up p_T density:

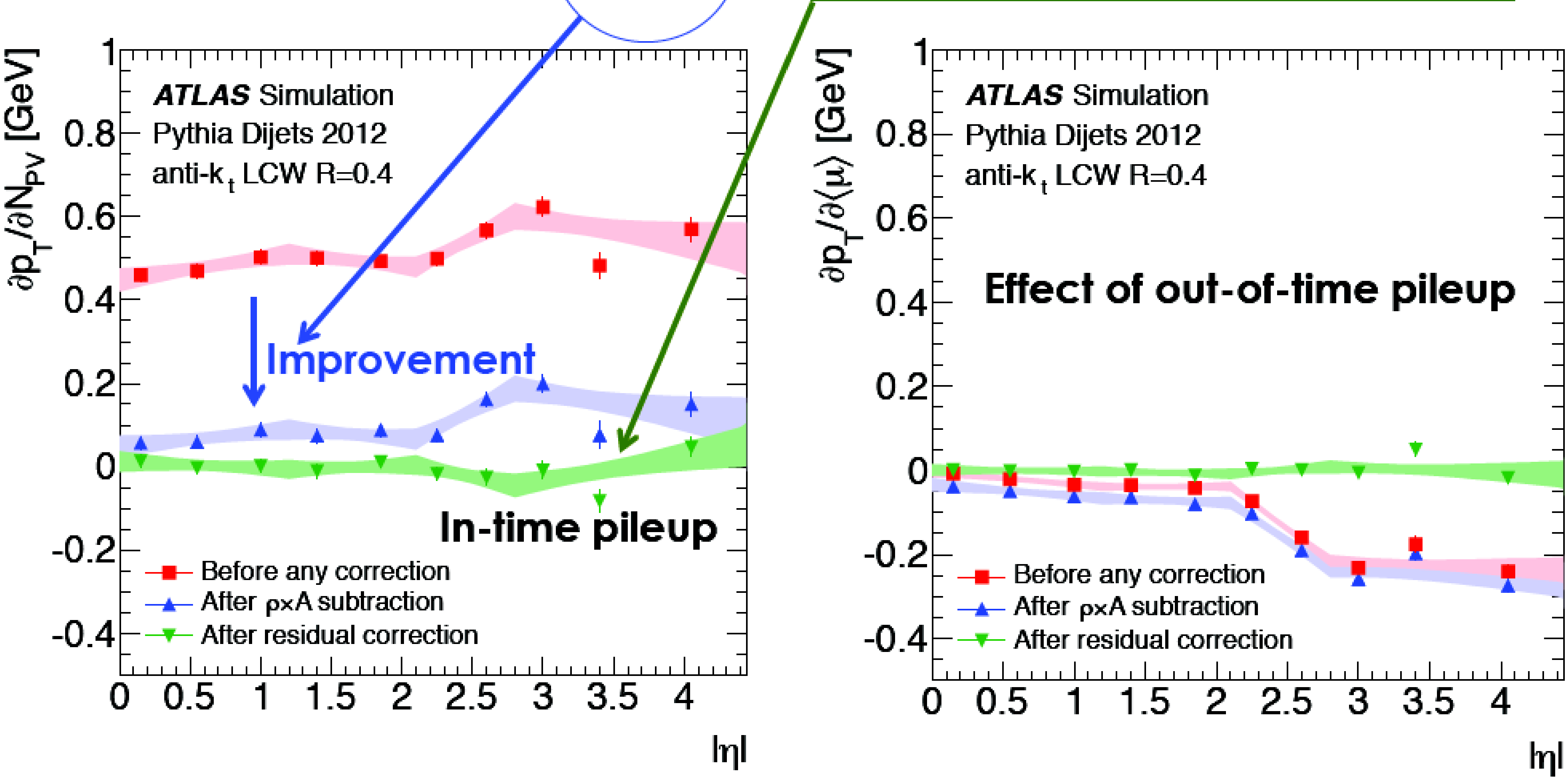
- Based on energy depositions outside hard jets
  - Subtract pileup contribution based on jet area
- Accounts for global pileup fluctuations from one event to another
- Global pileup estimate, not sensitive to local fluctuations



Pileup suppresion:Residual correction

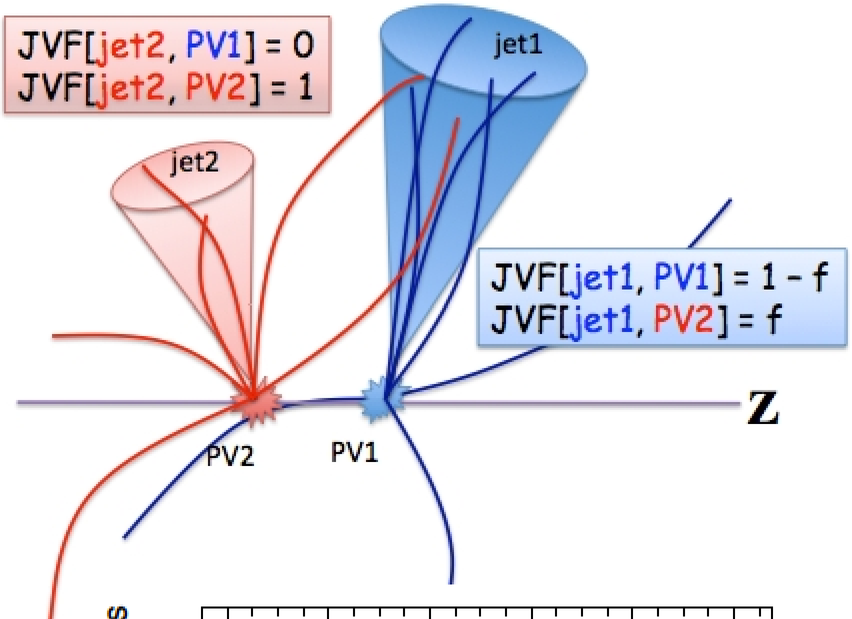
Residual correction

$$p_T^{corr} = p_T - \rho A_T - \alpha(N_{PV} - 1) - \beta\langle\mu\rangle$$



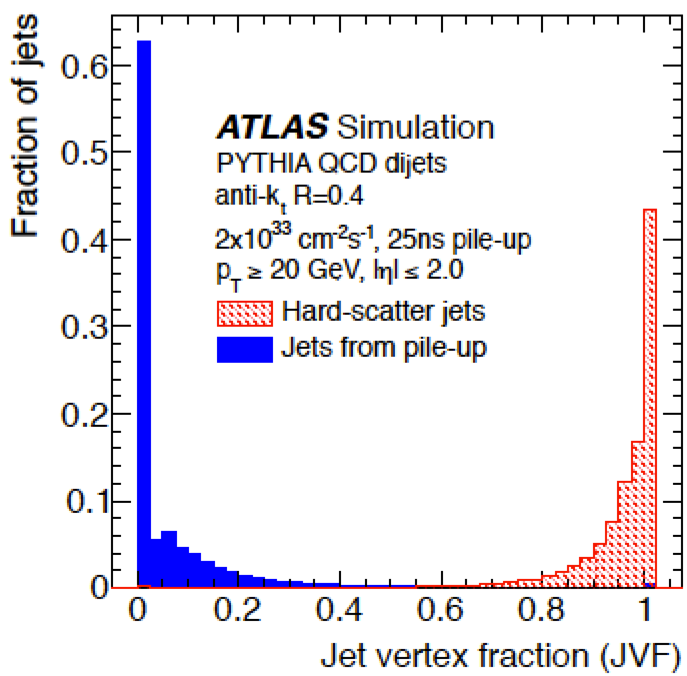
- <mu> is the average luminosity per luminosity block
    - sensitive to out-of-time pileup for fixed N_{PV}

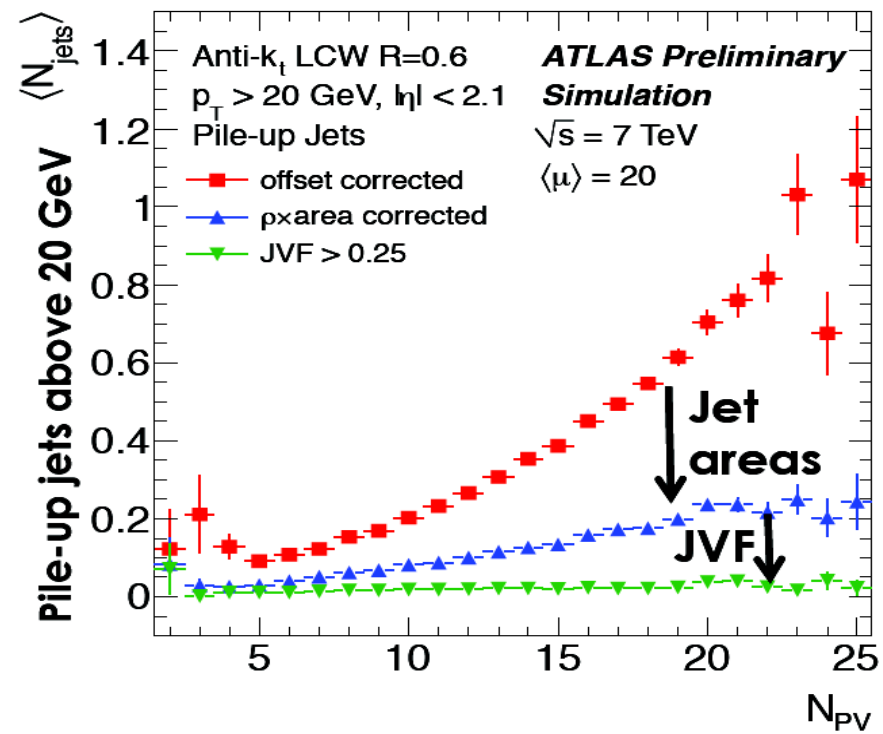
Pile-up suppression: JVF



- Pile-up local fluctuations within a same event can lead to fake pile-up jets:
  - Mix of QCD jets from additional interactions and random combination of particles from pile-up interactions

- Jet vertex fraction algorithm:
  - Reject fake pile-up jets using tracking and vertexing information

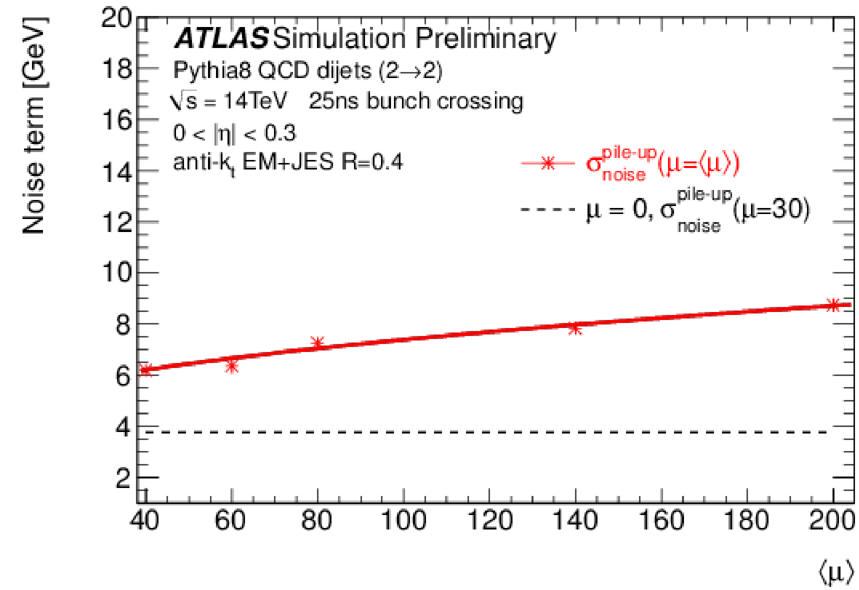


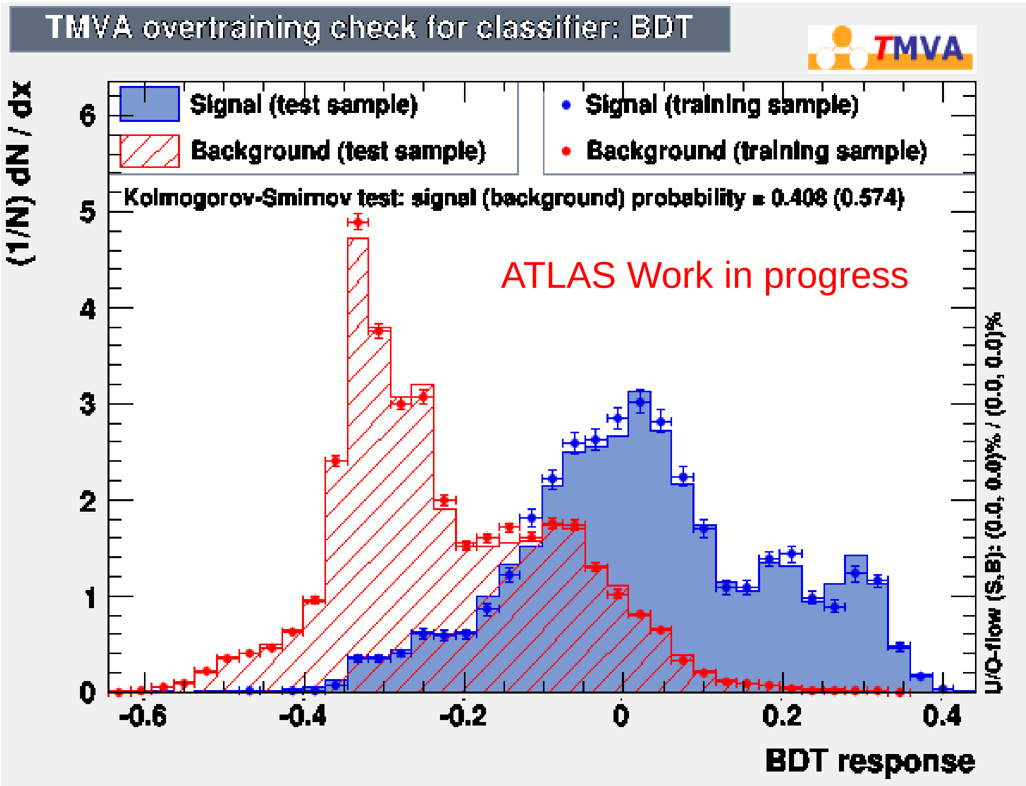


Pileup clusters suppression studies 1/2

Pileup fluctuations (noise term) are leading contribution at low pT for JER. Jet area method cannot cancel those local fluctuations.

We are studying the composition of clusters and see if we can discriminate between real and pileup clusters using calorimeter and tracking info.

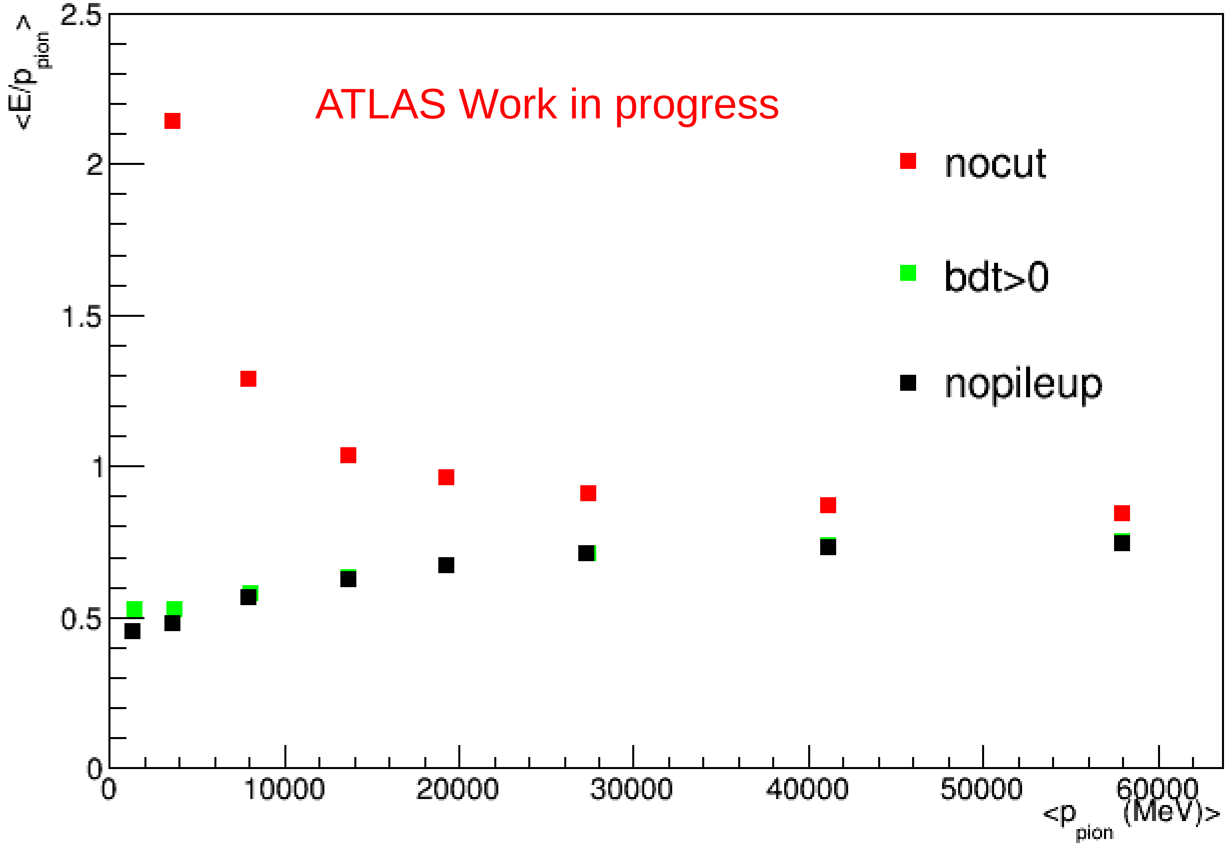




We trained a BDT using discriminant cluster moments. Cluster moments describe position and shape of a cluster in the calorimeter using also tracking information.

Pileup clusters suppression studies 2/2

Try to extimate the E/p response in a wider cone around the pion (R = 0.4) in the full pion p_T spectra.



For a cut of BDT>0 we see the same behaviour of nopileup case.

Conclusions

ATLAS techniques for jet reconstruction and calibration work well up to very high luminosities:

- Topological clustering and local hadron calibration
- Pileup suppression allows to maintain the same pileup offset than in Run 1 conditions

Resolution is degraded in some cases, but there is significant room for improvements:

- Use of tracks and vertices
- Reduce local pileup fluctuations and further suppress pileup jets
  - Track-cluster matching, charged hadron subtraction, improved JVF, forward tracking, topo-clustering)
  - Advanced subtraction techniques using more local information

Backup

Jet Area definition

Summing over the ghost four-momenta g_i belonging to a jet j, one obtains the jet area four-momentum A_j.

$$A_j = (1/v_g \langle g_t \rangle) \times \Sigma\, g \text{ (in jet)}$$

where $v_g \langle g_t \rangle$ is the transverse momentum density of the ghosts.