Local Hadron Calibration in ATLAS

PAOLA GIOVANNINI

on behalf of the ATLAS Liquid Argon Calorimeter Group

CALOR10 Beijing, CHINA

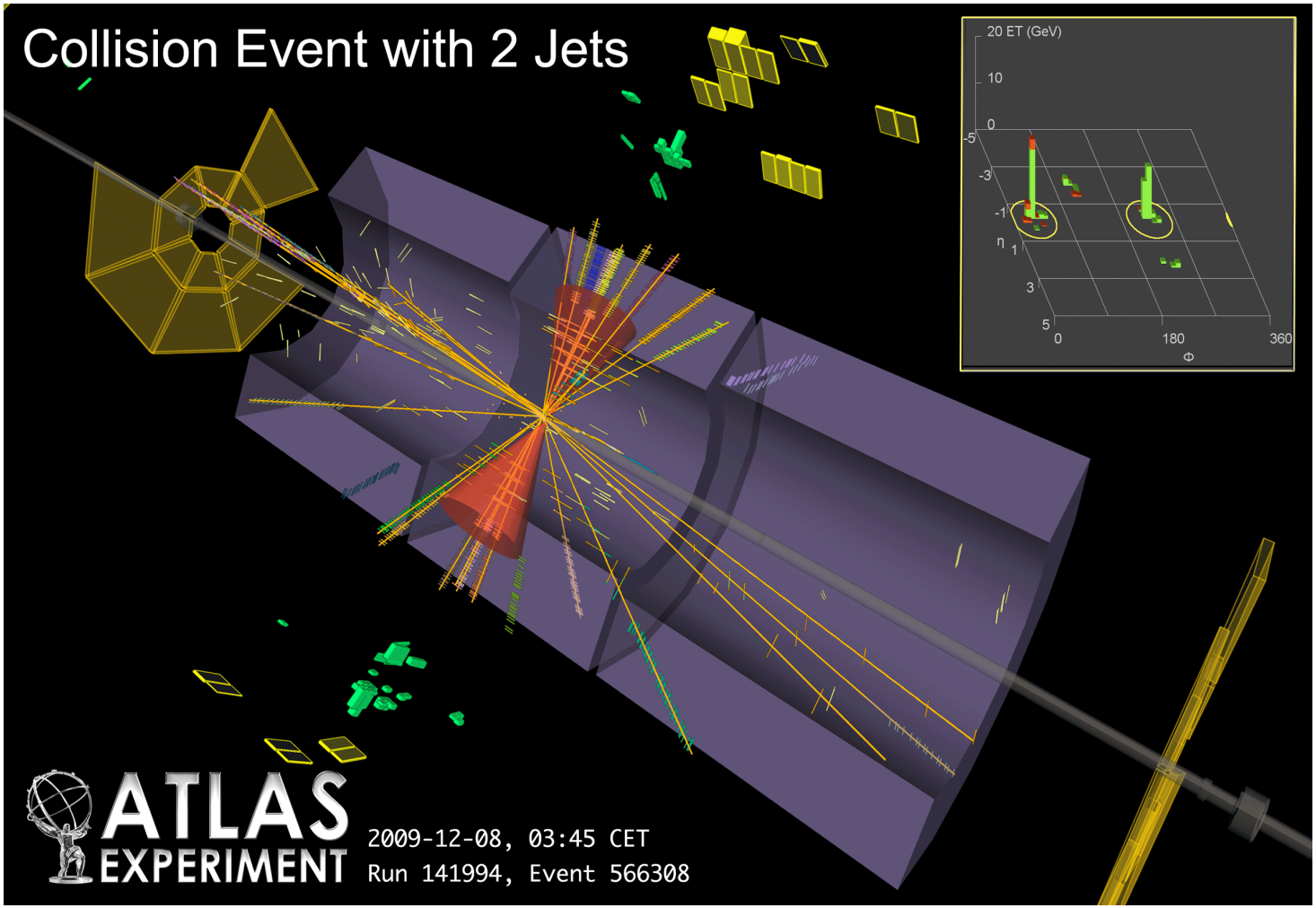
MAX-PLANCK-INSTITUTE FOR PHYSICS
MUNICH

MAX-PLANCK-GESELLSCHAFT

Outline

- the ATLAS experiment and calorimeter system
- Local Hadron Calibration schema
  - cluster level corrections
  - jet level corrections
- performance studies using GEANT4 information
  - truth cluster energy definition
  - cluster correction investigation
- 900 GeV minimum bias data results
  - DATA/MC comparison of cluster energy
  - DATA/MC comparison of cluster corrections

ATLAS Experiment



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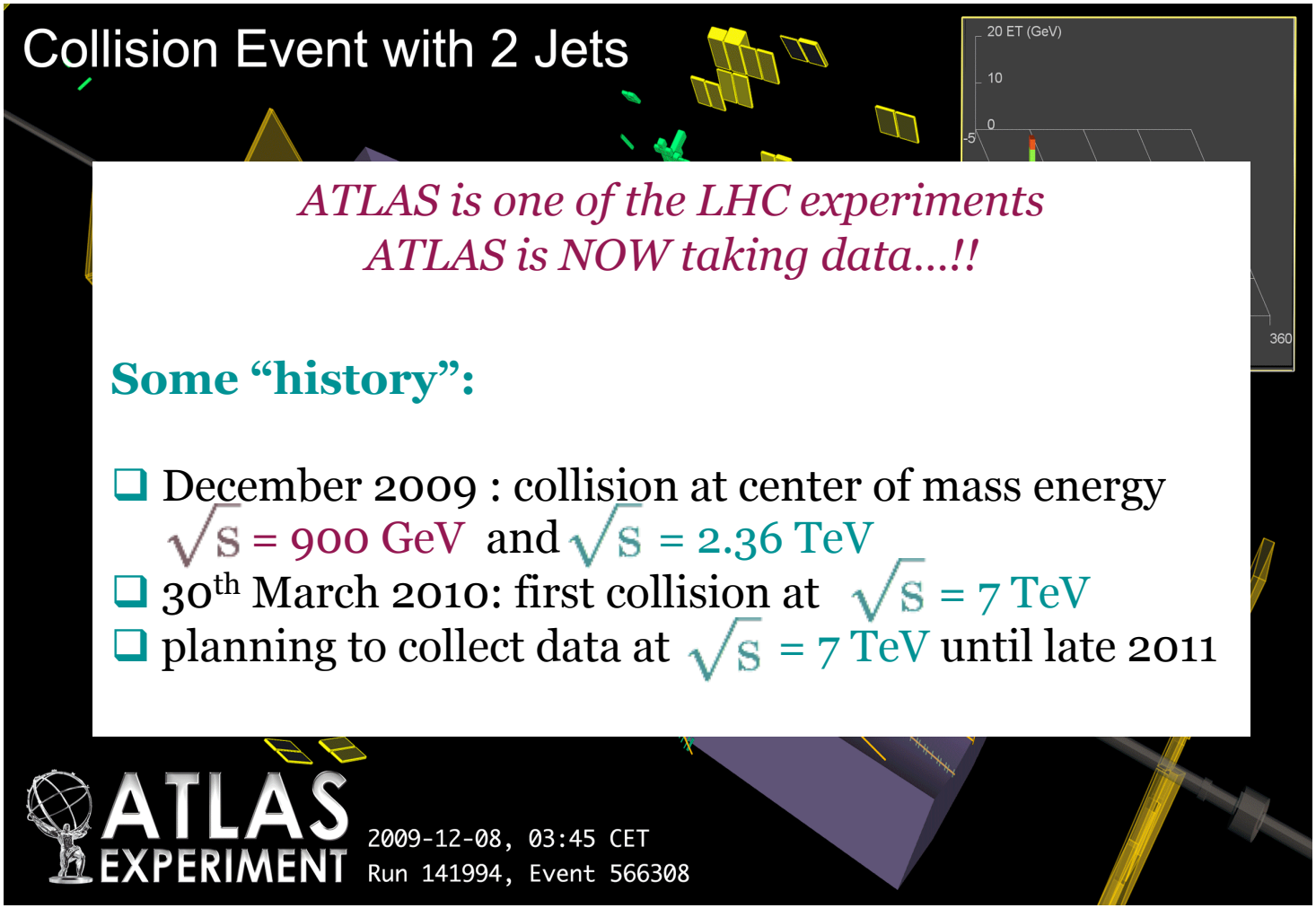
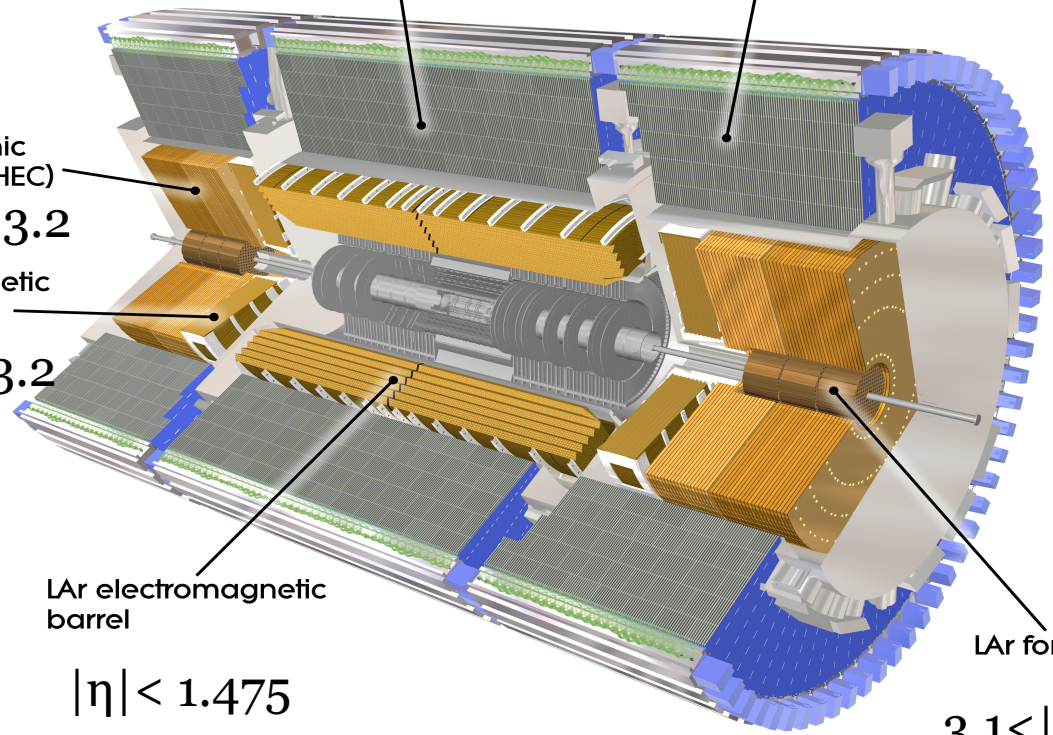


ATLAS is one of the LHC experiments
ATLAS is NOW taking data...!!

Some "history":

- December 2009 : collision at center of mass energy $\sqrt{s}$ = 900 GeV and $\sqrt{s}$ = 2.36 TeV
- 30th March 2010: first collision at $\sqrt{s}$ = 7 TeV
- planning to collect data at $\sqrt{s}$ = 7 TeV until late 2011

ATLAS Calorimeter System



the calorimeter is non-compensating: need of a dedicated calibration for hadronic signals

Local Hadron Calibration

3D Topological Clustering Algorithm
groups cells in Clusters, suppressing noise

creation of calorimeter objects

classifies Clusters in *em* or *had*

applies *had* weights (W)
corrects non-compensation

applies Out Of Cluster (OOC) weights
recovers for noise suppression of good cells

applies Dead Material (DM) weights
recovers for energy lost upstream and leakage

calibration of *ALL* calorimeter objects

runs jet finding on Calibrated Clusters
after all local corrections are applied

jet and missing transverse energy reconstruction

Jet Energy Scale

After the three cluster corrections jet energy linearity is not completely restored

Jet Level Corrections
developed as function of
jet E, η and shape

- correct for particles that leave no signal in the calorimeter cannot be corrected at a "local level"
- restore Jet Energy Scale inside 3% with respect to the truth particle jet

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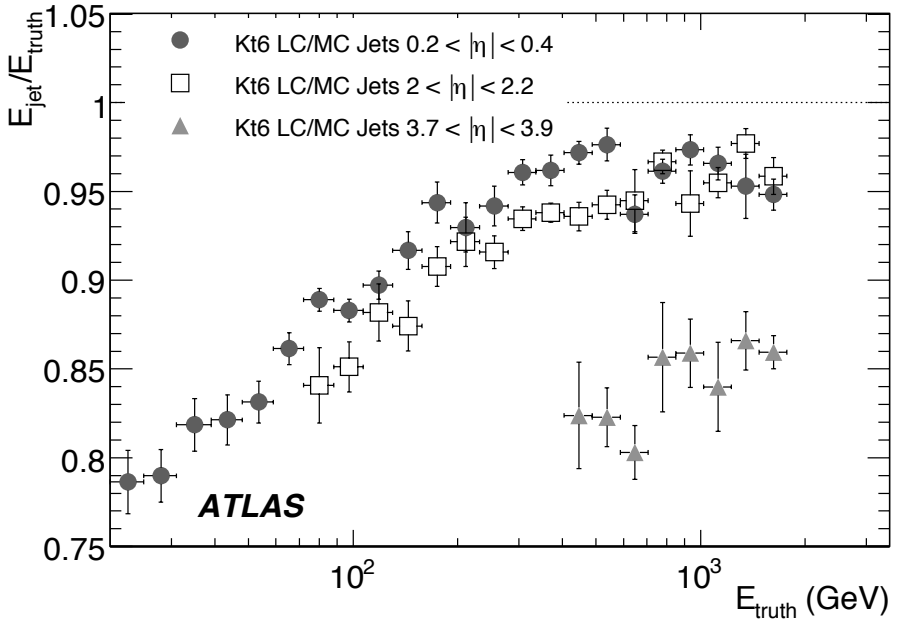


performance with respect to truth particle jet can't describe each contribution for the three cluster corrections

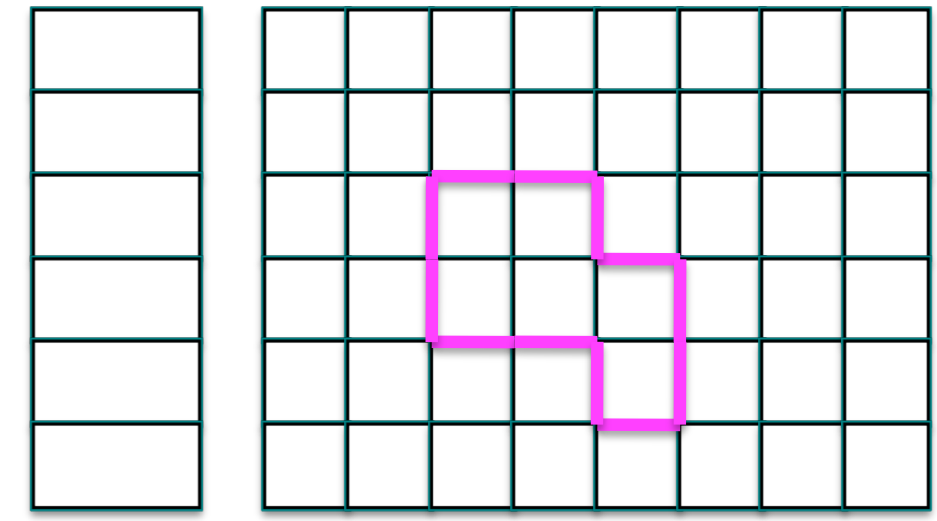
NEED OF A TRUTH CLUSTER ENERGY REFERENCE

Truth Energy for Clusters

Reconstruct cluster in Monte Carlo simulation

"Calibration Hit"

GEANT4 simulation information on the *truth energy* deposit in each Calorimeter *Cell*



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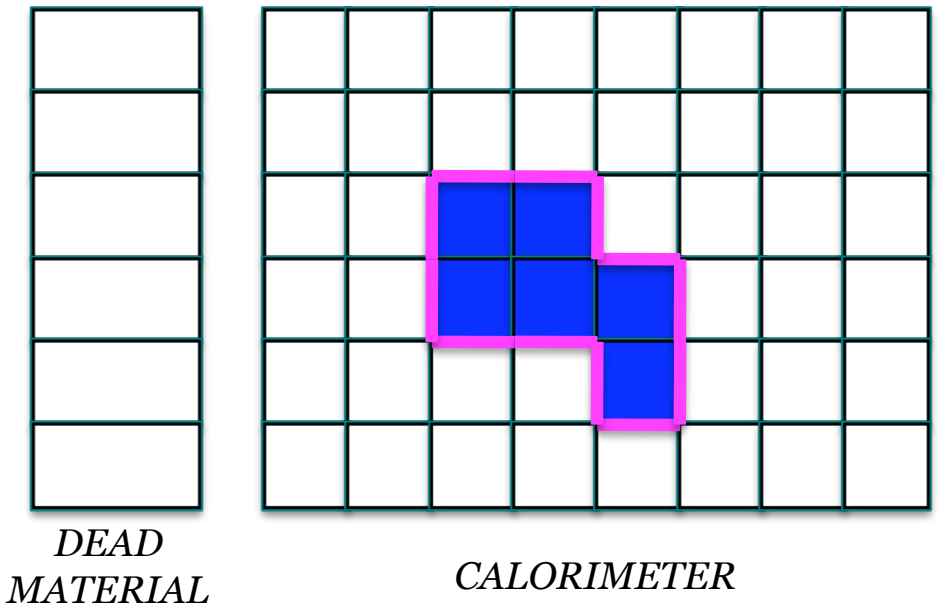

Reconstruct cluster in Monte Carlo simulation

Sum up the truth energy of cells inside the cluster

truth reference for cluster Energy after hadronic weights

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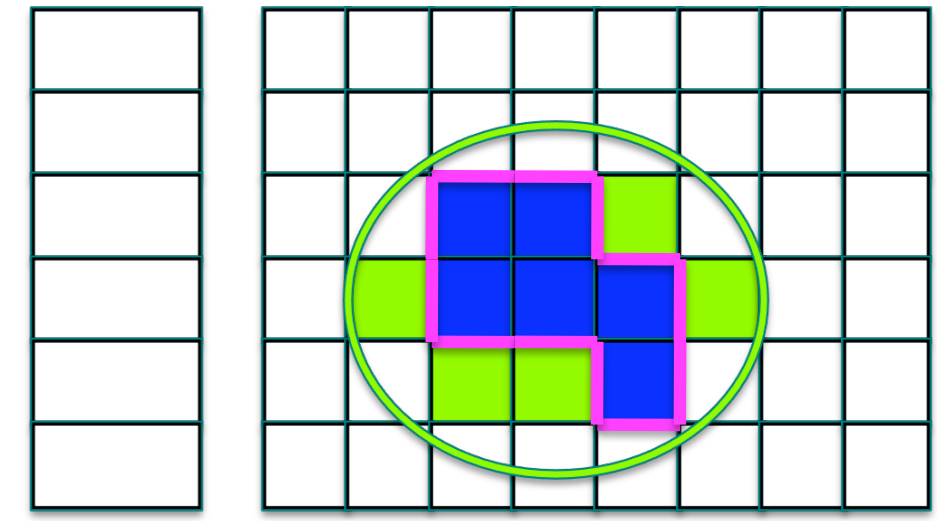

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Sum up the truth energy of cells "near" to the cluster

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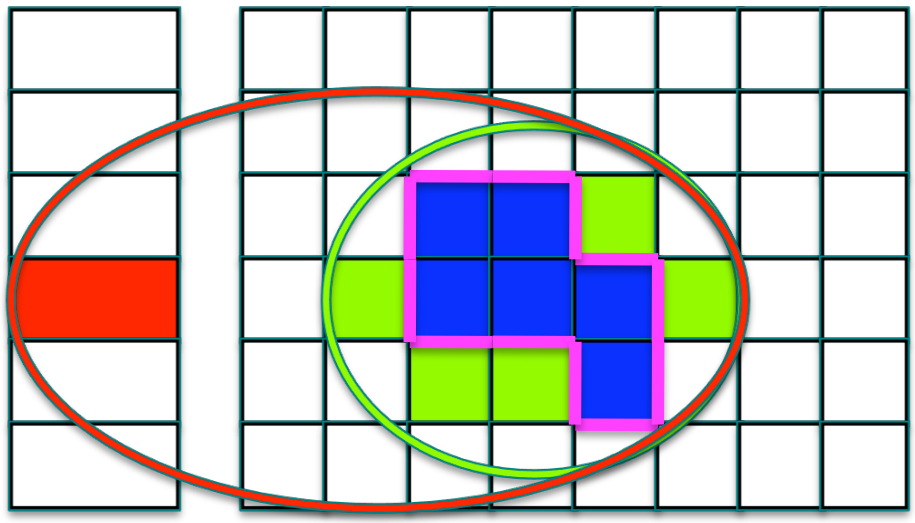


Reconstruct cluster in Monte Carlo simulation

Sum up the truth energy of cells inside the cluster

truth reference for cluster Energy after hadronic weights

Sum up the truth energy of cells "near" to the cluster

truth reference for cluster Energy after out of cluster weights

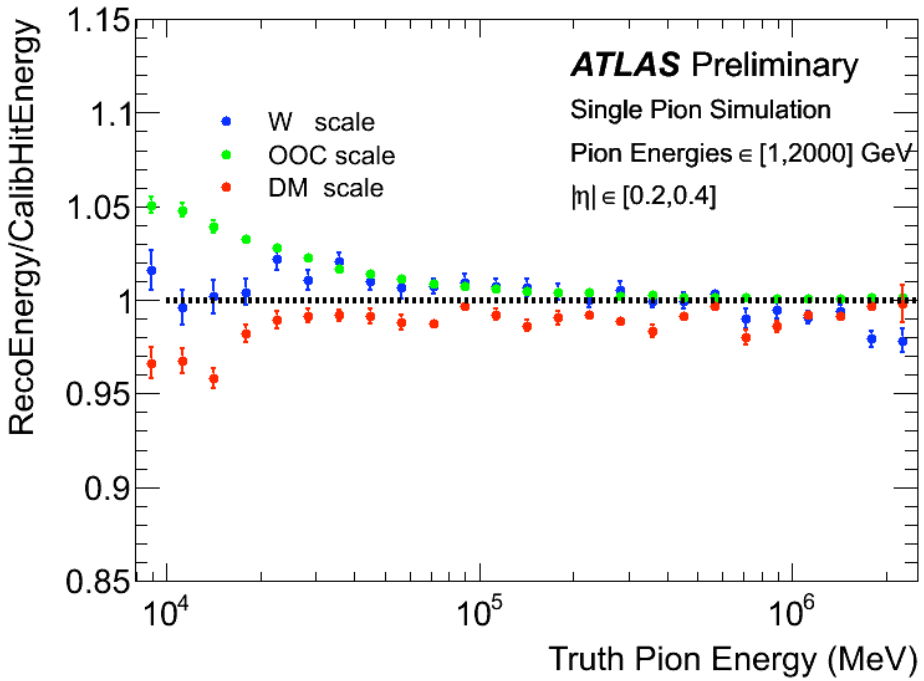
Sum up the truth energy deposited in dead material "near" to the cluster

truth reference for cluster Energy after dead material weights

“Local Truth” for pions

Local Hadron Calibration is developed and validated on single pion simulation

all the Clusters are created by the same particle → *the “local” truth energy of the pion is the sum of the “local” truth energy of all clusters*



DIAGNOSTIC STUDY
OF EACH CORRECTION EFFECT:

$$Y_{\text{axis}} = \frac{\text{RecoEnergy}_{\text{W}}}{\text{LocalTruth}_{\text{W}}}$$

$$Y_{\text{axis}} = \frac{\text{RecoEnergy}_{\text{OOC}} + \text{LocalTruth}_{\text{W}}}{\text{LocalTruth}_{\text{W+OOC}}}$$

$$Y_{\text{axis}} = \frac{\text{RecoEnergy}_{\text{DM}} + \text{LocalTruth}_{\text{W+OOC}}}{\text{LocalTruth}_{\text{W+OOC+DM}}}$$

“Local Truth” for jets

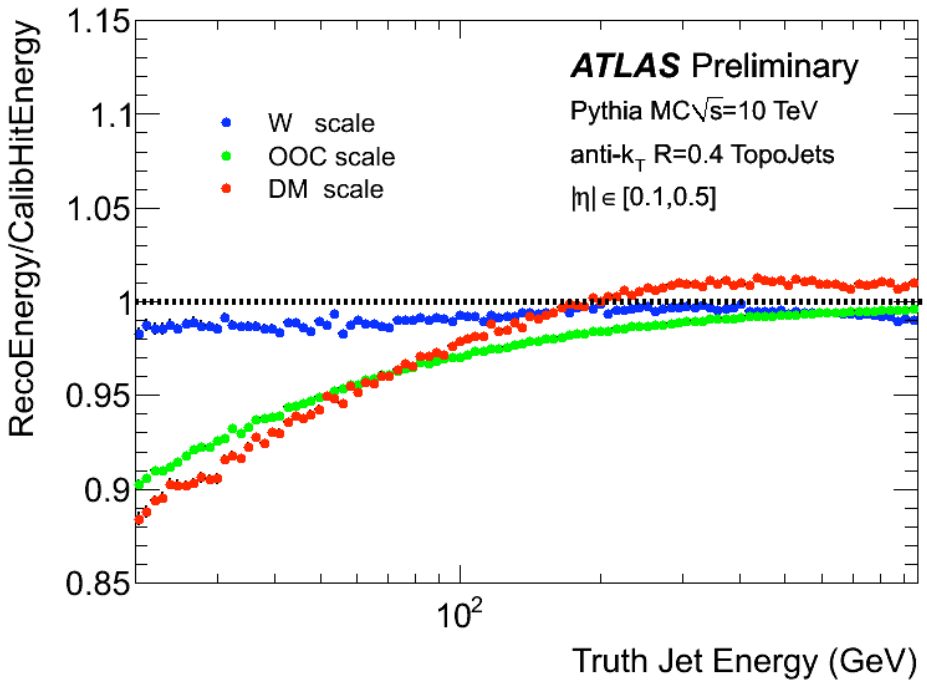
In the jet case it’s the jet algorithm that chooses the clusters

jet == collection of clusters

↓

“local” jet truth = sum of cluster “local” truth

} valid only before any jet-level correction is applied



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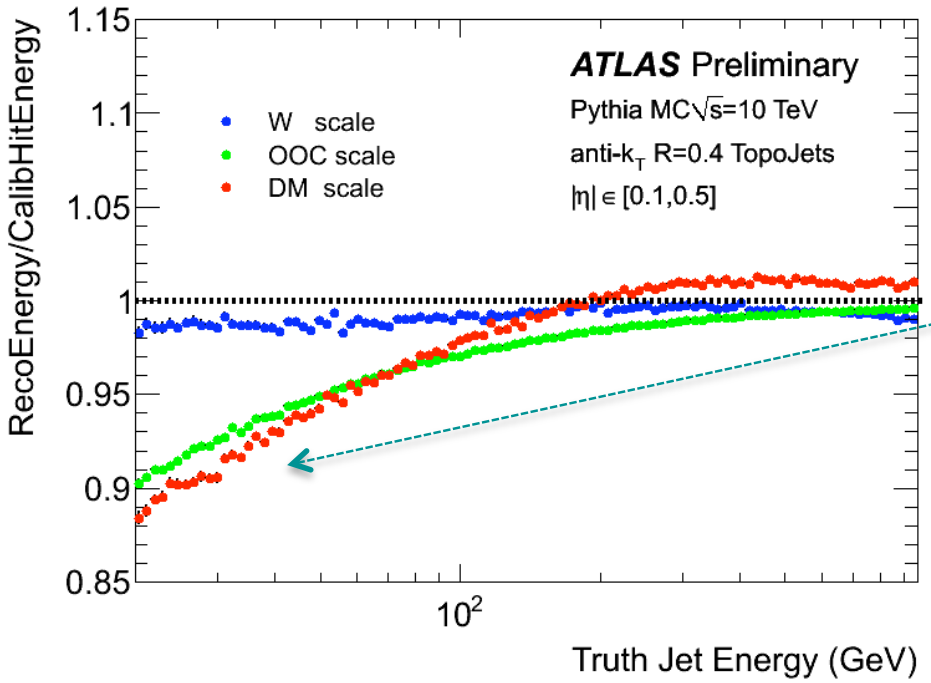

DIAGNOSTIC STUDY
OF EACH CORRECTION EFFECT:

lack of linearity at low ***JET*** energies:

- due to inclusion into truth definition of cell energy from lost particles
- developed a particle-cell assignment to make further quantitative studies

Local Calibration with data

DATA: $\sqrt{s}$ = 900 GeV collision data collected in December 2009

Event Selection:
- ✓ level 1 minimum bias trigger scintillators (MBTS)
- ✓ calorimeter and MBTS timing cuts (rejection of beam-halo events)
- ✓ Inner Detector, Calorimeter and Solenoid fully operational
- ✓ 330810 events are selected

Monte Carlo : double-diffractive, single-diffractive and non-diffractive processes generated with PYTHIA 6.4.21

Study based on Cluster properties:
- ❑ high statistics in minimum bias events
- ❑ calibrated Clusters are input to jets

900 GeV data results

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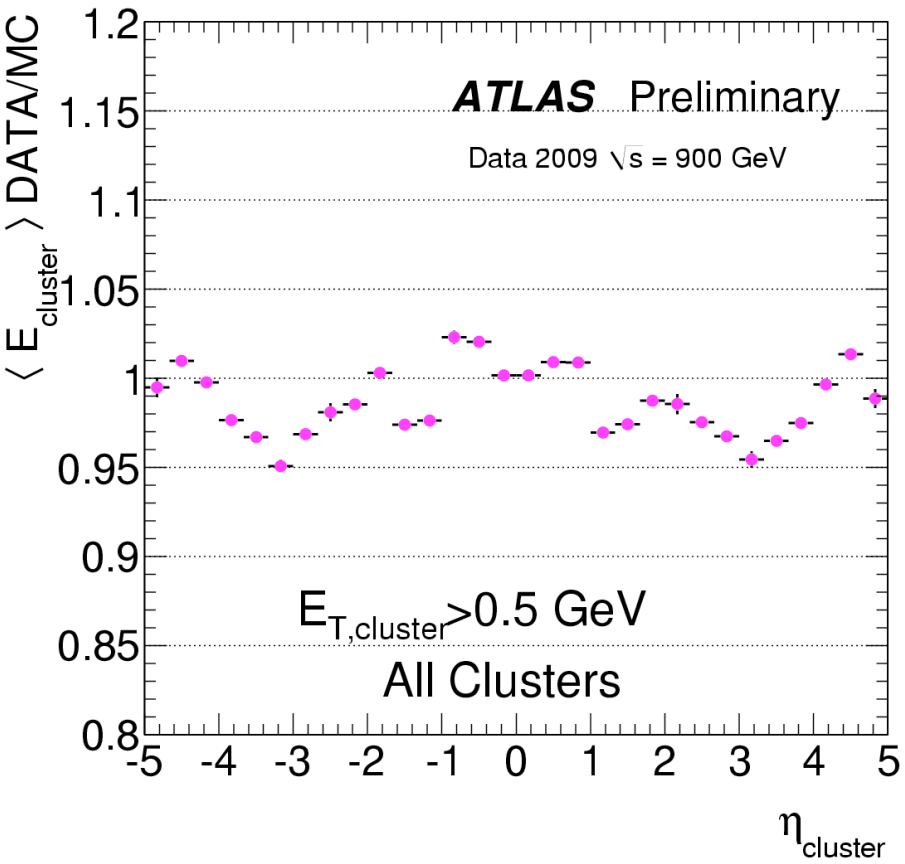
mean energy of clusters versus η



un-calibrated scale

the overall agreement between DATA and MC is very good :
barrel region ± 2%
end-cap/forward region ±5%

differences have to be understood with more statistics and MC tuning

DATA/MC comparison are possible for the calibrated scale as well

900 GeV data results

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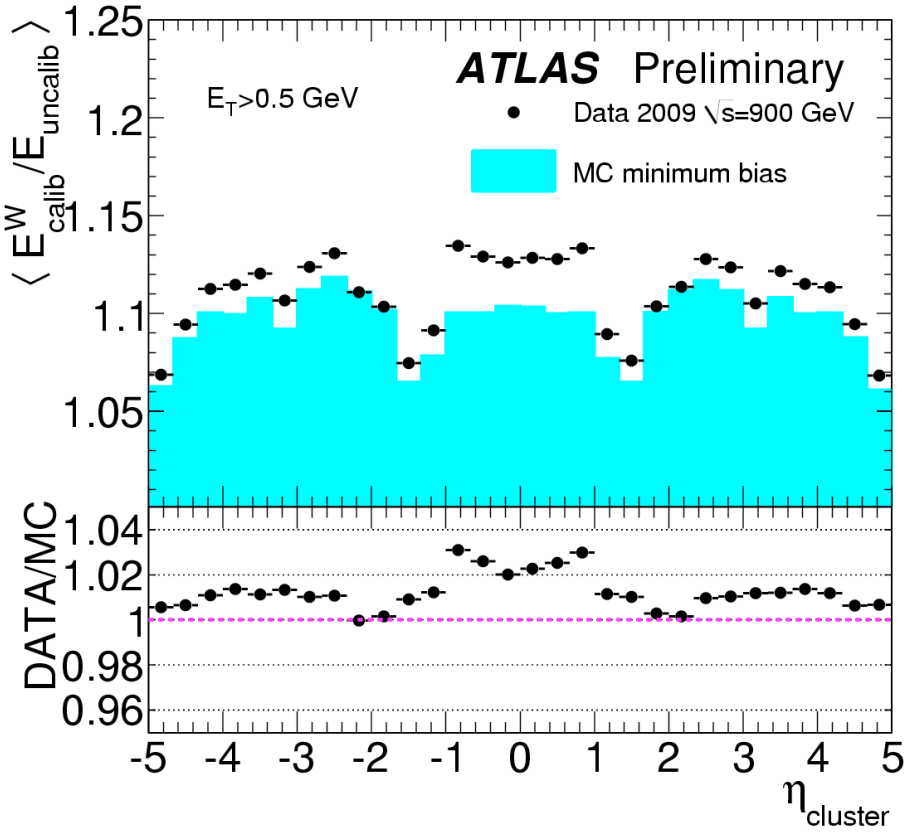
for clusters E_T> 0.5 GeV



ratio between calibrated energy and un-calibrated energy:

- ✓ reduces dependence to energy difference in DATA and MC
- ✓ allows first investigation of cluster properties on which local calibration weights are based

for the hadronic weights the agreement is very good ± 4 %

900 GeV data results

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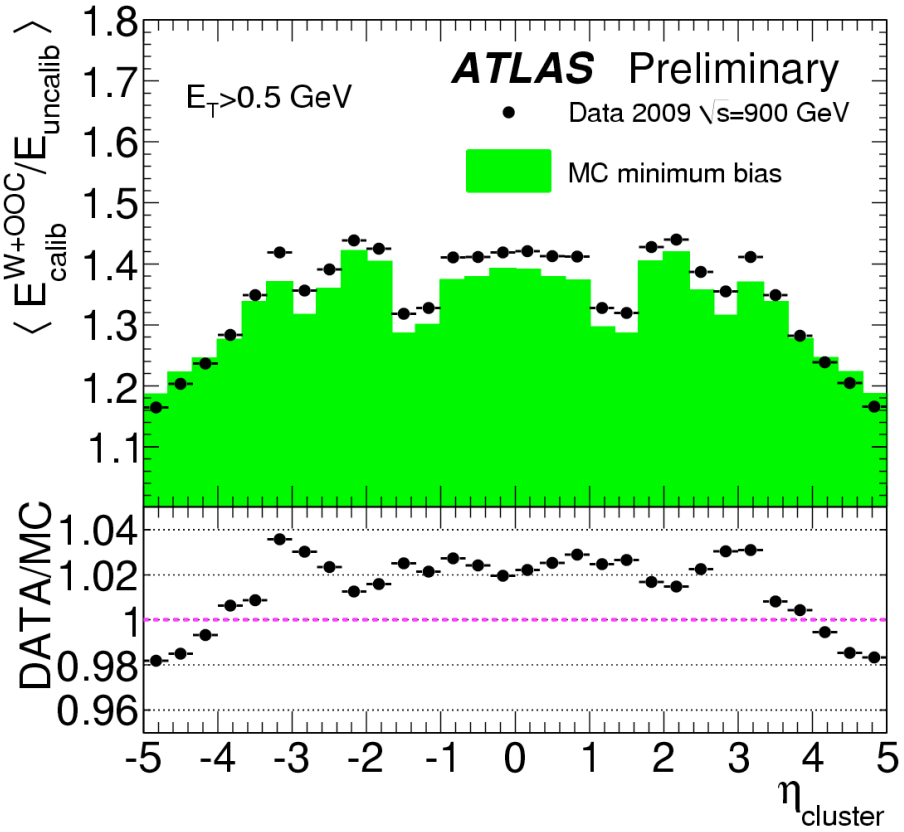
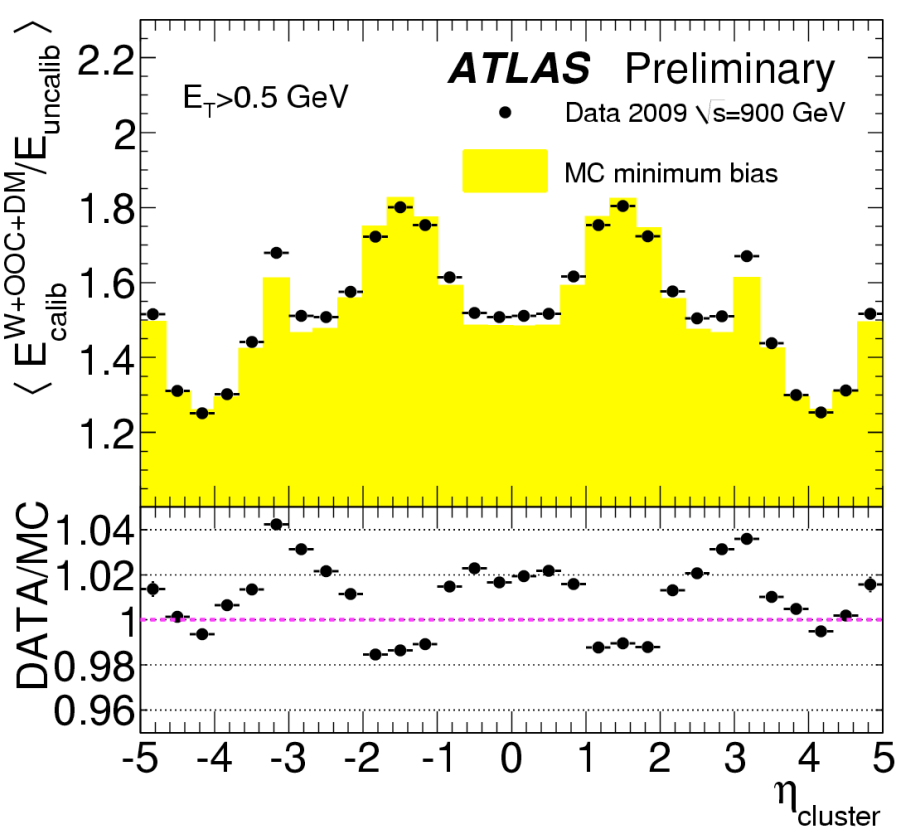
hadronic and out of cluster corrections Data/MC ± 4 %

hadronic and out of cluster and dead material: Data/MC ± 5 %





Conclusions

Local Hadron Calibration is a complete and modular approach to jet calibration

- a diagnostic method to evaluate the performance of each cluster correction at a jet level has been developed using GEANT 4 truth information
- further improvements are expected connecting GEANT 4 information to the primary particles of the simulation

- preliminary comparison of cluster energies in data and Monte Carlo shows very good agreement for the calibration weights, inside ± 5%
- first in-situ comparisons of Jet Energy Scale between data and Monte Carlo need more jet statistics and are foreseen for 7 TeV runs

THANKS

Back-up slides

Jet Calibration

Local Calibration Corrections

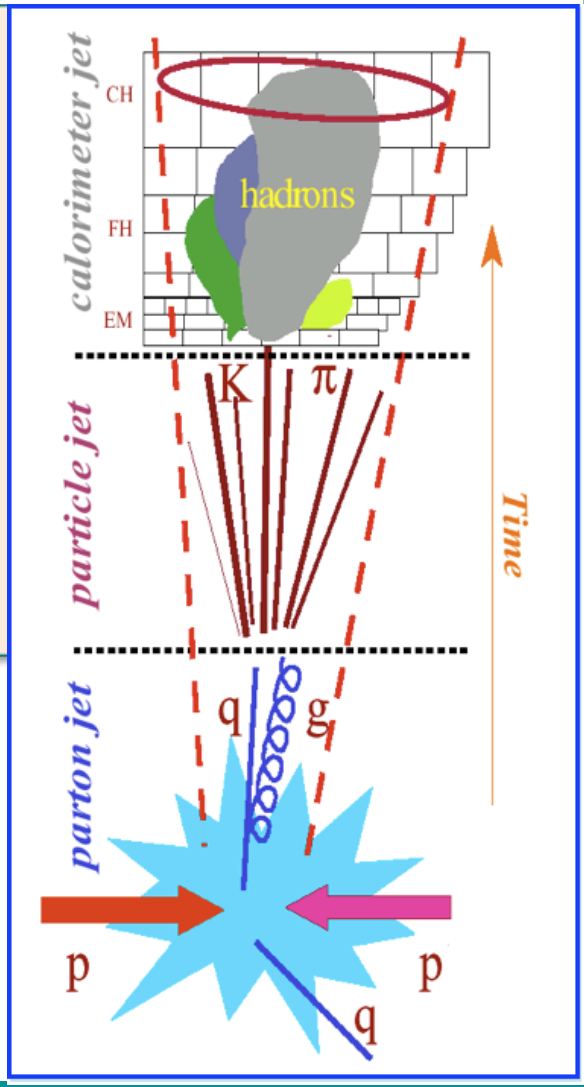
detector response (e/π)
electronic and detector noise
dead material and leakage

LC Jet Level Corrections

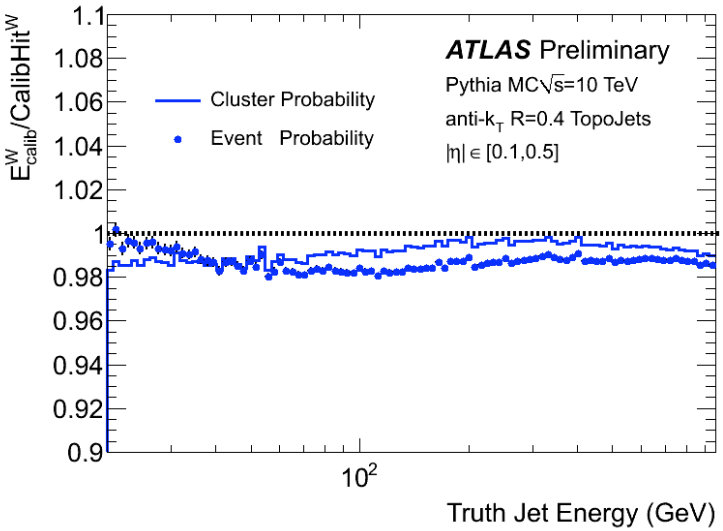
jet algorithm
lost soft particles

to be addressed separately in every physics analysis

underlying event
parton level corrections



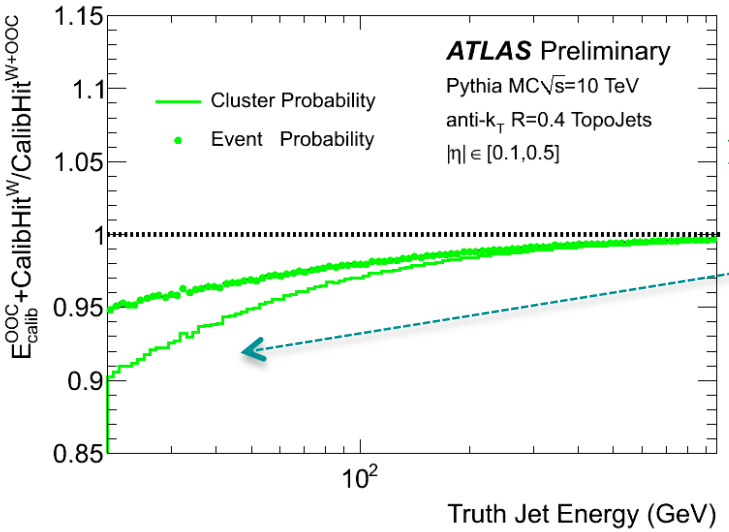
“Local Truth” for jets



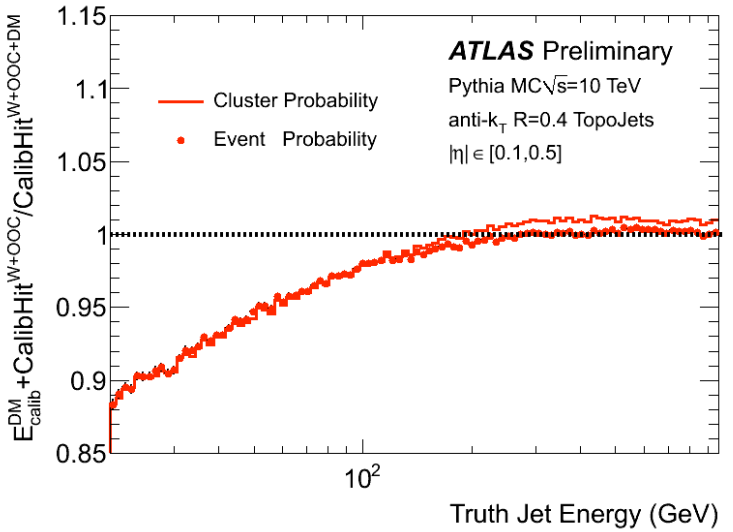
“Working Example”

two sets of corrections are tested:
different normalization factors
in the tables for weight calculation

- one cluster == 1 entry
- one event == 1 entry



main difference in linearity is coming from the OOC corrections



Local Truth Versus Particle truth