Jet Energy Scale at ATLAS

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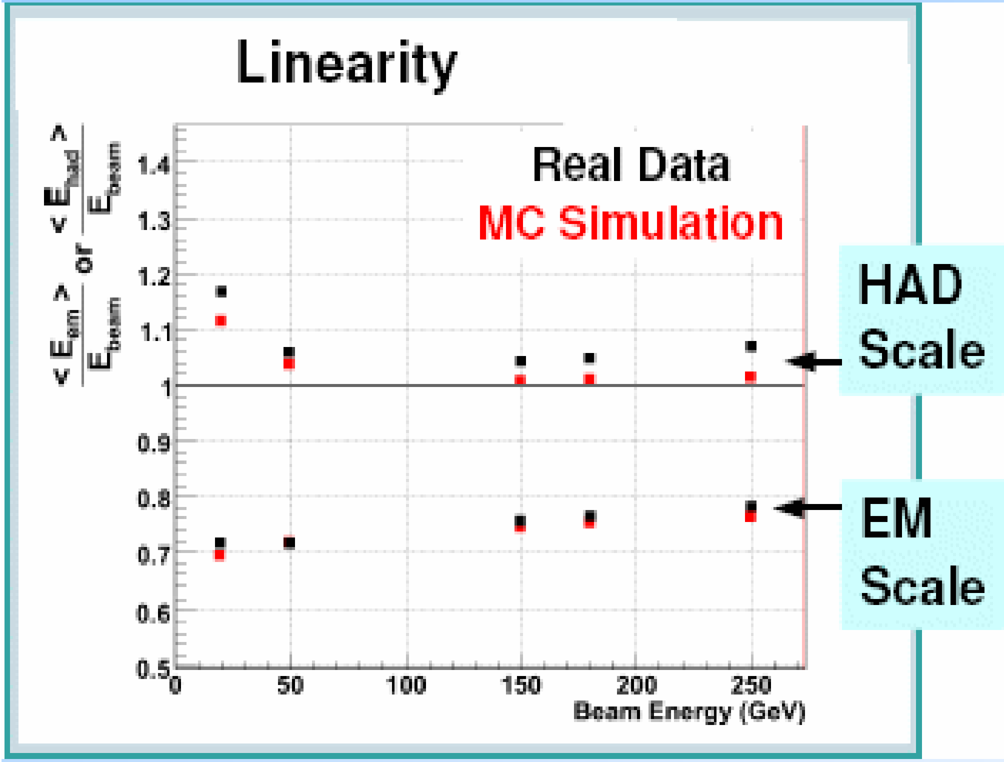
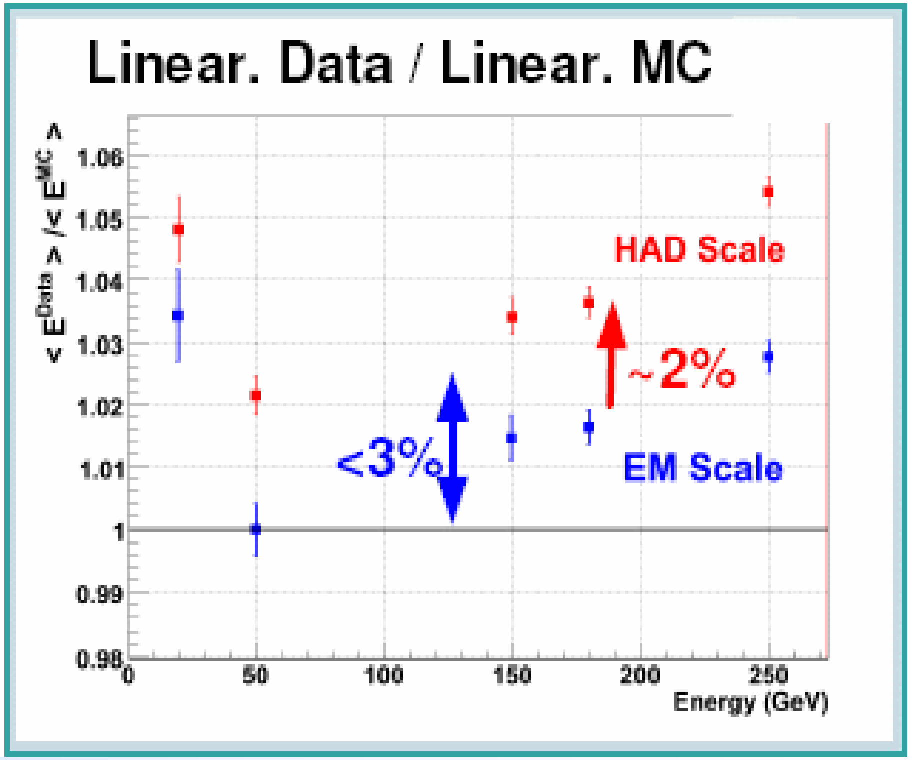
Jet Energy Scale

- The measured energy of jets of a given energy E(true) are distributed about a mean E(mean) due to the jet energy resolution.
- Jet energy scale errors occur if E(true) $\neq$ E(mean).
- Constraining the JES is important for many analyses (e.g PDF fitting, compositeness searches etc) and is a major goal of the jet calibration.

Test Beam Data

•Apply Jet Calibration to Combined test beam data for pions (MC and data)





Plots by **Paolo Francavilla (INFN-Pisa)**

•**At EM scale**: Data and MC disagree by ~ 3%

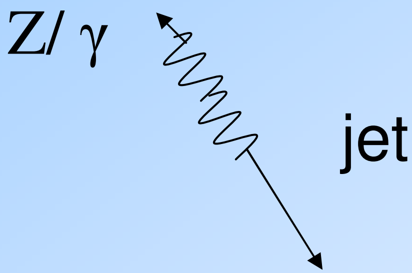
•**At Hadronic scale**: Data and MC 4-5%

•TDR predicts test beam data will allow JES of 5-10%

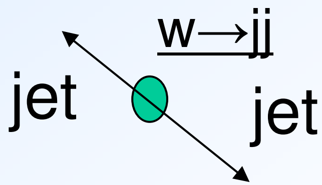
In-Situ Calibration Benchmarks

- Typically the electromagnetic scale is known to greater accuracy than the hadronic one.
- Many benchmarks try to connect the hadronic to the EM scale:

Z/γ + jets

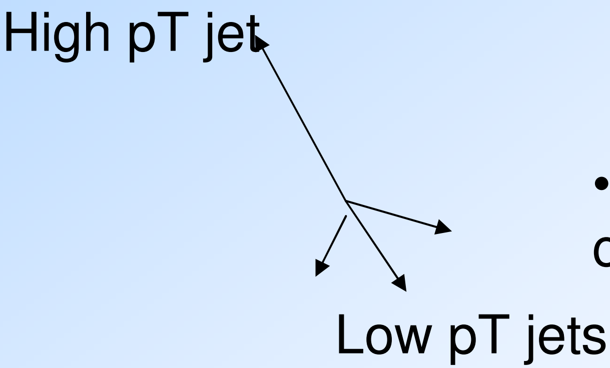


- Demand pT balance between Z/ γ and the recoiling jet. Good for calibrating jets with pT < 500GeV.



- Look for decay of W→jj and demand $M_{jj}=M_W$

Multi-jets



- Look for pT balance in multi-jet events to calibrate high pT jets against many low pT jets.

TDR Expectations and Limitations of Benchmarks

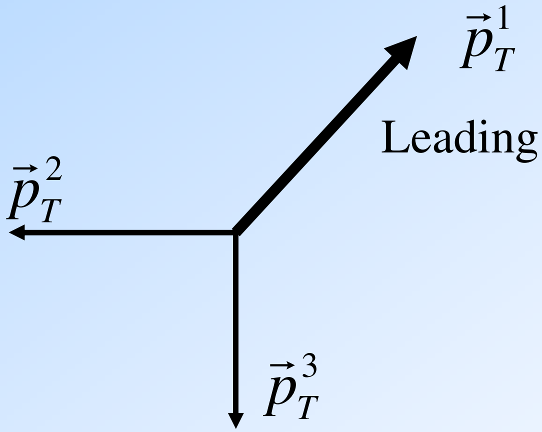
- TDR expectations of JES:
  - Test Beam data constrains JES to 5-10% (low pT) Use of isolated hadrons from tau decay to help transfer knowledge.
  - In-Situ techniques constrain JES to ~1% below pT~500GeV

- Typically a benchmark gives a good measurement of JEs but only at a particular (or narrow range) of energies.
- The jet calibration has to interpolate and extrapolate the benchmark data to provide corrections for jets at arbitrary energy.

Non-Linearities and High pT JES

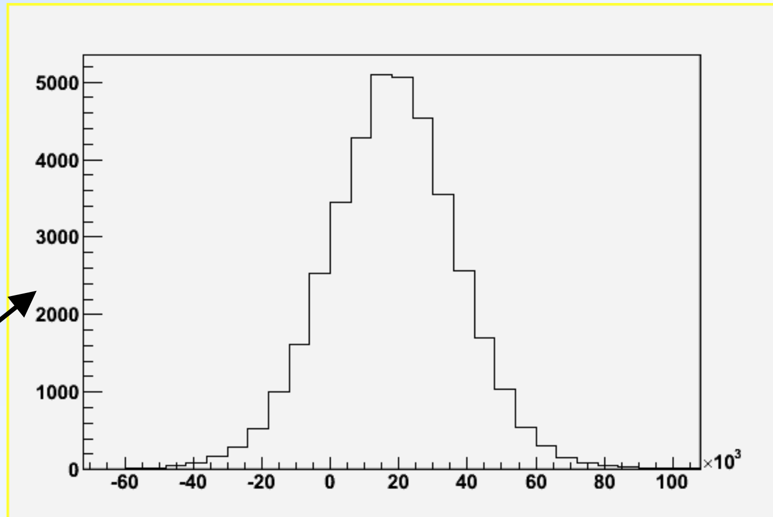
- JES at high jet pT is a problem as there are no calibration benchmarks.
- This region is however interesting for compositeness searches/constraining PDFs.
- The accuracy of extrapolation of calibration coefficients (of a given system e.g H1,pisa) is complicated by lack of knowledge of non-compensation in the ATLAS calorimeters.
- Can apply a bootstrap approach, i.e. use multijet events to transport low pT jet calibration to higher pT.

Bootstrap-Techniques



- Find the leading jet (in pT) which has a reconstructed pT=pT $^{(lead)}$
- Find the magnitude of the vector sum of all the other jets in the event pT $^{(bal)}$
- Require 3rd leading jet to have pT>40GeV
- Require $\Delta\varphi > 160^{\circ}$ between leading jet and balance pT.

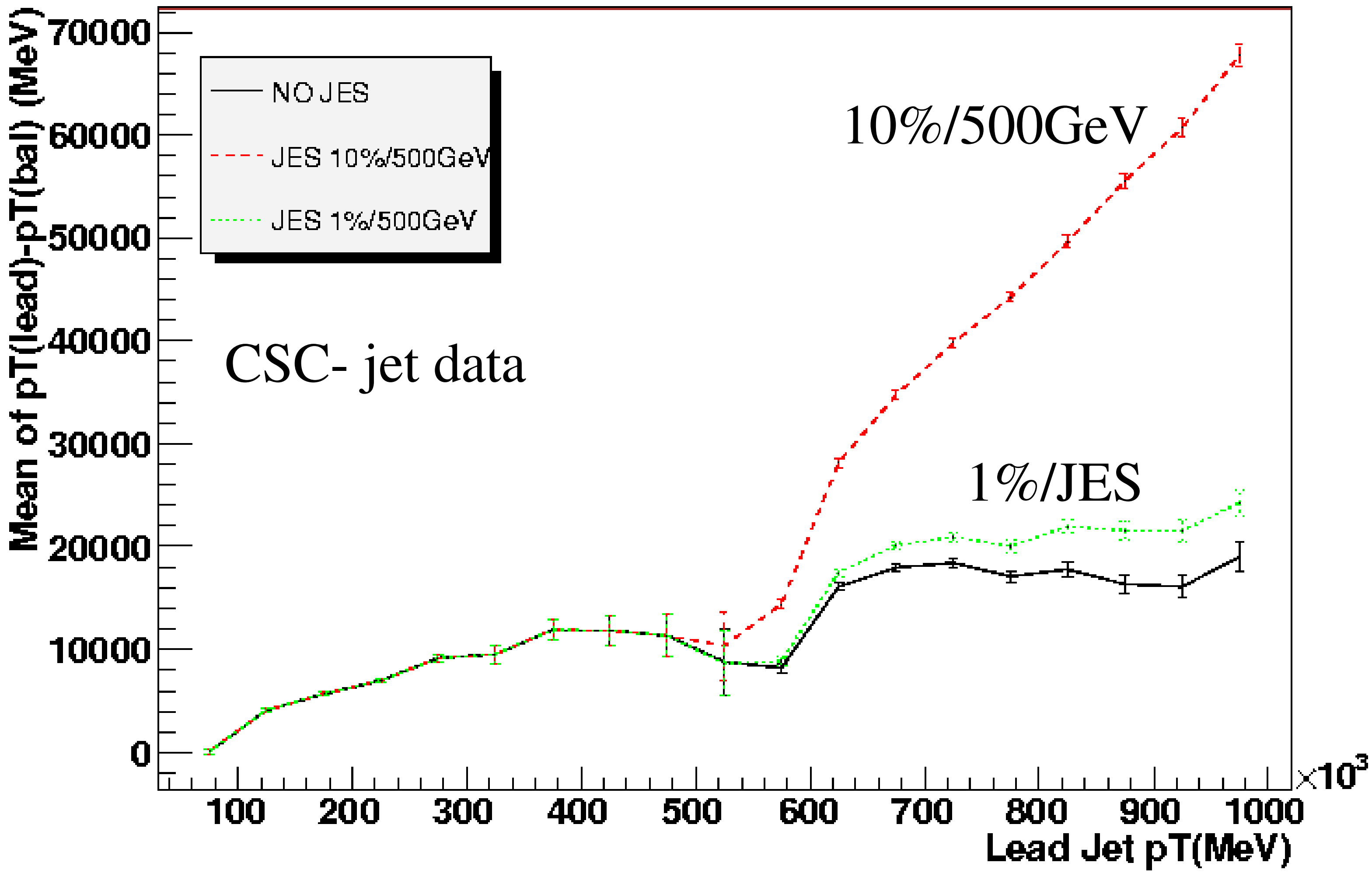
pT(lead)-pT(bal)



(MeV)

- Calculate pT(lead)-pT(bal) and record in a histogram. Have different histograms for different ranges in pT(lead).
- Plot the means of these distributions as a function of pT(lead).

Detecting Non-Linearities with Bootstrap method



Biases in Jet Balancing

•Resolution effects play a large contribution to the bias found in the reconstructed jets.

•However there is still a positive bias present in the truth in part from:

1. Greater energy in the form of neutrinos reconstructed away from the leading jet.
2. More soft activity in the direction away from the leading jet which can be missed in the reconstruction.
3. Low jet pT cuts, jet seed thresholds and low pT particles that don't make it to the calorimeter.

•Due to the preference for soft activity away from the leading jet, low jet pT cuts, jet seed thresholds and low pT particles that don't make it to the calorimeter and jet cone size all contribute to the bias.

Summary

•JES will be poor at start-up where only calibration data available is test-beam (5%-10%) at low pT.

•In-Situ techniques will improve JES to ~1% (maybe nearer 2%) for low pT (below 500GeV).

•High pT JES determination is complicated due to a lack of available benchmarks.