

Jet Energy Scale in ATLAS

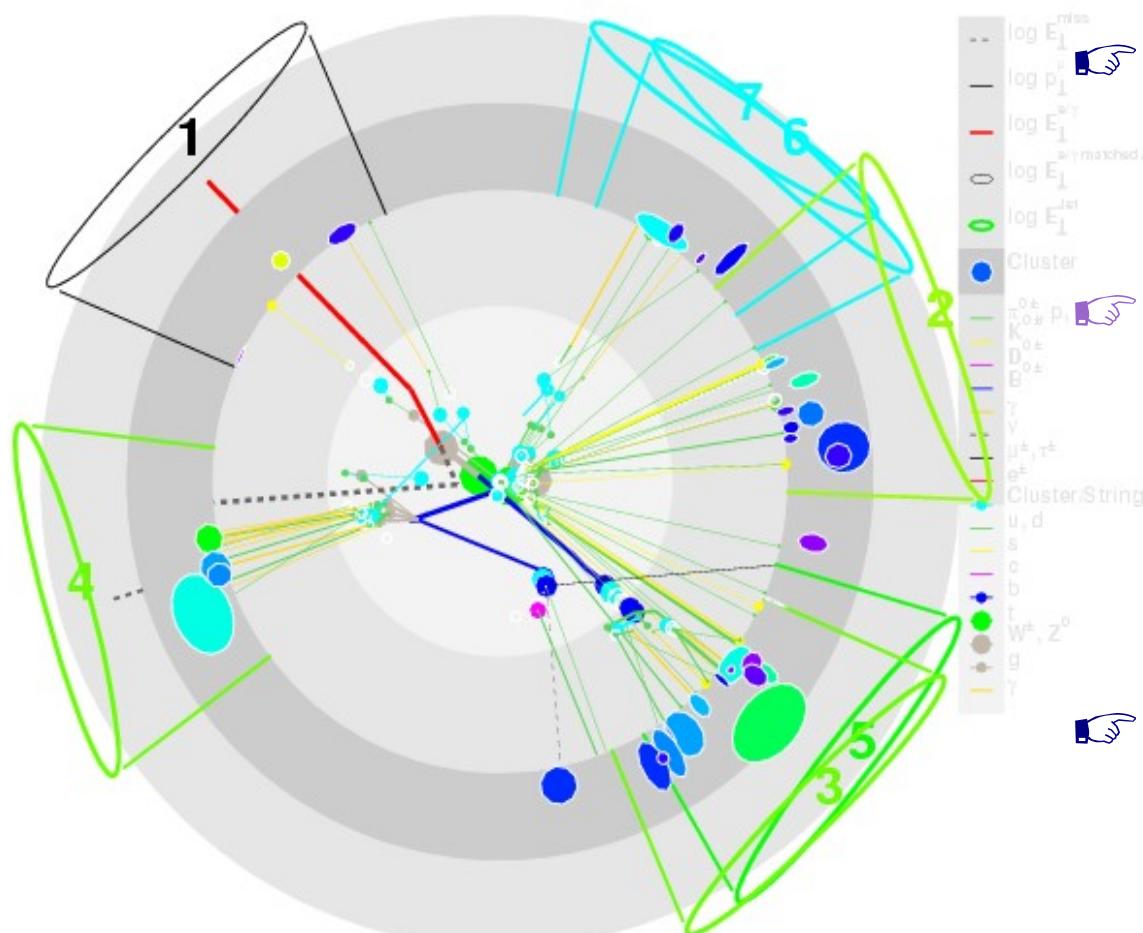
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June 20 th, 2008

Introduction

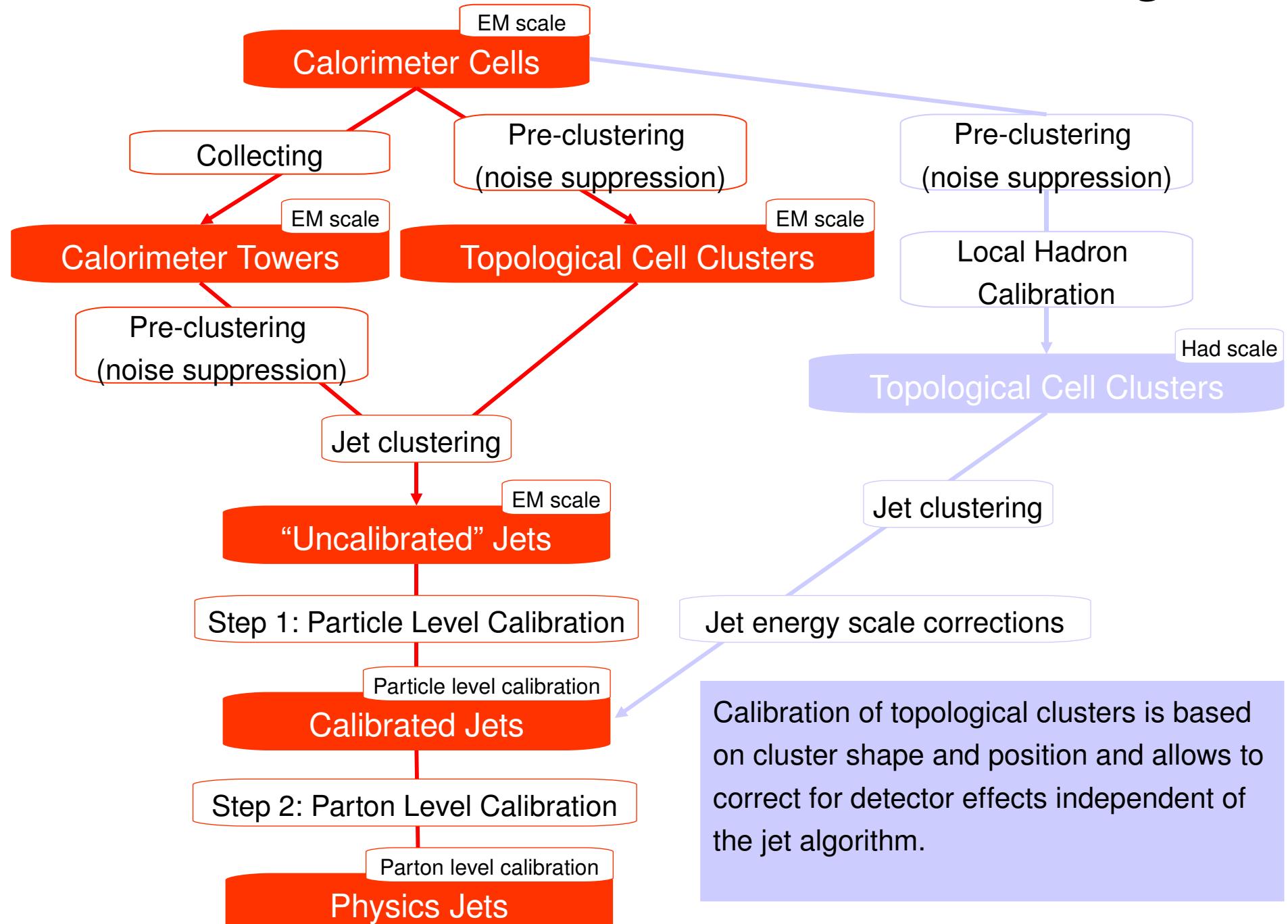
The jet energy scale determination with the ATLAS detector requires several steps:



S.Menke, MPI: a ttbar event at ATLAS

- ☞ tower/cluster reconstruction from the calorimeters,
- ☞ jet making using optimal algorithm settings: Cone-type and Kt-type algorithms are considered.
- ☞ calibration to stable particle level,
- ☞ calibration to parton level.

ATLAS Jet Reconstruction and Calibration Strategies



Slide from S.Jorgensen: CALOR 2006.

Jet Energy Scale Measurement at ATLAS

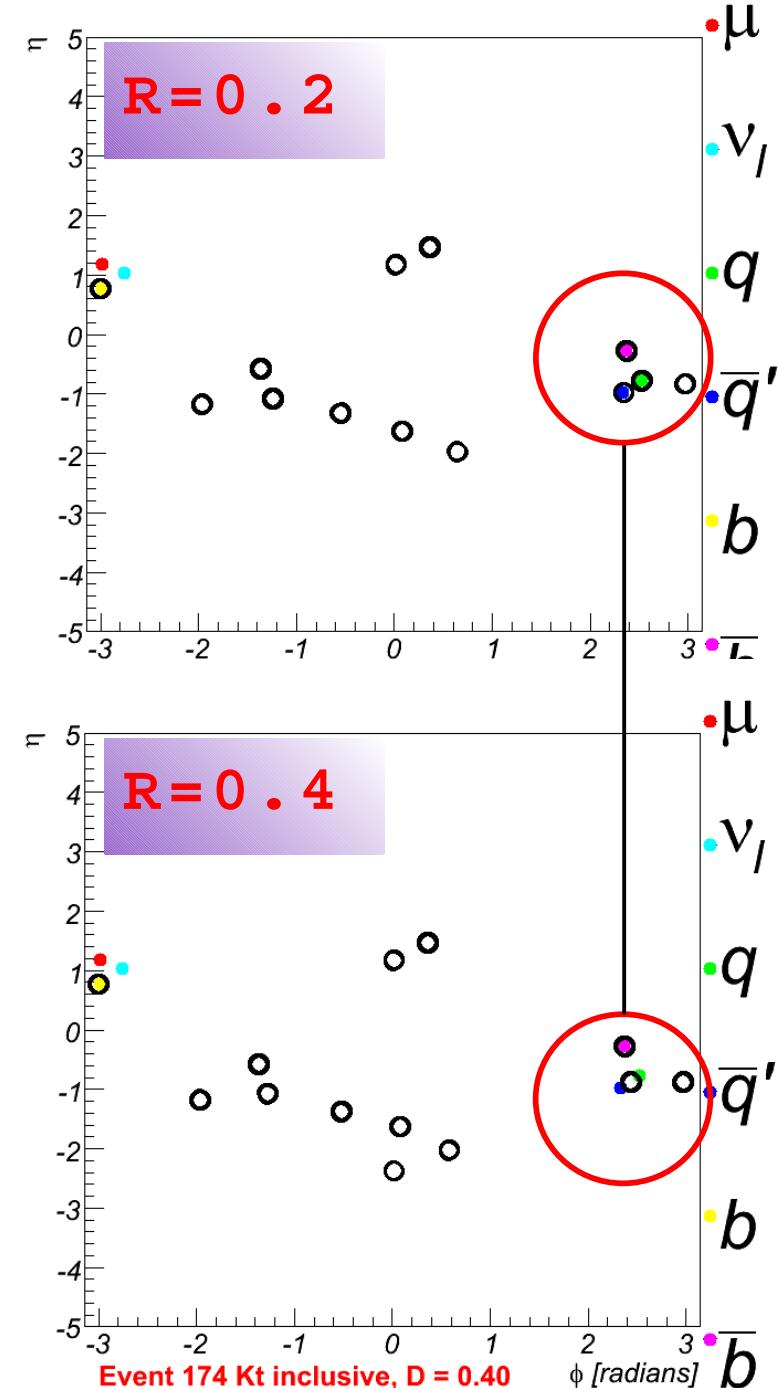
Several challenging approaches will be used at ATLAS for the JES determination.

These are:

- ☞ jet algorithm parameter optimization,
- ☞ use of $\gamma/Z^0 + \text{jets}$ events,
- ☞ di-jet calibration,
- ☞ in-situ calibration using ttbar events.

In the following slides, we will briefly review these different ongoing studies.

Jet Algorithm Optimisation for JES (1)

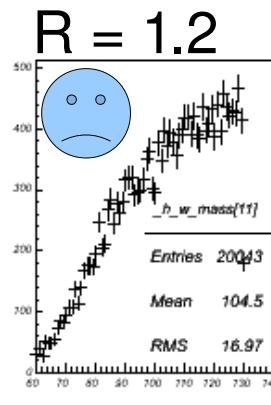
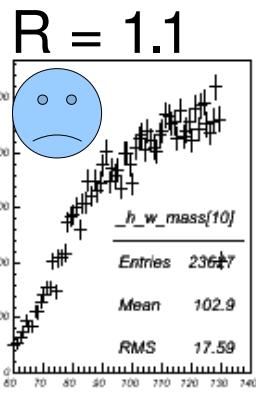
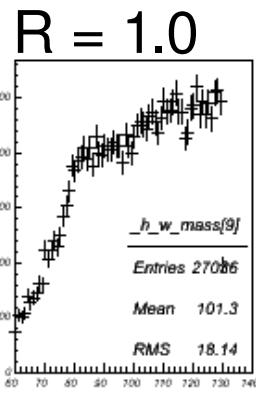
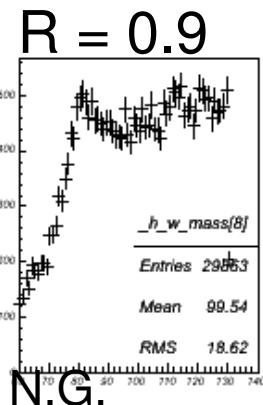
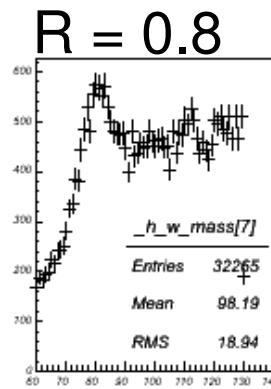
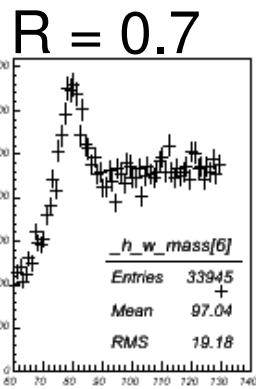
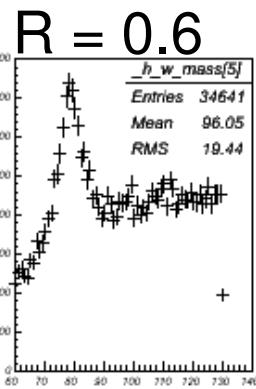
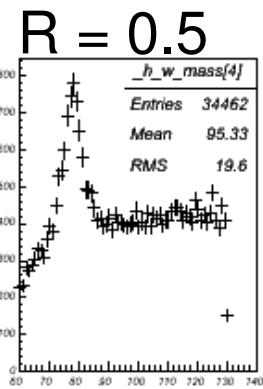
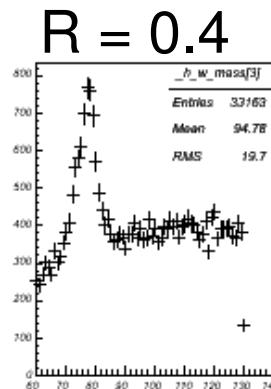
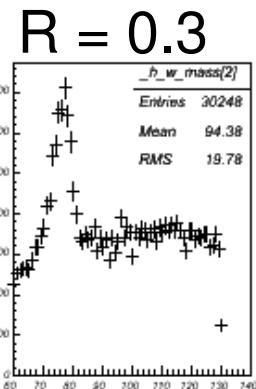
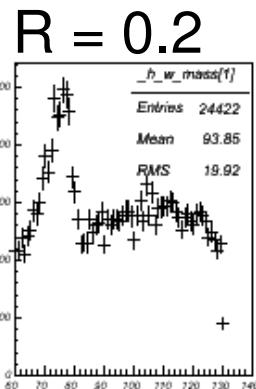
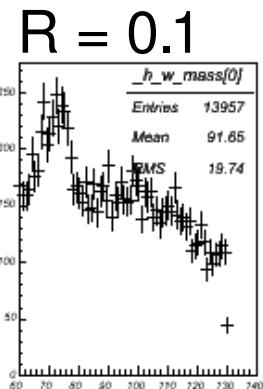


The understanding of the JES, requires an appropriate choice for the Jet reconstruction algorithm and the optimization of its parameters!

A typical example in the case of the top quark reconstruction

e.g. the Kt algorithm parameters need to be optimized, since a wrong choice leads to wrong/biased results.

Jet Algorithm Optimisation for JES (2)



N.G.

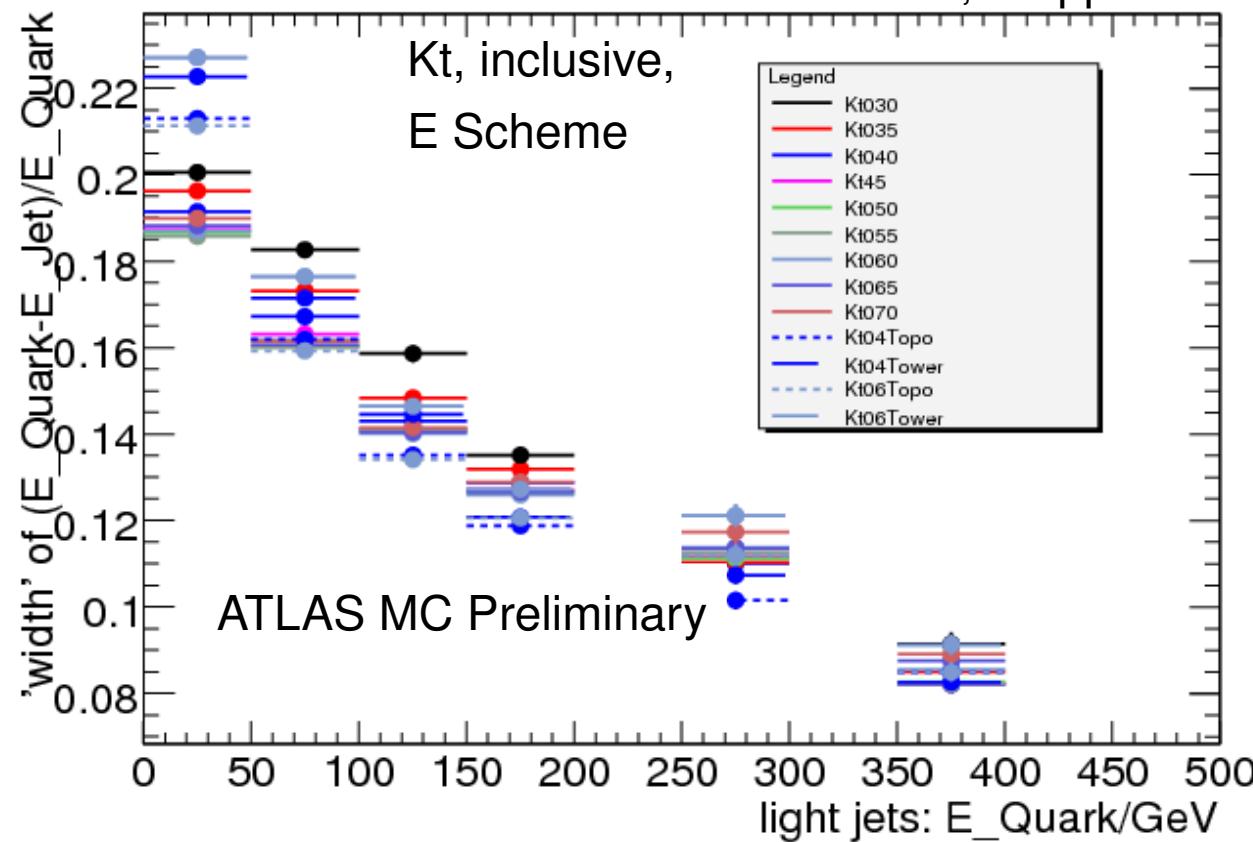
A sensitive observable for the optimization of the jet algorithm parameters, is the hadronic W-boson reconstructed from the light jets!

Corrections applied to the two light jets depend then strongly on the Jet algorithm parameters!

Moreover, this correction is process dependent!

Jet Algorithm Optimisation for JES (3)

M.Sandhoff., Wuppertal



Comparing the reconstructed jet resolutions for various R parameters, shows that the Kt, R=0.4-0.6 gives the most promising results.

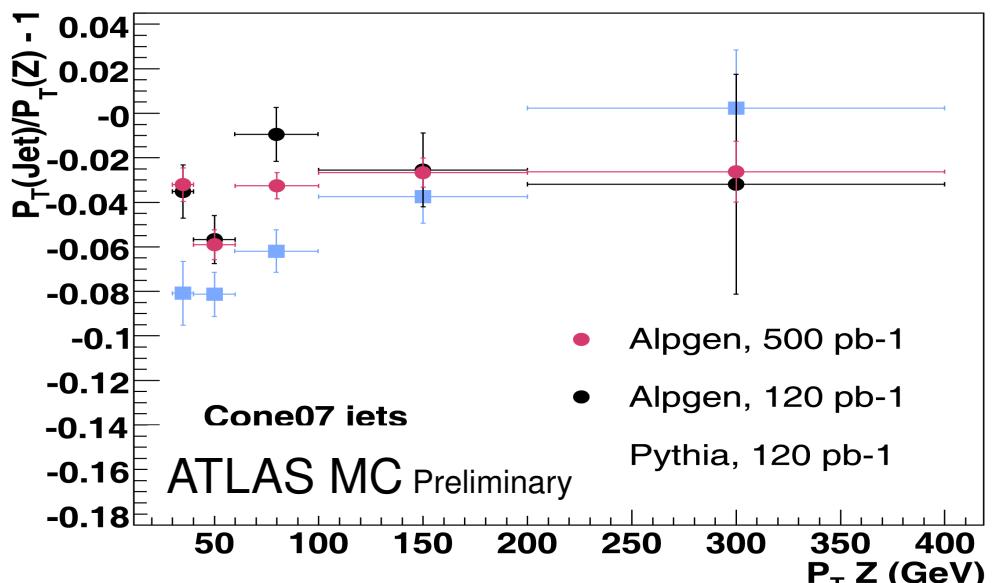
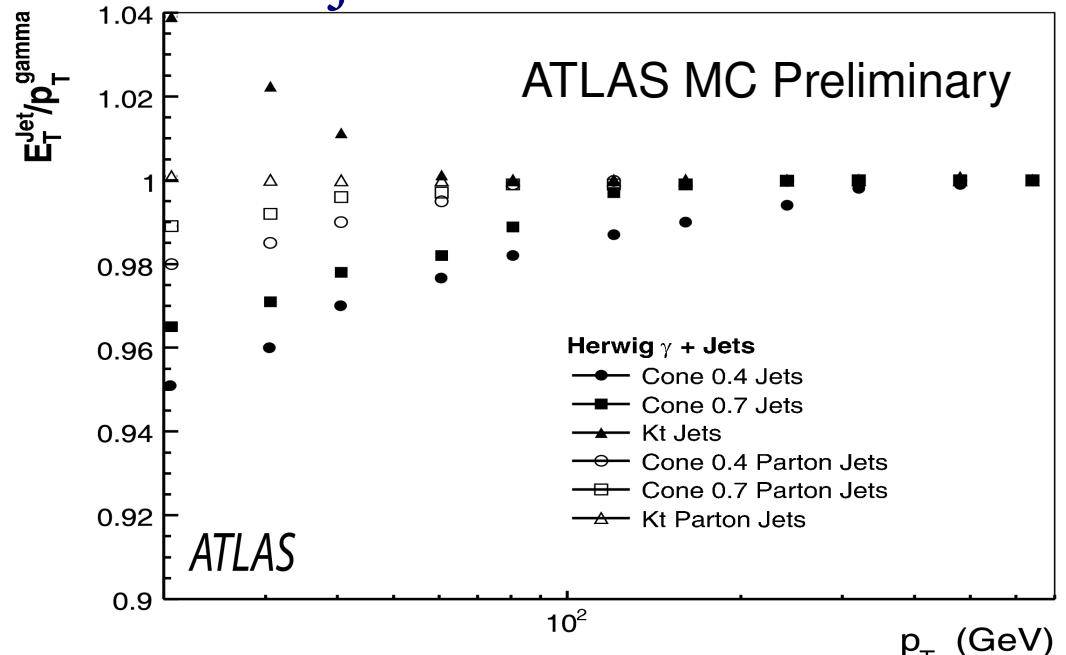
Not shown here : a comparison with Cone based jet algorithms, gives similar results.

$\gamma/Z^0 + \text{Jet}$ for JES: p_T balance

Idea: use the Pt balance between reconstructed γ/Z^0 bosons and leading jet to relate the hadronic scale of the jets to the well measured energy of EM objects.

$\gamma + \text{jet}$: large statistics, but significant contamination due to one misidentified jet as a photon in QCD dijet events.

$Z^0 + \text{jet}$: clear identification of $Z^0 \rightarrow e^+e^- / \mu^+\mu^-$, but low statistics.

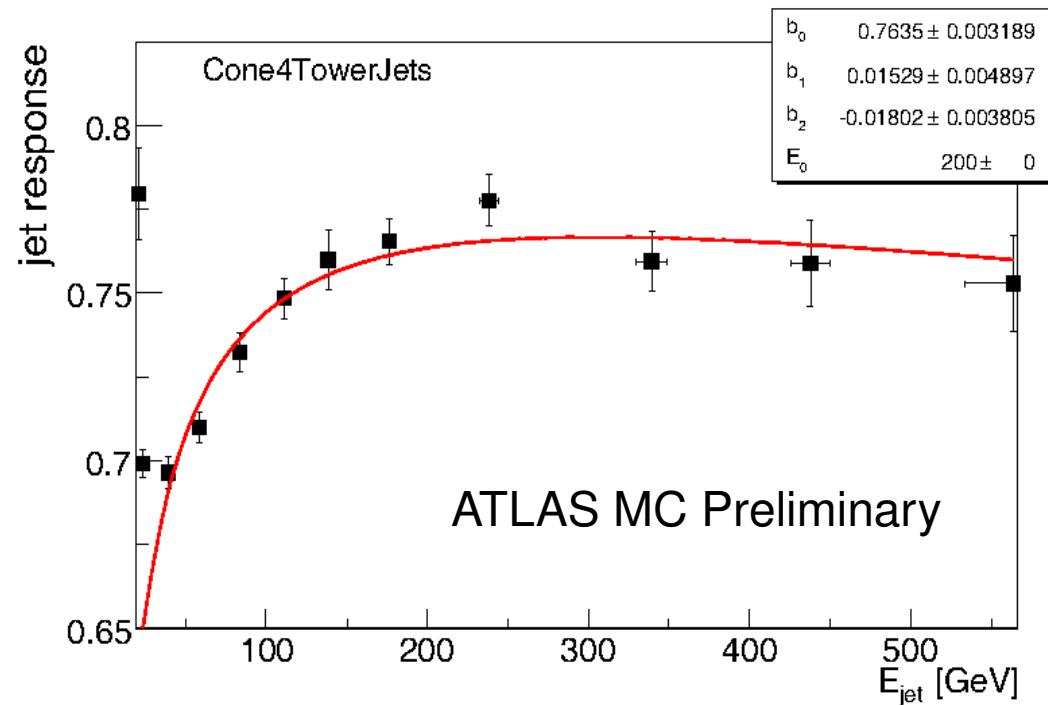


$\gamma/Z^0 + \text{Jet}$ for JES: missing ET Projection

Idea: at calorimeter level:

$$\vec{E}_{T,\gamma} + j(\vec{E}_{jet}) \cdot \vec{E}_{T,jet} = -\vec{E}_{T,Missing} \rightarrow j = \frac{\sum \vec{E}_T \cdot \hat{n}_\gamma}{\vec{E}_{T,\gamma}}$$

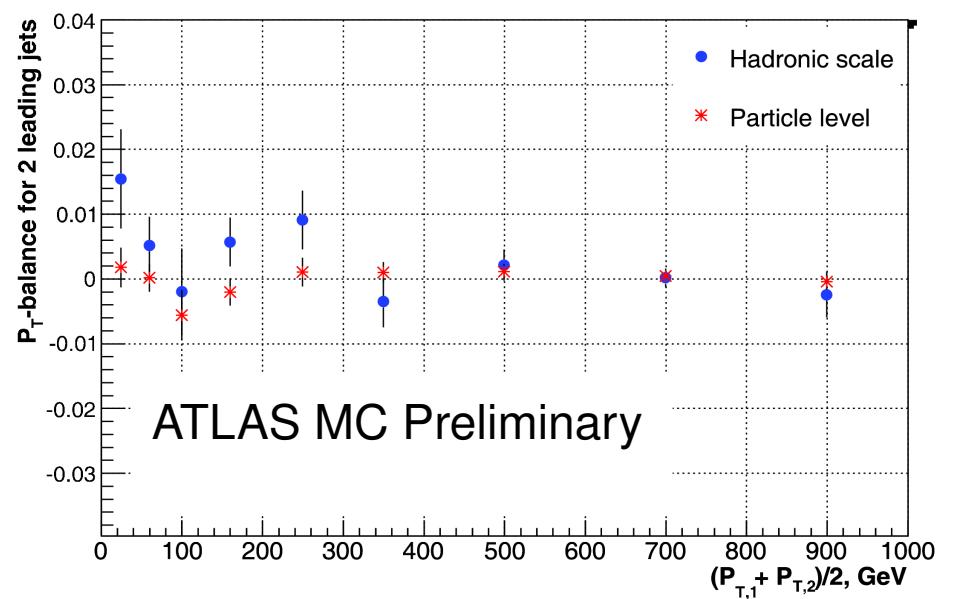
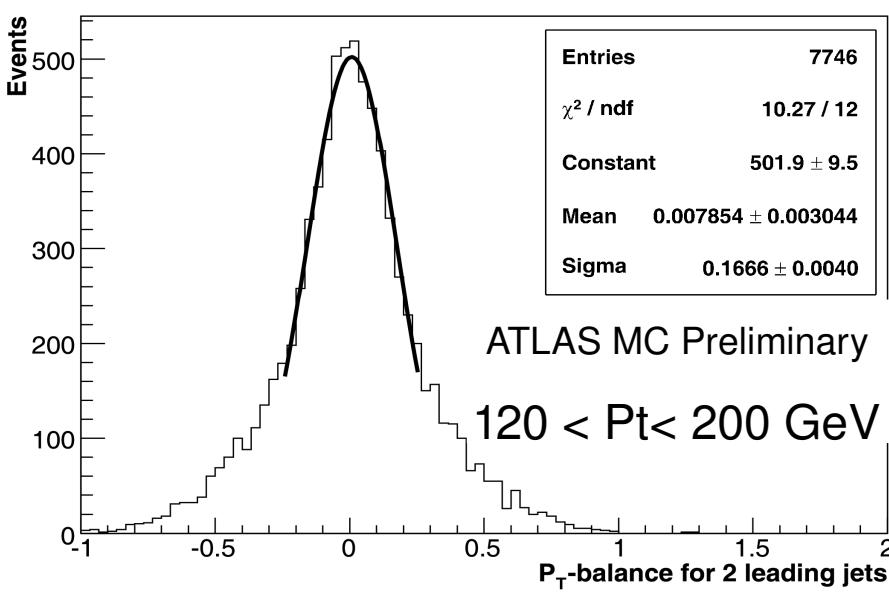
Method: project the missing Et against the reconstructed γ/Z^0 boson direction and fit in energy bins to extract the jet response.



Advantages: independent of underlying events and (almost) from jet algorithm choice.

QCD di-Jets for JES

- 👉 QCD di(multi)-jet pT balance will be used for JES and calibrations, since cross section about 3 times higher as compared to γ/Z^0 allows to cover higher energy ranges and larger $|\eta|$ values.



ttbar samples for the JES

- ☞ At ATLAS, achieving a top mass measurement with a 1 GeV error requires a 1% JES.

QCD di-jets, γ/Z^0 JES cannot be directly applied to the jets from ttbar events since mixture of light, b and gluon jets since different calibration factors are required!

Several methods are being investigated to extract the light JES directly from the $W \rightarrow jj$

- ☞ **Iterative rescaling** method
- ☞ **template** method

ttbar samples for the JES: $W \rightarrow jj$ Selection

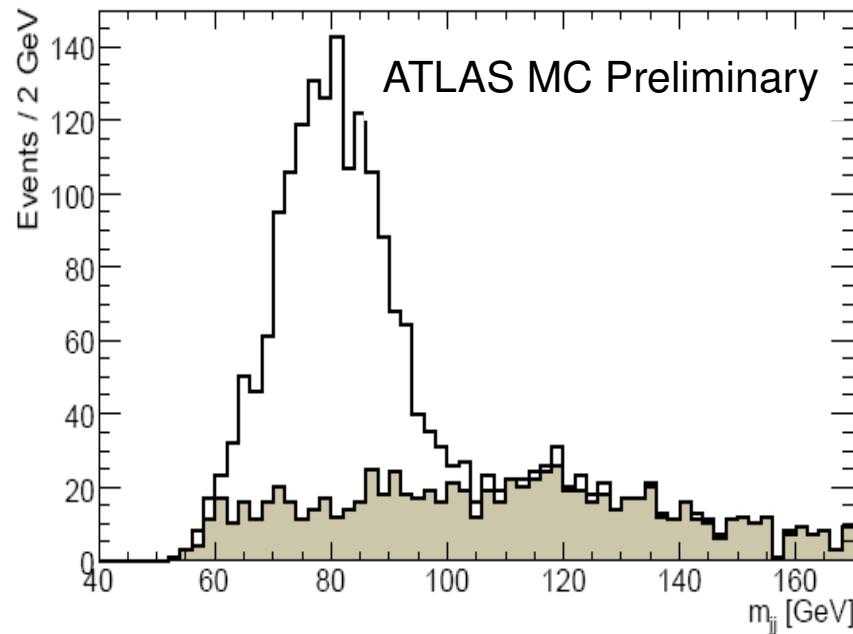
Semi-leptonic ttbar selection:

- one well identified lepton (e/μ) with $pT > 20$ GeV and $|\eta| < 2.5$,
- at least 4 (Cone $R=0.4$) jets with pT cut and $|\eta| < 2.5$, (two b-tagged)
- missing $E_T > 20$ GeV

$W \rightarrow jj$ pair selection:

- either events with only 2 light jets
- two jets with the invariant mass, the closest to the m_W^{true}

Finally add a mass window constraint on $150 < M_{jj} < 200$.



1/fb	2 jets only		2 jets or more	
	$p_T^{\text{cut}} [\text{GeV}]$	pairs	purity [%]	pairs
20	3100	76.9	7100	64.3
30	2300	77.7	4100	71.5
40	1200	81.0	1900	79.1

ttbar samples for the JES: Iterative Rescaling Method

Idea: start from the invariant di-jet mass:

$$M_{jj} = \sqrt{2 \cdot E_1 \cdot E_2 \cdot (1 - \cos \theta_{jj})}$$

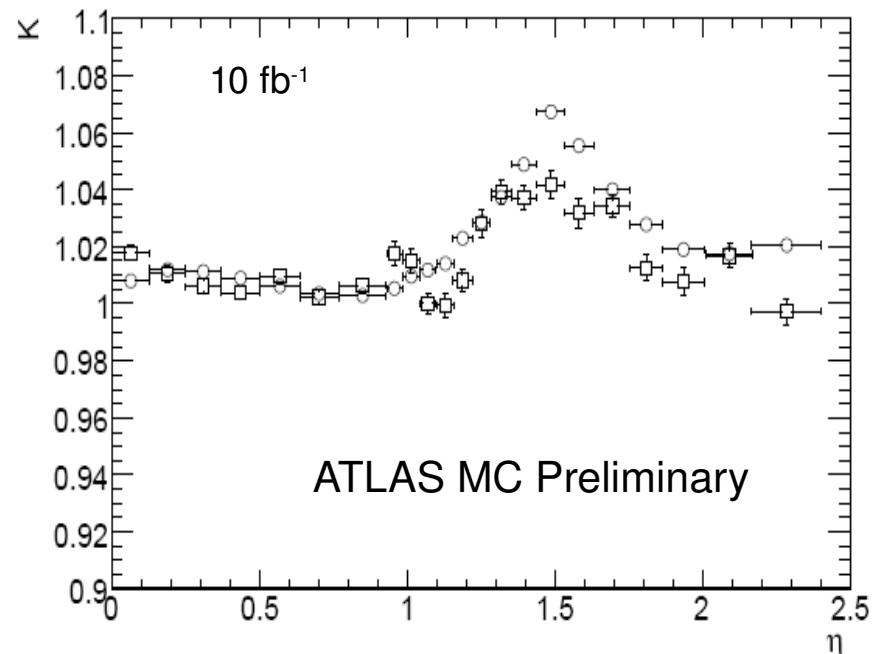
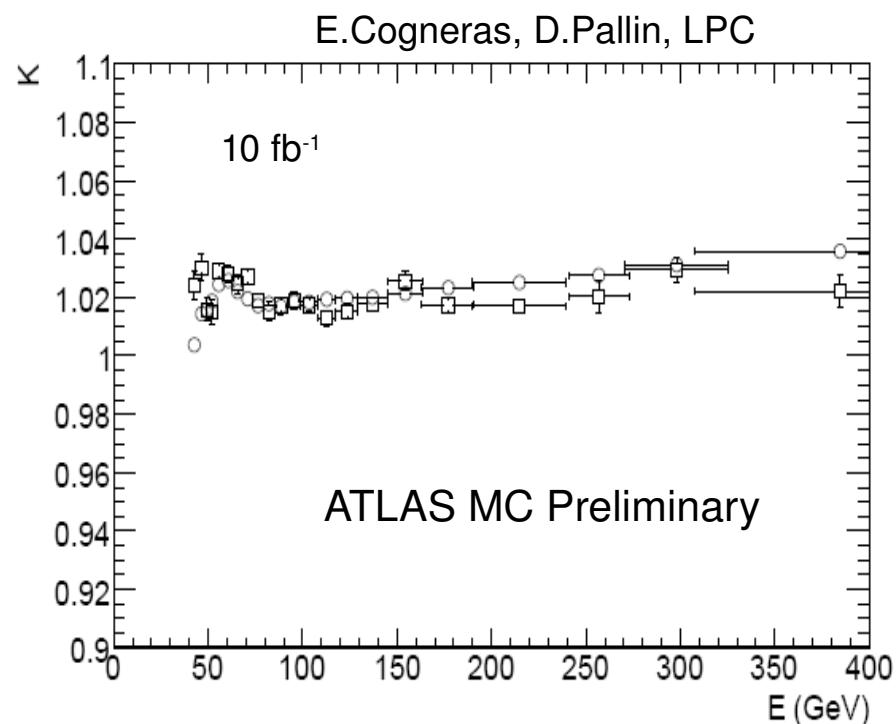
Since θ_{jj} is well reconstructed, use the W boson PDG mass to extract the light JES by measuring in a given bin of

E_j or η_j :

$$K = \frac{M_W^{PDG}}{\langle M_{jj} \rangle_{\text{fit}}}$$

Apply iteratively to converge to the value of K in this bin.

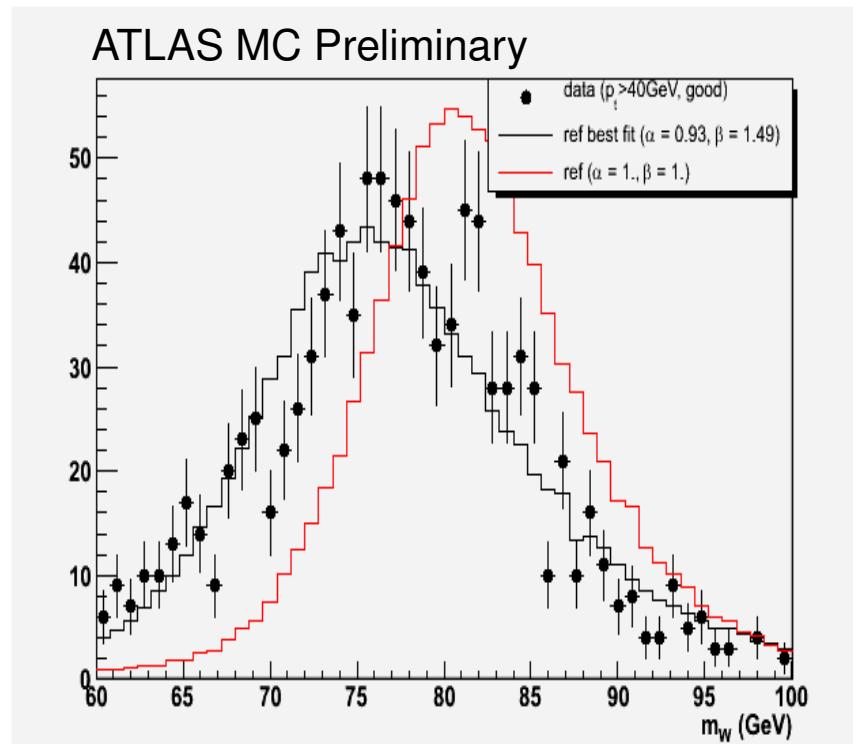
☞ $K = 1.014 \pm 0.003 \text{ (1/fb)}$



ttbar samples for the JES: Iterative Rescaling Method

Idea: use template histograms with various energy scales α and jet energy resolutions β .

- start with $W \rightarrow q \bar{q}$ from ttbar events,
- smear the quark's 4-momenta,
- generate a set of histograms with different set of parameters for α and β .
- fit each template to the data M_{jj} distribution and keep the one with the best chisquare



	α	β
2 jets, good combinations	0.9693 ± 0.0045	1.145 ± 0.054
2 jets, all combinations	0.9638 ± 0.0049	1.434 ± 0.064
≥ 2 jets, good combinations	0.9696 ± 0.0033	1.089 ± 0.035
≥ 2 jets, all combinations	0.9660 ± 0.0036	1.308 ± 0.041

Method also applied for EM scale determination with $Z \rightarrow e e$

Conclusion

Several methods about light Jet Energy Scale were reviewed in this talk.

Most of them are based on balancing a well reconstructed EM object to the jets

In the top case, challenging methods are being investigated to achieve the 1 GeV systematic error goal.

With the coming first data at 10 TeV, for most of the processes ($t\bar{t}$, $w+jets$) kinematics will be similar than at 14 TeV but cross section reduced by half, but room to validate these techniques.