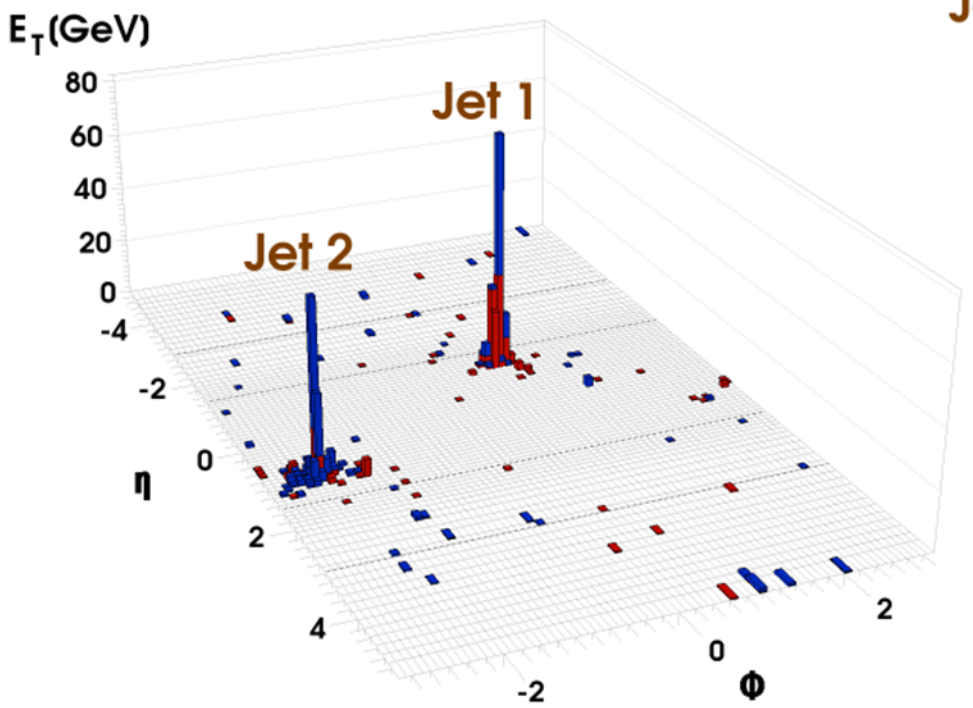
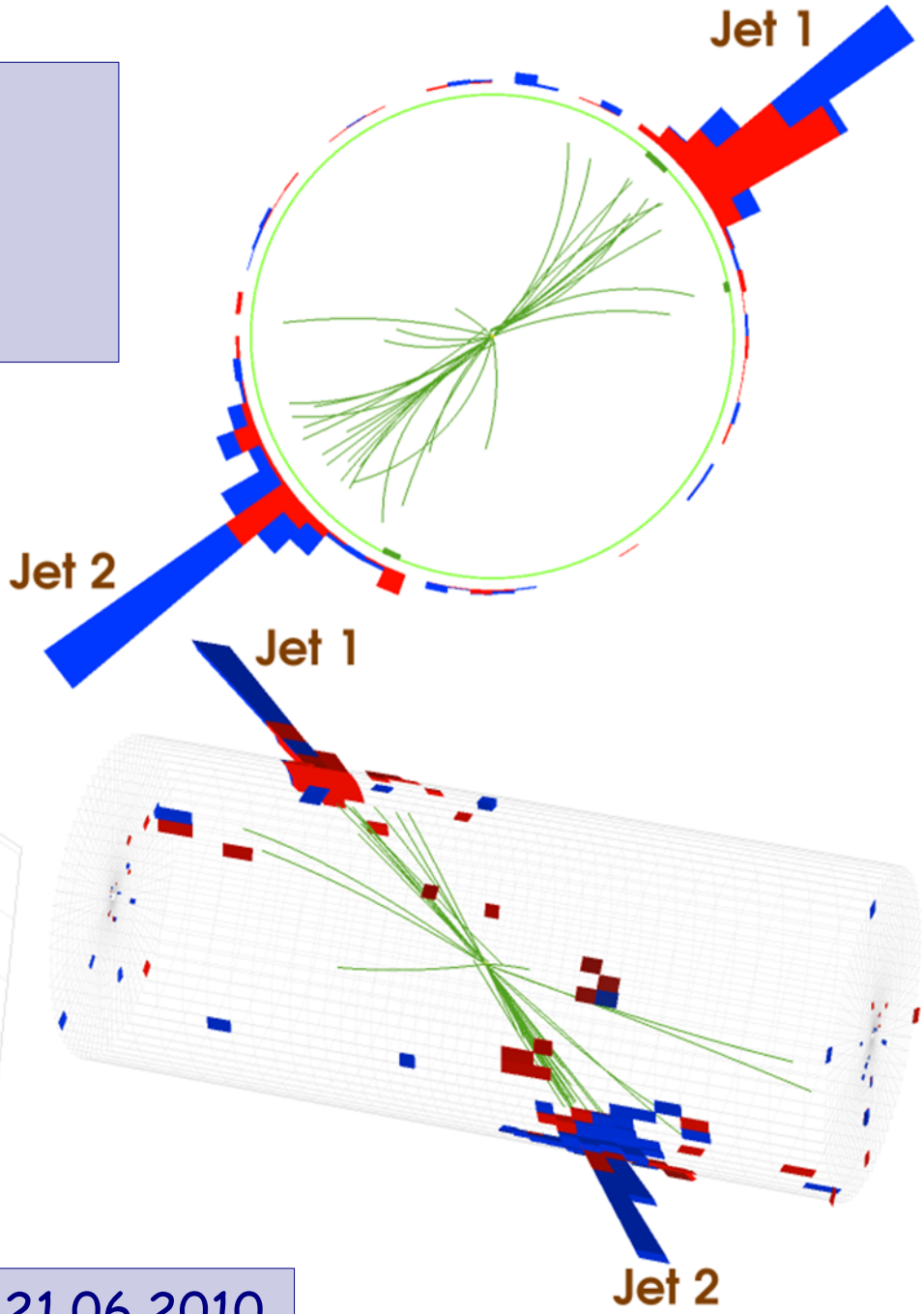
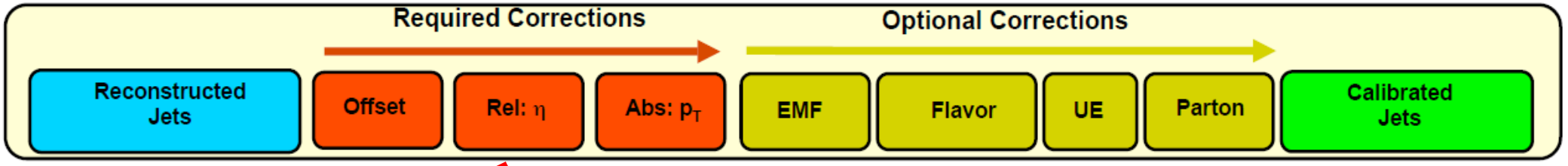
Top as a Tool for Jet Calibration

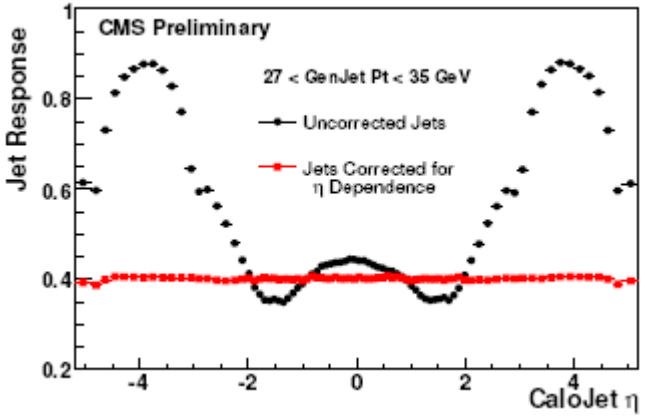




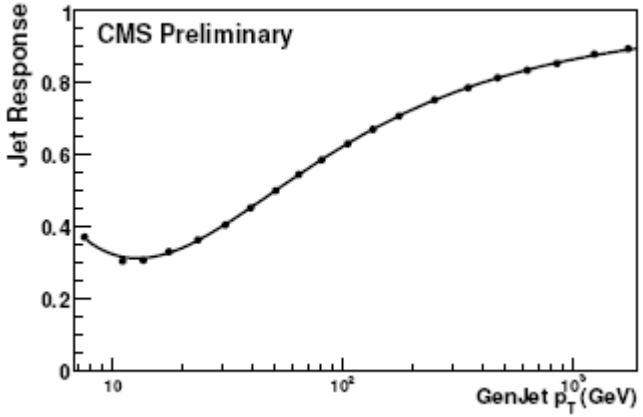
CMS Jet Calibration Scheme



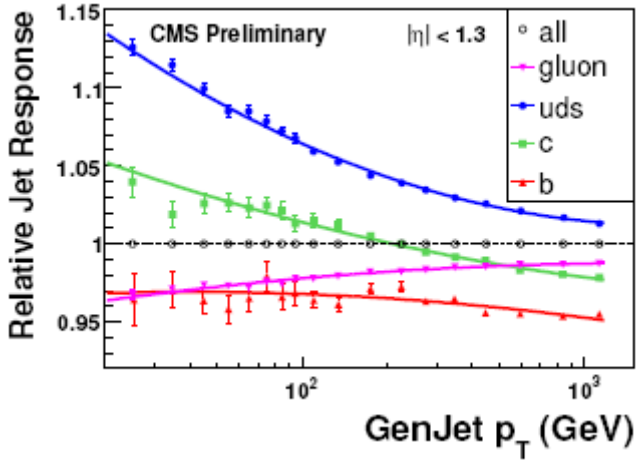
Relative:
correct to uniform calorimeter response in η.



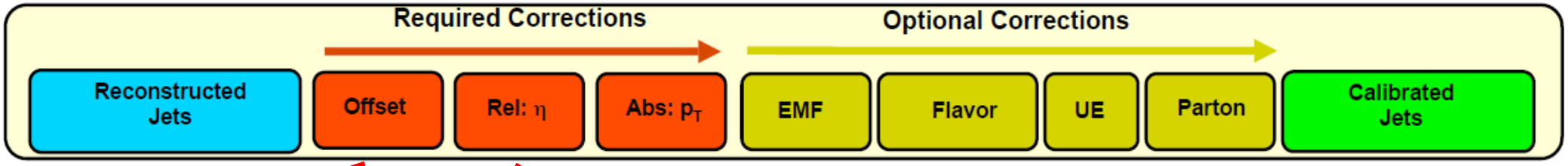
Absolute:
correct absolute energy scale.



Flavor:
correct for different calorimeter response of different flavors.



Calibration Strategies



Offset:
- Noise unsuppressed
- Zero-Bias runs
- jet-areas
- isolated tracks
- ϕ uniformity

Relative:
- Δpt of clean 2-jet evts [g]
- η uniformity

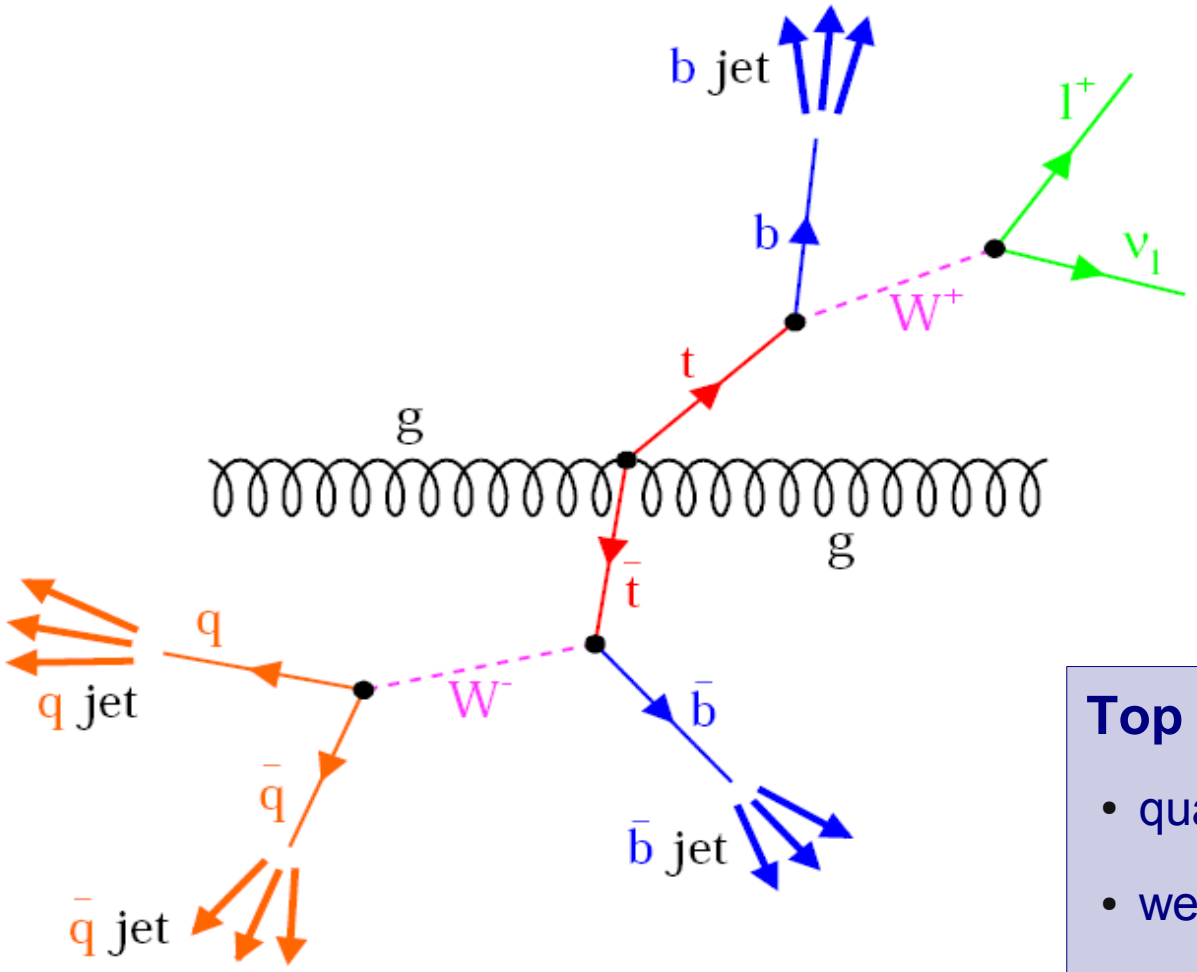
Absolute:
- γ+jet evts [q] (pt≤100GeV)
- Z+jet evts [q] (pt≤200GeV)
- 3-jet evts [g] (for higher pt)

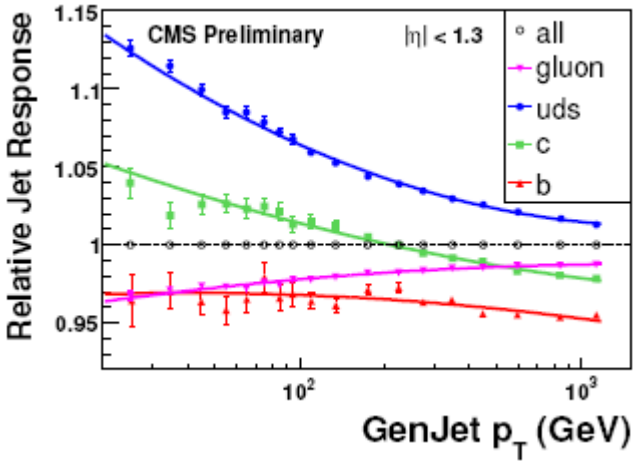
Optionals:
- will be taken from the MC (first).

- First all corrections are taken from MC, later replace step by step by data-driven.
- Initial correction up to **Absolute** energy scale only.
- Initial assumption on **JEC uncertainty: ±10%**.

[g]: gluon initiated
[q]: quark initiated

Relevance of Top Quarks for Jet Calibration





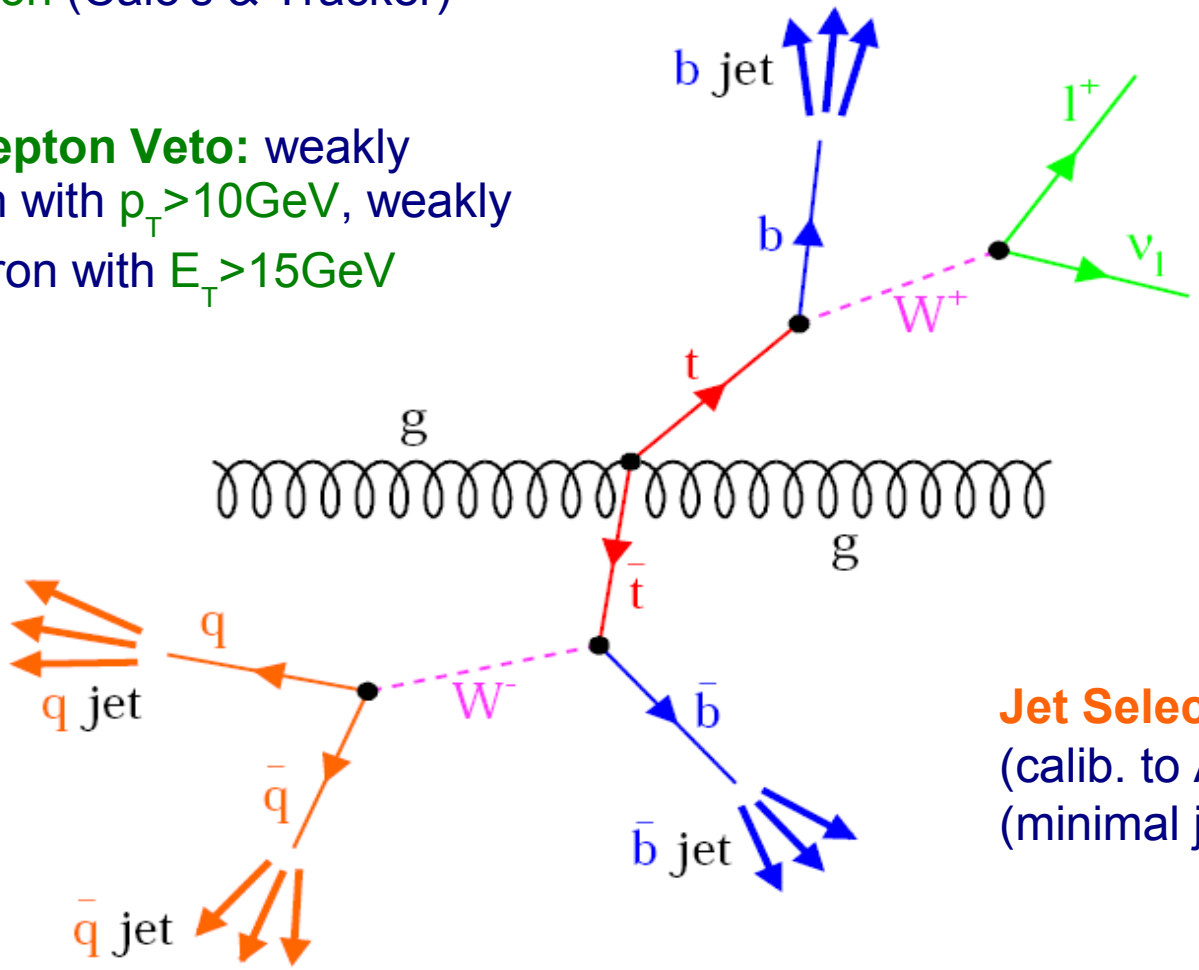
Top Events are a source of:

- quark initiated jets (indep. from Z/γ+jet)
- well defined/understood multijet topology
- b-jets with an increased chance of unambiguous identification

Top Quarks (semi-μ decay channel)

Muon Selection: p_T>20GeV, |η|<2.1, track quality, MIP signature in Calo's, relative isolation (Calo's & Tracker)

Additional Lepton Veto: weakly isolated muon with p_T>10GeV, weakly isolated electron with E_T>15GeV



Jet Selection: ≥4 jets, pt>30GeV (calib. to Absolute), |η|<2.4 (minimal jet cleaning)

Validation of JEC Factors on MC Level

For the Validation on MC Level we use:

- The full MC statistics (Madgraph(ttbar only), 7TeV ~9fb^{-1})
- A realistic selection on detector level (see above).
- MC truth to associate final state partons (from ME) to jets (unambiguous match within $\Delta R \leq 0.5$).

Matching Efficiency:

	Effizienz [%]
b_{lep}	$83,6 \pm 0,3$
b_{had}	$84,2 \pm 0,3$
W_{had}	$67,9 \pm 0,4$

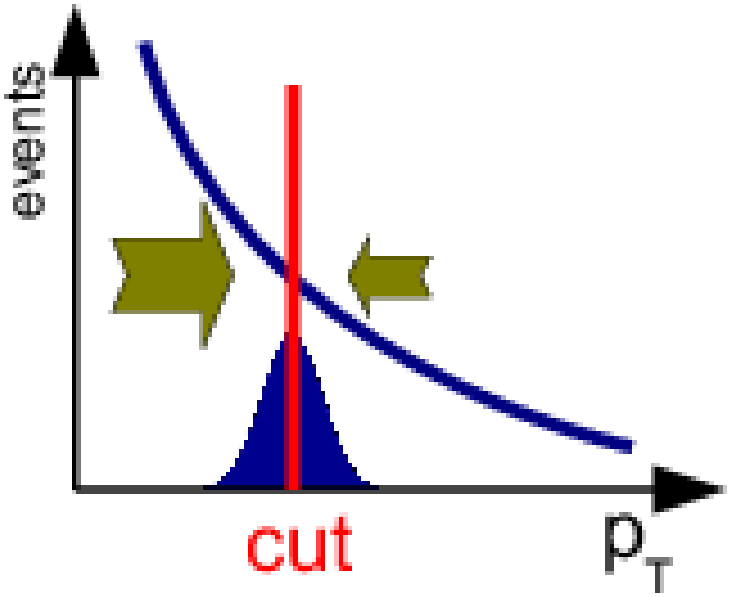
	Effizienz [%]
t_{had}	$56,9 \pm 0,4$
$b_{\mathrm{had}} \& W_{\mathrm{had}}$	$56,9 \pm 0,4$
$b_{\mathrm{lep}} \& b_{\mathrm{had}} \& W_{\mathrm{had}}$	$46,9 \pm 0,4$

→ **Overall efficiency**

Sources for Inefficiencies:

- Jets do not pass the p_T>30GeV (main source) or $|\eta|$<2.4 cut
- Partons cannot be associated unambiguously (more then one parton within $\Delta R \leq 0.5$)

Effects of Finite Resolution and Selection



Due to finite resolution and the steeply falling spectrum we expect two effects:

(1) More low p_T jets migrate to higher p_T then vice versa (→ **resolution bias**)

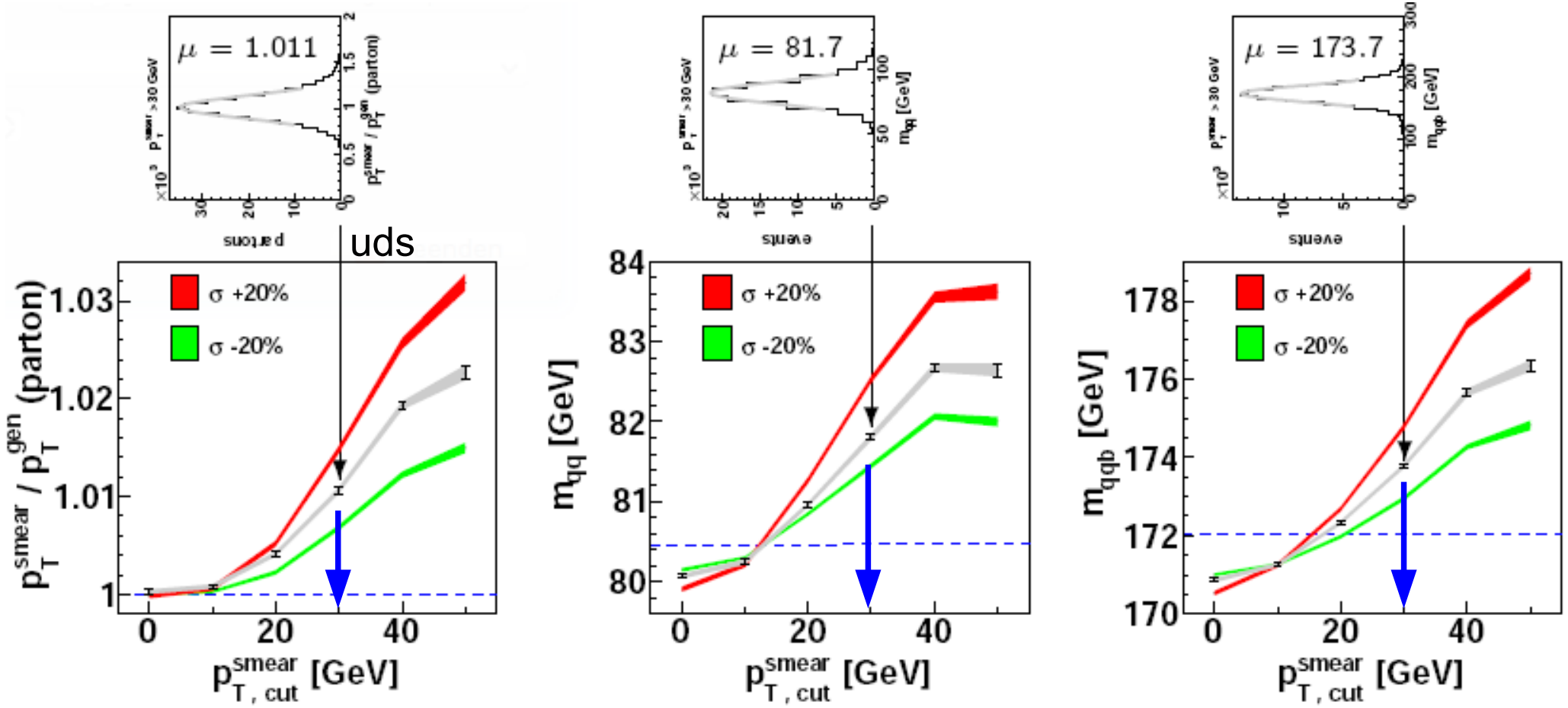
(2) More low p_T jets pass the selection cut due to upwards fluctuation than high p_T jets fail due to downwards fluctuation (→ **selection bias**)

- Both effects (1) and (2) will be visible even with perfect calibration and generator matching
- Study by smearing the partons (parton → detector) and cut on the smeared partons. Typical resolution function:

$$\frac{\sigma(E)}{E} = \frac{4{,}44\,\mathrm{GeV}}{E} \oplus \frac{1{,}11\,\sqrt{\mathrm{GeV}}}{\sqrt{E}} \oplus 0{,}03$$

Selection & Resolution Bias (integrated)

Effect on the Resolution/W-Mass/Top-Mass as a function of the selection cut on the smeared partons:



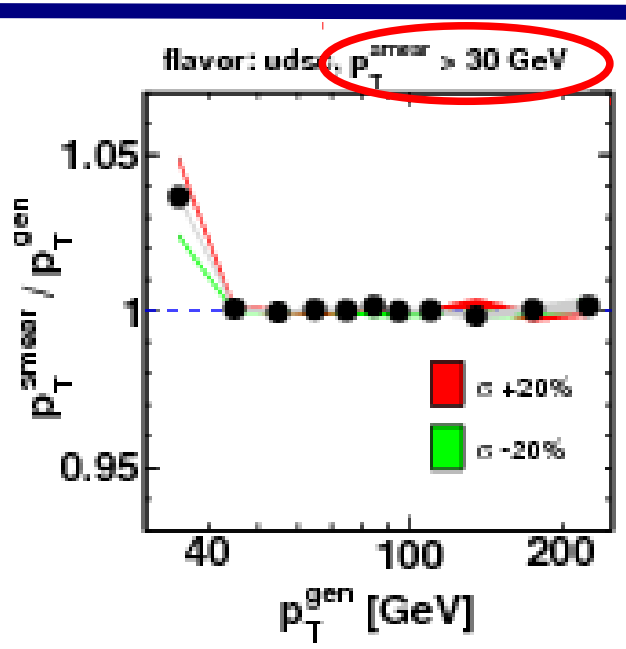
JES: 1.1±0.4%

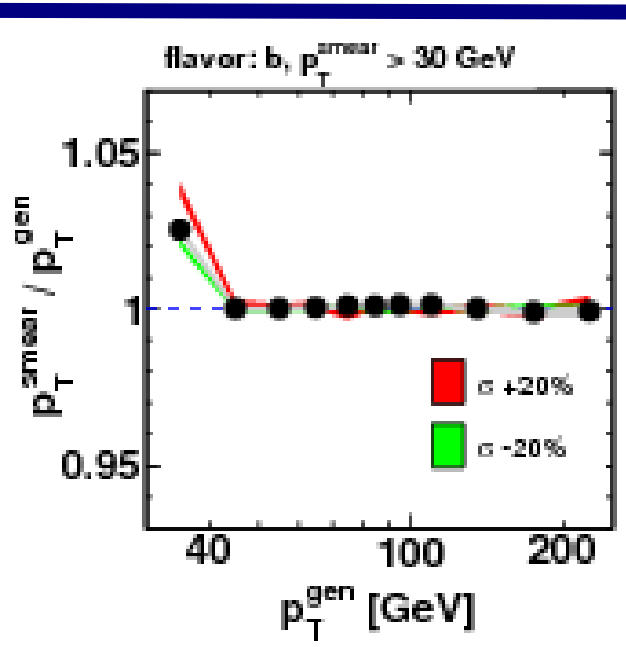
M_W: 1.3±0.5GeV

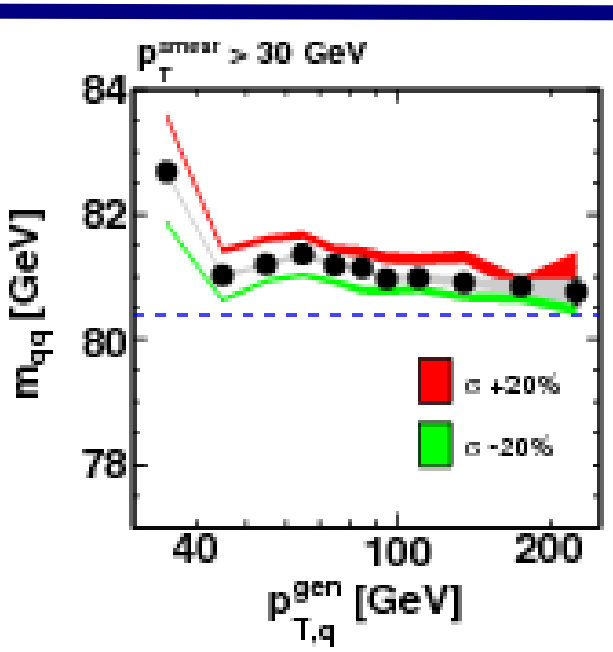
M_{Top}: 1.7±0.9GeV

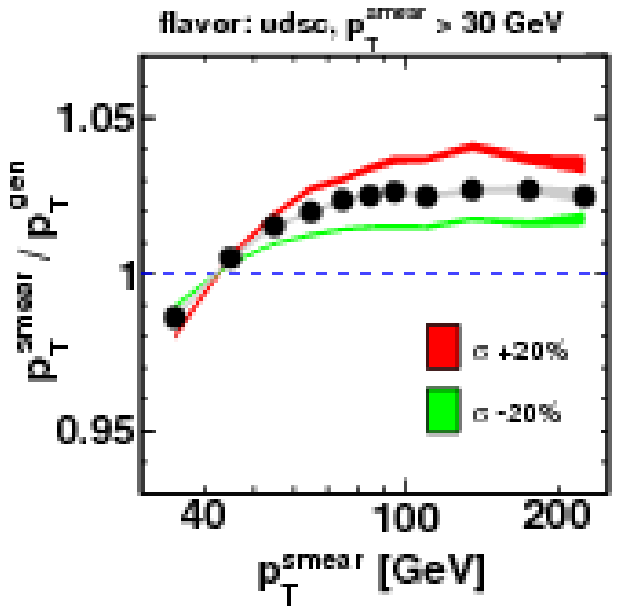
For a selection cut of 30GeV

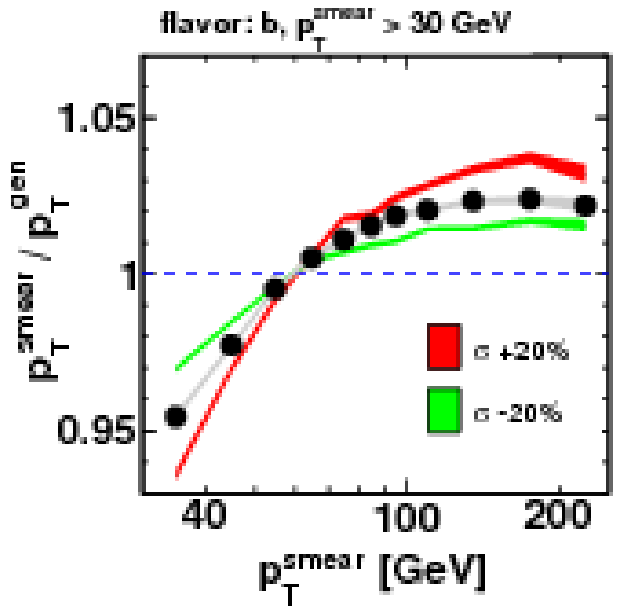
Selection & Resolution Bias (differential)

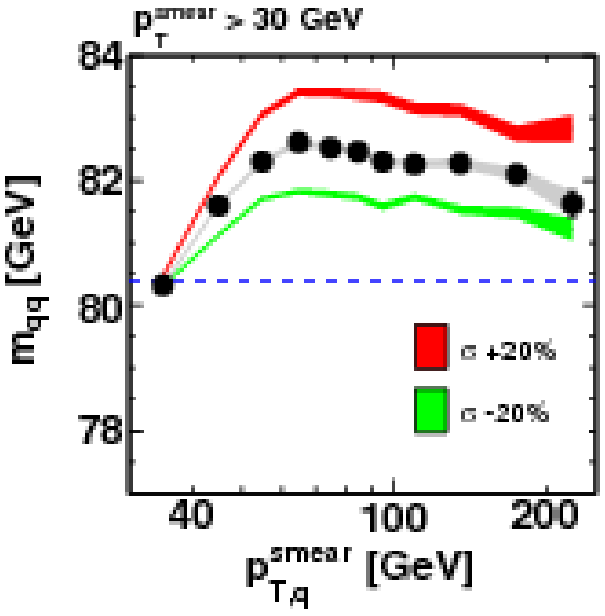




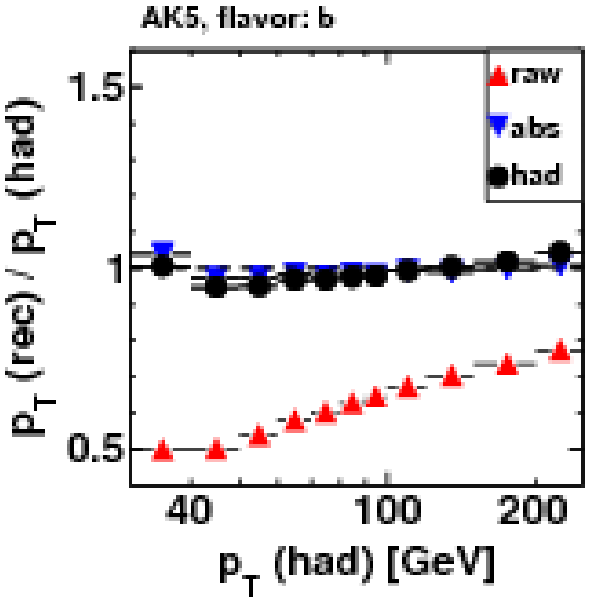


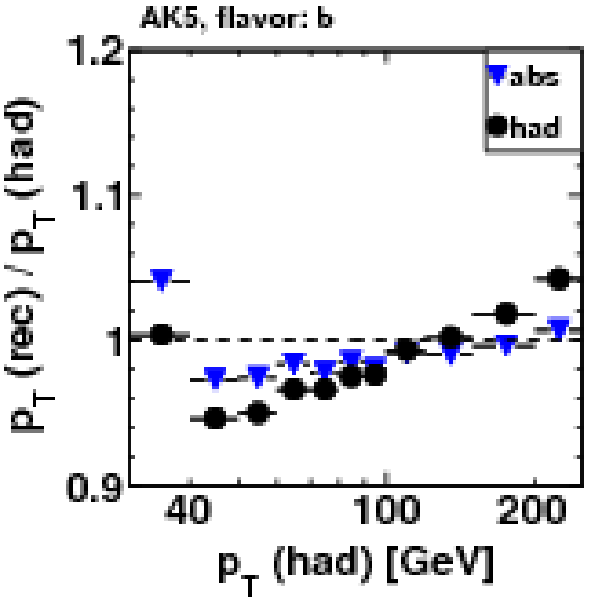


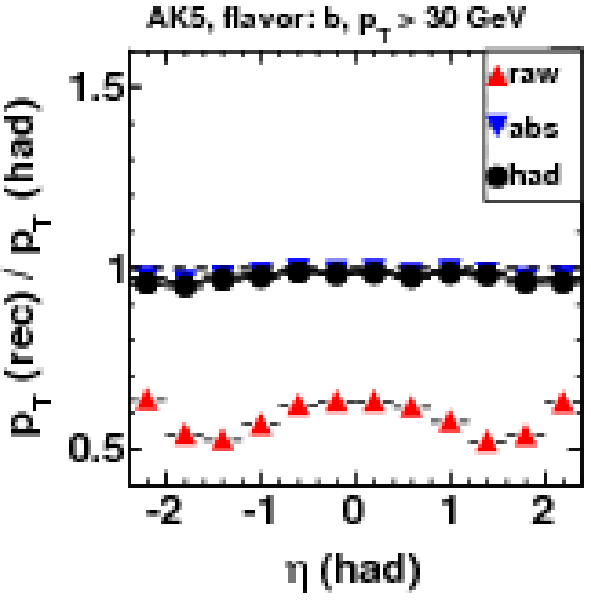


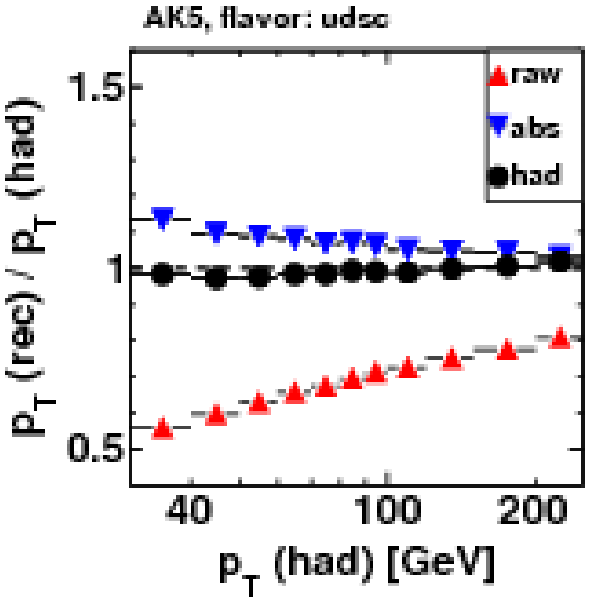


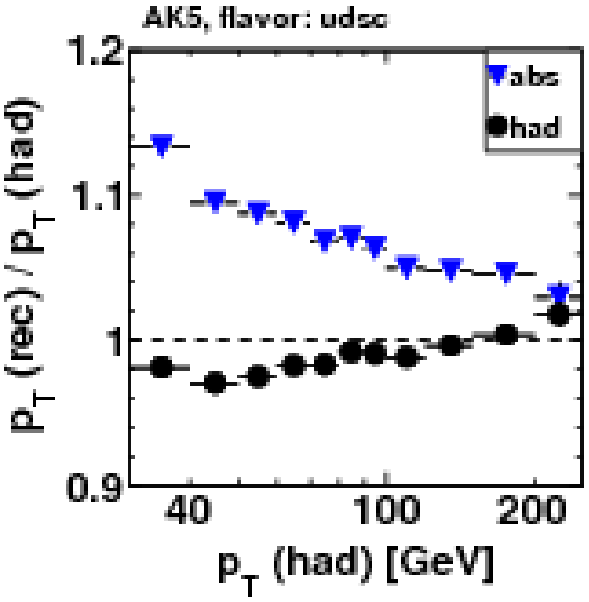
Validation of the JEC (derived from MC)

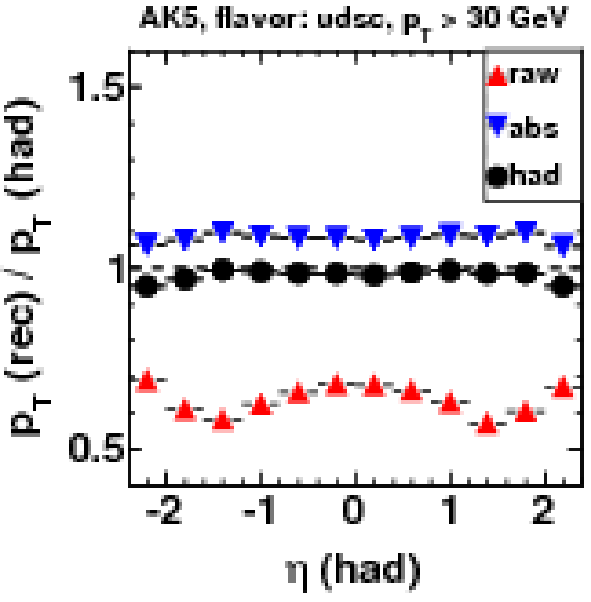




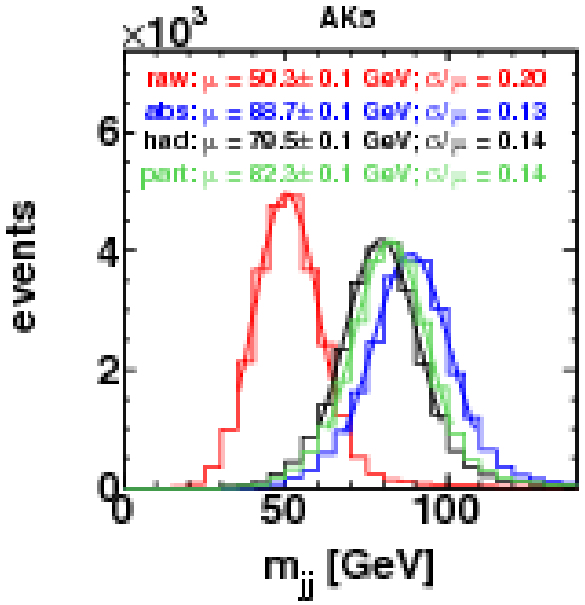


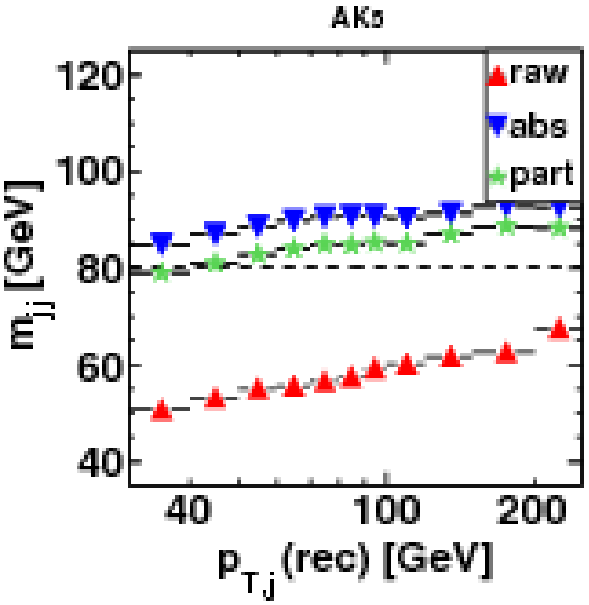


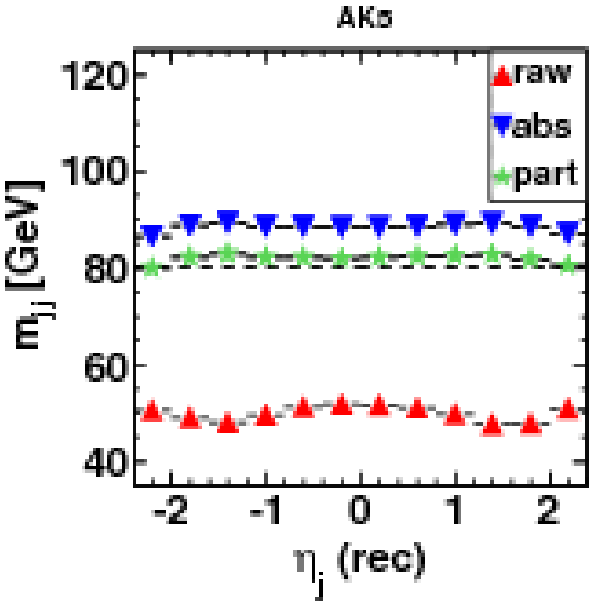


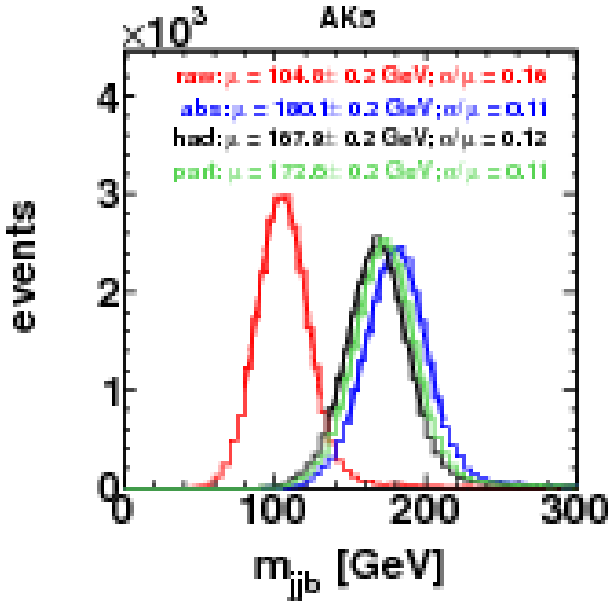


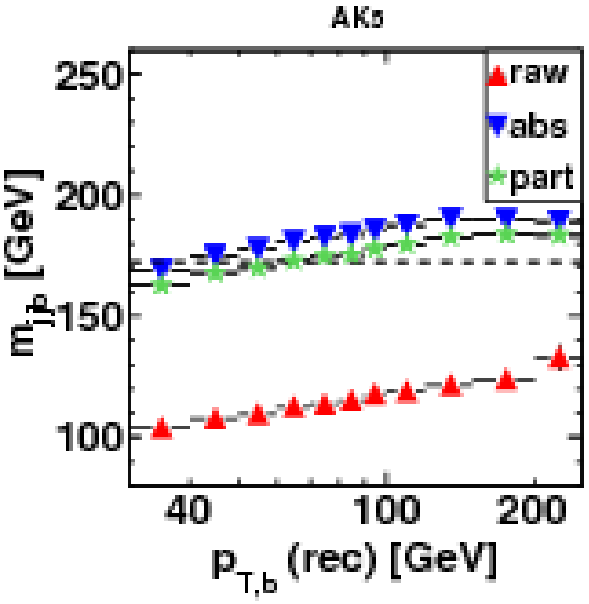
Reconstructed W-/Top-Mass

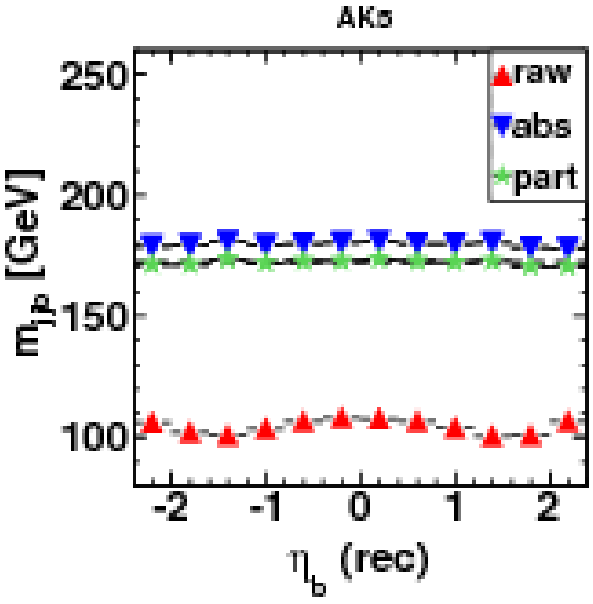






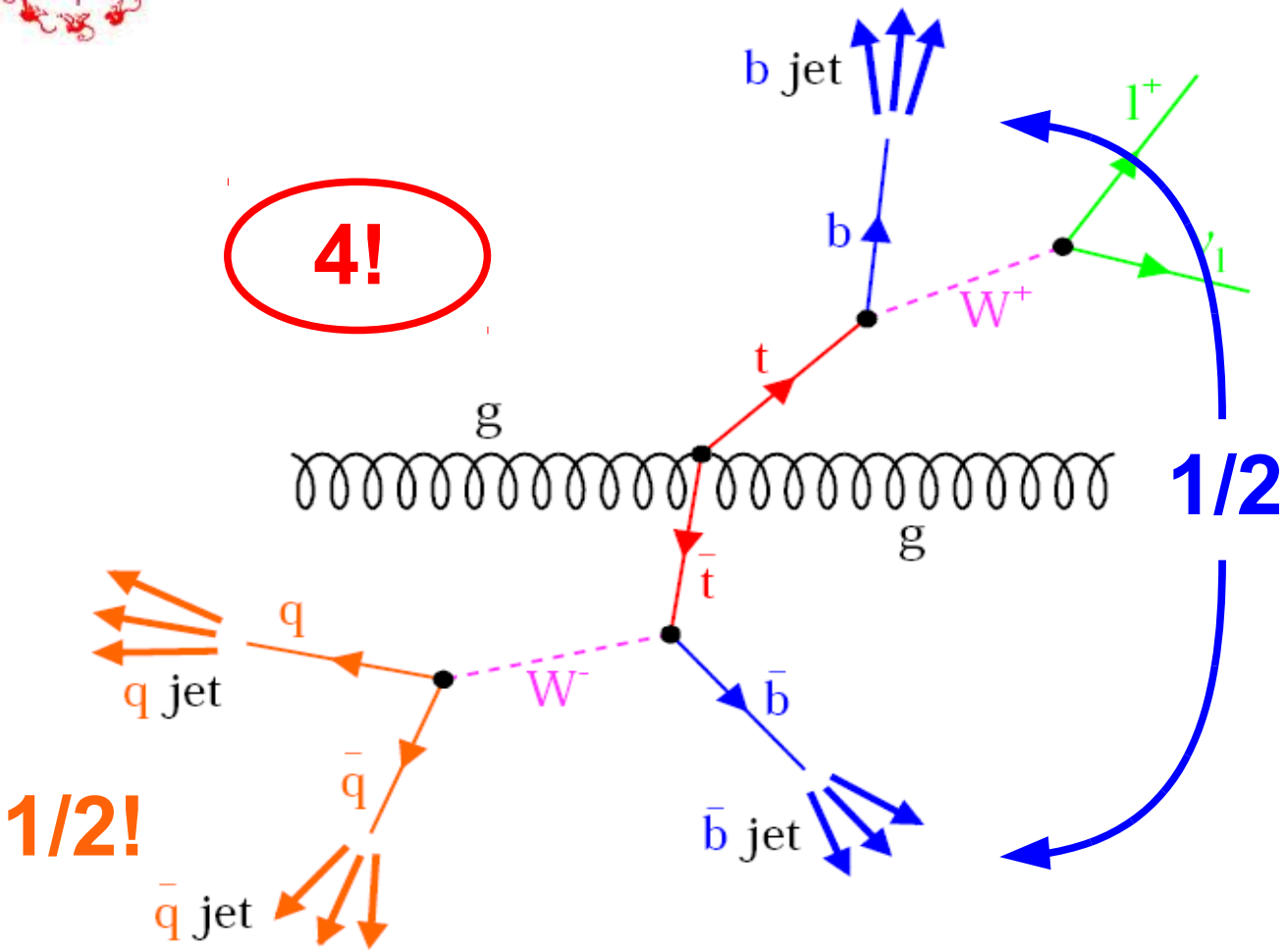






Jet Parton Association in Data

12 ways to associate jets to partons:



We check five different algorithms:

- **Geometric**: choose closest candidates in ΔR
- **MaxSumPtWMass**: choose largest $\Sigma(\mathrm{vec}(p_T))$ and best fit of W-Mass
- **WMassMaxSumPt**: see above, different order
- **MVA**: choose 4-5 kinematic variables
- **KinFit**: apply constraint kinematic fit (W-Mass, $M_{Top}=M_{\sim Top}$)

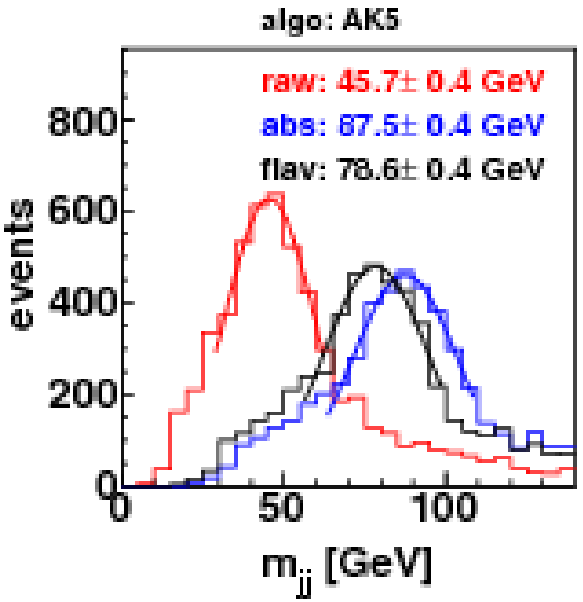
Jet Parton Association Performance

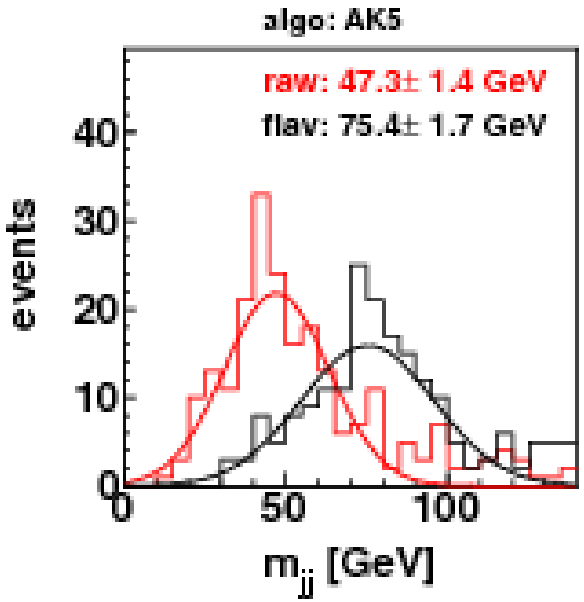
	Effizienz [%]		
	WMassMaxSumPt	MVA	KinFit
b_{lep}	$37,1 \pm 0,4$	$47,7 \pm 0,4$	$50,7 \pm 0,6$
b_{had}	$24,4 \pm 0,4$	$41,8 \pm 0,4$	$36,6 \pm 0,6$
W_{had}	$24,2 \pm 0,4$	$30,5 \pm 0,4$	$31,4 \pm 0,6$
t_{had}	$20,4 \pm 0,4$	$19,4 \pm 0,3$	$34,5 \pm 0,6$
$b_{\text{had}} \& W_{\text{had}}$	$12,2 \pm 0,3$	$16,5 \pm 0,3$	$23,3 \pm 0,5$
$b_{\text{lep}} \& b_{\text{had}} \& W_{\text{had}}$	$9,4 \pm 0,3$	$14,2 \pm 0,3$	$19,9 \pm 0,5$

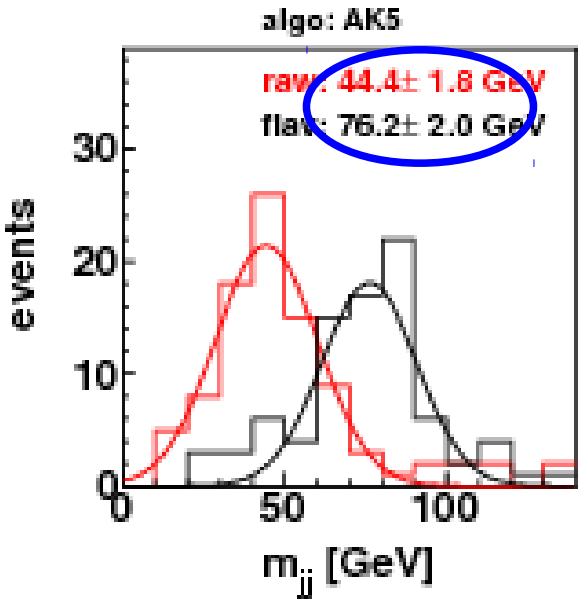
- Measure: **1/12 ≈ 8%**
- Keep in mind: ~50% of the associated jets not make the selection cuts (mostly p_T>30GeV)

- Enhance the probability to get the full system by 12(simple) – 250(KinFit) %
- We get the right t_{had} in more than 20% of all cases
- This is without B-Tag information, in the meantime we do better (Geometric → 30%)
- To keep things easy we stayed with the simples method (Geometric)

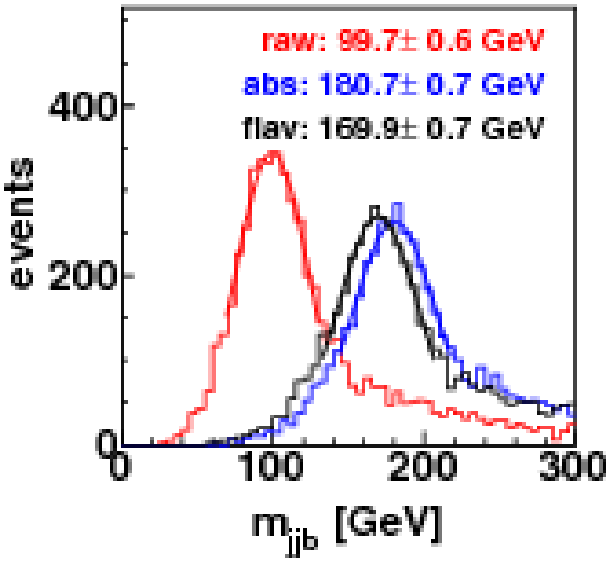
What we can expect from Data



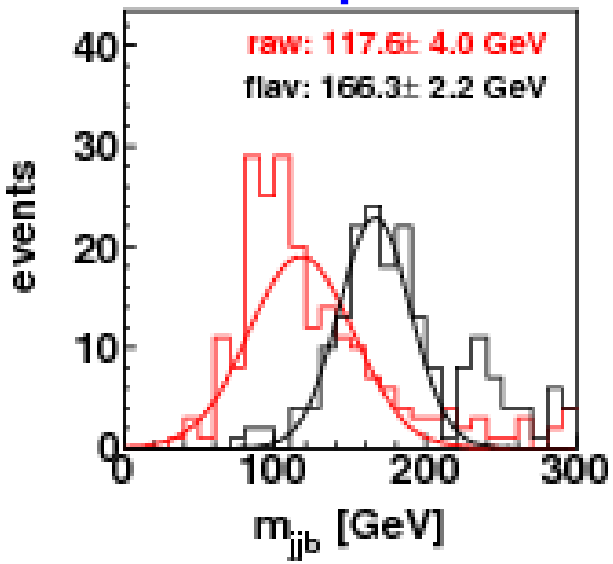




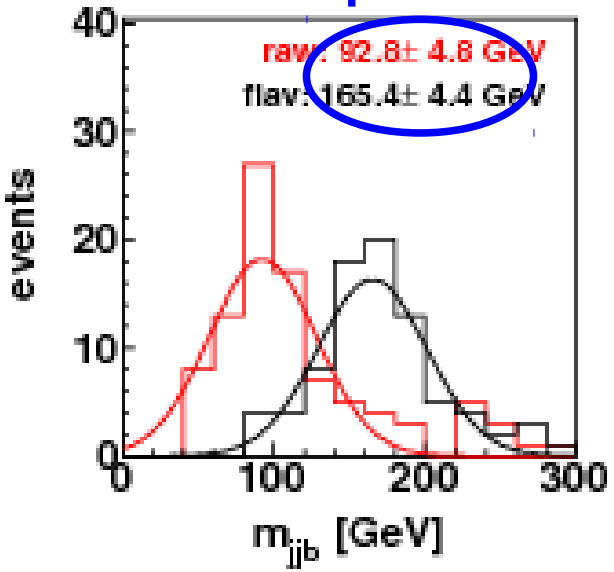
much



~100pb^{-1}



~50pb^{-1}

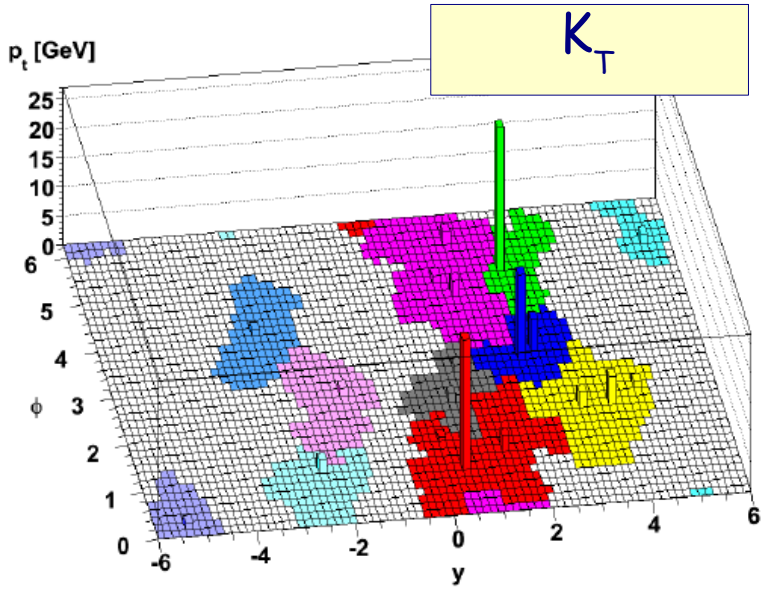


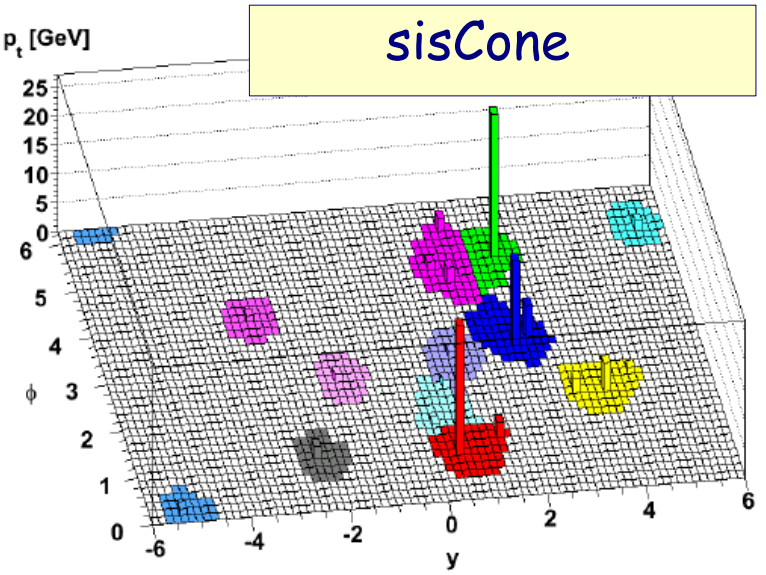
Summary

- Top Events will provide a good tool to validate JEC from other samples or from MC
- JEC derived from MC are validated within 1-2% for uds, some deviations O(5%) are seen for b-jets
- We had an detailed study of jet parton association algorithms (some time ago) – need to revoke and update
- A validation of the uds jet energy scale down to 2% seems possible with 50pb^{-1}, (more detailed studies needed and on or To-Do list)
- Will transform: JES validation on MC, JES validation on data and first top measurements into a PhD (Sebastian Naumann-Emme)
- Main statement will be the JES uncertainty on the production cross section for ttbar events
- Longterm aim: make use of top events to determine the JES (flavor dependent?) in the Kalibri calibration Ansatz of the UHH

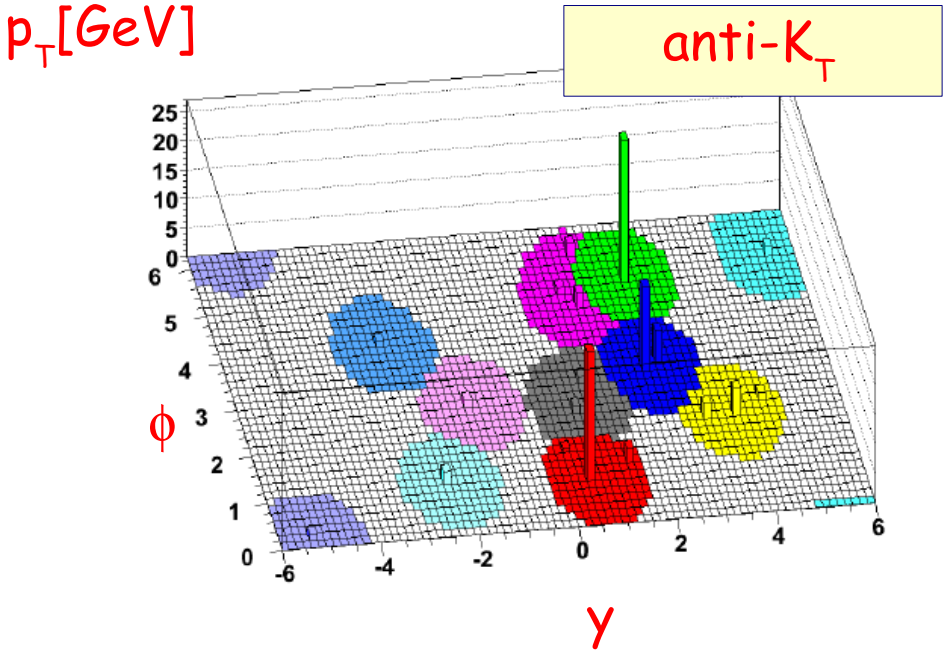
Backup

Jet Algorithms in Use





Algorithm	R	GenJet-Label	CaloJet-Label	PFJet-Label
AntiKt	0.5	ak5GenJets	ak5CaloJets	ak5PFJets
AntiKt	0.7	ak7GenJets	ak7CaloJets	ak7PFJets
SISCone	0.5	sisCone5GenJets	sisCone5CaloJets	sisCone5PFJets
SISCone	0.7	sisCone7GenJets	sisCone7CaloJets	sisCone7PFJets
kT	0.4	kt4GenJets	kt4CaloJets	kt4PFJets
kT	0.6	kt6GenJets	kt6CaloJets	kt6PFJets



Correction to Parton Level