Validation of Jet Energy Corrections for Events with Top Quarks

3rd Annual Workshop of the Helmholtz Alliance "Physics at the Terascale", LHC-D Top Parallel Session

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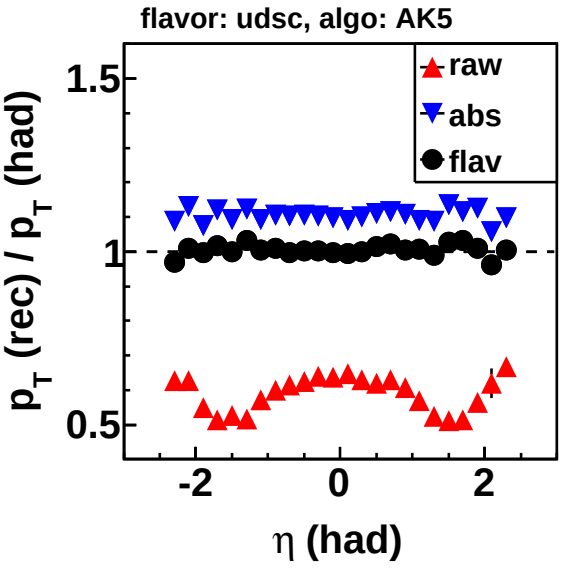
Disclaimer: will show "work in progress", no official CMS results!

Motivation

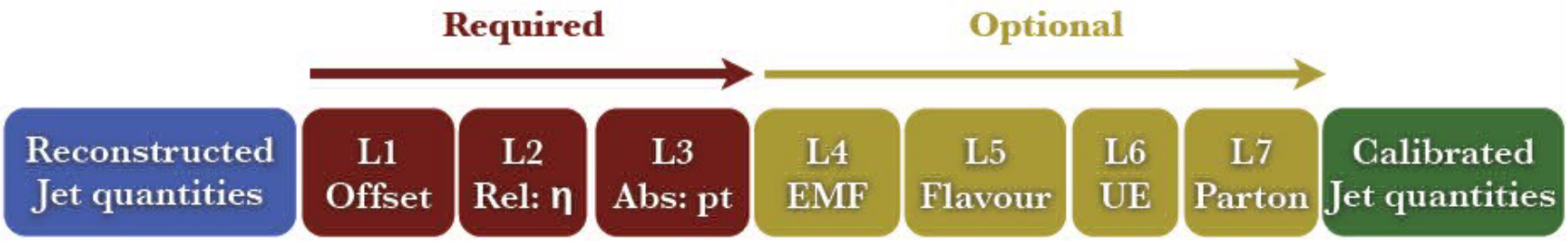
jet response: $\frac{p_T(\mathrm{rec})}{p_T(\mathrm{true})}$



- "raw" jet energies from the detector are too low and not uniform in η
- apart from imperfect calorimeter calibration, this is due to jet specific effects, some of which are flavor dependent
- jet energy corrections have to be applied

- these corrections can be derived from Monte Carlo or data and from different event topologies
- this talk is about how the quality of the obtained corrections can be validated for $t\bar{t}$ in data

CMS Jet Calibration Model



L2: correction for response variations in η, relative to the central region

L3: absolute scale correction as a function of p_T

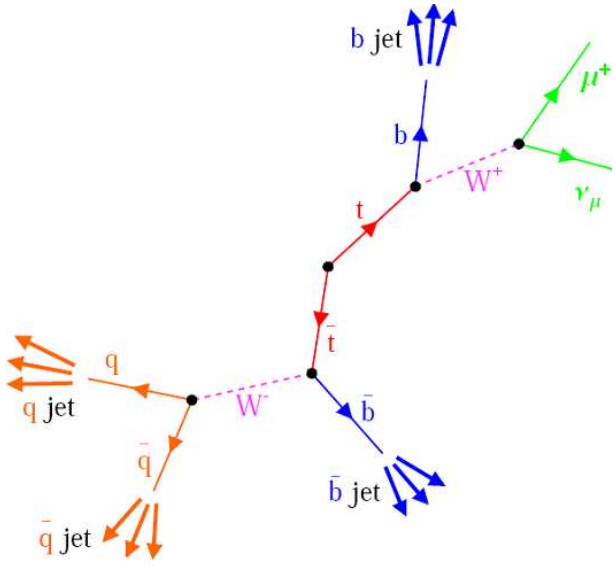
L5: correction for differences in the jet response that are due to the flavor (gluon, *uds*, *c*, *b*)

$\rightarrow$ flavor dependent corrections can only be applied if you have a hypothesis for the flavor of the parton that gave rise to your jet

$\rightarrow$ while L2 and L3 corrections will be derived from dijet and γ/Z+jet events, top events will later be used to derive flavor corrections

Top Events

use $t\bar{t}$ events in the semileptonic channel with a muon in the final state



selection criteria:

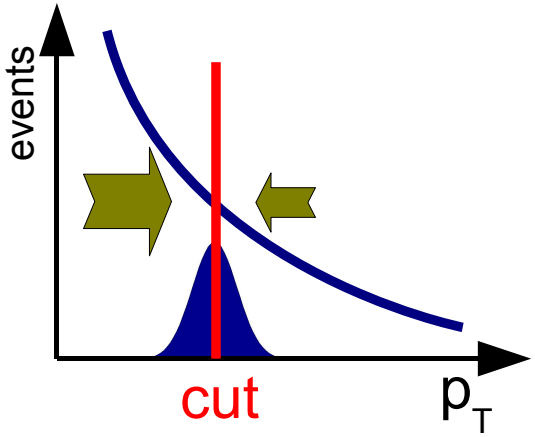
- exactly one isolated good muon with $p_T > 20\,\mathrm{GeV}$ in $|\eta| < 2.1$
- vetos on electrons and additional muons
- at least four anti-k_T jets with $p_T(\mathrm{L3}) > 30\,\mathrm{GeV}$ in $|\eta| < 2.4$

after event selection, focus on the hadronically decaying top:
one b jet plus two jets (uds or c) from the W boson

advantages of top events for deriving/validating jet energy corrections:

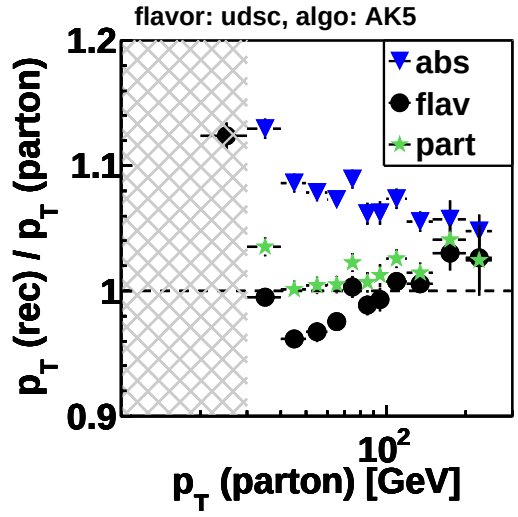
- known flavor composition
- constraints on m_{jj} and m_{jjb}

Caveats



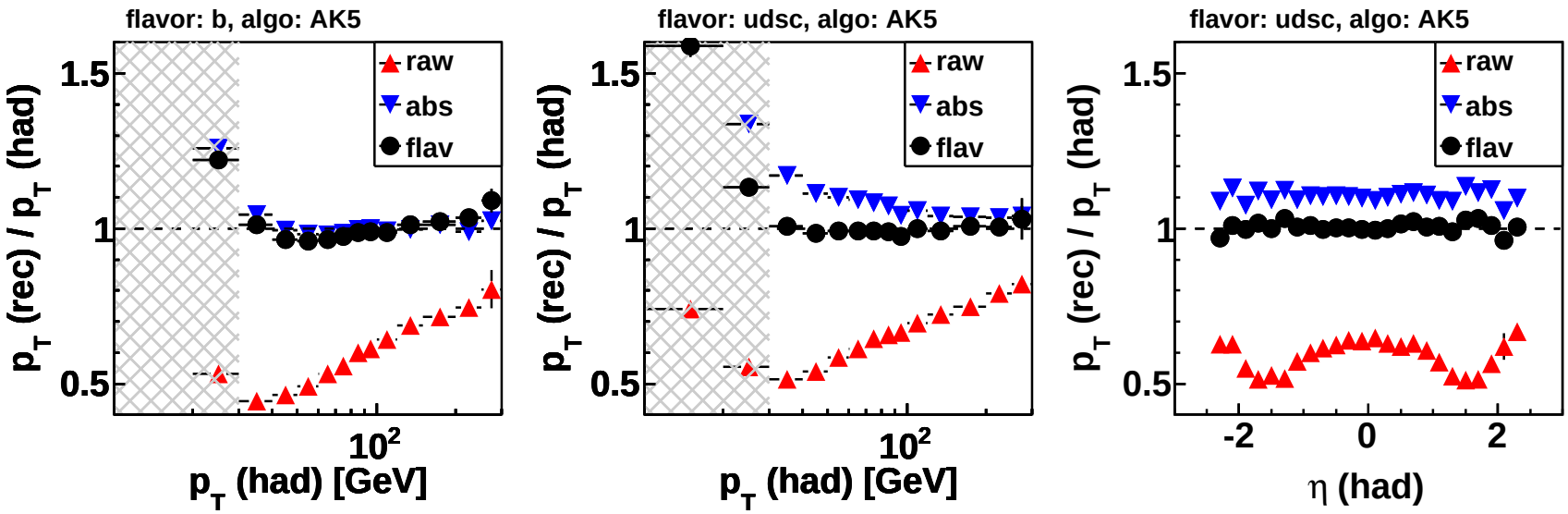
- both the falling p_T spectrum and a selection cut on the jet p_T result in an apparent jet response > 1.0, even for a perfect calibration
- consequence of the jet resolution

- we typically correct to hadron level jets
- there are differences in the order of 2-4% between hadron jets and partons from the hard interaction



Jet Response

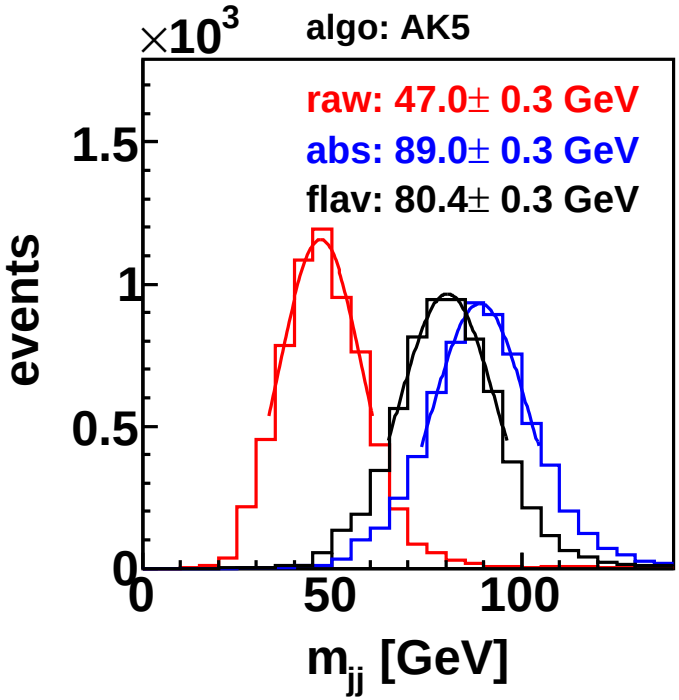
obtaining the jet-parton association from matching to generator particles:

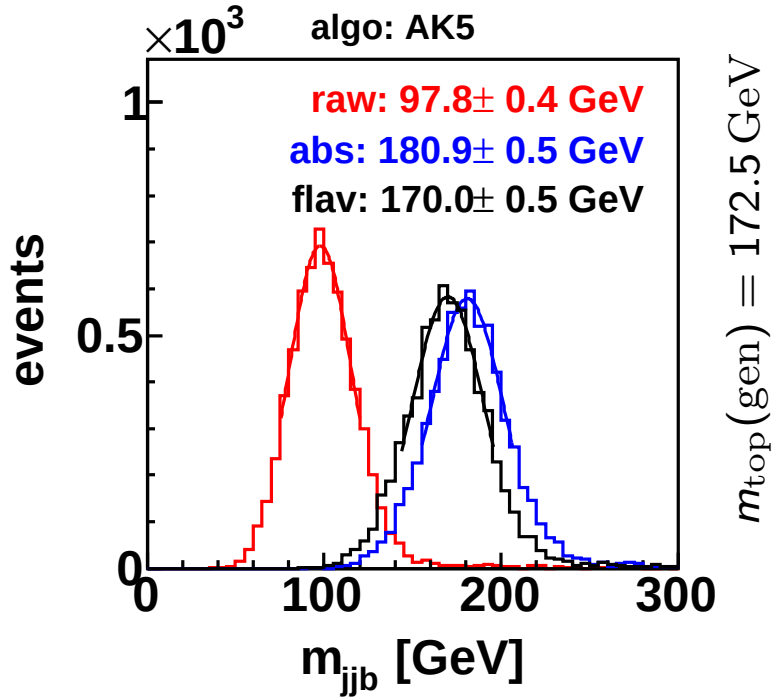


- large bias in the low p_T region (selection cut at $30\,\mathrm{GeV}$)
- nice response for b jets already without flavor dependent corrections
- for jets from W, the response is flat in η at L3 ("abs") but overcorrected by $\approx 10\%$ $\rightarrow$ within 2% after flavor corrections

Towards a Validation on "Real Data"

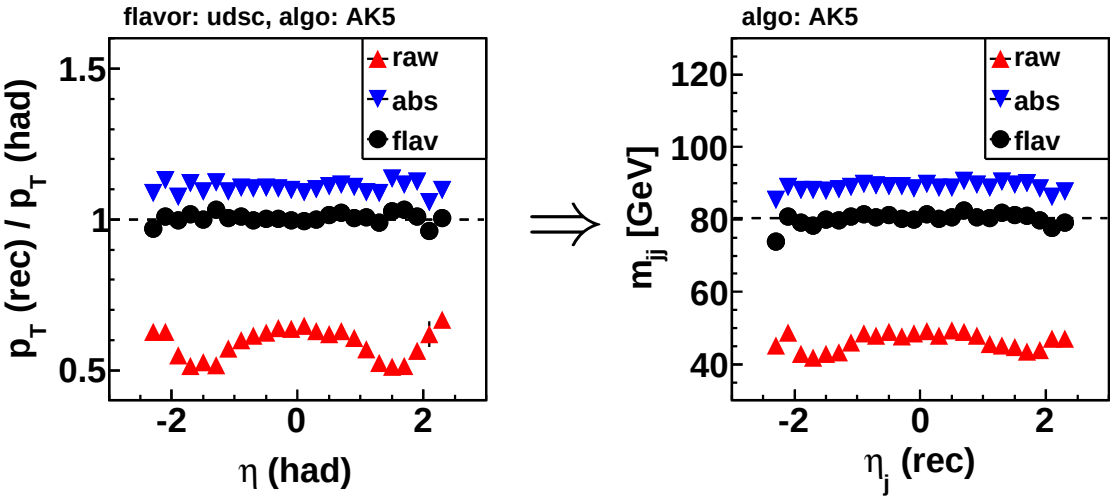
still using the jet-parton association from matching to generator particles:



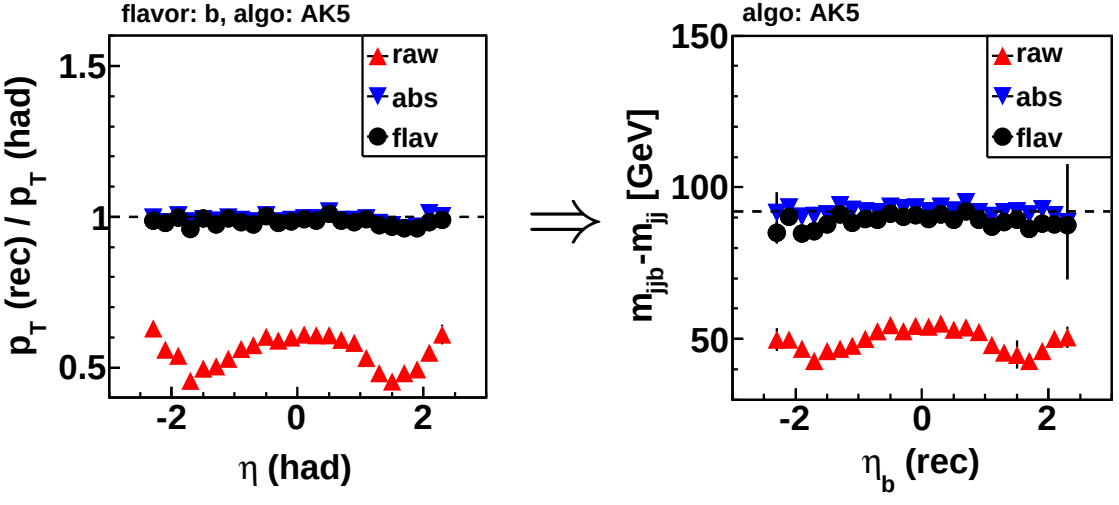


top events offer the possibility to validate jet energy corrections without knowing the true p_T from the Monte Carlo generator

Validation on "Real Data" Differentially



use the reconstructed m_{jj} to monitor the light jet response

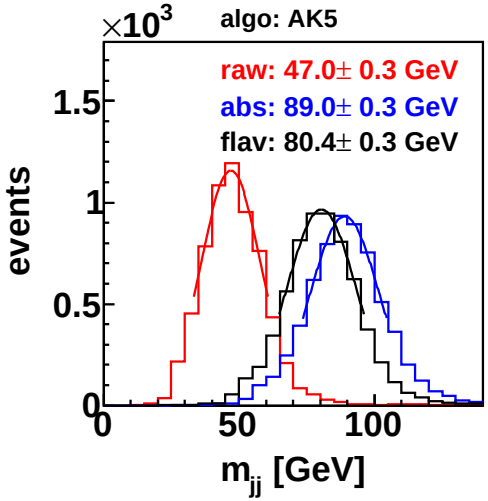


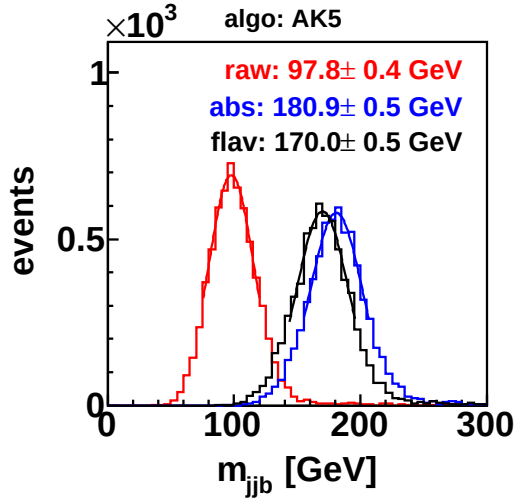
use the reconstructed m_{jjb}-m_{jj} to monitor the b jet response

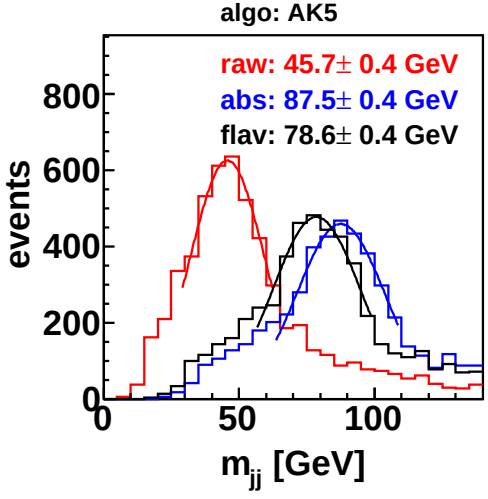
Data Driven Jet-Parton Association

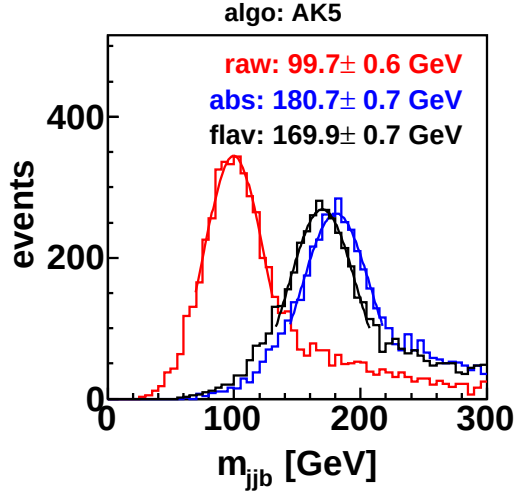
- use the four leading jets in a simple geometrical algorithm with *b*-tag information:
  1. associate those two light jet candidates to the hadronic *W* that have the smallest distance to each other
  2. associate to the hadronic *b* quark the (remaining) *b* jet candidate that has the smallest distance to the hadronic *W*
  3. associate to the leptonic *b* quark the remaining *b* jet candidate that has the smallest distance to the muon
- efficiency for correct assignment of all four partons $\approx 30\%$
- a mixture of the flavor corrections for *uds* and *c* is applied to the jets associated to the *W*: $\mathrm{corr} = \frac{3}{4}\mathrm{corr}(uds) + \frac{1}{4}\mathrm{corr}(c)$

Including Dominant Backgrounds









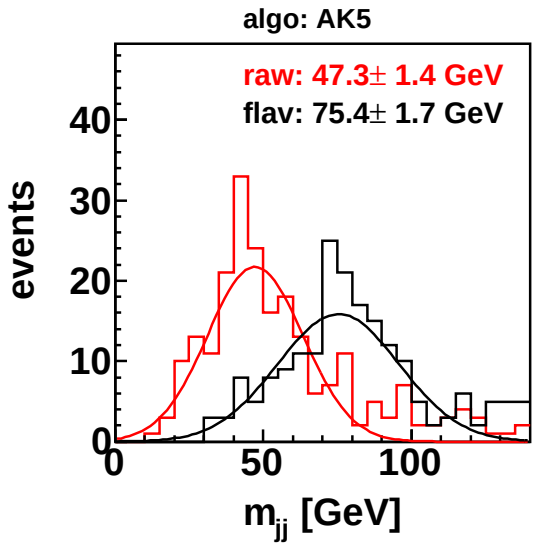
upper row:

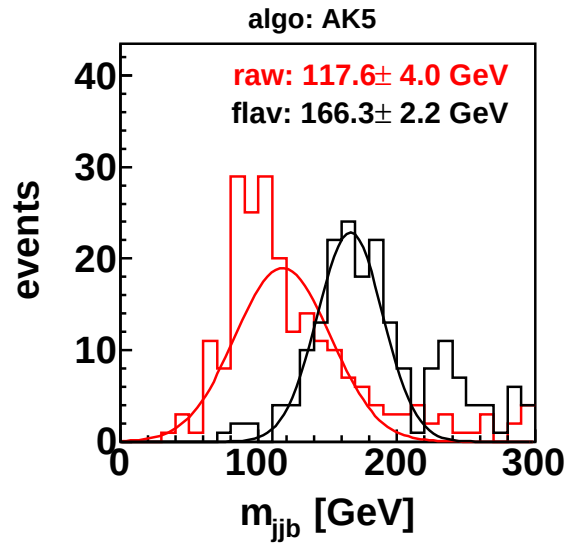
jet-parton association using true generator information, no background at all

lower row:

data driven jet-parton association, including combinatorial and background from other $t\bar{t}$ decay channels

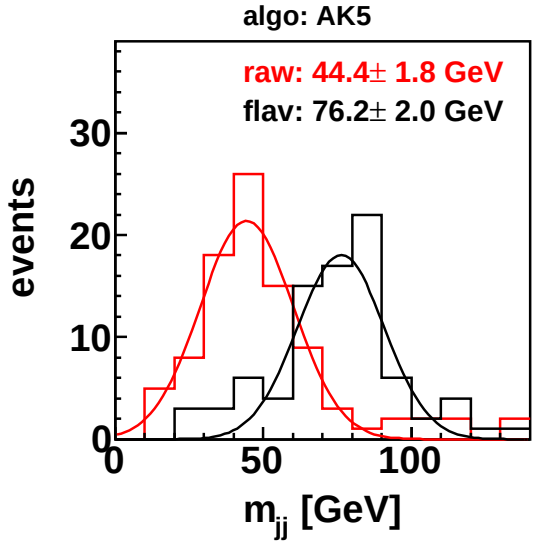
- in $50\,\mathrm{pb}^{-1}$ at $\sqrt{s} = 10\,\mathrm{TeV}$ we expect 223 ± 15 (stat.) events that pass all our selection and reconstruction criteria

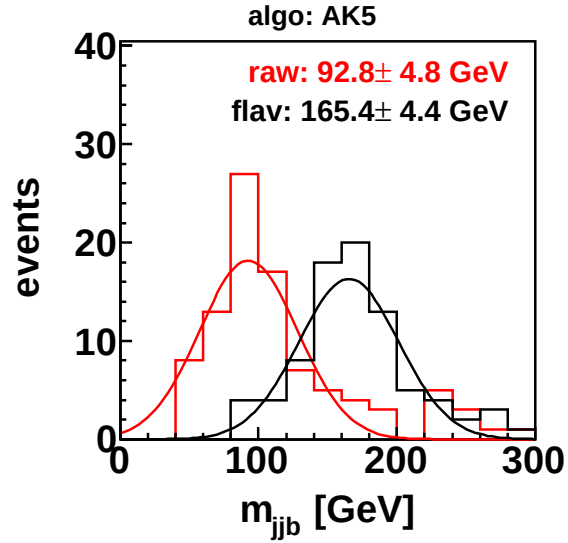




- a validation of the over-all jet energy scale using reconstructed W and top masses *might* be possible to the order of $\approx$ 1-2% (stat.), some backgrounds and systematic effects still under study

- in $50\,\mathrm{pb}^{-1}$ at $\sqrt{s} = 7\,\mathrm{TeV}$ we expect 89 ± 9 (stat.) events that pass all our selection and reconstruction criteria





- a validation of the over-all jet energy scale using reconstructed W and top masses *might* be possible to the order of $\approx 3\%$ (stat.), some backgrounds and systematic effects still under study

Conclusions

- top events offer a unique opportunity to validate the jet energy scale in data, specifically with respect to flavor dependent effects
  - known flavor composition
  - mass constraints

- a first check might be possible already with $50\,\mathrm{pb}^{-1}$ (statistical uncertainty in the order of 3%)

- the next step is to use top events to *derive* flavor dependent jet energy corrections from data