A Global Fit Approach To HCAL/JET Calibration

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- Framework
- Global Fit Calibration – a first try
- Validation

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Talk given by C. Autermann in CMS JES/MET meeting 17th Oct.

The Global-Fit Concept

Alignment of the tracker

Step by step

- Module, layer, pixel, strip, barrel, endcap

Global Fit

- Fit all structures in one go
- Use all data sets

➔First sucessful alignment of the CMS tracker using MillePede

M. Stoye: CMS-TS-2007/017

For Cal./Jet calibration the usual strategy is to factorize the problem, i.e.:

- **Tower by tower**
- **Offset**
- **Relative (η)**
- **Absolute (pT)**
- **Flavor**
- **Underlying event**
- **...**

See talk from Robert Harris
from 26.4.2007 during the JES workshop
http://indico.cern.ch/conferenceDisplay.py?confId=15200

Factorization vs. global approach

The factorization has advantages:

- Divide et impera: Many small problems instead of one large problem

Disadvantage: All correlations are neglected, e.g.:

- Global pT scale ⇔ inter – η calibration
- Global pT scale ⇔ jet flavor
- …?

➔ Alternative to factorization: A framework that combines all factors and performes a global fit.

- work is seperated by „samples/constraints", not by „factors"
  e.g. *γ-jet & track-tower*
- considers all correlations

Goals

The idea is to

- Check the factorization
- Evaluate systematics of factorial calibration
- Do an alternative calibration

No proof yet, if this is viable!

Challenge: Many fit prameters

Calibration on tower level: ➔ optimize jet E resolution

2084 HCAL towers, no longitudinal binning

E-Parametrization, e.g.:

➔ ~6000 fit parameters

$$\frac{E'}{E} = k_1 + k_2 \frac{1}{\sqrt{E}} + k_3 \frac{1}{E}$$

Additional parameters:

- EM/Had fraction
- HCal-Outer fraction
- Jet parametrization, i.e. invis. components, out-of-cone showering

Reduce parameters:

- Introduce symmetries (e.g. φ)

➔ O(10k) parameters, O(1M) events

Proof of principle: Successful tracker alignment using 50k parameters, 1M tracks

Currently testing Minuit and a new program by Volker Blobel: LVMINI; „Large-scale optimization with the limited-memory BFGS program" (algorithm by J. Nocedal)

The global chi2 function

$$\chi^2_{global} = \chi^2_{\gamma/jet} + \chi^2_{track/tower} + \chi^2_{\ldots} + \ldots$$

$$\chi^2 = \sum_i \frac{(t_i - f(m_i))^2}{\delta_t(t_i)^2 + \delta_m(f(m_i))^2}$$

f(m): some function parametrizing all the necessary corrections to the measurement *m*

Track/tower: t = track momentum
m = tower energy,

Gamma/jet: t = gamma energy
$f(m_i) \rightarrow \Sigma_k f(\text{jet}_i \text{ tower}_k \text{ energy})$.

Similar for Jet-calibration, → modify χ^2_{jet} by add. factor

The Framework

- **Dataset producer and filter**
  - γ – jet selection
  - Track – tower selection
  - *di-jet, tri-jet (2 jets, gluon), top-top selections, … not included yet*
- **Private ROOT tuple producer**
- **The calibration**
  - Express each selection as a χ^2 – term w.r.t. HCalo-Towers
  - Minimize the global χ^2 function
    - Minuit or BFGS/LVMini or (MillePede??? No local parameters)
    - Outlier rejection
  - Extract calibration constants for each HCalo-tower (and for jets)
- **Apply calibration on calo-tower, re-run jet algorithms, apply jet-corrections**
- **Create validation plots**

Example (1/4):

Test of the procedure:

- Fit one factor for all tower energies

$$f(E_t^{tower}) = k_1 \cdot E_T$$

- Fit three factors to parametrize jets

$$f(E_t^{jet}) = k_1 \cdot E_T + k_2 \cdot \sqrt{E_T} + k_3$$

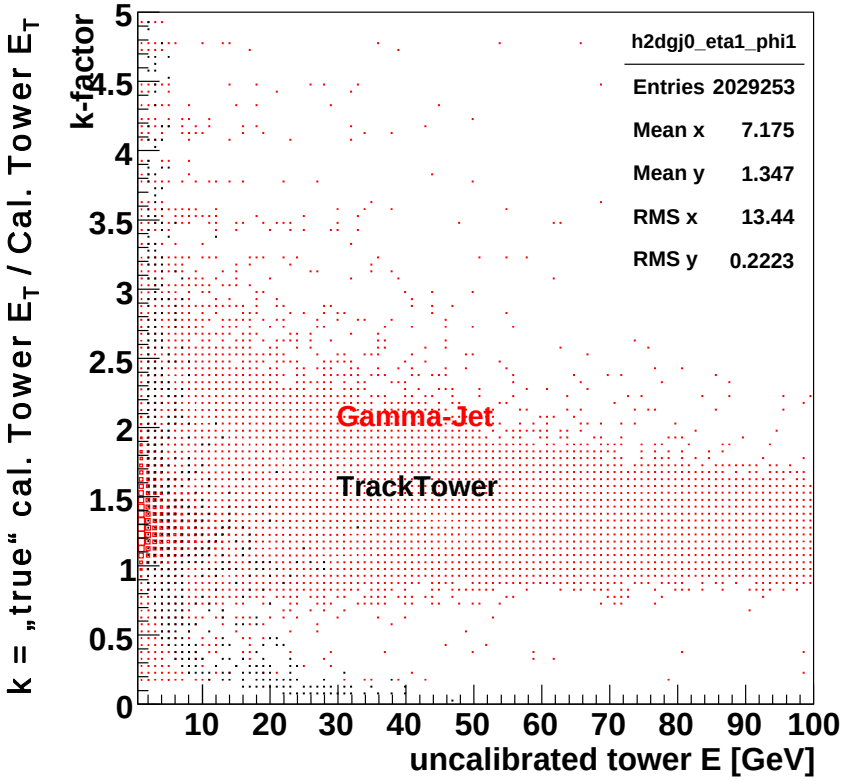
➔ No really physical meaningful calibration but a test of the tools!

Studies using more parameters started,

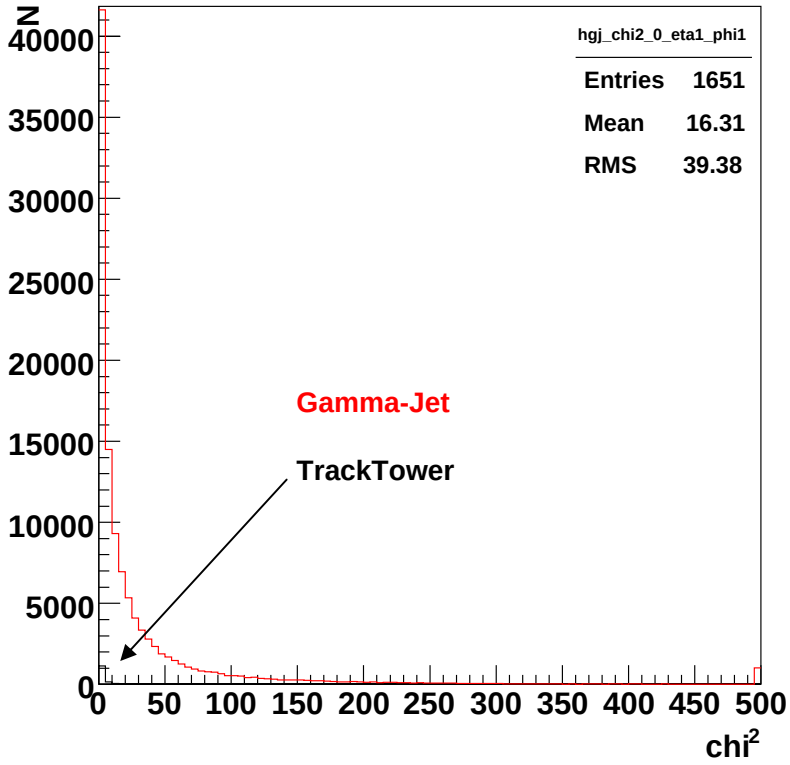
Ultimative goal: Fit on tower level

Example: (2/4)

k-factor per event



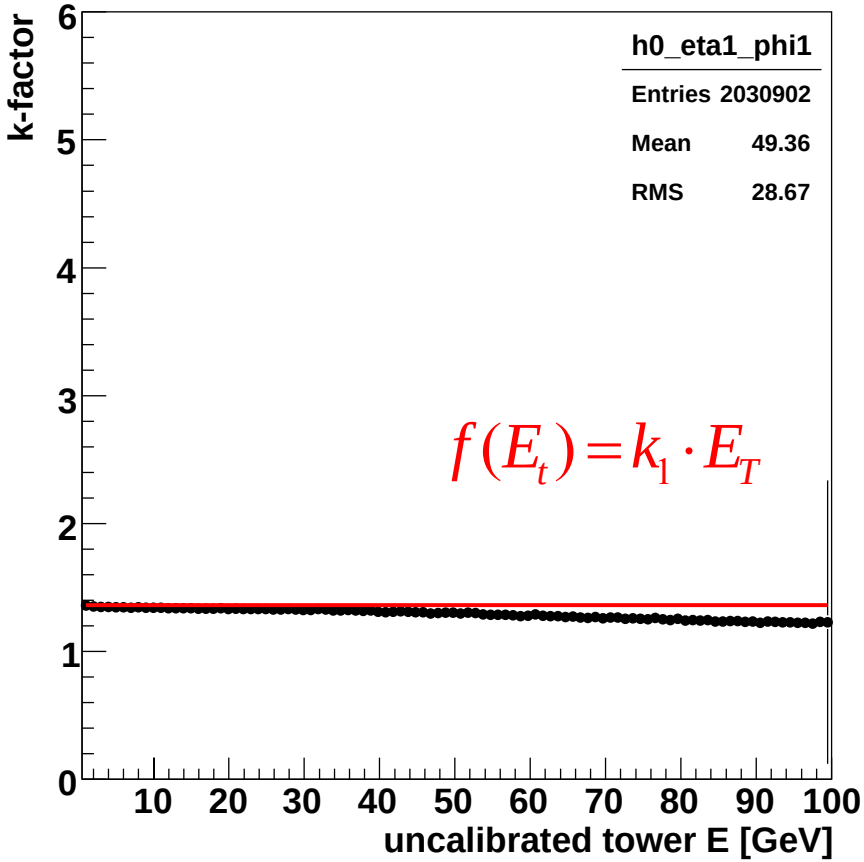
χ^2 - terms



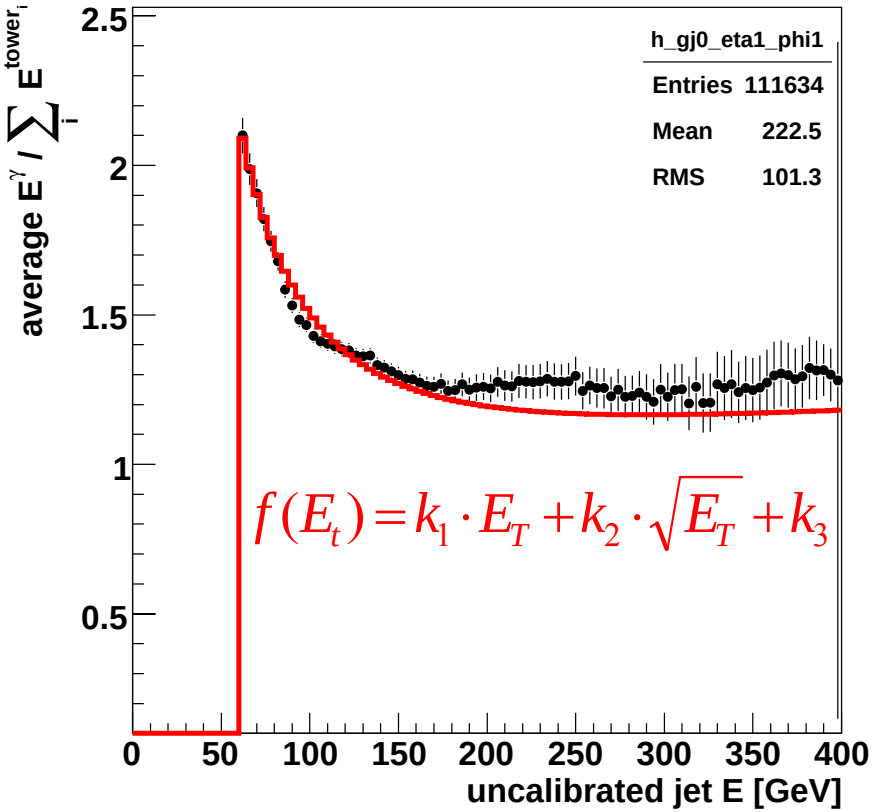
Optimization of selections necessary, however…

Example (3/4)

Cal-tower calibration



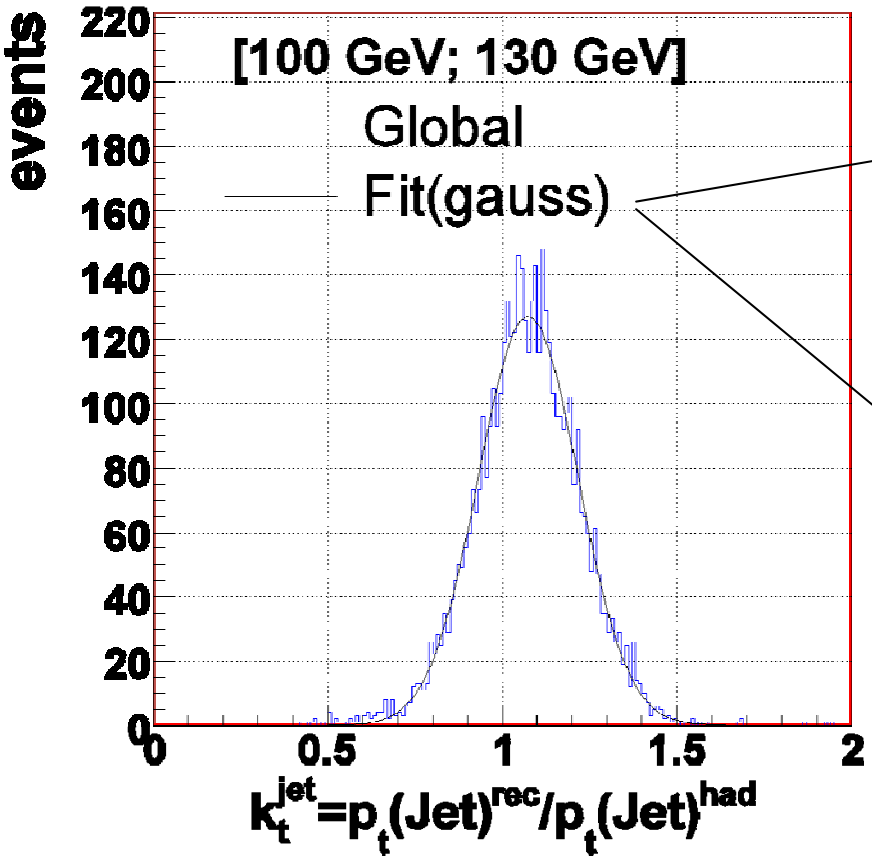
No η or φ dependance,
Fit only 4 parameters

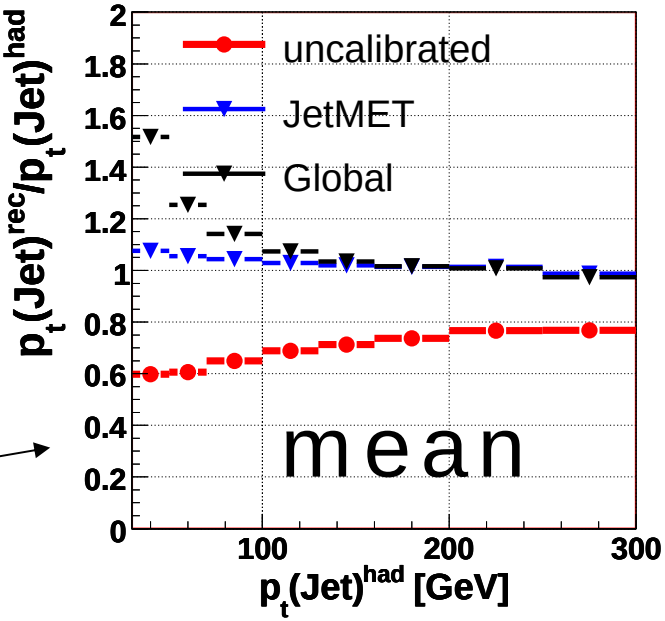


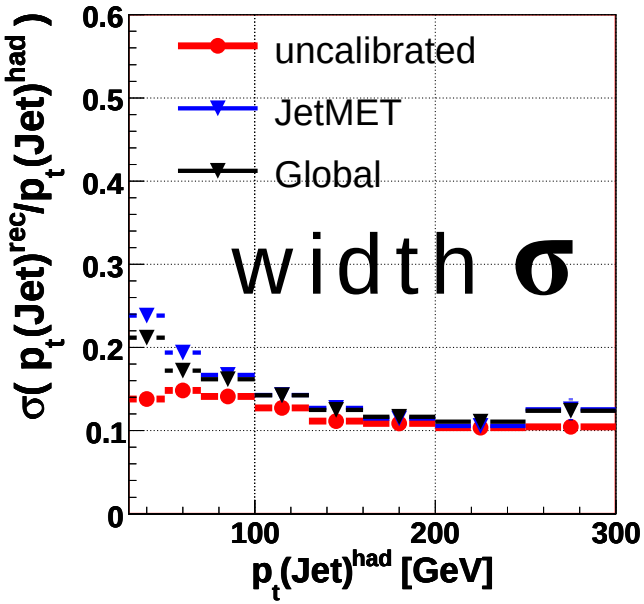
➔ machinery works

Validation of the „toy calibration"

Gauss-fit of „k_t^{jet}" in different gen.-jet p_T bins, e.g. [100-130 GeV]:







Validation sample: ttbar

Summary

Conclusions

- Started work on a framework to fit global HCal & Jet calibration constants
- Used so far γ-jet and track-tower events
- Global fit: Proof of principle shown in tracker alignment

Outlook

- Increase the number of fit parameters
- Use a better motivated E_T parametrization function
- Include other datasets like tt, di-jet, etc.
- Parametrize Cal. towers longitudinally
- Parametrize Jet energy losses (invis. E, out-of-cone) and underlying event
- Include the EM calorimeter towers
- … much to be done

Backup slides

Gamma-Jet Selection

- Gamma: correctedPhotons
  - pT > 5 GeV
  - $|\eta| < 2.5$
  - Isolation w.r.t. Calo towers:
    sum pT < 5 GeV, 0.2 < R cone < 0.7
  - Isolation w.r.t. Hadronic-Calo towers:
    sum pT < 2 GeV, 0.0 < R cone < 0.2
- Jet: iterativeCone5CaloJets
  - pT > 25 GeV
  - 2nd jet pT < 15 GeV
  - Sum pT (out of gamma, jet) < 15 GeV
- Matching (gamma, jet):
  $|\Delta\varphi - \pi| < 0.15$

110k events used
20-7000 GeV γ- pT

Not studied !

Track Tower Selection

- Tracks: ctfWithMaterialTracks
  - pT > 2 GeV
  - $|\eta| < 2.5$
  - Isolation w.r.t. tracks:
    sum pT < 0.5 GeV, 0.2 < R cone < 0.5
- Tower: towerMaker
  - pT > 2 GeV
  - $|\eta| < 2.5$
  - Isolation w.r.t. calo towers:
    sum ET < 0.5 GeV, 0.2 < R cone < 0.5
- Matching (track, tower):
  $\Delta\eta < 0.01$, $\Delta\varphi < 0.01$

1.5k events used from γ-jet events

Not studied !

➔ To low statistics, selection under study by C. Guenther