QCD background determination

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GEFÖRDERT VOM
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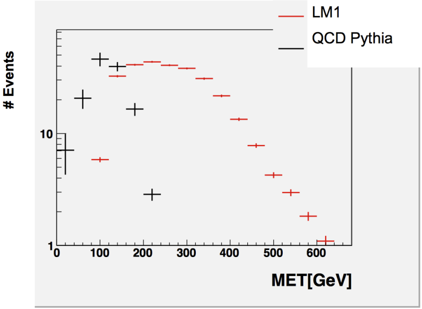
Motivation: Understanding the QCD background to $\not{E}_T$

- Missing transverse energy, $\not{E}_T$, is an important signature in the search for new physics
- Large $\not{E}_T$-background expected from QCD events in the all-hadronic channel:
  - Particles invisible to the calorimeter e.g. μ or ν
  - Mismeasurement due to intrinsic calorimeter resolution
  - Mismeasurement due to detector acceptance
  - ...

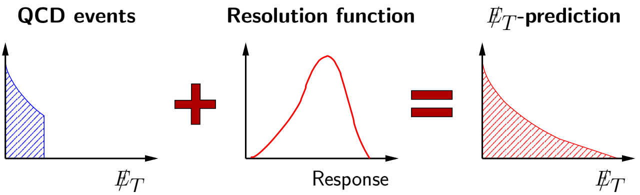


Understanding of QCD contribution to $\not{E}_T$ important

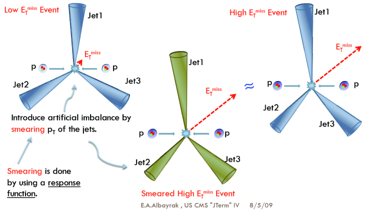
Outline

Outline

Concept of the jet smearing method



1. Selection of well measured QCD events
2. Smearing with resolution function

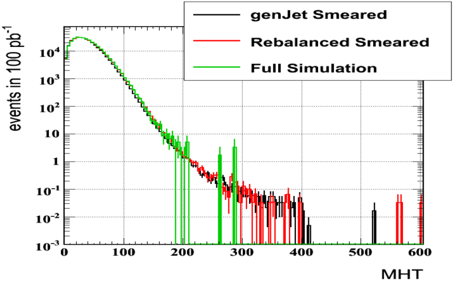


Application of the resolution function[1]

- Smearing of **measured** p_T with resolution function
- Bias in $\not\!\!E_T$ prediction
  - Double smearing
  - Selection cut on $\not\!\!E_T$
- Rebalancing of QCD events

$$p_{T,1} \rightarrow p'_{T,1} = -\sum_{i=2} p_{T,i}$$

- Smearing of artifical, perfectly balanced QCD events

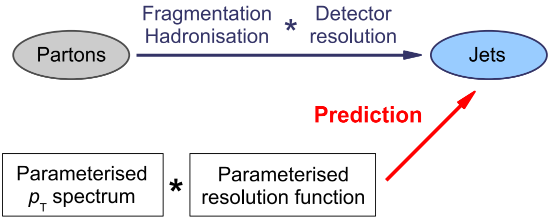


Good reproduction of the $\not\!\!E_T$ spectrum

[1] UCSB e.g. talk by M. Rydenfelt http://indico.cern.ch/conferenceDisplay.py?confId=61021

Outline

Concept of the resolution fit method



- In each event i, probability for a given dijet configuration p_T^1, p_T^2 is

$$\mathcal{P}_i^{1,2} \propto \int_0^\infty \mathrm{d}p_T^{\mathrm{true}}\, f_{\mathbf{b}}(p_T^{\mathrm{true}}) \cdot r_{\mathbf{b}}(p_T^1/p_T^{\mathrm{true}}) \cdot r_{\mathbf{b}}(p_T^2/p_T^{\mathrm{true}})$$

- $f_{\mathbf{b}}$ is the probability density function (pdf) of p_T^{true}
- $r_{\mathbf{b}}$ is the resolution function i.e. the response pdf

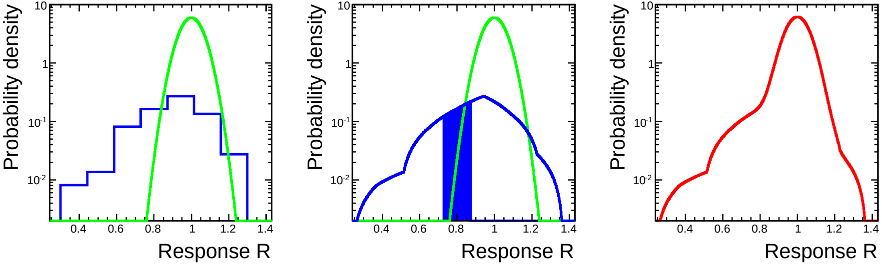
- Likelihood $\tilde{\mathcal{L}}(\mathbf{b}) = \prod_{i=0}^{N_{\mathrm{evt}}} \mathcal{P}_i^{1,2}$ maximal for correct parameter values $\mathbf{b}$
- Inclusion of other data types by appropriate definition of probability

Parameterisation of the resolution function

Superposition of Gaussian and interpolated step function

$$r_{\mathbf{b}}(R) = c \cdot G(R;\mathbf{b}) + (1-c) \cdot S_N(R;\mathbf{b}) \qquad R = p_{\mathrm{T}}/p_{\mathrm{T}}^{\mathrm{true}}$$

- Central Gaussian G around 1 (assume calibrated jets)
- Step function S with N parameters Plots: Arrows / numbers
  - (Sufficiently generic description of tails)
- Actual $S_N(R)$ is linear interpolation of adjacent bin contents
  - (Only $N-1$ parameters are fitted $\longrightarrow$ fixed scale)



Parameterisation of the p_T^{true} spectrum

Fit to pttrue spectrum

- p_T^{true} spectrum parameterised with powerlaw

$$f(p_T^{true}) \propto \frac{1}{(p_T^{true})^n}$$

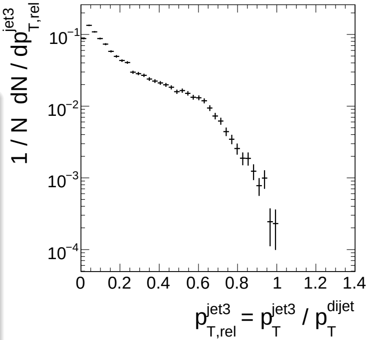
- Fair description of p_T^{gen} spectrum
- **Note**: $p_T^{gen} \neq p_T^{true}$ due to hadronisation and fragmentation effects
- Nonetheless used for validation purposes

Outline

1. Introduction
   - The jet smearing method
2. Concept of the resolution fit method
   - Technique
   - Parameterisation of the resolution function
   - Parameterisation of the p_T^{true} spectrum
3. Proof of principle for one $\hat{p}_T$ bin
4. p_T dependent resolution function
   - Concept
   - Results

Event selection

- L2L3 corrected Summer08 QCDDijets
- $600 < \hat{p}_T < 2200$ GeV
- Dijet selection similar to `CMS AN-2008/031`[2]



Dijet selection

- 2 jets leading in p_T with $|\eta| < 0.8$
- $p_T^3 / p_T^{dijet} < 0.1$ or $p_T^3 < 2$ GeV, where $p_T^{dijet} = \frac{p_T^1 + p_T^2}{2}$
- $|\Delta\phi^{1,2}| > 2.7$
- $0.07 < p_T^{had} / p_T^{1,2} < 0.95$
- $\Delta R(\mathtt{jet}, \mathtt{genjet}) < 0.1$ (important for validation)

[2] Determination of the Relative Jet Energy Scale at CMS from Dijet Balance

Results for one bin, fitted spectrum

Outline

p_T dependent parameterisation of the resolution

Dependence of resolution on p_T^{true}

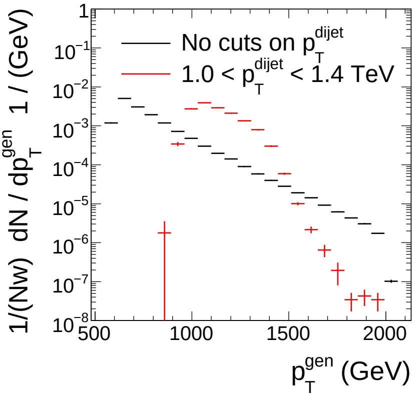
- Width of central Gaussian

$$\frac{\sigma(p_T/p_T^{true})}{\langle p_T/p_T^{true}\rangle} = \frac{a_1}{p_T^{true}} \oplus \frac{a_2}{\sqrt{p_T^{true}}} \oplus a_3$$

- No p_T^{true} dependence of step function

Separate fits in different p_T^{true} bins

- Interpolation of parameters
- **Data driven**: binning in p_T^{dijet}

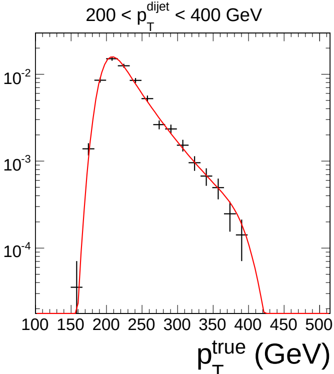


- Migration due to resolution and steeply falling spectrum

Description of p_T^{true} spectrum including cuts on p_T^{dijet}

Inclusion of p_T^{dijet} cuts into pdf of p_T^{true}

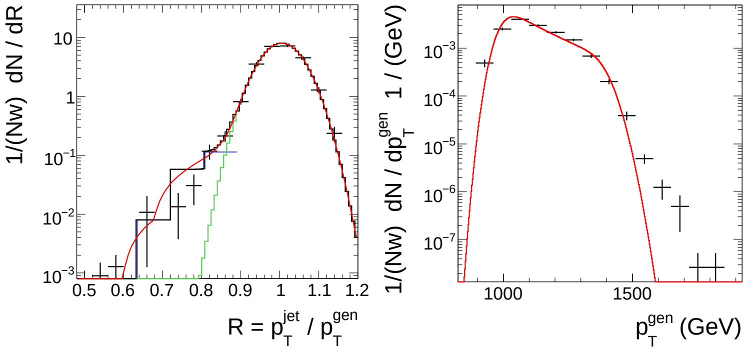
$$f(p_T^{true}) \propto f_0(p_T^{true}) \int_{p_{T,min}^{dijet}}^{p_{T,max}^{dijet}} \mathrm{d}x \, \frac{r(x/p_T^{true})\,p_T^{true}}{\sqrt{2}}$$



- Bin: $p_{T,min}^{dijet} < p_T^{dijet} < p_{T,max}^{dijet}$
- Response pdf r
- Pure spectrum $f_0 \propto 1/(p_T^{true})^n$
- Demonstration with `ToyMC` sample using Gaussian resolution

Description of p_T^{true} spectrum

Results for one bin $1000 < p_T^{\mathrm{dijet}} < 1400$ GeV



- Step function with 4 bins from $0.5 < R < 0.9$
- Gaussian resolution from fit on L2L3 corrected jets[3] assumed in p_T^{true} spectrum ($\rightarrow$ deviations at large p_T^{gen})
- Acceptable description of response

[3] V. Chetluru: `http://indico.cern.ch/conferenceOtherViews.py?view=standard\&confId=52598`

Summary & outlook

Summary

- The jet smearing method allows an estimation of the $\not{E}_T$ contribution from QCD events
- A data driven approach for the determination of the resolution function has been presented
- The method fits parameterised spectrum and resolution function in dijet events
- In particular, migration effects in p_T^{true} spectrum due to cuts on p_T^{dijet} have been described

Outlook

- Resolution function in different p_T^{dijet} and η bins
- Comparison to results using γ-jet events
- Evaluation of systematic uncertainties of the method