Update on jet smearing function studies

CMS SUSY hadronic working group meeting

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GEFÖRDERT VOM
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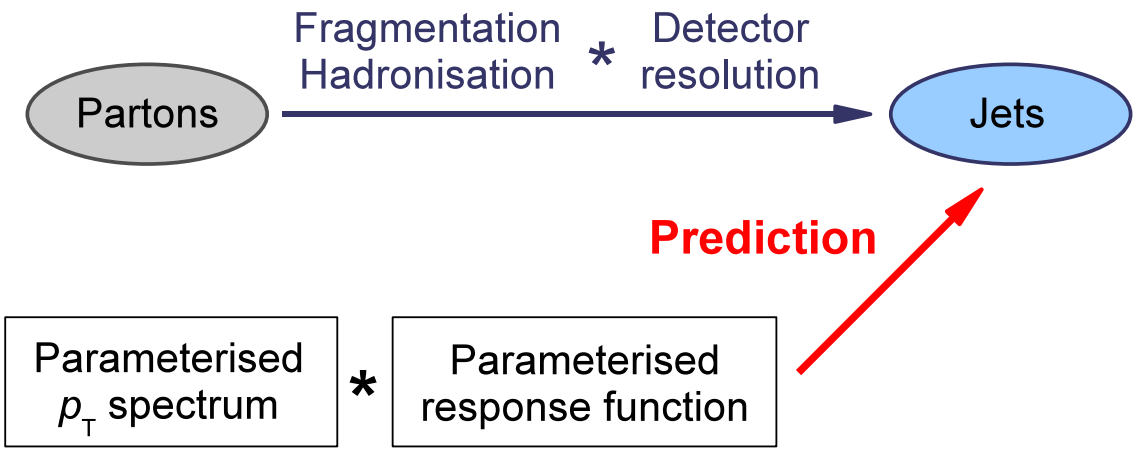
Outline

Concept of the response fit method



- In each event i, probability density of the 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 response pdf

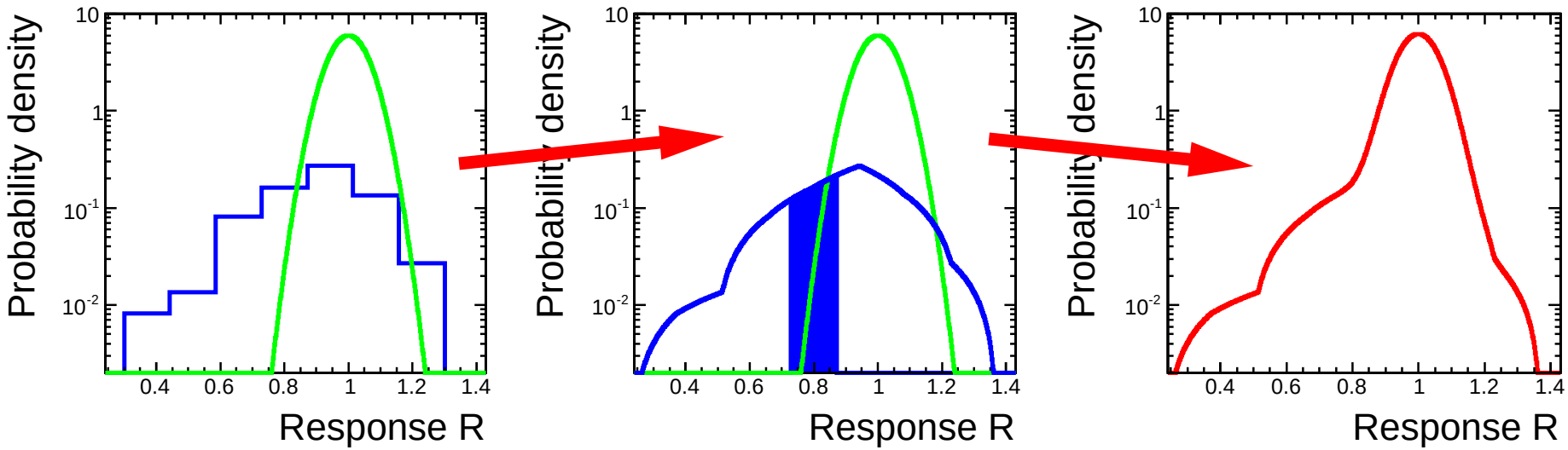
- Likelihood $\tilde{\mathcal{L}}(\mathbf{b}) = \prod_{i=0}^{N_{\mathrm{evt}}} \mathcal{P}_i^{1,2}$ maximal for correct parameter values $\mathbf{b}$

Parameterisation of the response 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
- Actual $S_N(R)$ is linear interpolation of adjacent bin contents



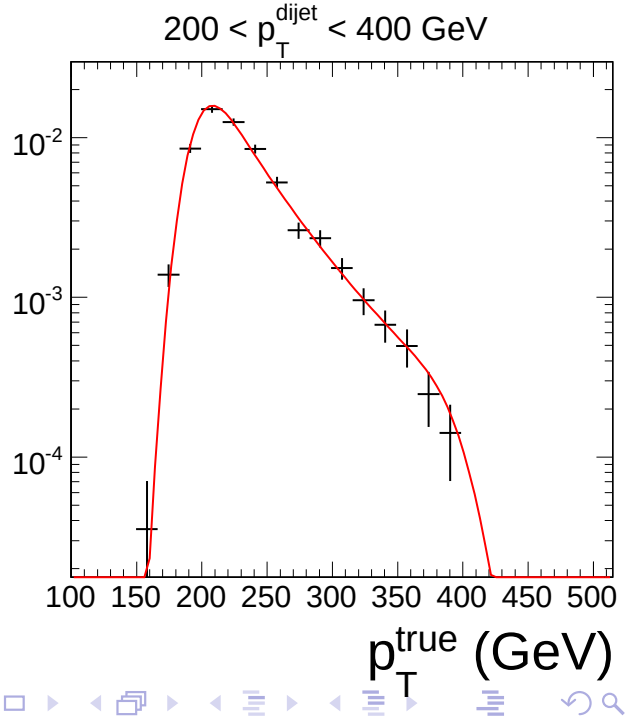
p_T dependent response parameterisation

- 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

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

$$f_{\mathbf{b}}(p_T^{true}) \propto \hat{f}_{\mathbf{b}}(p_T^{true}) \int_{p_{T,min}^{dijet}}^{p_{T,max}^{dijet}} dx \, \frac{r_{\mathbf{b}}(x/p_T^{true})p_T^{true}}{\sqrt{2}}$$

- Bin: $p_{T,min}^{dijet} < p_T^{dijet} < p_{T,max}^{dijet}$
- Response pdf $r_{\mathbf{b}}$, pure spectrum $\hat{f}_{\mathbf{b}} \propto 1/(p_T^{true})^n$



Technical details of the minimisation

- Calculation of likelihood computationally intensive due to integrations

$$\mathcal{P}_i^{1,2} = \frac{1}{\mathcal{N}} \int_0^\infty \mathrm{d}p_\mathrm{T}^\mathrm{true} \int_{p_\mathrm{T,min}^\mathrm{dijet}}^{p_\mathrm{T,max}^\mathrm{dijet}} \mathrm{d}x \, \frac{r_\mathbf{b}(x/p_\mathrm{T}^\mathrm{true})p_\mathrm{T}^\mathrm{true}}{\sqrt{2}} \cdot (p_\mathrm{T}^\mathrm{true})^{-n} \cdot r_\mathbf{b}(p_\mathrm{T}^1/p_\mathrm{T}^\mathrm{true}) \cdot r_\mathbf{b}(p_\mathrm{T}^2/p_\mathrm{T}^\mathrm{true})$$

$$\mathcal{N} = \int_0^\infty \mathrm{d}p_\mathrm{T}^\mathrm{true} \underbrace{\int_{p_\mathrm{T,min}^\mathrm{dijet}}^{p_\mathrm{T,max}^\mathrm{dijet}} \mathrm{d}x \, \frac{r_\mathbf{b}(x/p_\mathrm{T}^\mathrm{true})p_\mathrm{T}^\mathrm{true}}{\sqrt{2}}}_{\mathcal{C}} \cdot (p_\mathrm{T}^\mathrm{true})^{2-n}$$

- Integral $\mathcal{C}$ describes effects on $p_\mathrm{T}^\mathrm{true}$ by cuts on $p_\mathrm{T}^\mathrm{dijet}$
- Calculated only once per iteration to save CPU time

1. Storing $\mathcal{C}$ for different values of $p_\mathrm{T}^\mathrm{true}$ using current parameter values $\mathbf{b}$
2. Minimising $\mathcal{L}$ by varying $\mathbf{b}$ and n
3. Starting again at 1

Outline

Event selection

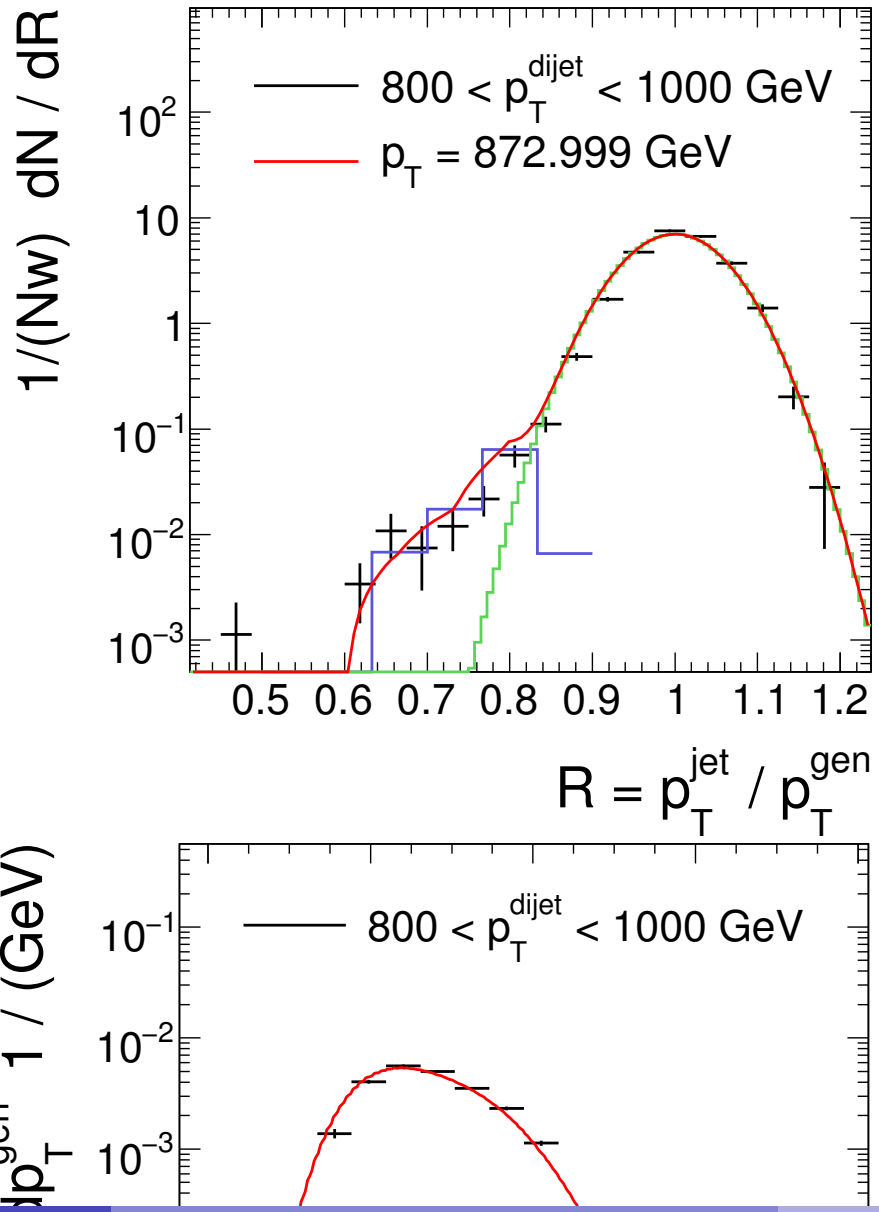
- L2L3 corrected Summer08 QCDDijets
- $800 < p_T^{dijet} < 1000$ GeV
- Dijet selection similar to CMS AN-2008/031[1]

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)

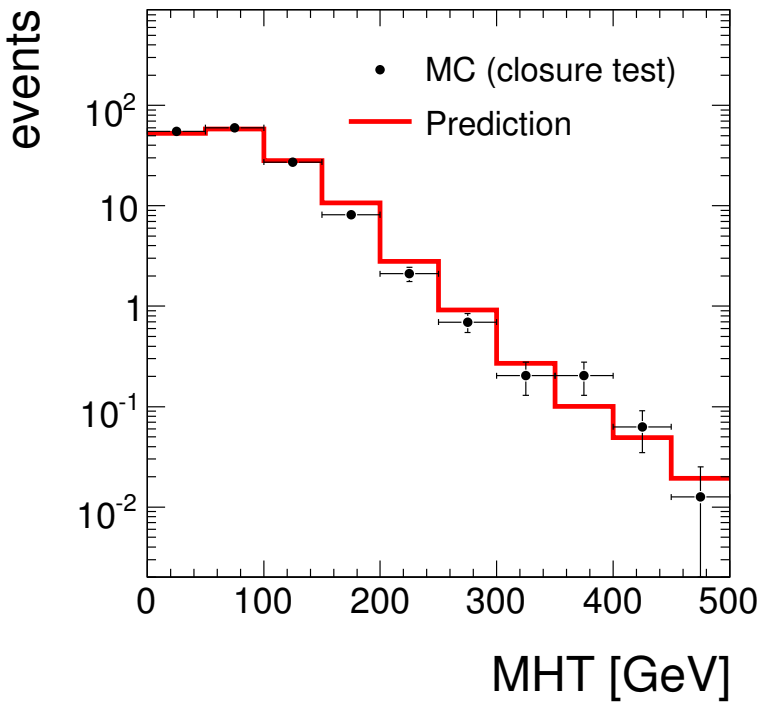
[1] Determination of the Relative Jet Energy Scale at CMS from Dijet Balance

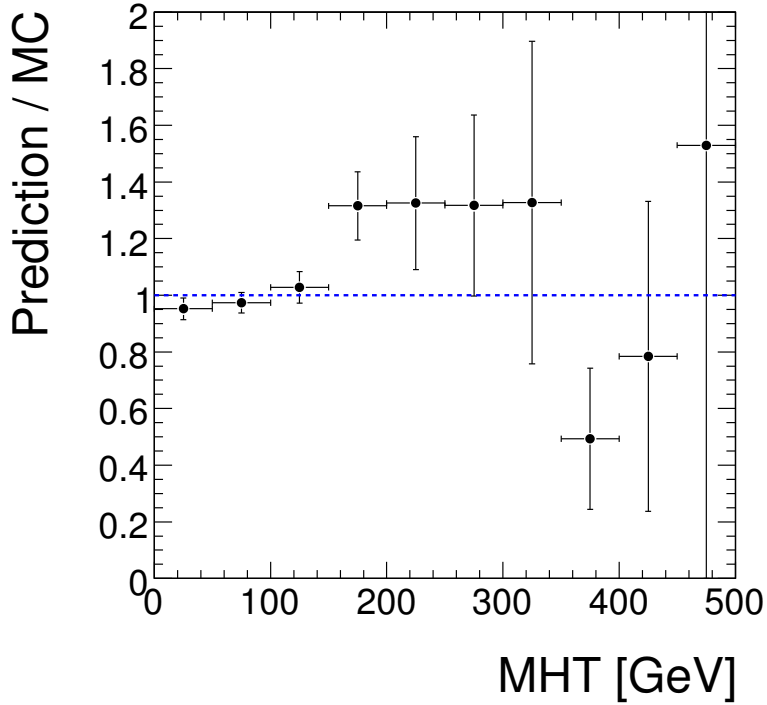
Fit results for one bin $800 < p_T^{dijet} < 1000$ GeV



Consistency check: predicted MHT spectrum

- Plots done with tool developed by Christian[2]
- Same dijet selection as for fit (no ΔR cut)
- Leading two jets in a selected event considered



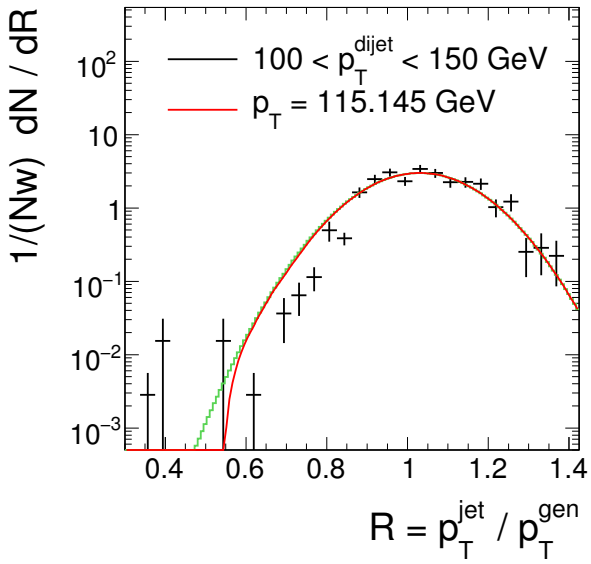


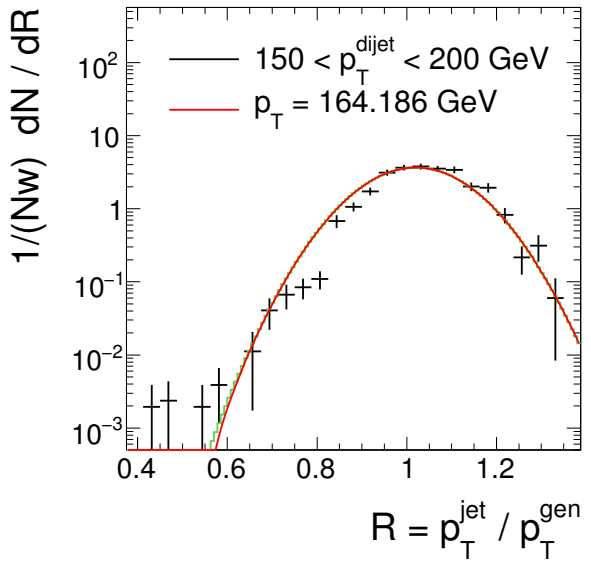
- Data points (MC) from L2L3 corrected `sisCone5CaloJets`
- Prediction from smeared `sisCone5GenJets` (3 times larger statistics)

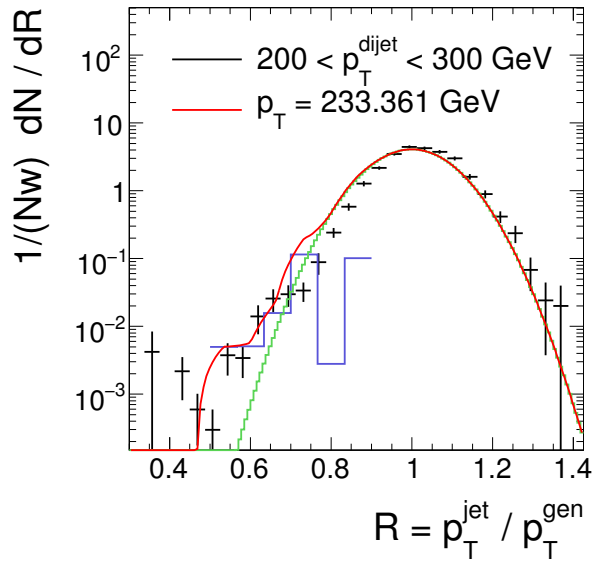
[2] `http://indico.cern.ch/conferenceDisplay.py?confId=73510`

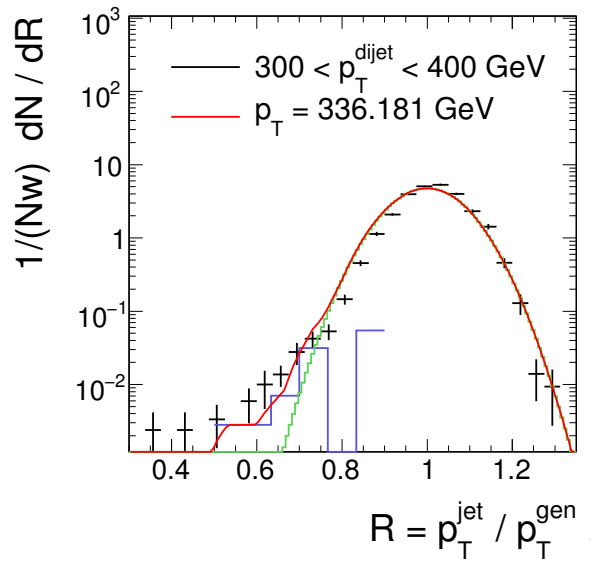
Outline

Fit results for p_T range $100 < p_T^{\text{dijet}} < 1000$ GeV

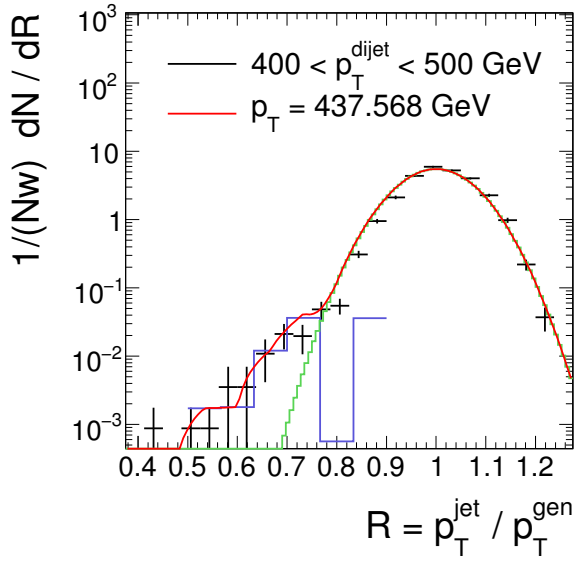


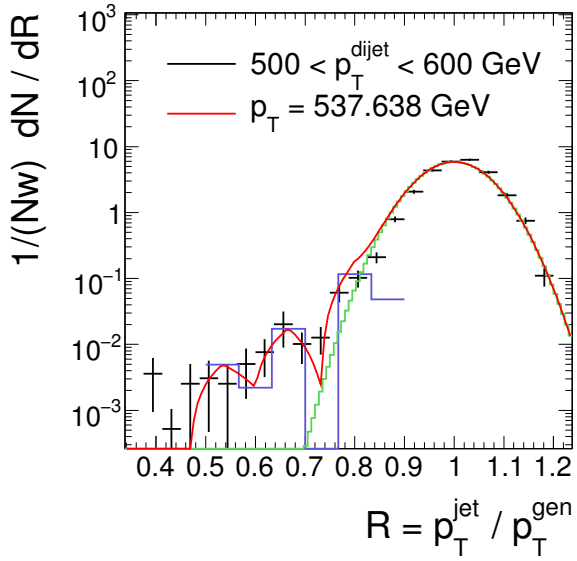


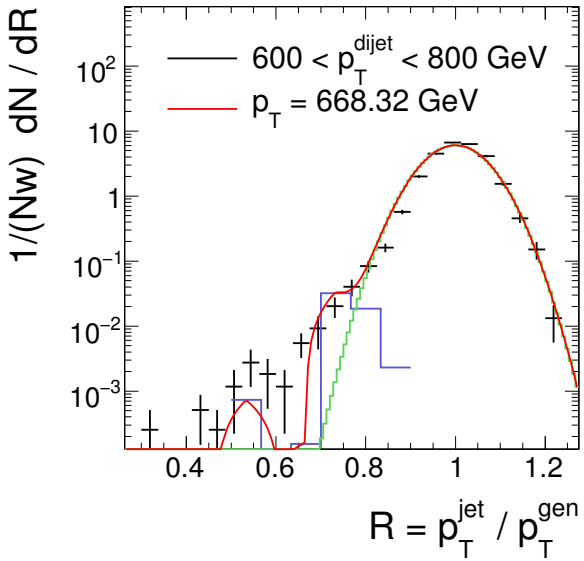


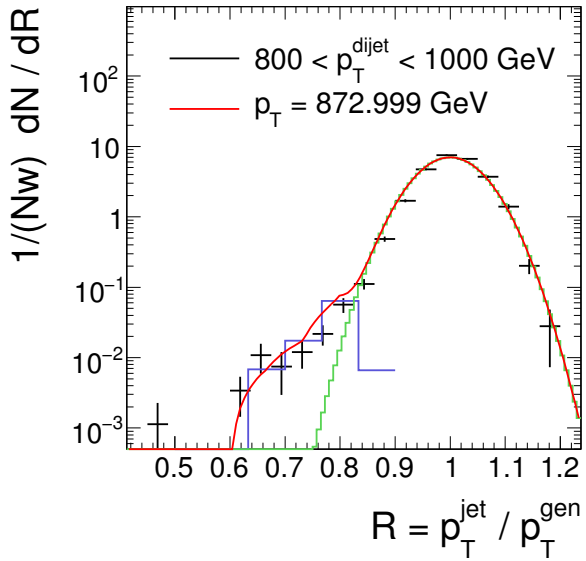


Fit results for p_T range $100 < p_T^{\text{dijet}} < 1000$ GeV



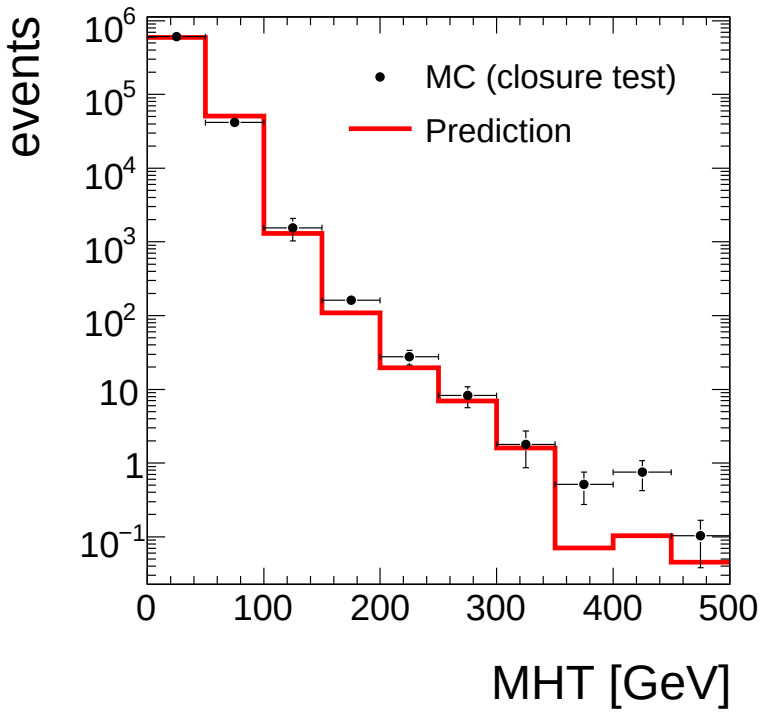


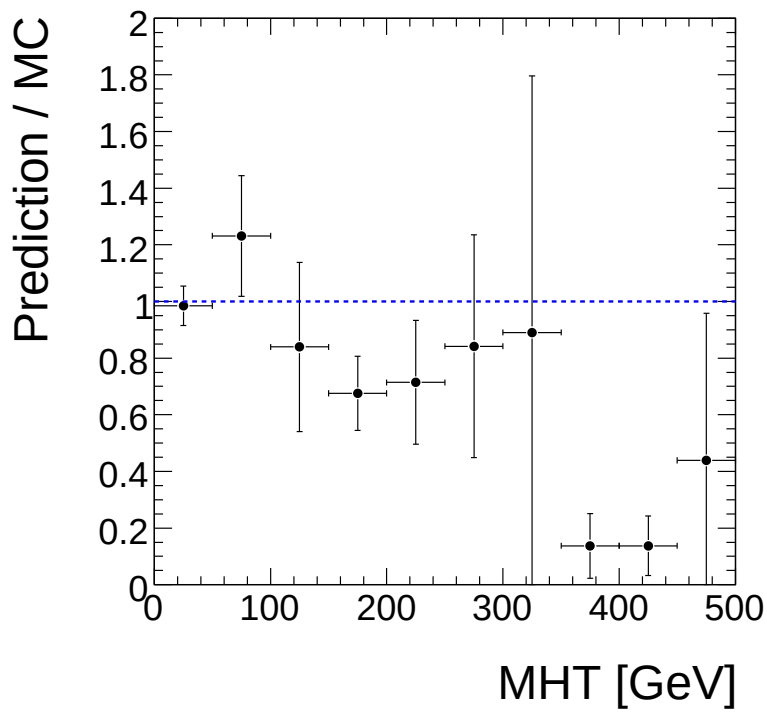




Consistency check: $100 < p_T^{\text{dijet}} < 1000$ GeV

- Same event selection as for fit (no ΔR cut), weights for 100 pb^{-1}
- Leading two jets in a selected event considered
- Smearing with response pdf corresponding to p_T of smeared genjet

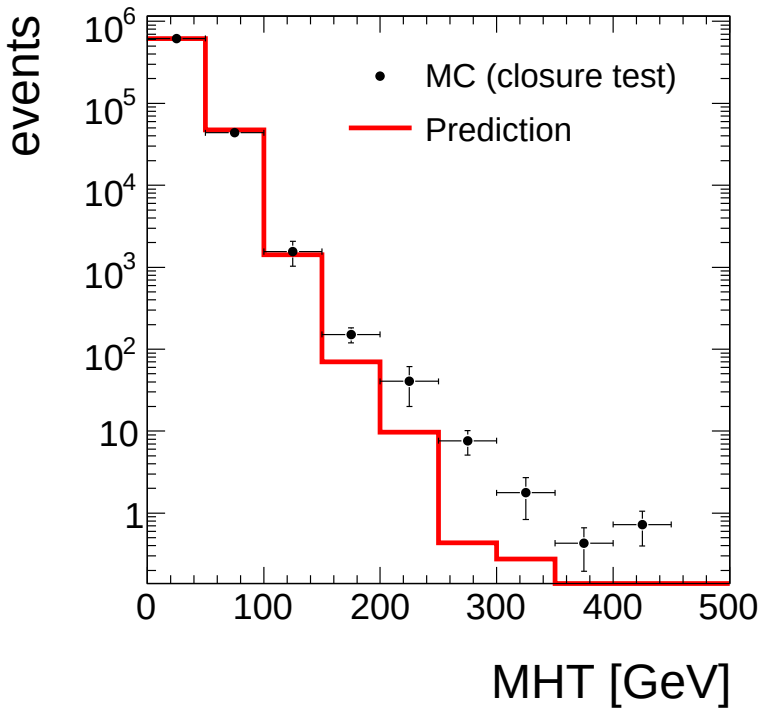


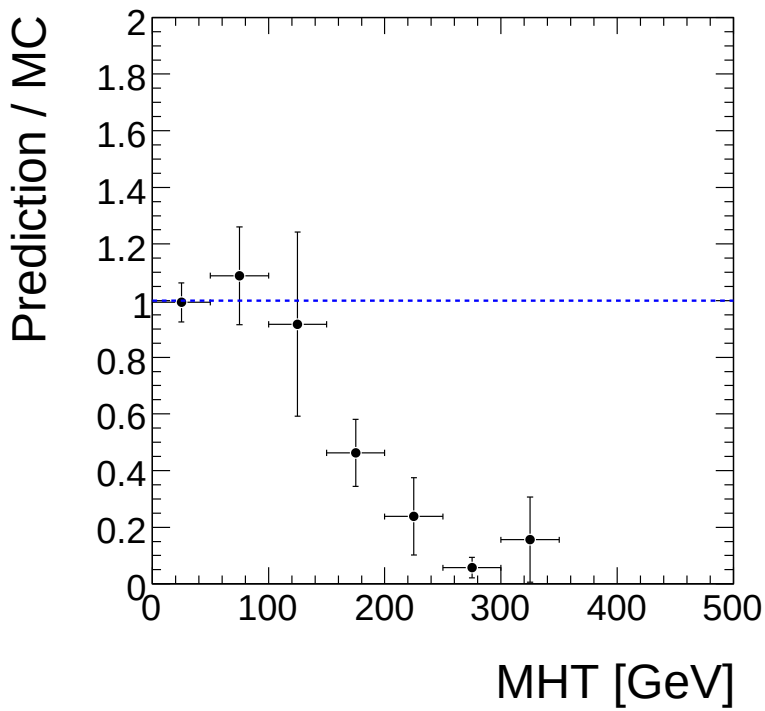


- Data points (MC) from L2L3 corrected `sisCone5CaloJets`
- Prediction from smeared `sisCone5GenJets`

Consistency check: $100 < p_T^{\text{dijet}} < 1000$ GeV

- Same event selection as for fit (no ΔR cut), weights for 100 pb^{-1}
- **All jets** in a selected event considered
- Smearing with response pdf corresponding to p_T of smeared genjet





- Data points (MC) from L2L3 corrected `sisCone5CaloJets`
- Prediction from smeared `sisCone5GenJets`

Outline

Conclusions

- A prediction for the MHT spectrum in QCD dijets has been presented
  1. Response functions have been determined for different p_T bins
  2. Genjets have been smeared with the appropriate response function
- The leading two jets have been considered
- Prediction is consistent for one p_T bin
- Underestimation of MHT for a range of several p_T bins
- Problem with fit of response function in low p_T bins: one-sided step function reaches far into Gaussian part
  - Usage of step function covering whole R range
- Systematic uncertainties of method
  - Parameterisation of spectrum
  - Binning of step function
  - Binning of response functions in p_T^{dijet}
  - QCD selection cuts