Multivariate Determination of the Missing Energy in the Transverse Plane ($\not{E}_T$) at $\sqrt{s} = 13$ TeV

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$\not{E}_T$ in CMS

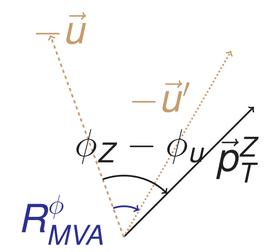
- First 42pb^{-1} of 50ns data have been analyzed with a modified $\not{E}_T$ definition
- $\not{E}_T$ is defined as $\sum_{PFCandidates} p_T$ with $|\eta| < 3.0$
- In the distributions shown, Jet energy corrections have been applied
- $\not{E}_T$ Filters remove noise

Motivation

- Particle-Flow $\not{E}_T$ is already an advanced technique using different corrections like
  - Jet Energy Corrections
  - $\not{E}_T$ Filters to remove noise
- But still: Pile-up biases the $\not{E}_T$
- $\not{E}_T$ is a crucial variable e.g. in the $H \to \tau\tau$ analysis where at least two neutrinos in the final state are involved
- MVA $\not{E}_T$ suppresses pile-up contributions by making use of additional knowledge about the event

Reconstruction of the Angle ϕ_u

- The first training: a correction on the polar angle ϕ_u
- Target variable: the angular difference between the recoiling object and the hard scatter decay products:



$$R^{\phi}_{MVA} = \phi_Z - \phi_u \qquad (3)$$

- So that the reconstructed angle ϕ_u^{corr} is

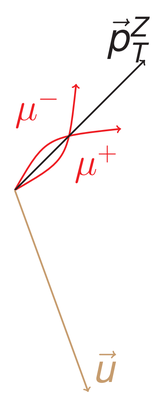
$$\phi_u^{corr} = \phi_u + R^{\phi}_{MVA} \qquad (4)$$

Approach

- MVA $\not{E}_T$: the best guess for the recoil of the hard scatter products $\vec{u}^{corr}$ with its transverse momentum and polar angle
- Training on a process without genuine $\not{E}_T$: Drell-Yan $Z \to \mu\mu$
- The recoil has a component parallel and perpendicular to $\vec{p}_T^{\,Z}$:

$$\vec{u}_{\parallel} = (\vec{u} \cdot \vec{p}_T^{\,Z})\vec{p}_T^{\,Z} / |\vec{p}_T^{\,Z}| \qquad (1)$$

$$\vec{u}_{\perp} = \vec{u} \times \vec{p}_T^{\,Z} / |\vec{p}_T^{\,Z}| \qquad (2)$$



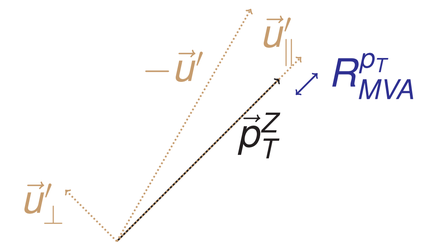
- Aims:
  - The multivariate $\not{E}_T$ response should be a good guess to the boson recoil
  - As little dependence on the p_T and pile-up as possible
  - Small resolution

Input variables:

- Recoil $\vec{u}$ and $\sum E_T$ of of five different definitions of $\not{E}_T$
- Leading- and Sub-leading Jet p_T, ϕ and η
- Number of primary vertices, Jets and Jets above $p_T = 30\mathrm{GeV}$

p_T reconstruction

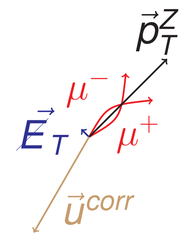
- The second training: correction for the projection of the ϕ-corrected, parallel component of $\vec{u}$, called $u'_{\parallel}$
- target variable: ratio between the transverse boson momentum p_T^Z and $u'_{\parallel}$



$$R^{p_T}_{MVA} = \frac{-p_T^Z}{u'_{\parallel}} \qquad (5)$$

- Final reconstructed parallel component of the original boson:

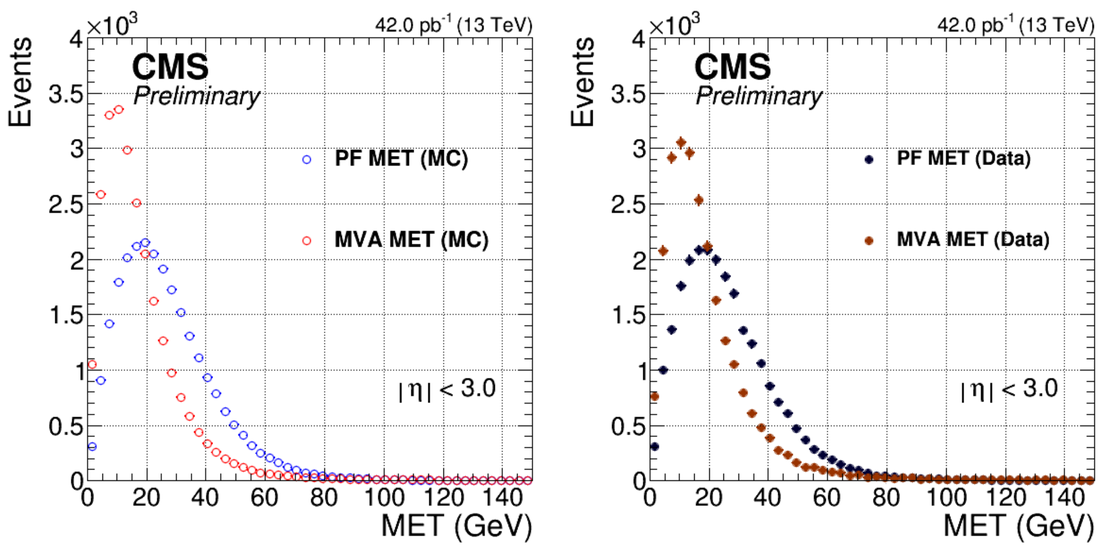
$$\vec{u}^{corr} = -R^{p_T}_{MVA} \cdot \vec{u}' \qquad (6)$$



- subtract Boson and get the $\not{E}_T$.

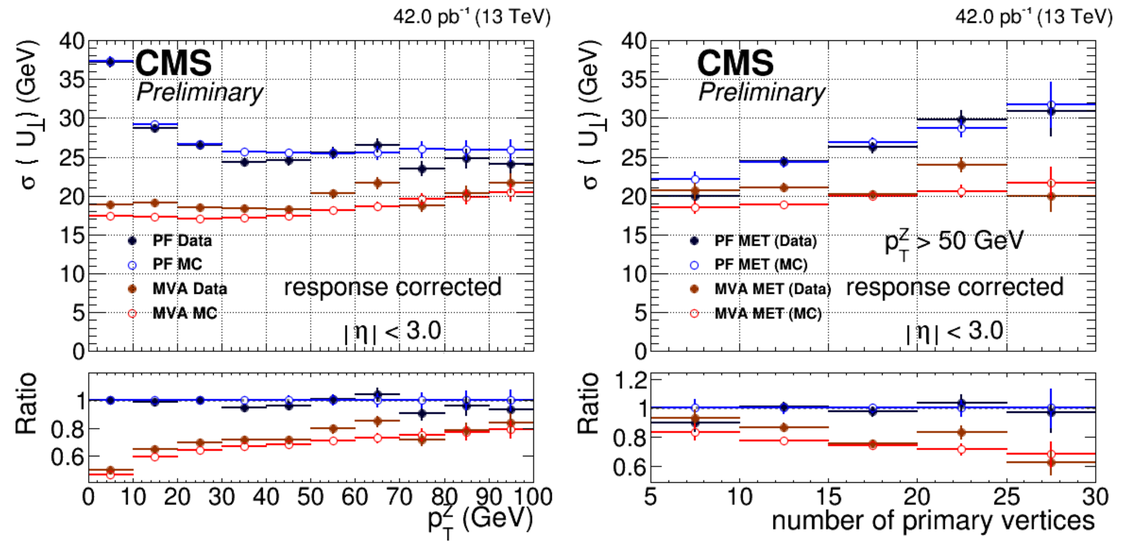
$$\vec{E}_T = -\vec{u}^{corr} - p_T^Z \qquad (7)$$

$\not{E}_T$ in Simulation and Data



- Bulk of events gets lower $\not{E}_T$
- Tails converge

Response Corrected $\not{E}_T$ Resolution



$$\rightarrow \sigma\left(U_{\parallel}^{PF}\right) = 13.7 + 3.11\sqrt{n_{PV}}$$

$$\rightarrow \sigma\left(U_{\parallel}^{MVA}\right) = 14.8 + 1.21\sqrt{n_{PV}}$$

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