LHCC Poster Session - CERN, 5 March 2014

Missing transverse momentum in ATLAS: current and future performance

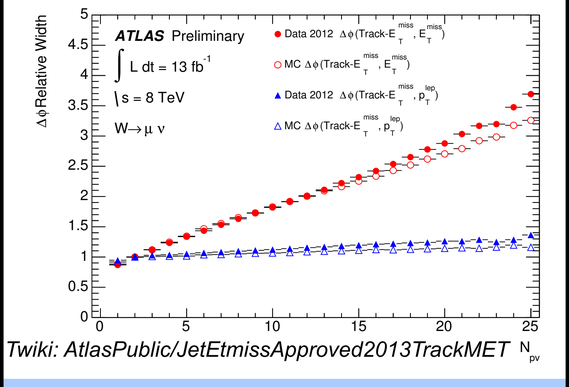
Track missing transverse momentum, $\mathrm{p_T^{miss}}$

Track-based methods use tracks from the primary vertex either matched to electrons, jets or, muons, or unmatched but fulfilling track quality criteria.

$$\mathrm{p}_{x,y}^{\mathrm{miss}} = \mathrm{p}_{x,y}^{\mathrm{miss},e_{\mathrm{track}}} + \mathrm{p}_{x,y}^{\mathrm{miss,jet_{track}}} + \mathrm{p}_{x,y}^{\mathrm{miss},\mu_{\mathrm{track}}} + \mathrm{p}_{x,y}^{\mathrm{miss,soft_{track}}}$$

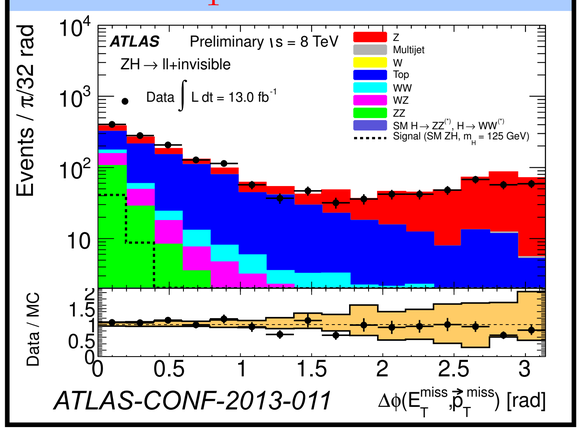
Limited by the tracking acceptance and missing contributions from neutral particles (jets, taus)

Only using PV tracks leads to minimal pileup dependence
Comparison to calorimeter $\mathrm{E_T^{miss}}$
Comparison to reference lepton



Twiki: AtlasPublic/JetEtmissApproved2013TrackMET

The angle between calorimeter and track missing transverse momentum is often used to veto backgrounds from fake $\mathrm{E_T^{miss}}$



ATLAS-CONF-2013-011

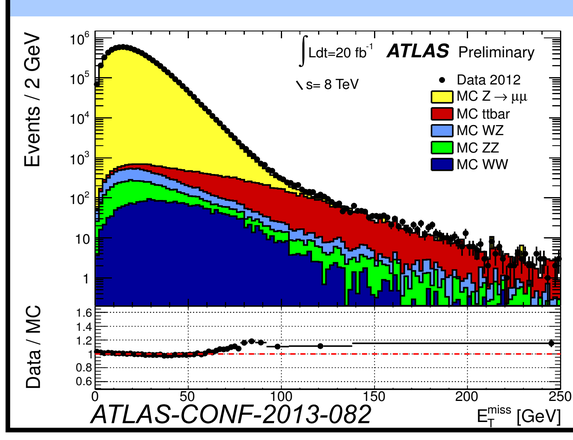
Calorimeter missing transverse momentum, $\mathrm{E_T^{miss}}$

Electrons · Photons · Taus · Jets · Muons · Other clusters

1. Select/calibrate objects → 2. Cluster-based overlap removal → 3. Compute relevant term

$$\mathrm{E}_{x,y}^{\mathrm{miss}} = \mathrm{E}_{x,y}^{\mathrm{miss},e} + \mathrm{E}_{x,y}^{\mathrm{miss},\gamma} + \mathrm{E}_{x,y}^{\mathrm{miss},\tau} + \mathrm{E}_{x,y}^{\mathrm{miss,jet}} + \mathrm{E}_{x,y}^{\mathrm{miss},\mu} + \mathrm{E}_{x,y}^{\mathrm{miss,soft}}$$

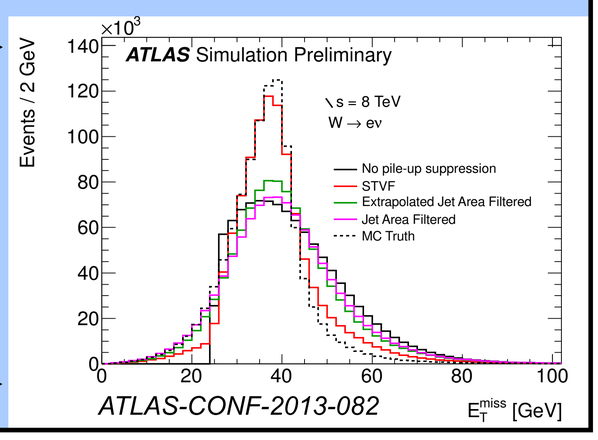
Using all objects and clusters in an event provides a complete measurement, but suffers from high sensitivity to pileup effects. Pileup-suppressed variants which exploit tracking information to reduce pileup have been developed.



ATLAS-CONF-2013-082

Comparing data to simulation after applying a $\mathrm{Z} \to \mu\mu$ selection, before pileup suppression. Agreement is reasonable over most of the spectrum

Simulated $\mathrm{W} \to e\nu$ events, showing the comparison to the truth shape. The use of STVF pileup suppression largely removes this, and almost matches the truth distribution



ATLAS-CONF-2013-082

Systematic uncertainties and pileup suppression of missing transverse momentum

ATLAS-CONF-2013-082

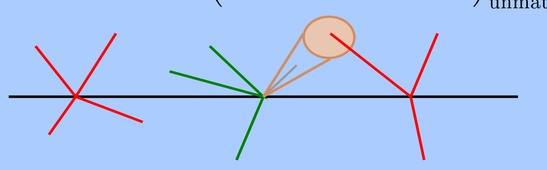
Systematic uncertainties for individual objects are propagated through the calculation, while the soft term offers two methods of estimation

$\mathrm{E_T^{miss,SoftTerm}}$ uncertainty	data/MC method		balance method	
	scale (%)	resolution (%)	scale ([GeV])	resolution (%)
Default	3.6	2.3	<1 GeV	2.0
STVF	7.9	4.8	<1 GeV	4.5
Extrap. Jet Area Filt.	4.7	2.0	<1 GeV	3.0
Jet Area Filtered	5.8	2.5	<1 GeV	2.0

Note: balance values are for small $\mathrm{p_T^{hard}}$

STVF: event-by-event correction for the fraction of track momentum from the Primary Vertex for unmatched objects

$$\mathrm{E}_{\mathrm{T,corr}}^{\mathrm{miss,soft}} = \mathrm{E}_{\mathrm{T}}^{\mathrm{miss,soft}} \cdot \left(\sum \mathrm{p}_{\mathrm{T}}^{\mathrm{track,PV}} / \sum \mathrm{p}_{\mathrm{T}}^{\mathrm{track}} \right)_{\mathrm{unmatched}}$$



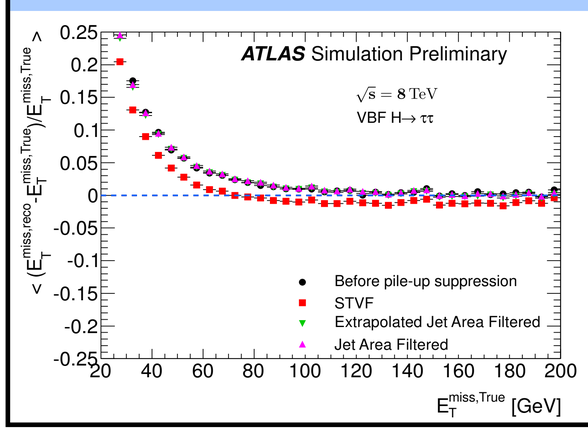
Jet area methods:
1. Compute event average energy density
2. Subtract pileup using each jet's area
3. Apply track filter

$$\mathrm{E}_{\mathrm{T,jet}}^{\mathrm{corr}} = \begin{cases} 0 & \mathrm{E_{T,jet}} \le \rho \mathrm{A_{jet}} \\ \mathrm{E_{T,jet}} - \rho \mathrm{A_{jet}} & \mathrm{E_{T,jet}} > \rho \mathrm{A_{jet}} \end{cases}$$

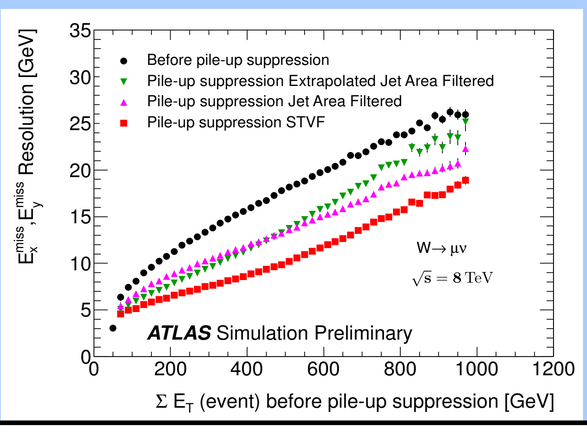
$$\mathrm{CO\_JVF} = \left(\sum \mathrm{p}_{\mathrm{T}}^{\mathrm{track,PV}} / \sum \mathrm{p}_{\mathrm{T}}^{\mathrm{track}} \right)_{\mathrm{kT}} > 0.25$$

Constant: Use median ρ for full η range
Extrapolated: parametrize shape $\rho(\mu, \mathrm{N_{pv}})$

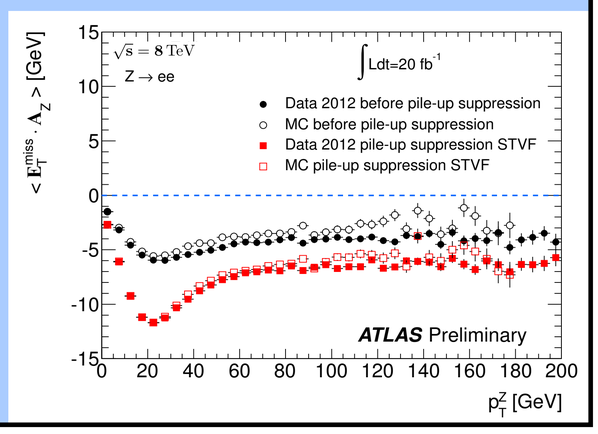
Linearity for VBF produced $\mathrm{H} \to \tau\tau$ events, showing good agreement between truth and reconstruction, particularly above ~60 GeV



Resolution of $\mathrm{W} \to \mu\nu$ events as a function of the full event scalar sum of transverse momentum, before and after pileup suppression



Projection of $\mathrm{E_T^{miss}}$ in $\mathrm{Z} \to ee$ events along the Z boson axis. The average is nonzero due to hadronic effects/response



Missing transverse momentum performance in Run-II and beyond

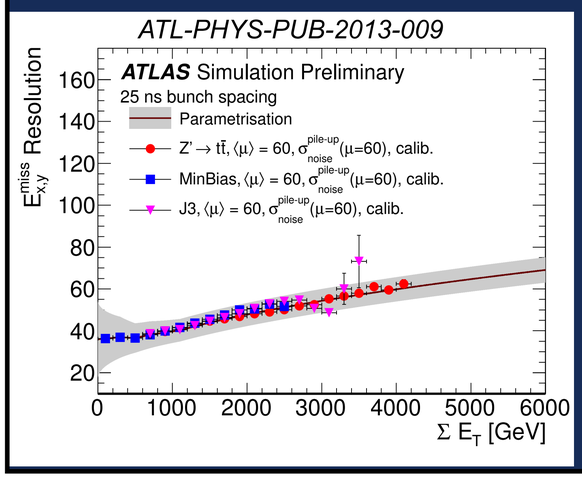
Performance studies at $\sqrt{\mathrm{s}} = 14$ TeV and high pileup conditions
ATL-PHYS-PUB-2013-009 and Twiki: AtlasPublic/JetEtMissApproved2013HighMuEtMiss

Integrating calorimeter and tracking information

Combining the strengths of calorimeter-based hard terms and track-based soft terms yields improvements in the precision and pileup stability of missing transverse momentum at high luminosity.

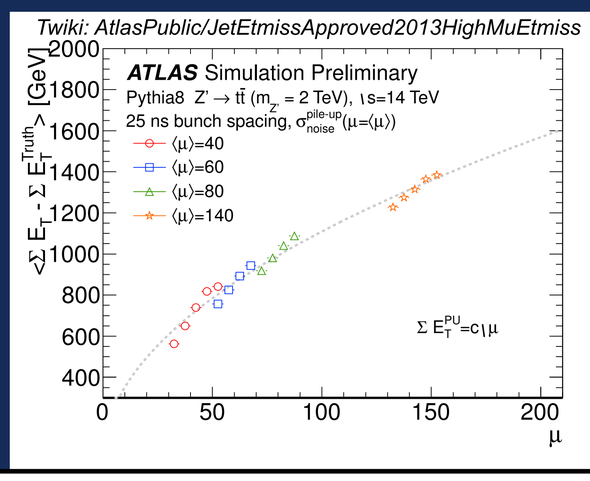
Resolution of the truth smearing parameterization compared with reconstructed resolution for Z', minimum bias, and dijet samples

ATL-PHYS-PUB-2013-009



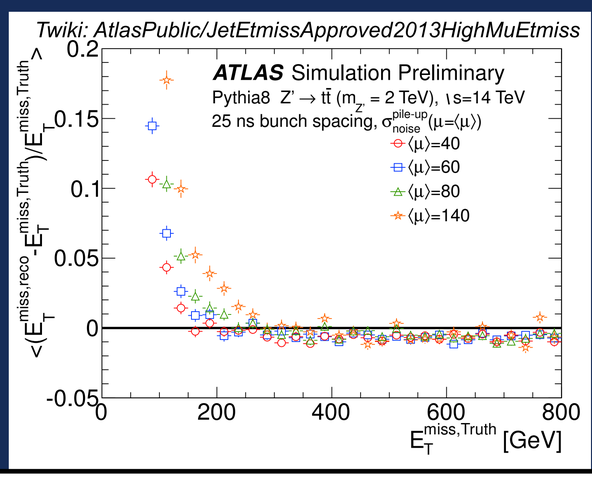
Pileup contributions to the scalar sum of transverse momentum as a function of the average number of interactions per bunch crossing

Twiki: AtlasPublic/JetEtmissApproved2013HighMuEtmiss



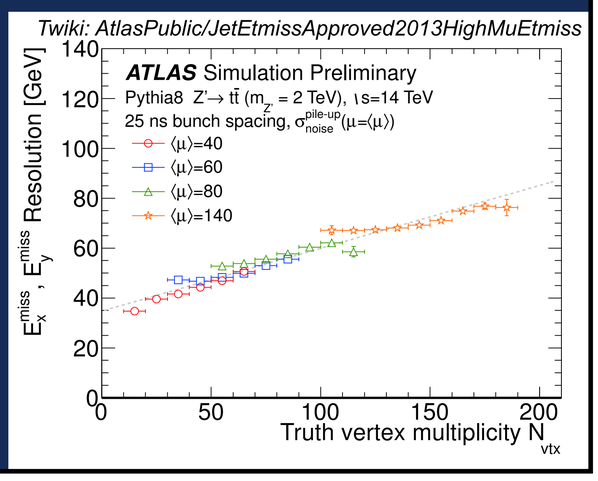
Linearity of missing transverse momentum for multiple possible values of the average number of interactions per bunch crossing

Twiki: AtlasPublic/JetEtmissApproved2013HighMuEtmiss



Resolution vs the number of vertices per event, for multiple possible values of the average number of interactions per bunch crossing

Twiki: AtlasPublic/JetEtmissApproved2013HighMuEtmiss



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