

# TOP-13-003: Updated unfolding systematic

# New unfolding systematic

- Our old unfolding systematic double-counted the data stat uncertainty
- We have re-evaluated the unfolding systematic based on linearity tests.
- Linearity tests done by adding an asymmetry to the SM MC distribution by weighting the MC
  - $\text{weight} = 1 + \text{slope} * f(x)$ , where  $x$  is the asymmetry variable at gen-level. 4 functional forms  $f(x)$  are chosen to simulate the observed deviation between data and MC.
- For each  $f(x)$  make PEs for each value of the “slope” (between -0.3 and +0.3) by Poisson-fluctuating the weighted reco-level MC distribution, and unfolding them using the default (unweighted) response matrix
- plot of mean unfolded asymmetry vs true asymmetry gives linearity

# Results

- Linearity plots all show zero “offset”, the only bias is from slope (“p l”) which deviates from 1
- Unfolding systematic taken from the worst slope observed, multiplied by the difference between the unfolded result in data and the MC truth:  $\text{syst} = \max(\text{abs}(p l - 1)) * (\text{data\_unf} - \text{MC\_true})$
- unfolding systematic is small if the data agrees well with the MC
- to prevent it going to zero, I added in quadrature the data stat uncertainty to  $(\text{data\_unf} - \text{MC\_true})$ , i.e.  $\text{syst} = \max(\text{abs}(p l - 1)) * \text{sqrt}[(\text{data\_unf} - \text{MC\_true})^2 + \text{stat}_{\text{data}}^2]$

	New unfolding syst	Old unfolding syst (incorrect)
AΔphi	0.004	0.008
Ac1c2	0.020	0.026
AP	0.002	0.014

- Note, the new unfolding systematic for  $A_P$  is small as required, because the data almost exactly matches the MC

# Old tables

Asymmetry variable	$A_{\Delta\phi}$	$A_{c1c2}$	$A_P$
experimental systematic uncertainties			
Jet energy scale	0.002	0.012	0.009
Jet energy resolution	0.000	0.000	0.000
Lepton energy scale	0.001	0.001	0.001
b-tagging SF	0.000	0.000	0.001
Lepton selection	0.000	0.000	0.000
Pileup	0.002	0.002	0.004
Background	0.003	0.001	0.006
$t\bar{t}$ modeling uncertainties			
Top mass	0.004	0.015	0.027
Fact. and renorm. scales	0.001	0.010	0.004
Tau decay	0.001	0.002	0.001
PDF	0.002	0.002	0.001
<b>Unfolding</b>	<b>0.008</b>	<b>0.026</b>	<b>0.014</b>
Total systematic uncertainty	0.010	0.034	0.033
Top $p_T$ reweighting uncertainty	0.012	0.010	0.008

Asym.	Data (unfolded)	Simulation	NLO (corr.)	NLO (uncorr.)
$A_{\Delta\phi}$	$0.113 \pm 0.010 \pm 0.010 \pm 0.012$	$0.110 \pm 0.001$	$0.115^{+0.014}_{-0.016}$	$0.210^{+0.013}_{-0.008}$
$A_{c1c2}$	$-0.021 \pm 0.023 \pm 0.034 \pm 0.010$	$-0.078 \pm 0.001$	$-0.078 \pm 0.006$	0
$A_P$	$0.005 \pm 0.013 \pm 0.033 \pm 0.008$	$0.000 \pm 0.001$	N/A	N/A

Table 2: Parton-level asymmetries. The uncertainties on the unfolded results are statistical, systematic, and the additional uncertainty from the top  $p_T$  reweighting. The uncertainties on the simulated results are statistical only, while the uncertainties on the NLO calculations for correlated and uncorrelated  $t\bar{t}$  come from scale variations up and down by a factor of 2. The result for  $A_{c1c2}$  is exactly zero in the absence of spin correlation by construction.

Table 1: Systematic uncertainties on the unfolded values of  $A_{\Delta\phi}$ ,  $A_{c1c2}$  and  $A_P$ .

# New tables

Asymmetry variable	$A_{\Delta\phi}$	$A_{c1c2}$	$A_P$
experimental systematic uncertainties			
Jet energy scale	0.002	0.012	0.009
Jet energy resolution	< 0.001	< 0.001	< 0.001
Lepton energy scale	0.001	0.001	0.001
b-tagging SF	< 0.001	< 0.001	0.001
Lepton selection	< 0.001	< 0.001	< 0.001
Pileup	0.002	0.002	0.004
Background	0.003	0.001	0.006
$t\bar{t}$ modeling uncertainties			
Top mass	0.002	0.009	0.016
Fact. and renorm. scales	0.001	0.010	0.004
Tau decay	0.001	0.002	0.001
PDF	0.002	0.002	0.001
<b>Unfolding</b>	<b>0.004</b>	<b>0.020</b>	<b>0.002</b>
Total systematic uncertainty	0.007	0.027	0.020
Top $p_T$ reweighting uncertainty	0.012	0.010	0.008

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note: these tables also have the updated mass systematic

# Old plots

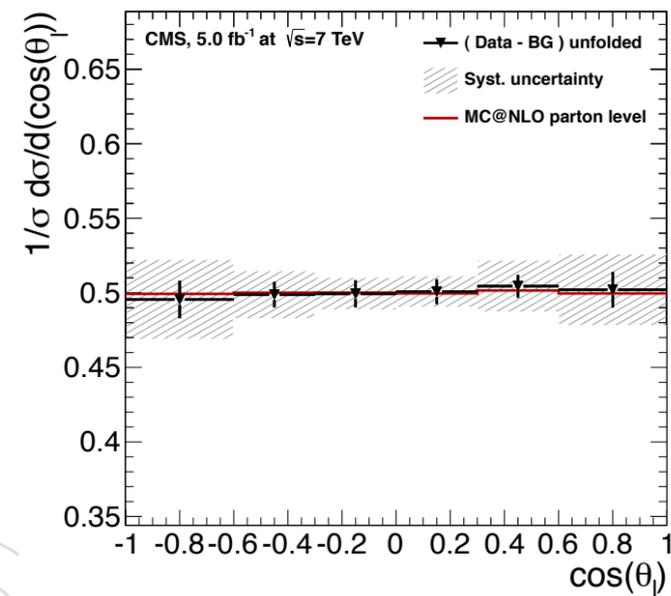
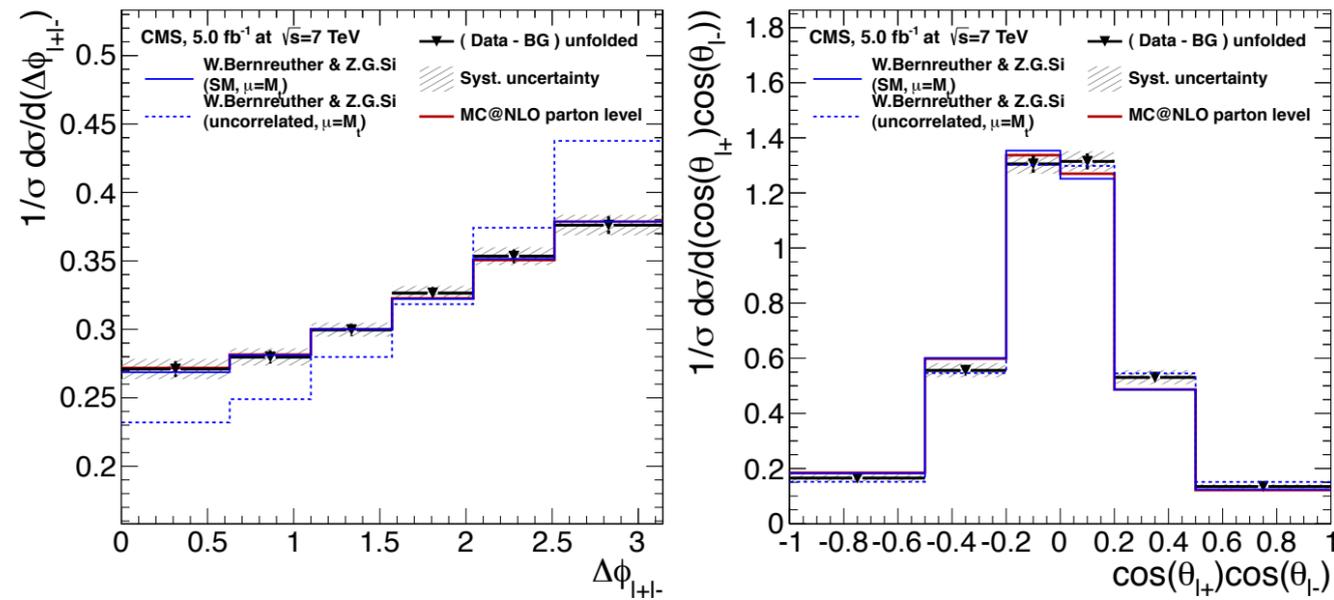


Figure 1: Background-subtracted and unfolded differential cross-sections for  $\Delta\phi_{l+l-}$ ,  $\cos(\theta_{l+}) \times \cos(\theta_{l-})$ , and  $\cos(\theta_l)$ . The error bars represent statistical uncertainties only, while the systematic uncertainty band is represented by the hatched area. Note that the bin values are correlated due to the unfolding.

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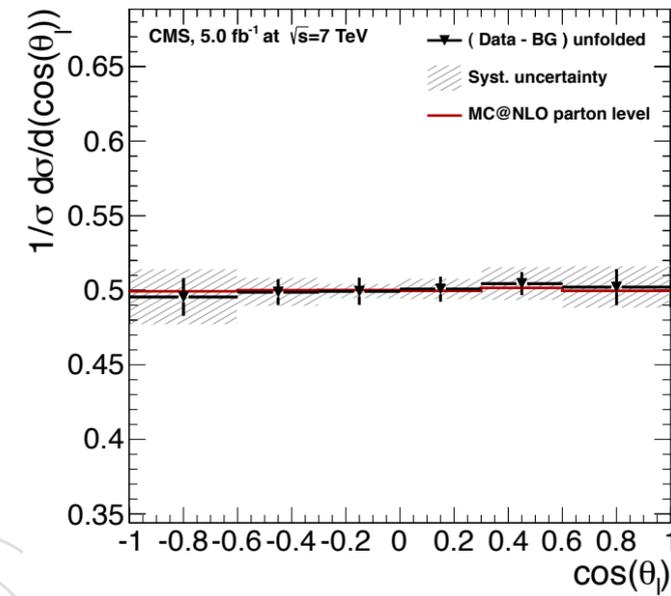
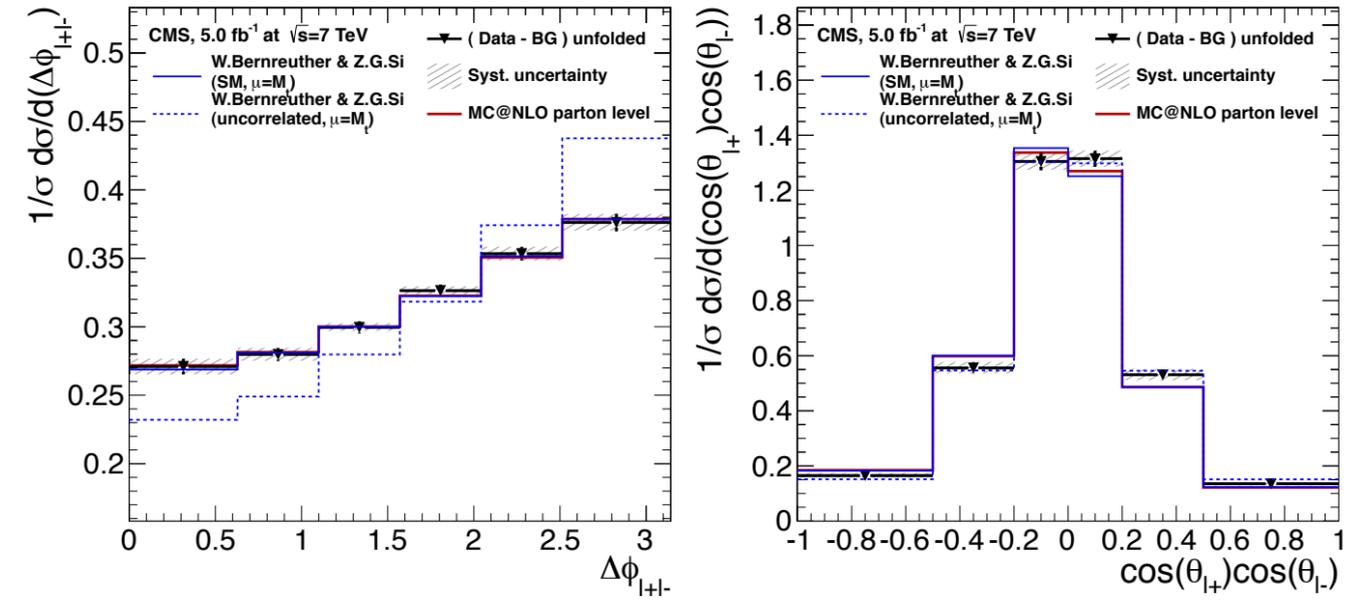


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note: these plots also have the updated mass systematic