# Test of top $p_T$ reweighting (7 TeV "AFB" analyses)

# Introduction

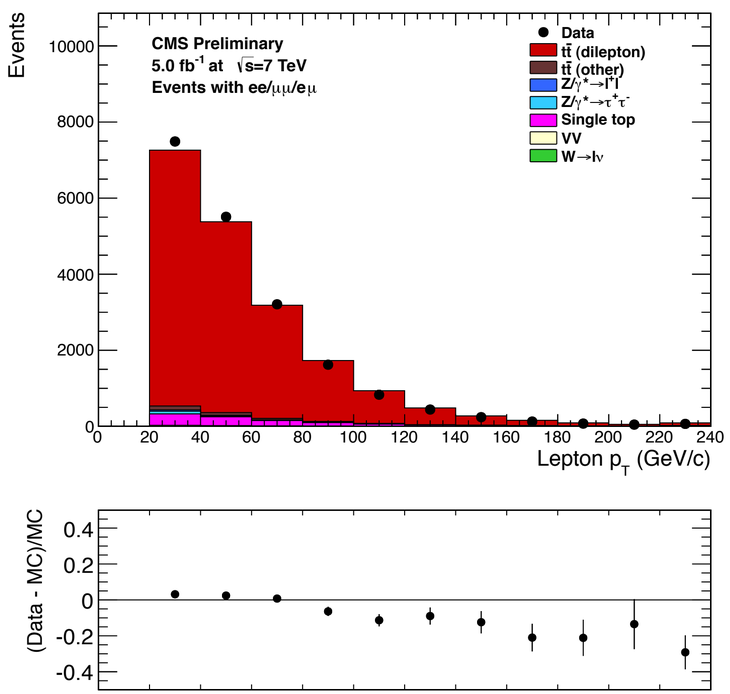
- These slides give a good summary of the reweighting procedure we're using: https://indico.cern.ch/getFile.py/access?contribId=1&resId=0&materialId=slides&confId=254297

- The plots on the following slides compare data and MC for our preselection, before and after reweighting, using 3 different MC samples (madgraph, powheg-tauola, and MC@NLO). The MC is normalised to the data.

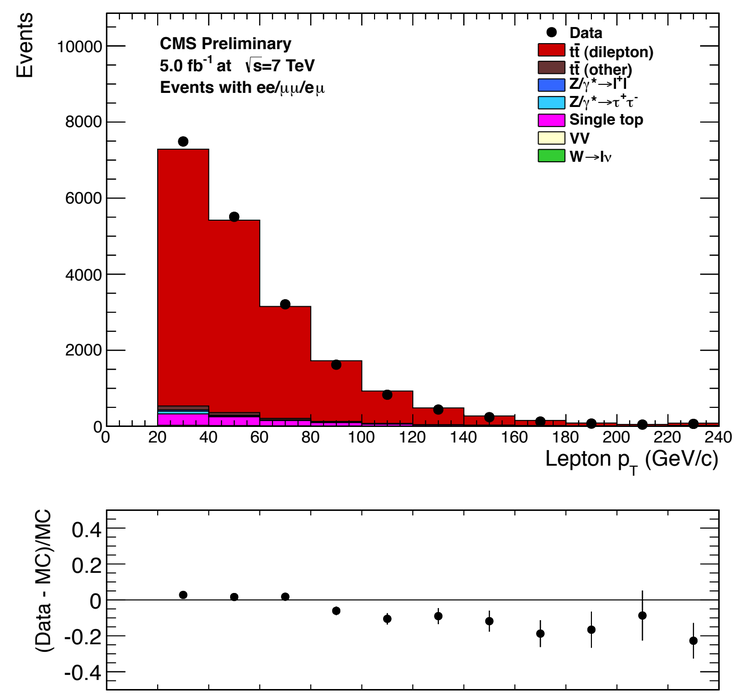
- Flick between each pair of slides to see the effect of the top $p_T$ reweighting on the 3 different MCs

# Lepton $p_T$, before reweighting

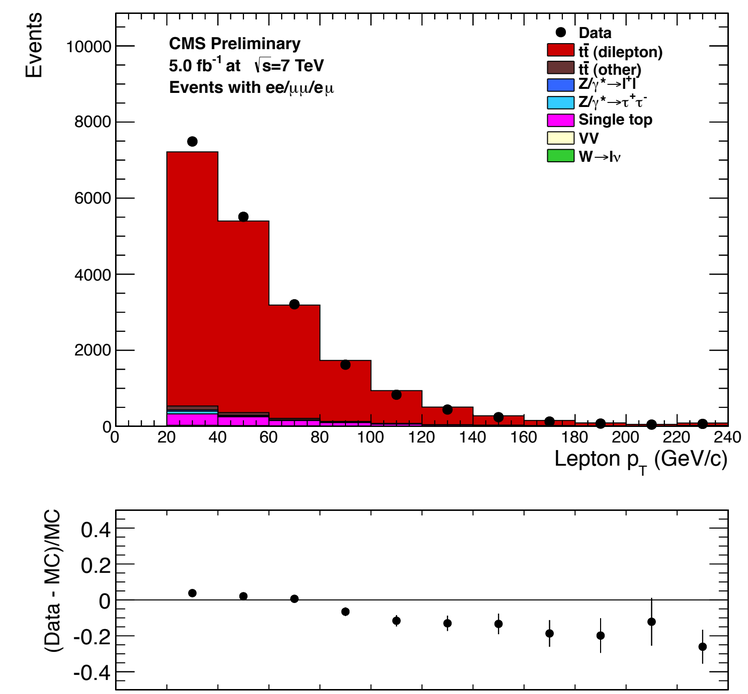
## madgraph




## powheg-tauola

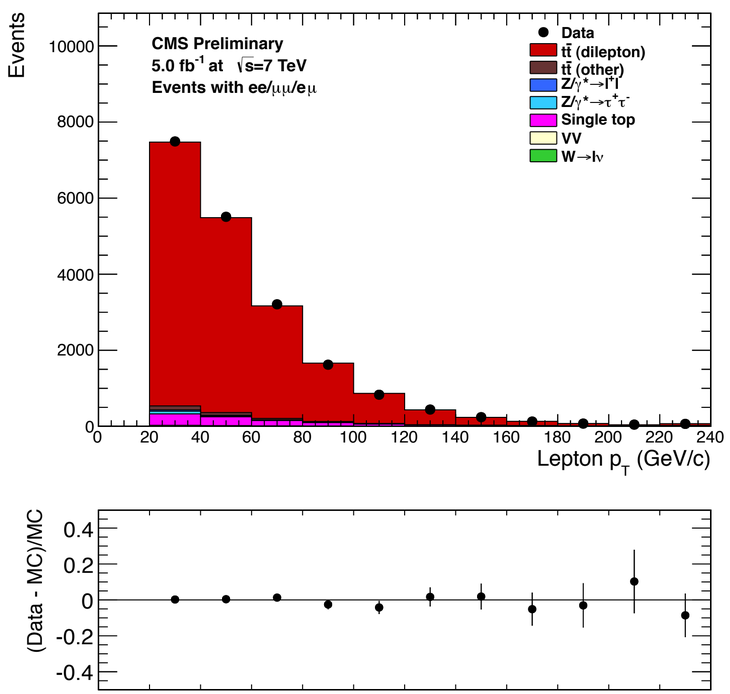



## mc@nlo

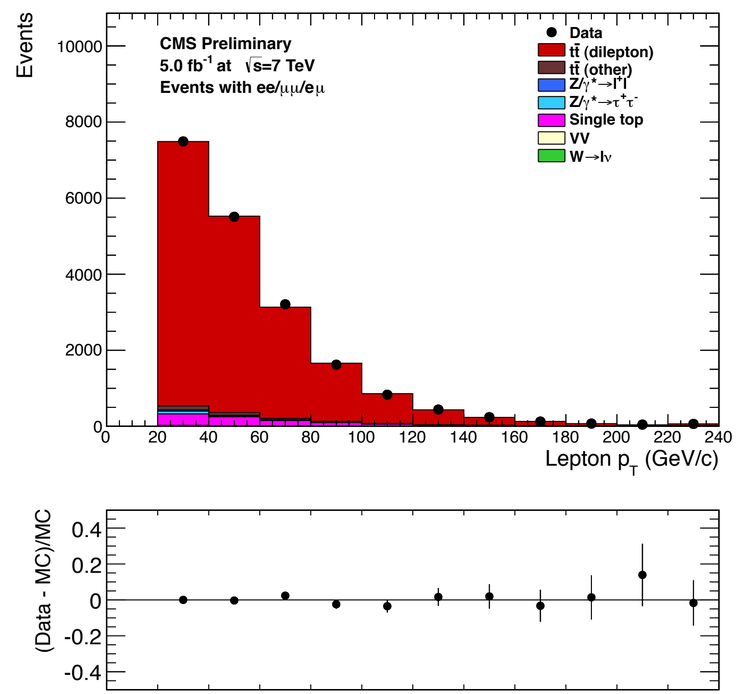


# Lepton $p_T$, after reweighting

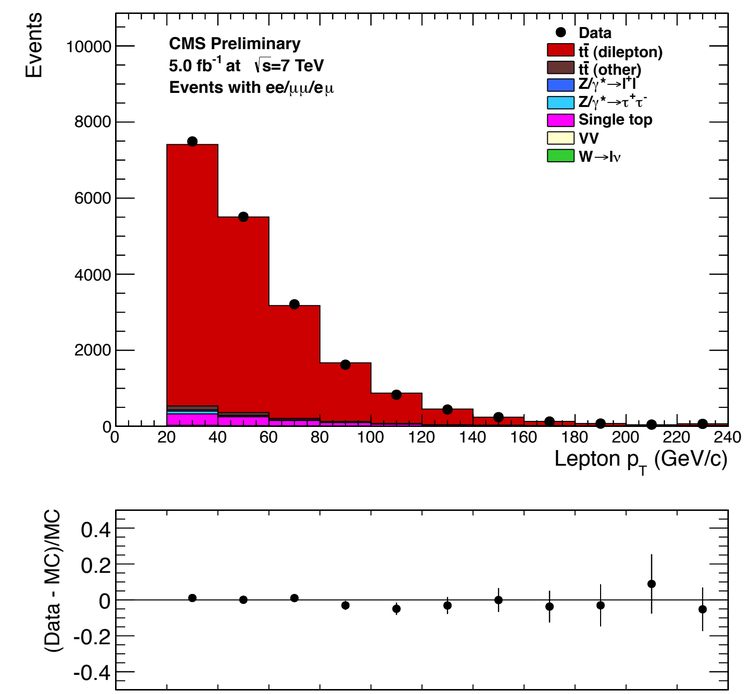
## madgraph




## powheg-tauola

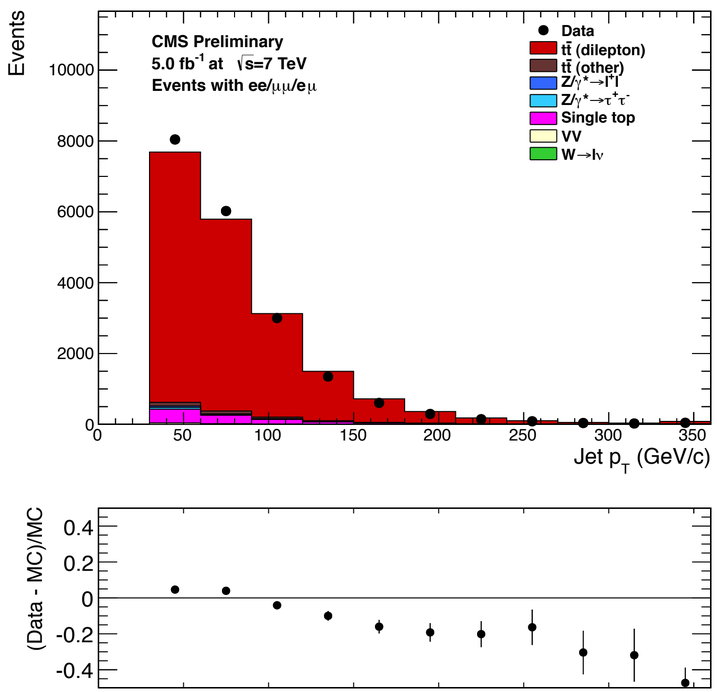



## mc@nlo

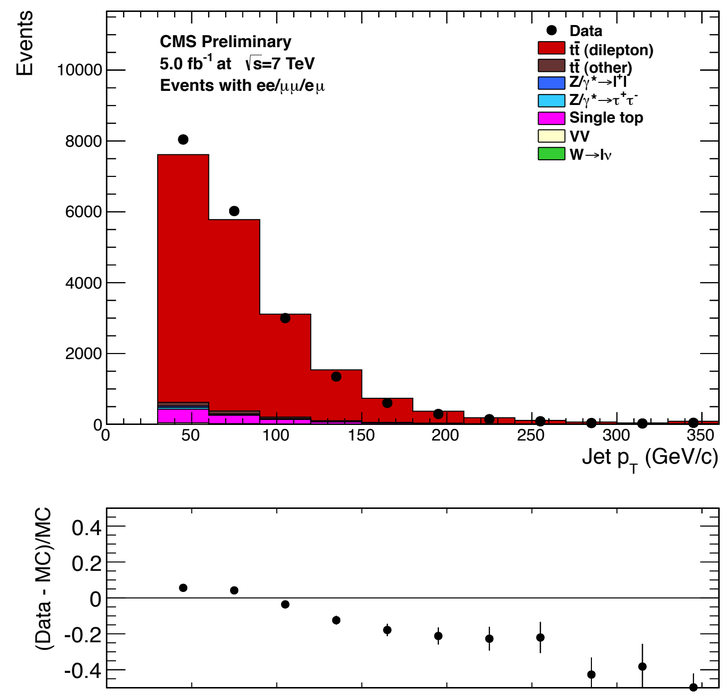


# Jet $p_T$, before reweighting

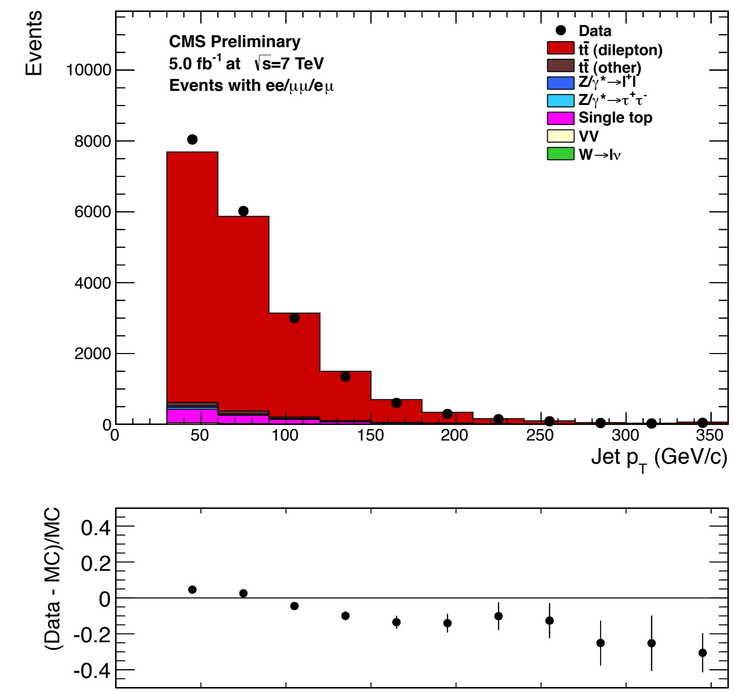
## madgraph




## powheg-tauola

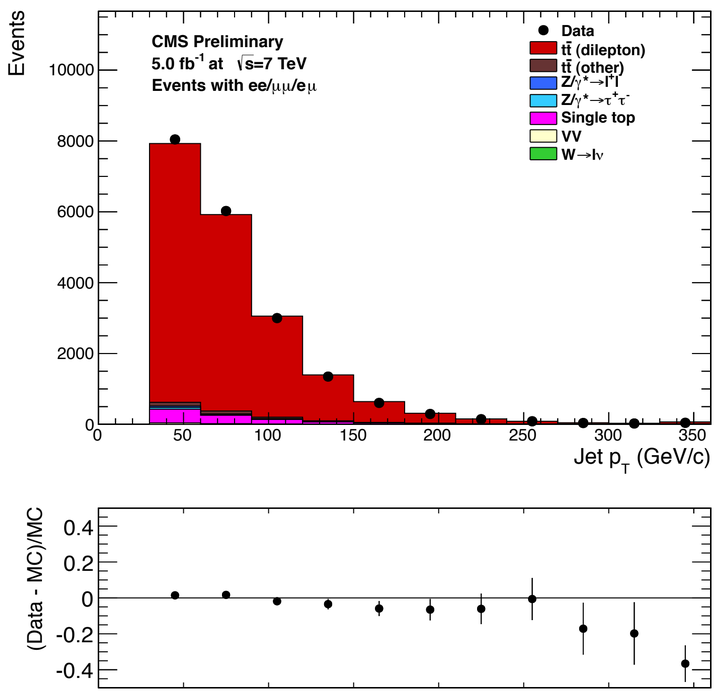



## mc@nlo

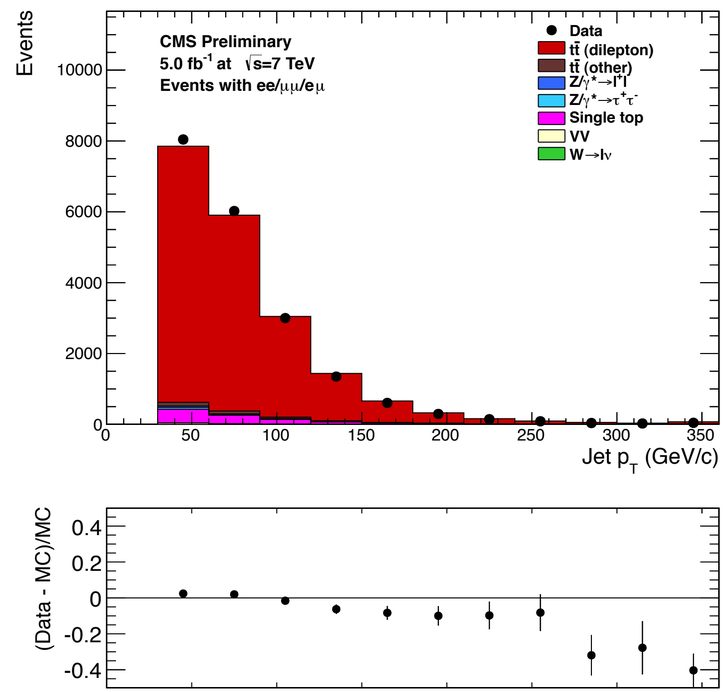


# Jet $p_T$, after reweighting

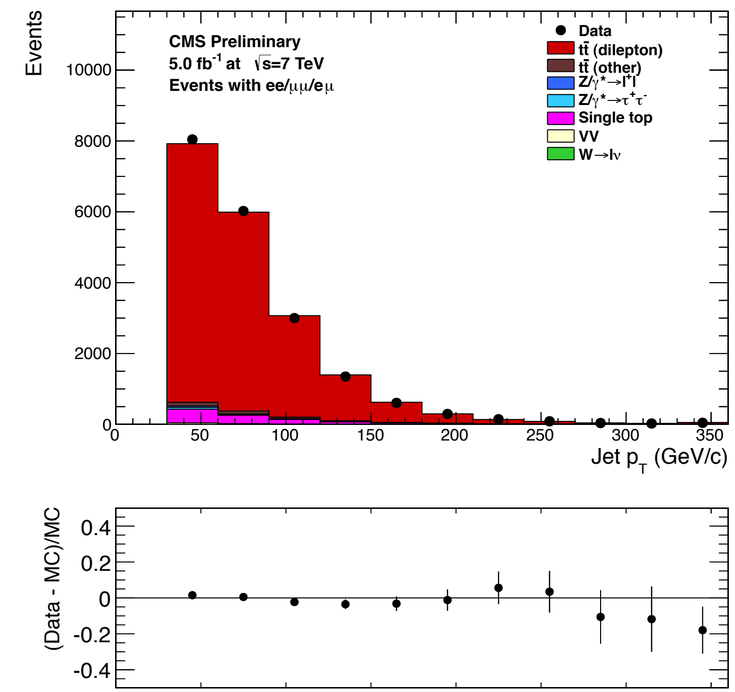
## madgraph




## powheg-tauola

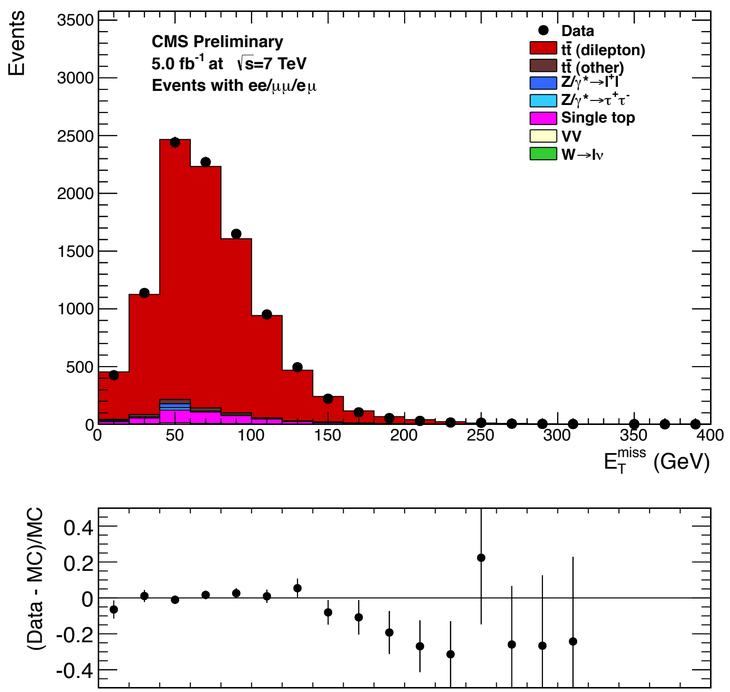



## mc@nlo

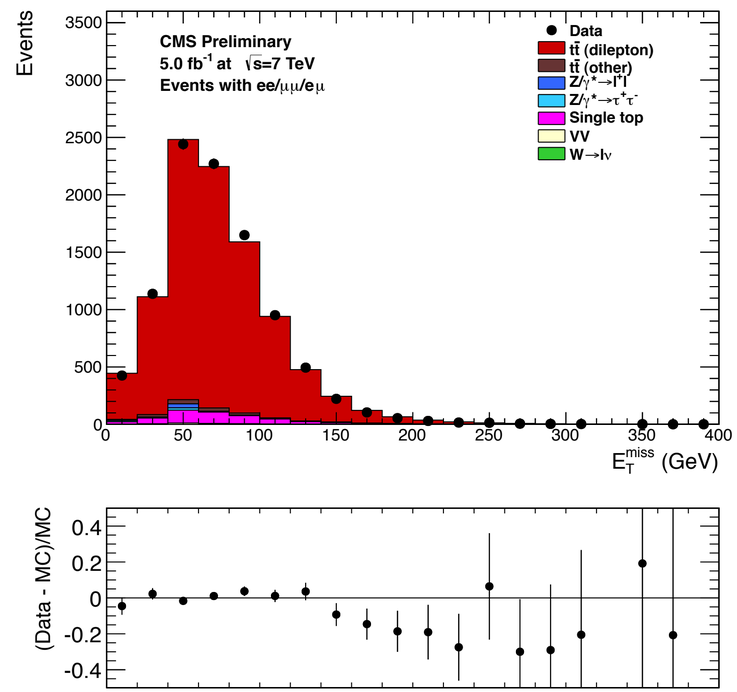


# MET, before reweighting

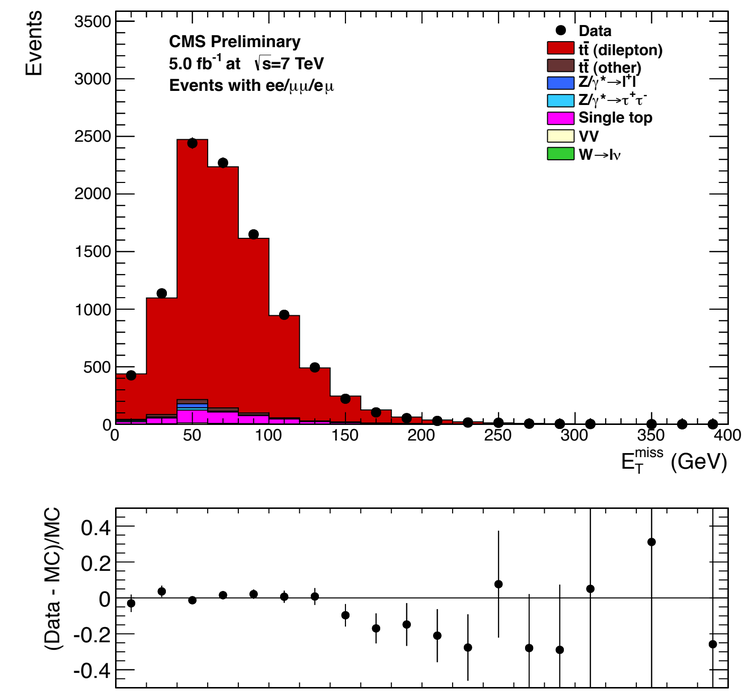
## madgraph




## powheg-tauola

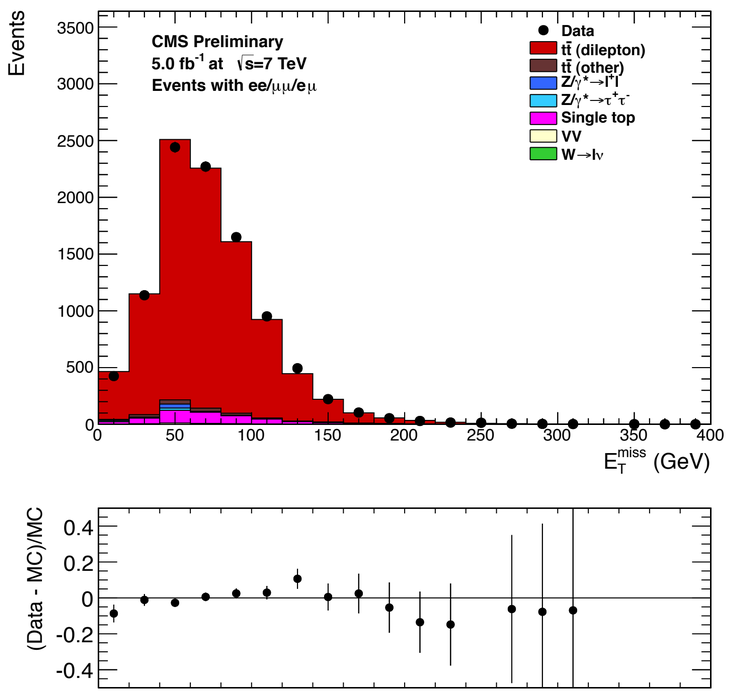



## mc@nlo

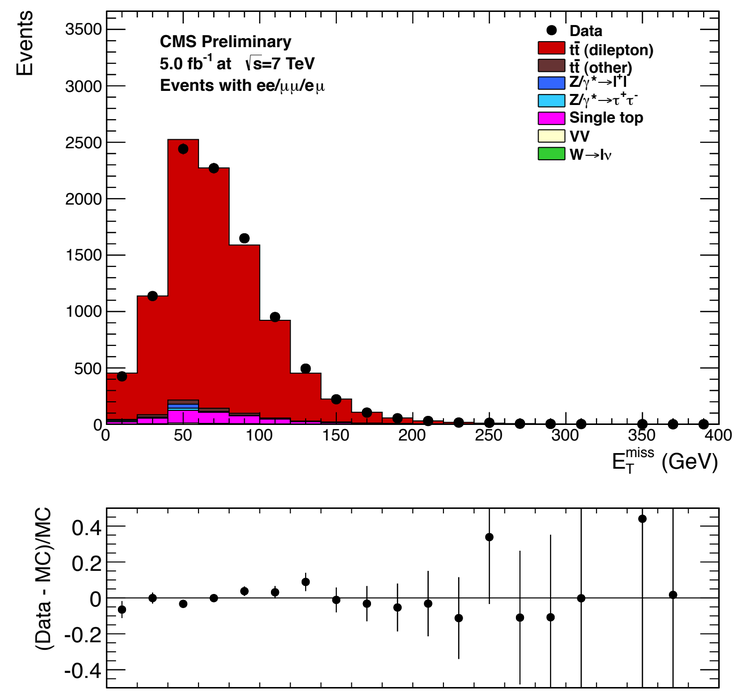


# MET, after reweighting

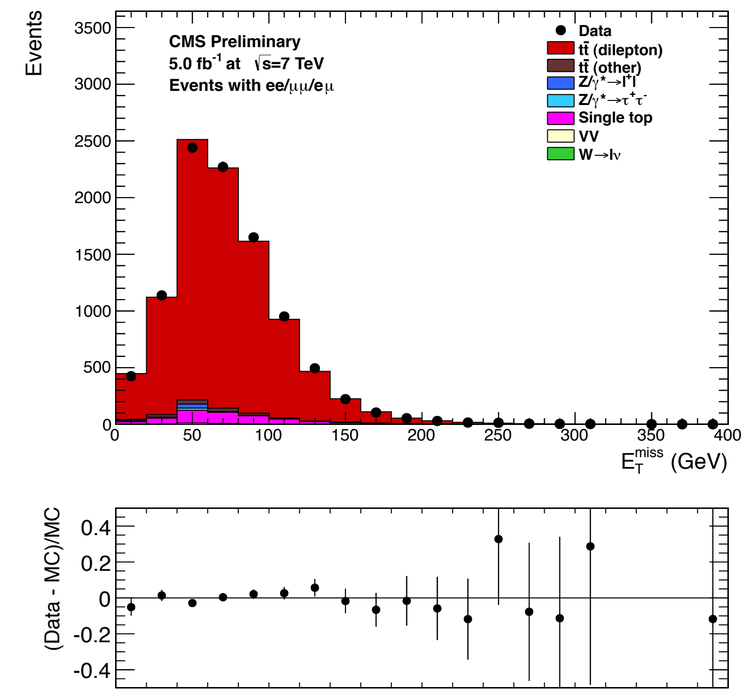
## madgraph




## powheg-tauola

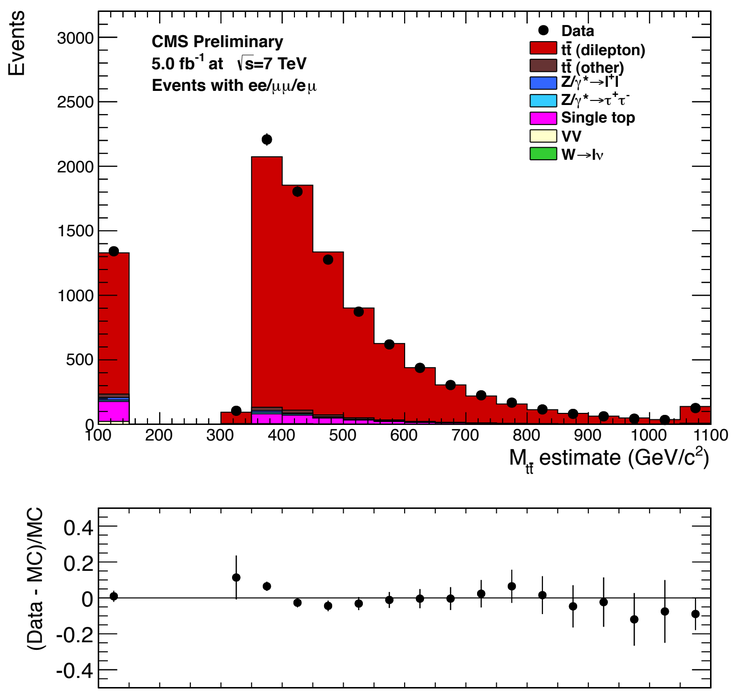



## mc@nlo

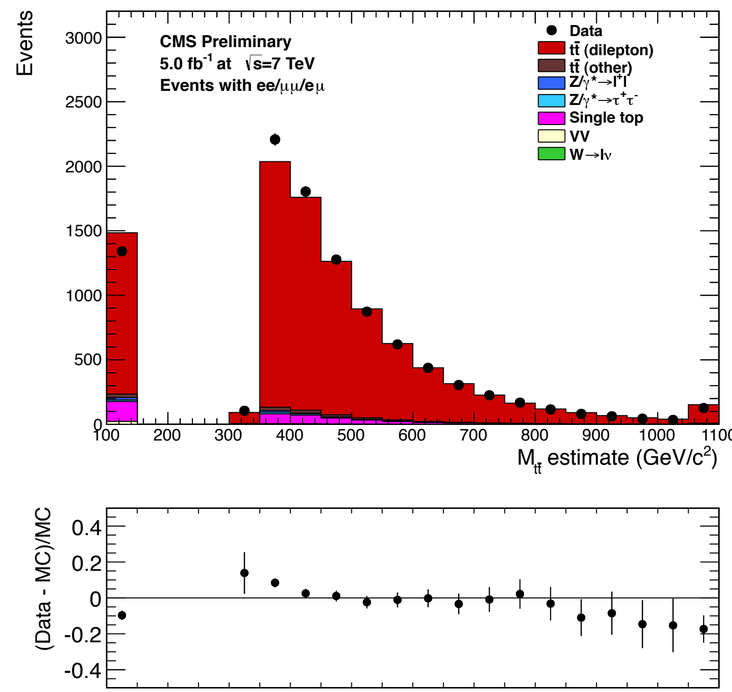


# $M_{ttbar}$, before reweighting

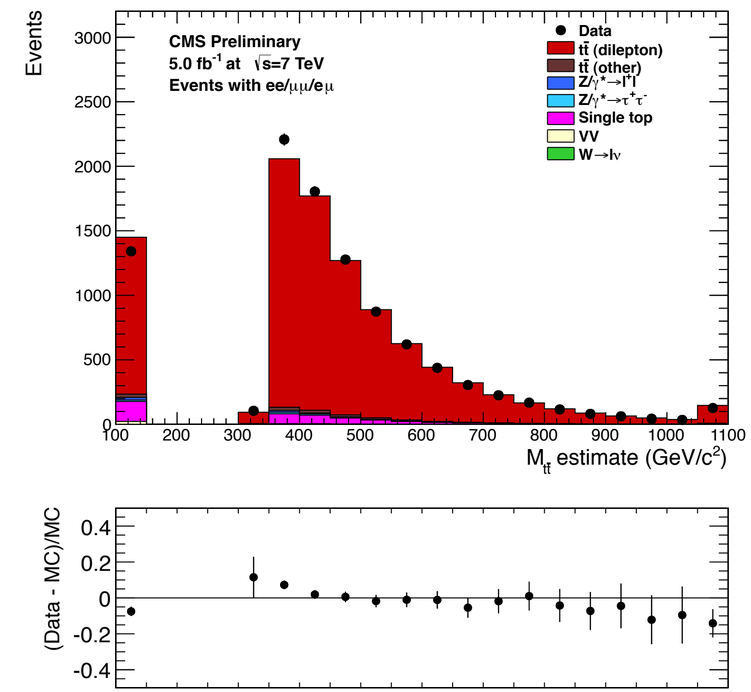
## madgraph




## powheg-tauola

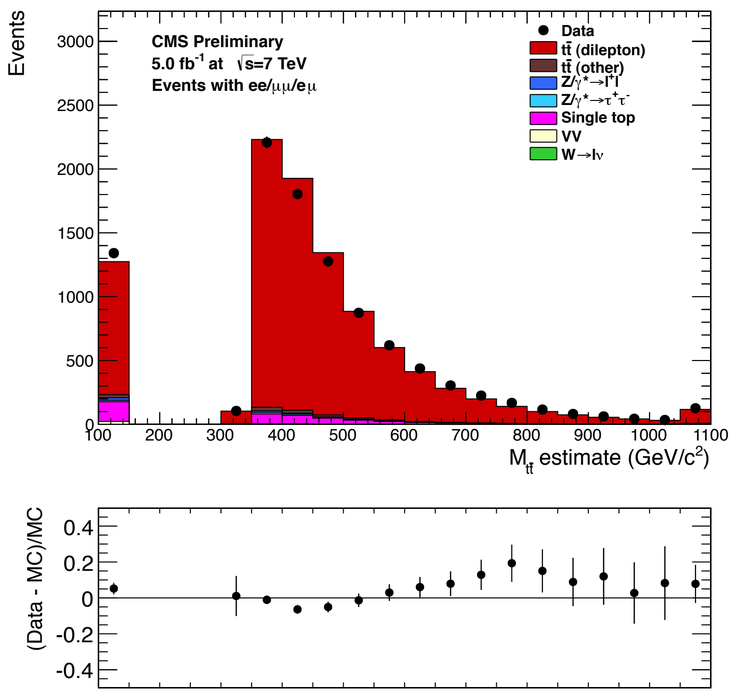



## mc@nlo

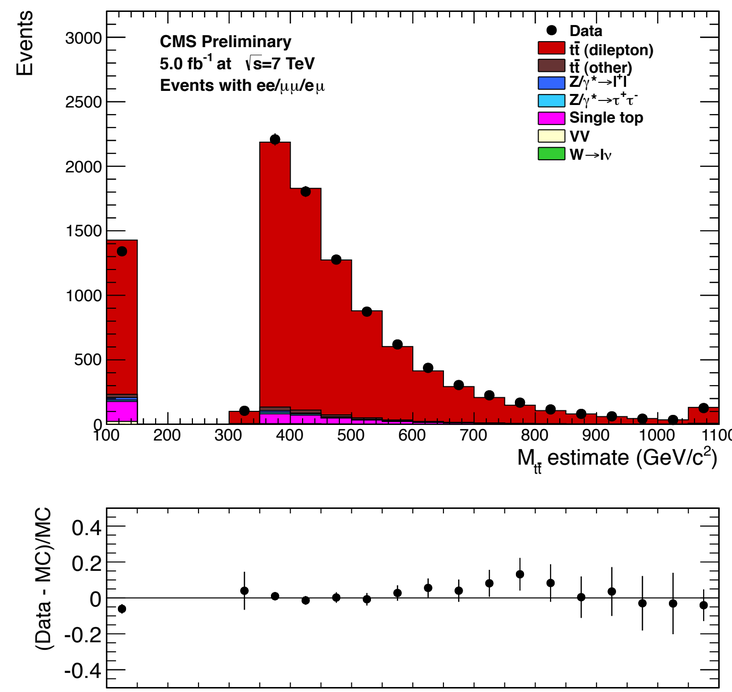


# $M_{ttbar}$, after reweighting

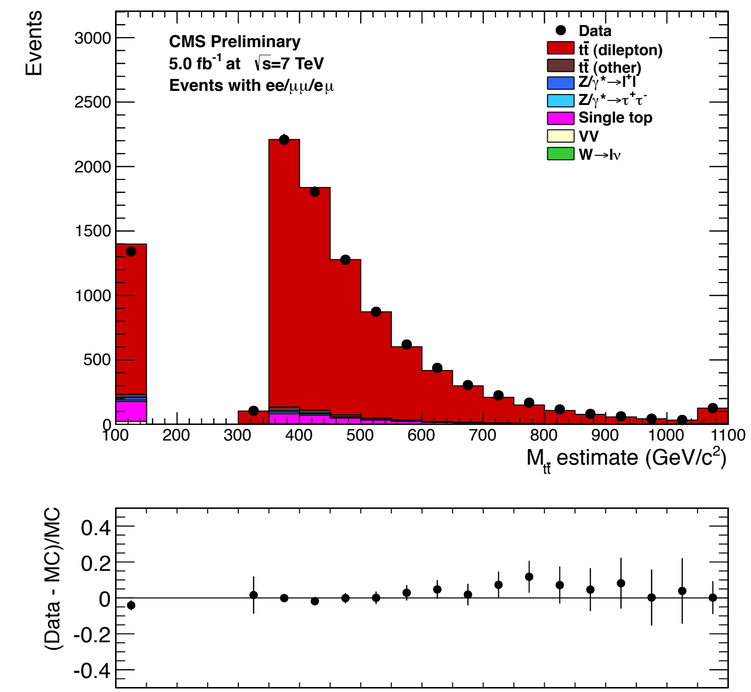
## madgraph




## powheg-tauola

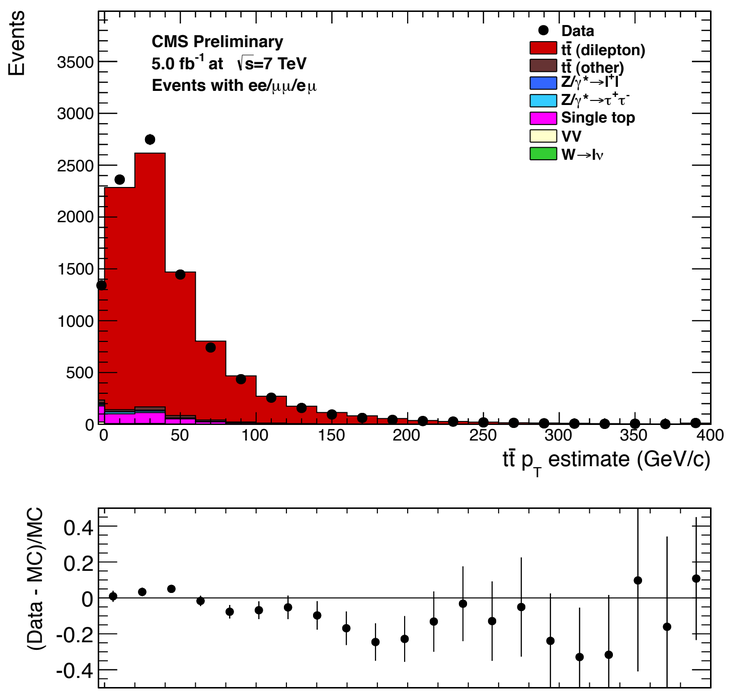



## mc@nlo

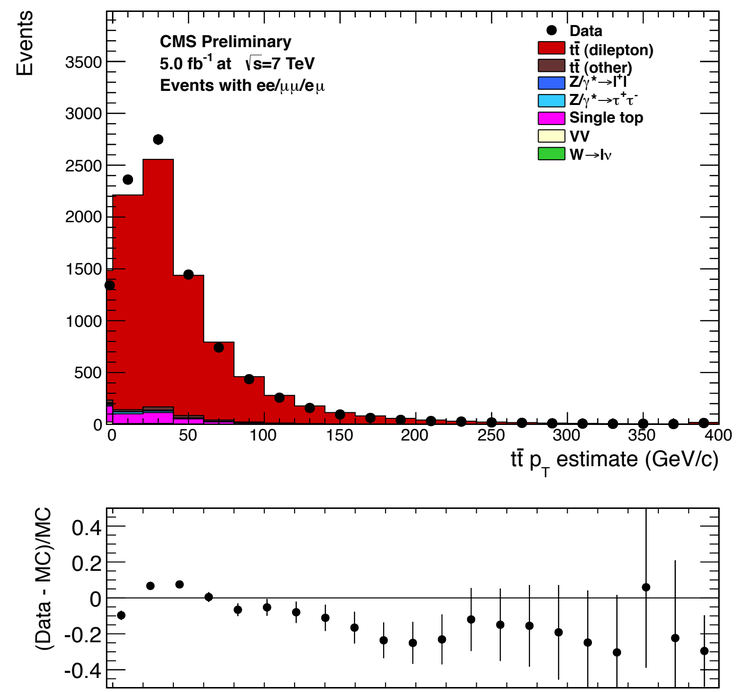


# ttbar $p_T$, before reweighting

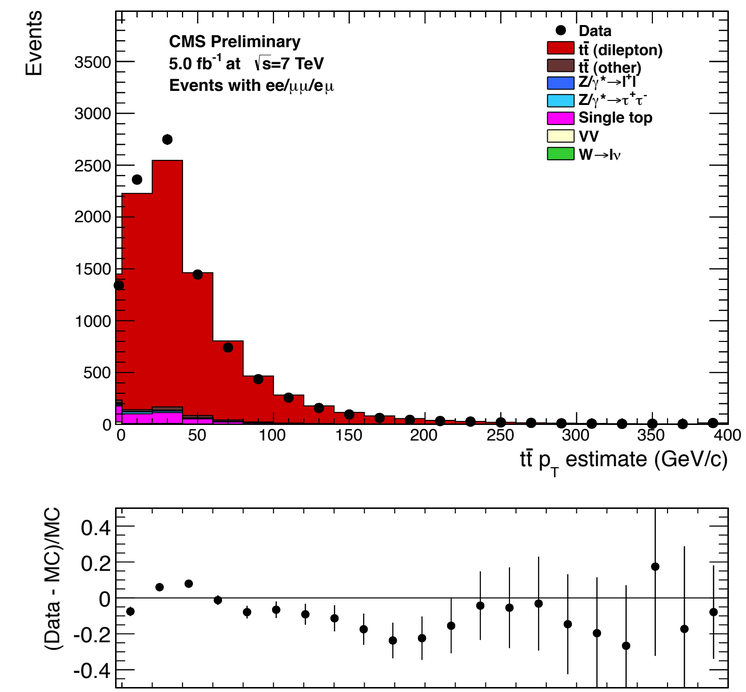
## madgraph




## powheg-tauola

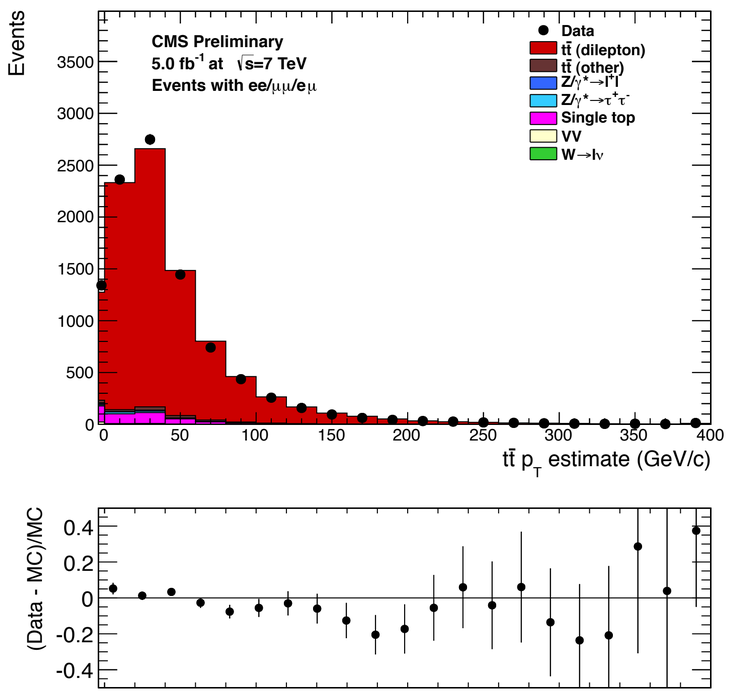



## mc@nlo

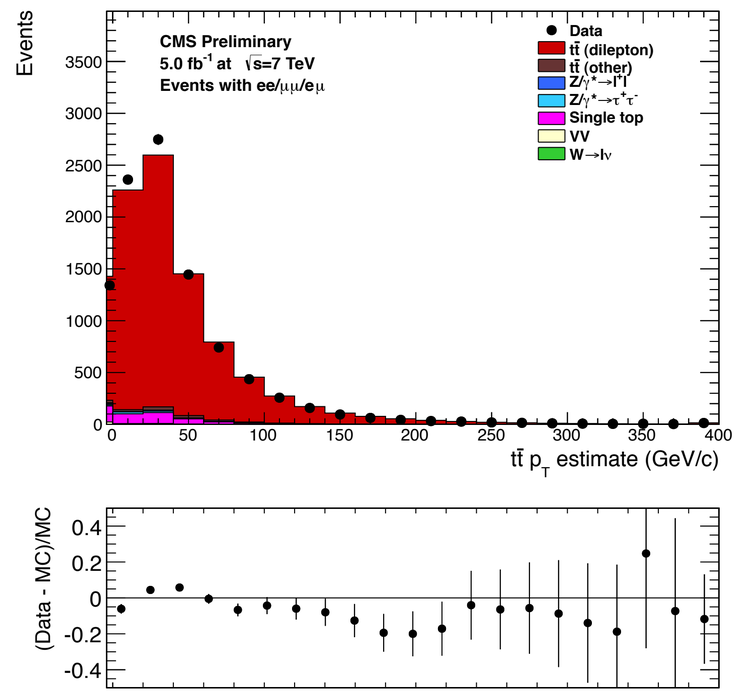


# ttbar $p_T$, after reweighting

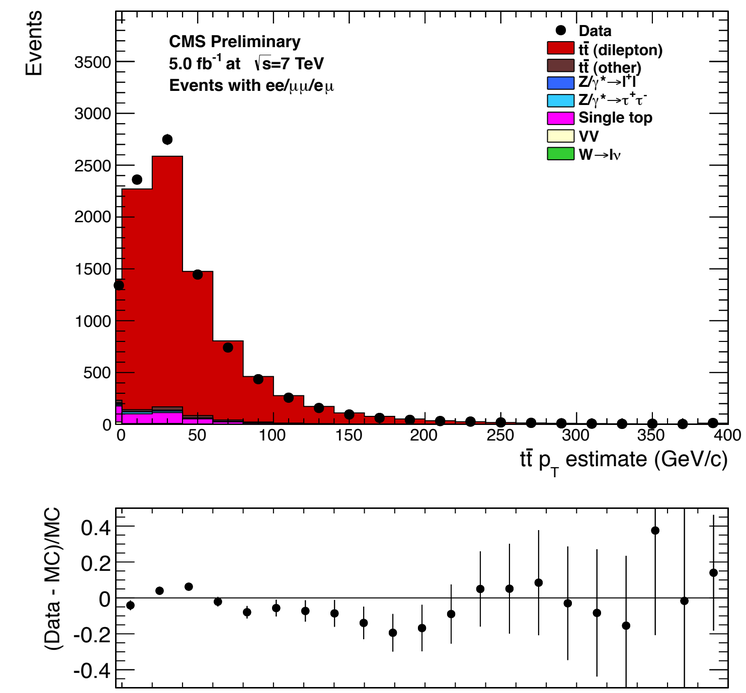
## madgraph




## powheg-tauola




## mc@nlo



# Conclusion on $p_T$ reweighting

- Top $p_T$ reweighting consistently improves data modeling of all three MC samples
  - of particular importance to our analysis, the reweighting significantly improves the MC modeling of $M_{ttbar}$, which we are using in 2D unfolding to measure $A_{FB}$ vs $M_{ttbar}$ etc.
  - if we were not to use top $p_T$ reweighting, we would have to consider an ad-hoc $M_{ttbar}$ reweighting, which unlike the top $p_T$ reweighting would not be unambiguously defined in fully inclusive phase space
  - also improves $p_{T,ttbar}$, which we are currently commissioning for 2D unfolding

# Top $p_T$ reweighting systematic

- It's clear the top $p_T$ reweighting improves the MC modeling of the data in general (not just a random # generator specific to our MC@NLO sample)
- Therefore seems sensible to use it even if the question of what it is correcting for is still open (e.g. is it a NNLO/NLO correction?)
  - Kidonakis's approx NNLO differential xsec in top $p_T$ agrees well with the data in both 7 TeV and 8 TeV, in both lepton +jets and dilepton, but apparently others have been unable to reproduce his results
  - good summary in these slides: https://indico.cern.ch/getFile.py/access?contribId=1&resId=0&materialId=slides&confId=254297
- The answer to the above question tells us how to estimate our systematic uncertainty on the top $p_T$ reweighting:
  - known effect: only the stat uncertainty on the $p_T$ reweighting function matters => take uncertainty directly from uncertainties on fitted function
  - unknown effect: no guarantee the reweighting improves all data/MC distributions (specifically, those we are trying to measure) => assign conservative systematic of 100% of the difference between nominal and reweighted (it can't be more wrong than this). For now we must take this systematic, but this can be changed at any time until the paper is finished.

# Consequences for our measurements

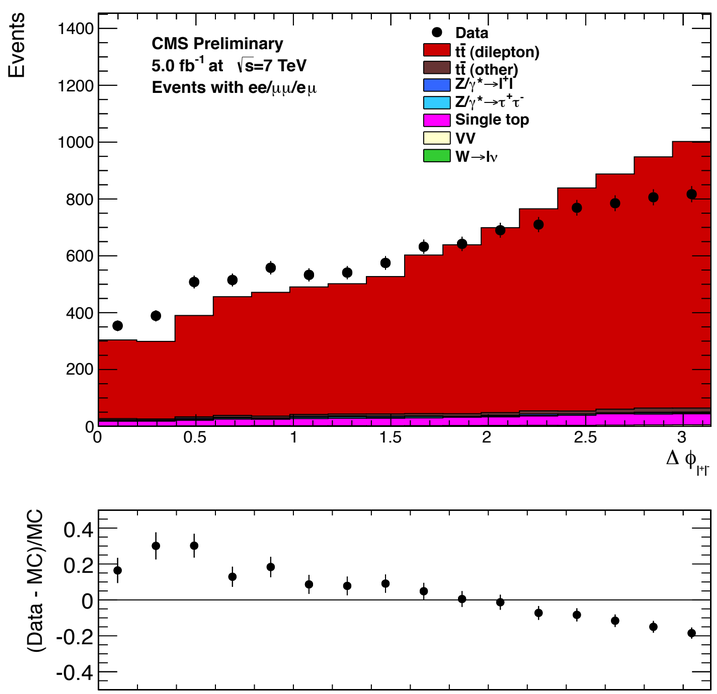
- Even the conservative systematic of 100% of the difference between nominal and reweighted is negligible for 4 of the 5 variables we are measuring. The total systematic uncertainty is only appreciably affected for lepton azimuthal asymmetry ( $\Delta$phi($l^+$,$l^-$) ).
- We measure A[$\Delta$phi(l+,l-)] = 0.113 ± 0.012 (stat) (using top $p_T$ reweighting)
- Total systematic uncertainty on A[$\Delta$phi(l+,l-)]:
  - excluding top $p_T$ reweighting systematic: 0.005
  - with 50% top $p_T$ reweighting systematic: 0.008 (50% is a conservative guess for the uncertainty from the fit alone. Here the top $p_T$ syst alone is equal to 0.006, i.e. roughly the total of all other systs)
  - with 100% top $p_T$ reweighting systematic: 0.013 (here the top $p_T$ syst is 0.012 and completely dominant, although still only the same size as the stat uncertainty)
- Note the PAS result had a very conservative total systematic uncertainty (A[$\Delta$phi(l+,l-)] = 0.097 ± 0.015 ± 0.036), so the result is significantly improved even with the 100% top $p_T$ reweighting systematic
  - even the most conservative top $p_T$ reweighting systematic gives a reduction by a factor of 3 in the total systematic uncertainty

# Next steps

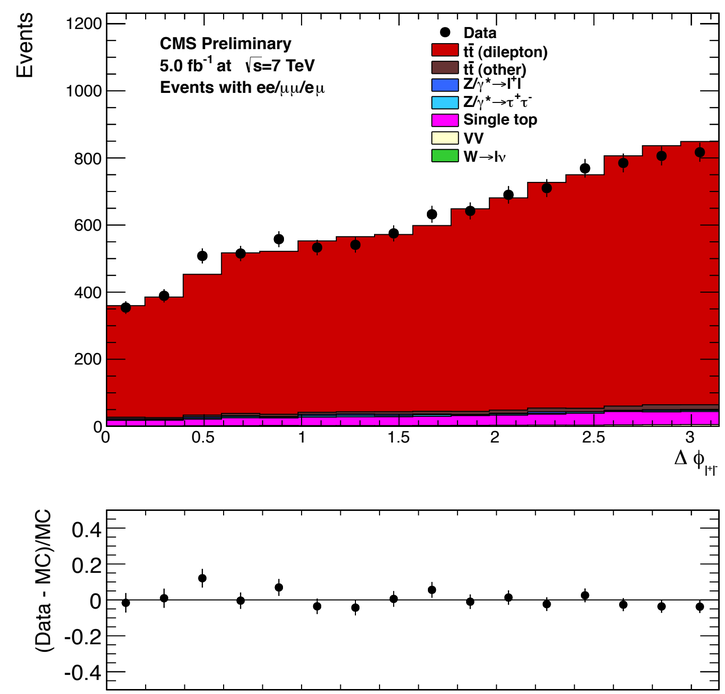
- Currently we have to view the $p_T$ reweighting as an "unknown effect", i.e. set 100% systematics
- However, if we can get a theory prediction for Δphi at NNLO vs NLO (or some estimate of the correction), and the effect is comparable to the one we observe from $p_T$ reweighting, we can argue for the smaller systematics
  - maybe the scale up/down samples could help here
- Δphi plots before/after reweighting are on the next two slides
  - lower $p_T$ tops have a greater degree of spin correlation, so reweighting has a significant effect
  - of course we can't use these distributions to test MC modeling because this is what we are trying to measure

# Δphi($l^+$,$l^-$), before reweighting

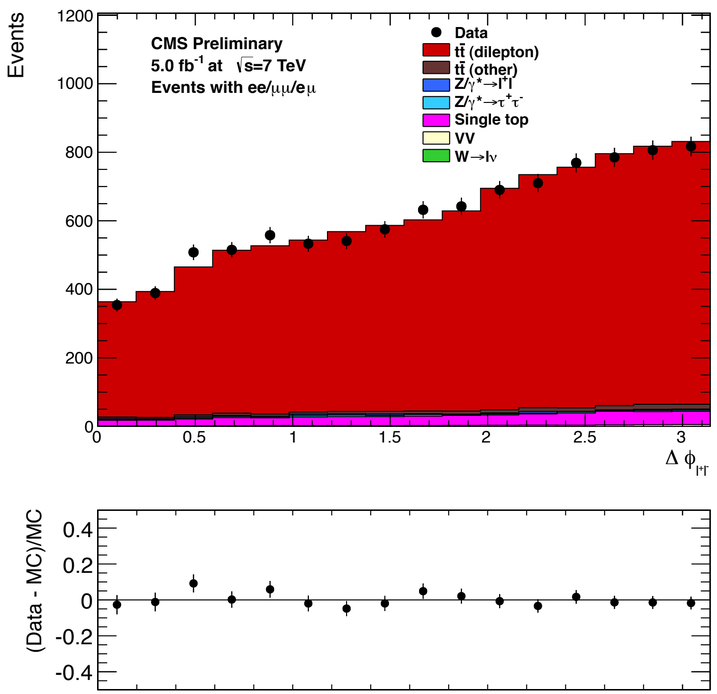
## madgraph*




## powheg-tauola



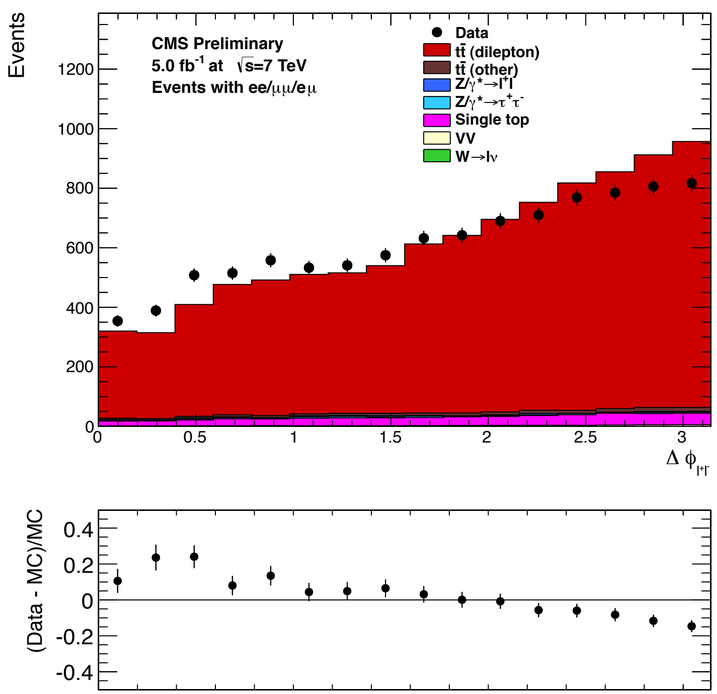

## mc@nlo



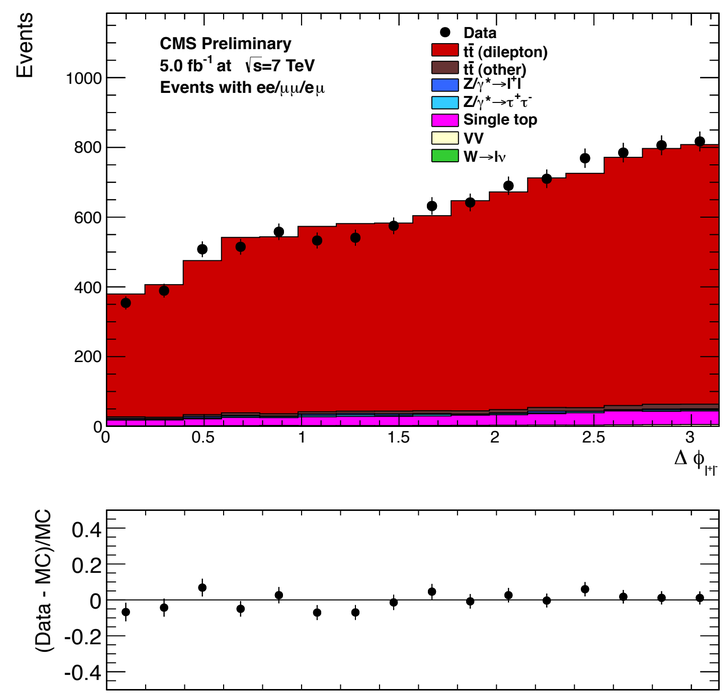

*** madgraph sample has no spin correlation**

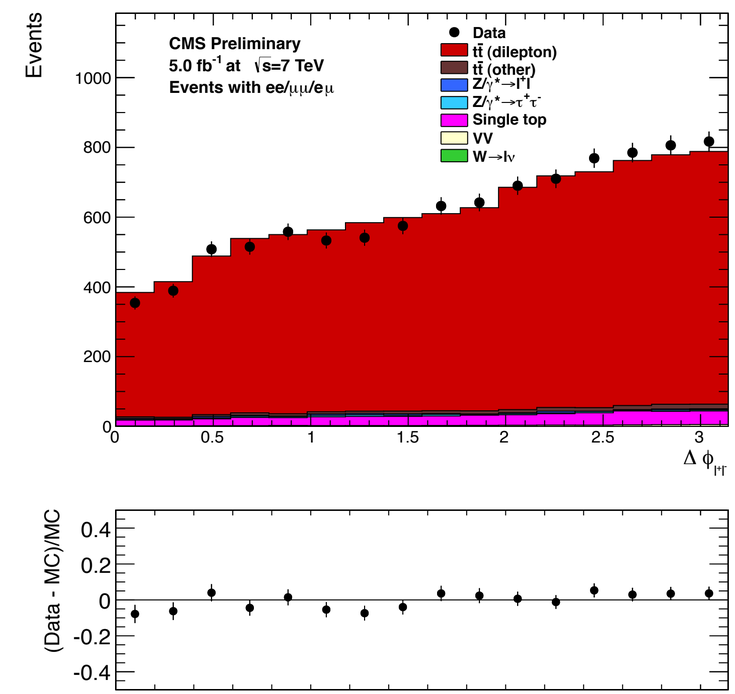
# Δphi($l^+$,$l^-$), after reweighting

## madgraph




## powheg-tauola




## mc@nlo