

# $t\bar{t}$ Differential Cross-Sections in the dilepton channel at 8TeV

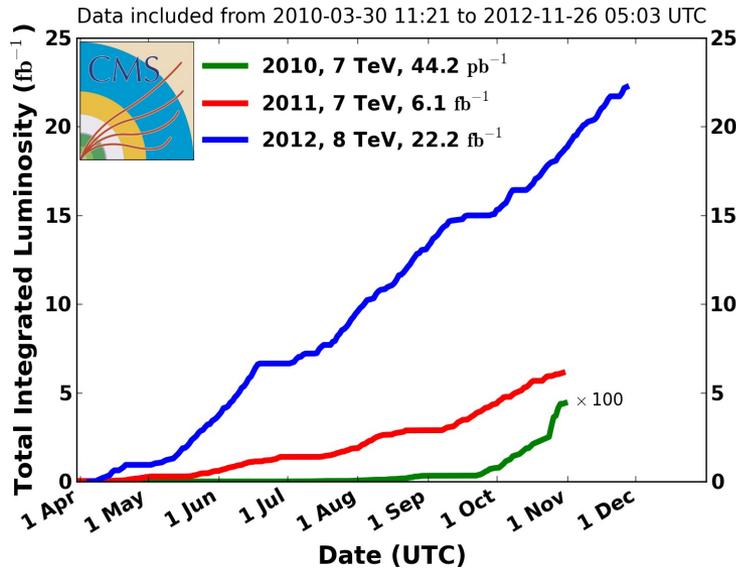
Ivan Asin  
Hamburg, 2012-12-03

- > 2012 data
- > Motivation
- > Control plots
- > Normalized differential cross section
- > Results
- > Summary



# 2012 Data

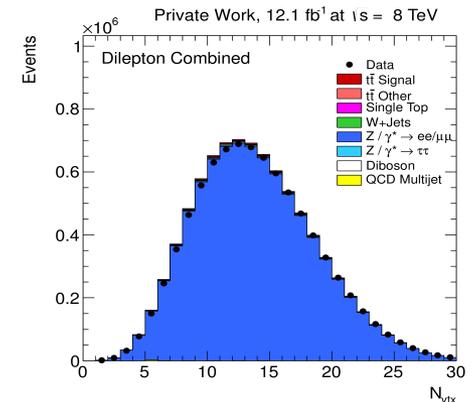
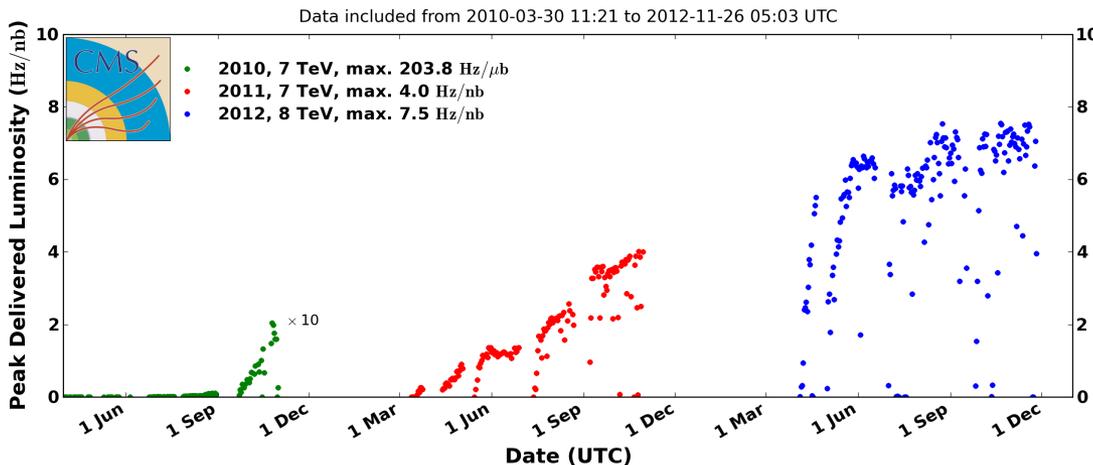
**CMS Integrated Luminosity, pp**



- > Large delivered and recorded luminosity: ~4x 2011 data
- > And still taking data!
- > In addition new “records” achieved:

- Peak inst. lumi: 7573.57E30cm<sup>-2</sup>s<sup>-1</sup>
- L ≈ 1 fb<sup>-1</sup> delivered every week
- Max. PU: 35
- <PU> = 22

**CMS Peak Luminosity Per Day, pp**



# Motivation of the analysis

- > First normalized diff. cross section at a new center of mass energy

- $\sqrt{s}=8$  TeV 
$$\frac{d\sigma}{\sigma dX}$$

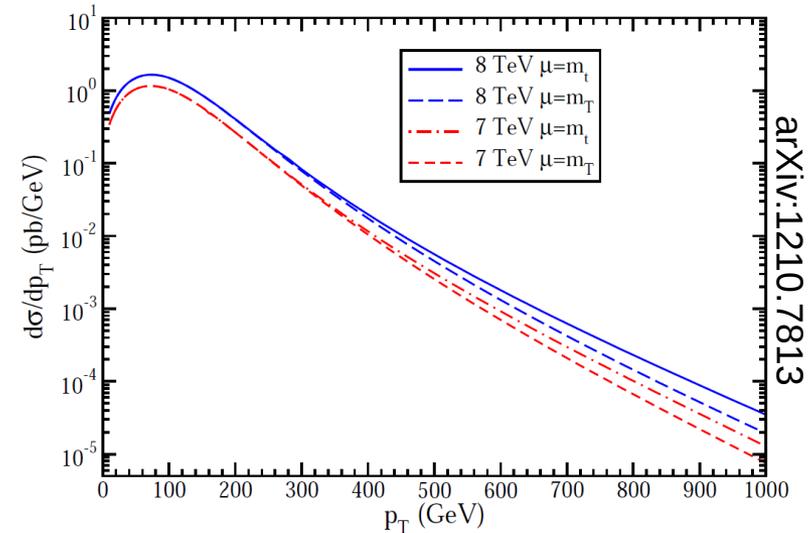
- > Test of Standard Model predictions

- pQCD for heavy-quark production

- > Test of theory models: MadGraph, POWHEG, MadGraph with Spin Corr.

- > Useful to add constraints on new physics

Top quark  $p_T$  distribution at LHC NNLO approx  $m_t=173$  GeV



- > Continuation of analysis at  $\sqrt{s}=7$ TeV :

- CMS, [arXiv: 1211.2220v1](https://arxiv.org/abs/1211.2220v1)  
(see presentation by J. Lange )



# Analysis Overview

> Same strategy and event selection as in [arXiv:1211.2220v1](https://arxiv.org/abs/1211.2220v1) (see presentation by J. Lange)

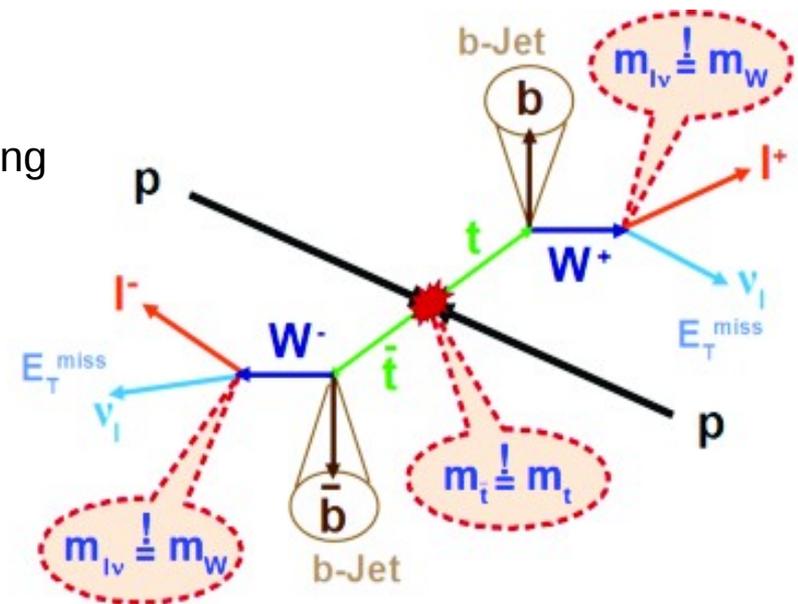
> 4 dilepton decay channels:  $ee$ ,  $e\mu$ ,  $\mu\mu$  and *combination* of 3 dileptonic channels

>  $\frac{d\sigma}{\sigma dX}$ , new variables:

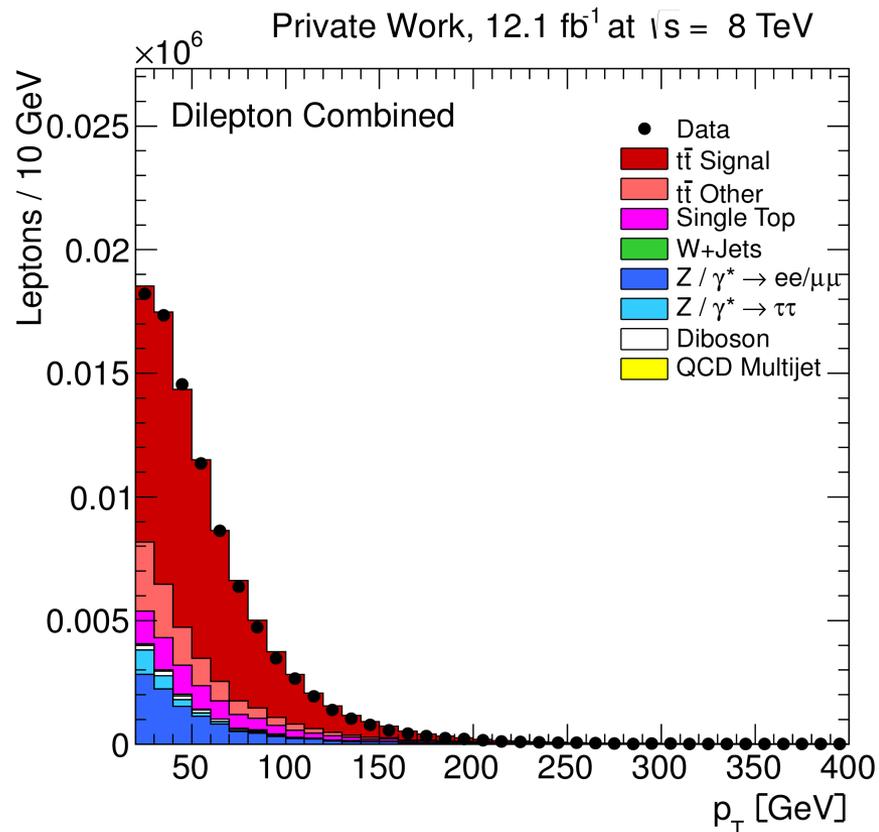
- particle's leading/next-to-leading  $p_T$  ordering
- lepton-b jet system mass
- lepton pair  $\Delta\Phi$

> Normalized to measured  $\sigma \Rightarrow$  shape measurement

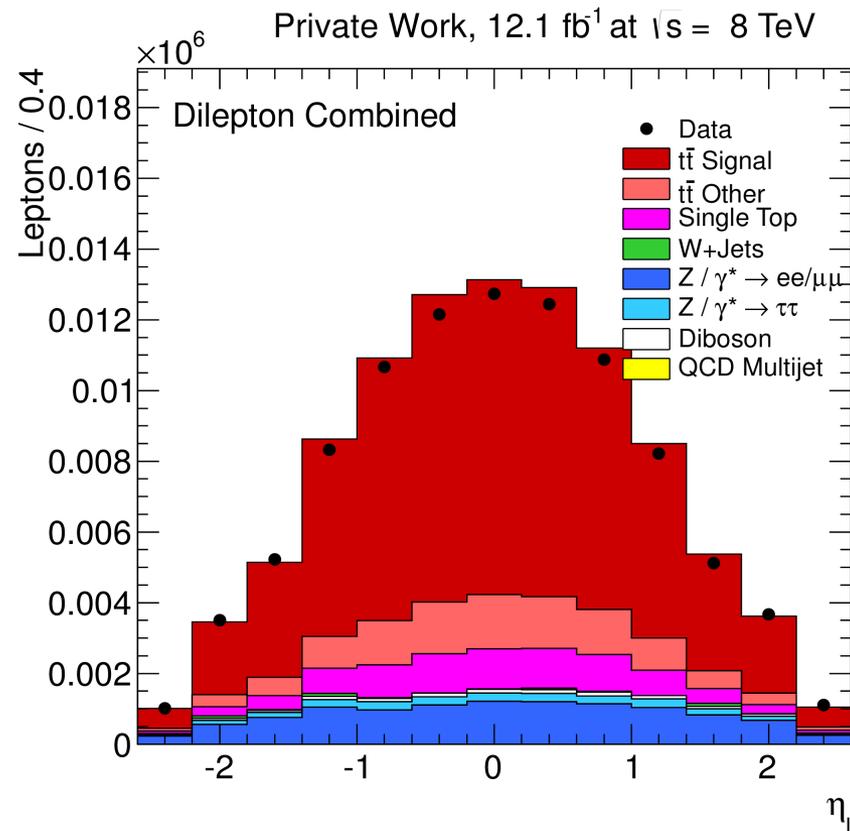
>  $L_{\text{int}} = 12.1 \text{ fb}^{-1}$



# Control Plots



Lepton  $p_T$

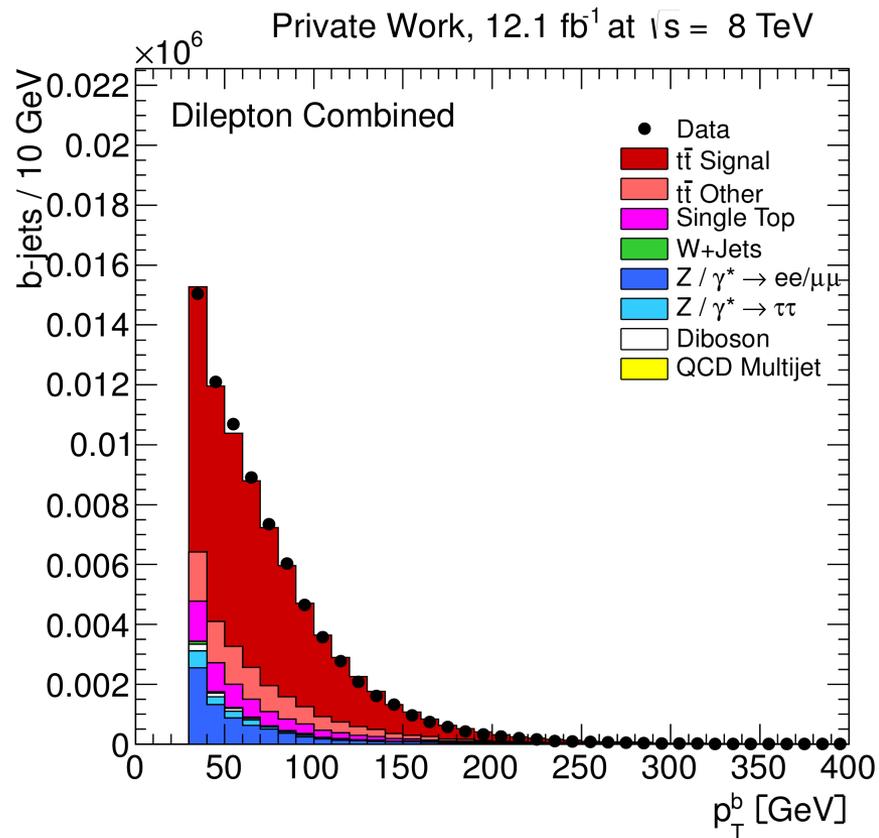


Lepton  $\eta$

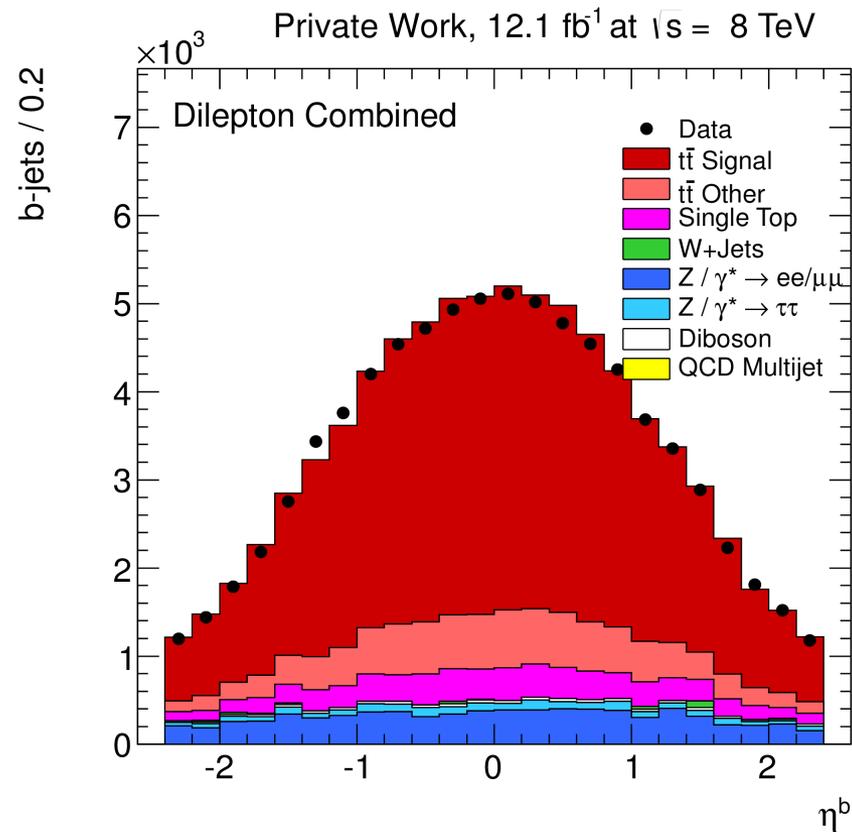
➤ Signal simulation normalized to measured  $\sigma$



# Control Plots



b-Jet  $p_T$

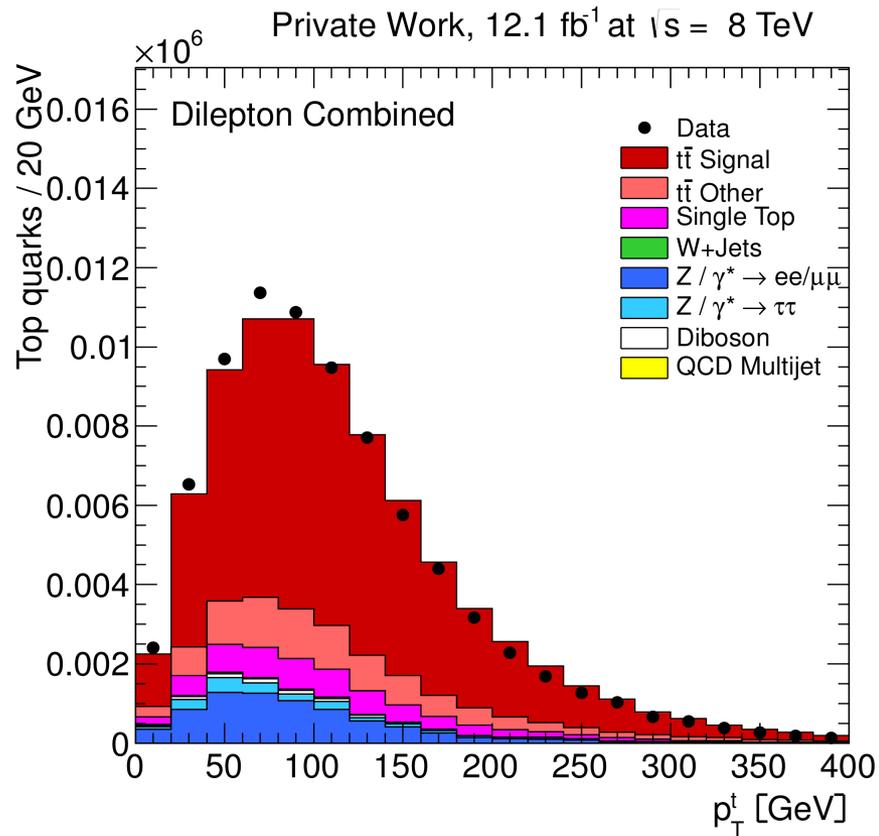


b-Jet  $\eta$

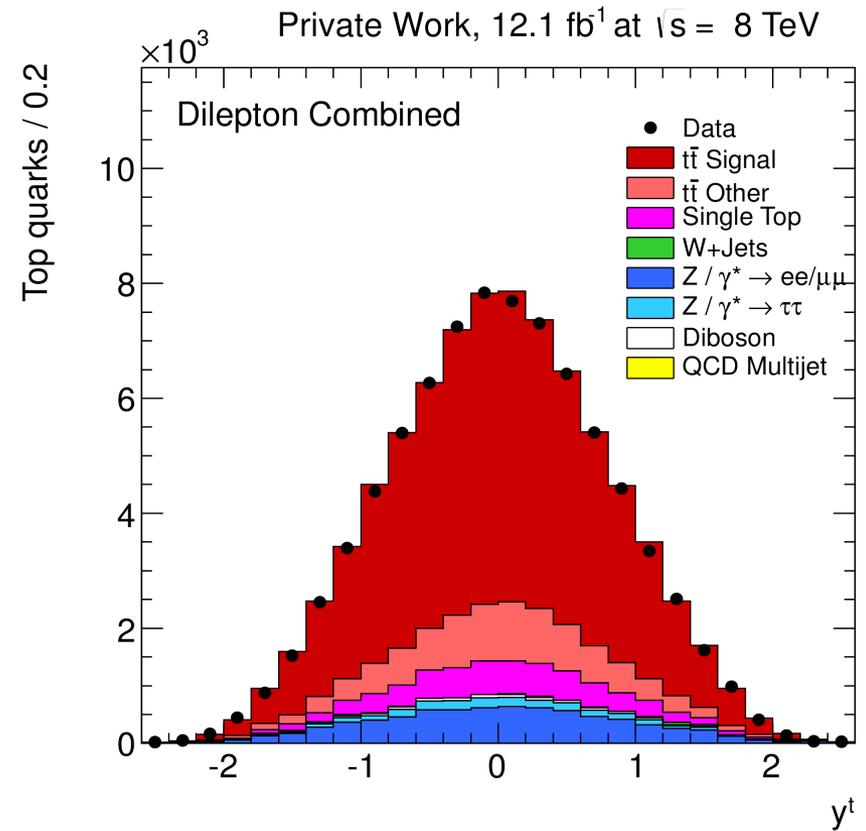
➤ Signal simulation normalized to measured  $\sigma$



# Control Plots



Top  $p_T$

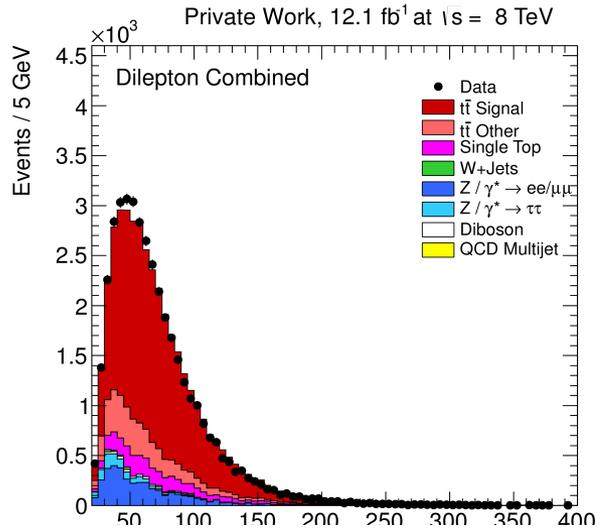


Top  $y$

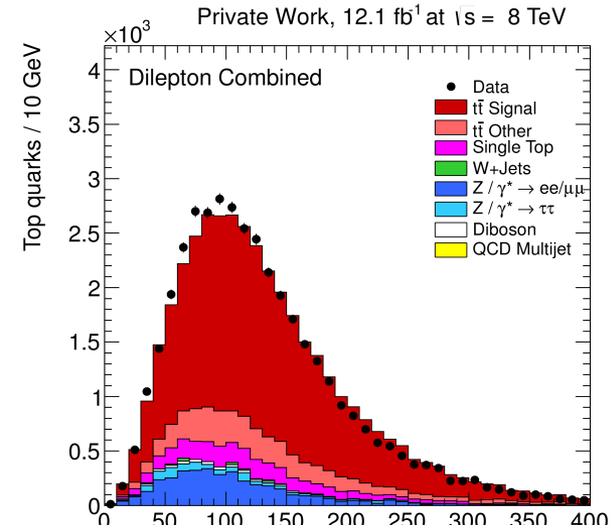
➤ Signal simulation normalized to measured  $\sigma$



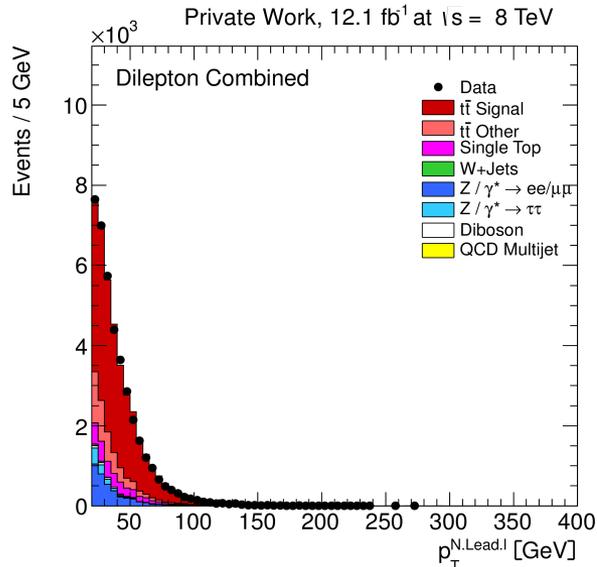
# Control Plots



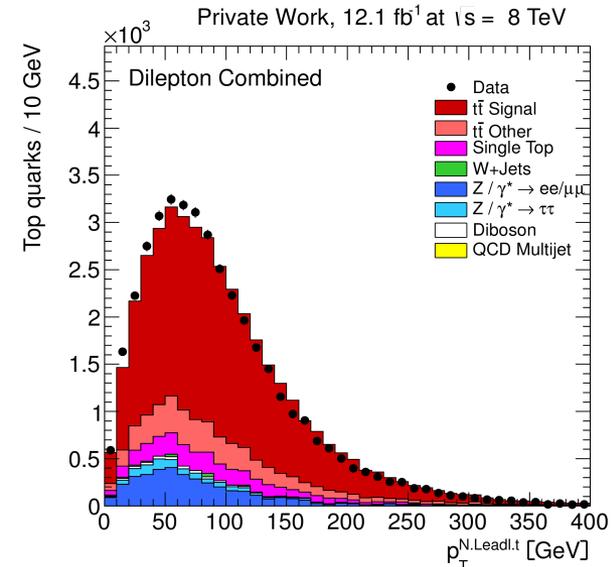
Lead.  $p_T$  lepton



Lead.  $p_T$  top



N. Lead.  $p_T$  lepton



N. Lead.  $p_T$  top

➤ Signal simulation normalized to measured  $\sigma$

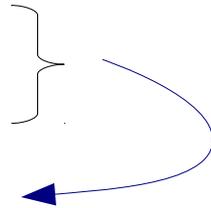


# Scale Factors

> Apply small corrections to simulation for better agreement with data

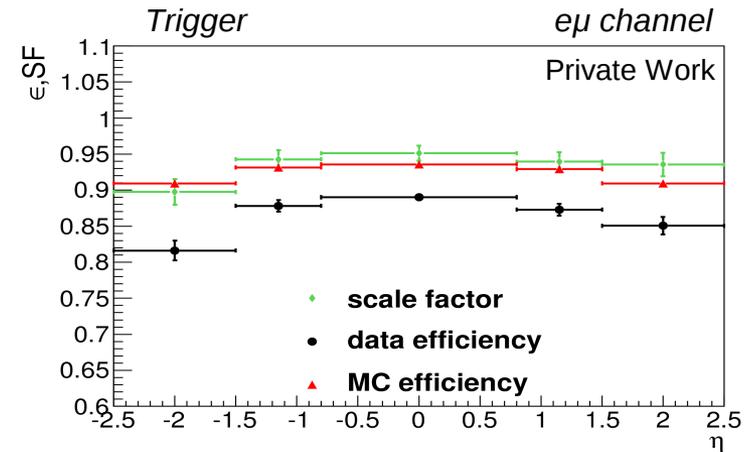
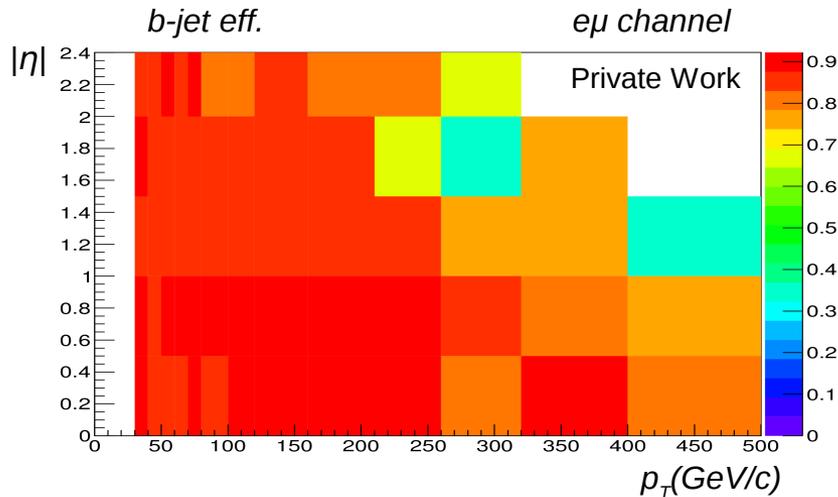
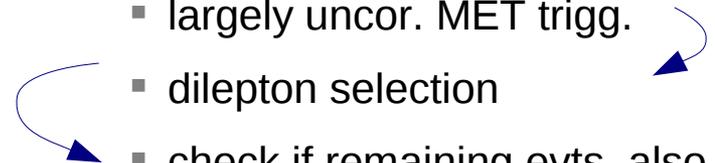
> b-tagging:

- per-jet efficiency
- per-jet SF
- $SF^{\text{evt.}}_{\geq 1 \text{ b-tag}}$



> Trigger

- largely uncor. MET trigg.
- dilepton selection
- check if remaining evts. also fire dilepton triggers
- $\eta$  &  $p_T$  dependency studied



# Normalized Diff. Cross Section

- > For each variable, each decay channel and each bin  $i$

$$\frac{1}{\sigma} \frac{d\sigma^i}{dX} = \frac{1}{\sigma} \frac{N^{data} - N^{bg}}{\Delta_X^i \epsilon^i L}$$

- > Account for migrations due to experimental resolution

- > Bin-by-bin method

- > Full phase space (PS):

- top quark, ttbar

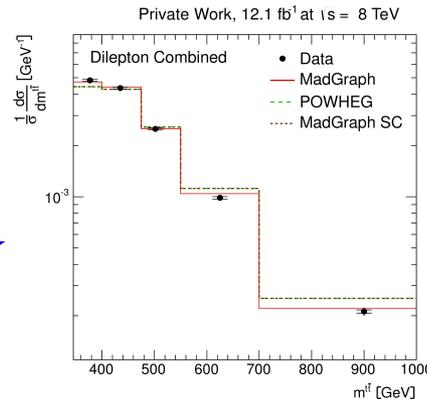
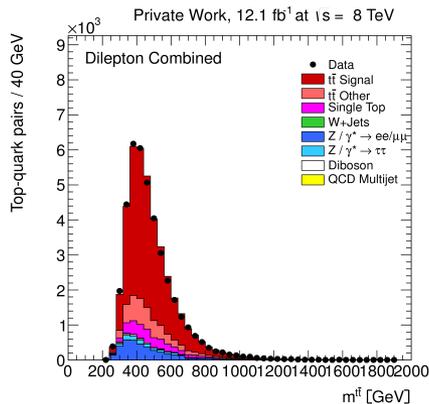
- > Particle level visible PS:

- leptons:  $p_T > 20\text{GeV}$ ,  $|\eta| < 2.4$

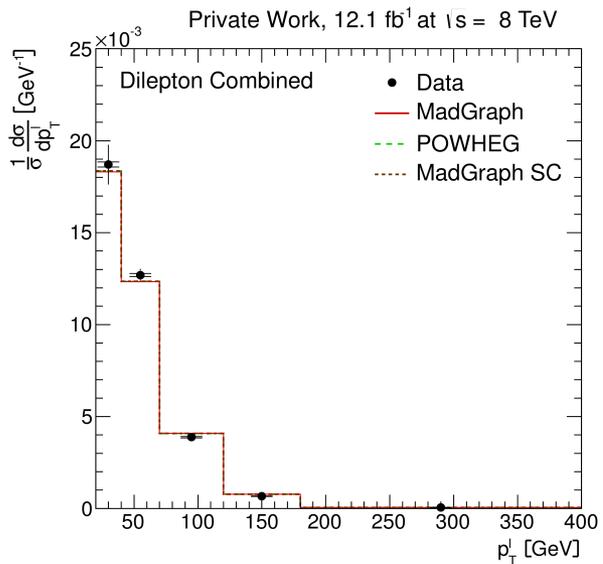
- b-jets:  $p_T > 30\text{GeV}$ ,  $|\eta| < 2.4$

- > Comparison to theory:

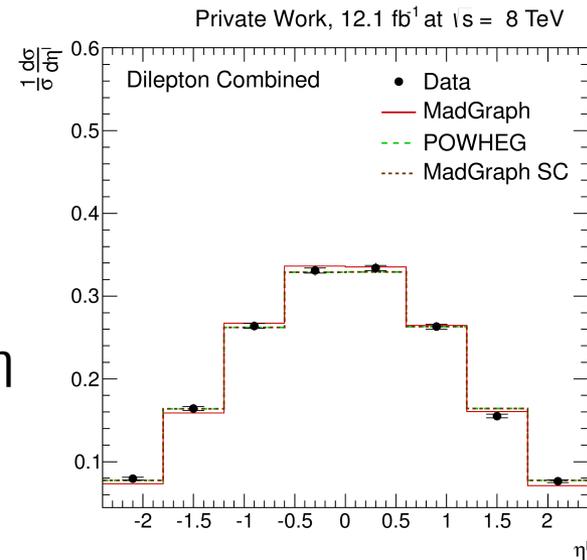
- MadGraph
- POWHEG
- MadGraph with Spin Correl.



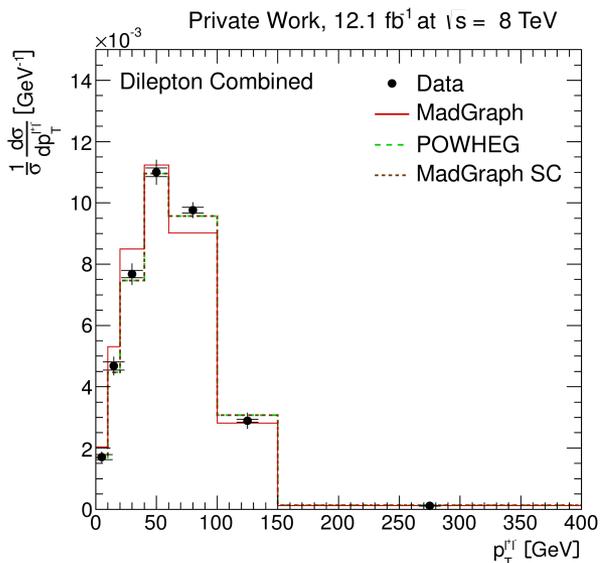
# Results



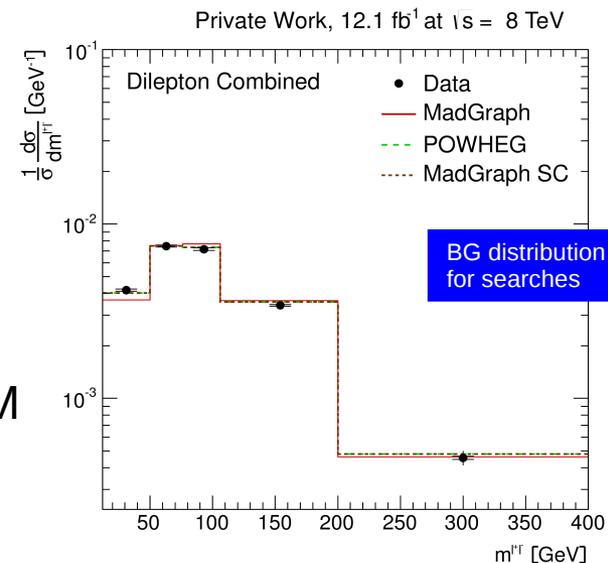
Lepton  $p_T$



Lepton  $\eta$

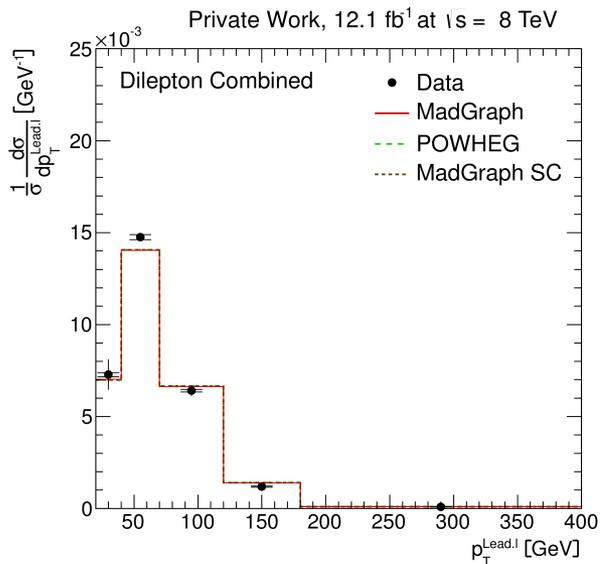


Lep. pair  $p_T$

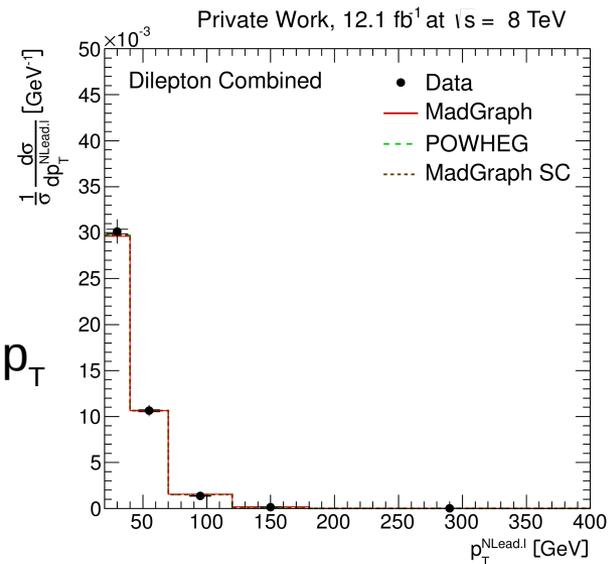


Lep. pair M

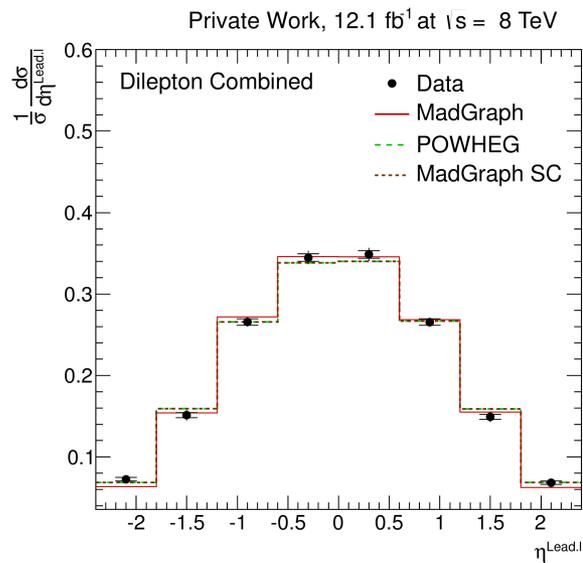
# Results



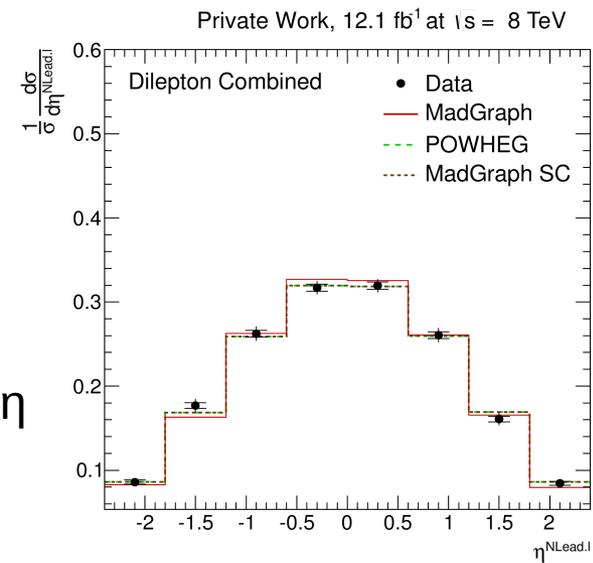
Lead. Lepton  $p_T$



N. Lead. Lepton  $p_T$

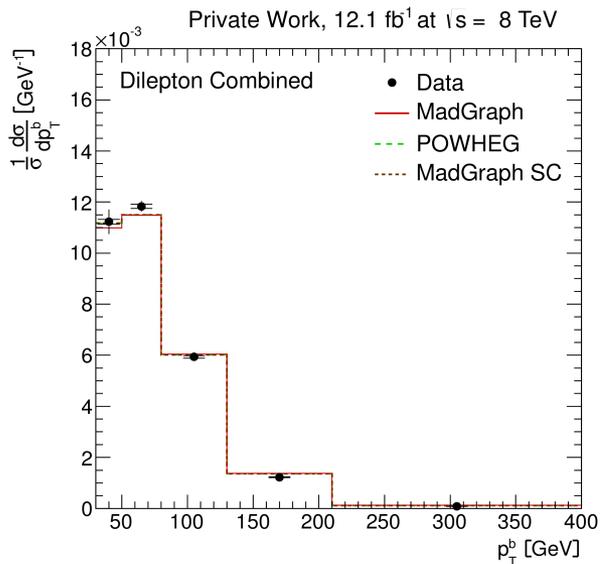


Lead. Lepton  $\eta$

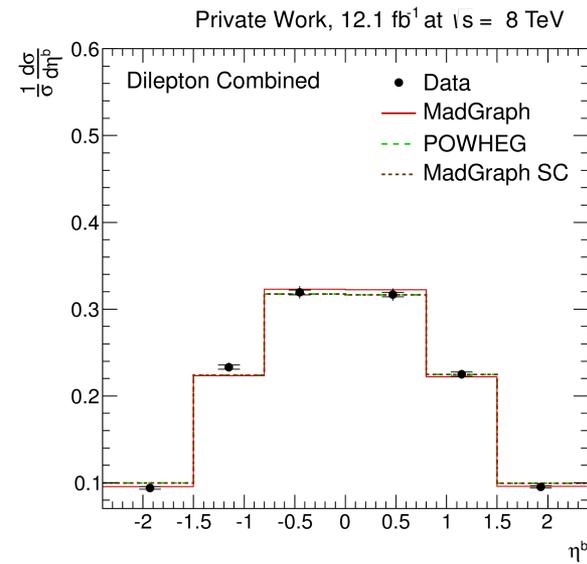


N. Lead. Lepton  $\eta$

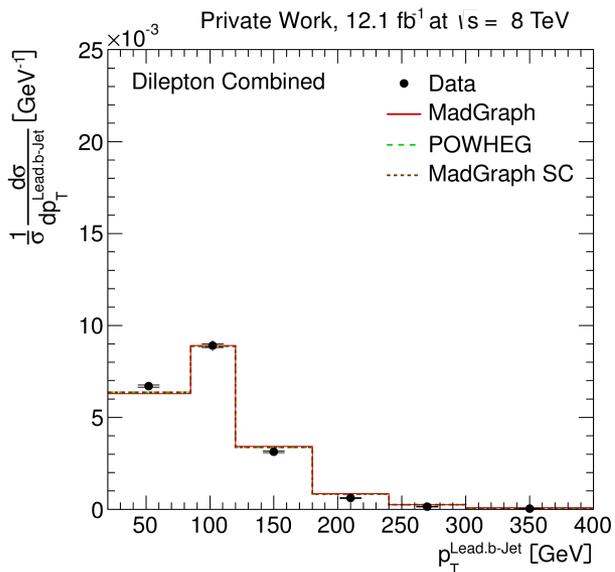
# Results



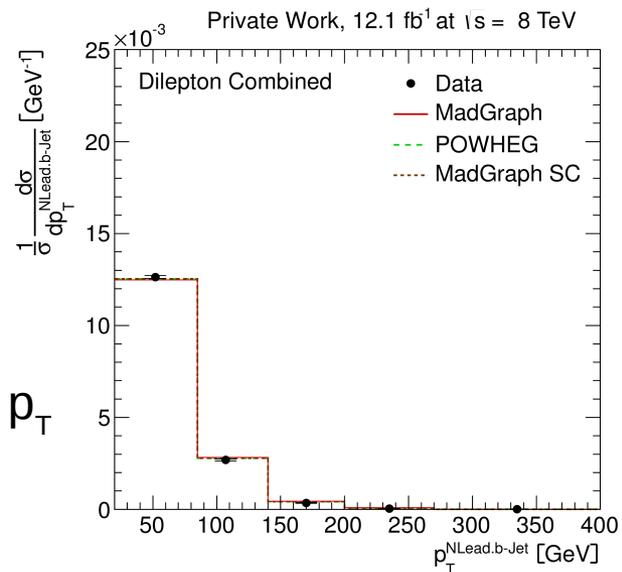
b-jet  $p_T$



b-jet  $\eta$

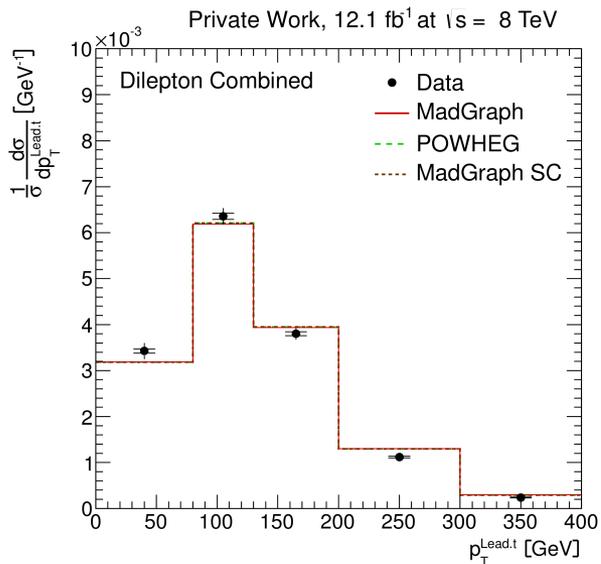


Lead. b-jet  $p_T$

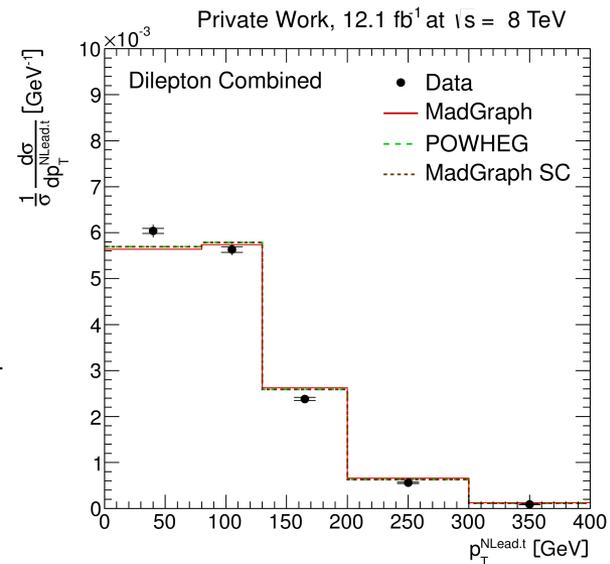


N. Lead. b-jet  $p_T$

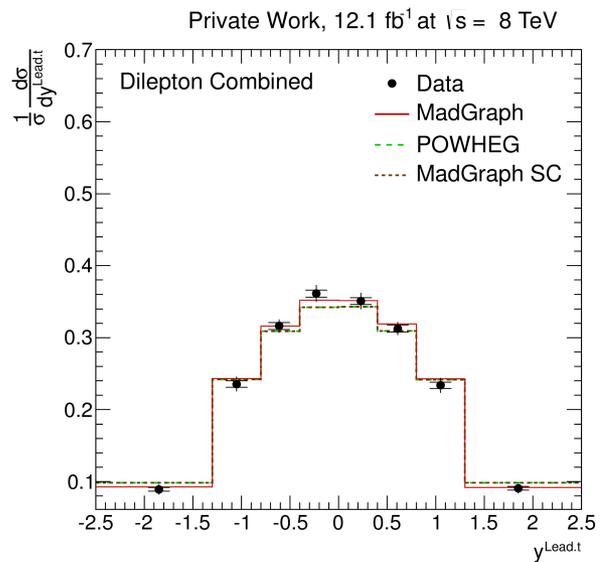
# Results



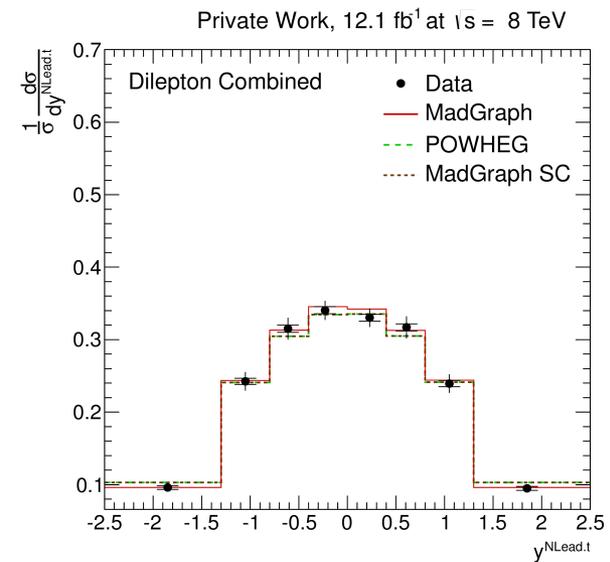
Lead. top  $p_T$



N. Lead. top  $p_T$

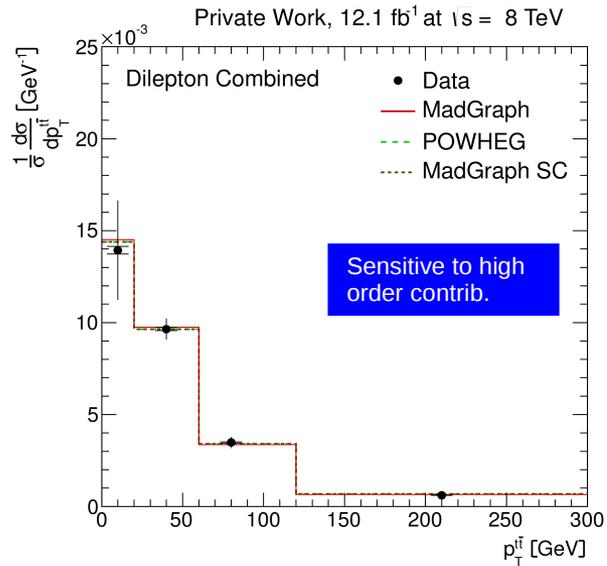


Lead. top  $y$



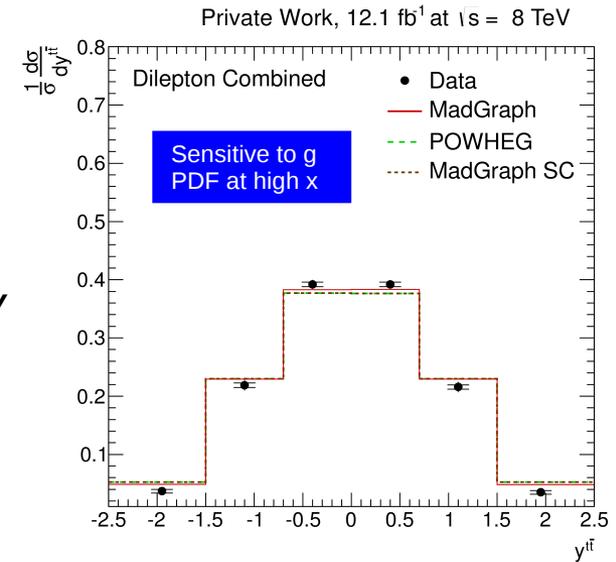
N. Lead. top  $y$

# Results

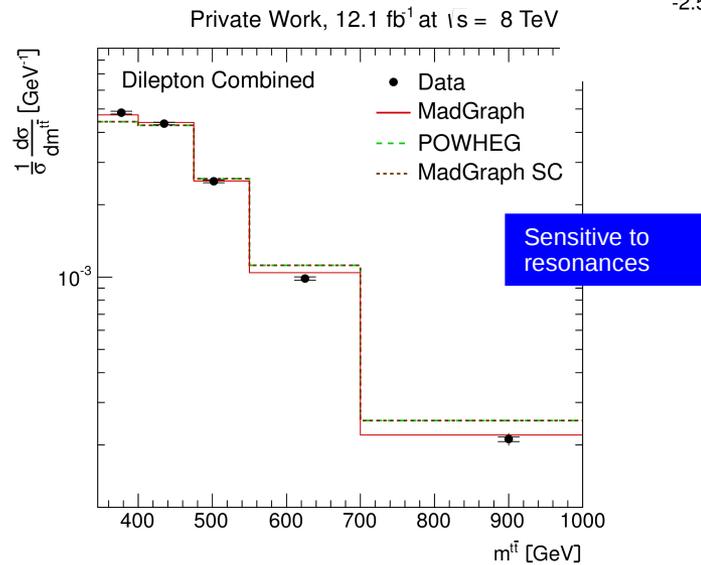


Top pair  $p_T$

Top pair  $y$

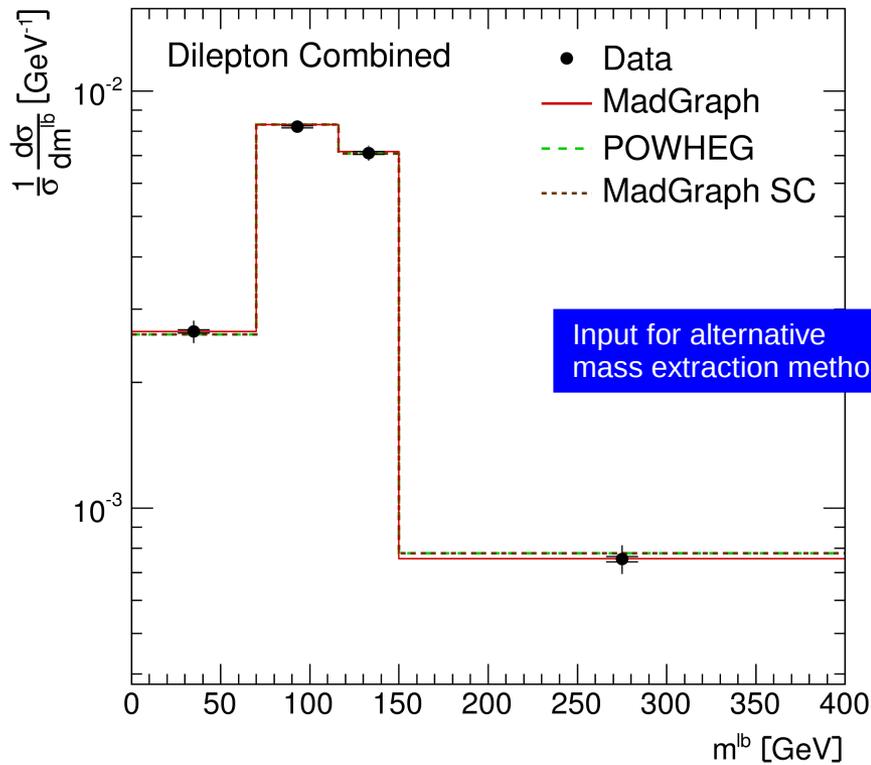


Top pair M



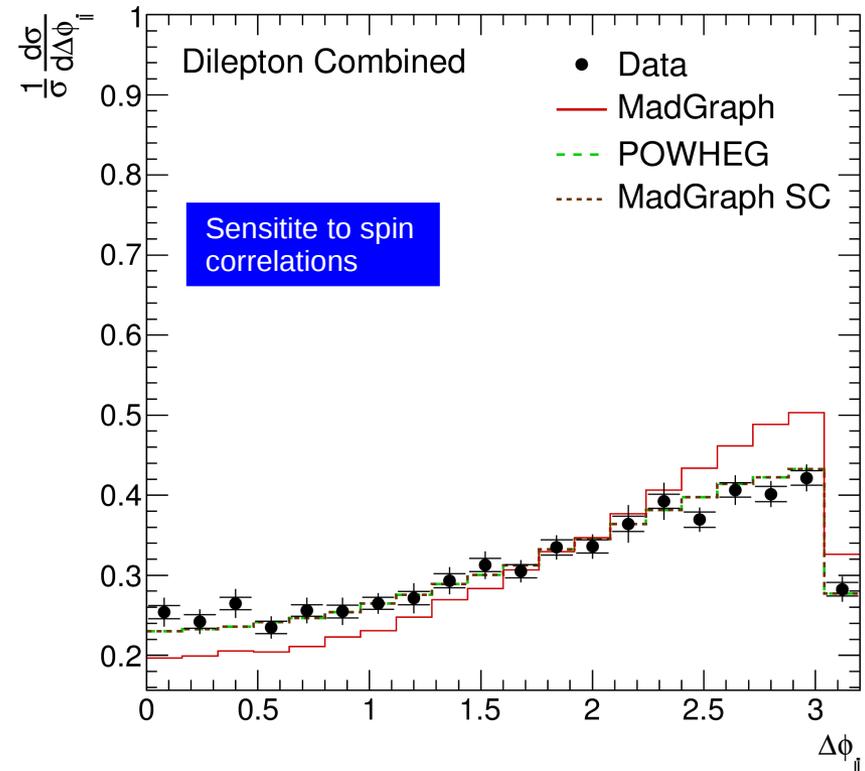
# Results

Private Work, 12.1 fb<sup>-1</sup> at  $\sqrt{s} = 8$  TeV



M(lb)

Private Work, 12.1 fb<sup>-1</sup> at  $\sqrt{s} = 8$  TeV



Lep. Pair  $\Delta\Phi$



# Conclusions

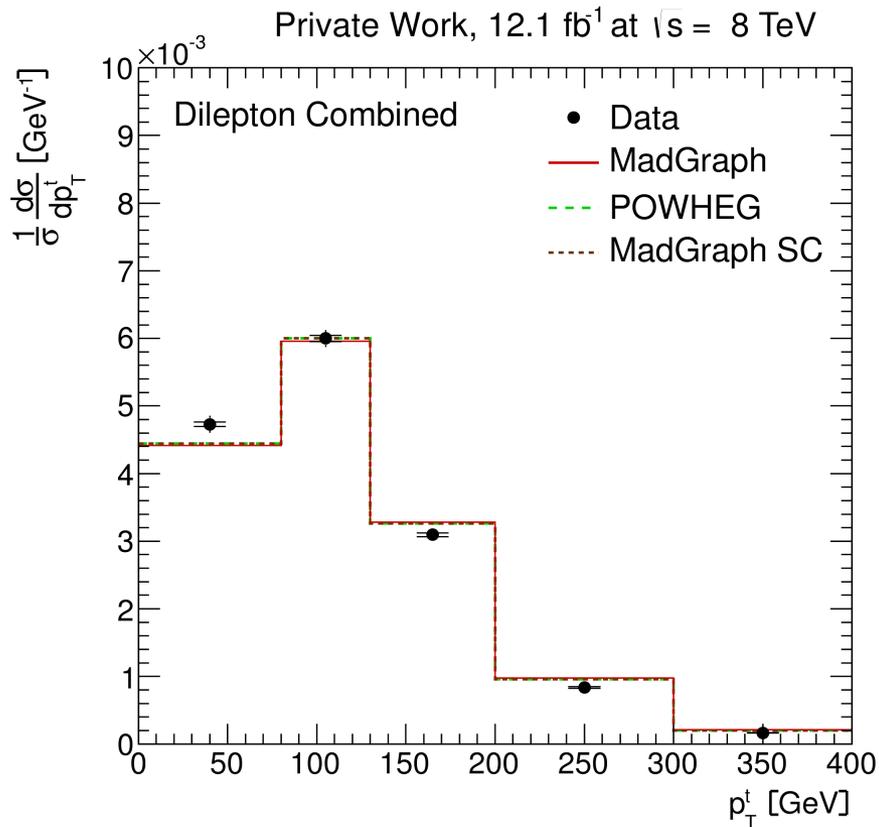
- > 1<sup>st</sup> normalized differential  $t\bar{t}$  cross section at  $\sqrt{s} = 8$  TeV in the dilepton decay channel
- > Many new different distributions: lepton, lep. pair, b-jet, top, top pair, lepton-b jet
- > Results compared to different theory predictions
  - MadGraph
  - POWHEG
  - MadGraph with spin correlations
- > In general good agreement Data-MC within uncertainties
  - Lepton pair distributions seem to be described better by MadGraph with Spin Correlations



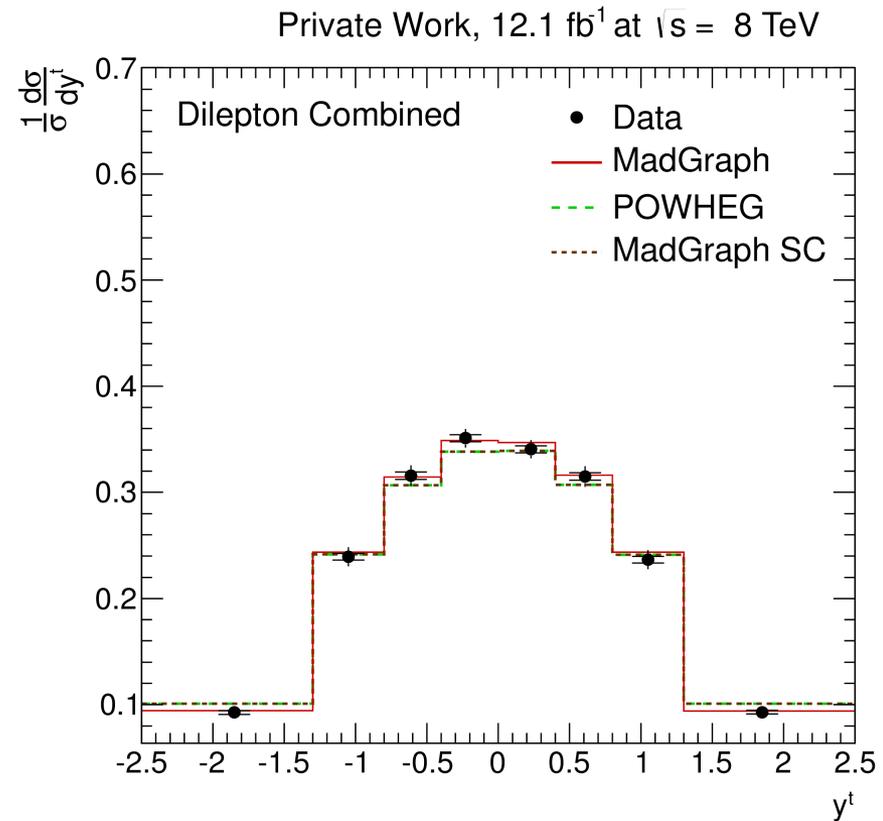
# BACKUP



# Results



Top  $p_T$

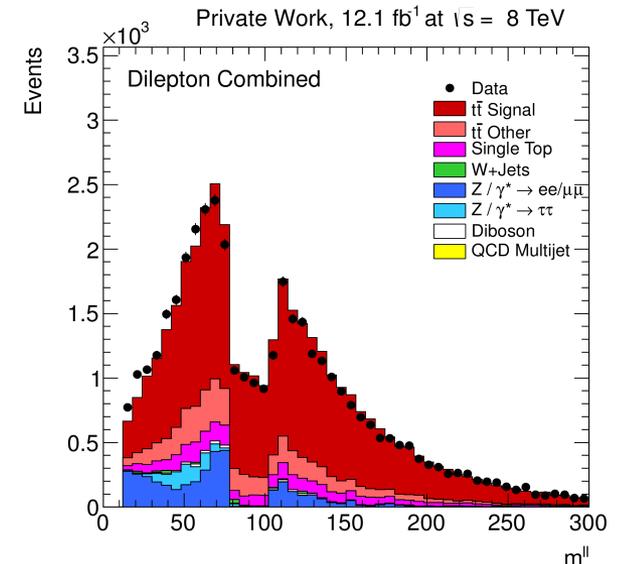
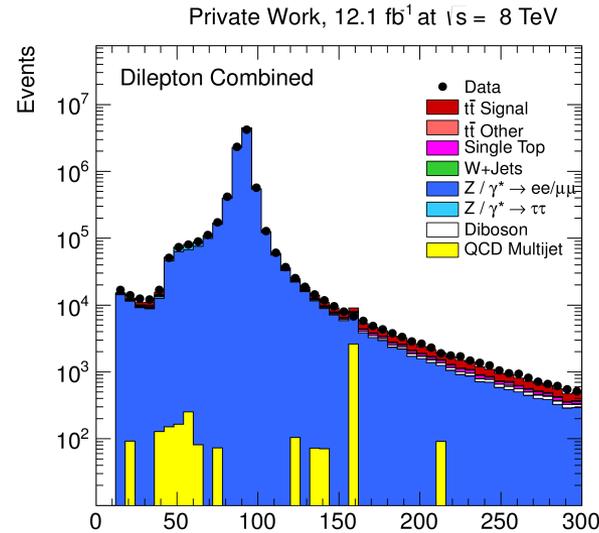


Top  $y$



# Event Selection

- > Dilepton triggers
- > 2 opposite sign & isol. leptons:
  - $p_T > 20 \text{ GeV}/c$
  - $|\eta| < 2.4$
  - $m_{ll} > 12 \text{ GeV}/c^2$
- > 2 jets:
  - $p_T > 30 \text{ GeV}/c^2$
  - $|\eta| < 2.4$
- > 1 b-tag: CSVL
- > In ee &  $\mu\mu$ :
  - $|m_z - m_{ll}| > 15 \text{ GeV}/c^2$
  - $MET > 30 \text{ GeV}/c$
- > Theory predictions normalized to the measured  $\sigma$



# Scale Factors

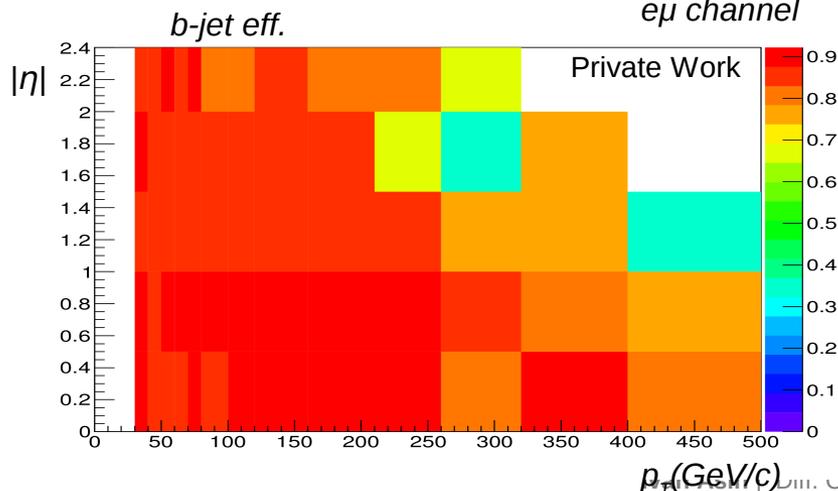
> Correct theory simulations to make them agree better with data

> DY: data-driven method

- $SF = DY_{data} / DY_{MC}$
- $DY_{data} = R_{out/in}^{ll, MC} (N_{in}^{ll} - 0.5 k_{ll} N_{in}^{e\mu})$

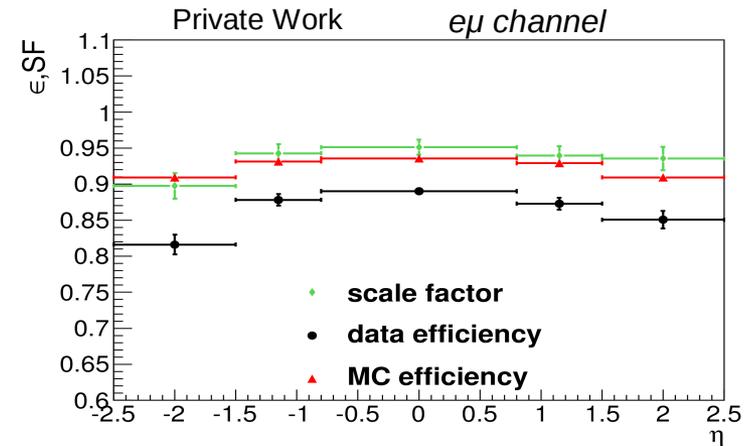
> b-tagging:

- per-jet efficiency
- per-jet SF
- $SF^{evt. \geq 1 \text{ b-tag}}$



> Trigger

- largely uncor. MET trigg.
- dilepton selection
- check if remaining evts. also fire dilepton triggers
- $\eta$  &  $p_T$  dependency studied



> Calculated in each bin of the measurement individually

> Model dependencies

- $m_t$
- matching
- scale

> Experimental:

- triggers
- b-tagging
- JER/JES
- DY
- PU
- BG

