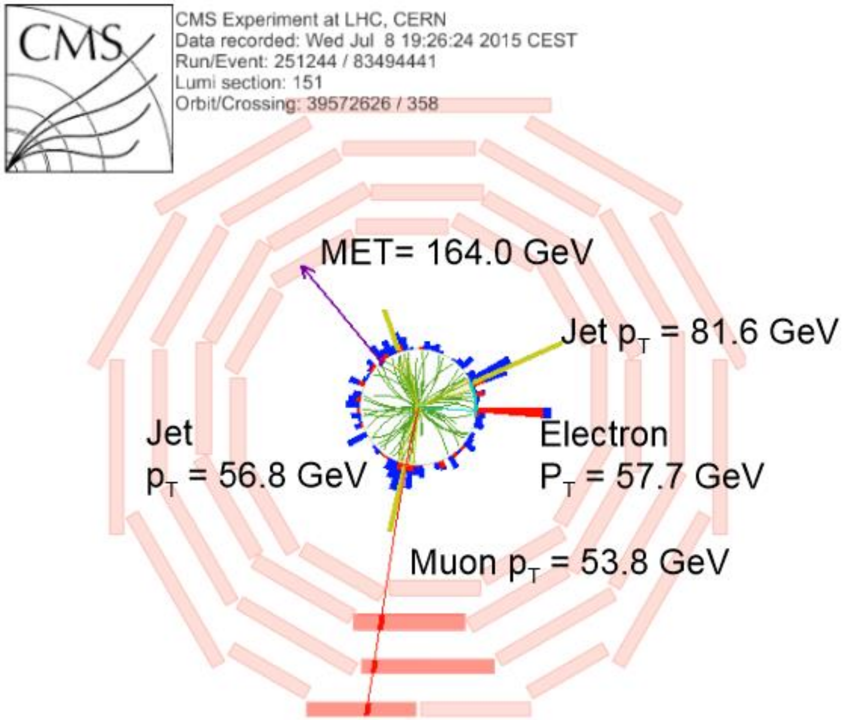
Towards a Precision Measurement of the $t\bar{t}$ Cross Section



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T.4.4
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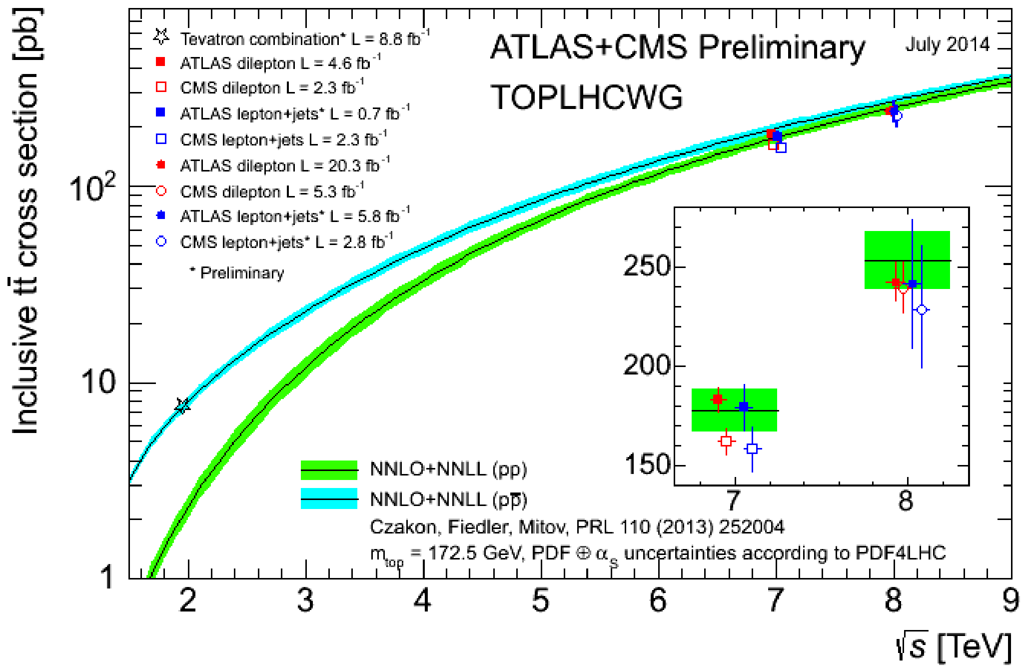
HELMHOLTZ | ASSOCIATION

Introduction

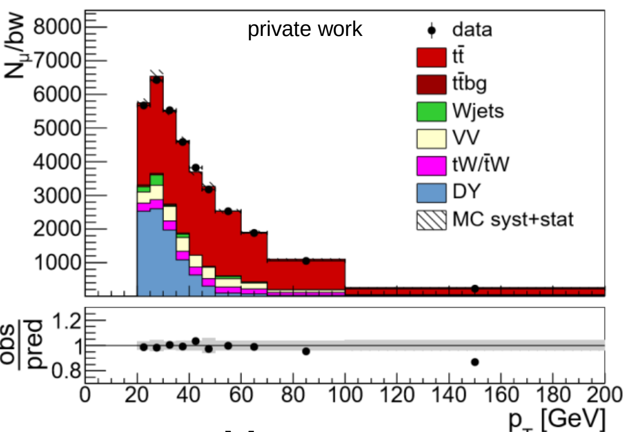
- Why is a **precision measurement** of the top pair production cross section important ?
  - Precision test of the SM, possible small deviations
  - Pole mass extraction
  - PDF/α_s extraction



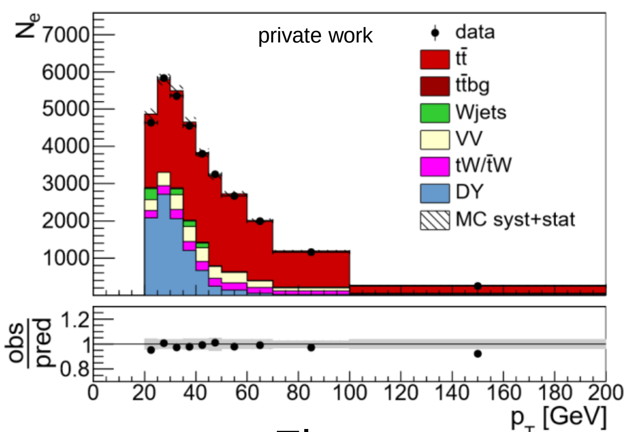
- How to obtain the **highest possible precision** ?
  - Focus on the highest systematic uncertainties
  - **Today**: Trigger and Lepton ID/ISO

Analysis Setup

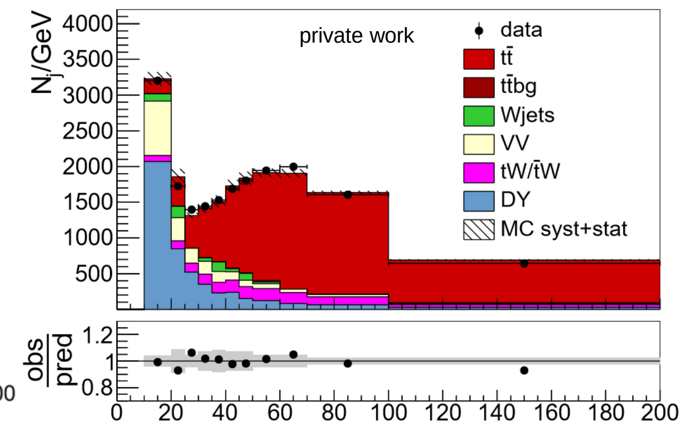
- Full **di-lepton** channel, including same flavor decays
  - $\geq$ 2 OS tight leptons, $p_T > 20\ \mathrm{GeV}$, $|\eta| < 2.4$,$m_{e\mu} > 20\ \mathrm{GeV}$ (see talk T4.3 from M. Savitskyi)
- Jets: $p_T > 30\ \mathrm{GeV}$, $|\eta| < 2.5$
- **Agreement between data and MC**
  - Subset of data with 24.9 fb^{-1}



Muon



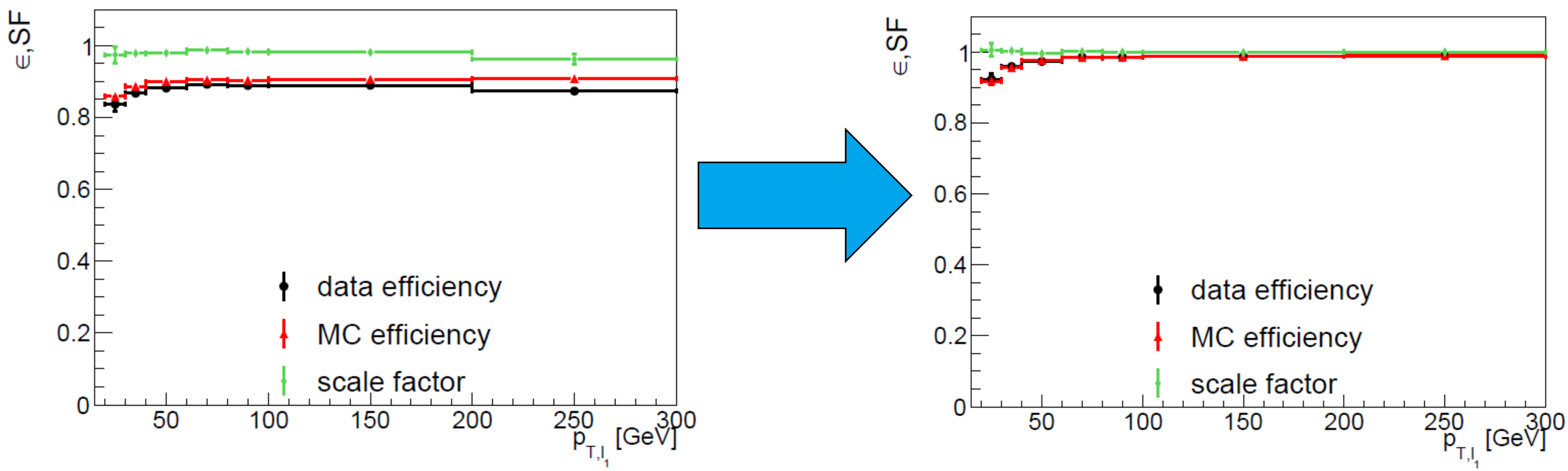
Electron



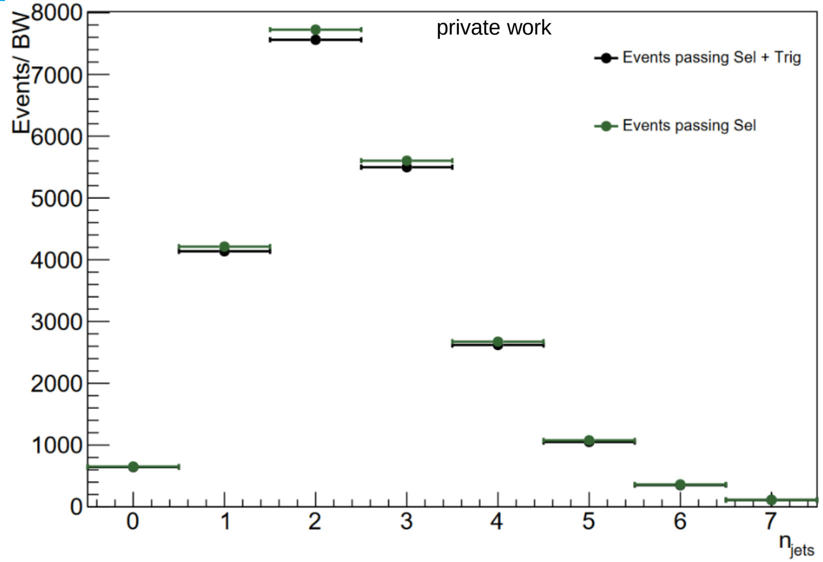
Leading jet

Trigger Efficiency

- **Until now**: Systematic uncertainty on the trigger efficiency determination/ scale factors one of the dominant uncertainties
  - 1.2 % Trigger uncertainty in latest measurement
- Precise determination of systematic uncertainty from comparisons of **different methods**
- Use a **combination** of single and di-lepton triggers
  - Higher efficiency → lower statistical uncertainty (binominal statistics)



Methods: MET Monitoring Triggers



> Independent monitor trigger

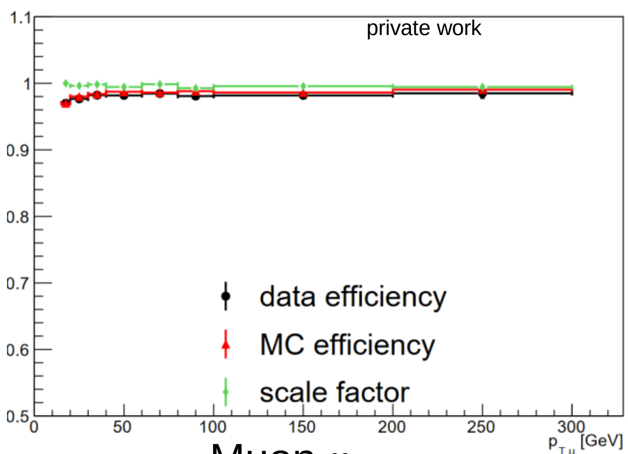
- $\epsilon = \frac{\#\text{Events(MET Trigger+Dilep Trigger+Dilep. Sel)}}{\#\text{Events(MET Trigger+Dilep Sel)}}$

> Pros:

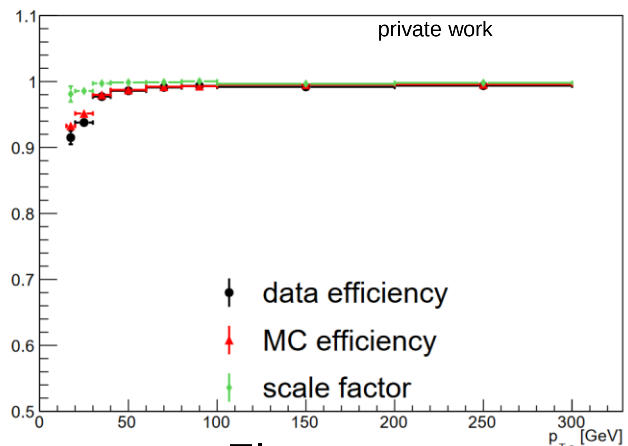
- Per event efficiency
- Measured in $t\bar{t}$ phase space

> Cons

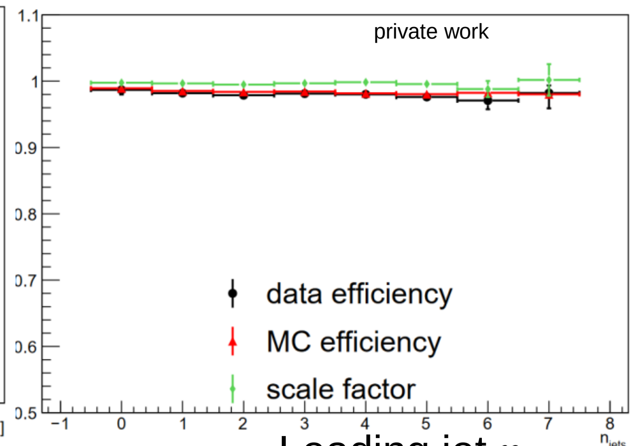
- Possible Correlations



Muon p_T



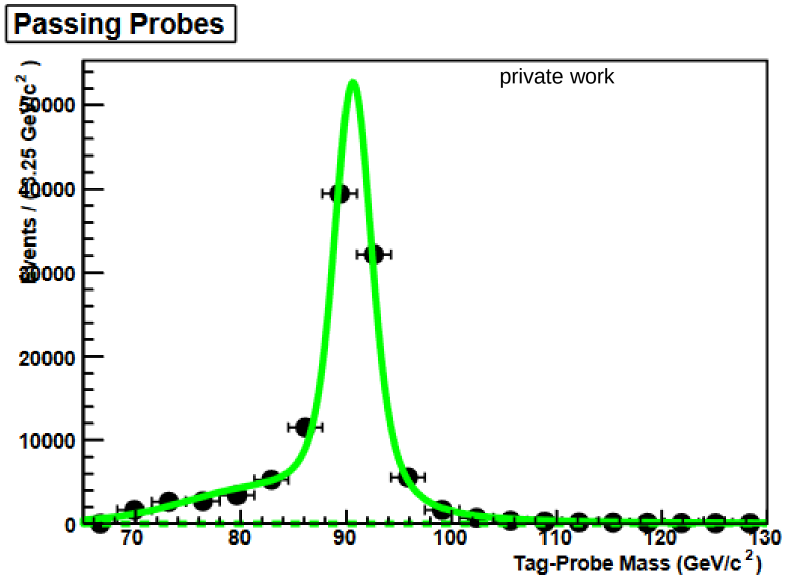
Electron p_T

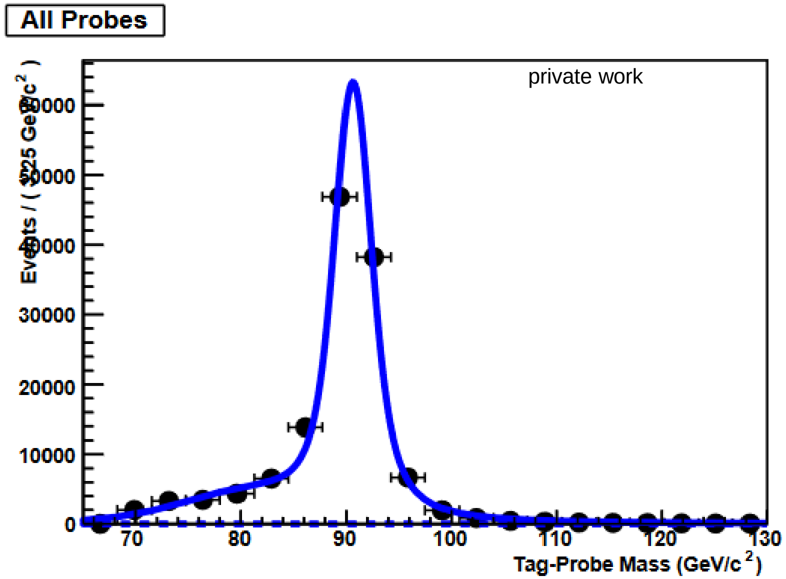


Leading jet p_T

Methods: Tag and Probe

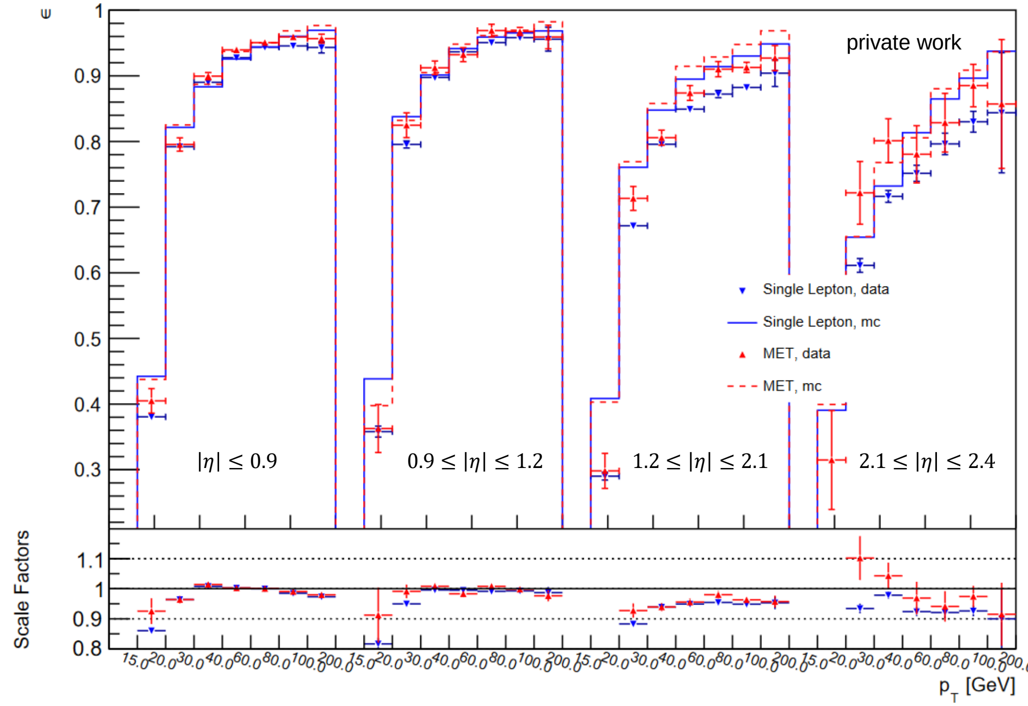
- **Two leptons** in the Z-mass window
  - Tag lepton: tight offline cuts + online trigger
  - Probe lepton: tight offline cuts
  - Passing probe: trigger to be measured
  - $\epsilon = \frac{\#\text{ passing probe}}{\#\text{ failing probe}}$
- **Pros**
  - Very high statistics
- **Cons**
  - Measures trigger efficiency in the DY phase space
  - Efficiency per trigger leg

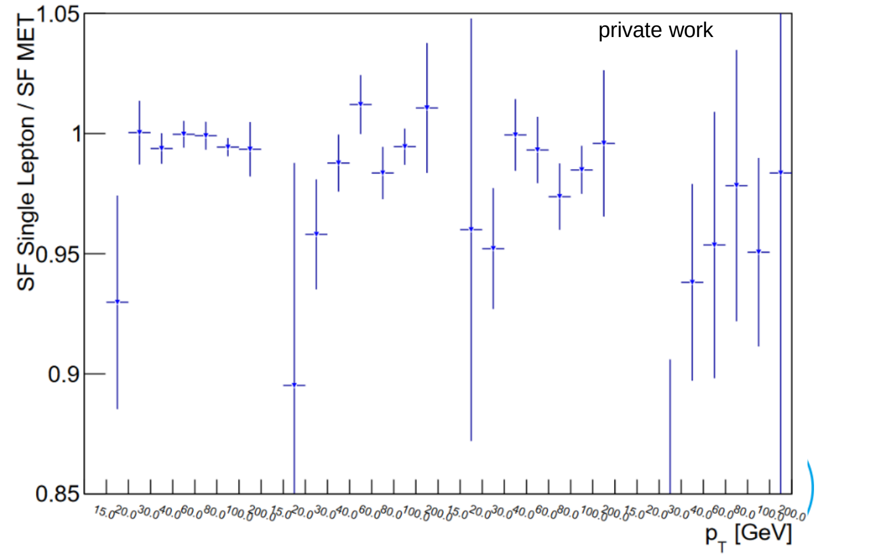




Comparison for the Single Electron Trigger Monitored with MET and Single Muon Triggers

- Comparison for the **single electron trigger efficiency monitored with single muon /MET** triggers
- Select eμ-pair offline
- Agreement over a wide range of phase space
  - **No global bias** from MET triggers
  - Similar results for Single Muon Triggers

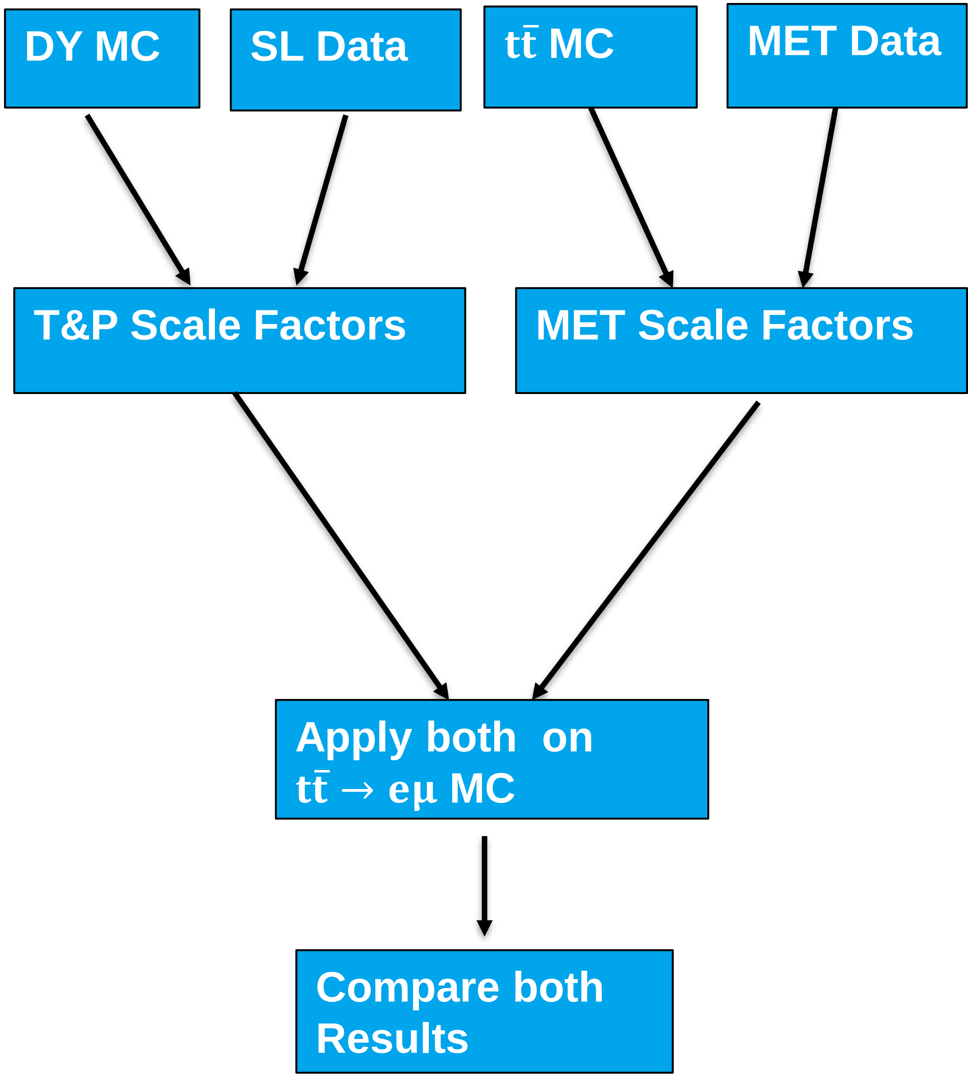




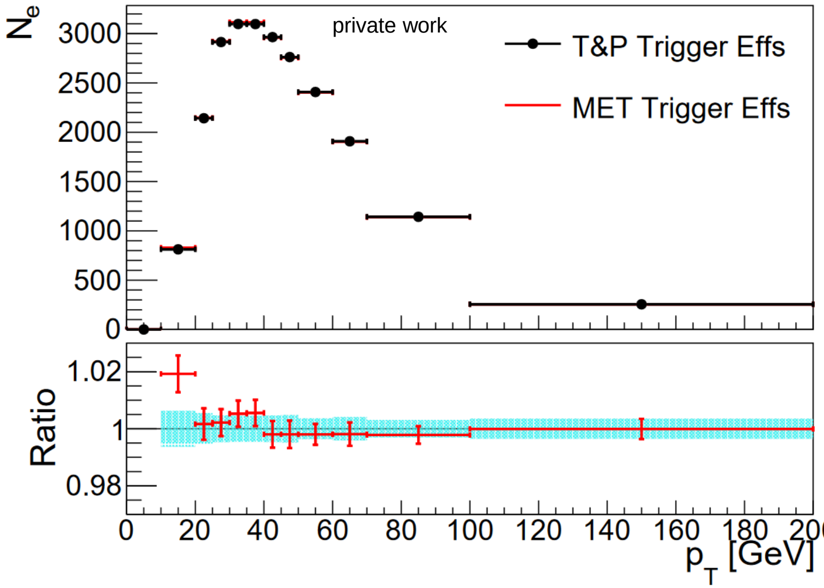
Comparison of Scale Factors Tag & Probe and Orthognoal Trigger Method

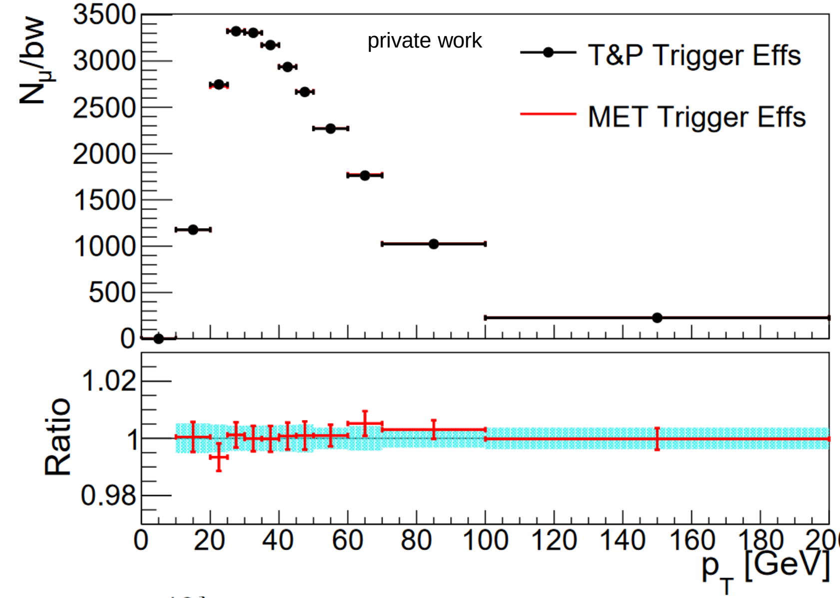
> **Compare two totally independent methods**
  - Efficiencies determined in DY and $t\bar{t}$ events
  - Per leg vs. per event methods

> $e\mu$ dataset: impact from electron and muon triggers
  - Phase space specific
  - Trigger selection specific

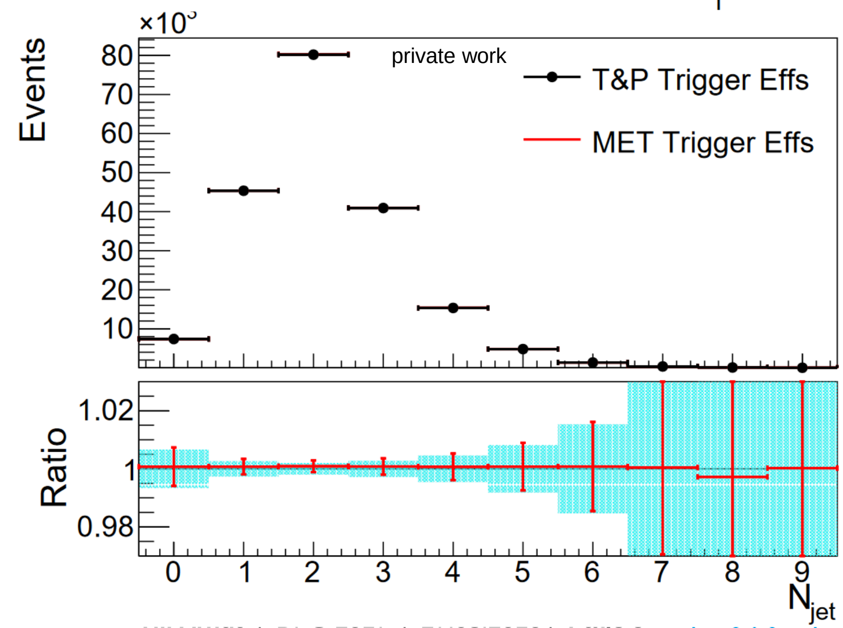


Tag & Probe vs. Orthogonal Triggers: Results



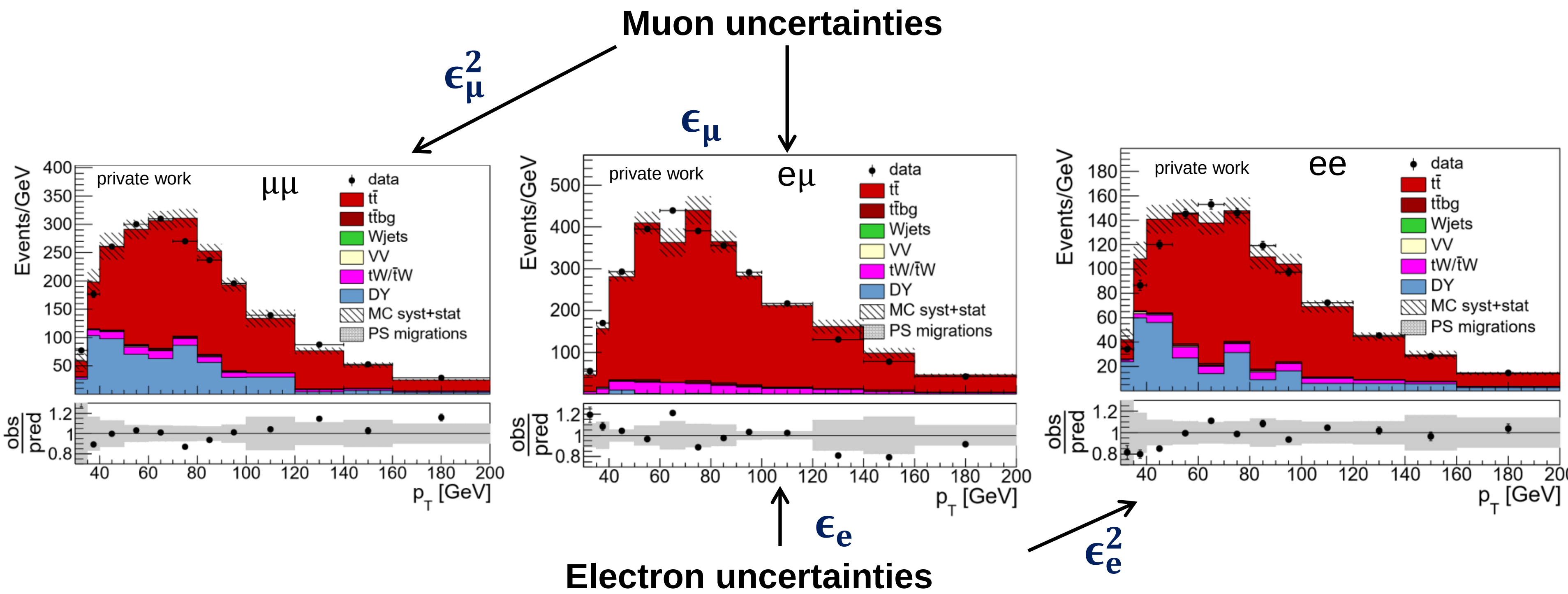


- **No sign of systematic difference over full phase space**
  - Region below 20 GeV not included in the measurement



Constraining Lepton ID/ISO Uncertainties

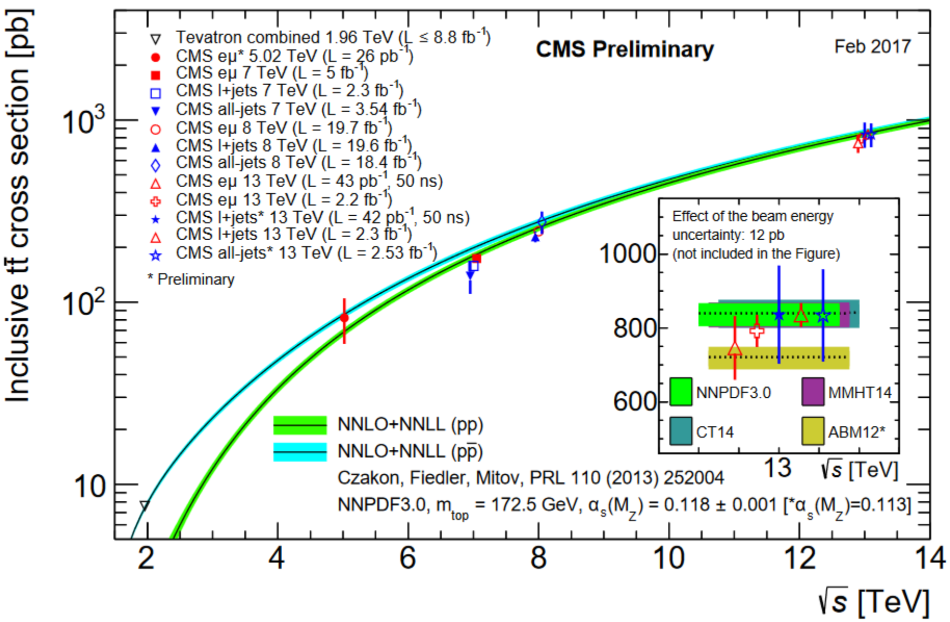
- Include same flavor channels as separate templates
- Muon uncertainties can be constrained in ee channel and vice versa
- Z-Veto mitigates impact of DY
  - We don't measure the DY cross section



Plots require exactly 2 Jets , 1 btag

Conclusions

- I am preparing a **precision measurements of the top quark pair production cross section** at 13 TeV
  - Earlier measurements confirmed SM
  - Any BSM contribution would be small
- **Significant improvement** over earlier results is possible
  - Incremental work on systematics
  - Work on trigger and lepton uncertainties shown today



Thank you for your Attention

Fit: General Description

- Method taken from Run I cross section measurement (CMS-PAS-TOP-13-004)
- Template fit to jet and b-jet distributions
- Templates (signal + background) taken from MC, fitted to data
  - Binned Poisson likelihood fit including nuisance parameters for systematic uncertainties λ_i
  - Binned Poisson likelihood fit: $\chi^2_{bin} = -2 \cdot \sum_{j=bjets} \ln P_{N_j(\vec{\lambda}, \sigma_{t\bar{t}})}(N_j^{data}) - nuis$
- Jet variables used to constrain uncertainty from b-tagging, jet energy corr.
  - First divide events into three bins by number of b-jets: $N_b = 1$; $N_b = 2$; $N_b = 0$ or $\mathrm{N_b} \geq 3$
  - Then for each of these take: N_{events} for events with no additional light jet
    p_T^{lead} for events with one additional light jet
    $p_T^{sublead}$ for events with two additional light jets
    p_T^{lowest} for events with three or more additional light jets
  - In total 12 distributions for the fit