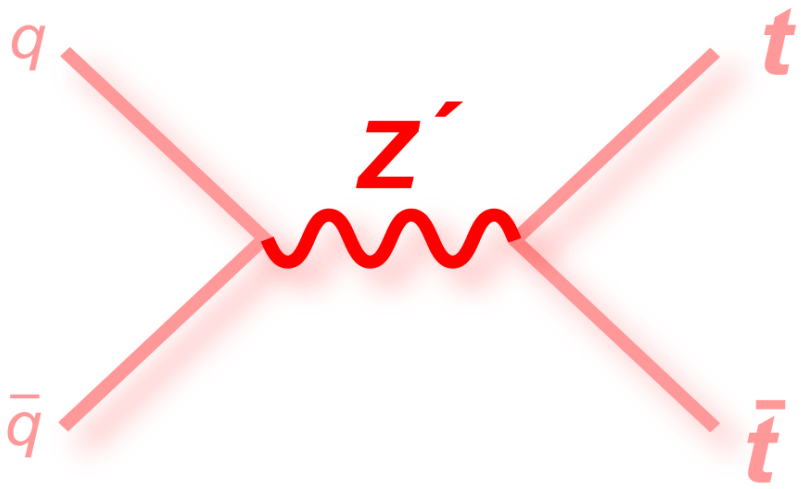
Discovery Prospects for $t\bar{t}$ Resonances in dilepton+jets final states



SUNY, Buffalo:
Supriya Jain, Ia Iashvili
Avto Kharchilava

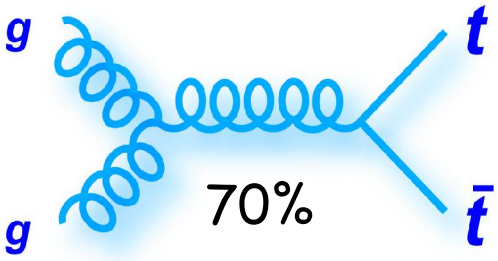
Florida State Univ:
Harrison B. Prosper

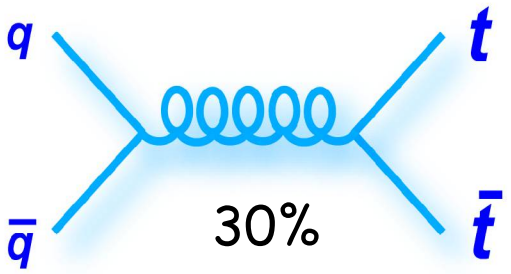
Snowmass 2013, Minnesota

Top Group Meeting, July 31

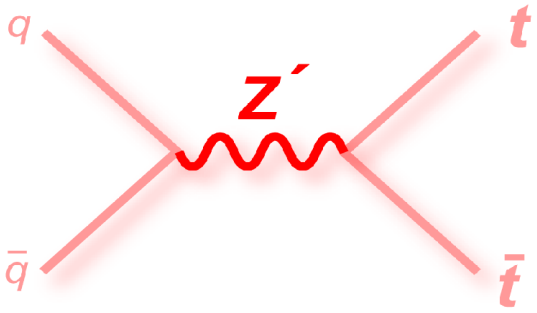
Introduction

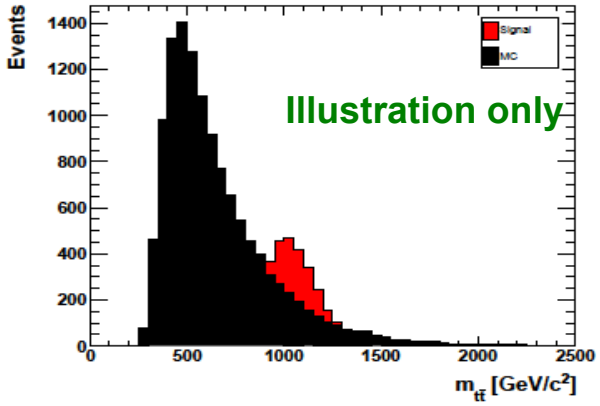
- The Standard Model (SM) predicts production of top-antitop pairs through the exchange of gluons





- But certain models beyond SM predict the production of a massive resonance, for example, Z' , that can decay to top-antitop pairs

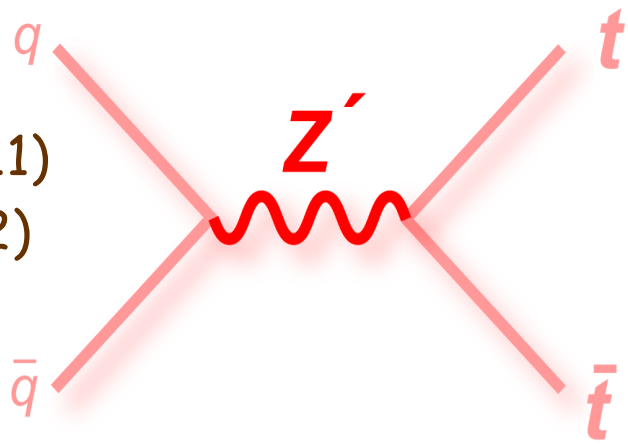




- Eg: "*Topcolor-assisted technicolor*" model which predicts a leptophobic Z' with strong couplings to the third generation: hep-ph/9911288: Hill, Parke, Harris

Current limits on Z' → ttbar

- Current limits on leptophobic Z' (of narrow width):

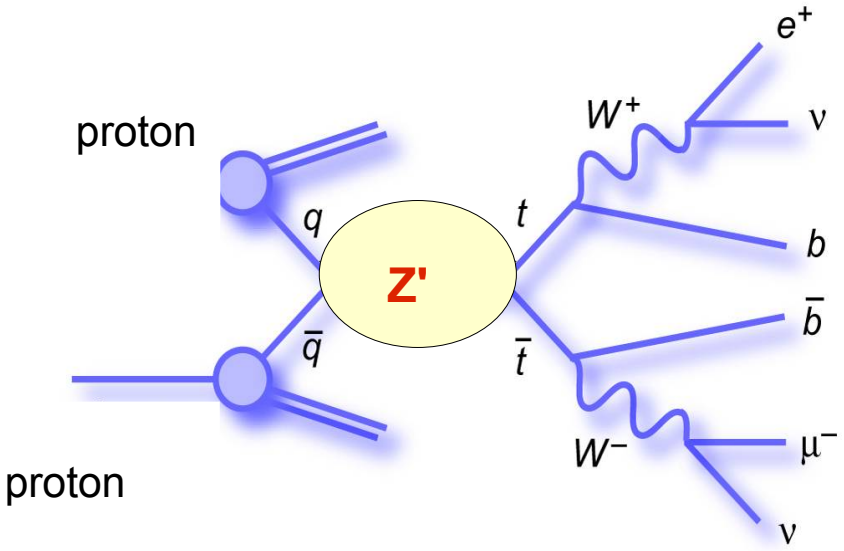


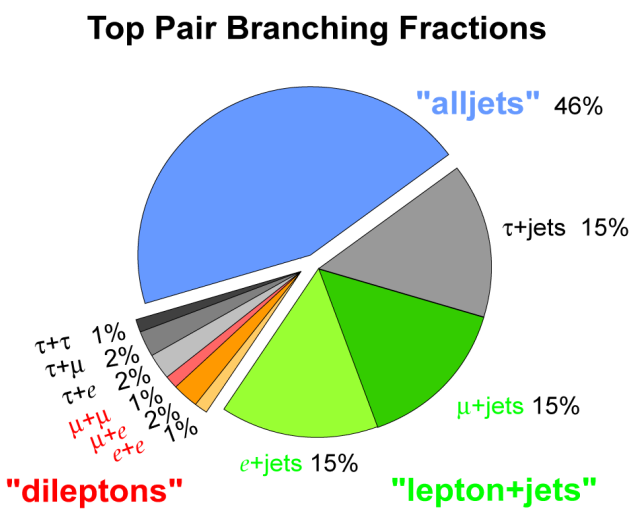
- Tevatron (lepton+jets final states)
  - CDF: M(Z') > 900 GeV, Phys. Rev. D84, 072004 (2011)
  - D0: M(Z') > 835 GeV, Phys. Rev. D, 85, 051101 (2012)

- LHC:
  - ATLAS:
    - lepton+jets: M(Z') > 1.7 TeV, arXiv:1305.2756
    - All-hadronic: excluded M(Z'): 0.70–1.00 and 1.28–1.32 TeV, J. High Energy Phys. 1301, 116(2012)
  - CMS:
  - lepton+jets: M(Z') > 1.5 TeV, J. High Energy Phys. 12, 015 (2012)
  - All-hadronic: excluded M(Z'): 1.3-1.5 TeV, J. High Energy Phys. 09, 029 (2012)
  - dilepton+jets: M(Z') > 1.3 TeV, Phys. Rev. D, 87, 072002 (2013)

Event Modeling - I

- Here, we consider Z' → ttbar → dileptons+jets

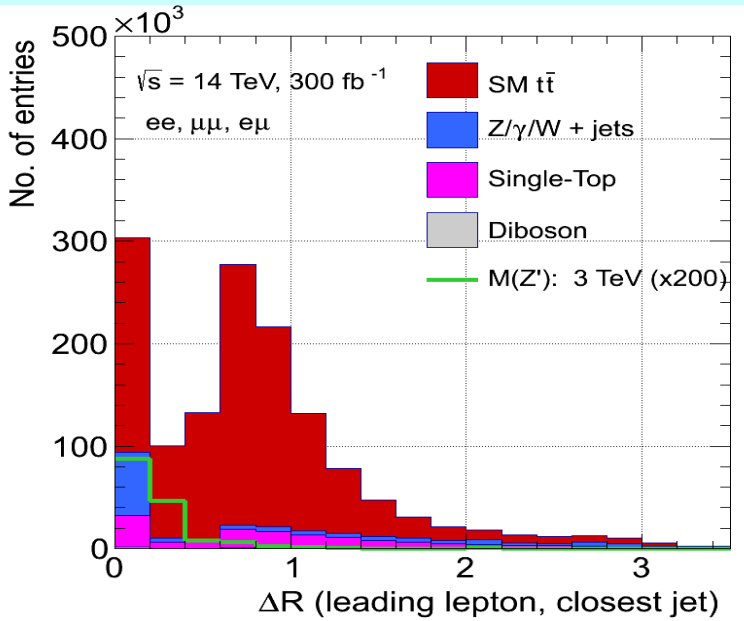


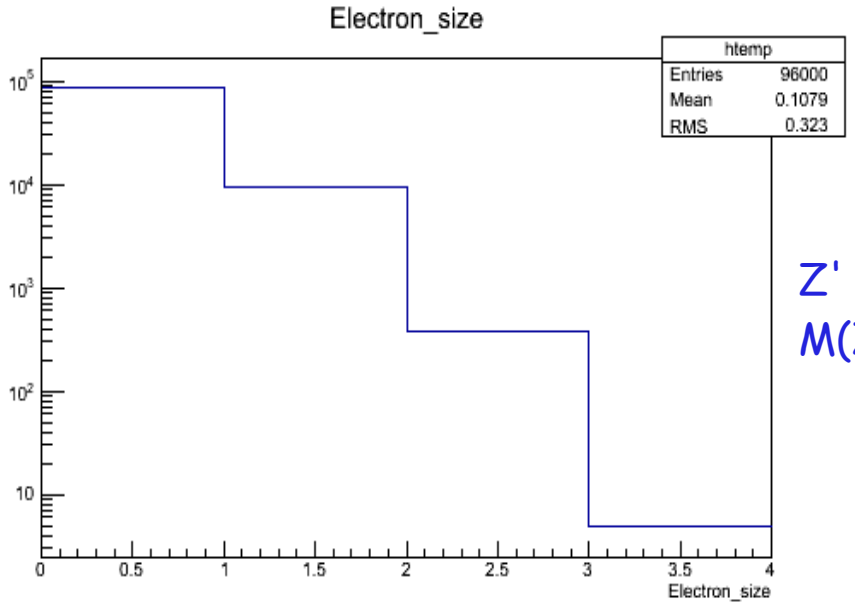


- Expected branching fractions: 1% (ee), 1% (mumu), 2% (emu)
- Principal sources of background
  - SM ttbar production
  - Drell Yan (DY)
  - Single-top production
  - Dibosons (WW, WZ, ZZ), W+jets
- All samples simulated for LHC 14 TeV, <μ> = 50 (pileup)

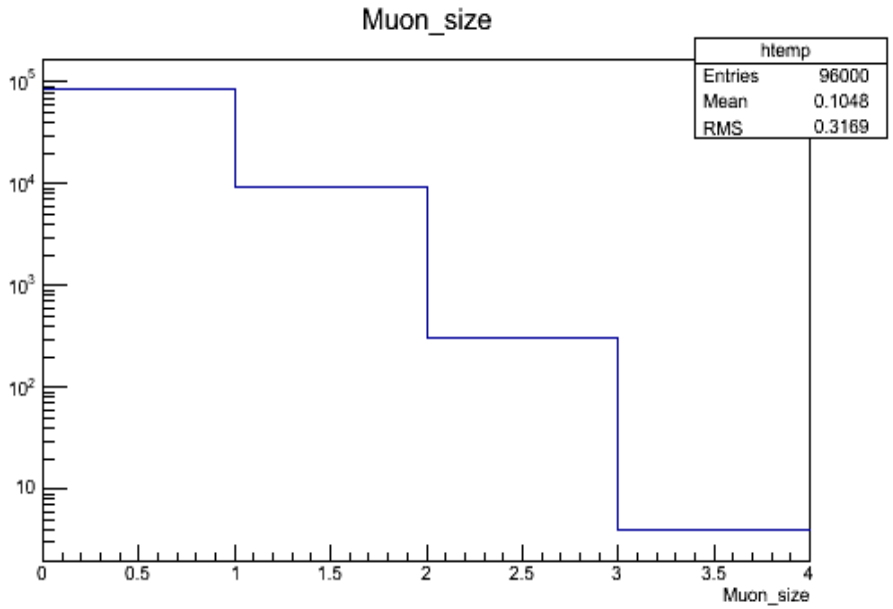
Event Modeling - II

- At $\sqrt{s}$ = 14 TeV, ttbar events are highly boosted
- Therefore, lepton isolation cut applied while reconstructing leptons in Delphes simulation, heavily reduces dilepton events from input rootfiles





Z' Delphes file
M(Z'): 3 TeV



Event Modeling - III

- We, therefore, use leptons from "Particle" branch
  - Choose the first four leptons from the Particle list
  - Sort them by pT
  - Select the two leading leptons

- Apply reconstruction efficiency
  (obtain parameters from Delphes card files)

- Also apply energy (pT) smearing for electrons (muons)
  (obtain parameters from Delphes card files)

- Resulting signal efficiences quite good as expected...

Analysis Strategy

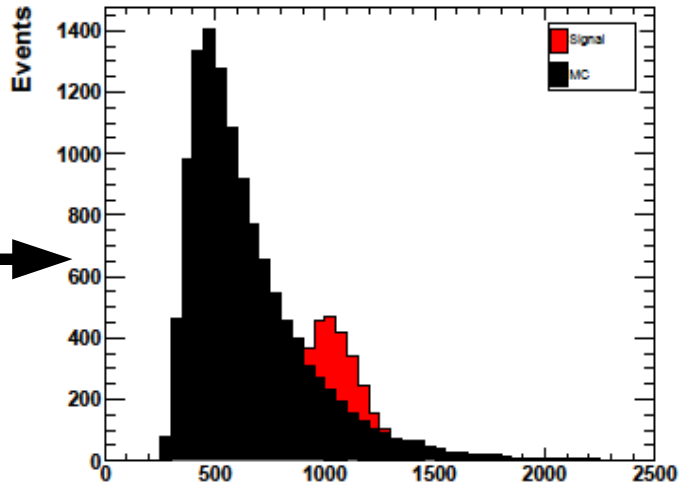
Signal & Background

@LHC 14 TeV, 50-pileup
(Integ. Lum: 300 /fb)
Generic detector simulation: Delphes

Signals: Z' → ttbar
[M(Z'): 2, 3, 4, 5 TeV]

Backgrounds: **HT-binned samples**
SM ttbar, Single top,
Bj (DY, W+jets), BB

Event Selections

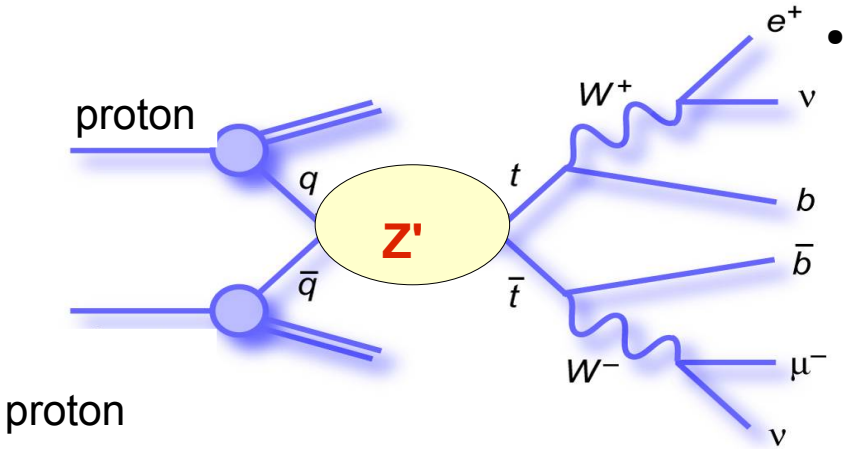


Mass variable M(2l,2jets,MET)

Statistical analysis:

- expected limits on σ(Z')*B(Z'->ttbar)
- discovery prospects of Z'

Event Selections - III



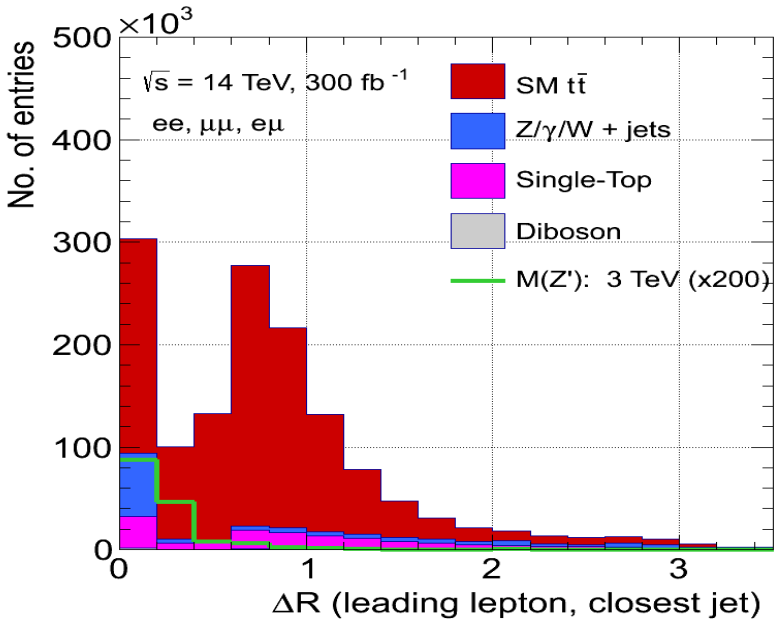
- We spilt events by lepton flavor: ee, mumu, emu

and, require:

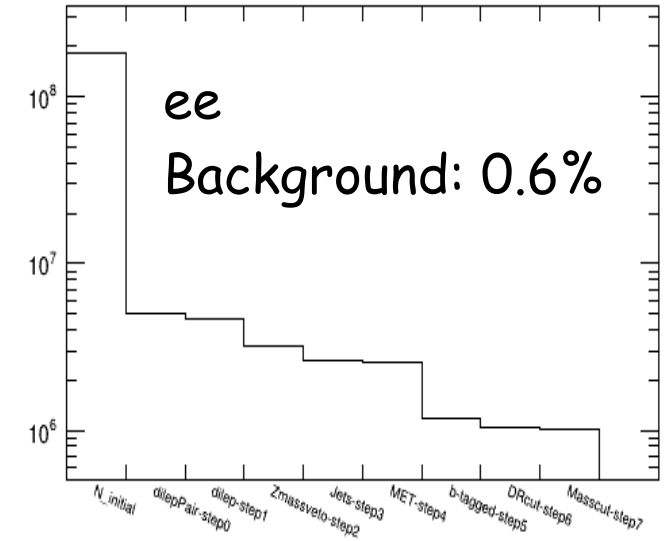
- 2 oppositely-charged leptons, and >= 2 jets, with |η| < 2.4
- Leading lepton pT > 55 GeV, second lepton pT > 25 GeV
- Leading jet pT > 100 GeV, second jet pT > 50 GeV
- Missing transverse energy, MET > 30 GeV
- m(ll) > 12 GeV;
  - also, 76 < m(ll) < 106 GeV in ee and mumu channels only
- At least **two b-tags** (Jet_BTag > 0)

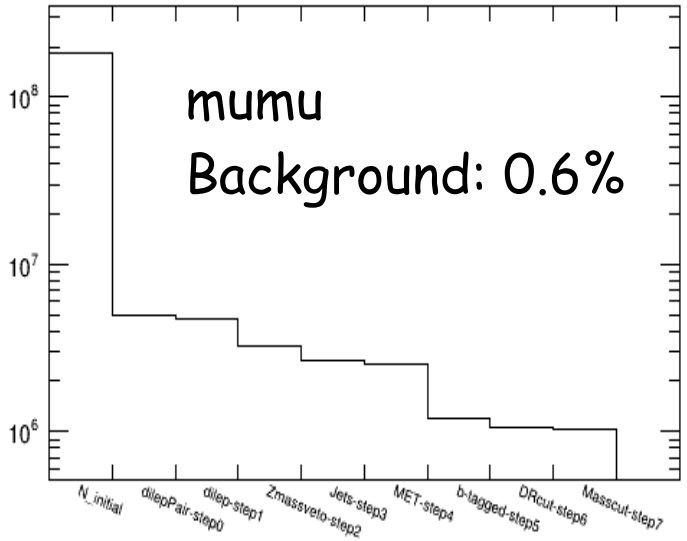
- We also require dR(jet, lepton1, 2) < 1.5
- M(ttbar) > 600 GeV

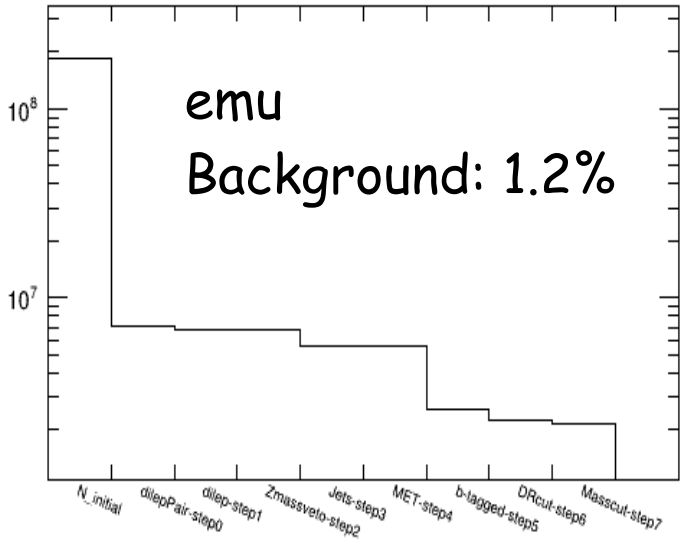
  (for constructing M, p_z of neutrinos is set to zero)

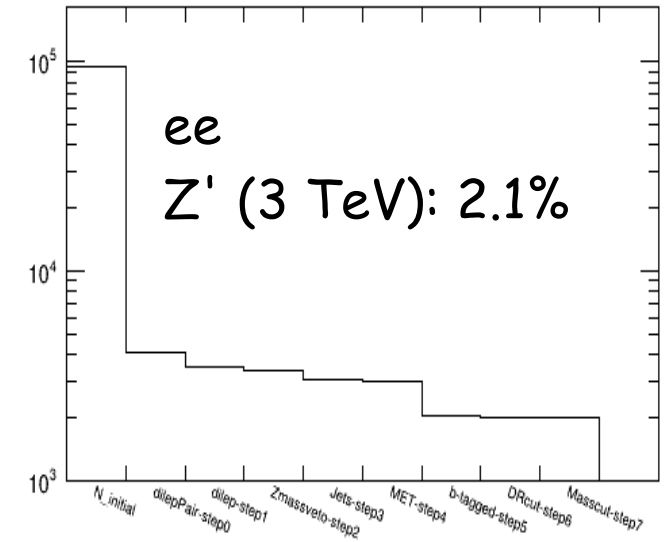


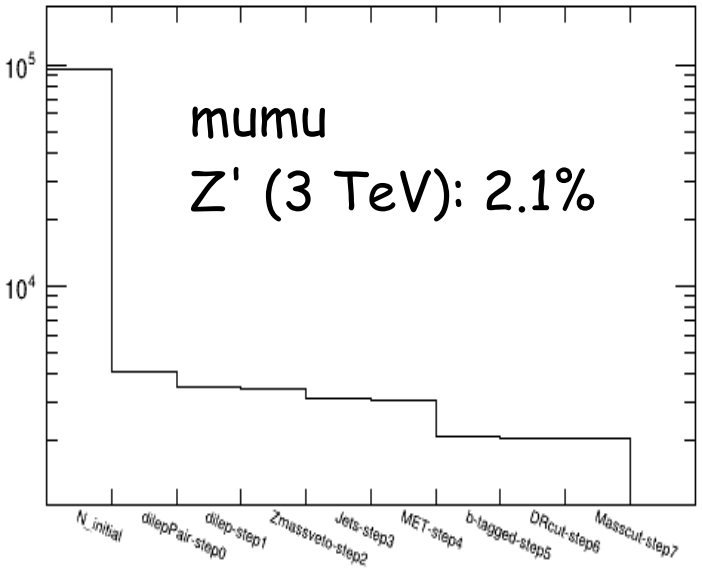
Selection efficiences

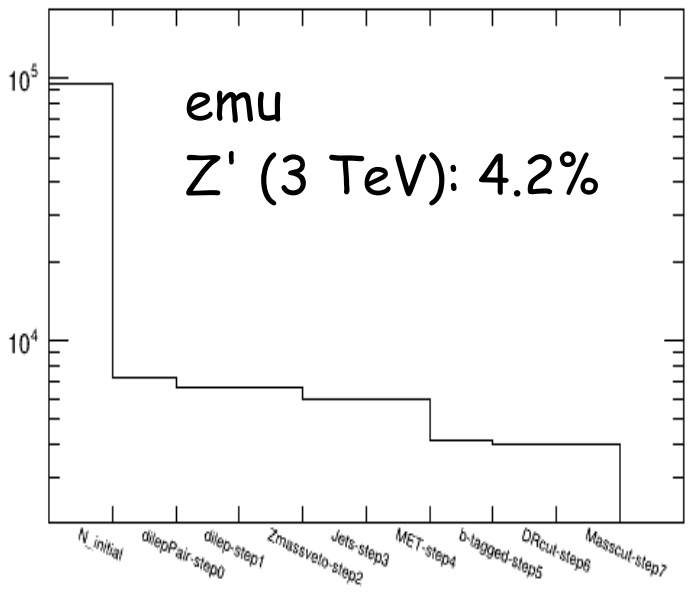












Event Yields (after all selections)

- Integrated luminosity: 300 /fb
- Cross section normalization:
  - Backgrounds:
    LO from generator, corrected for NLO
  - Z' signals: LO from Eur. Phys. J. C, 72, 2012,
  - K-factor of 1.3 from Phys. Rev. D 82, 2010

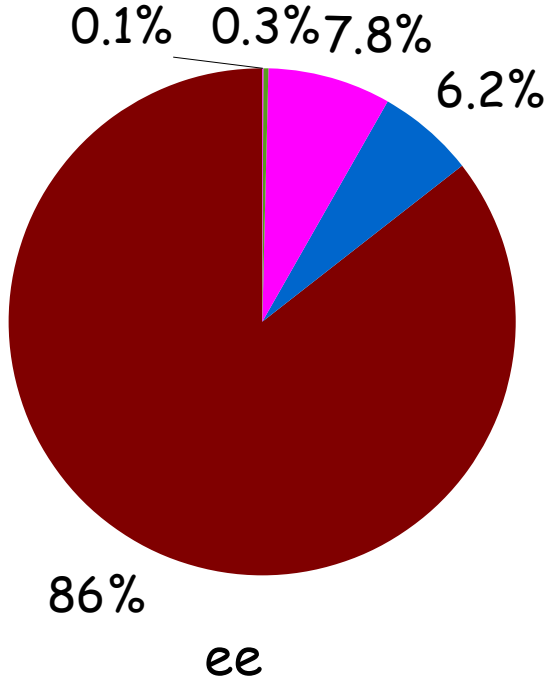
SM ttbar production

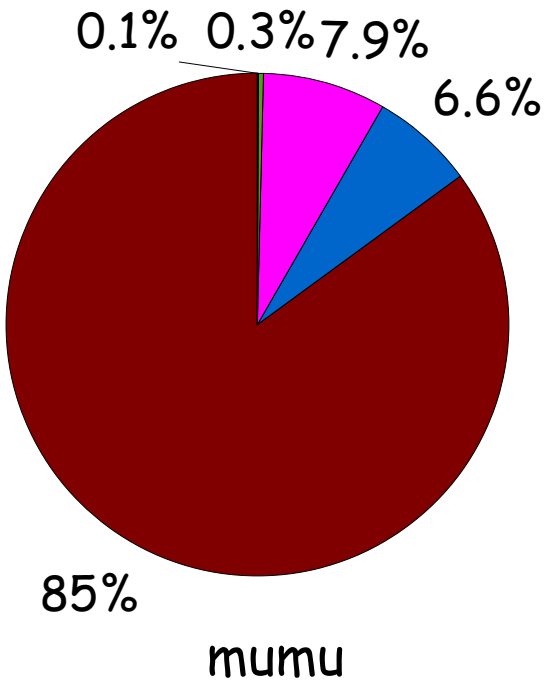
Drell Yan (DY) and W+jets

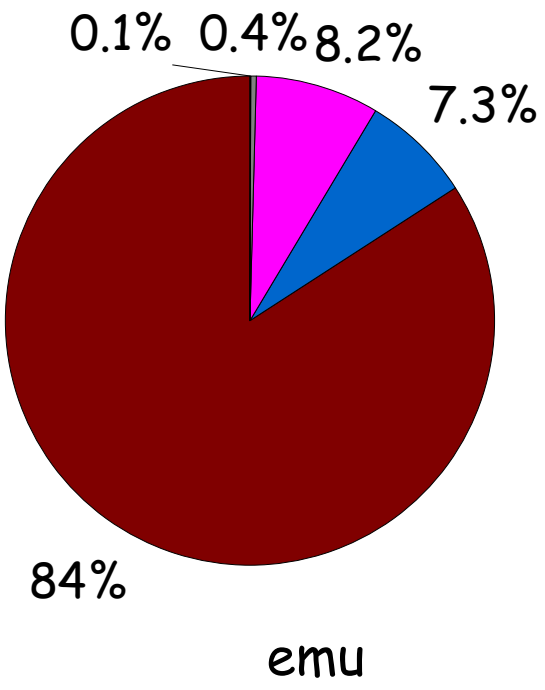
Single top production

Diboson (WW, WZ, ZZ)

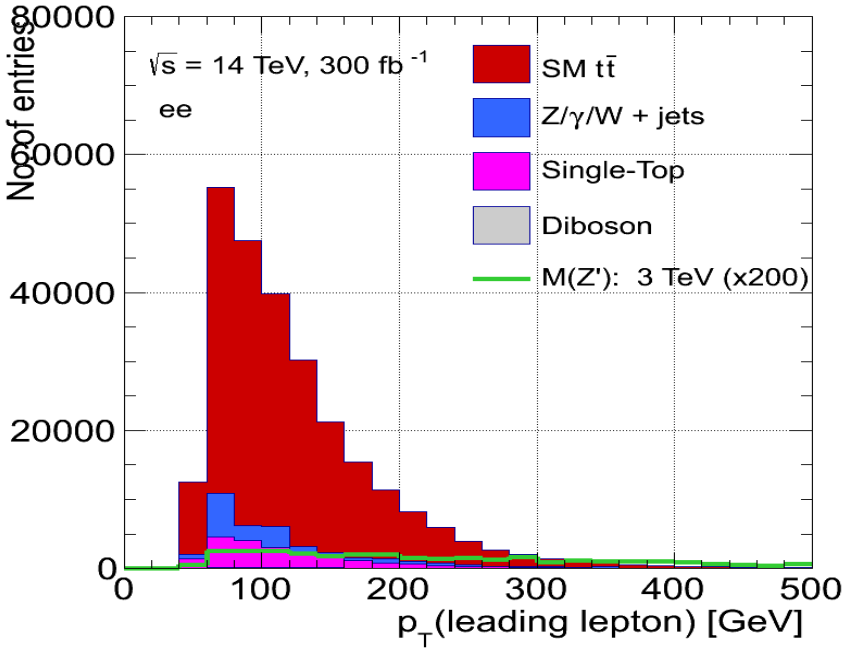
Z' signal: mass 3 TeV

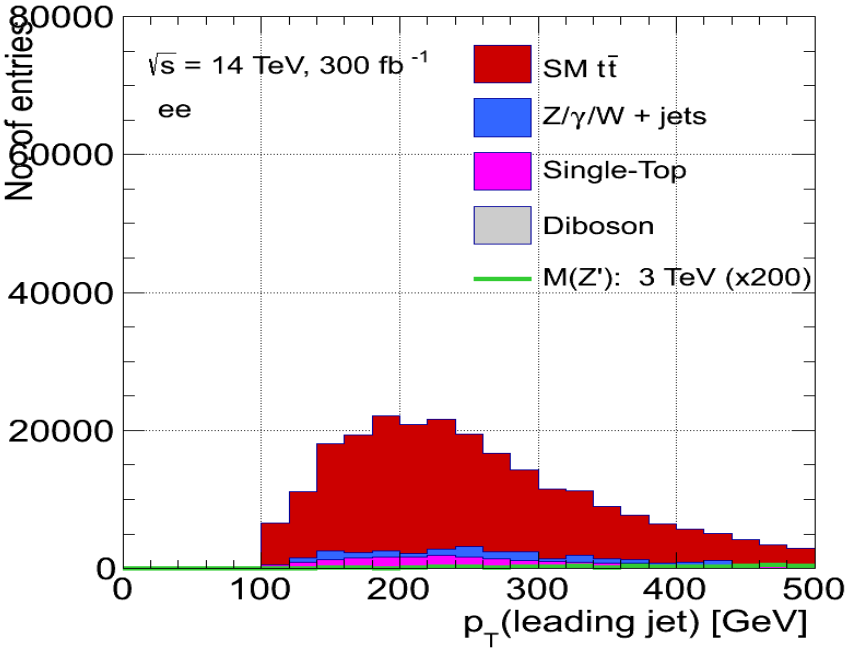




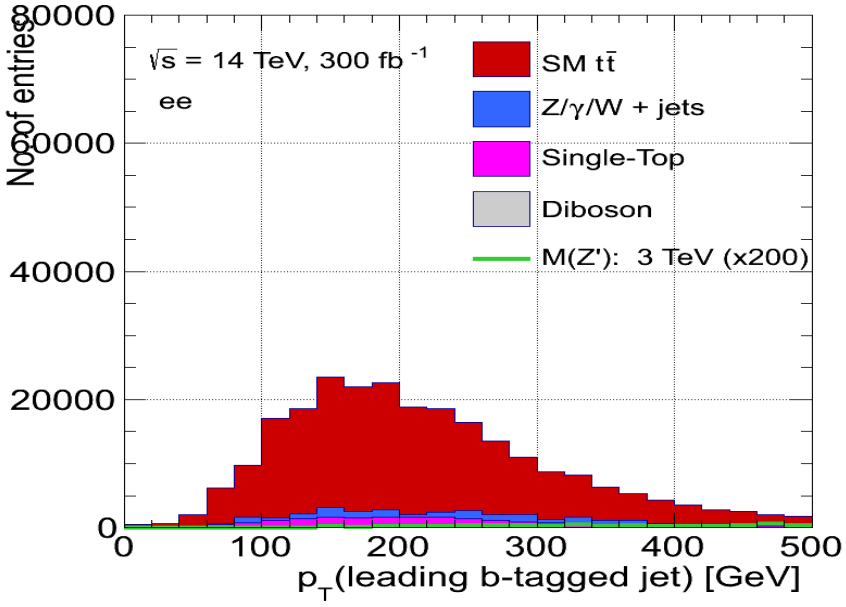


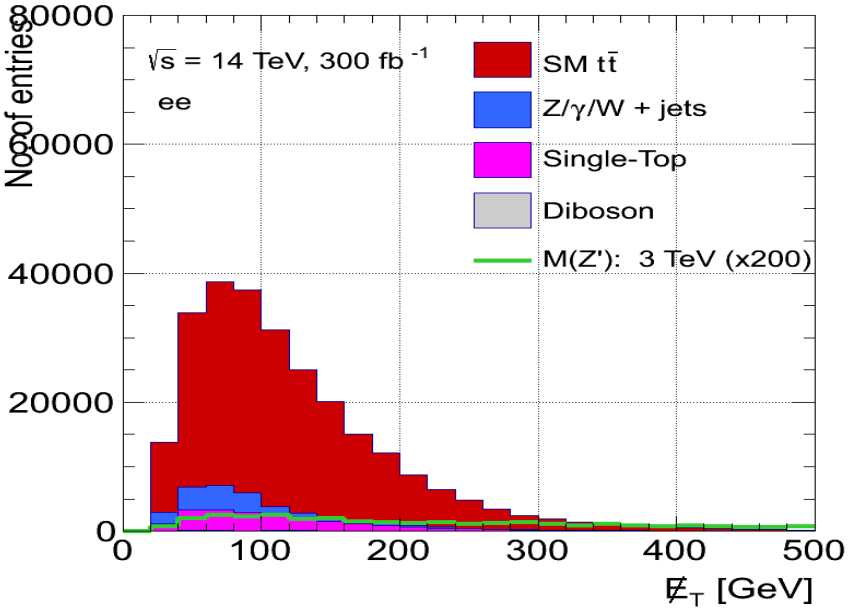
Kinematic Distributions: pT, MET



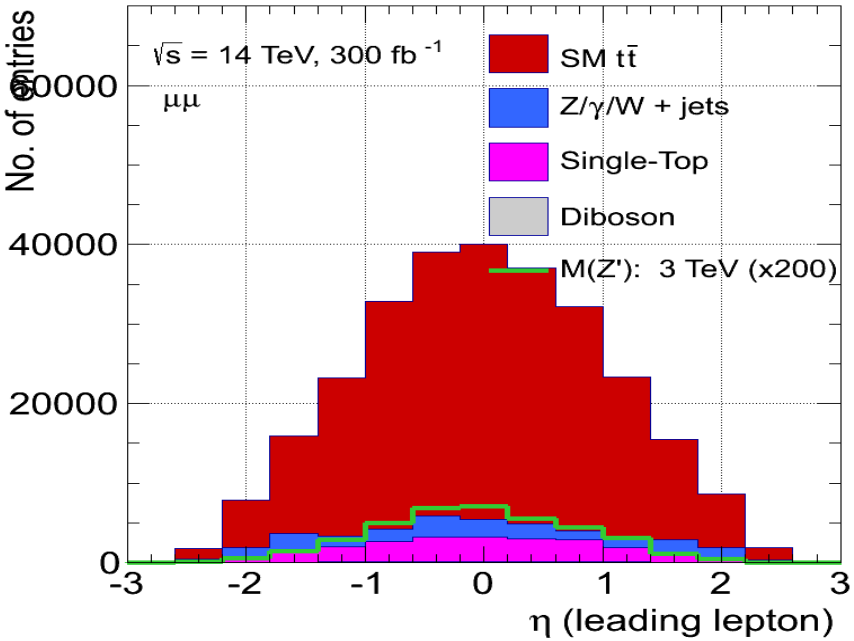


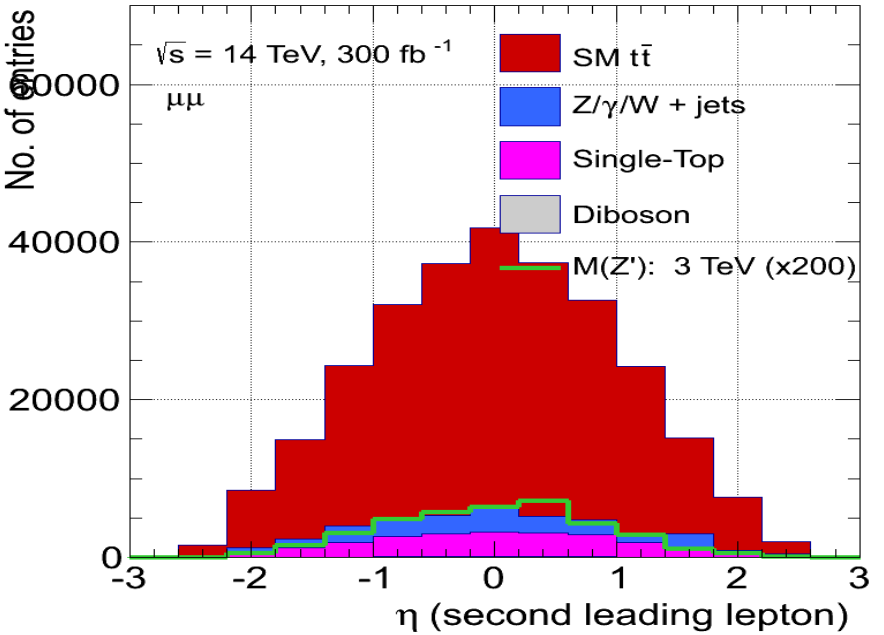
ee channel



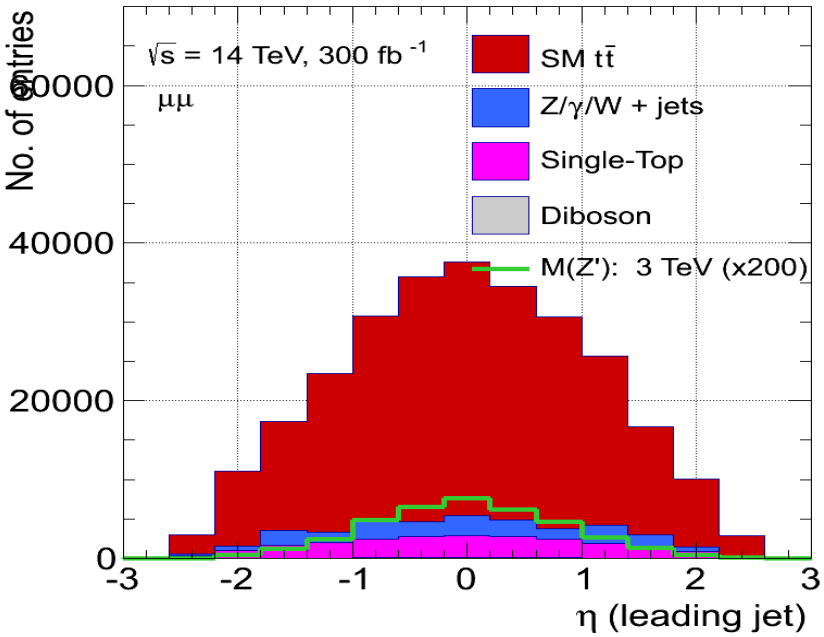


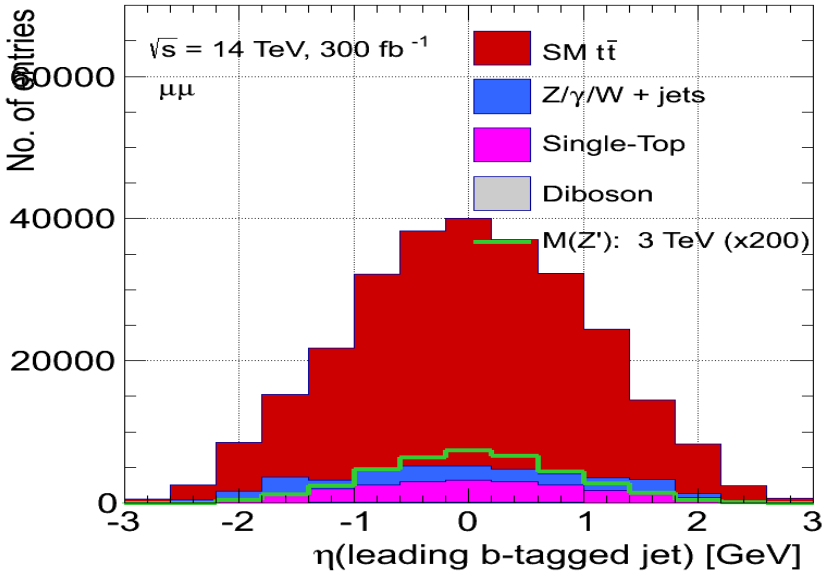
Kinematic Distributions: eta



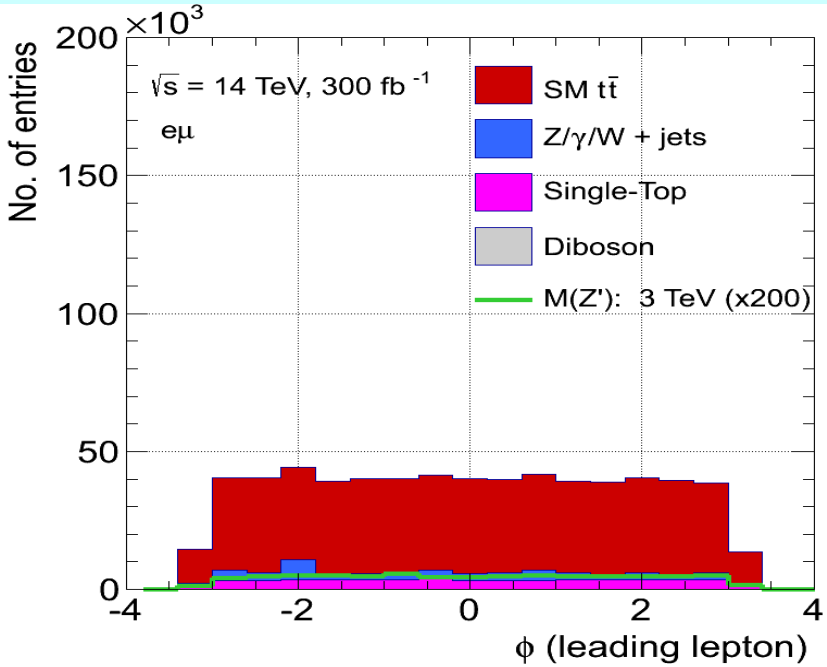


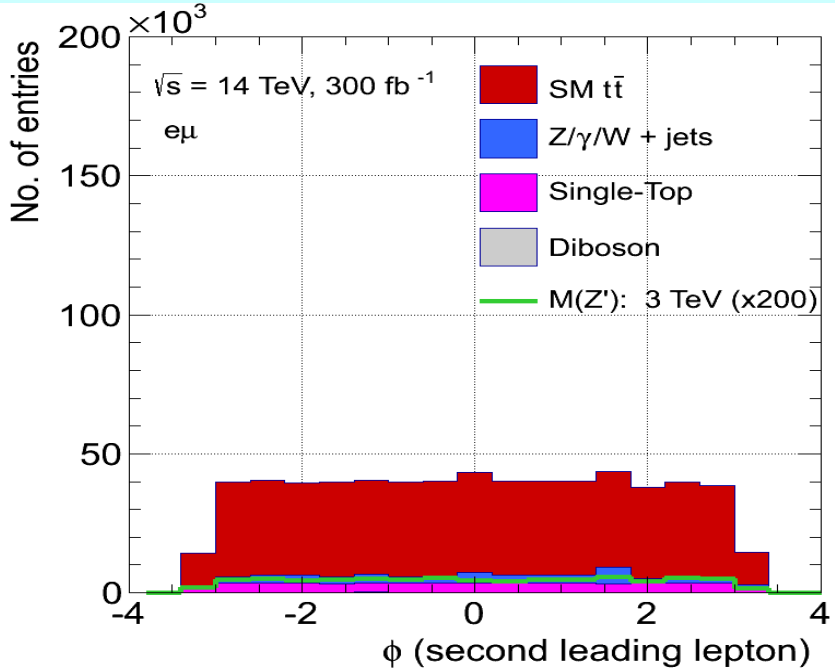
mumu channel



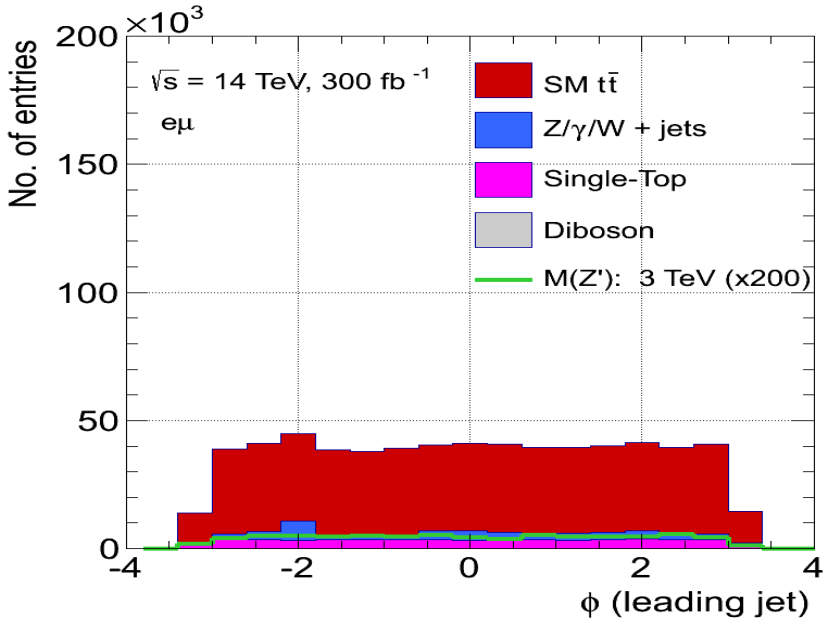


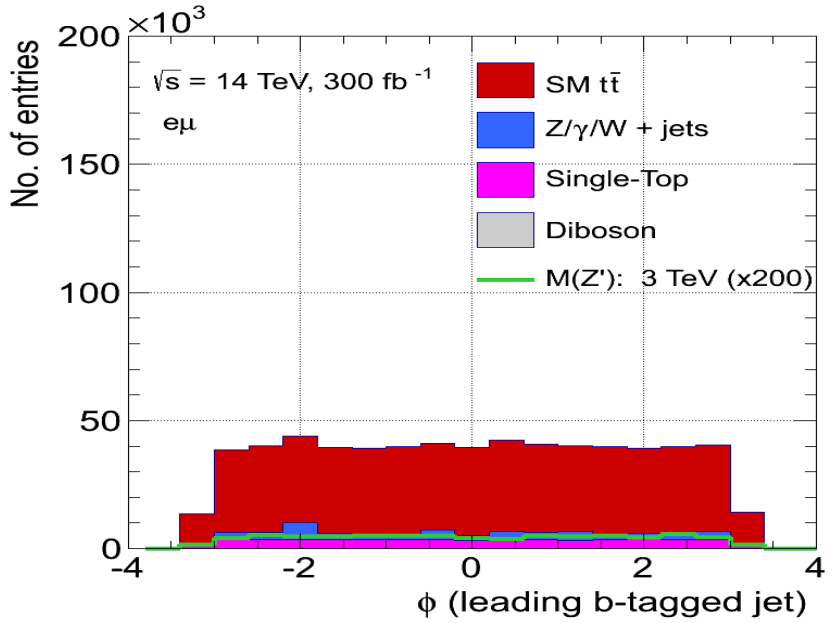
Kinematic Distributions: phi





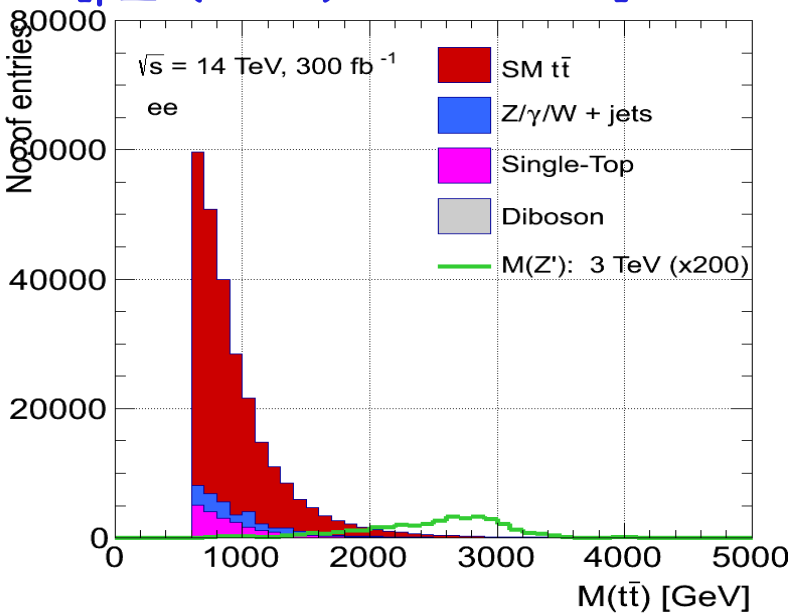
emu channel

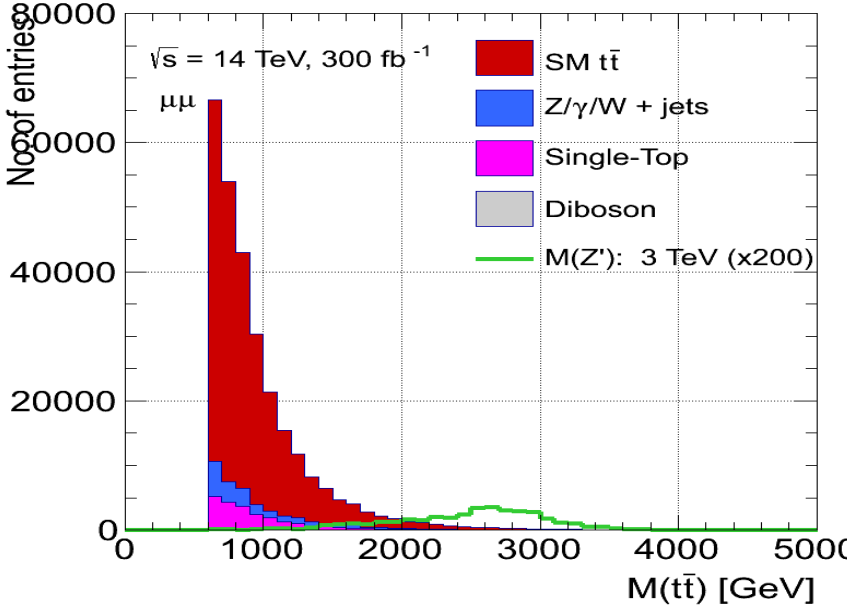


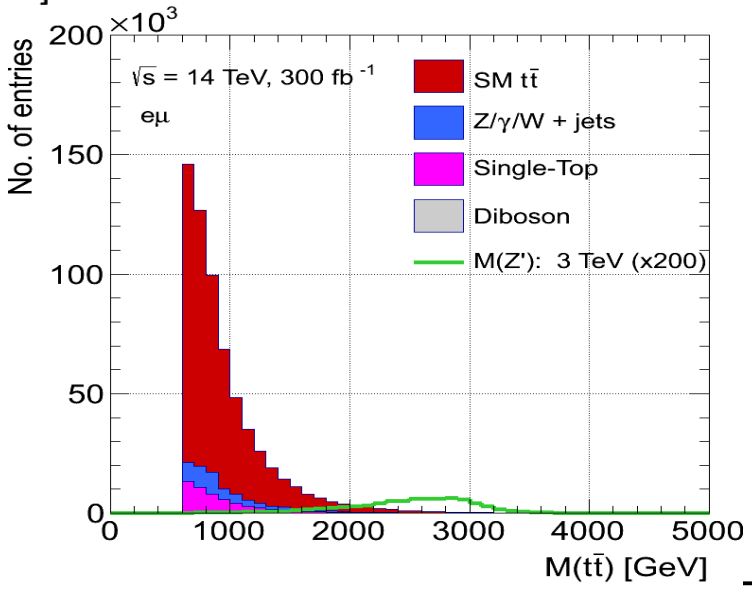


Mass Variable M

- We combine the 4-momenta of 2 leading leptons, 2 leading jets, and MET [p_z(MET) is set to 0]

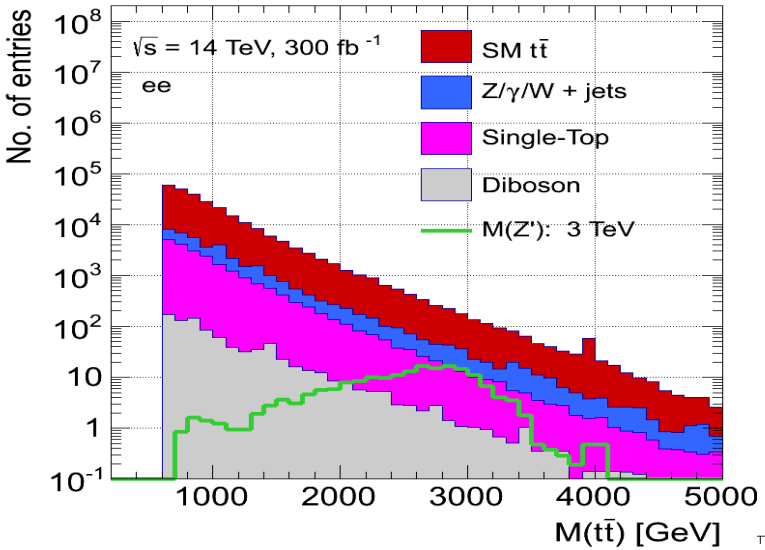


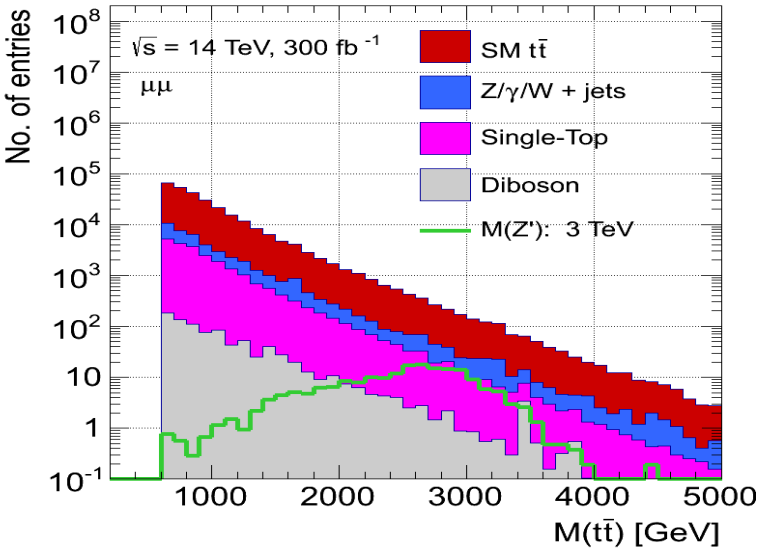


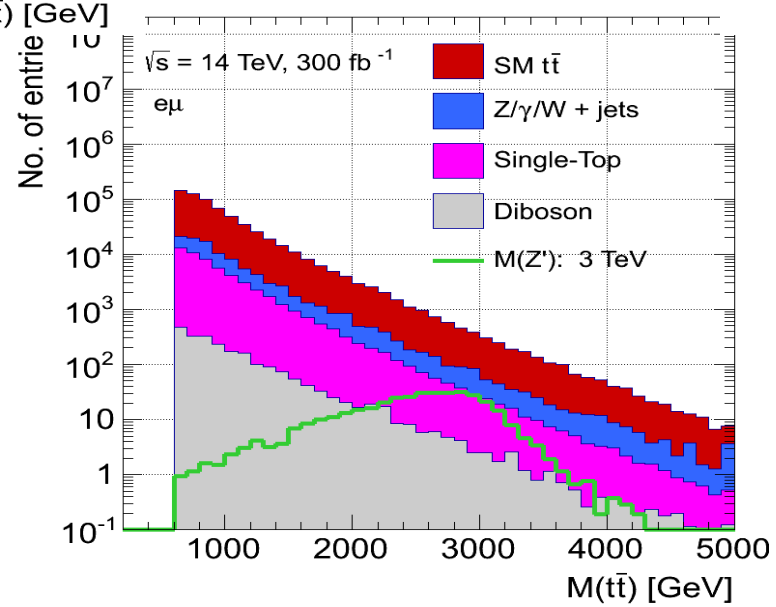


Mass Variable M (log scale)

- We combine the 4-momenta of 2 leading leptons, 2 leading jets, and MET [p_z(MET) is set to 0]





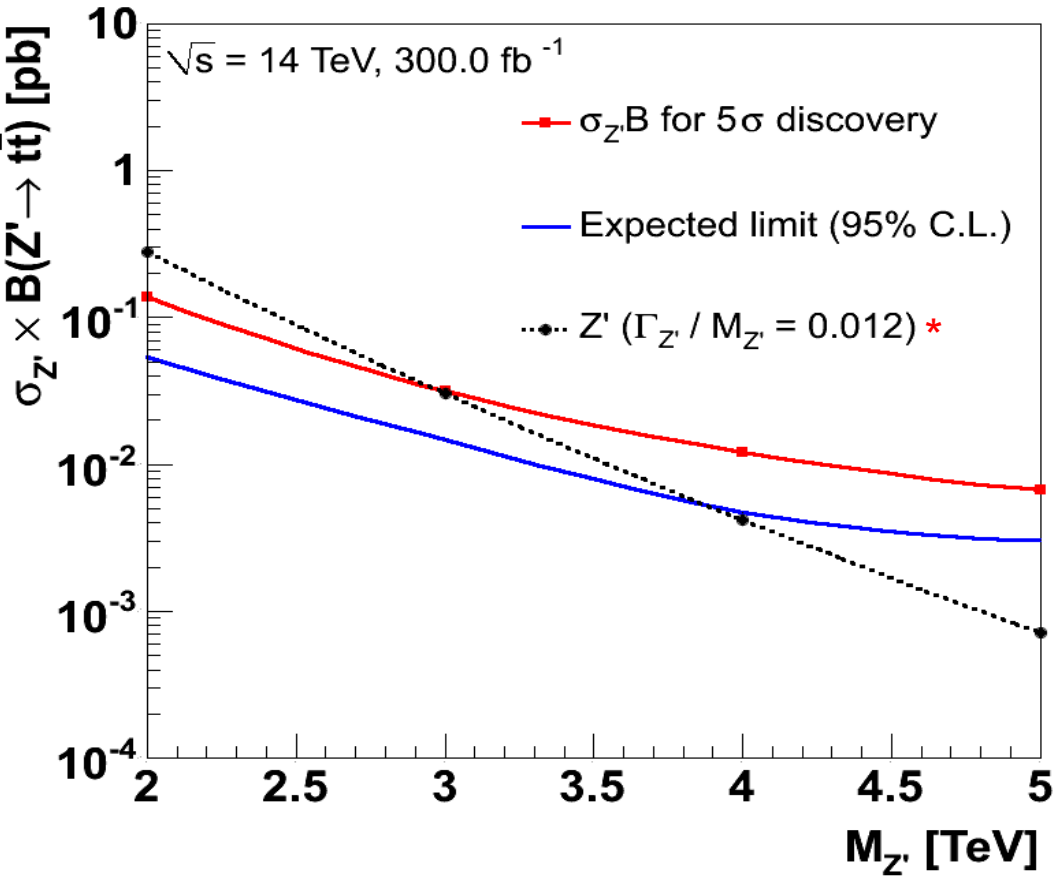


Systematic Uncertainties

- We assume following systematic uncertainties
  - ttbar cross section: 10%
  - DY, W+jets cross section: 10%
  - Single-top cross section: 10%
  - Diboson cross section: 10%
  - Jet energy scale (correlated across bkg and signal samples): 2%
  - B-tag efficiency (correlated across bkg and signal samples): 10%

Discovery Prospects for Z'

- We use "Theta" package http://www-ekp.physik.uni-karlsruhe.de/~ott/theta/testing/html
- Compute expected upper limits on σ(Z')*B(Z'->ttbar), using a Bayesian approach
- Effective σ(Z')B for a 5-sigma discovery



With current samples at LHC 14 TeV (300 /fb, 50-pileup events)

- Expected limit: **M(Z') > 3.9 TeV**
- Discovery at 5-sigma significance possible for **M(Z') = 3 TeV**

* hep-ph 9911288, Eur. Phys. J. C, 72, 2012 (Harris, Jain); Phys. Rev. D 82, 2010

Conclusions

- Discovery prospects explored for ttbar resonances in dilepton+jets final states
- Samples analysed at LHC 14 TeV, 300/fb, 50-pileup events/bunch crossing
- Expected upper limits at 95% CL on $\sigma(Z')B$ vary from 3-50 fb

  for M(Z') ranging from 2-5 TeV
- Theoretical predictions for a leptophobic Z' used to constrain M(Z') > 3.9 TeV
- Also predict 5-sigma discovery of Z' with M(Z') = 3 TeV
- Our plans:
  - Apply Random Grid Search to optimize selection efficiences
  - Also explore sensitivity at 3000 /fb under 140-pileup scenario