Same-Sign Di-Leptons

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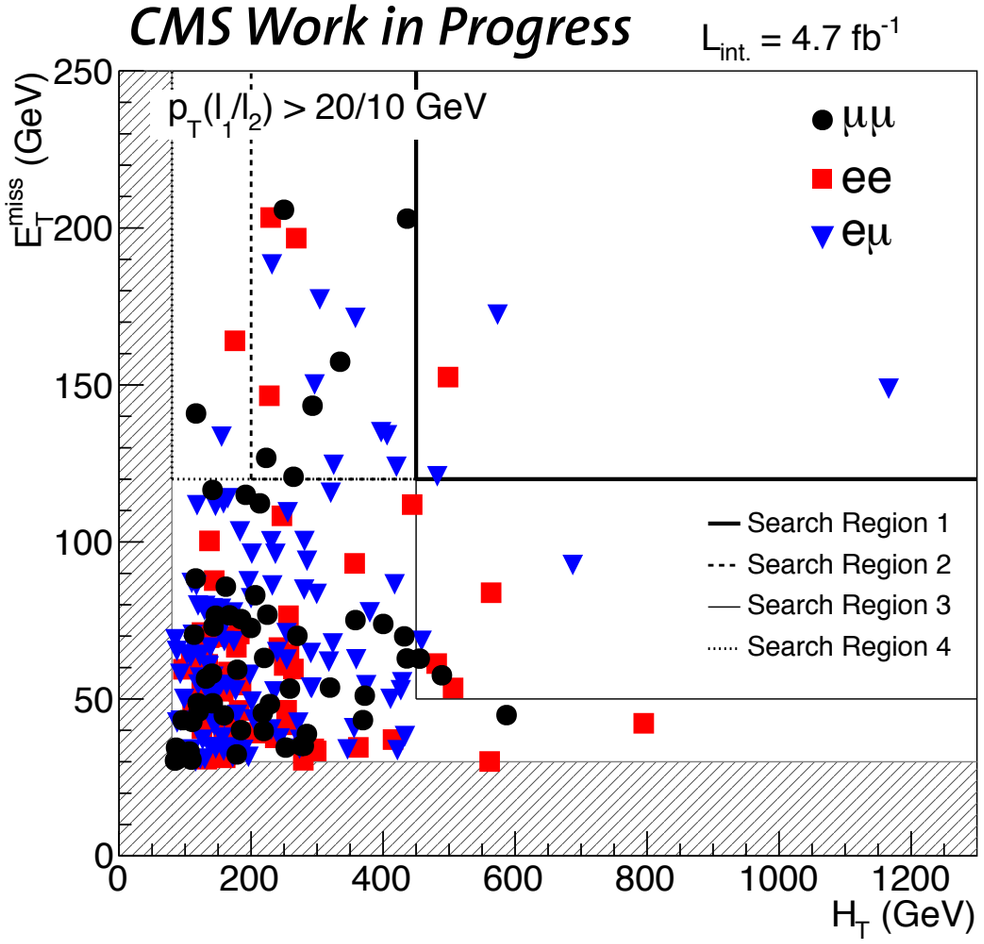
Introduction

- Search for new physics in events with **same-sign isolated di-leptons**, jets and missing transverse momentum
- Extremely **low SM backgrounds** expected
  - **Three broad categories**:
    - 'Fake' leptons from **hadronic activity**
    - **Charge misidentification** (only relevant for electrons)
    - Direct SM **same-sign production** (WZ, ttbarW, $W^{\pm}W^{\pm}$, ...)
- Naturally larger production in **many new physics scenarios** including but not limited to SUSY
- Focus here on fake lepton **background estimation**



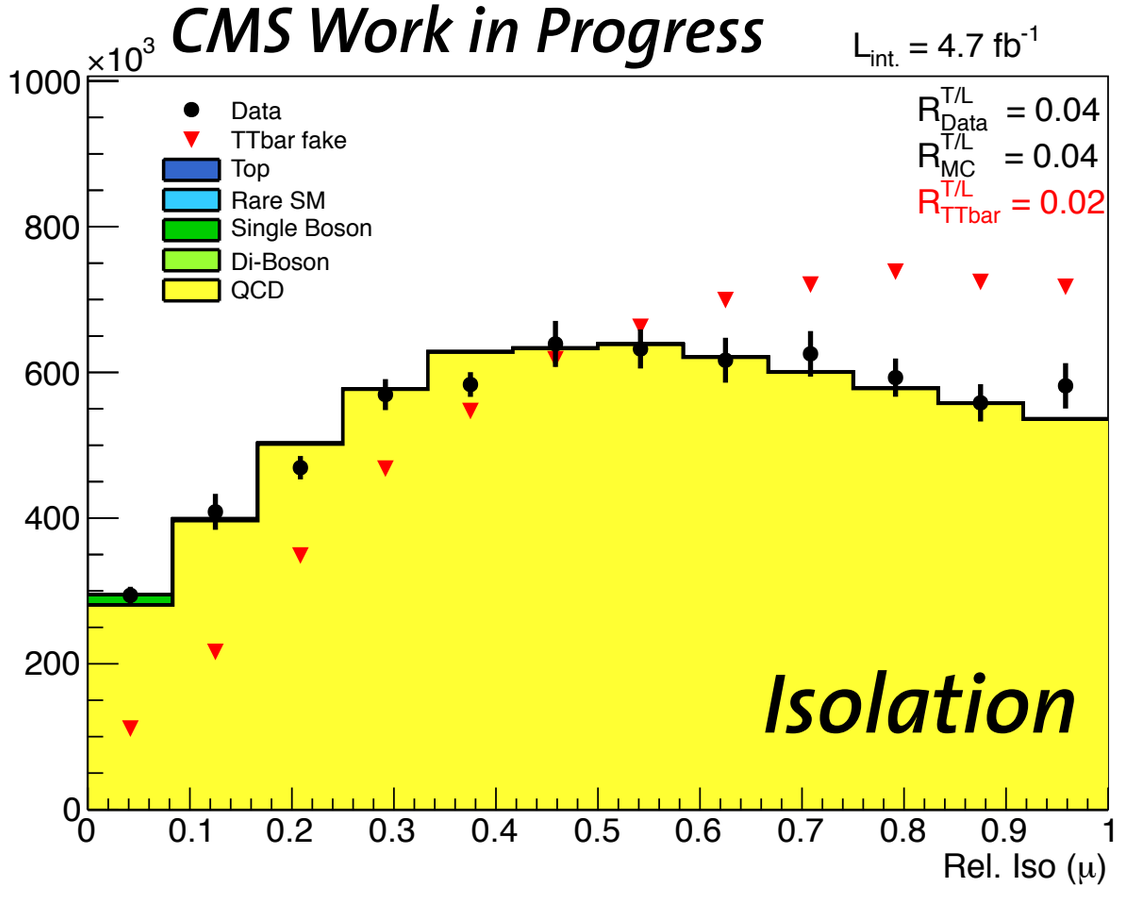
Non-Prompt Lepton Backgrounds

- **Dominant background** in most regions
  - Source is mainly **heavy-flavor decays** in ttbar and W+jets

- Don't want to rely on simulation for delicate modeling or production processes:
  - Use fully **data-driven methods** for estimation

- Method is based on a **loose to tight extrapolation**
  - Measure tight-loose ratio in **signal suppressed control region**
  - Apply to **sidebands of signal region**

- Covers backgrounds from **non-isolated leptons**



Fake Ratios Method

- Cut efficiencies *f* and *p* for **fake** and **prompt** leptons describe probability of loose leptons to pass tight cuts
- **Matrix equation** describing the admixture of events with **fake**/**prompt** and **loose**/**tight** leptons

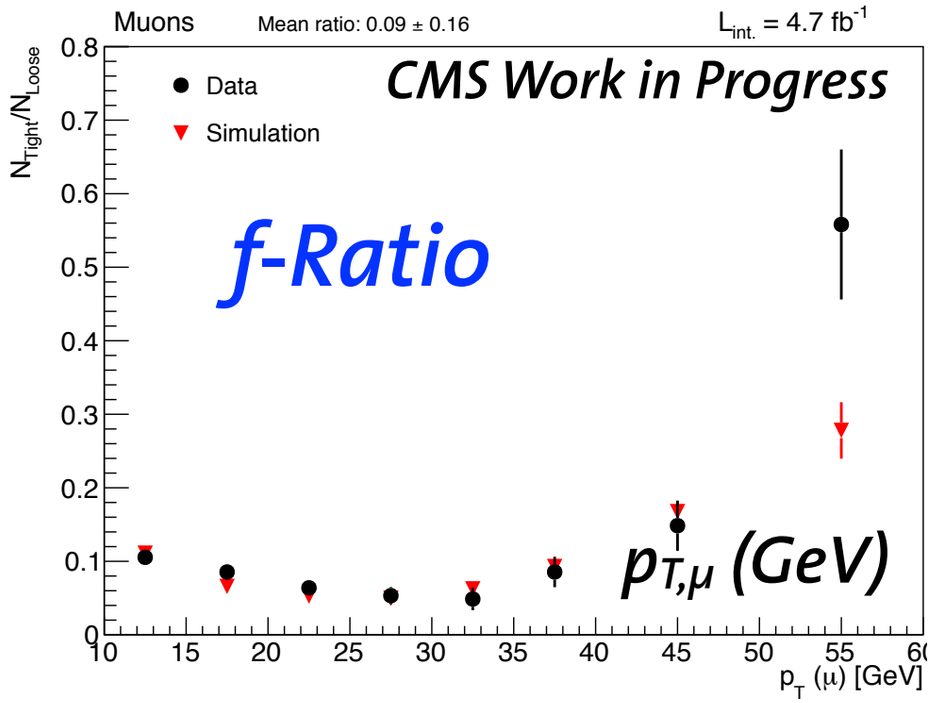
- Can solve for **unknown number of events** with fake leptons as functions of **measured tight/loose yields** and *f* and *p* ratios:

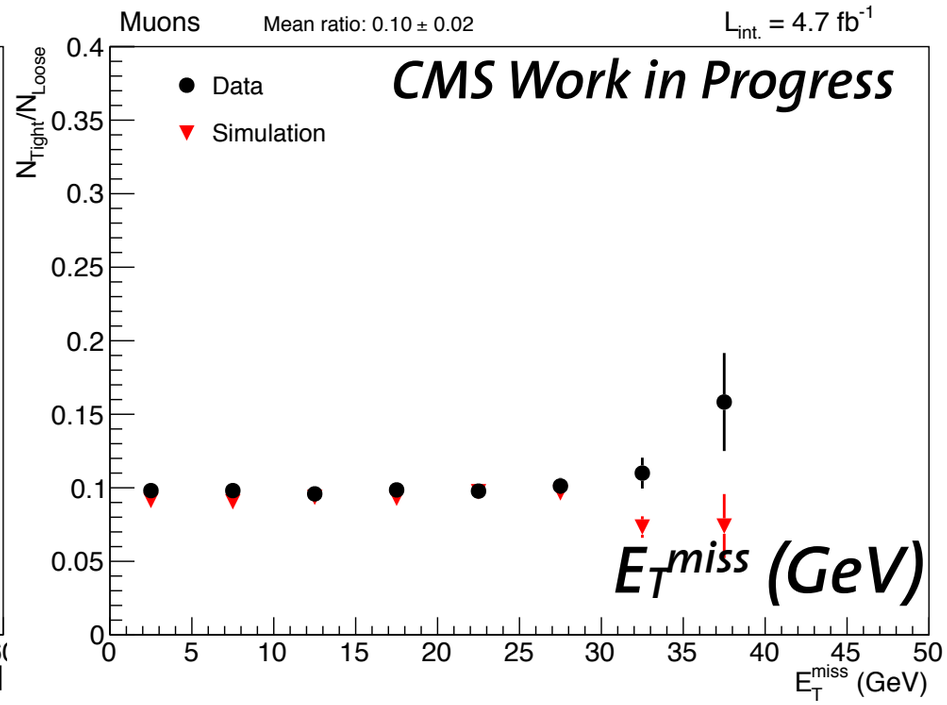
$$
\begin{aligned}
N_{pf} &= \frac{pf}{(p-f)^2}\left[-2fpN_{ll} + \left[f(1-p)+p(1-f)\right]N_{tl} - 2(1-p)(1-f)N_{tt}\right] \\
N_{ff} &= \frac{f^2}{(p-f)^2}\left[p^2N_{ll} - p(1-p)N_{tl} + (1-p)^2N_{tt}\right]
\end{aligned}
$$

- Crucial assumption is that signal suppression cuts in control regions don't change the shape of the extrapolation variable(s)

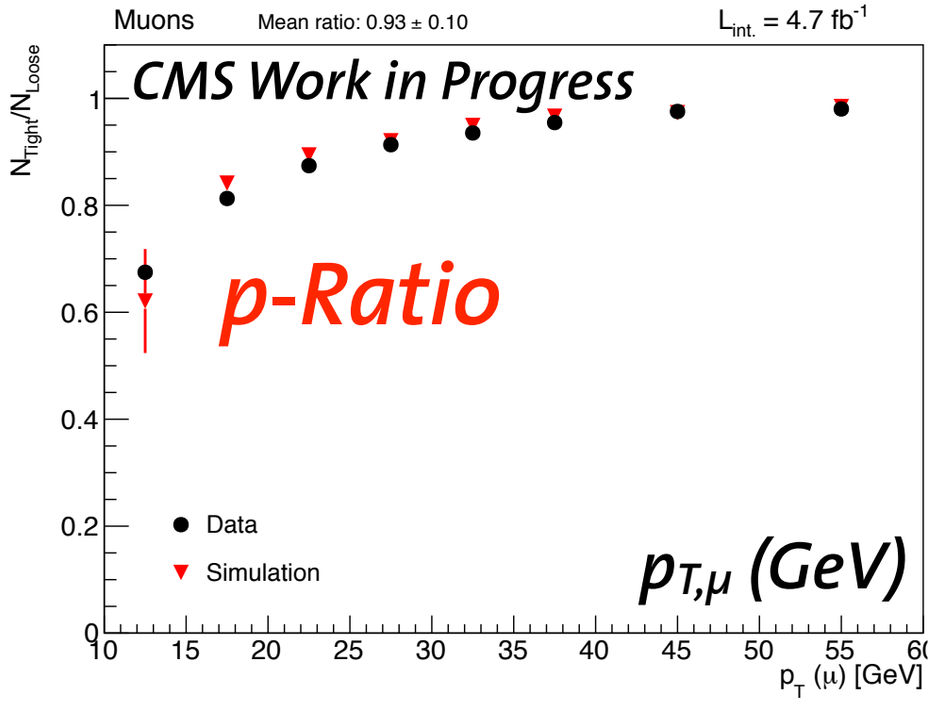
Study of Ratios

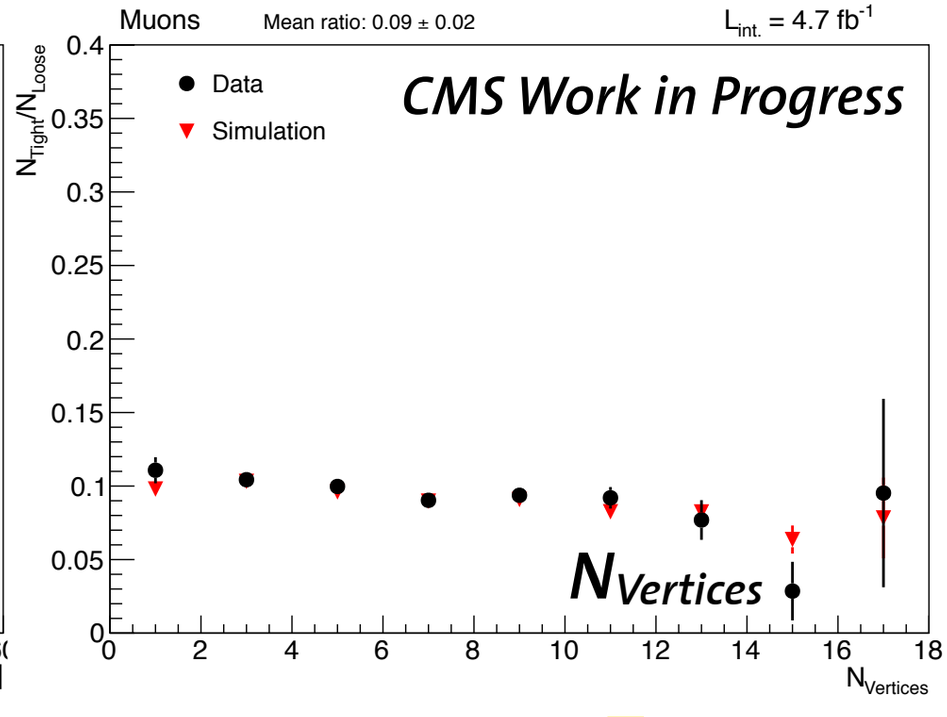
- Study dependence of ratios on various event quantities to assess **systematic uncertainties**





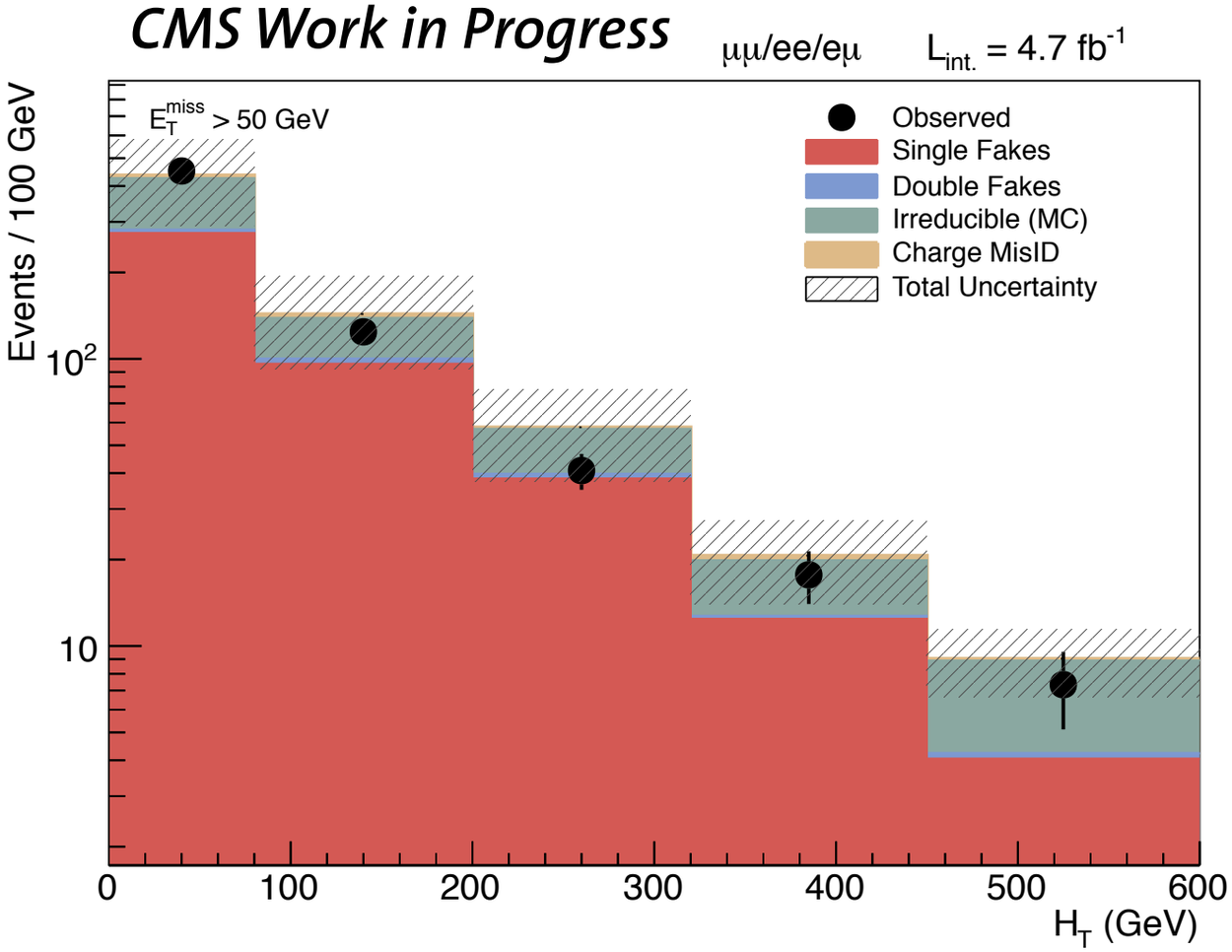
- Ratios are applied **differentially** in lepton momentum

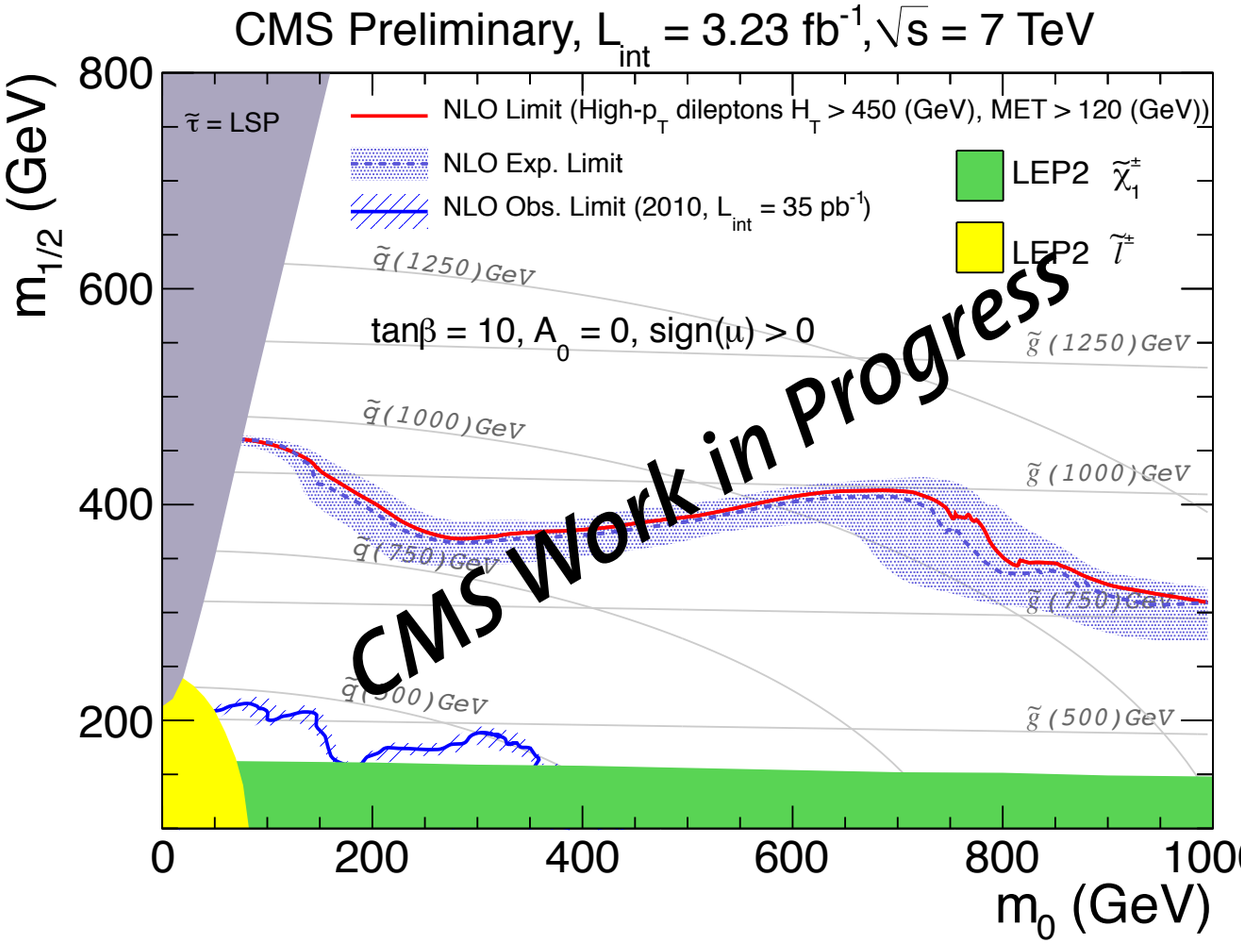


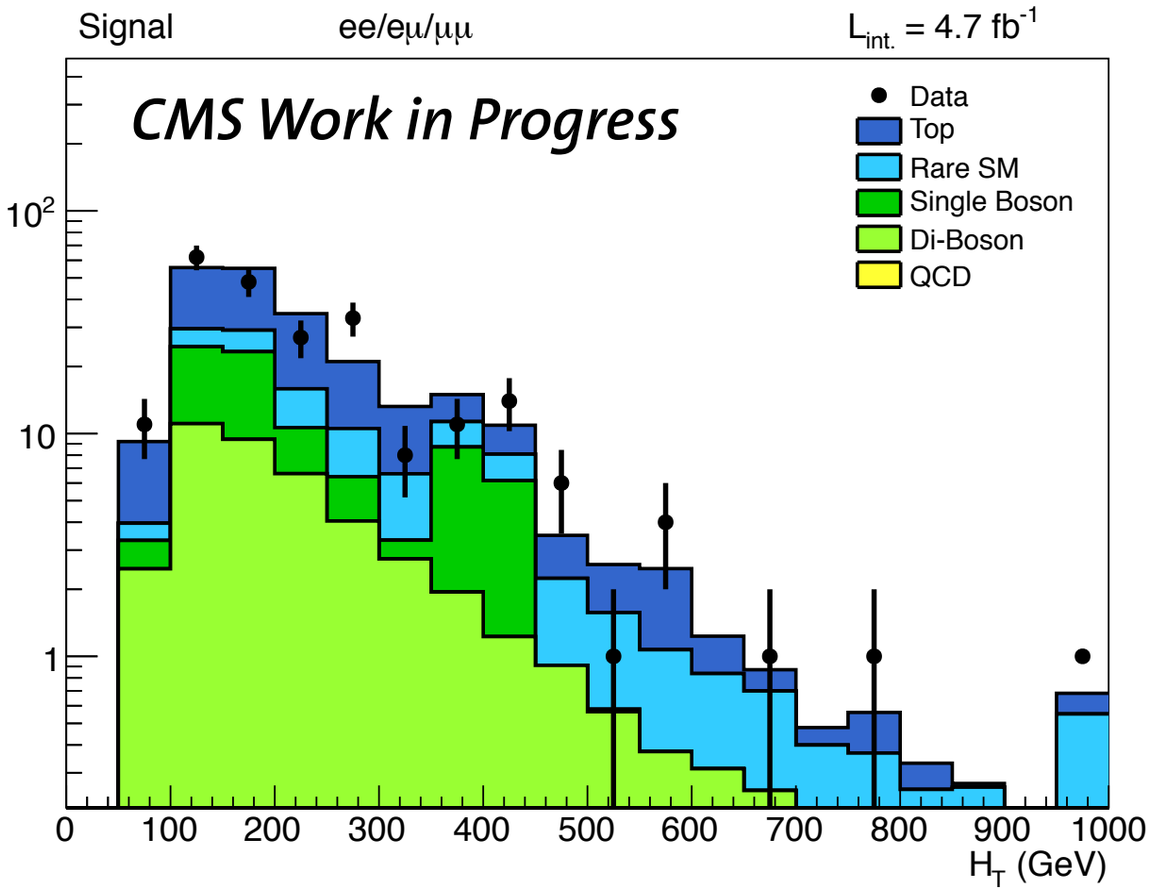


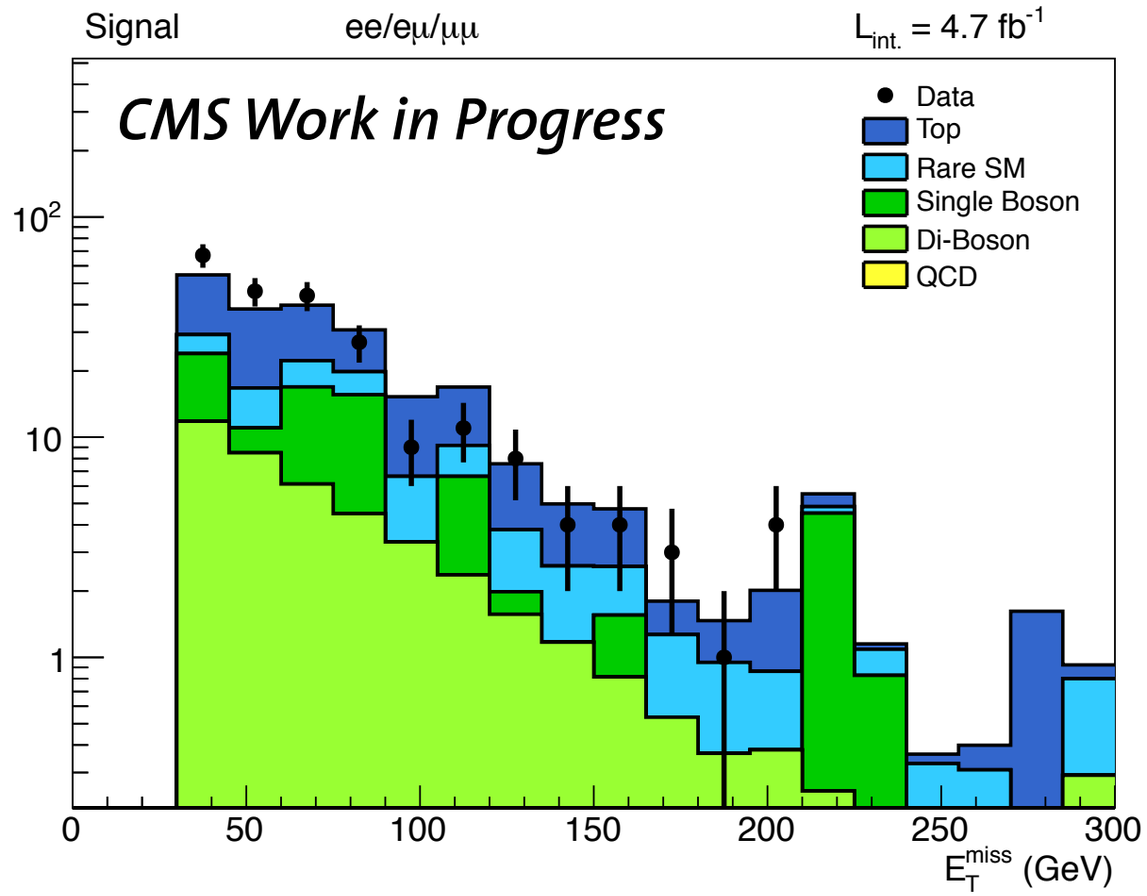
Results

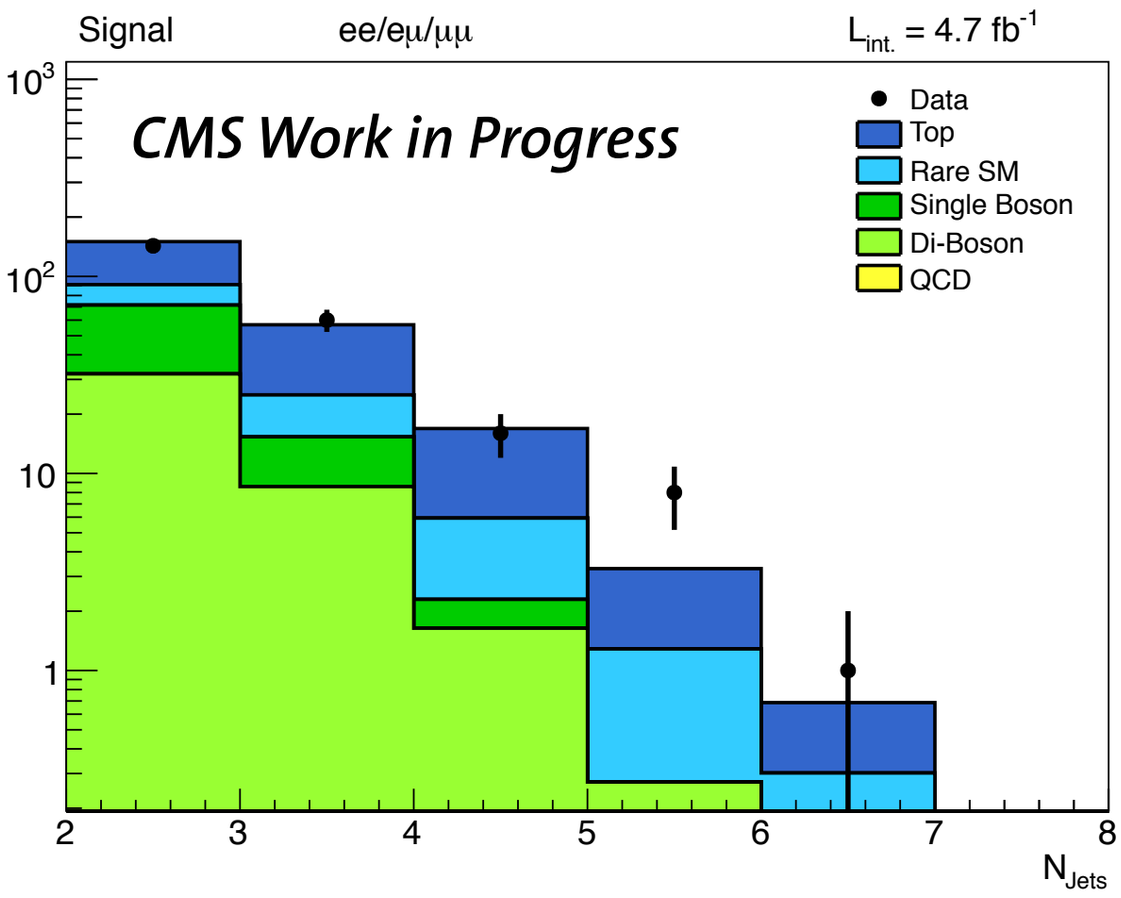
- Observations are **consistent with predictions** within uncertainties
- **Extend exclusion limits** on common models
- Provide information for theorists to calculate their own limits with our results

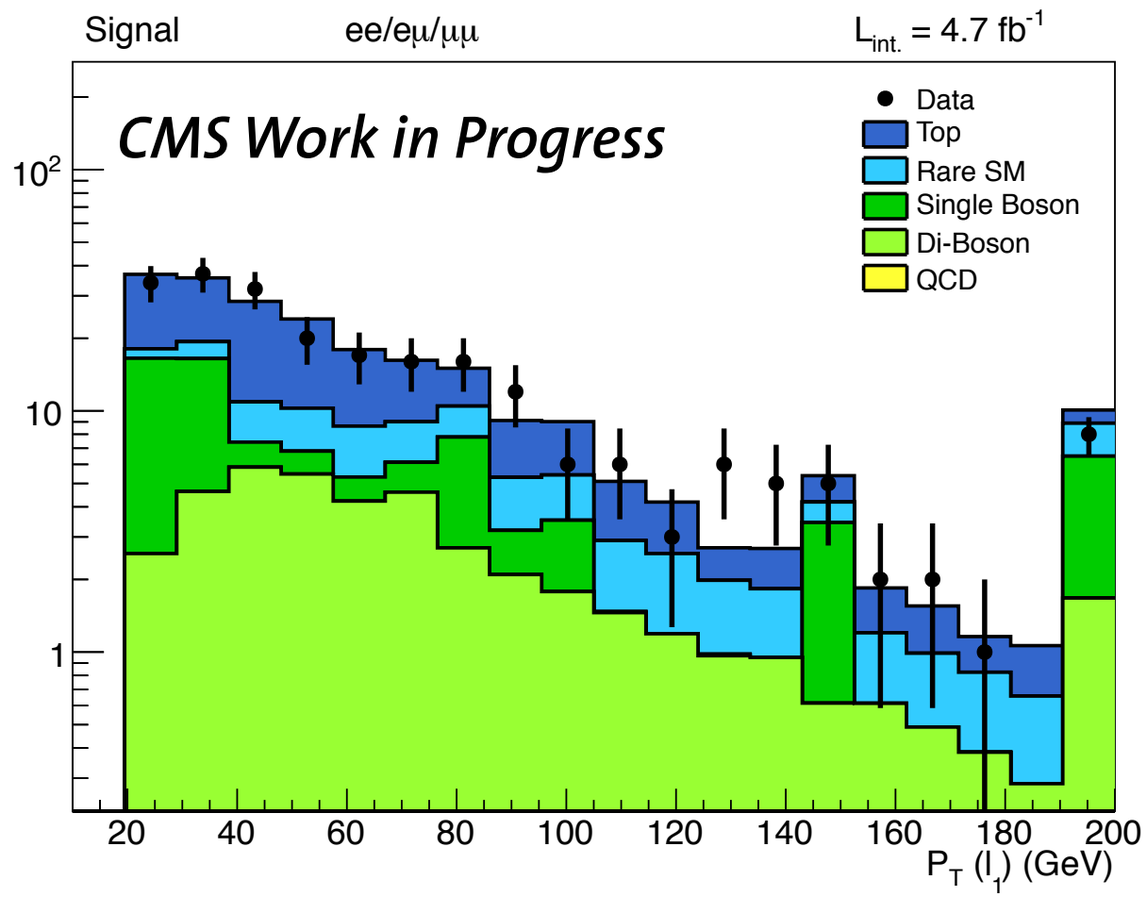





Signal
ee/eμ/μμ
$L_{int.}$ = 4.7 fb^{-1}
CMS Work in Progress
Data
Top
Rare SM
Single Boson
Di-Boson
QCD
10^2
10
1
0
100
200
300
400
500
600
700
800
900
1000
H_T (GeV)


Signal
ee/eμ/μμ
$L_{int.}$ = 4.7 fb^{-1}
CMS Work in Progress
Data
Top
Rare SM
Single Boson
Di-Boson
QCD
10^2
10
1
0
50
100
150
200
250
300
E_T^{miss} (GeV)


Signal
ee/eμ/μμ
$L_{int.}$ = 4.7 fb^{-1}
CMS Work in Progress
Data
Top
Rare SM
Single Boson
Di-Boson
QCD
10^3
10^2
10
1
2
3
4
5
6
7
8
N_{Jets}


Signal
ee/eμ/μμ
$L_{int.}$ = 4.7 fb^{-1}
CMS Work in Progress
Data
Top
Rare SM
Single Boson
Di-Boson
QCD
10^2
10
1
20
40
60
80
100
120
140
160
180
200
P_T (l_1) (GeV)