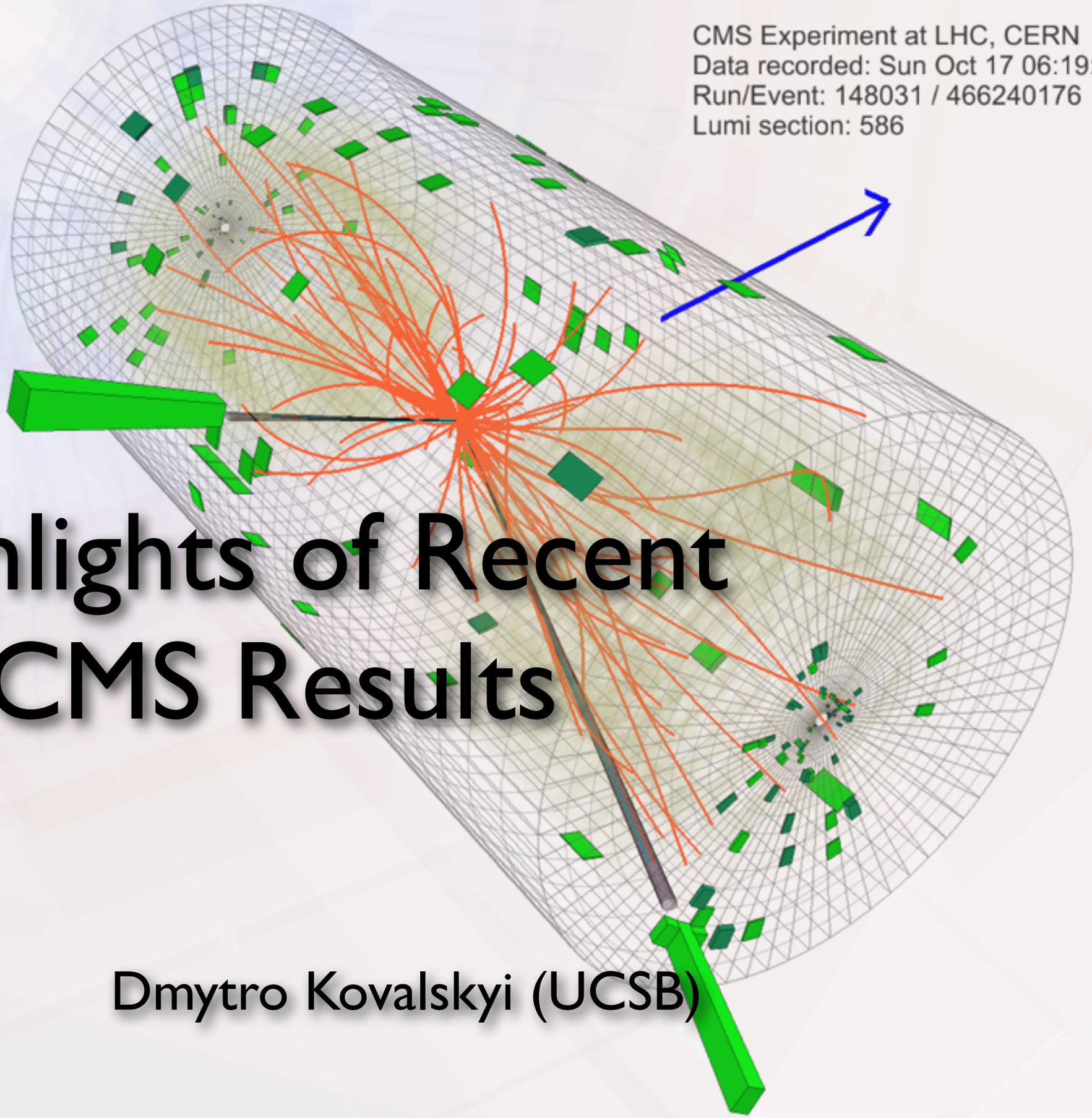


Highlights of Recent CMS Results

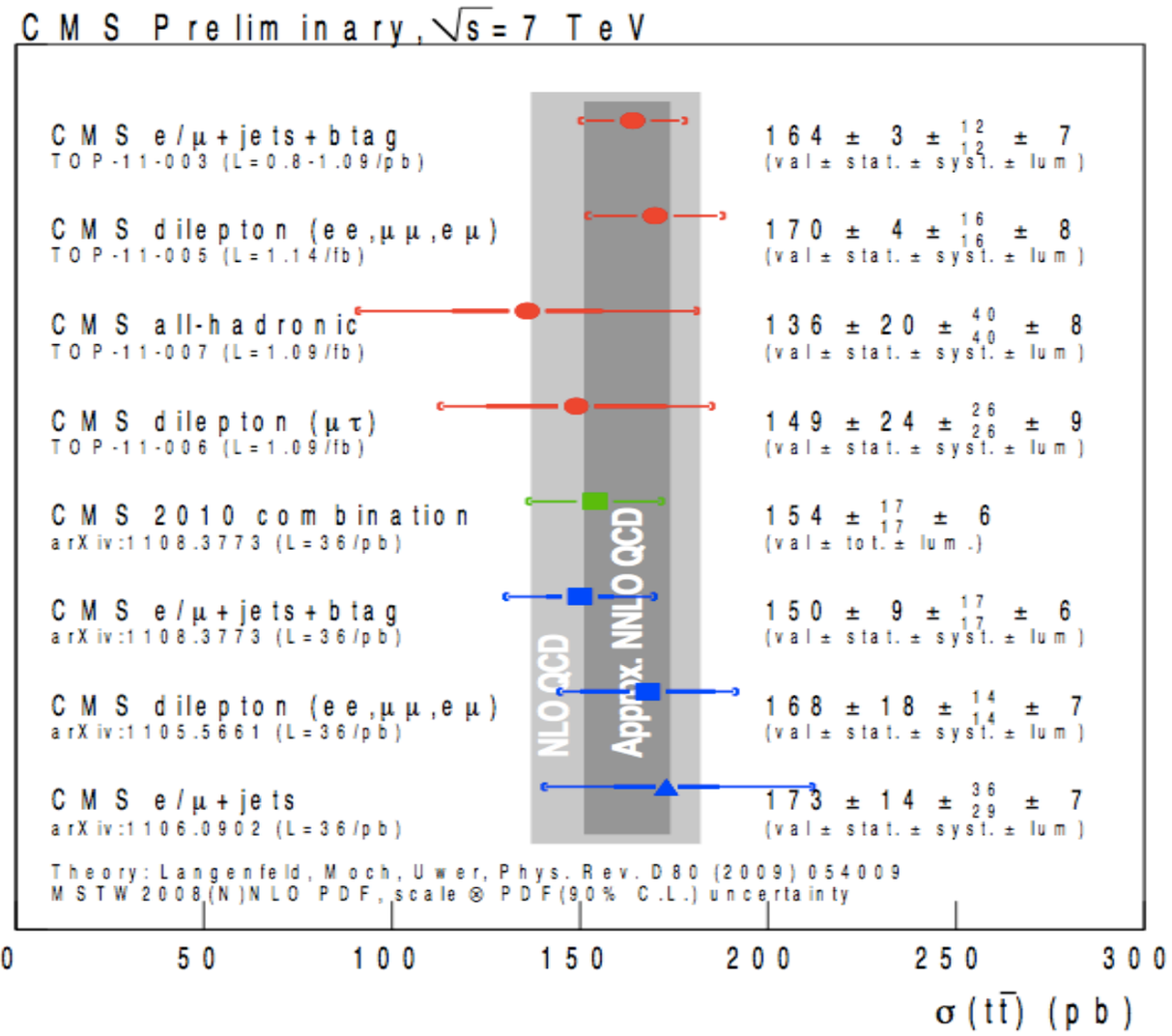
Dmytro Kovalskyi (UCSB)

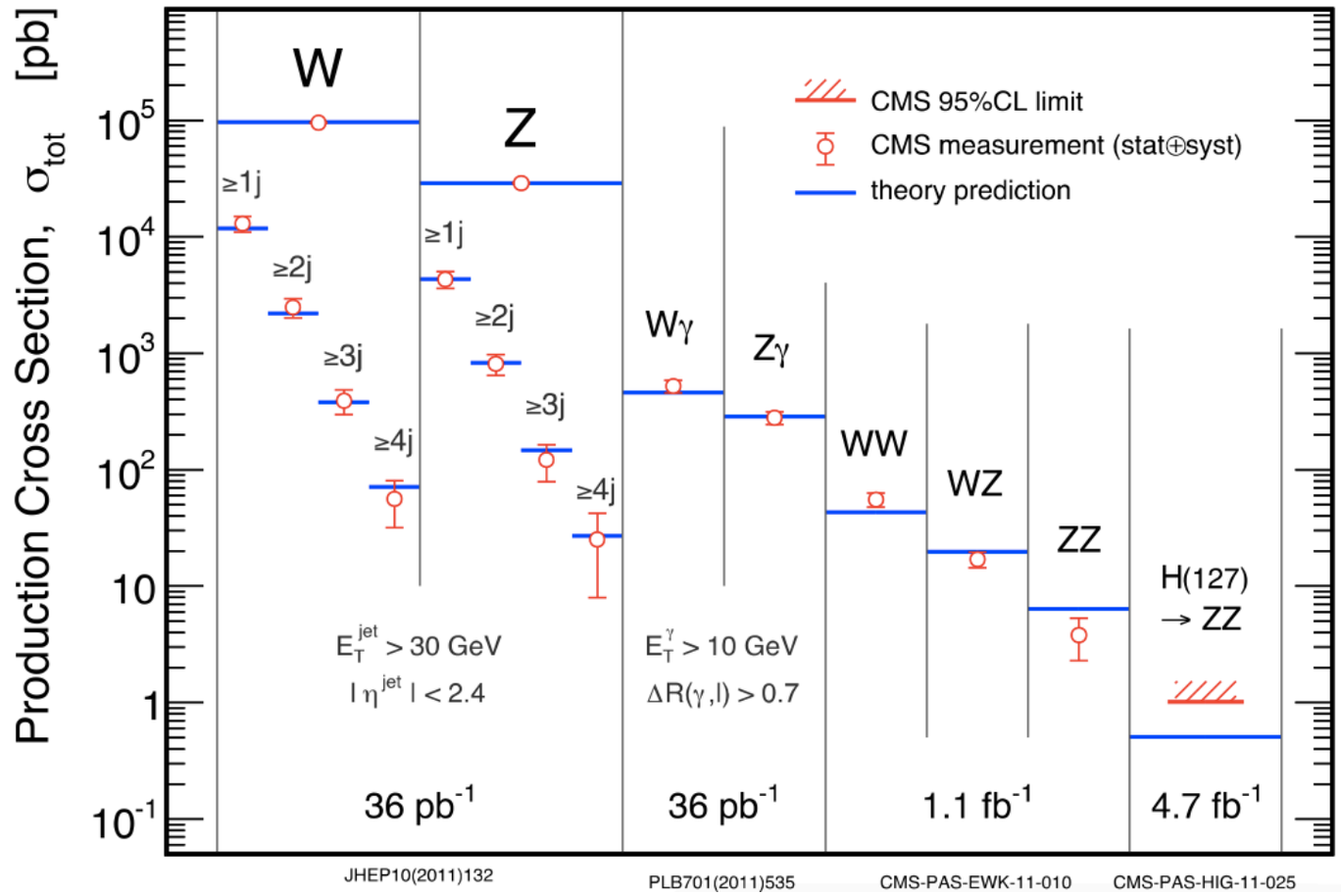
Introduction

- Number of CMS publication is over 100 already
  - It is very hard to review all the recent results in one talk
  - This talk concentrates on a few topics:
    - Higgs Searches
    - Dark Matter Searches
    - Searches for Physics Beyond the Standard Model
- Complete information about all CMS results:
  - https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResults

Standard Model at 7 TeV

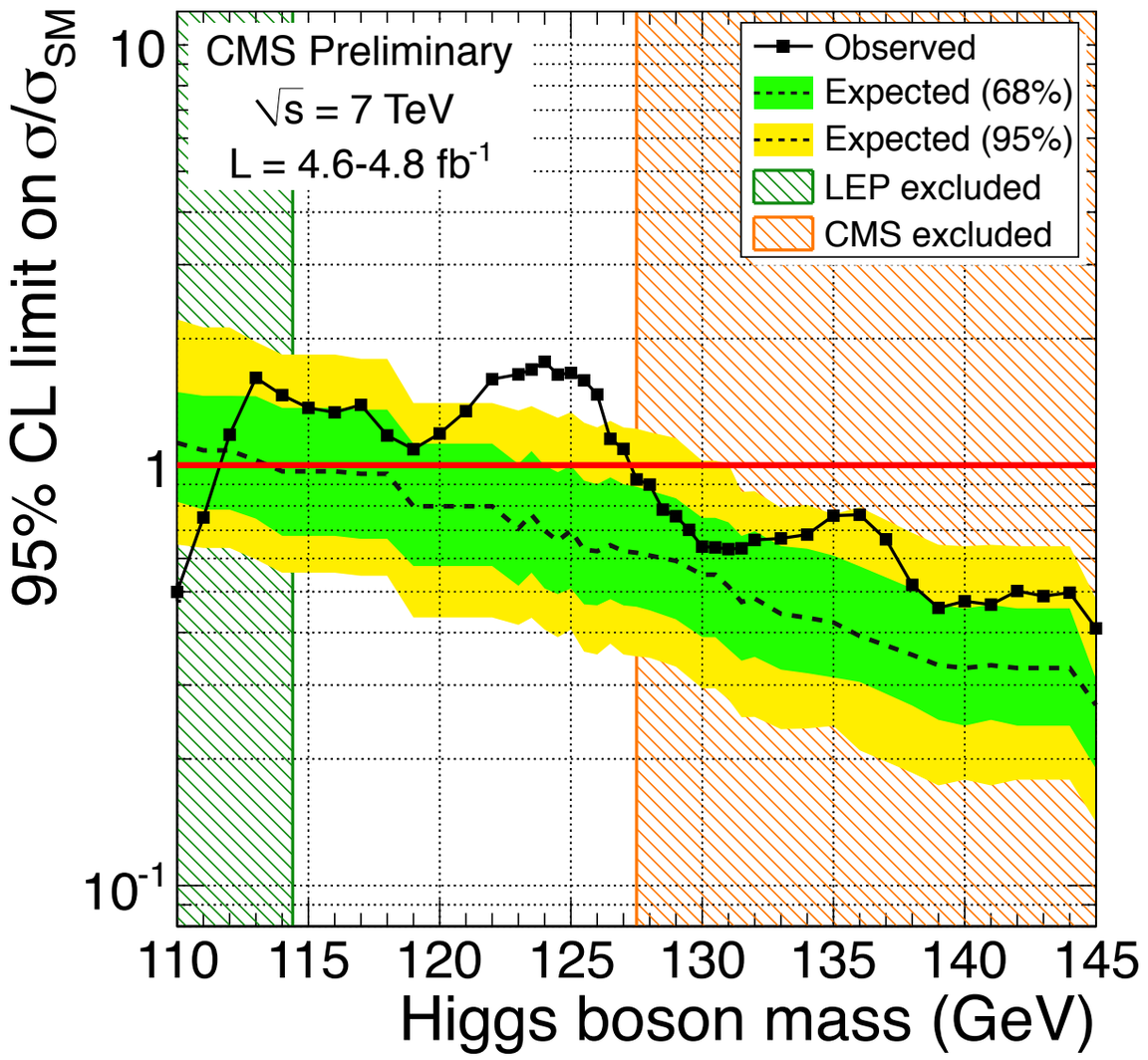
Standard Model is explored in details

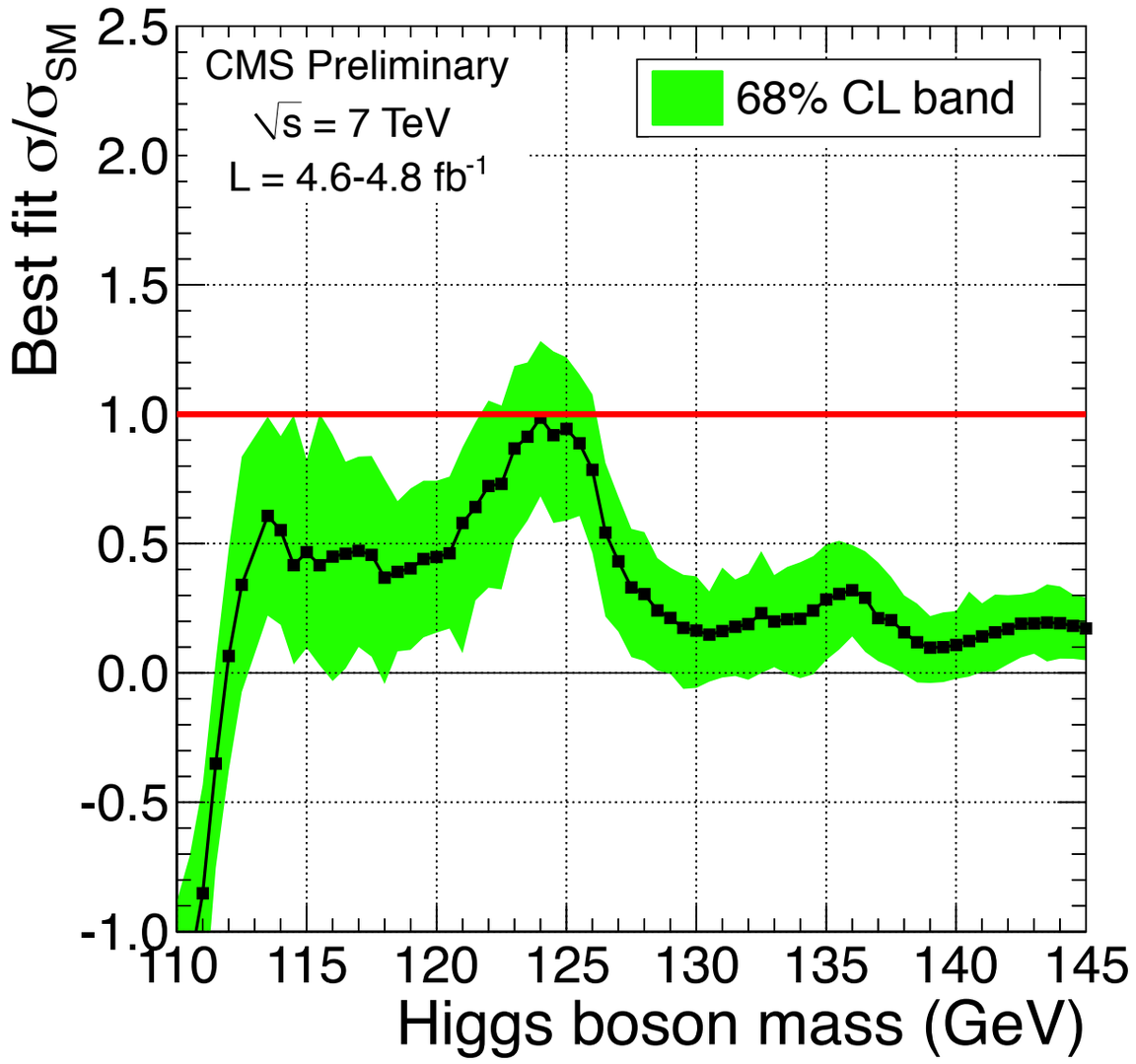




Higgs is next ...

Higgs Search Results

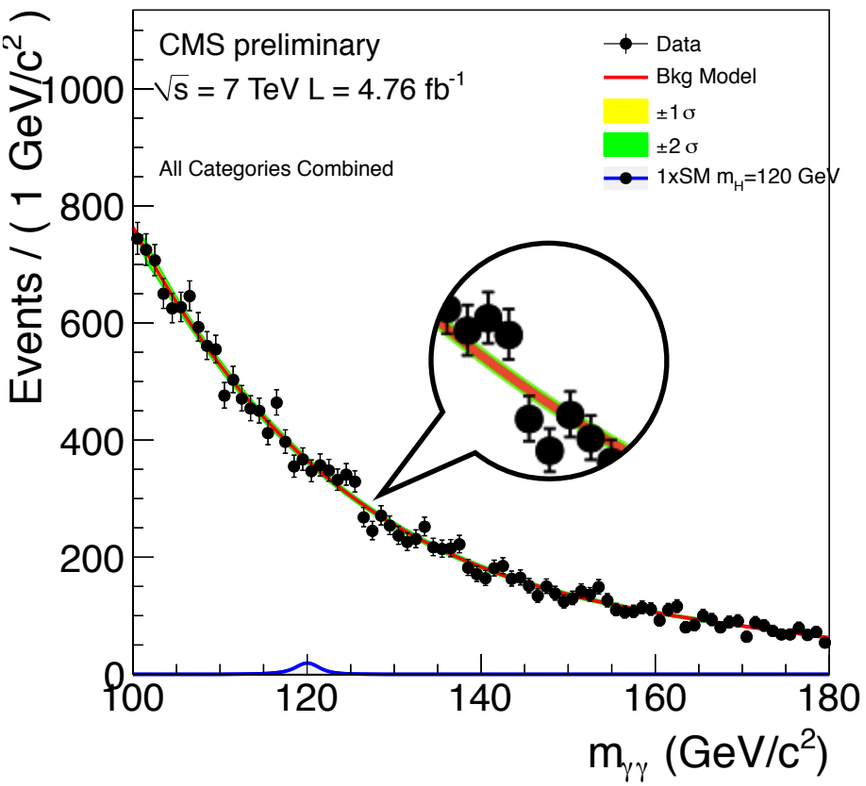


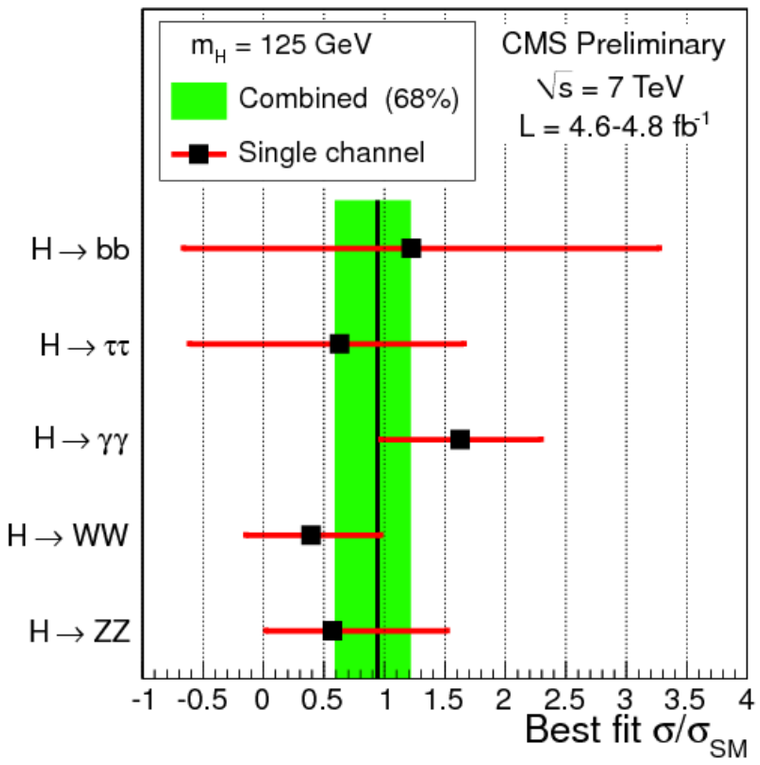


- Only narrow range is still allowed: [114-127.5] GeV
- Largest deviation from background:
  - 125GeV - 2.1σ global significance for 110–145 GeV window
    - Consistent with the excess in ATLAS

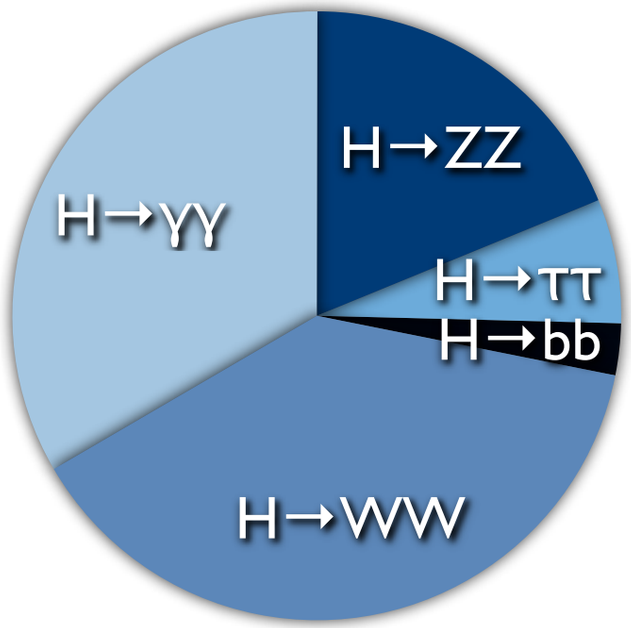
Phys.Lett. B710 (2012) 26-48
top cited physics result
from CMS

Higgs Search in Different Channels





Relative Contribution at 125GeV

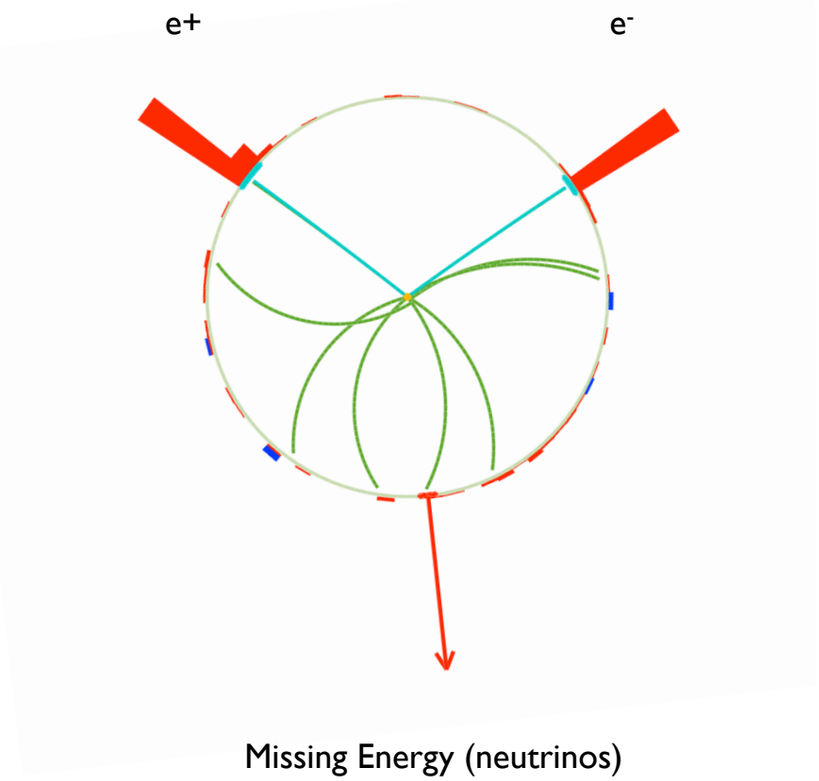


weight is defined as $1/\mu^2$, i.e. inverse expected signal strength squared

- Currently not a single channel has sensitivity to see Higgs at ~125 GeV
- H→γγ and H→WW have same sensitivity in the region of interest
  - H→ZZ→4 ℓ is close and can improve in future
- Convenient mass to measure all couplings
  - H→ττ and H→bb while contribute less, will soon provide unique information about couplings

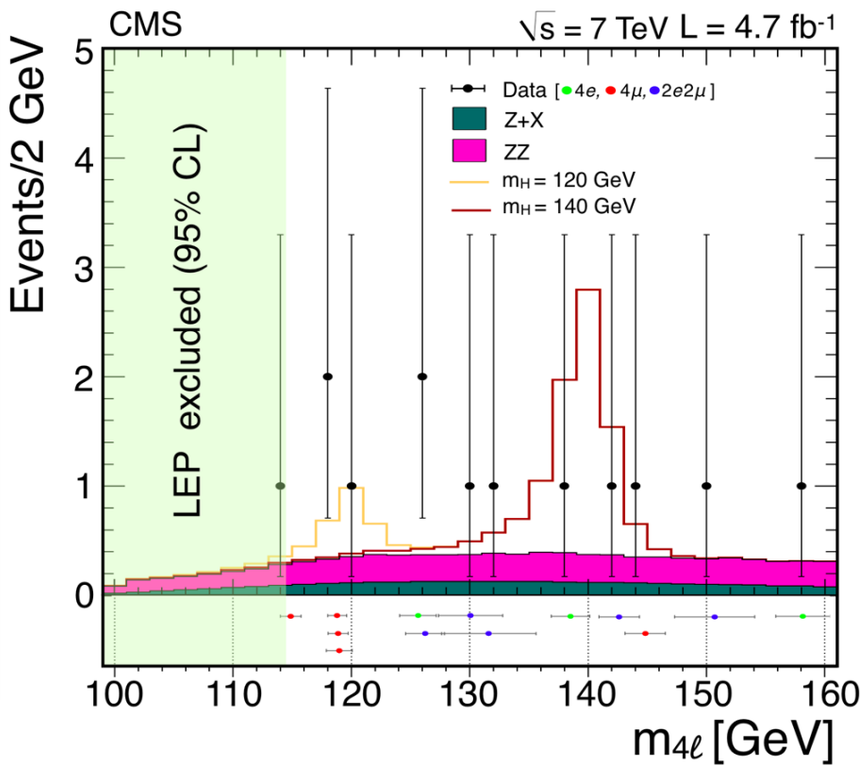
Main Contributors at 125 GeV

H→WW→2 ℓ 2ν



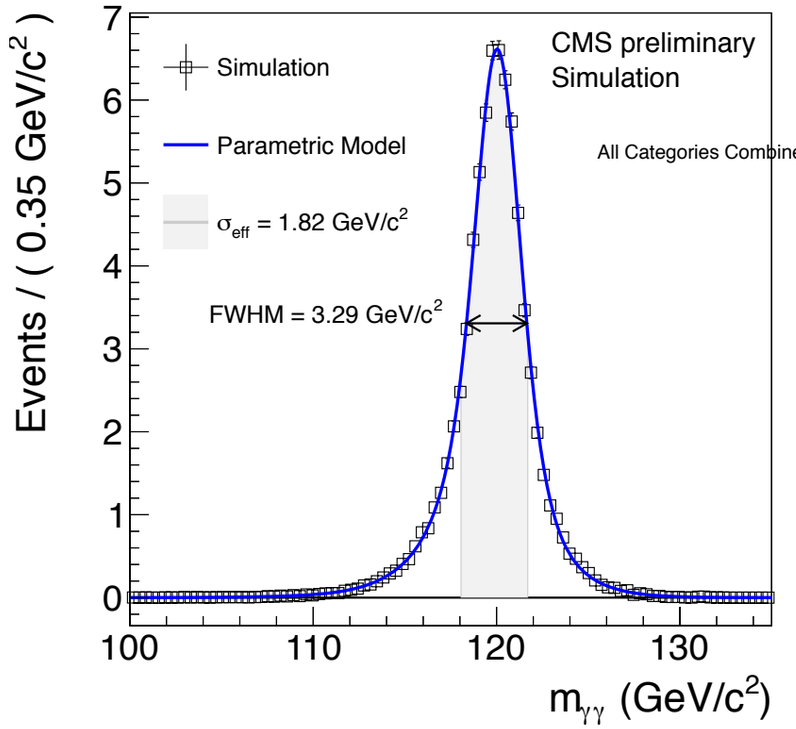
- HWW highest event yield
- No mass - background estimation is critical
- Excess is wide (mass resolution ~20GeV)

H→ZZ→4



- HZZ4L is far off-shell
- Leptons pt: 20/10/5/5
- Very few events
- Beside mass it allows to determine spin

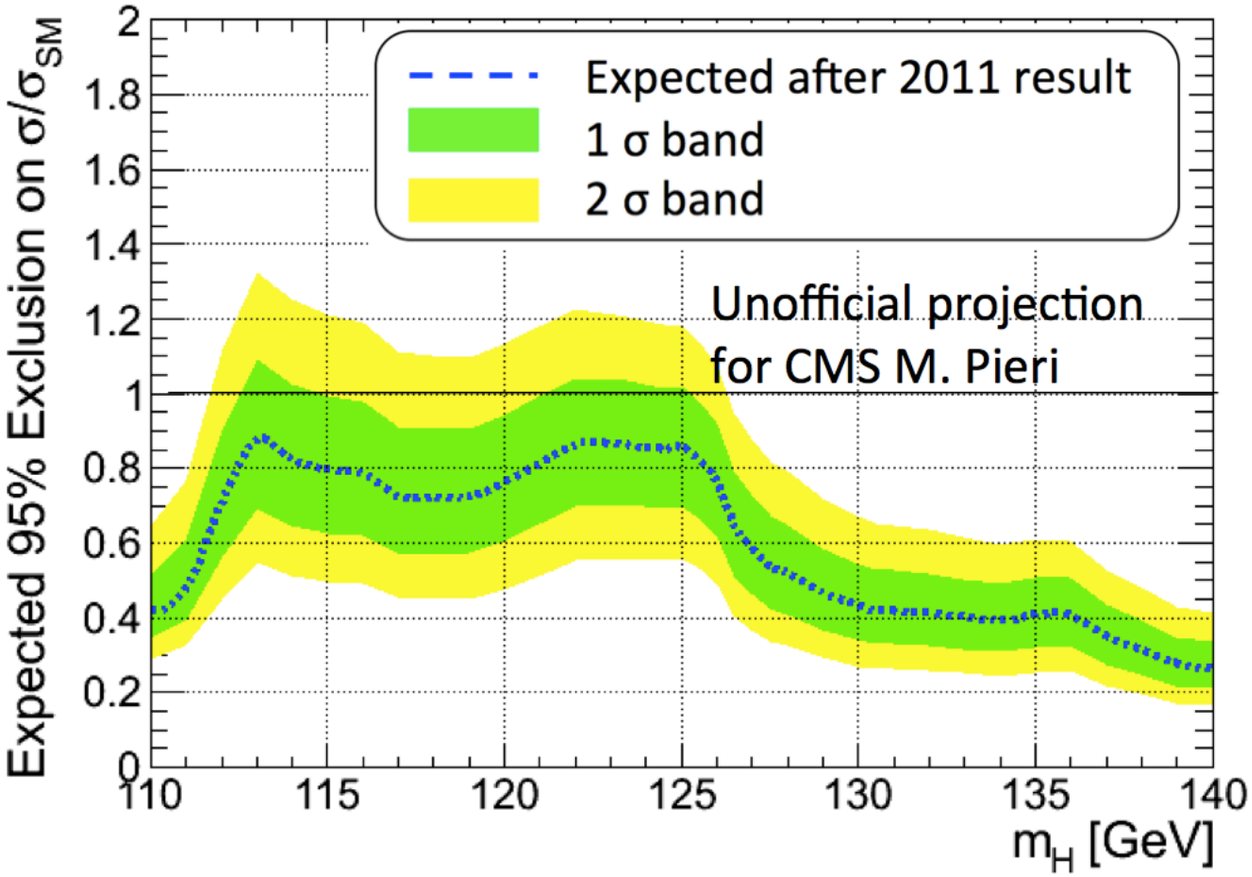
H→γγ



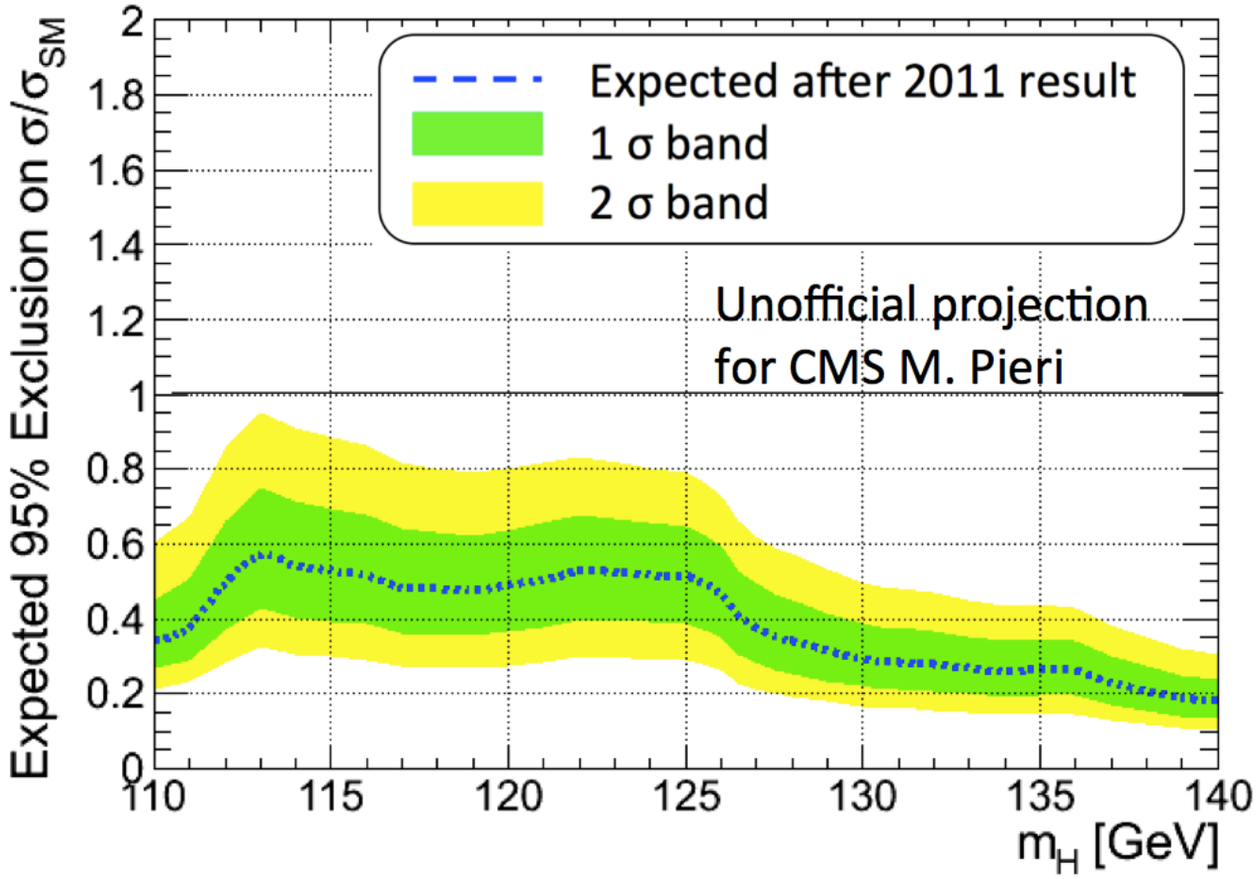
- Main challenge - mass resolution to reduce large SM background
- Main discovery channel

Expectations for Exclusion in 2012

5/fb(2011) + 5/fb (2012)



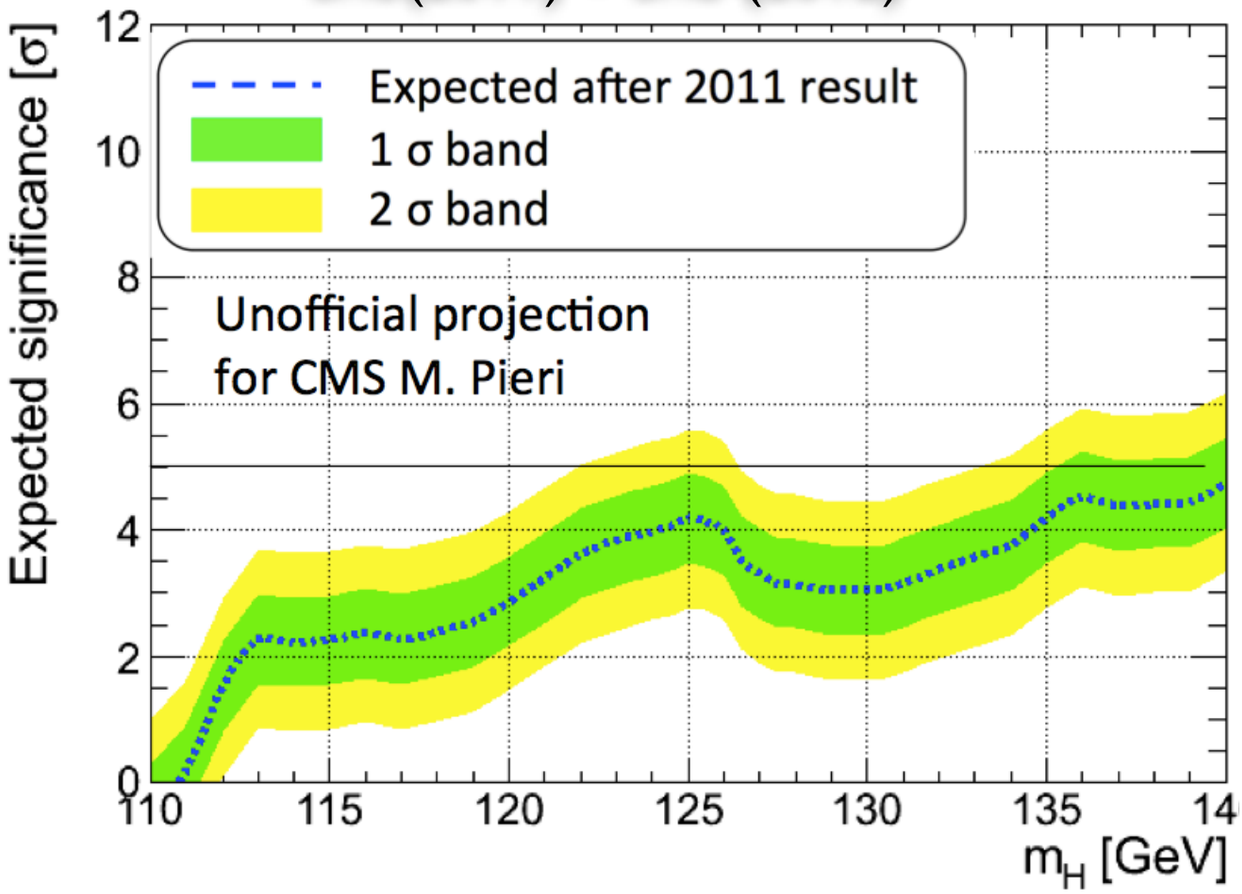
5/fb(2011) + 15/fb (2012)



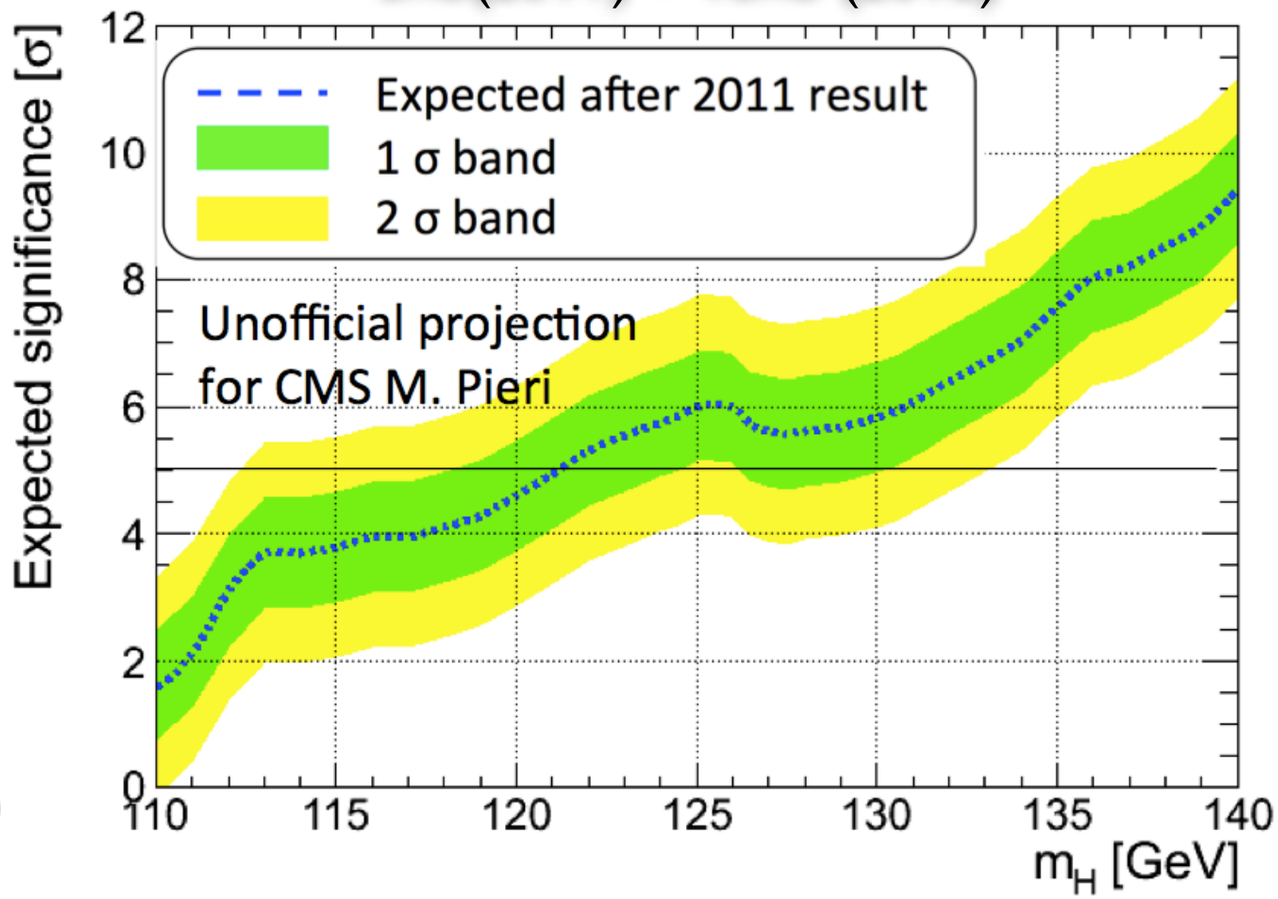
- Projections take into account observed 2011 results
- By ICHEP 2012 we may have ~ 5/fb
  - If Higgs doesn't exist we should exclude it at 95% CL with ~60% probability
- By the end of 2012 if LHC performs CMS will have enough sensitivity to certainly exclude Higgs in low mass range

Expectations for Discovery in 2012

5/fb(2011) + 5/fb (2012)



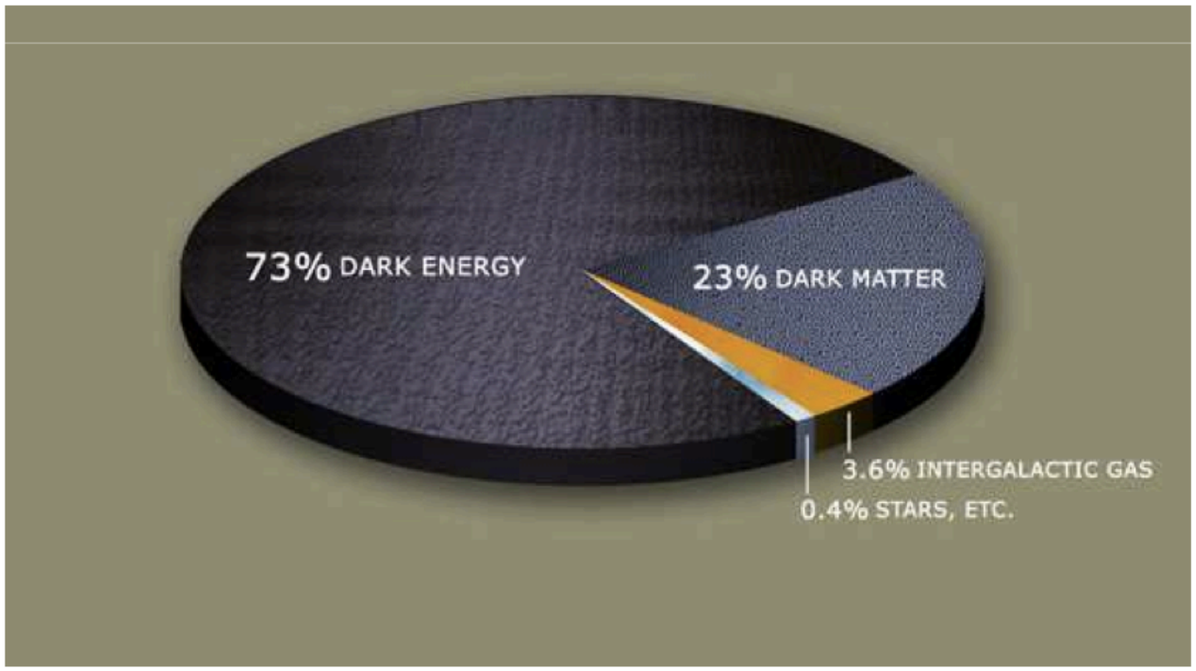
5/fb(2011) + 15/fb (2012)

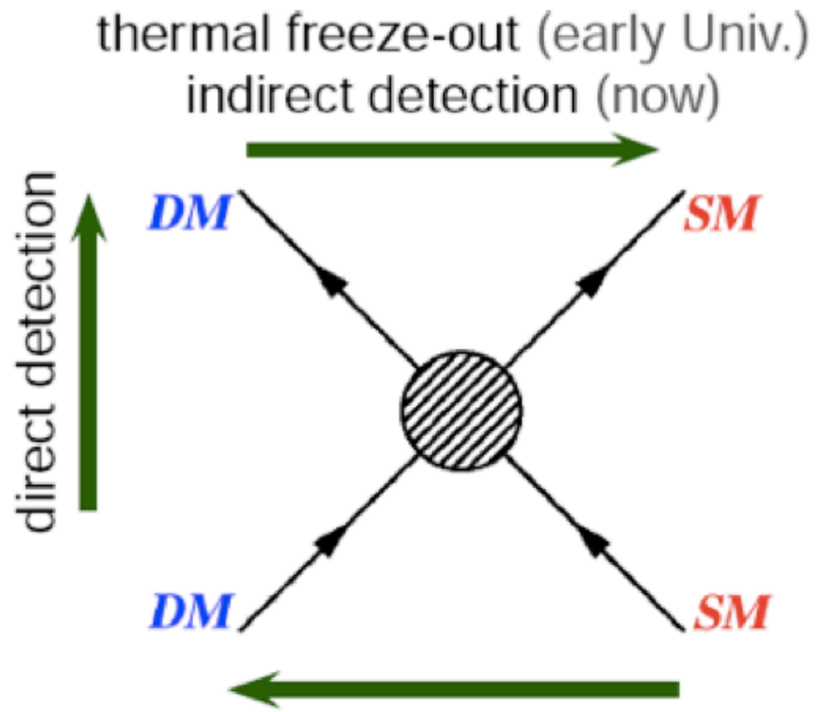


- Projections take into account observed 2011 results
- By ICHEP 2012 we may have ~ 5/fb
  - If Higgs exist and its mass is around 125 GeV the local significance is likely to increase from ~3σ to 4σ
- By the end of 2012 CMS should be able to discover Higgs at 5σ for Higgs masses above 120GeV

Dark Matter

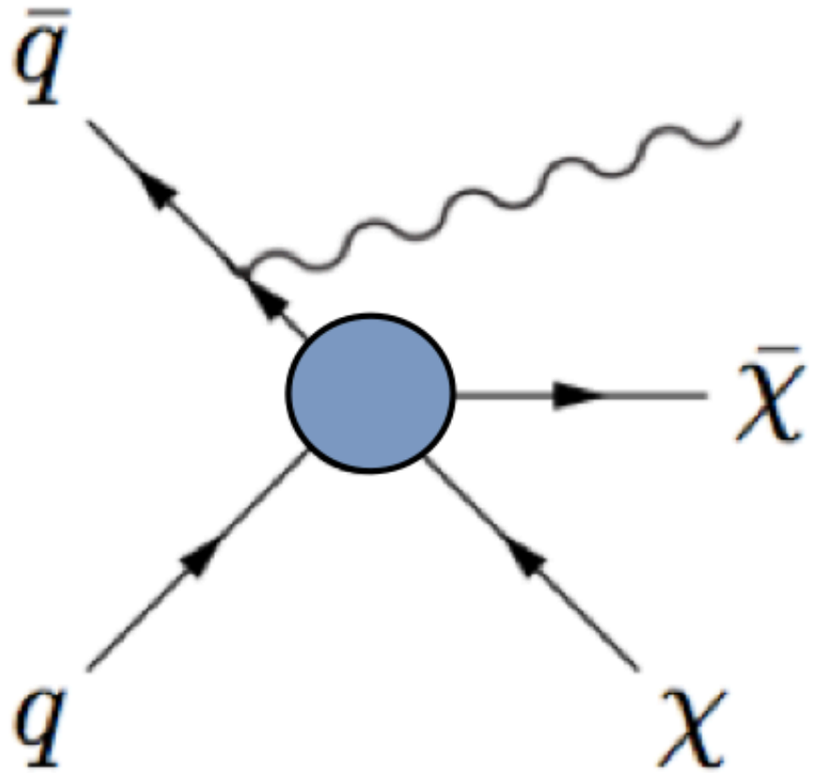
Dark Matter at Collider



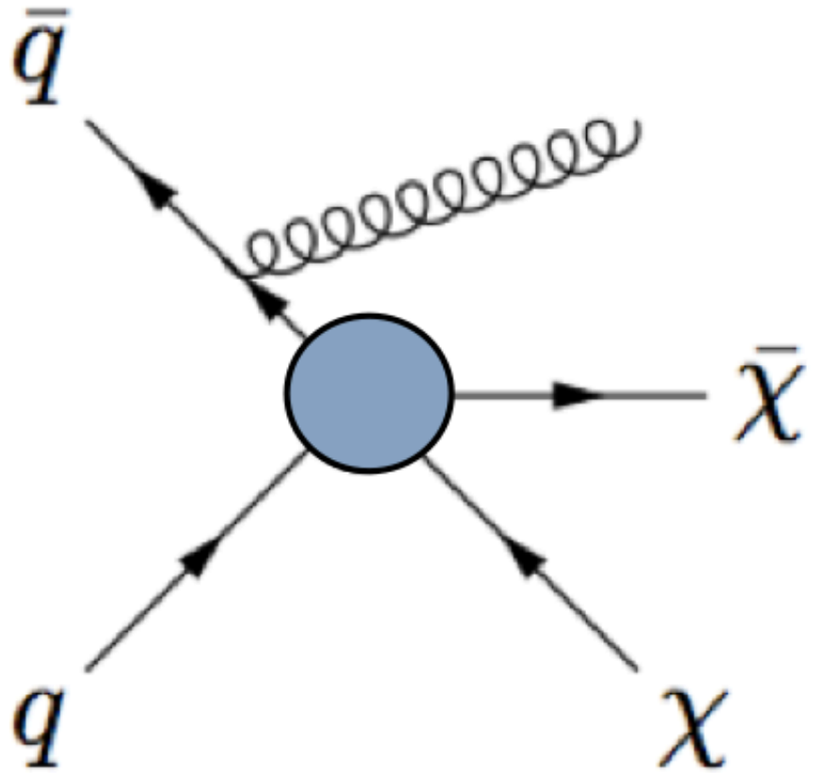


- Dark matter existence is well established based on gravitational effects
- We don't know what it is, but in the best case it's weakly interacting
  - In the detector it's undetectable as neutrinos
- Large amount of dark matter in the Universe suggests that it can have reasonably high interaction rate with Standard Model particles
- LHC can produce Dark Matter via the same process that is used in direct (dark matter-nucleon scattering) and indirect (dark matter annihilation) searches

Dark Matter Production



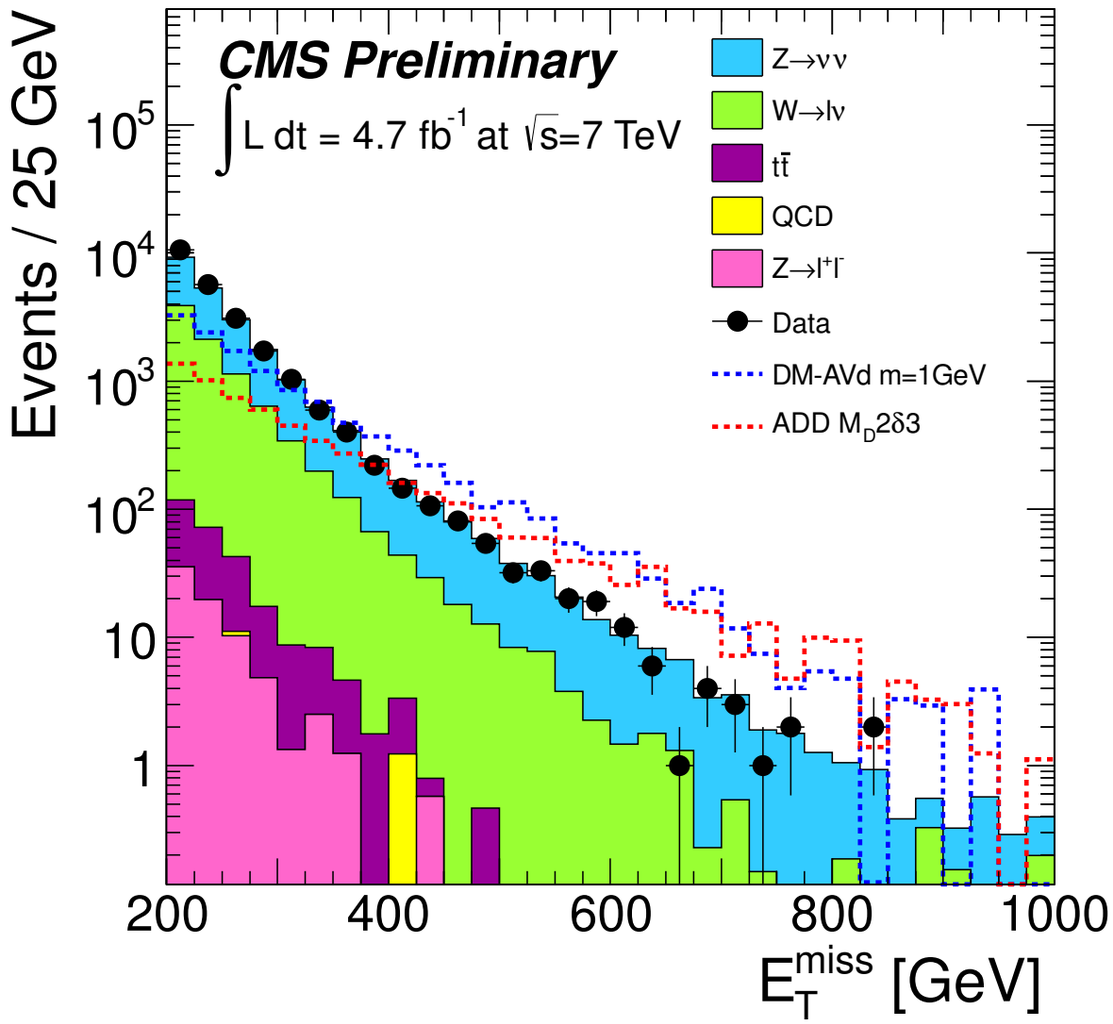
monophoton +MET



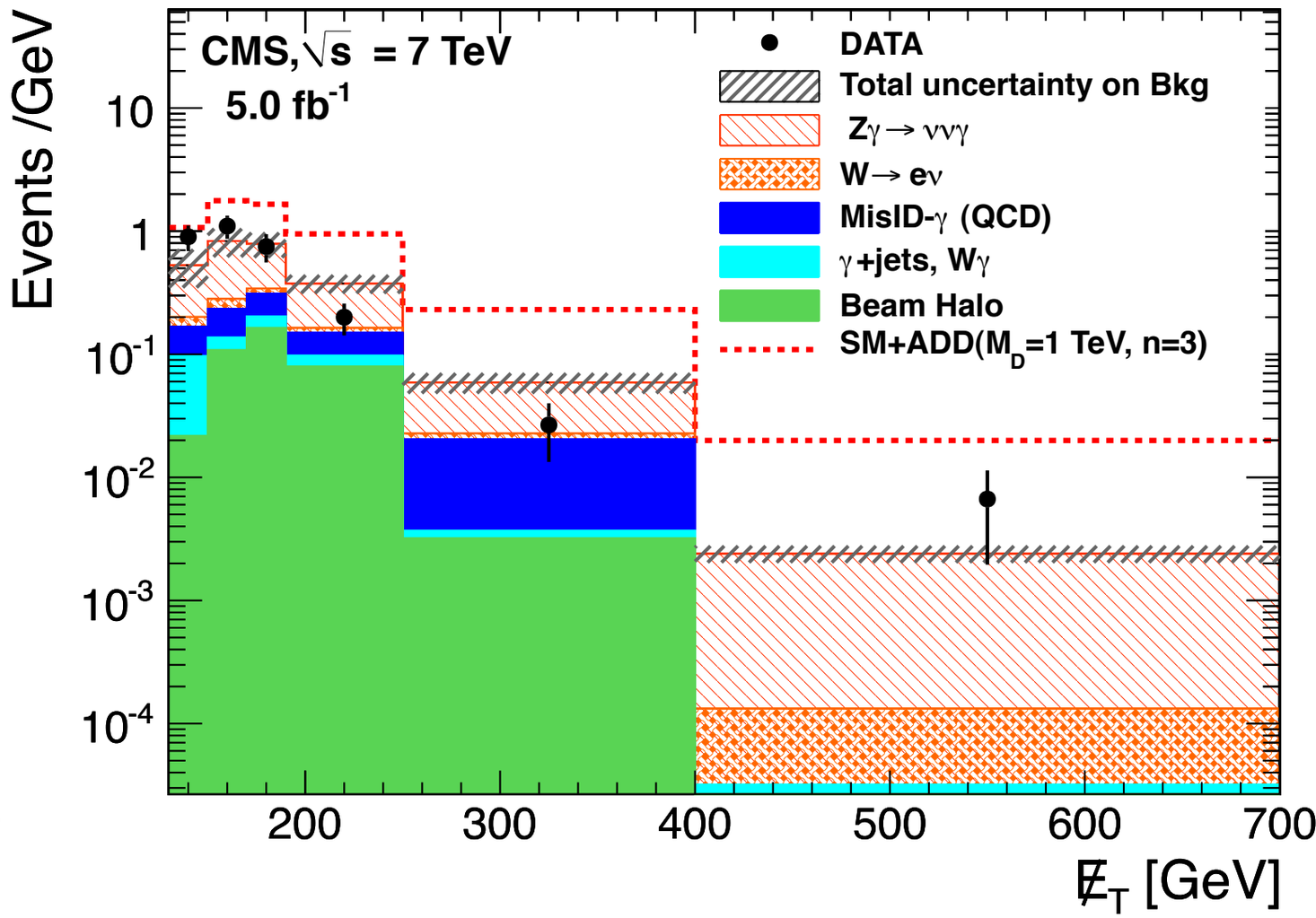
monojet +MET

Dark Matter Search

Mono-jet



Mono-photon



- Data is consistent with Standard Model prediction
- Dominant background is Z→νν+X

Dark Matter Production at LHC

Direct Detection

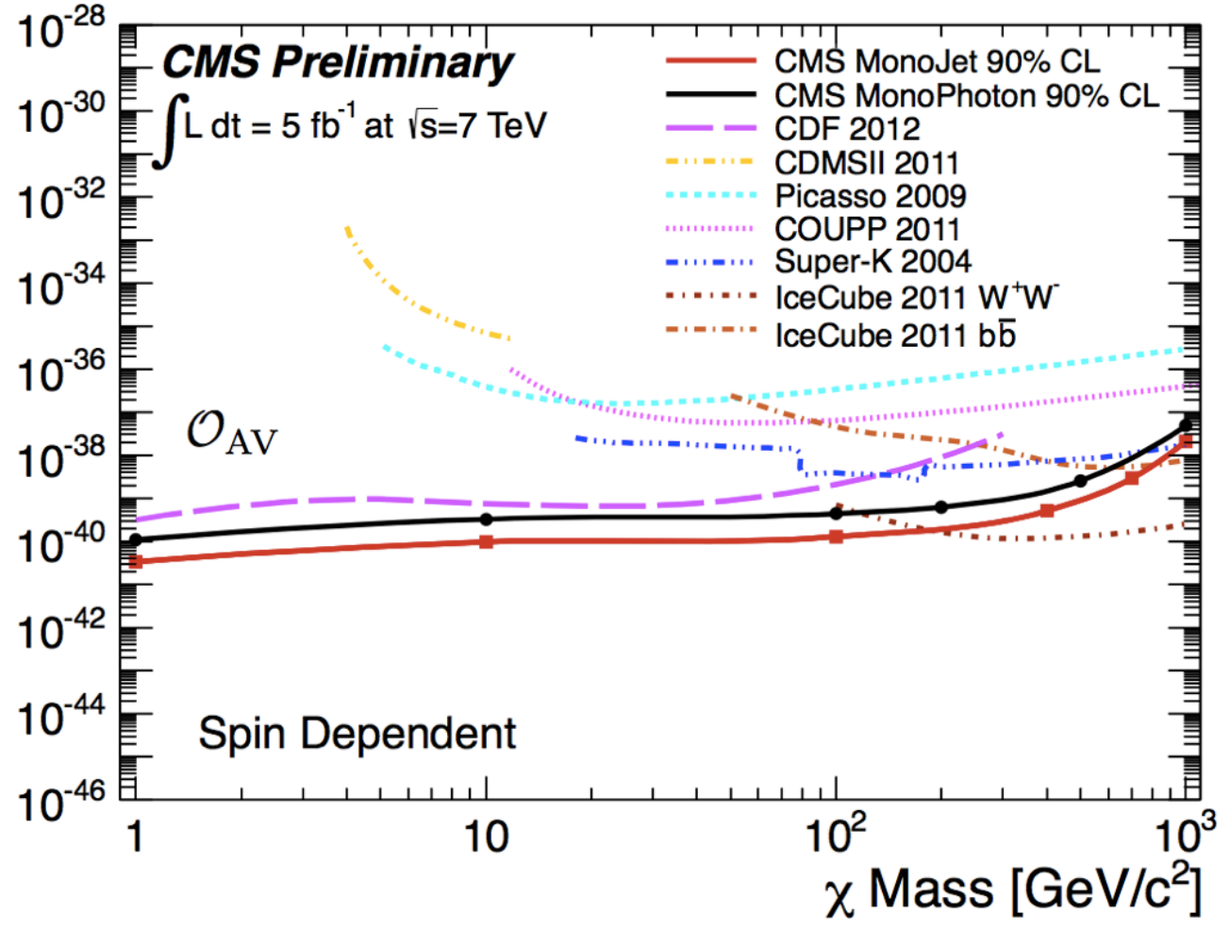
$$\sigma_{\mathrm{DD}} \sim g_\chi^2\, g_q^2\, \frac{\mu^2}{M^4}$$

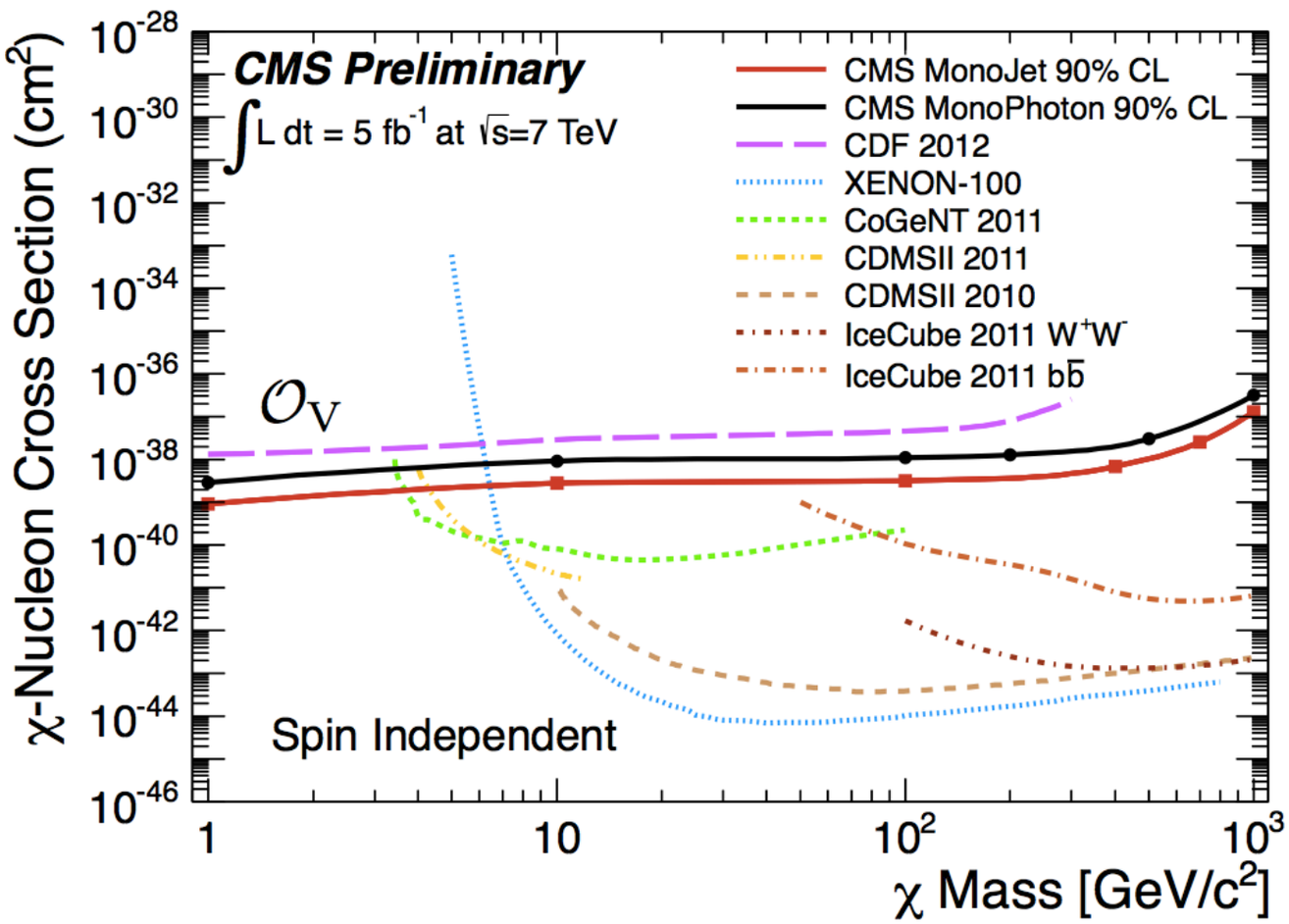
Mono-jet partonic production

$$\sigma_{1j} \sim \begin{cases} \alpha_s\, g_\chi^2\, g_q^2\, \frac{1}{p_T^2} & M \lesssim p_T\,, \\ \alpha_s\, g_\chi^2\, g_q^2\, \frac{p_T^2}{M^4} & M \gtrsim p_T\,, \end{cases}$$

- For heavy mediator (M>100GeV), mono-jet production is ~ 1000 larger than direct-detection one
- For light mediator, mono-jet production is smaller than the direct-detection one
  - If DM is observed in direct-detection experiments and not at LHC it can suggest existence of a light mediator

Dark Matter Search Results

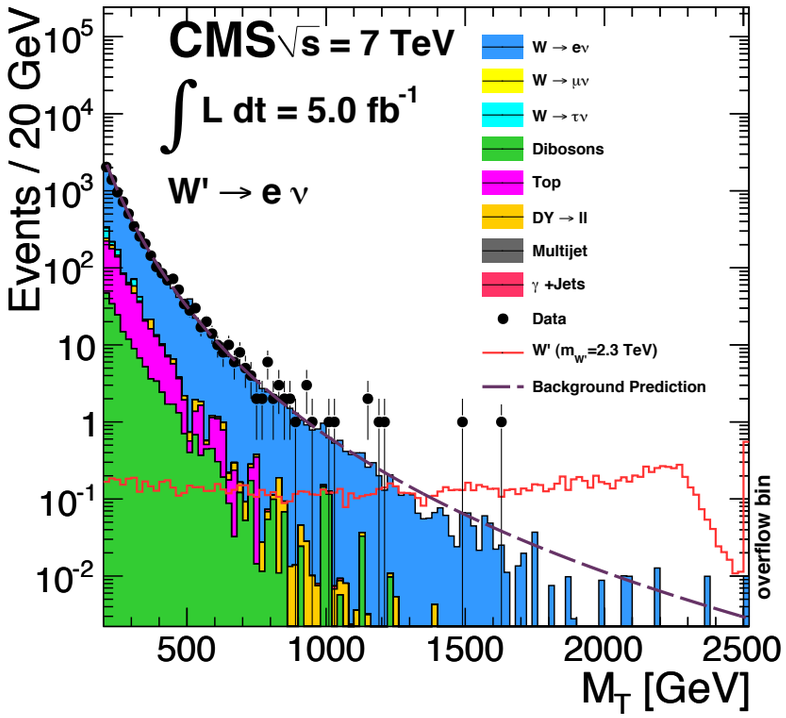


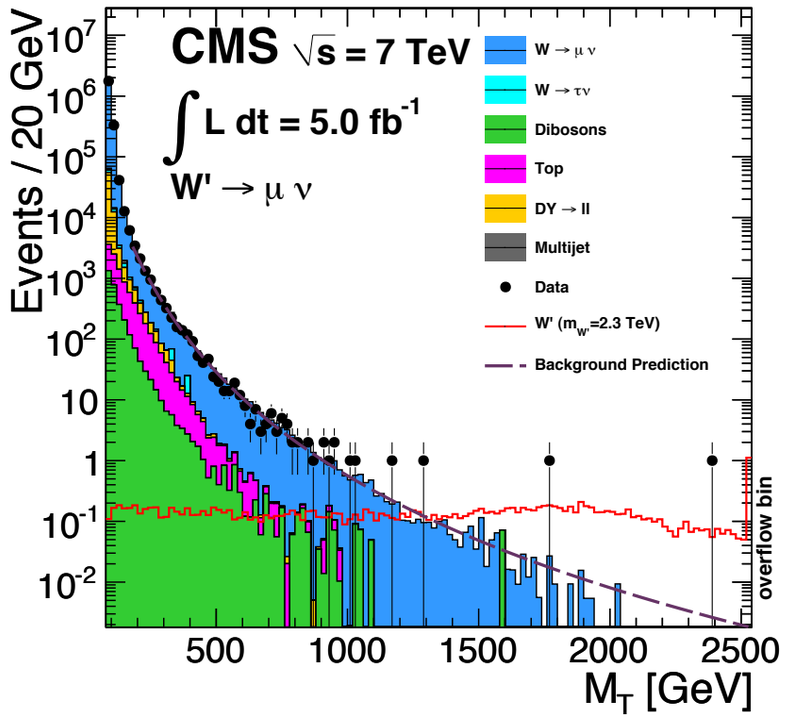


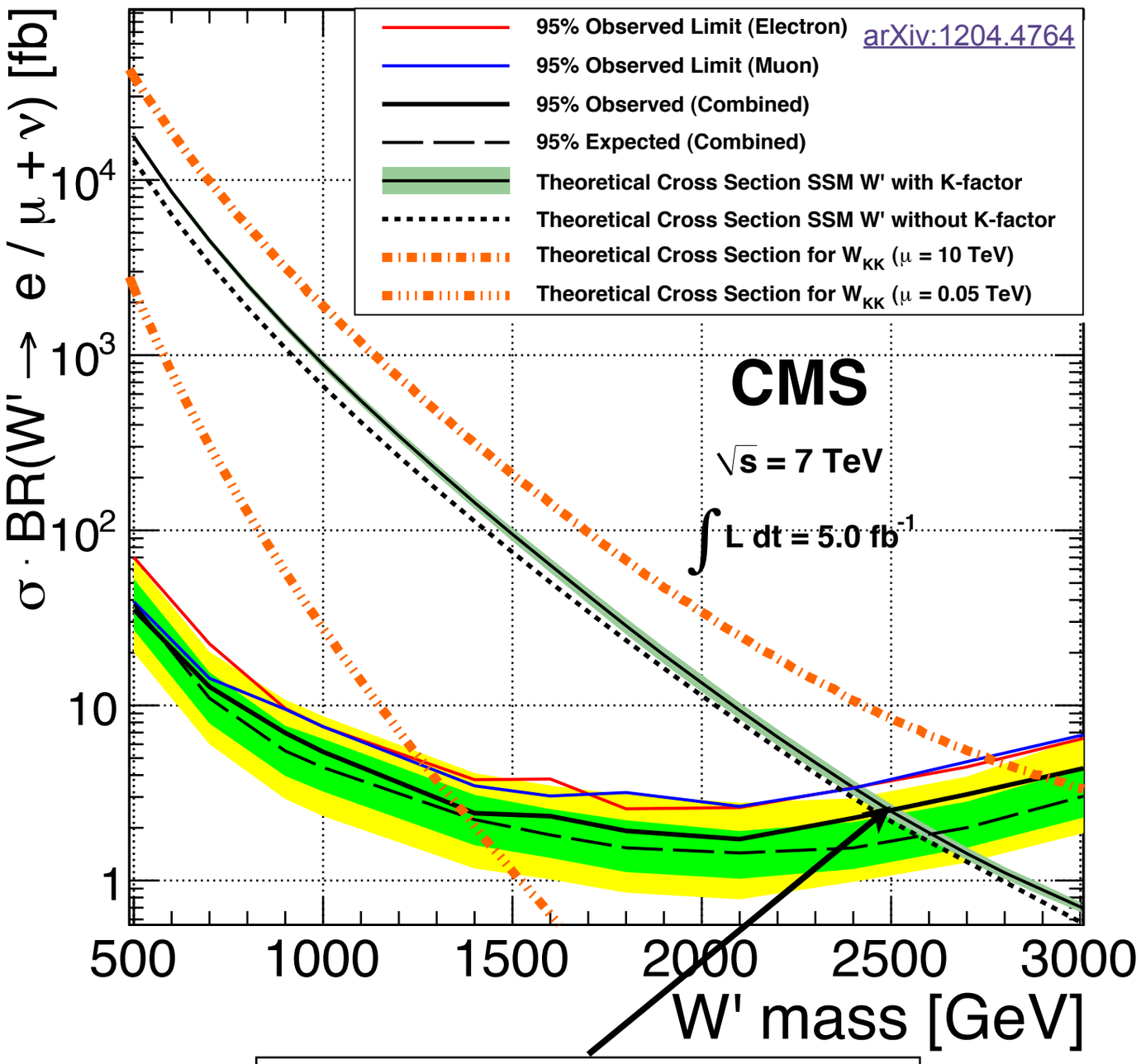
- Collider results dominate in spin dependent searches
- Cover low mass range for spin independent searches

Searches for Physics Beyond Standard Model

W′ Searches

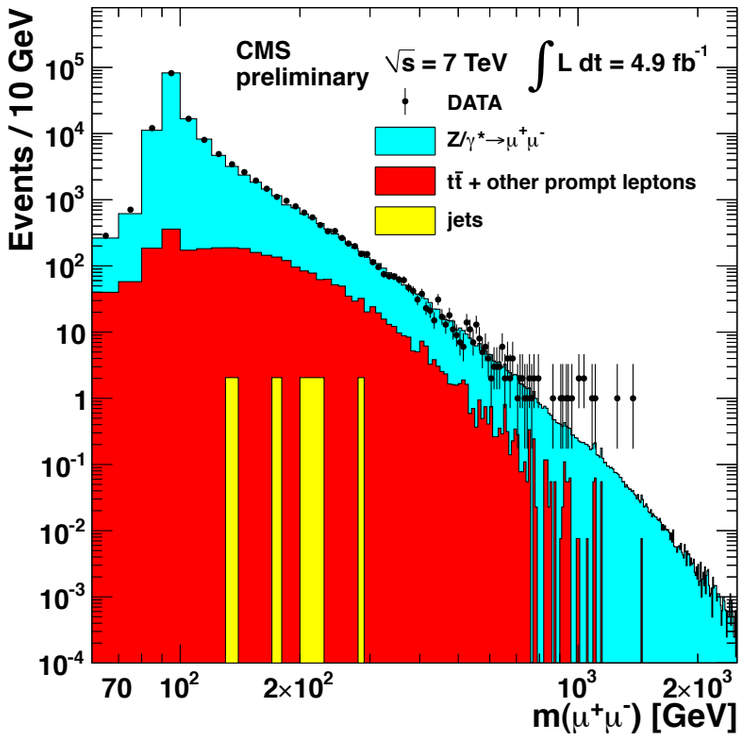




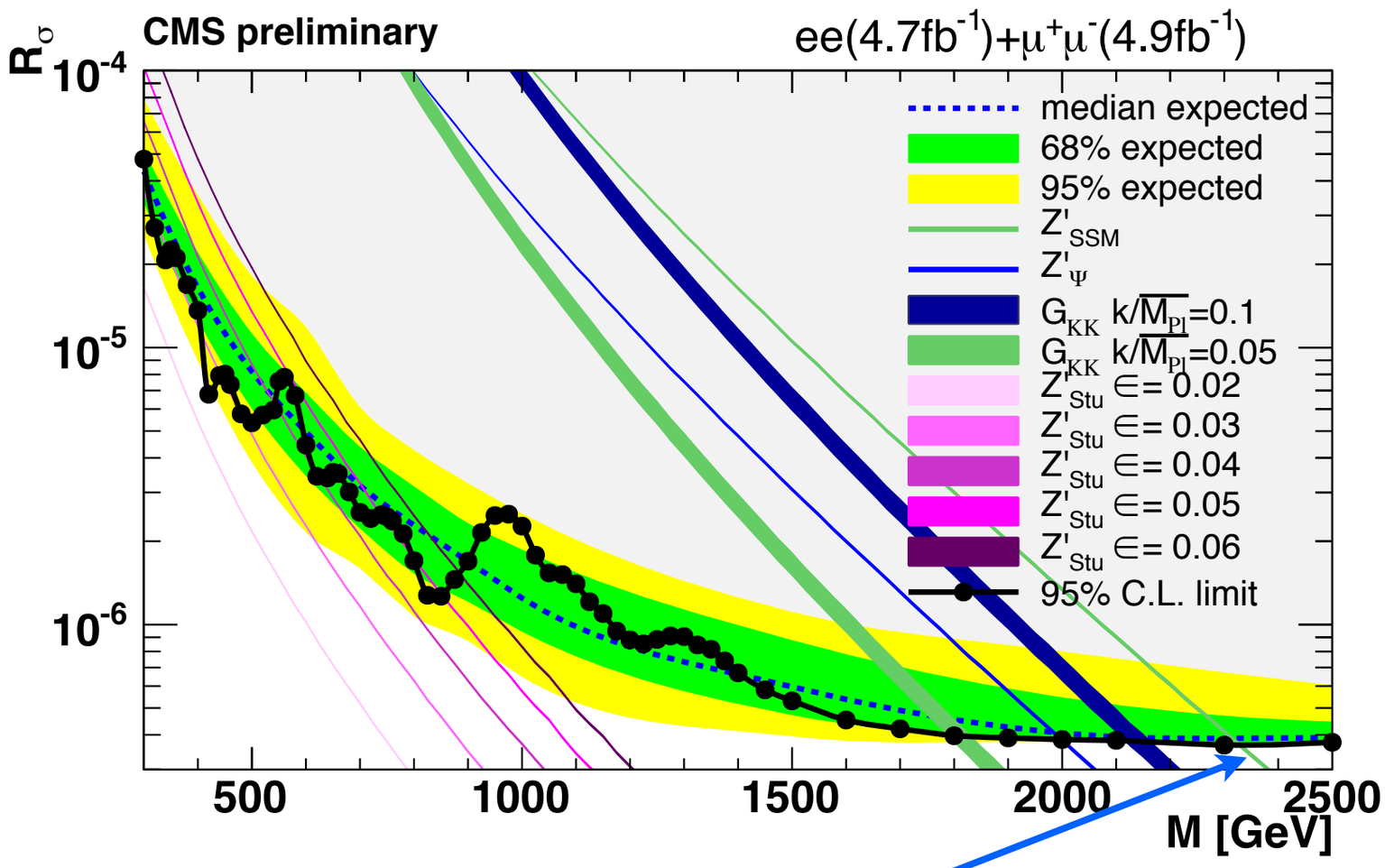


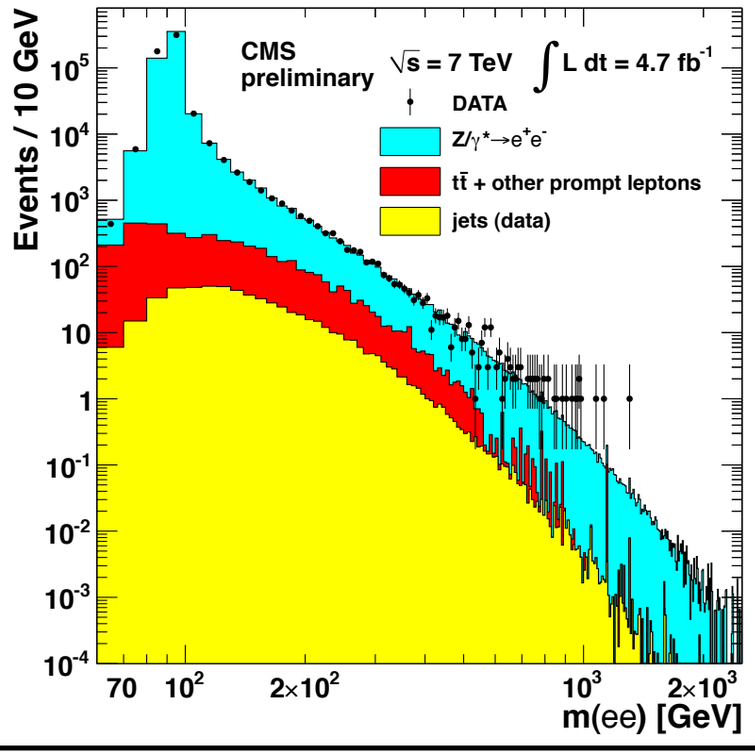
Sequential Standard Model W′ is excluded below 2.5 TeV

Z′ Searches



$$R_\sigma = \frac{\sigma(pp \to Z' + X \to \ell\ell + X)}{\sigma(pp \to Z + X \to \ell\ell + X)}$$

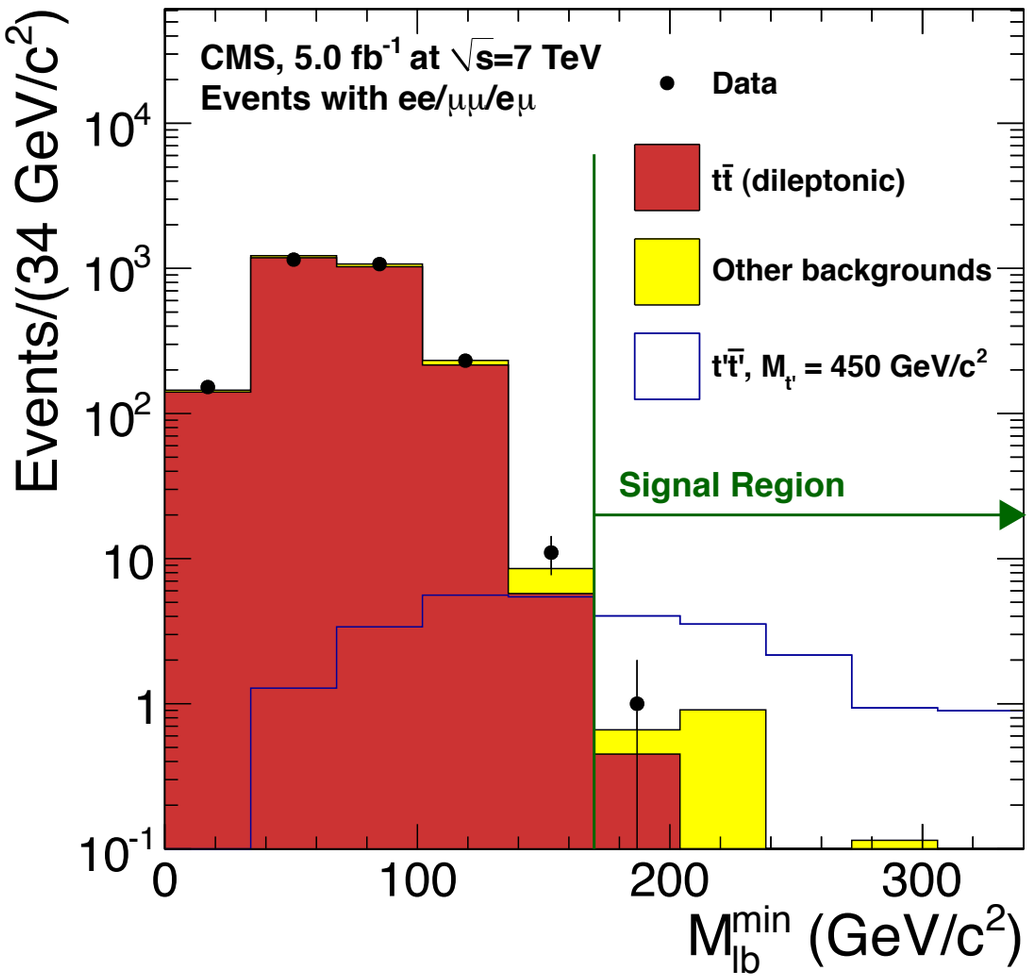


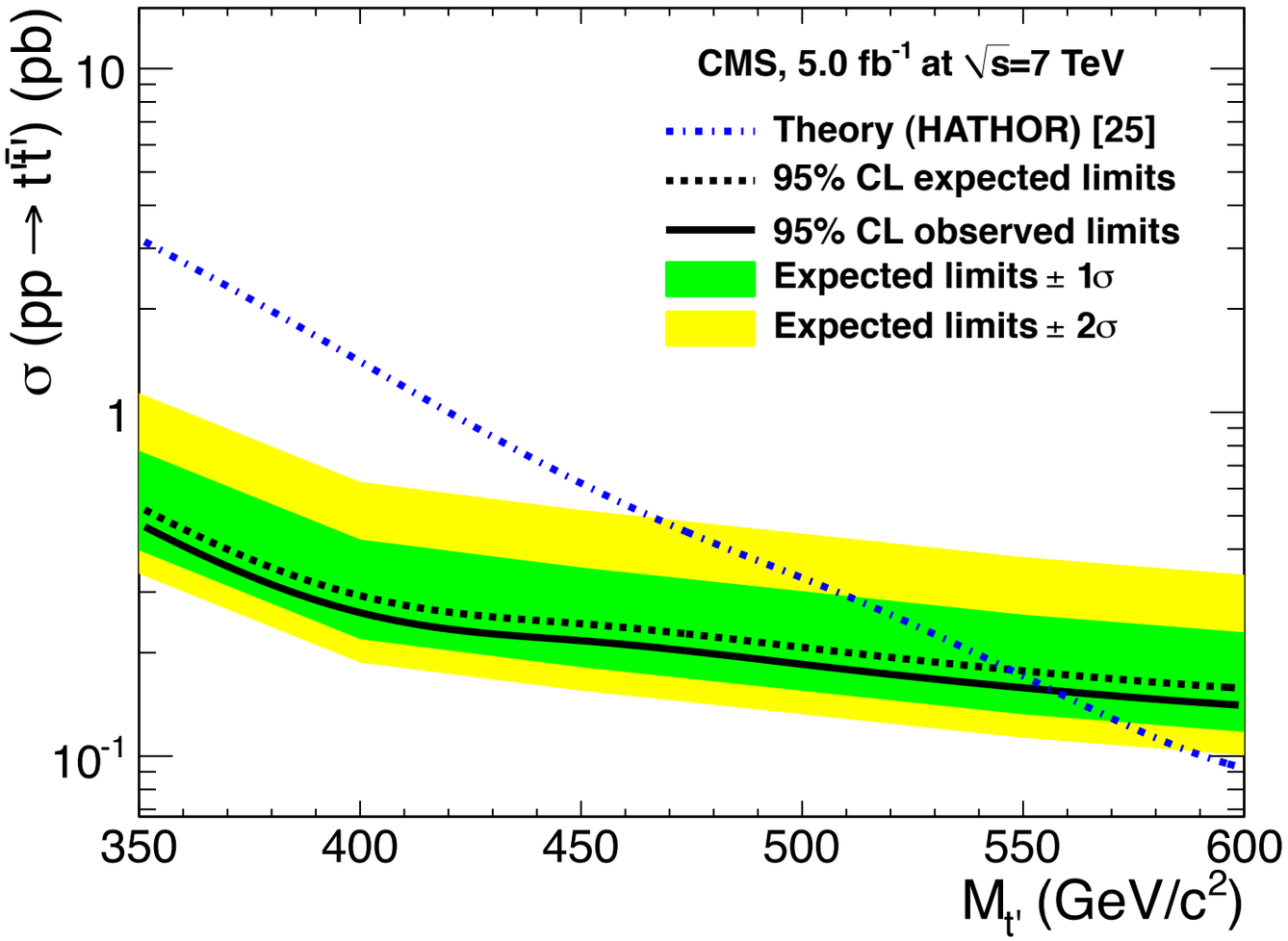


Sequential Standard Model Z′ is excluded below 2.3 TeV

t′ Searches

$$t'\bar{t}' \rightarrow bW^+\bar{b}W^- \rightarrow b\ell^+\nu\bar{b}\ell^-\bar{\nu}$$



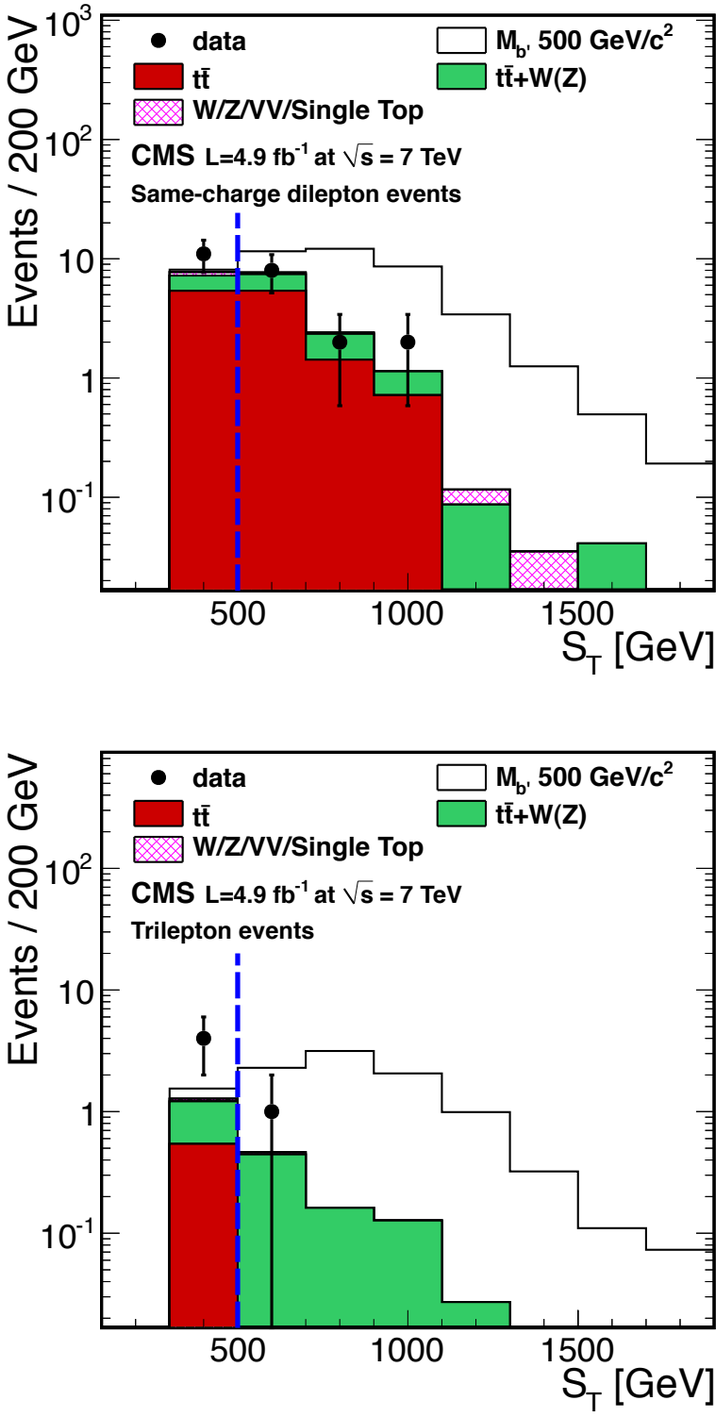


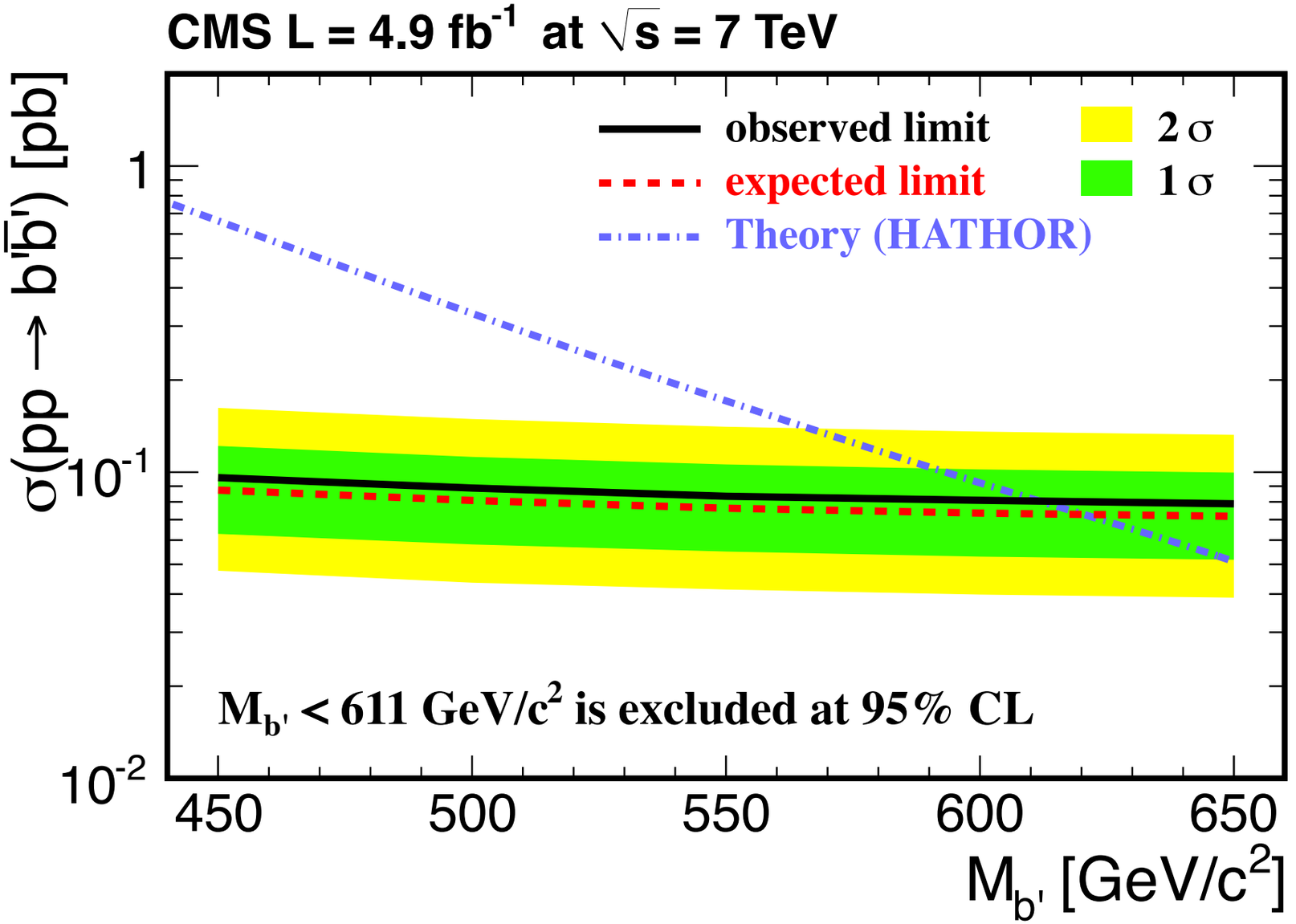
t′ excluded below 550GeV

b′ Searches

$b'\bar{b}' \rightarrow tW^-\bar{t}W^+$

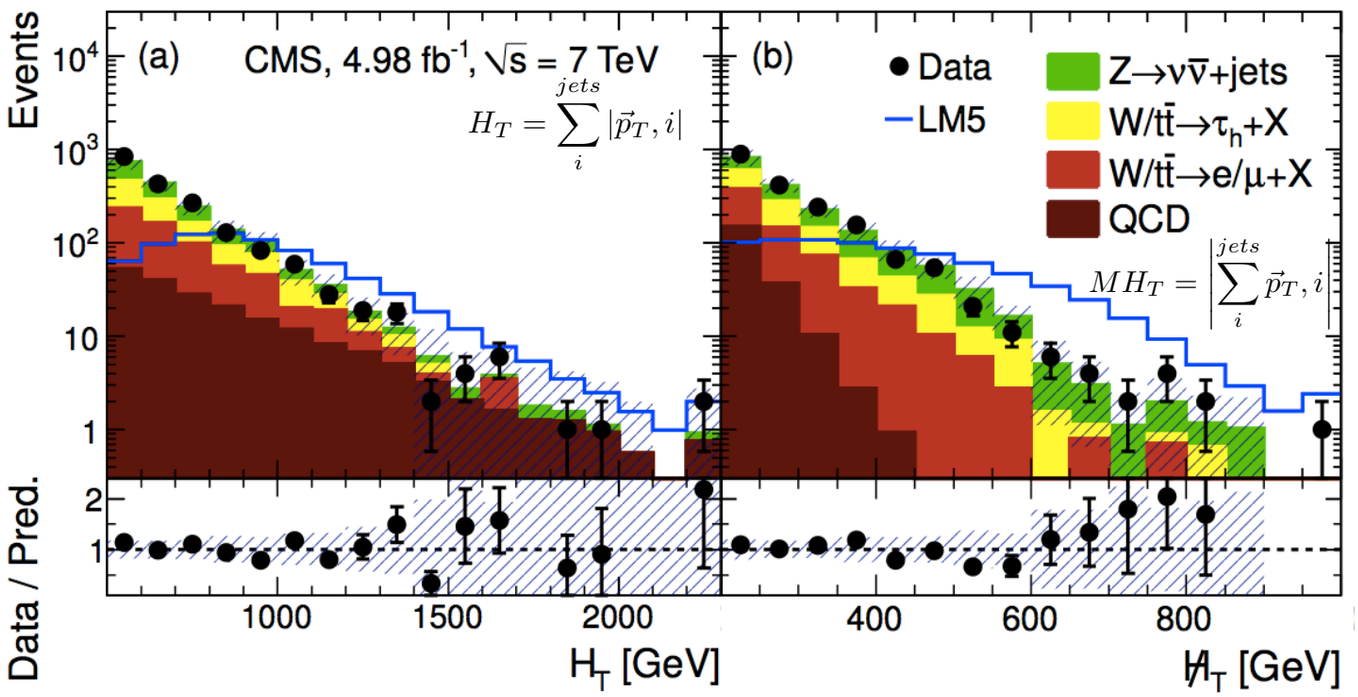
Look for 3 leptons or 2 leptons of same charge

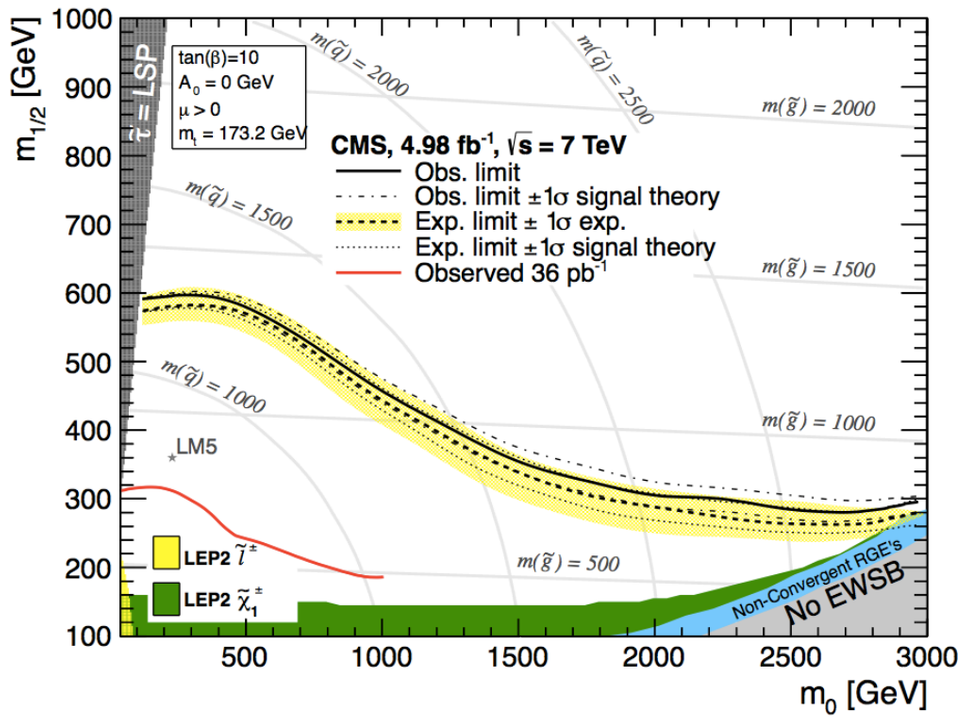


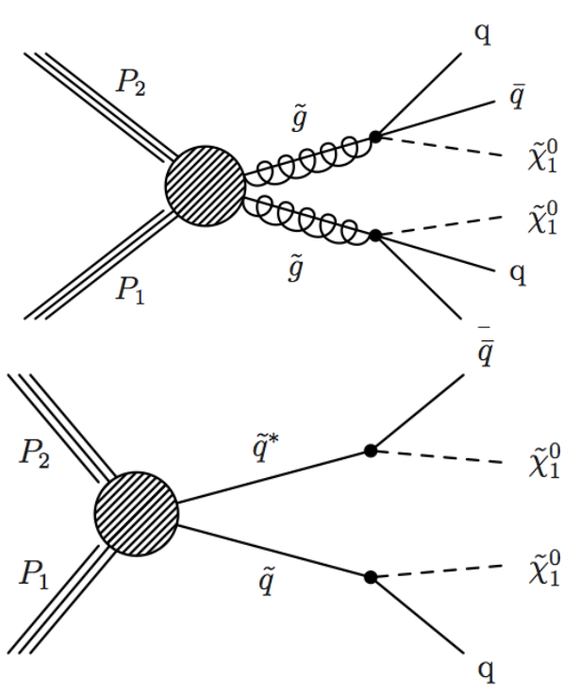


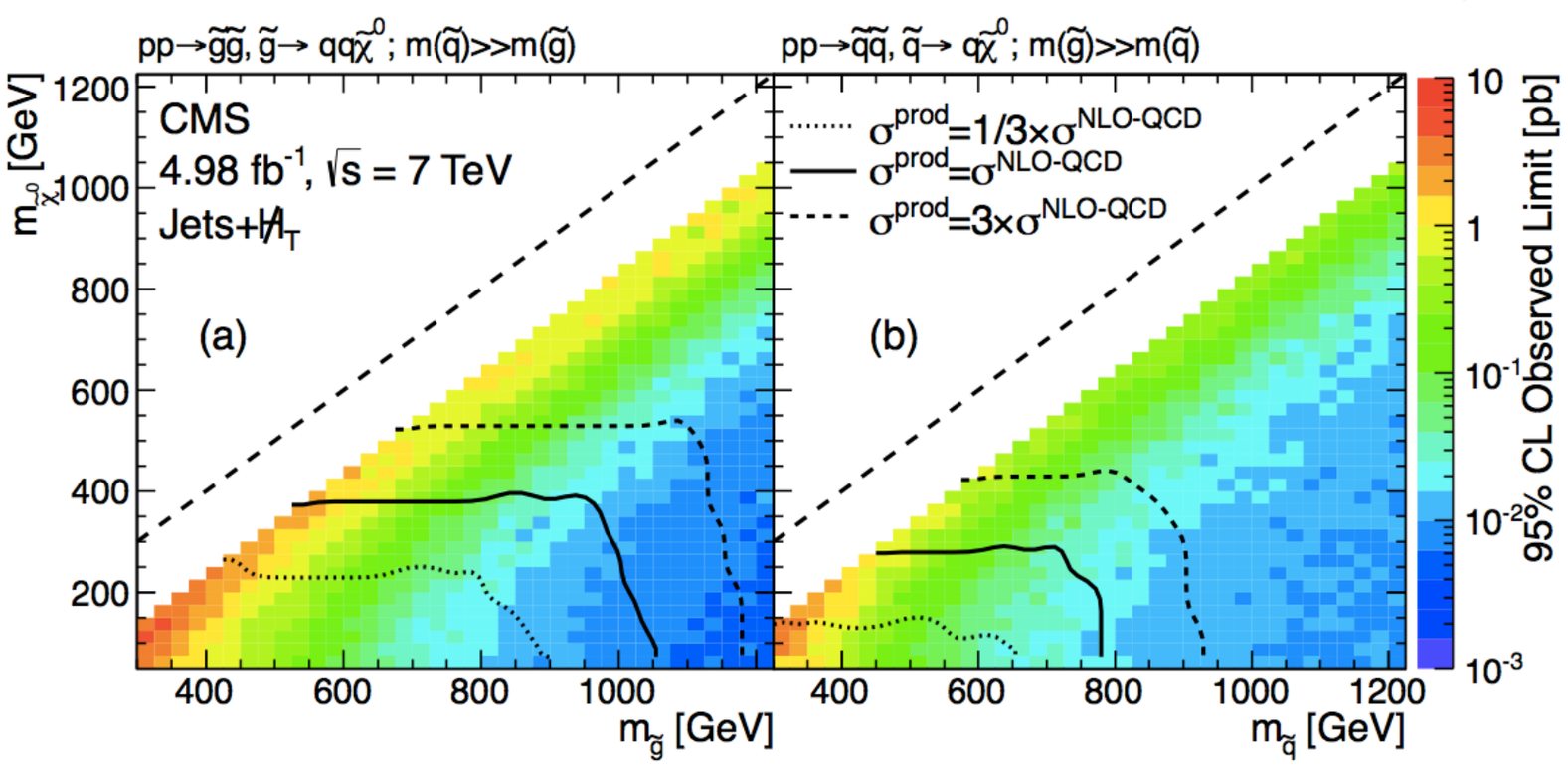
b′ excluded below 610 GeV

SUSY (all hadronic)









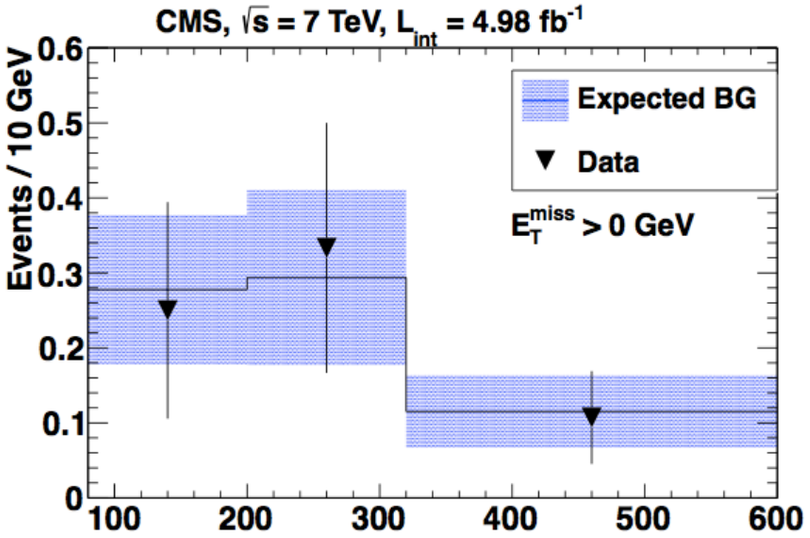
Observations are consistent with Standard Model

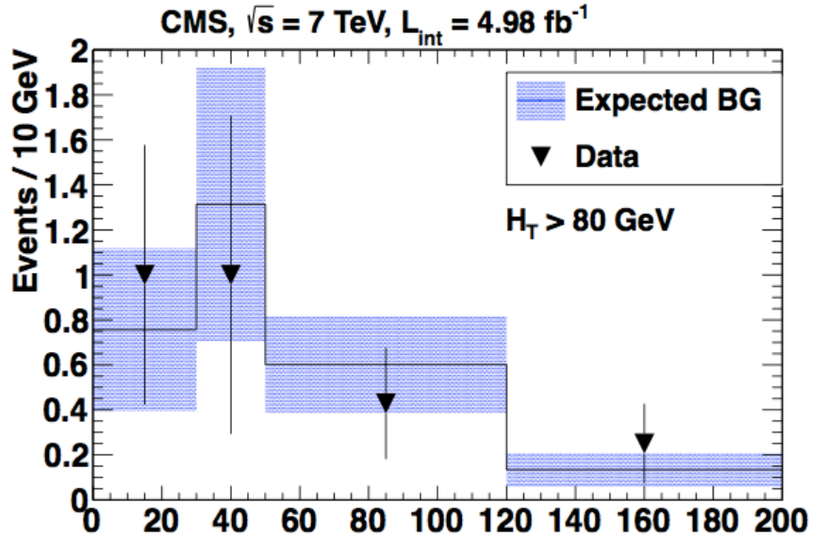
3d Generation SUSY

Same-sign leptons + MET + b-jets

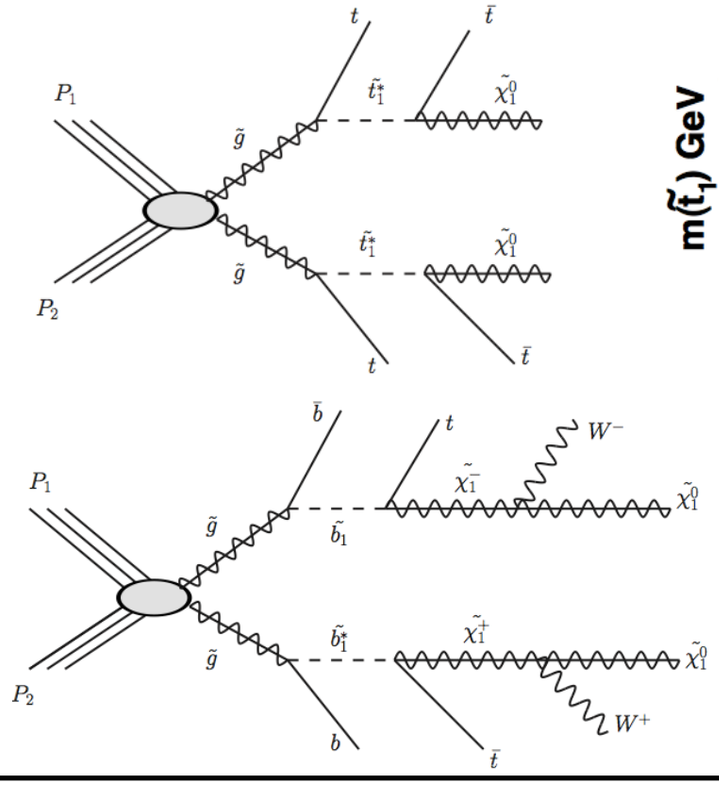
For SUSY to remain natural with Higgs ~ 120GeV

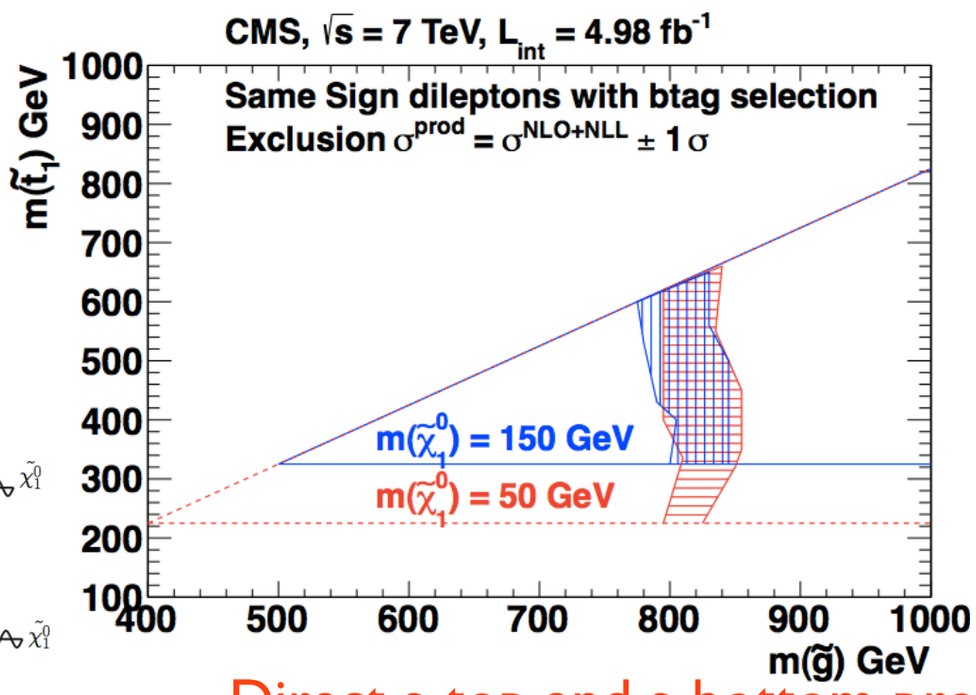
- s-top/bottom < 400 GeV
- gluino < 1500 GeV

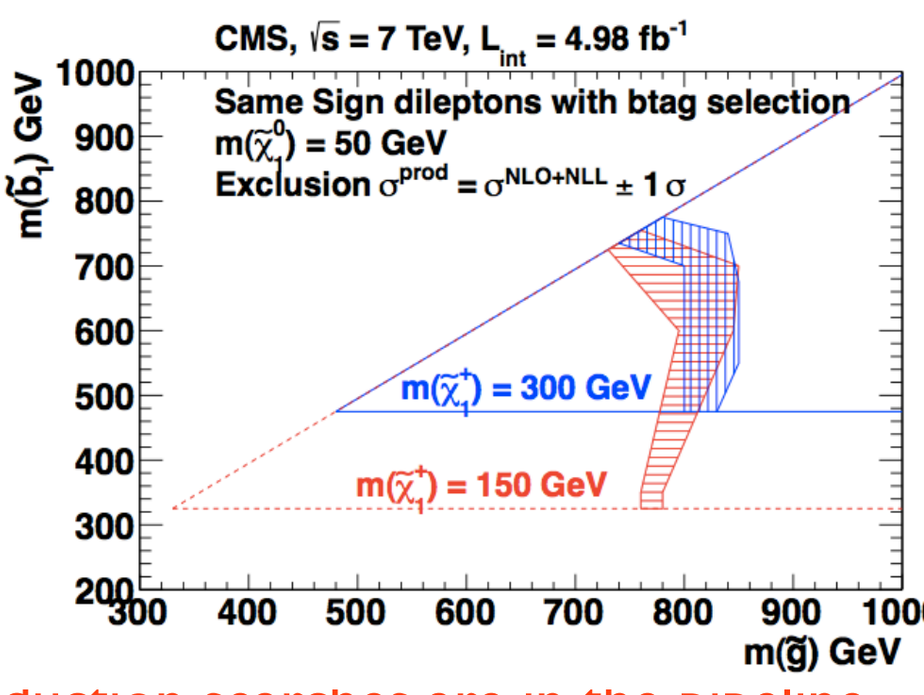




Gluon mitigated s-top and s-bottom production



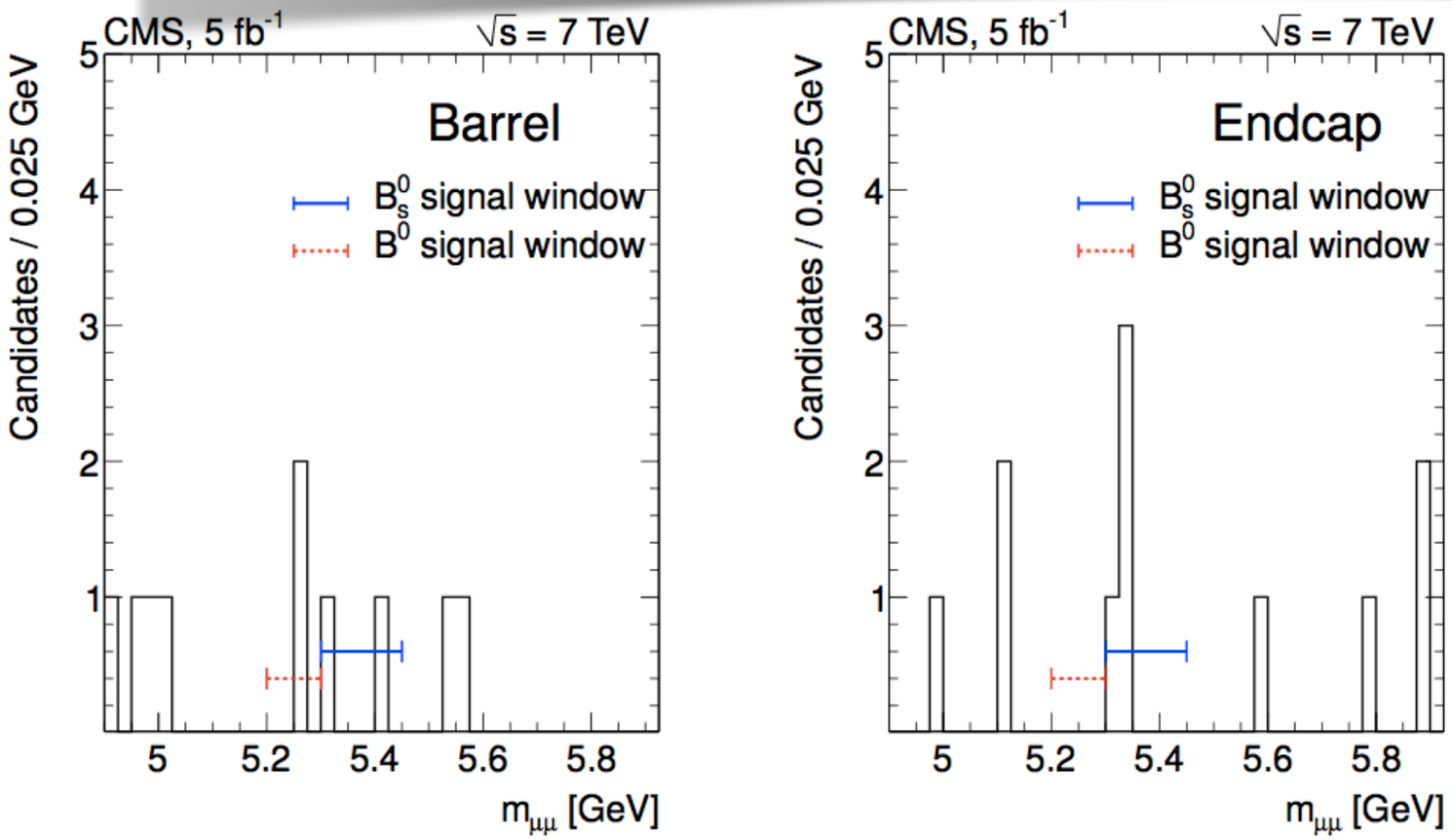




Direct s-top and s-bottom production searches are in the pipeline

Bs→μμ

$$\mathcal{B}(B_s^0 \to \mu^+\mu^-) < 7.7 \times 10^{-9} \text{ and } \mathcal{B}(B^0 \to \mu^+\mu^-) < 1.8 \times 10^{-9} \text{ at } 95\% \text{ CL}$$



Variable	$B^0 \to \mu^+\mu^-$ Barrel	$B_s^0 \to \mu^+\mu^-$ Barrel	$B^0 \to \mu^+\mu^-$ Endcap	$B_s^0 \to \mu^+\mu^-$ Endcap
ε_{tot}	0.0029 ± 0.0002	0.0029 ± 0.0002	0.0016 ± 0.0002	0.0016 ± 0.0002
$N^{\text{exp}}_{\text{signal}}$	0.24 ± 0.02	2.70 ± 0.41	0.10 ± 0.01	1.23 ± 0.18
$N^{\text{exp}}_{\text{peak}}$	0.33 ± 0.07	0.18 ± 0.06	0.15 ± 0.03	0.08 ± 0.02
$N^{\text{exp}}_{\text{comb}}$	0.40 ± 0.34	0.59 ± 0.50	0.76 ± 0.35	1.14 ± 0.53
$N^{\text{exp}}_{\text{total}}$	0.97 ± 0.35	3.47 ± 0.65	1.01 ± 0.35	2.45 ± 0.56
N_{obs}	2	2	0	4

- Rare FCNC helicity suppressed process
- Sensitive to new physics via loop effects
- Long history of searches
- SM Predictions:
  - $B(Bs \to \mu\mu) = (3.2 \pm 0.2) \times 10^{-9}$
  - $B(B \to \mu\mu) = (0.1 \pm 0.01) \times 10^{-9}$
- LHCb results:
  - $B(Bs \to \mu\mu) < 4.5 \times 10^{-9}$ 95% CL
  - $B(B \to \mu\mu) < 1.0 \times 10^{-9}$ 95% CL
- CMS can benefit from rapid increase in data in 2012

Conclusion

- Higgs searches narrowed the allowed region to [114,127] GeV
  - We see an excess at ~125GeV with a global significance of 2.1σ
  - In 2012 we should know for sure if Higgs exists
- CMS dark matter search results compete successfully with direct detection experiments
- Searches for Physics Beyond the Standard Model cover many possible scenarios
  - We see nothing new so far