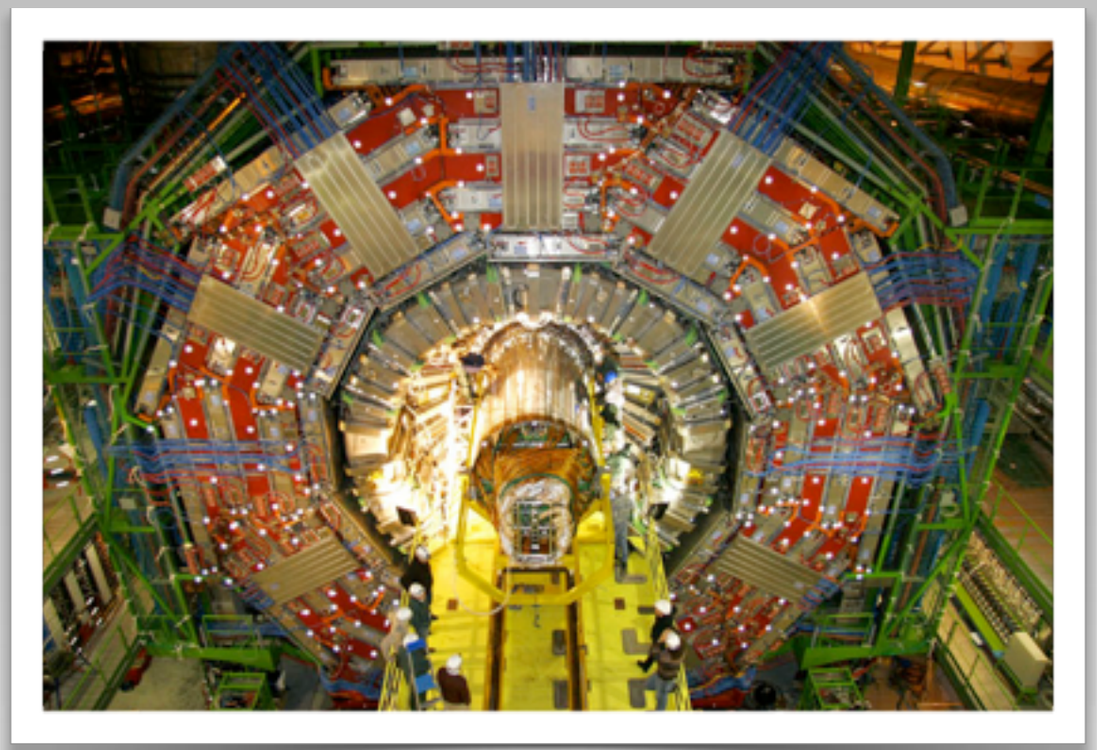


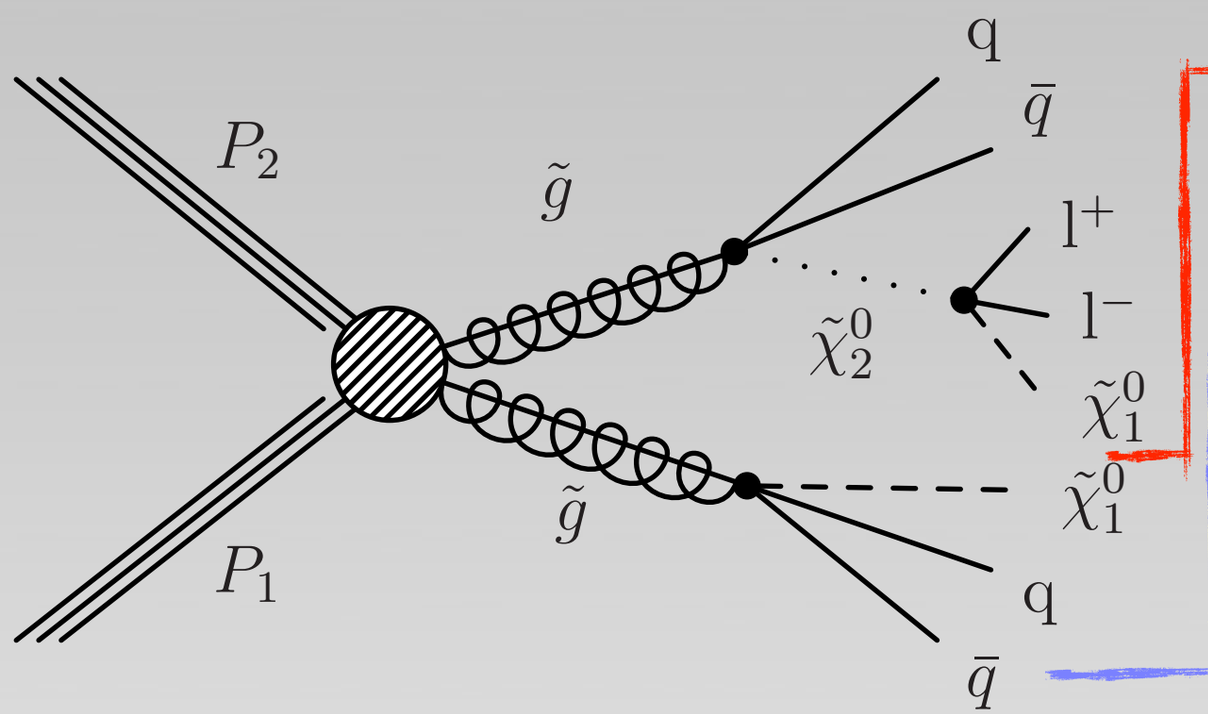
Searches for Supersymmetry with the CMS detector

Niklas Mohr
on behalf of the CMS collaboration

MCTP Higgs Symposium 17.4.2012

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

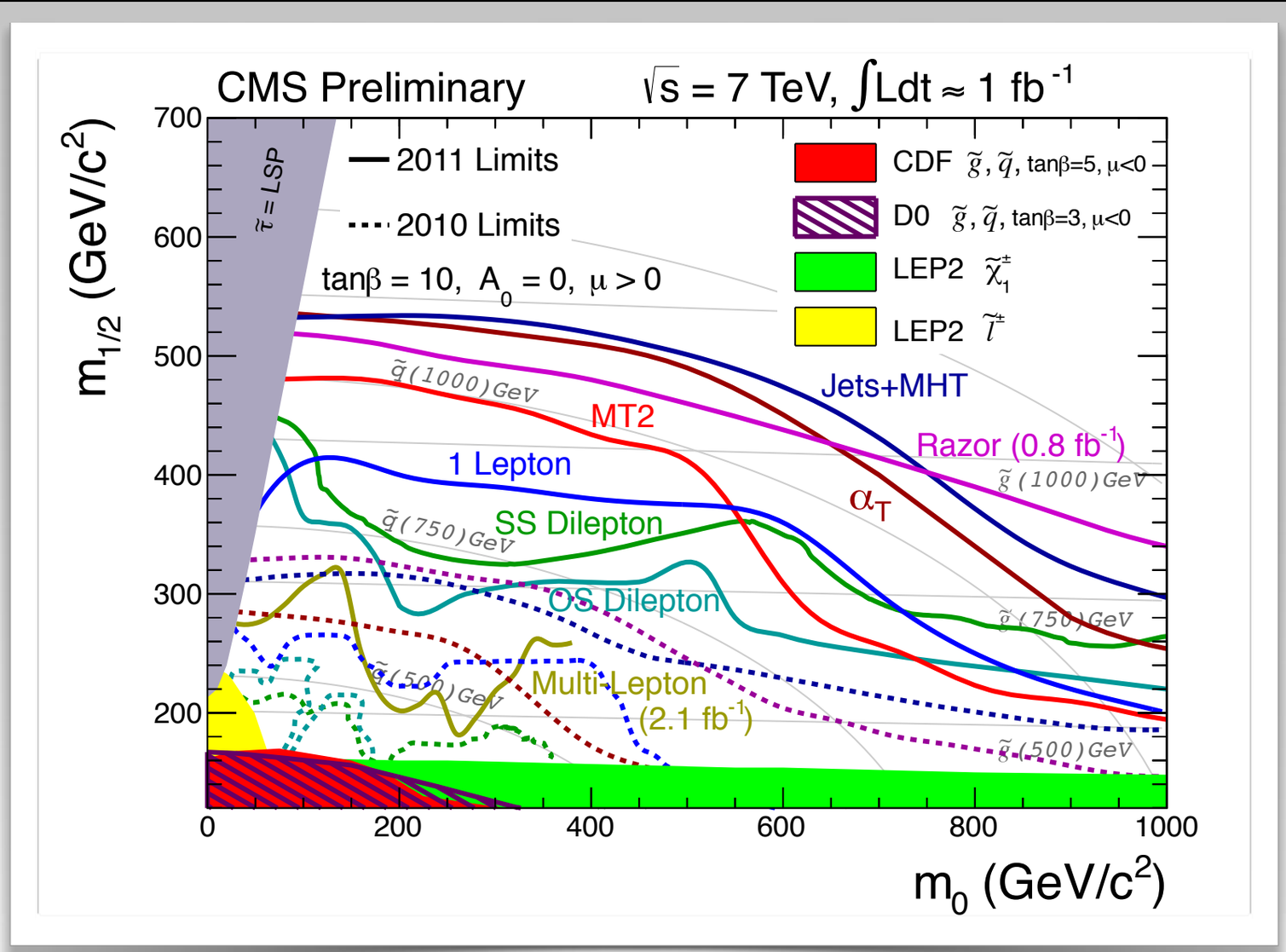
Introduction

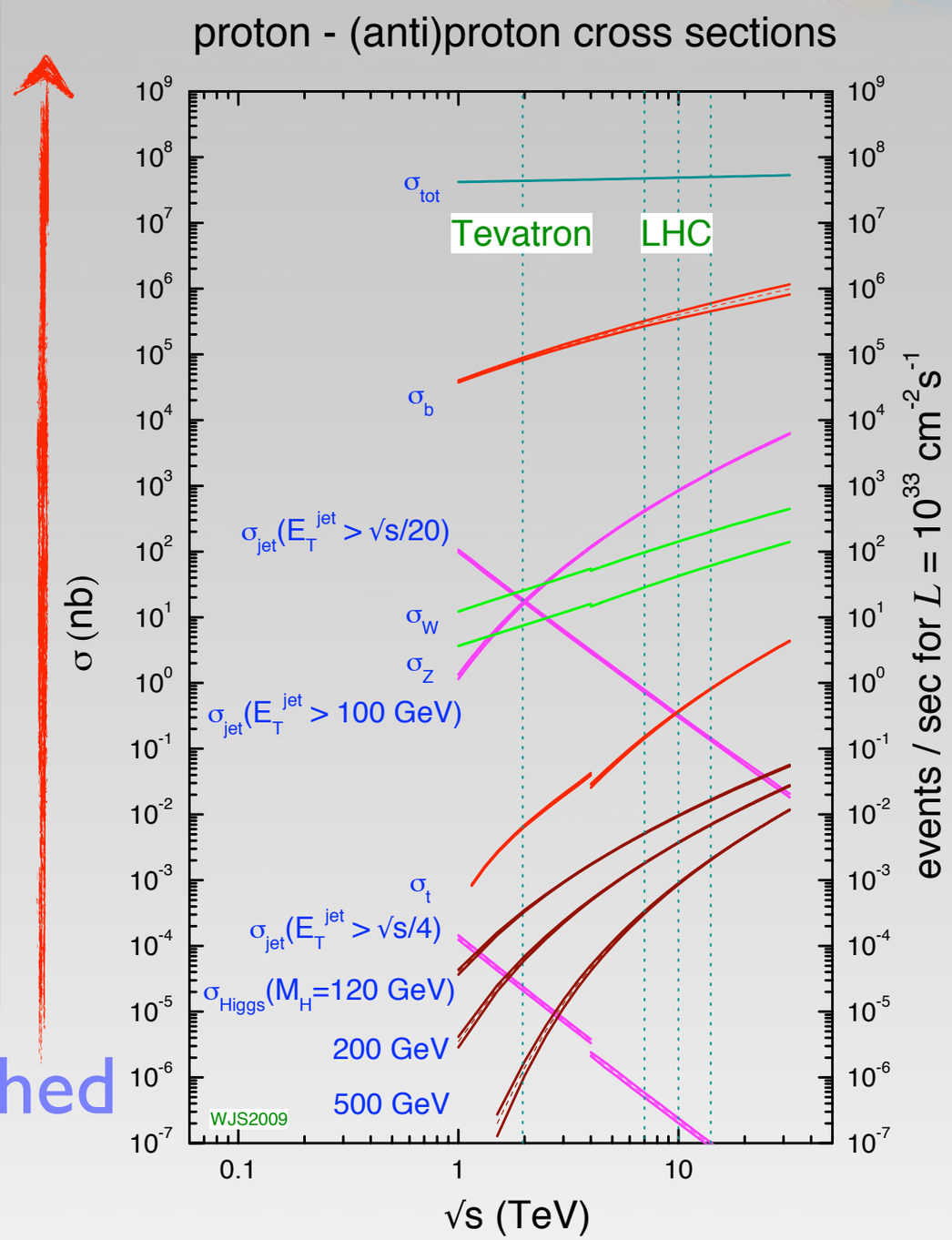


- Always 2 LSPs (MET)
  - M_{T2}, M_R, R^2, α_T, L_P, JZB
- Often jets ($H_T=\sum p_{T,i}$)
- Long cascade that can involve many particles

- Split search program based on objects
  - Number of leptons, photons in the final state
  - Try to be as model independent as possible
- Dedicated background control samples
  - From data wherever possible/necessary

Status as of Summer 11 (Outline)

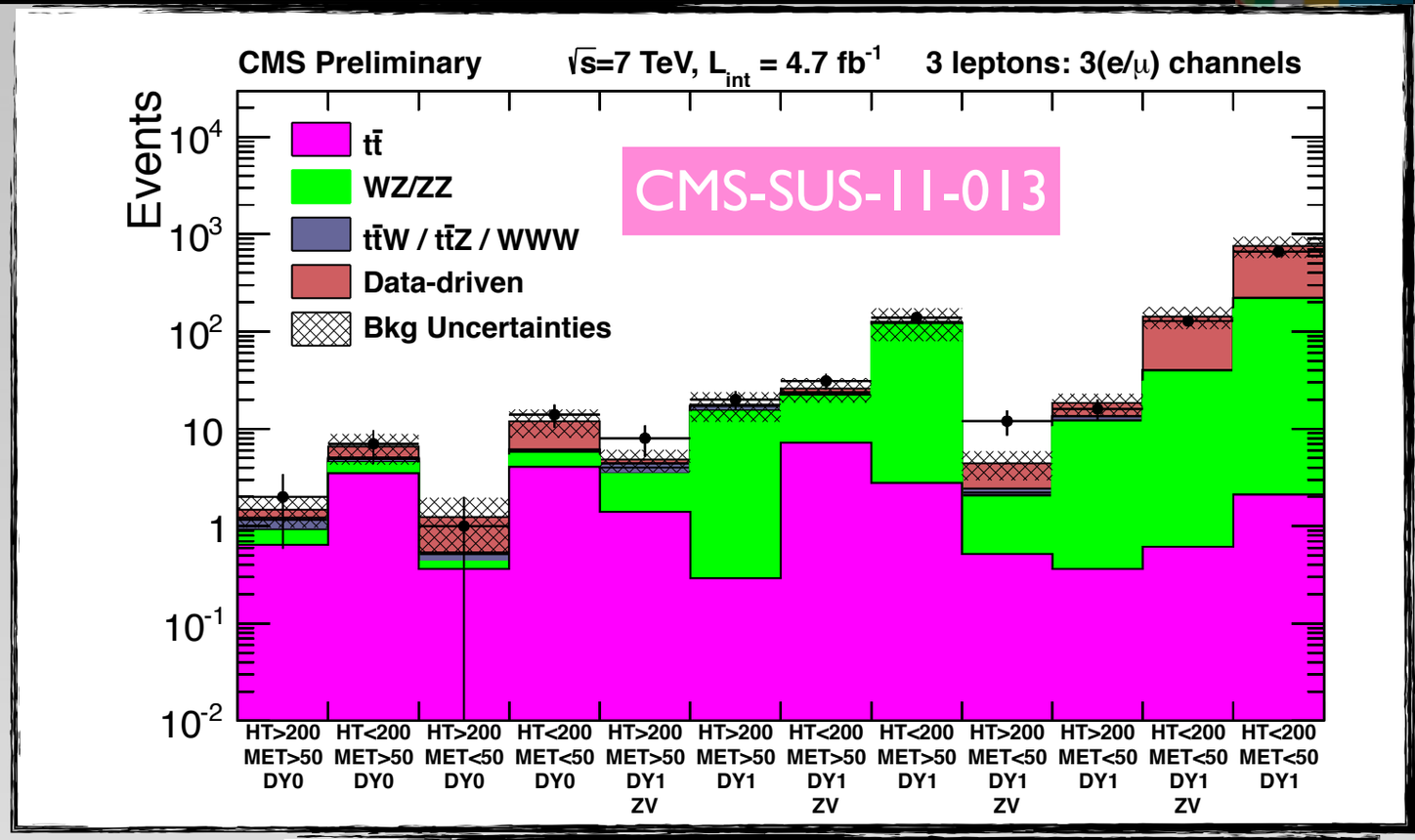


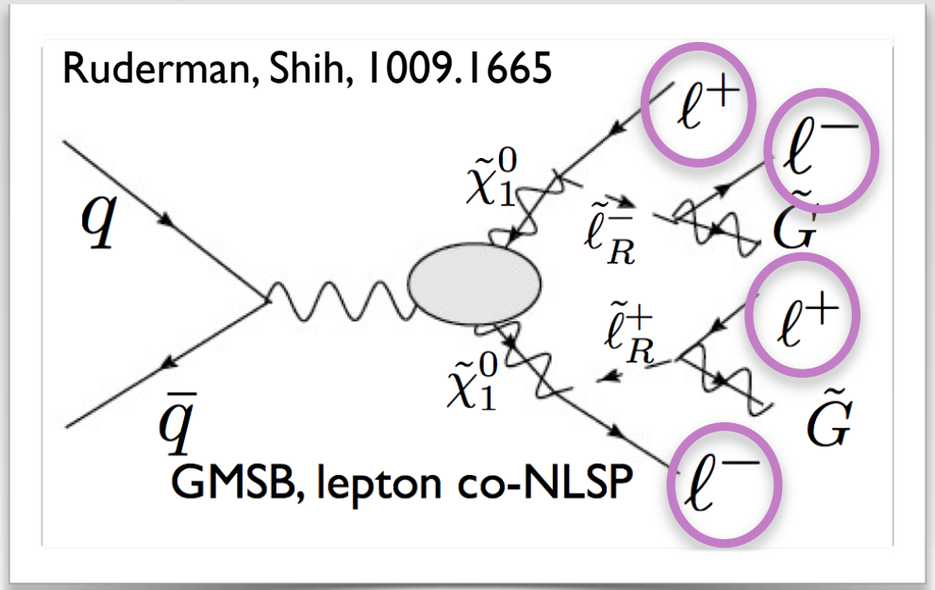


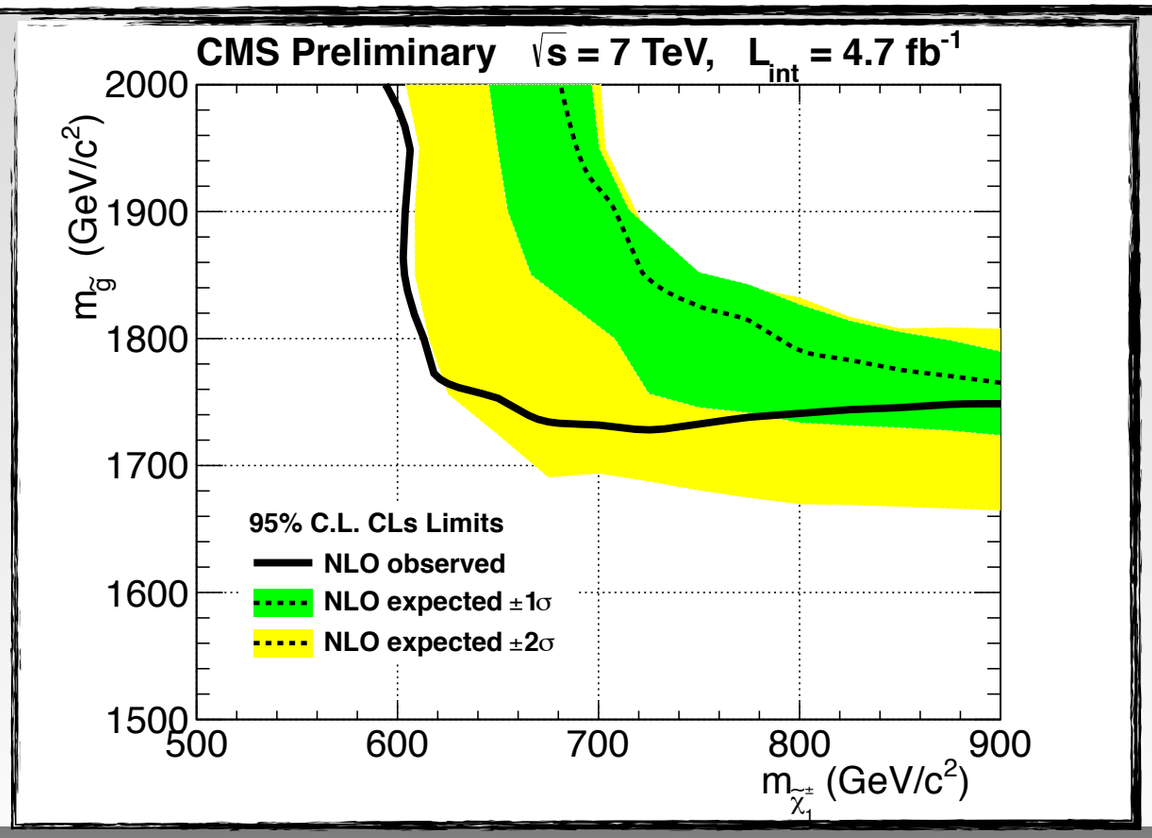
- ~35 public analyses, 11 published
  - Had to be brief and pick few analysis
- Focus on new results using 5 fb^{-1} of LHC data

Multilepton

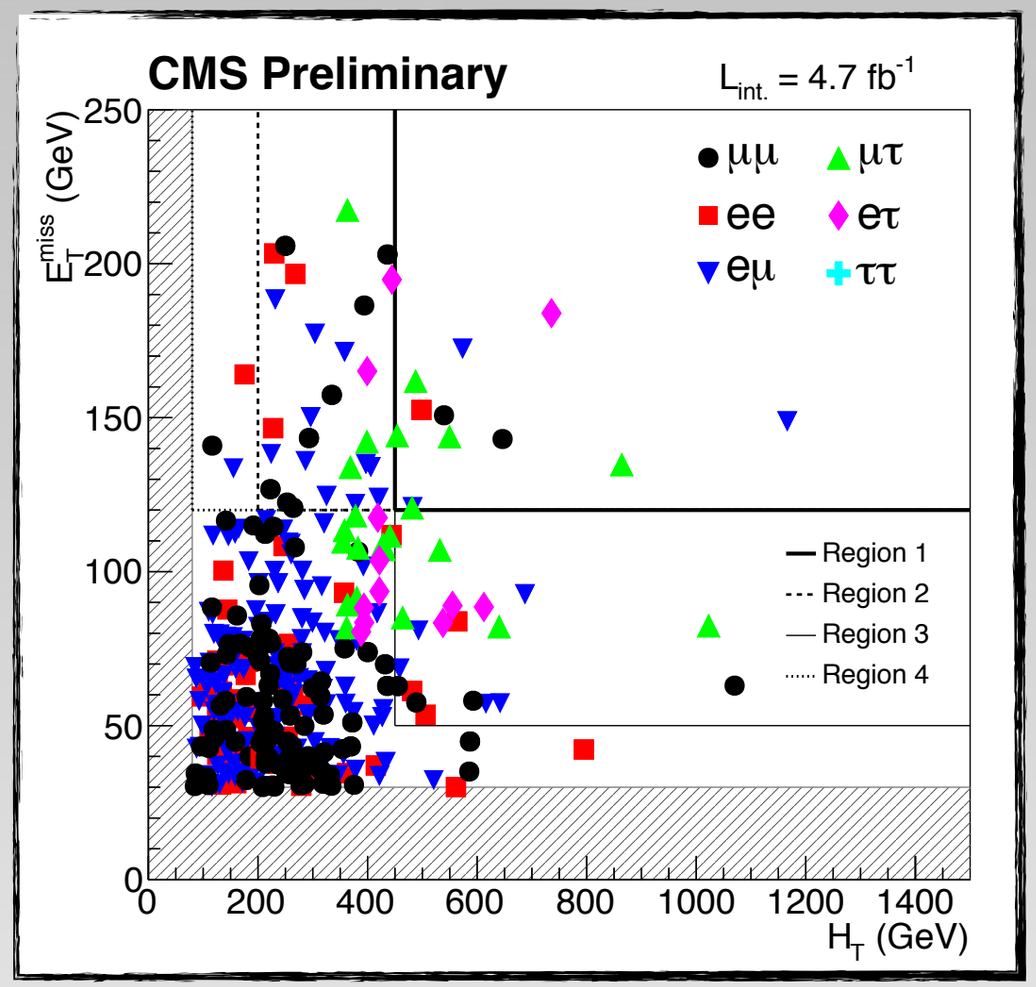
- 52 H_T, MET signal regions
- Background estimate
  - $Z\gamma \rightarrow ll(l)$ by photon to lepton fake-rate
  - Zjet$\rightarrow ll(l)$ by track to lepton fake-rate
  - Irreducible backgrounds from MC
- EWK production and RPV

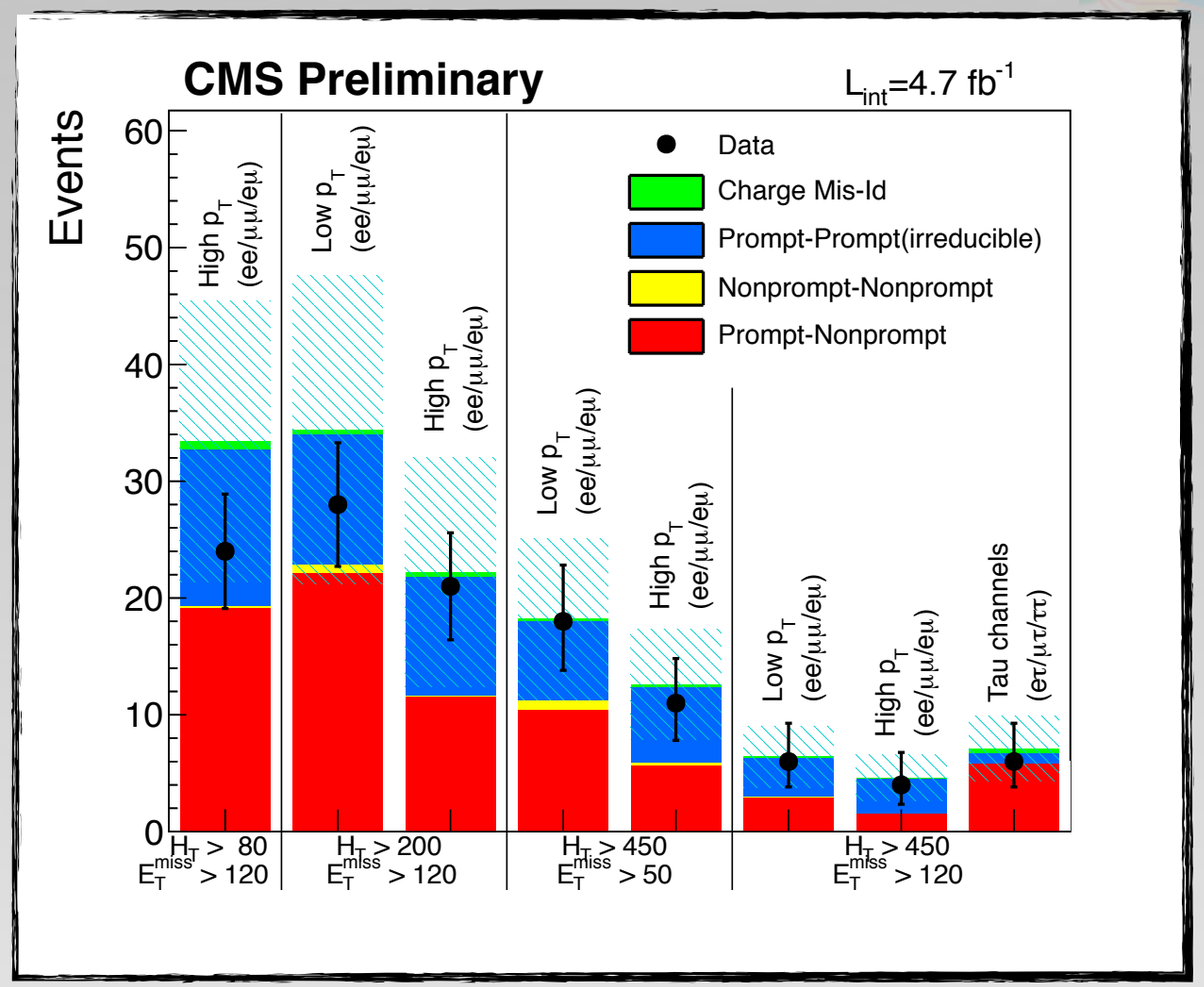


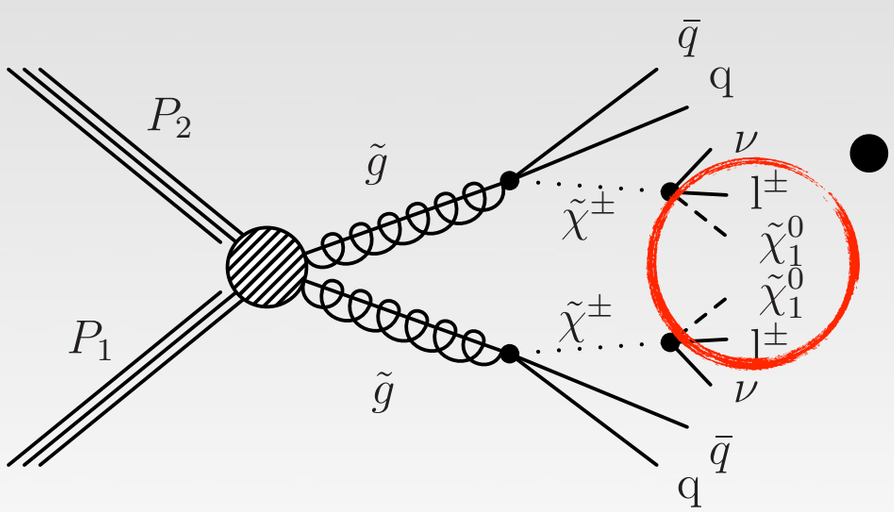




Same-sign dileptons



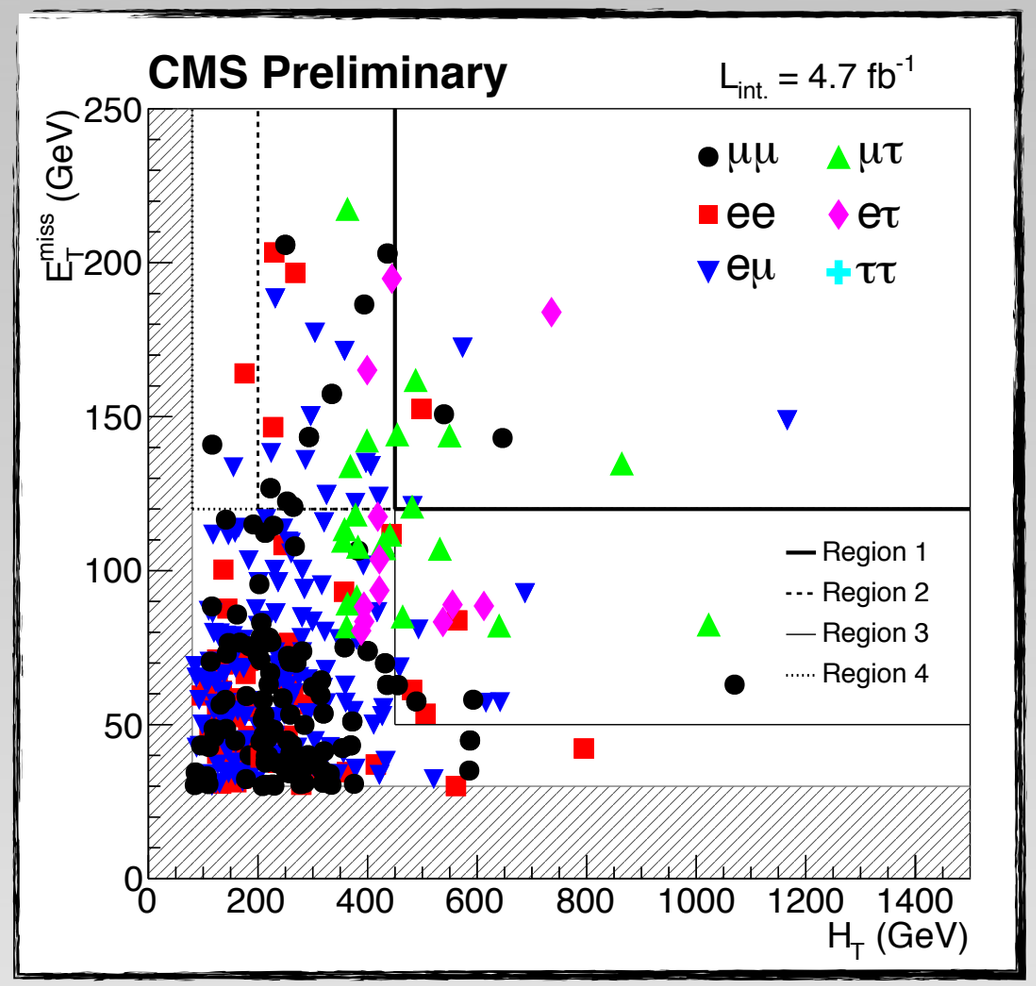


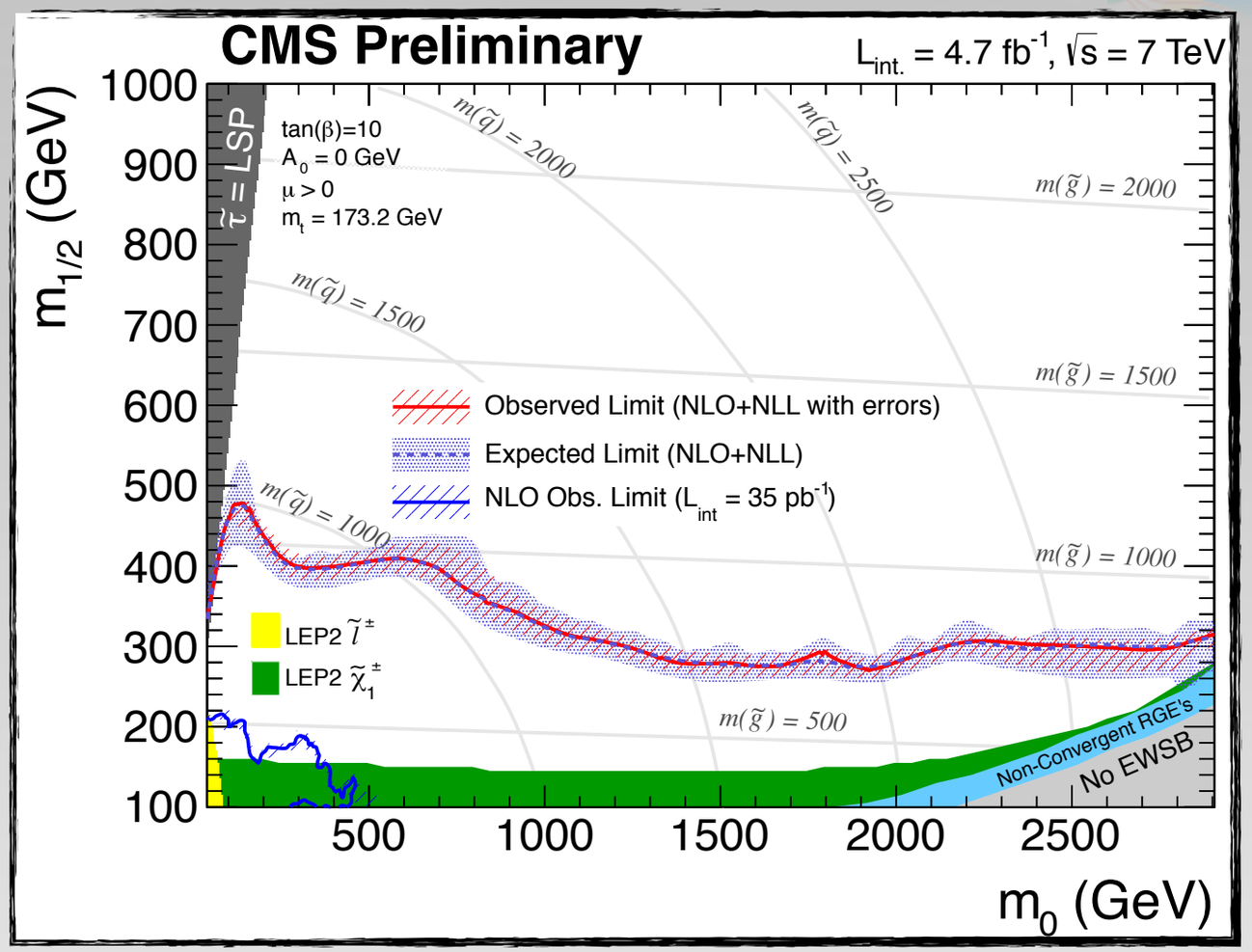


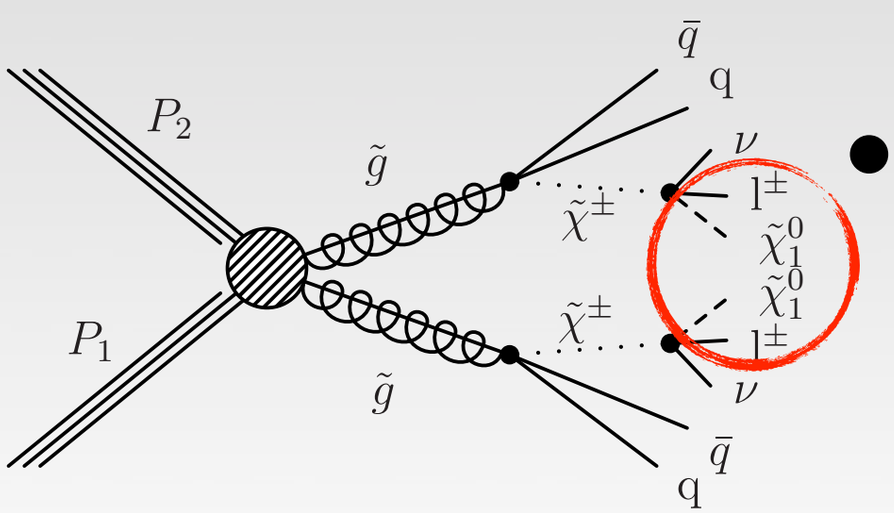
CMS-SUS-11-010

- Rare process in SM, several H_T, MET signal regions
  - Fake leptons from data, charge mis-identification small, WZ, ZZ, ttW, ttZ from MC

Same-sign dileptons



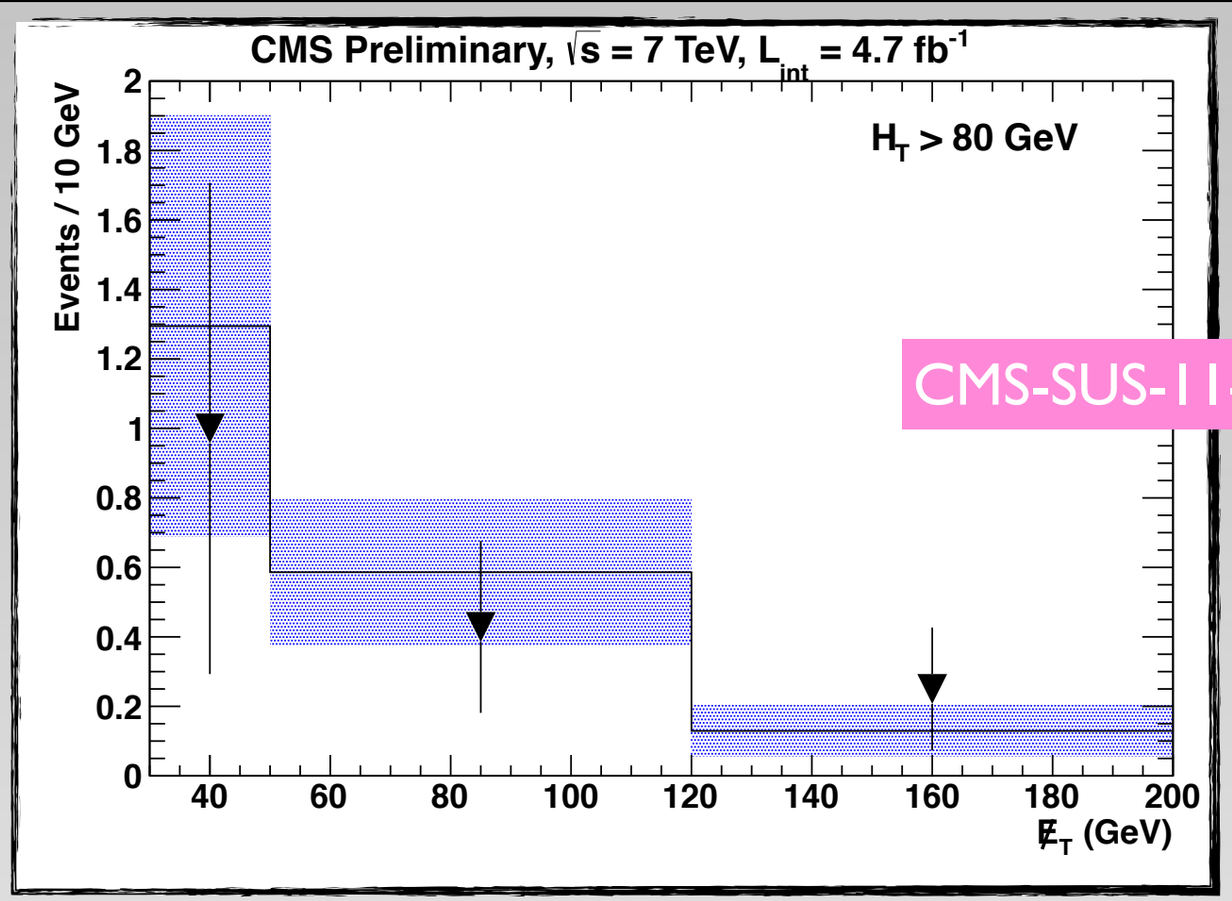




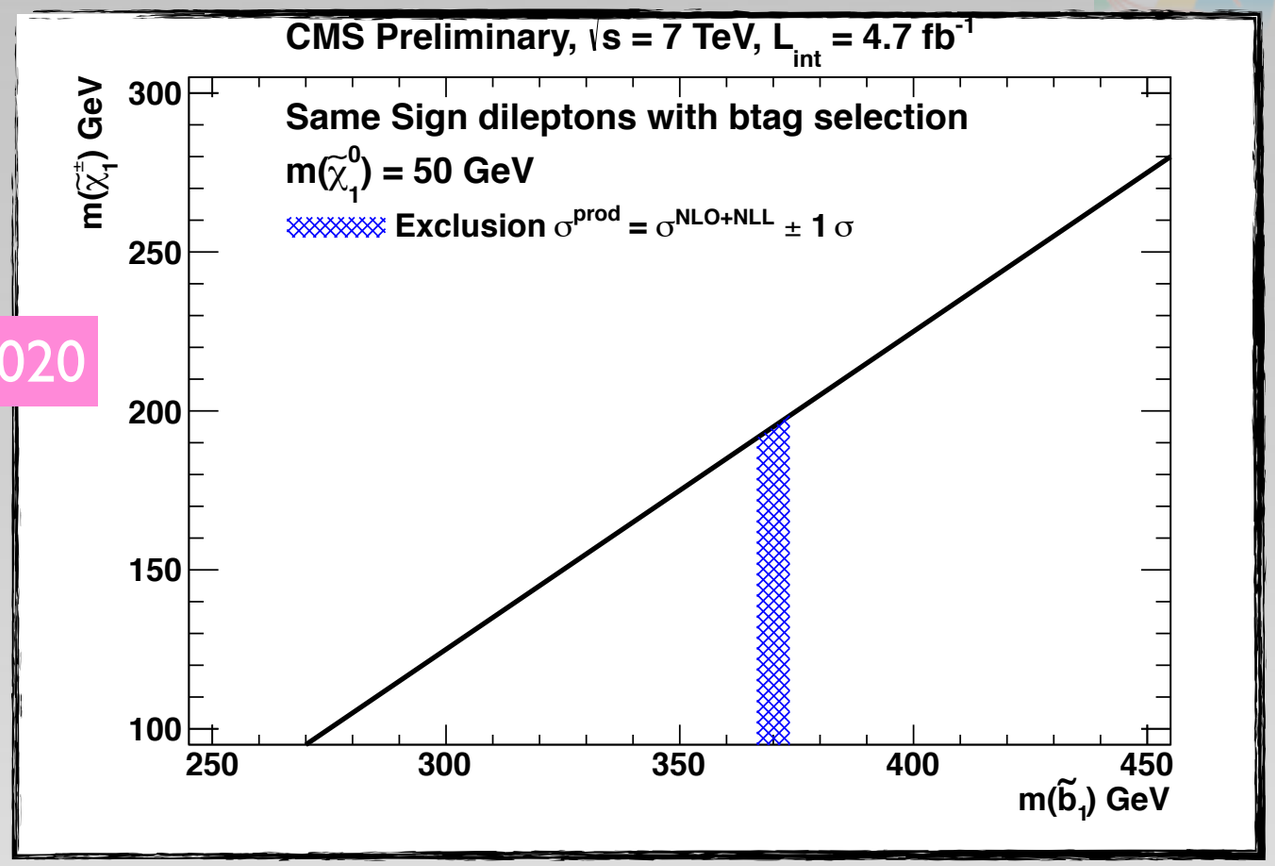
CMS-SUS-11-010

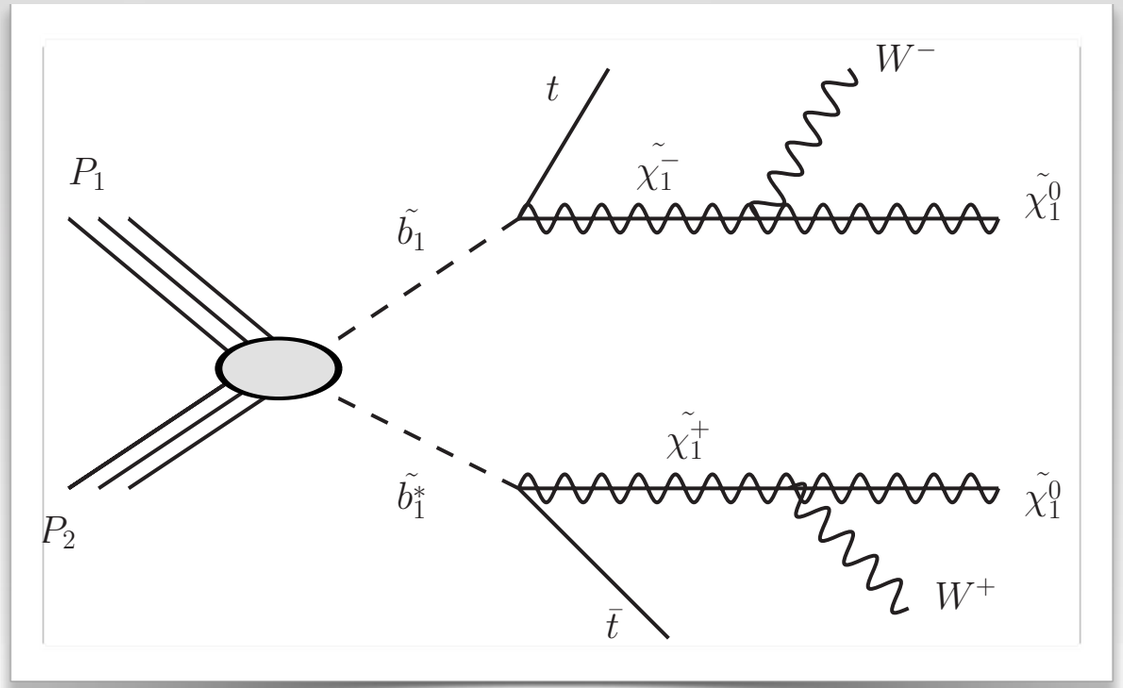
- Rare process in SM, several H_T, MET signal regions
  - Fake leptons from data, charge mis-identification small, WZ, ZZ, ttW, ttZ from MC

Same-sign dileptons + b-tag



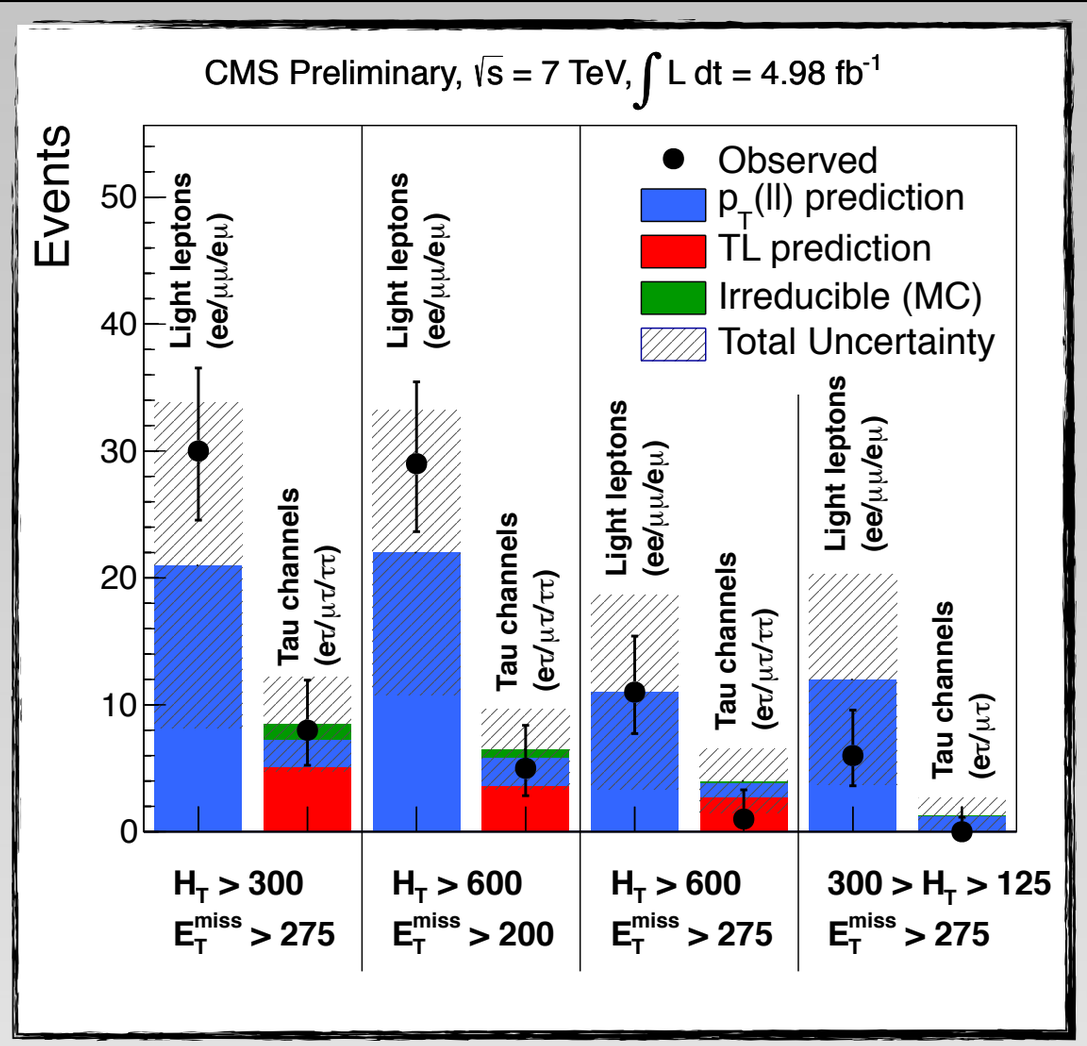
CMS-SUS-11-020

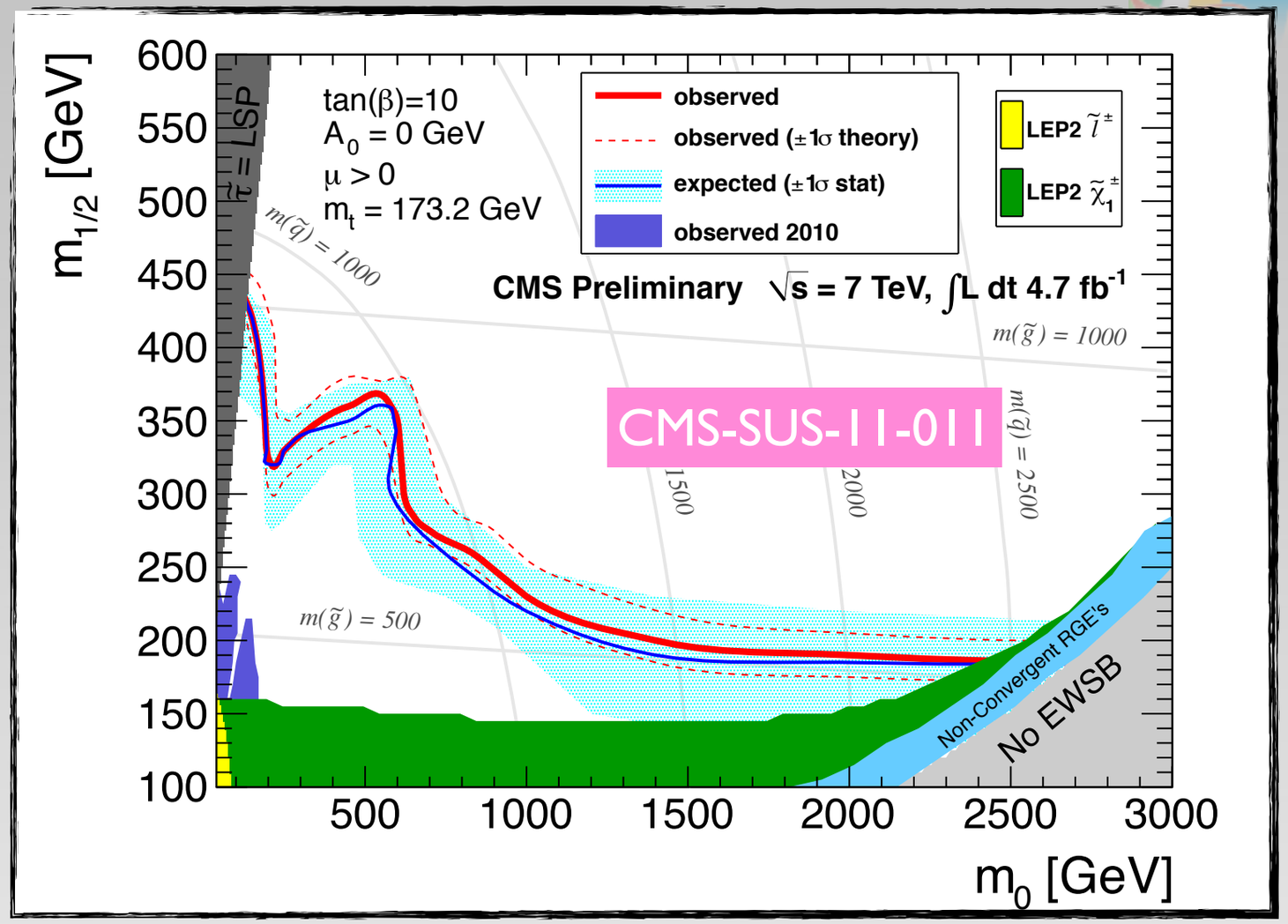


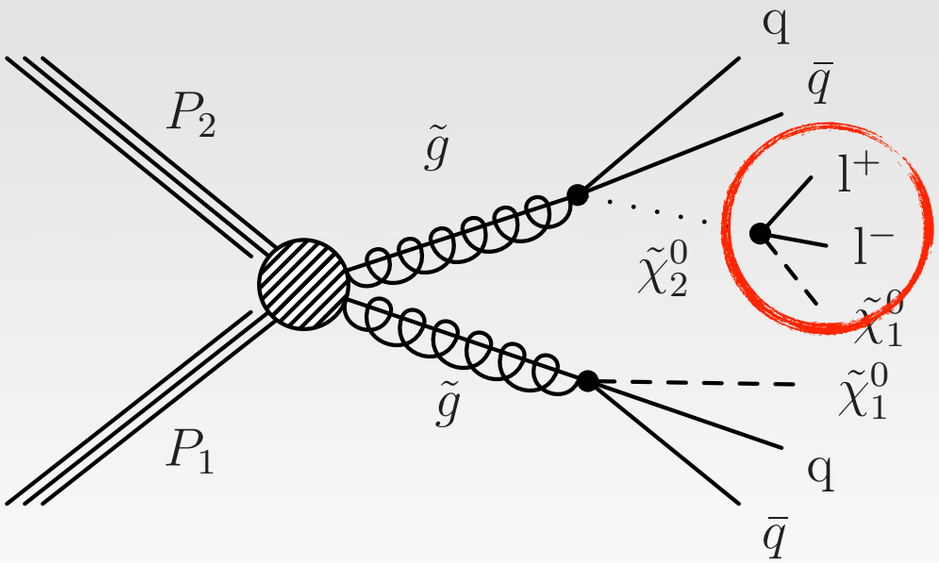


- Adding b-tag, several H_T, MET signal regions
  - Fake leptons from data, charge mis-identification small, WZ, ZZ, ttW, ttZ from MC

Opposite-sign dileptons

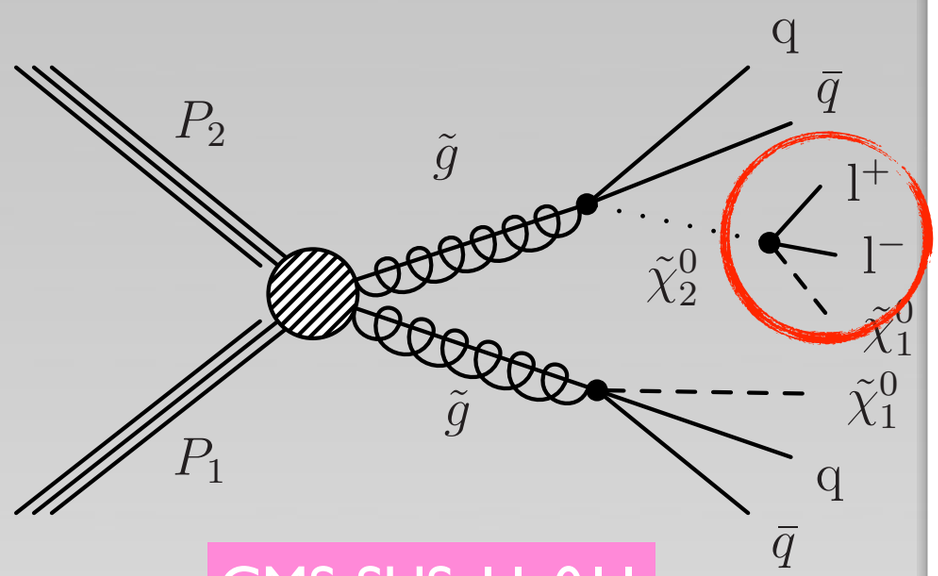




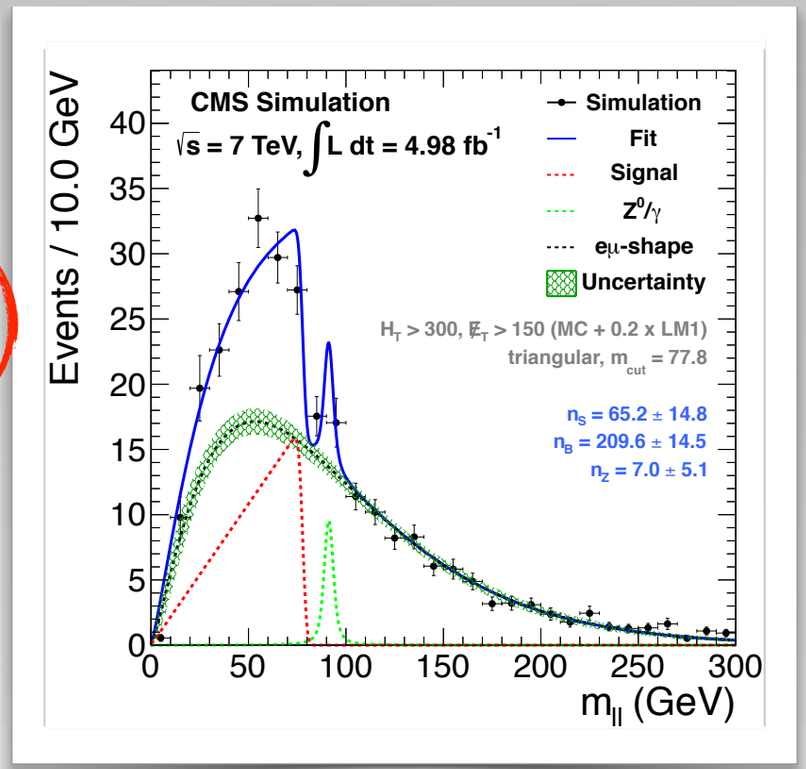


- H_T, MET signal regions
- Dominant: top background
  - $p_T(ll)=p_T(\nu\nu)$

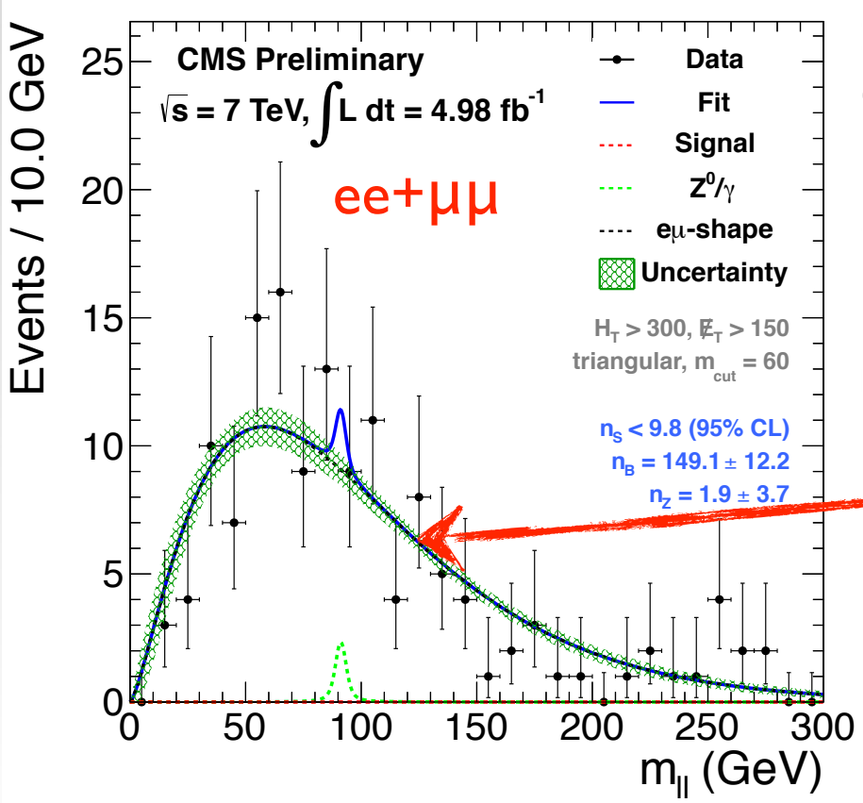
Opposite-sign off Z

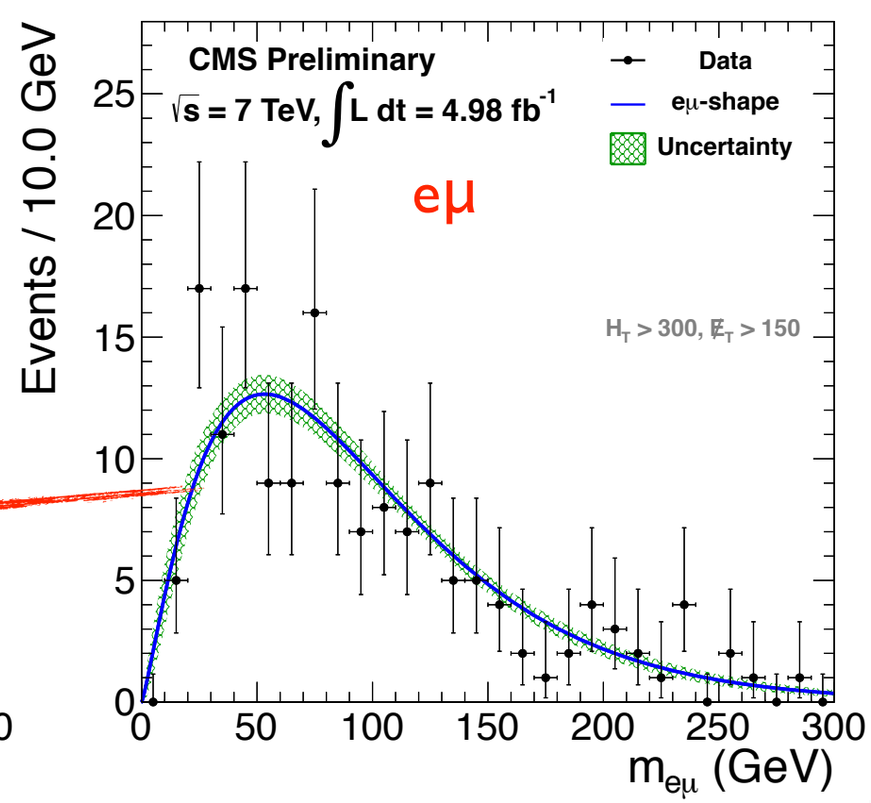


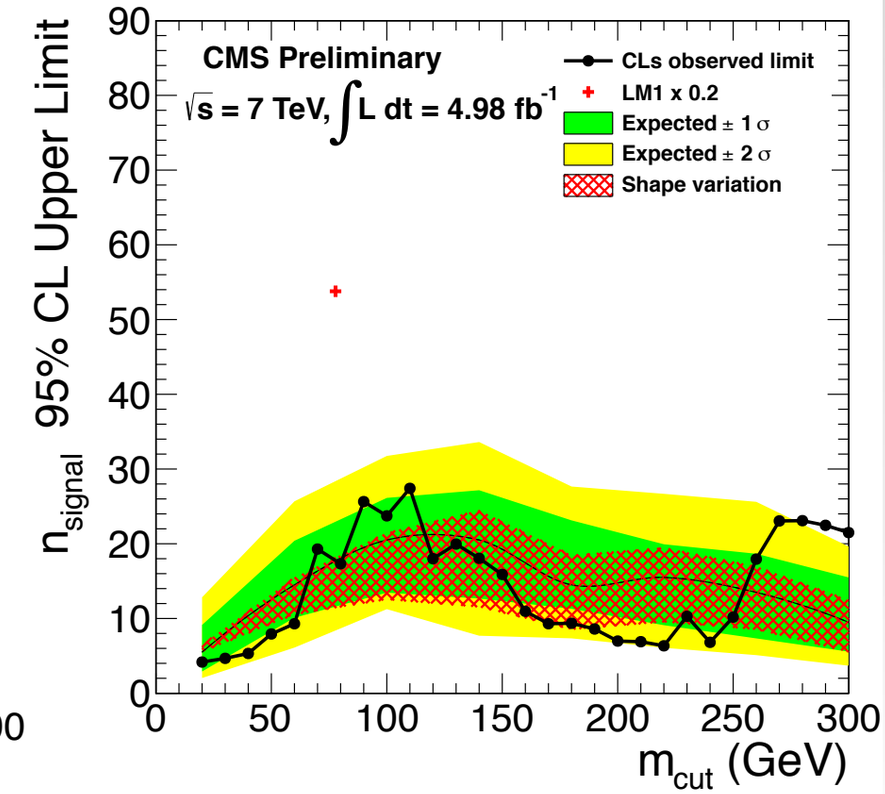
CMS-SUS-11-011



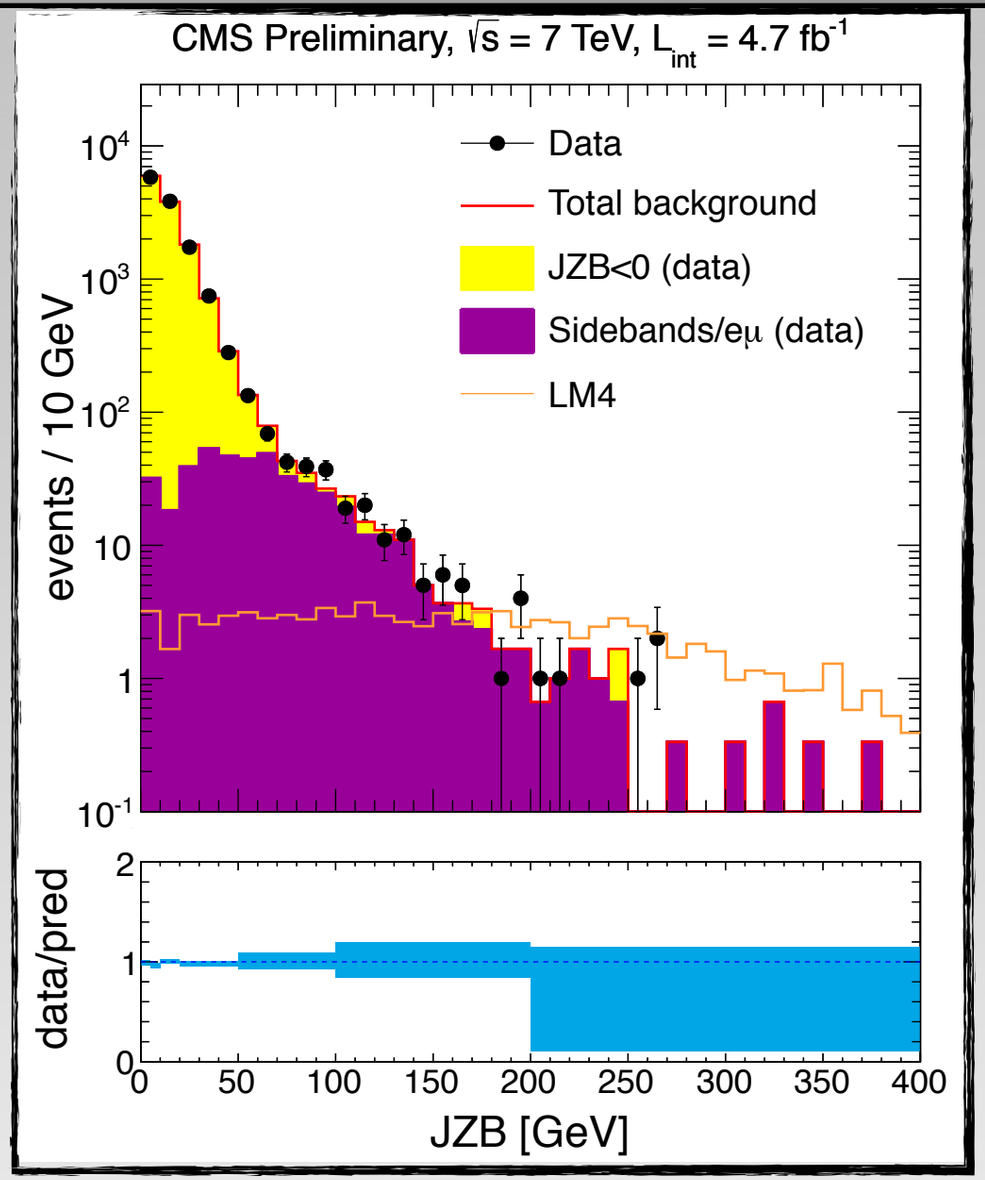
- Search for an edge structure in mll
  - H_T, MET selection
- Background from OF subtraction

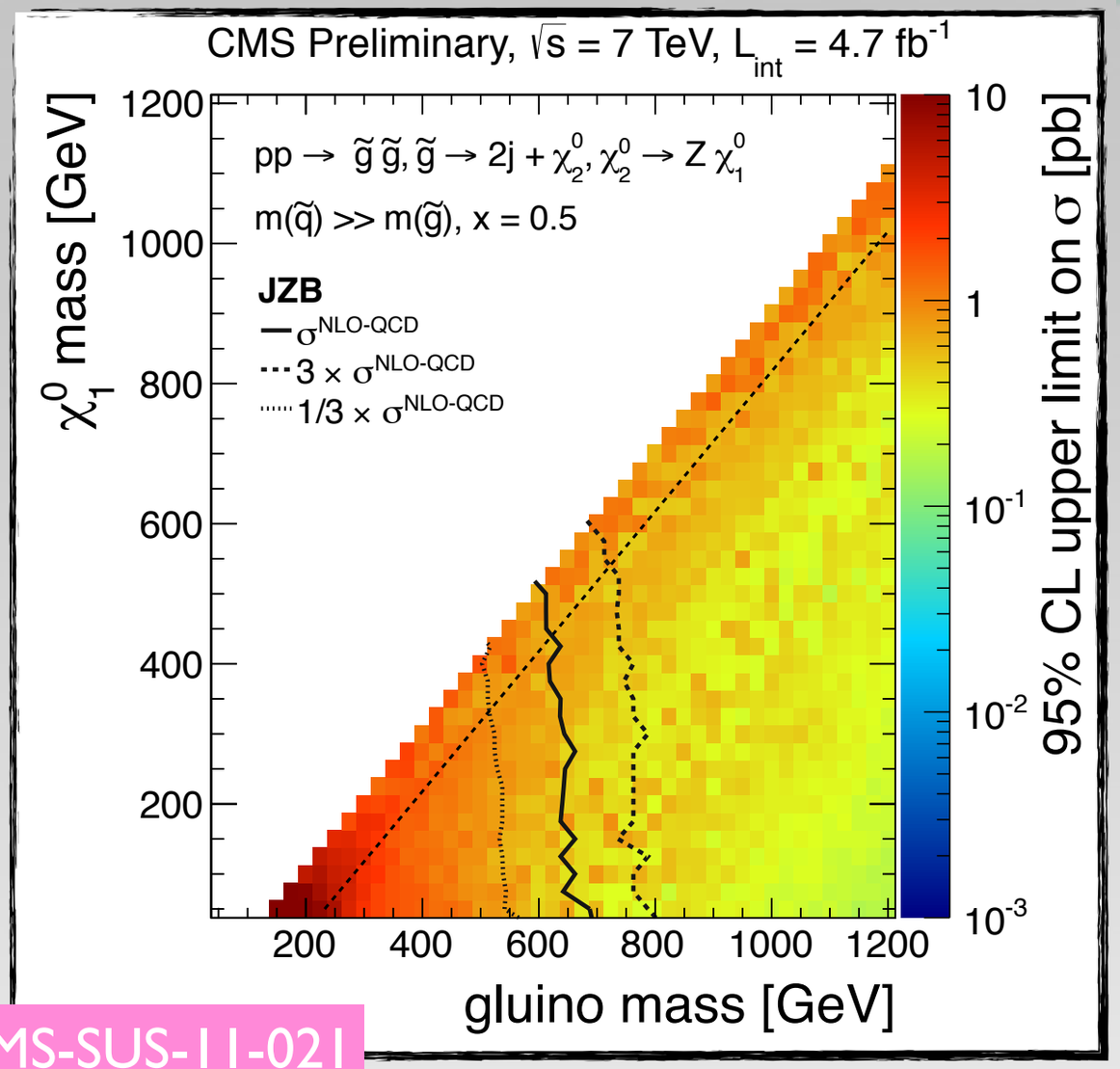




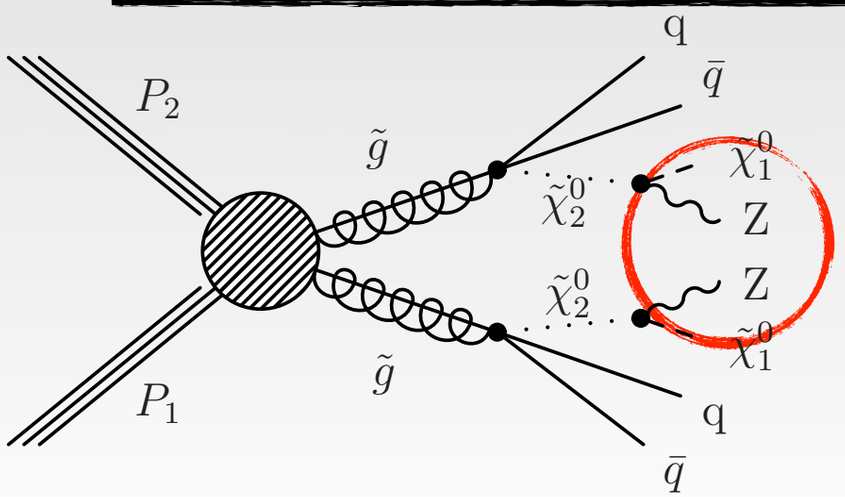


OS on Z (JZB)





CMS-SUS-11-021

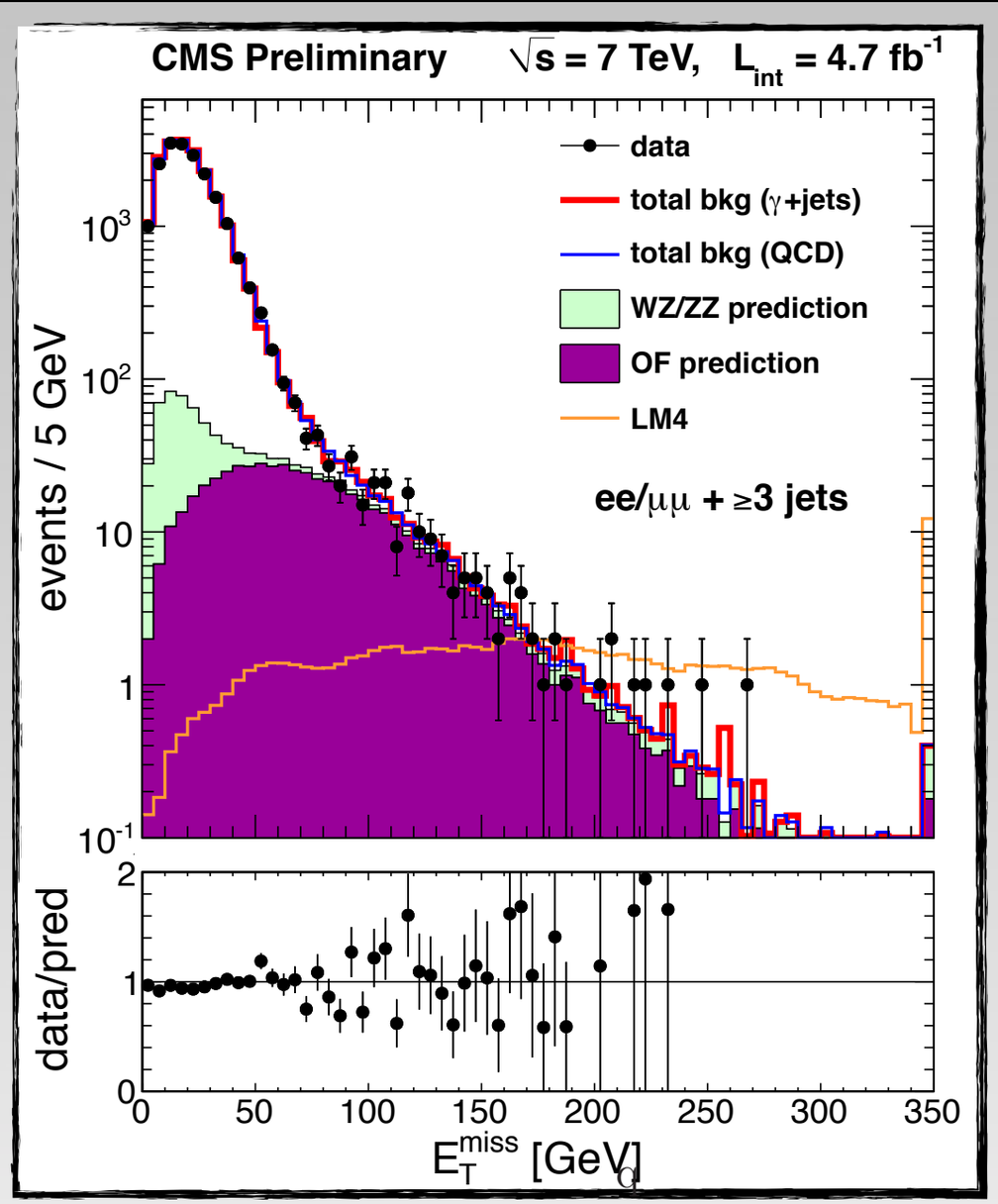


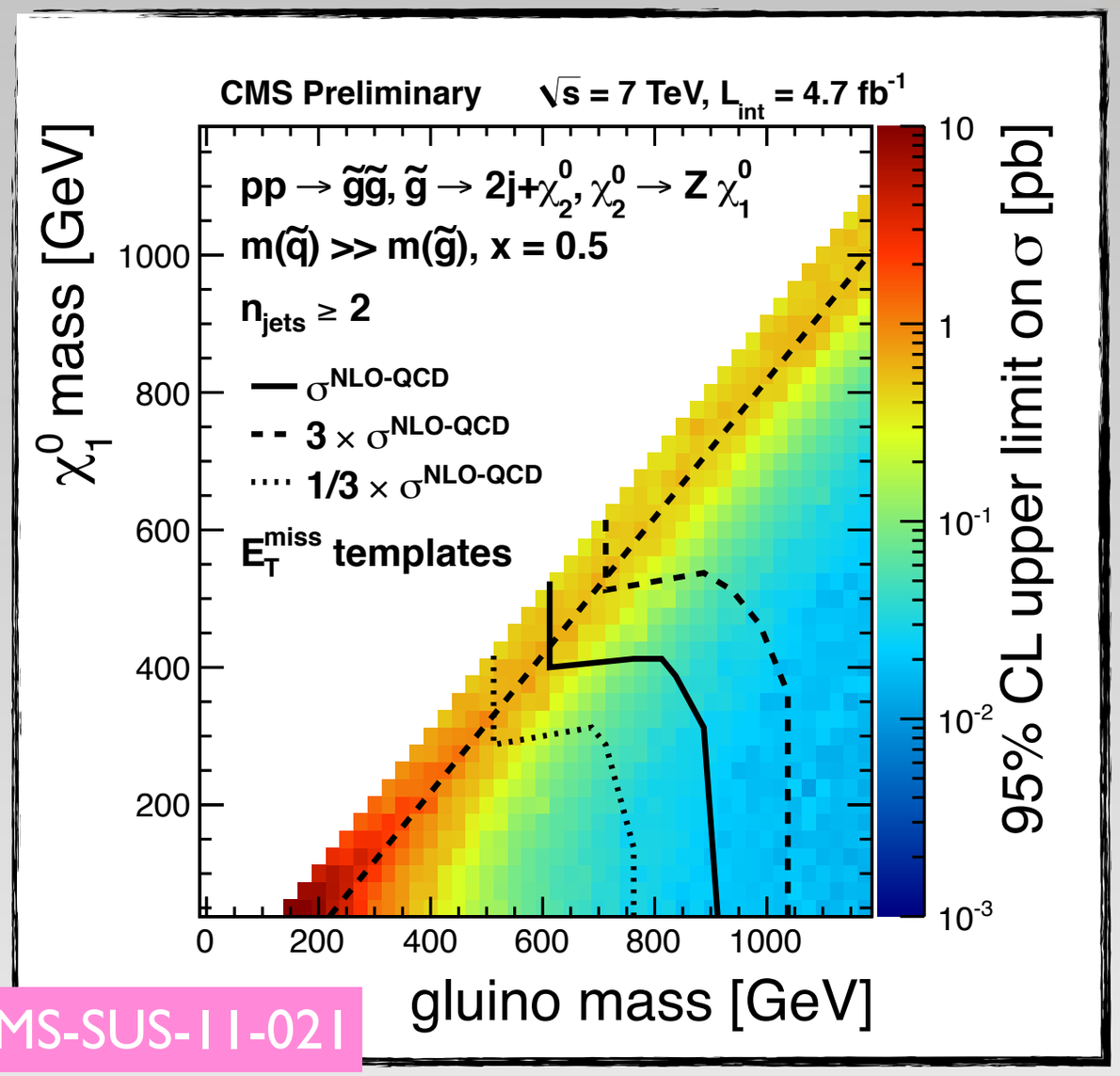
- Use Jet-Z-balance (JZB) to predict Z+jets tail

$$JZB = \left|\sum_{\text{jets}} p_T\right| - \left|\vec{p_T}^{(Z)}\right|$$

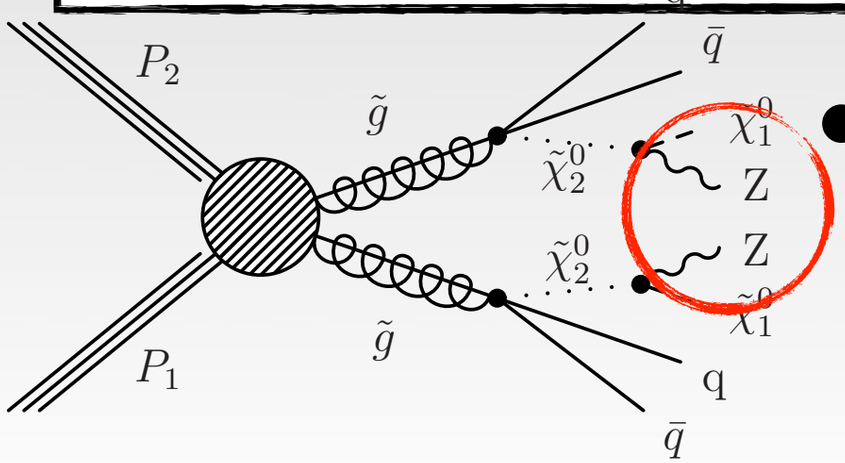
  - Flavour subtraction for dominant top background

OS on Z (MET spectrum)



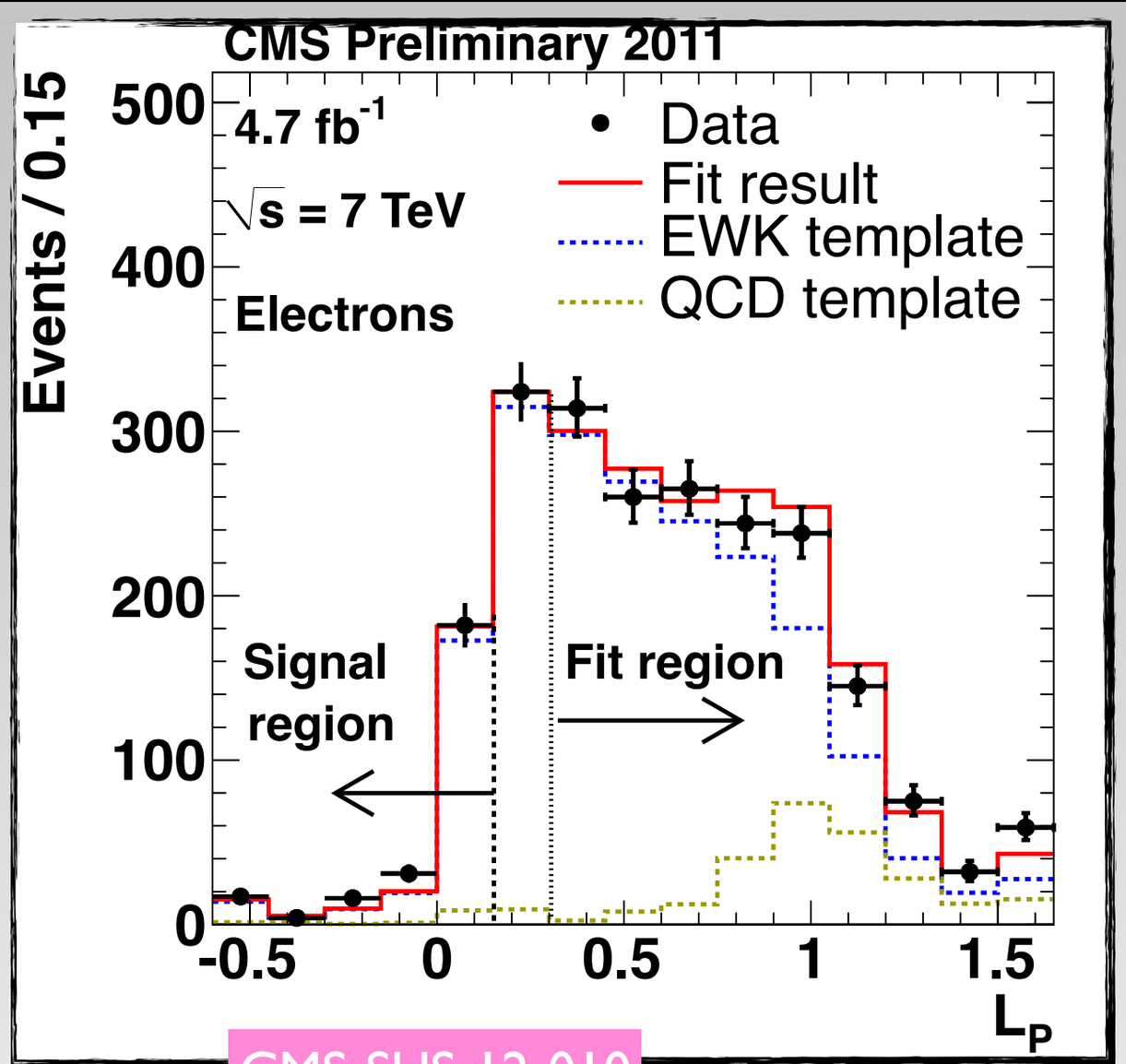


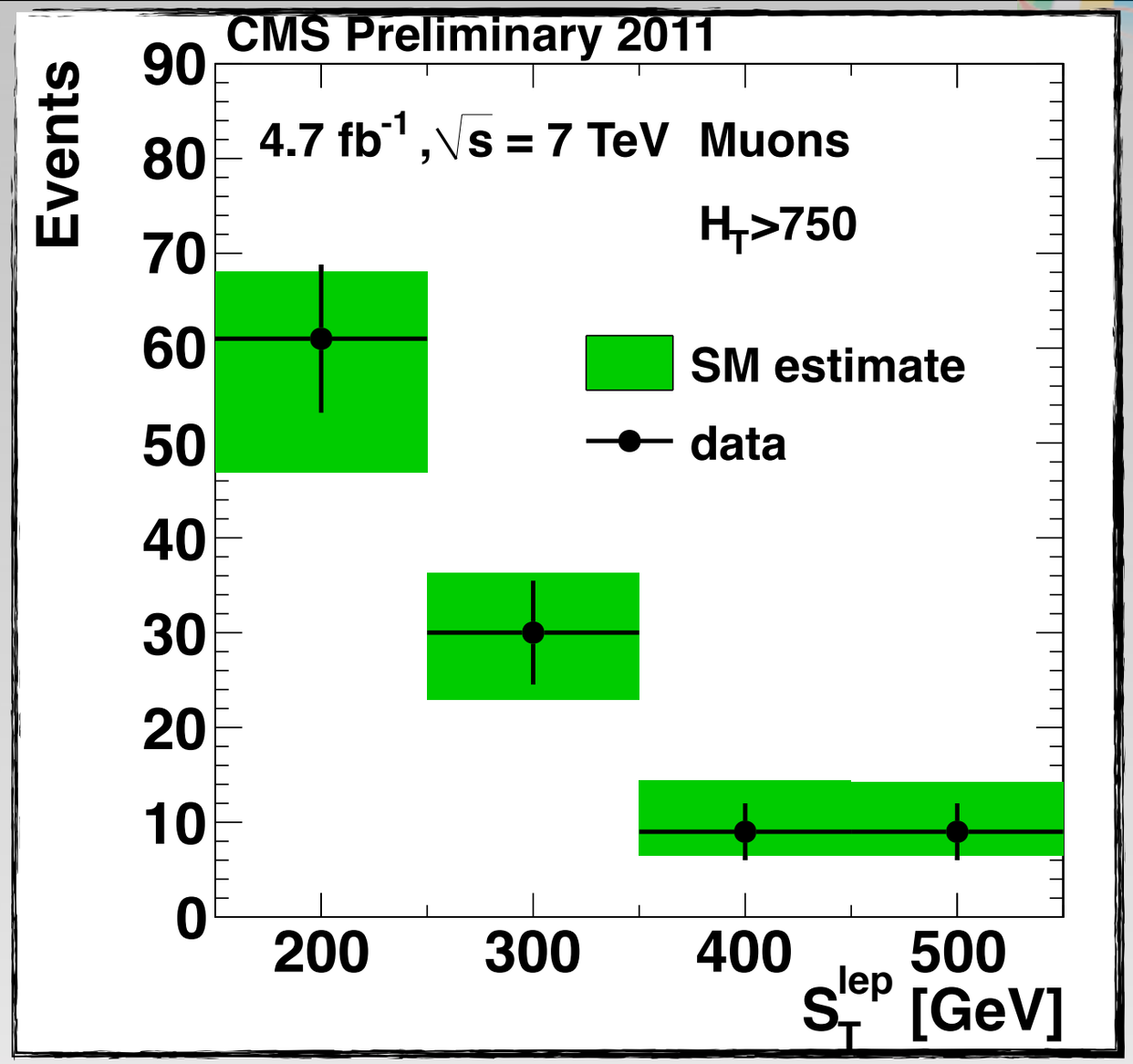
CMS-SUS-11-021



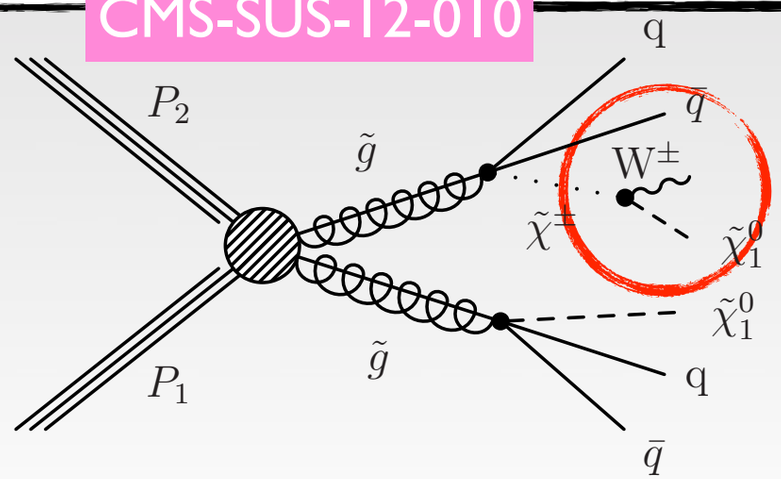
- MET templates derived from photon +jets data to model instrumental MET
  - Flavour subtraction for dominant top background

Single lepton (L_P)





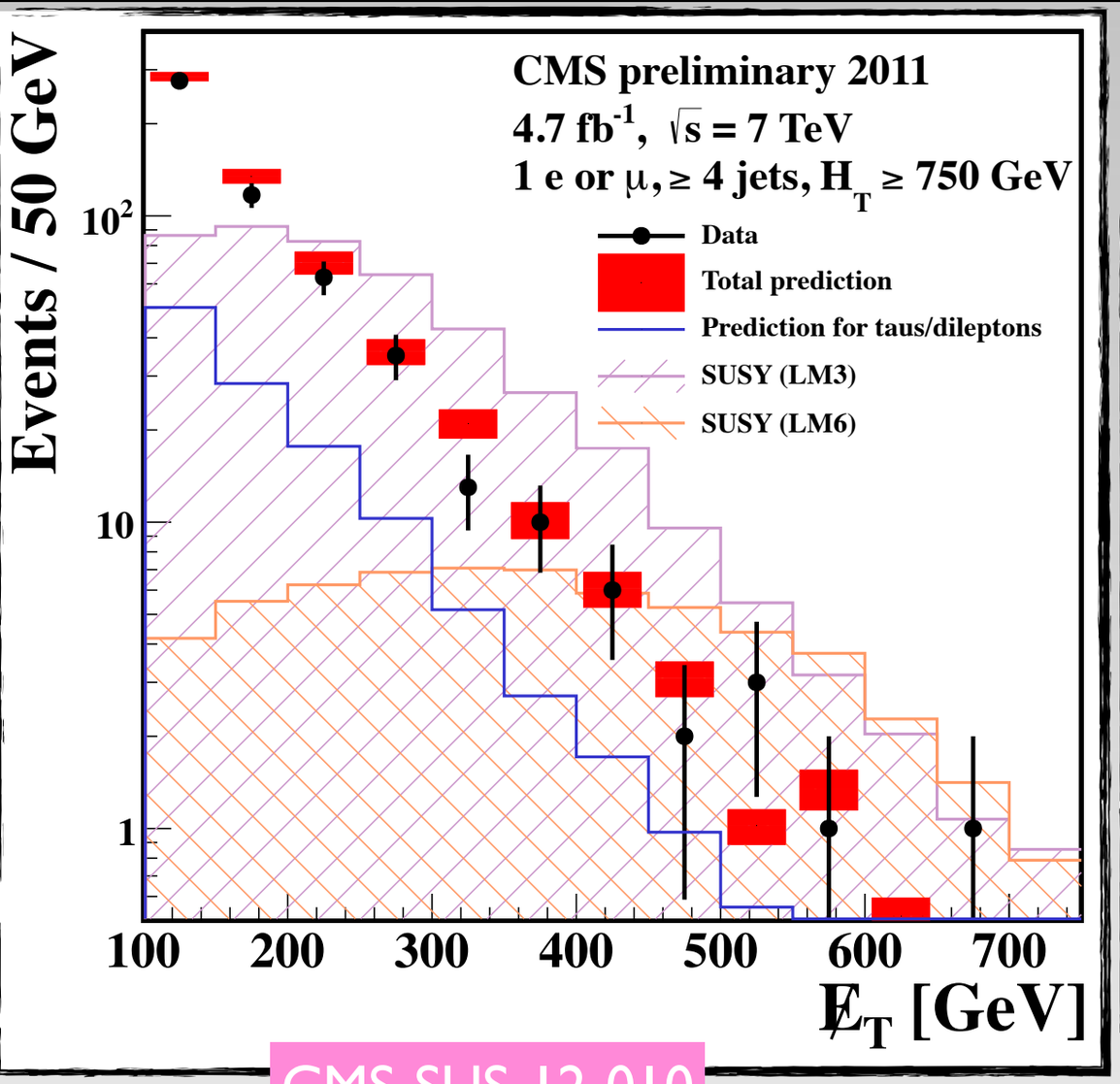
CMS-SUS-12-010

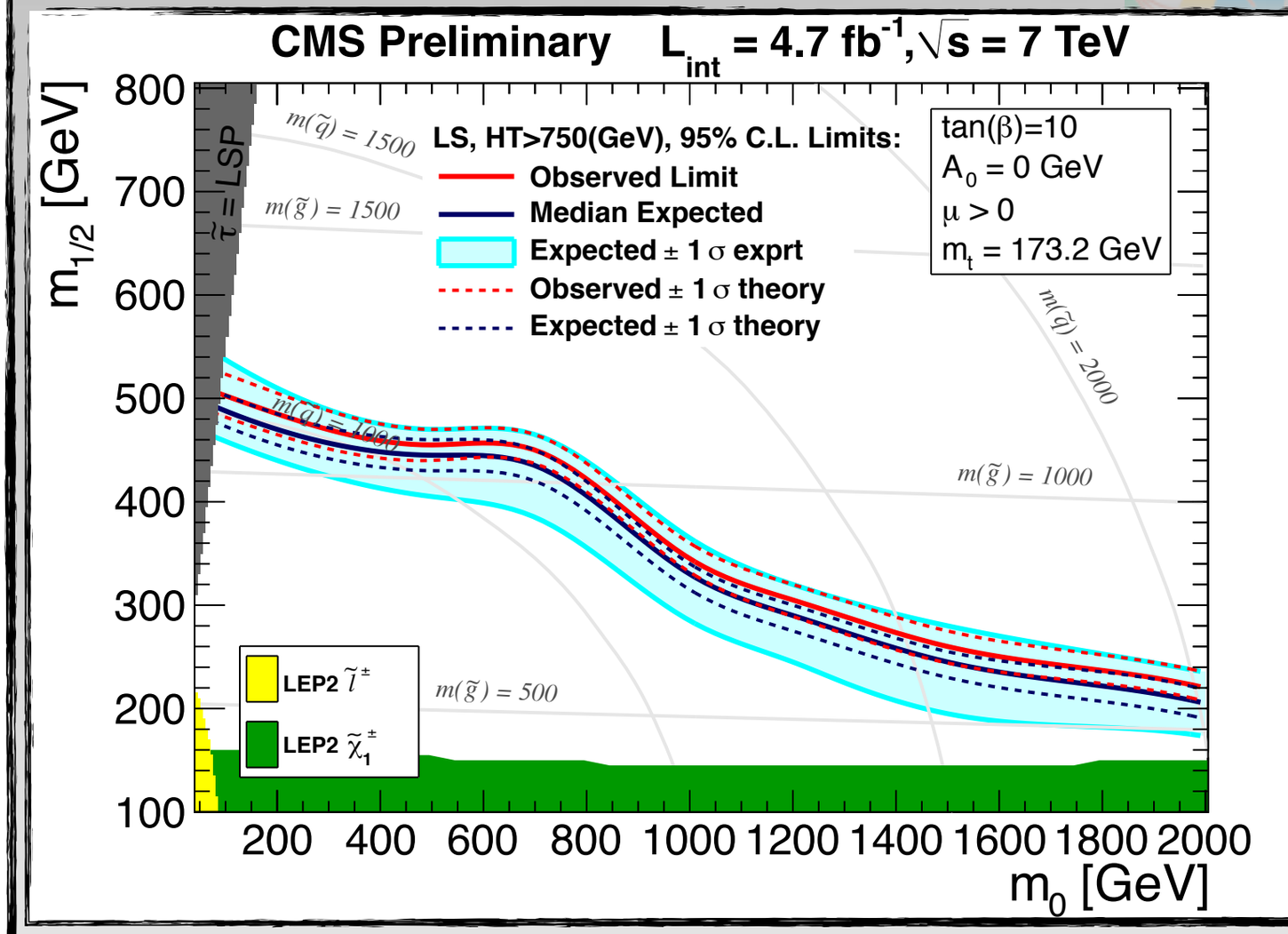


- S_T (l+MET) and Lp selection
- Background predicted by extrapolation in polarization

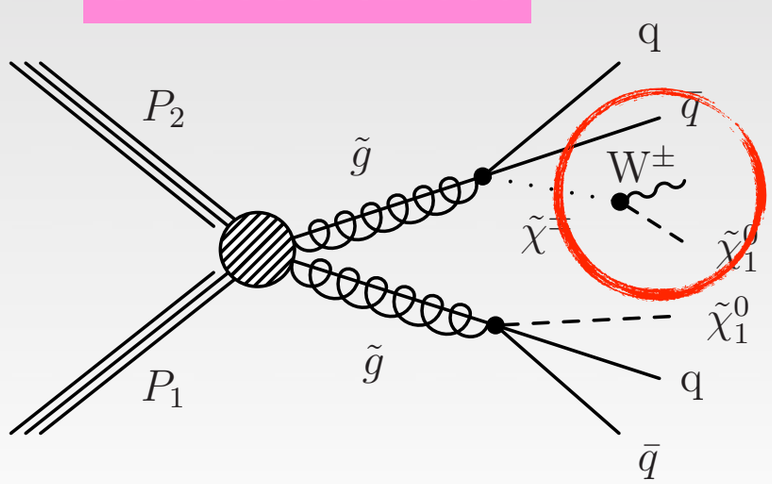
$$L_p = \frac{\vec{p}_T(\ell) \cdot \vec{p}_T(W)}{|\vec{p}_T(W)|^2}$$

Single lepton (MET spectrum)



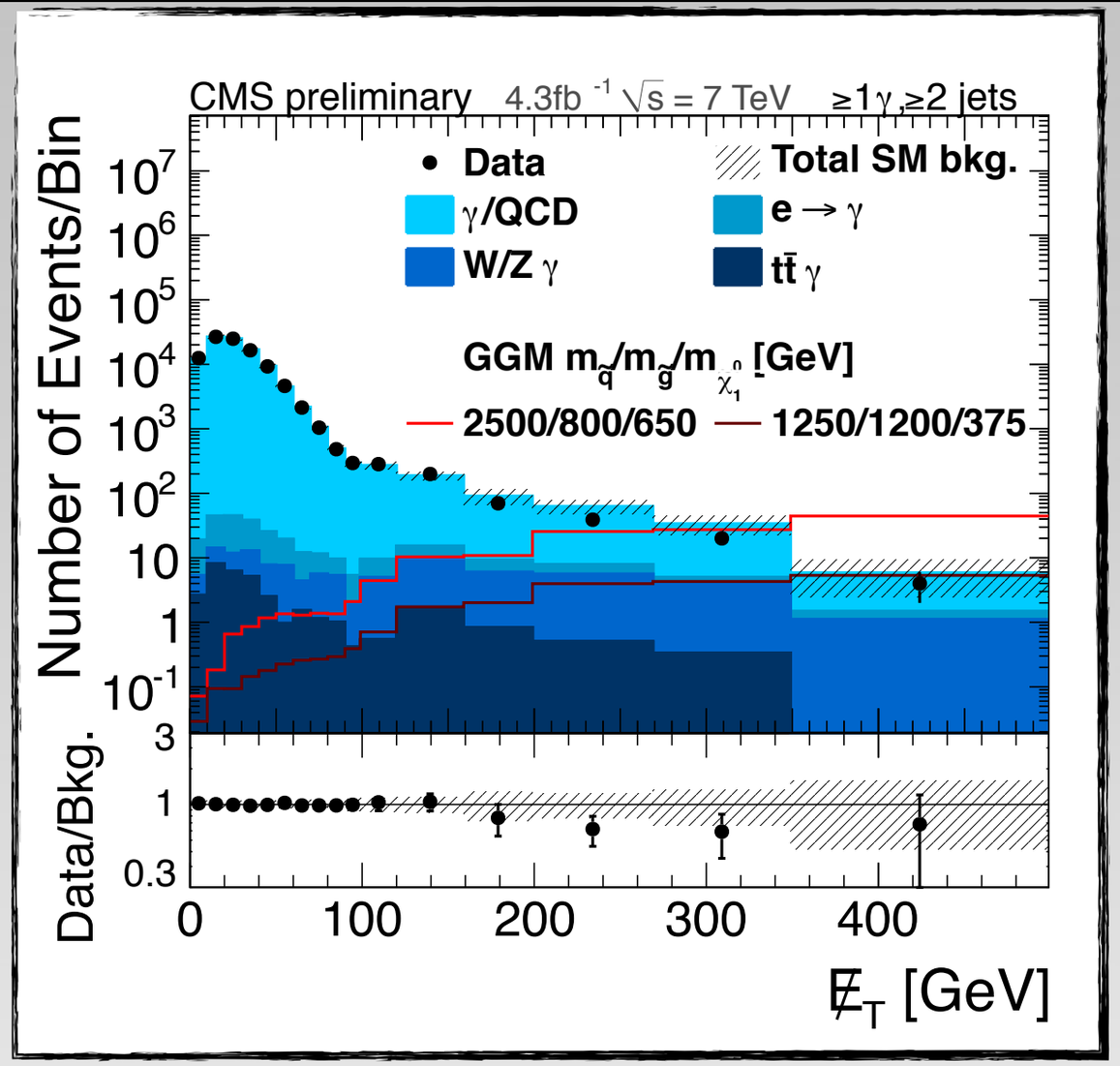


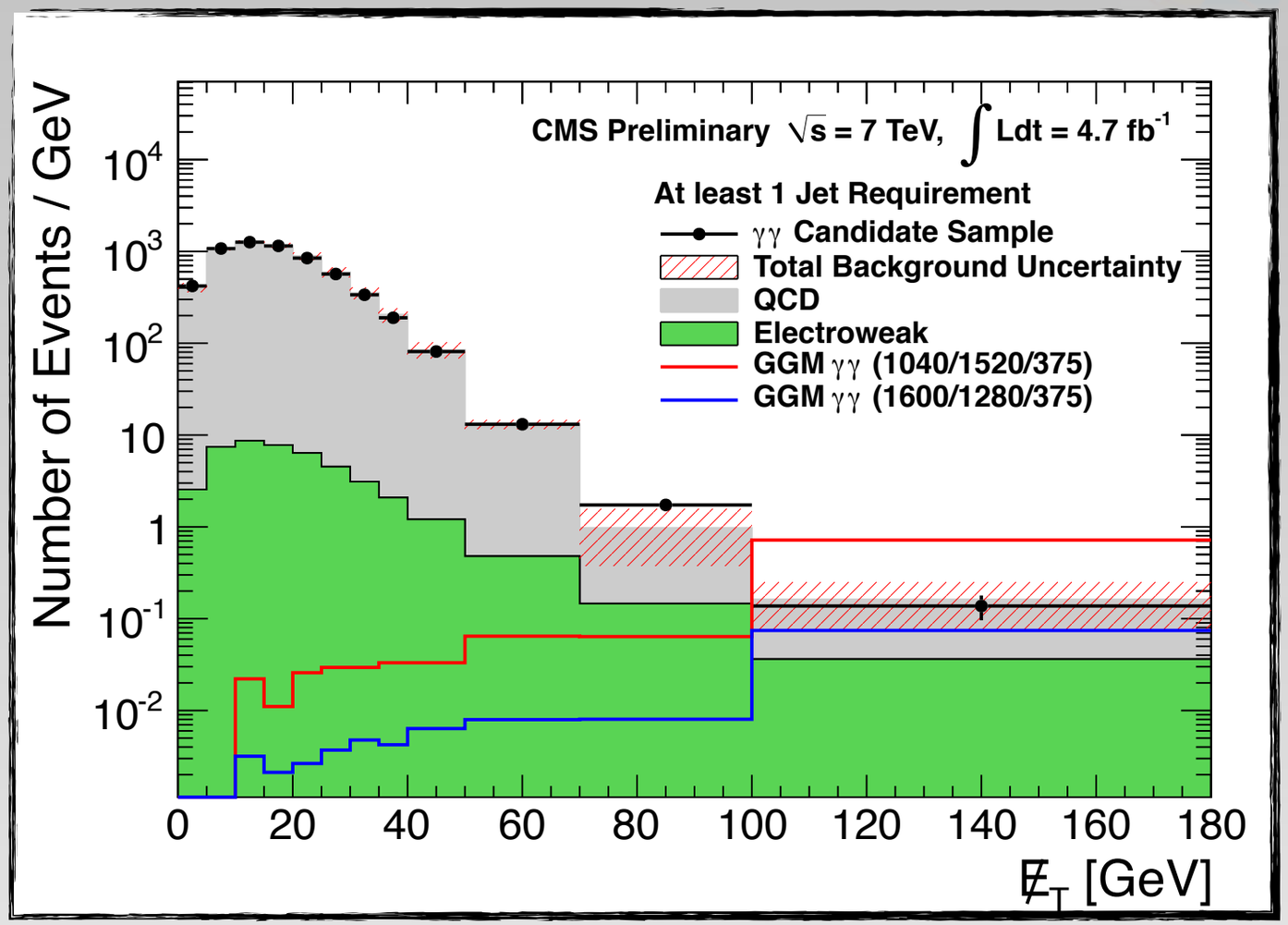
CMS-SUS-12-010



- H_T, MET selection
- MET distribution predicted using lepton p_T spectrum

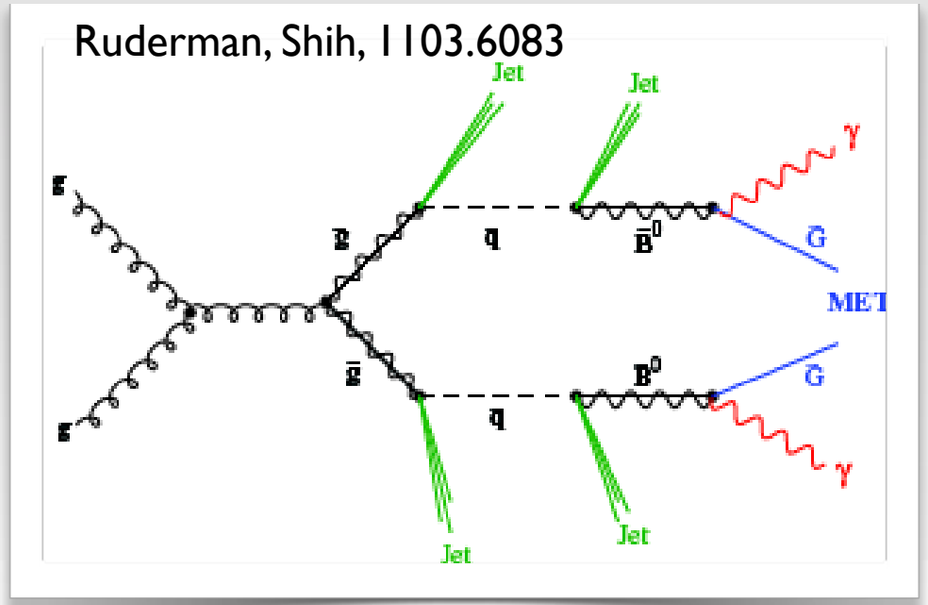
Photons



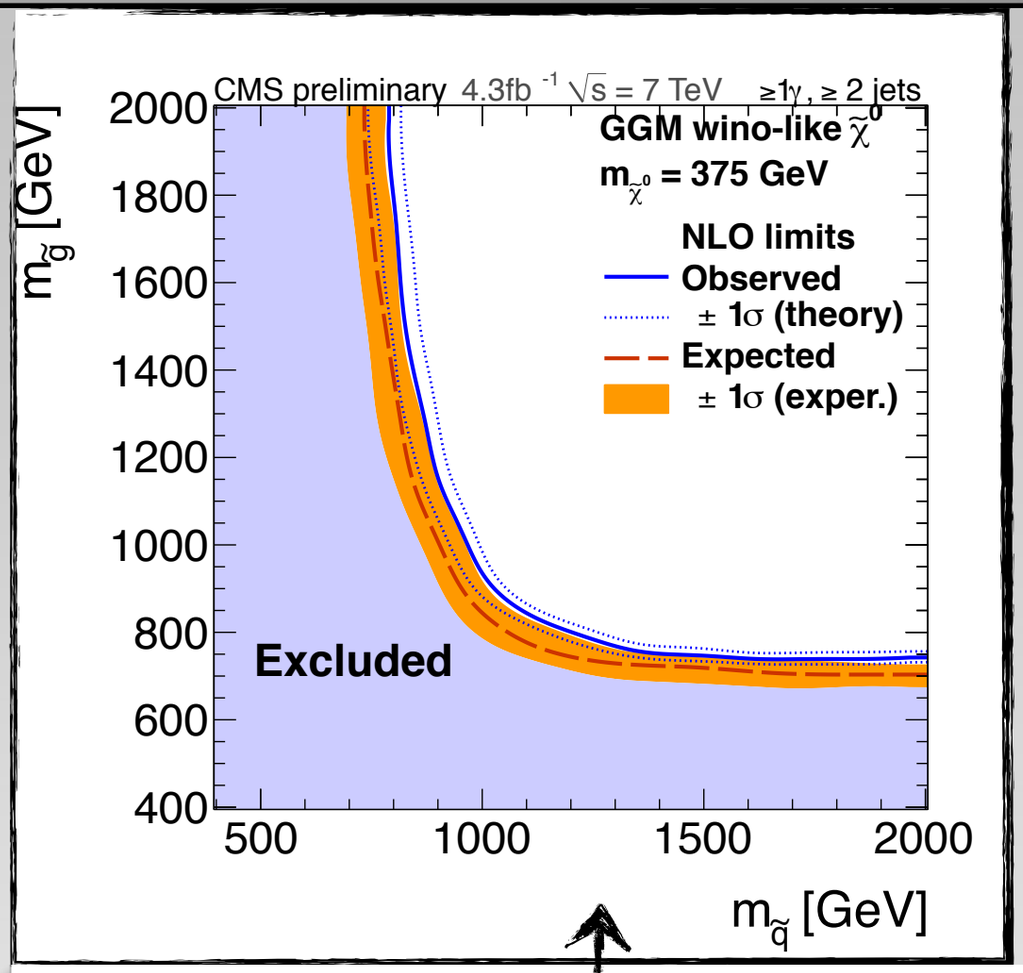


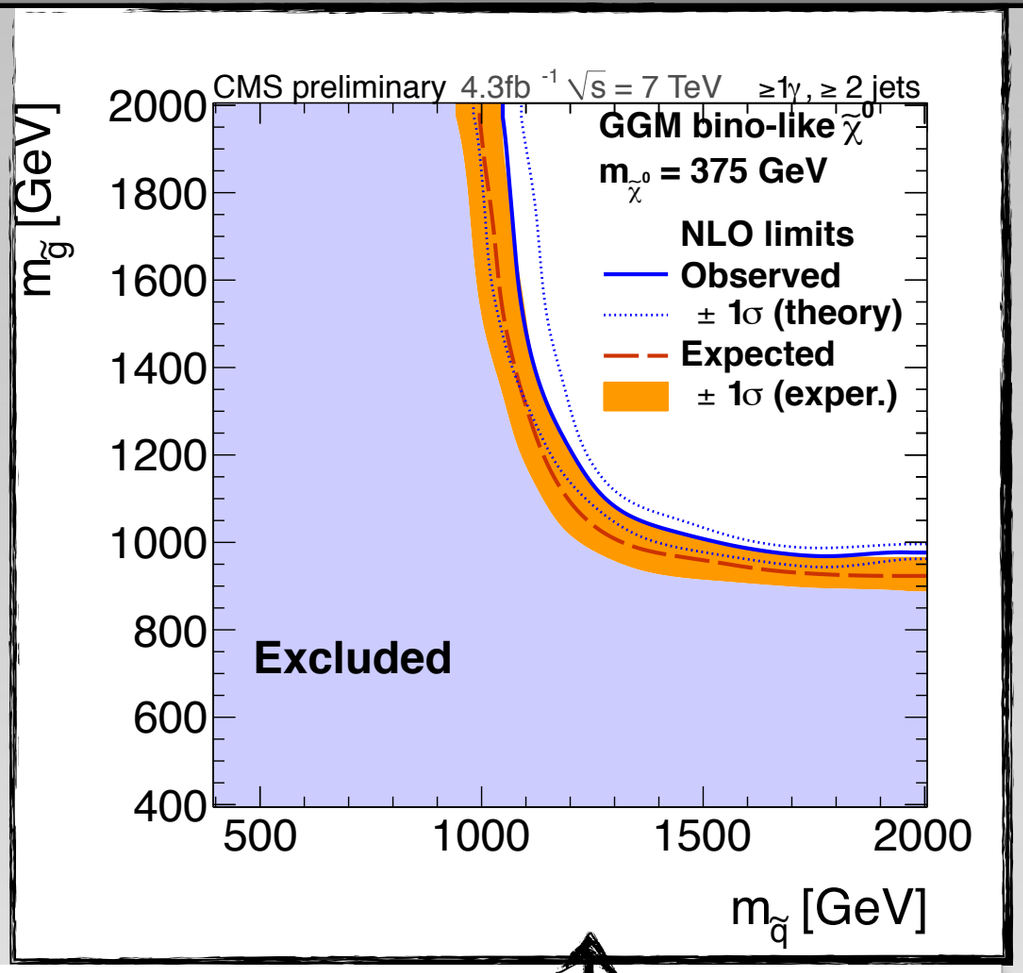
CMS-SUS-12-001

- H_T, MET selections
- Electron→γ (electron control), multijet control for jet→γ



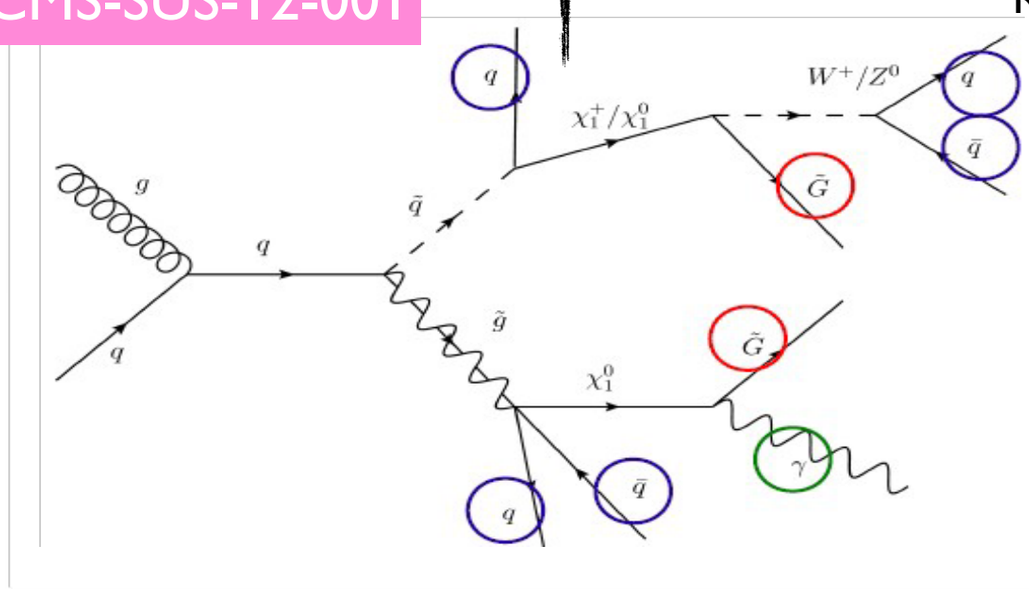
Photons

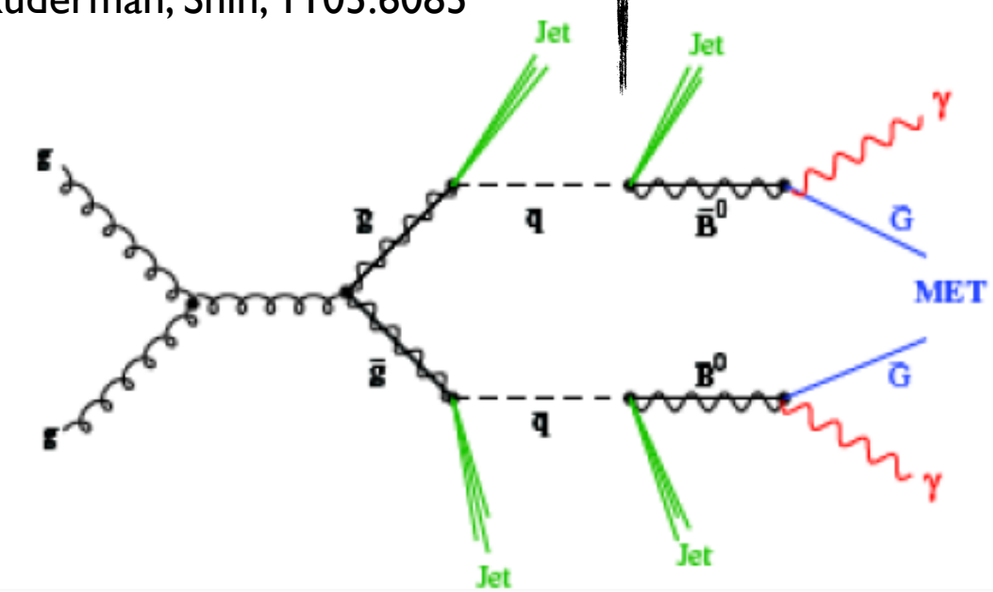




CMS-SUS-12-001

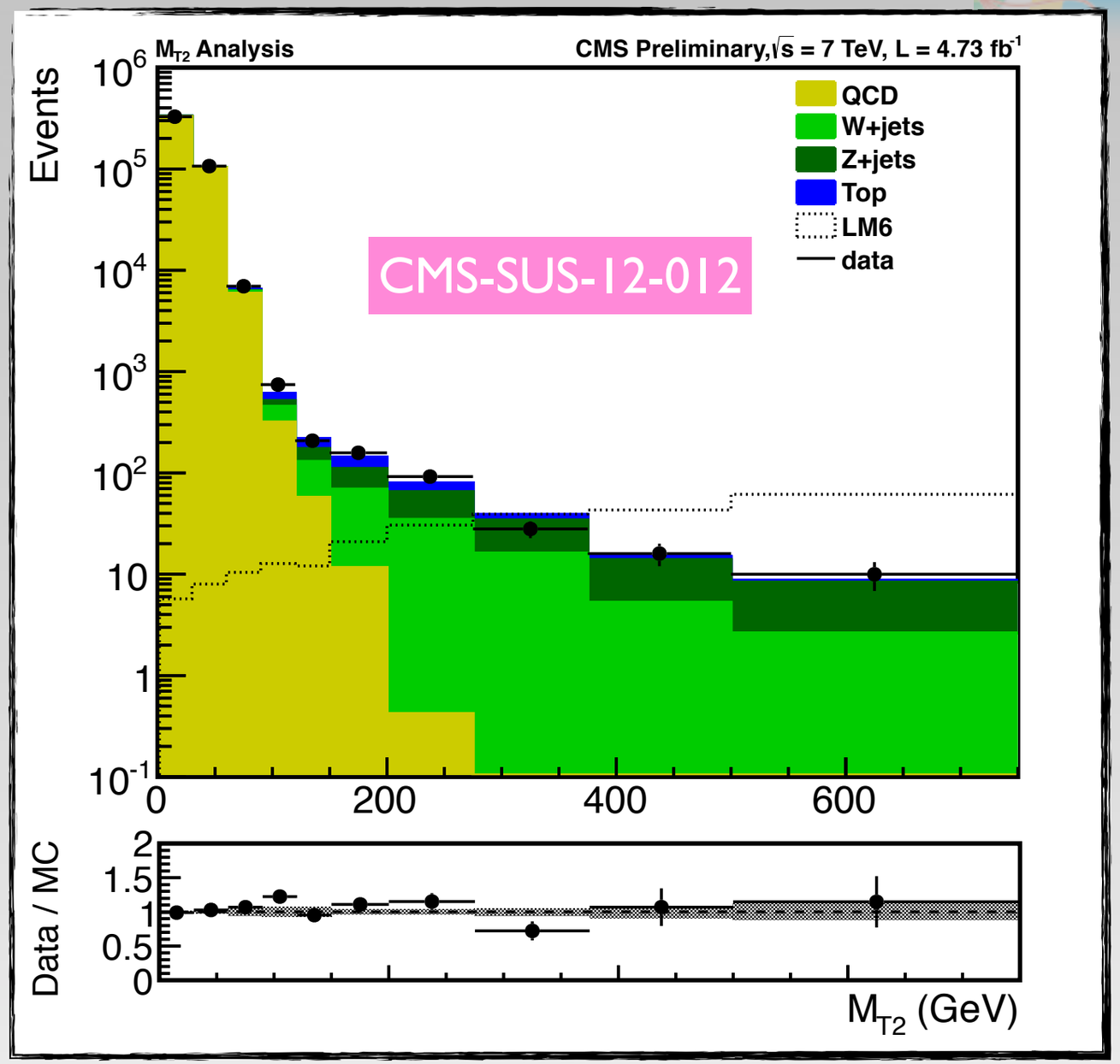
Ruderman, Shih, 1103.6083

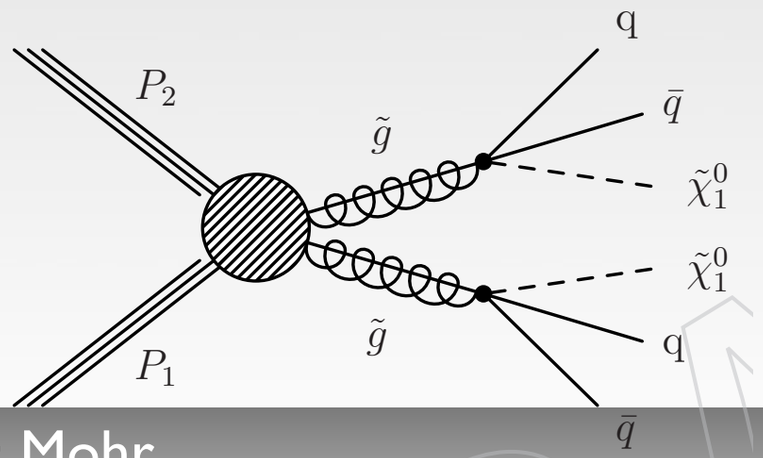




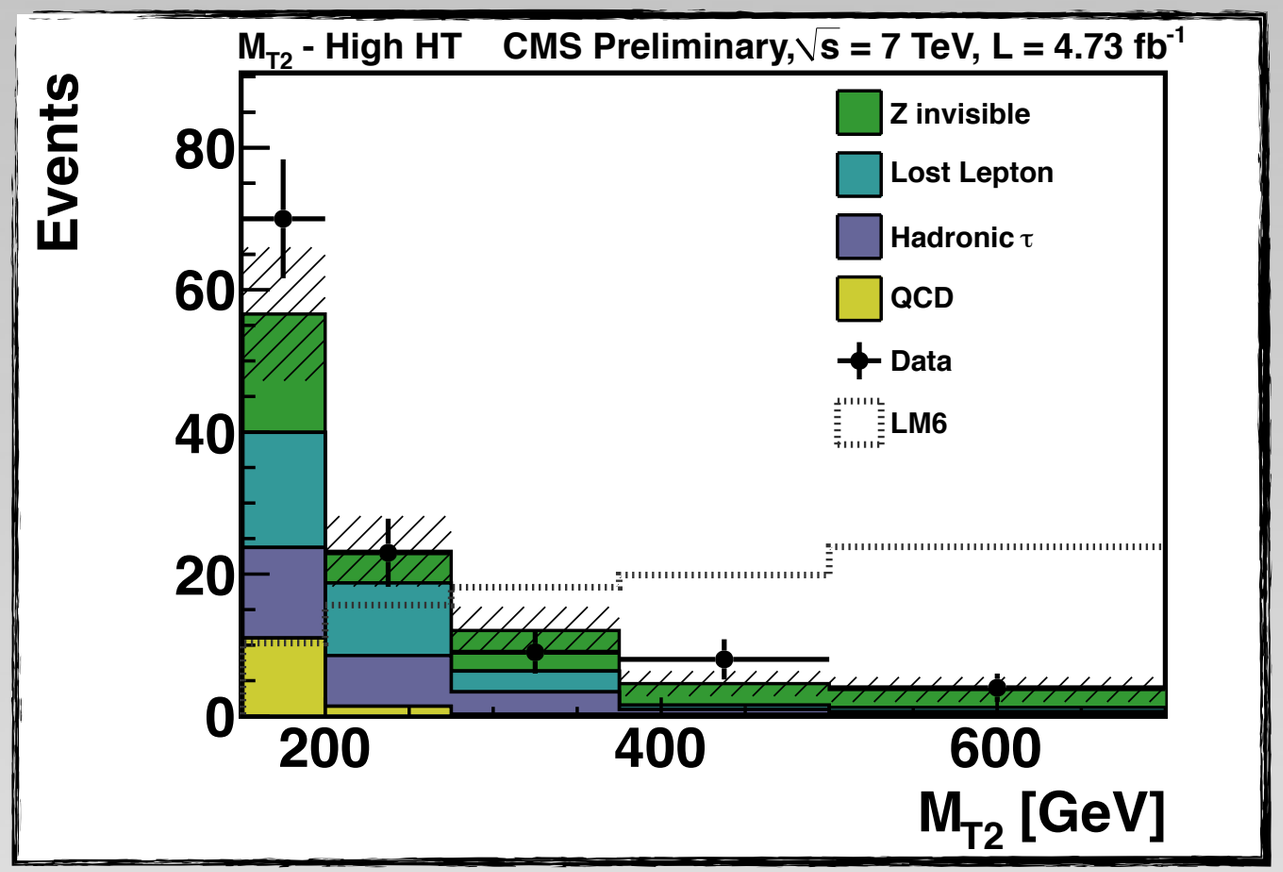
All hadronic M_{T2}

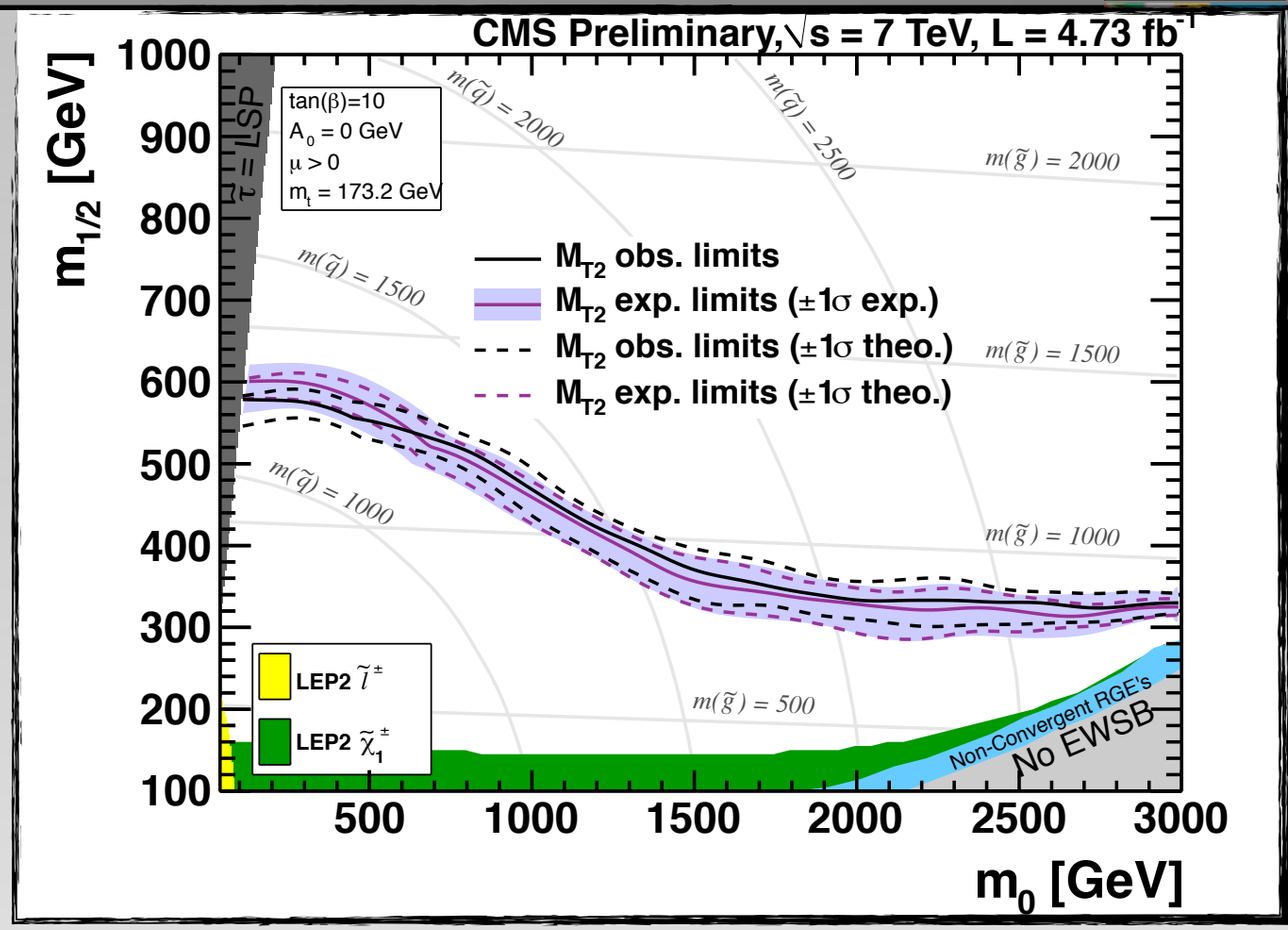
- All hadronic search based on M_{T2}
  - STransverse mass
  - Good QCD rejection
  - Sensitive to particle masses
- All backgrounds predicted individually from data
  - QCD (Factorization method)
  - W→μν (lost lepton method)
  - Z→νν (γ+jets/W→μν)





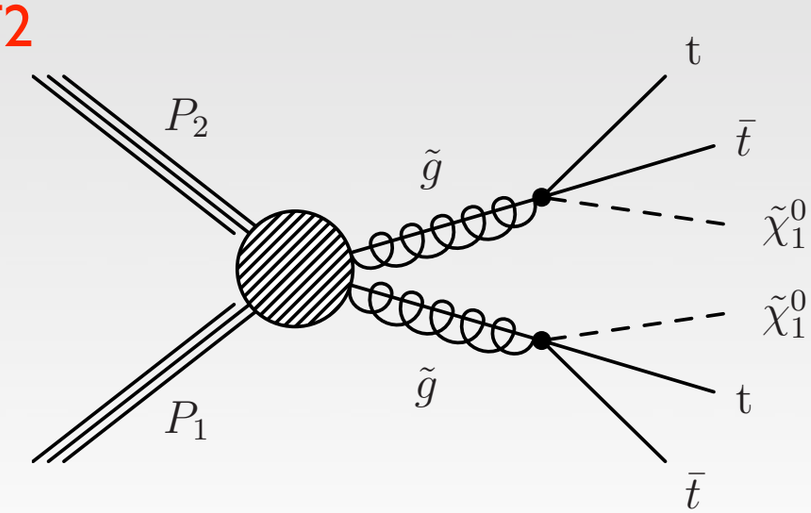
All hadronic M_{T2}



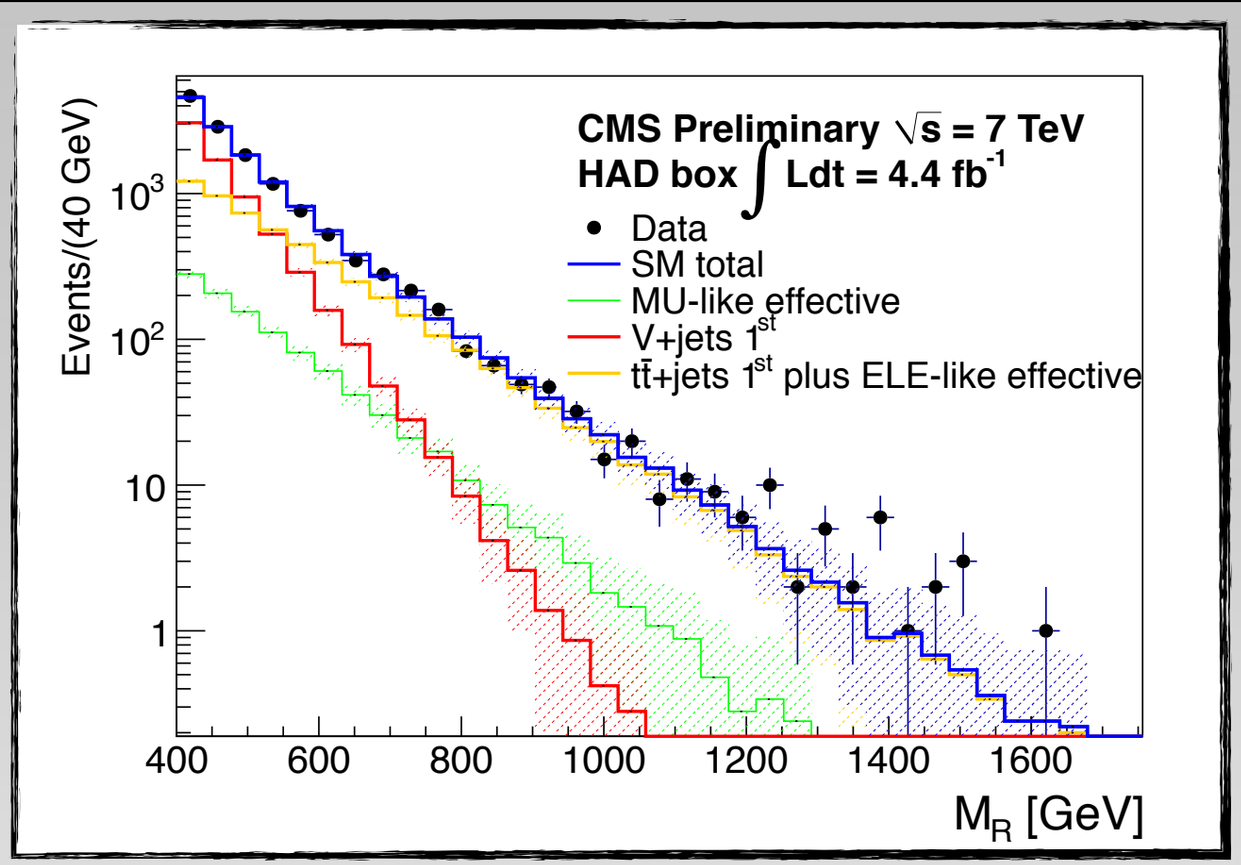


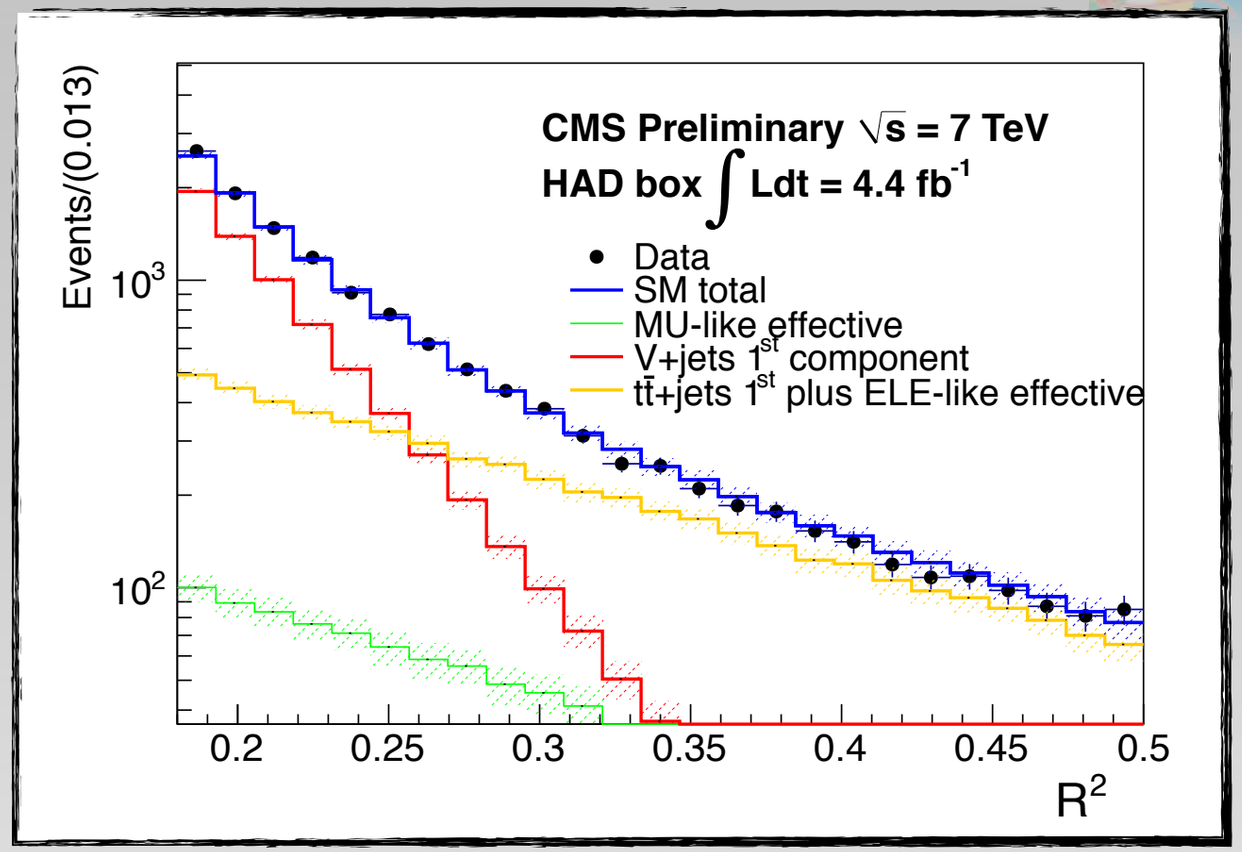
CMS-SUS-12-012

- Prediction in several bins of H_T, M_{T2}
- b-tagged part of the analysis
  - Sensitive to third generation signatures



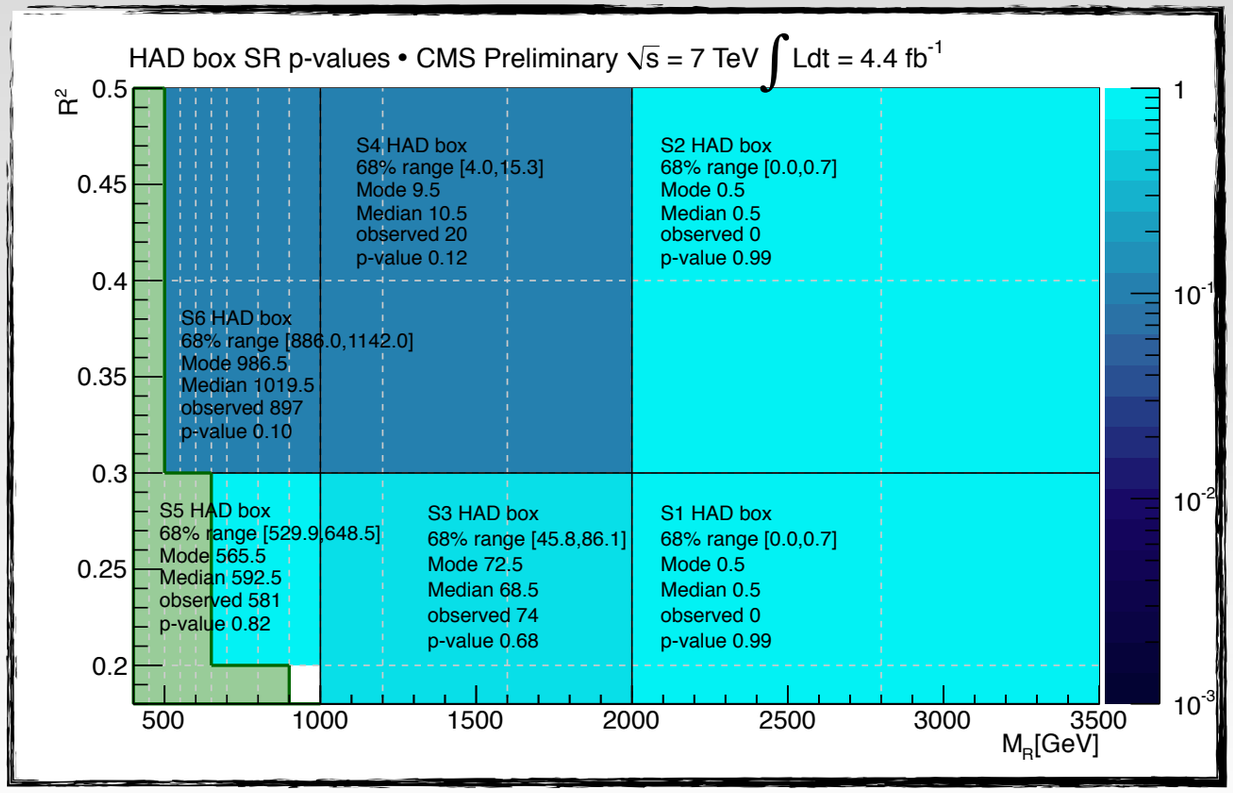
Razor (Inclusive)



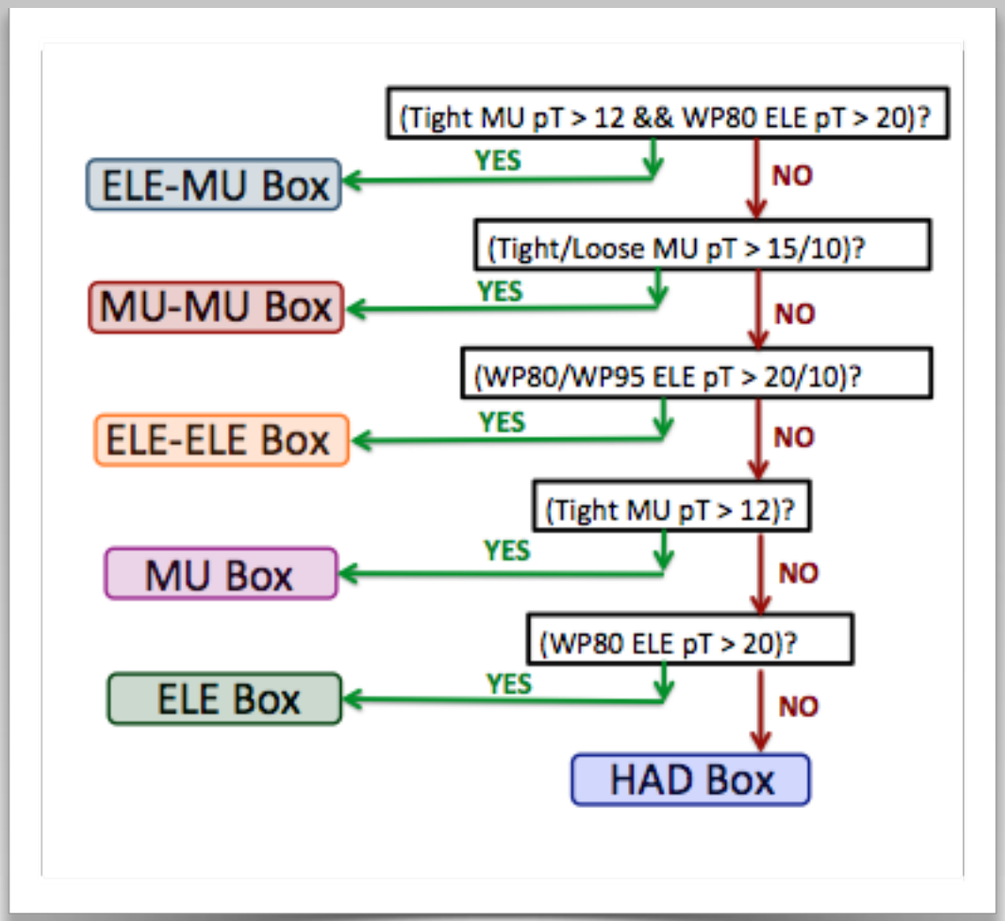


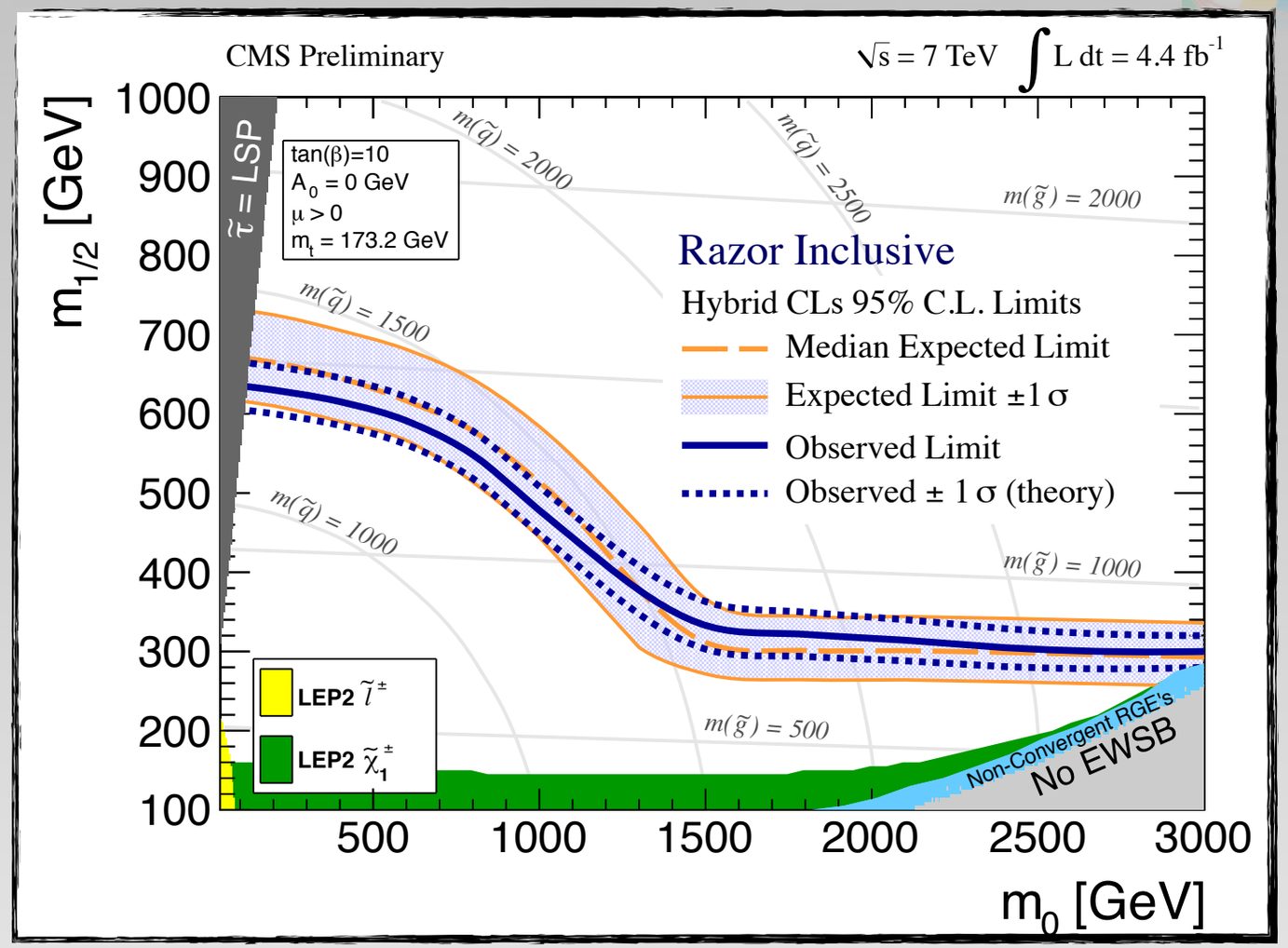
CMS-SUS-12-005

- M_R, R^2 (RAZOR)
  - Sensitive to scale, QCD rejection
- Backgrounds predicted via 2-D multi-component fit



Razor (Inclusive)



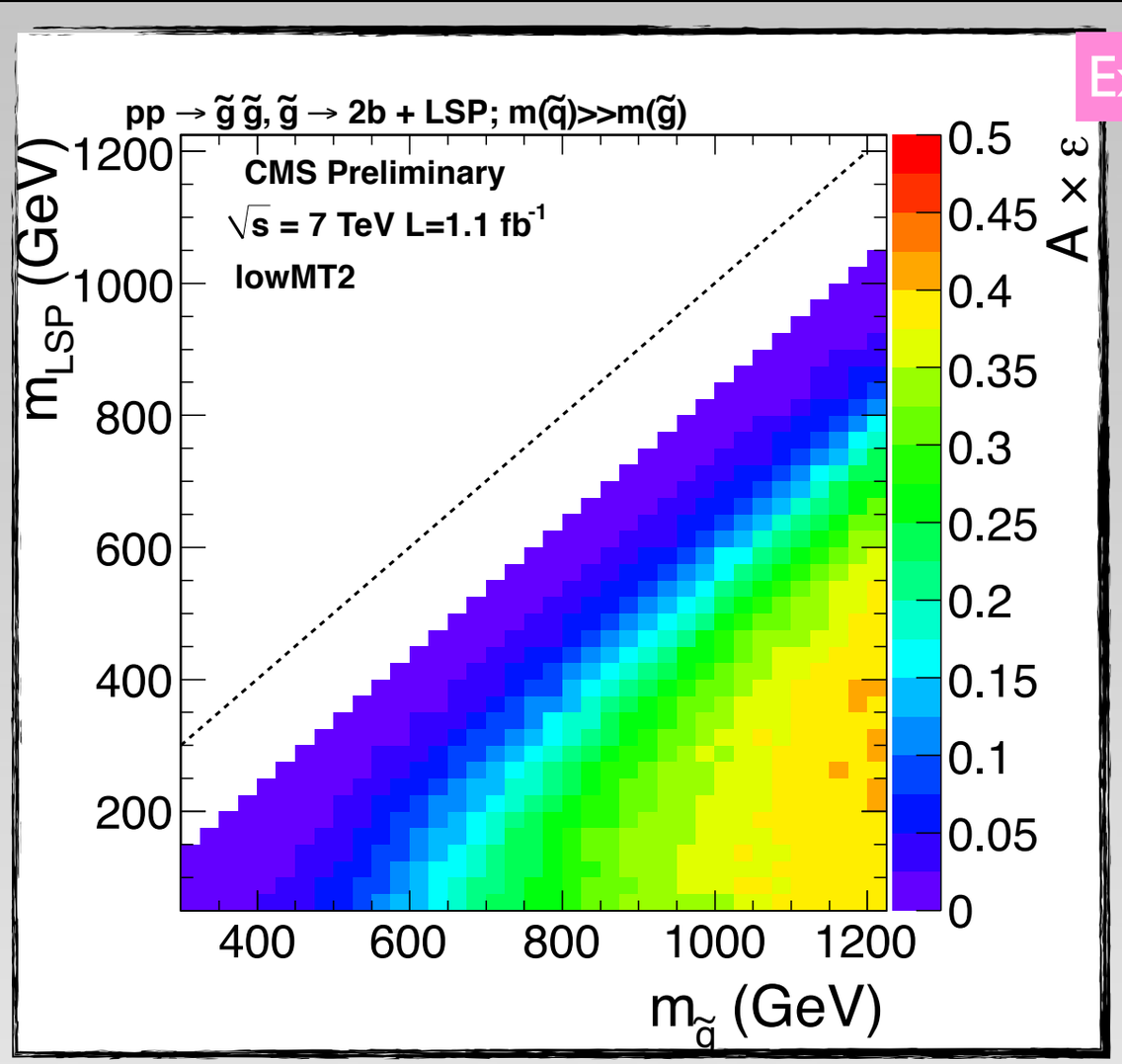


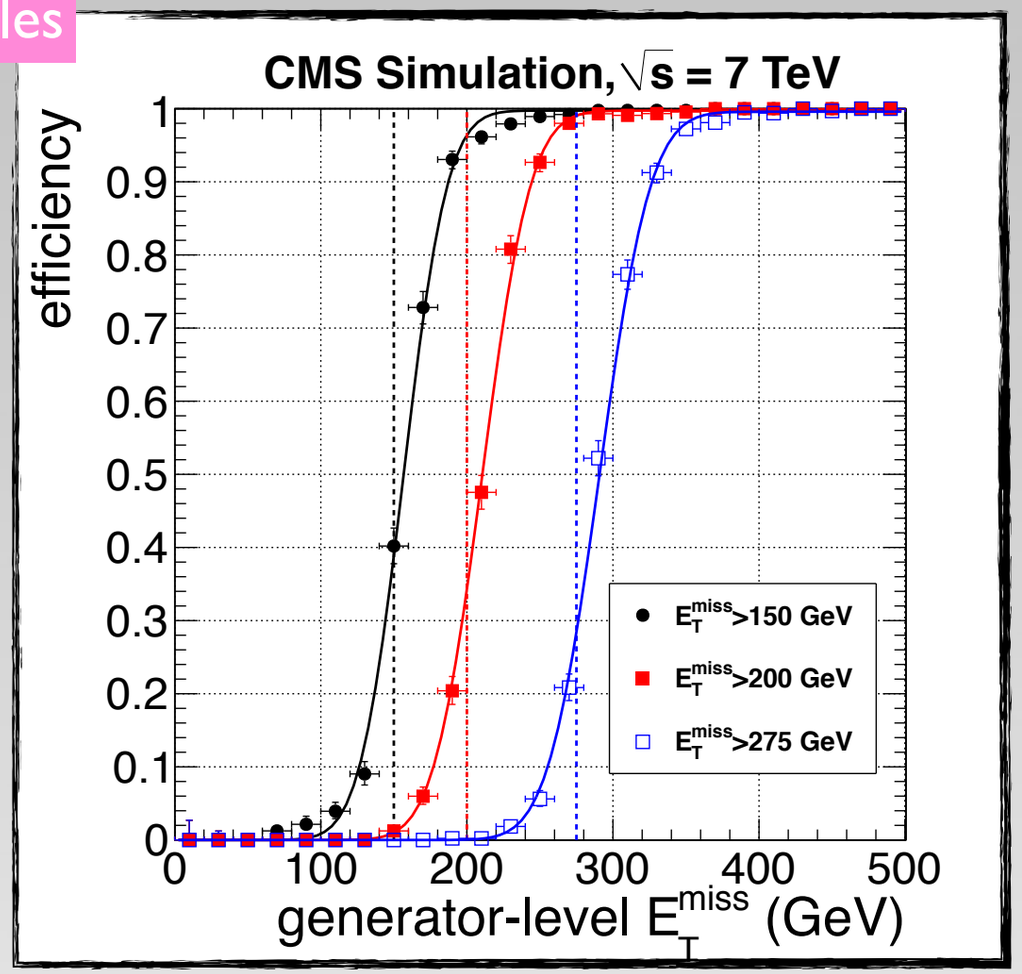
CMS-SUS-12-005

- Inclusion of leptonic boxes using same method for background prediction
- Unbinned likelihood used to derive the limit

Outreach

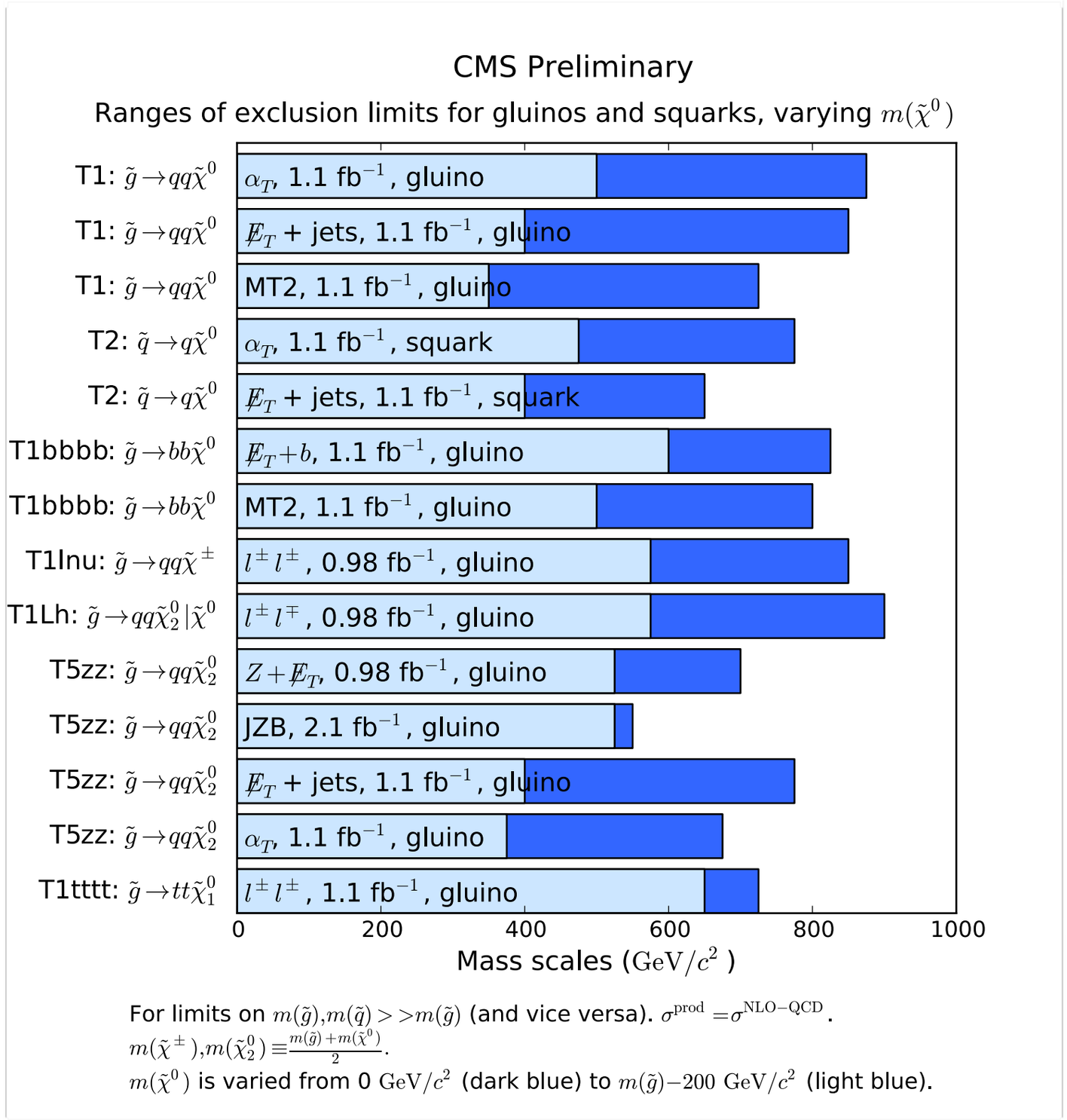
Examples

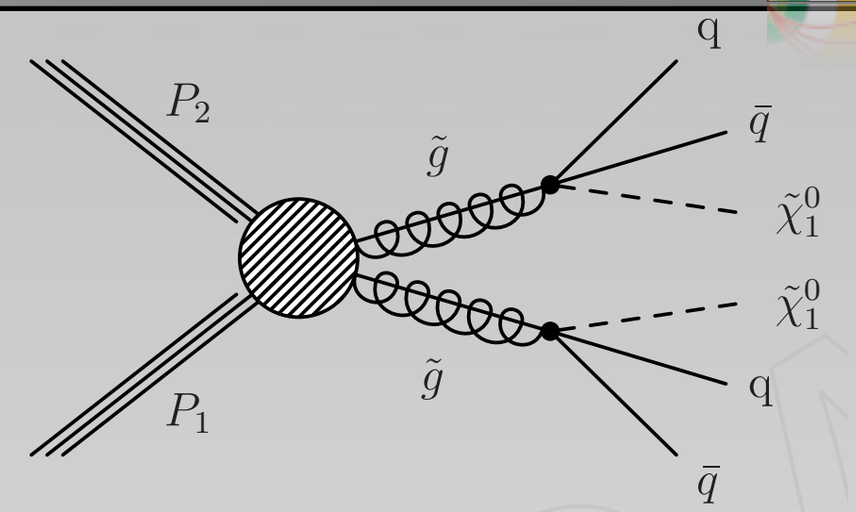




- As all analyses yielded null results
  - Exclusion are performed in limited set of models
- Allow comparison to other theories
  - Publish acceptance and efficiencies

Compressed spectra





- Exclusion at the TeV range for squarks and gluinos
  - Only for $m_{LSP} \ll m_{\tilde{g}}$
- Room for SUSY with compressed spectra
  - Extending searches to address compressed spectra

Conclusion

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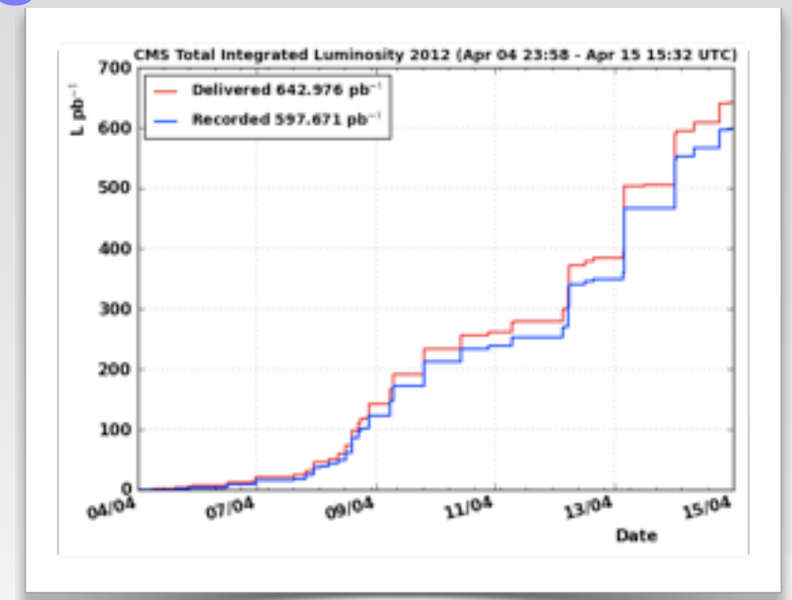

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- Empty box: No excess found
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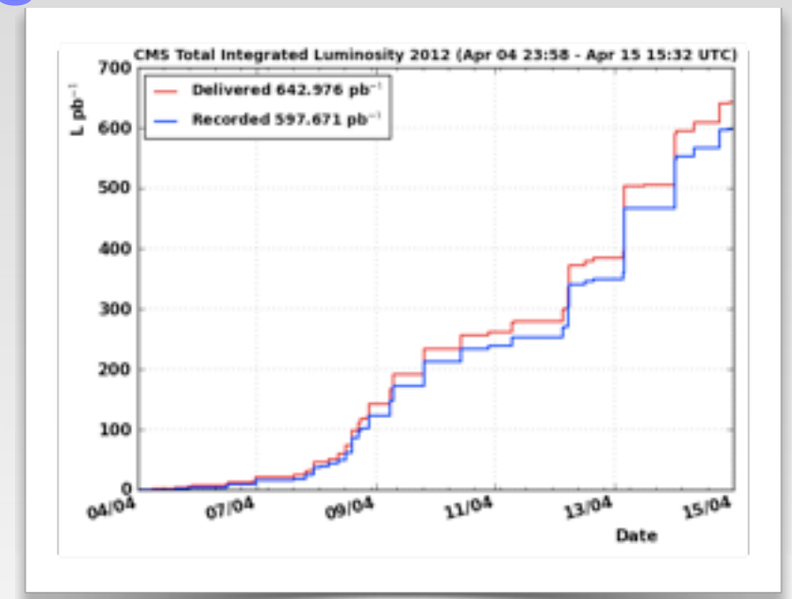
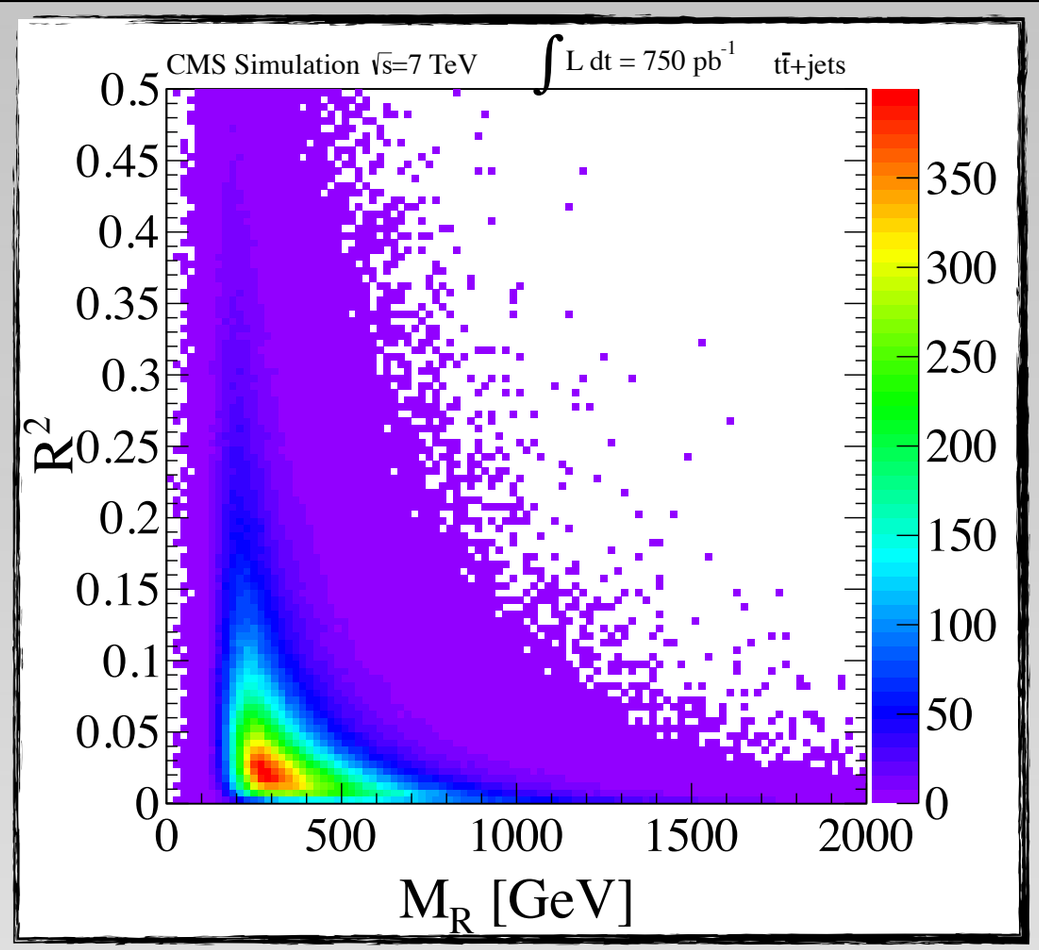
- Looking forward to 8 TeV LHC data
- Many more details and interesting SUSY results

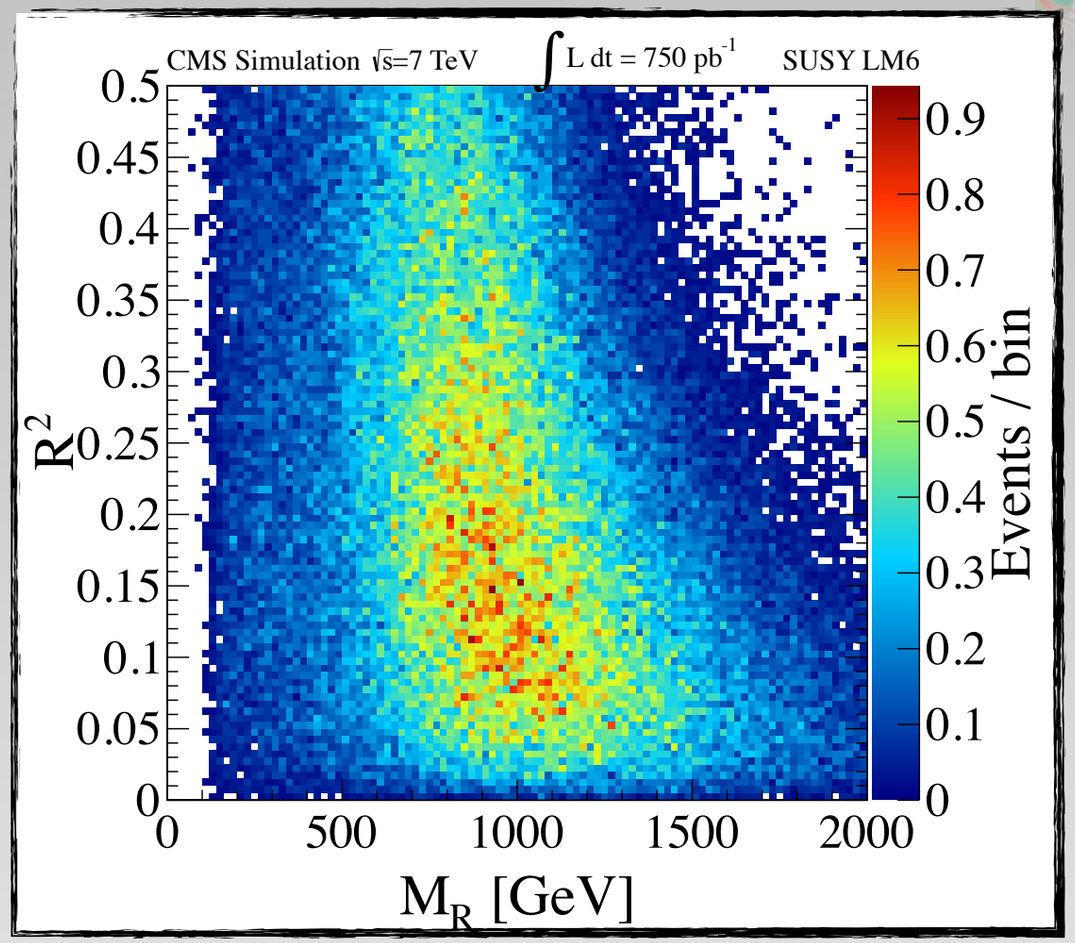
https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsSUS



Backup

Razor variables





$$M_R = \sqrt{(|\vec{p}_{j_1}| + |\vec{p}_{j_2}|)^2 - (p_z^{j_1} + p_z^{j_2})^2}$$

$$M_T^R = \sqrt{\frac{E_T^{miss}(p_T^{j_1} + p_T^{j_2}) - \vec{E}_T^{miss} \cdot (\vec{p}_T^{j_1} + \vec{p}_T^{j_2})}{2}}$$

$$R = \frac{M_T^R}{M_R}$$

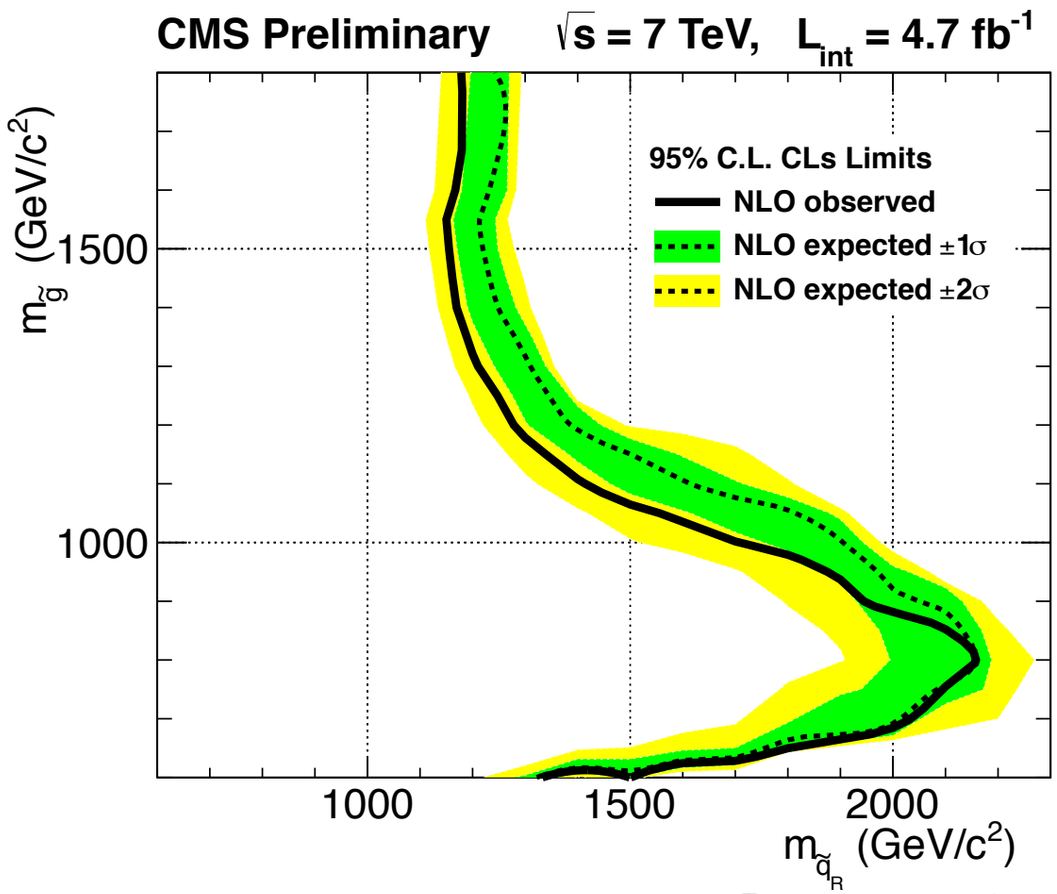
Ratio of two estimators of SUSY scale – describes transverse shape of event

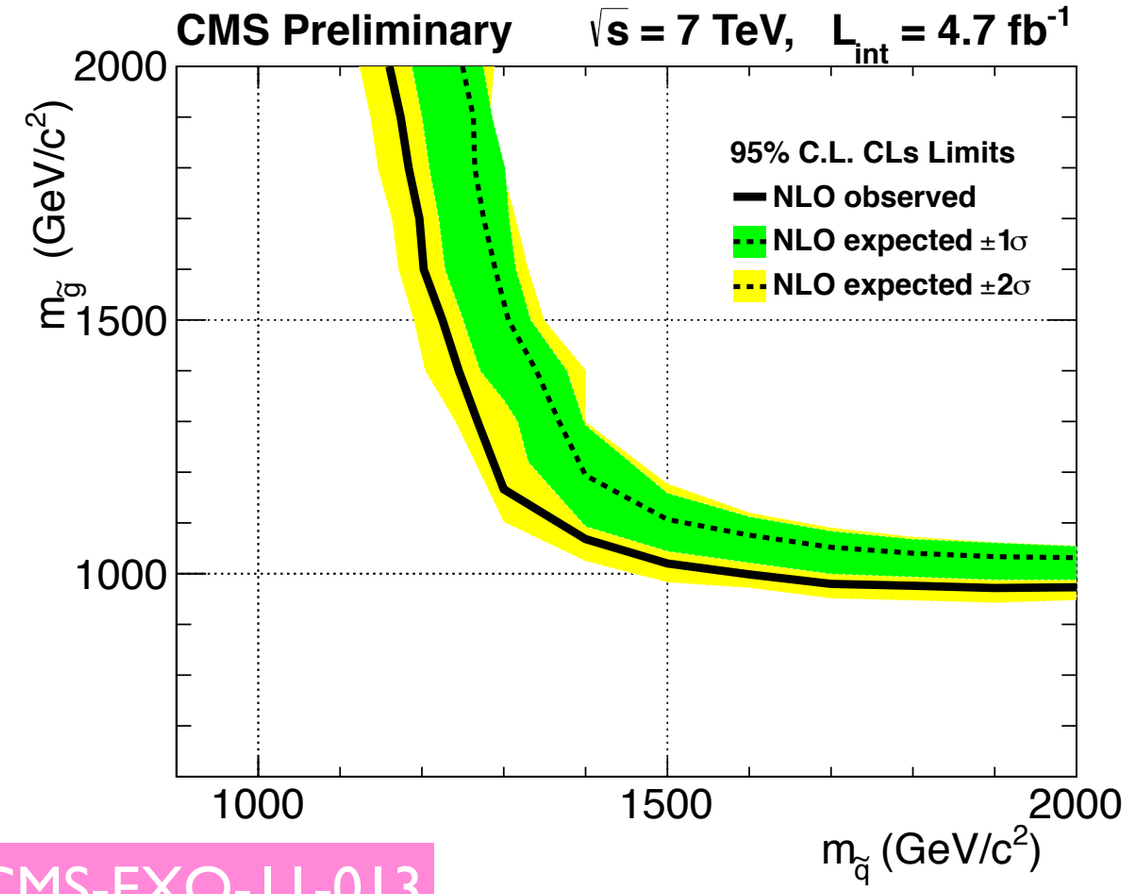
Peaks at

$$M_\Delta = \frac{M_S^2 - M_{\mathrm{LSP}}^2}{M_S}$$

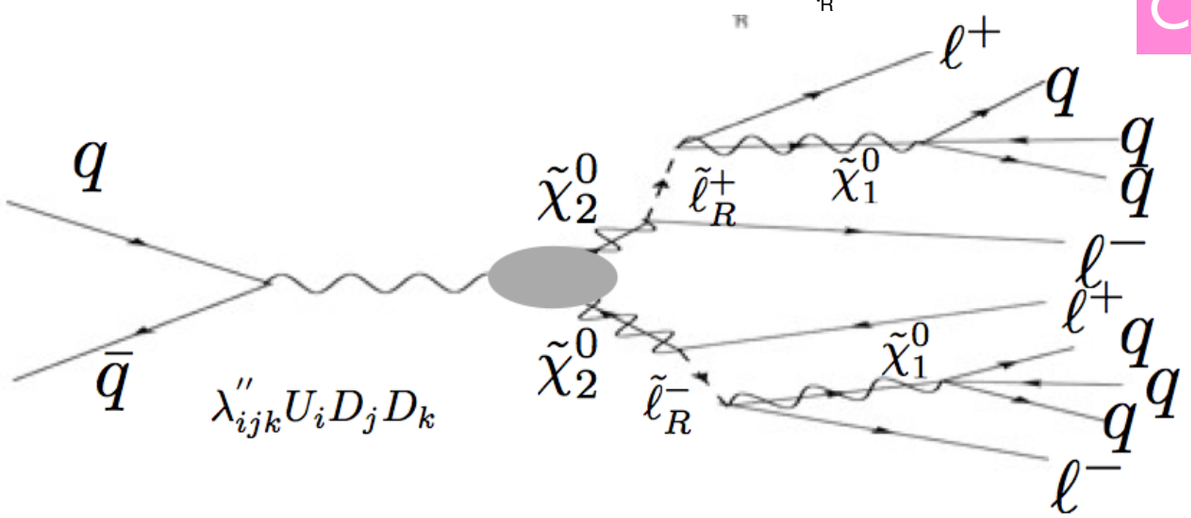
Edge at M_Δ

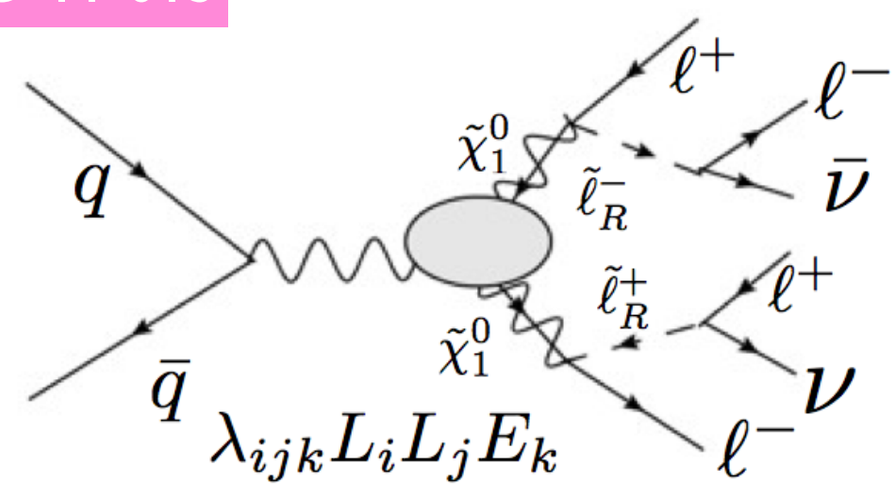
Multilepton RPV



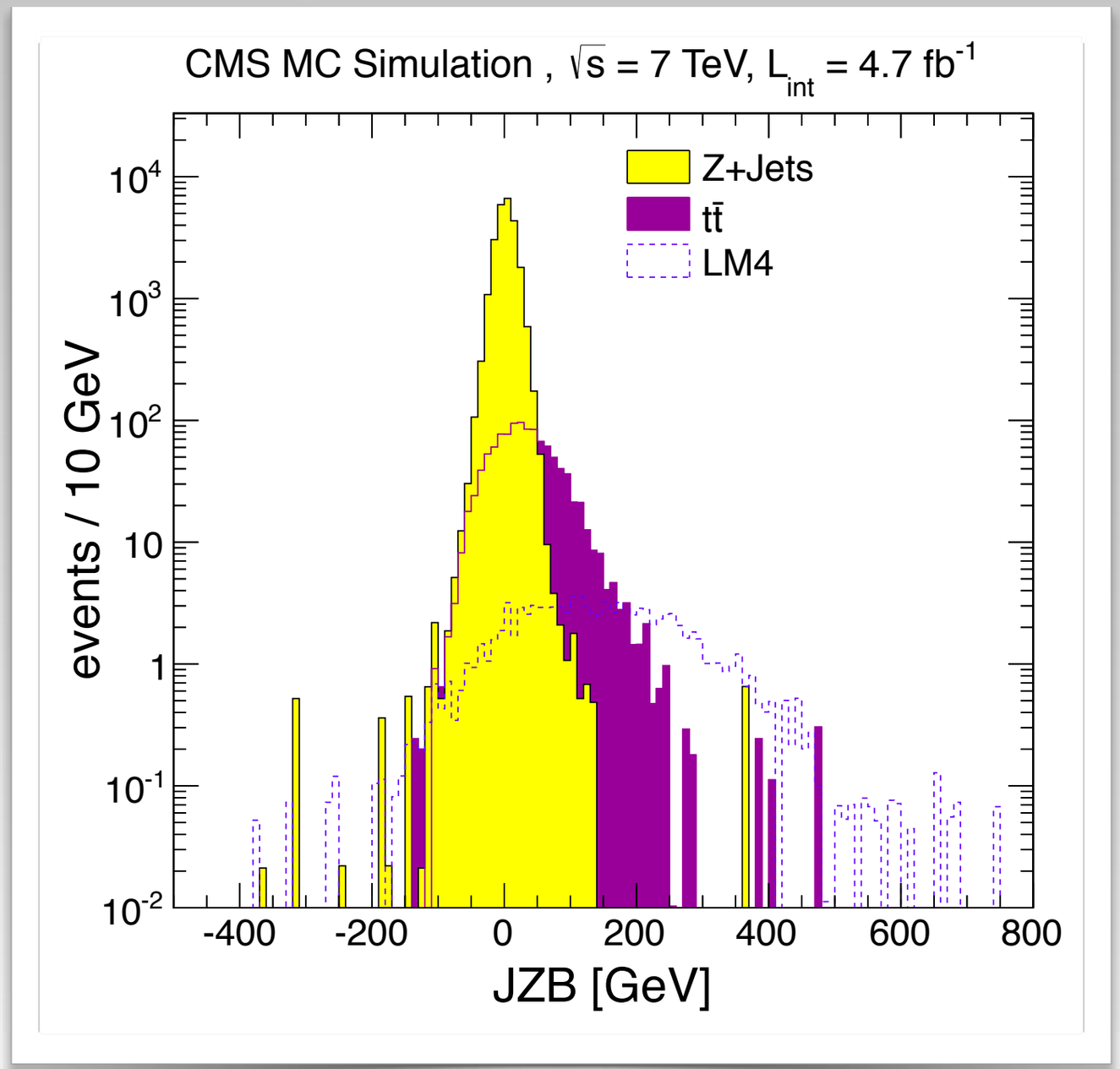


CMS-EXO-11-013





JZB variable

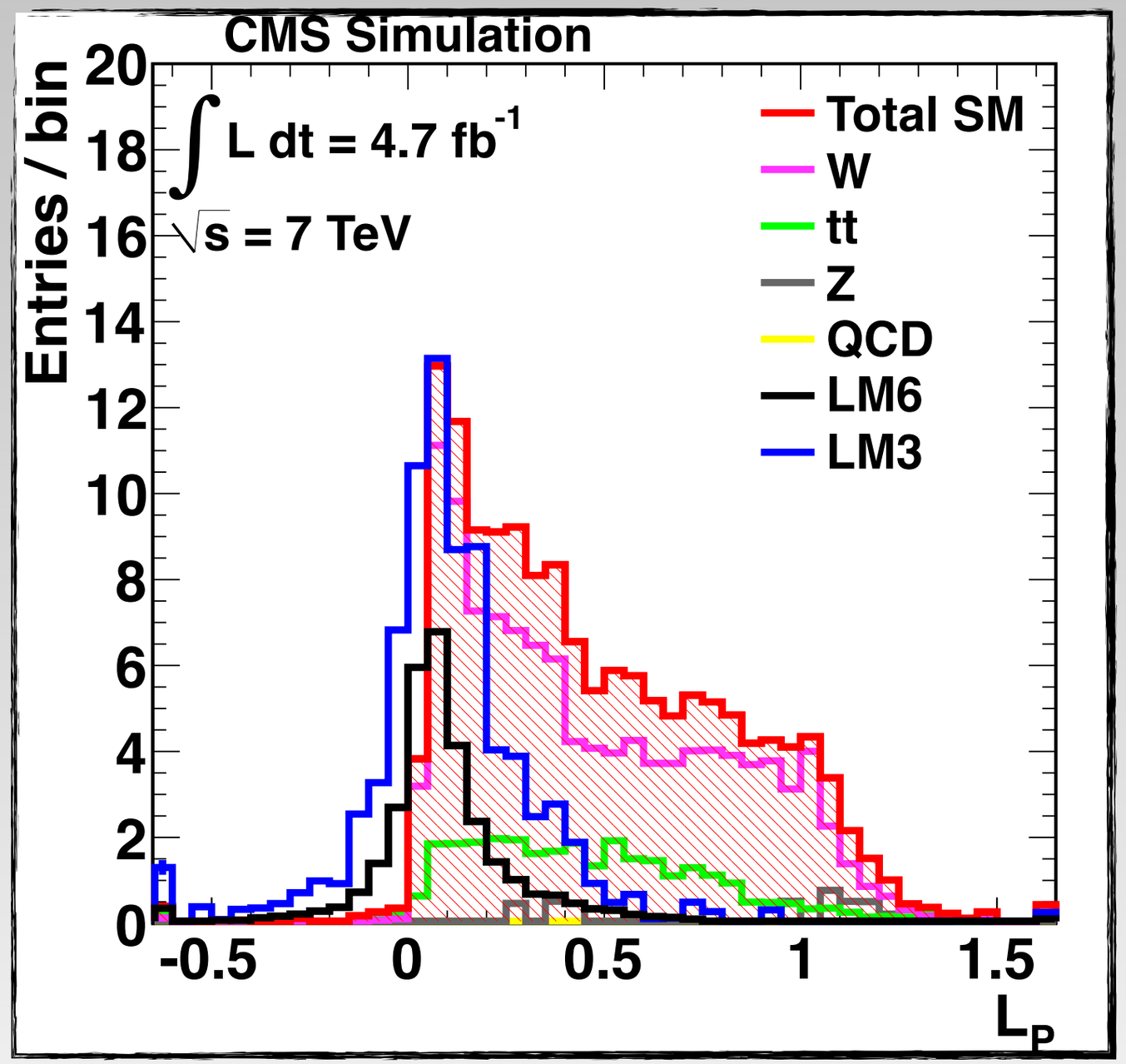


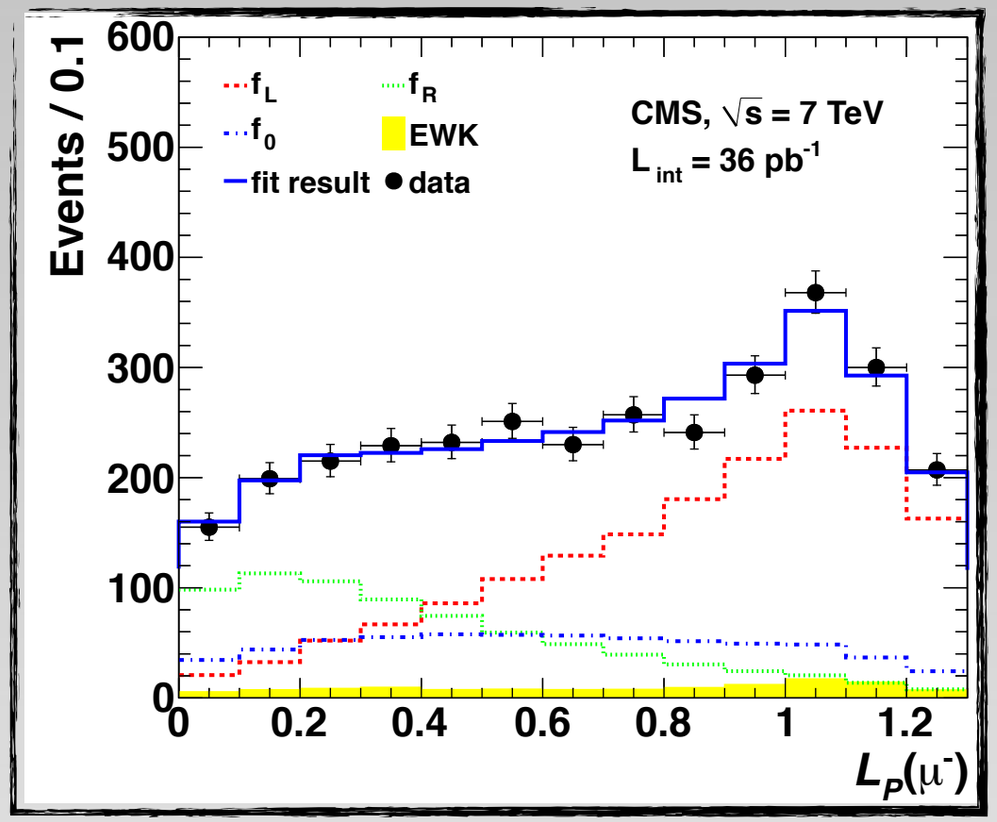
CMS-SUS-11-021

$$JZB = \left|\sum_{\text{jets}} p_T\right| - \left|\vec{p_T}^{(Z)}\right|$$

- Use Jet-Z-balance (JZB) to predict Z +jets tail
  - Flavour subtraction for dominant top background
- Several JZB selections,
  - need always jets

Lp variable



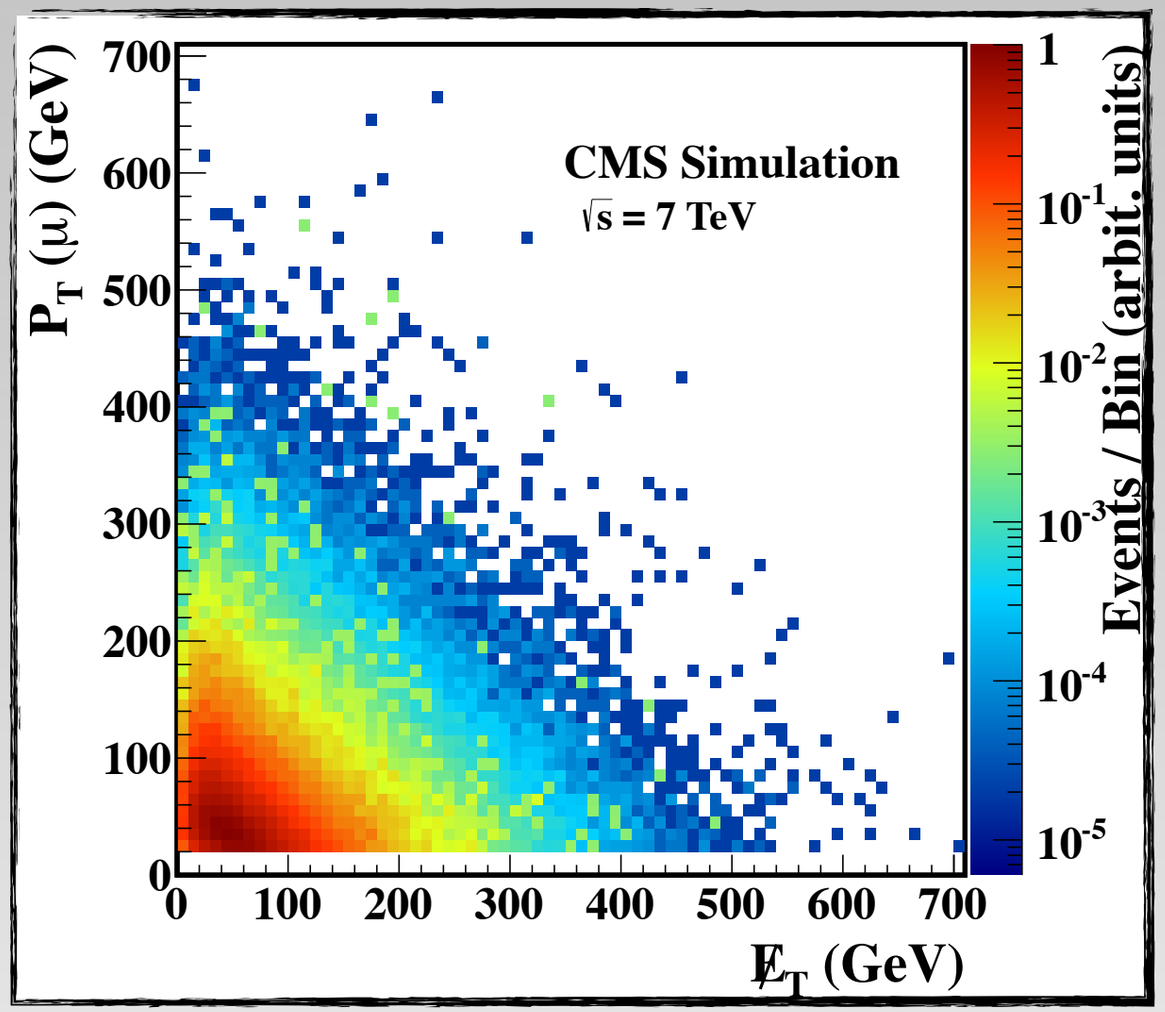


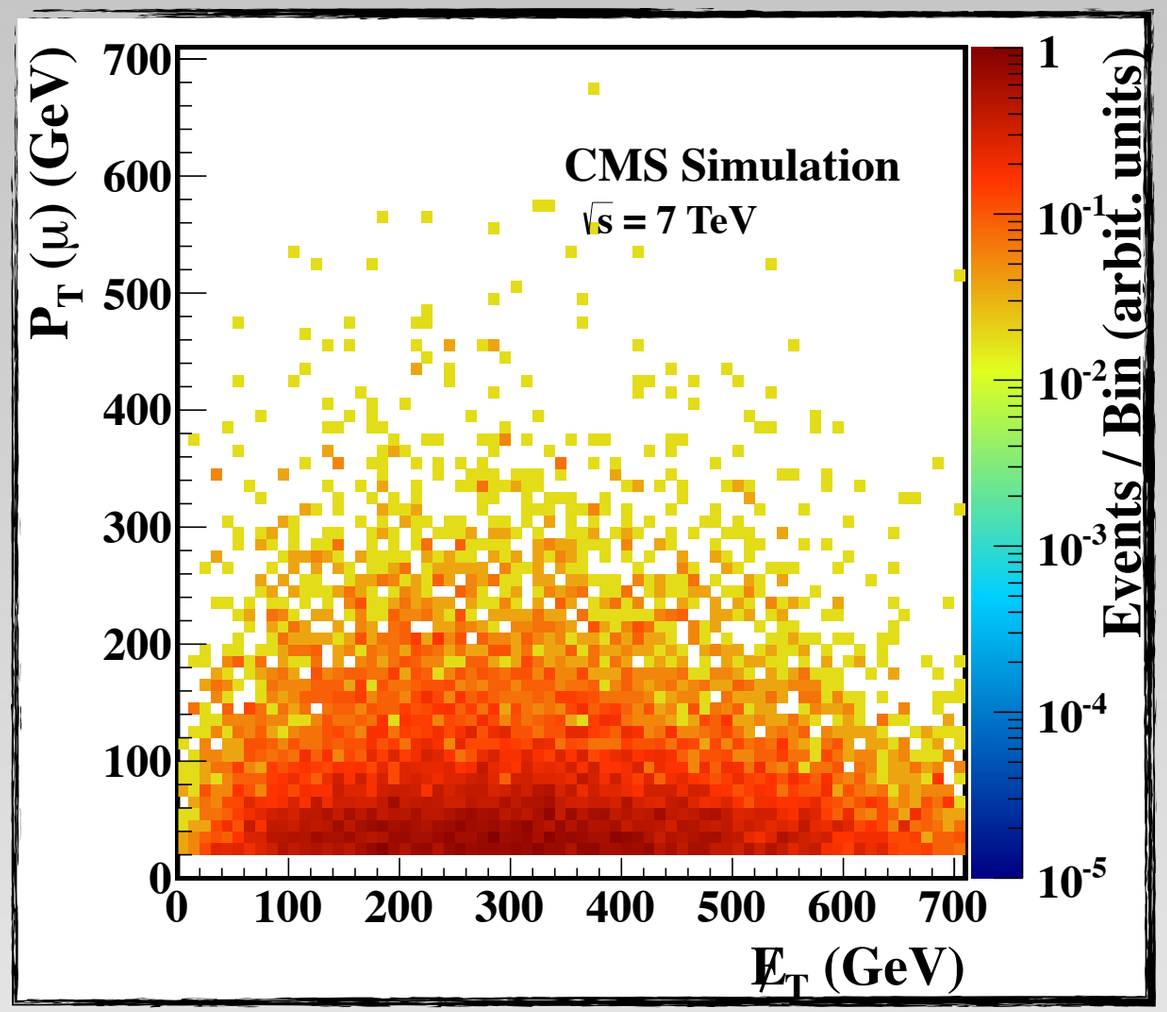
- Measurement 2011
- Polarization fraction as expected in SM

CMS-SUS-12-010

$$L_p = \frac{\vec{p}_{\mathrm{T}}(\ell) \cdot \vec{p}_{\mathrm{T}}(\mathrm{W})}{|\vec{p}_{\mathrm{T}}(\mathrm{W})|^2}$$

MET templates





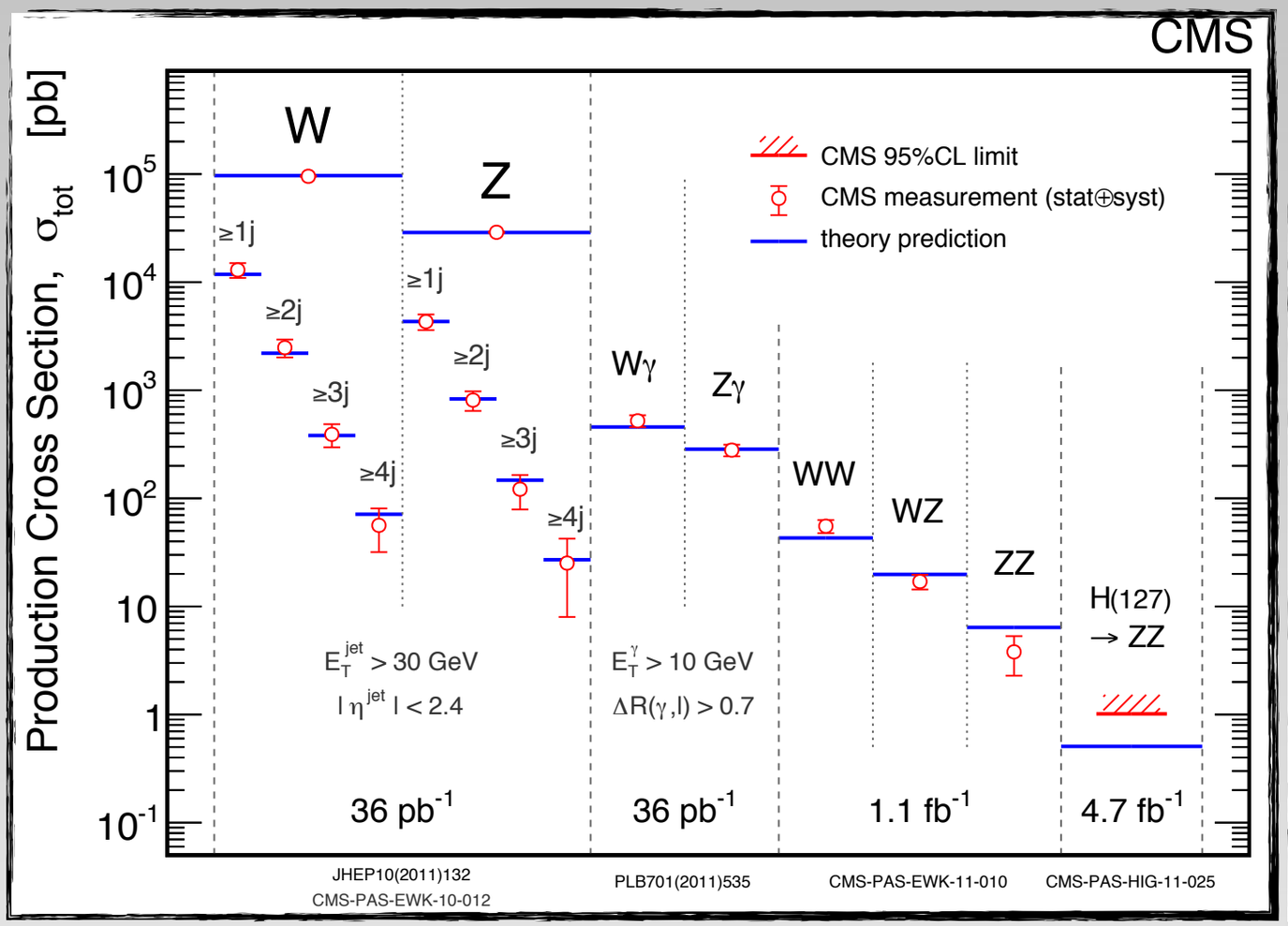
- top and W-events

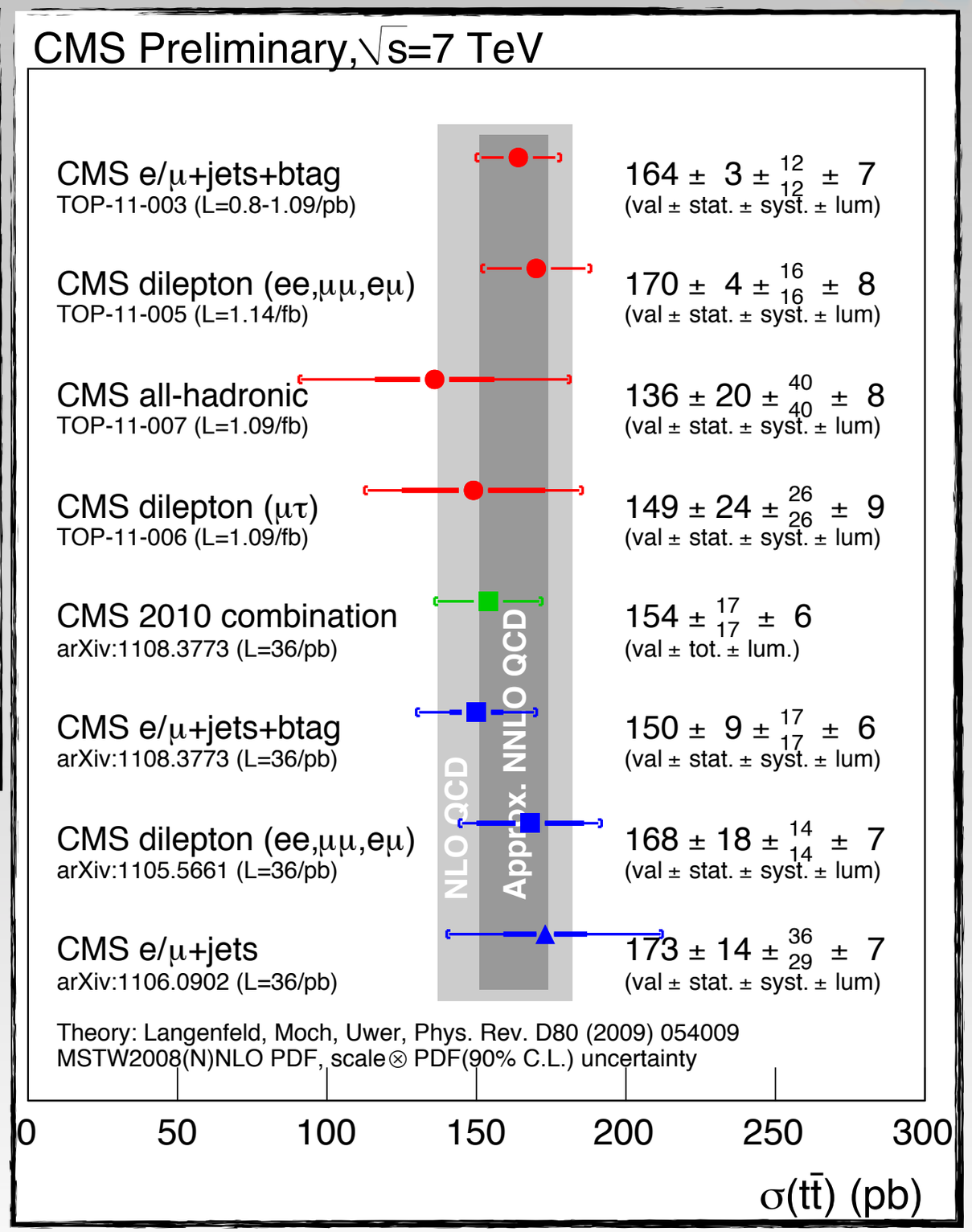
CMS-SUS-12-010

  - $p_T(l)=p_T(\nu)$

- Can be used to predict MET tail for SUSY

Cross-sections





- SM cross-sections
  - All in good agreement to theory

https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResults