Search for Supersymmetry in a Vector Boson Fusion-Like Topology at CMS

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On behalf of the CMS Collaboration

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New Perspectives 2016

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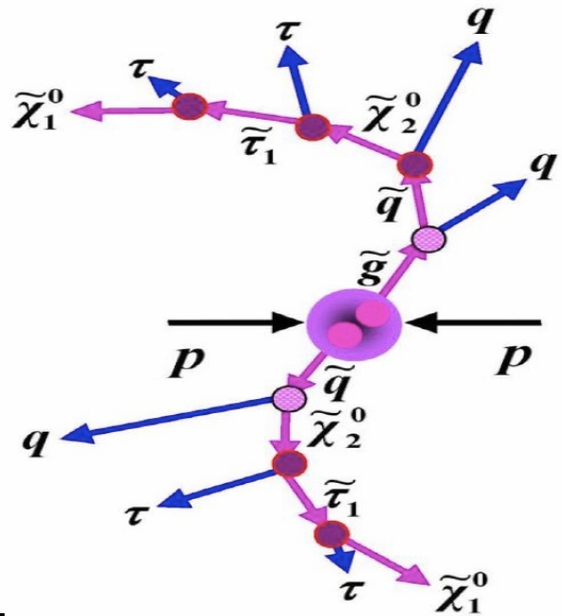
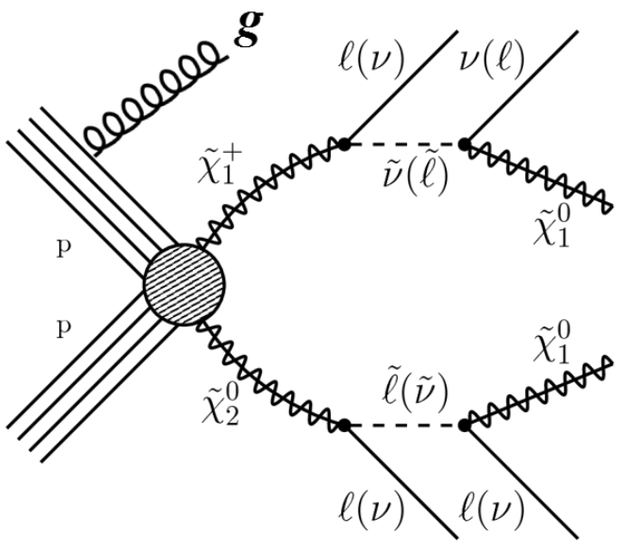
Outline

- Classical SUSY Searches
- Supersymmetry in VBF
- What is VBF and Why?
- 8 TeV Analysis
  - ❖ VBF + MET+Dilepton SUS-14-005, JHEP 11 (2015) 189
  - ❖ VBF + MET (arXiv:1605.09305)
- Prospect for 13 TeV search:
  - ❖ New Approach with Mu+VBF Trigger
- Summary

Classic SUSY Searches

- Many SUSY searches focused on the colored sector
- Limits of these models probe masses up to ~1.7 TeV for squark gluinos.
- These type of signatures have final states with MET +multijets (+leptons)(+photons)
- Colored objects expected to be heavy and the production cross-sections are large
- In compressed mass spectra scenarios MET is small and jets (+leptons) (+photons) are soft
- No good sensitivity for compressed spectra scenarios



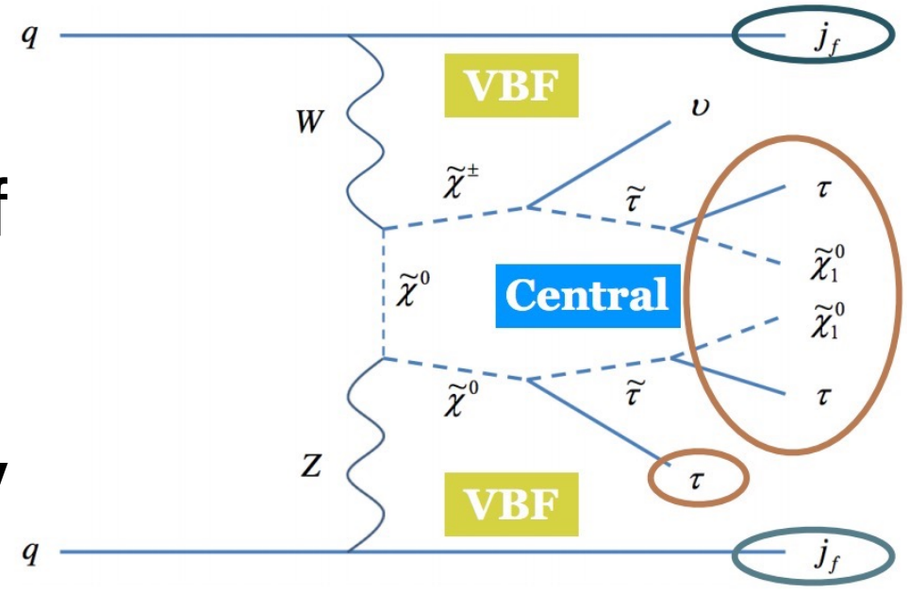


- DM particles produced in pairs after cascade decay of chargino neutralino
- Signature:Met+leptons and ISR Jet

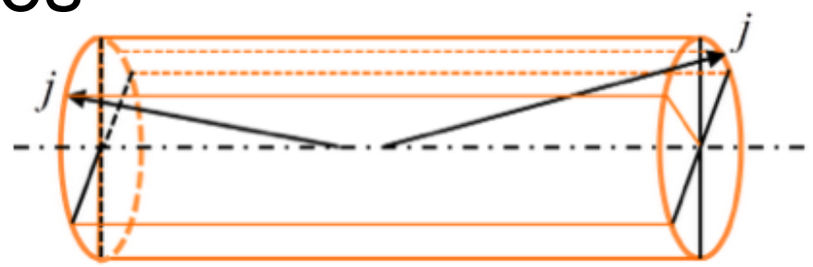
SUSY Electroweak Searches with VBF

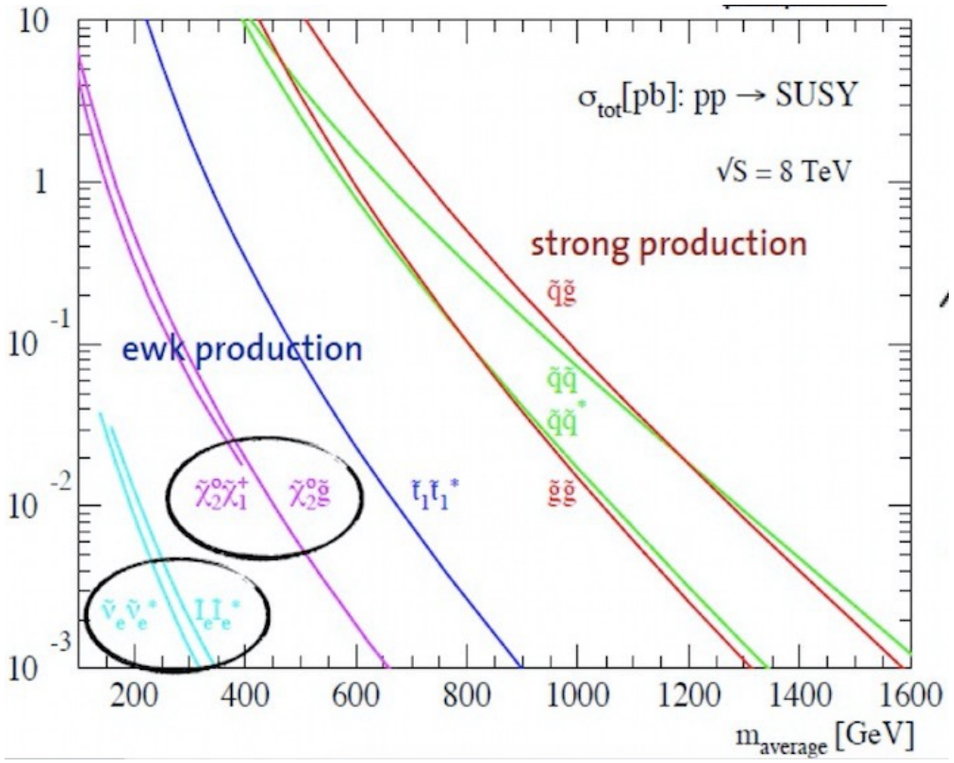
Why VBF?

- VBF tagging useful in tackling some of the interesting physics channels
- VBF topology provides a complementary probe to look for compressed spectra

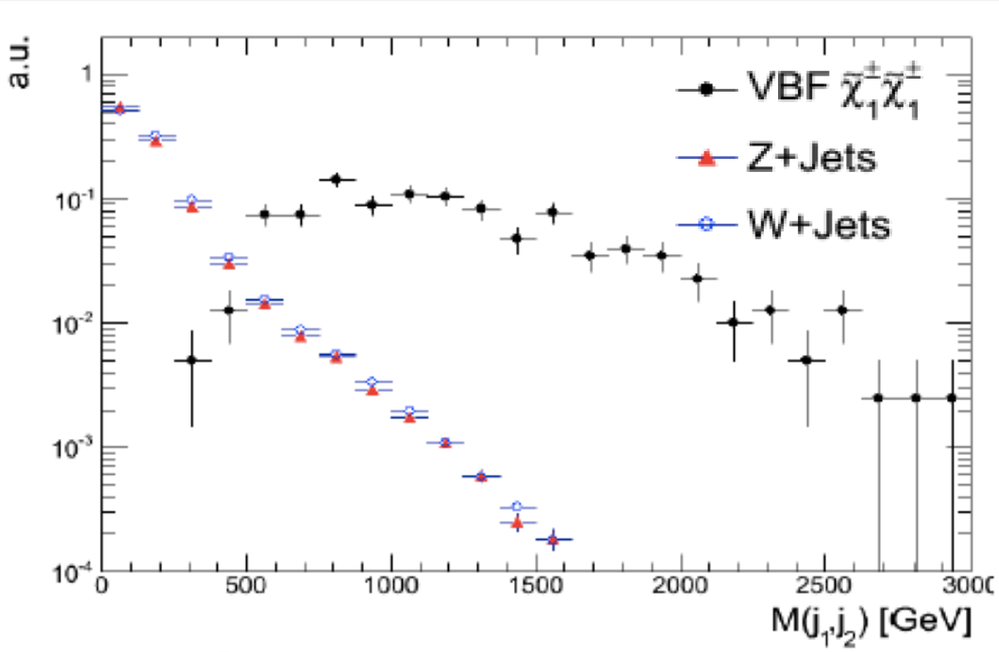


- Smaller predicted cross sections but lower level of hadronic activity
- Complements the color searches
- EWK's expected to be light compared to the colored particles

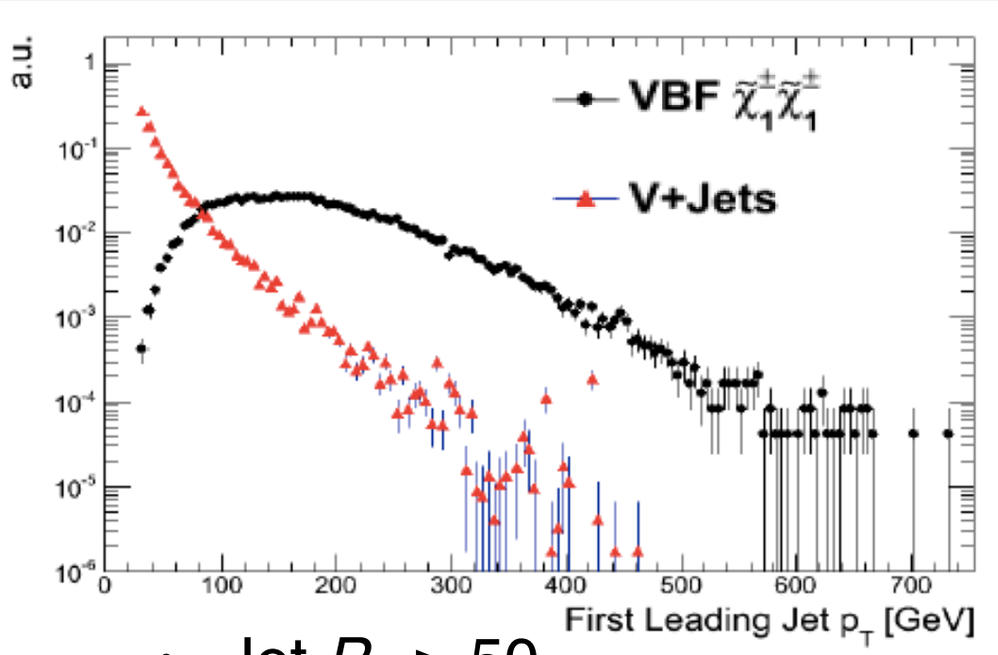




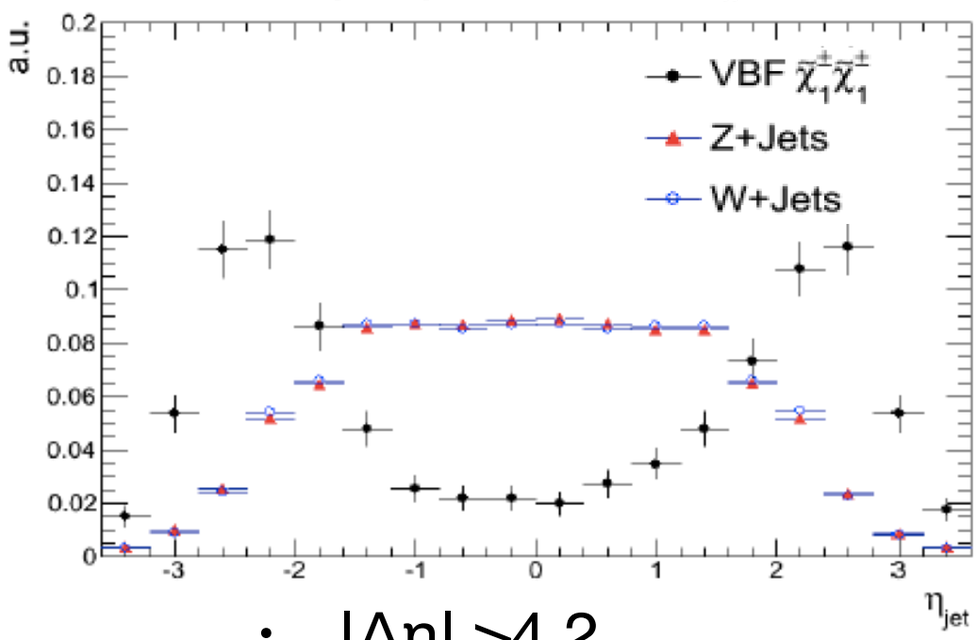
VBF Kinematics?



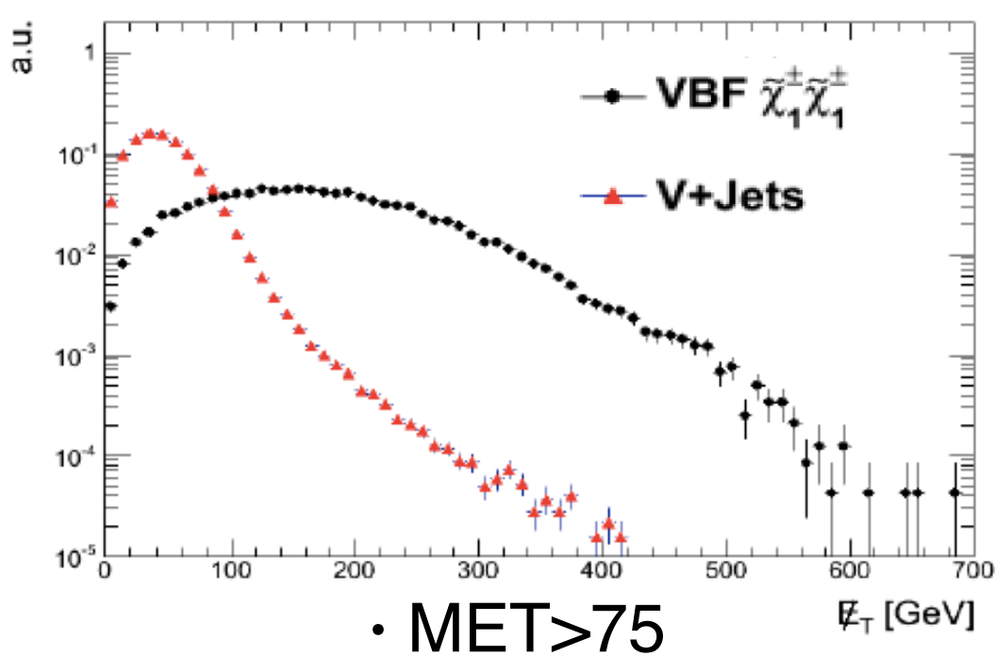
- One jet pair with m_{jj} >250



- Jet $P_T > 50$



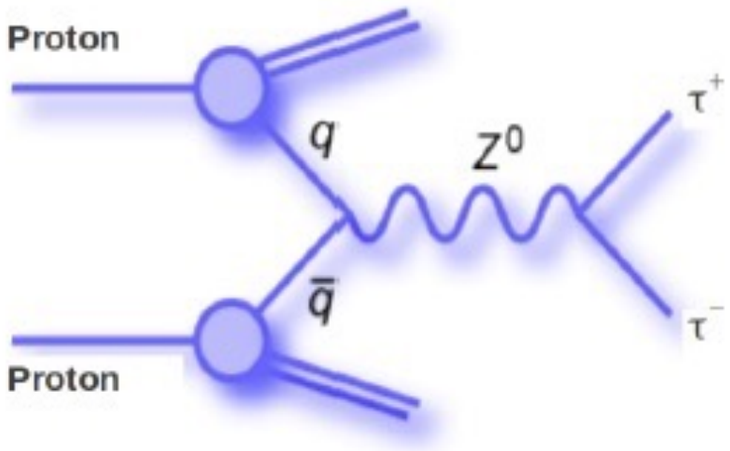
- $|\Delta\eta| > 4.2$

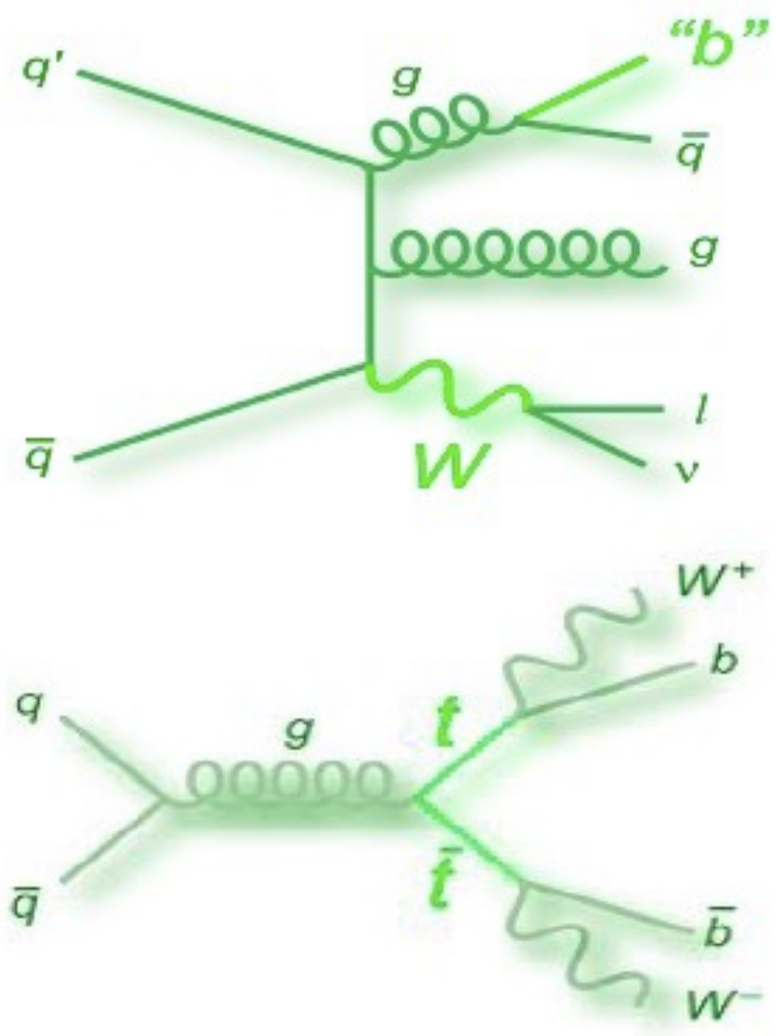


- MET>75

- While V+Jets more central with small dijet invariant mass, Signal characterized by non-central Jets with large dijet invariant mass

Main BG's





- $Z \to \ell\ell + jets$:
  1. Z $\to$ ee/$\mu\mu$: fake E_T^{miss} from mis-measured jets + ISR jets conforming to the VBF topology
  2. Z $\to \tau\tau$: real E_T^{miss} from the tau decays + ISR jets.

- $W + jets$: prompt lepton from the W ($W \to \mu/e/\tau + \nu$) and recoil jets and ISR jets passing the VBF cuts.

- multijets:
  1. b-jets and leptons from $t\bar{t}$
  2. QCD light quark/gluon

Data-Driven Background Estimation

$$N_{\mathrm{BG}}^{\mathrm{Data}} = N_{\mathrm{BG}}^{\mathrm{MC}}(\mathrm{w/o\ VBF}) \cdot CF(\mathrm{CR\ w/o\ VBF}) \times \epsilon_{VBF}$$

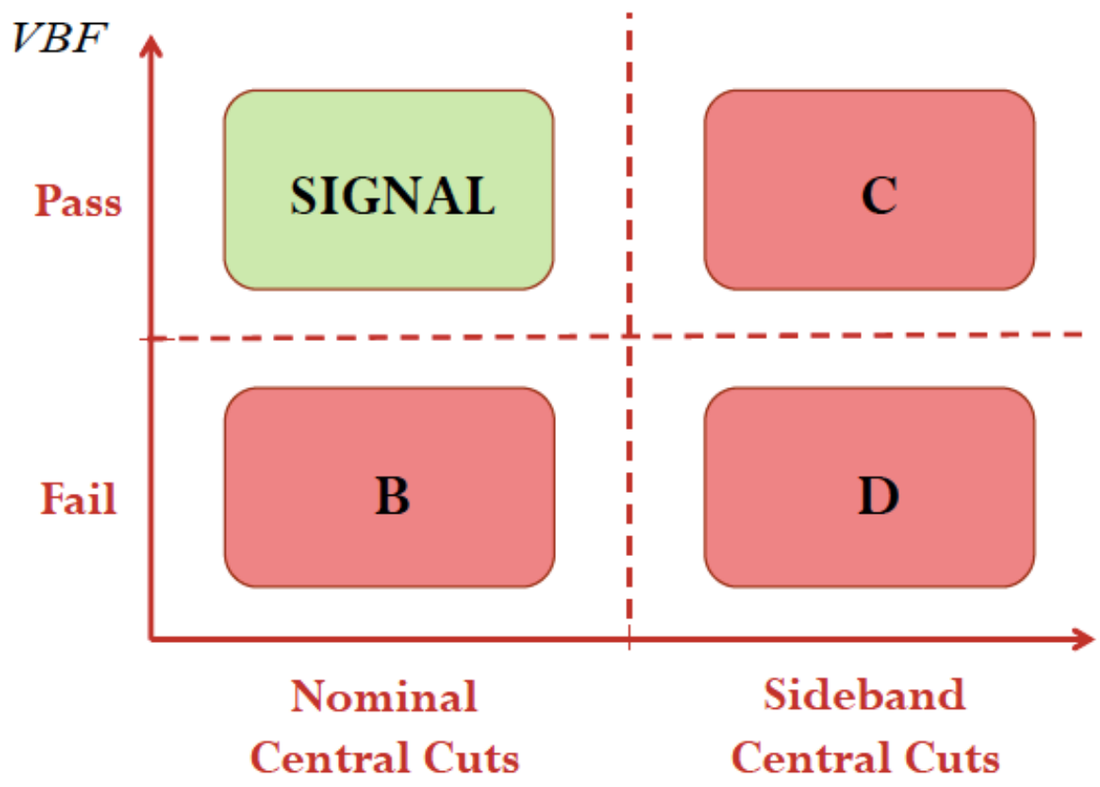
Predicted BG rate in the SR

Predicted rate in MC without VBF selection

Data-to-simulation correction factor

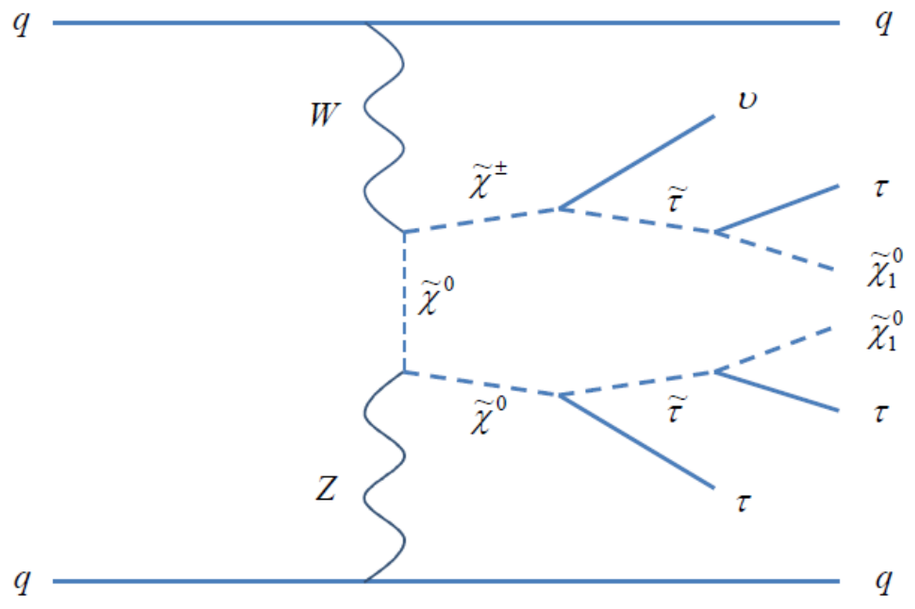
VBF eff determined from data in CR.For small BG's it is taken from MC

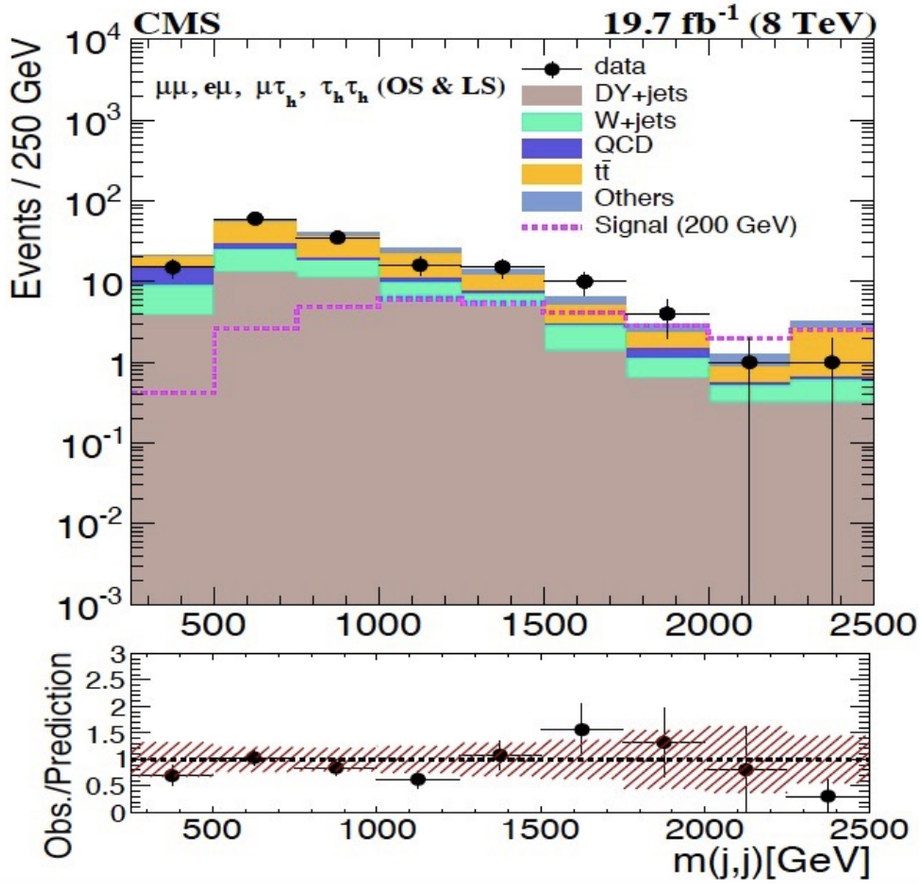
- Our general strategy to predict backgrounds across all channels:
- Scale background estimation before VBF cuts with a control region 'CF(CR w/o VBF)' where CF is correction factor data to MC
- Determine efficiency of VBF cuts with another (independent) control region 'ϵ_{VBF}'
- A closure test is performed in MC. The difference between the nominal and predicted yields in the closure test, is taken as a systematic error.



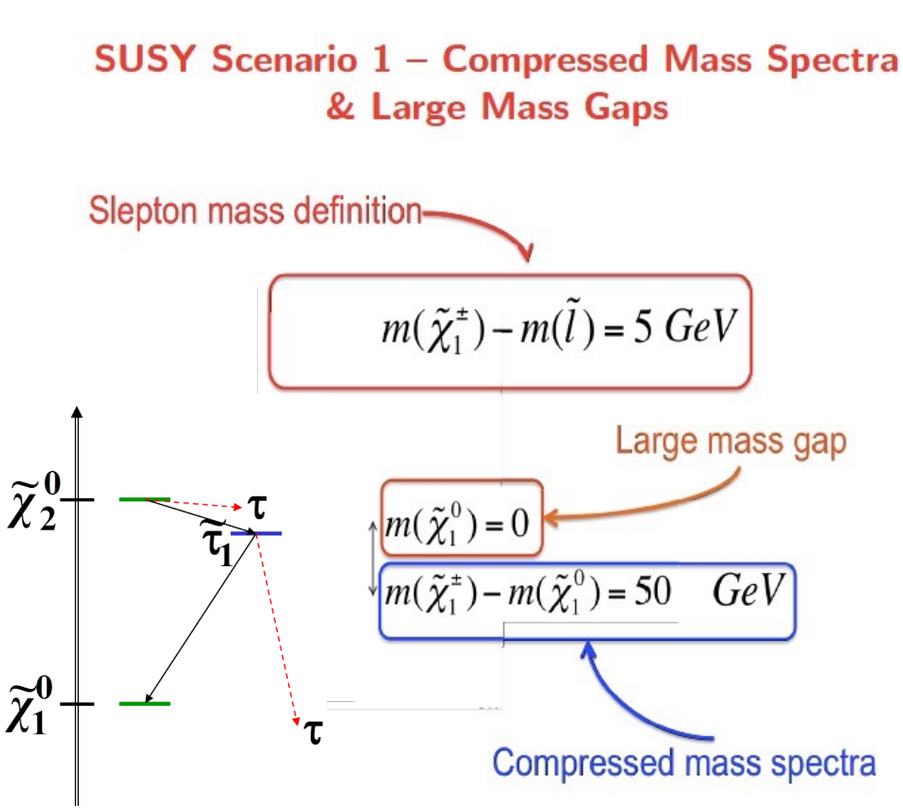
8 TeV EWK SUSY Search

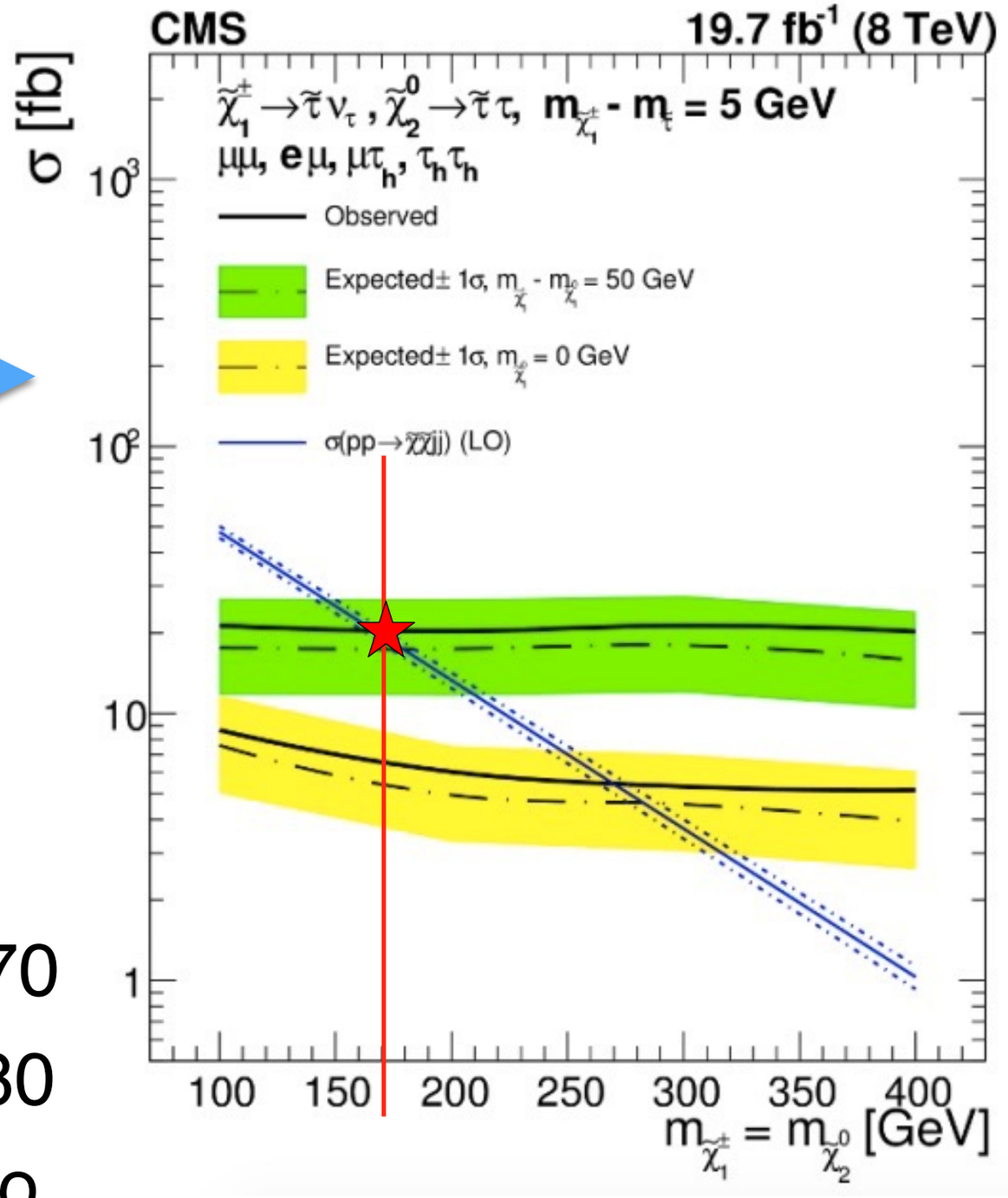
- Data: 19.7 fb^{-1} at 8 TeV with inclusive muon trigger (p_t^{μ}> 24GeV) and di-tau trigger (p_t^{τ}> 35 GeV)
- Final states with eμ, μμ, μτ_h, $\tau_h\tau_h$ plus MET and 2 VBF Jets
- Both Opposite and Same sign charge pair
- $|\eta_{lepton}|$<2.1, $|\Delta\eta_{jets}|$>4.2 and $\eta_1\eta_2$<0, p_t^{jets}>30/45 GeV p_t^{miss}>75/30 GeV
- Main Backgrounds: ttbar, V+Jets, VV
- Analysis performed by looking at shape of Mjj as discrimination variable





8 TeV EWK SUSY Search(Limits)

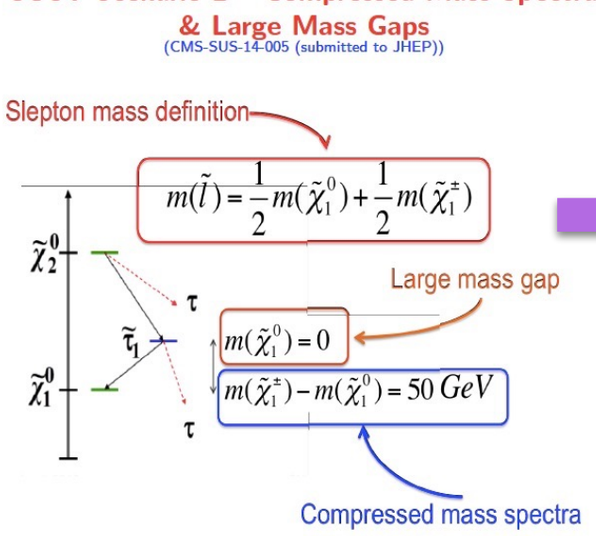


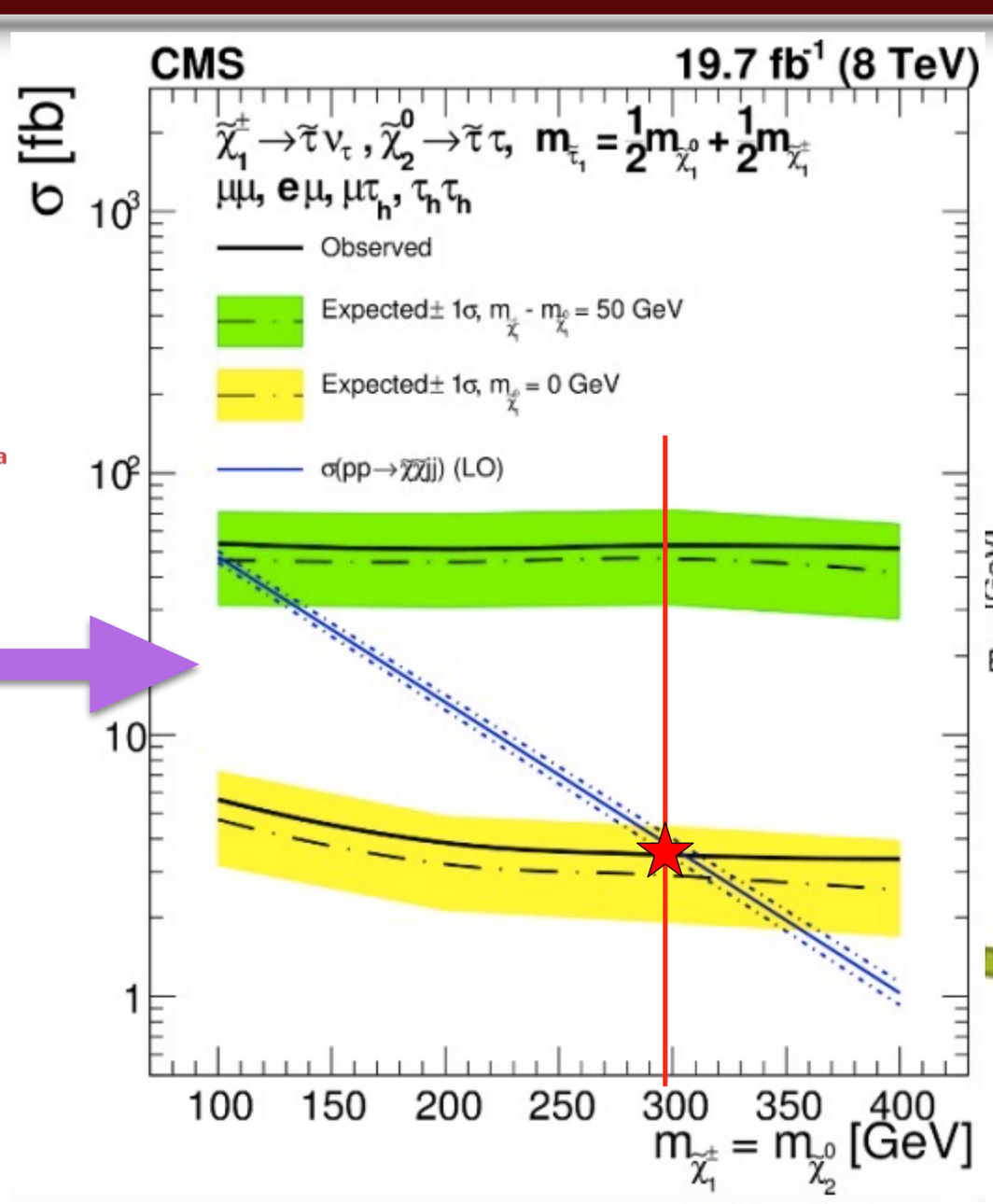


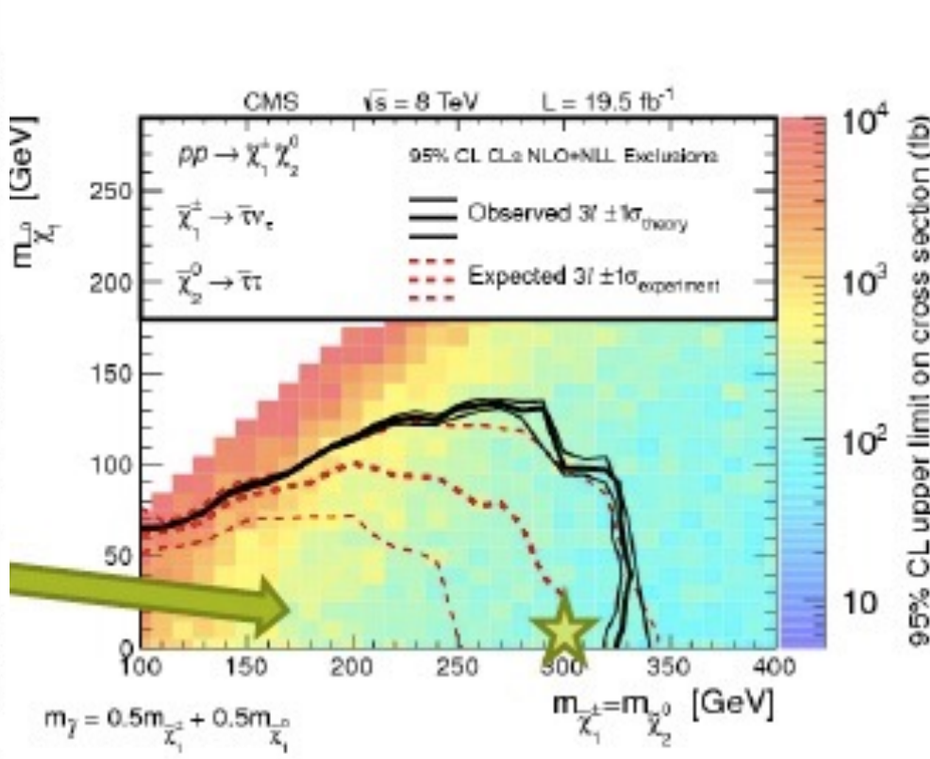
- All 8 channels combined
- Observed upper bound limit of 170 GeV and an expected limits of 180 GeV set for Compressed scenario

8 TeV EWK SUSY Search(Limits)

SUSY Scenario 2 – Compressed Mass Spectra & Large Mass Gaps
(CMS-SUS-14-005 (submitted to JHEP))







- For the average-mass assumption with an uncompressed-mass spectrum the corresponding limit is ~300 GeV

8 TeV Compressed Mass Spectra squark

Signature

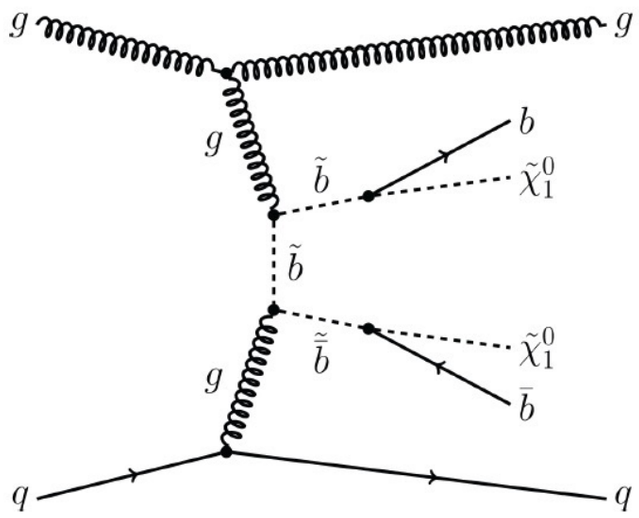
- 2 high-pT forward jets and large MET
- Same VBF-like topology strategy as in the EWKino case

SUS-14-019

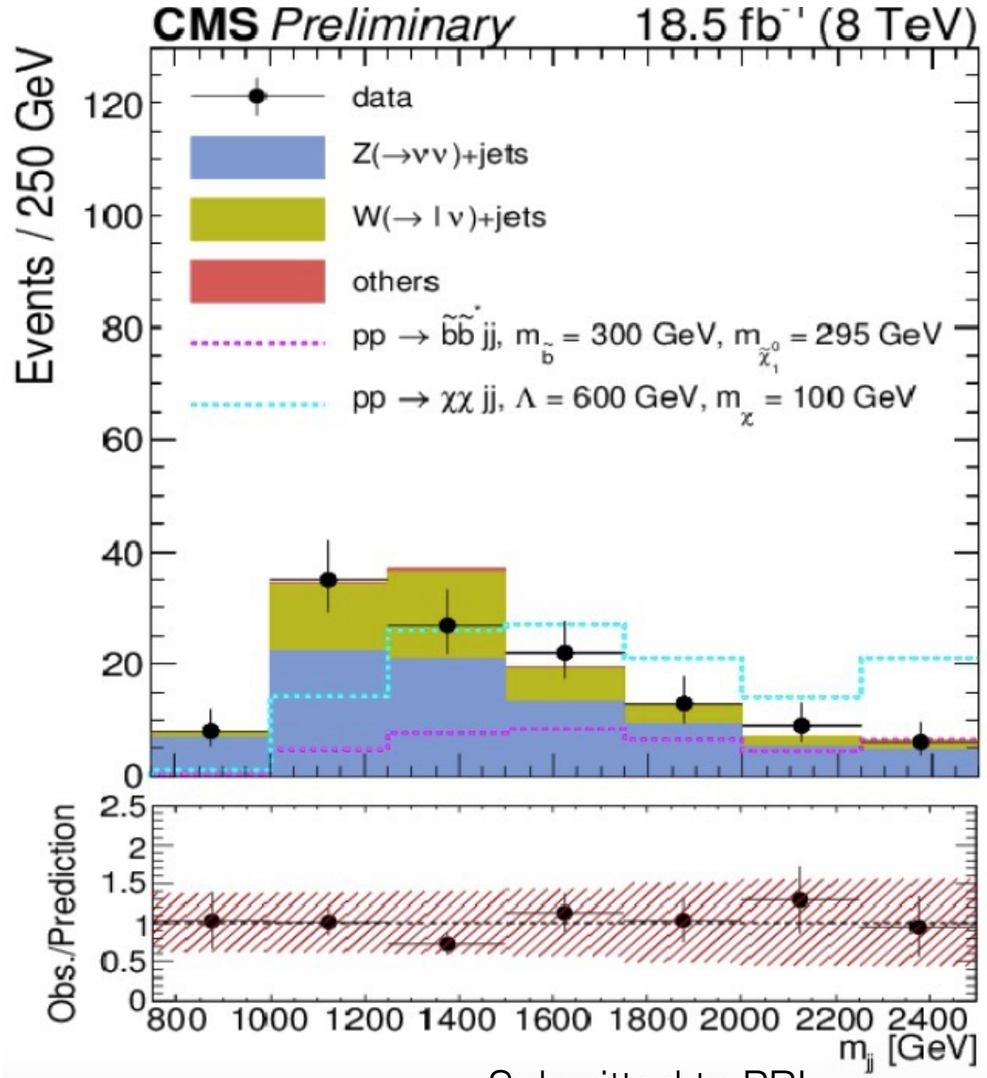
Trigger: MET65+VBFDiJet35

Selection: Two jets (p_T>50 GeV with $\eta_1\eta_2$<0; large rapidity gap $|\eta_1-\eta_2|$>4.2 and invariant mass m_{12}>750 GeV; no b-tag); MET>250 GeV; veto further jets (p_T>30 GeV)

Dominant bgs: $(Z \to \nu\nu) + \text{jets}$ & $(W^{\pm} \to l^{\pm}\nu) + \text{jets}$ estimated from data



	Expectation	Observed
Signal region	132 +/- 14	118



Consistent with SM!

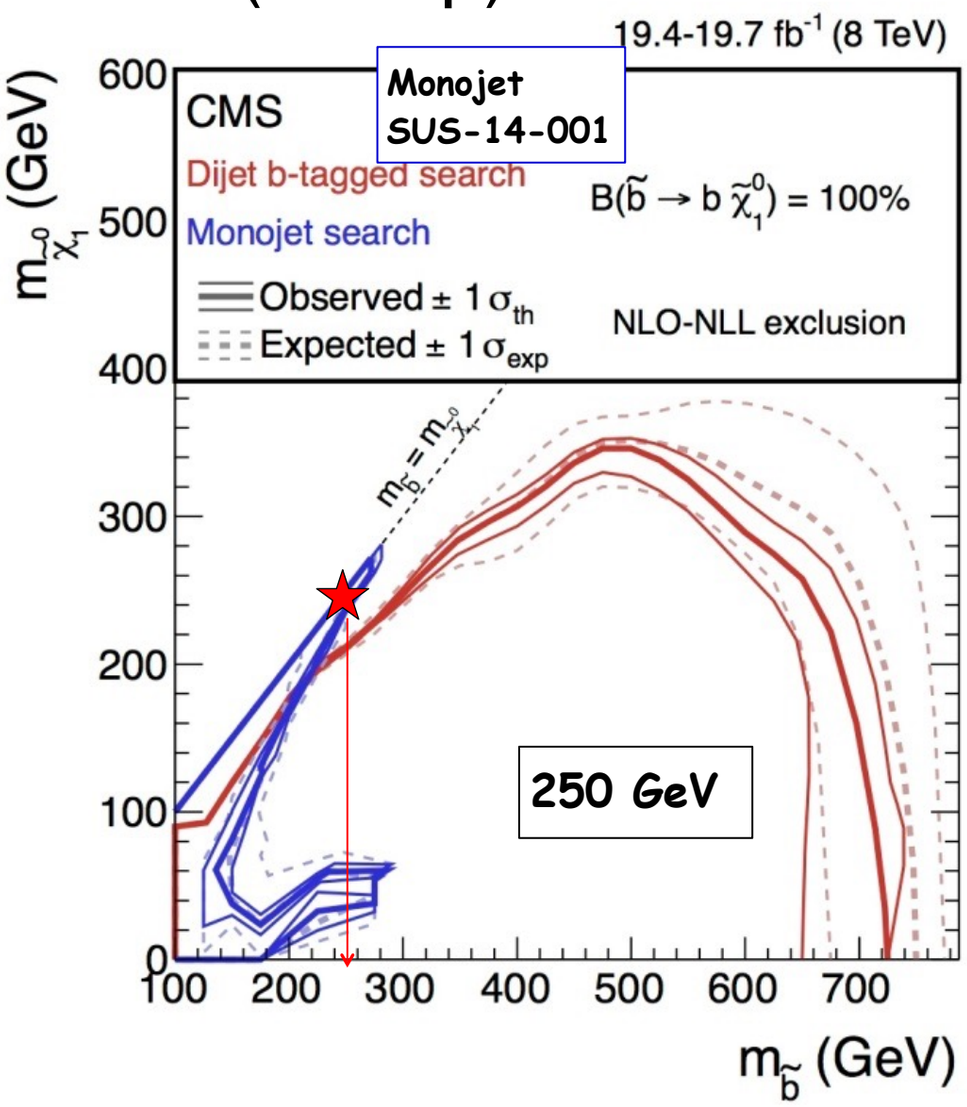
- Use yield and shape of dijet mass distribution to search for supersymmetry

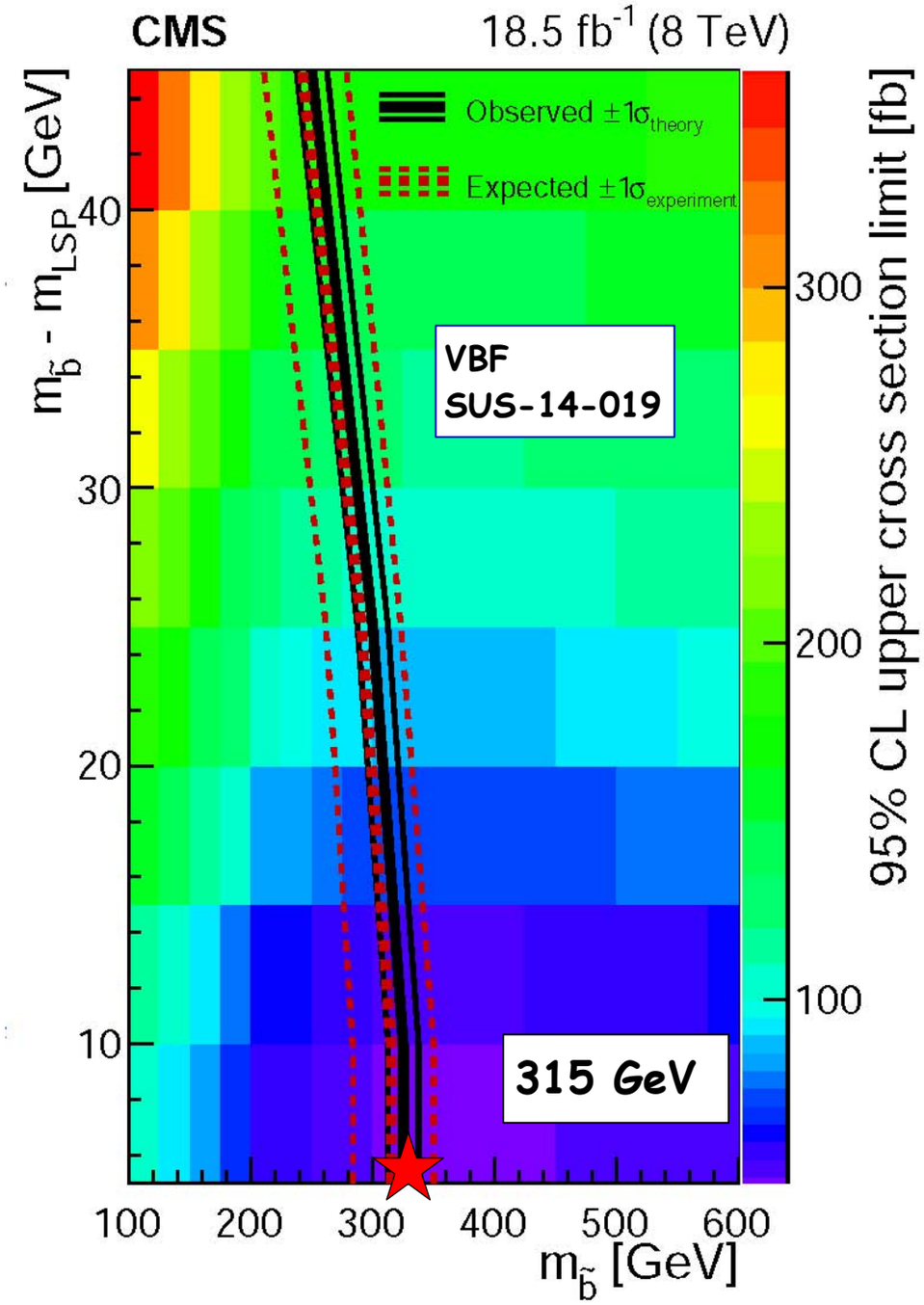
Submitted to PRL

8 TeV Compressed Mass Spectra squark

- Data is consistent with SM expectation
- Up to 315 GeV (obs.) and ~315 (exp.) for $\Delta M < 10$ GeV for compressed sbottom (& stop)

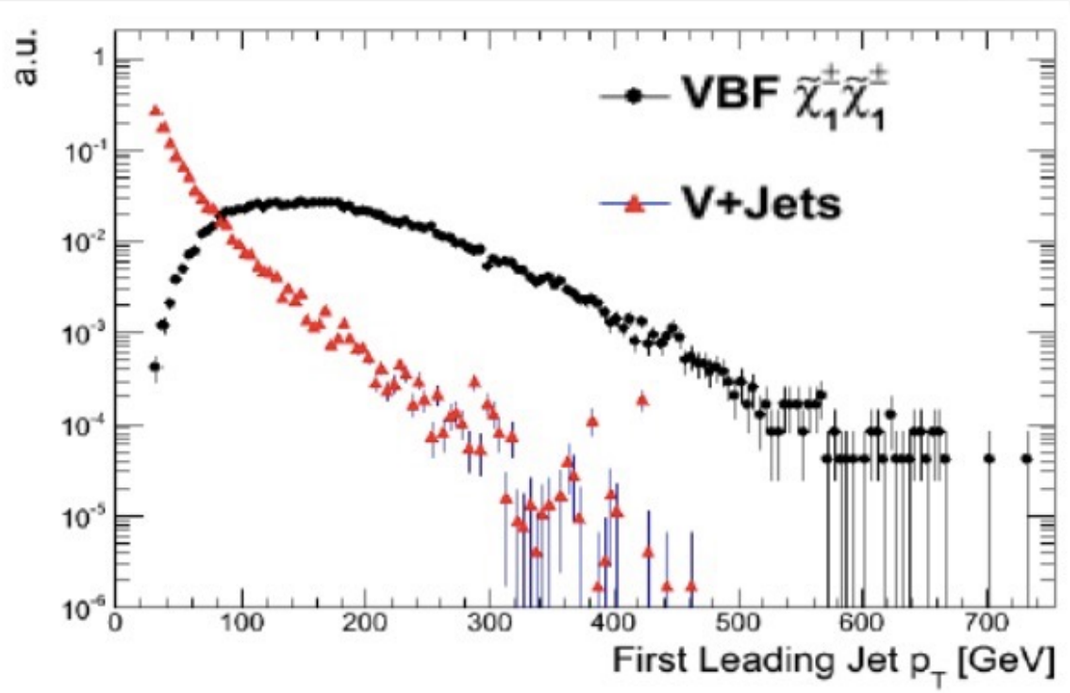
SUS-14-019(arXiv:1605.09305)

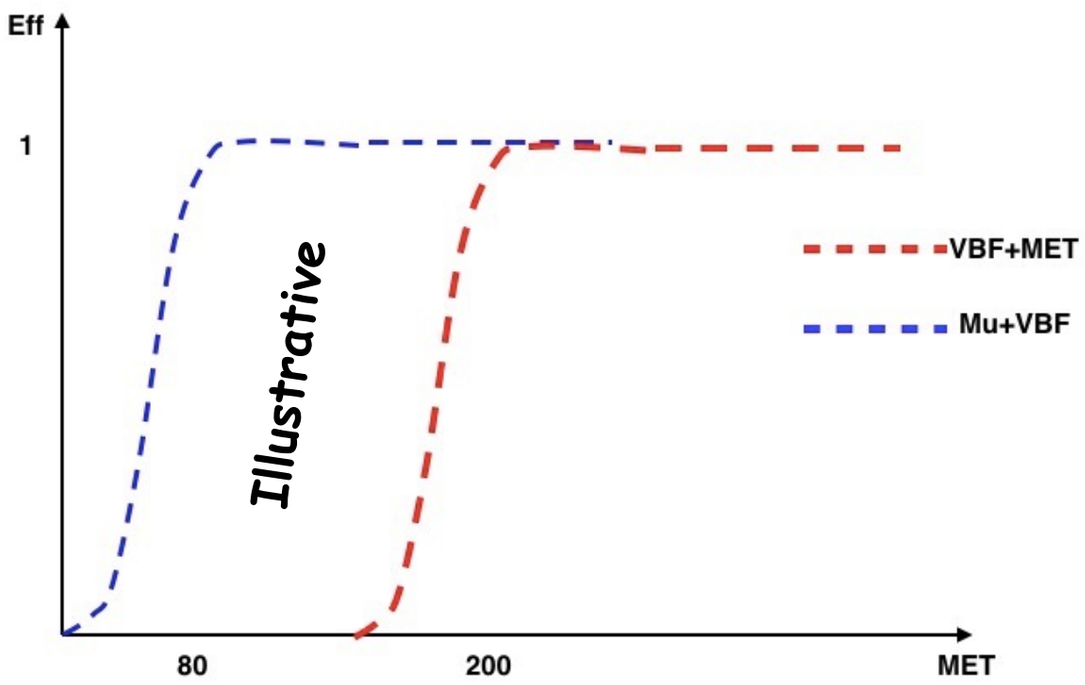


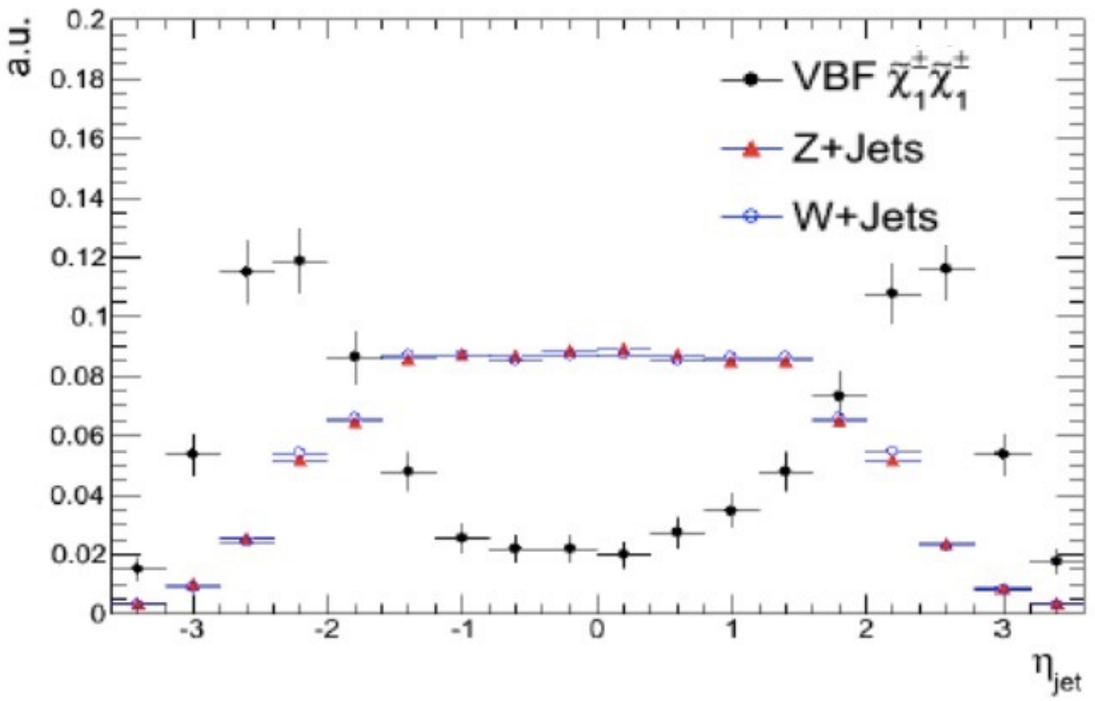


Prospects of Run II at 13 TeV

- Mu+VBF trigger is commissioned in Run II
- $p_t^{\mu} > 8$ GeV, Mjj>750, $p_t^{j} > 40$GeV, MET>60GeV
- Trigger Rate≈0.1 Hz in 2015
- New path enables us probe softer lepton + MET in VBF
- VBF+MET trigger (no lepton requirement), MET > 200 GeV at plateau(see below), where we want to have MET >~80 GeV like in Run1







Summary

- First VBF topology based search performed successfully with 8 TeV data of CMS
  - ❖ SUS-14-005 in dilepton + VBF channels (published in JHEP)
    - ➡ A combined observed upper bound limit of 280 GeV and an expected limit on 295 GeV is set, for the large mass gap scenario
    - ➡ For the compressed mass spectra scenario we set a combined observed upper bound limit of 170 GeV and an expected limits of 180 GeV
  - ❖ SUS-14-019 in MET + VBF channel (Submitted to PRL arXiv: 1605.09305)
    - ➡ The stringent limit of 315 GeV obs. and (~315 GeV expected) for squark in compressed mass spectrum scenario (ΔM ~5 GeV)
- New Dedicated lepton+VBF trigger for Run II to improve search sensitivity
  - ❖ Trigger active for all of 2016 data taking
- Stay tuned for interesting results!

Back-Up

Mjj Distributions