Interpretations of CMS SUSY Search Results using Combinations across multiple final states

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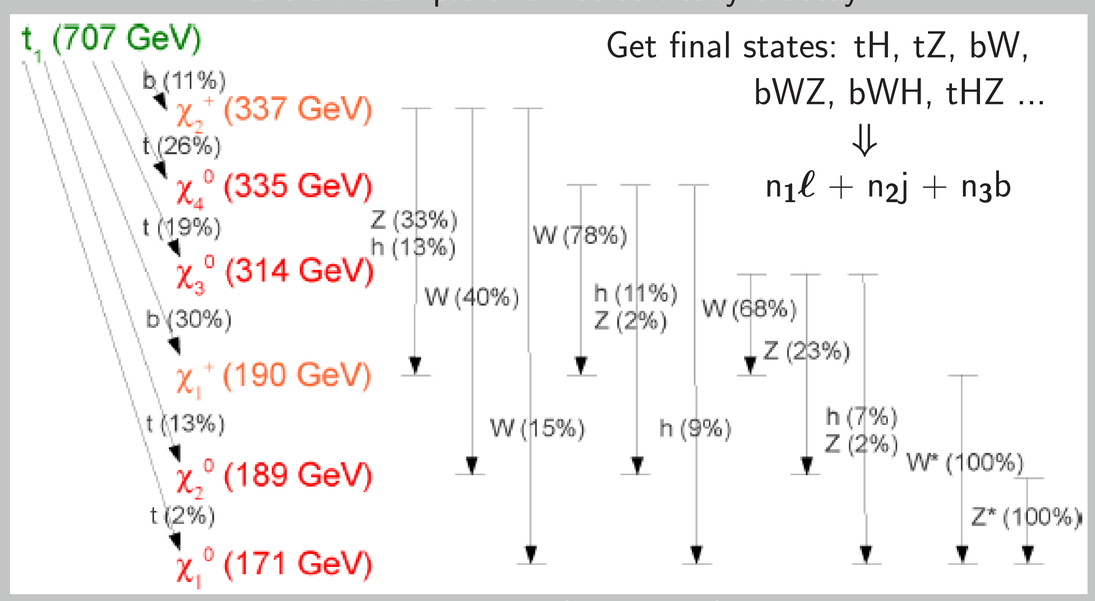
1. Example SUSY spectrum

Take an example of a not so heavy $\tilde{t}$ decay:



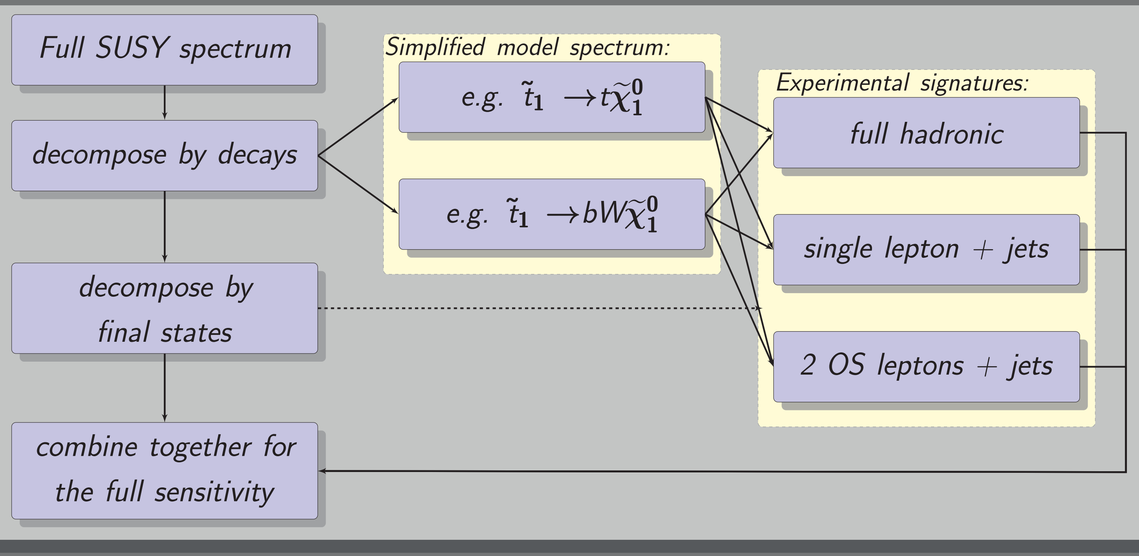
Get final states: tH, tZ, bW, bWZ, bWH, tHZ ...

$\Downarrow$

$n_1\ell + n_2 j + n_3 b$

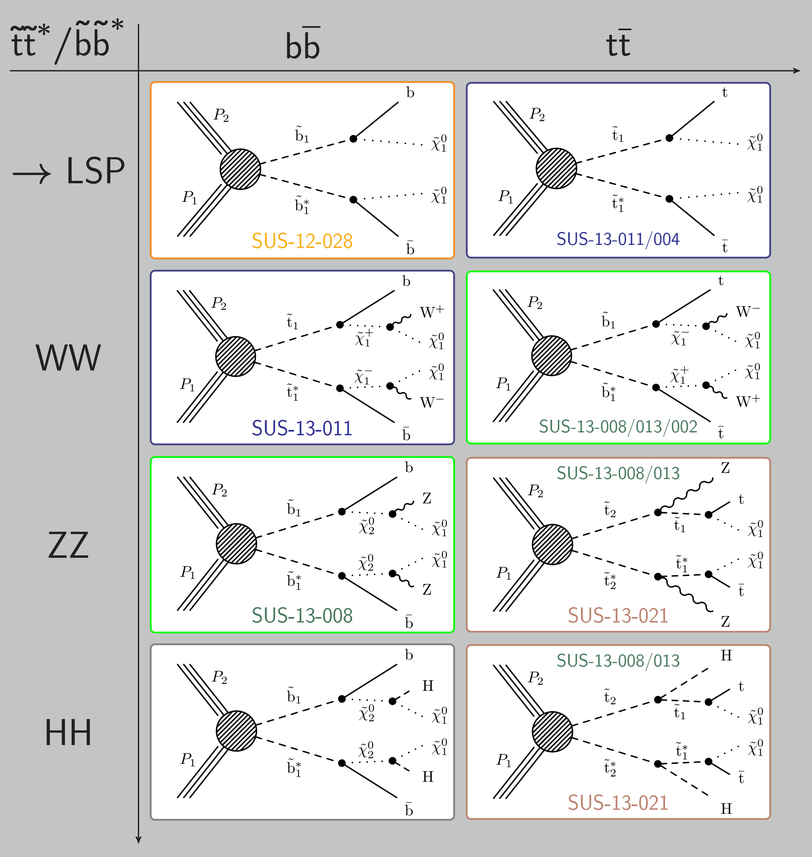
often get one analysis per (n_1, n_2, n_3) combination!

2. An experimental measurement



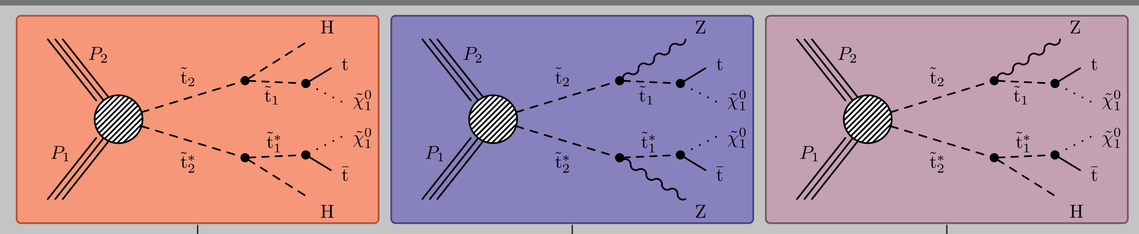
3. Overwhelmed with SMS (simplified model spectra)

Decay modes for the 3rd generation squarks:



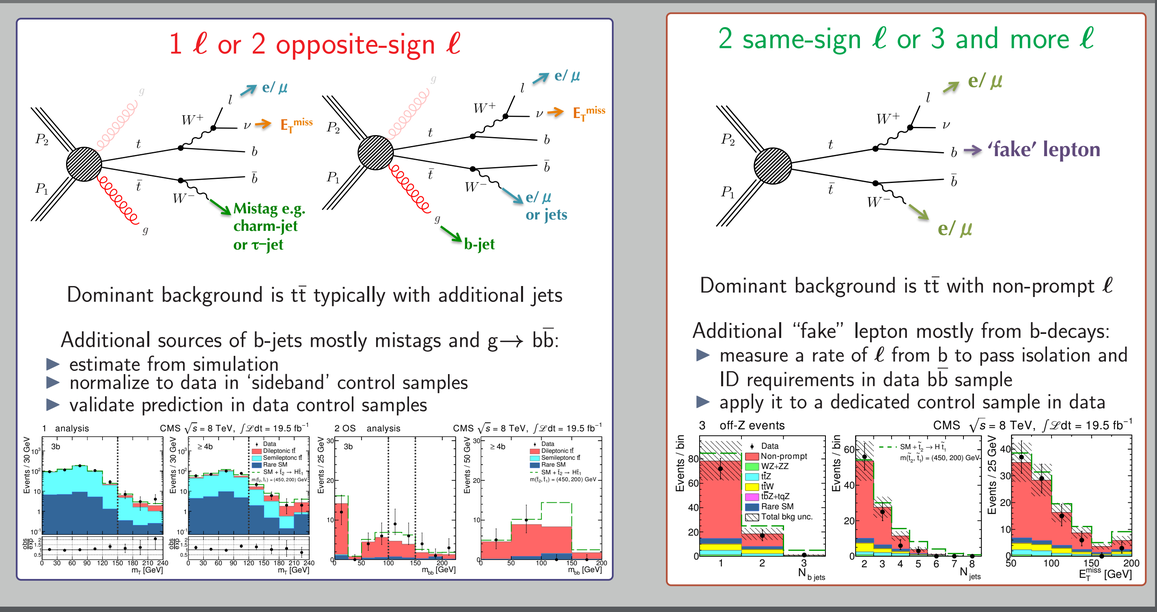
variety of analyses to cover every corner of new physics

4. Working example: $\tilde{t}_2$ decays

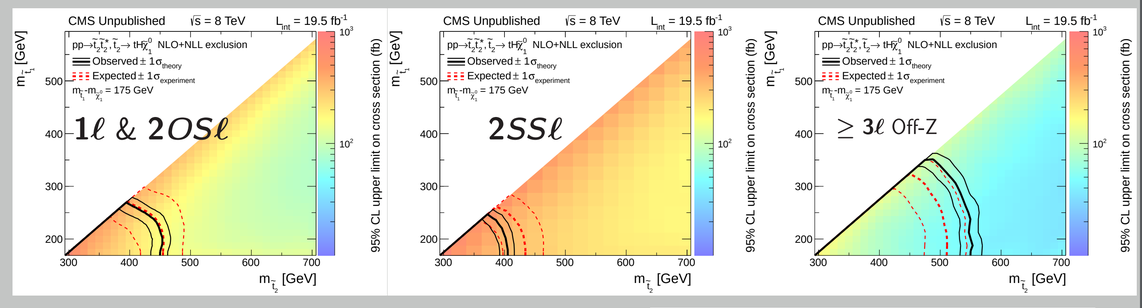


SUS-13-021	SUS-13-013	SUS-13-008
1 ℓ or 2 opposite-sign ℓ	2 same-sign ℓ	3 or more ℓ
& 3-4 b jets	& 1-2...b jets	& 1-2-3...b jets
target H→ $b\bar{b}$	target H→ ··· → ℓ	target H/Z→ ··· → ℓ

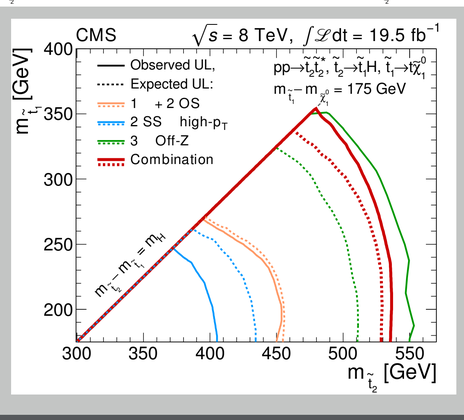
5. Why need to split: Backgrounds



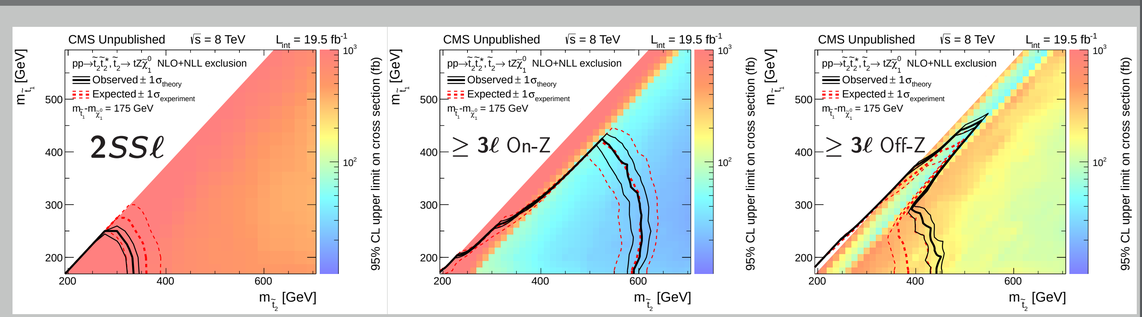
6. Results: $t\bar{t}HH$ final state



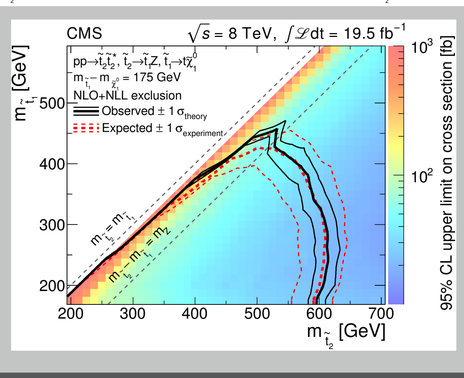
- **Signature**: large hadronic activity, moderate E_T^{miss}, high b-jet multiplicity
- **Signal regions used in limits**: 1ℓ / 2OSℓ / 2SSℓ/ Off-Z for 3ℓ (few real Zs)
- 3ℓ most sensitive: combining with 1ℓ / 2OSℓ / 2SSℓ improves reach by 20%



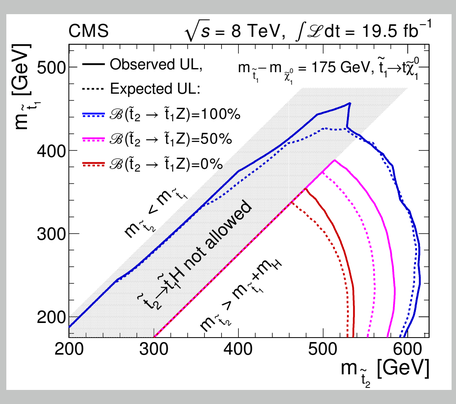
7. Results: $t\bar{t}ZZ$ final state



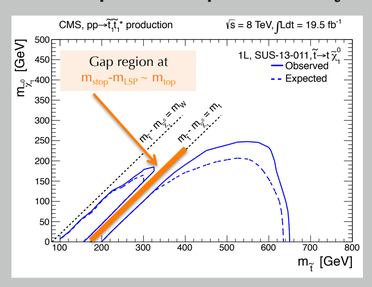
- **Signature**: large hadronic activity, moderate E_T^{miss}, low b-jet multiplicity, can have high ℓ multiplicity
- **Signal regions used in limits**: On-Z and Off-Z for 3ℓ
- On-Z and Off-Z search regions have complementary sensitivity



8. Results: Sensitivity for various $\mathcal{B}(\tilde{t}_2)$



- exploit cascade decays in a difficult place of a phase-space: $m_{\tilde{t}} \approx m_t + m_{\tilde{\chi}_1^0}$



Improve sensitivity by combining all channels: important for modes with H boson

9. Conclusions

- breakdown of the signatures to building blocks and then bringing them together guarantees the full view of the picture and provides the best sensitivity for the new physics searches
- in case of discovery such procedure is a vital component for understanding a nature of a new process

10. References

[1] CMS Collaboration, "Search for supersymmetry in pp collisions at $\sqrt{s}$ = 8 TeV in events with three leptons and at least one b-tagged jet", CMS Physics Analysis Summary CMS-PAS-SUS-13-008, 2013.

[2] CMS Collaboration, "Search for new physics in events with same-sign dileptons and jets in pp collisions at 8 TeV", *JHEP* **01** (2014) 163, doi:10.1007/JHEP01(2014)163, arXiv:1311.6736.

[3] CMS Collaboration, "Search for direct top squark pair production with Higgs bosons in the final state in pp collisions at $\sqrt{s}$=8 TeV", CMS Physics Analysis Summary CMS-PAS-SUS-13-021, 2014.

[4] CMS Collaboration, "Search for top-squark pair production with Higgs or Z bosons in the final state in pp collisions at 8 TeV", arXiv:1405.3886, 2014, Submitted to PLB.