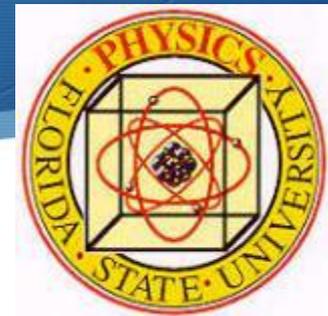
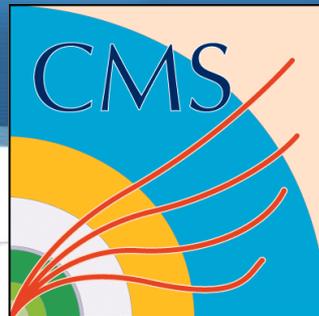




Searches for SUSY at CMS

Andrew Askew
For the CMS Collaboration





Motivation

- ◆ This space intentionally left blank.
- ◆ You came to a conference called SUSY2016, I'd say you're already probably motivated by **SOME** aspect of SUSY.



Persuasive...

- ◆ It is tempting to just buy in.





Overview:

- ◆ Where we were
- ◆ Where we are
- ◆ Where we're going

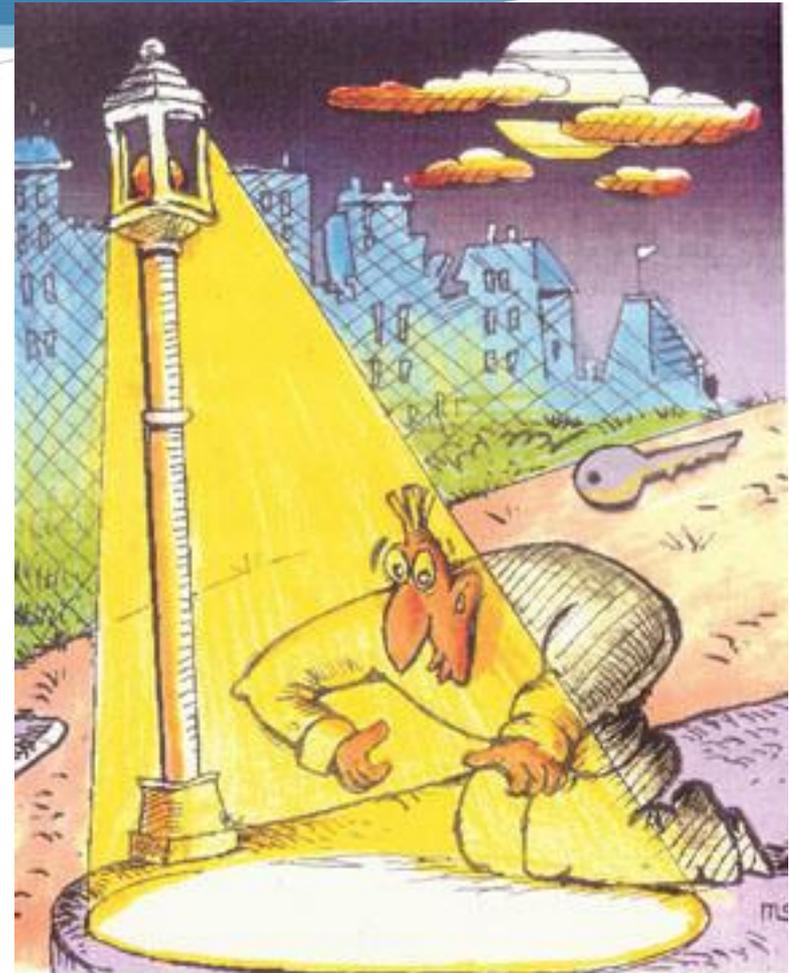


Overview:

- ◆ Where we were
 - ◆ Run I and early Run II results for SUSY
- ◆ Where we are
 - ◆ 2016 data collection
 - ◆ New results since early this year (post Moriond)
- ◆ Where we're going
 - ◆ Our future plans with what are starting to be some respectable sized 13 TeV datasets.

Where to look?

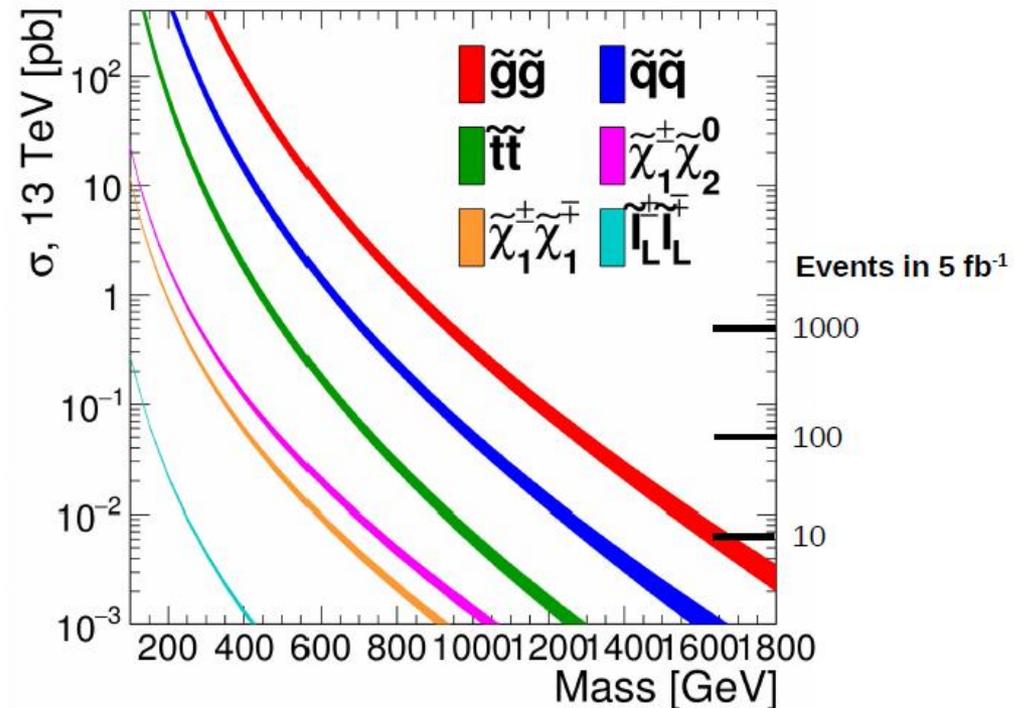
- ◆ I fully admit to having stolen this from a theory talk preRun I.
- ◆ Why look under the lamp-post? That's where the light is.
- ◆ As we gain more data, the illuminated circle, so to speak, widens and allows us access to regions we couldn't see before.



Into the LHC

- ◆ This is just meant to give a hint of why we've done what we've done.
- ◆ Clearly if you want to look for the highest cross sections you start with gluinos and squarks.

Production @ 13 TeV

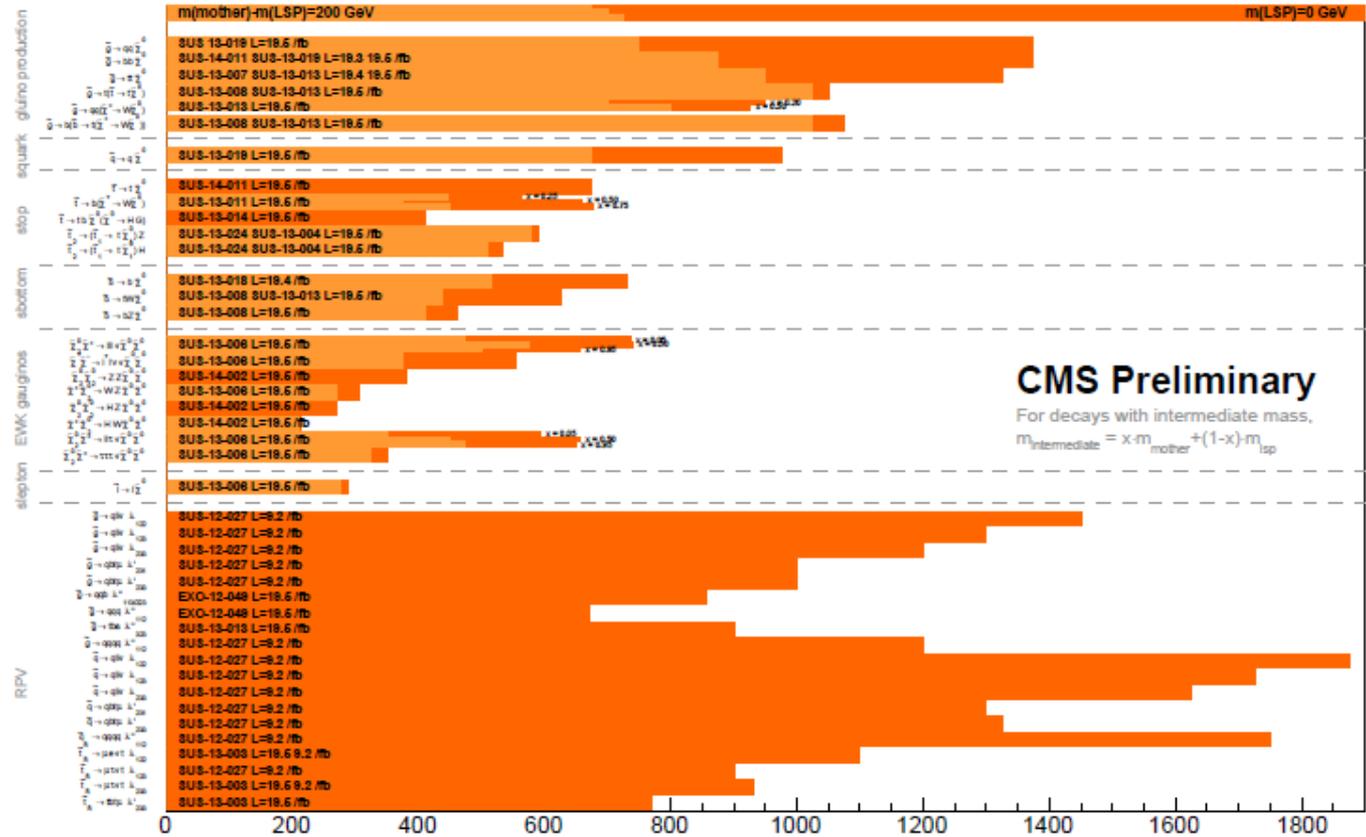


Where we were...

- ◆ A big summary of the searches for SUSY in Run I
- ◆ All SMS-es! A great leap forward in characterizing what we're actually able to say with our particular final state driven analyses.

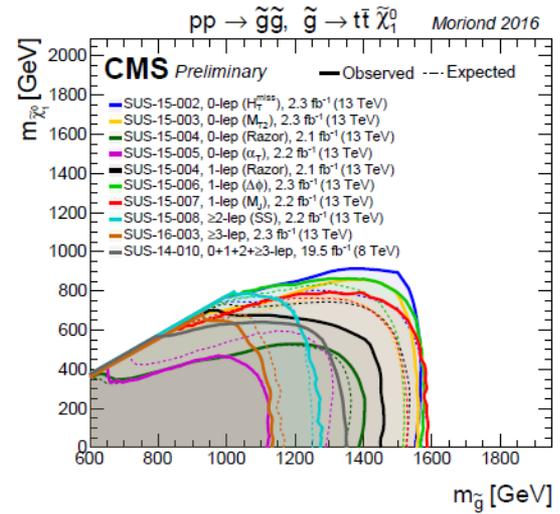
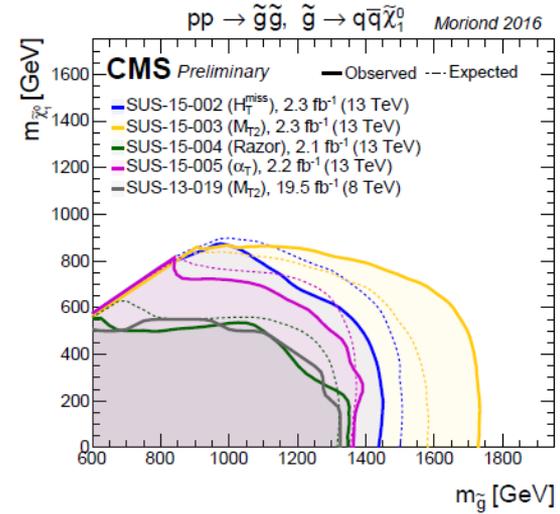
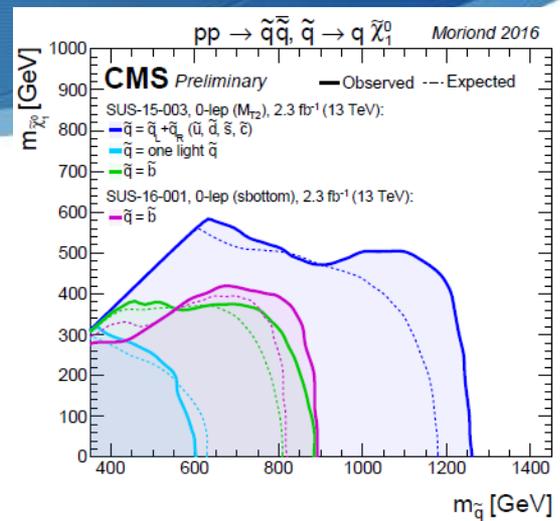
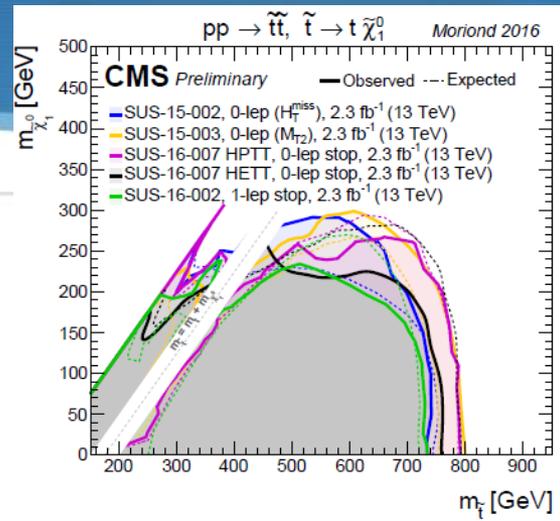
Summary of CMS SUSY Results* in SMS framework

ICHEP 2014

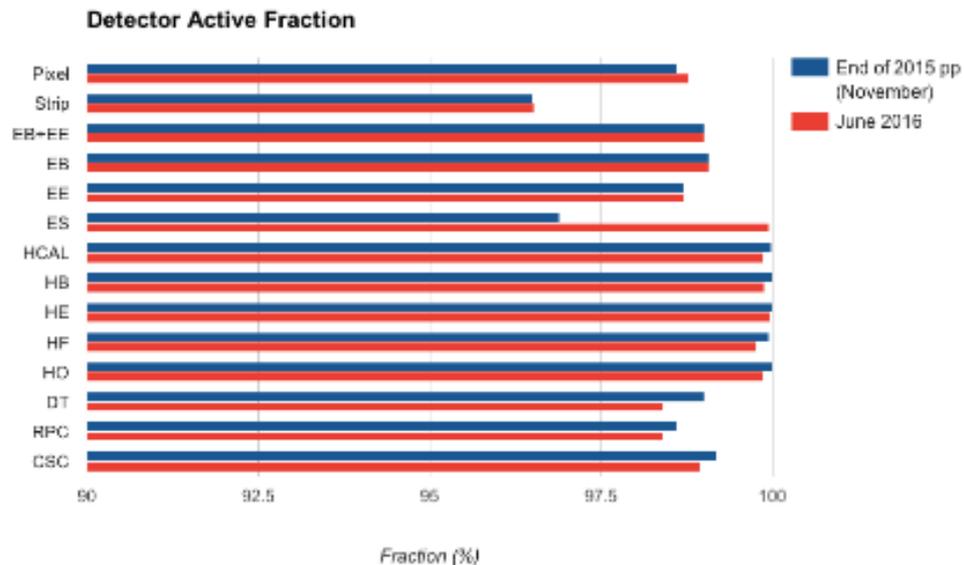
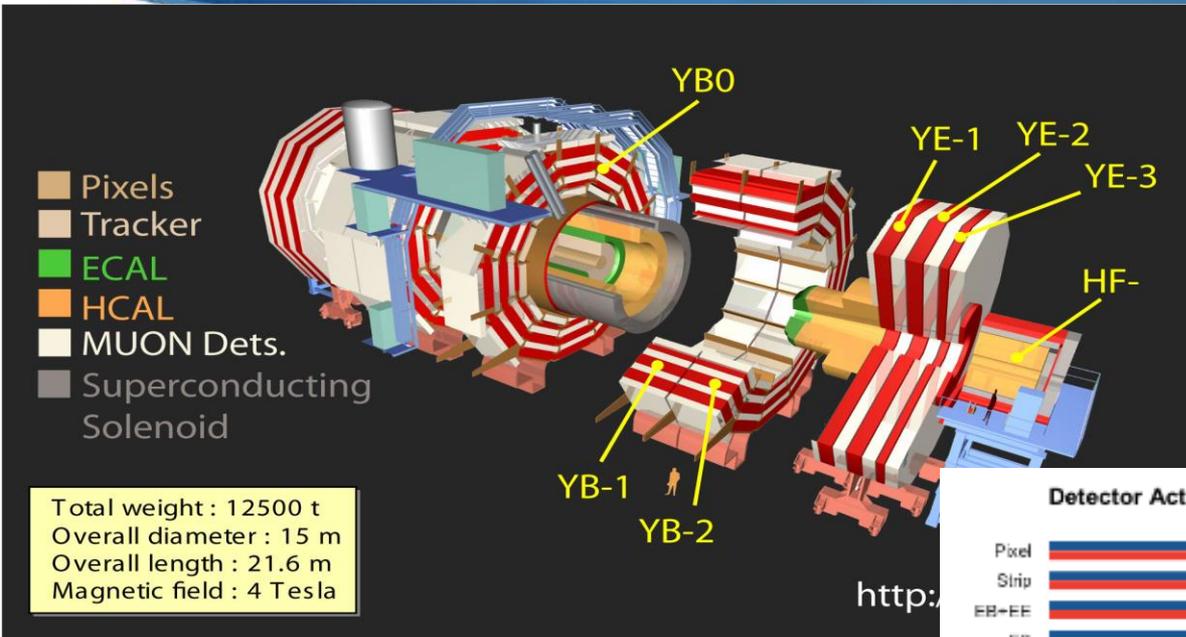


Where we were (2)

- ◆ At the end of 2015, there was a big analysis jamboree in which a lot of 13 TeV results were presented...
- ◆ And then of course there was Moriond.



Never complete without:



◆ An experimental talk is never complete without the star of our show.

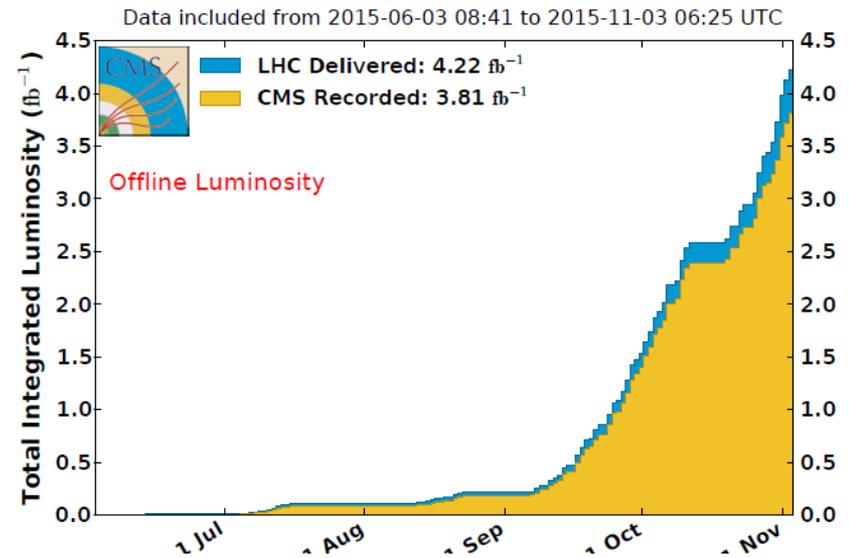


2016 Progress:

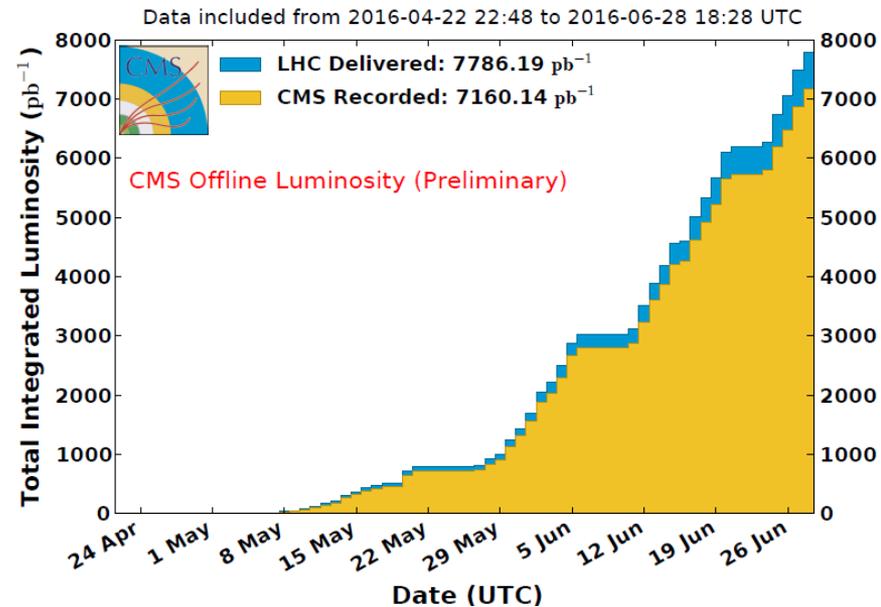


- ◆ LHC continues to provide a huge amount of data.
- ◆ With our cryo problems dealt with, CMS is recording a lot of high quality data quickly.
- ◆ Note the difference in both axes.

CMS Integrated Luminosity, pp, 2015, $\sqrt{s} = 13$ TeV

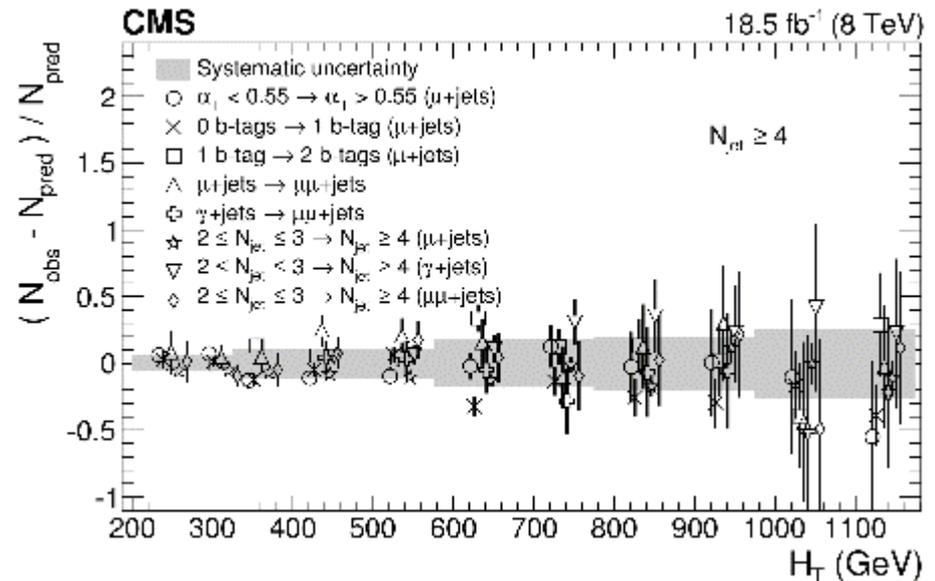


CMS Integrated Luminosity, pp, 2016, $\sqrt{s} = 13$ TeV



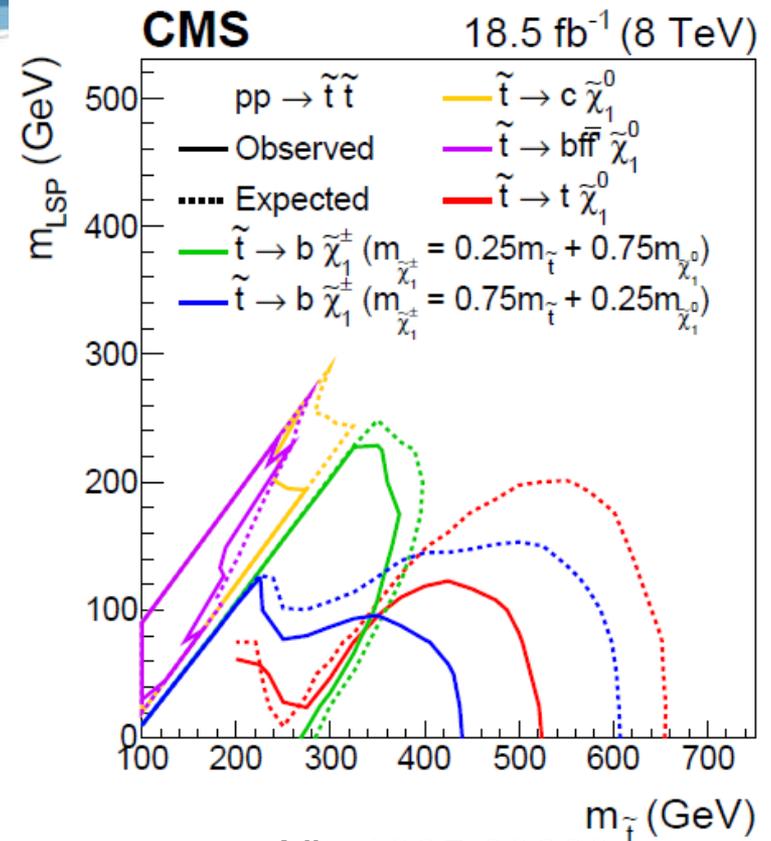
Hadronic searches

- ◆ For strong production, even in compressed scenarios, hadronic searches like α_T provide significant constraints.
- ◆ In what has become common, this analysis is performed across a variety of bins of total hadronic energy, jet multiplicity and b-tags



Results

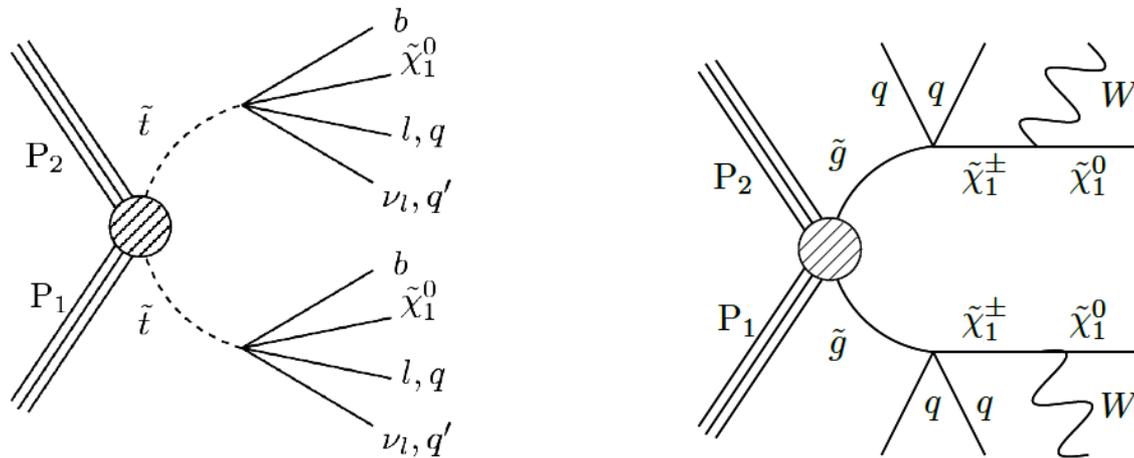
- ◆ Needed a separate slide for this, because this plot is showing what this one analysis is able to do across a variety of different scenarios.



arXiv:1605.08993

See talk by T. Sakuma

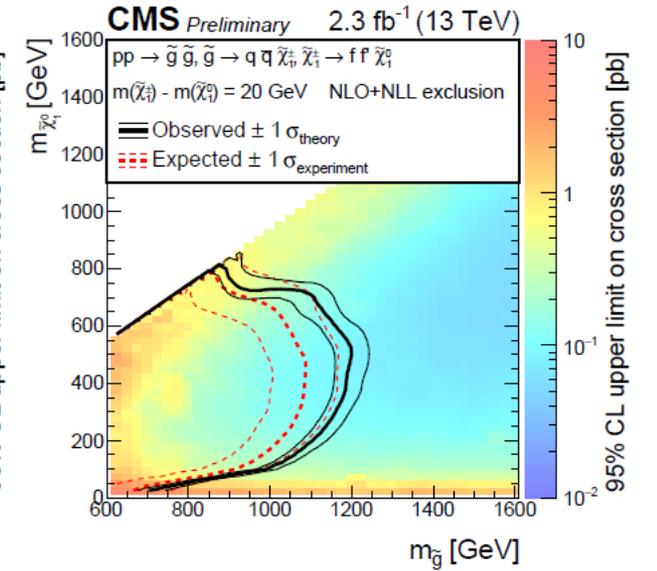
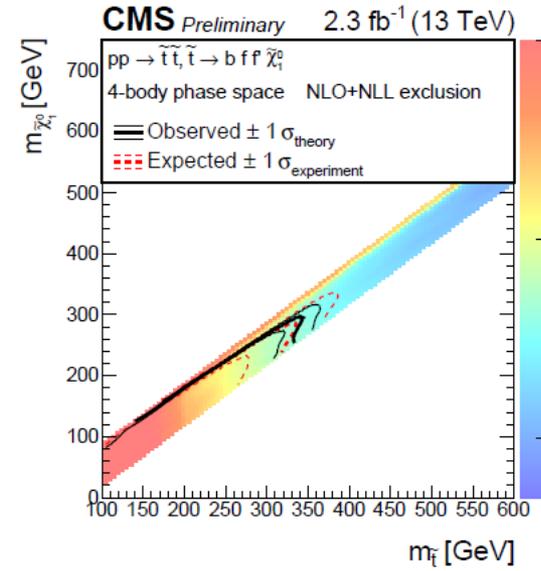
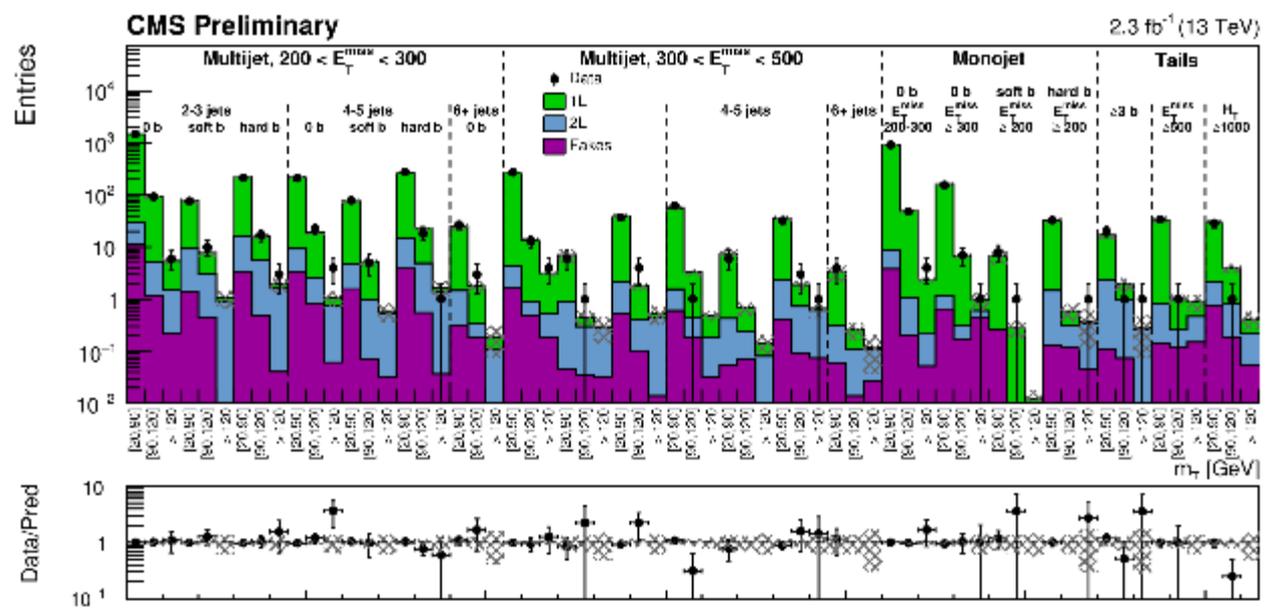
Soft leptons



- ◆ In order to maintain sensitivity in regions of phase space where the mass splittings may be small, dedicated analyses that go into the more difficult regions, like low lepton p_T are important.

Soft leptons

- ◆ Another tour de force of covering the space of jet multiplicity, missing transverse energy, and the real extrema of distributions.
- ◆ You can also see the novel slice of phase space that is uniquely excluded here.

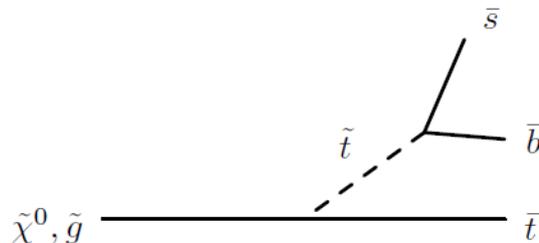




R-parity violating SUSY

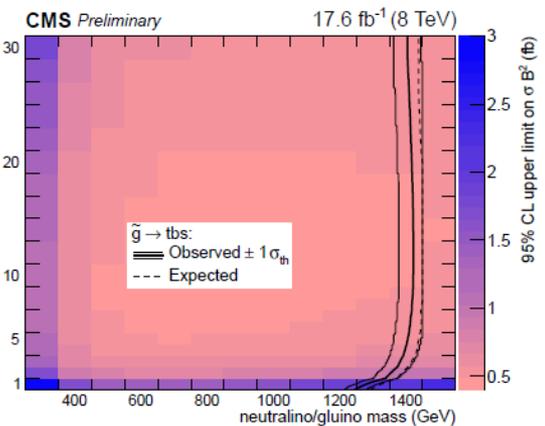
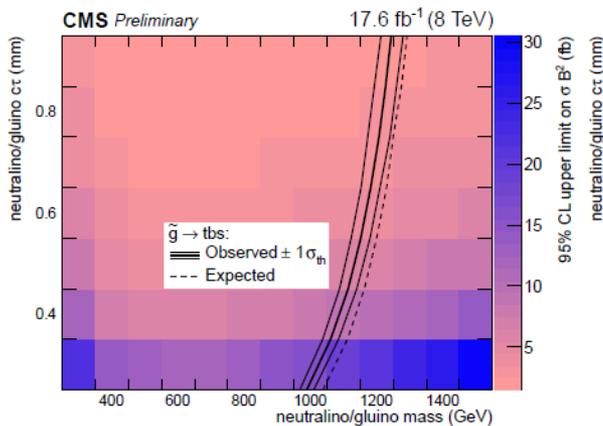
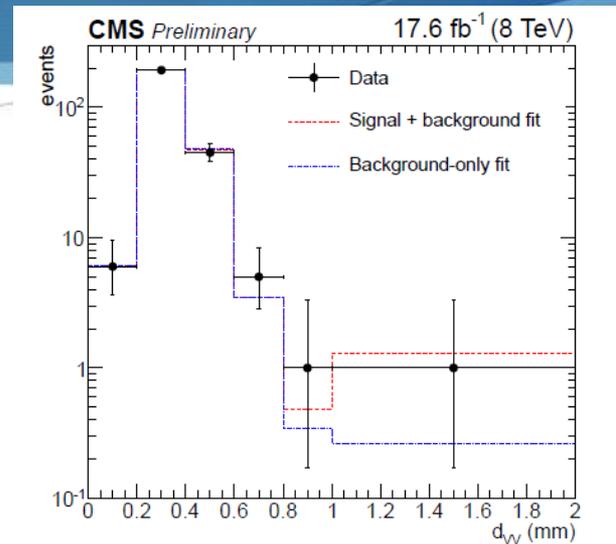
- ◆ R-parity violation experimentally can be a much different beast than our friendly R-parity conserving high missing transverse energy signatures.
- ◆ This particular effort searches for pair produced LSPs which are long lived, which thus gives rise to pairs of displaced vertices as a signature.

SUS-14-020

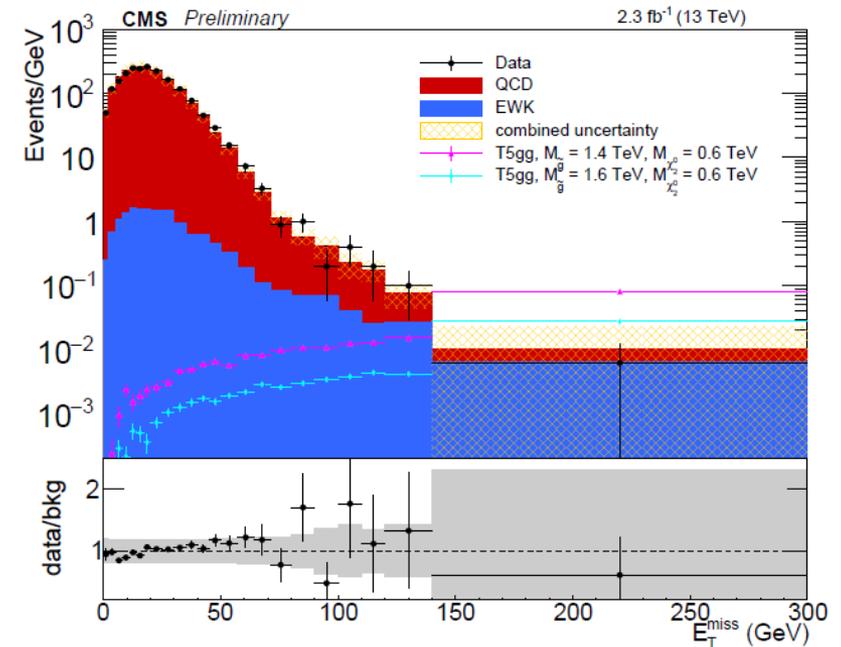
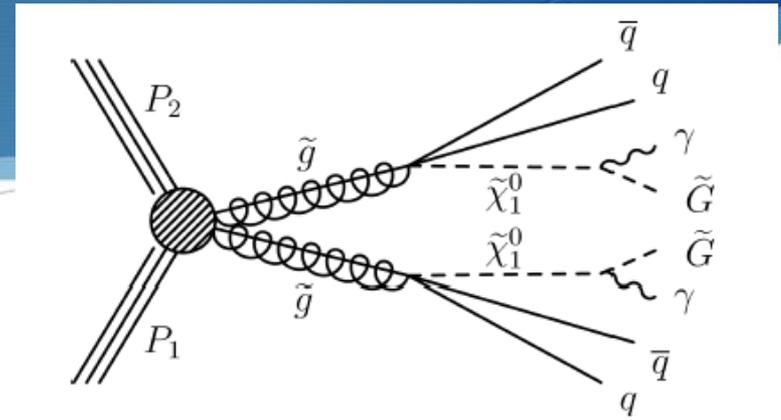


Displaced Vertices

- Analysis makes use of custom secondary vertex reconstruction, which is similar to that used in b-tagging, but without some of the kinematic assumptions



Photons and MET

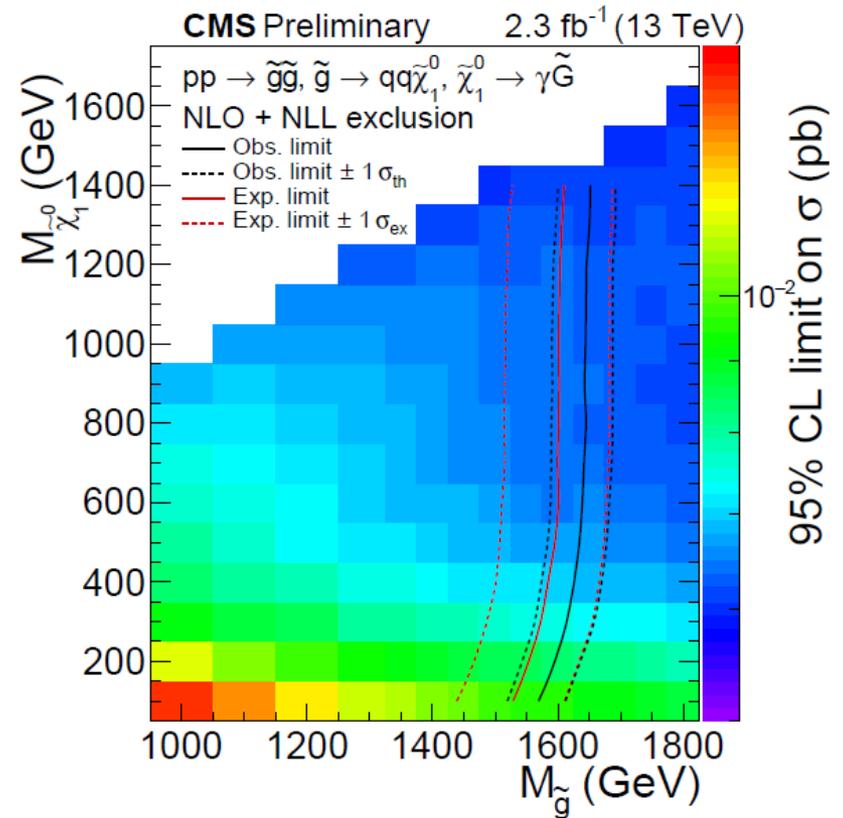


- ◆ A tried and true signature for GMSB SUSY.
- ◆ MET shapes are modeled using data control samples with no true missing transverse energy.
- ◆ Continuum backgrounds are large, and the tail of the distribution is the most sensitive region.



Photons and MET

- ◆ Note that while I showed the SMS strong production diagram, there's nothing in this analysis that is particular to that final state.
- ◆ With more data, and better understanding of some of the shape related uncertainties, this can also be applied to electroweak production.



SUS-15-012

See talk by J.

Schulz



PMSSM

- ◆ A pretty innovative idea, given our data, what can we really generally say about the constraints that we've placed on the full SUSY space?
- ◆ Not every analysis was incorporated, but a pretty wide net was cast.

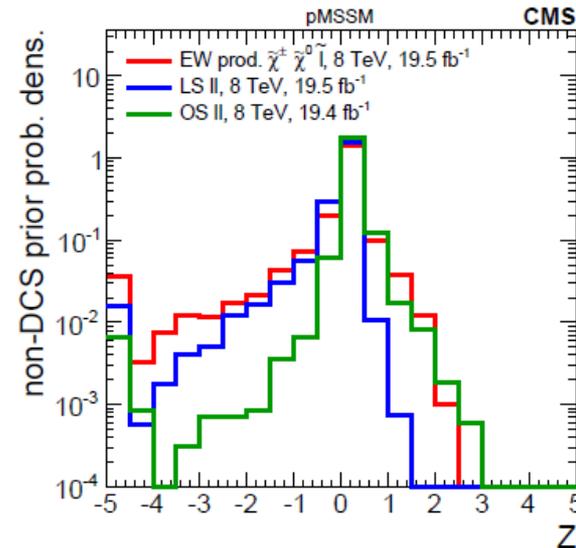
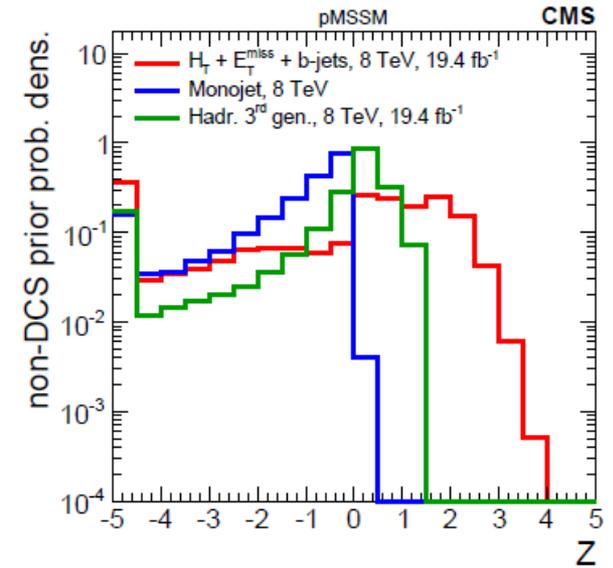
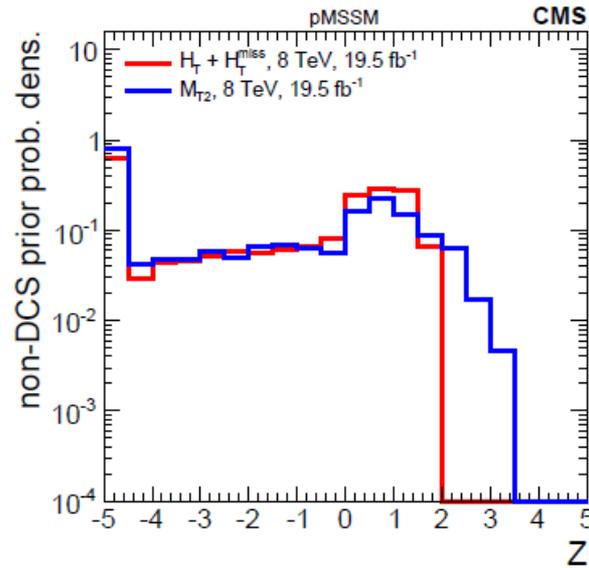
Analysis	\sqrt{s} [TeV]	\mathcal{L} [fb^{-1}]	Likelihood
Hadronic $H_T + H_T^{\text{miss}}$ search [8]	7	4.98	counts
Hadronic $H_T + E_T^{\text{miss}}$ + b-jets search [9]	7	4.98	counts
Leptonic search for EW prod. of $\tilde{\chi}^0, \tilde{\chi}^\pm, \tilde{1}$ [10]	7	4.98	counts
Hadronic $H_T + H_T^{\text{miss}}$ search [11]	8	19.5	counts
Hadronic M_{T2} search [12]	8	19.5	counts
Hadronic $H_T + E_T^{\text{miss}}$ + b-jets search [13]	8	19.4	χ^2
Monojet searches [14]	8	19.7	binary
Hadronic third generation squark search [15]	8	19.4	counts
OS dilepton (OS II) search [16] (counting experiment only)	8	19.4	counts
LS dilepton (LS II) search [17] (only channels w/o third lepton veto)	8	19.5	counts
Leptonic search for EW prod. of $\tilde{\chi}^0, \tilde{\chi}^\pm, \tilde{1}$ [18] (only LS, 3 lepton, and 4 lepton channels)	8	19.5	counts
Combination of 7 TeV searches	7	—	binary
Combination of 7 and 8 TeV searches	7, 8	—	binary

arXiv:1606.03577,
see talk by J. Sonnewald

PMSSM (2)

◆ There's a lot that COULD be said about both how this work was done and what it says in the end.

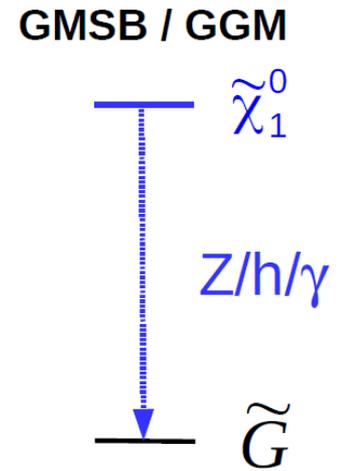
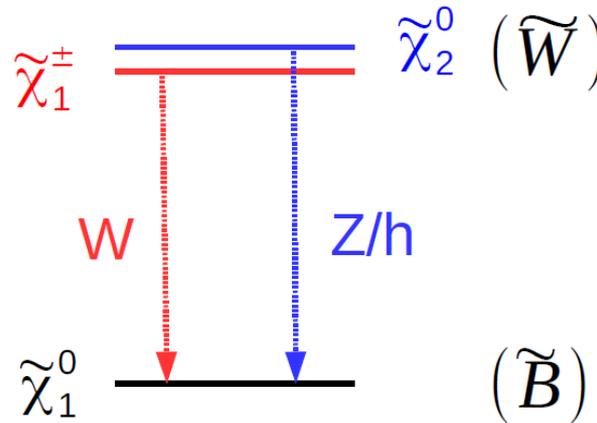
◆ I'll be brief here...



arXiv:1606.03577,
see talk by J. Sonnewald

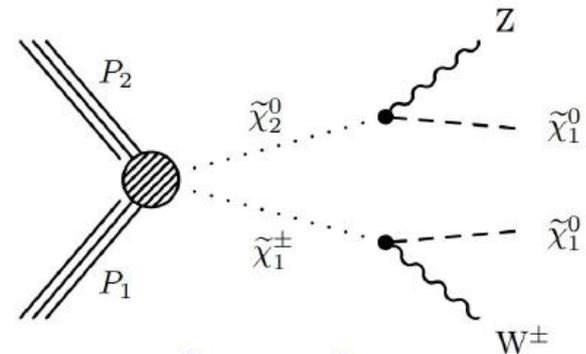
Plans

- ◆ Combinations are key.
- ◆ One of the only ways in which to form a consistent picture:
 - ◆ Cover all boson decay modes
 - ◆ Kinematics
 - ◆ Neutralino branching fractions

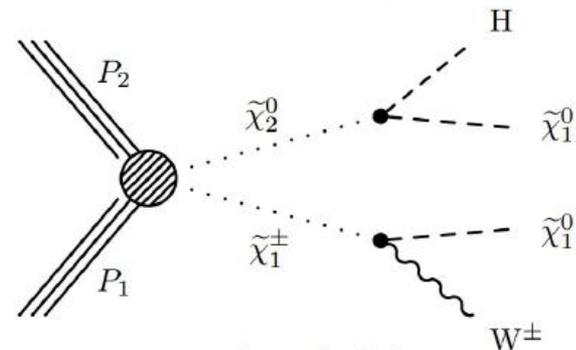


Combinations

- ◆ Note the ones I'm mentioning here.
- ◆ These are identically those production modes that didn't constrain the PMSSM very much, there's a reason for that.



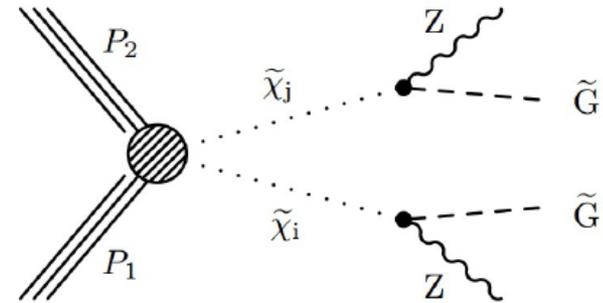
$3\ell, OS\ 2\ell\ onZ$
Soft OS 2l for compressed ?



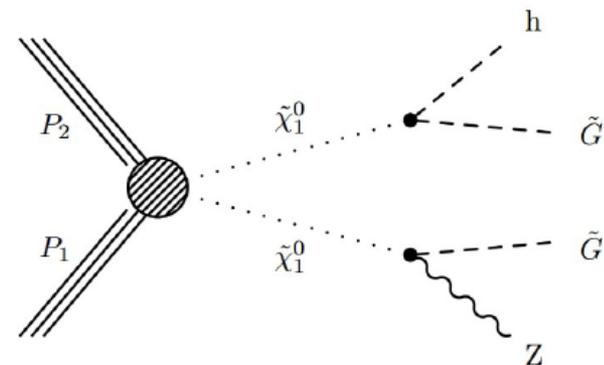
$3-4\ell, 1\ell+bb$

Combinations

- ◆ Note the ones I'm mentioning here.
- ◆ Careful planning and coordination between analyses facilitates combination (also making sure various analyses are disjoint)



4 ℓ , OS 2 ℓ onZ



3-4 ℓ , OS 2 ℓ onZ



Advertisement:

- ◆ I've purposefully kept this in generalities. There are dedicated talks...
 - ◆ Search for supersymmetry in the single-lepton final state with CMS, C. Seitz (DESY)
 - ◆ Search for SUSY in hadronic final states with the AlphaT variable at CMS, T. Sakuma (Univ. of Bristol)
 - ◆ Search for supersymmetry in hadronic final states with the MT2 variable, M. Masciovecchio (ETH Zürich)
 - ◆ Search for supersymmetry in events with photons and missing transverse momentum, J. Schulz (RWTH, I. Physik. Inst.)
 - ◆ Search for supersymmetry in the multijet and missing transverse momentum channel in pp collisions at 13 TeV, K. Pedro
 - ◆ Search for supersymmetry in events with two or more leptons in pp collisions at 13 TeV at CMS, J. Hoss (ETH Zürich)
 - ◆ Phenomenological MSSM interpretation of CMS results, J. Sonneveld (University of Hamburg)
 - ◆ Inclusive searches for SUSY using the razor variables in CMS, J. Duarte (California Inst. of Tech.)
 - ◆ Search for third generation squarks in pp collisions at 13 TeV at CMS, F. Lacroix (UC Riverside)
 - ◆ MSSM Higgs searches with the CMS experiment, Ye Chen (Inst. of High Energy Physics)



Summary

- ◆ We have done, and continue to do a very successful job constraining strong production.
- ◆ We're entering the era where we'll be able to say interesting things about electroweak production.
- ◆ Armed with 2016 data, you should keep in mind that the combinations foreseen are planned for later/ the end of this year.





◆ BACKUPS