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:

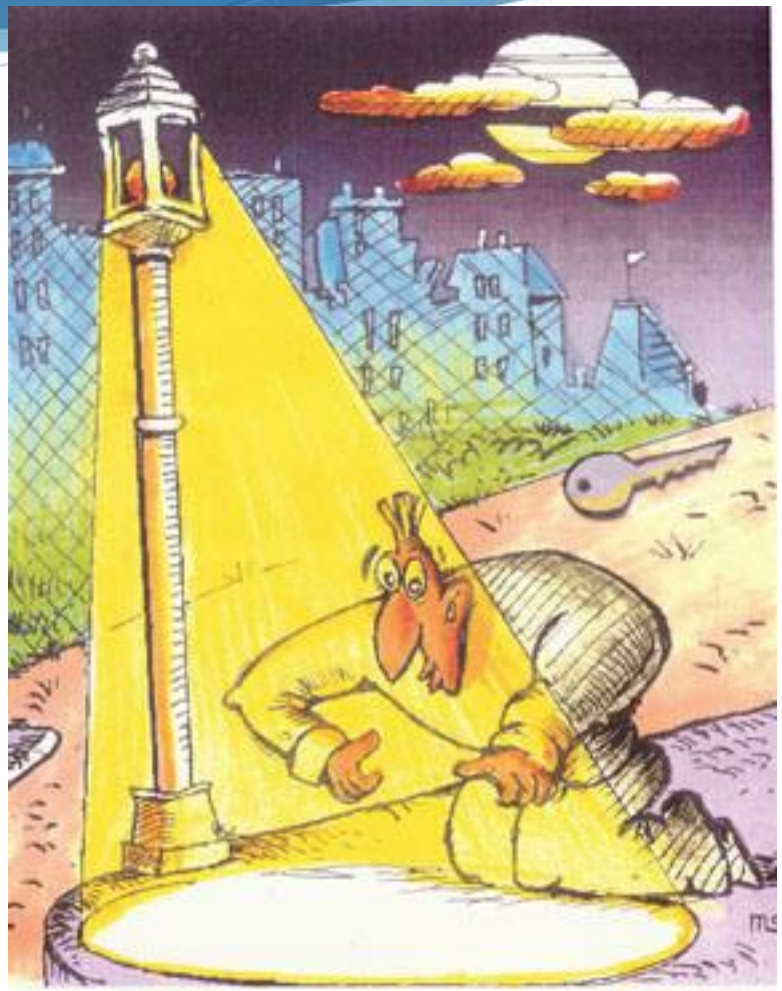
- Where we were
- Where we are
- Where we're going

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.

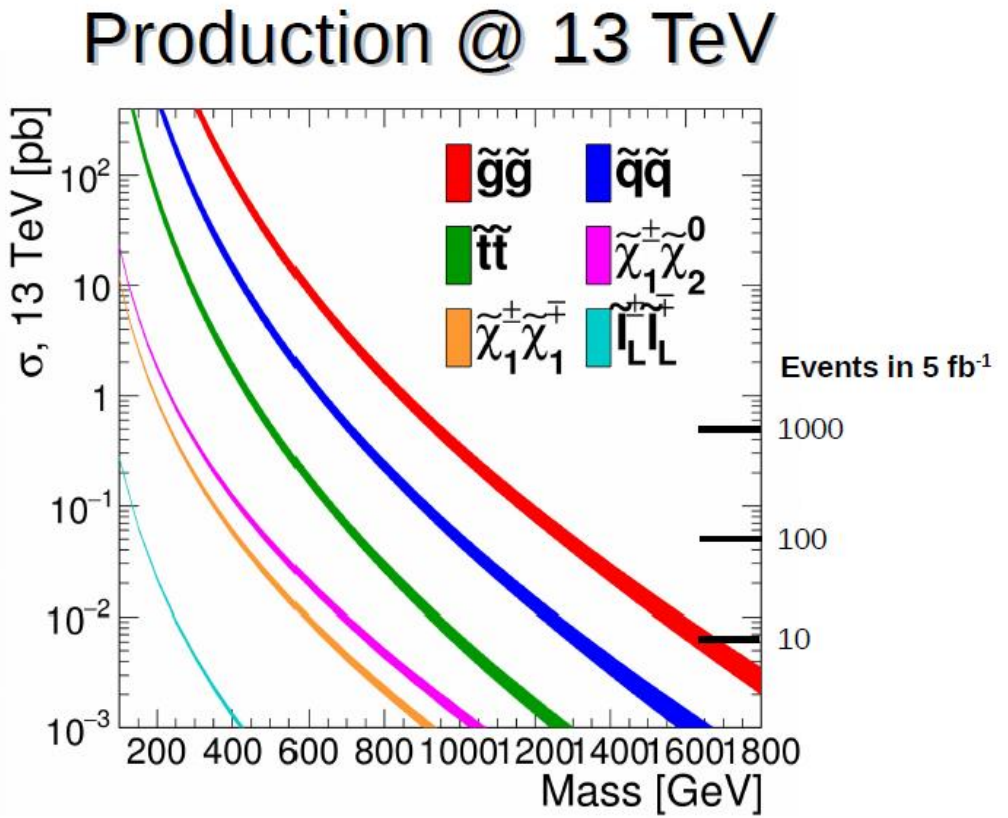
Where to look?

- 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

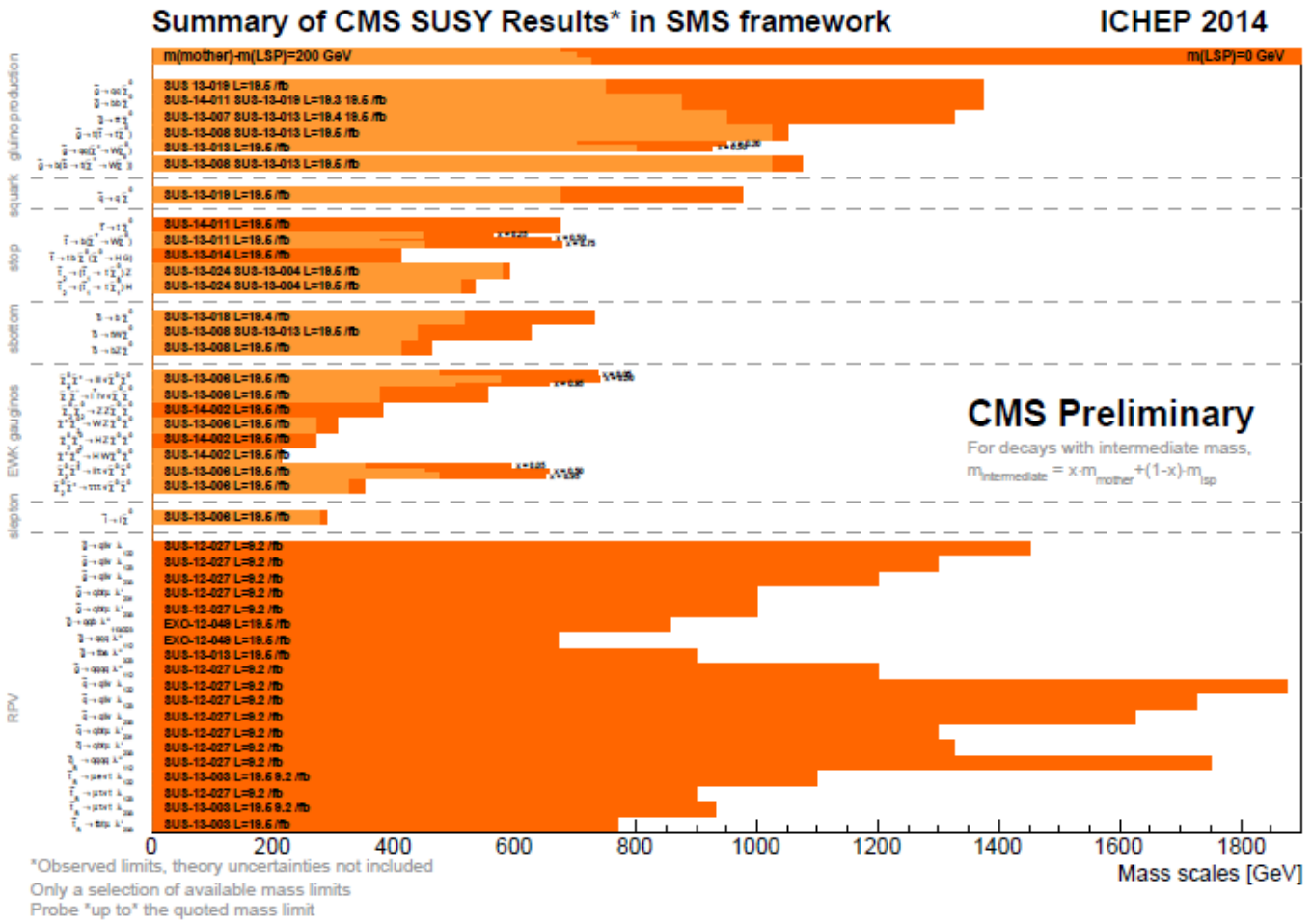
- This is just meant to give a hint of why we've done what we've done.
- Clearly if you want to look for the highest cross sections you start with gluinos and squarks.



https://twiki.cern.ch/twiki/bin/view/LHCPhysics/SUSYCrossSections

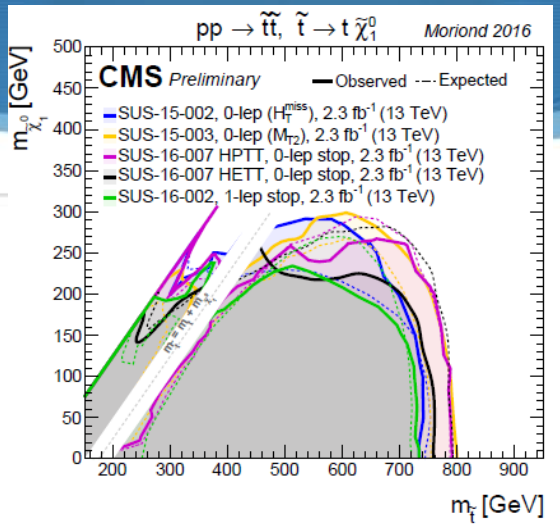
Where we were…

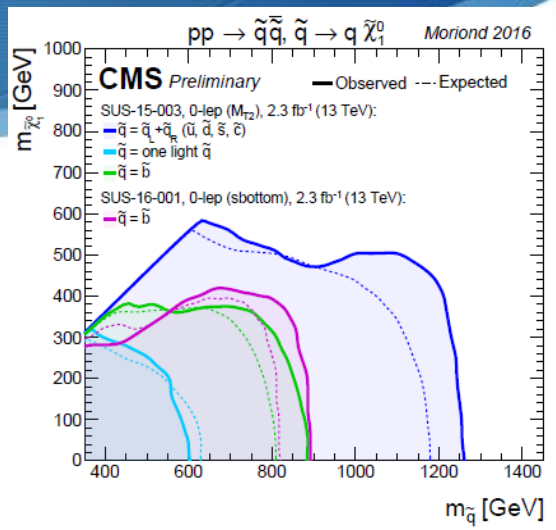
- A big summary of the searches for SUSY in Run I
- All SMS-es! A great leap forward in characterizing what we're actually able to say with our particular final state driven analyses.

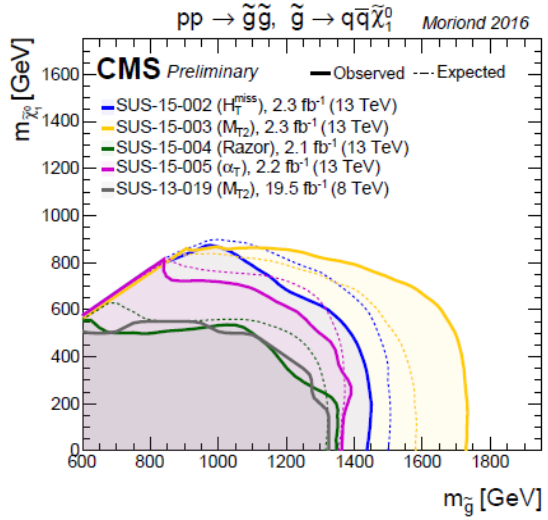


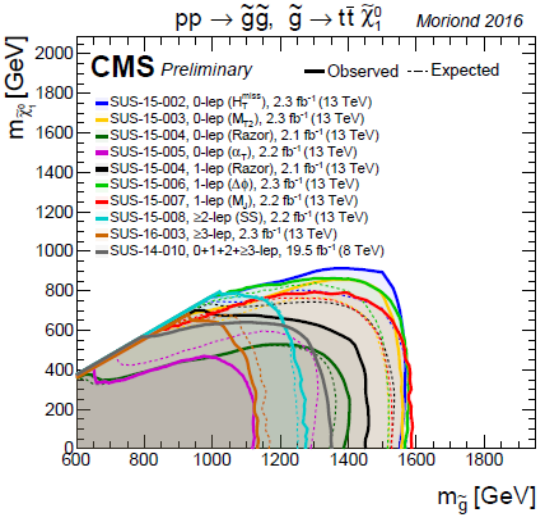
Where we were (2)

- 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.

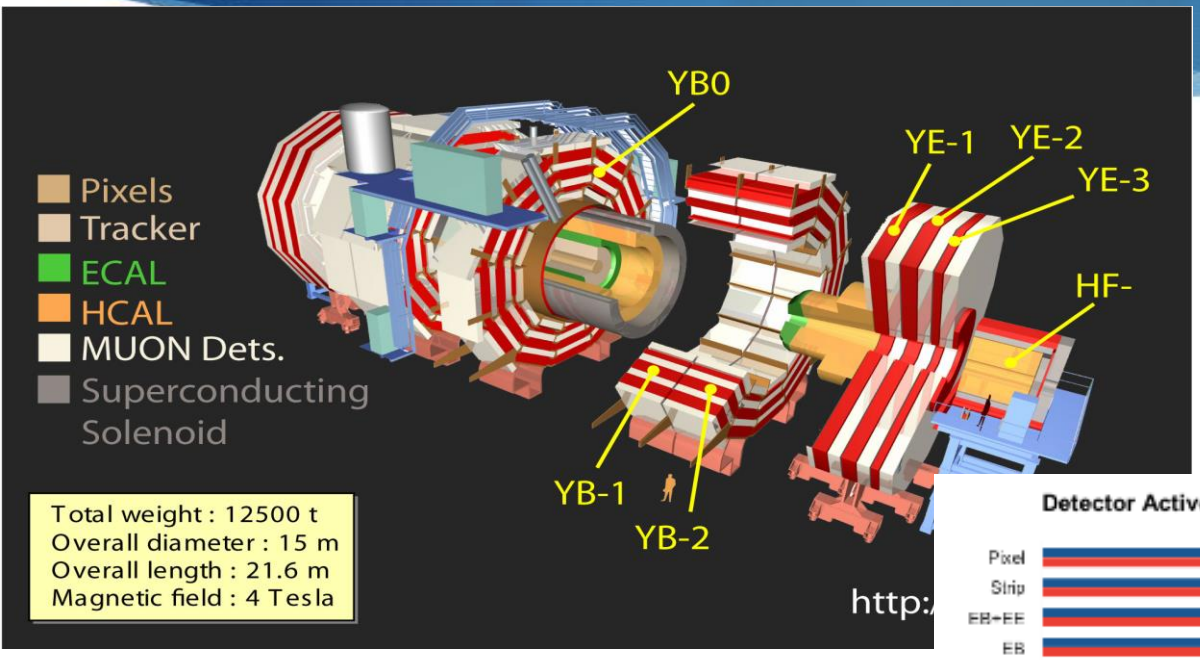


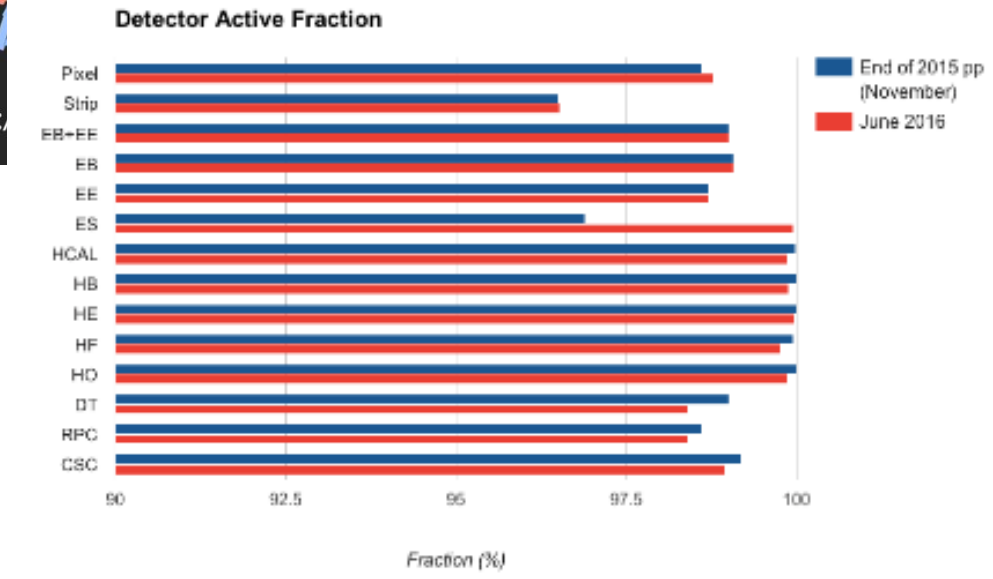






Never complete without:

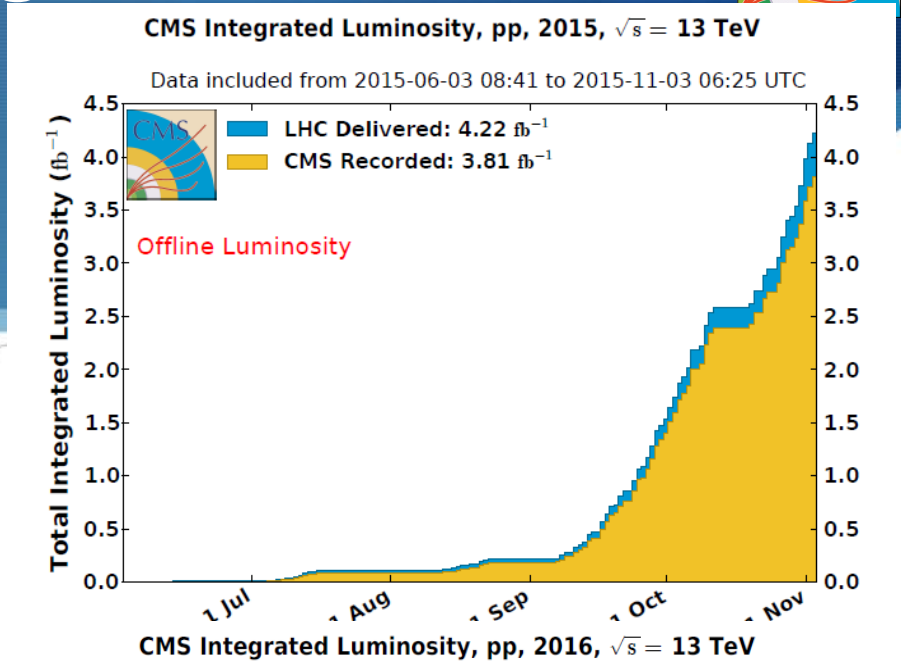


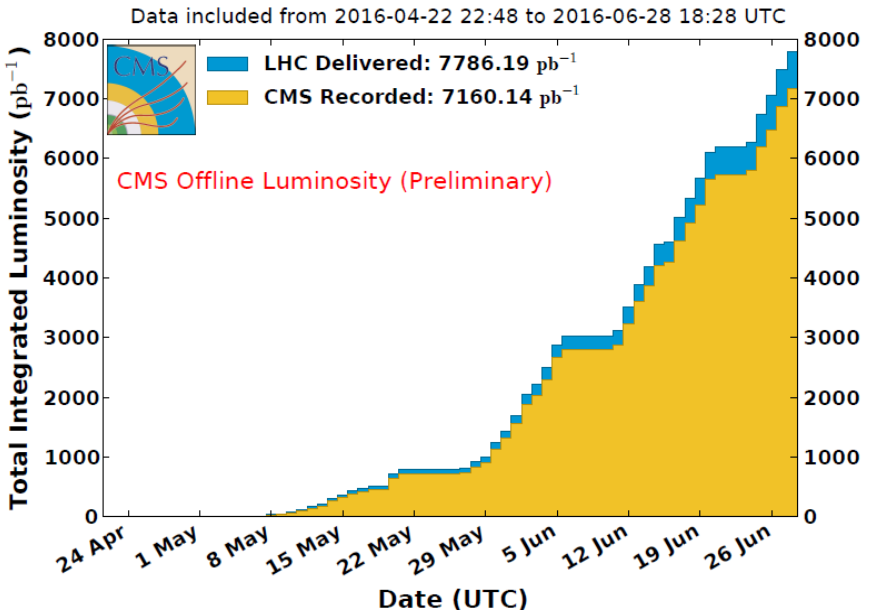


- An experimental talk is never complete without the star of our show.

2016 Progress:

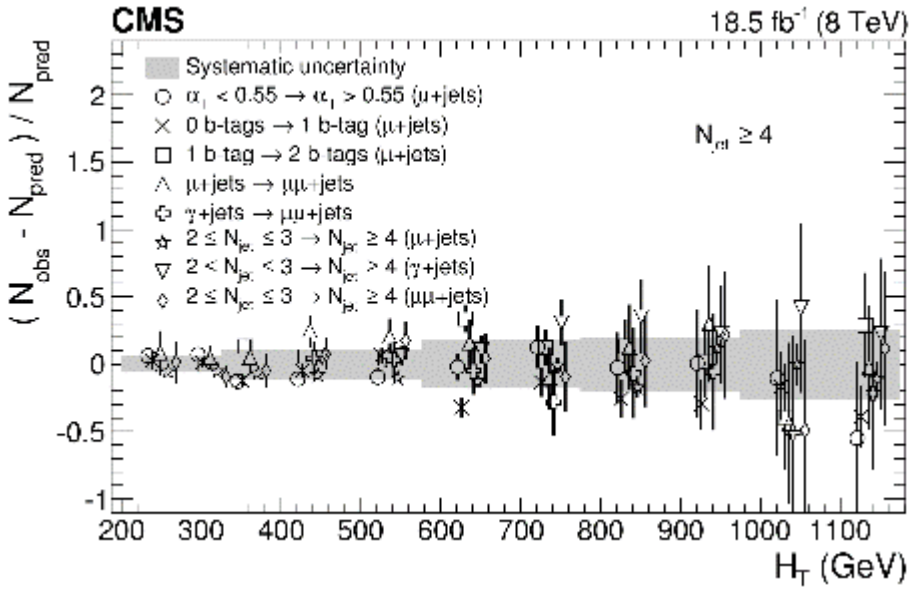
- LHC continues to provide a huge amount of data.
- With our cryo problems dealt with, CMS is recording a lot of high quality data quickly.
- Note the difference in both axes.





Hadronic searches

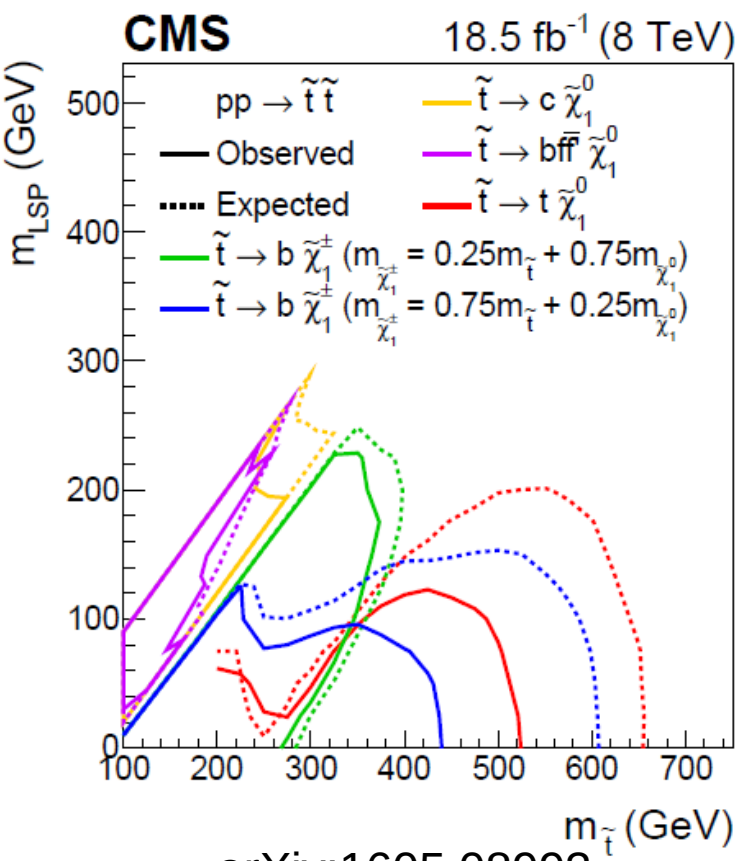
- For strong production, even in compressed scenarios, hadronic searches like α_T provide significant constraints.
- In what has become common, this analysis is performed across a variety of bins of total hadronic energy, jet multiplicity and b-tags



arXiv:1605.08993
See talk by T. Sakuma

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.



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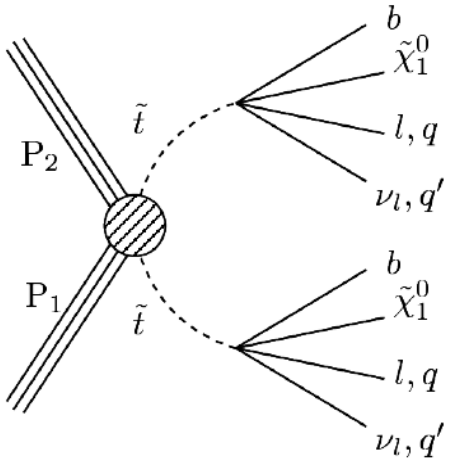
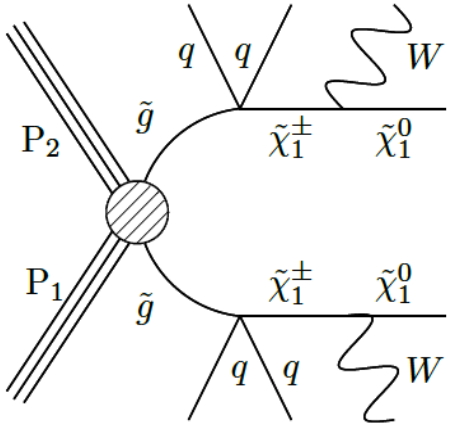
Soft leptons



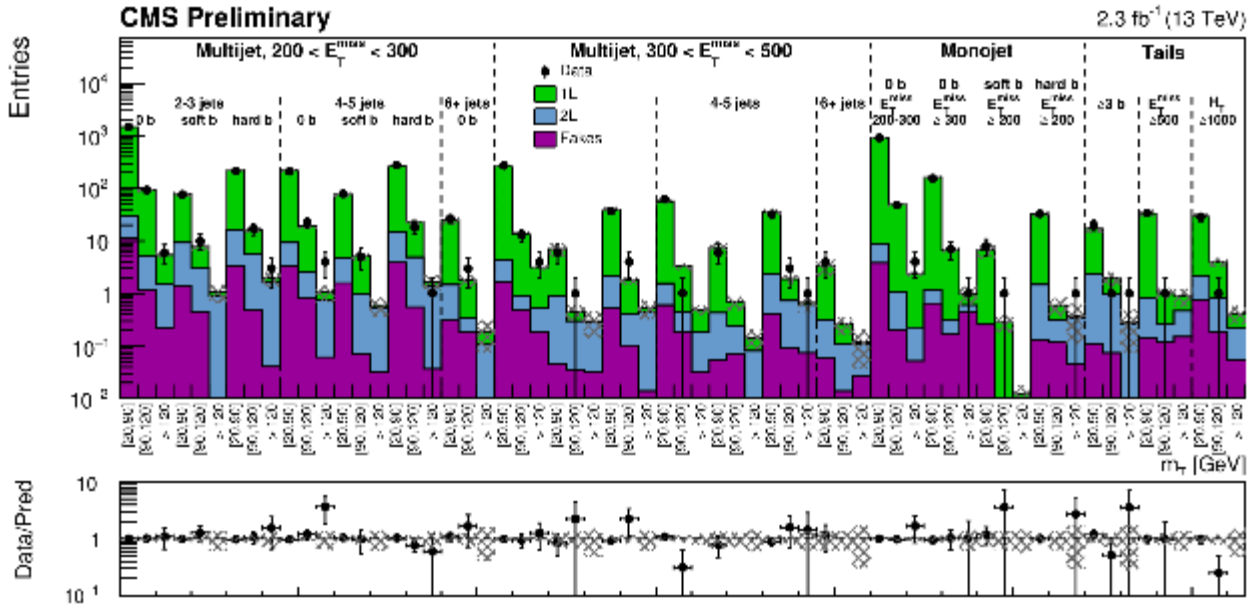


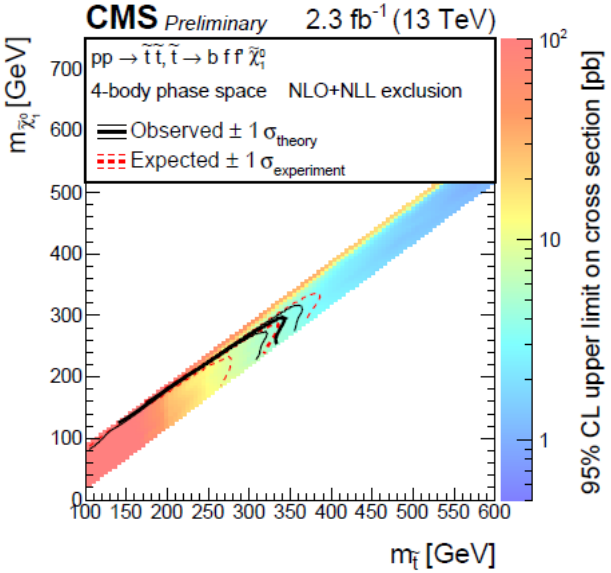
- In order to maintain sensitivity in regions of phase space where the mass splittings may be small, dedicated analyses that go into the more difficult regions, like low lepton p_T are important.

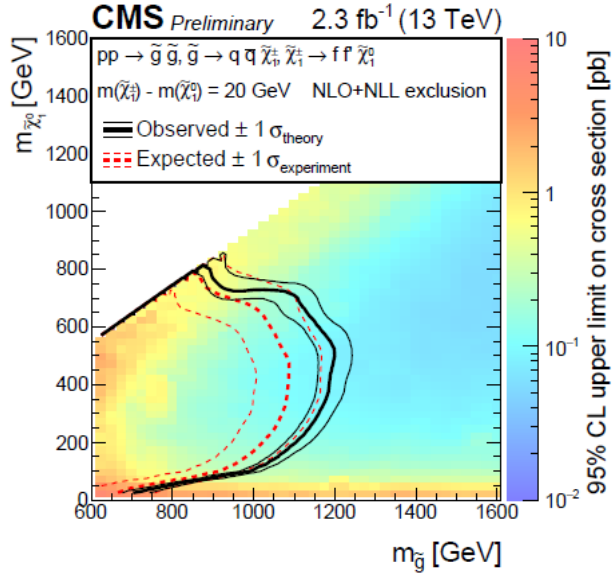
Soft leptons

- 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.

SUS-16-011



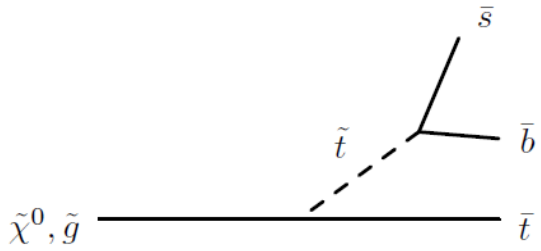




R-parity violating SUSY

- 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.

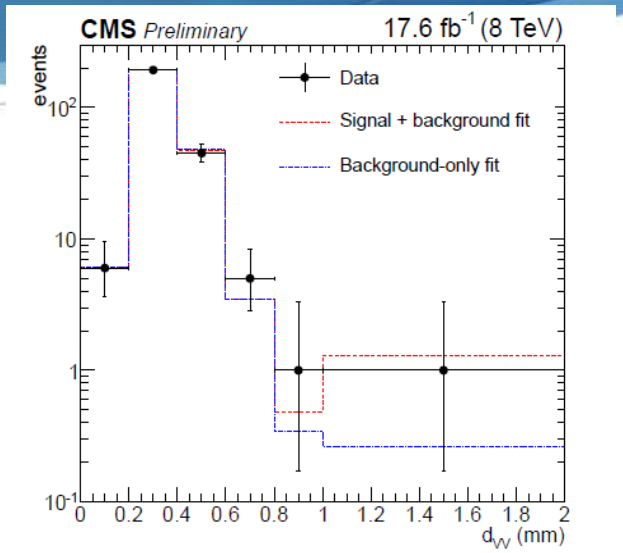
SUS-14-020

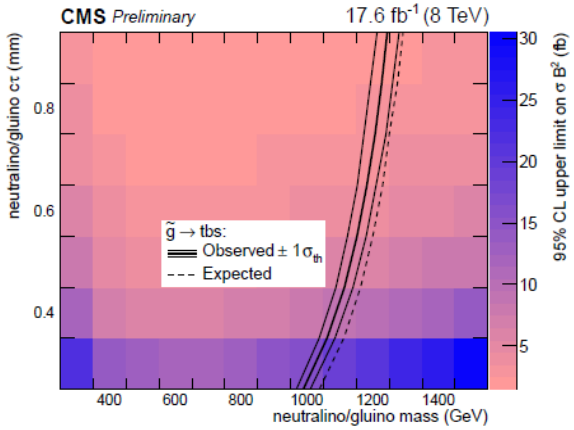


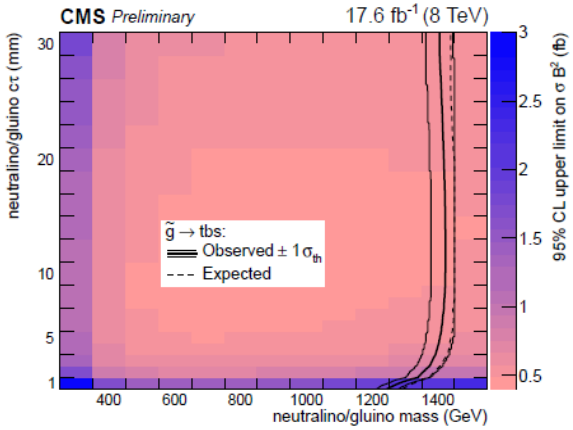
Displaced Vertices

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

SUS-14-020

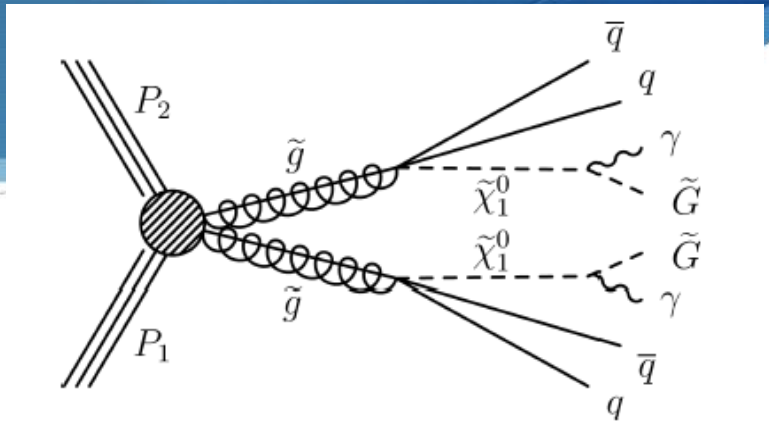


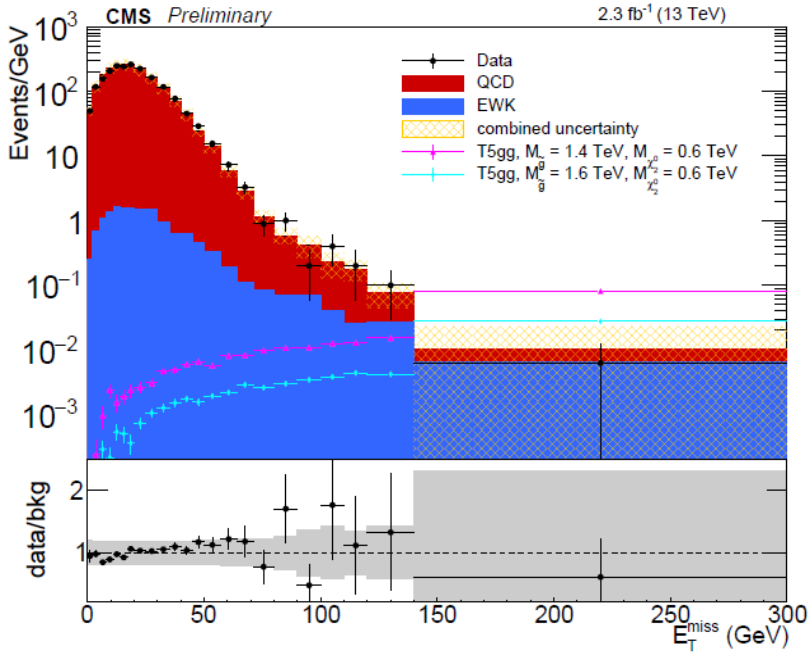




Photons and MET

- 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.

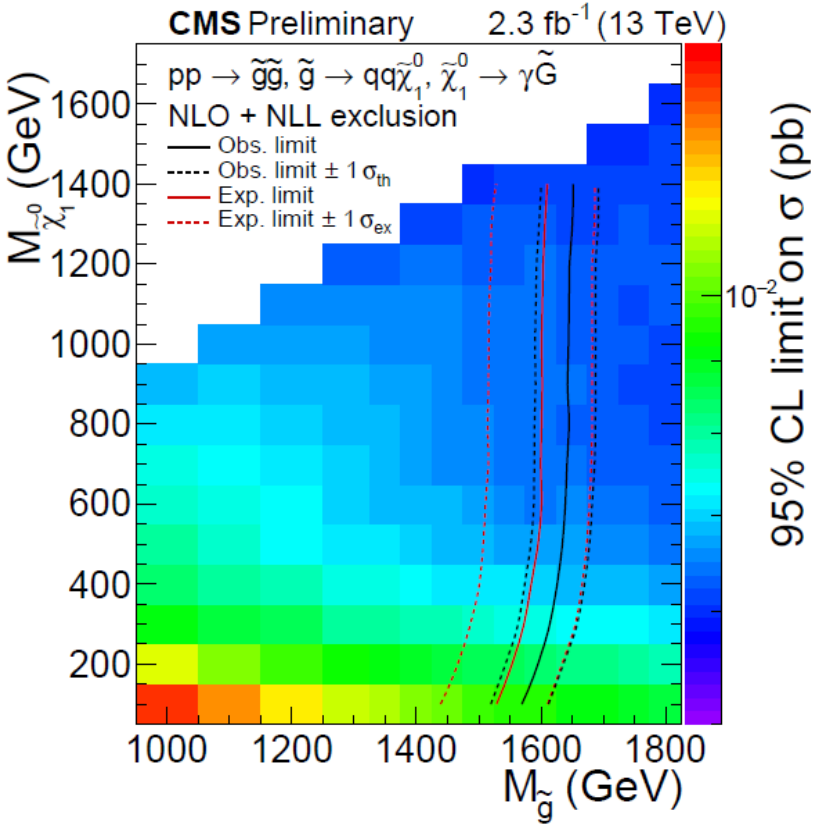




SUS-15-012
See talk by J. Schulz

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

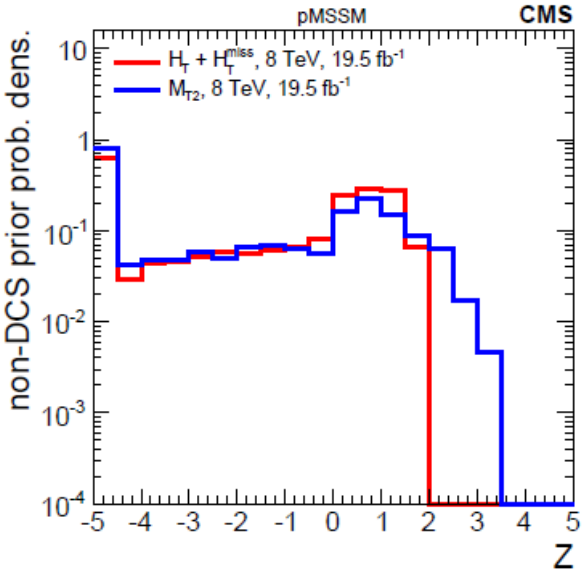
- A pretty innovative idea, given our data, what can we really generally say about the constraints that we've placed on the full SUSY space?
- Not every analysis was incorporated, but a pretty wide net was cast.

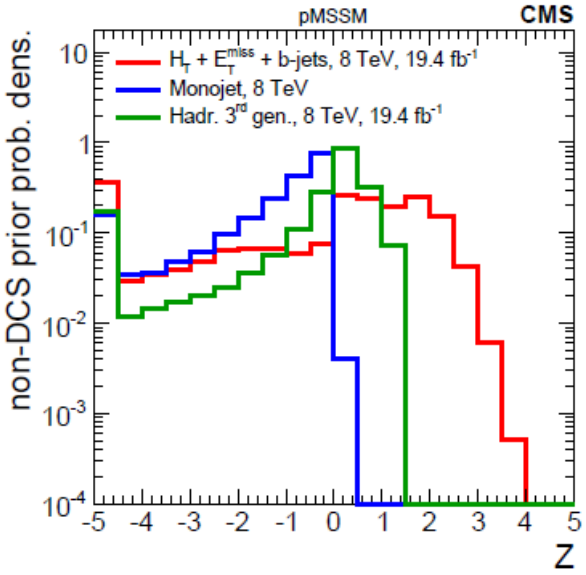
Analysis	$\sqrt{s}$ [TeV]	$\mathcal{L}$ [fb^{-1}]	Likelihood
Hadronic $H_T + H_T^{miss}$ search [8]	7	4.98	counts
Hadronic $H_T + E_T^{miss}$ + b-jets search [9]	7	4.98	counts
Leptonic search for EW prod. of $\tilde{\chi}^0, \tilde{\chi}^{\pm}, \tilde{l}$ [10]	7	4.98	counts
Hadronic $H_T + H_T^{miss}$ search [11]	8	19.5	counts
Hadronic M_{T2} search [12]	8	19.5	counts
Hadronic $H_T + E_T^{miss}$ + 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 ll) search [16] (counting experiment only)	8	19.4	counts
LS dilepton (LS ll) search [17] (only channels w/o third lepton veto)	8	19.5	counts
Leptonic search for EW prod. of $\tilde{\chi}^0, \tilde{\chi}^{\pm}, \tilde{l}$ [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

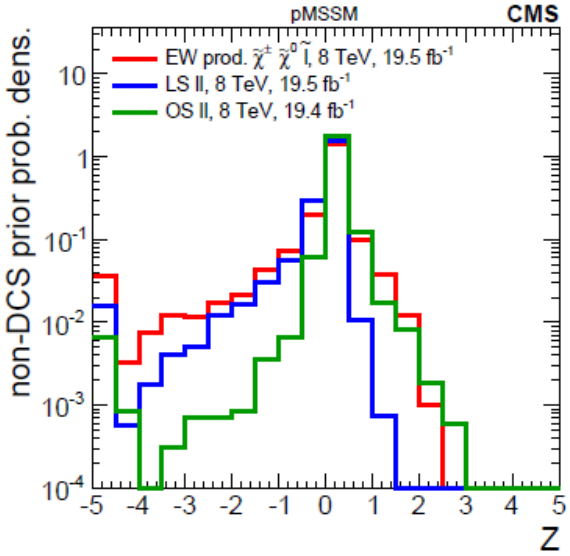
arXiv:1606.03577,
see talk by J. Sonneweld

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…



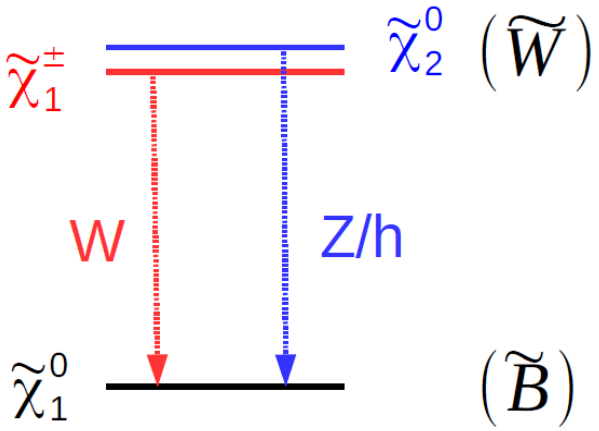


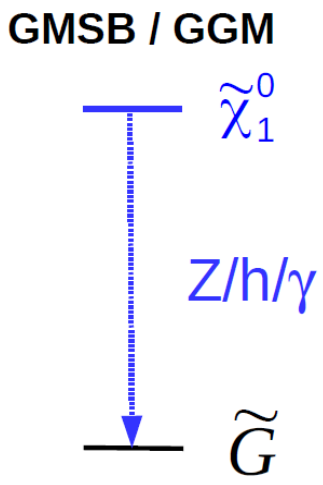


arXiv:1606.03577,
see talk by J. Sonneweld

Plans

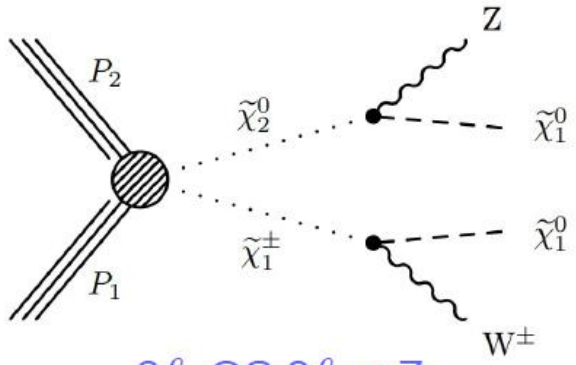
- Combinations are key.
- One of the only ways in which to form a consistent picture:
  - Cover all boson decay modes
  - Kinematics
  - Neutralino branching fractions



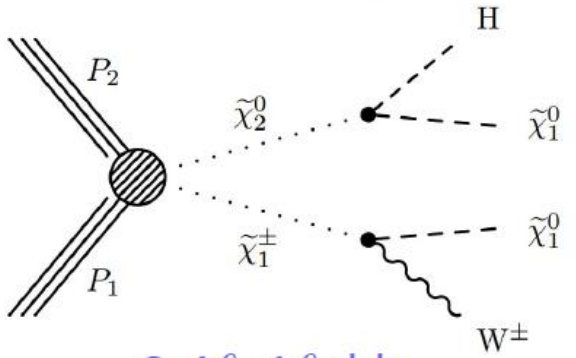


Combinations

- 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.



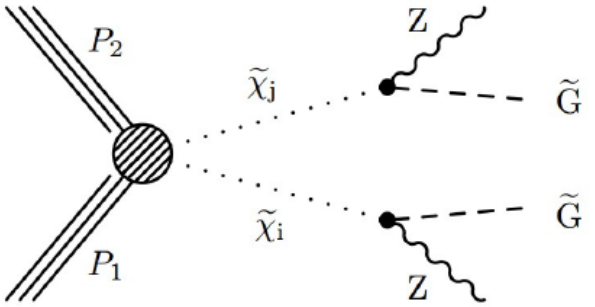
3ℓ, OS 2ℓ onZ
Soft OS 2l for compressed ?



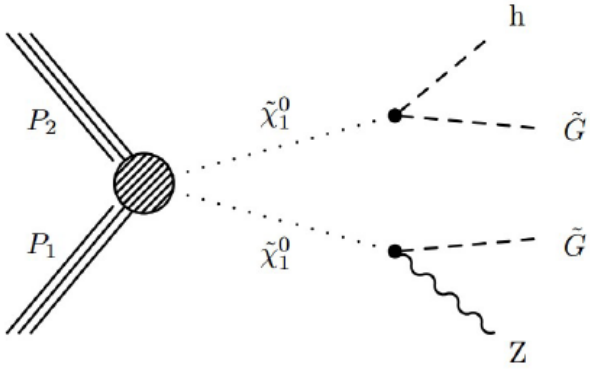
3-4ℓ, 1ℓ+bb

Combinations

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



4ℓ, OS 2ℓ onZ



3-4ℓ, OS 2ℓ 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