SANTIAGO FOLGUERAS (PURDUE UNIVERSITY)

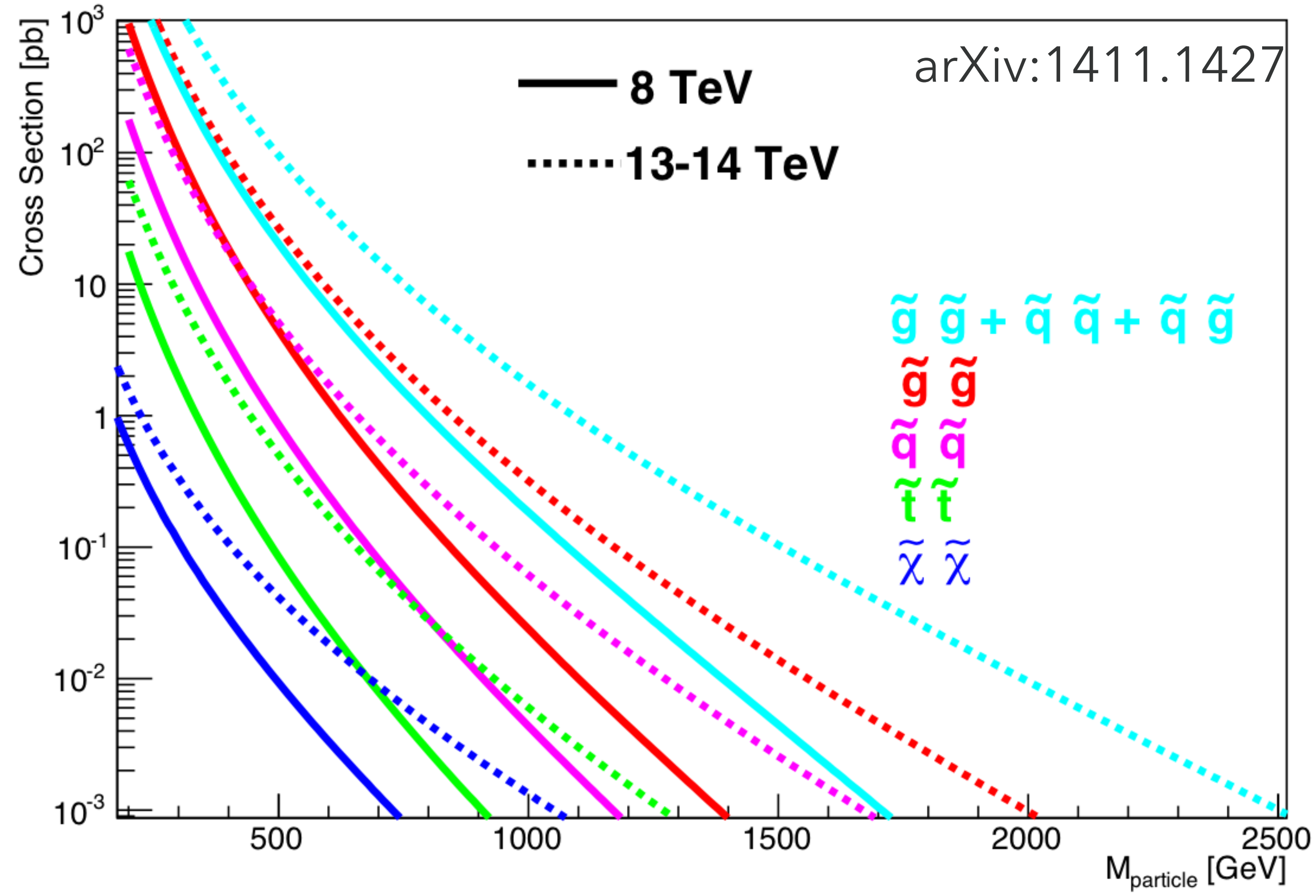
ON BEHALF OF THE CMS COLLABORATION

SEARCHES FOR ELECTROWEAK PRODUCTION OF SUSY AT CMS

MOTIVATION

Most of the LHC SUSY searches focus on **strong production**, with larger cross section.

Current searches probe masses of squarks and gluinos up to 2 TeV.

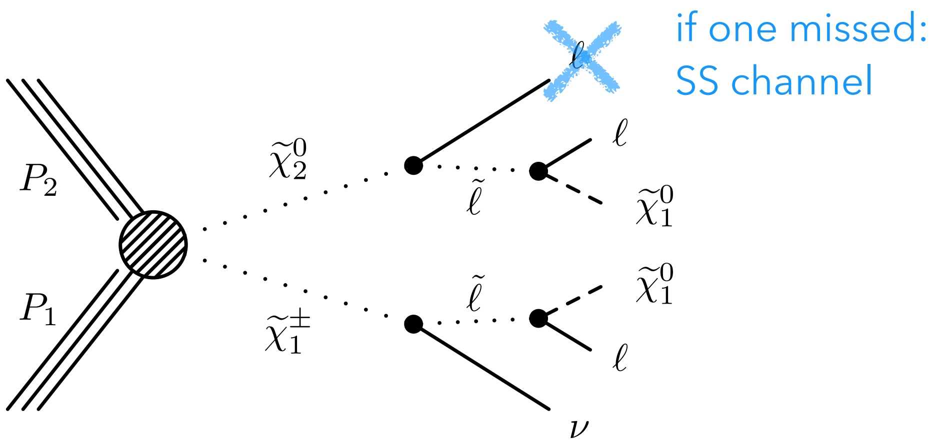


Heavy squarks and gluinos may **favour models with direct EWK production of charginos, neutralinos and sleptons** with low hadronic activity associated, and these could be the only accessible SUSY production at the LHC.

Charginos and neutralinos will decay then to sleptons or W, Z, h bosons.

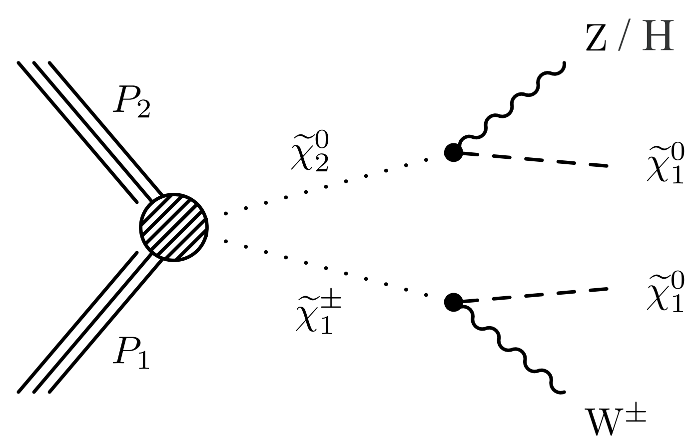
ELECTROWEAK SUSY PRODUCTION @CMS

light sleptons and sneutrinos, different mass splittings



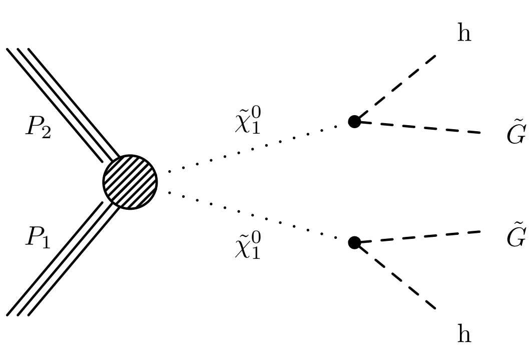
multi-lepton (2L same-sign/3L)

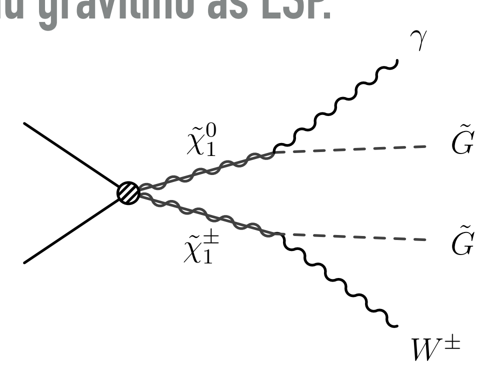
heavy sleptons, decays to W and Z/ H



multi-lepton (3L)
(soft) opposite-sign
1l + H(bb)
multi-lepton 3L (H to WW)

GMSB models with Higgsino as NLSP and gravitino as LSP.





1 photon + MET
H(bb)+HH(bb)

A very rich production with many different signatures in the final states, including W,γ,Z,H bosons

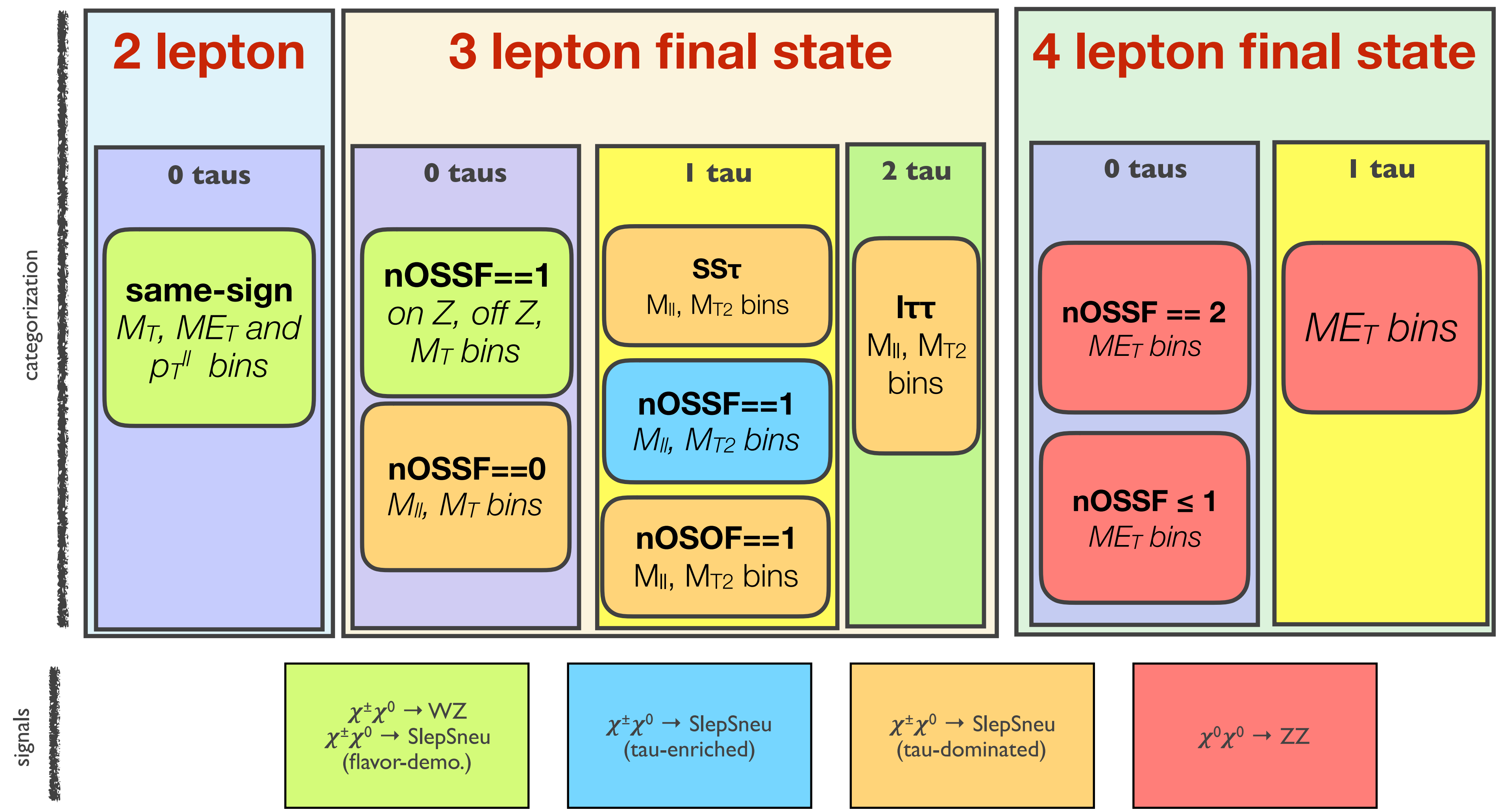
We focus on final states rather than specific theories: simplified models to guide our searches and interpret results.

MULTILEPTON (2LSS/3L) SEARCH

Events with 2 (same-sign), 3 or more leptons (up to $2\tau_{had}$) with p_T > 20(25), 10(15),10 GeV.

b-jet veto to suppress ttbar and ME_T > 60/50 GeV to suppress Z+jets, veto on the m_{3l} to suppress conversions. 0 or 1 ISR jet required only for SS.

Categorisation based on the **number of leptons and flavour:**



nOSSF = number of OSSF pairs (ee, μμ, ττ)
nOSOF = number of OS different flavour pairs (ee, μμ, eμ)

BACKGROUND ESTIMATION METHODS

Non-prompt leptons:

Data-driven, tight-to-loose ratio.

Probability for a fake lepton (fake ratio) to pass the tight requirements (dedicated control sample)

Probability applied then into the sidebands of the signal region.

Validity is checked on MC.

Rare SM processes: estimated from MC

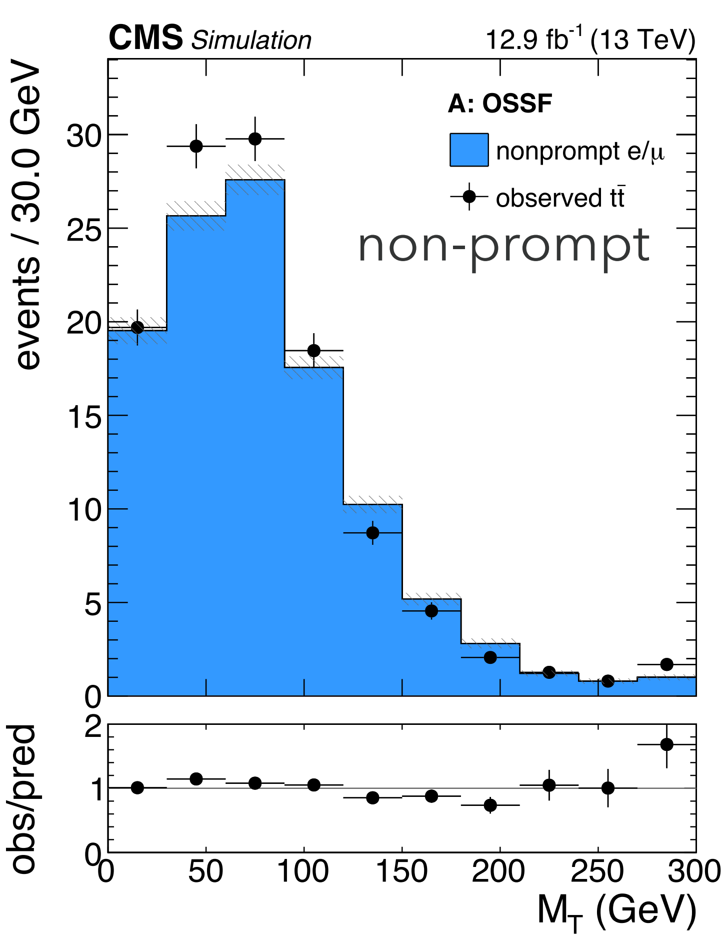
WZ:

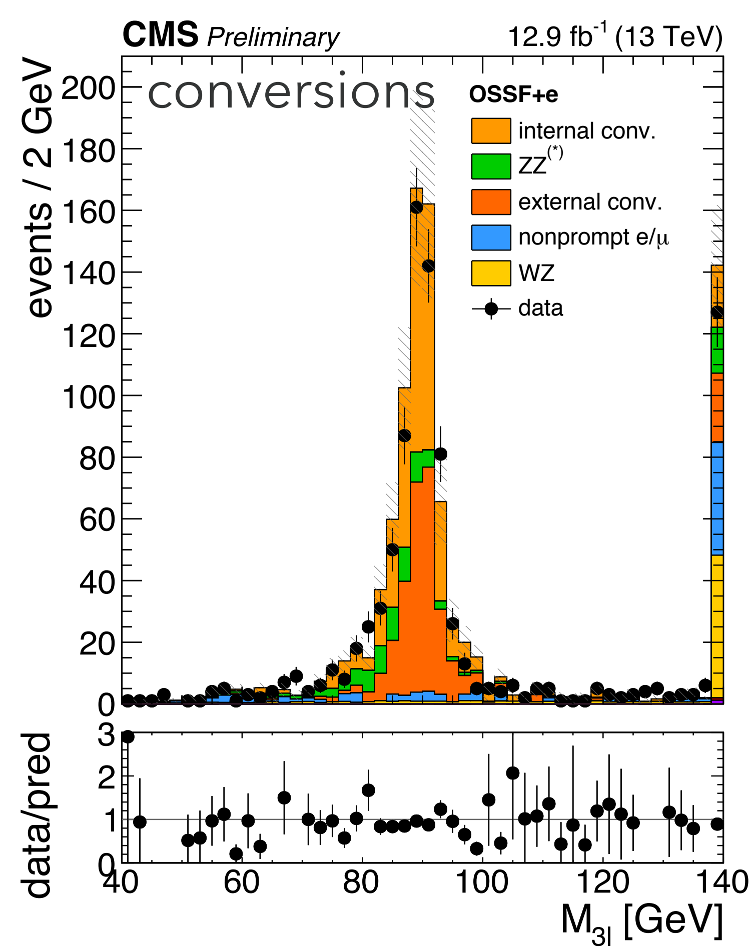
estimated from MC, normalisation and shape uncertainties driven by control region (CR) in data.

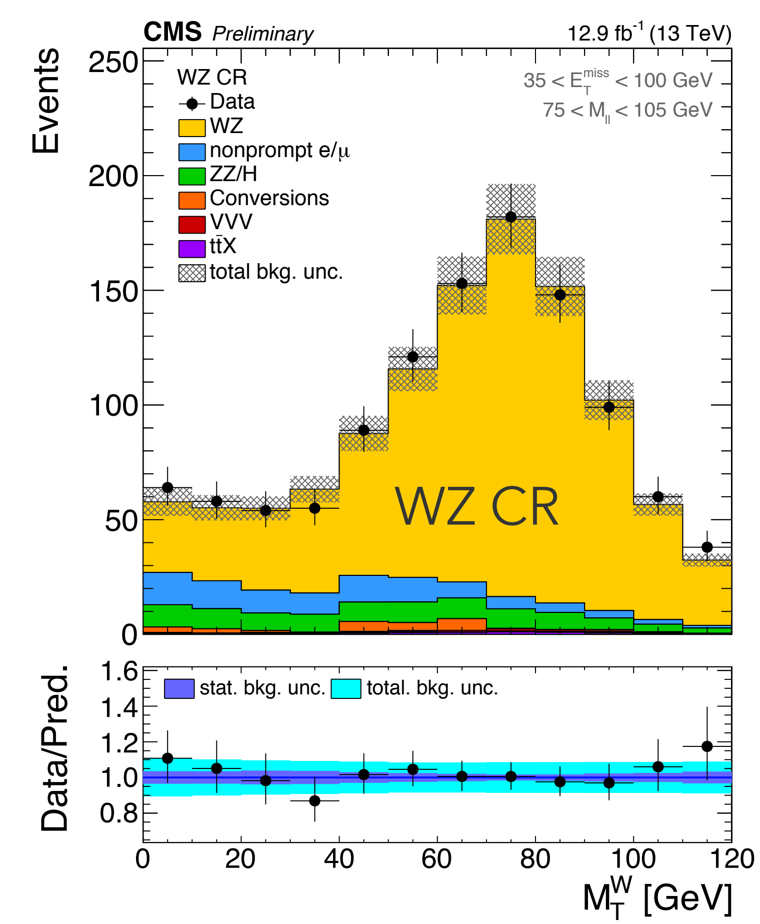
Conversions:

estimated from MC and validated in data. Two contributions: external (e) and internal (e,μ)

Flips: (only for SS), estimated from MC and validated in data.





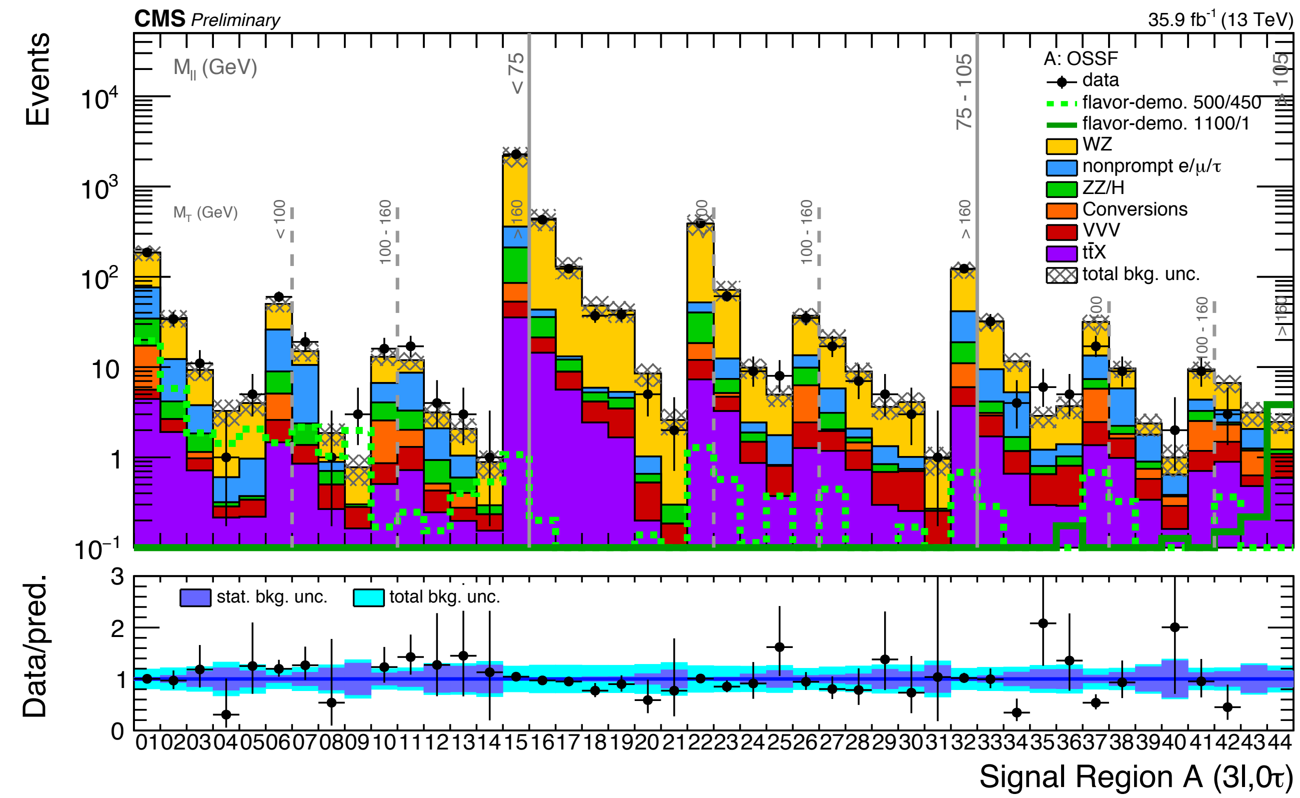


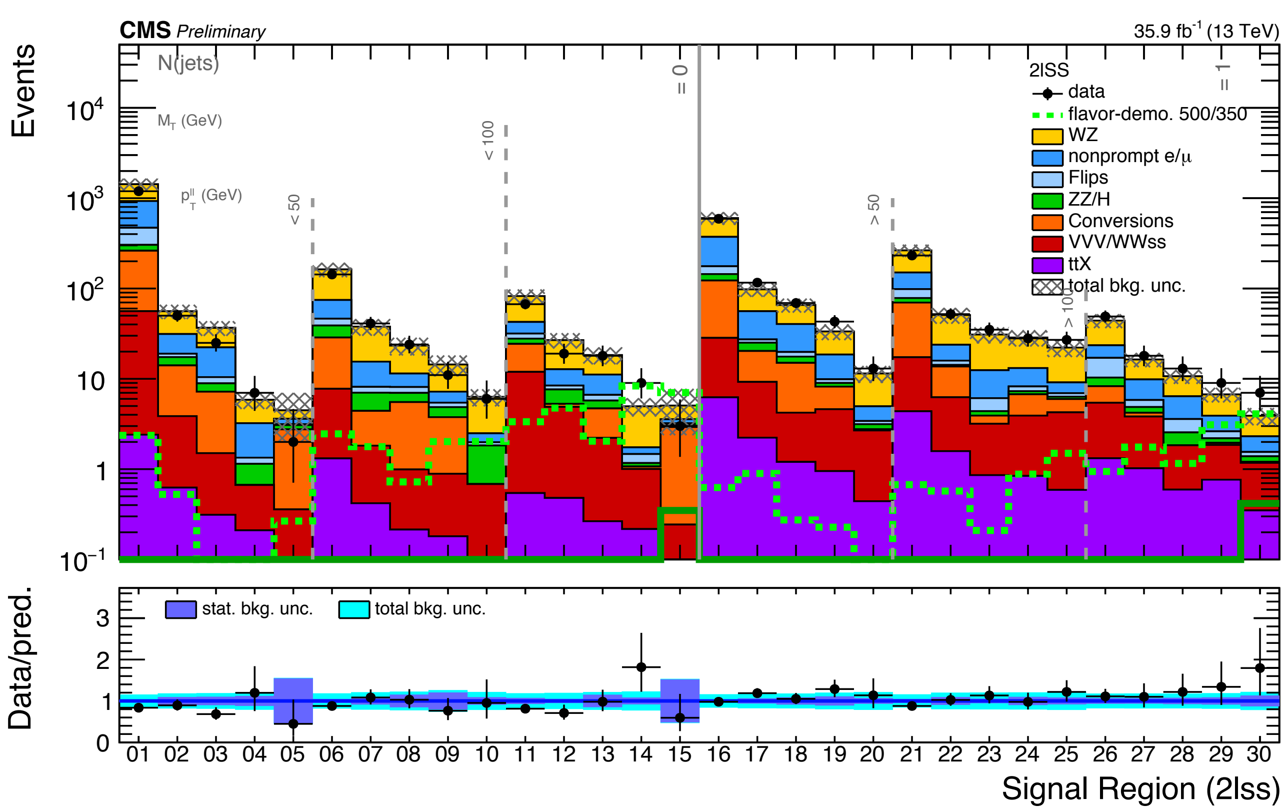
3L CHANNEL RESULTS

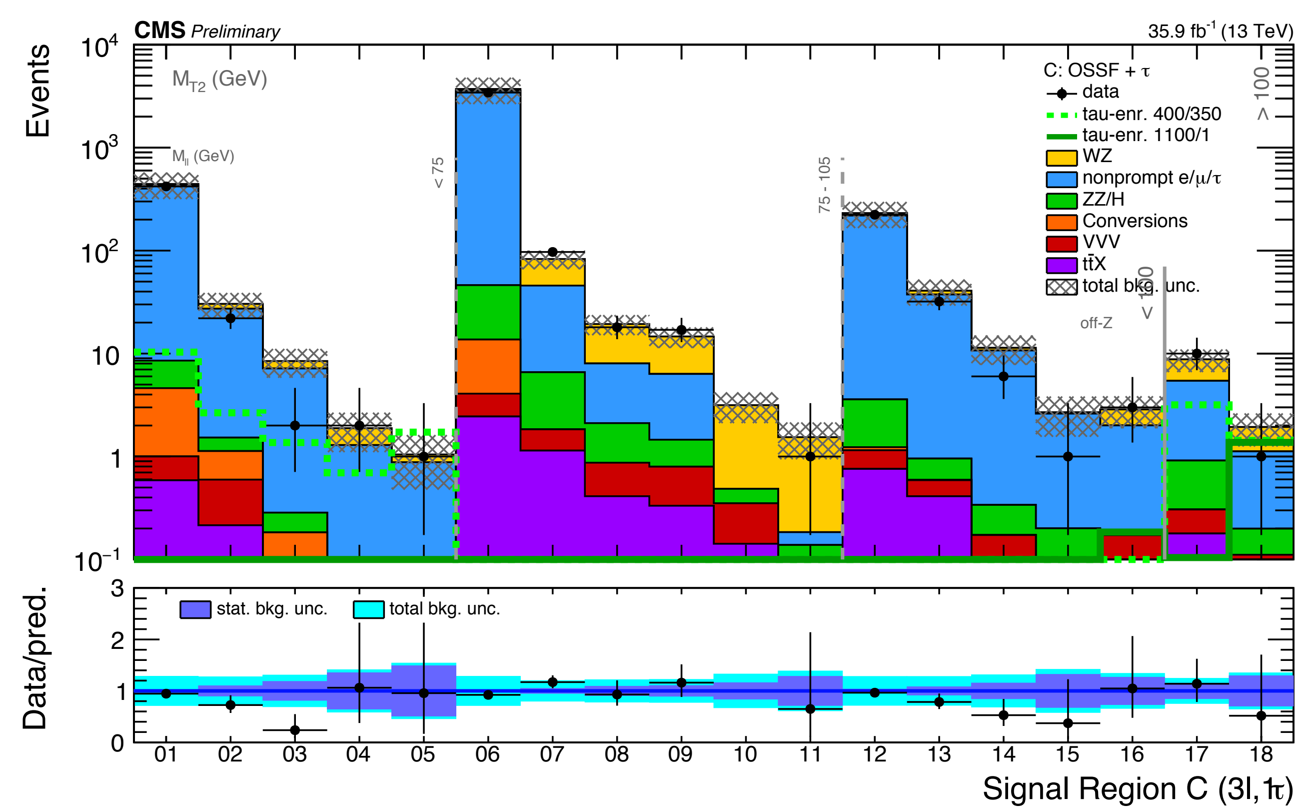
Events are further categorised in M_{ll}, $M_{T(2)}$ and ME_T to maximise sensitivity to different regions of the phase space.

No striking deviation from the SM prediction.

More results in the documentation, only showed a glimpse here.



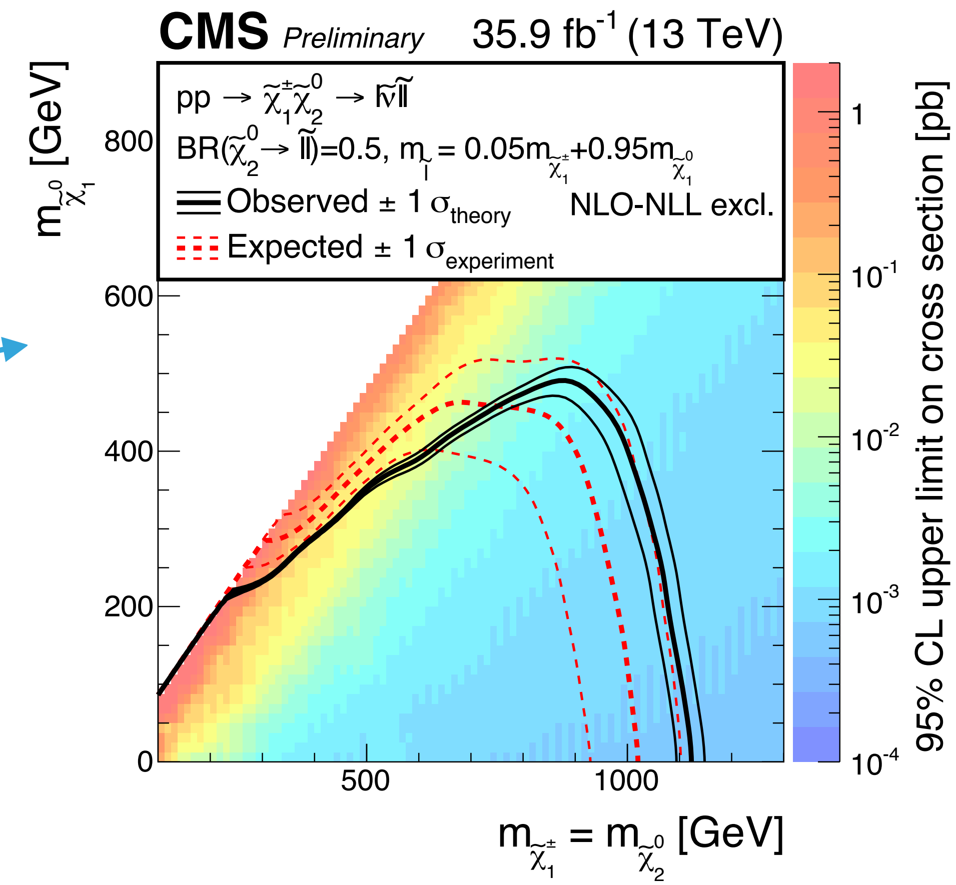




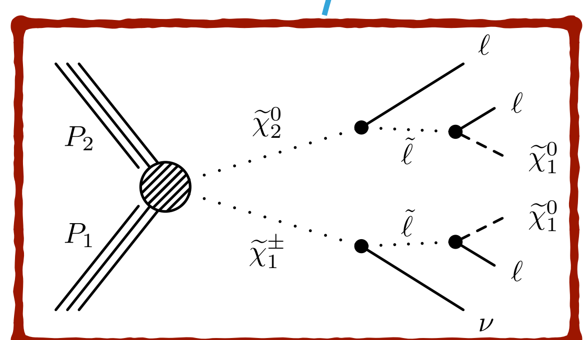
INTERPRETATION (I)

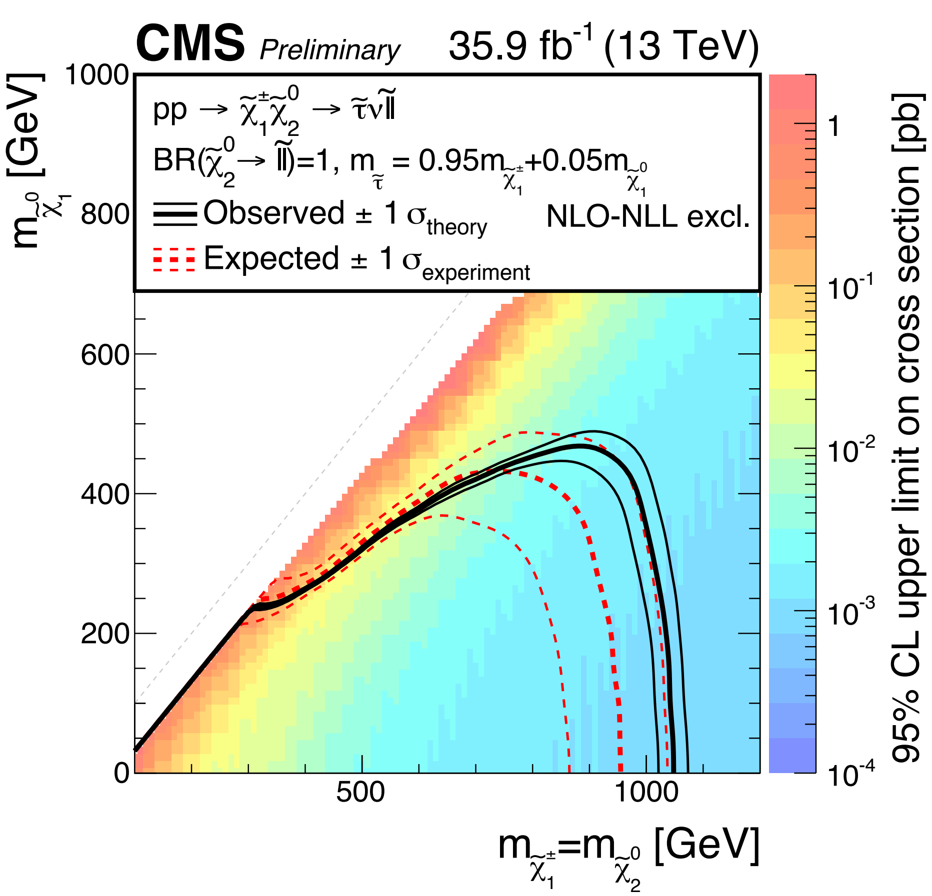
Results are interpreted in several scenarios and different mass splittings.

BEWARE: Many assumptions are made to draw these exclusion limits. (i.e. branching ratio to leptons is 100%.)

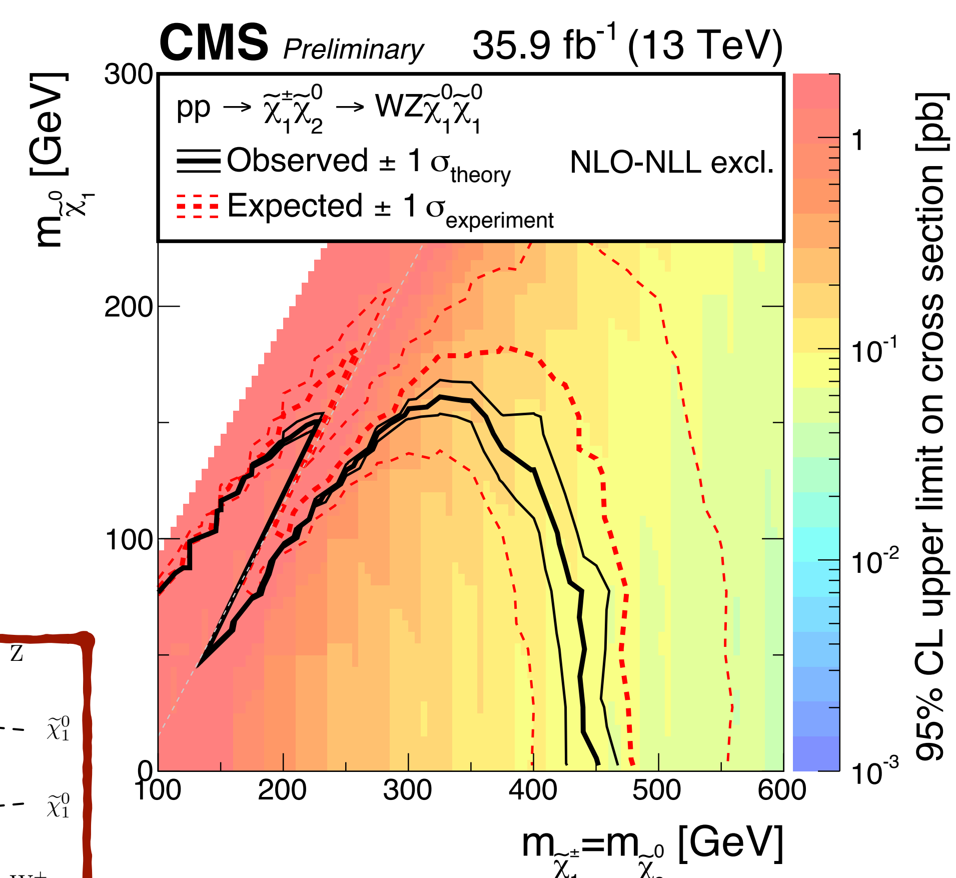


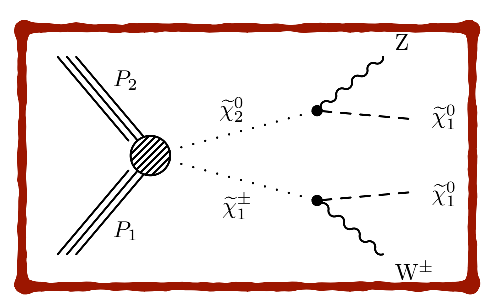
$m_{slep} = 0.05 \times (m_{chi} - m_{lsp})$





Only to taus in the final state



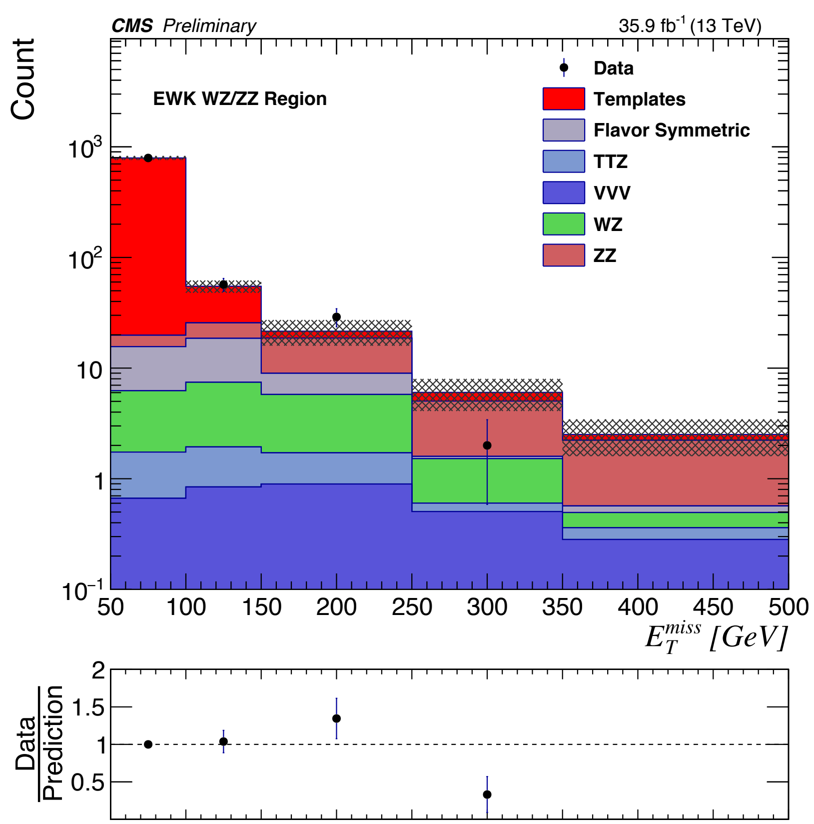


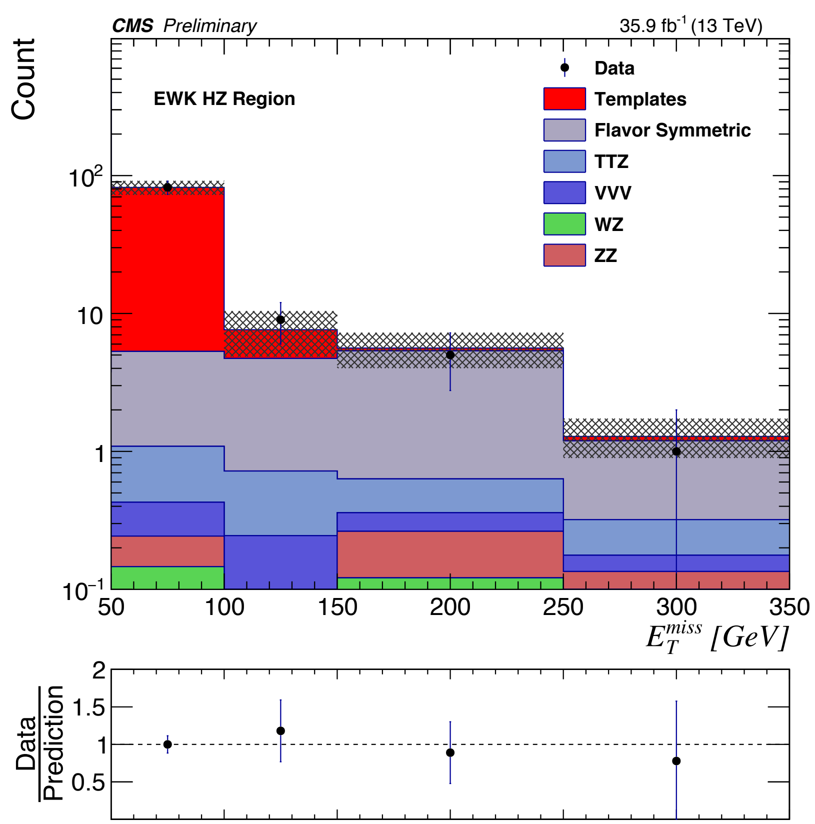
OS DILEPTON SEARCH

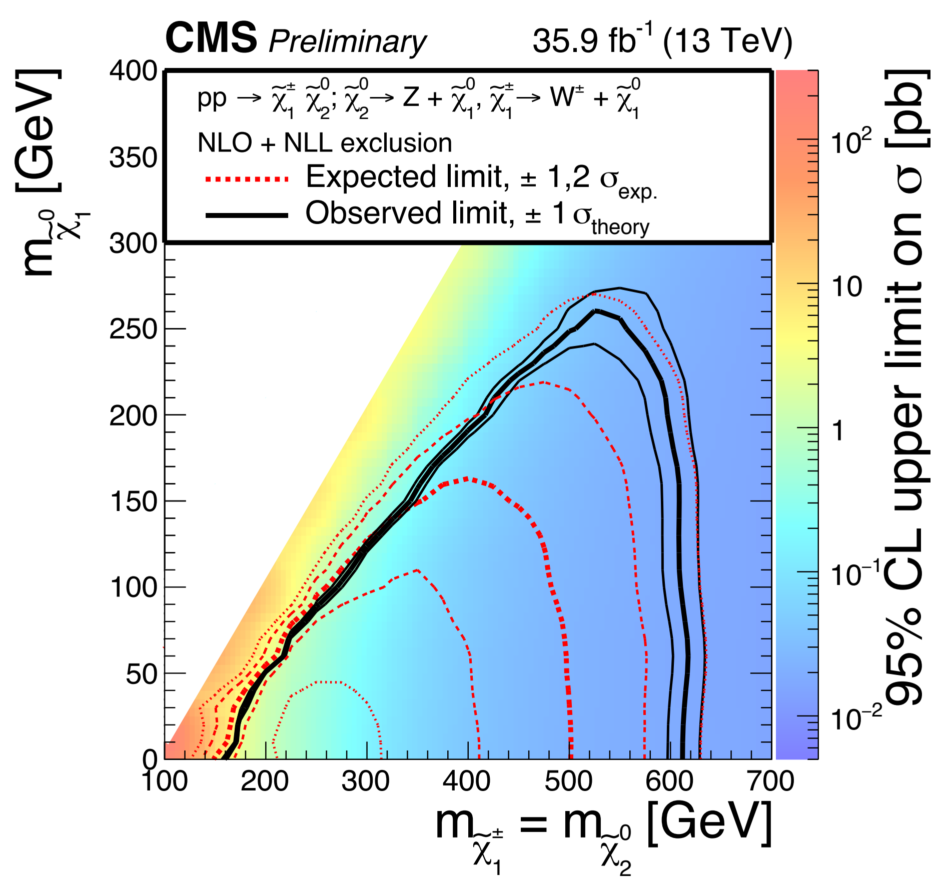
Search optimised for models with on-shell Z boson. We require two opposite-sign leptons compatible with the Z boson mass.

Background estimation: DY from gamma+jets control region: emulation of M_{T2} variable. ttbar predicted from opposite-flavor control region

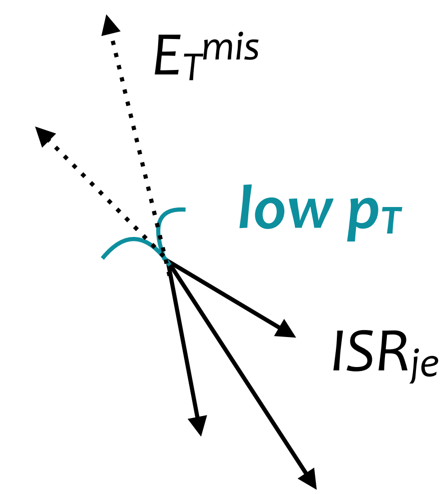
Search strategy: defined by applying tighter cuts on M_{T2} and ME_T and the angular distance between the ME_T and jet to suppress background from ttbar and fake ME_T.







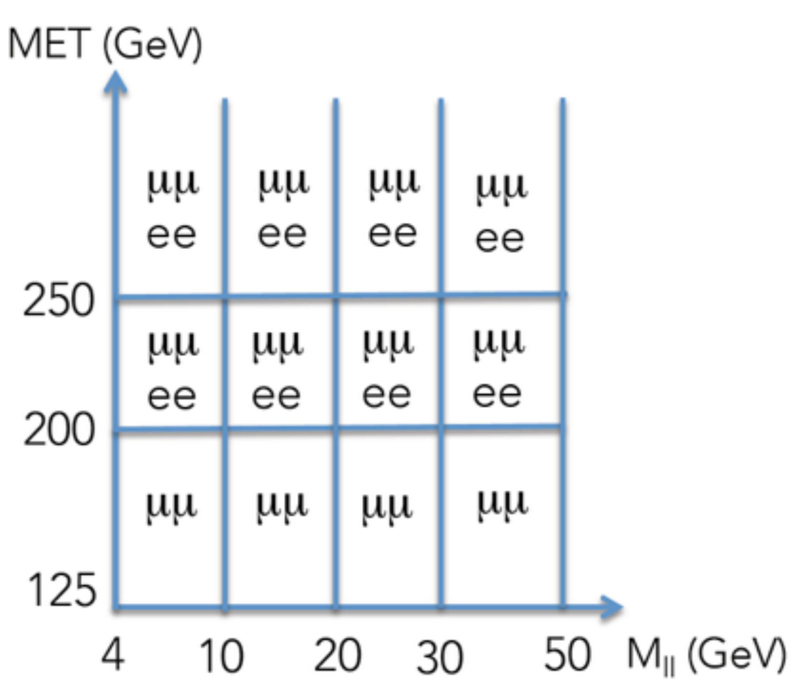
SOFT OPPOSITE SIGN DILEPTON ANALYSIS



Why compressed SUSY? Small ΔM models gaining interest, such small mass splitting already present in the SM.

2 soft opposite sign leptons (μμ/ee) with 3.5 (5) < p_T < 30 GeV + ME_T + jets. Optimized pre selection to reduce background contribution.

Search strategy: Bins of ME_T and M_{ll} of the two leptons.



Backgrounds:

Ttbar and DY, shape from MC. Normalised in dedicated data control regions. Extrapolation to SR also from MC.

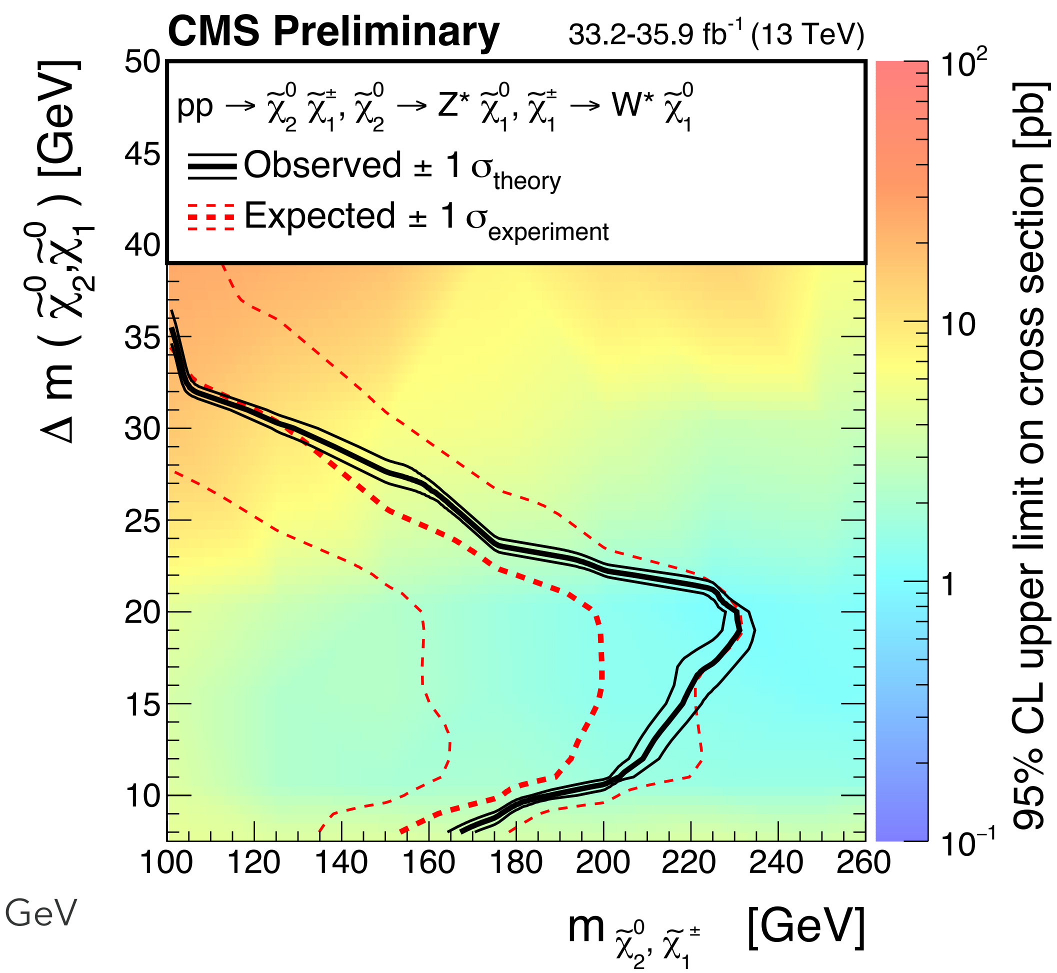
Nonprompt: data-driven (Tight-to-loose method)

Others from MC whenever is possible.

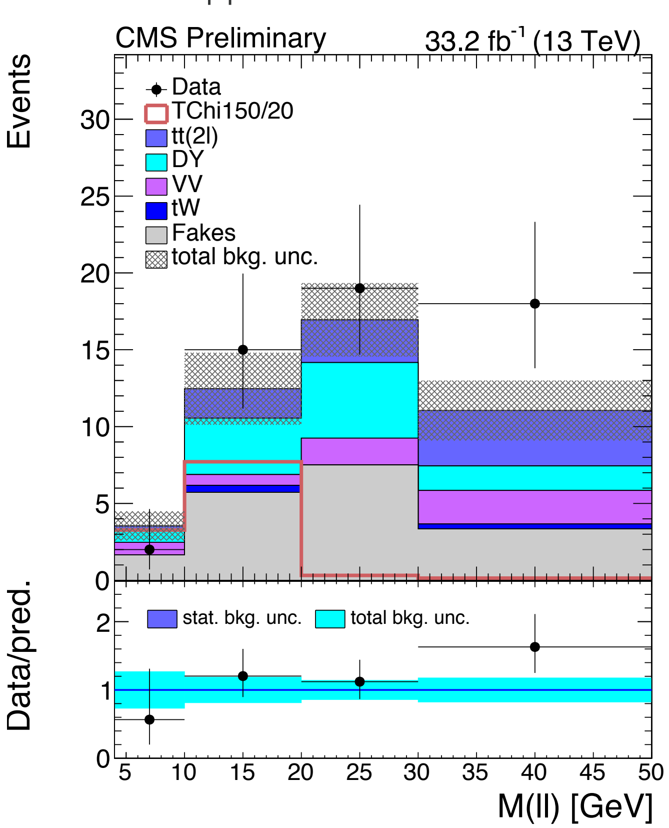
INTERPRETATIONS

Selection is **optimised for EWKino signatures**. Signal regions are defined by binning in the invariant mass of the dilepton pair.

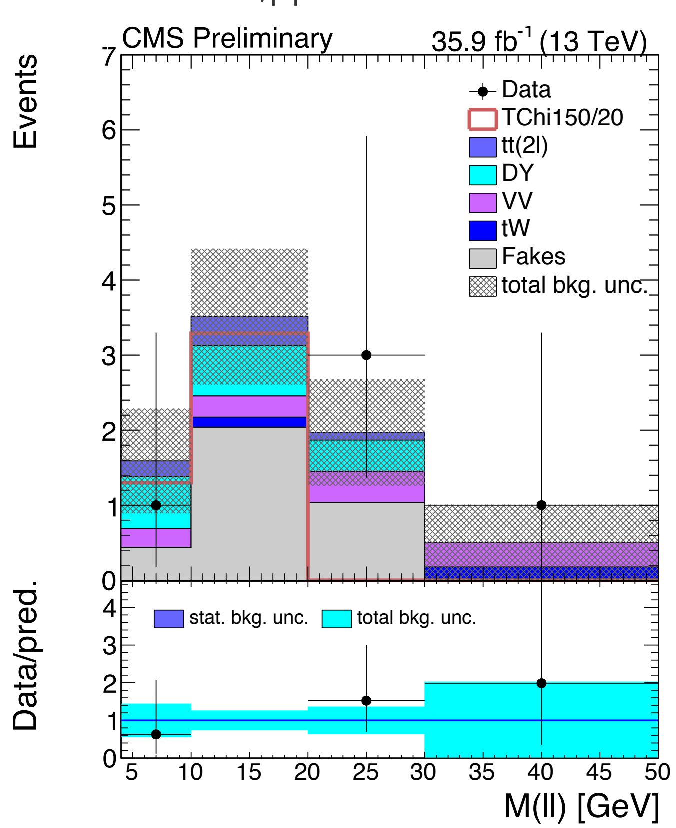
This analysis allows to probe a much more compressed region of the phase space, complimentary to other searches.



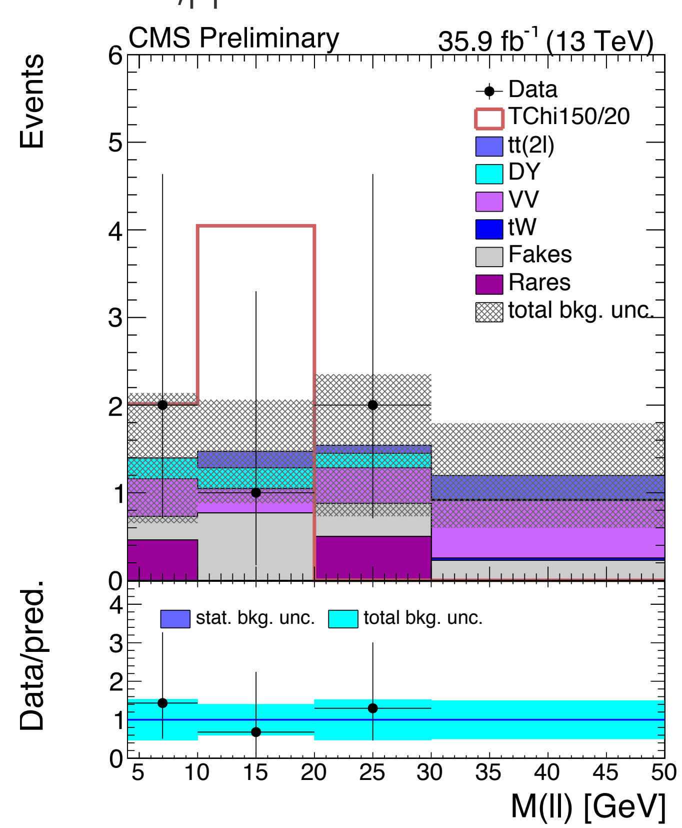
125 < MET < 200 GeV
μμ

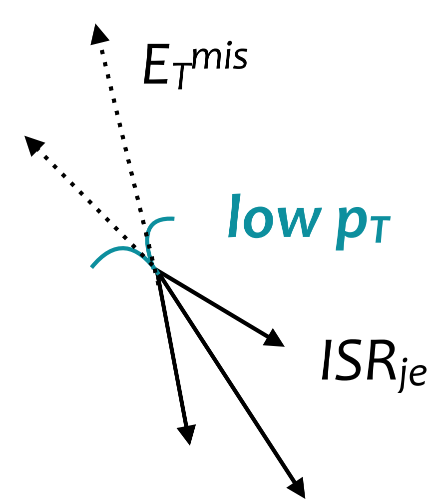


200 < MET < 250 GeV
ee,μμ



MET > 250 GeV
ee,μμ





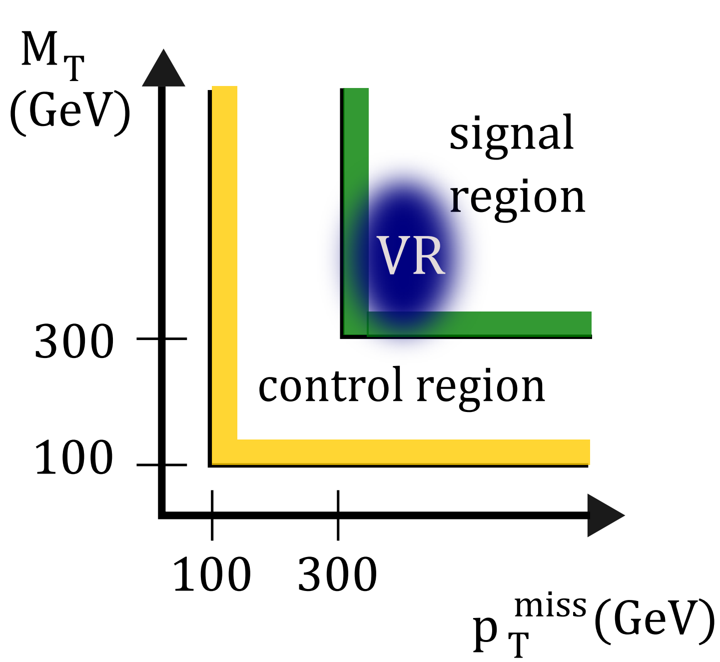
PHOTON+MET SEARCH

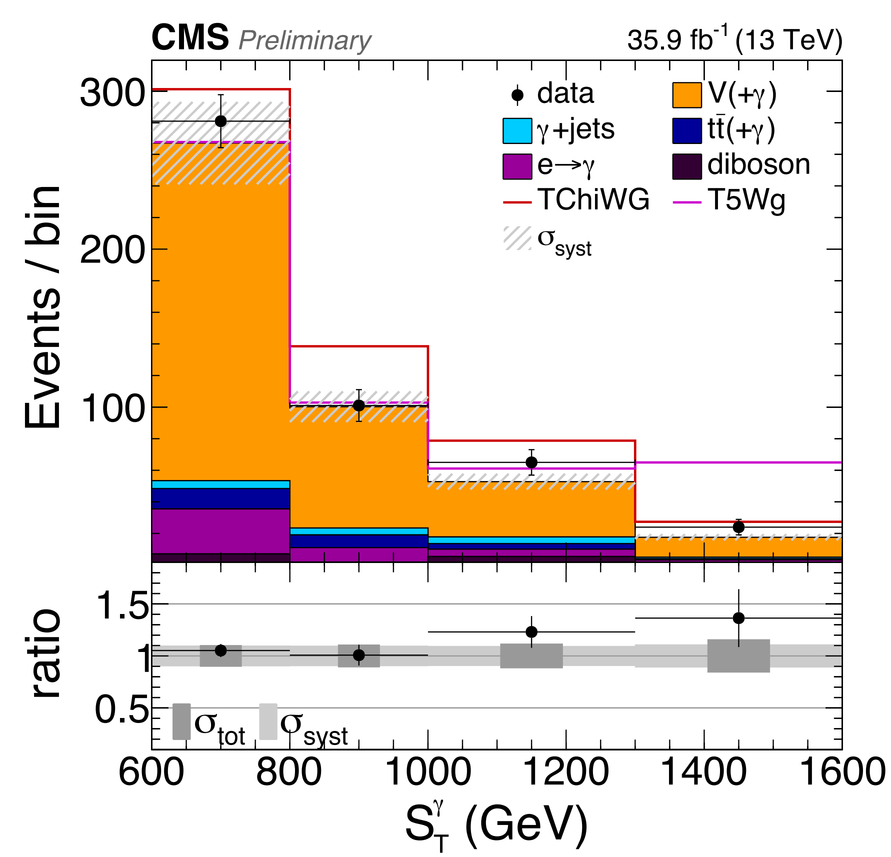
One hard photon (p_T > 180 GeV), transverse mass M_T > 300 and missing energy ME_T > 300 to target chargino-neutralino production decaying to Wγ

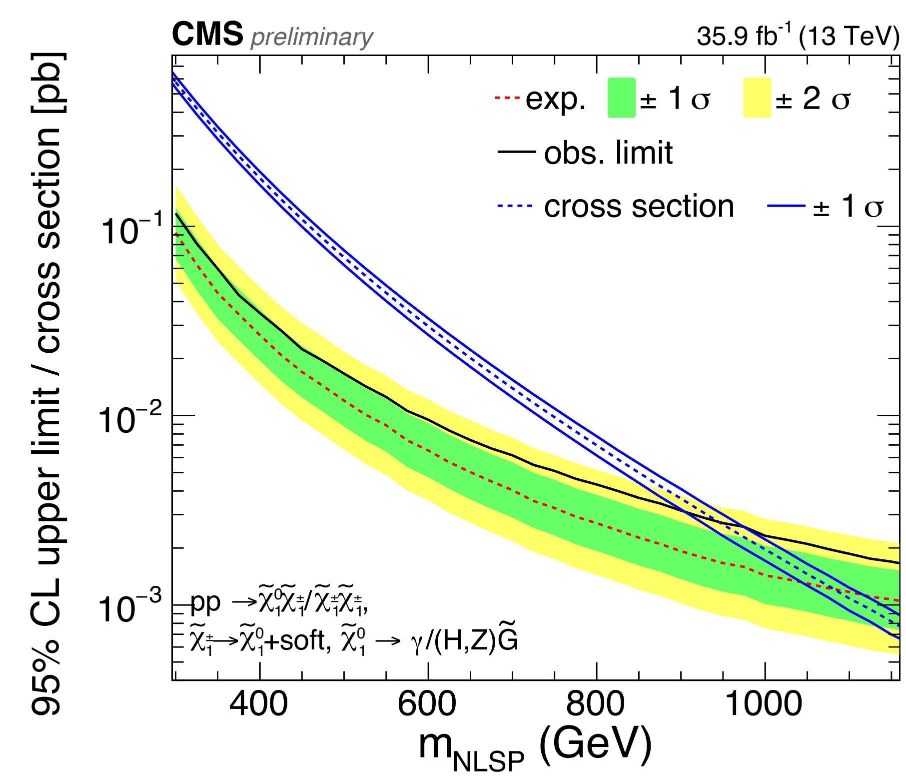
Also sensitive to other models.

Background: dominant background is SM V-boson production with ISR photons, estimation from Monte Carlo simulation, normalized in control region (low M_T and MET)

Search strategy: binning in S_T = scalar sum of ME_T and photon p_T







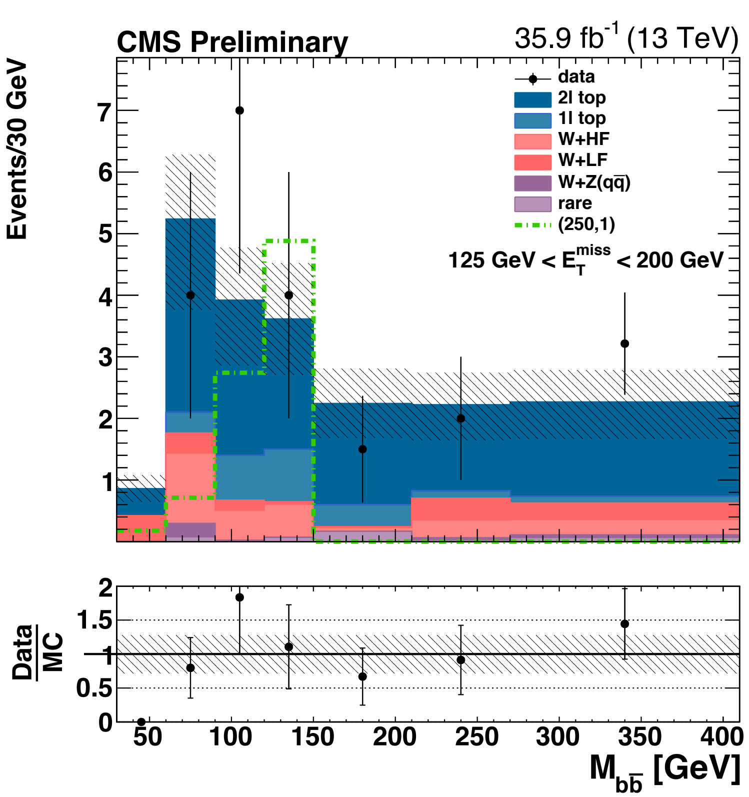
CHARGINO-NEUTRALINO PRODUCTION TO WH.

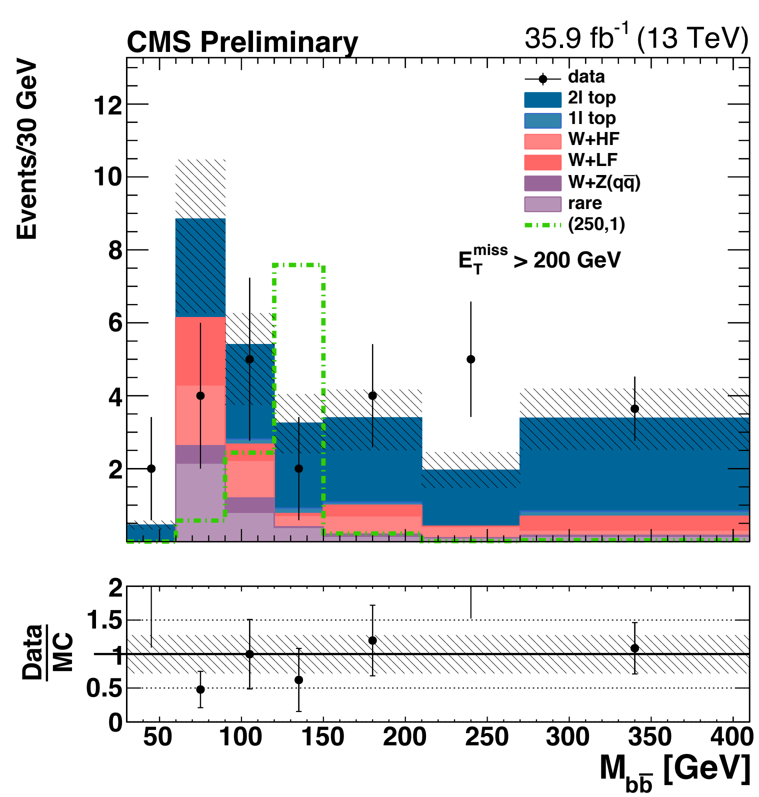
Targeting H decaying to bb. Select events with one lepton, 2 b-jets and ME_T > 100 GeV.. M_T and M_{CT} > 150 GeV to kill background semi-leptonic ttbar

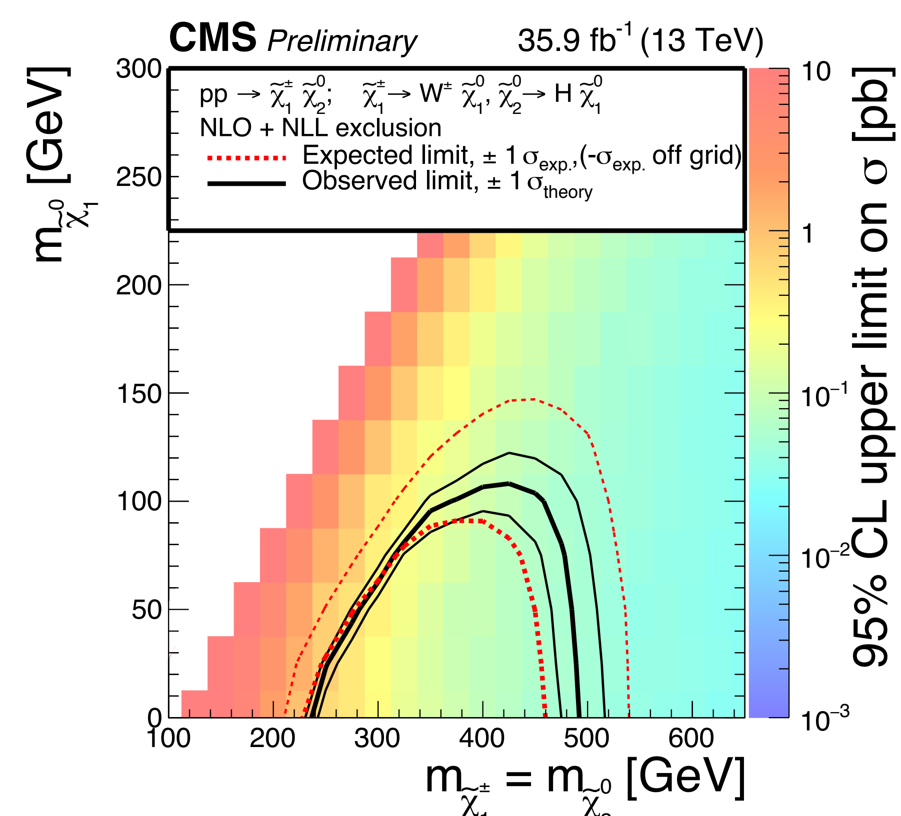
Signal region is defined by asking the M_{bb} to be compatible with the higgs mass. We then look for a resonance in the m_{bb} spectrum.

Background are modelled using MC simulation. Dedicated control regions are defined to assess the modelling of the most relevant backgrounds (dileptonic ttbar and W+jets):

1. M_{bb} modelled checked in a dilepton control region.
2. ME_T, M_T and M_{CT} are in an orthogonal sample built by inverting the M_{bb} requirement.
3. A b-jet veto control region is used to assess the modelling of the W+jets backgrounds.







4B'S + MET

Searching for GMSB HH-like model with H→bb, significant ME_T and 4jets.

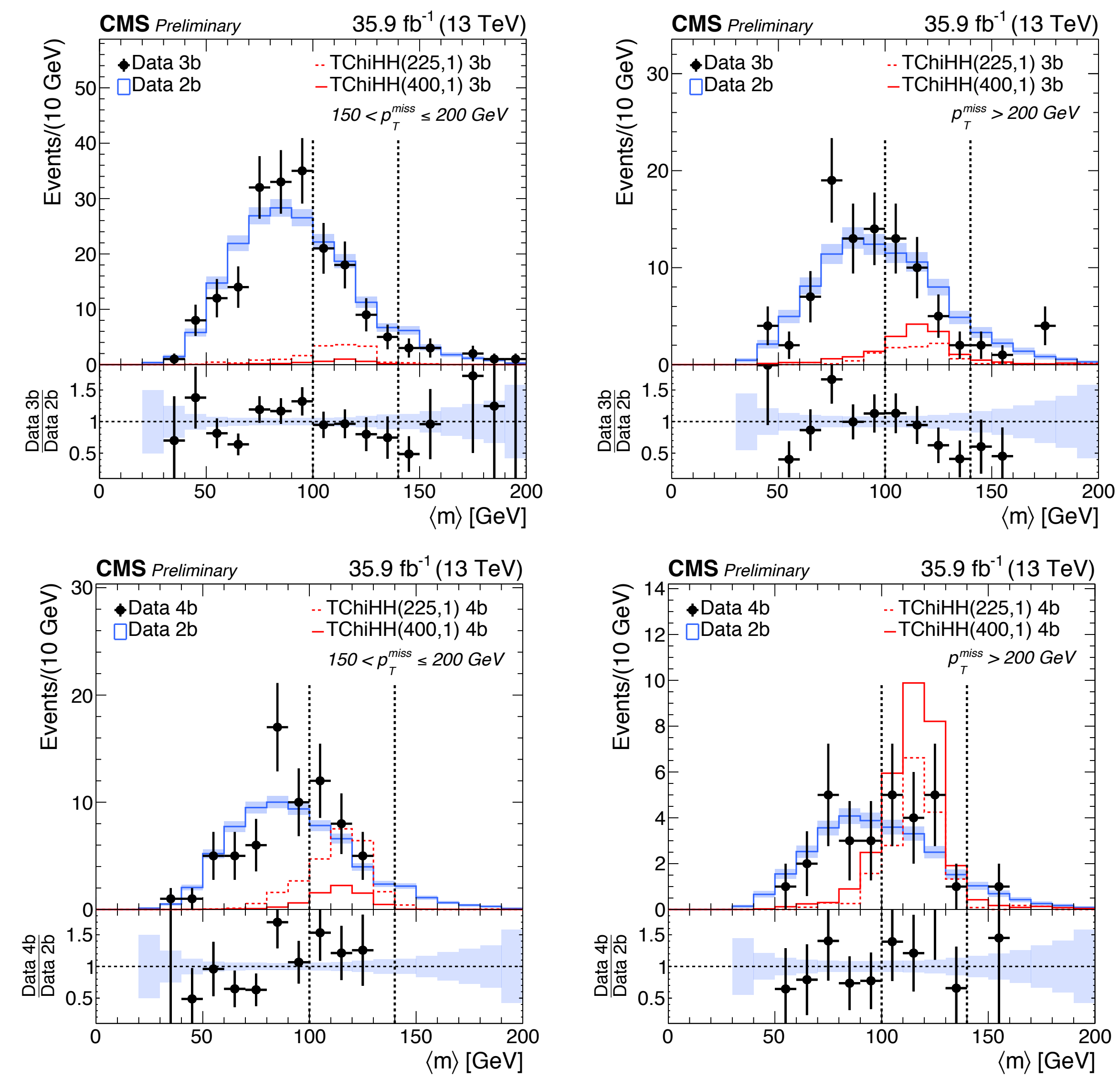
Strategy: reconstruct two H→bb candidates from 4 jets with highest b-tag score (improved b-tagging algorithm using deep neural network - 0.1% mis-tag rate)

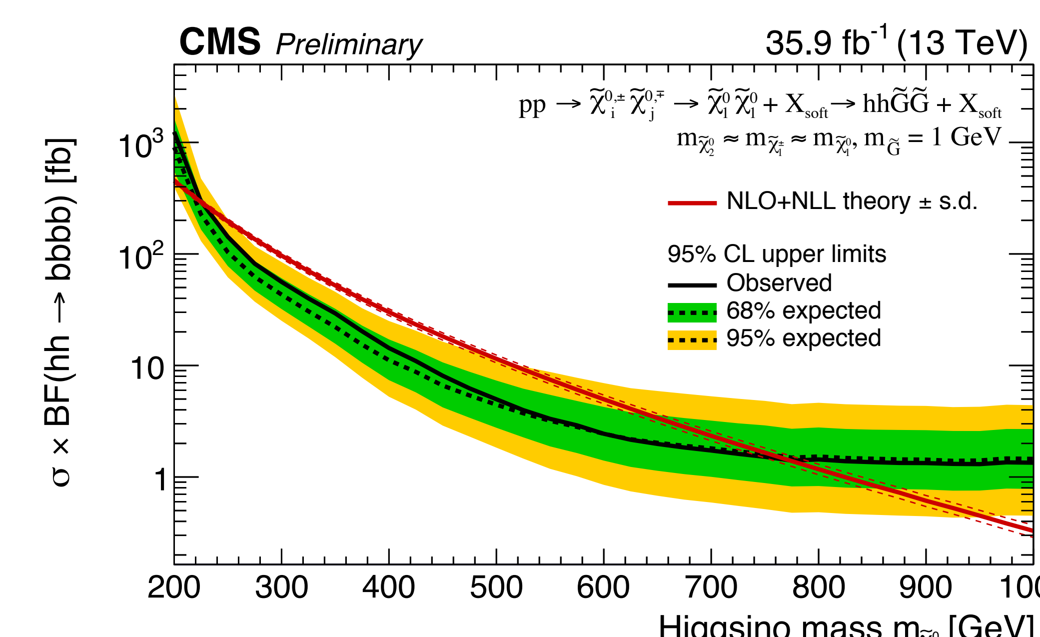
- select the pair of H candidates that minimises $\Delta m_H = m_{H1} - m_{H2}$
- use <m> for signal extraction (uncorrelated with number of b-tags) in bins of ME_T.

Background: dominant process is semi-leptonic ttbar and invisible DY+jets.

- data-driven ABCD method: use shape in 2b control region to predict shape in 3b and 4b regions

Exclusion **between 230 and 770 GeV** in a GMSB model



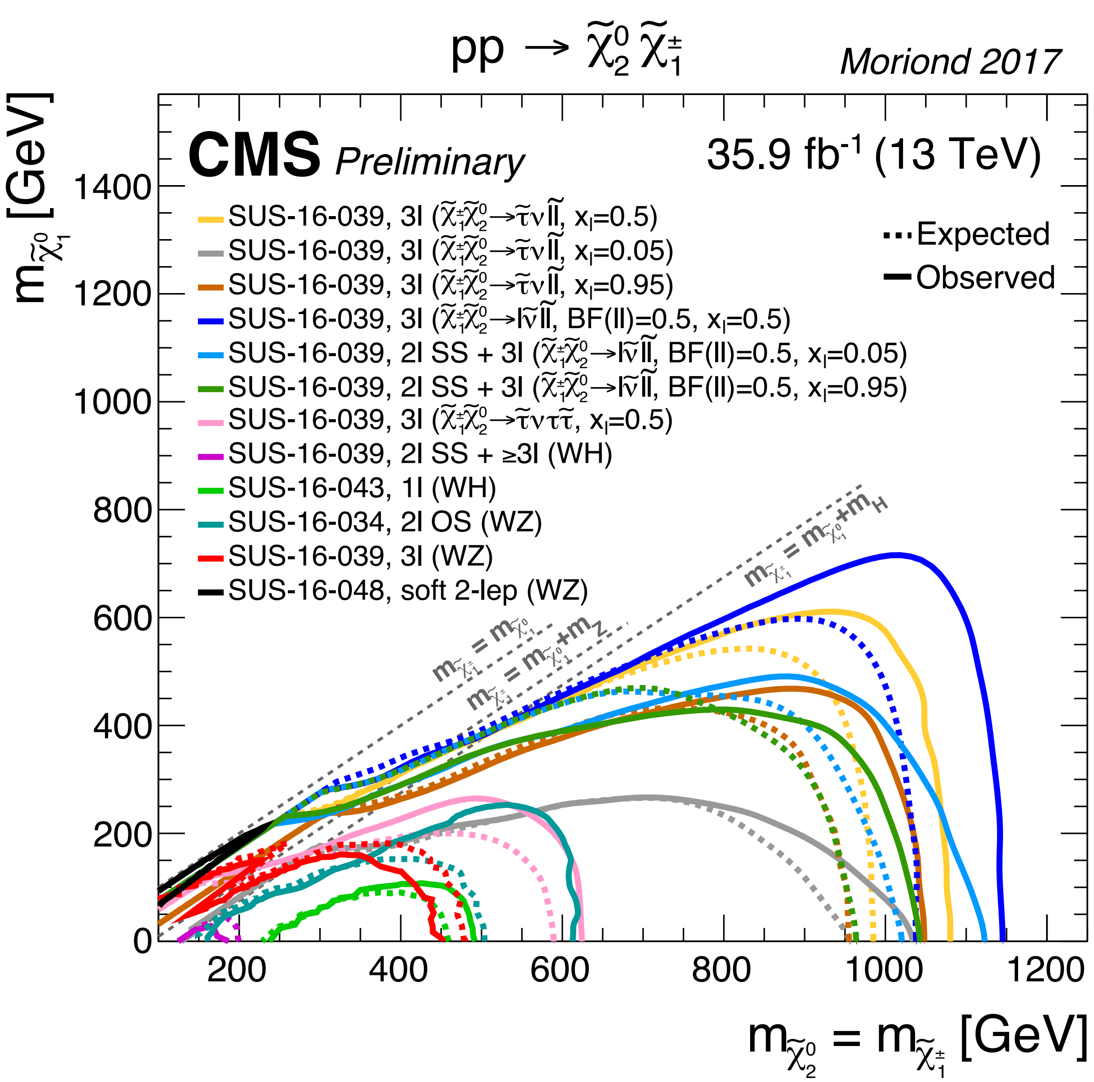


SUMMARY

A ver rich and complex strategy for ***Searches for EWK production of SUSY using 36 /fb at 13 TeV****, many final states allow to cover different regions of the phase space and overcome the low cross-sections.*

Extended 8 TeV and previous 13 TeV searches: improved search strategy, increased sensitivity almost everywhere surpassing previous results.

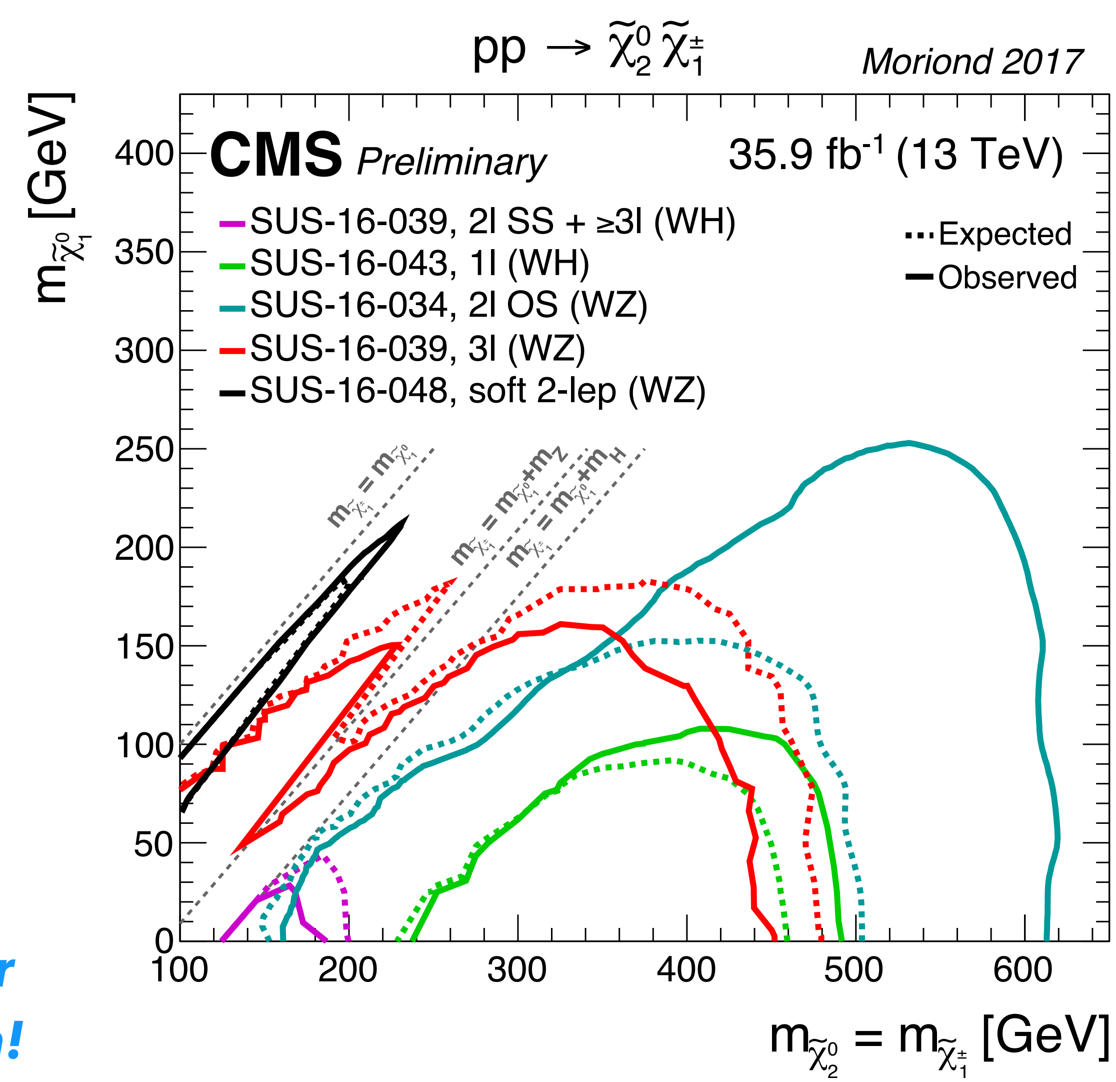
We probe masses up to 1.1 TeV (light sleptons), depending on the assumption of the model.



No evidence for new physics (yet)

New detector and much more data this year, stay tuned!

Thank you for you attention!



BACK-UP

BACKGROUND ESTIMATION METHODS

dileptonic ttbar:

Shape from MC. Normalised in dedicated data control region. Extrapolation to SR also from MC.

Drell-Yan:

Shape from simulation, Normalised in data control region. MC for extrapolation to SR.

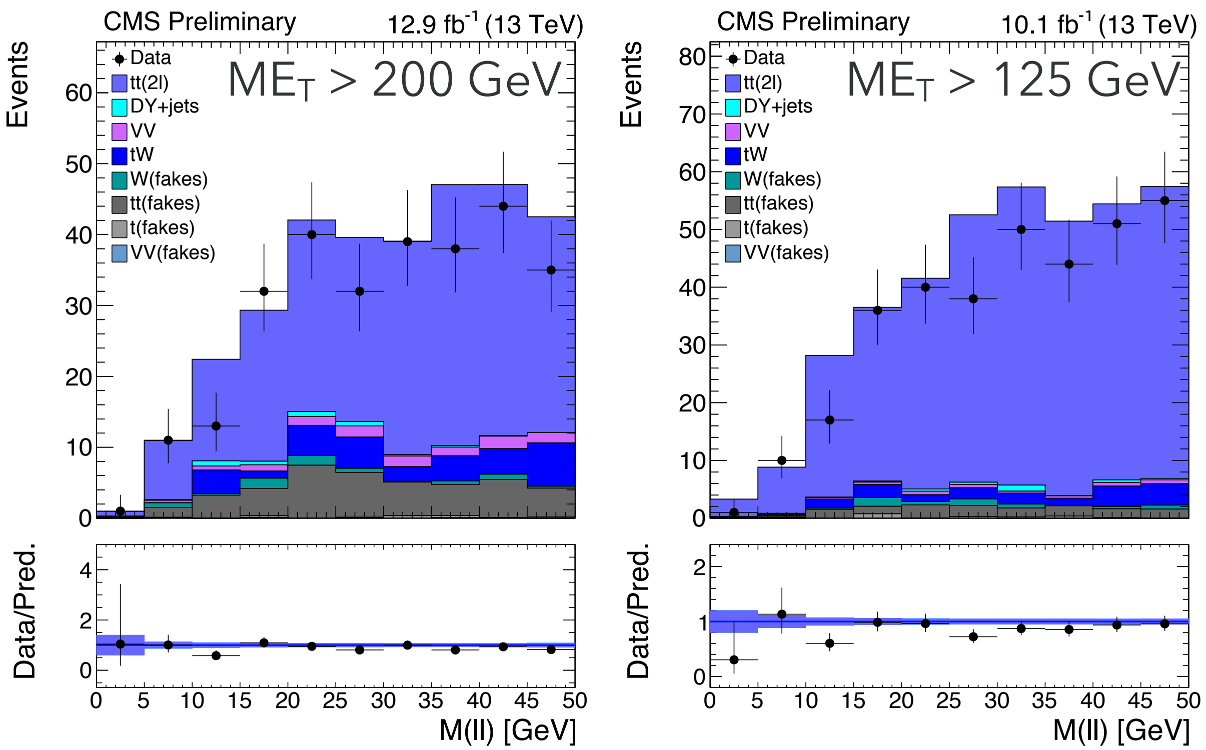
VV: from MC, validated in data

Non-prompt:

from data, using tight-to-loose method.

Rare SM processes: from MC.

TTbar control region



DY control region