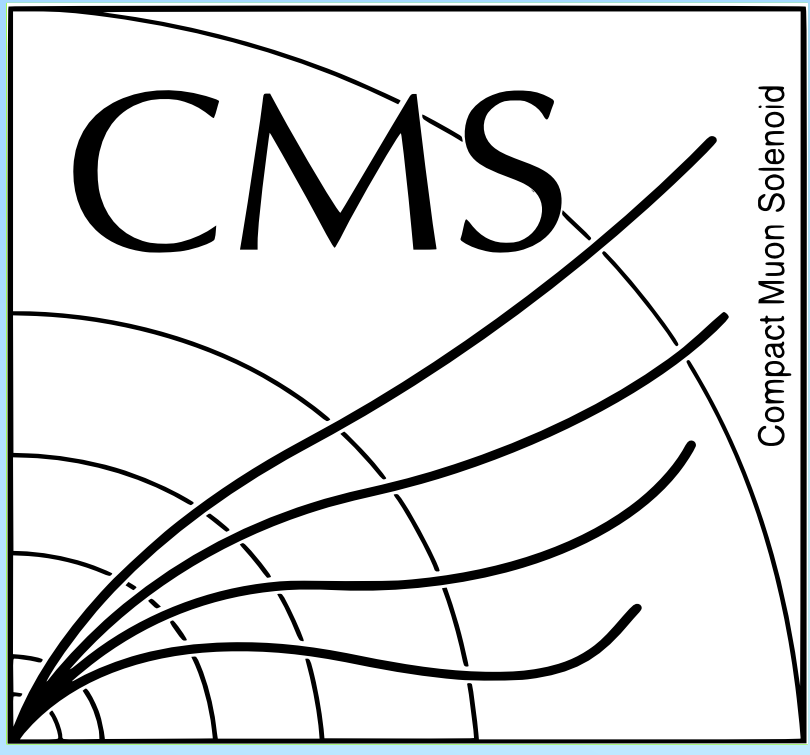# Combined search for electroweak production of charginos and neutralinos at 13 TeV with the CMS experiment

Carlos Francisco Erice Cid on behalf of the CMS Collaboration
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Universidad de Oviedo

Introduction

Supersymmetry (SUSY) is one of the most promising Beyond the Standard Model (BSM) paradigms. It has been thoroughly studied theoretically and experimentally at the LHC energy scales.

Electroweak SUSY production is *dominant* if strong-charged SUSY particles have very high masses. The SUSY partners of elementary bosons other than the gluon could be playing a relevant role at low energies.

Simplified models depending on a few parameters are built. We consider cases where 2-3 BSM light particles and their decay chains are added to the SM ones.

Final state topologies can be as rich as the ones from the W/Z/H SM bosons. Dedicated studies are developed specifically for each one. Excellent results have been obtained so far. It is to be expected that a statistical combination of individual results should provide with increased sensitivity to BSM physics.

A careful combination of CMS results taking into account the relevant correlated uncertainties is presented.

Multileptonic search optimization

Search focused on SUSY processes with kinematics nearly equal to SM WZ production ($m_{NLSP} - m_{LSP} \approx m_Z$)

Selection

"WZ-like" 3 lepton selection
3 light leptons (electrons or muons).
Same flavor, opposite sign lepton pair.
Missing transverse energy: $p_T^{miss} > 50$ GeV
No low-mass resonances: $m_{ll} > 12$ GeV
Photon conversion veto: $|m_{3l} - m_Z| > 5$ GeV

Background processes

WZ: dominant background. Normalized to data in specific control region.
Non-prompt leptons: data-driven estimation: *tight-to-loose* method.
Photon conversions ($X + \gamma$): Monte Carlo is validated in control region.
Others (minor): from Monte Carlo.

Uncertainty sources

Process specific uncertainties: derived specifically for each method. WZ and signal modeling dominate.
Global systematic uncertainties: related to trigger and different objects (lepton reconstruction, jet energy corrections, pile-up).

Signal extraction

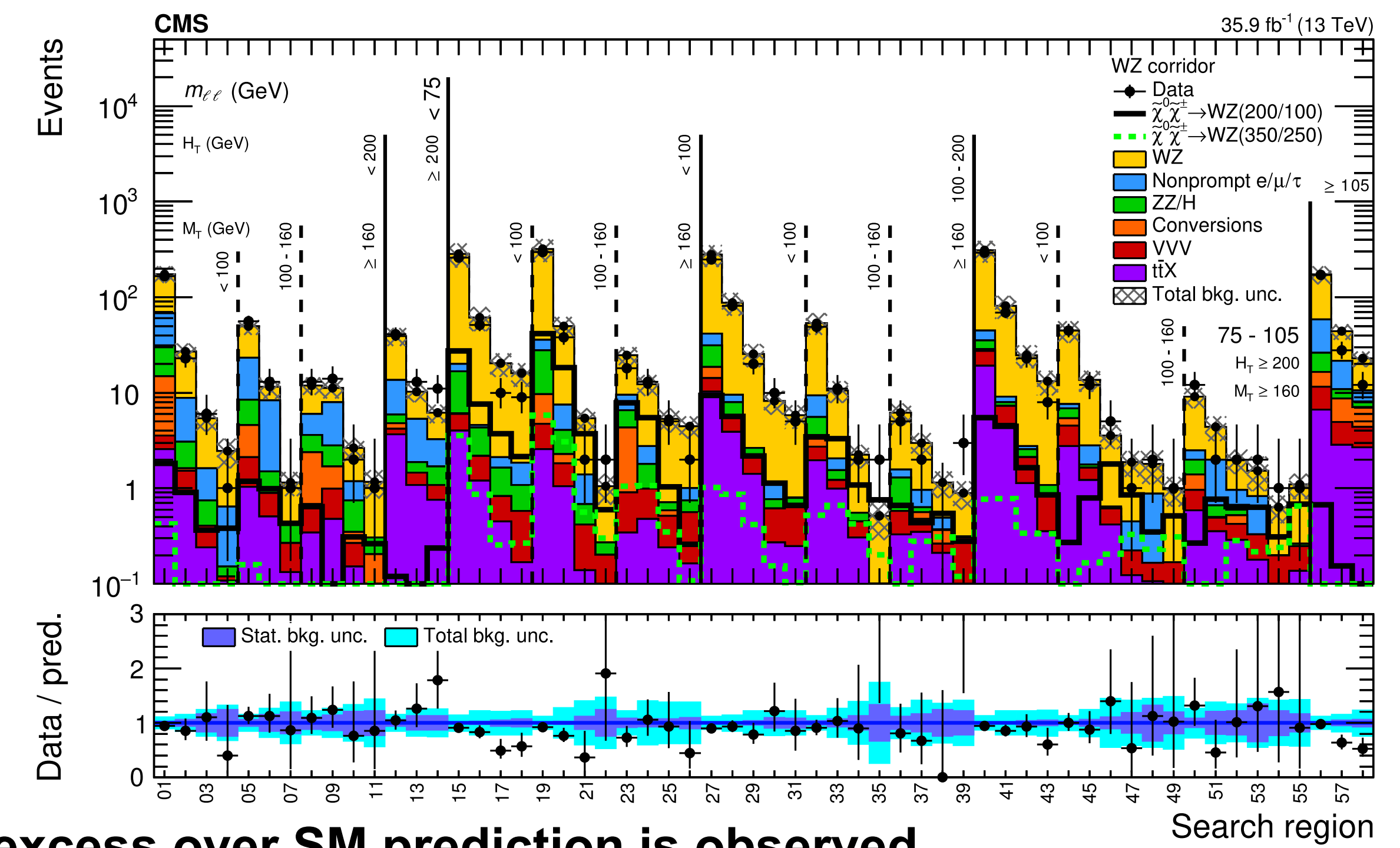Multiple search regions, 58, defined to control SM behavior and be sensitive to different SUSY scenarios based on:

> Closest to the Z mass dilepton invariant mass from an OSSF pair.

> Transverse mass computed with the remaining lepton.

> Total hadronic transverse momentum (sum of jet p_T).
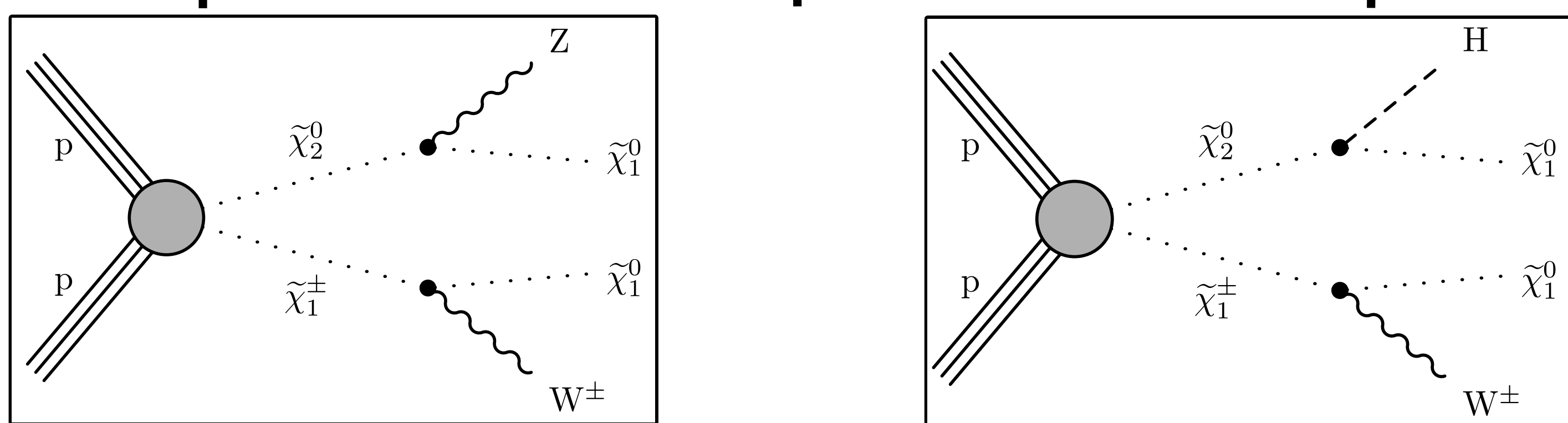
> Missing transverse energy.

No significant excess over SM prediction is observed

## Neutralino-chargino pair production: $\chi_1^\pm \chi_2^0$

Lightest neutralino, χ_1^0, as the lightest SUSY particle (LSP).
Models parameterized in terms of SUSY masses with $m_{\chi_1^\pm} = m_{\chi_2^0} > m_{\chi_1^0}$.
Different studies based on the chargino branching ratio.

$Br(\chi_0^2 \to Z\chi_0^1) = 1$ $Br(\chi_0^2 \to H\chi_0^1) = Br(\chi_0^2 \to Z\chi_0^1) = 0.5$ $Br(\chi_0^2 \to H\chi_0^1) = 1$
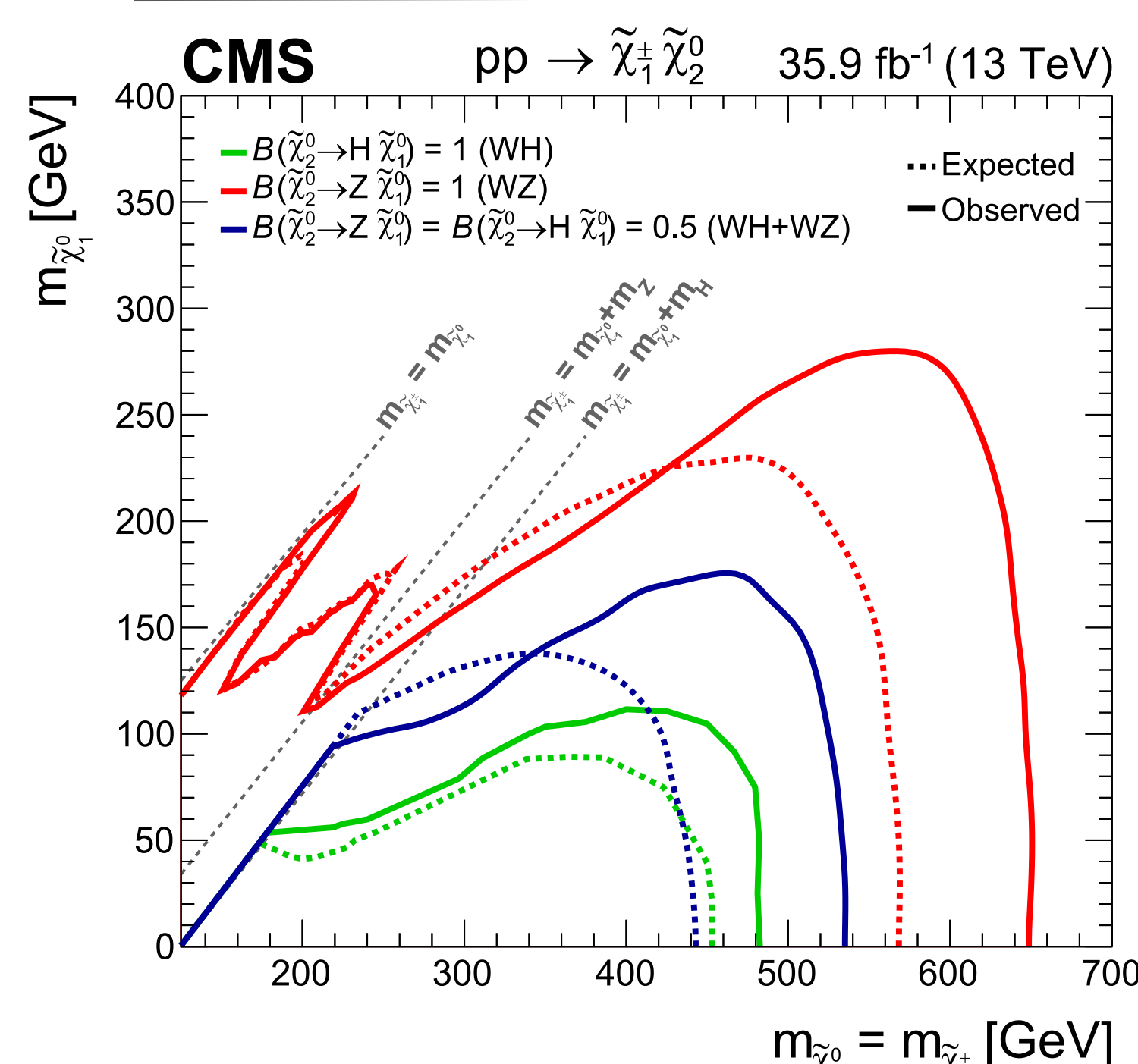

95% CL Upper limits are set using the CL_S criterion (asymptotic method)

### Individual analysis (excluded regions)
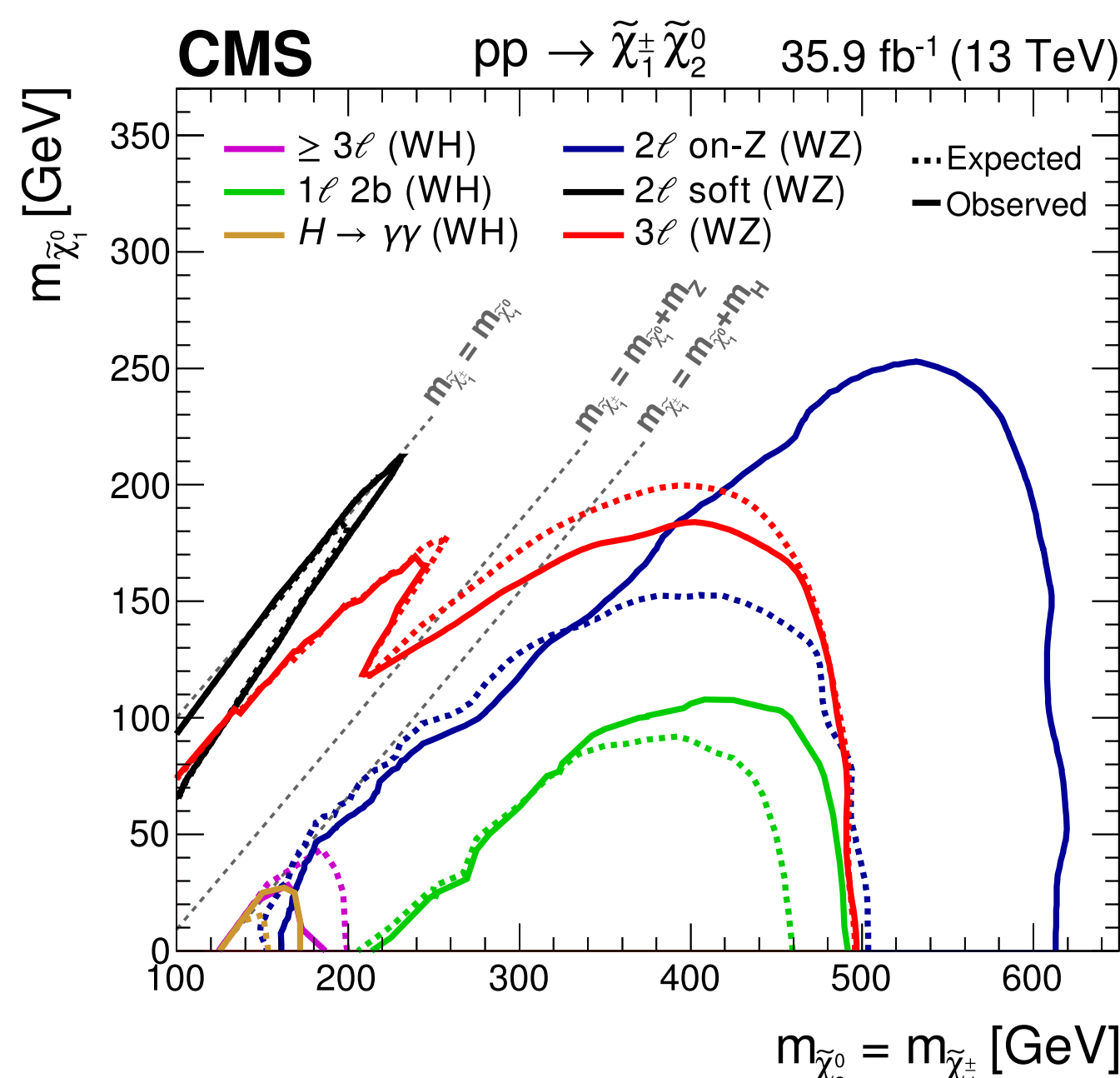
Combined results

Sizable improvements for different models and regions:

> Z-like χ_2^0: 40 GeV increase in excluded NLSP masses in the uncompressed mass spectra regions. Small gains (~ 10 GeV) in the compressed *gaps*.

> H-like χ_2^0: closed the *gap* between individual analysis' excluded regions. Improvement of up to 50 GeV in the LSP mass limits.

> Mixed case: new results. Up to 550 GeV (150 GeV) for the NLSP (LSP) mass.

## Neutralino pair production in GMSB: $\chi_1^0 \chi_1^0$

Set of models based on gauge mediated SUSY breaking (GMSB).
The LSP is assumed to be a (nearly-)massless gravitino, $\tilde{G}$.
The NLSP is the lightest neutralino -either Z-like or H-like- χ_1^0.
Models are parameterized in terms of NLSP mass and its branching ratios
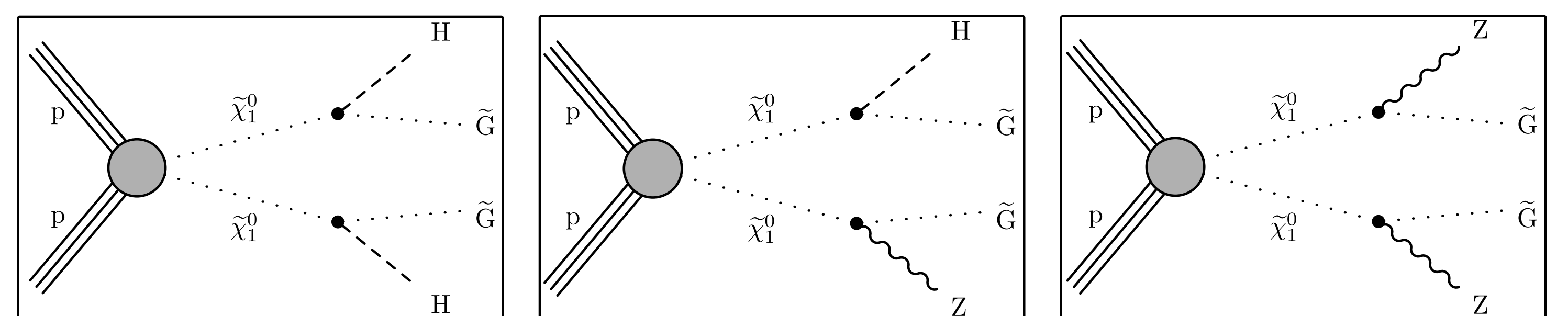
Combined results

95% CL upper limits are set using the CL_S criterion.
> Small *gap* for the higgsino-like models at low mass is closed.
> Improvements in the high mass region of up to 200 GeV.
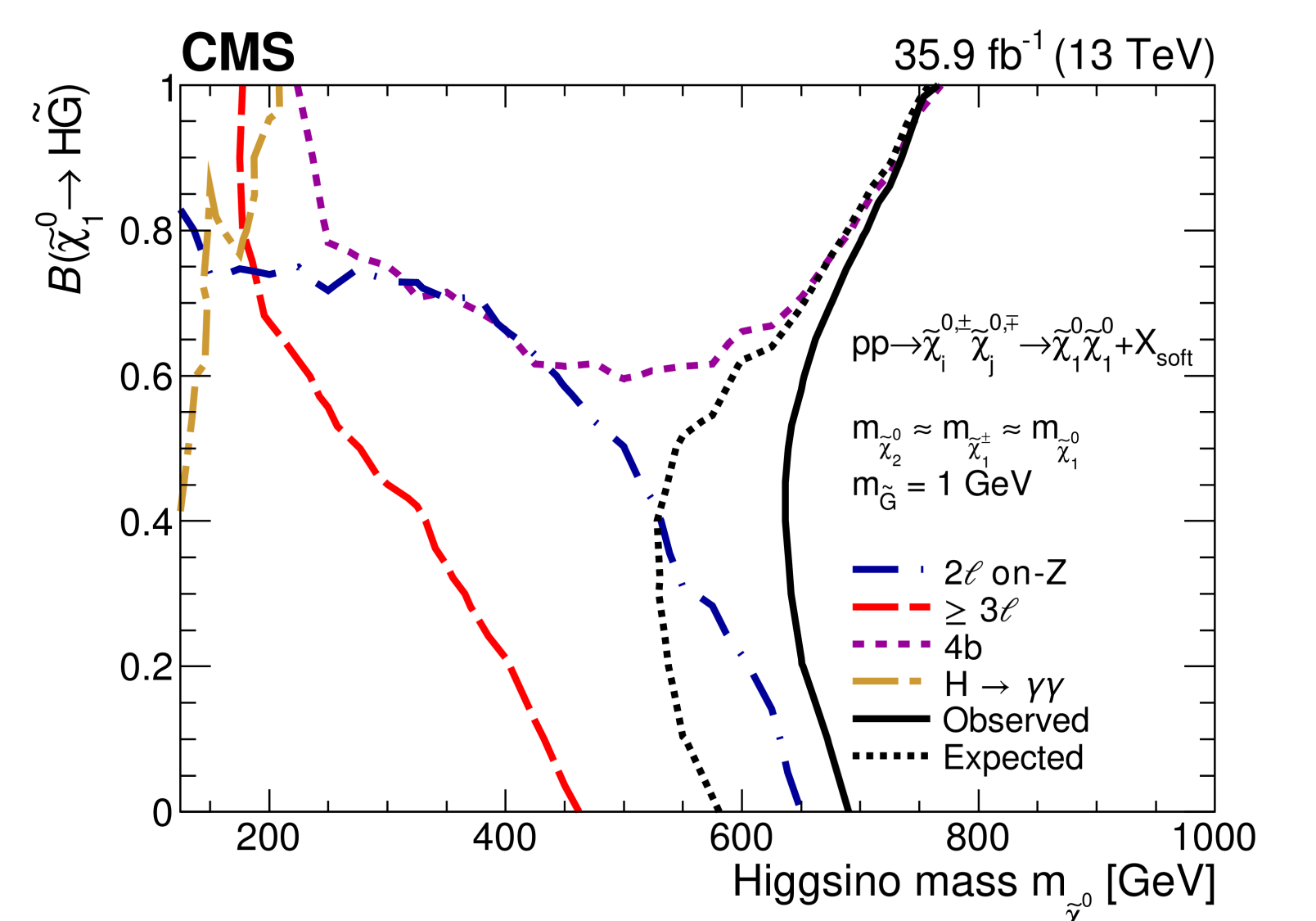
Final state comparisons

Best analysis in each point of the parameter space is plotted.
Can be used to deduce the relative *reach* of each final state topology in this kind of models.
HH to 4b and on-Z dileptonic search showing very good future prospects in this GMSB model.

References

Combined search for electroweak production of charginos and neutralinos in proton-proton collisions at $\sqrt{s} = 13$ TeV
CMS-SUS-17-004, CERN-EP-2017-283