



Search for supersymmetric partners of neutral Higgs bosons at CMS

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## The case for higgsinos



- Classic naturalness arguments require light Only higgsinos enter Higgs mass at tree level gluinos, stops, higgsinos
  - Gluinos and stops with largest cross section, strong exclusion exist

### Excluded masses (model dependent)



 $-\frac{m_Z^2}{2} = |\mu^2| + m_{H_u}^2 + \mathcal{O}$ 



### Analyses covered here





### GMSB: HH→bbbb



- Search for new physics in the HH+MET final state
- Sensitive to higgsinos in the context of GMSB
- Utilise largest Higgs branching fraction to bb
- Reconstruct two  $H \rightarrow bb$  candidates in events with 4 or 5 jets, 0l, and MET > 150 GeV
- Minimise mass difference  $\Delta m = Im(H1)-m(H2)I$ , calculate average  $\mathbf{A}_{4}$  mass  $\langle \mathbf{m} \rangle$

**Baseline selection:**  $0\ell$ , 4–5 jets  $N_{\rm b,T} \ge 2$  $p_{\rm T}^{\rm miss} > 150 \,{
m GeV}$ Track veto  $\Delta \phi_{1,2} > 0.5, \Delta \phi_{3,4} > 0.3$  $|\Delta m| < 40 \,\mathrm{GeV}$  $\Delta R_{\rm max} < 2.2$ 



### Background estimate









# Control regions for main backgrounds



![](_page_5_Figure_2.jpeg)

Extrapolation from 2b to 3b/4b (k) compatible with 1 in signal region (MET>150 GeV)

![](_page_5_Figure_4.jpeg)

### Improvements in algorithms...: HH→bbbb

![](_page_6_Figure_1.jpeg)

- Signal regions: 3b/4b xMET[150,200,300,450,Inf]
- First users of DNN-based b-tagging using ~same inputs as previous standard (and successors already on the way)
- Exclude GMSB Higgsinos between 225 and 770 GeV

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These are the kind of object improvements that help surpassing luminosity scaling of limits

### GMSB: $H \rightarrow \gamma \gamma$ razor

![](_page_7_Figure_1.jpeg)

![](_page_7_Picture_6.jpeg)

![](_page_8_Figure_0.jpeg)

EWK Combination (SUS-17-004)

![](_page_8_Figure_3.jpeg)

# Limits depend on branching fractions

![](_page_9_Figure_1.jpeg)

![](_page_9_Picture_3.jpeg)

# Limits depend on branching fractions

![](_page_10_Figure_1.jpeg)

![](_page_10_Picture_3.jpeg)

# Neutralino-chargino ( $\tilde{\chi}_2^0 - \tilde{\chi}_1^{\pm}$ ) pair production

![](_page_11_Figure_1.jpeg)

# Soft opposite-sign leptons

- Light higgsinos would likely have a compressed mass spectrum
- Results in low p<sub>T</sub> decay products
  - Target this signature with soft leptons
  - Rely on events with large ISR boost for sizeable MET
  - ▶ pT(µ): 3.5-30 GeV
  - ▶ pT(e): 5-30GeV
- Backgrounds: W+jets, 1L/2L tt, Z→tau,tau
  - From MC normalized to data in control regions

![](_page_12_Figure_9.jpeg)

### Navid's talk for details

![](_page_12_Picture_12.jpeg)

# Soft opposite-sign leptons

- Light higgsinos would likely have a compressed mass spectrum
- ▶ Results in low p<sub>T</sub> decay products
  - soft leptons

![](_page_13_Figure_4.jpeg)

### Navid's talk for details

![](_page_13_Picture_6.jpeg)

## Neutralino-chargino ( $\tilde{\chi}_2^0 - \tilde{\chi}_1^{\pm}$ ) pair production combination

![](_page_14_Figure_1.jpeg)

### Conclusions

![](_page_15_Figure_1.jpeg)

- Improving reconstruction and analysis techniques is key for probing beyond "early SUSY"
- Improved trigger for soft opposite-sign lepton search (muons down to 3.5 GeV) and DNN-btagging for GMSB HH $\rightarrow$ bbbb search prominent examples

- harvest Run 2 dataset to the fullest 14
- No supersymmetric neutral Higgs boson partners found, yet, but putting everything in place to

![](_page_16_Picture_0.jpeg)

![](_page_16_Picture_1.jpeg)

![](_page_16_Picture_2.jpeg)

![](_page_16_Picture_3.jpeg)

## Particle Flow (PF) approach

![](_page_17_Figure_1.jpeg)

### Supersymmetry or Supercemetry?

![](_page_18_Figure_2.jpeg)

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- No surprises with full 2016 dataset
- But: Simplified Model Searches (SMS) trick the eye (e.g. typically assume 100% branching fraction in a particular channel + mass degeneracy)
- Focus on compressed/EW/ Higgs/VBF and usage of new tools

![](_page_18_Picture_7.jpeg)

![](_page_18_Picture_9.jpeg)

# Neutralino-chargino ( $\tilde{\chi}_2^0 - \tilde{\chi}_1^{\pm}$ ) pair production

![](_page_19_Figure_1.jpeg)