

# Higgs Couplings and New Physics

Physics Requirements, Collider Accuracy and Systematic Uncertainties

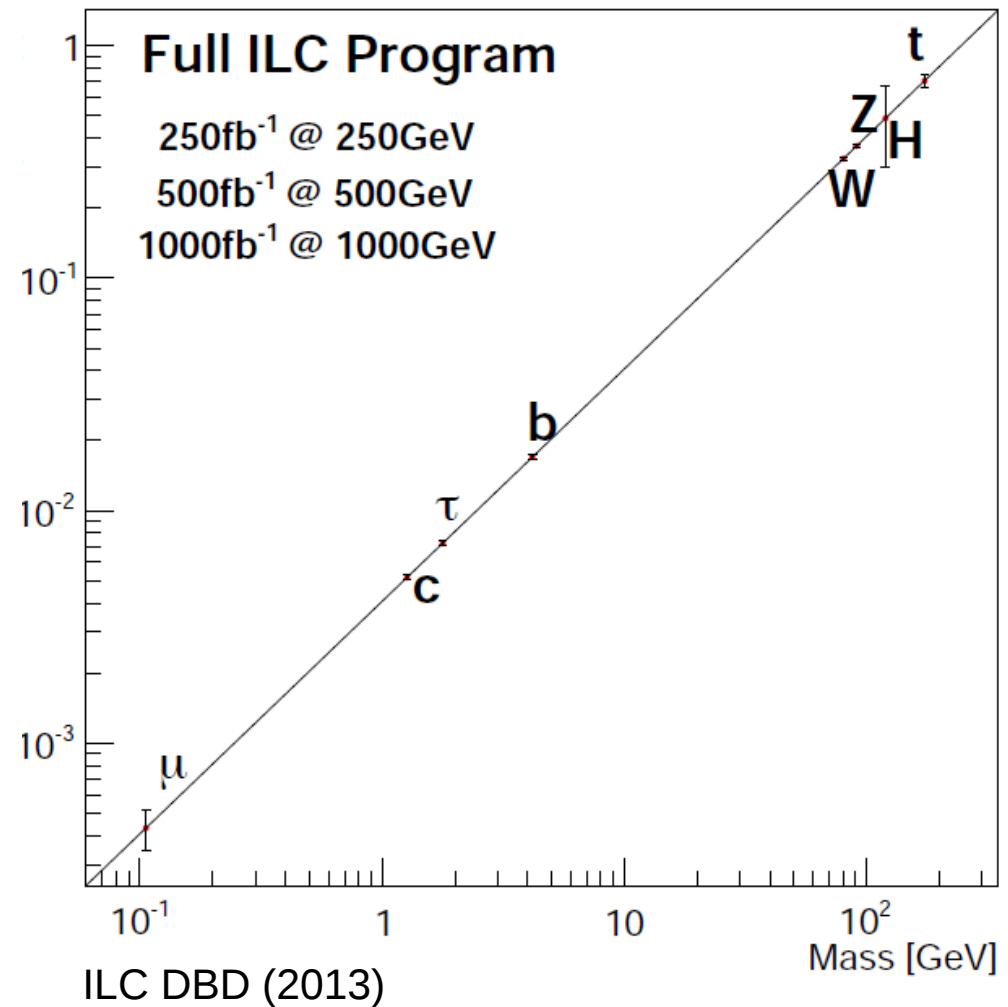
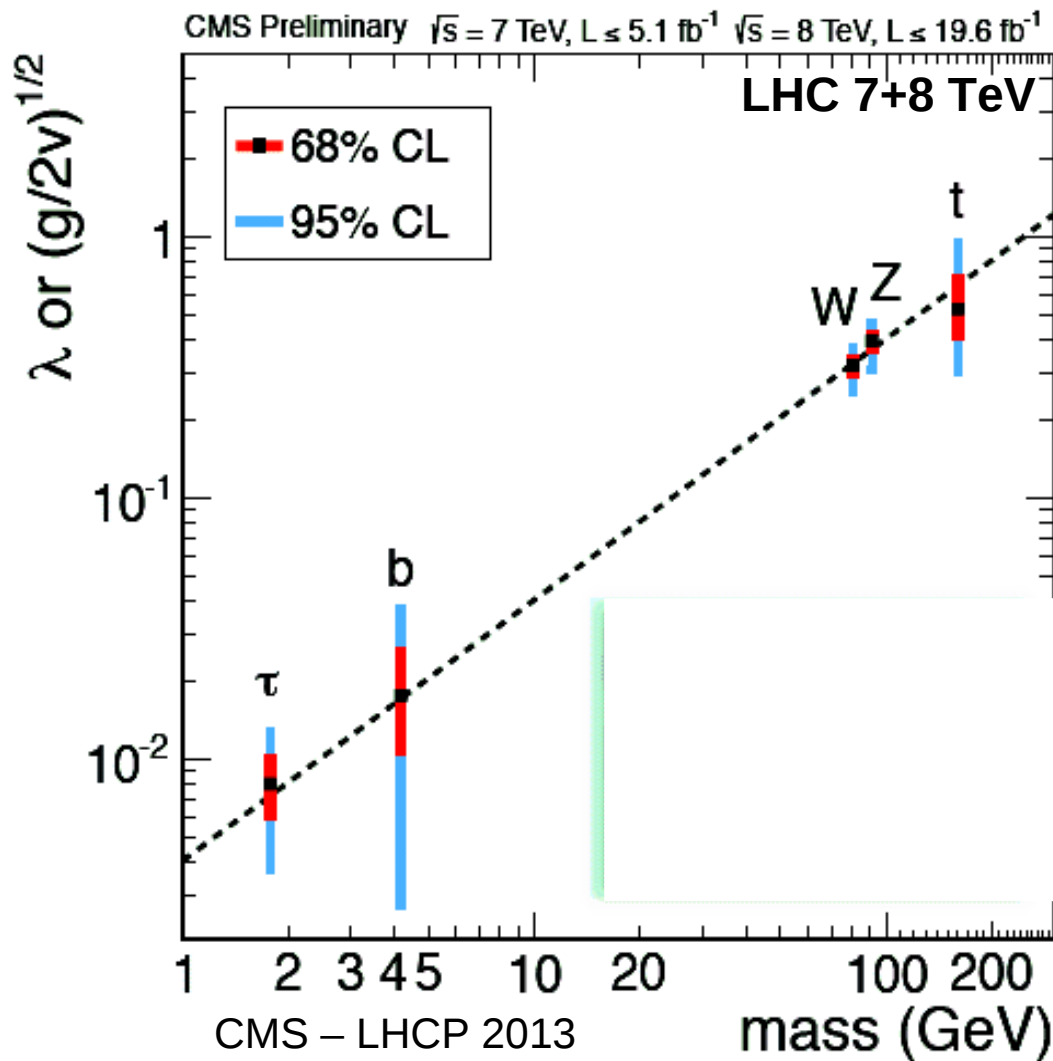
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in collaboration with

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Snowmass 2013 Community Summer Study  
Energy Frontier Workshop,  
U. of Washington – Seattle – June 30th, 2013

# Testing Higgs sector through couplings: from now to the ILC



# Models

## pMSSM:

19 parameters MSSM, test sensitivity to  $M_A$  and sparticle contributions to loops

## pMSSM with light neutralino:

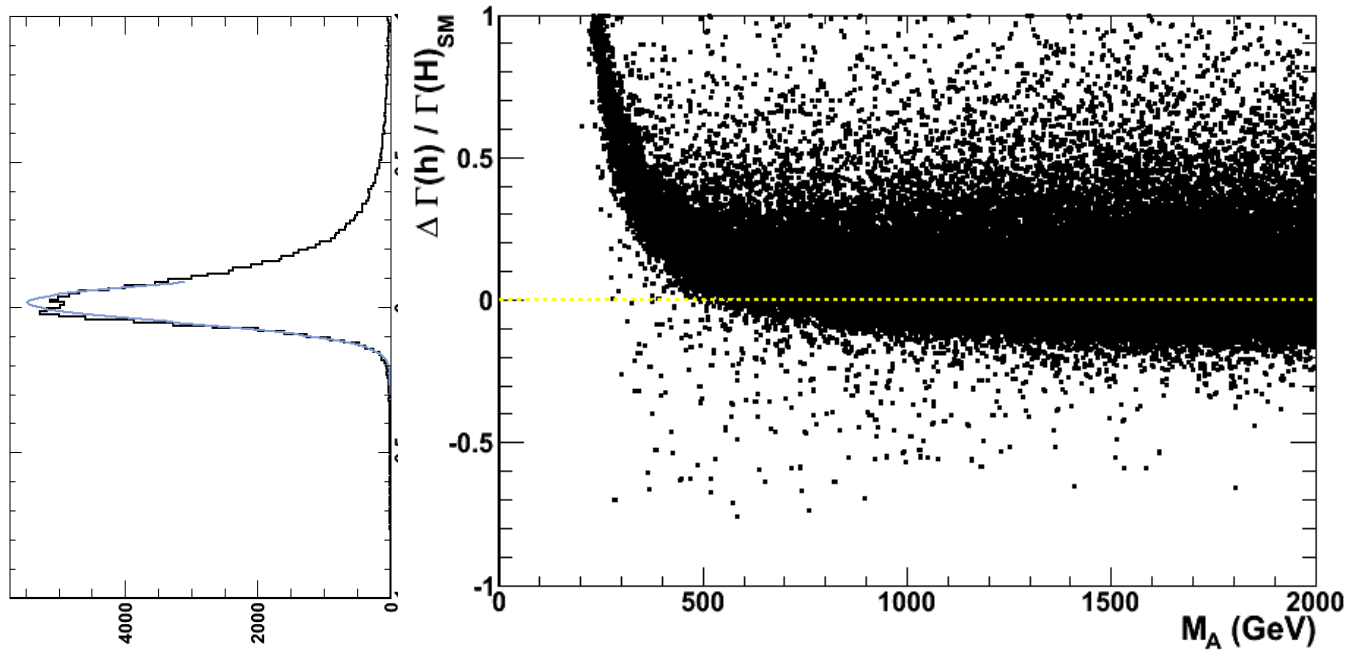
Scenarios compatible with light WIMPS in DM direct searches

Study shifts in  $h$  couplings,  $B_{\text{rs}}$  and total width through high statistics 19 parameter Scans (SoftSUSY + HDECAY 5 + SuperIso + Micromegas)

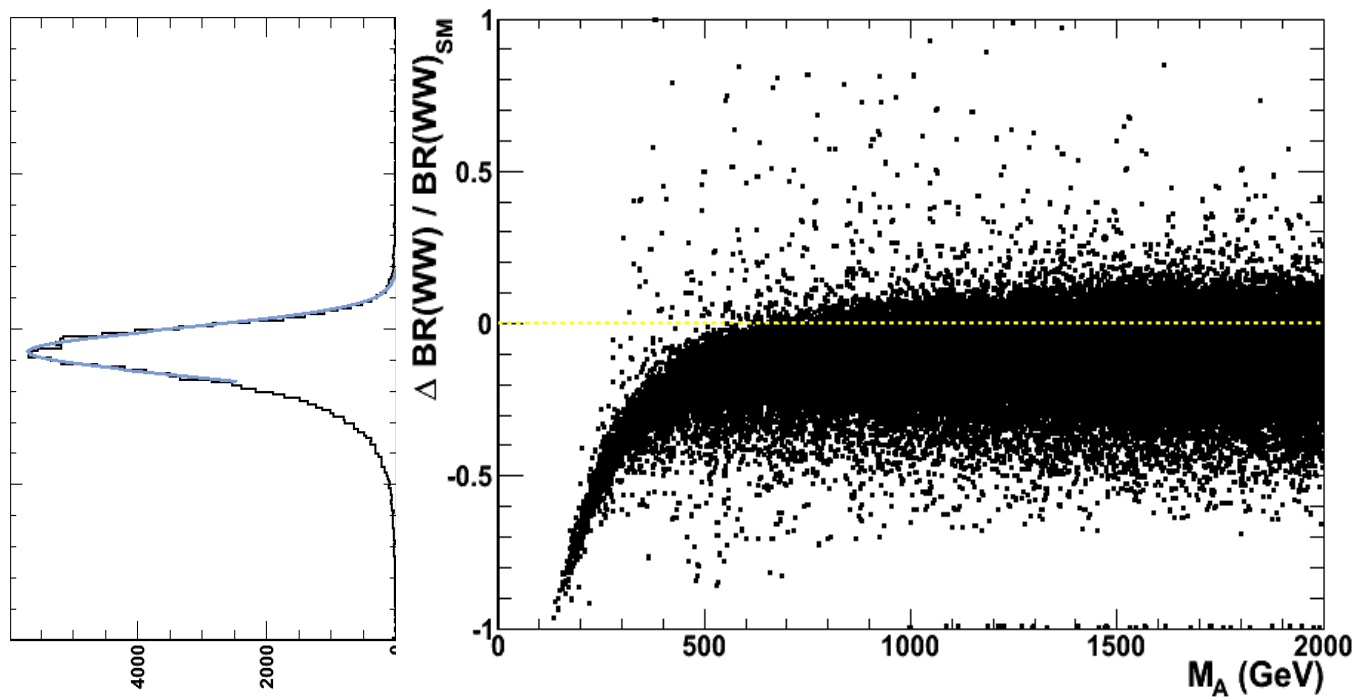
## SILH:

Generic SILH models with multiparameter scans  
and benchmark models (MCHM4 and MCHM5) (eHDECAY)

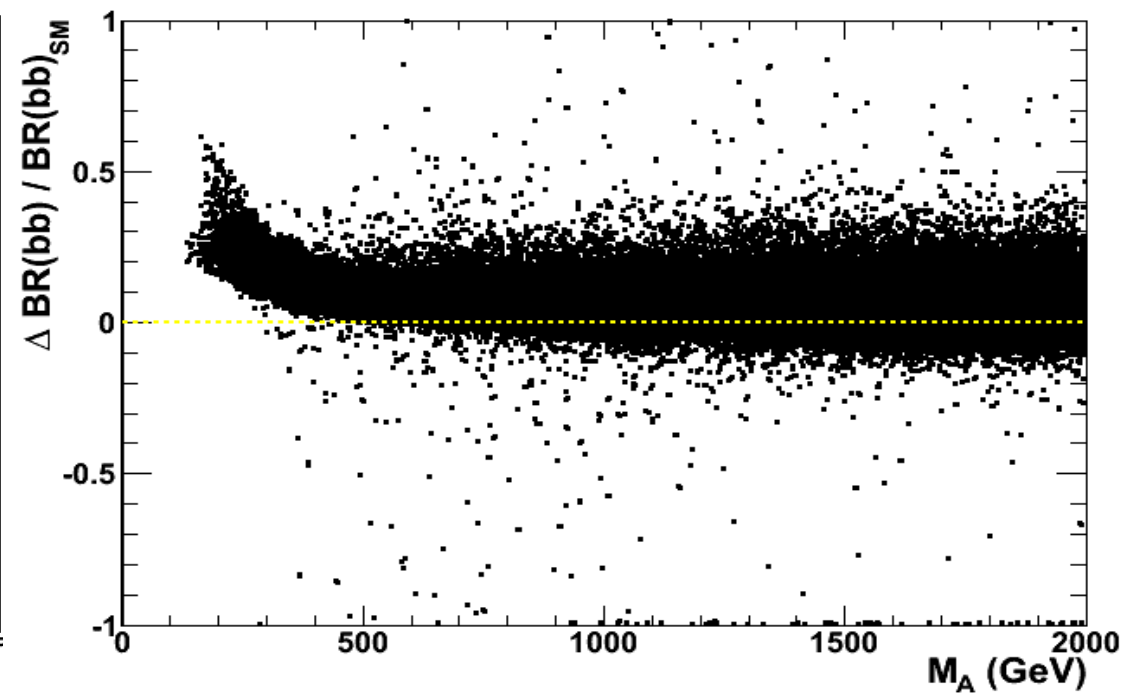
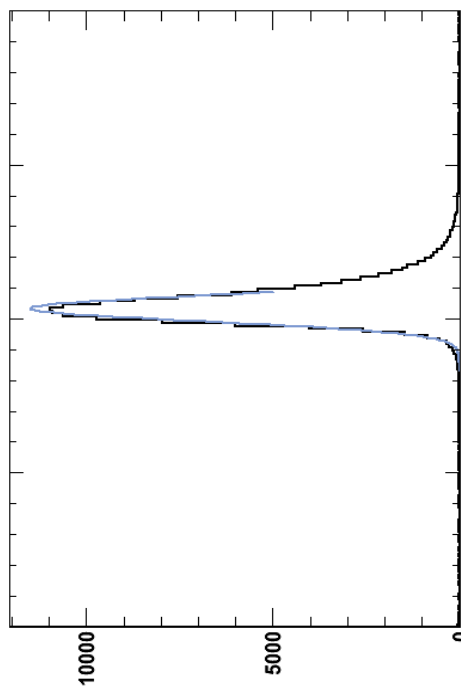
# MSSM: Higgs Width, Branching Fractions, $M_A$ and SUSY



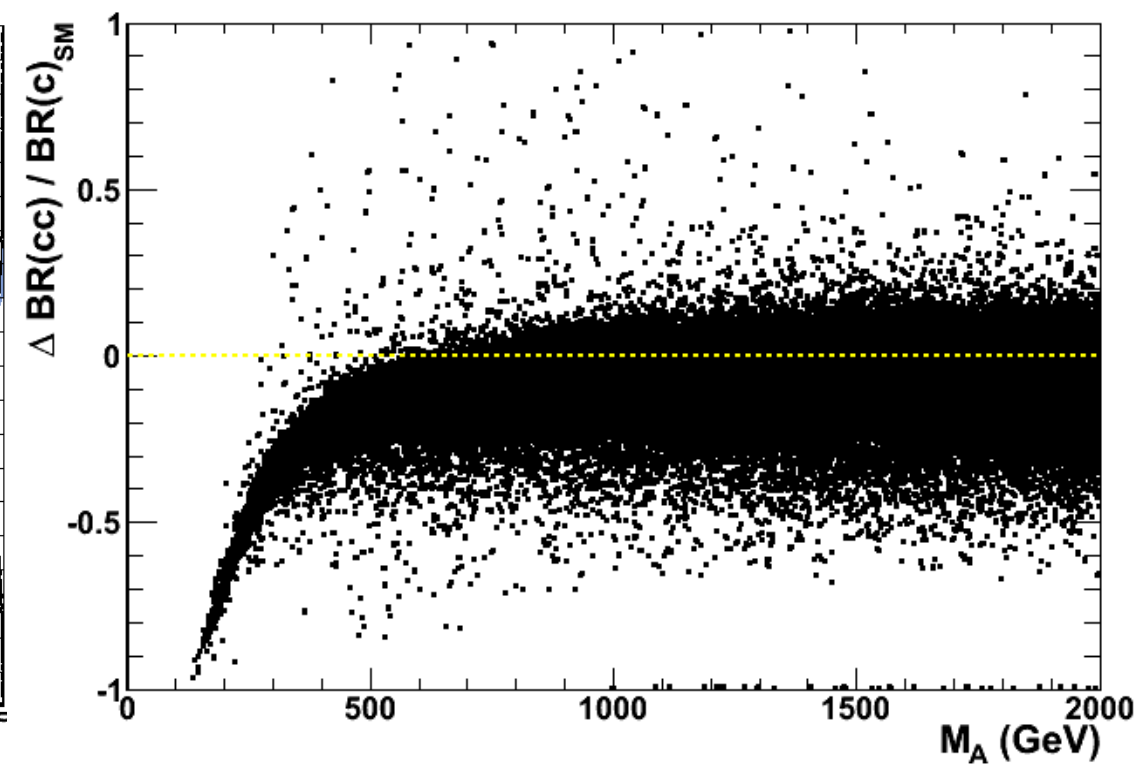
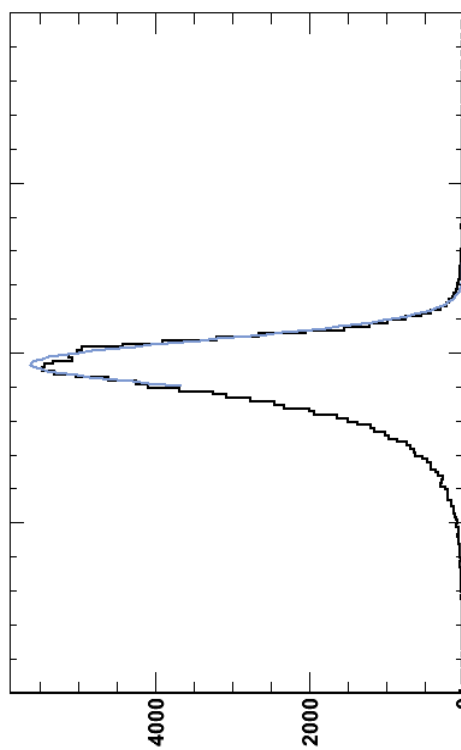
$\Gamma_h$



WW



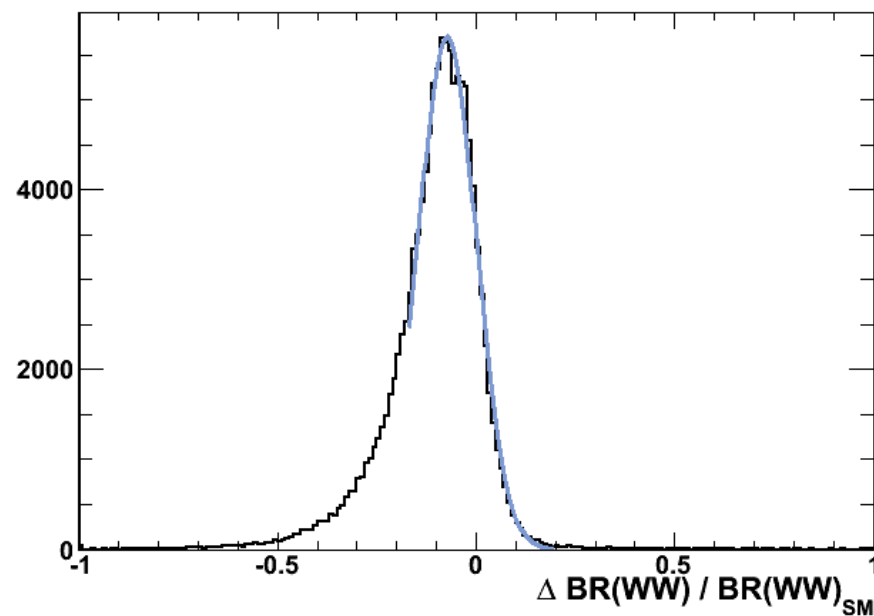
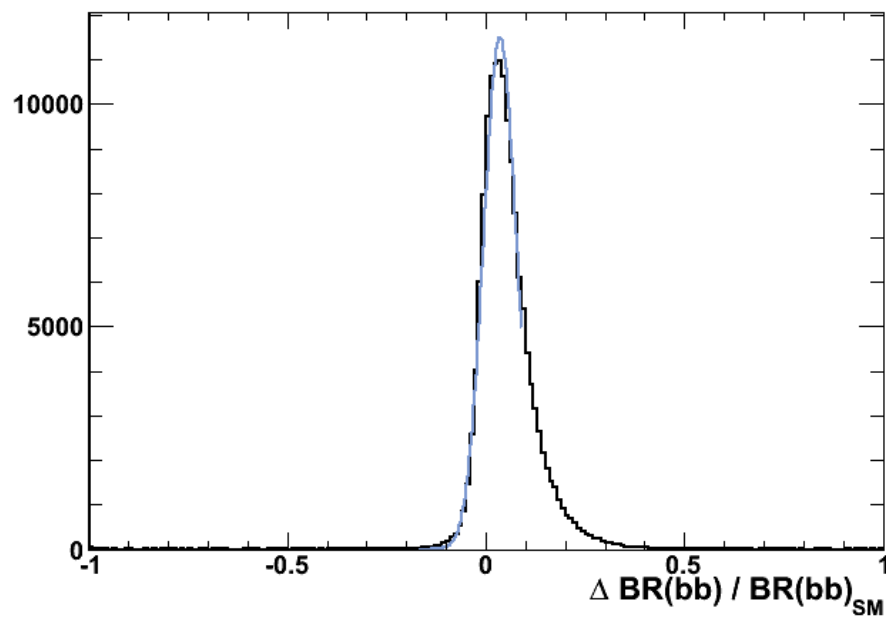
$bb$



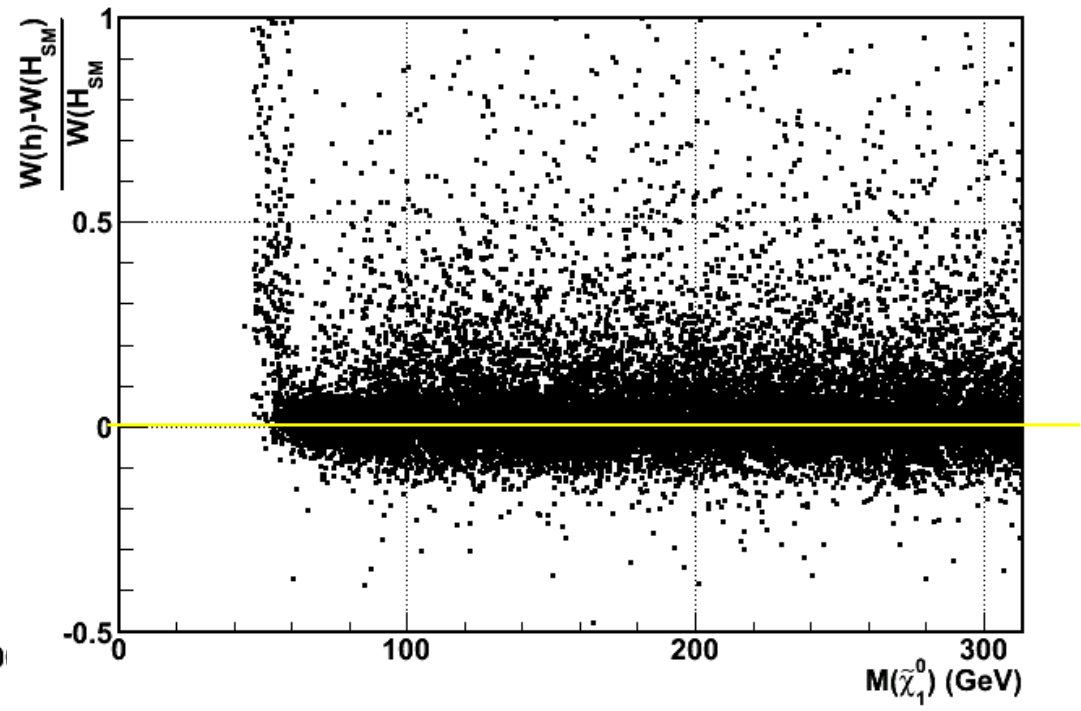
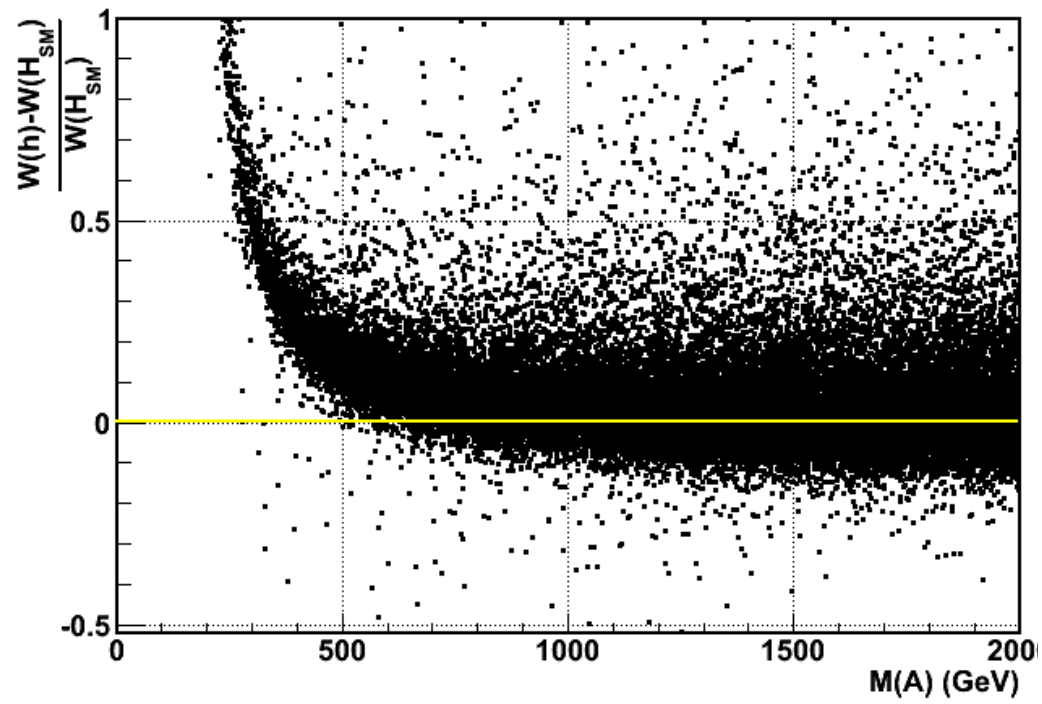
$cc$

# MSSM: Higgs Width, Branching Fractions, $M_A$ and SUSY

Observable	Gaussian RMS
$\Gamma(h)$	0.067
$\text{BR}(WW)$	0.075
$\text{BR}(bb)$	0.041
$\text{BR}(cc)$	0.072
$\text{BR}(\gamma\gamma)$	0.070



# MSSM: Higgs Total Width

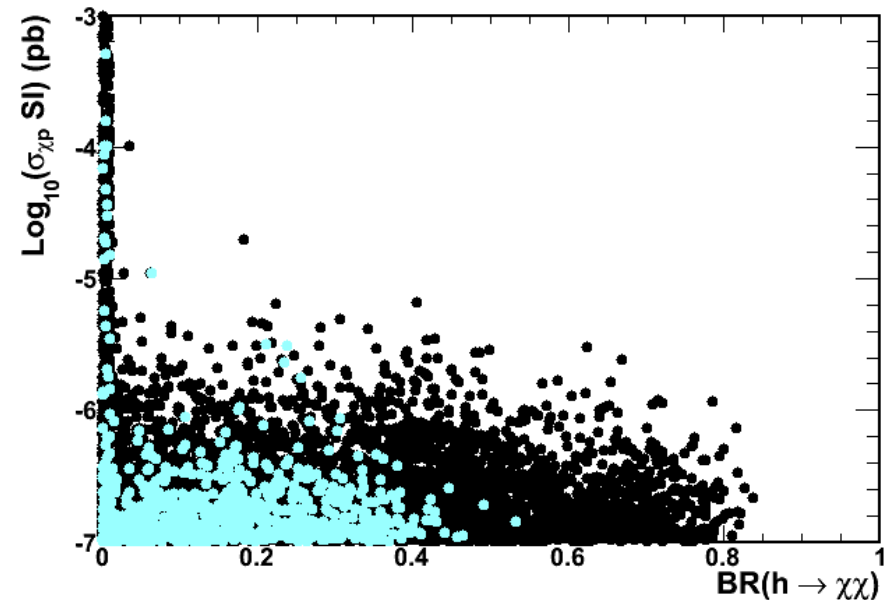
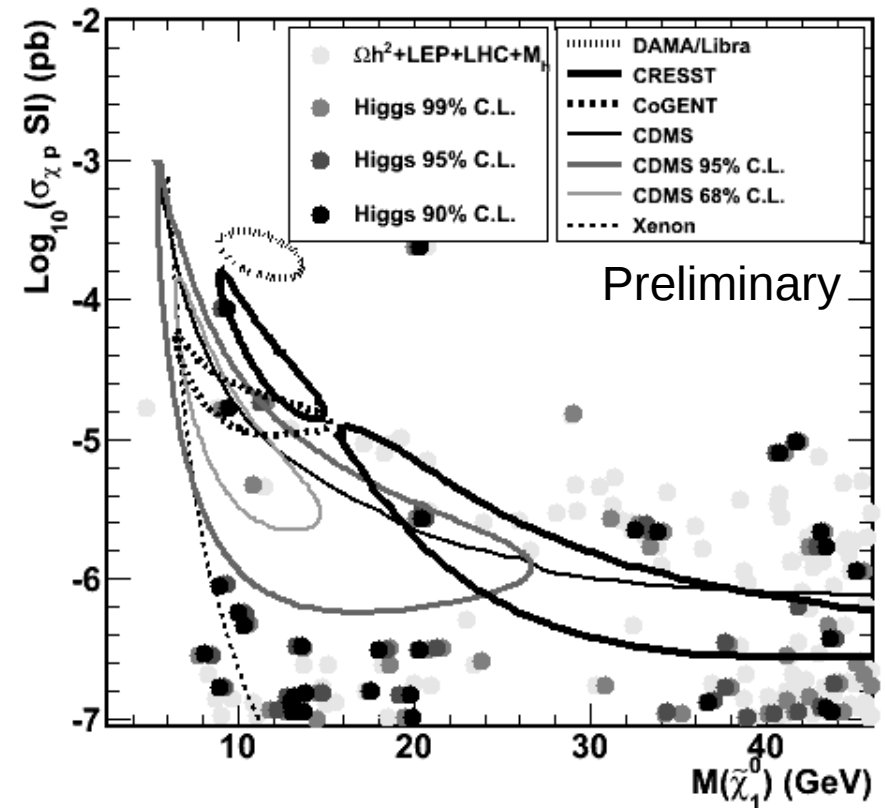


# MSSM: Higgs Invisible Decays

Scenarios with light neutralino compatible with direct detection events reported by CDMS and other experiments exist in the MSSM;

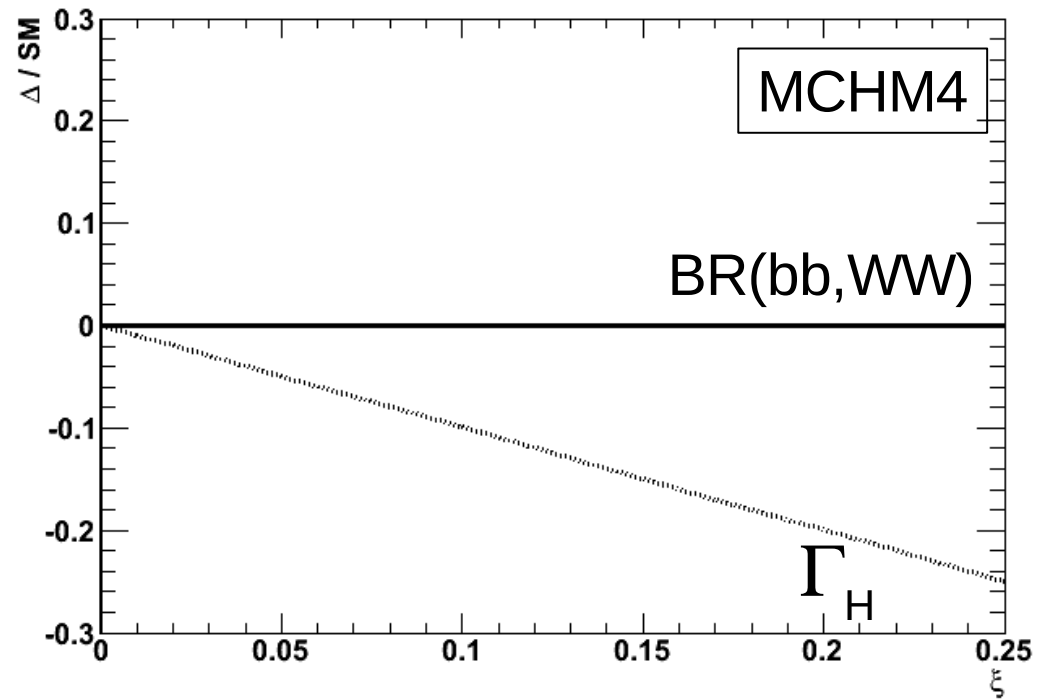
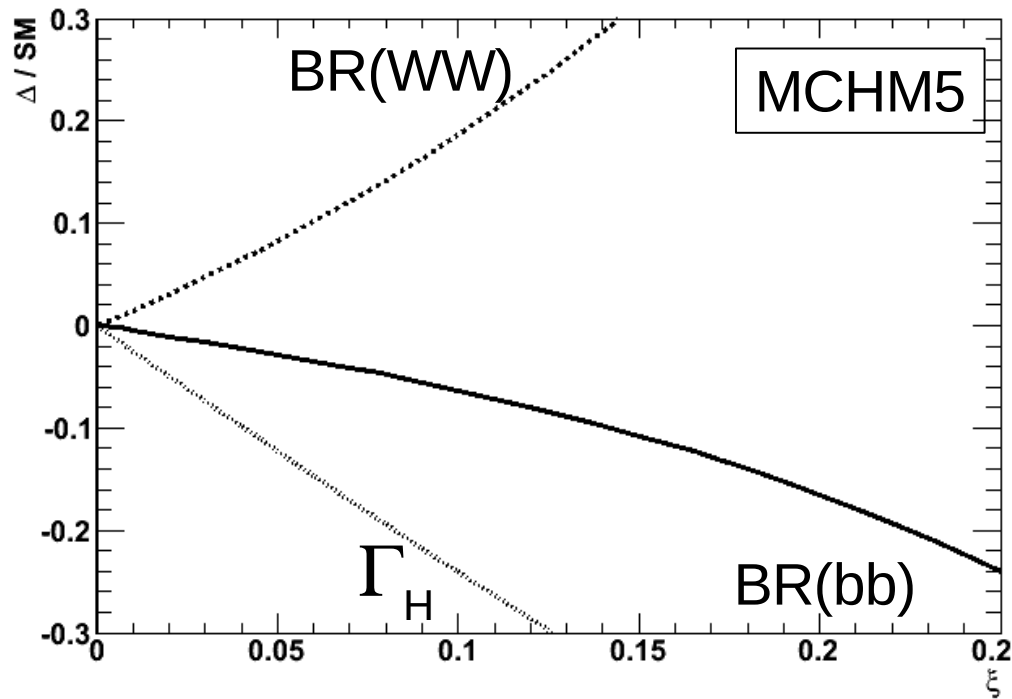
Light neutralinos put emphasis on invisible Higgs decays;

In the specific scenario identified so far (light, degenerate sbottom) invisible decay branching fractions are  $< 10\%$  which makes them interesting only for  $e^+e^-$  colliders.





# SILH: Higgs Branching Fractions and Total Width



MCHM 4 = Agashe Contino, Pomarol, NP B 719 (2005) 165

MCHM 5 = Contino, Da Rold, Pomarol, PRD 75 (2007) 055014

## Systematic Uncertainties: Parametric and Theoretical

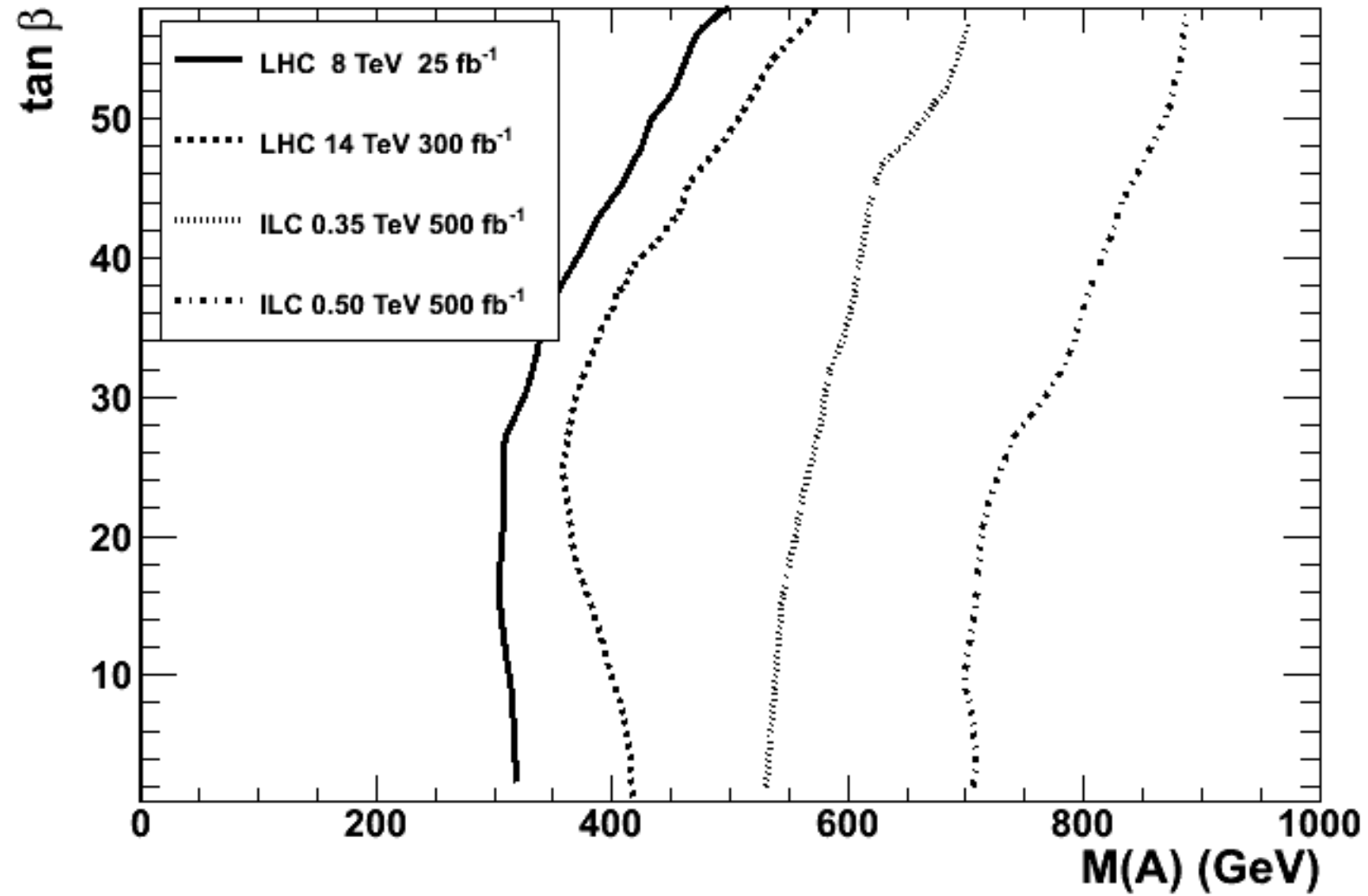
	$\Delta m_b$	$\Delta m_c$	$\Delta m_t$	$\Delta \alpha_s$	TH
$\Delta \text{BR}(\text{bb})/\text{BR}$	0.012	0.002	0.0001	0.004	0.007
$\Delta \text{BR}(\text{cc})/\text{BR}$	0.019	0.060	0.001	0.015	0.018
$\Delta \text{BR}(\tau\tau)/\text{BR}$	0.018	0.002	0.001	0.006	0.016
$\Delta \text{BR}(\text{WW})/\text{BR}$	0.002	0.002	0.0001	0.006	0.011

(see also S. Heinemeyer talk at this workshop)

Droll and Logan, PRD76 (2007)

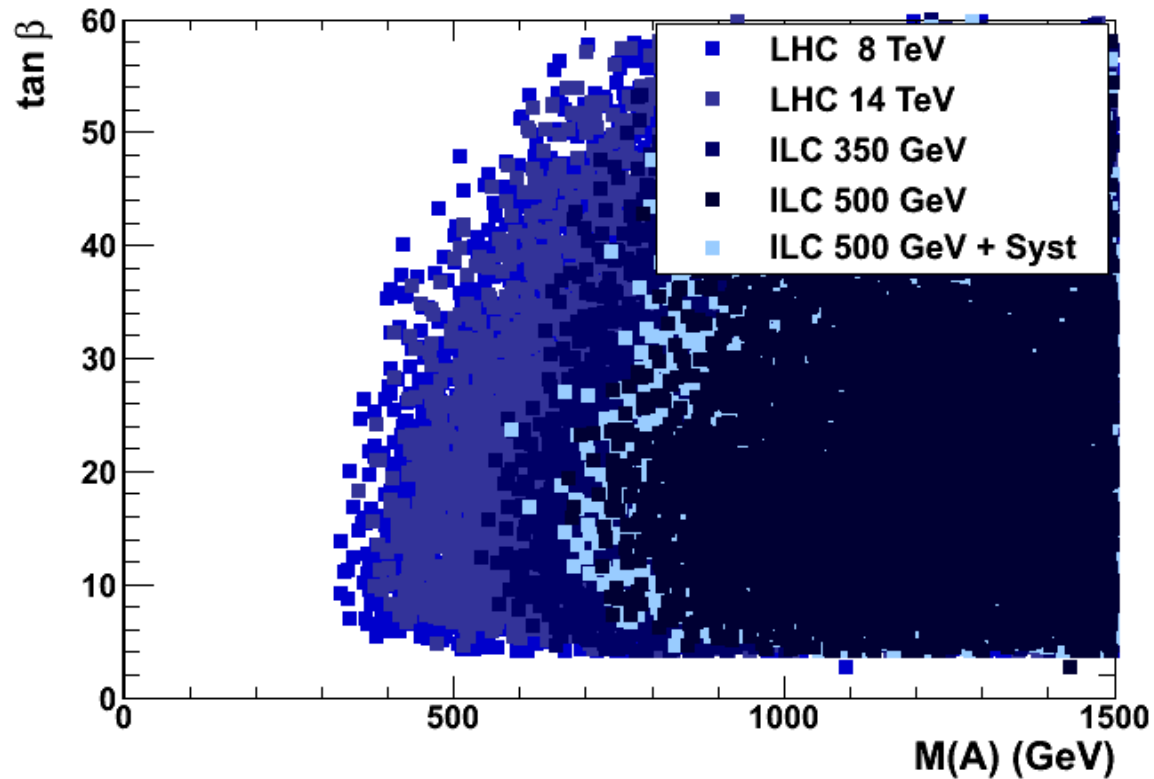
Denner et al. (LHC Higgs XSec WG), EPJC 71 (2011)

# MSSM: $M_A$ Sensitivity

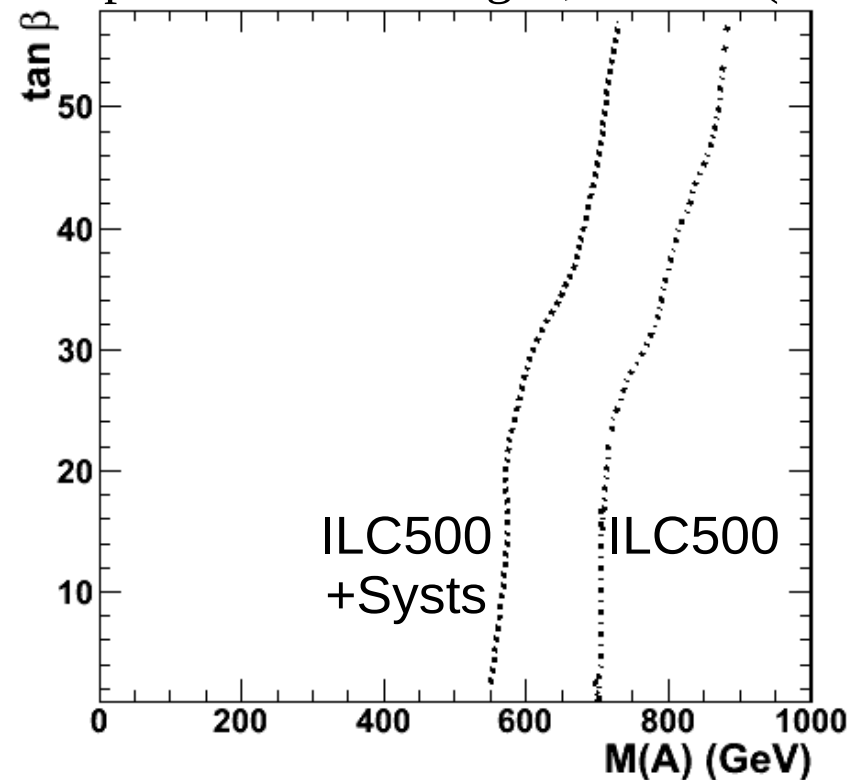


# MSSM: $M_A$ Sensitivity

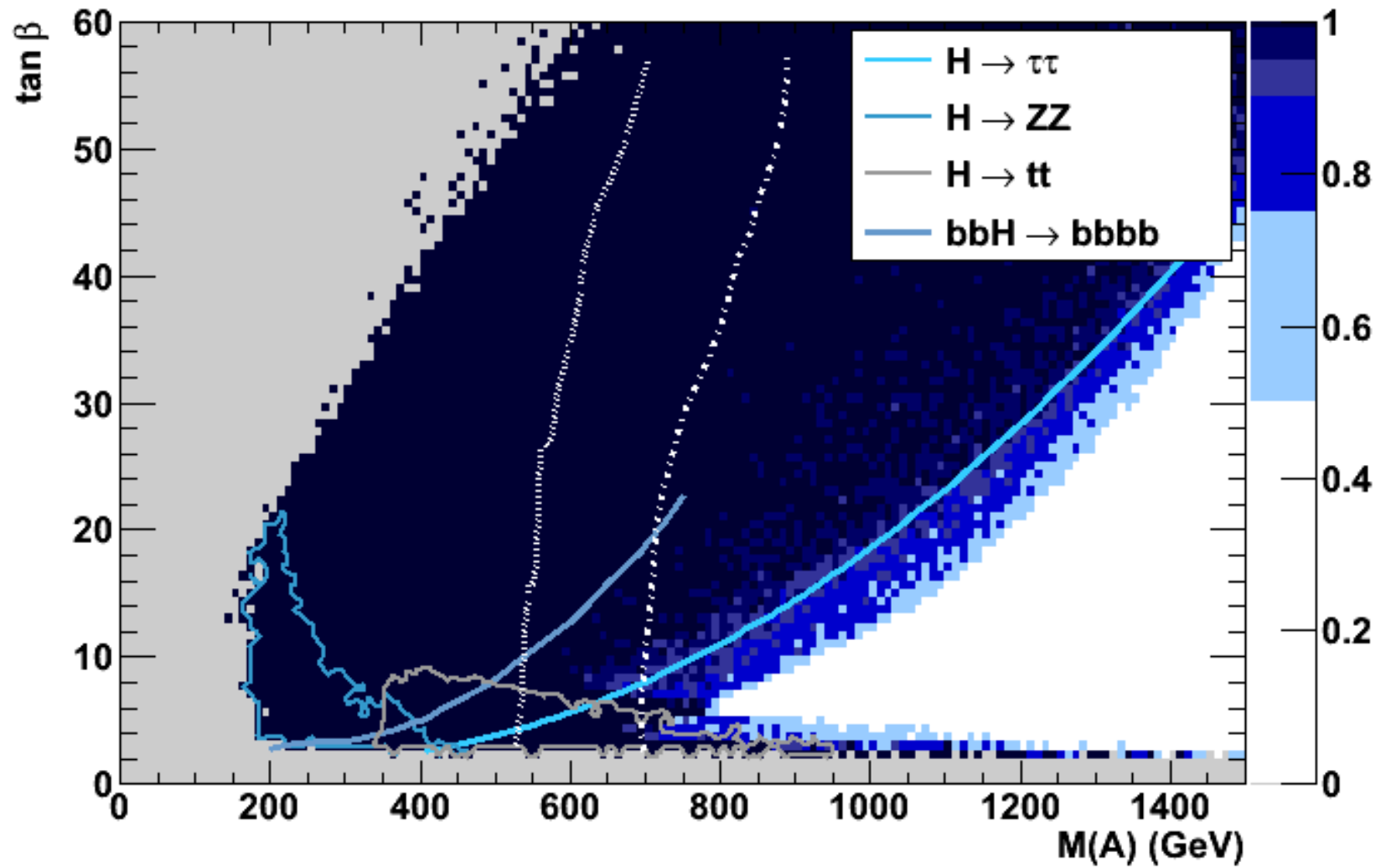
	pMSSM $M_A$ Exclusion (95%C.L.)
LHC	380 GeV
ILC 350	530 GeV
ILC 500	700 GeV
ILC 500 + Systs	550 GeV



compare Droll and Logan, PRD76 (2007)



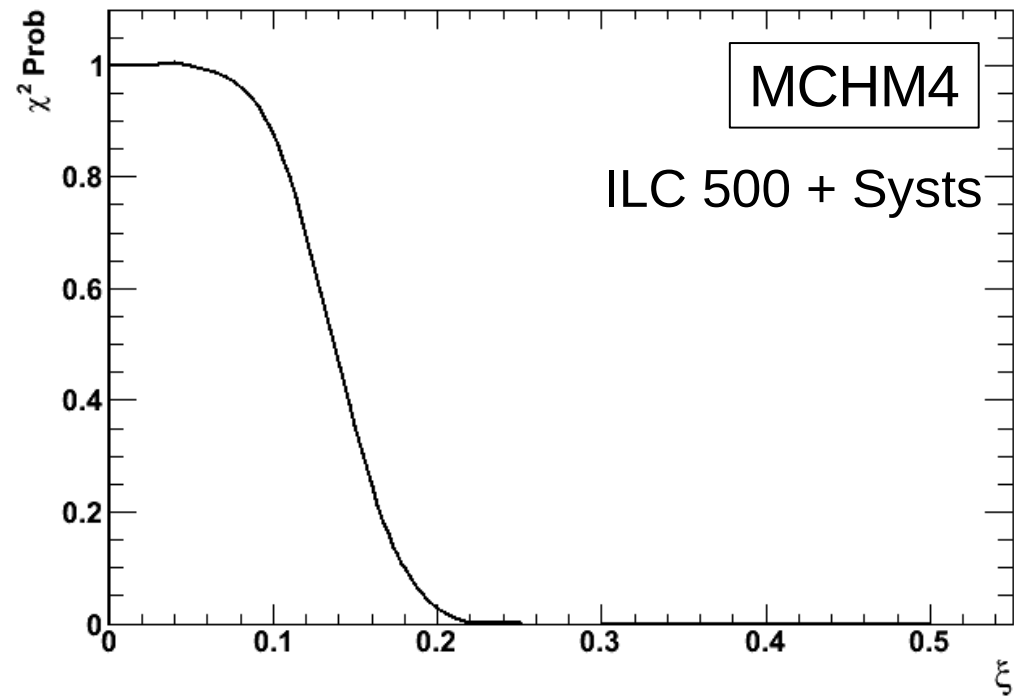
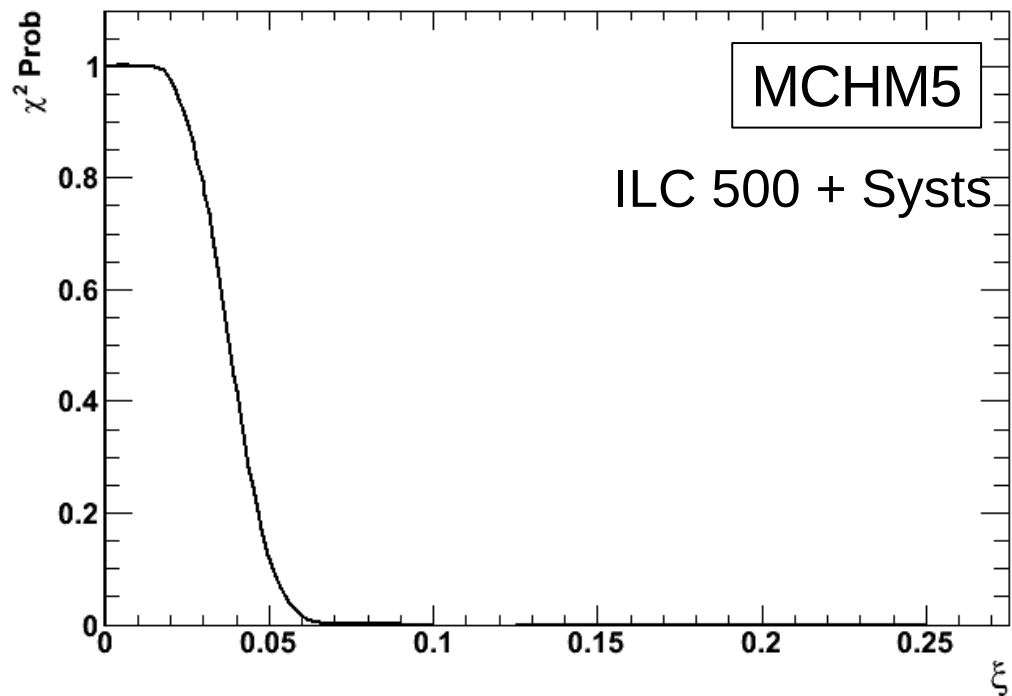
# MSSM: $M_A$ Sensitivity



Arbey, MB, Mahmoudi, arXiv:1303.7450

## SILH: $\xi$ Sensitivity

95% CL $\xi$ Limit	MCHM4	MCHM5
LHC	-	
ILC 350	0.29	0.056
ILC 500	0.18	0.046
ILC 500 + Sys	0.22	0.055



## Conclusions

Ongoing study of sensitivity to BSM physics through precision determination of Higgs properties based on various models;

BSM effects may be of order of few percent and determination of both branching fractions and total width essential to identify some models;

“Useful” experimental accuracy depends on BSM effects and parametric+theory systs;

Accuracy expected from ILC program at 0.25+0.35+0.5 TeV appears well matched to “useful” accuracy and provides indirect sensitivity up to and beyond LHC direct reach for BSM signals in the same models;

Further push in accuracy beyond ILC will not lead significant improvement in BSM sensitivity for scenarios considered so far, unless systematics are correspondingly reduced;

Plan to extend study to additional models and consider triple Higgs coupling.