Heavy SUSY Higgs Bosons
Direct Searches and Indirect Limits

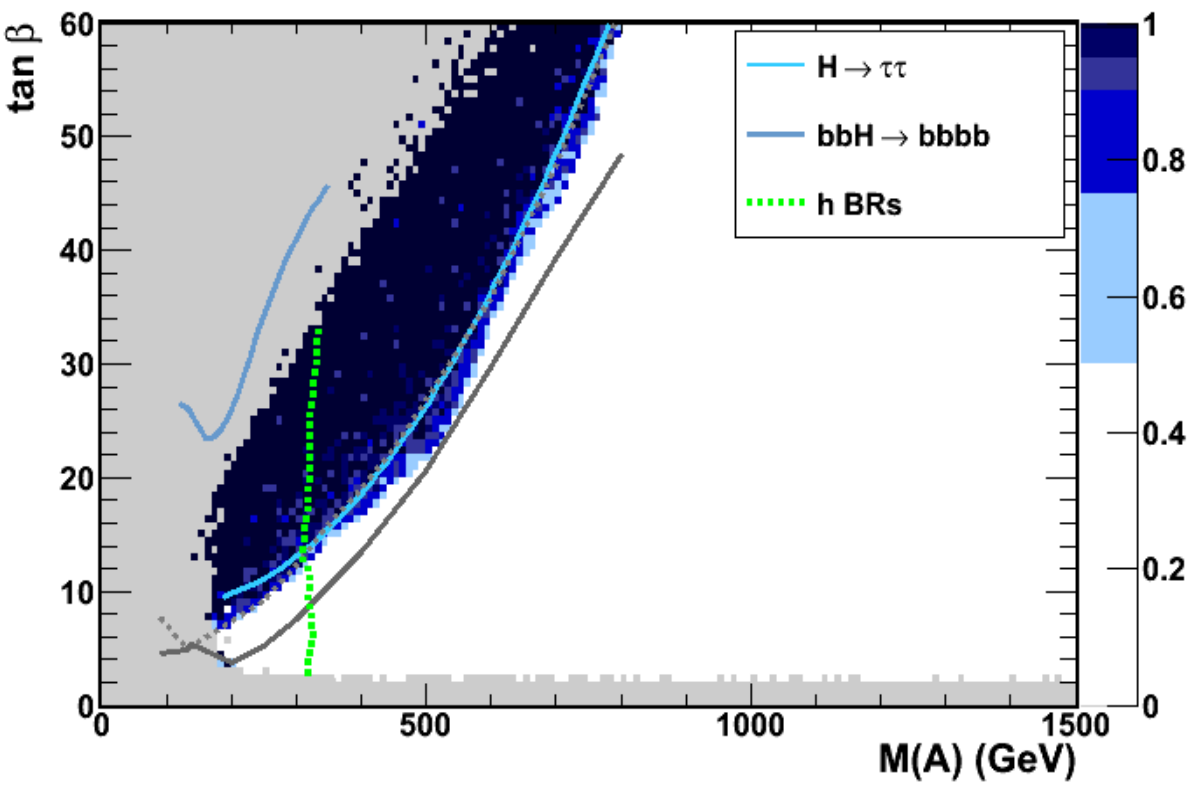
Marco Battaglia

in collaboration with
A Arbey and F Mahmoudi

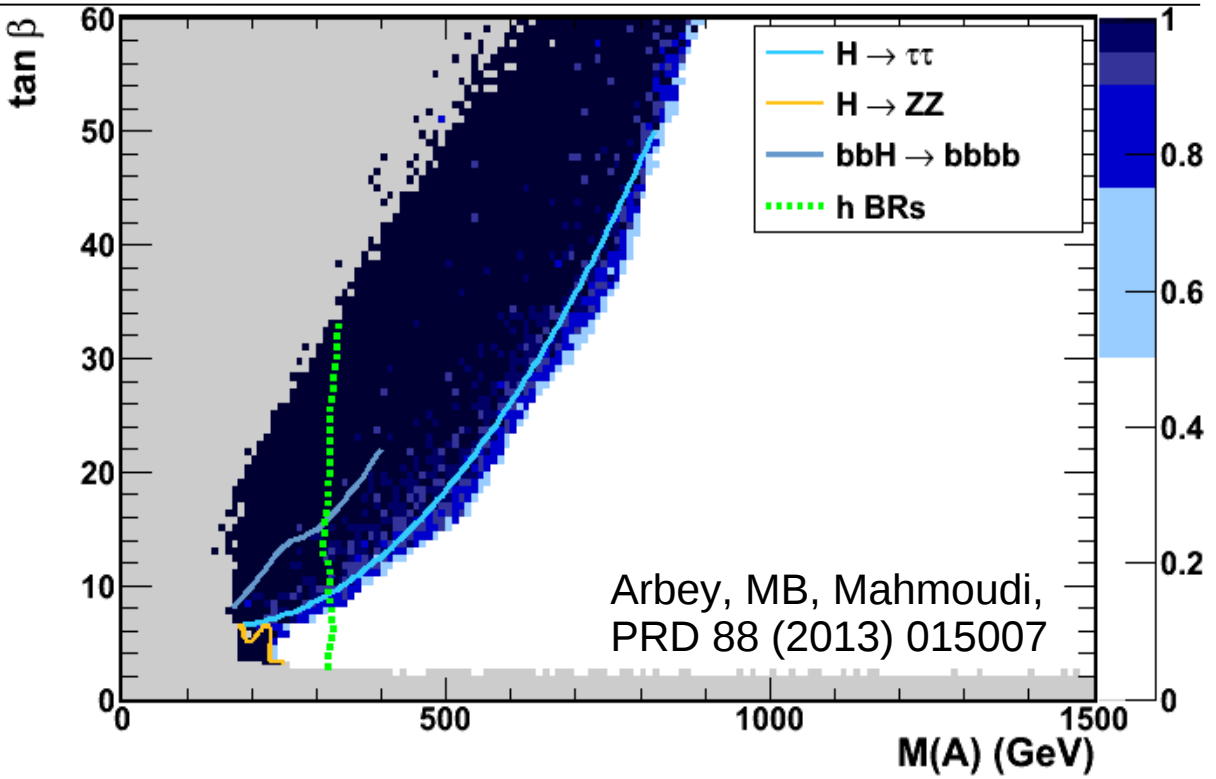
Thanks to A. Djouadi, B. Allanach, R. Harlander,
M. Spira and S Dittmaier

SUSY 2013
ICTP - Trieste, August 2013

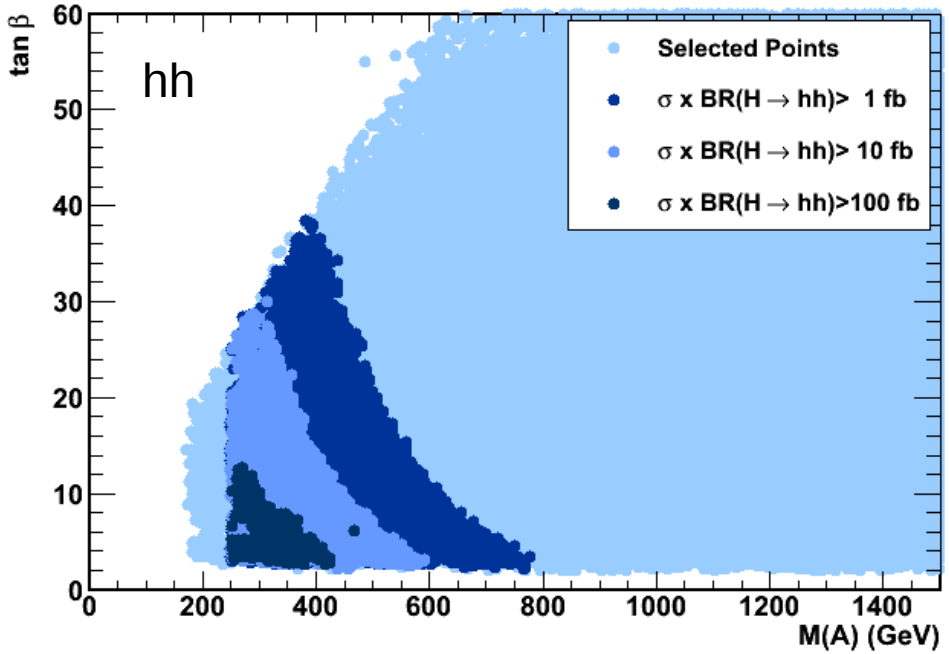
LHC Spring 2013 results

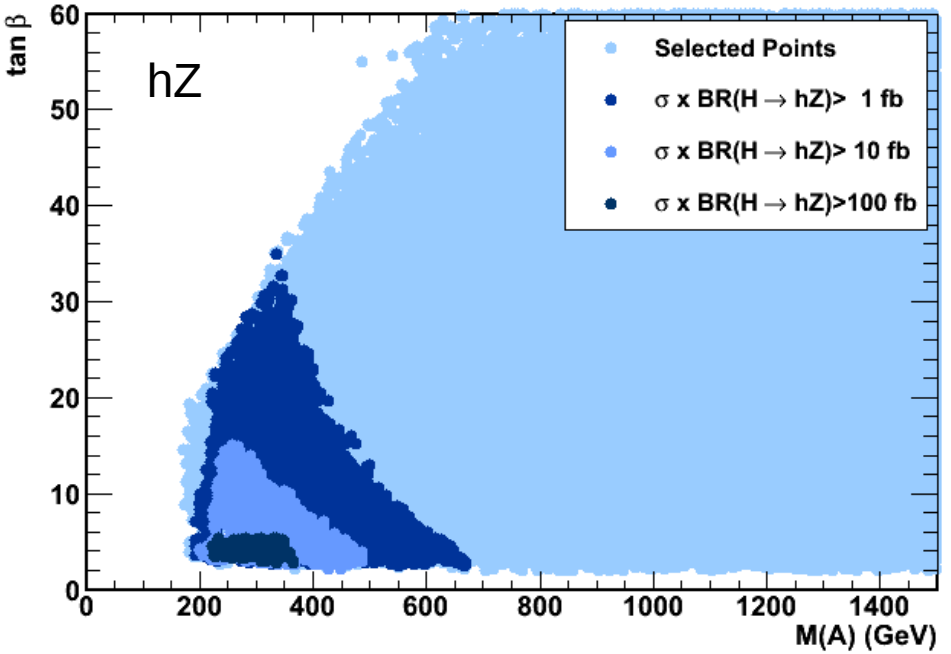


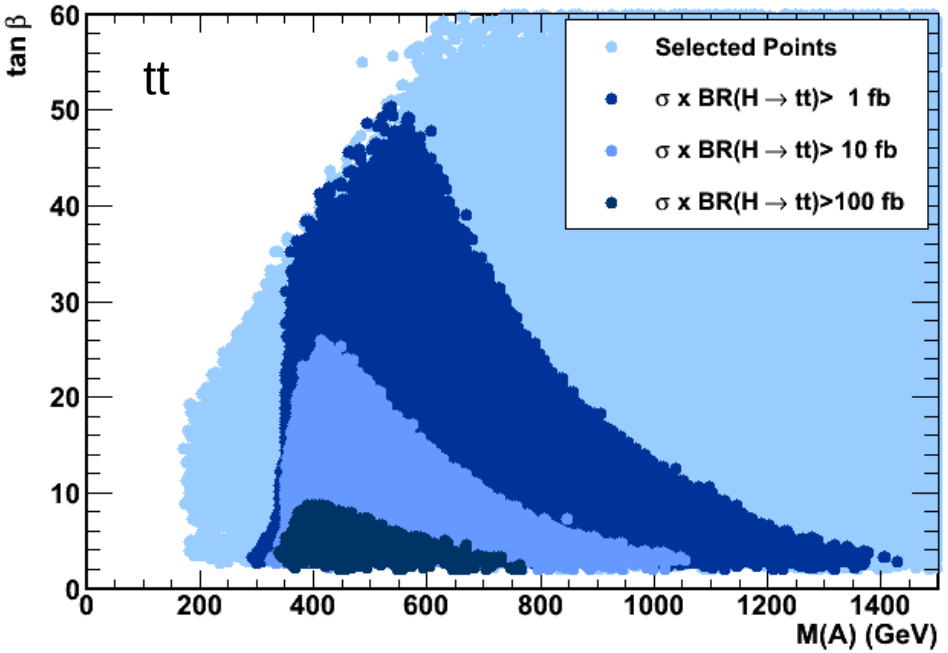
LHC 8 TeV 25 fb^{-1} projection

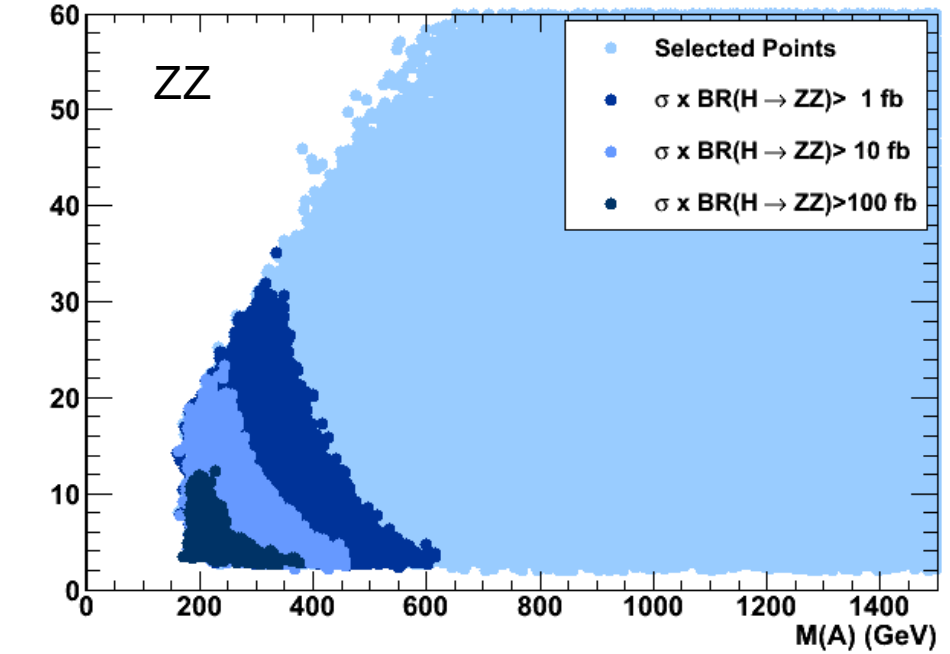


LHC 14 TeV


hh
Selected Points
σ x BR(H → hh)> 1 fb
σ x BR(H → hh)> 10 fb
σ x BR(H → hh)>100 fb
tan β
M(A) (GeV)


hZ
Selected Points
σ x BR(H → hZ)> 1 fb
σ x BR(H → hZ)> 10 fb
σ x BR(H → hZ)>100 fb
tan β
M(A) (GeV)


tt
Selected Points
σ x BR(H → tt)> 1 fb
σ x BR(H → tt)> 10 fb
σ x BR(H → tt)>100 fb
tan β
M(A) (GeV)


ZZ
Selected Points
σ x BR(H → ZZ)> 1 fb
σ x BR(H → ZZ)> 10 fb
σ x BR(H → ZZ)>100 fb
tan β
M(A) (GeV)

LHC 14 TeV 150 fb^{-1} projections from:

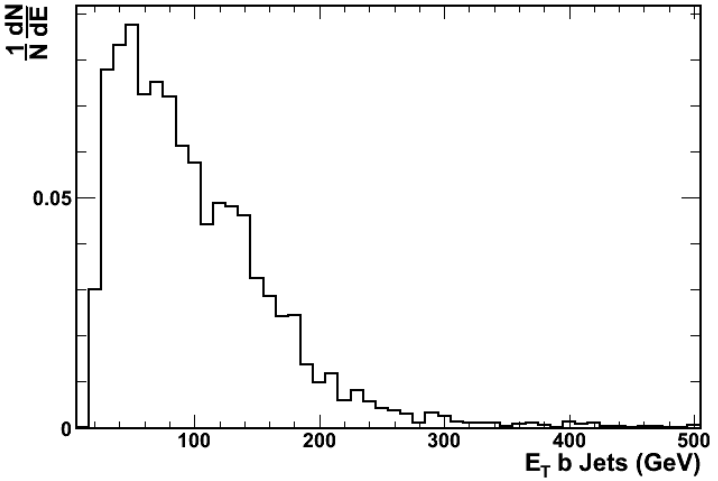
$\tau\tau$: CMS 4.8 (7 TeV) + 12.5 (8 TeV) fb^{-1}

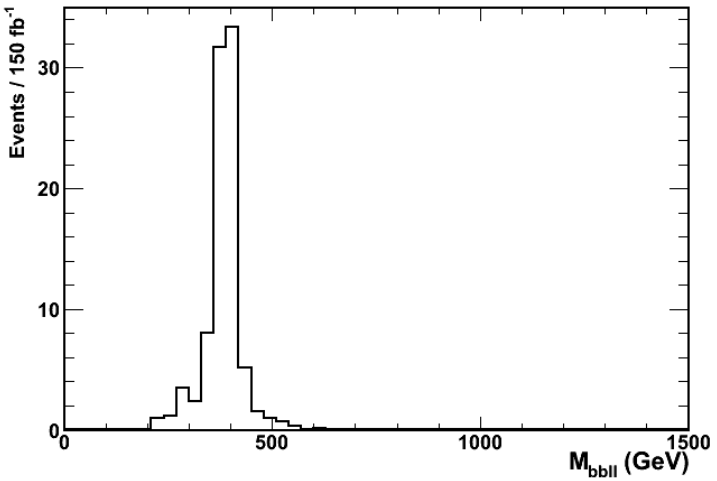
ZZ: $H_{SM} \rightarrow$ ZZ: ATLAS & CMS 4.8 (7 TeV) + 25 (8 TeV) fb^{-1}

tt: tt $\rightarrow$ Z' ATLAS & CMS 4.6 (7 TeV) + 14.3 (8 TeV) fb^{-1}

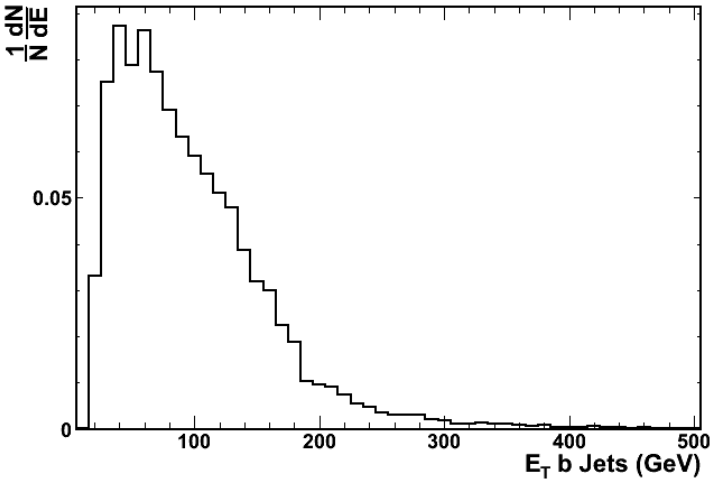
bbbb: CMS 4.8 (7 TeV) fb^{-1}

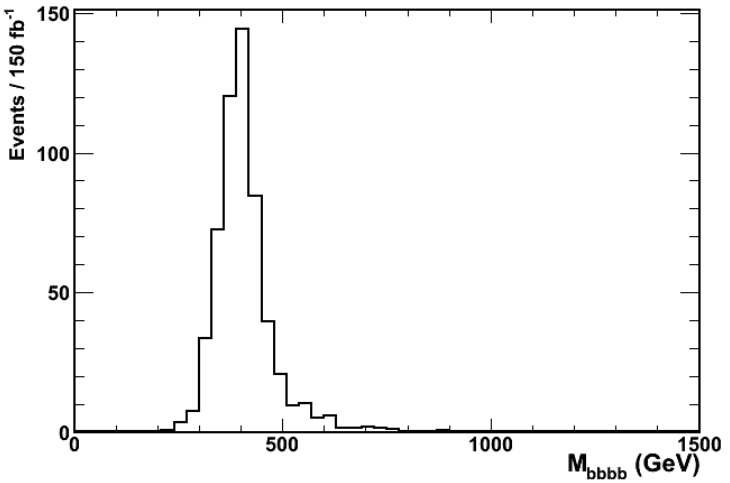
Zh



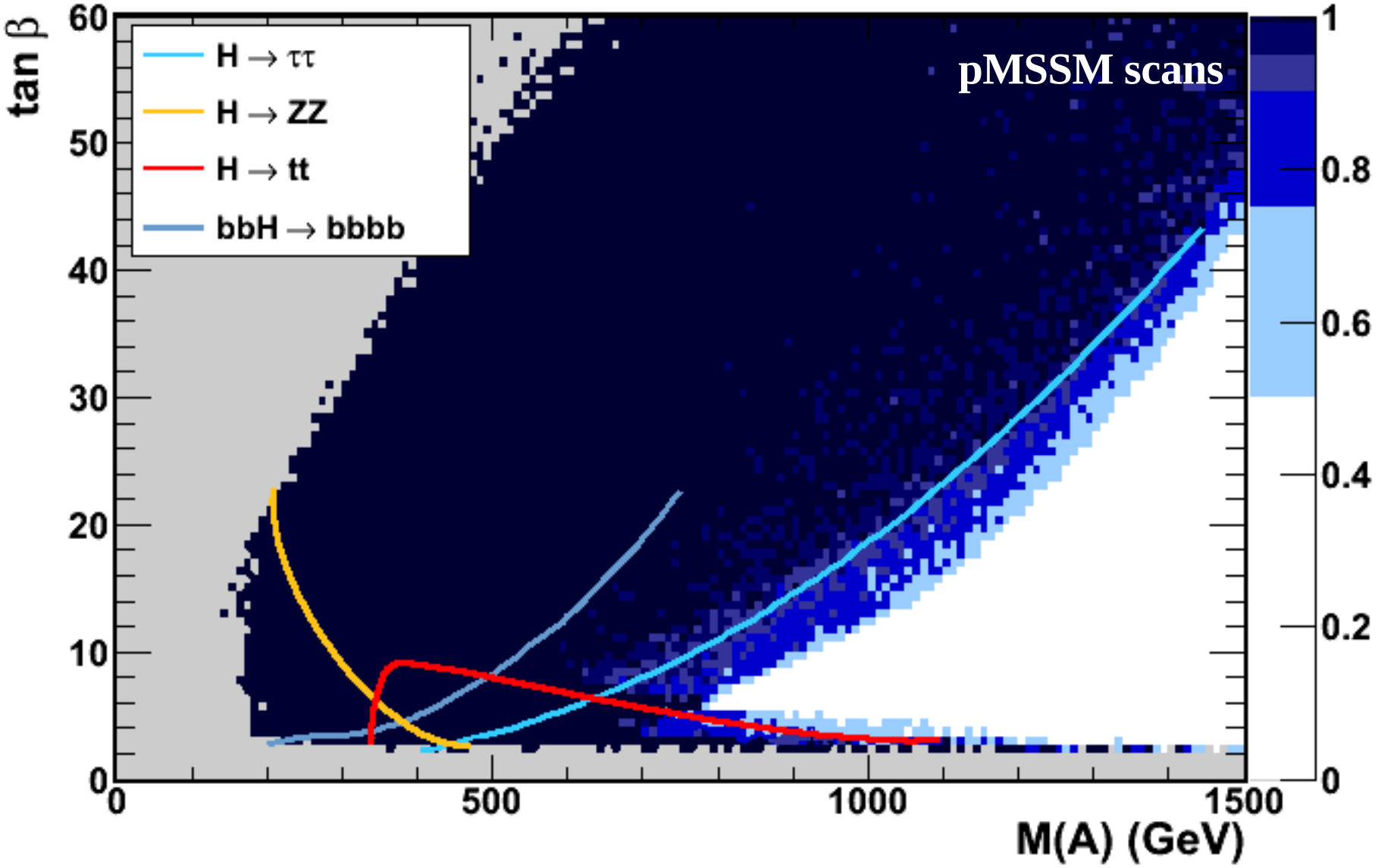


hh



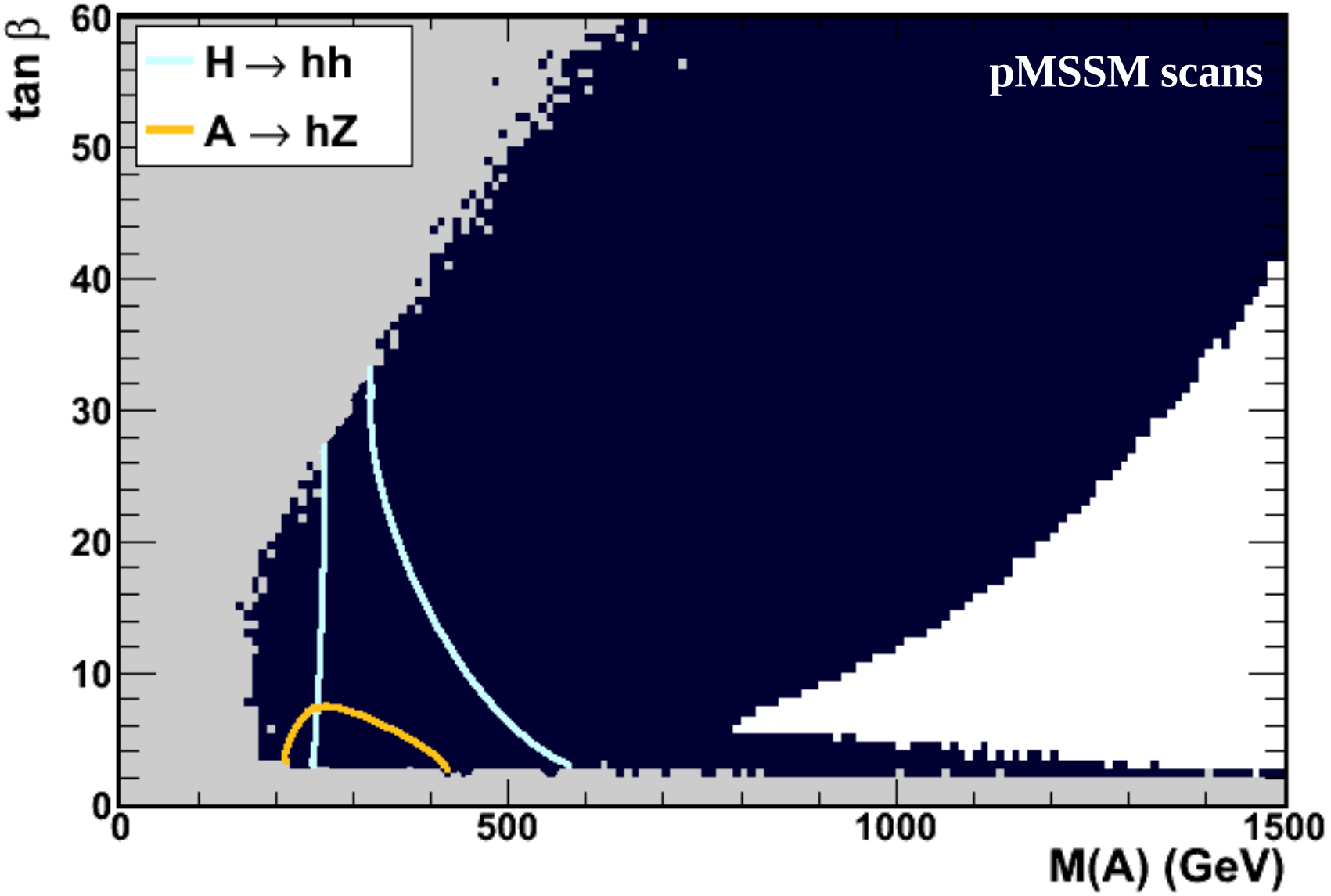


LHC 14 TeV 150 fb^{-1} projection



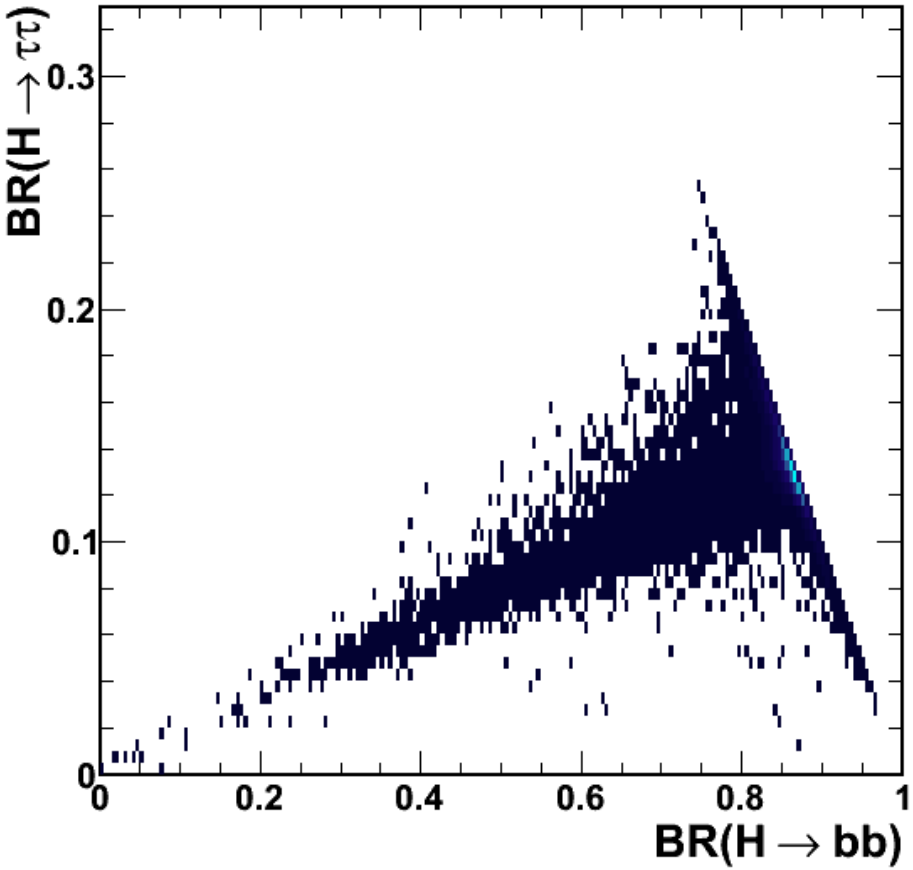
Arbey, MB, Mahmoudi,
PRD 88 (2013) 015007

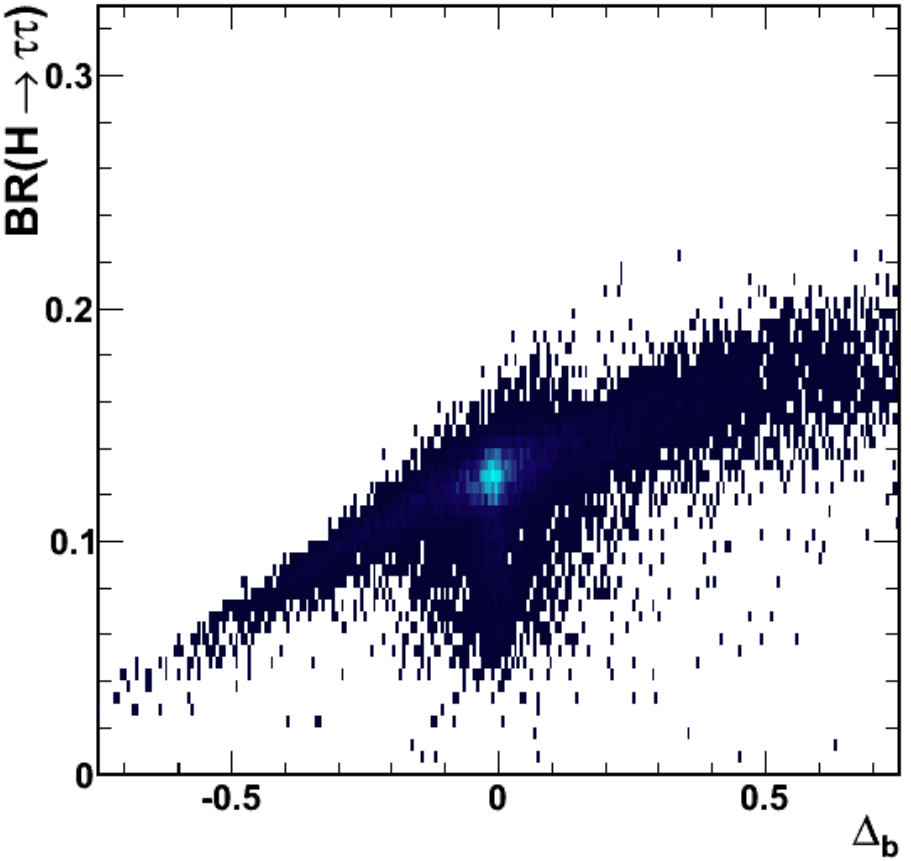
LHC 14 TeV 150 fb^{-1} projection



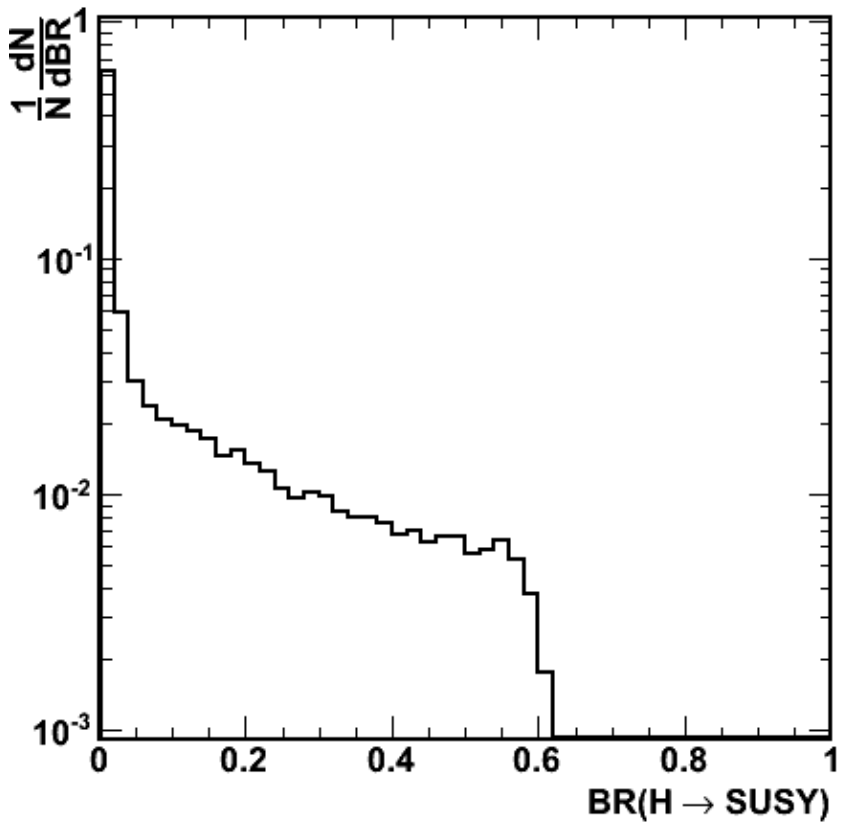
Arbey, MB, Mahmoudi,
PRD 88 (2013) 015007

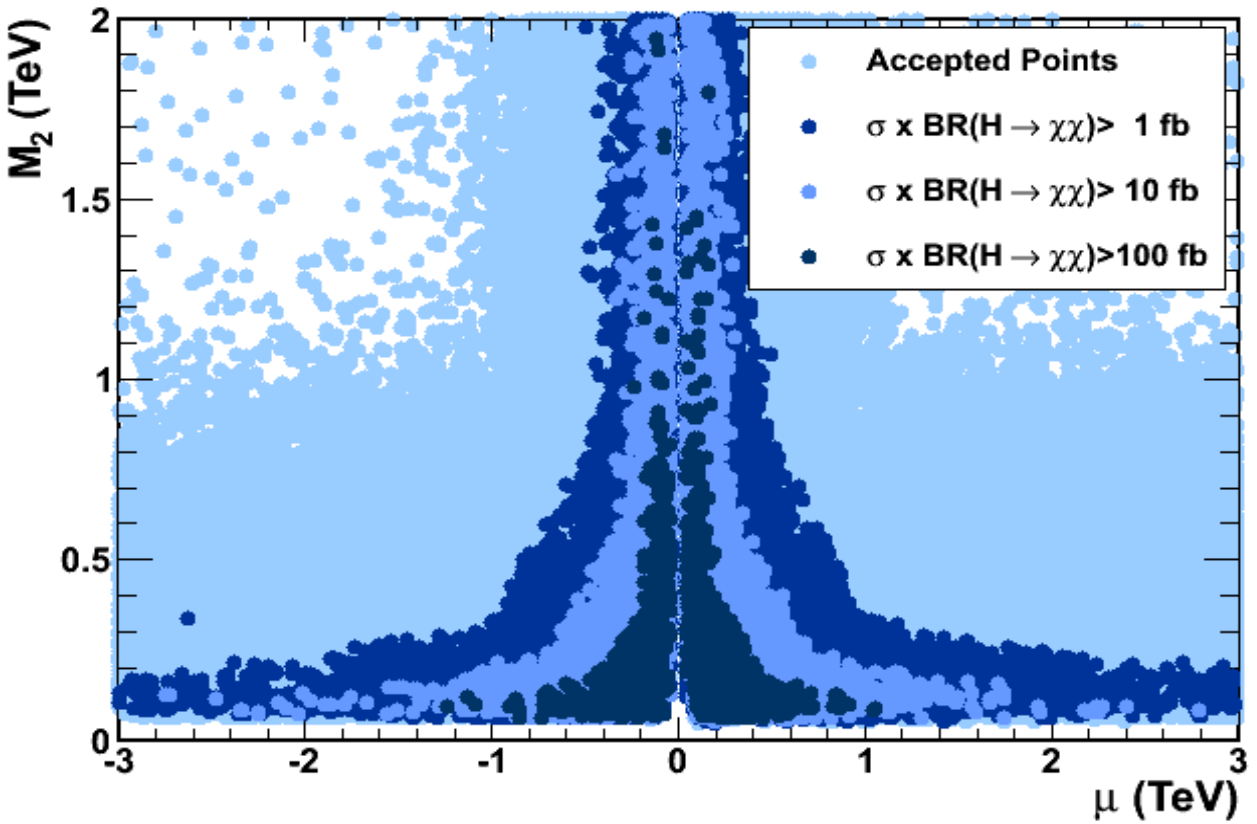
Evading the H/A → ττ limit: Δ_b



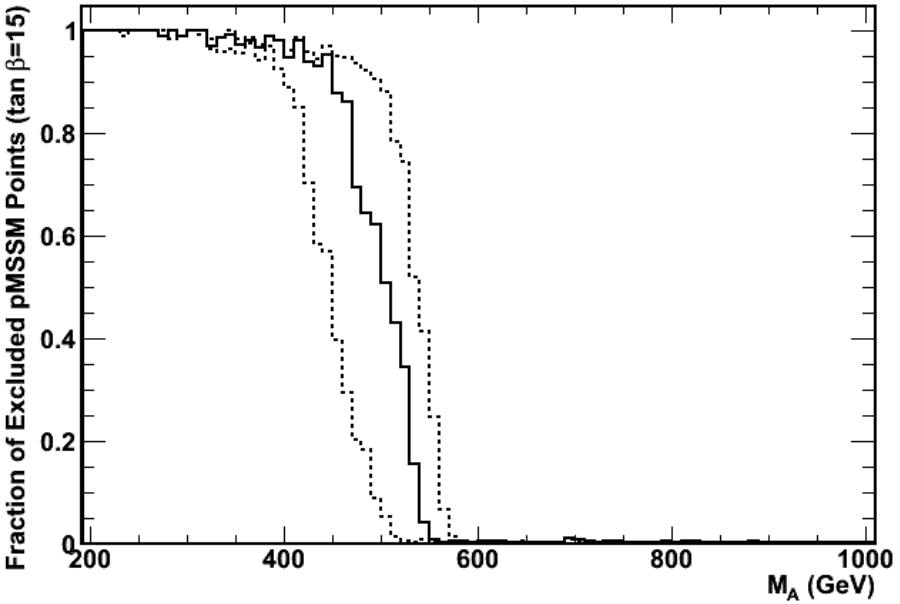


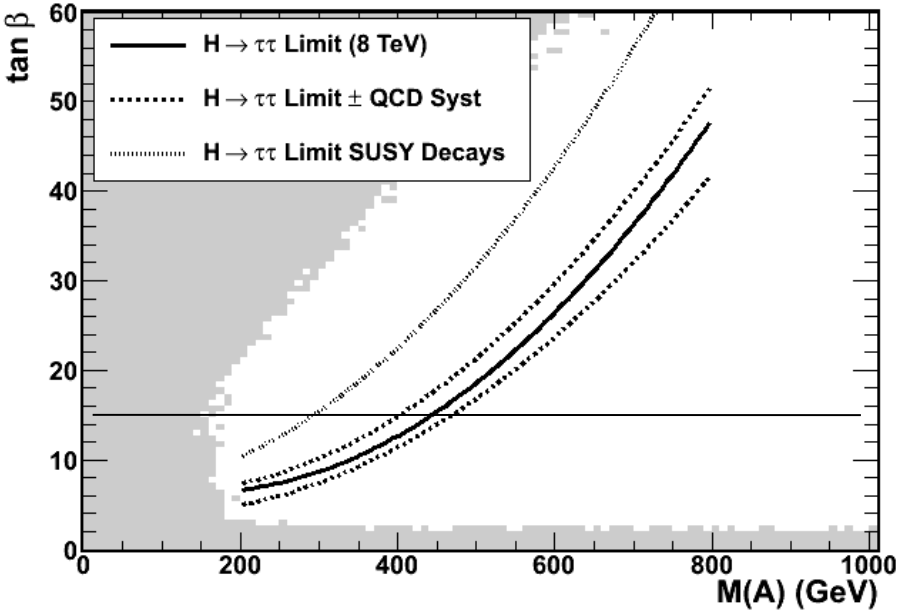
Evading the H/A → ττ limit: SUSY decays



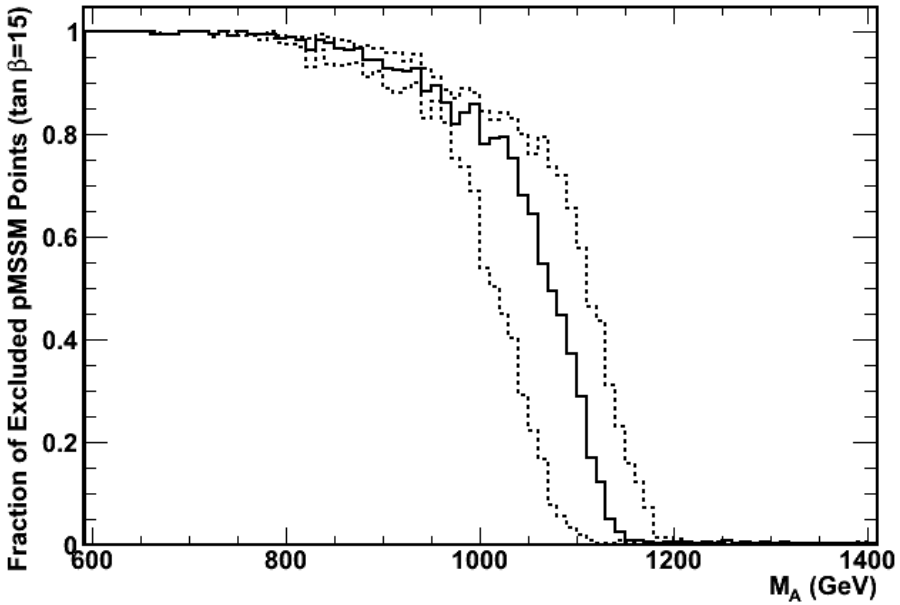


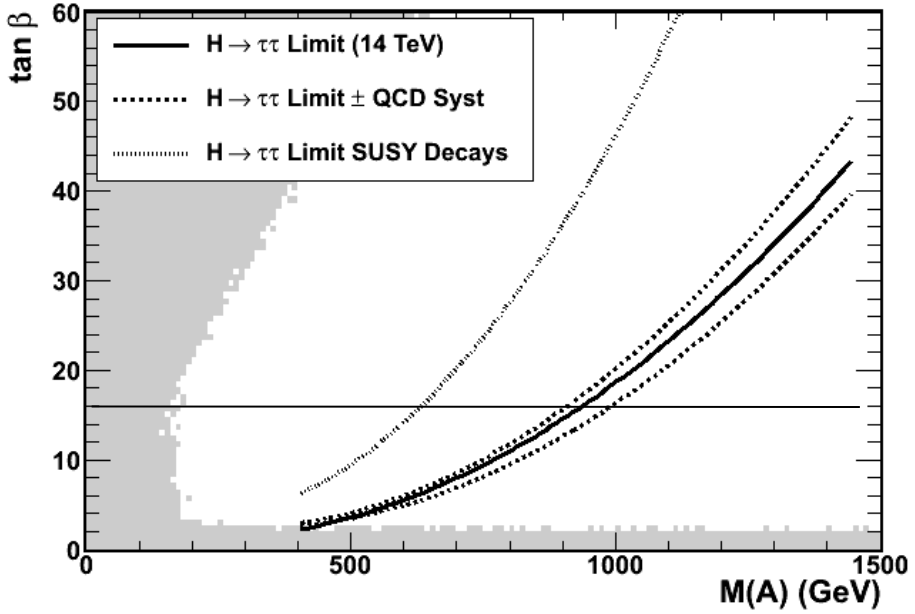
8 TeV


Fraction of Excluded pMSSM Points (tan β=15)
M_A (GeV)

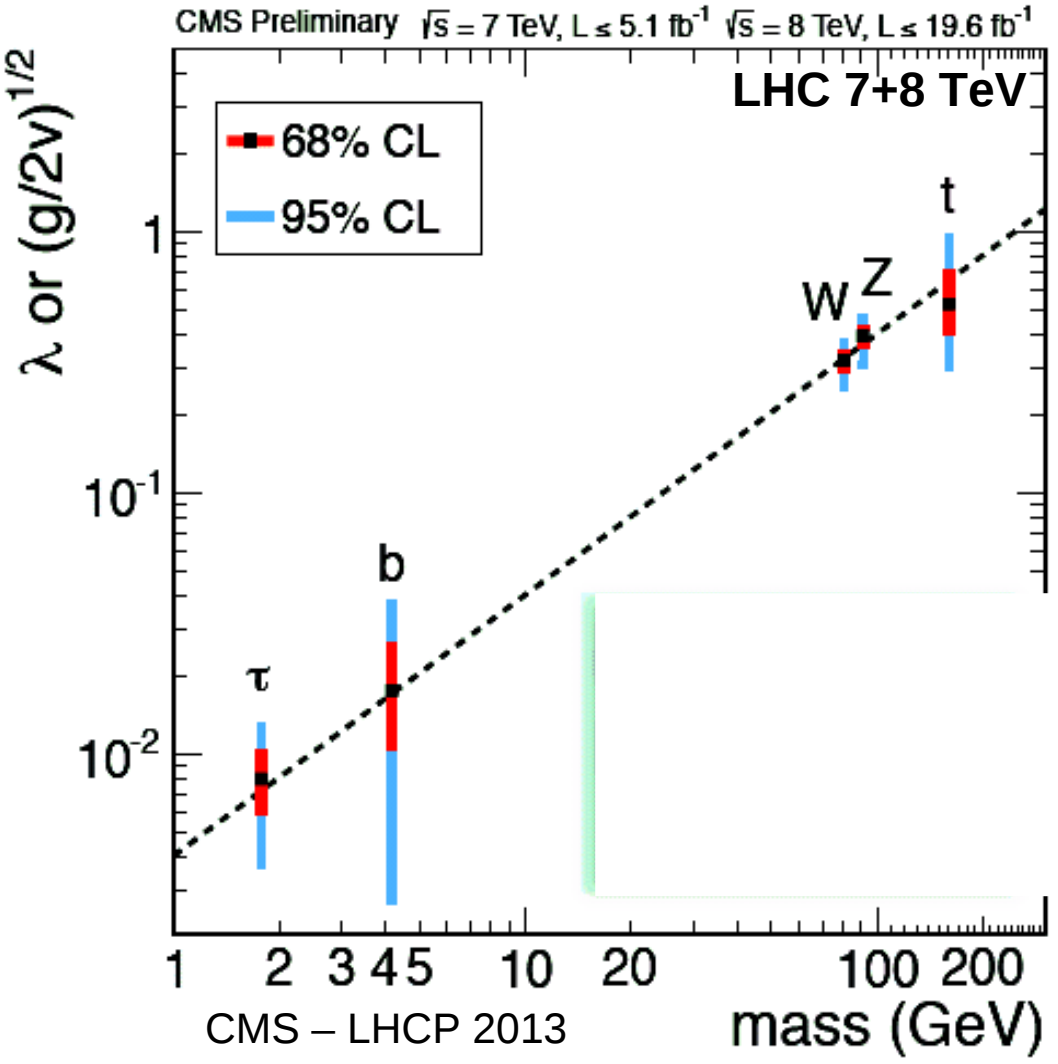

tan β
H → ττ Limit (8 TeV)
H → ττ Limit ± QCD Syst
H → ττ Limit SUSY Decays
M(A) (GeV)

14 TeV

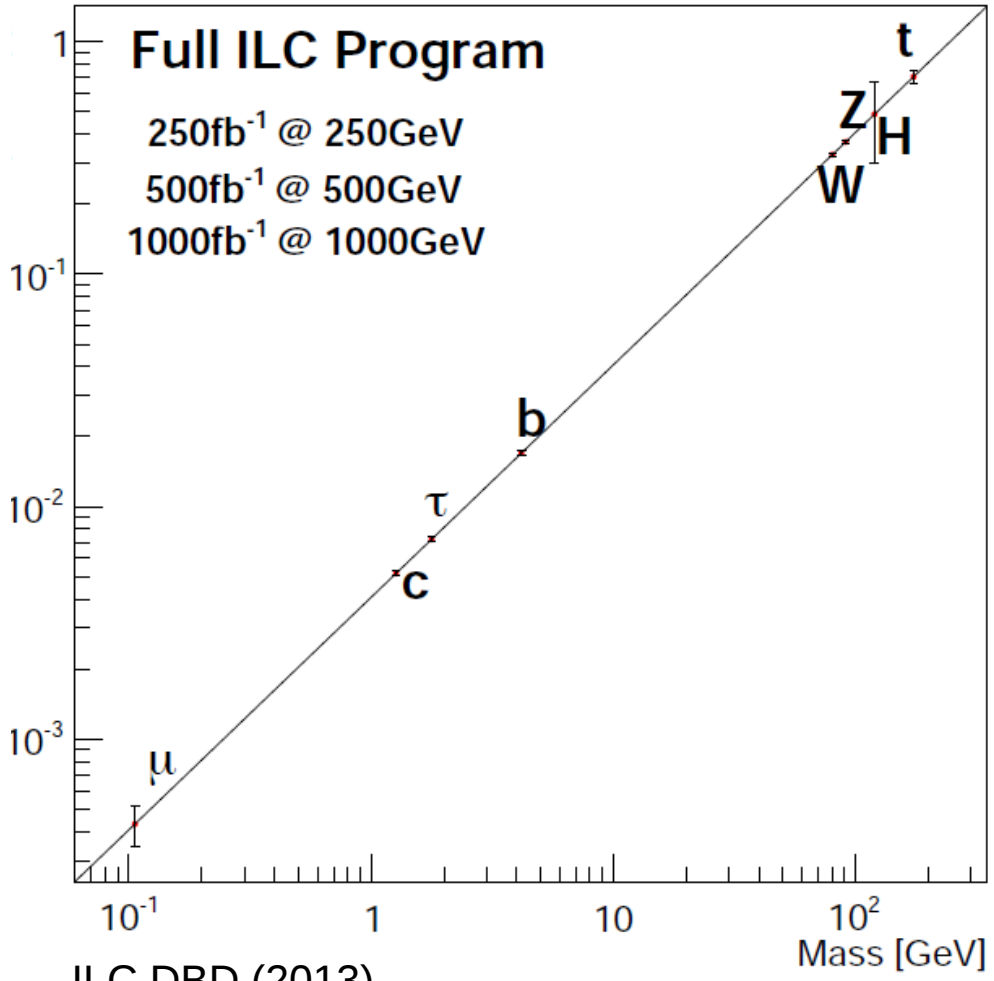

Fraction of Excluded pMSSM Points (tan β=15)
M_A (GeV)


tan β
H → ττ Limit (14 TeV)
H → ττ Limit ± QCD Syst
H → ττ Limit SUSY Decays
M(A) (GeV)

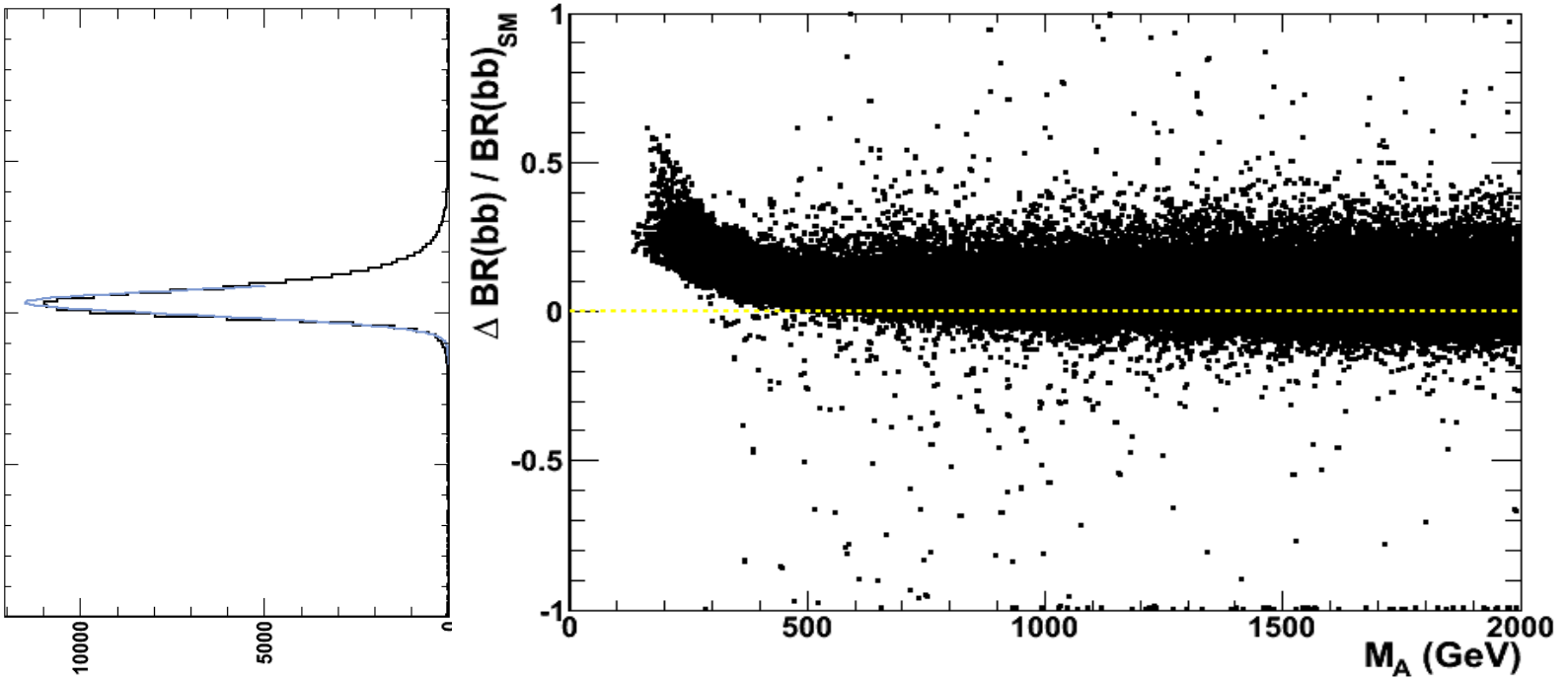
Testing heavy Higgs sector through couplings: from now to the ILC



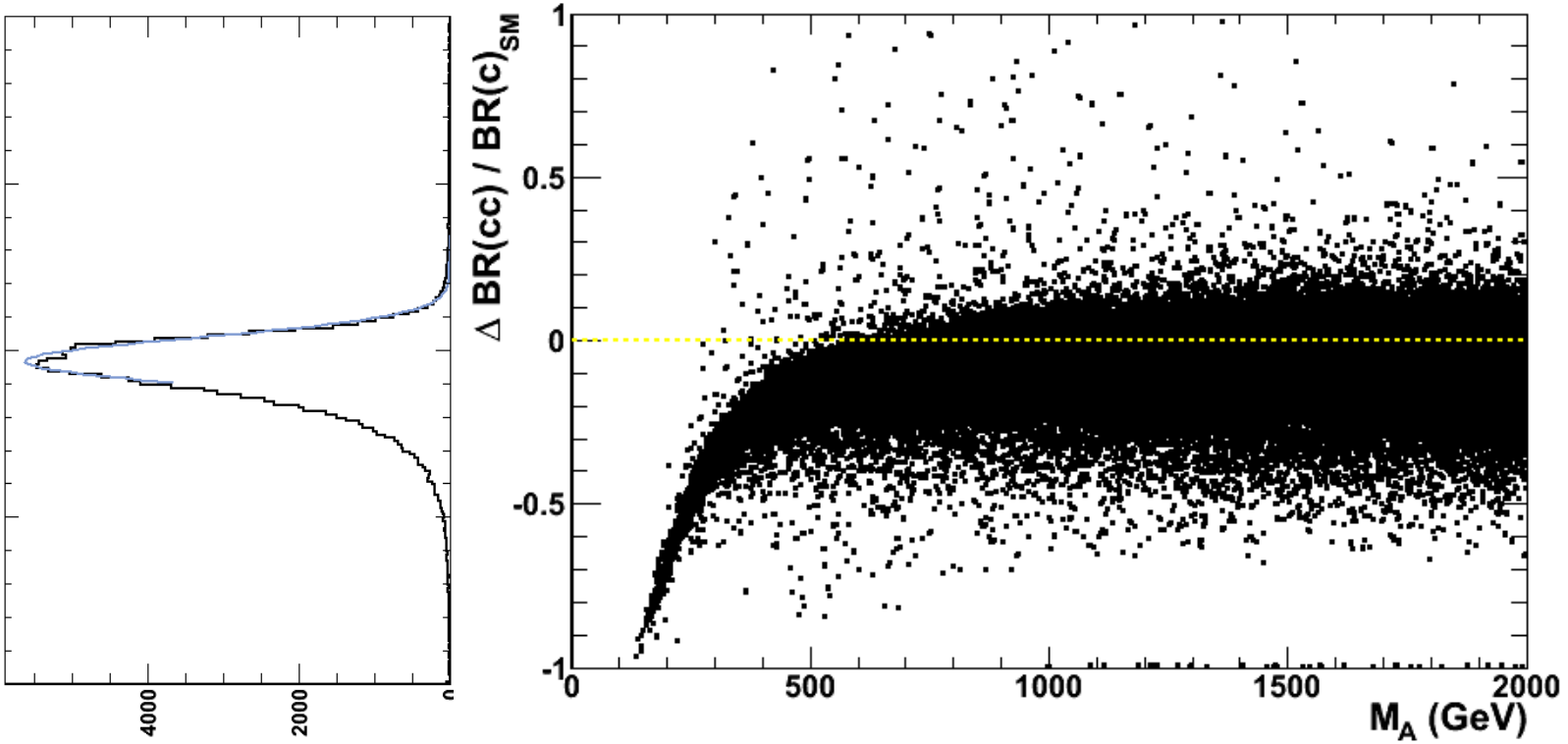
CMS – LHCP 2013



ILC DBD (2013)


10000
5000
0
1
0.5
0
-0.5
-1
Δ BR(bb) / BR(bb)SM
0
500
1000
1500
2000
MA (GeV)

bb


4000
2000
0
1
0.5
0
-0.5
-1
Δ BR(cc) / BR(c)SM
0
500
1000
1500
2000
MA (GeV)

cc

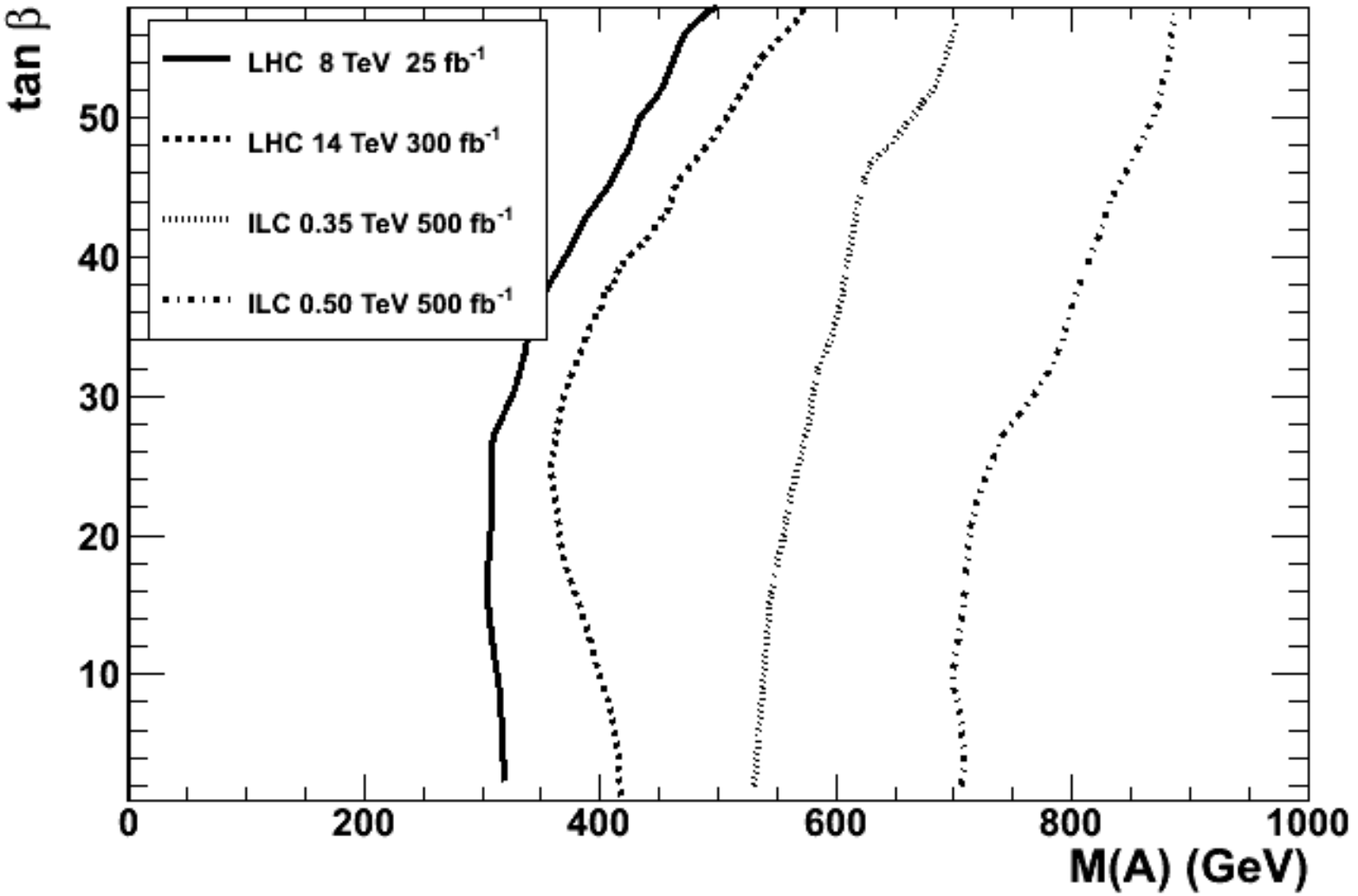
Current Systematic Uncertainties: Parametric and Theoretical

	Δm_b	Δm_c	Δm_t	$\Delta \alpha_s$	TH
ΔBR(bb)/BR	0.012	0.002	0.0001	0.004	0.007
ΔBR(cc)/BR	0.019	0.060	0.001	0.015	0.018
ΔBR($\tau\tau$)/BR	0.018	0.002	0.001	0.006	0.016
ΔBR(WW)/BR	0.002	0.002	0.0001	0.006	0.011

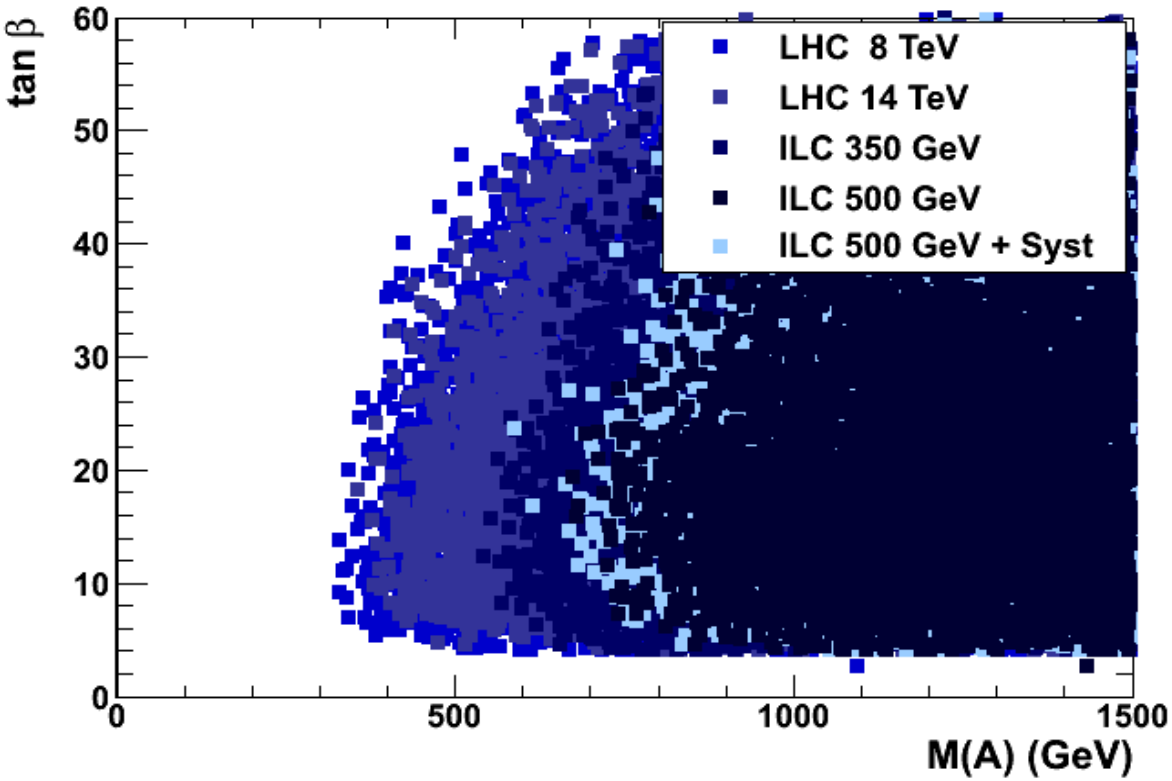
Droll and Logan, PRD76 (2007)
Denner et al. (LHC Higgs XSec WG), EPJC 71 (2011)

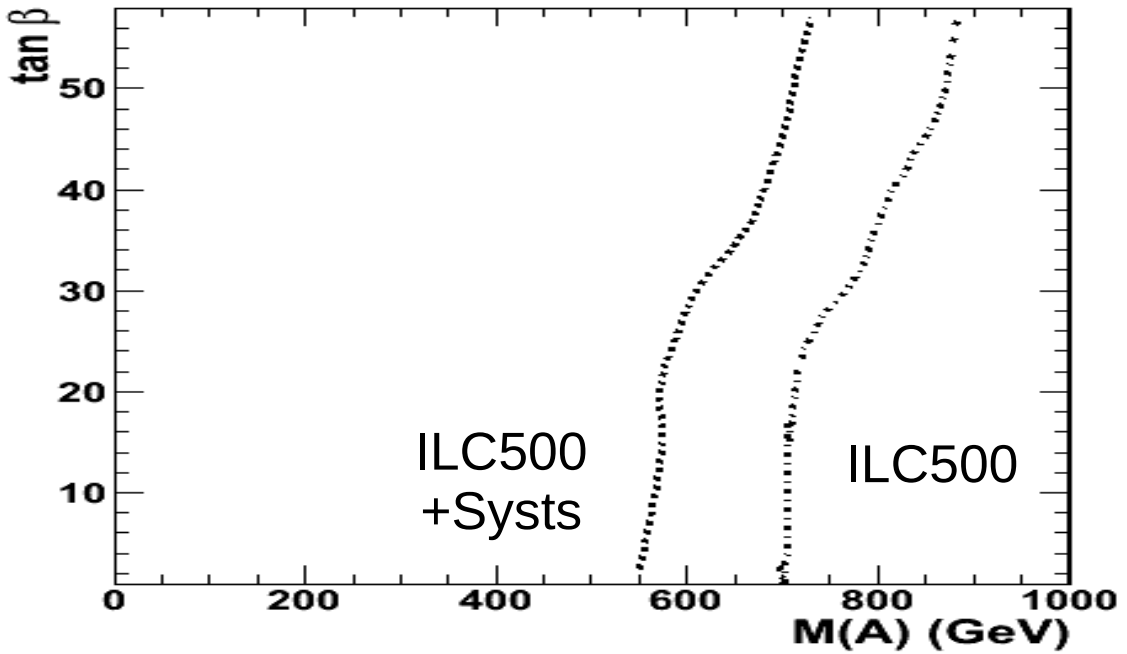
Parametric systs may improve with quark mass lattice calculations, theory systs with computation of missing terms; projections of uncertainties by HL-LHC and ILC era still controversial but may expect ~1%, or better.

Indirect M_A Sensitivity in pMSSM



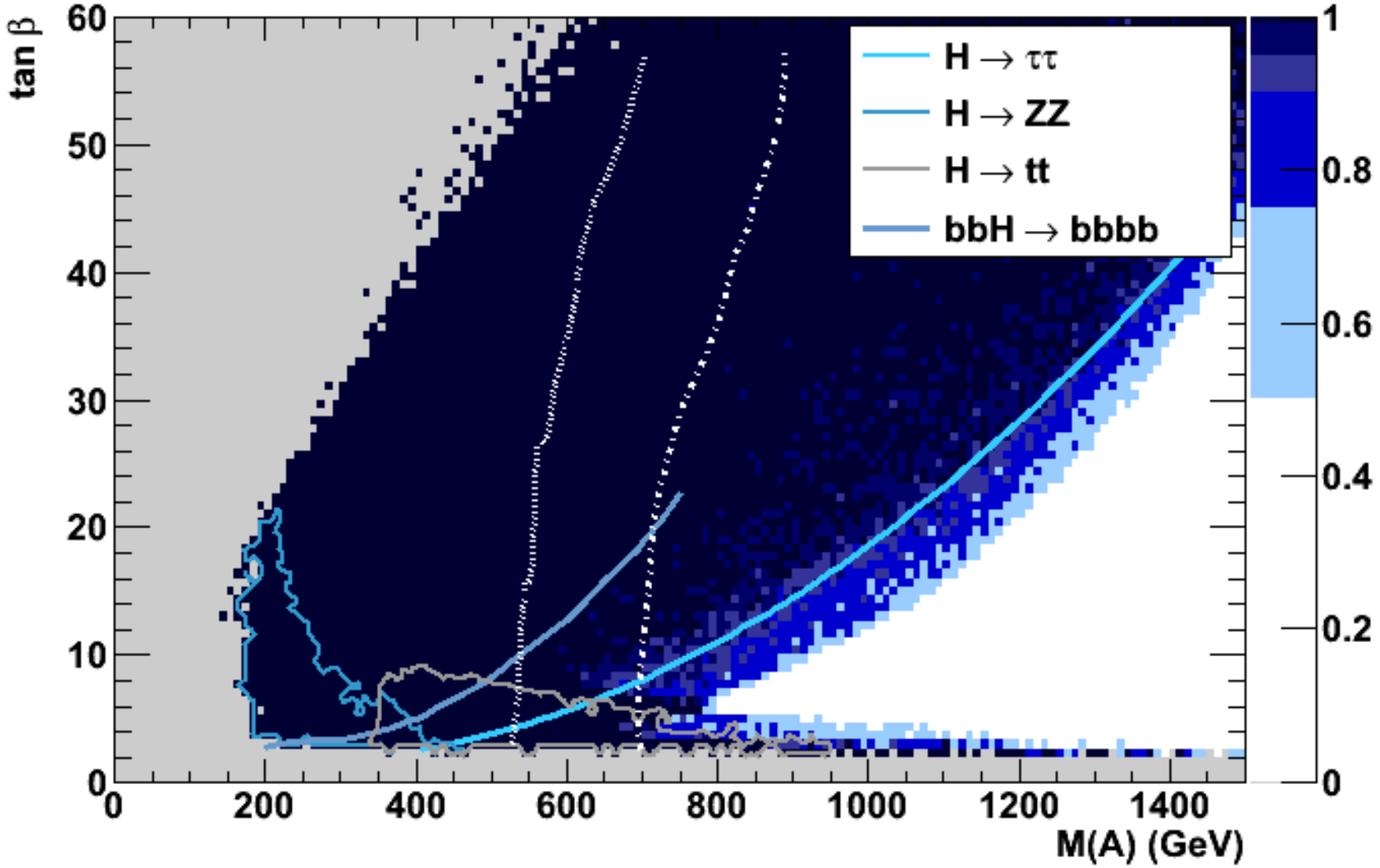
Indirect M_A Sensitivity in pMSSM





compare to
Droll and Logan, PRD76 (2007)

Indirect and Direct M_A Sensitivity in pMSSM



Modified from
Arbey, MB, Mahmoudi, PRD 88 (2013) 015007

Conclusions

Search for heavy Higgs bosons represents a next frontier in understanding Higgs sector;

LHC 7+8 TeV data should provide a lower mass limit for H/A > 320 GeV defined from the $\tau\tau$ channel and the light Higgs signal strengths;

At 14 TeV more final states (tt, ZZ, hh, Zh, …) become relevant, in particular at low tan β, a scenario still allowed for large M_{SUSY} scales, these states will overcome the LHC indirect mass sensitivity directly probing $M_A < 800$ GeV, for any tan β, but holes remain due to SUSY decays and QCD uncertainties, which need to be addressed in LHC searches;

Indirect sensitivity with ILC-like accuracies on branching fractions and decay widths will have similar reach to direct LHC searches for a compelling test of SUSY;

“Useful” experimental accuracy at e^+e^- depends on parametric+theory systs;

Accuracy expected from ILC program (0.25+0.35+0.5 TeV and 1 TeV + high lumi as option) appears well matched to “useful” accuracy in providing indirect sensitivity up to and beyond LHC direct reach;

Further push in accuracy beyond ILC will not lead significant improvement in BSM sensitivity for SUSY scenarios, unless systematics are very significantly reduced.