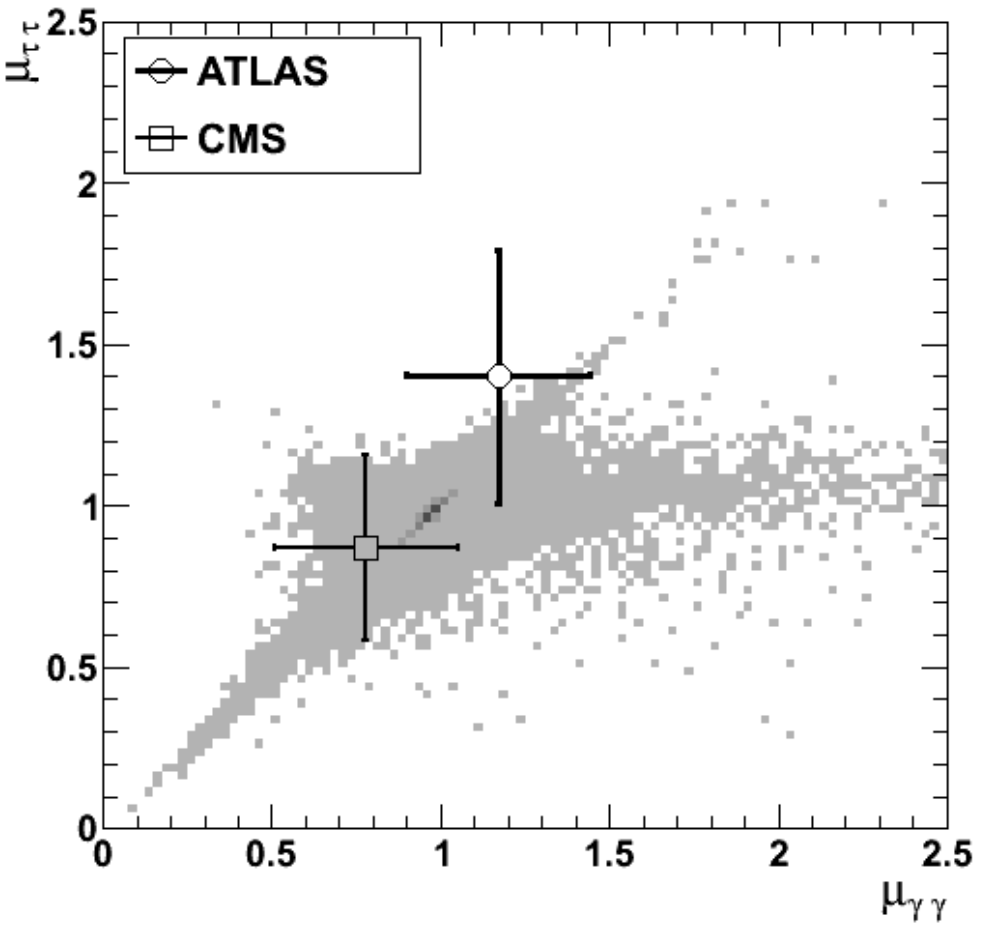
Sensitivity to MSSM from Higgs Branching Fractions after LHC Run-2 and Extraction of Model Parameters

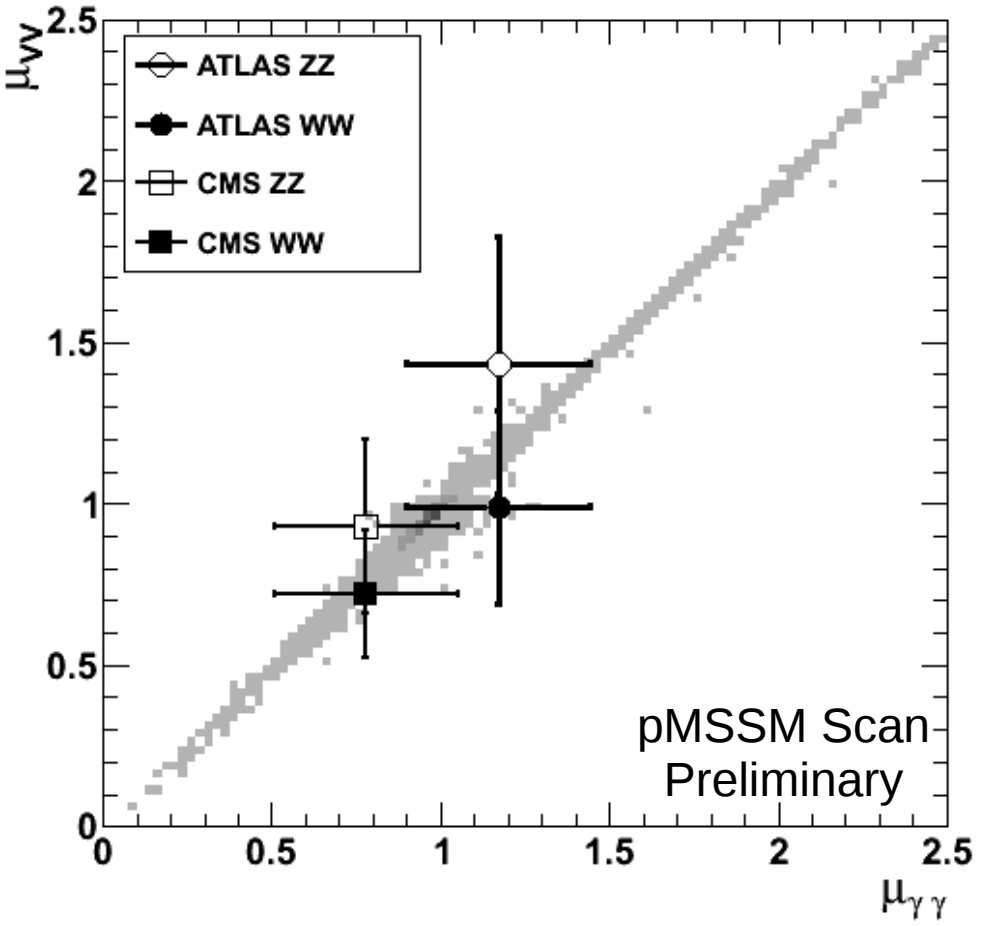
M Battaglia

in collaboration with A Arbey, A Djouadi, F Mahmoudi, M Spira, N Woods

LCWS14, Belgrade, 8th October 2014

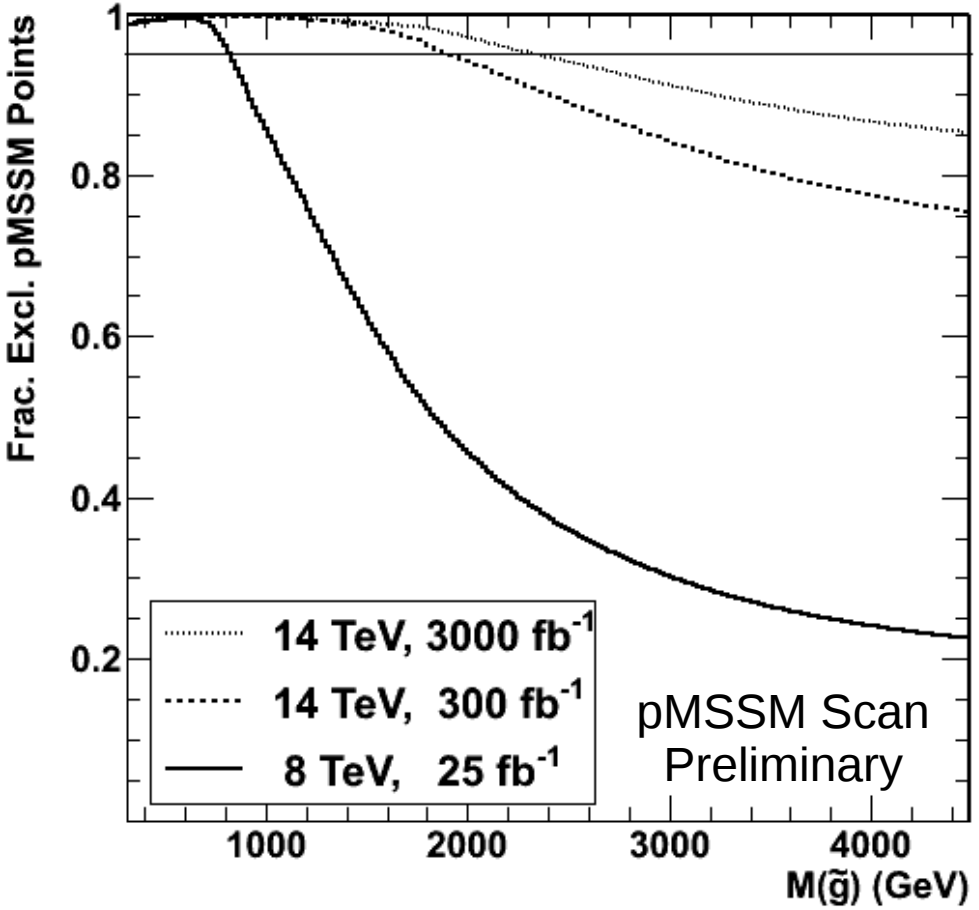
Higgs Signal Strengths at LHC and the MSSM



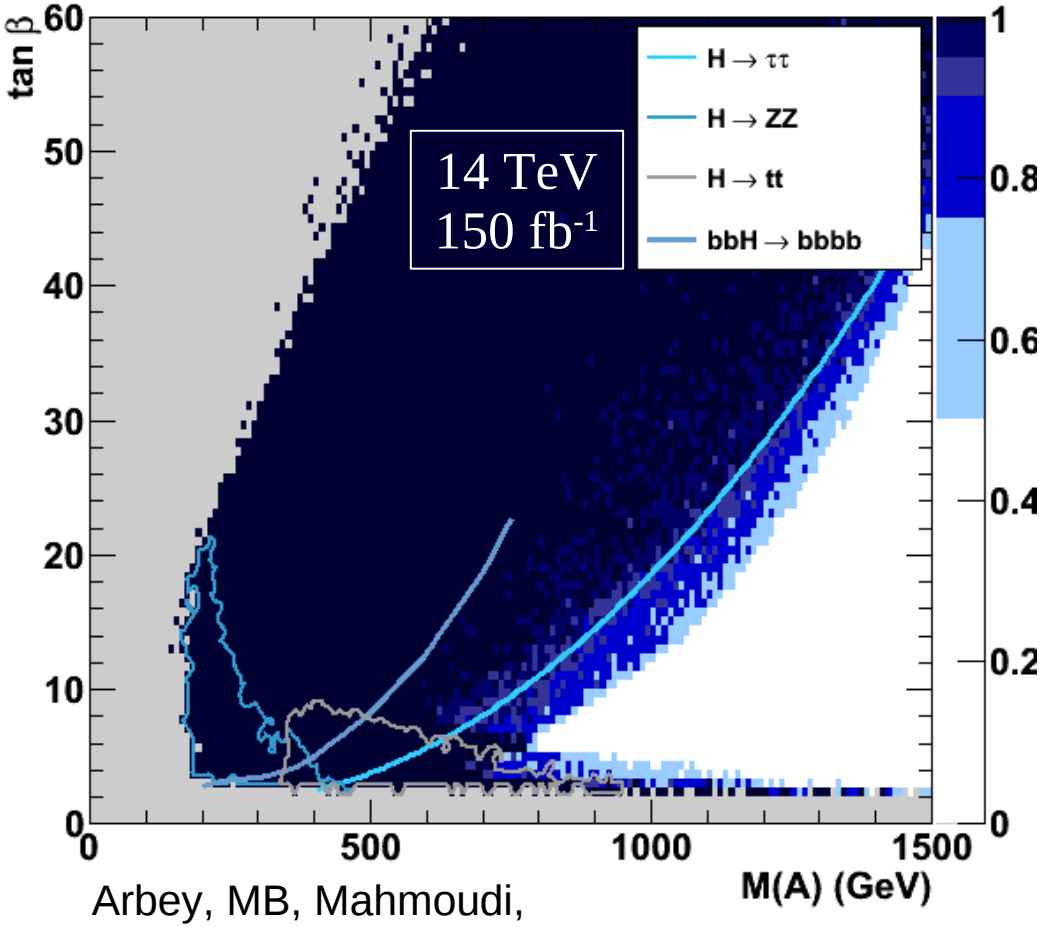


LHC constraints from 7+8 TeV to Run 2 and beyond

Gluino



A^0 boson



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

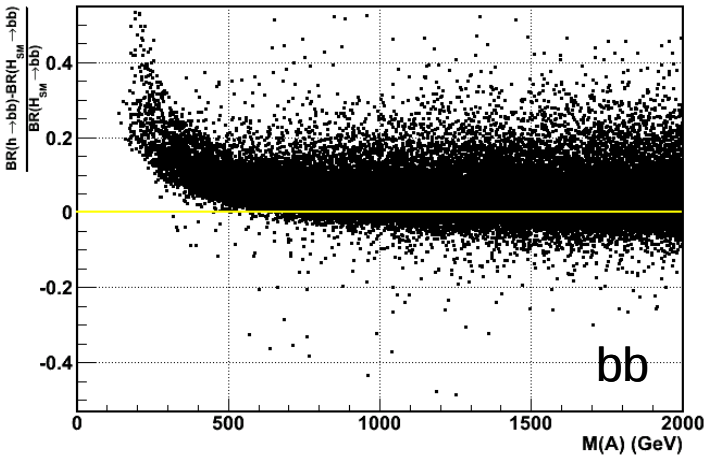
Higgs Branching Fractions and M_A

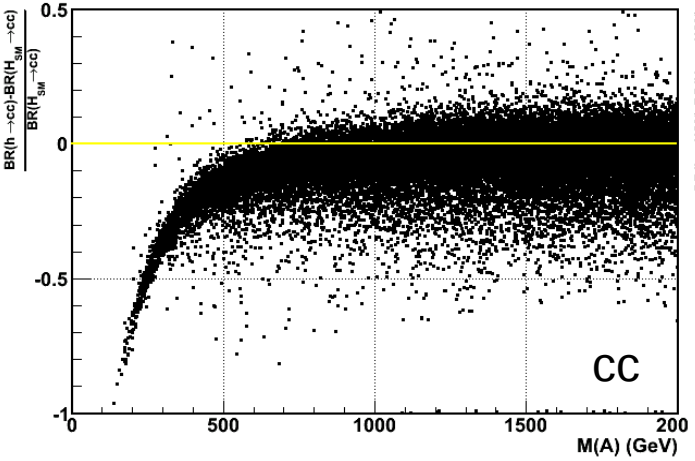
$$g_{hVV} \xrightarrow{M_A \gg M_Z} 1 - \frac{M_Z^4}{8M_A^4}\sin^2 4\beta \xrightarrow{\tan\beta \gg 1} 1 - \frac{2M_Z^4}{M_A^4 \tan^2\beta}$$

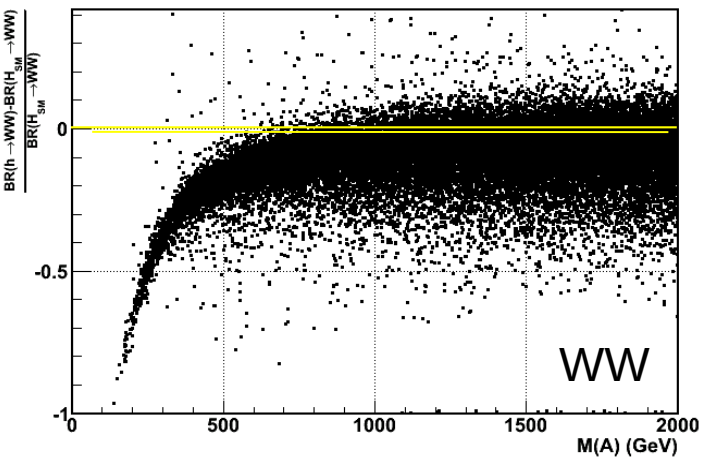
$$g_{huu} \xrightarrow{M_A \gg M_Z} 1 + \frac{M_Z^2}{2M_A^2}\frac{\sin 4\beta}{\tan\beta} \xrightarrow{\tan\beta \gg 1} 1 - \frac{2M_Z^2}{M_A^2 \tan^2\beta}$$

$$g_{hdd} \xrightarrow{M_A \gg M_Z} 1 - \frac{M_Z^2}{2M_A^2}\sin 4\beta \tan\beta \xrightarrow{\tan\beta \gg 1} 1 + \frac{2M_Z^2}{M_A^2}$$

Sensitivity $\Delta BR/BR$ vs M_A





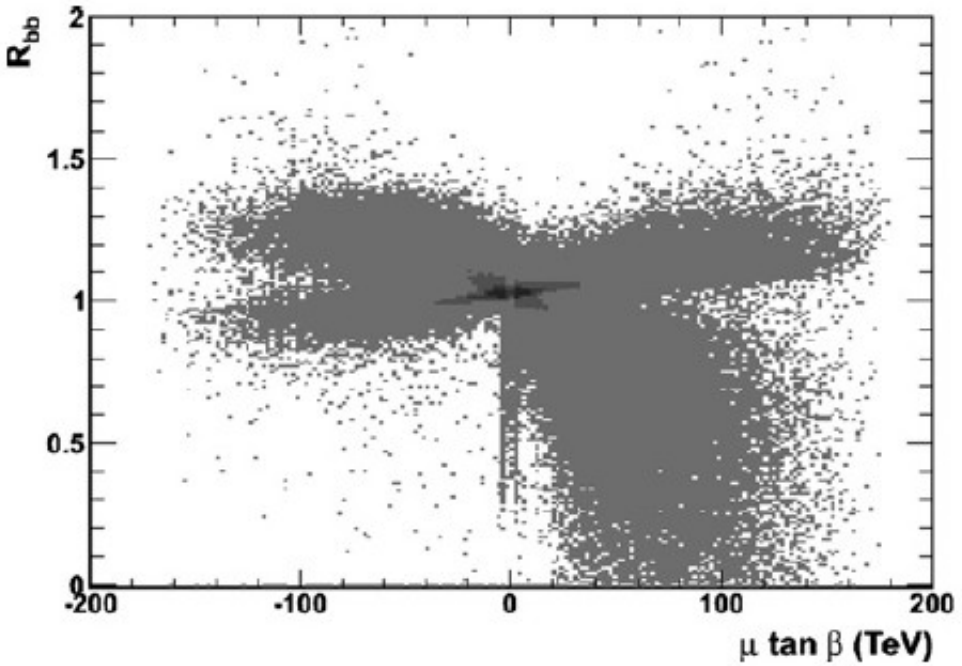


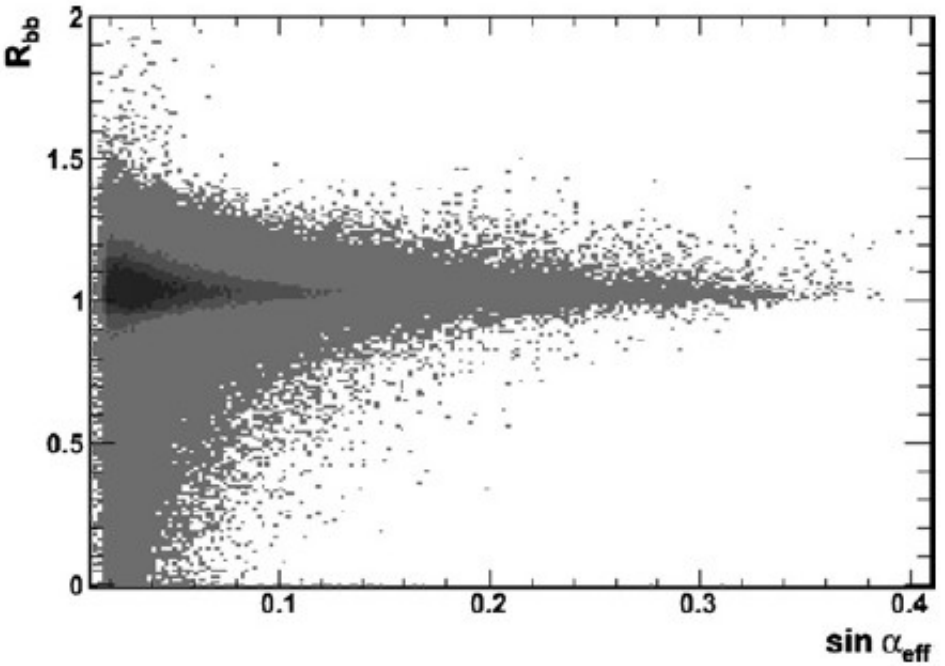
Higgs Branching Fractions and Δ_b

$$\Delta_b \approx \frac{2\alpha_s}{3\pi}\frac{m_{\tilde{g}}\mu\tan\beta}{\max(m_{\tilde{g}}^2, m_{\tilde{b}_1}^2, m_{\tilde{b}_2}^2)} + \frac{m_t^2}{8\pi^2 v^2 \sin^2\beta}\frac{A_t\mu\tan\beta}{\max(\mu^2, m_{\tilde{t}_1}^2, m_{\tilde{t}_2}^2)}$$

$$g_{hbb} \approx g_{Abb} \approx \tan\beta(1-\Delta_b)$$

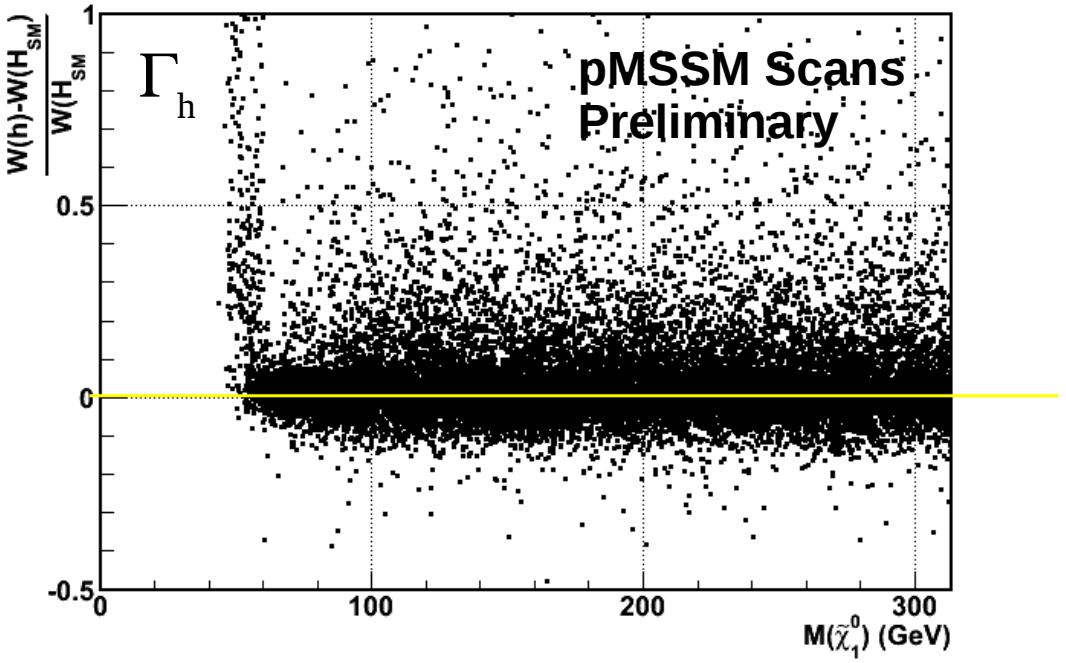
$$g_{hb\bar{b}} = -\sin\alpha_{\rm eff}/\cos\beta \approx 1 - \Delta_b/(\tan\alpha_{\rm eff}\tan\beta)$$

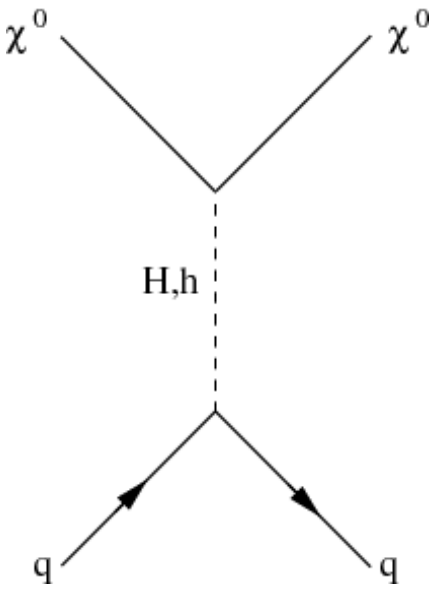


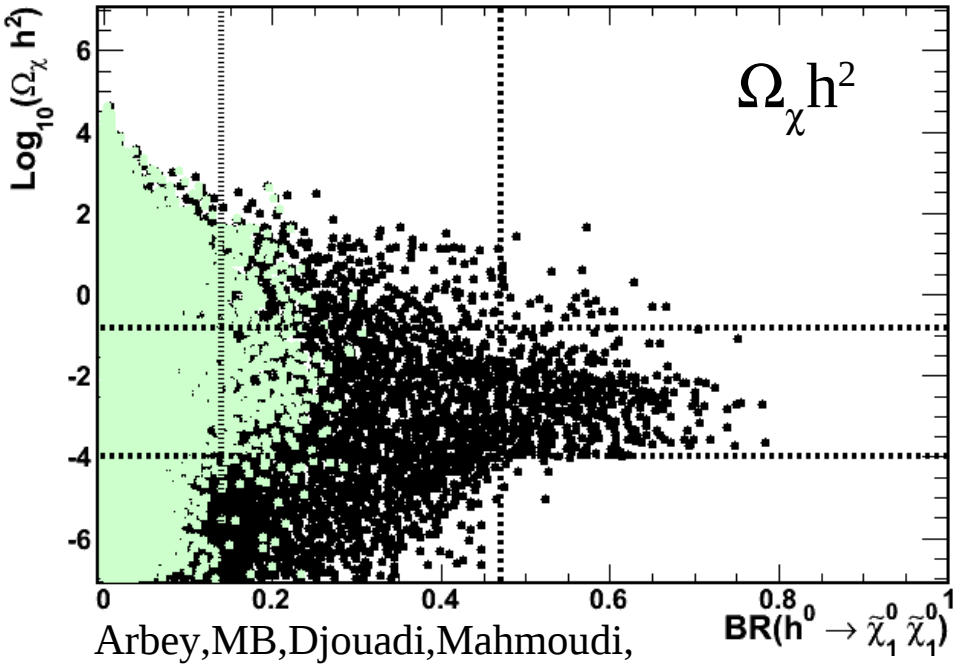


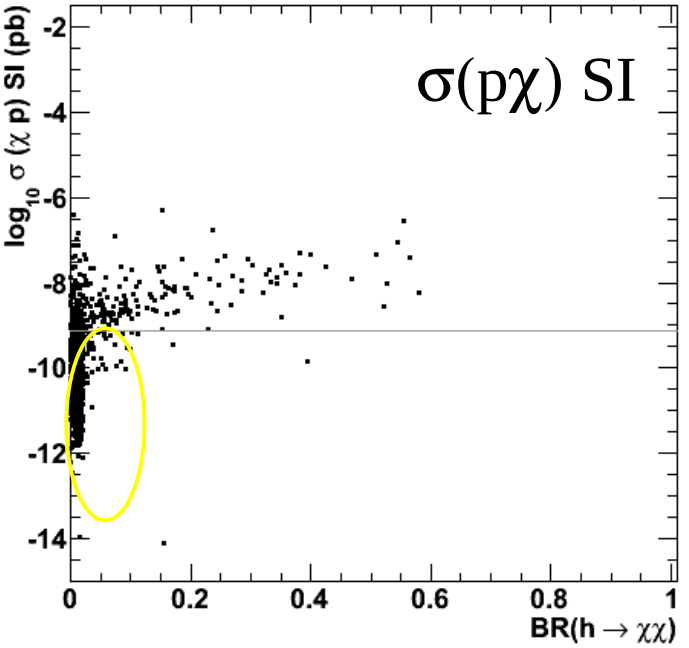
Arbey, MB, Djouadi, Mahmoudi, PLB 720 (2013)

Higgs Invisible Branching Fraction and Dark Matter









Arbey,MB,Djouadi,Mahmoudi,
PLB 720 (2013) 153

Study based on flat scans of pMSSM;

SUSY masses up to 5 TeV →

Impose flavour, DM & low energy constraints;

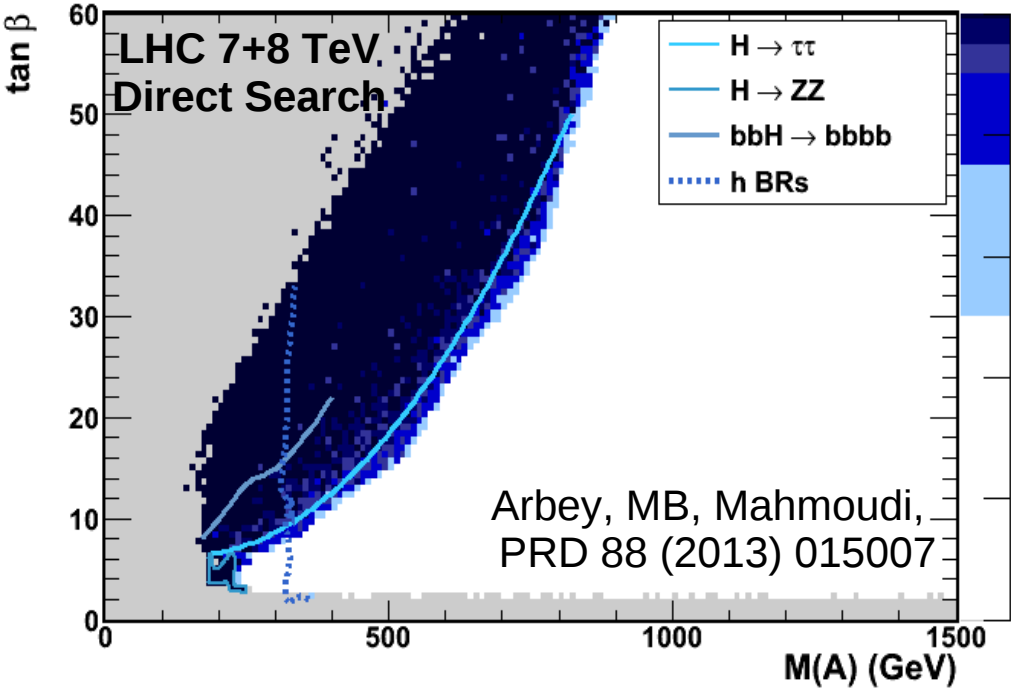
Include ATLAS j+MET, 2&3-l + MET
b + MET, j + l + MET;
ATLAS + CMS monojet + MET
ATLAS monoW/Z + MET
CMS, A/H → ττ searches
and extrapolate to 14 TeV;

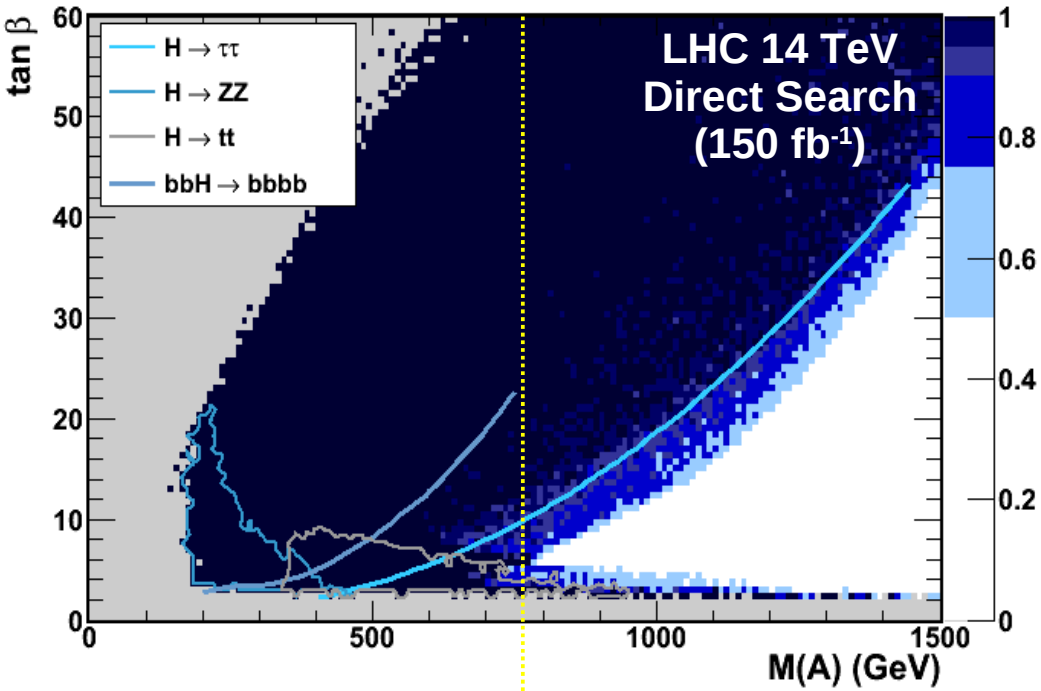
Impose 123 < M_h < 129 GeV, compute Higgs branching fractions with HDECAY 6;
EW corrections removed for SM to compare to MSSM values;

ILC h branching fraction accuracies (at 0.5 and 1 TeV) derived from Snowmass 2013 Higgs Report arXiv:1310.8361.

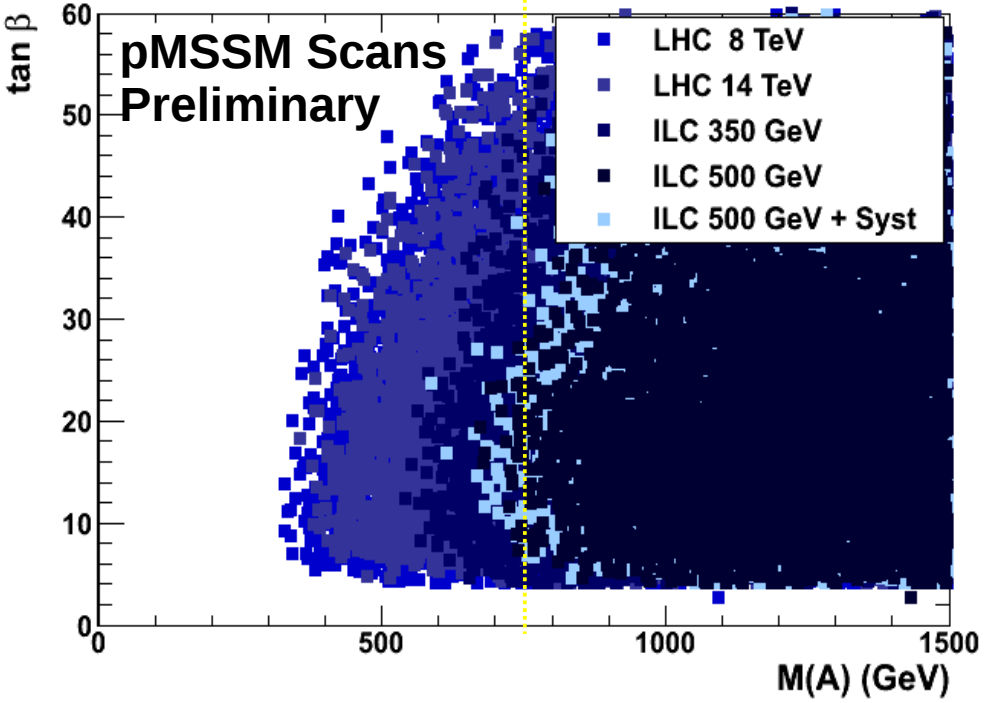
Parameter	Range
$\tan\beta$	[1, 60]
M_A	[50, 5000]
M_1	[-5000, 5000]
M_2	[-5000, 5000]
M_3	[0, 5000]
$A_d = A_s = A_b$	[-15000, 15000]
$A_u = A_c = A_t$	[-15000, 15000]
$A_e = A_\mu = A_\tau$	[-15000, 15000]
μ	[-5000, 5000]
$M_{\tilde{e}_L} = M_{\tilde{\mu}_L}$	[50, 5000]
$M_{\tilde{e}_R} = M_{\tilde{\mu}_R}$	[50, 5000]
$M_{\tilde{\tau}_L}$	[50, 5000]
$M_{\tilde{\tau}_R}$	[50, 5000]
$M_{\tilde{q}_{1L}} = M_{\tilde{q}_{2L}}$	[50, 5000]
$M_{\tilde{q}_{3L}}$	[50, 5000]
$M_{\tilde{u}_R} = M_{\tilde{c}_R}$	[50, 5000]
$M_{\tilde{t}_R}$	[50, 5000]
$M_{\tilde{d}_R} = M_{\tilde{s}_R}$	[50, 5000]
$M_{\tilde{b}_R}$	[50, 5000]

LHC and ILC M_A Sensitivity in the pMSSM

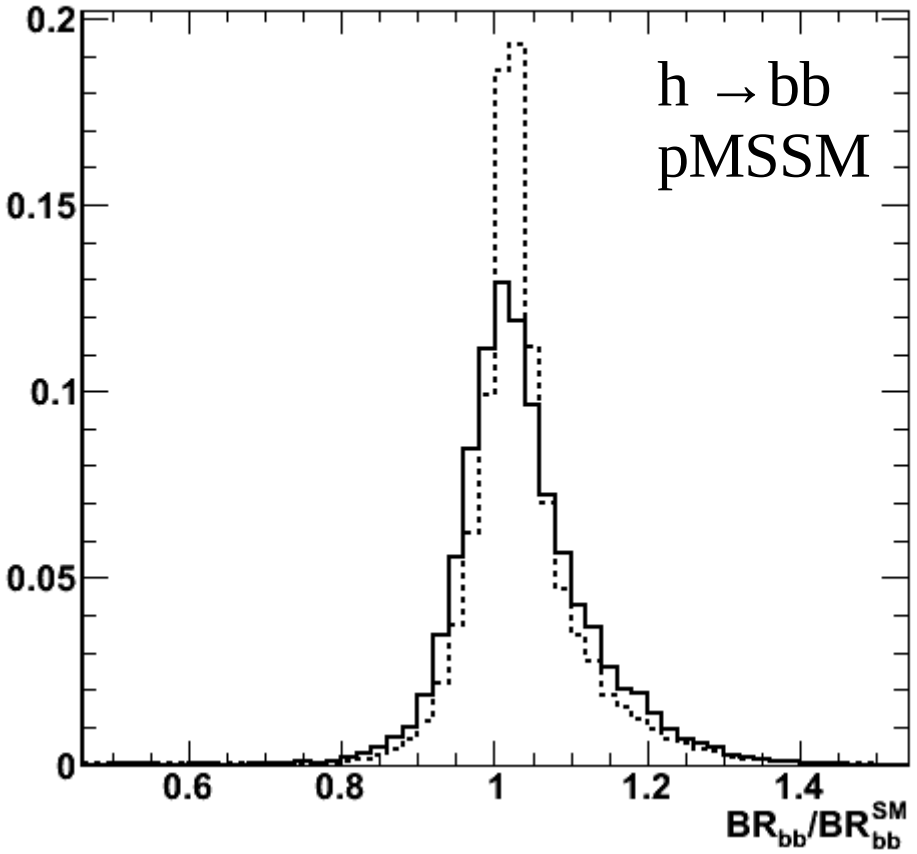


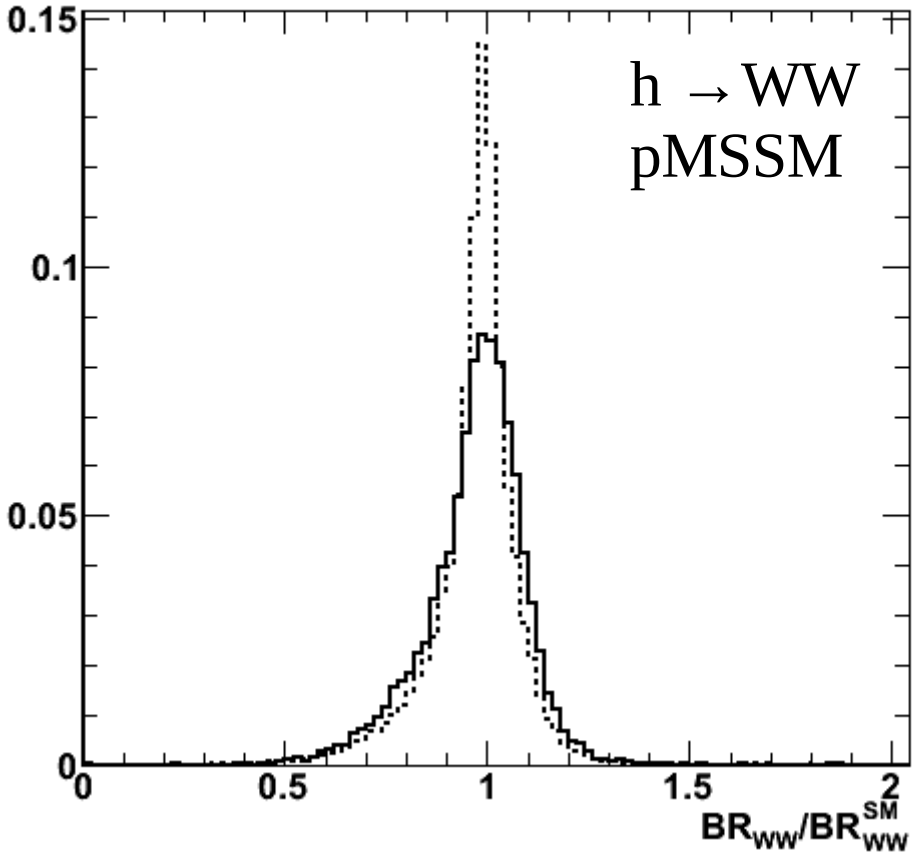


ILC indirect M_A sensitivity extends up to ~750 GeV corresponding to LHC direct detection reach at 14 TeV (150 fb^{-1})



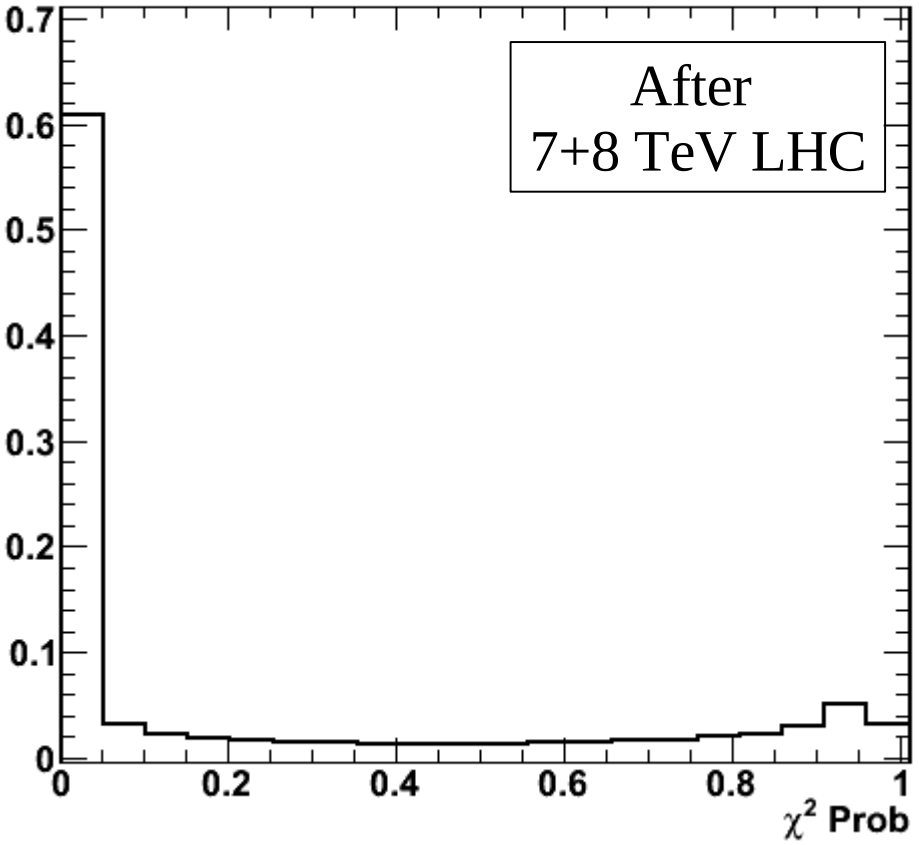
Higgs Branching Fraction in pMSSM after LHC constraints

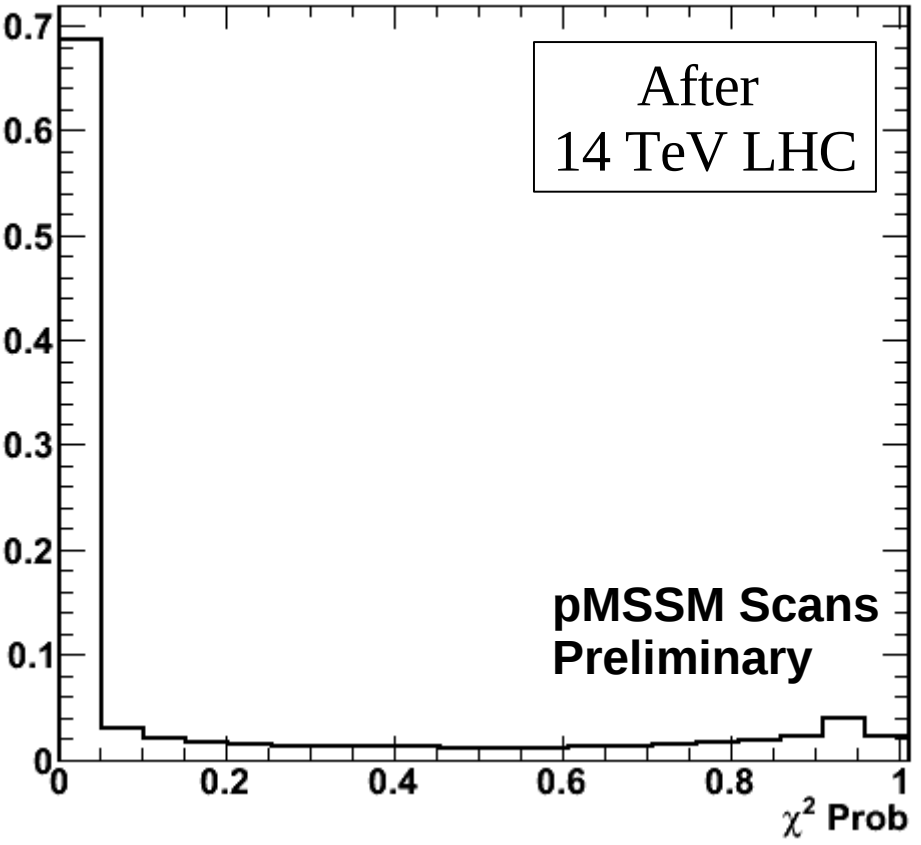




σ/BR (%)	8 TeV 25 fb^{-1}	14 TeV 300 fb^{-1}	14 TeV 3000 fb^{-1}
bb	3.94 ± 0.03	5.09 ± 0.02	5.80 ± 0.02
W^+W^-	5.54 ± 0.05	7.37 ± 0.02	8.68 ± 0.04

LC h BRs Sensitivity in the pMSSM: Test MSSM against SM Hypothesis

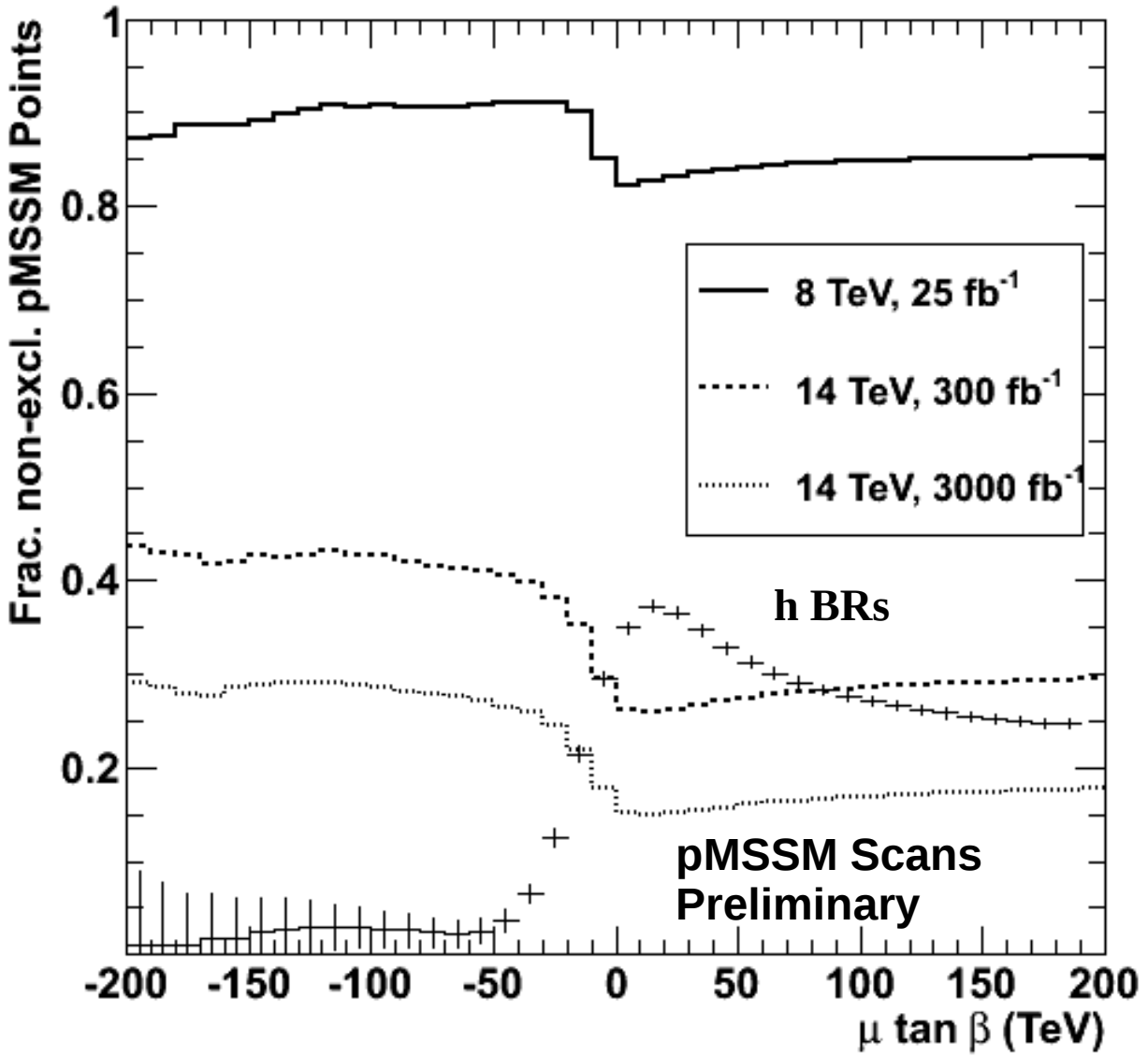




χ^2 probability test of pMSSM points against SM hypothesis (use bb, cc, $\tau\tau$, gg, $\gamma\gamma$, WW, ZZ and Γ_h , but not M_h in χ^2):

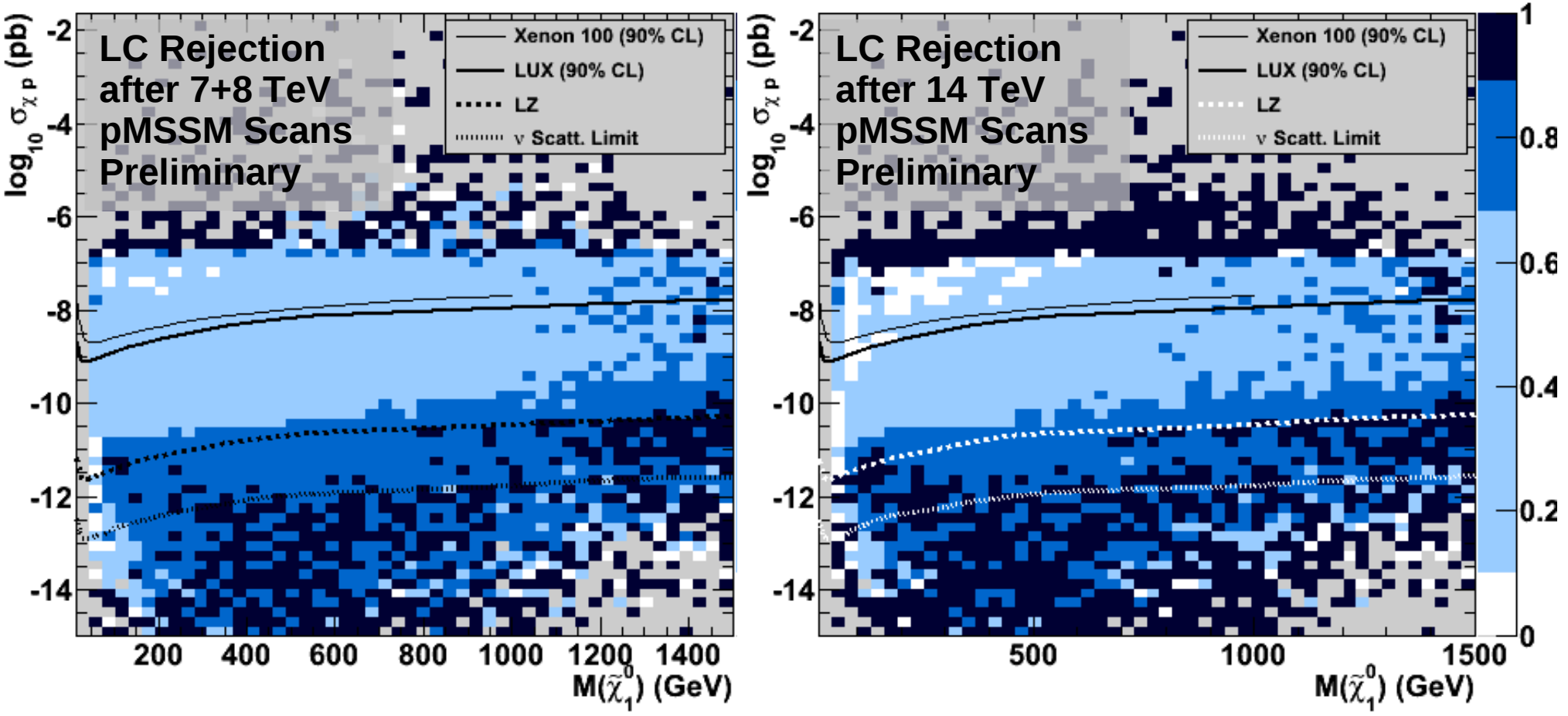
95% C.L. Exclusion	8 TeV 25 fb^{-1}	14 TeV 300 fb^{-1}
LC 0.5 TeV	0.591	0.666
LC 1.0 TeV	0.610	0.685

Higgs Branching Fraction in pMSSM after LHC constraints

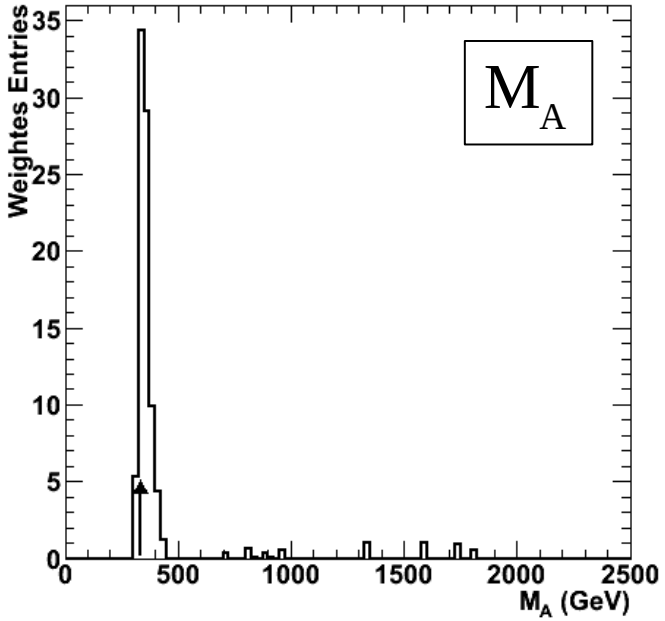


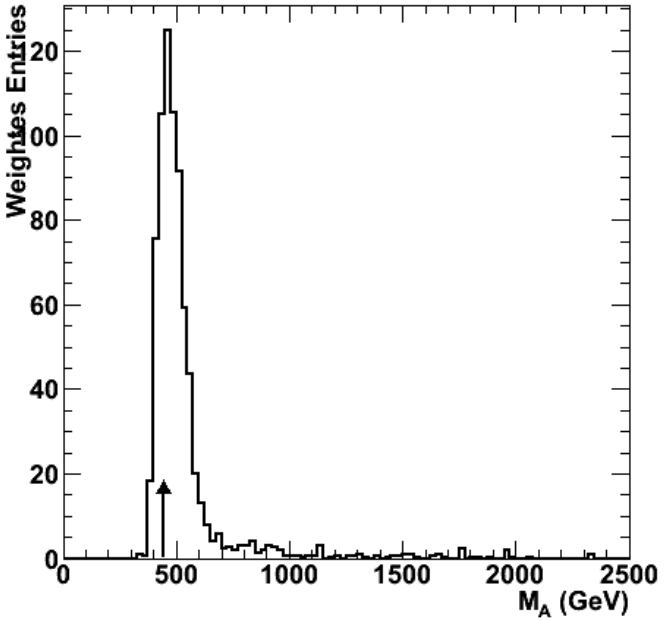
LC h BRs Sensitivity in the pMSSM: Implications with DM Direct Detection

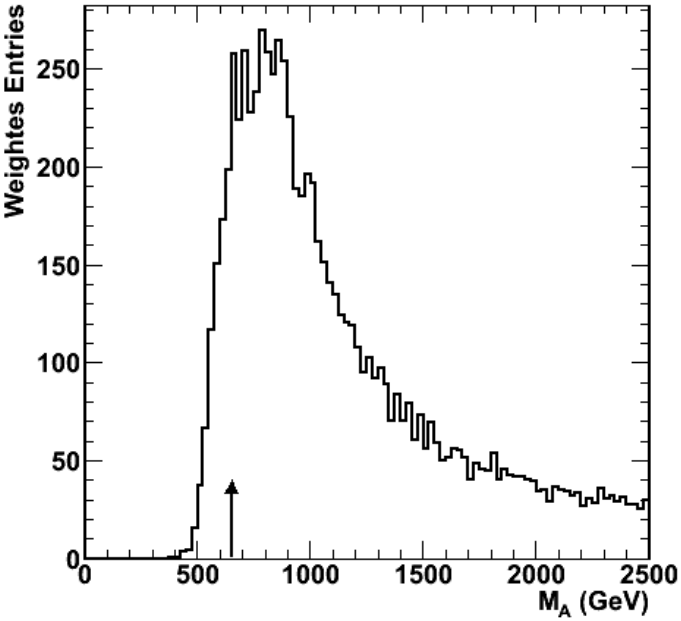
Fraction of pMSSM points incompatible with SM hypothesis after 7+8 TeV and 14 TeV LHC Data

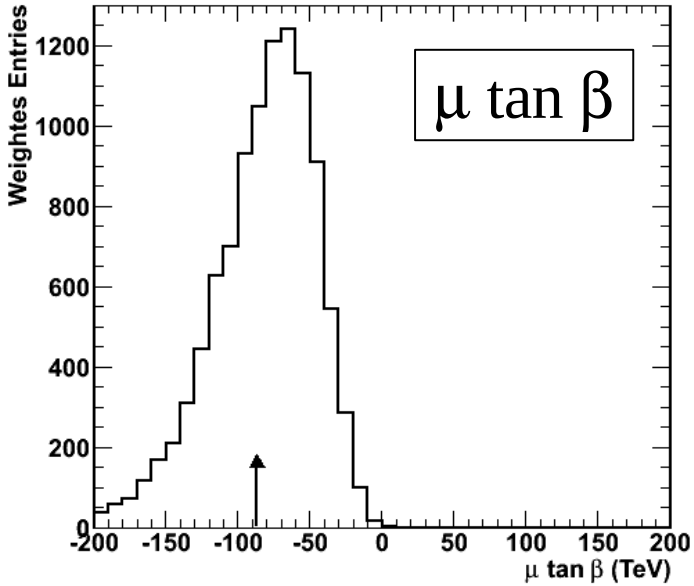


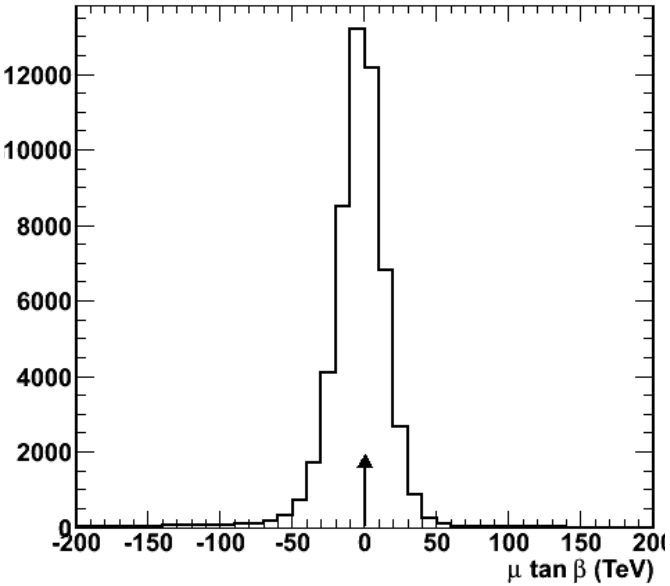
LC h BRs Sensitivity in the pMSSM:
Extraction of MSSM parameters for a set of MSSM benchmark points

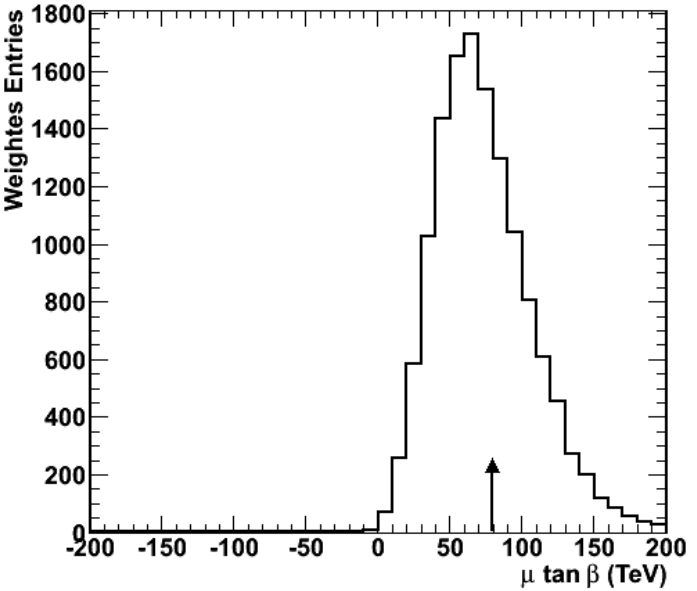












LC h BRs Sensitivity in the pMSSM: Extraction of MSSM parameters