
Resonant Benchmarks hh , hS , SS for the $\mathcal{L}HC$

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The \mathcal{NMSSM} Higgs Sector

- **Next-to-Minimal Supersymmetric Extension of the SM: NMSSM**

Fayet; Kaul eal; Barbieri eal; Dine eal; Nilles eal; Frere eal; Derendinger eal; Ellis eal;
Drees; Ellwanger eal; Savoy; Elliott eal; Gunion eal; Franke eal; Maniatis; Djouadi eal; Mahmoudi eal; ...

- **SUSY Higgs Sector:** at least 2 complex Higgs doublets, NMSSM: plus complex singlet field \rightsquigarrow

- **Enlarged Higgs and neutralino sector:** 2 complex Higgs doublets \hat{H}_u, \hat{H}_d , 1 complex singlet \hat{S}

7 Higgs bosons: $H_1, H_2, H_3, A_1, A_2, H^+, H^-$

5 neutralinos: $\tilde{\chi}_i^0 (i = 1, \dots, 5)$

- **Significant changes of Higgs boson phenomenology**

The $\mathcal{C}2\text{HDM}$

$$V_{\text{tree}} = m_{11}^2 \Phi_1^\dagger \Phi_1 + m_{22}^2 \Phi_2^\dagger \Phi_2 - \left[m_{12}^2 \Phi_1^\dagger \Phi_2 + \text{h.c.} \right] + \frac{1}{2} \lambda_1 (\Phi_1^\dagger \Phi_1)^2 + \frac{1}{2} \lambda_2 (\Phi_2^\dagger \Phi_2)^2 + \lambda_3 (\Phi_1^\dagger \Phi_1) (\Phi_2^\dagger \Phi_2) + \lambda_4 (\Phi_1^\dagger \Phi_2) (\Phi_2^\dagger \Phi_1) + \left[\frac{1}{2} \lambda_5 (\Phi_1^\dagger \Phi_2)^2 + \text{h.c.} \right].$$

- **CP Violation:** m_{12}^2 , λ_5 can be complex (all others real); indep. phase \rightsquigarrow CP violation
- **Particle content:**
 - 3 neutral CP-mixing Higgs bosons H_1, H_2, H_3
 - 1 charged Higgs pair H^\pm
- **Flavour-Changing Neutral Currents (FCNC) at tree-level:** forbidden by \mathbb{Z}_2 symmetry

$$\Phi_1 \rightarrow \Phi_1, \quad \Phi_2 \rightarrow -\Phi_2.$$

	Type I	Type II	Lepton-Specific	Flipped
Up-type quarks	Φ_2	Φ_2	Φ_2	Φ_2
Down-type quarks	Φ_2	Φ_1	Φ_2	Φ_1
Leptons	Φ_2	Φ_1	Φ_1	Φ_2

The $\mathcal{C}2\text{HDM}$

$$V_{\text{tree}} = m_{11}^2 \Phi_1^\dagger \Phi_1 + m_{22}^2 \Phi_2^\dagger \Phi_2 - \left[m_{12}^2 \Phi_1^\dagger \Phi_2 + \text{h.c.} \right] + \frac{1}{2} \lambda_1 (\Phi_1^\dagger \Phi_1)^2 + \frac{1}{2} \lambda_2 (\Phi_2^\dagger \Phi_2)^2 \\ + \lambda_3 (\Phi_1^\dagger \Phi_1) (\Phi_2^\dagger \Phi_2) + \lambda_4 (\Phi_1^\dagger \Phi_2) (\Phi_2^\dagger \Phi_1) + \left[\frac{1}{2} \lambda_5 (\Phi_1^\dagger \Phi_2)^2 + \text{h.c.} \right].$$

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	Type I	Type II	Lepton-Specific	Flipped
Up-type quarks	Φ_2	Φ_2	Φ_2	Φ_2
Down-type quarks	Φ_2	Φ_1	Φ_2	Φ_1
Leptons	Φ_2	Φ_1	Φ_1	Φ_2

C2HDM Parameter Scan

- **Scan over parameter space:**

with ScannerS, checks for: [Coimbra,Sampaio,Santos '13; Ferreira,Guedes,Sampaio,Santos '14]

- **Theoretical constraints:**

boundedness from below, tree-level perturbative unitarity, EW vacuum is global minimum of tree-level potential and also NLO [BSMPT, Basler,MMM '18]

- **Experimental constraints::**

* S, T, U parameters for EW precision observables [Baak eal '14]

* $R_b = \Gamma(Z \rightarrow b\bar{b})/\Gamma(Z \rightarrow \text{hadrons})$ and $B \rightarrow X_s \gamma$ [Haber,Logan '99;Deschamps eal '09; Mahmoudi,Stal '09; Steinhauser eal '17]

* Higgs exclusion bounds by HiggsBounds [Bechtle eal '08,'11,'13]

* Higgs rates checked via SUSHI and C2HDM_HDECAY, HiggsSignals [Harlander eal; Fontes eal; Bechtle eal]

* Electric dipole moment of the electron [The ACME Collaboration '18]

C2HDM Scan Ranges

	t_β	$\alpha_{1,2,3}$	$\text{Re}(m_{12}^2)$ [TeV ²]	m_{H^\pm} [TeV]	$m_{H_i \neq h}$ [TeV]
min	0.8	$-\frac{\pi}{2}$	0	0.15/0.59	0.01
max	20	$\frac{\pi}{2}$	0.5	1.5	1.5

$$10 \text{ GeV} \leq m_{H_j} < 1.5 \text{ TeV}$$

$$\begin{aligned}
 \alpha(M_Z) &= 1/127.92, & \alpha_s^{\overline{\text{MS}}}(M_Z) &= 0.118, \\
 M_Z &= 91.187 \text{ GeV}, & M_W &= 80.358 \text{ GeV}, \\
 m_t &= 172.5 \text{ GeV}, & m_b^{\overline{\text{MS}}}(m_b^{\overline{\text{MS}}}) &= 4.18 \text{ GeV}, \\
 m_\tau &= 1.777 \text{ GeV}.
 \end{aligned}$$

\mathcal{N} MSSM Scan

- **Conditions on the parameter scan:**

- * At least one CP-even Higgs boson $H_i \equiv h$ with: $124 \text{ GeV} \lesssim M_h \lesssim 126 \text{ GeV}$
- * Compatibility with μ_{XX}^{exp} ($X = b, \tau, \gamma, W, Z$) [SusHi, NMSSMTools, NMSSMCALC, HiggsSignals]
- * Compatibility with Higgs exclusion bounds [HiggsBounds]
- * Compatibility with SUSY searches
- * Compatibility w/ DM constraints [PLANCK, LUX, XENON1T, micrOmegas]

Constraints from low-energy observables, from LEP, Tevatron and LHC searches [NMSSMTools]

NMSSM Scan Ranges

	t_β	λ	κ	M_1	M_2	M_3	A_t	A_b	A_τ	$m_{\tilde{Q}_3}$	$m_{\tilde{L}_3}$	A_λ	A_κ	μ_{eff}
	in TeV													
min	1	0	-0.7	0.1	0.2	1.3	-6	-6	-3	0.6	0.6	-2	-2	-5
max	50	0.7	0.7	1	2	7	6	6	3	4	4	2	2	5

$$m_{\tilde{t}_R} = m_{\tilde{Q}_3}, \quad m_{\tilde{\tau}_R} = m_{\tilde{L}_3} \quad \text{and} \quad m_{\tilde{b}_R} = 3 \text{ TeV}$$

$$m_{\tilde{u}_R, \tilde{c}_R} = m_{\tilde{d}_R, \tilde{s}_R} = m_{\tilde{Q}_{1,2}} = m_{\tilde{L}_{1,2}} = m_{\tilde{e}_R, \tilde{\mu}_R} = 3 \text{ TeV}$$

$$\lambda^2 + \kappa^2 < 0.7^2$$

(1) C2HDM Benchmark Point - Max $\sigma(hh \rightarrow (b\bar{b})(b\bar{b}))$

$m_{H_1}/\Gamma_{\text{tot}}$ [GeV]	125.09	$3.64 \cdot 10^{-3}$
$m_{H_2}/\Gamma_{\text{tot}}$ [GeV]	310.99	0.35
$m_{H_3}/\Gamma_{\text{tot}}$ [GeV]	314.63	1.44
$m_{H^\pm}/\Gamma_{\text{tot}}$ [GeV]	372.62	0.99
σ_{hh}^{LO} [fb]	781	
$\sigma_{hh \rightarrow 4b}^{\text{LO}}/\text{wrt. SM}$ [fb]	261	42
$\mathcal{L}_{\text{excl}}$ [fb $^{-1}$]	266	
$\text{Re}(m_{12}^2)$ [GeV 2]	14860	
α_1	1.160	
α_2	$-6.066 \cdot 10^{-3}$	
α_3	1.2338	
$\tan \beta$	5.088	
R_{13}^2	$3.680 \cdot 10^{-5}$	
R_{23}^2	0.890	
R_{33}^2	0.110	

◇ R_{i3}^2 quantifies
singlet admixture

◇ $\sigma^{\text{NLO}} \sim 2\sigma^{\text{LO}}$

◇ enhancement due to
resonant H_2, H_3 production
w/ subsequent decay into hh :
 $\text{BR}(H_2 \rightarrow hh) = 0.428$,
 $\text{BR}(H_3 \rightarrow hh) = 0.707$

(1) C2HDM Benchmark Point - $\mathcal{M}ax \sigma(hh \rightarrow (b\bar{b})(b\bar{b}))$

$m_{H_1}/\Gamma_{\text{tot}}$ [GeV]	125.09	$3.64 \cdot 10^{-3}$	σ_{hh}^{LO} [fb]	781
$m_{H_2}/\Gamma_{\text{tot}}$ [GeV]	310.99	0.35	$\sigma_{hh \rightarrow 4b}^{\text{LO}}/\text{wrt. SM}$ [fb]	261 42
$m_{H_3}/\Gamma_{\text{tot}}$ [GeV]	314.63	1.44	$\sigma_{hh \rightarrow 2b2W}^{\text{LO}}/\text{wrt. SM}$ [fb]	101 40
$m_{H^\pm}/\Gamma_{\text{tot}}$ [GeV]	372.62	0.99	$\sigma_{hh \rightarrow 2b2\gamma}^{\text{LO}}/\text{wrt. SM}$ [fb]	1.12 45
σ_{hh}^{LO} [fb]	781		$\sigma_{hh \rightarrow 2b2\tau}^{\text{LO}}/\text{wrt. SM}$ [fb]	28 41
$\sigma_{hh \rightarrow 4b}^{\text{LO}}/\text{wrt. SM}$ [fb]	261	42	$\sigma_{hh \rightarrow 4W}^{\text{LO}}/\text{wrt. SM}$ [fb]	39 37
$\mathcal{L}_{\text{excl}}$ [fb ⁻¹]	266		$\sigma_{hh \rightarrow 2\tau 2W}^{\text{LO}}/\text{wrt. SM}$ [fb]	11 39
$\text{Re}(m_{12}^2)$ [GeV ²]	14860		$\sigma_{hh \rightarrow 4\tau}^{\text{LO}}/\text{wrt. SM}$ [fb]	3 41
α_1	1.160			
α_2	$-6.066 \cdot 10^{-3}$			
α_3	1.2338			
$\tan \beta$	5.088			
R_{13}^2	$3.680 \cdot 10^{-5}$			
R_{23}^2	0.890			
R_{33}^2	0.110			

(2) C2HDM Benchmark Point - Max $\sigma(SS/hS \rightarrow (b\bar{b})(b\bar{b}))$

$m_{H_1}/\Gamma_{\text{tot}}$ [GeV]	125.09	$3.74 \cdot 10^{-3}$
$m_{H_2(S)}/\Gamma_{\text{tot}}$ [GeV]	131.48	$7.95 \cdot 10^{-4}$
$m_{H_3}/\Gamma_{\text{tot}}$ [GeV]	313.33	6.45
$m_{H^\pm}/\Gamma_{\text{tot}}$ [GeV]	311.54	5.79
σ_{SS}^{LO} [pb]	3.20	
$\sigma_{SS \rightarrow 4b}^{\text{LO}}$ [pb]	1.26	
σ_{Sh}^{LO} [fb]	49.17	
$\sigma_{Sh \rightarrow 4b}^{\text{LO}}$ [fb]	17.79	
$\mathcal{L}_{\text{excl}}$ [fb ⁻¹]	287	
$\text{Re}(m_{12}^2)$ [GeV ²]	13786	
α_1	1.041	
α_2	0.0262	
α_3	-1.570	
$\tan \beta$	2.220	

◇ S here means large pseudoscalar admixture

◇ $\sigma^{\text{NLO}} \sim 2\sigma^{\text{LO}}$

◇ $H_2H_2 = SS$ enhancement due to resonant H_3 production w/ subsequent decay into SS :
BR($H_3 \rightarrow SS$) = 0.456

◇ $R_{13}^2 = 6.838 \cdot 10^{-4}$,
 $R_{23}^2 = 0.999$
 $R_{33}^2 = 1.412 \cdot 10^{-7}$

(2) C2HDM Benchmark Point - Max $\sigma(SS/hS \rightarrow (b\bar{b})(b\bar{b}))$

$m_{H_1}/\Gamma_{\text{tot}}$ [GeV]	125.09	$3.74 \cdot 10^{-3}$	σ_{Sh}^{LO} [fb]	49.17
$m_{H_2(S)}/\Gamma_{\text{tot}}$ [GeV]	131.48	$7.95 \cdot 10^{-4}$	$\sigma_{Sh \rightarrow 4b}^{\text{LO}}/\text{wrt. SM}$ [fb]	17.79 2.86
$m_{H_3}/\Gamma_{\text{tot}}$ [GeV]	313.33	6.45	$\sigma_{Sh \rightarrow 2\tau 2b}^{\text{LO}}/\text{wrt. SM}$ [fb]	1.9 2.92
$m_{H^\pm}/\Gamma_{\text{tot}}$ [GeV]	311.54	5.79	σ_{SS}^{LO} [pb]	3.2
σ_{SS}^{LO} [pb]	3.20		$\sigma_{SS \rightarrow 4b}^{\text{LO}}/\text{wrt. SM}$ [pb]	1.26 202.6
$\sigma_{SS \rightarrow 4b}^{\text{LO}}$ [pb]	1.26		$\sigma_{SS \rightarrow 2b 2W}^{\text{LO}}/\text{wrt. SM}$ [fb]	2.8 1.12
σ_{Sh}^{LO} [fb]	49.17		$\sigma_{SS \rightarrow 2b 2\gamma}^{\text{LO}}/\text{wrt. SM}$ [fb]	1.1 42.83
$\sigma_{Sh \rightarrow 4b}^{\text{LO}}$ [fb]	17.79		$\sigma_{SS \rightarrow 2b 2\tau}^{\text{LO}}/\text{wrt. SM}$ [fb]	139.8 206.57
$\mathcal{L}_{\text{excl}}$ [fb ⁻¹]	287		$\sigma_{SS \rightarrow 4\tau}^{\text{LO}}/\text{wrt. SM}$ [fb]	15.5 210.6
$\text{Re}(m_{12}^2)$ [GeV ²]	13786			
α_1	1.041			
α_2	0.0262			
α_3	-1.570			
$\tan \beta$	2.220			

(3) \mathcal{N} MSSM Benchmark Points - Max $\sigma(hh \rightarrow (b\bar{b})(b\bar{b}))$

$m_{H_1}/\Gamma_{\text{tot}}$ [GeV]	125.03	$3.60 \cdot 10^{-3}$	
$m_{H_2(S)}/\Gamma_{\text{tot}}$ [GeV]	170.66	0.27	$\diamond H_2$ singlet-like scalar
$m_{H_3}/\Gamma_{\text{tot}}$ [GeV]	454.90	2.80	A_1 singlet-like pseudoscalar
$m_{A_1(S)}/\Gamma_{\text{tot}}$ [GeV]	69.03	$7.26 \cdot 10^{-5}$	$\diamond \sigma^{\text{NLO}} \sim 2\sigma^{\text{LO}}$
$m_{A_2}/\Gamma_{\text{tot}}$ [GeV]	446.26	4.34	
$m_{H^\pm}/\Gamma_{\text{tot}}$ [GeV]	440.31	3.77	
σ_{hh}^{LO} [fb]	34.18		
$\sigma_{hh \rightarrow 4b}^{\text{LO}}/\text{wrt. SM}$ [fb]	12.42	1.99	
$\mathcal{L}_{\text{excl}}$ [fb $^{-1}$]	287		
$\tan \beta$	2.919		
λ	0.613		
κ	0.331		
A_λ [GeV]	-348		
A_κ [GeV]	-51		
μ_{eff} [GeV]	-159		

(3) \mathcal{N} MSSM Benchmark Points - Max $\sigma(hh \rightarrow (b\bar{b})(b\bar{b}))$

$m_{H_1}/\Gamma_{\text{tot}}$ [GeV]	125.03	$3.60 \cdot 10^{-3}$	$m_{H_1}/\Gamma_{\text{tot}}$ [GeV]	125.03	$3.60 \cdot 10^{-3}$
$m_{H_2(S)}/\Gamma_{\text{tot}}$ [GeV]	170.66	0.27	$m_{H_2(S)}/\Gamma_{\text{tot}}$ [GeV]	170.66	0.27
$m_{H_3}/\Gamma_{\text{tot}}$ [GeV]	454.90	2.80	$m_{H_3}/\Gamma_{\text{tot}}$ [GeV]	454.90	2.80
$m_{A_1(S)}/\Gamma_{\text{tot}}$ [GeV]	69.03	$7.26 \cdot 10^{-5}$	$m_{A_1(S)}/\Gamma_{\text{tot}}$ [GeV]	69.03	$7.26 \cdot 10^{-5}$
$m_{A_2}/\Gamma_{\text{tot}}$ [GeV]	446.26	4.34	$m_{A_2}/\Gamma_{\text{tot}}$ [GeV]	446.26	4.34
$m_{H^\pm}/\Gamma_{\text{tot}}$ [GeV]	440.31	3.77	$m_{H^\pm}/\Gamma_{\text{tot}}$ [GeV]	440.31	3.77
σ_{hh}^{LO} [fb]	34.18		σ_{hh}^{LO} [fb]	34.18	
$\sigma_{hh \rightarrow 4b}^{\text{LO}}/\text{wrt. SM}$ [fb]	12.42	1.99	$\sigma_{hh \rightarrow 4b}^{\text{LO}}/\text{wrt. SM}$ [fb]	12.42	1.99
$\mathcal{L}_{\text{excl}}$ [fb $^{-1}$]	287		$\sigma_{hh \rightarrow 2b2W}^{\text{LO}}/\text{wrt. SM}$ [fb]	4.4	1.72
$\tan \beta$	2.919		$\sigma_{hh \rightarrow 2b2\tau}^{\text{LO}}/\text{wrt. SM}$ [fb]	1.3	1.97
λ	0.613		$\sigma_{hh \rightarrow 4W}^{\text{LO}}/\text{wrt. SM}$ [fb]	1.54	1.47
κ	0.331				
A_λ [GeV]	-348				
A_κ [GeV]	-51				
μ_{eff} [GeV]	-159				

(3) \mathcal{N} MSSM Benchmark Points - Also Max $\sigma(hA_S, A_S A_S \rightarrow (b\bar{b})(b\bar{b}))$

$m_{H_1}/\Gamma_{\text{tot}}$ [GeV]	125.03	$3.60 \cdot 10^{-3}$
$m_{H_2(S)}/\Gamma_{\text{tot}}$ [GeV]	170.66	0.27
$m_{H_3}/\Gamma_{\text{tot}}$ [GeV]	454.90	2.80
$m_{A_1(S)}/\Gamma_{\text{tot}}$ [GeV]	69.03	7.26
$m_{A_2}/\Gamma_{\text{tot}}$ [GeV]	446.26	4.34
$m_{H^\pm}/\Gamma_{\text{tot}}$ [GeV]	440.31	3.77
$\sigma_{hA_S}^{\text{LO}}$ [fb]	69.97	
$\sigma_{hA_S \rightarrow 4b}^{\text{LO}}$ [fb]	38.32	
$\sigma_{A_S A_S}^{\text{LO}}$ [fb]	69.78	
$\sigma_{A_S A_S \rightarrow 4b}^{\text{LO}}$ [fb]	57.58	
$\mathcal{L}_{\text{excl}}$ [fb $^{-1}$]	287	

- ◇ H_2 singlet-like scalar
 A_1 singlet-like pseudoscalar
- ◇ $\sigma^{\text{NLO}} \sim 2\sigma^{\text{LO}}$
- ◇ hA_S enhancement due to resonant A_2 production w/ subsequent decay into $hA_{1(S)}$
- ◇ $A_S A_S$ enhancement due to resonant H_2 production w/ subsequent decay into $A_S A_S$:
 $\text{BR}(H_2 \rightarrow A_S A_S)=0.97$

(3) \mathcal{N} MSSM Benchmark Points - Also Max $\sigma(hA_S, A_S A_S \rightarrow (b\bar{b})(b\bar{b}))$

$m_{H_1}/\Gamma_{\text{tot}}$ [GeV]	125.03	$3.60 \cdot 10^{-3}$	$\sigma_{hA_S}^{\text{LO}}$ [fb]	69.97	
$m_{H_2(S)}/\Gamma_{\text{tot}}$ [GeV]	170.66	0.27	$\sigma_{hA_S \rightarrow 4b}^{\text{LO}}$ [fb]	38.32	6.17
$m_{H_3}/\Gamma_{\text{tot}}$ [GeV]	454.90	2.80	$\sigma_{hA_S \rightarrow 2b2\tau}^{\text{LO}}$ [fb]	3.7	5.46
$m_{A_1(S)}/\Gamma_{\text{tot}}$ [GeV]	69.03	7.26	$\sigma_{hA_S \rightarrow 2W2b}^{\text{LO}}$ [fb]	13.4	6.29
$m_{A_2}/\Gamma_{\text{tot}}$ [GeV]	446.26	4.34	$\sigma_{hA_S \rightarrow 2W2\tau}^{\text{LO}}$ [fb]	1.3	4.68
$m_{H^\pm}/\Gamma_{\text{tot}}$ [GeV]	440.31	3.77	$\sigma_{hA_S \rightarrow 2\tau 2b}^{\text{LO}}$ [fb]	4	6.07
$\sigma_{hA_S}^{\text{LO}}$ [fb]	69.97		$\sigma_{A_S A_S}^{\text{LO}}$ [fb]	69.78	
$\sigma_{hA_S \rightarrow 4b}^{\text{LO}}$ [fb]	38.32		$\sigma_{A_S A_S \rightarrow 4b}^{\text{LO}}$ [fb]	57.58	9.27
$\sigma_{A_S A_S}^{\text{LO}}$ [fb]	69.78		$\sigma_{A_S A_S \rightarrow 2b2\tau}^{\text{LO}}$ [fb]	5.55	8.2
$\sigma_{A_S A_S \rightarrow 4b}^{\text{LO}}$ [fb]	57.58				
$\mathcal{L}_{\text{excl}}$ [fb ⁻¹]	287				

(4) \mathcal{N} MSSM Benchmark Points - Max $\sigma(hH_S \rightarrow (b\bar{b})(b\bar{b}))$

$m_{H_1(S)}/\Gamma_{\text{tot}}$ [GeV]	100.11	$1.00 \cdot 10^{-3}$	$\diamond H_1$ singlet-like scalar A_1 singlet-like pseudoscalar $\diamond \sigma^{\text{NLO}} \sim 2\sigma^{\text{LO}}$
$m_{H_2}/\Gamma_{\text{tot}}$ [GeV]	125.23	$3.56 \cdot 10^{-3}$	
$m_{H_3}/\Gamma_{\text{tot}}$ [GeV]	660.38	7.80	
$m_{A_1(S)}/\Gamma_{\text{tot}}$ [GeV]	217.21	$6.92 \cdot 10^{-4}$	
$m_{A_2}/\Gamma_{\text{tot}}$ [GeV]	657.01	8.73	
$m_{H^\pm}/\Gamma_{\text{tot}}$ [GeV]	651.11	7.54	
$\sigma_{hH_S}^{\text{LO}}$ [fb]	15.68		
$\sigma_{hH_S \rightarrow 4b}^{\text{LO}}$ [fb]	8.43		
$\mathcal{L}_{\text{excl}}$ [fb $^{-1}$]	183		
$\tan \beta$	3.601		
λ	0.589		
κ	0.251		
A_λ [GeV]	593		
A_κ [GeV]	-148		
μ_{eff} [GeV]	178		

(4) \mathcal{N} MSSM Benchmark Points - Max $\sigma(hH_S \rightarrow (b\bar{b})(b\bar{b}))$

$m_{H_1(S)}/\Gamma_{\text{tot}}$ [GeV]	100.11	1.00 · 10 ⁻³	$m_{H_1(S)}/\Gamma_{\text{tot}}$ [GeV]	100.11	1.00 · 10 ⁻³
$m_{H_2}/\Gamma_{\text{tot}}$ [GeV]	125.23	3.56 · 10 ⁻³	$m_{H_2}/\Gamma_{\text{tot}}$ [GeV]	125.23	3.56 · 10 ⁻³
$m_{H_3}/\Gamma_{\text{tot}}$ [GeV]	660.38	7.80	$m_{H_3}/\Gamma_{\text{tot}}$ [GeV]	660.38	7.80
$m_{A_1(S)}/\Gamma_{\text{tot}}$ [GeV]	217.21	6.92 · 10 ⁻⁴	$m_{A_1(S)}/\Gamma_{\text{tot}}$ [GeV]	217.21	6.92 · 10 ⁻⁴
$m_{A_2}/\Gamma_{\text{tot}}$ [GeV]	657.01	8.73	$m_{A_2}/\Gamma_{\text{tot}}$ [GeV]	657.01	8.73
$m_{H^\pm}/\Gamma_{\text{tot}}$ [GeV]	651.11	7.54	$m_{H^\pm}/\Gamma_{\text{tot}}$ [GeV]	651.11	7.54
$\sigma_{hH_S}^{\text{LO}}$ [fb]	15.68		$\sigma_{hH_S}^{\text{LO}}$ [fb]	15.68	
$\sigma_{hH_S \rightarrow 4b}^{\text{LO}}$ [fb]	8.43		$\sigma_{hH_S \rightarrow 4b}^{\text{LO}}$ [fb]	8.43	1.36
$\mathcal{L}_{\text{excl}}$ [fb ⁻¹]	183		$\sigma_{hH_S \rightarrow 2W2b}^{\text{LO}}$ [fb]	3.1	1.2
$\tan \beta$	3.601				
λ	0.589				
κ	0.251				
A_λ [GeV]	593				
A_κ [GeV]	-148				
μ_{eff} [GeV]	178				

Thank You For Your Attention!



(1) $\mathcal{C}2\text{HDM}$ Benchmark Point - $\text{Max } \sigma(hh \rightarrow (b\bar{b})(b\bar{b}))$

σ_{hh}^{LO} [fb]	781	
$\sigma_{hh \rightarrow 2\gamma 2W}^{\text{LO}}/\text{wrt. SM}$ [fb]	0.4	42
$\sigma_{hh \rightarrow 4\gamma}^{\text{LO}}/\text{wrt. SM}$ [fb]	$5 \cdot 10^{-3}$	47
$\sigma_{hh \rightarrow 2\gamma 2\tau}^{\text{LO}}/\text{wrt. SM}$ [fb]	0.12	44

(2) C2HDM Benchmark Point - $\text{Max } \sigma(SS/hS \rightarrow (b\bar{b})(b\bar{b}))$

σ_{Sh}^{LO} [fb]	49.17	
$\sigma_{Sh \rightarrow 2W2b}^{\text{LO}}/\text{wrt. SM}$ [fb]	$4 \cdot 10^{-2}$	0.016
$\sigma_{Sh \rightarrow 2\gamma 2b}^{\text{LO}}/\text{wrt. SM}$ [fb]	$1.5 \cdot 10^{-2}$	0.61
$\sigma_{Sh \rightarrow 4W}^{\text{LO}}/\text{wrt. SM}$ [fb]	$1.6 \cdot 10^{-2}$	0.015
$\sigma_{Sh \rightarrow 2\gamma 2W}^{\text{LO}}/\text{wrt. SM}$ [fb]	$6 \cdot 10^{-3}$	0.58
$\sigma_{Sh \rightarrow 2\tau 2W}^{\text{LO}}/\text{wrt. SM}$ [fb]	0.77	2.78
$\sigma_{Sh \rightarrow 4\gamma}^{\text{LO}}/\text{wrt. SM}$ [fb]	$6.3 \cdot 10^{-8}$	0.015
$\sigma_{Sh \rightarrow 2\tau 2\gamma}^{\text{LO}}/\text{wrt. SM}$ [fb]	$8.2 \cdot 10^{-3}$	3.00
$\sigma_{Sh \rightarrow 2W 2\tau}^{\text{LO}}/\text{wrt. SM}$ [fb]	$4.3 \cdot 10^{-3}$	0.016
$\sigma_{Sh \rightarrow 2\gamma 2\tau}^{\text{LO}}/\text{wrt. SM}$ [fb]	$1.6 \cdot 10^{-3}$	0.6
$\sigma_{hh \rightarrow 4\tau}^{\text{LO}}/\text{wrt. SM}$ [fb]	0.21	2.88
$\sigma_{SS \rightarrow 4W}^{\text{LO}}/\text{wrt. SM}$ [fb]	$6.5 \cdot 10^{-3}$	$6.2 \cdot 10^{-3}$
$\sigma_{SS \rightarrow 2W 2\gamma}^{\text{LO}}/\text{wrt. SM}$ [fb]	$2.4 \cdot 10^{-3}$	0.24
$\sigma_{SS \rightarrow 2W 2\tau}^{\text{LO}}/\text{wrt. SM}$ [fb]	0.32	1.14
$\sigma_{SS \rightarrow 4\gamma}^{\text{LO}}/\text{wrt. SM}$ [fb]	$9.16 \cdot 10^{-4}$	9.1
$\sigma_{SS \rightarrow 2\gamma 2\tau}^{\text{LO}}/\text{wrt. SM}$ [fb]	0.12	43.7

(3) \mathcal{N} MSSM Benchmark Points - Max $\sigma(hh \rightarrow (b\bar{b})(b\bar{b}))$

$m_{H_1}/\Gamma_{\text{tot}}$ [GeV]	125.03	$3.60 \cdot 10^{-3}$
$m_{H_2(S)}/\Gamma_{\text{tot}}$ [GeV]	170.66	0.27
$m_{H_3}/\Gamma_{\text{tot}}$ [GeV]	454.90	2.80
$m_{A_1(S)}/\Gamma_{\text{tot}}$ [GeV]	69.03	$7.26 \cdot 10^{-5}$
$m_{A_2}/\Gamma_{\text{tot}}$ [GeV]	446.26	4.34
$m_{H^\pm}/\Gamma_{\text{tot}}$ [GeV]	440.31	3.77
σ_{hh}^{LO} [fb]	34.18	
$\sigma_{hh \rightarrow 2b2\gamma}^{\text{LO}}/\text{wrt. SM}$ [fb]	0.054	2.14
$\sigma_{hh \rightarrow 2W2\gamma}^{\text{LO}}/\text{wrt. SM}$ [fb]	0.019	1.83
$\sigma_{hh \rightarrow 2W2\tau}^{\text{LO}}/\text{wrt. SM}$ [fb]	0.47	1.69
$\sigma_{hh \rightarrow 4\gamma}^{\text{LO}}/\text{wrt. SM}$ [fb]	$2.3 \cdot 10^{-4}$	2.28
$\sigma_{hh \rightarrow 2\gamma 2\tau}^{\text{LO}}/\text{wrt. SM}$ [fb]	$5.7 \cdot 10^{-3}$	2.1
$\sigma_{hh \rightarrow 4\tau}^{\text{LO}}/\text{wrt. SM}$ [fb]	0.14	1.94

(3) $\mathcal{N}MSSM$ Benchmark Points - Also Max $\sigma(hA_S, A_S A_S \rightarrow (b\bar{b})(b\bar{b}))$

$\sigma_{hA_S}^{\text{LO}}$ [fb]	69.97	
$\sigma_{hA_S \rightarrow 2b2\gamma}^{\text{LO}}$ [fb]	0.03	1.33
$\sigma_{hA_S \rightarrow 2W2\gamma}^{\text{LO}}$ [fb]	0.012	1.15
$\sigma_{hA_S \rightarrow 2\gamma 2b}^{\text{LO}}$ [fb]	0.17	6.59
$\sigma_{hA_S \rightarrow 4\gamma}^{\text{LO}}$ [fb]	$1.44 \cdot 10^{-4}$	1.43
$\sigma_{hA_S \rightarrow 2\gamma 2\tau}^{\text{LO}}$ [fb]	0.016	5.83
$\sigma_{hA_S \rightarrow 2\tau 2\gamma}^{\text{LO}}$ [fb]	$3.58 \cdot 10^{-3}$	1.31
$\sigma_{hA_S \rightarrow 4\tau}^{\text{LO}}$ [fb]	0.39	5.37
$\sigma_{A_S A_S}^{\text{LO}}$ [fb]	69.78	
$\sigma_{A_S A_S \rightarrow 2b2\gamma}^{\text{LO}}$ [fb]	0.05	2
$\sigma_{A_S A_S \rightarrow 4\gamma}^{\text{LO}}$ [fb]	$4.4 \cdot 10^{-5}$	0.43
$\sigma_{A_S A_S \rightarrow 2\tau 2\gamma}^{\text{LO}}$ [fb]	$4.8 \cdot 10^{-3}$	1.77
$\sigma_{A_S A_S \rightarrow 4\tau}^{\text{xtLO}}$ [fb]	0.53	7.26

(4) $\mathcal{N}MSSM$ Benchmark Points - Max $\sigma(hH_S \rightarrow (b\bar{b})(b\bar{b}))$

$\sigma_{hH_S}^{\text{LO}}$ [fb]	15.68	
$\sigma_{hH_S \rightarrow 2b2\tau}^{\text{LO}}$ [fb]	0.88	1.3
$\sigma_{hH_S \rightarrow 2W2\tau}^{\text{LO}}$ [fb]	0.32	1.2
$\sigma_{hH_S \rightarrow 2\gamma 2b}^{\text{LO}}$ [fb]	0.038	1.52
$\sigma_{hH_S \rightarrow 2\gamma 2\tau}^{\text{LO}}$ [fb]	$4 \cdot 10^{-3}$	1.5
$\sigma_{hH_S \rightarrow 2\tau 2b}^{\text{LO}}$ [fb]	0.9	1.3
$\sigma_{hH_S \rightarrow 4\tau}^{\text{LO}}$ [fb]	0.094	1.3
$\sigma_{hH_S \rightarrow 2b2W}^{\text{LO}}$ [fb]	$3.8 \cdot 10^{-3}$	$1.5 \cdot 10^{-3}$
$\sigma_{hH_S \rightarrow 2b2\gamma}^{\text{LO}}$ [fb]	$1.0 \cdot 10^{-4}$	$4.1 \cdot 10^{-3}$
$\sigma_{hH_S \rightarrow 4W}^{\text{LO}}$ [fb]	$1.4 \cdot 10^{-3}$	$1.3 \cdot 10^{-3}$
$\sigma_{hH_S \rightarrow 2W2\gamma}^{\text{LO}}$ [fb]	$3.7 \cdot 10^{-5}$	$3.6 \cdot 10^{-3}$
$\sigma_{hH_S \rightarrow 2\gamma 2W}^{\text{LO}}$ [fb]	$1.7 \cdot 10^{-5}$	$1.7 \cdot 10^{-3}$
$\sigma_{hH_S \rightarrow 4\gamma}^{\text{LO}}$ [fb]	$4.6 \cdot 10^{-7}$	$4.6 \cdot 10^{-3}$
$\sigma_{hH_S \rightarrow 2\tau 2W}^{\text{LO}}$ [fb]	$4.1 \cdot 10^{-4}$	$1.5 \cdot 10^{-3}$
$\sigma_{hH_S \rightarrow 2\tau 2\gamma}^{\text{LO}}$ [fb]	$1.1 \cdot 10^{-5}$	$4 \cdot 10^{-3}$