

Updated constraints on the Georgi-Machacek model

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based on 2003.02272
with Heather Logan and Yongcheng Wu

The model

Georgi, Machacek '85;
Chanowitz, Golden '85

Extends SM Higgs sector with a real and a complex
 $SU(2)_L$ triplet

$$\Phi = \begin{pmatrix} \phi^{0*} & \phi^+ \\ -\phi^{+*} & \phi^0 \end{pmatrix}, \quad X = \begin{pmatrix} \chi^{0*} & \xi^+ & \chi^{++} \\ -\chi^{+*} & \xi^0 & \chi^+ \\ \chi^{++*} & -\xi^{+*} & \chi^0 \end{pmatrix}$$

$$\langle \Phi \rangle = \frac{v_\phi}{\sqrt{2}} I_2 \quad \langle X \rangle = v_\chi I_3$$

Preserves **custodial $SU(2)$** :

$$V(\Phi, X) = \frac{\mu_2^2}{2} \text{Tr}(\Phi^\dagger \Phi) + \frac{\mu_3^2}{2} \text{Tr}(X^\dagger X) + \lambda_1 [\text{Tr}(\Phi^\dagger \Phi)]^2 + \lambda_2 \text{Tr}(\Phi^\dagger \Phi) \text{Tr}(X^\dagger X) \\ + \lambda_3 \text{Tr}(X^\dagger X X^\dagger X) + \lambda_4 [\text{Tr}(X^\dagger X)]^2 - \lambda_5 \text{Tr}(\Phi^\dagger \tau^a \Phi \tau^b) \text{Tr}(X^\dagger t^a X t^b) \\ - M_1 \text{Tr}(\Phi^\dagger \tau^a \Phi \tau^b) (UXU^\dagger)_{ab} - M_2 \text{Tr}(X^\dagger t^a X t^b) (UXU^\dagger)_{ab}.$$

9 parameters, 2 fixed by m_h and G_F

Hartling, Kumar, Logan
1412.7387

Spectrum of Higgs bosons

- Organized into representations of custodial SU(2):
 - two singlets (m_h, m_H): h, H
 - one triplet (m_3): (H_3^0, H_3^\pm)
 - one fiveplet (m_5): $(H_5^0, H_5^\pm, H_5^{\pm\pm})$
- Take $m_h = 125$ GeV
- Fermiophobic fiveplet, couplings $\sim s_H \equiv 2\sqrt{2}v_\chi/v$

Implementing collider constraints

- **GMCALC**: computes spectrum, couplings, decays

Hartling, Kumar, Logan
1412.7387

- **HiggsBounds** (HB): constraints from direct searches for new Higgs bosons

Bechtle *et al.*, 0811.4169

- **HiggsSignals** (HS): constraints from measurements of 125 GeV Higgs

Bechtle *et al.*, 1305.1933

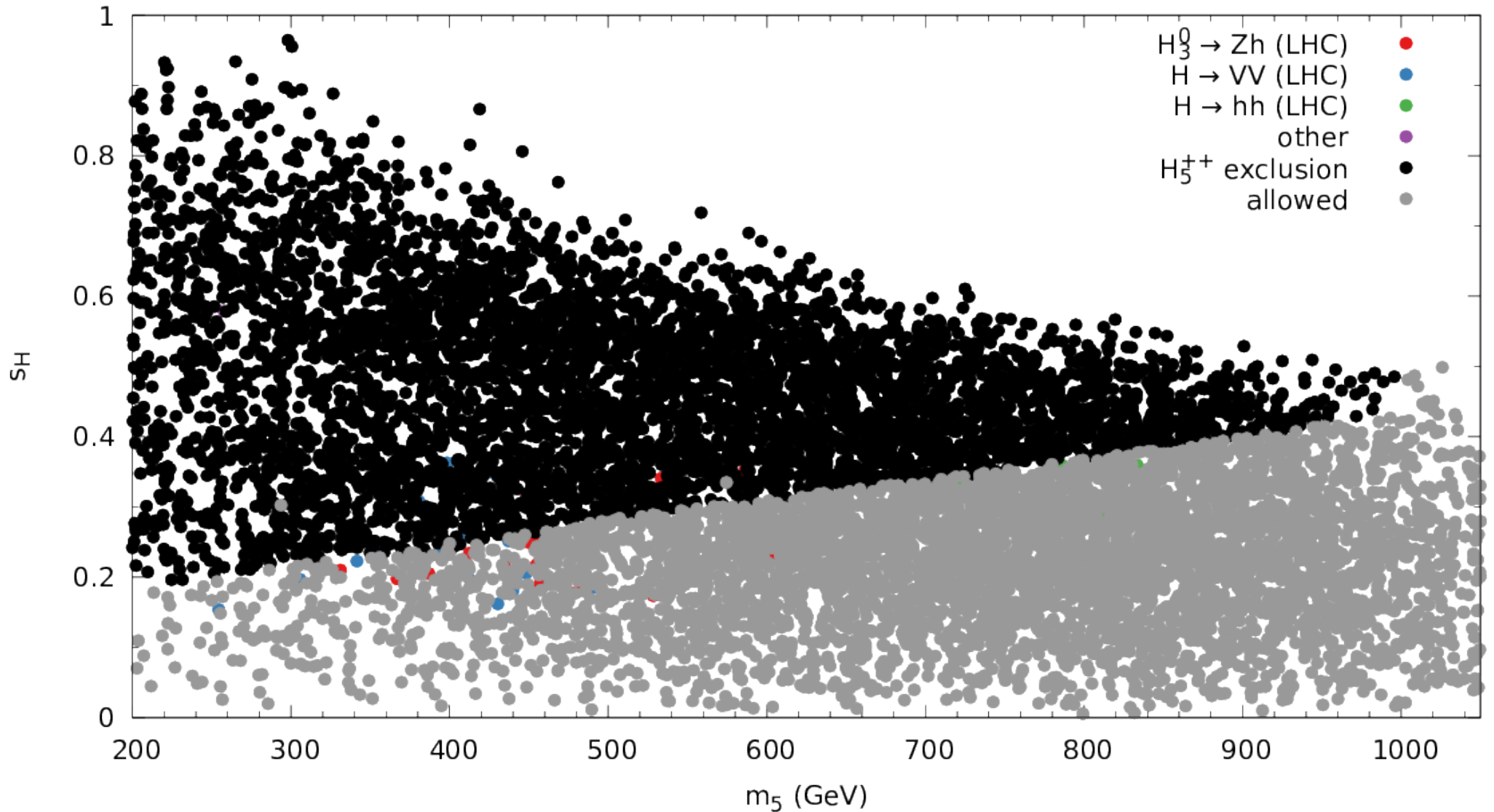
- Additional searches implemented directly in GMCALC:

- VBF / Drell-Yan $H_5^{\pm\pm} \rightarrow W^\pm W^\pm \rightarrow$ like-sign dileptons
- Drell-Yan $H_5^0 \rightarrow \gamma\gamma$

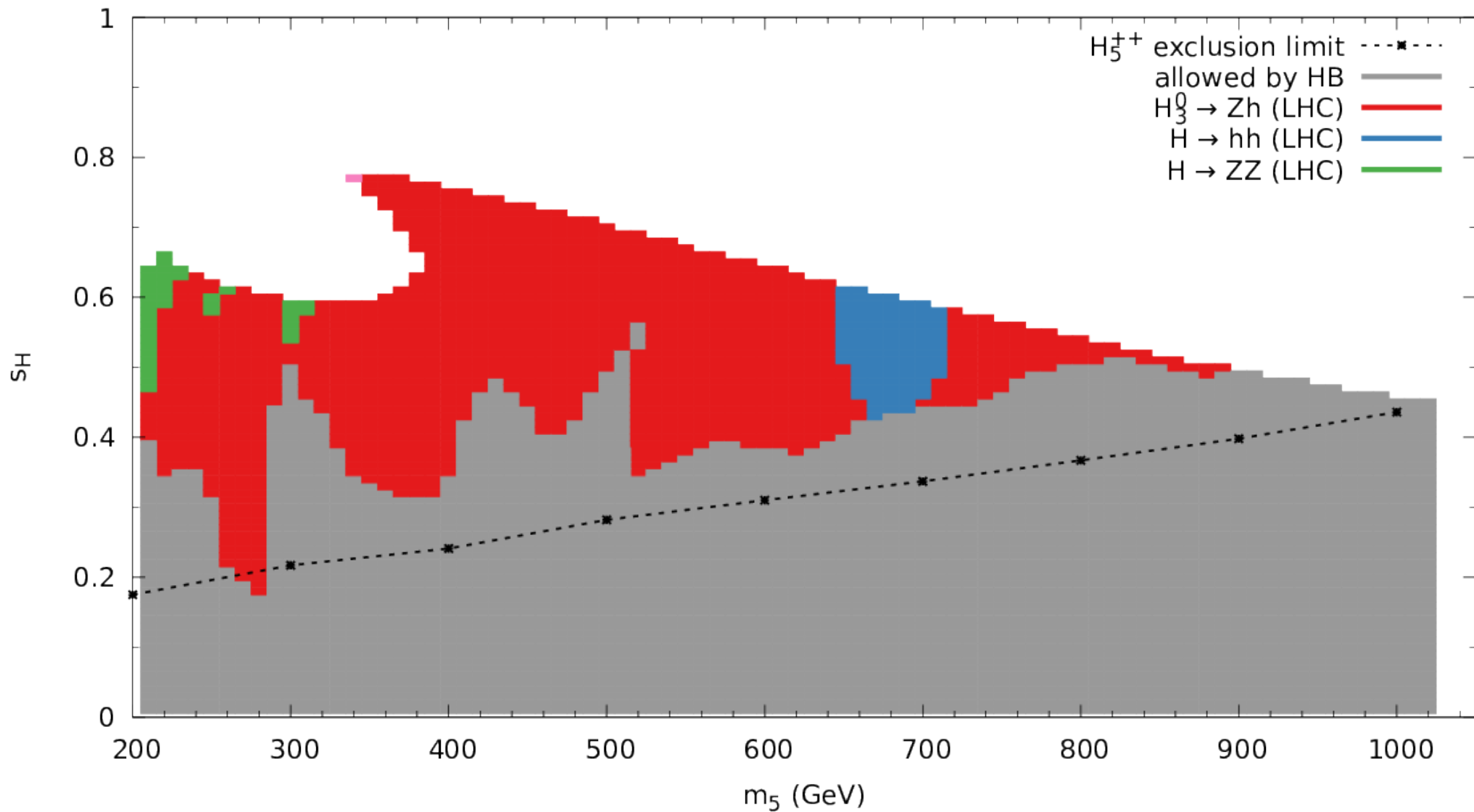
Implementing collider constraints

- Random sampling of 10^4 points from 7D parameter space
 - High- m_5 region: 200-1050 GeV
 - Low- m_5 region: 50-200 GeV
- Also examined two benchmark scenarios (2D slices)
- Key findings:
 - novel constraints from $H_3^0 \rightarrow Zh; H \rightarrow hh$
 - couplings of 125 GeV Higgs to vector bosons (fermions) constrained to $\pm 20\%$ ($\pm 30\%$) of SM values
 - large regions still allowed after applying all constraints

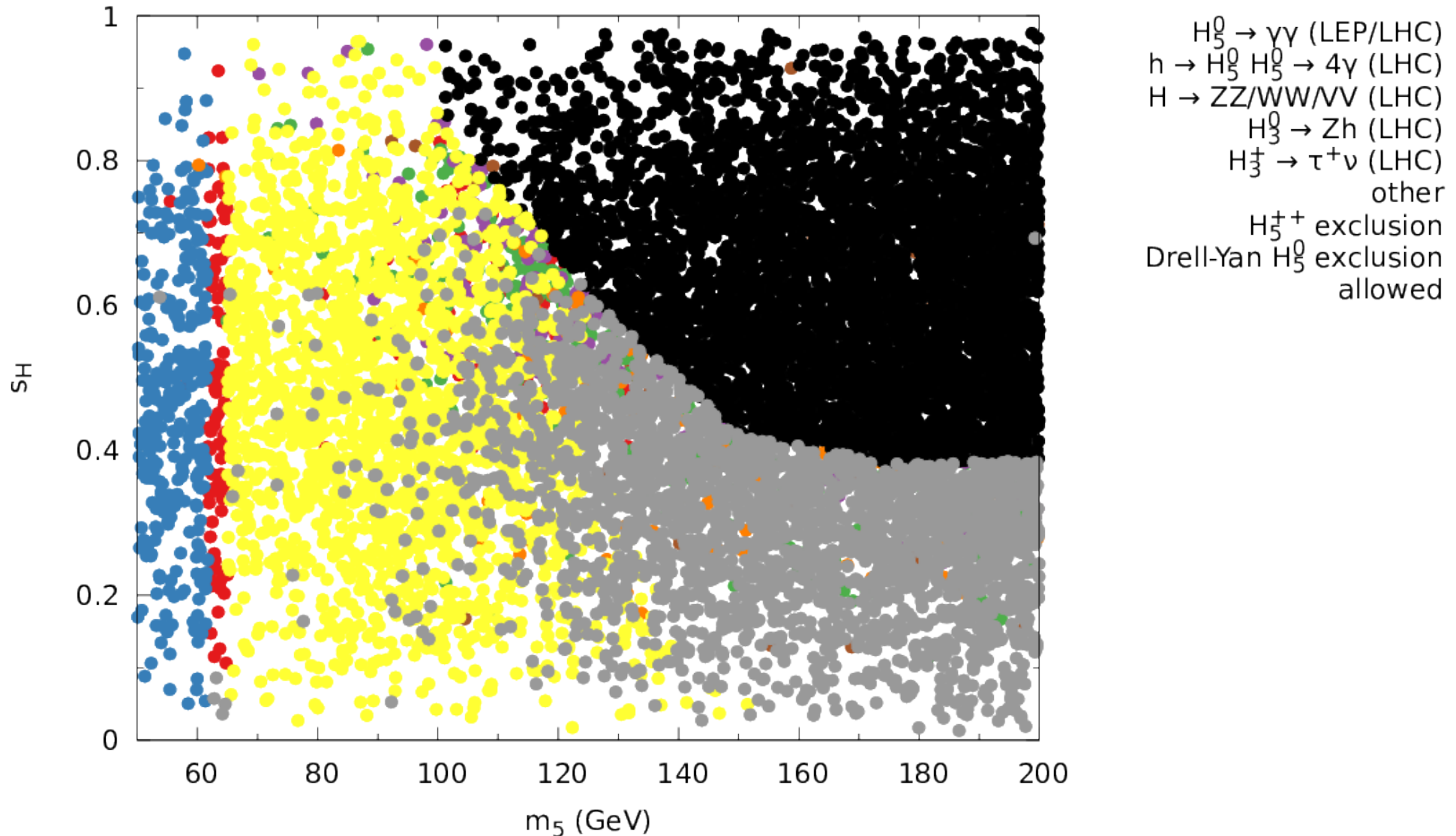
High m_5 , all constraints



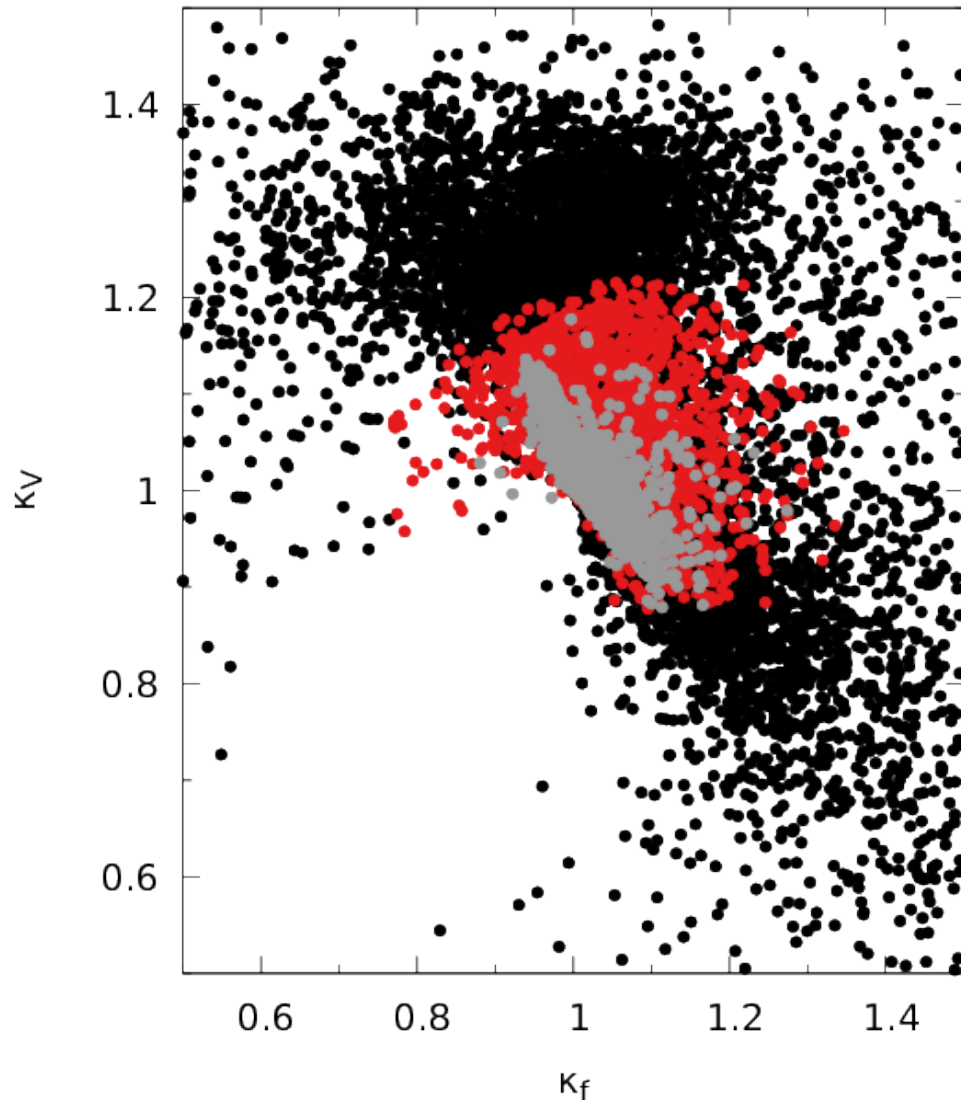
H5plane benchmark constraints



Low m_5 , all constraints



Allowed couplings of SM-like Higgs



excluded by HS and/or other constraints •
allowed by HS, otherwise excluded •
allowed •

allowed couplings:

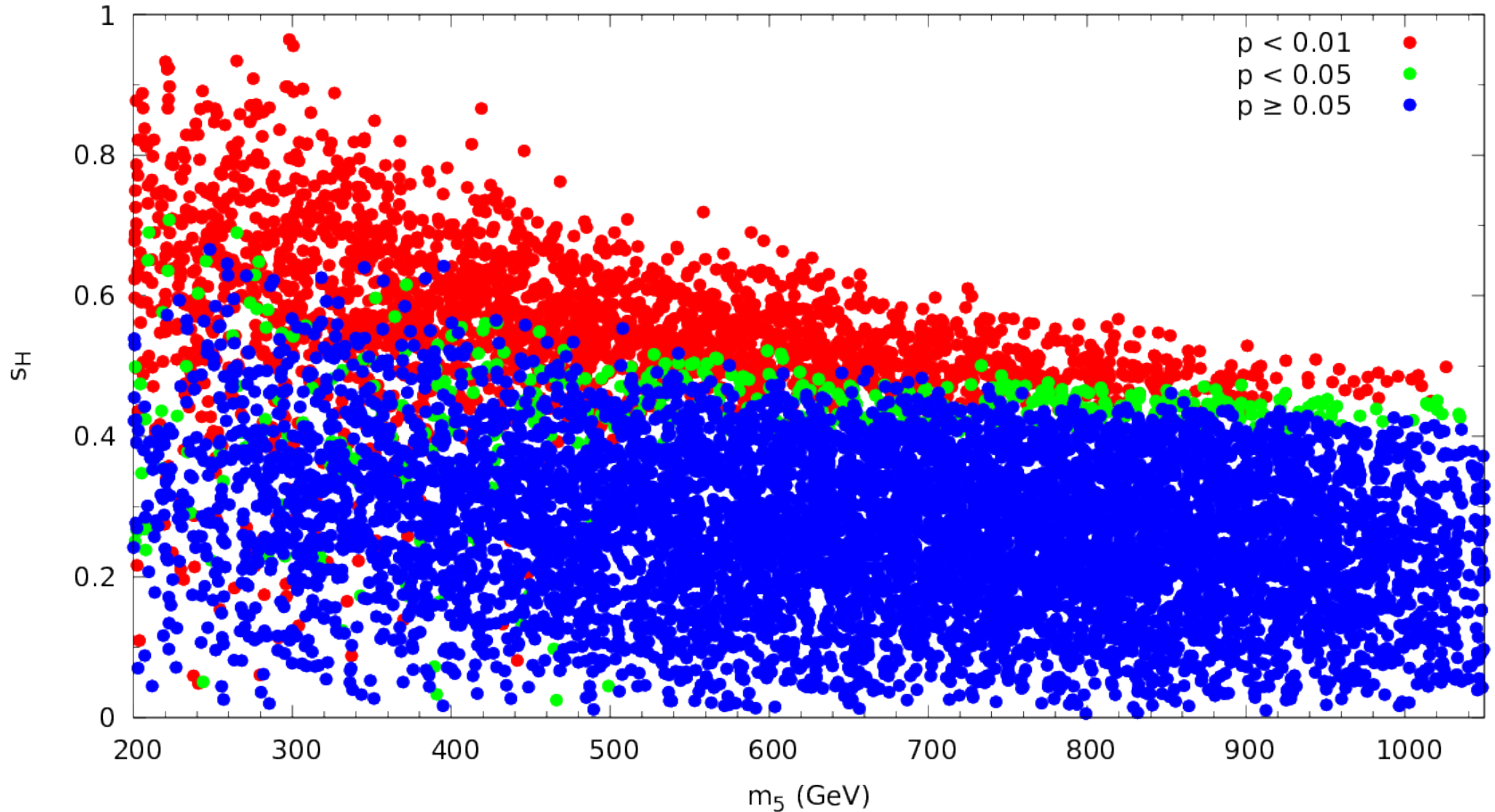
$$\kappa_f \in (0.88, 1.28); \kappa_V \in (0.87, 1.18)$$

Summary and outlook

- Many points not excluded after all constraints, up to $s_H \sim 0.6$
- Promising search channels: $H_3^0 \rightarrow Zh; H \rightarrow hh$
- Allowed couplings of SM-like Higgs most strongly constrained by direct searches for new Higgs bosons
- Code written to interface GMCALC with HB/HS released in version 1.5.0

Additional figures

HS constraints, high m_5



HS constraints, low m_5

