מכון ויצמן למדע
WEIZMANN INSTITUTE OF SCIENCE

AN EXCLUSIVE WINDOW ONTO HIGGS YUKAWA COUPLINGS

Yotam Soreq

A. Kagan, G. Perez, F. Petriello, YS, S. Stoynev and J. Zupan - 1406.1722

(C. Delaunay, T. Golling, G. Perez and YS - 1310.7029)

INTRODUCTION

Standard Model (SM): $y_f^{\mathrm{SM}} = \dfrac{m_f}{v}$

Current searches for Higgs Yukawas focus mainly on top, bottom and leptons.

What about Higgs couplings to light quarks?

INTRODUCTION

Indirect bounds on light-quark Yukawas from current Higgs data (naive χ^2):

$$y_u/y_b^{\rm SM} < 0.98(1.3) \qquad y_d/y_b^{\rm SM} < 0.93(1.4)$$
$$y_s/y_b^{\rm SM} < 0.70(1.4) \qquad y_c/y_b^{\rm SM} < 0.70(1.4)$$

@ 95% CL

only the corresponding Yukawa is varied

all Higgs couplings are allowed to vary

Can even be larger than the SM bottom Yukawa!

Leads to interesting Higgs phenomenology

Delaunay, Golling, Perez, YS
1306.5770

INTRODUCTION

- Challenges for probing light-quark (*u*,*d*,*s*,*c*) Yukawas:
  - The SM-Higgs branching ratios are tiny
  - Huge QCD background
  - Flavor tagging - only charm is possible

c-tagging
ATLAS-CONF-2013-068

Delaunay, Golling,
Perez, YS
1306.5770

Looks almost hopeless, at least in the inclusive rates.

EXCLUSIVE DECAYS

$h \to MV$

vector meson

$\gamma\, W\ Z$

work in progress

Bodwin, Petriello, Stoynev, Velasco 1306.5770

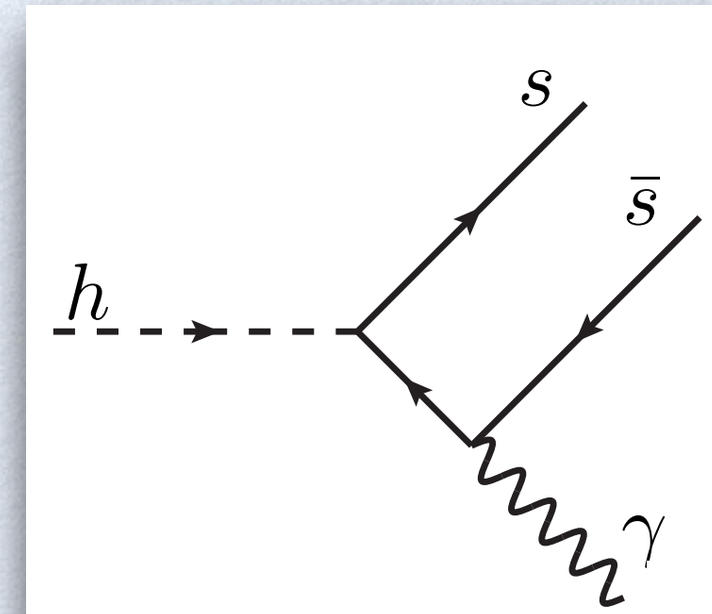
$h \to J/\psi\,\gamma \longrightarrow y_c$

$h \to \begin{matrix} \phi\gamma \\ \rho\gamma \\ \omega\gamma \end{matrix} \begin{matrix} \longrightarrow y_s \\ \\ \longrightarrow y_d\,,\ y_u \end{matrix}$

Small branching ratio, BUT reduced QCD background!

DIAGONAL COUPLING

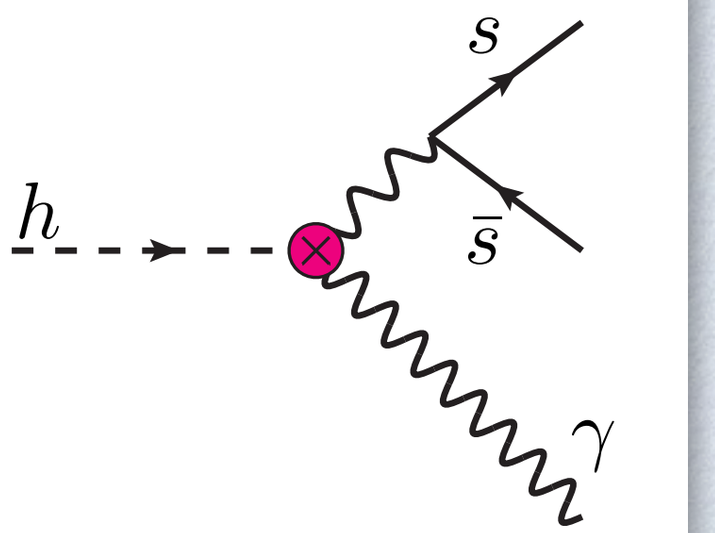
direct



$\propto y_s f_\perp^\phi \langle 1/u\bar{u} \rangle$

light-cone distribution amplitude (LCDA)

indirect



$\propto f_\phi$

$\Gamma(\phi \to e^+ e^-)$

main sensitivity to Yukawa due to interference!

RESULTING RATES

$$\frac{\mathrm{BR}_{h\to\phi\gamma}}{\mathrm{BR}_{h\to b\bar{b}}} = \frac{\kappa_\gamma\left[(3.0\pm 0.13)\kappa_\gamma - 0.78\bar{\kappa}_s\right]}{0.57\bar{\kappa}_b^2}\times 10^{-6}$$

can be improved
(both theoretically and experimentally)

$\pm\mathcal{O}(20\%)$

$$\bar{\kappa}_q \equiv y_q/y_b^{\mathrm{SM}} \qquad\qquad \kappa_\gamma^{\mathrm{SM}} = 1$$

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$$\frac{\mathrm{BR}_{h\to\rho\gamma}}{\mathrm{BR}_{h\to b\bar{b}}} = \frac{\kappa_\gamma\left[(1.9\pm 0.15)\kappa_\gamma - 0.24\bar{\kappa}_u - 0.12\bar{\kappa}_d\right]}{0.57\bar{\kappa}_b^2}\times 10^{-5}$$

$$\frac{\mathrm{BR}_{h\to\omega\gamma}}{\mathrm{BR}_{h\to b\bar{b}}} = \frac{\kappa_\gamma\left[(1.6\pm 0.17)\kappa_\gamma - 0.59\bar{\kappa}_u - 0.29\bar{\kappa}_d\right]}{0.57\bar{\kappa}_b^2}\times 10^{-6}$$

FUTURE EXPERIMENTAL PROSPECTS

- Focus on future hadron colliders
- $h \to \phi\gamma$ as an example:
  - 70-75% of the ϕ decays products fall in the central region (η<2.4).
- 3σ sensitivity with 3000 fb^{-1}:

$\sqrt{s}\,[\mathrm{TeV}]$	$\bar{\kappa}_s > (<)$	$\bar{\kappa}_s^{\mathrm{stat.}} > (<)$
14	$0.39\,(-0.97)$	$0.27\,(-0.81)$
33	$0.36\,(-0.94)$	$0.22\,(-0.75)$
100	$0.34\,(-0.90)$	$0.13\,(-0.63)$

factor 6 from the SM

SUMMARY

- Probing the Higgs Yukawa of the first two generations via inclusive rates and flavor tagging may only be possible for charm.
- Rare Higgs decays to a photon and a vector meson can explore the structure of the Higgs Yukawa of the first two generations.
- Exclusive decays can also be used to probe off-diagonal Higgs couplings and CP-violation.

Bhattacharya, Datta, London,1407.0695

BACKUP SLIDES