Approval Talk [HIG-23-005]
"Search for rare decays of the Higgs boson into a photon and a ρ^0, ϕ or K^{*0} meson"

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Documentation

- Collaboration of **MIT** and **Torino** groups, targeting different categories.
- CADI HIG-23-005
- Three analysis notes (two separate + one combined):
  AN-22-004 (MIT, v9), **AN-22-067** (Torino, v10), and **AN-23-004** (combined, v7)
- Q&A with ARC, L3, and L2 conveners: Twiki Q&A

Motivations

- SM prediction of branching ratios of $H \to \phi\gamma$ or $\rho\gamma$ within reasonable reach (??)
- ATLAS upper limit at 95% CL is $\mathcal{O}(10^{-4})$ to $\mathcal{O}(10^{-3})$.
- K_0^* channel added as an extension of ditrack + gamma final state analyses.

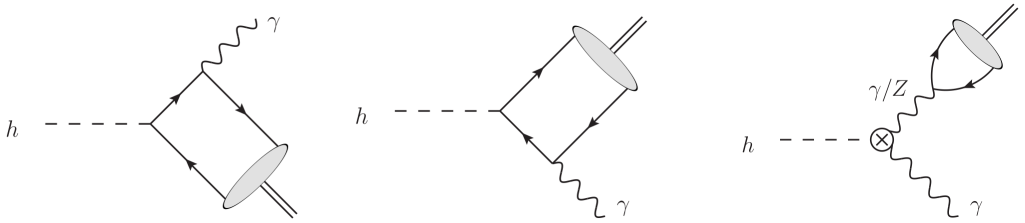
Channel	Coupling	SM $\mathcal{BR}(H \to M\gamma)$	Limits on $\mathcal{BR}$	Notes
$H \to \phi\gamma$	s	$(1.68 \pm 0.8) \times 10^{-5}$ [1]	Exp. $4.2^{+1.8}_{-1.2} \times 10^{-4}$ Obs. 5.0×10^{-4} [2]	ATLAS Run 2, 35.6 fb^{-1} $\phi\gamma \to K^+K^-\gamma$
$H \to \rho\gamma$	u, d	$(2.31 \pm 0.11) \times 10^{-6}$ [1]	Exp. $10.0^{+4.9}_{-2.8} \times 10^{-4}$ Obs. 10.4×10^{-4} [2]	ATLAS Run 2, 35.6 fb^{-1} $\rho\gamma \to \pi^+\pi^-\gamma$
$H \to K_0^*\gamma$	$d\&s$ (flavor-changing)	(Only available for $H \to d\bar{s} + \bar{d}s$) 1.19×10^{-11} [3]	Exp. $3.7^{+1.5}_{-1.0} \times 10^{-4}$ Obs. 2.2×10^{-4} [4]	ATLAS Run 2, 134 fb^{-1} $K_0^*\gamma \to K^\pm\pi^\mp\gamma$

Motivations

$H \to M\gamma$ [1]

- **Direct contribution**. The Higgs couples via Yukawa coupling to the quarks, one of which radiates a photon.
- **Indirect contribution**. The off-shell γ^* or Z^* produced in $H \to \gamma\gamma^*, \gamma Z^*$ *fragments* into a meson.

Direct and indirect contributions interfere destructively. Due to light quark masses, direct contribution is smaller than indirect. Direct contribution is sensitive to deviation from SM Higgs couplings. Branching ratios are $\mathcal{O}(10^{-5}\text{–}10^{-6})$.



(a) Direct contributions via Yukawa coupling to the light quarks.

(b) Indirect contribution via a virtual photon or Z boson.

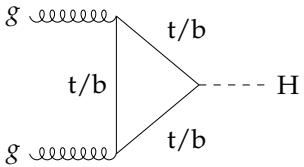
Figure 1: Leading order Feynman diagrams to the $H \to M\gamma$ processes. Image taken from Fig. 2 of [1].

Strategy

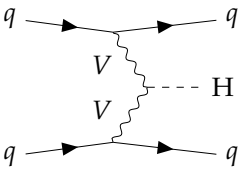
- **Final states**
  1. High energy **photon**
  2. High energy **ditrack** from meson

$$\phi(1020) \to K^+K^- \quad (\mathrm{BR} \sim 49\%)$$
$$\rho(770) \to \pi^+\pi^- \quad (\mathrm{BR} \sim 100\%)$$
$$K_0^*(700) \to K^\pm\pi^\mp \quad (\mathrm{BR} \sim 100\%)$$

- **Production**



ggH



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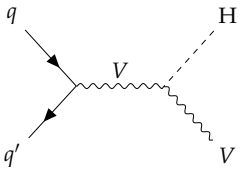

VH

Bibliography

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[2] ATLAS collaboration, "*Erratum to: Search for exclusive Higgs and Z boson decays to $\phi\gamma$ and $\rho\gamma$ with the ATLAS detector*", *Journal of High Energy Physics* **2023** (2023) .

[3] J.I. Aranda, G. González-Estrada, J. Montaño et al., "*Revisiting the rare $H \to q_i q_j$ decays in the standard model*", *Journal of Physics G: Nuclear and Particle Physics* **47** (2020) 125001.

[4] ATLAS collaboration, "*Search for exclusive Higgs and Z boson decays to $\omega\gamma$ and Higgs boson decays to $K_0^*\gamma$ with the ATLAS detector*", *Physics Letters B* **847** (2023) 138292.