

# More **light** on Higgs **flavor** at the LHC: Higgs couplings to light quarks through **$h+\gamma$** production

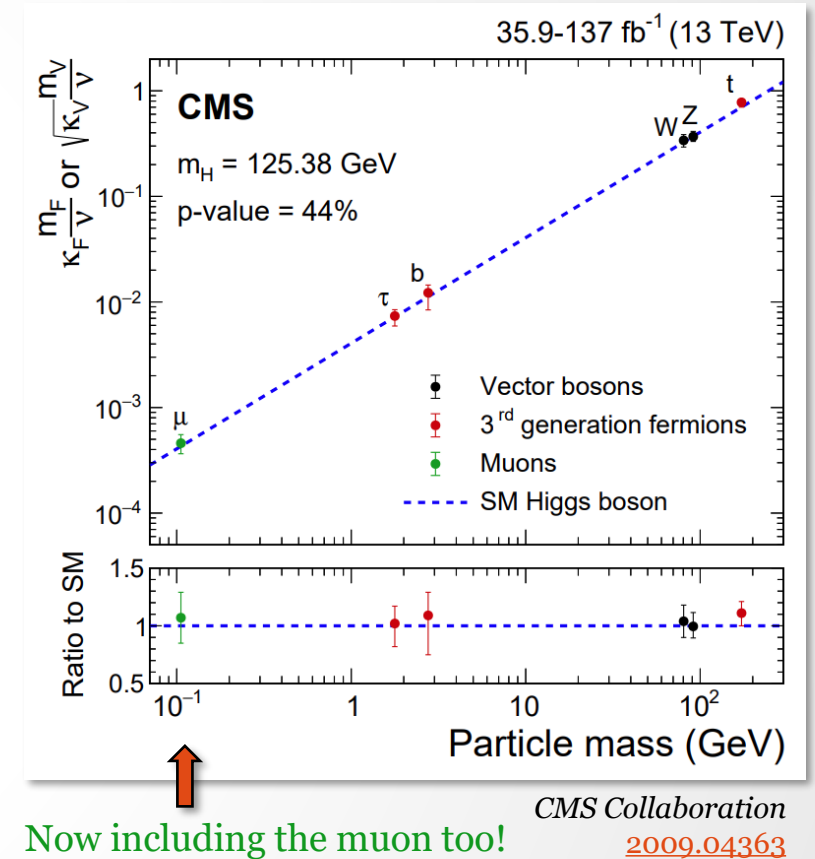


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Based on work in collaboration with:  
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[2008.12538](#)

# Motivation

While the couplings of the 125 GeV Higgs boson to EW bosons and third-generation fermions have been measured rather precisely at the LHC...



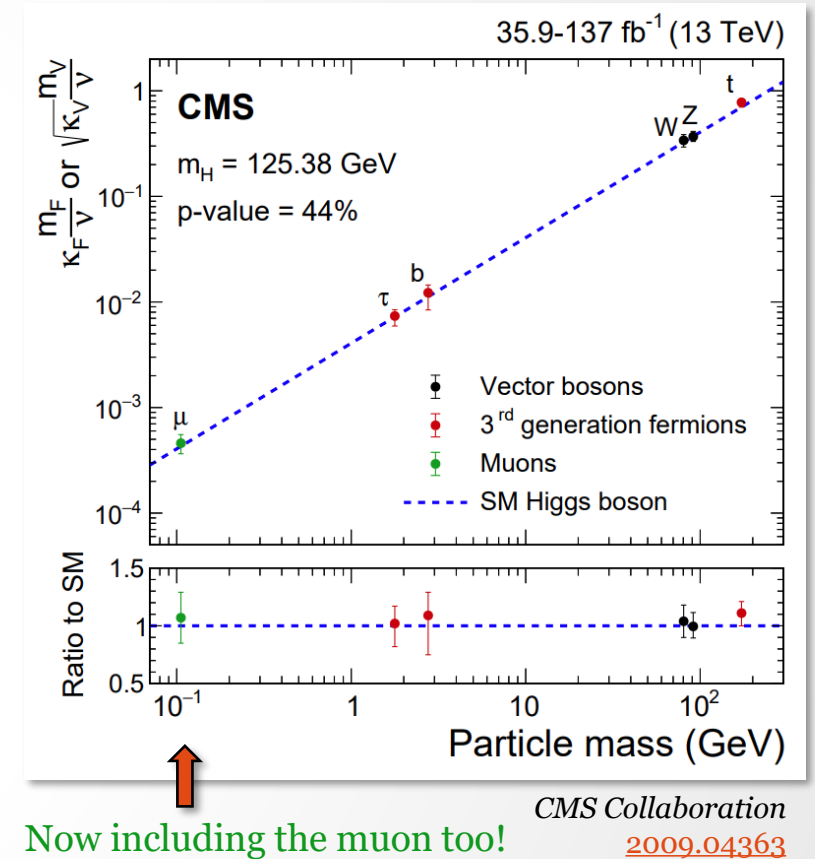
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While the couplings of the 125 GeV Higgs boson to EW bosons and third-generation fermions have been measured rather precisely at the LHC...

Yukawa couplings to the lighter SM fermions remain **weakly constrained** (or very weakly, for the first-generation fermions).

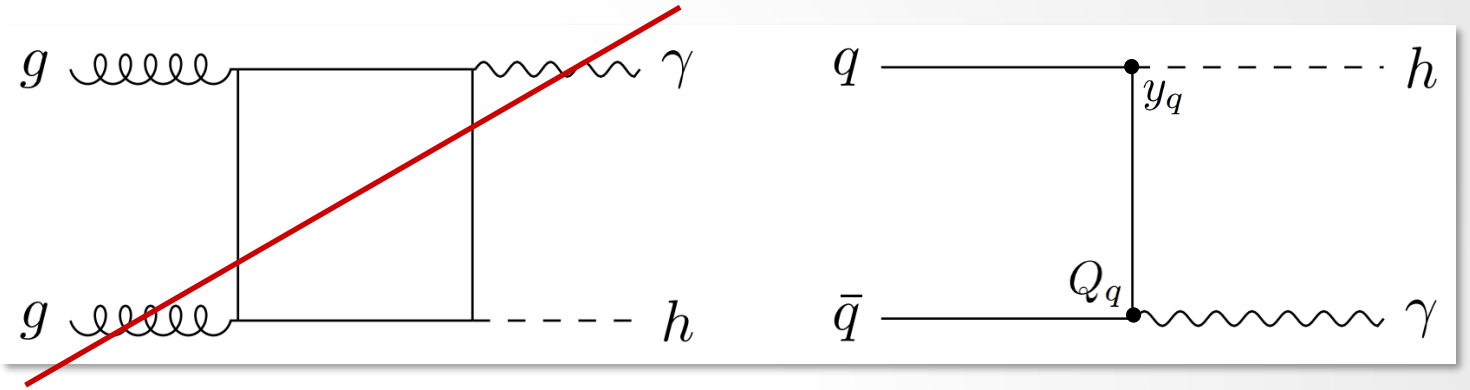
Yet, given our current lack of understanding of the **Higgs flavor structure**, their measurement is **key** to further test the SM **mass generation** paradigm!

New strategies at the LHC?



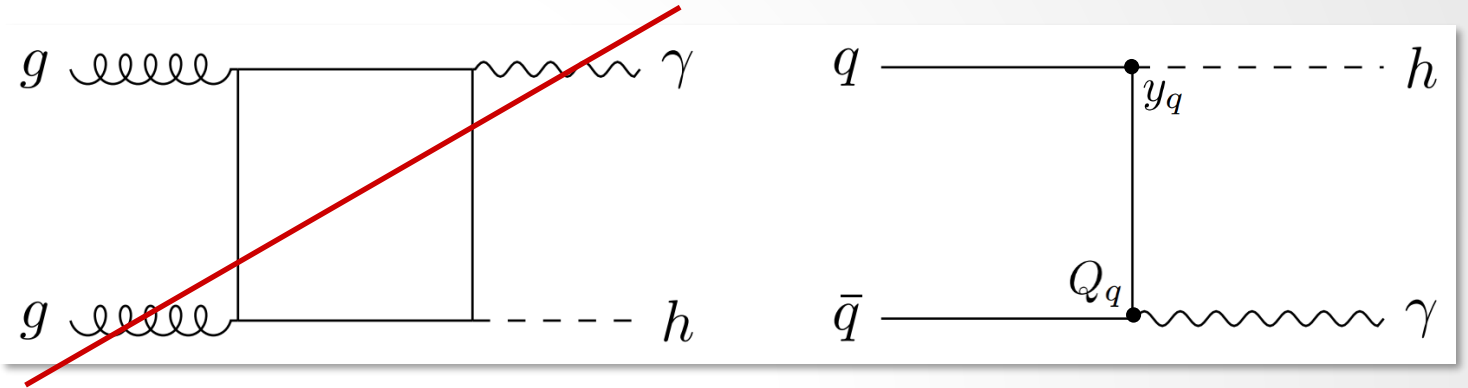
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The gluon-initiated contribution naively expected to lead vanishes due to **Furry's theorem**.



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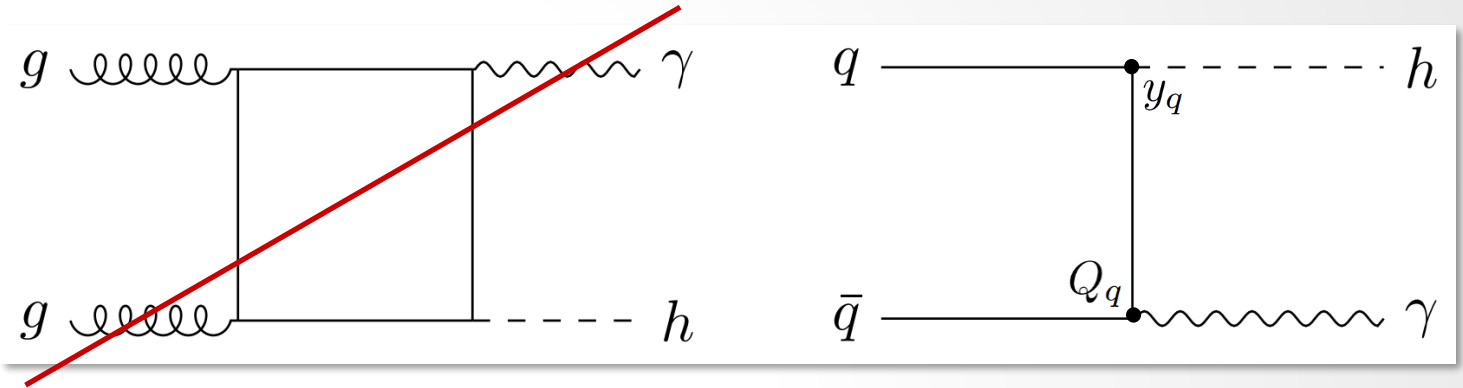
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- In the absence of extra partons in the final state, the **bottom** and **charm-initiated** contributions lead the production.
- A  $(Q_u/Q_d)^2 = 4$  factor enhances **up-type quarks** contributions w.r.t. that of down-type quarks, so focus on the first.

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- In the absence of extra partons in the final state, the **bottom** and **charm-initiated** contributions lead the production.
- The SM cross-section is unsurprisingly small, but **quadratically sensitive** to any BSM enhancement of the light quark Yukawa couplings:  $y_u(m_h) \sim y_c^{\text{SM}}(m_h) \rightarrow \sigma_{u\bar{u}} \sim 1.3 \text{ fb}$
- A  $(Q_u/Q_d)^2 = 4$  factor enhances **up-type quarks** contributions w.r.t. that of down-type quarks, so focus on the first.
- For its relatively **large branching ratio** and **clean** experimental profile, we focus on the decay:

$$h \rightarrow WW^* \rightarrow \ell^+ \nu \ell^- \bar{\nu}$$

# Dominant Backgrounds

$$h \rightarrow WW^* \rightarrow \ell^+ \nu \ell^- \bar{\nu} + \gamma$$

$(\ell = e/\mu)$

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$$pp \rightarrow Z\gamma \quad Z \rightarrow \tau^+ \tau^-$$

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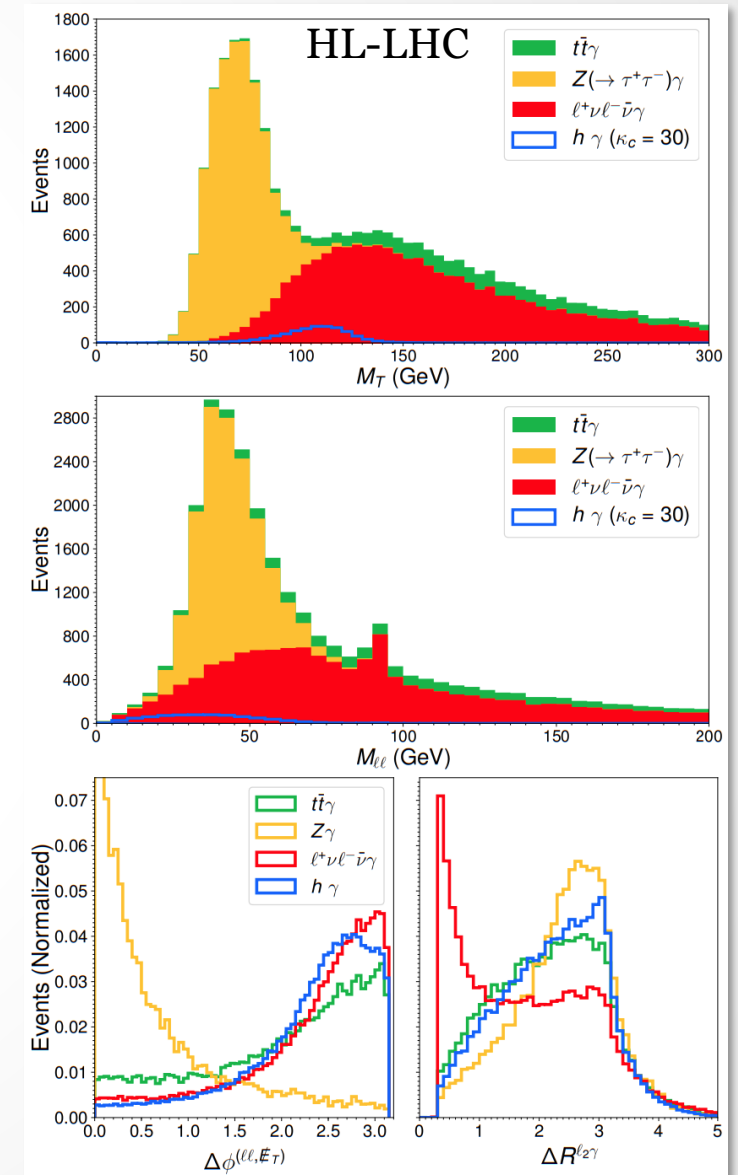
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Very **rich** event kinematics!

$$M_T, M_{\ell\ell}, M_{\ell\ell\gamma}, p_T^{\ell_1}, p_T^{\ell_2}, p_T^\gamma, \cancel{E}_T,$$

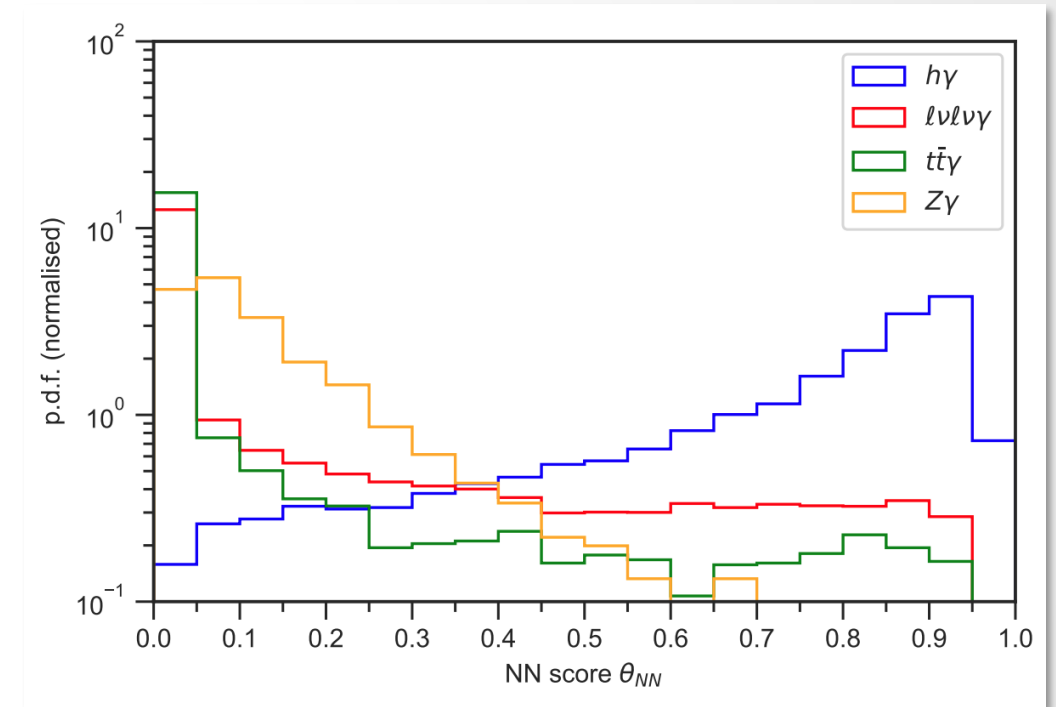
$$\Delta\phi^{\ell\ell}, \Delta\phi^{\ell_1\gamma}, \Delta\phi^{\ell_2\gamma}, \Delta\phi^{(\ell\ell, \cancel{E}_T)}, \eta^{\ell_1}, \eta^{\ell_2}, \eta^\gamma$$



# Multivariate Analysis & Results

How to better exploit them?

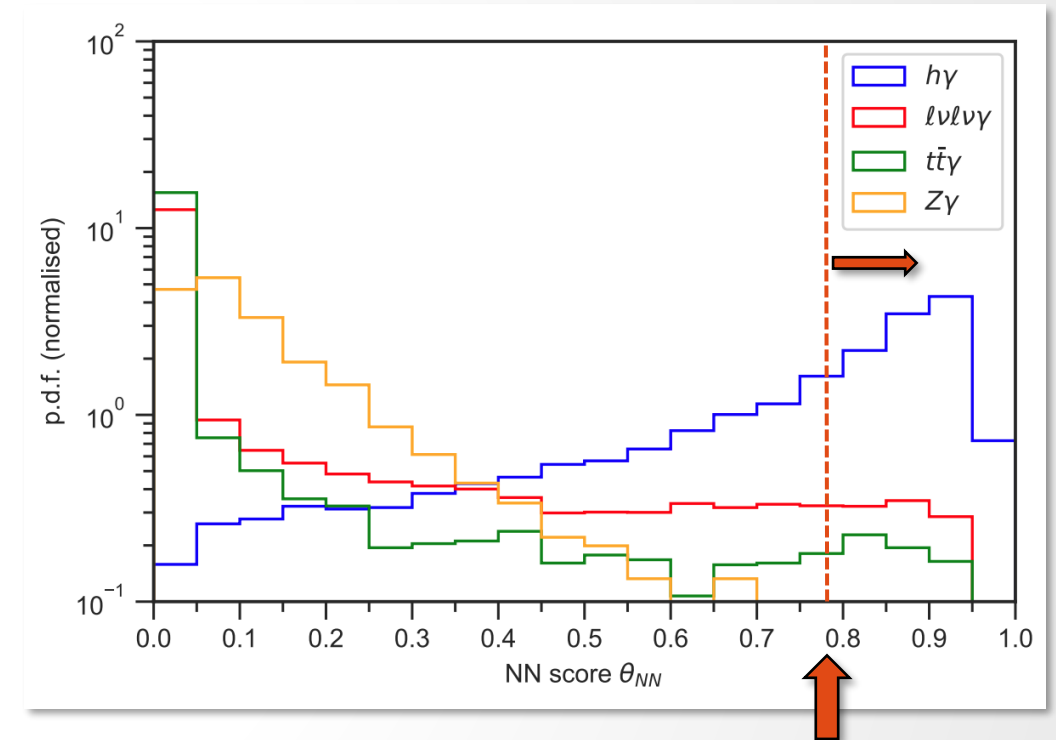
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 $\theta_{NN} > 0.78$

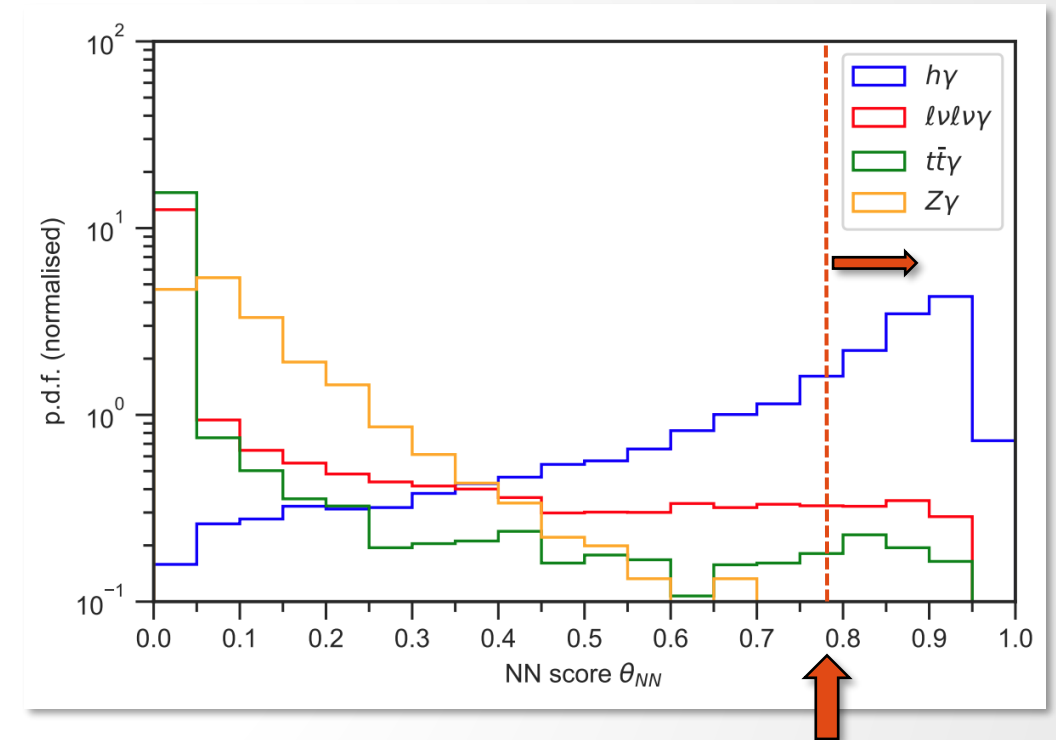
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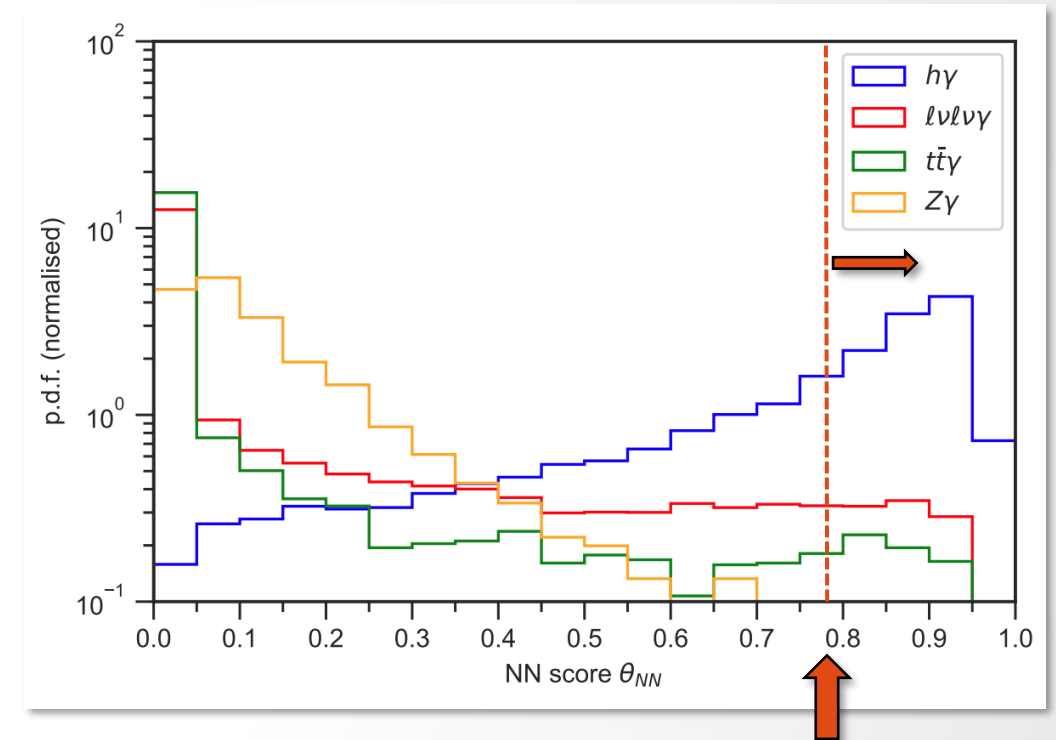
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Not far from testing up-charm universality!



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# Key points

- $h+\gamma$  is a very rare process, yet **unobserved** at the LHC...
- While it may **not** be **competitive** with the most sensitive probes for the **charm**... powerful tool to **constrain** the **up** quark Yukawa!
- But also a very **sensitive** probe of the **Higgs** boson **couplings** to **light quarks**!
- High **complementarity**! associated production with a photon differentiates between **up** and **down**-type quarks.
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## *Thank you*

come chat over **Mattermost** for more details!

