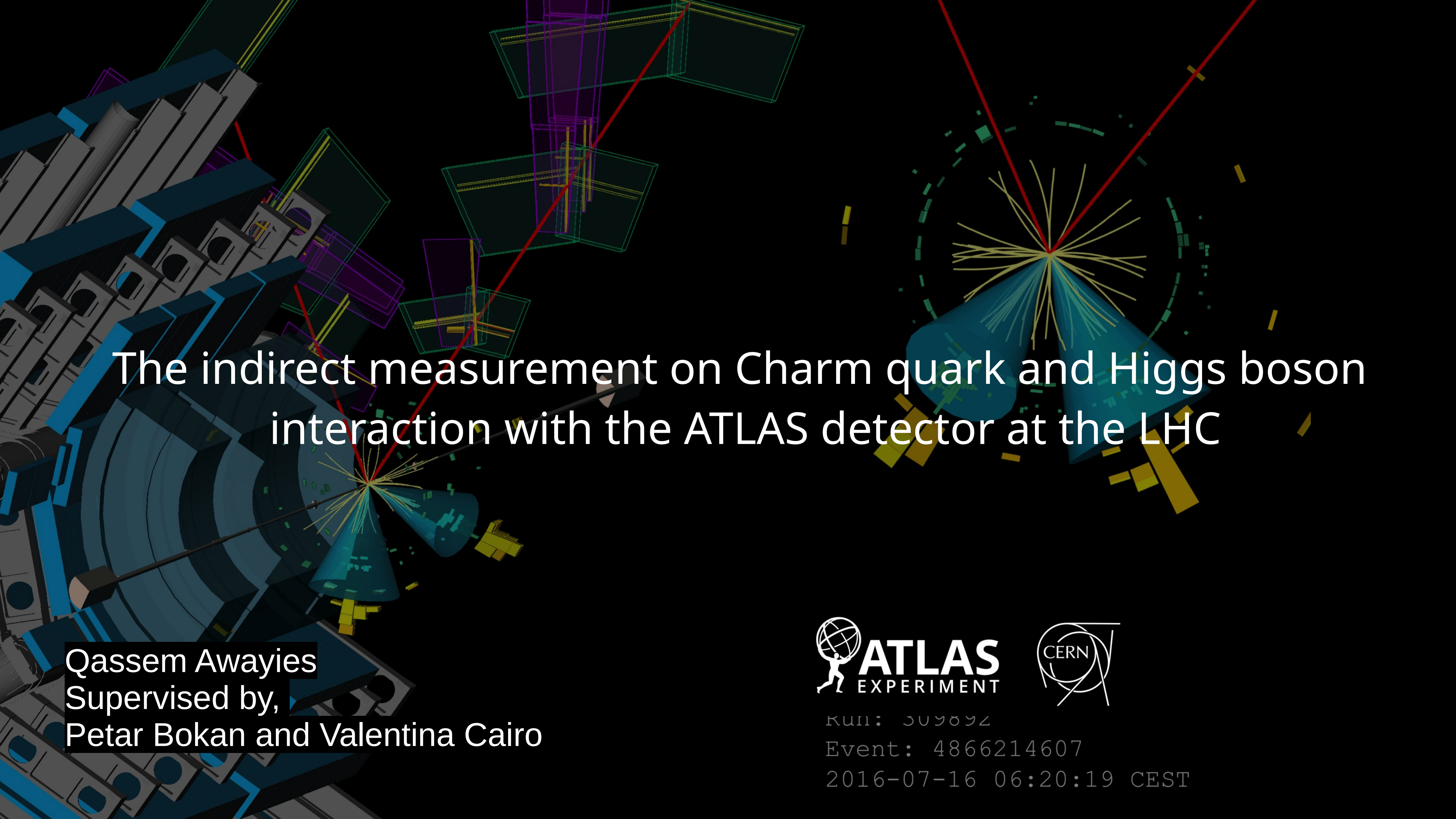
The indirect measurement on Charm quark and Higgs boson interaction with the ATLAS detector at the LHC



Qassem Awayies
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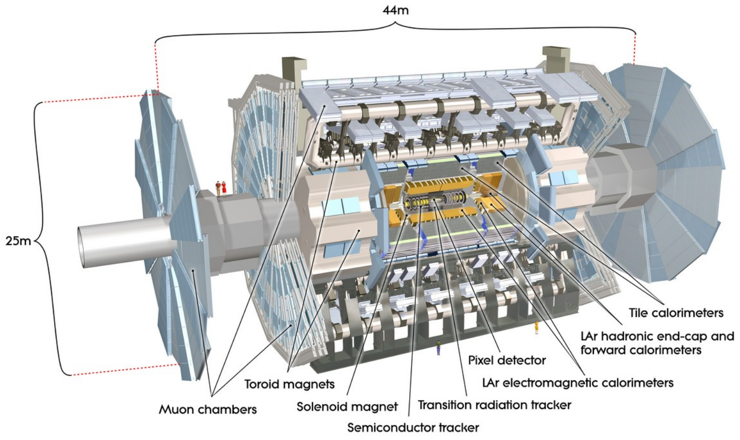
ATLAS EXPERIMENT

CERN

Intro: ATLAS and the Standard Model of Particle physics



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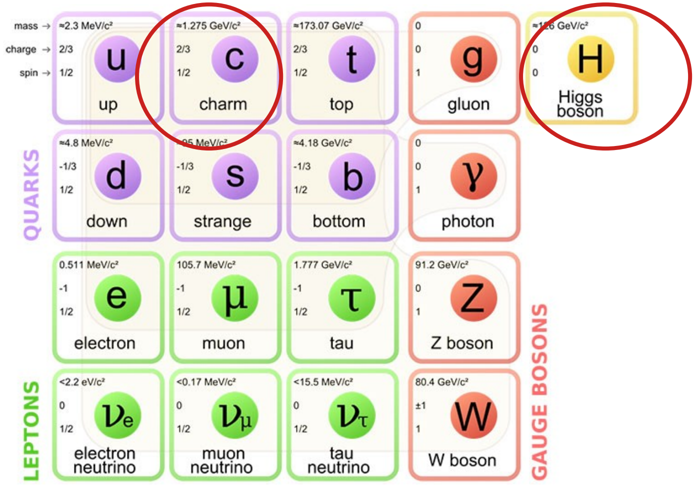
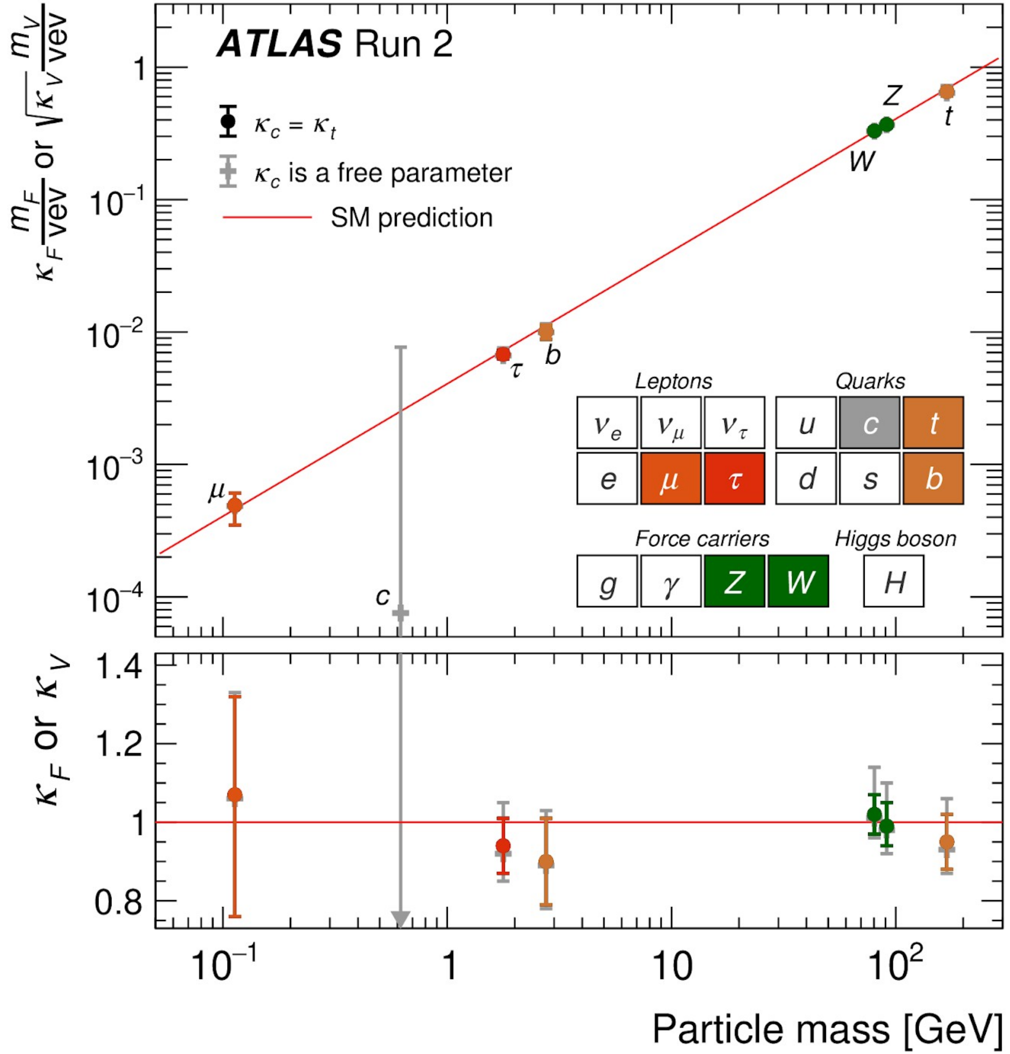


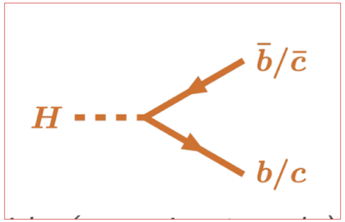
Do we observe the physics the standard model predicts?



Higgs coupling strength is proportional to the mass of the particle it couples to.

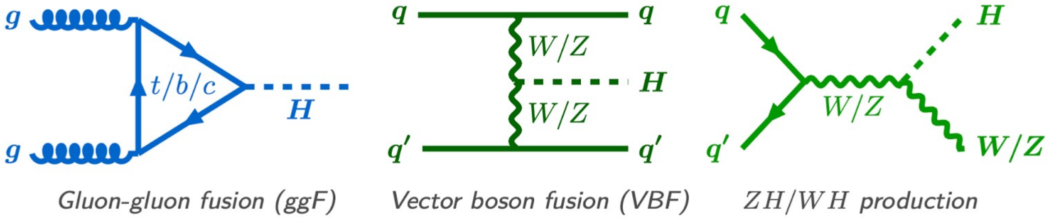
The lighter the particle the more difficult it is to measure its coupling strength.

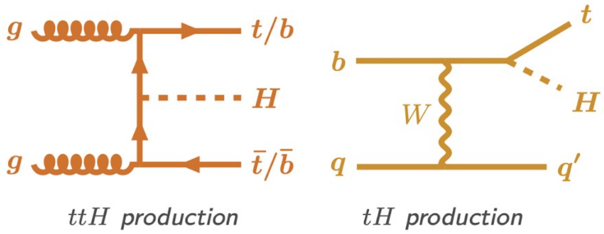
A direct yet a challenging way to measure the Charm-Yukawa coupling:



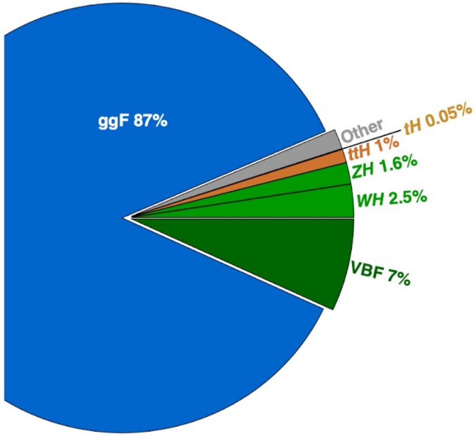
ATLAS $H \rightarrow c\bar{c}$ analysis sets an upper limit on the $y_c < 4.2 \times y_c^{SM}$ at 95% CL[HIGG-2020-20]

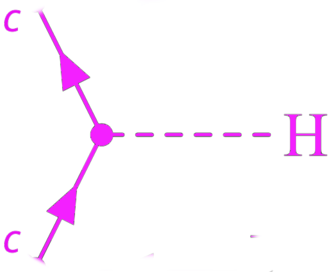
Indirect Charm-Yukawa coupling





Charm Yukawa interaction affects the Higgs boson cross section

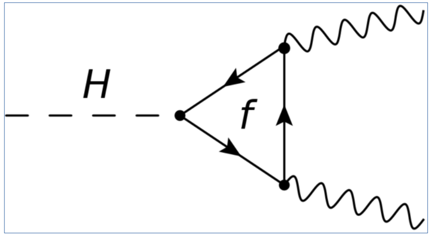




$$\kappa_p = \frac{y_p}{y_p^{SM}}$$

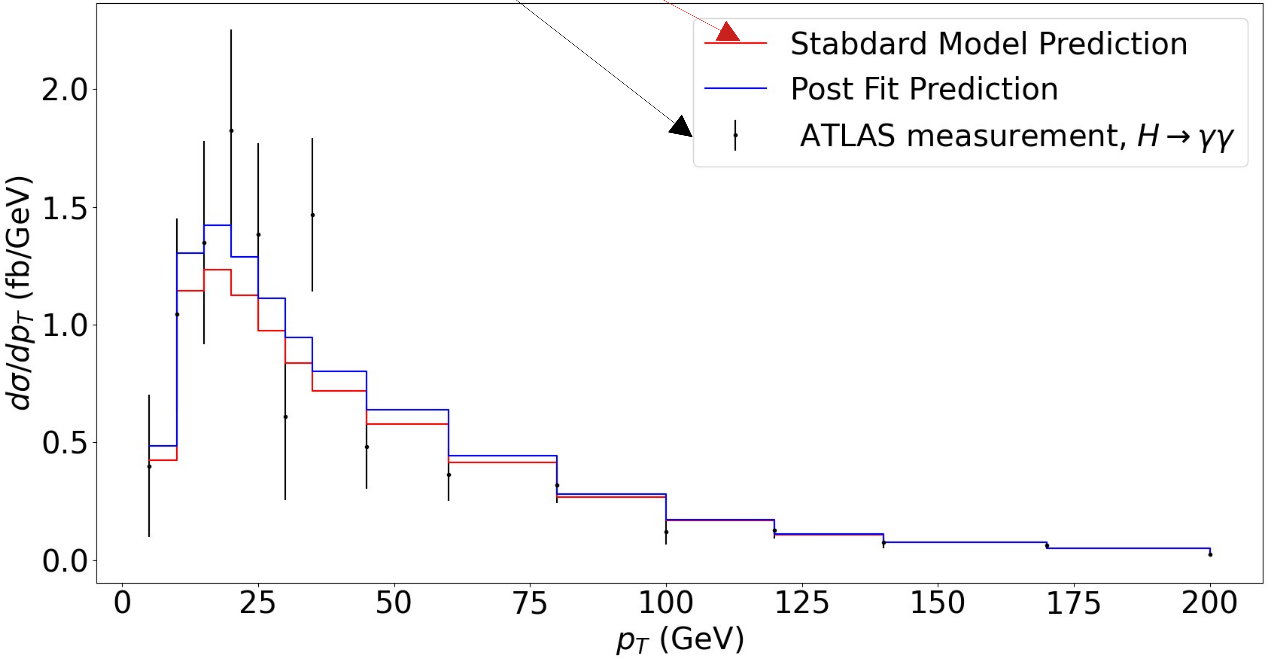
$$\begin{aligned}\sigma_{pp\to H}(\kappa_b,\kappa_c) &= \sigma_{\text{ggF}}(\kappa_b,\kappa_c) + \sigma_{b\bar{b}\to H}(\kappa_b) + \sigma_{c\bar{c}\to H}(\kappa_c) + \sigma_{\text{ttH}} + \sigma_{\text{other}} \\ &= \kappa_t^2 \cdot (\sigma_{\text{ggF}}^{tt} + \sigma_{\text{ttH}}) + \kappa_t \cdot \kappa_b \cdot \sigma_{\text{ggF}}^{tb} + \underline{\kappa_t \cdot \kappa_c \cdot \sigma_{\text{ggF}}^{tc} + \kappa_b \cdot \kappa_c \cdot \sigma_{\text{ggF}}^{bc}} \\ &+ \kappa_b^2 \cdot (\sigma_{\text{ggF}}^{bb} + \sigma_{b\bar{b}\to H}) + \underline{\kappa_c^2 \cdot (\sigma_{\text{ggF}}^{cc} + \sigma_{c\bar{c}\to H})} + \sigma_{\text{other}}\end{aligned}$$

Using differential Higgs boson cross-section measurements to constrain charm-Yukawa coupling

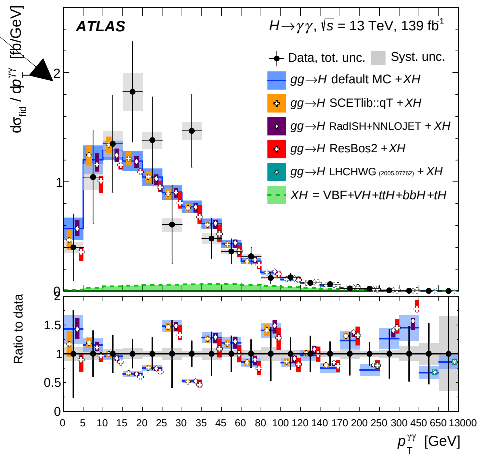


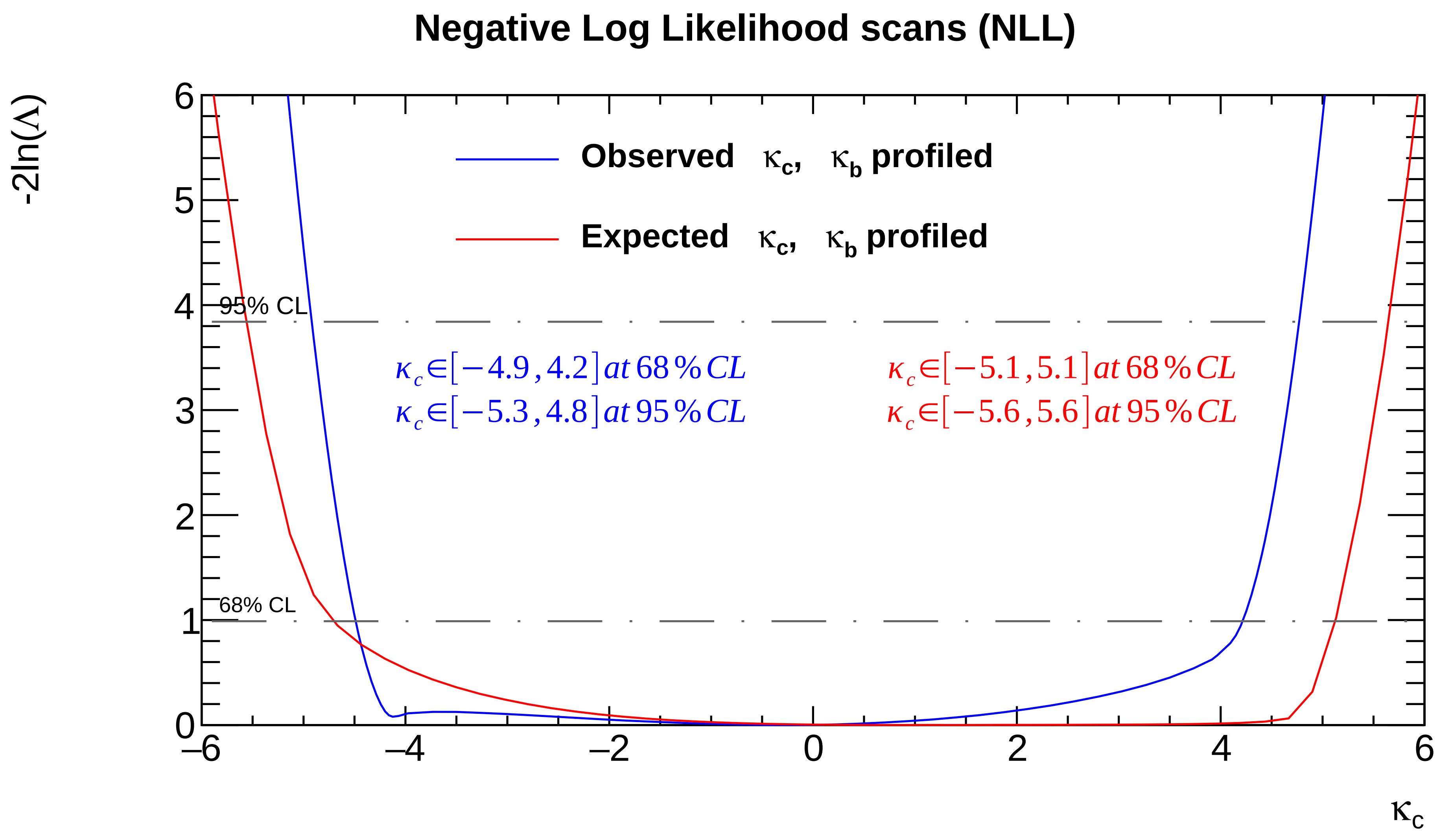
Measurement covariance matrix

$$L(\kappa,\theta)=\exp\left(-\frac{1}{2}\left(x-\sigma(\kappa,\sigma)\right)^{T}V^{-1}\left(x-\sigma(\kappa,\theta)\right)\right)\times\prod_{i} Gauss(\theta_{i};0,1)$$

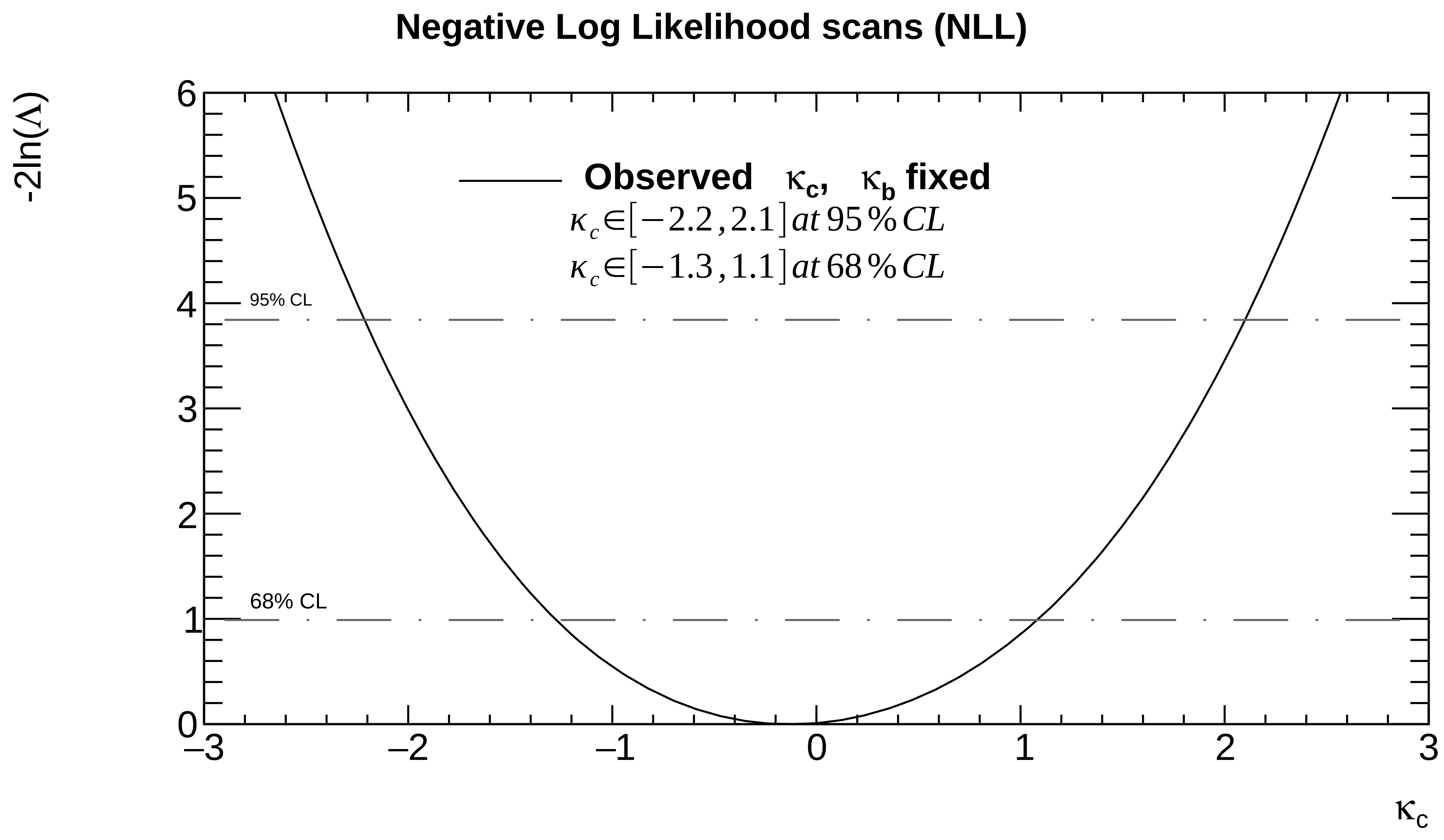


https://doi.org/10.1007/JHEP08(2022)027





Negative Log Likelihood scans (NLL)
-2ln(Λ)
Observed κc, κb profiled
Expected κc, κb profiled
95% CL
68% CL
κc∈[−4.9,4.2] at 68% CL
κc∈[−5.3,4.8] at 95% CL
κc∈[−5.1,5.1] at 68% CL
κc∈[−5.6,5.6] at 95% CL
0
1
2
3
4
5
6
–6
–4
–2
0
2
4
6
κc



systematic uncertainties not implemented*

Conclusion

- The coupling strength of the Higgs boson to other particles depend on the mass, and hence the difficulty of studying the Charm Yukawa coupling, especially with its challenging decay channel.

- I investigate how to set indirect constraints on the interaction between charm quarks and Higgs bosons by carrying a detailed analysis of the Higgs boson differential cross-section measurements in the $H \rightarrow \gamma\gamma$ final state

- When we assume $\kappa_b = 1$ and $\kappa_t = 1$(Standard Model prediction), the constraints, we obtain [-2.2, 2.1] at 95% CL.
- When we treat also κ_b as a free parameter, we obtain [-5.3, 4.8] at 95% CL.
- Next steps are to study further the model dependence of our results, the impact of systematic uncertainties and to understand how the results are expected to improve with more data.