

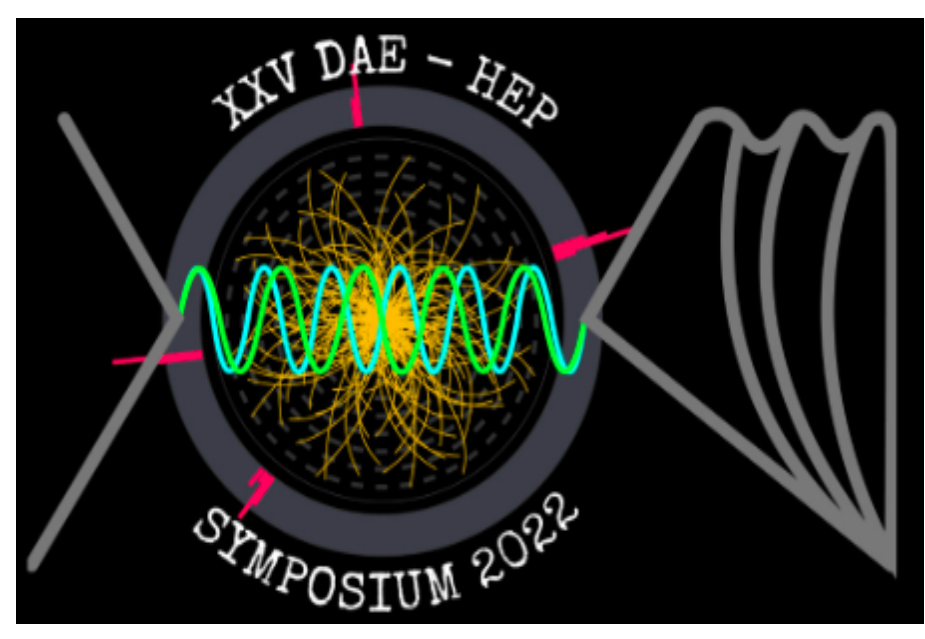
Disentangling CP-violating Higgs-top Interactions

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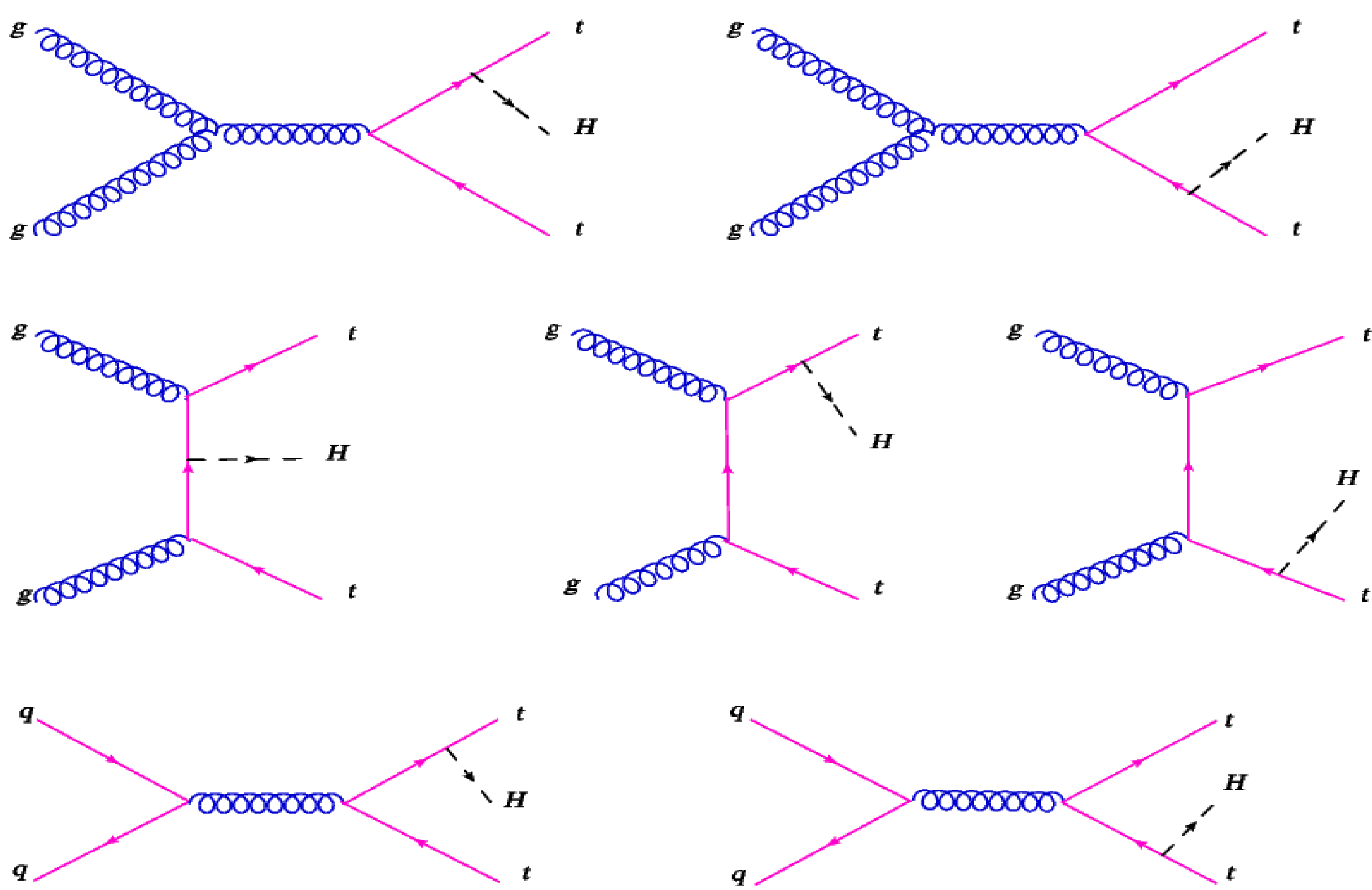
Abstract

We explore CP -violating anomalous htt couplings via associated production of Higgs boson at the LHC and its future variants using a set of newly proposed T-odd observables involving momentum of final state particles. Limits on such couplings are also presented using the production asymmetries associated with the process $pp \rightarrow t(\rightarrow l + \nu lb)\bar{t}(\rightarrow l - \nu \bar{l}b)h$. Our estimates reflect $|c_p| < 4.32 \times 10^{-2}$ at LHC with $\sqrt{S} = 13$ TeV and the integrated luminosity of 139 fb^{-1} . The corresponding bounds for HL-LHC with $\sqrt{S} = 14$ TeV and FCC-hh with $\sqrt{S} = 100$ TeV for the projected luminosities of 3 ab^{-1} and 30 ab^{-1} are found to be $|c_p| < 8.1 \times 10^{-3}$ and $|c_p| < 3.5 \times 10^{-4}$, respectively at 2.5σ level.

Introduction

- We perform a systematic and detailed investigation of the CP -violating effects of the Higgs-top coupling by means of T-odd observables [1] considering the dominating and the most promising Higgs production process $pp \rightarrow t\bar{t}H$.
- The most general parametrization of the Higgs-top Yukawa coupling that would lead to a modification in the SM is [2]:

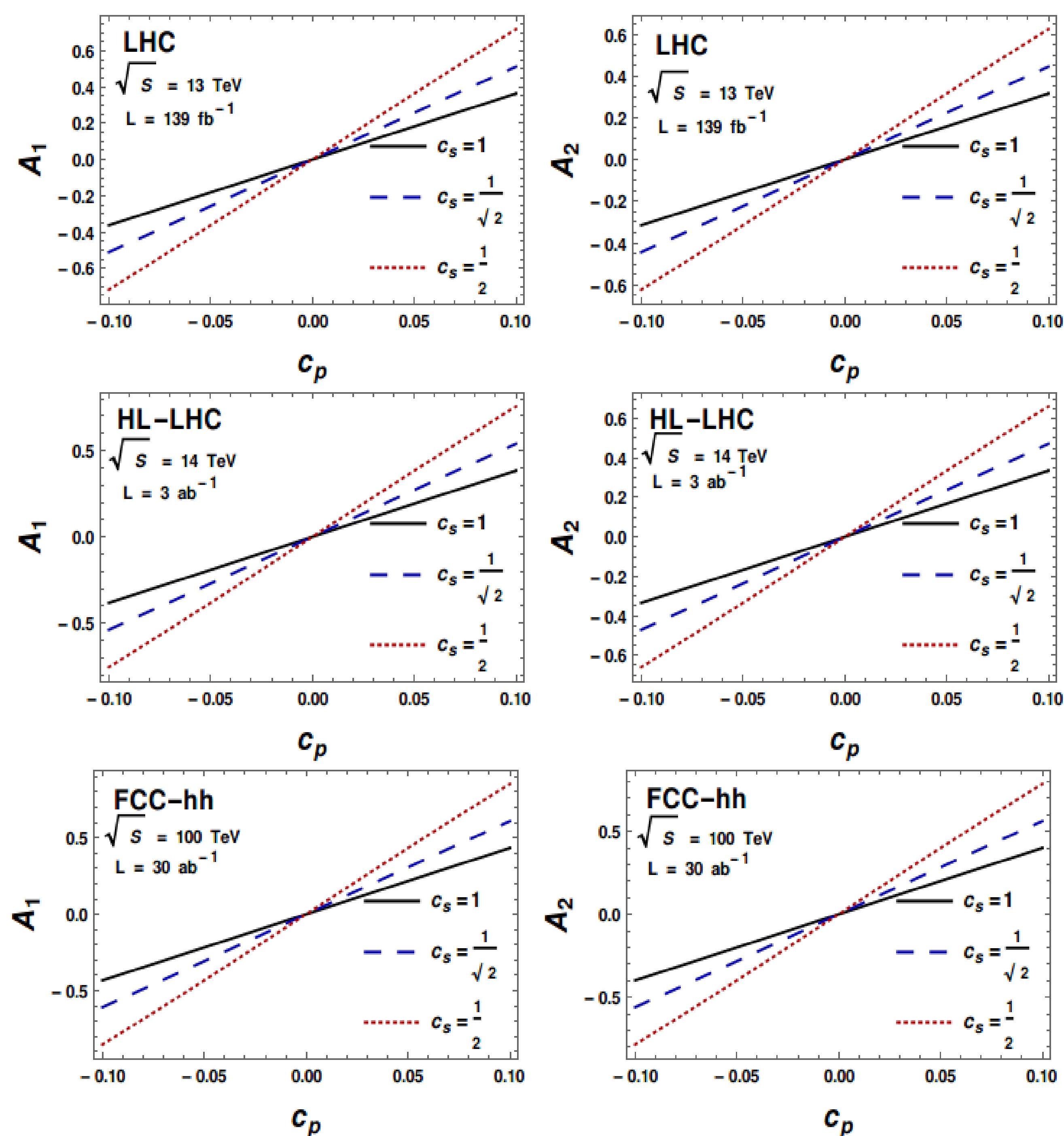
$$\mathcal{L}_{t\bar{t}H} = -\frac{y_t}{\sqrt{2}}\bar{t}(c_s + ic_p\gamma^5)tH, \quad (1)$$



Representative parton-level Feynman diagrams of the process $pp \rightarrow t\bar{t}h$ in leading order at the LHC

Results

Asymmetry as a function of anomalous coupling c_p :



Conclusions

- We find that the CP -violating component c_p has been constrained for \mathcal{A}_1 and \mathcal{A}_2 to its maximum value to $(4.32, 4.98) \times 10^{-2}$ at 2.5σ C.L. for $c_s = 1$ for the LHC with $\sqrt{S} = 13$ TeV and an integrated luminosity of 139 fb^{-1} .
- The corresponding limits for its luminosity intense variant HL-LHC and Future Circular Collider FCC-hh are estimated to be to $(8.1, 9.3) \times 10^{-3}$ and $(3.5, 3.8) \times 10^{-4}$ for the projected luminosities of 3.0 ab^{-1} and 30 ab^{-1} respectively at 2.5σ C.L.

T-odd correlations

- We investigate the CP -violating effects of the Higgs-top coupling arising due to the presence of $t\bar{t}H$ vertex in the $pp \rightarrow t\bar{t}H$ process.
- The analysis considers the following observables [3]:

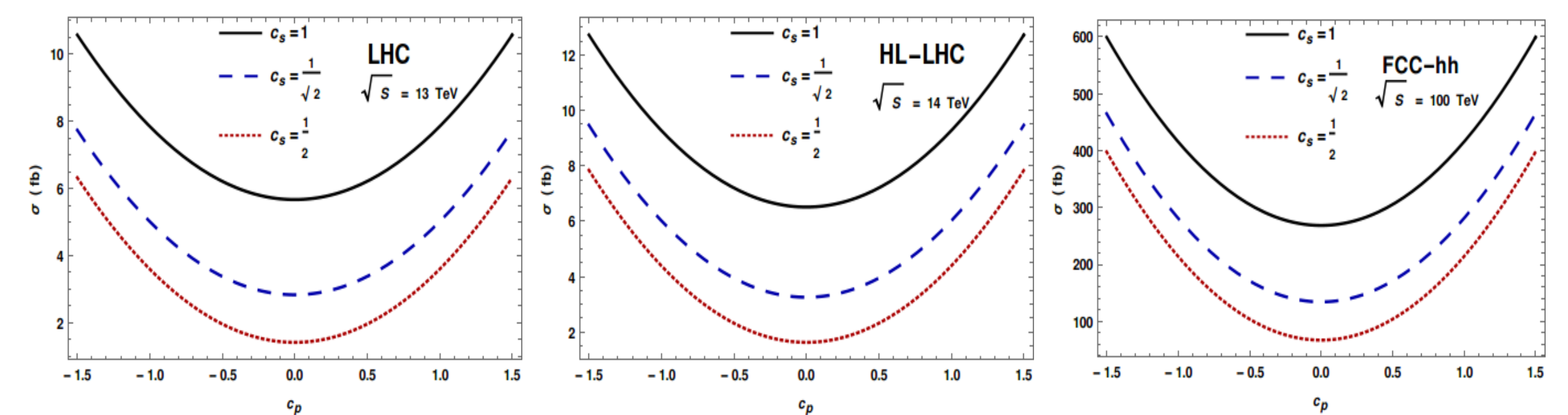
$$\begin{aligned} \mathcal{O}_1 &= \epsilon(P, p_b - p_{\bar{b}}, p_{l^+}, p_{l^-}), \\ \mathcal{O}_2 &= \epsilon(p_h, p_b - p_{\bar{b}}, p_{l^+}, p_{l^-}), \\ \mathcal{O}_3 &= \epsilon(p_b, p_{\bar{b}}, p_{l^+}, p_{l^-}), \\ \mathcal{O}_4 &= \vec{q} \cdot (p_{l^+} - p_{l^-}) \epsilon(p_b, p_{\bar{b}}, p_{l^+} + p_{l^-}, \vec{q}), \\ \mathcal{O}_5 &= \epsilon(p_b + p_{l^+}, p_{\bar{b}} + p_{l^-}, p_b + p_{\bar{b}}, p_{l^+} - p_{l^-}), \\ \mathcal{O}_6 &= \epsilon(P, p_h, p_b - p_{\bar{b}}, p_{l^+} - p_{l^-}), \\ \mathcal{O}_7 &= \epsilon(\vec{q}, p_h, p_b - p_{\bar{b}}, p_{l^+} - p_{l^-}), \end{aligned} \quad (2)$$

- The observables defined above are proportional to the triple product and take the form $\vec{p}_1 \cdot (\vec{p}_2 \times \vec{p}_3)$, where \vec{p}_i ($i = 1, 2, 3$) are momentum vectors.
- The observables used in our study are important in the sense that they don't require the reconstruction of the top-quarks and the spin of the particles produced.

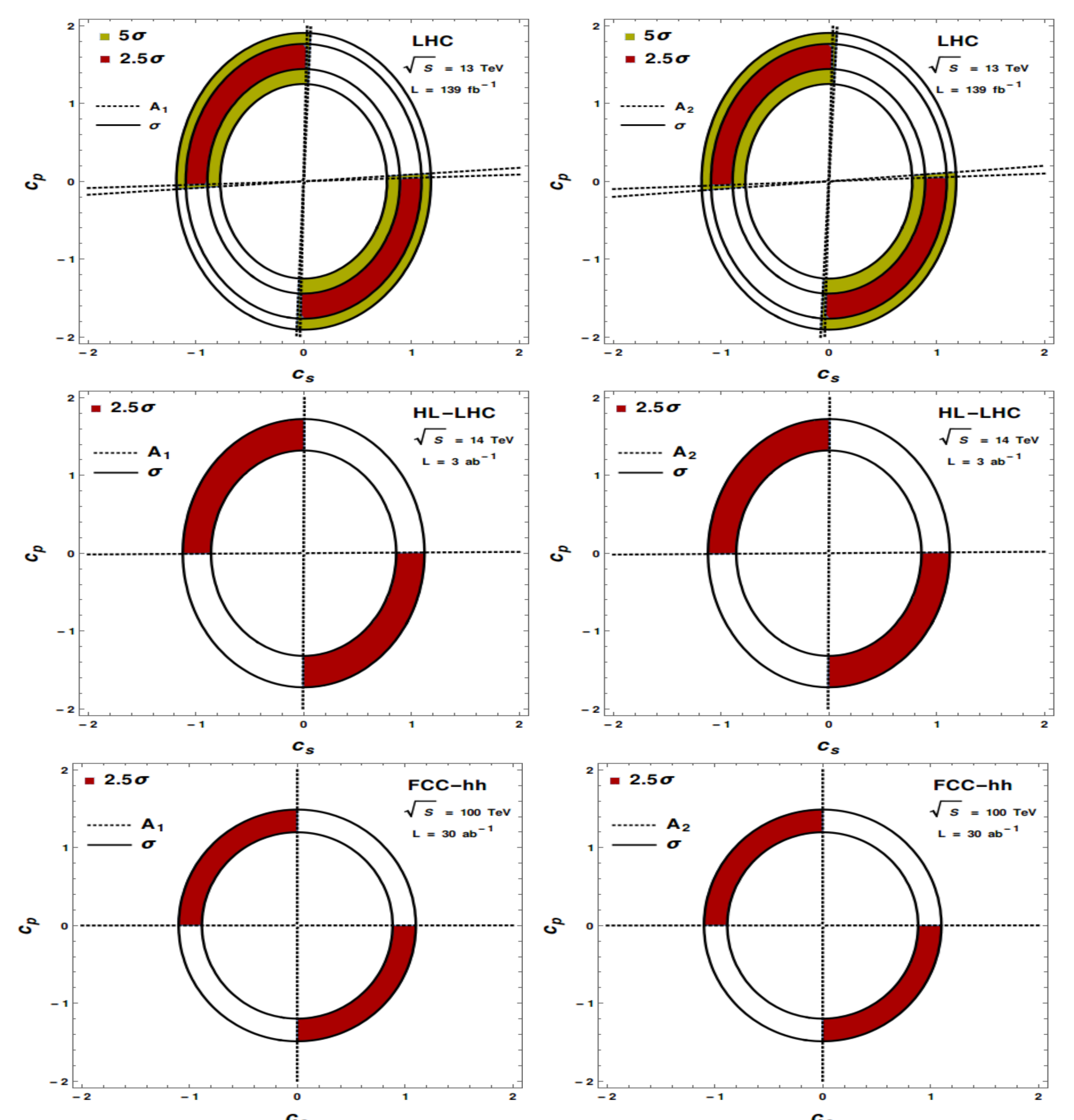
$$\mathcal{A}_{CP} = \frac{N(\mathcal{O}_i > 0) - N(\mathcal{O}_i < 0)}{N(\mathcal{O}_i > 0) + N(\mathcal{O}_i < 0)}, \quad (3)$$

- The presence of CP -violation in the Higgs-top interactions would be manifested by a non-zero value of the asymmetry \mathcal{A}_{CP} .

Cross-section as a function of anomalous coupling c_p



Contour plots of cross-section and production asymmetry in $c_p - c_s$ plane



References

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- [2] H. Bahl and S. Brass, JHEP **03**, 017 (2022) doi:10.1007/JHEP03(2022)017 [arXiv:2110.10177 [hep-ph]].
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