

Top Secrets: Long-lived ALPs in Top Production



A phenomenology study of long-lived Axion-Like Particles in top-antitop events at the LHC

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1. What are Axions and Axion-Like Particles?

Helioscopes

g oooo

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Axions

- Low mass, low energy particles
- First introduced to solve the strong CP problem in the SM
- Fixed mass-coupling relation

We can search for ALPs coming from

 the Dark Matter halo • the Sun with

Haloscopes



Axion-Like Particles (ALPs)

wall experiments

- More general class of pseudo-scalar particles
- In models with spontaneous broken global symmetry
- Non-fixed mass-coupling relation
- Occur in many extensions of the SM
- two-photon interactions • proton-proton collisions Light shining through the Large Hadron Collider

2. What are Long-Lived ALPs?

Long-lived particles (LLPs) travel a significant distance in the detector before they decay, giving unique long-lived signatures which can help increase the sensitivity in searches for LLPs, and reduce background with prompt signatures.





- Flavour-hierarchical ALP couplings to fermions with the strongest coupling to top quarks
- Assuming top coupling only

tta

Only top loop-induced decays

For the top scenario ALP model,

to a muon-antimuon pair in top-

antitop (tt) events.

the signal is given for ALP decays

tt**Z**^(*) A virtual or resonant Z boson (or photon) decays (converts) into a di-muon







H. Russel

$\sqrt{(|x_{\mu}| + |x_{\bar{\mu}}|)^2 + (|y_{\mu}| + |y_{\bar{\mu}}|)^2}$

- The di-muon with the smallest R_{Ixv} is selected in each event
- $R_{lxv} < 0.05$ is applied in signal selection.

5. Expected sensitivity

The expected sensitivity is estimated using the **muon displacement** in bins of I_{xv}



95% CL upper limits on the top-ALP coupling $c_{\rm fl}/f_{\rm a}$



6. General Scenario

95% CL upper limits on the proper decay length ct



7. Conclusions

Phenomenology study of **long-lived ALPs in tt** events with decays to displaced di-muons

- Focused on the top scenario for the top-ALP coupling c_{tt}
- Defined an **event selection** to suppress background and increase signal sensitivity

Introducing a general scenario for a new pseudo-scalar with an **arbitrary lifetime** produced in tt events.





Expected upper limits for the top scenario, and the general scenario with arbitrary lifetimes

Paper on arXiv:2306.08686







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