Snowmass2021 - Letter of Interest

PASSAT: **P**article **A**ccelerator helio**S**copes for **S**lim **A**xion-like-particle de**T**ection – A New ALP Detection Strategy

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NF Topical Groups:
■ (NF3) Beyond the Standard Model

RF Topical Groups:
■ (RF6) Dark Sector Studies at High Intensities

CF Topical Groups:
■ (CF1) Dark Matter: Particle Like

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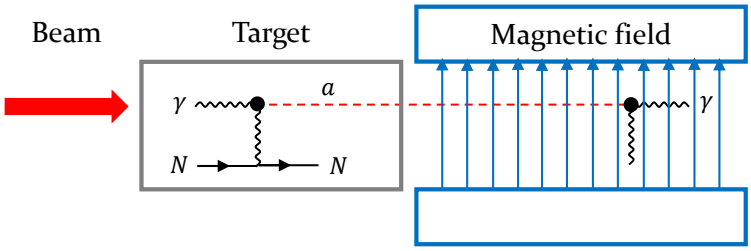

Figure 1: A schematic depiction of the PASSAT search strategy under consideration.

This Letter of Interest discusses the opportunity of pursuing a novel method to search for axion-like particles (ALPs) at particle accelerator experiments. ALPs produced at the target via the Primakoff effect subsequently enter a region with a magnetic field, where they are converted to photons that are then detected. See Figure 1 for a schematic depiction of the idea. Dubbed Particle Accelerator helioScopes for Slim Axion-like-particle deTection (PASSAT), our proposal uses the principle of the axion helioscope but replaces ALPs produced in the Sun with those produced in a target material. Since we rely on ALP-photon *conversions*, our proposal probes light (slim) ALPs that are otherwise inaccessible to laboratory-based experiments which rely on ALP decay, and complements astrophysical probes that are more model-dependent.

As a first application, in [1] we have reinterpreted existing data from the NOMAD experiment [2] in light of PASSAT, and constrained the parameter space for ALPs lighter than ~ 100 eV and ALP-photon coupling larger than $\sim 10^{-4}$ GeV^{-1}. As benchmarks of feasible low-cost experiments improving over the NOMAD limits, we have studied the possibility of re-using the magnets of the CAST and the proposed BabyIAXO experiments and placing them at the proposed BDF facility at CERN, together with some new detectors. We have found that these realizations of PASSAT allow for a direct probe of the parameter space for ALPs lighter than ~ 100 eV and ALP-photon coupling larger than $\sim 4 \times 10^{-6}$ GeV^{-1}, which are regions that have not been probed yet by experiments with laboratory-produced ALPs. In contrast to other proposals aiming at detecting single or two-photon only events in hadronic beam dump environments, that rely heavily on Monte Carlo simulations, the background in our proposal can be directly measured *in-situ*, its suppression optimized, and the irreducible background statistically subtracted.

We emphasize that the application of PASSAT to the BDF facility is solely for the purpose of illustrating how the idea can be realized in future beam dump facilities, i.e., the BDF facility can be replaced by other similar facilities such as beam-produced neutrino experiments. Thus, as part of this proposal, we will perform sensitivity evaluations with other beams and investigate the possibility of implementing PASSAT at the DUNE experiment.

In conclusion, given possible (relatively) low-cost implementation of PASSAT at the existing or near-future beam dump and/or neutrino facilities, we believe that it will be an important aspect of physics programs of the neutrino frontier, rare process frontier, and the cosmic frontier in the next decade and beyond.

References

[1] W. M. Bonivento, D. Kim and K. Sinha, *PASSAT: Particle Accelerator helioScopes for Slim Axion-like-particle deTection*, *Eur. Phys. J. C* **80** (2020) 164, [1909.03071].

[2] NOMAD collaboration, P. Astier et al., *Search for eV (pseudo)scalar penetrating particles in the SPS neutrino beam*, *Phys. Lett. B* **479** (2000) 371–380.