# T 12: Search for New Particles I

Time: Monday 16:00–18:20 Location: Tl

**Group Report** T 12.1 Mon 16:00 Tl

**Upcoming Experimental Axion Searches at DESY** — •Aaron Spector — DESY, Hamburg, Germany

With the physics case for axions and axion-like particles growing ever stronger, DESY is now set to host three upcoming axion searches, ALPS II, a light shining through a wall experiment, BabyIAXO, a solar axion helioscope, and MADMAX, a dark matter haloscope. While the methods used in each of these experiments are different, all of them utilize the Sikivie effect where axions convert to photons in the presence of a DC magnetic field with a rate proportional to the coupling constant $g_{a\gamma\gamma}$. Since they rely on different assumptions about the source of the axions, these searches will target complementary regions of the axion-like particle parameter space where evidence indicates these particles could exist. Together, their results will offer a cohesive picture of $g_{a\gamma\gamma}$ and potentially identify the cause of a number of phenomena which cannot be explained by the standard model. This talk will introduce these experiments and their sensitivity curves, in addition to providing a status report and timeline for each of them.

T 12.2 Mon 16:20 Tl

**Optical Design of the ALPS II experiment** — •Todd Kozlowski for the ALPS-Collaboration — University of Florida, Gainesville, USA

Currently under construction at DESY, the Any Light Particle Search (ALPS II) experiment will search for laboratory-generated axions and axion-like particles via photon-axion coupling. The experiment exploits several optical techniques in order to improve sensitivity. Two 122-meter long optical resonators are enclosed within a string of HERA dipole magnets. The first of these resonators is used to amplify the power of a laser field circulating inside the strong magnetic field to generate axions. This Production Cavity (PC) leads to an increase in the axion flux rate which can be measured on the other side of a light-tight barrier. For detection, a second resonator - the Regeneration Cavity (RC) - improves the reconversion rate of axions to photons which are measured with a heterodyne interferometer.

The optical systems must be actively controlled to assure that the frequency of the light circulating inside the PC is simultaneously resonant with the RC, but without allowing any PC light into the RC which would contaminate the detection. Additionally, the experiment requires at least a 95% overlap between the eigenmodes of the PC circulating light and the RC. This talk will discuss these challenges and the designs which will soon be implemented to solve them to allow first data-taking before the end of 2021.

T 12.3 Mon 16:35 Tl

**TES Detector for ALPS II** — •Rikhav Shah[1], Katharina-Sophie Isleif[2], Friederike Januschek[2], Axel Lindner[2], and Matthias Schott[1] for the ALPS-Collaboration — [1]JGU Mainz — [2]DESY, Hamburg

The Any Light Particle Search II (ALPS II) is a light-shining-through-a-wall (LSW) experiment at DESY, Hamburg, attempting to detect axions and axion-like-particles (ALPs). ALPS II will convert photons into axions/ALPs in an optical cavity. After passing through an opaque, light-tight barrier, these particles enter another optical cavity. Here, they can reconvert to photons and be detected. The detection requires a sensor capable of observing the extremely low rates of $\mathcal{O}(10^{-5})$ Hz, necessitating a very low dark rate and high detection efficiency. This can be achieved by using a TES, a Transition Edge Sensor, which is a cryogenic calorimeter exploiting the drastic temperature dependence of a material's electrical resistance in its transition region. We present the setup of a TES detector for ALPS II, its current status, and the analysis and improvement of its backgrounds. The viability and outlook of such a detector for the ALPS II experiment will be discussed, including future steps to understand its backgrounds and measure the detection efficiency.

T 12.4 Mon 16:50 Tl

**Estimation of reconstruction and trigger efficiencies in search for ALPs in Higgs boson decays at the LHC with ATLAS** — Bernard Brickwedde, Peter Krämer, Marten Mildeberger, Kristof Schmieden, Matthias Schott, and •Olivera Vujinovic — Johannes Gutenberg Universität Mainz

Some puzzling questions in particle physics, such as the strong CP problem or the discrepancy of the muon magnetic moment could be solved by introducing light scalar or pseudo-scalar axion-like particles (ALPs). ALPs may be produced at the Large Hadron Collider in Higgs decays. They further decay into a pair of photons ($H \to aa \to 4\gamma$). Depending on the ALP mass, the final photon-pairs will be reconstructed either as one (merged) photon or as two resolved photons. An artificial neural network (ANN) is used to identify merged photons amongst the immense background from prompt photons and $\pi^0$ from SM processes. Our analysis is using data collected at LHC within the ATLAS experiment. This talk will give an overview of the analysis's strategy to probe the ALP mass-coupling parameter space, including the preliminary estimations of the acceptance, reconstruction and trigger efficiencies using simulated Monte Carlo signal samples. The decay length of the ALPs is non-negligible and has a significant impact on the experimental acceptance, which will be discussed as well.

T 12.5 Mon 17:05 Tl

**Single-Photon Detector Development at DESY** — •Katharina-S. Isleif[1], Rikhav Shah[2], Friederike Januschek[1], Axel Lindner[1], Hartmut Grote[3], Dmitry Morozov[4], and Robert Hadfield[4] — [1]Deutsches Elektronen-Synchrotron — [2]Johannes Gutenberg Universität Mainz — [3]Cardiff University — [4]James Watt School of Engineering, University of Glasgow

In recent years, single-photon detector technologies have been continuously developed and improved. The advancement of photon-counting technologies has significantly contributed to scientific progress and enabled real-world quantum technology applications such as quantum key distribution. The performance of a single-photon detector can be quantified in terms of spectral range, dead time, dark count rate and detection efficiency, among others. The ALPS II axion-detection experiment, which is currently under construction at DESY in Hamburg, utilizes many of these properties, which we will highlight in this talk. We will demonstrate how single-photon detectors are characterized, what the current limitations of today's detectors are and we will give an outlook on the approaches we will study to undercut the given limitations to realize single-photon detectors with a rate of $10^{-5}$ counts per second and a detection efficiency of over 80% for 1064 nm photons. The goal is to eliminate spurious events at energies of 1.17 eV to below 1 event per day when the detector is connected to an experiment via optical fiber. Possible new detector structures will be addressed, such as a cryogenic dual on-chip transition edge sensor, and discuss low-noise optical interfaces and in-situ low-temperature optical filters.

T 12.6 Mon 17:20 Tl

**Deriving limits on ALPs coupling to the SM Higgs boson in multiphoton events recorded at the LHC with ATLAS** — Bernard Brickwedde, •Peter Krämer, Marten Mildeberger, Kristof Schmieden, Matthias Schott, and Olivera Vujinovic — Johannes Gutenberg Universität Mainz

Some puzzling questions in particle physics, such as the strong CP problem or the discrepancy of the muons magnetic moment could be solved by introducing light scalar or pseudo-scalar axion like particles (ALPs). Theoretic models allow a wide range of ALP-masses and couplings to SM particles such as the photon and the Higgs boson. Therefore, parts of the ALPs parameter space could be investigated with collider experiments like the ATLAS experiment at the LHC.

In the present analysis we search for SM Higgs bosons decaying to a pair of ALPs further decaying to two photons each.

In this talk, it will be discussed how limits on the ALP parameters can be derived after selecting events with two, three or four photons in the final state.

T 12.7 Mon 17:35 Tl

**Searching for ALPs in light-by-light scattering in pp collisions using AFP proton tagging with the ATLAS detector** — Peter Bussey[1], Tomaš Chobola[2], Petr Dostál[2], Hussain Kitagawa[3], Artem Kravchenko[2], •Patrick Odagiu[4], André Sopczak[2], Junichi Tanaka[5], Gen Tateno[5], and Koji Terashi[5] — [1]University of Glasgow — [2]CTU in Prague — [3]Okayama University — [4]EPF Lausanne — [5]ICEPP University of Tokyo

The search for an Axion-Like-Particle (ALP) is being performed us-

ing about $20\,\mathrm{fb}^{-1}$ data recorded with the ATLAS experiment and the ATLAS Forward Proton (AFP) detector in 2017. The AFP detector is positioned symmetrically at approximately 220 m away from the interaction point near the beam pipe and is used to measure the kinematics of surviving protons. The high-mass diphoton spectrum is studied to search for an ALP mediated by light-by-light scattering. The investigated mass range is between 0.1 TeV and 2 TeV ALP with a typical coupling $g = 1\,\mathrm{TeV}^{-1}$. Data containing photon information and AFP containers are prepared. A blinding strategy is established, along with the next steps in this search.

T 12.8 Mon 17:50 Tl

**Search for off-shell ALPs in ATLAS** — •Vincent Goumarre — Deutsches Elektronen-Synchrotron (DESY), Hamburg, Germany

An Axion Like Particle (ALP) is a Dark Matter candidate, but its expected small mass makes it difficult to detect in resonance searches at the LHC. However, it is possible to search for ALPs as off-shell mediators in s-channel processes (Phys. Rev. Lett. 124, 051802 (2020)). We report results based on ATLAS measurements of differential cross-section of pp->Z$\gamma$ and pp->WW production. This study leads to new constraints on the allowed parameter space in the context of an effective field theory model for ALPs with mass smaller than 100 GeV.

T 12.9 Mon 18:05 Tl

**LHC Constraints on Axion-Like Particles and Their Coupling to Top Quarks** — •Henrik Jabusch, Ksenia de Leo, Paolo Gunnellini, Johannes Haller, Roman Kogler, and Matthias Schröder — Institut für Experimentalphysik, Universität Hamburg

We investigate the possibility of axion-like particle (ALP) production at the LHC. At high-energy proton-proton collisions, ALPs could arise as off-shell mediators. Employing a model-independent effective field theory approach with ALP couplings to gluons and top quarks, ALPs lead to non-resonant signatures modifying the shape of the invariant mass distribution of the $t\bar{t}$ system.

We reinterpret a search by CMS for resonant $t\bar{t}$ production in the lepton+jets final state, based on $35.9\,\mathrm{fb}^{-1}$ of 13 TeV data. While the analysis is not optimized for non-resonant production, it allows us to study constraints on the ALP-top quark coupling for the first time.