PROCEEDINGS OF SCIENCE

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Searches for long-lived particles with ANUBIS: first commissioning results from proANUBIS

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Many extensions of the Standard Model with Dark Matter candidates predict new long-lived particles (LLPs). The LHC provides an unprecedented possibility to search for such LLP produced at the electroweak scale and above. The ANUBIS concept foresees instrumenting the ceiling and service shafts above the ATLAS experiment with tracking stations in order to search for LLPs with decay lengths of $\mathcal{O}(10\text{m})$ and above. A prototype detector, proANUBIS, has been constructed within the ATLAS experimental cavern to demonstrate the ANUBIS concept and verify the expected performance. The proANUBIS design and initial performance during 2024 LHC collisions are presented, and the planned analyses using prototype data are discussed.

42nd International Conference on High Energy Physics (ICHEP2024)
18-24 July 2024
Prague, Czech Republic

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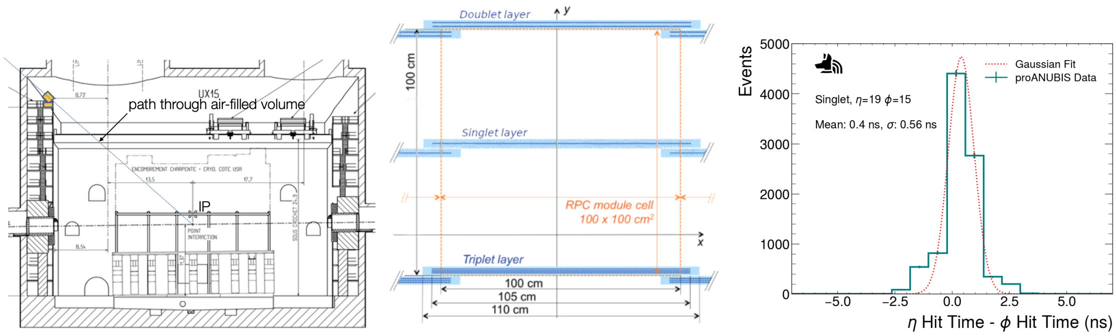
PoS(ICHEP2024)983

1. Introduction

A common feature of many BSM theories is the existence of new long-lived particles (LLPs). Many existing LLP models contain signatures that can be produced at energies achieved by LHC collisions, but for LLP signatures with long lifetimes ($c\tau \gtrsim 5$m) the finite size of the existing detectors greatly reduces their sensitivity as fewer decays occur within the detector volume. Several experiments with sensitivity to longer-lived LLP signatures exist or are currently being developed ($E.g.$ FASER [1], SHiP [2]), but due to their forward configurations their sensitivity to LLPs with masses $\gtrsim$ 1 GeV is limited. The ANUBIS proposal [3] would enable the detection of transverse LLP signatures by instrumenting the ceiling of the ATLAS cavern and the bottom of the access shafts using resistive plate chamber (RPC) technology. With this configuration, the cavern above the ATLAS detector can be used as a decay volume for LLPs produced in LHC collisions with the ATLAS detector itself serving as an active-veto for SM backgrounds.

The primary expected backgrounds for the ANUBIS experiment originate from punch-through jets with neutral leading constituents which deposit very little visible energy in ATLAS, yet scatter off of air molecules or decay in the cavern to produce a fake LLP signature in ANUBIS. Due to the difficulty of direct simulation of these processes, they must be measured experimentally to confirm the expected sensitivity of the ANUBIS proposal. A prototype detector ("proANUBIS") has been constructed in the ATLAS cavern to perform this measurement and additionally test the detector performance, track and vertex reconstruction, and timing resolution.



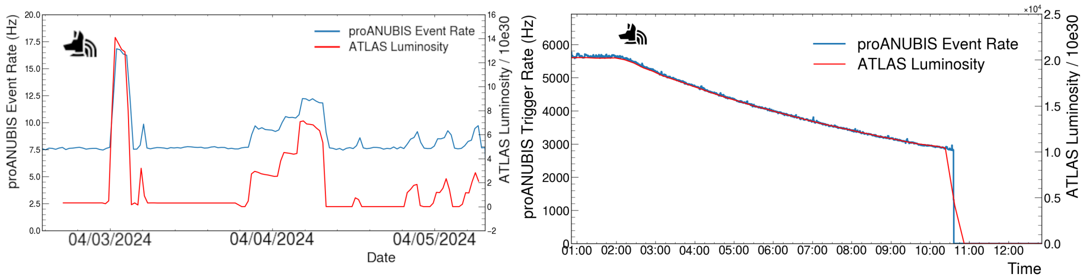
(a) (b) (c)

Figure 1: The proANUBIS location within the ATLAS cavern, represented by the highlighted box in the upper left (a), as well as the RPC chamber layout within it (b). The time difference between adjacent RPC planes in proANUBIS (c).

2. The proANUBIS Detector

The proANUBIS detector consists of three "layers" of RPCs, each consisting of a varying number of RPC planes (see Figure 1b). Each 2m x 1m RPC layer has 64 strip channels in the long direction ("ϕ") and 32 strip channels along the short direction ("η"). The RPC technology used in proANUBIS is based on the ATLAS BIS78 ("Barrel Inner Short") technology, which has recently been developed as a part of the ATLAS Phase-II upgrade project [4]. Events are collected using a coincidence trigger requiring hits in at least four η planes within 60 ns.

The proANUBIS detector is located on level 12 of the A-side scaffolding within the ATLAS cavern (Figure 1a), and is oriented with the normal to the RPC planes roughly pointed to the center of ATLAS. It has been collecting data for the majority of 2024 LHC collisions, corresponding to over 23 fb^{-1} as of the date of this conference with 572 of 576 total RPC strips active. Good agreement is seen in measurements of the event rate in proANUBIS and the ATLAS instantaneous luminosity (Figure 2b).



(a) **(b)**

Figure 2: The proANUBIS event rate and the ATLAS instantaneous luminosity during initial LHC beam setup (a), as well as during a full run (b).

3. Analysis and Outlook

Studies of the timing alignment in proANUBIS have been completed which compare the hit time in adjacent η and ϕ planes to calibrate time offsets and measure timing precision. The observed time deviations are on the order of 1ns, matching the expected time precision of the RPC planes. Preliminary track reconstruction algorithms have been completed, and good agreement between the observed angular distribution of cosmic muons and reconstructed proANUBIS tracks is observed.

The main next step in proANUBIS analysis involves time-aligning proANUBIS events with ATLAS events in order to perform combined event reconstruction. With this complete, studies of punch-through jets observed in both proANUBIS and ATLAS can be compared with simulation to validate the expected SM backgrounds in LLP searches, and extrapolated to lower energy deposits in ATLAS to produce more definitive sensitivity projections.

References

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