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Laboratory astroparticle physics: from the stability of laboratory blazar's jets to heavy axion searches

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Relativistic electron-positron plasmas are ubiquitous in extreme astrophysical environments such as black-hole and neutron-star magnetospheres, where accretion-powered jets and pulsar winds are expected to be sites of particle acceleration. So far, our experimental inability to produce large yields of positrons in quasi-neutral beams has restricted the understanding of electron-positron pair plasmas to simple numerical and analytical studies, which are rather limited. We will present the first experimental results confirming the generation of high-density, quasi-neutral, relativistic electron-positron pair beams using the 440 GeV/c beam at CERN's Super Proton Synchrotron accelerator. We show that the characteristic scales necessary for collective plasma behaviour, such as the Debye length and the collisionless skin depth, are exceeded by the measured size of the produced pair beams. In the first application of this experimental platform, the stability of the pair beam is studied as it propagates through a meter-length plasma, analogous to TeV γ-ray induced pair cascades in the intergalactic medium. We discuss how these experiments can provide fundamental insights on beams of energetic particles interacting with the background plasma, and possibly explaining the observed lack of reprocessed GeV emission from TeV blazars and hinting that physics beyond the standard model may be at play. We conclude the talk by presenting searches for axion like particles performed at Free Electron Laser facilities. New exclusion bounds are obtained in the mass range 10^{-3} eV $\lesssim m_a \lesssim 10^4$ eV. This was motivated by the new theoretical limit placed on the axion mass from consideration of the contribution to the relic axion abundance from the collapse of axion domain walls.