



Contribution ID: 9

Type: not specified

Prospects for exploring the Dark Sector physics and rare processes with NA64 at the CERN SPS

The CERN SPS offers a unique opportunity for exploring new physics due to the availability of high-quality and high-intensity secondary beams. In the 2016-18 runs, the NA64 experiment has successfully performed sensitive searches for Dark Sector and other rare processes in missing energy events using high energy electron interactions in an active dump. The NA64 Collaboration plans to continue such searches to fully exploit the potential of the experiment and increase its discovery reach with high-energy muon and hadron beams. Our research program with e^- - beam aims at a high sensitivity search for visible and invisible decays of dark photons, A' , and the exploration of the parameter space for the sub-GeV Dark matter production in invisible decays of A' mediator motivated by thermal Dark Matter models. It also includes clarification of the origin of the ^8Be anomaly, observed by the Atomki experiment, and searches for Axion Like Particles (ALP) particles. With the M2 muon beam, we propose to focus on the unique possibility to search for new states weakly coupled predominantly to muons, in particular a new gauge Z_μ boson of $L_\mu - L_\tau$ symmetry, which can resolve the long standing muon $(g-2)_\mu$ discrepancy. Further, more sensitive searches for the Z_μ as a vector mediator of Dark Matter production, LFV $\mu - \tau$ conversion and millicharged particles are also planned. Finally, the program includes probing Dark Sector with π , K beams, by looking for invisible decays $\pi^0, \eta, \eta', K_S^0, K_L^0 \rightarrow \text{invisible}$ of neutral mesons, which is complementary to the current CERN program in the kaon sector.

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Track Classification: Dark matter and dark sector (accelerator and non-accelerator dark matter, dark photons, hidden sector, axions)