Contribution ID: **256** Type: **Poster session only**

Novel multi-lepton signatures in meson decays from MeV QCD axions and dark sectors

We point out novel kaon and pion decays to several leptons pairs that can probe states beyond the Standard Model at the MeV scale. In particular, modes like K $\longrightarrow \pi$ 2(e+e-) have never been measured or considered before and could be used to search for MeV axions, as well as multi-component dark sectors. In particular, the "17 MeV QCD axion" is robustly tested with these signatures, as it predicts a branching ratio for $\pi 0 \longrightarrow$ 3(e+e-) at the level of 0.1%, much above the double-Dalitz mode.

arXiv number (if applicable)

https://arxiv.org/abs/2012.02142

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Session Classification: Poster Session