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Testing Lepton Flavor Universality and CKM Unitarity with Rare Pion Decays

A next-generation rare pion decay experiment motivated by several inconsistencies between SM theory and data will probe new physics at high mass scales. Using state-of-the-art instrumentation, computational resources, and high-intensity beams, two problems can be addressed with nearly the same apparatus and beamline. The first is a measurement of the charged-pion branching ratio to electrons vs. muons, $R_{e/\mu}$, which is extremely sensitive to new physics effects. At present, the SM prediction for $R_{e/\mu}$ is known to a 2 parts in 10,000, which is 15 times more precise than the current experimental determination. An experiment at a comparable level of accuracy opens a large window to test lepton universality at an unprecedented level, probing mass scales up to 3000 TeV. The second measurement concentrates on the rare process of pion beta decay, $\pi^+ \to \pi^0 e^+ \nu(\gamma)$, as well as various complementary rare decays modes. An order of magnitude improvement in sensitivity will determine V_{ud} in a theoretically pristine manner and test CKM unitarity at the quantum loop level. We will base our design on lessons learned form the recent PIENU and PEN efforts at TRIUMF and PSI. Improved resolution, greatly increased calorimeter depth, high-speed detector and electronic response, large solid angle coverage, and complete event reconstruction are all critical to the design, including a 4π LXe calorimeter, an internal pixelated active stopping medium and electron tracker, as well as a customized beam line.

Primary frontier topic

Rare Processes and Precision Measurements Frontier

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