Glimpsing one of Nature's Secrets: The π^0 Lifetime

Dustin E. McNulty
UMass

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Abstract

The π-mesons are nature's lightest and simplest hadronic systems. As such, they are readily produced in the laboratory and lend themselves as a test-bed for checking the predictions of fundamental theories of the standard model; one such prediction concerns the lifetime of the π^0. With a mean lifetime of $\sim 10^{-16}$ seconds, the π^0 decays electromagnetically into 2 photons $\sim 99\%$ of the time, and it turns out that this decay is dominated by a quantum anomaly. In other words, the relatively quick decay proceeds only because a symmetry of the classical theory is anomalously broken or violated in the quantized version. A measure of the $\pi^0 \rightarrow \gamma\gamma$ decay rate or partial decay width, $\Gamma_{\gamma\gamma}$, represents a direct probe of the anomaly and a test of the underlying theory. The PrimEx Collaboration at Jefferson Lab has extracted $\Gamma_{\gamma\gamma}$ from precision measurements of π^0 photo-production cross sections. Measurements were made using 5% radiation length nuclear targets of ^{12}C and ^{208}Pb with incident photons between 4.9 and 5.5GeV tagged by the Hall B tagger facility. The π^0 decay photons were detected by a specially constructed high resolution hybrid calorimeter. In this presentation, recent results from the PrimEx measurements will be given along with a general introduction and overview of the physics, experimental design and setup, detector performances, and data analysis strategies and techniques.