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High Precision Proton Charge Radius Experiments at Jefferson Lab

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In 2010, a new method using muonic hydrogen spectroscopy led to a proton charge radius (r_p) result that was nearly ten times more precise but significantly smaller than results obtained using the two traditional methods, namely $e-p$ elastic scattering and ordinary Hydrogen spectroscopy. This discrepancy triggered the so-called "proton charge radius puzzle".

To investigate this discrepancy, the PRad collaboration performed a new experiment in 2016 in Hall B at the Thomas Jefferson National Accelerator Facility. With both 1.1 and 2.2 GeV electron beams, the experiment measured the $e-p$ elastic scattering cross sections in an unprecedentedly low values of momentum transfer squared region ($Q^2 = 2.1\times10^{-4} - 0.06\ (\mathrm{GeV/c})^2$), with a sub-percent precision. The PRad experiment utilized a magnetic-spectrometer-free setup, which was based on a large acceptance and high resolution calorimeter (HyCal), a plane of two large-area Gas Electron Multiplier (GEM) detectors, and a windowless H_2 gas-flow target. In this talk, I will discuss details of the data analysis and present the results of this experiment. I will also focus on the newly approved PRad-II experiment. Through a number of major upgrades to the experimental setup and analysis method, the new experiment aims to reduce the total uncertainty of r_p by nearly a factor of 4 compared to that of PRad.

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