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Measuring the proton Zemach radius with the FAMU experiment at RIKEN-RAL

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The FAMU (Fisica degli Atomi Muonici) experiment has the goal to measure precisely the proton Zemach radius, with incoming low energy muons. It will contribute to precision tests of QED and may contribute to shed more light on the so-called proton radius puzzle, by studying the electromagnetic structure of the proton and muon-nucleon interactions. To this aim, the FAMU experiment makes use of a high-intensity pulsed muon beam at RIKEN-RAL impinging on a cryogenic hydrogen target with an high-Z gas admixture and a tunable mid-IR high energy laser, to measure the hyperfine (HFS) splitting of the 1S state of the muonic hydrogen. From the value of the exciting laser frequency, the energy of the HFS transition may be derived with high precision (10^{-5}) and thus, via new refined QED calculations, the Zemach radius of the proton. The experimental signature of the process will be the emission of characteristic X-rays from the de-excitation of the high-Z muonic atoms formed when the muon is transferred from p to Z in the cryogenic target. Preliminary studies have provided indications on the most suitable high-Z elements to be used and validated the experimental method and apparatus. The experimental apparatus includes a system of precise fiber-SiPM beam hodoscopes, a crown of 1" LaBr3 crystals read by photomultipliers complemented by additional 1/2" LaBr3 crystals read by SiPM arrays with temperature control and a few HPGe detectors for detection of the emitted characteristic X-rays around 100 keV . The system is in condition to detect the signal in a noisy environment and has been used for preliminary runs. The experimental apparatus and the innovative method to determine the Zemach proton radius with high precision will be described in detail.

Collaboration name

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