The FAMU Experiment: Measuring the Hyperfine Splitting of Muonic Hydrogen in the Ground State

Emiliano Mocchiutti [1, †] on behalf of the FAMU Collaboration

[1]Sezione INFN di Trieste, via A. Valerio 2, Trieste, Italy
†corresponding author's email: Emiliano.Mocchiutti@infn.it

The FAMU experiment (Fisica degli Atomi MUonici) aims to measure the hyperfine splitting of the ground state of muonic hydrogen. This measurement provides precise insights into the proton's magnetic structure, plays a crucial role in validating high-precision QED calculations, and tests the fundamental interaction between the proton and the muon. From this measurement, the Zemach radius of the proton can be estimated with an accuracy better than 1%.

The experiment is conducted at the ISIS facility of the Rutherford Appleton Laboratory (UK), specifically at the RIKEN Port1 beamline.

The experimental method relies on exciting the hyperfine splitting using a laser system and detecting the resulting increase in characteristic X-rays from muonic oxygen. This increase occurs due to the enhanced probability of muon transfer to an oxygen atom following the recoil de-excitation of the muonic hydrogen atom.

The X-ray detection system is designed to identify an increase in the characteristic X-rays of muonic oxygen following laser injection into the target. To achieve precise measurements, the detection apparatus must combine excellent timing performance with high energy resolution. The system consists of 34 cesium-enriched lanthanum bromide crystals, with 6 read by photomultiplier tubes and the remaining 28 by silicon photomultiplier arrays.

The pulsed laser used in the experiment, specifically developed by INFN Trieste for this application, is unique worldwide due to its tunability, energy, and spectral purity, key parameters for the success of the experiment. The transition of interest, expected around 183 meV, requires a laser operating in the mid-infrared region at approximately 6.78 μm. It must be capable of extremely precise and stable tuning to the target wavelength over an extended period.

The experiment began data collection in 2023, and four data-taking periods have been completed so far. Additional measurement periods are planned for 2025.

This presentation will provide an update on the current status of the experiment, its performance, and progress in data analysis.