Contribution ID: **3** Type: **Poster Presentation**

The FAMU Experiment at ISIS: the Muonic Hydrogen Atom as a Tool to Probe the Proton Structure

The objective of the FAMU experiment is to carry out a precision measurement of the muonic hydrogen ground state hyperfine splitting (1S-hfs), with an unprecedented accuracy of the order of 10^{-5}. This measurement would enable to extract the Zemach radius of the proton with an accuracy better than 1%, which will give precise insights on the structure of the proton, and play a crucial role in validating high-precision QED calculations on the proton-muon interaction. The experiment is running at the RIKEN-RAL Port1 pulsed muon beamline at the ISIS Neutron and Muon Source, with a beam of fixed-momentum (55 MeV/c) negative muons. Muonic hydrogen atoms are produced by injecting a pulsed low-momentum (55 MeV/c) negative muon beam in a pressurised 1-litre 8 bar gaseous target. The exotic atoms are let thermalise for a few hundreds of ns and then exposed to a tunable mid-infrared laser light (around 6788 pm) to excite the transition. The observable is the excess of laser-induced muonic oxygen X-rays, resulting from the kinetic energy gained by the muonic hydrogen atom after the non-radiative de-excitation of the 1S-hfs and its consequent enhanced transfer of muon to oxygen. A scan on the laser wavelength enables to find the resonance corresponding to the 1S-hfs energy.

The X-ray detector system, specifically designed for optimal time and energy resolution in the 100-200 keV region, is based on $LaBr_3$:Ce scintillators read-out by PMT's and SiPM's. The detector system also includes a muon beam monitor, capable of extracting the muon beam spot, the muon beam temporal information and the muon flux. It is used for on-line beamline monitoring and it plays a crucial role in data normalisation over the muon flux.

The contribution presents the technological challenges addressed in the experiment, the data analysis methodology and its first results, including an extensive study on the system stability and systematics.

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Session Classification: Poster session 2

Track Classification: Fundamental physics