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1S Hyperfine Splitting of Antihydrogen at the ALPHA experiment

The hyperfine structure consists on the splitting of energy levels in atoms and molecules due to the interaction between the electromagnetic multipoles of the nucleus and the orbiting electrons. The Hyperfine Splitting measurement on antihydrogen involves determining the Δf frequency associated with the splitting of the 1S state. This measure is carried out at the ALPHA experiment, one of the six experiments that are part of the complex of the antimatter factory, at CERN. The ALPHA experiment specializes in the production of antihydrogens atoms through the mixing of an antiproton and a positron plasma. The produced antihydrogen is then trapped exploiting the interaction between its magnetic momentum and the magnetic field produced by the superconducting magnet (for longitudinal confinement) and the octupole magnets (for transverse confinement) of the ALPHA-2 magnetic trap. To perform the experiment, the confined antihydrogens are irradiated with micro-wave light, which induces the energy transitions. During the micro-wave irradiation, a certain amount of antihydrogen ends up in an untrappable energy level, and thus annihilates on the trap walls of ALPHA-2. A silicon vertex detector, surrounding the trap, detects the annihilation of antihydrogen, reconstructing its vertex through the reconstruction of the tracks of pions passage. The counts of annihilations per frequency constitutes the experimental "line-shape". The Hyperfine Splitting of the 1S state of antihydrogen is extracted from the measurement of two line-shape onsets, after applying a procedure to remove the effect of the magnetic field drift over time. In this poster we present a simple Monte Carlo simulation developed within the context of this measurement. The objective of this study is to assess the statistical and systematic uncertainties associated with the procedure to extract the Hyperfine Splitting from the data collected during the 2023 data taking.

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