

Development and commissioning of a hydrogen ion source for the CERN ALPHA experiment

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Abstract-

The CERN ALPHA experiment makes precision measurements of antihydrogen atoms held in a superconducting magnetic minimum trap. Recent studies of the antihydrogen spectrum have provided unique tests of fundamental physics, and to improve on these studies ALPHA is now proposing upgrades to directly compare hydrogen and antihydrogen within their existing atom trap. One route towards producing cold, neutral hydrogen atoms is the integration of a hydrogen ion source into the experiment. Ideally, this should provide both positive (H^+ , H_2^+ , H_3^+) and negative (H^-) ions to facilitate different schemes for producing and trapping hydrogen atoms. For compatibility with ALPHA's existing beamlines, the source must produce modest ($\sim 10 \mu A$) beam currents at very low final energies (< 100 eV). PELLIS, previously developed at JYFL, is a filament-driven ion source that generates 5–10 keV H^- beams with small emittances and tens of microamps of beam current. Here, we present a modified PELLIS design to provide both positive and negative hydrogen ions for ALPHA. The use of an electromagnet filter field in PELLIS allows for the optimisation of H^- volume production, and also tuning of the positive ion species fraction. We present simulations of H^- (and similarly H^+) transport through the initial extraction optics, which have been configured for a lower beam energy of 5 keV and designed to match a proposed beamline to interface with ALPHA. We present the results of detailed vacuum simulations that were used to guide the optics design, allowing the source (at 10^{-2} mbar) to interface with a transport beamline ~ 0.5 m downstream that has strict vacuum requirements of $< 10^{-9}$ mbar. We present experimental results from commissioning of the source, and show that it broadly performs as designed for both positive and negative hydrogen ions.

Index Terms- Ion sources (positive ions, negative ions, electron cyclotron resonance (ECR), electron beam (EBIS)); Beam Optics

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