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Recent H^- Diagnostics, Plasma Simulations and 2X Scaled Penning Ion Source Developments at the Rutherford Appleton Laboratory

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The Rutherford Appleton Laboratory (RAL) is home to the ISIS Pulsed Spallation Neutron and Muon Facility and the Front End Test Stand (FETS). Both of these operational facilities use a Penning-type surface-plasma negative hydrogen (H^-) ion source. For research and development of the Penning H^- source, a Vessel for Extraction and Source Plasma Analyses (VESPA) has been constructed. The VESPA has demonstrated excellent beam transport of up to 80 mA using a novel elliptical-aperture einzel lens. The einzel lens replaces the legacy sector dipole magnet housed inside a refrigerated box which traps cesium vapor escaping the ion source.

In parallel with the einzel lens measurements, a 2X scaled-up Penning H^- ion source has been developed. This will enable improved performance at duty factors of up to 10%, with the advantage of either higher beam currents or longer lifetime due to the reduced plasma power load on cathode surfaces.

The long-term viability of the einzel lens and 2X source is now being evaluated, so new diagnostics devices have been installed. First, a pair of electrostatic deflector plates is used to correct beam misalignment and perform fast chopping, with a rise time of 24 ns. Next, a suite of four quartz crystal microbalances (QCMs) has shown that the cesium flux in the vacuum vessel is only increased by a factor of two, despite the absence of a dedicated cold trap. Finally, an infrared camera has demonstrated good agreement with thermal simulations, but has indicated unexpected heating due to beam-loss on the downstream electrode. These types of diagnostics are suitable for monitoring all operational ion sources; as such long-term behavior will be discussed.

As well as experimental campaigns and new diagnostics tools, the high-performance VSIM software package from Tech-X has been purchased recently, as well as the COMSOL multiphysics software. These will facilitate sophisticated collisional particle-in-cell (PIC) simulations of the ion source plasma, including cesium dynamics. As a first step, VSIM and COMSOL are being used for plasma simulations of two novel ion thrusters for space propulsion applications. Preliminary results will be outlined.

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