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Development of a High Reliability, Long Lifetime H^- Ion Source

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Phoenix Nuclear Labs (PNL) has designed a high current, long lifetime, negative hydrogen (H^-) ion source [1] and begun construction and testing. This system is being developed in partnership with the Fermi National Accelerator Laboratory as part of an ion beam injector servicing future Intensity Frontier particle accelerators under development at Fermilab and other Department of Energy laboratories. The beam specifications for Fermilab's Low Energy Beam Transport (LEBT) section are 5-10 mA of continuous H- ion current at 30 keV with <0.2 π-mm-mrad emittance.

In this application, continuous output with high reliability, long lifetime, and high efficiency are critical. Existing ion sources used by Fermilab rely on plasma-facing electrodes which erode over time and are inherently limited to lifetimes of a few hundred hours, while also requiring relatively high gas loads on downstream components. PNL's H^- ion source design features an electrodeless Electron Cyclotron Resonance (ECR) microwave plasma generator which has been extensively developed in our positive ion source systems, which have demonstrated 1000+ hours of operation and >99% continuous uptime at PNL.

The device is driven by a plasma chamber that produces energetic electrons, positive hydrogen ions, and neutral hydrogen atoms. Positive ions and hyperthermal neutrals drift toward a caesiated molybdenum surface, where a fraction is converted into H^- hydrogen ions, which are subsequently extracted into a low-energy beam using electrostatic lenses. A transverse magnetic dipole filter field preferentially removes high-energy electrons emitted by the source plasma, in order to decrease the rate of negative-ion destruction via electron-impact detachment.

The design of the H^- ion source subsystems and preliminary diagnostic results will be presented and discussed.

References

[1] Sherman, J. et al. *High Reliability, Long Lifetime, Negative Ion Source*. International patent application PCT/US2014/044382 (2014).