High-Yield Negative Ion Sources for Medical Cyclotrons

Enhanced H^-/D^- Medical Cyclotron Radioisotope through Utilization of Cesium Salt Pellets in the Penning Ion Source

Selkirk Ion-source Research Centre (SIRC), University of Saskatchewan, and TRIUMF
Funded by the Mitacs Accelerate Program

This Mitacs-funded project addresses a global challenge in medical radioisotope production—the need for higher-yield Medical cyclotrons producing diagnostic and therapeutic radiopharmaceuticals. By improving the output and efficiency of Penning ion sources that generate negative hydrogen (H^-) and deuterium (D^-) ions, the project supports the **affordability and accessibility of life-saving cancer diagnostics and treatments**. More than 1,300 medical cyclotrons worldwide rely on this technology; enhancing their performance would expand isotope supply while reducing power use and operating costs consistent with the goals of the Canadian Nuclear Isotope Council (CNIC).

Innovation

Conventional Penning ion sources in medical cyclotrons use tungsten or tantalum cathodes that limit H^-/D^- beam output and require high arc power. Building on D-Pace's/Siemen's preliminary results[1]—showing a 20% cyclotron extracted beam current increase and 30% Penning source power reduction using extremely small cesium salt cubes—the research team is developing cesium-impregnated cathode technology to stabilize and amplify this effect. Through plasma modelling, simulation, and experimentation, the project aims to establish reliable cesiation and operating protocols that **maximize beam yield and extend cathode life**.

Commercialization Potential

The research aims to pave the way for a **commercially viable cathode enhancement** that can be integrated into existing Penning ion sources in medical cyclotrons. This would allow operators to boost radioisotope production efficiently without major infrastructure changes, creating a clear path for technology licensing and spin-off development. The work aligns with TRIUMF's mission to commercialize accelerator-based innovations and strengthen Canada's leadership in the medical radio- and stable- isotope ecosystem.

Next Steps

Ongoing work will model and measure H^-/D^- beam performance, benchmark cesium-impregnated cathode performance, and refine cesiation protocols to support industrial integration and **advance this Penning-based ion source technology toward commercialization readiness**.

[1] D. Potkins, M. Dehnel, S. Melanson, T. Stewart, P. Jackle, J. Hinderer, N. Jones, L. Williams, "Improvements to Siemens Eclipse PET Cyclotron Penning Ion Source", *6th AIP Conference Proceedings 2052*, 050016 (2018).