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‘Finding a needle in a haystack;’ A Ba-tagging approach for an upgraded nEXO experiment

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nEXO is a proposed 5-tonne experiment that will search for neutrinoless double-beta decay ($0\nu\beta\beta$) in 5-tonnes of liquid xenon (LXe), isotopically enriched in Xe-136. If observed, $0\nu\beta\beta$ will violate the assumed symmetry of lepton number conservation in the Standard Model.

Complete position localization of events in the nEXO time projection chamber opens the possibility of extracting from the detector volume and identifying the Xe-136 $0\nu\beta\beta$ decay daughter Ba-136. This is called Ba-tagging, a technique being developed as a potential future upgrade for nEXO. The approach pursued by collaborating Canadian institutions involves the extraction of a small volume of LXe from the site of a potential $0\nu\beta\beta$ event using a capillary and deploying a combination of RF (Radio Frequency) ion transport and spectrometry techniques to identify single Ba-136 ions.

With an RF-only ion funnel, the extraction of Cf-252 fission ions from xenon gas (up to several atm) to high-vacuum has been demonstrated. To positively identify the extracted ions, a linear Paul trap (LPT) and a multiple-reflection time-of-flight mass spectrometer (MRTOF-MS) are being commissioned. A quadrupole mass filter (QMF), located downstream of the RF funnel, filters incoming ions, which are subsequently cooled and trapped in the LPT to detect the barium ion through laser fluorescence spectroscopy. After element identification, the cooled ions are ejected into the MRTOF-MS to determine the ion masses and to perform systematic studies of the ion bunch. The commissioning and results of initial testing of these devices will be presented.

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