

## Development of $^{211}\text{At}$ production via continuous extraction of $^{211}\text{Rn}$

Critically needed radionuclides for cancer therapy include the alpha-emitter  $^{211}\text{At}$  [1] and therapeutically useful Auger-electron emitters. The ATLAS (Argonne Tandem Linac Accelerator System) superconducting linac at Argonne National Laboratory is suitable for production of these radionuclides. Our work is initially focusing on demonstrating production capabilities for  $^{211}\text{At}$  (7.2 h half-life) using the  $^{209}\text{Bi}(^7\text{Li},^5\text{n})^{211}\text{Rn}$  reaction. Cross sections for these reactions peak at 600 mbarn [2,3] making production of 10's of mCi per batch feasible using only a very small percentage of the accelerator beam time. Presently, in the U.S.  $^{211}\text{At}$  is primarily produced at 3 university facilities using the  $^{209}\text{Bi}(\alpha,^2\text{n})^{211}\text{At}$  reaction at in-house cyclotrons. Hence, clinical use of  $^{211}\text{At}$  nation-wide is limited due to its short half-life. By using the lithium induced reaction, the  $^{211}\text{At}$  daughter is extracted from the parent  $^{211}\text{Rn}$ , which has a half-life of 14 h, significantly extending the time-frame for effective distribution and use of this important radionuclide. ATLAS is an appropriate and flexible accelerator for production of medical isotopes because it can provide beams of any ion including protons, helium, lithium, and heavier ions with energies adjustable over a wide range. An upgrade of the accelerator to produce more intense lithium beams and the construction of improved neutron shielding is in progress. Following the completion of this work, currents of lithium beams of 1-10 particle microamps will be available to support the development of a  $^{211}\text{Rn}/^{211}\text{At}$  generator. These combined upgrades will enable yields of ~100 mCi of  $^{211}\text{Rn}$  per batch. As part of this development, an option for the continuous collection of  $^{211}\text{Rn}$  from a bismuth oxide target followed by separation of the  $^{211}\text{At}$  daughter product is being investigated. Porous bismuth oxide targets have been developed by Innosense, LLC under a DOE Small Business Grant. [4] In two test runs to date,  $^{211}\text{Rn}$  released from the targets was collected in charcoal traps. In the first run a metallic bismuth target was used and in the second the recently developed bismuth oxide target was used. In both runs only a low fraction of the  $^{211}\text{Rn}$  was released and collected on line. The first case was limited by the melting point of the metal target, and the second was limited by the target being heated only to 60 oC. The release and capture were quantified by off-line gamma counting of the long lived  $^{207}\text{Bi}$  daughter remaining in the production target and in the charcoal. In upcoming test runs target heating up to 600 oC will be implemented to increase release and collection efficiency.

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