INTENSE PASSIVE COMMERCIAL X-RAY SOURCES FOR CHEMICAL AND ELEMENTAL ANALYSIS. C. G. Morrison, Astro Nuclear Engineer USNC-Tech, c.morrison@usnc-tech.com

Introduction: USNC-Tech is developing radioisotope technology initially focused on heat and electricity called the Chargeable Atomic Battery (CAB); however, the same technology can be used to generate source of passive x-rays much larger than that has been available in the past.

There are several types of analyses methods that have utilized x-rays derived from radioisotopes. The particle induced x-ray emission (PIXE) and alpha particle x-ray spectroscopy (APXS) are relevant. These systems have worked well. However, their scale is generally small. For example, the Mars Exploration Rovers utilized less than 50 milli-Curie sources of Cm-244 [1]. The amount of time required to complete a scientific analysis is heavily dependent upon the strength of the source. Most analyses complete by the Mars rovers took multiple hours to properly analyze. USNC-Tech's CAB technology provides significantly higher activity - up to a multiple 10s of kilo-Curies. Different types of commercial radioisotopes are compatible with the radioisotopes as shown in Table 1.

Table 1. Radioisotopes

Precursor	Radioisotope	Half-life [yr]
^{6}Li	^{3}H	12.3
^{169}Tm	^{170}Tm	129 days
^{59}Co	^{60}Co	5.7
^{151}Eu, ^{153}Eu	^{152}Eu, ^{154}Eu	11.0 (avg.)

About CABs: Chargeable atomic batteries are manufactured using natural non-radioactive precursor material embedded within an encapsulation material. The precursor material is then activated or "charged" inside a radiation source and packaged. This concept is known as a Chargeable Atomic Battery or CAB.

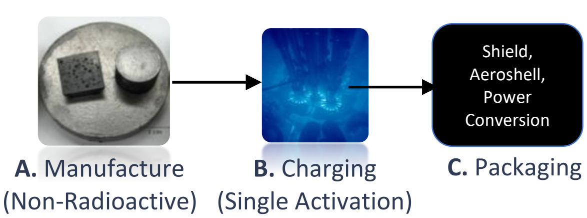

Fig 1. CAB Manufacturing Process

CABs can be manufactured in existing facilities and have a path toward a prototype using available technologies and facilities. For watt-scale batteries, the process can be demonstrated to a TRL of 6 with a ground demonstration and licensing in the next two years, focusing on a circa 2024 flight demo.

Science Applications: There could be multiple scientific use cases for the intense x-ray source offered by the CAB technology. An x-ray laser for example. The radioisotope could be modified with a pinhole collimated beam that could be directed at objects far away.

The intense x-ray beam could greatly reduce the spectroscopic scanning time for samples by a few orders of magnitude, enabling fast scanning of large numbers of samples. If the strong x-ray source is combined with a deep learning physics model, the composition of the ground up to several cm deep could be evaluated based on reflected x-rays and time of flight measurements. Remote sensing from a distance of meters or perhaps even km could be enabled.

Combining the intense x-ray source with other remote sensing methods such as visible light, infrared, and other neutron sources could offer a superior sensing technology for applications such as lunar water detection.

For lunar missions looking to survive the lunar night, passive heat generated by the x-ray source could be utilized to extend the mission lifetime.

Partners: USNC-Tech is looking for knowledgeable sciences to brainstorm possible novel sensing instruments enabled by the CAB technology. USNC-Tech would be interested in participating in upcoming science focused proposal calls such as PICASSO and the PRISM-2 call. Interested partners are encouraged to reach out to the author.

References:

[1] H. Firstenberg et. al. Nuclear Safey Analysis for the Mars Exploration Rover 2003 Project, AIP Conference Proceedings **699**, 285

.