# New strategies and developments for understanding the ISAC targets performance

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## Motivation

The goal of this study is to improve the release of radioactive short-lived isotopes of the ISAC targets through two techniques:

- Using an optical technique allowing for direct on-line temperature measurements of the target material
- Using a pulsed p+ beam to characterize the isotopes release efficiency as a function of material and geometry

Target temperature is a crucial parameter in the release efficiency of ISOL products – to date only engineering models have been used to estimate the target temperature. A new optical system has been developed to directly measure the temperature of the target on-line.

## Optical System

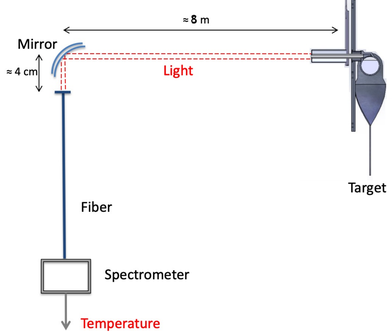



*Figure 1: Optical System Schematic: light emitted from a hot target is focused into the optical fiber using a silver parabolic mirror and analyzed using a NIR spectrometer.*

## Online preliminary results obtained with Optical System

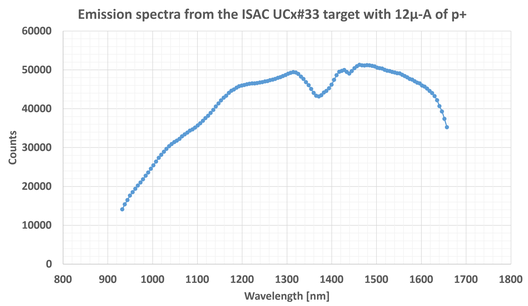



*Figure 2: Emission spectra from the ISAC UCx#33 target with 12 μ-A of p+ beam*

- **Preliminary results show an excellent correlation between these two independent measurements.**

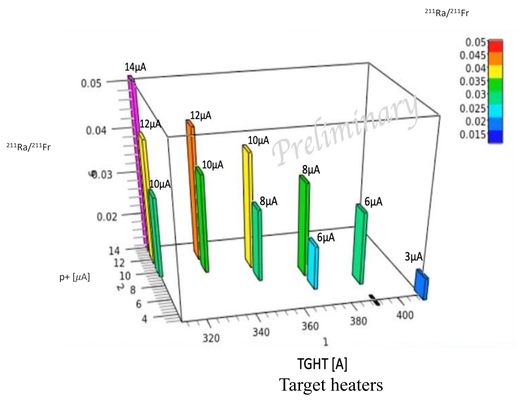



*Figure 3: Ratio of the $^{211}Ra/^{211}Fr$ at different target heater current settings and proton beam intensities*

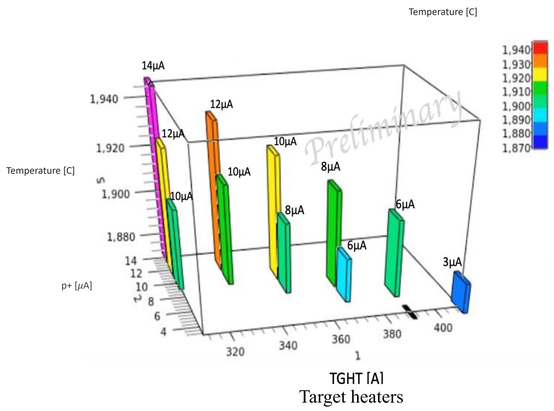



*Figure 4: Temperature values for different target heater current settings and proton beam intensities*

A critical input into the release efficiency of certain isotopes is the effusion time as a function of ion species and target conditions. A pulsed proton beam from the cyclotron gives us the opportunity to study the effusion time.

## Pulsing System

- Proton beam pulses are generated using the ISIS pulser (Ion Source & Injection System) using various % Duty Factor (%DF)

Pulse structures:

- Single or multiple pulses
- Pulse Length: 0.001-300 seconds
- Time in between pulses: 0.001-300 seconds

- p+ pulses recorded at ISAC from a toroid signal in BL2A, connected to the MIDAS data acquisition center: see Fig.5
- Isotope release recorded at the ISAC Yield Station: see Fig. 6 and 7.

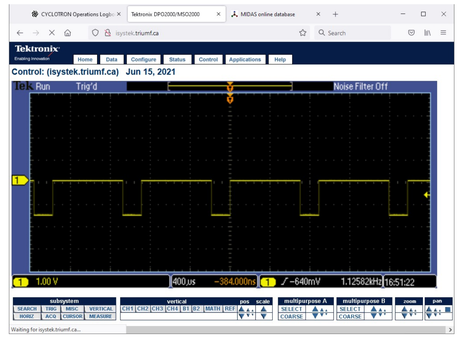



*Figure 5: Toroid signal seen in ISAC for 20% DF (Duty Factor)*

- One of the first p+ beam pulses was used to see the release of $^{142}Cs$ and built-up activity.

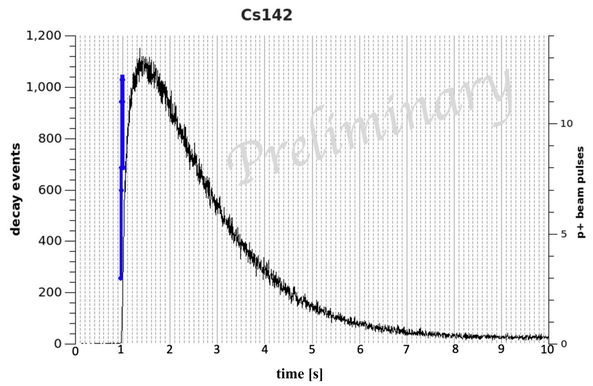



*Figure 6: $^{142}Cs$ release from 2 μA of 100 ms pulsed p+ beam from UCx#33 in ISAC*

- For a 100 ms pulse the $^{8}Li$ release and the built-up activity can be seen using the scintillator at the ISAC Yield Station and a channeltron.

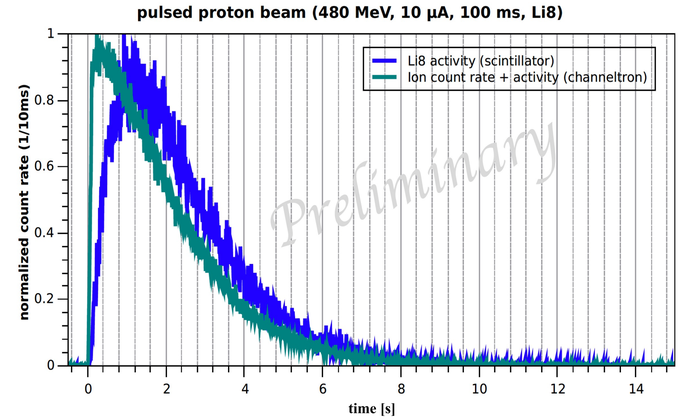



*Figure 7: $^{8}Li$ release from 10 μA of 100 ms pulsed p+ beam from UCx#33 in ISAC*

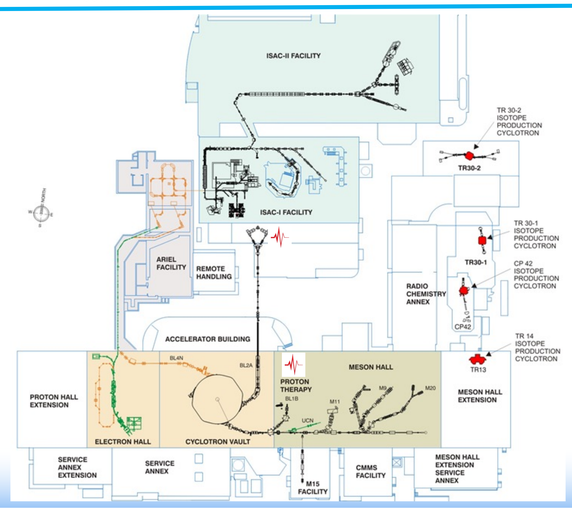
## Short p+ Pulses for Proton Therapy

Short p+ beam pulsing tested simultaneously in:

- ISAC facility for nuclear physics applications
- PT facility for medical science applications (FLASH)

The current PT facility can only deliver as short as ~ 350 ms, too long for FLASH where pulses have to be 50 ms to deliver 5 Gy at a dose rate of 100 Gy/s.

*Figure 8: p+ beam pulses sent simultaneously to ISAC and PT facility*



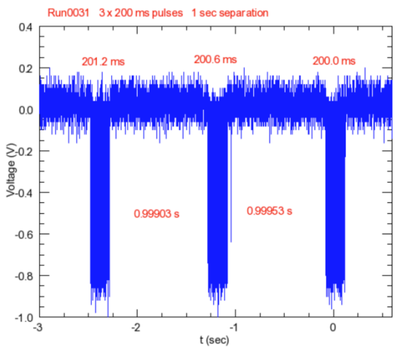




*Figure 9:* Measured scattered protons with a plastic scintillator to observe delivered bunch lengths

## Conclusions

- Both developments gave promising preliminary results for improving the short-lived isotopes releases of the ISAC targets
- Pulsing the p+ beam could become an important tool for other TRIUMF facilities
- For the medical science applications, specifically for FLASH proton therapy, this proton pulsing method can have a very important contribution

## References

1. A.S. Tanskanen, A. Laxdal, P. Kunz, M.R. Pearson, A. Shkuratoff "Developments of direct temperature measurements of ISAC and ARIEL targets at TRIIUMF" Nuclear Instruments and Methods in Physics Research B, 463 (2020) 248-250.

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