Discovery, accelerated

Improved isotope intensity and purity from a new spallation-driven proton-to-neutron converter at ISAC

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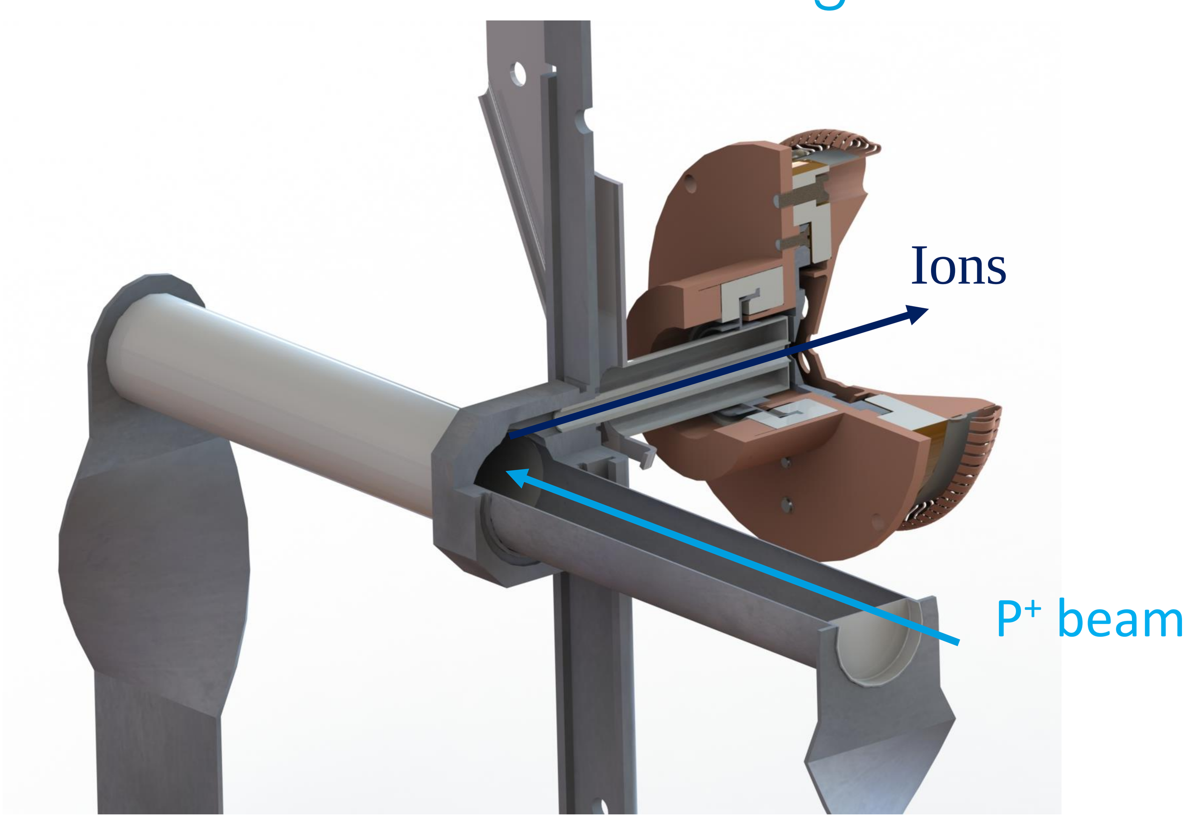
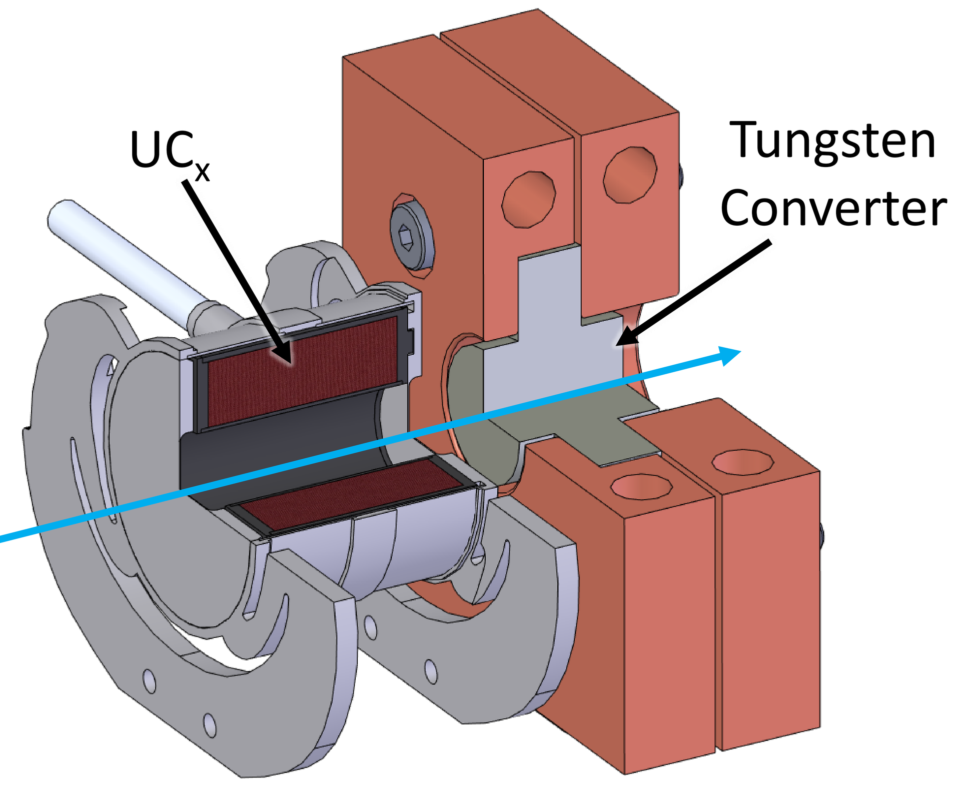
Introduction

A spallation-driven, proton-to-neutron converter has been developed and irradiated at the ISAC-TRIUMF facility, focusing on the production of Radioactive Ion Beams (RIBs) of neutron-rich fission fragments and limiting the production of their neutron-deficient isobaric contaminants. Moreover, this converter approach allows to deposit up to ~7 kW of proton beam power into a water-cooled converter, thermally decoupled to the target assembly, which enables a more homogeneous temperature distribution in the target material and resulting in a more optimized release of radioisotopes.

Conventional design

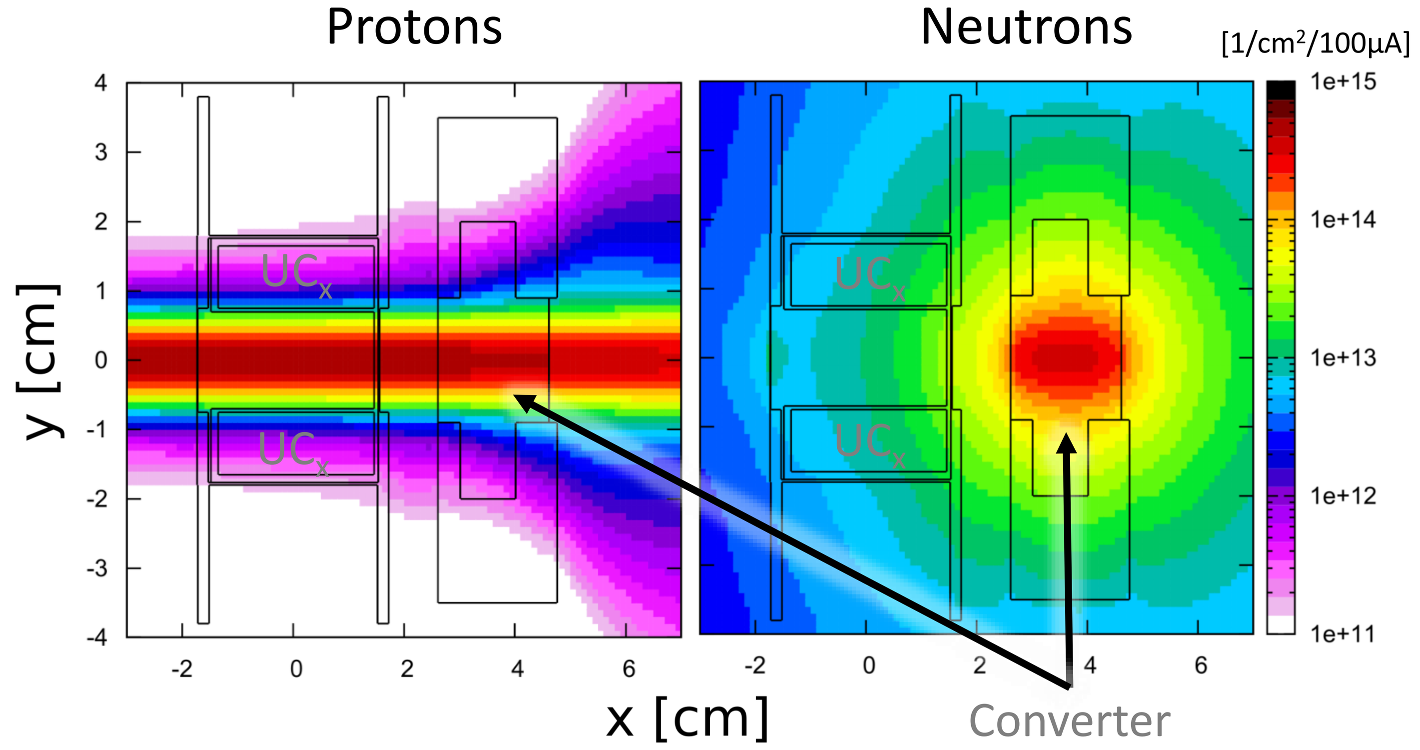


Converter design

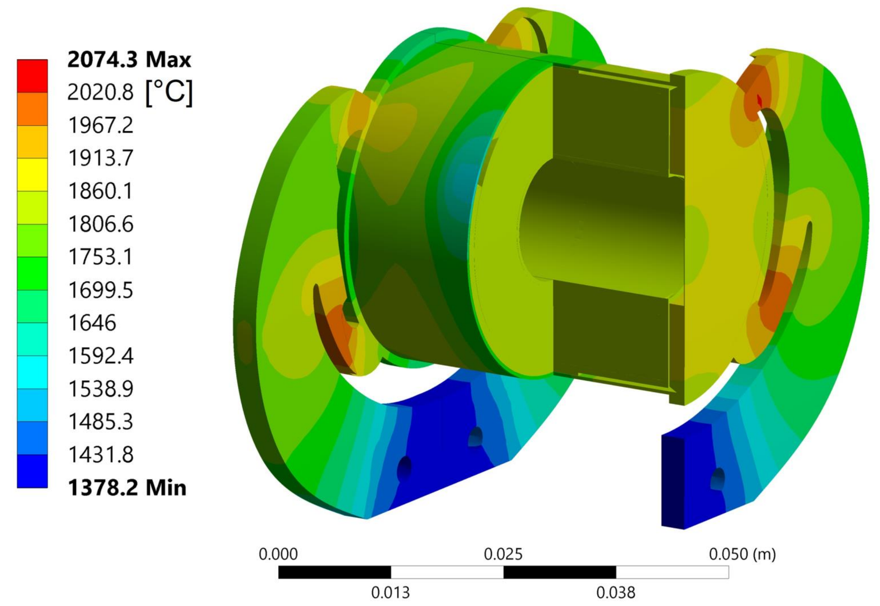


Conventional ISAC target (left) and proton-to-neutron target designs (right). The tungsten converter produces spallation neutrons upon proton beam interaction, which trigger fission in the upstream UCx annular target.

Simulated particle fluxes

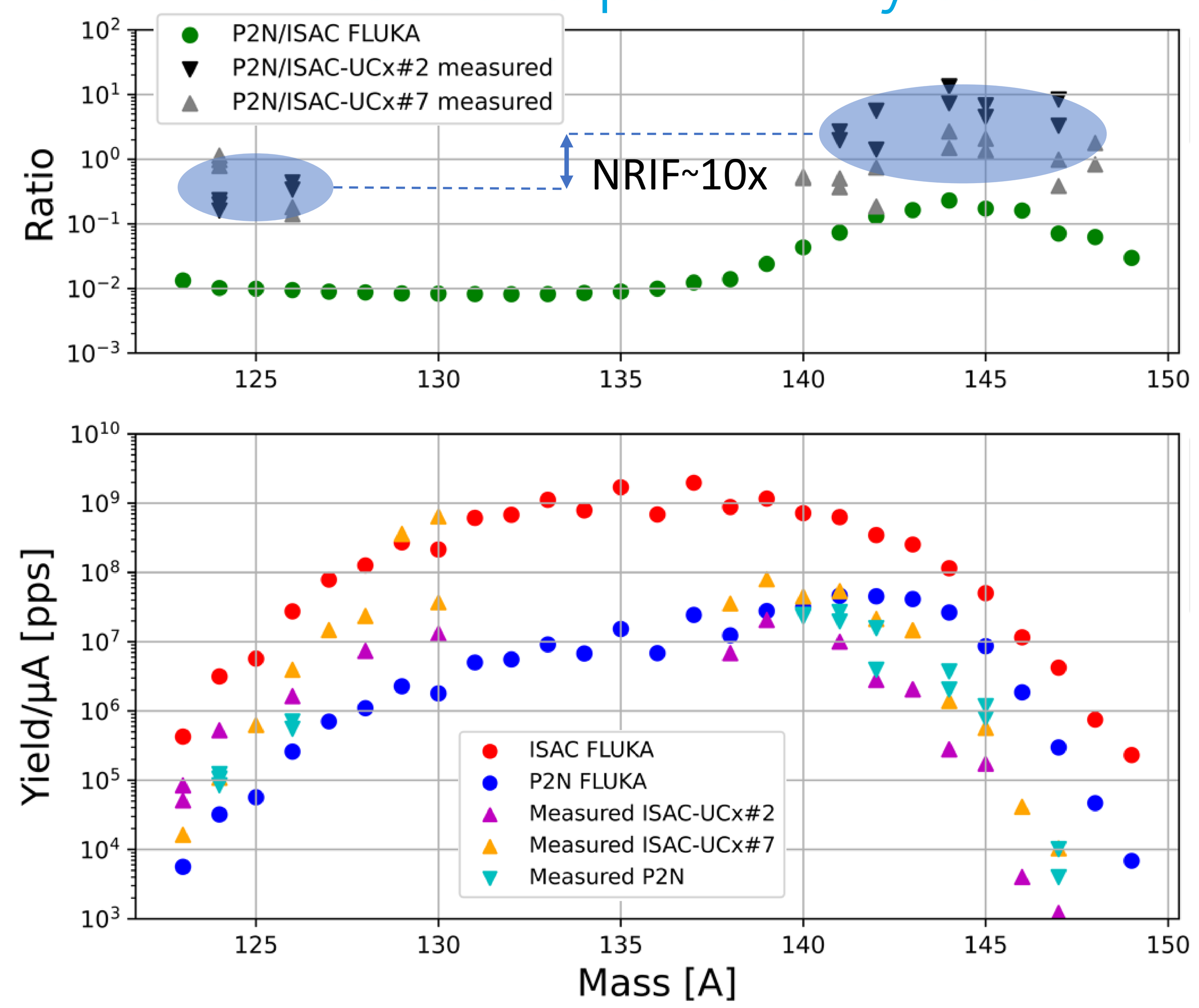


Simulated target temperature



Proton (left) and neutron (centre) fluxes shown across the P2N target middle plane. The annular UC_x target material is optimized to avoid excessive interaction with the central proton beam, while neutrons are emitted isotropically. Right: temperature distribution in the target assembly, including annular UC_x target material.

Cs isotope chain yields

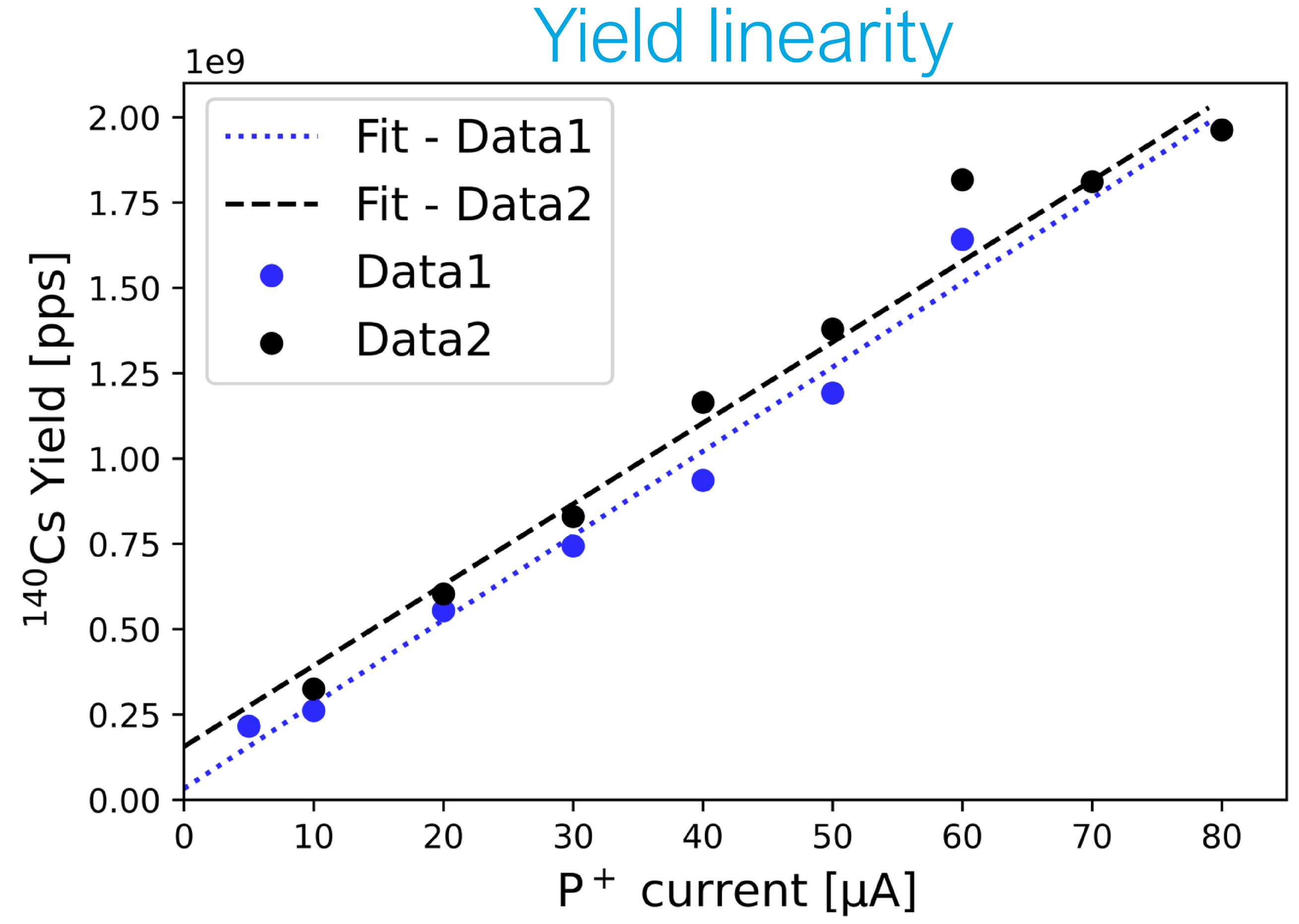


Methodology

Compare simulated in-target production and yield measured at the yield station by taking the ratio between converter and conventional targets. The Neutron Rich Improvement Factor (NRIF) quantifies the converter capability in reducing contaminants with respect to conventional ISAC targets.

- Simulated ratio (●) shows expected improvement in the neutron rich region.
- Measured ratios (▲▼) are half-life independent.
- NRIF ~ 10-50 measured for Rb, Cs, Sn.
- Yields/µA → converter can receive four times more proton beam intensity than conventional targets thanks to its thermally-decoupled converter.

Yield linearity



Methodology

Measured several ^{140}Cs and ^{141}Cs yields at different proton beam intensity, without changing any target heating parameter.

- Linear trend was found.
- Thermal decoupling was confirmed.
- No Radiation Enhanced Diffusion (RED) effect was noticed.
- Conventional targets require adjustments in resistive heating when the proton beam intensity is changed, which had so far prevented this systematic investigation on RED effect.

Conclusion

Neutron Rich Improvement Factors around 10-50 have been measured over two online beam times, pointing to the converter ability to **deliver on the simulated expectations for reducing isobaric contamination**. Moreover, yield measurements were interleaved with mass measurements at the TITAN facility using the MR-ToF. Ten first measurements of isotopes ^{83}Zn, ^{149}Cs, ^{150}Cs, ^{151}Cs, ^{151}Ba, ^{152}Ba, ^{136}Sn, ^{137}Sn, ^{138}Sn and ^{86}Ga were carried out, which would have been impeded by contamination without this new target design. The routine online operation of this converter is being discussed and planned for the next years of ISAC and ARIEL Proton Target West (APTW) station operation.