A “makeshift spallation neutron source” for neutron-rich Te isotopes at ISOLDE

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Introduction

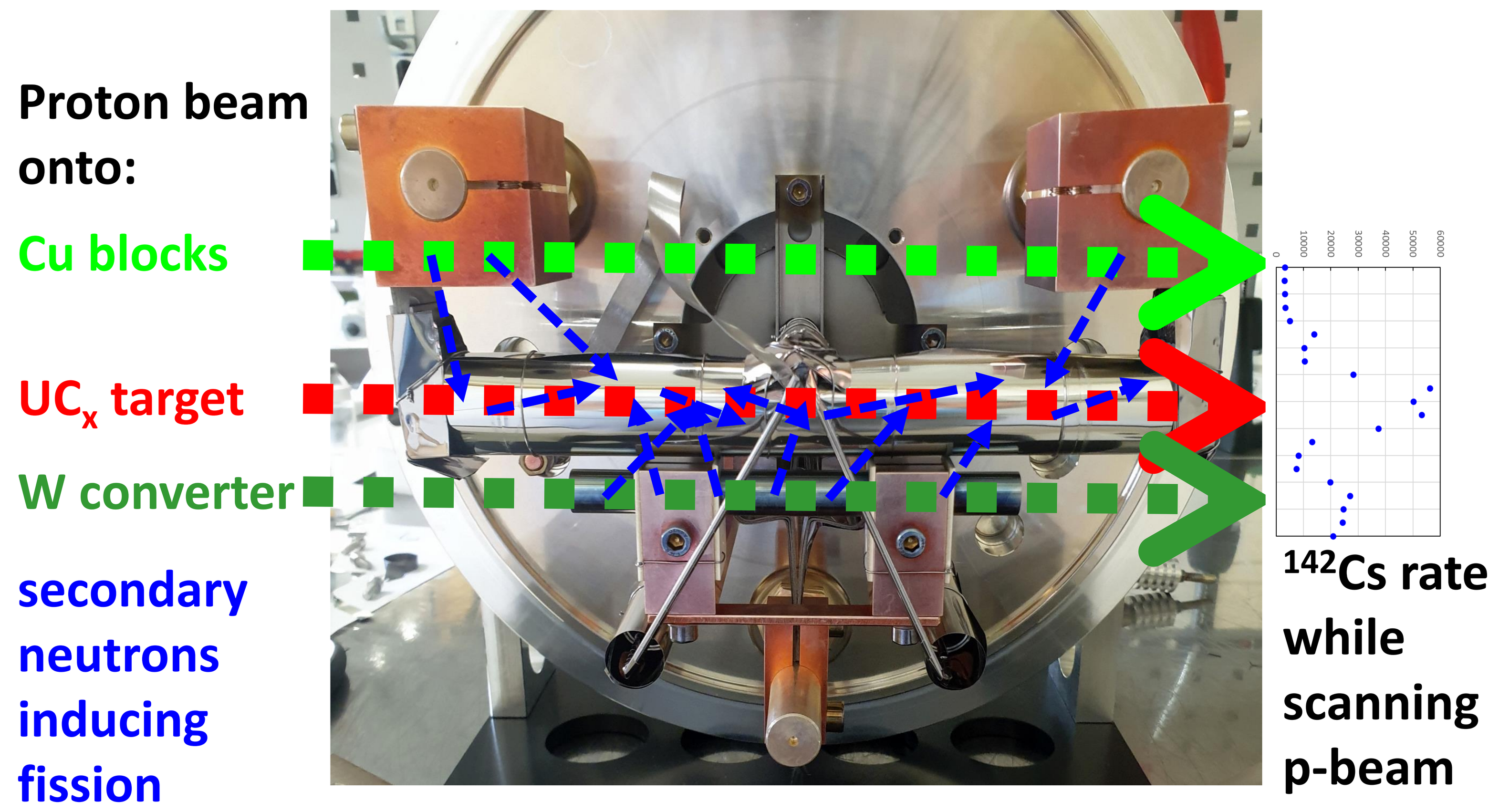
High-energy (GeV)-proton-induced fission generates a wide isobaric distribution ranging from neutron-rich to neutron-deficient isobars. This can lead to disturbing background of neutron-deficient, easily surface ionized isotopes, such as Rb or Cs, in particular when weakly produced neutron-rich isotopes around N=50 or N=82 are aimed for. Such background can be significantly reduced by the use of a so-called “neutron converter”, typically a tungsten rod mounted parallel to the target that serves as miniature spallation neutron source [1]. Mainly the laterally emitted part of the evaporation neutron spectrum will induce MeV-neutron-induced fission that provides an isobaric distribution centered on the neutron-rich side.

Only part of the ISOLDE target and ion source units are constructed with an integrated tungsten neutron converter. Thus, the use of a neutron converter has to be planned well ahead in the schedule and cannot be decided ad hoc during an experiment. However, in principle, the massive copper current leads that are present in every target unit could also serve as “makeshift neutron converter”. The secondary neutron yield of such medium mass spallation targets is reduced with respect to tungsten, but, at least for certain applications it can provide sufficiently intense and pure beams of neutron-rich isotopes. We present the first application of such a makeshift neutron converter at the example of beams of tellurium isotopes.

Experimental Setup

A standard UC_x target with W converter was irradiated with 1.4 GeV protons, directly onto the target or onto the W converter or onto the Cu blocks respectively.

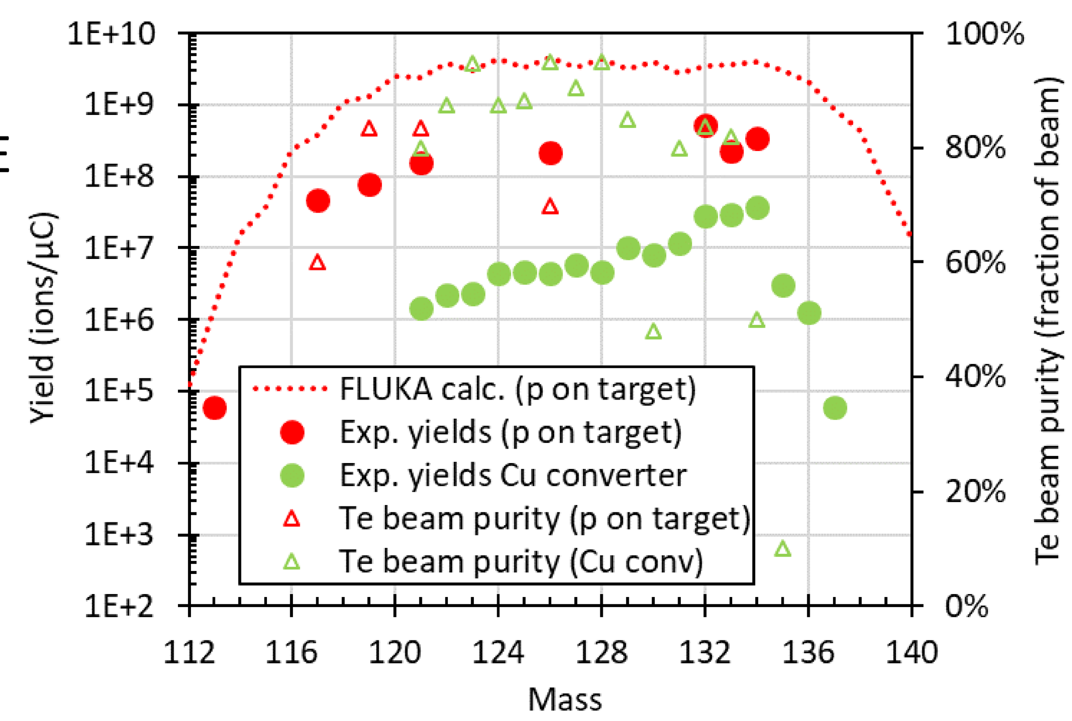
Te isotopes were laser ionized in a 2000 °C hot W line with a 3-resonant-step RILIS scheme (214 nm - 573 nm - 901 nm) [2].



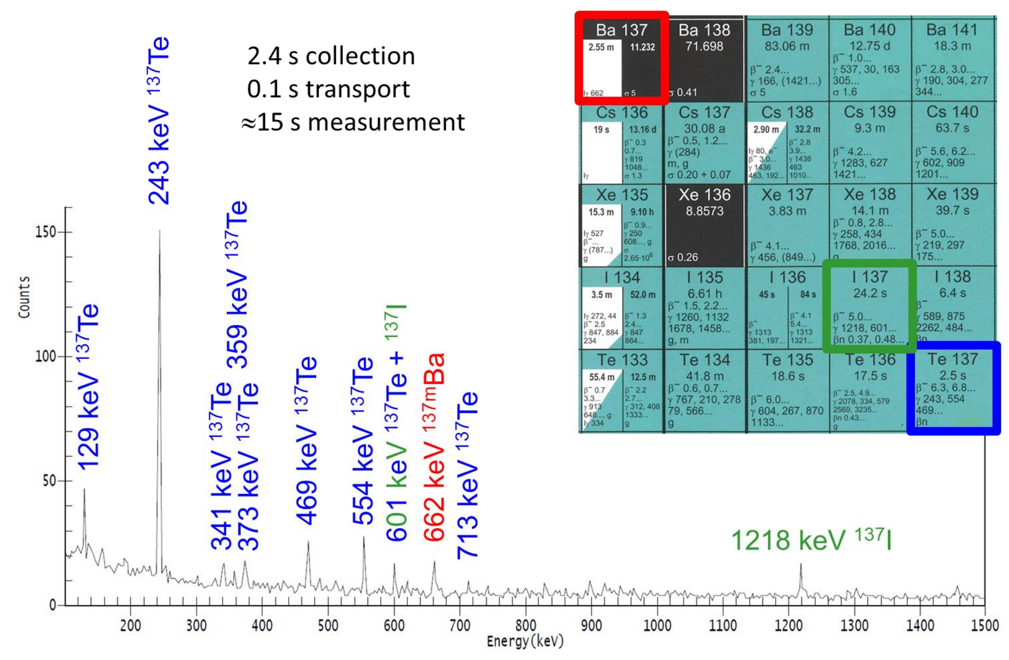
Results

Yields, release properties and isobaric contaminants were measured with the new ISOLDE fast tape station by β counting or γ-ray spectrometry [3] and by Faraday cup measurements respectively.

Comparison of experimental yields with FLUKA simulations shows an overall (release and ionization) efficiency of 5-10%.

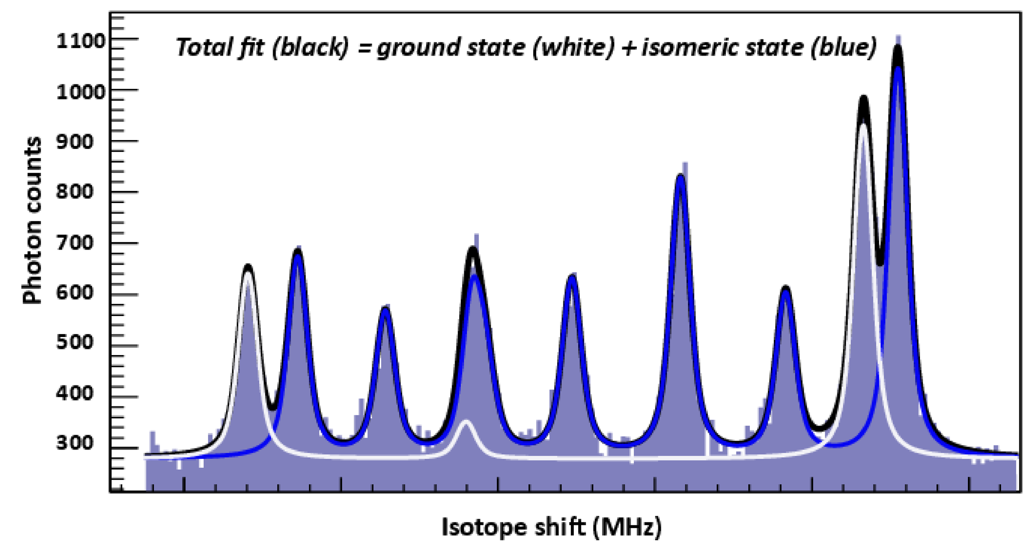


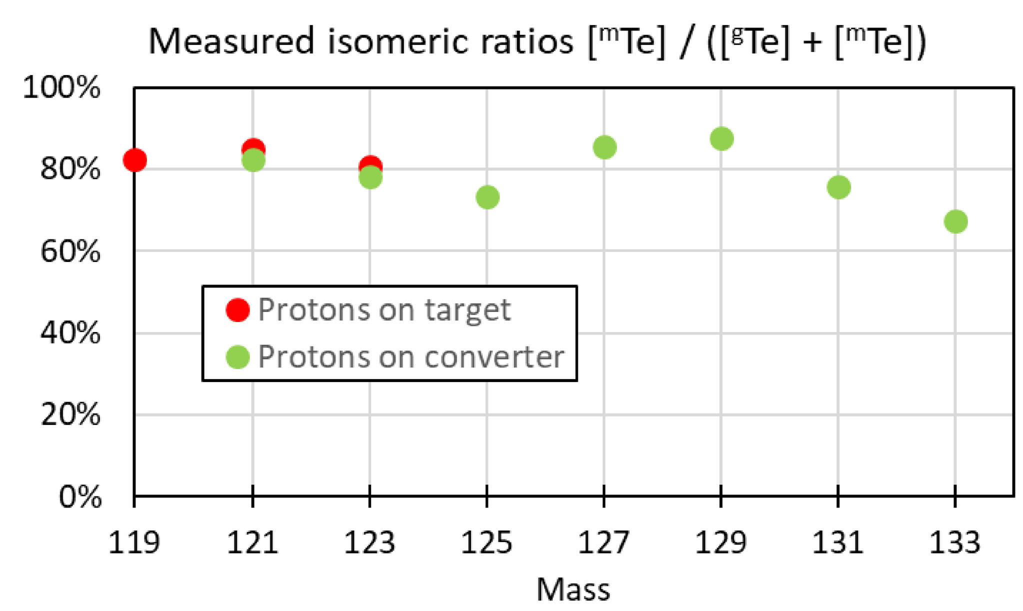
This example γ-ray spectrum of ^{137}Te decay demonstrates that, despite some isobaric background (here surface ionized ^{137m}Ba), the Te beams up to ^{137}Te are sufficiently pure for decay spectroscopy applications. ^{137}I is not directly ionized but a decay product of the ^{137}Te beam.



Isomeric ratios (here the relative production of the high-spin isomer to the sum of high- and low-spin isomer), can be determined by γ-ray spectrometry, provided the half-lives are not too long and the γ-ray intensities of the respective decays are well known.

The Te beams discussed above were used for a collinear laser spectroscopy experiment with the COLLAPS setup. This data set was also exploited to derive isomeric ratios by fitting the relative intensities of ground- and isomeric state resonances. This method is more universal than γ-ray spectrometry as it covers also long-lived and stable isomers.





As expected for fission production, the high-spin isomers are dominantly produced.

Conclusions and Outlook

- The copper current leads present in every ISOLDE target unit can serve as “makeshift neutron converter” for production of “clean” beams of neutron-rich isotopes (not only Te). Yields are lower by a factor 5-10 compared to usual W converters, but still useful.
- Te RILIS with a standard W line readily provides beam purities >80% for $^{122-133}$Te beams with protons on the “make-shift converter”.
- For A=134-137 the beam composition is dominated by isobaric Cs and Ba background, but Te decay spectroscopy is well possible.
- Use of a high temperature quartz transfer line could provide a further suppression of Cs and Ba isobars.
- Collinear laser spectroscopy with COLLAPS provides as side result reliable isomeric ratios of ISOL beams that are not biased by the knowledge of nuclear decay data.

[1] R. Catherall et al., Nucl. Instrum. Meth. B 204 (2003) 235.
[2] T. Day Goodacre et al., Nucl. Instrum. Meth. A 830 (2016) 510.
[3] S. Stegemann et al., contribution to EMIS-2022.