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Letter of Intent to the INTC

UCx prototype target tests for EURISOL

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Abstract

Within the EURISOL-Design Study project, several uranium carbide target prototypes are under development. In particular, a high-density uranium carbide material of 12g/cm^3 has already been tested at IRIS, Gatchina, with encouraging results for short lived isotopes. However, a lack of reference yields in a well defined geometry and at high proton beam intensity prevented the review panel held in Nov. 2007 to draw definitive conclusions [1]. The panel therefore strongly supported the target tests proposed at ISOLDE, subject of the present letter of intent. Yields and release curves for isotopes produced with a thick, high density UC target and the intense proton beam of the CERN-PSBooster need to be compared with the extensive database obtained with a conventional UCx material in the standard geometry used at ISOLDE. Further comparisons are proposed with a newly developed UCx material synthesized at INFN-LNL. Yields and release curves of representative isotopes will be measured at the tape station with the beta-gamma detector system and collections will be made for long-lived isotopes. Data will be analyzed in details and compared to the results obtained at IRIS for the same material, and at ISOLDE for the same target and ion source geometry.

1. Introduction

The production of radioactive ion beams by the ISOL technique relies on the online extraction and ionization of nuclear products from thick targets irradiated with energetic particle beams at high temperatures under vacuum. At ISOLDE, irradiation of Uranium Carbide targets with 2μA on average, 1.4 GeV pulsed protons from the PSBooster induces fragmentation, fission and spallation reactions. Neutron rich isotopes can also be produced by fission reactions with spallation neutrons coming from a solid Tungsten or Tantalum converter located nearby the UCx target. Such UCx targets have been developed and used for more than 25 years at ISOLDE, are operated in various facilities worldwide (ORNL-USA) and is the subject of an active R&D program for next-generation (SPES, SPIRAL II) and future radioactive ion beam facilities (EURISOL). Within the ongoing EURISOL-DS project, actinide targets are more particularly used either in combination with a 4MW liquid mercury loop proton-to-neutron converter or by direct 100kW proton beam irradiation. While ISOLDE UCx targets

are made by UO_2 and graphite powder cold-pressing and by subsequent carburization with a final density of ca 3.5g/cm^3, alternative materials become now available, such as pellets processed with binders and High-Density UC ceramics of up to 12g/cm^3. These High-Density UC materials have already been tested at the IRIS facility, PNPI, Gatchina, with encouraging results at low beam intensity [2] and need to be tested for real production conditions in a standard geometry such as those available at CERN-ISOLDE. Comparison and benchmarking will be possible thanks to the large set of available release data done with the previous UCx target and ion source units. Similarly a new kind of UCx material has been developed at INFN-LNL comprising binder materials for better mechanical properties, which will also need to be tested at ISOLDE in realistic conditions.

2. Tests to be performed at ISOLDE

Targets and Ion sources are tested at ISOLDE in a systematic way with a tape station equipped with a combined beta-gamma detector set-up. Thanks to the pulsed nature of the proton beam available at the PSB, release curves can be obtained for different isotopes with suitable yields and half-lifes, Figure 1. This can conveniently be fitted by a 3 exponential function or a more detailed function which take into account analytical expressions for diffusion and effusion phenomena [3, 4].

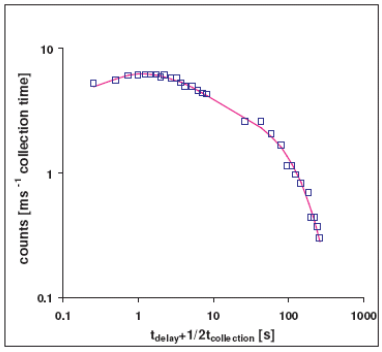

Figure 1: release function for 85Br obtained at ISOLDE from an UCx target coupled to a MK4 negative ion source. The continuous line is obtained with the best fit to the experimental points with the 3 exponential function: $P(t) = (1 - e^{\frac{-ln2t}{t_r}}) \cdot (\alpha\, e^{\frac{-ln2t}{t_f}} + (1-\alpha)\, e^{\frac{-ln2t}{t_s}})$ t_r= 0.31s, t_f=3.9s, t_s=116s, α=0.86 and a normalizing constant. See ref 3 for more details.

Systematic studies of release properties for a given series of chemical elements is possible thanks to the high production cross-sections provided by fragmentation, spallation and fission reactions of 1.4 GeV protons which covers most of the periodic table, either on the proton or on the neutron-rich side. It is thus possible to obtain yields and release properties of Li, Na, K, Rb, Cs and Fr alkali isotopes using a surface ion source and of He, Ne, Ar, Kr, Xe and Rn noble gas using a FEBIAD ion source coupled to a cold transfer line. The use of the RILIS ion source allows furthermore to selectively ionize diverse other elements of potential interest such as Ga or Ni isotopes [5].

3. Beam time request

We envisage to test 2 different Uranium Carbide materials in 3 separate target and ion source units in a standard configuration. We envisage to test first a High Density Uranium Carbide target material coupled to a surface ion source for alkali elements and RILIS for the test of Ga or Ni isotopes. In a second stage, we intend to combine it with a cold FEBIAD MK7 ion source to investigate noble gas elements. Finaly, we will test the UCx+binder material developed at INFN-LNL coupled to a surface ion source to study alkali elements. Tests will done by direct proton irradiation or by n-induced fissions for suitable elements.

Target and ion source	Beam time
HD-UC + MK8 (W), n-converter, RILIS	1 shift stable beam set-up + 1 shift to set-up RILIS + 5 shifts for radioactive beam tests.
HD-UC + MK7, n-converter	1 shift stable beam set-up+ 5 shifts for radioactive beams tests.
INFN-UCx + MK8 (W), n-converter	1 shift stable beam set-up+ 5 shifts for radioactive beams tests.

4. Conclusion and Summary

It is of primary importance for the various planed or operating worldwide ISOL-type facilities to carry-out tests for the quoted newly developed Uranium Carbide targets in a systematic and standardized approach. The ISOLDE facility offers a unique place to perform such tests thanks to the large available database and to the intense 1.4 GeV proton beam.

References

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