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Request to the Chairman of the ISOLDE Committee for additional beam time

Test of a High Power Tantalum Target

CLRC[1] - CERN[2] - Brighton[3] - Liverpool[4] - Manchester[5] -Surrey[5] collaboration

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1. The RIST Target Test at ISOLDE, December 1994

In December 1995 the performance of a high power (100 μA of 800 MeV protons) tantalum target, being built for the RIST project at ISIS, was measured at ISOLDE (proposal CERN ISC-94-12, ISC-P64). The test provided an important bench mark for the comparison of the target with the standard tantalum ISOLDE target.

The experiment on ISOLDE was successful and the results are summarised in a short report, RIST/TN4/95, attached (a full report is in preparation). The yields are within the spread of the yields obtained at ISOLDE but the response times are halved. During the experiment stable Yb vapour was introduced into the ioniser to simulate the intense beams of rare earths to be expected at proton currents of 100 μA. The yields of radioactive ions is reduced by no more than 10 %. The target ran for 7 days and received an integrated total of $3x10^{18}$ protons (an average dose for an ISOLDE target) before the experiment was terminated at the end of the cycle. The target is to be cut open in May 1995 to examine the state of the foils within the tantalum target tube.

The experiments threw up a number of further questions:-

i) The faster response time is assumed to be due to the foil geometry - discs instead of rolls. However, is the response time limited by diffusion through the foils or by effusion from the foils to the ioniser?

ii) Better statistics are needed to determine the spread of results from the RIST type target and the standard ISOLDE target on the PS-Booster under identical measuring conditions.

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A programme of experiments is suggested, aimed at improving the performance and understanding the processes within the target. However, the limited beam time available at ISOLDE in relation to the test of the RIST target at ISIS in April 1996, forces us to establishing an experiment priority.

Calculations show that the optimum geometry requires a more open target, but the relative importance of diffusion and effusion rates must be known. To test this, it is proposed to build and test a second target with foils of 0.1 mm thickness, 4 times thicker than that of the RIST target and 5 times that of the standard ISOLDE target. Reducing the number of foils would also have the advantage of simplifying construction, particularly for the RIST target.

2. Request for Additional Beam Time

A programme of further experiments is suggested from the results of the test of the RIST type target. As a priority, we wish to examine the relative importance of diffusion and effusion within the target by changing the target foil thickness from 0.0025 to 0.01 cm.

We request 3 shifts to carry out measurements using the ISOLDE tape system, preceded by 3 shifts of stable beam exercises (no protons on target). In addition the target will need to be assembled, conditioned and tested in the same way as a standard ISOLDE tantalum target before mounting on-line. The proton beam will be defocused as in the previous experiment.

RAL will provide the tantalum foils and ISOLDE will provide the target container and ioniser. The target will be prepared jointly by RAL and ISOLDE staff.

RIST Target Test at ISOLDE

Paul Drumm

1. Introduction

A proposal to test a RIST target was submitted in May 1994 to the ISOLDE Scientific Committee at CERN and was subsequently approved. The proposal, entitled "Test of a High Power Target Design", was supported by a collaboration between the Rutherford Appleton Laboratory, Daresbury Laboratory, CERN and various nuclear physics communities in the UK Universities. The experiment was run at ISOLDE in December 1994, prior to the CERN winter shutdown.

The aims of the experiment were :

1. To establish a set of benchmark yield measurements which could be used to measure the performance of the RIST target compared to the standard ISOLDE target at the SC and at the PS-Booster, and also of the RIST target at ISIS.
2. To see if the arrangement of the foils in the RIST target could lead to an increased rate of release of the radioactive products: faster release should lead to an increase in the yields of the shorter lived isotopes, ^{11}Li for example.
3. To see if there were problems with the design that might lead to a deterioration in the target that could shorten the lifetime and therefore decrease the yields.

2. The Measurements

Measurements of yield and the response curves reported in this document were taken with the ISOLDE tape-station using β-counting. In addition to the β-measurements, mass-scans were taken by measuring the intensity of a beam in the faraday cup at the focal plane of the separator magnet as a function of the magnet setting. These were made before and after irradiation of the target. All measurements were taken with the Booster proton beam defocused to approximately the size of the target diameter.

During the experiment, stable Yb vapour was introduced into the ion-source. The intention was to simulate the load due to rare-earth atoms that will build-up in the RIST target as a function of time during irradiation. The total magnitude of these beams can be estimated to be 50 times that measured at ISOLDE, or of the order of 200 nA total. With a Yb beam of this current, the observed beams of radioactive ^{25}Na and ^{176m}Yb were unaffected (<10% effect). At higher currents of Yb (~1μA), a 20-30% decrease in efficiency was observed and at 3-4 μA of Yb beam, a 50% loss of efficiency was observed. It is concluded that the build-up of the rare-earth nuclei in the target during the run should not be a problem for RIST.

3. Results

The results, together with the performance of the ISOLDE tantalum target taken from the "Yellow Book" and ISOLDE PS-Booster, are shown below for each element with some conclusions. The average yields are given with the spread of measurements in brackets. Figures 1 and 2 show this data and an empirical calculation of the yields, assuming no losses and 100% ionisation.

Table 1 Summary of Results

Isotope	RIST PS-Booster	ISOLDE PS-Booster	Yellow Book SC	Conclusions
^{8}Li ^{9}Li	1.3(±.4)x10^{8} 8.3(±1)x10^{6}	5.5(±3)x10^{7} 2.8(?)x10^{6}	3.9x10^{8} 3.6x10^{7}	Yield of ^{8}Li is high from the RIST target and comparable to the SC. The yield of ^{9}Li is lower than expected considering the faster release of the RIST target.
^{25}Na ^{26}Na	1.2(±.3)x10^{7} 1.2(±.5)x10^{6}	4(±3.8)x10^{7} -	3.7x10^{7} 4x10^{6}	Large spread in ISOLDE yields makes comparison difficult. Average yields comparable to SC.
^{46}K	4(?)x10^{5}	6.1(?)x10^{5}	5x10^{6}	RIST and ISOLDE comparable but considerably lower than SC. The RIST target is noticeably faster.
^{124}Cs				Some doubt about identification.
^{176}Yb	5x10^{5}	5.1(±4)x10^{5}	~10^{7}	RIST and ISOLDE comparable but considerably lower than SC
^{144}Eu	Yield Variable			Yield depends on target history but RIST, ISOLDE and SC are comparable.

Discussions with the ISOLDE group were held to draw conclusions about the run on the RIST target and its performance relative to the ISOLDE-Booster and ISOLDE-SC. However, there are a number of differences between the Booster and the SC in the proton pulse structure, energy and intensity and between the ISOLDE and RIST targets in the arrangement of the foils. It was not possible to resolve the apparent discrepancies and anomalies in the results for both the RIST and ISOLDE targets, let alone those for the ISOLDE target on the SC and the Booster.

4. General Conclusions

The yields from the ISOLDE tantalum targets vary widely. Yields from the 3 tantalum targets run on the Booster would appear to be generally lower than from those of the SC. Whether this is real, due to the different proton beam time structure and energy or the new separator etc., is not known. It would be expected that the yields would be higher on the Booster due to the higher proton energy. It is not the purpose of this experiment to investigate the variability in the yields from ISOLDE, but if the ISOLDE measurements of yield vary widely (an order of magnitude) then this variation could occur in the RIST target measurements. Nevertheless, the RIST target yields are well within the spreads of the ISOLDE target measurements and the RIST target response times are about twice as fast as those of the ISOLDE target.

There are a number of apparently strange anomalies in the comparisons. The RIST target seems to be fast for the alkalies, particularly K, yet the RIST target yield is not correspondingly superior to the ISOLDE targets, nor does the yield increase particularly for the shorter lived isotopes.

The ISOLDE target Ta#045 was examined briefly by ISOLDE. The activity on the target unit was 6 mSv/hr contact and 3 mSv/hr at 10 cm. The target container was cut open and some of the rolls of foils were removed. Only slight damage was seen on the entry window. However, there was considerable damage to the foils inside the target tube: local melting over a small cross section of the foils was evident at the beam entry end of the target. The target had been operated with a defocused beam except for the first 30 minutes when the usual small beam of ~3 mm diameter had been used. It is assumed that the damage had occurred during the focussed beam operation.

It was proposed to further investigate new RIST and ISOLDE targets when possible during future runs. A request for time to test a RIST target with a foil thickness of 0.1 mm would be made to the ISOLDE Committee, and was the highest priority. Increasing the foil thickness by a factor of 4 should test if diffusion or effusion is the limiting factor in the target response.

(A more complete version of this report is available on request).

20 April 1995

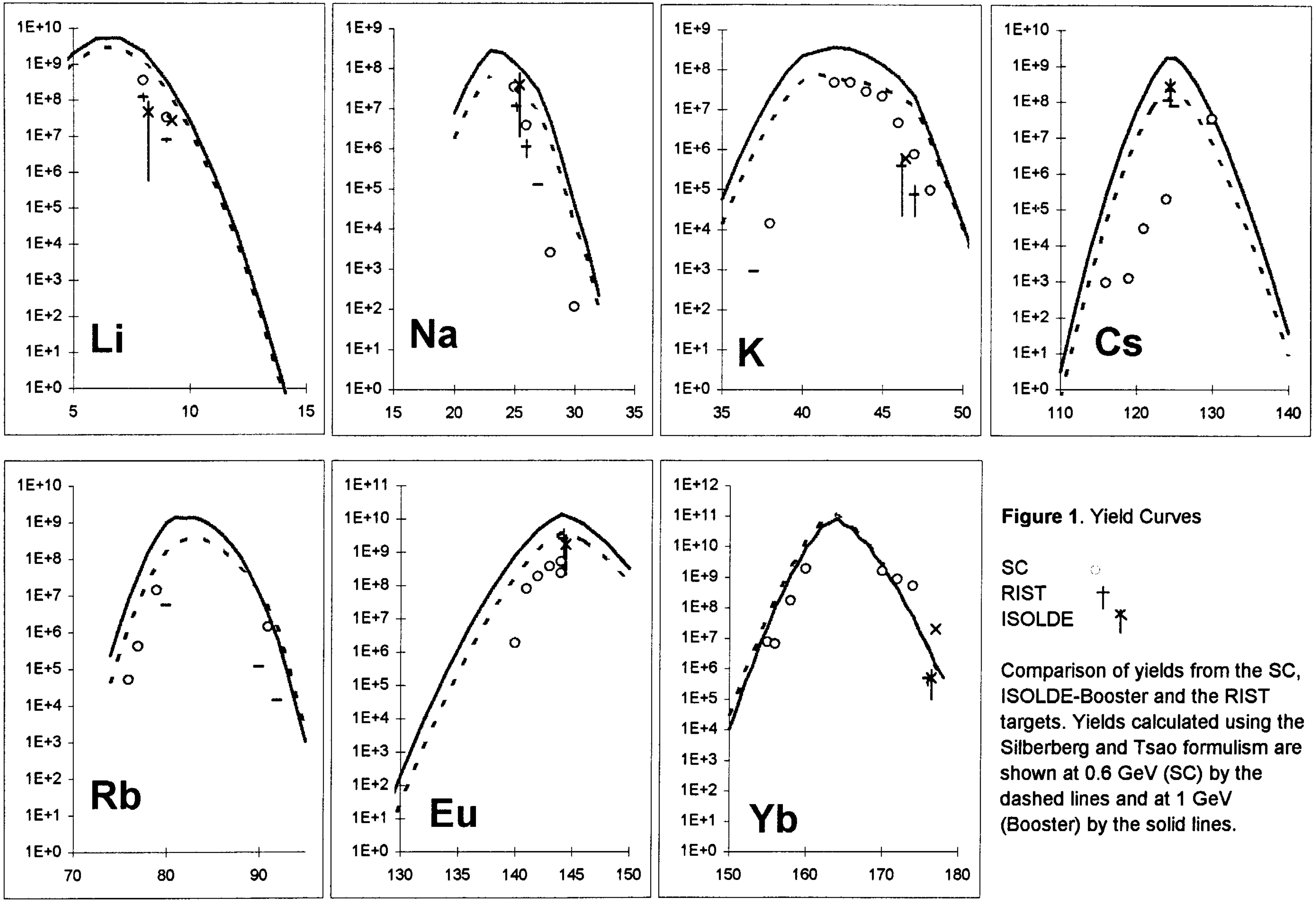

Figure 1. Yield Curves

SC ○
RIST †
ISOLDE ×

Comparison of yields from the SC, ISOLDE-Booster and the RIST targets. Yields calculated using the Silberberg and Tsao formulism are shown at 0.6 GeV (SC) by the dashed lines and at 1 GeV (Booster) by the solid lines.

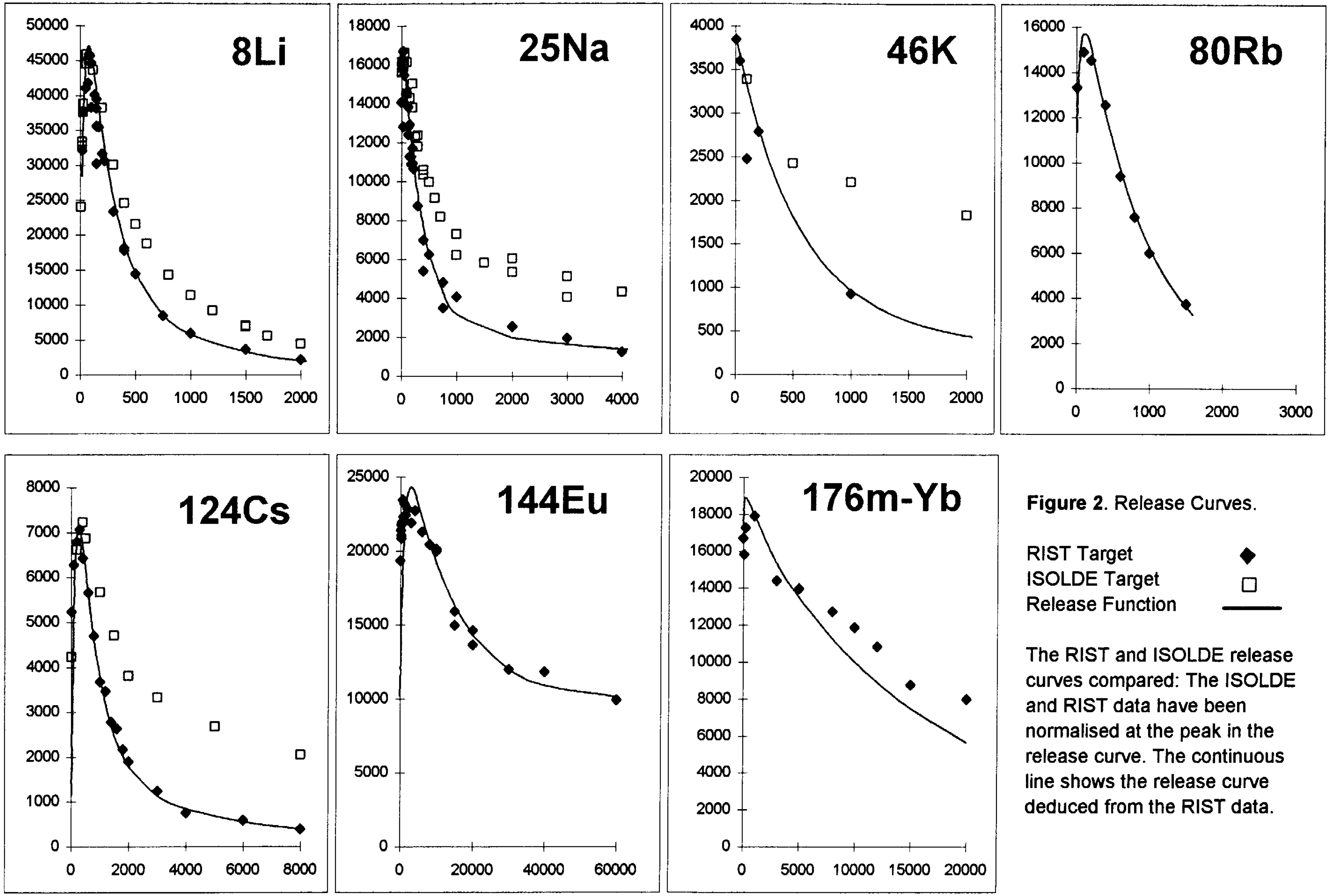

Figure 2. Release Curves.

RIST Target ◆
ISOLDE Target □
Release Function —

The RIST and ISOLDE release curves compared: The ISOLDE and RIST data have been normalised at the peak in the release curve. The continuous line shows the release curve deduced from the RIST data.