The RIST Project at ISIS

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Abstract

A description is given of the Radioactive Ion Source Test (RIST) Project to develop a target and ion source to produce intense beams of radioactive ions using the proton beam of the pulsed neutron scattering Facility, ISIS[1] at the Rutherford Appleton Laboratory. A tantalum foil target is bombarded by 800 MeV protons at currents of up to 100 μA. The target is kept at temperatures of 2000 - 2700 K. The radioactive particles diffusing out of the foils are ionised on a hot tungsten surface. The ions pass into a magnetic analyser and are identified by nuclear detection techniques.

1. INTRODUCTION

Radioactive nuclear beams have important, exciting and increasing uses in a wide area of science:-

- Nuclear Astrophysics
- Nuclear Physics
- Solid State and Atomic Physics
- Biology and Medicine

Radioactive nuclei can be produced by the impact of high energy protons on a thick target. This is the method employed by the on-line isotope separator, ISOLDE[2], using proton currents of up to 2 μA from the 1 GeV PS-Booster at CERN. The RIST Project is aimed at the development of a target and ion source to produce higher intensity radioactive beams. The world leading pulsed neutron facility, ISIS, with proton currents of up to 200 μA from the rapid cycling 800 MeV synchrotron, is well placed to carry out this development.

This project is part of a European and world-wide R&D programme to produce a proposal for an advanced radioactive ion beam accelerator facility.

2. THE AIMS

The aims of the project are specific and limited:-

a) To produce unstable nuclei from a tantalum target using the 800 MeV proton beam from ISIS, with mean proton currents of up to 100 μA.
b) To show that the radioactive ion currents are comparable to those of other similar sources, such as ISOLDE at CERN, at the same proton beam current on the target.
c) To show that the beams of these isotopes are increased in proportion to the proton current on the target.
d) To examine fluctuations of the high voltage on the target and ion source when the target is bombarded by intense pulsed proton beams.

3. THE TARGET AND ION SOURCE

The target and ion source will be built as closely as possible to the ISOLDE design so that comparisons of the performance are relevant. To limit the tests, only a tantalum target will be built. This will provide a wide range of radioactive particles, in particular the alkali metals and rare earths. The ISOLDE target consists of a tube containing short lengths of rolls of thin, 25 μm, tantalum foils. The tube is 2 cm in diameter and 20 cm long. The equivalent length of tantalum foil, through which the proton beam passes, is ~10 cm. The target absorbs about 600 W at 2 μA proton current.

The RIST target will be the same size as the ISOLDE target but will absorb up to 30 kW of proton beam power. To dissipate the higher beam powers in the RIST target it is necessary to change the configuration of the foils in the target tube. Good thermal conduction is required between the foils and the tube. To minimise the temperature rise in the foils they will be arranged effectively as a stack of discs welded to the inside of the tube. Each disc is 25 μm thick and spaced from its neighbour by 25 μm.

The target must be heated to temperatures of 2000 - 2700 K for sufficiently rapid diffusion of the short lived isotopes out of the thin foils. Electron beam heating will be used to heat the target at low proton beam currents. The particles then pass into an ion source. For simplicity a hot tungsten surface ioniser will be used similar to that employed at ISOLDE.

Dissipation of the heat from the high temperature target will be by thermal radiation to the surrounding water cooled vacuum vessel. The target must have no cold spots which could condense some of the products nor must it be allowed to become so hot that the target melts. Thermal stress must be minimised since tantalum is very weak at high temperatures. Thus the design must be optimised to keep the target at as uniform temperature as possible. A tapered hole through the centre of the target foil discs maintains the same beam power dissipation along the length of the target, helping temperature uniformity. Tests of the thermal properties of the target are underway.

4. THE SEPARATOR

The RIST target will be inserted through the top plug of the target station shield to replace the ISIS neutron production target which will be moved back to act as a beam stop. The target and ion source is at 30 kV and the radioactive ions are accelerated to ground potential and focused by an Einzel lens through a 5 cm diameter hole in the shielding to the top of the target station. All subsequent focusing is by electrostatic quadrupoles. A number of Faraday cups and slits are strategically placed along the beam line for setting up and measuring the beam. On emerging from the top of the shield plug, the ions are bent into the horizontal plane by a 90° electrostatic deflector and pass through a 60° bending magnet for mass separation. Finally their intensity and identity will be determined by Faraday cup and nuclear detection techniques. Figure 1 shows an illustration of the RIST equipment in the target station and an inset view of the target.

REFERENCES

[1] J L Finney, "ISIS: A Resource for Neutron Studies of Condensed Matter", Europhysics News, vol 20, 1989.

[2] H J Kluge (Editor), "ISOLDE Users Guide", CERN 86-05, 1986.

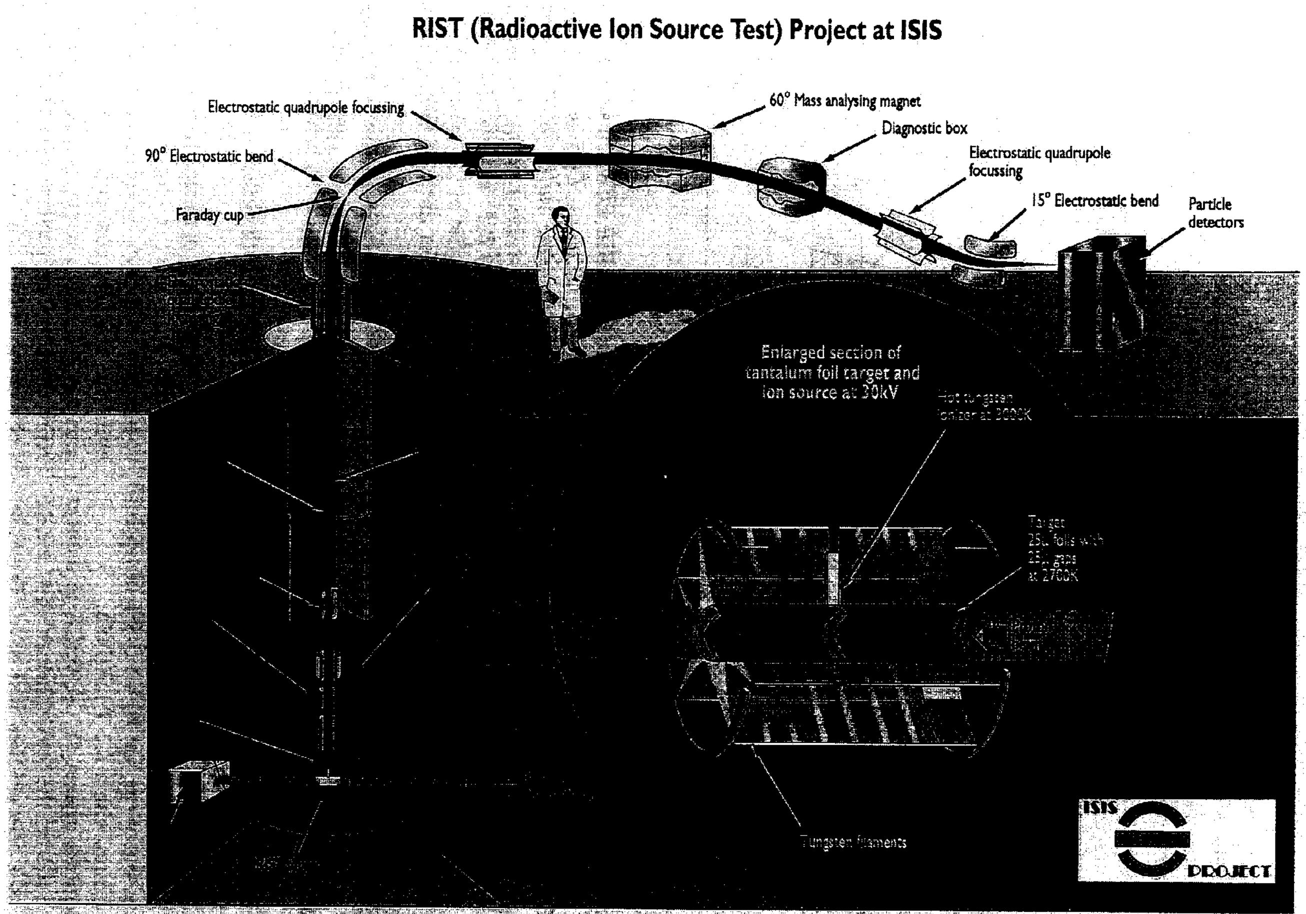

Figure 1 Illustration of the Radioactive Ion Source Test Project, RIST