Towards two-neutron transfer reactions with a tritium target: Characterization of a prototype $TiD_{0.24}$ target

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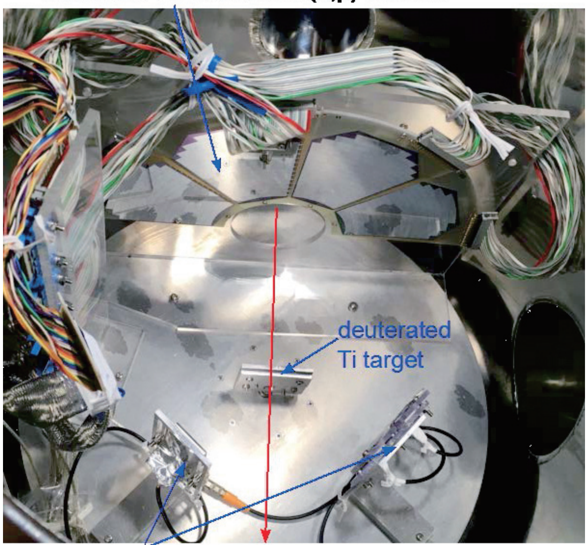
Two-nucleon transfer reactions are well-suited to investigate specific nuclear structure properties, like shape coexistence and pairing correlations. In particular neutron-adding reactions are of great interest because they can populate very exotic systems. The large neutron excess combined with the rather simple structure of the tritium nucleus makes it an ideal probe or target nucleus for two-neutron pair transfer reactions. With radioactive ion beams two-neutron transfer reactions have to be performed in inverse kinematics and therefore a radioactive tritium target is required. After pioneering work at REX-ISOLDE,[1,2] tritium targets are now also available at ATLAS at Argonne National Laboratory and TRIUMF's ISAC II facility. Transfer reactions are best performed at beam energies close to the Coulomb barrier. At RIBF, the full potential of this spectroscopic tool will be exploited with the completion of the OEDO facility.[3] Here, the high-intensity radioactive beam produced by projectile fragmentation and in-flight fission will be slowed down in a degrader. Re-bunching and focusing devices are used to restore the beam quality. The challenge in building a radioactive tritium target for RIBF is twofold. First the size of the target has to be sufficiently large. At RIBF, typical beam spot sizes are approximately 2 cm in FWHM, in stark contrast to the values of approximately 1 mm that are achieved through post-acceleration at ISOL facilities. In order to perform two-neutron transfer reactions at RIBF a tritium target with an area of 2.5 x 2.5 cm^2 is required. Secondly, the effective thickness of the tritium target material has to be sufficient to achieve reasonable luminosities for experiments with radioactive beams at RIBF. The target thickness has to result in a total activity below the limit of 10 TBq, but it also has to be suitable for a wide variety of experiments with different physics goals as well as beam energies. The approach used for RIBF is the loading of a titanium foil with hydrogen. Theoretically a hydrogen to titanium ratio H:Ti = 2:1 can be reached. However the large amount of hydrogen critically affects the mechanical stability.[4] This is a challenge for the construction of a large-area tritium target. In order to establish a production and handling method for a tritium target, prototypes containing non-radioactive deuterium instead of tritium are used.

At the Hydrogen Isotope Research Center at Toyama University a deuterated target with an intended ratio of D:Ti = 0.24:1 has been produced, the thickness of which is 20 μm Ti before loading. In order to characterize the properties of the target, and in-beam experiment has been performed.

The goal of the experiment was to (i) independently determine the deuteron content of the target, (ii) examine the behavior under high beam current, and (iii) investigate other possible types of radioactive contamination of the target due to fusion reactions of the Ti carrier material. The experiment was performed at the E7b beam line. A ^{20}Ne beam at an energy of 8.2 MeV/u was irradiated on the TiD target. Elastically scattered deuterons were detected in three pin diodes in the forward direction. In the backward direction an array of Si strip detectors was placed to detect protons from (d,p) transfer reactions.



At the end of the beam line, the unreacted beam was impinged on two additional Ti foils to investigate the background that could be created by fusion reactions on the Ti material. In order to establish a limit on the beam current that might cause the release of hydrogen from the Ti material, the mass distribution of the residual gas was monitored in a quadrupole mass spectrometer. The beam intensity was varied from 5 pnA to 200 pnA. Up to 20 pnA (1.3 x10^{11} pps) the partial pressure of A/q =2 was stable at background level. At higher currents the release of deuterium from the target was observed.

The analysis of the scattering as well as the activation data is ongoing. New prototype targets with different D:Ti loading ratios are being produced. The production of the final tritium target is envisioned for 2018.

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References

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