Commissioning a Rotating Target for Use in Heavy Element Studies

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Introduction

The heaviest elements are all produced artificially by fusing nuclei of light elements to form heavier nuclei. This process is complicated by the rapid fission rate of compound nuclei. The most direct method to increase the production rate of nuclei is to increase the beam intensity, necessitating the use of a rotating wheel target to minimize damage to the target by deposited heat. Such a target was commissioned for use at Texas A&M University, Cyclotron Institute in the Momentum Achromat Recoil Separator (MARS), shown in Figure 1 below. The purpose of this project was to implement and characterize the rotating target in an online experiment.

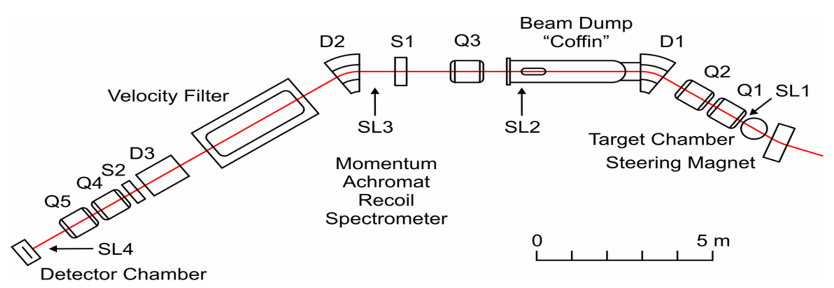

Figure 1: Diagram of the Momentum Achromat Recoil Separator

Rotating Target Wheel

Figure 2 shows the rotating target wheel used. The target consists of a heat-treated aluminum wheel with three banana-shaped cutouts, intended for the beam to pass through. Additionally, there are three black notches around the edge of the wheel to trigger signals from the fiber optic cable. The target is designed to rotate at 1700 rpm.

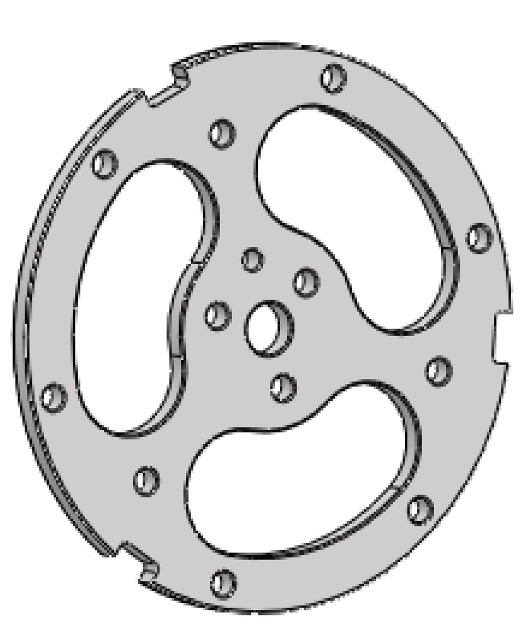

Figure 2: Rotating target wheel

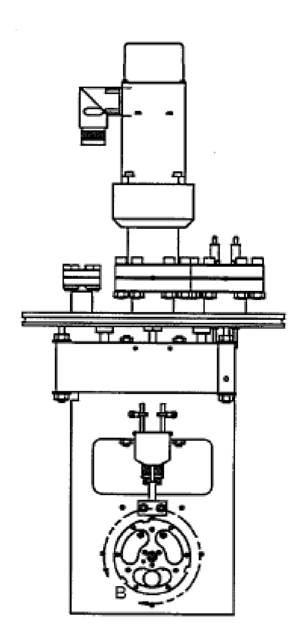

Figure 3: Target wheel assembly

Drive Shaft and Gear Box

The assembly's motor causes a drive shaft to turn, thus facilitating the rotation of the gears within the gear box shown in Figure 4, below. This box is attached to the target wheel and, thereby, causes it to spin with the rotation of the drive shaft.

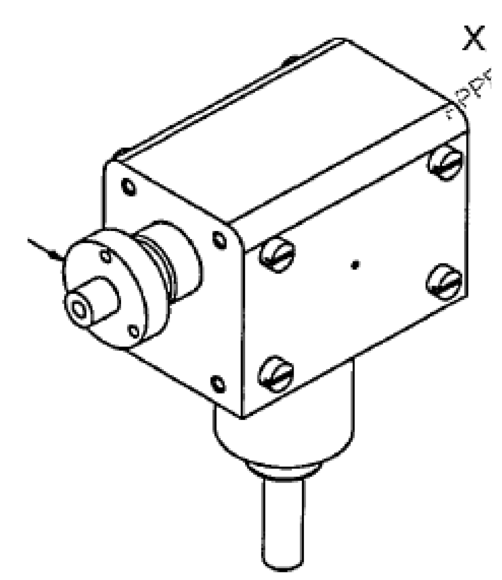

Figure 4: Gear box used to rotate the target wheel

Electrical Changes

A dedicated electrical panel, shown in Figures 5 and 6, was created to provide power to the target wheel. The motor which causes the wheel to spin is run by an Advanced Kollmorgen Drive, which had to be wired to the motor, as well as to a power supply. The drive also had to be connected to the control computer via an Ethernet cable, so that the wheel could be operated remotely using Kollmorgen Workbench software.

Figure 5: Front of the electrical panel

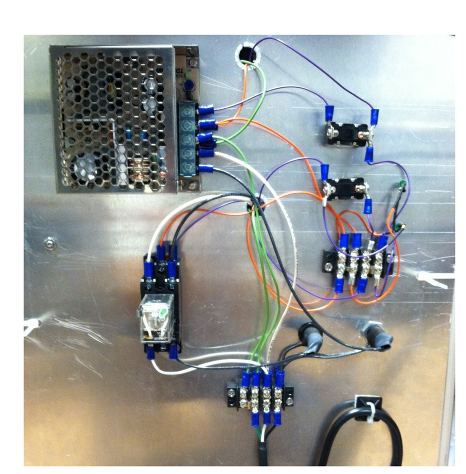

Figure 6: Back of the electrical panel

A 24 DC power supply provides the logic for the drive, while also powering a safety fault relay. This relay stops the flow of power to the drive should a disproportionate surge of electricity occur.

Fiber Optic Cable

The fiber optic cable, located above the wheel, is shown in Figure 7. The purpose of this cable is to reflect light back to the trigger box. Because a black notch does not reflect light, when one of these notches passes beneath the cable, the trigger box sends a signal to stop the beam, so as not to bombard the spokes on the target.

Figure 7: Fiber optic cable

When a notch passes the cable, it is detected by a trigger box, which then sends a TTL signal to the cyclotron stopping the beam. This box has an adjustable delay which is set via a USB interface.

Testing the Wheel

Following all modifications, the target wheel assembly was commissioned in a beam experiment. For the first portion of the experiment, the cyclotron's pulsing capabilities were determined by delivering a beam of ^{20}Ne at 15 MeV/u from the K500 cyclotron. The cyclotron was pulsed for 0.5-50 ms followed by a period of equal length without beam, resulting in a 50% duty factor. The beam was then detected by a ruggedized silicon detector downstream of the target position. The number of collisions per time interval was analyzed to determine the rate at which the cyclotron was able to effectively pulse the beam. Following this initial testing, the wheel was rotated at 500 rpm and the cyclotron was allowed to pulse the beam based upon the signals detected from the fiber optic cable. This was repeated at speeds increasing in steps of approximately 250 rpm, up to 1700 rpm.

Results

Analysis of the data suggests that the K500 cyclotron is capable of pulsing at rates of up to 250 Hz. This is sufficient for planned future

Results (continued)

experiments, however, initial experiments indicate that the cyclotron receives signals from the fiber optic cable with about 85% efficiency, causing the beam to bombard the spokes of the target wheel, as shown in Figure 9.

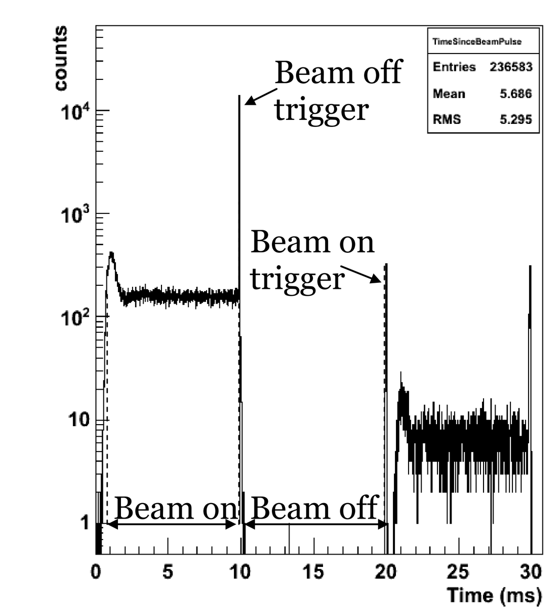

Figure 8: Beam pulsing at 10 ms on, 10 ms/off

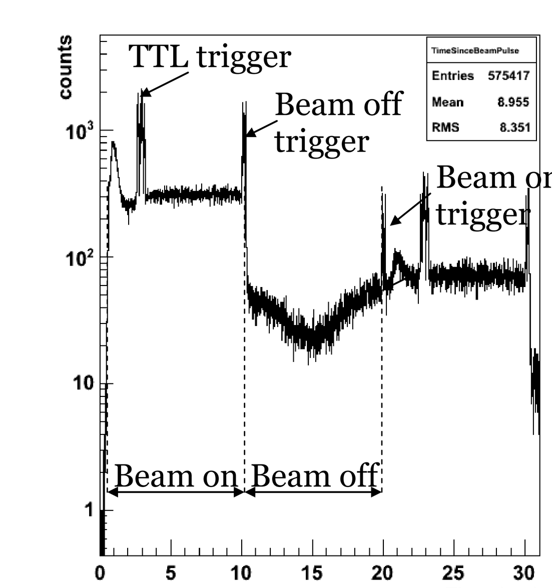

Figure 9: Beam on/off rate at 1000 rpm

Conclusion

It was concluded that the experiment was largely successful. However, before the target wheel can be fully commissioned for future heavy element studies, a new trigger box and additional experiments will be necessary.

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