Commissioning of a rotating wheel target for use in heavy element studies

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To withstand the heat load of high intensity beams needed for production of heavy and superheavy elements, a specialized rotating wheel target system was developed [1]. The assembly was designed by Ferrotec Corporation and is shown in Figs. 1*a* and 1*b*. The assembly is mounted on an ISO200 flange, with a ferrofluidic seal dividing the in-air motor from the vacuum components it drives. The target wheel consists of three banana-shaped segments, each with an area of 4.7 cm^2. To avoid activating the target frame spokes, and reduce scattered beam background, a signal from an optical fiber probe tracking the target position triggers beam pulsing. A custom power supply panel was fabricated to power the Ethernet-based servo driver and motor.

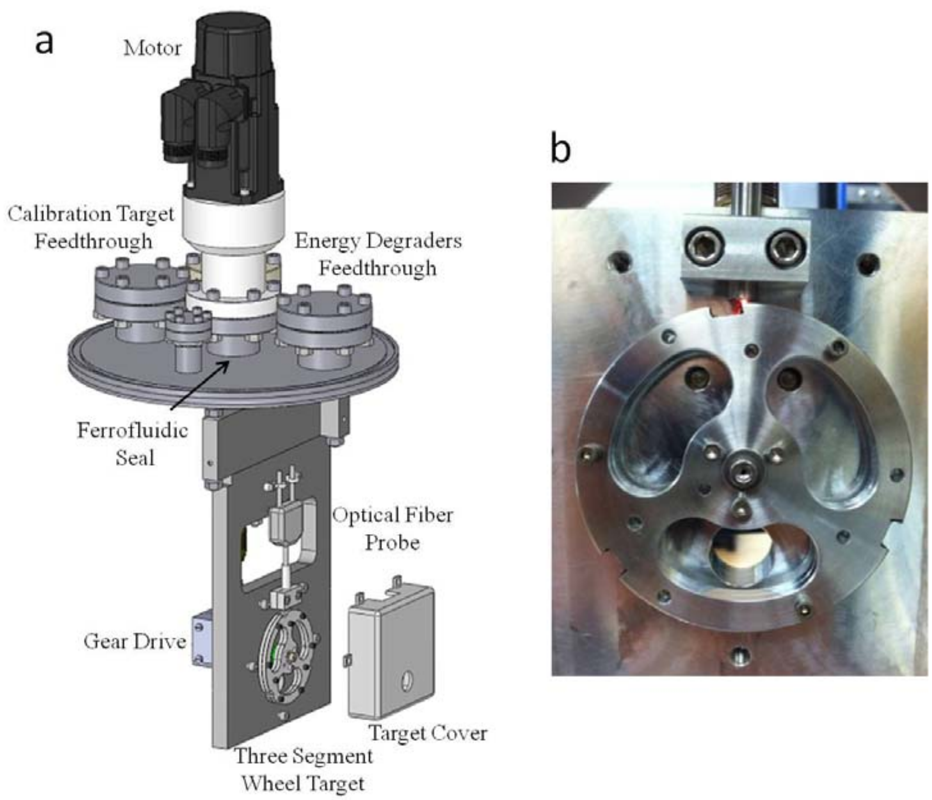

FIG. 1. (a) CAD drawing of rotating target wheel assembly, courtesy of Ferrotec Corp. (b) Image of the target wheel, with fiber optic probe positioned above and emitting a red light. The three notches serve as position markers to trigger beam pulsing.

The performance of the cyclotron and assembly to pulsing triggers was tested in an online experiment with a 15 MeV/u $^{20}Ne^{4+}$ beam (~500-1000 ions/s) delivered by the K500 cyclotron to the in-air station of the SEE-line cave. A ruggedized silicon detector, with an active area of 2.98 cm^2, was positioned behind the rotating wheel to record beam implantation events passing through the target position. Using a NIM gate generator, the experimental set-up was first tested by varying pulsing time between 0.5 – 50 ms, accomplished by shifting the dee B phase angle by 13.2°. It was determined that the K500 cyclotron is capable of pulsing the beam at frequencies of up to 250 Hz. Fig. 2a shows results for a 10 ms on / 10 ms off pulse time. Events beyond 20 ms are from missed beam-off triggers due to the substantial dead-time created by the high signal event rate; normal event rates in element production experiments are much lower.

The performance of the beam pulse trigger detected by the optical fiber probe was tested next. The target wheel was rotated at frequencies between 500 – 1700 rpm, in increments of ~250 rpm. Fig. 2b shows the result of that test for 1000 rpm. The fiber optic trigger is received as soon as the notch is seen by the optical fiber probe. The actual beam-off trigger is delayed just until the spoke between the target wedges enters the path of the beam. After another delay, a beam-on trigger follows. Both delays were calculated based on the wheel geometry and rotational frequency.

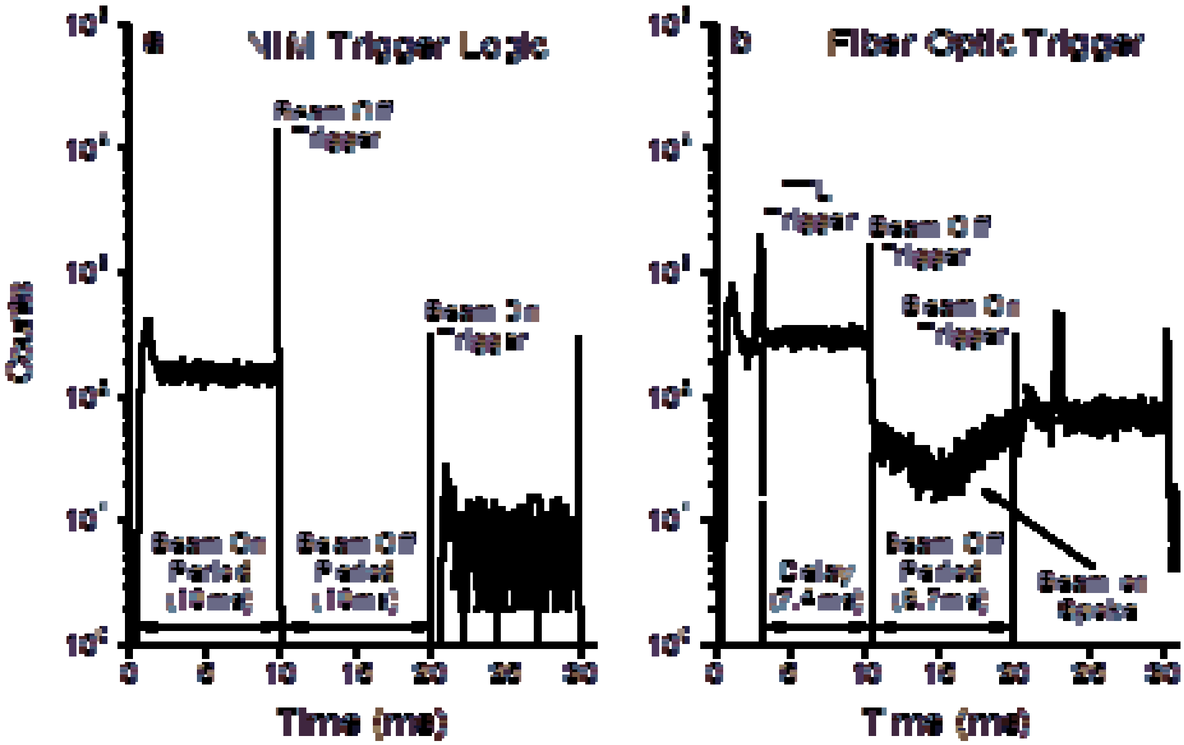

FIG. 2. (a) Beam implantation events with a 10 ms pulsing time triggered by a NIM gate generator. (b) Wheel target rotating at 1000 rpm. Beam-off triggers originate from notches on the wheel target (TTL trigger, see Figure 1b above). The time between the notch register and when the wheel spoke covers the beam path is the delay. The valley feature in the beam-off period is due to skipped beam-off triggers as discussed in the main text.

The performance of the system was overall satisfactory, with one drawback. The efficiency of the optical probe trigger was ~85%, suggesting a fault with either the analog (optical) input or digital (TTL pulse) output of the TTL signal generator. The presence of events in the beam-off window in Figure 2b is the result of this effect and the dip is from reduced event rate due to the spoke eclipsing the detector as it passed across the target position. Once this problem is addressed, the target wheel assembly should be ready for use in heavy element production experiments. Preparation of specialized targets for use with the assembly is discussed in a separate contribution to this report [2].

[1] M.E. Bennett *et al.*, J. Radioanal. Nucl. Chem. **299**, 1107 (2013).

[2] T.A. Werke *et al.*, *Progress in Research*, Cyclotron Institute, Texas A&M University (2013-2014), p. IV-48.