Status of Crocker Cyclotron Refurbishment

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Background

The Crocker Cyclotron requires vacuum to operate. At a minimum, this vacuum must be sufficient to prevent high voltage beam extraction elements from sparking. Over the last several years, the vacuum in the system has been degrading, and for the last year or so has only barely been adequate for operation. Following a scheduled maintenance shutdown in January of 2018, we were unable to achieve a low enough vacuum to operate at all. We spent several weeks attempting to remedy this, but eventually determined that the problem was a large number of small leaks, caused by the fact that the majority of the seals in the system were original, dating from the mid-1960s, and had simply reached end of life.

The decision was therefore made to open all flanges in the system and replace all of the o-ring seals. This involves 50-100 individual o-rings, ranging in size from roughly 1 inch to several feet in diameter. Each o-ring is custom made from bulk stock.

Scope of Work

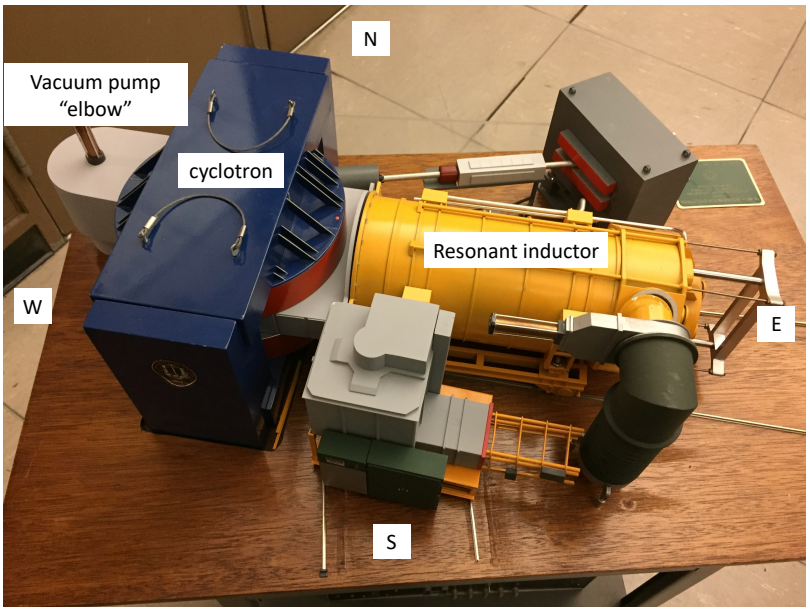

Figure 1: Model of cyclotron

The cyclotron layout is best understood by looking at model in Figure 1. The vacuum chamber sits within the magnetic yoke. The sides of the vacuum chamber consist of eight large metal flanges, sealed against the top and bottom plates, as well as complex corner pieces. Each large

plate has several smaller flange plates fastened to it. These provide electrical and cooling feed-throughs, as well as complex mechanical linkages to position extraction elements.

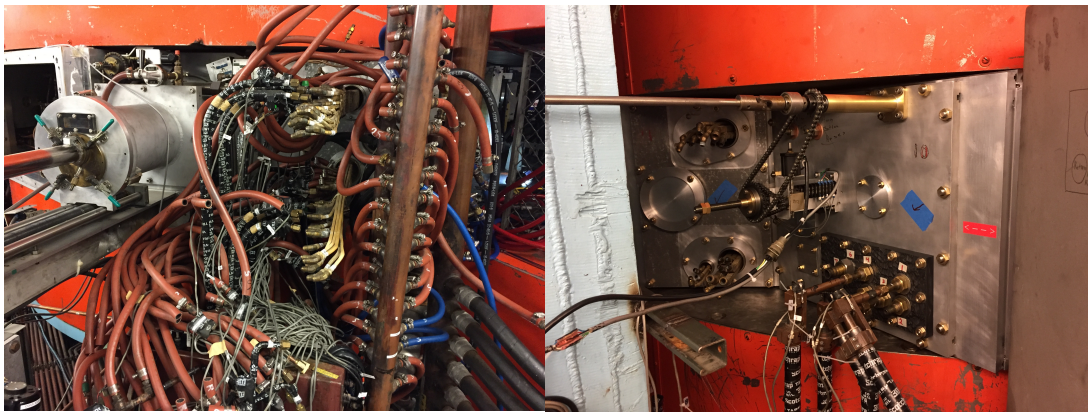

Figure 2: Complexity of feed-through plates

Figure 2 shows some examples of the complexity of the interfaces.

The situation was complicated by the fact that both the vacuum elbow on the West side and the resonator flange on the East side required crane access. This necessitated the removal of shielding blocks on top of the vault. Unfortunately, the top of the vault had been used for storage for some time, so clearing it required several days at the beginning of the operation, as illustrated in Figure 3.

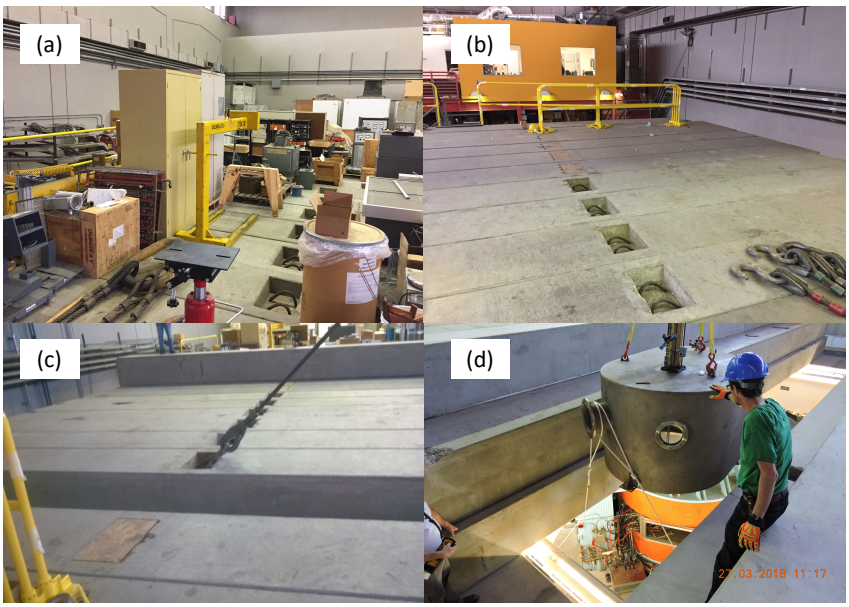

Figure 3: Roof operations, showing before (a) and after (b) clearing, the beginning of block removal (c) and the removal of the vacuum pump elbows.

Status and Outlook

Work has proceeded smoothly, and we are ahead of our original schedule, thanks to the hard work of the cyclotron staff. The flanges on the West side have been replaced and re-sealed. These included the most complicated flanges, for which there was some uncertainty as to how to proceed, given that some of these flanges have never been removed, and the people who assembled them are no longer alive. Shielding blocks have been rearranged, and we are currently working on the East side flanges, which are more straightforward.

At the rate work is proceeding, we should have the cyclotron vacuum seals complete by the end of May, at which point we can attempt to put the system under vacuum. If this is successful, there is some possibility we could return to operation within two weeks or so; however, given the extent of the work, it's probable that some residual leaks will remain, which will have to be serviced. We are therefore working with an internal schedule of restoring beam by the end of June and are currently not scheduling beam before August 20th.

We will revise these estimates after we attempt to put the system under vacuum.

It's not surprising that this refurbishment was required, after so many years of operation with minimal maintenance, but of course the most unfortunate aspect is the impact on the Eye Treatment Facility, which we consider our most important activity. Returning the ETF service in a timely fashion has been our primary motivation, and they will be given the highest scheduling priority when beam is reestablished.