K150 operations and development

G.J. Kim, B.T. Roeder, F.P. Abegglen, H.L. Clark, L. Gathings, D.P. May, and H. Peeler

We had another busy year operating the K150 cyclotron. For the reporting period as shown in Table I, we logged over 4024 hours of beam-on-target and 2888 hours for beam developments. Included in the beam-on-target time was 3672 hours (1676 for physics and 1996 for chemistry) for in-house science experiments and 352 hours for the SEE tests.

Table I. 2019-2020 operational time.

Time	Hours	% Time
Beam on target	4024	46.1
Beam development	2888	33.0
Scheduled maintenance	1656	19.0
Unscheduled maintenance	168	1.9
Total	8736	100

The big users of the K150 beams were: the SEE tests, the Yennello group, and the Folden and Melconian groups as they began their respective experiments.

The efforts to improve the K150 vacuum started in early 2019 and the vacuum readings ranged from $8x10^{-7}$ to $1.5x10^{-6}$ torr for the rest of 2019. With the vacuum improvement, heavier beams like ^{57}Fe, ^{63}Cu, and ^{78}Kr in 4.1 to 15 AMeV were developed and were used in experiments. The internal transmission improved with the vacuum improvement and this helped to achieve good beam intensities for various experiments; notably we achieved 24 μA of 15 MeV protons (from the H- source), 4 μA of 6.3 AMeV ^{40}Ar 11+, 5 μA of 10 AMeV $^{3}He^{1+}$, and 10 μA of 7.2 AMeV $^{4}He^{2+}$ beam. Early in 2020, the diffusion pump was removed from the cyclotron and cleaned in ordered to further improve the vacuum, however the initial cyclotron vacuum readings did not show improvement from those of 2019.

The SEE testings continued with 6 to 45 MeV proton beams using the H- source. In addition, we ran two ECR beams, 15 AMeV ^{4}He and 15 AMeV ^{40}Ar, for SEE customers on two separate occasions for the first time. The development of ECR SEE beams continued as time allowed, and to the 15 AMeV ^{14}N, ^{20}Ne and ^{40}Ar beams we developed last year, we were able to add 15 AMeV ^{63}Cu and 10 AMeV ^{78}Kr beams. We would like to develop 15 AMeV ^{78}Kr and even heavier ^{124}Xe beam in the 10 to 12 AMeV range.

The commissioning of the AGGIE spectrometer began with 6.3 AMeV $^{40}Ar^{11+}$ beam in July. The experiment would have preferred a 5.0 AMeV ^{40}Ar beam, but our difficulties with the 3rd harmonic beams, with tuning and beam intensity (conditioning the RF dee to high voltages has been difficult for frequencies above 14 MHz), pushed the experiment to use 1st harmonic 6.3 AMeV ^{40}Ar beam with a scheme to degrade the energy just in front of their target. We considered degrading the beam energy from 6.3 to 5 AMeV before the 160 degree Analyzing Magnet (AM) and then using AM to select one charge state with largest beam intensity after the degrader. While this method would have provided a clean 5 AMeV ^{40}Ar beam, the beam loss would have been substantial and hence was not tried. Prior to the July run we verified that we could obtain good beam intensities of about 360 particle nA of 6.3 AMeV $^{40}Ar^{11+}$ on FC02 and that the beam could be transported the experiment through the rather large 53 degree bend through the Maryland magnet. Through the fall, the Folden group used the argon beam 3 times, and the experimenters are now getting ready for their next campaign in the spring.

The commissioning of the TAMUTRAP gas cell, which shares with the Light Ion Guide (LIG) line, began with 10 AMeV $^{3}He^{1+}$ beam in August. The cell was designed to produce exotic ^{25}Si and ^{24}Si from ^{3}He beam on a ^{24}Mg target, and then stopping and collecting the product in a gas cell (a little larger one than for LIG). Due to the small cross sections for the production, and also due to the difficulty of collecting and transporting the product, having an intense ^{3}He beam was important for the experiment. The two beams of interest were 10 AMeV $^{3}He^{1+}$ and 23 AMeV $^{3}He^{2+}$ for producing ^{25}Si and ^{24}Si, respectively. After an initial study the Melconian group concentrated on the 10 AMeV beam. The production cross section for ^{25}Si is larger than that for ^{24}Si, and the lower energy beam produced lower energy recoils, which made the recoil collection more efficient in the gas cell. Thus far we were able to extract 5 μA of 10 AMeV $^{3}He^{1+}$ beam on FC02. To obtain an intense beam, a good flow of ^{3}He gas was needed into the ECR2 source, and we attached a large gas bottle to the source for a long and stable operation. The beam transport (from FC02) to the gas cell was carried out very similarly to transporting the beams to the LIG target – that is after verifying the beam on the viewer just upstream of the gas cell, we optimized the beam intensity on the faraday cup just downstream of the gas cell using the last 4 quadrupoles. Factoring in the fact that the beam particles would strip up to 2+ from 1+ charge state in going through a number of windows and a target material around the gas cell, around 80% transport efficiency from FC02 to the gas cell was obtained, which is comparable to the beam transport for LIG.