K150 Operations and development 2023-2024

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The operation of the K150 cyclotron continued this year, providing beams to the science program, SEE line users, and the astatine 211 production program. For the reporting period 4/23-3/24, we logged over 5416 of beam on-target and 1472 hours of beam development as shown in Table I. Included in the beam on-target time was 4968 hours for in-house science experiments and astatine production and 448 hours for SEE line testing.

TABLE I. 2023-2024 operational time for the K150 cyclotron

Time	Hours	% Time
Beam on Target	5416	62%
Beam Development	1472	17%
Scheduled Maintenance	1760	20%
Unscheduled Maintenance	88	1%
Total	8736	100%

The active users of the K150 beams were the light ion guide (LIG) group, Yennello, Folden, Rogachev and Adsley groups. There was one external group, Professor Sobotka from Washington University in St. Louis, that used a beam for a MARS experiment.

The LIG group ran 5 experimental campaigns using proton beams with intensities of up to 12 μA and energies ranging from 10 to 23 MeV. Producing these beams has been relatively easy with the continued operation of the H^- ion source. The ion source output is regulated with the arc discharge current, and only a few amps are necessary to produce the needed beam. The injection efficiency of the beam continues to be good and the extraction efficiency through the carbon stripper foil continues to be high, often 80-90%. However, the beam size after extraction is somewhat large, and not all of the beam can be transported to the LIG target. Nevertheless, once the edges of the beam are removed with the collimators, transmission of the beam from FC02 to FC23 downstream of the LIG gas cell is often 90-100%. The highlight of this year's LIG runs was the production and re-acceleration of ^{89}Nb and ^{89}Zr with the ^{90}Zr(p,2n) and ^{90}Zr(p,d) reactions. These efforts are described in a separate report.

The astatine 211 production program also is continuing to use the beam regularly. This reporting year, there were 9 separate production runs. Each beam consisted of $^4He^{1+}$ beam at 7.2 MeV/u and with intensities between 8 to 13 μA on target. A typical irradiation of the bismuth production target lasts overnight and has a total run time of 14-16 hours. The beam tune for the ^{4}He beam has become relatively routine and can often be optimized within 4-6 hours. However, small improvements to the beam tuning have been made, and this year a new record intensity of 20 μA extracted to FC02 was obtained. It should be noted that this result was observed on a day where there was particularly good vacuum reading ($7.6*10^{-7}$) on the cyclotron ion gauge.

High intensity metal ion beams are being developed with ECR2 and the K150 cyclotron with the MIVOC method. This year, iron and titanium beams were developed. A new coupling flange and fixture were tested such that the metal vapor could flow into the ion source through the side of the plasma chamber where the oven and sputtering fixture would normally be mounted. For the iron beam test, natural ferrocene was used and up to 38 μA of $^{56}Fe^{10+}$ was observed from ECR2. (Trimethyl)pentamethylcyclopentadienyltitanium(IV) was employed for the Ti beam test. Up to 18 μA of $^{48}Ti^{11+}$ was observed from ECR2, which led to about 200 nA of beam extracted from the cyclotron on FC02. The transmission of the $^{48}Ti^{11+}$ beam through the cyclotron for the high main magnet settings necessary for 6.5 MeV/u beam will be improved in subsequent runs. Further details about the MIVOC tests are given in a separate report.

Finally, beginning in January 2024, the existing H^- source was dismounted and replaced with a new filament ion source manufactured by D-Pace Inc. [1]. The new filament ion source can provide both positive and negative hydrogen ions as well as positive ^3He and ^4He ions. Installation of this new ion source took place from January-March 2023 and commissioning of the new source will continue in the coming year.

[1] Positive/Negative Filament Ion Source, Model # ISV.F-100, D-Pace Inc. – https://www.d-pace.com/?e=363