Installation and commissioning of the ECR4 ion source

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The final construction, installation and commissioning of the new 6.4 GHz ECR4 ion source gained increased urgency in November of 2020 when the ECR1 ion source failed abruptly due to an unrepairable vacuum leak in the thin aluminum wall of the plasma chamber.

In early February of 2021 ECR4 and its injection beam-line were ready for commissioning (Fig. 1). The axial-coil currents were initially set using the currents calculated using the program POISSON. The design of the axial magnet field structure for ECR4, specifically the fields at the injection and extraction ends of the plasma chamber as well as the central minimum, aimed to match the axial field of ECR1 for its most successful beams, but using fewer axial coils and a more compact steel yoke.

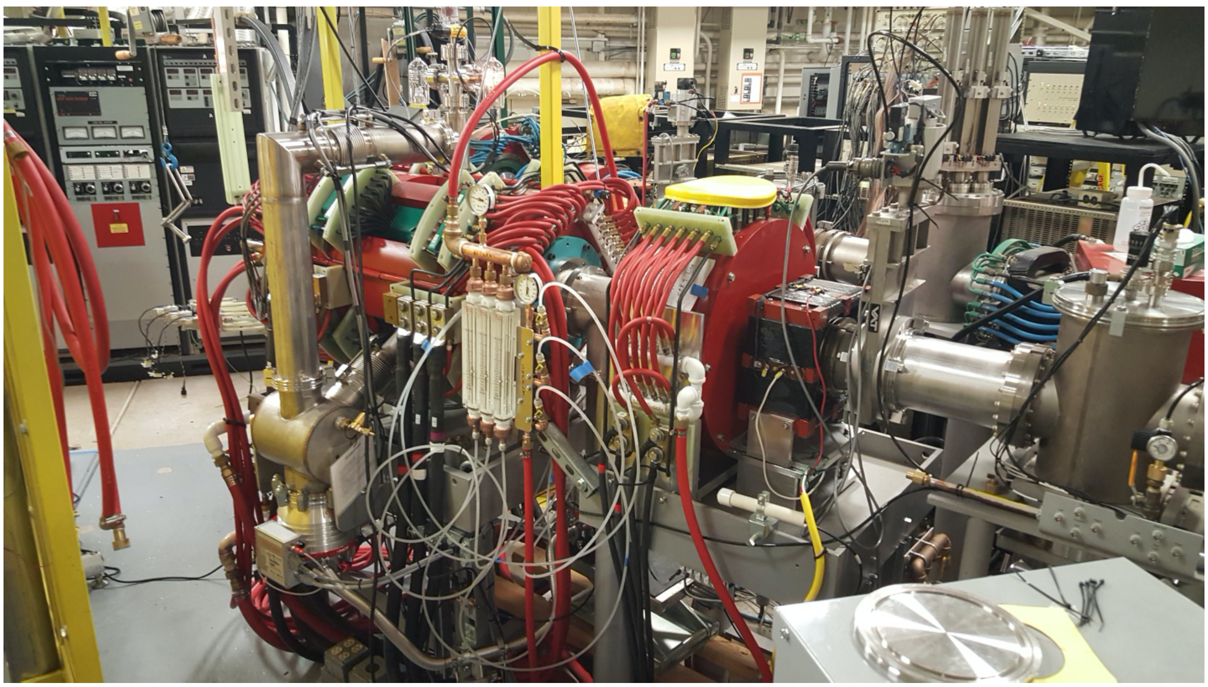

Fig. 1. ECR4 installed for K500 injection.

After power-up of the coils and of the microwave transmitter and after some trouble-shooting, the source was opened to show that the plasma "stars" on the opposite ends of the plasma chamber were thin and properly aligned (Fig. 2). Finally initial charge-state scans were obtained which enabled some tuning of the source. The axial-coil currents required for best performance were close to those obtained for ECR1. Differences could be ascribed to the inaccuracy of the ECR1 coil power supplies or to differences between ECR1 and ECR4 in the magnetic properties of their steel yokes and plugs. The exception was that the ideal central-field minimum for ECR4 seemed to be much lower than that calculated for ECR1. This was most certainly due to the fact that a high central-field minimum is required for the highest performance, but since this produces a higher plasma electron temperature more conditioning is required. This explanation seemed to be correct since raising this minimum initially produced more outgassing, but as this decreased raising the minimum gradually through several days produced the best performance.

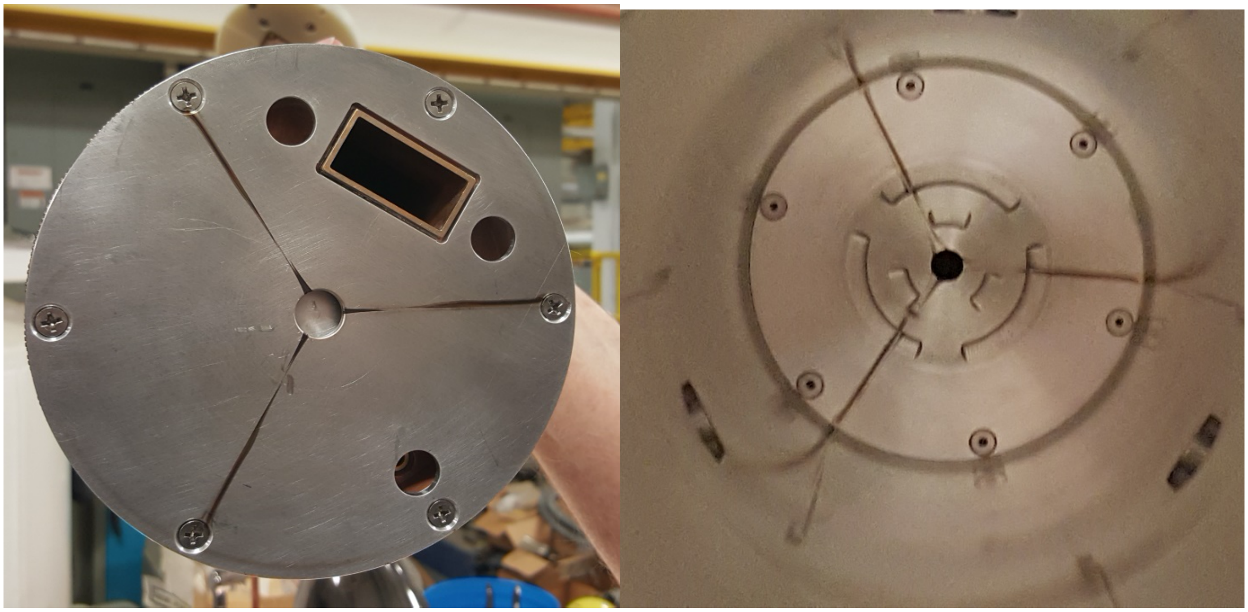

Fig. 2. The plasma "star" at the injection and extraction ends of the plasma chamber.

The performance of ECR4, as demonstrated by charge-state scans of argon beams, improved at a faster rate than the performance of the upgraded ECR1 in 1995. Ultimate performance could not be investigated, however, since ECR4 was urgently needed for K500 operation. The sputter targets were mounted in ECR4, and injection into the cyclotron began in March. Fig. 3 shows a scan of a silver beam from a sputter target.

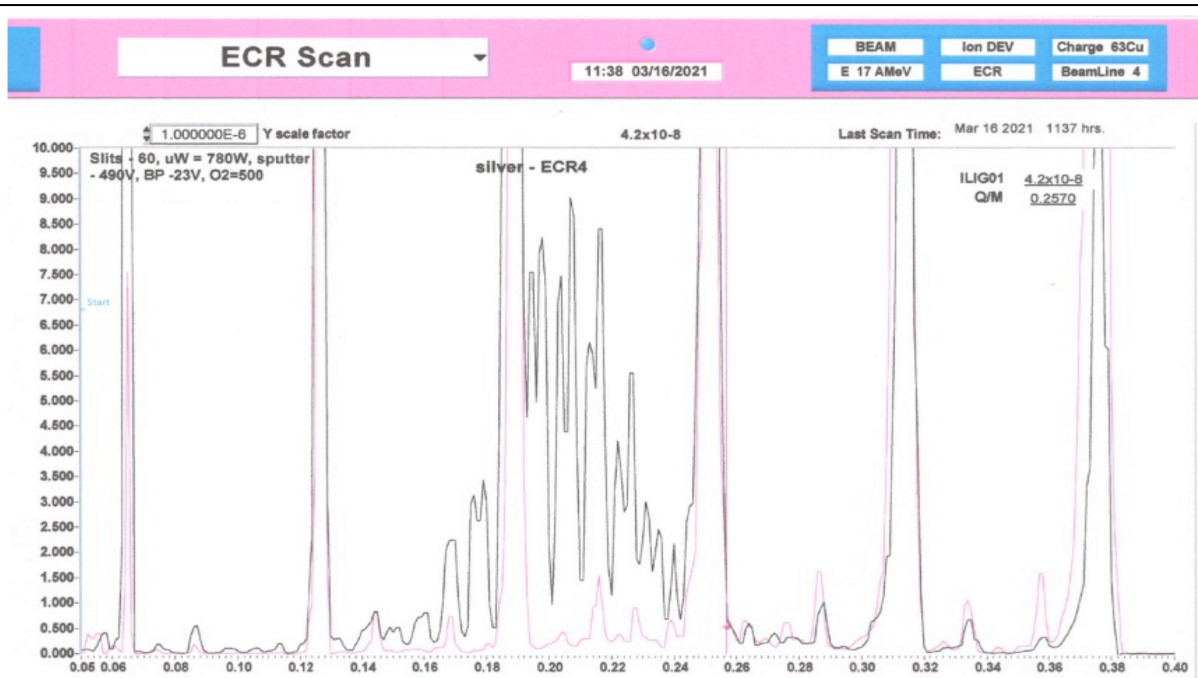

Fig. 3. ECR4 charge-state scan of silver beam.