Design of the Extraction System and Beamline of the Superconducting ECR Ion Source VENUS

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A new, very high magnetic field superconducting ECR ion source, VENUS, is under construction at the LBNL 88-Inch Cyclotron. It will boost the maximum energies and intensities for heavy ions from the cyclotron particularly for ions with mass greater than 60. It will also serve as R&D ion source for the proposed Rare Isotope Accelerator (RIA) project, which requires up to 10 pμA of U^{30+}. To transport these intense heavy ion beams the extraction system and mass analyzing system of the ion source is designed for a proton-equivalent current of 25mA at 30kV extraction voltage.

The effect of the high magnetic ion-source field (up to 3 T) on the ion beam extraction and matching to the beam line has been investigated in [1,2]. The various charge states focus differently in the high magnetic field of a superconducting ECR ion source. This leads to typical emittance patterns, where each charge state is oriented differently in phase space. For the 88-Inch Cyclotron operation, the LEBT must be versatile enough to transport many different ion beams and charge states at varying extraction voltages.

The tuning flexibility of the existing LBL ECR beamlines comes from the insertion of a solenoid lens between the extraction and the analyzing magnet. In this scheme the solenoid lens focuses the extracted beam to the first focal point of the analyzing magnet. Ion optics simulations show that a small waist in front of the analyzing magnet induces strong aberrations in high-space-charge ion beams. Further, the magnetic field of the solenoid lens must be more than one Tesla for the extraction voltages (up to 30 kV) considered for VENUS.

Therefore, we have decided to eliminate the waist in front of the analyzing magnet. Now the sole purpose of the solenoid lens is to adjust the angle of the beam going into the magnet. Since the actual beam diameter cannot be controlled with a single solenoid lens a sufficiently large magnet gap must be chosen to accommodate the highest anticipated beam intensities. To meet these requirements a multipurpose analyzing magnet is currently in design and will incorporate two quadrupole and two sextupole moments at the magnet edges and two more sextupole moments in the magnet center to compensate for higher order effects. 3D magnet calculations (Tosca 3D, ANSYS) are necessary to define the correct pole shape of the analyzing magnet. The resolution of the magnet will be m/Δm~100, its beam radius 55cm and its pole gap 18cm.

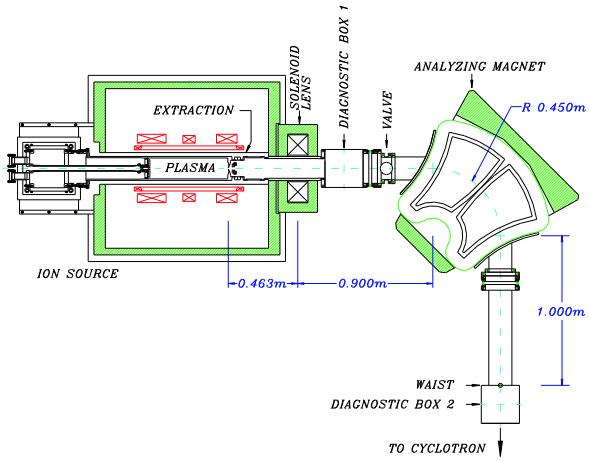

Fig. 1. VENUS beamline layout.

References

[1] Leitner, M.A., S.A. Lundgren, C.M. Lyneis, C.E. Taylor, and D.C. Wutte, Proceedings of the 14th International Workshop on ECR Sources (ECRIS'99), CERN, Geneva, Switzerland, May 3-6, 1999, p. 66.

[2] Wutte, D., M.A. Leitner, C.M. Lyneis, C.E. Taylor, and Z.Q. Xie, Proceedings of the Eighth International Conference on Heavy-Ion Accelerator Technology (HIAT 1998), Argonne, Illinois, October 5-9, 1998, p. 384.