Recent progress on the ECR4 ion source

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The construction of the new 6.4 GHz ECR4 ion source is nearing completion and will soon be installed and commissioned. Most significantly, the NdFeB permanent magnet bars that comprise the hexapole have been fitted into the ECR4 plasma chamber and the completed plasma chamber inserted into the yoke-and-coil structure. The power supplies, transmitters, stands and injection-line elements have all been installed.

The most crucial operation was the insertion of the permanent magnets in the hexapole structure. The insertion fixture is shown in Fig. 1. The plasma chamber was placed in the center, and the six radial arms controlled the movement of permanent magnet bars into their respective slots. A calculation had been performed with PANDIRA to determine the force radially inward on each bar in the hexapole configuration. This had been determined to be approximately 300 lbs. on each 22.4 in. long bar when all six bars are in their final positions. This force builds up rapidly to this maximum as the bars move radially inward, but if the bars are perfectly symmetric the azimuthal forces on any bar are balanced to zero. Each bar was constrained by its radially outward attraction to a 3.75 in. thick bar of soft steel. The magnetic force between each bar and its steel holder was determined by PANDIRA to be approximately 1140 lbs. giving a safety margin of almost a factor of four.

Fig. 1. Fixture used for inserting magnet bars into ECR4 plasma chamber.

To place each magnet on each steel bar first one permanent magnet bar was brought in by hand and, placed in its slot in the plasma chamber, and secured by brass rods in the slot. The control arm was

then attached to the fixture and the steel holder brought radially up to the magnet until three long stainless screws threaded through the holder encountered an aluminum bar taped to the magnets outer face. With this arrangement, the screws could control the approach of the holder to the magnet. When the holder was flush with the magnet then they both were brought out to maximum radius. Next a magnet bar 120° in position from this bar was attached to its holder and brought out to full radius in this manner. The next magnet was attached 120° from this position, and then with their side forces balanced the remaining three magnets were attached After all six magnet bars were attached in turn to their holders and brought out to full radius, they were moved in slowly and symmetrically into their slots in the plasma chamber. This process required six lab personnel as each arm was cranked in by hand. At this point the steel holders were pushed outward with the long screws to the point where their attraction to the magnet bars no longer is capable of pulling them from their slots.

Now with all the magnets safely installed, the plasma chamber was withdrawn from the fixture, wrapped in a stainless-steel shell and covered with an insulating plastic film. Fig. 2 shows the insertion of

Fig. 2. Plasma-chamber/hexapole being inserted into yoke and coil structure.

the plasma chamber into the steel-yoke and axial coil structure along an aluminum guide pole, and Fig. 3 shows the chamber in its final position.

At this point the magnetic field of the hexapole at the chamber wall was measured along each pole with a hand-held Hall probe. The field strength averaged a very uniform 4.94 kilogauss with 4.98 kilogauss for the strongest bar and 4.90 kilogauss for the weakest. The weakest point measured 4.73 kilogauss. This can be compared to the 4.76 kilogauss average pole strength measured for ECR1 with the weakest point descending to 4.39 kilogauss. These weak points on ECR1 have led to a gradual degradation of the performance of the ECR1 ion source even as the one bar with the weakest point was

replaced. It should also be noted that the ECR4 hexapole does not exhibit the sudden dips in field strength at the joints between the blocks forming the bars as does the ECR1 hexapole. With a more uniform field profile and more cooling capacity, the ECR4 hexapole should prove to be much more robust.

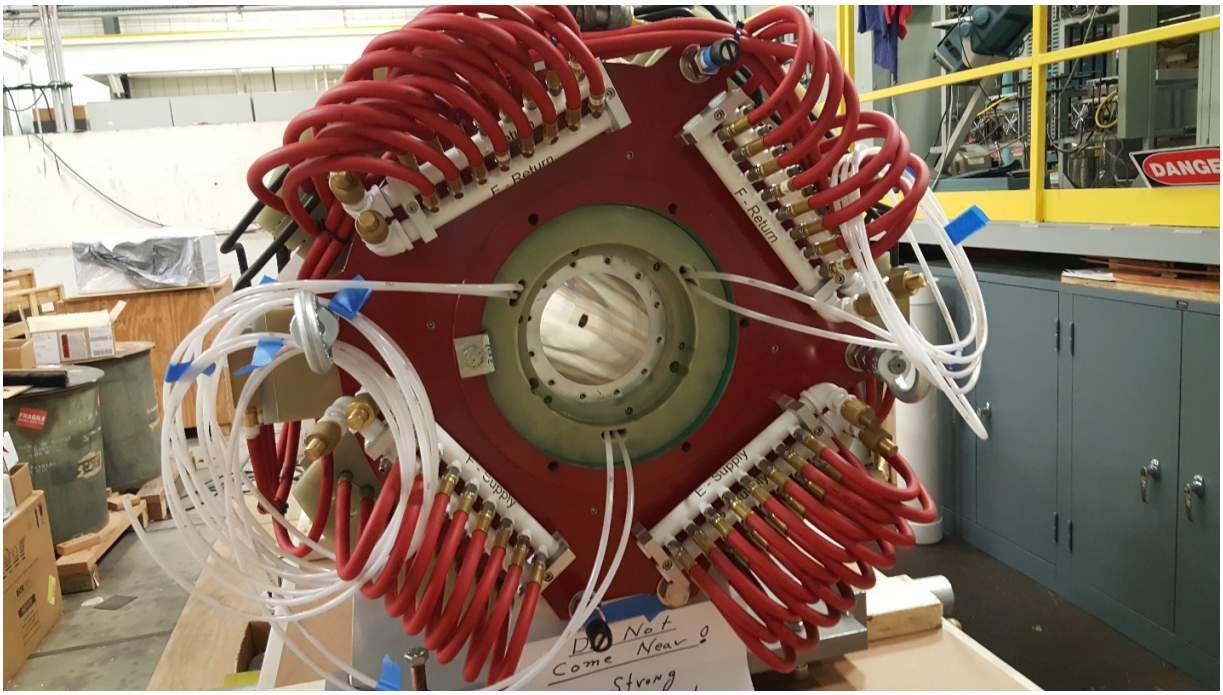

Fig. 3. Plasma chamber in its position inside the coils and steel yoke.