POSITIONING THE A1900 FOR THE COUPLED CYCLOTRON PROJECT

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The A1900 is a group of magnets to be installed immediately outside the K1200 cyclotron to form an analysis system similar to the present A1200.[1,2] This report will describe the steps to be used in installing the A1900 during the scheduled shutdown.

The beam leaves the cyclotron and passes through a combined function superconducting magnet with dipole and quadrupole tuning. It is followed by a 22.5° dipole and a quadrupole doublet to the production target beam chamber. The secondary radioactive beam is focussed by a large bore superconducting quadrupole triplet and deflected by a 50 ton superconducting dipole. The rest of the analysis system consists of seven large bore quadrupole triplets and three more dipoles to analyze the beam to the focal plane detector system. The task at hand is to place the dipoles at the corners of the beam path with the quadrupoles accurately located between them. From an alignment point of view, the magnets are positioned in a series of straight lines starting at the exit gate valve of the cyclotron, suspended approximately 125 cm. above the floor, and ending at the switching dipole in the transfer hall.

The first step will be to remove the present A1200 analysis system and the shielding walls. This will allow an unobstructed view of both the cyclotron and the transfer hall beamline magnets. The removal of the shielding walls will eliminate several beam height benchmarks, so a new set will be installed at this point. The height benchmarks consist of 3 in. tooling scales epoxied to aluminum brackets. The reading corresponding to beam height is scribed onto each mount. At the distances encountered in the laboratory, this method has been found to be accurate to within +/- 0.08 mm. The beam path will be laid out using benchmarks installed in the floor directly under the beam. They are to be placed at the vertex of each deflection of the beam path and directly under each diagnostic chamber. The benchmark consists of an adjustable mount for a plug target grouted into the floor. The plug targets are easily viewed from above and the side. As with the A1200, the angles between the legs of the separator are set with a rented digital theodolite to match the beam optics calculations, the cyclotron, and the transfer hall beamline. In the area of the transfer hall where the old K50 cyclotron once resided is a large pit, which must be crossed by the beamline. The benchmarking of this section will be accomplished using posts reaching down to the pit floor.

The combined function, 22.5° dipole, and doublet have their cryogenics fed from the same valve box that feeds the K1200 cyclotron. The rest of the A1900 is fed from a new cryogenic transfer system with individual valve boxes for each magnet. This arrangement allows great freedom in the order of installation. Because of space constraints in the area, the smaller magnets immediately outside the cyclotron are installed first. The combined function magnet is positioned using a jig transit mounted at the 22.5°dipole position, viewing the exit of the cyclotron and the benchmark directly under it. The most insensitive coordinate is the position along the beam axis. A plumb bob and tape measure set this value. In order to place the dipole, two instruments are used. One is mounted to the combined function magnet at the position of beampot #0 viewing downstream. It is calibrated using targets on both ends of the magnet. The second is placed at the production pot position viewing upstream. A jig attached to the poletip of the dipole has dowel pins to reference the theoretical lines intersecting inside the dipole. After the dipole is set, the second transit is also used to place the doublet on axis.

In order to confirm that the magnetic central axis of the A1900 triplets is aligned with the axis formed by a line running between the centers of the two end vacuum flanges, an alignment map of the magnet is needed after installation in the vault and cryogenic plumbing. This argues for placing and operating all of the triplets before the dipoles. Unfortunately, the triplets will shadow the beamline benchmarks from the transits mounted at the diagnostic chamber locations. A set of additional temporary benchmarks consisting of an X-Z displacement stage and alignment target, mounted at beam

height beyond the dipole positions will be needed. They are installed before the triplets are placed and protected with a cage. The optical transit is mounted at the diagnostic chamber positions for the positioning of the quadrupole triplets. The triplets need an external reference for position along the beam path, so the magnets are constructed with the pole tips centered with respect to the end flanges of the cryostat vacuum vessel. A simple tooling dock[3] can be used to locate the triplet's linear position along the beam path with respect to the floor benchmarks.

After the mapping is completed, the transit is recalibrated using the benchmark and the floor plug target, and the dipole is lowered into place. The pole tips of the dipoles have mounting holes for an internal set of alignment targets at each end. Because the temporary benchmark is beyond the dipole, the shielding wall in that area will have to wait until the alignments of the magnets are finished. Since the dipoles are centered and leveled at the intersection of two lines, their position along the beam axis is well defined.

The orthogonal adjusters for the dipoles are similar to those used on the large dipoles of the S800.[3] A 20 Ton screw jack is mounted to the bottom of the return yoke with a spherical joint attached to the end of its shaft. The pocket of the joint is riding on a set of cross roller bearings with ACME screws to move it from side to side. The adjusters for the quadrupoles use a large ACME screw instead of the jack. The spherical joint consists of a large ball bearing rolling in a groove. Ball bearings are supporting the joint with ACME side screws moving it in only one direction. This kinematic style mount with fewer adjusting screws can be used since the quadrupoles are much lighter than the dipoles. The stands for the magnets are placed along the beamline at an accuracy within their adjustment range and grouted to the floor.

After all of the A1900 magnets are installed, the interior instruments and detectors for the beam boxes are positioned. Up to this point, all the alignment optical hardware has been mounted at the beam box positions. Since the quadrupoles now define the beam axis, the telescopes are moved to right angle mounts located between the quads and the dipoles. At this position, the optics can be calibrated to the targets mounted to the end flanges of the quads, viewing the new detector positions. As on the S800, the detector mounts are attached to the floor, independent of the beam box, to prevent vacuum loading of the box walls from moving the detector after alignment.

This procedure should result in a beam analysis instrument installed at the required accuracy using existing equipment for the most part. The mounting of the magnets will result in a position of high stability and precision.

References

1. B. M. Sherrill, D. J. Morrissey, J. A. Nolen Jr., N. A. Orr, and J. A. Winger, Nucl. Instrum. Meth. **B70**, 298.
2. The K500 K1200, A Coupled Cyclotron Facility at the NSCL, **MSUCL-939**, 4-102.
3. D. P. Sanderson, NSCL Annual Report 1996, 204.