STATUS OF THE TEXAS A&M K500 SUPERCONDUCTING CYCLOTRON

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Abstract

Construction of a K500 superconducting cyclotron at Texas A&M University is progressing on schedule. The building to house the cyclotron has been completed, and most of the magnet components are either completed or nearing completion. The helium refrigerator has been delivered and is undergoing tests. Operation of the magnet is expected in early fall. Most of the components for the rf and trim coil power supplies are in house and the magnet supply is nearing completion.

Introduction

A superconducting cyclotron of the Michigan State University design[1] having K_b=500, K_f=160 is under construction at Texas A&M University. It will be used both alone and as a heavy-ion injector for the existing 224-cm (K=147) cyclotron. The expected performances of the facility are shown in Fig. 1. Details of the coupling between the two cyclotrons have been published elsewhere.[2] A description of the transfer line and of the injection into the 224-cm cyclotron has also been reported.[3]

Funding for the superconducting cyclotron and the building addition has been supplied by Texas A&M University and The Robert A. Welch Foundation. Construction began in 1981 and completion of the K500 cyclotron is expected in late 1985. After research begins with the K500 cyclotron, the 224-cm cyclotron will be shut down for modification and field mapping in preparation for coupled operation.

The status of major subsystems is described below.

Building

An approximately 7000 ft^2 addition to the existing building has been constructed to house the new cyclotron as well as a new experimental area. It was completed in June 1983. A cut-away view of both the present and new cyclotron areas and the experimental areas is shown in Fig. 2.

Iron

All the iron for the magnet is in-house. Individual items are described below. The yoke (83 tons of forged low carbon steel) was fabricated by Japan Steel Works and delivered in July 1983. The vendor provided a virtually finished yoke; the Institute had only to prepare the holes for vacuum sealing of the trim coil leads. This was built on time and within specifications. The pole tips and pole bases (Nichols, Houston) were delivered in April 1984 and meet specifications. During construction, several pieces had to be rejected and remade from scratch because of gouging during machining. Repair by welding was not adopted because it could modify substantially the magnetic properties of the iron (mainly the saturation induction, B_s). A small amount of work has to be done on them by Institute personnel.

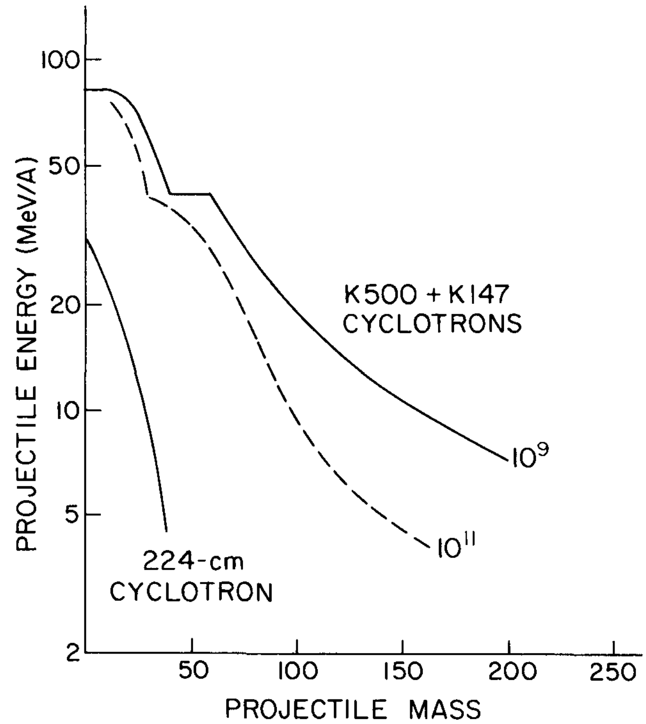

Fig 1. Heavy ion performance curves for the present TAMU cyclotron and the coupled cyclotron facility. (Estimated extracted beam intensities in particles per second).

Superconducting Coil

The K500 superconducting main coil has been wound and banded using the facilities of the National Superconducting Laboratory developed for winding and banding the NSCL K800 main coil. The winding apparatus con-

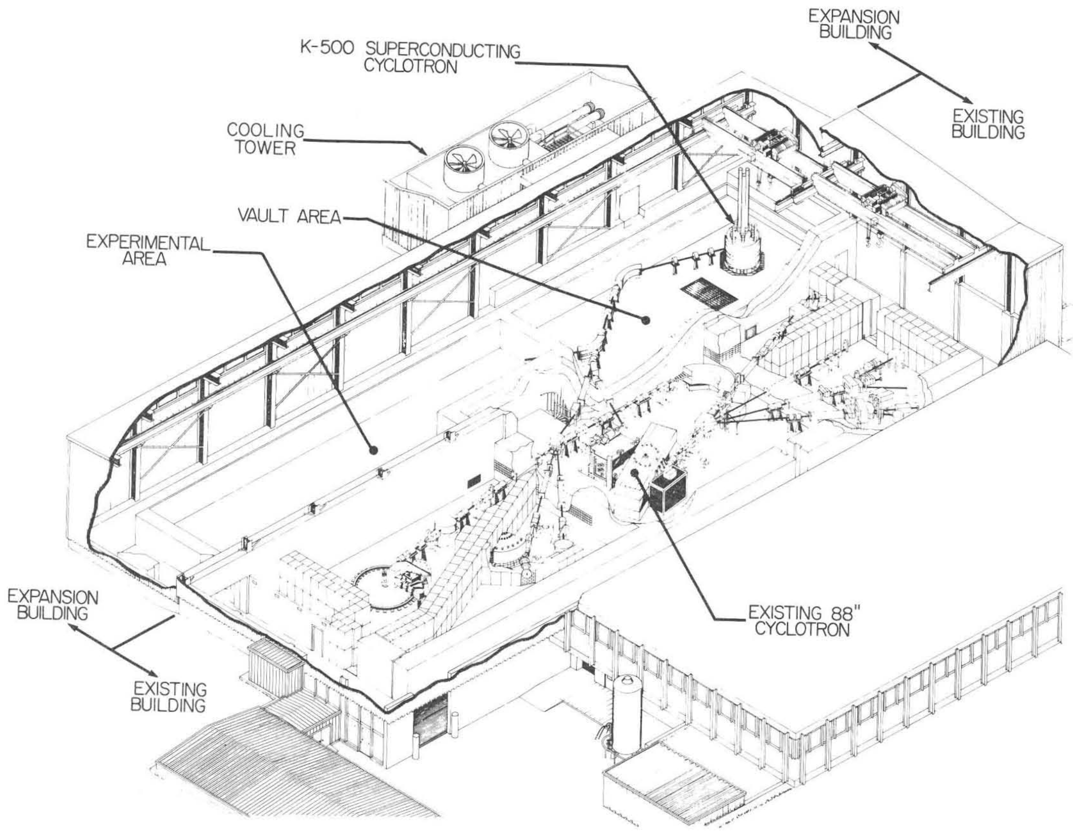

Fig 2. Cut-away view of the cyclotron building including the addition to house the K500 superconducting cyclotron.

sisted of a vertical lathe with winding line attached to the vertical lead screw. The stainless steel bobbin, which forms the inner, upper and lower walls of the helium vessel, turned on the ten-foot lathe bed. The winding line provided tensioning, cleaning, ultrasonic checking, and insulating of the wire before guiding it onto the bobbin. During the banding phase, the winding line was modified to provide the higher tension required for the aluminum banding.

The design of the Texas A&M coil follows closely that of the NSCL K500 coil. However, the superconducting wire, as shown in Fig. 3, is substantially different. The wire was manufactured by Oxford-Airco (Carteret, NJ) and consists of a round superconducting insert, containing 54 Nb-Ti filaments embedded in copper, soldered and crimped into a U-shaped channel in a rectangular substrate. The critical current specification of I_c=900 A at 5.5 T at 4.5°K and the copper resistance specification of $\rho(300°K)/\rho(10°K) \geq 150$ were exceeded in all the samples tested. Eleven lengths of wire were used, making a total of only seven joints in the four coils necessary. Also shown in Fig. 3 is the insulation between turns which consisted of 3 mils mylar with 1 mil adhesive applied to the top and bottom of the wire by the insulating fixture on the winding arm.

The winding method was similar to that used for the NSCL K800 coil, and only minor

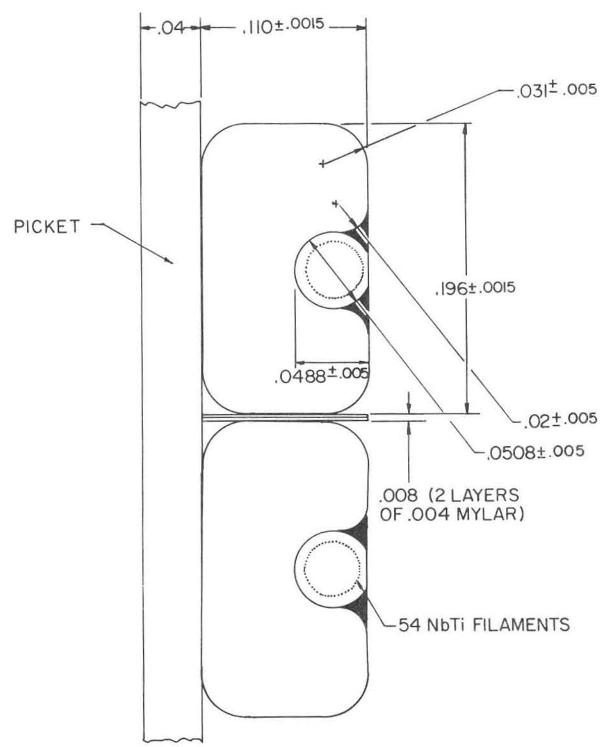

Fig 3. Cross section of the superconducting wire. All dimensions are in inches.

modifications to the winding line were necessary. The wire was helically wound at a tension of 2,000 psi. One-half inch wide G-10 blocks of varying height, spaced every 2°, were used to establish the pitch at the start of each layer, and to fill the space between the wire and the flange at the end of each layer. The layers were separated by 40 mils thick, 1/2 inch wide vertical G-10 pickets which had been pre-glued to the blocks. After all four coils had been wound, they were banded using 10 layers of 0.098 inch thick aluminum wire tensioned to 20,000 psi. Each small coil contains 1092 turns, while each large coil has 2250 turns. The total length of superconducting wire used was 34,660 m. As each layer was finished, all turns were checked for turn-to-turn shorts. Ultrasonic testing during winding revealed no voids in the solder fastening the insert to the main copper piece.

The winding started on January 19, 1984 and was finished on March 15, 1984. On April 2, the coil arrived at Texas A&M where the final coil assembly including the addition of the outer wall of the helium vessel, the LN_2-cooled radiation shield, the support links and the outer cryostat is underway.

Helium liquifier

The helium refrigeration system (Fig. 4) is a single expander cycle with liquid nitrogen precooling. It was fabricated by Cryogenic Consultants Inc. (Allentown, PA). The refrigeration system provides helium both for the coil and for the three internal cryopumps. To handle this load, estimated at 80 watts, the refrigeration capacity will be 188 W at 4.5°K, with a potential for expansion to 268 W at 4.5°K, if additional cooling is required for such items as beam line magnets or experimental equipment. Tests began in January, 1984, but a leak was detected inside the cold box, which is now undergoing repairs.

RF System

All components for the assembly of the major power supplies for the RF system have arrived. The grid and screen supplies are complete and work on the anode power supply is well under way with completion expected in the summer. The power monitoring equipment for the transmission lines have arrived along with a 50 kW 50 ohm water-cooled load that will be used for initial testing. Some parts for the three-phase generator are on order and the balance of the materials for the system should be on order in the next month. Design work and piece-part detail drawings are proceeding for the RF resonators and bids for components are expected to be out soon.

Computer Control System

The general features of the control system for the K500 cyclotron have been established including identification of control and monitoring requirements for all components. The system must be easily expanded to include control of the existing accelelerator and beam optics system and must require a minimum of in-house built hardware. CAMAC modules which

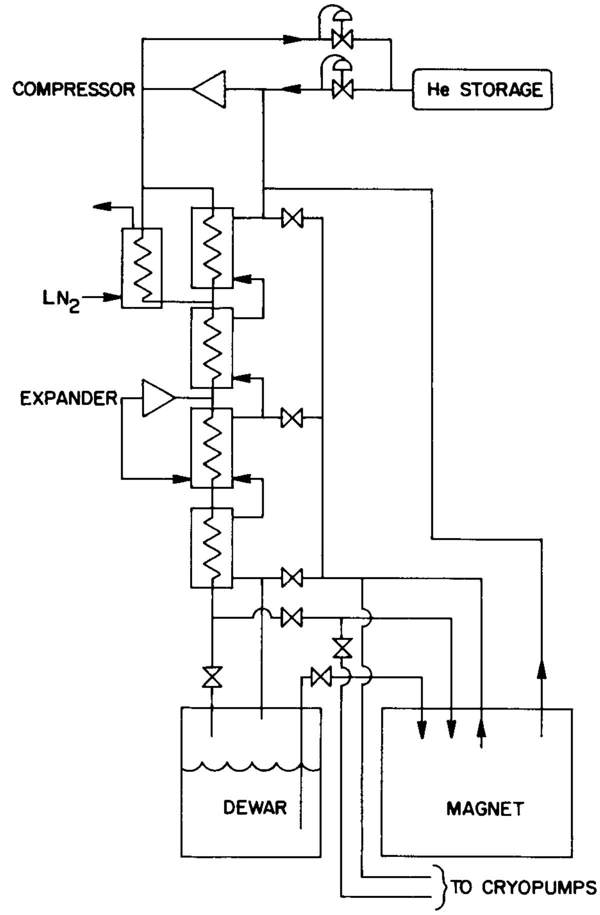

Fig 4. Simplified schematic of the K500 refrigeration system.

can provide the interface between the control system and the cyclotron components are available for most functions. The detailed configuration of the control panel has not yet been fixed. Individual processors will be devoted to CAMAC branch highway control, operator consol control, system-wide alarm processing, and high level accelerator diagnostics. The processors will be connected by a local area network. Much of the hardware for these specialized processors is available at the card level. Expansion of the system entails primarily the addition of more processors to the network. A subsystem to control the main magnet power supply is expected to be completed by fall.

Others

All parts are now on hand for construction of the main magnet and trim coils power supplies. Work is proceeding on these supplies with testing expected in the summer. The deflector power supplies have arrived and have been tested.

The full set of trim coils is now wound and is ready for mounting on the pole tips, which will take place after the first magnetic field measurements to allow the insertion of shims as necessary. These measurements will follow the scheme developed by the National Superconductiong Cyclotron Laboratory[4] for measurements on the K800 cyclotron.

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The extraction channels (M1 to M8) are completed.

Preliminary Studies of Axial Injection

The use of an external source such as ECR, on the K500 cyclotron would considerably increase the heavy ion capability of the facility and is strongly desired by the researchers. In addition, the injection of polarized deuterons from the existing polarized source would provide a unique facility for polarization and neutron experiments. The feasibility (as well as difficulties and limitations) of such injection for superconducting cyclotrons was established by Bellomo[5] using field predictions for the MSU K800 cyclotron.

A study of axial injection into the Texas A&M K500 cyclotron has been undertaken, using magnetic field data from the MSU K500 cyclotron. The results of the study are briefly summarized below.

1) The magnetic field on the axis is sufficient to provide the focussing of the beam, so that no element is needed inside the yoke.

2) It seems also that only one solenoid on the axis is sufficient to control both the emittance and the beam size (Fig. 5).

3) In order to limit the beam size, achromatic deflections are required for the charge selector and for the bending towards the cyclotron axis. For the latter, electrostatic deflectors can be used.

4) A possible layout of the external source is shown in Fig. 5, where a charge selector and a set of four quadrupoles for phase space matching can also be seen. The present polarized ion source can remain where it is, above the 224-cm cyclotron. A transfer line will then bring the beam to the K500 cyclotron.

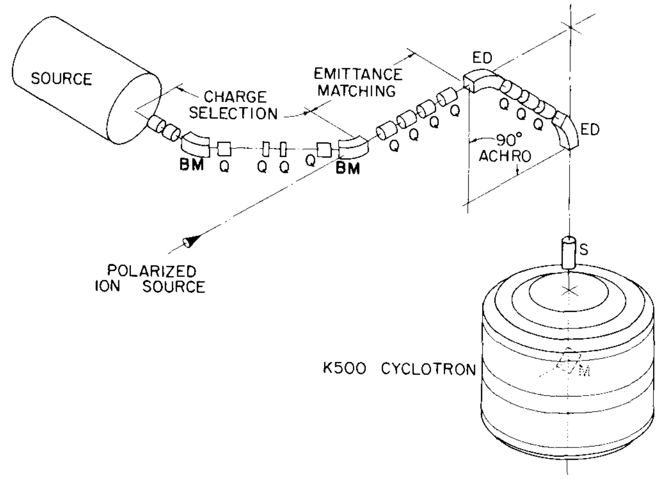

Fig 5. Possible layout of axial injection. For clarity the RF structure is omitted. (Q: quadrupole; BM: bending magnet; ED: electrostatic deflector; S: solenoid; M: electrostatic mirror).

References

1) H. G. Blosser et al., Proceedings of the Seventh International Conference on Cyclotrons and their Applications (Birkhauser, Basel, 1975), p. 584.

2) B. Launé et al., IEEE NS-30, 2, p. 1367.

3) B. Launé et al., IEEE NS-30, 4, p. 2111.

4) L. H. Harwood and J. A. Nolen, Magnet Mapping System for the MSU K800 Cyclotron, these proceedings.

5) G. Bellomo et al. NIM 206 (1983), p. 19.