STATUS OF THE ATLAS UPGRADE CRYOMODULE

J.D. Fuerst, K.W. Shepard, M.P. Kelly, M. Kedzie, Z. Conway, G. Zinkann, S. MacDonald, ANL,
Argonne, IL 60439, USA

Abstract

A new cryomodule for TEM-class superconducting (SC) cavities is under construction both as part of an accelerator improvement project to upgrade the existing ATLAS heavy ion linac at ANL and also to prototype a cryostat design for RIA. A novel design feature is the provision of separate cavity and insulating vacuum systems, which has not previously been attempted with TEM-class SC cavities. The separated vacuum systems will facilitate clean assembly of the cavity string. We present an update on the status of this effort, including progress on mechanical assembly as well as magnetic shield performance data. Initial cooldown and an engineering run of the cryostat should take place before the end of CY05.

INTRODUCTION

The ATLAS heavy ion linac at Argonne National Laboratory [1] will be upgraded with eight new SC cavities as part of an accelerator improvement project. These cavities will reside in a new cryomodule and consist of seven β=0.14 quarter-wave structures and one β=0.26 half-wave structure, all with expected accelerating fields of 8 MV/m [2]. The new cryomodule will replace an existing cryomodule and is expected to increase the total voltage of the linac by 12-14 MV [3].

The increased accelerating fields expected in these upgrade cavities are due to their optimized geometry and the use of clean fabrication and assembly techniques. Clean conditions are achieved and maintained by a cryomodule design which separates the cavity vacuum space from the insulating vacuum space.

DESIGN DETAILS

The key feature of the cryomodule design is the use of separate beam and insulating vacuum spaces. Several innovative design details were developed to combine this feature with a top-loading configuration, which simplifies assembly and access for maintenance and repair. Elements which enable this design include the beam valve spools, thermal shield, and magnetic shields.

Beam Valve Spool

Beam valve spool assemblies mount to the first and last cavities in the string, transitioning the beam line from inside the cryomodule to outside (Figure 1). These spools are part of the clean string assembly and, together with the vacuum manifold valve, serve to isolate the clean interior surfaces from the environment. This allows the cavity vacuum space to be evacuated, leak checked, and sealed inside the clean room.

The spool assembly provides the beam line transition from 4.5K to room temperature, including an 80K heat intercept and radiation screens at 4.5K and 80K. These screens also pump residual gas from the warm inter-cryostat beam tube section. The isolation valve itself is a VAT Series 010 Mini UHV gate valve using the MONOVAT seal configuration for low particulate operation. To fit the tight spacing requirement the valves are welded directly to both the angled plate and the 300K-to-80K bellows.

The angled plate on the spool assembly seals against the end-wall of the vacuum vessel when the dressed string assembly is lowered into the vacuum box (see Figure 1, inset and Figure 6). These spools have been successfully fabricated and tested for leaks and proper valve operation.

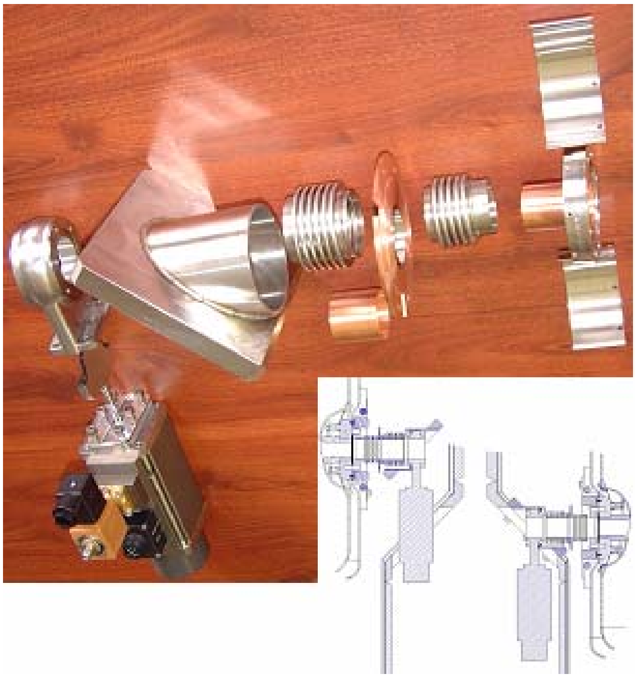

Figure 1: Beam valve spool components prior to braze assembly (photo) and being installed in the cryostat (inset).

Magnetic Shield Design and Performance

Magnetic shielding is provided by a single 0.040” thick layer of AD-MU-80 alloy supplied by Ad-Vance Magnetics, Inc. The shield operates at room temperature and is fixed to the inside surface of the vacuum vessel. To simplify fabrication and installation, 30” wide pre-punched shield sections are laid over threaded studs welded to the vacuum box interior (Figure 2). The overlapping sheet edges are secured with stainless steel batten strips to ensure intimate contact. This technique is low cost, simple to install, and eliminates the need for large welded & annealed shield components.

Shielding on the lid compresses a spring-loaded shield angle attached at the box flange for good box-to-lid shield contact. The design goal of <20 mG residual field was exceeded, with measured fields not exceeding 16 mG in the spaces occupied by cavities. Shielding levels will further improve once large holes at various penetration ports are covered by shield patches particular to each penetration. The photo in Figure 3 shows the assembly technique.

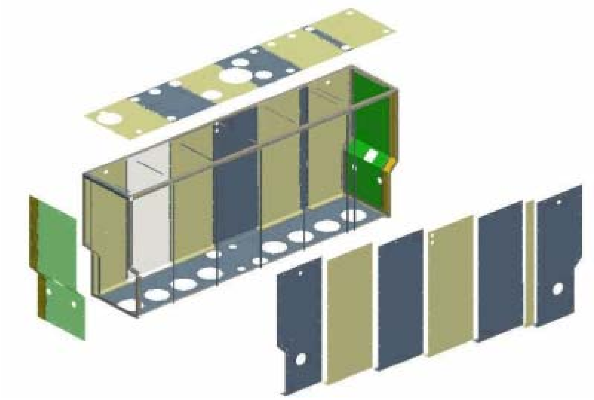

Figure 2: Exploded view of magnetic shield panels.

Figure 3: Magnetic shield panels with SS batten strips.

Thermal Shield Design/Installation

Keeping the insulating vacuum separate from the cavity vacuum permits the use of multilayer insulation (MLI). Reduced heat load on the liquid nitrogen (LN2) cooled thermal shield saves nitrogen and allows a thinner, conduction-cooled shield. Prefabricated panels of 0.065” thick copper hang from two rectangular LN2 manifolds mounted to the top of the box, spaced from the outer wall with G10 buttons. Figure 4 illustrates the thermal shield design concept.

Installation of the copper panels proved straightforward. MLI blankets are pre-rolled, grommeted, and hung from hooks on the vacuum vessel interior (35 layers) and thermal shield interior (15 layers). The photo in Figure 5 shows the 35 layer blanket as installed in one end of the vacuum vessel.

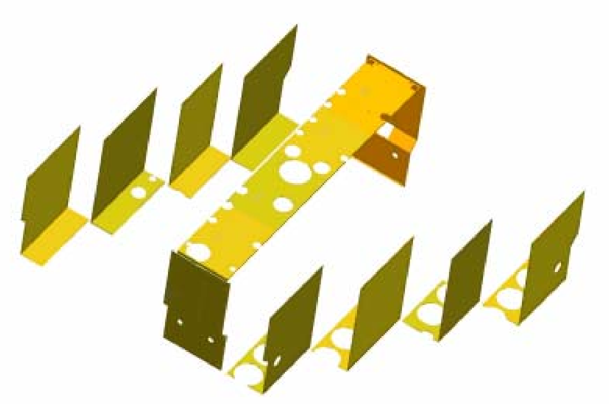

Figure 4: Exploded view of the thermal shield panels.

Figure 5: Multi-layer insulation blanket installed between vacuum vessel and thermal shield.

Assembly Sequence

Separate beam and insulating vacuum spaces minimize the number of components involved in clean assembly. Cavities, couplers, vacuum manifold, inter-cavity spools, and beam valves are assembled under clean conditions, the cavity vacuum is sealed prior to removal from the clean environment (see Figure 6, top). Subsequent assembly steps include installation of the fast and slow tuners, cryogenic connections, instrumentation, and alignment – none of which require especially clean conditions. The string of fully-dressed cavities is suspended from the lid (Figure 6, middle), then lowered into the vacuum box to complete the assembly (shown in cutaway in Figure 6, bottom).

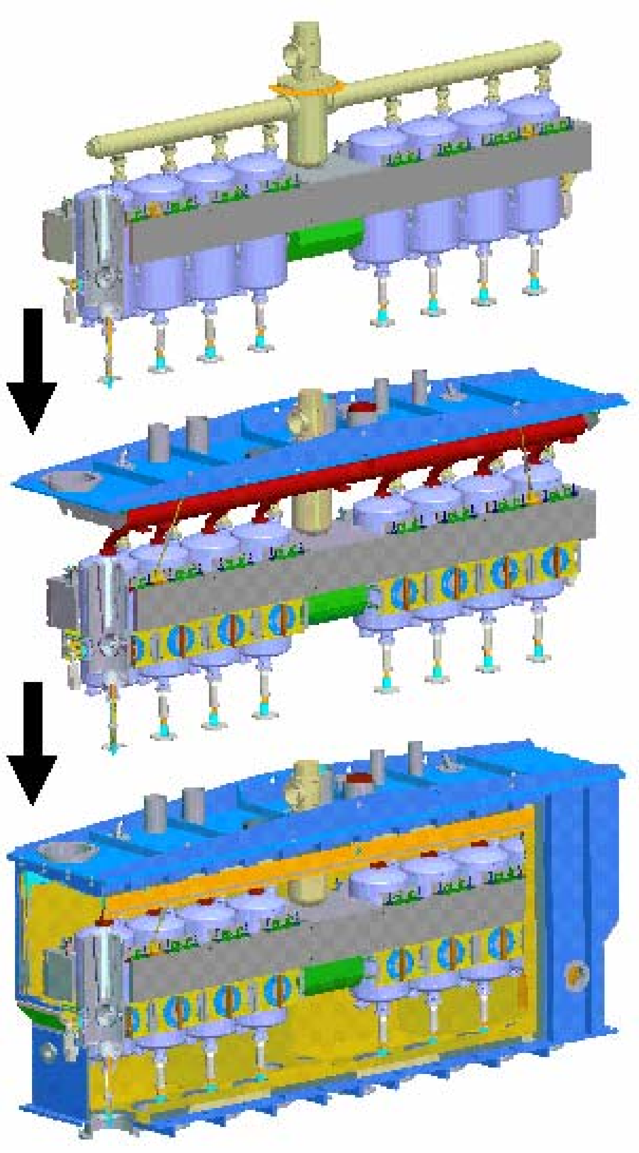

Figure 6: Upgrade cryomodule assembly sequence showing clean subassembly (top), dressed cavities suspended from lid (middle), and cutaway view of completed cryomodule (bottom).

CONCLUSIONS

A top-loading, box cryomodule has been developed which provides for separate cavity and insulating vacuum spaces. The design is cost-effective, not only in itself, but in facilitating. Clean assembly techniques by minimizing the number of components involved in clean assembly.

REFERENCES

[1] Den Hartog, P.K. et al, “Operational Experience of the ATLAS Accelerator,” NIM in Phys. Rev. A 287, 1990, p. 235-239.

[2] Shepard, K.W. et al, “Superconducting Intermediate-Velocity Cavity Development for RIA,” PAC2003, p. 1297.

[3] Shepard, K.W., “Superconducting Heavy-Ion Accelerating Structures,” NIM in Phys. Rev. A 382, 1996, p. 125-131.