Assessment of the MEGA/LASS Magnet at LANL

March 20, 2000

Executive Summary

A team established the condition of the MEGA/LASS magnet system currently at the LANSCE site at Los Alamos National Laboratory (LANL) in anticipation of its transfer to Jefferson Laboratory (JLab).

There is a high probability that the existing three coil system as presently configured was left in a working condition. This judgment is based on:

a. A visual inspection
b. Interviews with users, engineering and technical staff; and
c. Review of written records

All the documentation including drawings, test records, photos, design analyses and logbooks exist. At LANSCE, the three-coil system was operated successfully from 1987 to 1996, with approximately ten complete thermal cycles and at least 100 electrical cycles without incident.

In our opinion, if the three-coil system were cooled and powered in place it would work. Such a test, including physical preparations and hazard analysis, would take about three to four months. Since this would only be a three-coil test (without the fourth coil) such a test would be of little or no benefit and therefore not cost effective.

We conducted a visual inspection of the fourth coil which has been stored outdoors at the LANSCE site since the fall of 1986 in its original wooden shipping container which is largely intact albeit weathered. The inside of the shipping container is reasonably clean and free of foreign matter indicating that it has been undisturbed. The original seals on the two openings remain intact. The benign environment of Los Alamos contributes to our confidence about the condition of the coil. The iron and supports for the fourth coil also exist.

Since the MEGA experiment is completed and there is no other foreseen experimental program using the magnet, it is essential to consolidate all documentation and transfer this and the magnet system with the associated hardware to JLab as soon as possible to prevent damage and dispersal. We strongly recommend that the disassembly begin no later than January, 2001.

The replacement cost of the magnet is about $10M based on extensive world experience with the construction of comparable large magnet systems.

The cost for disassembly, loading, shipping, and re-assembly is estimated to be less than ten percent of the replacement cost.

The anticipated lifetime of the magnet is at least through the year 2025.

The committee discussed details of and verification checks after the disassembly, shipping and re-assembly of the magnet.

Introduction

A group convened at the LANSCE facility at Los Alamos on March 9 to 11, 2000 to assess the functionality of the MEGA/LASS magnet and the details involved in disassembly of the magnet, shipping, re-assembly at Jefferson Lab (JLab). This meeting took place in response to the JLab PAC subcommittee (Cassel committee) review of the Hall D project which proposes to use the magnet for the Hall D detector. In particular, the subcommittee expressed concern about the functionality of the MEGA/LASS magnet, especially the fourth coil. Given a positive assessment, the subcommittee recommended moving the magnet to JLab as soon as possible.

The MEGA/ LASS magnet was originally built for the LASS experiment at the Stanford Linear Accelerator Center (SLAC) and was transferred to LANL for the MEGA experiment. In the LASS configuration, four coils were used while for the MEGA experiment only three coils were used although all four coils were transferred to LANL.

The assessment group included:

- John Alcorn, JLab consultant. Alcorn was the project engineer for the SLAC LASS magnet (1970-75).
- Steve St.Lorant, JLab consultant. St.Lorant was the project physicist for the LASS spectrometer (1970-1977) and was the project manager for the transfer of the LASS magnet to LANL in 1986.
- Paul Brindza, JLab staff engineer and is system engineer for experimental equipment at JLab.
- Alex Dzierba, Indiana University professor and spokesperson for the Hall D collaboration
- Eric Scott, Indiana University mechanical technician.

This group interviewed the following staff members at LANL, all of whom are members of P-division.

- Jim Amann, staff physicist, MEGA collaborator and P-25 operations and safety officer.
- Martin Cooper, staff physicist who is MEGA spokesperson and Deputy Group Leader of P-25
- Val Hart, retired staff engineer for the MEGA project in charge of the transfer and re-installation of the magnet at LANL.
- Cy Hoffman, MEGA physicist in charge of the MEGA magnet.

- Larry Marek, chief technician for the MEGA experiment and cryo tech. Larry was the MEGA magnet technician throughout the MEGA installation and data-taking.

- Dick Mischke, staff physicist who is a Hall D collaborator and a MEGA collaborator.

- Jan Novak, retired staff member who was chief cryo engineer for the NP division.

- Andrea Palounek, staff physicist and P-25 Group Leader and Hall D collaborator.

Inspection of the Fourth Coil (Iron Yoke and Coil/Cryostat)

Both items are located outdoors on the north side service road next to the injector. The iron yoke, support legs and alignment screws show relatively little corrosion which will require refurbishment.

We conducted a visual inspection of the fourth coil, stored outdoors in its original wooden shipping crate since 1986. The two openings into the stainless steel cryostat are closed. The vacuum pumping line is capped with a plastic K-plug backed by fabric tape in good condition. We therefore assume that the vacuum space has been untouched by the elements.

The service access to the coil and nitrogen shield is protected by a metal cover and each coolant path isolated with a stainless steel "T" supporting a relief and a manual valve. We have been informed that the parts of three like assemblies exist. We therefore posit that this arrangement was used to render the coil system and radiation shields inert with nitrogen gas for shipping purposes. The manual valves are closed.

The crate containing the coil and the iron yoke have been stored above ground on cribbing and do not appear to have been moved frequently. The wooden shipping container is weathered.

Figure 1: The inside of the packing crate containing the fourth coil.

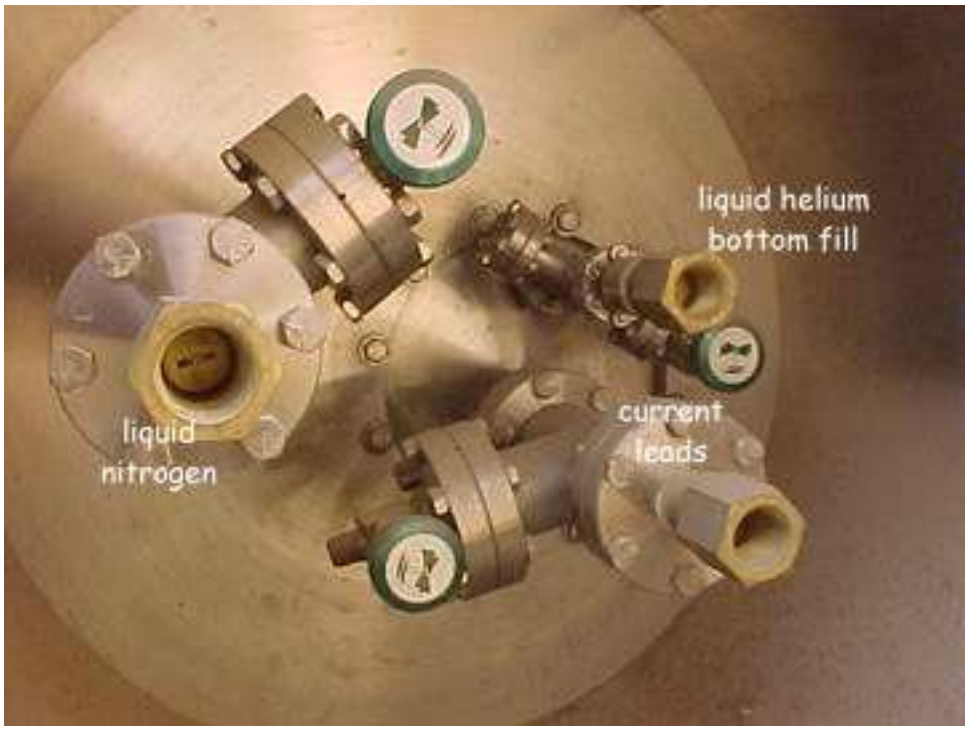

Figure 2: (top) The fourth coil valve assembly showing the pristine condition of the fourth coil service tower and (bottom) details of the valve assembly.

Inspection of the Three-Coil MEGA System

The MEGA system is located in Building A, in which a measure of temperature control was maintained for about two years following the final shutdown of the system in January, 1996. L. Marek indicated that this final activity was performed according to the normal procedures prescribed for a shut down following an experimental run, that is, the magnet was allowed to warm up slowly and the cryogens vented. Warm-up records exist.

We inspected the site on March 9. We noted that in spite of considerable congestion in the vicinity of the magnet due to the physics instrumentation, all operating areas were clean, uncluttered, and exhibited evidence of periodic maintenance. This was confirmed during the interviews.

We found no evidence of equipment removal from the system except for the two mechanical fore pumps which service the main insulating vacuum of the cryostats and the cryogenics and electrical services tower, a. k. a. Puffing Billy. We have been assured that the two pumps will be restored to the system. This apparently unauthorized pump removal underscores the urgent need for a timely disassembly and transfer of the MEGA magnet and subsystems to JLab. The vulnerability of the installation to casual "borrowing" of equipment is high and it is not clear whether the MEGA location can be adequately secured to prevent such activity. A listing of the principal components of the system, including coil four will be found in the Appendix.

The entire magnet system appears to have been properly "mothballed", i.e., given the resources, time and appropriate funding, it could be prepared for a cool down and operation. A sampling of the documentation and operations logs confirms this impression inasmuch as all significant entries noted refer to problems with refrigeration. The reliability of the magnet was underscored by the minimal attention and manpower requirements needed to maintain the system in operation. In depth interviews with cryogenics, engineering and operations staff did not reveal any untoward incidents in the history of the magnet other than the usual vacuum leaks and errors in wiring, characteristic of a startup operation following re-assembly of such a complex system.

All this might suggest an i*n situ* cool-down and power test. A complete test which involves moving, installing and connecting the fourth coil is, in our opinion, impractical. THE MEGA iron would have to be rearranged to accommodate the fourth coil, Puffing Billy opened and the existing intercoil buswork modified to include the fourth coil. Also it is not clear, without an engineering study, whether the existing pit is long enough to accommodate the additional length of the fourth coil and yoke. A limited test of the existing three-coil setup, on the other hand, is of little or no benefit and therefore not cost effective. It would take considerable manpower and time (3-4 months) to prepare for this test and to submit the necessary hazard analysis.

MEGA Documentation

The review team inspected the documentation of the MEGA magnet, which was found at various locations throughout LANSCE. The engineering drawings exist on aperture cards, apparently complete for the magnet proper, Puffing Billy and associated cryogenic and support equipment. Also, prints are available for many or most of these elements.

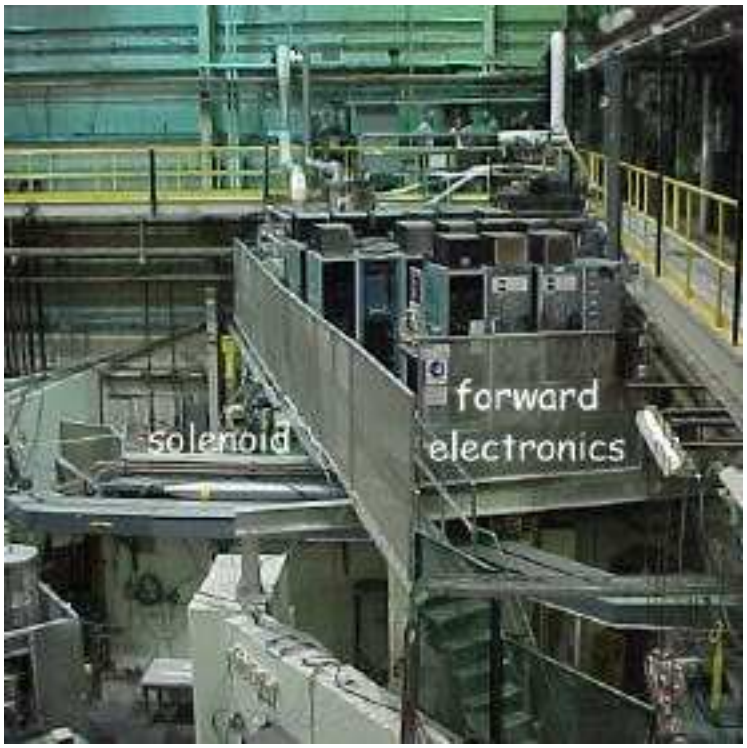

Figure 3: (top) - The MEGA magnet shown with platforms and Puffing Billy and (bottom) the electronics racks on the platform above the MEGA magnet.

The MEGA experiment operational logs were found. Several loose-leaf notebooks contain photographs of the disassembly of LASS at SLAC and re-installation in the MEGA configuration at the LANSCE site.

Detailed 3D magnetic field mapping data for the MEGA operating configuration exist. Another notebook contains complete identification and details of all coil instrumentation (voltage and temperature); coil resistance vs. temperature, and other data.

Budgetary Considerations

The costs associated with disassembly, loading, shipping and re-assembly of the magnet in the transfer from SLAC to LANSCE are detailed and well documented. This total cost, in 1986 dollars, was approximately $250K. Our estimate of under $1M to cover similar tasks takes into account inflation, the greater moving distance, ES & H considerations and inclusion of the fourth coil in re-assembly. The re-assembly at JLab will also require maintenance. Modifications will also be required to accommodate the experimental program.

Anticipated Lifetime

The anticipated lifetime of the MEGA/LASS magnet is surely long, since it has been properly operated and stored, but it is difficult to quantify. The cryogenic operating environment is benign. The radiation exposure of the magnet has been minimal both at SLAC and at LANSCE. The magnet has been carefully maintained and even ambient, outdoor storage of the fourth coil has been non-threatening as all ports appear to have retained their original seals. The coil/cryostat/radiation shield materials are stainless steel, copper, mylar inter-turn insulation and glass epoxy (FRP) ground insulation.

We therefore expect that this magnet can be operated at least through the year 2025.

Preparations for Transfer of the Magnet Assembly

The transfer agreement should be executed as soon as possible to establish the new ownership and to allow the shipment to begin. This agreement will involve the Program Director for Nuclear Physics at LANL, the Director of JLab and the DOE Office of Nuclear Physics.

A timely transfer is especially important as there are numerous small items and cabinets full of documentation that are highly portable or fragile. In particular, document records should be collected and shipped to JLab as soon as possible. The MEGA site should be secured. Small items associated with the MEGA magnet system should be collected and stored in an on-site JLab-owned shipping container. To repeat, the exposure to misplacement and/or loss of this essential material is high.

The LANSCE Division at LANL is the landlord of the site where the MEGA/LASS magnet is held, and as such has a role in the approval of safety plans associated with removal of the magnet. Physicists in the P-Division at LANL used the magnet for the MEGA experiment. Both divisions are therefore involved in the transfer and preparations.

The first step in the relocation is a comprehensive ES&H plan. This important process is extensive in nature and must be started as early as possible. A knowledgeable ES & H coordinator, a LANL staff member who has been made fully aware of the project goals, should be identified. The ES & H issues include among others, safety certification for radiological hazards, toxic materials, stored energy piping systems, electrical hazards, fire suppression and the cryogenic system.

The next step is to formulate the need for space and access to cryogenic services in the test lab at JLab and to establish a firm schedule for this activity.

The transfer operation requires that a JLab-employed coordinator for this activity must be identified as quickly as possible. This individual should be someone who is knowledgeable about LANSCE procedures and will also be responsible for the re-assembly of the magnet at JLab. This individual must have full authority to act on JLab's behalf at LANSCE and have all required safety training, access, privileges and purchasing authority needed to perform his task. He will be the prime contact for all contractors and all personnel working on JLab's behalf at LANSCE on the MEGA magnet transfer.

A rigging contractor identified by JLab should be contracted with for all aspects of the major disassembly, packing, loading, shipping, off loading and major re-assembly at JLab. It is essential that JLab control this important service. The 30-ton crane in Area A must be operated by LANSCE personnel.

The tasks and responsibilities include:

Members of the P-Division staff should:

- Remove all materials and equipment which P-Division staff wishes to retain, such as the helium refrigerator (not needed by the collaboration), detector electronics and some detector items. These items must be identified and mutually agreed upon by both laboratories prior to the transfer. A list of these items must be accessible to the coordinator.

- Remove and properly dispose of all identified hazardous materials.

Hall D Collaborators are responsible for the following items with the understanding that any disassembly, packing and the like activities will include documentation (including photos, videos and logbooks), labeling and and the maintenance of a detailed disassembly log. The collaborators will disconnect:

- The DC bus power supply and dump circuit.

- All electronics, cables and control items.

- The vacuum system and cryo system components.

- Three coils from Puffing Billy. The exposed ports should be protected as appropriate.

The Rigging/Packing/Shipping contractor will then remove the items and prepare them for shipping as appropriate. Further he will remove the system components, the service decks, yoke rings and coils. He will stage all items outdoors adjacent to Area A in preparation for certification by LANL radiation control for "Release to the Public."

The Rigging/Packing/Shipping contractor will pack and crate all items as needed and load for shipment. All items are to be shipped to JLab, there unloaded and prepared for reassembly.

For reference as to the extent of the task, the original shipment from SLAC to LANL was 15 truckloads.

APPENDIX
Items to be Transferred

- Fourth coil.
- Fourth coil iron yoke, alignment stands and supports, 2 cradles
- 3-coil MEGA magnet, alignment supports, yoke cradles and transport system
- Cryogenic and electrical services tower, i.e. Puffing Billy
- Platforms and stairs as applicable to the access to the operating environment of the MEGA magnet
- Vacuum system mounted on a steel framework, consisting of 2 diffusion pumps, 2 LN2 cooled baffles, two fore pumps of the appropriate capacity, all valving and instrumentation, header manifold for four coils and the service tower, and all vacuum readouts and controls
- Power supply
- Wet and dry energy dumps
- 535 mcm heavy current cabling
- Instrumentation and control racks
- Instrumentation cabling
- Control cabling
- Allen Bradley PLC industrial control system in steel enclosure
- Miscellaneous alarm and interlock systems
- Relief valves and vent system
- Cryogenic lines other than identified and retained by P-Division
- Cooled physics instrumentation racks, as offered by P-Division