IEEE Transactions on Nuclear Science, Vol. NS-30, No. 4, August 1983

WATER-COOLED TARGET BOX DESIGN AT LAMPF

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Summary

The target boxes in the main experimental beam line (Line A) at the Clinton P. Anderson Meson Physics Facility (LAMPF) have operated since 1976. A program of replacing the boxes is underway. This paper will present past history, design considerations, calculational results and the final box design.

Introduction

The target boxes in Line A were originally installed in 1974 and 1975. They are stainless steel vacuum chambers with copper tubes brazed to the exterior to dissipate the heat deposition from secondary scattering from the targets. The copper tubes were then flame-sprayed with copper to increase the heat transfer area. The original copper tubes have a high failure rate due to thermal cycling and built-in stresses from the original brazing. Reference 1 outlines the evolution of target chamber cooling schemes from that era to the present day.

Another persistent problem has been the leakage of the vacuum joints close to the targets due to thermal cycling.

Design Considerations

The present target box design scheme involves the use of double-walled water-cooled chambers which optimize the heat transfer to the coolant, eliminate erosion and corrosion problems and provide the highest possible integrity and reliability. The extra expense of this scheme (a factor of 3 to 7) is fully justified by also considering the expense of the remote repair and replacement of the earlier less expensive schemes.

Additional considerations are elimination of vacuum joints near the target. As opposed to earlier schemes, each joint is now shielded by the copper collimators in each of the lines. Figure 1 shows the relationship of the target to joints in each of the beam lines. The water-cooled copper collimators provide sufficient shielding to reduce the heat deposition to such a point that the temperature cycling of the joints is trivial.

In addition the copper collimators provide shielding for surrounding components from the scattered particles from the target. The collimators also provide a limiting beam aperture for the proton beam downstream as well as the pions in the secondary beam lines.

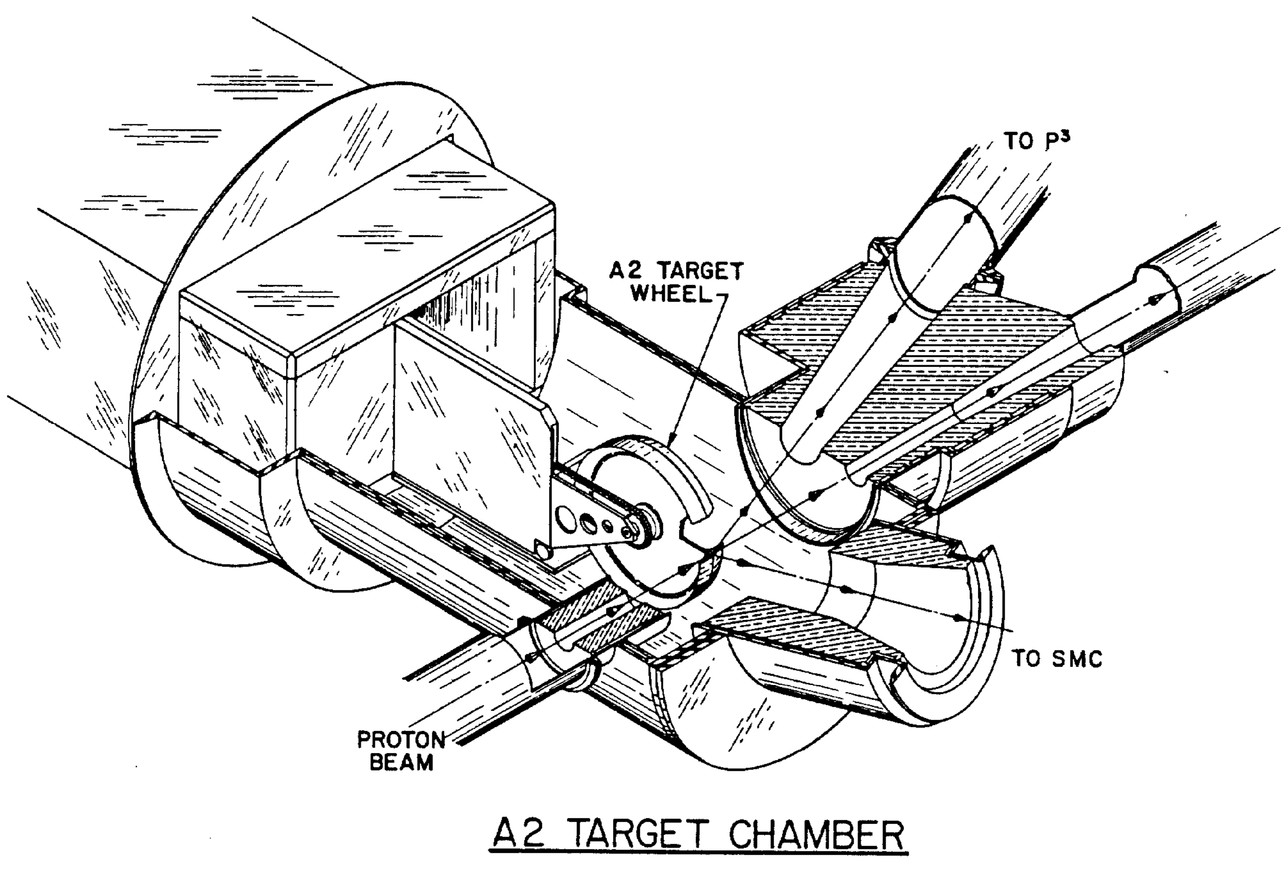

Figure 1

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Calculational Results

The potential target box design was analyzed using two Los Alamos authored finite element codes. These are Ayer and TSAAS, which provide temperature and stress distributions respectively.

The results of a portion of these calculations are presented below.

Figure 2, 3 and 4 show the finite element mesh, the temperature distribution and the principal stresses in the main shell of the target box.

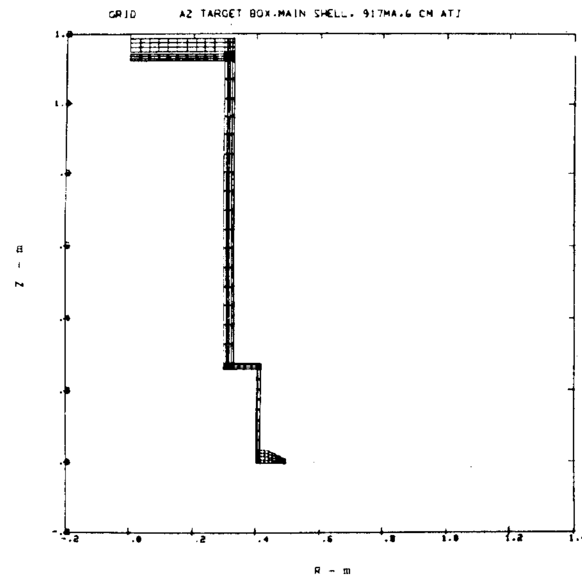

Figure 2

Finite Element Grid For Main Box Shell

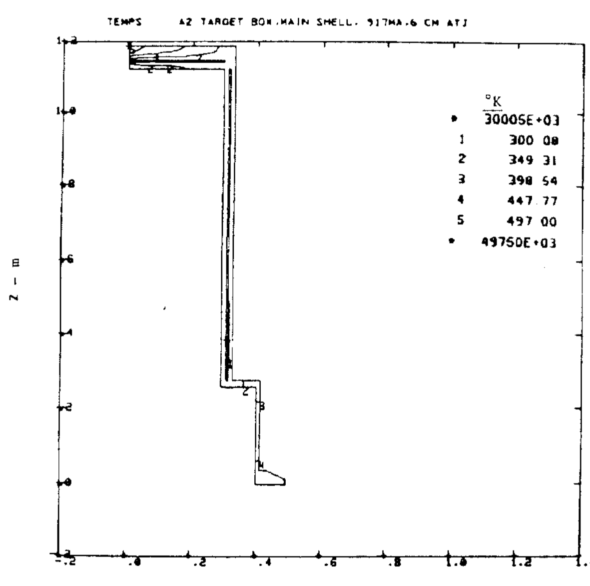

Figure 3

Temperature Distributions In Main Box Shell

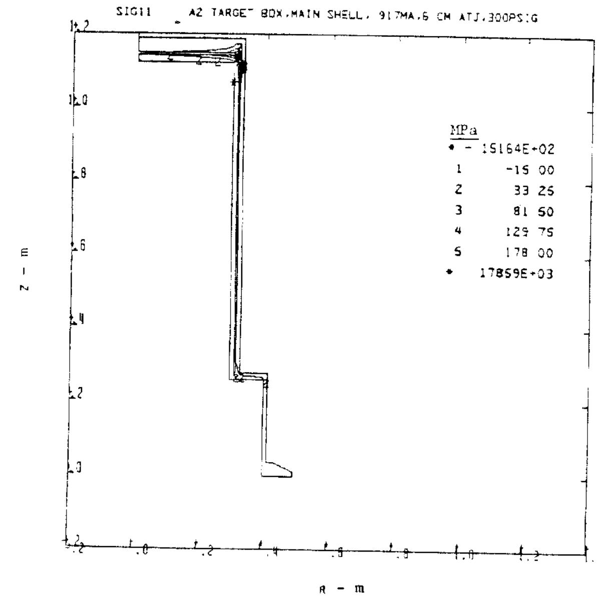

Figure 4

Stress Distributions In Main Box Shell

Figures 5, 6, and 7 show the finite element grid, the temperature distribution on the face nearest the target, and a temperature profile across the front face of the downstream - P^3 copper collimator. Only temperatures are shown since the stresses in the thick-walled copper pieces are insignificant.

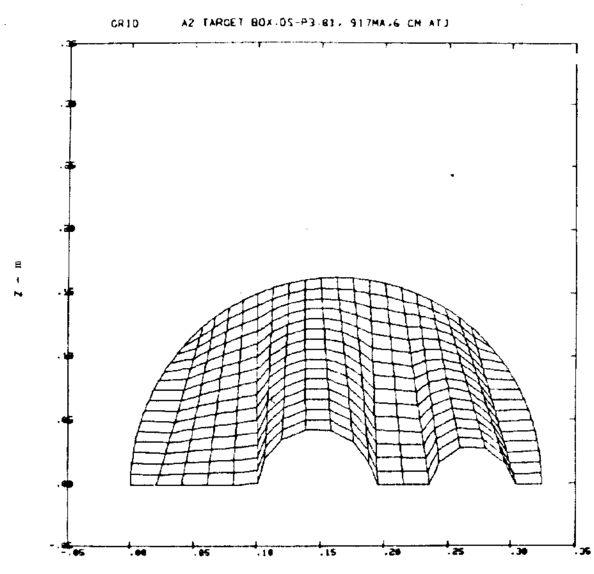

Figure 5

Finite Element Grid For Downstream - P^3 Collimator Face

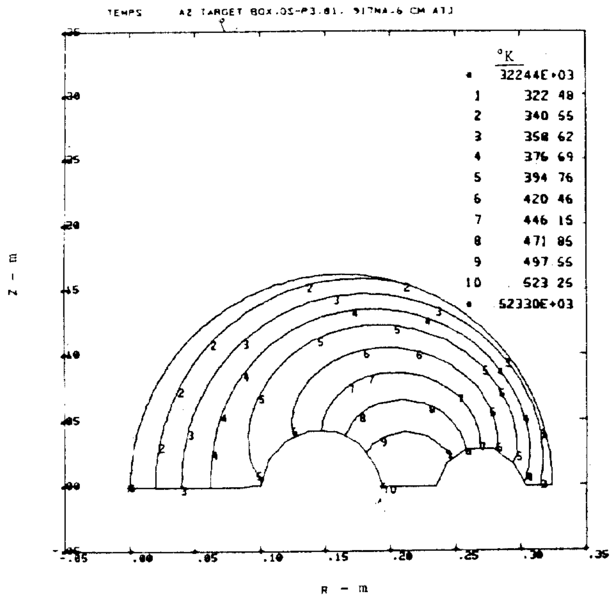

Figure 6
Temperature Distribution The Downstream -
P^3 Collimator Face

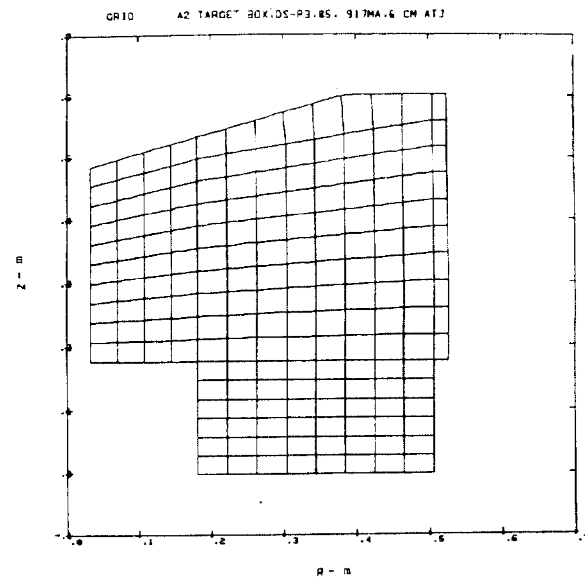

Figure 8
Horizontal Slice Through Downstream -
P^3 Collimator

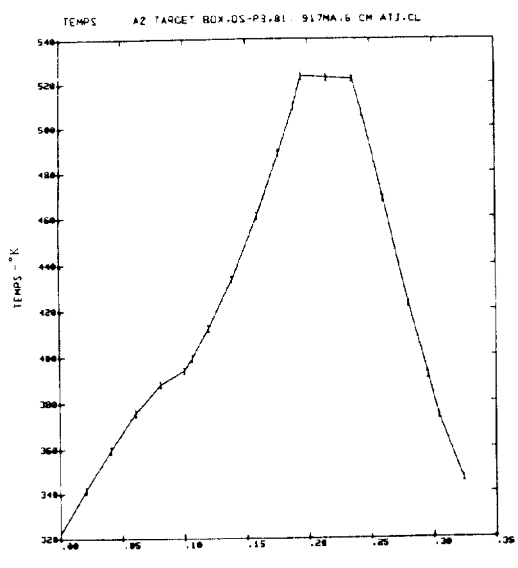

Figure 7
Temperature Profile On The Downstream
Collimator Front Face

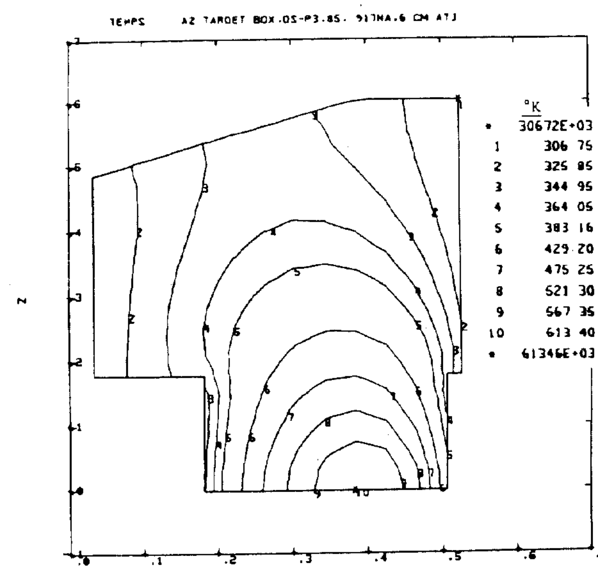

Figure 9
Temperature Distribution

Although three-dimensional finite element codes exist, the programming and computer times are prohibitive except for extremely critical areas where space or weight are severely limited. For less critical applications two-dimensional codes are used on three-dimensional objects by taking cuts through the object in various places.

Figures 8 and 9 are the results of such an analysis in a different direction; in this case a slice through the horizontal centerline of the downstream - P^3 collimator as well as the temperatures of the front face.

Conclusion

The seven years of experience and the use of modern calculational techniques provide an assurance that the new Line A target boxes at LAMPF will operate without significant deterioration and need for repair for several years.

References

1. D. L. Grisham and J. E. Lambert,"Water-Cooled Beam Line Components at LAMPF," Particle Accelerator Conference, Accelerator Engineering and Technology, Washington, D. C. (March 1981).