THE MECHANICAL DESIGN FOR THE DARHT-II
DOWNSTREAM BEAM TRANSPORT LINE*

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Abstract.
This paper describes the mechanical design of the
downstream beam transport line for the second axis of the
Dual Axis Radiographic Hydrodynamic Test (DARHT II)
Facility. The DARHT-II project is a collaboration
between LANL, LBNL and LLNL. DARHT II is a
20-MeV, 2000-Ampere, 2-µsec linear induction
accelerator designed to generate short bursts of x-rays for
the purpose of radiographing dense objects. The down-
stream beam transport line is approximately 20-meter long
region extending from the end of the accelerator to the
bremsstrahlung target. Within this proposed transport line
there are 15 conventional solenoid, quadrupole and dipole
magnets; as well as several speciality magnets, which
transport and focus the beam to the target and to the beam
dumps. There are two high power beam dumps, which are
designed to absorb 80-kJ per pulse during accelerator
start-up and operation. Aspects of the mechanical design
of these elements are presented.

1 INTRODUCTION

We are working on the engineering design of the
downstream beam transport components of the DARHT II
Accelerator [1]. Beam transport studies for this design
have been performed [2]. Figure 1 shows the proposed
layout for the elements in the system during early
commissioning of the downstream components. The
beamline from the exit of the accelerator to the
bremsstrahlung target. Within this proposed transport line
there are 15 conventional solenoid, quadrupole and dipole
magnets; as well as several speciality magnets, which
transport and focus the beam to the target and to the beam
dumps. There are two high power beam dumps, which are
designed to absorb 80-kJ per pulse during accelerator
start-up and operation. Aspects of the mechanical design
of these elements are presented.

2 TRANSPORT ELEMENTS

The magnets within the DARHT II transport line are all
water-cooled conventional dc electromagnets (except the
bias dipole and the kicker sextupole corrector). The
magnets are listed in Table 1.

The transport solenoids have external iron shrouds with
water-cooled copper coils. Solenoid coils are wound into
individual two-layer "pancake" coils. Each magnet has an
even number of these pancake coils. The pancakes are
installed in an A-B-A-B orientation to minimize axial
field errors. The inside diameters of the solenoid coils are
sized large enough to fit over the outside diameter of the
beam tube flanges.

The septum quadrupole and dipole magnets have solid
iron cores with water-cooled copper coils. The Septum
Quadrupole Magnet is a four-piece, solid-core construc-
tion. The Collins Quadrupole Magnets are two-piece solid
cores with non-magnetic support. The dipole magnet is a
three-piece, solid-core, "C" magnet.

The alignment requirements for the transport magnets
are ±0.4-mm positional tolerance and ±3-mrad angular
tolerance. Steering corrector coils will be installed under
many of the magnetic elements to allow for small
alignment errors or stray magnetic fields.

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Figure 1: Layout of the transport elements.

Figure 2: Picture of a Collins Quadrupole.

Figure 3: Picture of the Septum Quadrupole being characterised during a rotating coil test.

Table 1: Magnet specifications

| Magnet Type | Magnet Name | Max. Field (kG) or Gradient (kG/m) | Bore or Gap (cm) |
|-------------|-------------|-----------------------------------|-----------------|
| Solenoid    | S1          | 8                                 | 27              |
| Solenoid    | S2          | 8                                 | 27              |
| Solenoid    | S3          | 2.5                               | 27              |
| Dipole      | Bias Dipole | 0.009                             | 41              |
| Pulsed Dipole | Kicker     | -0.009 (equivalent)              | 12.8            |
| Sextupole   | Sextupole Corrector | 16 gauss @ 20.5 cm radius | 41              |
| Quadrupole  | Septum Quadrupole | 8.0                               | 38              |
| Quadrupole  | Collins-H   | 10.0                              | 12              |
| Quadrupole  | Collins-V   | 10.0                              | 12              |
| Quadrupole  | Collins-W   | 10.0                              | 12              |
| Quadrupole  | Collins-X   | 10.0                              | 12              |
| Solenoid    | S4          | 2.5                               | 27              |
| Solenoid    | S5          | 2.5                               | 27              |
| Solenoid    | Final Focus Solenoid | ~5                               | ~13             |
| Dipole      | Septum Dipole | 1.0                               | 16              |
3 VACUUM SYSTEM

The vacuum chambers for the DARHT II Transport Line are circular beam pipes constructed from 304L stainless steel. The region from the end of the accelerator through the septum has a 16-cm bore diameter. From the septum to the target, the bore diameter is reduced to 9.55 cm. The vacuum seals are made with conflat style knife-edge flanges with annealed copper gaskets. The use of all-metal seals is driven by the potential requirement to in situ bake the transport vacuum system. In situ bake-out may be required to minimize adsorbed gas on the beam tube walls, which may be desorbed by beam halo scraping the walls. The vacuum design requirement for the transport line is $10^{-7}$ Torr pressure.

Figure 4 shows a side view of the septum vacuum chamber. The chamber resides in the region where the beamline splits between the line going to the target and the line going to the main dump. The chamber is formed by two aluminum halves that are then welded together at the midplane.

The main beam dump absorbs the portion of the beam that is not deflected by the kicker system. The normal horizontal beam size at the main beam dump is 8 cm. However, the start-up parameters for the beam will not be well known. We must therefore provide some safety margin. First consideration is to keep the instantaneous temperature (temperature at the end of the 2-µsec pulse) of the impact area below the damage point for the material. At 1 pulse per minute repetition rate we can manage the average temperature increase. We also desire to keep the neutron yield low to minimize activation of components and simplify radiation shielding. The construction of the beam dump must be compatible with high vacuum as explained in the previous section.

4 BEAM DUMPS

There are two beam dumps included in the DARHT II downstream transport system; a main beam dump, and a shuttle dump. The purpose of the shuttle dump is to allow accelerator operations while personnel are working in the target area outside the accelerator hall. The shuttle dump will have a composite absorber, made up of a 3-inch thick graphite block, backed by 12-inches of tungsten. There will be additional shielding surrounding the beam stop to absorb radiation.

REFERENCES

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