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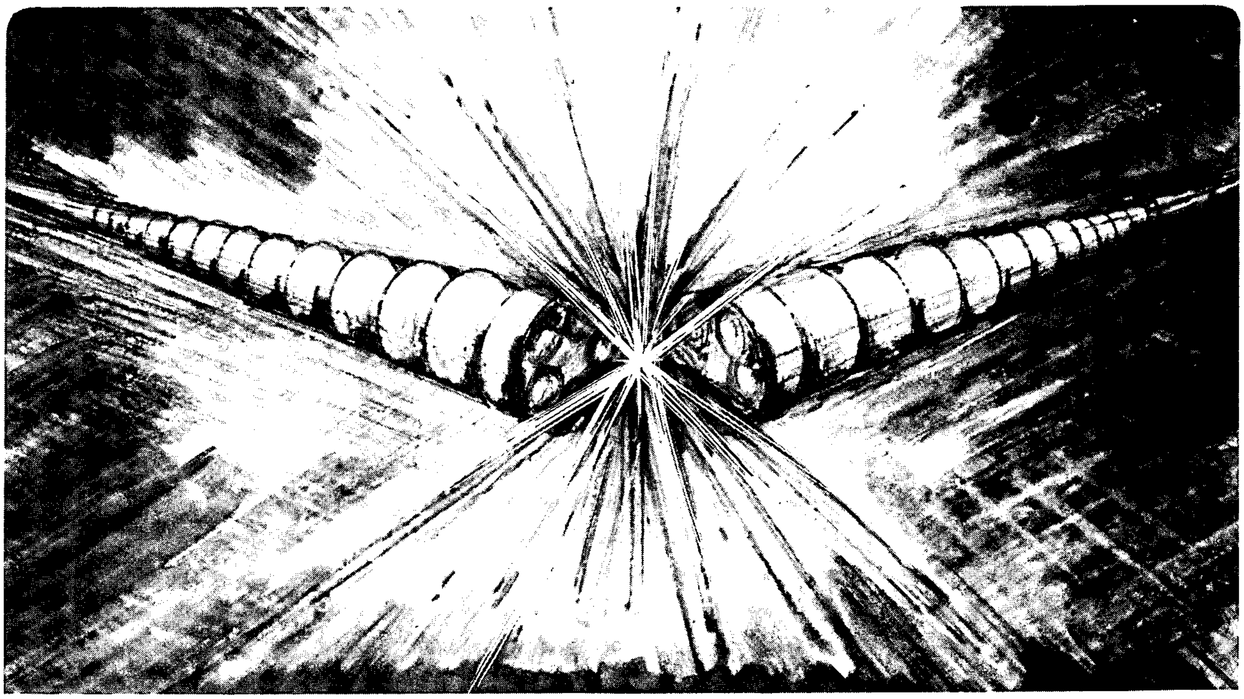

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# VACUUM SYSTEM FOR THE LBL ADVANCED LIGHT SOURCE (ALS)*

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## Abstract

A 1.5 to 1.9 GeV synchrotron light source is being built at LBL. The vacuum system is designed to permit most synchrotron photons to escape the electron channel and be absorbed in an antechamber. The gas generated by the photons hitting the absorbers in the antechambers will be pumped by titanium sublimation pumps located directly under the absorbers. The electron channel and the antechamber are connected by a 10-mm-high slot that offers good electrodynamic isolation of the two chambers for frequencies affecting the stored electron orbit. Twelve 10-meter-long vessels constitute the vacuum chambers for all the lattice magnets. Each chamber will be machined from two thick plates of 5083-H321 aluminum and welded at the perimeter. Machining both the inside and outside of the vacuum chamber permits the use of complex and accurate surfaces. The use of thick plates allows flanges to be machined directly into the wall of each chamber, thus avoiding much welding.

## Introduction

The small aperture of the ALS makes low pressure during operation both necessary and hard to achieve. The circulating electrons will distribute a large amount of gas-producing photons around the storage ring. The low longitudinal conductance of the electron channel (15 l/s/m) would require very many discrete vacuum pumps or distributed pumping to remove the desorbed gas. The traditional distributed ion pump used in electron storage rings utilizes the magnetic field of the dipole magnets. But only 15% of the circumference of the ALS storage ring has a magnetic field suitable for ion pumps.

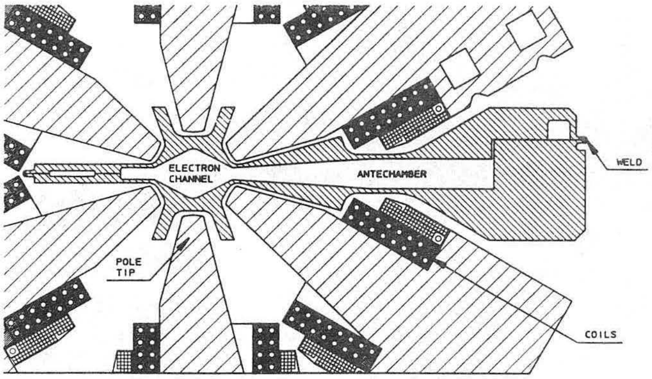

Figure 1 Cross section at sextupole

## Design Approach

The ALS vacuum chamber allows the dipole synchrotron photons out of the electron channel and absorbs them in an antechamber. These photons will be in a fan only 1-mRad high but they contain the source of most of the gas load to the vacuum system. Most dipole photons will be well clear of the electron channel and into the antechamber after traveling two meters, yet the footprint of the photons will be only 2-mm high. Photon absorbers, normal to the photon direction, can be relatively small and located over vacuum pumps. The ALS will use 96 dipole photon absorbers whose combined total length will be 16 meters. If the dipole radiation were to strike the outer wall of the electron channel, the total illuminated length would have been 197 meters, some of that length necessarily remote from vacuum pumps.

Figure 1 is a cross section of the storage ring at a sextupole but it is typical of sections in the sector chamber. The neck between these two chambers is 10-mm high and continues all around the storage ring except at the injection and RF sections. This 10-mm slot gives good electromagnetic isolation between the electron channel and the antechamber up to 15 GHz[1].

## Antechambers

The antechamber will be a uniform 25-mm high with a variable width depending on need. This chamber will have an average longitudinal conductance of 110 l/s/m, offering seven times the conductance of the electron channel. The higher conductance makes it possible to place appendage pumps farther apart and to rough from only one place in a sector chamber. The antechamber will contain, along with the photon absorber, 96 sputter ion pumps, 60 photon exit ports, 24 ion gauges, 12 RGAs, and other vacuum hardware that has the potential for disturbing the electrical impedance of the electron channel.

## Titanium Sublimation Pumps (TSP)

The dipole photons will stimulate desorption of gas in the antechamber when they land on sloping photon absorbers located directly above vacuum pumps as shown in Figure 2.

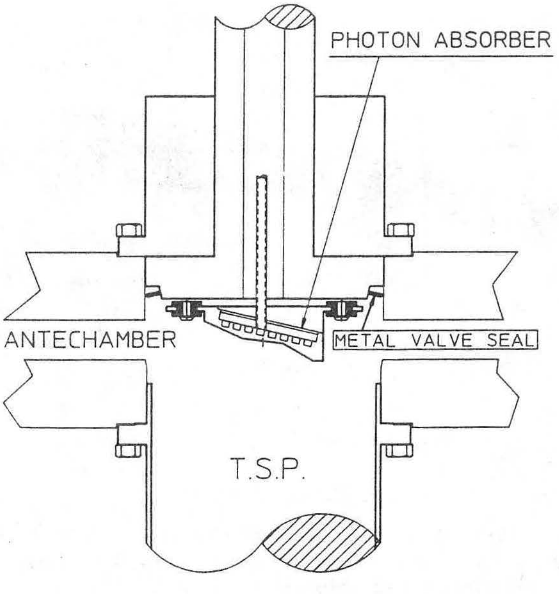

Figure 2 Photon Absorber and TSP

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It is important that as much gas as possible go directly into the pumps. The best way to achieve this goal is to have the mouth of the pumps subtend a large solid angle normal to the surface where the photons land. A large percent of gas molecules will thus go in a straight line from the photon impact area to the pumps without becoming a random walk gas.

The dipole radiation beam lines will receive their photons through a slot in the photon absorbers. It will be desirable to change photon absorbers from solid to slotted as dipole photon lines are commissioned without letting the main vacuum chamber to air. Mounting the photon absorber on the seal plate of a poppet valve will permit the absorber to be lowered and sealed in the TSP. The TSP will be able to be let up to air and the photon absorber replaced while the main chamber remain at high vacuum.

Maintenance is another advantage of an isolatable TSP. Burned out titanium filaments will be replaceable and titanium deposits will be removable before they become thick enough to flake. The TSP will be isolated from the main vacuum system during the sublimation cycle. This will permit the heating of the condensation surfaces, driving the hydrogen into the roughing system and improving the adhesion of the next titanium deposit.

The 96 photon absorbers will receive most of the photons that strike surfaces in the storage ring and hence are the most important to clean. The ability to move the absorbers from the main vacuum system into the TSPs under high vacuum creates an opportunity to glow discharge clean the absorbers in the TSP. .This eliminates the hazard of contamination of the main chamber's ion pumps with argon. Freshly deposited titanium present during glow discharge cleaning will help prevent recontamination of the absorbers.

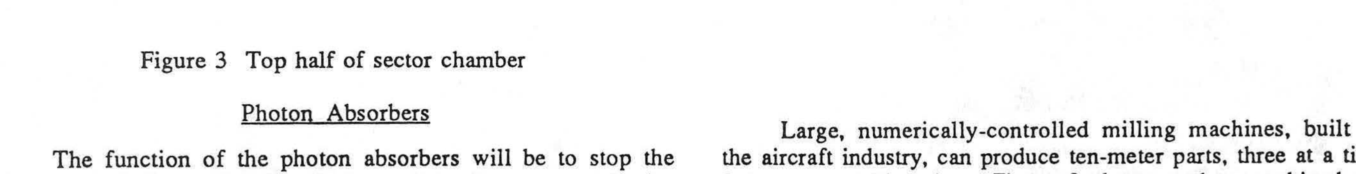

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Figure 3 Top half of sector chamber

### Photon Absorbers

The function of the photon absorbers will be to stop the photons and direct the desorbed gas into the pump. A six-degree wedge-shaped absorber performs this function well and, in addition, the power density will be reduced, making cooling easier. A simple wedge will not be used because of reflected and mis-steered photons. Steeper facets must be present at the front and the rear of the wedge so that the absorber can be 25-mm high but no deeper than 75 mm. During normal operations the photon beam will be centered and illuminate the six-degree portion of the wedge face, but if vertical mis-steering occurs the photons will be stopped by the steeper facets.

Some of the photons landing on the six-degree surface will be reflected, and it is important that these photons land on an appropriate surface. The steep facet at the rear of the photon absorber fulfills this role and any reflected photons from the steep facet will tend to go into the TSP. The direction of the gas emitted from this second surface will not be ideal for entering the TSP, but the amount and energy of photons landing on the second surface will be lower than those that land on the primary surface.

When bend magnet synchrotron radiation is to be used outside the storage ring, it will be channeled through the photon absorber in a slot cut in the absorber. The photons on either side of the beam that will go to a photon line will continue to be absorbed at an easy-to-cool grazing angle. This approach eliminates the hard-to-cool slender septum and the name "crotch."

### Fabrication

A continuous slot around the outer wall of the electron channel creates special mechanical problems. The vacuum load that would normally be directly carried by the outer wall of the electron chamber must now be transmitted to an outer radius wall now some distance away. To prevent excessive deflection under vacuum, thick sections and complex shapes are needed as shown in Figure 1. Such shapes suggest fabrication by machining from heavy plate; however, the minimum logical length of the storage ring sector chambers is ten meters.

Large, numerically-controlled milling machines, built for the aircraft industry, can produce ten-meter parts, three at a time, for an acceptable price. Figure 3 shows such a machined part before it is welded to a mating part to form a sector chamber. When completed, this chamber will have 70 ports and 725 tapped bolt holes.

Machining economics dictates that the vacuum chamber be made from aluminum. The selection of the alloy was made based on weldability and dimensional stability during machining. The stress level in the vacuum chamber will be very low so the strength of the alloy could be a secondary consideration. The alloy that was chosen was 5083-H321, which is a non-heat-treatable alloy with a small amount of cold work for ease of machining. It is also stretched and stabilized to reduce residual stress.

Machining vacuum chambers out of thick plate is certainly an expensive method of fabrication; but certain benefits accrue:

- The dimensional tolerances are those associated with machining rather than sheet metal.
- Flange surfaces can be machined directly into the outside surface.
- A saw-tooth texture can be machined in the top and bottom of the vacuum chamber along the path of the photons to suppress reflections.
- The very thick aluminum provides excellent heat distribution during bake.
- Machining avoids complex cutting, fitting, and welding with its attendant distortions.

The ALS sector chambers will be machined in two halves and welded around the perimeter. The perimeter weld will carry a small load and, therefore, can be small and weld-prepped. The potential virtual leak between the perimeter weld and the main vacuum volume will be ventilated by a groove.

## Summary

A vacuum system is being built for the ALS that will have twelve 10-meter machined aluminum chambers. These chambers will have two parts: an electron channel and an antechamber. These two chambers will be electrodynamically isolated by a slot between them for the low frequencies affecting the stored electron orbit, but for the high-frequency (short-wavelength) troublesome photons, they communicate. Most of the synchrotron photons generated in the electron channel will go to photon absorbers over vacuum pumps located in the antechamber. This two-chamber system will maintain an acceptably low beam impedance in the electron channel, and it is anticipated that the time to achieve the required operating pressure will be relatively short.

## References

1. W. Barry, G. Lambertson, and F. Voelker, "Impedance of a Beam Tube with Antechamber," *Proceedings of the 13th International Conference on High Energy Accelerators*, 1986.

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