# STATUS OF THE PEP-II LOW-ENERGY RING VACUUM SYSTEM

D. Cheng, D. Hunt, H. Hsieh, J. Meneghetti, K. Kennedy, T. Stevens, G. Jones, T. Miller, D. Colomb (LBNL, Berkeley, CA 94720), L. Bertolini, C. Belser, J. Kerns (LLNL, Livermore, CA 94550), E. Daly (SLAC, Stanford, CA 94309)

*Abstract*

The PEP-II *B* Factory* Low-Energy Ring (LER) will operate at 3.1 GeV with 2.1 A; design specifications are based on 3.5 GeV at 3 A. The vacuum system, 2200 m long, consists of 6 arcs and 6 straights. The arc vacuum system is based on an aluminum antechamber pumped by titanium sublimators located directly under discrete photon stops, supplemented by 110 l/s ion pumps near the end of each dipole. The straight sections serve various utility functions, including emittance control with a wiggler, injection, and an interaction region (IR). Vacuum chambers in most of the straight sections are circular stainless steel pipe with external copper plating to facilitate heat transfer to cooling tubes brazed to the outside wall. The wiggler chicane vacuum system uses both aluminum and stainless steel technology, along with a 24 m long distributed copper photon dump. The IR vacuum system is mainly based on copper extrusions. LER vacuum system components are either in the late stage of prototyping or already in full production.

## 1 INTRODUCTION

The vacuum system of the PEP-II *B* Factory LER is designed to maintain a <10 nTorr pressure storing a 3 A positron beam current at 3.5 GeV, although the nominal operating conditions will be 2.1 A at 3.1 GeV. Both the High Energy Ring (HER) and LER are made of 6 arc sections and 6 straight sections, with the LER located 35" (0.889 m) above the HER, each having a total circumference of about 2200 m. The straight sections provide for various functions such as beam injection, damping and emittance control with wigglers, and the IR where the beams collide in a detector. Vacuum calculations were conducted with VACCALC, a pipeline pressure computer code developed by M. Sullivan [1], showing the peak pressures to be ~7 nTorr, and average pressures below 3 nTorr during operation. LBNL, LLNL, SLAC are involved with the various designs and fabrication of the LER vacuum system components.

## 2 ARC REGIONS

Each of the six arc regions of the ring uses extruded aluminum antechambers, making up sixteen standard cells. A half-cell, shown in Figure 1, consists of a magnet chamber with a slotted appendage to pass the photon beam that is connected to a ~6 meter length of pumping chamber. On the far end is a discrete photon stop and titanium sublimation pump (TSP) mounted from the antechamber. Additional pumping is achieved with a 110 l/s ion pumped placed near the string of magnets.

### *2.1 Vacuum chambers*

Figure 2 shows the extrusion profiles of both types of chambers. The magnet chambers are currently being processed at LBNL, including the coating of the inside surface with a 1000-2000 Angstrom layer of titanium nitride. Due to the high positron current in the LER and the positron instability first seen at the KEK Photon Factory [2], it was decided that a TiN coating was needed to reduce secondary electron emission in these elliptical profile beam chambers. More details on this process can be found in another article at this conference [3]. The pumping chambers are being built at SLAC, while R&D work on coating these chambers with TiN has been completed at LBNL. A 3/4-cell mock-up of the arc vacuum system has been finished to test the assembly and installation procedures of these components into the tunnel (see Figure 3).

### *2.2 Photon Stops*

At the design value of 3.5 GeV, 3 A $e^+$ beam, each 45 cm dipole will produce 15 kW of synchrotron radiation power, which will be absorbed by photon stops approximately 6 meters from the dipole. These stops are made of grooved Glidcop®, optimized using the ANSYS finite-element code, absorbing the photons at a 70 mrad angle to the beam. The maximum thermal stresses are about 23 ksi (von Mises), well below the 39 ksi yield limit of brazed Glidcop® for a $\Delta T$ of ~130 °C, initial cooling water being 35 °C. The preliminary designs incorporated wire-brazing of the OFE copper backing plate to the stock copper-cladding around the Glidcop® with Nicusil-3 or equivalent. However, since the interface at the cladding cannot be guaranteed to function as a structural joint, a costlier brazing method of 25/75 Au-Cu foil was adopted, joining the backing plate directly to the Glidcop®, now plated with a 0.0015" cyanide copper barrier. Final designs of the photon stop are now complete and production is beginning.

### *2.3 Titanium Sublimation Pumps*

Located directly below the photon stops are TSPs, chosen for their high pumping speed and low cost. Active surfaces of the pump are fins of extruded 6063 Al, increasing the surface area by a factor of ten. The estimated pumping speed of these pumps is 8,000 liters

* Work Supported by U.S. Dept. of Energy contract nos. DE-AC03-76SF00098 (LBNL), DE-AC03-76SF00515 (SLAC), W-7405-Eng-48 (LLNL).

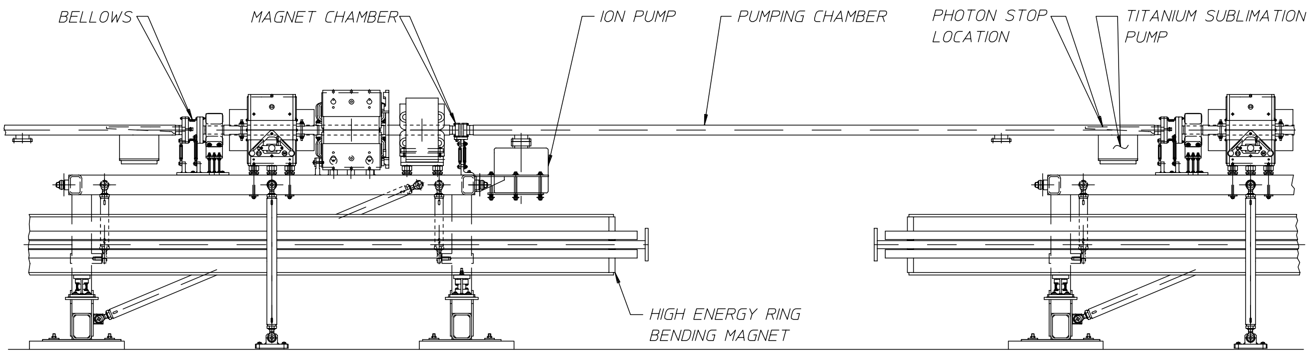


Figure 1: LER arc half-cell.

per second. The inital pumpdown of the chamber will be done with ion pumps, followed by activation of the TSPs. It is anticipated that the time between activations will be greater than three months. At these intervals, a 20 year lifetime for these filaments is expected.

### *2.4 Arc Bellows Shields*

The arc regions, with elliptical chamber profiles, will use a bellows design that has 0.030" thick RF contact fingers, held in contact to a Glidcop® rider stub by Inconel spring fingers (see Figure 4). This design is based on the HER arc bellows design, which is discussed in [4]. This bellows shield must allow an expansion of up to 3 cm (at 150 °C bakeout) plus alignment tolerances of ±0.25". The design was finalized in April 1997, and fabrication is slated to begin in May.

## 3 STRAIGHT SECTIONS

Because the straight section vacuum system does not have to absorb much synchrotron radiation power, the standard vacuum chambers are round, water-cooled, 3.5" I.D. stainless-steel tubing. These are the same chambers used in the HER, with a few geometric differences in lengths and in the locations of water cooling lines. With the lattice components frozen and additional vacuum hardware set, the lengths of all the drift tubes have been set and are now in production at SLAC, where the HER chambers were also fabricated. After fabrication, they will be glow discharge cleaned at LLNL before installation into the tunnel.

### *3.1 Interaction Region*

The Interaction Region (IR) is where the orbiting electrons of the HER collide with the LER positrons. The positrons are directed down to the elevation of the HER orbit by vertical bend magnets, collide head-on with electrons, then are directed back to the normal orbit elevation. Due to the highly non-standard nature of this region, the vacuum chambers are primarily HER-type copper extrusions to mask and absorb the radiation power in both the horizontal and vertical planes. Currently, prototyping is complete and the mechanical detailing of the chambers is just beginning. The IR bellows is also similar to the HER arc bellows [4]; detailed design of the IR bellows has been completed and it is ready for production.

### *3.2 Wiggler Chamber*

Two straight sections in the ring are fitted with chicanes to allow the placement of a wiggler since additional emittance control in the LER is necessary [5]. However, only one of these regions will be fitted with a wiggler at startup, since it was determined that sufficient control is achieved with only one. The wiggler vacuum chamber is approximately 25 meters long, composed of five 5 m long machined copper sections. Synchrotron radiation produced by the wiggler is absorbed by the water-cooled beam dumps on the walls of the chamber. The desorbed gases will also be continuously pumped by NEG pumps, which are described more in detail in [6]. The mechanical design was completed mid 1996, and the rough machining of the chambers has also been completed. The e-beam

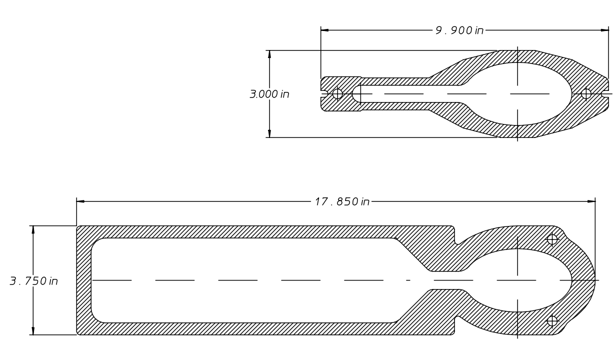


Figure 2: Magnet and Pumping chamber extrusions.

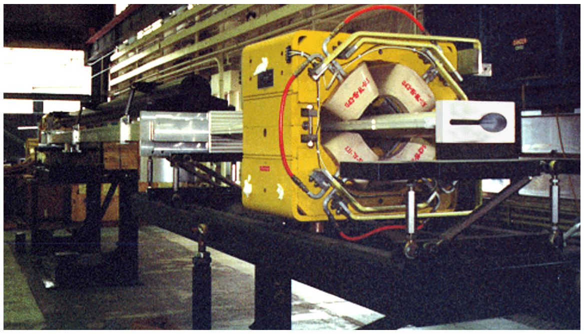

Figure 3: 3/4-cell mock-up of the LER arc vacuum and supports.

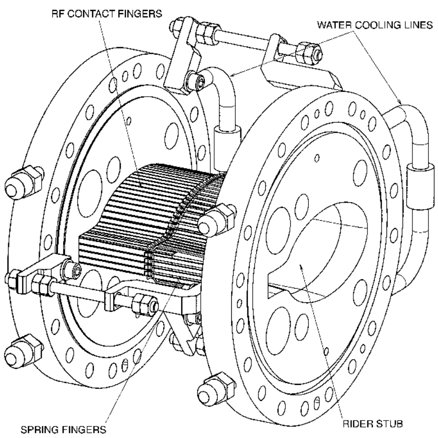


Figure 4: Arc bellows shield module (without bellows convolutions).

welding is about 50% complete, and the final machining has just begun in March 1997.

### *3.3 Injection Region*

The Linac beam will be injected vertically into both rings; therefore, as much as possible, the LER injection region is to be a twin of the already-designed HER injection region, using common vacuum components. This region is also highly non-standard, making use of 8" chambers to accommodate the beam-stay-clear of the aborted beam trajectory, and 2.5" ID ceramic chambers (and their corresponding bellows for mechanical compliance). The LER injection region layout was finalized in January 1997, and since most of the component designs have been finalized for the HER, production of components in tandem will allow the LER to undergo injection tests in the fall of 1997.

### *3.4 Straight Section Bellows Shields*

Since the chambers in the standard LER straight sections are of the same design found in the HER straights, the original intention was that the same bellows shields of HER straights were to be used as well. This bellows shield used a "Curly-Q" finger design that is described with more detail in [7]. However, during vacuum processing of the HER bellows, the initial bakeout at 200°C at its nominal position caused the spring fingers to relax and, under certain conditions, could then be made to lose RF contact with the stub. Whereas HER operating procedures guard against the bellows seeing such conditions, it was decided that with minimal effect to cost and schedule the bellows shields in the LER straights would be modified to the RF and spring finger/rider stub design, similar to that of the HER and LER arcs. See Figure 5. This change was finalized at the beginning of 1997 and components are currently in production.

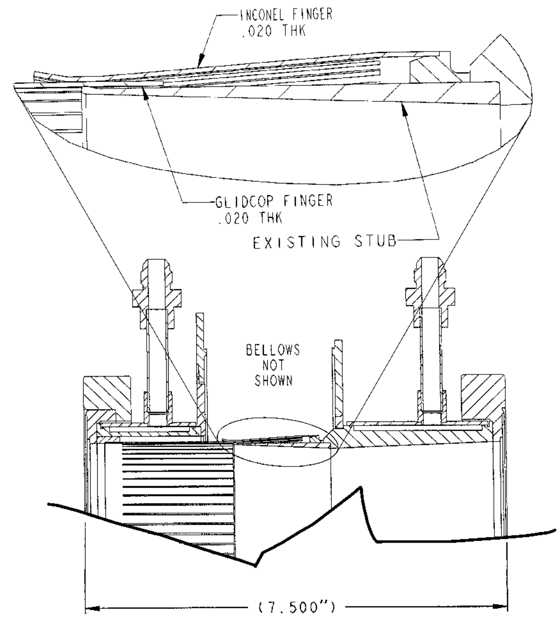


Figure 5: Detail and cross section of the LER straight section bellows module.

## 4 SUMMARY

The major components have been designed and are currently in production, so the LER vacuum system is progressing toward its commissioning target of spring 1998. Storage tests will follow, and first collisions are expected in the summer of 1998. The close-working of the three-lab LER design team, LBNL, LLNL, and SLAC, has been, and will continue to be the key factor in meeting these milestones.

## 5 REFERENCES

[1] M. Sullivan, "A Method for Calculating Pressure Profiles in Vacuum Pipes," PEP-II AP Note No. 6-94, Mar. 1, 1994.

[2] M. Izawa, Y. Sato, and T. Toyomasu, Phys. Rev. Lett 74, 5044 (1995).

[3] K. Kennedy, et al., "TiN Coating of the PEP-II Low-Energy Ring Aluminum Arc Vacuum Chambers," these proceedings.

[4] N. Kurita, A. Kulikov, J. Corlett, "Final Design and Manufacturing of the PEP-II High Energy Ring Arc Bellows Module," these proceedings.

[5] J. Heim, et al., "Wiggler insertion of the PEP-II B-Factory LER," in Proc. of 1995 PAC, Dallas, May, 1995, p.533.

[6] L. Bertolini, et al., "Design of the Linear Non-Evaporable Getter Pump for the PEP-II B Factory," these proceedings.

[7] J. Berg, et al., "High Current RF Shield of PEP-II Vacuum System Expansion Joint," in Proc. of 1996 EPAC, Barcelona, Spain, June, 1996, p. 1090.