Distributed Ion Pump Testing for PEP-II, Asymmetric B-Factory Collider

M. Calderon, F. Holdener, W. Barletta, D. Petersen
Lawrence Livermore National Laboratory

C. Foerster
Brookhaven National Laboratory

INTRODUCTION

At its design level, PEP-II will circulate asymmetric beams at 9 GeV and 1.5 A in a High Energy Ring and 3.1 GeV with 2.1 A in a Low Energy Ring. In addition, the vacuum systems of both rings will be designed to operate at a maximum current of 3 A to provide for higher current operation in the future. Pumping for both rings is provided by sputter ion pump systems.

In the High Energy Ring, high gas loads, deriving from the intense photon radiation, are calculated at 1.06×10^{-6} Torr liters s^{-1} m^{-1} using a desorption coefficient (eta) of 2×10^{-6} molecules photon^{-1}.

To maintain an average pressure of 5 nTorr or less in the arc cells, lumped ion pumps are used in the 2 m long straight sections and distributed ion pumps are used in the 6 m long dipole chambers where the conductance of the vacuum chamber is prohibitively low.

To achieve these pressures, the distributed ion pump system is required to have pumping speeds of 110 liters s^{-1} m^{-1} however, a design level of 165 liters s^{-1} m^{-1} has been set to provide a factor of safety of 50% based on pumping alone.

PUMP DESIGN

Ion pumps, using plate-type anodes, have been chosen to achieve these pumping speeds. The five plate anode shown in Fig. 1, contains four rows of pump cells in a staggered arrangement to produce a cell-area density of 68%. Cells, with a 1.8 cm diameter, intercept a dipole magnetic flux varying from 1800 gauss at the magnet pole center to about 1450 gauss at the pole edges. Although understood that cell diameter should increase with lowering field, we have elected to maintained a uniform cell diameter in order to maximize the total number of cells in the pump.

Contact fingers, between the titanium cathodes and chamber walls provide conduction cooling for the cathode plates. These spring contacts, spaced along the length of the cathode, are designed to remove a heat flux of 0.01 W cm^{-2} and the cathode plates have been shaped to provide the necessary stiffness to carry the contact spring force. A formed screen-plate, separating the beam tube from the pump chamber, contains 6 lines of slots pitched at 10 cm. The slots, 0.25 cm high by 9 cm wide, provide a calculated conductance of 1400 liters s^{-1} m^{-1} through the screen. Where possible, the slots in the screen have been aligned

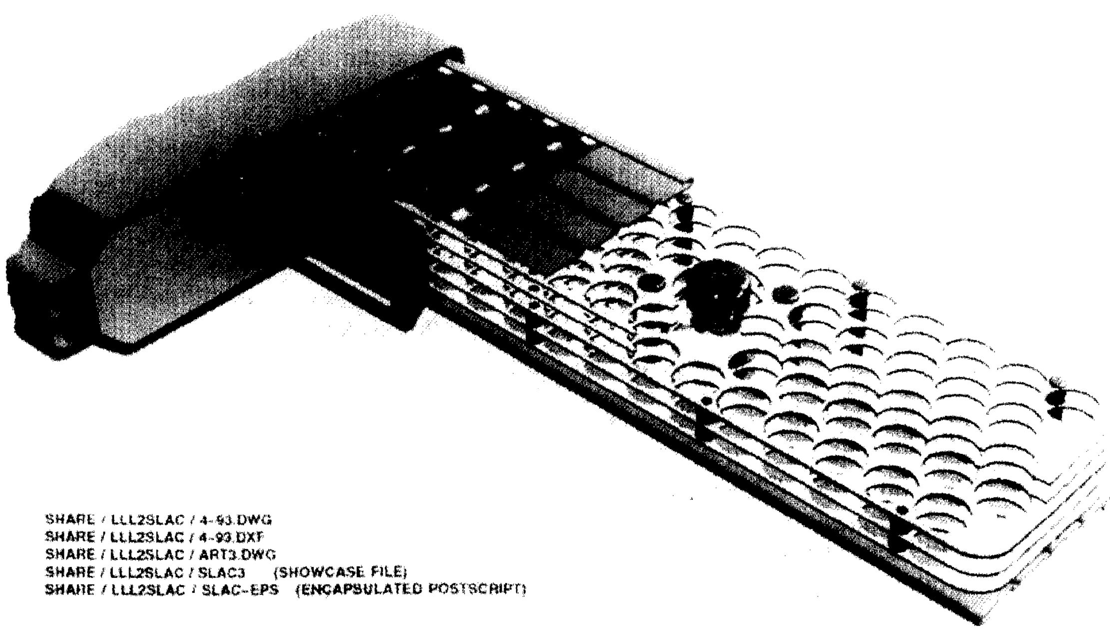

Figure 1. Distributed ion pump with screen-plate

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with the spaces between the anode plates to improve the overall conductance of the pump-screen combination. Also, the height of the slot has been selected to keep the impedance contribution to a negligible level and the height-to-length ratio of the slot has been chosen to minimize the effects of RF interference during operation. Anode designs will have either five or seven plates and the slot patterns in the matching screen plates will correspond to the anode geometry.

TEST PLAN

To validate the pumping speeds described above, we are preparing to test a series of ion pump designs with varying pump parameters that include cell diameter, spacing between anode plates, B field, B field uniformity and voltage. A tube-type anode, similar to the former PEP design, will also be tested and a concluding experiment will test a module as used on the VuV and x-ray beamlines at the National Synchrotron Light Source to provide a comparison. Initial testing will begin with N_2 gas, however, the final design will be tested with the CO, CO_2, H_2, CH_4, and H_2/CO gas mixtures.

TEST STAND

To test these designs, a test stand, that closely simulates actual ring conditions, was designed using a 12 control-volume model, as shown in Fig. 2, to establish pressures in the chamber.

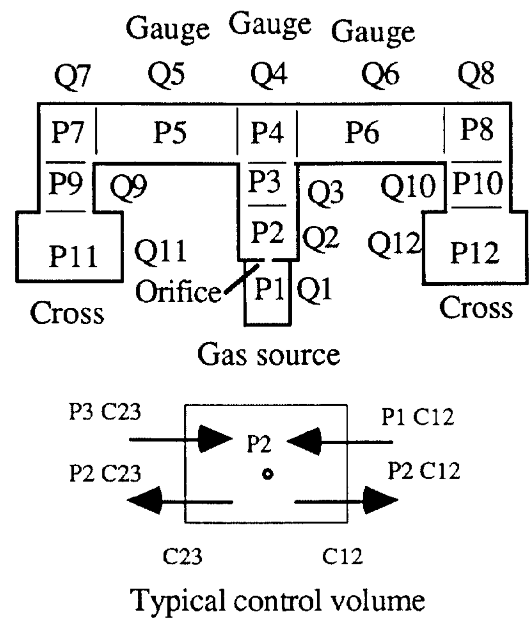

Figure 2. Pumping system schematic model.

The test chamber, shown inserted in the dipole magnet in Fig. 3, is sized to test pump modules 1 m long that are installed from the right. The system is pumped down with a

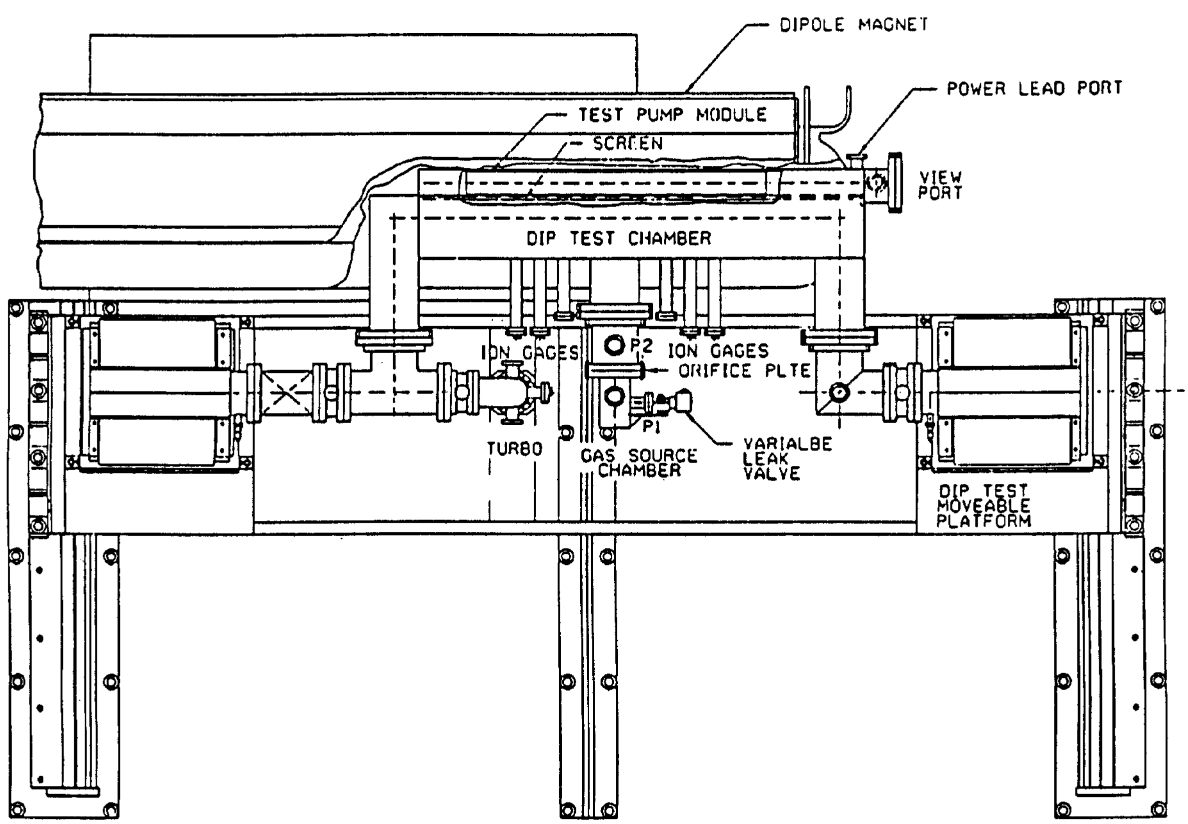

Figure 3. Dip test stand plan view.

1000 liters s^{-1} turbomolecular pump after which two, 400 liters s^{-1} ion pumps are used to bring the system into the 10^{-10} Torr range. A heating system, installed in the narrow space between the chamber and magnet pole faces bakes the chamber at 200°C during the high voltage conditioning of the module. Gas flow into the chamber will be determined by measuring the pressure difference across an orifice of known conductance. Once installed in the magnet, a programmable high voltage power supply conditions the module to 7 kV in a nominal field of 1800 gauss while at temperature. During a typical test run, a data acquisition system is programmed to monitoring pressures and to display gas flows into the chamber, pressure differences at the pump before and after gas injection, and pumping speeds, all as a function of time. The test stand, now nearing completion at LLNL, is shown under construction in Fig. 4.

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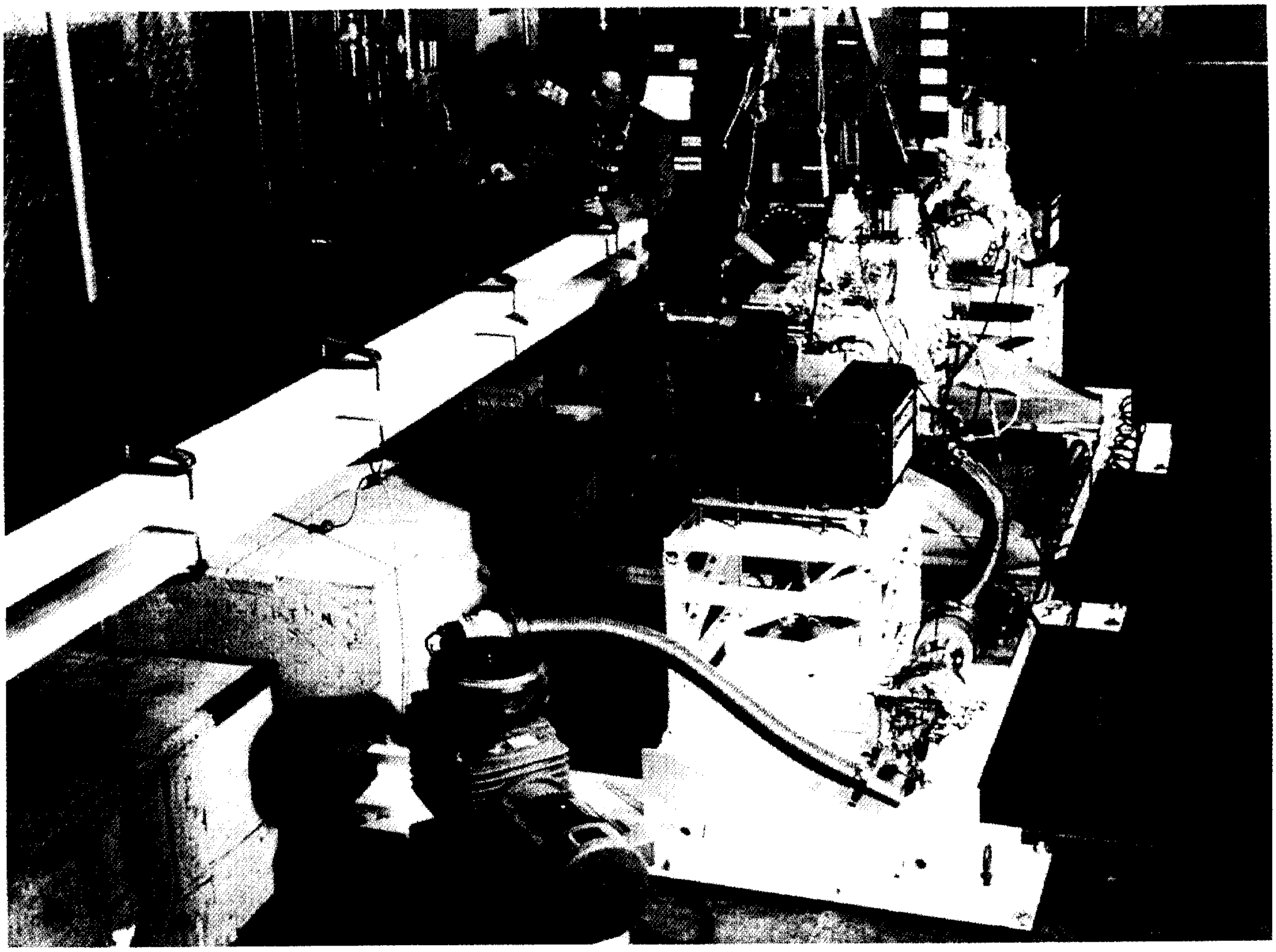

Figure 4. Dip test stand construction.