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Monte-Carlo simulations of the vacuum performance of differential pumps at the Advanced Photon Source

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Monte-Carlo computer simulations have been successfully applied in the design of vacuum systems. These simulations allow the user to check the vacuum performance without needing to make a prototype of the vacuum system. In this paper, we demonstrate the effectiveness and aptitude of these simulations in the design of differential pumps for synchrotron radiation beamlines. Eventually, a good number of the beamline front ends at the Advanced Photon Source (APS) will use differential pumps to protect the synchrotron storage ring vacuum. A Monte-Carlo computer program is used to calculate the molecular flow transmission and pressure distribution across the differential pump. A differential pump system, which consists of two 170 l/s ion pumps with three conductance-limiting apertures, was previously tested on an APS insertion-device beamline front end. Pressure distribution measurements using controlled leaks demonstrated a pressure difference of less than three decades across the differential pump. A new differential pump utilizes a fixed mask between two 170 l/s ion pumps. The fixed mask is used in the beamline to confine the photon beam, which has a conical channel with a small cross section of 4.5 x 4.5 mm^2 in the far end. Monte-Carlo simulations indicate that this configuration significantly improves the pressure reduction capability of the differential pump, to ~5 x 10^{-5}, within the operational range from ~10^{-4} to 10^{-10} Torr. The lower end of pressure is limited by outgassing from front-end components and the higher end by the pumping ability of the ion pump.

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