Beamstop for ultra-high heat loads

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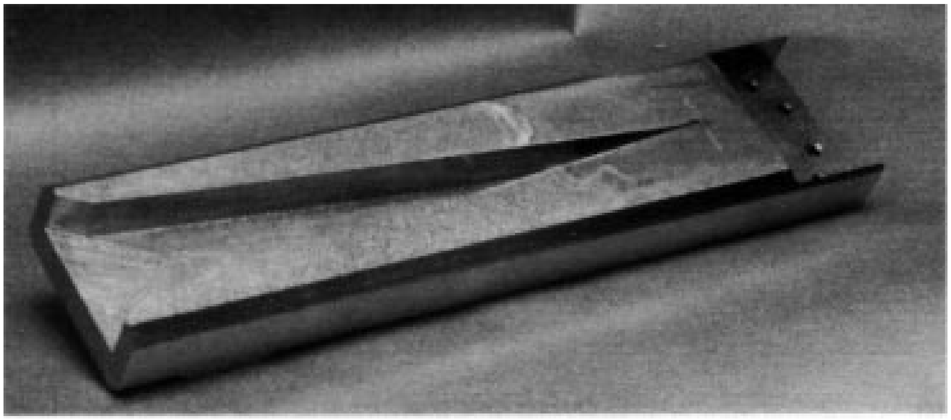


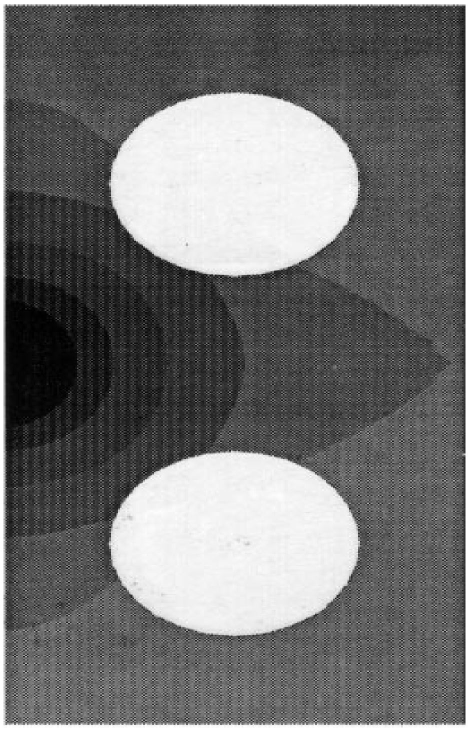
The copper portion of the primary A-line beamstop (see also cover photo and page 3).

The new A-line 25-pole permanent magnet wiggler can output 32000 Watts of power, with a critical energy of 23 keV, when CESR is running at 5.3 GeV and 500 mA. The beam size at the 10 meter point, where the first beam stop is located, is about 40 mm x 2 mm. This yields a linear power density of 800 W/mm and a surface density of 400 W/mm^2.

To design a safe beam stop for this hot beam, we have adopted the idea of water-cooled copper absorbers as proposed for the CESR B-factory [K. Smolenski, *et al*., SPIE Proceedings, (1992)]. Extensive heat load simulation and thermal cycling tests have been performed on a prototype water-cooled copper piece. The results show that at normal incidence power levels of 40 W/mm and 80 W/mm no damage was observed on the copper surface after several thousand thermal cycles, whereas at 160 W/mm some surface microcracks occurred.

Based on the test results and finite elements analysis, we will use a 5° horizontally-tilted copper surface with ample water cooling (see photo above). The 5° slope decreases the linear power density to 70 W/mm, which is a safe level according to the thermal cycling test. The surface power density is reduced to 35 W/mm^2, which is about the same as for the present A-line beamstop for the electro-magnet wiggler at 100 mA, and which has survived many years of operation. A finite-element ANSYS calculation on the 5° sloped beamstop shows (at left) a maximum surface temperature of 320°C at 500 mA with a film coefficient of 2 W/cm^2-°C. To reduce the overall length, we use a V-shaped design.

Some interesting conclusions can be drawn from our design process. First, the water channel placement is not a crucial factor as long as there are sufficient water channel surface area and copper volume around the channels. This is due to the fact that copper is such a good thermal conductor that any reasonable beam displacement can be compensated for by the conduction. Second, for a typical wiggler beam, tilting of the water cooled surface vertically or horizontally are not equivalent. For example, for a 5° slope, a vertical tilt results in a surface temperature of 900°C instead of 270°C as for the horizontal design shown above. The reason for the very effective side cooling is the matching of a wide horizontal beam with a long horizontal slope, thereby decreasing both the linear and the surface power densities, whereas a vertical slope only reduces the surface power density. Therefore, for a wiggler beamstop, the linear power density should be the dominating design consideration.



Left: Thermal profile of the new A-line beamstop produced by ANSYS calculation. At normal incidence (from left, centered) an x-ray beam produced by the 25-pole CHESS wiggler operating at 100 ma CESR current. Cooling water flows through the two channels. The shading changes density at temperatures of 300, 270, 240, 210, 180, 150, 120, and 90 ˚C. The cooling water temperature is 85 ˚F.

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