HARWI-II front-end filter design

H. Schulte-Schrepping, U. Hahn

The design of the new HARWI-II front-end enables the GKSS material science centre to provide tailored photon beams to the experimental stations. The new wiggler insertion device emits a total power of 30 kW at 150 mA storage ring current. The beam has a horizontal width of 3.8 mrad and a central power density of 54 W/mm^2. The front-end vacuum system has been rebuilt to accept this powerful wide beam. A photon beam filtering section in the beamline tunnel was introduced to handle the high thermal loads downstream the optical components. The section was adapted to the requirements of the experiments. The high power density together with a high total power at the filter section can only be handled with the layered design which we present in the following. The ability of carbon filters to convert the absorbed power into thermal radiation is used to lower the heat load to an acceptable level for water cooled copper filters. The different requirements in beam size and filtering are addressed by separating the filter functions in three units which will be switched individually into the beam as shown in fig.1 and fig.2.

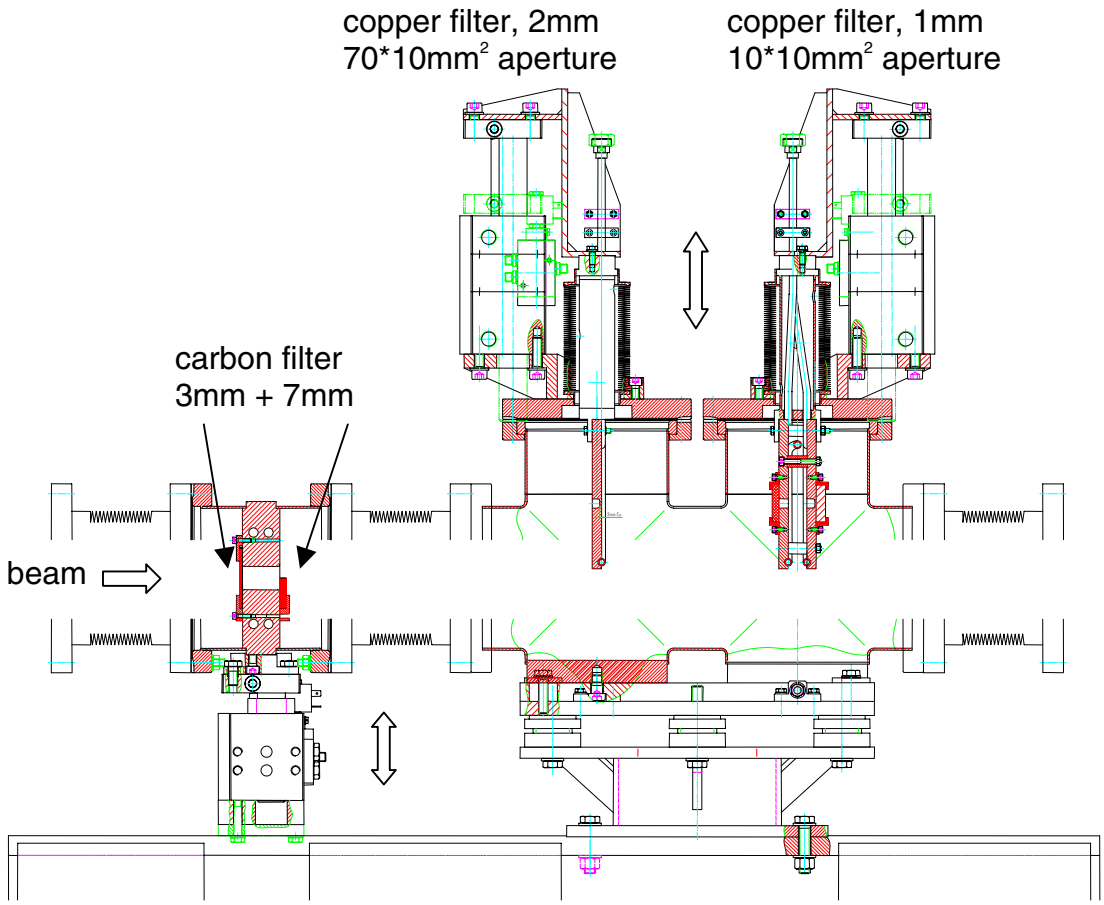

Figure 1: Schematic view of the filter unit assembly installed in the HARWI-II front-end. The separation into three separate units allows a flexible combination of attenuators. The white wiggler beam enters from the left and is permanently filtered by a 3 mm thick carbon filter; additional 7 mm are added by moving the whole assembly upwards. The copper filters (2mm and 1mm) are attached to linear feed-throughs and are moved down into the beam path by pneumatic actuators outside the vacuum. All filters are water cooled.

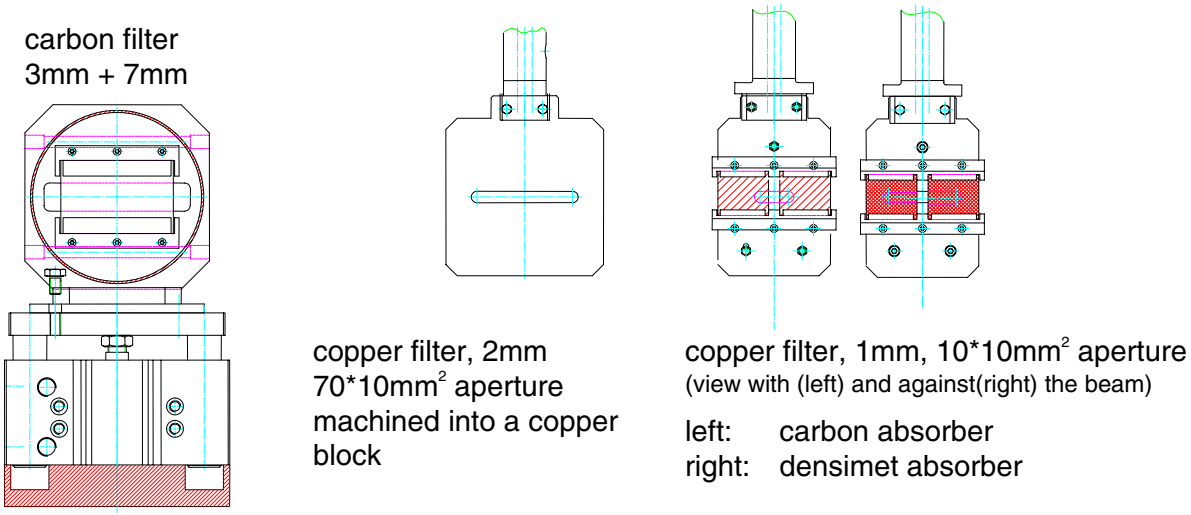

Figure 2: Left: filter unit with 3 mm and 7 mm thick carbon plates mounted on a copper block in a separate vacuum vessel. The whole assembly is decoupled from the beam pipe by bellows. The upwards movement changes from the permanent 3 mm to the 3 mm + 7 mm filter position. Centre: 2 mm thick copper filter with an aperture of 70 * 10 mm^2 machined into a 10 mm thick copper plate. Right: both parts of the 1 mm thick copper filter with an aperture of 10 * 10 mm^2. The first (left) plate is used in combination with 7 mm thick carbon absorbers to cut off the heat load outside the window. The horizontal beam size after passing the 1mm thick copper filter is defined by the densimet plates.

The 3 mm thick carbon filter will permanently attenuate the beam. It acts as a high pass filter. This filter also provides the basic thermal protection for all additional filter sections and the Be window which terminates the beamline vacuum. An additional 7 mm carbon filter further reduces the heat load on the copper filters and the first crystal in the monochromator section. For the hard X-ray options additionally either a 1 mm thick and 10 mm wide or a 2 mm thick and 70 mm wide copper filter can be inserted into the beam path. Both Cu filters withstand the thermal load with 10 mm carbon in front.

aperture size at a position of 26 m from the source	total power in the raw beam into the aperture	total power after 3 mm carbon	total power after 10 mm carbon	total power after 10 mm carbon and 1 mm copper	total power after 10 mm carbon and 2 mm copper
10 * 10 mm^2	2980 W	1962 W	1261 W	100 W	
70 * 10 mm^2	19632 W	12638 W	8025 W		704 W

Table 1: The power management of the HARWI filter section. The new HARWI wiggler emits a total power of 30kW at closed gap in a horizontal cone of 3.8 mrad at 150 mA DORIS beam current. The primary slit cuts the horizontal width down to 2.7 mrad. At a distance of 26m from the source, the relevant total powers for the filter design with 10*10mm^2 and 70*10mm^2 apertures are 2980W and 19632W, respectively.

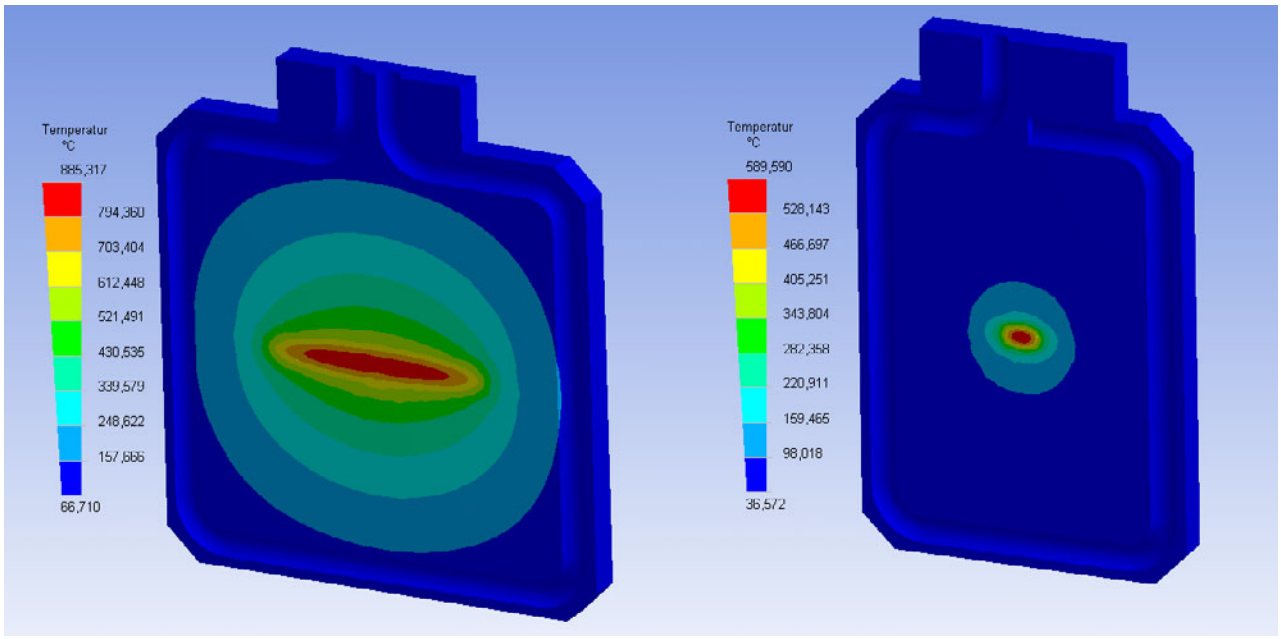

Figure 3: Finite element calculations of the copper filters for the highest possible heat load (DORIS with 150 mA) on the filter. For the calculations a uniform radiation power distribution over a strip height of 5 mm is assumed. The filter on the left (70 * 10 mm^2 and 2 mm thick) shows a temperature distribution close to critical values. The other filter (10 * 10 mm^2 and 1 mm thick) will heat up in the centre to 600 ºC.

The layout of the individual filters is based on FEM calculations with incident synchrotron light powers calculated with the SPECTRA [2] code. The presented design assumes a density of 2.25 g/cm^3 for the carbon filters. The use of glassy carbon with a density of 1.6 g/cm^3 and a corresponding larger thickness is foreseen in the actual realization. The calculations show critical peak temperatures of the Cu filters. The peak temperature will be reduced by limiting the beam height for the operation with closed wiggler gap.

References

[1] M. Tischer, J. Pflüger, L. Gumprecht, T. Vielitz. "A new wiggler for the HARWI-II beamline", this volume.

[2] SPECTRA version 7.13, T. Tanaka and H. Kitamura. J. Synchrotron Radiation 8 (2201) 1221.