An update on cryogenically cooled monochromators

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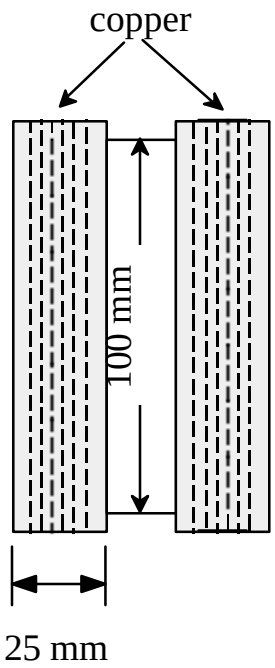
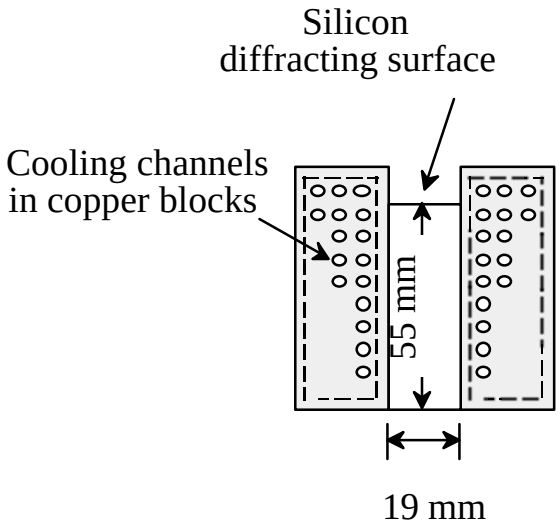
APS TWG meeting

APS Sector 1 indirect cryogenically cooled silicon monochromator



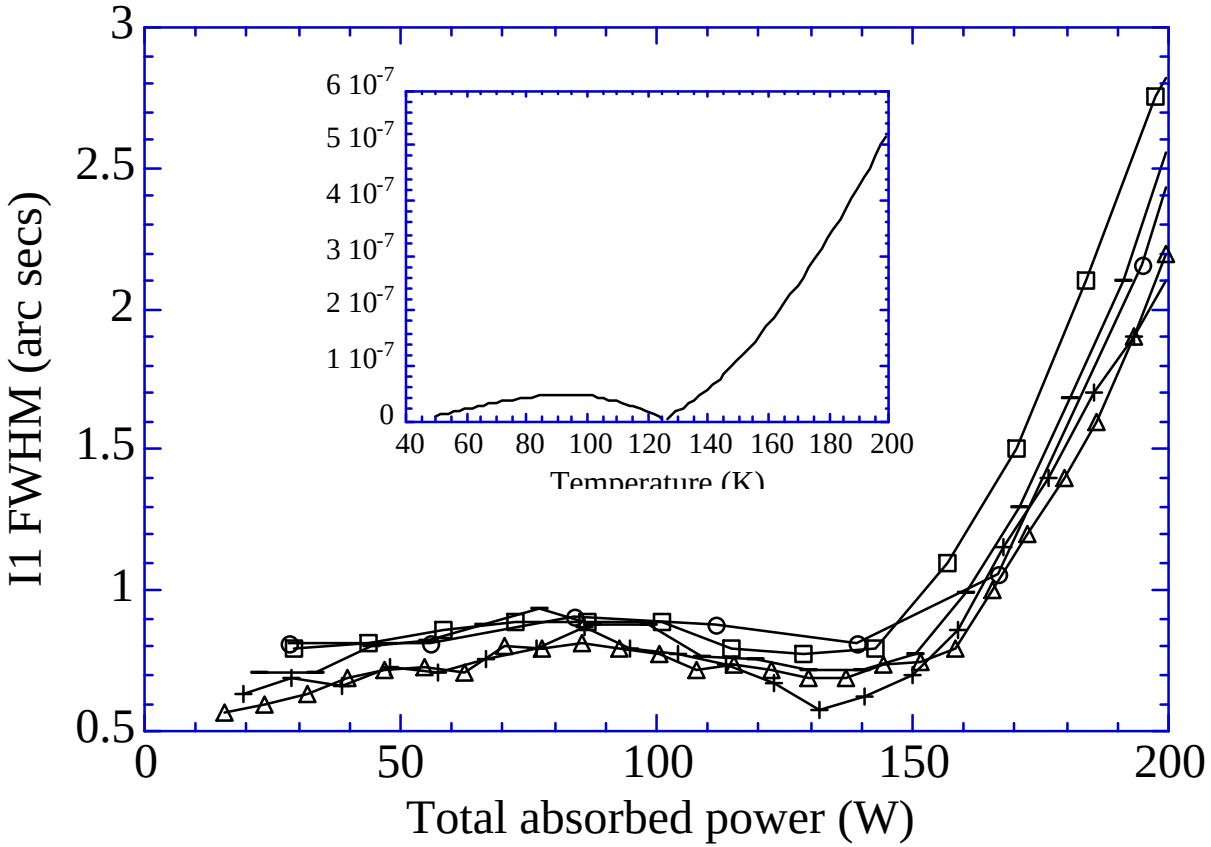
Top view



End view

1. Thermal contact via In-Ga (20-80)
2. Copper nickel plated to prevent Ga attack on Cu.

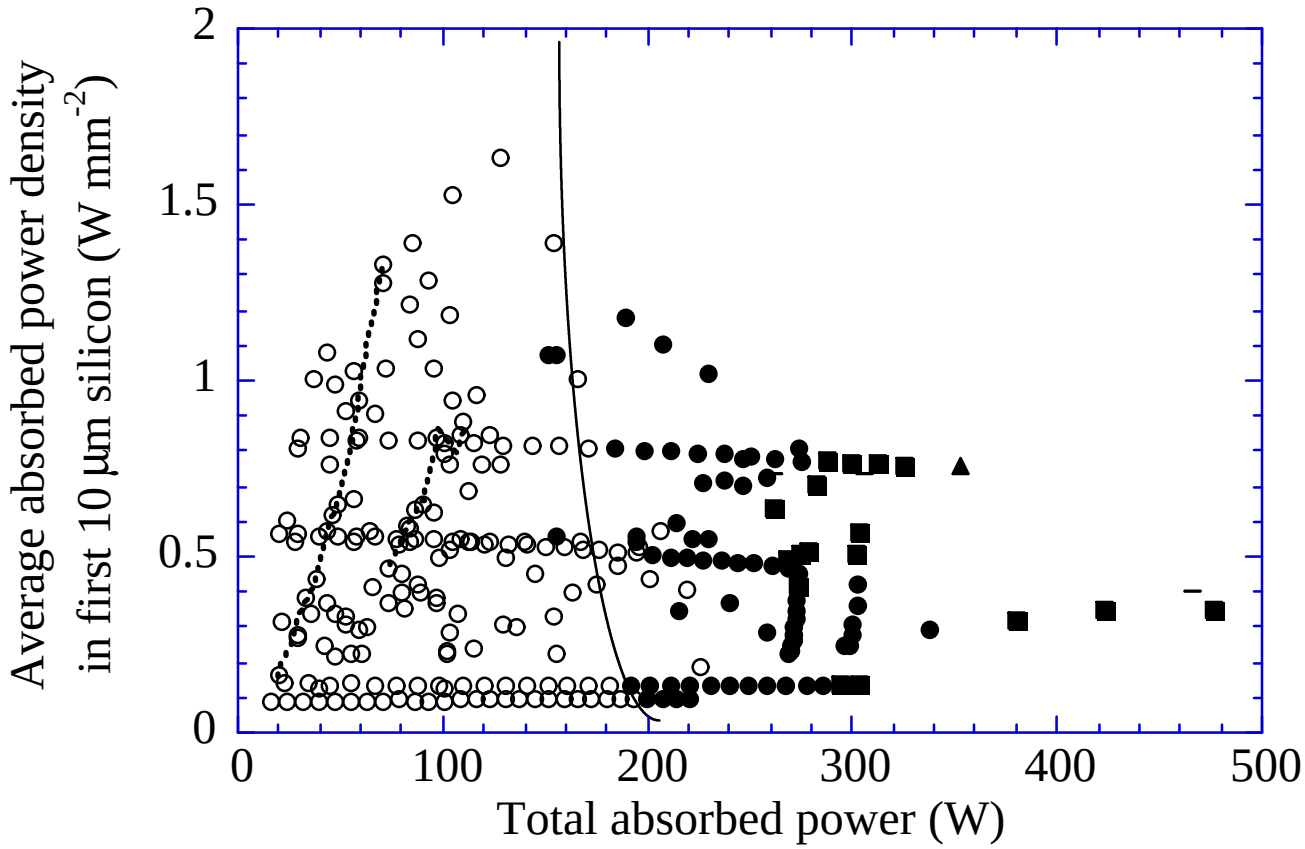
APS Sector 1: Summary of crystal performance



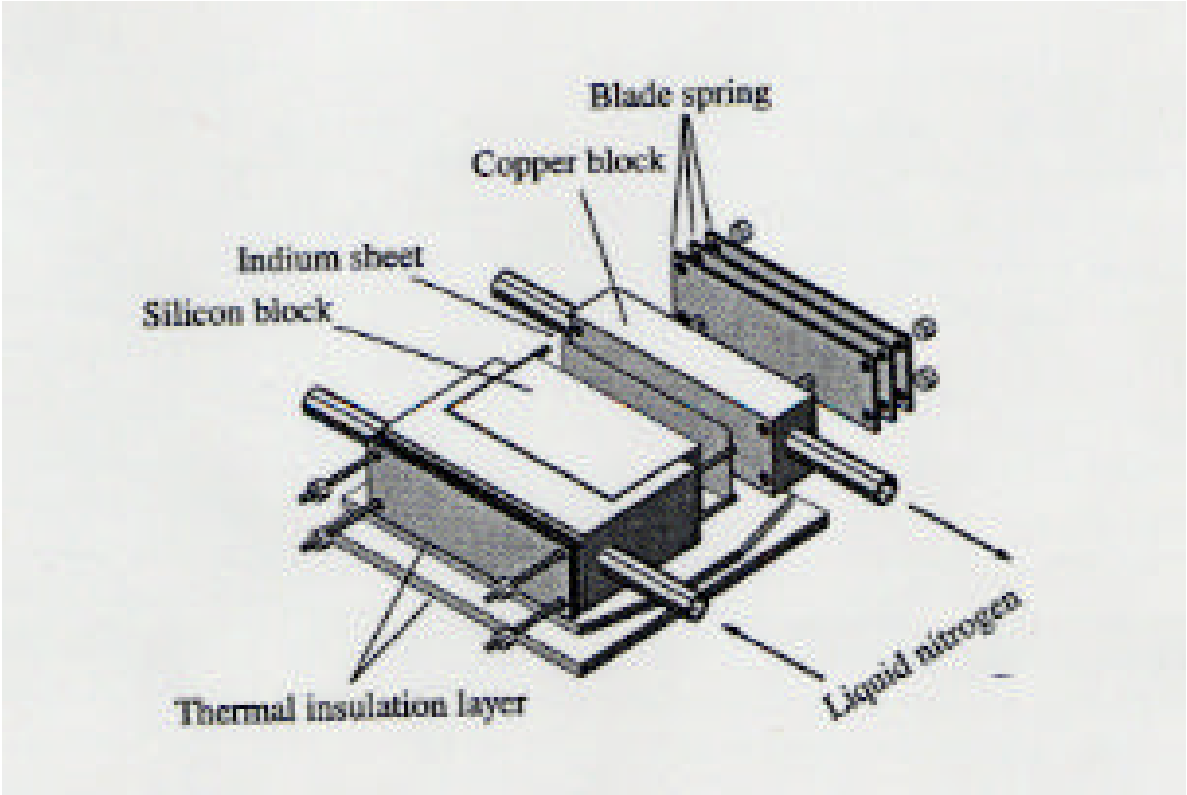
θ = 7.1-11.4°

Good performance up to about 150 W.

Ref: Lee et al., J. Syn. Rad. (2001). **8**, 22-25.


Average absorbed power density
in first 10 μm silicon (W mm-2)
2
1.5
1
0.5
0
0
100
200
300
400
500
Total absorbed power (W)

Spring-8



Crystal size = 90 mm L x 50 mm W x 35 mm H

Ref: Tamasaku et al., Proc. SPIE Vol. 4782 (2002) 132-142

$\theta = 6.9^{o}$

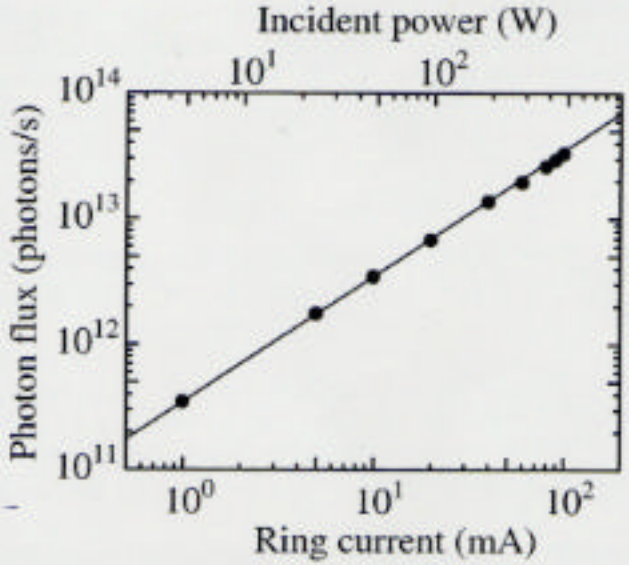


Figure 4. Stored ring current dependence of the absolute photon flux measured under the condition Ia (closed circles). Solid line indicates a linear extrapolation from the measured flux at lower currents.

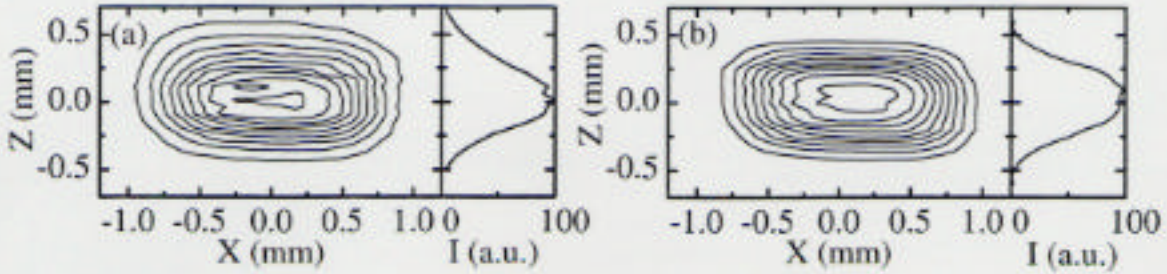
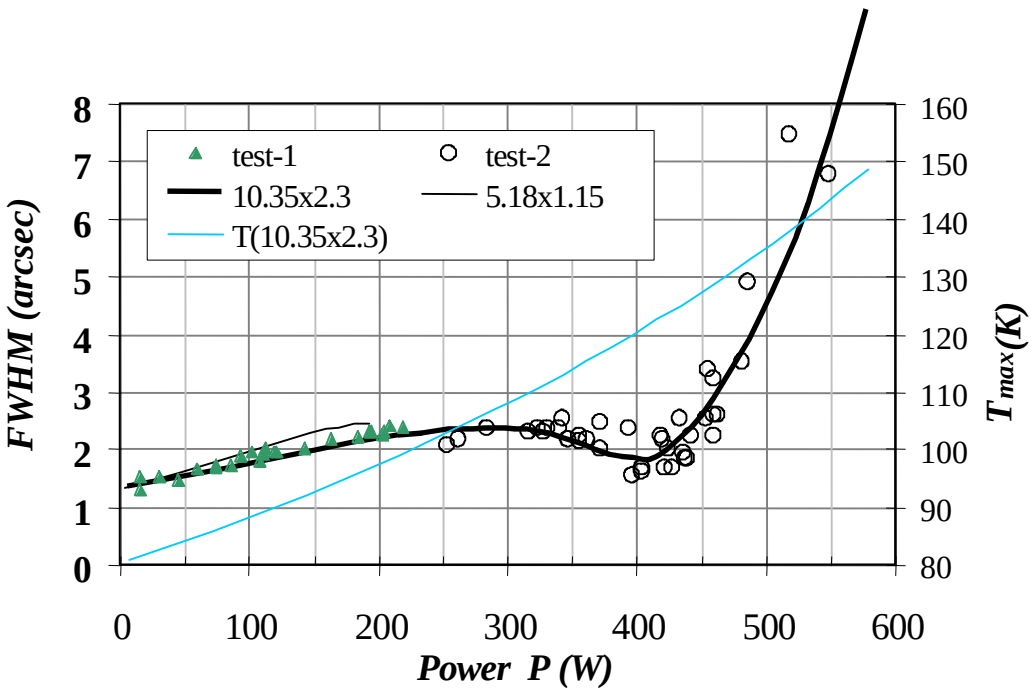
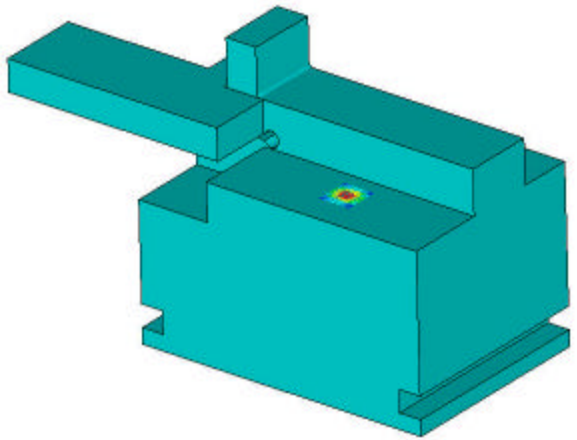


Figure 5. Beam intensity map (left panel) and the vertical section at $X = 0$ mm (right panel) measured by slit scan. (a) was measured under the high heat load condition Ia ($I = 89.8$ mA, $P = 430$ W) and (b) was measured under the negligible heat load (condition IIIa).

ESRF-ID9



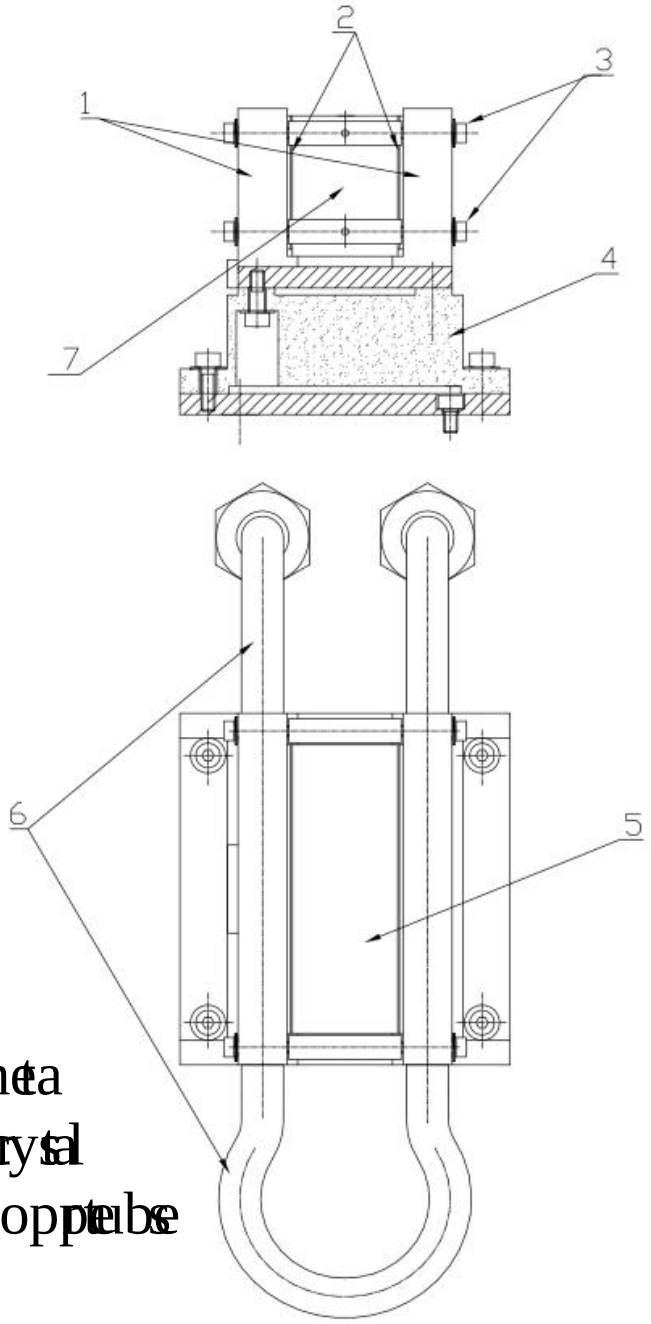
$\theta = 14.3^{o}$



Ref: Zhang et al., submitted to J. Syn. Rad.

ESRF-ID18

Ref: Chumakov et al., to be presented at SRI-2003



Crystal size: 80 mm L x 30 mm W x 40 mm H

Figure 1. Scheme of side cooling the monochromator crystals: 1 – copper heat exchanger; 2 – 0.5 mm-thick indium foil; 3 – four M4 screws to tighten the crystal between the heat exchangers; 4 – ceramic isolation; 5 – silicon crystal; 6 – copper tube for liquid nitrogen; 7 – position of temperature sensor.

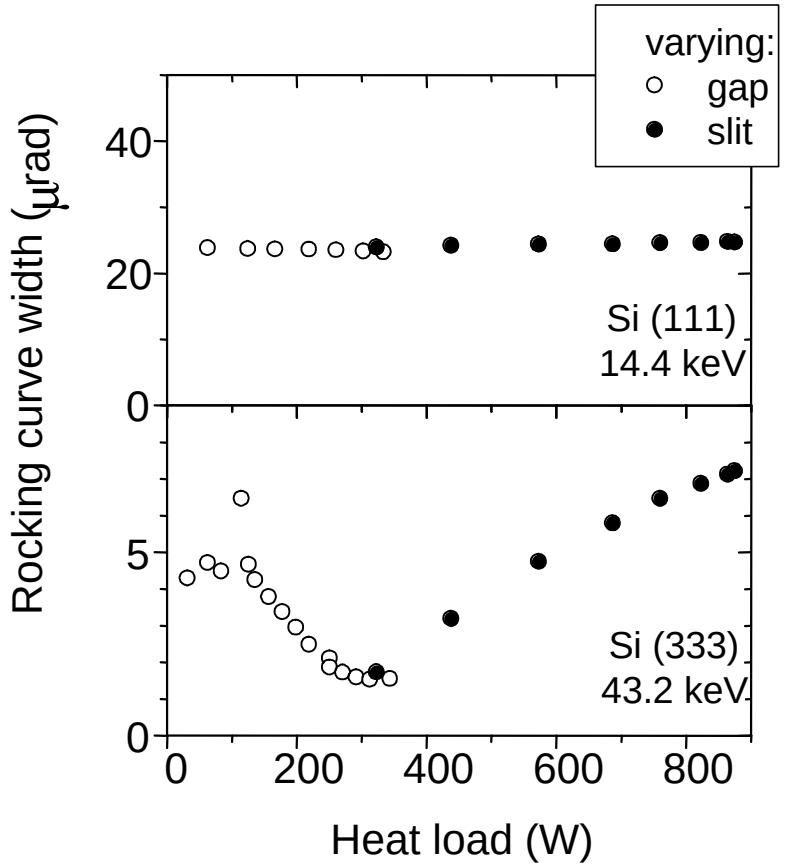


Figure 7. Rocking curve width (FWHM) of Si (111) reflection for 14.4 keV (top panel) and of Si (333) reflection for 43.2 keV (bottom panel) x rays as a function of heat load. An increase of the heat load was performed initially by closing undulator gaps (open circles) and then by opening first slit (solid circles).

Incidence angle = 6.9º

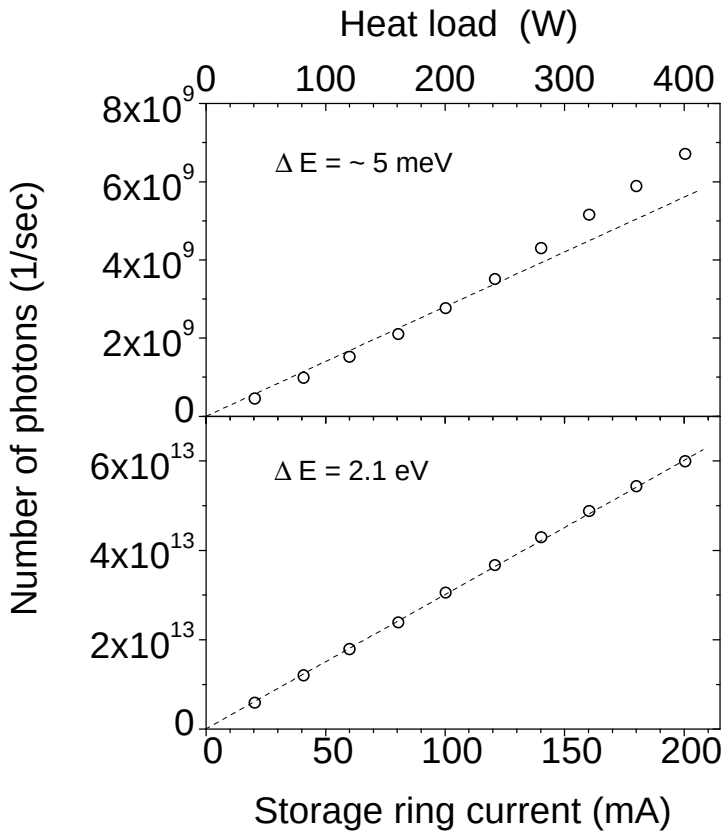


Figure 9. Measurements of flux and spectral density of the x-ray beam from the high-heat-load monochromator as a function of electron current in the storage ring. Upper horizontal axis shows the calculated heat load. The bottom panel shows in absolute units the number of 14.4 keV photons provided by the high-heat-load monochromator in Si (111) reflection (within 2.1 eV effective bandwidth). The top panel shows in relative units the measured flux of 14.4 keV radiation in ~5 meV energy bandwidth (not corrected for an angular acceptance of the high-resolution monochromator). Dashed lines are to guide the eyes.

Conclusions:

1. The original Sector-1 crystal probably did not achieve good thermal contact. Perhaps the nickel plating and the use of In-Ga instead of pure In are detrimental to the thermal contact.

2. It appears that indirect cryogenically cooled Si monochromators can work up to about 400 W. We hope to study this in more detail at the APS.