haracterization of the XSS

® reflection-grating monochromator
esolution Erect-Field Spectrometer)

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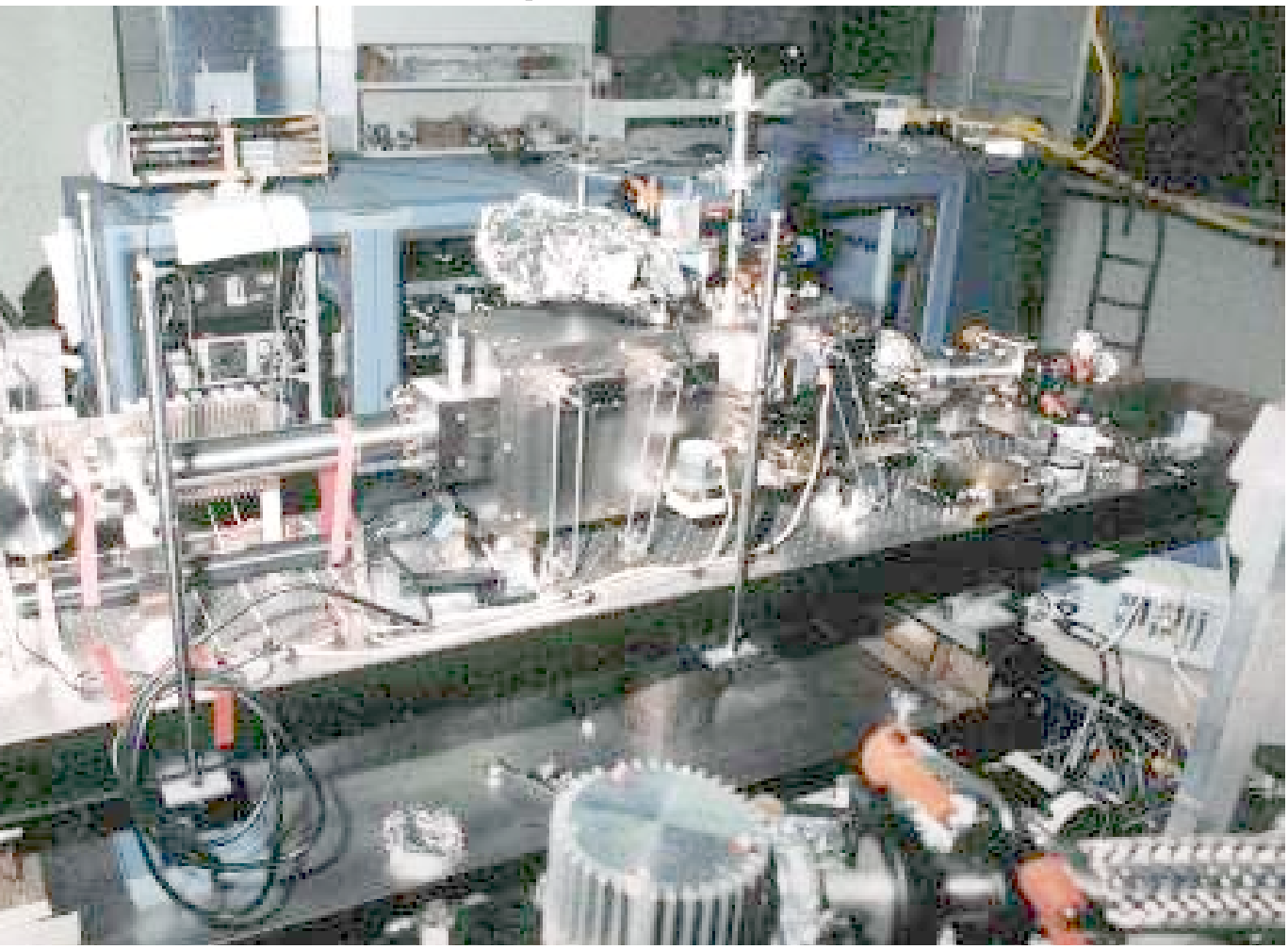
arshall Space Flight Center, Space Sciences Laboratory

HIREFS photo



Purpose

IREFS® monochromator and the Rigaku Rotating Anode provide flexibility in wavelength selection and resolution.

and HIREFS configured for high resolution

a narrow line at 277 eV (C-Kα) to measure MEG resolution.

and HIREFS configured for low resolution

wavelength across features in the grating response.

liscrete energies for measuring effective area.

Characterization activities

pecific count rates with FPC500.
ne dependence on resolution and grating order and
tigmatism setting.
to specific flux at HRMA entrance aperture.

nt

e-free spectral regions for using monochromator.
ccuracy and repeatability of wavelength scale.
effects of higher spectral orders.
ne contribution relative to first order.
gy resolution.
Å with PIGS (Penning source) and HRI
with FPC500

ty
ith FPC500 mapper.
ne dependence upon grating and wavelength setting.
ne dependence (in cross-dispersion direction) upon
tism setting.

ect images of RAS14–HIREFS with HRI.
e spot size at best-focus astigmatism setting.
h whether scattering is significant.
dependence of spot size and shape.
AS14 settings, primarily bias
elected HIREFS grating and wavelength setting

Description

g-anode x-ray generator from Rigaku

ay emission, even in continuum

size

tion-grating monochromator from Hettrick Scientific

e gratings

-2.0 keV

0-1.2 keV

2-0.40 keV

5-0.20 keV

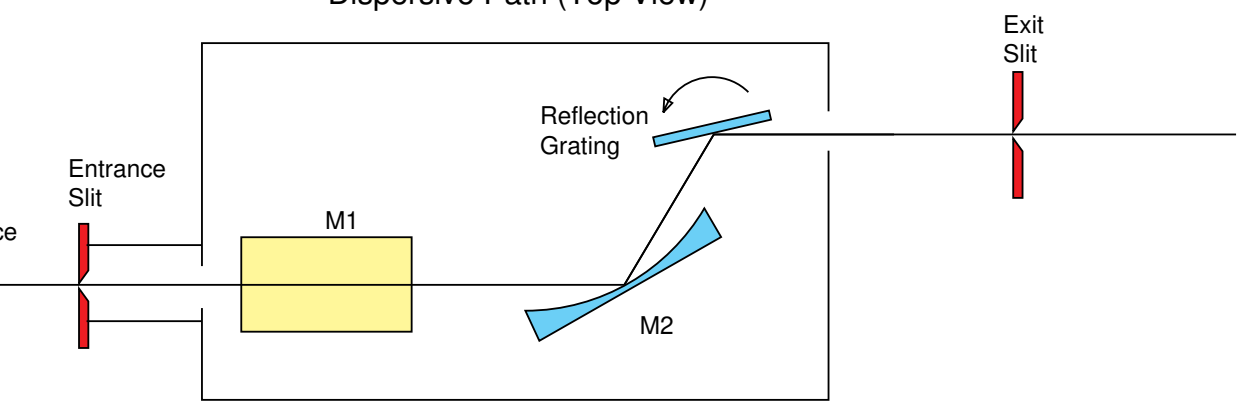
entrance and exit slit sizes define energy resolution

focusing mirror corrects for astigmatism in the cross-direction.

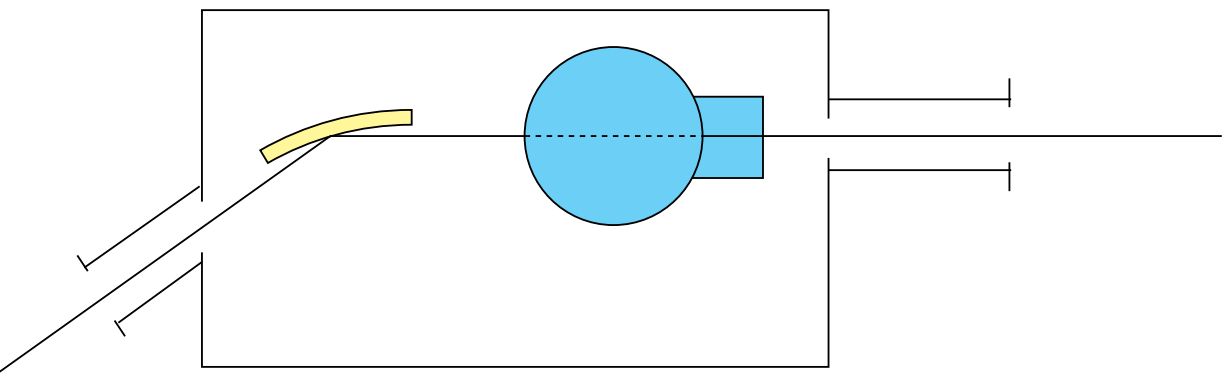
spectrum is focused at exit slit by a spherical mirror.

RAS14–HIREFS optical path

Dispersive Path (Top View)

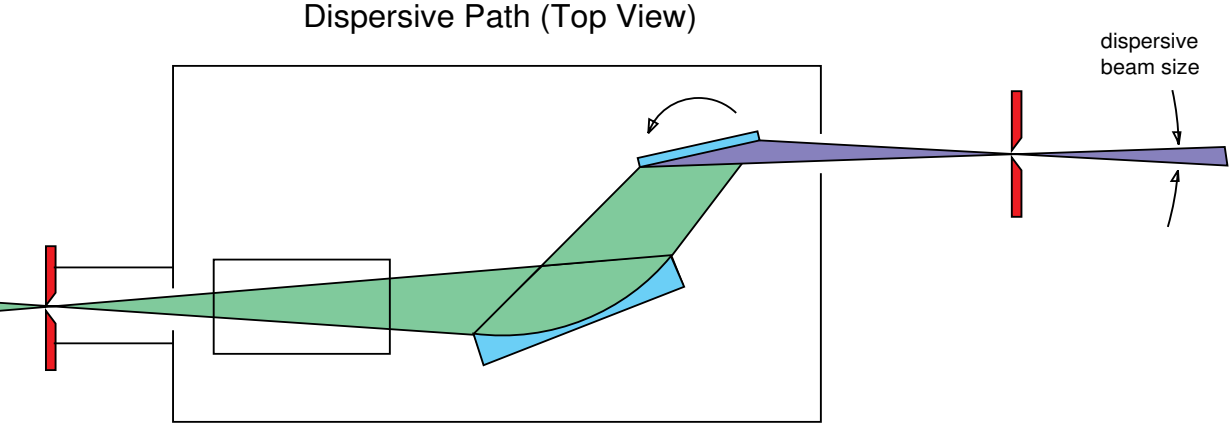


Non-Dispersive Path (Side View)

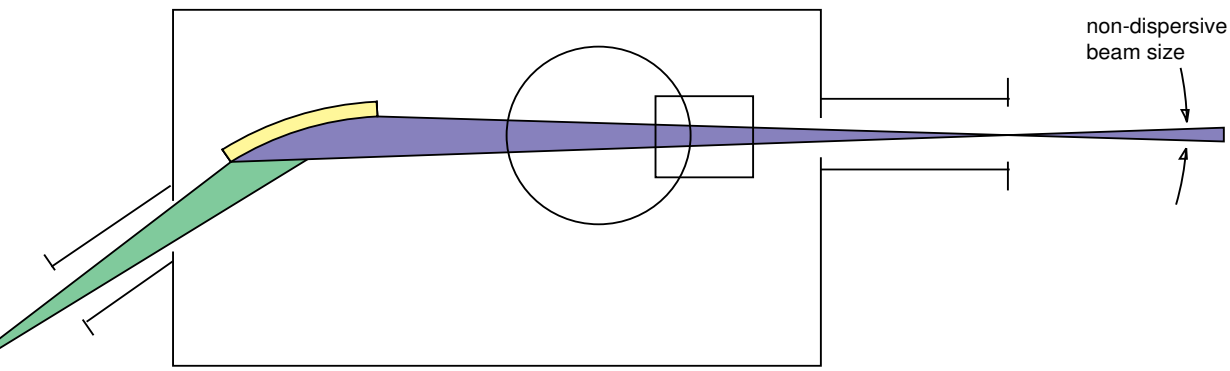


RAS14-HIREFS Beam Divergence

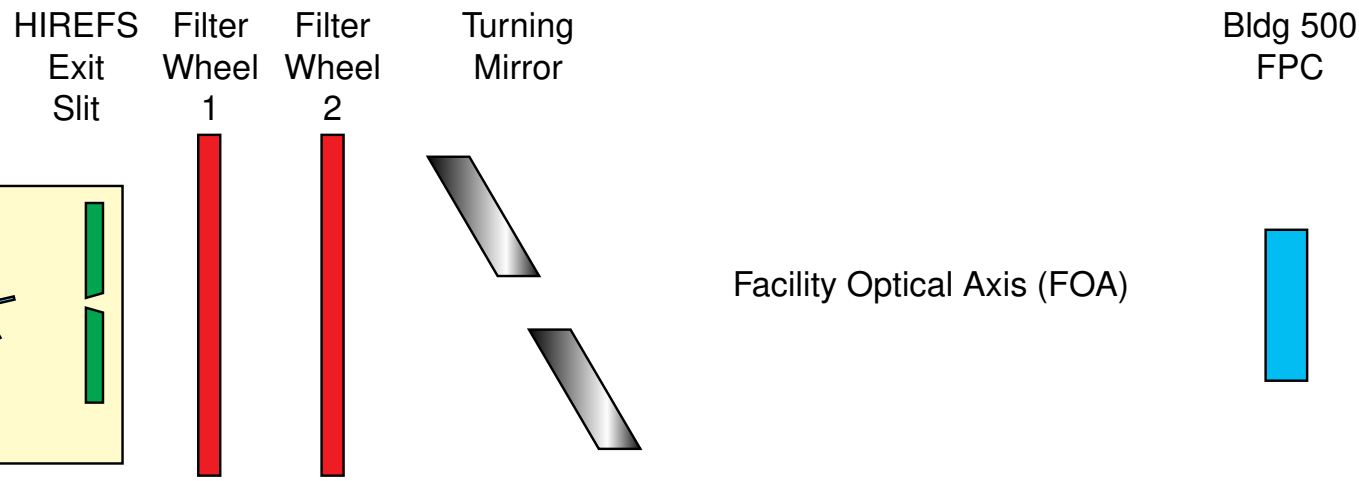
Dispersive Path (Top View)



Non-Dispersive Path (Side View)



On-line configuration



Data acquisition

on procedure

nd FPC operate independently, so system clocks are ynchronized.

data collection is initiated with the FPC.

ht spectra are acquired on relatively short (~10-s) time atively for the estimated duration of the scan.

iting pulse-height-spectrum file is recorded in file.

avelength scan is initiated.

of each step (each wavelength setting) in scan is ly longer (~100 s).

ontrol computer records completion time of each dwell.

Data reduction

procedure

correlated between FPC data and HIREFS log files.

during translations are rejected.

during each HIREFS dwell are summed.

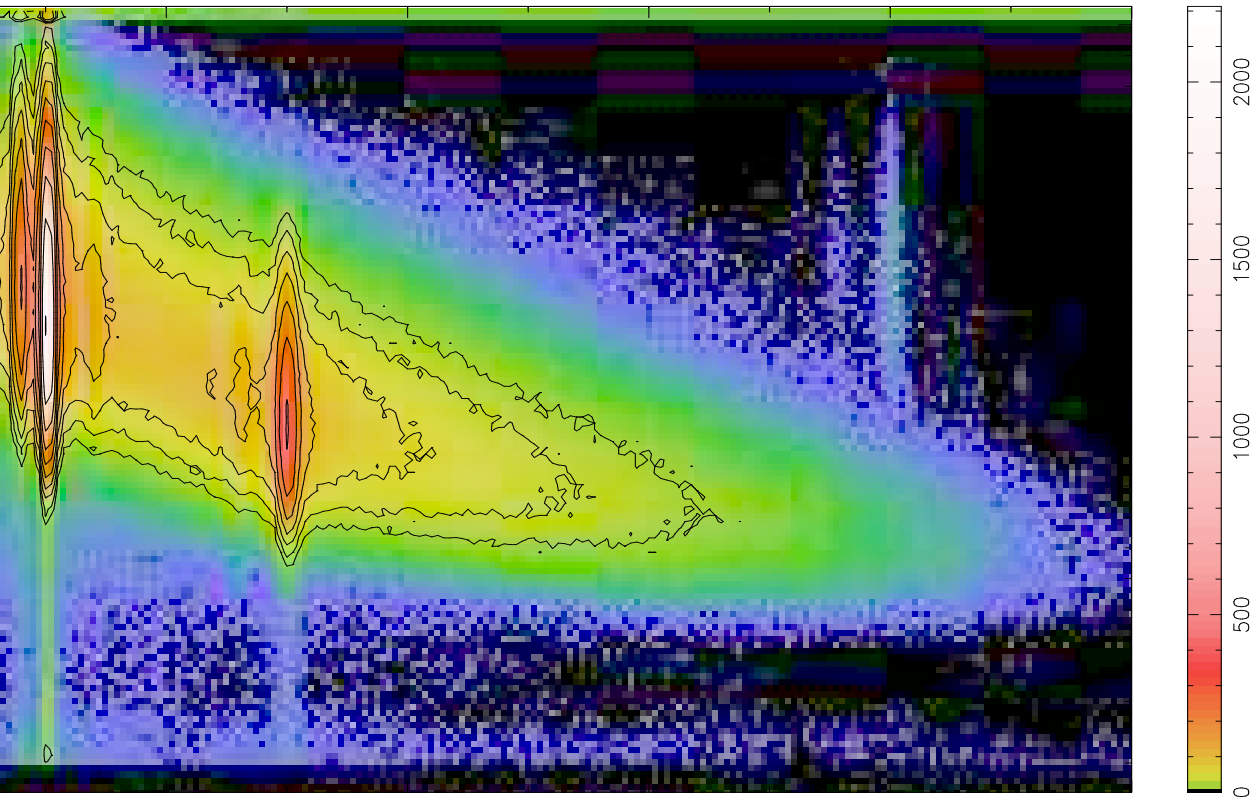
ata are converted to FITS files for analysis with XSPEC.

4 figures (“bi-spectrograms”) are the result of this procedure,
ns for each grating.

haracterization of the X-ray Source System (XSS)
IREFS reflection-grating monochromator HIREFS-12

HIREFS(SX) coarse scan

RAS14(W, 15 kV, 20%, 60 mA) – HIREFS(SX, 200 μm, 200 μm, –83)
ID 2332 FPC(P10, 400 Torr, 1650 V, 50 CG, 0.8 FG, 36 mm)



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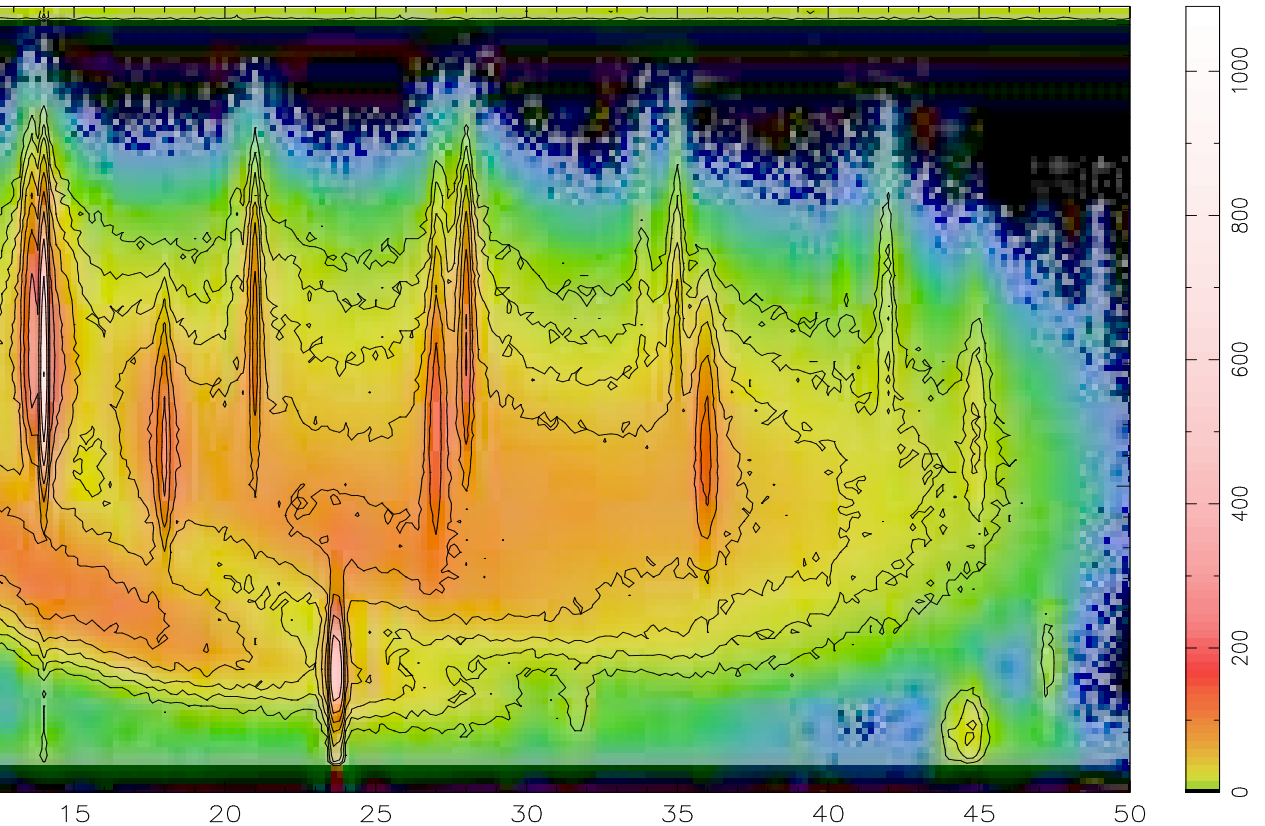
haracterization of the X-ray Source System (XSS)
IREFS reflection-grating monochromator HIREFS-13

HIREFS(SA) coarse scan

RAS14(W, 15 kV, 20%, 60 mA) – HIREFS(SA, 200 μm, 200 μm, –83)
ID 2320 FPC(P10, 400 Torr, 1650 V, 50 CG, 0.8 FG, 36 mm)



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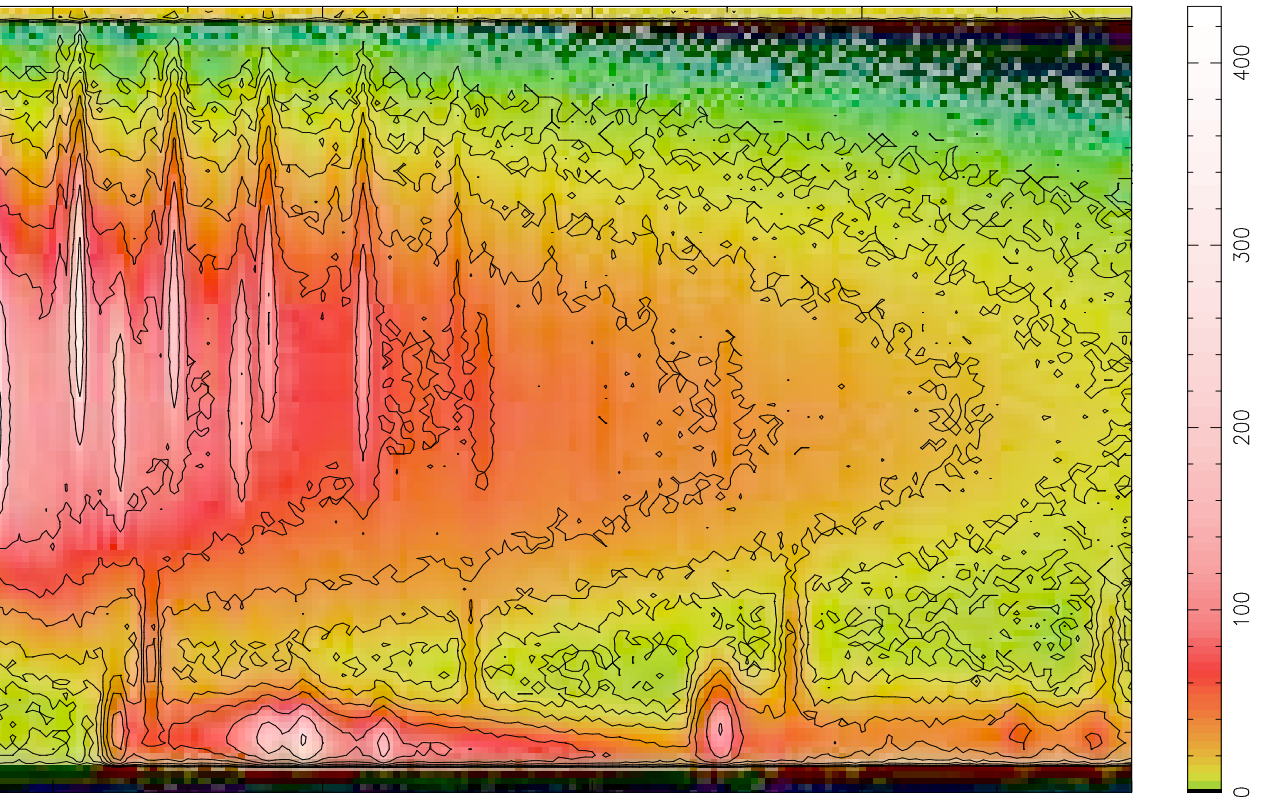
haracterization of the X-ray Source System (XSS)
IREFS reflection-grating monochromator HIREFS-14

HIREFS(SB) coarse scan

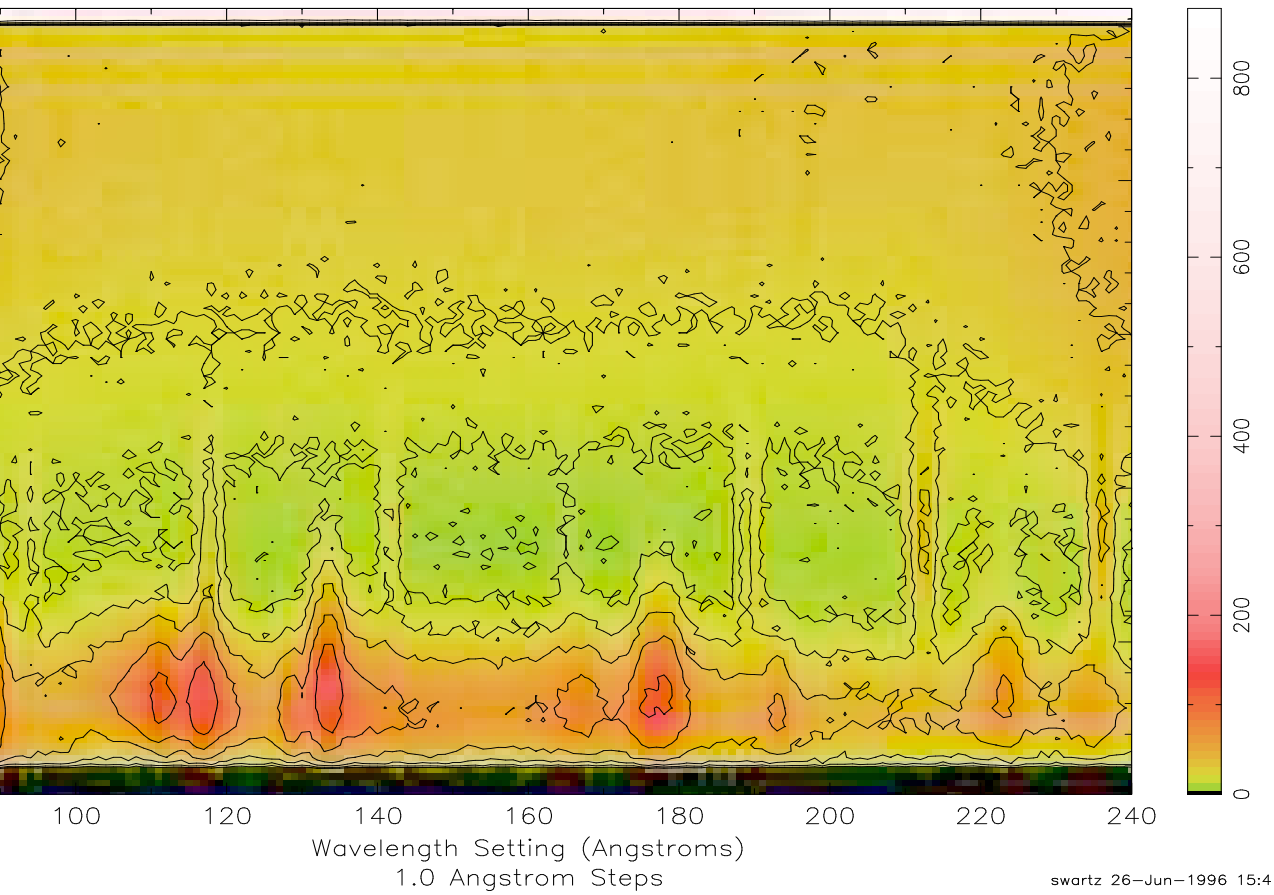
RAS14(W, 15 kV, 20%, 60 mA) – HIREFS(SB, 200 μm, 200 μm, –87)
ID 2303 FPC(P10, 400 Torr, 1650 V, 50 CG, 0.8 FG, 36 mm)



haracterization of the X-ray Source System (XSS)
IREFS reflection-grating monochromator HIREFS-15

HIREFS(SC) coarse scan

RAS14(W, 15 kV, 20%, 60 mA) – HIREFS(SC, 200 μm, 200 μm, –83)
ID 2350 FPC(P10, 400 Torr, 1700 V, 50 CG, 0.8 FG, 36 mm)



Modeling and Data Analysis

lers using XSPEC models “jmmodel” (SAO-supplied) and/or on.

not fit the low-energy shelf.

matrix is a simple diagonal matrix.

ckground subtracted.

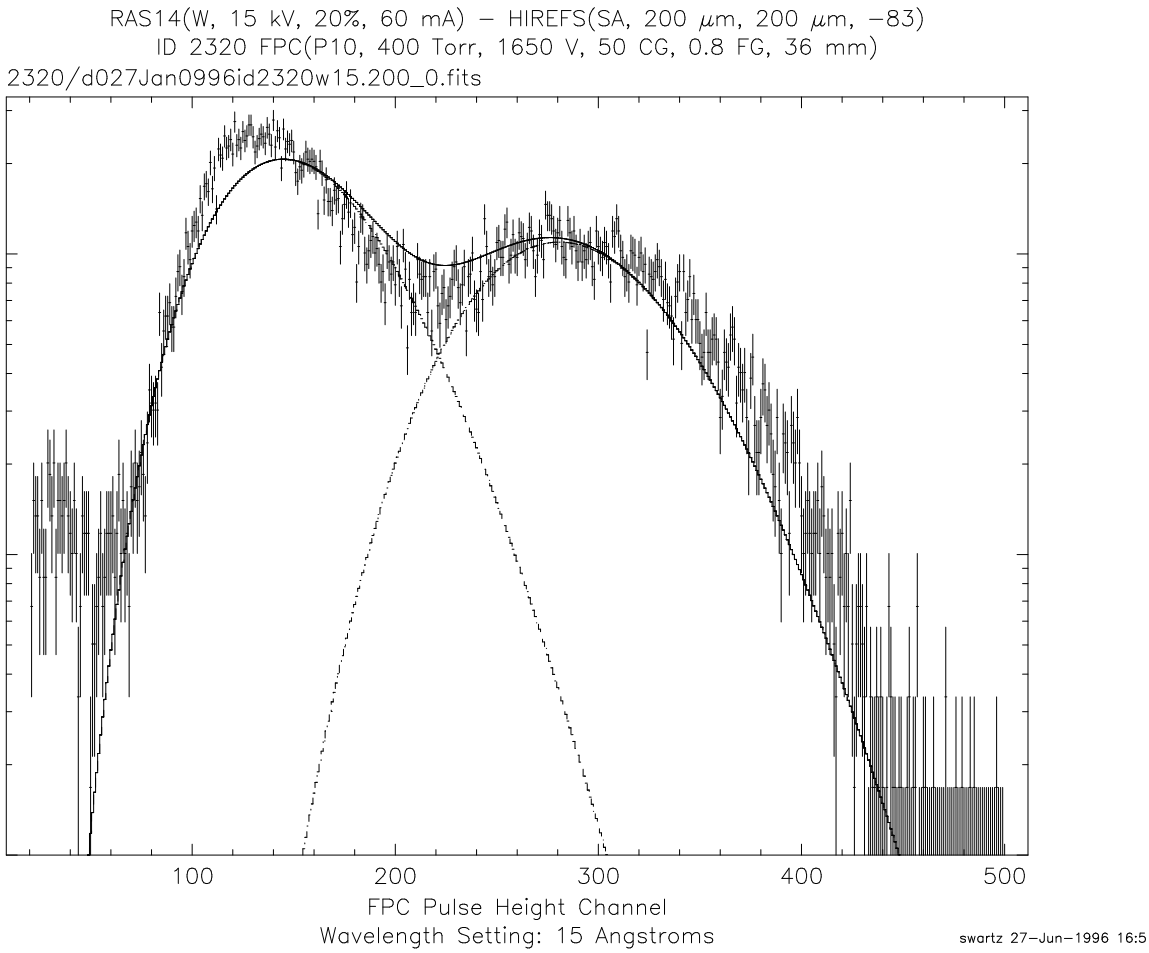
onochromatic source at wavelength given by HIREFS igher orders).

ns are held fixed in fitting.

otons cm^{-2} s^{-1} mA^{-1} at the HRMA.

-supplied quantum efficiency curve for FPC.

EFS(SA) pulse-height distribution at 15 Å



Specific flux at HRMA

ucial HIREFS parameters
lit width = 200 μm
dth = 200 μm
ng = -91 (Dependence on astig is discussed in a later

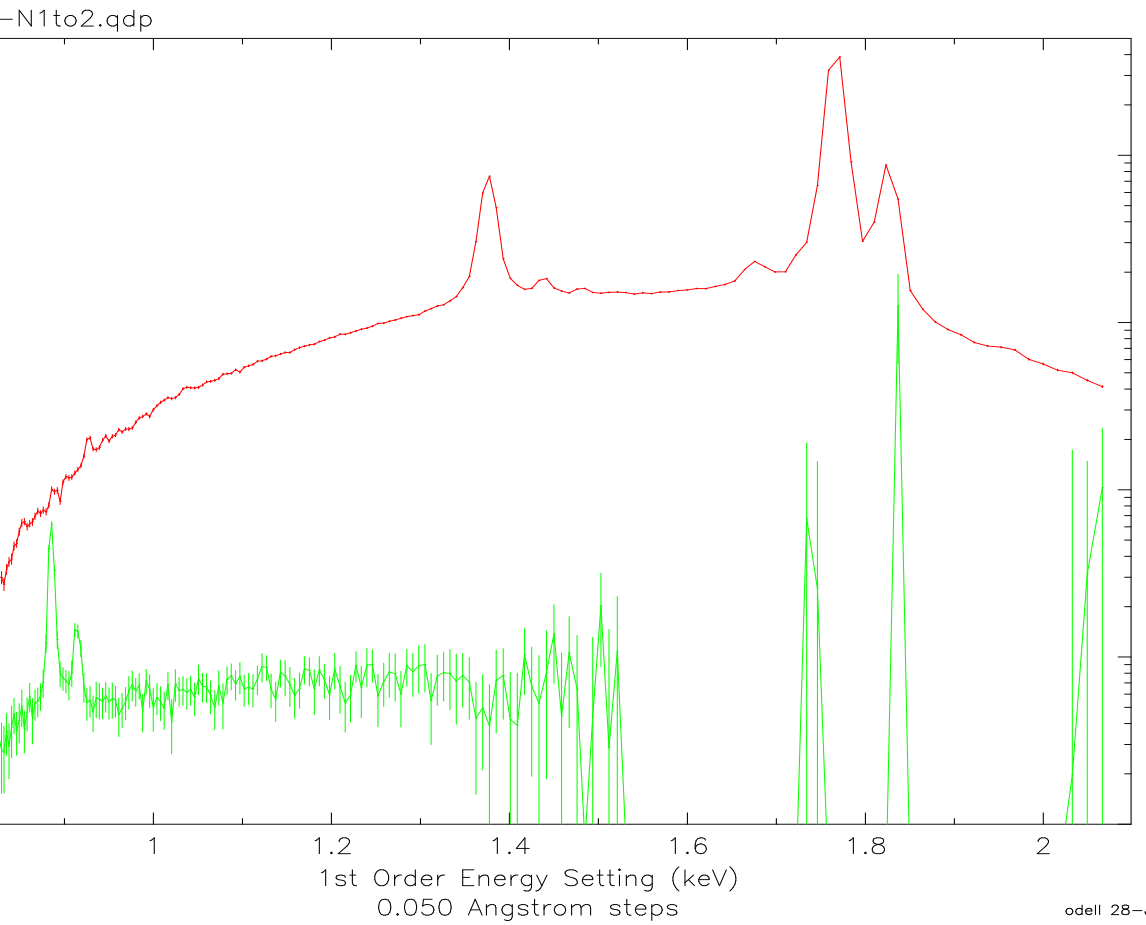
rating voltage (currently planned setting)
n widths of entrance and exit slits
t at continuum vs. resolution
scale as entrance slit width times exit slit width.
t at lines depends on line width.
width << resolution, it scales as entrance slit width.
width >> resolution, it scales as product of entrance slit widths.

Limitations

stimates within ~10% of the true rates.
source of fitting errors
orders overlapping at FPC spectral resolution
e of (un-modeled) low-energy shelf
tics cut off just above 2 keV.
dge lies at about 2.2 keV.
grazing angles give critical energy near 2 keV.
ecific flux at HRMA entrance aperture
t orders (1-2) for SX-grating coarse scans
t orders (1-5) for SA-grating coarse scans
1 relevant orders for SB-grating coarse scans.
aration is not possible for the SC grating.

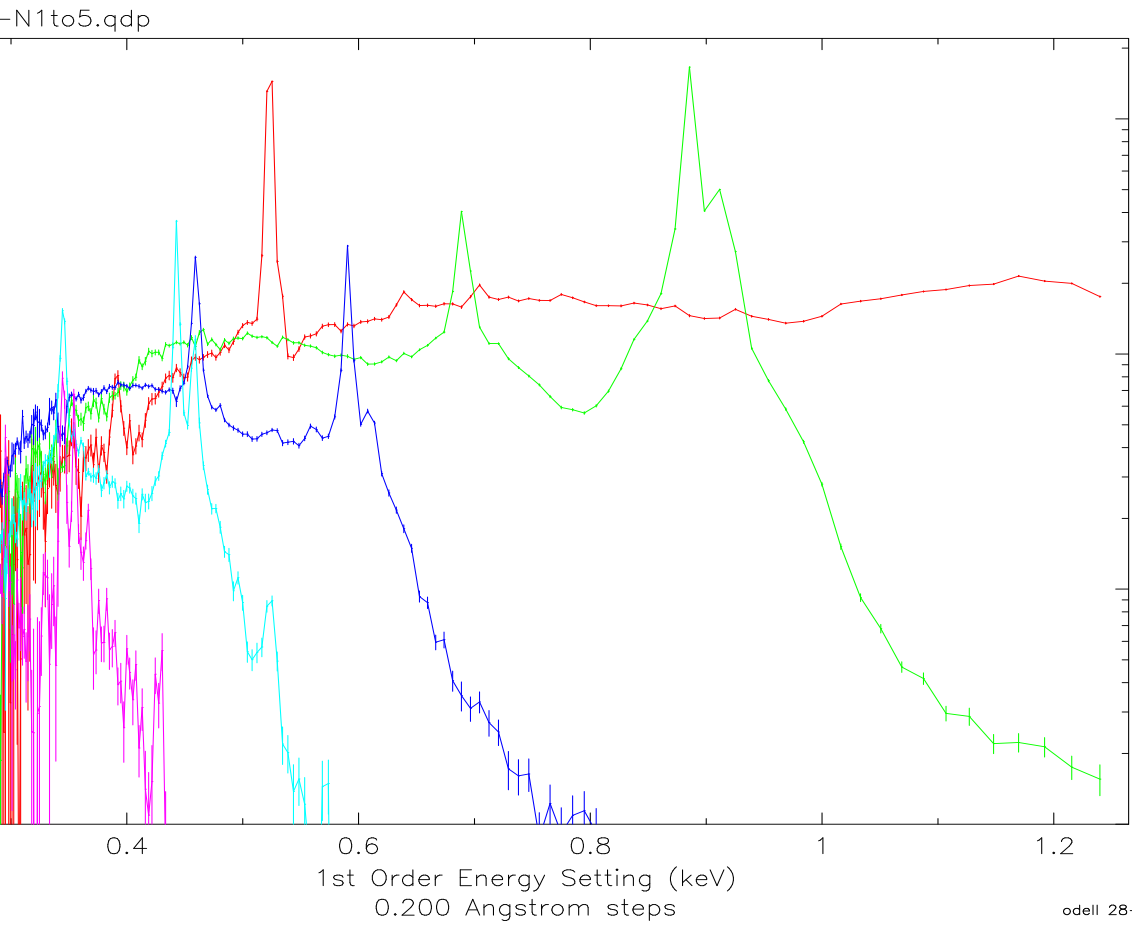
haracterization of the X-ray Source System (XSS)
IREFS reflection-grating monochromator HIREFS-20

REFS(SX) specific flux at HRMA aperture



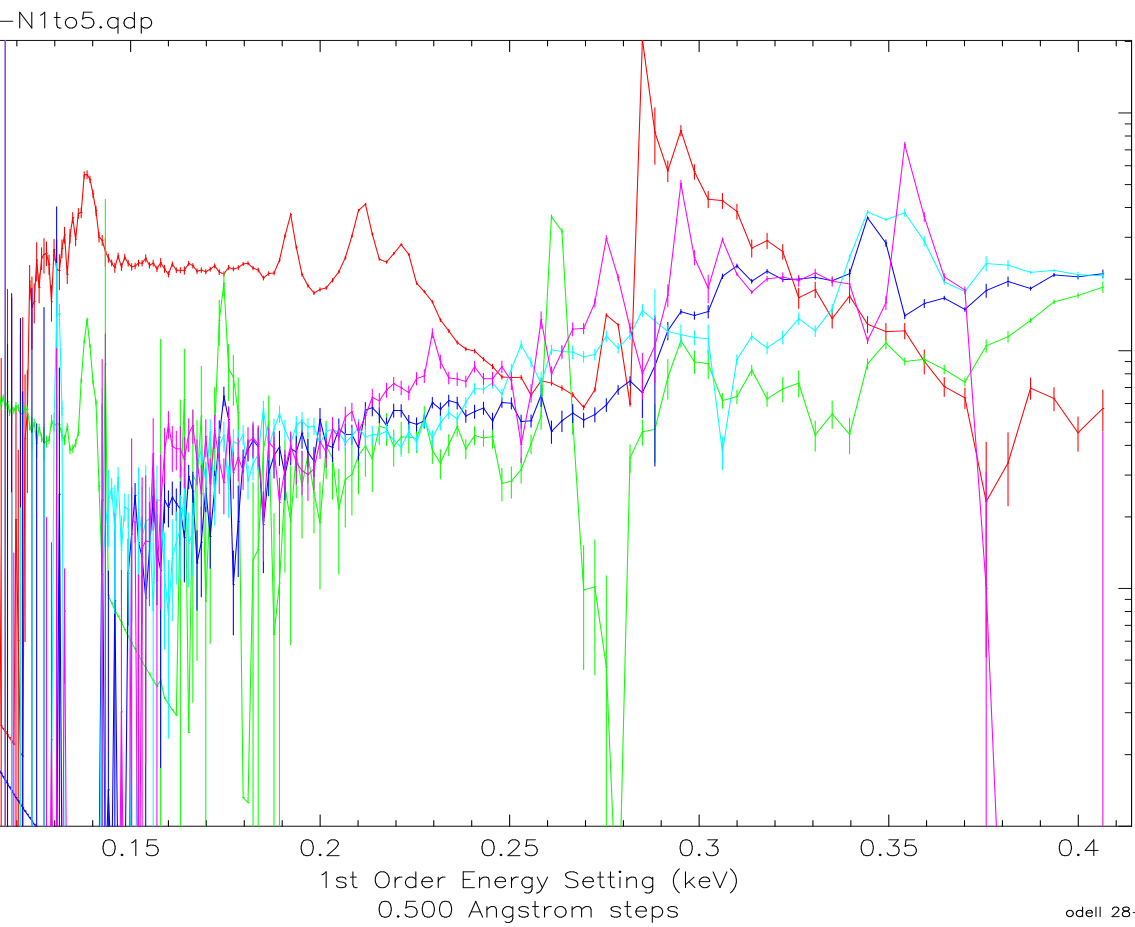
haracterization of the X-ray Source System (XSS)
IREFS reflection-grating monochromator HIREFS-21

EFS(SA) specific flux at HRMA aperture



haracterization of the X-ray Source System (XSS)
IREFS reflection-grating monochromator HIREFS-22

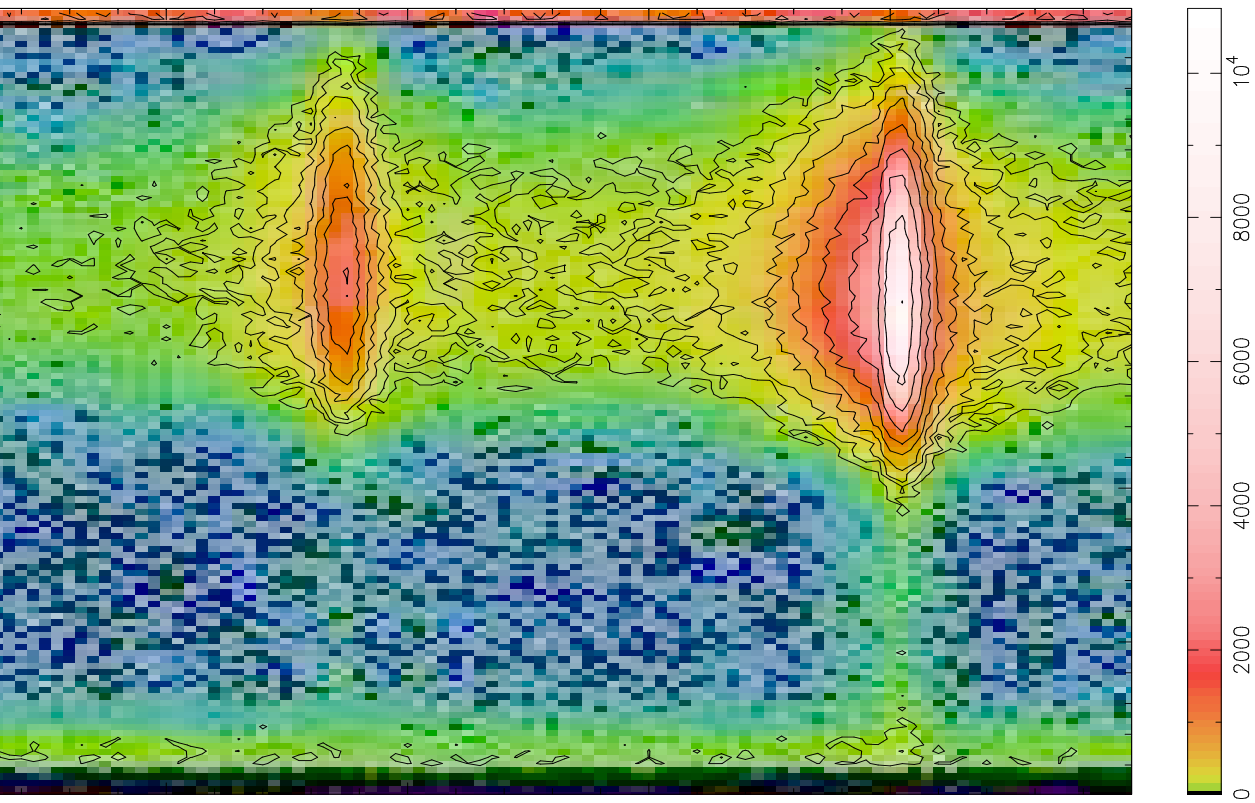
EFS(SB) specific flux at HRMA aperture



haracterization of the X-ray Source System (XSS)
IREFS reflection-grating monochromator HIREFS-23

HIREFS(SX) fine scan near W-Mα,β

RAS14(W, 15 kV, 20%, 60 mA) – HIREFS(SX, 20 μm, 10 μm, −79)
ID 2386 FPC(P10, 400 Torr, 1650 V, 50 CG, 0.8 FG, 36 mm)



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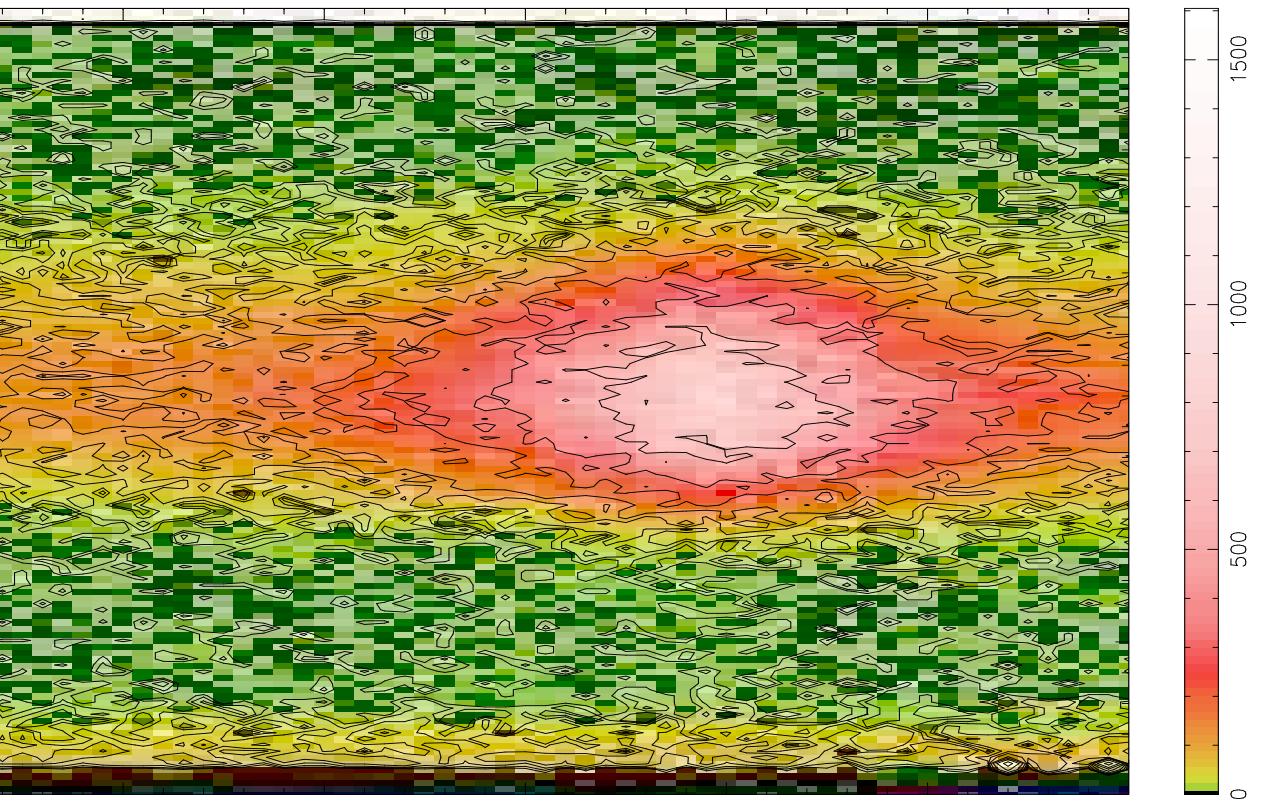
haracterization of the X-ray Source System (XSS)
IREFS reflection-grating monochromator HIREFS-24

HIREFS(SX) fine scan near W-Mζ

RAS14(W, 15 kV, 20%, 60 mA) – HIREFS(SX, 20 μm, 10 μm, −79)
ID 2387 FPC(P10, 400 Torr, 1650 V, 50 CG, 0.8 FG, 36 mm)



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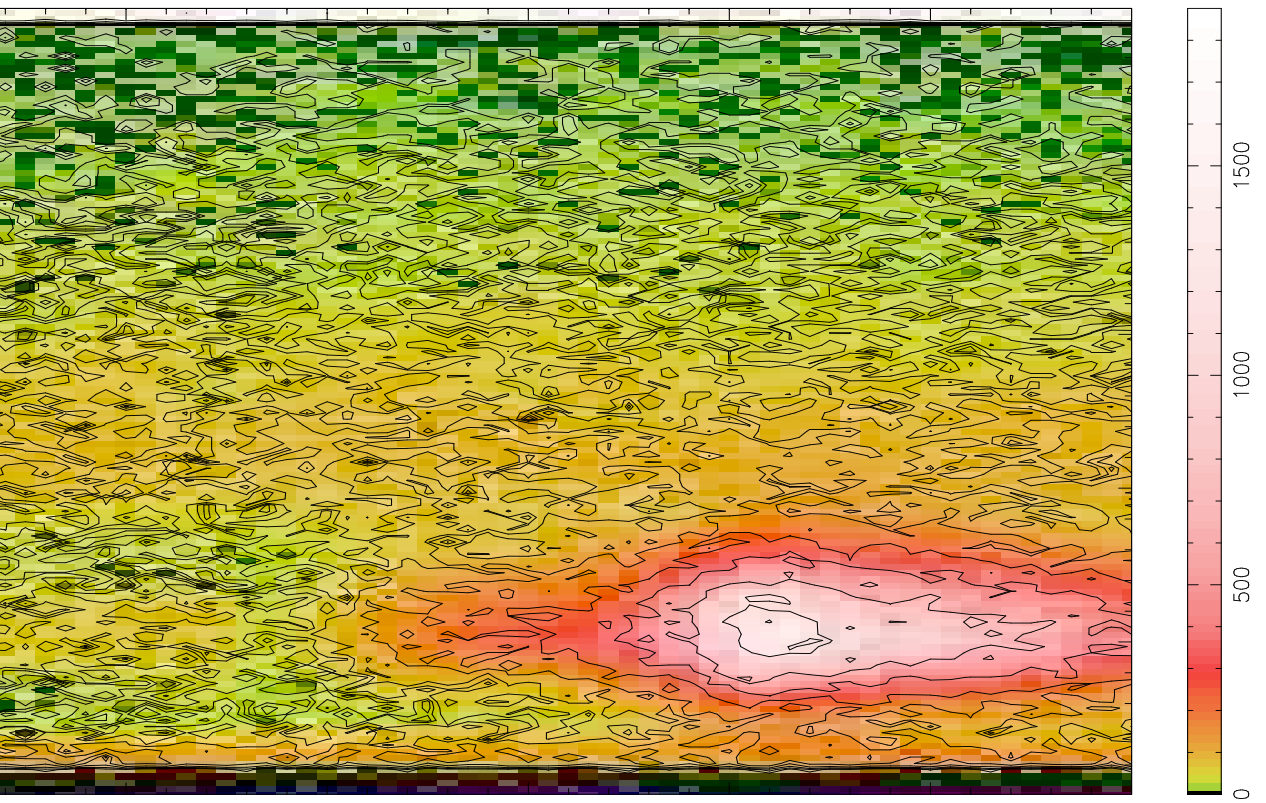
haracterization of the X-ray Source System (XSS)
IREFS reflection-grating monochromator HIREFS-25

HIREFS(SA) fine scan near O-Kα

RAS14(W, 15 kV, 20%, 60 mA) – HIREFS(SA, 20 μm, 10 μm, −79)
ID 2379 FPC(P10, 400 Torr, 1650 V, 50 CG, 0.8 FG, 36 mm)



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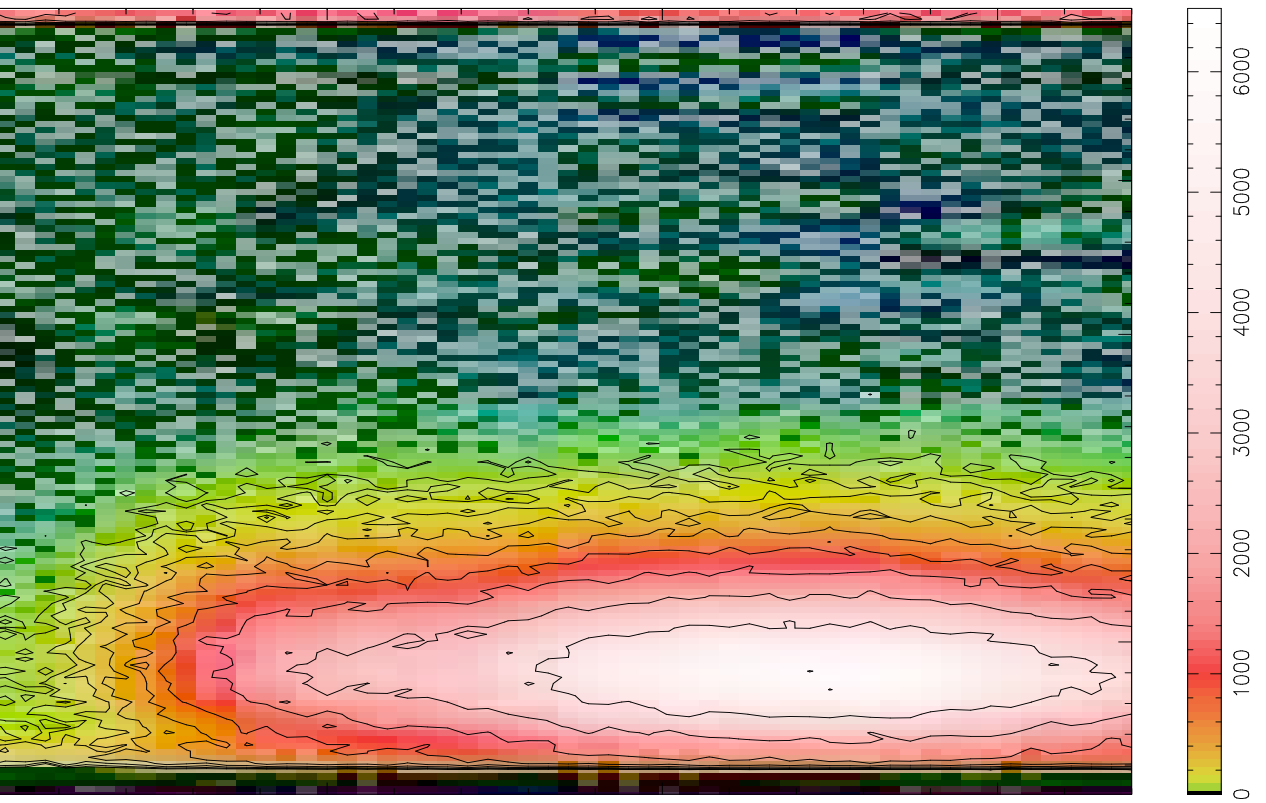
haracterization of the X-ray Source System (XSS)
IREFS reflection-grating monochromator HIREFS-26

REFS(SB) fine scan near C-Kα [C anode]

RAS14(C, 6 kV, 20%, 19 mA) – HIREFS(SB, 20 μm, 10 μm, −83)
ID 2405 FPC(P10, 400 Torr, 1700 V, 50 CG, 0.8 FG, 36 mm)



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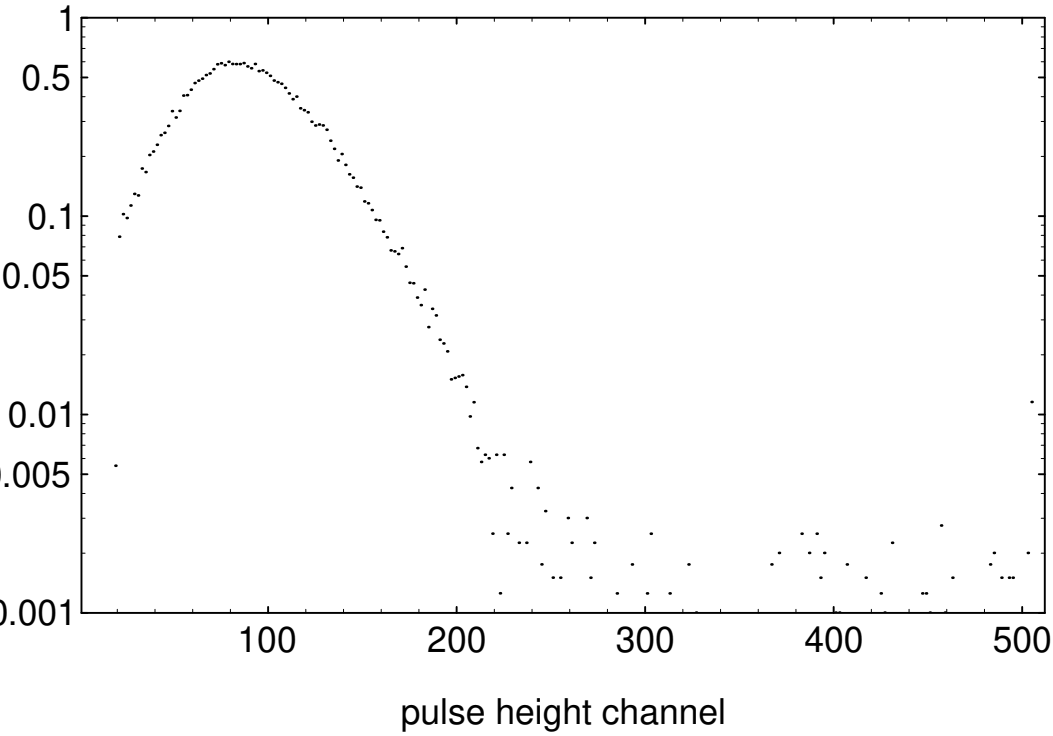
B) pulse-height distribution at C-Kα [C anode]

C-anode; SB; 0.277 keV; 10/5 slits; 6 kV; 19 mA;-83 astig



Specific Flux at HRMA = 0.0011 photons cm^{-2} s^{-1} mA^{-1}

Beam uniformity

FPC500 mapper

on is the same as for flux measurements.

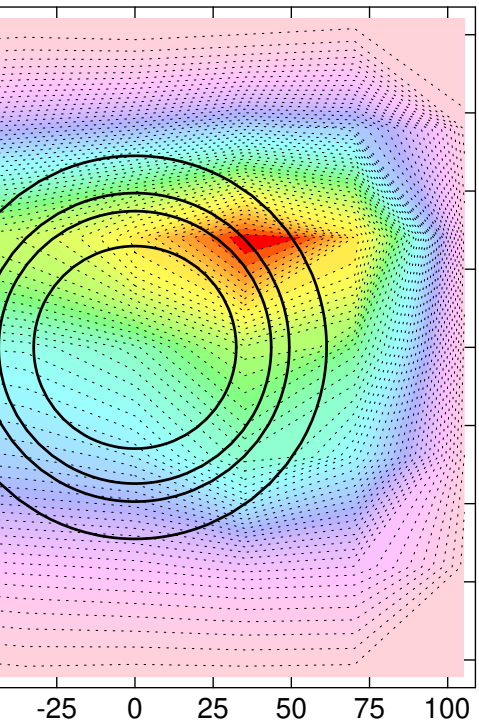
is obtained by raster scanning the FPC500 detector.

eam is inherently nonuniform.

haracterization of the X-ray Source System (XSS)
IREFS reflection-grating monochromator HIREFS-29

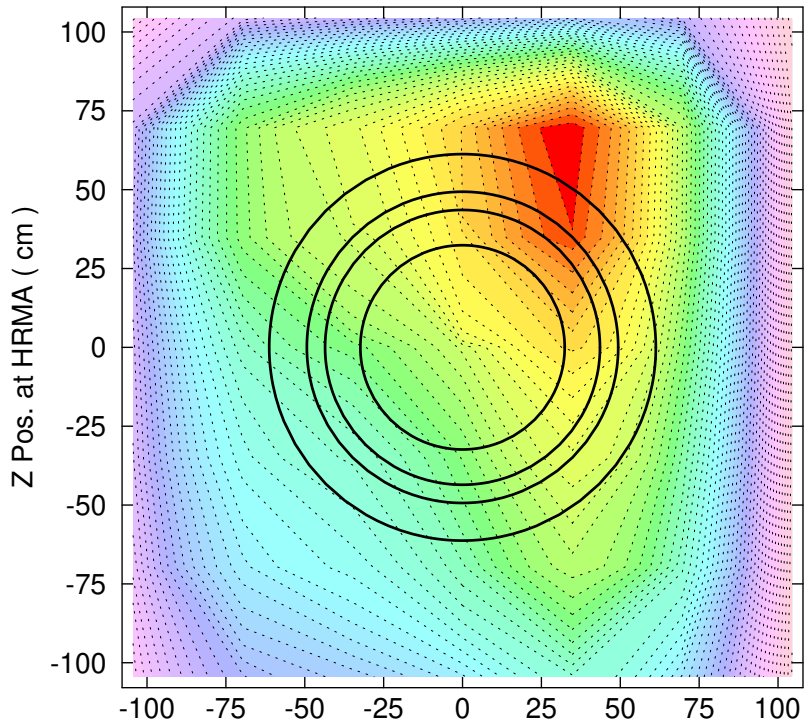
HIREFS(SB) beam maps

micron, 200 micron, -83) at 50 Angstrom

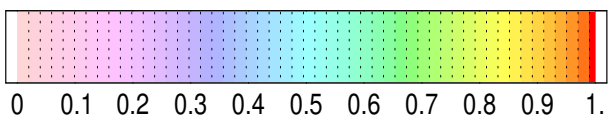


Y Pos. at HRMA (cm)

HIREFS (SB, 200 micron, 200 micron, -87) at 50 Angstrom



Y Pos. at HRMA (cm)



50 Å
continuum
W anode

Model / Analysis Technique

tribution of intensity is assumed separable.

+ b)(cz + d)

_1, y_2) and (z_1, z_2) and zero otherwise.

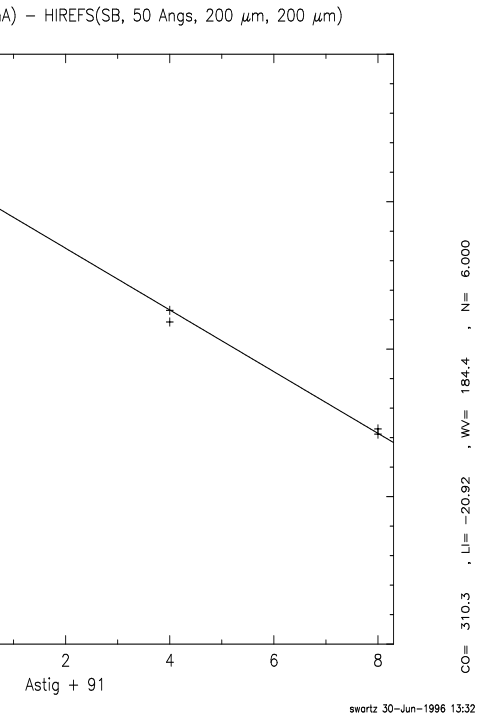
ata points, d_i, at points y_i, along the section z=0 is given
n y_min to y_max of (ay+b)∗W(r,y), with y_min = max(y_i-r,
W(r, y) = sqrt(r∗r-(y_i - y)∗(y_i - y)) for the circular FPC
ius r.

ence of order/energy dependence has been observed in
ergy beam maps.

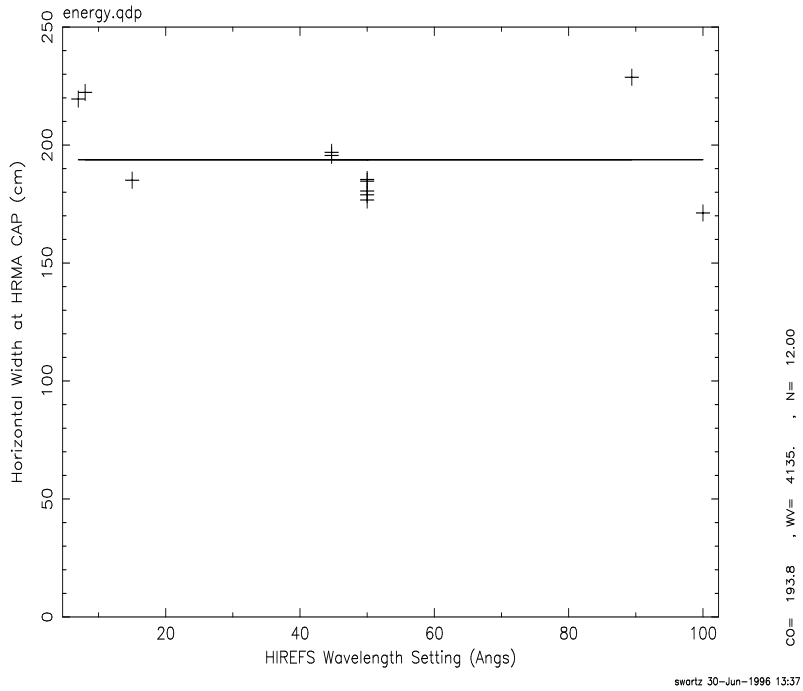
naps have not yet been analyzed, so a general relation
eam intensity and source parameters has not yet been
d.

Beam dimensions

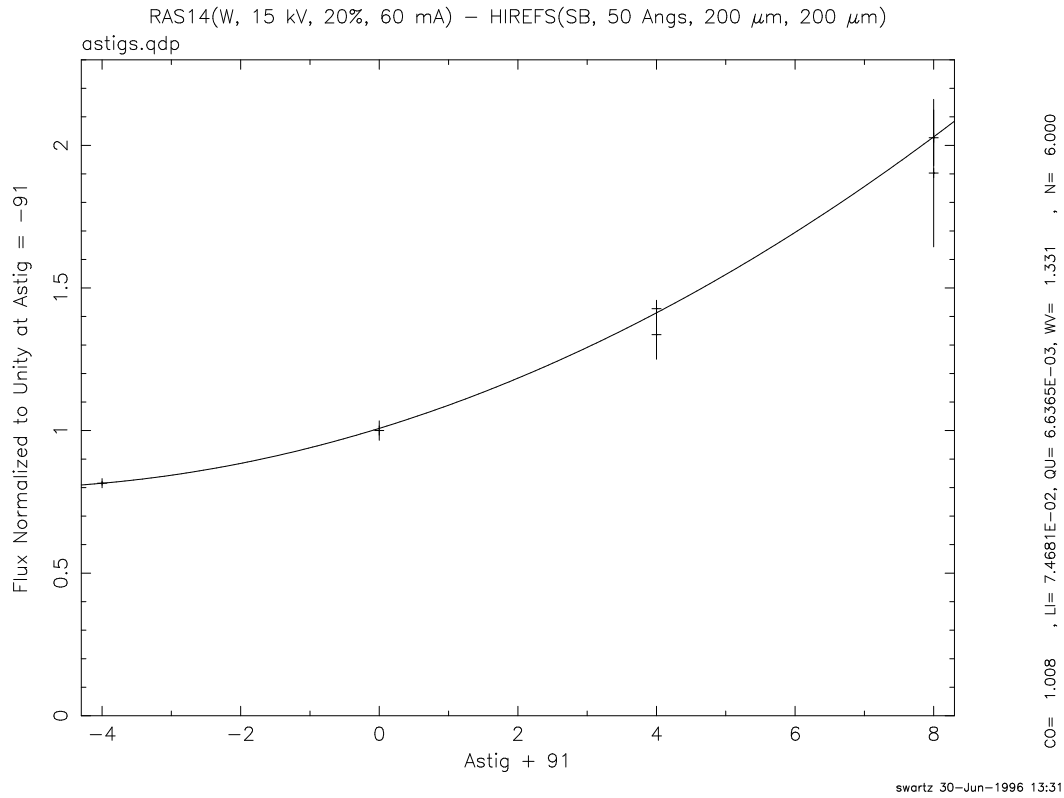
vs. astig setting



Beam width vs. wavelength



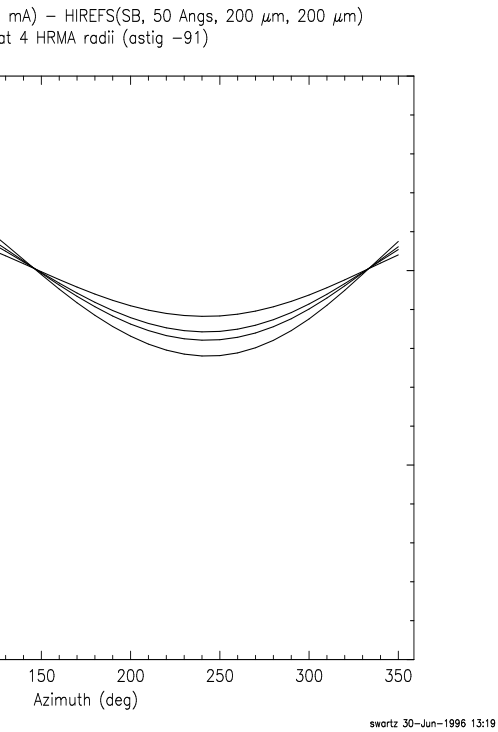
Dependence of flux upon astig setting



xis flux as a function of astigmatism setting, normalized to
e at an astig setting of -91.

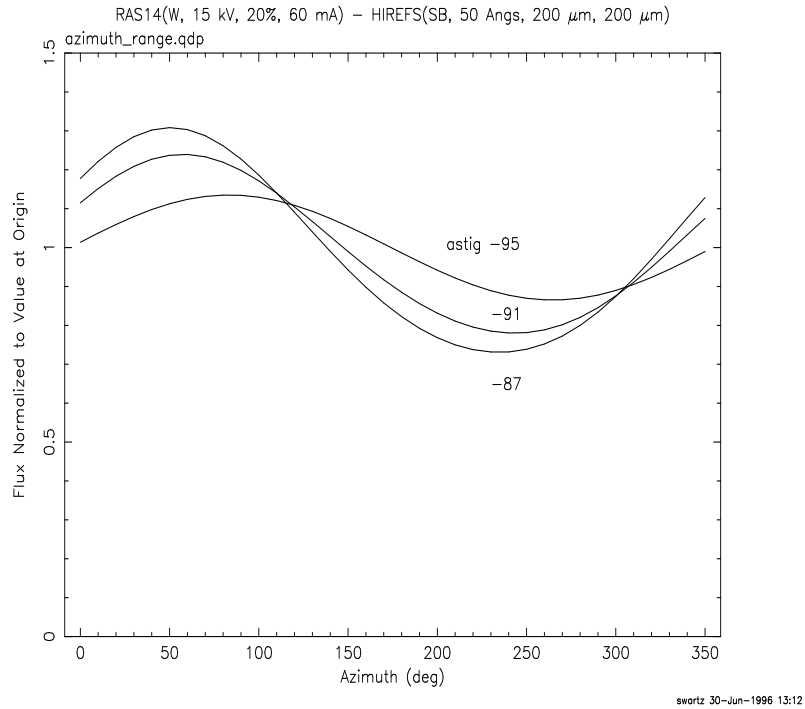
Variation of flux upon azimuth

upon HRMA shell



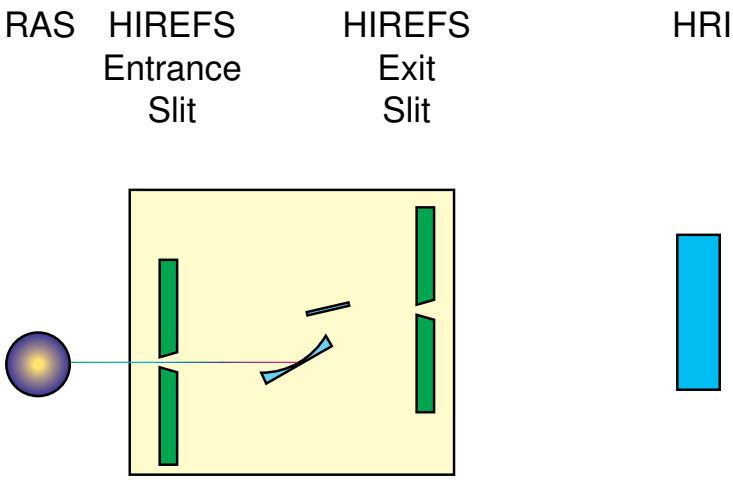
ion of flux relative to on-
ntrance aperture of each
an astig setting of -91.

Dependence upon astig setting

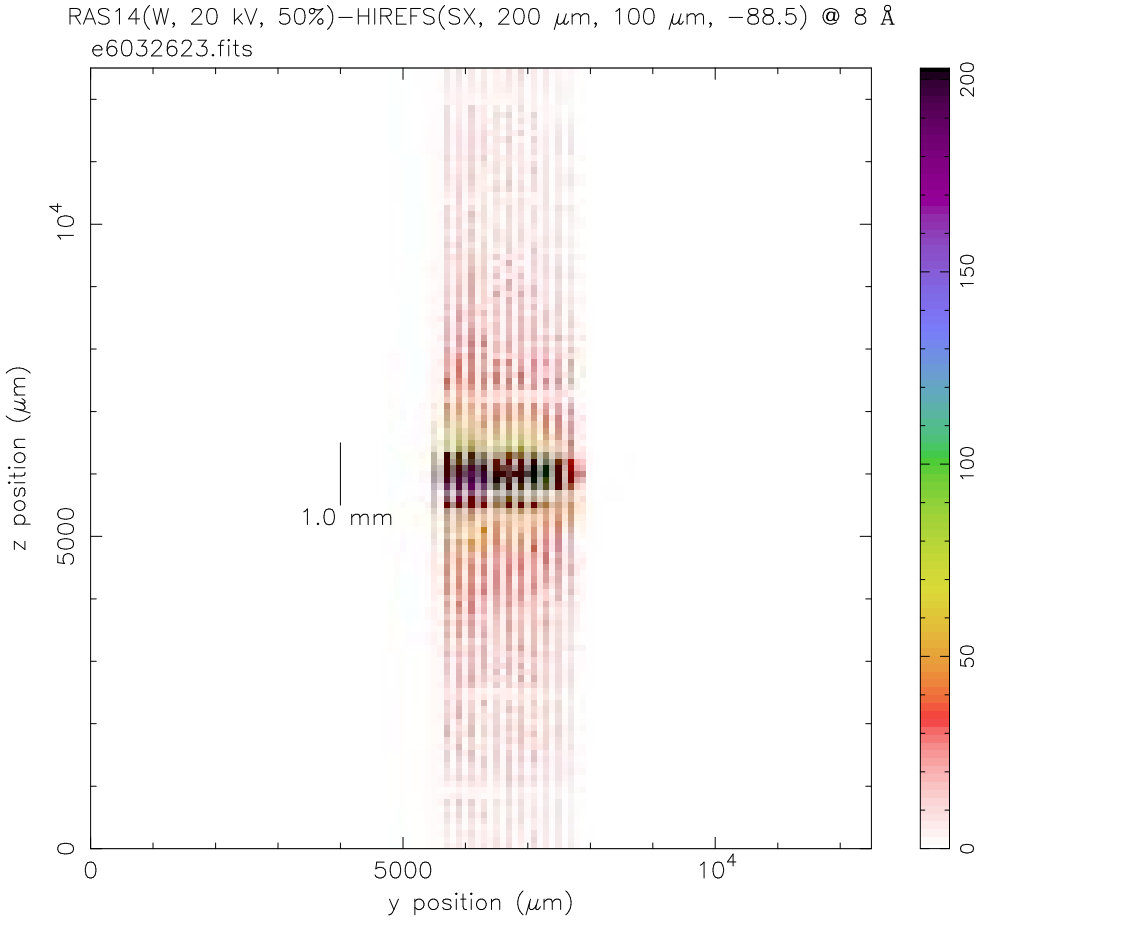


Azimuthal variation of flux, at entrance aperture of outermost HRMA shell, for astig settings of -87, -91, and -95.

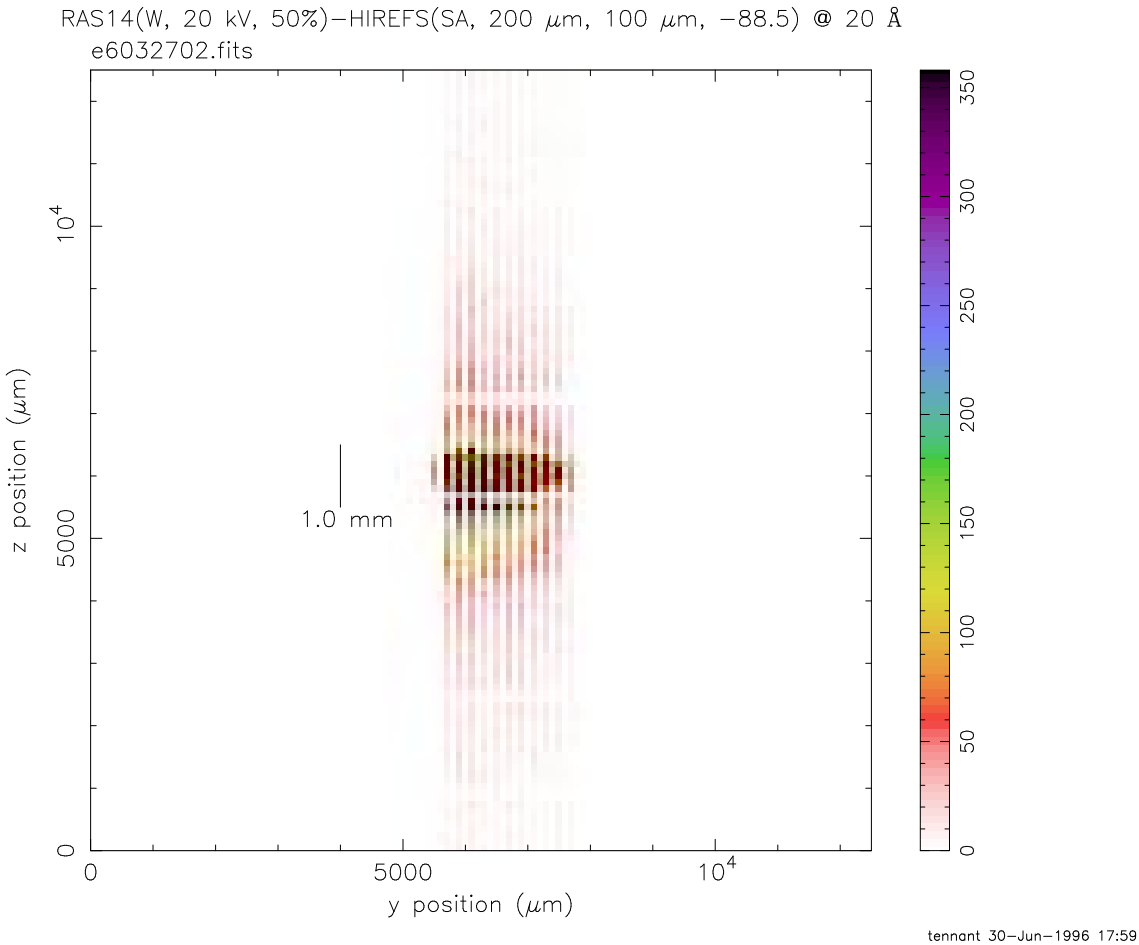
Measurement of RAS14–HIREFS spot



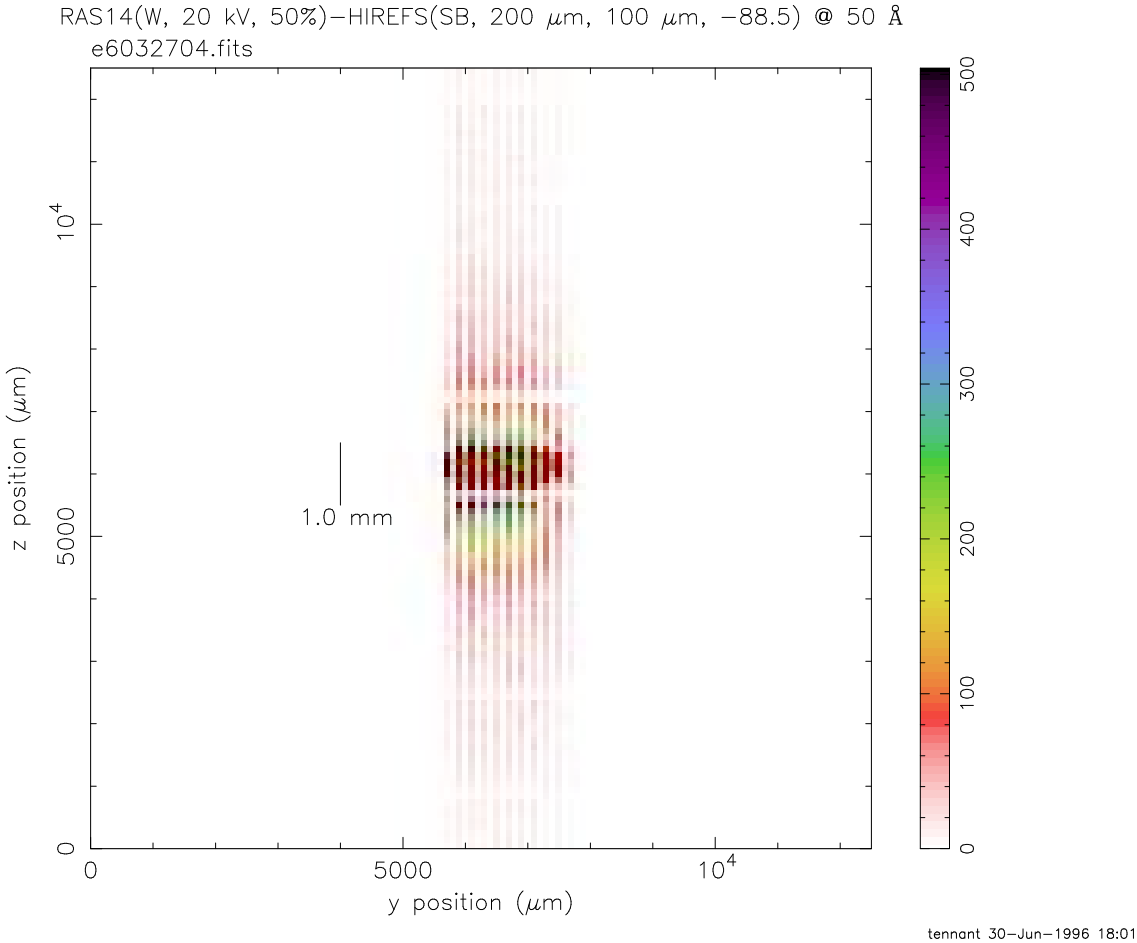
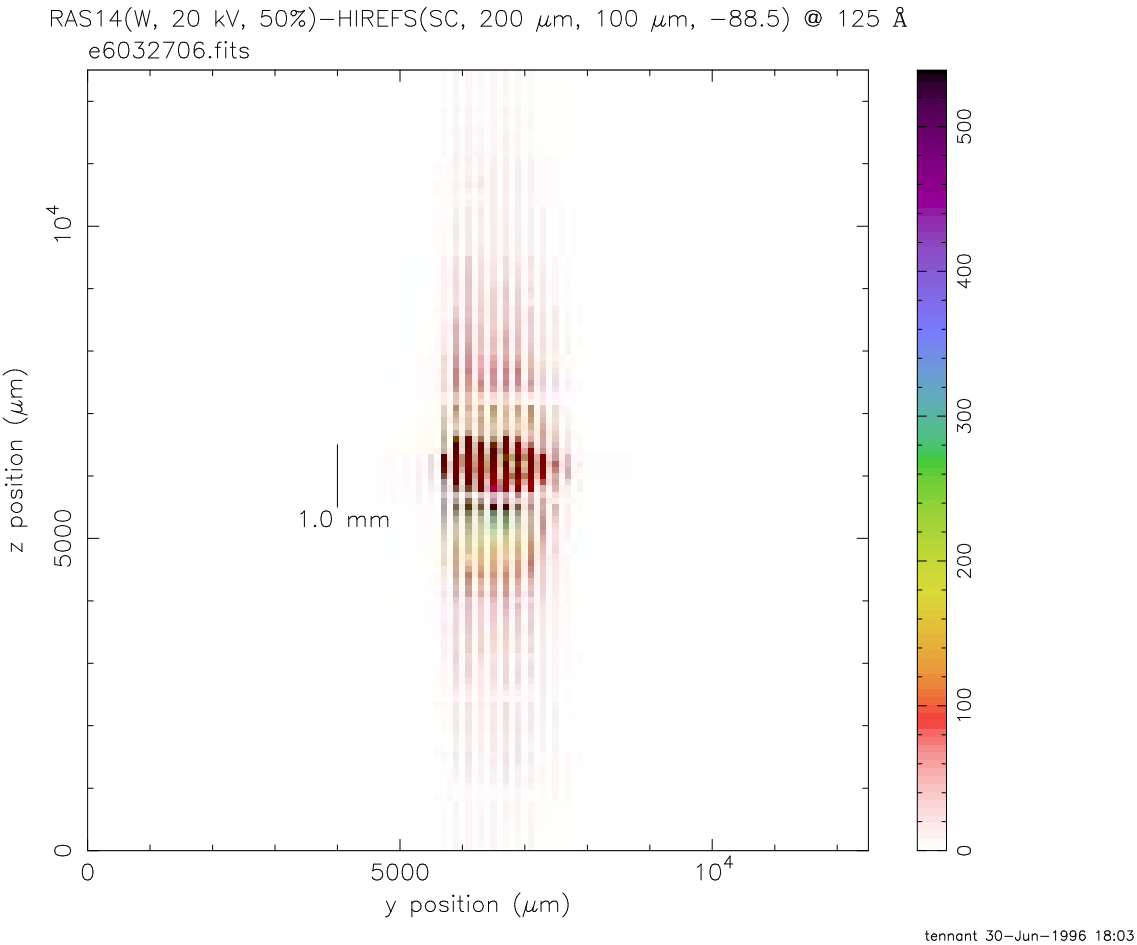
RAS14–HIREFS(SX) spot



RAS14–HIREFS(SA) spot



RAS14–HIREFS(SB) spot



RAS14–HIREFS(SC) spot