SXT 8G004
Rev. A

Sept. 14, 1990
JRL, HSH

SXT cal Note #5

The SXT X–ray Neutral–density Filters

1. Filter transmission

The SXT "neutral–density filters," nominally 10% transmission, consist of photoetched masks of square holes at a nominal 670 lines per inch. This corresponds to holes about 12 microns square at 37.91 micron separations. The mounting location of the filters is nominally 73 mm in front of the CCD face. Exact values for these numbers derived from independent measurements are not available at the present time. The transmission should be quite neutral across the wavelength range of interest

Two neutral–density filters were tested in the X–ray reflectometer with a small monochromatic beam at 23.62 Å (oxygen K–alpha) produced at the LPARL X-ray reflectometer. The beam dimensions were approximately 0.9 × 1.8 mm in the (y,z)–plane perpendicular to the beam direction. The primary measurements consisted of a square grid of approximately 5 x 5 positions across the filter area. There was a 20–second exposure at each position yielding a total of about 4500 counts in the central area of the filter, for a statistical error of about 1.5% The measurement error introduced by fluctuations in the number of mesh holes present at a given beam position can be estimated from

$$(fractional\ error) = \sqrt{\frac{(grid\ cell\ area)}{(beam\ area)}}$$

and is about 2.6%, so that this effect should dominate the error of measurement.

Both candidate filters showed appreciable variations at this precision of measurement, as summarized below.

Filter ID	Transmission	Range
5	(0.0906 ± .0010)	0.0042
8	(0.0821 ± .0007)	0.0021

The measured range of transmission was several times that expected from counting statistics, but not much larger than that expected from the fluctuation of hole count in one beam. Filter #5, the primary flight candidate, is slightly more transparent and non–uniform than filter #8. The "range" values quoted above are upper limits to any true photometric error that these filter non–uniformities could cause, because of the defocus of the image at the filter location. Nevertheless the uncertainty in

filter transmission could amount to several percent (of the transmission value), so we recommend that the orientation of the filter in its cell be recorded for the sake of analysis of flight data that might need ultimate precision.

2. Photometric errors

2.1. Mesh hole pattern

The mounting of the filter at a nominal distance of 73 mm from the detector implies that the defocused ray bundle from a point source occupies an annulus of diameter 5.416 mm and width 0.0174 mm. The area of this annulus is 0.0944 mm^2 or 65.7 unit cells of the mesh (nominal 37.91 micron hole spacing). This implies a photometric error with a peak–to–peak amplitude $< 1.5\%$ for an unresolved point source and correspondingly less for larger sources.

2.2. Diffraction

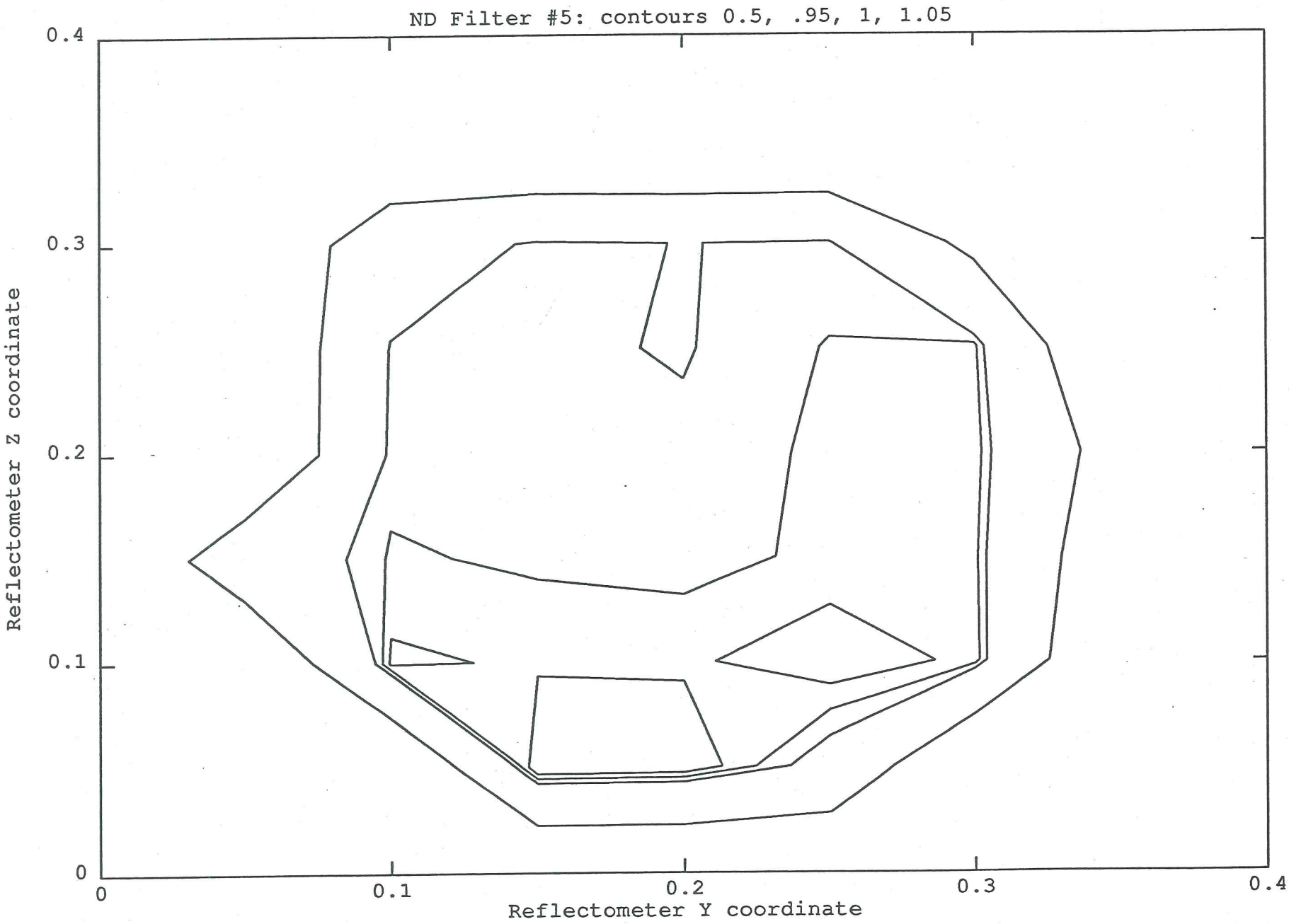
The significance of diffraction in the filters can be estimated from

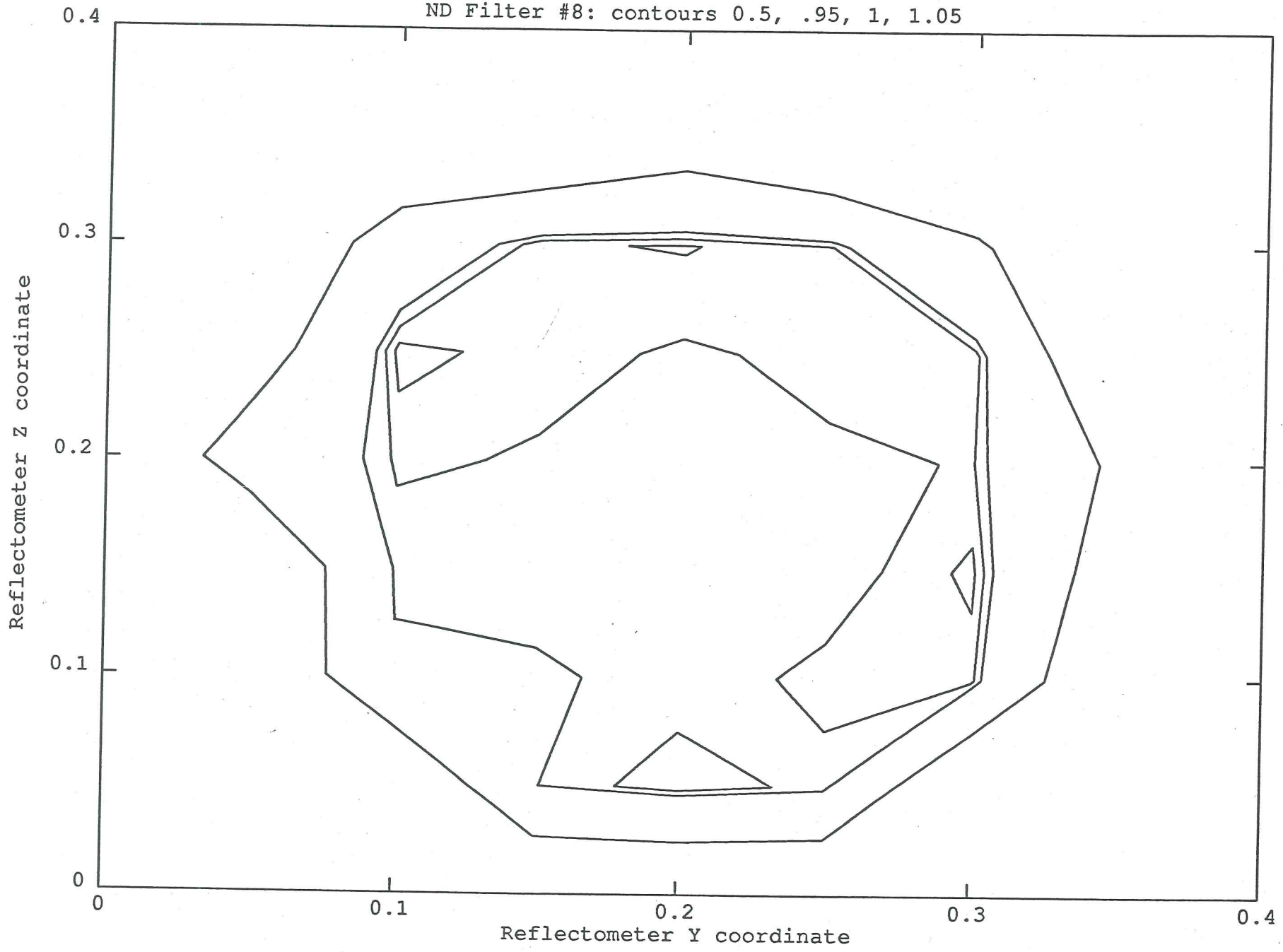
$$\theta = \sqrt{\lambda/d},$$

which gives the characteristic angle of Fresnel diffraction for a linear edge at distance d and wavelength lambda. For the 73 mm filter distance, this corresponds to the following displacements x ($= d \times \theta$) in the image plane:

λ (Å)	x (microns)
44.0	17.922
25.0	13.509
12.4	9.5142
6.00	6.6182
3.00	4.6797

At long wavelengths, the image will therefore be distorted on an angular scale comparable to the pixel size or Fraunhofer diffraction of the telescope itself, and will need to be remembered when performing detailed response calculations.


ND Filter #5: contours 0.5, .95, 1, 1.05
0.4
0.3
0.2
0.1
0
Reflectometer Z coordinate
0
0.1
0.2
0.3
0.4
Reflectometer Y coordinate


ND Filter #8: contours 0.5, .95, 1, 1.05
0.4
0.3
0.2
0.1
0
Reflectometer Z coordinate
0
0.1
0.2
0.3
0.4
Reflectometer Y coordinate