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Subject: Further Analysis of Required/Proposed Revisions for HETGS Masks
Cc: A.Fruscione, D.Burke/SDS Documentation Team
Date: 10 April 2003
Ref: `http://space.mit.edu/CXC/docs/Memo_tgbkg_1.1.ps.gz`
File: `http://space.mit.edu/CXC/docs/Memo_tgbkg_1.2.ps.gz`

Summary of Changes Required or Proposed

I have investigated the background binning regions and grating masks in somewhat more detail in the course of CIAO 3 testing, and received some feedback on the previous memo. This memo addresses Item 1 of that memo (parameter bug-fix) and defers Items 2 & 3 (sign conventions and polygonal masks) for further analysis.

1 Bug in `tg_create_mask`, `tgextract`

To recap:

> The `tg_create_mask` program creates a spatial filter for MEG and HEG regions from calibration data and an error-budget computation of the one-sigma cross-dispersion width (accounting for possible defocus and off-axis position), then scales by a factor. The parameter is `width_factor_hetg`, whose default value is 20. In `tgextract`, the default background parameters, `max_upbkg_tg_d` and `max_downbkg_tg_d`, extend further than the spatial filter. . . . When the spectrum is binned by `tgextract`, the `BACKSCAL` values are determined from the parameters, not the data, and are thus wrong.
>
> My experiments have shown that a `width_factor_hetg` = 40 mitigates the problem without compromising event resolution at 6–7 keV. Larger `width_factor_hetg` causes the HEG and MEG regions to overlap too much such that valid short-wavelength events are not resolved. . . .

To study the problem region in more detail, I processed a bright, hard, continuum source (Vela X-1, obsid 1928) with Level 1.5 mask width factors (`tg_create_mask.width_factor_hetg`) ranging from 5 to 40 in increments of 5, ran `tg_resolve_events` to empirically determine the maximum and minumum `tg_d` values, and extracted spectra with `tgextract` in order to see when and where the short-wavelength flux became truncated.

Figure 1 shows the maximum `tg_d` extent (half-width) for MEG and HEG *vs.* the `tg_create_mask` width factor. I also plotted the default source binning region and the default background binning regions (half-widths). To avoid truncation, the event coordinates must extend above the binning regions. You can see that the HEG events do not until the mask width factor is 40, and MEG not until the factor is 25. The default factor is 20 (see plots in previous memo).

Figure 2 shows the short-wavelength flux *vs.* `width_factor_hetg`. The dark-colored lines (blue & black) are HEG ± 1, and the light lines are (red & green) MEG (which has lower effective area at the shortest wavelengths). The largest emission line is Fe Kα fluorescence, and the smaller is Fe Kβ. There is virtually no change until the last panel, at `width_factor_hetg`$= 40$, when the HEG spectrum becomes severly truncated shortward of 1.9 Å.

At at `width_factor_hetg` of 35, however, we are still truncating the background region for the HEG (see Figure 1). The implied value should be about 10% lower.

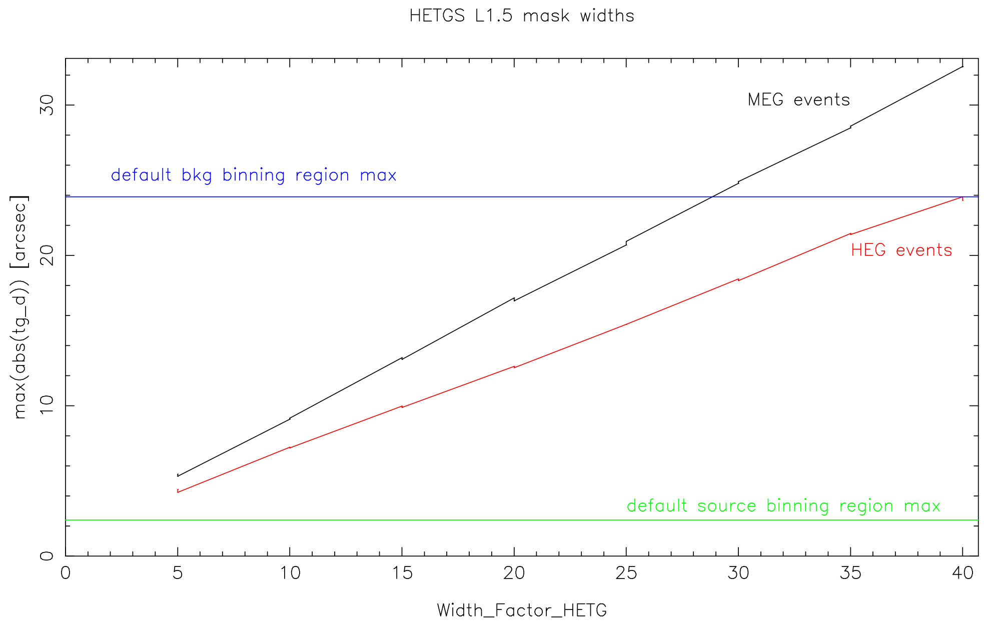

Figure 1: The maximum extent of events in cross-dispersion in the Level 1.5 mask is shown as a function of tg_create_mask.width_factor_hetg. Horizontal lines show the default source and background region widths.

2 Amended Recommendations

There are two changes which are fairly simple and should be made for CIAO3.

1. Change the default tg_create_mask.width_factor_hetg from 20 to 35 (I previously recommended 40).
2. Change the default max_upbkg_tg_d from 6.64×10^{-3} deg to 6.0×10^{-3} deg. This will result in change from 4.5 to 4.02 to the (one-sided) BACKSCUP and BACKSCDN keywords (these are computed by tgextract). (Note: the min_downbkg_tg_d is computed from the "up"-side to be symmetric.)

These parameters can be overridden by the user to define custom Level 1.5 masks or source and background binning regions.

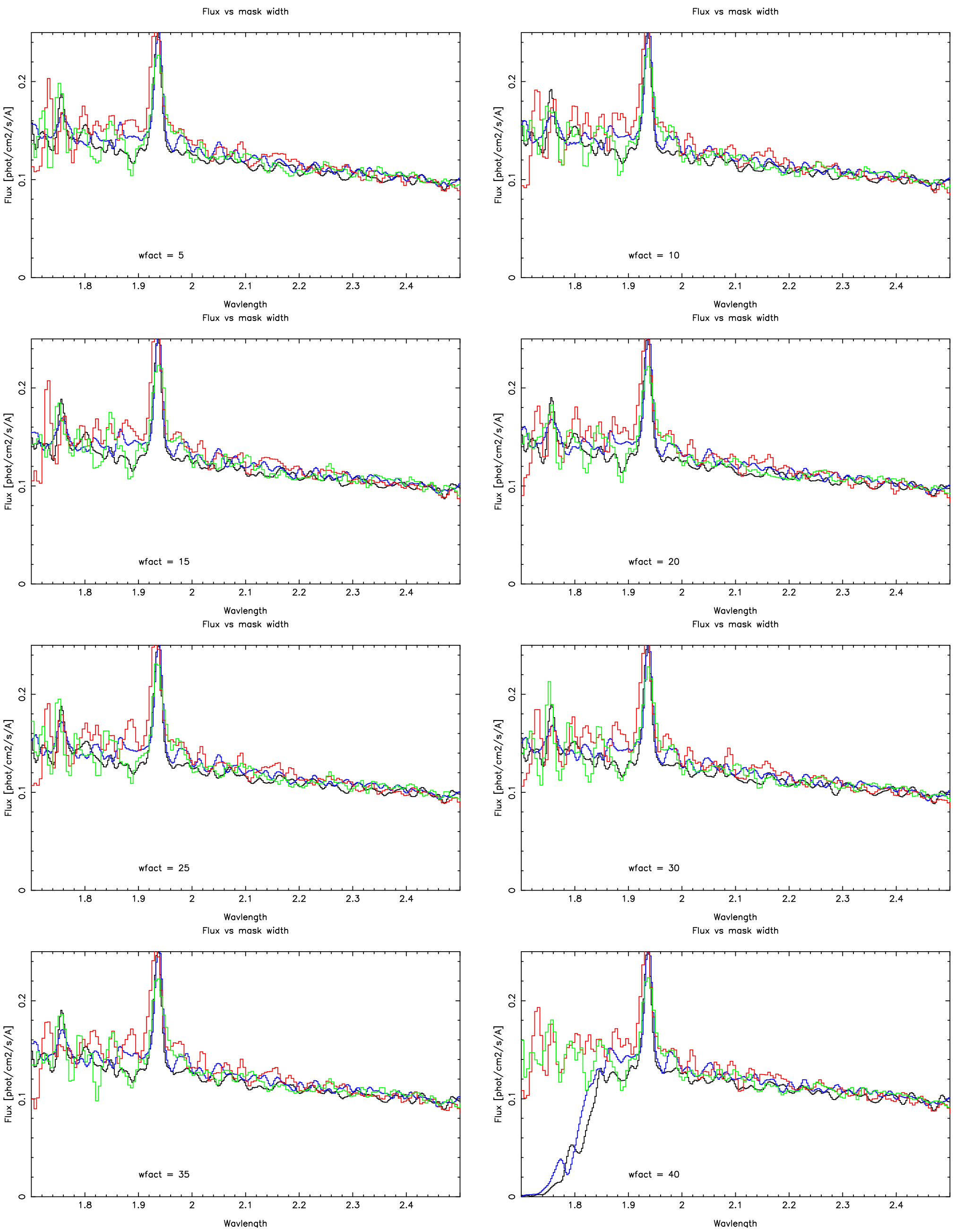

Figure 2: The extracted flux *vs.* `tg_create_mask.width_factor_hetg` for HEG (red & green) and MEG (black & blue) $\pm1^{\mathrm{st}}$ orders. Note that HEG is severly truncated for the `width_factor_hetg`$= 40$, but not noticeably affected for smaller values.

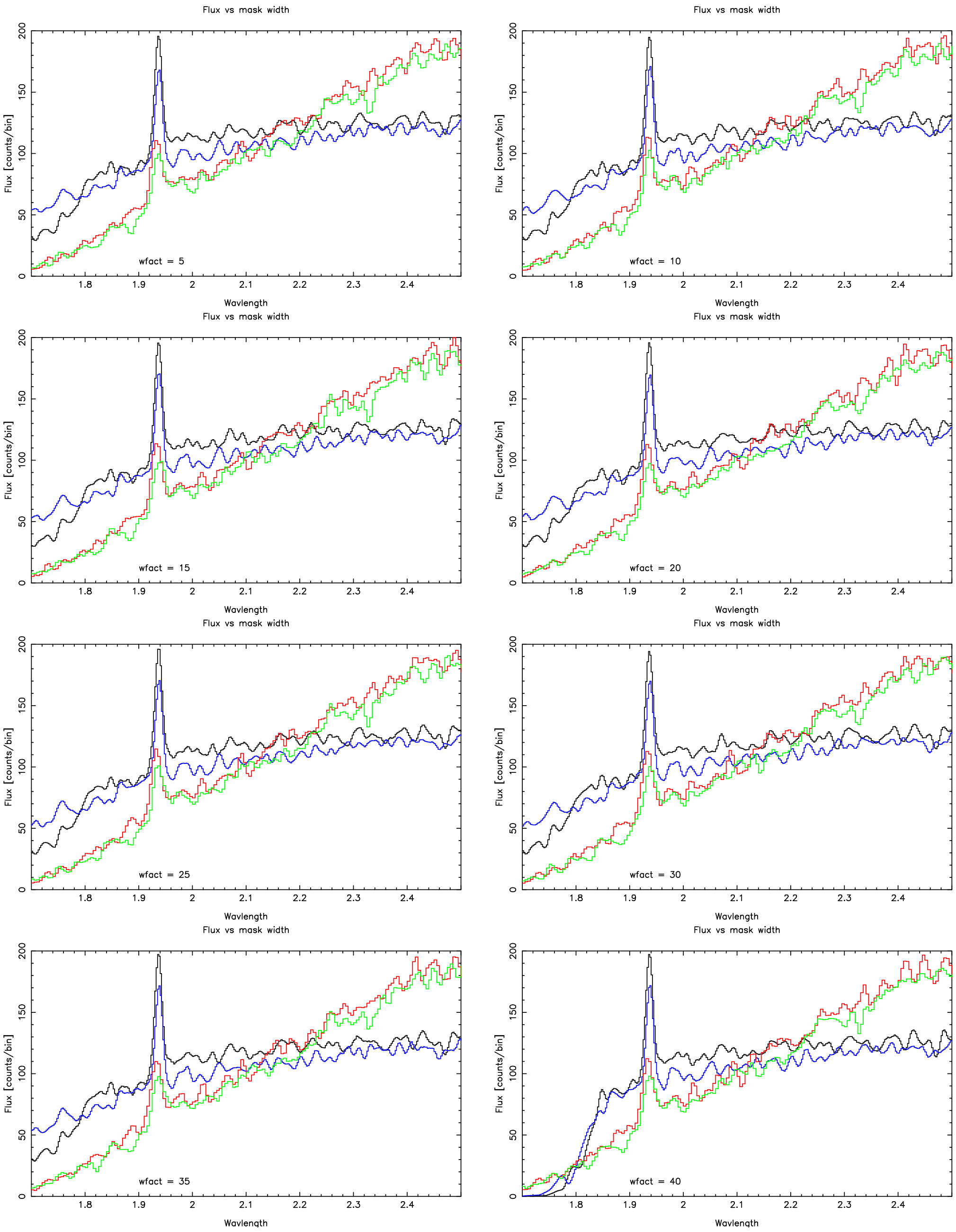

Figure 3: Similar to Figure 2, only showing counts instead of flux.