GHRS Photocathode Flat-Field Maps

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ABSTRACT
The first stage of the GHRS detection system consists of UV light sensitive photocathodes. Output from these two-dimensional photocathodes, in the form of an electron based image is ultimately detected using a one-dimensional digicon-diode array. A narrow slice from the photocathode (containing the illuminated spectrum in normal operation) is projected onto the digicon array via magnetic deflection control. Variations of sensitivity across the photocathodes (granularity) exist in several guises and are discussed in the GHRS Instrument Handbook. A general 2-D flat-field response map, sufficient for calibration is not available. The maps described in this report are sufficient for planning purposes of locating the position of particularly large sensitivity variations. It is the purpose of this report to document binary-format photocathode maps being made available through STEIS.

I. INTRODUCTION
Full two-dimensional flat-fielding of the GHRS photocathodes, sufficient for routine spectral calibrations, are not (and probably never will be) available. Flat-fielding, alternatively to be referred to as removal of photocathode granularity, is performed in practice through acquisition of data using the FP-SPLIT (fixed-pattern) mode of observation. With FP-SPLITS multiple spectra are taken with small offsets along the dispersion direction on the photocathode. Post-processing of these multiple spectra allows for separate solution (not always successful) for the stellar and photocathode granularity spectra. For planning purposes it would be useful to avoid the worst regions of the photocathodes; for this restricted purpose 2-d maps of photocathode response are available.

The GHRS photocathodes can be uniformly illuminated with an onboard monochromatic (about 1400Å) "flat-field" lamp. This is not adequate for providing calibration quality flat-fields for the following reasons:

1. Quantum efficiency variations are sometimes wavelength dependent, and cannot be quantified with monochromatic source illumination.

2. Spectra taken through the SSA illuminate the photocathode with an order only ~50μm tall. The detector diodes are 400μm high, therefore a uniform source illumination averages over a photocathode region some eight times larger than that used for most spectra.

The flat-field lamp derived granularity map will underestimate variations that occur on spatial scales of less than or about 50μm.
II. DERIVATION OF FLAT-FIELD MAPS

Observations of the flat-field lamp were obtained during ground testing. These were acquired by successive readouts after deflecting the electron beam from the photocathode by 200µm (half the diode height). A series of ~100 such observations maps out the full 2-D photocathode face: 100 x 200µm = 2 cm (in y) by 500 x 50µm = 2.5 cm (in x).

I have processed each 500 diode spectrum by:

1. correcting for the known diode-to-diode variations
2. fitting a line to the values along the 500 diodes
3. forming a fractional variation difference by subtracting the linear fit and normalizing to the same linear fit.

The resulting vector has a mean of zero and an r.m.s. of about 0.02 resulting from a combination of real photocathode granularity and sampling noise at about 0.01 for these data.

Figures 1 and 2 show two-dimensional maps of the photocathode responses.

III. USE OF FLAT-FIELD MAPS

As motivation for how these qualitative maps are intended to be used examine the region of Fig. 1 marked G140M. Large glitches exist near x-positions 150 and 470. It would be prudent for observations that might fall at this location on the photocathode to be positioned in x such that spectral features of primary interest do not fall on the known glitches.

Once an observation has been acquired one may examine these photocathode granularity images as a means of making quality judgements about specific spectral features. To allow this it is necessary to know which vertical position on the photocathode corresponds to the observation. The map (Figures 1 and 2) coordinates may be defined as diodes (in x) versus y-deflection (y-def, one unit = 6.25µm), only the latter quantity requires further definition. For examination after the fact the y-def is given in the .d0h header as HRS Pattern Keyword: IYDEF(1). Echelle wavelengths and y-deflection coordinates are listed on the right hand side of Figures 1 and 2. Binary files in .hhh, .hhd format, that may be displayed using IRAF facilities, or easily accessed via unformatted FORTRAN reads, are available via STEIS (anonymous FTP) from the ST Sci as pmapd1r and pmapd2r under

/instrument_news/ghrs_calibration.

Each of the data files is dimensioned 500x448. The second dimension consists of sets of 4 replicated lines such that the full map has effectively 50µm spacing in both directions, even though the real sampling scale was 200µm in y, consisting of 112 independent samples. The y-defs in these data tables are related to the second dimension index (j) as:

\[ ydef_j = 3848 - 8 \cdot j \]

Groups of 4 lines are identical and registration with respect to these maps should not be expected to be better than about 40 deflection steps, or 5 diodes.
To use these maps for planning purposes it is necessary to know the mapping function from wavelength to y-def units; these are indicated roughly on the Figures, and more precisely as follows. The first order gratings have for the SSA:

\[ y_{def} = A + B\lambda + C\lambda^2 \]

where the values A, B, and C for each first order element are given in Table I. For the LSA position subtract 128.0.

The similar equation for the Echelles is altered in the final term to a product of order number, \( m \), and wavelength:

\[ y_{def} = A + B\lambda + C(m\lambda). \]

<table>
<thead>
<tr>
<th>TABLE I. Y-DEFLECTION COEFFICIENTS</th>
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<tbody>
<tr>
<td>MODE</td>
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<tr>
<td>G140M</td>
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<tr>
<td>G160M</td>
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<tr>
<td>G200M</td>
</tr>
<tr>
<td>G270M</td>
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<tr>
<td>G140L</td>
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<tr>
<td>ECH-A</td>
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<tr>
<td>ECH-B</td>
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</tbody>
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3
FIGURE CAPTIONS

Fig. 1. Granularity map for the side 1 photocathode displayed as a gray-scale image. The horizontal axis is specified by diode number. Vertical axis is in y-def units as listed in the right hand column. Notice the coherent diagonal "sleeks" and large scale glitches near the right hand side.

Fig. 2. Granularity map for the side 2 photocathode. No coherent features are present, but localized glitches do exist.