Clocking angle and detector geometry inconsistencies in telD1999-07-23geomN0004.fits

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Summary

LETG+HRC-S and LETG+ACIS-S data processed with the geometry file `telD1999-07-23geomN0004.fits` exhibit quite different residual clocking angles between the axis of dispersed photons and the `tg_r,tg_d(0)` axis. While HRC-S data have a residual angle very close to 0, as shoud be the case, the angle for ACIS-S data is 8.8×10^{-2} deg, which corresponds to a `tg_d` shift of about 0.115 mm at the ends of the ACIS-S array. This suggests that the combination of the LETG clocking angle and the orientation of HRC-S and ACIS-S detectors in `telD1999-07-23geomN0004.fits` is inconsistent by the measured amount of 8.8×10^{-2} deg. These inconsistencies need to be resolved in order to ensure proper application of spectral extraction windows and extraction efficiencies, and to avoid small astrometric errors in off-axis sources.

1 Data Processing and Analysis

Observations analysed were OBSIDs 59 (HZ 43 HRC-S), 331 (PKS 2155-304 HRC-S) and 3669 (PKS 2155-304 ACIS-S).

Data were all uniformly reprocessed using the steps listed in the Appendix. In the first stage, the default CALDB geometry file

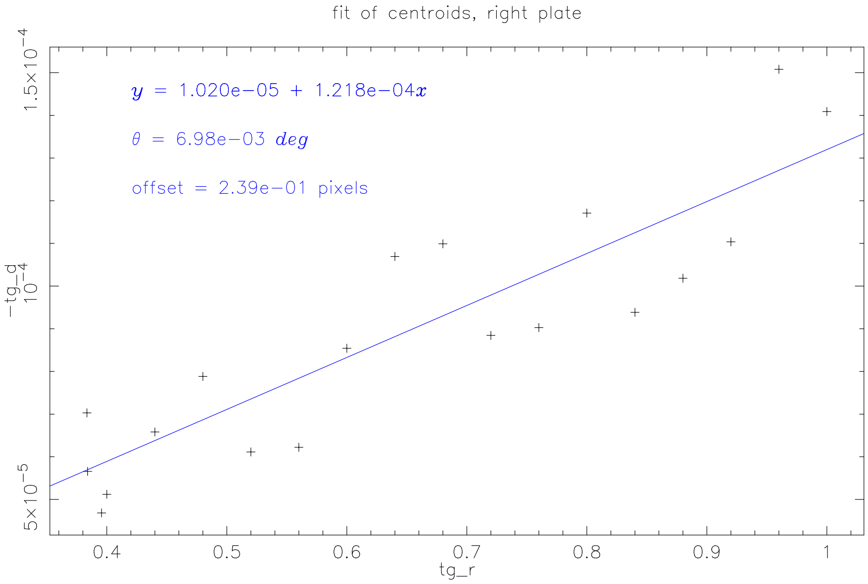
`caldb-2.18/data/chandra/tel/bcf/geom/telD1999-07-23geomN0004.fits`

was used. Residual angles between the true dispersion axis and the `tg_r,tg_d(0)` axis were determined by fitting gaussians to the data in `tg_r,tg_d` coordinates in the `tg_d` direction. In order to obtain a useful signal-to-noise ratio for the fitting process, data were binned in `tg_r` by approximately 0.15 mm and in tg_r by approximately 0.02 mm. In the case of LETG+HRC-S observations, this process was carried out independently for each of the HRC-S plates. The results for the default CALDB geometry file are illustrated in Figures 1 and 2.

Once a residual angle between the dispersion and tg_r,tg_d(0) axes and had been derived based on the data processed in the default way, the geometry file was edited using the FTOOLS task fv in order to change the clocking angle ALPHA to achieve a residual angle of 0. Data were then reprocessed using this geometry file and the residual angle redetermined as described above. In the case of the LETG+HRC-S data, the residual angle was found to be close to 0 and no modification was made. In the case of LETG+ACIS-S, the value of ALPHA 0.07 to -0.018. The results corresponding to this modified value ALPHA are illustrated in Figure 3.

2 Conclusions

There is a significant discrepency between the HRC-S and ACIS-S detector alignments amounting to approximately 0.088 deg in the current CALDB geometry file telD1999-07-23geomN0004.fits. This has been diagnosed through analysis of LETG+HRC-S and LETG+ACIS-S data in tg_r,tg_d coordinates, in which it was found that different grating clocking angles were required to match the true grating dispersion axis with the *Chandra* coordinate systems for HRC-S and ACIS-S detectors. The discrepency amounts to about 0.115 mm in the cross-dispersion direction at dispersion distances of 75 mm (corresponding to the end of the ACIS-S array). This discrepency should be corrected in order to: (i) properly apply spectral extraction windows and extraction efficiencies; (ii) avoid small errors in astrometry of X-ray sources detected off-axis.



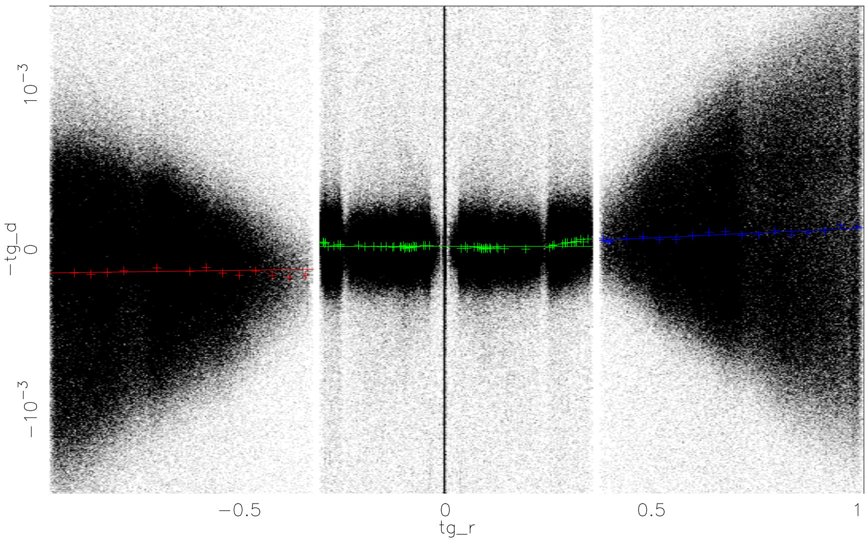


Figure 1: Illustration of the determination of the residual angle between LETG+HRC-S dispersion and tg_r,tg_d axes. The top panel shows the error-weighted linear fit to the dispersed data on the positive order HRC-S outer plate. The lower panel illustrates these linear fits superimposed on scatter plots of the photon events in tg_r,tg_d coordinates. Note the small vertical displacement of the events in the negative order plate relative to the other plates: a correction for this artifact through modification of the HRC-S plate coordinates in the geometry file is currently under test.

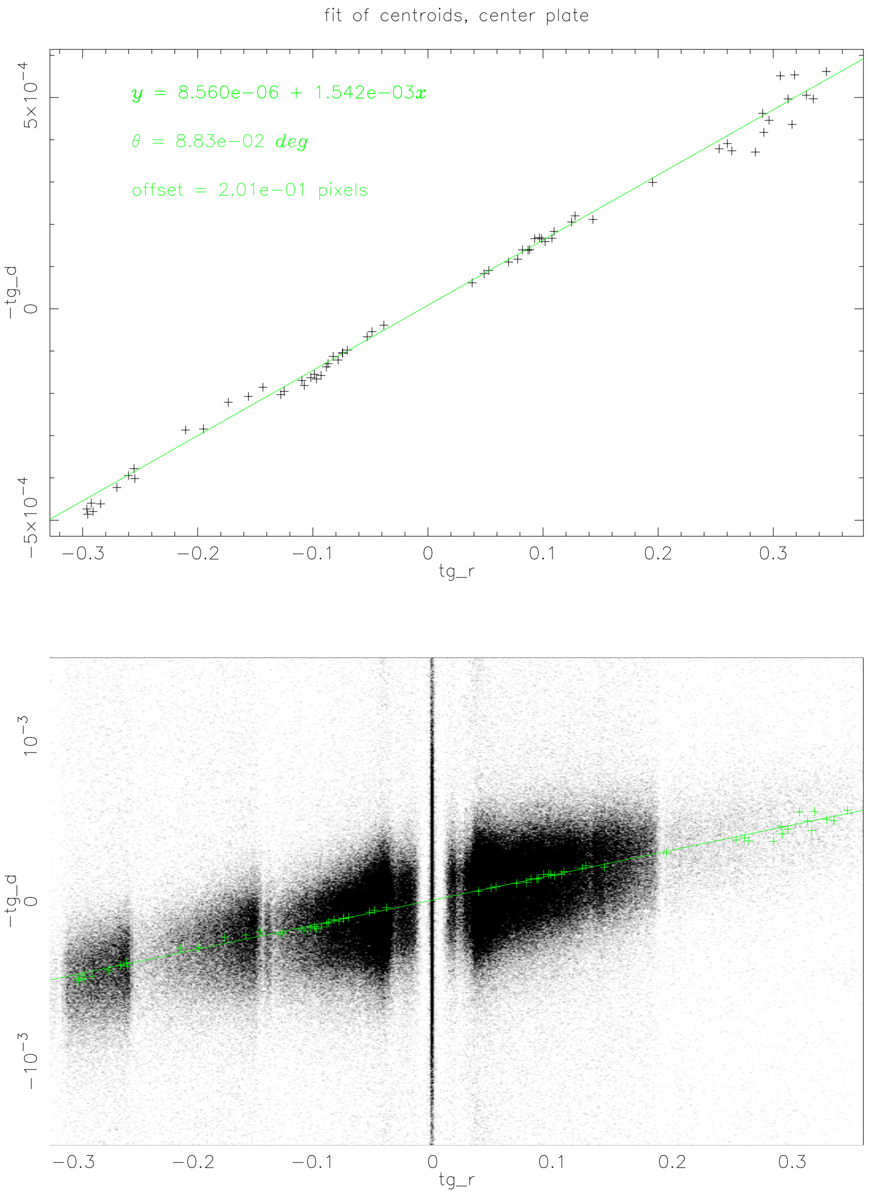


Figure 2: Similar to Figure 1 except for the ACIS-S detector. Note the large residual angle (and the difference in the vertical axis scale of the upper panel as compared to Figure 1).

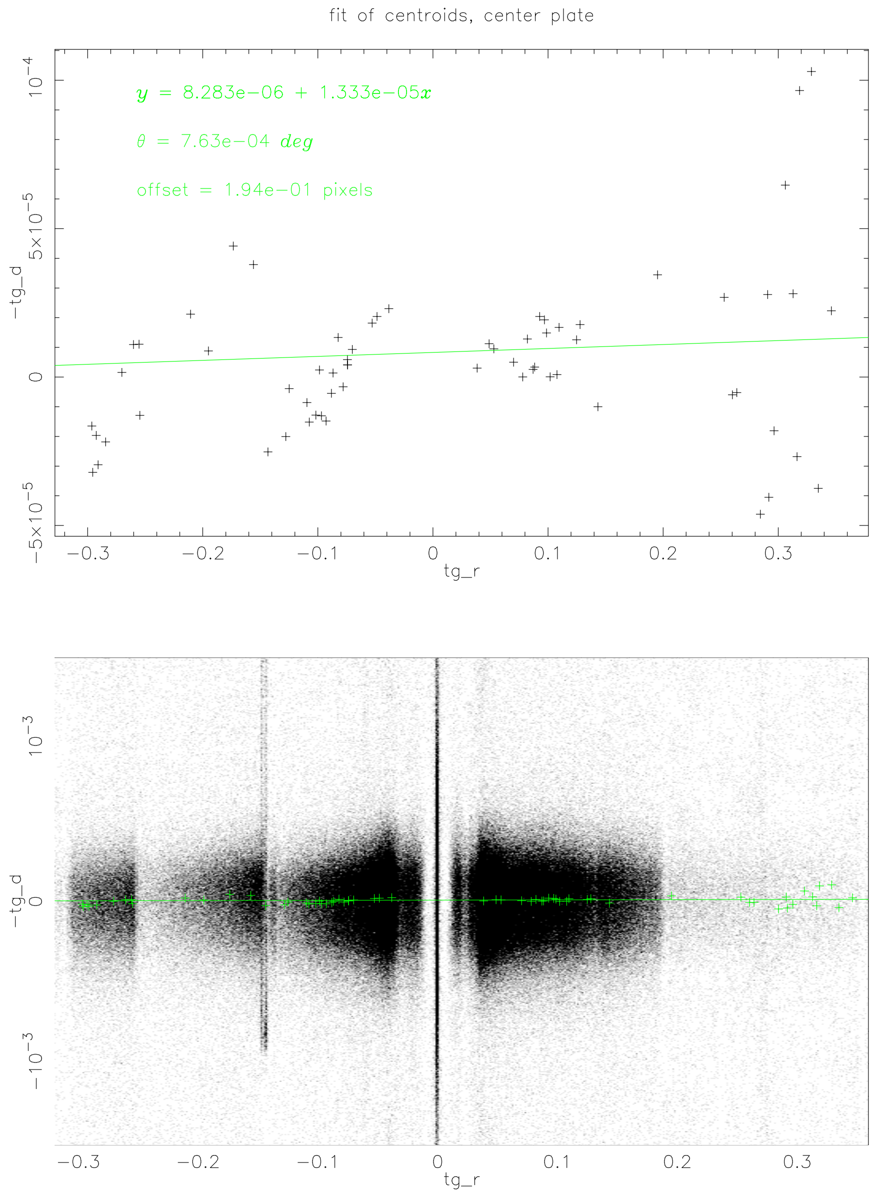


Figure 3: Similar to Figure 2 except for data reprocessed with the value of ALPHA in the geometry fits file changed from 0.07 to −0.018. The residual angle is vertical axis scale of the upper panel as compared to Figure 2).

Appendix: Data processing steps

LETG+ACIS-S

```
punlearn 'acis_process_events'

acis_process_events 'infile=./acisf03669_000N001_evt1.fits'
'outfile=tg_reprocess/acisf03669_000N002_evt1.fits'
'eventdef=)stdlev1' 'doevtgrade=no' 'clobber=yes' 'rand_pha=no'
'stop=none'
'gainfile=/usr/local/ciao-2.3/CALDB/data/chandra/acis/bcf/gain/\
acisD2000-08-12gainN0003.fits'

punlearn 'dmcoords'

dmcoords './acisf03669_000N001_evt1.fits' 'option=cel' 'celfmt=deg'
'ra=329.7167' 'dec=-30.2256' 'verbose=1'

punlearn 'tgdetect'

tgdetect 'infile=tg_reprocess/acisf03669_000N002_evt1.fits'
'outfile=tg_reprocess/acisf03669_000N002_src1a.fits'
'zo_pos_x=4183.73' 'zo_pos_y=4458.76' 'OBI_srclist_file=NONE'
'clobber=yes'

punlearn 'tg_create_mask'

tg_create_mask 'infile=tg_reprocess/acisf03669_000N002_evt1.fits'
'outfile=tg_reprocess/acisf03669_000N002_evt1_L1a.fits'
'input_pos_tab=tg_reprocess/acisf03669_000N002_src1a.fits'
'grating_obs=header_value' 'clobber=yes'

punlearn 'tg_resolve_events'

tg_resolve_events 'infile=tg_reprocess/acisf03669_000N002_evt1.fits'
'outfile=tg_reprocess/acisf03669_000N002_evt1a.fits'
'regionfile=tg_reprocess/acisf03669_000N002_evt1_L1a.fits'
'acaofffile=@tg_reprocess/pcad_asol1.lis' 'eventdef=)stdlev1_ACIS'
'clobber=yes'
```

```
punlearn 'dmcopy'

dmcopy
'tg_reprocess/acisf03669_000N002_evt1a.fits[EVENTS]\
[grade=0,2,3,4,6,status=000000000000xxxx0000000000000000]'
'tg_reprocess/acisf03669_000N002_flt1_evt1a.fits' 'opt=all'
'clobber=yes'

punlearn 'dmcopy'

dmcopy
'tg_reprocess/acisf03669_000N002_flt1_evt1a.fits[EVENTS]\
[@./acisf03669_000N001_flt1.fits.gz]'
'tg_reprocess/acisf03669N002_evt2.fits' 'opt=all' 'clobber=yes'

punlearn 'tgextract'

tgextract 'infile=tg_reprocess/acisf03669N002_evt2.fits'
'outfile=tg_reprocess/acisf03669N002_pha2.fits'
'outfile_type=pha_typeII' 'tg_srcid_list=all'
'tg_part_list=header_value' 'tg_order_list=default' 'ancrfile=none'
'respfile=none' 'clobber=yes'

punlearn 'destreak'

destreak 'infile=tg_reprocess/acisf03669N002_evt2.fits'
'outfile=tg_reprocess/acisf03669N002_dstrk_evt2.fits' 'ccd_id=8'
'clobber=yes'

punlearn 'tgextract'

tgextract 'infile=tg_reprocess/acisf03669N002_dstrk_evt2.fits'
'outfile=tg_reprocess/acisf03669N002_dstrk_pha2.fits'
'outfile_type=pha_typeII' 'tg_srcid_list=all'
'tg_part_list=header_value' 'tg_order_list=default' 'ancrfile=none'
'respfile=none' 'clobber=yes'
```

LETG+HRC-S-S

```
punlearn 'dmmakepar'
```

```
dmmakepar './hrcf00059_000N003_evt1.fits[events]'
'tg_reprocess/hrcf00059_000N004_obs.par' 'clobber=yes'

cp '-f' './hrcf00059_000N003_evt1.fits' 'tg_reprocess/tmp.fits'

punlearn 'dmhedit'

dmhedit 'infile=tg_reprocess/tmp.fits' 'filelist=none' 'operation=add'
'key=RANGELEV' 'value=90'

punlearn 'hrc_process_events'

hrc_process_events 'infile=tg_reprocess/tmp.fits'
'outfile=tg_reprocess/hrcf00059_000N004_evt1.fits'
'obsfile=tg_reprocess/hrcf00059_000N004_obs.par' 'do_amp_sf=yes'
'badpixfile=./hrcf00059_000N003_bpix1.fits.gz' 'eventdef=)stdlev1'
'acaofffile=@tg_reprocess/pcad_asol1.lis'
'alignmentfile=@tg_reprocess/pcad_asol1.lis' 'instrume=hrc-s'
'clobber=yes'

punlearn 'dmcoords'

dmcoords './hrcf00059_000N003_evt1.fits' 'option=cel' 'celfmt=deg'
'ra=199.0921' 'dec=29.0990' 'verbose=1'

punlearn 'tgdetect'

tgdetect 'infile=tg_reprocess/hrcf00059_000N004_evt1.fits'
'outfile=tg_reprocess/hrcf00059_000N004_src1a.fits'
'zo_pos_x=32900.71' 'zo_pos_y=32701.74' 'OBI_srclist_file=NONE'
'clobber=yes'

punlearn 'tg_create_mask'

tg_create_mask 'infile=tg_reprocess/hrcf00059_000N004_evt1.fits'
'outfile=tg_reprocess/hrcf00059_000N004_evt1_L1a.fits'
'input_pos_tab=tg_reprocess/hrcf00059_000N004_src1a.fits'
'grating_obs=header_value' 'clobber=yes'
```

```
punlearn 'tg_resolve_events'

tg_resolve_events 'infile=tg_reprocess/hrcf00059_000N004_evt1.fits'
'outfile=tg_reprocess/hrcf00059_000N004_evt1a.fits'
'regionfile=tg_reprocess/hrcf00059_000N004_evt1_L1a.fits'
'acaofffile=@tg_reprocess/pcad_asol1.lis' 'eventdef=)stdlev1_HRC'
'clobber=yes'

punlearn 'dmcopy'

dmcopy
'tg_reprocess/hrcf00059_000N004_evt1a.fits[EVENTS][pha=0:254,(tg_lam,pi)=\
region(/usr/local/ciao-2.3/CALDB/data/chandra/hrc/bcf/tgmask2/\
letgD1999-07-22pireg075_N0001.fits)]'
'tg_reprocess/hrcf00059_000N004_back_evt1a.fits' 'opt=all'
'clobber=yes'

punlearn 'dmcopy'

dmcopy
'tg_reprocess/hrcf00059_000N004_back_evt1a.fits[EVENTS][@./\
hrcf00059_000N003_std_flt1.fits.gz][cols
!crsu,!crsv,!amp_sf,!av1,!av2,!av3,!au1,!au2,!au3,!raw,!sumamps]'
'tg_reprocess/hrcf00059_000N004_flt1_evt1a.fits' 'opt=all'
'clobber=yes'

punlearn 'dmcopy'

dmcopy
'tg_reprocess/hrcf00059_000N004_flt1_evt1a.fits[EVENTS]\
[status=xxxxxx00xxxx0xxx0000x000x00000xx]'
'tg_reprocess/hrcf00059N004_evt2.fits' 'opt=all' 'clobber=yes'

punlearn 'tgextract'

tgextract 'infile=tg_reprocess/hrcf00059N004_evt2.fits'
'outfile=tg_reprocess/hrcf00059N004_pha2.fits'
'outfile_type=pha_typeII' 'tg_srcid_list=all'
'tg_part_list=header_value' 'inregion_file=CALDB'
'tg_order_list=default' 'ancrfile=none' 'respfile=none' 'clobber=yes'
```

An identical procedure was used for OBSID 331.

2.1 Working directories

For a period of at least 1 month after the date of this *memo*, the data and results can be found in the following directories

```
~rpete/rpete7/flight/data/obsid3669    (ACIS-S)
~rpete/rpete7/flight/data/obsid59      (HRC-S outer plates)
~rpete/rpete7/flight/data/obsid331     (HRC-S central plate)
```