

Chapter 41

Calibrating HSP Data

In This Chapter...

Pipeline Calibration / 41-1
Calibration Switches / 41-2
Calibration Algorithms / 41-4
HSP Calibration Parameter Tables / 41-6

This chapter explains how HSP data are calibrated. Discussions include information about the data format and file types, details about the calibration pipeline, its keyword switches, and necessary reference tables.

41.1 Pipeline Calibration

The HSP pipeline reduction was not used extensively by the HSP team, for a number of reasons. For example, many datasets are too large for IRAF and the ground system simply could not produce a FITS file. Some HSP data were taken at such high speeds that the time series consist of a few ones separated by large runs of zeroes, making the deadtime corrections and dark count subtraction inappropriate. Other calibrations, such as absolute timing of data samples, required working with fundamental data such as daily spacecraft clock calibrations which were not available to the pipeline as quickly as needed.

For these and other reasons, most HSP datasets were reduced in-house at the University of Wisconsin when needed. The following description of the pipeline will give the user an introduction on how raw data are converted into calibrated data.

HSP data are received in the raw and calibrated format. The STSDAS **calhsp** task can be run to recalibrate the raw HSP data. **calhsp** takes the raw GEIS files containing counts in the digital data and digital numbers in the analog data and

converts the data to calibrated data containing counts per second for point source and counts per second per square arcsecond for extended source data. All of the various data formats get calibrated, except for area scan data.

The **calhsp** task performs the following basic calibration processing steps (note that the sequence differs somewhat depending on the data type, see the flowchart on the next page):

- If the data are digital, raw data will be converted to count rate before any corrections are performed.
- Subtract detector dark background.
- Subtract pre-amplifier noise.
- Correct for high voltage factor.
- Correct for relative sensitivity.
- Correct analog data for gain factor (at this step, the DN reading is converted to counts per second).
- Subtract current-to-voltage converter offset from analog data.
- Subtract non-linearity caused by dead time in digital data.
- Convert raw data to count rate.
- For extended targets, divide count rates by the aperture area.

41.2 Calibration Switches

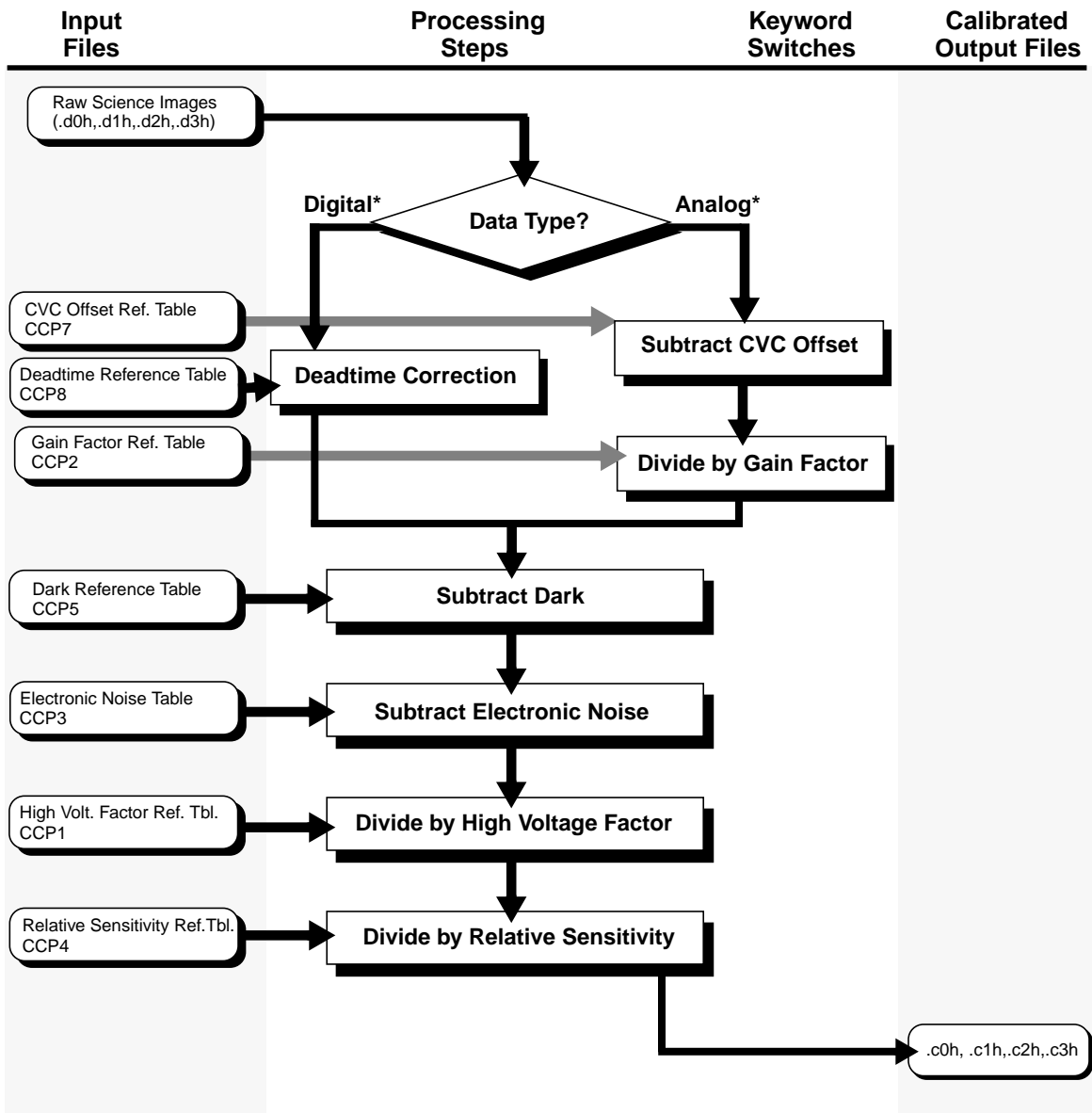
The HSP has three calibration switches: DEADTIME, TRUE_CNT, and TRUE_PHC. The first two apply to digital data, and the third applies to analog data. The calibration switches can be either turned on (set to PERFORM) or turned off (set to OMIT). Digital and analog data are calibrated differently. Digital data can be calibrated by: full calibration (both switches on), deadtime calibration (DEADTIME switch only), true count calibration (TRUE_CNT switch only), and no calibration (both switches off). Because an analog dataset has only one switch, the data are either calibrated or not calibrated. The switches were turned on or off during the reformatting in PODPS.

The following table lists the calibration switches currently used.

Table 41.1: HSP Calibration Switches

Switch	Description
DEADTIME	Correct dead time
TRUE_CNT	Compute true count rates for digital data
TRUE_PHC	Compute true count rates for analog data

Figure 41.1: Pipeline Processing by calhsp



* All **analog** steps are performed when the TRUE_PHC switch is turned on. For **digital** data, dead time correction is turned on using the DEADTIME switch, and all other steps are turned on using the TRUE_PHC switch.

41.3 Calibration Algorithms

Here we describe the algorithms used for each of the calibration steps:

- Correcting for dead time.
- Computing the true count rates for digital data.
- Computing the true count rates for analog data.

41.3.1 Correcting for Dead Time

The raw counts need to be converted into count rate. The following equation is used to find the count rate.

$$x = (\text{raw counts} / \text{sample time})$$

Where x is the observed count rate.

The following equation is used to correct for dead time.

$$y = x / (1 - x t)$$

Where:

- y – is the true count rate after deadtime correction.
- x – is the observed count rate.
- t – is the dead time.

41.3.2 Computing the True Count Rate

True count rates for digital data are corrected by using the first equation for a point source and the second for an extended source.

$$a = (y - \text{pre_amp} - \text{darkrate}) / (\text{highvolt} \times \text{pt_effic})$$

$$b = \frac{(y - \text{pre_amp} - \text{darkrate}) / (\text{highvolt} \times \text{ex_effic})}{\text{aperarea}}$$

Where:

- a – is the final calibrated true count rate for point source.
- b – is the final calibrated true count rate for extended source.
- y – is the true count rate after deadtime correction.

41.3.3 Computing the True Photocurrents

True photocurrents (count rates for analog data) are corrected by the first equation for point sources and the second equation for extended sources.

$$c = \frac{[(n - cvc_offset)/tubegain] - (darkrate + pre_amp)}{highvolt \times pt_effic}$$

$$d = \frac{[(n - cvc_offset)/tubegain] - (darkrate + pre_amp)}{highvolt \times ex_effic \times aperarea}$$

Where:

- c – is the final calibrated true count rate for point source.
- d – is the final calibrated true count rate for extended source.
- n – is the observed digital number.

41.3.4 Calculating Sample Time

The following equation is used to calculate the sample time. The sample time can be found in the data headers under the keyword SAMPTIME.

$$samptime = \frac{int_time + timebias}{1.024 \times 10^6}$$

41.3.5 Calibration Parameter Polynomial

The HSP calibration parameters listed in Table 41.2 are calculated using the following polynomials.

$$\begin{aligned} X = & X0 * [1.0 + a01 * (t - t0) + a02 * (t - t0)^2 + a03 * (t - t0)^3] \\ & + [a10 + a11 * (t - t0) + a12 * (t - t0)^2 + a13 * (t - t0)^3] * (T - T0) \\ & + [a20 + a21 * (t - t0) + a22 * (t - t0)^2 + a23 * (t - t0)^3] * (T - T0)^2 \\ & + [a30 + a31 * (t - t0) + a32 * (t - t0)^2 + a33 * (t - t0)^3] * (T - T0)^3 \end{aligned}$$

Where:

- X – is the calibration parameter value.
- $X0$ – is the base value of the calibration parameter.
- t – is the epoch (time in modified Julian days) of the observation.
- $t0$ – is the base time.
- T – is the temperature.
- $T0$ – is the base temperature.

Table 41.2: HSP Calibration Polynomials

Parameter	Definition
pre_amp	Scaled tube pre-amp contribution
darkrate	Scaled cathode dark rate
highvolt	Scaled high voltage factor
pt_effic	Scaled point source cathode efficiency
ex_effic	Scaled extended source cathode efficiency
cvc_offset	Current-to-voltage converter offset
tubegain	Scaled tube gain factor

41.4 HSP Calibration Parameter Tables

Table 41.3 lists the HSP calibration parameters as found in the Calibration Data Base (CDBS). When using **calhsp**, CDBS values are read into STSDAS binary tables. The tables are required in order to run a complete calibration of the data. These tables are all stored in the HST Archive and can be retrieved from there as described in Chapter 1.

Table 41.3: HSP Reference Tables in CDBS

Relation	Header Keyword	Description
cvccp0r	CCP0	Aperture size
cvccp1r	CCP1	High voltage factor
cvccp2r	CCP2	Gain factor
cvccp3r	CCP3	Pre-amplifier noise
cvccp4r	CCP4	Relative efficiency
cvccp5r	CCP5	Dark signal
cvccp7r	CCP7	CVC offset
cvccp8r	CCP8	Dead time
cvccp9r	CCP9	Dark aperture name