KPO @ AMES DESIGN NOTE

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Title: Format Information for Cadence Pixel Files

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Overview: This document contains selected pages from the Kepler DMC-SOC ICD that describe the format and content of the long-cadence cadence pixel files and their associated pixel mapping reference files. As illustrated by the headers and footers on the subsequent pages in this report, the original release dates and pagination are retained.

Table of Contents*

* The page numbers in the table of contents and the remainder of this document are retained from the original documents.

4. Data Products

4.1 Cadence Science Data

4.1.1 General

4.1.1.1 Purpose

Kepler cadence science data consists of multiple components: target pixels, background pixels, collateral pixels, and ancillary engineering data. These data components will be incorporated into FITS format data files during DMC level 1 processing to form the original science data set. The DMC will automatically transfer the original science data sets to the SOC upon completion of the DMC data processing pipeline. The SOC will return the calibrated cadence data to the DMC for archiving.

4.1.1.2 Composition

Each cadence will generate a number of FITS files that collectively are known as the 'cadence data set'. This cadence data set will contain files that hold the five types of photometer data present in the cadence telemetry: long cadence target data, short cadence target data, background data, long cadence collateral data, and short cadence collateral data. In addition, the cadence data set will contain other files such as a processing history file and an ancillary engineering data file.

During DMC data processing the five types of photometer data from the science telemetry will be separated into five types of FITS cadence data files. The collateral pixels will be included in the cadence data set, but not clutter the target data. Similarly, the background pixels will be used by the SOC to create a background model that will be subtracted from the data during SOC processing. It would be more efficient for the DMC to provide the SOC with a file of extracted background pixels, rather than make them read through all the pixels and separate out the background pixels during SOC processing. Separating the collateral and background pixels into separate files that are included in the cadence data set isolates the long and short cadence target pixels, which are of primary interest, in their own files. Collateral and background pixels are provided in the cadence data set.

The cadence science data files are FITS binary tables with 84 extensions, one extension for each module/output (channel). The data in the binary table are contained in three fields: one for the raw pixel value, one for the calibrated pixel value, and one for the calibration uncertainty. The raw pixel values are 32-bit integers and the calibrated pixel values and calibration uncertainty are 32-bit floating-point numbers.

Long and short cadence target data

Both the long and short cadence target data files will hold a table that contains raw and calibrated pixel values each stored in 32 bits. There will be 30 short cadence target data files and 1 long cadence target data file in the cadence data set. Short cadence files do not contain background pixels. **Background data**

The background data files have the same format as the long and short cadence target data files. Background pixels are only taken at long cadence with 4500 pixels in each of the 84 channels.

Long cadence collateral data

Each long cadence collateral data channel contains: 1070 black level pixels, 1100 masked pixels, and 1100 virtual smear pixels. All three types of collateral data will be contained in a single file. Long cadence collateral data are defined as s/c configuration parameters and have no corresponding target or aperture ids for inclusion in a pixel mapping reference file (see section 4.6.1).

Short cadence collateral data

Pixels selected for the short cadence collateral data are based on a projection of the target aperture onto the collateral pixel rows and columns. Hence, because of the relatively small number of targets per channel in short cadence data, not all collateral data in a channel are read out. Each target contains on average: 9 black pixels, 9 masked smear pixels, 9 virtual smear pixels, 1 black-masked pixel, and 1 black-smear pixel.

Data headers:

Kepler science data will use FITS format in order to comply with astronomical data standards.

Data headers will use standard FITS keywords to formulate the data definition. In addition Kepler data will attempt to comply with all FITS recommended keyword usage current at the time of header design.

FITS headers for cadence science data are specified in Appendix A. There will be a primary header unit that contains keywords inherited by all subsequent extension data units. The primary header unit will not contain a data array.

Each file that has the photometer as the data source will contain 84 table extensions, one extension for each of the 84 CCD channels.

Primary header keywords will specify data processing inputs, data quality, observational modes (long cadence, short cadence, FFI), proposal information (GO, PI), etc.

Keyword definitions are to be maintained in a database 'dictionary' that is part of the archive catalog and available through the archive interface. The keyword dictionary will contain the following information for each keyword:

- Keyword name
- Default value
- Possible values
- Units
- Datatype
- Keyword source
- Archive science catalog field
- Short comment for header
- Long description
- Header position

As a FITS header generation strategy, all header keywords should be inserted when the FITS files are created at DMC. FITS keywords are added in blocks of 2880 bytes. Since each 'card image' is 80 bytes, there are 36 keywords per block. Adding a keyword that overflows a block requires re-writing the entire FITS file. DMC and SOC processing of cadence data is more efficient if all keywords are present when FITS files are created at DMC. Keyword values are populated as processing proceeds through the DMC and SOC.

History files:

History files provide a record of the steps, along with associated comments and warnings, taken during the processing of a long cadence, short cadence, or FFI data set. History files are generated in printable ASCII text format with line breaks during data processing at the DMC and the SOC. The DMC produces the content in FFI history files. The DMC produces content in the cadence pixel files, then the SOC appends to these files during SOC processing.

4.1.1.3 Source

DMC data processing pipeline

4.1.1.4 Recipient

SOC data processing pipeline

4.1.1.5 Interface type

Automatic file transfer at the completion of DMC pipeline processing.

4.1.1.6 Priority

Cadence data are processed at lower priority than FFI data.

4.1.1.7 Naming Convention

The science data set file name will consist of a base file name, which is assigned by the MOC (MOC-DMC ICD, BATC 2207600), a suffix and an extension. The base file name remains constant through the ground segment processing, uniquely identifies the data cadence, and is the same for all science data products. The exception is for short cadence baselines, which are assigned the base file name of the corresponding long cadence by the MOC. The DMC renames the file to indicate the short cadence end time for the baseline. The base file name is defined as follows:

kplr<TIMESTAMP> where the variable fields are defined in Table 4-2. All alphabetic characters in the file names shall be lowercase.

Table 4-1 – Science File Timestamp Convention

Field	Description
TIMESTAMP	UTC time associated with the end of enclosed cadence data in YYYYDDDHHMMSS format where YYYY = 4 digit year DDD = 3 digit day of year (001-366) HH = 2 digit hour (00-23) MM = 2 digit minute (00-59) SS = 2 digit seconds (00-59)

At the DMC, the filename will also contain a suffix that will identify the pixel type of the data contained within the file. The specific suffixes are summarized in Table 4-1 Original and calibrated cadence data will be stored as separate binary table columns in the same file.

Although each pixel type will be sorted into a separate file, all long cadence files with the same data set name will be transferred as a complete long cadence data set. A complete short cadence data set will contain all of the relevant short cadence files in the corresponding long cadence time interval.

For all FITS files, a file extension of .fits is required. Hence, the science data set has a filename of the form: rootname_suffix.fits. See Appendix H for an explanation of the DMC file naming convention.

File naming example for a cadence data set:

- Data set name: kplr2010236042230
  - kplr2010236042230_lcs-targ.fits
  - kplr2010236042230_lcs-col.fits
  - kplr2010236042230_lcs-bkg.fits
  - kplr2010236042230_lcs-crct.fits
  - kplr2010236042230_lcs-crcc.fits
  - kplr2010236042230_lcs-history.txt
  - kplr2010236042230_scs-targ.fits
  - kplr2010236042230_scs-col.fits
  - kplr2010236042230_scs-crct.fits
  - kplr2010236042230_scs-crcc.fits
  - kplr2010236042230_scs-set-history.txt
  - kplr2010236042230_anc-eng.fits

4.1.2 Original Cadence Data Set

4.1.2.1 Purpose

The original cadence data set is generated to contain the uncalibrated pixel values and also includes collateral and ancillary engineering data.

4.1.2.2 Composition

Files:

An original science data set is a set of FITS files containing uncalibrated (level 1b) science data. Table 4-3 lists the possible files in an original data set.

Table 4-2 – Original Cadence Data files

Data type	Cadence	File suffix
Long cadence target data – original	30 min	lcs-targ
Long cadence collateral data – original	30 min	lcs-col
Long cadence processing history file	30 min	lcs-history

Background pixels – original	30 min	lcs-bkg
Short cadence target data – original	1 min	scs-targ
Short cadence collateral data – original	1 min	scs-col
Short cadence processing history file	30 X 1 min	scs-history
Ancillary engineering data	30 min	anc-eng
Ancillary engineering processing history file	30 min	anc-history

Data headers:

The original science data headers are specified in Appendix A.

Specific keywords –

LC_INTER/SC_INTER – provide the number of long cadence and short cadence intervals since the start of data collection in ascending. These interval keywords continue to increment even when data are not collected, such as during monthly contacts or quarterly rolls. In order for these keywords to get populated with the proper value, all cadences must begin on a cadence boundary as measured from the start of science data collection to within a tolerance of 2 seconds.

LC_COUNT/SC_COUNT – provide the number of long cadences and short cadences where data were accumulated in ascending order. Cadence counting begins at launch (commissioning cadences are counted).

DCT_PURP – The DCT_PUPR keyword will be used to convey spacecraft motion information from the MOC to the SOC through the DMC. During a KARF, which details a particular activity, a text field of “MOTION” or “NOMOTION” will be used in the DCT_PURP keyword value to indicate whether or not he spacecraft was in motion during data accumulation. For example, during KARF-39, the DCT_PURP keyword could have a value of “KARF039 NOMOTION” or “KARF039 MOTION”.

Data array:

Original data will be formatted as 32 bit integers (I*4) to hold the 23 bit data values. Original pixel values are contained in FITS binary table extensions, one extension per module/output. The data are represented as 32-bit two's complement binary integers as indicated by the TFORM1 = 1J keyword value in the data table definition.

In the event of a gap in the cadence data, the DMC will use a data fill value of 0xFFFFFFFF for the missing pixels. For original data represented as 32-bit two's complement binary integers, the value will be -1 in the data table.

4.6 *Pixel Mapping Reference Files*

The DMC uses reference files in data processing and calibration. Although these files will change periodically, they are applied to many cadences. Reference files are available through the DMC archive.

4.6.1 Pixel Mapping Reference File

4.6.1.1 Purpose

Each original and calibrated data value is associated with a pixel is a specific module/output (channel). Position information for a given pixel remains the same during the time a set of target and aperture definitions are in effect. If the pixel position information were included in the cadence data files, the size of these files would increase by a factor of 2-4. Cadence data volumes in the archive or user disks would be dominated by repetitive information.

To mitigate this problem, cadence data are separated into two files for each data type: a 'pixel data file' that contains the photometer pixel values (see section 4.1) and a 'pixel mapping reference file' that contains the target and aperture definition information associated with each pixel. Separating the target and aperture definition information from the pixel data files saves a significant amount of disk space and bandwidth for the cadence data sets.

A set of pixel mapping reference files maps the science data pixels to their corresponding target and aperture definition. There will be a new pixel mapping reference file generated by the DMC with each new delivery of a target and/or aperture definition, expected to occur on time scales of 1-3 months.

4.6.1.2 Composition

The cadence data pixel files are FITS binary tables with 84 extensions as described in section 4.1, one FITS extension for each module/output. There is a strict one-to-one correspondence between the table rows in the pixel mapping reference file and the pixel data files. If the pixel mapping reference file and the pixel data file are aligned side-by-side, they would form a complete table of individual pixel parameters and data values.

Table 4-7 – Cadence data table fields

	pixel mapping reference file						**pixel data file**	
data type	**target id**	**aperture id**	**row**	**column**	**pixel type***	**row or column offset**	**raw pixel value**	**calibrated pixel value**
	4 bytes	2 bytes	2 bytes	2 bytes	1 byte	2 bytes	4 bytes	4 bytes
long cadence target	x	x	x	x			x	x
short cadence target	x	x	x	x			x	x
background	x	x	x	x			x	x
long cadence collateral					x	x	x	x
short cadence collateral	x				x	x	x	x

*See Table 4-9

The fields present in the pixel mapping reference are different for each type of cadence data. The allocation of possible cadence data fields to the pixel mapping reference file and pixel data file is shown in Table 4-8 where the fields used for each data type are indicated by an 'x'. For example, in the case of long cadence target data, the pixel mapping reference file would be a FITS binary table with 84 extensions. The table would contain the fields for the row and column position of a pixel, the target id, and the aperture id.

Table 4-8 – Collateral pixel types

Pixel type ID	Pixel type
1	BlackLevel
2	Masked
3	VirtualSmear
4	BlackMasked
5	BlackVirtual

Cadence target data

The long cadence pixel mapping reference file contains one row for each target pixel that corresponds exactly with a long cadence pixel data file. Similarly, the short cadence pixel mapping reference file contains one row for each short cadence target pixel that corresponds exactly with a short cadence pixel data file.

Background data

The background pixel mapping reference file contains one row for each background pixel (4500 pixels per channel x 84 channels). Background pixels have both a target and aperture id that will be included in the background pixel mapping reference file. A background pixel mapping reference file does not save significant space, but provides consistency with the pixel data files.

Long cadence collateral data

The long cadence collateral pixel mapping reference file contains a field for the pixel offset along a row or column and the sentinel value of the collateral data type: black, masked smear, or virtual smear. There will be one row in the table for each collateral data pixel. Information contained in the long cadence collateral pixel mapping file can be gleaned from the header keywords and their values, but the file is provided for completeness and consistency with the other cadence data types.

Short cadence collateral data

The short cadence collateral pixel mapping reference file contains a field for the pixel offset along a row or column and a sentinel value for the collateral data type: black, masked smear, virtual smear, black-masked, or black-smear. There is one row in the table for each unique collateral data pixel.

Table 4-9 – Pixel data file to pixel mapping reference file keywords

Data file	**Pixel Mapping Reference file**	**Mapping file header keyword**
LC target data file	LC pixel mapping file	LCTPMTAB
SC target data file	SC pixel mapping file	SCTPMTAB
Background data file	Background pixel mapping file	BKGPMTAB
LC collateral data file	LC collateral pixel mapping file	LCCPMTAB
SC collateral data file	SC collateral pixel mapping file	SCCPMTAB

A FITS keyword in the primary header of the pixel data file points to the appropriate pixel mapping reference files for each cadence data set as listed in Table 4-10. There will be one pixel mapping reference file for each type of cadence data, and the header of each pixel data file will list for reference the entire set of associated pixel mapping reference files for that cadence. The Science Data Collection Configuration ID (section 4.5) will point to a specific target definition, which will in turn define the appropriate pixel mapping reference file. All pixel mapping reference files generated over time will remain on-line in the data processing environment and will be retrievable from the Kepler data archive.

4.6.1.3 Source

DMC pipeline processing

4.6.1.4 Recipient

SOC

4.6.1.5 Interface type

Automatic file transfer at the completion of DMC pipeline processing.

4.6.1.6 Naming Convention

The pixel mapping reference file naming convention is presented in Table 4-11.

Table 4-10 – Pixel Mapping Reference File names

Pixel Mapping Reference file	File name
LC pixel mapping file	kplr<yyyydddhhmmss>-<TDid>-<ADid>_lcm.fits
SC pixel mapping file	kplr<yyyydddhhmmss>-<TDid>-<ADid>_scm.fits
Background pixel mapping file	kplr<yyyydddhhmmss>-<TDid>-<ADid>_bgm.fits
LC collateral pixel mapping file	kplr<yyyydddhhmmss>-<TDid>-<ADid>_lcc.fits
SC collateral pixel mapping file	kplr<yyyydddhhmmss>-<TDid>-<ADid>_scc.fits

Appendix A. Original and Calibrated Science Data FITS headers

A.1.1: Cadence Pixel Data header

```
keyword = <default_val> comment                             datatype option_flg
(option_flg: Y = optional; N = required; C = constant,
                                                   i.e. default_val overrides code)

SIMPLE   = T                data conform to FITS standard                   L1   C
BITPIX   = 0                bits per data value                             I2   N
NAXIS    = 0                number of data array dimensions                 I2   N
EXTEND   = T                File may contain standard extensions            L1   N
NEXTEND  =                  Number of standard extensions                   I2   N

TELESCOP= Kepler            telescope used to acquire data                  C03 C
INSTRUME= CCD               identifier for instrument used to acquire data  C06 N
EQUINOX = 2000.0            equinox of celestial coord. system              R4   C

DATE     =                  date this file was written (yyyy-mm-dd)         C10 N
ORIGIN   = STScI            institution responsible for creating FITS file  C18 N
FILENAME=                   name of file                                    C39 N
DATSETNM=                   data set name of the file                       C34 N

         / Data content

DATATYPE= long cadence      data type: short cadence, long cadence, FFI     C13 N
PIXELTYP= target            pixel type: target, background, collateral      C10 N
LC_INTER=                   number of long cadence intervals                I4   N
LC_COUNT=                   number of long cadences executed                I4   N
SC_INTER=                   number of short cadence intervals               I4   Y
SC_COUNT=                   number of short cadences executed               I4   Y

         / Data times

DATE-OBS=                   UT date of start of observation (yyyy-mm-dd)    C10 N
TIME-OBS=                   UT time of start of observation (hh:mm:ss)      C08 N
STARTIME=                   MJD start time of data                          R8   N
END_TIME=                   MJD end time of data                            R8   N
FRAMELEN=                   duration of observation (end - start) in seconds R8  N
MID_TIME=                   central time used in velocity aberration corr.  R8   N
LASTROLL=                   MJD time of last roll maneuver                  R8   N
DATAEND =                   MJD stop time of data taking prior to last roll R8   N
DATASTRT=                   MJD start time of data taking after last roll   R8   N

         / Pointing information

RA-XAXIS=                   s/c -x axis Right Ascension (deg.)              R4   N
DEC-XAXS=                   s/c -x axis declination (deg.)                  R4   N
ROLLANGL=                   s/c roll angle (deg. from N.)                   R4   N
SUNANGLE=                   angle between s/c -x axis and center of sun     R4   N
MOONANGL=                   angle between s/c -x axis and center of moon    R4   N
EARTHANG=                   angle between s/c -x axis and center of Earth   R4   N

         / Science data processing parameters

PROCTIME=                   DMC processing time (MJD)                       C20 N
```

```
DMC_VER =                DMC software version                             C10 N
ANC_ENG =                ancillary engineering data included in dataset?  L1  N

         / Photometer parameters

INT_TIME= 2.5            integration time (variable between 2.5 to 8 sec) R4  N
READ_OUT= 0.5            read out time                                    R4  N
NUM_LONG= 600            number of integrations in a long cadence frame   I2  N
NUMSHORT= 20             number of integrations in a short cadence frame  I2  N
SHRTLONG= 30             number of short cadences per long cadence        I2  N
NUM_FFI = 300            number of integrations in Full Frame Image       I2  N
OPERTEMP=                photometer operating temperature                 R4  N
FOCUSPOS=                focus position (mm)                              R4  N

         / Collateral Pixel Definition

NROW_MSK= 20             total number of rows in the masked region        I2  N
FMASKROW= 0              first masked row used as collateral data         I2  N
LMASKROW= 19             last masked row used as collateral data          I2  N
NROW_VIR= 26             total number of virtual rows                     I2  N
FVIRTROW= 1044           first virtual row used as collateral data        I2  N
LVIRTROW= 1069           last virtual row used as collateral data         I2  N
NCOL_OVR= 32             total number of columns in the overscan region   I2  N
FSREGCOL= 0              first serial register column in collateral data  I2  N
LSREGCOL= 11             last serial register column in collateral data   I2  N
FVIRTCOL= 1112           first virtual column used as collateral data     I2  N
LVIRTCOL= 1131           last virtual column used as collateral data      I2  N

         / Derived photometer parameters

TINTTIME=                total integration time of all readouts in cadence R4  N
TREADTIM=                total readout time of all readouts in cadence    R4  N

         / On-board compression parameters

REQUANT = T              data requantized for downlink (T/F)              L1  N
HUFFMAN = T              data entropic compressed for downlink (T/F)      L1  N
BASELINE= F              data originated as baseline image (T/F)          L1  N
BASENAME=                rootname of baseline image                       C19 N
BASERCON= F              baseline created from residual baseline image    L1  N
RBASNAME=                rootname of residual baseline image              C19 N

         / On-board compression statistics

BITSPIXC=                actual avg number of bits per compressed pixel   R4  N
TBITSPXC=                theoretical avg num of bits per compressed pixel R4  N

         / SPICE kernel files

SPC-LSK =                file name of leap second kernel                  C21 N
SPC-SCLK=                file name of spacecraft clock kernel             C21 N
SPC-SPK =                file name of Kepler spacecraft ephemeris kernel  C21 N
SPC-SPK2=                file name of NAIF planet ephemeris kernel        C21 N

         / Science Data Collection Configuration

LCTRGDEF=                long cadence target definition identifier        I2  N
```

```
SCTRGDEF=               short cadence target definition identifier      I2   N
BKTRGDEF=               background definition identifier                I2   N
TARGAPER=               target aperture definition identifier           I2   N
BKG_APER=               background aperture definition identifier       I2   N
COMPTABL=               compression tables identifier                   I2   N

         / Pixel mapping reference files

LCTPMTAB= N/A           long cadence target pixel mapping table         C18 N
SCTPMTAB= N/A           short cadence target pixel mapping table        C18 N
BKGPMTAB= N/A           background pixel mapping table                  C18 N
LCCPMTAB= N/A           long cadence collateral pixel mapping table     C18 N
SCCPMTAB= N/A           short cadence collateral pixel mapping table    C18 N

         / Calibration tables and switches

USEBLPAR= F             use current black-level slope and intercept     L1   N
BLKCRCOR= PERFORM       search for cosmic rays during black-level fit   C08 N
BIASCORR= PERFORM       bias correction (perform, omit, complete)       C08 N
LINCORR = PERFORM       linearity correction (perform, complete, omit)  C08 N
LINTAB  = N/A           linearity table name                            C18 N
TDSENTAB= N/A           time dependent sensitivity table name           C18 N
DARKCORR= PERFORM       calculate dark current (perform, omit, complete) C08 N
SMEARCOR= PERFORM       smear correction (perform, omit, complete)      C08 N
FLATCORR= PERFORM       flat field correction (perform, omit, complete) C08 N
FLATFILE= N/A           flat field parameters table name                C18 N

         / Black-level fit input parameters for cosmic ray correction

FMSKRBLK= 6             first masked row in black-level fit             I2   N
LMSKRBLK= 13            last masked row in black-level fit              I2   N
FVRTRBLK= 1051          first virtual row in black-level fit            I2   N
LVRTRBLK= 1058          last virtual row in black-level fit             I2   N
FSRC_BLK= 2             first serial register column in black-level fit I2   N
LSRC_BLK= 9             last serial register column in black-level fit  I2   N
FVRTCBLK= 1121          first virtual column in black-level fit         I2   N
LVRTCBLK= 1128          last virtual column in black-level fit          I2   N
NCOL_BLK= 16            total number of columns in black-level fit      I2   N
N_BLKMSK=               number of pixels in black and masked regions    I2   N
N_BLKVIR=               number of pixels in black and virtual regions   I2   N

         / Cosmic Ray Correction Algorithm Parameters (need input from SOC)


END


XTENSION= BINTABLE      extension type                                  C08 N
BITPIX  = 8             bits per data value                             I2   N
NAXIS   = 2             number of data array dimensions                 I2   N
NAXIS1  =               length of first data axis                       I4   Y
NAXIS2  =               length of second data axis                      I4   Y
PCOUNT  = 0             number of parameter bytes following data table  I2   C
GCOUNT  = 1             number of groups                                I2   C
TFIELDS =               number of fields in each table row              I2   Y
INHERIT = T             inherit the primary header                      L1   C
EXTNAME =               extension name                                  C08 N
```

```
EXTVER   =                  extension version number                      I2   N

         / Extension parameters

CHANNEL  =                  channel number (1-84)                         I2   N
MODULE   =                  module number (2-24, except 5 and 21)         I2   N
OUTPUT   =                  module output number (1-4)                    I2   N

         / World Coordinate System and related parameters

WCSAXES  = 2                number of World Coordinate System axes (RA & Dec) I2   N
CRPIX1   = 551              x-coordinate of reference pixel               R8   N
CRPIX2   = 513              y-coordinate of reference pixel               R8   N
CRVAL1   =                  right ascension (degrees) at reference pixel  R8   N
CRVAL2   =                  declination (degrees) at reference pixel      R8   N
CTYPE1   = RA---TAN         the coordinate type for the first axis        C08  N
CTYPE2   = DEC--TAN         the coordinate type for the second axis       C08  N
CDELT1   = -0.0011055556    degrees per pixel, increasing eastward        R8   N
CDELT2   = 0.0011055556     degrees per pixel, increasing northward       R8   N
PC1_1    = 1.0              linear transformation matrix element cos(theta)  R8   N
PC1_2    = 0.0              linear transformation matrix element -sin(theta) R8   N
PC2_1    = 0.0              linear transformation matrix element sin(theta)  R8   N
PC2_2    = 1.0              linear transformation matrix element cos(theta)  R8   N

         / Velocity Aberration Corrections

DVA_RA   =                  velocity aberration correction RA offset (rad)   R8   N
DVA_DEC  =                  velocity aberration correction Dec offset (rad)  R8   N
VA_SCALE=                   velocity aberration scale factor              R8   N

         / Barycentric Times

BARYDELT=                   calculated Barycentric time correction from UTC  R8   N
BSTRTIME=                   Solar System Barycentric start time of cadence   R8   N
BSTPTIME=                   Solar System Barycentric stop time of cadence    R8   N

         / Parameters from black-level fit

BLKMSKSM=                   scalar sum of black values in masked region   R4   N
BLKVIRSM=                   scalar sum of black values in virtual rows    R4   N
BLKMSKAV=                   scalar average of black values in masked region  R4   N
BLKVIRAV=                   scalar average of black values in virtual region R4   N
BLKSLOPE=                   slope of the linear fit for black level       R8   N
BLKINTER=                   intercept of linear fit for black level       R8   N
BLKVAR   =                  variance of deviations of the intercept       R8   N
BLKVAR_I=                   normalized variance of the intercept          R8   N
BLKVAR_S=                   normalized variance of the slope              R8   N
BLKCOVAR=                   normalized covariance of slope and intercept  R8   N

         / Module/output Calibration Parameters

GAIN     = 1.0              channel gain in e-/ADU                        R8   N
READONSE=                   channel readout noise                         R8   N

         / Data table definition

TTYPE1   = orig_value       name of field 1: original data value          C14  C
```

```
TFORM1   = 1J            format in which field 1 is coded: one 32 bit int  C08 C
TDISP1   = I10           format in which field 1 is displayed              C08 C
TUNIT1   = DN            units of data value in field 1                    C08 C
TTYPE2   = cal_value     name of field 2: calibrated data value            C14 C
TFORM2   = 1E            format in which field 2 is coded: sp floating pt  C08 C
TDISP2   = F16.3         format in which field 2 is displayed              C08 C
TUNIT2   = ADU           units of data value in field 2                    C08 C

END
```

Appendix B. Reference File FITS headers

B.1.1: Target and Background Pixel Mapping Reference File header

```
keyword = <default_val> comment                                 datatype option_flg
(option_flg: Y = optional; N = required; C = constant,
                                                   i.e. default_val overrides code)

SIMPLE   = T                data conform to FITS standard                   L1   C
BITPIX   = 0                bits per data value                             I2   N
NAXIS    = 0                number of data array dimensions                 I2   N
EXTEND   = T                File may contain standard extensions            L1   N
NEXTEND  =                  Number of standard extensions                   I2   N

TELESCOP= Kepler            telescope used to acquire data                  C03 C
INSTRUME= CCD               identifier for instrument used to acquire data  C06 N
EQUINOX  = 2000.0           equinox of celestial coord. system              R4   C

DATE     =                  date this file was written (yyyy-mm-dd)         C10 N
ORIGIN   = STScI            institution responsible for creating FITS file  C18 N
FILENAME=                   name of file                                    C39 N
DATSETNM=                   data set name of the file                       C34 N

         / Data content

DATATYPE= long cadence      data type: short cadence, long cadence, FFI     C13 N
PIXELTYP= target            pixel type: target, background, collateral      C10 N
USE_TIME=                   UT time to start use of this reference file     C19 N

         / Science Data Collection Configuration

LCTRGDEF=                   long cadence target definition identifier       I2   N
SCTRGDEF=                   short cadence target definition identifier      I2   N
BKTRGDEF=                   background definition identifier                I2   N
TARGAPER=                   target aperture definition identifier           I2   N
BKG_APER=                   background aperture definition identifier       I2   N
COMPTABL=                   compression tables identifier                   I2   N

END


XTENSION= BINTABLE          extension type                                  C08 N
BITPIX   = 8                bits per data value                             I2   N
NAXIS    = 2                number of data array dimensions                 I2   N
NAXIS1   =                  length of first data axis                       I4   Y
NAXIS2   =                  length of second data axis                      I4   Y
PCOUNT   = 0                number of parameter bytes following data table  I2   C
GCOUNT   = 1                number of groups                                I2   C
TFIELDS  =                  number of fields in each table row              I2   Y
INHERIT  = T                inherit the primary header                      L1   C
EXTNAME  =                  extension name                                  C08 N
EXTVER   =                  extension version number                        I2   N

         / Extension parameters

CHANNEL  =                  channel number (1-84)                           I2   N
MODULE   =                  module number (2-24, except 5 and 21)           I2   N
```

```
OUTPUT  =                  module output number (1-4)                     I2  N

      / Data table definition

TTYPE1  = row              name of field 1: row pixel location (0-1069)      C08 C
TFORM1  = 1I               format in which field 1 is coded: one 16 bit int  C08 C
TDISP1  = I4.1             format in which field 1 is displayed              C08 C
TUNIT1  = pixels           units of data value in field 1                    C08 C
TTYPE2  = column           name of field 2: column pixel location (0-1131)   C08 C
TFORM2  = 1I               format in which field 2 is coded: one 16 bit int  C08 C
TDISP2  = I4.1             format in which field 2 is displayed              C08 C
TUNIT2  = pixels           units of data value in field 2                    C08 C
TTYPE3  = target_id        name of field 3: target id                        C14 C
TFORM3  = 1J               format in which field 3 is coded: one 32 bit int  C08 C
TDISP3  = I10              format in which field 3 is displayed              C08 C
TTYPE4  = aperture_id      name of field 4: aperture id                      C14 C
TFORM4  = 1I               format in which field 4 is coded: one 16 bit int  C08 C
TDISP4  = I5               format in which field 4 is displayed              C08 C
END
```

B.1.2: Collateral Pixel Mapping Reference File header

```
keyword = <default_val> comment                                datatype option_flg
(option_flg: Y = optional; N = required; C = constant,
                                                   i.e. default_val overrides code)

SIMPLE   = T                data conform to FITS standard                   L1  C
BITPIX   = 0                bits per data value                             I2  N
NAXIS    = 0                number of data array dimensions                 I2  N
EXTEND   = T                File may contain standard extensions            L1  N
NEXTEND  =                  Number of standard extensions                   I2  N

TELESCOP= Kepler            telescope used to acquire data                  C03 C
INSTRUME= CCD               identifier for instrument used to acquire data  C06 N
EQUINOX = 2000.0            equinox of celestial coord. system              R4  C

DATE     =                  date this file was written (yyyy-mm-dd)         C10 N
ORIGIN   = STScI            institution responsible for creating FITS file  C18 N
FILENAME=                   name of file                                    C39 N
DATSETNM=                   data set name of the file                       C34 N

         / Data content

DATATYPE= long cadence      data type: short cadence, long cadence, FFI     C13 N
PIXELTYP= target            pixel type: target, background, collateral      C10 N
USE_TIME=                   UT time to start use of this reference file     C19 N

         / Science Data Collection Configuration

LCTRGDEF=                   long cadence target definition identifier       I2  N
SCTRGDEF=                   short cadence target definition identifier      I2  N
BKTRGDEF=                   background definition identifier                I2  N
TARGAPER=                   target aperture definition identifier           I2  N
BKG_APER=                   background aperture definition identifier       I2  N
COMPTABL=                   compression tables identifier                   I2  N

END


XTENSION= BINTABLE          extension type                                  C08 N
BITPIX   = 8                bits per data value                             I2  N
NAXIS    = 2                number of data array dimensions                 I2  N
NAXIS1   =                  length of first data axis                       I4  Y
NAXIS2   =                  length of second data axis                      I4  Y
PCOUNT   = 0                number of parameter bytes following data table  I2  C
GCOUNT   = 1                number of groups                                I2  C
TFIELDS  =                  number of fields in each table row              I2  Y
INHERIT  = T                inherit the primary header                      L1  C
EXTNAME  =                  extension name                                  C08 N
EXTVER   =                  extension version number                        I2  N

         / Extension parameters

CHANNEL  =                  channel number (1-84)                           I2  N
MODULE   =                  module number (2-24, except 5 and 21)           I2  N
OUTPUT   =                  module output number (1-4)                      I2  N
```

```
         / Data table definition

TTYPE1  = col_pixel_type name of field 1: collateral pixel type          C14 C
TFORM1  = B              format in which field 1 is coded: character     C08 C
TDISP1  = I2             format in which field 1 is displayed            C08 C
TTYPE2  = pixel_offset   name of field 2: pixel offset                   C14 C
TFORM2  = 1I             format in which field 2 is coded: one 16 bit int  C08 C
TDISP2  = I4.1           format in which field 2 is displayed            C08 C

END
```