Look-Up Table Guide
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This document describes the Look Up Tables (LUTS) used in the generation of TWINS images. The LUTs are stored as arrays in IDL savesets. For a detailed description of the TWINS image making process, statistical smoothing, and background subtraction techniques used, refer to McComas et al. [2012], appendix A. Image processing is implemented in the IDL procedure *stat_smooth_f.pro*.

Detailed instrument calibration factors are stored in a series of LUTS. The LUTS were created using the calibration data from the TWINS flight units, performed at SwRI prior to launch. While the four TWINS sensor heads have an identical design, there are slight variations in performance due the manufacture variances (e.g., tolerances on mechanical and electrical components). Each of the TWINS sensor heads has its own unique set of LUTS so the correct calibration can be applied to each head.

A key TWINS science data product are the Direct Events (DEs). For every ENA that generates a valid coincident event, 6 values are measured and reported: Start Position, Stop Position, Start Height, Stop Height, Time of Flight (TOF), and Slice. DEs refer to these 6 values per valid event. The LUTs use the DEs and other parameters as input and convert them to physical quantities. The LUTs use integer values as parameters. Acceptable range of values for the DEs are; 0-63 for Start Position; 0-255 for Stop Position; 0-255 for Start Height; 0-127 for Stop Height; 0-255 for TOF; 0-3 for Slice.

TWINS uses three LUTS to convert the DEs into physical quantities: Angle LUT, Gfactor LUT, and TOF LUT. In addition, the image making software uses additional LUTS to store parameters and to speed up execution time by per-calculating energies commonly used in the images. The LUTS name contains the sensor head which it should be applied to. For example, FM1A_ANGLE.sav maps the DEs to angles for the Away sensor head on Flight Model 1. For the LUTS description below the general naming convention will use N will refer to the FM number, and H will refer to the head. For example, FMHN_ANGLE.sav. Allowable values for N is 1 or 2, and allowable values for H is A or T.

FMHN_ANGLE.sav: This LUT converts DEs Stop Position and Start Position into angles in the sensor head frame. When restored, this LUT contains the following elements:

```
FIT_ANGLES      FLOAT     = Array[256, 64]
SP_HT           INT
SP_LC           INT
SP_LL           INT
SP_RC           INT
SP_RR           INT
ST_LL           INT
ST_RR           INT
TOF_CULL        INT
```

The array FIT_ANGLES is parameterized by Stop Position and Start Position. To convert from the head frame to the instrument frame, the Away head is offset by +15 degrees, and the Toward head is offset by -15 degrees. The offset values are stored in the variable !TWINS.HEAD_TO_INST_FRAME, defined in define_twins_constants.pro. The remaining integer values are used for culling out DEs that give unphysical results. The culling values are repeated in a number of LUTS for convenience.

FMNH_tof_lut.sav: This LUT converts the TOF DE into seconds. When restored, this LUT contains the following elements:

FIT_PARMS DOUBLE = Array[3]
TOF_CULL INT
TOF_LUT DOUBLE = Array[256]

The array TOF_LUT is parameterized by the TOF DE, and converts it into seconds. The double array FIT_PARMS contains the fitting parameters of a third order polynomial that was used in the fitting of the calibration data. The remaining integer value is used for culling out DEs that give unphysical results. The culling values are repeated in a number of LUTS for convenience. The velocity of the event is calculated by dividing the distance traveled in the sensor by the TOF. The velocity in *cm / s* is

$$v = \frac{3.0 \not/ \cos\left(FIT\_ANGLES[StartPosition, StopPosition]\right)}{TOF\_LUT[TOF]}$$

gfact_fmNH.sav: This LUT converts the Stop Position, Start Position, and TOF DEs into the geometric factor for that bin in units of cm2 sr eV-1. When restored, this LUT contains the following elements. (Here FM1A is shown)
GFACT_FM1A FLOAT = Array[256, 64, 256]

The array GFACT_FMNH contains the geometric factor for events for each Stop Position, Start Position ,TOF. When making an image, the total geometric factor for a pixel is the sum of the LUT over the range of DEs included in the pixel. A further description of the TWINS Geometric factor is given in *'TWINS Geometric Factors*'

FMNH_CULL.sav: This LUT contains the values used in culling out DEs that give unphysical results. When restored, this LUT contains the following elements:
SP_HT INT
SP_LC INT
SP_LL INT
SP_RC INT
SP_RR INT
ST_LL INT
ST_RR INT
TOF_CULL INT

The routine 'cull_events.pro' uses the values in this LUT to select the subset of DE that are to be included in the images.

FMN_energy_calculations_10eV.sav: This LUT includes per-calculated values for the range of TOF DEs to include per angle for a specified image energy. It also includes the appropriately total geometric factor. This LUT is used to reduce the number of calculations required to make images, and is used in stat_smooth_f.pro, which is the main image making code. This LUT is only be used if the requested energy is between 100 eV and 100 kev, a multiple of 10 eV, and the use calling stat_smooth_f.pro does not set the 'force_en_calc' keyword

true_angle_le36.sav: This LUT contains the true actuation angle when given the sector number, Slice, and actuation direction. This LUT is used if the flight software version number is less than or equal to 36. This corresponds to the flight software version before the inclusion of the actuator updates to address the faulty position monitor. The software upload was performed in July 2009. When restored, this LUT contains the following elements:

TRUE_ANG INT = Array[45, 4, 2]

The array TRUE_ANG contains the actuation angle with 1 degree resolution. The parameters are sector number, Slice, and scan direction.

true_angle_gt36.sav: This LUT contains the true actuation angle when given the sector number, Slice, and actuation direction. This LUT is used if the flight software version number is greater than 36. This corresponds to the flight software versions which include the actuator updates to address the faulty position monitor. The software upload was performed in July 2009. When restored, this LUT contains the following elements:
TRUE_ANG INT = Array[45, 4, 2]

The array TRUE_ANG contains the actuation angle with 1 degree resolution. The parameters are sector number, Slice, and scan direction.

Reference:

McComas, D., N. Buzulukova, M. Connors, M. Dayeh, J. Goldstein, H. O. Funsten, S. Fuselier, N. A. Schwadron, and P. Valek (2012), Two Wide-Angle Imaging Neutral-Atom Spectrometers and Interstellar Boundary Explorer energetic neutral atom imaging of the 5 April 2010 substorm, *J. Geophys. Res., 117*, A03,225, doi: 10.1029/2011JA017273.