SWEA 3D Distributions into Phase Space Density

The IMPACT investigation’s SWEA sensor produces 3D suprathermal electron distribution functions in the energy range between about ~45 eV and 3 keV. In the IMPACT Level 1 data, these distributions are in raw counts obtained in the energy ranges given in Table 1 and in 80 look directions. SWEA is operated primarily in two modes (mode 0 and mode 1). Mode 0 predominates throughout the mission while mode 1 was used for about a year in 2008 – 2009. The mode ID number is provided in the SWEA Level 1 dataset. A map of the look directions is provided in Table 2 and is to be mapped over the entire 360-degree field of view. The sun is nominally at the point between cells 31,32, 47 and 48.

The SWEA team at IRAP, Toulouse converts these data into phase space density to produce Level 2 pitch angle distributions for each of the energy ranges. The algorithm by which this conversion to phase space density is performed we describe here.

|  |  |  |
| --- | --- | --- |
| Channel | Mode 0 | Mode 1 |
| 0 | 1347.08 – 2188.10 eV | 1498.46 – 2131.46 eV |
| 1 | 829.31 – 1347.08 eV | 1053.44 – 1498.46 eV |
| 2 | 510.56 – 829.31 eV | 740.59 – 1053.44 eV |
| 3 | 314.32 – 510.56 eV | 520.65 – 740.59 eV |
| 4 | 193.51 – 314.32 eV | 366.02 – 520.65 eV |
| 5 | 119.13 – 193.51 eV | 257.33 – 366.02 eV |
| 6 | 73.34 – 119.13 eV | 180.90 – 257.33 eV |
| 7 | 45.15 – 73.34 eV | 127.18 – 180.90 eV |
| 8 | 27.80 – 45.15 eV | 89.41 – 127.18 eV |
| 9 | 17.11 – 27.80 eV | 62.86 – 89.41 eV |
| 10 | 10.54 – 17.11 eV | 44.19 – 62.66 eV |
| 11 | 6.49 – 10.54 eV | 31.06 – 44.19 eV |
| 12 | 3.99 – 6.49 eV | 21.84 – 31.06 eV |
| 13 | 2.46 – 3.99 eV | 15.35 – 21.84 eV |
| 14 | 1.51 – 2.46 eV | 10.79 – 15.35 eV |
| 15 | 0.93 – 1.51 eV | 7.59 – 10.79 eV |

Table 1: Energy ranges of SWEA energy channels for modes 0 and 1. Note that the channels below 45 eV are dominated by electrons from internal charging of the instrument and so should generally be ignored except in very special circumstances.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 0 | 0 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 5 | 5 | 6 | 6 | 7 | 7 |
| 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 |
| 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 |
| 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 |
| 72 | 72 | 73 | 73 | 74 | 74 | 75 | 75 | 76 | 76 | 77 | 77 | 78 | 78 | 79 | 79 |

Table 2: Angle bin map for SWEA’s 80 look directions

Overview

Heritage

SWEA had substantial heritage in the WIND 3DPe instrument (Lin et al., 1995) and the FAST Electron ElectroStatic Analyzer (EESA) (Carlson et al., 2001). In particular, these represented the early stages of development of the 3D capability with the eventual adoption of ‘top-hat’ designs for the analyzers. We have made use of existing code originally written for the Wind/3DP instrument for data visualization. This code originally known as TPLOT was updated and included in the Themis mission’s TDAS/SPEDAS library.

Product Description

SWEA was originally designed to measure electrons with energies between 1 eV and 3 keV. The instrument’s field of view is 360 X 120 degrees and has a dynamic range of about 10^8 eV/(cm^2 \* sr \* eV \* s). Sauvaud et al. (2008), provided a complete description of the instrument as flown. Once in heliocentric orbit, it was found that the shadowing environment of SWEA on the end of the IMPACT boom, which permanently extends into the antisolar spacecraft wake (STEREO’s stabilized orientation is controlled by its sunward-pointing imagers), resulted in interior charging that limited the use of SWEA below ~45 eV. Thus the suprathermal electrons (>45 eV) are routinely measured as planned, but information about the thermal electron population requires special treatment (see Fedorov et al., 2011). The latter are not routinely executed or processed as data products-and thus not described here.

The >45 eV 3D distributions produced by SWEA are reported in 16 energy bins and 80 angle bins. The algorithm described takes the raw data in an array of (16,80) from raw counts to produce phase space density in these energy and angle bins:

The energy bins are defined by the following lines of IDL code:

;SWEA Mode ID = 0

;

;Min energy of energy bin (in eV)  
 E[\*,0,0] = [ 1347.08, 829.31, 510.56, 314.32, 193.51, 119.13, 73.34, 45.15, 27.80, 17.11, 10.54, 6.49, 3.99, 2.46, 1.51, 0.93 ]

;Center of energy bin (in eV)

E[\*,1,0] = [ 1716.84, 1056.95, 650.70, 400.60, 246.62, 151.83, 93.47, 57.54, 35.43, 21.81, 13.43, 8.27, 5.09, 3.13, 1.93, 1.19 ]

;Max energy of energy bin (in eV)

E[\*,2,0] = [ 2188.10, 1347.08, 829.31, 510.56, 314.32, 193.51, 119.13, 73.34, 45.15, 27.80, 17.11, 10.54, 6.49, 3.99, 2.46, 1.51 ]

;SWEA Mode ID=1

;Min energy of energy bin (in eV)

E[\*,0,1] = [ 1498.46, 1053.44, 740.59, 520.65, 366.02, 257.33, 180.90, 127.18, 89.41, 62.86, 44.19, 31.06, 21.84, 15.35, 10.79, 7.59 ]

;Center of energy bin (in eV)

E[\*,1,1] = [ 1787.15, 1256.40, 883.27, 620.96, 436.54, 306.90, 215.76, 151.68, 106.63, 74.97, 52.70, 37.05, 26.04, 18.31, 12.87, 9.05 ]

;Max of energy bin (in eV)

E[\*,2,1] = [ 2131.46, 1498.46, 1053.44, 740.59, 520.65, 366.02, 257.33, 180.90, 127.18, 89.41, 62.86, 44.19, 31.06, 21.84, 15.35, 10.79 ]

Likewise, the angle bin look directions are defined by:

solid = [ [0L, 8,24,40,56,72], $

[ 0, 9,25,41,57,72], $

[ 1,10,26,42,58,73], $

[ 1,11,27,43,59,73], $

[ 2,12,28,44,60,74], $

[ 2,13,29,45,61,74], $

[ 3,14,30,46,62,75], $

[ 3,15,31,47,63,75], $

[ 4,16,32,48,64,76], $

[ 4,17,33,49,65,76], $

[ 5,18,34,50,66,77], $

[ 5,19,35,51,67,77], $

[ 6,20,36,52,68,78], $

[ 6,21,37,53,69,78], $

[ 7,22,38,54,70,79], $

[ 7,23,39,55,71,79]]

Theoretical Description

The conversion from raw counts to phase space density is performed by the following IDL code created at IRAP:

;-------------------------------------------------------------------------------

FUNCTION get\_swea\_energy

;-------------------------------------------------------------------------------

; Return energy table

; - table 0: from 1.51 to 1347.08 eV

; - table 1: from 10.79 to 1498.46 eV

;-------------------------------------------------------------------------------

nbtables = 2L

nbenergies = 16

E = REPLICATE (0.,nbenergies,3,nbtables)

E[\*,0,0] = [ 1347.08, 829.31, 510.56, 314.32, 193.51, 119.13, 73.34, 45.15, 27.80, 17.11, 10.54, 6.49, 3.99, 2.46, 1.51, 0.93 ]

E[\*,1,0] = [ 1716.84, 1056.95, 650.70, 400.60, 246.62, 151.83, 93.47, 57.54, 35.43, 21.81, 13.43, 8.27, 5.09, 3.13, 1.93, 1.19 ]

E[\*,2,0] = [ 2188.10, 1347.08, 829.31, 510.56, 314.32, 193.51, 119.13, 73.34, 45.15, 27.80, 17.11, 10.54, 6.49, 3.99, 2.46, 1.51 ]

E[\*,0,1] = [ 1498.46, 1053.44, 740.59, 520.65, 366.02, 257.33, 180.90, 127.18, 89.41, 62.86, 44.19, 31.06, 21.84, 15.35, 10.79, 7.59 ]

E[\*,1,1] = [ 1787.15, 1256.40, 883.27, 620.96, 436.54, 306.90, 215.76, 151.68, 106.63, 74.97, 52.70, 37.05, 26.04, 18.31, 12.87, 9.05 ]

E[\*,2,1] = [ 2131.46, 1498.46, 1053.44, 740.59, 520.65, 366.02, 257.33, 180.90, 127.18, 89.41, 62.86, 44.19, 31.06, 21.84, 15.35, 10.79 ]

RETURN, E

END

;-------------------------------------------------------------------------------

FUNCTION get\_swea\_efficency, nosat, notable, nbaz, nbel, nbe

;-------------------------------------------------------------------------------

; Return efficency

;-------------------------------------------------------------------------------

efficency = REPLICATE (1d,nbaz,nbel,nbe)

IF nosat EQ 1 THEN BEGIN

efficency1 = [ $

[ 0.84, 0.92, 0.98, 0.89, 0.90, 0.95, 0.91, 0.81, 0.99, 1.00, 0.90, 0.84, 0.84, 0.85, 0.82, 0.76 ], $

[ 0.84, 0.92, 0.98, 0.89, 0.90, 0.95, 0.91, 0.81, 0.99, 1.00, 0.90, 0.84, 0.84, 0.85, 0.82, 0.76 ], $

[ 0.84, 0.92, 0.98, 0.89, 0.90, 0.95, 0.91, 0.81, 0.99, 1.00, 0.90, 0.84, 0.84, 0.85, 0.82, 0.76 ], $

[ 0.84, 0.92, 0.98, 0.89, 0.90, 0.95, 0.91, 0.81, 0.99, 1.00, 0.90, 0.84, 0.84, 0.85, 0.82, 0.76 ], $

[ 0.84, 0.92, 0.98, 0.89, 0.90, 0.95, 0.91, 0.81, 0.99, 1.00, 0.90, 0.84, 0.84, 0.85, 0.82, 0.76 ], $

[ 0.84, 0.92, 0.98, 0.89, 0.90, 0.95, 0.91, 0.81, 0.99, 1.00, 0.90, 0.84, 0.84, 0.85, 0.82, 0.76 ] $

]

END ELSE IF nosat EQ 2 THEN BEGIN

efficency1 = [ $

[ 0.82, 0.86, 0.88, 0.84, 0.88, 0.95, 0.90, 0.81, 0.89, 0.95, 0.92, 0.81, 0.99, 1.00, 0.96, 0.80 ], $

[ 0.82, 0.86, 0.88, 0.84, 0.88, 0.95, 0.90, 0.81, 0.89, 0.95, 0.92, 0.81, 0.99, 1.00, 0.96, 0.80 ], $

[ 0.82, 0.86, 0.88, 0.84, 0.88, 0.95, 0.90, 0.81, 0.89, 0.95, 0.92, 0.81, 0.99, 1.00, 0.96, 0.80 ], $

[ 0.82, 0.86, 0.88, 0.84, 0.88, 0.95, 0.90, 0.81, 0.89, 0.95, 0.92, 0.81, 0.99, 1.00, 0.96, 0.80 ], $

[ 0.82, 0.86, 0.88, 0.84, 0.88, 0.95, 0.90, 0.81, 0.89, 0.95, 0.92, 0.81, 0.99, 1.00, 0.96, 0.80 ], $

[ 0.82, 0.86, 0.88, 0.84, 0.88, 0.95, 0.90, 0.81, 0.89, 0.95, 0.92, 0.81, 0.99, 1.00, 0.96, 0.80 ] $

]

END

efficency1[\*,0] \*= 0.65

IF notable EQ 0 THEN BEGIN

;E[\*,0,0] = [ 1347.08, 829.31, 510.56, 314.32, 193.51, 119.13, 73.34, 45.15, 27.80, 17.11, 10.54, 6.49, 3.99, 2.46, 1.51, 0.93 ]

;E[\*,1,0] = [ 1716.84, 1056.95, 650.70, 400.60, 246.62, 151.83, 93.47, 57.54, 35.43, 21.81, 13.43, 8.27, 5.09, 3.13, 1.93, 1.19 ]

;E[\*,2,0] = [ 2188.10, 1347.08, 829.31, 510.56, 314.32, 193.51, 119.13, 73.34, 45.15, 27.80, 17.11, 10.54, 6.49, 3.99, 2.46, 1.51 ]

transmission = [1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 0.9, 0.5, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0]

END ELSE BEGIN

;E[\*,0,1] = [ 1498.46, 1053.44, 740.59, 520.65, 366.02, 257.33, 180.90, 127.18, 89.41, 62.86, 44.19, 31.06, 21.84, 15.35, 10.79, 7.59 ]

;E[\*,1,1] = [ 1787.15, 1256.40, 883.27, 620.96, 436.54, 306.90, 215.76, 151.68, 106.63, 74.97, 52.70, 37.05, 26.04, 18.31, 12.87, 9.05 ]

;E[\*,2,1] = [ 2131.46, 1498.46, 1053.44, 740.59, 520.65, 366.02, 257.33, 180.90, 127.18, 89.41, 62.86, 44.19, 31.06, 21.84, 15.35, 10.79 ]

transmission = [1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 0.9, 0.5, 0.0, 0.0, 0.0, 0.0]

END

transmission[WHERE(transmission EQ 0.5)] = 0.0 ; to remove data with E < 45 eV

FOR ienergie=0L,nbe-1 DO BEGIN

IF transmission[ienergie] NE 0 THEN BEGIN

efficency[\*,\*,ienergie] = efficency1\*transmission[ienergie]

END ELSE BEGIN

efficency[\*,\*,ienergie] = -1E31

END

END

RETURN, efficency

END

;-------------------------------------------------------------------------------

FUNCTION get\_swea\_geom\_factor, nosat, nbaz, nbel, nbe

;-------------------------------------------------------------------------------

; Return geom\_factor in cm2.sr.(eV/eV)

;-------------------------------------------------------------------------------

G = DBLARR(nbaz,nbel,nbe) ; geometric factor

G[\*,\*,\*] = 5e-4

IF nosat EQ 2 THEN BEGIN

G /= 1.6 ; Andrea le 06/04/2009 (Pasadena report SWG 2009)

END

RETURN, G

END

;-------------------------------------------------------------------------------

PRO stereo\_swea\_convert

;-------------------------------------------------------------------------------

nbaz = 16

nbel = 6

nbe = 16

filename = '/DATA/STEREO/DATA/l1data/ahead/swea/2008/02/STA\_L1\_SWEA\_DIST\_20080213\_V02.cdf'

; 20080213: table==0

;filename = '/DATA/STEREO/DATA/l1data/ahead/swea/2008/02/STA\_L1\_SWEA\_DIST\_20080214\_V02.cdf'

; 20080214: table==0 and table==1

;filename = '/DATA/STEREO/DATA/l1data/ahead/swea/2008/02/STA\_L1\_SWEA\_DIST\_20080215\_V02.cdf'

; 20080215: table==1

nosat = STRMID(FILE\_BASENAME(filename),2,1) EQ 'A' ? 1 : 2

distribution\_varname = 'Distribution'

notable\_varname = 'SWEAModeID'

;energy\_varname = 'Energy'

; Read cdf

fd = CDF\_OPEN (filename)

tmp = CDF\_VARINQ (fd, distribution\_varname, /zvar)

CDF\_CONTROL, fd, variable=distribution\_varname,/zvar,get\_var\_info=vinfo

nblines = vinfo.maxrec + 1

CDF\_VARGET, fd, distribution\_varname, distribution, REC\_COUNT=nblines, /zvariable

CDF\_VARGET, fd, notable\_varname, notable, REC\_COUNT=nblines, /zvariable

;CDF\_VARGET, fd, energy\_varname, energy\_table, /zvariable

CDF\_CLOSE, fd

notable = REFORM (notable)

solid = [ [0L, 8,24,40,56,72], $

[ 0, 9,25,41,57,72], $

[ 1,10,26,42,58,73], $

[ 1,11,27,43,59,73], $

[ 2,12,28,44,60,74], $

[ 2,13,29,45,61,74], $

[ 3,14,30,46,62,75], $

[ 3,15,31,47,63,75], $

[ 4,16,32,48,64,76], $

[ 4,17,33,49,65,76], $

[ 5,18,34,50,66,77], $

[ 5,19,35,51,67,77], $

[ 6,20,36,52,68,78], $

[ 6,21,37,53,69,78], $

[ 7,22,38,54,70,79], $

[ 7,23,39,55,71,79]]

sector = [ [ 2L, 1, 1, 1, 1, 2], $

[ 2, 1, 1, 1, 1, 2], $

[ 2, 1, 1, 1, 1, 2], $

[ 2, 1, 1, 1, 1, 2], $

[ 2, 1, 1, 1, 1, 2], $

[ 2, 1, 1, 1, 1, 2], $

[ 2, 1, 1, 1, 1, 2], $

[ 2, 1, 1, 1, 1, 2], $

[ 2, 1, 1, 1, 1, 2], $

[ 2, 1, 1, 1, 1, 2], $

[ 2, 1, 1, 1, 1, 2], $

[ 2, 1, 1, 1, 1, 2], $

[ 2, 1, 1, 1, 1, 2], $

[ 2, 1, 1, 1, 1, 2], $

[ 2, 1, 1, 1, 1, 2], $

[ 2, 1, 1, 1, 1, 2]]

count = REPLICATE (-1e31, nbaz, nbel, nbe, nblines)

psd = REPLICATE (-1e31, nbaz, nbel, nbe, nblines)

FOR iline=0,nblines-1 DO BEGIN

energy = get\_swea\_energy()

dt = 5.8E-3 ; en sec (doc de Dave Curtis "SWEA UCB to CESR Interface Control Document")

; validÃ© par Peter Schroder Ã  Toulouse le 30 avril 2007

; 27/10/2008: Andrei et Andrea dÃ©couvrent que 5.8E-3 est valable pour le mode 48E

; D'aprÃ©s eux, je dois utiliser une valeur 3 fois plus grande pour les modes Ã  16E

dt \*= 3.0

geom\_factor = get\_swea\_geom\_factor (nosat,nbaz,nbel,nbe) ; in cm2.sr.(eV/eV)

geom\_factor \*= 1e-4 ; cm2.sr.(eV/eV) -> m2.sr.(eV/eV)

efficency = get\_swea\_efficency (nosat, notable[iline], nbaz, nbel, nbe)

MASS = 9.10956d-31

EV = 1.602176d-19

FOR ie=0,nbe-1 DO BEGIN

FOR iel=0,nbel-1 DO BEGIN

FOR iaz=0,nbaz-1 DO BEGIN

raw = distribution[solid[iel,iaz],ie,iline] / sector[iel,iaz]

eff = efficency[iaz,iel,ie]

IF eff EQ -1e31 THEN CONTINUE

fg = geom\_factor[iaz,iel,ie]

IF fg EQ -1e31 THEN CONTINUE

E = energy[ie,1,notable[iline]]

count[iaz,iel,ie,iline] = raw

; PHASE SPACE DENSITY in sec^3 / km^6

psd[iaz,iel,ie,iline] = raw \* MASS \* MASS \* 1e18 / (dt \* eff \* fg \* 2 \* E \* E \* EV \* EV)

END

END

END

END

stop

END

Below we include the CDF “skeleton table” (CDF metadata) for the SWEA Ahead 3D distribution product:

! Skeleton table for the "swea210a.cdf" CDF.

! Generated: Wednesday, 15-Jul-2020 10:39:35

! CDF created/modified by CDF V2.7.1

! Skeleton table created by CDF V3.1.1

#header

CDF NAME: swea210a.cdf

DATA ENCODING: NETWORK

MAJORITY: ROW

FORMAT: SINGLE

! Variables G.Attributes V.Attributes Records Dims Sizes

! --------- ------------ ------------ ------- ---- -----

0/9 25 23 0/z 0

#GLOBALattributes

! Attribute Entry Data

! Name Number Type Value

! --------- ------ ---- -----

"Project" 1: CDF\_CHAR { "STP>Solar Terrestrial Probes" } .

"Source\_name" 1: CDF\_CHAR { "STEREOA>Solar Terrestrial " -

"Relations Observatory " -

"Ahead of the Sun-Earth " -

"Line" } .

"Discipline" 1: CDF\_CHAR { "Solar Physics>Heliospheric" -

" Physics" } .

"Data\_type" 1: CDF\_CHAR { "L1>Level 1" } .

"Descriptor" 1: CDF\_CHAR { "IMPACT/SWEA>In-situ " -

"Measurements of Particles " -

"and CME Transients/Solar " -

"Wind Electron Analyzer" } .

"Data\_version" 1: CDF\_CHAR { "1" } .

"PI\_name" 1: CDF\_CHAR { "J. Luhmann" } .

"PI\_affiliation" 1: CDF\_CHAR { "UCB/SSL" } .

"TEXT" 1: CDF\_CHAR { "The file contains Level 1 " -

"3D electron distributions " -

"from the IMPACT/SWEA " -

"instrument on the STEREO " -

"Ahead spacecraft." } .

"Instrument\_type" 1: CDF\_CHAR { "Plasma and Solar Wind" } .

"Mission\_group" 1: CDF\_CHAR { "STEREO" } .

"Logical\_source" 1: CDF\_CHAR { "stereoa\_l1\_impact/swea" } .

"Logical\_file\_id" 1: CDF\_CHAR { "stereoa\_l1\_impact/swea\_000" -

"00000\_v01" } .

"Logical\_source\_description"

1: CDF\_CHAR { "STEREO Ahead IMPACT/SWEA " -

"3D Distributions." } .

"Time\_resolution" .

"Rules\_of\_use" .

"Generated\_by" .

"Generation\_date" .

"Acknowledgement" .

"MODS" .

"ADID\_ref" .

"LINK\_TEXT" 1: CDF\_CHAR { "Experiment and Data " -

"descriptions for " -

"STEREO/IMPACT" } .

"LINK\_TITLE" 1: CDF\_CHAR { "STEREO/IMPACT PI Site" } .

"HTTP\_LINK" 1: CDF\_CHAR { "http://sprg.ssl.berkeley.e" -

"du/impact" } .

"File\_naming\_convention"

1: CDF\_CHAR { "source\_datatype\_descriptor" } .

#VARIABLEattributes

"CATDESC"

"DEPEND\_0"

"DEPEND\_1"

"DEPEND\_2"

"DEPEND\_3"

"DICT\_KEY"

"DISPLAY\_TYPE"

"FIELDNAM"

"FILLVAL"

"FORMAT"

"LABLAXIS"

"LABL\_PTR\_1"

"LABL\_PTR\_2"

"LABL\_PTR\_3"

"UNITS"

"UNIT\_PTR"

"VALIDMIN"

"VALIDMAX"

"VAR\_TYPE"

"SCALETYP"

"SCAL\_PTR"

"VAR\_NOTES"

"FORM\_PTR"

#variables

! No rVariables.

#zVariables

! Variable Data Number Record Dimension

! Name Type Elements Dims Sizes Variance Variances

! -------- ---- -------- ---- ----- -------- ---------

"Epoch" CDF\_EPOCH 1 0 T

! Attribute Data

! Name Type Value

! -------- ---- -----

"CATDESC" CDF\_CHAR { "Time since 0 AD" }

"DICT\_KEY" CDF\_CHAR { "time>epoch" }

"FIELDNAM" CDF\_CHAR { "Epoch" }

"FILLVAL" CDF\_EPOCH { 31-Dec-9999 23:59:59.999 }

"LABLAXIS" CDF\_CHAR { "Epoch" }

"UNITS" CDF\_CHAR { "ms" }

"VALIDMIN" CDF\_EPOCH { 01-Jan-1990 00:00:00.000 }

"VALIDMAX" CDF\_EPOCH { 31-Dec-2020 00:00:00.000 }

"VAR\_TYPE" CDF\_CHAR { "support\_data" }

"VAR\_NOTES" CDF\_CHAR { "Interval-centered time tag" } .

! RV values were not requested.

! Variable Data Number Record Dimension

! Name Type Elements Dims Sizes Variance Variances

! -------- ---- -------- ---- ----- -------- ---------

"SWEADistInterval"

CDF\_DOUBLE 1 0 T

! Attribute Data

! Name Type Value

! -------- ---- -----

"CATDESC" CDF\_CHAR { "SWEA 3D Distribution Time Interval in " -

"seconds" }

"DEPEND\_0" CDF\_CHAR { "Epoch" }

"FIELDNAM" CDF\_CHAR { "SWEA Distribution Time Interval" }

"FILLVAL" CDF\_DOUBLE { -1.0e+31 }

"FORMAT" CDF\_CHAR { "E13.6" }

"LABLAXIS" CDF\_CHAR { "Dist Time Interval" }

"UNITS" CDF\_CHAR { "s" }

"VALIDMIN" CDF\_DOUBLE { 0.0 }

"VALIDMAX" CDF\_DOUBLE { 100000.0 }

"VAR\_TYPE" CDF\_CHAR { "support\_data" } .

! RV values were not requested.

! Variable Data Number Record Dimension

! Name Type Elements Dims Sizes Variance Variances

! -------- ---- -------- ---- ----- -------- ---------

"SWEAModeID" CDF\_BYTE 1 0 T

! Attribute Data

! Name Type Value

! -------- ---- -----

"CATDESC" CDF\_CHAR { "SWEA Mode ID" }

"DEPEND\_0" CDF\_CHAR { "Epoch" }

"FIELDNAM" CDF\_CHAR { "SWEA Mode ID" }

"FILLVAL" CDF\_BYTE { -128 }

"FORMAT" CDF\_CHAR { "I2" }

"LABLAXIS" CDF\_CHAR { "SWEA Mode" }

"VALIDMIN" CDF\_BYTE { -127 }

"VALIDMAX" CDF\_BYTE { 127 }

"VAR\_TYPE" CDF\_CHAR { "support\_data" } .

! RV values were not requested.

! Variable Data Number Record Dimension

! Name Type Elements Dims Sizes Variance Variances

! -------- ---- -------- ---- ----- -------- ---------

"Angle\_Bins" CDF\_UINT4 1 1 80 F T

! Attribute Data

! Name Type Value

! -------- ---- -----

"CATDESC" CDF\_CHAR { "SWEA 3D Distribution Angle Bins" }

"FIELDNAM" CDF\_CHAR { "SWEA Distribution Angle Bins" }

"FILLVAL" CDF\_UINT4 { 4294967295 }

"FORMAT" CDF\_CHAR { "I3" }

"LABLAXIS" CDF\_CHAR { "Angle Bin" }

"VALIDMIN" CDF\_UINT4 { 0 }

"VALIDMAX" CDF\_UINT4 { 80 }

"VAR\_TYPE" CDF\_CHAR { "support\_data" } .

! NRV values follow...

[1] = 0

[2] = 1

[3] = 2

[4] = 3

[5] = 4

[6] = 5

[7] = 6

[8] = 7

[9] = 8

[10] = 9

[11] = 10

[12] = 11

[13] = 12

[14] = 13

[15] = 14

[16] = 15

[17] = 16

[18] = 17

[19] = 18

[20] = 19

[21] = 20

[22] = 21

[23] = 22

[24] = 23

[25] = 24

[26] = 25

[27] = 26

[28] = 27

[29] = 28

[30] = 29

[31] = 30

[32] = 31

[33] = 32

[34] = 33

[35] = 34

[36] = 35

[37] = 36

[38] = 37

[39] = 38

[40] = 39

[41] = 40

[42] = 41

[43] = 42

[44] = 43

[45] = 44

[46] = 45

[47] = 46

[48] = 47

[49] = 48

[50] = 49

[51] = 50

[52] = 51

[53] = 52

[54] = 53

[55] = 54

[56] = 55

[57] = 56

[58] = 57

[59] = 58

[60] = 59

[61] = 60

[62] = 61

[63] = 62

[64] = 63

[65] = 64

[66] = 65

[67] = 66

[68] = 67

[69] = 68

[70] = 69

[71] = 70

[72] = 71

[73] = 72

[74] = 73

[75] = 74

[76] = 75

[77] = 76

[78] = 77

[79] = 78

[80] = 79

! Variable Data Number Record Dimension

! Name Type Elements Dims Sizes Variance Variances

! -------- ---- -------- ---- ----- -------- ---------

"Distribution"

CDF\_REAL4 1 2 16 80 T T T

! Attribute Data

! Name Type Value

! -------- ---- -----

"CATDESC" CDF\_CHAR { "SWEA 3D Distribution in cnts" }

"DEPEND\_0" CDF\_CHAR { "Epoch" }

"DEPEND\_1" CDF\_CHAR { "Energy" }

"DEPEND\_2" CDF\_CHAR { "Angle\_Bins" }

"DISPLAY\_TYPE"

CDF\_CHAR { "spectrogram" }

"FIELDNAM" CDF\_CHAR { "SWEA 3D Distribution" }

"FILLVAL" CDF\_REAL4 { -1.0e+31 }

"FORMAT" CDF\_CHAR { "E13.6" }

"LABL\_PTR\_1"

CDF\_CHAR { "Distribution\_LABL\_1" }

"LABL\_PTR\_2"

CDF\_CHAR { "Distribution\_LABL\_2" }

"UNITS" CDF\_CHAR { "cnts" }

"VALIDMIN" CDF\_REAL4 { 0.0 }

"VALIDMAX" CDF\_REAL4 { 1.0e+10 }

"VAR\_TYPE" CDF\_CHAR { "data" } .

! RV values were not requested.

! Variable Data Number Record Dimension

! Name Type Elements Dims Sizes Variance Variances

! -------- ---- -------- ---- ----- -------- ---------

"V0" CDF\_BYTE 1 0 T

! Attribute Data

! Name Type Value

! -------- ---- -----

"CATDESC" CDF\_CHAR { "SWEA V0 Value" }

"DEPEND\_0" CDF\_CHAR { "Epoch" }

"FIELDNAM" CDF\_CHAR { "SWEA V0 Value" }

"FILLVAL" CDF\_BYTE { -128 }

"FORMAT" CDF\_CHAR { "I3" }

"LABLAXIS" CDF\_CHAR { "V0" }

"VALIDMIN" CDF\_BYTE { -127 }

"VALIDMAX" CDF\_BYTE { 127 }

"VAR\_TYPE" CDF\_CHAR { "support\_data" }

"SCALETYP" CDF\_CHAR { "linear" } .

! RV values were not requested.

! Variable Data Number Record Dimension

! Name Type Elements Dims Sizes Variance Variances

! -------- ---- -------- ---- ----- -------- ---------

"Distribution\_LABL\_1"

CDF\_CHAR 27 1 16 F T

! Attribute Data

! Name Type Value

! -------- ---- -----

"CATDESC" CDF\_CHAR { "Distribution\_LABL\_1" }

"FIELDNAM" CDF\_CHAR { "Distribution\_LABL\_1" }

"FORMAT" CDF\_CHAR { "A28" }

"VAR\_TYPE" CDF\_CHAR { "metadata" } .

! NRV values follow...

[1] = { "Comp 1 Distribution\_LABL\_1 " }

[2] = { "Comp 2 Distribution\_LABL\_1 " }

[3] = { "Comp 3 Distribution\_LABL\_1 " }

[4] = { "Comp 4 Distribution\_LABL\_1 " }

[5] = { "Comp 5 Distribution\_LABL\_1 " }

[6] = { "Comp 6 Distribution\_LABL\_1 " }

[7] = { "Comp 7 Distribution\_LABL\_1 " }

[8] = { "Comp 8 Distribution\_LABL\_1 " }

[9] = { "Comp 9 Distribution\_LABL\_1 " }

[10] = { "Comp 10 Distribution\_LABL\_1" }

[11] = { "Comp 11 Distribution\_LABL\_1" }

[12] = { "Comp 12 Distribution\_LABL\_1" }

[13] = { "Comp 13 Distribution\_LABL\_1" }

[14] = { "Comp 14 Distribution\_LABL\_1" }

[15] = { "Comp 15 Distribution\_LABL\_1" }

[16] = { "Comp 16 Distribution\_LABL\_1" }

! Variable Data Number Record Dimension

! Name Type Elements Dims Sizes Variance Variances

! -------- ---- -------- ---- ----- -------- ---------

"Distribution\_LABL\_2"

CDF\_CHAR 27 1 80 F T

! Attribute Data

! Name Type Value

! -------- ---- -----

"CATDESC" CDF\_CHAR { "Distribution\_LABL\_2" }

"FIELDNAM" CDF\_CHAR { "Distribution\_LABL\_2" }

"FORMAT" CDF\_CHAR { "A28" }

"VAR\_TYPE" CDF\_CHAR { "metadata" } .

! NRV values follow...

[1] = { "Comp 1 Distribution\_LABL\_2 " }

[2] = { "Comp 2 Distribution\_LABL\_2 " }

[3] = { "Comp 3 Distribution\_LABL\_2 " }

[4] = { "Comp 4 Distribution\_LABL\_2 " }

[5] = { "Comp 5 Distribution\_LABL\_2 " }

[6] = { "Comp 6 Distribution\_LABL\_2 " }

[7] = { "Comp 7 Distribution\_LABL\_2 " }

[8] = { "Comp 8 Distribution\_LABL\_2 " }

[9] = { "Comp 9 Distribution\_LABL\_2 " }

[10] = { "Comp 10 Distribution\_LABL\_2" }

[11] = { "Comp 11 Distribution\_LABL\_2" }

[12] = { "Comp 12 Distribution\_LABL\_2" }

[13] = { "Comp 13 Distribution\_LABL\_2" }

[14] = { "Comp 14 Distribution\_LABL\_2" }

[15] = { "Comp 15 Distribution\_LABL\_2" }

[16] = { "Comp 16 Distribution\_LABL\_2" }

[17] = { "Comp 17 Distribution\_LABL\_2" }

[18] = { "Comp 18 Distribution\_LABL\_2" }

[19] = { "Comp 19 Distribution\_LABL\_2" }

[20] = { "Comp 20 Distribution\_LABL\_2" }

[21] = { "Comp 21 Distribution\_LABL\_2" }

[22] = { "Comp 22 Distribution\_LABL\_2" }

[23] = { "Comp 23 Distribution\_LABL\_2" }

[24] = { "Comp 24 Distribution\_LABL\_2" }

[25] = { "Comp 25 Distribution\_LABL\_2" }

[26] = { "Comp 26 Distribution\_LABL\_2" }

[27] = { "Comp 27 Distribution\_LABL\_2" }

[28] = { "Comp 28 Distribution\_LABL\_2" }

[29] = { "Comp 29 Distribution\_LABL\_2" }

[30] = { "Comp 30 Distribution\_LABL\_2" }

[31] = { "Comp 31 Distribution\_LABL\_2" }

[32] = { "Comp 32 Distribution\_LABL\_2" }

[33] = { "Comp 33 Distribution\_LABL\_2" }

[34] = { "Comp 34 Distribution\_LABL\_2" }

[35] = { "Comp 35 Distribution\_LABL\_2" }

[36] = { "Comp 36 Distribution\_LABL\_2" }

[37] = { "Comp 37 Distribution\_LABL\_2" }

[38] = { "Comp 38 Distribution\_LABL\_2" }

[39] = { "Comp 39 Distribution\_LABL\_2" }

[40] = { "Comp 40 Distribution\_LABL\_2" }

[41] = { "Comp 41 Distribution\_LABL\_2" }

[42] = { "Comp 42 Distribution\_LABL\_2" }

[43] = { "Comp 43 Distribution\_LABL\_2" }

[44] = { "Comp 44 Distribution\_LABL\_2" }

[45] = { "Comp 45 Distribution\_LABL\_2" }

[46] = { "Comp 46 Distribution\_LABL\_2" }

[47] = { "Comp 47 Distribution\_LABL\_2" }

[48] = { "Comp 48 Distribution\_LABL\_2" }

[49] = { "Comp 49 Distribution\_LABL\_2" }

[50] = { "Comp 50 Distribution\_LABL\_2" }

[51] = { "Comp 51 Distribution\_LABL\_2" }

[52] = { "Comp 52 Distribution\_LABL\_2" }

[53] = { "Comp 53 Distribution\_LABL\_2" }

[54] = { "Comp 54 Distribution\_LABL\_2" }

[55] = { "Comp 55 Distribution\_LABL\_2" }

[56] = { "Comp 56 Distribution\_LABL\_2" }

[57] = { "Comp 57 Distribution\_LABL\_2" }

[58] = { "Comp 58 Distribution\_LABL\_2" }

[59] = { "Comp 59 Distribution\_LABL\_2" }

[60] = { "Comp 60 Distribution\_LABL\_2" }

[61] = { "Comp 61 Distribution\_LABL\_2" }

[62] = { "Comp 62 Distribution\_LABL\_2" }

[63] = { "Comp 63 Distribution\_LABL\_2" }

[64] = { "Comp 64 Distribution\_LABL\_2" }

[65] = { "Comp 65 Distribution\_LABL\_2" }

[66] = { "Comp 66 Distribution\_LABL\_2" }

[67] = { "Comp 67 Distribution\_LABL\_2" }

[68] = { "Comp 68 Distribution\_LABL\_2" }

[69] = { "Comp 69 Distribution\_LABL\_2" }

[70] = { "Comp 70 Distribution\_LABL\_2" }

[71] = { "Comp 71 Distribution\_LABL\_2" }

[72] = { "Comp 72 Distribution\_LABL\_2" }

[73] = { "Comp 73 Distribution\_LABL\_2" }

[74] = { "Comp 74 Distribution\_LABL\_2" }

[75] = { "Comp 75 Distribution\_LABL\_2" }

[76] = { "Comp 76 Distribution\_LABL\_2" }

[77] = { "Comp 77 Distribution\_LABL\_2" }

[78] = { "Comp 78 Distribution\_LABL\_2" }

[79] = { "Comp 79 Distribution\_LABL\_2" }

[80] = { "Comp 80 Distribution\_LABL\_2" }

! Variable Data Number Record Dimension

! Name Type Elements Dims Sizes Variance Variances

! -------- ---- -------- ---- ----- -------- ---------

"Energy" CDF\_REAL4 1 1 16 F T

! Attribute Data

! Name Type Value

! -------- ---- -----

"CATDESC" CDF\_CHAR { "SWEA Energy Bins" }

"FIELDNAM" CDF\_CHAR { "SWEA Energy" }

"FILLVAL" CDF\_REAL4 { -1.0e+31 }

"FORMAT" CDF\_CHAR { "E12.2" }

"LABLAXIS" CDF\_CHAR { "Energy" }

"UNITS" CDF\_CHAR { "eV" }

"VALIDMIN" CDF\_REAL4 { 0.0 }

"VALIDMAX" CDF\_REAL4 { 1.0e+10 }

"VAR\_TYPE" CDF\_CHAR { "support\_data" }

"SCALETYP" CDF\_CHAR { "linear" } .

! NRV values follow...

[1] = 1.00e+00

[2] = 2.00e+00

[3] = 3.00e+00

[4] = 4.00e+00

[5] = 5.00e+00

[6] = 6.00e+00

[7] = 7.00e+00

[8] = 8.00e+00

[9] = 9.00e+00

[10] = 1.00e+01

[11] = 1.10e+01

[12] = 1.20e+01

[13] = 1.30e+01

[14] = 1.40e+01

[15] = 1.50e+01

[16] = 1.60e+01

#end

Also below we include the CDF “skeleton table” (CDF metadata) for the SWEA Behind 3D distribution product:

! Skeleton table for the "swea210b.cdf" CDF.

! Generated: Wednesday, 15-Jul-2020 10:42:17

! CDF created/modified by CDF V2.7.1

! Skeleton table created by CDF V3.1.1

#header

CDF NAME: swea210b.cdf

DATA ENCODING: NETWORK

MAJORITY: ROW

FORMAT: SINGLE

! Variables G.Attributes V.Attributes Records Dims Sizes

! --------- ------------ ------------ ------- ---- -----

0/9 25 23 0/z 0

#GLOBALattributes

! Attribute Entry Data

! Name Number Type Value

! --------- ------ ---- -----

"Project" 1: CDF\_CHAR { "STP>Solar Terrestrial Probes" } .

"Source\_name" 1: CDF\_CHAR { "STEREOB>Solar Terrestrial " -

"Relations Observatory " -

"Behind the Sun-Earth Line" } .

"Discipline" 1: CDF\_CHAR { "Solar Physics>Heliospheric" -

" Physics" } .

"Data\_type" 1: CDF\_CHAR { "L1>Level 1" } .

"Descriptor" 1: CDF\_CHAR { "IMPACT/SWEA>In-situ " -

"Measurements of Particles " -

"and CME Transients/Solar " -

"Wind Electron Analyzer" } .

"Data\_version" 1: CDF\_CHAR { "1" } .

"PI\_name" 1: CDF\_CHAR { "J. Luhmann" } .

"PI\_affiliation" 1: CDF\_CHAR { "UCB/SSL" } .

"TEXT" 1: CDF\_CHAR { "The file contains Level 1 " -

"3D electron distributions " -

"from the IMPACT/SWEA " -

"instrument on the STEREO " -

"Behind spacecraft." } .

"Instrument\_type" 1: CDF\_CHAR { "Plasma and Solar Wind" } .

"Mission\_group" 1: CDF\_CHAR { "STEREO" } .

"Logical\_source" 1: CDF\_CHAR { "stereob\_l1\_impact/swea" } .

"Logical\_file\_id" 1: CDF\_CHAR { "stereob\_l1\_impact/swea\_000" -

"00000\_v01" } .

"Logical\_source\_description"

1: CDF\_CHAR { "STEREO Ahead IMPACT/SWEA " -

"3D Distributions." } .

"Time\_resolution" .

"Rules\_of\_use" .

"Generated\_by" .

"Generation\_date" .

"Acknowledgement" .

"MODS" .

"ADID\_ref" .

"LINK\_TEXT" 1: CDF\_CHAR { "Experiment and Data " -

"descriptions for " -

"STEREO/IMPACT" } .

"LINK\_TITLE" 1: CDF\_CHAR { "STEREO/IMPACT PI Site" } .

"HTTP\_LINK" 1: CDF\_CHAR { "http://sprg.ssl.berkeley.e" -

"du/impact" } .

"File\_naming\_convention"

1: CDF\_CHAR { "source\_datatype\_descriptor" } .

#VARIABLEattributes

"CATDESC"

"DEPEND\_0"

"DEPEND\_1"

"DEPEND\_2"

"DEPEND\_3"

"DICT\_KEY"

"DISPLAY\_TYPE"

"FIELDNAM"

"FILLVAL"

"FORMAT"

"LABLAXIS"

"LABL\_PTR\_1"

"LABL\_PTR\_2"

"LABL\_PTR\_3"

"UNITS"

"UNIT\_PTR"

"VALIDMIN"

"VALIDMAX"

"VAR\_TYPE"

"SCALETYP"

"SCAL\_PTR"

"VAR\_NOTES"

"FORM\_PTR"

#variables

! No rVariables.

#zVariables

! Variable Data Number Record Dimension

! Name Type Elements Dims Sizes Variance Variances

! -------- ---- -------- ---- ----- -------- ---------

"Epoch" CDF\_EPOCH 1 0 T

! Attribute Data

! Name Type Value

! -------- ---- -----

"CATDESC" CDF\_CHAR { "Time since 0 AD" }

"DICT\_KEY" CDF\_CHAR { "time>epoch" }

"FIELDNAM" CDF\_CHAR { "Epoch" }

"FILLVAL" CDF\_EPOCH { 31-Dec-9999 23:59:59.999 }

"LABLAXIS" CDF\_CHAR { "Epoch" }

"UNITS" CDF\_CHAR { "ms" }

"VALIDMIN" CDF\_EPOCH { 01-Jan-1990 00:00:00.000 }

"VALIDMAX" CDF\_EPOCH { 31-Dec-2020 00:00:00.000 }

"VAR\_TYPE" CDF\_CHAR { "support\_data" }

"VAR\_NOTES" CDF\_CHAR { "Interval-centered time tag" } .

! RV values were not requested.

! Variable Data Number Record Dimension

! Name Type Elements Dims Sizes Variance Variances

! -------- ---- -------- ---- ----- -------- ---------

"SWEADistInterval"

CDF\_DOUBLE 1 0 T

! Attribute Data

! Name Type Value

! -------- ---- -----

"CATDESC" CDF\_CHAR { "SWEA 3D Distribution Time Interval in " -

"seconds" }

"DEPEND\_0" CDF\_CHAR { "Epoch" }

"FIELDNAM" CDF\_CHAR { "SWEA Distribution Time Interval" }

"FILLVAL" CDF\_DOUBLE { -1.0e+31 }

"FORMAT" CDF\_CHAR { "E13.6" }

"LABLAXIS" CDF\_CHAR { "Dist Time Interval" }

"UNITS" CDF\_CHAR { "s" }

"VALIDMIN" CDF\_DOUBLE { 0.0 }

"VALIDMAX" CDF\_DOUBLE { 100000.0 }

"VAR\_TYPE" CDF\_CHAR { "support\_data" } .

! RV values were not requested.

! Variable Data Number Record Dimension

! Name Type Elements Dims Sizes Variance Variances

! -------- ---- -------- ---- ----- -------- ---------

"SWEAModeID" CDF\_BYTE 1 0 T

! Attribute Data

! Name Type Value

! -------- ---- -----

"CATDESC" CDF\_CHAR { "SWEA Mode ID" }

"DEPEND\_0" CDF\_CHAR { "Epoch" }

"FIELDNAM" CDF\_CHAR { "SWEA Mode ID" }

"FILLVAL" CDF\_BYTE { -128 }

"FORMAT" CDF\_CHAR { "I2" }

"LABLAXIS" CDF\_CHAR { "SWEA Mode" }

"VALIDMIN" CDF\_BYTE { -127 }

"VALIDMAX" CDF\_BYTE { 127 }

"VAR\_TYPE" CDF\_CHAR { "support\_data" } .

! RV values were not requested.

! Variable Data Number Record Dimension

! Name Type Elements Dims Sizes Variance Variances

! -------- ---- -------- ---- ----- -------- ---------

"Angle\_Bins" CDF\_UINT4 1 1 80 F T

! Attribute Data

! Name Type Value

! -------- ---- -----

"CATDESC" CDF\_CHAR { "SWEA 3D Distribution Angle Bins" }

"FIELDNAM" CDF\_CHAR { "SWEA Distribution Angle Bins" }

"FILLVAL" CDF\_UINT4 { 4294967295 }

"FORMAT" CDF\_CHAR { "I3" }

"LABLAXIS" CDF\_CHAR { "Angle Bin" }

"VALIDMIN" CDF\_UINT4 { 0 }

"VALIDMAX" CDF\_UINT4 { 80 }

"VAR\_TYPE" CDF\_CHAR { "support\_data" } .

! NRV values follow...

[1] = 0

[2] = 1

[3] = 2

[4] = 3

[5] = 4

[6] = 5

[7] = 6

[8] = 7

[9] = 8

[10] = 9

[11] = 10

[12] = 11

[13] = 12

[14] = 13

[15] = 14

[16] = 15

[17] = 16

[18] = 17

[19] = 18

[20] = 19

[21] = 20

[22] = 21

[23] = 22

[24] = 23

[25] = 24

[26] = 25

[27] = 26

[28] = 27

[29] = 28

[30] = 29

[31] = 30

[32] = 31

[33] = 32

[34] = 33

[35] = 34

[36] = 35

[37] = 36

[38] = 37

[39] = 38

[40] = 39

[41] = 40

[42] = 41

[43] = 42

[44] = 43

[45] = 44

[46] = 45

[47] = 46

[48] = 47

[49] = 48

[50] = 49

[51] = 50

[52] = 51

[53] = 52

[54] = 53

[55] = 54

[56] = 55

[57] = 56

[58] = 57

[59] = 58

[60] = 59

[61] = 60

[62] = 61

[63] = 62

[64] = 63

[65] = 64

[66] = 65

[67] = 66

[68] = 67

[69] = 68

[70] = 69

[71] = 70

[72] = 71

[73] = 72

[74] = 73

[75] = 74

[76] = 75

[77] = 76

[78] = 77

[79] = 78

[80] = 79

! Variable Data Number Record Dimension

! Name Type Elements Dims Sizes Variance Variances

! -------- ---- -------- ---- ----- -------- ---------

"Distribution"

CDF\_REAL4 1 2 16 80 T T T

! Attribute Data

! Name Type Value

! -------- ---- -----

"CATDESC" CDF\_CHAR { "SWEA 3D Distribution in cnts" }

"DEPEND\_0" CDF\_CHAR { "Epoch" }

"DEPEND\_1" CDF\_CHAR { "Energy" }

"DEPEND\_2" CDF\_CHAR { "Angle\_Bins" }

"DISPLAY\_TYPE"

CDF\_CHAR { "spectrogram" }

"FIELDNAM" CDF\_CHAR { "SWEA 3D Distribution" }

"FILLVAL" CDF\_REAL4 { -1.0e+31 }

"FORMAT" CDF\_CHAR { "E13.6" }

"LABL\_PTR\_1"

CDF\_CHAR { "Distribution\_LABL\_1" }

"LABL\_PTR\_2"

CDF\_CHAR { "Distribution\_LABL\_2" }

"UNITS" CDF\_CHAR { "cnts" }

"VALIDMIN" CDF\_REAL4 { 0.0 }

"VALIDMAX" CDF\_REAL4 { 1.0e+10 }

"VAR\_TYPE" CDF\_CHAR { "data" } .

! RV values were not requested.

! Variable Data Number Record Dimension

! Name Type Elements Dims Sizes Variance Variances

! -------- ---- -------- ---- ----- -------- ---------

"V0" CDF\_BYTE 1 0 T

! Attribute Data

! Name Type Value

! -------- ---- -----

"CATDESC" CDF\_CHAR { "SWEA V0 Value" }

"DEPEND\_0" CDF\_CHAR { "Epoch" }

"FIELDNAM" CDF\_CHAR { "SWEA V0 Value" }

"FILLVAL" CDF\_BYTE { -128 }

"FORMAT" CDF\_CHAR { "I3" }

"LABLAXIS" CDF\_CHAR { "V0" }

"VALIDMIN" CDF\_BYTE { -127 }

"VALIDMAX" CDF\_BYTE { 127 }

"VAR\_TYPE" CDF\_CHAR { "support\_data" }

"SCALETYP" CDF\_CHAR { "linear" } .

! RV values were not requested.

! Variable Data Number Record Dimension

! Name Type Elements Dims Sizes Variance Variances

! -------- ---- -------- ---- ----- -------- ---------

"Distribution\_LABL\_1"

CDF\_CHAR 27 1 16 F T

! Attribute Data

! Name Type Value

! -------- ---- -----

"CATDESC" CDF\_CHAR { "Distribution\_LABL\_1" }

"FIELDNAM" CDF\_CHAR { "Distribution\_LABL\_1" }

"FORMAT" CDF\_CHAR { "A28" }

"VAR\_TYPE" CDF\_CHAR { "metadata" } .

! NRV values follow...

[1] = { "Comp 1 Distribution\_LABL\_1 " }

[2] = { "Comp 2 Distribution\_LABL\_1 " }

[3] = { "Comp 3 Distribution\_LABL\_1 " }

[4] = { "Comp 4 Distribution\_LABL\_1 " }

[5] = { "Comp 5 Distribution\_LABL\_1 " }

[6] = { "Comp 6 Distribution\_LABL\_1 " }

[7] = { "Comp 7 Distribution\_LABL\_1 " }

[8] = { "Comp 8 Distribution\_LABL\_1 " }

[9] = { "Comp 9 Distribution\_LABL\_1 " }

[10] = { "Comp 10 Distribution\_LABL\_1" }

[11] = { "Comp 11 Distribution\_LABL\_1" }

[12] = { "Comp 12 Distribution\_LABL\_1" }

[13] = { "Comp 13 Distribution\_LABL\_1" }

[14] = { "Comp 14 Distribution\_LABL\_1" }

[15] = { "Comp 15 Distribution\_LABL\_1" }

[16] = { "Comp 16 Distribution\_LABL\_1" }

! Variable Data Number Record Dimension

! Name Type Elements Dims Sizes Variance Variances

! -------- ---- -------- ---- ----- -------- ---------

"Distribution\_LABL\_2"

CDF\_CHAR 27 1 80 F T

! Attribute Data

! Name Type Value

! -------- ---- -----

"CATDESC" CDF\_CHAR { "Distribution\_LABL\_2" }

"FIELDNAM" CDF\_CHAR { "Distribution\_LABL\_2" }

"FORMAT" CDF\_CHAR { "A28" }

"VAR\_TYPE" CDF\_CHAR { "metadata" } .

! NRV values follow...

[1] = { "Comp 1 Distribution\_LABL\_2 " }

[2] = { "Comp 2 Distribution\_LABL\_2 " }

[3] = { "Comp 3 Distribution\_LABL\_2 " }

[4] = { "Comp 4 Distribution\_LABL\_2 " }

[5] = { "Comp 5 Distribution\_LABL\_2 " }

[6] = { "Comp 6 Distribution\_LABL\_2 " }

[7] = { "Comp 7 Distribution\_LABL\_2 " }

[8] = { "Comp 8 Distribution\_LABL\_2 " }

[9] = { "Comp 9 Distribution\_LABL\_2 " }

[10] = { "Comp 10 Distribution\_LABL\_2" }

[11] = { "Comp 11 Distribution\_LABL\_2" }

[12] = { "Comp 12 Distribution\_LABL\_2" }

[13] = { "Comp 13 Distribution\_LABL\_2" }

[14] = { "Comp 14 Distribution\_LABL\_2" }

[15] = { "Comp 15 Distribution\_LABL\_2" }

[16] = { "Comp 16 Distribution\_LABL\_2" }

[17] = { "Comp 17 Distribution\_LABL\_2" }

[18] = { "Comp 18 Distribution\_LABL\_2" }

[19] = { "Comp 19 Distribution\_LABL\_2" }

[20] = { "Comp 20 Distribution\_LABL\_2" }

[21] = { "Comp 21 Distribution\_LABL\_2" }

[22] = { "Comp 22 Distribution\_LABL\_2" }

[23] = { "Comp 23 Distribution\_LABL\_2" }

[24] = { "Comp 24 Distribution\_LABL\_2" }

[25] = { "Comp 25 Distribution\_LABL\_2" }

[26] = { "Comp 26 Distribution\_LABL\_2" }

[27] = { "Comp 27 Distribution\_LABL\_2" }

[28] = { "Comp 28 Distribution\_LABL\_2" }

[29] = { "Comp 29 Distribution\_LABL\_2" }

[30] = { "Comp 30 Distribution\_LABL\_2" }

[31] = { "Comp 31 Distribution\_LABL\_2" }

[32] = { "Comp 32 Distribution\_LABL\_2" }

[33] = { "Comp 33 Distribution\_LABL\_2" }

[34] = { "Comp 34 Distribution\_LABL\_2" }

[35] = { "Comp 35 Distribution\_LABL\_2" }

[36] = { "Comp 36 Distribution\_LABL\_2" }

[37] = { "Comp 37 Distribution\_LABL\_2" }

[38] = { "Comp 38 Distribution\_LABL\_2" }

[39] = { "Comp 39 Distribution\_LABL\_2" }

[40] = { "Comp 40 Distribution\_LABL\_2" }

[41] = { "Comp 41 Distribution\_LABL\_2" }

[42] = { "Comp 42 Distribution\_LABL\_2" }

[43] = { "Comp 43 Distribution\_LABL\_2" }

[44] = { "Comp 44 Distribution\_LABL\_2" }

[45] = { "Comp 45 Distribution\_LABL\_2" }

[46] = { "Comp 46 Distribution\_LABL\_2" }

[47] = { "Comp 47 Distribution\_LABL\_2" }

[48] = { "Comp 48 Distribution\_LABL\_2" }

[49] = { "Comp 49 Distribution\_LABL\_2" }

[50] = { "Comp 50 Distribution\_LABL\_2" }

[51] = { "Comp 51 Distribution\_LABL\_2" }

[52] = { "Comp 52 Distribution\_LABL\_2" }

[53] = { "Comp 53 Distribution\_LABL\_2" }

[54] = { "Comp 54 Distribution\_LABL\_2" }

[55] = { "Comp 55 Distribution\_LABL\_2" }

[56] = { "Comp 56 Distribution\_LABL\_2" }

[57] = { "Comp 57 Distribution\_LABL\_2" }

[58] = { "Comp 58 Distribution\_LABL\_2" }

[59] = { "Comp 59 Distribution\_LABL\_2" }

[60] = { "Comp 60 Distribution\_LABL\_2" }

[61] = { "Comp 61 Distribution\_LABL\_2" }

[62] = { "Comp 62 Distribution\_LABL\_2" }

[63] = { "Comp 63 Distribution\_LABL\_2" }

[64] = { "Comp 64 Distribution\_LABL\_2" }

[65] = { "Comp 65 Distribution\_LABL\_2" }

[66] = { "Comp 66 Distribution\_LABL\_2" }

[67] = { "Comp 67 Distribution\_LABL\_2" }

[68] = { "Comp 68 Distribution\_LABL\_2" }

[69] = { "Comp 69 Distribution\_LABL\_2" }

[70] = { "Comp 70 Distribution\_LABL\_2" }

[71] = { "Comp 71 Distribution\_LABL\_2" }

[72] = { "Comp 72 Distribution\_LABL\_2" }

[73] = { "Comp 73 Distribution\_LABL\_2" }

[74] = { "Comp 74 Distribution\_LABL\_2" }

[75] = { "Comp 75 Distribution\_LABL\_2" }

[76] = { "Comp 76 Distribution\_LABL\_2" }

[77] = { "Comp 77 Distribution\_LABL\_2" }

[78] = { "Comp 78 Distribution\_LABL\_2" }

[79] = { "Comp 79 Distribution\_LABL\_2" }

[80] = { "Comp 80 Distribution\_LABL\_2" }

! Variable Data Number Record Dimension

! Name Type Elements Dims Sizes Variance Variances

! -------- ---- -------- ---- ----- -------- ---------

"Energy" CDF\_REAL4 1 1 16 F T

! Attribute Data

! Name Type Value

! -------- ---- -----

"CATDESC" CDF\_CHAR { "SWEA Energy Bins" }

"FIELDNAM" CDF\_CHAR { "SWEA Energy" }

"FILLVAL" CDF\_REAL4 { -1.0e+31 }

"FORMAT" CDF\_CHAR { "E12.2" }

"LABLAXIS" CDF\_CHAR { "Energy" }

"UNITS" CDF\_CHAR { "eV" }

"VALIDMIN" CDF\_REAL4 { 0.0 }

"VALIDMAX" CDF\_REAL4 { 1.0e+10 }

"VAR\_TYPE" CDF\_CHAR { "support\_data" }

"SCALETYP" CDF\_CHAR { "linear" } .

! NRV values follow...

[1] = 1.00e+00

[2] = 2.00e+00

[3] = 3.00e+00

[4] = 4.00e+00

[5] = 5.00e+00

[6] = 6.00e+00

[7] = 7.00e+00

[8] = 8.00e+00

[9] = 9.00e+00

[10] = 1.00e+01

[11] = 1.10e+01

[12] = 1.20e+01

[13] = 1.30e+01

[14] = 1.40e+01

[15] = 1.50e+01

[16] = 1.60e+01

#end

Code used for plotting SWEA pitch angle distributions and spectra can be found on the STEREO/IMPACT website and is archived in SolarSoft.

For example, the STEREO Ahead pitch angle distributions are plotted in these routines:

<http://stereo.ssl.berkeley.edu/stereo_idl/sta_summ_plot_new.pro>

<http://stereo.ssl.berkeley.edu/stereo_idl/stb_summ_plot_new.pro>

These IMPACT plotting routines rely on the SPEDAS software library found here:

<http://themis.ssl.berkeley.edu/software.shtml>

Error Analysis and Corrections

The standard deviation being the square root of the counts, +/- 1 sigma gives a confidence level of 68% and +/- 3  sigma gives 99%. Other errors come from the detector itself, for example from the non-concentricity of the spheres which slightly modulates the measured energy and the geometrical factor.

Another error comes from the MCP efficiency, which is energy dependent, however because the electrons are post-accelerated up to several hundreds of eV, this error is weak as the efficiency is almost constant over the reduced energy range of SWEA. Dead-time of the chain MCP+electronic produces errors at high count rates. This error can be corrected. This error is in the form:

y=x/(1-xt)

Where y is the true count rate, x, the measured one and t the dead time. The maximum measurable count rate is 1/t.

Calibration and Validation

Calibration

* + - 1. Pre-flight/On-ground Calibration

The on-ground, pre-flight calibrations have been performed in the Institut de Recherche en Astrophysique et Planétologie (IRAP) facilities, using an electron gun in a vacuum chamber. The beam thickness was negligible and had a stability of 10%. The calibrations consisted in detailed characterization of the geometric factor and angular and energy responses. MCP gain and dead-time were also characterized using an electron beam.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Quantity** | **Methods** | **Results** | **Comments** | **Data Products Affected** |
| Energy/Angle | Electron beam Energy-theta response of instrument | Energy resolution: 0.176  Angular resolution: - 22.5° in azimuth.  - on average 10° intrinsic in elevation | As planned | All |
| Geometric factor | Electron beam Energy-theta response of instrument | Smooth energy and angular response.  K factor ~ 6.36  Geo. factor at 0° of ~ 3.32E-02 cm² sr eV / eV | As planned | All |
| MCP efficiency | Vertical and horizontal steering of electron beam to characterrize all MCP sectors | Calibrations made with MCP voltage of 2800 V.  MCP efficiency 0.83  Deadtime of ordrer 130 ms. | As planned | All |
|  |  |  |  |  |

* + - 1. In-flight Calibration

In flight calibrations were performed using SWEA observations at energies between 100 and 250 eV in the strahl energy range. The reasons were that the instrument response was altered at lower energies due to electrostatic charging of the top cap at the entrance of the instrument. The inter-anode calibrations have consisted in the use of measurements at the same energies and same pitch-angles over large time intervals at several periods during the mission. Absolute calibrations have been made using measurements by other spacecraft at L1.

|  |  |  |
| --- | --- | --- |
| **Quantity** | **Methods** | **Data Products Affected** |
| Moments | Comparisons with L1 data | Moments |
| Angular / pitch angle response | Strahl comparisons with B field | PADs |
| Energy Spectra | Comparisons with L1 data | Spectra |
|  |  |  |

Validation

* + - 1. Comparisons with L1 electron measurements (WIND, ACE) in scientific analyses

Our data validations on IMPACT team are routinely carried out via application of the measurements to scientific analyses, often using comparisons with similar measurements at the L1 location upstream of Earth on WIND and/or ACE. These studies are led by both IMPACT team members and non-members. A selection of results that demonstrate the SWEA performance are given in the references by Yu et al. (2014), Liu et al. (2014), Moestl et al. (2012, and Nieves-Chinchilla et al. (2011). These describe the use of the SWEA data to analyze small-scale to large scale transient structures which have been shown to include counter-streaming electrons as a signature of closed magnetic structures in the solar wind. Studies of these types of events at L1 are complemented by the STEREO observations at a separated location. SWEA observations also have the advantage of being clear of the Earth’s foreshock where Earth ‘contaminates’ the interplanetary signature.

* + - 1. Inter-Comparisons between STEREO-A and –B in scientific analyses

Intercomparisons of STEREO IMPACT SWEA results also provide a unique opportunity to compare the electrons seen by nearly identical instruments on two separated spacecraft effectively in Earth’s orbit. Studies described by Opitz et al. (2010), Lavraud et al. (2010), Simunac et al. (2012), and Louarn et al. (2009) provide some examples. These comparisons are uniquely suited to timing studies and detailed comparisons because there are minimal instrumental differences involved. They show that for all practical purposes the two SWEAs on STEREO A and B are the same. (Note: STEREO-B contact was lost in October 2014, so the STEREO-B SWEA data, and thus these highly comparable observations, are only available from early 2007 to that date.)

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