TITLE: **SPIRE Spacecraft-Instrument Alignment Matrix (SIAM)**

By: Marc Ferlet (RAL)

DISTRIBUTION

- Herschel Science Centre (ESTEC & ESAC)
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- RAL/SSTD - SPIRE Project Team:
  S Sidher (RAL)

For info:
K King (RAL)
B Swinyard (RAL)
E Sawyer (RAL)
D Griffin (RAL)
T Lim (RAL)

For Project database/archive:
J Long (RAL)

CHANGE RECORD

ISSUE	DATE	SECTION	REASON FOR CHANGE
0.1	28/03/07	All	First draft, not released
1.0	23/05/07	All	First release
1.1	24/05/07	All	Typo corrected, added references
1.2	30/05/07	All	Aperture S55 is now assigned to parallel mode.
1.3	18/05/07	4	Addition of SIAM file data for the Parallel Mode.

CONTENTS

APPLICABLE AND REFERENCE DOCUMENTS

AD1 “ICD: Herschel Spacecraft / Instrument Alignment History”, PT-HMOC-FD-ICD-2111-OPS-GFT issue 1.3 (07/02/06)

AD2 IID-B Herschel/Planck Instrument Interface Document – Part B Instrument “SPIRE”, SCI-PT-IIDB/SPIRE-02124, issue 3.3 (21/06/04)

RD1 SPIRE Design Description, SPIRE-RAL-PRJ-000620 issue 2.0 (15/05/03)

RD2 SPIRE PACS Parallel Mode Observers’ Manual, HERSCHEL-HSC-DOC-0883 v1.0 (01/02/07)

This note reports on the generation of the Spacecraft-Instrument Alignment Matrix (SIAM) file data, as defined in AD1, for the Herschel/SPIRE instrument.

1. General description

The main components in the SIAM file are the Direction Cosine Matrices (DCM) for the individual pixels or “apertures”. The following scheme, in a bottom-up approach, is used for their generation:

**** Step 1:***
The arrangement (relative geometric location) of SPIRE detectors of different bands listed as relevant “apertures” for the SIAM file are taken from the relevant SPIRE BDA EIDP and implemented at the relevant detector focal planes of the official (configuration control) optical models (BOLSP509 and BOLPHOT155 respectively) for SPIRE Spectrometer and Photometer channels (see RD1).

**** Step 2:***
Backward raytraces are performed in order to find the intercept of each relevant “apertures” with the telescope focal surface at SPIRE entrance focal plane. This is done in the official ESA coordinate system (as defined by the optical interface, see the ICDs in AD2). These are reported in details in Appendix 1.
This approach allows finding what each detector actually see and therefore points towards rather than what they are expected to receive/collect and allows taking into account the second order effect (non perfect telecentricity, residual field distortion) compared to a linear first-order plate-scale-based approach.

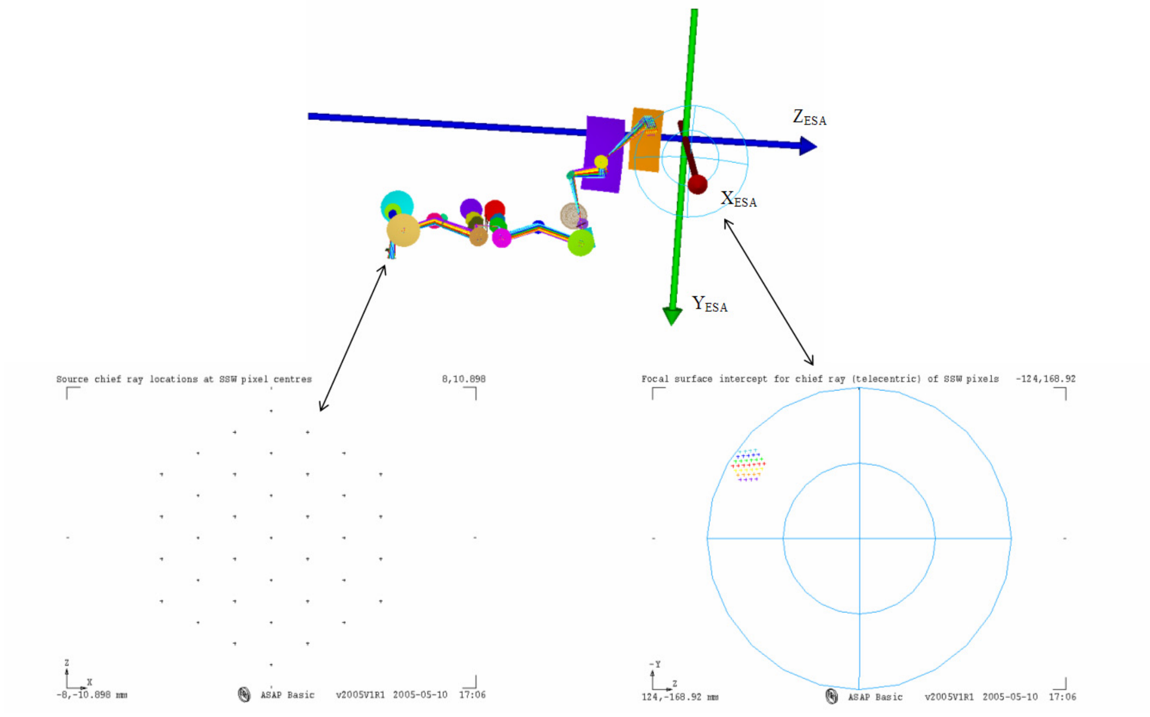

Figure 1: From detector layout at focal plane to optical interface plane with telescope

**** Step 3:***
Coordinates intercepts are then checked with measured data during ILT (PFM4 test campaign) when available for the relevant “apertures”. ILT tests are bound to be performed in same coordinate system

by the constraint of the set optical interface. The ESA coordinate system for the telescope is actually similar in axis orientation with the Herschel Spacecraft coordinate system as defined in AD1.

Step 4:
Confirmed intercepts are then further raytrace backward through the HSO telescope, up to far-field object-space of the telescope (on-sky region) where the geometric centroid of the individual "apertures" beam is now defined in term of direction cosine vector, representing the "apertures" line-of-sight (LOS). These are reported in details in Appendix 1.
NB: ***The final direction cosine vector coordinates are therefore dependent on the telescope parameters. Here the nominal baseline telescope design is used. Any deviations of the as-built HSO telescope wrt nominal design and/or of the relative position of SPIRE FPU flight model wrt telescope in the flight payload can impact the values of the "aperture" LOS.***

Step 5:
A Cartesian system based on right-handed orthonormal vector triad (u,v,w) is generated around the LOS for each aperture. The vector u is given by the respective direction cosine vector of the "aperture". The vectors v and w are obtained via the orthonormalisation procedure given in section 1.2.2 of AD1. The DCM is then generated first through individual coefficients as expressed in section 7.1.2 of AD1 and checked by an alternative more direct method.
A Matlab script, user-fed by the LOS for each "aperture", performing these computations is given in Appendix 3, along side its standard output on an example. Multiple verification of (u,v,w) orthonormality and of DCM orthonormality as a 3x3 rotation matrix is also performed by the script.

This completes the process of generating the main data, i.e. the DCM, for each "aperture".

2. SIAM file data

Below are listed the SIAM file data, in the format defined by AD1, for the nominal detector list in Appendix 2.

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S52_0 2007-05-22T10:50:13Z
+9.9999280559282370D-01 +2.4340900136135340D-03 +2.9092900162712630D-03
-2.4340797125002280D-03 +9.9999703759851500D-01 -7.0814947535420120D-06
-2.9092986347818600D-03 -8.4703294725430030D-22 +9.9999576798177190D-01

S53_0 2007-05-22T10:50:13Z
+9.9999401258012620D-01 +2.0294500255308900D-03 +2.8028800352607960D-03
-2.0294420536641970D-03 +9.9999794066417660D-01 -5.6883166732743460D-06
-2.8028858073439480D-03 +0.0000000000000000D-00 +9.9999607190786060D-01

S54_0 2007-05-22T10:50:13Z
+9.9999333367114390D-01 +2.3115300778323810D-03 +2.8265600951741460D-03
-2.3115208438468870D-03 +9.9999732841078080D-01 -6.5336961321479430D-06
-2.8265676466017980D-03 -8.4703294725430030D-22 +9.9999600524969040D-01

3. Additional SIAM file data (SLW)

Initially only the SSW detectors may have been thought to be relevant for the SPIRE Spectrometer channel because some SSW detectors were originally co-aligned with SLW ones. Actually since the inclusion of the field lenses in the Spectrometer optics (see RD1), the detector plane focal ratio changed and is now different between SLW and SSW, leading to non-perfect co-alignment of most detectors between these 2 bands except the central ones. So while SLW-C3 and SSW-D4 still share the same SPIRE aperture (viz. S24), there is a possible need for the SIAM file data to take into account the remaining SLW detectors as well.
AD1 (in its Annex A) allows up to 75 different elements to be included. From section 2 above and Appendix 2, it can be seen that nominally only 54 are used so that additional 18 for SLW detectors will still fit in the total allocation of the SIAM file for SPIRE. The same procedure as described in section 1 was applied and resulting SIAM file data for these “apertures” (link with SPIRE SLW detectors can be found from table at the end of Appendix 1).

S56_0 2007-05-23T09:22:26Z
+9.9999314122494310D-01 +1.8925000780187430D-03 +3.1837001312487570D-03
-1.8924904868202930D-03 +9.9999820922012400D-01 -6.0251635365181680D-06
-3.1837058325650940D-03 +0.0000000000000000D-00 +9.9999493199574350D-01

S57_0 2007-05-23T09:22:26Z
+9.9999201090356800D-01 +2.3870000260270250D-03 +3.2063000349603900D-03
-2.3869877563158890D-03 +9.9999715111137980D-01 -7.6534600707562040D-06
-3.2063091693780950D-03 +1.6940658945086010D-21 +9.9999485977754430D-01

S58_0 2007-05-23T09:22:26Z
+9.9999355207658030D-01 +1.6372999215344830D-03 +3.1960998468309780D-03
-1.6372915589369630D-03 +9.9999865962358530D-01 -5.2329810425971010D-06
-3.1961041308135740D-03 +0.0000000000000000D-00 +9.9999489244614910D-01

S59_0 2007-05-23T09:22:26Z
+9.9999132198492460D-01 +2.6228000576625620D-03 +3.2368000711614230D-03
-2.6227863181582760D-03 +9.9999656045401360D-01 -8.4895086133396410D-06
-3.2368112043224100D-03 -1.6940658945086010D-21 +9.9999476151289310D-01

S60_0 2007-05-23T09:22:26Z
+9.9999224737182890D-01 +2.0009000947870320D-03 +3.3914001606580740D-03
-2.0008885879365640D-03 +9.9999799819740180D-01 -6.7858664868866610D-06
-3.3914069495853170D-03 +8.4703294725430030D-22 +9.9999424916291510D-01

S61_0 2007-05-23T09:22:26Z
+9.9999170060615000D-01 +2.2438000013600900D-03 +3.4006000020612910D-03
-2.2437870275154840D-03 +9.9999748267760850D-01 -7.6302854971387830D-06
-3.4006085624893700D-03 +1.6940658945086010D-21 +9.9999421791398610D-01

S62_0 2007-05-23T09:22:26Z
+9.9999268285154060D-01 +1.7517999699591100D-03 +3.4007999416810940D-03
-1.7517898397297960D-03 +9.9999846559725540D-01 -5.9575303769248430D-06
-3.4008051598858650D-03 +8.4703294725430030D-22 +9.9999421724541200D-01

S63_0 2007-05-23T09:22:26Z
+9.9999106451398770D-01 +2.4791999120222950D-03 +3.4240998784912640D-03
-2.4791853782502910D-03 +9.9999692677917580D-01 -8.4890542062492550D-06
-3.4241104015386550D-03 -3.3881317890172010D-21 +9.9999413771679590D-01

S64_0 2007-05-23T09:22:26Z
+9.9999128442309860D-01 +2.1055799672013030D-03 +3.6052199438413550D-03
-2.1055662833416650D-03 +9.9999778326404390D-01 -7.5910957185617880D-06
-3.6052279356797500D-03 -8.4703294725430030D-22 +9.9999350114464840D-01

S65_0 2007-05-23T09:22:26Z
+9.9999180350377400D-01 +1.8549900064995190D-03 +3.5988800126097660D-03
-1.8549779935621150D-03 +9.9999827950455790D-01 -6.6758979438339640D-06
-3.5988862044770780D-03 +0.0000000000000000D-00 +9.9999352398807430D-01

S66_0 2007-05-23T09:22:26Z
+9.9999071800740000D-01 +2.3387400421150190D-03 +3.6185900651620040D-03
-2.3387247300231570D-03 +9.9999726514376800D-01 -8.4629646263855230D-06
-3.6185999615126600D-03 +0.0000000000000000D-00 +9.9999345284572650D-01

S67_0 2007-05-23T09:22:26Z
+9.9999350909120990D-01 +2.0344100184953690D-03 +2.9737100270347980D-03
-2.0344010233438690D-03 +9.9999793058579710D-01 -6.0497579905548360D-06
-2.9737161808852980D-03 -8.4703294725430030D-22 +9.9999557849626290D-01

S68_0 2007-05-23T09:22:26Z
+9.9999291786605130D-01 +2.2874500408679890D-03 +2.9886100533950390D-03
-2.2874398252799660D-03 +9.9999738378273300D-01 -6.8363140740598890D-06
-2.9886178722687210D-03 +2.5410988417629010D-21 +9.9999553407163440D-01

S69_0 2007-05-23T09:22:26Z
+9.9999398529876270D-01 +1.7755399738972090D-03 +2.9793999561988710D-03
-1.7755320932768610D-03 +9.9999842372765810D-01 -5.2900520590214340D-06
-2.9794046525520190D-03 +0.0000000000000000D-00 +9.9999556156410830D-01

S70_0 2007-05-23T09:22:26Z
+9.9999225027372030D-01 +2.5310498741393310D-03 +3.0154898500497460D-03
-2.5310383663946220D-03 +9.9999679688813740D-01 -7.6323796528026470D-06
-3.0154995090319960D-03 +0.0000000000000000D-00 +9.9999545337101960D-01

S71_0 2007-05-23T09:22:26Z
+9.9999380648938390D-01 +2.1733100141035300D-03 +2.7683400179649320D-03
-2.1733016862432470D-03 +9.9999763835900270D-01 -6.0164752922414440D-06
-2.7683465558056530D-03 +1.6940658945086010D-21 +9.9999616812133170D-01

S72_0 2007-05-23T09:22:26Z
+9.9999438483084010D-01 +1.9257199707882820D-03 +2.7426099583966780D-03
-1.9257127282022450D-03 +9.9999814579957800D-01 -5.2815085619427060D-06
-2.7426150437546490D-03 +0.0000000000000000D-00 +9.9999623902428850D-01

S73_0 2007-05-23T09:22:26Z
+9.9999317019497450D-01 +2.4259599276937080D-03 +2.7882399168958700D-03
-2.4259504975717830D-03 +9.9999705735488500D-01 -6.7641782117613880D-06
-2.7882481217205840D-03 +0.0000000000000000D-00 +9.9999611282865090D-01

4. Parallel Mode

In the Parallel Mode, PACS and SPIRE are operating in photometry mode simultaneously by definition (see RD2). The nominal LOS is logically at the centre/middle of the respective SPIRE and PACS Photometer FoV.
For SPIRE, “aperture” PSW E8 at the centre of the SPIRE Photometer FoV, is used as reference. Its SIAM matrix data is under label S14 above. For PACS, the on-sky angular coordinates are $Yc_{(PACS\ Phot)}$= 9.62 arcsec and $Zc_{(PACS\ Phot)}$= -623.78 arcsec[1]. Based on this, 2 approaches are possible:

- either defining the centre of these 2 references (which turns out to be very close to HIFI B6 channel at the telescope focal surface centre) at the telescope focal surface and generating the associated LOS vector on-sky;
- or generating the LOS vector for PACS Phot centre and averaging it with the one previously found for SPIRE PSW E8.

It was found that, for verification, these 2 approaches lead to on-sky LOS vector numerical coordinates with less than ~1.5% relative differences so that either of the 2 methods can be applied. From the LOS vector, the DCM matrix of the Parallel Mode can be found by application of the Step 5 in section 1 above which basically uses the procedure of AD1, implemented via the program listed in Appendix 3 of this note.
The SIAM file data to be used for the Parallel Mode aperture S55 is then:

S55_0 2007-07-18T16:59:26Z
+9.9999999737279010D-01 +2.3214879939000000D-05 +6.8669419820000020D-05
-2.3214879884265250D-05 +9.9999999973053470D-01 -1.5941523370316560D-09
-6.8669419838504040D-05 +0.0000000000000000D-00 +9.9999999764225540D-01

[1] Info from HSC spreadsheet via Sunil Sidher

Appendix 1 SPIRE Pixel Tables and SIAM Apertures

Below are given tables linking the pixel labelling as per PFM4 (last ILT performance test campaign on flight model including optical test data that can be used in relation to pixel location) and the SPIRE SIAM "aperture" list, given in Appendix 2, for the relevant SPIRE spectral bands (PSW, SSW and SLW). Illustration of the pixel labelling and related position in respective array and at telescope focal plane is also given.

- PSW band: only the 17 detectors listed in the SPIRE SIAM "aperture" list are reported here

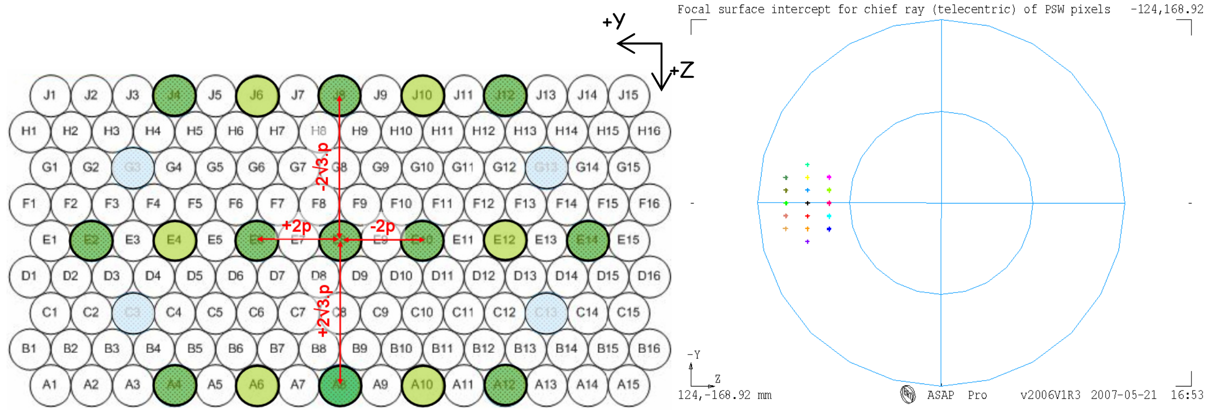

Figure 2: Left: Layout of PSW detector arrangement and labels as used in ILT. The bold circled ones are the one relevant for the SIAM file. **Right:** Image of their centres (seen from M2) at the telescope focal plane in the official coordinate system.

#Case of SPIRE Phot PSW				
#PixelNo	**Xesa**	**Yesa**	**Zesa**	***PFM4 label***
1	226.59	0.00	-90.08	E8
2	226.83	8.71	-90.10	E6
3	226.83	-8.71	-90.10	E10
4	227.56	17.44	-90.18	E4
5	227.56	-17.44	-90.18	E12
6	228.79	26.18	-90.31	E2
7	228.79	-26.18	-90.30	E14
8	219.24	0.00	-75.43	A8
9	219.49	8.81	-75.45	A6
10	219.48	-8.81	-75.45	A10
11	220.22	17.63	-75.51	A4
12	220.22	-17.62	-75.51	A12
13	235.31	0.00	-104.85	J8
14	235.56	8.64	-104.88	J6
15	235.56	-8.65	-104.88	J10
16	236.30	17.30	-104.98	J4
17	236.30	-17.30	-104.98	J12

#Case of SPIRE Phot PSW				
#PixelNo	**Aesa**	**Besa**	**Cesa**	***SIAM file ID***
1	0.999994900	0.000000000	0.003185500	14
2	0.999994900	-0.000297000	0.003178000	5
3	0.999994900	0.000297500	0.003178000	6
4	0.999994800	-0.000605000	0.003168400	13
5	0.999994800	0.000604900	0.003168000	15
6	0.999994600	-0.000917000	0.003166800	4
7	0.999994600	0.000917800	0.003166500	7
8	0.999996500	0.000000000	0.002649600	2
9	0.999996500	-0.000305000	0.002646100	11
10	0.999996500	0.000305660	0.002646040	12
11	0.999996300	-0.000615900	0.002640640	1
12	0.999996300	0.000615860	0.002640460	3
13	0.999993100	0.000000100	0.003702430	9
14	0.999993100	-0.000296400	0.003698870	16
15	0.999993100	0.000296670	0.003698780	17
16	0.999993000	-0.000601700	0.003695780	8
17	0.999993000	0.000601920	0.003695600	10

Table 1: Summary of the Telescope focal plane intercepts (in mm in ESA coordinate system) and the direction cosine vector coordinates for PSW detectors. The SIAM file identifier is added to allow link and traceability with respective relevant detector.

- SSW band: all 37 detectors are included

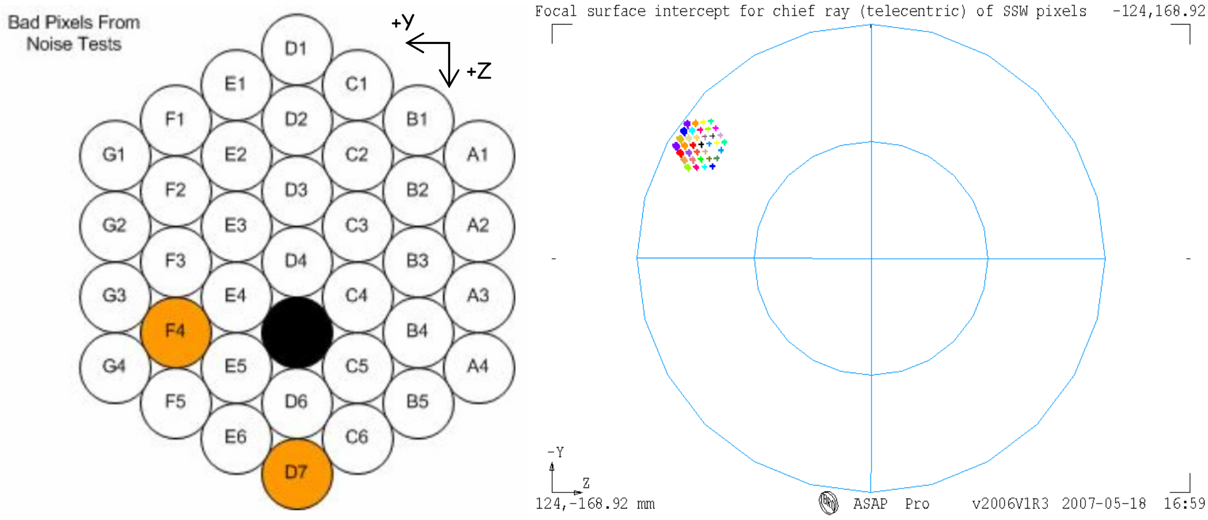

Figure 3: Left: Layout of SSW detector arrangement and labels as used in ILT. **Right:** Image of their centres (seen from M2) at the telescope focal plane in the official coordinate system

#Case of SPIRE Spectro SSW #PixelNo	Xesa	Yesa	Zesa	*PFM4 label*	#Case of SPIRE Spectro SSW #PixelNo	Aesa	Besa	Cesa	*SIAM file ID*
1	237.50	-60.40	-89.82	D4	1	0.999992600	0.002143800	0.003186200	24
2	239.77	-60.05	-94.11	D3	2	0.999992100	0.002133900	0.003341100	37
3	235.41	-60.76	-85.63	D5	3	0.999993100	0.002155700	0.003034400	48
4	242.21	-59.73	-98.49	D2	4	0.999991600	0.002123300	0.003501500	34
5	233.46	-61.12	-81.52	D6	5	0.999993500	0.002167000	0.002886900	51
6	244.83	-59.42	-102.96	D1	6	0.999991100	0.002113700	0.003664200	18
7	231.64	-61.49	-77.45	D7	7	0.999993900	0.002181000	0.002740200	30
8	240.76	-68.08	-90.31	B3	8	0.999992000	0.002401100	0.003200700	25
9	242.95	-67.66	-94.53	B2	9	0.999991500	0.002387100	0.003352100	38
10	238.73	-68.52	-86.17	B4	10	0.999992400	0.002417310	0.003054710	49
11	245.33	-67.25	-98.86	B1	11	0.999991000	0.002371500	0.003504130	35
12	236.85	-68.97	-82.12	B5	12	0.999992800	0.002434090	0.002909290	52
13	234.88	-52.53	-89.96	F3	13	0.999993200	0.001860170	0.003173020	23
14	237.23	-52.28	-94.31	F2	14	0.999992700	0.001854350	0.003330750	36
15	232.70	-52.79	-85.69	F4	15	0.999993700	0.001867670	0.003019940	47
16	239.77	-52.06	-98.75	F1	16	0.999992200	0.001849570	0.003490870	33
17	230.66	-53.05	-81.51	F5	17	0.999994100	0.001876480	0.002870220	50
18	240.15	-64.07	-92.11	C3	18	0.999992100	0.002268820	0.003272150	41
19	238.01	-64.46	-87.90	C4	19	0.999992500	0.002281370	0.003121110	45
20	242.46	-63.69	-96.41	C2	20	0.999991600	0.002256070	0.003425580	21
21	236.02	-64.87	-83.78	C5	21	0.999992900	0.002294900	0.002972920	28
22	244.96	-63.33	-100.82	C1	22	0.999991100	0.002242490	0.003583030	32
23	234.18	-65.28	-79.72	C6	23	0.999993300	0.002311530	0.002826560	54
24	237.24	-56.34	-91.96	E3	24	0.999992700	0.002000000	0.003255360	40
25	235.02	-56.64	-87.69	E4	25	0.999993200	0.002009650	0.003100550	44
26	239.63	-56.05	-96.32	E2	26	0.999992200	0.001992870	0.003412500	20
27	236.02	-64.87	-83.78	E5	27	0.999992900	0.002294900	0.002972920	27
28	242.21	-55.78	-100.79	E1	28	0.999991600	0.001985360	0.003575890	31
29	231.03	-57.27	-79.38	E6	29	0.999994000	0.002029450	0.002802880	53
30	243.68	-71.63	-92.86	A2	30	0.999991400	0.002523350	0.003286920	42
31	241.60	-72.10	-88.70	A3	31	0.999991900	0.002537490	0.003137340	46
32	245.92	-71.15	-97.11	A1	32	0.999991000	0.002505440	0.003435210	22
33	239.67	-72.58	-84.64	A4	33	0.999992300	0.002554000	0.002992400	29
34	235.01	-48.43	-92.45	G2	34	0.999993200	0.001712460	0.003253780	39
35	232.69	-48.63	-88.11	G3	35	0.999993700	0.001716650	0.003099600	43
36	237.50	-48.26	-96.89	G1	36	0.999992700	0.001708360	0.003414100	19
37	230.52	-48.86	-83.82	G4	37	0.999994200	0.001722590	0.002942930	26

Table 2: Summary of the Telescope focal plane intercepts (in mm in ESA coordinate system) and the direction cosine vector coordinates for SSW detectors. The SIAM file identifier is added to allow link and traceability with respective relevant detector.

- SLW band: all detectors are included (see section 3 for justification)

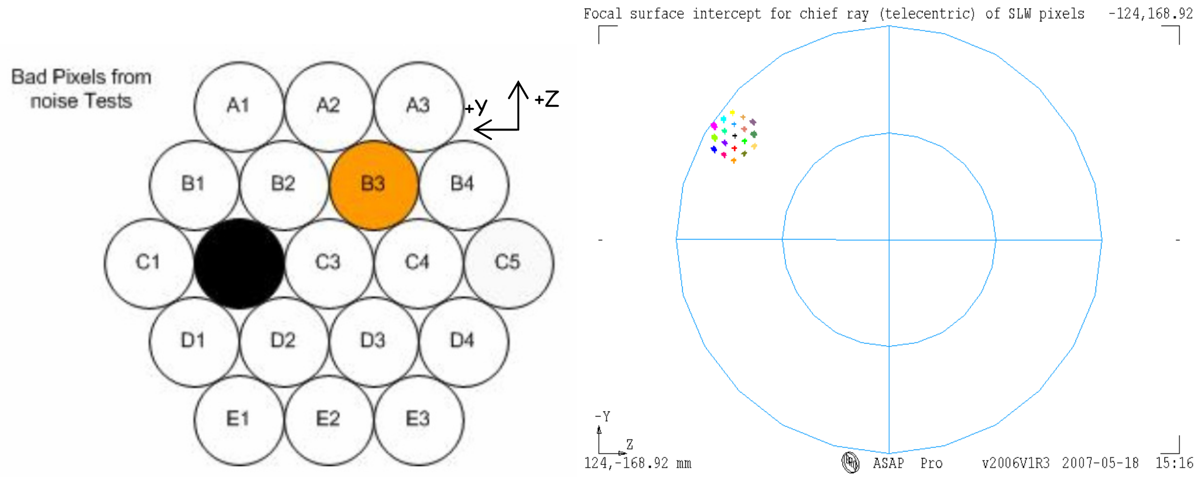

Figure 4: Left: Layout of SLW detector arrangement and labels as used in ILT. **Right:** Image of their centres (seen from M2) at the telescope focal plane in the official coordinate system

#Case of #PixelNo	SPIRE **Xesa**	Spectro **Yesa**	SLW **Zesa**	***PFM4 label***	#Case of #PixelNo	SPIRE **Aesa**	Spectro **Besa**	SLW **Cesa**	***SIAM file ID***
1	235.12	-53.34	-89.92	**C2**	1	0.9999931000	0.001892500	0.003183700	56
2	240.39	-67.29	-90.23	**C4**	2	0.9999920000	0.002387000	0.003206300	57
3	233.27	-46.10	-90.51	**C1**	3	0.9999936000	0.001637300	0.003196100	58
4	243.76	-74.02	-91.12	**C5**	4	0.9999913000	0.002622800	0.003236800	59
5	239.38	-56.48	-95.63	**D2**	5	0.9999922000	0.002000900	0.003391400	60
6	241.91	-63.34	-95.71	**D3**	6	0.9999917000	0.002243800	0.003400600	61
7	237.40	-49.49	-96.09	**D1**	7	0.9999927000	0.001751800	0.003400800	62
8	244.97	-70.05	-96.29	**D4**	8	0.9999911000	0.002479200	0.003424100	63
9	243.98	-59.50	-101.56	**E2**	9	0.9999913000	0.002105580	0.003605220	64
10	241.78	-52.55	-101.82	**E1**	10	0.9999918000	0.001854990	0.003598880	65
11	246.66	-66.14	-101.80	**E3**	11	0.9999907000	0.002338740	0.003618590	66
12	233.40	-57.30	-84.12	**B2**	12	0.9999935000	0.002034410	0.002973710	67
13	236.14	-64.41	-84.36	**B3**	13	0.9999929000	0.002287450	0.002988610	68
14	231.16	-50.02	-84.39	**B1**	14	0.9999940000	0.001775540	0.002979400	69
15	239.36	-71.34	-85.08	**B4**	15	0.9999923000	0.002531050	0.003015490	70
16	232.16	-61.37	-78.65	**A2**	16	0.9999938000	0.002173310	0.002768340	71
17	229.62	-54.37	-78.48	**A1**	17	0.9999944000	0.001925720	0.002742610	72
18	235.23	-68.52	-79.19	**A3**	18	0.9999932000	0.002425960	0.002788240	73

Table 3: Summary of the Telescope focal plane intercepts (in mm in ESA coordinate system) and the direction cosine vector coordinates for SLW detectors. The SIAM file identifier is added to allow link and traceability with respective relevant detector.

Appendix 2 SPIRE Aperture Identifiers

Nominal list of SIAM aperture identifiers are listed below with their SPIRE detector counterparts. The additional SLW aperture identifiers are highlighted in yellow.

Aperture	*Description*
S01_s	PSW Array: Bolometer A4 Co-aligned
S02_s	PSW Array: Bolometer A8 Co-aligned
S03_s	PSW Array: Bolometer A12 Co-aligned
S04_s	PSW Array: Bolometer E2 Co-aligned
S05_s	PSW Array: Bolometer E6 Co-aligned
S06_s	PSW Array: Bolometer E10 Co-aligned
S07_s	PSW Array: Bolometer E14 Co-aligned
S08_s	PSW Array: Bolometer J4 Co-aligned
S09_s	PSW Array: Bolometer J8 Co-aligned
S10_s	PSW Array: Bolometer J12 Co-aligned
S11_s	PSW Array: Bolometer A6
S12_s	PSW Array: Bolometer A10
S13_s	PSW Array: Bolometer E4
S14_s	PSW Array: Bolometer E8
S15_s	PSW Array: Bolometer E12
S16_s	PSW Array: Bolometer J6
S17_s	PSW Array: Bolometer J10
S18_s	SSW Array: Bolometer D1 Co-aligned
S19_s	SSW Array: Bolometer G1 Co-aligned
S20_s	SSW Array: Bolometer E2 Co-aligned
S21_s	SSW Array: Bolometer C2 Co-aligned
S22_s	SSW Array: Bolometer A1 Co-aligned
S23_s	SSW Array: Bolometer F3 Co-aligned
S24_s	SSW Array: Bolometer D4 Co-aligned
S25_s	SSW Array: Bolometer B3 Co-aligned
S26_s	SSW Array: Bolometer G4 Co-aligned
S27_s	SSW Array: Bolometer E5 Co-aligned
S28_s	SSW Array: Bolometer C5 Co-aligned
S29_s	SSW Array: Bolometer A4 Co-aligned
S30_s	SSW Array: Bolometer D7 Co-aligned
S31_s	SSW Array: Bolometer E1
S32_s	SSW Array: Bolometer C1
S33_s	SSW Array: Bolometer F1
S34_s	SSW Array: Bolometer D2
S35_s	SSW Array: Bolometer B1
S36_s	SSW Array: Bolometer F2
S37_s	SSW Array: Bolometer D3
S38_s	SSW Array: Bolometer B2
S39_s	SSW Array: Bolometer G2
S40_s	SSW Array: Bolometer E3
S41_s	SSW Array: Bolometer C3
S42_s	SSW Array: Bolometer A2
S43_s	SSW Array: Bolometer G3
S44_s	SSW Array: Bolometer E4
S45_s	SSW Array: Bolometer C4
S46_s	SSW Array: Bolometer A3
S47_s	SSW Array: Bolometer F4
S48_s	SSW Array: Bolometer D5
S49_s	SSW Array: Bolometer B4
S50_s	SSW Array: Bolometer F5
S51_s	SSW Array: Bolometer D6
S52_s	SSW Array: Bolometer B5
S53_s	SSW Array: Bolometer E6
S54_s	SSW Array: Bolometer C6

S55_s	SPIRE Parallel Mode
S56_s	SLW Array: Bolometer C2
S57_s	SLW Array: Bolometer C4
S58_s	SLW Array: Bolometer C1
S59_s	SLW Array: Bolometer C5
S60_s	SLW Array: Bolometer D2
S61_s	SLW Array: Bolometer D3
S62_s	SLW Array: Bolometer D1
S63_s	SLW Array: Bolometer D4
S64_s	SLW Array: Bolometer E2
S65_s	SLW Array: Bolometer E1
S66_s	SLW Array: Bolometer E3
S67_s	SLW Array: Bolometer B2
S68_s	SLW Array: Bolometer B3
S69_s	SLW Array: Bolometer B1
S70_s	SLW Array: Bolometer B4
S71_s	SLW Array: Bolometer A2
S72_s	SLW Array: Bolometer A1
S73_s	SLW Array: Bolometer A3

Appendix 3 DCM Generation Code

Below is given the Matlab script used to generate DCM from and its screen output (in the case of PSW E8).

```
%
% SPIRE_SIAM_generator.m
% Matlab script to generate matrix of SIAM file
% Marc Ferlet, RAL/SSTD, March 07
%

% initialisation
clear all
close all

DCM=zeros(3);

x=[1;0;0]; % X_SCA reference vector
y=[0;1;0]; % Y_SCA reference vector
z=[0;0;1]; % Z_SCA reference vector

disp(' ');
disp('**********************************************************************');
disp('*                    SPIRE SIAM file generator                       *');
disp('*               Marc Ferlet, STFC-RAL/SSTD, March 07                 *');
disp('**********************************************************************');
disp(' ');

% generation of the orthonormal INS vectors, based on LOS for a given aperture
disp(' ');
u=input('-> Enter the aperture LOS: ');  % Dir cos of pixel LOS from ASAP model; example of PSWE8 is [0.999994 0 0.0031855]

u=u.';                                 % transposition for ease of handling below
u=u/norm(u);          % normalisation (not necessary as already done by definition of dir cos vector)

v=y-sum(u.*y)*u; % orthogonalisation of y wrt u=LOS
v=v/norm(v);     % normalisation

w=cross(u,v);    % generation of last orthogonal vector of the INS right-hand triedre (u,v,w)


% manual (i.e. not vectorised) generation of the DCM
% by generation of the matrix element through individual vector scalar products
DCM(1,1)=sum(u.*x);
DCM(2,1)=sum(v.*x);
DCM(3,1)=sum(w.*x);

DCM(1,2)=sum(u.*y);
DCM(2,2)=sum(v.*y);
DCM(3,2)=sum(w.*y);

DCM(1,3)=sum(u.*z);
DCM(2,3)=sum(v.*z);
DCM(3,3)=sum(w.*z);

format +;format long e

disp(' ');disp(' And the Direction Cosine Matrix is: ');
DCM     % print the matrix in long format

% for verification/validation of orthonormalisation procedure
format
disp(' ');disp('-> Verification of :');disp(' ');
disp(' => Dot products on INS=(u,v,w) basis vectors (should be 0): ');
sum(u.*v)
sum(u.*w)
sum(v.*w)
disp(' ');disp(' => Cross-products in INS=(u,v,w) basis (should be [0 0 0]): ');
(cross(u,v)-w).'
```

```
(cross(v,w)-u).'
(cross(w,u)-v).'
disp(' '); disp(' => Determinant of DCM (should be 1): ');det(DCM)
disp(' '); disp(' => Orthogonality of DCM (should be I_3 matrix): ');DCM*DCM.'
disp(' '); disp(' => Transfer from INS=(u,v,w) to SCA=(x,y,z) (should be [0 0 0]): ');
(DCM*u-x).'
(DCM*v-y).'
(DCM*w-z).'
disp(' '); disp(' => Transfer from SCA=(x,y,z) to INS=(u,v,w) (should be [0 0 0]): ');
(DCM.'*x-u).'
(DCM.'*y-v).'
(DCM.'*z-w).'
disp(' ');disp(' -> Alternative (more direct/vectorised) way to generate the DCM: ');
format long e;DCM_altern=[u.'/x(1);v.'/y(2);w.'/z(3)]
disp(' ');
format long;DCM-DCM_altern   % this should be 0 / verification that the 2 methods give the same result

return;
```

```
**********************************************************************
*                     SPIRE SIAM file generator                       *
*              Marc Ferlet, STFC-RAL/SSTD, March 07                   *
**********************************************************************

-> Enter the aperture LOS: [0.999994 0 0.0031855]

 And the Direction Cosine Matrix is:

DCM =
   9.999949262726043e-001                        0    3.185502950659085e-003
                        0    1.000000000000000e+000                        0
  -3.185502950659085e-003                        0    9.999949262726043e-001

-> Verification of :

 => Dot products on INS=(u,v,w) basis vectors (should be 0):

ans =
     0

ans =
     0

ans =
     0

 => Cross-products in INS=(u,v,w) basis (should be [0 0 0]):

ans =
     0     0     0

ans =
     0     0     0

ans =
     0     0     0

 => Determinant of DCM (should be 1):

ans =
     1

 => Orthogonality of DCM (should be I_3 matrix):
```

```
ans =
     1     0     0
     0     1     0
     0     0     1

 => Transfer from INS=(u,v,w) to SCA=(x,y,z):

ans =
     0     0     0

ans =
     0     0     0

ans =
     0     0     0

 => Transfer from SCA=(x,y,z) to INS=(u,v,w) (should be [0 0 0]):

ans =
     0     0     0

ans =
     0     0     0

ans =
     0     0     0

 -> Alternative (more direct/vectorised) way to generate the DCM:

DCM_altern =
   9.999949262726043e-001                        0    3.185502950659085e-003
                        0    1.000000000000000e+000                        0
  -3.185502950659085e-003                        0    9.999949262726043e-001


verif =

     0     0     0
     0     0     0
     0     0     0
```