



Technical Note

SPIRE Spacecraft-Instrument
Alignment Matrix (SPIRE SIAM)

Ref: SPIRE-RAL-NOT-
002881

Issue: 1.0

Date: 23/05/2007

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TITLE: SPIRE Spacecraft-Instrument Alignment Matrix (SIAM)

By: Marc Ferlet (RAL)

DISTRIBUTION

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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

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1. General description
2. SIAM file data
3. Additional SIAM file data (SLW)

Appendix 1

Appendix 2

Appendix 3

APPLICABLE AND REFERENCE DOCUMENTS

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



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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 (under configuration control) optical models (BOLSP509 and POLPHOT155 respectively) for SPIRE Spectrometer and Photometer channels.

* 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). 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.

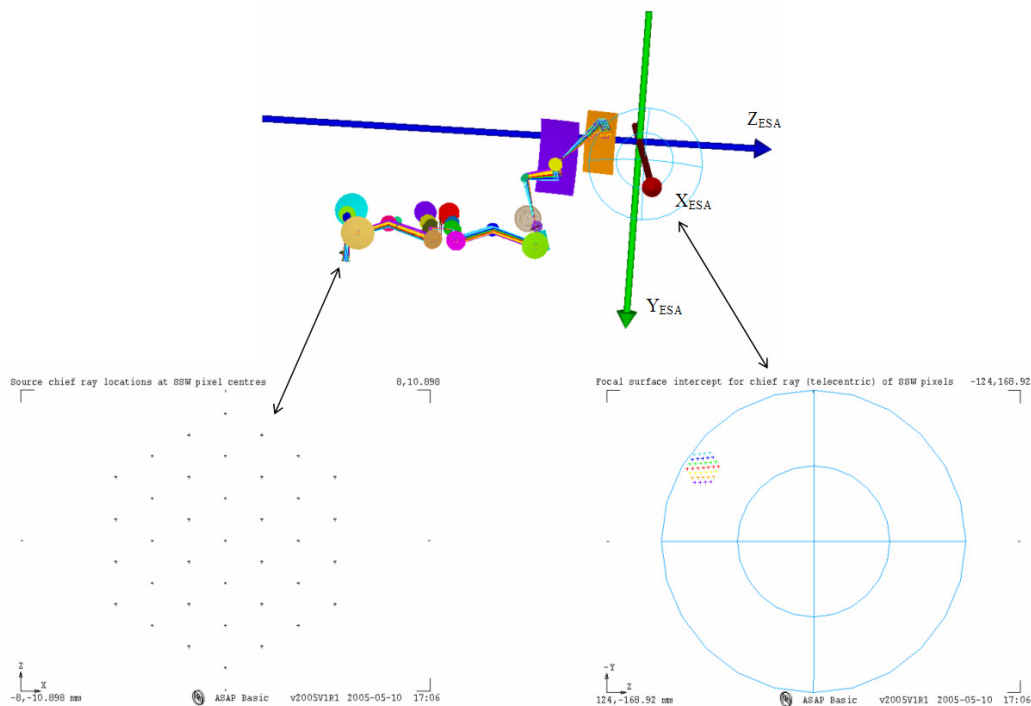


Figure 1: From detector layout at focal plane to optical interface plane with telescope

* 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.



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* 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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S49_0 2007-05-22T10:50:13Z

+9.9999241265061400D-01 +2.4173100305806880D-03 +3.0547100386442510D-03
-2.4172987522222290D-03 +9.9999707830183980D-01 -7.3842027913419790D-06
-3.0547189636110270D-03 +0.0000000000000000D-00 +9.9999533433514240D-01

S50_0 2007-05-22T10:50:13Z

+9.9999412031245640D-01 +1.8764800381161430D-03 +2.8702200583015630D-03
-1.8764723086986260D-03 +9.9999823940978350D-01 -5.3859201268017180D-06
-2.8702251115918140D-03 +8.4703294725430030D-22 +9.9999588089542090D-01

S51_0 2007-05-22T10:50:13Z

+9.9999348493866820D-01 +2.1669999673618820D-03 +2.8868999565191590D-03
-2.1669909372044610D-03 +9.9999765205281430D-01 -6.2559268001397600D-06
-2.8869067348237020D-03 +0.0000000000000000D-00 +9.9999583287606980D-01

S52_0 2007-05-22T10:50:13Z



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+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. Some SSW detectors are said co-aligned (i.e. with SLW ones). Actually since the inclusion of the filed lenses in the Spectrometer optics, the detector plane focal ratio changed and is now different between SLW and SSW, leading to none-perfect co-alignment of most detectors between these 2 bands except the central one. Hence, there is a possible need for the SIAM file data to take into account the 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 19 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).

Note that due the last co-aligned pair left (central detector of each Spectrometer band), S55 and S24 are actually similar as their associated detectors point in the same angular direction of the sky.

S55_0 2007-05-23T09:22:26Z

+9.9999262504913070D-01 +2.1431000536831890D-03 +3.1870000798321710D-03
-2.1430891699046150D-03 +9.9999770355844320D-01 -6.8300757270463890D-06
-3.1870073986084030D-03 +8.4703294725430030D-22 +9.9999492147902500D-01

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



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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



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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



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Appendix 1

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

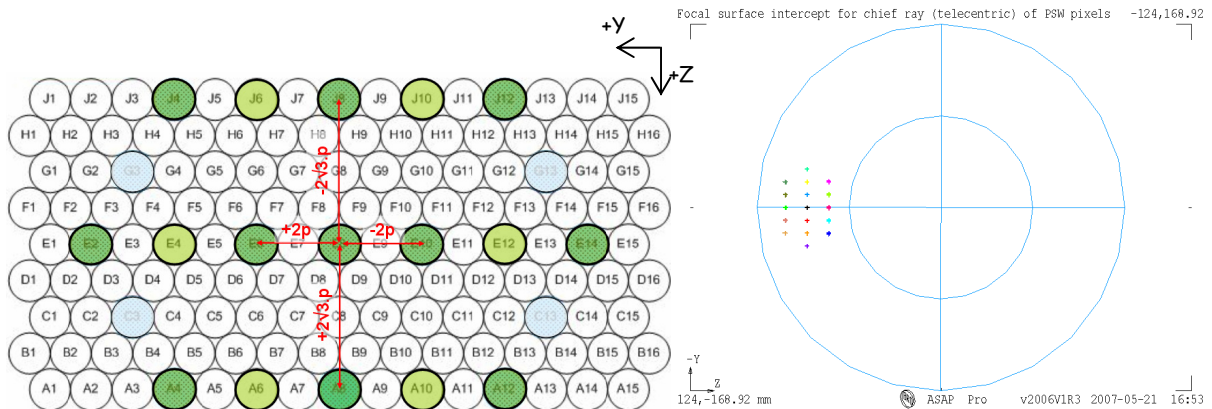


Figure 2: Left: Layout of PSW detector arrangement and labels as used in ILT. The bold circled ones are the one relevant for the SIAM file. Right: Image of their centres (seen from M2) at the telescope focal plane in the official coordinate system.

#Case of #PixelNo	Xesa	Yesa	Zesa	Phot PSW	PFM4 label	#Case of #PixelNo	Aesa	Besa	Cesa	Phot PSW	SIAM file ID
1	226.59	0.00	-90.08		E8	1	0.999994900	0.000000000	0.003185500		14
2	226.83	8.71	-90.10		E6	2	0.999994900	-0.000297000	0.003178000		5
3	226.83	-8.71	-90.10		E10	3	0.999994900	0.000297500	0.003178000		6
4	227.56	17.44	-90.18		E4	4	0.999994800	-0.000605000	0.003168400		13
5	227.56	-17.44	-90.18		E12	5	0.999994800	0.000604900	0.003168000		15
6	228.79	26.18	-90.31		E2	6	0.999994600	-0.000917000	0.003166800		4
7	228.79	-26.18	-90.30		E14	7	0.999994600	0.000917800	0.003166500		7
8	219.24	0.00	-75.43		A8	8	0.999996500	0.000000000	0.002649600		2
9	219.49	8.81	-75.45		A6	9	0.999996500	-0.000305000	0.002646100		11
10	219.48	-8.81	-75.45		A10	10	0.999996500	0.000305660	0.002646040		12
11	220.22	17.63	-75.51		A4	11	0.999996300	-0.000615900	0.002640640		1
12	220.22	-17.62	-75.51		A12	12	0.999996300	0.000615860	0.002640460		3
13	235.31	0.00	-104.85		J8	13	0.999993100	0.000000100	0.003702430		9
14	235.56	8.64	-104.88		J6	14	0.999993100	-0.000296400	0.003698870		16
15	235.56	-8.65	-104.88		J10	15	0.999993100	0.000296670	0.003698780		17
16	236.30	17.30	-104.98		J4	16	0.999993000	-0.000601700	0.003695780		8
17	236.30	-17.30	-104.98		J12	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.



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- SSW band: all 37 detectors are included

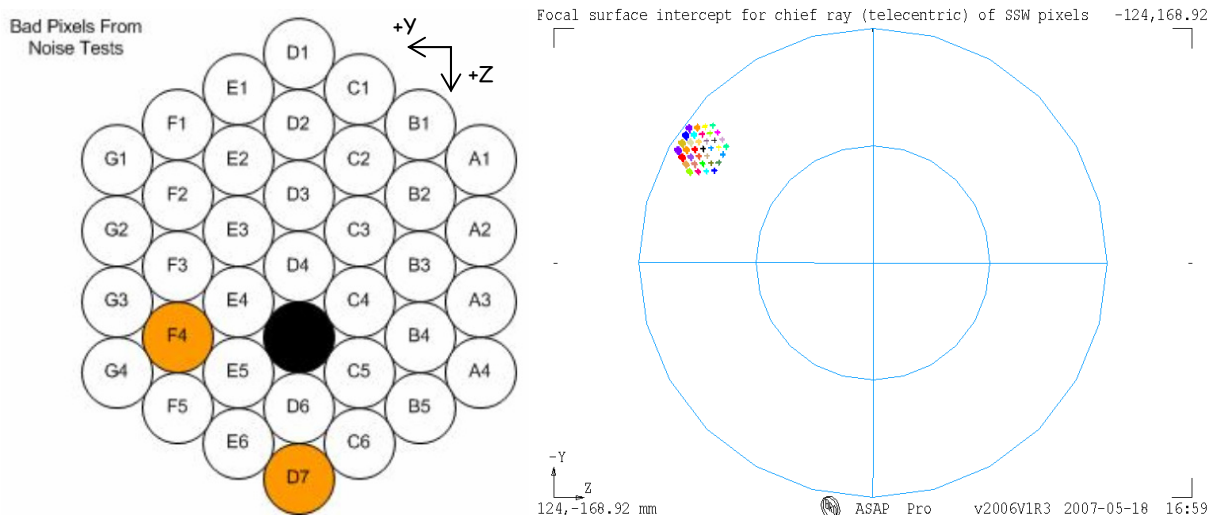


Figure 3: Left: Layout of SSW detector arrangement and labels as used in ILT. Right: Image of their centres (seen from M2) at the telescope focal plane in the official coordinate system

#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.



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

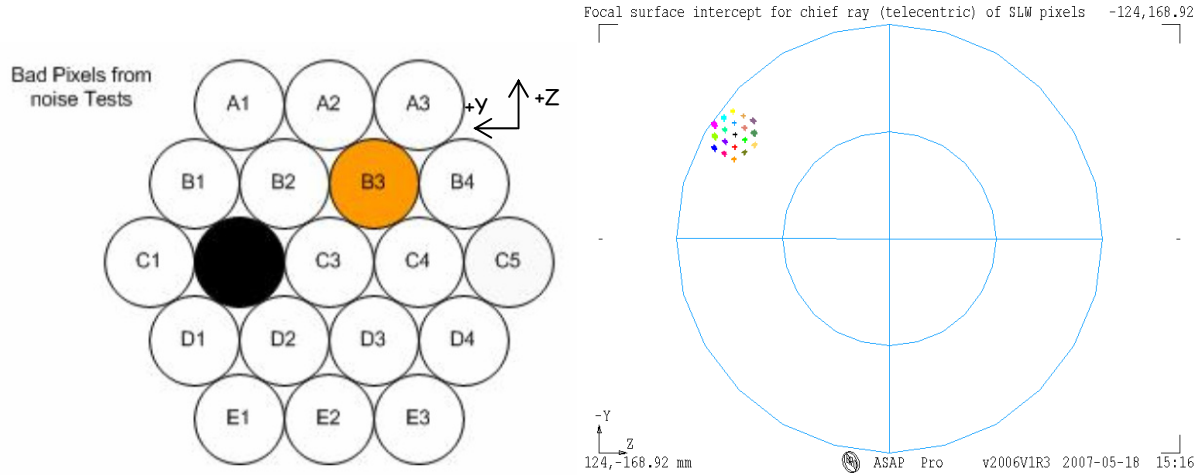


Figure 4: Left: Layout of SLW detector arrangement and labels as used in ILT. Right: Image of their centres (seen from M2) at the telescope focal plane in the official coordinate system

#Case of SPIRE Spectro SLW	#PixelNo of Xesa Yesa Zesa	PFM4 label	#Case of SPIRE Spectro SLW	#PixelNo of Aesa Besa Cesa	SIAM file ID
1	237.50 -60.39 -89.82	C3	1	0.999992600 0.002143100 0.003187000	55
2	235.12 -53.34 -89.92	C2	2	0.999993100 0.001892500 0.003183700	56
3	240.39 -67.29 -90.23	C4	3	0.999992000 0.002387000 0.003206300	57
4	233.27 -46.10 -90.51	C1	4	0.999993600 0.001637300 0.003196100	58
5	243.76 -74.02 -91.12	C5	5	0.999991300 0.002622800 0.003236800	59
6	239.38 -56.48 -95.63	D2	6	0.999992200 0.002000900 0.003391400	60
7	241.91 -63.34 -95.71	D3	7	0.999991700 0.002243800 0.003400600	61
8	237.40 -49.49 -96.09	D1	8	0.999992700 0.001751800 0.003400800	62
9	244.97 -70.05 -96.29	D4	9	0.999991100 0.002479200 0.003424100	63
10	243.98 -59.50 -101.56	E2	10	0.999991300 0.002105580 0.003605220	64
11	241.78 -52.55 -101.82	E1	11	0.999991800 0.001854990 0.003598880	65
12	246.66 -66.14 -101.80	E3	12	0.999990700 0.002338740 0.003618590	66
13	233.40 -57.30 -84.12	B2	13	0.999993500 0.002034410 0.002973710	67
14	236.14 -64.41 -84.36	B3	14	0.999992900 0.002287450 0.002988610	68
15	231.16 -50.02 -84.39	B1	15	0.999994000 0.001775540 0.002979400	69
16	239.36 -71.34 -85.08	B4	16	0.999992300 0.002531050 0.003015490	70
17	232.16 -61.37 -78.65	A2	17	0.999993800 0.002173310 0.002768340	71
18	229.62 -54.37 -78.48	A1	18	0.999994400 0.001925720 0.002742610	72
19	235.23 -68.52 -79.19	A3	19	0.999993200 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.



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Appendix 2

Nominal list of SIAM aperture identifiers with their SPIRE detector counterparts.

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



Technical Note

SPIRE Spacecraft-Instrument Alignment Matrix (SPIRE SIAM)

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Appendix 3

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 triad (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).'
```



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```
(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):



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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
```