TITLE: **Integration of Spectrometer PFM BDAs: alignment issues**

By: Marc Ferlet (RAL)

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CHANGE RECORD

ISSUE	DATE	SECTION	REASON FOR CHANGE
0.3	03/11/04	All	First issue of the document as TN (previously distributed as non-cc draft)

CONTENTS

APPLICABLE AND REFERENCE DOCUMENTS

RD1 Alignment Measurement Summary for PFM SLW BDA 10209800-4 SN008, Mark Weilert (JPL – 14 Dec 03), *as part of the delivered EIDP*

RD2 Alignment Measurement Summary for PFM SSW BDA 10209800-5 SN009, Mark Weilert (JPL – 31 Oct 04), *added in the delivered EIDP*

RD3 Alignment Requirements of detector arrays in SPIRE, SPIRE-RAL-NOT-000912 v0.3, Bruce Swinyard & Tony Richards (RAL, 17-Oct-2001)

This note briefly assesses the impact of the alignment measurements performed on PFM SLW and SSW BDAs (RD1 and RD2) wrt the integration of the respective BDAs into the SPIRE PFM FPU sub-assembly (Spectrometer detector box).

1. Defocus and lateral shift

From RD1 & RD2, the local coordinates system is reproduced below (originally from ICD). The local z axis is out-of-the plane of the figure.
NB: the local z axis is by design of the Spectrometer, parallel to the Y axis in the Herschel coordinates system.

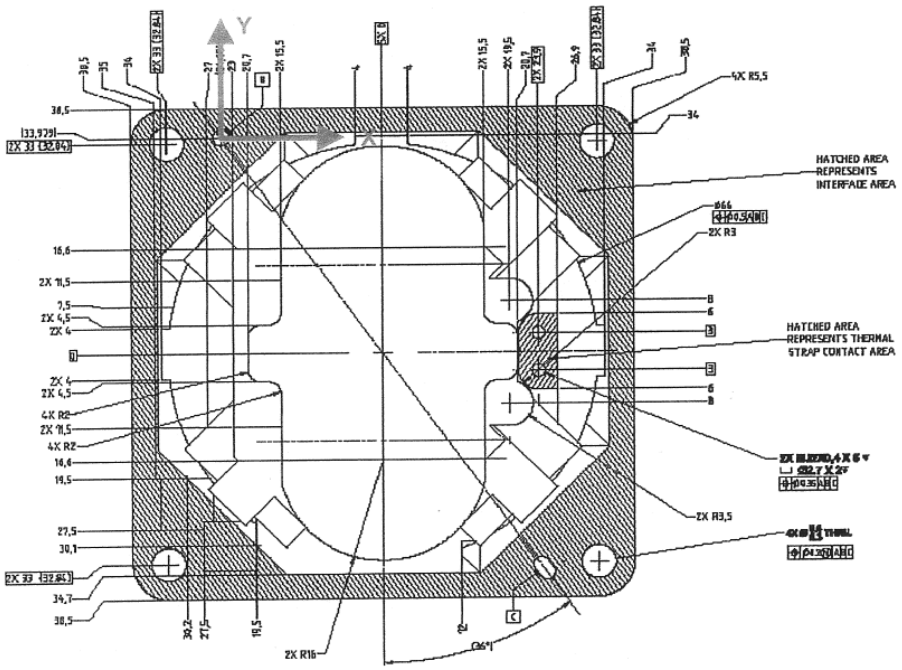


Figure 1 (excerpt from ICD dwg 10209721, with coordinate axes shown)

1.1 Case of SLW

The deviation found (total i.e. ambient and cold measurement from RD1) from the nominal plane along the local z axis is -0.185mm. This will translates into a defocus of the SLW BDA in operation wrt the nominal best focal plane. This is well within the +/-0.5mm allowed margin. This is therefore acceptable as it's a small value (about 2 orders of magnitude lower) when compared to the F/5 depth-of-focus at SLW wavelengths.

The lateral in-plane shift of the BDA centre wrt to nominal centre is found to be (total i.e. ambient and cold measurement):

- along X: - 0.247+/-0.05mm
- along Y: +0.379+/-0.05mm

so that the max displacement from centre is sqrt(dx^2+dy^2)~0.452+/-0.100mm. This represents ~11.6% of the SLW pixel size and, at the entrance focal plane (CFIL1 location), is equivalent to 0.802mm displacement which is within the oversize (wrt FoV) of the shaped aperture at CFIL1. Nevertheless this means that the centre of the SLW FoV is shifted on sky by ~5.65+/-0.5arcsec wrt the nominal location in the Herschel coordinates system but this does not affect directly the performances of the SLW channel.

1.2 Case of SSW

The deviation found (total i.e. ambient and cold measurement from RD2) from the nominal plane along the local z axis is +0.195mm. This will translates into a defocus of the SSW BDA in operation wrt the nominal best focal plane. This is well within the +/-0.5mm allowed margin. This is also acceptable as it's still a small value when compared to the F/5 depth-of-focus at SSW wavelengths.

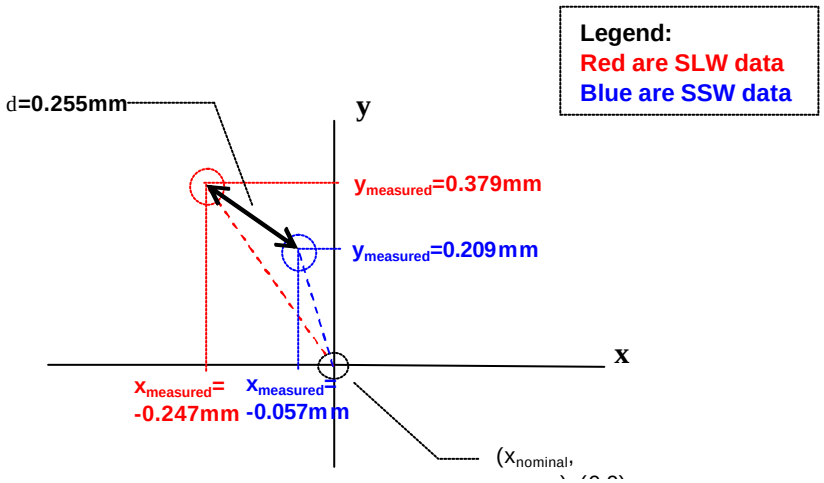
The lateral in-plane shift of the BDA centre wrt to nominal centre is found to be (total i.e. ambient and cold measurement):

- along X: - 0.057+/-0.05mm
- along Y: +0.209+/-0.05mm

so that the max displacement from centre is sqrt(dx^2+dy^2)~0.217+/-0.100mm. This represents ~9.6% of the SSW pixel size and, at the entrance focal plane (CFIL1 location), is equivalent to 0.377mm displacement which is within the oversize (wrt FoV) of the shaped aperture at CFIL1. Nevertheless this means that the centre of the SSW FoV is shifted on-sky by ~2.7+/-0.5arcsec wrt the nominal location in the Herschel coordinates system but this does not affect directly the performances of the SLW channel.

1.3 Conclusion

There is no direct requirement in RD3 wrt the in-plane lateral shift but a need to maintain co-alignment with SSW centre to within 120µm. Below is the illustrated summary of the BDAs centres lateral shift as-measured and reported in RD1 and RD2. The radial distance between SLW centre and SSW centre is twice the co-alignment specifications. ***It is therefore suggested to compensate at interface plate level SLW centre by 200mm along local –y and 200mm along local +x.***

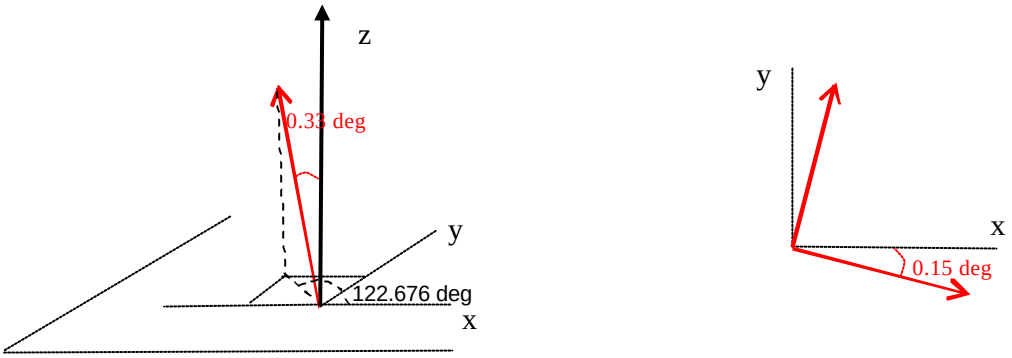


2. Tilt and rotation

2.1 Case of SLW

The measured tilt of the as-built x-y plane compared to the nominal one is found at ambient to be 0.33deg wrt the local z axis. Although this measurement is at ambient only, this is within the acceptable limit of

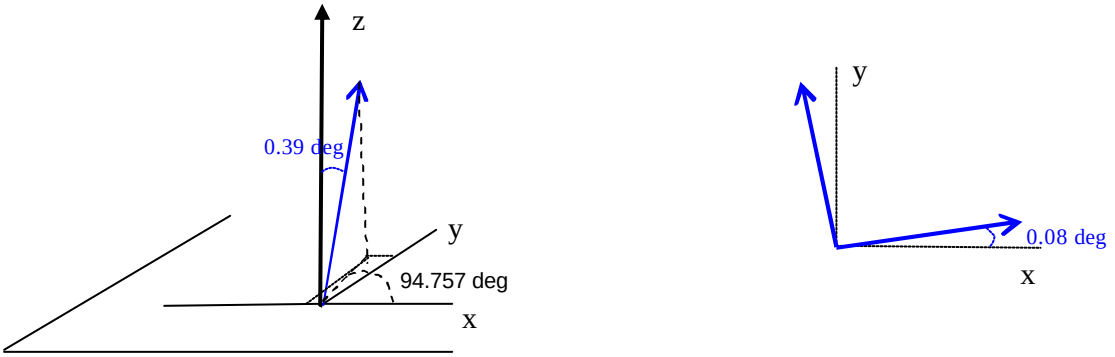
+/-30arcmin=+/-0.5deg tolerances around the gut ray which nominally is aligned with the local z axis at the centre of the array.



The in-plane rotation has been found (ambient + cold) to be 0.15deg which is within the specifications of 0.293deg (=17.6 arcmin stated in RD3). This should not affect significantly the chop & jiggle pattern (the "smile" pattern in RD3).

2.2 Case of SSW

The measured tilt of the as-built x-y plane compared to the nominal one is found at ambient to be 0.39deg wrt the local z axis. Although this measurement is at ambient only, this is within the acceptable limit of +/-30arcmin=+/-0.5deg tolerances around the gut ray which nominally is aligned with the local z axis at the centre of the array.
NB: in RD2, comments are made about a tilt about x of 0.34deg during cryo-cycling. The orientation is unknown and as well as if there is an associated rotation about y. If this tilt about x is positive, it will compensate almost completely the initial ambient one. If the tilt is negative, it will add to the ambient one (mostly in the yz plane as seen below) and will lead to a tilt beyond the initial specifications. It is not known if this tilt is reproducible over multiple cryo-cycles.



The in-plane rotation has been found (ambient + cold) to be 0.08deg which is within the specifications of 0.293deg (=17.6arcmin stated in RD3). This won't affect significantly the chop & jiggle pattern (the "smile" pattern in RD3).

2.3 Conclusion

From considerations above, it is suggested not to correct for SLW tilt and rotation as values are within specifications. ***For SSW, due to uncertainty wrt potentially large tilt of the BDA wrt the interface, it is suggested to compensate at interface plate level the known ambient tilt in the yz plane by a***

positive rotation of 0.4deg about local +x. This will give the full range of ±30arcmin allowed by specification for the eventual not well known and characterised tilt about x occurring during cooldown.

NB: It should be noticed that RD3 does not take into account the more recent addition of the field lens in front of each of the 2 Spectrometer BDAs. The combination of in-plane lateral shift above and tilt here for pixel. The additional field lens to improve telecentricity and incident beam adaptation to the planar location of the BDA feedhorn apertures is helping compensating. Small asymmetry (due to no symmetrical angular difference between pixel incident chief ray and as-built pixel boresight) between pixels at opposite edge of FoV could appear in beam coupling.

3. Conclusion and proposed corrective actions on respective interface plates

- SLW interface: The alignment data regarding the PFM SLW BDA indicates a location and orientation within the defined requirements to maintain the required performances. Only the in-plane (local x-y) lateral shift needs to be corrected, by shift of the mounting holes in the interface plate with detector box in the following way:
Displacement of the mounting points in interface plate wrt their nominal position by 200µm in x and -200µm in y (axes x and y), as sketched below (red arrows).

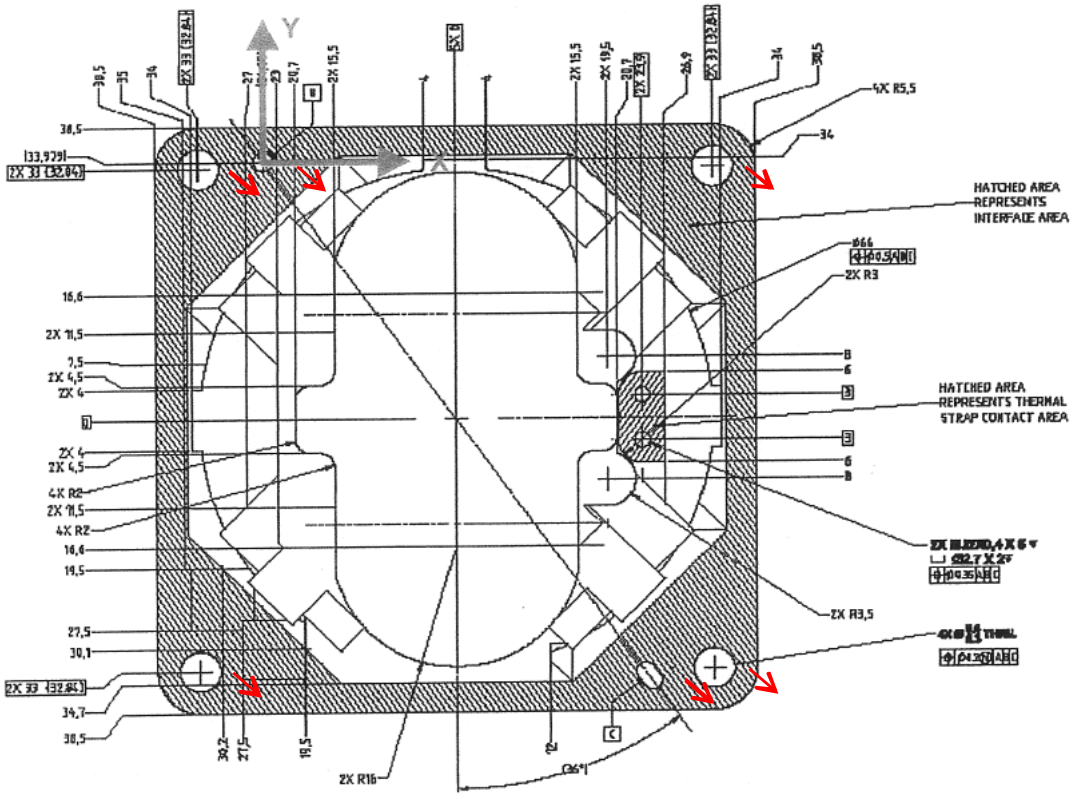
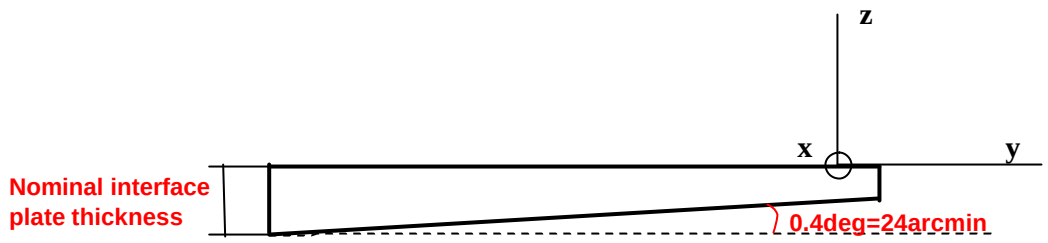


Figure 1 (excerpt from ICD dwg 10209721, with coordinate axes shown)

- SSW interface: The alignment data regarding the PFM SSW BDA indicates a location and orientation within the defined requirements to maintain the required performances. Only the uncertainties regarding tilt about x during cooldown can induce a general feedhorn plane angular misalignment beyond the required ±0.5deg. The proposed correction requires a slope on one side of the interface plate as shown below (local coord. system as per drawings above):



NB: the removal of material from the nominal constant thickness interface plate will produce an axial shift along +z which will also compensate partially the measured z shift reported above for SSW.