



Technical Note

Integration of Spectrometer FS BDAs:
alignment issues

Ref: SPIRE-RAL-NOT-
002661

Issue: 1.0

Date: 21/03/2006

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TITLE: Integration of Spectrometer FS BDAs: alignment issues

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CHANGE RECORD

ISSUE	DATE	SECTION	REASON FOR CHANGE
1.0	21/03/06	All	First issue of the document as TN

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2. Tilt and rotation

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- 2.3 Conclusion

3. Conclusion and proposed corrective actions on respective interface plates

APPLICABLE AND REFERENCE DOCUMENTS

RD1 Alignment Measurement Summary for PFM SLW BDA 10209800-4 SN015, Mark Weilert (JPL – 30 May 05), *as part of the delivered EIDP*

RD2 Alignment Measurement Summary for PFM SSW BDA 10209800-5 SN016, Mark Weilert (JPL – 20 Sept 05), *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)



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This note briefly assesses the impact of the alignment measurements performed on FS SLW and SSW BDAs (RD1 and RD2) wrt the integration of the respective BDAs into the SPIRE FS 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.

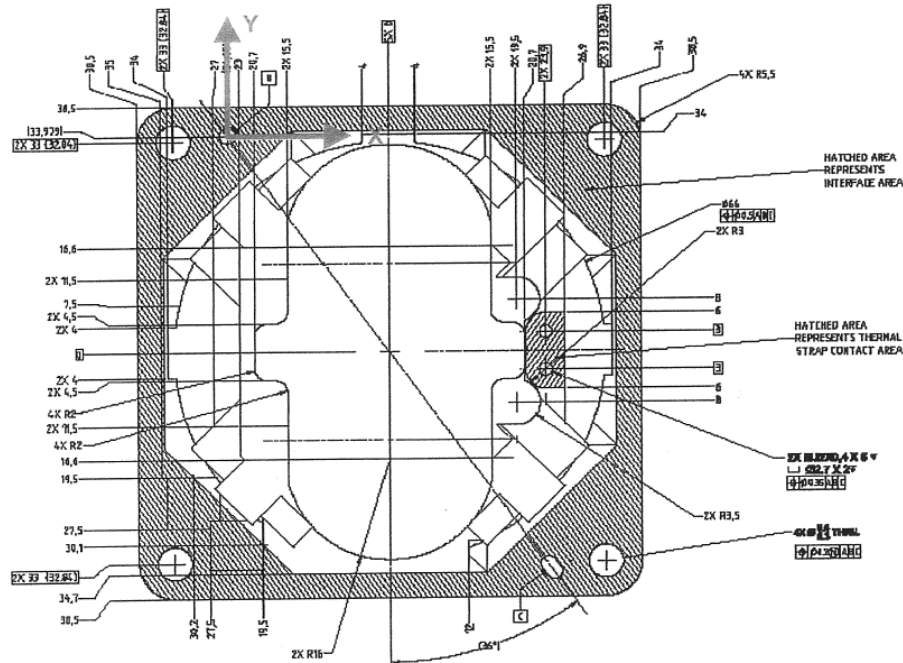


Figure 1 (excerpt from ICD dwg 10209721, with coordinate axes shown)

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 0.160mm. 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: -0.061+/-0.05mm
- along Y: +0.436+/-0.05mm

so that the max displacement from centre is $\sqrt{dx^2+dy^2}$ ~0.440+/-0.100mm. This represents ~8.8% of the SLW pixel size (feedhorn aperture diameter 5.0mm) and, at the entrance focal plane (CFIL1



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location), is equivalent to 0.764mm 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 $\sim 5.53 \pm 0.5$ arcsec 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 +0.102mm. This will translate into a defocus of the SSW BDA in operation wrt the nominal best focal plane. This is well within the ± 0.5 mm 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.

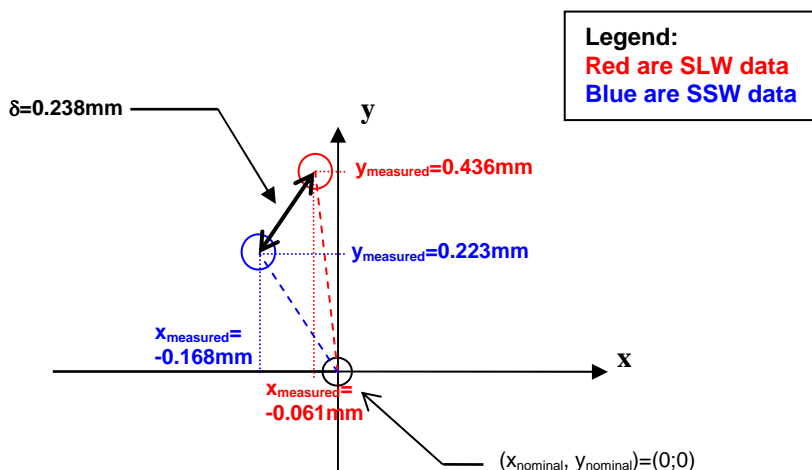
The lateral in-plane shift of the BDA centre wrt to nominal centre is found to be (total i.e. ambient and cold measurement):

- along X: -0.168 ± 0.05 mm
- along Y: $+0.223 \pm 0.05$ mm

so that the max displacement from centre is $\sqrt{dx^2+dy^2} \sim 0.279 \pm 0.100$ mm. This represents $\sim 12.4\%$ of the SSW pixel size and, at the entrance focal plane (CFIL1 location), is equivalent to 0.484mm 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 $\sim 3.5 \pm 0.5$ arcsec 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 $120\mu\text{m}$. 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 $200\mu\text{m}$ along local $-y$ and $100\mu\text{m}$ 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 0.67° wrt the local z axis. Additional no repeatable -0.09° rotation about x is quoted in RD1 when cryo-cycling. The additional cryo-cycle dependent tilt error is small compared to the nominal large tilt



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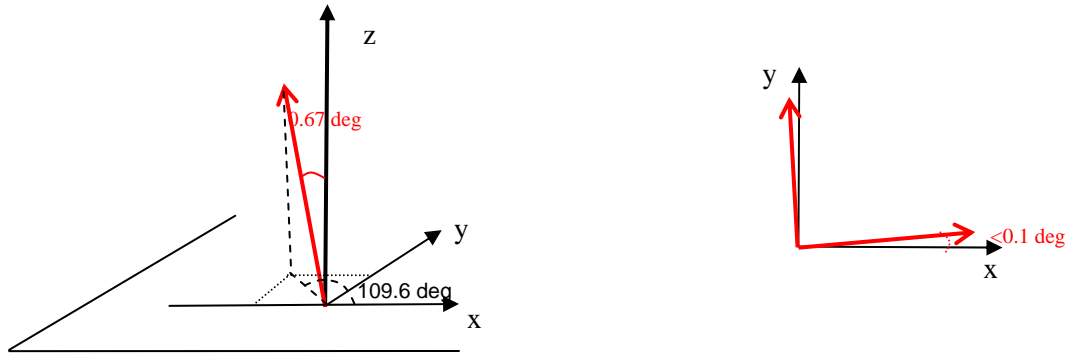
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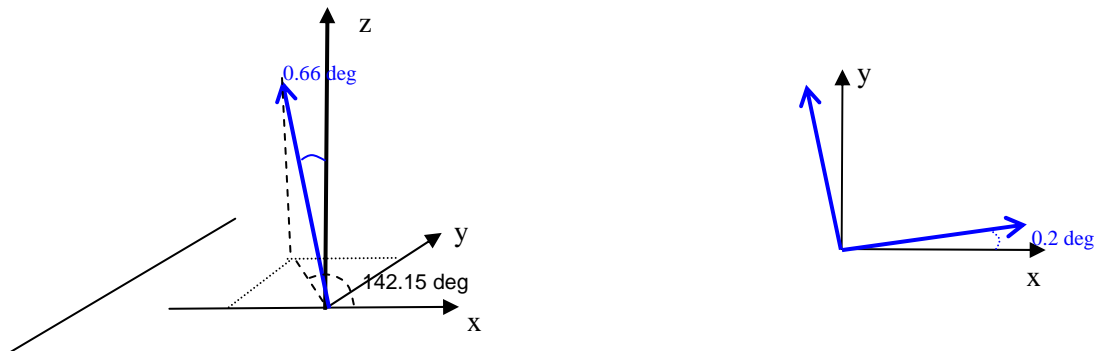
offset which is larger than the acceptable limit of $\pm 30 \text{ arcmin} = \pm 0.5 \text{ deg}$ tolerances around the gut ray (nominally is aligned with the local z axis at the centre of the array).



The in-plane rotation has been found (ambient + cold) to be $0.08 \pm 0.04 \text{ deg}$ which is within the specifications of 0.293 deg ($= 17.6 \text{ arcmin}$ 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 0.66 deg wrt the local z axis with additional 0.03 deg non repeatable rotation about x during cryo-cycle. The additional cryo-cycle dependent tilt error is small compared to the nominal large tilt offset which is larger than the acceptable limit of $\pm 30 \text{ arcmin} = \pm 0.5 \text{ deg}$ tolerances around the gut ray (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 0.2 deg which is within the specifications of 0.293 deg ($= 17.6 \text{ arcmin}$ 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 to correct for SSW and SLW tilt (not in-plane rotation) as values are not within specifications. **For SSW and SLW, it is suggested to compensate at interface plate level the global large tilt in the yz plane by a positive rotation of 0.5 deg about local +x only (for simplification instead of about a generally rotated axis in the xy plane inducing a more complex).** This will bring the tilt of SSW and SLW BDAs within the maximum allowed specification.

3. Conclusion and proposed corrective actions on respective interface plates



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- SLW interface: 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 and reference points in the SLW interface plate wrt their nominal position by: (-100) μ m in x and (-200) μ m in y (axes x and y), as sketched below (red arrows).

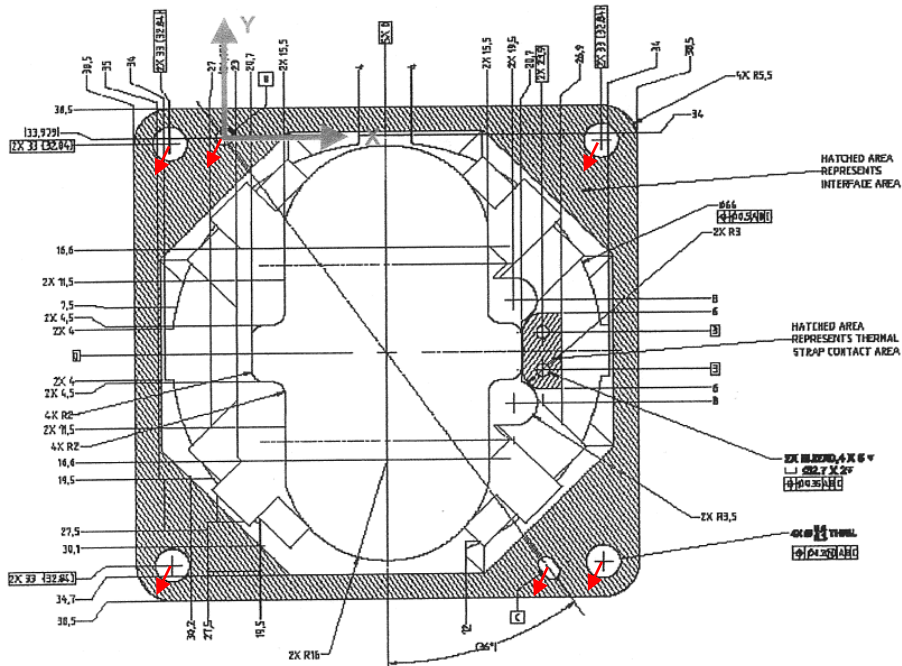
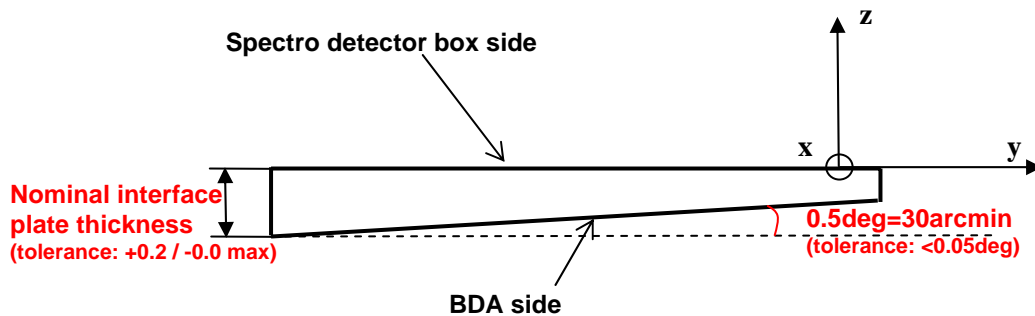


Figure 1 (excerpt from ICD dwg 10209721, with coordinate axes shown)

- SSW interface: The alignment data regarding the FS SSW BDA indicates a location within the defined requirements to maintain the required performances.

- **For SSW and SLW:** The alignment data regarding the FS SSW and SLW BDAs indicate a large tilt offset beyond specifications. **It is proposed here to compensate for it via a wedge interface plate as shown below in the cross-section diagram.**



NB: the removal of material from the nominal constant thickness interface plate will produce an axial shift along +z which is estimated to be of the order of +200-250 μ m max (suggested tolerance above



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tuned to minimise this). Added to the above nominal expected BDA internal defocus along z, the net result will still be well within the allocated +/-0.5mm.