TITLE: **Test report on FS BSM mirror surface orientation**

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CHANGE RECORD

ISSUE	DATE	SECTION	REASON FOR CHANGE
1.0	08/12/04	All	First issue of the document

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APPLICABLE AND REFERENCE DOCUMENTS

This note reports on the procedure and results of a comparative test between BSM OGSE and FS BSM (serial 070-001) mirror surface orientation when mounted on SOB.

1. Introduction

It was found needed to confirm that the FS BSM, planned to be integrated in the SPIRE PFM FPU and to be used in the near future in the PFM1 Spectrometer performance tests, has its mirror surface in the right orientation when mounted on the SOB (full subsystem assembly including the shoe for full interface representativity).
The BSM OGSE with its shoe was used during PFM ambient alignment campaign in June 2004 and from the excellent result obtained in pupil alignment. From this, the BSM OGSE is considered as reference.
Angular measurements (2 axes) are needed to compare the orientation of the FS BSM mirror surface. A calibrated MAT (same as the one used in SPIRE alignment campaigns) is used for that in auto-reflection and auto-collimation with the BSM OGSE and FS BSM successively mounted on a dummy bare SOB (origin: MSSL; no surface treatment) as PFM SOB not available for this test.
FS BSM is assumed at rest position while the OGSE BSM mirror is not actuated and has not been modified since alignment campaign in June 2004.

2. Experimental procedure

Date: 08/12/04

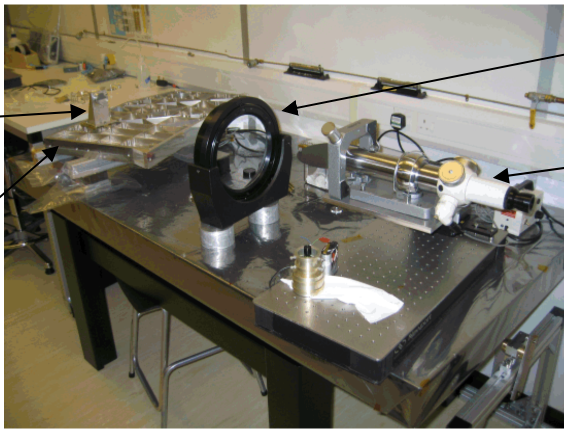
Location: RAL/SSTD – G56 tunnel area (cleanroom Class~100, ambient environment)

Experiment performed by: MF & BMS

Below is given an illustrated version of the procedure followed and reported in the PFM log book of 08/12/04.

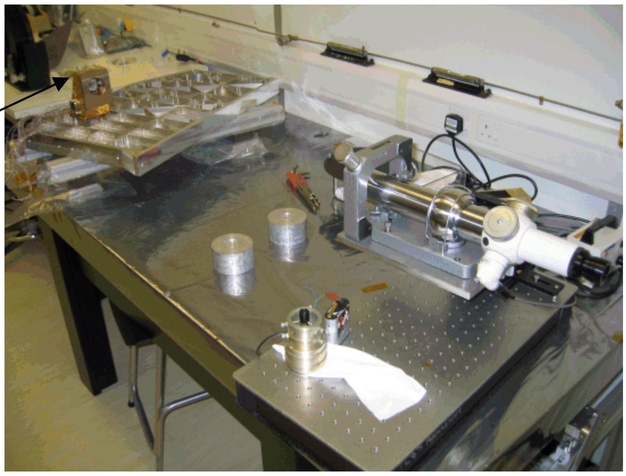
Alignment check of BSM on scrap SOB on table in RAL/SSTD – G56 tunnel area

- i) Place OGSE BSM on scrap SOB with dowels (x2) – no helicoils fitted so screws do not work – no significant movement
- ii) Align MAT to OGSE BSM to obtain auto-collimation
- iii) Align flat mirror to MAT as reference – transfers alignment reference to flat in case MAT is moved;



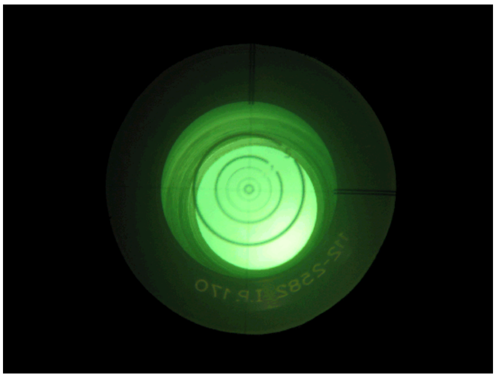
- iv) Move FS BSM from flowbench (wires not yet soldered)
- v) Replace OGSE with FS BSM on scrap SOB

FS BSM + its shoe

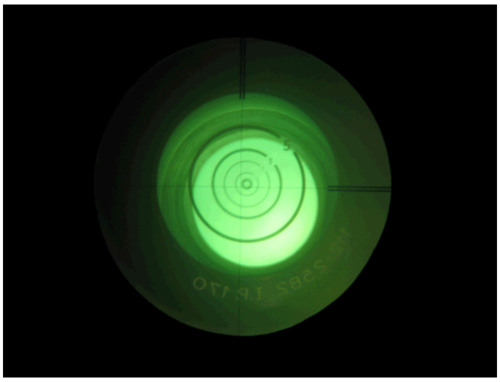


vi) Observe alignment of reticules – displaced – readjust focus for auto-reflection and auto-collimation:

Deviation in Az=0.65mm (red), deviation in El=0.45mm (red) to bring MAT aperture target centred onto reticule for auto-reflection;

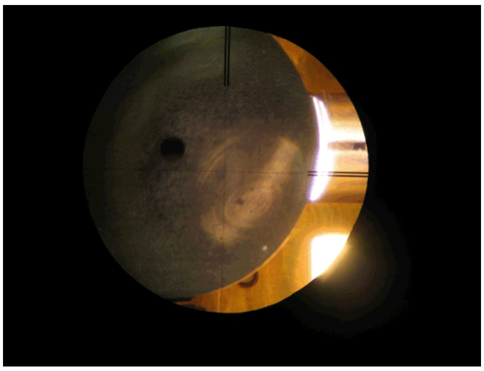


Auto-reflection on OGSE BSM



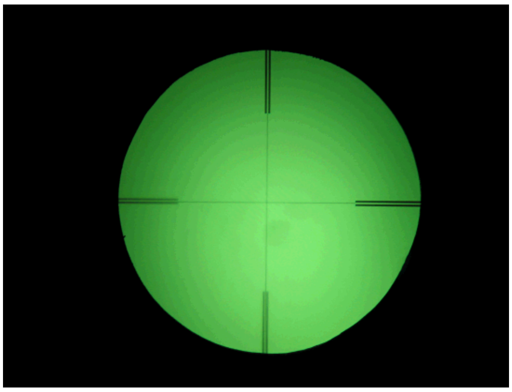
Angular difference with auto-reflection on FS BSM

Focus with MAT onto mirror surface via extra light on BSM (see photo below): difference with OGSE focus is <0.5mm on the outer circle on the 50.8mm diameter focus micrometer

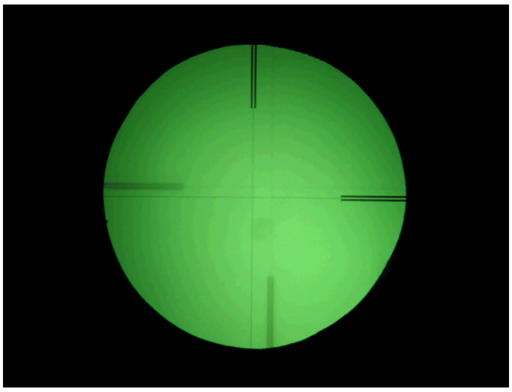


Distance measured (laser ranging system) from MAT aperture to FS BSM front surface (not mirror surface) is 927.0±0.5mm (corrected to 926.5±0.5mm on-axis; +21.85±0.5mm from front enclosure surface to mirror surface from drawings)

Auto-collimation results below obtained via digital camera picture at MAT eyepiece:

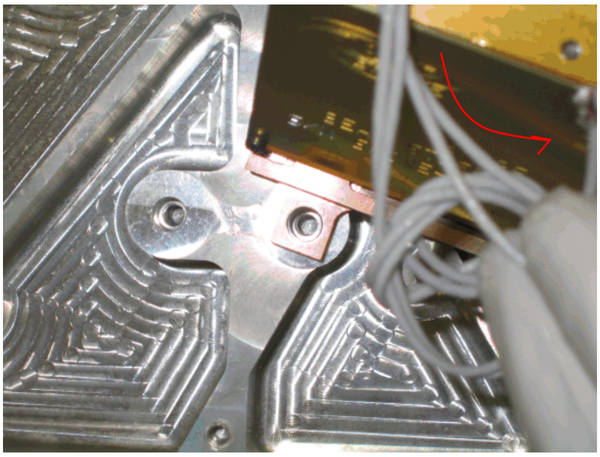


Autocollimation on OGSE BSM



Angular difference with autocollimation on FS BSM

vii) Qualitative assessment of required shimming
Back dowel removed at shoe/SOB interface
Azimuth small rotation induced to bring anti-clockwise about vertical axis (i.e. normal to SOB, at front dowel): not quantifiable but pic taken, see pic below



Front dowel removed: additional shims via 0.4mm thick sharp added at front dowel interface => this correction is approx x3-x4 at least to big at this location.

viii) Check for repeatability:
Reset dowels in place + measured deviation wrt MAT target: Deviation in Az= 0.82mm (red), deviation in El=0.55mm (red)

Removed FS BSM and replace with BSM OGSE: re-measured deviation wrt MAT target: Deviation in Az= 0.2-0.4mm (black), deviation in El=0 mm

3. Summary of results

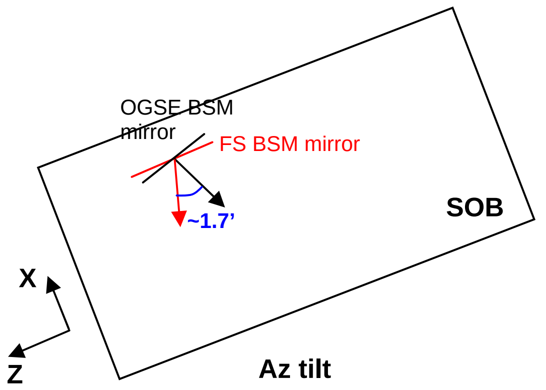
Measured angular differences between BSM OGSE and FS BSM mirror surface normal at rest position:

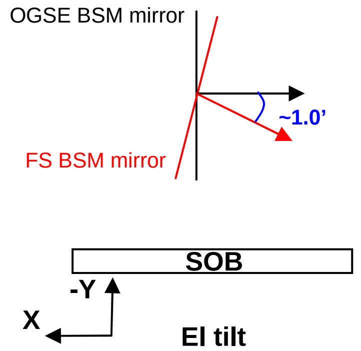
- By auto-collimation:
  - In Az: **1.81±0.18 arcmin**
  - In El: **1.02±0.10 arcmin**

- By auto-reflection (at 948.5±1.0mm from MAT along LOS):
  - In Az: ((0.85±0.25)/2)/(948.5)= **1.54±0.23 arcmin**
  - In El: ((0.50±0.05)/2)/(948.5)= **0.90±0.10 arcmin**

NB: Az is the tilt about a vertical axis, normal to the SOB plane. El is the tilt about a horizontal axis in the above set-up in a plane parallel to the SOB plane. SOB plane is parallel to (X,Z) plane in Herschel reference frame.

Better repeatability (lower relative uncertainty) was found for the small deviations in elevation compared to azimuth measurement due to the overall measurement set-up. But both methods agree well and converge to similar values: ~1arcmin in El and ~1.7arcmin in Az.



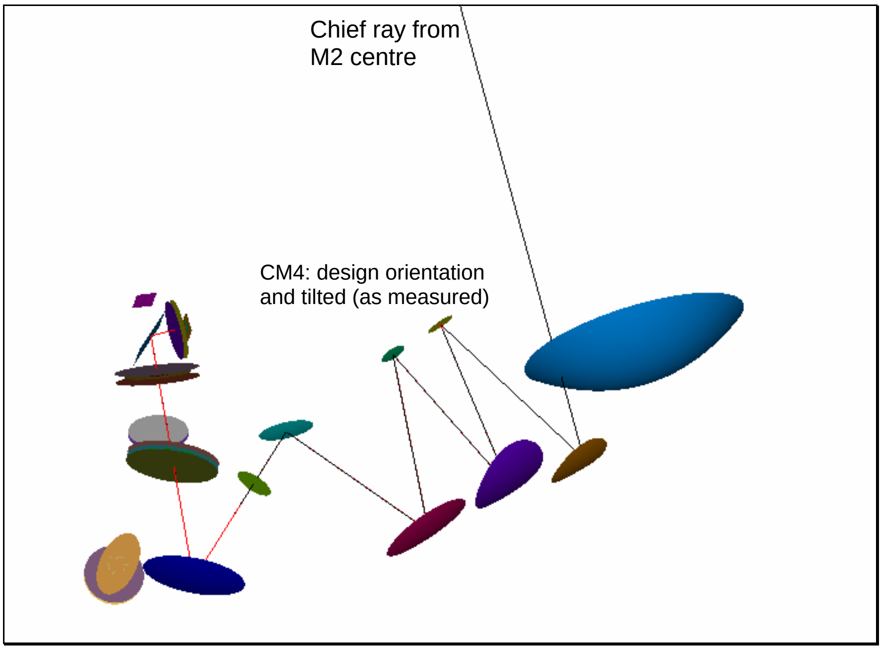


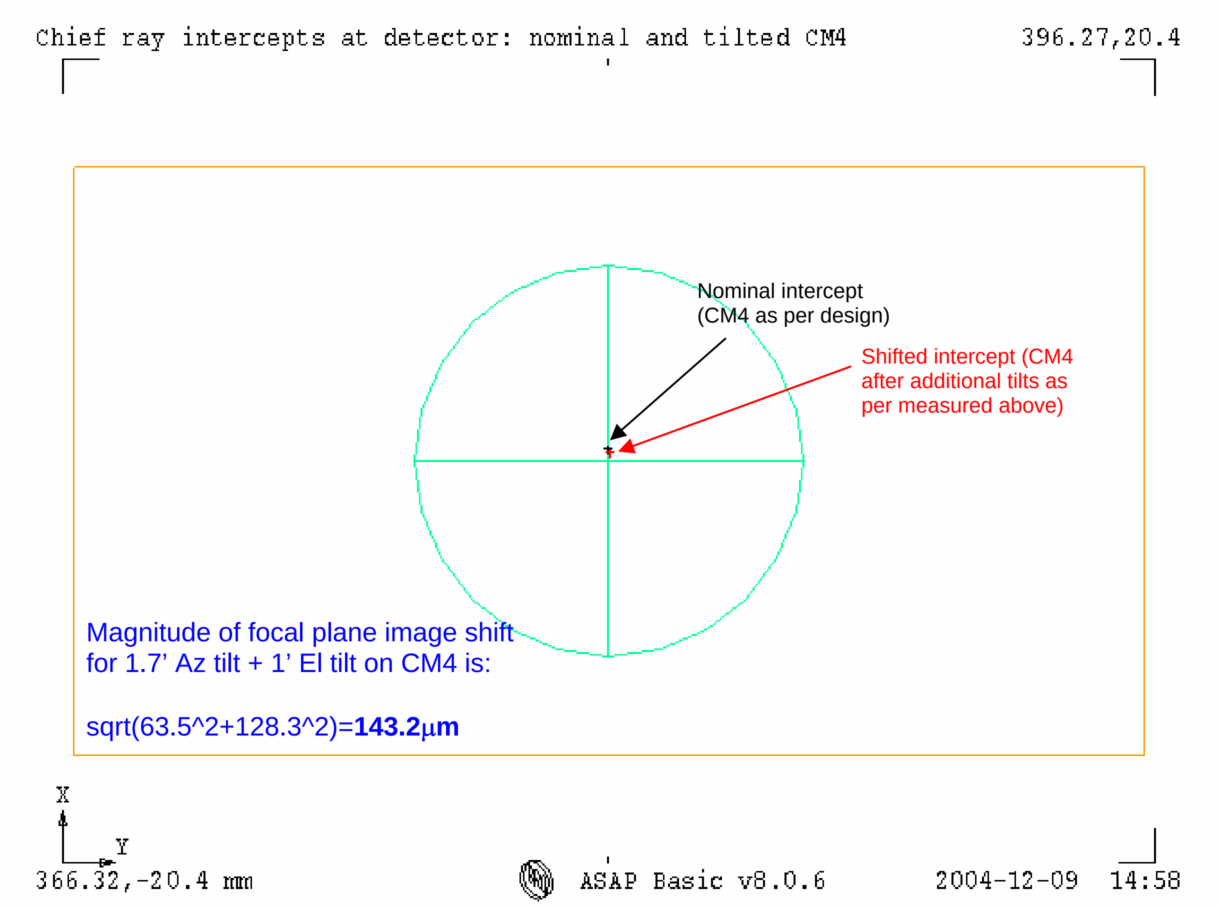
These are small compared to the travel ranges (chop & jiggle) of the BSM when actuated. It is therefore recommended to proceed with the integration of the FS BSM assembly (device + its shoe) in the PFM1 FPU without shims.

Remarks:

The (linear) difference in axial position between the 2 mirror surfaces when mounted on SOB is difficult to determine precisely with MAT due to large depth of focus and focussing range. Qualitative indication during measurement seem to imply a difference <0.5mm. More precise data could be obtained from metrology measurement, between respective mirror surface and interface point such as dowel holes when devices in contact with pads at shoe interface.

The (linear) lateral (i.e. in the transverse plane defined by mirror surface normal) position of the mirror surfaces have not been compared but the impact of a small difference is considered as small as BSM mirror (i.e. SPIRE CM4) is located at an image of the pupil (and assumed slightly oversized wrt composite FoV beam), see ASAP simulation below in the SPIRE Photometer optical model (ref. BOLPHOT155.inr, July 2001) showing the field transverse displacement induced by CM4 tilt.
The angular misalignment measured above would induce an image shift of 0.14mm at detector plane which is smaller than 1/15th of the SSW and PSW pixel size so the impact is negligible (equivalent to 0.25mm at telescope focus or ~1.8" on-sky).


Chief ray from
M2 centre
CM4: design orientation
and tilted (as measured)


Chief ray intercepts at detector: nominal and tilted CM4
396.27,20.4
Nominal intercept
(CM4 as per design)
Shifted intercept (CM4
after additional tilts as
per measured above)
Magnitude of focal plane image shift
for 1.7' Az tilt + 1' El tilt on CM4 is:
sqrt(63.5^2+128.3^2)=143.2µm
X
Y
366.32,-20.4 mm
ASAP Basic v8.0.6
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