SPIRE STM optical alignment campaign
1: Photometer cold stop alignment verification

KD, 23/5/2003

Reference documents

RD1 G. Rousset, "HERSCHEL-SPIRE, SPIRE STM MIRRORS, Optical measurement report", LAS.QUA.SPI.PRV.030024 Iss1 Rev0, 31/03/2003.

RD2 "Photometer C.S.-tool" drawing SPI-OAL-30-DD-01-A, 07-08--2002.

RD3 K. Dohlen, "Herschel-SPIRE: Optical error budgets", LOOM.KD.SPIRE.2000.002-4, 17/1/2002.

Introduction

Measurements on mirrors have shown that some of them suffer from several minutes of mis alignment between the optical surface normal and the mounting spigot. In order to measure the effect of these errors and determine whether other error sources were also contributing, the induced deviation of the gut ray was measured by projecting the PCS tool onto the M2 tool by placing a strong light source (fibre) in the SLW detector position. Figure 1 shows this setup and Figure 2 shows the projected shadow.

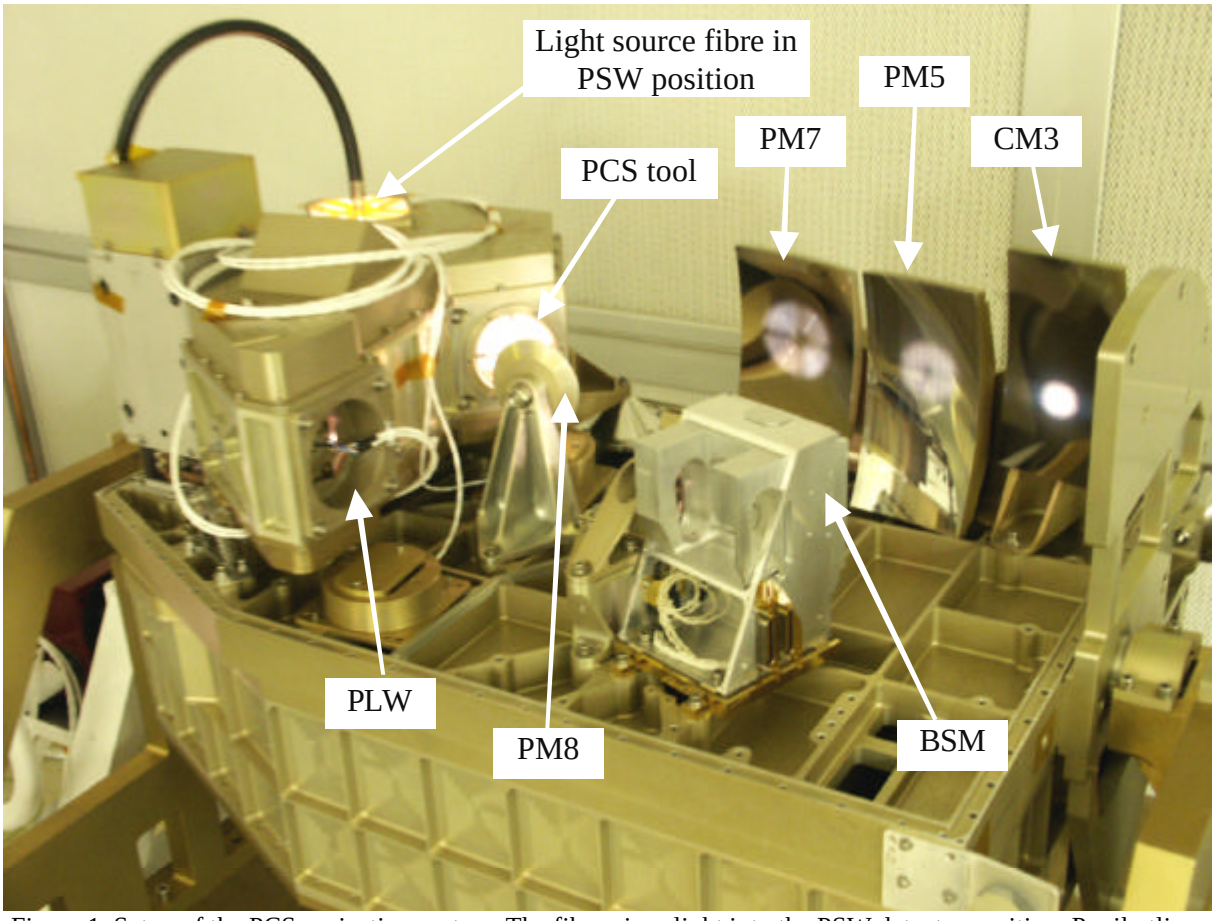

Figure 1. Setup of the PCS projection system. The fibre pipes light into the PSW detector position. Pupil otlines are clearly seen on all mirrors.

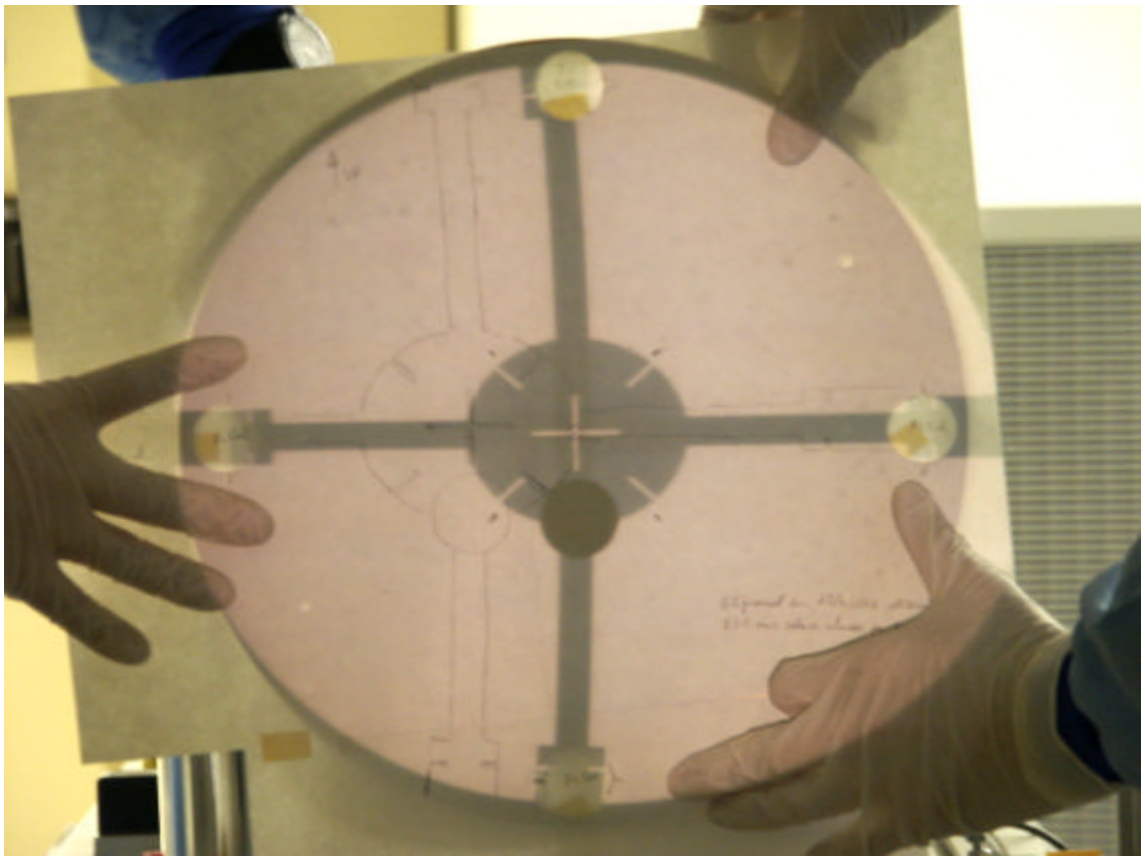

Figure 2. Shadow of the PCS tool projected onto the M2 tool. For clarity, a sheet of paper is held in front of the M2 tool, but the four holes around the edge of the tool indicating the edge of the telescope pupil are seen by transparence. The shadow seen here is obtined after readjustment of the M2 tool so that its centre coincides with the central cross of the PCS tool. The pencil trace on the paper shows the original PCS tool shadow obtained with the M2 tool aligned according to the theoretical instrument gut ray. The darker hole below the central cross is due to the central hole in the BSM mirror, offset be the insertion of a 4mm shim under its feet.

Analysis

The deviation of the projected PCS tool central cross and the centre of the M2 tool is ΔZ = 46.8mm along the SPIRE Z axis (oriented towards PAX) and ΔY = -4.0mm along the SPIRE Y axis (oriented towards the spectrograph).

Table 1 gives measured angular deviations, ThetaZ and ThetaY, of the mirror surface for each mirror in the photometer optical train. The values are obtained from RD1.

An error has also been detected in the definition of the photometer cold stop tool (PCS tool, RD2). The central PCStool reticle has been drawn centred in the elliptical CS aperture while it should have been located centred within the circular CS interface. This gives a decentering of 0.738mm along the Z axis (parallel with the SPIRE bench).

Zsens and Ysens represent the sensitivity of pupil centration on M2 for tilt of each mirror and decentering of the cold stop, obtained by raytracing (SpirePhotTol30.XLS). Zpup and Ypup are corresponding pupil centration errors.

The total theoretical pupil deviation obtained by summing the individual errors is SumZpup = 45.313mm and SumYpup = 3.120mm. This is within 1.7mm of the observed pupil deviation, corresponding to a residual relative pupil alignment error of 1.1%. This has been verified by introducing all the errors simultaneously in a ratracing model (BolPhtRev21_STM). Figure 3 shows plot of the theoretical instrument gut ray impoct on M2 overlaid on the photo of the PCS tool prejection.

Table 1. Measured mirror tilt errors and cold stop decentering error, and their effect on pupil alignment.

Subass'y	**Mirror**	**ThetaZ**	**ThetaY**	**Zsens**	**Ysens**	**Zpup**	**Ypup**
Fore optics		arcmin	arcmin	mm/arcmin	mm/arcmin	mm	mm
	CM3	-27.19	7.90	-1.581	1.519	42.99	12.00
	CM5	-0.90	3.60	1.461	-1.441	-1.31	-5.19
Photometer							
	PM6	3.00	-5.30	-0.949	0.858	-2.85	-4.55
	PM7	0.50	-0.70	1.71	-1.163	0.86	0.81
	PM8	0.00	0.20	-0.314	0.202	0.00	0.04
	PCS (mm)	0.74	0.00	7.631	6.583	5.63	0.00
	PM9	0.20	0.00	0.005	-0.014	0.00	0.00

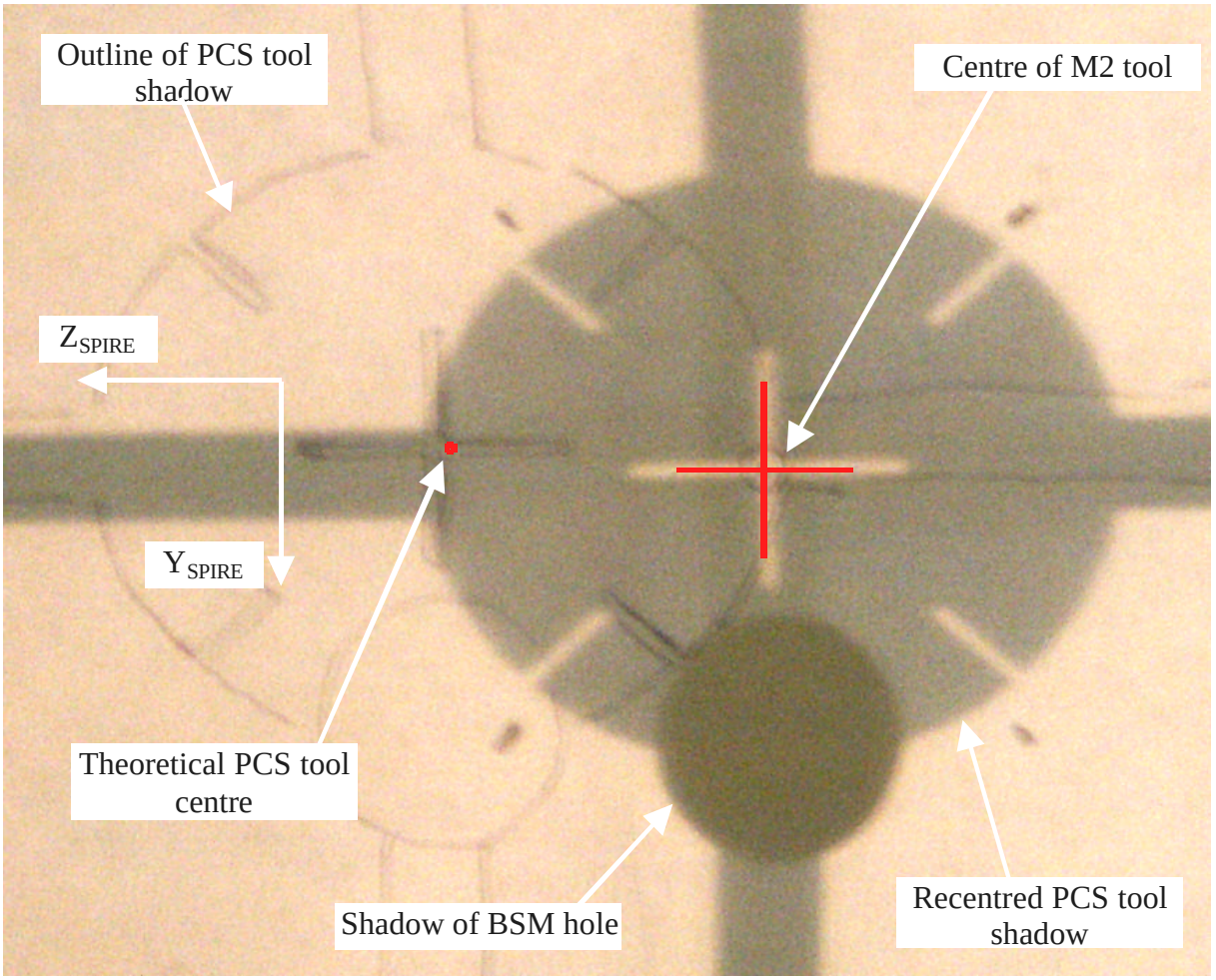

Figure 3. Detail of the PCS tool shadow on the M2 tool with theoretical raytracing result superimposed (red). Scale ~1:1.

Conclusion

We attribute the remaining 1.1% (1.7mm) pupil alignment error to perturbations in the SPIRE structure. This is well within the SPIRE error budget [RD3] allocation of 4.0% (6.2mm) internal instrument alignment error and 2.6% (4.0mm) external instrument alignment, indicating that the manufacture of the SPIRE structure is highly accurate.

When the excessive errors in CM3, PM5 and PM6 are corrected, the instrument will be well within its budget.