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SPIRE consortium response to questions on the Science and Technical Plan and the IID (PT-05387, 23 March 1998)

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SPIRE_GEN_1:

"Proven and reliable techniques" include optical design, ^{3}He cooler, filters and dichroics, cryogenic mechanism technology, warm electronics, etc. "Recent advances" refers to novel detector and cold readout technology allowing the use of large-format filled arrays at submillimetre wavelengths (see Section 3 of *Response of the SPIRE consortium to questions arising from the second FSEC meeting*, April 3 1998). This outlines the technical areas in which significant developments are required. In the case of the optical design, no significant developments are required, although careful attention will be needed in the areas of stray light control.

SPIRE-STP-1: Will the fall-back option be developed in parallel?

Yes. As described in Section 2.6 of the proposal, the fall-back detector technology is being developed by the Caltech group. A camera (BOLOCAM) incorporating a monolithic array of 144 "spider-web" detectors is now under construction, and should be fully operational in early 1999. The fall-back readout is a non-mulitplexed JFET readout similar to that base-lined for Planck HFI and BOLOCAM. All of the basic scientific specifications of SPIRE can be met by this fall-back option. As stated in the proposal, the selection among the four options for the bolometer technology (filled arrays using TES/SQUID readout, 1Fλ feed-horn + "spider-web" arrays using TES/SQUID readout, filled arrays using CMOS readout, or 2Fλ feed-horn + "spider-web" arrays using JFET readout) is scheduled for late 1999.

SPIRE-STP-2: Information on the dichroics

To be addressed later.

SPIRE-STP-3: Aberrations in spectrometer channel

An order of magnitude for aberrations in the spectrometer channel is given in the scientific and technical plan. Section 2.2.3 page 2.6 states: "The optical design is optimised to give close to diffraction limited imaging at all points in the FOV."

However, the connection between the spectrometer and the fore optics has not been studied in detail, and it may be necessary to optimise the two channels simultaneously and accept some trade-off in optical quality. We believe that there are enough parameters to play with (surface shapes, off-axis angles etc.) to ensure required quality in both channels. In its present form, the spectrometer channel starting at the pick-off mirror is not only diffraction limited, it is virtually aberration free (spots < 0.5 mm).

example with the IRTS) then in the upside down position (hot pump below cold evap.) you can get convective effect, which indeed we had, to a level which can prevent you of condensing any liquid at all (the heat involved warms up the evap.). This is why I have said before we should make sure we'll avoid some specific orientation on the ground. With the new design I suggest this problem becomes different. Indeed I am not using a spiral but pieces of straight section of tubes. This makes it easier to build, does not affect the tube (when you build a spiral or helix, you end up with many ripples along the tube) and in the upside down orientation you have at least one section of tube which has the correct orientation (warm side up). During condensation (ground testing) we will dump more power on the cold plate (only one section provides poor thermal conductance) but at least we should be able to condense. However there is still one orientation which may cause problems: the horizontal one with all sections of tubes in a same horizontal plane. I have shown during some previous experiments that convection is almost as effective in horizontal tube than in vertical one (warm side up). But this is to be checked for this particular arrangement."

We confirm, therefore, that the sorption cooler will operate in the vertical FIRST cryostat. We will also test the cooler in the same orientation during ground testing.

SPIRE-STP-9: Choice of microprocessors

To be addressed later.

SPIRE_STP_10: What is the expected maximum on-board data rate to the mass memory?

Assuming that only one instrument may provide full telemetry to the S/C computer at a time, the data rate from the instrument to the on-board mass memory determines the length of the 'dead' time at the end of an observation (see answer to SPIRE_IID_7). We would like to reduce this lost time to less than 1 minute (this gives an overhead of ~10% on 10 min observations). This implies a data rate from the instrument to the S/C computer (and on to the mass memory) of greater than 150 kbps. We might like to increase the rate beyond this, but we do not yet know whether the instrument telemetry interface will be able to cope with higher speeds.

SPIRE-STP-11: HIFI units on SVM

We require that the HIFI local oscillators are switched off during SPIRE operations to prevent high levels of submillimetre radiation entering the focal plane. At present, we do not see any requirement for the HIFI warm electronics units to be switched off. This will depend, however on the outcome of the EMC testing of both HIFI and SPIRE.

SPIRE_IID_1: Buffer amplifier (SPIRE 2)

The *start-up* temperature is 80 K; operating temperature depends on dissipation and thermal design, but should be around 120 – 150 K. Maximum power dissipation is revised to 1.9 W during photometer operation. During FTS operation the figure is 0.6 W. It will probably be necessary to maintain the dissipation at a constant value of ~ 2 W all the time while SPIRE is operating. Note that SPIRE 2 is only required for one of the detector array options (CEA filled array). The maximum allowed distance between SPIRE2 and the CVV is TBD cm [number to be specified later today], allowing for the box to be mounted on thermally isolating supports.

SPIRE_IID_6: Cleanliness levels

To be addressed later.

SPIRE_IID_7: Science data rate

The rate of generation of raw data from the instrument is much greater than the rate at which it can be down-linked in the telemetry. The raw data from an observation will therefore be processed to reduce the total amount of data from an observation to be consistent with the telemetry down-link rate.

This reduction is made by the integration (averaging) of data over a given time period; in the photometry mode data from several chop cycles will be averaged together, and in the spectrometry mode several interferograms will be averaged together. This will reduce the mean data rate to below the telemetry rate, but it will limit the minimum integration time possible on a given sky position. It should also be noted that the output data stream will be delayed from the start of the observation by this minimum integration time (while waiting for the first integration to occur) and consequently there will be a necessary 'dead' time at the end of an observation during which no data will be taken, but the final integration data are down-linked. This 'dead' time could be eliminated if it were possible to continue the transfer of data from one instrument while another is operating.

The current data rates apply to "the periods when SPIRE is observing" (no allowance is made here for dead time associated with spacecraft slewing, instrument warm-up, etc.), and assume an integration time of 1 sec. for photometry and 105 sec. for spectrometry (corresponding to the integration of 3 interferograms). The average data rate depends on the relative usage of the spectrometer and photometer during a "FIRST day". Only if the spectrometer is operating all or nearly all the time, with 105 sec. averaging period, is the IID-A specification not met. In this extreme case, increasing the spectrometry integration time to 140 sec. would reduce the average data rate for the spectrometer to 44.7 kbps, so meeting the specification with negligible impact on the data quality.

5. (a) The relative merits of focal plane arrays and feed-horn arrays have been considered in detail by the SPIRE team, including all of the issues raised here. Our conclusion is that the potential benefits of the filled arrays (summarised in the proposal - Section 2.4.1) are very attractive for SPIRE. A detailed note on this subject is attached as Appendix B.

The available field of view for SPIRE is actually limited by the area of the focal plane allocated to the instrument. SPIRE is designed to make maximum use of this area for any of the focal plane array options.

(b) Our analysis shows that this is not a problem for SPIRE provided that the beam diameter through the FTS is large enough (which it is, because a more stringent requirement is set by the need to minimise the effect of wave-front shear). This question is also addressed in the attached note on the FTS, Section 2.2.1 (see Appendix A).