SPIRE FPU PDR REVIEW COMMITTEE REPORT

Summary Statement

The review committee heard a very detailed presentation of the level of design of the Focal Plane Unit (FPU) of the SPIRE instrument on 7-9 July 1999. This review is the first of four SPIRE instrument reviews that form the complete instrument PDR. The further reviews are in November 1999 (warm units), January 2000 (detector selection), and March 2000 (Instrument PDR completion). We were quite impressed with the state of the design at this point and with the proposed capabilities of the instrument. The development plan for SPIRE also seems well organized and likely to lead to successful completion of the instrument. There were a number of issues, though, that came up during our discussions that we think should be addressed by the SPIRE team within the instrument PDR cycle in order to minimize risk during the development. We discuss these below in the context of the three areas we were asked to consider during our review: capability of SPIRE to meet its science goals, overall compatibility with the FIRST mission, and the likelihood of the development plan to lead to a successful and on-time completion of SPIRE.

I. Capability of SPIRE to meet its science requirements/goals

The SPIRE instrument as presented to us appears very well suited to meeting its science goals. The large focal plane coverage with simultaneous imaging at three wavelengths will be an excellent tool for both the prime science goal of deep extra-galactic surveys and many other science goals in extra-galactic, galactic, and solar system astronomy. The Fourier Transform Spectrometer (FTS) portion of the instrument is clearly important to be able to determine redshifts of interesting objects found in surveys as well as to perform astrophysical analyses of the state of the matter in any of the objects studies. There are several issues relevant to meeting the science goals that need further study or consideration, however.

(1) It was not completely clear to the committee how the science data from SPIRE would be analyzed to achieve the desired levels of performance given the realities of the FIRST telescope and spacecraft. In particular, the pointing performance of the spacecraft may affect the ability to perform the desired drift-scanning method of surveying. Modeling of this problem with expected spacecraft performance and SPIRE characteristics could be very important in planning the use of SPIRE (as well as in final design details of the detector modules and data acquisition electronics). A second issue in this category is the method of extraction of astronomical spectra from the FTS. Since the FTS essentially takes a difference of the SKY+TELESCOPE and an on-board "blackbody", the derivation of the true source spectrum clearly requires some kind of sky-differencing and removal of the calibrator spectrum. The committee was unsure how this would be accomplished and thought that some analysis and modeling of this issue is likely to minimize risk in the design of the FTS.

(2) SPIRE will be operating in a very high background environment relative to the natural sky background limit because of the telescope temperature relative to the wavelengths of operation. Therefore, stray light is clearly a VERY significant issue. The SPIRE team presented a detailed first analysis of this issue during PDR, but it is clear this must be an on-going issue. This stray-light analysis should continue through the entire instrument design and should be coupled with measurements as soon as possible on real optical models.

(3) Although improvements in spacecraft specs are always possible in the future, the promised data rate at this time of 100kbs is clearly less than optimum for SPIRE. The team should continue to examine the effects of this on all aspects of the instrument design (e.g. data compression) and operations planning.

(4) As mentioned later, the committee was somewhat worried about the level of design of the FTS at this point, and this issue is related to that concern. It appeared to us that the R=1000 goal on the FTS may be driving the design in a different direction than simply meeting the R=100 requirement would do. Although there are obvious scientific advantages in the higher resolution goal, there are clearly tradeoffs in FTS mechanism size, stage design, controller design, and even optics that are being made to achieve the higher resolving power. We recommend that the SPIRE team re-examine these tradeoffs relative to the science gain afforded by R=1000. Of course, this also depends strongly on completing the FTS design to the same level as the remainder of SPIRE.

(5) The cooler system for SPIRE is obviously a very critical single-point failure possibility that could completely eliminate SPIRE from operation on FIRST. The committee believes that some redundancy in the cooler

system is essential. This could involve either of several possibilities. A second cooler could be added either in parallel with the first one or better yet in a mode where one cooler was used for some of the arrays and one for the remainder of the arrays. Another possibility would be to use redundant heat switches, two in series and two in parallel. The various alternatives should be thoroughly studied, including all relevant parameters, i.e. design complexity, failure modes, resources (mass and thermal), level of achieved redundancy (protection against cooler failure). The decision on implentation of the selected redundancy concept should be based on this tradeoff.

II. Compatibility with the FIRST mission

The SPIRE instrument design at this point seems quite compatible with the FIRST mission as a whole. The continuing refinement of the design is unlikely to reveal any unexpected incompatibilities, but clearly issues like, thermal loads, pointing requirements, and EMI, must continue to be studied.

III. Development Plan

The development plan for SPIRE that was presented to us appears quite appropriate for completion of the instrument on time with relatively low risk. Aside from the natural evolution of the development plan to a greater level of detail, specific areas of development that appear to require further work during the "Delta-PDR" stage, i.e. up to completion of the instrument PDR cycle, are:

(1) Structural Design – The structural design at this time is very preliminary and almost no details of components and subsystems exist as far as we can see. We suggest that the issue of accessibility and replacement of subsystems (especially detector modules) without affecting the instrument alignment should be made a requirement. A similar issue that needs further analysis is the change in alignment of the instrument during cooldown, given the number of different materials proposed as structural components.

(2) FTS Design – For a system that is roughly half of the total SPIRE instrument, the details of this system are clearly critical to define as soon as possible, both the mechanical and control system design. This is one of the most important items requiring significant additional effort as soon as possible, since the committee felt that the current level of design was not at the "PDR" level. Early prototyping of the mechanism will be essential and should not wait for the design to finalize.

(3) Beam Steering Mirror (BSM) – We were presented only with estimates of the BSM performance and design details based on the ISOPHOT

chopper. It is now certainly appropriate to perform detailed design and modeling of the proposed SPIRE BSM system.

(4) Thermal Design – The thermal model of the FIRST focal plane and its interfaces to the cryostat require continued development, in line with the structural design work, since this feeds directly into issues like straylight, alignment, and basic instrument mounting, e.g. the possible mounting via "blades". This will presumably be an iterative process with the other instruments and the spacecraft.

(5) Shutter – The committee was convinced of the need for a "shutter" to perform functional testing on the ground at reasonable background levels. A design for such a shutter should be developed as soon as possible and tradeoffs between such a shutter versus a low-background "lid" on the cryostat should be examined.

(6) Detector Options – Although the SPIRE project has tried hard to develop the instrument design with 3 possible detector options, this committee strongly supports the choice of a date no later than Jan '00 for the detector selection in order to proceed with the detailed instrument design on an appropriate time scale. The CEA option appears to be resource-limited at this time, so the addition of further resources is likely to improve its chances of success, both at the down-select time and for CQM delivery.