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Technical Note on the ICC Work Package: Spectral Response

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Document History:

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Table of Contents:

1. Distribution List

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2. Reference Documents

ID	Title	Author
RD1	SPIRE ICC Consolidated WorkPlan, 1.0 draft 2	Ken King

3. Applicable Documents

Not applicable.

4. Acronyms

CALT	Calibration Team
CQM	Cryogenic Qualification Model
CSA	Canadian Space Agency
ICC	Instrument Control Centre
ICL	Imperial College London
IPAC	Infrared Processing and Analysis Center
ISDT	Instrument Software Development Team
JPL	Jet Propulsion Laboratory
LAM	Laboratoire d'Astrophysique de Marseille
OBST	Observations and Data Processing Team
RAL	Rutherford Appleton Laboratory
SMEC	Spectrometer Mechanism
SR	Spectral Response
TBC	To be confirmed
TFTS	Test Facility Fourier Transform Spectrometer
UoL	University of Lethbridge
ZPD	Zero Path Difference

5. Objective of this document

This document provides a comprehensive and detailed overview of the processes that go into the delivery of the ICC Work Package Spectral Response. It aims to collect and consolidate contributions from all involved groups and individuals.

6. Objective of Work Package

"Perform data analysis on calibration tests to identify the spectral response of the photometer and provide processing steps and software modules to correct for it. Compare to expected value using data for SPIRE components (Beamsplitter, filters, mirrors, telescope simulator, bolometers, etc.)." (RD1, 39)

7. Input

1. IA Development System
2. Calibration information to correct fro the instrument spectral response
3. Processed test detector data products

8. Output

1. Data Product Definitions
2. Processing modules
3. Conversion Data/Tables for each instrument model

9. Milestones

July 2004: Definition of Data Products

January 2005: Delivery of Processing Modules

January 2005: Delivery of Conversion Data/Tables

10. Involved parties

10.1. SPIRE teams

- Other users of input data: DRCU, in particular photometer bolometer arrays, spectrometer bolometer arrays, and SMEC (JPL ???; LAM, Jean-Paul Baluteau, …)
- Other users of output data: DRCU, in particular bolometer arrays (JPL ???; IPAC, LAM, Jean-Paul Baluteau, …)
- OBST (ICL, Matt Fox)
- Quality Control (ICL, Dave Clements)
- Trend Analysis (RAL, Sunil Sidher?)
- CALT (RAL, Tanya Lim)
- ISDT (RAL, Steve Guest)
- Instrument Team w.r.t. filters, beamsplitters, bolometers, SMEC, mirrors, etc.

10.2. Institutions

- ICL: Matt Fox (OBST, photometer deglitching), Dave Clements (Quality Control)
- LAM: Jean-Paul Baluteau et al. (spectrometer deglitching, SMEC data)
- RAL: Tanya Lim (CALT), Steve Guest (ISDT), Sunil Sidher? (Trend Analysis)
- Other providers/users of in/output data (JPL!?, …)

11. Implementation

11.1. Background

Mathematically, the signal, I, as measured by the bolometers may be expressed as:

$$I = \left[B(T_{bb})e^{-\tau} + B(T_{atm})(1-e^{-\tau})\right]O_{TFTS}SR \qquad (1)$$

where

- B is the Planck curve
- T_{bb} is the blackbody temperature
- T_{atm} is the air temperature in the cryolab
- τ is the optical depth of the atmosphere
- SR is the instrument's spectral response
- O_{TFTS} is the spectral effects on the radiation due to sources external to the instrument; e.g. the Test Facility FTS's beamsplitter, the cryostat window, (others?).

NB: Each term is the equation above is a function of wavenumber, υ.

In order to simplify the analysis and interpretation of the CQM data, two separate measurements should be taken at different blackbody temperatures T_1 and T_2. Using equation 1:

$$I_1 = B(T_{bb1})e^{-\tau} + B(T_{atm})(1-e^{-\tau})O_{TFTS}SR \qquad (2a)$$

$$I_2 = B(T_{bb2})e^{-\tau} + B(T_{atm})(1-e^{-\tau})O_{TFTS}SR \qquad (2b)$$

$$I_1 - I_2 = \left[B(T_{bb1}) - B(T_{bb2})\right]e^{-\tau}O_{TFTS}SR \qquad (3)$$

$$SR = \frac{I_1 - I_2}{\left[B(T_{bb1}) - B(T_{bb2})\right]e^{-\tau}O_{TFTS}} \qquad (4)$$

In order to perform a simulation of the SR prior to the CQM tests, data on the following components will be required:

- Spectral curves for the SPIRE beamsplitter and filters
- Expected response curves for the bolometers
- Expected effect of the telescope simulator
- Others?

11.2. Implementation

The layout for the SPIRE-CQM tests is shown in Figure 1. The radiation from the hot blackbody passes through the Test FTS and is directed at the cryostat window by way of the telescope simulator. The radiation then passes through the cryostat window to the SPIRE instrument, located in the cryostat, and on to the bolometer array where it is measured.

The input signal as shown in Figure 1 denotes the radiation after it has entered the cryostat. The output signal is that measured by the bolometers. The difference between these signals is the SPIRE Instrument Spectral Response. Two sets of measurements, with the blackbody set at different temperatures, will be recorded. Since the environmental conditions in the cryolab will also affect the measured signal, parameters such as lab temperature, pressure and humidity should be recorded and preferably should be kept constant for each set of blackbody measurements.

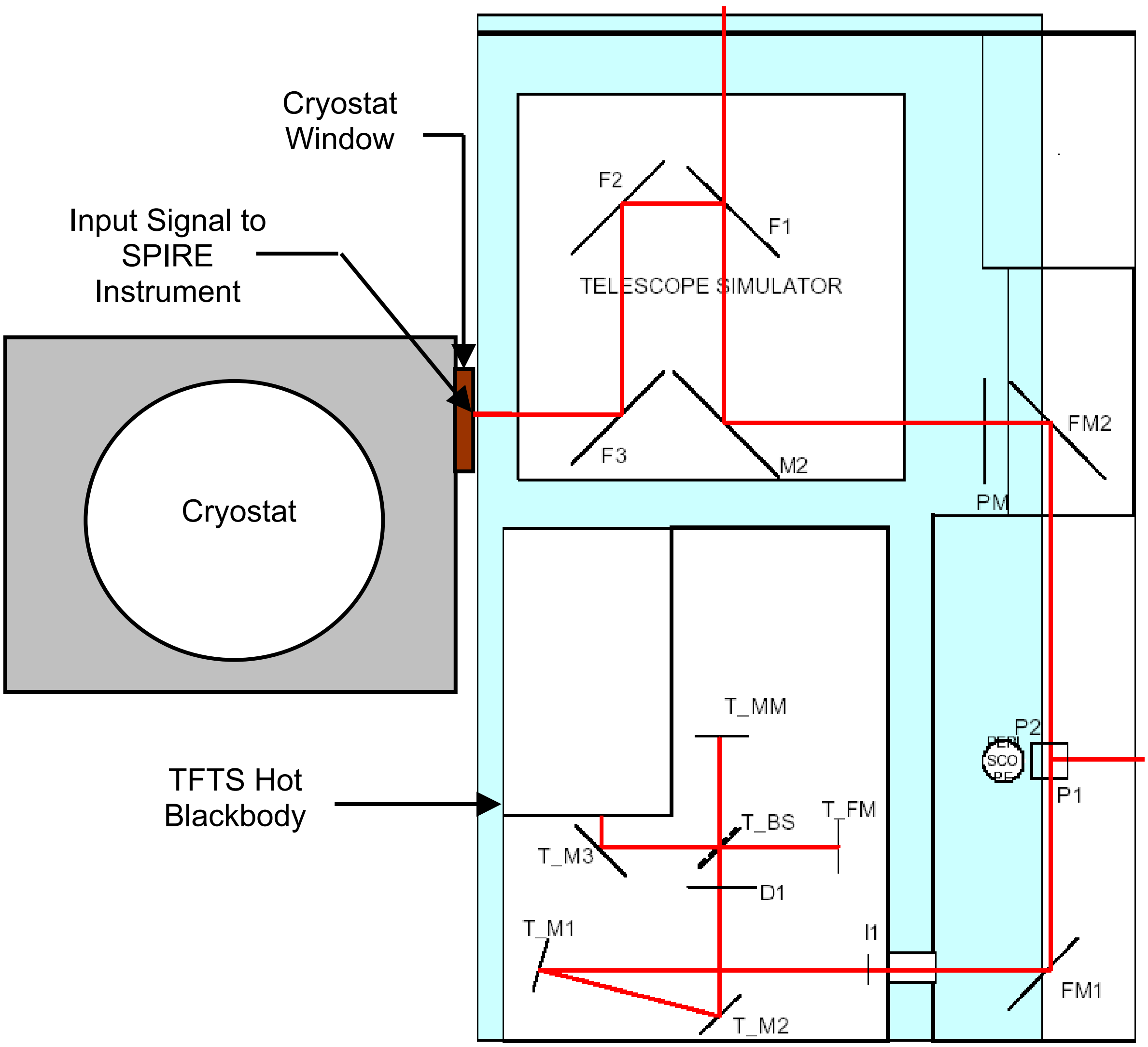

Figure 1 Mechanical Layout for the CQM Tests

11.3. Analysis

- Calculate the difference between the measured intensities at two blackbody temperatures.
- Divide the difference by the spectral curves of sources external to the cryostat.

- Compare the quotient with the expected value of the SR.

12. Open Issues

- Who will be involved in assessing the instrument's spectral characteristic? Put differently: Who can help to evaluate what we are seeing? What are the major contributors to the spectral profile?
- What measurements will be performed when to this end? Which instrument model(s)?

13. Checkpoints

Other users/OBST:

- Have all providers of input data agreed on its format?
- Have all users of the end product agreed on its format?

Quality Control:

- Are adequate flags for data quality and processing quality provided?

Trend Analysis:

- Are adequate flags for long-term trends in the data quality and processing quality provided?

CALT:

- Have all necessary calibration tables been identified?
- Can all necessary calibration tables be provided by the scheduled tests/operations?

ISDT:

- Are all software requirements (coding conventions, exception handling, test procedures, documentation, benchmarking) met?

Have all contributors to the spectral signature of the instrument been involved?