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COMMON-USER SUBMILLIMETRE BOLOMETER ARRAY - 2

SCUBA2

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1. INTERFACE DEFINITION

This document defines all the interfaces to the Fourier Transform Spectrometer (FTS) for the SCUBA-2 instrument.

2. ACRONYMS AND ABBREVIATIONS

CFI	-	Canadian Foundation for Innovation
EMI	-	Electromagnetic Interference
FTS	-	Fourier Transform Spectrometer
ICD	-	Interface Control Document
JAC	-	Joint Astronomy Centre
JCMT	-	James Clerk Maxwell Telescope
PC	-	Personal Computer
RTS	-	Real Time Sequencer
SCUBA	-	Submillimetre Common User Bolometer Array
U of L	-	University of Lethbridge
UBC	-	University of British Columbia
UKATC	-	UK Astronomy Technology Centre
ZPD	-	Zero Path Difference

3. APPLICABLE AND REFERENCED DOCUMENTS

Document Number	Title	Number & Issue
SC2/FTS/SYS/001	SCUBA-2 FTS Requirements Document	Version 1.1
SC2/SOF/S200/XX	SCUBA 2 Data acquisition software overview Part two	Version 1.0
SC2/FTS/SYS/003	SCUBA-2 FTS Software Requirements Document	Version 1.0
	Design and Construction Policies - JAC, Hale Pohaku, JCMT & UKIRT	
	JAC Health and Safety Manual	

4. INTERFACE REQUIREMENTS

4.1 REQUIREMENTS FOR THE U OF L

The U of L shall produce the FTS such that it conforms to the interface requirements detailed in the Interface Design section of this document. In addition, the U of L shall ensure that all the requirements detailed in the "FTS Requirements" and "FTS Software Requirements" documents are met.

4.2 REQUIREMENTS FOR THE JAC

The JAC shall make provisions for mounting of the FTS within the SCUBA-2 optics framework, as well as for the necessary infrastructure to hoist the FTS system or components into their mounting location.

4.3 REQUIREMENTS FOR SCUBA-2 SYSTEM SW

The SCUBA-2 System SW shall make provisions to ensure that a 32-bit mirror position value from the FTS can be recorded with every image frame while the FTS in use.

5. INTERFACE DESIGN

5.1 GENERAL

This document defines the interfaces to the FTS. The FTS consists of a series of optics mounted on a damped optical breadboard. A moving mirror assembly consisting of a pair of rooftop mirrors mounted on a linear motor drive is located in the centre of the breadboard, while two fixed mirror are mounted at each end of the breadboard. A pair of retractable mirrors is mounted on the top of the system to redirect a portion of the SCUBA-2 beam through the instrument. A framework that will allow the system to be hoisted as a unit will surround the entire FTS. More details can be found in the FTS requirements document (SC2/FTS/SYS/001) and the FTS OCD document (SC2/FTS/SYS/004).

5.2 MECHANICAL INTERFACES

For purposes of this document, the following orthonormal coordinate system is defined:

Origin = axis of elevation bearing, at the outer face of the bearing tube at the left Nasmyth, (4.15 m radially from the Azimthal axis)
X Axis = positive along the axis of the elevation bearing towards the azimuthal axis of the telescope
Y Axis = positive in the horizontal plane towards the front of the telescope
Z Axis = positive in the vertical direction

5.2.1 Space Envelope

The FTS will be a large (roughly 1 m x 3 m x 1.3 m XYZ) instrument weighing ~600 kg, and will require significant planning to ensure it can be mounted, aligned, and maintained at the telescope. The envelope of the FTS will extend over the coordinates X:+0.0,-1.0 Y:-1.9,+1.1 Z:-1.1,+0.2. The centre of mass will be roughly at coordinates X:-0.44 Y:-0.5 Z:-0.9.

5.2.2 Handling

The FTS will be provided with suitably rated lifting eyes or hoist attachments, such that it may be safely lifted onto the mounting structure on the telescope framework.

5.2.3 Mounting Structure

The most practical location that a FTS of sufficient resolution could be mounted between SCUBA-2 and the JCMT dish, without a redesign of the SCUBA-2 optics, is just outside the left Nasmyth elevation bearing within the mounting framework for mirror N1. The N1 mounting structure will need to support the mass of the FTS (~600 kg), as well as tolerate the inertial forces (~100 N at ~1 Hz TBD) generated by the moving mirror assembly, while maintaining alignment tolerances of the N1 mirror. Further mechanical design work is required before the precise centre of mass and dynamic force vectors can be specified.

The FTS also includes a cryogenic blackbody calibration source that will most likely be located just below the optical breadboard at [-0.3,-1.0,-1.1] m and will occupy a cylindrical volume of diameter ~0.4 m and height ~0.5m.
The system will be supported on the N1 framework with 4 adjustment screws, which will also allow levelling of the system.

5.2.4 Electronics and PC Location

The motion control unit must be located as close as possible to the FTS in order to minimize noise and servo problems associated with excessive cable lengths. Cable length must not exceed 10 m and will be shielded to minimize EMI. The control unit is a self-contained system within a 3U high, 19" rackmount chassis, and will most likely need to be mounted to the telescope framework near the FTS. A control PC is also part of the FTS system, and this unit can be located at any convenient location, within acceptable communication cabling distance from the motion control unit. The communication links should preferably be optical, but will depend on final selection of motion controller and design of FTS electronics.

5.2.5 Thermal

There are no anticipated thermal issues with the SCUBA-2 system or the JCMT dish due to power dissipation from the FTS mechanisms or electronics.

5.2.6 Actions

There will be the following possible actions for the FTS mechanisms, all of which will be under computer control:

- Inserting or retracting the FTS pickoff mirrors into or out of the main SCUBA-2 beam
- Moving the linear motion stage which supports the FTS rooftop mirrors to a given position at a given speed and acceleration
- Adjusting the temperature of the blackbody calibration source.

5.3 MAGNETIC INTERFACE

Although the SQUIDs used in SCUBA-2 for multiplexing and amplifying signals are extremely sensitive magnetometers, and must be well shielded from magnetic fields, it is not anticipated that the linear motors in the FTS will interfere with the detectors. To reduce EMI, the motion controller electronics must be located as close as possible to the FTS so that the motor drive cable length is minimized. The maximum length of the drive cable is 10 m. The FTS will be built with appropriate magnetic shielding such that the induced magnetic field measured at the SCUBA-2 1K box is no greater than the ambient magnetic field (~5×10^{-5} T)

5.4 OPTICAL INTERFACE

When in use, the FTS will add approximately 12 mirror reflections to the already complex SCUBA-2 optical path. While the FTS will have no impact on the design or alignment of the SCUBA-2 optics, initial alignment of the FTS will pose a significant challenge. The internal FTS optics can be aligned independently, however, alignment of the FTS to the SCUBA-2 system will require the use of laser alignment tools as well as feedback from SCUBA-2 imagery. Specifications for alignment and positional accuracy of the FTS optics will be driven by the overall SCUBA-2 optical parameters, and will be defined after optical modelling of the FTS is finalized.

5.5 DATA ACQUISITION COMPUTER INTERFACE

The FTS will in principle only interface with the SCUBA-2 system via a Data-Valid strobe signal, commands from the OCS (and return values), and mirror position values to be recorded by the SCUBA-2 data acquisition system with every frame while the FTS is in use.
There are two options for returning the FTS position values to the data acquisition system. The position values may be read in directly by the Data Acquisition Computer, or the FTS control PC could record the timestamped position values, and send them via the network to the data reduction computers. The first method would be a more seamless solution and similar to the fibre optic interface used between the DACs and the Multichannel Electronics, The second method requires no effort from the SCUBA-2 system development and is therefore a more likely solution (albeit more complex from a FTS software perspective).

5.6 RTS INTERFACE

The RTS system at the JCMT provides co-ordination between the telescope and the attached instruments (see the Real-Time Sequencer User Manual for details). The FTS electronics is required to use a sync signal, generated by the RTS master, to control the position sampling of the linear stage. The FTS electronics will be provided with a copy of the relevant RTS signal, Data Valid (DV), by means of a fibre optic link identical to that used for the Multichannel Electronics.

5.7 SOFTWARE INTERFACES

5.7.1 Data Analysis Pipeline interface

The U of L will produce the data analysis pipeline software needed to reduce individual sky-corrected frames to hyperspectral image cubes. This FTS pipeline software will run inside or in conjunction with the main SCUBA-2 data reduction pipeline. The FTS pipeline will take as inputs the 1 Hz frames from the DREAM algorithm and the moving mirror position values associated with each frame, and produce as an output a sequence of frames stacked as a function of frequency.

5.7.2 Quicklook Display interface

As a diagnostic tool for the observer, the FTS processing pipeline will produce simplified spectral data to be displayed on a monitor in the control room. In depth analysis of the spectral data cubes will not be possible in real time, but spectra from a few characteristic pixels may be displayed, as well instrumental parameters such as the current mirror positions, blackbody temperature, etc. in order to monitor the operation of the FTS. The details of what is displayed, and the refresh rate, will be determined at a later date.

5.7.3 Control Software interface

The FTS will be controlled by a dedicated PC, which will interface with the FTS sensors and motion controller, as well as the JCMT RTS, and network. The control software will accept commands from the OCS to perform fundamental actions such as moving the mirrors, and return appropriate error codes. The U of L will provide the control software such that it conforms to the JAC and JCMT software requirements.

5.8 TELESCOPE INTERFACES

5.8.1 General

The electronics must conform to JCMT safety standards and design construction policies. See the “Design and Construction Policies - JAC, Hale Pohaku, JCMT & UKIRT”, and the “JAC Safety Manual” for further information.

5.8.2 Power inlet

The FTS electronics must provide filtered IEC power inlets, with transient voltage protection. The inlets must accept the JCMT 110V AC, 60Hz mains supply. There will be mains inlets for the control electronics, control PC, and blackbody source.