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SPIRE Test Facility Requirements Specification

Distribution List :

SPIRE-Project	Ken J. King	**X**
	Bruce M. Swinyard	**X**
	Dave L. Smith	**X**
ATC	Colin Cunningham	**X**
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1 Scope of the document

This document describes the requirements specification of the FIRST/SPIRE Test Facility to be used for the thermal balance, cold functional tests and calibration of the CQM and PFM instruments (AD 1).

2 Documents

2.1 Applicable documents

	Title	Author	Reference	Date
AD 1	SPIRE outline AIV flow	B.Swinyard	SPIRE/RAL/N/0020	
AD 2	Outline Specification of the SPIRE instrument calibration facility	B.Swinyard	SPIRE/RAL/N/0058	
AD 3	SPIRE Development Plan			

2.2 Reference documents

	Title	Author	Reference	Date

2.3 Glossary

AD	Applicable Document
CDR	Critical Design Review
CQM	Cryogenic Qualification Model
DDR	Detailed Design Review
EGSE	Electrical Ground Support Equipment
FIRST	Far InfraRed Space Telescope
FIR	Far InfraRed
FPU	Focal Plane Unit
FTS	Fourier Transform Spectrometer
MGSE	Mechanical Ground Support Equipment
NA	Not Applicable
PFM	ProtoFlight Model
QMW	Queen Mary and Westfield College
RAL	Rutherford Appleton Laboratory
RD	Reference Document
SPIRE	Spectral and Photometric Imaging REceiver
TBC	To Be Confirmed
TBD	To Be Defined
TFCS	Test Facility Control System
WE	Warm Electronics

3 Description of the Test Facility

The AIV facility will comprise of two working areas. A clean room to house the cryostat and optical bench, and a control room to house the instrument EGSE and control equipment for the cryostat and calibration equipment, Figure 1. The working area around the cryostat will be class 100, and other areas in the clean room will be class 10, 000 or better.

The SPIRE instrument will be mounted in a cryostat to simulate the thermal conditions provided by the FIRST cryostat, namely 7-11K, 4K and 2K. External calibration sources will be viewed via a telescope simulator situated outside the cryostat at room temperature. A 20K-blackbody source mounted in the cryostat will provide an absolute calibration reference.

The telescope simulator is required to present the instrument with an F/5 beam to correctly represent the input from the FIRST telescope.

The control and monitoring of the calibration sources, telescope simulator and cryostat temperatures will be performed via a single test facility systems computer (TFSC), connected to the main SPIRE EGSE.

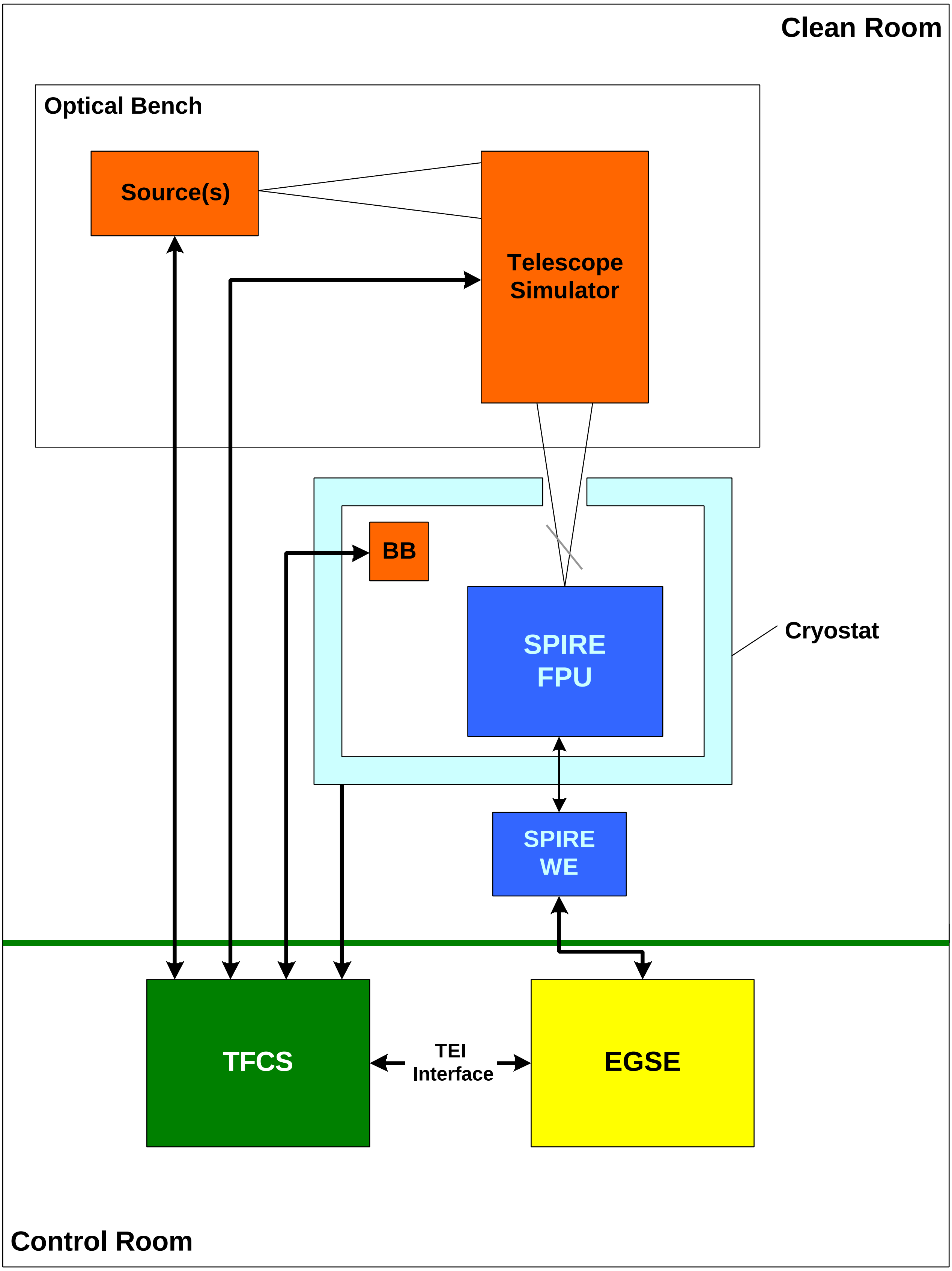

Figure 1: Fundamental elements of the SPIRE Test Facility

4 Requirements

4.1 Cryostat

4.1.1 General

R1.1	The calibration cryostat must be able to accommodate the SPIRE instrument and associated electronics units (JFET/Filter box).
R1.2	The cryostat will also house a cold blackbody source operating between 4K and 20K for use during calibration.
R1.3	The SPIRE instrument must be mounted with the baseplate horizontal (I.E., +Y direction down) so that the instrument mechanisms do not work against gravity.
R1.4	The distance from the Cryostat outer window to the SPIRE image plane must be no greater than 500mm.
R1.5	All materials used for the cryostat and equipment contained in the vacuum environment must be suitable for vacuum and low temperature use. Recommended vacuum materials include: Stainless Steel Aluminium Copper Gold Glass and Quartz Teflon Polymide (Trade named Vespel) Viton Carbon Composites Crystalline Filter Materials (e.g. MgF, LiF etc) Solder Kynar Where materials not on this list are to be used (e.g. black paint, adhesives), their outgassing properties must conform to ESA and NASA outgassing rates as specified in
R1.6	The instrument must be mounted in such a way as to allow ease of access and minimum effort during integration.
R1.7	The cryostat will be painted yellow.

4.1.2 Thermal

R2.1	The cryostat must be able to simulate the thermal environment provided by the FIRST cryostat. The main interface temperatures are 7-11K, 4K and 2K.
R2.2	At operating temperatures, the temperature of the SPIRE FPU should drift by no-more than TBD $Kmin^{-1}$
R2.3	The cryostat should enable the SPIRE instrument and electronics to attain operating temperature within 24 hours, at a maximum rate of $20Khr^{-1}$.
R2.4	The cryostat should allow a cryogen hold time of at least three days when the instrument is fully cooled. This will eliminate the need for an automatic liquid He delivery system, therefore reducing overall costs. The helium exhaust will not be recovered for future use.
R2.5	The cryostat design should allow the instrument to be heated to TBDK before allowing the He shrouds to warm up to prevent contamination of the instrument optics.

R2.6	Heat leaks must be kept to a minimum by anchoring the thermometer wires to the refrigerant tanks, and/or using low thermal conductivity wire.
R2.7	Temperatures of the thermal environment must be measured during the tests. The location and accuracy of the thermometers will be defined in the thermal test plan.

4.1.3 Vacuum

R3.1	The vacuum system must be able to pump the chamber to 10^{-6}mbar (TBD) within 24 hours before filling the cryogen tanks to ensure that the inside of the instrument is at least 10^{-4}mbar (TBC).
R3.2	The maximum pumping rate shall be TBD $Lmin^{-1}$ to protect the instrument filters. These rates also apply for backfilling.
R3.3	The pumping system must be mechanically isolated from the chamber to prevent vibrations being transmitted to the instrument optics.
R3.4	The pumping system must be oil free if possible to prevent contamination of the optical surfaces.
R3.5	A gate valve will be installed between the pumping system and cryostat. The valve must be closed before filling the cryogen tanks in order to prevent backflow of any lubricants into the main chamber. The gate valve must automatically close in the event of a failure of the pumping system.
R3.6	A burst valve must be installed to prevent the chamber exceeding atmospheric pressure either during controlled let-up-to-air, or a sudden loss of vacuum.
R3.7	The cleanliness standard and systems for the tank must conform to TBD. Mountings for TBD witness mirrors shall be provided in the calibration rig.
R3.8	The vacuum pressure must be measured during pumpdown. The pressure range is expected to be 1bar to 10^{-8}mbar. After high vacuum has been reached the pressure gauges will be switched off.
R3.9	A Residual Gas Analyser (range 1-200 AMU) is required to monitor partial pressures of contaminants in the chamber during commissioning. This is not required for the actual calibration tests.

4.1.4 Optical

R4.1	The support structure must ensure that the optical alignment is maintained to TBD'' when the instrument is cold.
R4.2	Optical filters will be mounted at each of the cryostat interfaces between the instrument aperture and telescope simulator. The specifications of these are TBD at the time of writing.
R4.3	A flip mirror will be mounted to allow the instrument to view the 20K-blackbody source.

4.1.5 Electrical Interfaces

R5.1	Electrical feedthroughs between the air and vacuum sides of the chamber will be provided for the instrument electronics, thermometry and cold calibration target(s).
R5.2	It must be demonstrated that there is no electrical interference to the supplies of the SPIRE instrument and EGSE.

4.2 Clean Room

The clean room will house the calibration cryostat, optical bench supporting the sources and telescope assembly and the SPIRE instrument mounted on MGSE. This area will only be used for instrument calibration and not for general AIT activities. Hence only limited workspace will be available to prepare test equipment and the instrument for the calibration.

4.2.1 Cleanliness

R5.1	The area immediately surrounding the cryostat, where instrument optics will be exposed, will be class 100.
R5.2	All other areas in the clean room will be class 10,000 or better.
R5.3	Airflow in the clean room must be directed away from the cryostat, where possible, such the entrance to the clean room and changing area are downstream.
R5.4	The entrance to the clean room must be wide enough to allow the instrument and MGSE to pass through.
R5.5	Cleanliness will be monitored throughout the SPIRE calibration period.

4.2.2 Electrical

R6.1	Two clean 28V power supplies must be provided for the SPIRE instrument.
R6.2	There shall be adequate power points for the SPIRE EGSE, test equipment and vacuum system.
R6.3	The electrical design of the facility must ensure that there are no ground loops that could pose an EMI problem.
R6.4	All electrical connections in the facility must be fully documented and readily accessible.

4.2.3 Access

R7.1	The entrance to the clean room must be wide enough to allow the instrument and MGSE to pass through.
R7.2	Due to limited space and to maintain cleanliness, access to the clean room will be restricted to a few authorised personnel. To prevent unauthorised access, a card key system will be installed.

4.2.4 Safety

R8.1	Oxygen monitors will be installed in the clean room that should sound a clear alarm in the event of O_2 going below safe levels.
R8.2	Escape from the room in the event of an emergency must be unrestricted.
R8.3	A full risk assessment must be carried out and emergency procedures must be ready before the facility is used for cryogenic work.
R8.4	Laser warning signs and eye goggles will be provided in accordance with RAL site regulations.
R8.5	A full risk assessment must be carried out and emergency procedures must be ready before using laser equipment.

4.2.5 Other

R9.1	The clean room should be light tight to allow use as a dark room.

4.3 Control Room

R10.1	There must be adequate space for the SPIRE EGSE, TFCS, vacuum equipment and at least 4-5 people.
R10.2	Access to the control room will be restricted by a card key system provided by the RAL AIV facility.
R10.3	The entrance to the clean room will have changing facilities.
R10.4	There will be sufficient power supplies for the EGSE and support equipment.
R10.5	The control room will have a telephone.
R10.6	Connection points will be provided to allow connection to the internet, and fax machines.

4.4 Telescope Simulator

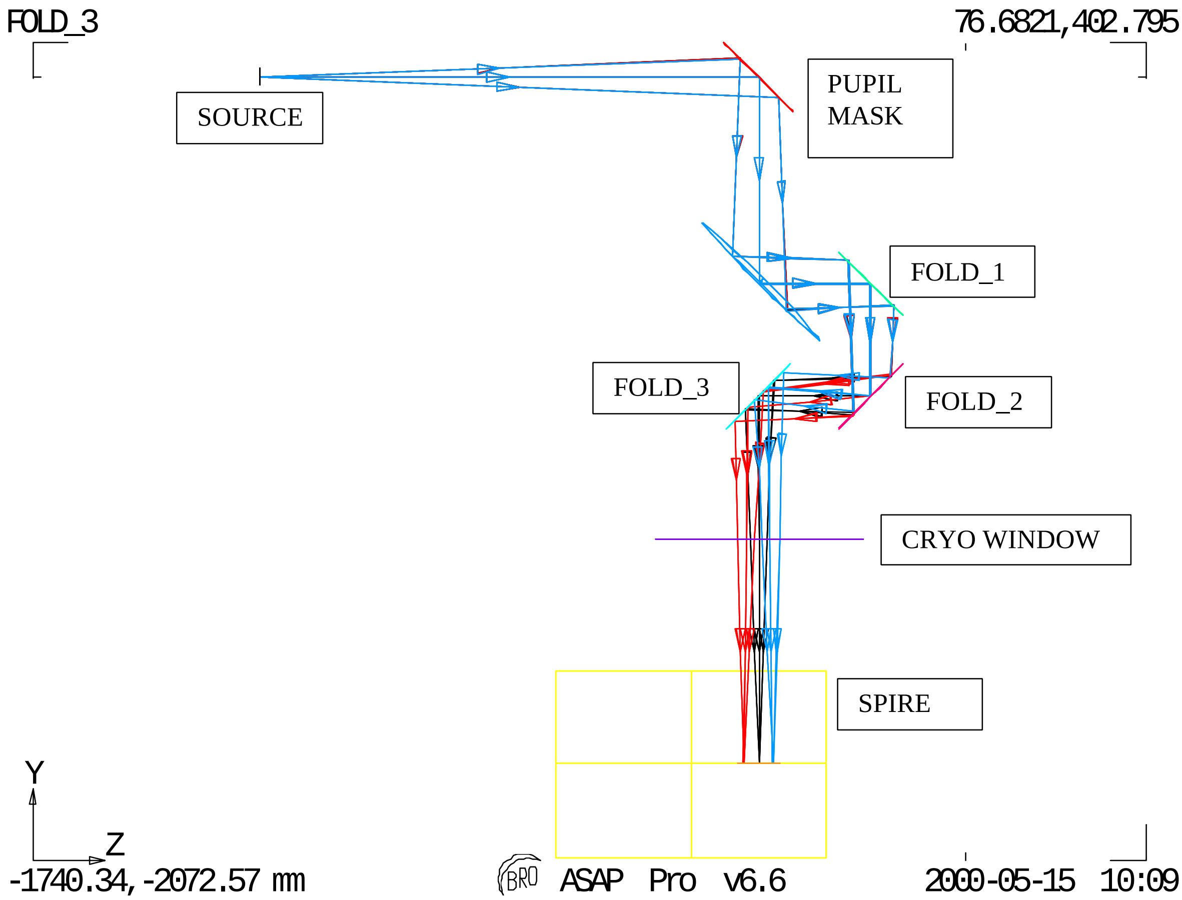

Figure 2: Optical design of the Telescope Simulator

R11.1	The Telescope Simulator will present the SPIRE FPU with an F/5 beam over the full FOV of the instrument.
R11.2	The SPIRE beam envelope must not be vingetted by the cryostat walls or simulator optics.
R11.3	The Telescope Simulator will occupy an area no larger than 550mm x 1200mm
R11.4	The distance from the 3rd fold mirror to the SPIRE image plane will be nominally 800mm
R11.5	The position of the moving mirrors will be remotely controlled and monitored by the TFCS.

4.5 Sources

The following sources will be required for the SPIRE calibration tests.

R12.1	Hg Lamp
R12.2	FIR Laser
R12.3	FIR FTS
R12.4	20K-Blackbody
R12.5	Reference Bolometer

4.6 Test Facility Control System (TFCS)

Fully automatic control of the calibration system is not necessary since the duration of the calibration tests is only a few weeks. Development of a fully automated system would be disproportionately expensive on cost and effort, and high risk. However remote control should be provided, where appropriate, for the vacuum system, temperature monitoring, liquid nitrogen and helium levels, and the calibration equipment.

R13.1	The TFCS will be used to provide central control for the test equipment, log temperatures and other test data (e.g. source levels).
R13.2	There will be a TCP/IP network to allow transfer of data between the TFCS and the SPIRE EGSE.
R13.3	The TFCS will be able to receive commands from the SPIRE EGSE
R13.4	The TFCS will transmit telemetry packets to the SPIRE EGSE
R13.5	The TFCS clock will be synchronised to the SPIRE EGSE to allow accurate matching of data.
R13.6	The TFCS will be able to run in a stand-alone mode.