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PFM5 Cold Test – Master Procedure

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1 Scope of Document

This procedure describes the activities to be performed during the PFM-4 cold thermal test campaign, which is a key inspection point (AD 1). The details of the instrument integration and cryostat operations are given in AD 7 and AD 8 respectively. The sequence of the performance testing is a an overview based on the SPIRE FM Calibration and Performance Test Plan (AD 3) which defines the flow and detailed procedures. The aim of this document is to ensure that the test objectives are achieved.

2 Documents

2.1 Applicable Documents

	Title	Author	Reference	Date
AD 1	SPIRE AIV Plan	B.J. Swinyard	SPIRE-RAL-DOC-000410 Issue 3	May 2003
AD 2	As Built Configuration List	Eric Sawyer	SPIRE-RAL-DOC-002326 Issue 2.8	Oct 2006
AD 3	SPIRE FM Calibration and Performance Test Plan	T. Lim	SPIRE-RAL-DOC-002535 Draft 0.2	15-Sep-2006
AD 4	Functional Test Specification	S. Ronayette Asier Abreu	SPIRE-RAL-NOT-1652 Issue 1.4	10-Dec-2004
AD 5	PFM2 Thermal Balance Test Specification	A.S. Goizel	SPIRE-RAL-DOC-002435 Issue 1	Dec 2005
AD 6	Input to SPIRE PFM3 Thermal Test Specification	A.S. Goizel	SPIRE-RAL-MEM-002563 Draft A	Feb 06
AD 7	SPIRE Harness Integration Procedures	D.L. Smith	SPIRE-RAL-PRC-2122 Issue 0.4D	Dec 2004
AD 8	SPIRE Cryostat Operating Procedures	D.L. Smith	SPIRE-RAL-DOC-001556 Issue 1.0	12-Jan-2005
AD 9	SPIRE Cryolab Risk Assesment	D.L. Smith	SPIRE-RAL-DOC-002103 Issue 2.0	28-July-2004
AD 10	SPIRE Instrument Operations Procedures	S. Sidher		
AD 11	SPIRE EGSE ILT Startup Procedures	S. Sidher and M. Requena	SPIRE-RAL-DOC-001630	24-Jun-2003
AD 12	DRCU Switch On Procedure	A. Aramburu	SPIRE-RAL-NOT-002222	
AD 13	SPIRE Cleanliness Plan	B.J. Swinyard	SPIRE-RAL-DOC-001070 Issue 1.0	9-Jan-2002
AD 14	RAL Safety Codes	CCLRC	http://www-internal.clrc.ac.uk/staff/notices/clrc_safety_codes/sc2.html	July-2003

3 Test Objectives

The PFM-5 test campaign is an additional test of the SPIRE PFM instrument to evaluate the stray light performance under dark conditions.

4 Test Configuration

4.1 Instrument Build

The model to be tested consists of the full flight model configuration of the FPU, DPU and DRCU. The table below provides a summary of the build standard of the PFM-4 instrument for information only. A more detailed breakdown of the components is given in the as built configuration list AD 2.

Unit /component	Build Standard
HSFPU	
Structure/baffles/standoffs etc	PFM
L0 straps	MGSE – New for PFM-4 with flight like flexible interface and light trap.
Mirrors	PFM
Filters	CFIL-1 – PFM SFIL2 – PFM SBS1 – PFM SBS2 - PFM SFIL3 to 5S – PFM SFIL3 to 5L – PFM CFIL1 - PFM PFIL-2 - PFM PFIL-3 - PFM PDIC-1 – PFM PDIC-2 – PFM PFIL-4S - PFM PFIL-5S - PFM PFIL-4M - PFM PFIL-5M - PFM PFIL-4L - PFM PFIL-5L - PFM PFIL-6L - PFM
Beam steering mirror	PFM
3He Cooler	PFM
300 mK thermal straps and supports	PFM
300 mK Thermal control system	PFM
Photometer LW array	PFM
Photometer MW array	PFM
Photometer SW array	PFM
SMEC	PFM
Spectrometer SW array	PFM
Spectrometer LW array	PFM
Photometer Calibrator	PFM
Spectrometer Calibrator	PFM – with 2% and 4% source redundant side disconnected for phot box GSE heater
FPU RF Filters	PFM
Thermometry	PFM

Unit /component	Build Standard
FPU internal harnesses	Spectrometer side – PFM Photometer side - PFM
HSJFP	
JFET Structure	PFM
JFET Modules	PFM – except one non flight but functional module
JFET box RF filter modules	PFM
JFET Backharness	PFM
JFET/FPU Harness	PFM
HSJFS	
JFET Structure	PFM
JFET Modules	PFM
JFET box RF filter modules	PFM
JFET Backharness	PFM
JFET/FPU Harness	PFM

Subsystem /component	Requirement
HSDCU	
DCU Structure	FM
Electrical Interfaces	Flight
Functionality	Full functionality
Electrical Component Level	Flight
HSFCU	
FCU Structure	FM
MCU	FM
Electrical Interfaces	Flight
Functionality	Full functionality
Electrical Component Level	Flight
SCU	FM
Electrical Interfaces	Flight
Functionality	Full functionality
Electrical Component Level	Flight
PSU	FM
Electrical Interfaces	Flight
Functionality	Full functionality
Electrical Component Level	Flight
HSDPU	FM
DPU Structure	Flight
Electrical Interfaces	Flight
Functionality	Full functionality
Electrical Component Level	Flight
On Board Software	
Functionality	Full functionality but no autonomy required Refer to table in section 4.4 for version numbers and patches
HSWIH	
Length/Connector type	Test harness
Electrical Interfaces	Form; fit; function
Functionality	Full functionality on prime side only
Electrical Component Level	Commercial

4.2 Cryostat

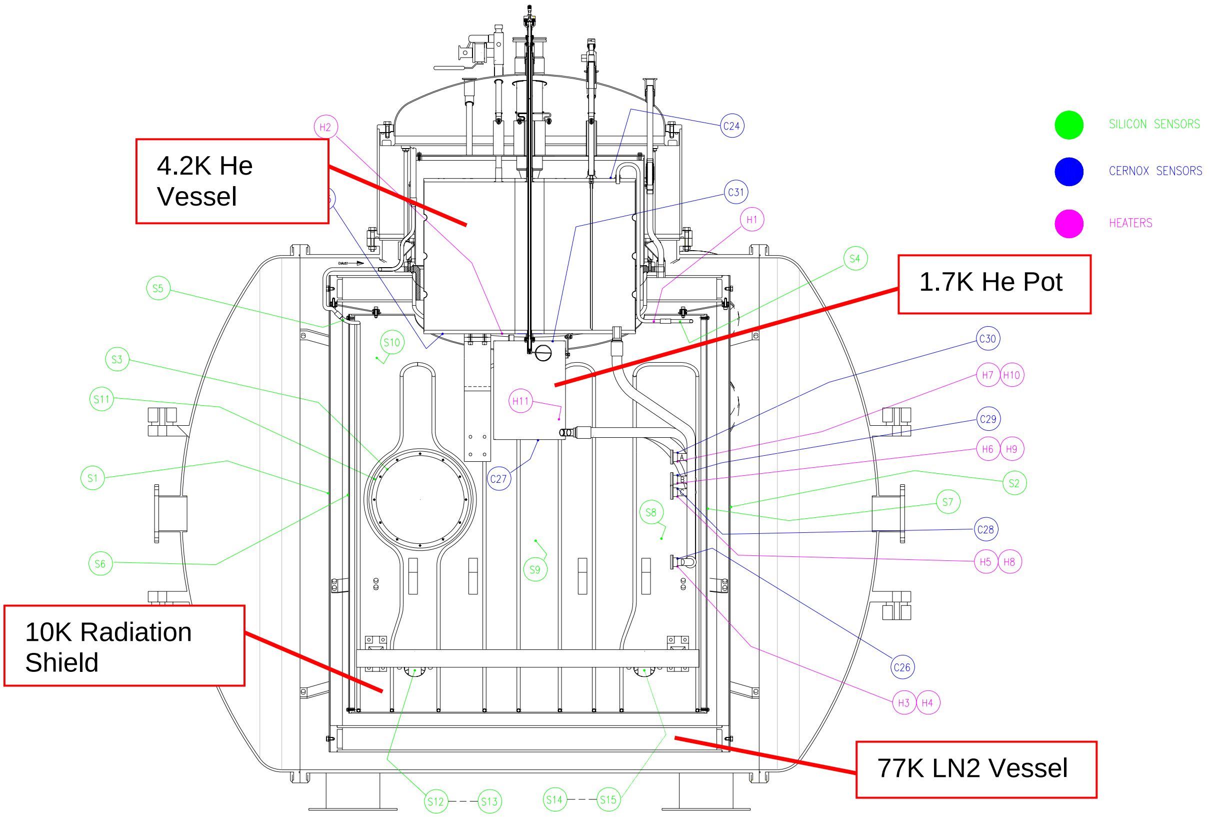


Figure 1: Cross section of SPIRE test cryostat showing the different temperature stages and thermometer locations.

The SPIRE Calibration Cryostat has four stages of cooling, an outer liquid nitrogen cooled vessel at 77K, a 10K radiation shield, a 4.2K liquid He vessel and a 1.7K pumped liquid He pot, Figure 1. A more detailed description of the cryostat and its operation is given in AD 8

4.3 OGSE

No optical equipment will be used for this test campaign as the entrance aperture of the instrument will be covered.

4.4 EGSE Configuration

The following table gives the build standard of the EGSE software at the start of the test campaign.

System	Version	Updated
SCOS-2000	2.3E patch 5	
HCSS	Build 1106 (Version 0.4.1)	
QLA	3.3	
MIB	PFM5	
OBS	2.2G	
TFCS	2.8	Nov-2006
TFTS server	1.6	25-Nov-2006

5 Constraints

5.1 Safety

All personnel working in the SPIRE test facility must read the facility risk assessment, especially as there are particular hazards associated with the cryostat and laser.

Great care should be taken when handling liquid nitrogen and helium. The main hazards associated with liquid Nitrogen and Helium are:

- Cold "burns" to the person.
- Explosions due to the vaporization of the liquefied gas into an enclosed space.
- Asphyxiation due to exclusion of oxygen.
- Spillage onto structural materials, which can cause thermal contraction of the metal, say steelwork, with resultant cracking.

All people working with the cryostat should have instruction on the safe handling of cryogenic liquids and familiarise themselves with the laboratory safety code CCLRC Safety Code 2 which can be found on http://www-internal.clrc.ac.uk/staff/notices/clrc_safety_codes/sc2.html The safety code must be followed at all times when handling cryogenic liquids. A risk assessment shall be performed before operating the cryostat.

The personal oxygen monitors provided must be used when entering the lab when the cryostat is cold. These are calibrated every 6 months by the manufacturers (Crowcon in Abingdon).

When the oxygen monitor alarm sounds leave the room immediately and call ext 5996. DO NOT attempt to enter the room afterwards until the all clear has been given.

The gloves provided shall be worn when transferring liquid helium and nitrogen into the tank.

Any dewars with worn or damaged castors or which are difficult to wheel safely should be taken out of service and returned to stores immediately for repair or maintenance.

5.2 Cleanliness

To minimise the level of contamination, the FPU should remain covered until the particulate count is below that for a class 6 (old class 1000) clean room. The maximum concentration limits as specified by ISO EN 14644-1 1999 Standard (particles per m³ of air) for particles greater than the considered sizes are

Size	Specification
0.1µm	1000000
0.2µm	237000
0.3µm	102000
0.5µm	35200
1.0µm	8320
5.0µm	293

The following clothing shall be worn at all times when working in the clean room to avoid contamination of the instrument or surfaces that the instrument will come into contact with.

Facemasks
Hats
Coats
Overshoes
Gloves – to prevent cross contamination via tools and test equipment

Personnel working in the clean room must first attend the RAL SSTD training session on clean room practice.

Where possible, personnel should work downstream of the instrument from the air-filters.

As space is extremely limited, only essential personnel are permitted to work in the clean room.

Tools for use in the clean room must first be cleaned using IPA wipes.

5.3 ESD Precautions

The SPIRE FPU, JFETS, DRCU and DPU are sensitive to electrostatic discharge. To prevent accidental damage to sensitive components, the units shall be grounded via a suitable earth strap while work is being performed. The earth straps may only be removed once the electronics have been connected together in accordance with the harness integration procedure. **ESD wrist straps shall be worn at all times when working either directly or within 1m of the instrument.**

All personnel who are working on or in the vicinity of the instrument must have attended the RAL SSTD training session on ESD.

6 Organisation

Once cold the typical daily plan for the test campaign is shown as follows

07:30-08:30 (2 people)
Top up He vessels

08:30-10:30 (2 people)
Top up LN2 vessel
Allow temperatures to stabilise
Recycle cooler if necessary
Switch on test equipment (laser) and allow temperatures to stabilise
Order Helium for next day

10:30-15:00
Instrument Testing – Team A (3 people, SCOS driver, QLA driver, Equipment driver)

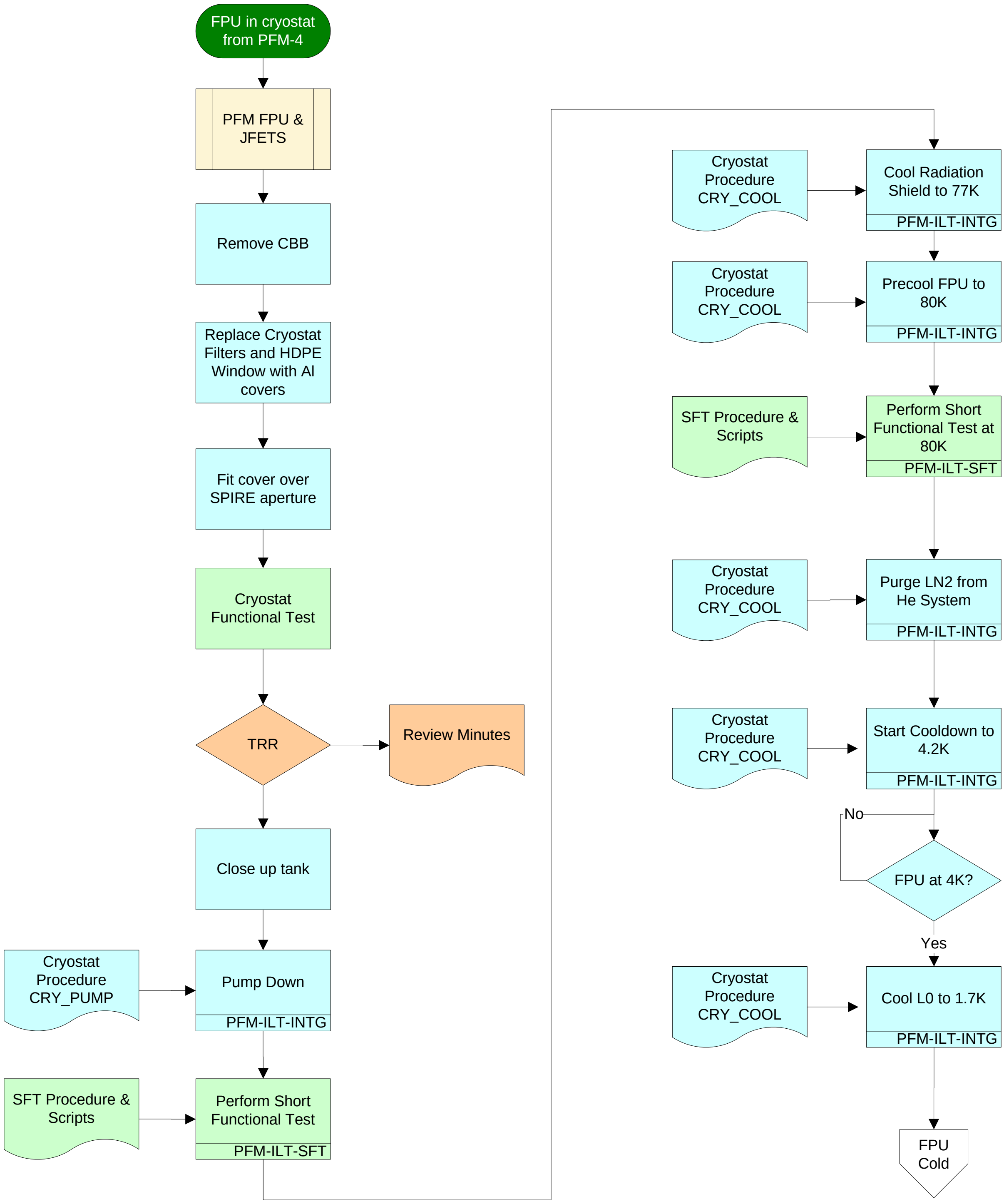
15:00-15:30
Daily planning meeting
Full team required
report on previous 24 hours
highlight major issues
plan next 24 hours activities

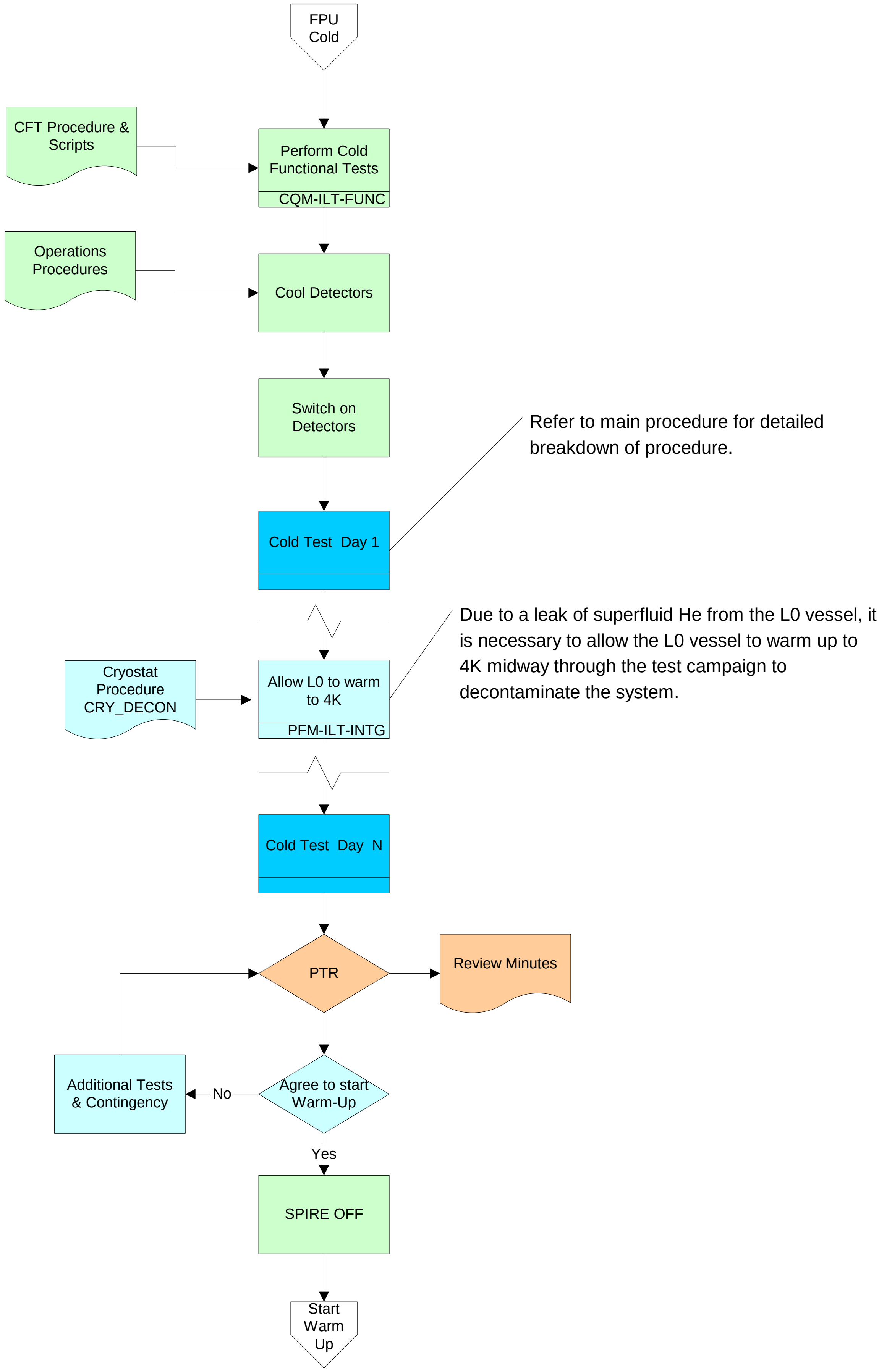
15:30-22:00
Instrument Testing – Team B (3 people)

22:00-23:00 – Team B
Prepare to store instrument for night

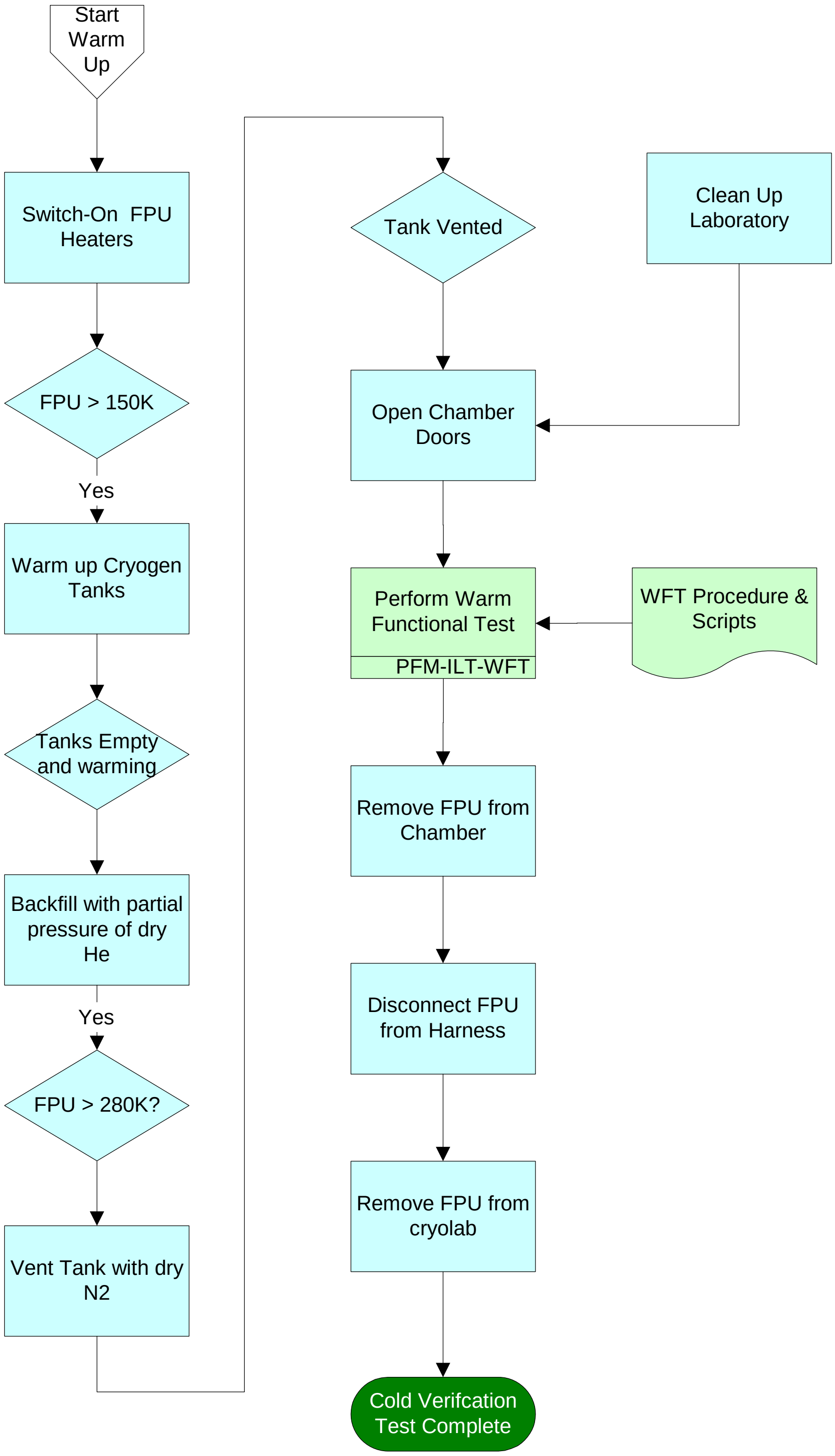
23:00-07:30
Thermal balance tests
Quiet Performance Tests (e.g. TFTS scans, noise tests)

7 Procedure Flowchart





FPU Cold
CFT Procedure & Scripts
Perform Cold Functional Tests
CQM-ILT-FUNC
Operations Procedures
Cool Detectors
Switch on Detectors
Refer to main procedure for detailed breakdown of procedure.
Cold Test Day 1
Due to a leak of superfluid He from the L0 vessel, it is necessary to allow the L0 vessel to warm up to 4K midway through the test campaign to decontaminate the system.
Cryostat Procedure CRY_DECON
Allow L0 to warm to 4K
PFM-ILT-INTG
Cold Test Day N
PTR
Review Minutes
Additional Tests & Contingency
No
Agree to start Warm-Up
Yes
SPIRE OFF
Start Warm Up


Start Warm Up
Switch-On FPU Heaters
FPU > 150K
Yes
Warm up Cryogen Tanks
Tanks Empty and warming
Backfill with partial pressure of dry He
Yes
FPU > 280K?
Vent Tank with dry N2
Tank Vented
Clean Up Laboratory
Open Chamber Doors
Perform Warm Functional Test
PFM-ILT-WFT
WFT Procedure & Scripts
Remove FPU from Chamber
Disconnect FPU from Harness
Remove FPU from cryolab
Cold Verifcation Test Complete

8 Test Procedure

Objectives:	See section 3 This is a key inspection point.
Initial Conditions:	SPIRE PFM Chamber at Atmospheric Pressure (~1000mbar) FPU in cryostat Vacuum system control electronics OFF Turbo Pump fan unit power OFF N2 supply closed 3 Phase supply OFF EGSE ILT OFF
Final Conditions:	FPU Removed from Cryolab
Constraints:	Pumping must not start until a test readiness review has been held and authorisation to proceed has been given. Grounding straps provided must be worn at all times when working on FPU and WE
Total Duration:	5 weeks

Step.	Action	Comments	Task Complete
1	**Hold Test Readiness Review**		
1.1	Required Personnel Instrument Manager – Eric Sawyer AIV Manager – Dave Smith PA Manager – Eric Clark System Engineer – Doug Griffin Thermal Engineer – Anne Sophie Goizel Calibration Scientist – Tanya Lim Instrument Specialist – Sunil Sidher Instrument Scientist – Bruce Swinyard		
2	**Reconfigure Instrument from PFM-4 campaign**		
2.1	Remove cold blackbody		
2.2	Replace filters with Aluminium blanks		
2.3	Replace HDPE window with Metal vacuum plate		
2.3	Fit aperture cover to SPIRE		
3	**Cryostat Functional Tests**		
3.1	Verify operation of cryostat instrumentation using procedure **CRY_CHECK** (ref AD 8)		
3.1	Verify correct operation of Pump System		
3.2	Verify thermometer connections		
3.3	Verfiy cryostat heater operations		

Step.	Action	Comments	Task Complete
4	**Close Cryostat**		
4.1	Replace 10K end-cap at west end of cryostat		
4.2	Connect thermometer harness and check function		
4.3	Replace 77K end-cap at west end of cryostat		
4.4	Connect thermometer harness and check function		
4.5	Replace 10K end-cap at east end of cryostat		
4.6	Connect thermometer harness and check function		
4.7	Clamp instrument cryoharness to 10K shield and verify electrical isolation		
4.8	Replace cowl on 10K end plate		
4.9	Replace 77K end-cap at east end of cryostat		
4.10	Place loose harness between MLI and 77K shield – ensuring that electrical isolation is maintained.		
4.11	Close doors of vacuum chamber and fasten clamps.		
5	**Pump-Down Cryostat**		
5.1	Start cryostat pump-down using procedure CRY_PUMP (ref AD 8)		
6	**Perform Short Functional Test – PFM-ILT-SFT**		
6.1	Vacuum chamber at 10^{-5}mbar?		
6.2	Perform Short Functional Test	Refer to document SPIRE-RAL-PRC-002322	
6.3	Leave SCU DC thermometry on for cooldown	Done as part of SPIRE-RAL-PRC-002322	
7	**Purge He Vessels**		
7.1	Purge He vessels with dry N2 gas according to procedure CRY_COOL (ref AD 8)		
8	**Cool LN2 Radiation Shield**		

Step.	Action	Comments	Task Complete
8.1	Fill LN2 Radiation shield according to procedure CRY_COOL (ref AD 8)		
9	**Pre-cool FPU to 80K**		
10.1	Cool SPIRE FPU to 80K using procedure CRY_COOL (ref AD 8) – NOTE This procedure will take several days to complete		
10.2	Once FPU has reached 80K remove liquid nitrogen from 1.7K and 4K vessels using step 4 of the cryostat operating procedure CRY_COOL (ref AD 8)		
10.3	Confirm that all liquid nitrogen has been removed from 1.7K and 4K vessels. **Do not proceed with pump/purge cycle without signing off this step!**		
10.4	Purge He vessels with He gas according to step 5 of cryostat operating procedure CRY_COOL (ref AD 8)		
11	**Perform Short Functional Test Before Filling with He – PFM-ILT-SFT**		
11.1	FPU thermometers below 100K?		
11.2	Perform Cool Functional Test	Refer to document SPIRE-RAL-PRC-002322	
11.3	Leave SCU DC Thermometry Running	Done as part of SPIRE-RAL-PRC-002322	
12	**Cool instrument to 4.2K**		
12.1	Cool SPIRE to 4.2K using procedure CRY_COOL (ref AD 8)		
12.2	Allow temperatures to stabilise		
12.3	Measure steady state temperatures and check thermometry		
13	**Perform Cold Full Functional Tests - Part 1**		
13.1	FPU Below 5K?		
13.2	Perform SPIRE Cold Functional Tests – step 1 to X inclusive	Refer to document SPIRE-RAL-PRC-002322	
14	**Cool to 2K**		
14.1	FPU below 5K?		

Step.	Action	Comments	Task Complete
14.2	Cool L0 interface to 2K using procedure CRY_COOL (ref AD 8)		
14.3	If FPU L0 at 2K proceed to step 19		
15	**Perform Cold Full Functional Tests - Part 2**		
15.1	All L0 temperatures at 2K and stable?		
15.2	Recycle cooler holding L0 vessel at 2K		
15.3	When evaporator temperature at 300mK, lower L0 vessel temperature to 1.7K.		
15.4	Continue cold functional tests from step X+1	Refer to document SPIRE-RAL-PRC-002322	
16	**Start Cold Test Activities**		

The following is a rough outline of the main activities to be performed for the first two weeks of the test campaign. The eventual flow of the test campaign will depend on schedule and the availability of key personell.
A spreadsheet with a detailed step-by-step sequence to be followed by the test team will be produced on a daily basis.

Day 1
Phase up for photometer
Overnight load curves

Day 2
PTC optimisation
Overnight photometer load curves at higher temp

Day 3
PTC optimisation
Overnight noise test

Day 4
EMC
Overnight photometer load curves at higher temp

Day 5
EMC
Overnight photometer load curves at higher temp

Step.	Action	Comments	Task Complete
	Day 6 Phase up Spectrometer Overnight spectrometer load curves **Day 7** Phase up Spectrometer Load Curves Overnight noise tests **Day 8** SMEC Operations Overnight load curves at higher temp **Day 9** SMEC Step and look tuning **Day 10** Microphonics Overnight load curves at higher temp		
17	**Post Test Review**		
17.1	Hold test review to assess need for additional/repeat tests before warming up.		
18	**Switch OFF SPIRE**		
18.1	Switch OFF SPIRE, leaving SCU DC thermometry running.		
18	**Warm Up**		
18.1	Warm SPIRE to ambient using procedure CRY_WARM (ref AD 8)		
19	**Let Up to Atmosphere**		
19.1	Let up chamber to atmospheric pressure using procedure CRY_LETUP (ref AD 8)		
20	**Perform Warm Functional Test**		
20.1	Chamber at atmospheric pressure?		
20.2	Perform warm functional test	Refer to document SPIRE-RAL-PRC-002322	

Step.	Action	Comments	Task Complete
20.3	Check that all SPIRE subsystems have been switched OFF	Done as part of SPIRE-RAL-PRC-002322	
21	**Open Cryostat**		
21.1	Return MGSE from G56 clean room		
21.2	Connect MGSE to facility ground		
21.3	Monitor Particulate levels in laboratory		
21.4	Particulate levels for class 6 clean room (old class 1000) Maximum concentration limits (particles per m³ of air) for particles > than the considered sizes below.		
	(see table below)		
21.5	Open cryostat doors – ensure that Oxygen monitor is on person at all times during this procedure as the chamber will be full of nitrogen gas – allow oxygen levels to recover before returning to lab		
21.6	Remove 77K end caps and store in cryostat doors		
21.7	Remove cowl from 10K shield		
21.8	Unclamp instrument harness from 10K shield		
21.9	Remove 10K end-caps		
22	**Remove FPU from Cryostat**		

Size	Specification	Measured
0.1µm	1000000	
0.2µm	237000	
0.3µm	102000	
0.5µm	35200	
1.0µm	8320	
5.0µm	293	

Step.	Action	Comments	Task Complete
22.1	Remove CBB from cryostat – bag and return to G56 clean room		
22.2	Replace aperture cover		
22.3	Disconnect cryostat flexibles from the FPU and move out of way		
22.4	Unclamp and lower the FPU and HOB frame onto wheels		
22.5	Connect MGSE trolley rails to cryostat rails		
22.6	Move FPU out of cryostat onto MGSE trolley.		
22.7	Secure FPU and HOB assembly onto MGSE		
22.8	Connect FPU to HOB plate using grounding strap		
22.9	Disconnect Cryo-Harness to FPU according to integration procedure ref **ILT_INTG_HARN** (AD 7)		
22.10	Replace covers on FPU		
22.11	Disconnect MGSE from facility ground		
22.12	Return FPU to G56 clean room		

Schedule

The following schedule is based on the pump-down starting on 23-Jan-2007.

ID	Indicators	Task Name	Duration
1		Start	0 days
2			
3		**EGSE Updates**	**12 days**
4		HCSS Delivered	0 days
5		Update HCSS on local machines	3 days
6		MIB Updated	0 days
7		Update QLA	2 days
8		OBS Acceptance Test	2 days
9			
10		**Integration into Cryostat and Chec**	**15 days?**
11		Spectrometer JFET Troubleshoo	2 days
12		Warm Mircrophonics	1 day
13		SMEC Functional Test	0.5 days
14		TFCS Functional Test	0.25 days
15		Harness Repairs	5 days?
16		Close Chamber	0.5 days
17		TRR	0.5 days
18		**Perform WFT**	3 days
19		**Cool-Down**	**9.5 days**
20		Pump Down	84 hrs
21		Flush He Vessels	1 day
22		Fill LN2 shield	0.5 days
23		Cool to 80K	108 hrs
24		Perform SFT	6 hrs
25		Purge LN2 from system	24 hrs
26		Cool to 4K	24 hrs
27		Cool to 1.7K	6 hrs
28		**Test Phase 1**	**16.88 days**
29		Cold Functional Tests	24 hrs
30		Test Day 1	12 hrs
31		Test Day 2	12 hrs
32		Test Day 3	12 hrs
33		Test Day 4	12 hrs
34		Test Day 5	12 hrs
35		Test Day 6	12 hrs
36		Test Day 7	12 hrs
37		Test Day 8	12 hrs
38		Test Day 9	12 hrs
39		Test Day 10	12 hrs
40		Test Day 11	12 hrs
41		Test Day 12	12 hrs
42		Test Day 13	12 hrs
43		Test Day 14	12 hrs
44		Test Day 15	12 hrs
45		**Warm Up Phase**	**6.5 days**
46		Warm up	96 hrs
47		Vent Chamber	1 day
48		Perform WFT	1 day
49		Remove FPU from chamber	1 day
50		Disconnect FPU from Harness	1 day
51		Remove FPU from cryolab	0.5 days
52		Cold Thermal Verification Comp	0 days