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HERSCHEL/PLANCK

REF. : H-P-ASPI-MN-406

+5 attachments

DATE : 1 & 2/10/2001 | PAGE : 1/9

**COMPTE RENDU DE REUNION / *MINUTES OF MEETING*** | LIEU / *PLACE* : ALCATEL Cannes

OBJET / *PURPOSE* : CLASSIFICATION :

# Herschel EQM AIV Meeting

| PARTICIPANTS *ATTENDEES* | SOCIETE *FIRM* | SIGNATURE *SIGNATURE* | PARTICIPANTS *ATTENDEES* | SOCIETE *FIRM* | SIGNATURE *SIGNATURE* |
|---|---|---|---|---|---|
| See sheet 2. | | | | | |
| Approved by | | | | | |
| D. MONTET | ALCATEL | | | | |
| J. BRUSTON | ESA | | | | |
| B. SWINYARD | RAL | | | | |
| [illegible] | SRON | | | | |
| Otto H. Bauer | MPE | | | | |
| REDACTEUR / *WRITTEN BY* : | D. MONTET | | | | |

CONCLUSION :

The EQM testing is well understood by all parties.

All actions are also well understood by all parties.

Next working meeting to be organised after completion of all actions --> November 20th @ ESTEC

| DISTRIBUTION : PARTICIPANTS / *ATTENDEES* | POUR ACTION : *FOR FURTHER ACTION* |
|---|---|
| | POUR INFORMATION : *FOR INFORMATION* |

APPROUVE PAR / *APPROVED BY*

| | | | | |
|---|---|---|---|---|
| NOM / *NAME* | | | | |
| SIGNATURE / *SIGNATURE* | | | | |

| ALCATEL SPACE | HERSCHEL/PLANCK | REF. : H-P-ASPI-MN-406 | |
|---|---|---|---|
| | | DATE : 1 & 2/10/2001 | PAGE : 2 |
| **COMPTE RENDU DE REUNION / *MINUTES OF MEETING*** | | LIEU / PLACE :ALCATEL Cannes | |

SUITE / CONTINUED : HERSCHEL EQM AIV MEETING

ACTION

PARTICIPANTS

| NAME | COMPANY / INSTITUTE |
|---|---|
| JÜRGEN KROEGER | ASTRIUM - ED - 49 7545 8 9984 |
| Wolfgang Rühe | ASTRIUM - ED - 497545 83068 |
| Thijs de Graauw | SRON |
| Matt Griffin | Cardiff University - 44 29 2087 4 203 |
| Bruce Swinyard | Rutherford Appleton Lab. (44 1235 44627) |
| Bernard Collaudin | Alcatel |
| Denis Montet | Alcatel |
| Otto H. Bauer | MPE |
| Reinhard Katterloher | MPE |
| Eberhard Wilke | ASTRIUM - ED |
| Udo Sagner | Astrium - TN |
| Christian Schlosser | Astrium - TN |
| Lees Wafelbakker | SRON |
| W. Luinge | SRON |
| N. NIKOLAIZIG | ESTEC |
| Jean BRUSTON | ESTEC |
| Nick Whyborn | SRON |
| Michel PASTORINO | Alcatel |
| Edgar Hölzle | Astrium-ED 497545-83668 |
| Chris Jewell | ESA/ESTEC |
| Rüdiger Hohn | ASTRIUM 49-7545-8-2023 |
| Glenn Lund | ALCATEL +33-4 9292.3406 |

SUITE / *CONTINUED* :

ACTION

Introduction

Presented by D. Montet / Alcatel (Attachment #1)

Instrument test requirements

1. SPIRE (Attachment #2)

Required minimum (cannot be tested at instrument level) is :

- thermal balance under representative flight thermal conditions
- EMC testing (RS tests)
- vibration susceptibility
  ↳ this requirement not taken into account by ALCATEL / ASTRIUM for EQM testing = NOT A REQUIREMENT ON EQM TO TEST VIBRATION.

Note : I/F verification can be done by analysis.

If needed, the EGSE would be installed inside the Herschel test cavity for RS testing.

2. PACS (Attachment #3)

Interface / system discussion with CDMS verification is requested
⇒ Impact on CDMS FEE (EGSE design)

SOLA case operate at room temperature during EQM testing (TBC by SOLA)

SUITE / *CONTINUED* : ACTION

## 3. HIFI Attachment #4

- Alignment
- thermal verification ] useful
- GNC (*)

(*) but not critical
→ need can be evaluated at room temperature

⇒ HIFI position = STM needs Ok !

EQM Test program (Astrium) Attachment #5

LOU is not within a test cryostat

The test cavity (instead of a QM cover) to be used, is the same as the one to be used at PFM level (with covers in 'open' position)

The Helium flow design is compatible with the cryostat in horizontal position.

- Background characteristics :

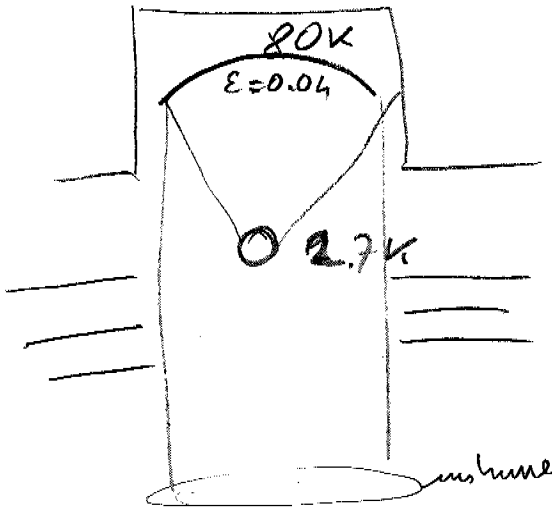
PACS HIFI to provide charts for background AI #

SUITE / *CONTINUED* :

ACTION

Expression of instrument needs :
the cold background should be equivalent to a black body at 2.7K - 4K seen through a 80K / ε=0.04 telescope.

one possible realisation could be :




Test cavity will be designed accordingly

Astrium to study possible implementation and design-

SPIRE, PACS, HIFI } to confirm that all the tests can be performed with cryostat in horizontal position (tilted by 90°) — AI # 1 — 15.10.2001

SPIRE, PACS, HIFI } to provide updated test sheets according to new input are provided by Alcatel / Astrium during the meeting (Cf. Astrium's presentation in Annex) — AI # 2 — 15.10.2001

SUITE / *CONTINUED* : ACTION

Conclusion

The main open points are

1) Representativeness of the set-up regarding the EMC testing (refer to page 7)

2) Configuration of the WU in "AVM standard" knowing that the H-PLM EQM shall be tested for test purpose (refer to instrument's presentation)

Astrium understanding is that WU AVM are similar as form and fit in order to be accommodated on the ISO SVM panels in the same position than on Herschel SVM panels.

to PLM boxes function

PACS, SPIRE, HIFI } to provide their definition of each item part of the Instrument EQM delivery including the Warm Units

Skill standard

AI # 3 15.10.2001

Hardware compliance testing to be provided → for each test
+ tests to be performed → for AVM testing at unit level.

SUITE / *CONTINUED* :

ACTION

EMC discussion

The baseline is to perform only CE and CS due to the expected shielding of the Cryostat w.r.t radiative environment.
According EMC analysis, it is the case in low frequencies [10kHz - 10 MHz].

From HIFI, the main question is "Is conducted EMC critical for Instruments ?"

The conducted testing shall be performed at least to confirm the E-field.

Regarding radiated testing, the need and the definition should be an outcome of the EMC working group.

Action to address this point to the agenda of the next EMC working group planned on November 5th.

EI #4
5.11.2001

SUITE / *CONTINUED* :

ACTION

ALCATEL to collect all necessary inputs to prepare the EMC working groups - Inputs in term of:

- Source
- Shielding
- susceptibility

This analysis shall take into account what is "on" and "off".

AI #5 28.10.2001

3) perturbations

The implementation of this test will be addressed by Astrium after the EMC working group decision

The pumps will be a source of perturbations -

For EQM testing, the baseline is to minimize the outputs from different sources -

There is no requirement for perturbation test

AOB

Astrium to provide PLM PFM AIT flow sequence.

AI #6

closed refer to Attachment #6

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**LISTE D'ACTIONS** / *ACTION ITEM LIST*

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OBJET / *PURPOSE* :

# Herschel EQM AIV Meeting

| Origine | ACTION N° | ACTION Description | ACTION Responsable / *Responsible* | DATE Echéance / *Due* |
|---|---|---|---|---|
| | 1 | To confirm that all the tests can be performed with Cryostat in horizontal position | SPIRE | 15.10.2001 |
| | | | PACS | |
| | | | HIFI | |
| | 2 | To provide updated test sheets according new input from Astrium given during the meeting. | SPIRE | 15.10.2001 |
| | | | PACS | |
| | | | HIFI | |
| | 3 | To provide the strict standard definition of each items part of the instrument CQM delivery including the Warm units * | SPIRE | 15.10.2001 |
| | | | PACS | |
| | | | HIFI | |
| | 4 | To address the need and the definition of radiated EMC testing to the next EMC Working Group and give proposal. | ALCATEL / L. TROUGNOU | 5.11.2001 |
| | | | | |
| | | | | |
| | 5 | To perform and circulate an evaluation of EMC level inside cryostat | ALCATEL / L. TROUGNOU | 25.10.2001 |
| | | | | |
| | 6 | TO provide PLM PFM AIT flow sequence | Astrium | Closed ! |
| | | | | |
| | | * Compliance matrix for AVM and CQM | | |
| | | | | |

1

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## Herschel EQM AIV Meeting

### Agenda

- Introduction – Aim and "boundaries" of the meeting.
  **Alcatel**
- Preliminary Instrument test requirements.
  **PI's**
- Synthesis of the Herschel EQM PLM Test program.
  **Astrium**
- Conclusion
  Agreements on technical work and milestones to be achieved to establish a preliminary EQM Test Plan.





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Herschel EQM AIV Meeting

### Introduction

- Due to a PFM approach for the Herschel cryostat, there are two main objectives of using the ISO cryostat QM for Herschel EQM testing .

  ➔ The first one is at Cryostat level aiming to train the relevant team regarding instrument integration tasks as well as overall cryogenic tasks.
  ➔ The second one, in line with the IID-A is to operate the three instruments in a representative Herschel environment early in the program. The execution of the Instrument IST's at this stage will serve as a reference for the PFM testing.

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## Herschel EQM AIV Meeting

### Aims of this Meeting -1

- To achieve a common understanding of what tests the instruments need as a minimum for the EQM to be of benefit to them, and what additional tests would be desirable.
- To refine our understanding of, and conclude on all major technical aspects with respect to the above tests, including the environment to be provided to the instruments during the test campaign.
- To agree on a top-level definition of the tests to be performed in the frame of the IMT sequence.





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### Aims of this Meeting -2

- **Once the technical discussions have defined a minimum set of tests to be performed, any issues related to schedule can be identified and discussed in a separate follow-on meeting.**

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Herschel EQM AIV Meeting

## Objectives of the Herschel EQM tests

- Mechanical integration of the FPU's
- Validation of the HIFI FPU/LOU alignment procedure
- Alignment check due to evacuation and cooldown
- Thermal environment check (inputs for thermal model)
- Instrument IST
- Conducted EMC testing of instruments at operating temperature
- Validation of the straylight performances with the use of the "Cold Background" device at this stage





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Herschel EQM AIV Meeting

## Herschel CQM Instruments Definition

- The Herschel CQM instruments are composed of the Focal Plan Units (FPUs) accommodated inside and outside the PLM and of the Warm Unit (WUs) accommodated inside the SVM.

- According IID-A, the WUs "CQM" can be delivered in a so-called "AVM" standard; it is the case for SPIRE (DPU) and for PACS (DMC1, BOLC, DPU and SPU nominal)

- The FPUs simulators for AVM Satellite test purpose will be part of the delivery.

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## Herschel EQM AIV Meeting

### HIFI CQM/AVM Hardware Matrix

| | EQM | AVM |
|---|---|---|
| Focal Plane Unit | CQM | |
| Focal Plane Control Unit | CQM | Simulator |
| Local Oscillator Unit | CQM | |
| Local Oscillator Control | CQM | Simulator |
| Local Oscillator Source Unit | CQM | Simulator |
| Local Oscillator Waveguide Unit | CQM | |
| High Resolution Spectrometer IF Processor | CQM | |
| HRS ACS Horizontal polarisation | CQM | Simulator |
| HRS ACS Vertical polarisation | CQM | |
| Wide Band Spectrometer IF Processor | CQM | |
| WBS AOS | CQM | |
| WBS Electronic | CQM | Simulator |
| Instrument Control Unit | CQM | AVM |
| Warm Interconnection Harness | CQM | TBC |





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Herschel EQM AIV Meeting

### PACS CQM/AVM Hardware Matrix

| | EQM | AVM |
|---|---|---|
| Focal Plane Unit | CQM | Simulator |
| Detector Mechanism Control 1 | AVM | AVM |
| Detector Mechanism Control 2 | - | - |
| Bolometer/Cooler Control | AVM | AVM |
| Buffer Amplifier | CQM | Simulator |
| DPU | AVM | AVM |
| SPU nominal | AVM | AVM |
| SPU redundant | - | - |
| Warm Interconnection Harness | AVM | AVM |

## SPIRE CQM/AVM Hardware Matrix

| | EQM | AVM |
|---|---|---|
| Focal Plane Unit | CQM | DRCU Sim. |
| JFET/RF Box | CQM | DRCU Sim. |
| Detector Read-out & Control unit | CQM | DRCU Sim. |
| Digital Processing Unit | AVM | AVM |
| Warm Interconnection Harness | CQM | DRCU Sim. |





Herschel EQM AIV Meeting

## Herschel CQM Instruments Delivery

- The full set of Herschel CQM instruments will be delivered by relevant PIs with their EGSE interfacing the CCS (refer to HSCDT-TN-17):
  - HCSS
  - MIB Editor
  - OBS M
  - RTA
- All these items will be delivered to Astrium trough Alcatel after acceptance at PIs' premises under ESA responsibility.

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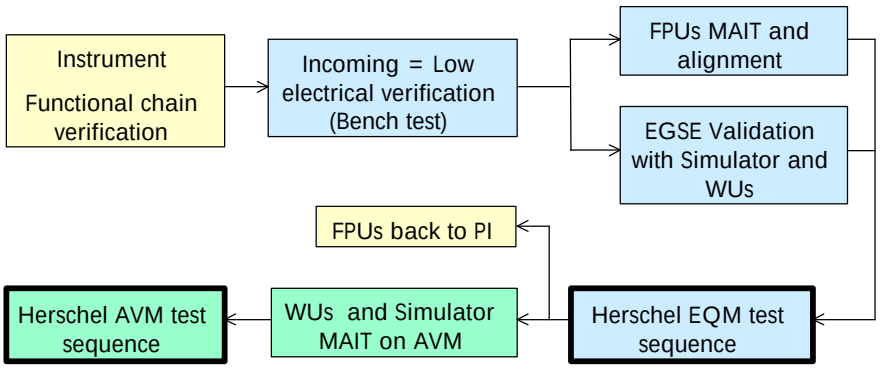
## Herschel EQM AIV Meeting

### Flow Sequence







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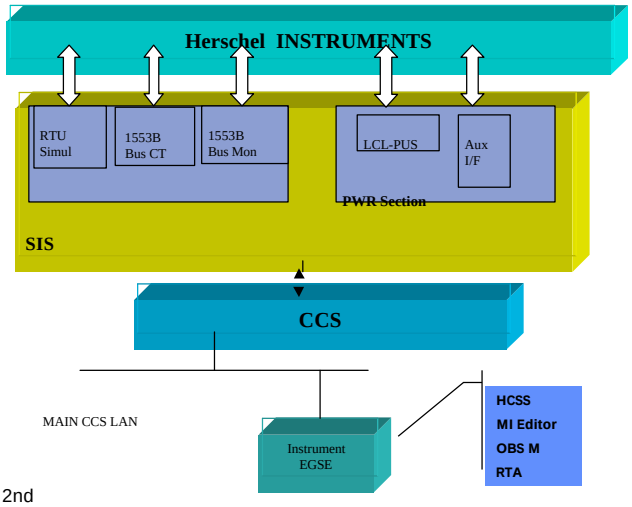
## Herschel EQM AIV Meeting

### EGSE Architecture at Instrument level



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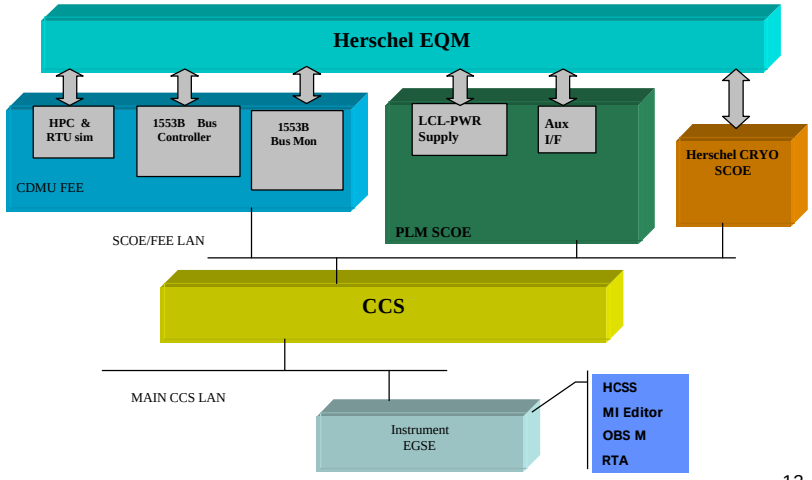
## Herschel EQM AIV Meeting

### EGSE Architecture at Herschel EQM level



# Herschel/SPIRE
# Input to
# EQM Meeting

Bruce Swinyard
RAL

## 1,2 October 2001



## Outline of SPIRE Verification Requirements for EQM Testing

- An analysis of the SPIRE verification requirements (SPRE-RAL-PRJ –000592) has shown that we can do all the required testing at instrument level with the exception of:
  - Instrument thermal balance under representative flight thermal conditions
  - System level EMC testing – most especially radiative susceptibility tests
  - Microvibration susceptibility - this is just difficult and there is little meaningful testing that can be done at system level
- We would like therefore to carry out system level tests in the EQM cryostat to complete the instrument verification for thermal balance and EMC
- To do the tests we need a certain set of requirements on the EQM cryostat

## Outline of SPIRE Requirements on EQM Cryostat

- All electrical interfaces with the system need to be present; functional and flight representative
- The EMC environment in the cryostat has to be fully representative of the Herschel cryostat and demonstrated to be so by modelling or analysis.
- The instrument must be capable of being placed into an “EMC” sensitive mode in order that we can detect any noise generated by EMI.
- The cryostat must have the ability to replicate the in-flight thermal conditions in terms of temperatures of the optical bench and shields nearest to the instruments and the mass flow rate through the vent pipes.
- The cryostat has to be held in flight condition for a sufficiently long time that we can recycle the cooler and run through the critical tests for the instrument thermal balance
- In order to recycle the cooler the cryostat must be capable of being tilted to ~20 degrees from vertical.
- In order to test the spectrometer mechanism the cryostat must be tilted to near to horizontal (actual angle TBD)
- All electrical; mechanical and thermal interfaces for the system CQM model must have been verified against the specification before integration of the instruments.



## SPIRE Pre-cursor Testing

- We need to validate the functioning of the instrument before and after cooldown
  - Will define Warm Functional Test and Cold Functional Test to be carried out at critical stages in the integration
- We need to ensure that the cooler will recycle correctly and that the cryostat and instrument temperatures will settle to nominal values
  - We have defined a standalone cooler recycle thermal balance test in addition to the test of the nominal cooler recycle flight operations test
- We need to verify that the ambient photon background is at a level compatible with whichever test is to be done
  - This will done with a predefined Ambient Background Test – details in later slide

## SPIRE Proposed Tests (I)
### Pre-Cursor

- Stand Alone Cooler Recycle:
  - Cryostat in flight condition – means both shield temperatures and mass flow must be flight like
  - PLM tilted by ~20 deg around Z-axis towards +Y
  - Cooler is recycled and instrument temperatures allowed to recover to nominal condition
  - Takes ~3 hours – instrument can (and should) then be operated continuously for 45 hours
- Ambient Background Measurement
  - This test is done to check what the background photon level is within the SPIRE instrument
  - Maybe done under a variety of circumstances – shutter closed or open; instrument cover blanked off; GSE in place
  - Instrument is switched on in photometer mode and allowed to settle
  - Load curves are taken to determine the optical loading on the detectors
  - Could take about an hour



## SPIRE Proposed Tests (II)
### Flight Operations Thermal Balance Tests

- Photometer Chopped Mode
  - Cryostat in flight condition – cooler recycled and instrument at nominal temperatures
  - Ambient photon background such as to allow meaningful measurements of the detector signals (~<5x expected in flight)
  - Instrument switched to photometer mode and allowed to settle
  - Simulated chopped observation carried out
  - Looking for instrument thermal stability and no excess radiation onto the detectors
  - No requirement on tilting of the PLM
  - Should take about 2-3 hours

## SPIRE Proposed Tests (III)
### Flight Operations Thermal Balance Tests

- Spectrometer Mode
  - Cryostat in flight condition – cooler recycled and instrument at nominal temperatures
  - Ambient photon background such as to allow meaningful measurements of the detector signals (~<5x expected in flight)
  - PLM must be tilted to ~90 deg around the Z-axis either ±Y direction
  - Instrument switched to spectrometer mode and allowed to settle
  - Simulated spectrometer observation carried out
  - Looking for instrument thermal stability and no excess radiation onto the detectors
  - Should take about 2-3 hours



## SPIRE Proposed Tests (IV)
### EMC Test

- EMC Test Ready Condition
  - Cryostat in flight condition – cooler recycled and instrument at nominal temperatures
  - Ambient photon background such as to allow meaningful measurements of the detector noise – ideally to be detector noise limited (lower than expected in flight)
  - Instrument switched to photometer mode and allowed to settle
  - Noise traces taken during EMC tests sequence – expected to be BOTH radiated and conducted susceptibility
  - Looking for no excess noise
  - Length of test depends on what is done

## SPIRE EMC Control Plan/test plan (I)

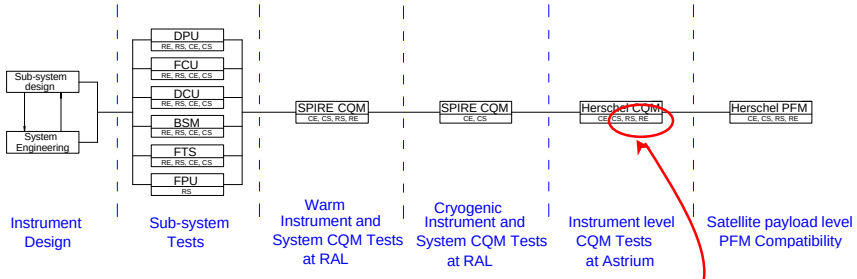
- A draft version of the the SPIRE EMC Control Plan (SPIRE-RAL-PRJ-000852) exists:
  - The plan shows how SPIRE⇔Herschel and SPIRE subsystem compatibility is achieved
  - The document cross references
    - The Test Procedure identification numbers (the procedures are TBW in a separate document)
    - The SPIRE model used in the test
    - The Location of the test
    - The test conditions (cryogenic or warm etc)
    - The pertinent IID-A requirements paragraph
  - It covers flight items only; EGSE is assumed to be compliant
  - It covers testing at unit, instrument and satellite levels



## EMC Control Plan/test plan (II)

- Identifies the fact that SPIRE is far more concerned about RFI corrupting the detection and readout circuit than in the more routine units on the SVM
  - Bolometers are sensitive to 1pW
  - RFI currents cause ohmic heating to the bolometers which becomes indistinguishable to the readout circuitry
  - Difficult to model (but we are doing modelling!!!)
- Highlights the fact that SPIRE is left very vulnerable to the current AIT plan and schedule as indicated in IID-A 2/0, July 2001
- *As the IID-A currently stands we don't find out if the most critical part of our instrument is susceptible to RFI until approx Q1, 2005*
  - *This is leaves Herschel and SPIRE very exposed*

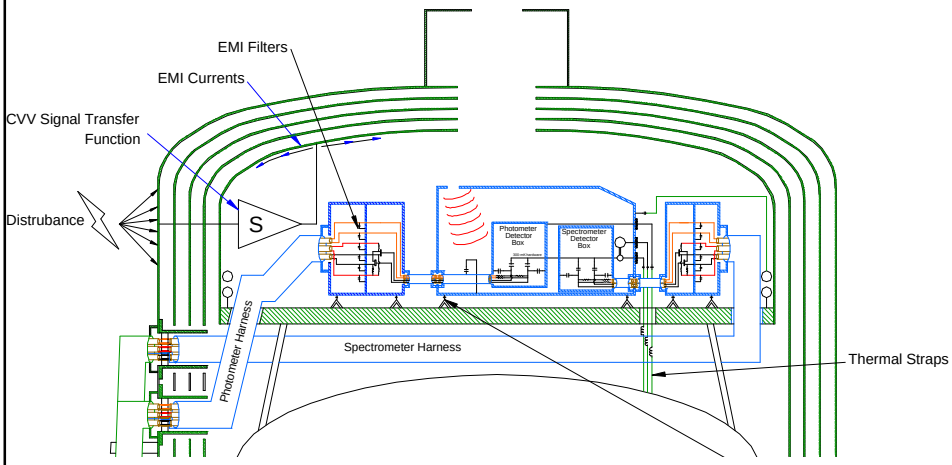
# SPIRE EMC Test Flow Chart



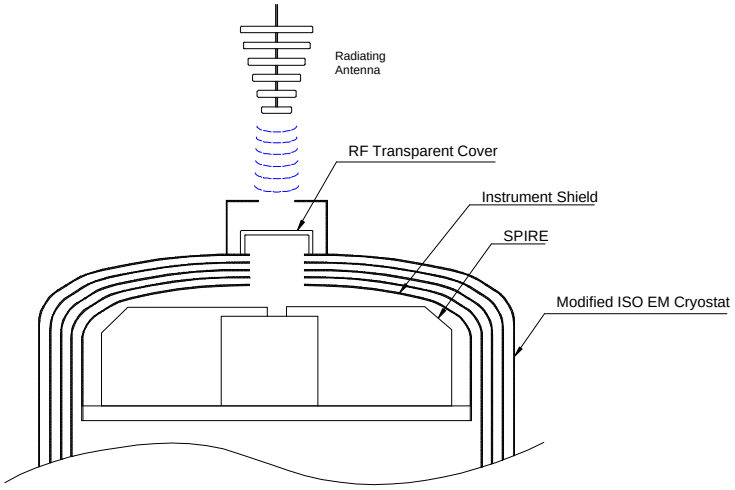

Incompatible with current test programme



# Cryogenic Layout of SPIRE Detection System



# Summary of EQM RE/RS Testing

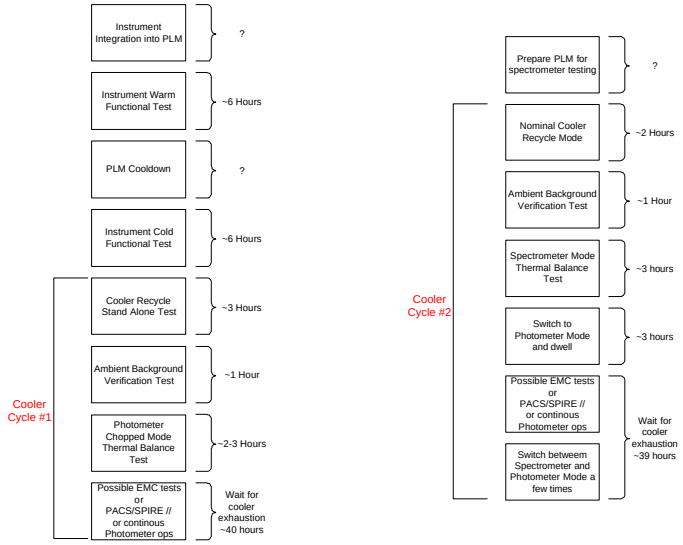





# SPIRE Proposed Test Sequence (I)

- Testing sequence is based on need to look at the following aspects of SPIRE operations:
  - Recovery from cooler recycle
  - Settling time for photometer mode switch on
  - Switching from photometer to spectrometer mode
  - Switching from SPIRE prime to PACS/SPIRE parallel
  - Total cooler hold time during nominal operations
- Sequencing needs to be based around the nominal cooler recycle times

# SPIRE Proposed Test Sequence (II)



SPIRE

# SPIRE EQM Test Program Definition

Bruce Swinyard
RAL

Test Case Form

| *Title:* | *Experiment:* |
|---|---|
| Flight Operations Thermal Balance Test – **Cooler Recycle** | Herschel/SPIRE |

*Objectives:*
To verify the temperature stability and balance of the SPIRE instrument during cooler recycle mode operations
To prepare the instrument for operation with the photometer or spectrometer detectors

*Test Description:*
The EQM cryostat will be placed in a condition that as nearly as possible replicates the expected flight conditions i.e. the mass flow rate and shield temperatures must be those expected in flight.
The SPIRE cooler recycle sequence will be carried out and the temperatures of the various stages monitored.
The results will be compared to those from the SPIRE Instrument Thermal Model (ITMM)

| *Instrument Configuration:* | *Specific Requirements on PLM (e.g. PLM tilted about 30° around z-axis):* |
|---|---|
| OFF -> ON -> Standby -> Cooler Recycle -> Standby | At least 17 degrees tilted around Z-axis towards +Y |

*Particular Environmental Constraints (e.g. level 0-2 temperatures, mass-flow - during what time):*
Mass flow rate as expected in flight
Shield temperatures as expected in flight
These should be maintained for the duration of the test and thereafter for the start of the follow on photometer test.

*Success Criteria:*
Cooler is successfully recycled and temperatures settle to within operational limits as predicted by the SPIRE ITMM

| *Duration:* | *Applicable:* | |
|---|---|---|
| ~3 hours | PLM EQM | ☒ |
| | PFM | ☒ |

# SPIRE EQM Test Program Definition

Bruce Swinyard
RAL

Test Case Form

*Title:*
Flight Operations Thermal Balance Test – **Photometer Chop Mode**

*Experiment:*
Herschel/SPIRE

*Objectives:*
To verify the temperature stability and balance of the SPIRE instrument during photometer chopped mode operations.

*Test Description:*
The EQM cryostat will be placed in a condition that as nearly as possible replicates the expected flight conditions i.e. the mass flow rate and shield temperatures must be those expected in flight.
The ambient background in the instrument is such as to allow meaningful signals from the detectors to be seen and has been verified by a dedicated test
The SPIRE cooler has been recycled and the instrument is at nominal temperature
The photometer JFETs are switched on and the instrument temperatures allowed to settle
A simulated photometer chop observation is carried out – this will include operation of the photometer calibrator and beam steering mirror.
The results will be compared to the ILT and the SPIRE ITMM

*Instrument Configuration:*
Standby -> Phot Standby -> Phot Observe -> Phot Standby -> Standby

*Specific Requirements on PLM (e.g. PLM tilted about 30° around z-axis):*
No restriction on the tilt

*Particular Environmental Constraints (e.g. level 0-2 temperatures, mass-flow - during what time):*
Mass flow rate as expected in flight
Shield temperatures as expected in flight
These conditions should be maintained following the cooler recycle (see Cooler Recycle sheet)
Photon background within x5 (TBC) of that expected in flight (this may be achieved using the SPIRE shutter (TBD))

*Success Criteria:*
The instrument temperatures stay within pre-defined limits as predicted by the SPIRE ITMM
No excess background is seen on the detectors during operations

*Duration:*
~1 hour

*Applicable:* PLM EQM ☒
PFM ☒

Test Case Form

*Title:*
Flight Operations Thermal Balance Test – **Ambient Background Verification**

*Experiment:*
Herschel/SPIRE

*Objectives:*
To check the photon background on the photometer detectors after cooler recycle and before all other tests

*Test Description:*
The EQM cryostat will be placed in a condition that as nearly as possible replicates the expected flight conditions i.e. the mass flow rate and shield temperatures must be those expected in flight.
The SPIRE cooler has been recycled and the instrument is at nominal temperature
The photometer JFETs are switched on and the instrument temperatures allowed to settle
The SPIRE shutter may be closed (TBD)
Load curves are taken on the photometer detectors by varying the bias voltage

*Instrument Configuration:*
Standby -> Phot Standby -> Standby

*Specific Requirements on PLM (e.g. PLM tilted about 30° around z-axis):*
No tilt requirements

*Particular Environmental Constraints (e.g. level 0-2 temperatures, mass-flow - during what time):*
Mass flow rate as expected in flight
Shield temperatures as expected in flight
These conditions should be maintained following the cooler recycle (see Cooler Recycle sheet)

*Success Criteria:*
Data analysed in real time to calculate the background flux on the detectors. Background should be within limits defined for the follow on test

*Duration:*
~1 hour (TBC)

*Applicable:* PLM EQM ☒
PFM ☒

Test Case Form

*Title:*
Flight Operations Thermal Balance Test – **Spectrometer Mode**

*Experiment:*
Herschel/SPIRE

*Objectives:*
To verify the temperature stability and balance of the SPIRE instrument during spectrometer mode operations

*Test Description:*
The EQM cryostat will be placed in a condition that as nearly as possible replicates the expected flight conditions i.e. the mass flow rate and shield temperatures must be those expected in flight.
The ambient background in the instrument is such as to allow meaningful signals from the detectors to be seen and has been verified by a dedicated test
The SPIRE cooler has been recycled and the instrument is at nominal temperature
The spectrometer JFETs are switched on and the instrument temperatures allowed to settle
The spectrometer calibrator is switched on
A simulated spectrometer chop observation is carried out – this will include operation of the photometer calibrator and beam steering mirror.
The results will be compared to the ILT and the SPIRE ITMM

*Instrument Configuration:*
Standby -> Spec Standby -> Spec Observe -> Spec Standby -> Standby

*Specific Requirements on PLM (e.g. PLM tilted about 30° around z-axis):*
90 degrees tilted around z-axis (?Y)

*Particular Environmental Constraints (e.g. level 0-2 temperatures, mass-flow - during what time):*
Mass flow rate as expected in flight
Shield temperatures as expected in flight
These conditions should be maintained following the cooler recycle (see Cooler Recycle sheet)
Photon background within x5 (TBC) of that expected in flight (this may be achieved using the SPIRE shutter (TBD))

*Success Criteria:*
The instrument temperatures stay within pre-defined limits as predicted by the SPIRE ITMM
No excess background is seen on the detectors during operations

*Duration:*
~1 hours

*Applicable:* PLM EQM ☒
PFM ☒

Test Case Form

*Title:*
EQM EMC Test – **EMC Test Ready**

*Experiment:*
Herschel/SPIRE

*Objectives:*
To set the instrument into its most sensitive mode to allow the effects of EMI to be verified

*Test Description:*
The EQM cryostat will be placed in a condition that as nearly as possible replicates the expected flight conditions i.e. the mass flow rate and shield temperatures must be those expected in flight.
The ambient photon background in the instrument is low enough such that meaningful noise measurements can be made on the detectors. The background shall be verified by a dedicated test
The SPIRE cooler has been recycled and the instrument is at nominal temperature
The photometer JFETs are switched on and the instrument temperatures allowed to settle.
Noise traces are taken from the detectors at the highest data sampling frequency allowed by the electronics before and during conducted and radiated EM testing.
The results will be compared to the ILT and the SPIRE EMC model.

*Instrument Configuration:*
Standby->Phot Standby->Standby

*Specific Requirements on PLM (e.g. PLM tilted about 30° around z-axis):*
No tilt requirement.
The background requirements will probably imply that the PLM instrument cover should be thermally blanked off
The PLM cover should allow for radiated EMC into the cryostat

*Particular Environmental Constraints (e.g. level 0-2 temperatures, mass-flow - during what time):*
Mass flow rate as expected in flight
Shield temperatures as expected in flight
These conditions should be maintained following the cooler recycle (see Cooler Recycle sheet)
Photon background as low as practically possible to attempt to have the noise dominated by the intrinsic detector noise

*Success Criteria:*
No excess noise is seen on the detectors during conducted and radiated EMC testing. Noise levels should be lower than those set by the SPIRE project (TBD).

*Duration:*
TBD

*Applicable:* PLM EQM ☒
PFM

# PACS EQM Test Program

# Requirements

R. Katterloher





## PACS EQM Integrated Instrument Test Requirements

- PACS EQM Test will consist of 5 sets of test sequences (test sequences developed and proven during ILT phase, cf. Test Plan PACS-ME-PL-012):
- (1) an almost complete ILT1 (full functional test)
- (2) a few selected ILT2 performance test procedures (short performance test)
- (3) AOT Tests
- (4) PACS/SPIRE Parallel Mode
- (5) EMC Test

Success criteria: Verification of test results by QLA, SCOS2000 and comparison of EQM values to ILT results

## PACS EQM Integrated Instrument Test Requirements (ctd.)

- Software validation
  (all instrument operations involving CDMU/PACS IF)
- Background signal during tests within a factor of 3 of nominal telescope background (external source 80K @ 4% emissivity)
- Required cryostat tilt for cooler recycling: 20° around z-axis
- Thermal requirements (temperature levels) according to IID-B
- Estimated duration of PACS related tests (pure testing time):
  - PACS Instrument Tests (1,2,3) ≈ 3 days
  - PACS/SPIRE parallel mode (4) ≈ 1 day
  - PACS EMC tests (5) ≈ 2 days
- PACS instrument delivery (CQM+AVM) proposed 1st October 2003 after finalizing the ILT phase





## PACS Instrument Tests (1)

- Full Functional Test (ILT1)
  - PACS switch-on procedure, including validation of connection between EGSE and instrument, memory load and dump
  - Validate function of FPDPU
  - Validate function of FPSPU and data reduction/compression SW
  - Validate function of FPDEC/FPMEC
  - Validate function of FPBOLC/A
  - Verify function of detectors, detector readouts, detector heaters and temperature sensors
  - Verify function of mechanisms (grating, chopper and filter wheels)
  - Verify function of calibration sources
  - Validate function of redundancy chains (not available at EQM Test)
  - Verify PACS Autonomy functions (limit checks)
  - Verify PACS telemetry rates
  - Verify time synchronization procedure between CDMU and PACS
  - Validation of PACS deactivation (shut-down) procedure

# PACS Instrument Tests (2)

- Short Performance Test (part of ILT2)
  - Validation of PACS activation sequence
  - Test PACS FPFPU thermal behaviour
  - Performance test of PACS mechanisms, synchronous operation and grating offset accuracy
  - Detector electronics signal quality, Photoconductor part
  - Detector electronics signal quality, Bolometer part
  - Detector signal quality, Photoconductor part
  - Detector signal quality, Bolometer part
  - Performance of internal Blackbody Sources
  - Check of Spectrometer
  - Cryostat Background (external source / telescope simulation)
  - Cooler recycling





# PACS Instrument Tests (3)

To verify in a *short* and representative way that the planned observation strategies are compatible with the system

- AOT Tests
  - Test of PACS Single Band Photometry Mode
  - Test of PACS Dual Band Photometry Mode
  - Test of PACS Line Spectroscopy Mode
  - Test of PACS Range Spectroscopy Mode
  - Test of PACS Calibration Measurement using FPU internal blackbodies

## PACS/SPIRE Parallel Mode (4)

- PACS activation
- PACS thermal behaviour, with SPIRE being switched on
- Test of PACS/SPIRE parallel mode AOT, with PACS in single band Photometry mode
- Test of PACS/SPIRE parallel mode AOT, with PACS in dual band Photometry mode
- PACS deactivation





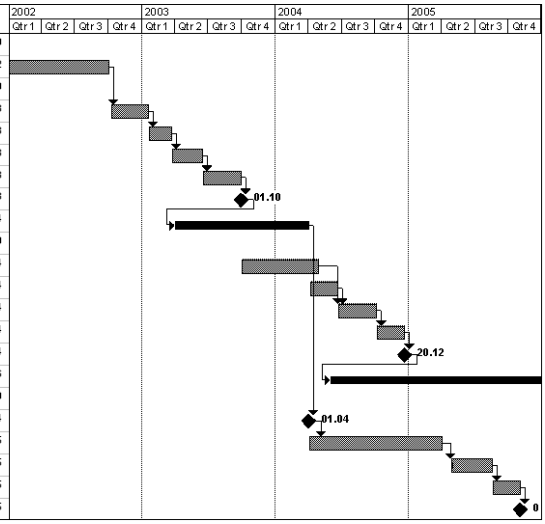
## PACS EQM EMC Tests (5)

During ILT, two specific test sequences required for certain EMC measurements will be developed. During EQM, performance of these sequences will allow verification of certain EMC requirements in addition to the results from specified test set-ups. Note: EQM EMC testing might very likely require conducted and radiated emission and susceptibility measurements (details TBD)

- PACS activation
- PACS in "most noisy" mode(s)
  (actuators ON etc.)
- PACS in "most sensitive" mode(s)
  (mechanisms quiet, detector read-outs in most sensitive status, etc.)
- PACS deactivation

# PACS AIV Schedule

| ID | Task Name | Start | Finish |
|---|---|---|---|
| 1 | **AVM** | **01.12.00** | **01.12.00** |
| 2 | AVM Integration and Test at MPE | 01.01.02 | 04.10.02 |
| 3 | **CQM** | **01.12.00** | **01.12.00** |
| 4 | CQM Performance Tests at MPE | 08.10.02 | 20.01.03 |
| 5 | FPU Cold Vibration at CSL | 21.01.03 | 24.03.03 |
| 6 | Performance Verification at MPE | 25.03.03 | 16.06.03 |
| 7 | Wavelength Calibration at LENS | 17.06.03 | 01.10.03 |
| 8 | Delivery CQM FPU+AVM to ESA | 01.10.03 | 01.10.03 |
| 9 | Satellite EQM AIV | 01.04.03 | 01.04.04 |
| 10 | **FM** | **01.12.00** | **01.12.00** |
| 11 | FM WE Integration and Test | 02.10.03 | 28.04.04 |
| 12 | PFM Cold Vibration at CSL | 06.04.04 | 21.06.04 |
| 13 | PFM Performance Tests at MPE | 22.06.04 | 04.10.04 |
| 14 | Wavelength Calibration at LENS | 05.10.04 | 20.12.04 |
| 15 | Delivery PFM to ESA | 20.12.04 | 20.12.04 |
| 16 | Satellite FM AIV | 01.06.04 | 29.12.06 |
| 17 | **FS** | **01.12.00** | **01.12.00** |
| 18 | Redelivery of CQM from ESA | 01.04.04 | 01.04.04 |
| 19 | CQM Refurbisment | 02.04.04 | 01.04.05 |
| 20 | FS Performance Test at MPE | 28.04.05 | 17.08.05 |
| 21 | Wavelength Calibration at LENS | 18.08.05 | 02.11.05 |
| 22 | Delivery FS to ESA | 02.11.05 | 02.11.05 |



Space Research Organization Netherlands
Stichting Ruimteonderzoek Nederland

4

# HIFI Input to cQM Discussion

## EQM Meeting at Alcatel

## Cannes, 1-2 Oct 2001

N. D. Whyborn
Space Research Organisation, Netherlands
N.D.Whyborn@SRON.RUG.NL

Attach sheet #4

# HIFI Viewpoint Regarding cQM Tests

1. an alignment procedure verification is useful, particularly LOU-FPU (visible OK)
2. dynamic and static thermal verification is useful
3. straylight model verification not of importance for HIFI, but…
   - straylight from LO window to PACS & SPIRE is critical, but …
   - important coupling path via telescope secondary not present ☹
4. verification of standing wave level in optical path is important, but…
   - critical path via secondary not present ☹
5. test of conducted & radiated EMC is THE most useful aspect
   - conducted EMC not expected to be critical – fidelity EQM PDU/CDSS?
   - radiated most important – fidelity EQM re telescope/cryostat i/f?
6. HIFI has significant costs to provide a cQM: ~8 month HIFI development

# Alcatel EQM Objectives Reviewed

- not impressed by the usefulness of the current EQM test programme
- no significant difference of EQM with HIFI ILT, e.g. conducted susceptibility
- THE most critical EMC aspect for HIFI, radiated susceptibility, is not tested

  This will not be tested until the Herschel FM is assembled. A problem discovered at that stage will be an **unmitigated disaster!**

- standing waves not tested
- LO window straylight level not tested

# Alcatel EQM Primary Objectives

1. "To verify the compatibility of the instruments (mechanical, electrical and thermal)" – **STM ok, don't need sub-mm active FPU**
2. "To perform early tests which include as complete a detection chain as possible" – this is done **earlier** in our **ILT** (apart from the satellite DMSS which is anyway tested in the AVM set-up)
3. "To perform a conducted EMC test at orbital representative cryogenic conditions" – what is the relevance of "orbital representative cryogenic conditions" to the conducted EMC test?
   - N.B. only conducted EMC tests are planned which we will/can do on our test cryostat anyway
   - this is not our main EMC worry

# Alcatel EQM Secondary Objectives

4. "An alignment procedure verification of all three instruments … and the LOU…"
   - ➢ visible alignment verification OK – purely optical
5. "Validation of the thermal background conditions ..." (straylight?)
   - ➢ HIFI not sensitive to the thermal background/stray light
   - ➢ no HIFI sub-mm test required
6. "To gain operational experience with cryogenic procedures"
   - ➢ not affected by what we supply for the cQM!

**Conclusion:**

an Alignment/Structural/Thermal Model is sufficient for this programme!!

# HIFI EMC Summary

- conducted EMC not expected to be critical – checked in our AIV programme
- modest RS sensitivity in SVM – leakage at inputs to spectrometers
- high to extreme RS sensitivity at FPU – weakest signal, hard to shield,
  - ➢ testing is in progress
  - ➢ preliminary results indicate ~ 120 dB gap between 2V/m and our sensitivity level
- unknown shielding factor of cryostat – AI on Alcatel
- unknown EM level in Herschel with transmitter OFF – AI on Alcatel
- Frequency plan – AI Alcatel ?

# Proposed RS EMC Strategy

- determine likely EMC levels at SVM
  - the present value of 0.3 V/m is not realistic – see separate sheet
- Either
  - full-up RS EMC test of representative s/c – see below
- Or
  - test/calculate shielding effectiveness of cryostat – can be at room temp
  - determine RS sensitivity of HIFI FPU – can be at room temp, HIFI AIV
  - combine the above to determine the allowed EM field at the SVM
  - compare result with expected/measured EM field at the SVM
- the RS tests can be done at **room temperature** with little loss of fidelity.

# Limits on Herschel EM Field Levels

- what are the sources of EM field?

**external to HSO** none significant, apart from during ground contact
~1 V/m is possible in **LEO**
0.3 V/m @ L2 requires 10 GW ERP at the Earth!

**internal to HSO** none significant, apart from during ground contact
0.3 V/m @ 1 m requires **13 kW** in a box with 80 dB shielding!
**10 W** into a dummy load (-80 dB shielding) ⇨ **< 0.01 V/m**

- the emission limit in the TC receiver band is typically < **10 µV/m!!** (e.g. ISO)
- HIFI non-operational (i.e. survival) limits are >> 2 V/m

# Ideal cQM Test

- test configuration
  - ➢ three FP's of the instruments operating on the optical table
  - ➢ cryostat with representative cryostat cover (open!), panels etc
  - ➢ representative telescope: primary with associated hole & secondary
  - ➢ HIFI-FPU with two end-to-end signal chains
  - ➢ WBS for IF data analysis

# Ideal cQM Test (2)

- test programme
  - Radiated EMC tests – with representative structures (see proposal)
  - Standing wave tests – with baffles & secondary (ILT ?)
  - Conducted EMC tests – representative harness (ILT)
  - Alignment procedure checks – optical
  - Alignment LO-FPU procedure checks – with LO at low temperatures
  - Verify handling procedures and compatibility between instruments

# Input from HIFI for the EQM Test Program Definition

## *General remarks to the task contents of the schedule:*

Task 99 PLM EQM integration - part 2

It is not explicitly mentioned that prior to connecting cables an electrical interface check is foreseen. More generally, interface checks prior to integration should also be carried out for mechanical interfaces.

Task 107 Integration FPU QM's onto OB

What seems to be missing is an interface verification before integration. Furthermore we miss the alignment check between OB and external reference, OB and FPU's and between FPU and LOU prior to evacuation and cooldown. This measurement is needed to determine the reference against which changes due to evacuation and cooldown can be measured.

Task 129 Evacuation & Leak Check

We assume that after evacuation the relative alignment will be checked (change in alignment due to evacuation). This measurement applies to alignment between OB and external reference, OB and FPU's and between FPU and LOU. Or is this covered by task 133?

Task 133 Prep. Cooldown & Filling

Again we expect that change in alignment will be measured after cooldown which is not clear from the EQM Test Program Definition Schedule.

Task 142 Integrated Module Test (electrical only)

We assume that this task refers to Instrument tests. We provide input for tests within this block by means of the test case forms. We only mention those tests that are not planned in between integration steps. It is furthermore a little bit unclear what is meant by "electrical only". Could this be clarified?

Task 144 Depletion & Warm up

We suggest to measure the alignment once again after warm up and after pressurasation in order to compare this to the initial alignment state. It is quite important to check if the system restores to its original alignment state.

Test Case Forms (arranged to reflect the logical sequence)

Notes:

All tests mentioned here are directed towards the final EMC test. The preparation for the EMC test has to ensure that the instrument is working properly and that performance is within the predicted and as-verified limits prior to the EQM Test Program. During the EMC test we will assess the susceptibiliy of the instrument, in other words how performance is affected by radiated and conducted EMC stimuli, by direct comparison to already obtained performance characterisation results.

We assume that no beam pattern measurement is foreseen on the integrated satellite including telescope.

We assume that it is only allowed to test the instrument via its EGSE and that no external stimuli or test equipment is allowed other that the alignment device and camera needed for FPU - LOU alignment.

Time estimates are success-oriented, no safety margin is added.

## *Test 1*

| | |
|---|---|
| Title: | Alignment Check |
| Note: | This test will be carried out in between integration, evacuation, cooldown and warmup activities |
| Experiment: | HIFI |
| Objectives: | Check change in alignment due to evacuation and cooldown |
| Test Description: | During this test the relative alignment between FPU and OB and between the LOU and FPU will be monitored. Alignment devices located on the FPU and alignment devices installed on the LOU will be used. The alignment will be checked by an external alignment camera to be supplied by Astrium. It is furthermore assumed that Astrium will take care of handling, mounting and read-out of the alignment test equipment. We assume that the alignment state will be recorded prior to evacuation, after evacuation / prior to cooldown, after cooldown / prior to warmup and after warmup. |
| Instrument Configuration: | FPU, LOU, Alignment devices on LOU and read-out equipment |
| Specific Requirements: | Do we need to repeat alignment checks for different tilt angles? |
| Environmental Constraints: | None |
| Success Criteria: | Images of AD's / relative excursions within tolerances defined the alignment budgets (IID-B). |
| Duration | 4 days (1 day for each alignment check) |
| Applicable: | PLM EQM x<br>PFM x |

## *Test 2*

| | |
|---|---|
| Title: | Thermal Test |
| Note: | We assume that relevant temperature levels needed to assess heat-lift and to verify the thermal model will be monitored by the EGSE of Astrium. |
| Experiment: | HIFI |
| Objectives: | Check thermal response on sequential switch-on of dissipating elements within the HIFI instrument. |
| Test Description: | During this test the temperature levels will be monitored to determine the changes after switching on the following elements within HIFI. 1) IF Box inside FPU, 2) MSA: mixer and IF amplifier, 3) LOU: Power amplifier and multiplier stages, 4) Diplexer mechanism, 5) Focal plane chopper, 6) Calibration source. The required levels, transient times, heat lift, switching time between two bands (if available) will need to be determined / checked. Transient effects during a particular observation mode |

| | |
|---|---|
| | will be monitored as part of the instrument functional and performance tests. |
| Instrument Configuration: | FPU s/s, LOU s/s, ICU and EGSE. |
| Specific Requirements: | None |
| Environmental Constraints: | 300K temperature of LOU (outside not cooled) not representative for thermal effects inside LOU. This test might need to be carried out during the Thermal Vacuum test. |
| Success Criteria: | Transient and levels TBD. Success criteria to be based on DM test results and thermal models. |
| Duration | 2 days |
| Applicable: | PLM EQM x<br>PFM x |

### *Test 3*

| | |
|---|---|
| Title: | Functional Test |
| Experiment: | HIFI |
| Objectives: | Verify proper functioning of HIFI instrument and check continuity before starting performance tests. |
| Test Description: | Check parameters and limits of HIFI with EGSE. Check commandability of those aspects where more than one subsystem is involved (measurement of mixer IF noise to check spectrometers and FPU IF noise; at one selected LO frequency: are mixers pumped by LO, is LO level tunable, is gain and noise temperature within limits). For trend and continuity into the S/C test phase this test is to be checked without external stimulators if feasible (e.g. LO pump level, magnet current). |
| Instrument Configuration: | FPU s/s, LOU s/s, WBS, HRS, ICU and EGSE. |
| Specific Requirements: | None |
| Environmental Constraints: | None |
| Success Criteria: | (Change in) housekeeping values within pre-defined limits |
| Duration | 1 day |
| Applicable: | PLM EQM x<br>PFM x |

## *Test 4*

| | |
|---|---|
| Title: | IF Properties |
| Experiment: | HIFI |
| Objectives: | Check IF standing waves due to representative coax cables between IF box and spectrometers as well as spectral features due to leakage / finite shielding / isolation. |
| Test Description: | In this test the IF chain of HIFI will be checked in a representative environment. Important changes with respect to HIFI DM tests are the change in harness (coax cables) and the environment (different locations / geometry / configuration and other systems involved). It is therefore needed to check the IF properties of the HIFI IF chain in terms of gain, noise, spectral ripple and spectral artefacts (spurs). |
| Instrument Configuration: | FPU s/s, LOU s/s, WBS, HRS, ICU and EGSE. WBS and HRS running separately or in parallel if the latter is a foreseen observation mode. |
| Specific Requirements: | None |
| Environmental Constraints: | None |
| Success Criteria: | IF gain / noise, ripple and spectrum within values applicable to IF chain. |
| Duration | 1 day |
| Applicable: | PLM EQM x<br>PFM x |

## *Test 5*

| | |
|---|---|
| Title: | Receiver Tuning |
| Experiment: | HIFI |
| Objectives: | Relate pump current to LO power (expressed in μA). Generate update of tuning tables corresponding to current state of integration (in the DM phase we have to see whether it is relevant to update all parameters) |
| Test Description: | Because the FPU-LOU alignment might be slightly different to that during the HIFI DM test phase new relations between LOU power parameter settings and pump current on the FPU mixers have to be established. It might furthermore be possible that because of different temperature levels and because of a different environment configuration wise the tuning tables need an update. The updating of the tuning tables is futhermore an exercise that has to be verified since this procedure in needed during in-orbit calibration. |
| Instrument Configuration: | FPU s/s, LOU s/s, WBS, HRS, ICU and EGSE. |
| Specific Requirements: | None |

| | |
|---|---|
| Environmental Constraints: | None |
| Success Criteria: | Establishment of relation between pump current and LO power setting. Succesfull generation of updated tuning tables. Deviations determined by comparing to measurement results obtained during HIFI DM ILT are within TBD % or understood. |
| Duration | 3 days |
| Applicable: | PLM EQM x<br>PFM x |

### *Test 6*

| | |
|---|---|
| Title: | Receiver Tuning |
| Experiment: | HIFI |
| Objectives: | Relate pump current to LO power (expressed in μA). Generate update of tuning tables corresponding to current state of integration (in the DM phase we have to see whether it is relevant to update all parameters) |
| Test Description: | Because the FPU-LOU alignment might be slightly different to that during the HIFI DM test phase new relations between LOU power parameter settings and pump current on the FPU mixers have to be established. It might furthermore be possible that because of different temperature levels and because of a different environment configuration wise the tuning tables need an update. The updating of the tuning tables is futhermore an exercise that has to be verified since this procedure in needed during in-orbit calibration. |
| Instrument Configuration: | FPU s/s, LOU s/s, WBS, HRS, ICU and EGSE. |
| Specific Requirements: | None |
| Environmental Constraints: | None |
| Success Criteria: | Establishment of relation between pump current and LO power setting. Succesfull generation of updated tuning tables. |
| Duration | 3 days |
| Applicable: | PLM EQM x<br>PFM x |

### *Test 7*

| | |
|---|---|
| Title: | Radiometry |
| Experiment: | HIFI |
| Objectives: | Determination of (conversion) gain and noise temperature over the RF band. |
| Test Description: | The noise temperature and gain will be determined at a limited number of points within the mixer bands that are present. This test |

| | |
|---|---|
| | is needed to verify proper heterodyne functioning before entering the detailed performance assessment during EMC test. |
| Instrument Configuration: | FPU s/s, LOU s/s, WBS, HRS, ICU and EGSE. |
| Specific Requirements: | None |
| Environmental Constraints: | None |
| Success Criteria: | Deviations determined by comparing to measurement results obtained during HIFI DM ILT are within TBD % or understood. |
| Duration | 1 day |
| Applicable: | PLM EQM x<br>PFM x |

### *Test 8*

| | |
|---|---|
| Title: | EMC Test |
| Experiment: | HIFI |
| Objectives: | Assess EMC susceptibility due to radiated and conducted EMC. |
| Test Description: | During this test the EMC susceptibility of HIFI in a representive environment will be assessed. Susceptibility will be measured in terms of changes in performance parameters like noise temperature, but also in terms of spectral information (spurious responses). For the mixer / LO bands present the RF bands will be fully tested on performance for all receiver settings. The internal calibration source will be used as the stimuli for the performance test. IF properties might be separately tested under simulated EMC environment again as part of this EMC test. |
| Instrument Configuration: | FPU s/s, LOU s/s, WBS, HRS, ICU and EGSE. |
| Specific Requirements: | None |
| Environmental Constraints: | None |
| Success Criteria: | Deviations determined by comparing to measurement results obtained during HIFI DM ILT are within TBD % or understood. |
| Duration | 10 days? |
| Applicable: | PLM EQM x<br>PFM x |

### *Summary*

| | |
|---|---|
| Total number of tests: | 8 |
| Total time estimate: | 25 days |
| Remark: | Succes-oriented, no safety margin added |

# Herschel
## PLM EQM Test Program

EQM Meeting
October 1st/2nd 2001

## PLM EQM Test Program
### 0. Table of Content

Herschel EPLM

## PLM EQM Test Program

### 1. Test Objectives

Herschel EPLM

- **EQM test objectives as defined in the AIV requirement specification are:**
  - Instrument compatibility verification (mechanical, electrical, thermal) at orbit representative cryogenic conditions
  - EMC test at realistic cryogenic conditions
  - IST test sequence debugging for PFM
- **Advantages of an EQM test program:**
  - Ability to perform functional tests under nearly orbit conditions, which is not possible with the PFM




## PLM EQM Test Program

### 2. Summary of Thermal Requirements

Herschel EPLM

- **Sources for Requirements**
  - IID-A: SCI-PT-IIDA-04624
  - IID-B HIFI: SCI-PT-IIDB/HIFI-02125
  - IID-B PACS: SCI-PT-IIDB/PACS-02126
  - IID-B SPIRE: SCI-PT-IIDB/SPIRE-02124
  - Baseline is issue 1/0 from 01.09.2000
  - Issue 2/0 from 31.07.2001 reviewed by Astrium
  - No major changes found in the thermal requirements between IID-B's versions 1/0 and 2/0

## PLM EQM Test Program

### 2. Summary of Thermal Requirements

Herschel EPLM

- **General Requirements (from IID-A)**
  - BOLA/LOU mounted
  - LOU within a test cryostat (TBC)
  - Cryostat cover either Herschel QM or GSE test cover
  - Upper part of PLM allows mounting of a GSE cavity to simulate orbital background conditions
  - Mass flow rate as expected in orbit (about 2.5 mg/s - to be achieved at least during the instrument test periods)
  - Cryostat harness will be electrically representative to PFM
  - Instrument AVMs will be mounted on an electrically representative plate
  - The instrument units will be connected to a functionally representative CDMS and Power S/S (including EGSE deployment)




## PLM EQM Test Program

### 2. Summary of Thermal Requirements

Herschel EPLM

- **HIFI Requirements (from IID-B)**
  - Level 0 temperature range: 0 K ... 2 K, stability 0.006 K/100s
  - Level 1 temperature range: TBD ... 6 K, stability 0.006 K/100s
  - Level 2 temperature range: TBD ... 20 K, stability 0.015 K/100s

## PLM EQM Test Program

### 2. Summary of Thermal Requirements

Herschel EPLM

- **PACS Requirements (from IID-B)**
  - Level 0 temperature range: 1.6 K ... 1.75 K (2.2 K, 3.5 K)
  - Level 1 temperature range: 3.0 K ... 5.0 K
  - Level 2 temperature range: n.a.
  - Stability not defined
  - Tilting around z-axis by up to 30° (20° issue 2/0) for $He_3$ cooler recycling




## PLM EQM Test Program

### 2. Summary of Thermal Requirements

Herschel EPLM

- **SPIRE Requirements (from IID-B)**
  - Level 0 temperature range: N/A ... 2 K
  - Level 1 temperature range: N/A ... 6 K
  - Level 2 temperature range: N/A ... 15 K
  - Stability not defined
  - Tilting around z-axis by more than 17° for $He_3$ cooler recycling
  - Tilting around z-axis by 90° to operate the SPIRE FTS mechanism
  - Monitoring of I/F temperatures (3 on level 0, 1 on level 1, 2 on level 3 and 3 on the optical bench's mechanical interfaces)

## PLM EQM Test Program

### 3. Consequences for EQM Design

Herschel EPLM

- **Electrical requirements**
  - Additional intermediate ring to allow integration of vacuum connectors (64 maximum - TBC)
  - Optical bench as Herschel FM
  - EQM harness according FM design
- **Orbital background requirements**
  - Background requirements could be achieved by closing the shields using the test cavity
  - Same approach as on PFM




## PLM EQM Test Program

### 3. Consequences for EQM Design

Herschel EPLM

- **Level 0 to level 2 temperature requirements**
  - He bath temperature in He II tank of less than 1.7 K necessary
  - Will be achieved by adequate pumping (pumping capacity of Helium pumping units will be increased compared with ISO)
  - Minimum bath temperature achieved on ISO was 1.56 K
- **Mass flow rate through optical bench of 2.5 mg/s**
  - Nominal mass flow rate on ground 30 mg/s (TBC)
  - Mass flow can be reduced during testing by a combination of the following solutions:
    - adding an auxiliary tank inside the torus of the main tank
    - throttling the pumping
    - adding an additional forced shield cooling
  - Detailed thermal analysis will be performed

## PLM EQM Test Program
### 3. Consequences for EQM Design

Herschel EPLM

### ➢ Summary

| | | |
|---|---|---|
| BOLA and LOU shall be mounted | ⇒ | Upper cylindrical part of the CVV acc. Herschel design |
| LOU within a test cryostat (TBC) | ⇒ | Baseline is to operate the LOU at room temperature. Upper cylindrical part of the CVV acc. Herschel design. Possibility to mount the LOU-cryostat (which is a CFE) has to be checked. |
| Cover either Herschel QM or GSE test cover | ⇒ | GSE test cover |
| Upper part of PLM allows mounting of GSE cavity | ⇒ | Upper part of PLM according Herschel design |
| Mass flow rate about 2.5 mg/s | ⇒ | Will be achieved by a combination of using an aux. tank and/or additional shield cooling and/or throttling of the pumping performance. Mass flow rate will be adapted to the predicted value, which can be in the range of 2.0 mg/s ... 2.5 mg/s |




## PLM EQM Test Program
### 3. Consequences for EQM Design

Herschel EPLM

### ➢ Summary (cont'd)

| | | |
|---|---|---|
| Cryostat harness shall be electrically representative to PFM | ⇒ | QM harness will be electrically of FM standard |
| Instrument AVM's mounting requirements | ⇒ | AVM's will be mounted on support structure, similar to PFM design, at the interface plate of the ISO SVM (TBC) |
| Instrument units connected to functionally representative CDMS and power S/S | ⇒ | EGSE configuration |
| Level 0 temperature requirements | ⇒ | He II tank temperature ≤ 1.7 K |
| Level 1 & 2 temperature requirements | ⇒ | Combination of He II tank temperature and concepts to reduce mass flow to 2.5 mg/s |
| Tilting up to 90° around z-axis | ⇒ | Combination of test set-up and test plan (liquid level in He II tank) |
| I/F temperature monitoring on OB | ⇒ | QM OB according FM design |

## PLM EQM Test Program
### 4. Proposed EQM Design

Herschel EPLM

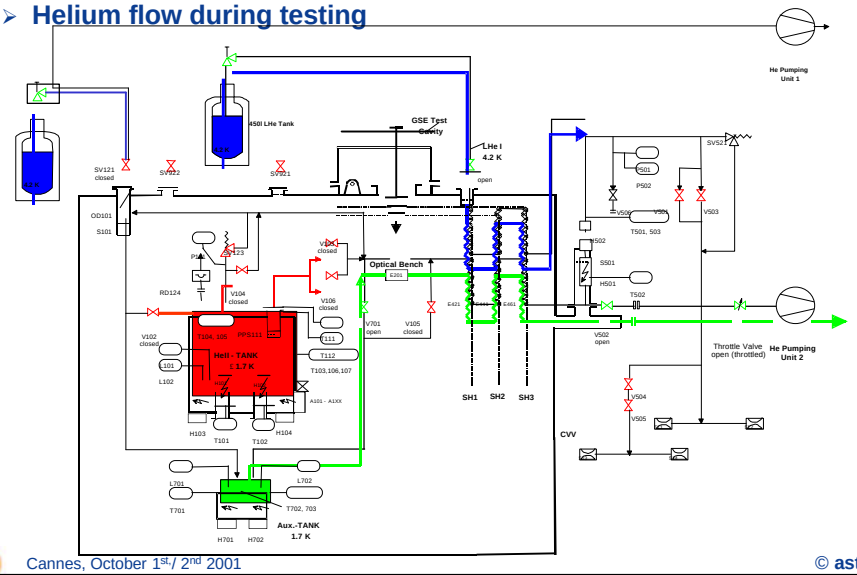
- **EQM upper part identical to Herschel design (instead of ISO upper bulkhead) to allow mounting of the GSE cavity**
  - Mounting of test cavity possible
  - Test cavity will be used instead of Herschel QM cover
  - Alignment only from y/z-axis possible
  - Allows usability verification of test cavity
  - Closest to FM design




## PLM EQM Test Program
### 4. Proposed EQM Design

Herschel EPLM

- **Helium flow during testing**

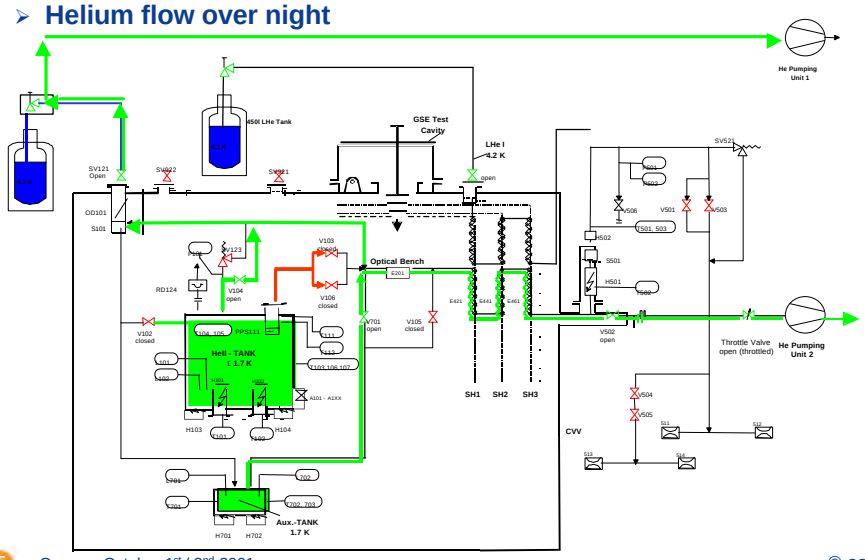


## PLM EQM Test Program

### 4. Proposed EQM Design

Herschel EPLM

- **Helium flow over night**





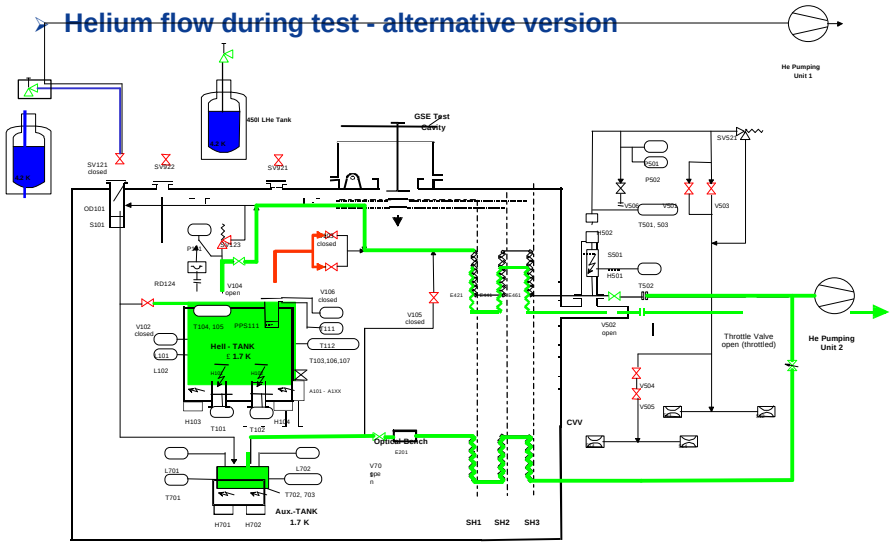


## PLM EQM Test Program

### 4. Proposed EQM Design

Herschel EPLM

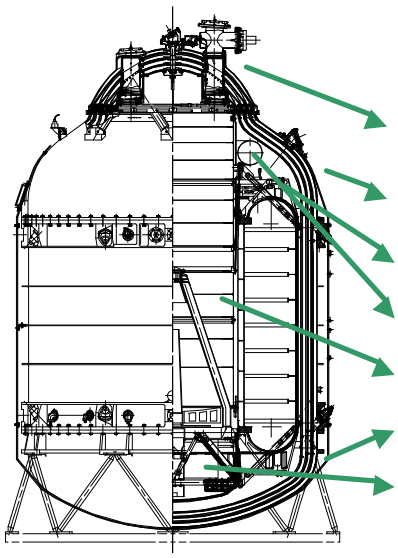
- **Helium flow during test - alternative version**



## PLM EQM Test Program

### 4. Proposed EQM Design

Herschel EPLM



**Main Modifications:**

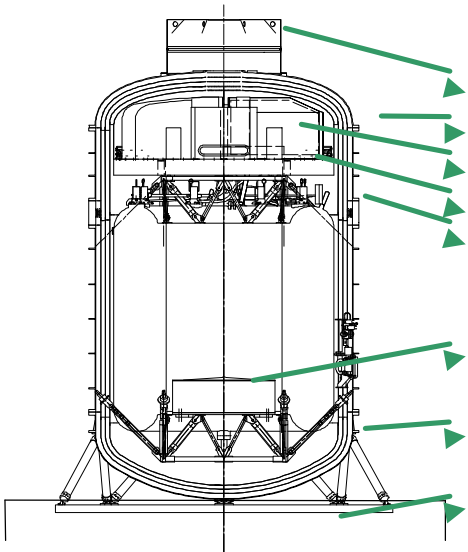
- Dismount ISO Cryocover (only baseplate mounted)
- Dismount ISO Upper Cone
- Modify He - Tubing
- Remove He-I Tank
- Dismount Baffle
- Dismount ISO lower bulkhead
- Remove OSS




## PLM EQM Test Program

### 4. Proposed EQM Design

Herschel EPLM



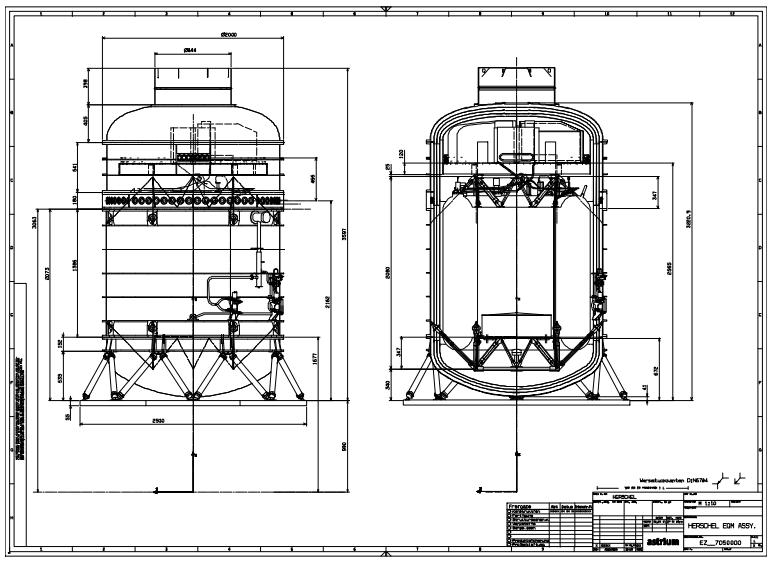
**Main Modifications:**

- Add Herschel Test Cavity
- Add Herschel Upper Bulkhead
- Integrate Experiments and OB
- Integrate Internal Harness
- Add Connector Ring for Harness Feed -Throughs
- Implement He-I Tank
- Integrate Ext. Harness
- Use modified SVM Platform for AVMs

## PLM EQM Test Program

### 4. Proposed EQM Design

Herschel EPLM



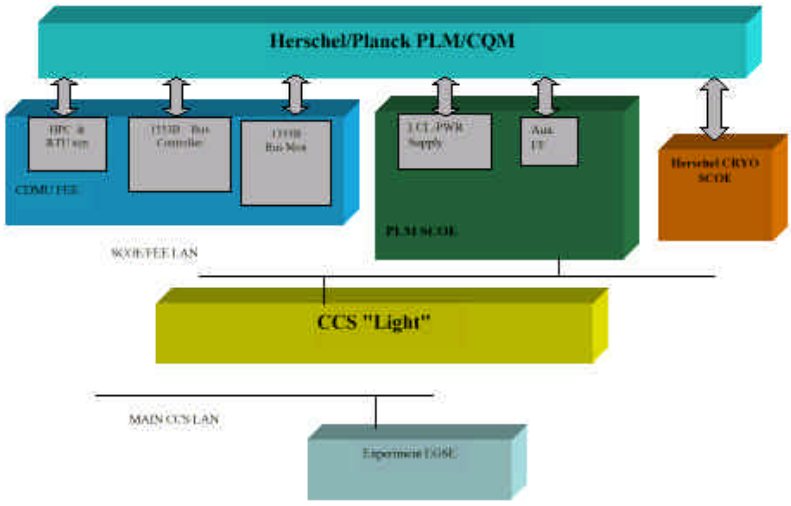




## PLM EQM Test Program

### 5. EGSE Setup

Herschel EPLM



## PLM EQM Test Program

### 6. Questions to Instruments

Herschel EPLM

- **Could you please confirm that the development plan of the CQM/AVM units are in accordance with IID-A (especially EMC tests have to be performed before delivery to Astrium)**
- **LOU configuration for ground testing not yet known in detail:**
  - necessity to cool the LOU to orbit temperatures
  - if it is cooled: What does the cooling device (LOU test cryostat) look like, what are the interfaces, which support do you need (power, coolant etc.)?
  - if not cooled: Is it possible to perform a test in the most sensitive mode with a LOU at 300K?
  - Is it possible to perform an alignment measurement if the LOU test cryostat is mounted?
- **What are the required background conditions for EQM testing (maximum allowed temperature for the cover resp. test cavity)?**




## PLM EQM Test Program

### 6. Questions to Instruments

Herschel EPLM

- **The distance LOU - HIFI FPU must be fairy constant. What are the requirements related to vibration (e.g. of pumping units, lift etc.) during testing?**
- **Which tests have to be performed?**
- **Tilting around +z-axis or -z-axis or equal required?**
- **Tests with dark background on PFM necessary?**