Title: **EQM Design Description**

CI-No: 150000

Prepared by:	Alo/Kersting & EQM Team	Date:	29.04.04
Checked by:	J. Kroeker	Date:	30.4.2004
Product Assurance:	R. Stritter	Date:	30.04.04
Configuration Control:	A. v. Ivády	Date:	30.04.04.
Project Management:	W. Rühe	Date:	30.4.04

Distribution: See Distribution List (last page)

Issue	Date	Sheet	Description of Change	Release
1	12.6.02	All	first issue	
1.1	17.6.02	10 14 15 20 22 45 63 – 65 76 77 all pages	§ 2.2: Update of RD list § 3: Modification of figure title § 4.2.2: Incorporation of cooler recycling angles § 5: Clarification of contents § 5.3: Incorporation of missing Figure numbers § 6.2.4: Comment to He flowchart § 6.3.1: Update acc. To results of PDR assessment meeting § 7.3.1: RD included and correction of referenced figure § 7.3.2: Update of chapter CTA replaced by cooled plate	
2	29.4.04	all pages	Completely reworked for CDR Incorporation of design evolution	

Table of Contents

List of Figures

List of Tables

1 INTRODUCTION

The HERSCHEL PLM program adapts a two model philosophy comprising

- an EQM (Engineering Qualification Model)
- a PFM (Proto Flight Model)

The PFM will be launched into orbit having run through its total qualification/acceptance sequence.

The tight PFM schedule makes it necessary to lower the development risk in certain areas by using and adapting the existing ISO-QM to the Herschel EQM within a reasonable effort and schedule to allow early testing in the following areas:

- Functional testing of scientific instruments in an almost flight representative environment
- EMC testing of the scientific instruments focal plane units and associated cryo harness in a representative environment.

Specific aims at FM representatives are:

- L0, L1, L2 temperatures
- harness layout and routing
- straylight background

Additional essential spin-off of integration and a.m. test activities relevant for PFM are:

- early verification of alignment operations
- potential “on line” optimisation of scientific software
- closer determination of L0, L1, L2 temperatures
- testing of ground operations including specifically all cryogenic operations

The subject of this document is a summary description of

- the EQM design as derived from ISO-QM
- overview of the EQM integration and testing activities planned respectively already achieved

The last point is described in detail in the “HERSCHEL PLM/EQM AIT Plan” (RD3) i.e. main emphasis of this document is on the EQM design.

The Herschel EQM is based on the existing ISO-QM and is used as ground based test cryostat. It will see neither the launch environment nor orbital parameters.

2 DOCUMENTS AND ABBREVIATIONS

This document was compiled to explain the HERSCHEL EQM functionality and its relation to the PFM. It is not a specification and detailed technical information may be of exemplary character only, reflecting the status of the issue date.

2.1 Applicable Documents

AD-1	Herschel/Planck Instrument Interface Document, Part A, SCI-PT-IIDA-04624, Issue 3.1, 01.07.2002
AD-2	Herschel/Planck Instrument Interface Document, Part B; Instrument “HIFI”, SCI-PT-IIDB/HIFI-02125, Issue 3,1, 13.01.2004
AD-3	Herschel/Planck Instrument Interface Document, Part B; Instrument “PACS”, SCI-PT-IIDB/PACS-02126, Issue 3,1, 20.01.2004
AD-4	Herschel/Planck Instrument Interface Document, Part B; Instrument “SPIRE”, SCI-PT-IIDB/SPIRE-02124, Issue 3.11, 07.01.2004

2.2 Reference Documents

RD-1	General Design and Interface Requirements HP-1-ASPI-SP-0027, Issue 4/1
RD-2	ISO-PLM-QM, Configuration Status List Prior to Delivery to ESTEC ISO-LI-B4330.013, issue 1
RD-3	HERSCHEL PLM/EQM AIT Plan HP-2-ASED-PL-0022
RD-4	EMC Specification FP-ASPI-RS-1003, Issue 3/1
RD-5	Schedule document for Herschel EPLM and Satellite AIT HP-2-ASED-PL-0005
RD-6	ISO PLM Integration Dolly Technical Specification ISO-VV-ZYYR-SP-0043
RD-7	MPT Item Specification XM-IS-APC-0098
RD-8	EDU Item Specification XM-IS-APC-0262
RD-9	ISO PLM Test Dolly Technical Specification ISO-VV-ZYYX-SP-0473
RD-10	ISO PLM MGSE Hoisting Equipment Technical Specification ISO-VV-ZYYY-SP-0048
RD 11	Herschel PA Plan HP-2-ASED-PL-0007
RD 12	Herschel Contamination Control Plan HP-2-ASED-PL-0023
RD 13	Description of the PLM FM Cryo Control Instrumentation HP-2-ASED-TN 0048

RD 14	Payload Module Instrumentation Specification ISO-DS-BEE00.001, issue 1
RD 15	H-EPLM Design Description HP-2-ASED-RP-0003
RD 16	H-PLM Helium Subsystem Description HP-2-ASED-RP-0034
RD 17	Instrument testing on PLM EQM level HP-2-ASED-PL-0021
RD 18	Alignment Method, Plan & Results HP-2-ASED-TN-0097, issue 1
RD 19	Optical Configuration and Straylight during Ground Testing HP-2-ASED-TN-0076, issue 2

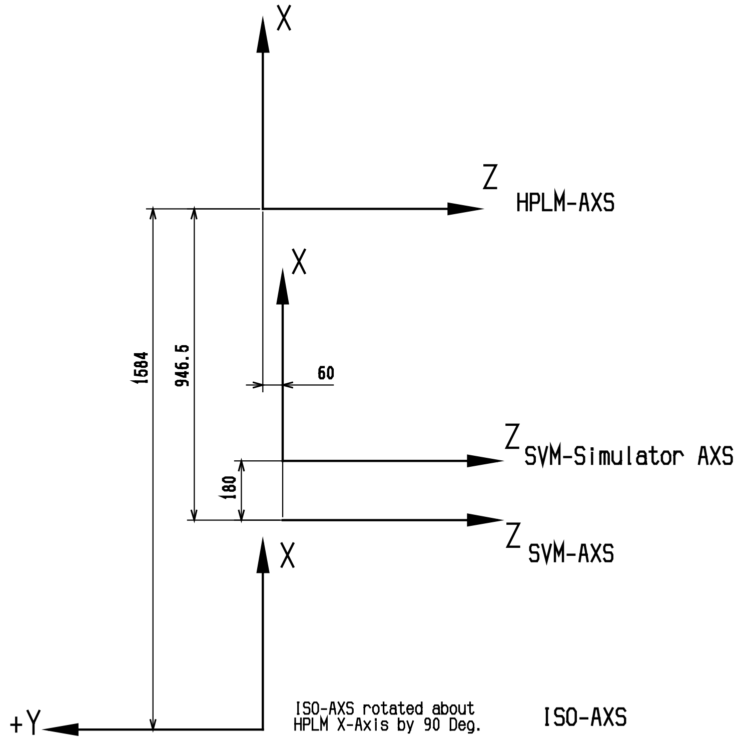
2.3 Abbreviations

AIT	Assembly Integration and Test
AVM	Avionics Module
AXT	Auxiliary Tank He-II (EQM)
BOLA	Bolometer Amplifier
C/L	Centre Line
CCH	Cryostat Control Harness
CCS	Central Check-out System
CCU	Cryo Control Unit
CFC	Carbon Fibre Composite
CIC	Cryo Instrumentation Components
CoC	Certificate of Compliance
CoG	Centre of Gravity
cm	Centimeter (Wavelength)
CQM	Cryo Qualification Model
CSS	Cryo Subsystem (Cryostat)
CTA	Cryo Test Adapter
CVSE	Cryo Vacuum Service Equipment
CVV	Cryostat Vacuum Vessel
CVVIP	Vacuum Vessel I/F Plate
dm	Decimeter (Wavelength)
DSPG	Distributed Single Point Grounding
ECCP	EQM Cryo Cover Plate
EDU	Equipment Drive Unit
EGSE	Electrical Ground Support Equipment
EMC	Electromagnetic Compatibility
EQM	Engineering Qualification Model
FoV	Field of View
FPA	Focal Plain Assembly
GLC	Ground Loop Coupling
HIFI	Heterodyne Instrument for the Far Infrared
HOT	Auxiliary Tank He-I (PFM)
HTT	He-II Tank (PFM)
I/F	Interface
IMT	Integrated Module Test
IR	Infrared
ISO	Infrared Space Observatory
ITT	Invitation to Tender
LHe	Liquid Helium
LLS	Liquid Level Sensor
LOU	Local Oscillator Unit
MGSE	Mechanical Ground Support Equipment
MLI	Multi Layer Insulation
MPT	Multi Purpose Trolley
MSS	Mechanical Support Structure
n/a	not applicable
MoI	Moment of Inertia
OBA	Optical Bench Assembly
OSS	Optical Support Structure
PACS	Photodetector Array Camera and Spectrometer
PFM	Proto Flight Model
PTR	Post Test Review
QM	Qualification Model
RF	Radio Frequency
SCOE	Special Check-Out Equipment
SE	Shielding Effectiveness
SFT	Short Functional Test
SIH	Scientific Instrument Harness
SPIRE	Spectral and Photometric Imaging Receiver
SST	Stainless Steel
SVM	Service Module
TBC	To be confirmed
TBD	To be defined
TM/TC	Telemetry/Telecommand
TRR	Test Readiness Review
TTC	Transport and Test Cover
TTD	Transport and Tilting Dolly
w/o	without
w.r.t.	with respect to
WU	Warm Unit
XMM	X-Ray Multi Mirror Satellite

3 COORDINATE SYSTEM

The Herschel PLM reference frame (X_{PLM} , Y_{PLM} , Z_{PLM}) is defined such that :

- X_{PLM} coincides with the nominal optical axis of the Herschel telescope. The positive X_{PLM} axis is oriented towards the target source. The X_{PLM} axis has an offset of 60 mm to the longitudinal X axis of the SVM and the launcher.
- Z_{PLM} is in the plane orthogonal to the X_{PLM} axis, such that nominally the sun will lie in the (X_{PLM} , Z_{PLM}) plane (zero roll angle with respect to Sun). Positive Z_{PLM} axis is oriented towards the Sun.
- Y_{PLM} completes the right handed orthogonal reference frame.



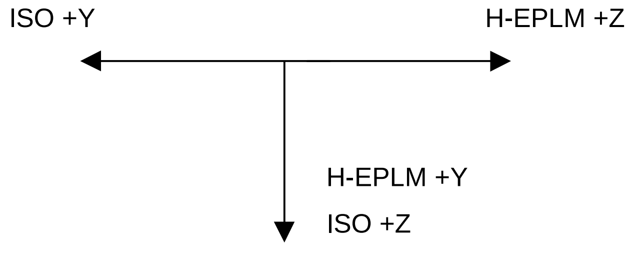


Figure 3-1: Herschel PFM / EQM Coordinate System Details

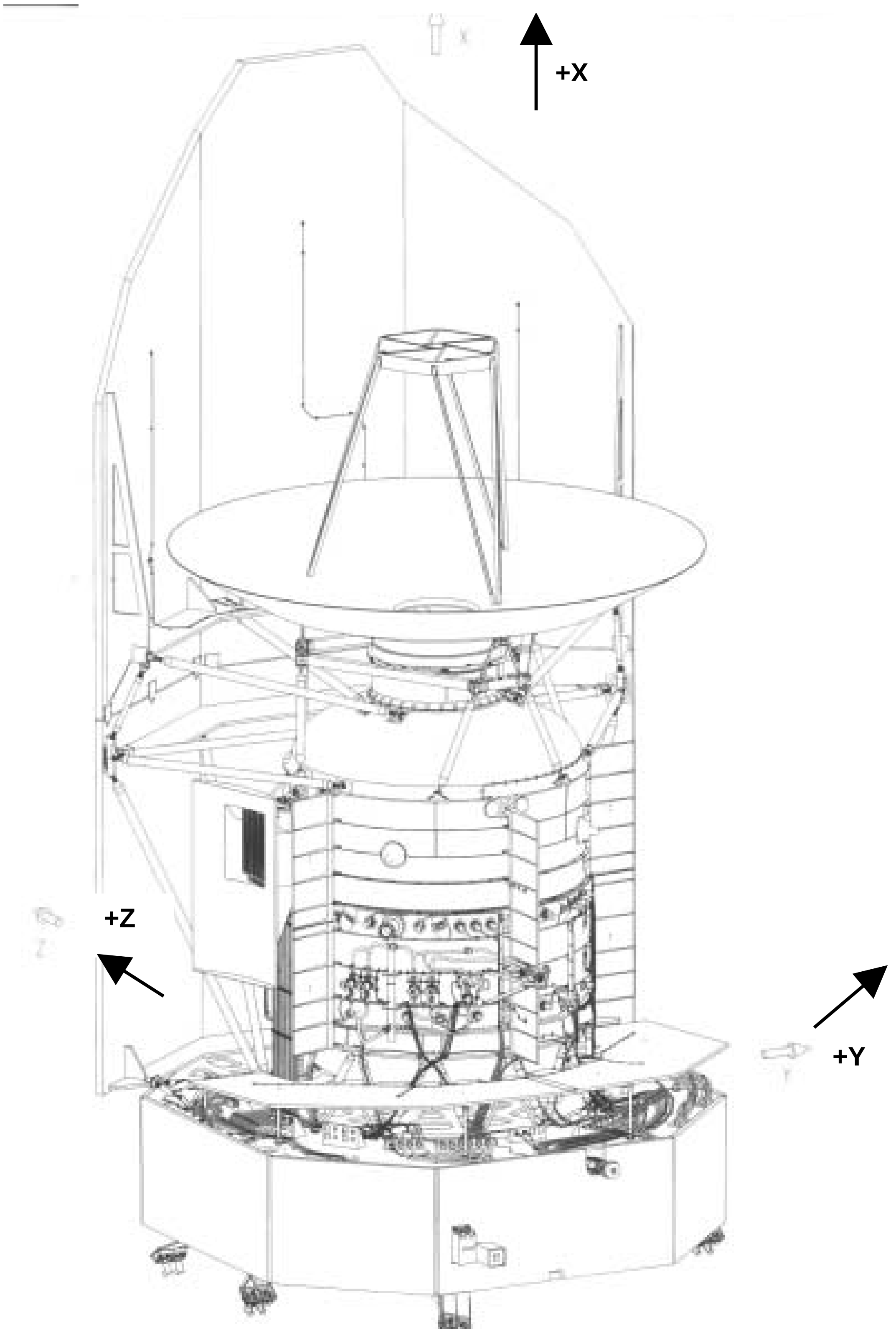


Figure 3-2: Herschel PFM Coordinate System Overview

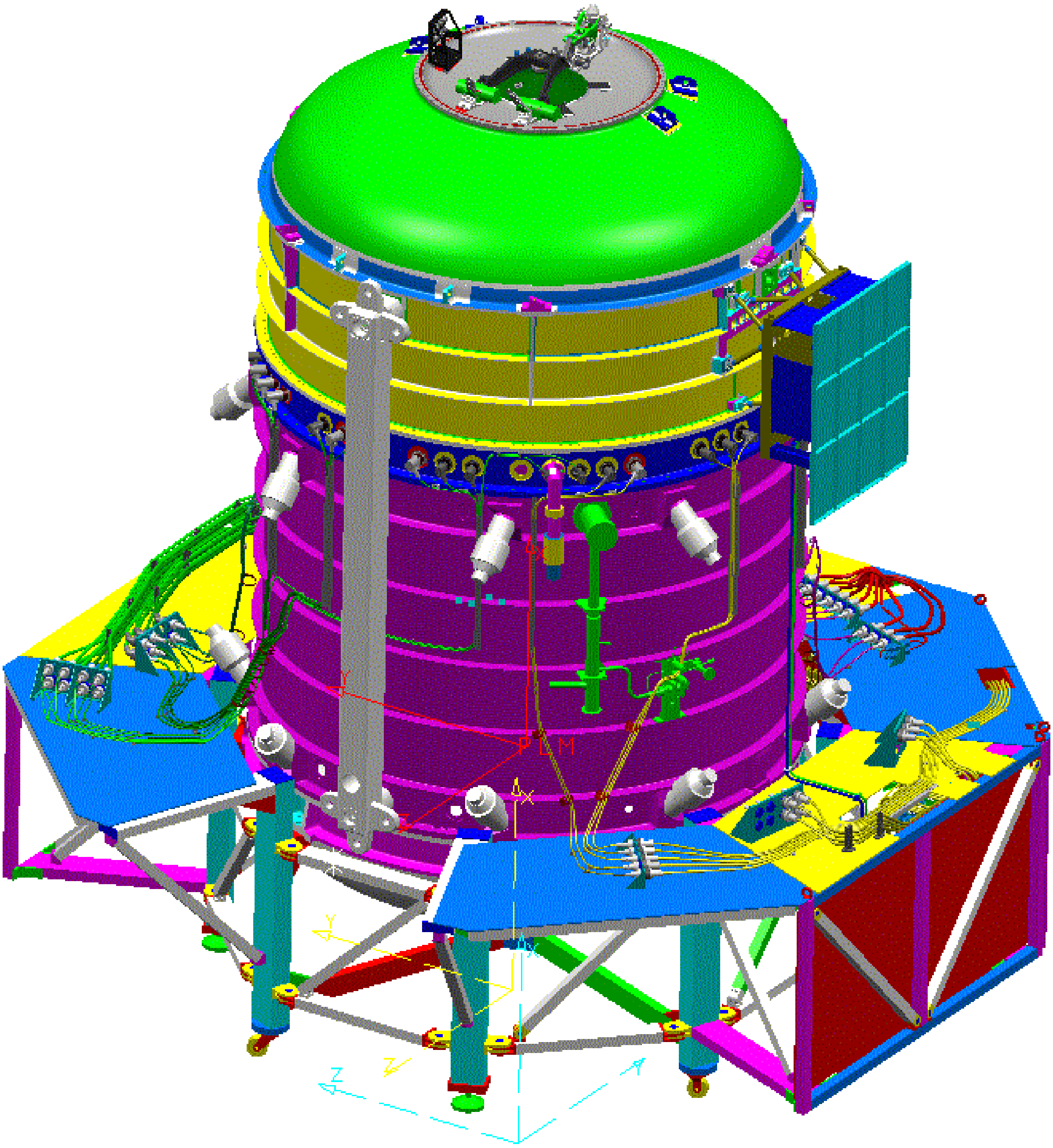


Figure 3-3: Herschel EQM Coordinate System Overview

4 EQM REQUIREMENTS AND DEVELOPMENT OVERVIEW

4.1 Fundamental Requirements and Constraints

- The EQM shall provide a test platform to allow a functional and EMC-testing of the Scientific Instruments as early as possible in the Herschel program.
- The EQM shall provide an almost flight representative environment to the Scientific Instruments as far as necessary for the conduction of a.m. tests.
- The EQM shall make use of the existing ISO-QM to the maximum extent possible.

4.2 EQM Performance Requirements

4.2.1 Thermal

- The EQM shall provide the correct L0, L1, L2 temperatures for the FPU's as for the instruments required.

  The instrument FPU does require three different temperature levels. A fourth temperature level is required for the SPIRE JFETs. The required operating temperatures per instrument are summarised in the following tables and are based on the IIDBs for PACS, SPIRE and HIFI. These temperatures shall be provided by the HERSCHEL cryostat cooling system.

Instrument Interface	Temp. Level	TMM Node	Operating		Heat Load
PACS			Min.[K]	Max.[K]	[mW]
Red Detector	L0	721	1.6	1.75	0.8
Blue Detector	L0	723	1.6	2.0	2.0
Cooler Pump	L0	761	1.6	10 5	500 (peak) 2
Cooler Evaporator	L0	762	1.6	1.85	15
Optics/Structure assy.	L1	781 782 783	2.0	5.0	30
HOB Interface	L2			12	0

Table 4-1: PACS Temperature Requirements

Instrument Interface	Temp. Level	TMM Node	Operating		Heat Load
SPIRE			Min.[K]	Max.[K]	[mW]
Detector Enclosure	L0	814	0	2.0 1.71 (goal)	4.0 1.0 (goal)
Cooler Pump	L0	815	0	10 2	500 (peak) 2
Cooler Evaporator	L0	816	0	1.85 1.75 (goal)	15 15 (goal)
SPIRE OB units	L1	800 830	0	5.5 3.7 (goal)	15 13 (goal)
HOB Interface	L2			12 8 (goal)	0 0 (goal)
Instrument Shield	L2			16	0
PM-JFETs	L3	831		15	50
SM-JFET	L3	832		15	25

Table 4-2: SPIRE Temperature Requirements

Instrument Interface	Temp. Level	TMM Node	Operating		Heat Load
HIFI			Min.(K)	Max.(K)	[mW]
L0 boundary	L0	949	0	2	6.8
L1 boundary	L1	939	0	6	15.5
FPU structure	L2	910	0	20	22

Table 4-3: HIFI Temperature Requirements

- The L1 and L2 requirements shall be fulfilled with the nominal on orbit GHe mass flow calculated to about 2.2 mg/sec.
- The temperature of the Innermost Shield shall be adjustable by a selectable GHe mass flow to the predicted on orbit value of about 32K and/or to fine adjust the L2 temperature level.

4.2.2 Operational Requirements

- Nominal orientation of EQM for longer testing periods shall be with the x-axis vertical (+x upwards)
- For cooler recycling of the FPU's a tilting of the EQM around z-axis towards +y orientation shall be possible in fully integrated state, i.e. SVM dummy mounted and connected to the EGSE.

4.2.3 Interface Requirements

The EQM shall provide adequate and safe interfaces to

- the SVM simulator accommodating the instrument warm units
- all GSE as described in Para 6.3.

4.3 EQM Development Overview

These requirements determine in principle the EQM-configuration based on the ISO QM model as follows:

- Lower Part:
  - Removal of internal parts of ISO like OSS, Baffle, etc
  - use of existing ISO lower bulkhead CVV and thermal shields incl. MLI
  - attachment of HERSCHEL SVM simulator for accommodation of Scientific Instrument warm boxes.
- Cylindrical Part: use of ISO hardware unchanged
- Upper Part:
  - Replace Auxiliary Tank of ISO by the HERSCHEL Optical Bench Assembly with integrated Instrument FPU's (CQM status as close as possible to PFM).
  - Upper Bulkhead (CVV + Shields + MLI) must be consequently of HERSCHEL PFM Design including the Scientific Instrument Harness and the Cryo Control Harness.
- Actively cooled mirrors, as part of the cryo cover, in front of the instruments shall provide almost orbit representative background conditions to allow functional and EMC testing of the PLM, especially of the sensitive scientific instruments. The CVV cover qualification model will be used for this purpose, being refurbished afterwards to become the flight spare.

The SVM will be placed in the approximate correct height such as to allow to use flight representative harness length and routing. As the CVV connector ring interfaces at the EQM are shifted about 180mm in +x compared to the PFM, the LOU waveguides have to be shortened accordingly.

Details of the EQM program should be taken from the subsequent chapters and RD3, “Herschel PLM/EQM AIT Plan”. As an introduction a short summary of the activity flow is given in the figure below.

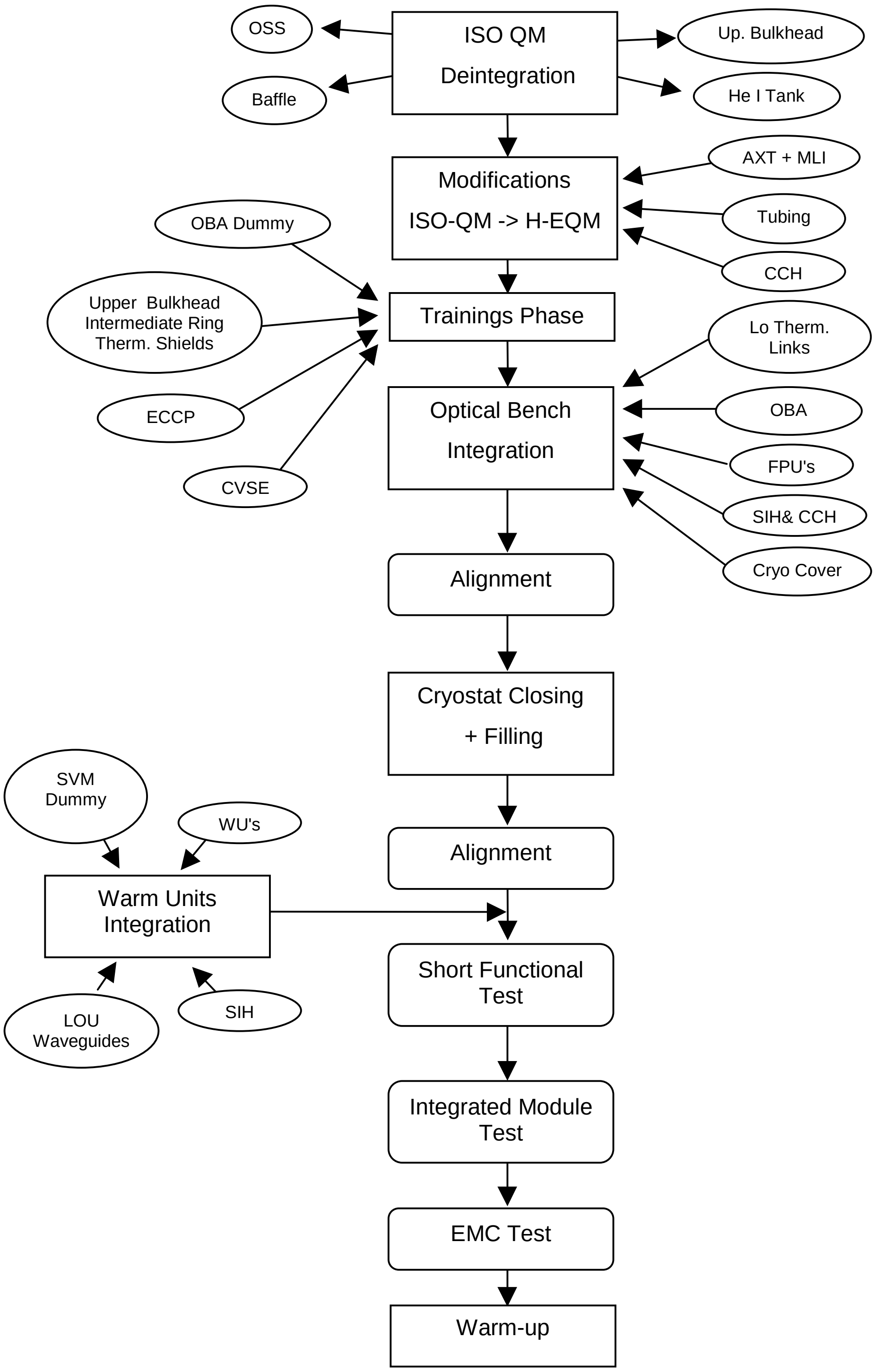


Figure 4-1: Summary of EQM Activities

Amongst detailed activities, the sequence comprises 3 essential activity blocks:

- ISO QM refurbishment and modification
- Integration of Herschel specific components
- Tests

4.4 Interfaces to PFM Program

The PFM program is structured success oriented to a high degree. Nevertheless, a certain feedback from EQM to PFM with modifications of the latter are expected, as can be seen from the detailed schedule in RD 5.

5 ISO – QM DESCRIPTION

This chapter summarizes the hardware development and performed tests within the ISO program.

The ISO program was based on 3 models of the payload module i.e.

- 1 Structural model (STM),
- 1 Qualification model (QM), refurbished from the STM and now basis for the Herschel EQM
- 1 Flight model (FM).

5.1 Cryostat Design

The ISO STM/QM design is characterised by the overall Cryostat layout :

- Cryostat Vacuum Vessel (3 pieces)
- 16 GFC/CFC tank support straps (chain design), and strap tensioning device
- Upper and lower spatial framework carrying the tank
- Main 2286 l He-II tank with related valves, safety devices, He-II-phase separator and tubing
- 60 l auxiliary tank for launch autonomy
- 3 GHe cooled thermal shields (attached to straps) plus 1 OSS - attached shield, covering the FPUs, all equipped with MLI
- External He-piping with 4 valves, heater to avoid ventline freezing, and nozzles for momentum free He exhaust
- External and internal harness
- Cryostat cover, consisting of:
  - ➢ Vacuum tight shell
  - ➢ Clampband fixation to CVV
  - ➢ 3 MLI insulated radiation shields, passively cooled by a total of 20 low force (500 N total force) thermal contacts: shields fixed by 8 GFC-beams
  - ➢ LHe –flush cooling of the innermost cover shield to provide 5 K background during dedicated FPU-operations on ground
  - ➢ 2 optical channels of 100mm diameter, with thermal filters each, thermally anchored to the 2 innermost shields

5.2 Performed Tests

The ISO STM/QM was used for structural qualification of the PLM and for verification of the thermal mathematical model. In order to achieve these objectives all hardware consisted of flight standard design and configuration.

The ISO PLM-STM testing on cryostat comprised:

- Ground lifetime test
- Functional tests (cryostat performance)
- Thermal vacuum test (early orbit and final equilibrium)

- Vibration tests (sine, low level) cold
- Static load testing of the suspended mass
- Vibration tests (sine, qual. level, two axes) warm

The PLM-QM consisted of the PLM-STM model with the dummy telescope replaced by the STM/QM telescope. The structural, cooling and insulation subsystems have been refurbished from the STM to the maximum extent. All subsystems and units were qualification units. Experiment focal plane units (FPU) were alignment mass and thermal models.

The test program of the ISO PLM-QM was separated into two sequences:

PLM QM Test Phase I – test sequence prior to QM system tests comprising:

- Cooldown and filling of the cryostat with LHe-I
- Functional test of the cryostat
- Cold Vibration Test of the cryostat

PLM QM Test Phase II – test sequence after QM system tests comprising:

- De-integration of the QM telescope for inspection /test
- Integration of baffle plate for focus shift measurement
- Closure of cryostat
- Focus shift measurement 1 (warm) opt. Reference measurements
- Cooldown and filling of the cryostat with LHe-I
- Focus shift measurement 2 (cold, LHe-I)
- LHe-II production and LHe-II top up
- Launch operation s activities with an ARIANE IV – Fairing Mock-up
- Filling of He-I tank (V502 ventline/nozzle venting)
- Focus shift measurement 3 (cold, He-I)
- Depletion and controlled warm-up of the cryostat
- Focus shift measurement 4 (warm)
- Bake out of cryostat
- Storage of the ISO PLM QM

5.3 Curriculum Vitae of the ISO QM

07.1989 – 01.1990	Integration of the ISO STM/QM at ASTRIUM (Figure 5-1)
02.1990 – 12.1990	1st Cooldown, He-II-Production, TV-Test (Figure 5-2), Vibration Test (cold & warm; Figure 5-3)
01.1991 – 06.1991	Modification STM -> QM, Vibration test (cold)
07.1991 – 02.1992	Transport to AS – Cannes in cold condition (Figure 5-4); System Integration; System Qualification Tests: Vibration, Acoustic Noise, Alignment, CoG, Warm up, De-mating, Transport of warm PLM to OTN
03.1992 – 12.1992	QM Testphase–II: Integration QM-Telescope, Alignment Verification, Bake-out, Launcher I/F-Tests,
01.1993 – 12.1993	Diverse Tests in warm and cold conditions, transport (warm) to ESTEC
06.1994	Fit Check of the PLM in the TV-Chamber – LSS at ESTEC
10.1994	Removal of the Cryostat Cover and installation of cover plate; re-evacuation
08.1996	Installation into the ISO Transport Container for storage
07. 2001	Opening of the Container and 1st check at ESTEC (Figure 5-5)
09. 2001	Transport of the ISO-QM in the Transport Container to ASTRIUM OTN
12.2001	Installation of the PLM in the Cleanroom facility of ASTRIUM OTN (Figure 5-6)
since 04.2002	Start of Inspection and De-integration for modification to HERSCHEL – EQM (Figure 5-7 and Figure 5-8)

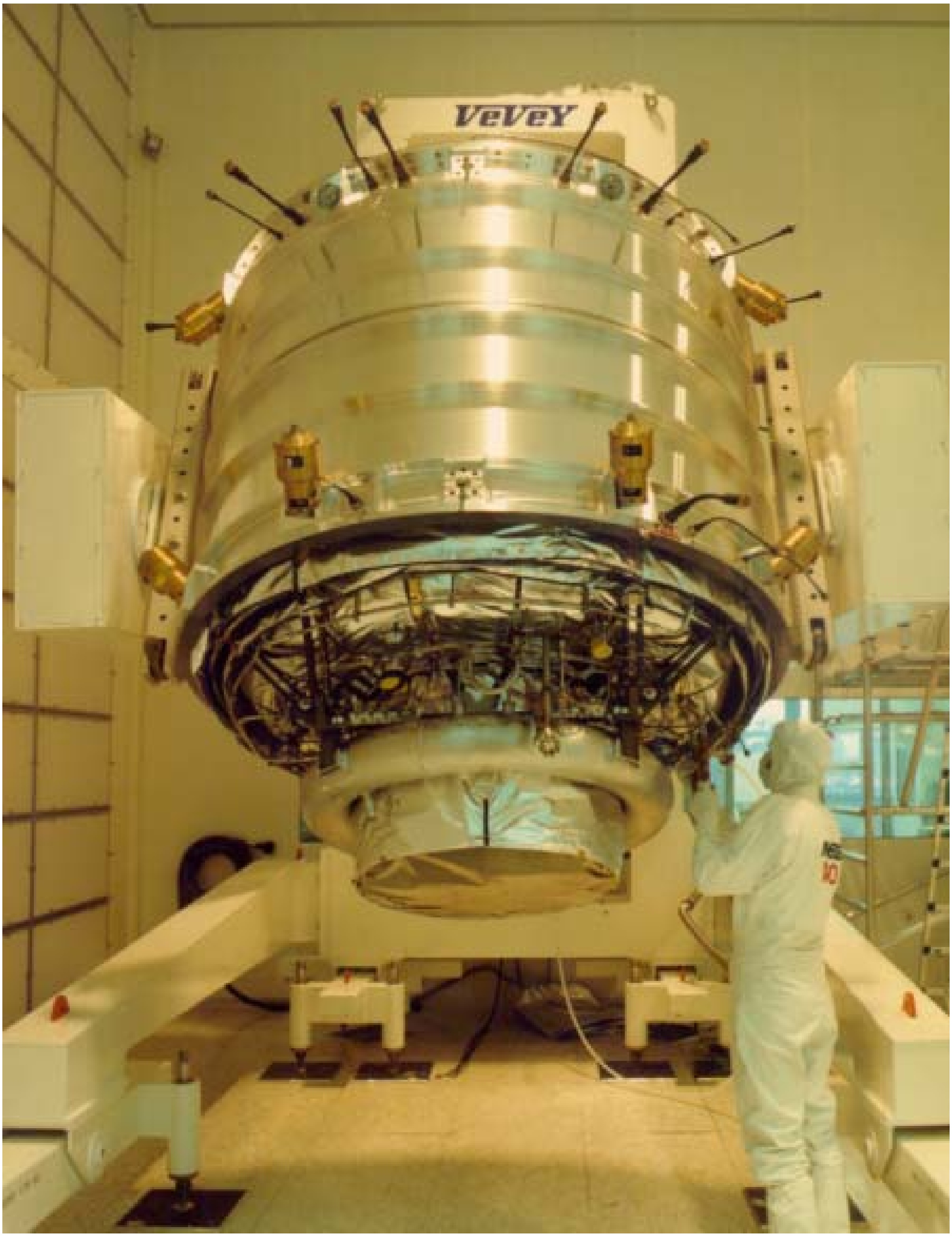


Figure 5-1: ISO PLM Integration in Cleanroom class 100 at ASTRIUM in Ottobrunn

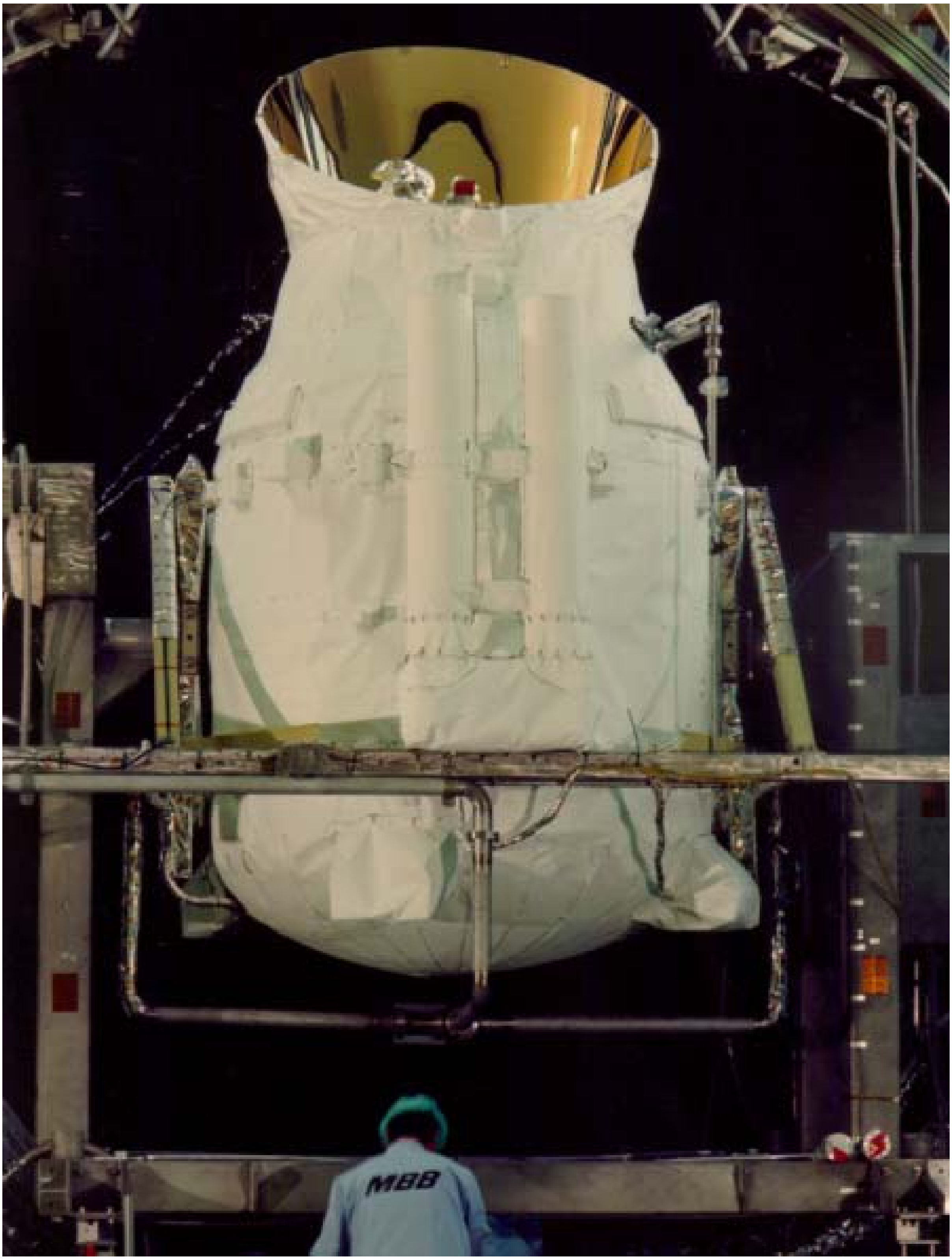


Figure 5-2: Preparation of the ISO PLM for the TV – Test at IABG

Figure 5-3: Preparation of the ISO PLM for the Vibration Test at IABG

Figure 5-4: ISO PLM mounted in the Transport Container

Figure 5-5: ISO PLM in the opened Transport Container at ESTEC

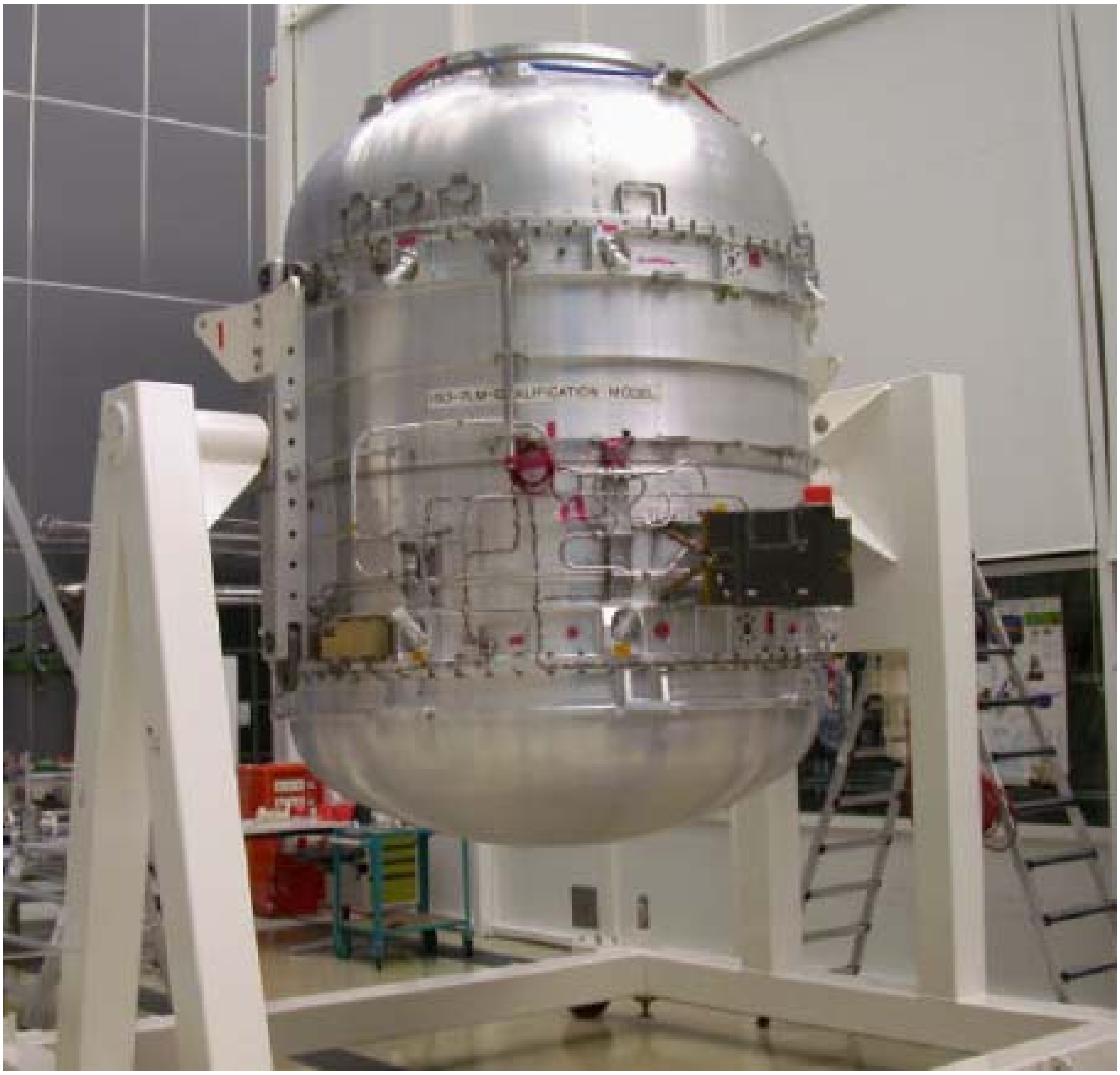


Figure 5-6: ISO-QM in Transport Dolly at ASTRIUM, in preparation to conversion to HERSCHEL EQM

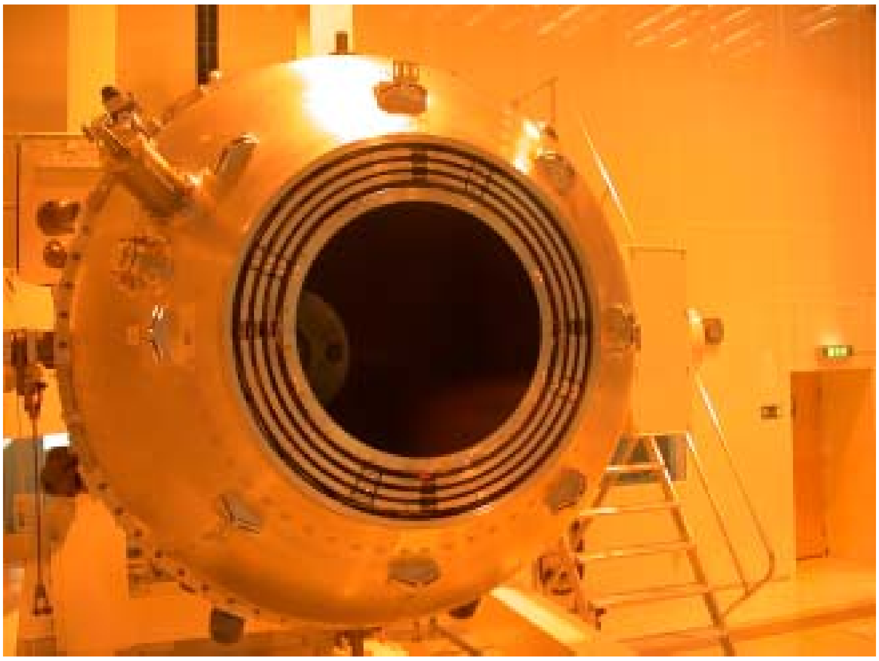


Figure 5-7: Open Cryostat in Integration Dolly in Clean Room 100 at Astrium Ottobrunn

Figure 5-8: Cryostat tilted in Integration Dolly in Clean Room 100 at Astrium Ottobrunn

6 ISO MODIFICATIONS AND HERSCHEL EQM DESIGN

6.1 EQM configuration

Main modifications of the ISO QM to Herschel-EQM:

- Cryostat
  - Main tank (torus) used as He-I reservoir for ventline-cooling of the thermal shields only
  - New auxiliary tank (AXT) as He-II reservoir instead of the ISO auxiliary tank for ventline-cooling of payloads as well as for cooling of the instrument LO-interfaces
  - Internal harness/instrumentation electrically representative to PFM (as far as useful)
  - ISO Baffle dismounted
  - ISO OSS dismounted
  - ISO auxiliary tank dismounted
  - ISO ext. tubing dismounted except heater and safety valve (SV521, P501, P502, V506)
- Optical bench and instrument shield in Herschel FM design with HIFI-, PACS-, and SPIRE Focal Plane Units mounted on the optical bench and the HIFI LOU mounted on the outside of the CVV, all these instrument units with cryogenic qualification status (CQMs).

  EQM-Optical bench plane is mounted in warm conditions 6,5mm higher (towards +x) versus PFM to compensate thermal distortion and measured manufacturing tolerances of ISO-tank/spatial frame work after cooling down.
- Scientific Instrument cryo harness (SIH) flight representative
- CVV upper part representative to Herschel FM (including shields, and MLI)
- Additional intermediate connector ring for scientific instrument and cryo-control harness vacuum feedthroughs and provides the interface for the V512
- Additional He S/S components for new EQM design (e.g. rupture disc for auxiliary tank)
- Additional ventline for auxiliary tank
- He S/S internal tubing adapted to new EQM design including modified filling port, airlock and SV121
- Actively cooled FM representative cover to close the cryostat and to simulate orbital representative background conditions. During training phase the ECCP (EQM Cryo Cover Plate) will be used
- SVM platform dummy with support frame, equipped with warm units AVMs/CQMs. Arrangement of SVM instrument panels representative to PFM in position and size (external SIH and SVM SIH routing almost identical to PFM)

  SVM-dummy is mounted 180mm higher versus PFM-SVM to keep the same distance between SVM platform plane and the CVV-intermediate ring connector axis. This configuration allows the use of PFM representative harness.

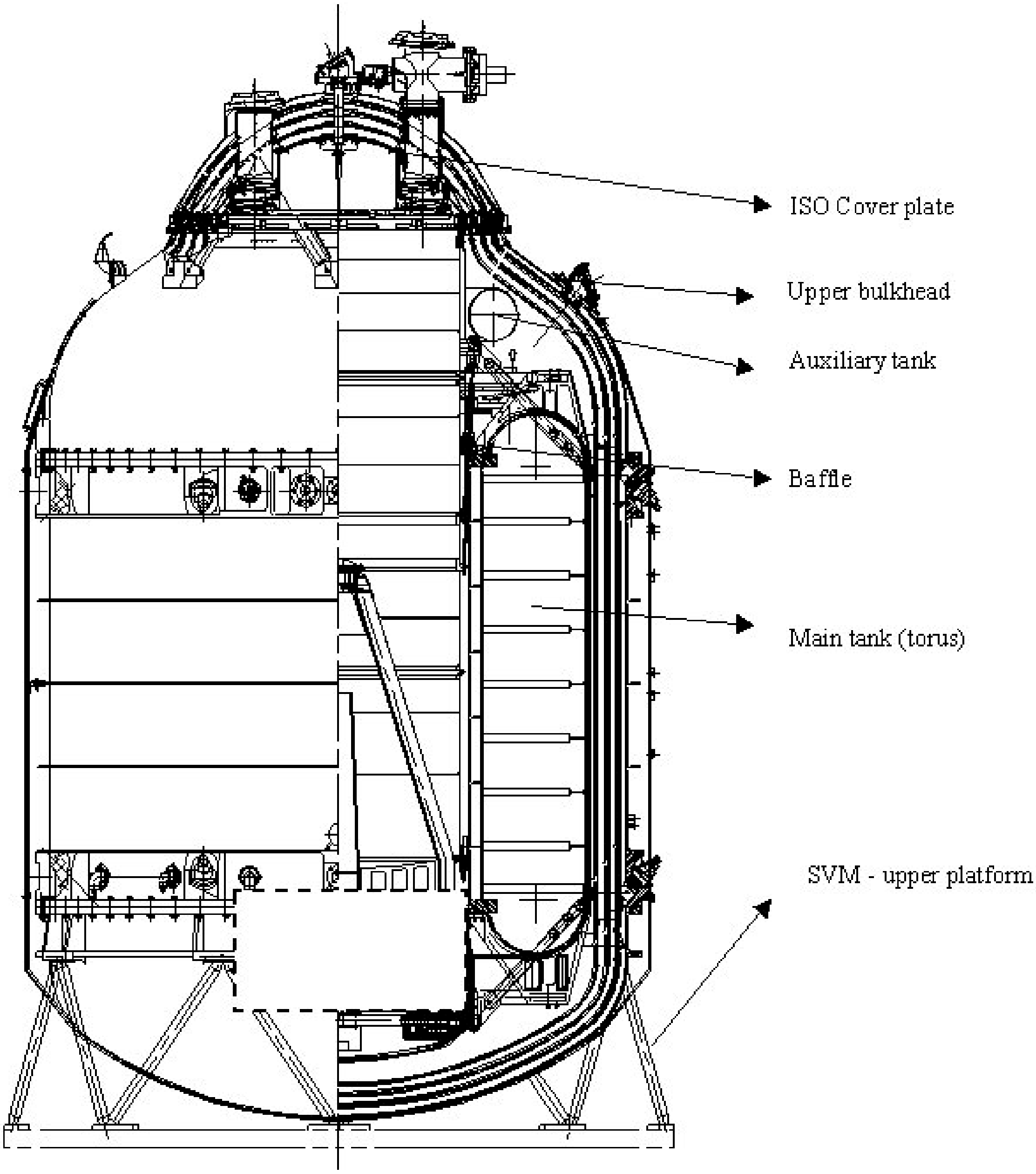


Figure 6-1: ISO-QM basic design

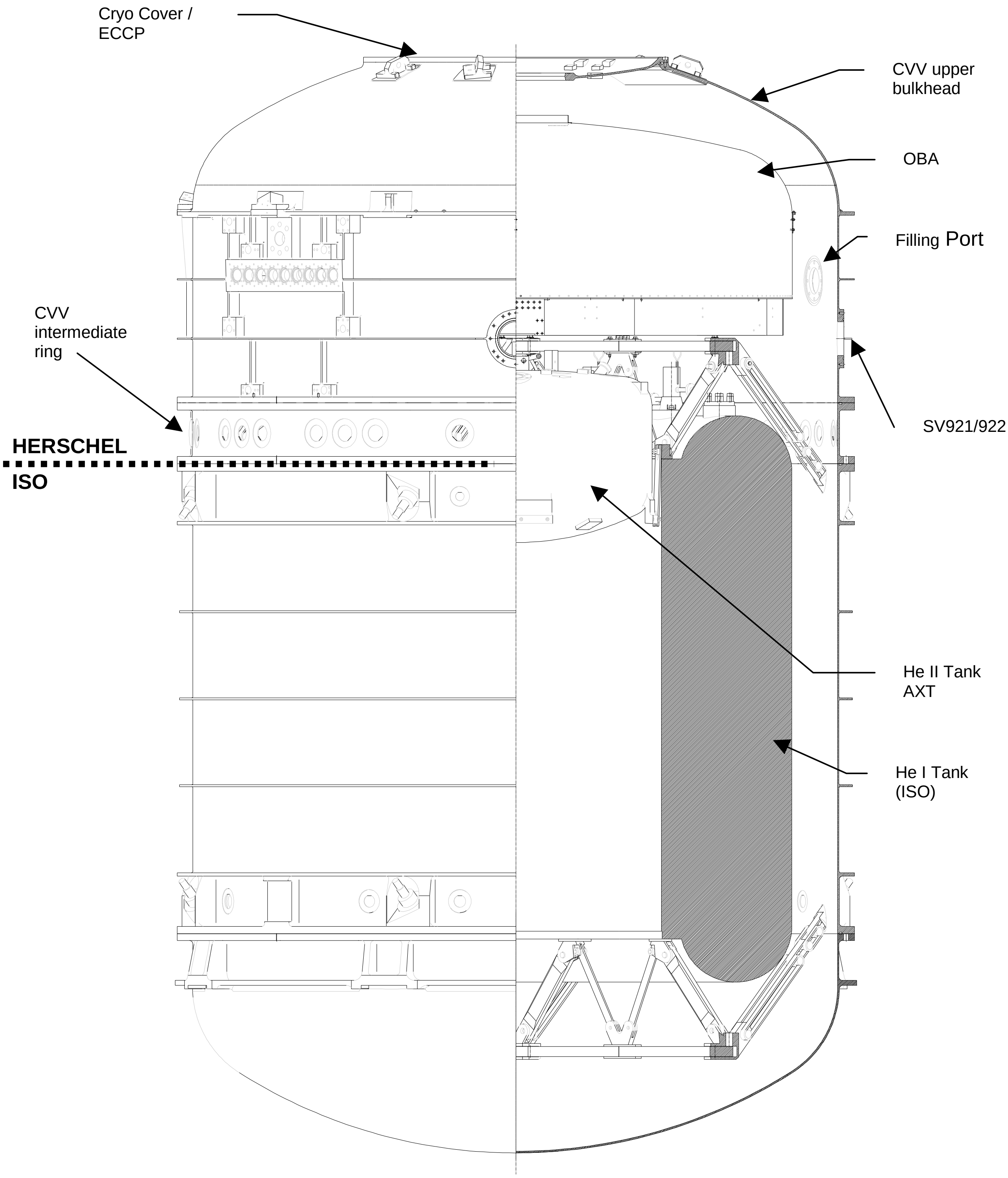


Figure 6-2: Modifications from ISO-QM to Herschel-EQM

6.2 Subsystems Description

6.2.1 Structure

The EQM structure consists of three main groups:

1. Those parts/components, which will be used unchanged from ISO QM.
2. Those parts/components, which will be used from ISO QM with some modifications.
3. Those parts/components, which shall be built for EQM application only, identical to or representative of PFM design, either to substitute the respective ISO QM components or to be built for specific EQM needs.

6.2.1.1 Unchanged parts/components

The following components will be used structurally unchanged from ISO QM:

- ISO QM lower structure with CVV Lower Bulkhead and Cylinder
- ISO QM Lower Thermal Shields and Cylindrical Shield Assembly incl. MLI
- ISO QM He-I Tank
- Lower and Upper Spatial Framework and Tank Suspension

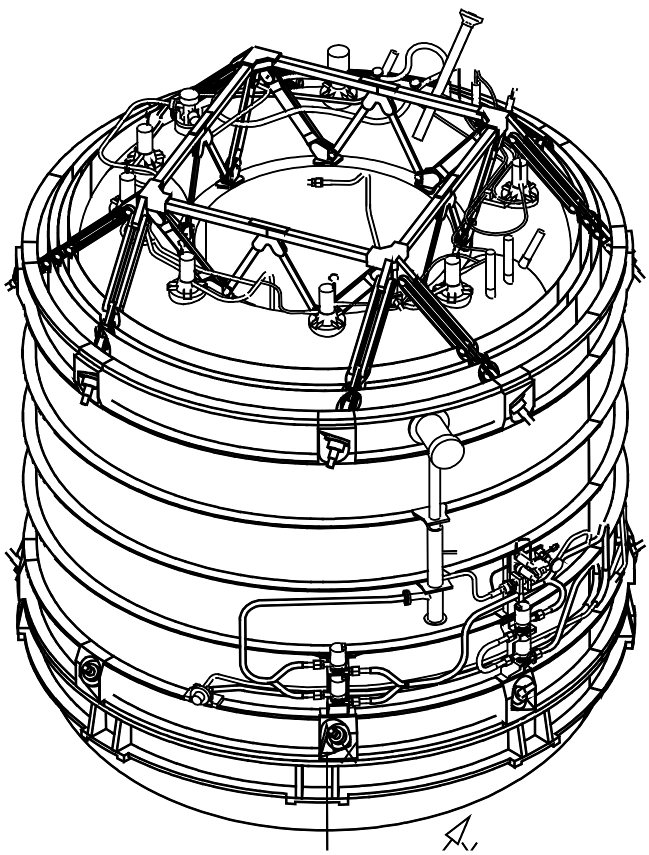


Figure 6-3: ISO QM lower structure

6.2.1.2 Modified parts/components

The internal He Tubing system is adapted to the EQM He flow schematics as shown in Figure 6-29.

The adaptation is focussed on re-routing the internal He - tubing system with some limited re-location of He-components mounted on the He-II Tank.

The filling port/airlock/SV121 assembly is adapted to the EQM upper bulkhead contour and orientation. Some limited improvements mainly with regard to the SV121 plug and its opening mechanism are implemented.

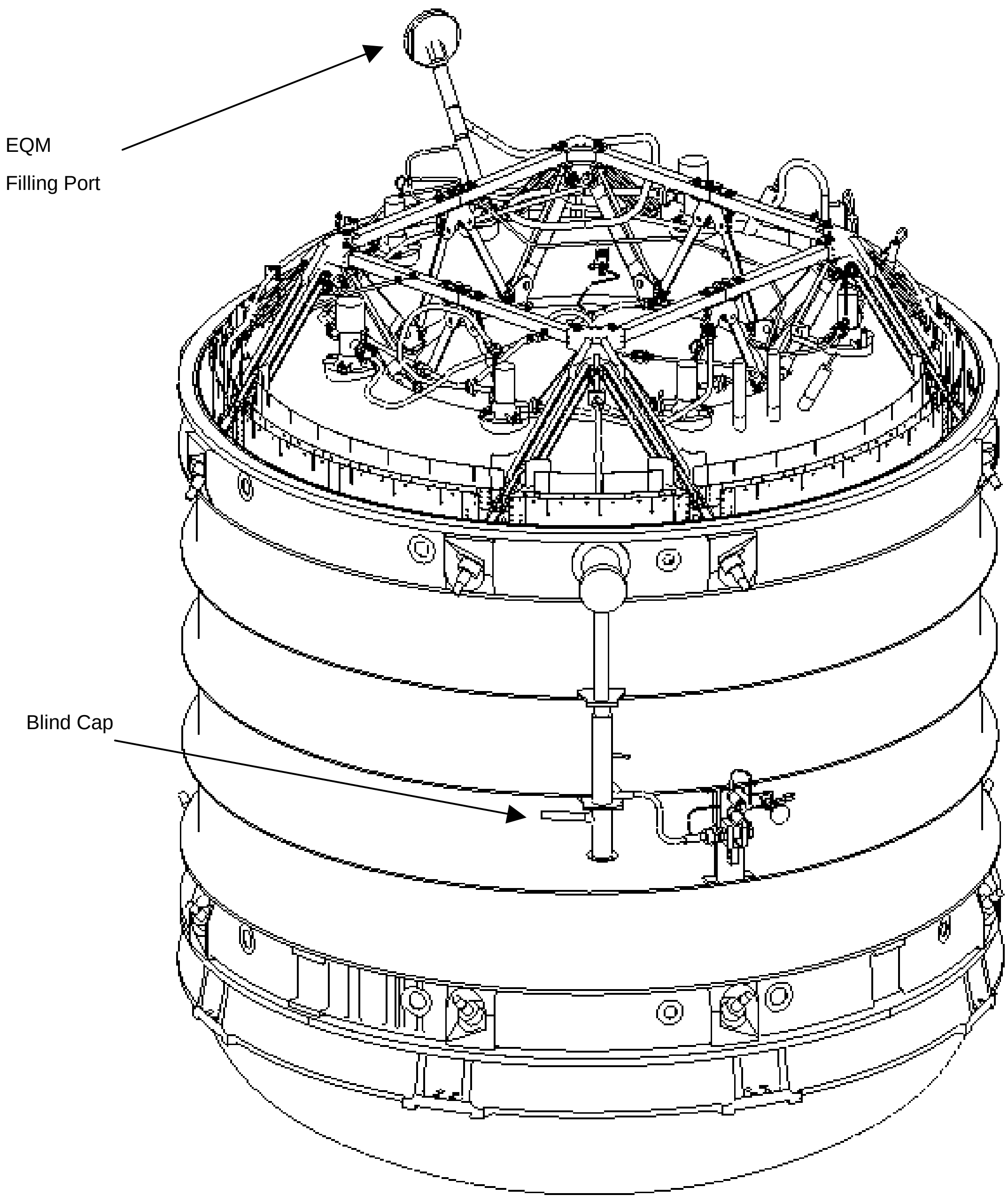


Figure 6-4: Modified / adapted ISO QM tubing

6.2.1.3 New parts/components

The following components will be designed for EQM needs:

- CVV intermediate connector ring
- CVV upper bulkhead
- CVV Cryo Cover and ECCP
- Upper thermal shields (IR & UB) incl. MLI
- OBA Fixation brackets
- Auxiliary Tank (AXT) incl. MLI
- HeI-tank MLI (internal-adaptation)
- SV723
- Filling Port
- LOU + Waveguides (only 2)
- SVM simulator structure
- EQM int. cryo control harness (CCH)

CVV Intermediate Connector Ring:

This component is part of the EQM CVV with following main mechanical interfaces:

- CVV cylinder - flange I/F with vacuum sealing (screw pattern used from ISO QM)
- CVV upper bulkhead - flange I/F with vacuum sealing similar to CVV cylinder
- 63 electrical feedthroughs with 100 pins each
- Interface to He ventline with V 512

This ring has been implemented mainly for the integration of the large number of electrical feedthroughs located in the level of the upper tank suspension on PFM side.

The intermediate ring is made of the same aluminium alloy as all EQM/PFM CVV parts and procured from the same supplier according to the procurement spec. (HP-2-ASED-PS-0002).

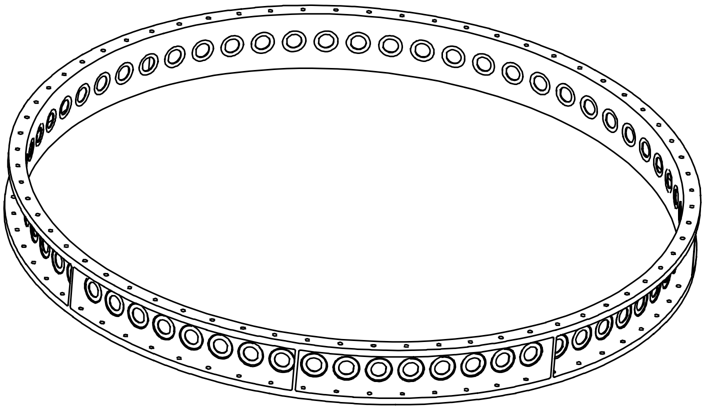


Figure 6-5: EQM CVV Intermediate Ring principle design

CVV Upper Bulkhead:

The overall dimension of the intermediate ring together with the upper bulkhead is representative to the overall dimension of the PFM upper bulkhead.

Following main mechanical interfaces are used for the EQM:

- CVV intermediate ring - flange I/F with vacuum sealing similar to CVV cylinder
- cover interface
- MGSE interface for handling/hoisting of UB and complete EQM PLM
- LOU interface with optical windows
- Filling port interface
- Pumping port interfaces (2 ports)

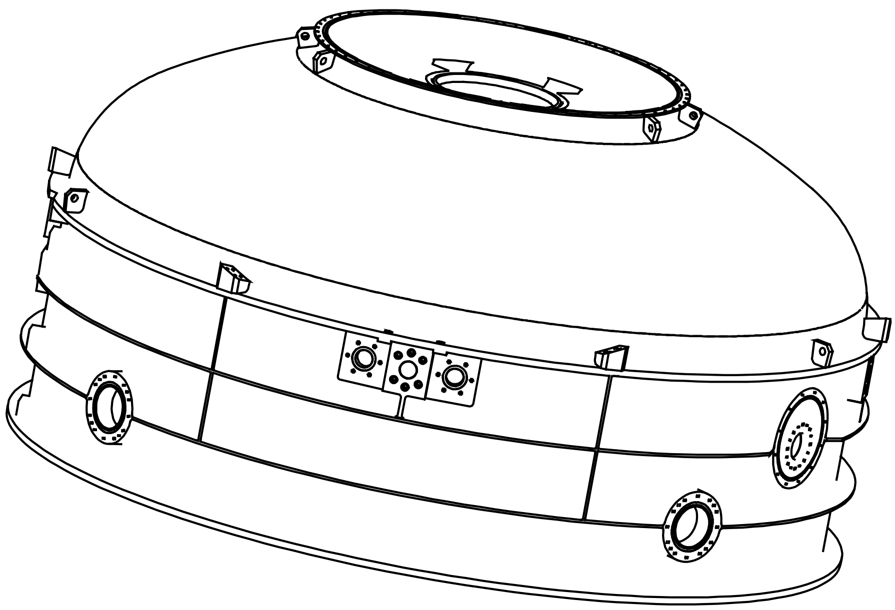


Figure 6-6: EQM CVV Upper Bulkhead

Upper Thermal Shields:

The upper shields are built representative to the upper thermal shields of the PFM. For assembly reasons, the shields needed to be split at the level of the intermediate connector ring. At this level a screwed interface is implemented similar to the screwed interface at the cylinder level.

Following main interfaces are taken into account:

- Cylindrical shields
- Filling port
- Pumping port (safety valves SV921/922)
- Beam Entrance baffle
- HIFI/LOU Optical windows and straylight baffles
- Additional ventline (V512)
- Temperature sensors

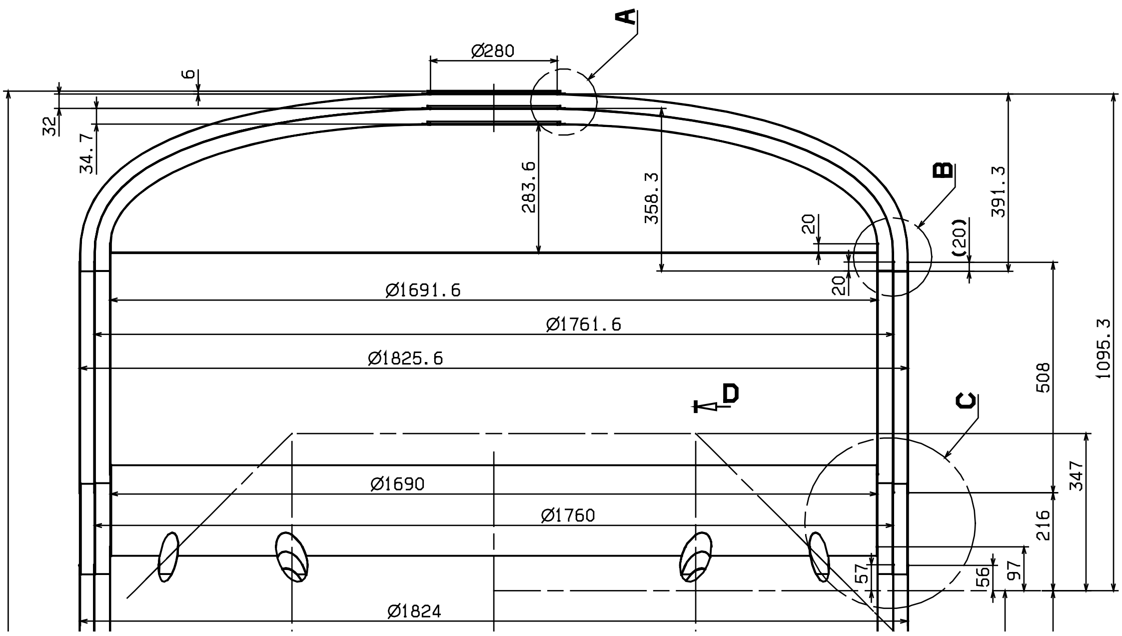


Figure 6-7: Upper Thermal Shields

Cryo-Cover

The EQM and PFM Cryostat Cover are identical. For the EQM no Cryostat Baffle is required. A detailed description is covered in the H-EPLM Design Description (RD 15). In the following a summary description is provided.

For the EQM training phase the ECCP (Figure 6-10) is used. A detailed description is covered in the ECCP - upper bulkhead test top plate leak test (HP-2-ASED-TR-0020).

The cryo cover consists of the cover itself with the corresponding seal to the CVV and the cover heat shields including PACS and SPIRE curved mirror surfaces equipped with a Helium/Liquid Nitrogen cooling loop, the hinges with associated bearings, the drive mechanism, the hold-down and release mechanism including actuator, temperature sensors and end switches and a pertinent harness with a connector bracket.

On the EQM the QM model of the cryo cover is used, that will later on become the flight spare after proper refurbishment.

A cover release and opening test is not foreseen during the EQM test campaign.

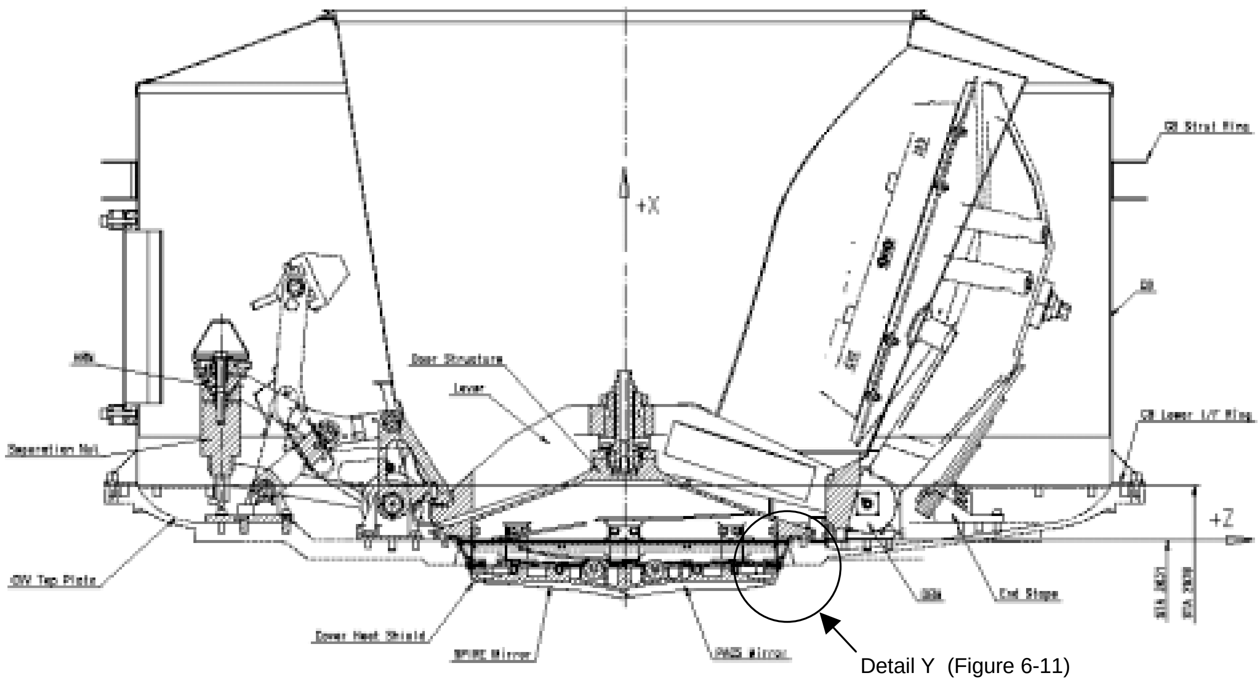


Figure 6-8: Cryo Cover in open and closed position

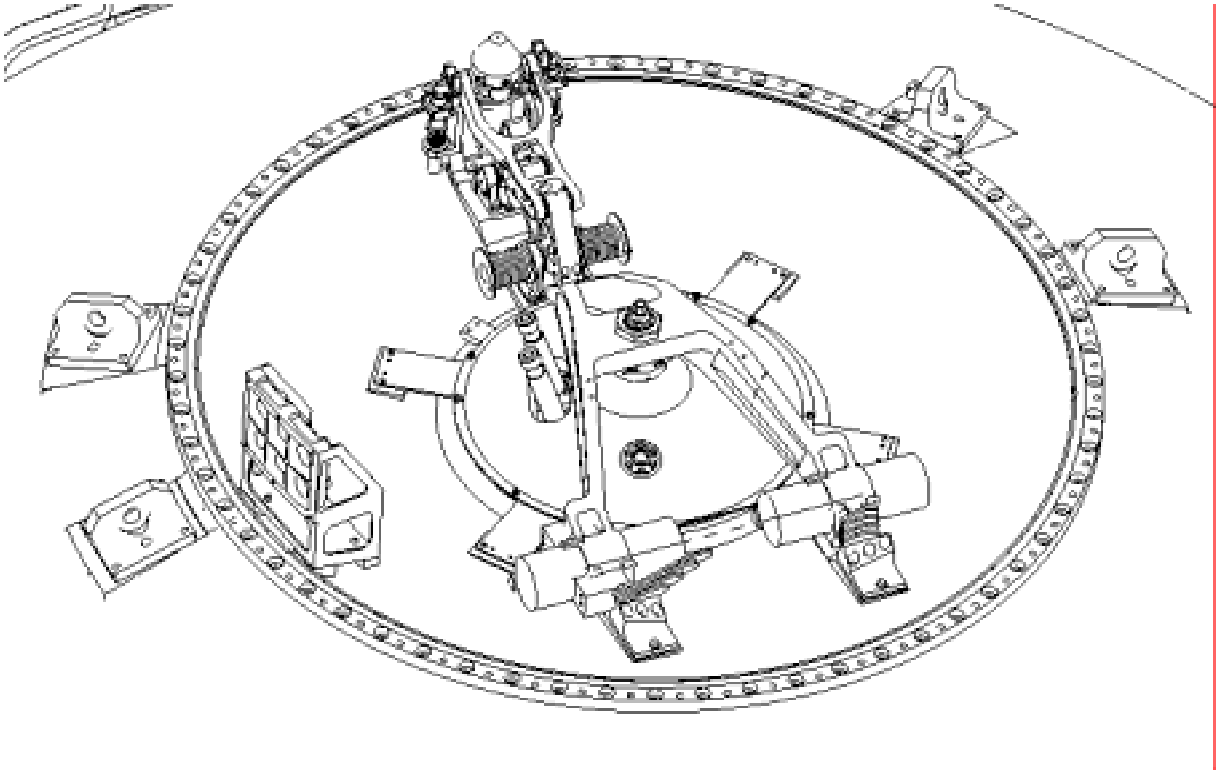


Figure 6-9: Cryo Cover top view

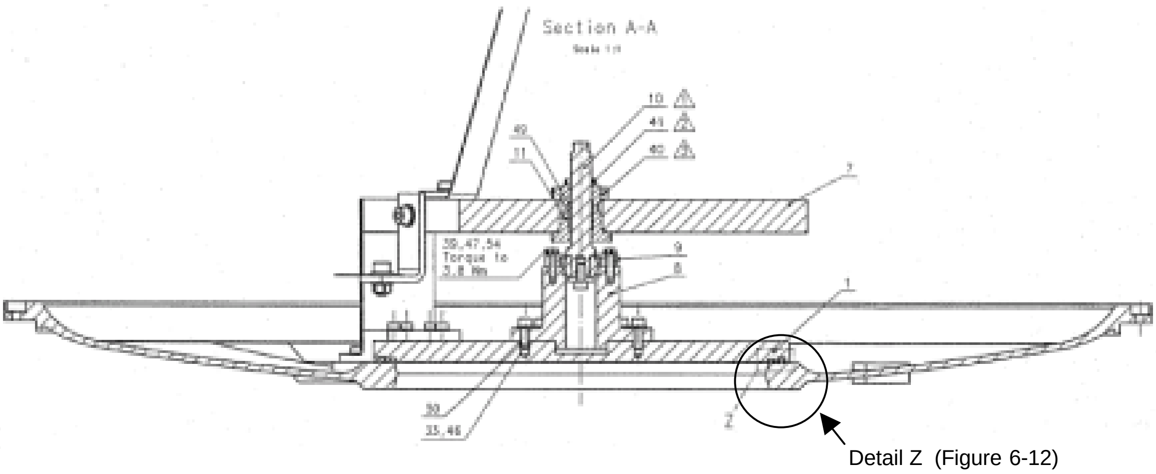


Figure 6-10: ECCP

Detail Y (acc. Figure 6-8) :

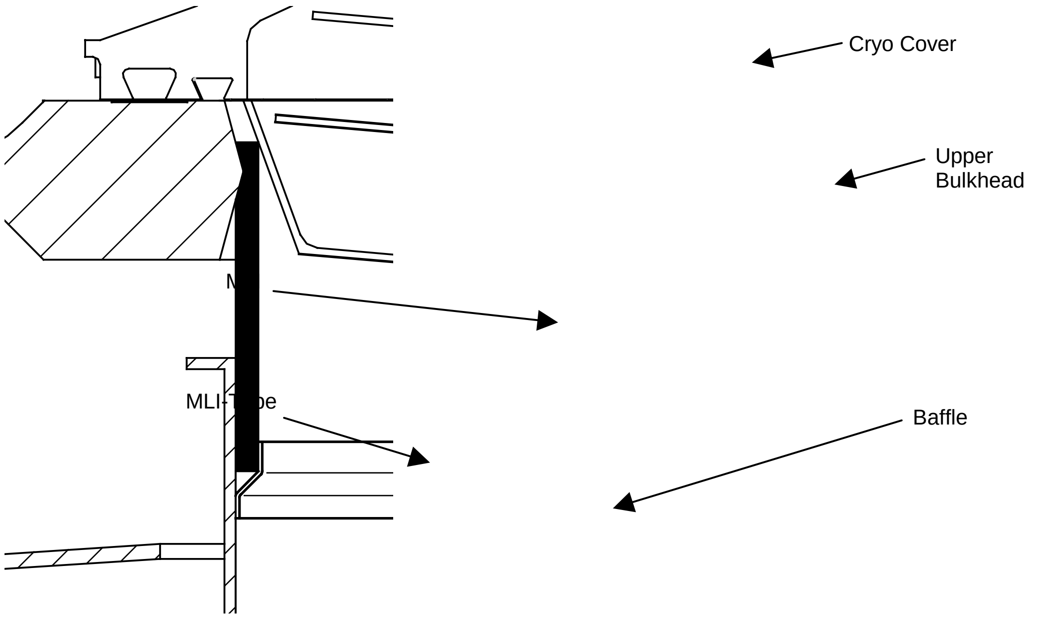


Figure 6-11: Upper Closure MLI between Cryo Cover and Therm. Shield Baffle (testing phase)

Detail Z (acc. Figure 6-8):

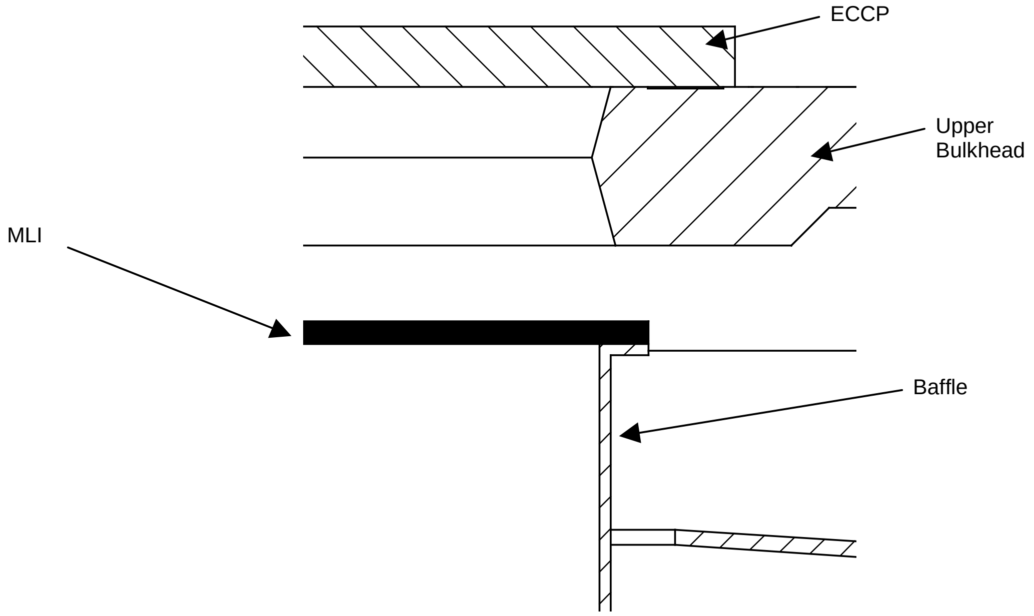


Figure 6-12: Upper Closure MLI between ECCP and Therm. Shield Baffle (training phase)

<u>Optical Bench Assembly (OBA)</u>

The EQM OBA is identical to the PFM OBA with the following exceptions:

- EQM does not provide L0 open pods
- The rigid pods are made of Cu
- Minor adaptations at the interface to auxiliary tank and the ISO-spatial frame work are necessary

A detailed description of the PFM OBA is provided in the H-EPLM Design Description (RD 15).

A summary is provided in the following:

The EQM OBA [CI 121140] is defined as the assembly which consists of the following items:

- Optical Bench Plate (OBP,) with mounting brackets to the Spatial Framework (SFW) [CI 121 141],
- Optical Bench Shield (OBS), including entrance and LOU baffles [CI 121142],
- Optical Bench Helium Cooling Loops, including mounting brackets (OBHCL) [CI 121143],
- Thermal Interface Links to Scientific Instruments (OBTL)
    - L0 thermal links EQM ‘L0TL’ [CI 151144-01]
    - L1 thermal links ‘L1TL’ [CI 121144-02]
    - L3 thermal links ‘L3TL’ [CI 121144-03]
    - MGSE Items: OBA MGSE [CI 121150]
        - Hoisting Device for OBA: [CI 121150-01]
        - Handling Structure [CI 121150-02]
        - Transport Container [CI 121150-03]
- Optical Bench Instrumentation interfaces
- Scientific Instrument and Cryostat Instrumentation Harness (SIH & CIH) interfaces

The following items must be considered, which will be integrated by the Customer:

- Scientific Instrument Harness (SIH), Cryostat Instrumentation Harness (CIH)
- Instrumentation on the OBA, e.g. Temperature Sensors, Accelerometers etc.

The basic function of the Optical Bench Assembly (OBA) is to provide through the Optical Bench Plate (OBP) itself a solid and alignment stable support of the Scientific Instruments (PACS, HIFI, SPIRE FPU, SPIRE-JFETs) within the Herschel cryogenic environment.

The OBP shall be a light aluminium plate, which is supported at four I/F points and provides I/F for the instruments and associated parts of instrument harness as well as for Optical Bench Instrumentation (OBI).

The following thermal I/F links (OBTL) shall be foreseen:

- Level 0 EQM Auxiliary Tank (EQM)

- Level 1 FPU's to OBHCL1 (OBHCL1 thermally isolated from OBP, is defined from PACS level 1 attachment area to HIFI level 1 attachment area)

  OBHCL1 and OBHCL2 thermally isolated by special segment

  OBHCL2 to OBP (OBHCL2 thermally well connected to OBP, is defined from first to the last thermal attachment point to the OBP)
- Level 2 OBP temperature
- Level 3 JFET's to OBHCL 3

The Thermal Links and the Cooling Loop belongs to the Helium Subsystem. A detailed description is given in the H-PLM Helium Subsystem Description (RD 16).

The EQM model is delivered with a minimum test sequence: leak test at ambient, dimensional checking, alignment at ambient. An optional refurbishment of EQM-OBP to FS is foreseen.

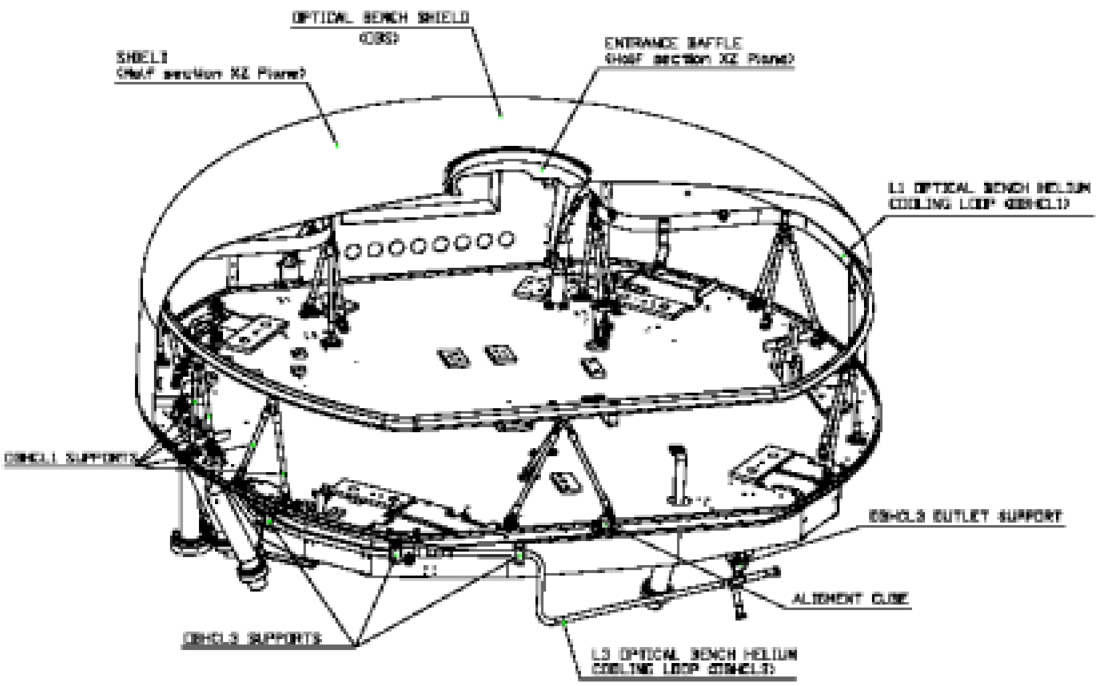


Figure 6-13: OBA Main Assembly

OPTICAL BENCH PLATE

The Optical Bench Plate (OBP) is the sub-assembly that provides the interfaces for the Scientific Instruments Focal Plane Units (FPU's), OBS, OBHCL, Optical Bench Instrumentation (OBI) and for the Scientific Instrument and Cryostat Instrumentation Harness (SIH & CIH). It provides also the attachment points of the OBA to the Spatial Framework through four flexible brackets. Additionally it includes devices to guarantee light tightness of the volume enveloped by the OBS and the OBP itself.

The Optical Bench Plate consists of the following main parts:

- Base Plate

Blade Brackets (BB) 3 mm shortened due to additional shear plate for EQM acc.

- Figure 6-15
- OBHCL Supports
- Light Tightness Devices (LTD)
- Alignment Cube

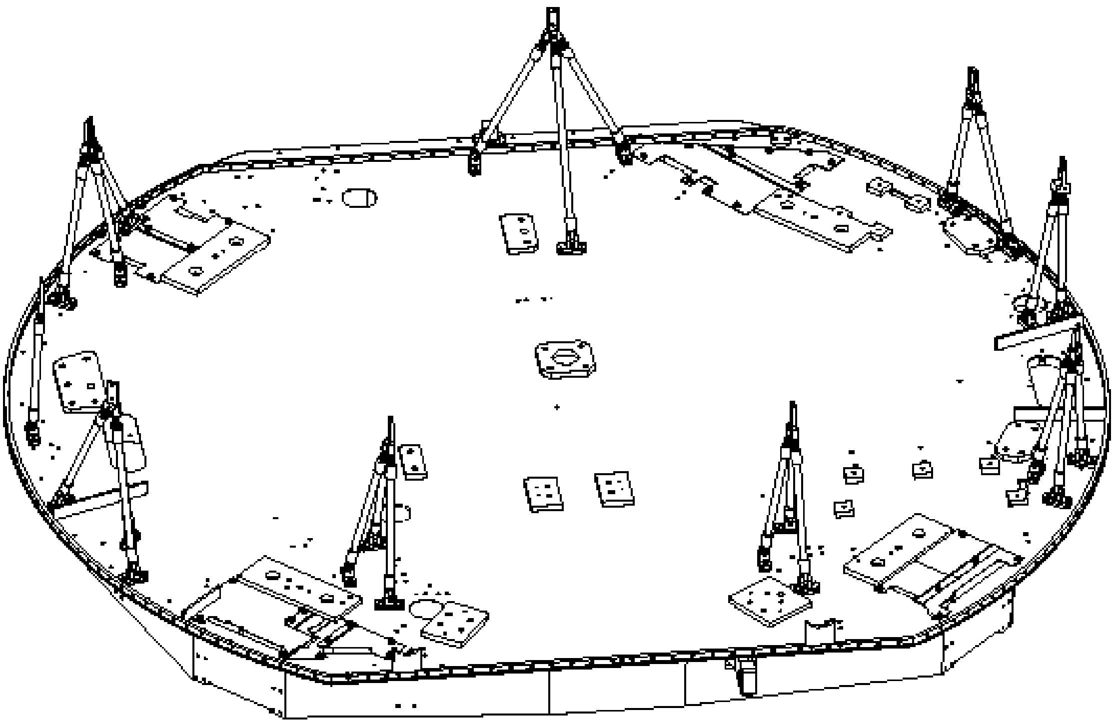


Figure 6-14: OBA Overview of the Optical Bench Plate sub-assembly, front side

Base Plate:

The Base Plate is the component that properly provides the interfaces for the FPU's, OBS, OBHCL supports, Blade Brackets, OBI, SIH & CIH and alignment cube.

The Base Plate is a structural plate of Ø1634mm with two flat edges at a distance of 1422mm and a total thickness of 131mm. The upper surface is a thin plate (between 1.5mm and 3.5mm thickness) reinforced by a web of ribs (height 110mm typical and 56mm for some ribs, with thickness between 2 and 13.5mm) to provide the required stiffness and strength for supporting the FPU's. Four small ribs have been provided on the upper face of the plate to stiffen the outermost side the plate.

The plate will be manufactured from a single AA5083-0 plate that will be milled to obtain the final shape.

Blade Brackets

The Base Plate is attached to the ISO Spatial Framework (SFW) by means of four brackets called Blade Brackets (BB) due to their shape as shown in Figure 6-15.

Following alignment calculation is taken into consideration:

EQM		Deviation	PFM	
EQM-ISO SFW upper plane in +X	1849,5		PFM SFW upper plane	1841,0
Basis distance between EQM und PFM (Design)		+8,5		
Reduced distance between EQM und PFM by not using of Shimming plates (2mm) between Blade Brackets and SFW	-2			
EQM-OBA LOU Axis (warm)	2040,7	**+6,5**	PFM - OBA LOU axis	2034.2

Table 6-1: Alignment at warm condition

EQM		Remaining Deviation	PFM	
Calculated thermal distortion between inside (tank / OBA / SFW) and outside (CVV)	-3,2			
Correction of 0,8mm derived from the actual measured dimension of ISO He II tank and SFW hardware	-0,8			
EQM-OBA LOU Axis	2036,7	**+1,5**	EQM/PFM - CVV Upper Bulkhead LOU Axis	2035.2

Table 6-2: Alignment at cold condition

The remaining distance of 1,5mm between EQM OBA windows axis and the CVV upper bulkhead windows resp. LOU axis is within the allowable tolerance.

The main design driver for these brackets is to allow thermal differential distortions between the OBA and the SFW in the radial direction, and to constraint relative motion. This is achieved by brackets that are flexible in one transversal direction while stiff in the other. They are installed every 90° with the flexible direction in the radial direction.

Optical Bench (OB) - Fixation:

In the PFM model the aluminium based Herschel Optical Bench will be mounted on a spatial framework made also from aluminium alloy. This is different to the ISO QM spatial framework, hence the H-EQM, that uses a CFC main frame and titanium corner brackets. The fixation of the flight representative OB on the EQM (ISO QM) spatial framework therefore has been designed for thermal displacements in the range of 2,5mm from the x-axis down to operating temperature.

The realised fixation concept is based on the design of the PFM with four blades and a screwed interface on OB side, but a clamp interface made of titanium to compensate thermal distortion on spatial framework side.

The design principle (w/o OBA) is shown in the following figure:

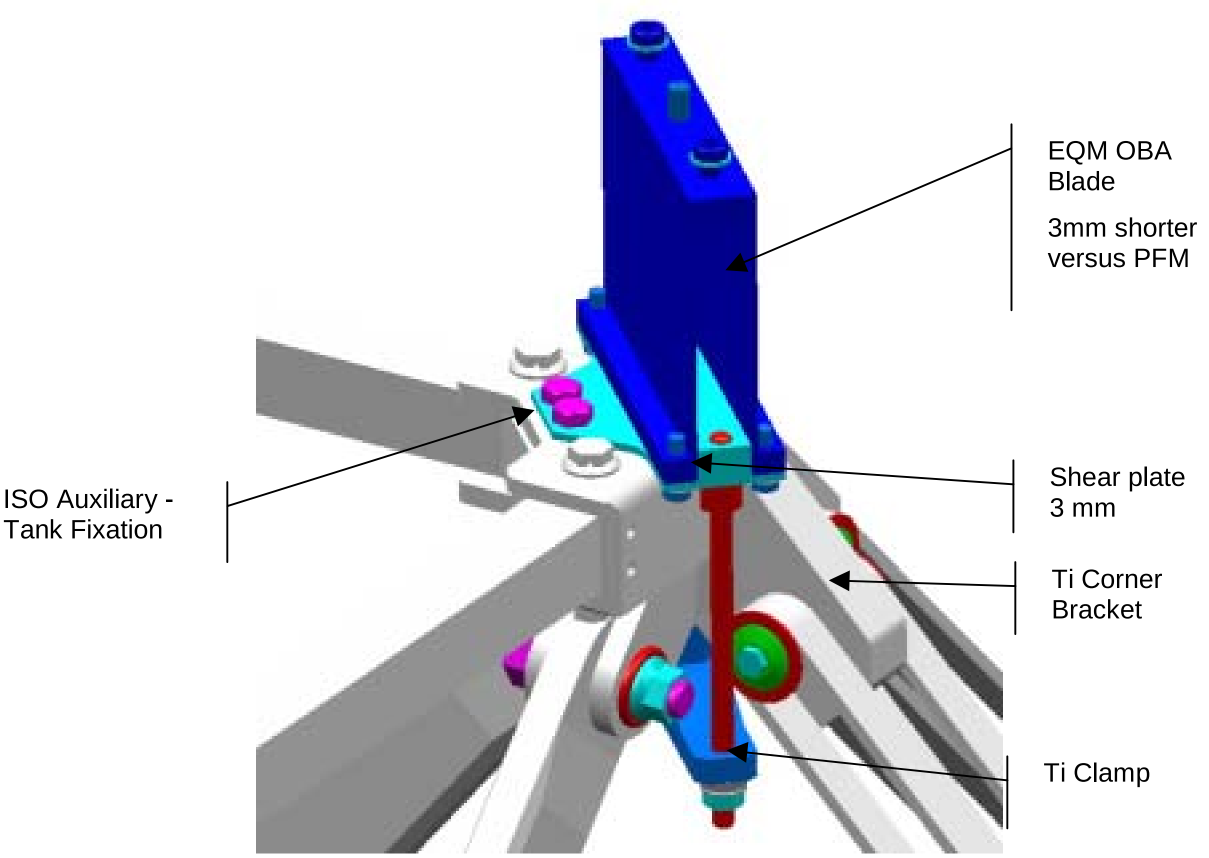


Figure 6-15: OBA fixation brackets for EQM

OBHCL Supports

The OBHCL1 is the segment of the tube above and around the OBP starting from PACS level 1 attachment area to HIFI level 1 attachment area. It is located in a plane 253 mm above OB I/F plane.

The supporting structure of the OBHCL1 attaches the finned pipe to the OBP and it maintains thermal insulation between both components. From a mechanical point of view, OBHCL1 supports must guarantee enough stiffness to survive OBA vibration levels, and flexibility enough to absorb thermal distortions between OBP and OBHCL1.

The OBHCL1 supporting structure is based on struts forming tripods, bipods and monopods. There are 9 supports with a total of 23 struts. The tripods are fixed structures that immobilize the attached point of the OBHCL1. The bipods allow the displacement of the attached point in one direction. The monopod only constrains vertical displacement of the tube. The overall arrangement has been optimised to reduce the number of struts and their cross area..

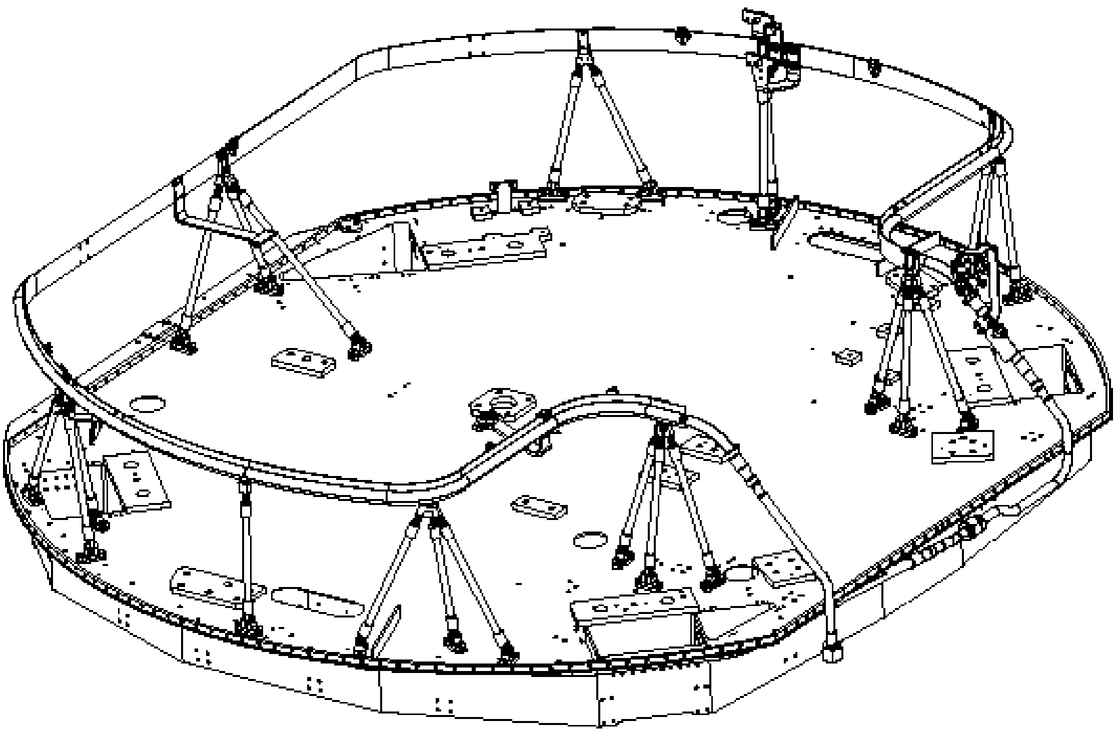


Figure 6-16: OBHCL1 Supports configuration (view from -Y +Z)

EQM L0 Links

The LO thermal links are composed by copper rigid pods bolted onto pure aluminium pods which are welded at the upper bottom of the auxiliary tank, and at the upper part with flexible thermal links connected to the instruments as shown in Figure 6-17, Figure 6-18 and Figure 6-20.

According to CEA tests results a thermal computation has been performed. The table below gives the thermal conductance foreseen for each EQM L0 thermal link:

Instruments	EQM tank contact	External Pod	I/F contact	Ext Pod / Flexible link contact	Flexible link	Flexible link / FPU contact	Total	Spec	Margin %
Pacs Blue Detector	5.92	3.1	1.7	3.3	0.068	1.66	0.060	0.007	+755
Pacs Red Detector	5.92	3.1	1.7	3.3	0.188	1.66	0.137	0.016	+754
Pacs Cooler Pump	5.92	7.4	1.7	3.3	0.154	3.33	0.125	0.06	+108
Pacs Cooler Evaporator	5.92	2.0	1.7	3.3	0.158	3.33	0.122	0.1 *)	+22.1
Spire SM Detector Enclosure	5.92	2.0	1.7			2.37	0.59	0.1 *)	+495
Spire Cooler Pump HS	5.92	1.9	1.7			2.37	0.55	0.06	+823
Spire Cooler Evaporator	5.92	2.4	1.7			2.37	0.59	0.3 *)	+98.5
HIFI L0 Detector Enclosure	5.92	2.1	1.7	3.3	0.088	3.33	0.079	0.023	+244

*) Design goal.

Table 6-3: EQM L0 links thermal performance

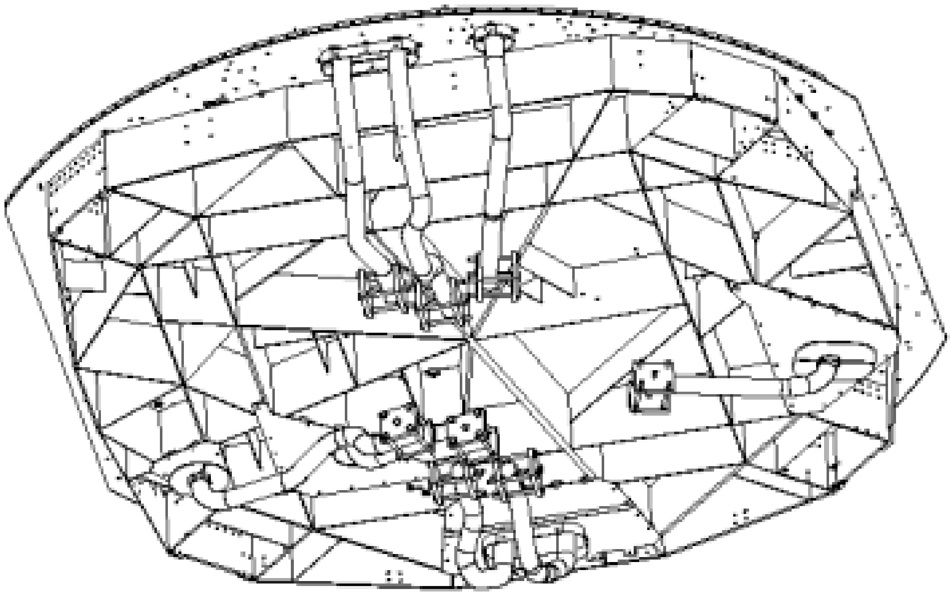


Figure 6-17: EQM L0 links (Light Tightness Device not used for EQM)

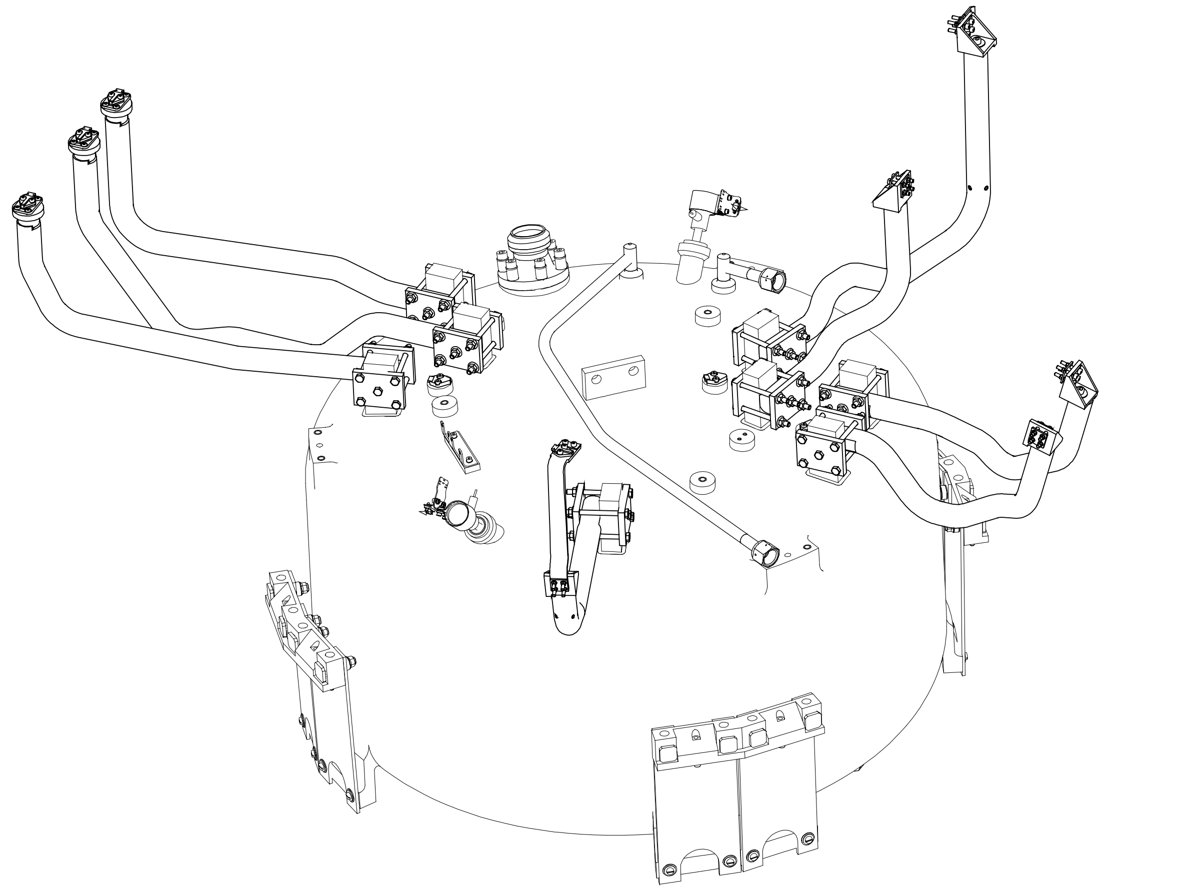


Figure 6-18: EQM L0 links on AXT and fixation of AXT

OPTICAL BENCH SHIELD

The Optical Bench Shield is the sub-assembly that covers the FPU's, and protects them form stray light together with the OBP and light tightness devices. The Optical Bench Shield consists of the following main parts:

- Shield
- HIFI Cover
- Entrance Baffle
- LOU Baffle

The Shield is manufactured from different plates welded together. Two different Aluminium Alloys have been used due to manufacturing reasons. The dome-shaped plate is made of Aluminium Alloy (AA) 1100-0 1mm thick. The rest of the plates are made of AA 6061-T6 1.2mm thick. Unused openings are closed with tapes.

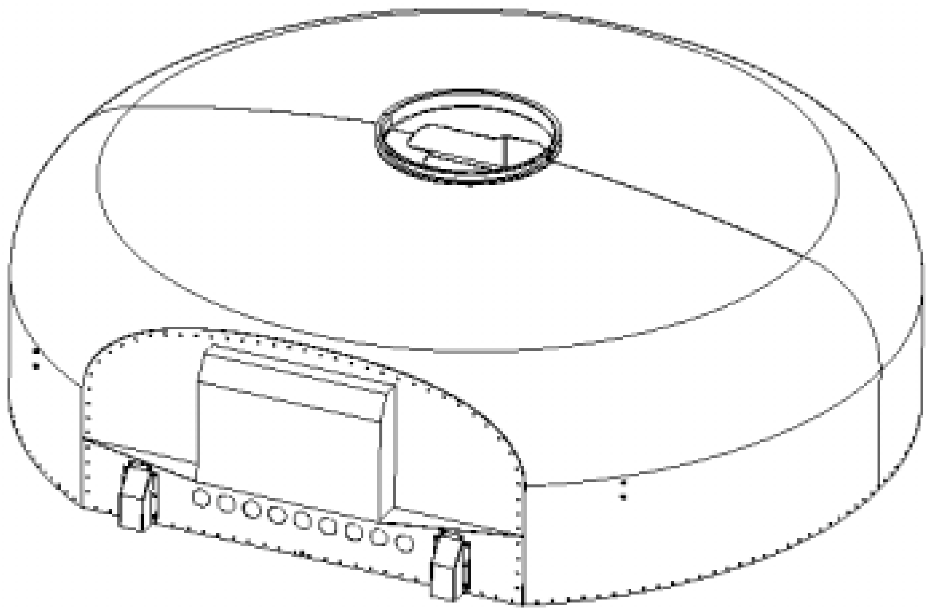


Figure 6-19: OBS (top view)

Auxiliary Tank (AXT)

The AXT is a major part of the Herschel-EQM and serves as the reservoir for the liquid helium (He-II) foreseen to provide the cooling power for the actively cooled components on the optical bench.

The AXT design is given in Figure 6-18 and the figure below:

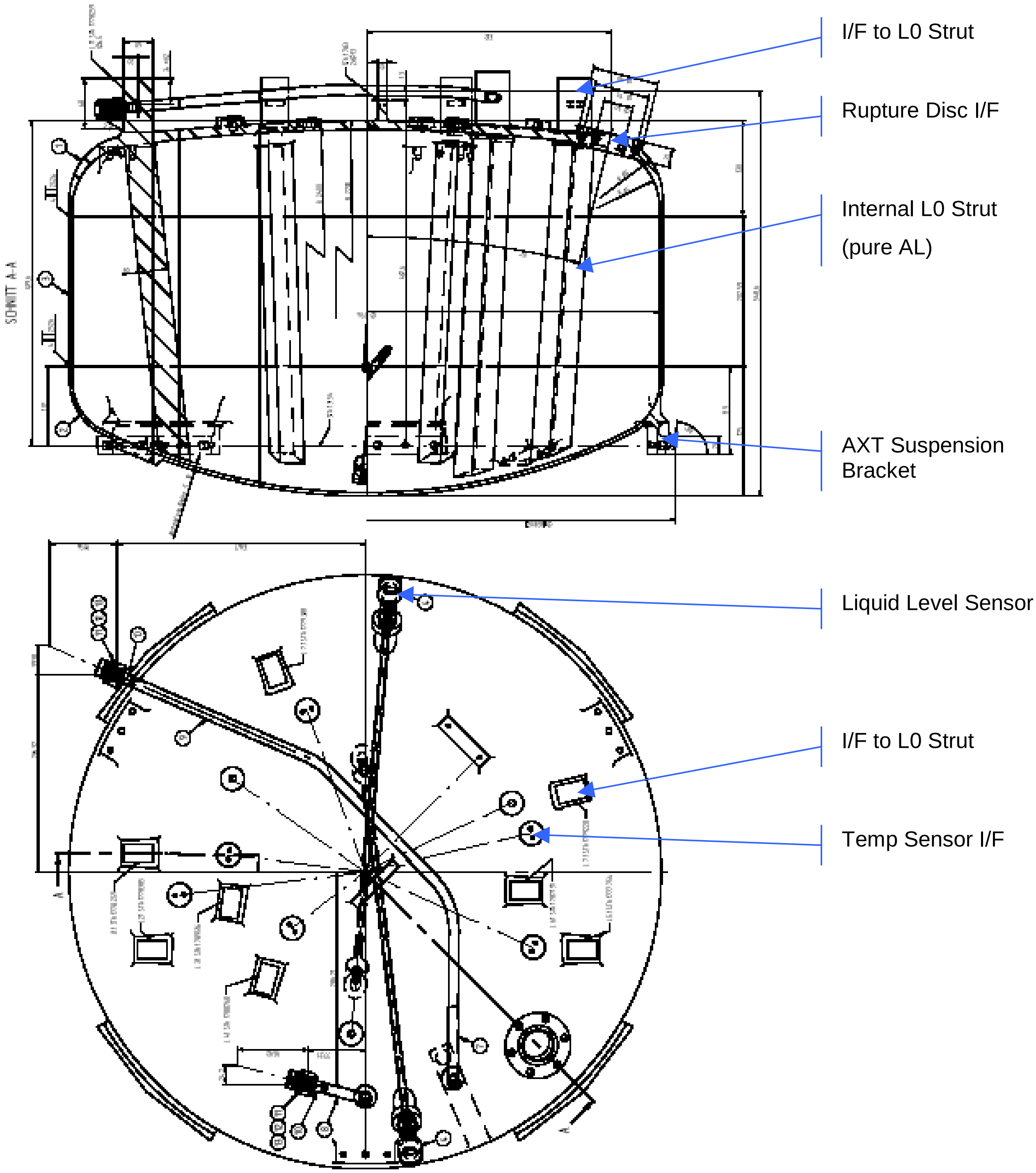


Figure 6-20: AXT design

The AXT provides a screwed interface to the L0 struts. To optimize the thermal flux from He-II to the L0 Struts pure (AL5N) aluminium struts are welded inside the tank. They almost reach to the bottom of the tank thus ensuring contact to liquid helium under gravity with even nearly empty tank.

Heaters and temperature sensors are located at several appropriate positions on the tank surface.

The AXT is attached to the Upper Flange of the ISO Main Tank using modified (shortened) CFC support blades which were formerly used to support the ISO Main Baffle. The objective of these supporting blades is two fold:

- mechanical fixation of the AXT to the Upper Flange of the Main Tank
- Thermal isolation from the Main Tank as far as the cross sections of the supports blades allow

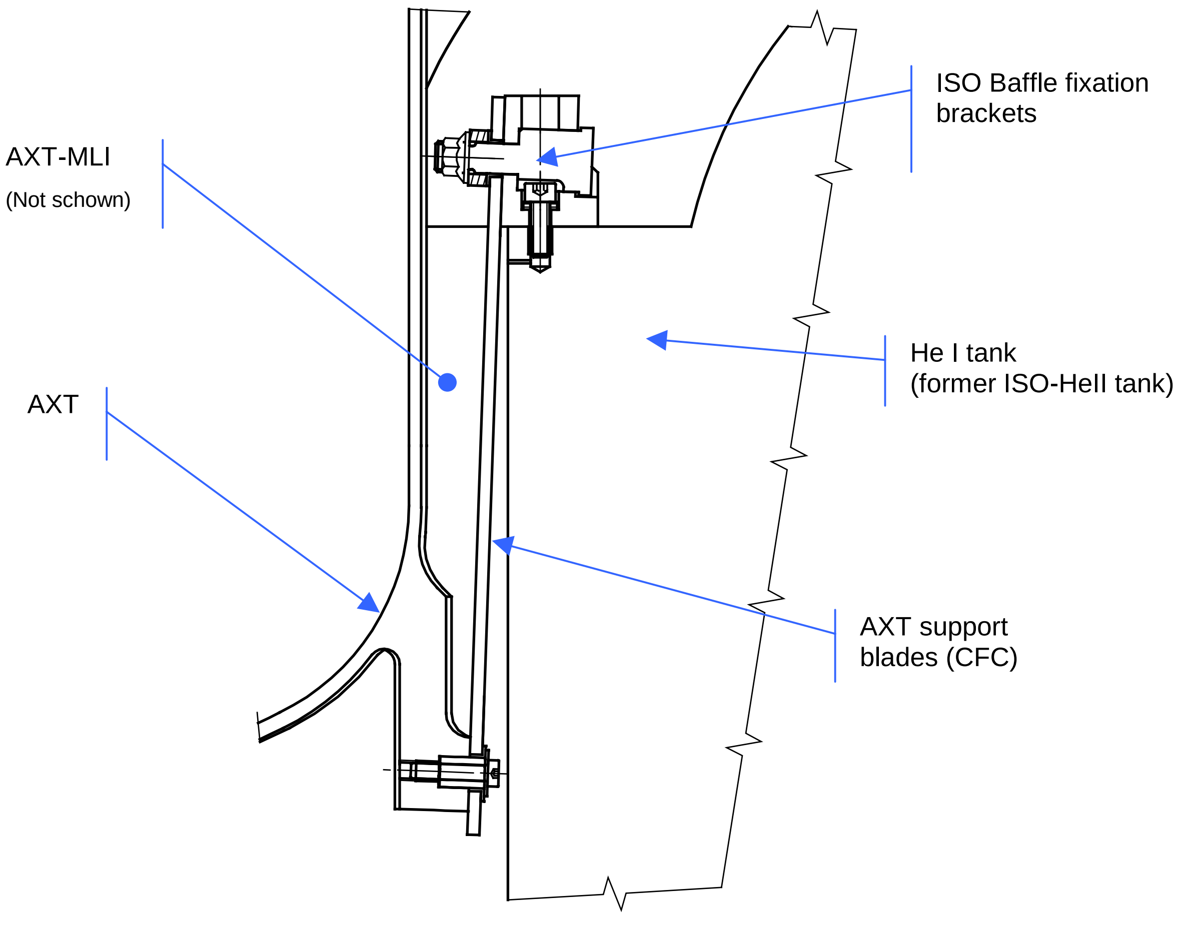


Figure 6-21: AXT fixation

6.2.2 SVM Simulator for Warm Units

6.2.2.1 Conceptual description

The SVM simulator is a structure to support the instrument CQM/AVM warm units (WU) during the EQM test program. The SVM simulator is a non flight item. A major step in the EQM test program is a radiated EMC test with the EQM PLM (with the SVM simulator attached to it). To allow representative EMC predictions for the PFM, certain conformities (EMC aspects) between the EQM SVM simulator and the PFM/SVM are requested. Basic conformities are as follows:

- SVM simulator position in PLM X-direction close to PFM
- equal or better electromagnetic shielding integrity
- routing (and fixation) of the external scientific instrument harness (SIH)
- configuration and routing of the EQM waveguides
- as far as possible placement of the warm units within the SVM simulator
- intersection electrical bonding as far as possible identical

Stability of the structure allows tilting of the EQM together with the SVM dummy and WUs during tests. Relative shift of the coordinate system between SVM and PLM of 60 mm in +Z direction is regarded.

Dismounting of the WU boxes during testing is principally possible, even if the EQM is mounted in the test dolly.

Limited mobility of the equipped SVM simulator (without the CVV attached to it) is ensured.

6.2.2.2 Design description

The SVM simulator is a roughly octagonal structure and consists of the following major parts:

- robust struts at the CVV interface points providing the backbone of the simulator which is aible to support the complete EQM-PLM
- I/F clamps to mount the SVM simulator to the PLM
- 4 lateral (external) panels to accommodate the WUs and their associated harness identical as the PFM-SVM

Panel 1	-Y panel	HIFI 1
Panel 2	-Y / -Z panel	HIFI 2
Panel 3	-Z panel	SPIRE
Panel 4	+Y / -Z panel	PACS

Table 6-4: Accommodation within the SVM-Simulator

- segmented (easiness for integration and accessibility to SVM equipment) upper closure panel to provide support for the harness and harness connector brackets

- Closed structure by using of side, inside and bottom plates or aluminium foil's considering EMC requirements

SVM simulator technical details and dimensions are shown in the drawings on the next pages.

6.2.2.3 SVM simulator equipment

The following WUs are foreseen to be mounted to the SVM dummy structure:

Instrument	Warm Unit	Appr. Size	Appr. Mass
HIFI 1 (panel 1)	LSU	424*286*265	19,0 kg
	LCU (AVM)	340*290*260	15,8 kg
	HRH (AVM)	390*355*102	12,9 kg
	IFH	107*70*107	1,0 kg
	WOH	400*170*130	6,0 kg
	WEH (AVM)	290*240*176	7,2 kg
HIFI 2 (panel 2)	ICU	274*258*194	8,0 kg
	FCU	326*289*180	8,9 kg
SPIRE (panel 3)	DPU	274*258*194	7,2 kg
	FCU (QM1)	332*300*315	16,3 kg (tbc)
	DCU (QM1)	491*300*315	14,4 kg (tbc)
PACS (panel 4)	DECMEC (AVM)	400*270*120	23,0 kg (tbc)
	DPU	240*258*194	6,6 kg
	SPU (AVM)	280*240*350	7,0 kg (tbc)
	BOLC (QM1)	328*300*314	15,3 kg (tbc)
	Power Supply Unit (2x)	TBD	TBD

Table 6-5: Warm Units

Two of the instruments (FCU and DCU) require positioning of external power supply in the vicinity of the warm units.

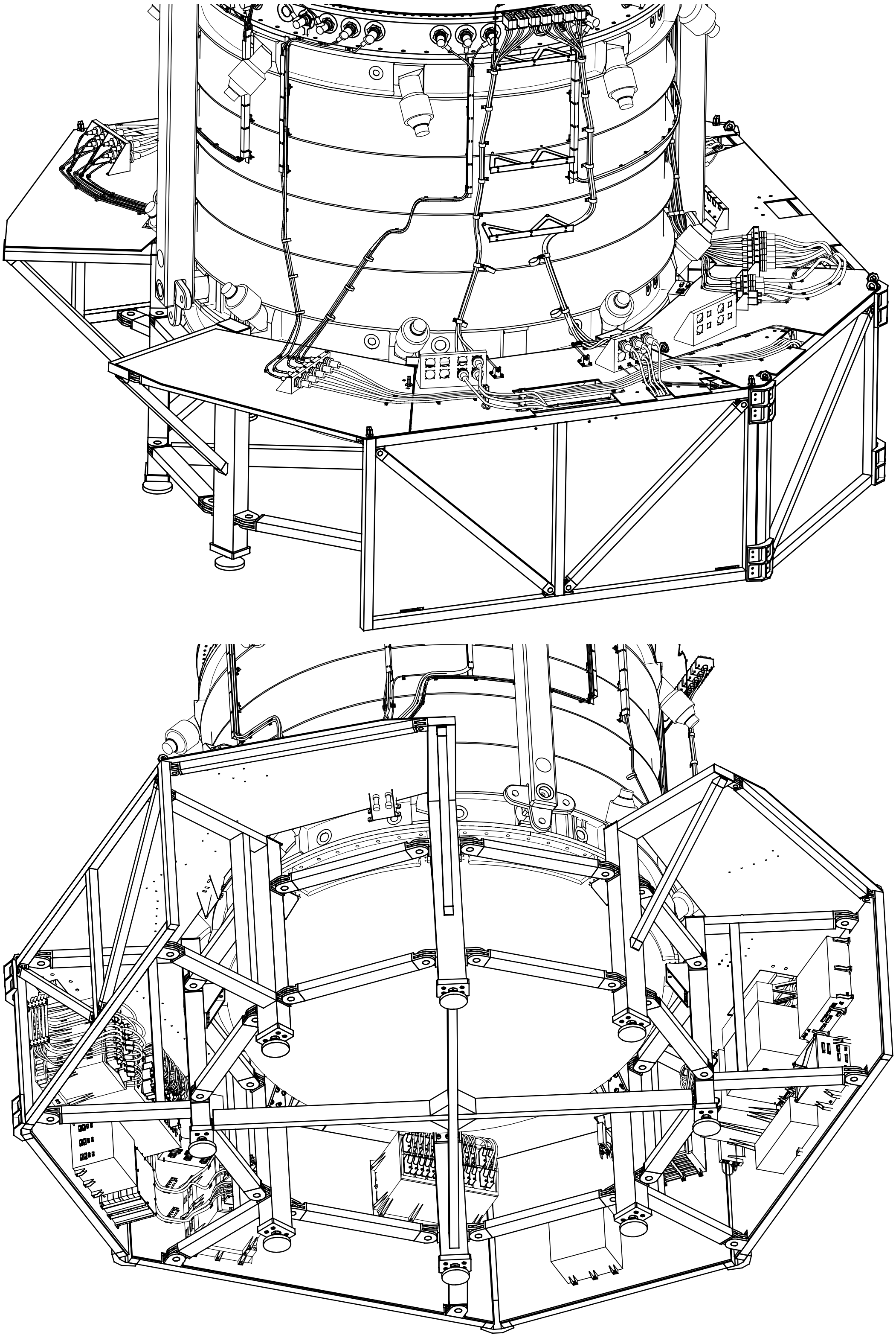


Figure 6-22: 3D view of SVM simulator with PLM/EQM (bottom and side/inside plates not shown)

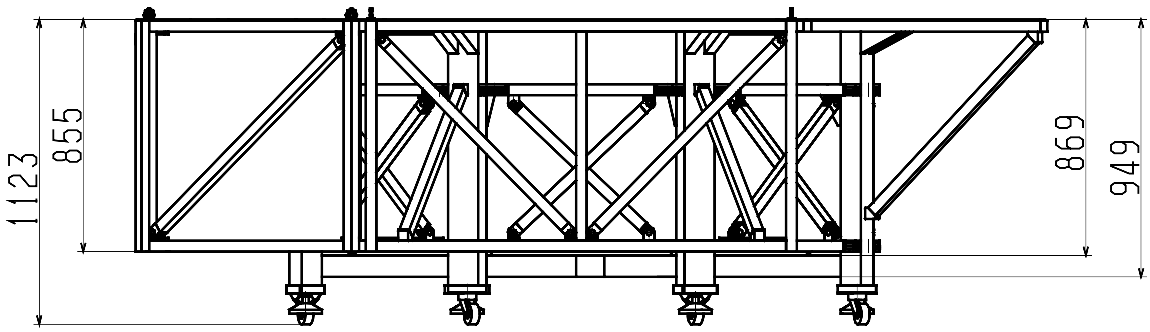


Figure 6-23: Side view SVM simulator with its basic dimensions (side/inside plates not shown)

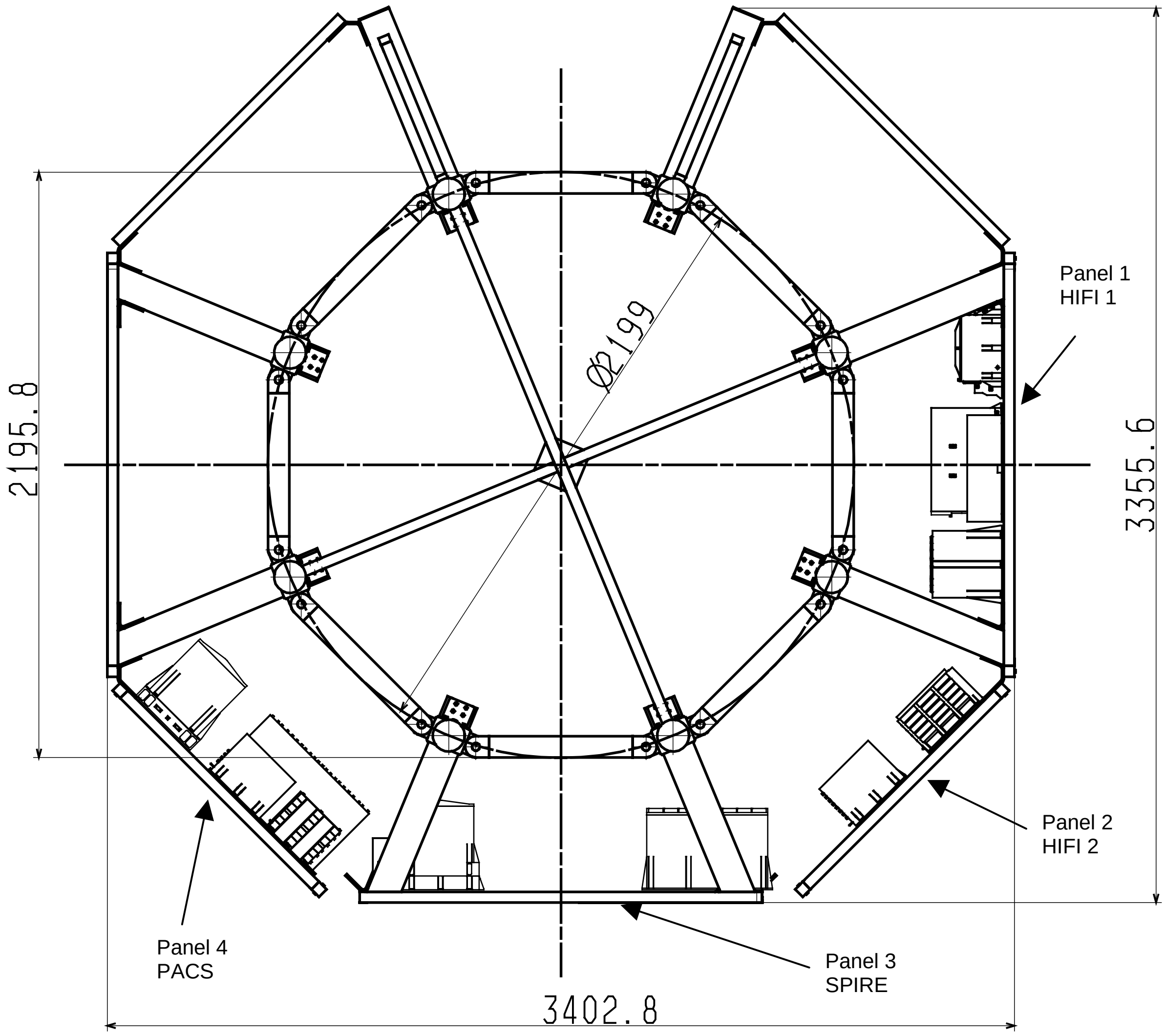


Figure 6-24: Bottom view of SVM Simulator with its basic dimensions (bottom plate not shown)

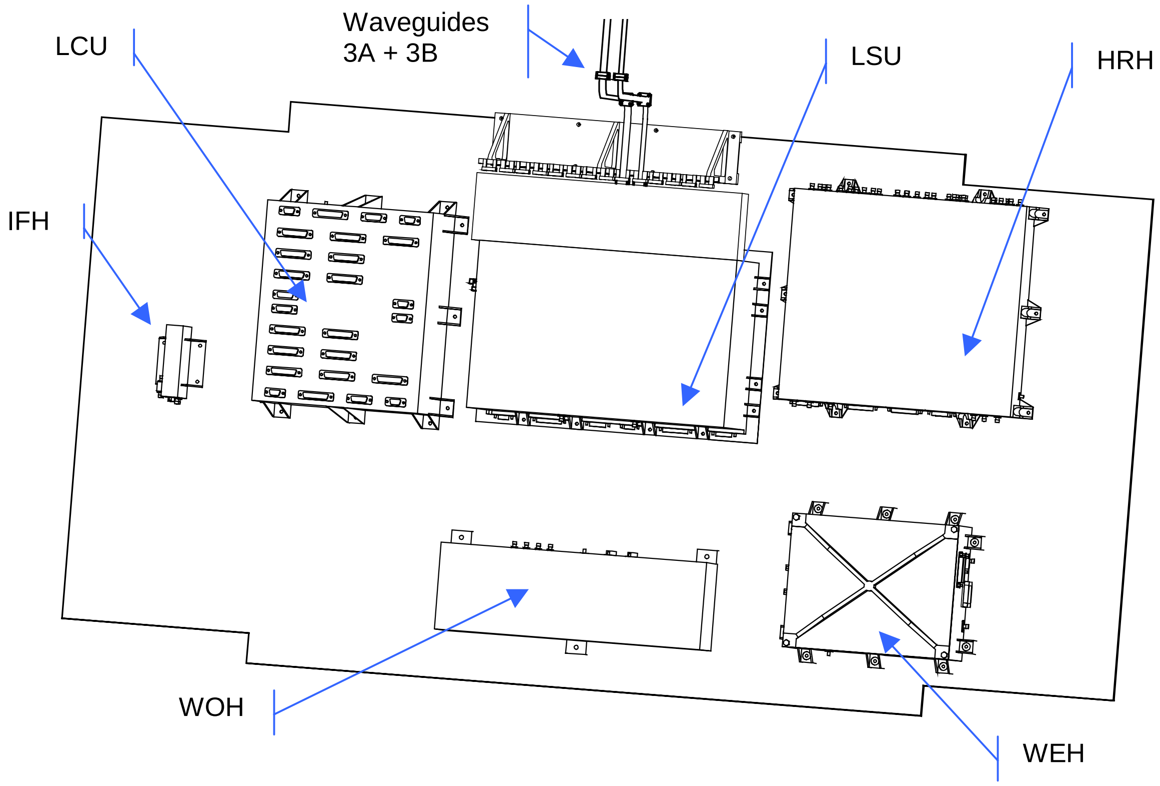


Figure 6-25: SVM-Simulator Panel 1 - HIFI 1 + Waveguides

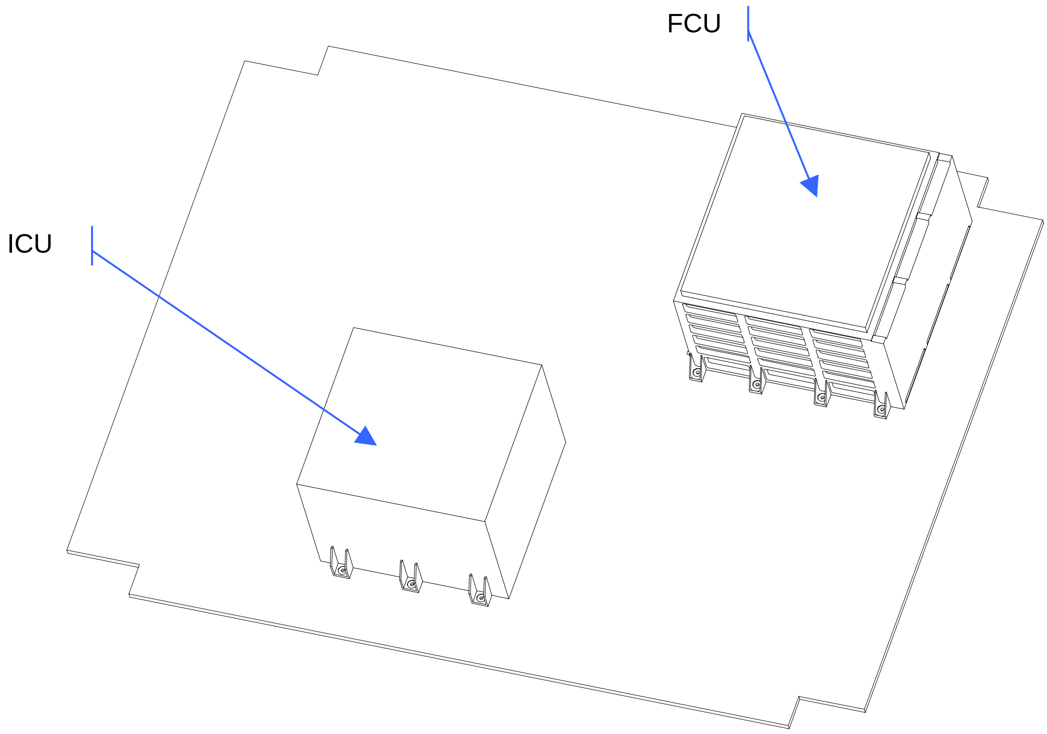


Figure 6-26: SVM-Simulator Panel 2 - HIFI 2

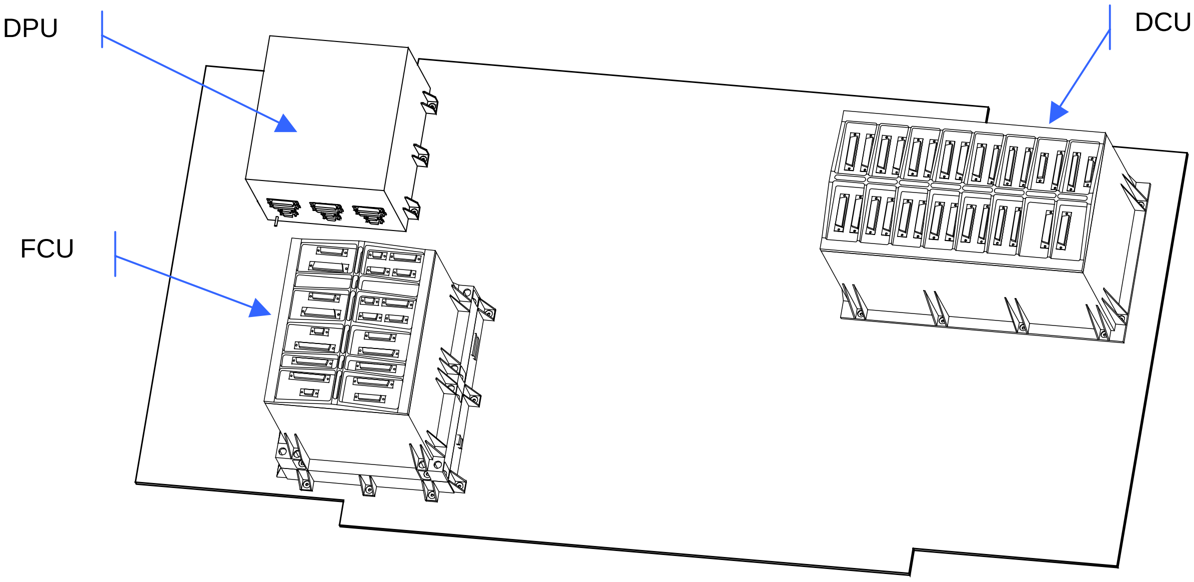


Figure 6-27: SVM-Simulator Panel 3 - SPIRE

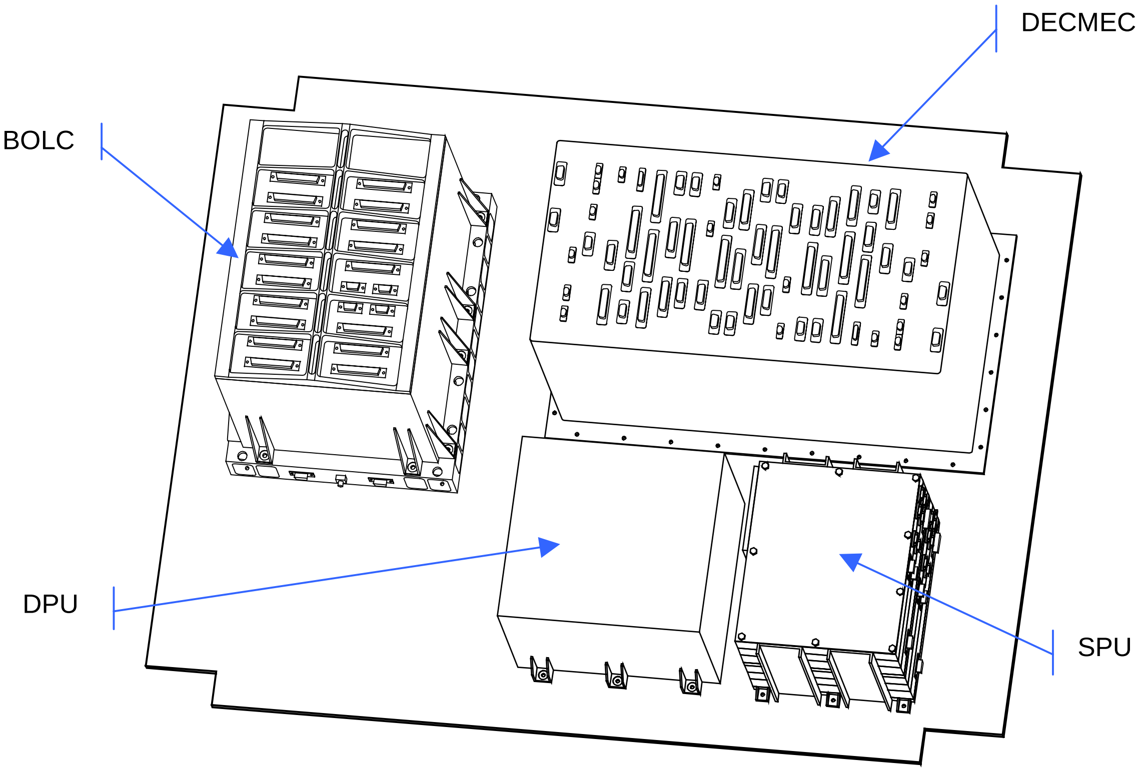


Figure 6-28: SVM-Simulator Panel 4 - PACS (power supply units not shown)

6.2.3 He Subsystem

In order to fulfil the requirements for instrument testing the EQM He subsystem is realised as given in the flow diagram below.

Main characteristics of this concept are as follows:

- The main tank will be filled with He-I at 4.2 K. For instrument testing it will be used to cool down the shields only (bypassing the optical bench) to nearly orbital temperature, i. e. approx. 30 K at the innermost shield. This temperature condition will be achieved by adjusting the helium mass flow through heating the main tank accordingly. The main tank is vented via V502 to the ambient
- The auxiliary tank will be used as a He-II tank, to cool down the optical bench with the required flight representative mass flow of approx. 2.2 mg/sec. This will be realised by pumping at the new additional aux. tank (V512). The adjustment of the required mass flow will be done by heating of the aux. tank and throttling the pumping capacity

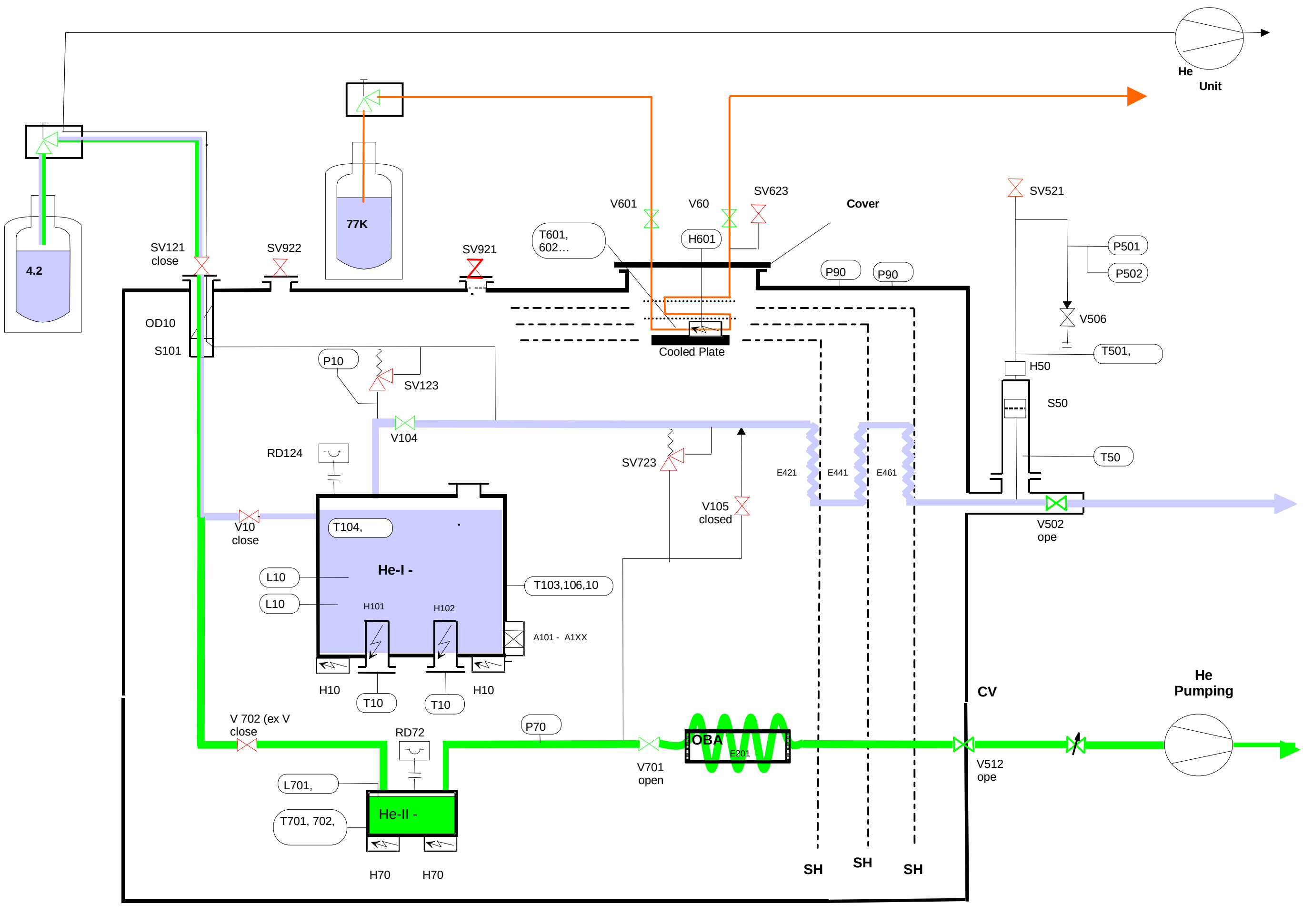


Figure 6-29: EQM He Flowchart

6.2.4 Thermal Insulation

The thermal shields and the corresponding MLI of the ISO QM cylinder and lower bulkhead are reused with out modification. This is amended by Herschel PFM representative MLI for the intermediate connector ring and upper bulkhead thermal shields. For safety of operation both tanks are covered with a standard 10 layer MLI too. Two additional small parts of MLI will be used for thermal upper closure between thermal shield baffle and the cryo cover bottom resp. ECCP acc. Figure 6-11and Figure 6-12.

6.2.5 Electrical S/S

6.2.5.1 CCU

Integration and Operation of the CCU is not foreseen during the HERSCHEL EQM Program. Operation and monitoring of the complete Cryo Control Instrumentation will be performed from EQM Cryo SCOE

6.2.5.2 Cryo Control Instrumentation

6.2.5.2.1 Cryo Control Instrumentation Overview

The HERSCHEL EQM cryo control instrumentation shall cover all requests about control and monitoring of the EQM cryostat during the test and operation phases. To fulfil these demands, the EQM is equipped with instrumentation components. These components should provide:

- sensor information to monitor the status of the Cryostat like
  - temperatures
  - pressures
  - liquid levels
  - status monitoring

- control of the Cryostat status by means of activating and monitoring
  - heaters
  - valves

Only components with an electric connection are considered in this description.

6.2.5.2.2 EQM Subsystems/Unit's Overview

The Herschel EQM cryostat consists of the following main parts/components:

- Subsystems/Unit's from the former "ISO QM"

- "HERSCHEL PFM" representative Subsystems/Unit's.
- New special "HERSCHEL EQM" Subsystems/Unit's.

From the earlier ISO the following parts become including their instrumentation reuses:

- the Main He-II tank (without PPS)
- Cylinder and Lower Bulkhead structure (without Instrumentation)
- Cylinder and Lower Bulkhead Shields
- Tank Support Structure (without Instrumentation)

Instrumentation components of the ISO QM which remain inserted in the cryostat (e.g. temperature sensors on the chains) are not used farther.

The ISO valves used in the EQM again are equipped in addition with a de-blocking heater and a temperature sensor.

The HERSCHEL PFM representative Subsystems/Unit's including their instrumentation consists of:

- OBA (Optical Bench Assembly)
- Upper Bulkhead Shields

The new special HERSCHEL EQM Subsystems/Unit's including their instrumentation consists of:

- AXT (Auxiliary Tank)

6.2.5.2.3 EQM Cryo Instrumentation Component Overview

The EQM instrumentation consists of the components of the Subsystems/Unit's named in the paragraph before. To deliver the required information about the operational status of the Cryostat, the Cryo Control Instrumentation itself is subdivided in several Cryo Instrumentation Components (CIC) subdivided into the following categories:

- Heater
- Liquid Level Sensor
- Pressure Sensor
- Temperature Sensor
- Valve
- Vacuum Gauge
- Status Indicator

The following table gives an overview about the applied components and their number in the EQM:

Category	Number of Component
Electrical Latch Valve	5
Heater	11
Liquid Level Sensor	2
Pressure Sensor	2
Status indicator	4
Temperature Sensor	70
Vacuum Gauge	2
Total:	96

Table 6-6: Cryo Instrumentation Components general overview

The cryo instrumentation categories as described above consist of several single components. These single components are adapted to their application and the relevant operational conditions. The table below gives an overview of the individual type and number of components intended for installation in the Herschel EQM:

Category	Component type	Number of component	Connected to		Remark
			Cryo SCOE	Ext. EGSE	
Electrical Latch Valve	Electrical Latch Valve	5	5		used from ISO
Heater	DLCM Heater brass, 50Ω cold	2	2		used from ISO
	Depletion Heater high load resistor 330Ω ambient	2	2		used from ISO
	Valve Heater foil, Nicolitch Heater foil RS00903069KF, R=90W R=90Ω	5	5		
	High Load Resistor Vishay-Dale RER-55-F90-R9-R R= 90,9W ± 1%	2	2		
Liquid Level Sensor	super-conducting probe	2	2		
Pressure Sensor	Auxiliary tank Pressure Sensor = TBD	1	1		
	Pressure Sensor BHL-4201-01	1	1		
Temperature Sensor	C10	1	1		used from ISO
	C100	39	39		several sensors used from ISO
	PT500	15	15		used from ISO
	PT1000	15	15		
Status indicator	Status Switch	4	2	2	
Vacuum Gauge	Penning Gauge	2		2	used from ISO
	Total number:	96	92	4	

Table 6-7: Component type and electrical Connection Overview

6.2.5.2.4 Electrical Connection

Each of the individual Cryo Instrumentation Components (CIC) is electrically connected to the EQM CCH (Cryostat Control Harness). Commanding, Readout and Control of the CIC's will be performed by the Cryo SCOE or by an external EGSE. Readout of the vacuum gauges will be performed by their own electronics (Ext. EGSE), readout can be sent via an analogue output to the Cryo SCOE for monitoring and data storage.

Special operations as for example DLCM are not intended.

All Instrumentation Components are accessible at the corresponding Vacuum feed-through connectors (end of CCH), either at the intermediate connector ring (Herschel PFM specific mainly) or at the "old" ISO lower connector ring (former ISO and new Herschel EQM mainly).

The Table 6-7 includes also an overview of the electrical connection of the components.

6.2.5.2.5 Mechanical Allocation

The "ISO QM" components are taken over with regard to their mechanical position invariably from the ISO and are used in the EQM farther. All these components are marked with-I at the end of the component name.

An exception is considered to the AXT valves. For the AXT the EQM internal Ventline is adapted. Two valves are also adapted for it. The valve ISO V701 becomes functional the V702, the mechanical position remains unchanged. For the new V701 the taken out V103 on the position of the V701 is inserted.

The "Herschel PFM" components are inserted like in the PFM intended also in the EQM. The corresponding components are described in the document TN-0048 in detail. All these components are marked with their PFM name.

The "Herschel EQM" components are inserted like in the part / Components EQM intended. All these components are marked with-E at the end of the component name.

The Table 6-8 gives a summary of the cryo instrumentation components, the category, type, functional allocation and the number. The drawing in Figure 6-30 gives a schematic overview about the distribution of the components to the Parts/Components. The description of the symbols is contained in the legend on the drawing.

More details about the Cryo Instrumentation components are given in the documents:

HP-2-ASED-TN-0048 ⇒ for the Herschel PFM Instrumentation

ISO-DS-BEE00.001 ⇒ for the ISO QM Instrumentation

Component		ISO QM					Herschel PFM					Herschel EQM			
		Shield Group			Main LHe Tank	CVV outside	OBA		Thermal Shield Group Upper Cone Shields					Total:	Remarks
Category	Type	1st Shield	2nd Shield	3rd Shield			Bench	OB Shield	TS1	TS2	TS3	Cover	AXT		
Electrical Latch Valve	Electrical Latch Valve				3								2	5	used from ISO, AXT Valve mechanically mounted on Main He Tank
Heater	DLCM Heater brass, 50Ω cold				2									2	used from ISO
	Depletion Heater high load resistor 330Ω ambient				2									2	used from ISO
	Valve Heater foil, Nicolitch Heater foil RS00903069KF, R=90Ω				3								2	5	
	High Load Resistor Vishay-Dale RER-55-F90-R9-R R= 90,9Ω ± 1%												2	2	
Liquid Level Sensor	super-conducting probe												2	2	Liquid Level Sensors on Main He Tank not operational
Pressure Sensor	Auxiliary tank Pressure Sensor = TBD												1	1	
	Pressure Sensor BHL-4201-01				1									1	
Temperature Sensor	C10				1									1	
	C100				4		27	2					6	39	
	PT500	3	3	3	4								2	15	
	PT1000						5	1	2	2	2	2	1	15	
Status indicator	Status Switch											4		4	
Vacuum Gauge	Penning Gauge					2								2	
	Total:	3	3	3	20	2	32	3	2	2	2	6	18	96	

Table 6-8: EQM Cryo Instrumentation: Components Mounting Position, Component Types

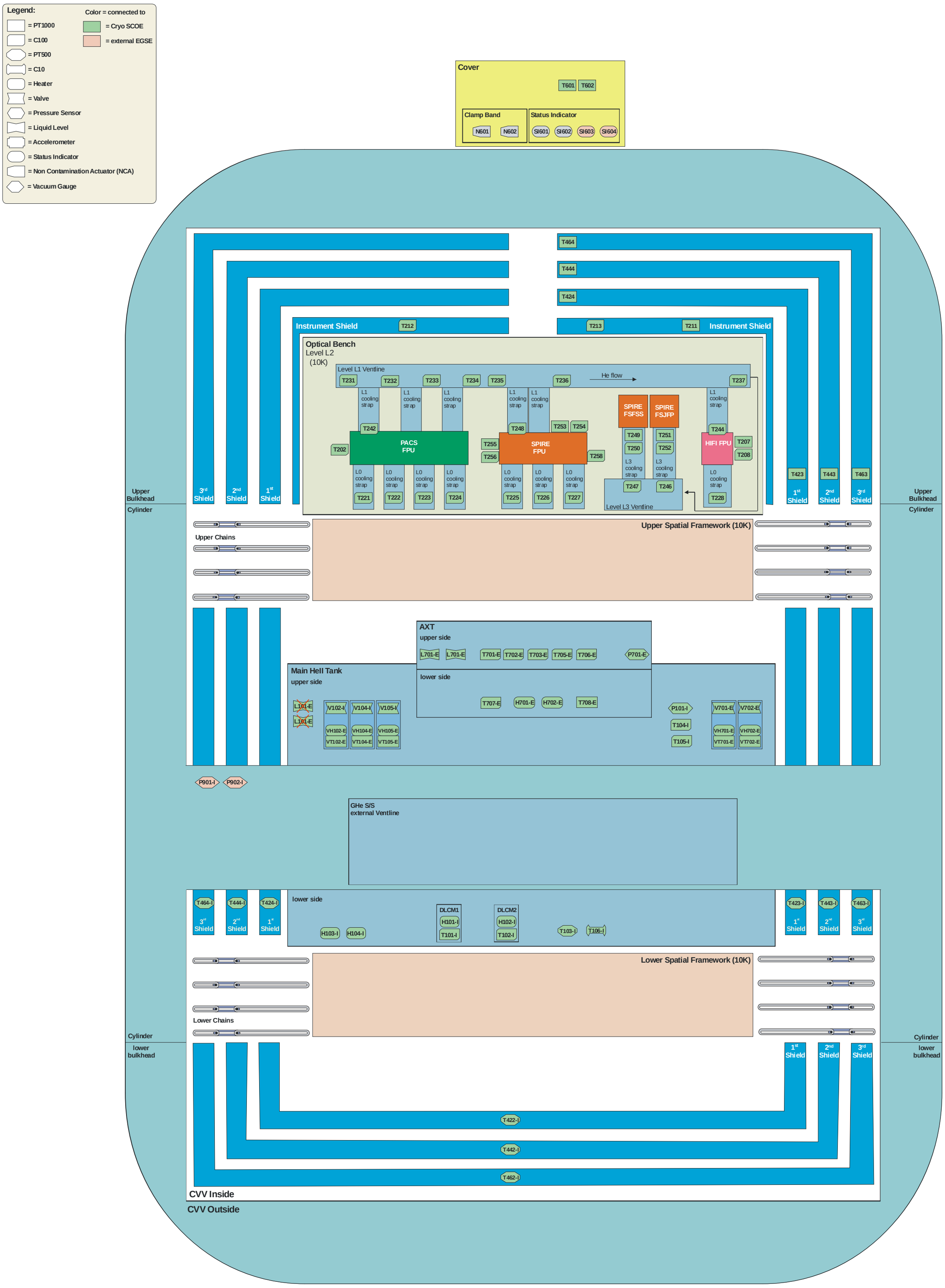

Legend:
Color = connected to
= PT1000
= C100
= PT500
= C10
= Heater
= Valve
= Pressure Sensor
= Liquid Level
= Accelerometer
= Status Indicator
= Non Contamination Actuator (NCA)
= Vacuum Gauge
= Cryo SCOE
= external EGSE
Cover
Clamp Band
Status Indicator
Instrument Shield
Optical Bench
Level L2
(10K)
Level L1 Ventline
He flow
PACS FPU
SPIRE FPU
SPIRE FSFSS
SPIRE FSJFP
HIFI FPU
Level L3 Ventline
Upper Bulkhead
Cylinder
Upper Spatial Framework (10K)
Upper Chains
AXT
upper side
lower side
Main HeII Tank
GHe S/S
external Ventline
DLCM1
DLCM2
Lower Spatial Framework (10K)
Lower Chains
lower bulkhead
CVV Inside
CVV Outside

Figure 6-30: EQM Cryo Instrumentation Components Allocation Overview

6.2.5.3 Harness

6.2.5.3.1 General Overview

Corresponding to the PFM, the EQM Payload Module Cryostat Harness (PCH) consists of

- The Scientific Instrument Harness (SIH)
- The Cryostat Control Harness (CCH)

The Scientific Instrument Harness (SIH) provides all necessary connections between

- The Scientific Instrument Warm Units installed in the SVM Simulator
- The CVV-Unit HIFI LOU installed on outside of CVV
- The Focal Plane Units (FPU's) installed in the Cryostat onto the Optical Bench Plate.

The Cryostat Control Harness (CCH) interconnects the Cryostat Control Instrumentation to the

- Cryo SCOE
- External EGSE

A connection of "Orbit" representative Cryo Instrumentation Components to CCU is not foreseen.
Both harnesses, SIH reduced to the EQM needs and CCH partly, shall be FM representative.

In the ISO cryostat the instrument FPU's were accommodated in the lower part of the cryostat on the OSS. Therefore, the SIH was routed to the FPU's via the lower connector ring and the lower chains, while the CCH was routed to the instrumentation mainly via the upper connector ring and the upper chains.

In the Herschel the SIH is routed to the FPU's on the basis of their mounting position on the OBA via the upper connector ring. To be able to accommodate this also in the Herschel EQM, the former ISO Harness must be altered completely and be adapted.

Because the upper connector ring of the ISO cylinder cannot be applied for the Herschel SIH, an Intermediate ring is inserted. In this intermediate the connector positions are in the ring immediately with those in the Herschel PFM, but the ring is from the mounting position in X direction divergently to the PFM. Therefore, the routing of the cables between the chains to the plugs is differently to the PFM. This has been considered in the design.

The ISO SIH has been removed completely.

The ISO CCH between the CVV connectors of the upper connector ring routed via the upper chains up to the upper SFW has been removed also completely, so that the chains are free for the Herschel SIH.

Cryo components of the old ISO which are fixed on the upper chains and cannot be removed are not used any more and, therefore, are not connected any more to the Herschel EQM Harness. An exception is the connection with the furthermore used cylinder shield sensors ISO. The new bundle to the sensors will be routed on the bottom of the chain 06. The SPIRE bundles are routed about the top side of chain 06.

More details about the EQM SIH and CCH are given in the cryo harness interconnection diagrams:

- HP-2-ASED-ID-0087-01-0… CCH Upper Ring CVV (EQM)
- HP-2-ASED-ID-0087-02-0… CCH Lower Ring CVV (EQM)
- HP-2-ASED-ID-0092-01-0… HIFI EQM
- HP-2-ASED-ID-0093-01-0… PACS EQM
- HP-2-ASED-ID-0094-01-0… SPIRE EQM

6.2.5.3.2 *Scientific Instrument Harness (SIH)*

The Scientific Instrument Harness (SIH) installed in the EQM shall be corresponding in form and function to the SIH for the PFM. Consequently, the routing of the harness bundles, fixation and thermal connections shall be according to the PFM design. Differences between PFM and EQM, e.g., Intermediate ring and SVM simulator are considered in the design. Vacuum feed-throughs will be installed in the CVV Intermediate Ring near their FM positions. The SIH for HIFI and SPIRE will be reduced in agreement with the instruments to the EQM needs.

The figure below gives an schematic overview of the EQM SIH design.

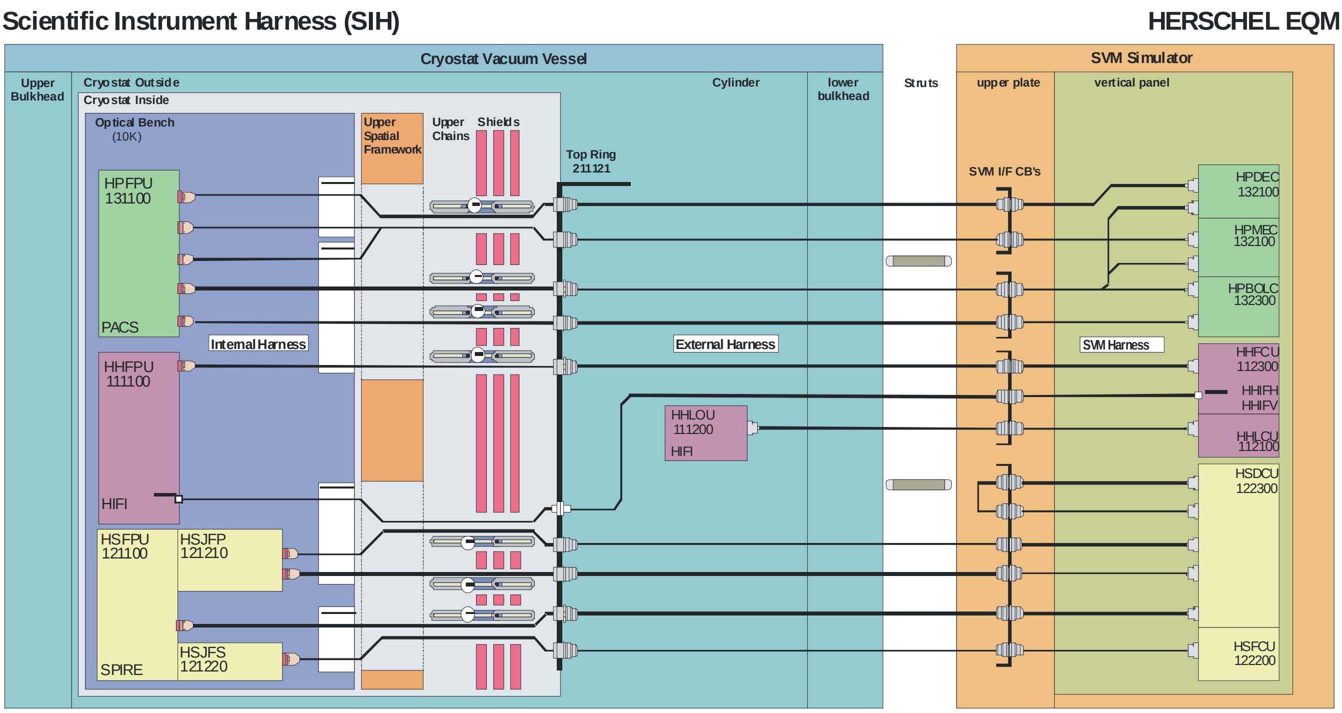


Figure 6-31: EQM SIH Schematic Overview

6.2.5.3.3 *Cryostat Control Harness (CCH)*

The Herschel EQM CCH consists of the following main parts:

- Harness bundles from the former ISO QM Instrumentation Harness
- HERSCHEL PFM representative CCH
- CCH for the new special HERSCHEL EQM Subsystems.

The CCH for the Herschel EQM ends on the CVV vacuum feed-through.

6.2.5.3.3.1 *Harness bundles from the former ISO QM Instrumentation Harness*

To adapt the former ISO QM Instrumentation Harness for the Herschel EQM several activities and reconstruction works are necessary. These activities can be divided in:

- Harness bundles to be removed
- Harness bundles to be reused
- New harness bundles to connect the reused ISO QM bundles to CVV vacuum feed-through

<u>Harness to be removed</u>

- External Harness completely
- Internal harness between CVV upper Ring and upper SFW completely
- Internal harness between CVV lower Ring and lower SFW excepted bundles

  ISO C-V12 and ISO C-V13

<u>Harness to be reused</u>

- Internal Harness bundles between upper SFW and reused Cryo Instrumentation Components on Main He-II Tank
- Internal Harness bundles between the reused ISO temperature sensors and the belonging I/F connectors on the shields already mounted on
  - the ISO cylinder shields
  - the ISO lower bulkhead shields
- Internal harness bundles between CVV lower Ring and lower SFW
  - ISO C-V12 (between CVV, lower SFW and lower bulkhead shields)

– ISO C-V13 (between CVV and ISO DLCM Heater)

<u>New harness bundles</u>

- Internal Harness bundles between upper SFW and lower SFW
- Internal Harness bundles between lower SFW and CVV vacuum feed-through
- Internal Harness bundles between new valve heaters and temperature sensors

The vacuum feed-throughs of the new harness bundles will be inserted in not more used holes in the lower connector ring.

Former ISO subsystems including their instrumentation connected to the EQM CCH are:

- The Main tank He-I (former ISO He-II tank without PPS)
- Cylinder and Lower Bulkhead Shields

The ISO CCH bundles between Main He-I tank and upper SFW become unchanged reuses. From their already existing interfaces on the upper SFW two new bundles (power and signal) will be connected and routed from the upper SFW along outside of the Main He-I tank inner wall to the interface on the lower SFW. From this interface another new bundles via chain 16 (power) and chain 17 (signal) are routed to the CVV vacuum feed-through.

Each of the ISO valves used in the EQM is additionally equipped with a new de-blocking heater and temperature sensor. The heater and the temperature sensor are connected to an interface connector mounted on the valve interface bracket. From these interfaces a new bundle will be connected and routed along outside of the Main He-I tank inner wall to the Interface on the lower SFW. From this interface another new bundle via chain 16 (power) is routed to the CVV vacuum feed-through.

The ISO CCH bundles between temperature sensors on the ISO cylinder shields and the belonging shields interface connectors become unchanged reuses. From this already existing interface a new bundle will be connected and routed via the upper SFW, along outside of the Main He-I tank inner wall to the interface on the lower SFW. From this interface another new bundle via chain 17 (signal) is routed to the CVV vacuum feed-through.

The ISO CCH bundles between temperature sensors on the ISO lower bulkhead shields and the belonging Interface on the shields and further via ISO bundle V-C12 become unchanged reuses.

6.2.5.3.3.2 HERSCHEL PFM representative CCH

The HERSCHEL PFM representative subsystems including their belonging cryo instrumentation components in the EQM are the

- OBA inclusive OB Shield
- Upper Bulkhead Shields (1st, 2nd and 3rd shield)

For these subsystems a PFM representative CCH will be manufactured and installed. The internal CCH bundles shall be routed according to the PFM coming from the single instrumentation components located on OBA down to the interface on upper SFW. On the SFW the interface connectors will be fixed deviating from the PFM design with clamps as already used in ISO instead of an interface bracket. The position of the interface connectors for the PFM representative bundles on the upper SFW will be as far as possible according to the position in the PFM. If reused ISO connectors are mounted on such a position, the ISO connector will be shifted. From this interface the bundles will be routed according PFM along the chain 08 to the relevant vacuum feed-throughs installed in the CVV Intermediate Ring near their FM positions.

The upper bulkhead shields will be equipped with harness bundles according PFM. From the interface connectors on the shield the bundles will be routed along the intermediate shields to the chain 08 to the relevant vacuum feed-throughs installed in the CVV Intermediate Ring near their PFM positions. Deviations to PFM in the position of the interface connectors and the routing are considered in the design.

With the cover no CCH is intended from the interface Bracket.

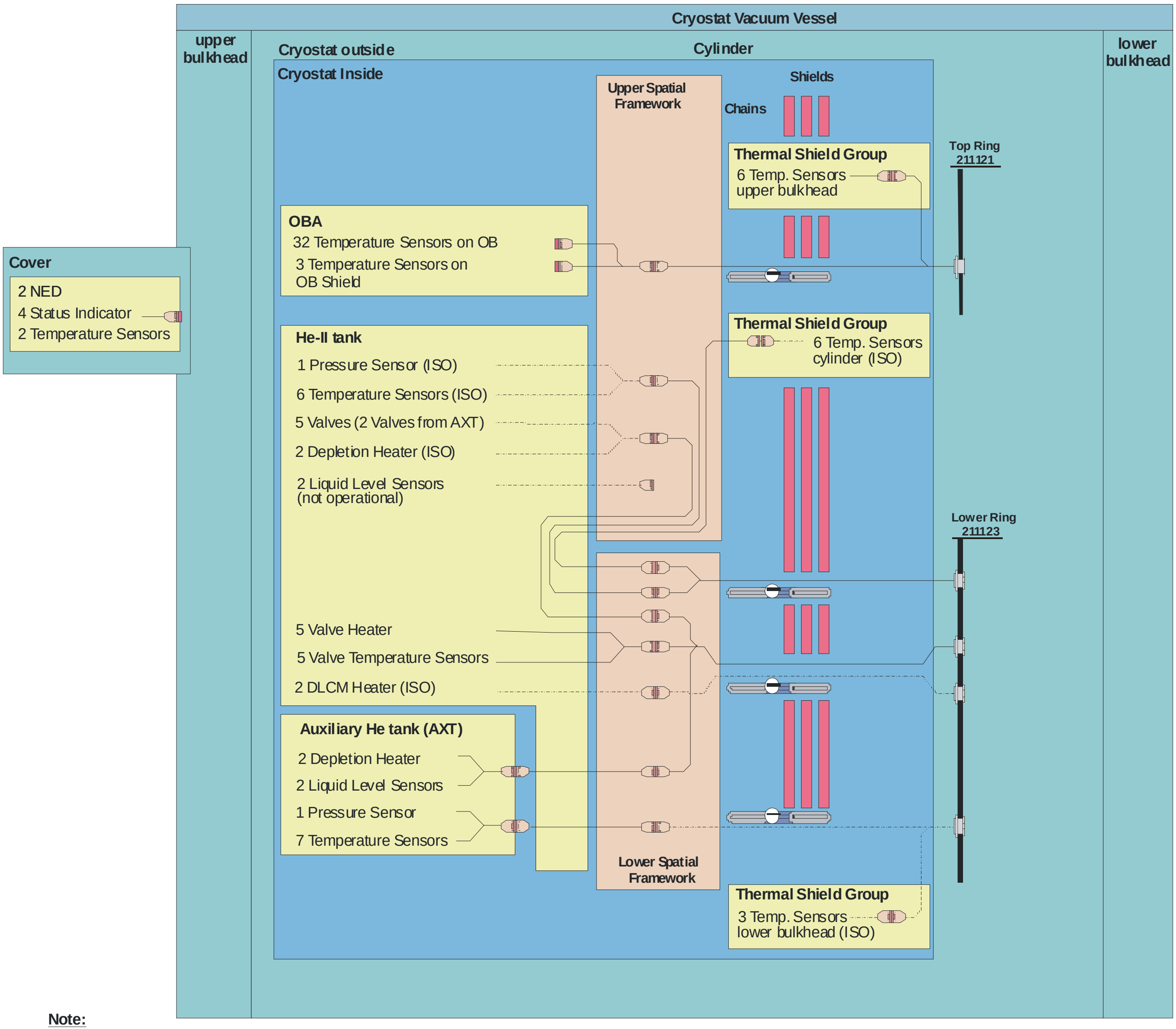
6.2.5.3.3.3 CCH for the new special HERSCHEL EQM Subsystems

The new Herschel EQM Subsystem is the

- Auxiliary He-II tank (AXT)

For this subsystem a new CCH will be manufactured and installed.

The AXT itself is equipped with an internal harness. This harness is installed onto the AXT between the cryo instrumentation components and the AXT interface bracket. From the AXT interface bracket two new bundles (power and signal) will be connected and routed from the AXT to the outside of the Main He-I tank inner wall and along this wall to the interface on the lower SFW. From this interface the power will be connected to the new bundle routed via chain 16 (power) to the CVV vacuum feed-through. The signal bundle will be connected on the lower SFW to the ISO bundle V-C12.



Note:

= new Harness

= reused ISO Harness

Figure 6-32: EQM CCH Schematic Overview

6.3 EQM GSE

6.3.1 MGSE

Due to the same requirements for MGSE H/W (w.r.t. load, basic dimensions and I/Fs) between ISO/PLM and Herschel PLM, existing ISO MGSE items will be used for the Herschel EQM AIT phase.

Herschel PLM MGSE refurbished and re-qualified comprises the following items:

Item No.	MGSE Item	Quantity	Remark
1	Clean room class 100 integration dolly (Integration dolly)	1	ISO MGSE
2	Test dolly No. 1	1	ISO MGSE; stainless steel, without paint
3	Test dolly No. 2	1	ISO MGSE; white painted
4	Test dolly No. 3	1	New item
5	Hoisting Equipment No. 1	1	ISO MGSE (length adaptation of the hoisting-bars)
6	Hoisting Equipment No. 2	1	
7	SVM Simulator	1	New item

Table 6-9: EQM - MGSE

General MGSE Functional Characteristics

The MGSE shall be designed to provide all mechanical and environmental integration and test support required for ground operations.

The EQM MGSE shall be designed to handle, protect, transport, assemble, integrate, refurbish and verify the PLM and/or its modules. It shall provide the auxiliary items required for personal access to accommodate any operations.

Clean room class 100 integration dolly (Integration dolly)

This item is used for the integration of the EQM PLM up to / and including cryostat closure and evacuation in clean room class 100. Functional and technical details according ISO-VV-ZYYR-SP-0043.

Test dolly No. 1

This MGSE is made from stainless steel and can be used for integration and testing of the PLM without SVM simulator in environment clean class 100 000. Functional and technical details according ISO-VV-ZYYX-SP-0473.

Test dolly No. 2

This MGSE will be used for integration and testing of the PLM without SVM simulator in environment clean class 100 and clean class 100 000. Functional and technical details according ISO-VV-ZYYX-SP-0473.

Test dolly No. 3

This MGSE will be used for integration and testing of the PLM with the SVM simulator attached to it in environment class 100 000.

Hoisting Equipment No. 1/2

This MGSE is used for hoisting the ISO PLM and the Herschel EQM PLM completely integrated (with SVM simulator) with the tanks full, X-axis in vertical or horizontal position (Y- or Z-axis vertical). Functional and technical details according ISO-VV-ZYYY-SP-0048.

Hoisting Equipment Nr. 1/2 adaptation of length of the hoisting bars is necessary for the extended CVV (intermediate ring + upper bulkhead)

SVM Simulator

This MGSE is used for testing of the EQM PLM. It accommodates the warm units of the instruments and provides representative interfaces to the harness and the waveguides. More details in chapter 6.2.2.

6.3.2 CVSE

The Cryo Vacuum Service Equipment (CVSE) shall be used to perform all cryogenic and vacuum operations of the Herschel PFM/EQM program.

The CVSE shall comprise the following units:

- High vacuum pumping unit with turbo molecular pumps
- LHe service vacuum pump unit I
- LHe service vacuum pump unit II
- CVSE equipment rack
- LHe transfer lines (He I and He II service)
- LHe flushing lines for cover cooling
- General purpose vacuum pumps
- GHe and vacuum piping in order to connect the Herschel PFM/EQM with the pumping units
- Safety unit
- Scaffolding
- Flow meter units
- He leak detector
- Bake out unit
- LHe supply tanks 450 L
- Standard vacuum parts

The CVSE shall allow the basic operations with the Herschel PFM/EQM:

- Leak check of cryogenic system
- Evacuation and leak check of the cryostat isolation system
- Cool-down of the He I tank (former ISO HeII tank) and the auxiliary He II tank (AXT) from ambient to LHe temperatures
- Filling of the He I tank and He II tank with LHe in vertical position
- Production of LHe II in the He II tank and refilling of the He II tank with He II
- Production of He II in the He I tank and refilling of the He I tank with LHe II (for training phase)
- He II conversion
- Warm up of the He I and He II tanks from LHe temperatures to ambient temperature
- Cooling of the cover by flushing to LHe at T = 4.2 K (pending on instrument tests)

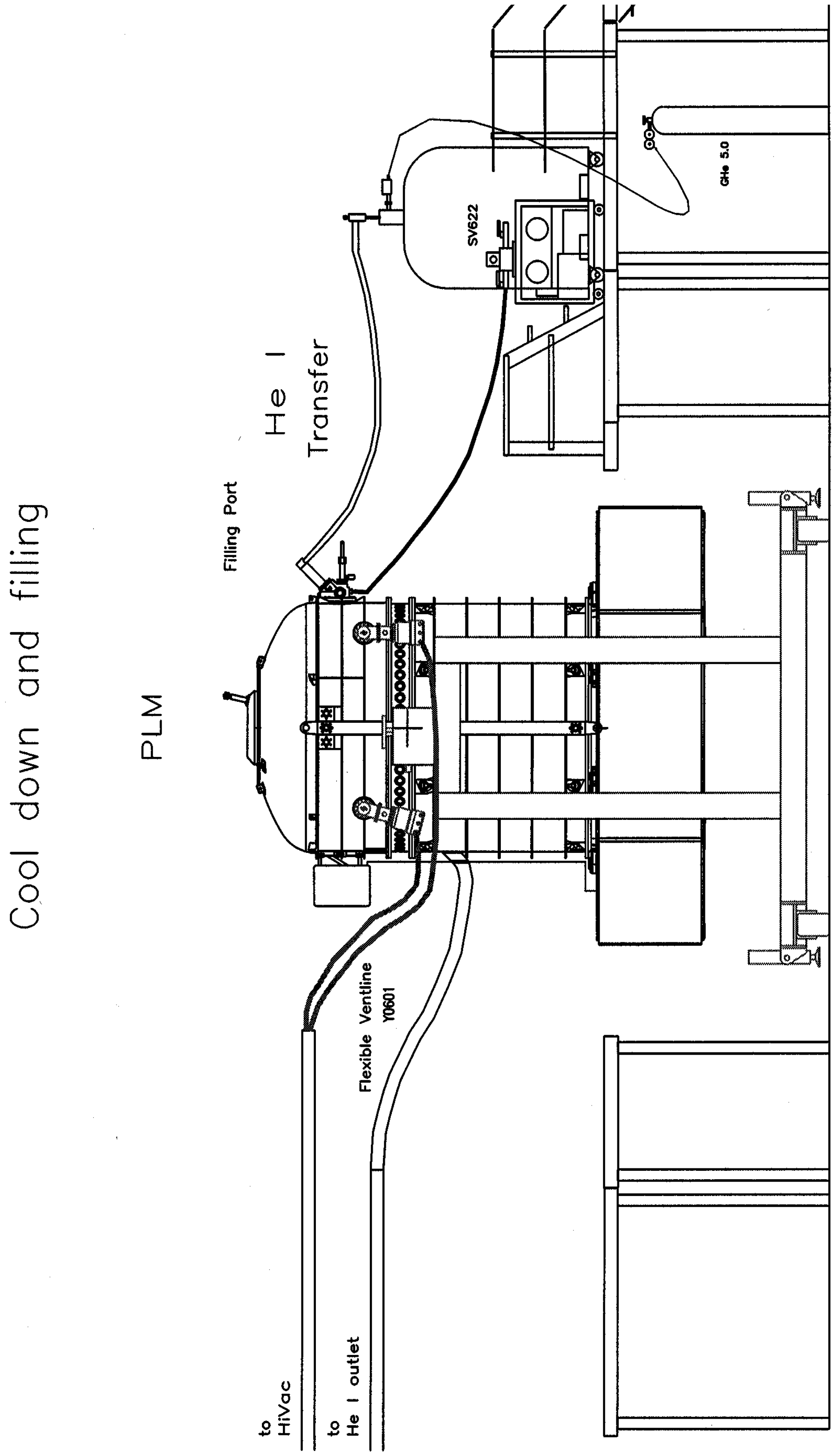


Figure 6-33: Herschel EQM cryo operations

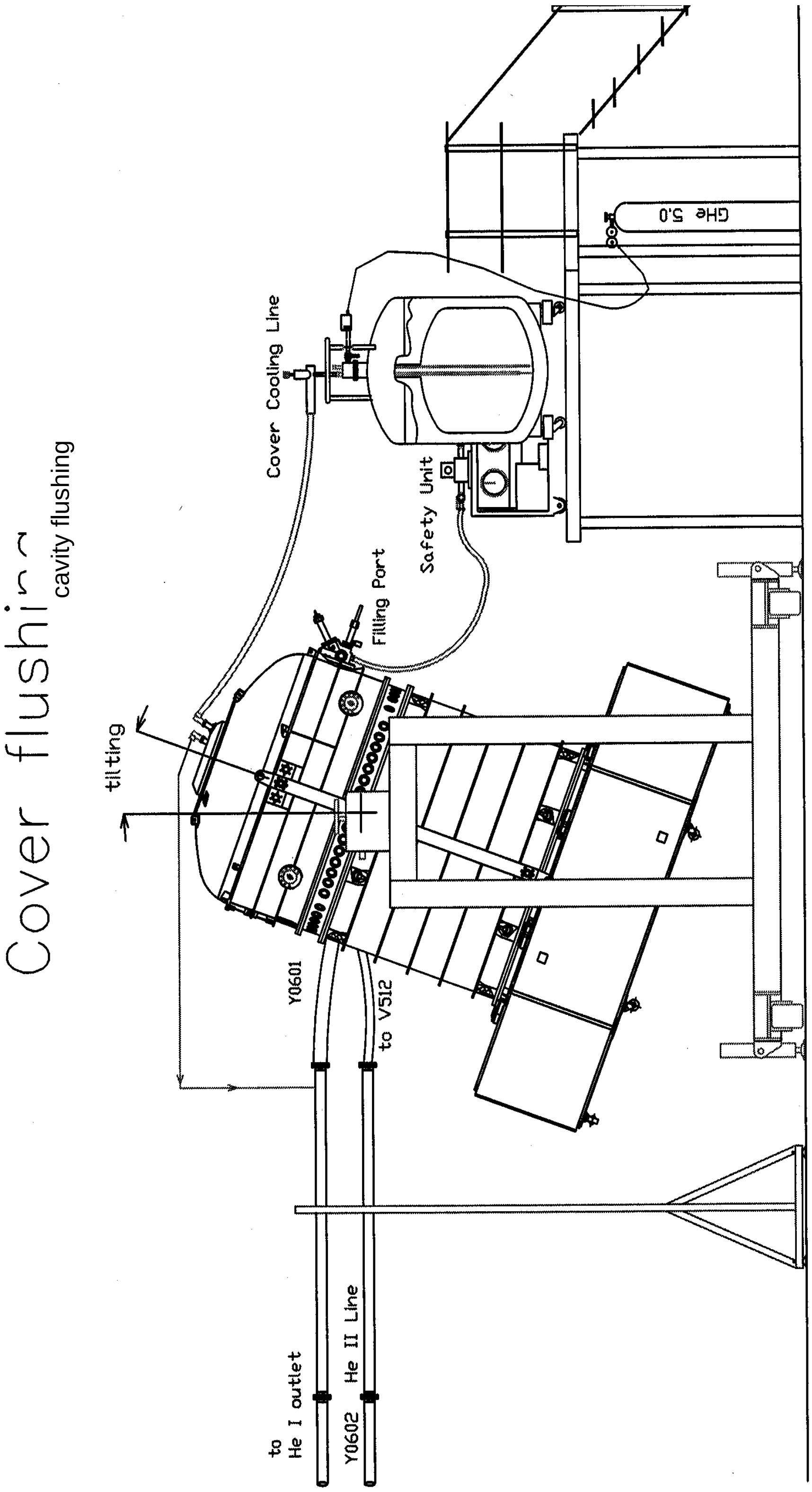

Cover flushi
cavity flushing
tilting
Cover Cooling Line
Safety Unit
Filling Port
GHe 5.0
Y0601
to V512
to He I outlet
Y0602
He II Line

Figure 6-34: Herschel EQM cryo test set-up

6.3.3 EGSE

The principle PLM EQM test set-up is shown in figure below. It consists of the EPLM EQM equipped with the 3 instrument FPU CQM's and a SVM simulator structure with the integrated instrument warm units AVM's and the EGSE. The EGSE consist of CCS "light" and the PLM EGSE with data- and power front ends which provide flight representative interfaces to the instruments, the Cryo SCOE to control the cryostat and the Instrument EGSE. The Instrument EGSE consists of 1 nominal EGSE and 1 back-up EGSE. The Instrument EGSE is common for all instruments.

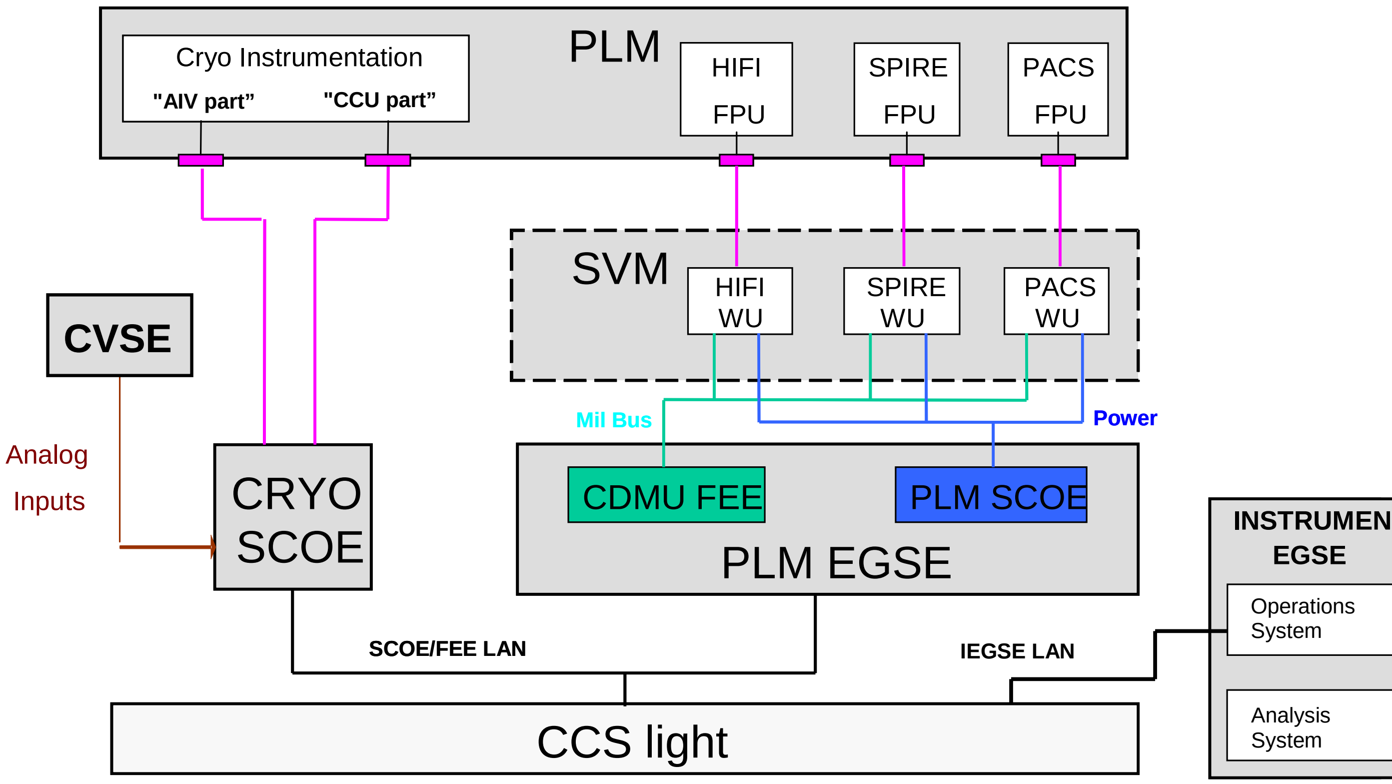


Figure 6-35: EGSE set up for instrument testing

For the two liquid level sensor's (LLS's) at the AXT separate read out electronic equipment will be used. These electronic equipments have been used and tested during the complete qualification program of the LLS's

7 EQM AIT PROGRAM

7.1 Integration

7.1.1 Pre- Integration Inspection and H/W release

Before starting the integration, an inspection will be performed on each incoming equipment, to control the quality of the hardware to be integrated.

As a minimum, the following controls/measurements will be performed:

- control of data package according to the shipping list
- visual inspection
- cleanliness inspection
- conformity of identification markings and serial numbers to the configuration status
- fit check (if possible) dimensional check and planarity
- instrument health check after shipment

Release of hardware for integration will be controlled. Parts required for a particular integration activity will be kited to reflect the requirements of the governing procedure prior to the need date. This kiting operation shall include an inspection according to the system/module assembly drawing and subsystem manufacturing drawings to ensure that all parts / materials are available and that obvious anomalies are found prior to the beginning of integration activities.

7.1.2 Mechanical Integration / Disassembly

Mechanical integration/deintegration will be performed according integration/deintegration procedures in step by step format (RD 3). All activities will be given in correct timely order.

All de-integration and re-integration activities of the EQM internal cryostat are being performed in cleanroom class 100 environment.

The handling- and integration activities of EQM hardware will be carried out using the ISO refurbished MGSE. It will be done by trained authorised personnel with the necessary experience (ISO heritage).

The deintegration and storage of Herschel relevant H/W from ISO is performed such that they can be reused for Herschel PLM/EQM (e.g. protection of flange I/F's is mandatory). Generally all parts which show anomalies (e.g. helicoil inserts, gaskets) have to be replaced. Clear marking of dismounted parts is performed for precise identification during reintegration phase.

The re-integration will be completed after closure of the cryostat with a successfully performed leak tightness test at room temperature. The final integration activities will be continued in cleanroom class 100.000 (e.g. LOU integration, external harness and waveguides integration, SVM integration …).

7.1.3 Electrical Integration/Deintegration

The general approach is a sequential assembling and testing (RD 3). Each unit will be reasonably functionally tested within existing constraints and as far as possible, before further units are added. The philosophy shall allow the identification of problems as clearly and early as possible.

7.1.3.1 Harness and Waveguides

Harness and waveguides will be handled and installed only by adequate and authorised personnel.

Harness interfaces will be protected by connector savers during integration. Mating/demating during ground handling will be made by separating “non flight” hardware interfaces. Electrical integration of harness will be completed by execution of detailed functional checks/tests. Open ends of the waveguides will be protected by adequate caps.

ISO harness no longer required for Herschel, will be either removed (it is preferable to detach a suitable harness I/F before cutting of harness cables) or short-circuited such that they do not create any interference i.e. during EMC testing.

7.1.3.2 Instrument cold units integration

Grounding and precaution of static discharge requirements will be verified before any activity. Electronic unit/box connectors will be protected by connector savers during integration.

The-Instrument cold units integration will be supported by short electrical interface checks performed with adequate instrument unit tester.

7.1.3.3 Instrument Warm Units integration

Grounding and precaution of static discharge requirements will be verified before any activity. Electronic unit/box connectors will be protected by connector savers during integration. Mating/demating during ground handling will be made by disconnecting “non flight” hardware interfaces.

Electrical integration of units and subsystems will be completed by execution of detailed functional checks/tests.

The instrument warm-units will be integrated onto the SVM simulator side panels in parallel to the cryostat integration as offline activity in cleanroom class 100.000. The warm-unit integration will be completed by a test sequence debugging, using FPU simulators and the PLM EGSE together with the Central Check-out System (CCS-light).

These pre-integrated SVM panels will be finally installed to the SVM dummy and the cryostat prior to instrument testing.

7.2 Cryo Operations

In order to allow instrument testing in the required thermal environment, the cryostat has to be cooled down and the tanks filled with LHe. Instrument cool down requirements will be respected.

7.2.1 Cooldown & Filling

The cooldown and filling will be performed according procedures based on the verified ISO documents and using the refurbished ISO CVSE.

Cooldown and filling will start after a successfully performed leaktest of the internal Helium S/S to the cryostat isolation vacuum and isolation vacuum to ambient. After filling of the main tank with LHe-I, a cold leaktest will be performed.

Similar procedures will be used for filling the auxiliary tank with LHe-I.

Cooldown and filling will be performed in vertical position only.

7.2.2 Helium II Production & Top Up

The Helium II production and top up will be performed according procedures based on the verified ISO documents and using the refurbished ISO CVSE.

According to the EQM design concept of the cryostat, the auxiliary tank will be used as He-II reservoir for instrument testing, venting through the optical bench directly out of the CVV via V512 to the Helium pumping units. It provides the required level 0 temperatures as well as the level 1 and level 2 temperatures, by adjusting the required flight representative mass flow of approximately 2.2 mg/s.

These conditions have to be maintained during the complete test sequence. Refilling of the auxiliary tank will start at least at a liquid level of 10 %.

He-II production and top up will be performed in vertical position only.

7.2.3 Cover Flushing Operation

To provide a cold background for the instruments in order to perform their instrument testing, the cryostat cover components have to be cooled during test

Most of testing with the EQM cryostat will be performed with x-axis in horizontal position. Tilting of cryostat via test dolly is possible.

7.2.4 Depletion & Warm-Up

The depletion and warm-up will be performed according to procedures based on the verified ISO documents and using the refurbished ISO CVSE.

It will start after finalising the instrument testing. It will be performed using the internal heaters of the main tank and auxiliary tank.

7.3 EQM Tests

7.3.1 Instrument Tests

The following table gives an overview of the instrument tests to be carried out on EPLM EQM level with their instrument related objectives. Details are provided in RD17.

Test	Test Objectives	Conditions	Remarks
Instrument Incoming Inspection	Visual inspection of the instrument for damage. Check of completeness of hardware items and documentation.	Ambient	

Test	Test Objectives	Conditions	Remarks
Instrument EGSE Validation	Check of Instrument EGSE function (self-test). Check of Instrument EGSE interfaces to CCS.	Ambient	Prior to start EPLM level instrument test programme.
Instrument Electrical Integration Check	Check of grounding, shielding and, if required, input/output circuits function and characteristics.	Ambient	Prior to connection of instrument to spacecraft. Prior to connection of FPU to warm units via the cryoharness.
Instrument Alignment Check	Check of instrument alignment and validation of alignment procedure (as far as possible).	All	In warm and cold conditions.
Instrument Short Functional Test (SFT)	Instrument switch on and functional verification of instrument interfaces. Evaluation should preferably be based on housekeeping data. Three different types of instrument SFT's: warm, cold He-I and cold He-II.	SFT warm: Ambient SFT cold He-I: Tank temperature 4.2 K SFT cold He-II: Tank temperature 1.7 K	SFT warm: Before cool down of the cryostat. SFT cold He-I: After cool down (He-I). SFT cold He-II: After He-II production..
Instrument Specific Performance Test (SPT)	Verification of dedicated aspects of the performance of the integrated instrument. Tests may require a specific spacecraft configuration.	Tank temperature: 1.7 K	Scheduling depending on test set-up requirements.
Integrated Module Test (IMT)	Verification of the functional performance of the integrated instrument in all possible modes. Check of the instrument performance as far as possible with EPLM configuration.	Tank temperature: 1.7 K	
EMC Test	Check of functional performance of the integrated instrument under electromagnetic worst case conditions (radiated susceptibility)	Tank temperature: 1.7 K	Instruments to be in the most sensitive mode(s) for susceptibility tests

7.3.2 Alignment Verification

This chapter provides an overview of the Herschel alignment concept. A more detailed description is given in RD 18 (Alignment Method, Plan & Results).

Proper function of the three Herschel scientific instruments requires their precise alignment. The instruments have to be aligned to an optical reference system.

During the on-ground alignment two constraints must be taken into account:

- The alignment requirements are valid for in-orbit conditions
- The alignment requirements are specified for operational conditions, whereas the alignment can only be performed at ambient conditions.

The alignment in the Herschel EQM is limited to ensure that the instruments are in the correct position (e.g. HIFI FPU vs. LOU) to allow proper instrument testing, when the cryostat is in cold conditions.

Alignment verification and alignment procedure validation will be done on the Herschel STM program.

AIT Logic Flow

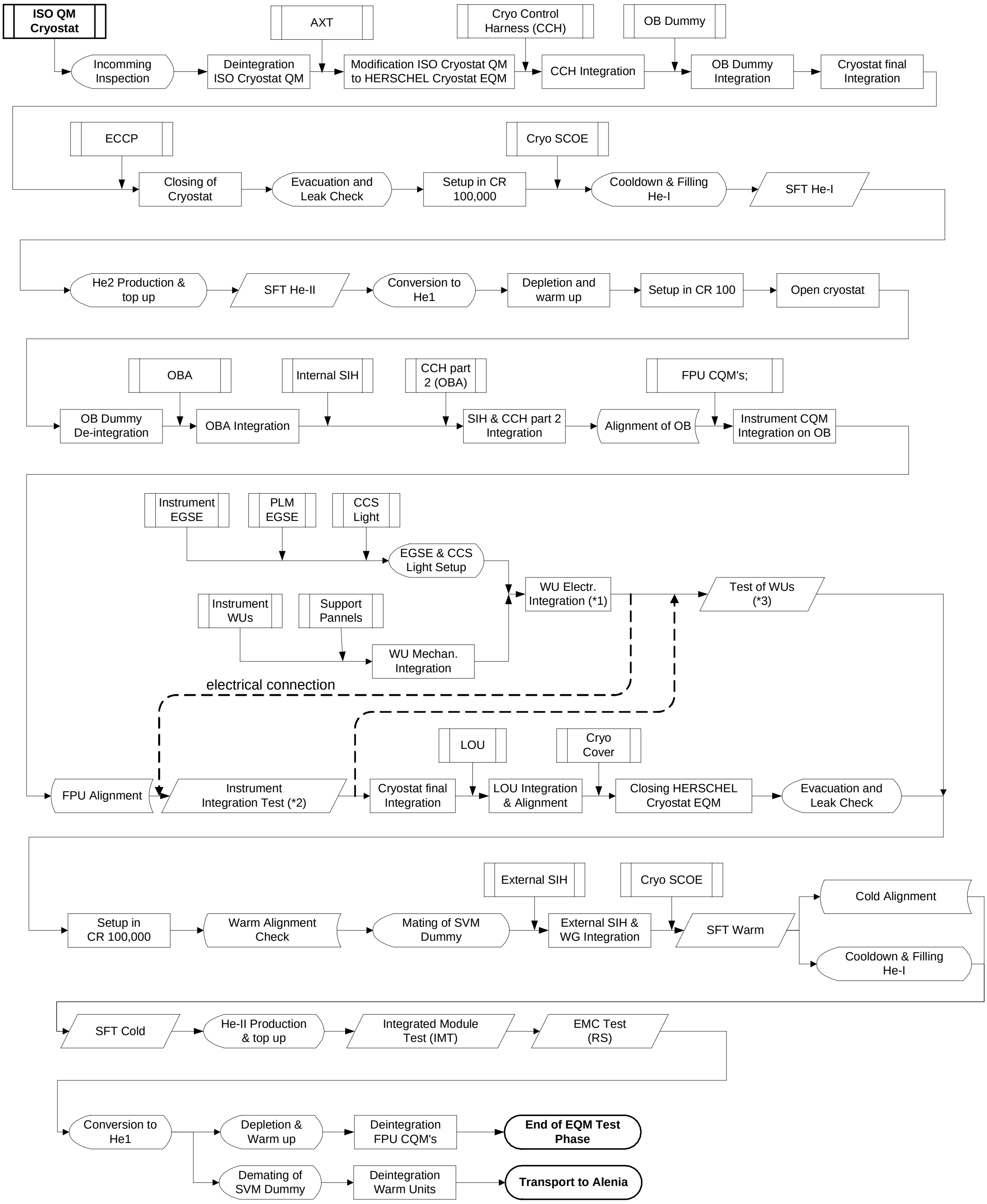


Figure 7-1: Logic flow for Herschel PLM/EQM AIT activities

***1)** Instrument specific tasks (all offline)

PACS:

- WU harness interconnection (from PACS)
- Connection of WU **with FPU CQM** (before PACS CQM FPU integration on OB)
- Connection of WU with PACS EGSE
- PACS bench test

HIFI:

- WU harness interconnection (from HIFI)
- Connection of WU with **FPU Simulator** (via HIFI harness)
- Connection of WU with HIFI EGSE
- HIFI bench test

SPIRE:

No bench test (tbc)

***2)** ASED specific tasks (supported by instruments)

PACS:

- WU harness interconnection (from PACS) already done
- Connection of WU **with FPU CQM** integrated on OBA via SIH
- Connection of WU with PACS EGSE
- PACS instrument integration test

HIFI:

- WU harness interconnection (from HIFI) already done
- Connection of WU **with FPU CQM** integrated on OBA via SIH
- Connection of WU with HIFI EGSE
- HIFI bench test

SPIRE:

- WU harness interconnection (from SPIRE) already done
- Connection of WU **with FPU CQM** integrated integration on OBA via SIH
- Connection of WU with SPIRE EGSE
- SPIRE instrument integration test

***3)** ASED specific tasks (supported by instruments)

PACS:

- WU harness interconnection (from PACS) already done
- Integration of WU with PLM EGSE inclusive I/F verification (by IDAS)
- PACS WU functional check
- Disconnection of WU from PLM EGSE

HIFI:

- WU harness interconnection (from HIFI) already done
- Connection of WU with FPU simulator

- Integration of WU with PLM EGSE inclusive I/F verification (by IDAS)
- HIFI WU functional check
- Disconnection from FPU simulator/PLM EGSE

SPIRE:

- WU harness interconnection (from SPIRE) already done
- Integration of WU with PLM EGSE inclusive I/F verification (by IDAS)
- SPIRE WU functional check
- Disconnection of WU from PLM EGSE

7.4 EQM Development Overview

These requirements determine in principle the EQM-configuration based on the ISO QM model as follows:

- Lower Part:
  - Removal of internal parts of ISO like OSS, Baffle, etc
  - Use of existing ISO lower bulkhead CVV and thermal shields incl. MLI
  - Attachment of HERSCHEL SVM simulator for accommodation of Scientific Instrument warm boxes.
- Cylindrical Part: use of ISO hardware unchanged
- Upper Part:
  - Replace Auxiliary Tank of ISO by the HERSCHEL AXT and Optical Bench Assembly (OBA) with integrated Instrument FPUs (CQM status as close as possible to PFM).
  - Upper Bulkhead (CVV + Shields + MLI) must be consequently of HERSCHEL PFM Design including the Scientific Instrument Harness and the Cryo Control Harness.
- An actively cooled plate in front of the instruments shall provide almost orbit representative background conditions to allow functional and EMC testing of the PLM, especially of the sensitive scientific instruments. The CVV cover qualification model will be used for this purpose, being refurbished afterwards to become the flight spare.

The SVM simulator will be placed in the approximate correct height such as to allow to use flight representative harness lengths and routing. As the CVV connector ring interface at the EQM is shifted about 180mm in +x compared to the PFM, the length of the waveguides are adapted.

Details of the EQM program should be taken from the subsequent chapters and RD3, "Herschel PLM/EQM AIT Plan". As an introduction major steps of the activity flow are given below.

- Disassembly of ISO components not used further on
- Integration of new auxiliary tank and L0 cooling struts
- He S/S tubing re-routing/completion
- Re-routing of CCH
- Closure PLM lower / upper part
- Closure of cryostat for training phase with temporary installed items
  - OB template
  - ECCP
  - CVV connector ring with blind flanged vacuum connector feedthrougs
- Evacuation and leaktest
- Move PLM in cleanroom class 100 000 into test dolly
- *Training phase*
  - Connection of cryo. SCOE
  - SFT warm
  - Cool down and filling; adjustment strap of strap pretension
  - SFT cold
  - He II production AXT
  - SFT He II conditions

- *End of training phase*
- Move PLM in clean room class 100 integration dolly
- Open cryostat upper part
- Deintegrate temporary installed items
- Integration of AXT LO struts (if not already done)
- Integration of OBA
- Connection of optical bench ventline
- Preintegration of CCH and SIH
- Integration of intermediate thermal shields
- Integration of connector ring
- Continue CCH and SIH integration (vacuum feedthrough connectors in intermediate ring)
- Integration of FPU's and connecting of L0 and L1 cooling straps
- Alignment FPU's vs. OBA
- Final integration of instrument harness
- Integration of OBA shield and instrumentation
- Closure of CVV upper part (thermal shields, upper bulkhead and filling port/SV121)
- Integration of LOU
- Alignment LOU vs. OBA
- Integration of cryo. cover
- Installation of vacuum pumps
- Evacuation and leak test
- Transport to clean room 100 000 into test dolly

Amongst detailed activities, the sequence comprises 3 essential activity blocks:

- ISO QM refurbishment and modification
- Integration of Herschel specific components
- Tests

8 EMC ASPECTS

8.1 General

This EMC design is based on the grounding concept meanwhile best justified in the space businesses: The Distributed Single Point Grounding Concept (DSPG). The quality of the DSPG concept determines the EMC performance of the equipment, the instruments and HERSCHEL.

Good quality means in general:

- All bonding have been made low resistive and low inductive, considering thermal constraints,
- Digital interfaces are differential with optimised balanced signals,
- Analogue TM/TC and non-differential interfaces use lines isolated from ground.

Grounding and Isolation

The grounding scheme comprises a DSPG system for minimum noise pick-up as well as a minimum of emissions. The principle is based on the use of single ended or differential driver interfaces in combination with differential receivers or optically coupled interfaces. As a feature derived from ISO, there is no dedicated ground connection for the cryostat foreseen, i.e.: Grounding of the cryostat will be accomplished by overall shield mesh between the cryostat and the SVM, i.e. by cable bundles overall shield and coaxial outer conductors only.

8.2 Harness Design

For a good EMC design of the HERSCHEL harness the following two tasks were essential:

1. Minimise emission of- and susceptibility to radiated electromagnetic fields, i.e.
    a) optimise shielding effectiveness (SE) of shield
    b) route of harness as close as possible to structure in order to minimise structure loops
    c) intermediate grounding of the cable shields, where possible
2. Minimise emission of- and susceptibility to conducted noise, i.e.
    a) apply wire twisting
    b) use impedance balanced lines for a wire pair (same cable lengths and type)
    c) minimise cable lengths

For Herschel we can distinguish 3 types of harness, the SVM harness, the CVV external cryo harness and the CVV internal cryo harness. For the EQM the selection of a built standard for each harness type has to consider the rules applicable for electrical and configurational representativity as well as configurational flexibility necessary to perform the different kinds of tests on the EQM PLM together with the avionics models of the SVM.

Details of all the harness design objectives and compromises will be reflected in the relevant HERSCHEL harness design documentation.

a) SVM harness (Copper, flight harness):

Flight harness are used to interconnect the so called "avionics models" . Thermal constraints do not exist, therefore we use copper harness as usual.

b) CVV external cryo harness:

For the external Cryo Harness we use SST or Brass lines. Each cable bundle or separate routed line is properly overshielded by a Manganin braid in order to optimise the shielding efficiency under consideration of the thermal constraints.

c) CVV Internal Cryo Harness (SST flight harness):

Thermal and mission constraints (lifetime) dictate the use of SST for the cryo harness outside the cryostat as well as inside the cryostat.

9 STRAYLIGHT AND GROUND TESTING

The selected optical configuration during ground testing is described here shortly. It is planned to operate the instruments with an optical background similar to that expected in orbit. A configuration had to be found with closed cryostat entrance and appropriate optical background. Earlier solutions have been replaced by a concept with concave mirrors placed on to the cryocover, i.e. both PACS and SPIRE view onto a dedicated concave mirror. Closely related to that subject is the straylight to be expected during the ground test with a warm CVV ring.

A further basis for the work done here is the requirement on the optical background during ground testing. This requirement is evaluated in detail in RD 19; it is shown that the associated accuracy of 25% (in terms of an absolute accuracy) can be considered as a goal, but not guaranteed. However, on a relative basis the optical radiance can be adjusted to a broad range of optical background desired by the scientists with good accuracy.(see cryo cover description PFM)

The technical solution found has the properties

- ground testing does not induce intolerable straylight for the experiments
- thermal/straylight problems of a black cryocover in orbit are avoided
- contamination hazard is reduced.

The straylight results are given (as usual) in % with 100% = telescope irradiation (70 K, total ε=0.03). If the telescope will have a substantially lower emissivity (present tendency), then these relative values will increase accordingly.

The results for scattered light shows a value of 5.8% for SPIRE while the value found for PACS is 2.7%. This difference is mainly due to the position of the SPIRE thermal filter 1 near to the SPIRE entrance, the corresponding PACS filter is positioned far away from the entrance.

The diffraction calculations show satisfactory values for most cases. Exceptions are

- long wavelengths of SPIRE
- the case of experiment internal misalignment with a direct view from the detectors onto strongly irradiated edges (also relevant for beam chopping within PACS towards the internal calibration devices).

10 PA ASPECTS

10.1 Overview

In order to ensure the usefulness of the obtained qualification results as explained in Para. 4 in relation to the Herschel EPLM the following PA tasks will be implemented during the Herschel EQM programme:

Remark: It has been decided, that no structural qualification is performed with the Herschel EQM. Therefore only structural design and test requirements as applicable for pressure-, vacuum vessels, ground test equipment and cryogenic liquids (He-I and -II) will be implemented. No requirements as applicable for flight hardware with respect to static- and vibration- loads will be respected.

10.2 Product Assurance

10.2.1 Product Assurance Organisation

In order to ensure effective product assurance management a Product Assurance Organisation has been established as mentioned in Para.2.1 of the Document: HP-2-ASED-PL-0007; Product Assurance Plan for Herschel E-PLM & S/C AIT.

The Herschel Product Assurance Manager is René Stritter.

10.2.2 Key and Mandatory Inspection Points

In order to minimise risks during integration and tests, Key and Major Inspection Points will be defined in the manufacturing, assembly and test flow at critical points and will be performed according to Para. 10.5.2

10.2.3 Product Assurance Reporting

Reporting on the progress and status for the PA programme will be performed
as defined in Para. 3.4 of RD [06]

10.2.4 PA Procedures

The PA- team will support the establishing of procedures as mentioned in Para. 3.5 of RD [11]

10.2.5 Configuration control

Configuration control will be carried out by the project configuration management in accordance with the configuration management plan as mentioned in Para 3.7 of RD [11]. The procedures utilised by configuration management will be checked by PA to ensure that the as built status is recorded and conforms to the applicable as designed referenced baseline

10.2.6 Qualification Status Reporting

Astrium will prepare a qualification status list (QSL) for the Herschel EPLM which gives also reference to the qualification results reached with the Herschel EQM tests as mentioned in Para. 3.9 of RD [11]

10.3 Safety Assurance

A Safety Assurance Programme as mentioned in Para. 5 of RD [11] will be established in order to initiate safety provisions and to demonstrate that an appropriate safety programme is implemented in accordance with the ECSS-Q-40A. The Safety precautions to be attended for the Herschel EQM are mentioned in the Herschel PLM EQM AIT Plan. RD [03]

The following activities will be performed:

- Safety Testing will be performed if necessary for FM
- Training of personnel for hazardous operations will be implemented if necessary for Herschel EQM
- NCRs established at ISO STM/ QM will be reviewed about impact to safety hazards & items.

10.4 Components Quality and Procurement Control

In general, requirements as defined in Par. 6 of RD [11] will be respected. Due to availability reasons and due to the fact that components & parts developed from ISO STM/ QM will be used, also parts with Non Hi-Rel. Standard shall be used for the Herschel EQM. This shall be evaluated by review of the related ISO ADPs and complete components and parts list for the Herschel EQM and treated via summary RfW.

(See matrix overview to major components used for EQM mentioned under Para.10.6)

10.4.1 Mechanical Parts, Material and Process (PMP) Control

The PMP Programme will be implemented in such a way that the requirements of ECSS-Q-70A/ PSS-01-700 will be taken into account as mentioned in Para 7 of RD [11]

10.5 Quality assurance

10.5.1 Design and Drawing reviews

Design and drawing review control will be established as mentioned in Para 8.2 of RD [11] i. e. the following activities will be performed

- Review and approval of design specifications carried out by PA engineers and participation on the Change Control Board (CCB) activities in the frame of EQM
- All units and assemblies used in qualification and flight hardware will be described by drawings, all drawings will be reviewed by QA for compliance with the QA requirements.

10.5.2 KIP / MIP

KIP and MIP as explained in Para 3.3 of RD [11] will be performed

- KIP: Key inspection points, to be carried out on contractor level only
- MIP: Mandatory inspection points, to be carried out by contractor with the attendance of higher level contractor and / or ESA

The planned KIPs / MIPs for the EQM are defined in the Document Herschel AIT Plan for EQM, RD [03]

10.5.3 Assembly, Integration and Test (AIT) Control

The assembly, integration and Test Control will be established as described in Para. 8.7, RD [11] i.e. the following activities will be performed:

- An AIT Plan has been established see RD [03]
- Test procedures will be established and applied
- Test Facilities/ Test equipment required to conduct the test programme has been specified in the EQM- AIT plan
- Test Readiness Reviews (TRR) and Post Test Reviews (PTR) will be held
- Historical Records (Logbook) will be established for all operations and tests
- Test reports will be provided for each performed test

10.5.4 Cleanliness and Contamination Control

Cleanliness and contamination control activities will be defined and performed in order to ensure proper function of the Helium Subsystem, reaching the required vacuum level and in order to ensure the required contamination level for the Herschel Instruments which shall be integrated into the EQM hardware.

PA will be responsible for the cleanliness monitoring and control through Herschel EQM AIT phases.

All control and monitoring activities are defined and explained in the Contamination Control Plan RD12

10.5.5 Non- conformance Control

Non conformance system as applicable & mentioned in Para 8.9 of RD [11] will be applied for the Herschel EQM.

NCRs established during tHe-ISO STM/ QM Program will be reviewed for an impact to the quality of components which shall be used again for the Herschel EQM and about Safety Critical Items for attention to the Herschel EQM test program.

10.6 Overview of major components to be used for the Herschel EQM

Major Hardware components	Hardware Definition (equal to / only)	Taken from ISO (STM / QM / FS)	Visual inspection 1)	cleaning 2)	calibration	leaktest	NDI	Refurbishm. to be performed	Acceptance (test) to be perfomed	Hi- Rel part 3)	Non Hi- Rel 4)	Remarks
Cryostat Vacuum Vessel						x						leaktest with integrated components, 5)
Cryostat Upper Bulkhead	**H** (E-PLM)								x			(NDI + leaktest included)
Intermediate Ring	**H** (EQM)								x			(NDI + leaktest included)
Cryostat Cylinder	**I**	**STM/QM**	x									
Cryostat Lower Bulkhead	**I**	**STM/QM**	x									
Cryostat Insulation						x						(on assy. Level)
1st/ 2nd/ 3rd Rad. Upper Bulkhead Thermal Shields	**H** (E-PLM)								x			
1st/ 2nd/ 3rd Rad. Interm. Cylinder Thermal Shields	**H** (EQM)								x			
1st/ 2nd/ 3rd Rad. Cylinder Thermal Shields	**I+**	**STM/QM**	x	x		x						
1st/ 2nd/ 3rd Rad. Lower Bulkhead Thermal Shields	**I**	**STM/QM**	x									
Optical Bench Shield	**H** (E-PLM)								x			
Cryostat MLI												
1st/ 2nd/ 3rd Rad. Shield Upper Bulkhead MLI	**H** (E-PLM)		x									
1st/ 2nd/ 3rd Rad. Interm. Cylindrical Shield MLI	**H** (EQM)		x									
1st/ 2nd/ 3rd Rad. Cylindrical Shield MLI	**I**	**STM/QM**	x									
1st/ 2nd/ 3rd Rad. Shield Lower Bulkhead MLI	**I**	**STM/QM**	x									
He I tank MLI *(ISO-HeII-tank- MLI)*	**I**	**STM/QM**	x									
Optical Bench Shield MLI	**H** (E-PLM)		x									
Auxiliary Tank MLI *(He II- tank)*	**H** (EQM)		x									
QM Delta MLI	**H** (EQM)		x									
Upper Lower Tank Support Frame												
Upper& lower Spatial Framework	**I**	**STM/QM**	x									
Upper& lower Tank Support	**I**	**STM/QM**	x									
Upper& lower Chains	**I**	**STM/QM**	x									
Strap Pretension Devices 15 piece	**I**	**STM/QM**	x									
Strap Pretension Devices 1 piece	**I**	**FS**	x			x						(replacement due to leak)
Instrument Optical Bench												
EQM Optical Bench Shield	**H** (E-PLM)								x			
Optical Bench Structure	**H** (E-PLM)								x			
Interface Brackets to SFW Fasteners	**H** (E-PLM)								x			
Instrument Thermal Connectors (cooling straps)	**H** (E-PLM)								x			
Instruments												
PACS												
PACS-CQM	**H** (E-PLM)								x			Cust. Furn. item
PACS-Interface-Solid to OB (screws, etc)	**H** (E-PLM)								x			
PACS-Cryo-Interface (cooling straps)	**H** (E-PLM)								x			
PACS-Harness	**H** (E-PLM)								x			Cust. Furn. item
PACS-Alignment References	**H** (E-PLM)								x			

Major Hardware components	Hardware Definition (equal to/ only)	Taken from ISO (STM/ QM/ FS)	Visual inspection 1)	cleaning 2)	calibration	leaktest	NDI	Refurbishm. to be performed	Acceptance (test) to be perfomed	Hi- Rel part 3)	Non Hi- Rel 4)	Remarks
HIFI												
HIFI-CQM	**H** (E-PLM)								x			Cust. Furn. item
HIFI-Interface-Solid to OB (screws, etc)	**H** (E-PLM)								x			
HIFI-Cryo-Interface (cooling straps)	**H** (E-PLM)								x			
HIFI-Harness	**H** (E-PLM)								x			Cust. Furn. item
HIFI-Alignment References	**H** (E-PLM)								x			
SPIRE												
SPIRE-CQM	**H** (E-PLM)								x			Cust. Furn. item
SPIRE-Interface-Solid to OB (screws, etc)	**H** (E-PLM)								x			
SPIRE-Cryo-Interface (cooling straps)	**H** (E-PLM)								x			
SPIRE-Harness	**H** (E-PLM)								x			Cust. Furn. item
SPIRE-Alignment References	**H** (E-PLM)								x			
Cryostat Helium Subsystem												
Main tank (He- I)*(ISO-HeII-tank)*	**I**	**STM/QM**	x			x						leaktest with integr. Components & piping
Plug mounted instead PPS 111	**H** (EQM)								x			No PPS 111 necessary
Direct Liquid Control Measurement Device 1/ H101-I/ T101	**I**	**STM/QM**	x									mounted without function
Direct Liquid Control Measurement Device 2/ H102-I/ T102	**I**	**STM/QM**	x									mounted without function
Helium Level Probe L101-I	**I**	**STM/QM**										defect - not used
Helium Level Probe L102-I	**I**	**STM/QM**										defect - not used
Tank Heaters H103-I/ H104-I	**I**	**STM/QM**										
Helium Rupture Disk RD124	**I**	**STM/QM**	x									5.)
He 2 Safety Valve SV123	**I**	**STM/QM**	x									
He 2 Valve SV123 spare	**I**	**FS**	x									used as SV723
Helium Gas Adsorber Foils	**I**	**STM/QM**	x									
Helium Filling Port SV 121	**H** (E-PLM)								x			
Oscillation damper S101	**I**	**STM/QM**	x	x								
Internal Liquid Helium Valve V102-I/ V104-I/ V105-I/ V701-I/ V702-I	**I**	**STM/QM**	x									funcional check to be perf.
Valve heater VH102-E/ VH104-E/ VH103-E/ VH702-E (valve heater foil 90 Ohm)	**I+**	**STM/QM**										
Valve temp. Sensor VT102-E/ VT104-E/ VT105-E	**I+**	**STM/QM**			x						x	
Valve V502	**I**	**STM/QM**	x			x						5.)
Filter S 501	**I**	**FS**	x									
Temperature sensor T502-I	**I**	**STM/QM**	x									
Pressure gauge P101 (BHL 4201-01)	**H** (E-PLM)								x			
Pressure gauge P701-E	**H** (E-PLM)								x			
Pressure gauge P901-I (penning gauge)	**I**	**STM/QM**	x									functional check tbp, 5.)
Pressure gauge P902-I (penning gauge)	**I**	**STM/QM**	x									functional check tbp, 5.)

Major Hardware components	Hardware Definition (equal to / only)	Taken from ISO (STM / QM / FS)	Visual inspection 1)	cleaning 2)	calibration	leaktest	NDI	Refurbishm. to be performed	Acceptance (test) to be perfomed	Hi- Rel part 3)	Non Hi- Rel 4)	Remarks
Safety valve CVV SV921	I	STM/QM	x			x		x				functional check tbp, 5)
Safety valve CVV SV922	I	STM/QM	x			x		x				functional check tbp, 5)
Auxiliary Tank (He- II)	H(EQM)								x			(NDI + leaktest included)
Auxiliary Tank Support (ISO Baffle Tabs)	I+	STM/QM						x	x			
Aux. Tank Level probe L701-I	H(EQM)								x			
Aux. Tank Level probe L702-I	H(EQM)								x			
Aux. Tank Helium Rupture Disk RD72	H(EPLM)								x			
Helium System Tubing												
He- I Tank Tubing (ISO- He II- tank)	I +	STM/QM		x		x	x		x			NDI on new weld. Seams
Additional Ventline Tubing	H(EQM)			x					x			(NDI + leaktest included)
Auxiliary Tank Tubing (He- II tank)	H(EQM)			x					x			(NDI + leaktest included)
Shields Tubing	I +	STM/QM	x									
External Tubing Ventline	H(EQM)			x								
QM Delta Tubing	H(EQM)			x					x			(NDI + leaktest included)
Optical Bench He Ventline	H(EQM)			x					x			(NDI + leaktest included)
Cryostat Control Instrumentation												
Vacuum feed trough Connectors with cables connected to sensorsT106-I/ T801-I/ T802-I/ T803-I/ T804-I/T101-I/ T102-I/ T104-I/ T105-I	I	STM/QM	x			x					x	continuity test and insulation test (low voltage)to be perf.
Vacuum feed trough Electrical Connectors for new instrumentation harness	**H** (E-PLM)					x			x	x		
Electrical Connectors for new scientific harness	**H** (E-PLM)								x	x		
Cryo Control Harness	**H** (EQM)								x			
Scientific Instrument Harnesses	**H** (E-PLM)								x			
External harness	**H** (EQM)								x			
Aux. Tank Heater H701-E/ H702-E	I	STM/QM									x	
Surface Thermometer *(C10)* T106-I/ T801-I/ T802-I/ T803-I/ T804-I	I	STM/QM	x								x	continuity test and insulation test (low voltage)to be perf.
Surface Thermometer *(C 100*, Allen bradley carbon resistor) T104-I/ T105-I	I	STM/QM	x								x	continuity test and insulation test (low voltage)to be perf.
Surface Thermometer *(C 100*, Allen bradley carbon resistor) T202-H/ T204-H/ T206-H/ T208-H/ T212-H/ T213-H/ T221-H/ T222-H/ T223-H/ T224-H/ T225-H/ T226-H/ T227-H/ T228-H/ T221-T/ T222-T/ T223-T/ T224-T/ T225-T/ T226-T/ T227-T/ T228-T/ T232-H/ T233-H/ T234-H/ T235-H/ T236-H/ T237-H/ T242-H/ T244-H/ T246-H/ T248-H/ T250-H/ T252-H/ T254-H/ T256-H/ T258-H/ T702-E/ T703-E/ T705-E/ T706-E/ T862-H/ T961-E/ T962-E/ T971-E/ T972-E/ T981-E/ T982-E/ T983-E/ T232-T/ T233-T/ T234-T/ T235-T/ T236-T/ T237-T/ T238-T/ T239-T/ T261-T/ T262-T/ T271-T/ T272-T/ T273-T/ T274-T/ T274-T/ T275-T/ T281-T/ T282-T/ T285-T/	**H** (E-PLM)				x				x		x	continuity test and insulation test (low voltage)to be perf.
Surface Thermometer *(PT 500)* T103-I/ T422-I/ T423-I/ T424-I/ T442-I/ T443-I/ T444-I/ T462-I/ T463-I/ T464-I/ T501-I/ T805-I/ T806-I/ T807-I/ T808-I/ T851-I/ T852-I/ T853-I/ T854-I/ T855-I/ T856-I/ T857-I/ T858-I/ T851-I	I	STM/QM	x								x	continuity test and insulation test (low voltage)to be perf.

Major Hardware components	Hardware Definition (equal to/ only)	Taken from ISO (STM/ QM/ FS)	Visual inspection 1)	cleaning 2)	calibration	leaktest	NDI	Refurbishm. to be performed	Acceptance (test) to be perfomed	Hi- Rel part 3)	Non Hi- Rel 4)	Remarks
Surface Thermometer *(PT 1000)* T102-E/ T104-E/ T105-E/ T211-H/ T231-H/ T241-H/ T243-H/ T245-H/ T247-H/ T249-H/ T251-H/ T253-H/ T255-H/ T257-H/ T423-H/ T424-H/ T443-H/ T444-H/ T463-H/ T464-H/ T701-E/ T702-E/ VT704-E/ T861-H/ T901-E/ T902-E/ T921-H/ T922-H/ T931-H/ T932-H/ T933-H/ T934-H/ T935-H/ T963-E/ T964-E/ T973-E/ T974-E/ T984-E/ T991-E/ T992-E/ T993-E/ T994-E	**H** (E-PLM)				x				x		x	continuity test and insulation test (low voltage)to be perf.
Heater (tbd) H961-E/ H962-E/ H971-E/ H972-E/ H981-E/ H984-E/ H991-E	**H** (E-PLM)								x		x	
Cryostat Electrical Subsystem												
Cryostat Control Electronic	**H** (E-PLM)								x			
PLM external components												
Optical Windows and Filters Support Frames	**H** (E-PLM)								x			
LOU Support Structure	**H** (E-PLM)								x			
LOU Waveguide Mounting Devices	**H** (E-PLM)								x			
LOU-Beam Feed Baffle FPU-CVV	**H** (E-PLM)								x			
Instrument Secondary Structure (SVM Simulator)	**H** (E-PLM)								x			
Cryostat Cover	**H** (E-PLM)								x			

Column Hardware Def:

I = identical to ISO (STM/ QM/ FS taken from ISO)
I+= ISO design + modification
H= new design (EQM design only for EQM)
H= new design (E-PLM design identical to E-PLM)
NDI= Non destruct. Inspect. (x-ray, penetr. Inspection)

1) Depending of accessibility, further actions on behalf of NCR
2) Additional cleaning to the stand. cleaning during AIT flow
3) Procured with PAD sheet acc. ECSS
4) Commercial Standard, design equal to Hi-Rel
5) Viton Sealing rings to be replaced by new one´s

Table 10-1: Major Hardware Components

11 SUMMARY

The described EQM is an efficient way of supporting early instrument testing for HERSCHEL . The re-use of the ISO cryostat and of ISO components is possible by the basic commonality in size of the cryostat for both systems. In addition, ISO technologies are used again and allow the improvement of items like:

- the LHe valves
- thermal isolation techniques
- generation of HeII
- separation of LHe from gas
- temperature and pressure measurement
- the general cleaning and filling procedures.

The Herschel EQM is optimized for early instrument testing. Thanks to similar dimensions of the Herschel PLM and the ISO PLM, the ISO QM cryostat can be used to accommodate the Herschel QM optical bench with all the scientific instruments FPU CQMs on top of the ISO HeII-tank.

A Herschel specific auxiliary tank (AXT) will be placed inside the torus of the ISO HeII-tank. The instrument CQMs will be thermally linked to this AXT via special level 0 struts. This tank will be filed with Helium II to ensure correct temperatures during Herschel instrument testing. A separate and independent tubing for the AXT and the OBA allows adjusting nearly orbit representative mass-flow with nearly orbit representative thermal environment.

The QM cover with a cooled mirror helps fulfilling the optical requirements for the specific instruments tests.

END OF DOCUMENT

	Name	Dep./Comp.		Name	Dep./Comp.
X	Alberti von Mathias Dr.	SM 34		Stauss Oliver	SM 33
X	Alo Hakan	OTN/TP 26			
X	Barlage Bernhard	ED 11		Steininger Eric	ED 422
X	Bayer Thomas	ED 541	X	Stritter Rene	ED 11
X	Faas Horst	EA 65	X	Tenhaeff Dieter	SM 34
	Fehringer Alexander	SM 33		Thörmer Klaus-Horst Dr.	OTN/ED 65
	Frey Albrecht	ED 422		Wagner Klaus	SM 31
X	Gerner Willi	ED 11	X	Wietbrock, Walter	ED 521
	Grasl Andreas	OTN/EN 64		Wöhler Hans	SM 34
	Grasshoff Brigitte	ED 521			
X	Hauser Armin	SM 31			
X	Hinger Jürgen	SM 31	X	Alcatel	ASP
X	Hohn Rüdiger	ED 541	X	ESA/ESTEC	ESA
	Hölzle Edgar	ED 421			
X	Huber Johann	ED 543		**Instruments:**	
X	Hund Walter	SE 76		MPE (PACS)	MPE
X	Idler Siegmund	ED 432		RAL (SPIRE)	RAL
X	Ivády von András	ACE 32		SRON (HIFI)	SRON
X	Jahn Gerd Dr.	SM 31			
	Kalde Clemens	ED 532			
	Kameter Rudolf	OTN/EN 64		**Subcontractors:**	
	Kersting Stefan	OTN/EN 64		Air Liquide, Space Department	AIR
X	Kettner Bernhard	SM 34		Air Liquide, Space Department	AIRS
X	Knoblauch August	ED 531		Air Liquide, Orbital System	AIRT
X	Koelle Markus	ED 523		Alcatel Bell Space	ABSP
X	Kroeker Jürgen	ED 65		Astrium Sub-Subsyst. & Equipment	ASSE
X	Kunz Oliver Dr.	SM 31		Austrian Aerospace	AAE
X	Lamprecht Ernst	OTN/SM 222		Austrian Aerospace	AAEM
X	Lang Jürgen	SE 76		APCO Technologies S. A.	APCO
X	Langfermann Michael	ED 541		Bieri Engineering B. V.	BIER
X	Mack Paul	OTN/EN 64		BOC Edwards	BOCE
X	Muhl Eckhard	OTN/EN 64		Dutch Space Solar Arrays	DSSA
X	Pastorino Michel	ASPI Resid.		EADS CASA Espacio	CASA
	Peitzker Helmut	ED 65		EADS CASA Espacio	ECAS
	Peltz Heinz-Willi	SM 33		EADS Space Transportation	ASIP
	Pietroboni Karin	ED 65		Eurocopter	ECD
	Platzer Wilhelm	ED 23		HTS AG Zürich	HTSZ
X	Puttlitz Joachim	OTN/EN 64		Linde	LIND
	Rebholz Reinhold	ED 541		Patria New Technologies Oy	PANT
X	Reuß Friedhelm	ED 62		Phoenix, Volkmarsen	PHOE
X	Rühe Wolfgang	ED 65		Prototech AS	PROT
	Runge Axel	OTN/EN 64		QMC Instruments Ltd.	QMC
	Sachsse Bernt	ED 21		Rembe, Brilon	REMB
X	Schink Dietmar	ED 422		SENER Ingenieria SA	SEN
X	Schlosser Christian	OTN/EN 64		Stöhr, Königsbrunn	STOE
	Schmidt Rudolf	ACE 32		Rosemount Aerospace GmbH	ROSE
X	Schweickert Gunn	SM 34		RYMSA, Radiación y Microondas S.A.	RYM