FIRST/PLANCK

Science Team Presentation

3. FIRST Payload Module

3. FIRST PAYLOAD MODULE

3.1 Instrument Requirements

Mechanical Interfaces:

BOL: 690 x 410 x 410 mm irregular, 29.3 kg,

PHC: 690 x 530 x 410 mm irregular, 32 kg
shape now change to 690 x 470 x 410 mm irregular

HET: 400 x 310 (530 incl. M3) x 372 mm irregular, 25 kg

Electrical Interfaces:

BOL: 424 wires, 45 shields (15 to 70K-level)
PHC: 309 wires, 68 shields (15 to 300K-level)
HET: 404 wires, 9 shields (15 to 300K-level)

Optical Interfaces:

- Focus of Telescope now 222 mm above Optical Bench
- Absolute Alignment Requirements of FPU's w.r.t Optical Bench as given in IID B's

	Δx	Δy	Δz	Θx	Θyz (comb.)
BOL 1	± 1 mm	± 1 mm	± 1mm	± 5′	± 3′
PHC 1	± 1 mm	± 1 mm	± 1 mm	± 5′	± 3′

Alignment requirements as given by HET-scientists during IID clarification meeting:

	Δx	Δy	Δz	Θx	Θy	Θz
Focal Plane (M3)[a]	6 mm (tbc)	2 mm	2 mm	0.7°	0.3°	0.3°
LO window[b]	0.9 mm	420 mm	.0.9 mm	0.03°	0.4°	0.03°

[a] Displacements and rotations of instrument are relative to centre of M3
[b] Co-ordinates of reference point are (0, -850, 205)

Thermal Requirements:

Heatloads on 1.7K-level:

1.7K-level	op.	nonop.	serendipity
BOL	2.2 mW	2.1 mW	2.2 mW
PHC	0.3 mW	0.3 mW	0.3 mW
HET	0.13 mW	0.12 mW	
BOL+PHC op,HET nonop.	2.62 mW		
BOL+PHC nonop., HET op.	2.53 mW		
average (2/3 BOL+PHC op., 1/3 HET op.)	2.59 mW		
all nonop.	2.52 mW		

Heatloads on 4.3K-level:

4.3K-level	op.	nonop.	serendipity
BOL	6.7 mW	5.3 mW	6.7 mW
PHC (incl. struct.+harness?)	9.2 mW	1.5 mW	9.2 mW
HET (incl. harness diss?)	4.2 mW	3.1 mW	
BOL+PHC op, HET nonop.	19.0 mW		
BOL+PHC nonop., HET op.	11.0 mW		
average (2/3 BOL+PHC op., 1/3 HET op.)	16.3 mW		
all nonop.	9.9 mW		

Heatloads on 15K-level:

15K-level	op.	nonop.	serendipity
BOL	0.4 mW	0.0 mW	0.4mW
PHC	10.0 mW	0.0 mW	10.0 mW
HET	26.0 mW	0.0 mW	
BOL+PHC op, HET nonop.	10.4 mW		
BOL+PHC nonop., HET op.	26.0 mW		
average (2/3 BOL+PHC op., 1/3 HET op.)	15.6 mW		
all nonop.	0.0 mW		

3.2 Cryostat Design Review

- Design based on ISO (same CVV diameter, identical lower bulkhead, similar He-subsystem and tank suspension)
- 2560 l He II-tank
- Anti-sun side radiator area on CVV used to cool the CVV in orbit, other areas equipped with MLI with aluminium surface
- CVV provides mounting interfaces for the Local Oscillator Assembly, the Startrackers (perhaps), the Telescope Assembly, the Sunshield , the SVM/PLM interface struts and the 2 ^{3}He- and 2 ^{4}He-pressure bottles for the dilution cooler supply of BOL.

- Cryostat Cover derived from IBSS (Infrared Background Signature Survey)-cryostat
- Scientific instruments fixed on an Optical Bench upon the upper Spatial Framework frame (upper HeII-tank fixation)
- Cooling to ≤ 2K-level by direct strapping to the HeII-tank
- ≤ 4.3K-level provided by wheel-shaped heat-exchanger fixed below Optical Bench
- < 23K-level provided by ventline running around the instruments on the Optical Bench

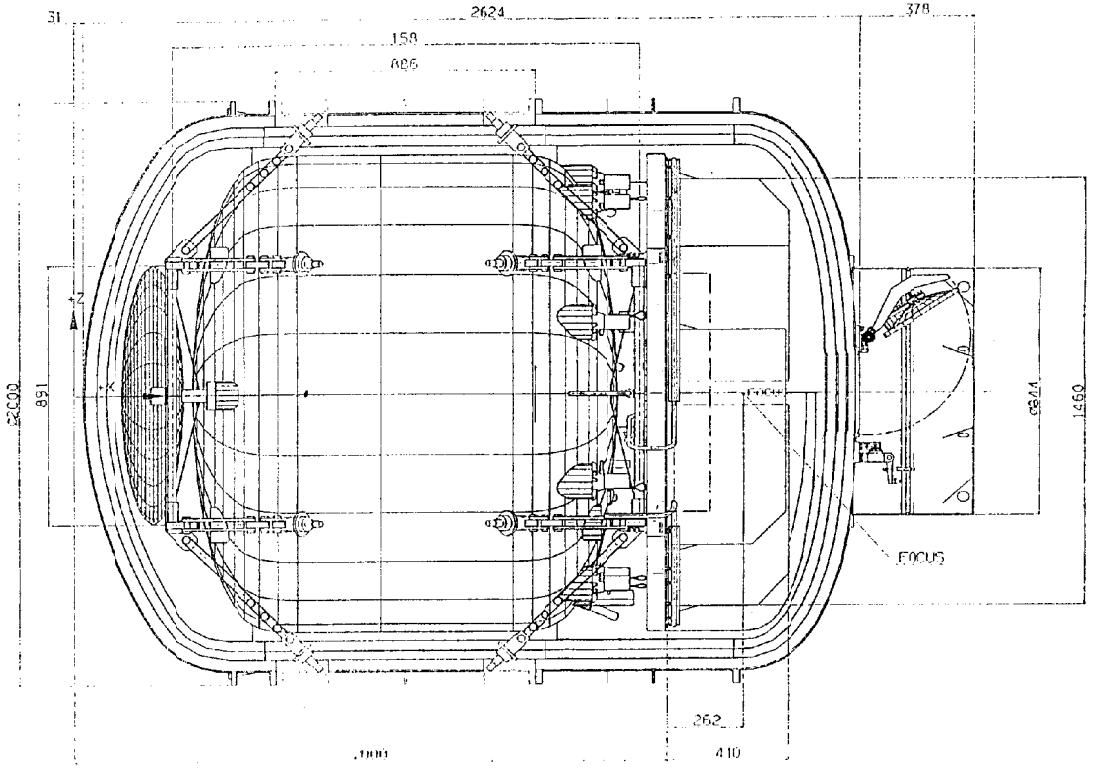


Fig.: FIRST-Cryostat Longitudinal Section

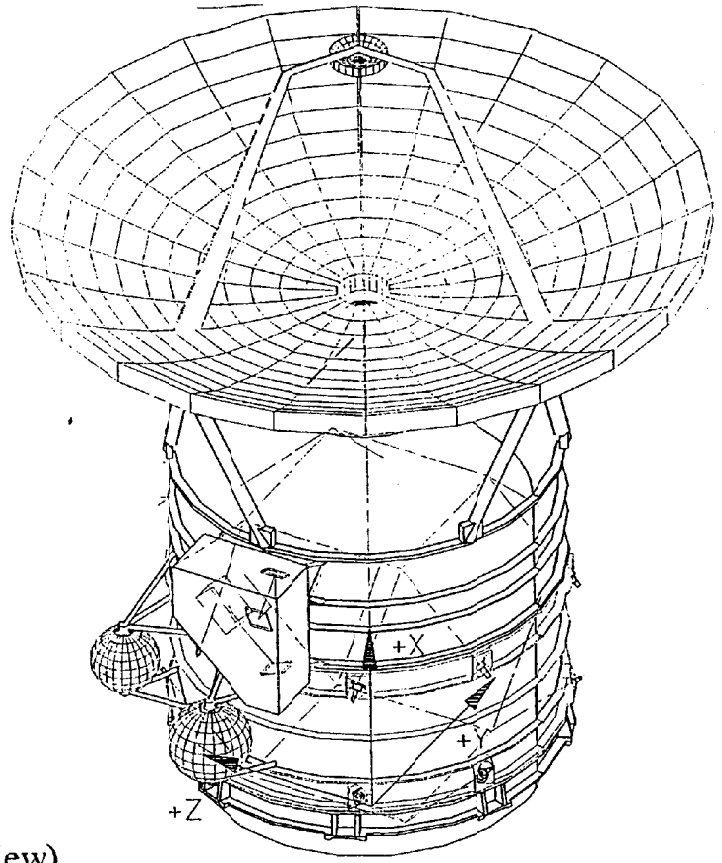


Fig.: FIRST-Cryostat (External View)

Hibernation Mode

- FIRST Instruments switched off → no dissipation in instruments/instrument harness
- resulting massflow reduced by 15 % results in elongated cryostat lifetime

ODS : (Orbital Disconnect Support) Reduction of heatflow by reducing tank strap tension

- gain in lifetime by 17 %

3.3 Instrument Accomodation: Focal Plane Units

Mechanical Interfaces

- For fixation of the Instruments the Optical Bench is equipped with 4 inserts per instrument

- The bolt at the reference hole is fixed, the others are floating to allow for differential expansion w/o misalignment

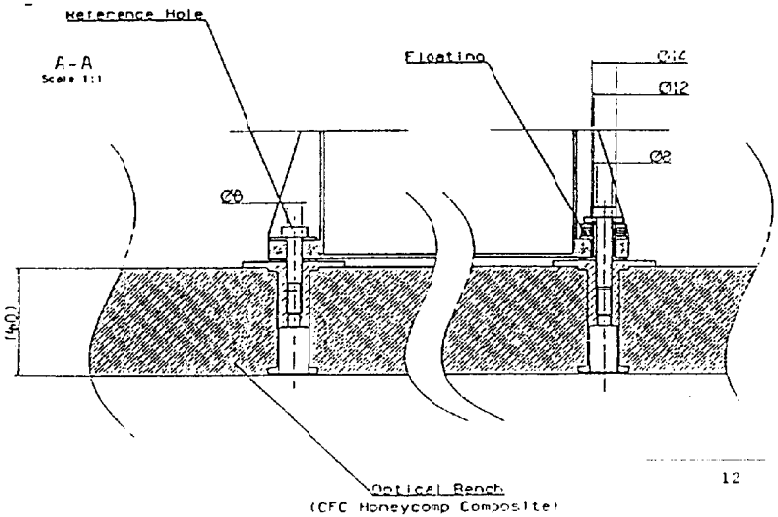


Fig.: Instrument Fixation Principle

updated mechanical instrument dimension implemented

Problem: overlapping of HET with BOL/PHC fixation

Clarification of instrument volume required

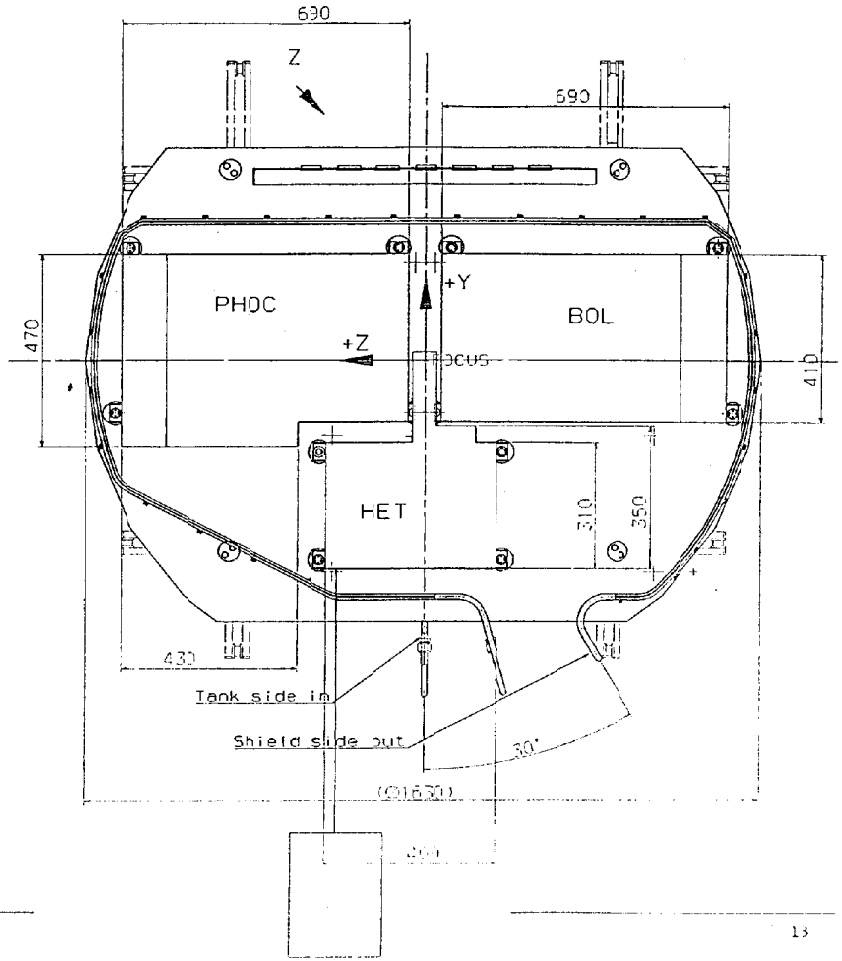


Fig.: Focal Plane top view

Electrical Interfaces:

4 to 15K-level: instrument internal wires (detailed table attached)
Assumptions: Using ISO-Wires and some brass wires similar to ISO-SST-wires
Wires 30 cm long, $\Delta T = 11K$.

	BOL	PHC	HET	sum
SST	7.38 mm²	7.09 mm²	10.00 mm²	24.47 mm²
Brass	0.06 mm²	0.57 mm²	3.24 mm²	3.87 mm²
Teflon	59.09 mm²	70.0 mm²	51.20 mm²	180.29 mm²
CuBe			0.20 mm²	0.2 mm²
CuNi (tubes)	3.6 mm²			3.6 mm²

BOL-Instrument: 0.577 mW diss., 0.423 mW cond.
PHC-Instrument: 1.887 mW diss., 0.619 mW cond.
HET-Instrument: 8.73 mW diss., 1.652 mW cond.

15K-level to CVV: (detailed table attached)

	BOL	PHC	HET	sum
SST	7.85 mm^2	7.93 mm^2	10.00 mm^2	25.78 mm^2
Brass	0.13 mm^2	0.78 mm^2	4.46 mm^2	5.37 mm^2
Teflon	64.08 mm^2	80.41 mm^2	53.09 mm^2	197.58 mm^2
CuBe			0.20 mm^2	0.2 mm^2
CuNi (tubes)	3.6 mm^2			3.6 mm^2

Assumptions: JFET-box on CVV;

1.25 m distance between 15K-level and 1st heatshield, except Bol-wires with 0.35 m.

BOL: 2.07 mW/m diss., 1.34 mW cond.
PHC: 6.46 mW/m diss., 0.58 mW cond.
HET: 23.09 mW/m diss., 1.64 mW cond.

Thermal Interfaces:

≤ 2K-level:

- The ≤ 2K-level is provided by direct strapping to the HeII-tank
- The tank straps are fed through dedicated holes in the OB directly to the interface points on the upper HeII-tank bulkhead
- One silver tank strap (20mm x 1mm cross-section and 30- 40 cm length) per instrument
- Temperature difference between HeII and the instrument will be ≤ 0.05K

≤ 4.3 K-level:

- Wheel-shaped heat-exchanger below the Optical Bench will provide the contact area between the instrument „4.3K"-level and the He-flow from the tank

- The connection between this heat-exchanger and the instrument shall be done by copper-straps as on ISO

- Copper-straps are fixed to the massive spokes of the heat exchanger by clamp, nuts and screws.

- Three copper-straps per instrument

- Temperature difference between instrument internal busbar and He in the ventline ≤ 0.17K for normal operation of instrument (Assumption: 11 mW, 3 copper-straps 20x 1mm cross-section, 12 cm length assumed)

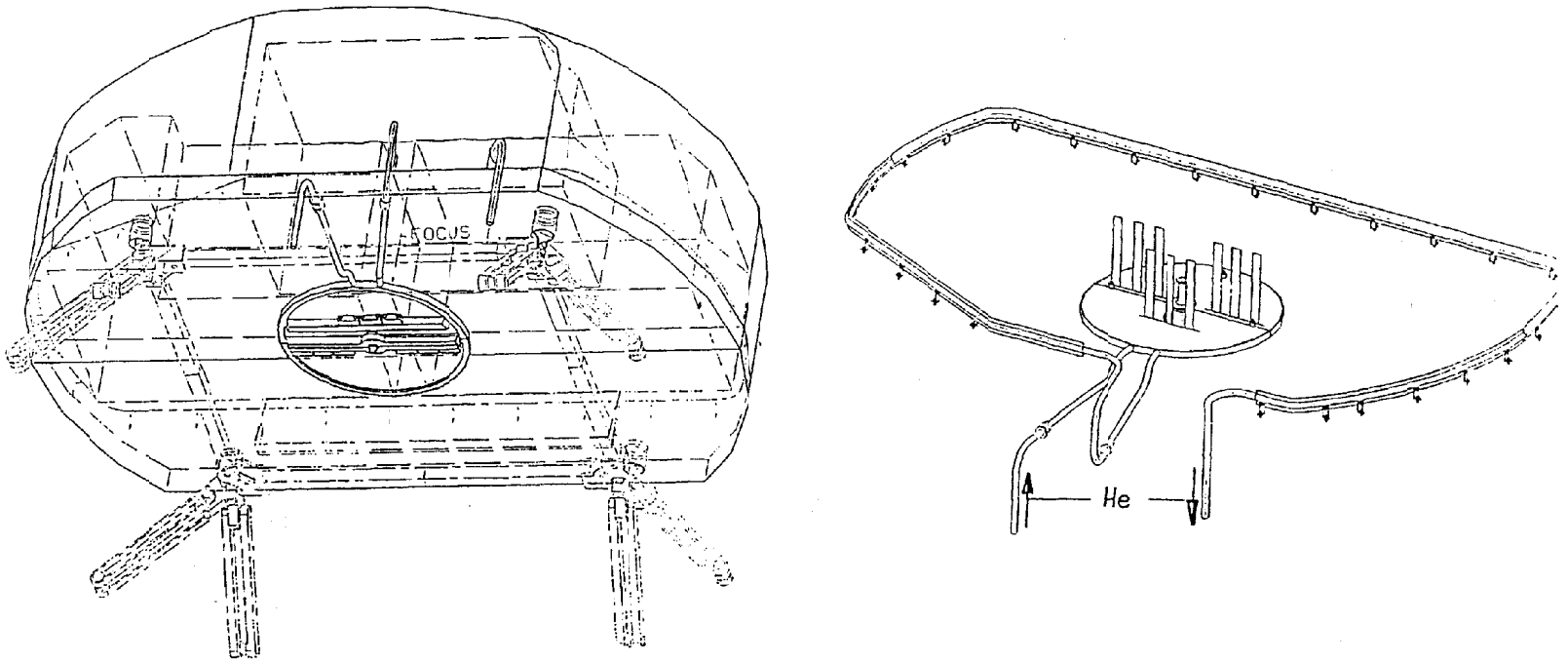


Fig.: Wheel shaped heat exchanger (bottom view with OB and top view w/o OB)

15K-level:

- He-ventline is running around the instruments on the upper OB-side
- The ventline is a finned tube with even an internal fin for optimum heat transfer
- Instruments are connected by copper-straps to this ventline

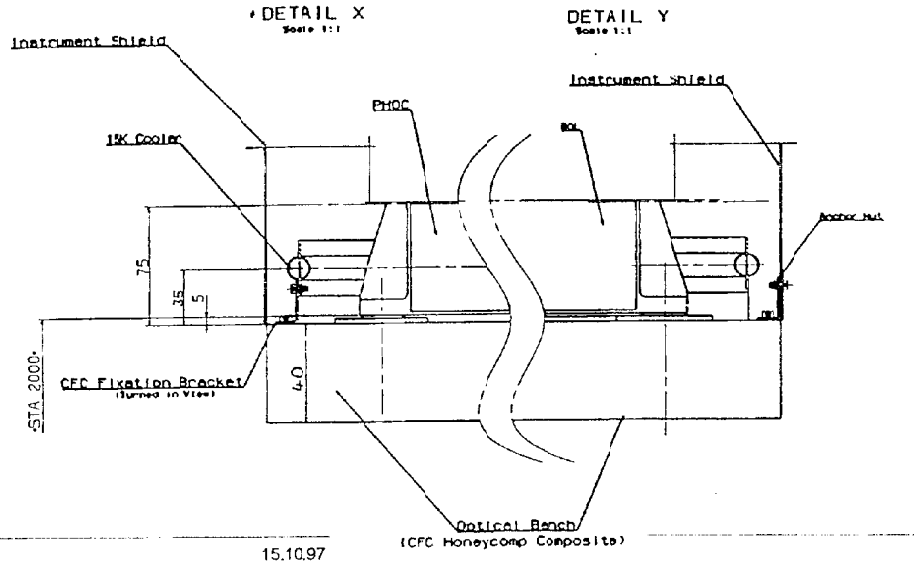


Fig.: 15K-level

Optical Bench and Common Instrument Shield:

- Instruments mechanically fixed but thermally decoupled from Optical Bench:
  to avoid heat-input to HeII-tank via OB and Spatial Framework
  and to avoid thermal interference between instruments

- Optical Bench temperature: about 11 K

- The three instruments are protected by a Common Instrument Shield

- Common Instrument Shield Temperature: about 11 K

Cryostat Baffles:

- Cryostat Baffles are radiatively coupled to the Instrument Entrance Mirrors

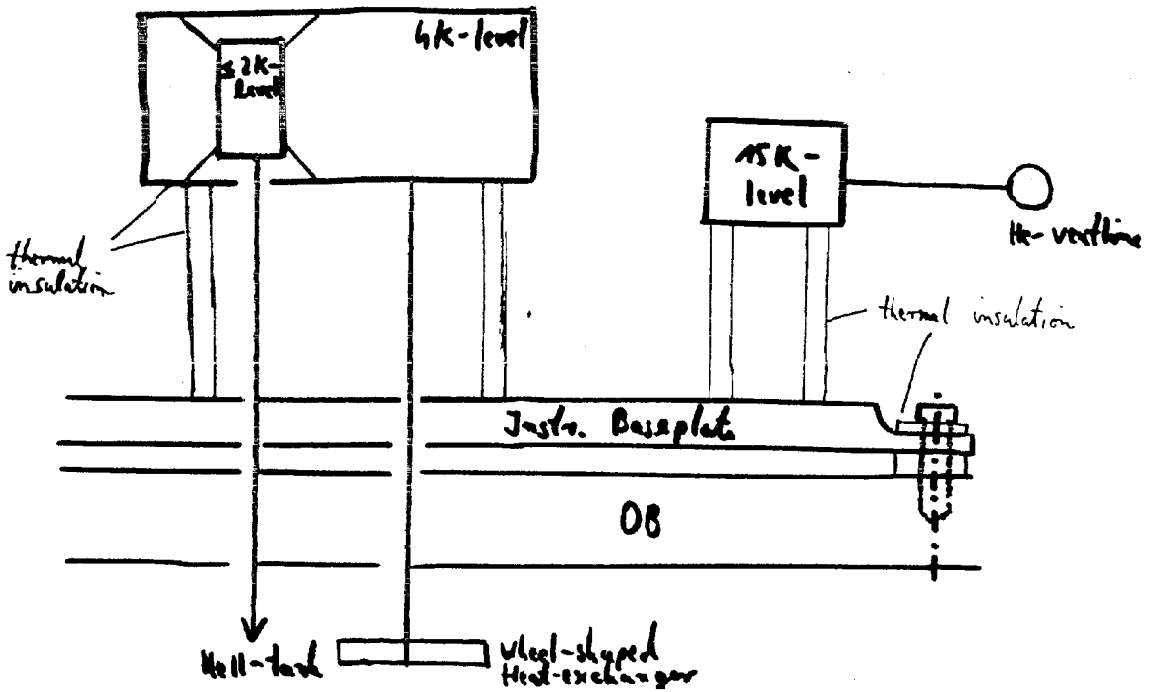


Fig.: Thermal Interfaces

Summary of thermal interfaces:

- Recent instrument dissipations and harness figures implemented in TMM
- Massflow of 1.56 mg/sec, but now very sensitive to instrument dissipation and ohmic dissipation of harness wires
- to provide temperature of ≤ 4.17 K on „ 4.3 K-level", the heatload has to be ≤ 15 mW

JFET module

- Description:
  Size: 500 x 225 x 50 (shape matched to curvature of radiation shield)
  Mass: 5kg
  Power dissipated: 0.4 Watt
  Maximum distance of this unit from the FPU is defined to 500 mm (connected by harness)

Box cannot be fixed to a thermal shield due to high mass and size. (Maximum 1 kg and 30 mm thick) ⇒ Box proposed to be mounted on the CVV

- Harness length along tank straps to CVV is 950 mm (see sketch)
- Minimum harness length can be achieved by horizontal routing to the CVV outside
- Connectors on the instrument box have to be at the outer edge of instrument box

- Number of harness wires routed to JFET box have to be minimized
- Thermal shields need slits to allow integration of the harness

Problem:

- Complicated integration procedure required (to be checked further in detail); problem of accessability of vacuum feedthroughs
- JFET box has to be directly connected to the vacuum-feedthroughs to reduce harness-length
- possible interface problem with Startracker

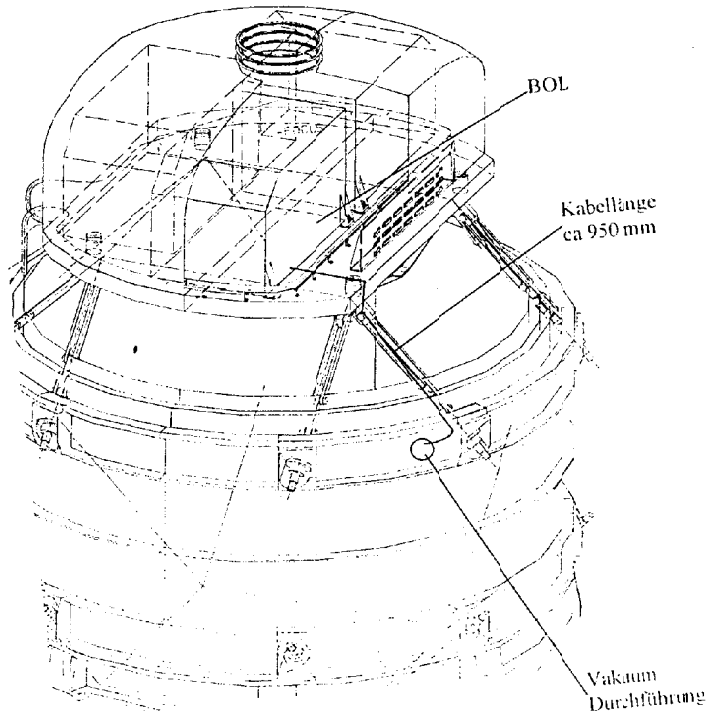


Fig.: Minium distance to CVV along tank-straps

Local Oscillator

- Description:
  Size: 300 x 300 x 220
  Mass: 17kg (includes everything except a strut support)
  Power dissipated: 6 Watt
  Center of LO-box: 222 mm above optical bench
  205 mm distance from y-axis

Problem with actual LOU configuration (1 vertical row with 6 beams)

- the fourth beams hits the stiffening ring between cylindrical part and upper bulkhead

- Two upper beams are located on the upper bulkhead

- Unfavourable configuration , window in stiffening ring not possible, window in upper bulkhead should be avoided

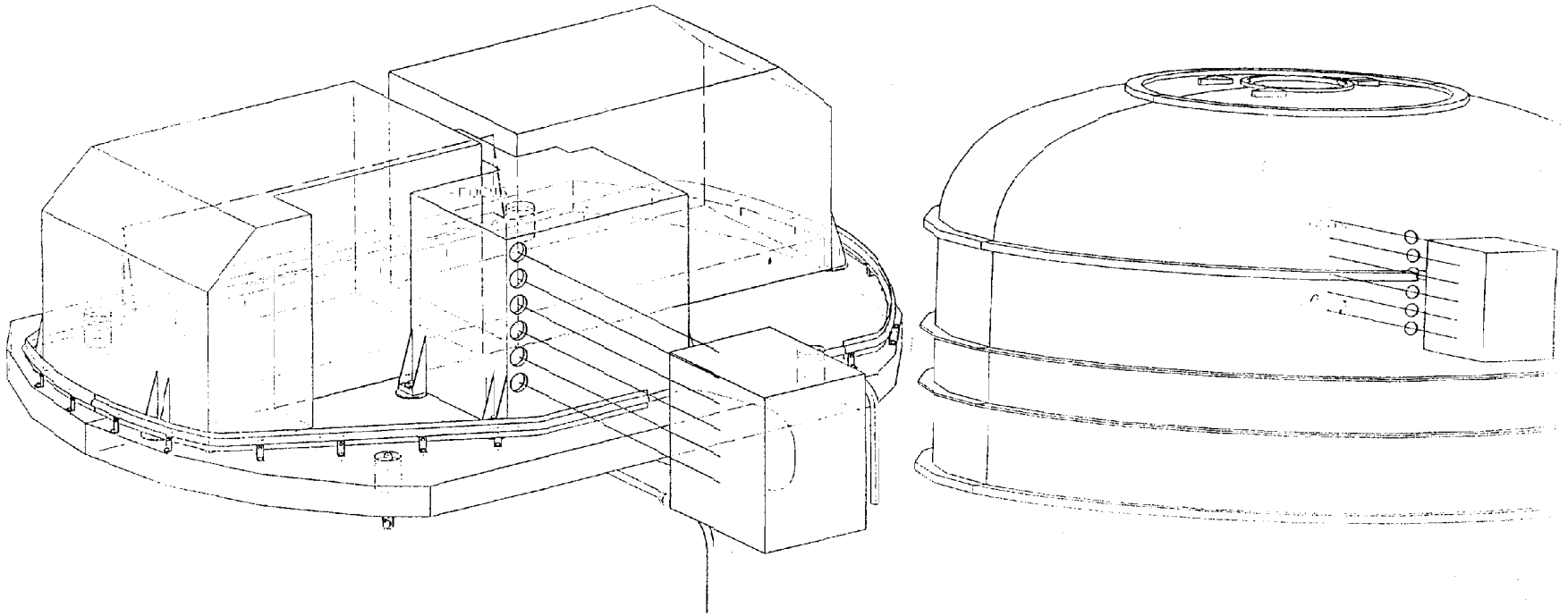


Fig.: LO configuration as proposed by HET

Proposed solution:

- each window has its own flange
- minimal distance between center of the LO-beams 76 mm, only two windows can be arranged in vertical direction
- 2 rows of 3 windows

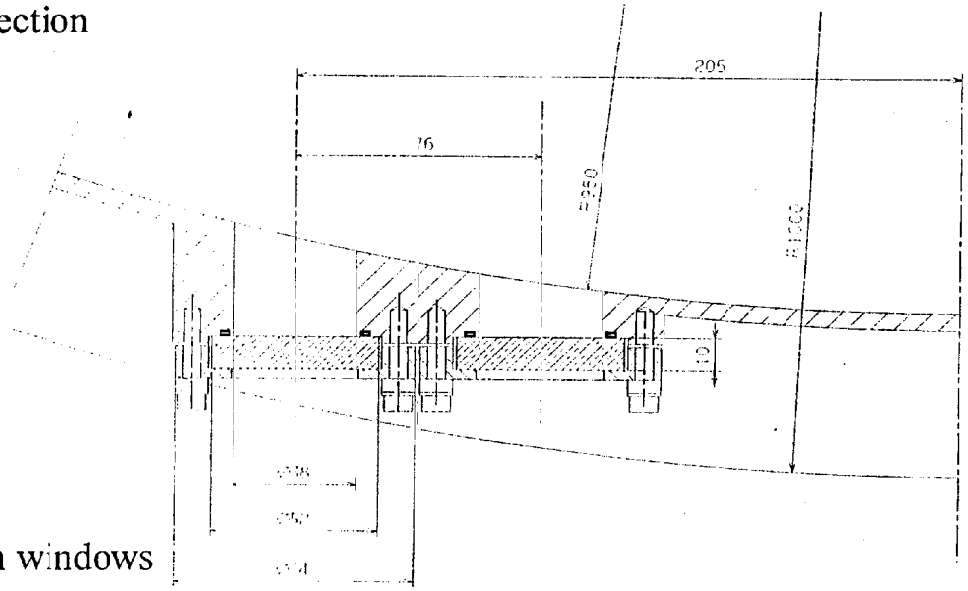


Fig.: Minimal distance between windows

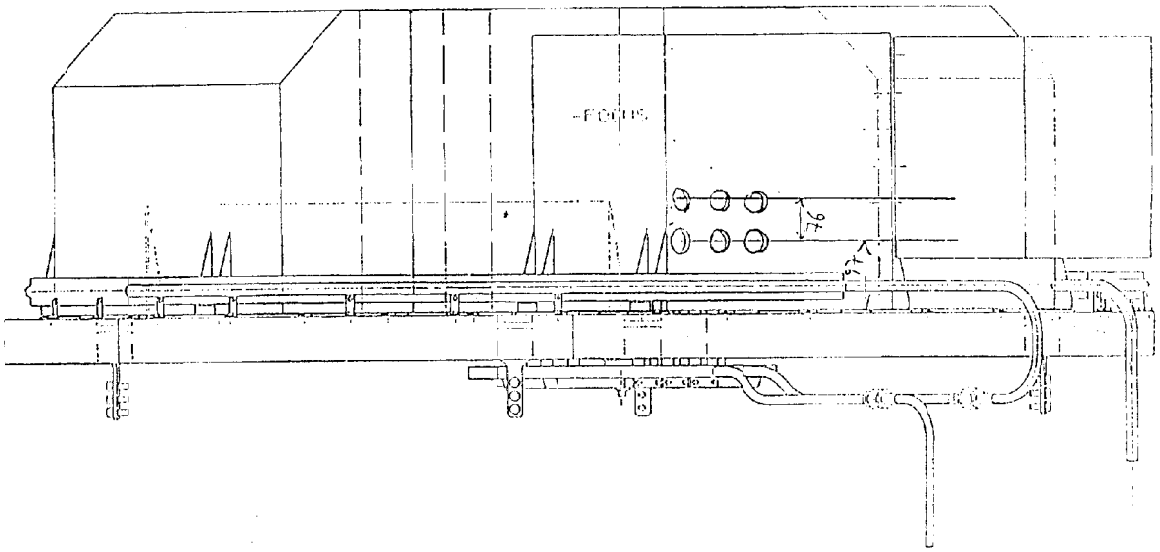


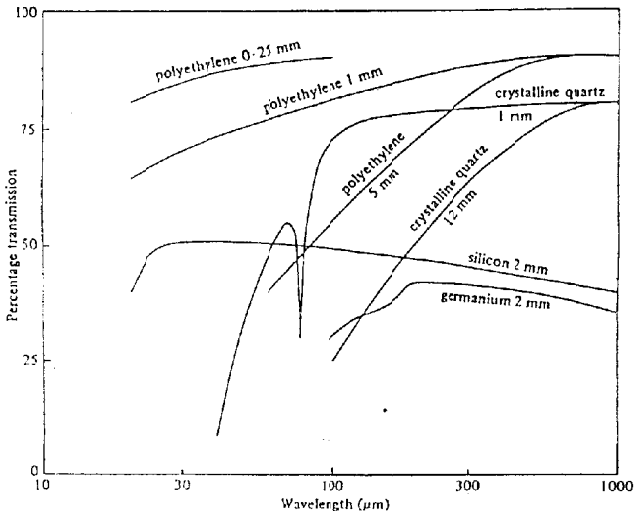
Fig.: New proposed configuration

Transmission of windows:

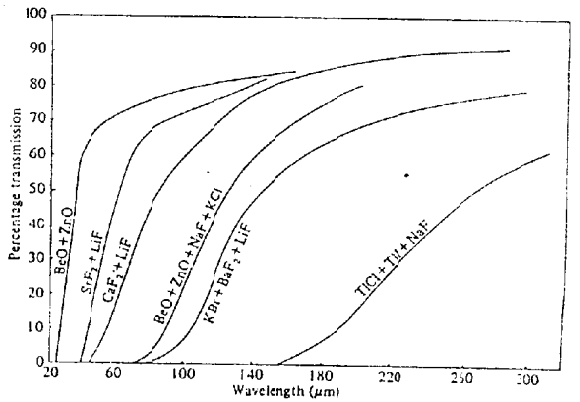
- Requirement: Transmission of 80% in the wavelength range 115 to 187.5 µm and 90% from 240 to 612 µm
- Thickness of 6 mm necessary for window with 36 mm inner free diameter
- Crystalline Quartz as window material

Result of Assessment:

- Assuming a antireflex coating on both sides of the window, the transmission due to absorption will be 56% at 115 µm, 77% at 200 µm and 97% at 600 µm
- The transmission of a filter will be about 80% (polyethylene loaded filter)
- The above given transmission values can not be reached for the shorte wavelength, even assuming a perfect anti-reflection coating



Transmission of window materials (from many sources).



Transmission of polyethylene 'loaded' filters (Yamada *et al.*, 1962).

Fig.: Transmission of window and filter material (Ref.FAR-INFRARED TECHNIQUES, M.F. Kimmitt, Pion Limited 1970)