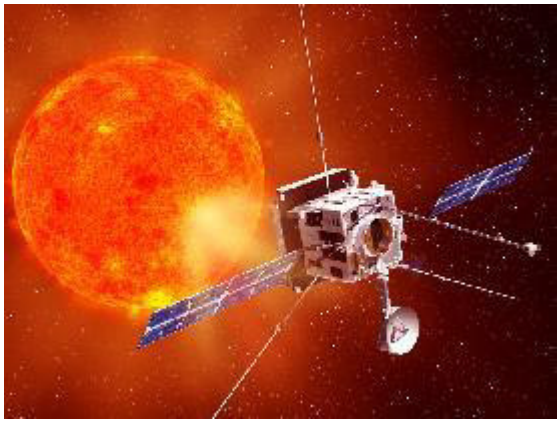

SOLAR ORBITER ENERGETIC PARTICLE DETECTOR

Integration guidelines of EPT-HET1&2 FMs on S/C

Document ID: SO-EPD-KIE-PR-0037

Issue: 1

Revision: 3

Date: 08/11/2016

Note:

Annex A: pre-handover activities.
Annex B: MLI user manual.
Annex C: Contingency plan.

Signature not needed if electronically approved by route

Written	Checked	Approved Configuration Control	Approved QA	Approved Experiment Manager	Approved Principal Investigator
Ravanbakhsh Ali Ravanbakhsh Date and Signature	S.R. Kulkarni Lars Seimetz Bob Wimmer Date and Signature	César Martín Date and Signature	Michael Richards Date and Signature	Date and Signature	Date and Signature

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CHANGES RECORD

Issue	Revision	Date	Modified by	Section / Paragraph modified	Change implemented
1	0	23/09/2016		All	Initial release
1	1	25/10/2016	A.Ravanbakhsh Based on the FAR-RIDs and follow up guidelines from ESA/ADS: FAR-74 and SOL.EPD.MN.00067.pdf	Sec. 3.2	[RD-6],[RD-7]&[RD-8] have updated revisions.
				Sec.4	STEP 15-1 added for S/C I/F MLI actions.
					STEP 65-1 added for S/C I/F MLI actions.
					STEP 65: screw locking with scotchweld is set as the baseline for the unit-MLI GND stud screw. TBC by ADS.
				Annex A	Annex A added for pre-hand over activities.
				Annex B	Annex B added for MLI user manual.
1	2	02/11/2016	A.Ravanbakhsh Based on the inputs during FAR-RIDs and follow up AIT telecom with ESA/ADS on 25/10/2016 and different inputs received before DRB.	Sec. 1.2	Notes are added to the scope of the document.
				Sec. 3.2	[RD-6]: updated revision. [RD-11]: EPD MLI shipping plan is added. [RD-12] and [RD-13] are added.
				Sec. 4	STEP 00: Fig. A and Fig. B are added to highlight handling points. STEP 05:Fig.5-1 and Fig.5-2 are added to show how to remove the unit from the unit aluminum support baseplate. STEP 65: Using scotchweld for MLI GND screw locking is confirmed.
				Sec. 5	Red tag covers information is added.
				Annex A	Updated information.
				Annex C	Annex C is added for unit-S/C integration contingency plan.
1	3	08/11/2016	A.Ravanbakhsh Based on the inputs after DRB.	Sec. 3.2	[AD-6], [AD-7] and [AD-8] are added. [RD-1], [RD-7] and [RD-8]: updated revisions. [[RD-14] is added.
				Sec. 4	STEP 25: updated: ADS will supply the M4 screw/washer. And MLI GND screw torque is defined.

				Annex A	The format and information is updated in the scope of post-DRB actions and according to [AD-6], [AD-7] and [AD-8]
				Sec. 6	Ground (AIT) Constraints are added.

TABLE OF CONTENTS

1 INTRODUCTION

1.1 Purpose

The aim of this document is to provide guidelines for the EPT-HET1&2 FMs installation on the S/C. This integration guideline is a traveler with the unit and will be updated according to the reviewers' comments by the time of the flight hardware delivery.

The design and build information of the FM units can be found in [RD-3].

The exact dimensions and the detailed mechanical interface definition of both EPTHET-1&2 units with the S/C can be found in the [RD-4].

The traveler documents indicated as [RD-6], [RD-7], [RD-8], [RD-9] and [RD-10] support the present integration guidelines and will be delivered in hardcopy as traveler accompanying the units.

1.2 Scope

This document applies to all activities related to the installation of EPT-HET1&2 FM units on S/C performed by all institutions and personnel involved in the FM units' integration into the S/C.

Important notes:

1) Packing and unpacking is performed by CAU personnel prior to handover

2) After handover, activities are ADS's responsibility.

3) Should it be necessary to return a sensor to Kiel, ADS can bring the unit back to the "point" of handover, i.e., onto the EPD interface plate or onto a clean bench, and commence purge.

4) At this point a handover ADS-CAU is performed, after which:

5) CAU personnel re-pack the units and bring them back to Kiel.

6) The current revision of this document is applicable only to the flight MLI integration. According to [RD-11] and [RD-12], the adequate non-flight MLIs will be used for S/C solar illumination tests. For the non-flight MLI integration the relevant sections will be updated accordingly in the next revisions.

2 GLOSARY AND DEFINITIONS

2.1 Acronyms and Abbreviations

ADS Airbus Defence & Space

CAU Christian-Albrechts-Universität zu Kiel

EIDA Experiment Interface Document-Part A

EPD Energetic Particles Detector

EPT Electron, Proton Telescope

EUT Equipment Under Test

FM Flight Model

FOV Field of View

GND Grounding

HET High Energy Telescope

I/F Interface

IFP Interface Plate

LTS Long Term storage

MLI Multi-layer Insulator

PFM Protoflight Model

S/C Spacecraft

SSM Second Surface Mirrors

TBC To Be Confirmed

URF Unit Reference Frame

3 APPLICABLE AND REFERENCE DOCUMENTS

3.1 Applicable Documents

ID.	Title	Reference	Iss./Rev.	Date
AD-1	Experiment Interface Document part A	SOL-EST-RCD-0050	5/0	16/03/2015
AD-2	Interface Control Document part-B	SO-EPD-PO-IF-0001	4.0	15/03/2016
AD-3	EPD Electrical Interface Control Document	SO-EPD-PO-IF-0004	2/2	30/04/2014
AD-4	EPT-HET and STEP Assembly, Integration and Test Plan	SO-EPD-KIE-PL-0010	2/1	30/10/2013
AD-5	SOLAR ORBITER - EPTHET & STEIN FMFS MLI Acceptance Data Package	KI001-ADP-0005	1/0	24/05/2016
AD-6	Minutes of the meeting of „EPD FM DRB on 03.11.2016" Sent by Kristin Wirth (ESA)	SOL-EST-MN-14788	NA	Sent on 07/11/2016
AD-7	Email from Filippo Marliani (ESA) Email subject: EPD AIT teleconference -> summary and actions	N/A	N/A	Sent on 07/11/2016
AD-8	EPD/ADS agreed pre-handover steps Sent by Emmanuel Bouland (ADS) EPD-KIEL_pre-handover_activities_sheet_v1_ADS_Adds_in_20161107.docx	N/A	N/A	Sent on 07/11/2016

3.2 Reference Documents

ID.	Title	Reference	Iss./Rev.	Date
RD-1	EPD LONG TERM STORAGE USER MANUAL	SO-EPD-PO-MA-0007	1/2	18/10/2016
RD-2	2016-04-01-cau-MLI-integration-plan-draft-v4.pdf	N/A	Provided by EPD-Kiel	01/04/2016
RD-3	CIDL-ABCL for EPTHET-1 FM and EPTHET-2 PFM	SO-EPD-KIE-LI-0011	1/4	23/09/2016
RD-4	Drawing: EPTHET Mechanical Interface Control Drawing EPD_EPTHET_23092016_5-6_SO-EPD-KIE-DR-0001_fm_micd.pdf	SO-EPD-KIE-DR-0001_fm.idw	5/6	23/09/2016
RD-5	Unit-S/C MLI interface: EPD MLI Summary - 01.09.16.pdf	N/A	Provided by ADS	01/09/2016
RD-6	EPT-HET FM Packing/Unpacking, Storing, Transport & Handling Procedure (Traveller document with unit)	SO-EPD-KIE-PR-0035	1/4	27/10/2016
RD-7	EPT-HET1 FM Shipping List (Traveller document with unit)	SO-EPD-KIE-LI-0013	1/3	04/11/2016
RD-8	EPT-HET2 FM Shipping List (Traveller document with unit)	SO-EPD-KIE-LI-0014	1/3	04/11/2016
RD-9	Connector Mate/Demate log record of EPT-HET-1 (Traveller document with unit)	N/A	N/A	N/A
RD-10	Connector Mate/Demate log record of EPT-HET-2 (Traveller document with unit)	N/A	N/A	N/A

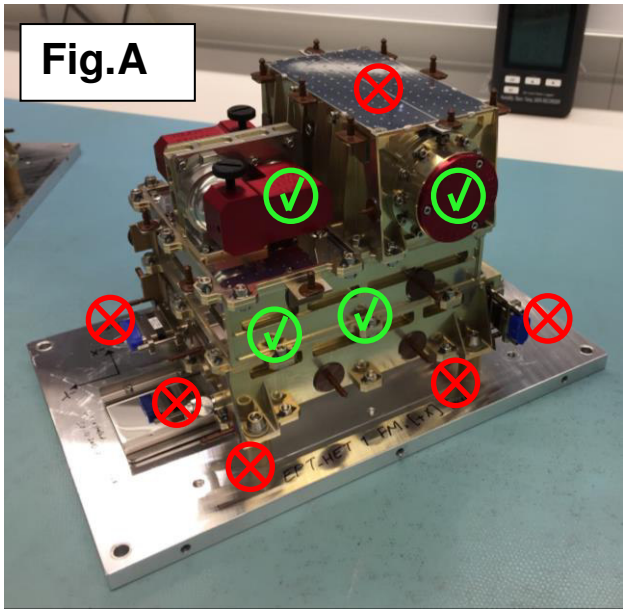
RD-11	EPD MLI shipping plan	SO-EPD-KIE-PL-0006	1/0	28/10/2016
RD-12	EPD MLI plan-ADS review_v1-for DRB.pdf	NA	v1	01/11/2016
RD-13	Email from C. Martin(EPD-Kiel) to K. Wirth (ESA) on 07.07.2016: "2016-07-06-rfws-answer-to-KW-email.pdf"	N/A	N/A	07/07/2016
RD-14	EPTHET1 FM and EPTHET-2 PFM Functional test plan and procedure	SO-EPD-KIE-TP-0038	1/3	31/08/2016

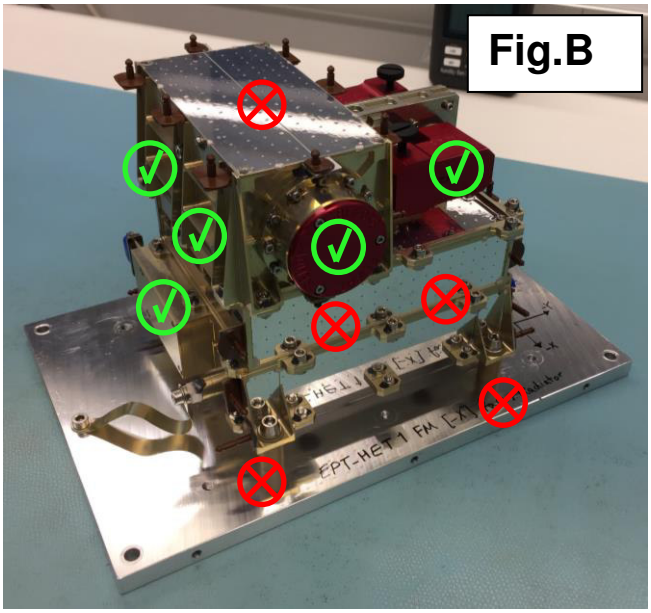
4 STEP-BY-STEP INTEGRATION PROCEDURE

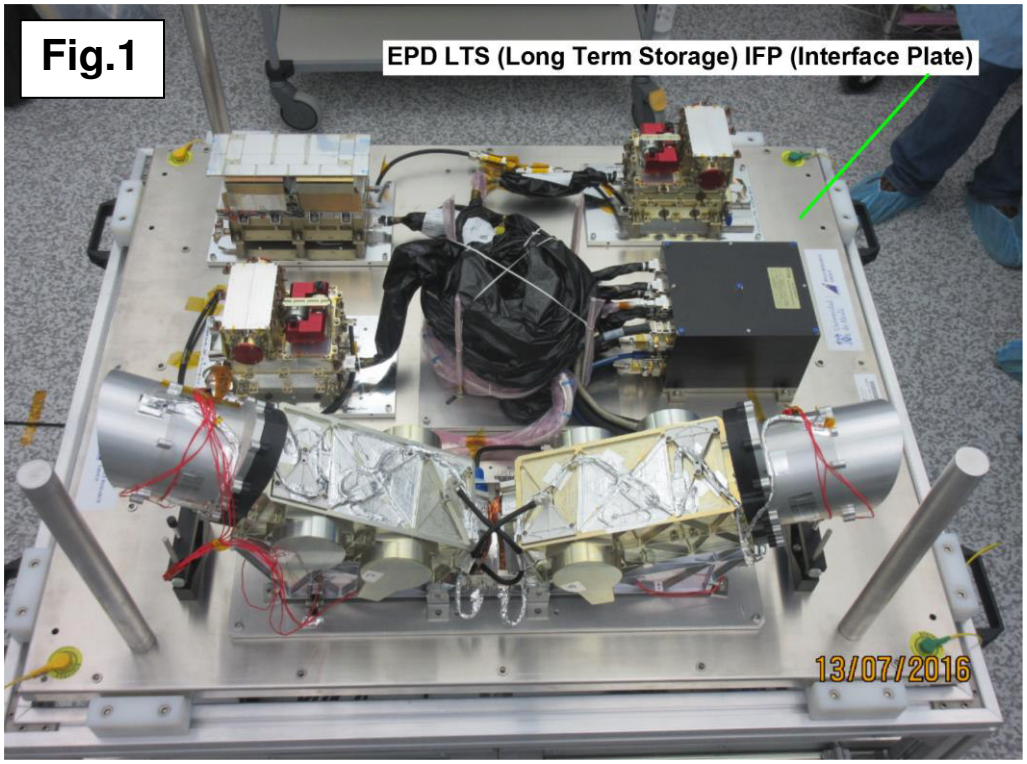
STEP 00: Important remarks and safety precautions before start

1. EPD-Kiel personnel (two persons) are required for the integration of the FM units and their MLIs on the S/C. This is specially required to integrate the MLI correctly and to ensure that the MLI does not interfere with the FOV of the FM units at the end of integration.
2. Although EPT-HET-1 and EPT-HET-2 will be integrated in two different locations on the S/C, both units are identical with identical MLI. So, the guidelines which are presented here are applicable to both EPT-HET-1 and EPT-HET-2.
3. Identify the units by labels: "EPD/EH1-FM" for EPT-HET-1 and "EPD/EH2 –FM" for EPT-HET-2.
4. EPT-HET-1&2 are delivered without their MLI integrated to the unit. The MLI integration to the unit is part of the unit integration to the S/C.
5. This integration guideline applies to the activities from the removing the EPT-HET1&2 FMs from the EPD Long Term Storage (LTS) Interface Plate (IFP) to the final installation of the instrument and its MLI on the S/C. See [RD-1] and Fig.1.
6. Due to the susceptibility of the Germanium Kapton (upper MLI of the units) to the corrosion caused by humidity, there is a proposal from EPD-Kiel [RD-2] in order to integrate the FM upper MLI for EPT-HET-1 and EPT-HET-2 after the S/C tests. In the case that the upper MLI of the units are needed for the S/C tests, PQM and STM MLIs can be used. This is TBC between EPD-Kiel and ADS after receiving more information of S/C AIT activities.
7. The required time for the MLI integration (both bottom and upper MLIs) for each FM unit is estimated 2 hours in the lab. It is foreseen that during the S/C integration the estimated time for the unit and its MLI integration may be longer.
8. The unit-S/C MLI interface is under discussion between EPD-Kiel and ADS [RD-5], this is important to be confirmed before unit integration as some of the unit MLI standoffs will be used by the S/C.
9. The guidelines do NOT include the two electrical connectors' connection from the S/C to the unit as this electrical connection is not EPD-Kiel responsibility. The electrical connectors should be compliant with [AD-3].
10. All of the coordinates mentioned in this guideline and in the figures, e.g. [-X] face, are in the URF. See Fig.2 and Fig.3.
11. To apply ESD precautions.
12. To apply as minimum ISO 8 cleanliness requirements.
13. To use non-magnetic tools if working close to EPT sensor head. Note that EPT contains very strong permanent magnets!
14. Do NOT remove red-tag covers until integration is finished. See Fig.2.
15. Do NOT touch SSMs (second surface mirrors). See Fig.2.
16. Do NOT load MLI standoffs.
17. Do NOT load purge adaptor unnecessarily. See Fig.2.
18. Pliers, plastic tweezers and spare MLI stand offs and FOV clearance check auxiliary tool, see Fig.42 and Fig.43, will be supplied by EPD-Kiel to support the integration.

Only the aluminum parts of the unit shall be used for handling including red tag covers and also with special care considering the nearby MLI satnd offs, connectors, purge adaptor, GND strap, and sensitive surfaces.







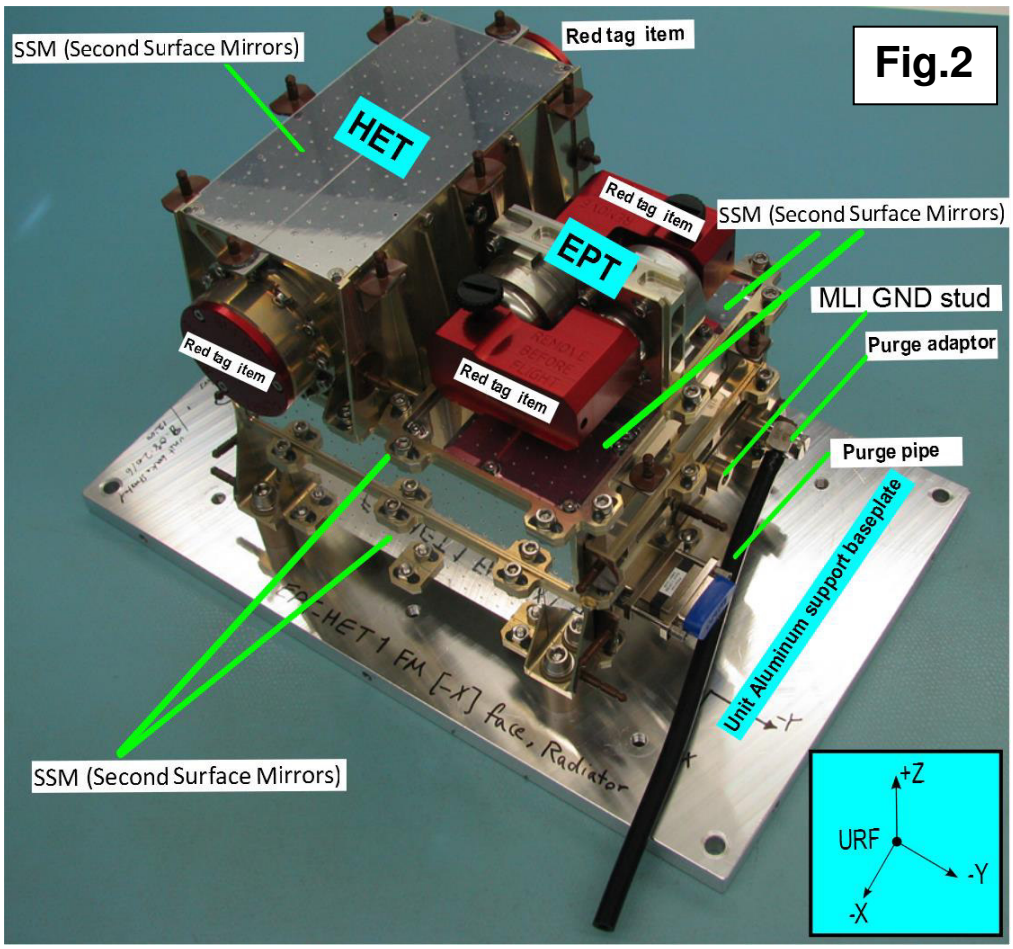


Fig.2
SSM (Second Surface Mirrors)
Red tag item
HET
Red tag item
EPT
SSM (Second Surface Mirrors)
MLI GND stud
Purge adaptor
Red tag item
Red tag item
Purge pipe
Unit Aluminum support baseplate
SSM (Second Surface Mirrors)
+Z
URF
-Y
-X

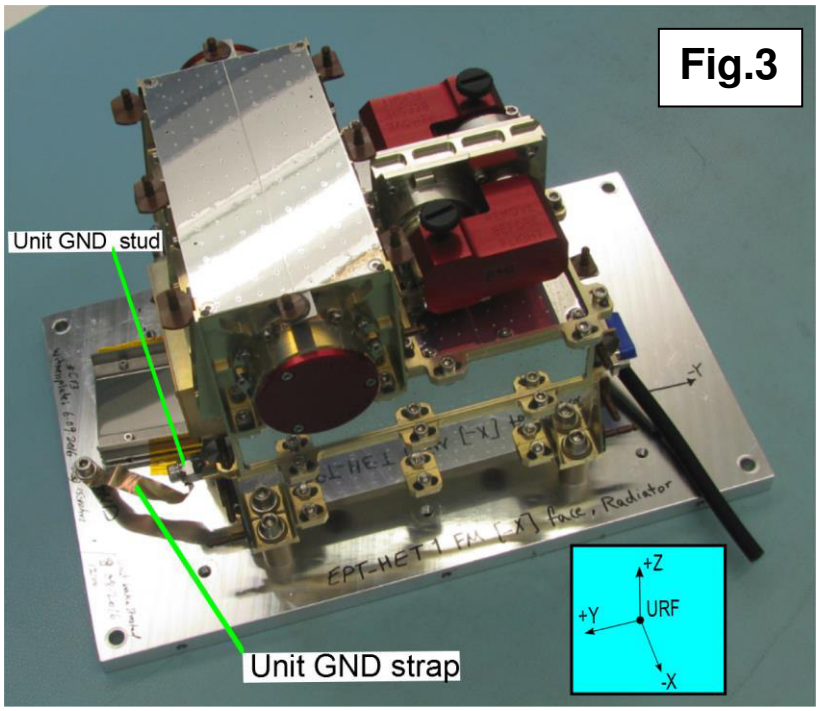
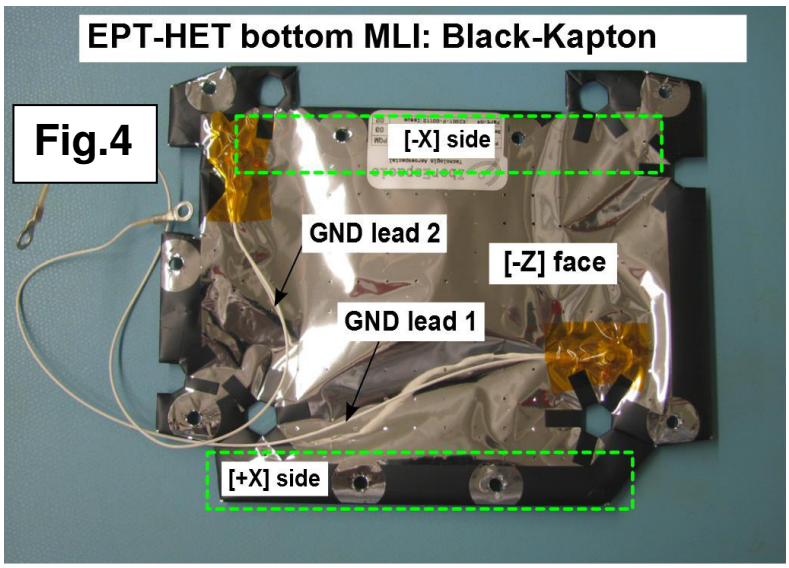
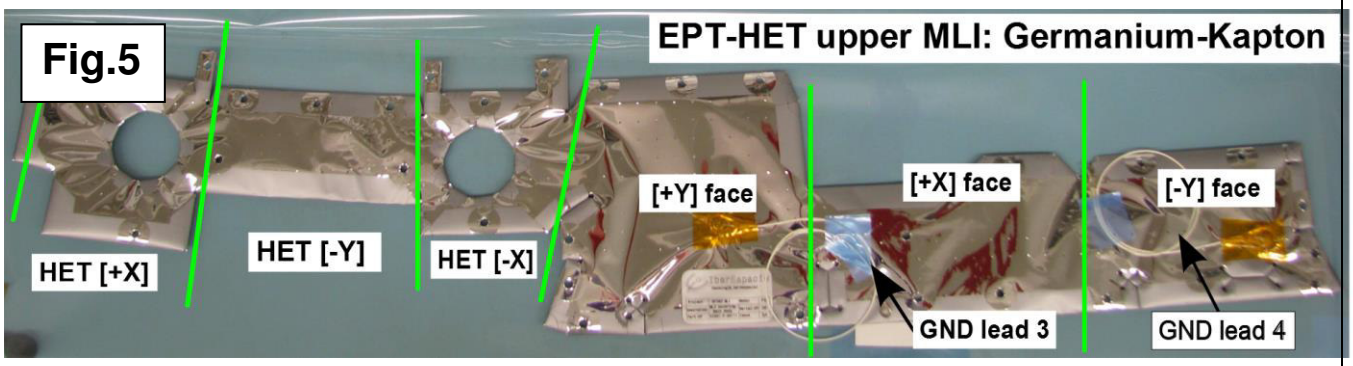


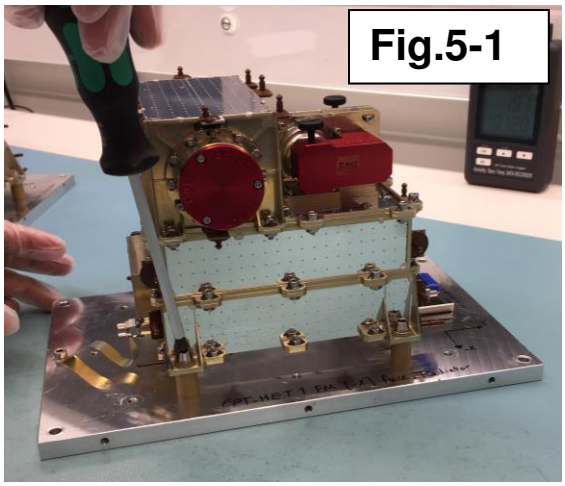
Fig.3
Unit GND stud
Unit GND strap
+Z
+Y
URF
-X

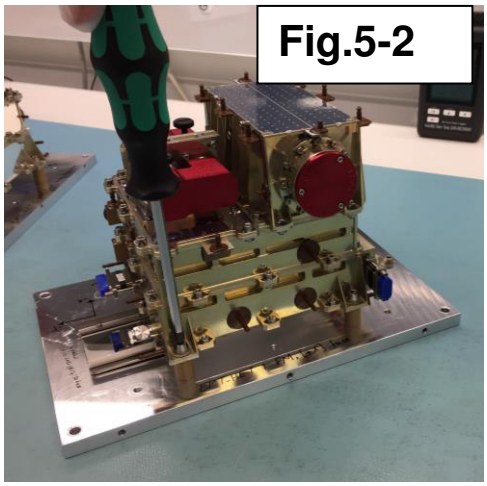




STEP 05: Remove the unit from the EPD LTS (Long Term Storage) IFP (Interface Plate)

- Remove the unit purge pipe form the LTS purge pipe.
- Remove the unit GND strap from the end connected to the unit aluminum support baseplate. Note that from this step the unit chassis is not grounded anymore (i.e. unit GND strap is not connected to anywhere). So, temporary ESD protection is needed while moving the unit from the aluminum support plate to the S/C bracket and until the time that the unit GND strap is connected to the S/C bracket. The unit GND strap is shown in Fig.3.





STEP 10: Put the bottom MLI on the S/C bracket and afterwards put the unit on top of the MLI

- Pay attention that the correct sides of the MLI w.r.t unit are selected, Fig.6.
- Pay attention that the two GND leads of the bottom MLI exit from [-Y] side of the instrument, Fig. 7.

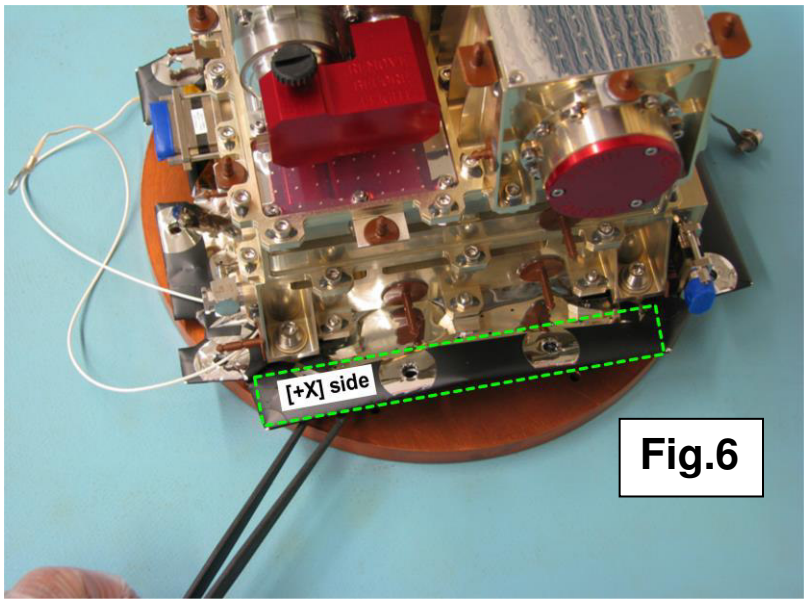


Fig.6

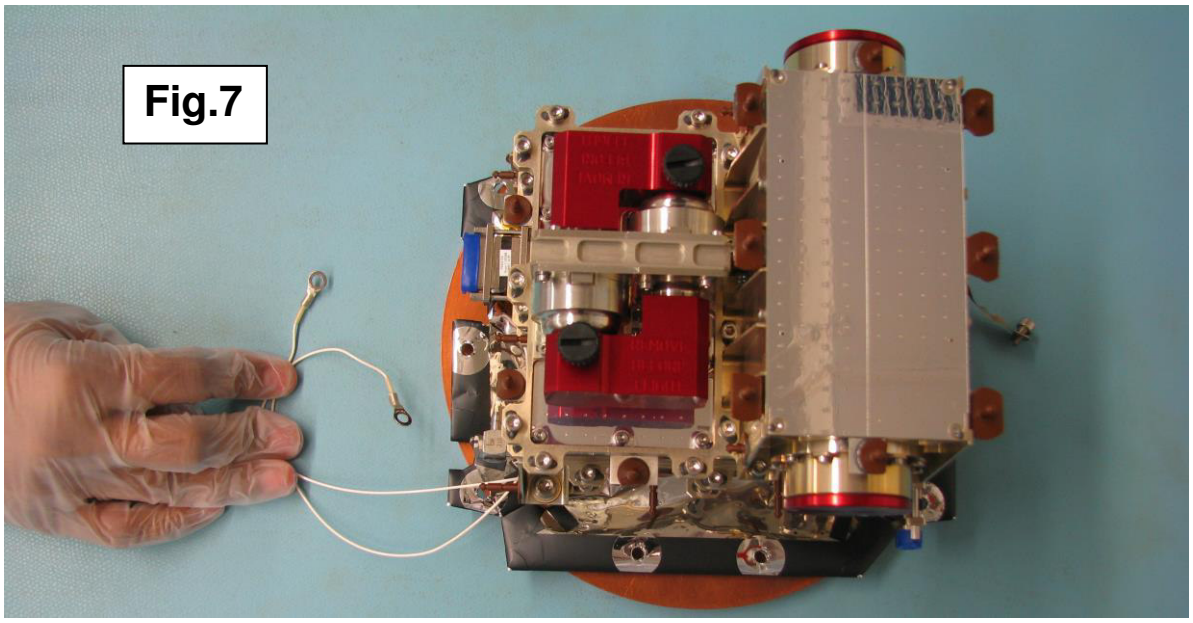
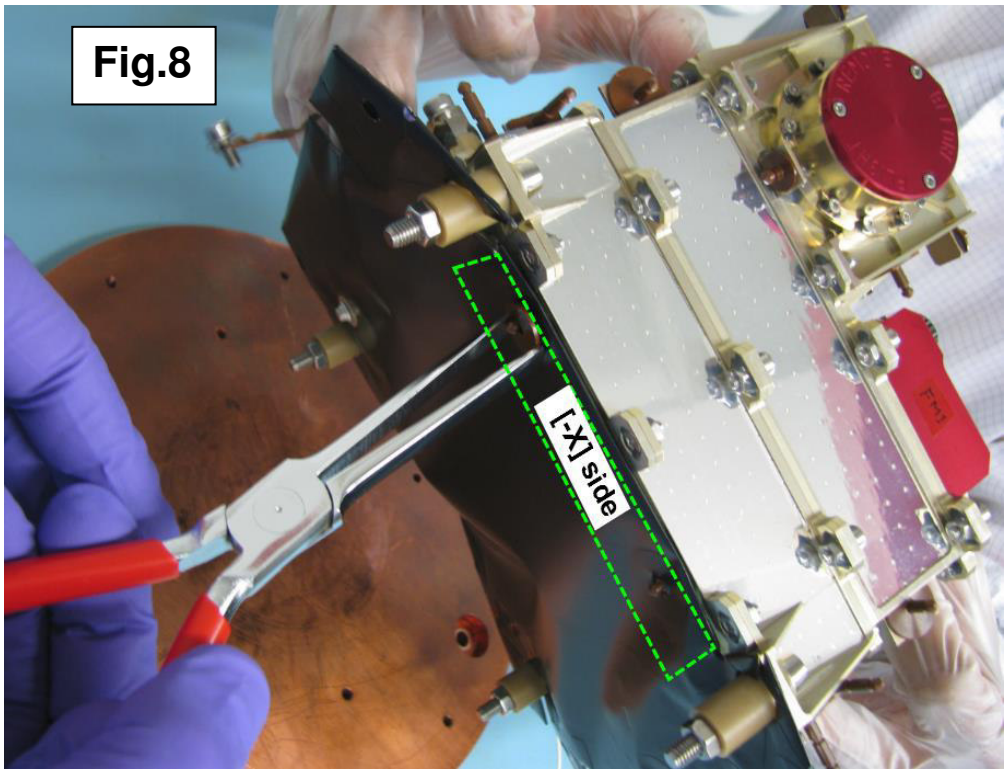
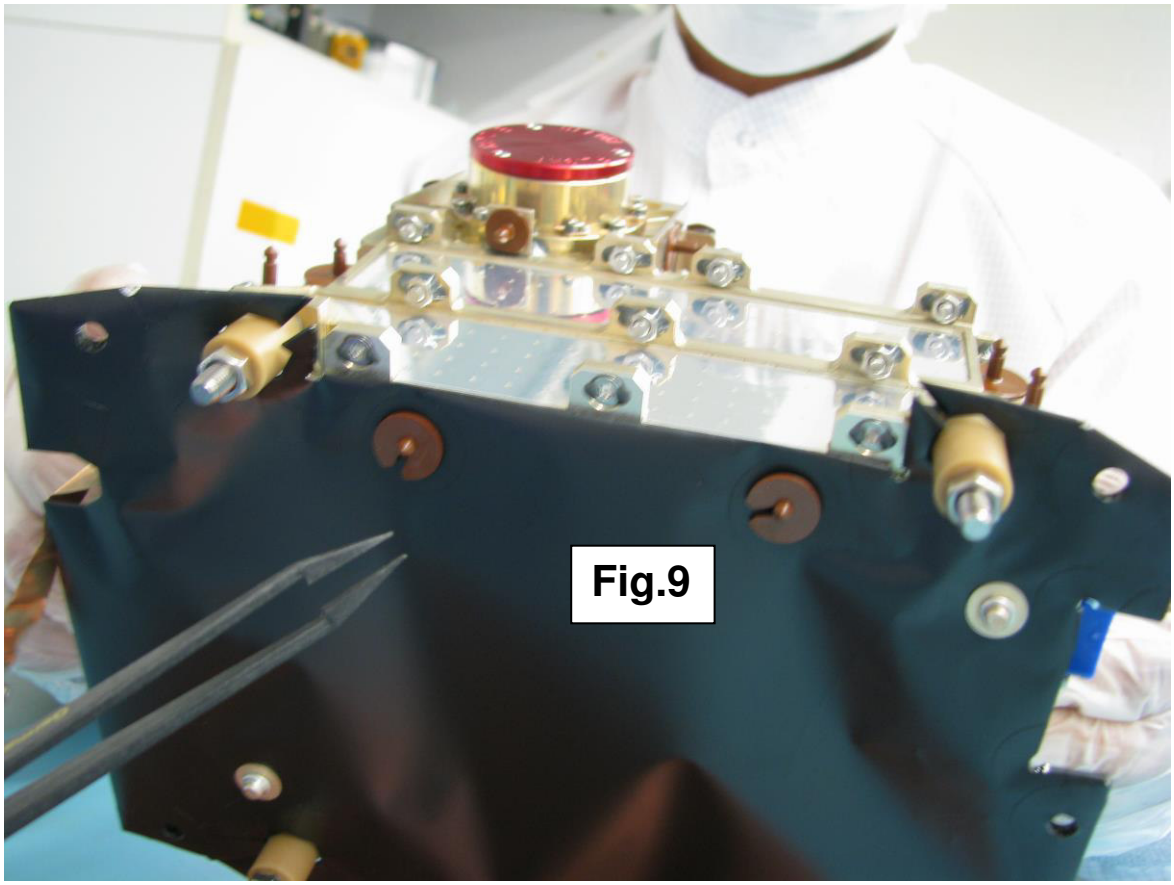


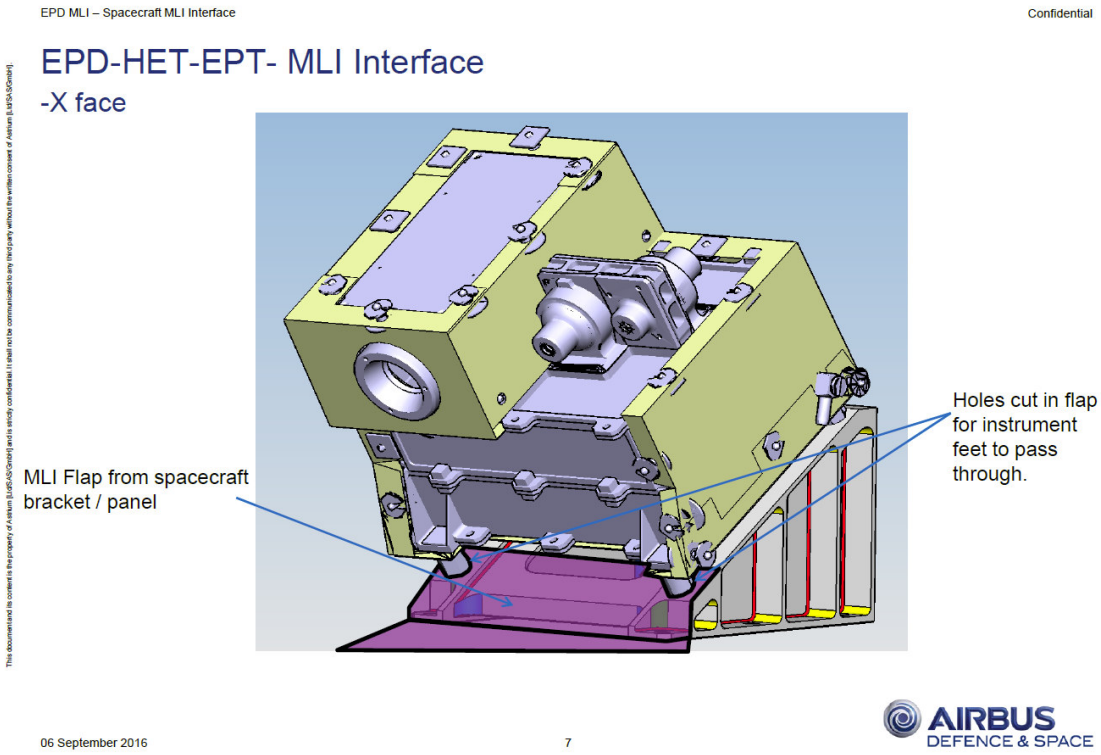
Fig.7

STEP 15: Before torque the unit four interfaces (MJ5 screws) to the bracket, put the two clip washers on the [-Z] face





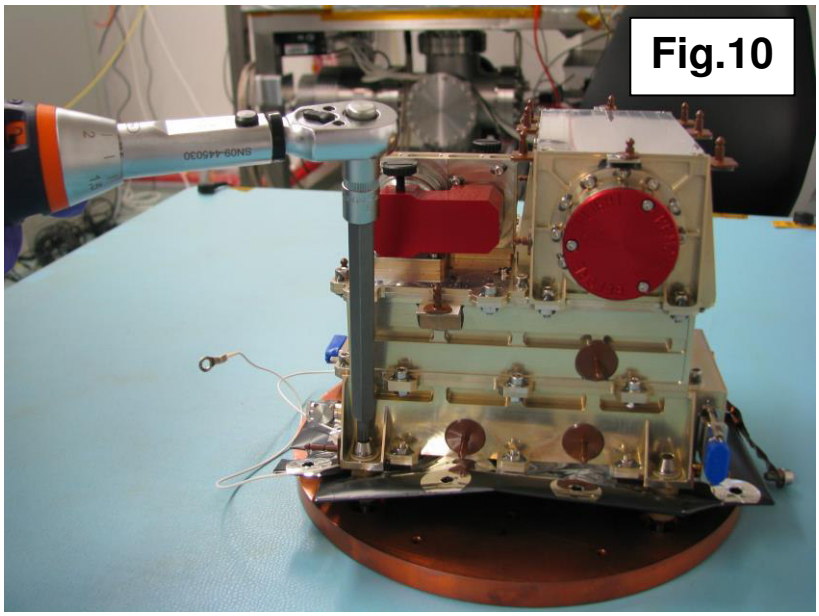
STEP 15-1: Before torque the unit four interfaces (MJ5 screws) to the bracket, put the MLI Flap from spacecraft bracket / panel under the unit, photo from [RD-5].

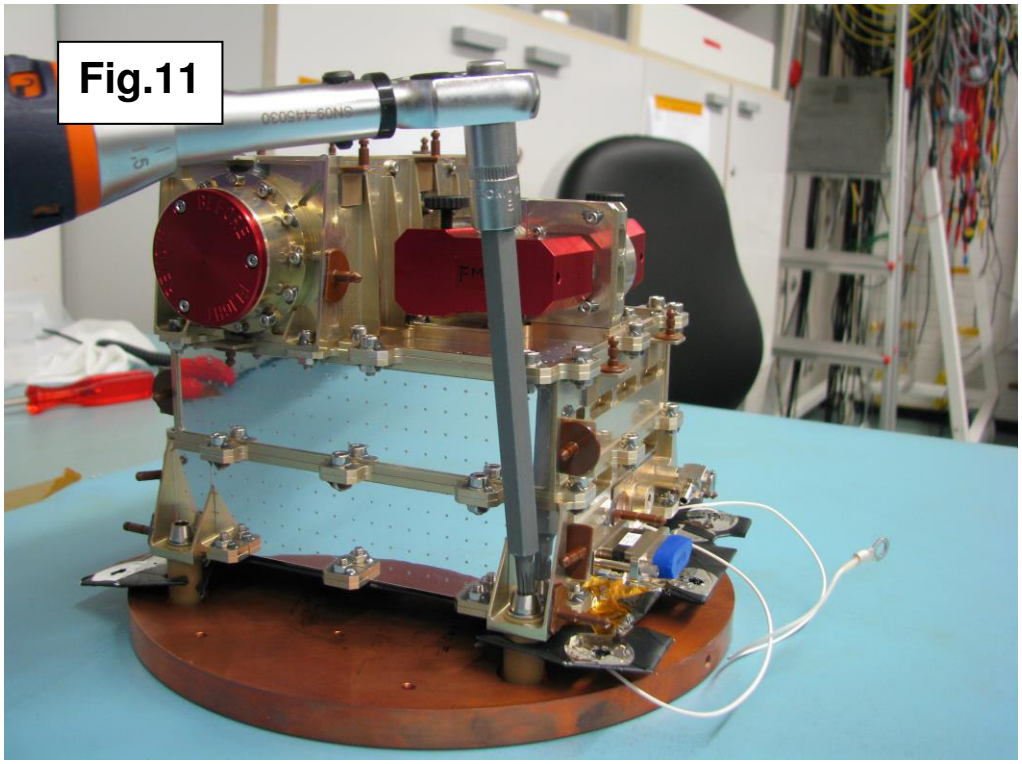


STEP 20: Put the unit with the bottom MLI on to the bracket including the S/C I/F MLI and torque the unit interfaces to the S/C bracket.

See remark No.8 is step 00.

- Pay attention that the torque tool does not touch the SSM (Second Surface Mirrors) on the [-X] face of the unit, see Fig.11.



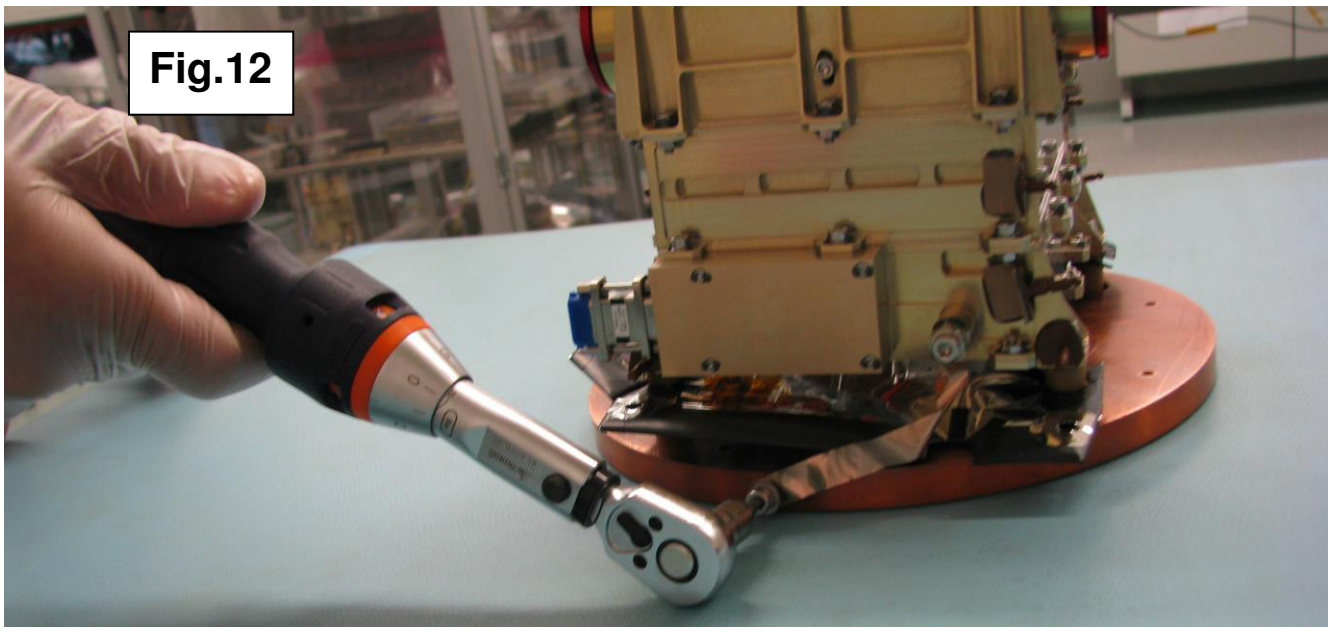


STEP 25: At this step the unit GND strap can be torqued to the S/C bracket

- ADS will supply the M4 screw/washer (for unit-S/C GND strap, Fig.12) with the unit.

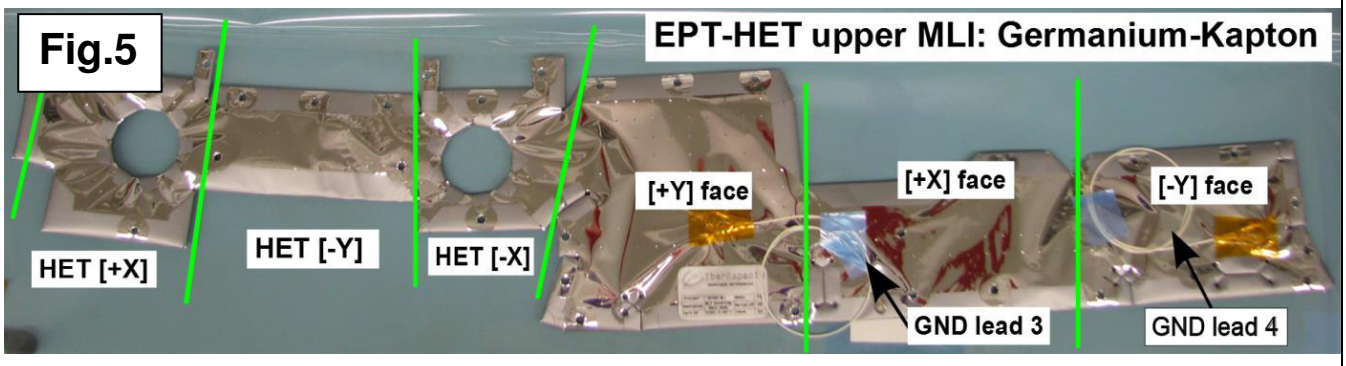
- If the upper Germanium coated Kapton MLI integration is NOT needed for the S/C tests, (see remark No.5 in Step 00):
  - At this step the two GND leads (GND leads 1 and 2 in Fig.4) of the bottoms MLI can be torqued to the MLI GND stud on the unit, Fig.12. In case apply the torque to the M4 screw equal to (1.20 ±0.2 Nm), Fig.20. The bolt and washer (M4x8-A2/70-stailess steel) will be provided by EPD-Kiel
  - Put the clip washers of the bottom MLI standoffs and possibly the unit-S/C MLI interface [RD-10] in [+X], [+Y] and [-Y] faces.
  - In this case the EPT-HET unit and bottom MLI (Black Kapton) integration to the S/C is finished.
  - Connect the S/C purge line to the unit purge pipe.

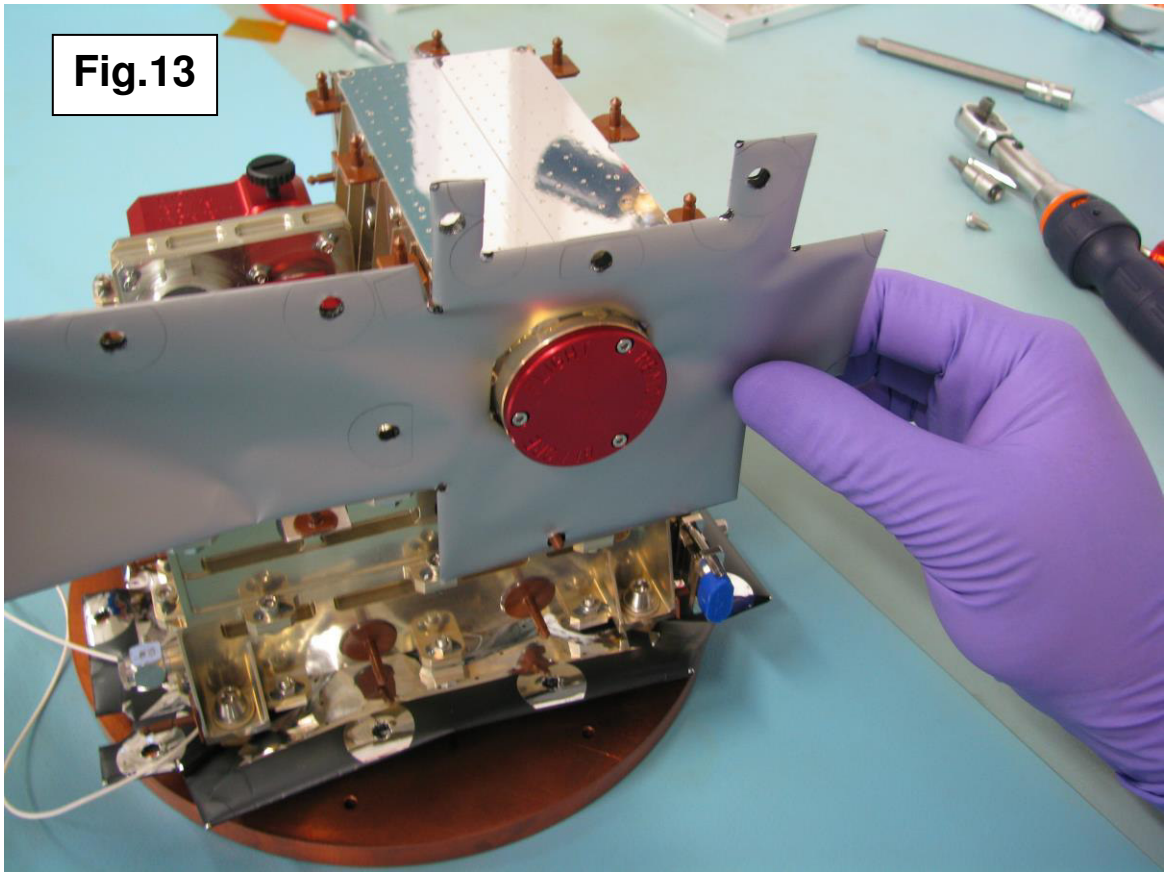
- And if the upper Germanium coated Kapton MLI integration is needed for the S/C tests, (see remark No.6 in Step 00):
  - Follow step 30 onwards.



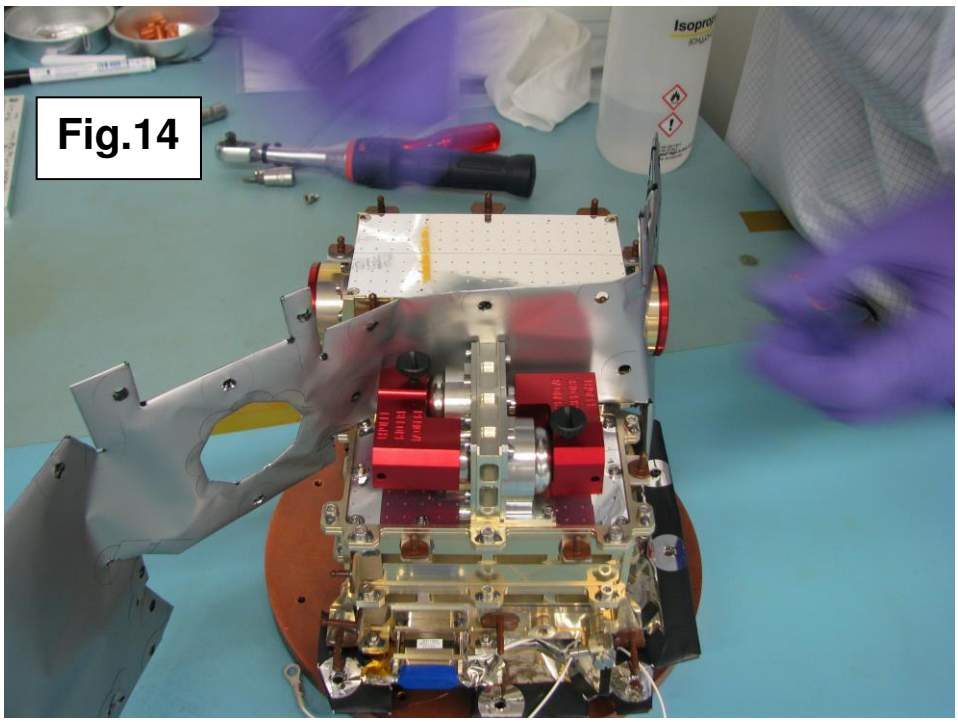
STEP 30: Upper MLI integration: Start with HET [+X]

- Pay attention while handling as upper MLI is made of Germanium Kapton and is susceptible to corrosion due to humidity; see [RD-2].
- Start with HET [+X], Fig.5 and Fig.13.





STEP 35: Upper MLI integration: Continue with HET [-Y]



STEP 40: Upper MLI integration: Continue with HET [-X]

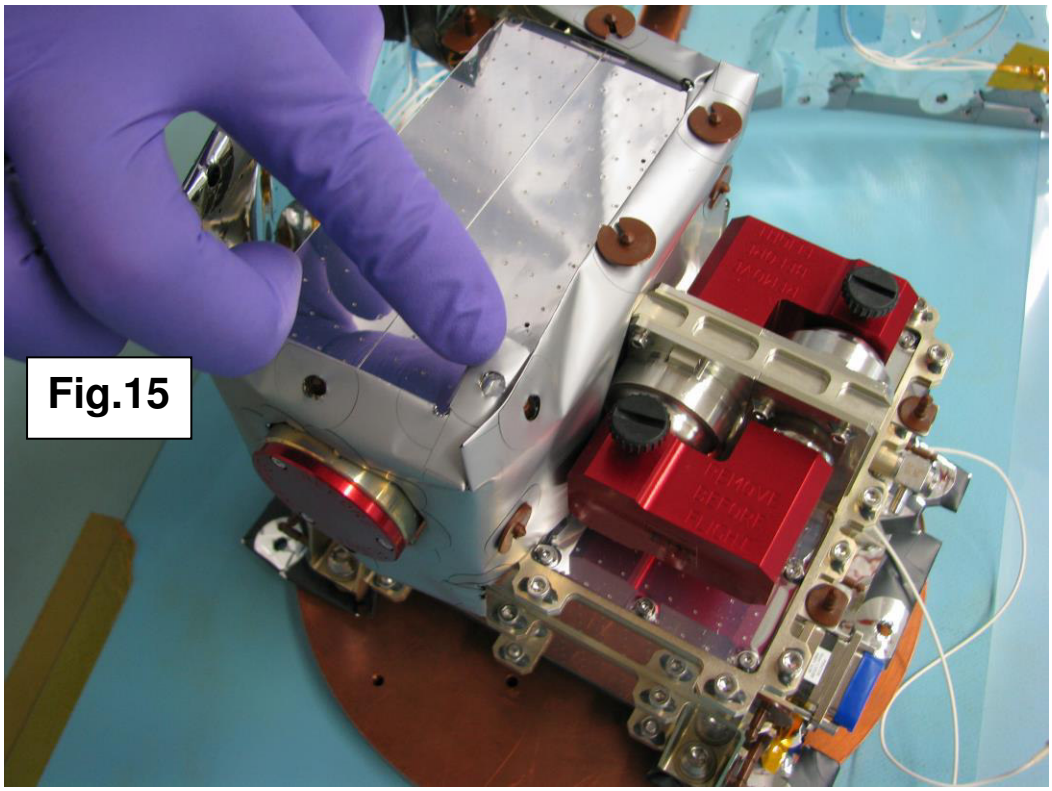


Fig.15

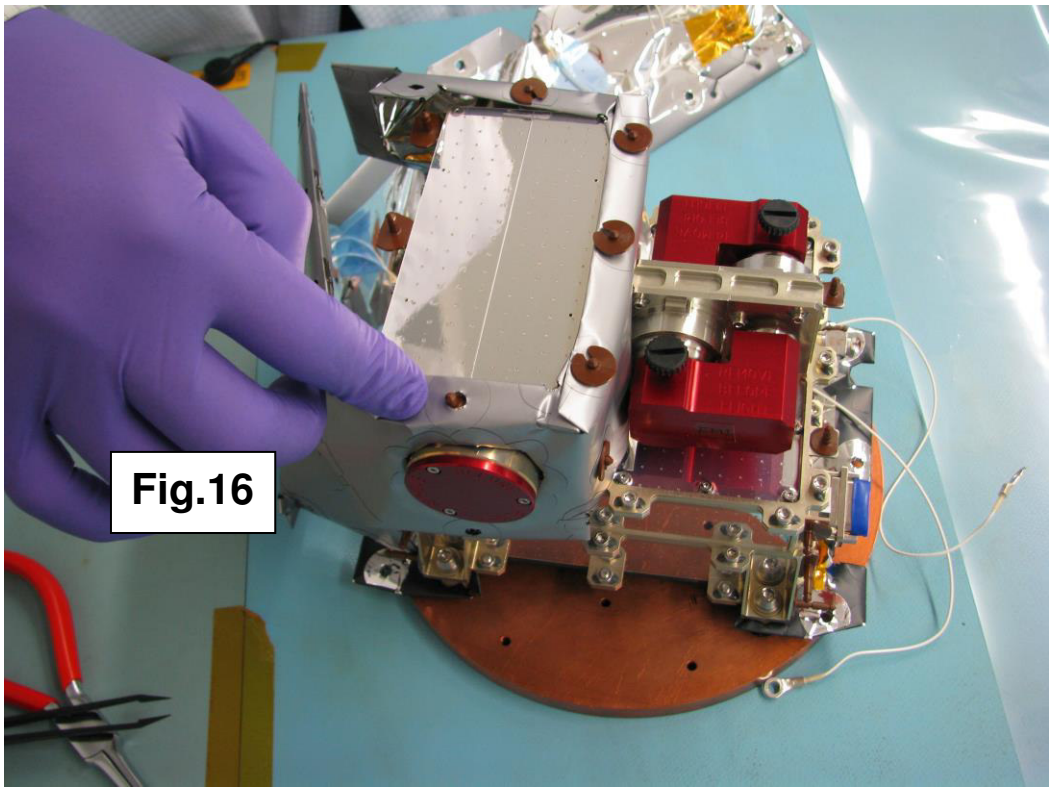


Fig.16

STEP 45: Upper MLI integration: Continue with [+Y] face

- Route the GND lead No.3 below the unit and with a plastic tweezer take it from [-Y] side of the unit, Fig.17 and Fig.18. (Note that the MLI GND stud is on the [-Y] side of the unit and all MLI GND leads need to be routed here.)
- Continue with [+Y] face MLI and pay attention to the cut out for the unit-S/C GND stud cut out in the MLI, Fig.19 to 22.

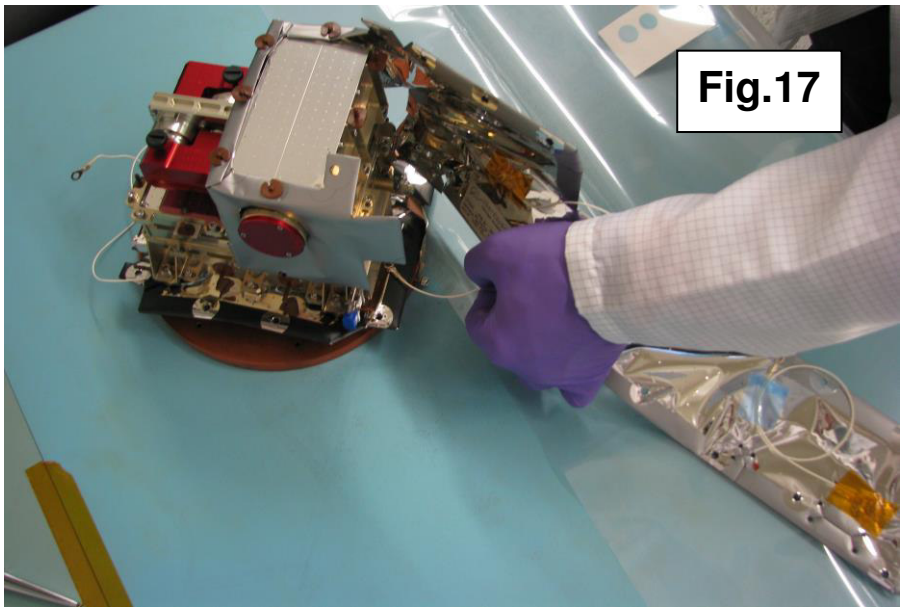


Fig.17

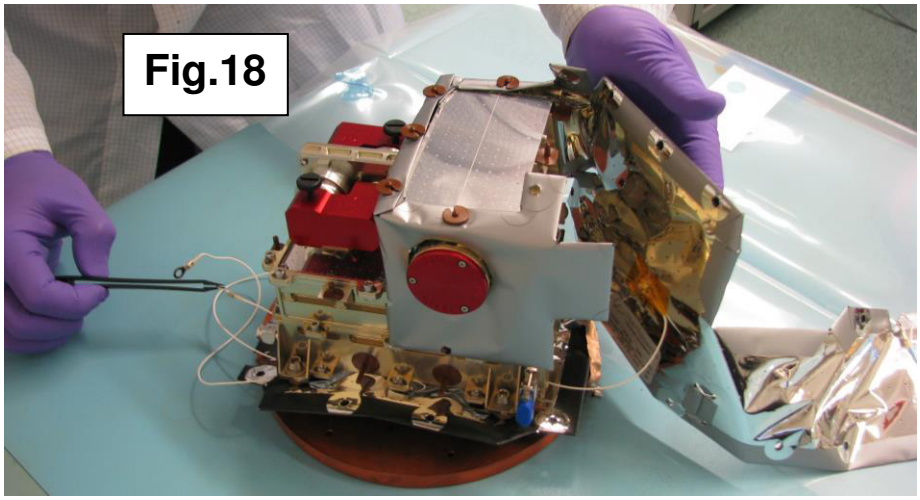


Fig.18

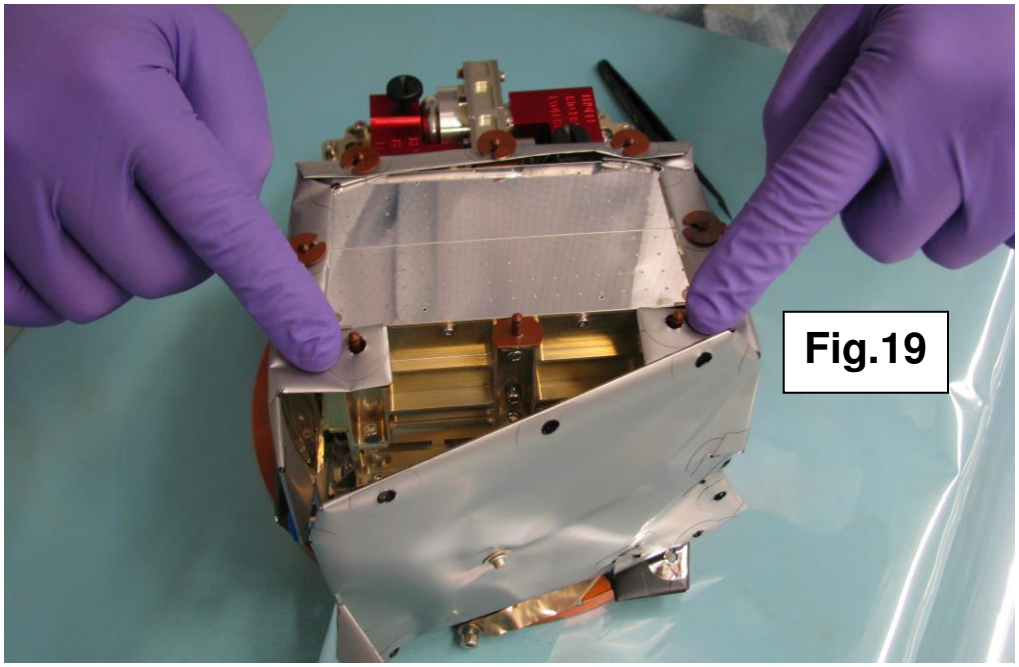


Fig.19

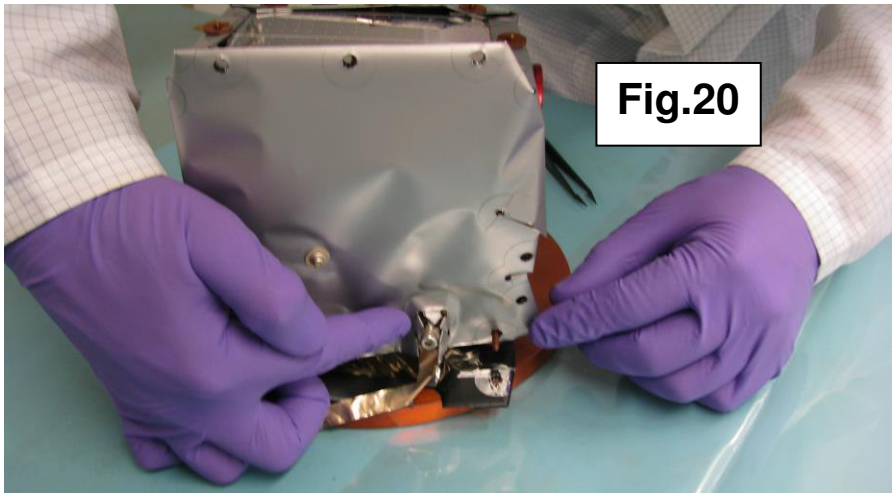


Fig.20

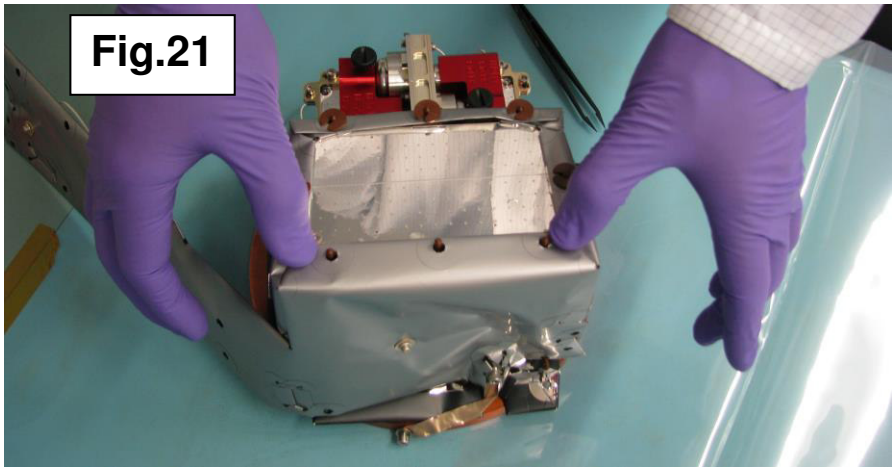
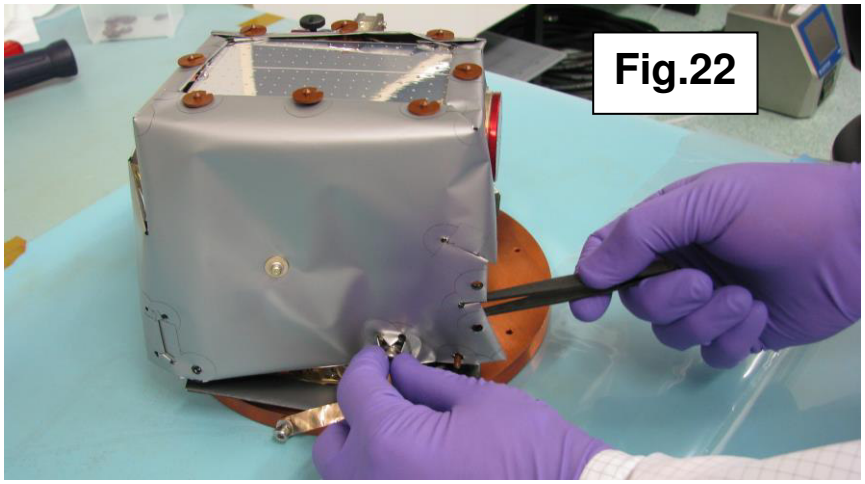
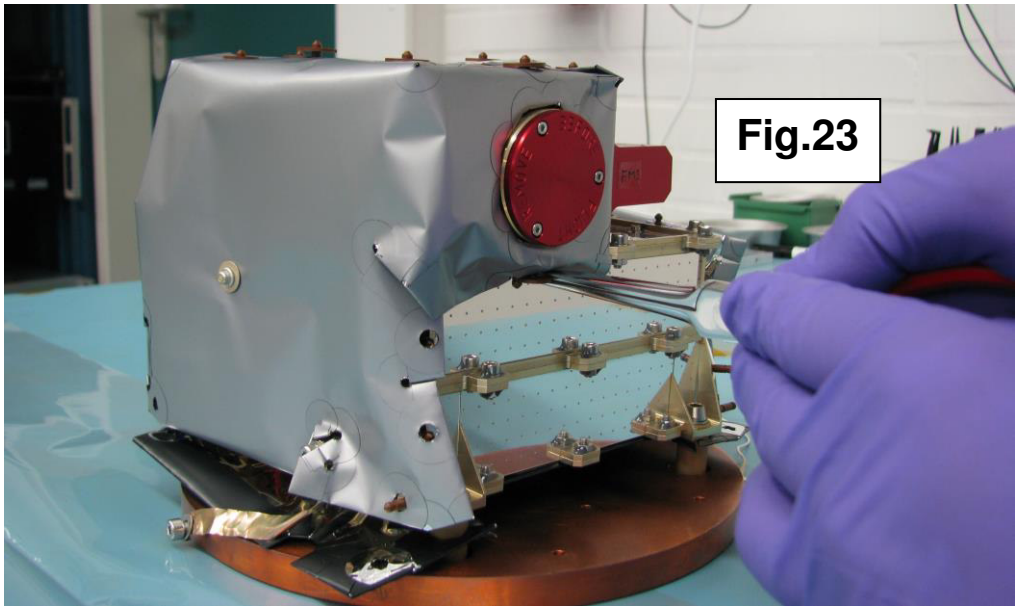


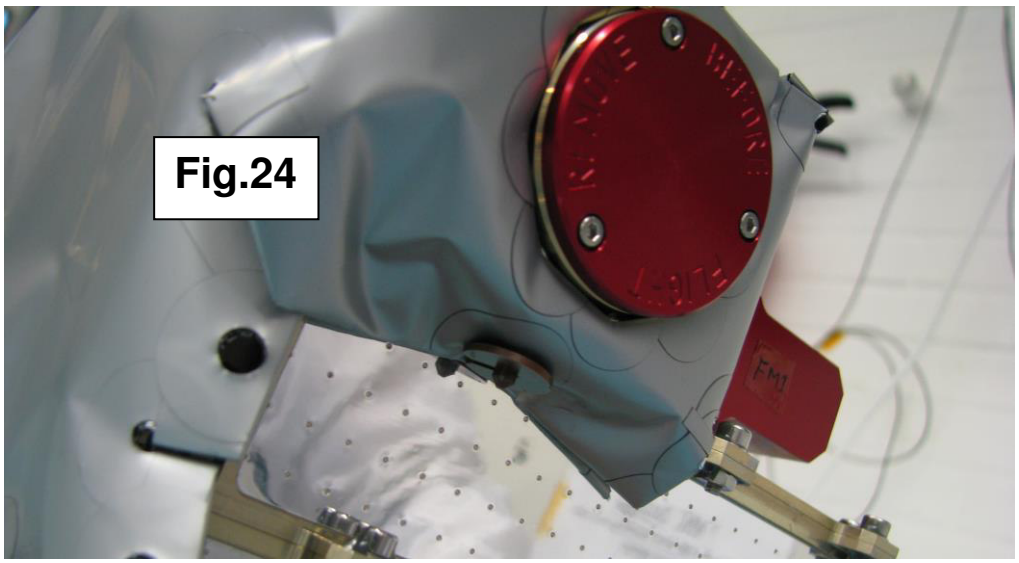
Fig.21

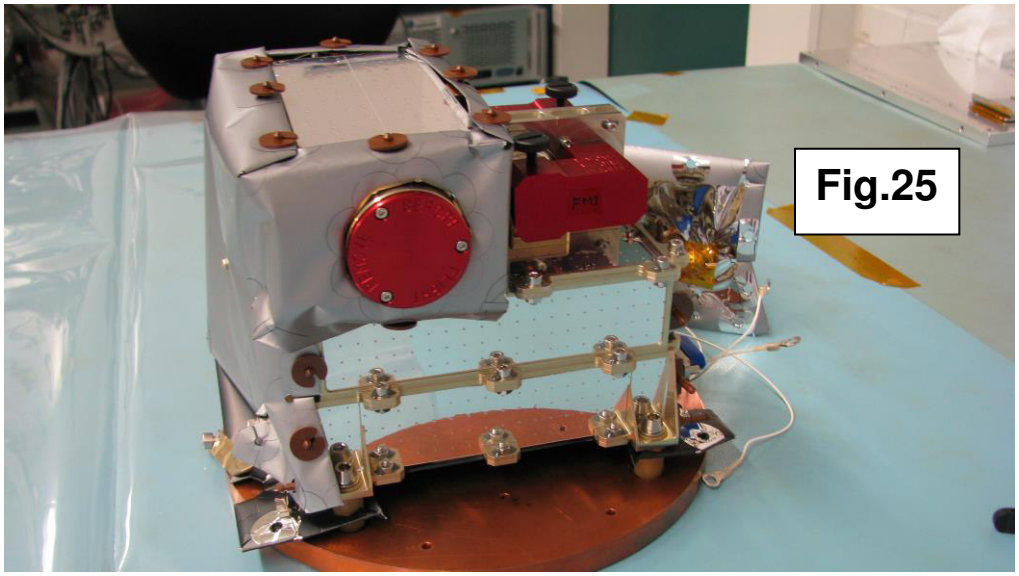


STEP 50: Upper MLI integration: continue with [-X] face clip washers

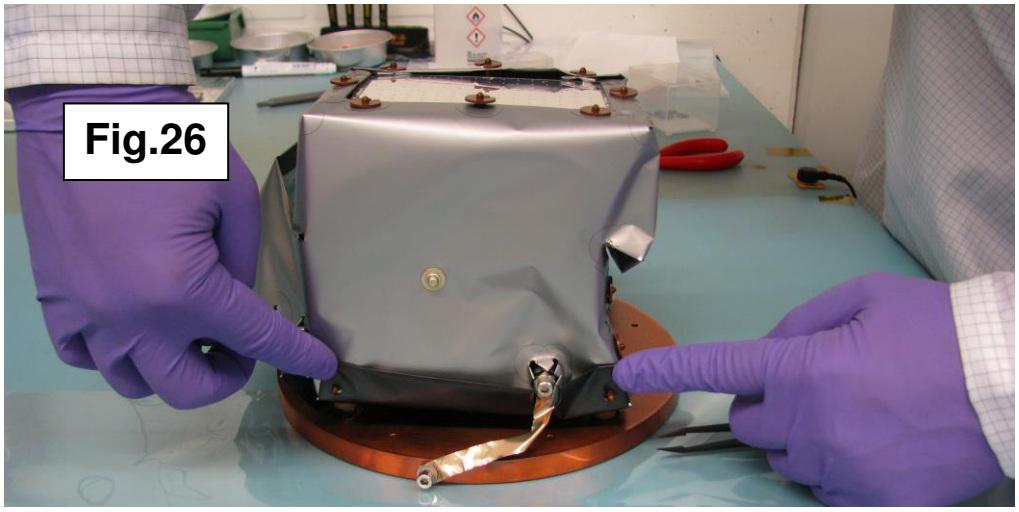
- Pay attention that the plier used for putting the clip washer does not touch the SSM (Second Surface Mirrors) on the [-X] side of the unit.







STEP 55: Upper MLI integration: continue with [+Y] side clip washers



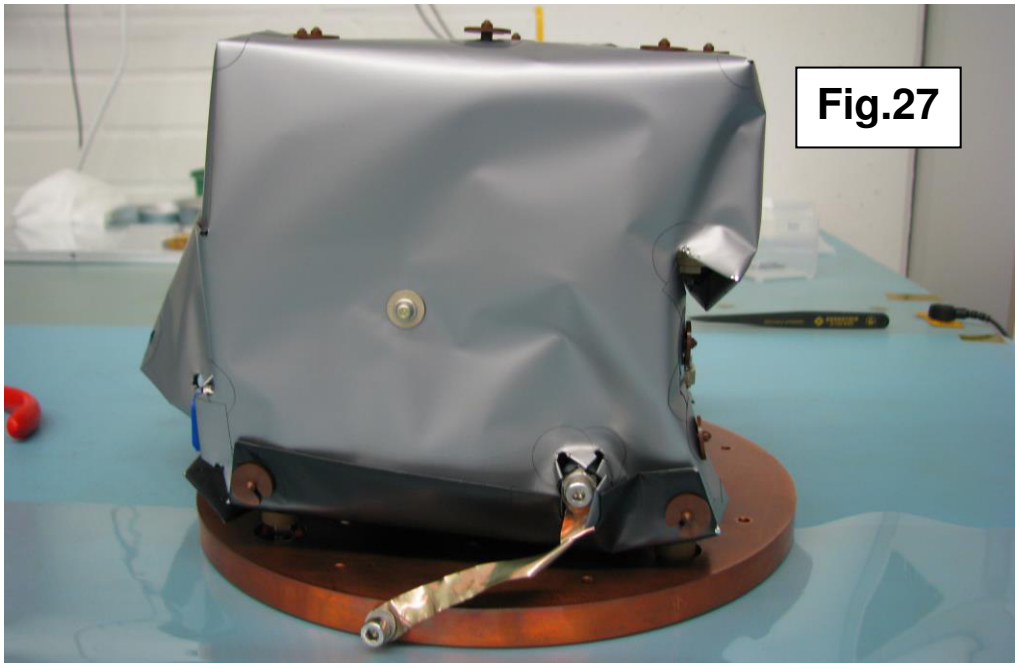


Fig.27

STEP 60: Upper MLI integration: Continue with [+X] face

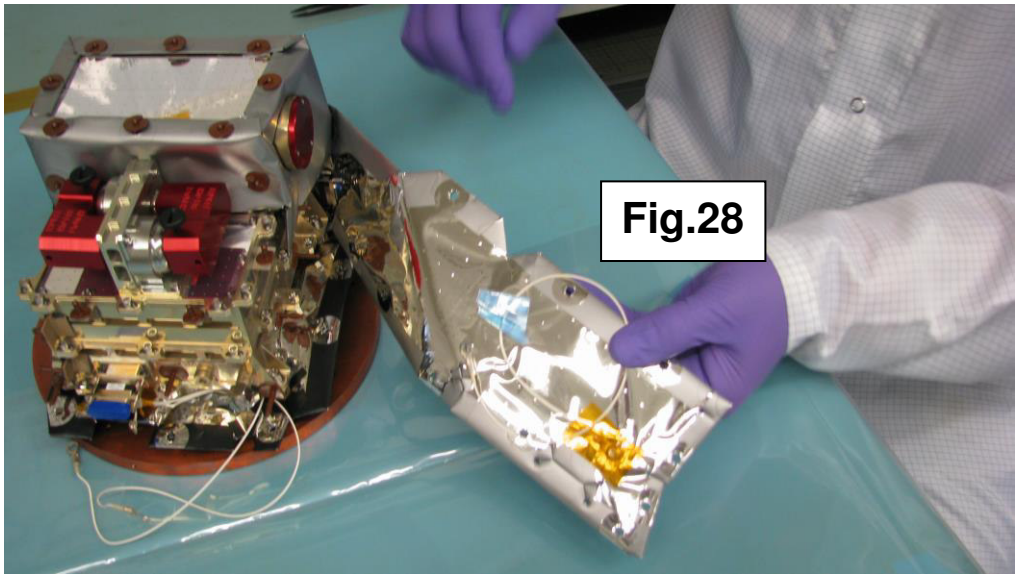


Fig.28

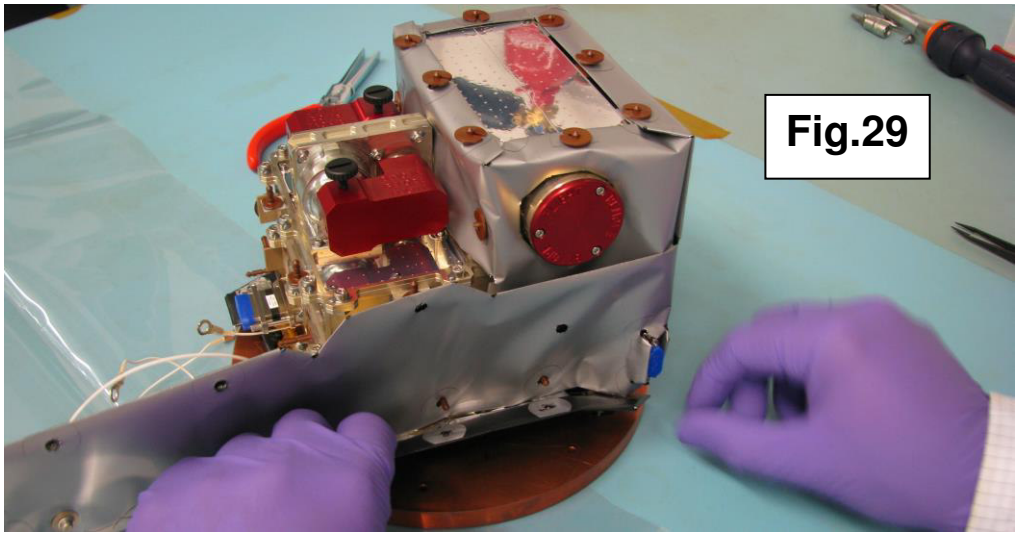


Fig.29

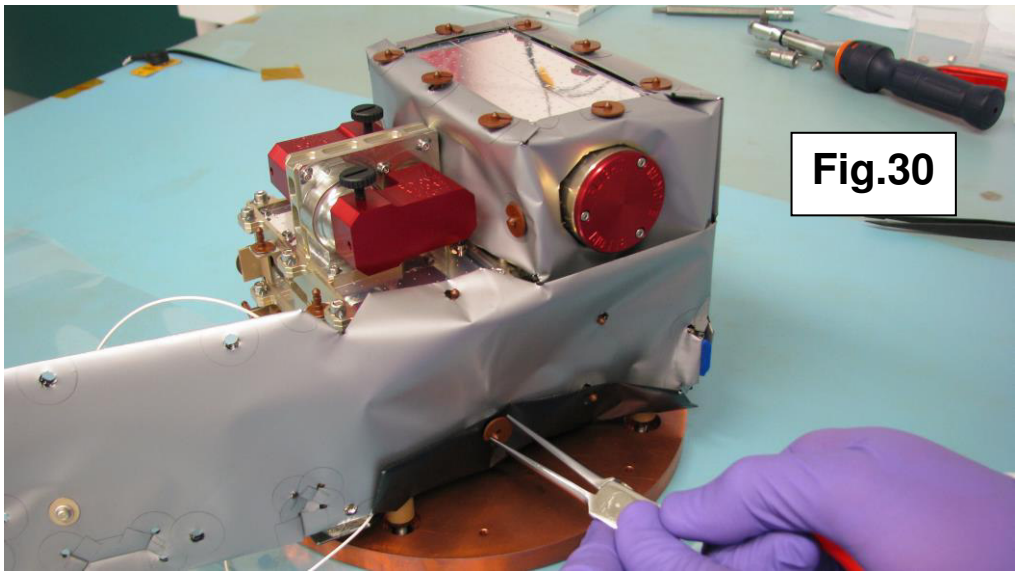


Fig.30

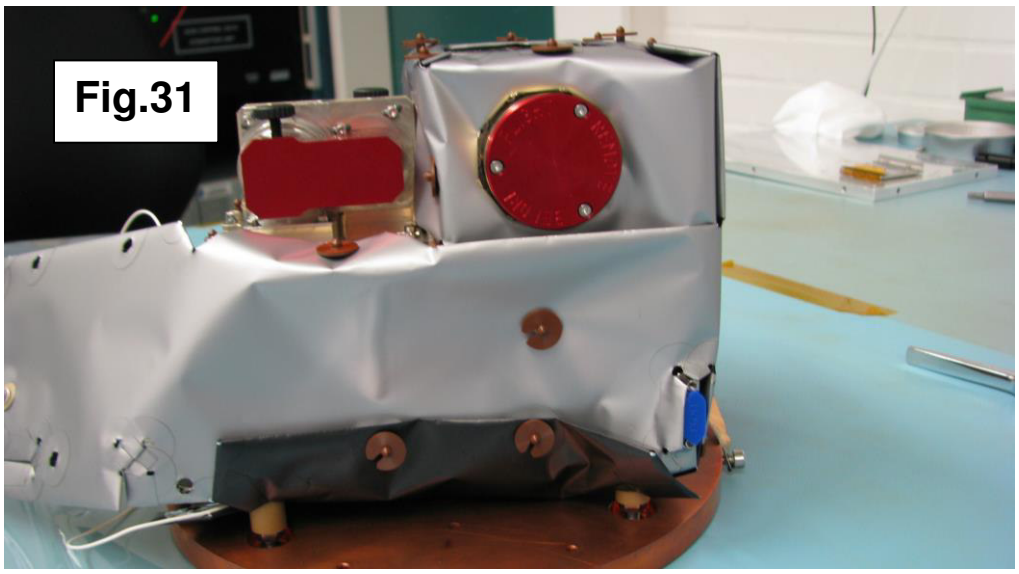


Fig.31

STEP 65: Upper MLI integration: Continue with [-Y] face

- Put the washer and the four MLI GND leads' lugs into the M4 screw, Fig.32, and torque it to the instrument MLI GND stud. (Only to keep the screw connected to the unit, not final torque).
- Pay attention that the MLI GND leads wires do not interfering with the unit MDM25 electrical connector.
- Purge pipe adaptor can be rotated to facilitate the integration; this is a design feature of the purge adaptor of the unit, Fig.33.
- Add strain relief for the MLI GND leads by supporting them on the [-Y] face using Kapton tape, Fig.34.
- After finalizing the proper radial position of the MLI GND leads lugs, apply the torque to the M4 screw equal to (1.20 ±0.2 Nm), Fig.20. The bolt and washer (M4x8-A2/70-stailess steel) will be provided by EPD-Kiel.

  Note: for screw locking of this screw, scotchweld shall be used.
- After applying the final torque, cover the M4 screw head with a piece of Kapton tape, Fig.36.
- To finalize the MLI integration on the [-Y] face, rotate the purge pipe adaptor toward [-Z] direction, Fig.37.
- Attach the clip washers, Fig.38 to 40.

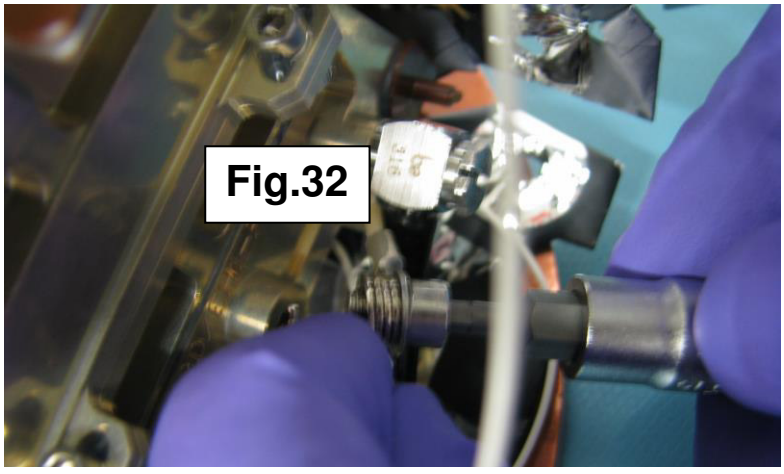


Fig.32

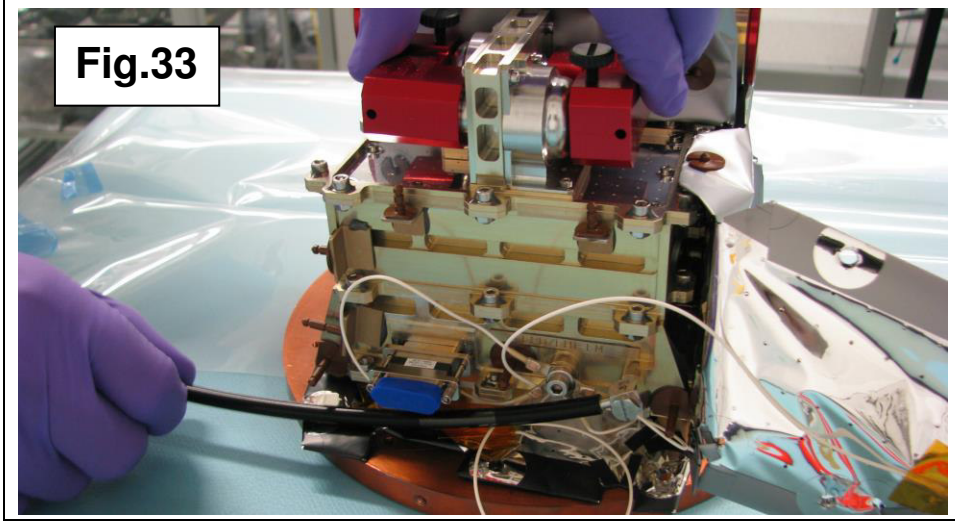


Fig.33

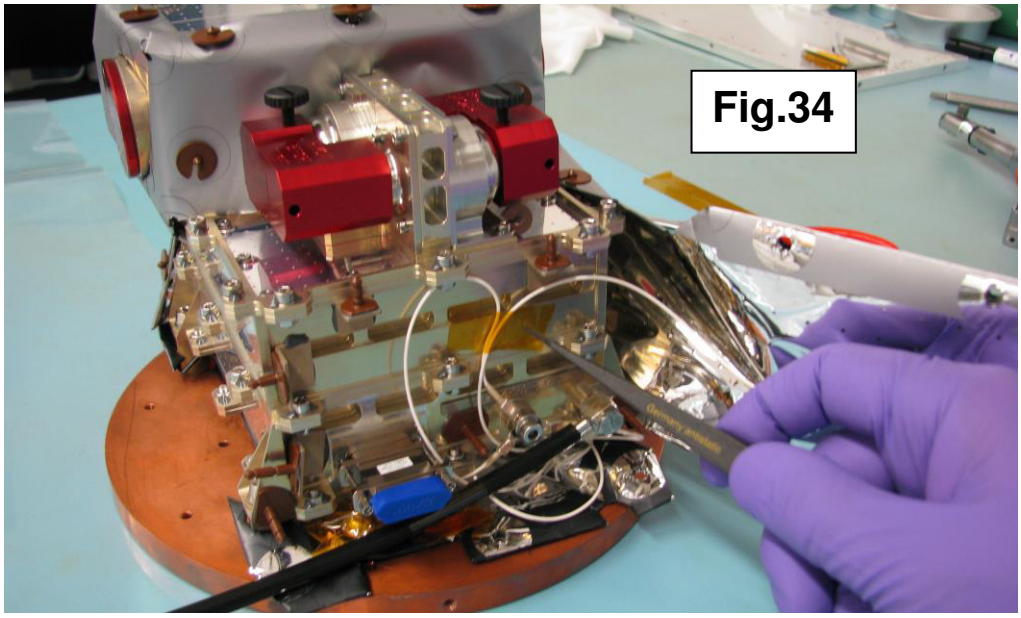


Fig.34

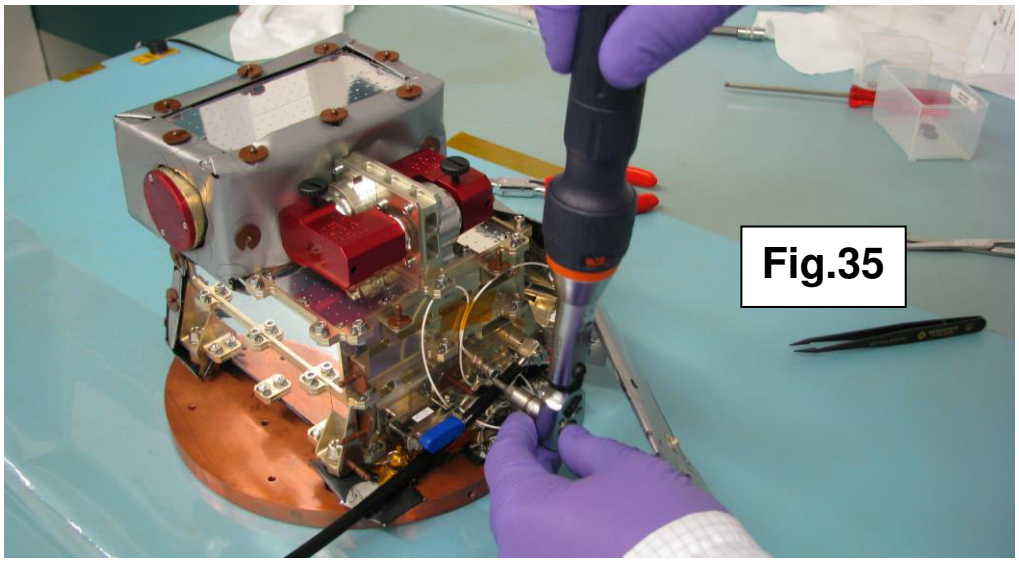


Fig.35

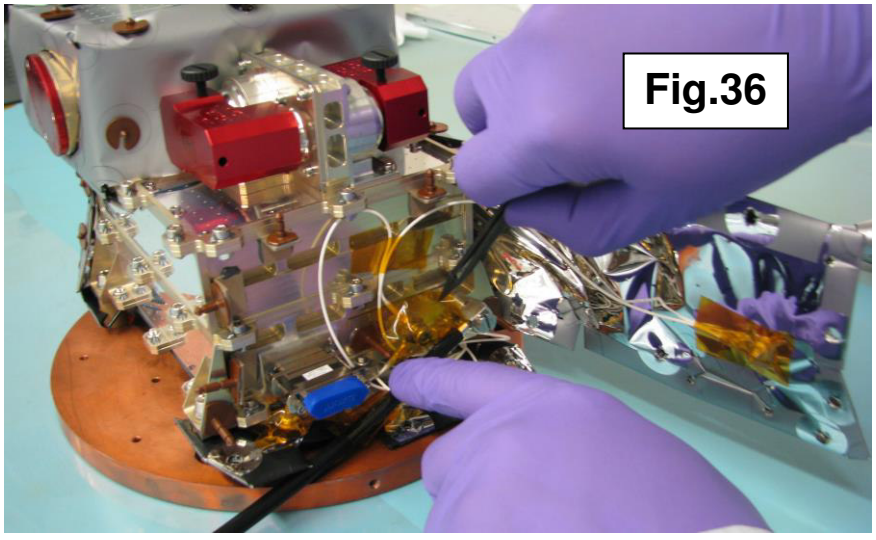


Fig.36

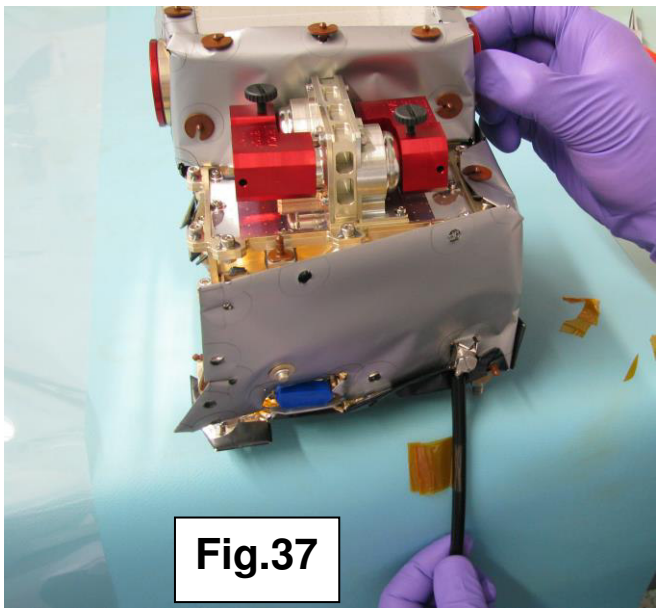


Fig.37

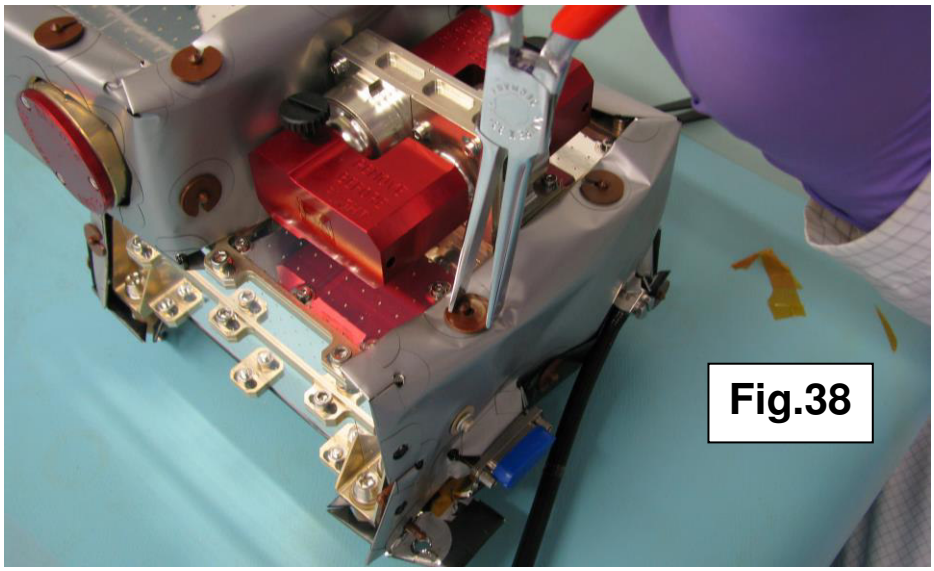


Fig.38

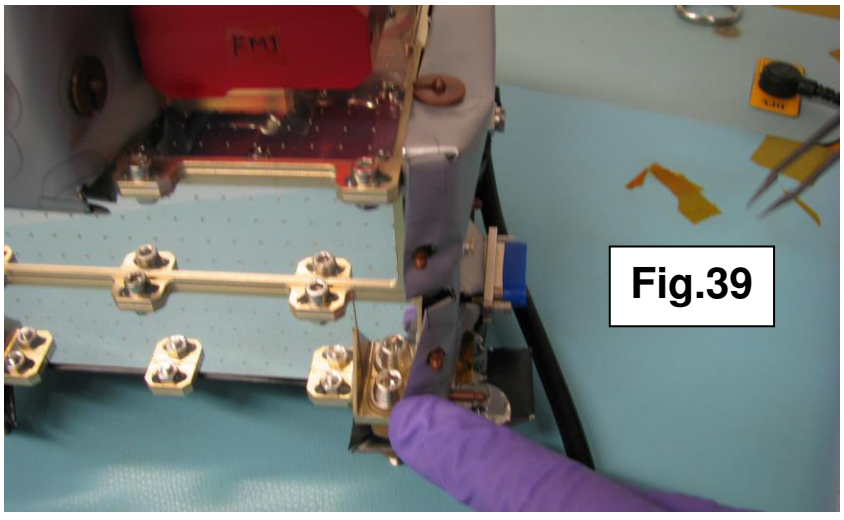


Fig.39

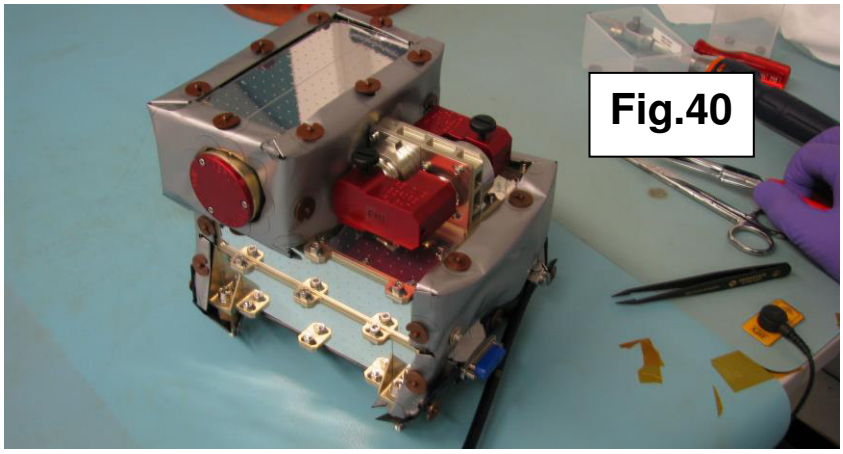


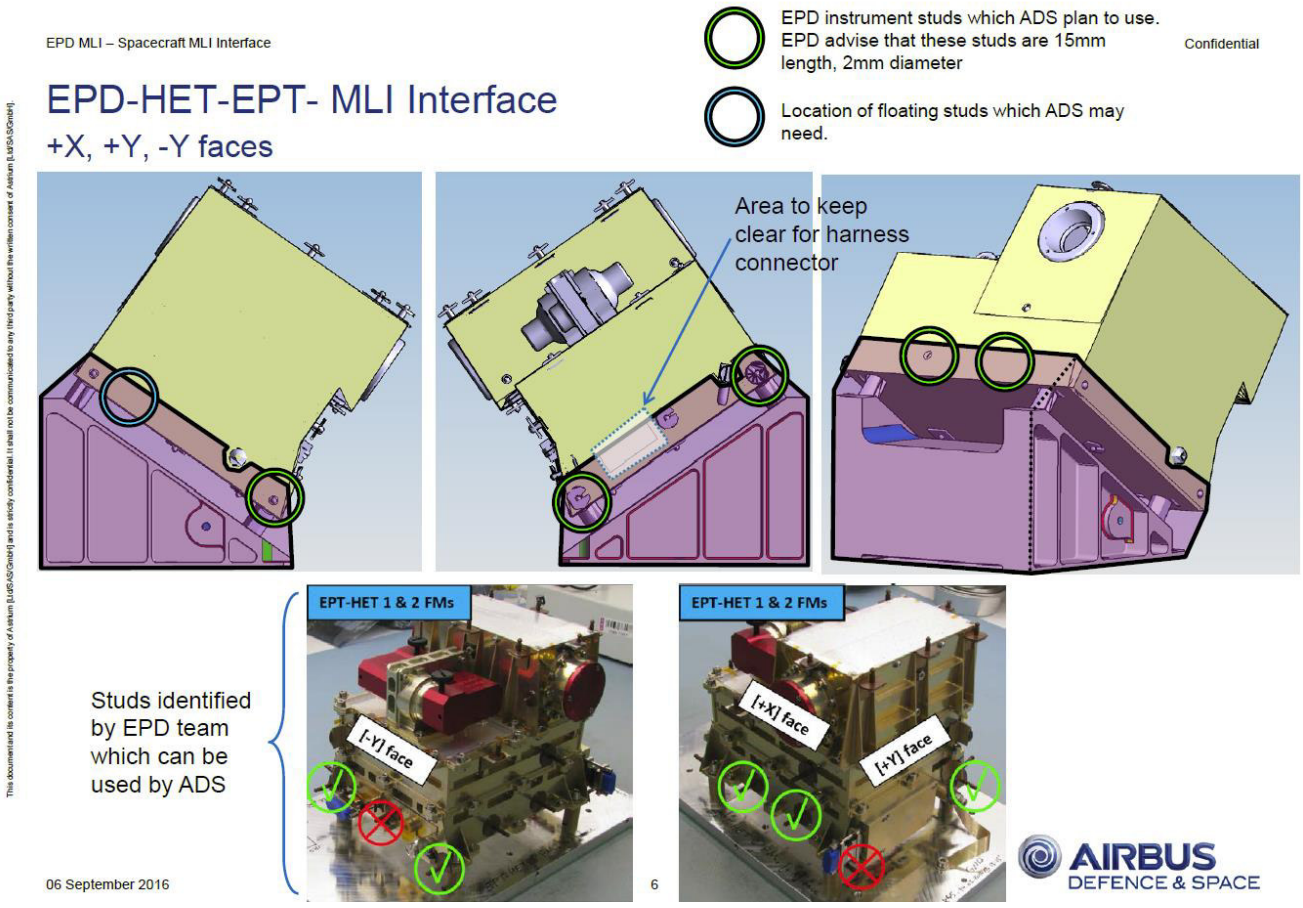
Fig.40

STEP 65-1: At this step the integration of the S/C I/F MLI on the sides of the unit can be done.

Photo from [RD-5].

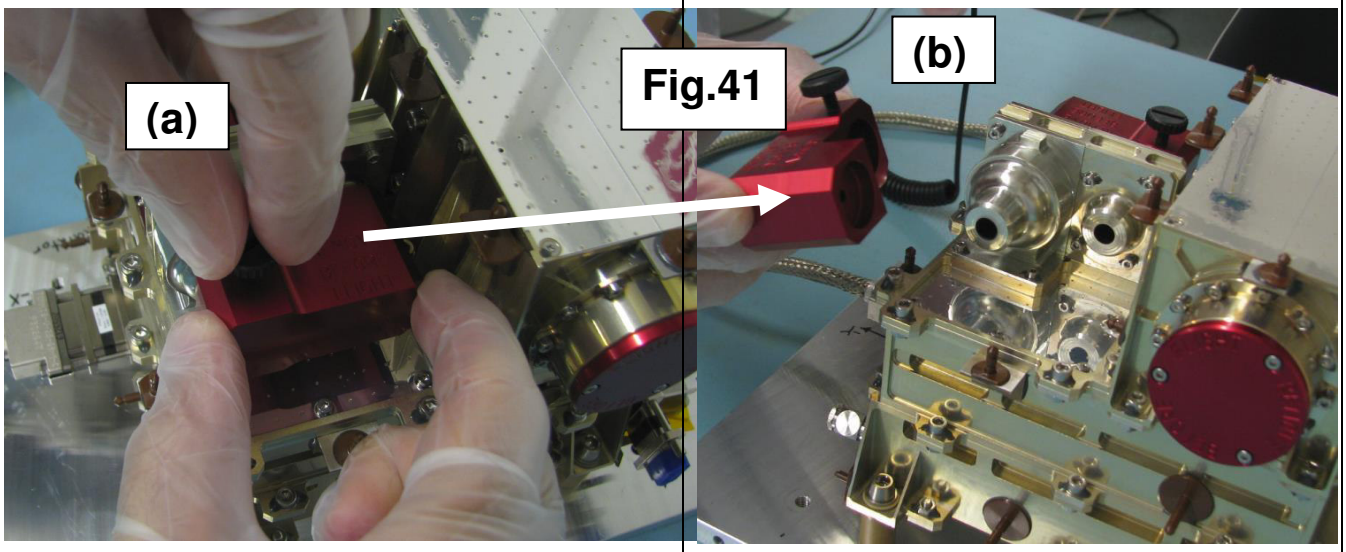
For the floating stud, the hole on the bottom MLI can be applied using a punching plier at this step, or before the MLI integration.

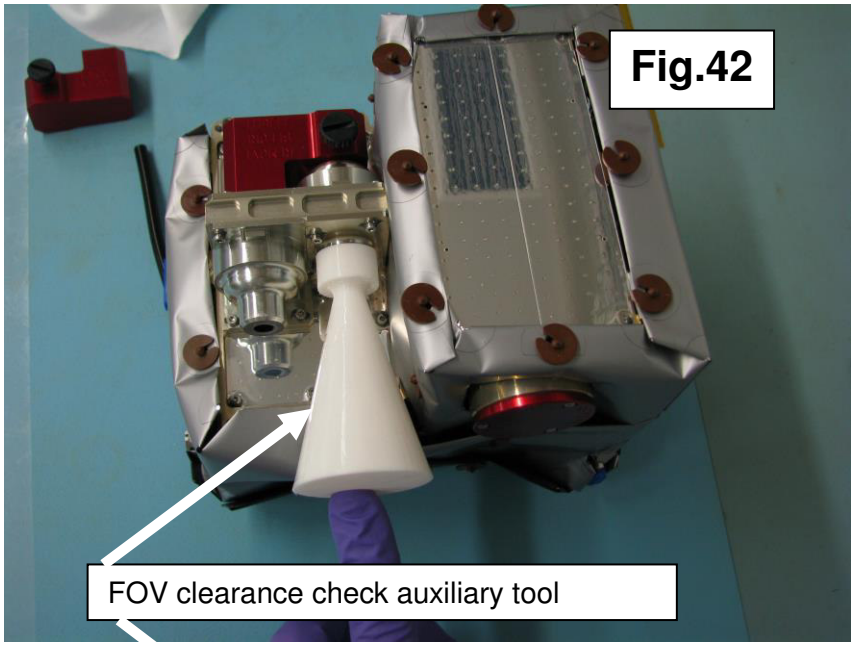
EPD-Kiel will provide an MLI fit check set to be used whenever needed by ADS before action on the real MLI.



STEP 70: Finalizing the MLI integration

- Remove EPT red tag cover which is located on [+X] side of the unit, Fig.41(a),(b).
- Make sure that EPT collimator FOV is free. This can be done by removing the EPT, Fig.42 and Fig.43. To ensure this requirement, put a piece of Kapton tape where is pointed by tweezer in Fig.44.
- Use Kapton tape to close gaps where necessary, e.g. where is pointed by tweezer in Fig.45.
- The unit with its MLI integration should look like what is seen in Fig.46 to 48.





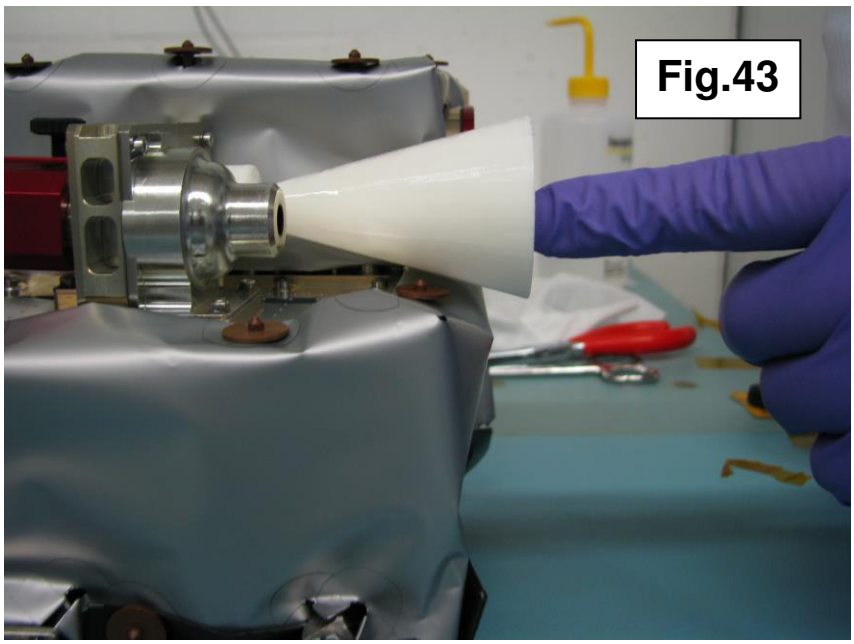


Fig.43

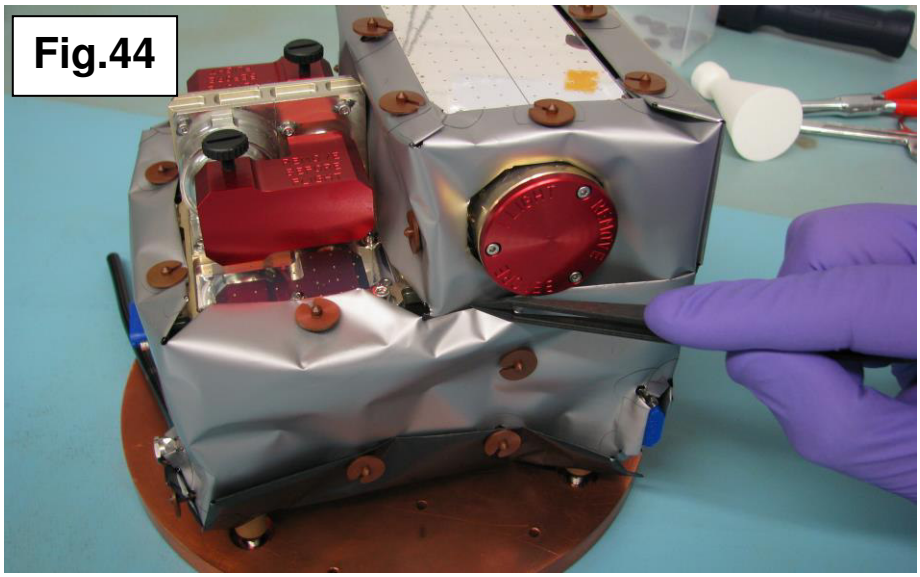


Fig.44

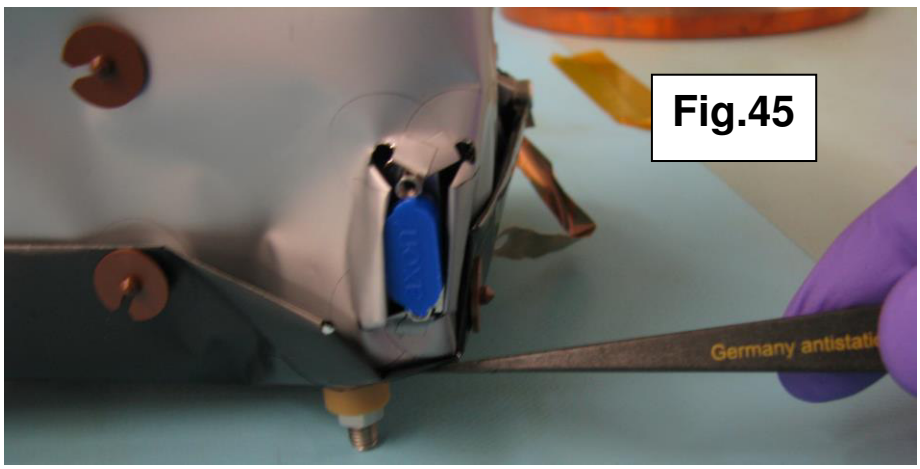
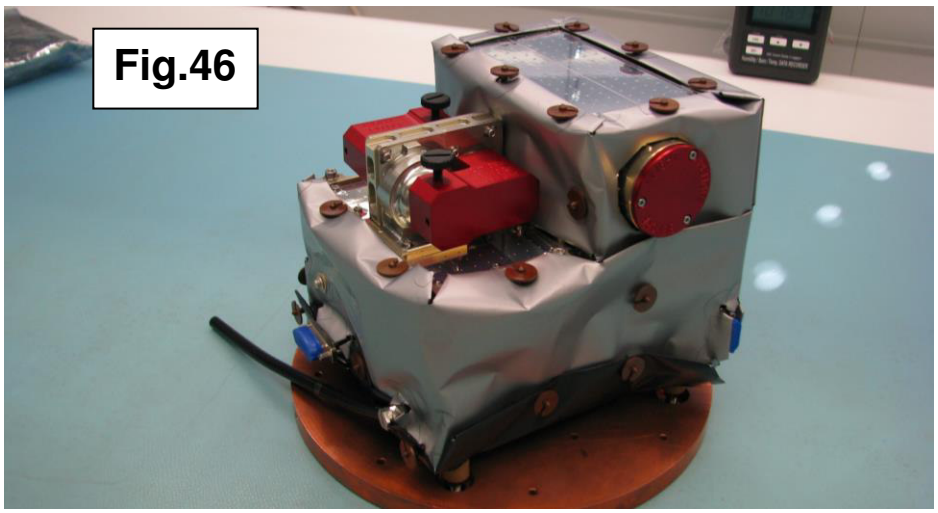
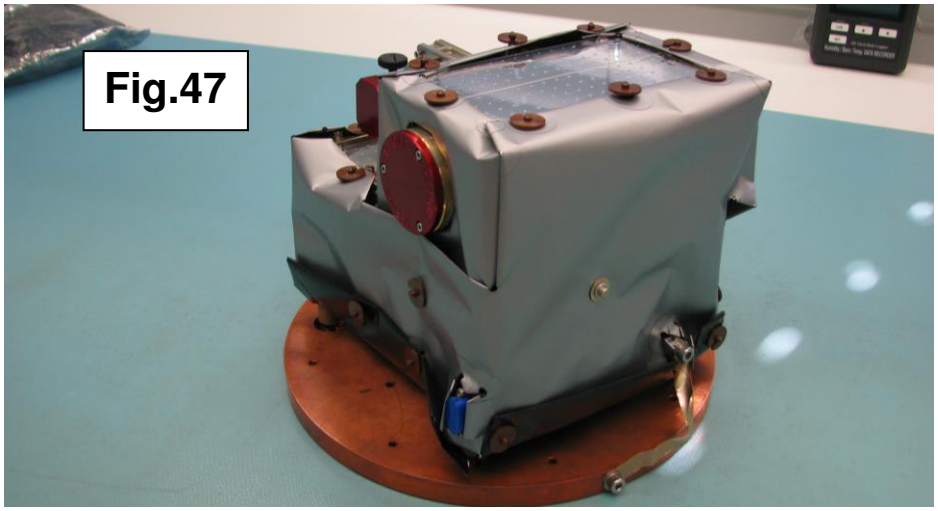
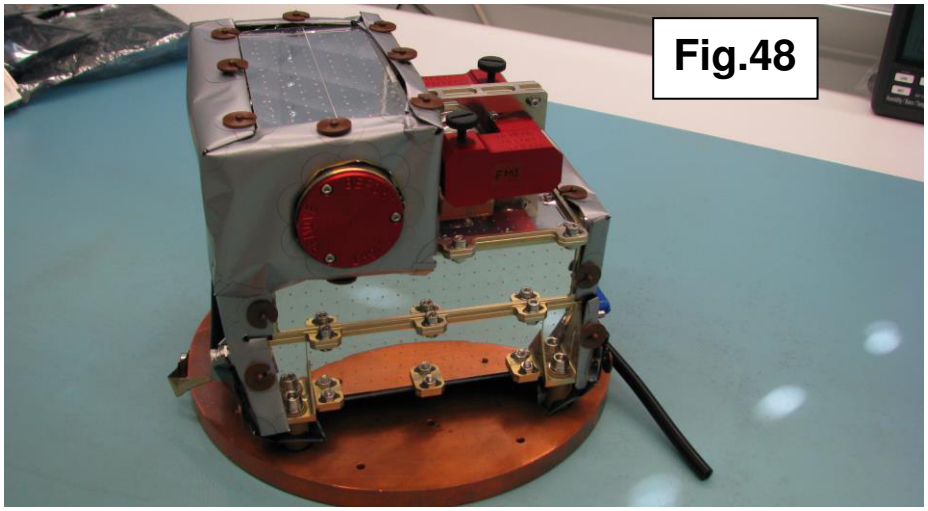


Fig.45







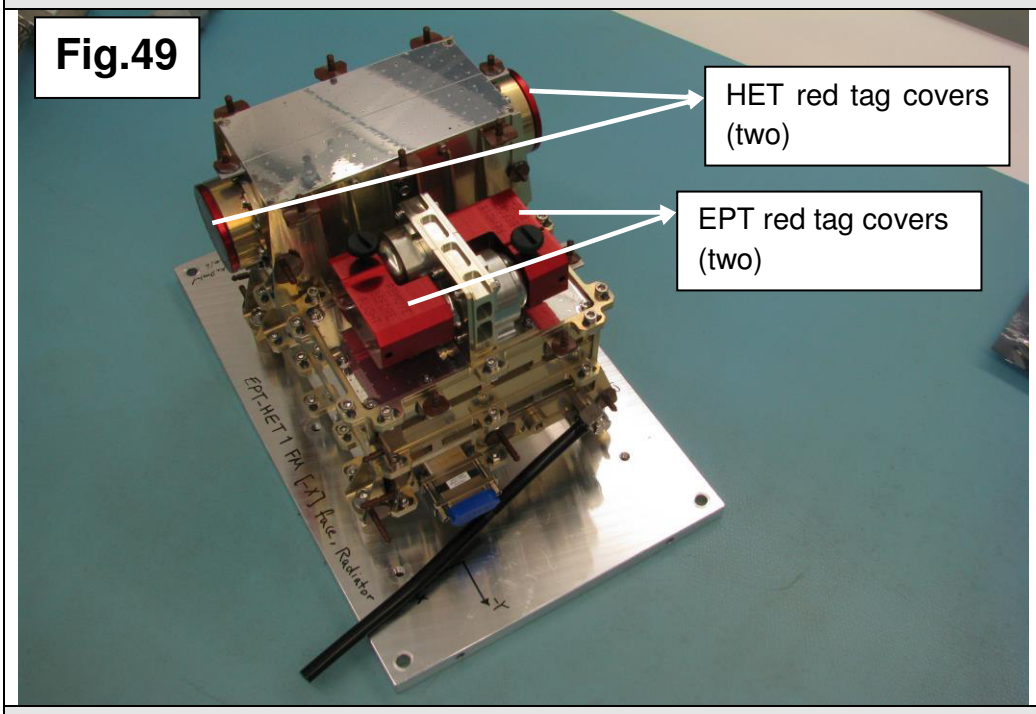
STEP 75: Connect the instrument purge pipe to the S/C purge line

5 RED TAG COVERS

Both EPT-HET1&2 FMs are delivered with red-tag covers which in total are four items. These have been manufactured from Aluminum and are thus „hard“. They are easy to handle, remove, and install. Note: The blue connector caps are for ESD protection during the handling.

EPT-HET red tag covers are indicated in Fig.49.

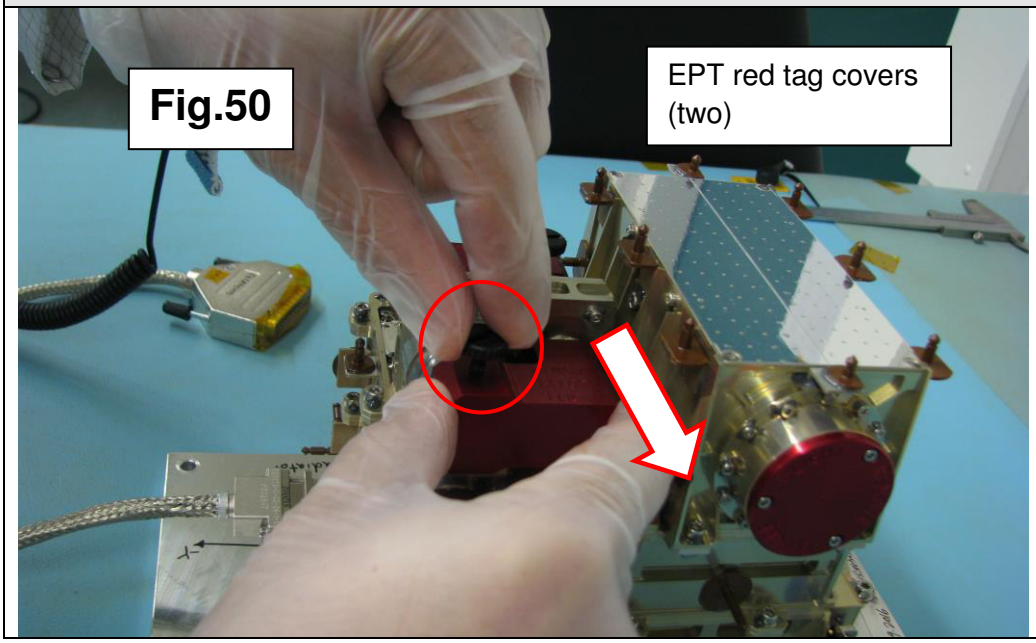
Fig.49

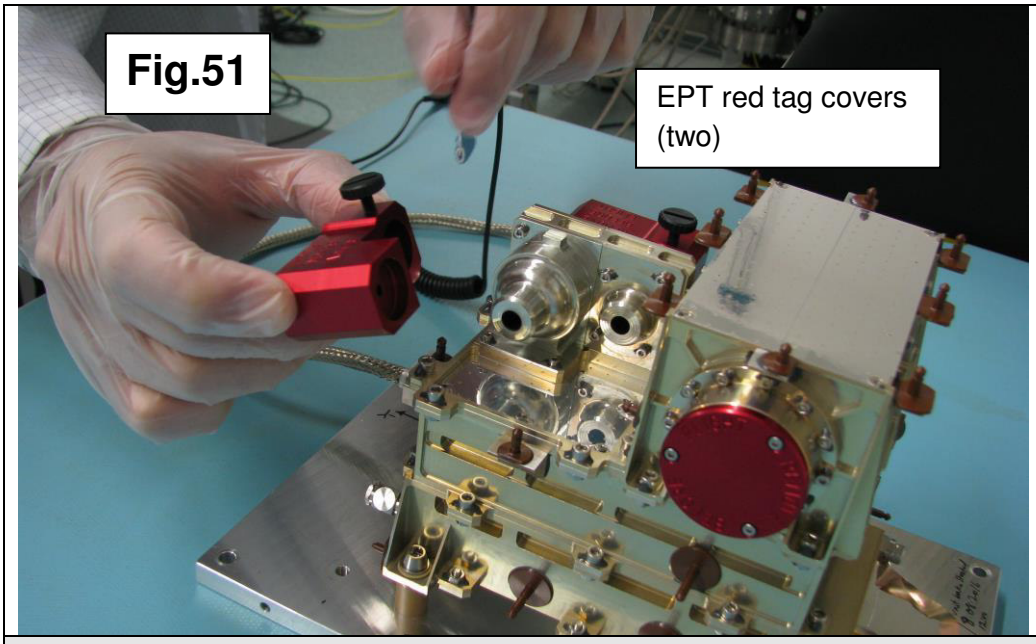


EPT red tag covers shall be removed as shown in Fig.50 and Fig.51.

The shown screw is part of the red tag cover and it is only needed to be loosened and not removed from the red tag cover. After loosening the screw (plastic), pull gently the red tag cover from the EPT collimator.

Fig.50





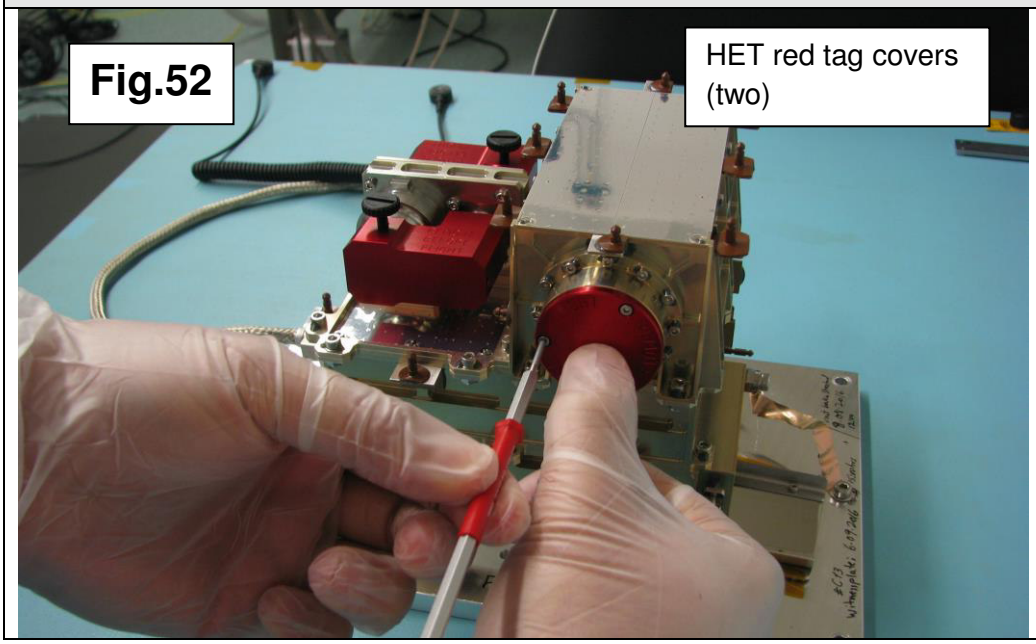
HET red tag covers shall be removed as shown in Fig.52.

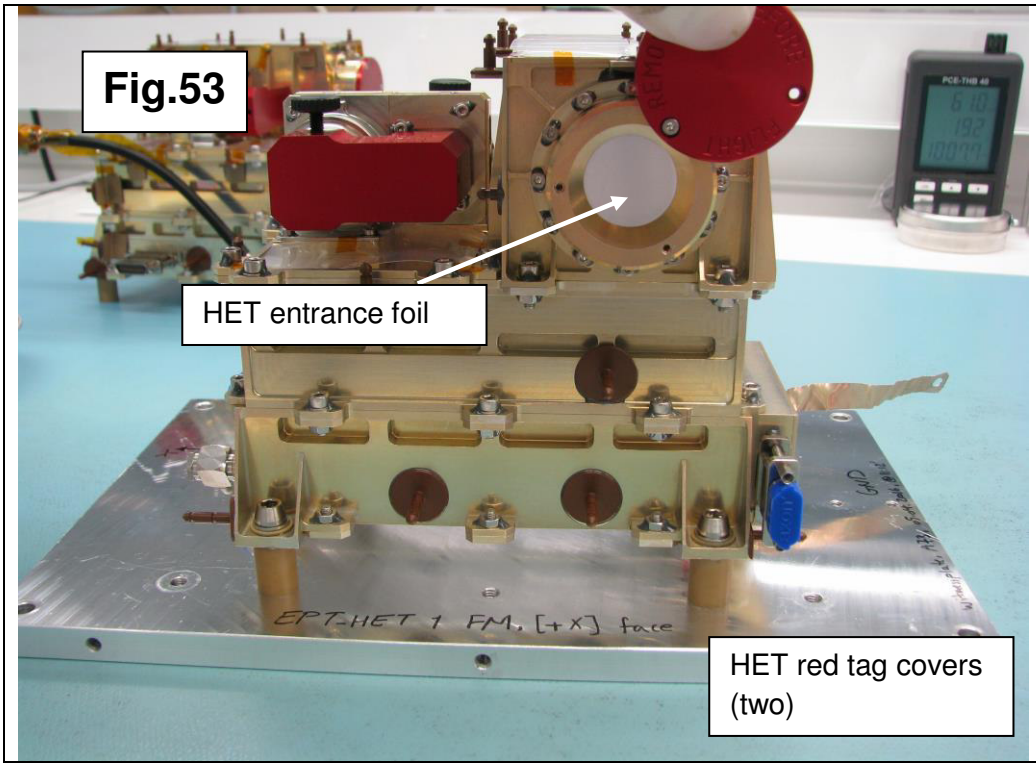
The red tag cover removal tool is Hex socket key ("Allen key"), no-ball head, 1.5mm and will be provided with the unit as indicated in the shipping list [RD-7] and [RD-8].

The HET red tag cover screws are rather small (M2, 4mm length). It is convenient to use a tweezer to keep them while opening in order to avoid losing them accidentally.

These screws are hand tight and in case a torque wrench is used the torque shall not exceed 0.28 N.m.

As seen in Fig.53, there is an entrance foil on HET collimator below the red tag cover. This foil is a sensitive surface and installing and removal of the HET red tag cover shall be done carefully.





5.1 Red tag covers during S/C environmental tests

According to [RD-13], the following is the current baseline for the red tag covers handling during the S/C tests:

- The red-tag covers for EPT-HET 1&2 shall be removed prior to vibration testing. EPT-HET 1&2 shall be bagged prior to vibration testing.
- After vibration testing, the bags shall be removed and the red-tag covers re-installed.
- The red-tag covers for EPT-HET 1&2 shall be removed prior to thermal vacuum testing.
- After thermal vacuum testing, the red-tag covers of EPT-HET 1&2 shall be re-installed.
- For functional tests of the units, the red-tag items shall be installed on EPT-HET 1&2. EPT detectors are sensitive to light and functional tests without the red-tag covers will result in unwanted noise and lead to unnecessary questions about the test results.
- No soft covers are foreseen for the apertures. The bags replace the functionality of soft covers. Because only ADS know the interface to which the bags need to be attached we believe that ADS should provide and install the bags.
- Because we have recently added our SSMs as sensitive surfaces, we strongly recommend that EPT-HET 1&2 remain bagged throughout S/C AIVT.

6 GROUND (AIT) CONSTRAIUNTS FOR EPTHET-1&2 AND STEP

EPD-Kiel assumes that ADS will comply with all instructions given in the handling procedure and in the spacecraft integration guidelines [SO-EPD-KIE-PR-0035, SO-EPD-KIE-PR-0036, SO-EPD-KIE-PR-0037 and SO-EPD-KIE-PR-0038].

When in a standard environment (clean room, AIT hall, clean bench, etc.), all CAU units shall only be operated with red-tag items on. Specifically, this applies to any functional test.

Thermal Vacuum Tests:

Coronal Discharge: The units may be powered at ambient pressure, but when inside the vacuum chamber, they need to be OFF in the pressure range between 1.e-4 mbar and 700 mbar.

Red-Tag items shall be removed before thermal tests and shall be re-installed thereafter before any functional tests.

Structural Tests (Vibration and Shock):

Red-tag items shall be removed prior to structural tests and the units shall be covered with a protective cover as described in section 5 of SO-EPD-KIE-PR-0037 and SO-EPD-KIE-PR-0038. After structural tests and before any functional tests the protective covers shall be removed and the red-tag items shall be re-installed.

Special precaution for STEP:

When STEP red-tag covers have been removed, STEP shall only be operated in a dark environment such as a vacuum chamber.

Annex A: pre-handover activities

The ADS added steps are highlighted in green according to: [AD-8: EPD/ADS agreed pre-handover steps].

STEP 00: Show up at ADS Stevenage site	**Responsible/ Estimated time**
EPD-Kiel personnel (four persons) will hand-carry the EPD-Kiel three units (EPT-HET1, EPT-HET2 and STEP) and also the deliverable MLIs in total of four suitcases with the dimensions of 55x45x25 cm, 8-10 kg. In addition to the above four suitcases, a normal box/bag with the maximum dimensions of 55x45x25 cm, 8-10 kg will be hand-carried. This includes a power supply and calibrated multimeter for stand-alone checks. Nevertheless, EPD-Kiel requires ADS to provide a power supply (0-32 V dc, 0.5 -1 A) as a backup plan. EPD-Kiel units inside the suitcases are double-bagged (passive purged), this means that no active purge is needed until the reception process at the ADS Stevenage is concluded and EPD-Kiel personnel are escorted by ADS personnel to the cleanroom which the stand alone check will be done. All pre-hand over activities will be done by EPD-Kiel personnel.	Resp: EPD 30 Minutes Only once
STEP 05: Goods-in Inspection and Transfer to Hercules Major Clean Room	
Perform Goods-in Inspection and record incoming items into ADS system ADS will provide EPD team Awareness training regarding working practices in Clean Room. Refer to LDS.0449 [AIT Working Practices in Clean Room] iaw LDS.0449 Clean and register all items entering Hercules Major Clean Room Complete transfer into Clean Room to Solar Orbiter Payload Bay (CAZ)	Resp:ADS 30 minutes Resp: ADS 15 minutes Resp: ADS 15 minutes Resp: ADS 15 minutes
STEP 10: Before unpacking the unit	
EPD-Kiel units will be unpacked for stand-alone check one after each other. This means that each unit will be unpacked after the preceding unit has finished its standalone check and already installed on the EPD-LTS interface plate. Before unpacking the unit, check whether the EPD-LTS is ready for hosting the unit after the stand alone check. This is important as the 6hours purge outage	Order of unpacking: 1. Tool box 2. EPT-HET 2 3. STEP 4. EPT-HET1

limit, [AD-2: Interface Control Document part-B], starts after unpacking and before this limit reach; the unit should be installed in the EPD-LTS and should be connected to purge. Required from ADS: • An ESD safe table and cleanroom environment as minimum ISO 8. The preference is having a clean bench (ISO 7 or better) for the stand alone check. • EPD-Kiel requires ADS to provide a power supply (0-32 V dc, 0.5 -1 A) as a backup plan. • LTS up and ready for purging EPD sensors • Three EPD-CAU staff will need to be present for the pre-handover activities: Ali Ravanbakhsh, Lauri Panitzsch, and Shri Kulkarni.	30 minutes only once Inspection of table and ADS equipment: 15 minutes only once A.R. and S.K. are non-EU citizens.
STEP 15: Unpack the unit	
Unpack the unit according to [RD-6: EPT-HET FM Packing/Unpacking, Storing, Transport & Handling Procedure]. • ADS QA to witness unpacking operations	Resp: EPD 15 minutes per unit ADS Sign Off
STEP 20: Unit fuctional test (stand-alone check)	

Perform the functional test according to [RD-14: EPTHET1 FM and EPTHET-2 PFM Functional test plan and procedure].
 	
• For each EPD-Kiel unit, the estimated time required performing the unpacking and the functional test is around three hours. EPD-Kiel units do not require purge for the FT realization.
  ○ Note (1): This time does not include the time required for the inspection and briefing by ADS before the start of unpacking in ISO 8 class environment.
  ○ Note (2): This time does not include the time needed to install the units on the EPD-LTS (Long Term Storage). See STEP 35.
 	
• After concluding the FT (health of the instrument after transportation from Kiel to ADS), a copy of the As-Run functional TP can be provided to ADS if required. This may serve a proof of unit health before the flight units hand over.
	Resp: EPD
	
	150 minutes per unit

STEP 25: remove connector savers	
Remove connector savers from the unit and keep the blue protective caps. Note: the conncetors mate/demate log sheet should be updated at this step.	Resp: EPD

STEP 27: ADS Incoming Inspection of Unit	
Perform incoming inspection of Unit iaw SOL.S.ASTR.PR.00047 [Solar Orbiter Hardware Receipt Inspection Procedure] This inspection can happen in parallel of Step 30 to 35 inclusive being performed but must be performed prior to installation to LTS (step 40)	Resp: ADS 45 minutes
STEP 30: connect unit purge pipe to the unit	
• The unit purge pipe will be connected to the unit after the unit FT and before mounting the unit of the EPD-LTS. • ADS QA and Mechanical Engineer to witness purge pipe fitting operations	Resp: EPD 15 minutes per unit ADS Sign Off
STEP 35: Remove the unit traveler witness place	
• Each unit traveler witness plate shall be removed and returned to EPD-Kiel for the analysis. • This is to ensure that there is no contamination during the hand carry transport. • ADS QA and Mechanical Engineer to witness purge pipe fitting operations	Resp: EPD 15 minutes per unit ADS Sign Off
STEP 40: Install the unit on the EPD-LTS interface plate	
Put the unit on the EPD-LTS according to [RD-1: EPD LONG TERM STORAGE USER MANUAL]. The EPD-LTS shall be next to the location of the unit tests. CAU does not intend to repack the units. • ADS QA and Mechanical Engineer to witness installation to LTS and purge connection operations and confirm fully trained	Resp: EPD 15 minutes per unit ADS Sign Off
STEP 50: Perform Inspection of MLIs	
Perform incoming inspection of MLIs iaw SOL.S.ASTR.PR.00047 [Solar Orbiter Hardware Receipt Inspection Procedure]	Resp:ADS 60 minutes (TBC)

Annex B

IberEspacio
Tecnología Aeroespacial

PROJECT:	**KI001**
CLIENT:	**UNIVERSITY OF KIEL**

TITLE:

EPTHET & STEIN MLI
User Manual

DOCUMENT No: **KI001-PR-0001**	ISSUE: **1**
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TABLE OF CONTENTS

Page

LIST OF FIGURES

Page

1. SCOPE

The objective of this document is to provide an ordered sequence of operations which will ensure efficient use of available time, controlled handling of hardware, a thorough system of documentation, and assurance that the EPTHET and STEIN MLI can be mounted as designed.

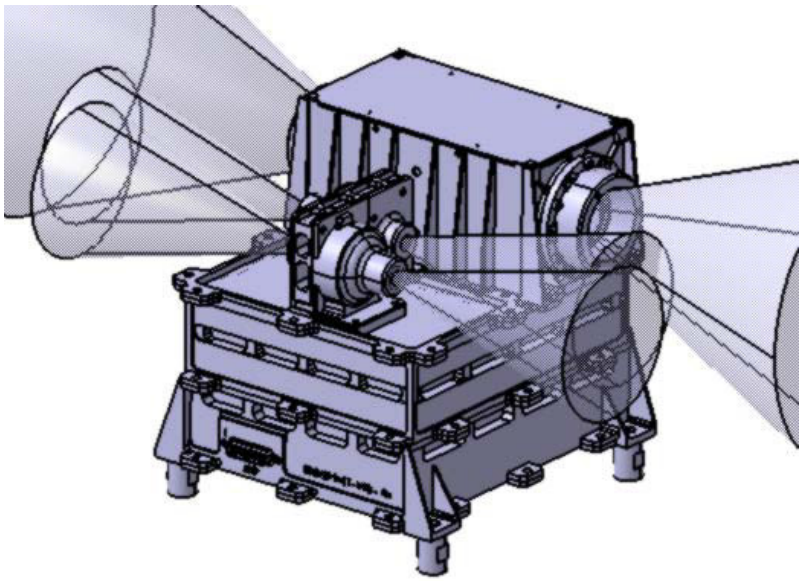


Figure 1-1 : *EPTHET Instrument*

Note that Issue 1 of this document only shows information for EPTHET, since the STEIN MLI are not deliverable for the STM.

1.1 ACRONYMS

CRC	Clean Room Clothing
CRFP	Carbon Fiber Reinforced Polymers
EEE	Electrical, Electronic and Electromechanical Parts
ICD	Interface Control Drawing
I/F	Interface
IE	IberEspacio
MAIT	Material, Assembly, Integration & Tests
MLI	Multi-Layer Insulation
N/A	Not Applicable
PPI	Parts & Processes Inspection
SOW	Statement of Work
TBC	To be Confirmed
TBD	To be Determined
TBI	To be issued
w.r.t.	With Respect To

Figure 1-2 – *Acronyms*

2. REFERENCES

2.1 APPLICABLE DOCUMENTS

AD	Ref.	Title	Date	Issue / Rev.
[AD01]	KI001-O-0001	EPTHET and STEIN MLI Proposal	06/03/2013	03

2.2 REFERENCE DOCUMENTS

RD	Ref.	Title	Date	Issue / Rev.

3. GENERAL REQUIREMENTS

3.1 REQUIRED TOOLS

The following elements are needed to integrate the OA Cover assembly:

- Clean Room clothing
  - Clean lint-free acetone impenetrable gloves (nylon gloves are not acceptable).
  - CRC100.000
- Cleaning tools:
  - Isopropyl-alcohol cleaning fluid.
  - Cleanroom compatible wipes or lint-free cloth, synthetic swabs.
- General purpose tools
  - Adhesive bonding tools.
  - Spatula for mixing and application of adhesive.
  - Tables in sufficient number and sizes with approved working surfaces.
  - Glass fiber scratcher.
  - Hollow punch.
  - Metallic tweezers.

3.2 PERSONNEL REQUIRED

The following personnel shall be available:

- Experienced MLI integration personnel.
- Quality assurance personnel, as required.

3.3 CHANGES

Deviations from this assembly procedure may be made with redline approval by the Project Manager. Steps may be performed out of sequence as deemed necessary at the discretion of the assembler. However, this should be noted as a redline on the procedure.

3.4 PRECAUTIONS

General guidelines for the integration of space hardware must be followed.

3.5 PRE-REQUISITES

The following pre-requisites have to be met before the integration can take place:

- None

4. LIST OF HARDWARE TO BE INTEGRATED

The following items will be integrated as part of the EPTHET & STEIN MLI:

Table 4-1 : *List of Hardware to be Integrated*

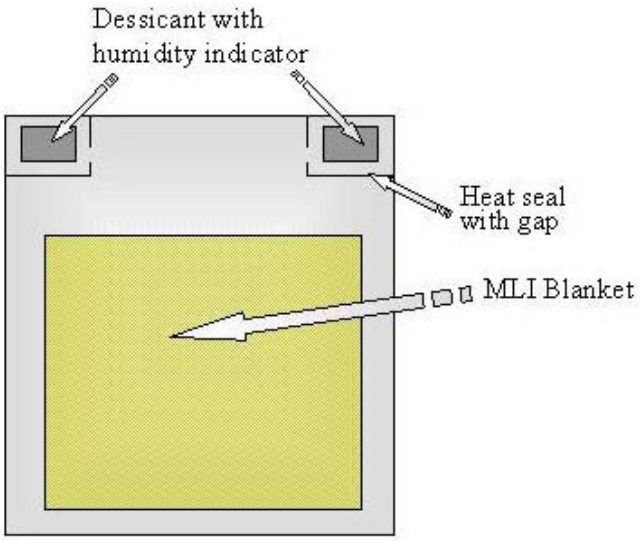
Part Number	Quantity	Description
EPTHET Hardware		
KI001-F-00111	1	MLI covering main body
KI001-F-00112	1	MLI covering bottom area
KI001-F-01051	5	Stand-off bracket
KI001-F-03561C	12	Simple stand-off
KI001-F-03562C	5	Double stand-off
IEF001-F-03563C	22	Clip Washer
STEIN Hardware		
TBD	TBD	TBD

5. HANDLING THERMAL HARDWARE

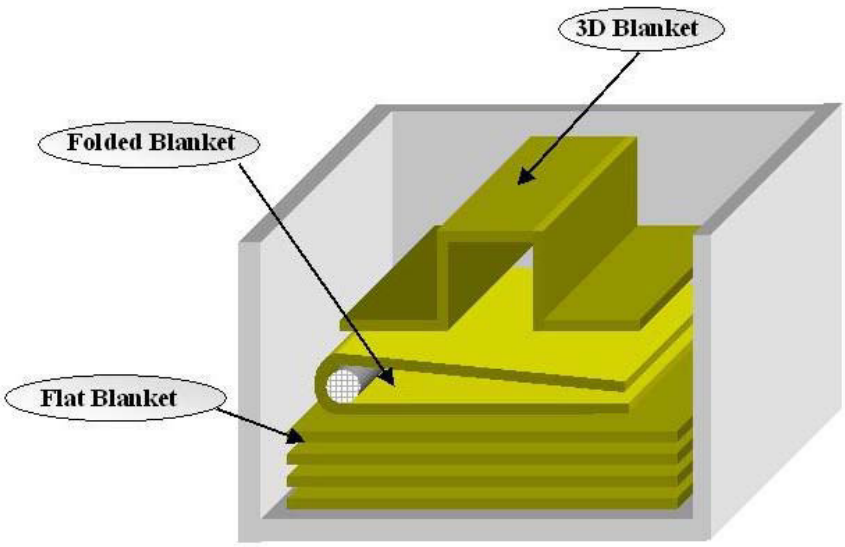
GENERAL	• Gloves must be used at all times. • Extreme care must be taken when manipulating TH due to its high cost and limited reparability. • In case of manipulating foils with germanium deposition, the use of mask is mandatory.
CLEANLINESS	• All equipment, such as tables, which come in direct contact with the foils, must be appropriately clean. The relevant cleanroom procedure has to be followed. • Cleanliness conditions are essential for thermal hardware to operate properly. Therefore these items are manufactured, integrated, checked and handled under clean conditions. • The thermal blankets are to be protected against contamination by particles or fluids/greases. They may only be handled by personnel wearing gloves. The spots on the TH shall be removed immediately.
THERMAL BLANKETS AND FOILS	• To prevent damaging sensitive surfaces, the foils shall not glide one on another or on the table. By applying appropriate care, touching, rubbing or tearing of the blankets on equipment in the cleanroom is to be avoided. • Thermal blankets and foils, especially 3-dimensional shaped ones, shall not be bent, folded or deformed unduly to protect the foils and their coatings. • Thermal hardware should be put down carefully and never dropped. Care must be taken to avoid using excessive force (especially during integration).

BONDING LEADS	• External thermal blanket are equipped with grounding leads. Thermal blankets are never to be picked up or held on the grounding leads. The grounding leads must not be unduly bent or folded. • Grounding leads shall be rolled to a diameter of approx. 60 mm when not being attached to the spacecraft in order to keep them from being caught by cleanroom equipment, from touching the ground and from scratching the sensitive surfaces of the foils.
METALLIC PARTS	• Metallic parts, which are already cleaned, may only be handled in a clean environment and only using suitable gloves.
NON METALLIC PARTS	• Non metallic parts (eg. VESPEL stand-offs), which are already cleaned, may only be handled in a clean environment and only using suitable gloves.

6. PACKING AND UNPACKING

PACKING OF SLI / MLI	• Up to 4 thermal blankets / foils may be wrapped together in clean, clear Mylar. They are spaced from each other by clear Mylar foils. • Humidity indicator / desiccants (min. 160 g desiccant / m^2 polyethylene bag) are added and finally the polyethylene outer bag is sealed as shown in Figure 5-1 below.  Figure 6-1 : *Packing of TH* • If a large blanket must be folded once for packing into the container, it must be packed singly. In order to prevent the SLI / MLI from been damaged at the folding line, a roll of crinkled 1.0 mil Mylar is added (approx. ∅ 50 mm).
UNPACKING OF BLANKETS AND FOILS	• *Quality Assurance:* *The container's outer surface shall be cleaned before entering the cleanroom with the container. QA personnel must be present when the blanket container is opened.* • The container shall be opened and the bags containing TH shall be removed. Only one bag should be removed at a time. The containers shall be closed between each bag removal and after removal

	of all blankets. • *Quality Assurance:* *The status of the humidity indicator enclosed within the outer package must be recorded before opening the package. Using lint-free gloves is mandatory.* • Open the outer bag. The blankets shall be taken from the package as necessary, wrapped in clean clear Mylar when not fully protected. • Blankets may be piled up as long as it is ensured that each one is singly wrapped in clean clear Mylar to avoid scratches.

STACKING SEQUENCE FOR CONTAINERS	The following stacking sequence has to be strictly maintained when packing blankets into an aluminum box container (see figure 5-2): • bags containing “flat” blankets are placed first into the container • bags containing “folded” blankets are placed after the “flat” blankets • bags containing “3D” blankets are placed last, on top of all other bags  Figure 6-2 : *Stacking of blankets in containers*
PACKING OF NOM METALLIC PARTS	• Small parts, such as stand-offs and clip washers, may be put together into one polyethylene bag. • Flat parts, such as doublers, may be put together into one polyethylene bag, which is finally heat-sealed. • 3D-shaped parts shall be individually packed in a polyethylene bag, which is heat-sealed when ready. • Each outer bag will be provided with a label at least containing the part number of the parts included.

INSPECTION	• Each time hardware items are placed into their respective protection bags, they should be visually inspected for any signs of damage.
STORAGE	• In order to lay down thermal blankets and foils for less than 1 working day, the insulation item is to be put on one of the dedicated clean areas and to be covered by clean, clear Mylar foils. • If the foreseen storage time exceeds that period, it is recommended that the respective insulation item is packed in accordance to the applicable packing procedure and stored in the dedicated transport and storage container.

7. TRANSPORT

GENERAL	• Thermal blankets and foils can be transported by road, rail and air.
PRECAUTIONS	• If the container is not water tight, it should be adequately covered if exposed to humid environments. • The container must be adequately secured by means of tension straps or netting retention. • During transport shocks should be avoided to prevent damaging the container and contents.
STORAGE	• For short and long-term storage a clean covered facility is required.
CONTAINER LABELLING	• The container will be externally marked using labels, written in English, and/or international symbols. • Moreover, each shelf will be labeled in English indicating which blankets have to be stored in the named shelf. • Damaged labels should be replaced by new ones.

8. MLI INTEGRATION DESCRIPTION

8.1 GENERAL INSTRUCTIONS FOR THE INTEGRATION OF MLI

8.1.1 REQUIREMENTS

- A sufficient number of tables shall be available, such that all blankets can be laid out without undue deformation.
- These tables shall have a Teflon working surface or any other approved working surface.
- Clear clean Mylar shall be made readily available for covering of unpacked blankets.
- Any possible contamination source (particulate or molecular) must be removed.

8.1.2 PREPARATION OF WORKING SURFACES

- The tables shall be visibly clean. If necessary they shall be pre-cleaned using Isopropyl-alcohol cleaning fluid.
- Working surfaces shall remain smooth in order to avoid blanket damage.

8.1.3 UNPACKING OF BLANKETS

- Blankets are packed inside polyethylene bags with desiccant bags and humidity indicators.
- Open with care the polyethylene bag in which the blanket is packed.
- Remove desiccant bags and humidity indicators.
- *Quality Assurance*: Check humidity indicators.
- When not working with a blanket, always keep it protect it by two clean clear Mylar foils to protect both surfaces.

8.1.4 ATTACHMENT OF CLIP WASHERS

- Clip washers must be applied very carefully to avoid undue force on the stand-offs. Clip washers shall be applied as shown in the following figure:

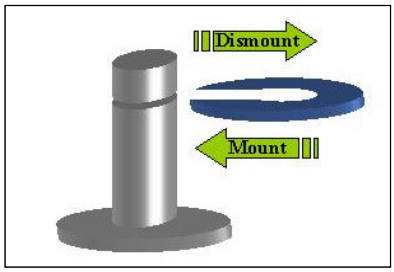


Figure 8-1 : *Clip Washer Attachment*

8.1 GENERAL INSTRUCTIONS FOR THE INTEGRATION OF MLI

- Removal of clip washers must be performed following the reverse procedure. Pliers may be used as shown in the figure below:

Figure 8-2 : *Removal of Clip Washer*

8.1.5 DOCUMENTATION

The electrical resistance between the rivet of one bonding point and its structural reference shall be measured and recorded for each MLI blanket / foil radiator.

8.1.6 BLANKET REMOVAL

In order to remove a blanket, the reverse procedure shall be followed

Quality Assurance: *Before removal of a blanket verify,*

- That all overlaps are free.
- All clip washers have been removed.
- All bonding leads have been disconnected.

Quality Assurance: The maximum allowable number of mountings/dismounting of MLI is 10.

8.1 GENERAL INSTRUCTIONS FOR THE INTEGRATION OF MLI

8.1.7 OPEN WORK

Open works are defined as a number of cut-outs, slits etc. have to be made during integration.

They will be registered in the relevant ADP.

Quality Assurance: This work is to be performed by IE integration personnel in presence of an IE QA representative to ensure that the same manufacturing standards / methods are applied as during the production of this hardware.

8.2 STAND-OFF BONDING WITH ADHESIVE SCOTCHWELD 2216 B/A

8.2.1 GENERAL

- Due to the variety of stand-offs, an established routine must be followed to avoid bonding a stand-off to an incorrect position.
- For each batch of adhesive a bonding sample with stand-offs and a relevant structure sample is necessary. The samples shall be kept for traceability reasons.
- These processes have to be performed by a qualified operator.

8.2.2 POSITION MARKING

- Position the MLI over the structure
- The positions where stand-offs will be bonded must be temporally marked on the structure.
- Stand-offs should be positioned with the help of templates.

8.2.3 UNPACKING OF STAND-OFFS

Quality Assurance: Open packages in the presence of QA personnel.

Open the package containing the stand-off type which is due for bonding. Stand-offs are supplied in clean condition.

8.2.4 STAND-OFF BONDING

Will be performed according to IberEspacio's procedure IEF001-IT-8011 Iss. 2 or other customer procedure (if applicable).

8.2.5 FIXATION FOR CURING

Fix the stand-off with one or two pieces of flashbreaker tape over the base to avoid slippage.

8.2.6 CURING OF THE ADHESIVE: SCOTCHWELD 2216 B/A

Curing time before loading: 24 hours min. at RT

Removal of tapes: after 8 hours

8.3 PUNCHING OF STAND-OFF HOLES

Not Applicable.

MLI delivered to customer with stand-off holes already punched.

8.4 INSTALLATION OF BONDING LEAD PARTS

1. Locate the Structural Bonding Point.
2. Attach the free bonding lead connector to its corresponding bonding point.
3. Screw the inner bolt with a washer. TORQUE = TBD Nm
4. Fix the routing with patches of plain Kapton tape (1 inch x 1 inch), taking care that this routing does not cross over detachable parts of the structure.

8.5 MLI INTEGRATION

8.5.1 EPTHET & STEIN MLI

8.5.1.1 *REQUIREMENTS*

Follow the general guidelines established in 8.1.

8.5.1.2 *MLI Integration*

1. Open the bag and take out the EPTHET & STEIN MLIs.

Figure 8-3 : *EPTHET MLI's unpacking*

2. Position the MLI's over the instrument and adapt it to the instrument's shape.

3. Connect the grounding leads to the instrument and measure the resistance. The electrical resistance between the MLI's and the instrument shall less than 5 Ω.

Include the measured resistance value in the table in Annex A.

Figure 8-4 : *MLI grounding leads*

8.5 MLI INTEGRATION

5. Install the VIHI & STC MLI's in this sequence:
    1. KI001-F-00111: MLI covering main body
    2. KI001-F-00112: MLI covering bottom area

6. Apply a clip-washer to every stand-off.

Figure 8-5 : *Application of Clip-Washer on Stand-Off*

7. Tape the MLI overlaps and slits as necessary to prevent solar trapping.

IBERESPACIO recommends using Flashbreaker tape until the final assembly since Kapton tape may be hard to remove.

9. CLEANING

SAFETY CONSIDERATIONS	• The personnel has to follow supplier safety data sheets, especially when using isopropyl alcohol or acetone • Protective clothing and gloves must be used.
CLEANING PROCESSES	• The cleaning of the delicate hardware has to be performed with utmost care. • Cleaning shall only take place in the appropriate environment. • Care must be taken not to degrade thermo-optical properties of the hardware and not causing scratches on the surface.
CLEANING OF THERMAL BLANKETS AND FOILS	CLEANING WITH CLEANING SOLVENT: • Thermal blankets and foils shall be cleaned using isopropyl alcohol as solvent and a disposable wiper or lint-free cloth. • Organic contaminants shall be removed from the blankets/foils with a soaked wiper. No solvent should penetrate the perforation holes on the foils. • 5 minutes should be allowed for full evaporation of the solvent.
	CLEANING WITH GN_2: • Particles can be removed by means of a compressed GN_2 jet and/or vacuum.
CLEANING OF BONDING LEADS	• If bonding leads are contaminated, wipe them thoroughly with a disposable wiper soaked in Isopropanol.

CLEANING OF MATERIAL PARTS	• Stand-offs, clip washers, grounding washers etc. have been cleaned before their delivery. If contamination occurs, a replacement shall be considered, as spare parts are available in most cases. • If cleaning of such parts is decided, they should be cleaned according to the appropriate procedures.
CONTAINER CLEANING	• First clean the container outer surfaces. This can be performed using water and wipers. • Isopropyl alcohol, diluted with water (50 : 50) shall be used for the precision cleaning of the container, both internally and externally. Lint-free cloth must be used. • Although the seal in the container rim is capable of coming into contact with the cleaning medium, it should not be saturated with such. • The container shall be located close to the airlock in a pre-cleaned environment and shall be cleaned thoroughly internally and externally. • The container must remain closed when no loading/unloading activity is in progress. • Leave 5 minutes to allow for evaporation of cleaning agent.
CLEANLINESS INSPECTION	• After performing cleaning, a visual inspection has to be performed to verify the cleanness of the hardware.
DOCUMENTATION	• After delivery each cleaning process has to be recorded.

10. REPAIR

GENERAL	• Damaged layer of a blanket/foil, attachment, electrical bonding provisions, etc. have to be repaired with a material similar to that of the material being repaired. • Generally, for a damaged aluminized layer, VDA / Kapton tape can always be used. VDA / Kapton tape used to repair shall always be attached if possible on the non-space side.
REPLACEMENT CRITERIA	Typically, as guideline, a new blanket must be manufactured if: • Tears in a damaged outer layer exceed 150 mm. • Holes in a damaged layer exceed ∅ 020 mm. • Total repair area exceeds 10% of the total blanket area. • One or more layers are damaged in such a way, that the required mechanical/thermal/electrical performance cannot be achieved, and the respective layers cannot be replaced. • High contamination level that prevents achieving the required thermal/electrical performance and local repair or cleaning is impossible. • Grounding point repair is impossible. Nevertheless, final decision to re-manufacture has always to be made via MRB.
DOCUMENTATION	• For each repair, an NCR has to be done. • Each repair has to be recorded in the ADP of the blanket with reference to the respective NCR. The extension of the repair and mass has to be noted.

ANNEX A: MLI VERIFICATION CHECK SHEET

MLI INSTALLATION CHECK SHEET										
Part Number	Serial Number	Stand-off bonding	Fit to check	Modifications	Stand-off hole punching / Crack stopper application	Grounding Lead Resistance	MLI Installation	Floating Stand-offs	Final Closure with tape	Remarks
KI001-F-00111						R1= R2=				
KI001-F-00112						R1= R2=				

ANNEX B: ADHESIVE MIXTURE RECORD

IberEspacio Tecnología Aeroespacial	**ADHESIVE MIXTURE RECORD**	Item: Page: Date:

Project Name:	Project Ref.:	Location:

ADHESIVE

	Description	Batch Nr.
Part A:	SCOTCH-WELD 2216 A	
Part B:	SCOTCH-WELD 2216 B	

DOCUMENTATION

	Title	Reference
Reference Document:	-	-
Applicable Document:	-	-

MIXTURE

Mixture Ratio: R = Mass Part A / Mass Part B = 7/5 = 1.4

	Part A	Part B	Ratio
Theoretical	Divide by 1.4 →		1.4
Measured	↑		

ENVIRONMENTAL CONDITIONS

Temperature: ºC	Humidity: % r.H.

CURING INFORMATION

Pot Life: 90 min	Minimum cure time at room-temperature: 8h
Time to handling strength: 24h (25ºC)	Time to full cure: 7 days (24ºC)

BONDING SAMPLES

Materials:	
Number of samples:	Sample ID:

REMARKS

Performed by	Verified by
Date:	Date:

Formato IT-3301-F4-I Ed. 2

ANNEX C: ADHESIVE DATA SHEETS

3M

Scotch-Weld™

Epoxy Adhesive

2216 B/A

Technical Data **December, 2009**

Product Description

3M™ Scotch-Weld™ Epoxy Adhesive 2216 B/A is a flexible, two-part, room temperature curing epoxy with high peel and shear strength. Scotch-Weld epoxy adhesive 2216 B/A is identical to 3M™ Scotch-Weld™ Epoxy Adhesive EC-2216 B/A in chemical composition. Scotch-Weld epoxy adhesive EC-2216 B/A has been labeled, packaged, tested, and certified for aircraft and aerospace applications. Scotch-Weld epoxy adhesive 2216 B/A may be used for aircraft and aerospace applications if proper Certificates of Test have been issued and material meets all aircraft manufacturer's specification requirements.

Typical Uncured Physical Properties

Note: The following technical information and data should be considered representative or typical only and should not be used for specification purposes.

Product	3M™ Scotch-Weld™ Epoxy Adhesive					
	2216 B/A Gray		2216 B/A Tan NS		2216 B/A Translucent	
	Base	Accelerator	Base	Accelerator	Base	Accelerator
Color:	White	Gray	White	Tan	Translucent	Amber
Base:	Modified Epoxy	Modified Amine	Modified Epoxy	Modified Amine	Modified Epoxy	Modified Amine
Net Wt.: (lb/gal)	11.1-11.6	10.5-11.0	11.1-11.6	10.5-11.0	9.4-9.8	8.0-8.5
Viscosity: (cps) (Approx.) Brookfield RVF #7 sp. @ 20 rpm	75,000 - 150,000	40,000 - 80,000	75,000 - 150,000	550,000 - 900,000	11,000 - 15,000	5,000 - 9,000
Mix Ratio: (by weight)	5 parts	7 parts	5 parts	7 parts	1 part	1 part
Mix Ratio: (by volume)	2 parts	3 parts	2 parts	3 parts	1 part	1 part
Work Life: 100 g Mass @ 75°F (24°C)	90 minutes	90 minutes	120 minutes	120 minutes	120 minutes	120 minutes

Features

- Excellent for bonding many metals, woods, plastics, rubbers, and masonry products.
- Base and Accelerator are contrasting colors.
- Good retention of strength after environmental aging.
- Resistant to extreme shock, vibration, and flexing.
- Excellent for cryogenic bonding applications.
- The tan NS Adhesive is non-sag for greater bondline control.
- The translucent can be injected.
- Meets DOD-A-82720.

3M™ Scotch-Weld™
Epoxy Adhesive
2216 B/A

Typical Cured Physical Properties

Product	3M™ Scotch-Weld™ Epoxy Adhesive		
	2216 Gray	2216 Tan NS	2216 Translucent
Color	Gray	Tan	Translucent
Shore D Hardness ASTM D 2240	60 65	65 70	35 60
Time to Handling Strength	8-12 hrs.	8-12 hrs.	12-16 hrs.

Typical Cured Electrical Properties

Product	3M™ Scotch-Weld™ Epoxy Adhesive	
	2216 Gray	2216 Translucent
Arc Resistance	130 seconds	
Dielectric Strength	408 volts/mil	630 volts/mil
Dielectric Constant @ 73°F (23°C)	5.51–Measured @ 1.00 KHz	6.3 @ 1 KHz
Dielectric Constant @ 140°F (60°C)	14.17–Measured @ 1.00 KHz	—
Dissipation Factor 73°F (23°C)	0.112 Measured @ 1.00 KHz	0.119 @ 1 KHz
Dissipation Factor 140°F (60°C)	0.422–Measured @ 1.00 KHz	—
Surface Resistivity @ 73°F (23°C)	5.5 x 10^{16} ohm–@ 500 volts DC	—
Volume Resistivity @ 73°F (23°C)	1.9 x 10^{12} ohm-cm–@ 500 volts DC	3.0 x 10^{12} ohm-cm @ 500 volts DC

Typical Cured Thermal Properties

Product	3M™ Scotch-Weld™ Epoxy Adhesive	
	2216 Gray	2216 Translucent
Thermal Conductivity	0.228 Btu-ft/ft^{2}h°F	0.114 Btu-ft/ft^{2}h°F
Coefficient of Thermal Expansion	102 x 10^{-6} in/in/°C between 0-40°C 134 x 10^{-6} in/in/°C between 40-80°C	81 x 10^{-6} in/in/°C between -50-0°C 207 x 10^{-6} in/in/°C between 60-150°C

Typical Cured Outgassing Properties

Outgassing Data
NASA 1124 Revision 4

	% TML	% CVCM	% Wtr
3M™ Scotch-Weld™ Epoxy Adhesive 2216 Gray	.77	.04	.23

Cured in air for 7 days @ 77°F (25°C).

Handling/Curing Information

Directions for Use

1. For high strength structural bonds, paint, oxide films, oils, dust, mold release agents and all other surface contaminants must be completely removed. However, the amount of surface preparation directly depends on the required bond strength and the environmental aging resistance desired by user. For suggested surface preparations of common substrates, see the following section on surface preparation.
2. These products consist of two parts. Mix thoroughly by weight or volume in the proportions specified on the product label and in the uncured properties section. Mix approximately 15 seconds after a uniform color is obtained.

3M™ Scotch-Weld™
Epoxy Adhesive
2216 B/A

Handling/Curing Information *(continued)*

3. For maximum bond strength, apply product evenly to both surfaces to be joined.
4. Application to the substrates should be made within 90 minutes. Larger quantities and/or higher temperatures will reduce this working time.
5. Join the adhesive coated surfaces and allow to cure at 60°F (16°C) or above until firm. Heat, up to 200°F (93°C), will speed curing.
6. The following times and temperatures will result in a full cure:

Product	3M™ Scotch-Weld™ Epoxy Adhesive		
	2216 Gray	2216 Tan NS	2216 Translucent
Cure Temperature	Time	Time	Time
75°F (24°C)	7 days	7 days	30 days
150°F (66°C)	120 minutes	120 minutes	240 minutes
200°F (93°C)	30 minutes	30 minutes	60 minutes

7. Keep parts from moving until handling strength is reached. Contact pressure is necessary. Maximum shear strength is obtained with a 3-5 mil bond line. Maximum peel strength is obtained with a 17-25 mil bond line.
8. Excess uncured adhesive can be cleaned up with ketone type solvents.*

Adhesive Coverage: A 0.005 in. thick bondline will typically yield a coverage of 320 sq. ft/gallon

Application and Equipment Suggestions

These products may be applied by spatula, trowel or flow equipment.

Two-part mixing/proportioning/dispensing equipment is available for intermittent or production line use. These systems are ideal because of their variable shot size and flow rate characteristics and are adaptable to many applications.

Surface Preparation

For high strength structural bonds, paint, oxide films, oils, dust, mold release agents and all other surface contaminants must be completely removed. However, the amount of surface preparation directly depends on the required bond strength and the environmental aging resistance desired by user.

The following cleaning methods are suggested for common surfaces.

Steel or Aluminum (Mechanical Abrasion)

1. Wipe free of dust with oil-free solvent such as acetone or alcohol solvents.*
2. Sandblast or abrade using clean fine grit abrasives (180 grit or finer).
3. Wipe again with solvents to remove loose particles.
4. If a primer is used, it should be applied within 4 hours after surface preparation.

*When using solvents, extinguish all ignition sources, including pilot lights, and follow the manufacturer's precautions and directions for use. Use solvents in accordance with local regulations.

3M™ Scotch-Weld™
Epoxy Adhesive
2216 B/A

Surface Preparation *(continued)*

Aluminum (Chemical Etch)

Aluminum alloys may be chemically cleaned and etched as per ASTM D 2651. This procedure states to:

1. Alkaline Degrease – Oakite 164 solution (9-11 oz/gal of water) at 190°F ± 10°F (88°C ± 5°C) for 10-20 minutes. Rinse immediately in large quantities of cold running water.
2. **Optimized FPL Etch Solution (1 liter):**

Material	Amount
Distilled Water	700 ml plus balance of liter (see below)
Sodium Dichromate	28 to 67.3 grams
Sulfuric Acid	287.9 to 310.0 grams
Aluminum Chips	1.5 grams/liter of mixed solution

   To prepare 1 liter of this solution, dissolve sodium dichromate in 700 ml of distilled water. Add sulfuric acid and mix well. Add additional distilled water to fill to 1 liter. Heat mixed solution to 66 to 71°C (150 to 160°F). Dissolve 1.5 grams of 2024 bare aluminum chips per liter of mixed solution. Gentle agitation will help aluminum dissolve in about 24 hours.

   To etch aluminum panels, place them in FPL etch solution heated to 66 to 71°C (150 to 160°F). Panels should soak for 12 to 15 minutes.
3. Rinse: Rinse panels in clear running tap water.
4. Dry: Air dry 15 minutes; force dry 10 minutes (minimum) at 140°F (60°C) maximum.
5. If primer is to be used, it should be applied within 4 hours after surface preparation.

Plastics/Rubber

1. Wipe with isopropyl alcohol.*
2. Abrade using fine grit abrasives (180 grit or finer).
3. Wipe with isopropyl alcohol.*

Glass

1. Solvent wipe surface using acetone or MEK.*
2. Apply a thin coating (0.0001 in. or less) of 3M™ Scotch-Weld™ Structural Adhesive Primer EC-3901 to the glass surfaces to be bonded and allow the primer to dry a minimum of 30 minutes @ 75°F (24°C) before bonding.

*When using solvents, extinguish all ignition sources, including pilot lights, and follow the manufacturer's precautions and directions for use. Use solvents in accordance with local regulations.

3M™ Scotch-Weld™
Epoxy Adhesive
2216 B/A

Typical Adhesive Performance Characteristics

A. Typical Shear Properties on Etched Aluminum
ASTM D 1002
Cure: 2 hours @ 150 ± 5°F (66°C ± 2°C), 2 psi pressure

Test Temperature	Overlap Shear (psi)		
	3M™ Scotch-Weld™ Epoxy Adhesive		
	2216 B/A Gray Adhesive	2216 B/A Tan NS Adhesive	2216 B/A Trans. Adhesive
-423°F (-253°C)	2440	—	—
-320°F (-196°C)	2740	—	—
-100°F (-73°C)	3000	—	—
-67°F (-53°C)	3000	2000	3000
75°F (24°C)	3200	2500	1700
180°F (82°C)	400	400	140

Test Temperature	Shear Modulus (Torsion Pendulum Method)
-148°F (-100°C)	398,000 psi (2745 MPa)
-76°F (-60°C)	318,855 psi (2199 MPa)
-40°F (-40°C)	282,315 psi (1947 MPa)
32°F (0°C)	218,805 psi (1500 MPa)
75°F (24°C)	49,560 psi (342 MPa)

B. Typical T-Peel Strength
ASTM D 1876

Test Temperature	T-Peel Strength (piw) @ 75°F (24°C)		
	3M™ Scotch-Weld™ Epoxy Adhesive		
	2216 B/A Gray Adhesive	2216 B/A Tan NS Adhesive	2216 B/A Trans. Adhesive
75°F (24°C)	25	25	25

3M™ Scotch-Weld™
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Typical Adhesive Performance Characteristics *(continued)*

C. Overlap Shear Strength After Environmental Aging-Etched Aluminum

Environment	Time	Overlap Shear (psi) 75°F (24°C)		
		3M™ Scotch-Weld™ Epoxy Adhesive		
		2216 B/A Gray Adhesive	2216 B/A Tan NS Adhesive	2216 B/A Trans. Adhesive
100% Relative Humidity @ 120°F (49°C)	14 days 30 days 90 days	2950 psi 1985 psi 1505 psi	3400 psi 2650 psi	1390 psi
*Salt Spray @ 75°F (24°C)	14 days 30 days 60 days	2300 psi 500 psi 300 psi	3900 psi 3300 psi	1260 psi
Tap Water @ 75°F (24°C)	14 days 30 days 90 days	3120 psi 2942 psi 2075 psi	3250 psi 2700 psi	1950 psi
Air @ 160°F (71°C)	35 days	4650 psi	4425 psi	
Air @ 300°F (149°C)	40 days	4930 psi	4450 psi	3500 psi
Anti-icing Fluid @ 75°F (24°C)	7 days	3300 psi	3050 psi	2500 psi
Hydraulic Oil @ 75°F (24°C)	30 days	2500 psi	3500 psi	2500 psi
JP-4 Fuel	30 days	2500 psi	2750 psi	2500 psi
Hydrocarbon Fluid	7 days	3300 psi	3100 psi	3000 psi

*Substrate corrosion resulted in adhesive failure.

D. Heat Aging of 3M™ Scotch-Weld™ Epoxy Adhesive 2216 B/A Gray
(Cured for 7 days @ 75°F [24°C])

Overlap Shear (psi)	Time aged @ 300°F (149°C)			
Test Temperature	0 days	12 days	40 days	51 days
-67°F (-53°C)	2200	3310	3120	2860
75°F (24°C)	3100	5150	4930	4740
180°F (82°C)	500	1000	760	1120
350°F (177°C)	420	440	560	—

3M™ Scotch-Weld™
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Typical Adhesive Performance Characteristics *(continued)*

E. Overlap Shear Strength on Abraded Metals, Plastics, and Rubbers.

Overlap shear strengths were measured on 1" x 1/2" overlap specimens. These bonds were made individually using 1" by 4" pieces of substrate (Tested per ASTM D 1002).

The thickness of the substrates were: cold rolled, galvanized and stainless steel – 0.056-0.062", copper – 0.032", brass – 0.036", rubbers – 0.125", plastics – 0.125". All surfaces were prepared by solvent wiping/abrading/ solvent wiping.

The jaw separation rate used for testing was 0.1 in/min for metals, 2 in/min for plastics, and 20 in/min for rubbers.

	Overlap Shear (psi) @ 75°F (24°C)	
	3M™ Scotch-Weld™ Epoxy Adhesive	
Substrate	2216 B/A Gray Adhesive	2216 B/A Tan NS Adhesive
Aluminum/Aluminum	1850	2350
Cold Rolled Steel/Cold Rolled Steel	1700	3100
Stainless Steel/Stainless Steel	1900	
Galvanized Steel/Galvanized Steel	1800	
Copper/Copper	1050	
Brass/Brass	850	
Styrene Butadiene Rubber/Steel	200*	
Neoprene Rubber/Steel	220*	
ABS/ABS Plastic	990*	1140*
PVC/PVC, Rigid	940*	
Polycarbonate/Polycarbonate	1170*	1730*
Acrylic/Acrylic	1100*	1110*
Fiber Reinforced Polyester/ Reinforced Polyester	1660*	1650*
Polyphenylene Oxide/PPO	610	610
PC/ABS Alloy / PC/ABS Alloy	1290	1290

*The substrate failed during the test.

Storage

Store products at 60-80°F (16-27°C) for maximum storage life.

Shelf Life

When stored at the recommended temperatures in the original, unopened containers, the shelf life is two years from date of shipment from 3M.

3M™ Scotch-Weld™
Epoxy Adhesive
2216 B/A

Precautionary Information	Refer to Product Label and Material Safety Data Sheet for health and safety information before using this product. For additional health and safety information, call 1-800-364-3577 or (651) 737-6501.
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This Industrial Adhesives and Tapes Division product was manufactured under a 3M quality system registered to ISO 9001:2000 standards.

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Annex C: unit-S/C integration contingency plan

This proposed contingency plan is TBC between EPD/ESA/ADS based on further clarifications.

- In case of any abnormal situation during S/C AIT activities, ADS shall inform the EPD-Kiel team.
- Examples of abnormal conditions from the hardware point of view which may occur during the unit-S/C integration and the S/C AIT activities:
    - Damage to the unit sensitive surfaces.
    - Damage to the unit MLI standoffs.
    - Damage to the unit MLI.
    - Damage to the unit purge tube.
    - Damage to the ground strap.
    - Purge interruption more than allowed limit.
- After clarifying the damage, the unit can be removed from the S/C following the reverse steps of the unit-S/C integration guidelines and the unit shall be stored either on the EPD-LTS interface plate or in a clean bench for further investigations by EPD-Kiel personnel.
- Depending on the agreed reaction time to investigate the damage to the unit, the unit shall be purged as required, i.e. no purge interruption more than 6 hours.
- EPD-Kiel personnel are required to inspect and possibly pack and return the damaged unit to CAU-Kiel for further inspection. The unit handling of ADS personnel is limited to the activities after the handover and, in the case of an abnormal condition, until moving the unit back from S/C to the EPD-LTS interface plate or clean bench. No packing shall be done by ADS personnel.
- Abnormal conditions which may occur from a functionality point of view during the S/C AIT activities will be covered by the EPD functional test procedure.