SPIRE-LAM-PRJ-001842

Herschel – SPIRE

OPTICAL ALIGNMENT PLAN

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Liste des abréviations

	Signification	Traduction éventuelle
AC	A Confirmer	
AD	A Déterminer	
ADC	Analog to Digital Converter	Convertisseur analogique numérique
BSM	Beam Steering	Miroir d'orientation du faisceau optique
CCAP	Cahier des Clauses Administratives Particulières	
CCTP	Cahier des Clauses Techniques Particulières	
CEA-Sap	Commissariat à l'Energie Atomique – Service d'Astrophysique	
CNES	Centre National d'Etudes Spatiales	
CNRS	Centre National de la Recherche Scientifique	
DA	Document Applicable	
DAC	Digital to Analog Converter	Convertisseur Numérique Analogique
DIL	Dual In Line	
DSP	Digital Signal Processor	Processeur de Signal Numérique
DPU	Data Process Unit	Unité de traitement des données
EPROM	Erasable Programmable Read-Only Memory	Mémoire effaçable programmable en lecture seule
ESA	European Space Agency	Agence Spatiale Européenne
FDP	Carte Fond De Panier	
FPGA	Field Programmable Gate Array	
IFSI	Inst. Di Fiscia dello Spazia Interplanetario	
IID	Instrument Interface Document	Document d'interface de l'instrument
INSUE	Institut National des Sciences de l'Univers et de l'Environnement	
LAM	Laboratoire d'Astrophysique de Marseille	
LVDT	Linear Voltage Differential Transducer	
MAC	Multi Axis Controller	Contrôleur Multi-Axes
MCU	Mechanisms Control Unit	Unité de Contrôle des Mécanismes
MQ	Modèle de Qualification	
MR	Modèle de Rechange	
MV	Modèle de Vol	
PID	Régulation Proportionnelle Intégrale Dérivée	
PROM	Programmable Read-Only Memory	Mémoire programmable en lecture seule
SMEC	Spectrometer MEChanism subsystem	Sous-système Mécanisme du Spectromètre
SMECm	Spectrometer MEChanism – mechanism	Mécanisme du spectromètre
STBE	Spécification Technique de Besoin d'Essai	
SPIRE	Spectral and Photometric Imaging Receiver	
SVM	SerVice Module	Module de service du satellite
VHDL	Very high speed integrated circuit Hardware Description Language	

Table des matières

1 Introduction:

This document presents the alignment philosophy and gives the procedure to verify and to adjust the Spire optical system, both photometer and spectrometer.
This documents gives details of procedure at ambient and cryogenic conditions.

2 Alignment principle:

Internal optical alignment of Spire has to be checked with respect to an absolute reference given by a simulator of the Herschel telescope axis.

This simulator consists of a honeycomb structure with same satellite I/F as Spire experiment, having a reference mirror and a crosshair to define direction and location of the telescope axis. This simulator, called LAM HOB, defines the direction of the Herschel telescope axis within +/- 0.5arcmin in two orthogonal angles, and the lateral location within +/- 0.02mm. Discards from theoretical values will be take into account during alignment procedure.

As two feet are directly attached each one to a cover it's not possible to access to mirrors during integration phase when Spire is mounted on a satellite dummy I/F. This apparatus (MGSE) maintains in safe conditions and allows accessibility to the spectrometer or the photometer optical bench when a cover (only one at each time) is dismounted.

Spire optical bench will be hold at horizontal by this MGSE (cold calibration cryostat assembly, RAL HOB plate and Spire optical bench assembly fixture) with the LAM HOB fixed onto Spire feet.

The whole LAM OGSE benches will be adjusted on the LAM HOB.

2.1 Applicable Documents

no.	document name	document number, Iss./Rev.
AD1		

2.2 Reference Documents

no.	document name	document number, Iss./Rev.
RD	N/A	

3 Procedure

3.1 Pre integration

Goal: Assembly of the instrument box, integration of detector box, 3D metrology

3.1.1 Integration of the instrument box

3.1.1.1 Putting together the different elements of the instrument structure according to MSSL procedure to ensure optimum flatness of the bench. Presumably this includes a series of mountings, dismountings as well as low-amplitude vibration (?) to remove strains.

Comments: Following this procedures, lids can be taken off one side at a time without loss of alignment. The validity of this is to be verified by 3D measurement in the following procedure.

3.1.1.2 Mount CS tool in place, without bus bars, so that the top lid is dismountable without need to dismount the box.

3.1.1.3 Mount SOR.

3.2 3-D metrology

3.2.1 Mounting SPIRE in the rotisserie

3.2.2 3D metrology of the box, including telescope interface points, and edge of the bench, including SOR.

Comments: Determine instrument coordinate system. Verify the location of the instrument box in these coordinates. Verify coordinates and orientation of SOR.

3.2.3 Remove Photometer panels

3.2.4 3D metrology of remaining box structure to compare with above measurements

Comments: Detect possible anomalies due to dismounting of the panel.

3.2.5 Remount panels, measure again and compare. Repeat TBD times.

3.2.6 Repeat for spectrometer side.

3.2.7 Remove panels photometer side

3.2.8 Visual inspection of interfaces

Comments: Detect particles or surface defects

3.2.9 3D metrology of interfaces

Comments: Verification of the coordinates and the orientation of the interface planes with respect to the optical design. Any error detected will be analyze to find its cause and corrected if necessary. A specific, "3 D tool" will be used in place of the mirrors in order to ease the 3-D measurement and to avoid damage of the mirror surface.

3.2.10 Replace photometer panels

3.2.11 Remove Spectrometer panels

3.2.12 Visual inspection of interfaces

Comments: Detect particles or surface defects

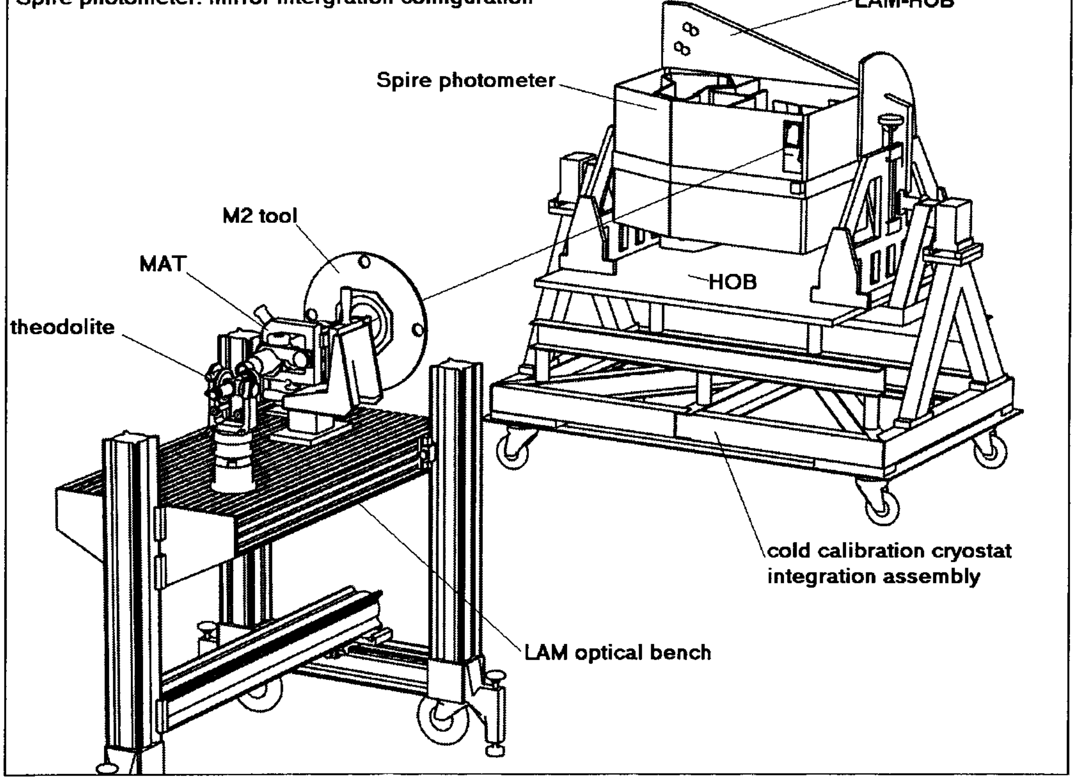
3.2.13 3D metrology

Comments: Verification of the coordinates and the orientation of the interface planes with respect to the optical design. Any error detected will be analyze to find its cause and corrected if necessary. A specific, "3 D tool" will be used in place of the mirrors in order to ease the 3-D measurement and to avoid damage of the mirror surface.

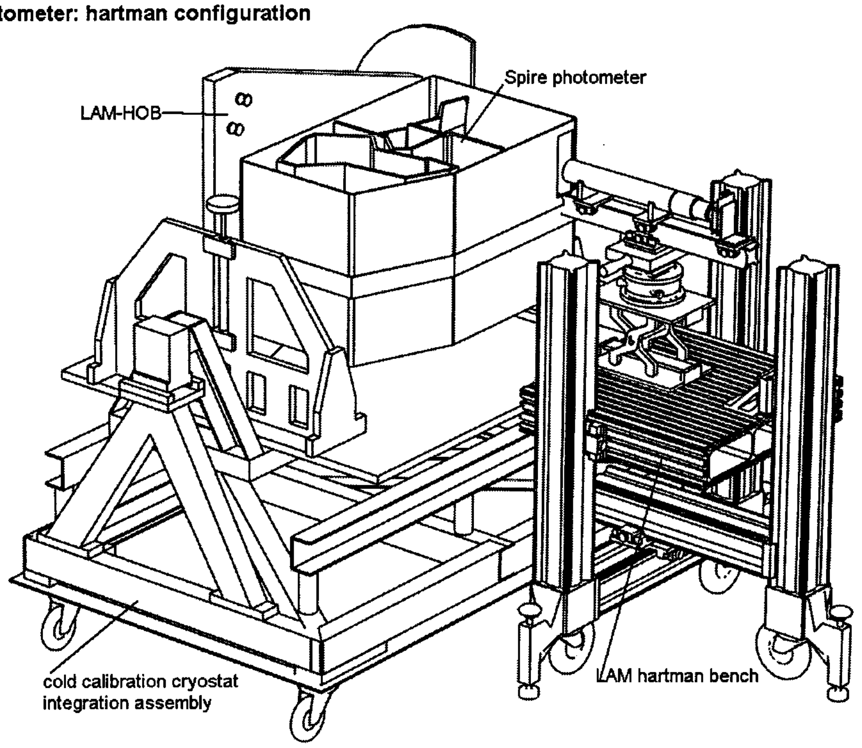
3.2.14 Replace spectrometer panels

3.3 Global views of OGSE at ambient configuration

Spire photometer: mirror intergration configuration



Spire photometer: hartman configuration



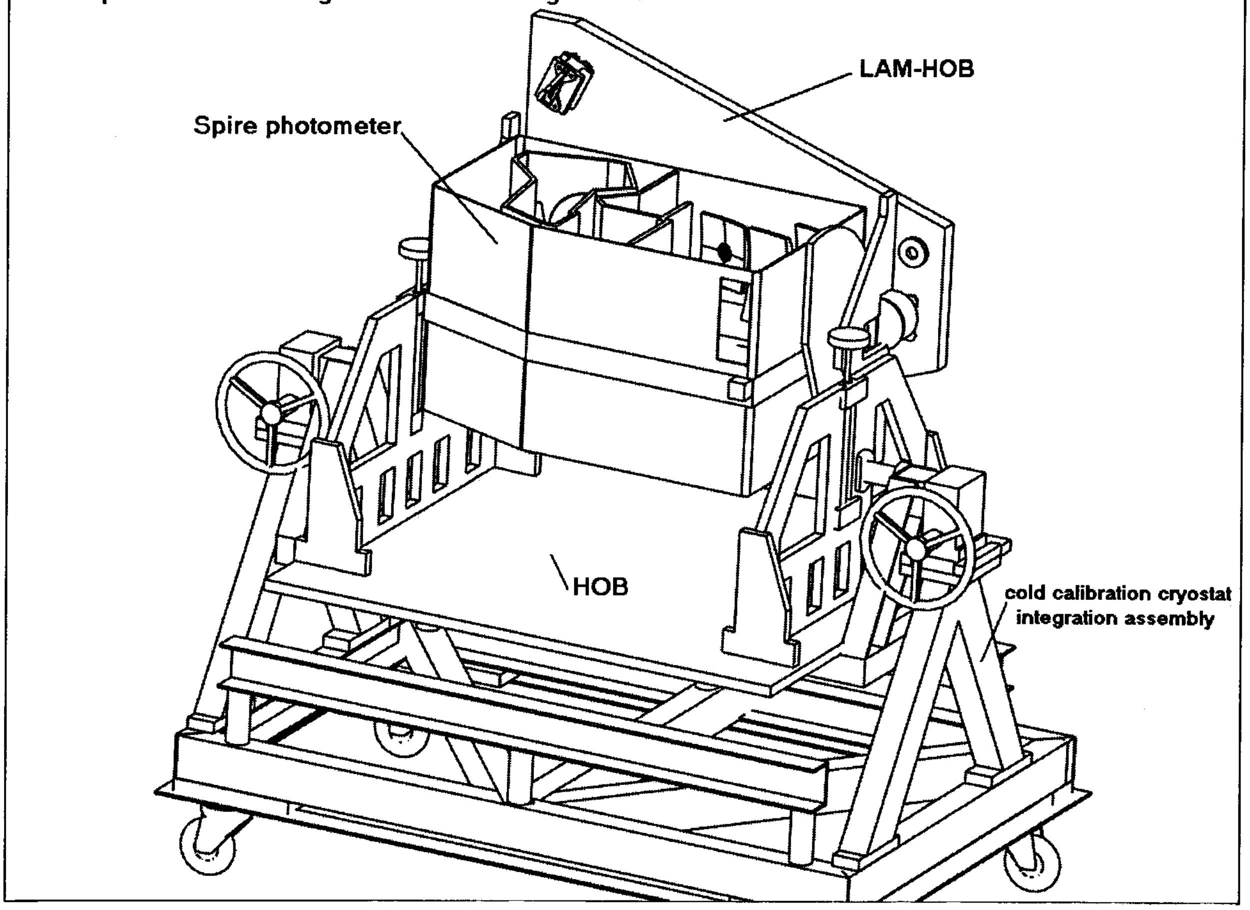
3.4 Pre-alignments of LAM optical bench

Goal: Perform optical alignments of the LAM bench with respect to the LAM-HOB mounted on the feet of Spire which gives the absolute reference (after compensation of some deviations) of the telescope axis.

3.4.1 Set Spire optical bench level

3.4.1.1 SPIRE mounted in rotisserie, photometer pointing up, covers on.

SPIRE photometer in integration mirror configuration



3.4.1.2 Remove photometer panel. Install a precision spirit level on mechanical reference areas of the Spire bench.

3.4.1.3 Adjust Spire optical bench to be horizontal in two perpendicular directions, checked by means of precision spirit level.

Comments: Accuracy required better than ± 10 arcsec. Rotisserie will be finely tilted by means of its three adjustable feet (TBC)

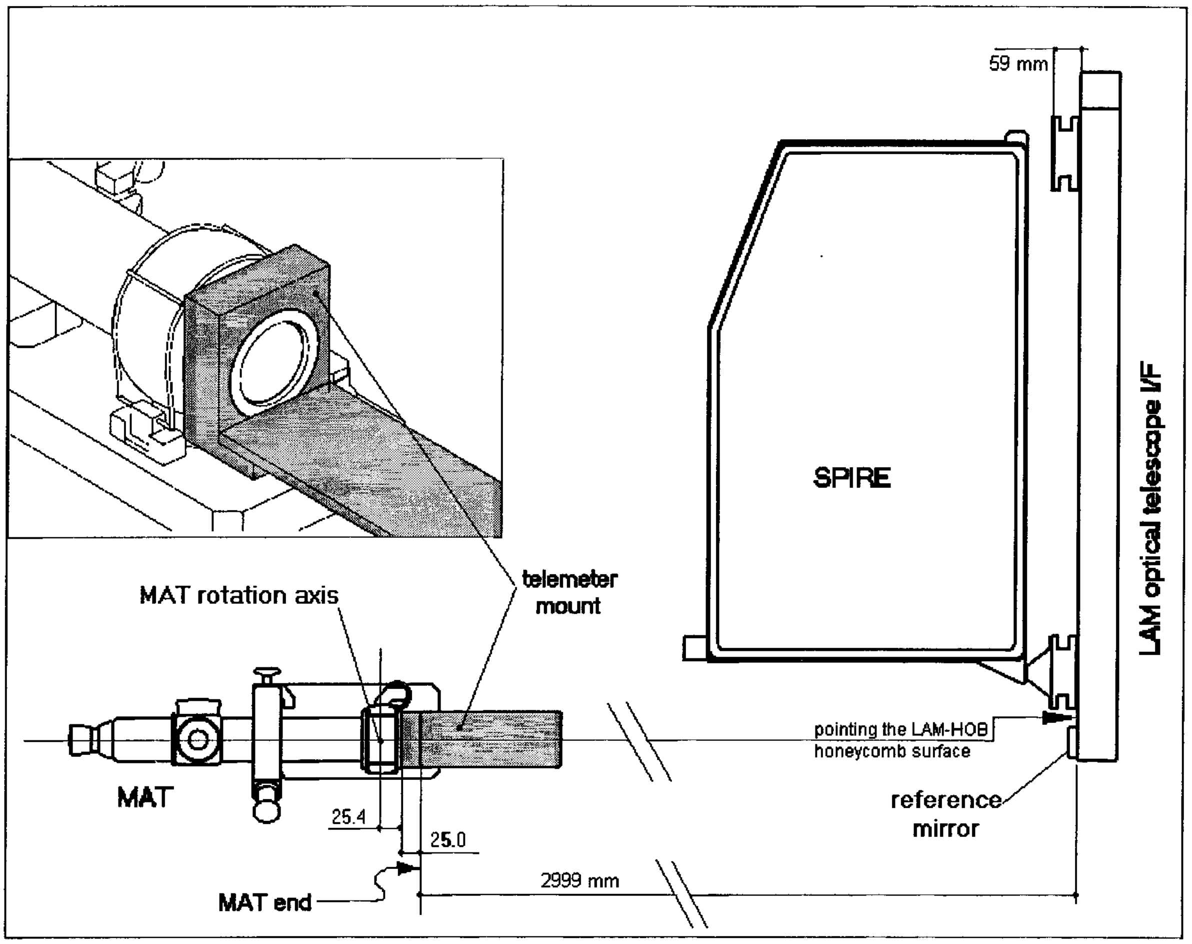
3.4.1.4 Remove spirit level, replace photometer panel.

3.4.1.5 Mount LAM-HOB on the feet of Spire.

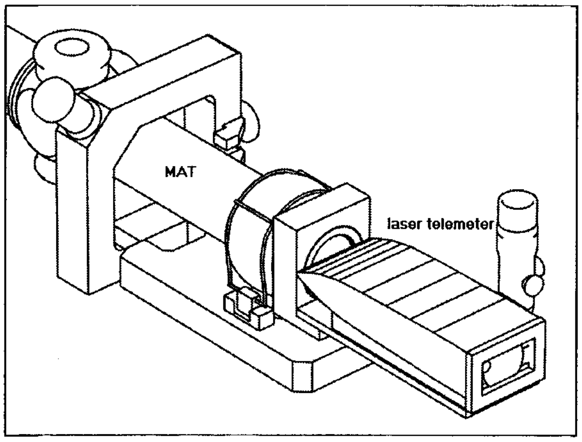
3.4.2 Setting of LAM optical bench

3.4.2.1 "MAT/LAM-HOB" distance adjustment

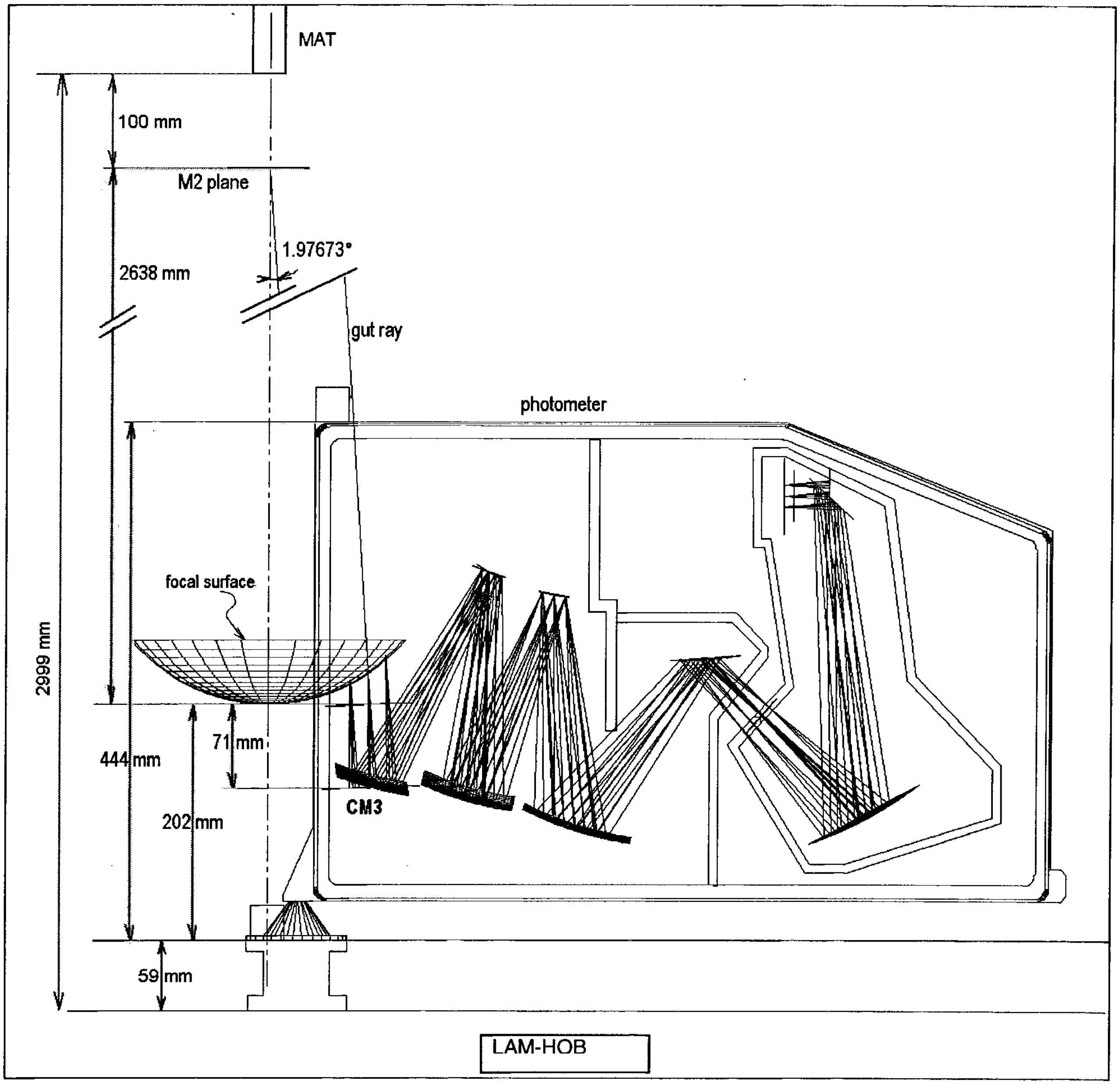
3.4.2.1.1 The MAT mounting sphere must be placed against the telemeter mount in a such way that they are aligned precisely on the extremity of the MAT body. See detail on following figure.



3.4.2.1.2 Setting up MAT in distance with respect to the LAM –HOB at 2999 mm



Comments: The telemeter must aim at the LAM-HOB surface, just beside the reference mirror. Distance is roughly adjusted by axial translation of the whole LAM optical bench. Fine adjustment (< 10 mm) is obtained with translating MAT mount on the bench.



Comment: 2999 mm total distance is equal to the sum of :

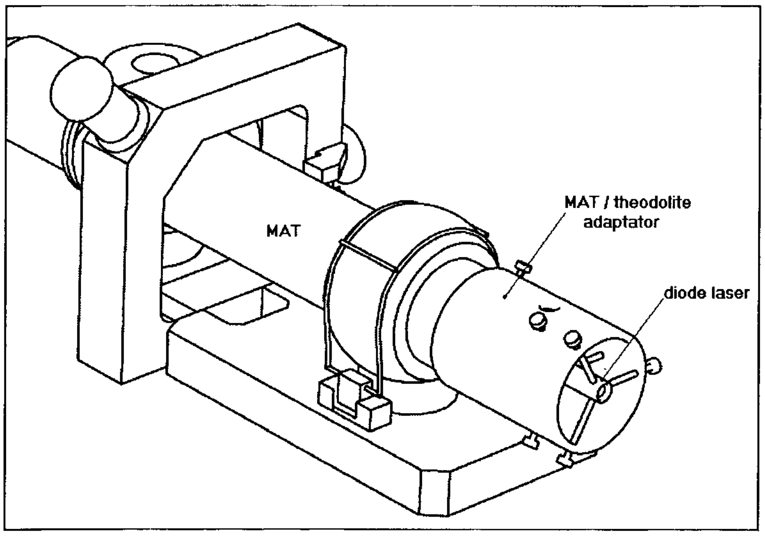
(M2-focal plane) + (base plan-focal plane) + (MAT- M2 tool) = 2638 + 202 + 100+59* = **2999 mm***

**MAT is placed at 100mm (TBC) behind the M2 tool plane.*
**59 mm height of spacers between LAM HOB and feet of Spire*

3.4.2.1.3 Remove the telemeter and its mount attached to MAT.

3.4.2.2 **"MAT/LAM-HOB" angular adjustment**

3.4.2.2.1 Mount the tool of collimated laser diode on the MAT end.



3.4.2.2.2 Verify on a long distance co-alignment of the laser and optical MAT axis.
<u>Comment:</u> use a folding mirror to increase distance, for example aim a wall far away in the clean room.

3.4.2.2.3 Set the MAT translation plates, vertical and horizontal, at mid-travel.

3.4.2.2.4 Perform <u>rough autocollimation</u> with laser beam on the reference mirror using adjustable angular knobs of the MAT, and move the whole bench to recenter it laterally on the mirror.
<u>Comment:</u>Several iterations will probably be required to perform this adjustment. When adjustment is close to the autocollimation, remove the tool with laser diode.

3.4.2.2.5 Connect the power supply of the MAT lamp, and achieve autocollimation with <u>fine adjustment</u> of MAT angular knobs while re-centering laterally the MAT on the reticule of the reference mirror by means of translation plates.

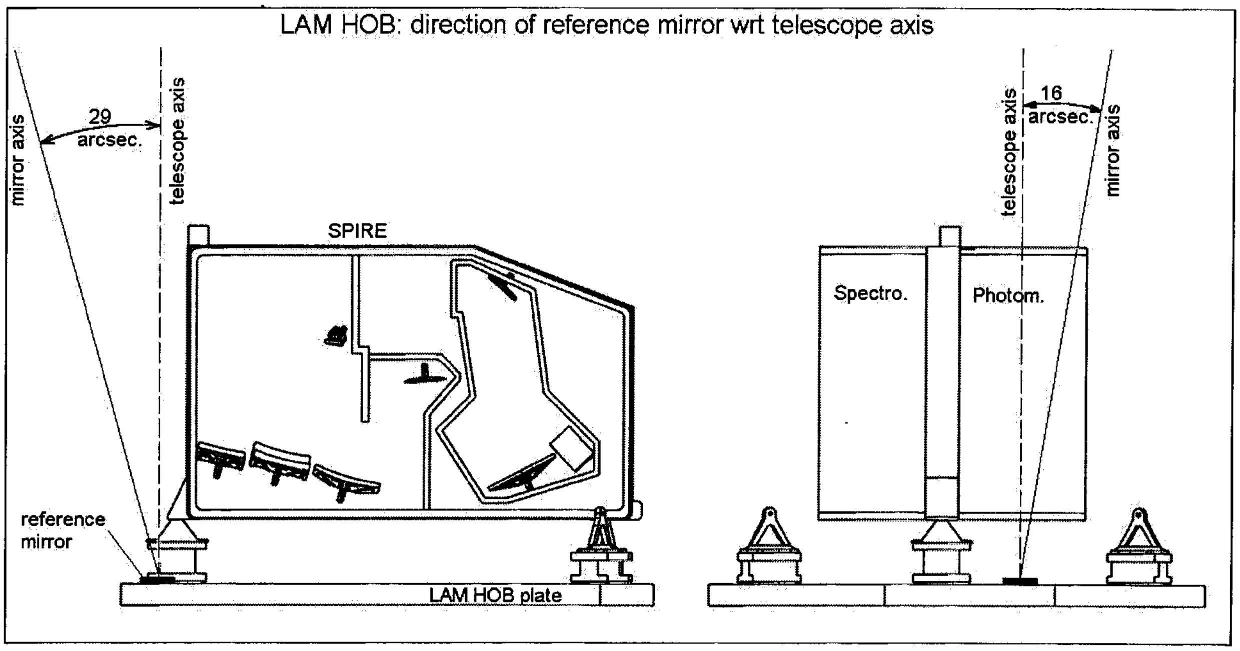
3.4.2.2.6 When autocollimation is reached, remount the telemeter on its holder at the end of the MAT. Check, adjust and note the distance to the LAM-HOB.

Distance MAT to LAM –HOB must be equal to 2999mm +/- 1.5mm

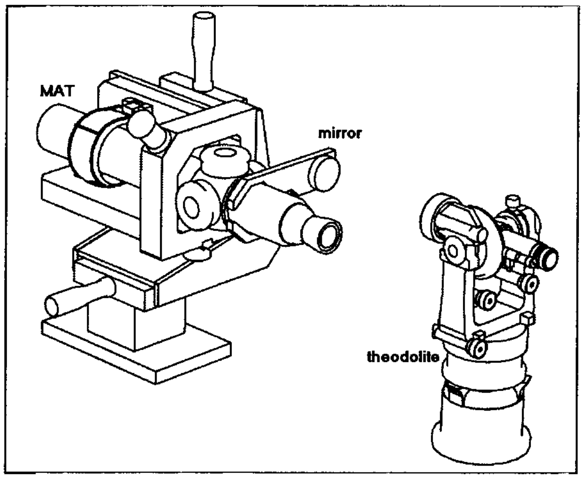
3.4.2.2.7 Remove the telemeter and its mount.

3.4.2.3 MAT alignment on the telescope axis (angular and lateral)

Comment: angular deviation have been checked between reference mirror glued on LAM HOB and theoretical telescope axis.



3.4.2.3.1 Install the theodolite and its mount behind the MAT in such a way it is placed roughly in front of the mirror.



3.4.2.3.2 Perform autocollimation on the mirror with the theodolite.

Note the angular values of theodolite reference direction:

$Azimuth_{ref.}$ = . . . ° . . ' . . "

$Elevation_{ref}$ = . . . ° . . ' . . "

3.4.2.3.3 Applying correction, set elevation and azimuth of the theodolite to "theoretical" telescope axis.

$Azimuth_{tel\ axis.}$ = $Azimuth_{ref.}$ +/- 29 arcsec. (+ or - depends on theodolite

$Elevation_{telt\ axis}$ = $Elevation_{ref}$ +/- 16 arcsec. compare with figure above)

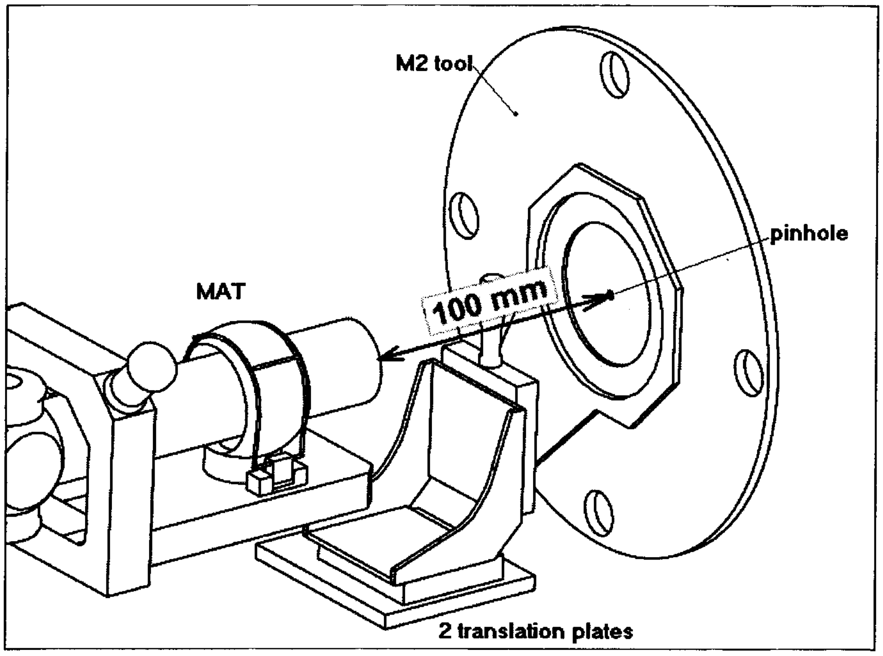
3.4.2.3.4 Rotate MAT in both directions to be auto collimated again on theodolite.

3.4.2.3.5 Translate MAT in order to center it on the crosshair in center of reference mirror.

3.4.2.4 **Adjustment of M2 distance to LAM-HOB**

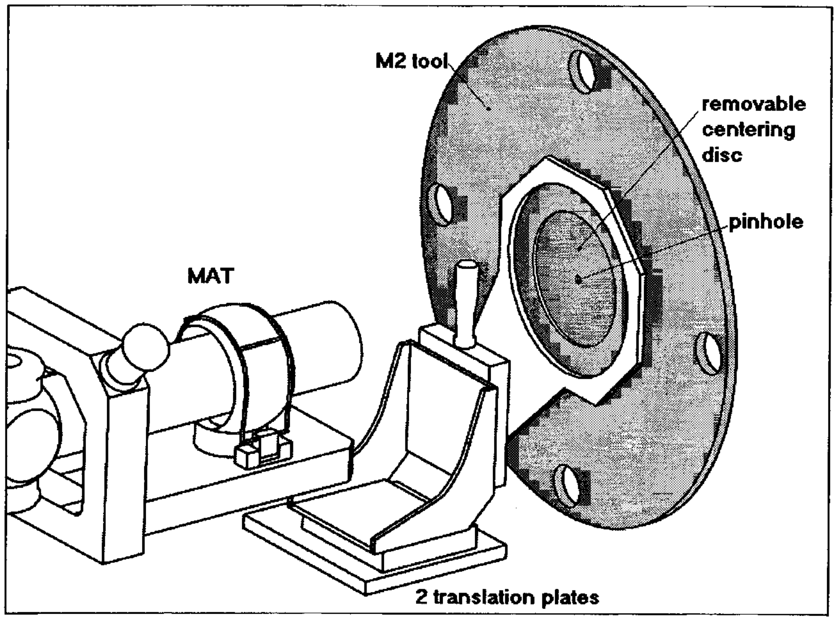
3.4.2.4.1 Install the M2 tool in front of the MAT on the LAM-HOB. Center roughly the M2 tool manually on MAT. Block the whole tool on the bench with screws.

3.4.2.4.2 To set the M2 tool distance to LAM-HOB at 2899mm (2840+59), using a steel rule, adjust it to 100 mm with respect to the MAT.



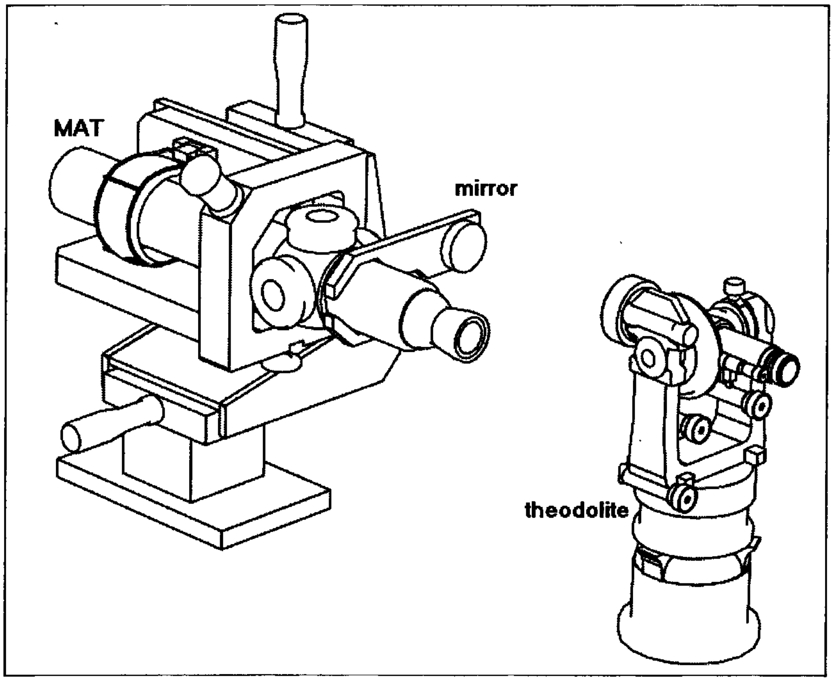
3.4.2.5 **Setting up of the M2 Tool on MAT axis**

3.4.2.5.1 Mount the centering disc equipped with a pinhole on the M2 tool.



3.4.2.5.2 Using the translation plates adjust finely the centering of the M2 tool on MAT axis.
<u>Comment:</u> during control take into account the little play of the centering disc.
By pushing it in 4 directions (vertical and horizontal) determine the effective M2 tool center.

3.4.2.6 **Angular adjustment of MAT on gut ray**



Angular values of theodolite normally same as in 3.1.3.3:

$\text{Azimuth}_{\text{tel axis.}}$ = . . . ° . . ' . . "
$\text{Elevation}_{\text{tel axis}}$ = . . . ° . . ' . . "

3.4.2.6.1 Set the azimuth direction of the theodolite to "telescope axis" + 1.97673 deg.

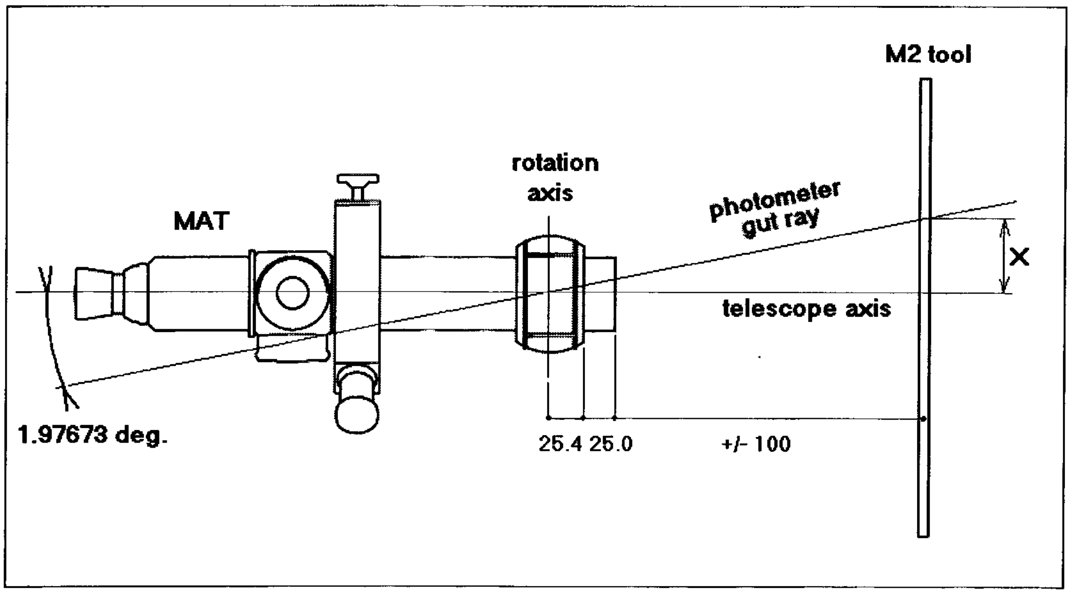
$\text{Azimuth}_{\text{gut ray.}} = \text{Azimuth}_{\text{tel axis.}} + 1°58'36"$
$\text{Elevation}_{\text{gut ray}} = \text{Elevation}_{\text{tel axis}}$

Comment: The offset value 1.97673 deg.(1°58'36") corresponds to the theoretical angle between gut ray of the Spire spectrometer and the Herschel telescope axis.

3.4.2.6.2 Rotate the MAT in horizontal plane using the corresponding control knob in order to realize autocollimation of the mirror with the theodolite.

3.4.2.7 Lateral compensation of the MAT after rotation on gut ray

After having rotated the MAT in order to align it on the theoretical value of gut ray, that introduces a lateral shift of the MAT axis; this is due to the fact the rotation point is not included in the M2 plane, and also the rotation wasn't made at the end of the MAT. Rotation axis of the MAT is at 50,4mm from its end.



Shift calculation: X= tan(1.97673)*(25.4 + 25.0 + 100) = 5.19 mm
In this example, distance between MAT and M2 tool is fixed to 100mm, which could not be exactly the same value during alignments.

3.4.2.7.1 Mount the pinhole on the M2 Tool.

3.4.2.7.2 Translate the MAT, by means of horizontal translation plate, in order to aim the pinhole.

3.4.2.7.3 Verify the translation is closed to the calculated value.

3.4.2.8 **Set up of the auxiliary theodolite to monitor the Spire optical bench stability**

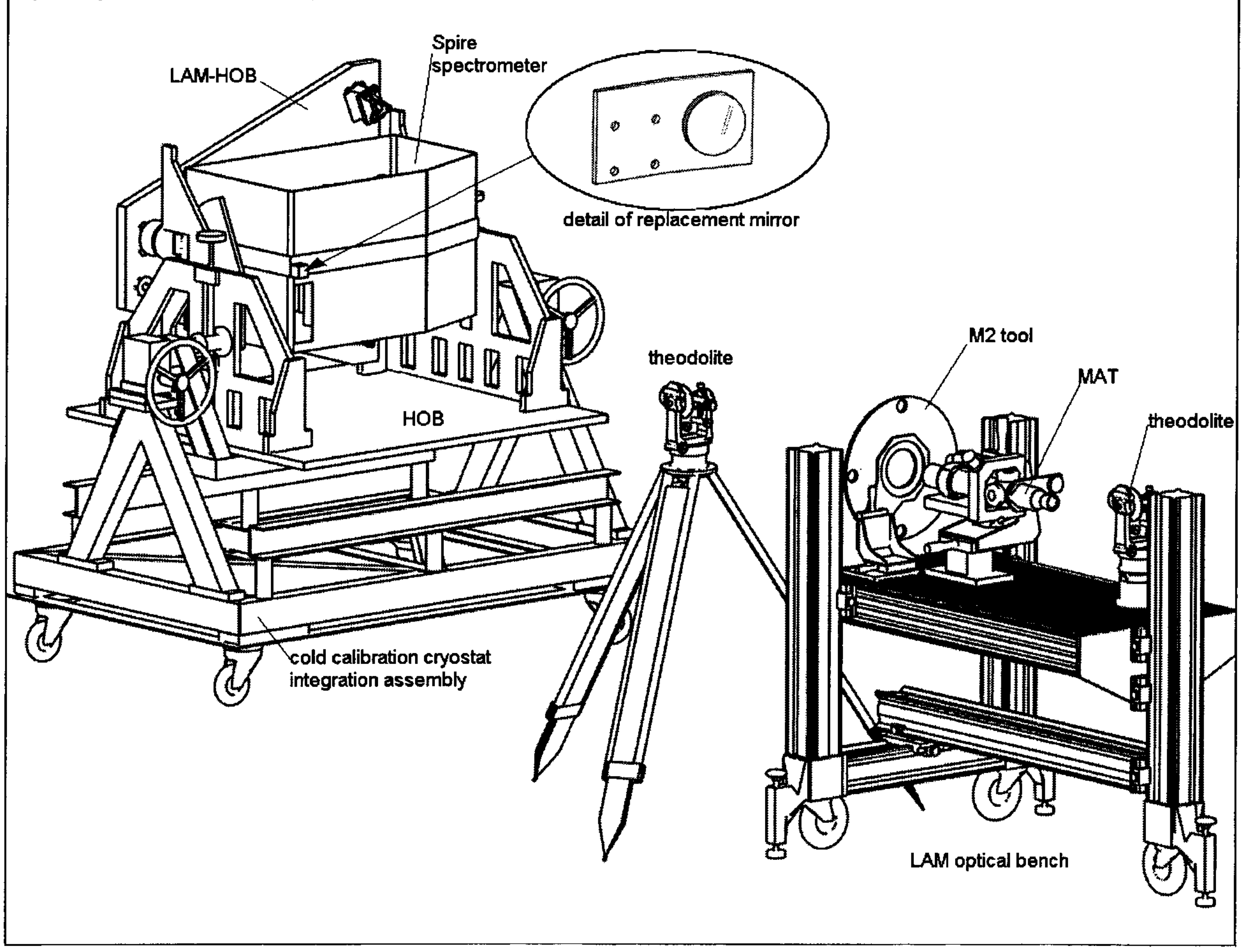
3.4.2.8.1 Remove if necessary the cube fixed on the Spire optical bench.

3.4.2.8.2 Mount the replacement mirror (glued on an aluminium folded plate) on the I/F cube on Spire optical bench.

3.4.2.8.3 Install the theodolite on its tripod in such a way to allow autocollimation on the flat mirror.

3.4.2.8.4 Check time to time, when operation of mounting and dismounting of optical components is performed on the Spire structure.

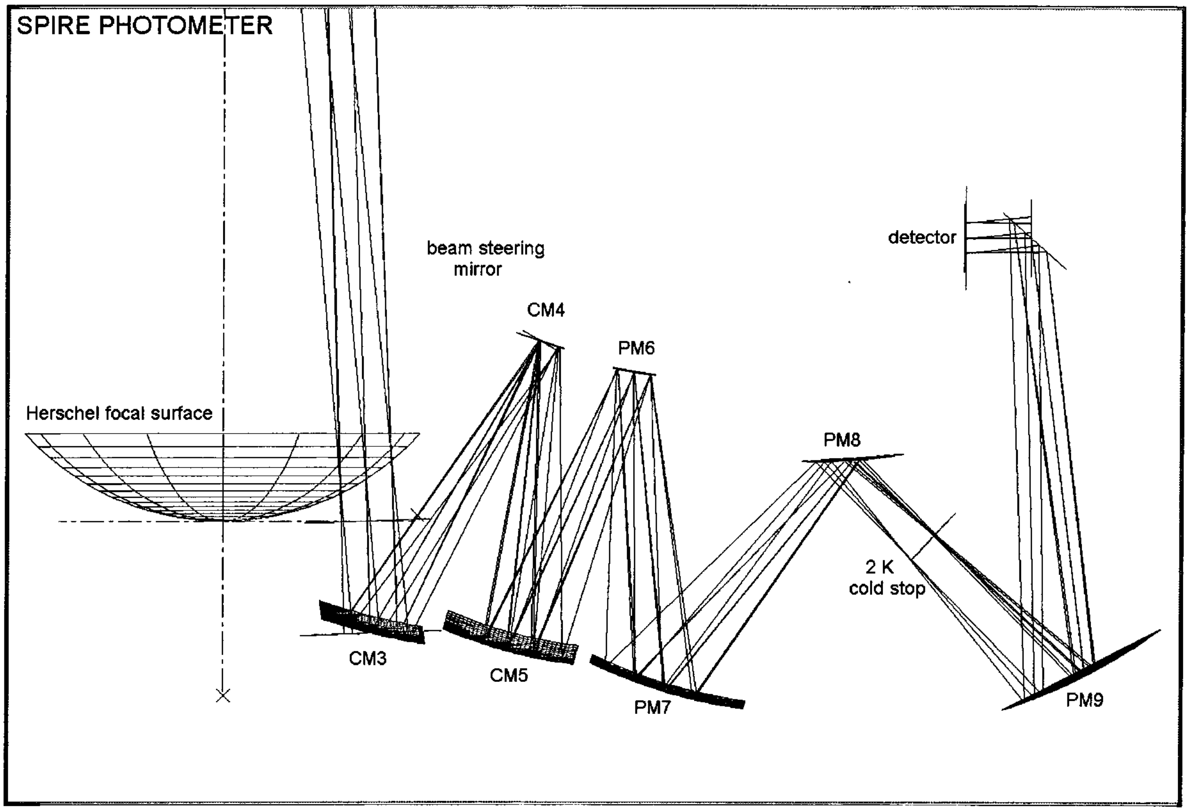
Spire spectrometer configuration



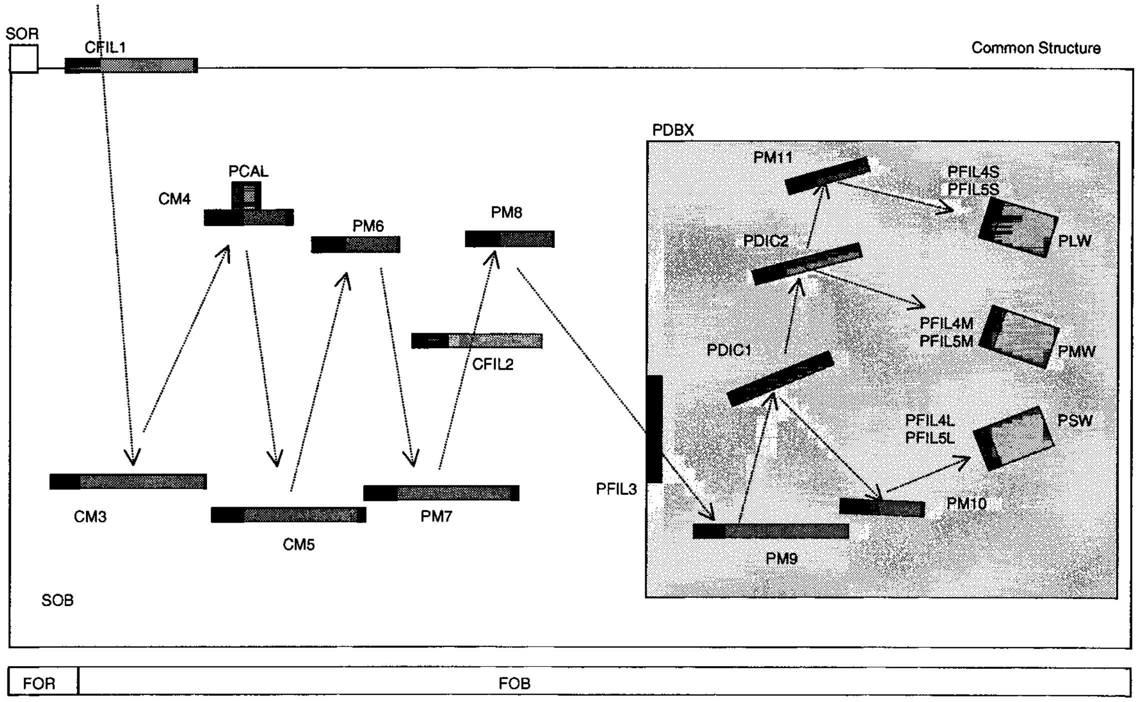
3.5 Photometer integration

Goal: Determination of telescope axis wrt instrument interfaces, integration of mirrors one by one to ensure alignment alorig gut ray. Deviations are quantified and recorded. Verification of detector centering, deviations are recorded and used in definition of detector interfaces.

3.5.1 Photometer optical scheme

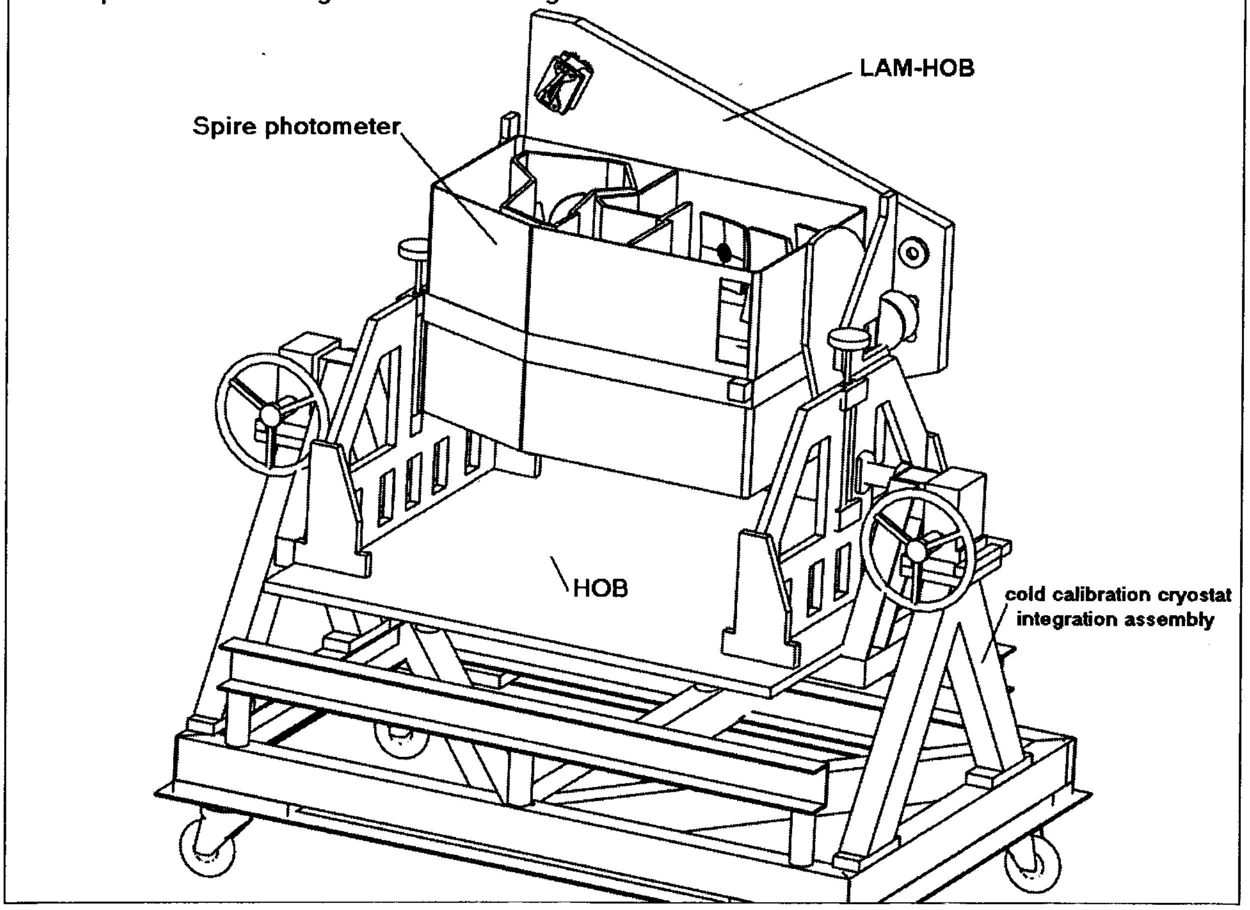


3.5.2 Spire photometer: mirror designation



3.5.3 Set Spire optical bench

SPIRE photometer in integration mirror configuration



3.5.3.1 SPIRE mounted in rotisserie, photometer pointing up, covers on.

3.5.3.2 Remove photometer panel. Install a precision spirit level on mechanical reference areas of the Spire bench.

3.5.3.3 Adjust Spire optical bench to be horizontal in two perpendicular directions, checked by means of precision spirit level.

Comments: Accuracy required better than ± 10 arcsec. Rotisserie will be finely tilted by means of its three adjustable feet (TBC)

3.5.3.4 Remove spirit level, replace photometer panel.

3.5.4 MAT alignment with HOR

3.5.4.1 The LAM-HOB is mounted on the feet.
Comments: The weight of the HOB simulator is counteracted by a jig.

3.5.4.2 M2 tool equipped with central reticule axially located in plane of M2 by aid of laser distance meter.

3.5.4.3 MAT located behind M2 tool

3.5.4.4 MAT angular position is adjusted for auto-collimation on HOR

3.5.4.5 MAT lateral position is adjusted by observation of the HOR crosshair.

3.5.4.6 M2 tool lateral position adjusted by alignment of its central cross hair on MAT axis

3.5.4.7 A theodolite (TH1) is set up to monitor MAT angular position
Comments: Allows precise angular movement of MAT and detects any spurious movements of MAT. Should be verified regularly (at TBD intervals).

3.5.4.8 Another theodolite (TH2) is set up to monitor SOR angular position
Comments: Detects any spurious movements of the instrument. Should be verified regularly (at TBD intervals).

3.5.4.9 Remove HOB simulator, verify TH2-SOR alignment

3.5.4.10 Remount HOB simulator, verify MAT-HOB alignment. Repeat TBD times.

3.5.4.11 Remove HOB simulator

3.5.5 MAT alignment with photometer gut ray

3.5.5.1 MAT is rotated parallel with the photometer gut ray. MAT controlled with Th1.
Comments: *Orientation of gut ray is defined by optical calculation.*

3.5.5.2 MAT is translated laterally to be aligned with M2 tool cross hair

3.5.5.3 Th1 verifies that MAT angular direction is maintained. If not, re iterate previous tasks.
Comments: *Ensures alignment of MAT axis to gut*

3.5.5.4 Remove photometer panels. Verify SOR alignment

3.5.5.5 Place Apex tool in CM3 position and verify centred on gut ray

3.5.5.6 Integration of common and photometer optics

3.5.5.7 Move Apex tool to CM5 position, mount CM3 and BSM replacement tool, verify gut ray centering.

3.5.5.8 Move Apex tool to PM6 position, mount CM5, verify gut ray centering.

3.5.5.9 Move Apex tool to PM7 position, mount PM6, verify gut ray centering.

3.5.5.10 Move Apex tool to PM8 position, mount PM7, verify gut ray centering.

3.5.5.11 Move Apex tool to PM9 position, mount PM8 and CS tool (TBC), verify gut ray centering on CS tool and apex tool.
<u>Comments:</u> *CS tool may need to be mounted in advance for practical reasons.*

3.5.5.12 Move Apex tool to PM10 position, mount PDIC1 simulator, verify gut ray centering

3.5.5.13 Remove Apex tool, mount PM10, mount D-tool in PSW position, verify gut ray centering on D-tool
<u>Comments:</u> *Deviations are recorded and used in definition of detector interfaces*

3.5.5.14 Mount PDIC2 simulator, mount D-tool in PMW position, verify gut ray centering
<u>Comments:</u> *Deviations are recorded and used in definition of detector interfaces*

3.5.5.15 Mount Apex tool to PM11 position, verify gut ray centering

3.5.5.16 Remove Apex tool, mount PM11, mount D tool in PLW position, verify gut ray centering.
<u>Comments:</u> *Deviations are recorded and used in definition of detector interfaces*

3.5.5.17 Close detector box, verify gut ray centering on D tool and CS tool. Repeat open/close/verification TBD times.
<u>Comments:</u> *If changes occur during open/close operations, improve open/close procedure.*

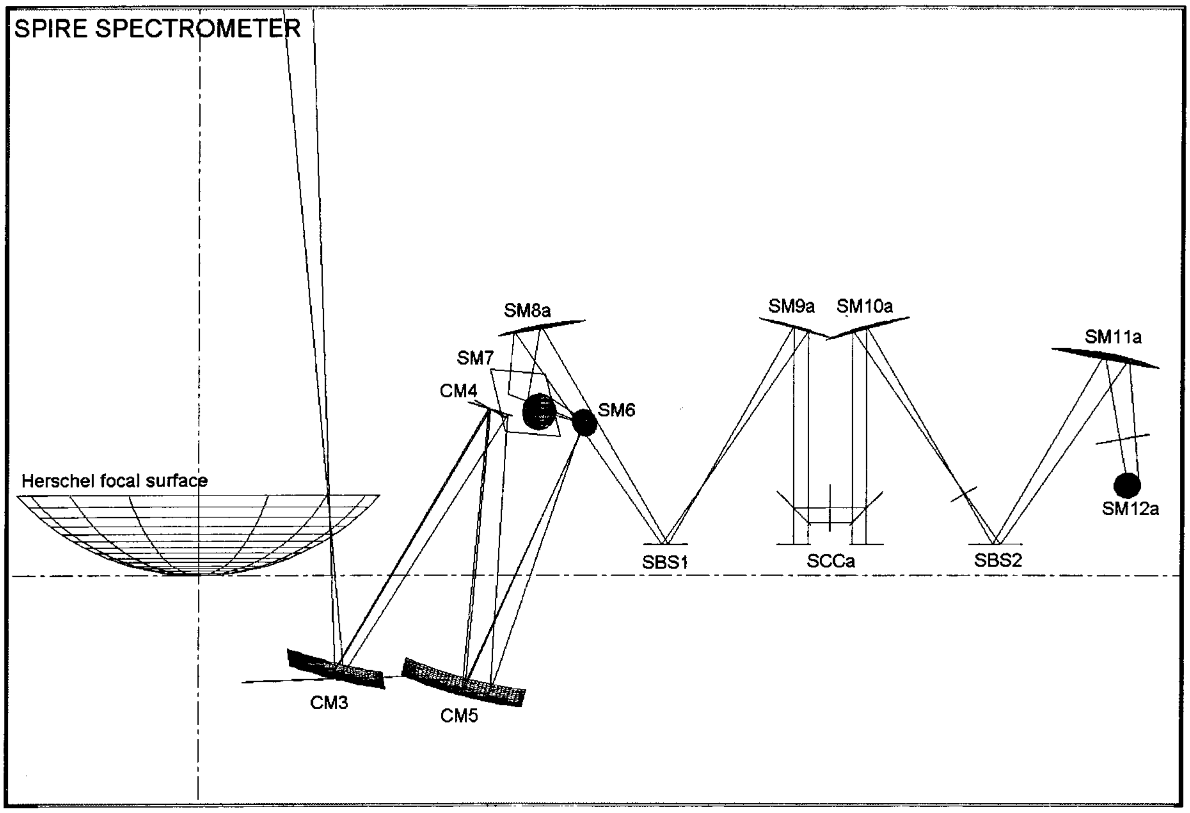
3.5.5.18 Close SPIRE box, verify gut ray centering on D tool and CS tool. Repeat open/close/verification TBD times.
<u>Comments:</u> *If changes occur during open/close operations, improve open/close procedure.*

3.5.5.19 Mount LAM-HOB, reorient MAT with optical axis, verify alignment with HOR.

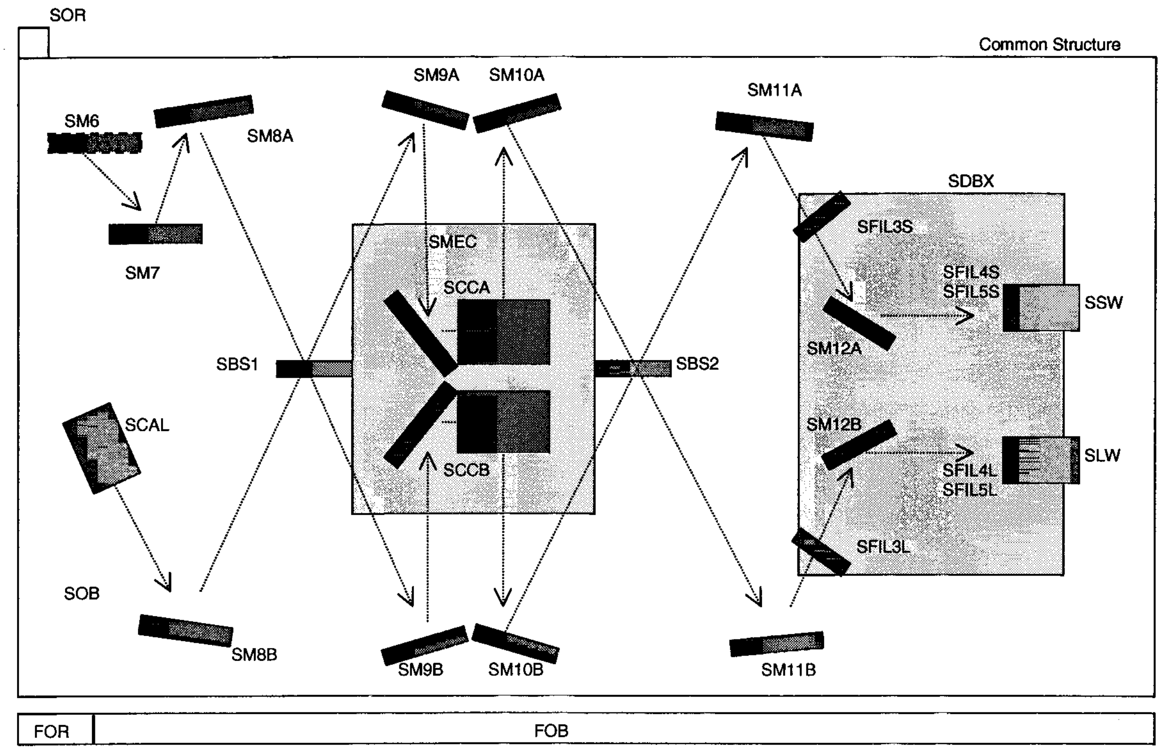
3.6 Spectrometer integration

Goal: Determination of telescope axis wrt instrument interfaces, integration of mirrors one by one to ensure alignment along gut ray. Deviations are quantified and recorded. Verification of detector centering, deviations are recorded and used in definition of detector interfaces.

3.6.1 Spectrometer optical sheme



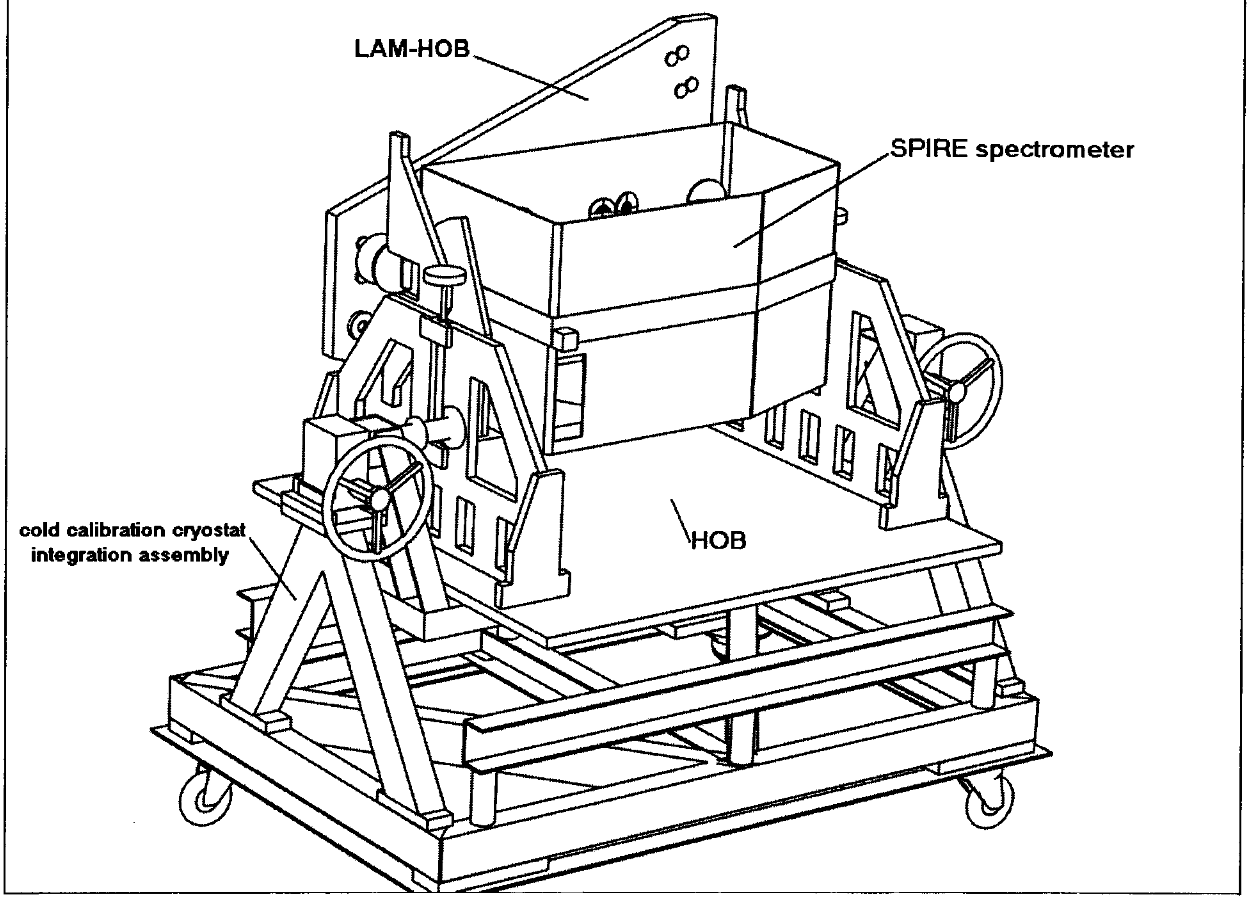
3.6.2 Spire spectrometer: mirror designation



3.6.3 Set Spire optical bench level

3.6.3.1 Turn SPIRE box around. Rotate 180 deg. rotisserie to face LAM optical bench.
Comments: When Spire is turned to 180° to have spectrometer upsided, the rotisserie have to be rotated to an other 180° turn (left-right) in horizontal plane.

Spire spectrometer in integration mirror configuration



3.6.3.2 Set SPIRE bench level following above procedure.

3.6.4 MAT alignment with HOR

3.6.4.1 Change height of LAM optical bench by about 255mm. Height changes from 850mm to 1105mm

3.6.4.2 Align MAT with HOR following "MAT alignment with HOR" procedure above.

3.6.5 MAT alignment with spectrometer gut ray

3.6.5.1 Align MAT with spectrometer gut ray following "MAT alignment with photometer gut ray" procedure above, replacing "photometer " with "spectrometer".
Comments: Orientation of gut ray is defined by optical calculation.

3.6.6 Integration of spectrometer optics

3.6.6.1 Remove spectrometer panels. Verify SOR alignment

3.6.6.2 Place Apex tool in SM6 position and verify centred on gut ray

3.6.6.3 Move Apex tool to SM7 position, mount SM6, verify gut ray centering in SCS and on Apex tool.

3.6.6.4 Move Apex tool to SM8 position, mount SM7, verify gut ray centering.

3.6.6.5 Move Apex tool to SM9B position, mount SM8 and SBS1 simulator, verify gut ray centering (transmission through SBS1).

3.6.6.6 Move Apex tool to SM9A position, verify gut ray centering (reflection at SBS1).

3.6.6.7 Mount SM9 A and B, verify autocollimation
Comments: *???Focalise MAT on central reticule of tool in SPIRE object plane (SO-tool). Twin images returned by autocollimation should coincide with reticule.???*

3.6.6.8 Place Apex tool in SM10A position, mount SMEC tool, verify gut ray centering.
Comments: *Deviation indicates lateral displacement of RT apex*

3.6.6.9 Move Apex tool to SM11A, mount SM10A, SM10B and SBS2 pellicle replacement, verify gut ray centering
Comments: *Identify image transmitted through SBS2 to verify alignment of SM10B*

3.6.6.10 Move Apex tool to SM11B, verify gut ray centering
Comments: *Identify image transmitted through SBS2 to verify alignment of SM10A. Identify image reflected at SBS2 to verify alignment of SBS2.*

3.6.6.11 Move Apex tool to SM12A, mount SM11A, verify gut ray centering

3.6.6.12 Move Apex tool to SM12B, mount SM11B, verify gut ray centering

3.6.6.13 Mount SM12A and SM12B, verify gut ray centering on detector tools (SD tools).
Comments: *Deviations are recorded and used in definition of detector interfaces*

3.6.6.14 Close SPIRE box, verify gut ray centering on D tool and CS tool. Repeat open/close/verification TBD times.
Comments: *If changes occur during open/close operations, improve open/close procedure.*

3.6.6.15 Mount HOB simulator, reorient MAT with optical axis, verify alignment with HOR.

3.7 Post integration verifications

Goal: Final verification of cold stop centering. Verification of pupil image quality. Verification of image quality.

3.7.1 Spectrometer pupil alignment verification

3.7.1.1 Align MAT with HOR (cf above)

3.7.1.2 Align MAT with gut ray

3.7.1.3 Verify cold stop aligned with gut ray

3.7.2 Spectrometer pupil quality verification

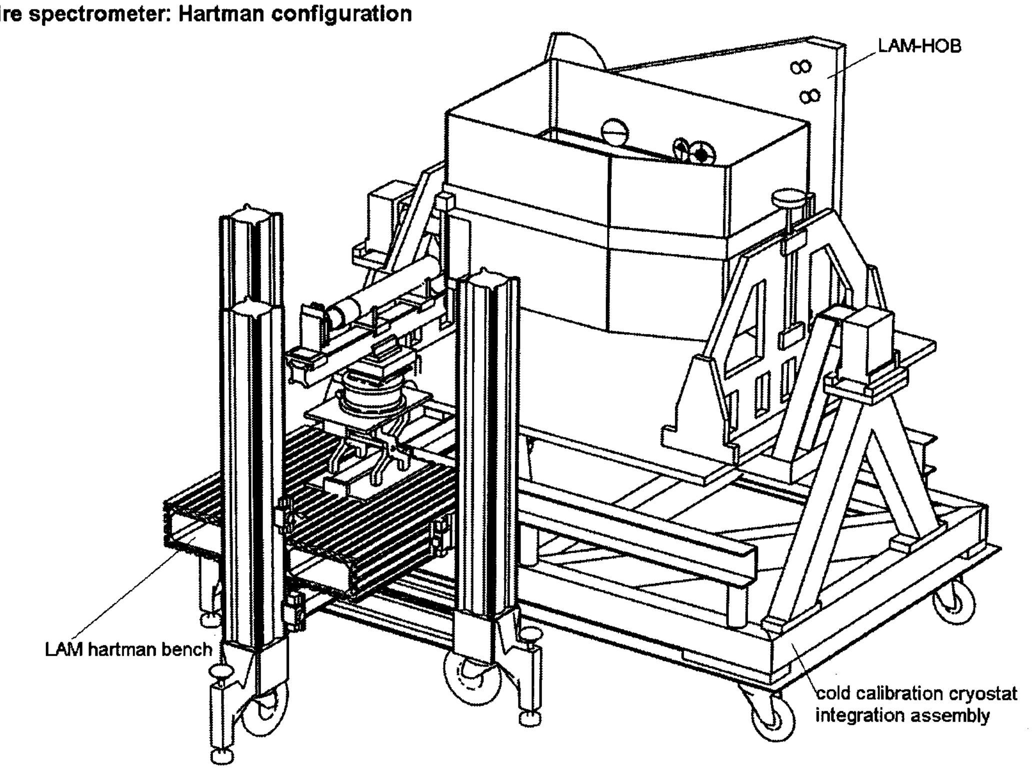
3.7.2.1 Locate M2-tool with respect to the SPIRE box
Comments: This will already be the case if above procedure followed.

3.7.2.2 Verify cold stop position for different field points
Comments: Observe (by the aid of the specially designed loupe) the projected edge of the CS-tool through one of the edge reticules in the M2-tool. Light up sequentially each of the sources in the D-tool, measure position of the edge for each field point. Repeat for each of the edge reticules in the M2-tool. Deviations are recorded and compared with optical model.

3.7.3 Focus verification

3.7.3.1 Adjust Hartmann optical bench on the gut ray.

Spire spectrometer: Hartman configuration



3.7.3.2 Hartmann lunette adjusted according to central Dtool source. Axial position adjusted by the aid of laser meter. Axially adjust CCD to best focus. Compare with calibrated CCD position.
Comments: This can be done with or without mask (CS tool or Hartmann tool) in the cold Stop position. Exact procedure is under elaboration (see below). For spectrometer, repeat for both Dtools.

3.7.4 Image quality verification

3.7.4.1 Hartmann lunette adjusted according to central Dtool source. Record on CCD intra and extra focal images. Results are analysed and compared with optical model.
Comments: Two options are being tested: Hartmann test (using Hartmann tool) or Roddier test (without screen).

3.7.5 Photometer pupil alignment verification

3.7.5.1 Align MAT with HOR (cf above)

3.7.5.2 Align MAT with gut ray

3.7.5.3 Verify cold stop aligned with gut ray

3.7.6 Photometer pupil quality verification

3.7.6.1 Locate M2-tool with respect to the SPIRE box
Comments: This will already be the case if above procedure followed.

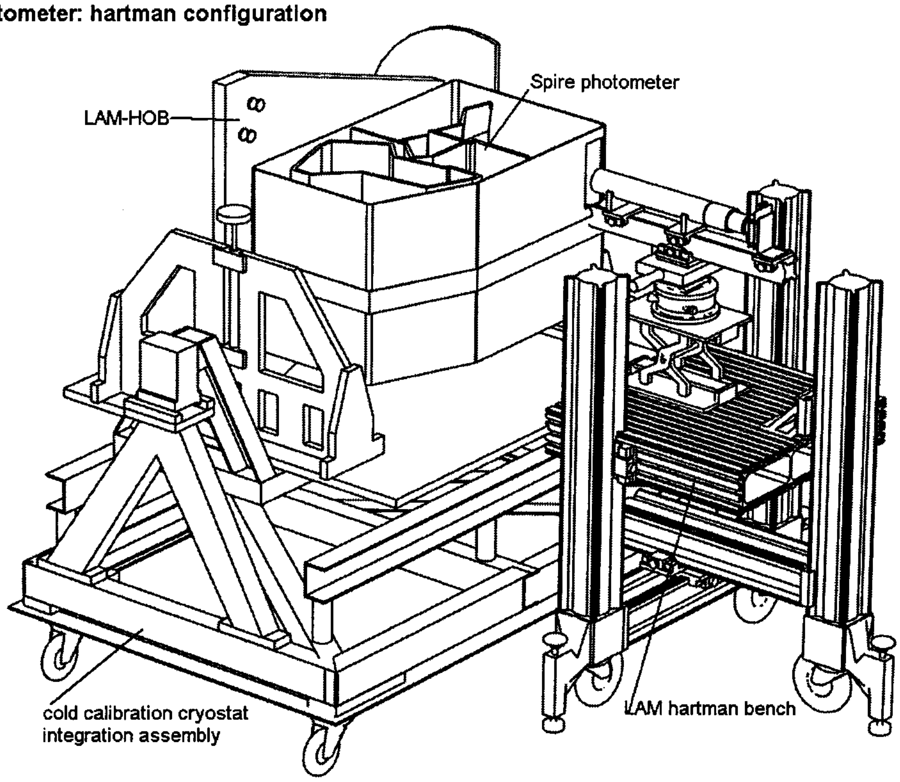
3.7.6.2 Verify cold stop position for different field points
Comments: Observe (by the aid of the specially designed loupe) the projected edge of the CS-tool through one of the edge reticules in the M2-tool. Light up sequentially each of the sources in the D-tool, measure position of the edge for each field point. Repeat for each of the edge reticules in the M2-tool. Deviations are recorded and compared with optical model.

3.7.7 Focus verification

3.7.7.1 Hartmann lunette adjusted according to central Dtool source. Axial position adjusted by the aid of laser meter. Axially adjust CCD to best focus. Compare with calibrated CCD position.

Comments: This can be done with or without mask (CS tool or Hartmann tool) in the cold stop position. Exact procedure is under elaboration (see below). For photometer, may be repeated for all field points (TBC).

Spire photometer: hartman configuration



3.7.8 Image quality verification

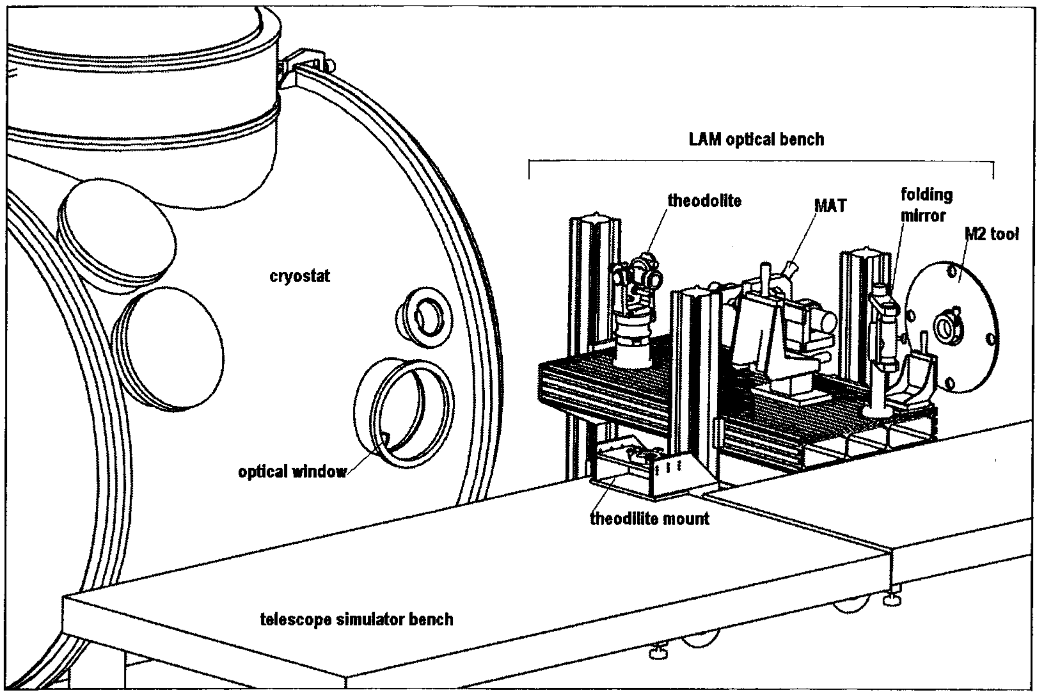
3.7.8.1 Hartmann lunette adjusted according to central Dtool source. Record on CCD intra and extra focal images. Results are analysed and compared with optical model.

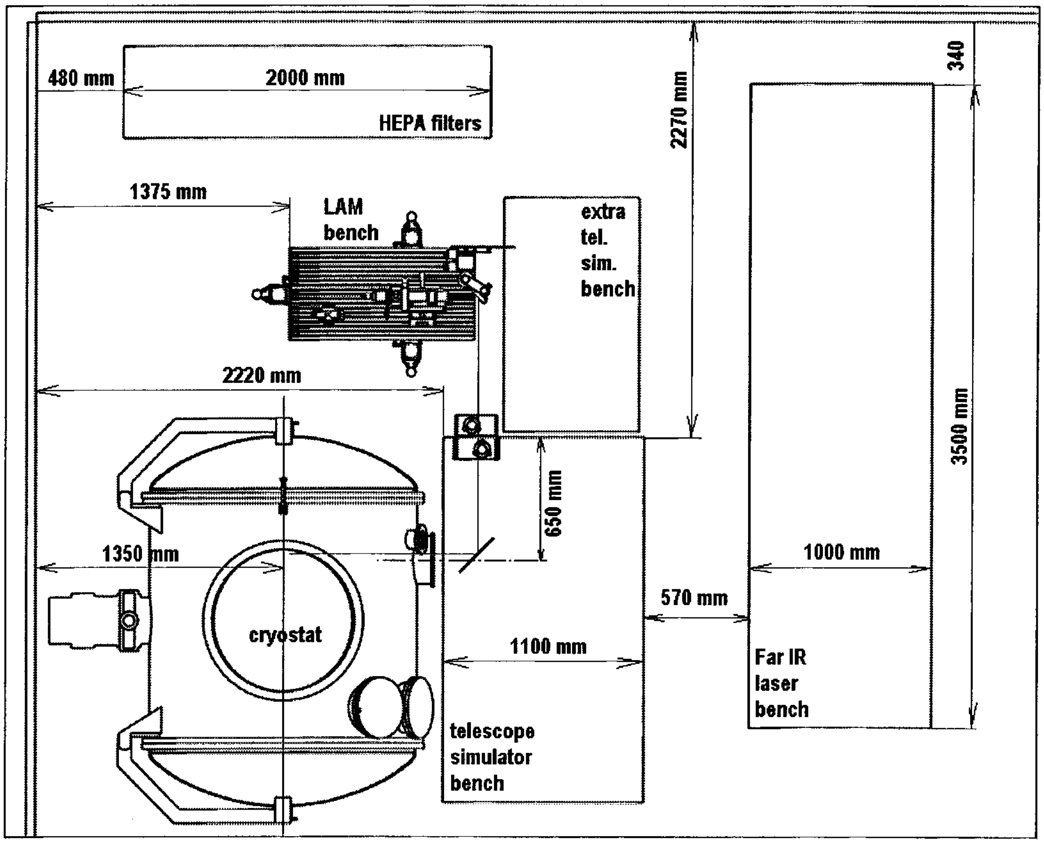
Comments: Two options are being tested: Hartmann test (using Hartmann tool) or Roddier test (without screen). For photometer, may be repeated for all field points (TBC).

3.8 Cryo verification

Goal: Series of measurements performed at ambient vacuum, cold vacuum, and again at ambient vacuum. Allows monitoring of changes to instrument externally and internally. Cube orientation, cold stop position, image position

3.8.1 Global views of OGSE at cryo configuration





3.8.2 Ambient vacuum reference measurements

3.8.2.1 SPIRE mounted in cryostat with RAL-HOB and HOR.

Comments: RAL-HOB and HOR are not made to be absolute references, so only serve as relative references.

3.8.2.2 Mount theodolite onto telescope simulator bench facing HOR. Adjust for autocollimation on HOR. Adjust for autocollimation on cryostat window. Record difference in theodolite orientation

Comments: Although the cryostat window may not be optically flat, it is assumed that it will not change shape between hot and cold vacuum. It can therefore serve locally as reference surface. The instrument will move and change orientation on cool-down. This test verifies the relative orientation of HOR and SOR.

3.8.2.3 Mount theodolite onto telescope simulator bench facing SOR. Adjust for autocollimation on SOR. Adjust for autocollimation on cryostat window. Record difference in theodolite orientation

3.8.2.4 Align MAT to HOR (cf above).

3.8.2.5 Align MAT to photometer gut ray (cf above), central D tool source is lit, focalise on CS tool. Record deviation.

Comments: Deviation represents error in HOR.

3.8.2.6 Light sequentially other D tool sources, record deviations.

3.8.2.7 Light up central D-tool source, focalise on D tool, record deviation.

3.8.2.8 Align MAT to spectrometer gut ray (cf above), one D tool source is lit, focalize on CS tool. Record deviation. Repeat for other D tool.

3.8.2.9 Focalise on D tool, record deviation. Repeat for other D tool.

3.8.3 Cold measurements

3.8.3.1 Cool down, repeat above procedures. Compare results.

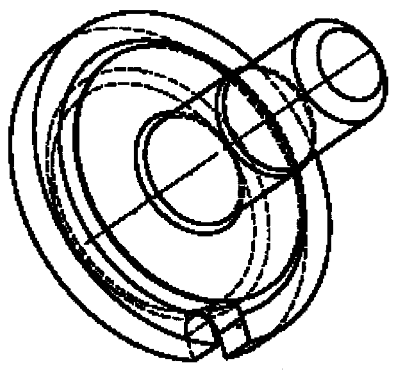
3.8.4 Ambient re-verification

3.8.4.1 Heat up, repeat, compare.

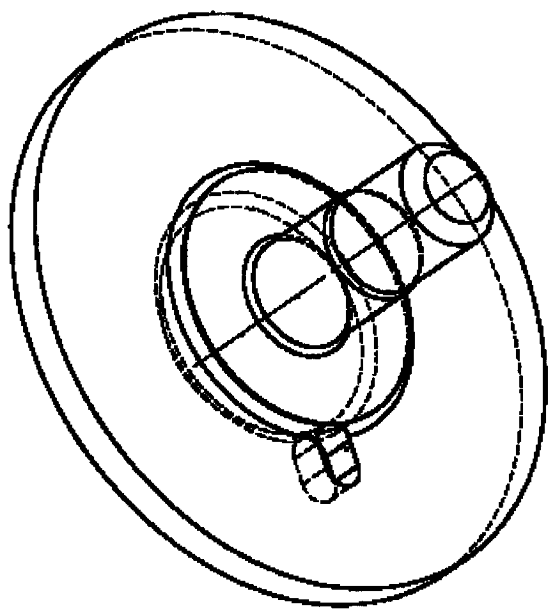
4 Alignment tools

4.1 3D tools

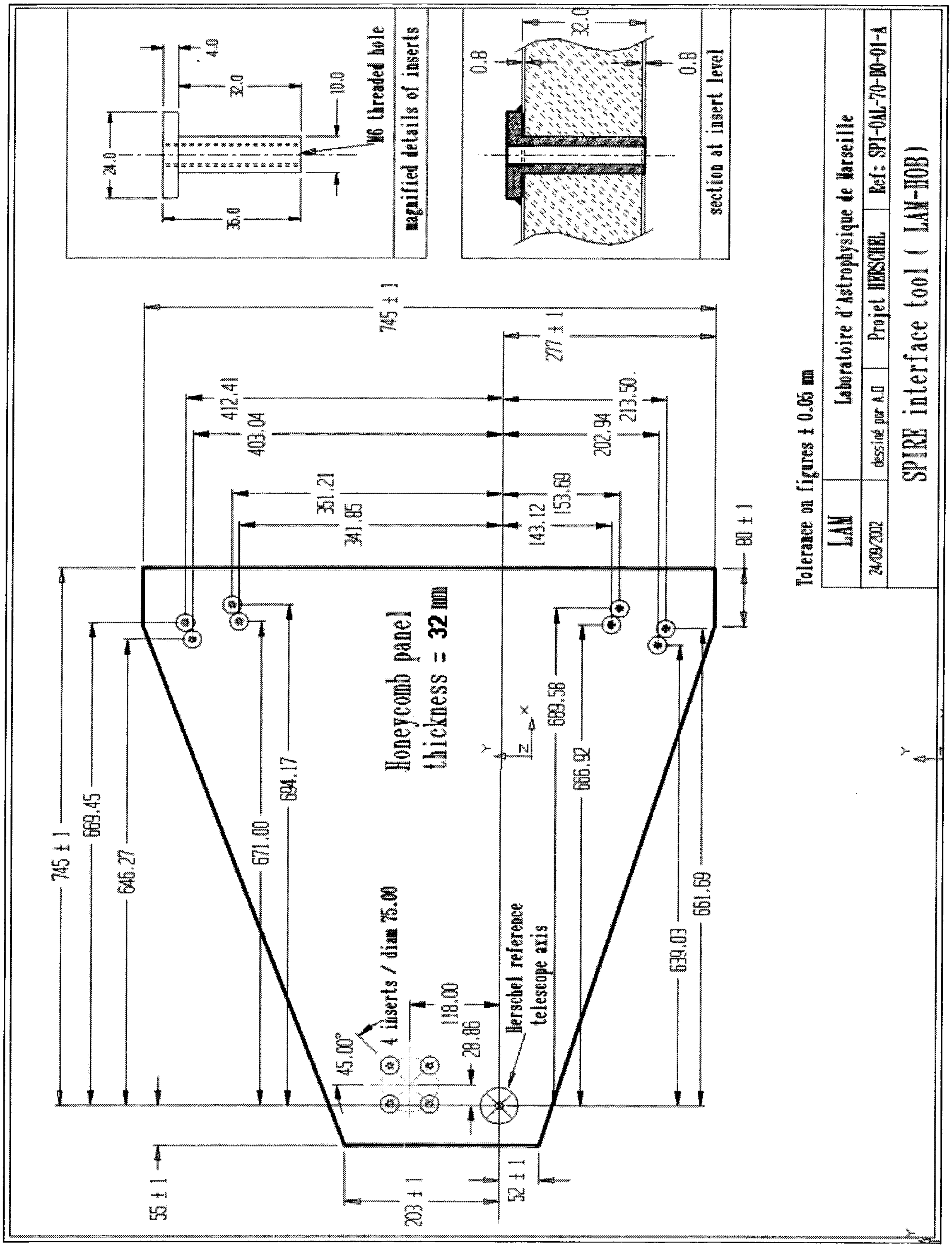
3D tool 26mm



3D tool 45mm

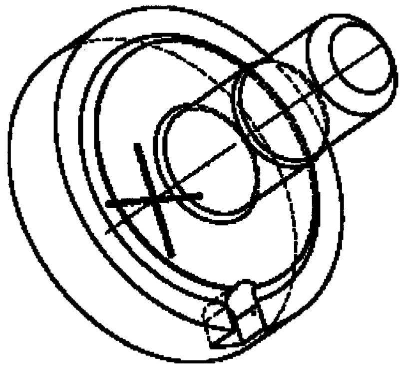


4.2 Spire telescope tool

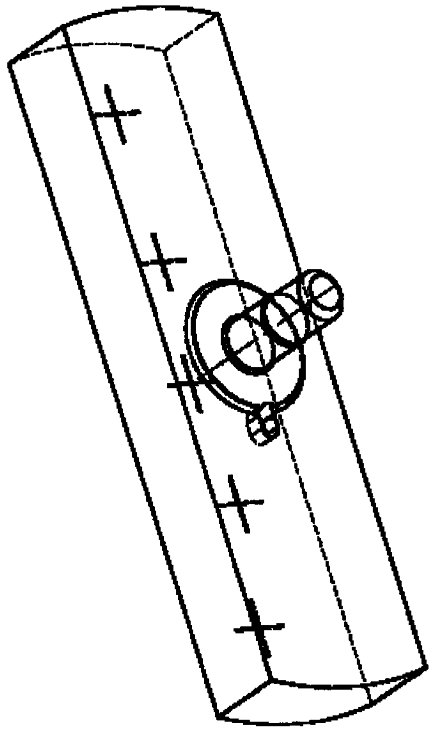


4.3 Apex tools

Apex tool 7 mm

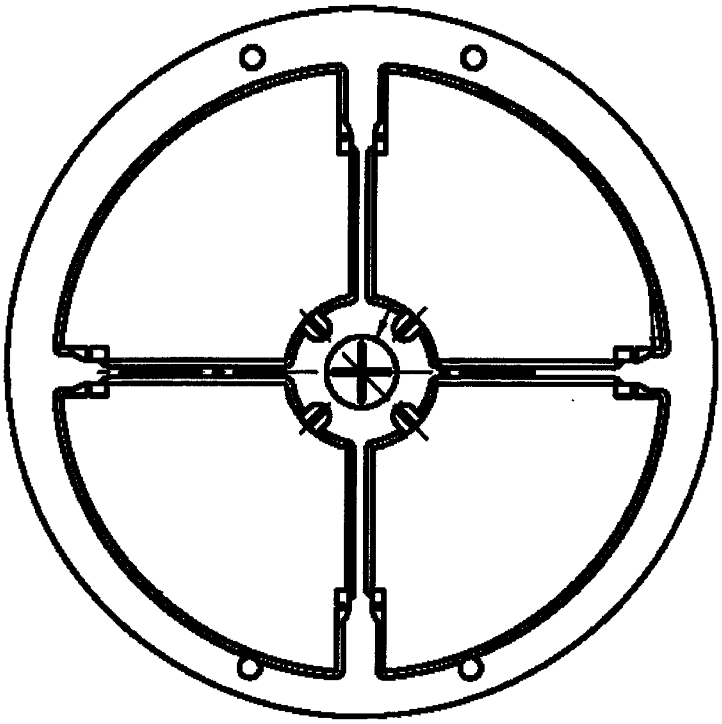


Apex tool 15 mm

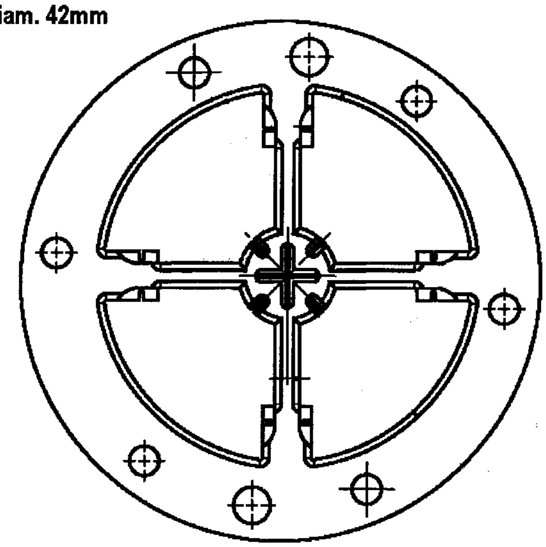


4.4 Cold stop tools

Photometer CS tool
diam. 59.97mm

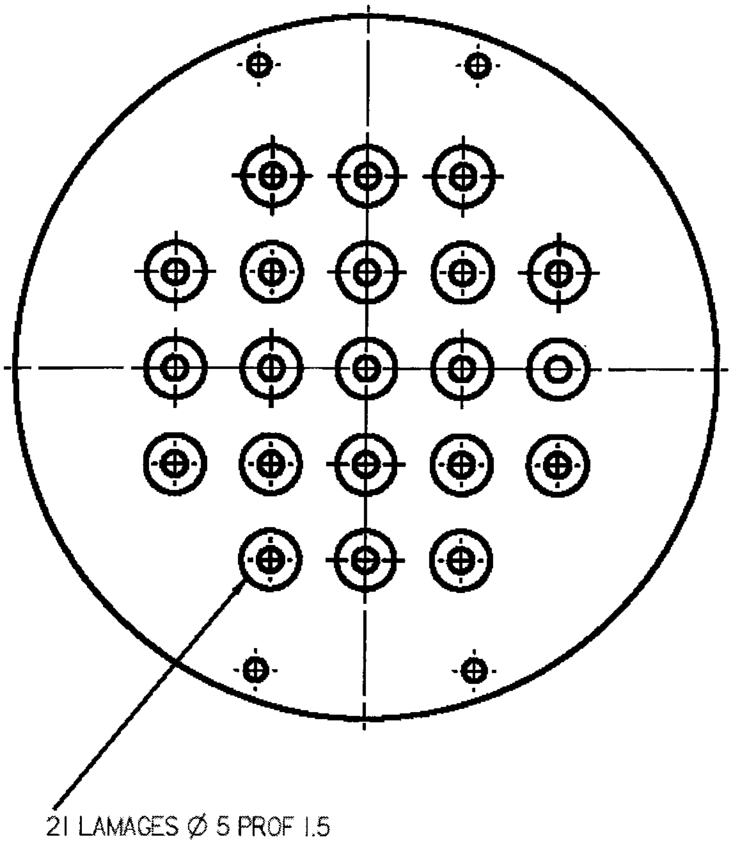


Spectrometer CS tool
diam. 42mm

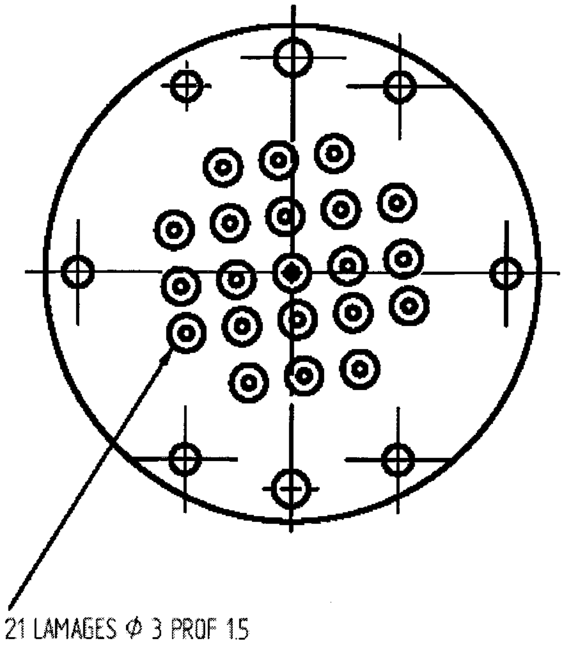


4.5 Hartman tools

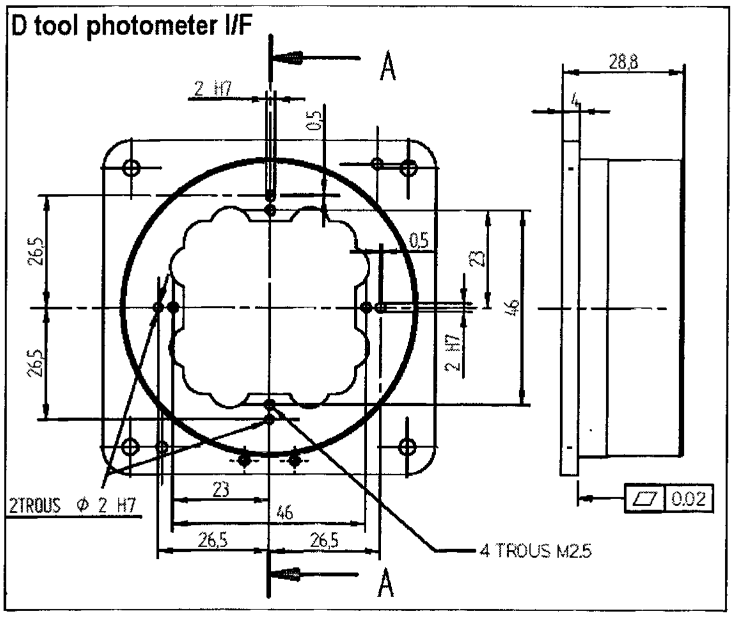
Photometer Hartman tool
diam. 59.97mm

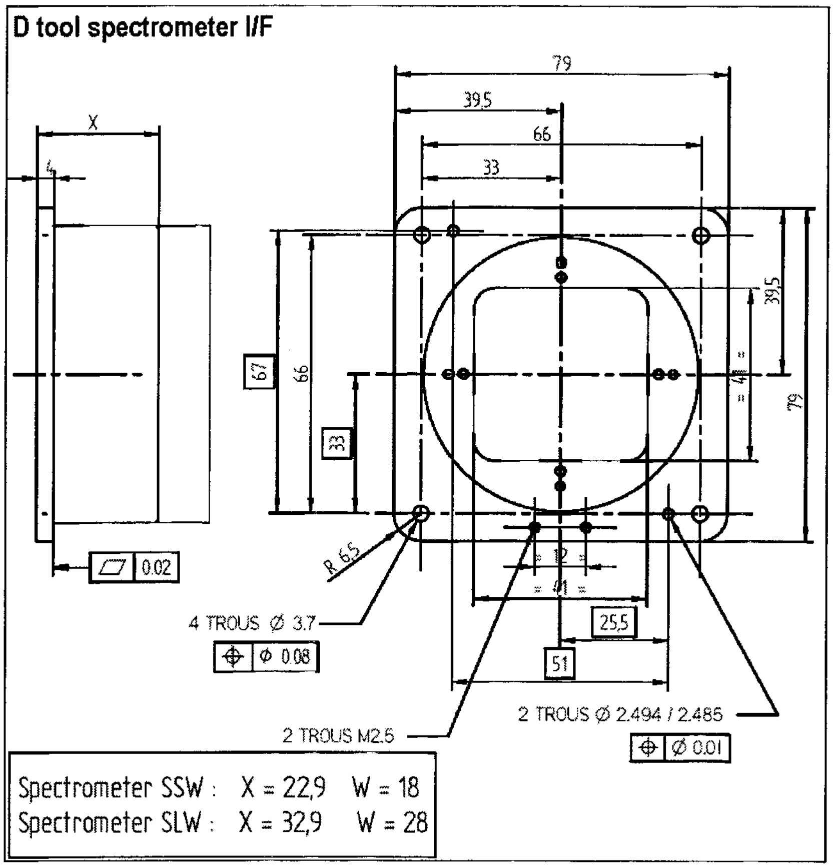


Spectrometer Hartman tool
diam. 42mm



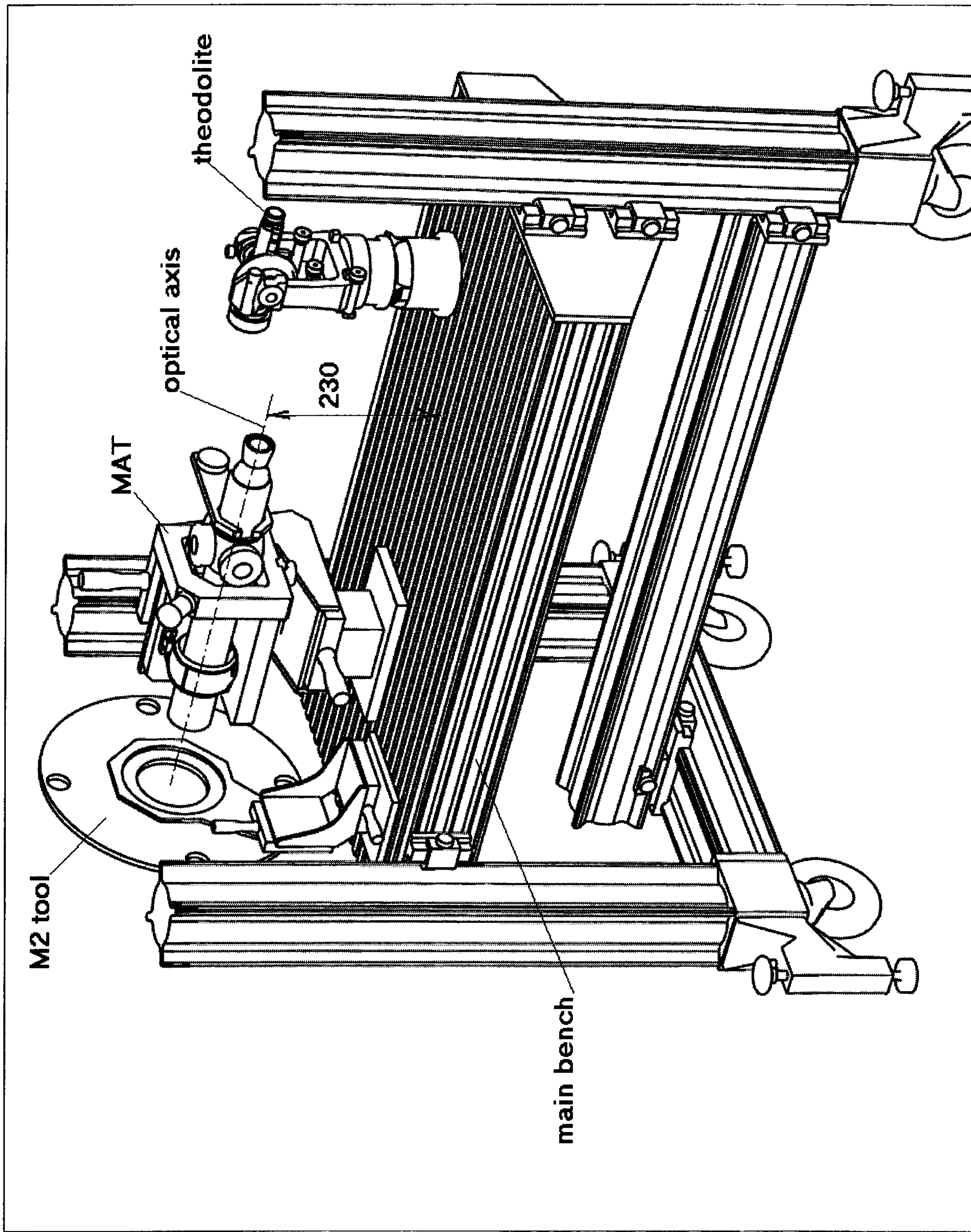
4.6 Detector tools





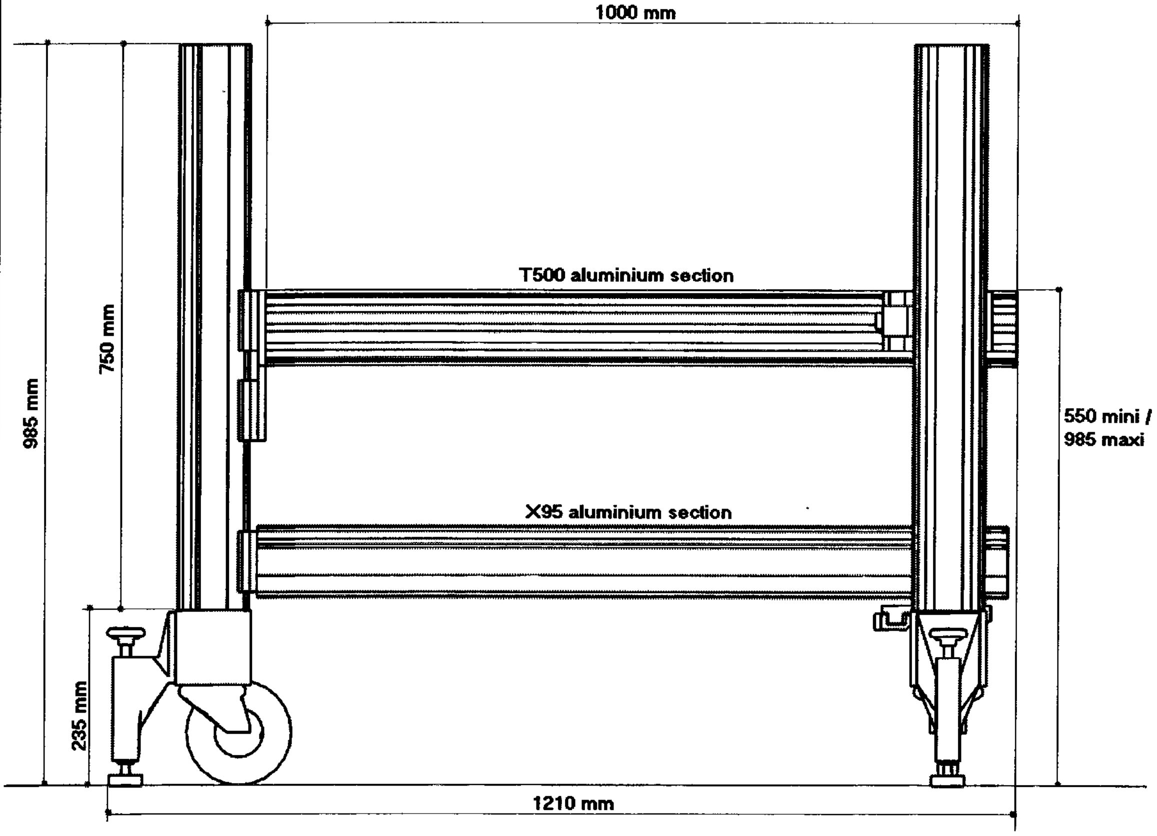
5 LAM benchs

5.1 LAM optical bench

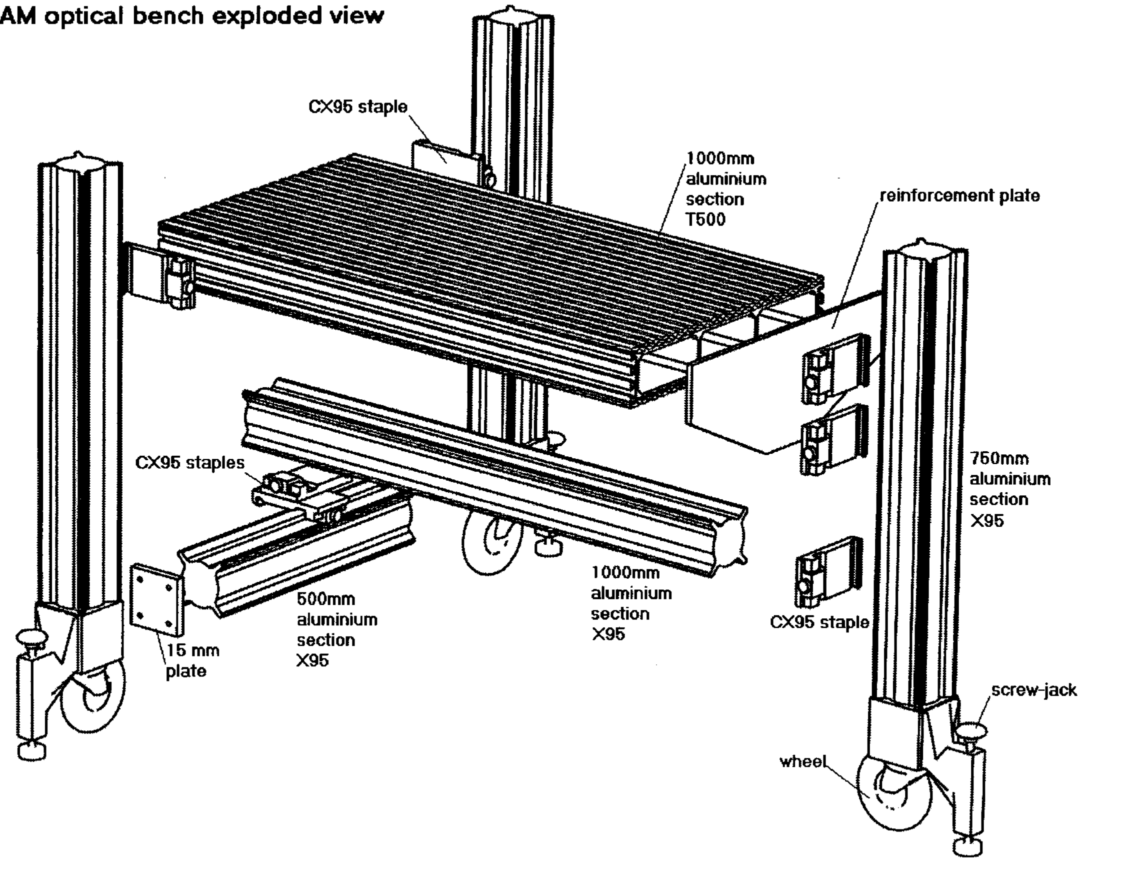


LAM optical bench : general view

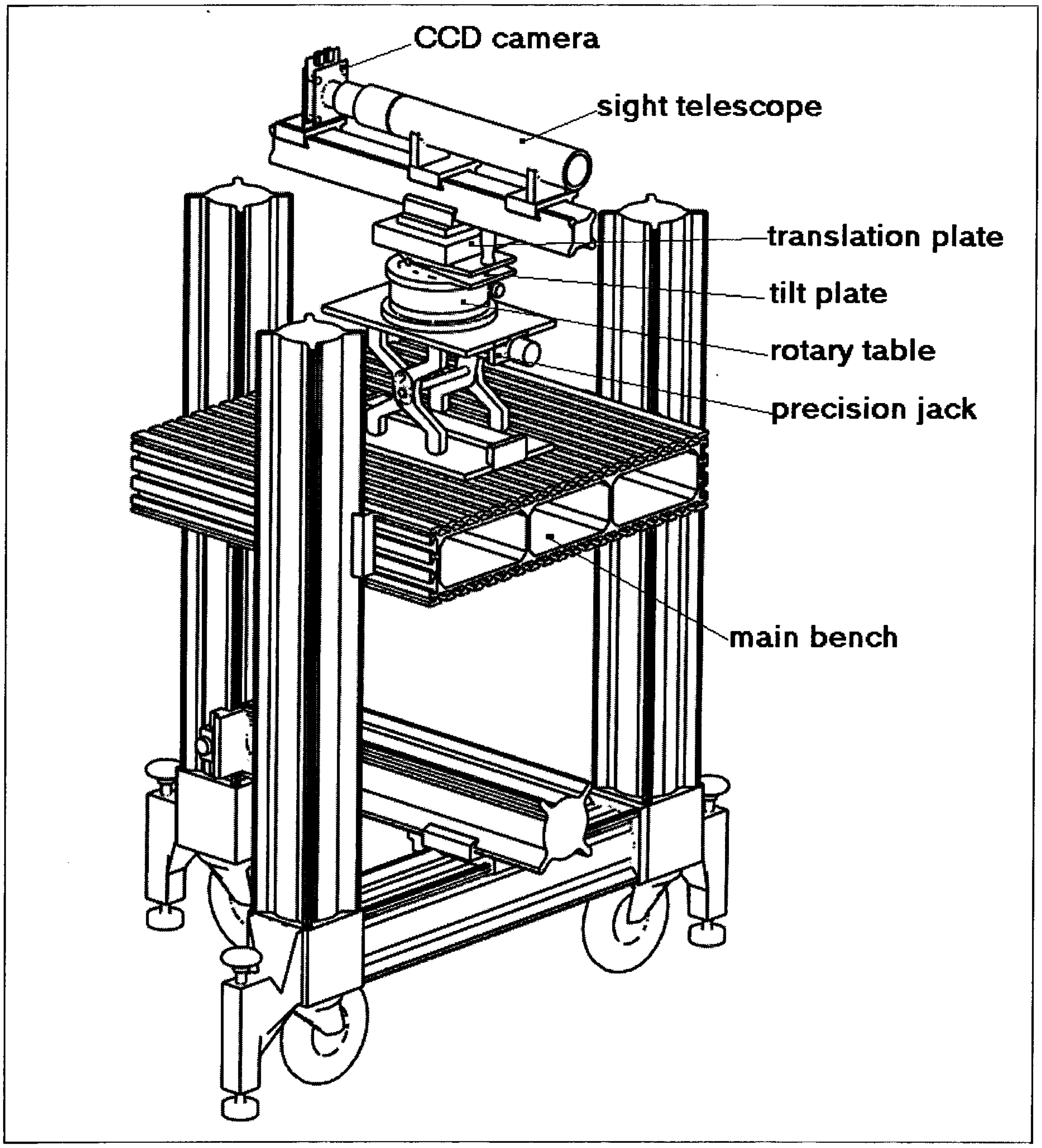
LAM optical bench

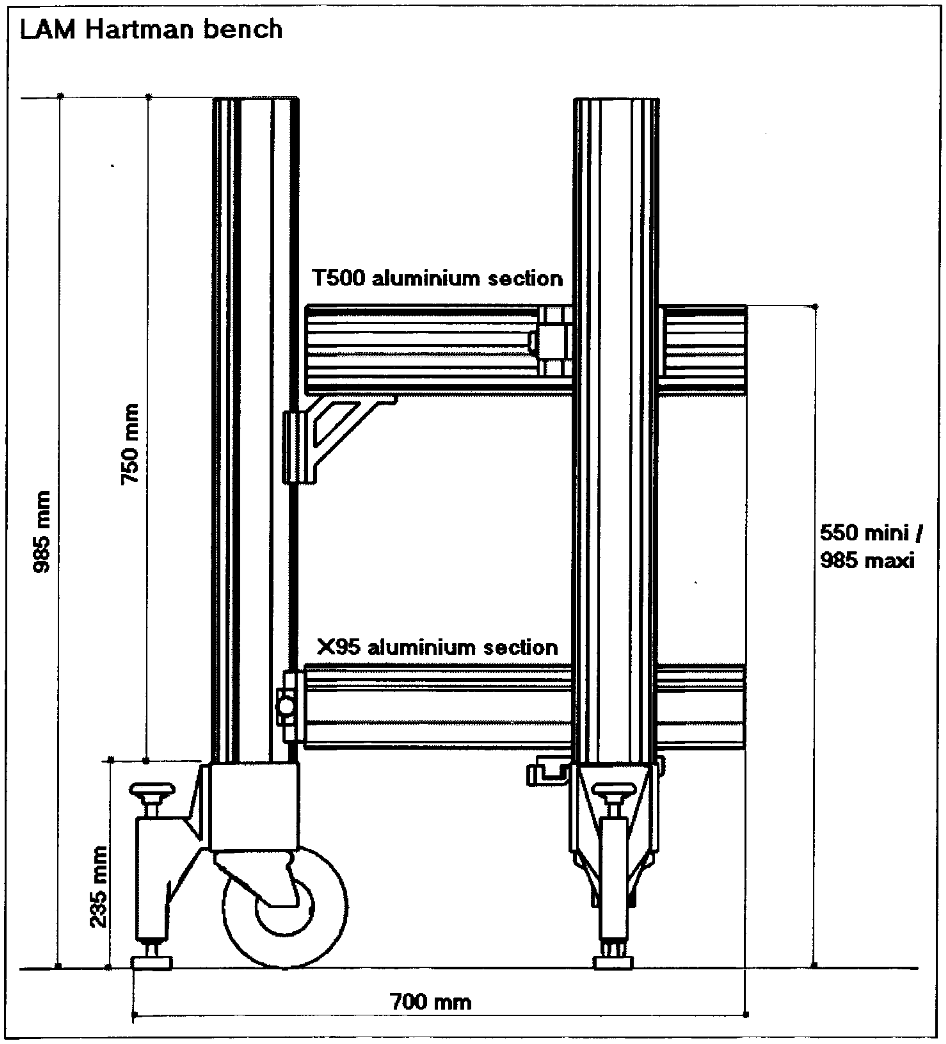


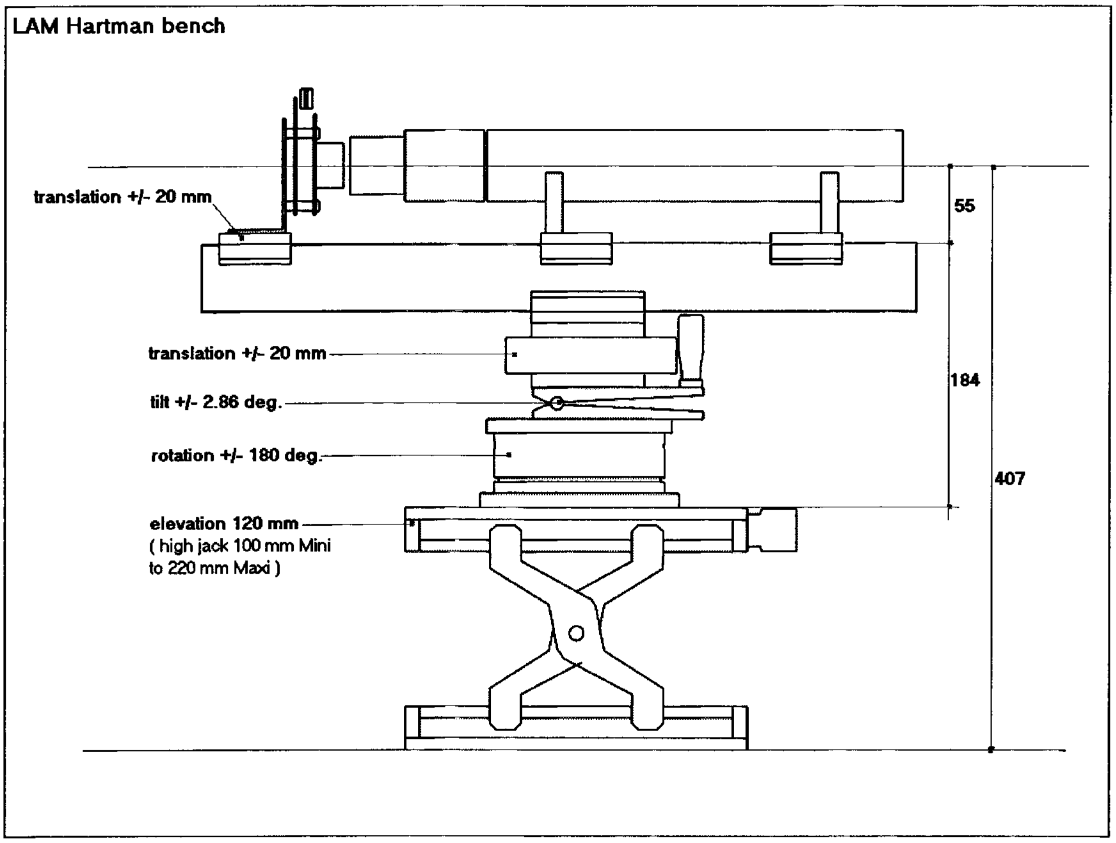
LAM optical bench exploded view



5.2 LAM Hartman bench




LAM Hartman bench
T500 aluminium section
750 mm
985 mm
550 mini /
985 maxi
X95 aluminium section
235 mm
700 mm


LAM Hartman bench
translation +/- 20 mm
55
translation +/- 20 mm
tilt +/- 2.86 deg.
184
rotation +/- 180 deg.
407
elevation 120 mm
(high jack 100 mm Mini
to 220 mm Maxi)