ANNEXES TO THE TECHNICAL SPECIFICATIONS

OF THE OPTICAL COMPONENTS OF THE MISTRAL BEAMLINE AT THE ALBA SYNCHROTRON RADIATION FACILITY

Dossier number: 58/07

Complementary documents

- **Conceptual design report** of the MISTRAL beamline in ALBA synchrotron radiation Facility (EXD-BL09OP-GD-0001),
- **Interfaces to the ALBA Control System** (CCD-BLCT-CC-0001),
- **Technical terms of delivery and acceptance** for the electrical installations of the ALBA beamlines (END-BLEL-CC-0001),
- **General specification for the vacuum system** of the ALBA beamlines (END-BLVC-CC-0001),
- **Alignment and Handling Requirements** for ALBA Beamlines (END-BLAL-CC-0001).

Annex A.

Technical Specifications of

Lot MISTRAL I: Beamline Backbone

A-1. Scope of Lot I

This lot comprises the beamline backbone which includes several hardware components described below and also the interfacing and coordination tasks with the contractors of the other lots. Due to this, the contractor of Lot I may be considered as the main contractor since it has to ensure that the beamline as a whole has no inconsistencies or mismatches.

Document END-BLVC-CC-0001 describes the requirements that shall be accepted concerning vacuum, document END-BLAL-CC-0001 the ones corresponding to survey and alignment monuments, document CCD-BL-CT-CC-0001 rev 2.1 corresponding to control electronics, and document END-BLVC-CC-0001 the ones corresponding to the electrical installations.

It has to be quite clear that the interfacing between the Lot IV (mirrors) components and Lot I components are under the responsibility of the Lot I contractor. This applies to the other lots too (II and III). In other words **it is the responsibility of the contractor of Lot I to assure the coordination between the different lots and the integration of the components from these lots into the overall beamline.**

A-2. Deliverables

A-2.1. Hardware deliverables

The hardware deliverables included in this lot are:

- The vacuum chambers of mirrors M1, M2 & M4 as well as mirrors positioning mechanics, their associated equipment (like, e.g., stepping motors and encoders), and support structures. In the case of the M4 chamber a mask is foreseen for the M4 mirror to stop any zero-order diffraction coming from the grating.
- Bremsstrahlung-stopper (item 6 in Figure 1/Table 2 Section 6).
- PGM entrance slit set-up including linear stage (item 8 in Figure 1/Table 2 Section 6), upstream horizontal aperture, mesh beam diagnostic, and granite support structure.
- PGM exit slit set-up including linear stage (item 12 in Figure 2/Table 2 Section 6), upstream horizontal aperture, mesh beam diagnostic, and granite support structure.
- White beam diagnostics, 2-jaw vertical cooled aperture and support structures.
- Bremsstrahlung stopper
- Vacuum pipes, bellows, connectors, and supports as required by the vacuum system, up to (and excluding) the experimental end-station.

A-2.2. General deliverables

In addition to the documents detailed in Section 2 of the main document, general deliverables associated with this lot are:

- Technical and engineering drawings for the beamline layout and for all the components included in this Lot,
- Study of the beamline vacuum profile with and without photon beam (please note that the vacuum performance is of within the responsibility of the contractors of the corresponding lots),

A-3. Interfaces

A-3.1. Interface with ALBA facilities.

The interface of Lot MISTRAL I with the ALBA facilities consists of the following items:

- Front end all metal gate valve DN40CF,
- Media supply connections in accordance to the detailed definition of interfaces described in the PDR:
  - Cooling water outlets,
  - Pressurized air outlets,
  - Electricity outlets,

  where CELLS will provide and install the piping from the media distribution boards to the beam line components.
- Control system cabling connectors in accordance to the detailed definition of interfaces described in CCD-BLCT-CC-0001.

The beamline will be located in a hutch with different enclosures: a lead-shielded enclosure for the first optics M1 & M2 (first optical enclosure, FOE, see Table 2 Section 6) and a second enclosure for the monochromator and the experimental station. The final design will be provided by CELLS in accordance to the PDR.

A-3.2. Interface with ALBA standard components.

Some of the elements on the beamline will be provided as ALBA standard components. The interfaces between them and the beamline backbone (Lot MISTRAL I) are given by the length of the component and the type of flanges. A list of them is given below (values for component length excluding bellows are given. Details are to be discussed with CELLS):

- Non-cooled beam diagnostics set-ups (three items see Figure 1/Table 2 Section 6)
  - DN40CF flanges,
  - Approximate length (from flange to flange): 126 mm,

A-3.3. Interface with Lot MISTRAL II

The interface between the monochromator chamber (Lot MISTRAL II) and the beamline backbone (Lot MISTRAL I) are the flanges of the monochromator chamber as well as the requirements of the overall beam geometry.

The contractor of Lot MISTRAL II must inform the contractor of Lot MISTRAL I (and CELLS) about whatever change in the vertical beam offset introduced in the monochromator, which is proposed to be 15 mm between the centre of the optical surface of M3 (PGM pre-mirror) and the centre of the optical surface of the gratings.

A-4. General conditions and requirements

See sections 7 and 8 on the main document.

A-4.1. Layout

The design of the layout of the beamline is within the scope of supply of Lot MISTRAL I. Some information and requirements for such a design are detailed in this section.

A-4.2. Front end

The front end is supplied by CELLS and includes the following components (sequence along the beam direction):

- Gate valve,
- 1st fixed mask,
- (fluorescent screen),
- x-ray beam position monitor (blade type),
- 2nd fixed mask,
- Photon shutter,
- Gate valve,
- Fast shutter,
- 1st movable mask,
- 2nd movable mask,
- Gate valve
- Bremsstrahlung-shutter 1 and 2,
- Trigger unit,
- Gate valve.

A-4.3. Layout Requirements

The layout of the beamline must be designed in order to allocate the optical system, consisting of the mirrors, gratings, slits and diagnostic sets detailed in the conceptual design report of the MISTRAL beamline (EXD-BL09OP-GD-001).

A-4.4. Components of the beamline layout

The MISTRAL beamline layout is composed by the following components:

- White beam diagnostics
- 2-jaw vertical cooled aperture

- M1 mirror chamber (including the M1 mirror in the scope of supply of Lot IV),
- Non-cooled beam diagnostics set-up (supplied by CELLS)
- M2 mirror chamber (including the M2 mirror in the scope of supply of Lot IV)
- Bremsstrahlung stopper,
- Non-cooled beam diagnostics set-up (supplied by CELLS),
- Entrance slits set-up,
- Monochromator chamber (including the M3 mirror, the grating(s) and one dummy fluorescent grating), in the scope of supply of Lot MISTRAL II,
- M4 mirror chamber (including the M4 mirror in the scope of supply of Lot IV),
- Exit slits set-up consisting in a pinhole arrangement
- Non-cooled beam diagnostics set-up (supplied by CELLS),

Their corresponding specifications are given in the following sections.

A-5. Vacuum system

A-5.1. Function

The vacuum system of the MISTRAL beamline must maintain the whole beamline under clean UHV conditions so as to avoid the contamination of the mirrors, to maintain their optical properties (mainly the reflectivity, which is affected by carbon contamination and by oxidation). To this aim, only dry pumps and oil free pumps will be used to ensure the absence of hydrocarbons in the residual gas.

In addition, since no filters/vacuum windows are used in the beamline, the beamline vacuum system is directly connected to the vacuum system of the storage ring.

A-5.2. Specification

The design of the vacuum system shall comply with the guidelines given in the "General specification for the vacuum system of the ALBA beamlines" (END-BLVC-CC-0001), as well as the general vacuum requirements given in Section 8.1. in the main document. Additional information is given below.

The base pressure of each vacuum recipient of the beamline vacuum system after bake out and subsequent cool down should be equal or better than 5×10^{-10} mbar (without beam).

The different vacuum sections and vacuum chambers of the MISTRAL beamline downstream the radiation protection hutch are to be separated by gate valves (metal bonnet seal, Viton gate seal). All metal-sealed right angle valves with an appropriate flange size (i.e., DN63CF for mirror chambers and DN40CF for smaller vacuum recipients) are to be foreseen on each vacuum section for initial pump down.

Each mirror or monochromator vessel is to be equipped with a diode-type ion pump. Mirror chambers in the white beam section are to include provisions for installing a Titanium Sublimation Pump (TSP) (incl. cryoshroud). Pirani and cold cathode vacuum gauges are to be installed on each mirror and monochromator vessel. Additional pumps are to be installed where necessary, i.e., on long beam pipes, etc.

The vacuum system is composed of the following kind of items:

- Vacuum chambers,
- Vacuum pumps,
- Pressure gauges,
- Vacuum valves.

The specification for the different items is given in the following subsections.

A- 5.2.1. Vacuum sections

The beamline will be divided in presently six different vacuum sections. A tentative vacuum section distribution of the beamline is represented in Figure 1 Section 6 in the main document. The dashed black lines in the figure represent the valves that divide the different vacuum sections.

The contractor may propose a different distribution of vacuum sections, as long as it complies with the following requirements:

- The different sections of the beamline must be separated by vacuum valves,
- Each mirror vessel must be in a different vacuum section from other mirror vessels,
- There must be valves upstream and downstream the monochromator chamber,
- There must be a valve between M2 and the monochromator chamber.

A- 5.2.2. Vacuum chambers

The mirror chambers for the MISTRAL beamline consist of a vacuum vessel and a mirror holder moved by motors preferably placed in air outside the vacuum recipient.

The vacuum vessels must fulfill the following requirements:

- Box-type or bell jar-type chamber with top lid for fast and easy maintenance of mirror set-up,
- Base pressure after bakeout and without photon beam must be 5×10^{-10} mbar or less using an ion pump together with a TSP,
- Pressures inside the mirror chambers with white photon beam must be less than 1×10^{-7} mbar during commissioning and less than 1×10^{-8} mbar during normal operation,
- Flanges:
    - Port for ion pump with no direct line of sight to mirror surface (incl. in-vacuo chimney hat on in-vacuo flange neck of pumping port if necessary),

- Port for TSP or NEG pump with no direct line of sight to mirror surface (incl. in-vacuo chimney hat on in-vacuo flange neck of pumping port if necessary),
- Beam entrance,
- Beam exit,
- Two Penning gauge heads DN40CF,
- One Pirani gauge head DN16CF,
- Roughing valve (all metal, preferably DN63CF),
- RF antenna flange or flange for UV lamp (DN63CF, for future installation of plasma cleaning system) without direct sight of the mirror surface,
- Two spare flanges DN40CF,
- At least two DN63CF (or DN100CF) viewports, with direct line of sight on mirror surface,
- Feedthroughs:
  - Water feedthroughs (2 pipes per cooled mirror, if applicable),
  - Thermocouple feedthroughs for K-type thermocouples (2 pairs per mirror),
  - High-voltage feedthroughs for piezo actuators (if applicable).

A- 5.2.3. Vacuum pumps

As mentioned earlier, CELLS will supply the vacuum pumps. However, since the contractor of Lot MISTRAL I will be responsible for the vacuum performance of the beamline (except for Lot MISTRAL II – monochromator chamber), the contractor shall define the pumping speeds required at the different vacuum chambers for satisfying the vacuum requirements.

Carbon contamination must be avoided. Therefore, only dry pumps are acceptable for initial pump-down during the whole lifetime of the vacuum recipient. This includes the vacuum conditioning at the manufacturer's premises.

The ion pumps will be equipped with the associated controllers and high-voltage cables of appropriate length (up to 30 m).

Additional ion pumps are to be installed where necessary, i.e., on long beam pipes, etc.

In case a TSP will be installed on the vacuum chambers in addition to an ion pumps, the contractor has to specify for the DDR at the latest whether these TSPs (together with their 8 inch cryoshrouds) are to be installed on the ion pump body itself (i.e., using either a 180 or 90 degree configuration) or on a separate vacuum chamber flange.

In case NEG pumps will be installed on the mirror/monochromator chambers (i.e., instead of TSPs), the NEG cartridges are to be installed inside a separate recipient mounted on the corresponding vacuum chamber. The NEG recipient is to be provided with a Viton-sealed manual gate valve for separating the NEG from the vacuum chamber volume. In addition, a Penning gauge and a right-angle valve are to be mounted on the NEG recipient. In the case of the NEG or TSP pumps, a single controller for each type of pump together with one required set of cables will be provided.

A- 5.2.4. Pressure gauges

As for the other vacuum standard components, pressure gauges will be provided by CELLS. Thus the following is for information purposes only.

Each one of the vacuum sections along the beamline separated from each other by gate valves has to be equipped with one Penning and one Pirani vacuum gauge (except beam pipes where the pumping current from the ion pump is assumed to be sufficient).

A- 5.2.5. Vacuum valves

Vacuum valves will be provided by CELLS. Nevertheless, the contractor of Lot MISTRAL I must specify the number and type/size of valves to be installed. What follows is for information purposes.

Each one of the vacuum sections along the beamline separated from each other by gate valves will be equipped with one all-metal right-angle valve.

Gate valves will be equipped with metal bonnet seal and Viton gate seal. The valve actuator motion will be transmitted via edge-welded bellows (i.e., no O-ring feedthroughs). Viton-sealed and metal-sealed valves will be bakeable up to 250° C and 300° C, respectively.

All gate valves will be provided with double-acting pneumatic actuators incl. solenoid (24 VDC) and position indicators (non-bakeable).

A-6. White beam diagnostics & 2-jaw vertical cooled aperture

The white beam diagnostics consist on a fluorescence screen and a W electrically isolated mesh for I_0 monitoring. Both elements have to be cooled and should be retractable.

A 2-jaw vertical defining aperture will be positioned before the first optical element M1 at approximately 15 m from the source.

The 2-jaw aperture must be:

- cooled: when the system is closed it has to be able to absorb 100 W,
- motorized (one motor per blade) and electrically isolated,
- indexed with an external ruler.

The requirements are:

- blade range: 0-30 mm
- resolution: 0.05 mm
- repeatability: 0.1 mm
- rms straigthness ≤ 10 µm

A-7. PGM entrance slit set-up

The entrance slit set-up determines the size of the beam transmitted to the monochromator and its vertical aperture contributes to the stability and energy resolution of the monochromator itself. Therefore, a high degree of mechanical stability is important.

We prefer the vertically defining entrance slits to be based on a single double sided flange, independently supported and isolated with bellows. For this design it is necessary that the bellows length-to-width ratio be large enough to tolerate the specified range of the roll adjustment (see table below); we suggest at least 2:1. In addition we prefer that gas and X-rays should be able to pass only through the slits and nor around them. In other words, slits are “sealed”.

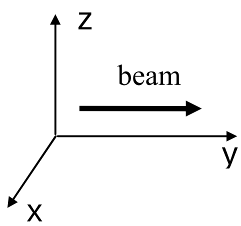
A-7.1. Description

The slit system must have the following components:

- One motorized, electrically isolated slit mechanism,
- The entrance slit blades must be isolated from ground and equipped with drain current monitor cables and BNC vacuum feedthroughs for vertical beam position monitoring. These cables must allow the slit movements in the range given in the table below,
- One pair of viewports (upstream and downstream the entrance slit), allowing the observation of the first order minima within the diffraction pattern produced by transmitting a red laser beam (632 nm) through a say 5 μm slit size.
- Two edge-welded bellows (one upstream, one downstream) enabling the positioning of the entrance slit along the beam direction,
- One manual linear translation stage (longitudinal direction along the beam direction),
- One mounting table with a dedicated adjustable mounting stand and the necessary mechanisms to align roll angle and the height. The pitch and yaw angles only need to be pre-set at installation.

A-7.2. Specification

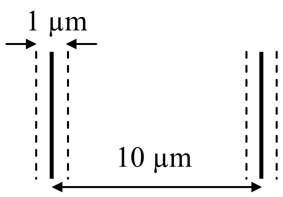
The vertically defining entrance slit must be controlled according to the specifications given in the following table. The coordinate system is the following:



ENTRANCE SLITS (S1)		
longitudinal position (Y)	range (manual)	± 100 mm
	resolution	≤ 0.1 mm
vertical position (Z)	range (manual)	± 10 mm
	resolution	1 µm $
	Repeatability	1 µm
vertical opening	range (motorized)	3-200 µm
	Resolution	1 µm
	Repeatability	0.5 µm
	blade parallelism & straightness	1 µm *
horizontal position (X)	range (manual)	± 20 mm
	Resolution	0.1 mm
	Repeatability	0.1 mm

$ if this resolution cannot be achieved manually, the Z would then be motorized.

* the deviation from a straight line of the slit edge should be less than 1 µm RMS:



Alignment requirements for entrance slits are given below:

ENTRANCE SLITS (S1)	Manipulator	Resolution/Accuracy	Range
Pitch	Pre-installation on bench	-	-
Roll	Manual (outside vacuum)	50 µrad / - *	±1 mrad
Yaw	Pre-installation on bench	-	-

* no requirement for adjustment accuracy but initial installations should be horizontal within ±1 mrad.

A-7.3. Miscellaneous

After a standard 120°C bakeout and subsequent cooling down of the entrance slit assembly the Z (height)-position must be maintained within 2 µm. The yaw, roll and pitch angle of the linear translation stage must be maintained within their fine adjustment ranges.

A-8. PGM exit slit set-up

We contemplate two options and let the bidders suggest their suitability:

Option 1: Conventional set of high precision 4 jaw slits

Option 2: A series of pinholes of different apertures.

Please, quote both options separately.

A-8.1. Option 1: exit slit set-up

The exit slit set-up (horizontally and vertically beam defining slits) is used to select the photons of a well defined energy among the fan dispersed by the grating of the monochromator. The vertical aperture of the exit slit determines the resolution of the monochromator. Therefore, a high degree of mechanical stability is very important.

We prefer the slits to be based on a single double sided flange, independently supported and isolated with bellows. For this design it is necessary that the bellows length-to-width ratio be large enough to tolerate the specified range of the roll adjustment (see table below); we suggest at least 2:1. In addition we prefer that gas and X-rays should be able to pass only through the slits and nor around them. Slits are “sealed”, in other words.

A- 8.1.1. Description

The slits system must have the following components:

- One motorized slit mechanism,
- Two pairs of viewports (upstream and downstream the exit slit), allowing the observation of the first order minima within the diffraction pattern produced by transmitting a red laser beam (632 nm) through a say 5 µm slit size,
- Two edge-welded bellows (one upstream, one downstream) enabling the positioning of the exit slit along the beam direction,
- One manual aperture just upstream the exit slit confining the beam horizontally (inside the same vacuum chamber, if possible),
- One motorized linear translation stage (longitudinal direction along the beam direction),

- One mounting table with a dedicated adjustable mounting stand and the necessary mechanisms to align roll angle and the height. The pitch and yaw angles only need to be pre-set at installation.

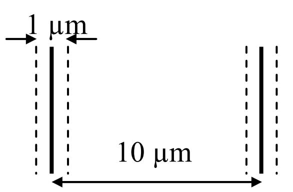
A- 8.1.2. Specification

The vertical & horizontal exit slits must be controlled according to the specifications given in the following table:

EXIT SLITS (S2)		
longitudinal position (Y)	Range (motorized)	± 50 mm
	Resolution	≤ 0.1 mm
vertical position (Z)	Range (manual)	± 10 mm
	Resolution	1 µm [$]
	Repeatability	1 µm
vertical opening	Range (motorized)	3-200 µm
	resolution	1 µm
	repeatability	0.5 µm
	blade parallelism & straightness [*]	1 µm
horizontal position (X)	range (manual)	± 1 mm
	resolution	3 µm
	repeatability	3 µm
horizontal opening	range (manual)	10-200 µm
	Resolution	3 µm
	Repeatability	3 µm
	blade parallelism	3 µm

$ if this resolution cannot be achieved manually, the Z would then be motorized.

[*] the deviation from a straight line of the slit edge should be less than 1 µm RMS:



Alignment requirements for exit slits are given below:

EXIT SLITS (S2)	Manipulator	Resolution/Accuracy	Range
Pitch	Pre-installation on bench	-	-
Roll	Manual (outside vacuum)	10 mrad / - *	±1 mrad
Yaw	Pre-installation on bench	-	-

* no requirement for adjustment accuracy but initial installations should be horizontal within ±1 mrad.

A-8.2. Option 2: Pinholes arrangement

For any given wavelength the x-ray beam arriving at the exit-slit plane is coming to a focus in both the horizontal and the vertical planes (stigmatic focus). This focus must be regarded as a secondary source that will be used to illuminate the microscope sample and therefore needs to be confined in both directions. This implies that the exit slit will be in the form of a rectangular pinhole rather than a conventional exit slit although, since we are speaking in the context of a monochromator, we continue to refer to it as the exit slit.

In fact the exit slit mechanism will consist of a single heavy-metal foil (10 µm of gold for example) that is thick enough to fully stop the x-ray beam and in which a series of rectangular pinholes have been etched. The pinholes will have a horizontal width of 45 ± 1 µm and vertical widths of 8 ± 1 µm, and 16, 24, 32 and 40 (all ± 1 µm) and will be equally spaced in a vertical straight line with period of 5 mm. The pinholes will be interchanged by a computer-controlled vertical motion (range 0-50 mm) and positioned horizontally with a horizontal motion, also computer controlled (range ± 5 mm). The extra vertical range beyond the 20 mm needed for positioning the pinholes, will be used to allow a fluorescent screen to be placed in the beam for viewing the image quality by eye. A viewport must be included to permit such viewing. In addition a fixed plate must be provided with only one hole to allow the delivered beam to pass and positioned so that x-rays leaking through the non-operational pinholes will be blocked.

X-Z motion specification:

MOTION	**UNIT**	**VALUE**
Z range	mm	50
Z resolution	µm	1
Z accuracy	µm	1
X range	mm	±5
X resolution	µm	±2
X accuracy	µm	±2

A-8.3. Miscellaneous

After a standard 120°C bakeout and subsequent cooling down of the exit slits the Z (height)-position must be maintained within 2 µm. The yaw, roll and pitch angle of the linear translation stage must be maintained within their fine adjustment ranges.

A-9. M1, M2 & M4 vessel chambers and mirror mechanics

Two options apply for mirrors M1, M2 & M4 in the scope of Lot IV:

option 1: all three mirrors will have a bending system to bend them into shape,

option 2: all three mirrors will be rigid and directly polished into shape.

If option 2 applies then the holders will then be included in the scope of Lot I.

Details on mirror dimensions, positions, power load etc. can be found in the Conceptual Design Report document EXD-BL09OP-GD-0001. Some of these details are given in tables below as, for example, the technical specifications for the mirror mechanics, the computing and structure requirements.

A-9.1. Deliverables

The deliverables associated to the Kirkpatrick-Baez condenser-mirror system (M1 & M2) and the elliptically bent mirror M4 are:

- The adjustable support structures of the corresponding mirror setups. This includes the granite or concrete table rigidly fixed to the floor with limited adjustments, as well as holders for alignment fiducials and/or reference marks. CELLS will most probably implement a floor mounting scheme using an aligned steel plate glued to the floor on which the base of the mirror support can be aligned in the horizontal plane as well as rigidly mounted.
- The mirror mechanics including the required motors, encoders, limit and reference switches.
- The vacuum vessel for each mirror. The vessel will include the specified flanges, viewports, and connecting pieces.
- The holders of the three mirrors if option 2 applies.
- All associated hardware and electrical feedthroughs.
- Ultra high vacuum conditioning and leak tests using a residual gas analyzer (RGA).
- Technical and engineering drawings and manuals.

A- 9.1.1. Mirror positioning for M1, M2 & M4

MIRROR POSITIONING

ITEM	DESIRED FUNCTION	NOMINAL VALUE	RANGE RELATIVE TO NOMINAL	RESOLUTION/ ACCURACY
Direction of surface normal* in tangential plane (“pitch”)	Computer-controlled adjust for M1, M2 & M4	88.8° to beam (G.A.[$] = 1.2 º)	0.5< G.A. [$] <1.5	M1, M2 & M4: 0.1 µrad / 5 µrad
Direction of surface normal* in sagittal plane (roll)	Computer-controlled adjust for M1, M2 & M4	M1: vertical M2: horizontal M4: vertical	%	M1, M2 & M4: 10 µrad [#] / 100 µrad
Rotation about surface normal* (yaw)	Preset at installation [a] for M1, M2 & M4	Long edge parallel to tangential plane	%	0.2 mrad / 2 mrad
Positioning parallel to surface normal* (Z)	Computer-controlled adjust for M1 and M2	Beam centered on mirror pole	–10, +5	0.01 mm / 0.01 mm
	Preset at installation [a] for M4		%	0.01 mm / 0.01 mm
Positioning perpendicular to normal*: tangential plane (Y)	Preset at installation [a] for M1, M2 & M4	Correct pole-to-source distance	%	1 mm / 1 mm [†]
Positioning perpendicular to normal*: sagittal plane (X)[@]	Computer-controlled for M1& M4	Beam centered on mirror pole	%	0.5 mm / 0.5 mm
	Preset at installation for M2			

Notes:

* The “normal” refers to the normal through the mirror pole.

$ G.A. is the grazing angle.

[a] This implies a manual setting but it must be indexed and capable of alteration without breaking vacuum.

This is to meet the optical requirement for perpendicularity of the mirrors.

[@] X translation should be computer-controlled for changing the use of the two coatings depending on working energy.

% Since we are specifying a setting to a given value, there is no operational range. However, in practice such a setting does require an adjustment method with a finite range. The contractor is responsible for defining and implementing this.

† The position of the mirror along the optical axis (Y) will be ensured by the correct positioning of the support structure of the mirror mechanics via surveying.

A- 9.1.2. Computer control and monitoring specific to the mirrors

COMPUTER CONTROL & MONITORING

DEVICE	HARDWARE PROVIDED BY	DEVICE FUNCTIONS	REQUIRED VENDOR ACTIONS
Cooling water flow monitors for M1	CELLS	Measure and display water flow, interlock to cause slow BL isolation if out of range	–
Cooling water temperature monitors for M1	CELLS	Measure and display in/out water temperatures, interlock to cause slow BL isolation if out of range	–
Mirror front plate temperature monitors for M1	Vendor	Measure and display plate temperature, interlock to cause a slow BL isolation if out of range	Attach two (redundant) thermocouples to each plate with wiring but not controls
Vacuum pumps, gauges, valves, residual-gas analysers	CELLS	Standard (see END-BLVC-CC-0001)	–
Mirror Z (see Table 4.2.4)	Vendor	Execute and display motion as per Table 4.2.4 with ALBA standard motors and encoders (CCD-BLCT-CC-0001)	Vendor to design and supply all mechanics, encoders, motors but not motor controllers or encoder controllers
Mirror pitch (see Table 4.2.4)	Vendor	Execute and display motion as per Table 4.2.4 with ALBA standard motors and encoders (CCD-BLCT-CC-0001)	Vendor to design and supply all mechanics, encoders, motors but not motor controllers or encoder controllers,
Drivers of the mirror bending levers	Vendor	Execute motion with required range and force. Motion data should be displayable in a flexible way and should be scannable to enable searching for an optimum*	Vendor to design and supply all mechanics, encoders, encoder controllers, motors but not motor controllers
Fast valve sensors	CELLS	On M1, M2 & M4 vacuum vessels	–

Notes:

*The drivers should have high mechanical advantage so that they hold a stable setting when motors are switched off; a mechanical break would also be acceptable. The driver positions should be referenced to encoders that give a meaningful reading all the time. A calibration curve for the bender mechanism yielding information on the mirror geometry as a function of the motor position is to be included in the scope of supply (if applicable).

A- 9.1.3. Support structure and vibration isolation

We assume that the mirror vacuum vessel will be well-isolated from the beam pipes either side of it by bellows. Therefore we consider that vibrations from the pipes will not be an important source of noise. It follows that there is no pressing need to make two separate support structures attaching the mirror and the vacuum vessel to the floor. The main sources of vibrations will therefore be the cooling water and the floor. Thus for M1 we recommend the following general design guidelines.

- As indicated by the power load calculations, cooling water should be introduced into the mirror, or into cooled structures which are in contact with the mirror, as close as possible to a rigid mirror support.
- For best vibration isolation, the water flow rate should be as slow as possible ideally in the laminar flow regime.
- The thin part or “skin” of the vacuum vessel should not be used to support the mirror or its bending base. In the case of a bent mirror, we recommend that the bending base should be closely coupled to the structure connecting to the floor. Specifically its anchor points on the side of the vessel should be close to the attachment points of the support structure on the outside of the vessel. The constant-force principle of mirror bending provides some isolation of the mirror from pump-down distortions that are small compared to the bending-driver stroke.
- The support structure should be extremely stiff (no resonances below 70 Hz) and should incorporate damping.

A- 9.1.4. *Stability of mirrors*

The height variation of mirrors M1 and M4 once mounted in the mechanical stage shall stay within 1 μm in 1 minute and 5 μm in 1 day, assuming that during this period the temperature does not change by more than ±1ºC.

The pitch stability of all three mirrors M1, M2 & M4 once mounted in the mechanical stage shall stay within 0.2 μrad in 1 minute, and 2 μrad in 1 day, assuming that during this period the temperature does not change by more than ±1ºC.

A- 9.1.5. *Miscellaneous*

We foresee to use a cleaning process with O_3 made by, e.g, UV lamps.
It needs one CF 63 port on each of the three mirror chambers to fix a UV lamp, which should not "see" the surface directly, and 2 CF 40 ports at each end of each mirror.

A-10. Support structures

Edge welded bellows are to be foreseen between the mirrors and slits chambers and adjacent beamline components mounted on different support structures in order to allow an independent alignment of the individual components.

When possible from the point of view of a safe mounting, supports with kinematic triangular mounts without play shall be used.

The necessary space for the installation of pumps, electronics, etc. has to be included in the design of the supports. The specifications for the support are as follows:

- Lateral (horizontal) adjustments: ±25 mm,
- Height adjustment (around nominal beam height without taking floor unevenness into account): ±25 mm,
- Rotation around horizontal axis perpendicular to photon beam direction: ±2.5°,
- Rotation around vertical axis: ±2.5°,
- Rotation around beam axis: ±2.5°.

All three translations and three rotations shall be performed on the supports via manual adjustment screws.

The stand height must be calculated taking into account that the nominal height of the storage ring electron beam is at 1400 mm above the floor. For details about beam height see Table 2 Section 6.1 in main document.

If necessary, the floor unevenness is to be compensated using compensation plates underneath the feet of the support structure.

The resonance frequencies (eigenfrequencies) of the support structures for the mirror mechanics and the vacuum chamber should take into account the ALBA site vibration spectrum (see Figure 3 Section 7.7 in main document) in order to minimize the vibration level. Within the frequency range of - at best - 0.01 Hz to 70 Hz, mechanical vibrations from an outside source are to be efficiently damped by appropriate passive damping devices (sand filled columns, granite stands etc.) as far as the support structures of mirror and slit mechanics are concerned.

A-11. Beam conditioning set-up

The beam conditioning set (item number 6 in Figure 1/Table 2 Section 6 in main document) is placed in the first optical enclosure, downstream the M2 mirror vessel. It contains elements to absorb the high energy photons.

A-11.1. Description

The beam conditioning set downstream the M2 mirror vessel has the following components (looking downstream):

- One water cooled bremsstrahlung stopper, in order to absorb the high-energy bremsstrahlung radiation. The bremsstrahlung collimator must have clearance enough not to obstruct the reflected photon beam. This element should be made of a heavy metal such as tungsten (for the part inside UHV) or lead (for the part outside UHV), to efficiently stop very high energy photons.
- Vacuum chamber to house the component mentioned above and its support structure.

CELLS will further provide details on radiation safety aspects and the corresponding technical requirements regarding the whole beam conditioning set. A scheme is given in Figure A3. The proportions and geometry of the components does not intend to be realistic.

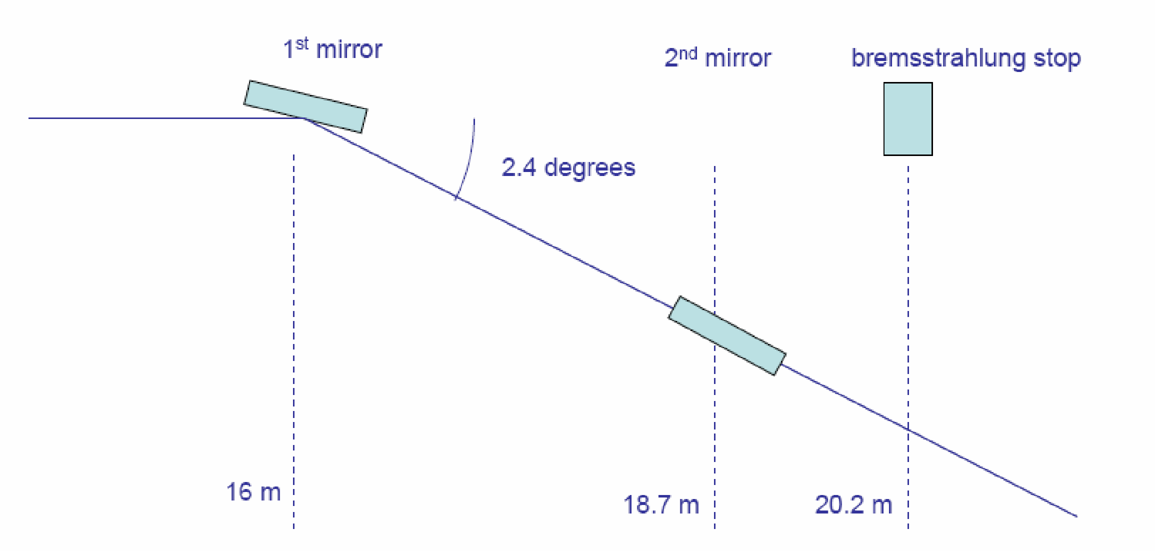


Figure A3: Outline of the components (side view).

It is highly recommended to foresee a collimator around the last part of the beamìpe in the optics hutch (FOE) to reduce sufficiently the scattered synchrotron radiation that could enter the monochromator section. This collimator could be defined once more details are available concerning the vacuum vessels.

A-11.2. Specifications

- All the parts, components and materials of the beam conditioning chamber must be radiation resistant,
- The following power load and power load density must be handled by the heat absorber mask:
    - Integrated power = 100 W,
    - Power density = 1 W/mm^2 (position ~2 m behind M2),
- The following specifications apply: 10 cm thick tungsten beamstop with 13 cm (long) × 10 cm (wide) centered on the white beam.

A-12. Acceptance tests

The generalities on the acceptance tests given in Section 9 are applicable also in this section. Information on acceptance tests specific for the mirrors within Lot MISTRAL I is given below.

A-12.1. Mirror surface finishing

A- 12.1.1. Slope errors and mirror roughness

A complete test report of figure errors, slope errors, and surface roughness is required. CELLS reserves the right to have inspections performed by independent metrology laboratories (e.g., at BESSY II, ESRF, Elettra) regarding the specifications mentioned in this chapter where such inspections are deemed necessary. Tests have to be done with mechanical clamping and cooling devices (if applicable).

Whereas the compliance with surface slope error specifications (excluding thermal heat bumps) have to be demonstrated and documented by the contractor with LTP or interferometer measurements, expected slope errors due to thermal heat bumps have to be derived from finite element analysis model calculations to be included in the scope of supply. Data on the absorbed power density for each individual mirror can be obtained from CELLS upon request.

A- 12.1.2. Grinding and polishing

As part of the bidding process, the suppliers will provide a detailed description of the sequence of steps to be used in the entire fabrication process, from raw material to the finished product. The fabrication process should be acceptable to CELLS. A confidentiality agreement between the successful bidder and the customer can be arranged.

A- 12.1.3. Scratch-Dig

The optical surface shall be free from visible scratches and digs (1 µm scratch width – 50 µm dig diameter). The density of defects must be less than 0.5 scratches or dig defects per cm^2. None of the scratches of the surface will be more than 10 mm long. Inspection of the optical surface is to be performed using an appropriate collimated lamp including condenser optics, at grazing incidence.

A-13. Preparation for delivery

See general specifications given in Section 10.

Annex B.

Technical Specifications of

Lot Mistral II: Plane Grating Monochromator chamber and mechanics

B-1. Scope

This is the specification for the fabrication, delivery, and installation of one grating chamber for the MISTRAL beamline at the ALBA synchrotron radiation facility.

This grating chamber for the wide-range MISTRAL beamline will be used to house the plane pre-mirror as well as two Variable Line Spacing (VLS) gratings on individual substrates or one Variable Groove Depth VLS grating. Procurement of the pre-mirror and grating(s) is done under Lots MISTRAL III and IV respectively.

B-2. Deliverables

B-2.1. Hardware Deliverables

The hardware deliverables included in this lot are

- One grating chamber, including the UHV vessel, the manipulator for a plane mirror and two (or one) gratings, as well as the associated equipment and supports (excluding the gratings and PGM mirror M3 themselves since they are included in Lots III and IV, respectively). The monochromator should house an additional dummy grating (with a phosphor coating), including an own grating holder, for beam alignment purposes as well as for providing some additional space for testing future gratings. This should be discussed with CELLS in case it leads to an undue complexity regarding the grating chamber mechanics.
- A zero-order buffer consisting of a Cu plate with an aperture for the first positive diffraction order and manual in vacuum Z motion.

B-2.2. Interfaces

Lot MISTRAL II interfaces with Lots MISTRAL I, III, IV, and with the ALBA facilities. The contractor of Lot MISTRAL II is responsible for the interfaces between Lots MISTRAL III and IV.

B-2.2.1. Interface with ALBA facilities.

The interface of Lot MISTRAL II with the ALBA facilities consists of the following items:

- Media supply connections in accordance to the detailed definition of interfaces described in the PDR
    - Cooling water outlets
    - Pressurized air outlets
    - Electricity outlets
- Control system cabling connectors in accordance to the detailed definition of interfaces described in the PDR

The grating chamber will be allocated in an enclosure after the optical hutch. This is not a radiation protection hutch and is to be accessible on operation. The final design of the beamline hutches will be provided by CELLS in accordance to the PDR.

B-2.2.2. Interface with Lot MISTRAL I.

The interface between the grating chamber (Lot II) and the beamline backbone (Lot I) are the flanges of the grating chamber.

The supplier of Lot II must inform the supplier of Lot I (and CELLS) about whatever change in the beam vertical offset introduced in the monochromator, which is proposed to be 15 mm.

B-2.2.3. Interface with Lot MISTRAL III.

The interfaces between the gratings (Lot III) and the grating chamber (Lot II) are the grating holder for the gratings. The holders have to be provided within Lot II, and just the grating bodies are in the scope of supply of Lot III.

B-2.2.4. Interface with Lot MISTRAL IV.

The interface between the pre-mirror (Lot IV) and the grating chamber (Lot II) is the mirror holder for PGM mirror M3. This holder has to be provided within Lot II, and just the mirror body is in the scope of supply of Lot IV.

B-3. General conditions and requirements

B-3.1. General

See sections 7 and 8 on the main document.

B-3.2. Vacuum compatibility

- The grating chamber must be ultra-high vacuum (UHV) compatible.
- After standard bake out procedures, a vacuum within the 10^{-10} mbar should be obtained using an ion pump together with a TSP or NEG without photon beam.
- The total He leak rate as measured by standard He leak detection techniques must be less than 1×10^{-10} mbar l s^{-1}.
- No organic or high vapor-pressure inorganic materials may remain on the internal parts or on the vacuum side of the chamber wall after the final cleaning.
- The grating chamber and all internal parts must not produce carbon contaminants with partial pressures above 1×10^{-12} mbar.

B-3.3. Mechanics

- The grating manipulator has to provide a very precise and accurate pitch rotation of the pre-mirror and of the gratings for photon energy scanning.

- The grating chamber must permit an in-vacuum adjustment of the yaw, roll, pitch and z-position of the pre-mirror and the gratings for their alignment.

B-3.4. Materials

- The grating chamber and all internal components must be fabricated from UHV-compatible materials. The stainless steel used as a construction material should be 304L (or equivalent).
- All ceramics must be vacuum fired to minimize their water content. All fastening screws must be silver plated. Other types of materials used (including any UHV lubricants) are subject to approval by CELLS.

B-4. Mirror and grating manipulator

B-4.1. Requirements

The mirror and grating mechanics system must hold the grating and the mirror in their positions as well as provide the movement capabilities required for the energy selection. The mirror and grating manipulator are subjected to the following requirements:

- Comply with the optical layout sketched in Figure B1 (p.27), with the corresponding geometrical parameters shown in Table B1 (p.27), in order to minimize the dependence of the beam height on the angular position of M3. Some features of the given layout are:
  - The grating pitch axis is on the grating surface pole (R_G in Figure B1).
  - The pitch rotation axis for M3 (R_{M3} in Figure B1) lies above the grating, at a distance optimized to minimize the beam offset variation with mirror angle.
  - The nominal beam vertical offset (Z_G) is 15mm. The supplier must inform CELLS if this value cannot be met.
- Hold one mirror substrate (M3) without introducing any stress that could be translated into slope error.
- Hold the gratings substrates along the same pitch axis without introducing any stress that could be translated into slope error.
- The manipulator must provide access to the connections of the cooling system and for the thermocouples to be installed close to the active surface of the mirror and of the grating. With the following requirements:
  - The pipes and cables must not limit the range of movement of the grating or the mirror below the ranges specified below:
  - They must not intercept the beam path.
- The mirror and grating manipulators must provide motorized control of the pitch rotation of the grating and of the mirror, since these constitute the energy selection mechanism of the monochromator. In addition to the

range and accuracy specifications, the following requirements must be fulfilled for this movement.

  - Actuated by in-air stepper motors while the grating chamber is under UHV.
  - Pitch mechanism must be free of crosstalk in roll and yaw for the mirror and grating surfaces.
  - Incremental encoders (differential output) with an appropriate resolution and reference marks together with the associated electronics must be provided for the two pitch axes. In-vacuum angular encoders directly mounted on the plane mirror/grating pitch axes are clearly preferred.
  - The stability of the scanning mechanism against pressure and temperature variations (photon beam intensity-related or environment-related) should approximately match the step size specified below.
  - Appropriate balancing with counterweights should facilitate the precision and speed of the scanning mechanism operation.

- The grating manipulator must provide a horizontal shift mechanism (if more than one grating is procured) in order to select which grating is inserted in the beam path. This grating selection mechanism must fulfill the following requirements:
  - To provide the capability to move each grating to working position while the chamber is in UHV.
  - The stroke of the grating carriage must be such that the full optical surface of any of the two (if applicable) gratings (plus one fluorescent grating dummy) can be moved to the beam path.
  - The grating selection must be independent of the pitch angular setting. This means that it is not necessary to set the gratings at a particular pitch position before changing the gratings.
  - Similar motion with similar accuracy is required to tune the groove depth if a single VGD grating is used.
- The mirror and grating manipulator must allow for the following internal adjustments:
  - Fine and coarse adjustments for z-position, yaw, pitch and roll must be provided for each grating in operation position (see Figure B2 p.27 for coordinate definition).
  - Fine and coarse adjustments for z-position, and roll must be provided for the mirror (see Figure B2 for coordinate definition).
  - These adjustments must be strictly decoupled and independent from each other.
  - Coarse adjustments are to be performed through an open port when the vacuum chamber is under atmospheric pressure.
  - Fine adjustments are to be performed from outside the vacuum chamber when it is under UHV.

- Fine adjustments must be made via a rotary linear gimbaled feedthrough which allows the adjustment of four socket-head screws located near each other, one for each rotation and one for the z-position adjustment.
- Each one of the mirror/grating holders must be separately removable from the mirror/grating carriage; the position of the each mirror/grating holder must be reproducible and free of backlash so that mounting the mirror/grating holders again does not require any optical realignment.

Alternatively, the same adjustments can be provided without access at UHV but in this ease a demonstration to satisfy CELLS of the dimensional stability of the system when measured before and after bakeout must be made.

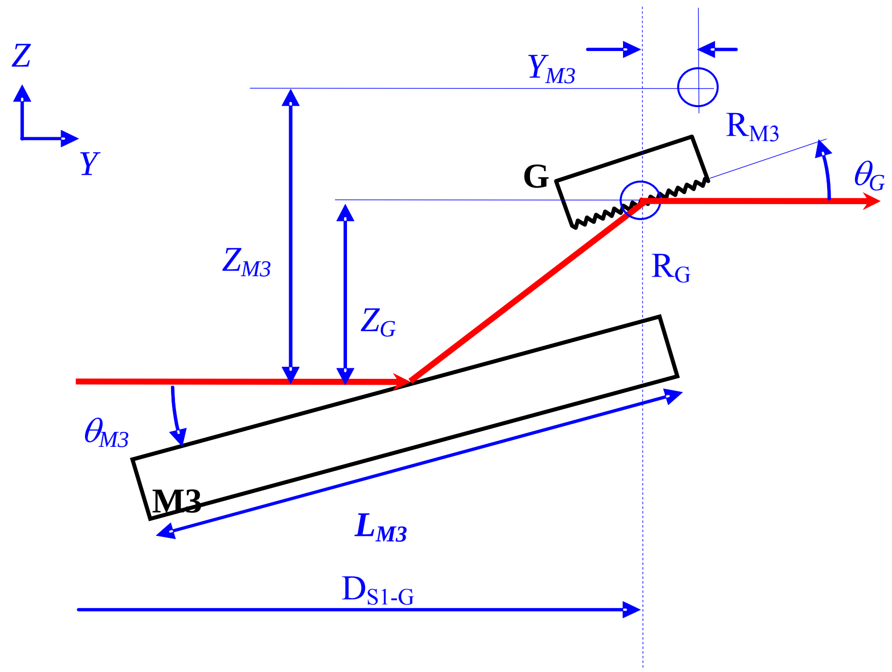


Figure B1: Scheme of the Plane Grating Monochromator (side view). The photon beam is drawn in red.

Table B1: Geometrical parameters of the monochromoator setup (refers to Figure B1).

parameters	**value (mm)**
Z_G	15
Z_{M3}	22.5
Y_{M3}	0
L_{M3}	450
D_{S1-G}	1000

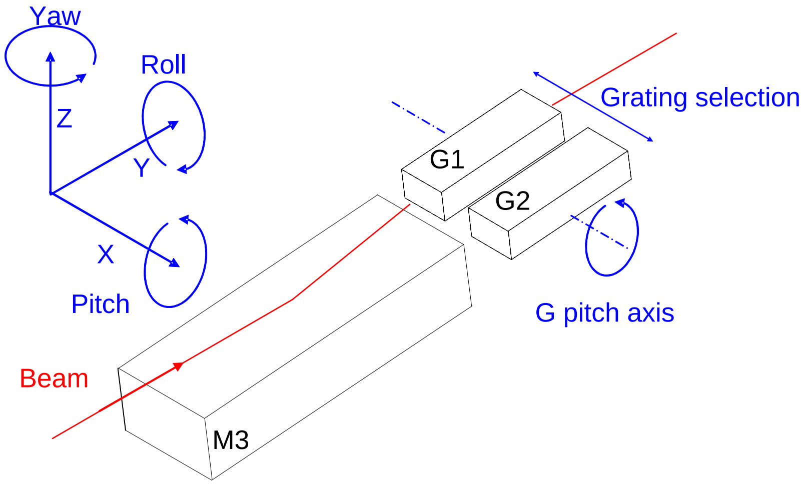


Figure B2: Coordinate convention referred to an isometric view of the optical components of the monochromator chamber.

B-4.2. Specification

The following specifications apply to the grating and mirror mechanics:

B-4.2.1. Pitch rotation

Pitch rotation mechanism		
Mirror pitch (θ_{M3}, grazing angle of principal ray)	Range	-0.5° to 5°
	Resolution (step size)	≤0.3 µrad
	Repeatability & stability	≤1.5 µrad RMS
Grating pitch (θ_G, diffraction angle of principal ray)	Range	-0.5° to 8°
	Resolution (step size)	≤0.3 µrad
	Repeatability & stability	≤1.5 µrad RMS

B-4.2.2. Grating selection & M3 coating selection

The mechanism for the grating selection if two gratings are procured must fulfill the following specifications:

Grating selection mechanism		
x-position	Range	150 mm
x-position	Resolution	≤100 µm
x-position	Repeatability	≤100 µm
z-position	Parasitic motion	≤5 µm
grating pitch	Parasitic motion	≤10 µrad

In the case that a VGD VLS grating (with two coating stripes) covering all the energy range is offered in the scope of Lot III, an X translation mechanism will be needed to move from one coating to the other (Ni to Rh).

As two coatings should be provided for the M3 mirror (in scope of Lot IV), an X translation mechanism will be needed to move from one coating to the other (Ni to Rh).

B-4.2.3. Fine adjustment

The mechanism for the fine in-vacuum adjustment of the gratings and mirrors must have the resolution and the stability given in the table below:

Fine adjustment of mirror and grating		
z-position	Resolution and stability	≤ 5 µm
Roll	Resolution and stability	≤ 2.5 µrad
Pitch	Resolution and stability	≤ 2.5 µrad
Yaw	Resolution and stability	≤ 100 µrad

B-4.2.4. Bakeout stability

After a standard 120º bakeout of the grating chamber (after the chamber has already met the vacuum requirement) the z-position of the gratings and the mirror must be stable within the values given in the following table.

Bakeout stability of mirror and grating position		
z-position	Bakeout stability	≤5 μm
Roll	Bakeout stability	≤1.5 μrad
Pitch	Bakeout stability	≤1.5 μrad
Yaw	Bakeout stability	≤100 μrad

B-4.3. Photon energy scan

Usually the monochromator is operated step by step. As the required step size is 0.3 μrad and the angular range of the pitch rotation is ca. 8º, then the total number of steps required to scan the total range is ca. 465 000.

B-5. Vacuum vessel

B-5.1. Requirements

The UHV system grating chamber must be equipped with the following Conflat flanges:

- Photon beam in (DN40CF or larger on a DN200CF, for alignment purposes).
- Photon beam out (DN40CF or larger on a DN200CF, for alignment purposes).
- ion pump port.
- Ti sublimation or NEG pump port.
- one Pirani (DN16CF) and one ion (DN40CF) pressure gauge
- Residual gas analyzer (DN40CF).
- roughing valve (DN63CF)
- K-type thermocouple feedthroughs (4 pairs).
- auxiliary spare flanges for O_2 discharge cleaning setup:
  - one flange DN40CF: leak valve,
  - one flange DN63CF: feedthrough for RF antenna perpendicular to the mirror and grating surfaces.
- 2 Flanges for vacuum switches required for the personnel safety system (PSS) (DN40CF).

The scope of supply of the vacuum system has to include all flanges like, e.g., viewports, blanks, reducing flanges etc. together with the necessary metric fasteners and

OFHC copper gaskets. Viewports are to be equipped with additional lead glass disks on the atmosphere side of the viewports for radiation protection.

In addition to the above, viewports with the following specific features must be included:

- Observation viewport for viewing the pre-mirror.
- Observation viewport for viewing the entire ruled surface of the grating in the operation position. Specially indicated if the dummy mirror is installed.
- One mirror/grating adjustment viewport for viewing the angular adjustments of the mirror/grating in the operation position (i.e. to view the screwdriver tip engaging into the screws for the fine adjustment).
- One grating carriage observation viewport for observing the grating selection.
- One set of viewports reserved for HeNe laser alignment using the diffracted spots from the grating surface.
- One spare ion gauge conflat port and two more conflat spare ports (all DN40CF).

As a general rule: every surface that may intercept the beam must have a viewport to see it.

B-6. Grating chamber support structures

B-6.1. Requirements

- The contractor must supply a stable stand for the grating chamber.
- The stand must allow variation of the x, y, and z position of the chamber as well as its yaw, roll, and pitch angles.
- All three translations and three rotations shall be performed on the supports via manual adjustment screws.
- The thin walls of the vacuum vessel may not be used as part of a support structure but the mechanics and vessel may be supported on a common structure.
- The necessary space for the installation of pumps, electronics, etc. has to be included in the design of the supports.
- The resonance frequencies (eigenfrequencies) of the support structures for the grating chamber mechanics and the vacuum chamber should be outside the frequency range from 0.1 to 100 Hz. Within this frequency range, mechanical vibrations from an outside source are to be efficiently damped by appropriate passive damping devices like, e.g., sand-filled columns, granite stands etc.

B-6.2. Specification

The specifications for the support adjustments are as follows:

- lateral (horizontal) adjustment parallel and perpendicular to the plane of incidence: ± 25 mm
- height adjustment (around nominal beam height without taking floor unevenness into account): ± 25 mm
- The x-, y-, and z-position of the chamber must be thermally stable to ±10 µm in an environmental temperature range of 20 ± 1° C. Contractor is also responsible for the dimensional stability of all materials used in the operating environment of the beamline including after (but not during) bakeouts.

B-7. Acceptance tests

The generalities on the acceptance tests given in Section 9 are applicable also in this section. Information on acceptance tests specific for Lot MISTRAL II is given below.

B-7.1. Quality inspection

Unless otherwise specified in the contract or purchase order, the supplier is responsible for performing the required inspections (factory acceptance tests, acceptances tests at the customer's site etc.) as specified herein. Except if specified otherwise, the contractor may utilize his own facilities or any commercial laboratory acceptable to CELLS. CELLS reserves the right to perform or witness any of the inspections set forth in the specifications where such inspections are deemed necessary to assure supplies and services conform to the prescribed requirements.

B-7.2. Design inspection

In order to meet the above technical specifications, CELLS reserves the right to inspect the mechanical design of the grating chamber and its internal mechanisms as well as to ask the supplier for design changes. An agreement between the contractor and CELLS on the entire design drawings must be reached before the manufacturing of the grating chamber is initiated.

B-7.3. Precision and stability

During the factory acceptance tests, the contractor has to install a dummy mirror and dummy gratings with the same weight and dimensions as the original optical elements inside the grating chamber and provide evidence that the specifications stated herein with respect to resolution, reproducibility, and stability of the various motions have been satisfied. This will generally include laser alignment, laser interferometer or autocollimator tests. The same procedure has to be repeated at ALBA site after the final installation of the grating chamber at the MISTRAL beamline.

The following tests on the performance of the grating chamber are to be performed on the grating chamber during the factory acceptance tests:

- Vacuum tests on grating chamber vacuum recipient.
- Resolution and repeatability of pre-mirror and grating pitch mechanism
- Grating index drive resolution and repeatability (grating lateral position and height)

- Grating and mirror holder removal/reinsertion repeatability (grating lateral position, height, and surface alignment).
- Tests on vibration behavior.

The tests on the resolution and repeatability of the pre-mirror and grating pitch mechanisms are to be repeated during the acceptance tests at the customer's site subsequent to the installation of the grating chamber.

B-7.4. Alignment

For the alignment of the grating chamber at ALBA site, the contractor has to provide reference marks outside the grating chamber that can be survey to ±0.05 mm. Such marks must be referenced with respect to the pitch rotation axes of the pre-mirror and the grating scan mechanism as well as to the incoming/outgoing photon beam direction.

The alignment strategy for both optical elements inside the grating chamber with respect to the pitch rotation axes/diffraction plane using laser light as well as the technical provisions foreseen on the grating chamber setup for alignment purposes are to be explained in the documents included in the bid.

B-7.5. Compliance with vacuum requirements

The contractor must supply CELLS with evidence that the completed grating chamber meets the vacuum compatibility requirements. The kind of tests used to ensure vacuum compliance should be

- base pressure measurement
- a residual gas analysis at ultrahigh vacuum pressures 10^{-10}mbar range) after bakeout and cooldown.
- an analysis of the outgasing rate of the surfaces inside the vacuum

CELLS must approve the details of the test method proposed by the contractor. Use of the services of an independent testing laboratory is subject to approval by CELLS.

B-8. Preparation for delivery

See general specification given in Section 10.

Annex C.

Technical Specifications of

Lot MISTRAL III: Gratings

C-1. Scope

This lot comprises the design fabrication, delivery and installation of the gratings of the MISTRAL beamline.

C-1.1. Deliverables

C-1.1.1. Hardware deliverables

The deliverables for this lot can be either

option 1) two laminar plane diffraction variable line spacing (VLS) gratings, ruled on two different blanks. The gratings are referred below as:

- Low-energy grating (275 – 800 eV).
- High energy grating (800 – 2600 eV).

option 2) one laminar plane variable groove depth VLS grating to cover all the energy range (275 – 2600 eV).

Both will have the same VLS pattern.

Since the gratings (G) must be integrated in the grating chamber, the design of the mirror holder and entrance mask must be made in close collaboration with the suppliers of Lot MISTRAL II.

C-1.1.2. General deliverables

The general deliverables associated with this lot are the technical and engineering drawings for the grating system.

C-1.2. Interfaces

The interface of Lot MISTRAL III with Lot MISTRAL II consists on the mount of the grating holder on the grating chamber. Only the grating blanks are within the scope of supply of Lot MISTRAL III, whereas the grating mounts connections to the grating blanks are a part of Lot MISTRAL II.

Technical drawings on the interface between the grating substrates and the corresponding holder mechanics are subject to approval by CELLS before manufacture of Lot MISTRAL III components.

In order to demonstrate the accurate positioning of the grating optical surfaces as well as the compatibility of the grating substrate with the corresponding holder, the provider has to provide references of the optical surface with respect to the mounting points of the holder. The corresponding report with the referencing results is considered as a part of the scope of supply of Lot MISTRAL III.

C-2. Requirements

General requirements given in Section 8, especially those concerning vacuum apply also for Lot MISTRAL III. Detailed specifications concerning shape and slope error are given in this annex.

C-2.1. Slope error and figure errors

It is necessary to meet or improve the slope error tolerance specifications given in the following table (see section C-3). The bidder has to inform CELLS if any of the requirements cannot be met.

C-2.2. Vacuum compatibility

All optical components should be compatible with UHV requirements and bakeout up to 100°C. All parts should be cleaned and free from any contamination of residual organic or high vapor-pressure materials. Holes should be plugged during polishing.

C-3. Technical Specification

We define the groove spacing of the VLS grating at a distance *w* from the center (*w* = 0) (Figure C1) as:

$$d(w) = d_0(1 + \nu_1 w + \nu_2 w^2 + ...) \qquad (1)$$

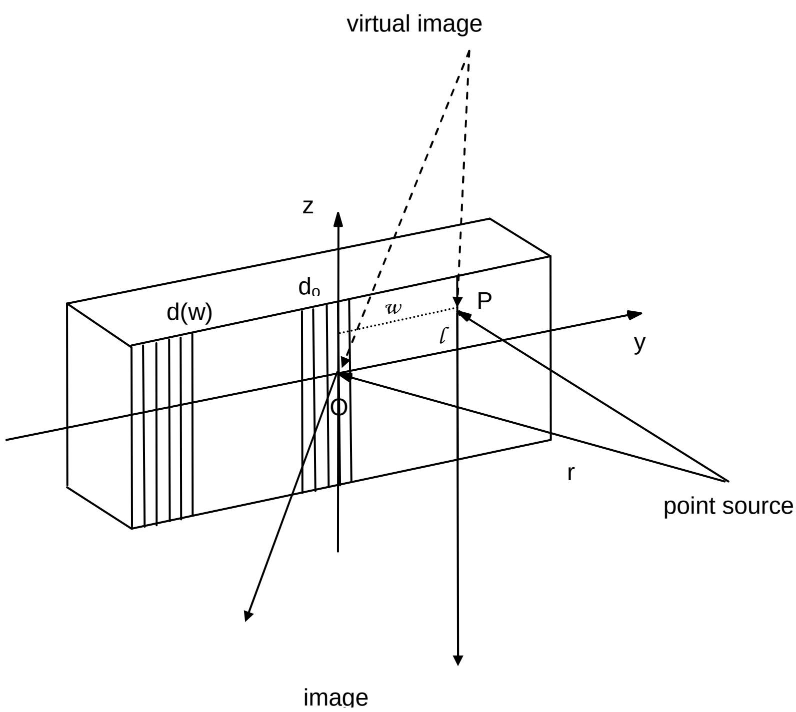


Figure C1: **VLS grating schematic view.**

However some workers prefer a specification based on the variation of the groove density $s(w)$ as follows:

$$s(w) = s_0 + s_1 w + s_2 w^2 + \ldots = s_0\left(1 + \frac{s_1}{s_0} w + \frac{s_2}{s_0} w^2 + \ldots\right) \equiv \frac{1}{d_0(1 + \nu_1 w + \nu_2 w^2 + \ldots)} \quad (2)$$

The VLS coefficients and required groove profile parameters for the two-grating solution, are indicated in the following Table.

<table>
<tr><th colspan="8">Grating profile parameters</th></tr>
<tr><th colspan="2">Gratings</th><th>Min E (eV)</th><th>Max E (eV)</th><th>groove density</th><th>groove spacing</th><th>groove depth</th><th>Groove-to-period ratio</th></tr>
<tr><td rowspan="2">option 1</td><td>G1</td><td>800</td><td>2600</td><td rowspan="2">s_0= 6000 cm^{-1}
s_1= -120 cm^{-2}
s_2=1.8 cm^{-3}
s_3= -0.024 cm^{-4}
s_4= 0.0003 cm^{-5}</td><td rowspan="2">d_0=0.000167 cm
ν_1= -0.02 cm^{-1}
ν_2= 0.0001 cm^{-2}
ν_3= 0 cm^{-3}
ν_4= 0 cm^{-4}</td><td>65 (±5%) Å</td><td rowspan="2">0.5 (±5%)</td></tr>
<tr><td>G2</td><td>275</td><td>800</td><td>120 (±5%)Å</td></tr>
<tr><td>option 2</td><td>G</td><td>275</td><td>2600</td><td>s_0= 6000 cm^{-1}
s_1= -120 cm^{-2}
s_2=1.8 cm^{-3}
s_3= -0.024 cm^{-4}
s_4= 0.0003 cm^{-5}</td><td>d_0=0.000167 cm
ν_1= -0.02 cm^{-1}
ν_2= 0.0001 cm^{-2}
ν_3= 0 cm^{-3}
ν_4= 0 cm^{-4}</td><td>60 – 160 (±5%)Å</td><td>0.5 (±5%)</td></tr>
</table>

The common specifications of the gratings are given in the following Table.

Common specification of gratings				
Material	Substrate		Single Crystalline Si	
	Coating	LE*	Ni: 60 ± 10 nm	
		HE*	Rh: 60 ± 10 nm	
Optics	Shape		Flat (R>15 km)	
	Slope Error		Tangential	< 1 μrad RMS
			Sagittal	< 10 μrad RMS
	Roughness		≤ 4Å	
Size	Substrate		Tangential	150 mm
			Sagittal	60 mm
			Thickness	40 mm
	Ruled area		Tangential	140 mm
			Sagittal	50 mm

* The low-energy (LE) VLS grating will be used to cover energies from 275 eV to 800 eV. The high-energy (HE) grating will be used to cover energies from 800 eV to 2600 eV.

The size of the grating body must be agreed with the contractor of Lot MISTRAL II.

It is strongly suggested to the supplier to consider the possibility of having one Variable Groove Depth VLS grating to cover all the energy range from 275 eV to 2600 eV. In that case, the grating will have two stripes: one of Ni and the other of Rh.

Groove positioning tolerances

The measured groove position or density should agree with *d(w)* or *s(w)* (defined in the previous section) within ± 0.01 %.

C-4. Acceptance tests

The generalities on the acceptance tests given in Section 9 are applicable also in this section. Additional information on acceptance tests specific for Lot MISTRAL III is given below.

C-4.1. Grating surface finishing

C-4.1.1. Slope errors and roughness

A complete test report of figure errors, slope errors, and surface roughness is required. CELLS reserves the right to have inspections performed by independent metrology laboratories (e.g., at BESSY II, ESRF, Elettra) regarding the specifications mentioned in this chapter where such inspections are deemed necessary.

The specified surface slope error contributions have to be demonstrated by the contractor with LTP or interferometer measurements.

CELLS reserves the right to witness any test that are done to verify compliances with the specifications.

C-4.1.2. Groove profile

A complete test report of:

- groove density at the grating pole
- groove density (or groove spacing) as a function of position, *i.e.* to be compared to s(w) or d(w) defined in section C-3.
- groove depth

is required. CELLS reserves the right to have inspections performed by independent metrology laboratories (e.g., at BESSY II, ESRF, Elettra) regarding the specifications mentioned in this chapter where such inspections are deemed necessary.

The specified grove profile parameters have to be demonstrated by the contractor with interference microscope or AFM, or any other instrument approved by CELLS.

C-4.2. Interfaces

Tests on the functionality of the interfaces are to be arranged between the contractors of Lot MISTRAL II on one side, and of Lot MISTRAL III on the other side. Factory acceptance tests should be using dummy grating components with identical dimensions regarding the above interface. CELLS has to be informed on the results from this compatibility test.

C-5. Preparation for delivery

See general specification given in Section 10.

Annex D.

Technical Specification of

Lot MISTRAL IV: Mirrors

D-1. Overview

This lot comprises the design fabrication, delivery and installation of all the mirrors (M1, M2, M3 & M4) of the MISTRAL beamline.

Two options apply for M1, M2 & M4:

1) all three mirrors will have a bending system to bend them into shape,

2) all three mirrors will be rigid and directly polished into shape.

If **option 1** applies, the benders will be included in the scope of this lot as well as the cooling system of M1. If **option 2** applies, only the cooling system of M1 will be on the scope of this lot.

The bidders of Lot IV are free to subcontract the bender mechanisms of M1, M2 and M4 (if applicable) and the cooling system of M1 with the approval of CELLS.

D-1.1. Deliverables

D- 1.1.1. Hardware

The deliverables for this lot is

- One flat PGM mirror (M3) with two coating stipes.
- Three polished x-ray mirrors (M1, M2 & M4) with their two coatings (two stripes on each mirror: Ni & Rh) and their benders (if applicable – option 1), as well as the cooling system of mirror M1.
- Metrology of the optical surface roughness, measures of the slope errors of the mirrors outside the bender as well as in working conditions (bent to shape – if applicable), as part of the factory acceptance tests. A complete test report is to be presented to the customer for approval of the factory acceptance test.
- Calibration curves yielding information of the mirror curvature/shape as a function of the stepping motor position.

D- 1.1.2. General deliverable

The general deliverable associated with this lot is:

- Technical and engineering drawings for the mirror system.
- Finite element analysis study of the thermo-elastic deformation of the M1 mirror.

D- 1.1.3. Interfaces

The interfaces between the PGM mirror M3 (Lot MISTRAL IV) and the PGM monochromator (Lot MISTRAL II) are the mirror holders. These mirror holders have to be provided within Lot MISTRAL II, and just the mirror body is in the scope of supply of Lot MISTRAL IV.

The interfaces between the mirrors M1, M2 & M4, its benders (option 1) and cooling system are the support structures and the holders (if option 2 applies) of the vessel chambers in the scope of Lot I.

D-2. Requirements

General requirements given in Section 8, especially those concerning vacuum apply also for Lot MISTRAL IV. Detailed specifications concerning shape and slope errors are given in this annex.

D-2.1. Slope error and figure errors

Figure measurements must be made using interferometer or LTP methods. Full documentation and raw data (if requested) must be supplied to ALBA.

D-2.2.Vacuum compatibility

All optical components should be compatible with UHV requirements and bakeout up to 100°C. All parts should be cleaned and free from any contamination of residual organic or high vapor-pressure materials.

D-3. Monochromator Pre-mirror M3

D-3.1. Specifications

The following table specifies the figure and slope error specifications for the mirror.

Monochromator pre-mirror M3			
Substrate material		Single Crystal Si	
Coating		Rh & Ni 50 nm (0,+20 nm)	
Optical Surface (tangential × sagittal)	mm^2	430 ×15	
Substrate size #	mm	600 preferred 450 minimum	
Figure		Flat	
Incidence angle	º	86.75-88.9	
		Tangential	**Sagittal**
Radius of curvature	mm	∞ (>15Km)	∞ (>15Km)
RMS Slope Error	µrad	<1	<10
RMS roughness	Å	<5	

The mirror substrate size should be agreed with the supplier of Lot MISTRAL II.

D-4. Specifications of the KB system (M1 & M2) and the elliptically bent mirror M4

The following sections give the specification for M1, M2 & M4 (see conceptual design EXD-BL09OP-GD-001). The coordinate system for all the mirrors is shown in Figures A1 and A2. X, Y and Z follow the Shadow convention; pitch, yaw and roll are defined with respect to the plane of incidence.

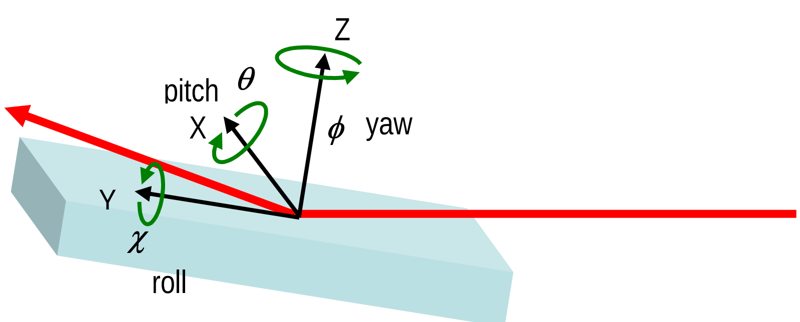


Figure A1: Coordinate system for mirror M1 & M4.

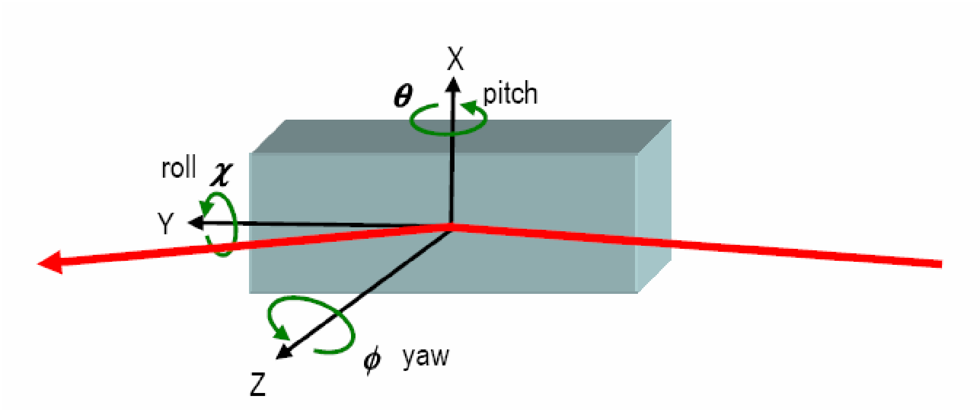


Figure A2: Coordinate system for mirror M2.

D-4.1. Mirror sizes and positions with respect to the source to be imaged

MIRROR SIZES & POSITIONS

ITEM		UNIT	M1	M2	M4
source dimension to be imaged		µm FWHM	133.3 (ALBA, horizontal)	76.4 (ALBA, vertical)	11.3 (virtual image of S1*, vertical)
Source-to-mirror distance		m	16.000	18.707	1.8045
Mirror-to-image distance		m	5.333 (focus at S1)*	6.236 (focus at S2)*	1.8045 (focus at S2)*
Magnification			1/3	1/3	1
Grazing angle		degrees	1.2	1.2	1.2
Minimum mirror optical length		m	0.96	1.2 [$]	0.82
Mirror width		m	0.1	0.075	0.075
Mirror thickness (bending)		m	0.030	0.030	0.030
Mirror thickness (rigid)			polisher's option	polisher's option	polisher's option
Beam footprint	LE	m	0.920 × 0.030	1.600 × 0.014	0.720 × 0.010

Notes:

*S1 and S2 are the monochromator entrance and exits slits respectively (see conceptual design EXD-BL09OP-GD-001).

$ The desired optical length is 1.4 m but this value is negotiable.

Mirror bending system (option 1)

If the strategy for fabricating the optical surfaces is via bending then the following considerations apply. There are many techniques for bending a mirror and we do not rule out any of them. However we do have certain preferences that we will try to indicate here.

- A constant-force system such as can be arranged using weak springs, is preferred to a constant displacement system (piezoelectric driver for example) because it is immune to some types of environmental disturbances and manufacturing errors if they are small compared to the stroke of the bender driver.
- The stress in the mirror is quite small for most bender schemes but whatever the design the stress in a silicon mirror must be below 8 MPa.

If either mirror is made from silicon, the issue of joining the mirror to the bending mechanics must be solved. One approach is purely mechanical; variations on a four-point bender, which will probably require an increase of the mirror length. Another is to attach metal end-plates to the mirror by epoxy. Both are acceptable. If epoxy is used we recommend Hysol EA 9309.3NA or equivalent. This epoxy has been used to glue metal attachment plates on to mirrors at The Advanced Light Source at Berkeley (USA), and its strength, outgassing and shrinkage properties have proved satisfactory over long term service (5-10 years).

Mirrors polished into plane elliptical shape (option 2)

M1, M2 and M4 could also be polished into plane elliptical shape as long as the optical surface tolerances are fulfilled (see next section A- 8.2.2).

D-4.2. Optical surface and tolerances

OPTICAL SURFACE & TOLERANCES

ITEM	UNIT	M1	M2	M4
Surface shape		Elliptical cylinder*	Elliptical cylinder*	Elliptical cylinder*
2 optical coatings, thickness	nm	Ni & Rh, 50 nm (0,+20 nm)	Ni & Rh, 50 nm (0,+20 nm)	Ni & Rh, 50 nm (0,+20 nm)
Major axis	M	10.666	12.472	1.8045
Minor axis	M	0.1451	0.1697	0.0378
Eccentricity difference from unity		9.252132E-5	9.252669E-5	2.19234E-2
Correction for gravity effect?		yes	no	yes
Edge profiling for elliptical bending?		no	no	no
Radii of curvature (max, center, min)	M	546, 509, 470	628, 595, 561	80,86,80
Slope error tolerance (tangential) [$]	μr RMS	1.0	2.0	1.0
Slope error tolerance (sagittal)	μr RMS	20	20	20
Roughness tolerance [#]	nm RMS	< 0.8	< 0.8	< 0.8

Notes:

*Lines in the surface are elliptical in the tangential direction and straight in the sagittal direction.

[$] This tolerance must be met and measurements for figure verification should be made, with the mirror mounted the way it will be in the beam line. Thus, for M1 & M4, gravitational effects will be present and must be countered successfully to meet the specification.

[#] Measurements for roughness verification should be made after coating and should include the spatial period range 20 µm to 2000 µm.

D-4.3. Definition of power load

POWER LOADS for 1.5 mrad collection

		M1 MIRROR		**M2 MIRROR**	
ITEM	**UNIT**	**NORMAL TO BEAM**	**ON MIRROR SURFACE**	**NORMAL TO BEAM**	**ON MIRROR SURFACE**
Total incident power	W	97.2		5.3	
Incident on-axis power density	W/mm^2	0.97	0.0204	0.108	0.00226
Incident vertical σ	mm	1.66	79.2	2.42	2.42
Total absorbed power	W	91.8		1.84	
Absorbed power density on axis	W/mm^2	0.92	0.019	0.037	0.0008
Absorbed vertical σ	mm	1.51	72.1	2.1	2.1
Area of beam collected	mm^2	24.0×19.2		28.0×22.4	
Power profile along mirror length		–	truncated Gaussian	–	rect. func.
Power profile across mirror width		–	rect. func.	–	truncated Gaussian
Grazing angle	degrees	1.2		1.2	

Following the power load calculations we conclude that cooling is required for M1 but not for any of the downstream optical elements (as M2 & M4, which are in the scope of this Lot MISTRAL I). For M1, the required cooling is moderate and there are many cooling methods that could be effective. However, we have certain preferences and some requirements as follows.

Preferences:

- If this mirror is made by bending, then clamps must not be applied to the portion of the mirror which must be accurately bent (the clear aperture). If it is made as a rigid mirror then we prefer direct cooling or indirect (i.e., side) cooling via a soft metal gasket, such as indium, rather than methods based on liquid metal.
- Note that the heat load is moderate so a single cooling channel may suffice. In such case either gun-drilling or a face-plate design may be used. In bending schemes the cross section must remain constant over the clear aperture of the mirror. The only exception for this is that vendor may choose to manipulate the cross section in order to counter the gravity effect in M1 and M4. ALBA can advise how to do this on request.
- There must be no water-to-vacuum seals.
- The entire mirror vacuum system must be built to UHV standards as defined in supplementary document END-BLVC-CC-0001. For the present purpose we add to the list of acceptable UHV materials viton "O" rings if suitably radiation shielded.
- Both mirrors should have a protective stainless-steel (Cu or W) plate a few mm in front of the upstream end of the mirror to prevent the mirror from receiving a miss-steered x-ray beam at normal incidence. These plates must also have a (adjustable) beam defining aperture corresponding to the beam aperture sizes given in the table. This steel (Cu or W) plate must be cooled in the case of M1 but not M2. Such cooling can be in series with the mirror cooling. The size of the plate must be such that the plate or its aperture always receives the entire beam for all possible positions of the mirror. The plate must be coated with fluorescent material and a viewport (with or without a mirror) must be provided so that the position of the beam relative to the beam defining aperture in the plate can be seen by a TV camera.

- ALBA/CELLS will be responsible for providing cooling water and for monitoring the flow rate and temperature. The Contractor only needs to provide standard plumbing connections accessible outside the vacuum.
- In the case that M1 is made by bending, the point on the mirror or on apparatus joined to the mirror at which the water enters must be rigidly captured. Note that it is never acceptable to run water in direct contact with a metal bellows.
- In-vacuum cooling water supply can be made either
    - out of a *single/continuous* piece of OFHC copper tubing with enough (spooled) length for not having a detrimental influence on the mechanical performance of the mirror bender and/or the mirror mechanics. Within this scenario, the OFHC copper tube must be a single piece without welds running from the feedthrough flange through the mirror cooling system and back to the feedthrough flange.

    or

    - out of air/vacuum-guarded cooling water supply. Here, edge-welded or hydroformed bellows will accommodate a (radiation-resistant) polymer (teflon, Viton etc.) cooling water tubing. The bellows (either under atmosphere or under static rough vacuum) are to be flexible and long enough in order not to having a detrimental influence on the mechanical performance of the mirror bender or the mirror mechanics. The cooling water feedthroughs are to be provided with a vacuum manifold on the atmosphere side that will allow keeping the air guard under static rough vacuum and installing a permanent vacuum gauge for pressure monitoring.

D-5. Acceptance tests

The generalities on the acceptance tests given in Section 9 are applicable also in this section. Information on acceptance tests specific for Lot MISTRAL IV is given below.

D-5.1. Mirror surface finishing

D- 5.1.1. Slope errors and mirror roughness

A complete test report of figure errors, slope errors, and surface roughness is required. CELLS reserves the right to have inspections performed by independent metrology laboratories (e.g., at BESSY II, ESRF, Elettra) regarding the specifications mentioned in this chapter where such inspections are deemed necessary.

Whereas the specified surface slope error contributions have to be demonstrated by the contractor with LTP or interferometer measurements.

D- 5.1.2. Grinding and polishing

As part of the bidding process, the suppliers will provide a detailed description of the sequence of steps to be used in the entire fabrication process, from raw material to the finished product. The fabrication process should be acceptable to CELLS. A confidentiality agreement between the successful bidder and the customer can be arranged.

D- 5.1.3. Scratch-Dig

The optical surface shall be free from visible scratches and digs (1 µm scratch width – 50 µm dig diameter). The density of defects must be less than 0.5 scratches or dig defects per cm^2. None of the scratches of the surface will be more than 10 mm long. Inspection of the optical surface is to be performed using an appropriate collimated lamp including condenser optics, at grazing incidence.

D-5.2. Interfaces

In order to demonstrate the accurate positioning of the mirror poles/optical surfaces as well as the compatibility with the mirror holders, the provider is to reference the optical surface as well as the mirror pole with respect to the mounting points on the mirror holder. The corresponding report with the referencing results is considered as a part of the acceptance tests of lot MISTRAL 4.

Tests on the functionality of the interfaces are to be arranged between the contractors of Lot MISTRAL II. Factory acceptance tests should be using the real mirror holders or dummy components with identical dimensions regarding the above interface. CELLS is to be informed on the results from this compatibility test.

D-6. Preparation for delivery

See general specification given in Section 10.