TECHNICAL SPECIFICATIONS

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

Dossier number: 58/07

Contents

Complementary documents

- Annexes to the Technical Specifications of the optical components of the MISTRAL beamline at the ALBA Synchrotron Radiation Facility.
- 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).

1. Overview

CELLS is a consortium created to construct and exploit the ALBA synchrotron facility to generate X rays for basic and applied research. The facility will include a 3 GeV, low-emittance storage ring able to run in top-up mode. The storage ring is planned to be operated at a nominal current of 250 mA, although in the future it is foreseen to operate at a maximum of 400 mA. One of the beamlines in first construction phase is the X-ray Microscopy beamline MISTRAL, which will be dedicated to transmission full field imaging of biological "thick" samples from 275 eV to 2600 eV. It is expected to record tomographic data sets by amplitude and phase contrast mechanisms depending on the working energy in few minutes with 30 nm spatial resolution. See document EXD-BL09OP-GD-0001, *Conceptual design of the microscopy beamline*, for a detailed functional description of the beamline.

This document is organized as follows. Chapter 2 and references therein describe the scope of the contract as well as the hardware and documents deliverables. Chapter 3 refers to the organization of the contract in lots, and the proposed time schedule. Chapter 4 specifies the tendering conditions and the documentation to be provided by the bidders. Chapter 5 refers to the contract management and conditions, including reviews, meetings, responsibilities, quality assessments, guarantees and accesses to contractor premises. Chapters 6 to 8 and references therein are devoted to the general technical specifications of the beamline, Chapters 9 and 10 refer to the acceptance tests and the delivery requirements, respectively. Finally Chapter 11 details the list of attached documents. The technical specifications for the different lots are given in the annexes of this document: Annex A for Lot I (beamline backbone, supports, white beam diagnostics, 2-jaw vertical cooled aperture, vacuum vessels, mirror manipulators and PGM slits), Annex B for Lot II (monochromator chamber and mechanics), Annex C for Lot III (gratings) and Annex D for Lot IV (mirrors).

2. Scope of the contract

The scope of this tender exercise comprises the design, manufacturing, testing, delivery, and installation of all the optical components of the MISTRAL beamline up to the monochromator exit slits (therefore the front end components, safety hutches, and experimental stations are excluded).

2.1. Deliverables: hardware components

The hardware components to be delivered are described in section 6.2 and references therein according to the technical specifications given in the documents.

The standard vacuum components (gate valves, right angle valves, vacuum pumps, vacuum gauges and controllers, residual gas analyzers) are not included in this contract, and will be provided by CELLS. However, since the contractors of Lot I and Lot II will be responsible for the vacuum performance of the corresponding beamline components, the choice regarding the size of vacuum pumps (diode-type ion pumps, TSPs, NEGs) is to be determined by the contractors.

The stepper motor controllers and the other components of the beamline control system are not included in this contract and will be provided by CELLS.

2.2. Deliverables: documentation

The documentation included in the contract is grouped in three main reports: the Preliminary Design Report, the Detailed Design Report, and the Manufacturing Report. These reports are detailed below. Additionally, there will be the First Technical Project Report and the Progress Reports to be supplied monthly (see section 5.1.2).

The documentation will be delivered in English on paper (one copy) and CD-ROM

2.3. Preliminary Design Report (PDR)

The Preliminary Design Report shall include the following documentation:

- Complete detailed list of the beamline components to be delivered,
- Beamline drawing including all components and interfaces (taking into account the layout of the hutches, of the front end, and of the experimental stations, etc.),
- Architecture and functional analysis of each main beamline component and major subcomponents with general drawings in reasonable detail,
- Detailed time schedule,
- Justification of the proposed performances (tests reports on existing similar components or prototypes, calculations, vacuum calculations, etc.),
- Justification of the safety and reliability. This is done through reports for already designed equipments and through a Failure Mode Effects and Criticality Analysis (FMECA) for newly designed components,
- Preliminary alignment procedure,
- Detailed description of the factory acceptance tests to be done to satisfy the acceptance tests,
- Detailed definition of interfaces (electrical connectors, media supply lines, interfaces and signals to the ALBA beamline control system, etc.),
- Wiring diagrams.

2.4. Detailed Design Report (DDR)

The Detailed Design Report comprises the following documentation:

- Detailed assembly drawings of all components and major subcomponents,
- Detailed technical drawings of the optical elements (including mirror holders and mirror cooling systems),
- Detailed description of the Quality Assurance program in effect at the contractor's site and at the sites of subcontractors,
- Detailed schedule for the different components, including manufacturing, installation and test phases, with regular milestones to allow progress to be monitored,
- Description of the procedures for welding, cleaning, baking and testing the different materials used in the manufacturing (especially stainless steel and copper),
- Detailed description of the draft program for the Factory Acceptance Tests (FAT),
- Detailed description of the draft program for the Site Acceptance Tests (SAT),
- Description of the procedure for the surveying of the beamline components and the optical elements.

2.5. Manufacturing report

The Manufacturing Report shall include the following documentation:

- As-built beamline drawings,
- As-built general drawings of the components,
- As-built definition of the interfaces,
- Handling drawings,
- Quality report (test and control reports, conformity certificates, raw material certificates, derogations requested and/or accepted by the customer, modifications requested and/or approved by the customer, etc.),
- Alignment documentation, including:
    - Report of the 3D positioning of the functional faces with respect to the alignment marks for all the elements,
    - Formulae or tables giving the relation between any position within the stroke (6 parameters) of the functional faces and the number of motor steps or encoder pulses of each axis of the component, from the origin,
- User’s instructions,
- Maintenance instructions, including:
    - Elementary maintenance operation sheets,
    - Schedule of maintenance operations,

- Recommended spare parts.

2.6. List of Tasks

The tasks that have to be fulfilled within the scope of this contract include:

- Designing,
- Drawing,
- Writing of the Preliminary Design Report,
- Conduction of Failure Mode Effects and Criticality Analysis (FMECA) meetings (for new designs only),
- Writing of the Detailed Design Report,
- Supply of materials,
- Manufacturing,
- Cleaning, assembling and cabling,
- Inspection and testing at the contractor's premises,
- Writing of the Manufacturing Report,
- Packaging and shipping to ALBA premises,
- Installation and alignment at the ALBA Light Source,
- Initial commissioning at the ALBA Light Source without beam.

3. Organization of the contract

3.1. Lots

The design and procurement of the beamline optical components and associated equipment is divided in five different lots which are administratively independent among each other. The bidders may tender for a single lot or several lots:

- Lot I: Beamline backbone including supports, white beam diagnostics, two-jaw cooled apertures, Bremsstrahlung stopper, high precison entrance and exit slits for the monochromator, vacuum vessels and positioning mechanics for M1, M2 and M4, and their holders if rigid mirrors apply.
- Lot II: Monochromator chamber and mechanics.
- Lot III: Gratings.
- Lot IV: Mirrors M1, M2, M3 and M4, benders if M1, M2 and M4 are made with a bending system, and cooling system for M1.

The bidder may submit separate offers for any of the lots. The offers for each lot have to be self consistent and include separate information on pricing, scheduling and all the requested details. See chapter 6 and references therein for detailed description of the lots. The customer encourages the bidders to submit offers for several lots, including package discounts, in case that two or more lots are awarded to the same bidder.

For Lot IV (mirrors), the bidders are free to subcontract the bender mechanisms for M1, M2 and M4 (if required) and also the cooling system for M1 with the approval of CELLS.

Lot I is of particular importance. In addition to the responsibility for the components of this lot, it also includes the responsibility for the coordination as well as the interface management with the contractors of the other lots. The contractor of Lot I also has to assume the responsibility for the integration of the components from the other lots (including the components provided by the customer), and to provide technical drawings of the overall beamline layout.

Each bidder is encouraged to suggest alternative designs for beamline components of the lot while maintaining the overall layout of the beamline. The alternative designs must comply with the functional specifications of the beamline given in the present technical specifications. The bidder must be able to demonstrate in the offer that the suggested alternative designs comply with these functional specifications.

3.2. Proposed time schedule

The planned time schedule of the project is given in Table 1. The calendar should be negotiated and agreed with CELLS to ensure it fits to the calendar of the whole project.

An estimation of 12 months is foreseen from the signature to the end of the contract(s). This implies a smooth and fluent collaboration with CELLS that has to provide the details of the optical design, the information on the interface with the ALBA control system and other components provided by the customer and, in particular, that of the personnel safety system hutches.

After the procurement phase, the assembly process will be split in two periods: one for the assembly of the infrastructure (hutches, cables, fluids) and another for the assembly of the optical components and vacuum hardware. The first one is under the responsibility of CELLS; the second one is under the responsibility of the contractors.

The relevant phases are given (in months) in Table 1.

Table 1. Indicative temporal phases (in months) for the MISTRAL beamline procurement.

T_0	Signature of the contract
T_0 + 0.5	Start-up meeting. Review of the First Technical Project Report
T_0 + 2	Review and acceptance of the Preliminary Design Report
T_0 + 3	CELLS provides the design of a reference Personnel Safety Hutch to the main contractor
T_0 + 4	Review and acceptance of the Detailed Design Report
T_0 + 9	The beamline infrastructures (fluids, cryogenic lines, electrical power and hutches) are assembled in the Experimental Hall of ALBA under the responsibility of CELLS.
T_0 + 9	Approval of Factory Acceptance tests, delivery to ALBA site and acceptance of delivery
T_0 + 10	Assembly of the beamline optical components
T_0 + 11	End of installation and alignment. Acceptance tests of installation and alignment
T_0 + 12	End of commissioning without beam. Final Acceptance tests of working equipments.

4. Tendering

4.1. Contact

All interested contractors are strongly encouraged to contact CELLS and discuss details of the present technical specifications so to ensure that the bidder understands completely the requirements and implications of the specifications before making an offer. Enquiries of a technical nature shall be directed to:

Dr. Eva Pereiro, CELLS
Tel.: +34 93 592 43 76
Email: epereiro@cells.es

Enquiries of a contractual nature shall be directed to:

Mariano Sazatornil, CELLS
tel.: +34 93 592 43 07
Email: msazatornil@cells.es

4.2. *Criterion for adjudication*

CELLS shall adjudicate the bids by considering the technical and value-for-money aspects of the formal bid. See also the folder of administrative clauses for further details.

4.3. *Documentation required with the tender*

The bidder shall provide with the tender documents sufficient information to allow an informed choice of contractor. The tender documents shall include:

1) Description of the proposed solutions with full technical details, including technical drawings of the proposed beamline components as well as major subcomponents in reasonable details. Photographs *only* are not acceptable,
2) Justification of the proposed performances (references, test reports on identical equipments or similar equipments, calculations, etc.),
3) Conformity table summarizing the performance of each main component. The table should have the following fields:

Component	Function	Characteristics	Required Performance	Proposed Performance	Reference of the justification documents	Conformity (yes/no)

4) Confirmation of acceptance, or otherwise non-acceptance, of the clauses of the present specification,
5) Details of the Quality Assurance scheme under which the manufacturer operates,
6) For each lot, a breakdown of costs into the following categories:
   - Design,
   - Construction and testing of all the individual beamline components with the price of each component, including the signaled options specific for the lots,
   - Installation, final testing and initial commissioning of the beamline components without beam,
7) Draft schedule showing the design, ordering of materials, manufacturing, testing, assembly, delivery and installation of the principal components,
8) Draft schedule for installation,
9) Details of the delivery arrangements,
10) List of the items that will be subcontracted and the names of the main subcontractors,
11) List of planned staff devoted to the project, the description of their fields of competence and the management structure,

12) List of previous similar or comparable projects (in terms of size and scope), at other synchrotron facilities. Of particular interest to CELLS are those projects carried out on microscopy beamlines,

13) Draft version of the test program to be applied during the Factory and the Site Acceptance Tests as well as test protocols from similar beamline components manufactured previously,

14) List of proposed test and inspection equipment which will be used during the FAT and the SAT.

The tender documents shall be clearly numbered, with the numbering shown above.

5. Contract management

5.1. Contract Responsible

At the start of the contract the Contractor shall nominate a "Contract Responsible" who will be responsible for all reporting to, and contact with, CELLS.

5.2. First technical Project Report, Kick-off meeting and Progress Reports

Within two weeks of the commencement of the contract the Contractor must issue the First Technical Project Report, consisting of a detailed program covering the design, procurement, manufacturing, testing and assembly phases in sufficient detail to allow regular progress monitoring.

The First Technical Project Report will be presented in the Kick-off review meeting, to be held within half a month from the beginning of the contract. In this meeting, the detailed program and the technical specifications will be reviewed, and a program of technical and progress meetings will be agreed between the Contractor and CELLS.

Thereafter, and throughout the contract, the Contract Responsible shall supply a written report to CELLS every month detailing progress with respect to the program.

5.3. Design Reviews

The Design Reviews will be held at the CELLS site. At these meetings CELLS verifies that all design requirements are satisfied. In case of approval by CELLS, the contractor is allowed to go ahead and begin the next phase. The documents examined during the meetings must be transmitted to CELLS at least 2 weeks before the meeting.

- Preliminary Design Review for each lot: examination of the Preliminary Design Report.
- Detailed Design Review for each lot: examination of the Detailed Design Report.

5.4. List of acceptance phases and milestones

Unless otherwise agreed in writing by CELLS, CELLS must approve by written authorization each of the following phases before the start of the following ones:

- Approval of the Preliminary Design Report (PDR),
- Approval of the Detailed Design Report (DDR),
- Successful completion of the Factory Acceptance Tests (FAT),
- Approval of the undamaged delivery of components at CELLS site,
- Successful completion of the installation, alignment, commissioning and the subsequent Site Acceptance Tests (SAT).

See section 3.2 for the proposed time schedule.

5.5. Contract completion

For the contract to be complete, all the following statements shall be fulfilled:

- All components have satisfactorily completed their Factory Acceptance Tests including mechanical, optical (if applicable) and vacuum tests,
- All components have been delivered undamaged to the ALBA site,
- All components have been installed in the Experimental Hall and connected to the mechanical, fluids and electrical services,
- All components installed in the Experimental Hall are under ultra-high vacuum to the level specified and have been shown to perform according to the agreed specifications (commissioning without photon beam),
- All documentation (as-built drawings, user manuals, calculations, QA reports, vacuum related reports, technical datasheet etc.) has been received.

5.6. Responsibility of the Contractor

The Contractor will be responsible for the final design, the production methods and the correct performance of all the items supplied, irrespective of whether they have been chosen by the manufacturer or suggested by CELLS.

CELLS approval of the design and components does not release the Contractor from his responsibilities in this respect.

5.7. Quality management

The entire project from the design to the commissioning will be controlled. For each phase of the process the contractor will have to prove that the result of the phase is in respect with the requirements of this phase.

5.7.1. *Deviation from the Specification*

If after the order is placed, the contractor discovers that the specification has been misinterpreted, this will not be accepted as an excuse. The contractor will have the obligation to deliver the equipment compliant with the technical specifications at no extra cost.

During the construction, all proposed deviations from the specification must be submitted to CELLS in writing; CELLS will give its approval or refusal also in writing.

5.7.2. *Management of the modifications*

To be valid the modifications of the specifications will be formalized by written request from CELLS. For each modification the consequences regarding the price and the time of delivery will have to be communicated by the contractor to the customer in writing in order to allow an evaluation by the customer.

5.7.3. *Quality inspection*

Unless otherwise specified in the contract or purchase order, the contractor is responsible for performing the required inspections as specified herein. Except if specified otherwise, the vendor may utilize his own facilities or any commercial laboratory acceptable for CELLS.

CELLS reserves the right to perform any of the inspections listed in the specifications where such inspections are deemed necessary to assure that supplies and services conform to the prescribed requirements.

5.7.4. *Access to the Contractor's Premises*

Nominated members of CELLS staff or their appointed representatives must be guaranteed reasonable access to the premises of the manufacturer, and also to the premises of any subcontractor, for the purpose of progress meetings, inspection visits etc., with the main contractor present. See administrative clauses paragraph 27.

5.7.5. *Guarantee*

The Contractor shall guarantee the delivered equipment against defects due to either faulty components or faulty manufacture for a period of 24 months after successful completion of the SAT.

6. Beamline technical description

The beamline specified here is outlined in the "Conceptual Design Report of the MISTRAL beamline at the ALBA synchrotron radiation facility" (EXD-BL09OP-GD-0001). The mechanical design resulting from this technical specification must fit the optical design described there.

Several aspects, which determine the performance of the MISTRAL beamline, are considered in the present specification. They are:

- **Precision mechanics:** all mirror mechanics, monochromator mechanics, slit and aperture systems must provide high resolution, stability and repeatability,
- **Ultra high vacuum:** the vacuum system must provide extremely low base pressures and a chemical composition of the residual gas in accordance with the requirements given in the technical specifications. To that end, all materials and components used (including optical components) must conform to the requirements regarding thermal and photon-induced desorption,
- **Cooling system**: the cooling system of the mirrors and slits being under photon heat load must be designed in such as a way as to minimize thermal deformations of the mirror and slit surface as well as the associated thermal drifts,
- **Mirror figuring:** high-end mirrors are required to guarantee the expected flux on sample, focal sizes and spectral resolution of the monochromator.

The elements of the beamline are outlined in Figure 1 and Table 2. The beamline is divided in 3 main sections:

- **First optical enclosure section (FOE)**: comprises the elements included in the lead-shielded hutch, that cannot be accessed when the x-ray beam is on (see Table 2),
- **Monochromator section (MS)**: the monochromator section includes the entrance slit, the monochromator chamber, the mirror M4 and the exit slit (see Table 2),
- **Experimental section (ES)**: contains the end-station with the soft X ray full-field microscope (see Figure 1)

The beamline elements included in these sections, as well as a proposal for the vacuum sectors are given in Figure 1.

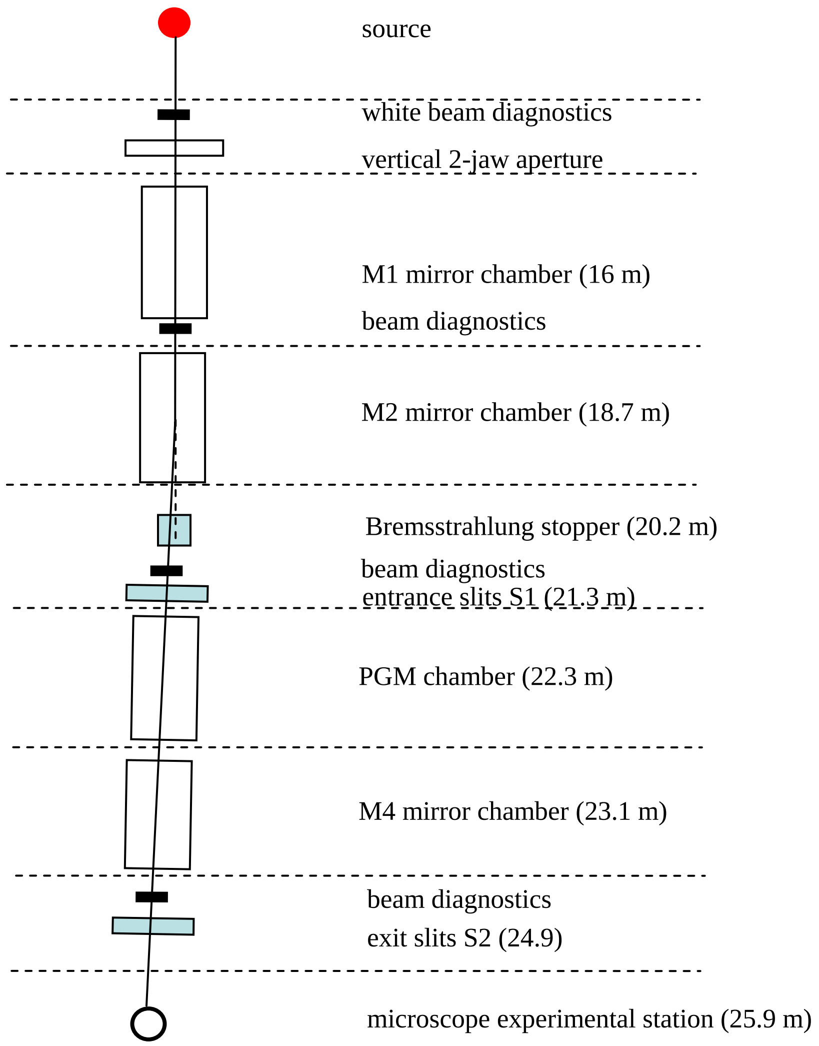

Figure 1: Layout of the Mistral beamline components. The dashed lines indicate the separation between the different vacuum sections.

6.1. Concise list of beamline elements

A succinct list of components of the beamline is given in Table 2. This list includes the name of the component, the corresponding section of the beamline, as well as the lots that are involved in the procurement. Moreover Table 2 indicates the distance of the center of each component from the source (along the beam propagation direction), as well as the horizontal and vertical deviation angles downstream each one of the components (conventions: 0° is the direction of the x-ray beam as emitted by the source, positive angles are either for a deflection to the right looking downstream from the source or for a deflection upwards).

Table 2. List of the MISTRAL beamline main components (valves, pipes and bellows, as well as the experimental end-stations are excluded from this list). The beamline sections, as well as the involved lots are also specified. The deviation angles are the angles at which the x-ray beam leaves each element (positive values are for deflections upwards or sideways to the right looking downstream).

N.	Component	Section	Lot	Distance from source along beam direction (m)	Height above floor (mm)	Horiz. deviation angle (°)	Vert. deviation angle (°)
1	White beam diagnostics	FOE	1	-	1400	0	0
2	2-blade vertical cooled aperture	FOE	1	15.0	1400	0	0
3	Elliptically bent mirror M1	FOE	4	16.0	1400	0	2.4
4	Beam diagnostic	FOE	CELLS	~ 17.5	1463	0	0
5	Elliptically bent mirror (M2)	FOE	4	18.7	1513	2.4	0
6	Bremsstrahlung stopper	FOE	1	~20.2	1400	0	0
7	Beam diagnostics	FOE	CELLS	~20.8	1605	0	0
8	Entrance slits (S1)	MS	1	21.3	1622	0	0
9	PGM plane mirror (M3)	MS	4	21.9 - 22.2	1649	0	6.5 – 2.2
10	Grating(s)	MS	3	22.3	1664	0	(-6.5) – (-2.2)
11	Elliptically bent mirror (M4)	MS	4	23.1	1698	0	-2.4
12	Beam diagnostics	MS	CELLS	~24	1698	0	0
13	Exit slits (S2)	MS	1	24.9	1698	0	0
14	Microscope	ES	CELLS	25.4	1698	0	0

Shadowed items are out of the scope of supply of this call for tender since they are to be provided as ALBA beamline standard components.

No valves, bellows or pipes have been included in the list, although vacuum pipes and bellows are included in the scope of supply of this call for tender.

6.2. Hardware deliverables

All the hardware components of the beamline are to be supplied by the contractors of lots I, II, III, and IV with the following exceptions:

- Standard vacuum components will be supplied by CELLS and are out of the scope of supply of this call for tender. This applies to ion pumps, gate and right angle valves, pressure gauges, TSPs, NEGs, residual gas analyzers and the corresponding controllers.
- Motor controllers and other beamline control system components will be supplied by CELLS and are out of the scope of supply of this call for tender. Cabling up to the beamline components will be provided by CELLS. All connectors used on the beamline components have to comply with the standards as defined in the annex document “Interfaces to Alba's control system”.
- The white beam diagnostics set-up upstream of the mirror chamber M1 is included in the scope of supply of Lot I. On the other hand, the non-cooled beam diagnostics downstream the M1 mirror setup will be supplied by CELLS as free issue materials.

The remaining components are to be included in the scope of supply and are detailed in the annexes of this document, corresponding to the different Lots:

- Lot I: The items that comprise the beamline backbone, entrance & exit slit setups of the monochromator, the vessels and manipulators of mirrors M1, M2 & M4 as detailed in Annex A,
- Lot II: The items that comprise the monochromator chamber as detailed in Annex B,
- Lot III: The gratings as detailed in Annex C,
- Lot IV: The mirrors M1, M2, M3 & M4, the bend systems (if applicable) of M1, M2 & M4, and the cooling system of M1 as detailed in Annex D.

6.3. General deliverables and tasks

In addition to the hardware deliverables, general deliverables like technical and engineering drawings or performance study reports are needed. Additional information is detailed in the technical specifications of each Lot.

In general, all contractors are responsible with respect to CELLS.

It is of utmost importance to note that the coordination and integration of the different lots of the beamline is within the responsibility of the contractor of Lot I (beamline backbone etc.).

The main contractor (Lot I) will communicate/interface directly with the others, providing the corresponding information to CELLS.

The contractors of Lots II, III, and IV shall supply the interface information as required by the main contractor (Lot I) for preparing the PDR as well as the DDR. The contractual duties of these Lots include the obligation to report and cooperate with the Lot I contractor in that respect. The same applies to the interface between the contractors of Lot II (monochromator chamber) and Lots III (gratings) and IV (for PGM mirror M3).

6.4. *Interfaces*

There are a number of interfaces between the different lots and the experimental hall of the ALBA synchrotron radiation facility.

General information on the interface between the beamline and the ALBA radiation facility is given in the following section 7. The specific interfaces for each lot are given in the Annex documents.

7. General Conditions

7.1. *Fluids*

Beamline components are supplied with electricity, cooling water, pressurized air, and dry nitrogen via a central supply system. For that purpose, CELLS will take care of providing the corresponding outlets along the beamline in accordance to the PDR.

Commercially available couplings will be mounted on the outlets. Starting from these central outlets, the piping up to the corresponding beamline components will be provided by CELLS up to each beamline component.

The fittings for connecting pipes and tubes to the beamline components shall be agreed with CELLS.

The following media are available:

- Cooling water: 23°C ±0.2°C, demineralized water, 0.2 µS/cm,
- Pressurized air: 6 bar, 0.01 microns max. particle size, dew point -40° C at 6 bar,
- Electricity:
  - 230 V AC, 50 Hz
  - 3-phase 380 V AC, 50 Hz.

Additional information is given in annex document “Technical Terms of Delivery and Acceptance for the Electrical Installations of the ALBA Beamline” (END-BLEL-CC-0001).

The connections and fittings, and all the hardware parts exposed to cooling water should be resistant to corrosion by deionized water.

7.2. Control Cabling

CELLS will take care of providing the cabling from the control system racks up to the different beamline components.

The interface between the part of the beamline control system provided by CELLS and the scope of supply of the contractor consists of the connectors of the control system devices (e.g., stepping motors, encoders, reference and limit switches) right at the beamline components.

Interfaces to ALBA control system shall fulfill the requirements given in annex document "Interfaces to the ALBA Control System" (CCD-BLCT-CC-0001). Any exception must be approved by CELLS in writing.

7.3. Temperature

Ambient temperature:

- 23°C ±1°C in ALBA hall,
- 23°C ±1°C in beamline hutches.

7.4. Hutches and radiation protection system

The major part of the beamline and the end station will be accommodated in a control hutch (light metal, glass, and wood structure), with a separate first optical enclosure (FOE) from the outer side of the radiation protection wall up to and including the bremsstrahlung stopper downstream the KB mirrors. The FOE will be shielded for radiation protection.

The FOE will accommodate all the beamline components downstream the radiation protection wall, up to the beam diagnostics (item 7 in Figure 1/Table 2), which will be the first component outside.

Due to increased radiation level inside the FOE (first optical enclosure), radiation resistant devices (electronics, motors, tubes, gauges etc.) must be used. The radiation resistance of components inside the radiation protection hutch is of vital interest for, e.g., the KB mirrors set-up.

The FOE as well as the beamline control hutch will be provided by CELLS, in accordance to the PDR.

7.5. Available floor space

According to the present planning, the MISTRAL beamline is allocated to the BL09 port in the ALBA storage ring (see Figure 2). The ALBA storage ring radiation protection wall, as well as the neighboring beamlines, defines the available floor space for the MISTRAL beamline. Besides the floor space needed for the beamline components, enough space has to be foreseen for the installation and service of beamline components.

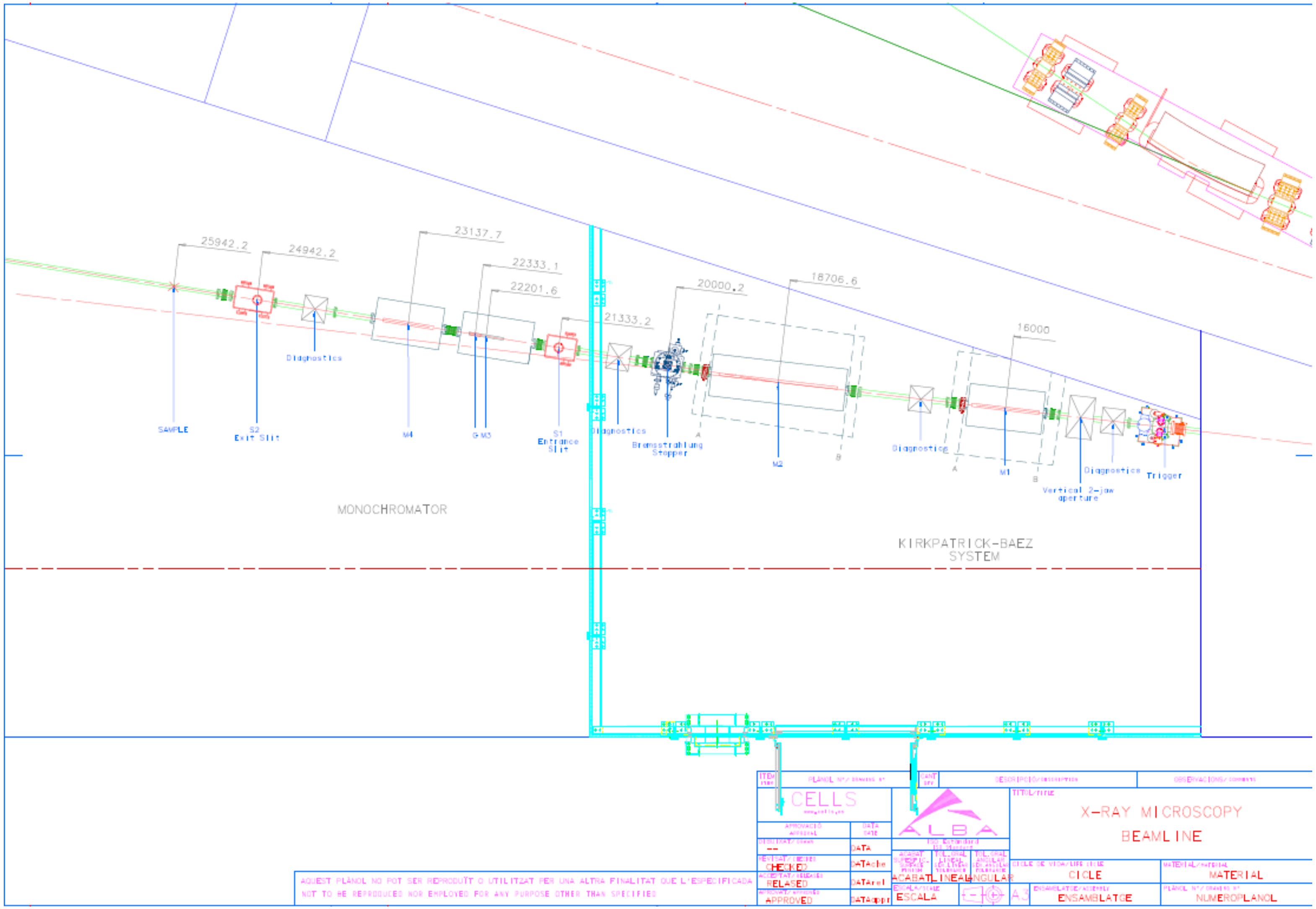

Figure 2: Floor plan for the MISTRAL beamline in the ALBA experimental hall.

Prior release of the designs for manufacturing, the corresponding AutoCAD drawings must be submitted to CELLS (including a side view as well as a top view) in order to verify the compliance of the beamline components with the available floor space.

7.6. Beam Height

The nominal height of the storage ring electron beam is 1400 mm above the floor.

Given the optical design proposed in the Conceptual Design Report, the height of the beam is 1400 mm above the floor from the front-end up to the mirror M1. It will then be deflected upwards (2.4º) onto M2 and will leave the monochromator chamber with the same deflection up to M4, which will finally steer the beam again parallel to the experimental floor. For more details on the height above the floor for the different elements of the beamline and of the vertical deviation angles refer to Table 2.

7.7. Beamline ground

The specifications regarding beamline ground are the following

- Surface admissive load
  - Static: 1500 daN/m^2
  - Dynamical: 2000 daN
  - Maximum in a point: 5000 daN
- Induced vibrations: See spectral excitation in Figure 3 below

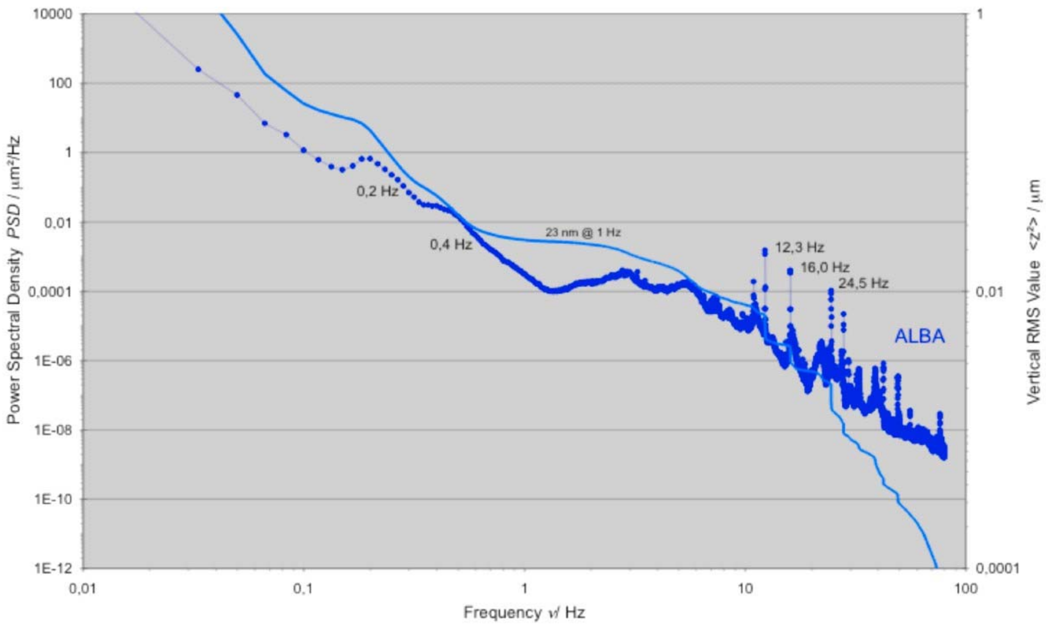

Figure 3 : ALBA site vibration spectral excitation.

- Default floor planarity: ± 5 mm/m
- Maximum deviation on the whole Experimental Hall: 15 mm

7.8. Installation and alignment

The contractor has to bring all tools that are necessary for the installation of the beamline. This does not include surveying instrumentation.

CELLS will provide enough space for the storage, assembling etc. of beamline components inside the ALBA experimental hall. A crane (12 tons maximum) which is operated by CELLS is available inside the experimental hall.

The surveying and alignment of the MISTRAL beamline components after the installation will be performed by CELLS staff, in cooperation with the contractors of Lot I and Lot II. In that context, CELLS will assure the operation of the laser tracker.

Regarding the installation of the optical components within Lot III (gratings) and Lot IV (for the PGM mirror), the installation shall be done in cooperation with the contractor of Lot II.

CELLS can supply the following instrumentation for the alignment:

- Laser tracker,
- Theodolite,
- Optical level,
- Portable coordinate measuring machine.

Any further equipment must be provided by the contractor.

8. General requirements

8.1. Vacuum

General information on this issue, applicable to the MISTRAL beamline is given in the attached document "General Specification for the Vacuum System of the ALBA Beam Lines", (END-BLVC-CC-0001). Additional information is given below.

The whole MISTRAL beamline - from the source to the CCD - will operate under ultra high vacuum (UHV) conditions.

All vacuum sections of the MISTRAL beamline require bakeout. Suggested bakeout temperatures are:

- Vacuum vessels not containing optics: 180ºC,
- Vacuum vessels containing precision mechanics (e.g. slits): 150ºC,
- Vacuum vessels containing optics: 120ºC.

Bakeout time is at least 48 hours. The vessels containing the optical elements will be baked for longer periods (e.g., for up to one week). The temperature ramping in this case will be slow (about 0.1ºC/min).

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

The contractors of Lots I and II have to assume the responsibility for the base pressure without beam mentioned above inside the MISTRAL beamline vacuum system. As mentioned earlier, the appropriate sizes (i.e., the pumping speeds) of the various pumps along the beamline (diode-type ion pumps, TSPs, NEGs) are thus to be determined by the corresponding contractor.

8.2. Control

General information on this issue, applicable to the MISTRAL beamline is given in the attached document "Interfaces to the ALBA Control System"(CCD-BLCT-CC-0001). Additional information is given below.

The control system for the MISTRAL beamline will be provided by CELLS. The control system for the beamline is based on TANGO.

All components shall have a self safe behavior, e.g. cooling devices shall be equipped with flow rate controls, all movements will include limit switches, etc.

All axes must have limit switches. Provisions for incremental encoder (including a home reference pulse) and reference switches, all of them with an appropriate resolution, must be included for critical axes, which will be determined by CELLS in due time.

8.3. Electrical installation

General information on this issue, applicable to the MISTRAL beamline is given in the attached document "Technical Terms of Delivery and Acceptance for the Electrical Installations of Beamlines" (END-BLEL-CC-0001).

8.4. Alignment and handling

General information on this issue, applicable to the MISTRAL beamline is given in the attached document "Alignment and Handling Requirements for ALBA Beamlines". ALBA (END-BLAL-CC-0001). Additional information is given below.

The installation of all MISTRAL beamline components is a part of the scope of supply. The contractor has to bring all tools that are necessary for the installation of the beamline. Metrology instrumentation detailed in section 7.8 can be provided by CELLS. Laser tracker operation will be covered by CELLS staff.

The alignment strategy of CELLS as well as the resulting technical requirements to be taken into account in the design of the beamline components (i.e., the type, the number, and the location of fiduciary marks/fiducial holders on the beamline components; which positions and angles are to be aligned etc.) will have to be arranged with CELLS during the PDR and the DDR.

8.5. Safety

CELLS will provide information on the safety policy for beamline components.

Most of the components of the beamline will be outside the radiation protection hutch (FOE) and will thus be accessible during operation. This will be possible only if the walls of the vacuum chambers represent enough shielding with respect to radiation. These vacuum chambers are therefore subject to the following restrictions:

- Bellows may need shielding (typically for bellows upstream the monochromator chamber),
- The walls of the monochromator vacuum chamber may have to be adapted to radiation safety requirements,
- Viewports may need lead-doped glass cover on the atmosphere side,
- Provision for redundant double vacuum switches (DN40CF) may be required for the vacuum vessels within the white beam section

8.6. Particular requirements for the lots

The specific requirements for Lots I, II, III, and IV are included in their technical specifications given in the annex documents.

9. Acceptance tests

The acceptance phases are detailed in Section 5.4. Additional information is given here.

Factory tests shall provide an exhaustive characterization of the hardware deliverables. The acceptance tests will be arranged and performed within the responsibility of the contractor and are to comply with the following requirements:

- CELLS should be informed three weeks in advance when acceptance tests are being performed so that one or more of the individuals in charge at CELLS can be present during the tests,
- Written report of all the results on the above acceptance tests shall be provided to CELLS in order to verify compliance with the specifications,
- The contractor shall foresee the insurance of the equipment during the tests,
- The tests should first be performed with the contractor's own control systems (like stepper motor controllers, encoder readout counters etc.). In addition, a compatibility test may be performed with the same components but supplied by CELLS. These will be loaned to the contractor premises.

9.1. General Conditions

The tests will be performed in working conditions, in terms of payload, fluid connections, cooling devices, control, etc, and in vacuum whenever possible.

The acceptance test shall be carried out with the suppliers own control system.

For the planned compatibility tests, a rack with stepper motors drivers and encoder readout counters will be supplied by CELLS. This rack will be able to drive the motors with the requested number of steps and to read the encoder values.

All the tests will be performed by means of metrology instrumentation (e.g. interferometers, autocollimators) that is to be **external** with respect to the system to be tested and **not** with the built-in encoders as well as directly on the part of interest (e.g., mirror dummies, grating dummies etc.).

9.2. Definitions

The following definitions apply for the acceptance tests.

9.2.1. Motion-related definitions

9.2.1.1. Resolution

The *resolution* is the minimum amount of motion which can be induced by the actuator.

9.2.1.2. Range

The *range* is the maximum amount of motion that can be induceed by the actuator.

9.2.1.3. Repeatability

The *repeatability* is the maximum of the differences between the average position and the single positions to which the device returns after a given closed travel taking into account the hysteresis of the system.

9.2.1.4. Stability

The *stability* is the maximum difference between the average position and the positions measured at given time intervals on a given time range without motion.

9.2.2. Mirror optics definitions

9.2.2.1. Surface error

The surface error is the local deviation of the surface normal from its nominal orientation, which is given for each point of the surface by the geometrical function that defines the mirror figure (i.e., toroid, flat, sphere, or ellipsoid). Depending on the spatial frequency of such a deviation one distinguished between figure error, slope error, or roughness.

9.2.2.2. Slope error and figure error

Slope error is the surface error integrated from spatial frequencies below $1mm^{-1}$, that is, corresponding to correlation lengths between 1 mm and the maximum length of the mirror. It is given by its two components, the meridional slope error and the sagittal slope error, corresponding to the projection along the mirror longitudinal plane and transversal plane, respectively.

For flats, spheres, cylinders, and toroids the best fit radii of curvature are usually subtracted. The difference between these radii and the nominal ones is referred to as the figure error.

9.2.2.3. Roughness

Surface error integrated from spatial frequencies between 1 mm^{-1} and 1 $µm^{-1}$, that is, corresponding to correlation lengths between 1 µm and 1 mm It is usually given in terms of profile differences from the nominal profile (actually the 1st integral of the slope error, although profile is directly measured in roughness measurements).

9.3. Interfaces

The conformity of all interfaces will be verified according to the specifications included in the Preliminary Design Report. Interfaces shall include, among other, fluid and power connectors, mounting holes on the ground, flanges, interfaces between mirrors and mirror holders, mirror holders and mirror mechanics etc.

9.4. Vacuum tests

The following tests must be carried out in order to characterize the vacuum properties of the components.

9.4.1. Leak test

This test will be performed by means of a leak test with He.

9.4.2. Limit vacuum test

This test consists in determining the limit base pressure reached after bakeout (see bakeout temperatures as suggested in section 8.1) and subsequent cool-down.

9.4.3. RGA (Residual Gas Analysis)

A RGA test will be performed before the vacuum base pressure test as well as after bakeout/cooldown.

9.4.4. Mechanical stability

Since the alignment of the optical components will probably be done in air, it is of importance to check whether the optical components have moved after having pumped down the chamber, due to atmospheric forces acting on the mechanics. Thus, during the vacuum test, the position of optical components (e.g. mirrors) is to be controlled at atmospheric pressure and at a 10^{-3} mbar pressure. Test procedures will have to be mutually agreed between the contractor and the customer.

9.5. Motion and positioning tests

The specifications shall be fulfilled in open loop operation.

The following characteristics of all the specified movements (linear or rotary) of each component will be tested.

9.5.1. Resolution

The resolution of the linear movement shall be tested by plotting the evolution of the element's position, incrementing single motor steps and using an external high accuracy sensor over the entire linear range. The minimum displacement per single motor step will be obtained as the RMS value of the individual incremental displacements.

A high-accuracy sensor (autocollimator, interferometer etc.) is to be used for the test.

9.5.2. Range

The total range of movement for each degree of freedom will be tested using conventional tools. The full range of movement must be free of obstructions by cables, cooling pipes or any other part.

9.5.3. Repeatability

The repeatability of the linear movement shall be tested by plotting the evolution of the element position as a function of motor steps for six full travels forth and back throughout the entire range starting from the home position taking into account the hysteresis of the system. The repeatability will be checked on the entire specified stroke in at least 20 evenly spaced points along the stroke. In addition, the customer can ask to test the accuracy in specific locations within the stroke.

The repeatability is taken equal to the RMS value of the difference between positions measured at the same nominal motor position for the same travel directions.

9.5.4. Hysteresis

The hysteresis is defined the measured difference between initial and final positions (with a high accuracy sensor), after moving forward from the starting point by a pre-defined number of motor steps, and moving back by the same number of steps. This test shall be repeated five times for each travel direction (10 measures).

The hysteresis will be taken as the RMS value of those differences.

9.5.5. Crosstalk

Tests will be performed to check the independence of the axis in respect with the specified values.

As example, the influence of a translation on the vertical rotation will be performed by means of a high accuracy inclinometer or optical method by measuring the induced rotation when a translation motion is done.

The standard deviation of induced movement for several motions will be calculated.

9.5.6. Stability

Unless otherwise defined in the technical specifications of some specific item, the stability shall be measured as follows.

9.5.6.1. Short term stability

Short term stability tests shall be performed to check the position and the orientation of the optical elements without movement during two hours in respect with the specified values.

This test will be performed by means of a high accuracy sensor compared with the ground by plotting the evolution of the elements positions every 2 minutes.

The ambient temperature shall remain within ±1ºC during the measurement, and the fluid connections and motors shall be in working conditions.

9.5.6.2. Long term stability

Long term stability tests shall be performed to check the position and the orientation of the optical elements without movement during 24 hours in respect with the specified values.

This test will be performed by means of a high accuracy sensor compared with the ground by plotting the evolution of the elements positions every 10 minutes.

The temperature shall remain within ±1ºC during the measurement, and the fluid connections and motors shall be in working conditions.

9.5.7. Vibration

The acceptance tests regarding vibrations include:

- Difference between the measurement of the position of the optics before and after a shock excitation,
- Spectrum of the dynamical response to an excitation,
- One acceleration sensor will be put on the dummy mirror or grating, and the signal will be recorded during a shock excitation.

9.6. Mirror optics tests

9.6.1. Slope error tests

Slope error tests shall be performed by means of LTP or interferometer, or any other instrument approved by CELLS.

The slope error shall be measured along the whole mirror active surface. Both the tangential and sagittal slope profile shall be reported to CELLS.

Whenever possible, the mirror should also be tested when being installed inside the mirror holder and in its working position.

9.6.2. Roughness tests

Roughness tests shall be performed by means of interference microscope, or atomic force microscope or any other instrument approved by CELLS.

The roughness shall be measured in at least 15 randomly distributed points of the mirror active surface. The obtained roughness profile shall be reported to CELLS.

9.6.3. Grating profile test

The groove density, groove density variation, groove density variation error, groove depth, groove-depth-to-period ratio and trapezoidal angle of gratings should be measured by an interferential microscope or an atomic force microscope.

The groove profile shall be measured in at least 20 randomly distributed points of the mirror active surface. The obtained groove profile shall be reported to CELLS.

9.7. Alignment tests

For each optical component, the following alignment tests will be carried out:

- Checking the type of survey marks and their interfaces,
- Measuring the relation between the 3D coordinates of the optical part and the 3D coordinates of the survey marks,
- Checking the ability to put the optical part of the component to the theoretical position according to the following procedure:
    - Put the laser tracker at the adequate place,
    - Put all optical devices (dummy mirrors, dummy gratings, slit blades, diagnostic devices, etc.) in a random position,
    - Measure the position of the fiducial marks with the laser tracker,
- Apply the number of pulses to the stepper motors given by the formulae or tables provided by the contractor to reach the required position,
- Measure the new position of the fiducial marks with the laser tracker; compare the results with the required positions,

- The expected accuracy is less than 0.1 mm. The test will be crosschecked by measurements on the dummies with the portable Coordinate Measuring Machine.

9.8. Specific tests for the lots

The acceptance tests required specifically for Lots I, II, III, and IV are included in their technical specifications.

10. Preparation for delivery

The finished pieces must be thoroughly cleaned and free from any organic material or cutting fluid.

Any UHV equipment must be packed in such a way that foreign materials (gases, particles, etc.) cannot penetrate inside the UHV chambers. CELLS suggests to ship the UHV chambers in a sealed state and back filled with dry nitrogen at a pressure slightly greater than 1 bar. Other packaging methods used are subject to approval by CELLS.

Packing for shipment must ensure that the equipment is insulated from severe shock and rough handling. Package markings shall indicate the fragile nature of the contents. The protective containers are to be equipped with shock and tilt indicators at appropriate locations on the outside walls.

11. List of annex documents

The following documents are part of the present specification:

- **Annex A** “Technical Specifications of Lot I: Beamline Backbone
- **Annex B** “Technical Specifications of Lot II: Plane Grating Monochromator Chamber and mechanics”,
- **Annex C** “Technical Specifications of Lot III: Gratings”,
- **Annex D** “Technical Specifications of Lot IV: Mirrors”,
- **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).