Appendix A
Description of the Subject of Public Procurement

A set of components for soft x-ray beamline

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1 General information

The object matter of the tender is the design, manufacturing, testing and delivery of a vacuum chambers and components with supports, standard vacuum components and motorization plus optic elements for the PHELIX beamline including:

a) Optic element M3b (toroidal mirror)
b) The diagnostic1: new diagnostic element downstream M3 unit
c) The vacuum section1 with supports and pumping
d) The exit slit unit
e) The gas cell
f) The diagnostic2: photodiode, calibration samples and YAG screen
g) The mirror unit for M4b optics with pumping and dummy mirror
h) The vacuum section2 between mirror units with one small ion pump
i) The mirror unit for M4c optics with pumping and dummy mirror
j) Optic element M4b – sagittal cylinder
k) Optic element M4c – elliptical
l) The diagnostic3: element with photodiode

The delivery of components together with required documentation should be performed to National Synchrotron Radiation Centre SOLARIS (hereinafter called: SOLARIS). The beamline vacuum components installation and SAT will be performed by SOLARIS' engineers. Under the contract, the Contractor will install an optic element in existing double mirror unit M3 and provide service of supervision over the remaining optic elements installation process and tests, carried out by 1 Contractor's employee at the SOLARIS facility. The service covers a maximum of 4 working days at the site, with SOLARIS agreeing to order at least 2 working days, with the reservation that a single visit will last for a minimum of 2 business days.

Within the scope of the Agreement, the Contractor is required to provide a suitable design of the mechanical system of the beamline components (including 3D designs) in consideration of the required parameters and edge conditions such as the existing infrastructure and beamline constrains.

The SOLARIS synchrotron is the 3rd generation source of the electromagnetic radiation based on the 1.5 GeV storage ring. It is characterized by a low emittance of 6 nm·rad, and the maximum current of the electron beam of 500 mA. The magnetic lattice of the ring is composed of 12 identical achromatic "cells" – Double-Bend Achromat (DBA) each of which constitutes a single, iron block. Detailed storage ring parameters can be found in Appendix SOURCE. Twelve straight sections have been designed each of 3335 mm in length. The critical energy of the synchrotron radiation beam from the bending magnet (magnetic field of 1.31 Tesla) is approximately 2 keV.

The PHELIX beamline is operating in the soft X-ray energy range using an elliptically polarizing undulator as a photon source. For detailed EPU specification see Appendix SOURCE-ID06. The main experimental techniques are: Photoemission Spectroscopy (PES), Soft X-ray Angle Resolved Photoemission Spectroscopy (SX-ARPES) and X-ray Absorption Spectroscopy (XAS).

Abbreviation glossary
PDR = preliminary design review
FDR = final design review
FAT = factory acceptance test/tests
SAT = site acceptance test/tests
BL = beamline
EPU = elliptically polarizing undulator
UHV = ultra-high vacuum

2 General specification of the scope of delivery

Contractor undertakes to design, manufacture and deliver to the Purchaser a set of beamline chambers and components as well as all necessary vacuum components (like valves, ion pumps, controllers) according to SOLARIS standards (Appendix VAC1 and VAC2). The scope of the order therefore includes all X-ray optics components, all diagnostic components, slits, etc. The beamline components will be installed in the experimental hall of the SOLARIS facility.

2.1 The detailed scope of delivery

The detailed scope of delivery is listed in the following sections.

2.1.1 Included

a) Design and delivery of the beamline components with supports including chambers, devices, optic elements, dummy optics, connection pipes, bellows, consumables as necessary for the vacuum elements assembly (screws, washers, caps, seals, connectors, etc.) and all other nonstandard tools. The description and general functional assumptions of particular beamline components are listed in Paragraph 2.4 and 2.5.
b) Pneumatic and cooling system design and construction (pneumatic actuators, compressed air installation within particular component, flexible cooling pipes).
c) In- and ex-vacuum cabling, electrical connectors in a common interface box (patch panel) for each girder. The design of the internal wiring of the units is the responsibility of the Contractor.
d) Vacuum components according to standards for Solaris described in Appendix VAC1 and VAC2 (vacuum valves – viton gate valves, all metal angle valves; ion pumps).
e) Preliminary design report and final design report.
f) Power supplies and controllers (for ion pumps).
g) Motors, encoders and limit switches.
h) Report analyzing the thermal behaviour and finite element analysis calculations for elements exposed to synchrotron radiation radiation and required cooling (possible diagnostic elements) allowing estimation of the maximum temperature and cooling

efficiency of the proposed solution. All details related with the EPU source needed for heat load calculations can be found in Appendix SOURCE-ID06.

i) Control system: software (Device Servers for non-standard SOLARIS equipment) described in Appendix CS0, CS1.
j) Technical and engineering drawings without property solution of the company, assembly drawings and 3D models.
k) Functional descriptions or manuals.
l) The Factory Acceptance Tests (FAT) including the training of the Ordering Party's representatives in handling the subject of the contract performed during FAT.
m) The Contractor will ensure installation of the optic element in M3 unit and the presence of a Supervisor during the installation of the optical elements at M4b and M4c unit (no longer than four working days).

2.1.2 Excluded

a) Motion control hardware (controllers and drivers). Appendix CS1 contains details of the motion control standard at SOLARIS.
b) Installation of the beamline vacuum chambers and components with supports, bake out and obtaining UHV conditions.
c) Control system (configuration, installation, GUIs).
d) Turbomolecular pump (80 l/s) and fore vacuum pump for gas cell.
e) Diagnostic measurement devices and controllers (picoammeters, cameras).
f) Cabling (buying, laying, prefabricating and connecting cables) between components/patch panels and rack.

2.1.3 The elements and scope of work delivered/made by Purchaser

The elements and scope of work described in the following points will be delivered/made by Purchaser.

a) The CCD camera used for the beam visualization on fluorescent screens will be delivered by Purchaser.
b) Frame/backbone infrastructure for the beamline section. In the direct vicinity of the components Purchaser is to install all the necessary IT network terminals, electrical switchgear for predefined sockets and electronic racks, sets of signal cables, cooling water and compressed air lines. This also concerns carrying posts for infrastructural installations. The cooling water and compressed air pipes and tubes will be run to connectors situated directly on the Contractor delivered equipment or suitable connection boards mounted on the equipment supports according to specifications in the Appendix WAT-CW1 and WAT-CA1.
c) PLC Safety System for the BL protection. MPS and PSS – design, detailed coordination, performance and installation of the system as per the guidelines presented by the Contractor.
d) Configuration of all controllers, power supplies, equipment, electronics, diagnostic elements into a complete set.
e) Electronic devices and controllers for the BL diagnostic elements, HV power supplies.

f) Providing connection to the mains for the controller/s and driver/s.
g) Providing Ethernet connection between the racks, network switches and control system computers.
h) Providing the IT infrastructure for the controller, i.e.: servers, network switches and cabling, connection to the desired server, placing in the rack cabinet.
i) Providing Tango Controls system backbone including properly configured virtual machines, Device Servers for SOLARIS standard devices as well as integration of all control system (including Device Servers supplied by the Contractor).
j) Providing GUI-s.
k) Providing Control System computers with the operating systems if needed.
l) Providing IcePAP controllers for the motors/encoders and their configuration.
m) Cables and installation of cables for the motors of slits, shutters, etc. for the progressive/translation and rotary motions where applicable, from the racks with IcePAP controllers to the patch panels located on the support of the motorized element.
n) Purchase and installation of cables for the standard vacuum components.
o) Electronic equipment racks. The Purchaser provides the racks of a selected type for the beamline components.
p) Reflectors for the beamline vacuum chamber geometry measurements will be ensured by Purchaser.
q) Sub-assembly transport within the area of the synchrotron facility is to be ensured by the Purchaser employees. The weight limit for the individual unit is 8 tons.
r) SOLARIS will carry out the installation of the vacuum chambers and part of optic elements (under Contractor's supervision, if required), pumping and obtaining UHV conditions and the SAT no later than two months after successful delivery.

2.2 Requested information with the offer

a) The offer shall include sufficient information to evaluate the performance of the beamline components like description of the proposed solutions with technical details. Additionally, the list of planned vacuum ports can be presented in the offer together with specification and justification of the purpose (e.g. beam inlet, beam outlet, ion pump, viewports, gauge, cooling and electrical feedthroughs, maintenance etc.). The heat load calculations for specific diagnostic elements can be postponed to the final design meeting.
b) Justification of the performances of proposed solutions (reference, test reports on identical or similar equipment, for each motorized axes information including range, repeatability and motion resolution, etc.).

2.3 General design consideration

a) All specifications for the deliverables of this package are described in this document and related attachments and in case of any doubts, a question should be asked to the Ordering Party by using the electronic means of communication described in the Specification of order conditions.
b) The cooling scheme shall be designed so that no heat dissipates to the vacuum chamber

or supports.

c) The design of the vacuum chambers shall include ion pumps, valves and bellows. Appendix VAC1 contains details of the standard vacuum components used in SOLARIS. The pumping speed and model of the pumps will be defined by the Contractor latest at the final design stage. Sputter ion pumps equipped with heaters shall be used. Small sputter ion pump controllers shall be used for all sputter ion pumps. If the proposed mechanical solution requires special pumps, the Contractor should include these in the tender.

d) The vacuum chamber welding elements (flanges, seals, and all integral, non-instrumentation components) shall be bakeable to a temperature suitable to reach the required vacuum level and this temperature shall be given in the documentation. Water lines that are feed into the vacuum chamber shall have no direct water to vacuum joints.

e) A sufficient number of rotatable flanges shall be provided.

f) The photon beam height at the insertion device is 1300 mm above the floor level. The photon beam height downstream Plane Grating Monochromator (left and right beamline branch) is 1324 mm above the floor level. The photon beam is horizontal and parallel to the floor.

g) The Contractor is responsible for designing the beamline components and sections with a suitable location and sizes of all the pump systems to reach the base pressure (vacuum level) $\leq 5 \times 10^{-10}$ mbar within 48 hours after bake out and vacuum level $\leq 1 \times 10^{-9}$ mbar with photon beam (see Appendix VAC1). A total Helium leak rate should be $\leq 2 \times 10^{-10}$ mbar*l/s.

h) Edge-welded bellows shall be installed upstream and downstream of all movable components. Hydro-formed bellows should be used only as a transition between pipes to ensure small positioning errors and thermal expansion movements during bake out operation. The range of all bellows should be defined by the Contractor and according with the movements of the components.

i) The size of the beam pipes should not be bigger than DN63 and the Contractor should propose the size depending on the design of the components and pumping requirements.

j) The geometry of the active beam elements should exclude possibility for direct and straight path of photoelectrons to the sputter ion pumps.

k) Threads should comply with metric standard.

l) All motor driven motions must be equipped with high duty limit switches and absolute encoders (“instant on”) with an appropriate resolution. The Contractor is responsible for preparing intermediate patch panels between motorized elements and SOLARIS standard motion controllers (IcePAP) – if applicable, see Appendix CS1. The location of the patch panels on the support of motorized element will be defined at design phase.

2.4 Background and list of components

It has to be emphasised that a major limitation for the ordered set of components is the proximity of the existing beamline components and beamline backbone infrastructure. One has to take into consideration available space for the location of the supports and individual elements of the BL.

General overview

Current configuration: The operational beamline contains optics for one branch with end station presented in *Figure 1*. The orange section contains M3a optic element in M3 mirror unit, vacuum section and Exit slits chamber. The existing green optical part contains the gas cell, refocusing mirror M4a and end station. The green optical part will be reinstalled to the left branch by SOLARIS.

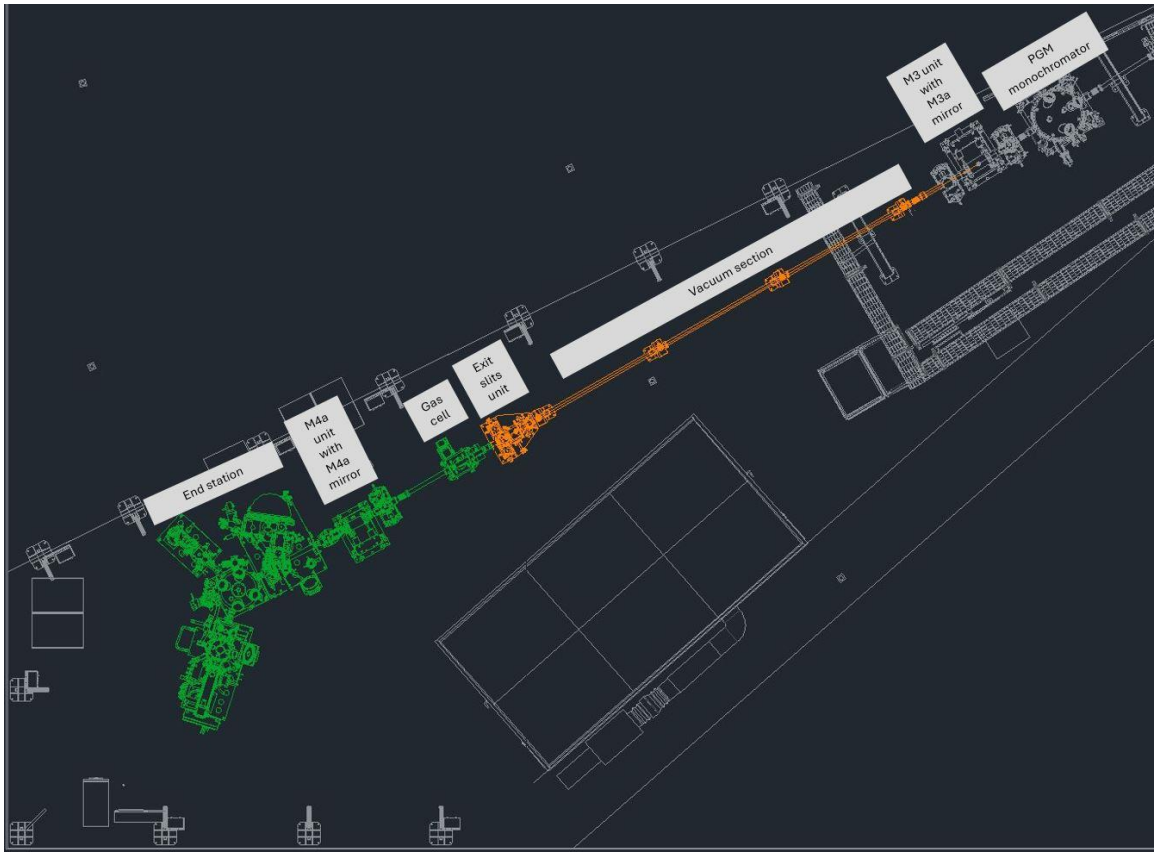

Figure 1. *The top view, it represents current beamline configuration with fully installed right beamline branch.*

The scope of delivery is schematically presented at the *Figure 2* by violet and blue parts. The violet part is related with left branch from M3 mirror unit to Exit Slits unit and the blue section is related with right branch and contains gas cell, diagnostics and refocusing M4b and M4c optics.

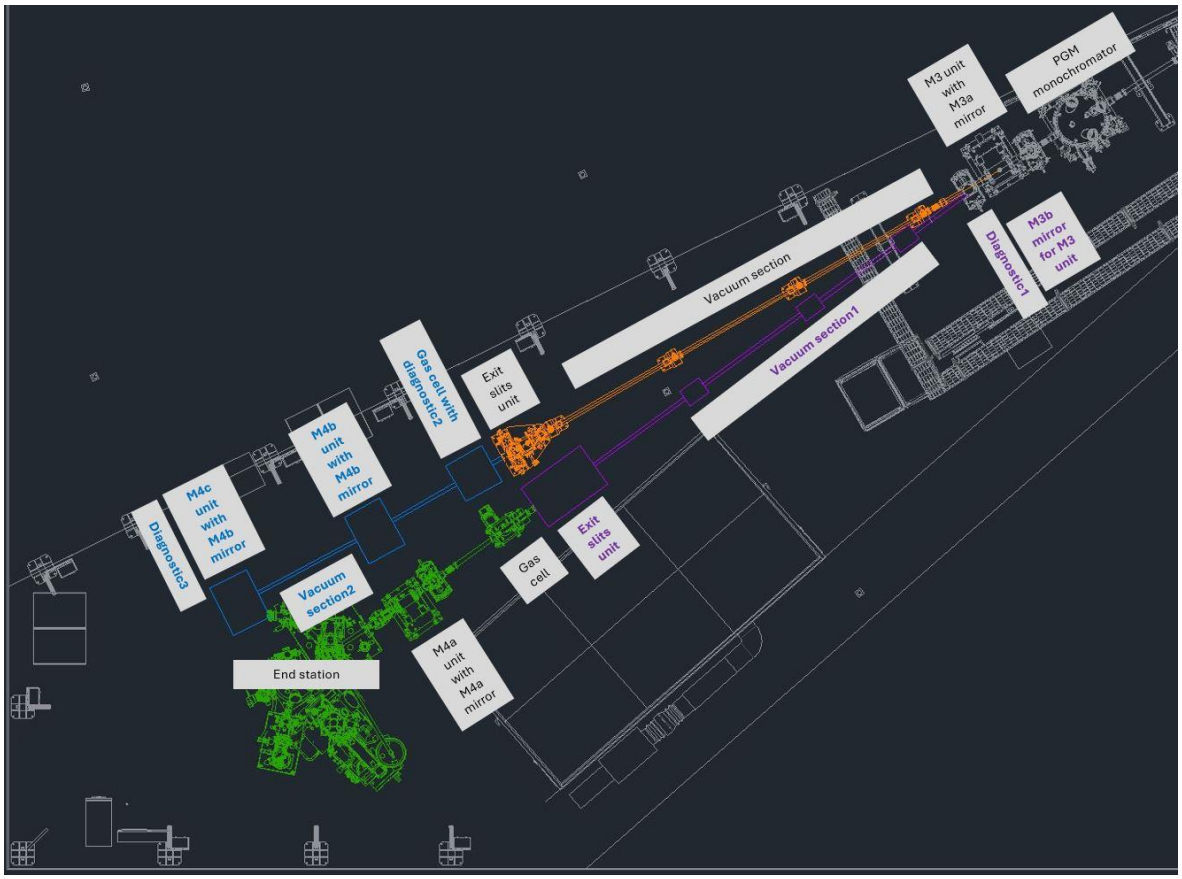

Figure 2. *The beamline top view, it represents beamline configuration after delivery and reinstallation of currently used end station.*

The list of the ordered components with some general description is presented in *Table 1*. The detailed description of each component can be found in Paragraph 2.5.

No	Component	Provided by
0	The M3 vacuum chamber with one optic element. 17 000 mm from EPU source	Solaris
1	M3b optic element Toroid: L x W x H: 420 x 60 x 40 mm^3	Contractor
2	Diagnostic1: new diagnostic element downstream M3 unit : fluorescent screen/plate.	Contractor
3	Vacuum section1: between M3 unit and exit slits	Contractor
4	Exit slits (horizontal and vertical)	Contractor
5	Gas cell with photoionization element and two manual valves with soft X-ray membranes	Contractor
6	Diagnostic2: photodiode, space for calibration samples and YAG screen	Contractor
7	Vacuum tubes with pumping and bellows (upstream M4b mirror unit)	Contractor
8	Mirror unit for M4b optic element with dummy optics and pumping	Contractor

9	M4b optic element Sagittal cylinder: L x W x H: 240 x 50 x 40 mm^3	Contractor
10	The vacuum section2: between M4b and M4c mirror units with pumping	Contractor
11	Mirror unit for M4c optic element with dummy optics and pumping terminated with gate valve	Contractor
12	M4c optic element Elliptical: L x W x H: 240 x 40 x 40 mm^3	Contractor
13	Diagnostic3: element with photodiode	Contractor
14	Standard vacuum components Sputter ion pumps equipped with heaters, gate valves, all-metal angle valves; controllers for vacuum components (ion pumps)	Contractor

Table 1. *The list of main components of the beamline optics.*

The Contractor will design, manufacture and deliver components with compressed air and water cooling system, if required. The beamline components section can be connected with water cooling infrastructure by Purchaser using flexible tubes (delivered by SOLARIS) connected to water inlet and outlet of the BL infrastructure (for details see the guidelines for the scope of the project and execution of the compressed air and the cooling water system given in Appendix WAT-CA1 and WAT-CW1, respectively).

Components delivery will be divided into three parts.
Part 1 contains positions from 1 to 6 listed at *Table 1* and related standard vacuum components from position 14.
Part 2 contains positions 11 and 12 at *Table 1* and related standard vacuum components.
Part 3 contains positions from 7 to 10 plus position 13 listed at *Table 1* and related standard vacuum components from position 14.

2.5 Technical description of main components

The main components of the X-ray optics for PHELIX beamline components were briefly defined in *Table 1*. In the following sections the detailed description and technical parameters for each main component are defined.

2.5.1 Optic element M3b

The M3b mirror is a toroidal mirror operating for left branch. The new optic element will be installed in the second holder place in the already installed M3 unit. The main parameters of the optic element are summarized in *Table 2*. The technical drawing of the already installed M3a optic element in M3 unit can be presented to Contractor at the design phase.

Parameter	Value and unit
Name	Toroidal focusing mirror (M3b)
Material	Si

Shape	Toroid
Substrate dimensions (Length x Width x Height)	L x W x H: 420 x 60 x 40 mm^3
Optical surface	400 x 40 mm^2
Mirror clamp groove dimensions (distance to base x depth x width)	10 x 10 x 10 mm^3
Incidence angle	2.0º
Tangential radius	596 374 mm ± 1 %
Sagittal radius	331.6 mm ± 0.5 %
Tangential slope error (rms)	≤ 10 μrad
Sagittal slope error (rms)	≤ 25 μrad
Roughness	≤ 0.5 nm
Coating	Au 50 nm
Binding layer	Cr or Ta (depends on the Manufacturer)

Table 2. *The main technical parameters for M3b mirror element.*

2.5.2 The diagnostic1: new diagnostic element downstream M3 unit

The new required diagnostic element is fluorescent screen/shutter with fluorescent coating. It should be able to cover both reflected radiation cones from M3a and M3b optic element (right and left branch), respectively. The distance between two beam axis of left and right reflection at diagnostic element position (628 mm downstream M3a and M3b mirrors) is 65.9 mm. For the right (existing) branch the incident angle at M3a mirror is 1 degree and for the left branch the incident angle at M3b mirror will be 2 degrees which all together gives 6 degrees difference but asymmetric. The dimensions for fluorescent screen should be roughly, horizontal x vertical: 100 mm x 30 mm assuming vertical “reflection” towards camera. Camera orientation of 30-45 degrees vs incoming beam horizontally is possible with modifications of the existing vacuum vessel – no viewport. The fluorescent screen/plate can be installed in already existing vacuum vessel 17 628 mm from EPU source. If needed – new vacuum vessel is required. Please see photo of the existing vacuum vessel (*Figure 3*).
The screen should be motorized. The required motion resolution and repeatability should be 5 microns or better using stepper motor. The cooling requirements depend on the radiation beam heat load and that aspect must be verified by Contractor.

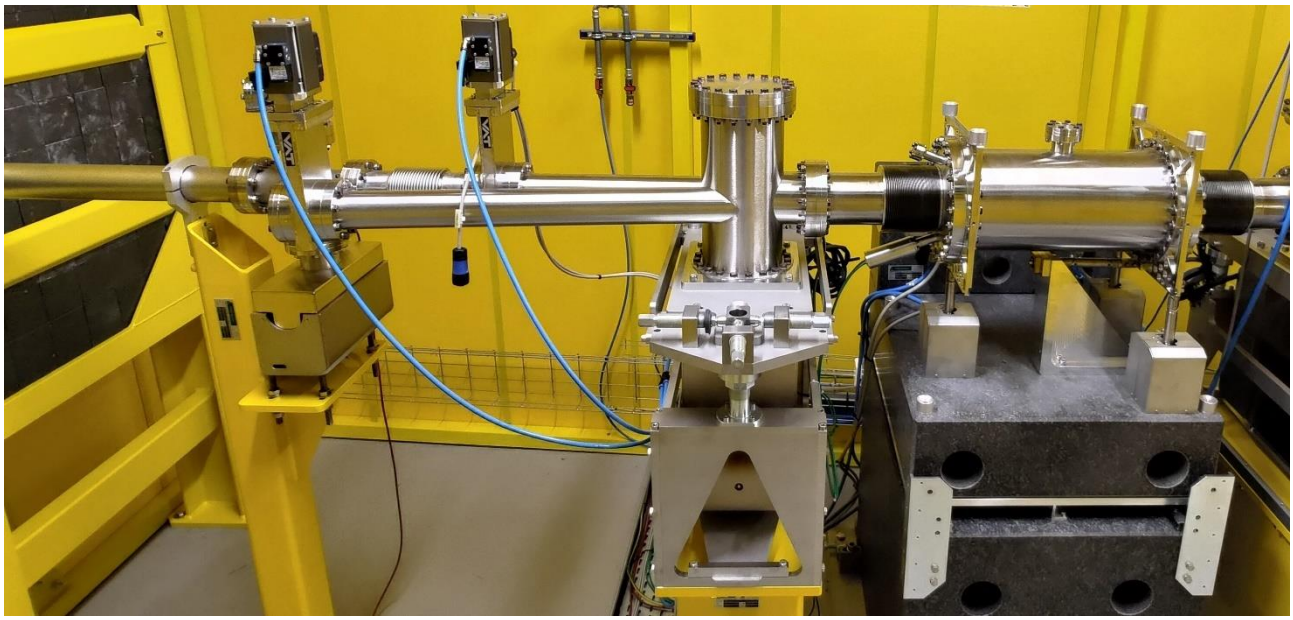

Figure 3. *Existing vacuum vessel installed downstream M3 mirror unit.*

2.5.3 The vacuum section1 with pumps and supports

The M3 mirror unit vacuum section is terminated by vacuum valve for each branch. Between the diagnostic element (downstream M3 unit) and Exit slit unit the synchrotron radiation transfer line with appropriate pumping stations, supports/support columns and vacuum bellows should be installed. The total length of the section will be less than 7400 mm, depending on the Exit slit unit solution. It is required to use vacuum gate valve in the middle of that section. The section should terminate with additional gate valve. We assumed 3-4 ion pumps for that section.

2.5.4 The Exit Slits unit (horizontal and vertical)

The Exit Slits (ES) unit will be used to determine energy resolution and to modify vertical beam size at the sample position. The unit should stand on separate support. To get the lowest possible vibration properties, the support should be made of a granite block. The chamber needs to contains mechanism allowing to change vertical gap from 0 to at least up to 1.8 mm and horizontal gap at least up to 10 mm with overlapping also 10 mm. In the FAT documentation should be written the values of the encoder positions when active slit edge for each blade is located at the beam axis position (chamber axis). These values should be determined with accuracy of 0.2 mm. The other technical parameters are summarized in *Table 3*. The blades (horizontal and vertical) should be coated with fluorescent material from the upstream side and the vacuum chamber should contain among other the viewports oriented towards the slits for camera allowing monitor the beam motion in horizontal direction. In the vacuum section with ES unit, upstream ES chamber the ion pump and gate valve should be installed. The vertical slits should be 26 500 mm from EPU source.

Parameter	Value and unit
Vertical slit gap	From 0 to 1800 μm
Vertical full step resolution	≤ 0.2 μm
Vertical repeatability	≤ 2 μm
Horizontal slit gap	From -10 mm to 10 mm
Horizontal full step resolution	≤ 1 μm
Horizontal repeatability	≤ 2 μm
Encoder resolution	≤ 20 nm
Limit switches	Two limit switches per limit, normally closed
Blade material	Tungsten or tungsten alloy
Vertical blade parallelism	≤ 1 μm over 10 mm
Horizontal blade parallelism	≤ 20 μm over 10 mm
Blades coating	Fluorescent material at front surface
Linear stroke of the chamber	+/- 50 mm

Table 3. *The main technical parameters for Exit slit unit mechanism.*

2.5.5 The gas cell unit

The purpose of this device is the energy calibration of the monochromator using ionization effects in gases (Nitrogen, Argon, Neon, etc.). Inside the chamber, two electrodes should be installed. The electrodes are charged with a high voltage. The photoionization current (at level below 50 pA) should be able to measured via dedicated feedthrough. The unit length should be maximum of 250 mm (flange to flange). The chamber will be located around 27 100 mm from EPU source. The free aperture should be at least H x V: 10 mm x 5 mm. At the entrance and exit port manual valve with dedicated soft X-ray membrane should be foreseen. The typical operation pressure is in the range of 10^{-2} mbar but the maximum allowed pressure should be at least 10 mbar. The required ports: electrical and HV feedthrough, needle valve for gas dosing, full range vacuum gauge. The special by-pass/connection tube with valve between needle dosing valve and high vacuum section of turbomolecular pump needs to be used. The turbo pump needs to be connected to the gas cell chamber via right angle valve to allow closing the section and switch off turbomolecular pump when needed. The turbomolecular pump (Pfeiffer HiPace 80 l/s, CF63 mounting flange), roughing pump for turbo and full range vacuum gauge will be delivered by SOLARIS.

2.5.6 The diagnostic2: element with photodiode, calibration samples and YAG screen

Downstream gas cell unit the motorized diagnostic element with photodiode (type AXUV, active area: 10 x 10 mm^2) and YAG screen should be installed. Additionally two slots for calibration samples (maximum sample size for each sample 11 mm, minimum sample size is

5 mm, square. It need to be allowed to install also rectangular samples) need to be foreseen. Each sample cartridge need to be electrically isolated to allow drain current measurements (total electron yield). The signal cable for each sample/slot need to be provided using BNC electrical feedthrough. All details can be discussed during design phase. The diagnostic2 unit needs to be installed directly downstream gas cell to minimize distance between photodiode and exit slits. The full step resolution for the liner stage should be ≤ 10 μm and repeatability ≤ 10 μm. Next to the diagnostic element the ion pump should be installed. The chamber should be compact and the section will be terminated with gate valve.

2.5.7 The mirror units for M4b and M4c optics with pumping

The mechanical system for both mirror units should allow the mirror to move in certain directions, while the "all in air" solution is required (without motors and other lubricated elements moving inside the chamber). The distance between center of the optical element and external slide shouldn't be larger than 375 mm. The Purchaser requires the Contractor to apply mechanical restrictions and limit switches to prevent damage of the mirror. The solution of vacuum chambers for both mirrors (M4b and M4c) must allow horizontal linear movement perpendicular to the incident beam of light, vertical linear movement and rotations providing three degrees of freedom (5 axis motorized: 2x translations and 3x rotations, *Table 4*), the reference system being defined by looking "from the source" towards the end station. Z coordinate determines the vertical direction and points to the floor. The X coordinate is oriented horizontally in the direction perpendicular to the beamline. The Y coordinate is oriented along the beam and points the end station. In the above reference system, rotation around the axis lying in the plane of the mirror and perpendicular to the direction of the beam (vertical axis) is referred to as "Pitch". Rotation around the axis along the mirror is referred to as "Roll". Rotation about the axis perpendicular to the mirror surface is referred to as "Yaw".

Parameter	Value and units	Repeatability	Remark
Vertical movement in Z axis		≤ 10 μm	**Motorized**
Range	±4 mm		
Resolution	≤ 5μm		
Transversal movement in X axis		≤ 10 μm	**Motorized**
Range	±4 mm		
Resolution	≤ 2μm		
Pitch		≤ 5 μrad	**Motorized**
Range	±8 mrad		
Resolution	≤ 1μrad		
Roll		≤ 5 μrad	**Motorized**
Range	±8 mrad		
Resolution	≤ 2μrad		
Yaw		≤ 5 μrad	**Motorized**
Range	±8 mrad		
Resolution	≤ 2μrad		

***Table 4**. Specifications of the possible movement of both mirrors (M4b and M4c).*

Repeatability for the translation axes and the "Roll" and "Yaw" rotation axes given in the *Table 4*, should be understood as one-way repeatability, while the repeatability for the "Pitch" rotation axis should be understood as bi-directional repeatability.
Due to the fact that the both refocusing mirrors will reflect a monochromatic beam, mirror cooling systems are not required.

With reference to the vacuum chambers solution for both KB mirrors, the Purchaser requires from the Contractor that:

a) The chambers of both mirrors are made in ultrahigh vacuum (UHV) technology and should contain pumping element (ion pumps). The assumed locations of the mirror units respect to the EPU source (to be confirmed during design phase) are: 29 300 mm for M4b mirror unit and 31 900 mm for M4c mirror unit, respectively.
b) The axis of the beam outlet must be set at angle of 2 degrees for M4b (reflection to the right looking from the source towards end station) and 3 degrees for M4c (reflection to the right looking from the source towards end station) to the input beam axis, respectively.
c) For both mirror chambers, both inlet and outlet flanges are DN63CF.
d) It should be possible to measure a photocurrent (drain current) at both mirror units from the M4b and M4c mirror.
e) Both of the chambers are supplied with the appropriate cylindrical and elliptical mirrors (M4b and M4c). Additional mechanisms which secure mirrors and mechanisms themselves for transportation, must be implemented in both chambers. In that situation dummy mirrors must be delivered in separate boxes. However, if, for objective reasons, the Contractor supplies the mirrors separately, the chambers must be delivered with the dummy mirrors attached and the both mirrors must be provided in separate boxes properly secured.
f) The mechanism of mounting for both mirrors in the vacuum chambers takes into account specific physical dimensions of the mirrors (item 2.5.8 of this specification).
g) The way of mounting of the mirrors shall not introduce stresses, vibrations but at the same time it should prevent uncontrollable shifting the optical element (the value of the incidence angle of 1 degree for M4b and 1.5 degree M4c, respectively, being critical for mounting mechanism in case of both mirrors). All materials/elements needed to correct mounting of both mirrors shall be provided by the Contractor, if needed. The last flange for M4c mirror unit should finish maximum 32 170 mm from source.
h) The solution of the vacuum chambers of the both mirrors enables easy (with minimal disassembly) installation / replacement of the optical element, i.e. without interfering with the beamline settings.
i) Each of the chambers shall have a view port DN63CF perpendicular to the optical surface of the appropriate mirror, which allows for the evaluation of the optical surface.
j) The chambers of both mirrors are delivered under vacuum conditions, which means that all vacuum flanges should be sealed in order to hold the vacuum inside the

chambers.

Additional equipment that should be included with each of the mirror chambers:
a) Stepper motors, precision absolute encoders, limit switches and other motorized elements enabling mirror control along with appropriate wiring (Appendix CS1).
b) Granite support or steel support (RAL 1023 color), however for the horizontal focusing chamber, a support is required whose dimension does not exceed 300 mm from the center of the mirror to the downstream support part.
c) Frames, holders and the adjustment elements of supports should allow the chamber position to be adjusted in the x, y, z directions (see Appendix ALIGN), additional external elements enabling the transfer of the chamber by means of an overhead crane (Appendix MECH1).
d) The Contractor has to foresee M6 holes with flat surfaces for mounting of fiducials standardized and free issued by SOLARIS. The Contractor shall mount these fiducials and use them for surveying within FAT before delivery. Fiducialization data shall be submitted with the delivery (Appendix ALIGN).
e) Materials for mounting the chamber to the supports and the support to the floor (screws, pins, anchors etc.) (Appendix MECH1).
f) One all metal angle valve should be foreseen for each vacuum section.
g) One ion pump for each mirror unit (compliant with SOLARIS standards - Appendix VAC1) equipped with a heater, mounted in such a way that it can be exchanged without moving the entire chamber (Contractor will design the port and size of ion pump suitable for the required vacuum level - Appendix VAC1 and VAC2).

2.5.8 Optic element M4b and M4c

The width and height both of the focusing mirrors (cylindrical and elliptical) should be appropriate to the final optical parameters of the mirrors. The Purchaser leaves the Contractor free to choose the mechanism of mounting the M4b and M4c mirrors, provided that their motion parameters are taken into account in a dedicated vacuum chambers (*Table 4*). The proposed physical and required optical parameters for both mirrors are listed below (*Table 5* and *Table 6*).

M4b mirror – sagittal cylinder

Parameter	Value and unit
Name	Vertically focusing mirror (M4b)
Material	Si
Shape	Sagittal cylinder
Substrate dimensions (Length x Width x Height)	L x W x H: 260 x 50 x 40 mm^3
Optical surface	240 x 20 mm^2
Incidence angle	1.0^o
Tangential radius	∞
Sagittal radius (*)	61.25 mm ± 0.3 %
Tangential slope error (rms)	≤ 1 μrad

Sagittal slope error (rms)	≤ 10 μrad
Roughness	≤ 0.3 nm
Coating	Au 50 nm
Binding layer	Cr or Ta (depends on the Manufacturer)

Table 5. *The main technical parameters for M4b mirror element. (*) The Purchaser reserves the right to change the radius curvature within +/- 10% due to possible space constrains related with Mirror unit dimensions which may cause need of adjusting/changing position of the M4b optic element along the beamline. Final confirmation of these parameters will be provided as soon as possible but latest at the PDR meeting.*

M4c mirror – elliptical curvature

Parameter	Value and unit
Name	Horizontally focusing mirror (M4c)
Material	Si
Shape	Elliptical
Substrate dimensions (Length x Width x Height)	L x W x H: 260 x 50 x 40 mm^3
Optical surface	240 x 20 mm^2
Incidence angle	1.5º
Semi-major axis (*)	4750 mm ± 0.3 %
Semi-minor axis (*)	103.2 mm ± 0.3 %
Tangential slope error (rms)	≤ 1 μrad
Sagittal slope error (rms)	≤ 10 μrad
Roughness	≤ 0.3 nm
Coating	Au 50 nm
Binding layer	Cr or Ta (depends on the Manufacturer)

Table 6. *The main technical parameters for M4c mirror element. (*) The Purchaser reserves the right to change the radius curvature within +/- 10% due to possible space constrains related with Mirror unit dimensions which may cause need of adjusting/changing position of the M4c optic element along the beamline. Final confirmation of these parameters will be provided as soon as possible but latest at the PDR meeting.*

The height and width of the mirrors may be different (according to recommendations dictated by the experience of the Manufacturer).

2.5.9 The vacuum section2: between mirror units

Between M4b and M4c mirror unit and its pumping parts the separate vacuum section should be provided. The section should contain vacuum chamber with ion pump for pumping and angle valve. The tubes length with chambers needs to be at least 1000 mm starting and terminated with gate valves. Downstream that section separate pumping for downstream mirror unit is needed. The purpose of that section is to allow deinstallation of the existing energy analyzer from the end station in case of failure. That is why this section should be

designed in such a way that relatively easy can be vented and later on baked out without influence on the M4b and M4c mirror unit vacuum level.

2.5.10 The diagnostic3: element with photodiode

Downstream the M4c mirror unit the motorized diagnostic element with photodiode (type AXUV, active area: 10 x 10 mm^2) is required. The full step resolution for the liner stage should be ≤ 10 μm and repeatability ≤ 10 μm. The total stroke depends on the design but should not exceed 100 mm. The install flange needs to be CF63.

3 Additional conditions

3.1 Schedule (design, manufacturing, tests, delivery)

The Contractor has to present a detailed schedule of all the activities referred to in these terms of reference.

a) The time schedule shall contain milestones (design reviews, tests and delivery) and give a rough overview about the design and manufacturing process that allows for an easy communication of the project progress.
b) The time schedule shall contain delivery dates etc. for all parts to be provided by the Purchaser.
c) The time schedule shall contain dates/periods for meetings, on-site visits etc.
d) The time schedule shall contain delivery dates for documentation prior to milestones.

Milestone	**Points to fulfil before the milestone is considered completed**	**Deadline**
Start up meeting/video-conference	Time schedule	Until the end of 3rd week from signing the contract
PDR (Preliminary Design Review)	The Contractor should have identified all technical issues and proposed technical solutions	To be agreed during Start up meeting
FDR (Final Design Review)	Detailed design completed. Acceptance of FDR by the Contracting Authority gives approval prior to manufacturing.	The design phase should be completed within 5 months of signing the contract including FDR meeting and possible corrections to the project and final acceptance within 2 weeks from the Design Review Meeting
FAT (Factory Acceptance Tests) and training	Agreed tests should have been completed by the Contractor and approved by Purchaser. Local staff has been trained by the	To be agreed during FDR Meeting

	Contractor with respect to proper maintenance and safe service of the provided equipment.	
Delivery of the beamline components	The goods should have been delivered to the agreed address and inspected for possible damage.	Part 1: 13 months from the contract signing Part 2: 15 months from the contract signing Part 3: 17 months from the contract signing
On-site installation	The assembly of ready elements with the rest of the beamline components will be performed by SOLARIS team. The Contractor will install optic element in M3 mirror unit and ensure the presence of a Supervisor during the installation of the remaining optical elements (no longer than four working days).	Until 2 months after complete delivery (point 3.6).
SAT (Site Acceptance Tests)	Agreed tests should have been completed by Purchaser and the delivered equipment should have passed all performed tests successfully.	Until 2 months after complete delivery

Table 7. *The time table of the project with main milestones.*

3.1.1 Preliminary and final design review

A preliminary design review (PDR) and a final design review (FDR) shall be foreseen. Documentation necessary for the approval of project milestones (e.g. PDR, FDR) shall be submitted sufficiently prior to these occasions (not later than 8 working days before meeting). During the Design Review (DR) Meeting, SOLARIS will approve the documentation or presents its remarks or objections. In case the corrections are necessary, the Contractor shall deliver the updated version of the documentation not later than 10 working days later after the DR meeting. The approval is to be granted within 2 weeks from obtaining all necessary documents and the final project of the subject matter of the contract related with certain review/milestone and particular milestone meeting. The SOLARIS approval will be limited to examination of the design with respect to the requirements stated in the technical specification of the Object of the order and the Contractor's offer. Any approval does not influence the Contractor responsibility for the overall performance and achieving the required operating characteristics.

All communication shall be in English. The Contractor shall appoint a project manager who throughout the whole undertaking acts as key contact for Purchaser. Meetings can take place at the Purchaser or at the Contractor's site or via video conference. All parties shall cover for their own travel and hotel expenses and will not be reimbursed by the other party.

<u>Preliminary design shall contain:</u>

a) Technical description of the beamline components,
b) Preliminary scheme of the cooling system for all delivered components requiring water

cooling,
c) Preliminary scheme of the compressed air system,
d) Number and type of motors for motorized axes, number and type of required encoders,
e) Preliminary 3D models, preferably in STEP file format,
f) Layout drawing including interfaces.

Final design shall contain:
a) Detailed technical description of the beamline components,
b) The 2D and 3D model and drawings of the beamline components including all elements with defined position of all required connectors (water, compressed air, power plugs, cable connectors, patch panels, etc),
c) Finite element analysis calculations for elements exposed to synchrotron radiation and required cooling (possible diagnostic elements) allowing estimation of the maximum temperature and cooling efficiency of the proposed solution,
d) Detailed scheme of the electrical wiring and supply,
e) Final list of recommended spare parts and cost,
f) Detailed scheme of the cooling system for all delivered components requiring water cooling,
g) Detailed scheme of the compressed air system for all delivered components requiring compressed air,
h) Final list for the motorized axes (number and type of motors for motorized axes, number and type of required encoders). The Contractor shall provide a table of motor and encoder models for each motorized axes, including range, repeatability, full step motion resolution and accuracy of each movement latest at FDR. All required data are described in the Appendix CS1,
i) The manuals and information necessary for the correct / safe operation of the components,
j) All the necessary information necessary to design the control system of the beamline section especially for mirror units motorization,
k) The list of the scope of installation work for both Parties.

The acceptance of the FDR for particular components of the beamline section by Purchaser gives approval prior to their manufacturing.

3.1.2 Factory and site acceptance tests

The Contractor shall foresee witness points during the assembly of critical parts. The FAT and SAT shall be foreseen. The scope of the FAT and SAT shall be agreed at the FDR meeting. The Contractor shall submit an agenda for the FAT. The agenda for SAT should be agreed between both Parties depending on installation obligations. Each Party shall submit an agenda for the SAT for their scope of work.

During Factory Acceptance Tests all standard tests shall be performed (vacuum tests, hydraulic function tests, mechanical metrology on all motorized motions, all electrical components shall be tested). The Contractor has to provide hardware and software needed to perform all tests of motion. All electrical components (switches, temperature sensors, etc.)

shall be tested at the FAT. All the tests are described in this document in section *4.1 Factory acceptance tests*. The components should be prepared for installation. The Contractor shall mount all components on each respective frame belonging to one support. The Contractor shall align all components on each respective frame with respect to each other and to the fiducialization points and provides fiducialization data.

The Purchaser shall conduct the SAT no later than two months after accepted assembled delivery. All necessary consumables as necessary for the sections assembly (screws, washers, caps, seals, connectors, required cooling water and compressed air circuits prefabricated components, etc.) and all other nonstandard tools will be delivered by Contractor. At the SOLARIS site, the pre-assembled sub-systems on each dedicated support will be aligned and checked. The documentation describing safety procedures during the assembly and disassembly process of each subassembly and the whole system should be provided to Purchaser and SOLARIS centre not later than one month prior to the delivery of a particular sub-assembly. A few pumping stations equipped with the turbomolecular pump with required pumping capacity and quadrupole mass spectrometer as well as bakeout controllers with heating tapes and thermocouples, bakeout jackets and aluminium foil will be provided during SAT by Purchaser. The SAT should be planned without photon beam. It is impossible to test the beamline components at full heat load within the scope of the SAT. The Purchaser therefore expects that the Contractor takes responsibility for obtaining required base pressure with photon beam in that sections and for failure free performance of the beamline components under full heat load within the warranty.

3.1.3 Installation

The SOLARIS will carry out the vacuum chambers installation and the SAT no later than two months after successful delivery of the certain part of the order. The Contractor will install optic element in M3 unit and will ensure the presence of a Supervisor during the installation of the optical elements (all together no longer than four working days). The subject of the order should be delivered in a form that is not very sensitive to the shipment.

3.2 Design and drawings of the beamline section

3.2.1 General requirements

The detailed design shall contain a geometrical scheme of the beamline vacuum chambers based on calculations and simulations confirming the achievement of the section specification. The SOLARIS approval will be limited to examination of the drawings with respect to vacuum and functional suitability of the design and does not influence the Sellers responsibility for the overall performance. The drawings must be updated as a result of any modification (as-built drawings). At the latest with the last delivery of the Subject of the order (latest together with the delivery of the beamline elements) the Contractor shall supply one hard copy and one soft copy of the assembly drawings and the manual (including technical data, procedures for system assembly, disassembly, maintenance and service).

The Contractor will provide guidelines and detailed information (described below) which will be the base for design and construction of the whole section infrastructure. All design

guidelines for compressed air, water cooling, electricity, signal cables and IT infrastructure shall be delivered together with the FDR meeting report. All data required for the motorized axes configuration (see Appendix CS1) shall be delivered within 2 months from the design approval (FDR meeting).

3.2.2 Mechanical requirements

The design will be provided in 2D (DWG or DXF) and 3D (STEP or IGES) formats and will include the location of the components: vacuum components and vacuum chambers, together with supports. The drawings will be the base for the project of the infrastructure (power electrical installation, low–current cable installation, cooling water and compressed air installations, IT infrastructure, radiation protection shielding and PLC system).

The Contractor is required to follow the requirements described in the NSRC SOLARIS mechanical standards (see Appendix MECH1).

3.2.3 Electrical requirements

The Contractor will present an ideographic diagram of electrical and signal installation for all components. Also provided shall be requirements for sockets and interfaces. The Contractor will provide guidelines for the low-current installation design (signal cables) – location of the connection points at the devices and their types (2D and 3D models).

3.2.4 Cooling water and compressed air requirements

The Contractor will provide guidelines for the cooling water installation and compressed air (location of the connection points at the devices, their types and required flows, pressure drops, 2D and 3D models). The BL components will be connected with water cooling infrastructure by Purchaser using flexible tubes (delivered by SOLARIS). Water lines that are feed into the vacuum chamber shall have no direct water to vacuum joints. The Contractor shall state the need for stabilized water temperature (temperature tolerance) for cooling of sensitive and synchrotron radiation beam defining elements. All details can be found in Appendix WAT-CW1 and WAT-CA1.

3.2.5 IT infrastructure requirements

The Contractor will provide guidelines for the IT infrastructure – beamline component location, 2D and 3D models, number of Ethernet interfaces needed to control the equipment foreseen in the project. The control system for all the BL elements will be based on the Tango Controls system (http://www.tango-controls.org/) (see Appendix CS0 and CS1).

The Device Server level software of Tango Control System for devices that are not SOLARIS standard will be delivered by Contractor. All control system software delivered by the Contractor shall be written in Python and be compatible with versions 3.6 of that language. It has to be licensed under an open-source license (e.g. GPL, LGPL, MIT, etc.). Device Servers must have unit tests written with test context (a part of PyTango, Python binding to TANGO), in-line functional documentation in Sphinx-compatible format and user guides.

3.2.6 PLC systems

The PLC systems is divided to two subsystems: Machine Protection System (MPS) and Personal Safety System (PSS). The Contractor is to deliver guidelines for the PLC safety systems designs including connections at components and their kind (2D and 3D models). All design guidelines shall be delivered within 2 months of the components design approval (FDR).

a) The Contractor will provide specification of all equipment which will be connected to the PLC systems, in particular wiring diagrams of on board interfaces and external connectors, voltage and current requirements etc.
b) It's preferred that all equipment served by PLC safety systems shall accept 24VDC signals as a standard voltage level.

3.2.7 Alignment

The Contractor is required to provide all the delivered devices with reference nests for the reference points. The location of the reference points needs to be agreed with the Contracting Authority in the design stage. The Purchaser will supply the Contractor with the required number of nests before fiducialization procedure within the deadline agreed with the Contractor. Together with delivery of the equipment and devices, the Contractor delivers documentation necessary for the positioning of the components including information on the situation of the reference points with respect to the beam axis (fiducialization documentation) surveyed during the post-production measurement (see Appendix ALIGN). Positioning of the components and supports are to be made by the SOLARIS employees based on the documentation delivered by the Contractor.

3.3 Compliance with SOLARIS standards

The IcePAP motion controllers will be delivered by Purchaser. All other elements will be delivered by the Contractor as ready for connection with the systems and technologies applied at SOLARIS and will be consistent with the standards described in the attachments. Exceptions from this rule are admissible solely where it is not possible to include standard elements in the Contractor's design. Such exceptions must be explained and discussed with the SOLARIS centre team. Other technical solutions if propose and production modes must be presented to the Purchaser in writing for approval. Approval, if granted will be in writing.

3.4 Quality control

Upon request of Purchaser the Contractor will present original certificates concerning the used materials determining their content, physical and chemical properties mainly for the materials which need to be used in the case of UHV sub-assemblies. Also possible will be audits and inspections during the section production.

3.5 Assembly identification

Identification marking on the stainless-steel plate mounted on the vacuum chamber, chemically etched or electrically engraved must enable identification of each subassembly

separately.

3.6 Packaging and delivery

All sub-assemblies of the BL components are to be delivered to the Purchaser by the Contractor. All subassemblies will be shipped in protection against damage or pollution during transport. All vacuum flanges shall be protected with blinds or mechanical covers to safeguard the surface of flange seals and prevent pollution of the BL elements. Where necessary, the BL section elements shall be protected with suitable protection material. Suitable packaging and protection is to be ensured. The transported sub-assemblies of the components (including transport boxes or without them) shall be rigid so it is possible to raise them using the fork lift or crane without the risk of damage.

The procedure for accepting the delivery of the subject of the contract to the place of destination (before installation) will be carried out as follows:

a) The Contractor shall deliver the subject of the contract to the address indicated on the contract, in boxes, containers, on pallets, etc., properly secured and equipped with shock sensors and/or tilt sensors. At the time of accepting the delivery, the Purchaser will inspect the packaging and shock sensors visually and in the event of any damage or activation of the sensors, draw up an appropriate report and inform the Contractor and the entity responsible for transport.
b) The Contractor shall provide for the Purchaser a list of items (packing-list), which can be found in each box, package, pallet, etc., placed outside the packaging (box, pallet, etc.), inside the packing or by sending it by email no later than one day before delivery.
c) After adoption of the transport by the Purchaser, the subject of the contract (goods) will remain unpacked for at least two working days in order to the thermal stabilization.
d) The Purchaser will check the conformity of the delivered goods with the list of items delivered/attached by the Contractor.
e) The Purchaser shall inform the Contractor about the condition of the delivered equipment, and on the compliance of the contents of individual packages (chests, packages, pallets) with the list of items provided by the Contractor. Any shortages or damage (both packaging and things included in the list of items) will be immediately reported to the Contractor (up to 10 working days) together with attached photo or video documentation. The confirmation of the delivery will be an appropriate acceptance report in which the Purchaser accepts the delivery in full, in part or refuses to accept all or part of the delivery due to the damage found.
f) In the case of damage to the good, the Contractor is obliged to repair it on site or at the Contractor's office (packing costs, adequate security and transport / shipping of the goods shall be borne by the Contractor), or to replace the defective element with a new one within a specified period by the Purchaser after consultation with the Contractor.
g) After eliminating all irregularities (if they take place), the delivery is considered complete, confirmed by an appropriate protocol.

4 Contract completion

4.1 Factory acceptance test (FAT)

The Contractor is required to carry out and documented the following tests at the factory.

4.1.1 Vacuum tests

The Contractor is required to perform all vacuum tests at FAT stage. The tests shall be conducted according to Appendix VAC1, *Section 4. Acceptance tests*. The declaration of performance and performance of the outgassing rate tests for all vacuum sectors is one of the criteria for offer evaluation.

4.1.2 Mechanical tests

Verification of all mechanical movements in the designed range shall be performed.

4.1.3 Adjustment tests

The Contractor is required to check the settings of all elements of the beamline section on supports.

4.1.4 Electrical tests

a) Wiring test
b) Continuity tests
c) Functional tests: all cables and connections will be checked as per the following items: checking the consistency with the electrical design, concerning end switches, position encoders and all electro-mechanical subassemblies will be carried out using the relevant controlled for consistency with their specifications. All remotely controlled devices will be checked for correct operation. Compressed air actuators, motorized actuators, motorize axes and end switches will be verified with respect to the entire operating specified range.

4.1.5 Hydraulic tests

The Contractor is required to check internal cooling channels of each equipment by dry leak test with compressed air.

4.1.6 Motion tests

The motorised and unmotorised axes motion tests will be carried out in regarding total travel movements and limit switches activation. Additionally for all motorized axes measurements of an accuracy, resolution and motion repeatability parameters shall be performed. The position of the limit switches will be measured in reference to the absolute encoder position, marker 0 (zero) of incremental encoder or reference switch and written to the report. The tests shall be conducted with mounted encoders and external measuring devices. All control lines (Home, Limit+, Limit-, Disable) should be tested with hardware compatible with control lines electrical interface shown in the Appendix CS1 *Section 3.2*.

The Purchaser shall be entitled to witness all tests that may be necessary under the terms

of this specification, and shall be informed about the tests at least 3 weeks in advance. The test results must be documented and form an integral part of the required documentation.

4.2 Final site acceptance test on the construction site (SAT)

The SAT shall be planned without photon beam in the beamline section. The exact time of the SAT, as well as, its detailed scope and manner of its conducting are to be described and shall be agreed upon at the FDR meeting. The SAT will be carried out after accepted assembled delivery of all elements and will consist of at least the following tests:

4.2.1 Vacuum tests

All vacuum tests defined in the *Section 4. Acceptance tests* in the Appendix VAC1 except outgassing test.

4.2.2 Mechanical test

Mechanical operation test.

4.2.3 Electrical tests

a) Wiring test,
b) Continuity tests,
c) Functional tests: all cables and connections will be checked as per the following items: checking the consistency with the electrical design, concerning end switches, position encoders and all electro-mechanical subassemblies will be carried out using the relevant controlled for consistency with their specifications. All remotely controlled devices will be checked for correct operation. Compressed air actuators, motorized actuators, motorize axes and end switches will be verified with respect to the entire operating specified range.

4.2.4 Hydraulic function

The following tests are required in particular: static water pressure tightness for all water circuits.

4.2.5 Motorization tests

Total travel movements with limit switches activation will be tested for all motorised axes. Those tests will have to be conducted using IcePAP controllers and mounted encoders.

5 Documentation provided by the Contractor

Documentation necessary for the approval of project milestones (e.g. PDR, FDR, FAT, SAT) shall be submitted sufficiently prior to these occasions.
Documentation for all the mounted sub-assemblies regarding beamline section shall cover at least the following:

a) Stock-taking document concerning all the delivered equipment included their serial numbers, dates of delivery, names of manufacturers named as per the sub-assembly drawing code as well as stock-taking document of all the delivered cables.

b) Executive designs in the sense of assembly drawings and 3D (STEP or IGES format) simplified models and 2D (DWG or DXF format) models of the supplied equipment. It is responsibility of the Contractor to ensure that the information in the drawings is correct and complete.
c) Description of technical parameters of the regular services and maintenance. The Contractor shall supply the manual (procedures for system installation, assembly, disassembly, maintenance and service). The cost of all documentation shall be included in the contract. Together with documentation the drill plan of all required anchor holes for complete beamline section supports installation shall be provided. The location and size of the holes shall be defined as projection to the concrete floor respect to the photon beam axis from the source.
d) Instruction manual and electrical schemes.
e) Instruction manual and water PID and schemes.
f) The results of the motion tests, vacuum measurement reports and media (water) pressure tests performed during FAT.
g) Documentation of the fiducialization (procedure and results-coordinates).

6 Attachments

The terms of reference document is appended with the following attachments. The Attachments include technological descriptions used in SOLARIS, which the Contractor shall observe and comply with. Attachments constitute an integral part of the Terms of Reference.

a) Appendix MECH1 – Mechanics
b) Appendix MECH3-ID06 – Description of the ID06 beamline area
c) Appendix ALIGN – Guidelines in field of alignment
d) Appendix WAT-CW1 – Cooling water basic standards_2.3
e) Appendix WAT-CA1 – Compressed air basic standards_2.3
f) Appendix VAC1 – Guidelines for UHV Components at Solaris
g) Appendix VAC2 – Technologies and materials for SOLARIS UHV devices
h) Appendix CS0 – SOLARIS Control System Standards
i) Appendix CS1 – Motion Control Standard
j) Appendix SOURCE – synchrotron radiation source parameters
k) Appendix SOURCE-ID06 – EPU source parameters