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Specifications of the Monochromator for the X-ray Tomographic Microscopy (XTM) beamline (X02DA) of the Swiss Light Source

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Call for Tender:

Optical system consisting of a Double Crystal/Multilayer Monochromator including Vacuum Chamber and Support Structure.

The optical system is to be fabricated according to these specifications. The factory acceptance test will be surveyed by PSI staff and the site acceptance test will be performed by PSI staff accompanied by contractor representatives.

1 Project Overview

The Swiss Light Source (SLS) is a 2.4 GeV, 400 mA electron storage ring, operated at the Paul Scherrer Institut (PSI) in Villigen, Switzerland. The SLS started its operation in summer 2001 and currently five beamlines are open for users. In the immediate future, two additional beamlines will start their operation. The next beamline to be built is the X-Ray Tomographic Microscopy beamline (XTM). The new beamline will be dedicated to high-throughput microtomographic investigation at the micron- and submicron level, as well as real-time radiology.

The schematic layout of the XTM beamline is depicted in Fig. 1. The new beamline will be located at the X02DA port of the SLS and will receive photons from a 3.1 T superbend. The beamline has been designed to provide monochromatic as well as white beam to the experimental station .

The front-end includes SLS standard radiation safety equipment as well as an aperture system to reduce Bremsstrahlung and the total radiation power. The maximal angular extension of the photon beam, defined by the aperture, is ±1.0 mrad horizontally and ±0.3 mrad vertically. A CVD diamond window of 100 microns thickness located at 6480 mm from the source separates the UHV section of the machine from the HV section of the front-end.

The optical system described in this call will be installed in this HV section of the front-end and consist of a fixed-exit double crystal/multilayer monochromator (DCMM). The DCMM filters the X-rays produced by the superbend using a pair of Si(111) crystals coated with two different multlayers stripes. The space between the two stripes will be used for the Si(111) reflection. The vertical beam offset is 7 mm when operating with the multilayers and 25 mm when operating with the Si(111). The projected power impinging on the first monochromator crystal is 0.2 W/mm^2.

The crystal optics, the cooling unit and the vacuum equipment will be supplied by the SLS, while the contractor must provide the vacuum chamber and the mechanical assembly with the necessary feedthroughs.

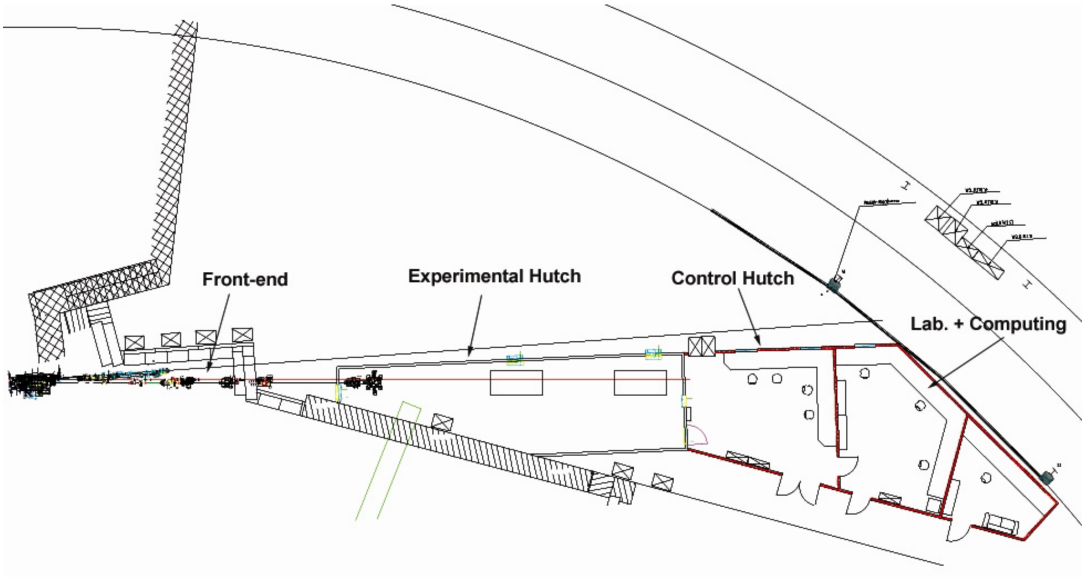

Figure 1: Layout of the XTM beamline X02DA. The optical system described in this call for tender will be installed in the front-end.

2 Summary

2.1 Scope of the specifications

These specifications cover the supply of design, materials, manufacture, cleaning, testing and delivery of the optical system of the XTM beamline X02DA of the Swiss Light Source (SLS). In addition to quotation the tenderers are encouraged to comment upon the specifications and are encouraged to make alternative technical proposals to PSI. After the contract has been placed, modification from the agreed specifications will not be allowed, except with written permission of SLS. The complete system must be delivered within 8 months of the contract award date.

2.2 Design concept and general specifications

The optical system will be installed in the front-end of the XTM beamline X02DA and consists of a double crystal/multilayer monochromator (DCMM). The DCMM should be designed to work with Si(111) reflection, with Bragg angles between 3° and 20° and with multilayers, with Bragg angles between 0.2° and 2.5°. This results in a long translation of the second crystal/multilayer along the beam direction. Characteristic features of the monochromator can be summarized as follows:

- high resolution of angular motion;
- high stability of angular position;
- good repeatability of angular position;
- good parallelism of the crystals;
- tight spatial constraints both in the direction of the beam and perpendicular to it;
- high vacuum environment
- possibility for white beam (direct beam)

The monochromator is expected to operate with a variable vertical offset (25 mm for Si(111), 7mm for the multilayers) and an independent rotation of the two crystals. The vacuum chamber must be as small as possible since the available space in the front end is limited (see drawing 0-30040.15.007). In the direction perpendicular to the beam (X), the delivered system cannot cross the dividing line between the DA and DB beamlines, in order to allow the positioning of additional equipment on the DB part of the front-end (see drawing 0-30040.15.006). The chamber must have two gate valves at the beam entrance and exit respectively.

The monochromator consists of two goniometers, which provide independent rotations θ_1 and θ_2 of the 1st and 2nd crystal, respectively. Both goniometers are equipped with a motorized horizontal translation stage (X_1,X_2) as well as a motorized adjustment of the angle around the beam direction (γ_1,γ_2-angle, roll). In addition, the 2nd goniometer is motorized along the vertical direction Y_2 and the beam direction Z_2 and includes a motorized adjustment around the crystal surface normal (ω_2–angle, yaw). The Y_2 translation is required to change the offset from 7 mm (multilayer operation) to 25 mm (Si(111) operation) and to maintain a fixed exit.

For diagnostic purposes it should be possible to remotely (and safely) place a small phosphor screen after the first crystal and remove it during normal operations.

The above described goniometers are placed in a vacuum chamber. The geometry of the vacuum tank is not specified but the outer dimensions as well as the positions of the optical elements according drawing 0-30040.15.007 have to be respected. The mechanics in the vacuum chambers should be accessed from all sides by removing the whole upper part of the chamber.

The monochromator is mounted on an optical table, which allows for a motorized vertical translation of the entire device. Jack and screws on the bottom part of the table provide the possibility for non-motorized vertical and horizontal translations as well as tilting about all 3 axes for alignment of the monochromator in the beamline. Both possible solutions, a separation of the vacuum system from the optical table as well as a combined system where the vacuum system forms an integrated system with the table are acceptable if they fulfill the specifications.

The whole system (support structure – optical table – vacuum chamber) must be removable from its location as a single unit with the hall-crane. This is very important since the system will be located in the front-end and in case of maintenance or urgent intervention a quick-removal as well as a precise re-insertion in the original position must be guaranteed.

Table 1: General Specifications:

Beam entrance height	1400 mm
Beam offset	7 mm (multilayer) upwards 25 mm (Si111) upwards
Bragg angle range	–0.5 ° to 25 °
Angular resolution	0.25 µrad
Angular repeatability[1]	2.5 µrad
Crystal parellelism[2]	5 µrad
Operating pressure	$< 2\cdot 10^{-7}$ mbar
Back-out temperature	130 °C

2.3 Definitions

2.3.1 Coordinates and motion

The Z-axis is pointing in the beam direction, Y is the vertical axis perpendicular to Z and X is perpendicular to both Y and Z (right handed system). Rotations around X, Y and Z are called pitching θ, yawing ω and rolling γ, respectively, when the Bragg angle is set to $\theta = 0$ ˚, see Figure 2 .

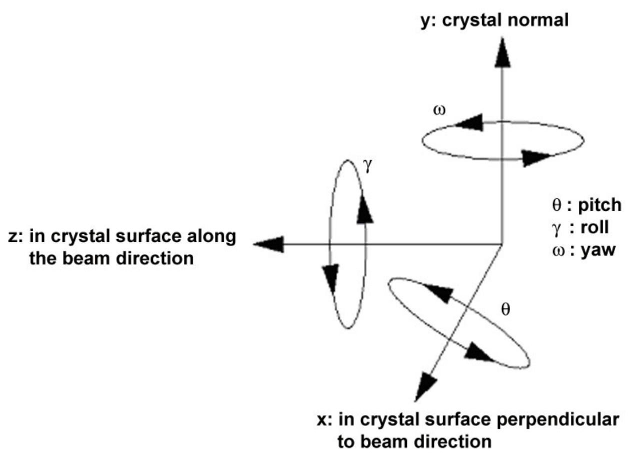

Figure 2: Definition of the coordinate system

2.3.2 Ideal resolution

Expected motion per one step of the stepping motor in full step mode.

2.3.3 Resolution

Minimum amount of motion which can be made by the actuator, resulting in a positional change with a relative accuracy better than 10%.

[1]See definitions in section Section 2.3.
[2]Defined as the maximum angular difference between the crystal orientation after a commanded rotation of both crystals of 0.2 ˚ in a scan.

2.3.4 Repeatability

Maximum difference between the primary position and the position to which the crystal returns after a specified loop travel.

2.3.5 Absolute accuracy

Maximum deviation between the desired position (angle or distance) and that to which the devices moves for any single motion from the origin position within the whole range of the motion.

2.3.6 Relative accuracy

Maximum deviation between the desired position (angle or distance) and that to which the device moves for any single motion within a specified range of motion.

3 Specifications

3.1 Design and fabrication of the vacuum chamber

3.1.1 Introduction

The optical system will be positioned between the filter/wire-monitor system A19 and the front-end shutter A21 (see drawing 0-30040.15.007) in the front end of the X02DA beamline. The supplier is asked to perform the design and fabrication of the chamber according to the specifications defined in this section. Deviations that differ from these specifications will be allowed only after approval of SLS.

The main components of the optical system are

- vacuum chamber
- optical table
- electrical connections
- water feedthrough
- blind flanges
- view ports
- alignment marks
- support structure

In the following section a description of the components is given.

3.1.2 Vacuum chamber

3.1.2.1 Vacuum

The optical system should be operated at a base pressure of less than $2 \cdot 10^{-7}$ mbar. This level of pressure should not be exceeded when the stepping motors run. The finished vacuum chamber, with installed double crystal monochromator but without the parts supplied by PSI, shall be demonstrated by the contractor to be helium leak tight and to produce a vacuum better than $2 \cdot 10^{-7}$ mbar. All vacuum flanges must be provided with a notch for leak testing.

The DCMM will be directly pumped by a 500 l/s ion pump (Varian VacIon Plus 500), supplied by PSI. With standard SLS pre-pumping equipment, the specified vacuum should be reached within 10 hours.

3.1.2.2 Bake-out provisions

The whole mechanism should be bakable at 130 °C for 24 hours. The tenderers are encouraged to provide alternatives if this should not be possible.

3.1.2.3 Electrical feedthroughs

The vacuum vessel should have the following electrical feedthroughs:

- one separate feedthrough for each pair of motors and their limit switches;
- one separate feedthrough for each encoder;
- one separate electrical feedthrough with at least 12 pins. This feedthrough will be used for the temperature sensors.
- at least two spare electrical feedthroughs.
- one spare feedthrough for two motors and their limit swithces

We prefer to have all electrical feedthroughs of the same type. The type should be discussed with PSI.
The corresponding male/female parts of all electrical feedthroughs should be delivered with the monochromator. All plugs should be disconnectable from both sides without soldering.

3.1.2.4 Feedthroughs for cooling circuit

The vacuum vessel should have two feedthroughs for the water-cooling of the first monochromator crystal. Its precise location in the vessel should be discussed with PSI. All air-side parts of the cooling feedthroughs should be supplied with the corresponding male/female parts.

3.1.2.5 Viewing ports

Two viewing ports (CF-150) made of glass should be provided at easily accessible points to permit optical inspection of each crystal. When located in the diagnostic position the retractable phosphor screen should be visible from the first window. The phosphor screen will be provided by PSI.

3.1.2.6 Pumping ports

The port for the ion pump is CF150 and should be rotatable. A CF100 (for an optional turbomolecular pump), must be foreseen, oriented along the vertical direction (preferably upwards) and be vibration-isolated. A CF40 port with gate valve (VAT series 10, supplied by PSI) is required for roughing, dry-nitrogen venting and leak-testing.

3.1.2.7 Port for vacuum gauge

The vessel shall have a CF40 port for pressure measurement (Balzers Compact Full Range Gauge PKR 260, supplied by PSI). In order to provide reliable pressure readings, this flange should be not too close to the ion pump.

3.1.2.8 Pumps, valves gauges

The pumps and standard vacuum equipment are not part of this call for tender. However, the design of the optical system should respect the space requirements of these items. The ion pump is heavy and an appropriate support and sufficient space for mounting should be foreseen.

3.1.2.9 X-ray ports

The vacuum flanges connecting the vacuum chamber to the up- and downstream components are CF63, if compatible with the DCMM design. The beam-inlet flange should be rotatable and the beam-outlet flange fixed. Vacuum seals are to use metal O-rings. Two all-metal valves, up- and downstream of the vacuum-chamber will be provided by PSI.

3.1.2.10 Large vacuum joints

Any vacuum joint of size greater than C-150 should include the possibility of using Viton O-rings. Note that the optical system will be located in the front-end where radiation-damage is an issue. Radiation sensitive joints should be therefore positioned as far as possible from the beam-orbit (1400 m from ground).

3.1.2.11 Reserve ports – Additional ports

Four CF40 and two CF63 reserve ports should be provided. The tenderer is invited to propose any supplementary ports and feedthroughs necessary for alignment, maintenance, handling and operation of the monochromator.

3.1.2.12 Access to goniometer mechanics

The design of the vacuum vessel should provide an easy access from all horizontal directions to the goniometer mechanics. Provision shall be made to lift the lids of the vacuum chamber with an overhead crane.

3.1.2.13 Location of feedthroughs, viewing and vacuum ports

The location of all feedthroughs, viewing and vacuum ports have to be approved by SLS.

3.1.3 Support structure

The optical table shall be supported by suitable support structures provided by the contractor. If a lateral load of 1000 N is applied to the support structure, the supported components shall not move more than 0.1 mm. Moreover, if a load of 300 N is applied to either of the vacuum flanges, the optical table shall not move by more than 5 μm. There shall be no vibrations of the optical table of more than 0.1 μm (rms) amplitude in the frequency range from 1 to 100 Hz.

The structures shall be made of carbon steel. The support structures must be painted with at least one primer coat and one coat of high-grade paint. The color must be deep blue.
The adjustment of the vertical position of the optical table shall be motorised. The main specifications are summarized in Table 2. Coarse manual adjustment of the optical table position and angle shall be provided, see Table 3.

Table 2: Y_T - optical table height adjustment

Actuator	Stepping motor
Motion range	± 10 mm
Resolution	10 μm
Maximal pitch	< 100 μrad over full range
Encoder with home position	Yes

The 500 l/s ion pump and gate valve shall also be supported by the support structure in a manner that allows the pump to be removed without dismounting the vacuum chamber.

Table 3: Manual bold adjustment for rough alignment of the optical table

	Range	Resolution
Vertical translation	± 10 mm	0.1 mm
Horizontal translation	± 10 mm	0.1 mm

3.1.4 Alignment and handling of the optical system

3.1.4.1 Alignment relative to the X-ray beam

The design of the optical system should provide an easy means to align the optical components relative to the X-ray beam. Namely, the monochromator vacuum vessel should be fitted out with at least 3 (preferably 4) holes for mounting survey monuments. An area with 50 mm diameter shall be left free around the holes for alignment target. The distances between the holes shall be maximised and their position relative to X-ray beam shall be known with an accuracy of 100 μm. A reference mark shall be positioned on the top and on the side of the DCM-vacuum chamber, indicating the nominal beam height (1400 mm from the floor) when all adjustments are in the mid position. The detailed layout of the holes will be provided by PSI.

3.1.4.2 Reproducibility of the alignment

All removable and exchangeable parts of the monochromator (covers, adjusting plates, etc.) should be supplied with appropriate fittings (precisely machined holes, pins, etc.) to provide reliable repositioning of the units. All internal mechanical assemblies must be designed so that disassembly and reassembly can be easily done.

3.1.4.3 Handling

All heavy components of the optical system should have provision for handling and lifting by a crane.

3.2 Design and fabrication of the 1st crystal goniometer and adjustment mechanisms

3.2.1 Introduction

The 1st and the 2nd crystal goniometers form a fixed-exit double crystal/multilayer monochromator. The vertical offset between the incident beam and emerging beam is 7 mm or 25 mm upwards when using multilayers or Si(111) respectively. The first crystal is water-cooled. Si(111) crystals with multilayers as well as the cooling unit will be provided by PSI.

Precision machining is expected on all mechanical components. All internal mechanical assemblies must be designed so that disassembly and reassembly can be easily done through the use of location pins or machined shoulders. If not stated otherwise, the axes of rotation lie in the crystal surface. The machining should allow the positioning of the rotation axis on the surface of the crystal with a precision of less than 100 microns.

In order to avoid temperature changes of the whole mechanical system induced by the operation of the goniometer motors, the motors should be cooled directly or using an heat exchange mechanism. In addition, special care has to be taken to minimize heat flow from the motor to the mechanics, e.g. by using ceramic couplings and spacers.

3.2.2 General description

The 1st crystal goniometer consists of a

- translation stage in X_1-direction
- θ_1 Bragg-angle adjustment
- γ_1 roll adjustment

The requirements on this goniometer and stages are summarised in Table 4 -Table 6. The horizontal translation stage and the goniometer should be equipped with linear and rotary encoders.

3.2.3 Detailed specifications

Table 4: X_1 - translation

Actuator	Stepping motor
Motion range	70 mm (± 35 mm)
Ideal Resolution	5 µm
Resolution	2.5 µm
Velocity	> 2 mm/s
Pitch (θ)	20 µrad, 2 µrad over 1 mm
Roll (γ)	25 µrad
Yaw (ω)	50 µrad
Limit switches	2
Encoder with home position	Yes

Table 5: γ_1 roll adjustment

Actuator	Stepping motor
Motion range	± 2 °
Ideal Resolution	10 µrad (full step)
Resolution	5 µrad
Velocity	> 0.1 °/s
Repeatibility	10 µrad
Axial wobble / surface run-out	10 µm
Limit switches	2
Momentum roll stiffness	1 µrad/kg·cm

Table 6: θ_1 and θ_2 Bragg angle adjustments

Actuator	Stepping motor
Motion range	-0.5 ° to 25 °
Ideal Resolution	0.5 µrad (full step)
Resolution	0.25 µrad
Velocity	> 0.25 deg/s
Accuracy over 0.2°	2 µrad
Repeatibility	1 µrad
Roll (γ)	±20 µrad
Yaw (ω)	±50 µrad
Axial wobble / surface run-out over 0.5°	1 µm
Limit switches	2
Encoder with home position	Yes

3.3 Design and fabrication of the 2^nd^ crystal goniometer and adjustment mechanisms

3.3.1 Introduction

The 2nd crystal goniometer holds the second monochromator crystal. It has a very long travel distance along the beam direction in order to cover the required energy range with the multilayers.

3.3.2 General description

The 2nd crystal goniometer consists of

- translation stage in X-direction
- translation stage in Y-direction
- translation stage in Z-direction
- θ_2 Bragg-angle adjustment
- ω_2 yaw adjustment
- γ_2 roll adjustment.

The requirements on these goniometer and stages are summarized in Table 7- Table 11. The Θ_2-Bragg angle adjustment is identical to the 1st crystal (Table 6).

Table 7: X_2 - translation

Actuator	Stepping motor
Motion range	70 mm (± 35 mm)
Ideal Resolution	5 µm
Resolution	2.5 µm
Velocity	> 2 mm/s

Pitch (θ)	20 µrad, 2 µrad over 1 mm
Roll (γ)	25 µrad
Yaw (ω)	50 µrad
Limit switches	2
Encoder with home position	Yes

Table 8: Y_2 - translation

Actuator	Stepping motor
Motion range	-5 mm to +30 mm
Ideal Resolution	5 µm
Resolution	2.5 µm
Velocity	> 0.5 mm/s
Pitch (θ)	25 µrad, 5 µrad over ± 0.5 mm
Roll (γ)	25 µrad
Yaw (ω)	50 µrad
Limit switches	2
Encoder with home position	Yes

Table 9: Z_2 - translation

Actuator	Stepping motor
Motion range	800 mm
Ideal Resolution	5 µm
Resolution	2.5 µm
Velocity	> 5 mm/s
Pitch (θ)	± 50 µrad, 5 µrad over ± 1 mm
Roll (γ)	± 50 µrad
Yaw (ω)	± 50 µrad
Limit switches	2
Encoder with home position	Yes

Table 10: γ_2 roll adjustment

Actuator	Stepping motor
Motion range	± 2 °
Ideal Resolution	5 µrad (full step)
Resolution	2.5 µrad

Velocity	> 0.1 °/s
Repeatibility	2.5 µrad
Axial wobble / surface run-out	10 µm
Limit switches	2
Momentum roll stiffness	1 µrad/kg·cm

Table 11: ω_2 yaw adjustment

Actuator	Stepping motor
Motion range	± 2 °
Ideal Resolution	5 µrad (full step)
Resolution	2.5 µrad
Velocity	> 0.1 °/s
Repeatibility	1 µrad
Axial wobble / surface run-out	10 µm
Limit switches	2
Momentum roll stiffness	1 µrad/kg·cm

4 Deliverables

4.1 Plans and schedules

To be provided to PSI within 3 weeks of placing the contract, for written approval:

- A time and manpower schedule of all activities covered by the contract;
- The quality assurance documents for all activities covered by the contract;
- A complete set of manufacturing, cleaning and testing procedures.

4.2 Inspection reports

Inspection reports have to be provided to PSI as they become available and as a complete set in the form of a documentation file at the end of the contract:

- Demonstration of compliance with the repeatability, accuracy and resolution of the inclination and translation positioning systems;
- Vacuum test results of the vessel.

4.3 Lists and procedures

The procedures for system assembly, disassembly and maintenance.

- A list of all tools and jigs required during the assembly, testing and alignment of the 1^{st} and 2^{nd} goniometer. These tools and jigs will later be available free of charge to PSI.
- A list of all drawings used in the manufacture, assembly, testing and alignment of 1^{st} and 2^{nd} goniometer. The drawings will remain in the possession of the contractor, but, upon request, they will be made available free of charge to PSI to facilitate repairs or modifications. PSI guarantees that information from the drawings will not be given to any third party without the written consent of the contractor.

4.4 The optical system

- The optical system as specified in Section 3 of this specification.

The tenders are asked to provide a separate quotation for the optical system with the motors/encoders supplied by the contractor and without the motors/encoders. PSI suggests the use of Renishaw or Numeric Jena encoders.

4.5 Look-up tables

The tenders are asked to provide calibration lookup tables to guarantee crystal parallelism for the Z_2-translation.

5 Standardization

5.1 Vacuum components

Design and fabrication of the vessels shall conform to the document: “UHV Materials and Technologies for SLS Front End and Beamline” (SLS-TME-TA-1998-0014). All the flanges and the gaskets must be Conflat (CF) type.

The vacuum chamber and pipes must be made of stainless steel AISI 304L, the flanges must be made of AISI 316LN-ESR; UHV Aluminum alloy A2219T87; the gaskets must be made of OFHC copper. Only non-porous ceramics which have been vacuum-fired should be used. The manufacturer must be approved by PSI and certificates must be provided. Other materials may be used as well, but must be approved by PSI with written notice.

Standard stainless steel bolts used for the final flange assembly shall be A4-80 Class, according to the UNI 7323 or similar standard; hexagon screw heads are requested for these bolts. All the bolts must be silver-plated, according to UNI ISO 4521. No brazed joint shall separate a water-filled channel from a vacuum environment.

All components inside the vacuum chamber including insulations and lubrificants, must be radiation resistant up to 10^7 rad.

5.2 Stepping motors, sensors, end-switches, encoders thermocouples

All stepping motors, encoders, cables and electronics must either be situated outside of the vacuum chamber or be compatible with a high radiation and a high vacuum environment.

Any stepping motors used to move the components shall be a 4 phase motor with 6 or 8 leads. PSI suggests to use HV-compatible Phytron (Waltham, MA, USA) 4 phase stepping motors (series VSS). The motors for θ_1 and θ_2 have to be cooled either by means of water or by connecting them to a temperature stabilized heat sink, in order to avoid temperature changes of the actuator system. Any other sensors included in the design shall likewise be readable via commercially-available VME cards.

All the end-switches must be mechanical types; PSI suggests using the products of Caburn UHV, Lewes, UK: model VH5LR for external use and model VH3 for internal use.

5.3 Contaminants and cleaning for high-vacuum service

High-vacuum compatibility is also required for the materials, coatings, bearings and lubricants of positioning mechanisms within the vacuum vessel. The delivered optical system is to be clean and ready for use in a high-vacuum environment for qualification without beam at $2\cdot10^{-7}$ mbar.

6 Quality assurance requirements

PSI prefers that manufacturers are registered to comply with ISO 9002 or an equivalent national standard. The requirements of PSI for quality assurance are stipulated in the specification ESRF/ENG/89/02 "Quality assurance requirements".

Control visits by PSI representatives must be possible, as described in the supply contract. In addition, a mandatory control will be carried out at the following points:

- during positioning, resolution and repeatability measurements
- before the final assembly

In order to schedule such inspections, it is required that PSI receives announcements of such events with two weeks advance notice.

PSI reserves the right to visit the contractor, upon reasonable prior notice, to review progress of the manufacturing process.

The contractor shall notify PSI immediately for review and approval of any design changes, fabrication discrepancies, changes in documented schedules or other commitments according to this specification and all terms of the purchase order.

7 Packing and shipping

The vacuum vessel, goniometers and support structures shall be packed and shipped separately. Upon arrival at PSI, it is the responsibility of the contractor to mount the complete assemblies into the vacuum vessel.

The contractor is responsible for the safe delivery of the optical system DDU. PSI. The shipping address is:

Dr. Marco Stampanoni
Swiss Light Source
Paul Scherrer Institut
CH-5232 Villigen PSI

Besides the shipping address, the following is to be displayed clearly on the outside of the packaging:

- the PSI contract number
- the weight of the loaded package
- support points for transport and lifting
- tilt indicators

8 List of components supplied by PSI

The multilayer crystals, the cooling support for the 1st crystals as well as the support for the second crystal will be supplied by PSI. Detailed drawing concerning these topics will be provided to the contractor within 2 weeks after the contract award time.

8.1 Components for inclusion in the optical systems

- 500 l VacIon Plus Star Cell Ion Pumps — 1 piece
- CF100 pneumatic gate valve — 1 piece
- CF40 pneumatic valves (VAT) — 1 piece
- Balzers PKR 260 DN40 Compact Full Range vacuum gauge — 1 piece
- Phosphor screen — 1 piece
- Linear and rotary (2) encoders with scale and home position markers if not purchased by the tender.

8.2 Components for test purposes at PSI

- HP 5529A Dynamic Calibration System
- Autocollimator Electronic Elcomat 2000, Möller Wedel
- Stepping motor controller
- Encoder display
- Vibration measurement tool
- Turbo molecular pump / Pre-pump
- Varian ion-pump controller

9 Drawings, Figures and Tables

9.1 List of attached drawings

- 0-30040-15.006 Front End (top view) – See Appendix A
- 0-30040-15.007 Front End (components layout, top + side view) – See Appendix B

10 Time Schedule

After signing of the contract there will be a joint design meeting at PSI within 5 weeks. The tenderer is requested to deliver the optical system to PSI by July 15th, 2005.

11 Appendix A

Low resolution drawing 0-30040.15.006: Tomography BL General Layout - Front End

12 Appendix B

Low resolution drawing 0-30040.15.007: FE - Components Layout