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Specifications of the Optical System of the SLS coherent Small Angle X-ray Scattering beamline X12SA (cSAXS)

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Call for Tender:

<u>Optical system consisting of double crystal monochromator and mirror vacuum chamber</u>
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.

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1 Project Overview

The Swiss Light Source (SLS) is a 2.4 GeV, 400 mA electron storage ring, operated at the Paul Scherrer Institute (PSI) in Villigen, Switzerland. The SLS started its operation in summer 2001 with currently seven beamlines that are open for users. One of the next beamlines to be built is the coherent small angle x-ray scattering (cSAXS) beamline X12SA. In the first phase of this project the hard x-ray branch of X12SA is constructed. The design of the beamline optics for this hard x-ray branch will be based on that of the existing Protein Crystallography beamline X10SA. The optical concept and the experimental environment are optimised for stability and reproducibility combined with a high degree of flexibility.

A schematic of the layout of the beamline X12SA is depicted in Fig. 1 and drawing 0-30040.65.007). The beamline will be located in a short straight section (X12S). A minigap, in-vacuum undulator (U19) serves as radiation source and will provide high brightness X-rays in the energy range 4.5 – ~20 keV for the hard x-ray end station. The front-end includes SLS standard radiation safety equipment as well as an aperture system to reduce Bremsstrahlung and the total radiation power. These apertures in the front-end define the maximal angular extension of the photon beam ±0.150 mrad horizontally and ±0.045 mrad vertically.

At a distance L of 28.5 m from the mid-point of the straight section, the X-rays will be energy filtered by a Double Crystal Monochromator (DCM). The fixed-exit monochromator will be equipped with Si(111) crystals with the second crystal being sagittally bent for horizontal focussing of the X-ray beam. Vertical focussing is achieved by means of a bent mirror, which is located in the vacuum chamber following the DCM (29.5 m). The optical elements will be placed on the same optical table. The power density impinging on the first monochromator crystal is as high as 12 W/mm^2 so that liquid nitrogen cooling is required. The vertical beam offset is 50 mm. A beam and Bremsstrahlungs-stop is necessary to protect the downstream equipment and because of the high contamination due to the small gap in-vacuum undulator.

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

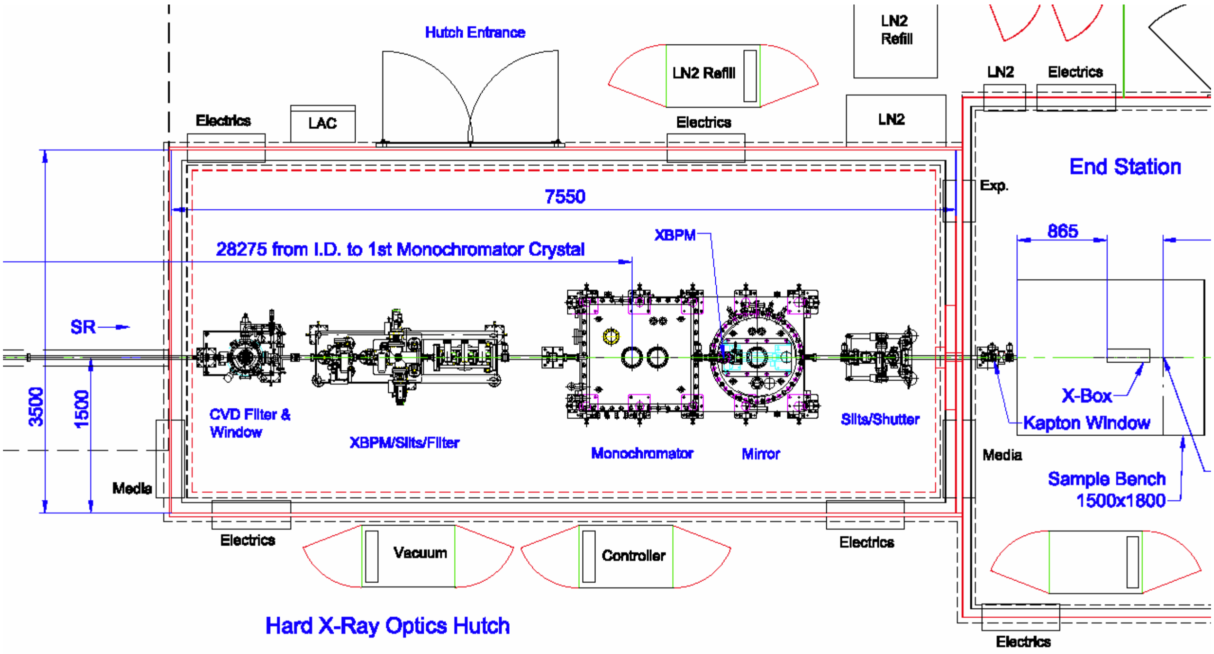

Figure 1: *Schematic representation of the layout of the hard x-ray optics hutch of the coherent small angle x-ray scattering beamline X12SA (for more details see attached drawings 3-30040.65.007 & 3-30040.65.008).*

2 Summary

2.1 Scope of the specifications

These specifications cover the supply of design, materials, manufacture, cleaning, testing and delivery for the optical system of the coherent small angle x-ray scattering beamline X12SA of the Swiss Light Source (SLS). In addition to quotation the tenderers are encouraged to comment upon the specifications and 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 nine months of the contract award date.

2.2 Design concept and general specifications

The optical system will be installed at the coherent small angle x-ray scattering beamline X12SA. It consist of a horizontally focussing double crystal monochromator (DCM) and a vertically focussing mirror. Only the former is part of the Call-For-Tender while the latter will be supplied by the SLS. The liquid nitrogen cooled first crystal holder will be supplied by the PSI. The sagittal bender for the second crystal should be fabricated by the tenderer. Characteristic features of the monochromator can be summarized as follows:

- high stability of angular position;
- high resolution of angular motion;
- good repeatability of angular position;
- good parallelism of the crystals for same angular increment;

- tight spatial constraints in the direction of the beam;
- high vacuum environment.

The monochromator is expected to operate with a fixed vertical offset and an independent rotation of the two crystals. The fixed offset is maintained by the horizontal translation of the 1st crystal along the beam propagation direction.

The double crystal monochromator and the mirror system are located on the same optical table. This design not only saves space but also provides highest stability. PSI proposes to use two vacuum chambers for DCM and mirror separated by two gate valves.

The monochromator consists of two goniometers, which provide independent rotations Θ_1 and Θ_2 of the 1st and 2nd crystal, respectively. The first crystal goniometer is placed on a horizontal translation stage, which moves the goniometer along the beam keeping the vertical offset constant when the Bragg angle is altered. The vertical offset is 50 mm. Both goniometers are equipped with a motorised adjustment of the angle around the beam direction (χ-angle, roll), while the 2nd stage also includes a motorised adjustment around the crystal surface normal (ϕ–angle, yaw). In addition, the 2nd goniometer is motorised in vertical (Y_2) and horizontal (X_2) direction.

The above described goniometer is 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 3-30040.65.008 have to be respected. The mechanics in the vacuum chambers can be accessed by opening a lit or removing the upper cover or the whole upper part of the chamber.

The monochromator and the mirror system are mounted on a common optical table, which allows for a motorised vertical translation of the devices. Bolts on the bottom part of the table provide the possibility for vertical and horizontal translations as well as all 3 axes tilting for alignment of the monochromator in the beamline.

TABLE 1. General Specifications:

Beam entrance height	1400 mm
Beam offset	50 mm
Bragg angle range	–0.5 ° to 25 °
Angular resolution	0.25 µrad
Angular repeatability[1]	1.0 µrad
Crystal parellelism[2]	2 µrad
Operating pressure	$< 2\cdot 10^{-7}$ mbar

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 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 ϕ and rolling χ , respectively, when the Bragg angle is set to $\Theta = 0\,^\circ$.

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 provoked by the actuator resulting in a positional change with a relative accuracy better than 10%.

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 chambers

3.1.1 Introduction

The optical system will be positioned between the filter system and the secondary slits – shutter system (see 3-30040.65.008) in the optics hutch of beamline X12SA. 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 can be followed only after approval of SLS.

The main components of the optical system are

- vacuum chambers, optical table, electrical connections, LN_2 feedthrough, blind flanges and view ports and alignment marks
- support structure

Drawing 3-30040.65.008 shows the principle view of the optical system. The vacuum vessels house the double crystal monochromator and a beam- and Bremsstrahlung stop as well as the mirror and a X-ray beam position monitor. The DCM and the mirror are mounted on a common optical table. The XBPM will be installed directly in front of the mirror, mounted on a motorized X-Y actuator accessible from outside the vacuum chamber. Room has to be reserved for the installation of the beam-stop (see drawing 2-30040.56.515 and 2-30040.56.516).

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

3.1.2 Vacuum chambers

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.

The DCM and the mirror vessel will be directly pumped by a 500 l/s and a 300 l/s ion pump (Varian VacIon Plus 500/300, supplied by PSI), respectively. With standard SLS pre-pumping and turbomolecular pump equipment, the specified vacuum should be reached within 10 hours.

3.1.2.2 Mirror vessel

The mirror and the bender will be provided by PSI. Drawing 3-30040.56.059 shows side and top views of the system. Drawing 1-30040.56.022a shows the lateral translation mechanism that allows the coating of the mirror to be selected. The design of the vessel should minimize the space requirements in the direction of the beam.

3.1.2.3 Electrical feedthroughs

The vacuum vessels should have the following electrical feedthroughs:

i) one separate feedthrough for two stepping motors and their limit switches;

ii) one separate electrical feedthrough for each encoders;

iii) one separate electrical feedthrough for the XBPM;

iv) one separate electrical feedthrough with at least 8 pins in both vessels. These feedthroughs will be used for the temperature sensors, controlling the temperature of crystals and beam-stop, respectively;

v) one spare electrical feedthrough in each vessel.

We prefer to have all electrical feedthroughs of the same type, if possible with 22 pins. The type should be discussed with PSI. Appendix A contains a summary of the required pins.

The corresponding male/female parts of all electrical feedthroughs should be delivered with the monochromator. The re-assignment of the pins to the individual motor cables should be done by means of an additional patch panel.

3.1.2.4 Feedthroughs for cooling circuits

The vacuum vessel should have two feedthroughs for the cooling by liquid nitrogen of the first monochromator crystal. The feedthroughs for the LN_2 should be located in the upstream wall of the vacuum chamber. Flexible tubing will connect the feedthroughs with the crystal holder, connected via standard joints at both ends. The feedthrough should allow the tubes to be disconnected without breaking the vacuum. Drawings 1-30040.36.580a and 1-30040.36.390b show the principle layout of the flexible tubing inside the vessel. Its precise location in the vessel should be discussed with PSI.

All air parts of the cooling feedthroughs should be supplied with the corresponding male/female parts.

3.1.2.5 Viewing ports

Two big viewing ports (typically CF-150) should be provided at easily accessible points to permit optical inspection of each crystal holder. The material of the windows can be glass.

3.1.2.6 Pumping ports

The ports for the ion pumps are CF150 and CF100 flanges, respectively. They should be rotatable. CF63 ports with gate valves (VAT series 10, supplied by PSI) are required on the left side of each chamber when viewed along the beam direction for roughing, dry-nitrogen venting and leak-testing.

3.1.2.7 Ports for vacuum gauges

The vessels 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, these flanges should be not too close to the ion pumps.

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 pumps are heavy and appropriate support should be foreseen.

3.1.2.9 X-ray ports

The vacuum flanges connecting the vacuum chambers to the up- and downstream components are CF40. The beam-inlet flange should be rotatable and the beam-outlet flange fixed. Vacuum seals are to use metal O-rings. The O-ring grooves shall be designed such that the rings do not fall out upon disassembly.

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.

3.1.2.11 Access to goniometer and mirror mechanics

The design of the vacuum vessel should provide an easy access to goniometer and mirror mechanics. Provision shall be made to lift the lids of the vacuum chambers with an overhead crane.

3.1.2.12 XBPM manipulator

The installation of a XBPM (provided by PSI) is foreseen upstream of the mirror (see drawing 3-30040.65.008). A motorized actuator shall be integrated in the vacuum chamber in order to position it relative to the beam. Its stroke relative to the optical axis of the system shall be at least +/- 8 mm in horizontal and +20 / -3 mm in the vertical direction. The ideal resolution should be 2,5 µm in X and Y direction and the resolution should be 5 µm.

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 adjustment of the vertical position of the optical table shall be motorised. The main specifications are summarised 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

The 300 and 500 l/s ion pumps shall also be supported by the support structure in a manner that allows the pumps 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, both the monochromator and the mirror vacuum vessel should be fitted out with at least 4 holes for mounting survey monuments. The layout of the holes is represented in Appendix B. An area with 50 mm diameter shall be left free around the holes for the survey monuments. 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.

3.1.4.2 Reproducibility of the alignment

All removable and exchangeable parts of the monochromator and mirror (covers, adjusting plates, etc.) should be supplied with appropriate fittings (precisely machined holes, pins, etc.) to provide reliable repositioning of the units.

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 monochromator. The vertical offset between the incident beam and beam on-exit is 50 mm upwards. The first crystal is cooled by means of liquid-nitrogen, the second is sagittally bent. Both, the cooled crystal holder, and the LN_2 cooling tubes are supplied by PSI according to drawings 1-30040.36.390b and 1-30040.36.580a. The sagittal bender (drawings 1-30040.36.1848 and 1-30040.36.960c) should be fabricated by the tenderer. The Si(111) crystals 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 lies in the crystal surface.

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 consist of a

- horizontal translation stage in Z-direction
- Θ_1 Bragg-angle adjustment
- χ_1 roll adjustment.

The requirements on these goniometers and stage are summarised in Table 4 - Table 6. The horizontal translation stage and the goniometers should be equipped with linear and rotary encoders (Renishaw RGH25-UHV), respectively.

3.2.3 Detailed specifications

TABLE 4. Z_1 - translation

Actuator	Stepping motor
Motion range	200 mm
Ideal Resolution	0.5 µm
Resolution	1 µm
Velocity	> 2 mm/s
Pitch (Θ)	20 µrad, 2 µrad over 5 mm
Roll (χ)	50 µrad
Yaw (ϕ)	50 µrad
Limit switches	2
Encoder with home position	Yes

TABLE 5. χ_1 roll adjustment

Actuator	Stepping motor
Motion range	± 2.5 °
Ideal Resolution	10 µrad (full step)
Resolution	5 µrad
Velocity	> 0.1 °/s
Repeatability	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 (χ)	±20 µrad
Yaw (ϕ)	±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 2nd crystal goniometer and adjustment mechanisms

3.3.1 Introduction

The 2nd crystal goniometer holds the sagittally bent crystal monochromator.

3.3.2 General description

The 2nd crystal goniometer consist of

- horizontal and vertical translation stages
- Θ_2 Bragg-angle adjustment
- ϕ_2 yaw adjustment
- χ_2 roll adjustment.

The requirements on these goniometers and stage are summarised in Table 7 -Table 10. The Θ_2-Bragg angle adjustment is identical to the 1st crystal (Table 6).

TABLE 7. Y_2 - translation

Actuator	Stepping motor
Motion range	± 2.5 mm
Ideal Resolution	5 µm
Resolution	2.5 µm
Velocity	0.25 mm/s
Pitch (Θ)	20 µrad, 2 µrad over ± 0.5 mm
Roll (χ)	20 µrad
Yaw (ϕ)	50 µrad
Limit switches	2

TABLE 8. X_2 - translation

Actuator	Stepping motor
Motion range	± 10 mm
Ideal Resolution	5 µm
Resolution	2.5 µm
Velocity	0.25 mm/s
Pitch (Θ)	20 µrad, 2 µrad over ± 0.5 mm
Roll (χ)	25 µrad
Yaw (ϕ)	50 µrad
Limit switches	2

TABLE 9. χ_2 roll adjustment

Actuator	Stepping motor
Motion range	± 2.5 °
Ideal Resolution	1 µrad (full step)
Resolution	0.5 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 10. ϕ_2 yaw adjustment

Actuator	Stepping motor
Motion range	± 2.5 °
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

4.0 Deliverables

4.1 Plans and schedules

To be provided to PSI within 4 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

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:

- Interferometric measurement results demonstrating 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 1st and 2nd 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 1st and 2nd 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 3.0 of this specification.

The tenderers are asked to provide a separate quotation for the optical system with the motors supplied by the contractor and without the motors.

5.0 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.

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

5.2 Stepping motors, sensors, end-switches and thermocouples

All stepping motors, encoders, cables and electronics must either be situated outside of the vacuum chambers 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 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 to use 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 of 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 $2 \cdot 10^{-7}$ mbar.

6.0 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.

7.0 Packing and shipping

The vacuum vessels, 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 vessels.

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

Swiss Light Source
Paul Scherrer Institute
CH-5232 Villigen PSI
Attention: Dr. Franz Pfeiffer

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

8.0 List of components supplied by PSI

The crystals will be supplied by PSI. Detailed plans of the crystal holder geometry, the coolant connection and the sagittal crystal bender will be provided to the contractor within 2 weeks after the contract award time.

8.1 Components for inclusion in the optical systems

- 300 and 500 l VacIon Plus Star Cell Ion Pumps 2 pieces
- VAT series 10, DN 63 CF pneumatic gate valve 2 pieces
- CF40 pneumatic valves (VAT) 3 pieces
- Balzers PKR 260 DN40 Compact Full Range vacuum gauge 2 pieces
- Mirror bender with mirror and translation mechanism
- Beam stop
- X-ray BPM
- Renishaw linear and rotary (2) encoder with scale and home position markers
- Phytron 4 phase in-vacuum motors (requirements for DCM to be specified by contractor)

8.2 Components for test purposes

- HP 5529A Dynamic Calibration System
- Stepping motor controller
- Encoder display
- Vibration measurement tool
- Turbo molecular pump
- Varian ion-pump controller

9.0 Drawings, Figures and Tables

9.1 List of attached drawings

0-30040.65.007	X12SA Beamline Overview
3-30040.65.008	X12SA Optics Layout
2-30040.56.515	Beam Stop Assembly ('Strahlstop Zusammenstellung')
2-30040.56.516	Beam Stop Support ('Strahlstop Stuetze')
3-30040.56.059	Mirror ('Spiegel')
1-30040.56.022a	Mirror Assembly (‘Spiegel Zusammenstellung’)
1-30040.36.390b	Crystal Cooling ('Kristallkuehlung')
1-30040.36.580a	Crystal Cooling Assembly ('Kristallkuehlung Zus.').

1-30040.36.1848 Crystal Bender Assembly

1-30040.36.960c Crystal Bender ('Kristallverstellung Baugruppe')

9.2 List of attached figures / documents

- SLS-TME-TA-1998-0014
- Appendix B: Alignment hole

9.3 List of attached tables

- Appendix A: Pin requirements of electrical feedthroughs

10 Tentative Time Schedule

Deadline for quotes	15. November 2005
Signing of contract	30. November 2005
Finalized design following design review meeting	15. January 2005
Setup at PSI finished	31. August 2006

The joint design meeting should take place at the PSI within 6 weeks after signing the contract.