Description of the subject of the order
System for measurements using the small-angle X-ray scattering method for installation at the end station of the SMAUG beamline

The purchase is carried out as part of the investment project *Construction of an experimental beamline for research using small angle X-ray scattering* financed by the Ministry of Science and Higher Education (IA/SP/564156/2023).

Table of content

1. General information

The subject of the tender procedure is the construction of a system for small angle X-ray scattering (SAXS) studies, which is ultimately to serve as the end station of the SMAUG synchrotron beamline, constructed by Adam Mickiewicz University in Poznań. This involves several stages, beginning with the delivery and installation of the SAXS system at the SOLARIS National Synchrotron Radiation Centre. Subsequently, the system is to be launched using stationary X-ray sources. The next step involves integrating the SAXS system as the end station within the synchrotron system using the transfer line of synchrotron radiation. Finally, commissioning takes place to ensure the system's operation with synchrotron radiation, along with team training in its operation and service.

List of abbreviations:

PDR - *preliminary design review*

FDR - *final design review*

FAT - *factory acceptance test/tests*

SAT - *site acceptance test/tests* (in SOLARIS NSRC)

BM - *bending magnet*

SDD - *sample to detector distance*

2. SOLARIS NSRC and SMAUG beamline

SMAUG is a synchrotron beamline for research using small angle scattering of synchrotron radiation (SAXS). This beamline is constructed as part of a project coordinated by the University of Adam Mickiewicz in Poznań, and is located at the SOLARIS National Synchrotron Radiation Center in Kraków (SOLARIS NSRC). The SOLARIS synchrotron is a 3rd generation source of electromagnetic radiation based on a modern storage ring operating with an energy of 1.5 GeV. It possesses a low emittance value of 6 nm·rad and can sustain a maximum electron beam current of 500 mA. The magnetic structure of the storage ring consists of 12 identical achromatic "sectors" (Double-Bend Achromat - DBA), each of which was made of one iron block. Twelve straight sections were designed, each 3335 mm long. Ten of them are available for various types of insertion devices generating synchrotron radiation. The SMAUG beamline will operate on the basis of synchrotron radiation obtained from a bending magnet and is located in the new part of experimental hall of SOLARIS NSRC (Fig. 1). Detailed technical parameters of the BM source are described in Appendix SOURCE-1.

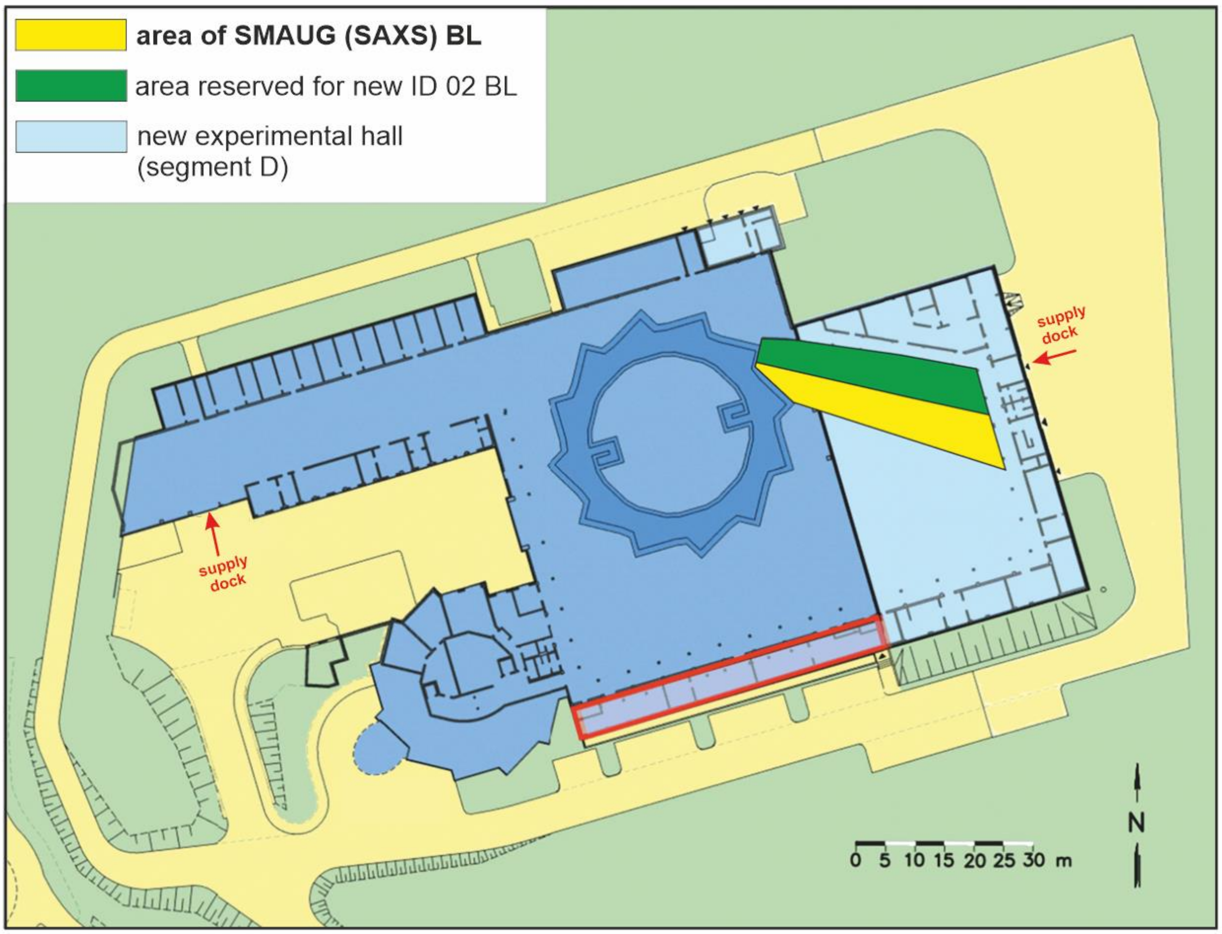

Figure 1. Schematic representation of the SOLARIS NSRC with the marked area in the experimental hall, dedicated for the construction of SMAUG beamline (yellow polygon), and loading docks enabling the delivery of beamline components.

3. General specification of the scope of the order

The SAXS system to be purchased through this tender is anticipated to possess the capability to perform X-ray scattering measurements in diverse geometric configurations and under various environmental conditions.

The system should have the ability to directly interface with the X-ray optics section of the SMAUG synchrotron line, which will serve as the primary radiation source. Additionally, the system should include auxiliary X-ray sources equipped with Cu and Mo anodes, as well as an optical collimation system. Furthermore, a vacuum experimental chamber should be provided, allowing for measurements to be conducted both in vacuum and in ambient air conditions.

In addition, the system should be equipped with a set of sample holders and sample chambers for studies in non-standard (non-ambient) conditions, attachments for specialized tests, X-ray detectors, appropriate detector holders, a cooling/heating system, a vacuum system, full infrastructure for generation of vacuum in the system (pumps, valves, pressure gauges, etc.), filter system (if necessary), computers for control of data collection and data analysis, as well as the necessary software for system control, data acquisition, data processing and analysis and a set of spare parts (at least for 2 years of system operation).

During the installation phase, it is essential for the system to possess complete measurement capabilities utilizing stationary sources. This involves the utilization of generators with high-flux microfocus X-ray tubes with Cu and Mo anodes with focussing optics.

The initial stage of the contract requires the Supplier to install the provided SAXS system utilizing stationary X-ray sources. They will be responsible for verifying the proper functionality of the experimental station using these stationary X-ray sources, following the specifications provided by the Ordering Party. **In the subsequent stage of the contract,** after the SMAUG beamline optics sector becomes operational, the Supplier will integrate the SAXS system with the optical infrastructure of the SMAUG beamline. They will also ensure the accurate integration of the experimental station with the synchrotron radiation source, adhering to the specifications provided by the Ordering Party.

The supplier of the device will be obliged to launch it in accordance with the permission granted to this entity to launch devices of this type (Act of November 29, 2000 - Atomic Law (Journal of Laws of 2023, item 1173 - Dz.U. z 2023 poz. 1173) and the current RRM). The Supplier will provide a copy of the documents submitted to the National Atomic Energy Agency (PAA) in order to obtain the above-mentioned. permits.

4. Technical parameters to be characterized by the delivered SAXS system

The X-ray scattering research system, the focus of this tender procedure, will ultimately function as the end station of the SMAUG beamline. Its primary purpose will be to facilitate the investigation of diverse biological systems such as proteins, nucleic acids, and lipids in solution, enabling bioSAXS studies. Additionally, the system will be utilized for measuring samples encompassing a wide range of materials, including liquids (e.g., nanoparticle solutions, polymers, liquid crystals), gels, and solids (such as polymers, polymer composites, and molecular sieves).

4.1. Source of X-ray radiation

The system will be used in two experimental modes determined by the choice of radiation source.

The first measurement mode includes operation using two stationary (laboratory) X-ray sources intended for research before the integration of the final station with the SOLARIS synchrotron and during periods when, for technical reasons (periods of service downtime), the synchrotron ring is turned off.

The second measurement mode involves the use of synchrotron radiation supplied to the SAXS system from the BM02 SOLARIS bending magnet via the optics of the SMAUG beamline.

4.1.1. The stationary (laboratory) X-ray source

The supplied SAXS system must have a stationary (laboratory) X-ray source consisting of at least two independent X-ray tubes, integrated with an appropriate generator (or generators) and an optical system, that will allow the system to operate in a situation when synchrotron radiation is not supplied.

The X-ray source is an X-ray tube with a micro-point focus of size ≤ 50 µm and power P: 30 W ≤ P ≤ 50 W, combined with dedicated 2D X-ray optics providing monochromatic Cu Kα and Mo Kα radiation using a single reflection (for higher efficiency of X-ray photon flux).

The laboratory X-ray source should be characterised by the following parameters of the generated photon beam:

- for the Cu Kα radiation, the total flux of X-ray photons incident on the sample must be greater than 450,000,000 ph/s (number of photons/second),
- for the Mo Kα radiation, the total flux of X-ray photons incident on the sample must be, greater than 10,000,000 ph/s (number of photons/second).

4.1.2. The source of synchrotron radiation – basic parameters of synchrotron radiation beam delivered by SOLARIS NSRC

The source of synchrotron radiation for the small-angle X-ray scattering experimental system intended for the end station of SMAUG beamline is the bending magnet of the storage ring at the SOLARIS National Synchrotron Radiation Centre located in section BM02.

The specific parameters of the source are outlined in Appendix SOURCE-1, providing detailed information. Additionally, Appendix SOURCE-2 contains the anticipated parameters of the synchrotron radiation beam, which will be focused and collimated within the optical section of the SMAUG beamline.

The Ordering Party (OP) expects that the Contractor will connect the SAXS system (end station) to the synchrotron radiation source, after completing the construction of the optical part of the SMAUG beamline. The expected integration date is the first half of 2026 (approximately 24 months from signing the contract). Simultaneously with the tender for the SAXS system (end station), a separate tender will be conducted for the construction of the optical section of the SMAUG beamline. The Ordering Party will provide the Contractor with all required technical data of the designed X-ray optics of the SMAUG beamline, in particular the beam position calculated from the experimental hall floor at the integration point and the parameters of the synchrotron radiation photon beam (diameter, intensity). However, the Ordering Party allows for a 6-month extension of the deadline due to the need to put the optical sector of the SMAUG beamline into operation (in case of any technical problems). To facilitate the connection of the X-ray optics section of the SMAUG beamline during the construction phase, a beryllium window or a window composed of a similar material will be fabricated. The window will meet the radiation transmission parameters specified by the Ordering Party, as defined in a separate tender for the optical sector of the SMAUG beamline. This window will serve as the termination point of the synchrotron radiation transfer line from the optical section. The schematic diagram of the optical section of the SMAUG beamline is presented in the attachment - SOURCE-2.

4.2. Basic technical parameters of SAXS system (end station)

The SAXS system must meet the following minimum technical parameters as required by the Ordering Party:

The expected resolution and covered range of the scattering vector should be:

- $Q_{min} \leq 0.009$ nm^{-1}, $\Delta Q_{pixel} \leq 0.002$ nm^{-1} (this value should be given based on the physical pixel size of the proposed detector), where $Q = \frac{4\pi}{\lambda} \sin\theta$, and 2θ is the scattering angle.
- $Q_{max} \geq 45$ nm^{-1}. **Q values calculated for Cu Kα**.

The collimation system must consist of at least 2 scatterless, fully motorized slits that provide a continuous change of aperture in the range of ~150 μm to ~2 mm in each direction.

The SAXS system should feature the ability to conduct experiments without the use of a beam stop (beam attenuator) as a fully integrated function of the system. It is intended to provide absolute beam intensity measurements by directly measuring beam transmission through the sample (instead of a semi-transparent beam stop). The detector must be equipped with a motorized protective window that can be automatically lowered and raised in front of the detector, which means the ability to remove the window during measurement under SAXS conditions or the ability to protect the detector when required. The protective window may be integrated with the detector or implemented in another way to achieve the required detector protection functions. The utilization of a semi-transparent beam attenuator for measuring beam transmission through the sample should also be incorporated into the plans for synchrotron radiation experiments.

The SAXS system should possess the capability to conduct automatic SAXS measurements without the need to turn off the radiation beam. It should also support direct detection of X-ray beam scattering, eliminating the requirement for a primary beam attenuator or beam stop in the configuration with stationary X-ray sources. In the operational setup, automatic SAXS measurements using a synchrotron radiation beam should be facilitated, including the option to perform measurements with a primary beam attenuator (beam stop). The inclusion of a beam stop in synchrotron radiation measurements is intended to safeguard the detectors against potential damage.

The SAXS system must also be delivered with a full complement of auxiliary equipment (vacuum pumps, cooling/heating systems, etc.) necessary for proper operation of the system.

4.2.1. Bonse-Hart module

The SAXS system is also to be able to measure samples with micrometric particle dimensions, therefore it is required to install a Bonse-Hart optics module (in the configuration offered in the tender). The Bonse-Hart optics module is to be fully automated for measurements in the USAXS (*ultra-small angle X-ray scattering*) range. This module should consist of a four-reflection silicon monochromator (Si (111) crystal plane) primary and an analyzer located in front of the detector creating a Bonse-Hart type system (in 0D detector mode), increasing in such setup the resolution of the SAXS system to $Q_{min} \leq 0.0015\ nm^{-1}$, **Q-values are calculated for Cu Kα**. The Bonse-Hart optics module is intended to enable the measurement of particles up to 2.5 μm in size and provide automatic continuous measurement in the USAXS/SAXS/WAXS (*Wide Angle X-ray Scattering*) range up to the scattering vector value $Q_{max} = 49\ nm^{-1}$. The Bonse-Hart module should be removable by the user if necessary or have the ability to automatically remove it from the radiation beam during measurements that do not require its use.

4.2.2. Experimental chamber and sample stages

The experimental chamber of the SAXS system should offer sufficient room to accommodate custom sample racks or measurement attachments, whether designed by the users themselves or specifically tailored for their needs

The experimental chamber should have a volume of at least 80 liters and be able to automatically detect the position of samples, holders and attachments/measuring chambers.

The design of the chamber must allow for the installation of an auxiliary WAXS detector with a matrix of up to 500,000 pixels.

- Motorized sample rack (stand) along 2 axes perpendicular to the X-ray beam propagation axis (along X and Z axes) for analysing and scanning of multiple samples. The rack must be capable of installing, moving, and positioning holders for multiple liquid samples, capillaries, powder samples, gels and solid samples (at least 15) for SAXS/WAXS measurements.

- All offered types of sample holders or attachments must be positioned automatically and controlled by the software controlling the measurements.

The experimental system, which will be purchased in this tender procedure must ensure scattering measurements with the sample in air and with a minimum air path (< 150 mm) for measurements in SAXS and WAXS geometries.

- The system must be able to fully reduce (attenuate) cosmic radiation to achieve a low noise level. The effect of cosmic radiation must be corrected by internal software, rather than by the detector's high-energy discriminator, so that it does not affect the detector's X-ray photon counting rate.

For the purposes of experiments using synchrotron radiation, the SAXS measurement system should be equipped with a semi-transparent beam stop based on a PIN diode (P-type, Intrinsic, N-type semiconductor).

4.3. Detectors

The X-ray detectors used in the SAXS system purchased in this tender should be capable of accommodating routine experiments involving both synchrotron radiation without attenuating the primary beam (with the option to install a beam-stop if necessary) and laboratory-sourced X-rays (specifically Mo Kα and Cu Kα). The photon flux for the synchrotron radiation beam will have an intensity of approximately 10^{12} photons/second with a cross-section beam size in both directions of approximately 100 to 150 µm.

4.3.1. Main SAXS detector

The SAXS system should be delivered with an integrated SAXS detector. This X-ray detector should meet the requirements of a ***semiconductor hybrid single photon counting detector*** with a single pixel size of 75 µm or smaller, based on a silicon matrix with a thickness of at least 450 µm. Required X-ray detector reference technology: Dectris Eiger2 or newer or equivalent. The expected resolution of the detector is at least 4,000,000 pixels (4M). The detector should possess the capability to operate effectively with both stationary sources equipped with copper and molybdenum anodes, as well as synchrotron radiation beams, without any significant loss in radiation energy within the range of 6 keV to 14 keV. The detector should be new, not older than 10 months.

The only acceptable method of attenuating the synchrotron radiation beam is a primary beam attenuator ("beam stop") located in the centre of the detector. The detailed technological parameters of the SOLARIS synchrotron are included in Appendix SOURCE-1, as well as the detailed parameters of the radiation beam formed in the optical system of SMAUG beamline and incident on the sample are included in Appendix SOURCE-2.

The detector installed in the SAXS system should be motorized along 2 axes perpendicular to the X-ray beam propagation axis (along the X and Z axes) to obtain an X-ray photon detection area > 200x200 mm^2.

The system must be equipped with a motorized hybrid photon counting detector with direct conversion of X-ray data. This detector should be mounted on a motorized stand along the beam axis (Y) to facilitate automatic adjustment of the sample-to-detector distance (SDD) within a range of at least 42.5 mm ≤ SDD ≤4500 mm.

The detector must have the necessary control and data acquisition system, integrated with the measurement control software. Acceptable number of dead pixels below 0.03%. The accumulation of dead pixels in a single detector area is unacceptable, as it will in any way affect the system parameters. The detector must have all required self-calibration and cooling systems.

4.3.2. Additional detektor – WAXS detector

The WAXS detector is designed for dynamic experiments with the possibility of simultaneous GISAXS and GIWAXS measurements or simultaneous SAXS and 2D WAXS measurements. The WAXS detector should be equipped with motorization capabilities to enable movement along a 1/8 Ewald sphere cantered on the sample measurement position. This movement is necessary to collect both in-plane and out-of-plane scattering data within the range of $Q \geq 57\ nm^{-1}$, allowing for the analysis of anisotropy. The WAXS detector must be movable, motorized and automatically moved outside the measurement chamber to a safe (parking) position so as not to interfere with the operation of the main detector for 2D SAXS/WAXS/GISAXS/GIWAXS, which means that it should not limit the SDD achievable by the main detector. To perform other scattering experiments (SAXS/WAXS/USAXS), it should not be required to remove the detector out of the experimental chamber. The WAXS detector should be a hybrid 2D photon-counting detector with direct X-ray detection (the required technology for the detector is a Dectris Eiger2 or a comparable alternative that offers similar performance and specifications.) with at least 500,000 pixels, with a physical pixel size of 75 µm or less.

The detector must have the necessary control and data acquisition system, integrated with the measurement control software. Acceptable number of dead pixels below 0.03%. The accumulation of dead pixels in a single detector area is unacceptable, as it will in any way affect the system parameters. The detector must have all required self-calibration and cooling systems.

4.4. Exposition module, exposition cuvettes and automatic sample changer for liquid samples.

The SAXS system will be used for studies of wide range of liquid samples (protein solutions, nucleic acids, etc.), therefore it is necessary to select an appropriate exposition module that will allow for the automation of these measurements and easy cleaning as well as maintenance. Therefore, a SAXS system should have the following components.

- The cell for SAXS measurements of liquid samples in small volumes, capable of measuring samples up to 5 μL (solutions of proteins and other macromolecules or valuable samples). It should be able to connect a UV-VIS spectrometer to measure the concentration at the sample exposition site (X-ray exposure).

- Flow through cell, capillary and low-noise (low X-ray background) cuvettes or cells with the option of the continuous delivery of sample (from microfluidic chamber - external).

- The studies conducted on the SAXS system will be used to verify samples from microfluidic experiments (carried out independently by users on external systems), therefore the measurement chamber (or cell) for liquid samples should enable manual introduction (injection) of samples obtained in microfluidic systems. The chamber/cell should therefore guarantee controlled manual injection of the sample using a syringe.

- Dedicated cell for liquid samples enabling direct injection of the sample via pipette into the measurement cell, without breaking the vacuum, with minimal transfer from the end of the pipette to ensure minimal sample loss and minimize surface tension effects for samples of high protein concentration and samples containing surfactants. This system must be equipped with an automated sample delivery/injection system using a robotic system.

- Automated pipetting system with direct sample delivery/injection into the measuring cuvette, featuring the following specifications:

    - ❖ A robot arm with precise control for automated operations.
    - ❖ Two 96 well trays/plates.
    - ❖ Reduced sample consumption to 10 μL (or smaller volumes).
    - ❖ Utilization of disposable pipette tips to ensure contamination-free measurements in the cuvette.
    - ❖ Thermostatic 96-well plates in the trays capable of maintaining a required working temperature range of at least +4 °C to +60 °C.
    - ❖ Automatic cleaning and drying of exposition cuvette (possibility to use 3 cleaning agents).
    - ❖ Seamless transition to sample measurements within the chamber without the need for dismantling the measurement cell or robot.

- The cell for liquid samples should also be equipped with an automated pumping system coupled with video monitoring that ensures automatic sample alignment in the cell, as well as continuous control of sample position during measurement and sample flow during measurement to reduce radiation damages.

- SEC-SAXS valve – the system should be equipped with a dedicated valve that enables Size Exclusion Chromatography (SEC) experiments coupled with SAXS. This valve will facilitate the seamless integration of a High Performance Liquid Chromatography (HPLC) system for comprehensive analysis.

- Video camera to monitor the measurement inside the chamber and/or in the cuvette. The system should be able to visualize samples during measurements.

4.5. Other experimental modules

- GISAXS (grazing incidence small angle X-ray scattering) experimental stage with adjustment of the radiation beam angle from -3° to +5° (omega) with resolution 0.002° or better. The module should be adapted to analyse various samples (different consistencies) with a holder diameter of at least 60 mm. The GI SAXS measurement stage should also be equipped with an additional degree of Phi rotation around the vertical axis in the range from -91° to +91° for texture and scattering anisotropy analysis. Resolution of Phi angle 0.01° or better.

- A holder (stage) for high-temperature X-ray scattering measurements adapted to experiments in vacuum on solids, capillaries, thin layers and the possibility of working in the SAXS/WAXS/GISAXS range. It should be able to operate in a temperature range of at least -150°C to + 350°C. The holder should be delivered in a set with a liquid nitrogen cooling system and an adapted Dewar vessel.

- Sample stage (holder) for measurements of multiple samples in heating/cooling regime using a Peltier module, capable of operating in a vacuum in the temperature range of at least -30 °C to +150 °C. This module must be adapted to studies of solids, powders, capillaries and capable of handling at least 8 samples of each type.

- Tensile stage – operating in temperature range -150°C to + 350°C and high force range 0-600N (0.01 N resolution), low force range 0-2 N (with 10^{-5} N resolution).

- RheoSAXS attachment – a compact shear cell (cuvette type), designed for simultaneous rheological and SAXS measurements (reoSAXS), providing axial and tangential measurement. The expected temperature range is at least +10 °C to +65 °C. The shear rate range should be at least from 0.2 s^{-1} to 1020 s^{-1}. Constant gap of 1 mm between the cylinder and the inner surface of the rotor. Operating mode: in controlled rotation speed (CR) and oscillation mode. The sleeve (funnel) and outer rotor of the cylinder should be made of polycarbonate or equivalent material ensuring effective X-ray transmission and low X-ray scattering. The cell should be adapted to work in the air.

- The dedicated cell for simultaneous measurements of differential scanning calorimetry (DSC) and X-ray scattering composed of single experimental chamber with temperature control and temperature scanning range from at least -150 °C to +600°C and the temperature change (scanning rate) of at least 100 °C/minute.

4.6. Software for control and data analysis

The SAXS system should be delivered with full computer software enabling control of the system and all its components, execution of measurements and processing of the results obtained.

In particular, the Ordering Party requires that the software provided with the system allows for the control of all system components, such as: source, shutter, slits, sample stages, robot for liquid samples, vacuum control system, temperature control system, detector position, all detector functionalities (data collection, data reduction, data transfer, etc.), data collection and other functionalities. The software should take into account the change in wavelength by the user (or beamline operator) in the energy range planned for the SMAUG line - from 6 keV to 14 keV. This functionality should be available in the control mode, preferably integrated during the final stage of the end station's integration with the synchrotron radiation beam. The wavelength change can be accomplished using a dedicated software of the SMAUG beamline. Wavelength information can be transferred automatically to the end station software (SAXS system under this tender procedure) or entered manually. This aspect should be decided during the FDR meeting.

In addition, the software must have a graphical interface for data processing enabling visualization of experimental data and their on-line pre-processing (2D images) during acquisition. The software should provide a real-time display of the ongoing measurements in the form of 2D images and 1D data profiles. It should include essential image processing tools to allow for necessary modifications to the 1D data profiles. The software should also incorporate advanced 2D data processing capabilities, such as GIWAXS (spherical Ewald projection) image correction and the ability to display 2D images in user-defined coordinates as per user requirements. The software also has to provide support for standard measurement functions and allows users to create custom macros using the software's documentation and user manual. This feature enables users to program and automate specific measurement procedures according to their needs.

The system should also be equipped with dedicated software to perform basic data analysis functions, such as automatic peak search, shape factor adjustment, determination of particle size distribution, calculation of specific surface area, calculation of the degree of crystallinity, determination of lamellar structure parameters, etc. 1D data should be compatible for further data processing with the open analytical software SASFit, ATSAS, SASView and IRENA package.

4.7. Computers for control of the SAXS system and data analyzis

The system should be delivered with a set of at least 3 computers:

- 1 computer for the control of measurements,
- 1 computer for data storage
- 1 computer intended for advanced data processing.

2 computers (for measurement control and data storage) should be selected adequately to the requirements of the SAXS system, and must have the following minimum parameters:

- Processor: Intel® Core™ i7-13700 (or equivalent)
- RAM (minimum) 32 GB DDR5-4 400MHz (UDIMM)
- Other parameters:
    - Discs:
        - 1st - SSD at least 1 TB, M.2 2280, OB M.2 SSD G4
        - 2-nd HDD – at least 4 TB 7200 rpm
- 2 x Intel I210-T1 PCIe 1Gb/s Ethernet Adapter (or equivalent)
- Integrated graphics card
- Power supply of at least 500W
- Operating system: Linux Ubuntu (or equivalent)
- Monitor: 2 x 27" 4K UHD LCD IPS Monitor 16:9 3840 x 2160

The computer for data processing and analysis should have parameters no worse than the example system below:

- Processor: AMD Threadripper PRO 2024, 24-Core 3.80 GHz AMD Threadripper Pro 5965WX (or equivalent)
- Processor cooling system: Liquid Cooling System (CPU; extra stability and low noise)
- RAM: 256 GB (4 x 64 GB 3200 MHz DDR4 ECC/REG)

- GPU Support: 1 GPU-Ready for 1x RTX 4090/4080 (1200W power supply) (or equivalent)
- system: Linux Ubuntu or similar
- Graphics card: NVIDIA RTX 4090 24 GB (or equivalent)
- SSD drive (operating system, applications): 15.36 TB PCI-E 4.0 NVMe SSD
- HDD drives: 2 x 22 TB HDD
- Network: 802.11ac WiFi + Bluetooth + 10 Gigabit Ethernet (built-in)
- Monitor: 32" 4K UHD LCD IPS Monitor 16:9 3840 x 2160 (or equivalent)
- Warranty/Support: Lifetime Expert Care & 3 Year Warranty.

4.8. Integration with the optical system of the SMAUG beamline

Following the installation at the NCPS SOLARIS, the SAXS system will initially operate solely with stationary X-ray sources (X-ray tubes) for an approximate period of 18 months. During this time, the installation of the optical section and synchrotron radiation transfer line will be carried out. **The Ordering Party requires the Contractor to integrate the SAXS system with the X-ray optics after completing the installation of the SMAUG beamline X-ray optics sector.** Integration also includes appropriate software modifications, if necessary, to maintain all required functionalities.

The Ordering Party requires that the integration process maintains optimal parameters of the synchrotron radiation beam supplied from the optical section. The Contractor should therefore provide appropriate parameters of the collimating slits (diaphragms) if the slits routinely supplied with the system require modification to adapt them to the synchrotron radiation beam described in Appendix SOURCE-2.

4.9. Other required parameters and technical conditions

The SAXS system and all of its components must be sourced as brand new equipment (including also all components from external suppliers).

Warranty - The entire device, excluding computers, detectors and X-ray sources supplied with it, comes with a standard 24-month warranty. Stationary X-ray sources, computers and detectors should have an extended warranty of 36 months. The warranty period is calculated from the moment of deployment.

Expected delivery and installation date of the full device: 7 months from signing the contract. The device must be connected to the SOLARIS synchrotron beamline within 18 months of its installation and must guarantee correct operation with this type of source.

The Ordering Party permits a 6-month extension to the integration stage, considering the parallel project involving the construction of the optical part of the SMAUG beamline.

4.10. The proposed location of the SAXS system in the experimental hall

The proposed location of the SAXS system in the experimental hutch of the end station is shown in Figure 2 and in files MECH1-SMAUG and MECH2-SMAUG. The SAXS system, as depicted in the schematic representation below, should be installed in the experimental hutch.

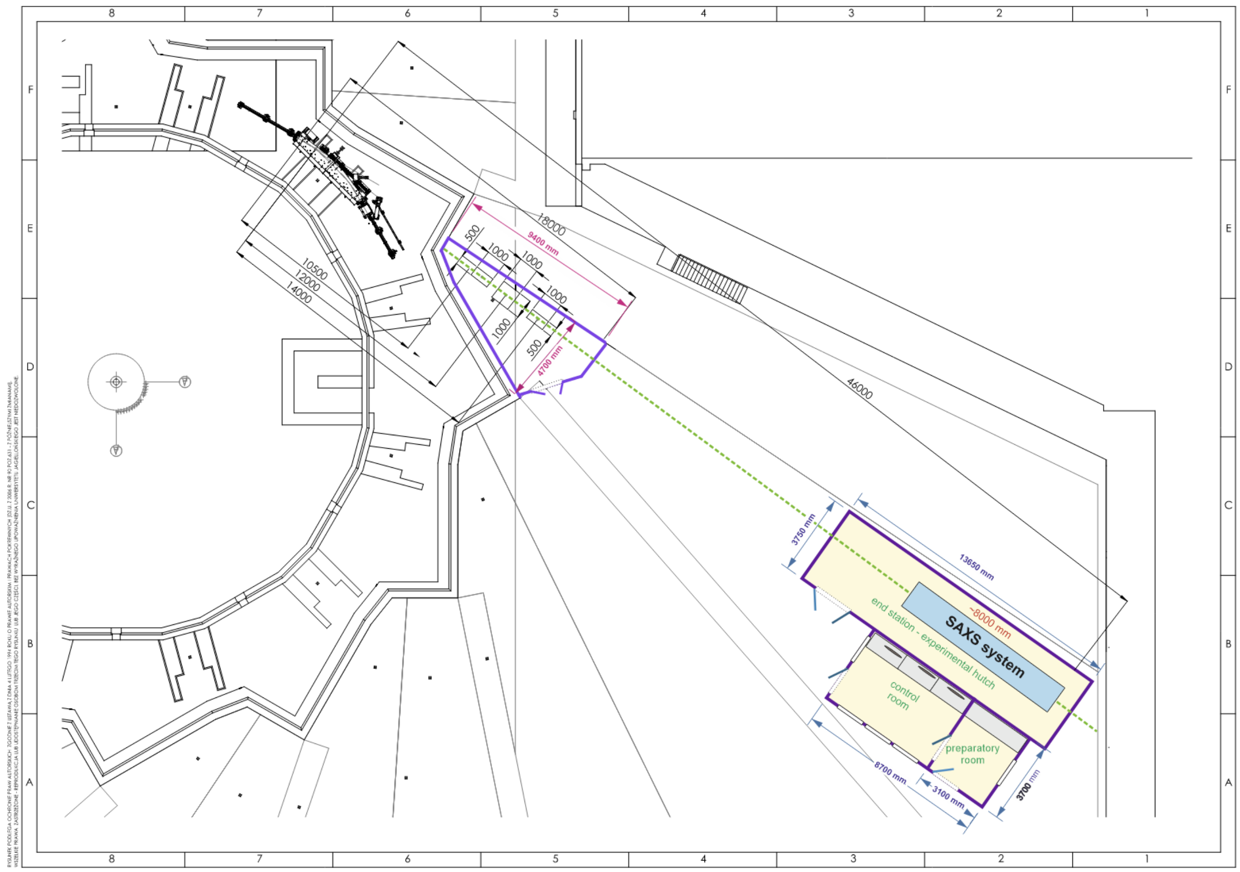

Figure 2. Schematic representation of the SMAUG beamline in the SOLARIS NSRC experimental hall (segment D) - optical section hutch and the end station area (marked in cream), including the experimental hutch and the control room.

4.11. SAXS system positioning

In order to ensure a precise connection between the SAXS system purchased through this tender procedure and the beam transfer line that delivers a monochromatic synchrotron radiation beam from the optical section of the SMAUG beamline, the Ordering Party deems it necessary to install reference sockets. Therefore, the Contractor is obliged to equip the system with reference sockets. The location of the reference points must be agreed with the Ordering Party and the SOLARIS NSRC team at the project approval stage (PDR, FDR). The Ordering Party will provide the contractor with the necessary quantity of sockets prior to the agreed -upon deadline for the fiducialization procedure.

Alongside the delivery of the devices, the Contractor furnishes the essential documentation for system positioning, which includes details about the reference point locations relative to the beam axis (fiducialization documentation. These details are verified during FAT tests through post-production measurements. For more information, please refer to Appendix ALIGN1.

The Ordering Party indicates that the positioning of the SAXS system in the experimental hall will be performed by the Contractor's employees in cooperation with the SOLARIS team based on the documentation provided by the Contractor (FAT tests).

5. Additional terms and conditions of order execution

5.1. IT infrastructure

The Contractor will provide guidelines regarding the required IT infrastructure, especifically outlining the requirements for LAN connections, including potential location specifications. The location must be agreed with the Ordering Party and the SOLARIS NSRC team at the project approval stage (PDR, FDR).

5.2. Security systems PSS (PLC protection)

The security systems employed at the SOLARIS NSRC are divided into two subsystems: the Synchrotron PSS and Experimental Beamline PSS. These subsystems, namely the Machine Protection System (MPS) and the Personal Safety System, have been developed with the purpose of ensuring the safety of personnel and users within designated areas. They are designed to prevent any exposure to ionizing radiation and have the ability to halt the synchrotron operation in the event of a hazardous situation. The security systems are built on PLC controllers (programmable logic controllers) and incorporate components that are reliable, safe in the event of damage, redundant and diversified (especially the most critical parts).

The Contractor will provide guidelines for the design of security systems if it is necessary to integrate the SAXS system with them. All project guidelines should be provided within 2 months of accepting the overall design (FDR).

After receiving radiological calculations and the radioprotection shield design for the above-mentioned system in the configuration as a separate end station as well as in the case of integration with synchrotron radiation, a decision will be made to build a radiation hutch and integrate it with the existing PSS system at SOLARIS NSRC.

If the SAXS system will not require the installation of an integrated PSS system when configured as the end station, it is necessary to provide appropriate documentation indicating compliance with radiological standards, etc. required by the Polish Law.

If the integration with the PLC system is necessary, the Contractor will be responsible for furnishing a comprehensive list of devices that necessitate connection to the PLC systems, in particular electrical connection diagrams elucidating the dedicated interfaces and external connectors, along with the requisite current and voltage parameters, and other pertinent specifications. The preferred devices supported by PLC safety systems are those that accept 24 VDC as the standard voltage on external input/output interfaces.

5.3. Cooling water and compressed air systems

5.3.1. Cooling water

The Contractor is obliged to comply with the SOLARIS NSRC requirements regarding the cooling water standards, as described in Appendix WAT-CW1.

The Contractor should present the requirements of the SAXS system regarding the use of the cooling water installation, if it is planned to be used during the execution of the order. The presentation of this data is expected no later than the Preliminary Design Review (PDR) meeting to ensure that they are considered during the design phase of the experimental hutch for the end station

5.3.2. Compressed air

The Contractor is obliged to comply with the SOLARIS NSRC requirements regarding the compressed air standards, described in Appendix WAT-CW1.

The Contractor should present the requirements of the SAXS system regarding the use of compressed air installations (continuous consumption, maximum instantaneous consumption). The presentation of this data is expected no later than the Preliminary Design Review (PDR) meeting to ensure that they are considered during the design phase of the experimental hutch for the end station.

5.4. Power Supply

Ordering Party provides electricity supply with a voltage 230/400V and frequency 50Hz.

To connect devices, use a 16A type E plug for 230V voltage and 32A 5P CEE plug for 400V voltage. Due to short distance from transformer, any overcurrent protection MCB, should have a short-circuit strength of 10kA.

5.5. Project schedule (design, production, delivery)

The Contractor will present a detailed schedule of all activities described in this specification and deliver it within one month from the date of signing the contract.

a) The schedule contains key dates of individual stages (designs, tests, deliveries) and is intended to provide a general overview of the design and production processes and to provide quick information on the progress of the project.
b) The schedule should include dates and delivery methods for all items to be delivered by the Ordering Party.
c) The schedule should include dates/periods for meetings, site visits etc.
d) The schedule should include deadlines for submitting documentation before individual stages.

Table 1. Summary of the main stages of the project.

Stage		**Elements necessary to consider the stage completed**	**Stage completion dates**
		Stage 1	
1.1	Start-up meeting/videoconference	Project schedule	Up to 2 weeks from signing the contract
1.2	PDR (Preliminary Design Review)	Contractor should identify all technical issues and proposed technical solutions.	6 weeks from signing the contract
1.3	FDR (Final Design Review)	Completion of detailed design. Acceptance of the FDR by the Ordering Party gives consent to production.	10 weeks from signing the contract
1.4	FAT (Factory Acceptance Tests)	The agreed tests should be performed by the Contractor and approved by the Ordering Party.	23 weeks from signing the contract
1.5	Delivery of end station (SAXS system) components	The items should be delivered to the indicated address and checked for any damage.	6 months from signing the contract

1.6	Installation of end station (SAXS system), SAT (site acceptance tests) and training	The agreed tests should be performed by the Ordering Party under the supervision of the Contractor (if required) and the delivered equipment should successfully pass all tests. The Contractor will provide training to the staff on the appropriate maintenance and safe operation of the equipment being supplied.	7 months from signing the contract for installation with laboratory X-ray sources (without synchrotron radiation beam)
Stage 2			
2.1	Integration of the end station with the beamline (on-site acceptance tests with a synchrotron radiation beam)	The agreed tests should be performed by the Ordering Party under the supervision of the Contractor (if required) and the integrated device should successfully pass all tests.	25 months from signing the contract. **The Ordering Party allows for the integration to be postponed by 6 months due to the need to complete the optical sector**

5.6. Approval of implementation stages

The preliminary design should include:

- Preliminary guidelines for the cooling system design for all elements requiring water cooling.
- Initial guidelines necessary for the compressed air system design.
- Preliminary guidelines for the functional aspects of the experimental hutch (design constraints related to the location of components and the installation process, infrastructure constraints, required electrical and IT connections).
- Preliminary guidelines for security systems (PSS), if their introduction is deemed necessary for the system. Radiological documentation confirming that there is no need to install PSS or that the system does not necessitate their implementation.

The final project should include:

- Detailed guidelines for the cooling system design for all elements requiring water cooling or acceptance of the design previously presented by the Ordering Party.
- Detailed guidelines for the compressed air system design or acceptance of the design previously presented by the Ordering Party.
- Detailed guidelines for the experimental hutch from the functional side (design limitations related to the location of components and the installation process, infrastructure limitations, required electrical and IT connections) or acceptance of the design previously presented by the Ordering Party.
- All necessary information for the design of beamline safety systems
- Scopes of installation works for both parties.

5.7. Proposed scope of acceptance tests (SAT, FAT)

Detailed scope of FAT and SAT tests will be agreed at the initial meeting or or no later than the Preliminary Design Review (PDR) meeting. The Ordering Party envisages the participation of members of the SMAUG beamline team in selected factory tests and acceptance tests.

The proposed acceptance tests at the Contractor's site (FAT)

- beam stability tests,
- mechanical tests of the robot,
- detector control tests,
- test measurements using the Contractor's standards,
- tests of all moving parts of the system (mechanics of the detector, attachments and sample holders, etc.).

The proposed site acceptance tests at SOLARIS NSRC (SAT) - after installation of the system with laboratory sources

- beam stability tests,

- mechanical tests of the robot,
- mechanical tests of all moving system components (mechanics of the detector, attachments and sample holders, etc.),
- test measurements (proposed standards: water, bovine albumin (BSA) and the Contractor's validation standards delivered with the LaB6 device, glassy carbon). Appropriate standards for test of GI SAXS module and DSC module will be selected on FDR.

5.8. Packing, delivery and installation

The system will be delivered by the Contractor to the installation site designated by the Ordering Party. The destination of delivery and installation is the experimental hall of the SOLARIS National Synchrotron Radiation Centre, ul. Czerwone Maki 98, 30-392 Kraków, where the installation is to be carried out. All components of the SAXS system for the end station of the SMAUG beamline must be properly shipped so that they are not damaged or become dirty during transport. Proper packaging and protection must be provided during transport. Due to internal regulations at SOLARIS NSRC, access to the hall is provided through the loading dock, therefore it must be ensured that the transported components are rigid, packed in boxes or other packaging that guarantees safety, and that it is possible to lift them using a forklift or an overhead crane without endangering them to damage. There is an overhead crane with a capacity of 8 tons in the experimental hall. The Contractor should estimate the working area in the hall required for storage and partial assembly of the system elements.

6. Final documentation delivered by Contractor

The documentation necessary for approval of project stages (e.g. PDR, FDR, FAT, SAT) should be submitted well in advance to ensure timely review and approval.
Documentation of all installed components of the SAXS system, which is the main element of the end station, should include at least:

- Acceptance document for all delivered devices including their serial numbers, delivery dates, manufacturer's names based on the component drawing code and acceptance document for all cables delivered.
- Warranty cards for all devices and components delivered by Contractor to the SOLARIS NSRC.
- Description of the technical parameters of regular service and maintenance of the delivered system. The contractor will provide a manual (procedures for installation, disassembly, maintenance and servicing of the system). The cost of all documentation will be included in the contract.
- User manual of SAXS system in Polish and English.
- Software installation files for SAXS system control, measurements and data analysis. The Contractor should ensure free updates of the software for at least 5 years.
- The Contractor should ensure that the software can be developed for at least next 5 years after installation, especially for new modules or components offered to the Ordering Party.
- Results of mechanical tests, reports of vacuum measurements and media (water) pressure tests performed during FAT.
- Documentation of system positioning (fiducialization) - procedure and result coordinates.

7. List of attachments

- Appendix MECH1-SMAUG – Plan of the SMAUG beamline work area.
- Appendix MECH2- SMAUG – Dimensions of the working area of the SMAUG end station.
- Appendix ALIGN1 – General technical assumptions for the construction and equipment of insertion devices, front-end sections or experimental beamlines in field of alignment issues.
- Appendix WAT-CW1 – Cooling water standards.
- Appendix WAT-CA1 – Compressed air standards.
- Appendix SOURCE-1 –parameters of the synchrotron radiation source (BM02).

- Appendix SOURCE-2 – The schematic diagram and parameters of the optical section of the SMAUG beamline.