BEATS

Workpackage 3

The X-ray Source

Front-End technical specifications for tender

D 3.5

July 2020

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☐	PP - Restricted to other programme participants & EC:	
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OVERVIEW

Work package 3 and work package 4 of the H2020 funded project BEATS (A tomography beamline for SESAME) both deal, among other tasks, with the layout of the beamline from source to experimental station.

During the technical design of the beamline's Front-End, experts from ALBA, ELETTRA, ESRF, and SESAME were involved.

It turned out that

- some of the Front-End components would be standard components already installed at other beamlines at ELETTRA and ESRF, for which fabrication drawings are already available, while
- others would have to be designed and fabricated following technical specifications established by ALBA.

Work package 3 and 4 therefore propose to divide the procurement of the Front-End components into two lots:

- Lot 1: (fabrication drawings exist at ELETTRA/ESRF) comprises the fixed mask, the CVD window, and the attenuator system, and
- Lot 2: (procurement consists of design and manufacturing) comprises the pumping unit #1 and #2, the x-ray beam position monitor, the photon shutter, the bremsstrahlung stopper, the trigger unit, and the combined stopper.

This deliverable, intended to serve as technical input for the upcoming Call for Tender therefore is composed of the following sections:

- Technical specifications (general technical specifications applicable to both lots)
- Conceptual design of the ALBA components
- Conceptual design and reference to the fabrication drawings of the ESRF/ELETTRA components

Apart from the technical specifications, some recommendations concerning legal and contractual consideration are given within this document. These are of course of indicative nature, as the final Call for Tender will be established by the SESAME Administration in consultation with the BEATS Procurement Advisory Board.

TECHNICAL SPECIFICATIONS

Introduction

The Synchrotron-Light for Experimental Science and Applications in the Middle East (SESAME) is an independent laboratory located in Allan in the Balqa governorate of Jordan, created under the auspices of UNESCO on 30 May 2002. The facility was established by a Consortium made of Bahrain, Egypt, Israel, Jordan, Pakistan, and Turkey and is operated under the supervision of a permanent Council composed by, at present, Cyprus, Egypt, Iran, Israel, Jordan, Pakistan, the Palestinian Authority, and Turkey. After several years of operation, a new beamline dedicated to X-ray tomography will be built. This beamline is being funded through the H-2020 project BEATS (Grant Agreement #822535).

A Front-End is the connection between the storage ring and the beamlines. Each Front-End comprises the elements from the vacuum gate valve on the storage ring until the valve downstream the trigger unit at the outer side of the shielding wall.

The objectives of the Front-End can be summarized as follows:

- To provide the vacuum path for the synchrotron light, from the storage ring to the beamline's optical hutch.
- To ensure radiation safety beyond the shielding wall during beam operation.
- To maintain and protect the vacuum in the storage ring from any accident occurring during the operation of the beamline.
- To protect optics and experimental stations from undesired synchrotron radiation.
- To monitor the photon beam position as well as the characteristics of the photon beam.

Scope of work and deliverables

The scope of the tender is the **design, manufacture, testing, packing and delivery** to SESAME of a series of Front-End components according to these technical specifications.

The Front-End components are divided into 2 lots as given below. SESAME can award the lots to different contractors.

- Lot 1: Pumping unit #1 and #2; Trigger Unit; Photon Shutter Unit; Bremsstrahlung Stopper Unit; Combined Stopper Unit; XBPM Unit
- Lot 2: Fixed Mask; CVD Window; Attenuator

The acceptance test on the SESAME site as well as the commissioning with beam will be the responsibility of SESAME and outside the scope of the contract.

Contractors Deliverables

Equipment	Pumping Unit #1
	XBPM Unit
	Fixed Mask
	Photon Shutter Unit
	CVD window
	Pumping Unit #2
	Attenuator
	Bremsstrahlung Stopper Unit
	Trigger Unit
	Combined Stopper Unit
	Detailed program for execution of the contract.
Reports and Documentation All documentation must be supplied in English unless otherwise agreed. All documents must be delivered in electronic format.	Monthly status reports (throughout all the execution period)
	Preliminary Design Review (PDR) documentation.
	Quality Control Protocol.
	Final Design Review (FDR) documentation.
	Test plan: Factory Acceptance Test Procedure(s).
	Factory Acceptance Test Reports.
	Full support documentation for all items of equipment, including all installation, operation and maintenance manuals.
	A maintenance plan proposal.
	Full set of electrical wiring diagrams for all equipment supplied to SESAME.
	Safety report.
	Quality Assurance Documents for the completed device with copies of all specified material certificates, details of all quality control checks and intermediate test results.
	A list of recommended spare items and any spare parts included within the tender: the costs of such items must be clearly identified whether included in the tender or to be purchased separately.
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Components and services supplied by SESAME

The following items will be provided by SESAME or will be procured at a later stage, and therefore, **are not included** in the scope of the contract:

Right angle valves	VAT all-metal right angle valve
Ion pumps	150l/s and 300l/s ion pumps
Vacuum gauges	Pirani and Cold Cathode vacuum gauges
Trigger gauges	Cold cathode gauges to activate Fast Closing Shutter
RGA head	CF63 RGA head that will be installed on the Bremsstrahlung Shutter unit

SESAME reserves the right to provide itself particular components, to be used in the construction of the Front-End. Bidders may propose that SESAME provides alternative ones, provided they are of the same quality, functionally compatible and more economical than the ones proposed by SESAME.

Timescales

The contract is divided in two phases: **Phase I: Design** and **Phase II: Production and delivery**.

Following the signature of the contract, the Design Phase (**Phase I**), shall not exceed five (5) calendar months, and the Production and delivery Phase (**Phase II**), shall not exceed ten (10) calendar months from the finalization of Phase I (or fifteen (15) months from the signature of the contract).

Accordingly, the main milestones of the contract are shown in the following table:

Milestone	Months after signature of contract
	PHASE I: Design
Start of contract	0
Kick-off meeting	1
Preliminary Design Review (PDR)	3
Final Design Review (FDR)	5
	PHASE II: Production and delivery
End of Front Ends production	14
Factory acceptance tests	14.5
Delivery and acceptance tests	**15**

Table 1: Main milestones of the contract

The month of August **shall be considered as a working month**.

General conditions of the contract

Contractor's Responsibilities

The Contractor is responsible for meeting all the requirements of these specifications, for all aspects of the performance of the device: mechanical, vacuum and electrical, as well as safety aspects, including testing and certification.

The Contractor will be responsible for the final design, the production methods and the correct performance of all items that are supplied, irrespective of whether they have been chosen by the Contractor or suggested by SESAME. Any approval of the design and components by SESAME does not release the Contractor from his responsibilities in this respect.

The Contractor will be responsible for the Factory Acceptance Test and transport of the supplies to the SESAME site. The transport shall be arranged in such a way that Front-End components do not suffer any damage during transportation.

The Contractor must provide all material and any necessary tooling, jigs and fixtures required for the manufacture of the Front-End. The contractor must also provide all test equipment and measuring instruments required to certify the performance of the device.

The Contractor is advised to work in close contact with SESAME at all stages of the contract in order to resolve any technical issues or problems that arise in the most timely and efficient manner.

The equipment shall be guaranteed a minimum of 24 months from the signature of the corresponding Certificate of Acceptance mentioned in the Administrative Terms and Conditions document (hereinafter referred as "ATC"), after the delivery of the supply, (including against faulty components or faulty manufacture).

The contractor will be responsible for the fulfilment of the information and publicity obligations requested by Authorities regarding the funding of the subject-matter of the contract.

Contract Management

Contract Contact Engineer

At the start of the contract the Contractor shall assign an engineer (the Contract Engineer) who will be responsible for all reporting to, and contact with SESAME.

SESAME will assign a technical contact person, at the same moment.

Contract Team members

At the start of the contract the Contractor shall assign a team of engineers and technicians which will be responsible for the different tasks.

The number and qualifications of the members **should be as a minimum**:

- One Mechanical Engineer
- One Vacuum Engineer
- One Mechanical Technician

Kick-off meeting

As indicated in Table 1, a Kick-off meeting will be held with the Contractor either at the SESAME site or through a videoconference.

The Contractor must issue a detailed programme for the execution of the contract covering the design, manufacturing, assembly, and testing phases in sufficient detail to allow a regular progress monitoring, it will have to be approved by SESAME.

The aforementioned programme shall include at least:

- Start and finishing dates of the tasks included in the scope of the contract.
- Dates for the PDR and the FDR.
- Material and equipment procurement periods.
- Fabrication period.
- Testing of major components and Factory Acceptance Test dates.
- Recommended site visits by SESAME personnel.
- Shipment and delivery to SESAME.
- Delivery date of the whole supplies of the contract.

Progress reports

After the Kick-off meeting and throughout the contract, the Contract Engineer shall supply a written report to the technical contact person of SESAME every month detailing progress with respect to the programme.

In the case delays of more than two weeks against any milestone in the agreed programme are anticipated, the Contractor will both inform SESAME immediately in writing, and will undertake all corrective actions to mitigate the impact on the contract deliverables.

Inspections

SESAME, or its representative, reserves the right to perform inspections at the Contractor's premises and, when deemed necessary, at that of its subcontractors. Contract inspections will be concerned with all contract compliance issues including programme, quality and performance. The Contractor must allow access to his premises by SESAME employees.

Preliminary Design Review (PDR)

As indicated in Table 1, within three (3) months of the signature of the contract a Preliminary Design Review will be held with the Contractor at the SESAME site (or per teleconference).

During this review the Contractor will present the proposed design solutions. SESAME and the Contractor must agree that the solution proposed is suitable and that one should proceed to a full design. The accompanying report shall contain, at least, the following information, and will have to be approved by SESAME:

- List of deliverables.
- Layout drawing including interfaces.
- Preliminary 3D models, preferably in STEP file format.
- Functional analysis of each component.
- A detailed manufacturing and testing programme, with regular milestones to allow progress to be monitored.
- Justification of proposed performances.
- Justification of safety and reliability.
- Preliminary alignment procedure.

- Detailed description of the FAT.
- Detailed definition of interfaces.
- Electrical design and wiring diagrams.

The Contractor must issue the Preliminary Design Report with the above mentioned information two weeks in advance of the meeting to allow for endorsement by SESAME.

An agreed set of minutes for this meeting will be produced by the Contractor following the PDR accurately recording the state of the design work as well as all agreements and actions.

Final Design Review (FDR)

As indicated in Table 1, within five (5) months from the signature of the contract, SESAME and the Contractor must agree on the final design at the Final Design Review meeting to be held at the SESAME site (or via teleconference).

At the Final Design Review the Contractor must present to SESAME for its approval, a report with the detailed final design, including:

- Production documentation:
    - 3D models, in STEP and Parasolid file formats.
    - List of commercial components.
    - Production specifications.
- Quality Assurance Program.
- Detailed schedule for components.
- Detailed alignment procedure.
- Detailed handling procedure.
- An outline of maintenance, operating and risk management documents.
- Updated PDR documentation.

The Contractor must issue the Final Design Report two weeks in advance of the meeting to allow for endorsement by SESAME.

An agreed set of minutes for this meeting will be produced following the FDR accurately recording whether all aspects of the design listed above have been completed, as well as all agreements and actions.

With the acceptance of the Final Design Report by SESAME, phase I of the contract is completed.

Production Phase

Unless otherwise agreed in writing, SESAME must approve the Final Design Report presented at the Final Design Review before the Contractor proceeds towards ordering of any material, components or equipment required to fulfil this contract.

The procurement of items having long delivery periods before the acceptance of the final design review is only possible with the written permission of SESAME.

The **minimum required installations and equipment** for the production of the components are:

- One engineering project office
- One Mechanical workshop with precision machinery
- One Welding workshop with the welding equipment
- One Electronics workshop

At the monthly reports, the status of the production of the different items shall be specifically mentioned.

Factory Acceptance Test (FAT)

A Factory Acceptance Test (FAT) will be performed at the Contractor's premises prior to the shipment of the equipment to SESAME. The FAT must establish that all items of the manufactured equipment completely meet the performance requirements as described in these specifications.

SESAME, or its representative, will have the right to observe all factory tests. The Contractor shall give at least 2 weeks' notice of any test date to allow the necessary travel arrangements to be made.

At the FAT, the Contractor will provide the quality control documents as follows:

- A full set of electronic copies of "as-built" manufacturing drawings.
- Wiring diagrams and electrical interfaces if different from those delivered at the PDR or FDR stage.
- Copies of material certificates.
- List of measurement equipment.
- Purchase orders.
- Traceability documents.

Each component of the Front-End will be accompanied by the following quality control documents:

- Material certificates.
- Wiring test, insulation test, and continuity test.
- Vacuum leak test.
- Residual Gas Analysis.
- Functional test.
- Bake-out test.
- Mechanical inspection.
- Fluid supply test.

Approval before Delivery

Delivery to SESAME shall not commence until successful completion of the Factory Acceptance Tests and after written authorisation by SESAME.

Site Acceptance Test (SAT)

A Site Acceptance Test (SAT) will be performed at the SESAME premises after the delivery of the equipment.

SESAME reserves the right to perform any of the factory tests again (general inspection, vacuum tests, electrical tests, functionality tests, etc.). The practical acceptance of the Front-End components will be given within two months after delivery at SESAME site

It is a condition for the SAT that all supporting documentation has been received and accepted by SESAME, in particular:

- Testing, certifications and inspections.
- Risk analysis.
- Maintenance and operating manuals.
- Quality Assurance documents.
- As-built mechanical and electrical drawings.

Deviation from the Specification

During the manufacturing phase, all eventual deviations from the final design report must be submitted to SESAME for approval in written form. Nevertheless, deviations may only be proposed when essential to ensure the proper and successful performance of the contract. SESAME will give its approval in written form.

Absence of written approval shall be considered as refusal. These deviations shall not imply any economic change of the price offered.

In the event of the contractor having misinterpreted any of the specifications or written instructions provided by SESAME, the misinterpretation will be corrected by the contractor at no extra cost.

Reliability and Maintenance

All equipment shall be manufactured in accordance with the best existing techniques and recognised good engineering practices available at the time of manufacture. All systems shall be designed and manufactured for a long lifetime. Subassemblies shall be designed for repair rather than replacement. This point has to be addressed during the final design review meeting, through a maintenance plan proposal.

Norms and Standards

A basic separation between power and signal cables should be provided.

The Contractor shall also comply with SESAME standards as provided in the Call for Tender.

Quality Assurance

The Contractor shall provide and implement a quality assurance program for the design, manufacture and testing of all systems and equipment provided by them, which includes carrying out all relevant inspections and tests as detailed in section “Technical requirements” of this chapter.

At the moment of delivery, the Contractor must provide a Quality Assurance document for the supplied equipment, certifying that it complies with the specifications and the supplied engineering drawings, and containing all material certificates, the results of all inspections and tests, and the procedures used.

A chart showing the organisational and functional responsible person involved in the contract, including Project Engineer, the Quality Manager, and relevant supervisory staff has to be sent to SESAME.

Safety and Risk Management

The Contractor shall carry out a safety assessment of the equipment and its operation. This shall be fully documented in the corresponding manuals.

SESAME requires Contractors to employ risk management techniques to reduce the risk of personnel being injured as a result of interaction with their equipment. This has to be addressed in the operation manual mentioned in the deliverable documentation.

Consideration should be made of risks that exist at all stages of the life of the equipment, including installation, commissioning, operation, maintenance, repair, decommissioning and disposal. The analysis should include risks that may occur during fault conditions and should include all potentially hazardous materials. The risk management system should:

- Identify hazards
- Reduce severity
- Mitigate likely hazards
- If possible, predict casualty rates.

A risk list, identifying all risks associated with the equipment, should be provided by the Contractor in draft form at the Design Review, and in final form as part of Operation and maintenance manuals.

Drawings

The Contractor shall provide 2 (two) full sets of paper copies of the final functional mechanical and electrical drawings, on good quality (80 gram plus paper) punched and put in white 4 ring presentation binders not exceeding 75% filling, unless otherwise agreed with SESAME during PDR or FDR.

The Contractor shall also provide an electronic copy of the functional mechanical and electrical drawings.

The Contractor shall make drawings available as required throughout the term of the contract.

Where deviations from the information or dimensions contained in the manufacturing drawings is authorised by SESAME during manufacture, the Contractor must note the changes. The Contractor should update all drawings of the final design report according to the production.

All labelling and documentation must be in English.

Manuals

Detailed installation, operation and maintenance manuals shall be prepared for the Front-End. Included in the manual shall be detailed assembly / disassembly and alignment instructions, routine maintenance requirements, fault diagnosis instructions, start-up and conditioning procedures. Supporting these requirements shall be appropriate mechanical and electrical schematic drawings and diagrams, and Process & Instrumentation diagrams.

The maintenance schedule shall include a description and justification for each operation, the conditions under which it must be performed and an estimate of the time required.

Delivery

As indicated in section “Contractor’s Responsibilities” of this chapter, the Contractor is responsible for the transportation and delivery of the Front-End components to the SESAME site, under the incoterm indicated in the Administrative Terms and Conditions document. The Contractor has to provide SESAME with detailed unloading instructions. Unloading is the responsibility of SESAME.

The Contractor shall ensure that all equipment within the extent of this supply is fully and satisfactorily protected during handling and transportation. Packing cases must be robust and suitable for lifting and transportation without damage. Internal packing must be adequate to prevent movement or vibration during transportation.

Shock and tilt indicators must be fitted to reveal evidence of any mishandling between the Contractor’s premises and SESAME.

The Contractor shall detail dimensions and weights of individual components to be delivered.

Individual items weighing more than 30 kg shall be provided with sufficient lifting hooks and/or be compatible with fork-lift trucks. If special lifting jigs are required, these shall be provided by the Contractor.

Technical requirements

Materials

General

Each piece of stainless steel or copper must be identified. The Contractor will propose an adequate system to ensure the traceability of each piece of material during manufacture. The Contractor must have a storage area dedicated to the materials necessary for this contract.

Stainless steel vacuum components (except flanges and standard fittings)

The vacuum components will be fabricated from austenitic stainless steel (304L).

Each batch or part of a batch must be delivered with a quality control certificate following the ISO 404 standard (or equivalent) including:

- Physical and chemical analysis.
- Ultrasonic test.
- Metallographic analysis for structure and inclusions.
- Brinell hardness test.
- Measurement of ferrite content.

The presence of phase sigma and carbide precipitation is not permitted. The material must be free of cracks.

The chemical composition of the stainless steel shall be within the following margins

Chemical composition	
Constituents	%
Cr	17.5-19
Ni	9-12
C	0.03 max
Si	1 max
Mn	2 max
P	0.045 max
S	0.030 max
Fe	remainder

The following (non-exhaustive) list of standards cover sheets with suitable composition and mechanical properties need to be respected:

- France Z2CN18-10
- Germany 1.4306
- UK 304S12
- Sweden 2352
- Italy X2CrNi1811

The stainless steel used must have the following properties:

Minimum yield stress 0.2%	N/mm^2	180
Minimum ultimate tensile strength	N/mm^2	490
Minimum elongation at break	%	40
Brinell hardness	BH	160 min
		190 max

Flanges, standard fittings, fasteners and gaskets.

Flanges and other pieces to be milled are to be manufactured from forgings. The structure of these forgings shall be homogeneous, free from porosity and fully austenitic with less than 1% ferrite. The presence of sigma phase of precipitated carbide is not permitted.

Knife-edge vacuum flanges shall be manufactured from electro slag refined (ESR) hot forged austenitic stainless steel grade 304L. The material may be in the form of forged bars for diameters up to and including 70 mm. All CF flanges gaskets must be of certified OFHC copper. They may be silver plated (depending on the application); bolts used must be of stainless steel and silver plated.

In case the CF flanges are manufactured in-house, the Contractor will send to SESAME, for approval, a detailed drawing for each type of flange used together with the full material specification.

In case the CF flanges are purchased from another company, SESAME approval of the proposed flange contractor must be sought prior to purchase.

Fasteners will be made of high tensile strength stainless steel A4-18/12 MO. The fasteners must be silver plated to ensure that they do not seize after bake-out. A minimum layer thickness of 5 μm must be achieved; the maximum layer thickness must be limited to a thickness that will not cause interference between the mating threads.

Copper-based heat-absorbing elements

Those Front-End components that have to interact directly with the photon beam (Photon Shutter) will be manufactured using one of the following copper-based materials: OFHC copper, Glidcop Al-15, or CuCrZr.

The final selection of the material will depend on the results of Finite Elements Analysis calculations carried out by SESAME.

The design criteria for each one of the considered materials are listed in the following table:

	Maximum Temperature (at power deposition) [ºC]	Maximum Temperature (at wall cooling channel) [ºC]	Maximum Stress [MPa]	Maximum Strain [%]
OFHC copper	173	100	60	0.10
CuCrZr	200	100	270	0.15
Glidcop Al-15	323	100	250	0.20

The Contractor will provide material certificates to prove that the materials used meet the expected requirements. The material certificate will include chemical analysis and mechanical properties.

Other materials

The Contractor must use exclusively the type of material defined in the drawings.

Cleaning

Standard UHV practices must be adopted through all stages of the manufacturing, handling, and assembly of the vacuum components, to guarantee the highest level of cleanliness.

The basic requirement is to remove surface contamination such as dust, grease or tenacious oil without etching the surface. Therefore, generally, the cleaning process should not include an acid etch or treatment.

The general procedure for cleaning the vacuum components made of stainless steel to be applied is as follows:

- First: wash with hot (80ºC) pressurized water mixed with a mild detergent, then rinse with hot pressurized water to remove the traces of the detergent, then dry with hot air. Pay particular attention to any trapped areas or crevices.
- Second: immerse the chamber in an ultrasonic bath of hot solvent for 15 min., then expose to the vapour of the solvent, then clean with hot (80ºC) pressurized demineralized water.
- Third: the component is to be immersed in an ultrasonic bath (5 min) of alkaline degreaser and then cleaned immediately with hot (80ºC) pressurized demineralized water.
- Fourth: the component must be dried with dry clean hot air.

The following is a general procedure for cleaning vacuum components made of copper and copper alloys:

- Under most circumstances, copper can be cleaned using the same procedure as for stainless steel, however, it should be noted that some of the properties of the alkaline degreasers attack copper and leave surface stains.
- In some circumstances a light chromic acid or citric acid etch may be carried out with the prior agreement of SESAME.

The manufacturer is requested to submit a detailed description of the proposed cleaning process (with the cleaning agents to be used) with the tender.

After cleaning the vacuum surface must be protected against accidental contamination.

After cleaning and bake-out any component that is not going to be immediately used will be wrapped in aluminium foil, sealed in a clean polyethylene bag and stored in a protective box.

Welding and Brazing

The welding plan must contain all necessary information to qualify the weld to be performed for the vacuum assemblies, such as beam parameters, welding speed, shielding gas, electrode diameter and type.

All parts to be welded must be thoroughly cleaned and degreased to ensure HV/UHV leak-tight welds. Prior to and during welding the cleaned surfaces must never be in contact with oily or greasy objects, including bare hands.

To prevent undue oxidation all vacuum sealing welds are to be backed by an inert gas purge to be maintained until the part has cooled down to 60ºC.

All welds shall be internal. Where vacuum sealing welds are made externally there should be full penetration leaving a smooth surface inside. Any brushing or other finish work applied after welding on the welds is strictly prohibited.

The use of dye-penetrant is strictly forbidden.

If at any stage of manufacture a weld is found to be faulty no rectification is to be done without prior approval from SESAME.

All vacuum braze and weld regions shall be flush and free from scale, voids or blow holes and there should be no visible evidence of inclusions. Some degree of discoloration of material in the weld area may be acceptable.

Inspection and testing of the welds are to be in accordance with ISO standards.

The supplier must qualify the welders for each process.

Filler material shall not be used. In case of absolute necessity the rods must be of identical material as the parts to be welded. The filler material has to be approved by SESAME.

Brazing considerations

In order to fulfil ultra-high vacuum requirements, the quality of the brazing is of prime importance. The brazing process shall therefore guarantee a complete homogeneous braze, without any trapped volume.

Vacuum

Vacuum general considerations

The Front-End components are designed to operate under ultra-high vacuum, and hence their parts must be perfectly clean. A high degree of cleanliness will be necessary at all stages of the production, to guarantee an acceptably low outgassing rate and weld integrity.

All machining work is to be carefully controlled to ensure that no foreign matter is embedded in the surface of the material.

The use of abrasive wheels or cloths which can leave foreign matter embedded in the HV/UHV surfaces is explicitly forbidden. Scale cleaning shall be by hand brushing with a stainless steel brush. Surface finishing by hand shall use a dry stone or material such as maroon Scotch Brite™.

All mechanical cold working operations must exclude the use of heavy organic lubricants since these can be retained to some extent on the surface after the process.

All machining coolants shall be water soluble and sulphur free.

At no time should any surface, which is to be exposed to vacuum or immersed in vacuum, be marked out, inscribed or similar except by scribing with a clean sharp point. The use of dyes, marker pens or paints is to be avoided. It is good practice not to use these on external surfaces because of possible cross-contamination in subsequent cleaning operations. Similarly, it is possible to temporarily block porosity in material with such coatings.

Cleanliness is important at any stage of production. Frequent cleaning of items before, during and after manufacturing processes is required. Care should be taken not to cross-contaminate "clean" and "dirty" components. Clean components should be handled wearing clean, dry, lint-free gloves, and all tools should be cleaned before use (including the handles). Care needs to be taken not to contaminate (accidentally) the gloves while handling / cleaning an assembly.

The atmosphere in which clean assembly for HV/UHV is being undertaken is important. The air should be clean and of low humidity, free from gases or oils exhausted by vacuum pumps, machine tools or stacker truck engines. It should be dust and particulate free (Class 10,000 is adequate). Local areas of cleanliness may be achieved using portable laminar flow filtration units. Operators should be dressed appropriately to prevent dust shedding.

Components should be stored under clean conditions, e.g. by wrapping in clean aluminium foil and sealing in clean dry polythene bags. Enclosures should have all apertures sealed, and preferably be filled with dry nitrogen before sealing.

Care must be taken with all handling processes to avoid damage (scratches or dents) to vacuum sealing faces, especially to knife edges. The possibility of distortion of sealing flanges during lifting and slinging operations must also be kept in mind.

If it is necessary to use adhesive tape or a masking agent on any vacuum surface, then immediately after removal all adhesive residue must be thoroughly removed with an appropriate solvent such as acetone.

Vacuum leak-test

Vacuum leak testing shall be carried out in accordance with the procedure described in this section. All gaskets used in such tests shall be of a type approved by SESAME for the purpose. They will normally be of the type specified for use of the vessel, component or assembly under investigation. However, with the prior approval of SESAME an alternative type of seal presenting a similar bolt loading to that expected in service might be considered acceptable.

Leak detection shall be done in a clean area, the vacuum chamber shall be put on a clean support or table, the contact surface between the chamber and the support must be covered with a clean aluminium foil.

Leak detection shall be done with a suitable helium leak detector. The sensitivity of the leak detection system shall be checked with a suitable calibrated leak.

The pumping system of the leak detector must be composed of dry (oil free) pumps. The leak detector must not introduce any contamination into the tested chamber. No vacuum grease shall be used to guarantee the leak tightness of the connection of the vacuum chamber to the leak detector.

Vacuum leak test and desorption test will be carried out before and after baking the component at 200 - 250°C during 24 hours once room temperature is reached after cooling down.

The leak test must be carried out by spraying all surfaces, welds/brazing, and the sealing flanges with helium.

The leak tightness of the completed chamber has to be below 1×10^{-10} mbar·l·s^{-1} (the measurement must include the background), a total desorption rate < 1×10^{-12} mbar·l·s^{-1}cm^{-2} is to be demonstrated (<1×10^{-10} mbar·l·s^{-1}cm^{-2} for Viton sealed components). The upper limit of the leak rate has to be documented for each component in the Quality Assurance Document.

The total pressure measurement after the bake out must be in the low 10^{-10} mbar range (with the Ion Pump flashed and running).

If a component has an integrated absorber or an assembly containing cooling circuits penetrating into the vacuum, the helium test must also be performed through the cooling water pipe work, to check the water-to-vacuum integrity.

On receipt at SESAME, vessel assemblies or components will be leak tested before acceptance.

Bake-out

The vacuum system of Front-End components must be designed to be in-situ bakeable up to 210ºC.

The complete components and individual parts (vacuum pipes, hydroformed bellows…) will be baked at 210ºC for 24 hours by the Contractor.

SESAME has not undertaken any detailed design of the bake-out equipment. The Contractor will propose adequate equipment as part of the documentation to be presented to the Final Design Review.

Residual Gas Analysis

The Residual Gas Analysis procedure will be used to define acceptance criteria for vacuum chambers and assembled units after they have been baked. The aim is to provide evidence that each individual component or part is clean following SESAME UHV standards before it is shipped to SESAME.

Before connection of the vacuum vessel or component to the pumping system, the RGA will be connected to the pumping system to ensure that the pumping system itself is clean.

Before carrying out the analysis, pumping must obtain an ultimate pressure better than 5×10^{-10} mbar.

A RGA from 0 to 100 amu will be undertaken for each individual component (vacuum vessel, pipe, bellow, valve, etc.) under the following circumstances:

- Before bake-out (after cleaning stage).
- When the bake-out temperature is first reached.
- At the end of the 24 hours at 200 – 250ºC.
- At room temperature after bake-out.

The residual gas analysis of each component must show that hydrocarbon contamination defined by the total partial pressure of all masses greater than 28 (with exception of mass 44) is less than 1.0% of the total pressure.

In addition, there shall be no indication of residual acid or alkali cleaning detergents or halogen in the spectra.

All RGA measurements have to supply sufficient information on appropriate scale ranges in order to be able to interpret the data at a later date.

Each RGA measurement must have time and date indicated.

Included with the certificate there will be a temperature profile of the bake-out cycle used with the date, time and total pressure as read on the pumping system and gauges.

On receipt at SESAME, a residual gas analysis of the components will be carried out before acceptance.

Mechanical requirements

Support structure

Each Front-End component must have an adequate support structure that takes into account the space constraints inside the tunnel.

The holes for the fixation of the support on the floor shall have a diameter of 18 mm and positioning tolerances of ±0.5 mm.

Painting and surface protection

The steel frame of the support structure has to be painted with one coating of primer and two coats of epoxy RAL840HR 4001 (lilac).

If aluminium or aluminium alloy is used in any Front-End component, it must be anodised colourless.

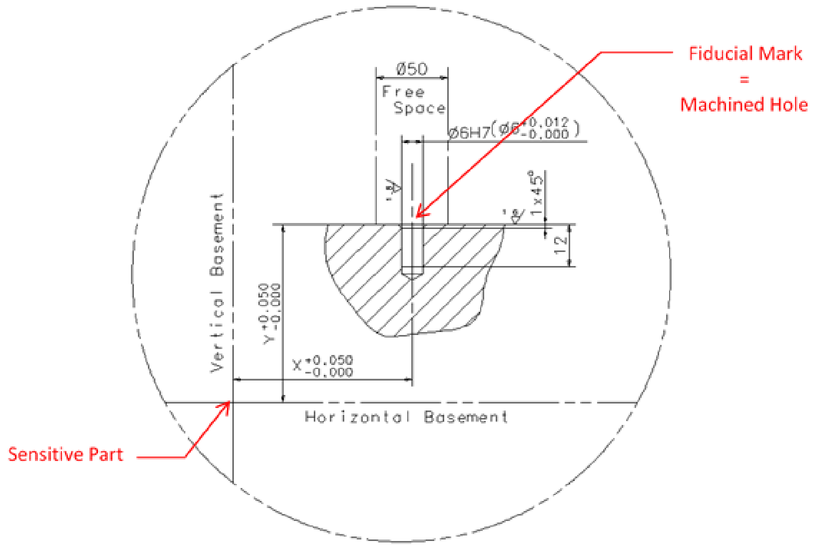
Protection of moving parts

All moving parts must be protected and comply with the CE directives for prototype machines.

Alignment and adjustment

SESAME alignment is based on laser tracker measurements, and hence adequate fiducial marks have to be foreseen for each individual component.

Fiducial marks shall consist of a 6H7 machined hole on a machined planar surface, as shown below.



Each Front-End unit shall have at least 4 fiducial marks. The exact number depends on the kind of element and shall be approved by SESAME

The fiducials shall be set on a rigid frame mechanically linked with the active element to be aligned. A fiducial on a movable part will be rejected.

All Front-End components inside the tunnel shall be aligned from a single position of the Laser Tracker. The line of sight from the Laser Tracker to all the fiducials has to be optimized.

The position of the fiducial marks with respect to the active elements of each Front-End component shall be given with an accuracy of ±50 µm. These positions have to be included in the fiducialization report, which has to be delivered as part of the FAT documentation.

The supports of the Front-End components have to be designed to allow a position adjustment in all three dimensions of ±10 mm.

The individual components aligned to the unit support will be designed to allow for a position adjustment in all three dimensions of ±5 mm. The angular adjustment will be of ±2º, by means of the use of spherical washers on the vertical adjustment to adjust the tilt. The pitch of all the adjustment screws will be 1 mm.

Once aligned, the support must block the individual components in place.

All units will be aligned according to drawing dimensions.

Handling

Complete Front-End components will be installed using a crane. The Contractor will equip the units with proper handling devices. The final choice will be made during the design review with SESAME.

Water cooling

The Contractor will design a water cooling system on each Front-End component where it is required.

Flexible hoses have to be suitable for working at 10 bars and radiation resistant. They will be tested at 16 bars. Flexible hoses material can be EPDM type (ethylene propylene diene monomer).

Each Front-End component for which water cooling is required will have an inlet and outlet manifold fixed onto its support. Each circuit branch will have its own regulation valve, and an additional regulation valve and a purging valve on the return pipe to the manifold outlet.

Each cooling circuit branch will be equipped with its own flowmeter installed on the return circuit. The flowmeter switch shall be set-up at 50% of nominal flow.

Flowmeters will be of type PKP model DS01.2.2.1.W24A.1.1.0. The Contractor will design the outlet manifolds in order to mount these elements on the stands of the units. Special care has to be taken in order to comply with the installation requirements (minimum inlet and outlet straight runs and pipe sections) specified by the flowmeter’s manufacturer.

The Contractor must ensure that any brazed joints, valves or pipes are compatible with de-ionised water. There must be no aluminium in contact with the de-ionised cooling water.

The following materials shall be used:

- Water fittings will be stainless steel “Swagelok” type.
- Valves will be stainless steel.
- Pipes will be copper or stainless steel.

Pneumatic elements

Pneumatic circuits must be non-lubricated. All pneumatic components must be suitable for operation using non-lubricated air.

All pneumatic pipe work must be copper.

Compressed air will be supplied at a pressure of 6 bar.

An adjustable air pressure switch, monitoring the air supply of pneumatic elements, will be mounted on each component concerned (Photon Shutter unit and Bremsstrahlung Shutter unit). The air pressure switch shall be wired to be fail safe and set at 4.5bar.

The compressed air circuit must include a reservoir in order to allow the pneumatically actuated elements to perform a few cycles in the case of an air supply failure.

Elements to be connected to the compressed air circuit include adjacent pneumatic valves (for both the Photon Shutter and the Bremsstrahlung Shutter units) and the fast closing shutter (only in the case of the Photon Shutter).

Motor-controlled elements

A document laying out the SESAME standards for motor controlled elements in its most up to date version shall be attached to the Call for Tender as an Annex.

Electrical distribution and systems specification

General aspects

The supplied equipment shall be in full compliance with the Jordanian Safety, Protection, and EMC Regulations in force as well as relevant IEC (International Electrotechnical Commission) standards and recommendations.

Each Front-End component will have an electrical connection box receiving signals from its components (flowmeters, limit switches, compressed air switches, thermocouples, motors, encoders, etc.). The location of the connection box will be agreed between the Contractor and SESAME during the design phase.

All electrical equipment will have to be radiation resistant. Particular care must be taken with the specification of the cables which are in a radiation zone.

The design should avoid as much as possible the proximity of electrical wiring to bakeable areas of the Front End units.

Due to the modular construction of the Front-End, consideration must be given to the design of the cable management system, to accommodate practical assembly and disassembly of the individual Front-End components, for installation and maintenance purposes.

Grounding

Each Front-End component support shall provide, either foot or top side, one hole M8, 15mm deep. The M8 hole shall contain the appropriate screw to fix a terminal spade, crimped with either a bare copper 29mm^2 cable or a green/yellow jacket isolated copper 25mm^2 cable, according to the current safety rules.

Internal cabling

The bidder must provide a complete wiring diagram that will not leave any kind of ambiguity about the instrument internal cabling connection and routing.

- Each cable must have a unique identifier assigned. In the case of using a multiwire cable with more than one connector at its end (for example using blade connector terminals) a unique identifier on each wire should be assigned to avoid any possible ambiguity in the documentation or installation.
- The bidder must provide information about all the internal components (considered within the scope of this document) included in the wiring diagram. This information shall include its physical location, the manufacturer reference, a unique identifier and the referenced mating connector/s.
- The cable routing shall be documented.

The bidder must provide a list of the cables of the instrument with the following information:

- Unique Identifier.
- Cable manufacturer and reference code - Internal bidder reference will not be accepted.
- Connectors or terminals manufacturer and reference code - Internal bidder reference will not be accepted.
- Pinout maps for each connector.

All cables installed should be labelled, including their unique identifier, at least close to both ends. In the case of multiwire cables (as blade connector terminals) all wires should be labelled.

Label positions within the cables shall ease future maintenance operations. The provision of duplicated labels in the cables to allow their identification without the need of any hardware manipulation would be highly valued.

All hardware components and their connectors shall include a label with their unique identifier according with the documentation delivered by the bidder.

All cables contained in the instrument shall be assembled strictly following the cable and connector manufacturer's assembly procedures.

All cables and wiring with a core section greater than $0.75mm^2$ must be LSOHFR (Low Smoke, Zero Halogen, Fire Retardant) according with IEC 60754-1 and IEC 60332.

The use of aerial cable to cable internal connectors is strongly discouraged.

The cable operation regime must not exceed the cables and connectors manufacturer's specification limits for all possible working conditions.

Installation requirements

The on-site installation of the Front End is the responsibility of SESAME.

The Contractor shall provide SESAME a full risk register and method statements for the installation.

Operating, maintenance and installation instructions must be supplied with the equipment which, if followed, will ensure compliance with all the relevant SESAME site regulations/guidelines.

Acceptance tests

The tests at the factory and on site must establish that all items of the manufactured equipment completely meet the performance requirements as described in these specifications.

The Contractor shall submit a detailed quality schedule specifying the intermediate tests and checks that will be made during the whole manufacturing, testing and assembly procedure. The Contractor shall provide all the equipment, facilities, funds and personnel for carrying out the tests. For each test mentioned below, a procedure must be submitted.

The acceptance test procedures shall include, but not be limited to, the test procedures specifically outlined in this document, but also those necessary to prove compliance with these specifications. Test procedures must include details of how tests are set up and performed, and the criteria for acceptance / rejection. The Contractor shall present a full test plan at the FDR. Included in the plan shall be detailed procedures and tests, with a list of test equipment and the tolerances of the readings for the relevant parameters. These test procedures are subject to SESAME review and acceptance.

All individual items (chambers, bellows, photon shutter…) must be labelled and given a serial number for reference inscribed at a straight part of the item close to the flange at the upper outer wall. The marking process must be carried out by means of dry scribers vibrating engravers or laser engravers. This serial number will be used to identify the chambers during the testing procedure and results recording.

Testing shall comply at all times with the local safety rules.

All measuring equipment (electrical, mechanical, vacuum, thermal…) used for inspection and testing will be maintained and calibrated in accordance with the manufacturer's instructions and national standards.

Test results will be reported on contractual documents as defined in section "Contract Management / Factory Acceptance Test (FAT)".

SESAME reserves the right to require additional or more extensive tests to be conducted in the event of marginal design or performance.

Acceptance Tests

This section describes the tests that must be completed successfully at the Contractor's premises before shipment.

Within the tender documents bidders should provide the procedure and the equipment to be used for the tests which are foreseen for the Factory Acceptance test.

The minimum required premises and equipment are:

- One Vacuum area with bake out and leak detection equipment.
- One Mechanical workshop with fluids and metrology equipment.
- One Electronics laboratory with electrical test equipment.

A report for the Front-End components will be performed at the Contractor factory based on the results of the factory tests of the units and individual elements (vacuum pipes, hydro-formed bellows…). The Front-End components will not be dispatched to SESAME before the successful performance of the Factory Acceptance Tests.

Functional tests:

- The movement of the Photon Shutter and the Bremsstrahlung Stopper will be cycled 50 times on the completed unit without increasing the transient vacuum pressure by more than one order of magnitude.
- After bake-out all electrical equipment will be checked for functionality.
- Water will be connected to water cooled units and circulated through all pipes. The system will be checked for leaks.

- Cooling circuits will be purged after the tests, before delivery to SESAME.
- Compressed air at 6 bar will be connected to the system and functionality checked.
- Translation stages tests:
    - Determine the resolution and repeatability of each stage.
    - Check the actuation of the limit switches, and determine the motion range defined by them.
    - Check the actuation of the Home switch, and determine its position relative to a reference configuration.
    - Check the perpendicularity between the two motion axes of each stage.

Electrical tests: The following tests must be performed:

- Wiring test:
    - Functional test for switches.
    - Functional test for thermocouples.
    - Visual inspection of assembled parts.
    - Visual inspection of cables, connectors, and components labelling (to comply with the approved electrical design).
- Insulation test.
- Continuity test.

Visual inspection:

- A visual inspection will be carried out with particular attention to the surface finish and cooling pipes brazing.
- After assembly of a unit, a visual inspection will be carried out to verify that all the elements are correctly fixed on the chassis (nuts, screws…).

Fluid supply tests:

- The water cooling circuits shall be filled with water, pressurized at 16 bars and sealed. The pressure shall be recorded at intervals of 5 minutes for a period of 30 minutes. For acceptance there must be no evidence of water leakage.
- The hydraulic test must be done only when the water-cooled item in question (Fixed Mask, Photon Shutter…) is correctly protected from water or any other source of contamination.
- After successfully passing the hydrostatic test, complete units will be filled with water running at 9 bar for 30 minutes. The water flow of each circuit will be recorded. The flowmeter diaphragm will be adjusted in order to have a flow reading of 2/3 of the complete scale at nominal flow.

Bake-out tests:

- The Front-End units are designed to be bakeable in-situ up to 210ºC.
- The complete units will be baked at 210ºC for 24 hours by the Contractor to prove their integrity and leak tightness.
- After cooling down a pressure better than 5×10^{-10} mbar must be attained.
- A RGA plot of each unit will be recorded after cooling down and should not show any peak related to air leaks (amu's 14, 28, 32, 40). The RGA plot will be part of the documentation.

Vacuum tests:

- Each component or unit must be leak tight by standards of helium mass spectrometer before and after bake-out. Components and units will be leak tight according to section "Technical requirements / Vacuum".
- The units will be delivered under pure dry nitrogen, all ports being closed with blank flanges.

Tendering

Clarifications

During the time period for submitting offers, bidders may contact Majeda Salama (Procurement/ Tendering Manager) (e-mail: majeda.salama@sesame.org.jo), Maher Attal (Technical director) (e-mail: maher.attal@sesame.org.jo), Mohammad Al Najdawi (Head of mechanical, vacuum and cooling groups) (e-mail: Mohammad.najdawi@sesame.org.jo) or Gianluca Iori (beamline scientist) (e-mail: gianluca.iori@sesame.org.jo) in case of any doubts or clarifications needed. All questions and doubts will be published in the contractor's profile indicated in the ATC.

Information required with the tender

With the tender documents, bidders shall provide sufficient information to allow an educated choice of Contractor, as detailed below. It is essential that this information accompanies the tender proposal and is complete and organized **respecting the structure detailed below**. **The absence of this technical information won't be rectifiable and therefore the bid may be rejected as non-compliant.**

The technical proposal, **to be included in Electronic File B**, as indicated in the ATC, will comprise at least, the following documents:

General outline:

- A Fabrication Plan, with an outline schedule, showing the main design, ordering and manufacturing, testing, installation and commissioning phases of the principal components, along with a list of proposed milestones for design / progress verification.
- A document stating the acceptance and assessment of compliance with the technical requirements.

Management plan and proponent qualifications:

- Controls protocols that the Contractor will apply during the production of the components, as well as a contingency plan in case of problems.
- List of proposed work packages, if necessary.
- Working team proposed for the execution of all the tasks of the contract.

Documentation and information of the Engineering and Manufacturing proposal:

- The preliminary mechanical and electronic design of the different components of the deliverable, including full description and technical justification.
- Equipment to be used during the manufacturing of the deliverables, including the critical materials used, and methods for assembly and fixing, etc.
- Outline proposal for the method of fiducializing the reference surfaces/holes.
- Equipment, installations or infrastructure and procedures to be used in the performance of the Factory Acceptance Tests of the deliverables.
- Dimensions and weights estimation of individual components to be delivered.
- Proposed alternative cleaning procedures in case that it is not possible to comply with the requested procedure due to national law or bidders consider better to follow their own ones, with description of the improvements associated with these proposed alternatives (included environmental benefits).
- Lifetime of critical components and main parts of the deliverables recommended spares not included in the offer, including estimated time of replacement.

The Capital costs breakdown, **to be included in Electronic File C**, as indicated in the ATC, will comprise, at least, the following documents.

- The economic offer, using the model included in the ATC.
- A document including the breakdown costs for the deliverables detailed in Annex 1
- A document including the cost of replacing of the recommended spares.

IMPORTANT REMARK: the inclusion of whatever information listed in this point 5.2.3 or any other economic data, in an Electronic File different from this Electronic File C, will be considered a non-amendable mistake and therefore **will imply the automatic exclusion of the tenderer**.

Information and publicity

The **contractor** will be obliged to fulfil the information and publicity obligations established in applicable laws on public contracts.

CONCEPTUAL DESIGN ALBA-COMPONENTS

Introduction

Details on the BEATS project and the principal functioning of a Front-End are laid out in the previous chapter.

Reminder: The Front-End consists of a series of components connected by vacuum pipes; some of these are specified by ALBA, and some of them will be provided by other partners of the project (ESRF and ELETTRA). In this chapter, we present a general description of the Front-End for BEATS and the Conceptual Design for those components which are under the responsibility of ALBA.

Beamline characteristics

From the point of view of the Front-End, the relevant parameters of the beamline are the power emission characteristics of the photon source and the required user aperture. The proposed photon source for BEATS is a 3-pole wiggler (3PW) with a peak field of 3 Tesla and an overall length <1m [2]. The relevant parameters of the 3PW are listed in Table 2. The machine parameters required to determine the emission characteristics of the proposed ID have been taken from [3]. In Table 2 we have listed as well the required apertures in both horizontal and vertical plane as defined by a fixed mask in the Front-End.

	BL BEATS
Magnetic Length [m]	**<1**
Peak Field B_0 [Tesla]	**3.00**
Total power @400mA [kW]	**0.99**
Peak power density @400mA [kW/mrad^2]	**0.25**
Horizontal user aperture [mrad]	**1.0**
Vertical user aperture [mrad]	**0.36**

Table 2: Photon source characteristics for the 3PW for BEATS

It can be seen that the total power emitted by the ID is relatively small (~1 kW) and that the peak power density (250 W/mrad^2) is larger than that emitted by the storage ring bending magnets (123 W/mrad^2) by only a factor of 2. As a comparison, a Front-End at ALBA with an ID as a source has to deal with peak power densities in the range 10-50 kW/mrad^2, and the peak power density associated to bending magnets is 250 W/mrad^2. Therefore, it seems reasonable to use the design of asks and shutters for ALBA Front-Ends with a bending magnet as a source as reference for the BEATS Front-End.

Proposed location and layout

The proposed location for the installation of BEATS' ID is the straight section SS10. The accelerator tunnel environment at that location is shown in Figure 1. The available length for the installation of FRONT-END components inside the tunnel is roughly 8m.

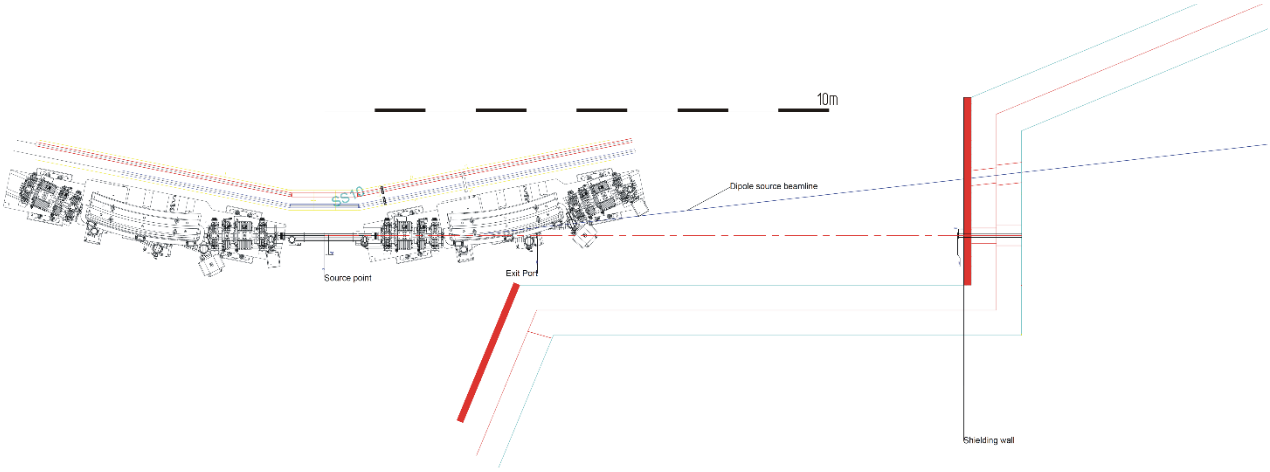


Figure 1: Tunnel environment at the proposed location for the BEATS FRONT-END

The layout of BEATS beamline will be detailed in the BEATS technical design report [4]. The part of the layout corresponding to the Front-End and the optics hutch is shown in Figure 2. We have included the optics hutch because, despite being installed in the optics hutch, the Trigger Unit is functionally linked to the Front-End.

For the sake of completeness, we will provide a short description of all Front-End components shown in Figure 2. However, only those elements which are explicitly indicated (the ones highlighted in yellow in Figure 2) are under the scope of this chapter and will be specified in detail in the subsequent sections. Starting from the SR side, the FRONT-END components include:

1. Crotch absorber: it is used to protect the downstream UHV chamber and Front-End components from synchrotron radiation emitted by bending magnets adjacent to the ID.
2. Pumping Unit #1 (ALBA): it provides pumping capacity and vacuum readings to the Front-End zone next to the SR. In particular, this unit shall pump down the outgassing generated by the XBPM.
3. X-ray Beam Position Monitor or XBPM (ALBA): it is a diagnostic element that provides information regarding the position of the photon beam.
4. Fixed Mask (ELETTRA-ESRF): this aperture cuts off that part of the photon beam emitted from BEATS ID that will not be used by the beamline in any circumstance. This element defines the maximum aperture available for the beamline (aperture in Table 2: Photon source characteristics for the 3PW for BEATS), and reduces the heat load on all the Front-End components installed downstream.
5. Photon Shutter (ALBA): this element is able to block completely the synchrotron radiation beam, and isolates the downstream components from the source. The Fixed Mask and the Photon Shutter shall be mounted one next to the other on a common support, which will also provide pumping capacity for absorbing the radiation outgassing together with local vacuum readings.
6. Fast Closing Shutter (ELETTRA-ESRF): it is a fast reacting element (closing time ~10msec) that protects the storage ring vacuum integrity from any accident occurring in the beamline.

The two trigger gauges controlling the actuation of this element will be installed on the Trigger Unit on the beamline side. The Fast Closing Shutter acts as a conductance restriction system but is not vacuum tight. Therefore, an additional standard gate valve is installed next to it and is actuated during the same shut off operation.

7. Primary slits: they allow the beamline users to define the photon beam dimensions within the aperture defined by the Fixed Mask.
8. CVD window (ELETTRA-ESRF): it is a cooled CVD diamond window used to separate the vacuum from the storage ring (10^{-10} mbar level) from that on the beamline (10^{-8}-10^{-9} mbar level).
9. Pumping Unit #2 (ALBA): a second pumping unit will be installed to pump down the ~1.8 m gap between the CVD window and the next Front-End component (Attenuators).
10. Attenuators Unit (ELETTRA-ESRF): it is used to tailor the energy spectrum and to dissipate heat from the beam. It consists of a series of foils made of different materials and thicknesses that can be introduced into the path of the photon beam by means of actuators.
11. Bremsstrahlung Stopper (ALBA): This device is used to block the high-energy radiation (gas Bremsstrahlung radiation, secondary Bremsstrahlung radiation, etc.) directed towards the beamline. It consists of a pneumatically actuated block of UHV compatible tungsten alloy. The stopper block is uncooled and cannot be exposed directly to the photon beam; therefore, the Bremsstrahlung Stopper has to be actuated together with the upstream Photon Shutter. This unit shall also incorporate pumping capacity and vacuum readings, as well as a RGA analyzer.
12. Wall pipe: it is a vacuum pipe providing the connection between the SR tunnel and the beamline.
13. Trigger Unit (ALBA): it is the first element in the optics hutch of the beamline. It provides pumping capacity, vacuum readings, and allocates at least one of the two trigger gauges in charge of activating the upstream Fast Closing Shutter. In addition, this unit will host a Wire Scanner Monitor, consisting of a tungsten wire that will be scanned through the beam by means of a motorized actuator in order to obtain the beam profile.
14. DMM: the Double Multilayer Monochromator is the principal optical component of the BEATS beamline, allowing to select the photon beam energy. The DMM will leave the possibility to operate the beamline in white beam mode. Therefore, and due to the beam offset between the white and monochromatic beam, all components after the DMM will be large enough to cope with the offset between monochromatic and white beam.
15. Beam viewer: it is used to check the photon beam position and to visualize its footprint at the end of the DMM. It will consist of an actuator-driven screen imaged by an optical system.
16. Combined Stopper (ALBA): this element will give the possibility to access the experimental hutch while keeping the monochromator under heat load. Therefore, it has to combine the Photon Shutter and Bremsstrahlung Stopper functions.

The following equipment is out of the scope of the present Call For Tender: crotch absorber; fast closing shutter; primary slits; wall pipe; DMM and the beam viewer.

In order to provide an adequate division in sectors from a vacuum point of view there will be all-metal pneumatic valves installed at following locations:

- At the interface between the storage ring and the Front-End.
- Between the Photon Shutter and the Primary Slits.
- Between the Attenuators Unit and the Bremsstrahlung Stopper.

As a final reminder, Table 2 lists the FRONT-END units which are under the responsibility of ALBA and will be described in detail and specified in this chapter.

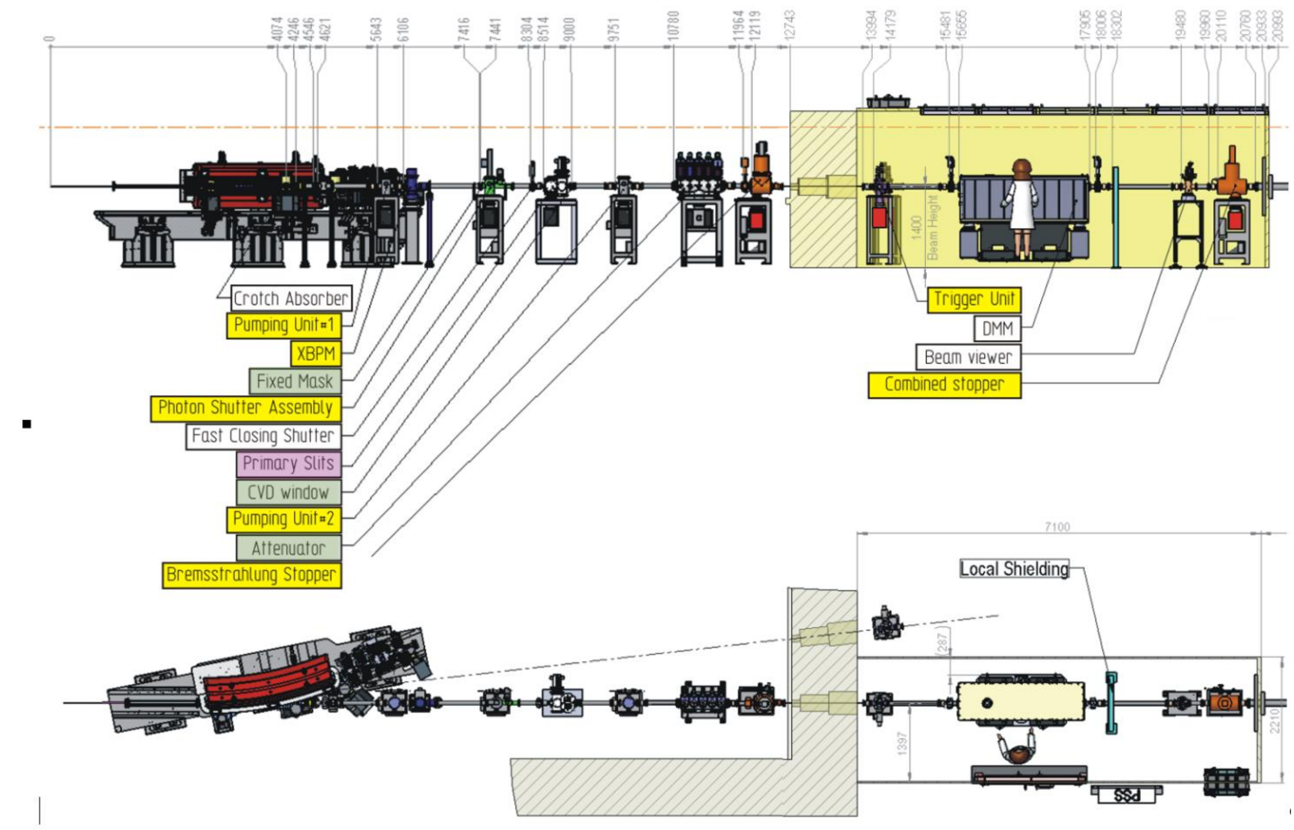


Figure 2: Proposed layout for the FRONT-END and the OH of BEATS beamline at SESAME. The elements highlights in yellow are under the responsibility of ALBA and will be specified in this chapter.

Unit name	Distance from source to the center equipment center [m]
Pumping Unit #1	5.77
XBPM Unit	6.23
Photon Shutter	7.57
Pumping Unit #2	9.89
Bremsstrahlung Stopper	12.22
Trigger Unit	14.27
Combined Stopper	20.36

Table 3: List of FRONT-END/OH units for BEATS beamline under the responsibility of ALBA that are specified in this chapter.

Functional requirements and conceptual design

In this section we describe the functional requirements for the Front-End components listed in Figure 2 and provide a conceptual design for them, with indications of dimensions, number and arrangement of vacuum ports, etc.

Pumping Unit #1

The first Pumping Unit consists of a vacuum chamber with a Pirani and a cold cathode gauge, one all metal right angle valve, and a 300 l/s ion pump. The chamber must have an adequate support structure, allowing its alignment. The support structure will also include a guided platform for installation / removal of the 300 l/sec ion pump, all the elements for the cooling water distribution to the adjacent XBPM, as well as a connection box for the flowswitch signal to the Equipment Protection system (EPS). A conceptual sketch of the Pumping Unit is shown in Figure 3.

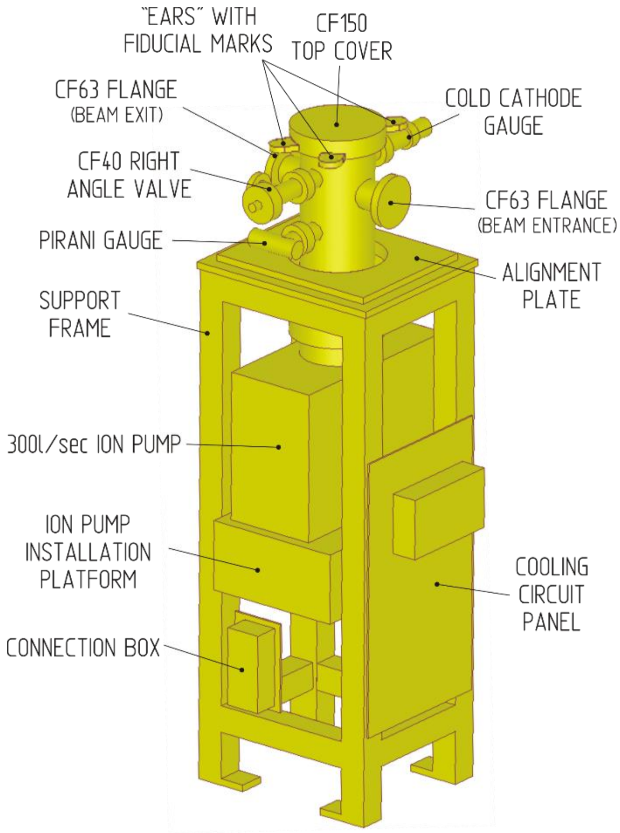


Figure 3: Conceptual sketch of the Pumping Unit #1

The main body of the chamber is made from a vertically aligned 159×3 mm size 304L stainless steel pipe, with CF150 flanges at the top and the bottom; the bottom flange is used for the installation of the ion pump, and the top one must be equipped with 4 “ears” that will allow the installation of fiducial references. Along the beam direction the chamber is equipped with two CF63 ports to connect it to the adjacent Front-End components , for a total flange-to-flange distance of 300 mm. Along the direction perpendicular to the beam, the chamber shall be equipped with three CF40 ports for the installation of two vacuum gauges (Pirani + Cold Cathode) and one right angle valve.

The proposed alignment system consists of a15 mm thick zinc-plated steel plate that is screwed onto the top of the welded support frame, and whose position can be adjusted by means of lateral pushers. This plate has three symmetrically placed threaded holes that allow to attach to it three M16×1.5 bars, which act as support columns for the vacuum chamber. The interface between the support bars and the vacuum chamber is provided by three pieces with a hole of 17.5 mm diameter the middle, welded around the body of the chamber by means of ribs; a couple of nuts and washers per bar allow to adjust and fix the vertical position and the orientation of the chamber.

The support frame must incorporate the rigid piping for the cooling water circuit of the adjacent XBPM. This circuit shall include the inlet / outlet connections to the cooling water distribution system at SESAME, regulation valves at the entrance and exit, a flowswitch, and a T-derivation with a purging valve. A schematic diagram of the cooling circuit is shown in Figure 4. The signal cables from the flowswitch must be directed to a connection box mounted on the support frame, which will provide the interface to the SESAME control system. The requested layout for the interface connectors is detailed in the last section of this chapter.

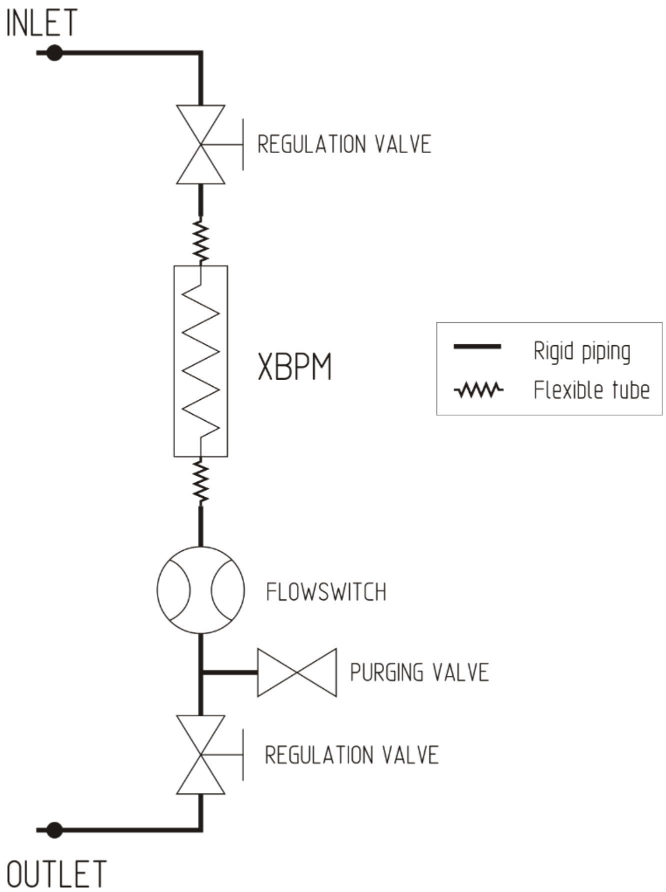


Figure 4: Schematic diagram of the cooling circuit to be installed on the support frame of the Pumping Unit to supply the adjacent XBPM unit

X-ray Beam Position Monitor

The X-ray Beam Position Monitor (XBPM) setup consists of an adjustable rigid support structure, a XBPM UHV chamber, a water-cooled XBPM sensor, and a motorized X-Z table. A conceptual design of the XBPM is shown in Figure 5.

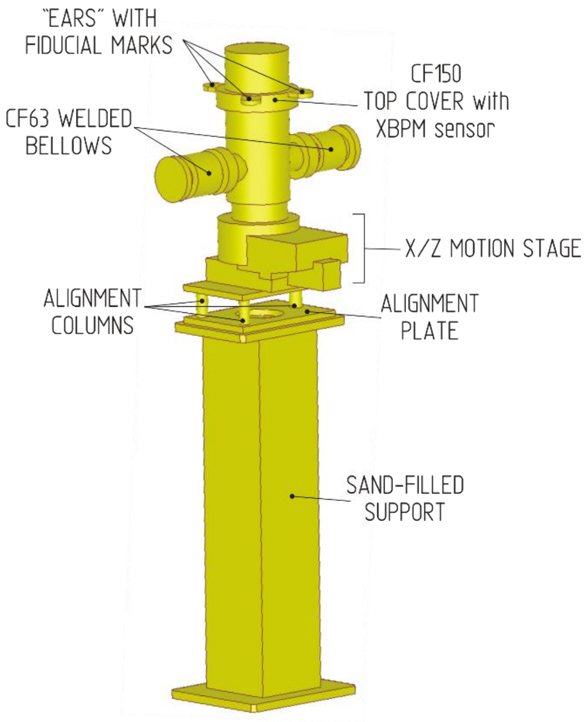


Figure 5: Conceptual sketch of the XBPM unit

The adjustable support structure is a rigid steel column prepared for sand filling. It has to include a manual adjustment mechanism that allows the alignment of the X-Z table including the XBPM vacuum chamber in terms of transversal position, pitch, roll and yaw with respect to the support column.

The beam position monitor is mounted inside a movable UHV chamber made from an upright 159×3 mm size 304L stainless steel pipe, with a CF150 flange at the top. The XBPM sensor will be mounted on the covering CF150 flange. This base flange must provide the feedthroughs to extract the electrical signals from the sensor (blades' currents and thermocouple readings) and for the water cooling system. This flange must also be equipped with four "ears" to install fiducial marks on them, which will be referenced with respect to the photon beam axis between the sensor blades. The main chamber is connected to the adjacent Front-End components by means of CF63 ports, for a total flange-to-flange distance of 280 mm. In order to absorb the displacements of the XBPM chamber, the connections to adjacent units will be done using two 160 mm long welded bellows, increasing the flange-to-flange distance of the whole assembly up to 600 mm. The welded bellows must be designed for a maximum lateral stroke of 6 mm and for at least 10,000 cycles.

The XBPM sensor uses up to four blades, whose narrow front edges are oriented towards the radiation source, to sense the off-axis radiation of the photon source and to provide an on-line determination of the position of the centre of the photon beam using the emitted photoelectron currents from the four blades. In the case of a photon source with a vast horizontal divergence such as the 3PW we propose using a Staggered Pair Monitor (SPM) configuration, which is only sensitive to the vertical position of the photon beam [5]. A scheme of this type of sensor is shown in Figure 6. The size, geometry, and material of the blades must be adapted to the particular beam characteristics of the 3PW source in order to achieve the maximum photocurrent yield together with an optimized sensibility, position accuracy and linearity. This optimization of the XBPM design is included in the scope of supply of the procurement of this unit.

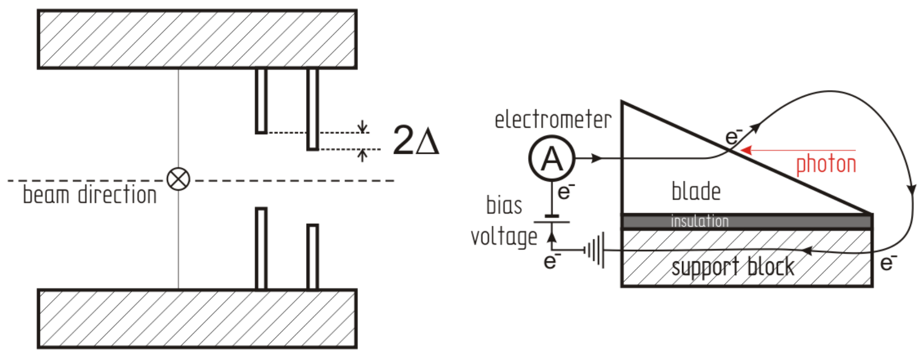


Figure 6:XBPM in Staggered Pair Monitor (SPM) configuration. Δ parameter corresponds to the vertical offset between the two pairs of blades.

The XBPM blades shall consist of tungsten or other UHV compatible material adapted to the spectral range of the photon beam to be monitored. The cooling system of the XBPM sensor and the mechanical layout of the sensor head components exposed to the photon beam must be designed to withstand the associated thermal load. The cooling water distribution and flow monitoring will be provided by the adjacent Pumping Unit.

The connection of the XBPM blades to the readout electronics (multichannel electrometer) will be made through Triax cables and connectors in order to allow biasing the blades with voltages up to 1kV. The system has also to be equipped with at least one thermocouple (K-type) in order to monitor the temperature of the support block.

A motorized X-Z table will allow the horizontal / vertical displacement of the XBPM chamber in a plane perpendicular to the incoming photon beam. The two axes of the X-Z motion table are to be provided with electrical limit switches (NC type) so that the movement is stopped electrically via interlock signals at full stroke when the movement goes beyond the maximum mechanical range. In addition, mechanical hard stops are required in order to prevent any damage in case of failure of the electrical limit switches. Each actuator must be equipped with a linear encoder with an appropriate resolution. Either absolute encoders or incremental encoders with a reference homing pulse are acceptable; in both cases, the use of a dedicated home switch at a known reference point is recommended. The encoders used must be radiation-tolerant from both the point of view of the associated electronics as well as the materials used for the encoders internals (i.e. a glass encoder ruler is not acceptable).

Both axes of the motion table must fulfil at least the following requirements:

- Total Stroke: 10mm (±5mm).
- Minimum step size: ±1µm.
- Minimum accuracy: ±5µm ± 5% *d* (where *d* stands for relative displacement)

The following forces shall be taken into account in the design of the motor stages: with no displacement the only force is the weight of the movable part (vacuum chamber, XBPM sensor and flanges); with a lateral displacement of the chamber, each welded bellow acts like a spring inducing a force proportional to the displacement. The Contractor must select the motors accordingly.

Photon Shutter component

The Photon Shutter component consists of a vacuum chamber that contains a pneumatically actuated water-cooled OFHC copper block that can intercept completely the x-ray photon beam. The chamber must be equipped with vacuum gauges to monitor its vacuum level and with a 300 l/s ion pump to deal with the outgassing from the Photon Shutter itself and from the adjacent Fixed Mask;

it must also have an adequate support structure, allowing its alignment. The support structure will include a guided platform for installation / removal of the 300 l/sec ion pump, as well as the elements for the cooling water distribution to the Photon Shutter and the adjacent Fixed Mask (which will be connected in parallel), the elements for the compressed air distribution to the Photon Shutter and the adjacent valves (one standard pneumatic valve and the Fast Closing Shutter), and a connection box providing connectors for the following signals: (a) flowmeter switches, (b) air pressure switch, (c) Photon Shutter position switches signals to the EPS system, and (d) dedicated Photon Shutter position switches to the Personnel Safety system (PSS). A conceptual sketch of the Photon Shutter unit is shown in Figure 7.

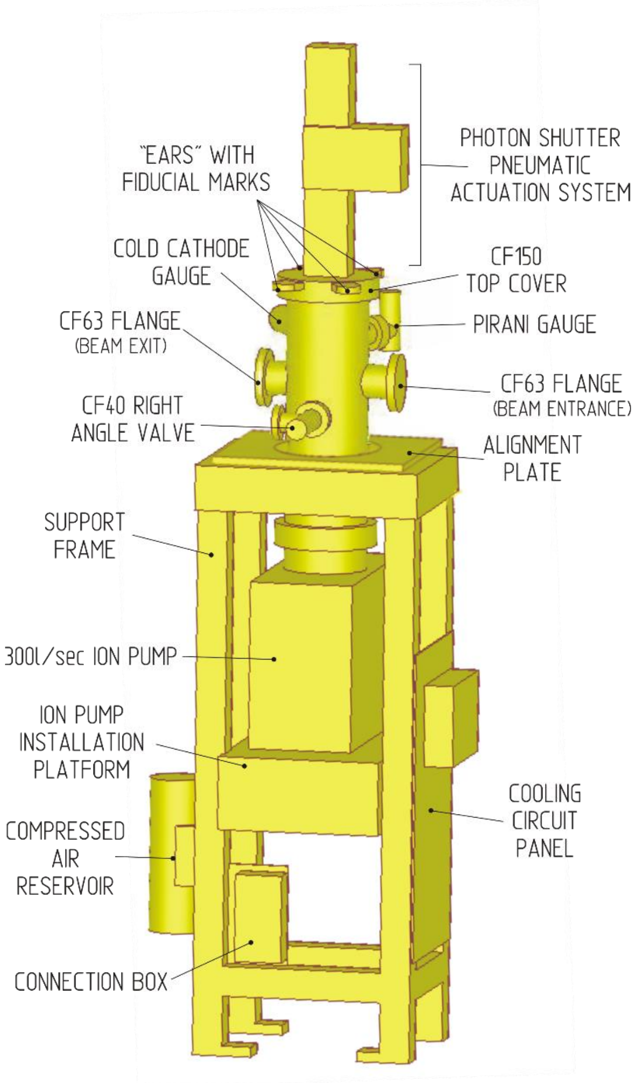


Figure 7: Conceptual sketch of the Photon Shutter unit.

The dimensions and configuration of the power absorbing block are shown in Figure 8. The block is pneumatically actuated with a stroke of 60mm, allowing to interrupt completely the photon beam or allowing its free passage. The incidence angle of the photon beam on the block is 30º. The bellows connecting the in-vacuum block to the external driving system must be designed for at least 100,000 cycles.

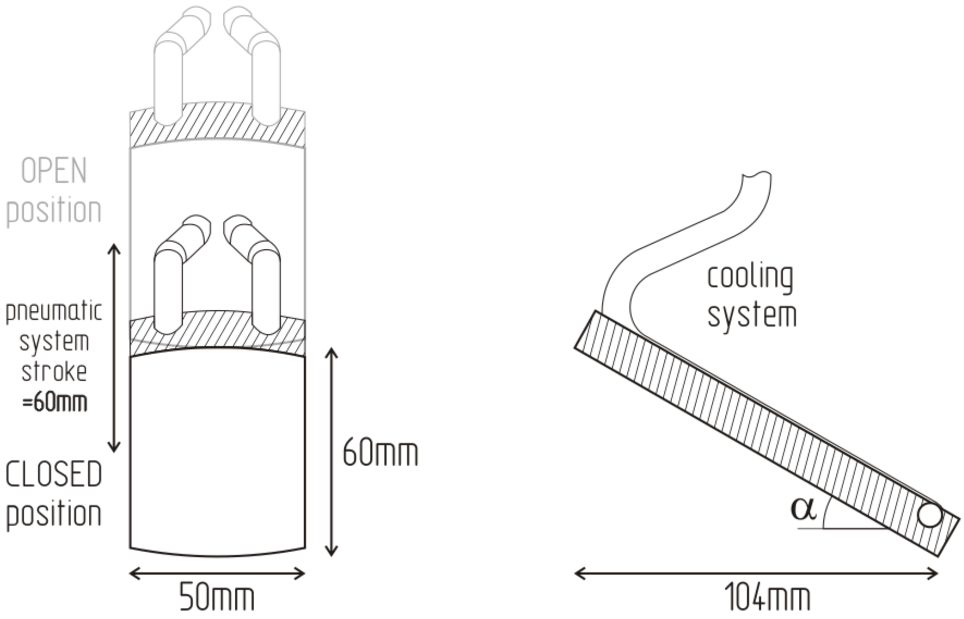


Figure 8: Geometry and dimensions of the OFHC copper power absorbing block for the Photon Shutter.

The Photon Shutter actuator must be simultaneously connected to the EPS and the PSS system. It must have two pairs of position switches to detect when it is in open / close position. The two switches to detect the open position are of electromechanical type, and are only wired to the EPS system. Regarding the switches to detect the closed position, there is an electromechanical one, wired to the EPS system, and a non-contact magnetic safety switch (Allen-Bradley MC1 440N-Z2NRS1), wired to the PSS system. The signal cables from both sets of switches must be directed to the connection box mounted on the support frame, which will provide the interface to SESAME control system

Out of the heat load of ~1kW (@400mA) emitted by the 3PW insertion device, only 63.5W reach the Photon Shutter after passing through the aperture of the Fixed Mask installed immediately upstream. The footprint of the photon beam on the Photon Shutter is shown in Figure 9. The operational parameters of the Photon Shutter for BEATS (total power, maximum power density, etc.) are summarized in Table 4. In the same table we also include the corresponding parameters for an equivalent shutter operating in a bending magnet Front-End at ALBA; it can be seen that the figures are very similar. The copper block must be equipped with a type-K thermocouple in order to allow monitoring its temperature.

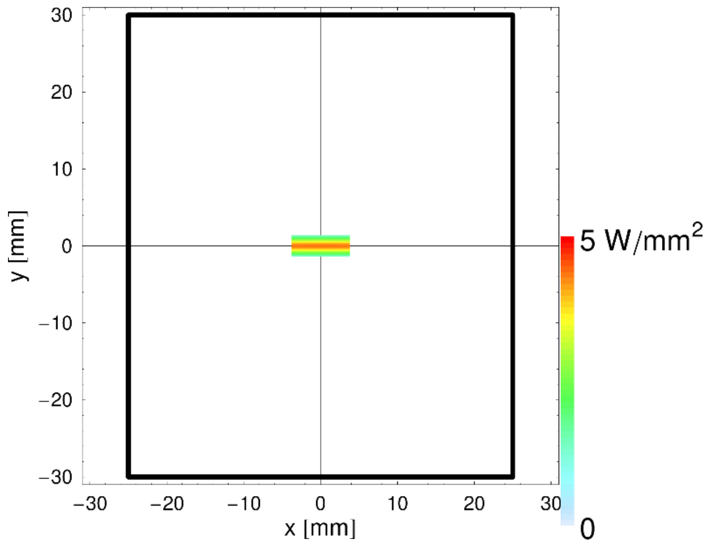


Figure 9:Footprint of the photon beam at the position of the Photon Shutter indicating the power density (@400mA) at normal incidence.

Photon Shutter	FE BEATS @SESAME	FE BM @ALBA
Distance from source (center)	7.57	7.76
Max P_{dens} [W/mm^2]	4.38	4.14
Absorbed power [kW]	0.063	0.064
Incidence angle α [deg]	30	30
Effective max. P_{dens} [W/mm^2]	2.2	2.1

Table 4: Operational parameters of Photon Shutter for FE of BEATS @400mA. As a comparison, we show the parameters of an equivalent Photon Shutter for a Bending Magnet BL at ALBA.

The main body of the vacuum chamber containing the Photon Shutter is very similar to the one described for the Pumping Unit #1: An upright 159×3 mm size 304L stainless steel pipe with CF150 flanges at the top of the bottom. As in that case, the bottom flange is used for the installation of the 300 l/sec ion pump, whereas the top one is used to install a modified CF150 flange containing the Photon Shutter with its driving system. In this case, the “ears” providing the alignment reference points must be welded to the top covering flange, which is rigidly linked to the Photon Shutter actuation mechanism. Along the beam direction the main chamber is equipped with two CF63 ports to connect it to the adjacent Front-End components, for a total flange-to-flange distance of 300 mm. Along the direction perpendicular to the beam, the chamber shall be equipped with three CF40 ports for the installation of two vacuum gauges (Pirani + Cold Cathode) and one right angle valve. The alignment system for the chamber shall be equivalent to the one described for the Pumping Unit #1.

The support frame must incorporate the rigid piping for the cooling water circuit of the Photon Shutter and the adjacent Fixed Mask. The circuit shall include the inlet / outlet connections to the cooling water distribution system at SESAME: Two parallel branches, each one with an entrance regulation valve and a flowswitch, and a common exit with a regulation valve and a T-derivation to a purging valve. A schematic diagram of the cooling circuit is shown in Figure 10. The signal cables from the two flowswitches must be directed to the connection box mounted on the support frame, which will provide the interface to SESAME control system.

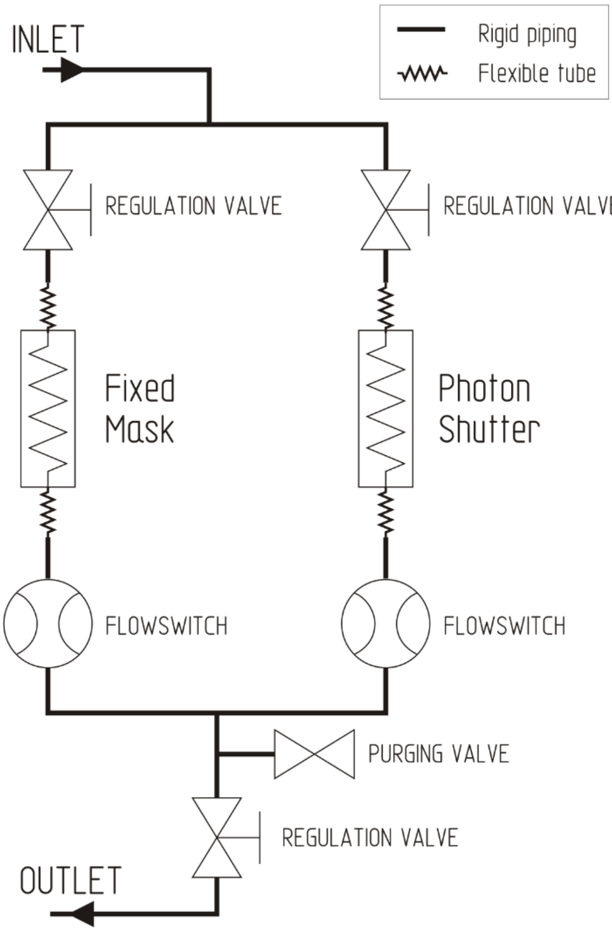


Figure 10: Schematic diagram of the cooling circuit to be installed on the support frame of the Photon Shutter unit, which will supply the Photon Shutter itself and the adjacent Fixed Mask

The support frame must also incorporate the compressed air circuit to feed the pneumatic actuator of the Photon Shutter itself and the adjacent gate valve and Fast Closing Shutter. The circuit shall include a non-return valve at its entrance, a 2-liter air reservoir to ensure the operation of the system for a few cycles in the case of an air supply failure, a pressure switch, and a manifold with an exit for each element that has to be connected to the circuit. A schematic diagram of the compressed air circuit is shown in Figure 11. The signal cables from the pressure switch must be directed to the connection box mounted on the support frame, which will provide the interface to SESAME control system.

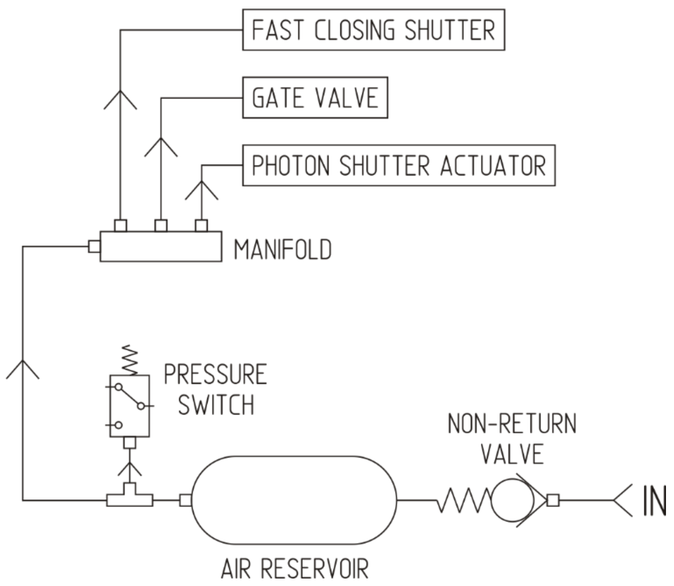


Figure 11:Schematic diagram of the compressed air circuit to be installed on the support frame of the Photon Shutter unit, which will supply the pneumatic actuator of the Photon Shutter itself and the adjacent Gate Valve and Fast Closing Shutter.

Pumping Unit #2

The second Pumping Unit is identical to the first one (#1), but without the cooling water distribution circuit (nor the electrical connection box), given that there are no neighbouring elements that need cooling.

Bremsstrahlung Stopper unit

The Bremsstrahlung Stopper consists of a main vacuum chamber accommodating a pneumatically actuated tungsten block with only two positions: “open” and “close”. The main vacuum chamber is mounted on a support structure that allows aligning it. The support must also include a guided platform for installation/removal of the 300 l/sec ion pump, the elements for the compressed air distribution of the pneumatic actuator and the adjacent vacuum valve, and a connection box providing connectors for the following signals: (a) air pressure switch and Bremsstrahlung Stopper position switches signals to EPS system, and (b) dedicated Bremsstrahlung Stopper switches to the PSS system. A conceptual sketch of the Bremsstrahlung Stopper Unit is shown in Figure 12

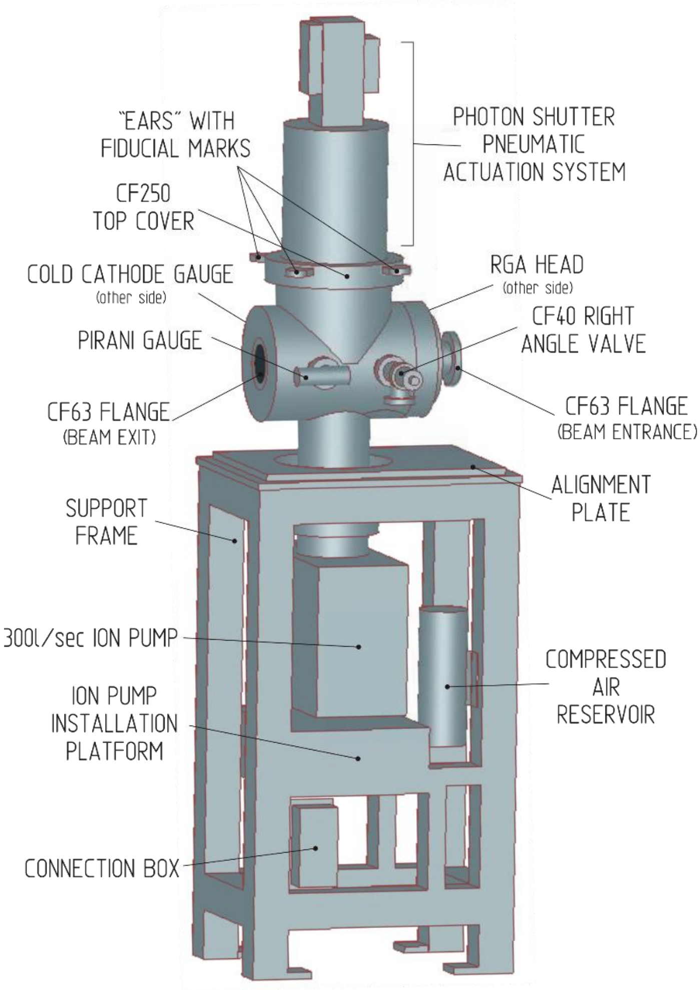


Figure 12: Conceptual sketch of the Bremsstrahlung Stopper unit

The tungsten block has a parallelepipedal shape with a square cross section of 120 mm × 120 mm, and a length of 200 mm, for a total weight of ~55 kg. The block is placed in a welded stainless steel frame linked to the actuating system. The total stroke of the pneumatic actuator is 100 mm. The material of the block must be UHV compatible. The bellows connecting the in-vacuum block to the external driving system must be designed for at least 100,000 cycles. Due to the weight of the block, the actuation system must be guided by means of ball bearings sliding on guide rods (preferably three of them).

The tungsten block actuator must be simultaneously connected to the EPS and the PSS system. It must have two pairs of position switches to detect when it is in open / close position. The two switches to detect the open position are of electromechanical type, and are only wired to the EPS system. Regarding the switches to detect the closed position, there is an electromechanical one, wired to the EPS system, and a non-contact magnetic safety switch (Allen-Bradley MC1 440N-Z2NRS1), wired to the PSS system. The signal cables from both sets of switches must be directed to the connection box mounted on the support frame, which will provide the interface to SESAME control system.

The chamber containing the stopper consists of a longitudinally aligned 256 × 3 mm size 304L stainless steel pipe. The chamber is closed at the beam entrance and exit with welded covers with CF flanges on their centres, for a flange-to-flange distance of 340 mm. The entrance flange aperture is CF150 in order to ease the access to the tungsten block during assembly/maintenance, and the exit flange aperture is CF63. In front of the entrance flange a CF150-to-CF63 reducer is mounted, with a length of 80 mm, thus increasing the total flange-to-flange distance of the assembly up to 420 mm. Above and below the main chamber two tubes are welded in T configuration: the top one is a 256 × 3 mm ending with a CF250 flange, which will be used to install the block with its pneumatic actuation system; the bottom one is a 159 × 3 mm ending with a CF150 flange, for the installation of a 300 l/sec ion pump. The "ears" providing the alignment reference must be welded around the top covering CF250 flange, which is rigidly linked to the Bremsstrahlung Stopper actuation mechanism. On each lateral side of the main chamber there will be two CF40 ports for the installation of two vacuum gauges (Pirani + Cold Cathode), a RGA head and a right angle valve.

The alignment system of the main chamber will be conceptually similar to that described for the Pumping Unit (#1) but, due to the geometry and dimensions of the chamber, four support columns (one on each corner) instead of three will be used.

The support frame must also incorporate the compressed air circuit to feed the pneumatic actuator of the Bremsstrahlung Stopper itself and the adjacent gate valve. The circuit shall include a non-return valve at its entrance, a 2 litre air reservoir to ensure the operation of the system for a few cycles in the case of an air supply failure, a pressure switch, and a manifold with an exit for each element that has to be connected to the circuit. A schematic diagram of the compressed air circuit is shown in Figure 13. The signal cables from the pressure switch must be directed to the connection box mounted on the support frame, which will provide the interface to SESAME control system.

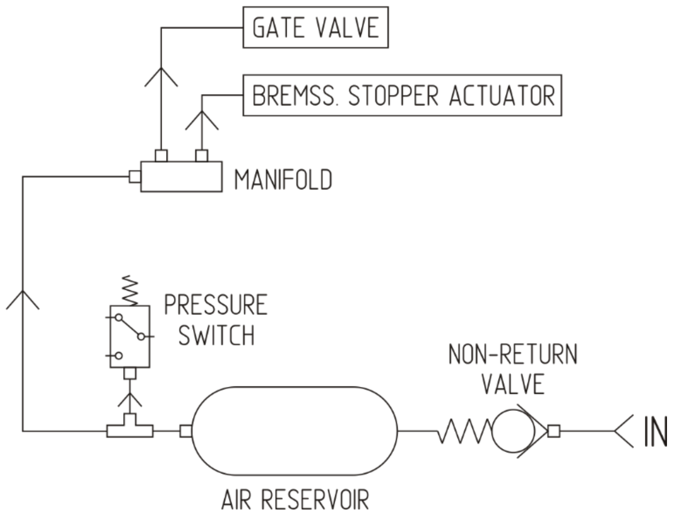


Figure 13: Schematic diagram of the compressed air circuit to be installed on the support frame of the Bremsstrahlung Stopper unit, which will supply the pneumatic actuator of the Stopper itself and the adjacent Gate Valve.

Trigger unit

The Trigger Unit consists of a vacuum chamber equipped with two dedicated trigger gauges in addition to Pirani / cold cathode gauges, an all-metal right angle valve, and a 150 l/sec ion pump. The chamber is mounted on a support structure that allows aligning it, and provides a guided platform system for installation/removal of the 150 l/sec ion pump.

The main body of the chamber is made from a vertically aligned 108 × 2 mm size 304L stainless steel pipe with CF100 flanges at the top and the bottom; the bottom flange is used for the installation of the ion pump and the top one will be used to install a wire scanner beam diagnostic device which is outside the scope of this specifications. Along the beam direction the chamber is equipped with two CF63 ports to connect it to the adjacent Front-End components, for a total flange-to-flange distance of 300 mm. Along the direction perpendicular to the beam the chamber shall be equipped on one side with a CF63 port for the installation of a right angle valve, and on the other side with two CF40 ports where two T-pieces will be mounted to allow the installation of two pair of vacuum gauges: a conventional Pirani + Cold Cathode pair for vacuum level reading and the two trigger gauges in charge of activating the Fast Closing Shutter.

The alignment system for the main chamber is equivalent to that described for the Pumping Unit (#1)

Combined Stopper unit

The Combined Stopper consists of a main vacuum chamber accommodating a combination of a water cooled copper piece equivalent to the one described for the Photon Shutter but at normal incidence and a tungsten block identical to the one described for the Bremsstrahlung Stopper. Both elements must be actuated by a single pneumatic system with only two positions: open and close. The main vacuum chamber is mounted on a support structure that allows aligning it. The support must also include a guided platform for installation / removal of the 300 l/sec ion pump, as well as the elements for the cooling water distribution to the cooper piece, the elements for the compressed air distribution of the pneumatic actuator, and a connection box providing connectors for the following signals: (a) flowmeter switch, (b) air pressure switch and (c) pneumatic actuator position switches signals to EPS system, and (d) dedicated safety switches to the PSS system.

Given the larger distance of this element with respect to the source as compared to the Photon Shutter (a factor ~3 of difference, see Table 2), the power density of the incident photon beam will be much smaller (by a factor of 9); due to this reason, we propose mounting the copper block at normal incidence. The vertical dimension of the copper block has to be large enough so as to protect the tungsten block behind it from the photon beam along the whole stroke of the pneumatic actuator.

The total stroke of the pneumatic actuator is 100mm, and it must be equipped with a ball bearings-based guiding system as the one described for the Bremsstrahlung Stopper. The bellows connecting the in-vacuum assembly to the external driving system must be designed for at least 100,000 cycles.

The water-cooled cooper block must be equipped with a type-K thermocouple in order to allow monitoring its temperature.

The pneumatic actuator must be simultaneously connected to the EPS and the PSS system. It must have two pairs of position switches to detect when it is in open/close position. The two switches to detect the open position are of electromechanical type, and are only wired to the EPS system. Regarding the switches to detect the closed position, there is an electromechanical one, wired to the EPS system, and a non-contact magnetic safety switch (Allen-Bradley MC1 440N-Z2NRS1), wired to the PSS system. The signal cables from both sets of switches must be directed to the connection box mounted on the support frame, which will provide the interface to SESAME control system.

The chamber containing the stopper blocks shall be similar to the one described for the Bremsstrahlung Stopper but with a length increased by 100 mm in order to leave room to install the water-cooled copper block, for a total flange-to-flange distance of 520 mm.

The support frame must incorporate the rigid piping for the cooling water circuit of the copper block. The circuit shall include the inlet/outlet connections to the cooling water distribution system at SESAME, regulation valves at the entrance and exit, a flowswitch, and a T-derivation to a purging valve. A schematic diagram of the cooling circuit is shown in Figure 14. The signal cables from the flowswitch must be directed to the connection box mounted on the support frame, which will provide the interface to SESAME control system.

The support frame must also incorporate the compressed air circuit to feed the pneumatic actuator of the combined stopper. The circuit shall include a non-return valve at its entrance, a 2-liter air reservoir to ensure the operation of the system for a few cycles in the case of an air supply failure, a pressure switch, and a manifold with an exit for each element that has to be connected to the circuit. A schematic diagram of the compressed air circuit is shown in Figure 14. The signal cables from the pressure switch must be directed to the connection box mounted on the support frame, which will provide the interface to SESAME control system.

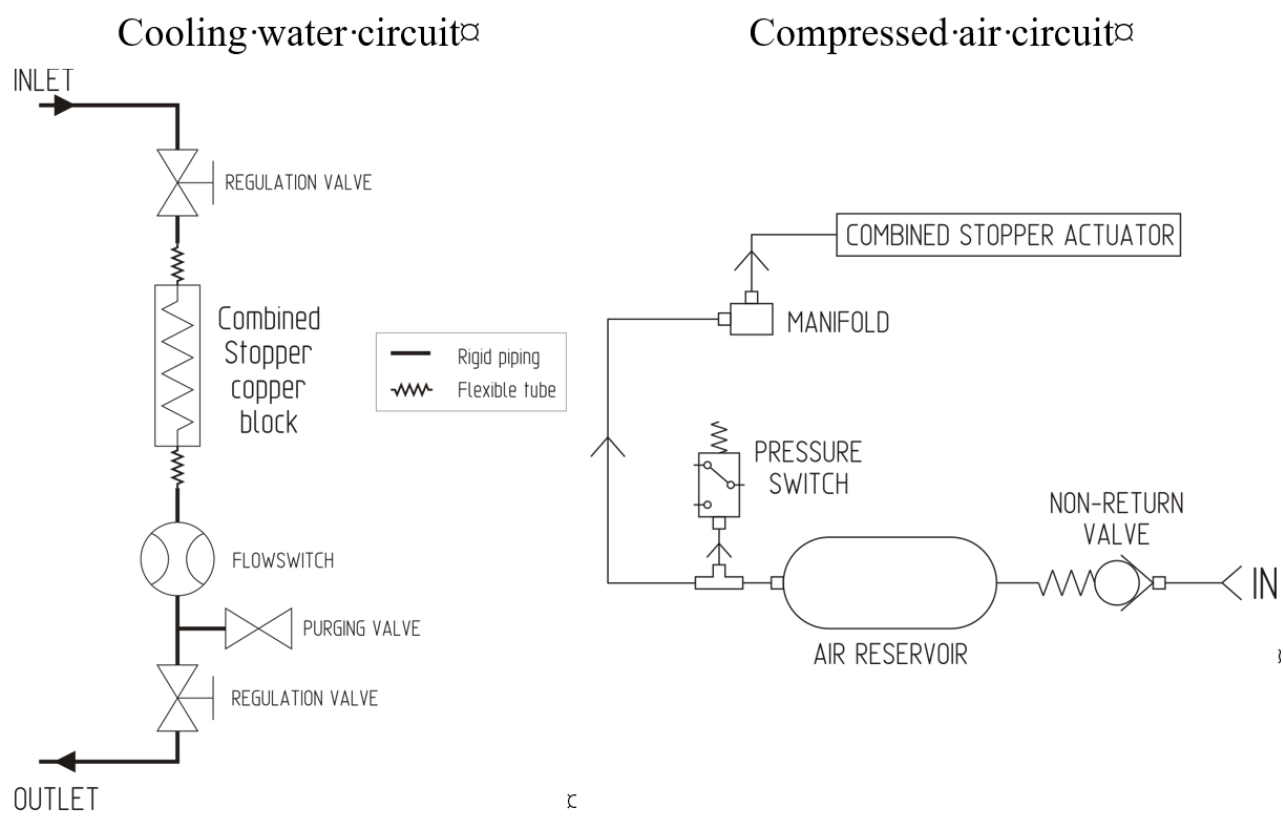


Figure 14: Schematic diagram of the water cooling (left) and compressed air (right) circuits to be installed on the support frame of the Combined Stopper unit.

Front end elements summary (ALBA)

	Pumping Unit #1	XBPM Unit	Photon Shutter Unit	Pumping Unit #2	Bremss. Stopper Unit	Trigger Unit	Combine d Stopper Unit
Total length flange-to-flange [mm]	300	600	300	300	420	300	520

Table 5: Dimensions of FE units for BEATS BL at SESAME under the responsibility of ALBA.

Insertion Device Parameters

The power density along horizontal and vertical axes at a distance from the source of 10 m and the 2D angular power density distribution emitted by the 3PW device at minimum gap (11mm) and for the maximum attainable electron beam current at SESAME (400 mA) are shown in Figure 15. Power density calculation has been carried out using SRW software [6], taking as inputs the magnetic field distribution described in [2] and the electron beam parameters in [3].

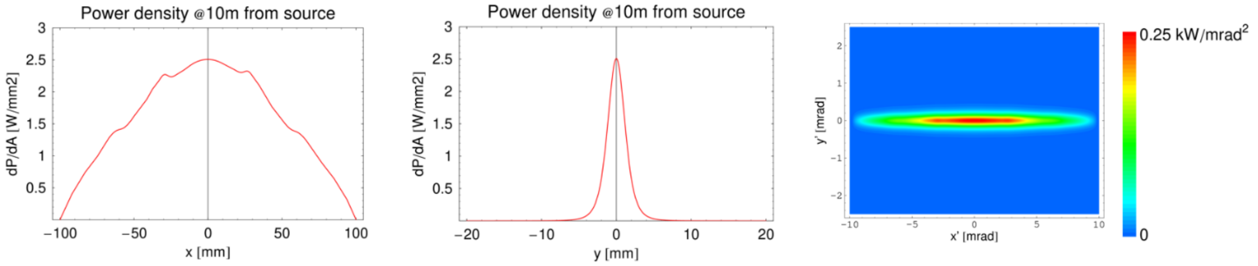


Figure 15: Power distribution emitted by 3PW device at minimum gap (11mm) and maximum electron beam current (400mA).

Switches and connectors

The specifications of limit switches and connectors to the control system (EPS and PSS) detailed in this section represent the standard in use at ALBA and shall be further modified to comply with SESAME control system standards before the launch of the Front End CfTs.

The Photon Shutter, Bremsstrahlung Stopper and Combined Stopper actuation systems are simultaneously connected to the EPS and the PSS system. In both cases the limit switches detecting the open/close positions are duplicated. Three of the switches in each system are of electromechanical type, whilst one of the lower switches detecting the closed position of the system is a non-contact magnetic switch (Allen-Bradley MC1 440N-Z2NRS1). The two upper switches are connected only to the EPS system; as for the lower switches, the electromechanical one is connected to the EPS and the magnetic one to the PSS system. For the connection of pneumatically actuated elements to the EPS system a 12-pin circular connector receptacle wall mount (UTG01412PH) is used. For the corresponding connection to the PSS system a special 19-pins circular connector receptacle wall mount Souriau VGE1 B22-14SN has been selected. The pinout of the connectors to the EPS/PSS system is the same for the two pneumatically actuated systems, and is shown in Figure 16.

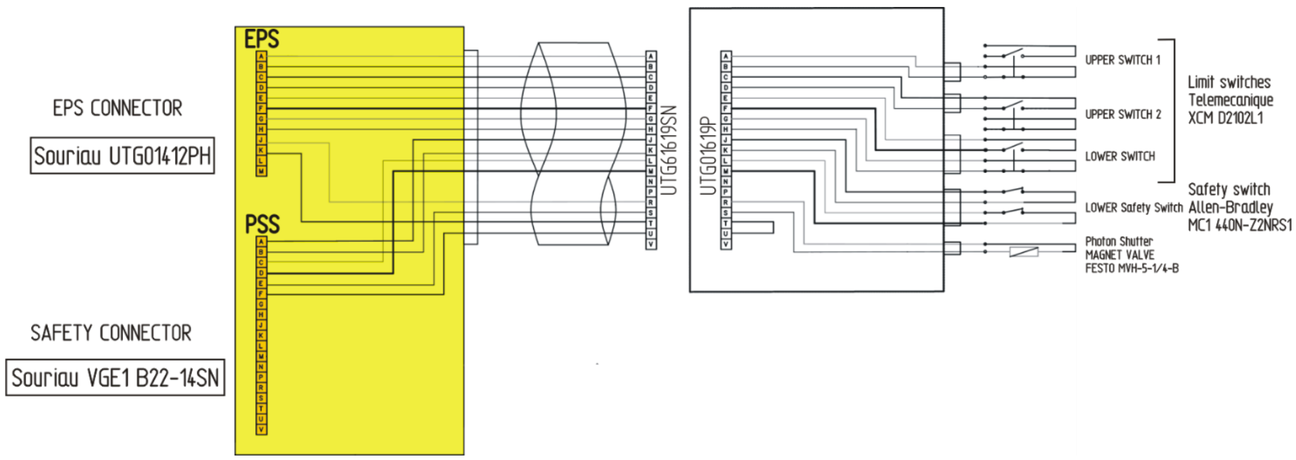


Figure 16: Wiring diagram for the connection of the pneumatic actuator of the Photon Shutter, Bremsstrahlung Stopper and Combined Stopper to EPS and PSS systems.

Regarding flow meters, at SESAME the PKP model DS01.2.2.1.W24A.1.1.0 flow monitor and switch is used. These monitors are equipped with a single NO switch (see Figure 17), requiring a total of 2 contacts per flow meter. Depending on the number of independent circuits, 1 (Pumping Unit) or 2 monitors (Photon Shutter unit) are installed in each FE unit. The connection to the EPS system is done by means of a 12-pin circular connector receptacle wall mount (UTG01412P). One example of wiring diagram for the flow monitors indicating the pinout of the connector to the EPS system is shown in Figure 17.

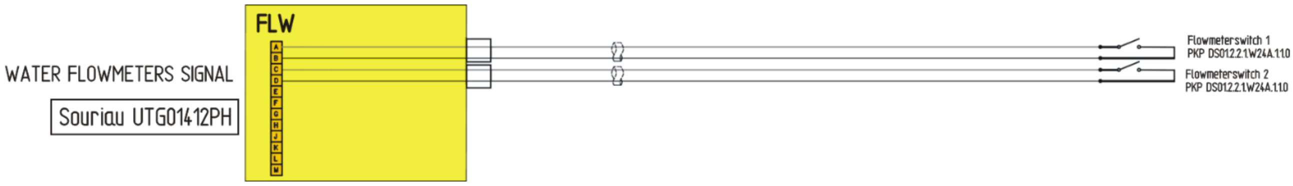


Figure 17: Wiring diagram of cooling water flowswitches.

As for compressed air switches, we will assume that FESTO PEV-1/4A-SW27 pressure switches or similar are used where required (Photon Shutter Unit and Bremsstrahlung Shutter Unit). All three contacts of the SPDT switch are connected to the EPS system using a 12-pins circular connector receptacle wall mount (UTG01412P), as shown in Figure 18.

Figure 18: Wiring diagram of compressed air switches.

CONCEPTUAL DESIGN ELETTRA-ESRF COMPONENTS

Introduction

Within the frame of supply of the Front-End for BEATS, ELETTRA and ESRF are issuing the present Call For Tender within the scope to supply:

- A Fixed Mask
- A CVD Window
- An Attenuator

Manufacturing drawings (2D in pdf, 3D in STP file format), will be attached to the Call for Tender, and all the items listed in the different Bills of Materials have to be quoted by the tender.

Figure 2 presents the Front End and the Optical Hutch. The elements highlighted in green are the ones under the responsibility of ELETTRA and ESRF and are specified in this chapter. The elements highlighted in yellow are those described in chapter "Conceptual design ALBA components" and are under the responsibility of ALBA. The element without highlighting will be part of a separate Call for Tenders, or are commercial products.

Regarding the Primary Slits (highlighted in pink) it has to be noted that the slit assembly at ESRF's imaging beamline ID19 will be exchanged at the end of 2020 to cope with the increased power of the ESRF after the EBS upgrade. Therefore, after their exchange, it is envisaged to test and refurbish these slits and ship them to SESAME for use in the BEATS beamline.

Fixed Mask

The Fixed Mask is the first Front-End component impacted by the photon beam. It defines the maximum aperture available for the beamline and protects downstream Front-End components that are not designed to withstand the thermal load of the photons, absorbing unwanted radiation from the adjacent bending magnets passing through the crotch absorber window and to limit the beam size from the 3-Pole Wiggler.

The heat absorbing body of the mask is obtained from a single solid piece of OFHC copper to handle the heat flux of the source, brazed to the DN 63 CF stainless steel flanges. The water-cooling pipes are brazed on the back side of the copper body (see Figure 19).

The temperature of the absorber block is monitored by a thermocouple entering by a DN 16 CF feedthrough.

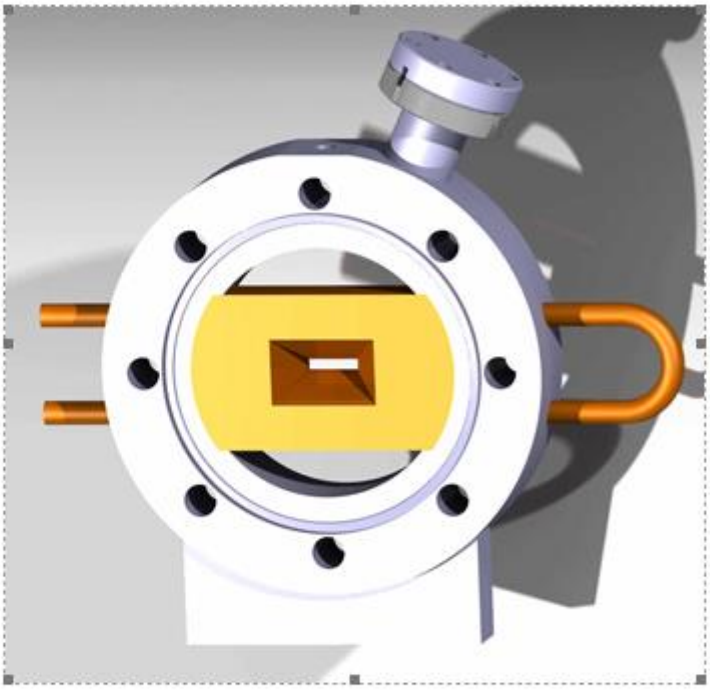


Figure 19: Conceptual design of the fixed mask

The Fixed Mask will receive a total power of 230.4 W and will absorb 166.9 W with maximum power density of 4.5 W/mm2 (with an incident power of 2.25 W/mm2 due to the sloped walls).

These walls define a central aperture with dimensions of 7.428 mm (H) x 2.7 mm (V). This aperture tailors the downstream beam divergence to 1.0 mrad (H) x 0.36 mrad (V), while the crotch absorber acceptance was 3.0 mrad (H) x 1.0 mrad (V).

The aperture features are precision machined and referenced to the external fiducial holes and a top flat surface to align the mask before screwing it.

Name	Distance [m]	P_{tot} [W]	P_{abs} [W]	P'_{max} [W/mm2]	H/V Beam size [mrad x mrad]	H/V Beam size [mm x mm]
Fixed mask	7.428	230.4	166.9	4.5	1.0/0.36	7.428/2.7

Table 6: Fixed mask operational parameters for the front end of BEATS

CVD Window

The first window is mandatory to separate the machine UHV-sector (usually 10^{-10}mbar), from the Front-End and the beamline vacuum (typically 10^{-8}-10^{-9} mbar). The window must also prevent any vacuum accident in the storage ring in the event of a leak in the beamline. As a consequence, the window is designed to sustain atmospheric pressure on the beamline side. For this purpose, a cooled Chemical Vapour Deposited (CVD) diamond window will be used. For easy maintenance the window will be placed between two UHV valves and must have pumps on both sides.

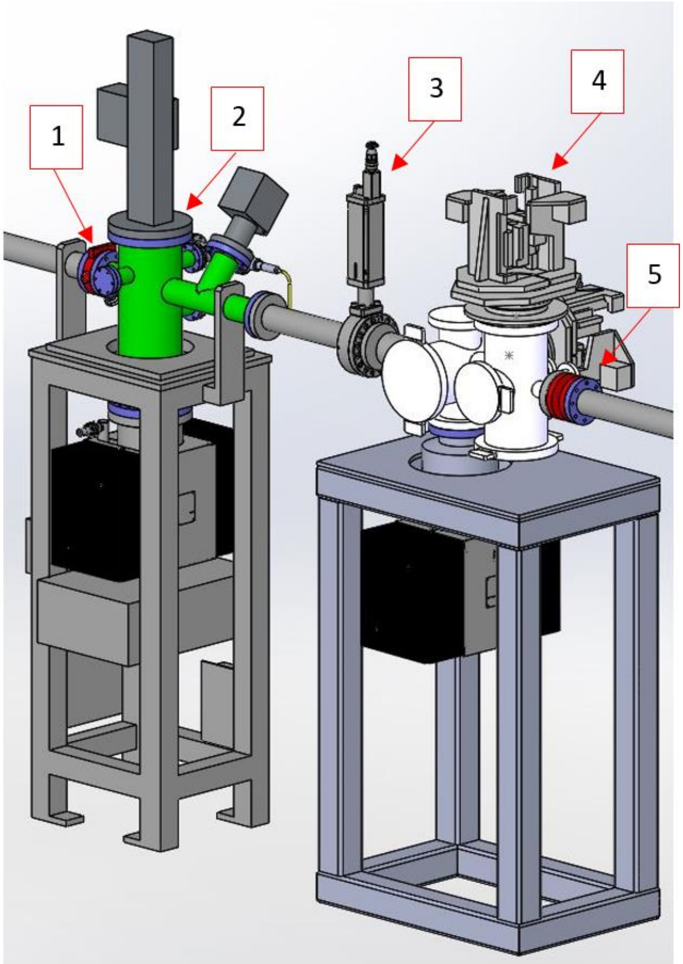


Figure 20: Second part of the front end(1: Fixed mask; 2: Photon absorber; 3: Vacuum Fast Shutter; 4: Primary slits; 5: CVD window)

The front end window is positioned at 9.0 m from the photon source. At this location, the white beam has a full width of 9.6 (H) x 3.2 (V) mm^2 . A window with an opening of 11 (H) x 5.5 (V) mm^2 and a possible thickness between 150 µm and 400 µm (after consultation with manufacturers) is considered. The surface roughness of the CVD will be low (e.g. < 5nm Ra) to conserve the flatness of the beam front.

The diamond CVD window is brazed on a copper body with cooling channels embedded in the flange. It absorbs an average power of 18 W with maximum power density of 0.68 W/mm^2 for a thickness of 0.4 mm of CVD diamond. Figure 21 shows the power density on the first CVD window.

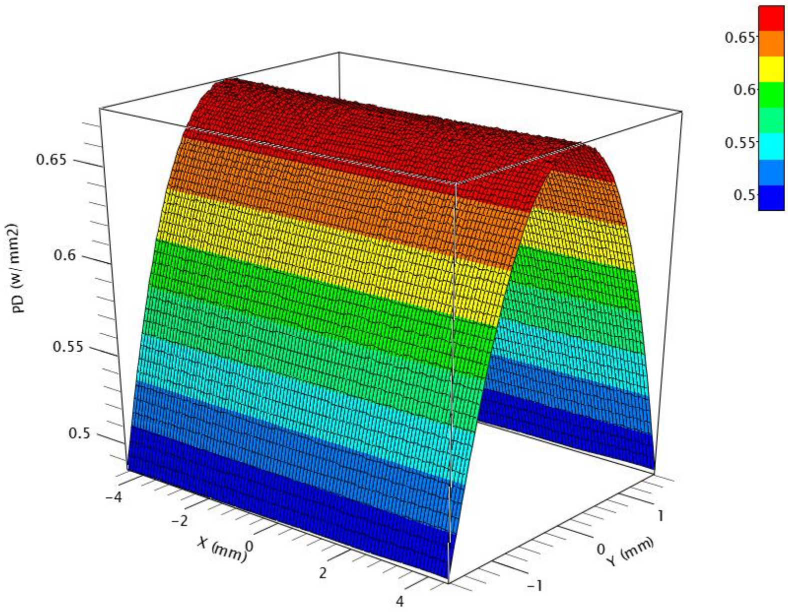


Figure 21: Absorbed power distribution on the first CVD window

According to these parameters, Finite Element Analysis results (Figure 22) show a maximum temperature of the diamond of 30.3 °C, with maximum von Mises stress of 84 MPa (Figure 23), due to thermal deformations as well as pressure gradient on the opposite sides. This corresponds to the worst case scenario: with air on the beamline side and vacuum on the opposite side, the worst heat load and a bad gap conductance at the interface between CVD and copper.

If a static pressure difference of 1 bar is applied on the faces of the window (no thermal load, 0.4 mm thickness), the maximum computed stress is around 2 MPa (to be compared with the Flexural Strength of the diamond which is 137 MPa), causing a deflection of 2 10^{-9} m.

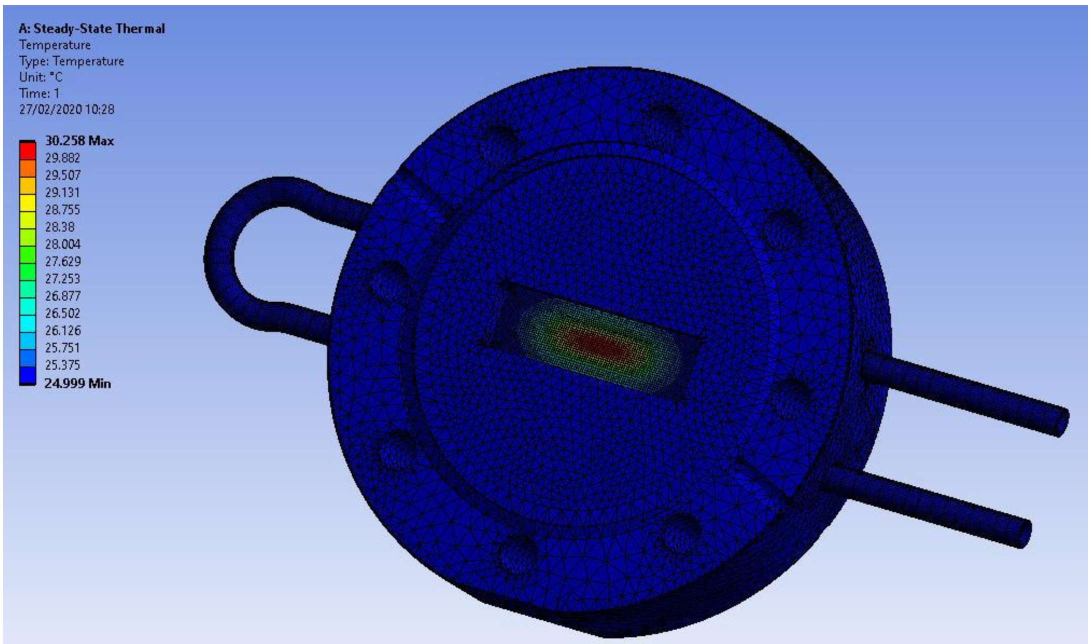


Figure 22: Temperature distribution CVD window. Preliminary finite elements simulations were carried out considering a fixed mask opening of 2 mrad. Simulations for an aperture of 1 mrad are under preparation.

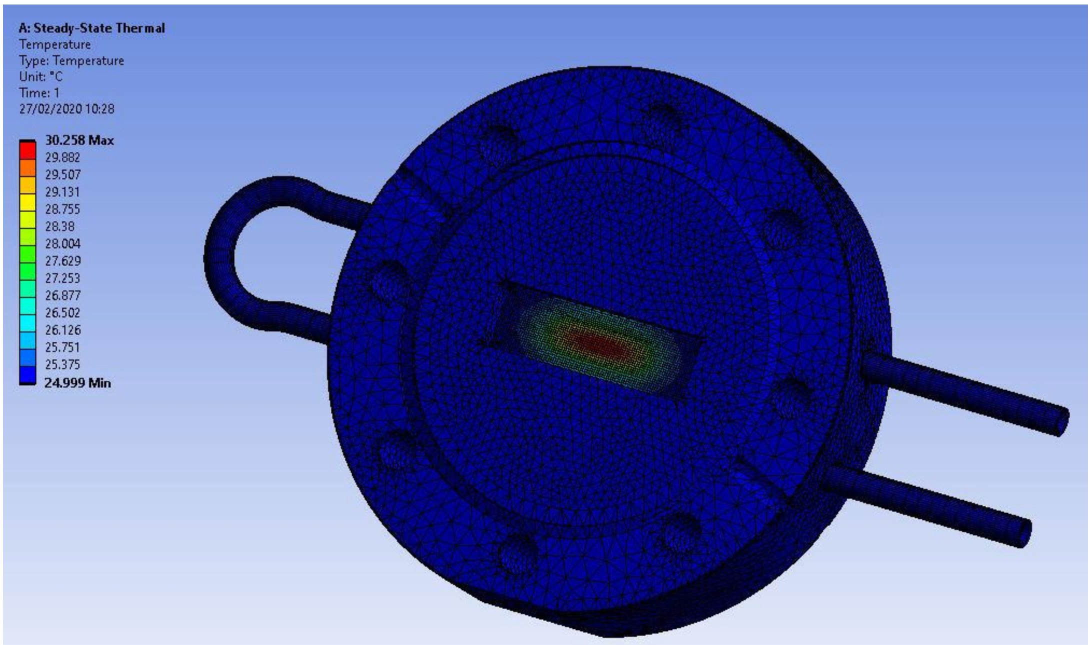


Figure 23:Equivalent stress distribution for a CVD window

Attenuator

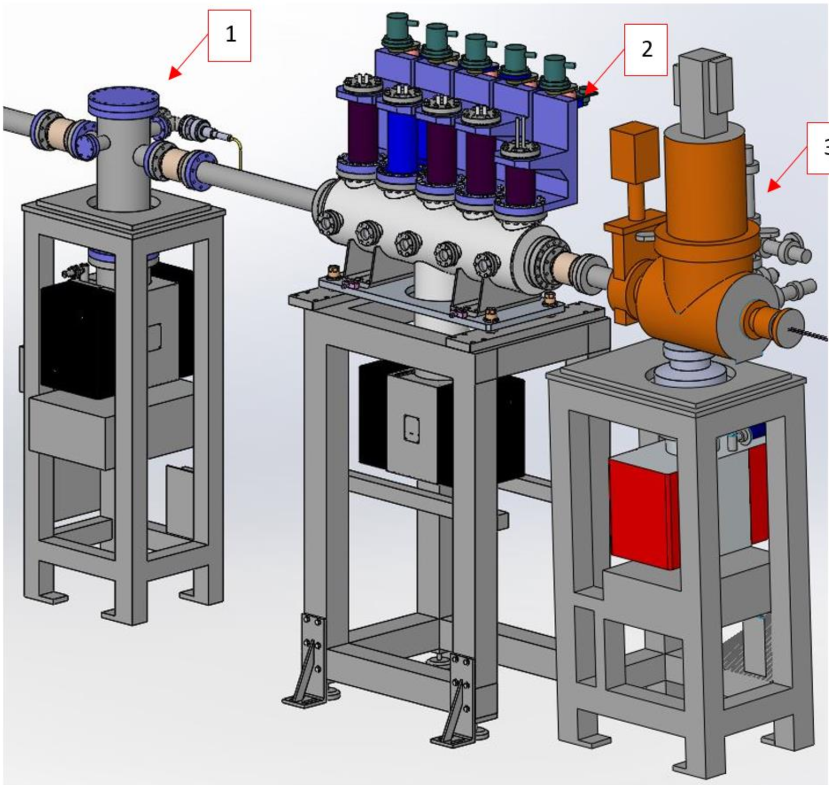


Figure 24: Third part of the front end (1: Pumping station; 2: Attenuator; 3: Bremsstrahlung shutter)

The Attenuator consists of polished foils made of different materials and thicknesses which are designed to decrease the beam intensity and to protect sensitive samples from possible degradation. Aluminium, copper, iron, graphite and palladium are preliminary considered as attenuating materials.

The Attenuator tailors the energy spectrum, for white or monochromatic beam, and dissipates heat. If the absorbed heat load is extremely high, the foils have to be cooled by means of both radiation and conduction. The cooling will be provided by channels around the filter frame (see Figure 25, right).

The filters' holder arms will be inserted in or out from the beam by actuators moved by stepper motors. The Attenuators vessel will be connected to an ion pump. A control system will define if the filters are in the beam's way.

The attenuator device considered for BEATS is based on the attenuator designed for the ESRF beamline BM18, comprising 5 axes, for a total of 15 foils of attenuating materials. The position of each filter axis can be controlled either with position switches or with encoders and limit switches. The maximum aperture of the device for BM18 is 65 (H) × 4 (V) mm^2. For BEATS, this has been modified to leave space for a 13.2 (H) × 4.2 (V) mm^2 beam at the position of the attenuator.

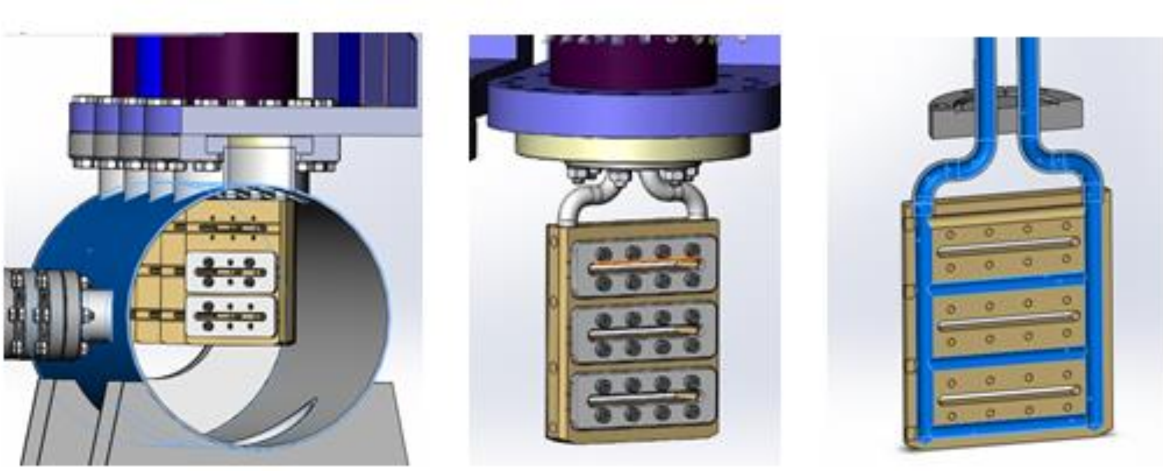


Figure 25: Details of the attenuator system design for BM18 at the ESRF. (Courtesy: F. Cianciosi)

The bidder will quote the manufacturing and supply of 1 support and vacuum vessel as well as 5 axes as indicated in the attached drawings.

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