BEATS

Work package 5

Procurement and construction of beamline infrastructure

Launch of the Radiation Safety Hutches CFT

D 5.1

September 2020

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CONTENTS

INTRODUCTION

Objective

The objective of this document is to describe the preparation of the Call for Tender (CfT) of lead radiation safety hutches and the lead shielding of a transfer pipe of the BEATS beamline at the SESAME synchrotron facility in Jordan. The design of the BEATS X-ray radiation shielding aims at guaranteeing public zone radiation levels outside all hutches and shielding elements during operation of the BEATS beamline. The dose rate limit of 0.5 µSv/h for non-exposed workers, assuming 2000 working hours per year, must be respected for SESAME's experimental hall.

General description

A schematic layout of BEATS is shown in Figure 1. The beamline will be operated in monochromatic as well as in pink beam modes. During operation of SESAME, the BEATS hutches and beam transfer pipe sections will provide radiation protection to users and all persons in the main hall. The main workplace will be in an unshielded control cabin located on the right-hand side of the experimental hutch.

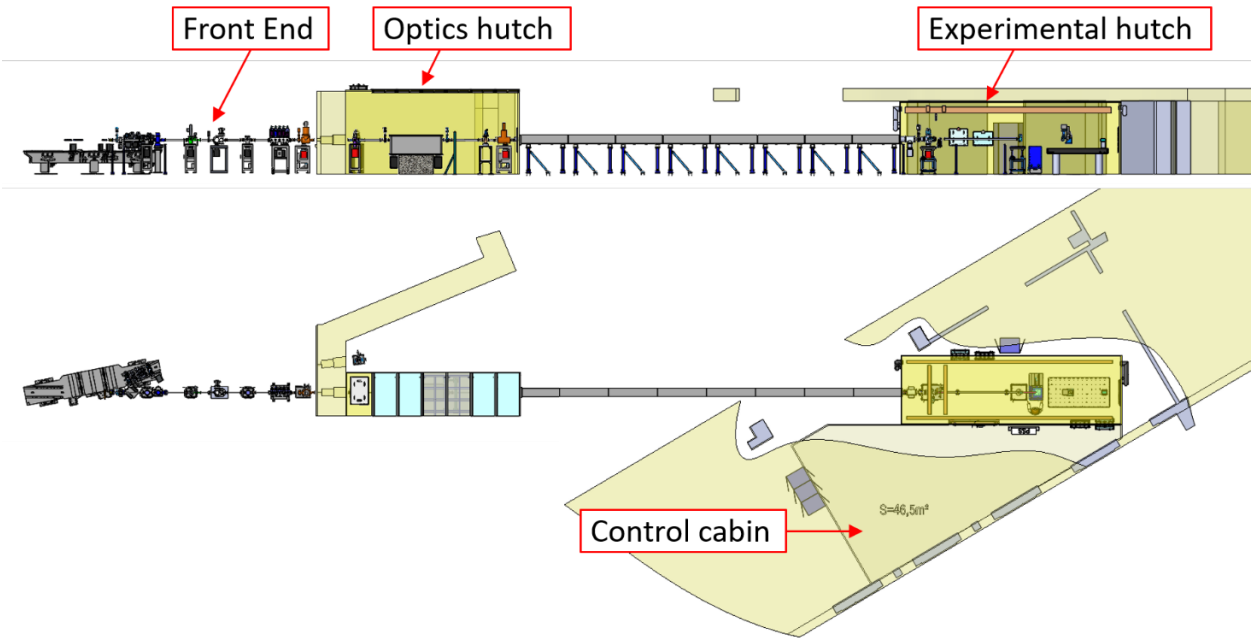

Figure 1: Layout of the BEATS beamline showing the location of the equipment inside the SESAME storage ring tunnel (beamline front end) and experimental hall (optics and experimental hutches)

Location of the beamline in the SESAME facility

The position of the BEATS beamline in the SESAME experimental hall and service area is shown in Figure 2. By making use of SESAME's experimental hall and of two rooms of the adjacent service area it is possible to accommodate a beamline with a maximum length of 45 m. The modifications to the service area of the SESAME building required to make room for BEATS consist of:

- Dismantlement of toilets and adjacent laboratory (power supply laboratory). The laboratory will be moved to another free room of the service area.
- Dismantlement of the false ceiling, mechanical parts, electrical pipes and of 3 walls.
- Reinforcement of the floor with concrete (22 cm) and screed (8 cm) reinforced by high tension steel; mechanical polish; epoxy layer.

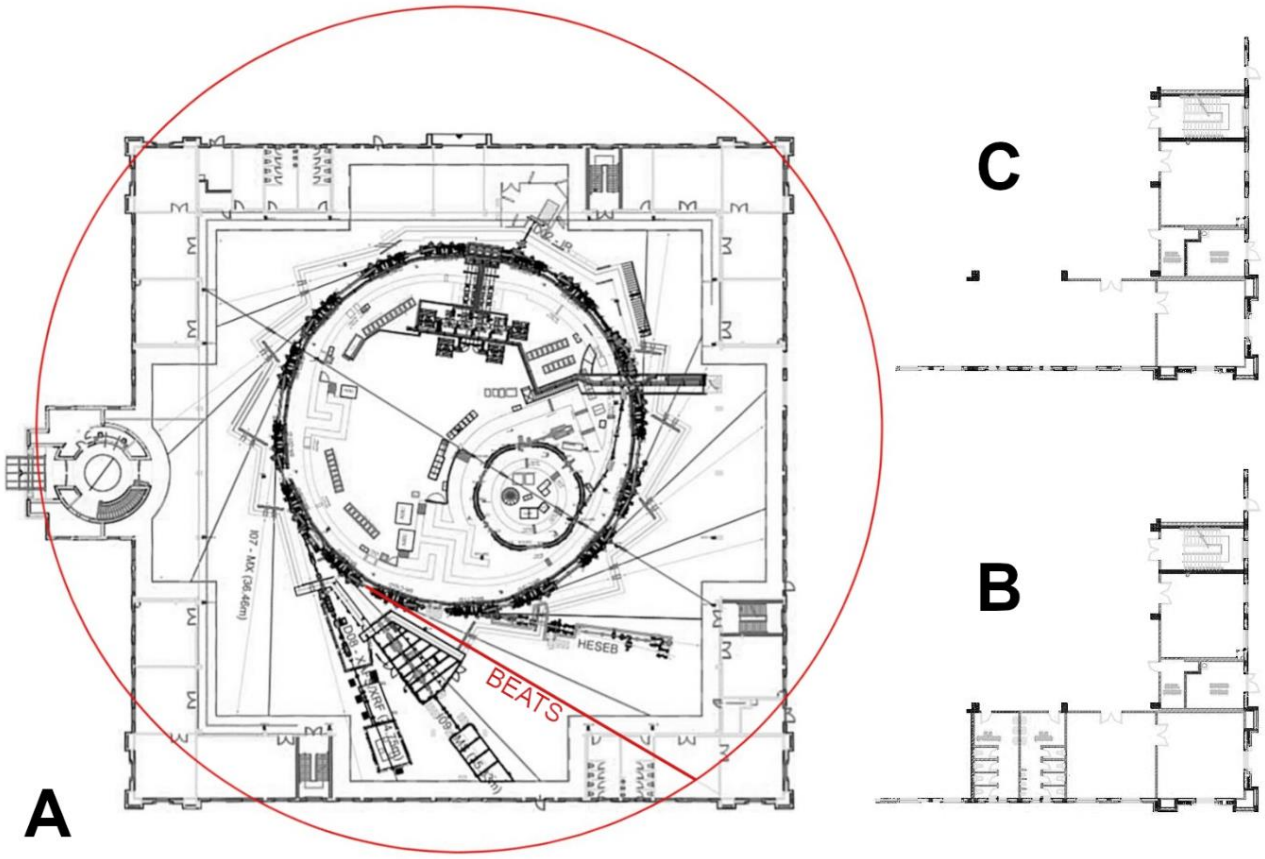

Figure 2: A: Floor plan of the SESAME facility showing the location of BEATS. The red circle indicates the end point of a 45 m long beamline. B: Detail of the current facility floor plan at the location of the BEATS experimental hutch (service area). C: Sketch of the modifications to the SESAME service area building required to host the infrastructure of BEATS.

General scope of the CFT

The scope of the radiation safety hutches CFT includes:

- Supply and installation of an Optics Hutch (OH) in the SESAME experimental hall.
- Supply and installation of an Experiment Hutch (EH) in the SESAME service area.
- Supply and installation of 16.0 m of vacuum pipe shielding, from OH to EH (including supports, flange boxes, etc).

Unless stated otherwise, the works include the supply and installation of the material, products and equipment, as well as the commissioning and warranties described in the Call for Tender document.

CONTENTS OF THE CFT

The CfT for the BEATS radiation safety hutches has been established along the line of similar CfT documents at the partner facilities ALBA and ESRF. The content of the CfT is listed in Table 1.

Table 1: Contents of the BEATS Radiation Safety Hutches CFT

Milestones and time schedule

The contract for the supply, delivery and installation of the BEATS hutches will be divided in two phases: Phase I: design and Phase II: manufacture and installation.

The design phase is to be completed within max. 5 weeks of the start of the contract. A Preliminary Design Review (PDR) meeting will take place via videoconference at this time. A Final Design Review (FDR) videoconference meeting will take place not later than 10 weeks after the start of contract. The installation phase should be completed within 8 months after the FDR meeting.

The contract timeline will thus be composed of the milestones listed in Table 2.

Milestone	Months after signature of contract
PHASE I: design	
Start of contract	0
Kick-off meeting	0
Preliminary Design Review (PDR)	1.2
Final Design Review (FDR)	2.5
PHASE II: manufacture and installation	
End of installation	10.5

Table 2: Milestones and timeline for the BEATS Radiation Safety Hutches CFT

Deliverables

Design phase

The following items shall be delivered by the contractor to SESAME at least two weeks before the FDR meeting:

- A time and manpower schedule of all activities covered by the contract.
- A description and time schedule of the installation procedure at the SESAME site.
- The quality assurance documents for all activities covered by the contract.
- The list of operations to be performed in the factory prior to delivery of the units to SESAME.
- A report containing lists and detailed descriptions of components, materials and suppliers or subcontractors.
- A complete list of the quantities of components, materials, etc. to be purchased by the Contractor to build the hutch.
- All drawings used in the manufacturing of the shielded hutches in printed and electronic in 2D and 3D forms saved under “DWG” and “STEP” extensions.

- Calculation notes on the mechanical stability of the hutch structure and the load on the experimental hall and service area floor.

Manufacture and installation phases

The works on the beamline shall be delivered and installed according to the present specification and respecting the time and manpower schedule delivered by the contractor within the design phase. The delivery refers to:

- Shielded Optics Hutch, BEATS-OH
- Shielded Experimental Hutch, BEATS-EH
- Shielding Hard X-Ray Pipe, BEATS-TP

The delivery must proceed in three steps:

- Following the supply and installation, a technical visit is made with SESAME technical and radioprotection groups to identify any kind of reservation (light-test).
- Release reservations: all the reservations have been repaired and a new technical visit is made with SESAME technical and radioprotection groups in order to confirm it (light-test).
- Radiation test: final test, done by the SESAME radio protection group (with the synchrotron beam) to identify any radiation leak.

The installation of all transfer pipe sections will be coordinated with the contractor, in order to perform the installation of the vacuum transfer pipe concomitantly with the installation of shielding support elements. A detailed description of the procedure, including time schedule and tentative dates should be delivered to SESAME within the design phase.

In addition, a set of test certificates and inspection reports should be delivered as required by this specification at the conclusion of the installation phase.

The manufacture and installation phase shall not start without written approval from SESAME, covering both engineering and radiation safety aspects.

Specific shielding requirements

Optics hutch - Version A (OHA)

Bidders participating in the CfT of the BEATS radiation protection hutches will be asked to make an offer for two different design options of the BEATS optics hutch:

- BEATS optics hutch Version A (OHA; Figure 3): this version encloses the BEATS optical components area as well as the area for optical components of an eventual future neighbouring bending magnet beamline. This option offers several advantages:
    - Reduced length of hutch walls, since the storage ring tunnel concrete wall can be used for shielding
    - Offer shielding for the optical components of a future neighbouring bending magnet beamline to be installed at SESAME
    - Leave more space around the BEATS DMM facilitating the installation and commissioning of this component.

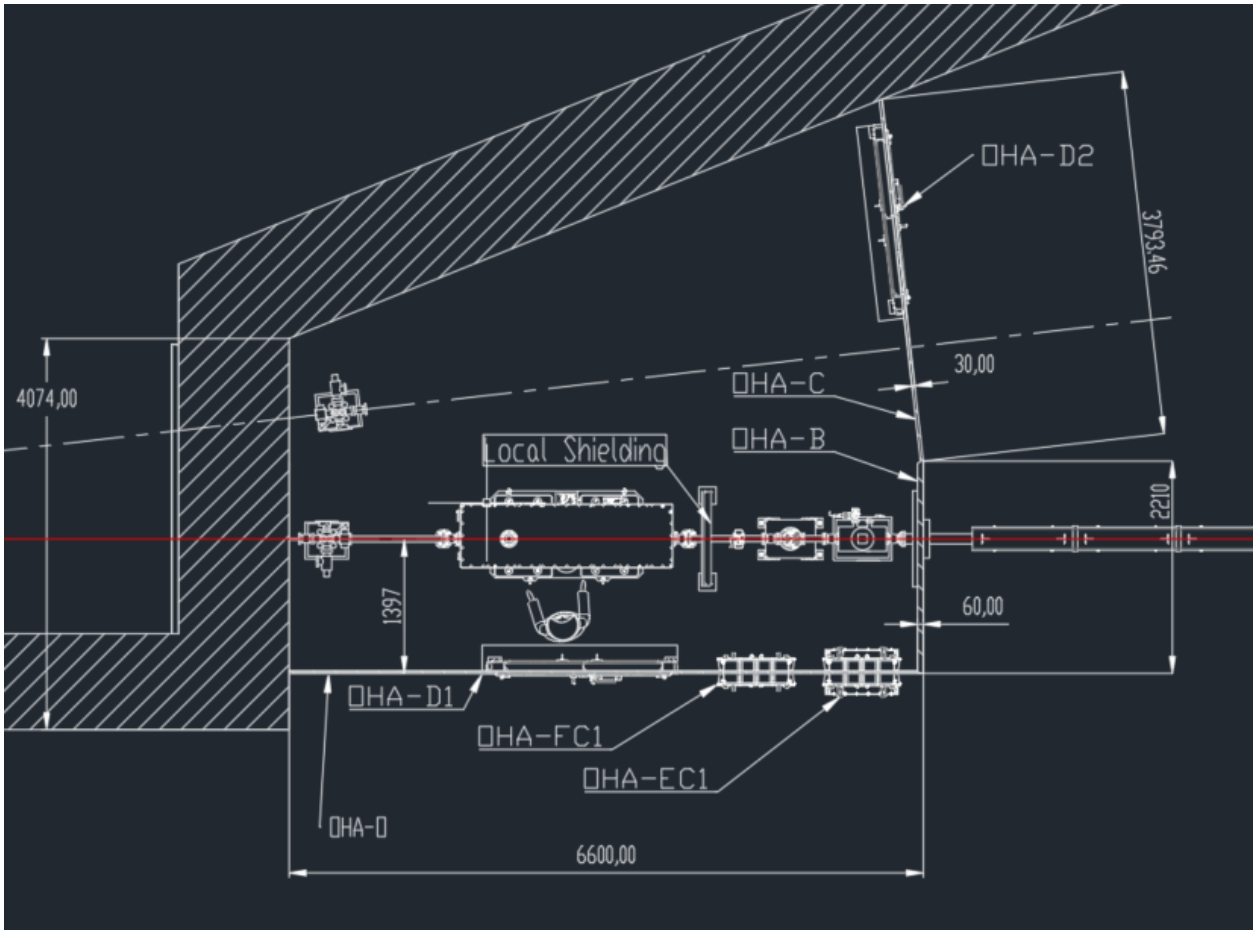

Figure 3: BEATS optics hutch Version A (OHA).

Size and hutch shielding

The BEATS OH Version A (OHA) has a height of 3000 mm and consists of 3 main walls, where the outer wall (OHA-O) has a length of 6600 mm and the downstream wall (OHA-B) is 2210 mm. The angle between OHA-O and OHA-B is 90 degrees.

The third wall (OHA-C) connects OHA-B to the shielding wall of the storage ring tunnel and it is 3793.5 mm in length. The inner angle between OHA-B and OHA-C is 183.5 degrees. The size of the BEATS OHA walls are:

Item	Name in Figure 3	Size (length × height)
Sidewall	OHA-O	6600 mm × 3000 mm
Backwall	OHA-B	2210 mm × 3000 mm
Backwall	OHA-C	3793.5 mm × 3000 mm

Local shielding

The wall penetration on OHA-B for the transfer pipe shall be fitted with the diameter of a CF flange (outer CF150 diameter is 102 mm). The beam height at the exit from OHA-B is 1410 mm.

A beam exit for the future installation of a Bending Magnet (BM) beamline should be predisposed on OHA-C. The BM beamline beam height at the exit on OHA-C is 1410 mm. This exit is foreseen for future utilization and should be closed with a lead radiation tight plug.

The following additional shielding elements must be installed:

#	Shielding element	Qty	Height (cm)	Width (cm)	Thickness (cm)	Material
1	Tunnel-to-OHA guillotine	1	30	30	2	Lead
2	Local Pb screen 1 behind DMM	1	100	100	2	Lead
3	Sidewall OHA-O neutron screen	1	-	-	10	Polyethylene
4	OHA-B-to-TP guillotine (inner)	1	40	40	6.5	Lead
5	OHA-B bremsstrahlung wall	1	100	100	5	Lead
6	OHA-B-to-TP guillotine (outer)	1	-	-	2	Lead

The 50-mm-thick bremsstrahlung reinforcement of wall OHA-B must have a surface of at least 1 m × 1 m. The reinforcement must be integrated into the panel structure of wall OHA-B and supported with a steel frame following the ESRF reference design 00.67.0600. The central hole is located at the nominal beam position of 1410 mm from floor. The design must assure complete absence of radiation leaks.

Doors, chicanes and other components

OHA must be equipped with the following components:

Component	Qty	Ref. Design
Electrical chicane (wall OHA-O)	3	ESRF 00.67.0200
Fluids chicane (wall OHA-O)	2	ESRF 00.67.0202
Ventilation entrance chicane (wall OHA-O)	1	ESRF 00.67.0205
Ventilation exit chicane (wall OHA-R)	1	ESRF 00.67.0204
Double door without window (wall OHA-O)	1	ESRF 00.67.0304
Double door without window (wall OHA-C)	1	ESRF 00.67.0304

Hutch roof and support structure

The roof of the BEATS OHA (OHA-R) has a total surface of approximately 30.96 m^2 and must have a minimum lead thickness of 15 mm. The roof weight should be transmitted to the floor slab through pillars of adequate dimensions. The chicane BEATS OHA-R has to be removable. The steel support structure of OHA-R can include steel poles inside the same hutch area. The position of these steel poles must not interfere with the optical and beamline components present inside OHA,in particularly the monochromator chamber and support. The distance between these steel poles and the equipment of OHA should be maximized in the design.

Optics hutch - Version B (OHB)

The BEATS optics hutch Version B (OHB) encloses only optical components belonging to the BEATS beamline. By including only the BEATS components, this version must not interfere with the future installation of a bending magnet beamline neighbouring to BEATS in the SESAME experimental hall.

Size and hutch shielding

OHB is composed of three walls and one roof. The sidewalls length is increased to 7000 mm to leave more space around the monochromator for its commissioning. The OHB roof height is 3000 mm. The size of the BEATS OHB walls are:

Item	Name in Figure 3	Size (length × height)
Outer Sidewall	OHA-O	7000 mm × 3000 mm
Backwall	OHA-B	2210 mm × 3000 mm
Inner Sidewall	OHA-I	7000 mm × 3000 mm

Local shielding

OHB must be equipped with the following additional shielding elements:

#	Shielding element	Qty	Height (cm)	Width (cm)	Thickness (cm)	Material
1	Tunnel-to-OHA guillotine	1	30	30	2	Lead
2	Local Pb screen 1 behind DMM	1	100	100	2	Lead
3	Sidewall OHA-O neutron screen	1	-	-	10	Polyethylene
4	Sidewall OHA-O neutron screen	1	-	-	10	Polyethylene
5	OHA-B-to-TP guillotine (inner)	1	40	40	6.5	Lead
6	OHA-B bremsstrahlung wall	1	100	100	5	Lead
7	OHA-B-to-TP guillotine (outer)	1	-	-	2	Lead

Doors, chicanes and other components

OHB must be equipped with the following components:

Component	Qty	Ref. Design
Electrical chicane (wall OHA-O)	2	ESRF 00.67.0200
Fluids chicane (wall OHA-O)	1	ESRF 00.67.0202
Ventilation entrance chicane (wall OHA-O)	1	ESRF 00.67.0205
Ventilation exit chicane (wall OHA-R)	1	ESRF 00.67.0204
Double door without window (wall OHA-O)	1	ESRF 00.67.0304

Experimental hutch (EH)

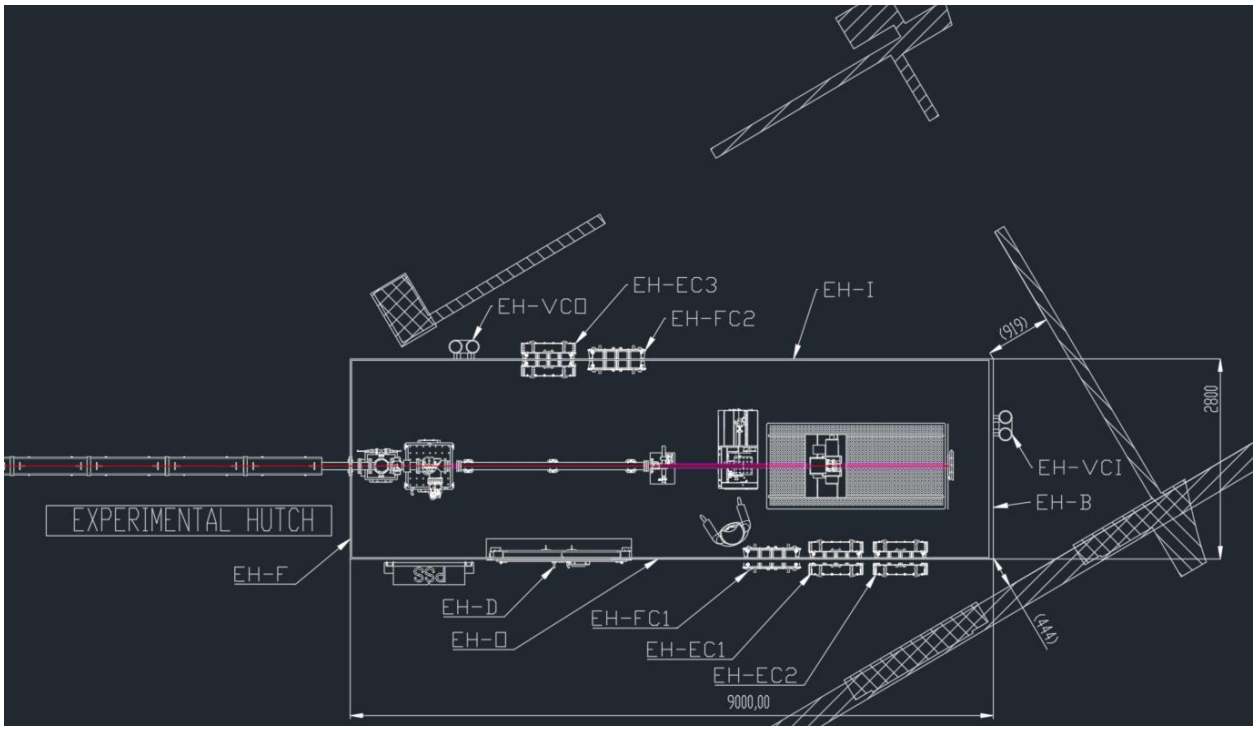

Figure 4: BEATS experimental hutch (EH).

Size and hutch shielding

The size of the BEATS EH walls and roof are:

ITEM	Name on Figure 4	Size (length × height)
Frontwall	EH-F	2800 mm × 2900 mm
Outer sidewall	EH-O	9000 mm × 2900 mm
Inner sidewall	EH-I	9000 mm × 2900 mm
Backwall	EH-B	2800 mm × 2900 mm
Roof	EH-R	9000 mm × 2800 mm

EH must be installed in the service area below the concrete floor of the offices building and has therefore a limited height of 2900 mm.

Local shielding

The wall penetration on EH-F for the transfer pipe shall be fitted with the diameter of a CF flange (outer CF200 diameter is 253 mm). The beam height at the exit from OHA-B is 1410 mm.

The following additional shielding elements must be installed:

#	Shielding element	Qty	Height (cm)	Width (cm)	Thickness (cm)	Material
1	Sidewall EH-I neutron screen	1			5	Polyethylene
2	Sidewall EH-O neutron screen	1			5	Polyethylene
3	TP-to-EH guillotine (outer)	1	30	30	2	Lead
4	TP-to-EH guillotine (inner)	1				Lead
5	EH beam stop	1	12	12	20	Lead
6	EH-B bremsstrahlung wall	1	100	100	5	Lead

The 50-mm-thick bremsstrahlung reinforcement of wall EH-B must have a surface of at least 1 m × 1 m. The reinforcement must be standalone and must be supported by a steel frame following the ESRF reference design 00.67.0602.

Doors and chicanes

The BEATS EH must be equipped with the following components:

Component	Name on Figure 4	Qty	Ref. Design
Electrical chicane (walls EH-O and EH-I)	EH-EC1; EH-EC2; EH-EC3	3	ESRF 00.67.0200
Fluids chicane (walls EH-O and EH-I)	EH-FC1; EH-FC2	2	ESRF 00.67.0202
Ventilation entrance chicane (wall EH-B)	EH-VCI	1	ESRF 00.67.0205
Ventilation exit chicane (wall EH-I)	EH-VCO	1	ESRF 00.67.0204
Double door with window (wall EH-O)	EH-D	1	ESRF 00.67.0304

Hutch roof and support structure

The roof of the BEATS EH (EH-R) has a total surface of 25.2 m^2 and must have a minimum lead thickness of 15 mm. Loads coming from the roof should be transmitted to the floor slab through pillars of adequate dimensions. The BEATS EH will be installed in the service area under the concrete first floor of the office building. The nominal height of the concrete ceiling is 3 m, and the BEATS EH-R should be installed as close as possible to the ceiling to exploit the full height available. The bidder can propose a reduction in height of the BEATS EH if required for the installation of the roof.

Long vacuum transfer pipe shielding

A lead shielding for the vacuum transfer pipe connecting OH and EH must be provided. The shielding must be installed on a mechanical support with adjustable height (the nominal height is 1410 mm) over the entire TP length. The vacuum pipe to be shielded is 16-m-long and is composed of two consecutive sections with different diameter:

- A 8-m-long CF150 section followed by
- A 8-m-long CF200 section.

Each section is divided in shorter sub-sections connected by CF150 and CF200 flanges, respectively. The lead shielding must consider enough space at the locations of these flanges.

Radiation-tight connections to the OH and EH must be provided.

The final values of the lead thickness for the BEATS hutches walls and the transfer pipe are currently (September 2020) being established via raytracing simulations using the Fluka software suite [Battistoni et al. 2006, Ferrari et al. 2005] and will be provided to the bidders in the Call for Tender. It is foreseen to officially publish the Call for Tender in October 2020.

REFERENCES

[1] "The FLUKA code: Description and benchmarking" G. Battistoni, S. Muraro, P.R. Sala, F. Cerutti, A. Ferrari, S. Roesler, A. Fasso`, J. Ranft, Proceedings of the Hadronic Shower Simulation Workshop 2006, Fermilab 6--8 September 2006, M. Albrow, R. Raja eds., AIP Conference Proceeding 896, 31-49, (2007).

[2] "FLUKA: a multi-particle transport code" A. Ferrari, P.R. Sala, A. Fasso`, and J. Ranft, CERN-2005-10 (2005), INFN/TC_05/11, SLAC-R-773.