Istituto Nazionale di Fisica Nucleare

RIUNIONE INFN4LS
Laboratori Nazionali del Sud (Catania)
30-31 gennaio 2024

Il centro BNCT ANTHEM a Caserta: stato del progetto e prospettive

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Delegato del Rettore all'Edilizia di Ateneo

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Università degli Studi della Campania *Luigi Vanvitelli*

1 SCOPE

This presentation provides the progress of the project of the **BNCT building complex in Caserta**, giving emphasis to:

- project layout
- design phases
- design issues

In general, the main purpose of the project is to guarantee the effectiveness of the laboratory lay-out but also the optimization of the structures for radio-protection issues and environmental compatibility.

TEAM

Parthership

Project coordination and responsibility

Engineering and architectural design

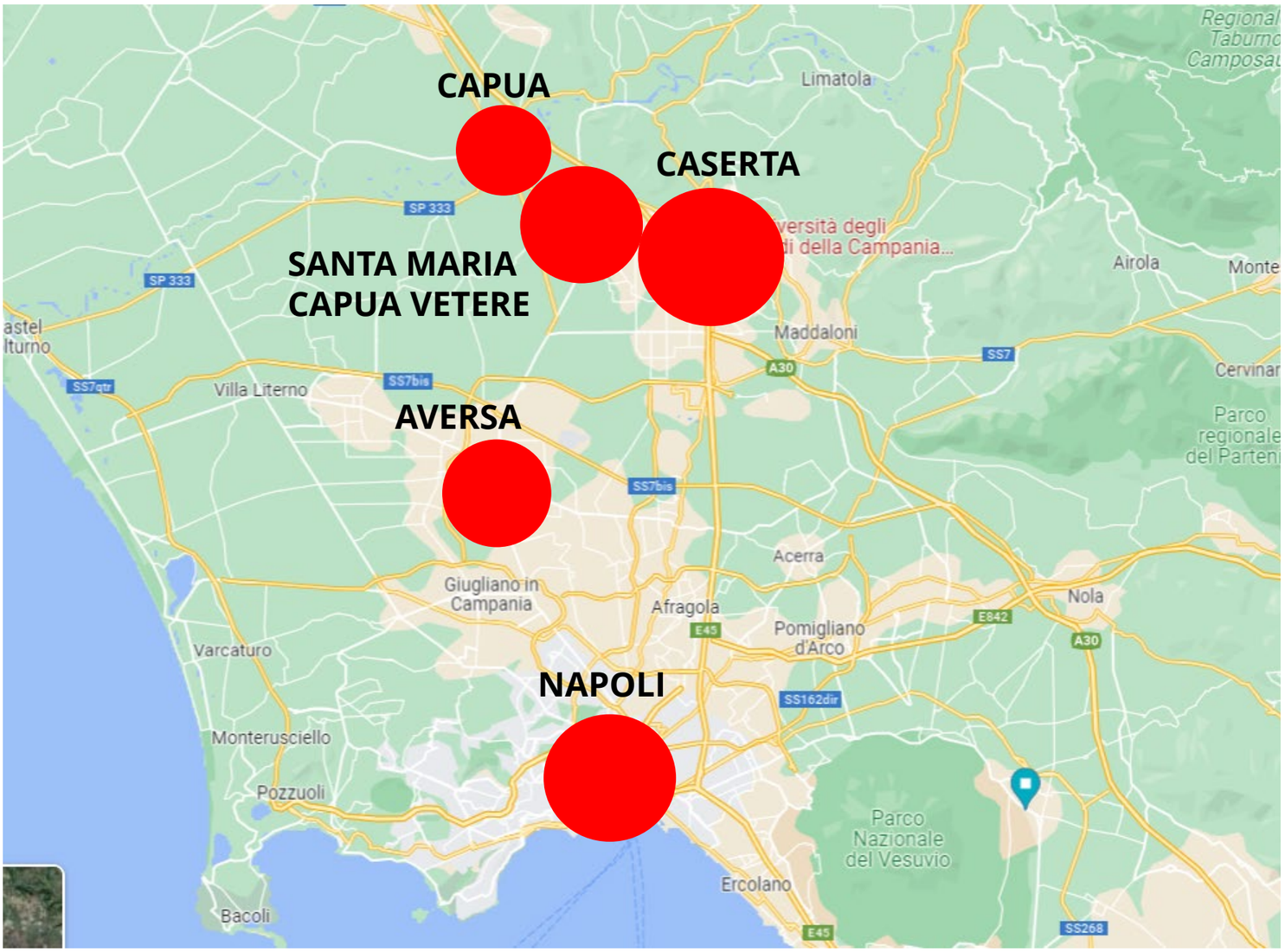
Scientific support for the RFQ accelerator and radio-protection issues

Università degli Studi della Campania *Luigi Vanvitelli*

ALCOTEC

INFN Istituto Nazionale di Fisica Nucleare

3 PROJECT DESCRIPTION



I Dipartimenti dell'Università degli studi della Campania Luigi Vanvitelli nei vari Poli

AVERSA
- Dipartimento di Architettura e Disegno Industriale
- Dipartimento di Ingegneria

CASERTA
- Dipartimento di Matematica e Fisica
- Dipartimento di Psicologia
- Dipartimento di Scienze Politiche
- Dipartimento di Scienze e Tecnologie Ambientali Biologiche e Farmaceutiche

CAPUA
- Dipartimento di Economia

NAPOLI
- Dipartimento di Medicina di Precisione
- Dipartimento della Donna, del Bambino e di Chirurgia Generale e Specialistica
- Dipartimento di Medicina Sperimentale
- Dipartimento Multidisciplinare di Specialità Medico – Chirurgiche e Odontoiatriche
- Dipartimento di Scienze Mediche Traslazionali
- Dipartimento di Scienze Mediche e Chirurgiche Avanzate
- Dipartimento di Salute Mentale e Fisica e Medicina Preventiva

SANTA MARIA CAPUA VETERE
- Dipartimento di Giurisprudenza
- Dipartimento di Lettere e Beni Culturali

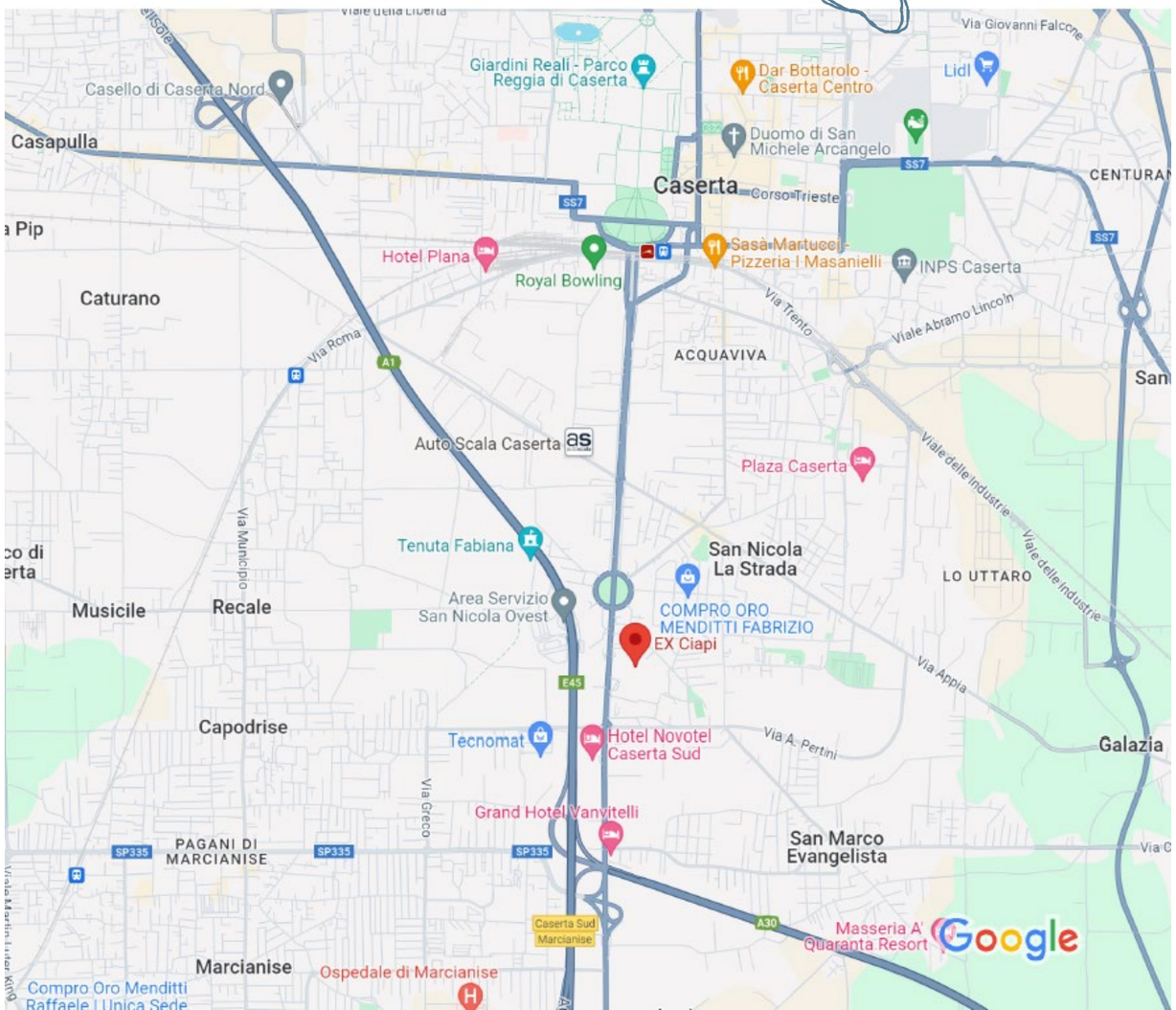
3 PROJECT DESCRIPTION

BNCT – NEW PROTONTHERAPY CENTER OF CASERTA

The Project refers to the design of a new building for **BNCT - Boron Neutron Capture Therapy**, located near Caserta (the "BNCT"), in San Nicola La Strada. The project area is adjacent the ex-Ciapi building where to CIRCE laboratory of the University of Campania Luigi Vanvitelli is placed.

The Center, under development, will allow the Region Campania an award as a **Center of Excellence and International Research for Radiotherapy of Oncological Diseases**. It would be the first equipment of this kind in all the central and southern Italy, the second in all of Italy.

PROJECT AREA CONTEXT



EX CIAPI BUILDING

3 PROJECT DESCRIPTION

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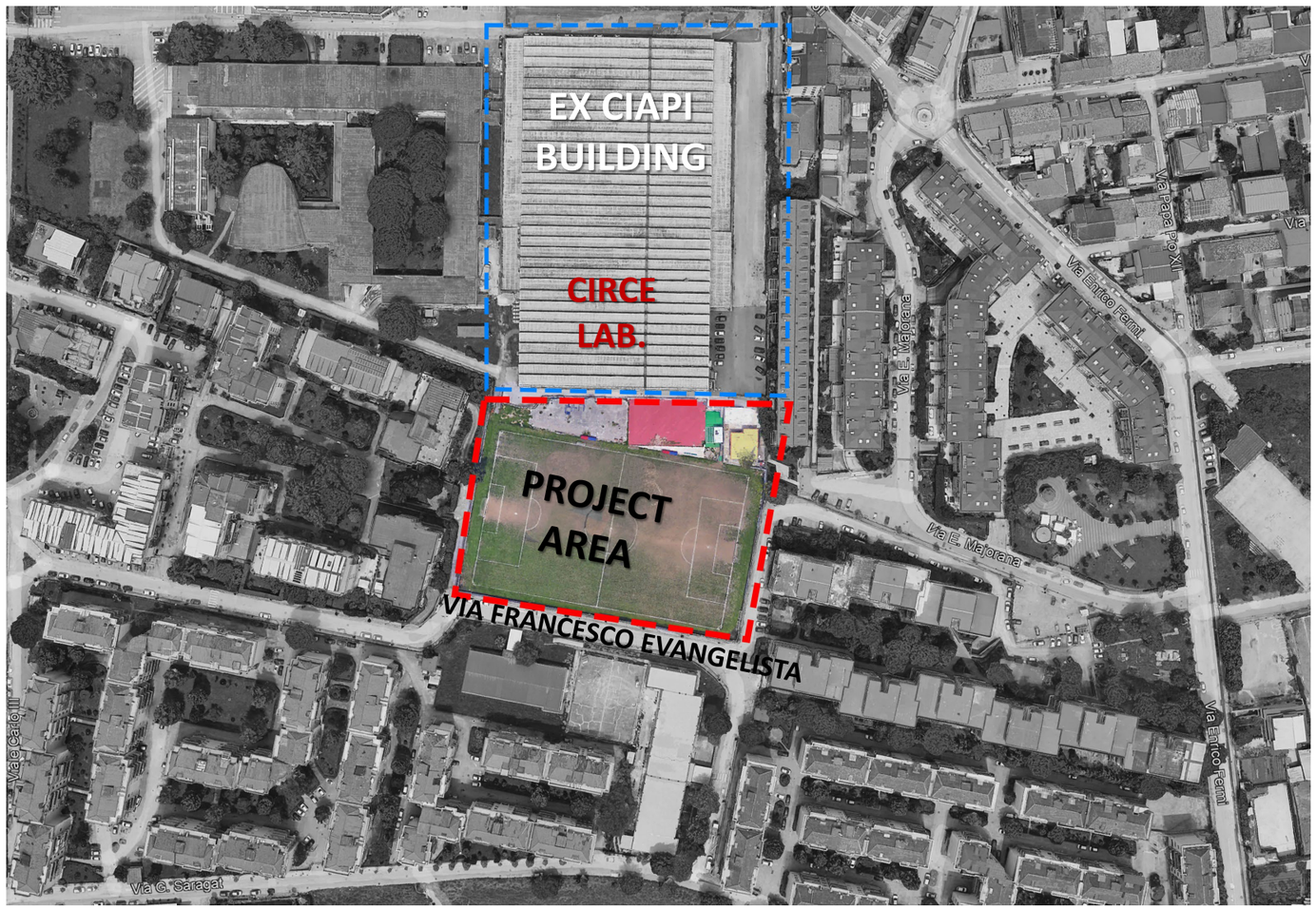


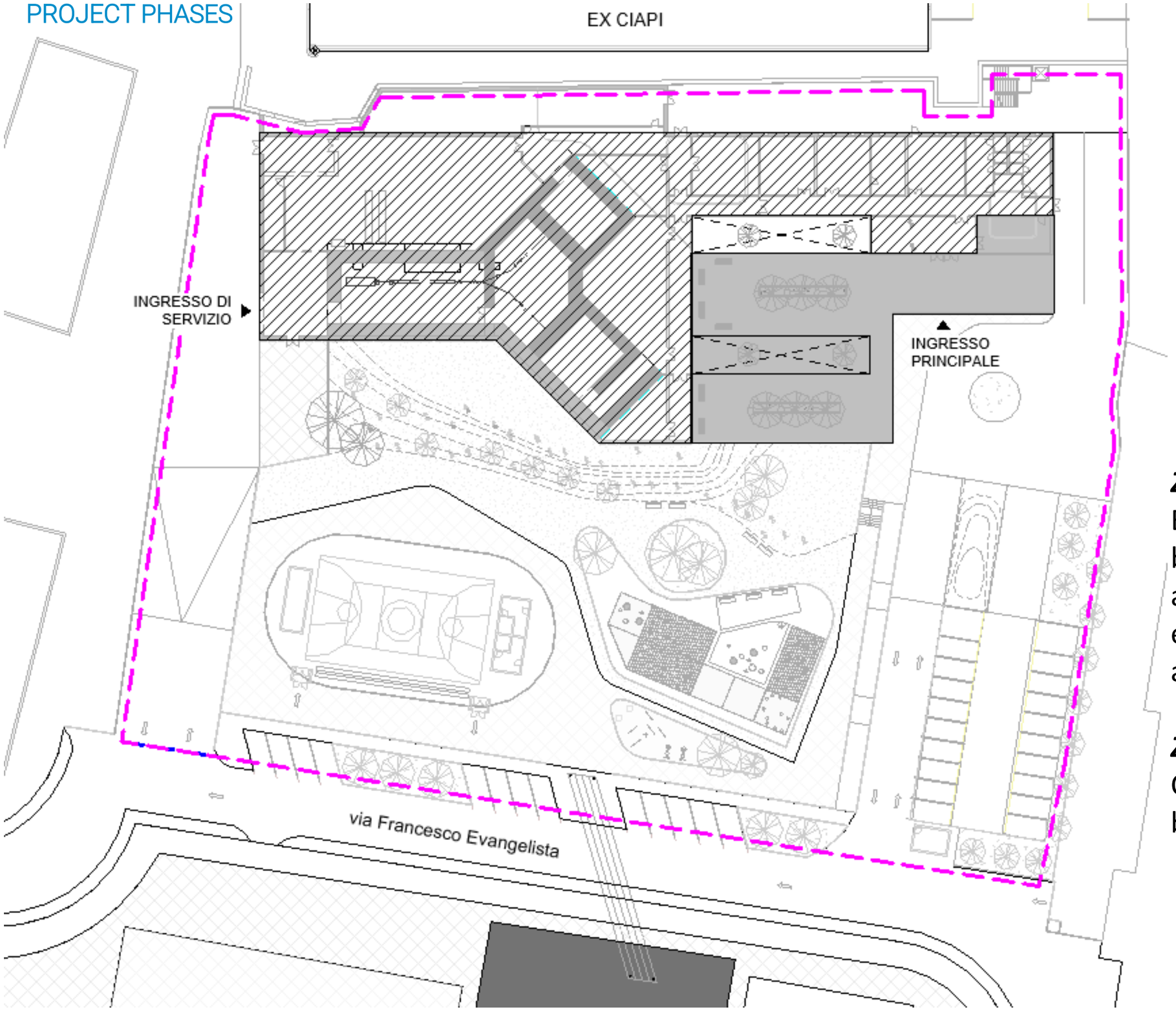
3 PROJECT DESCRIPTION

4 LAYOUT

VIEW OF THE EXISTING AREA

4 LAYOUT

PROJECT PHASES



ZONE 1

ZONE 2

PROJECT PLOT

Zone (phase) 1

BNCT bulding including the bunker area and the research area, with facade, roof with equipements and external areas

Zone (phase) 2

Completion of the BNCT building, with medical area

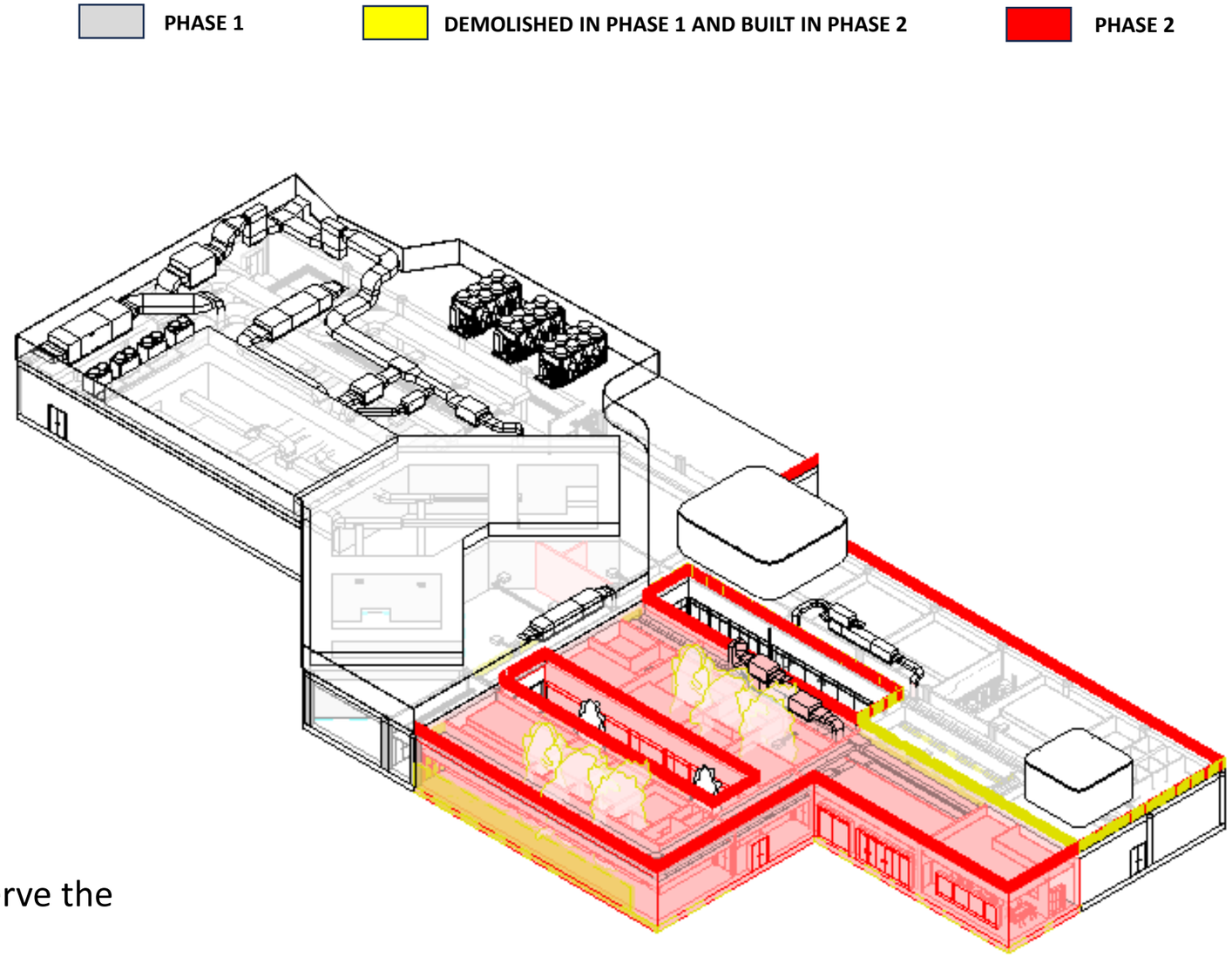
The proposed *technical solutions* are intended to be indicative and will be carefully evaluated during the final and/or executive development phase of the project.

4 LAYOUT

PHASES DESCRIPTION

Phase 01 involves the construction of the Bunker and its related treatment rooms, service and functional spaces useful for the commissioning of the building.
In this phase, the following rooms will be built:

- Accelerator Control Room
- Treatment Control Room
- Treatment planning room
- Biochemistry Lab
- Meeting room and Physical/medical room
- Locker room and restrooms.



Phase 02 includes an expansion of the building, transforming the facility with a clinical area to serve the centre.
In this phase, the following rooms will be provided:

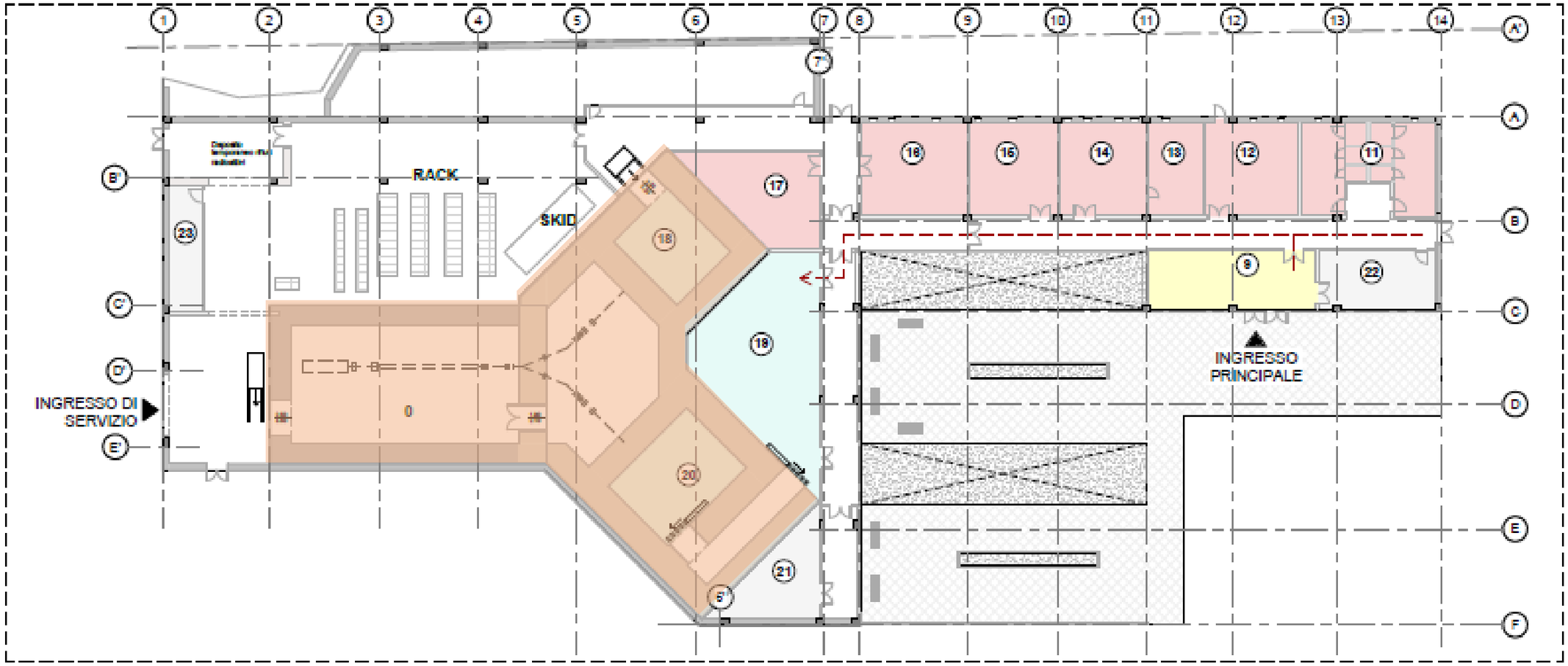
- Pre-Treatment Spaces
- Post - treatment Spaces
- Patient Reception Foyer - triage
- Medical Rooms
- Additional restrooms to serve the clinic area

4 LAYOUT

ZONING GROUND FLOOR – PHASE 1

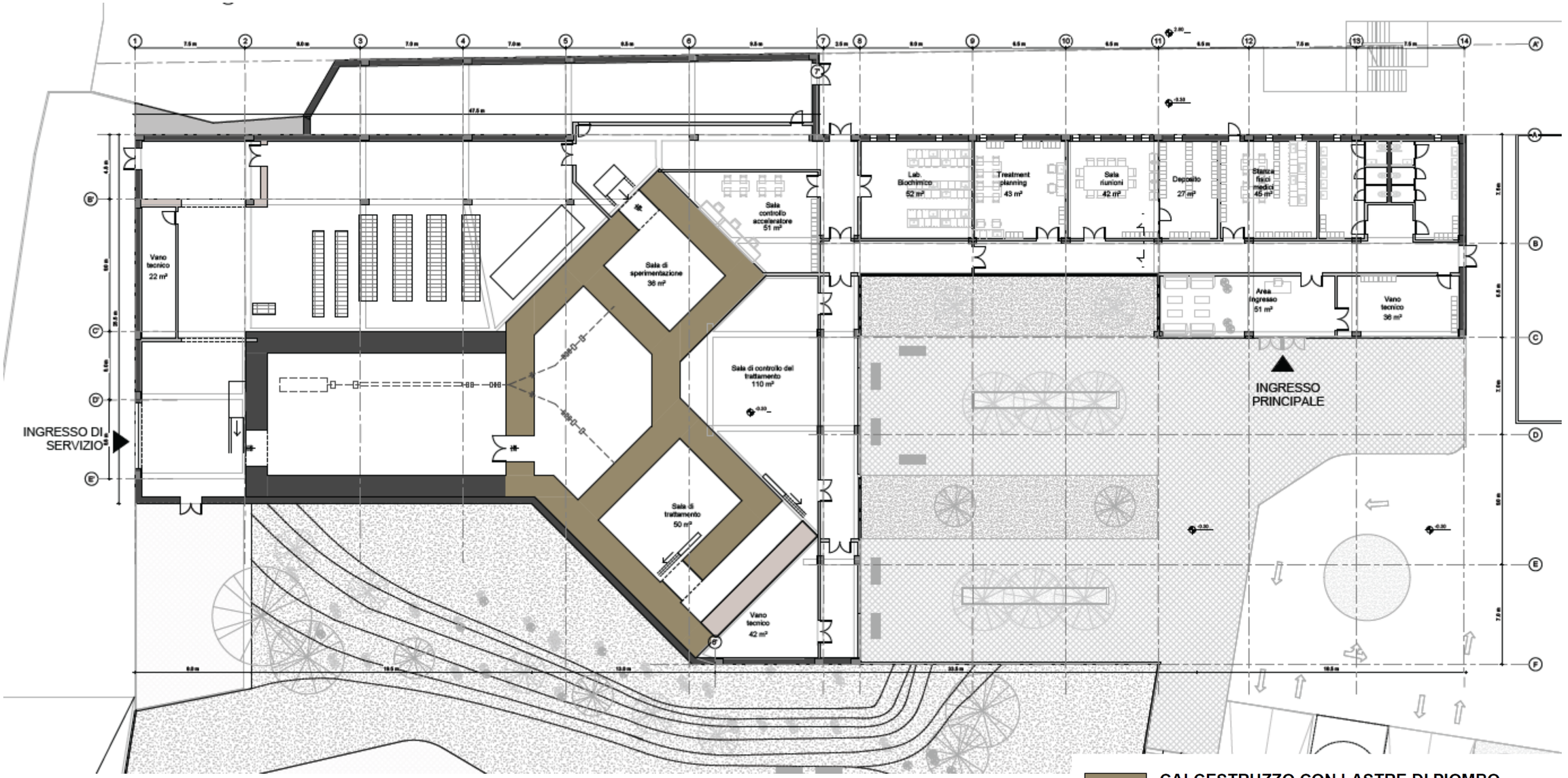
- AREA INGRESSO / ATTESA / RECEPTION / ACCOGLIENZA / UFFICI / SICUREZZA
- AREA TECNICO - MEDICA
- PERCORSO TECNICI e MEDICI
- BUNKER
- LOCALI TECNICI
- IMPIANTI
- SALE DI TRATTAMENTO

ABACO LOCALI		
N°	Destinazione d'uso	Superficie del locale
9	Area Ingresso	50 m²
11	Spogliatoi e S.I.	60 m²
12	Stanza fisici medici	50 m²
13	Deposito	30 m²
14	Sala riunioni	40 m²
15	Treatment planning	40 m²
16	Lab. Biochimico	50 m²
17	Sala controllo acceleratore	50 m²
18	Sala di sperimentazione	40 m²
19	Sala di controllo del trattamento	120 m²
20	Sala di trattamento	50 m²
21	Vano tecnico	30 m²
22	Vano tecnico	40 m²
23	Vano tecnico	20 m²



4 LAYOUT

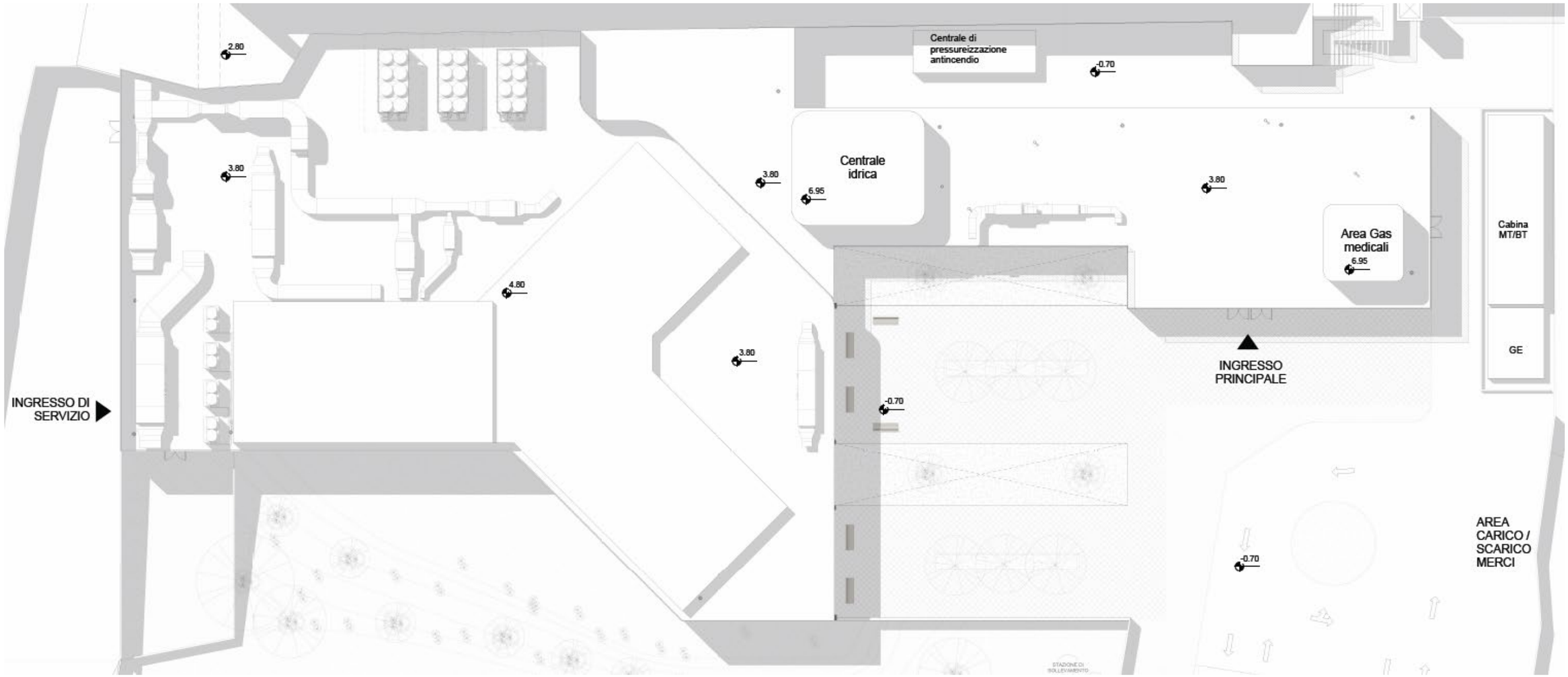
FUNCTIONAL LAYOUT – PHASE 1



The proposed *technical solutions* are intended to be indicative and will be carefully evaluated during the final and/or executive development phase of the project.

4 LAYOUT

ROOF PLAN – PHASE 1



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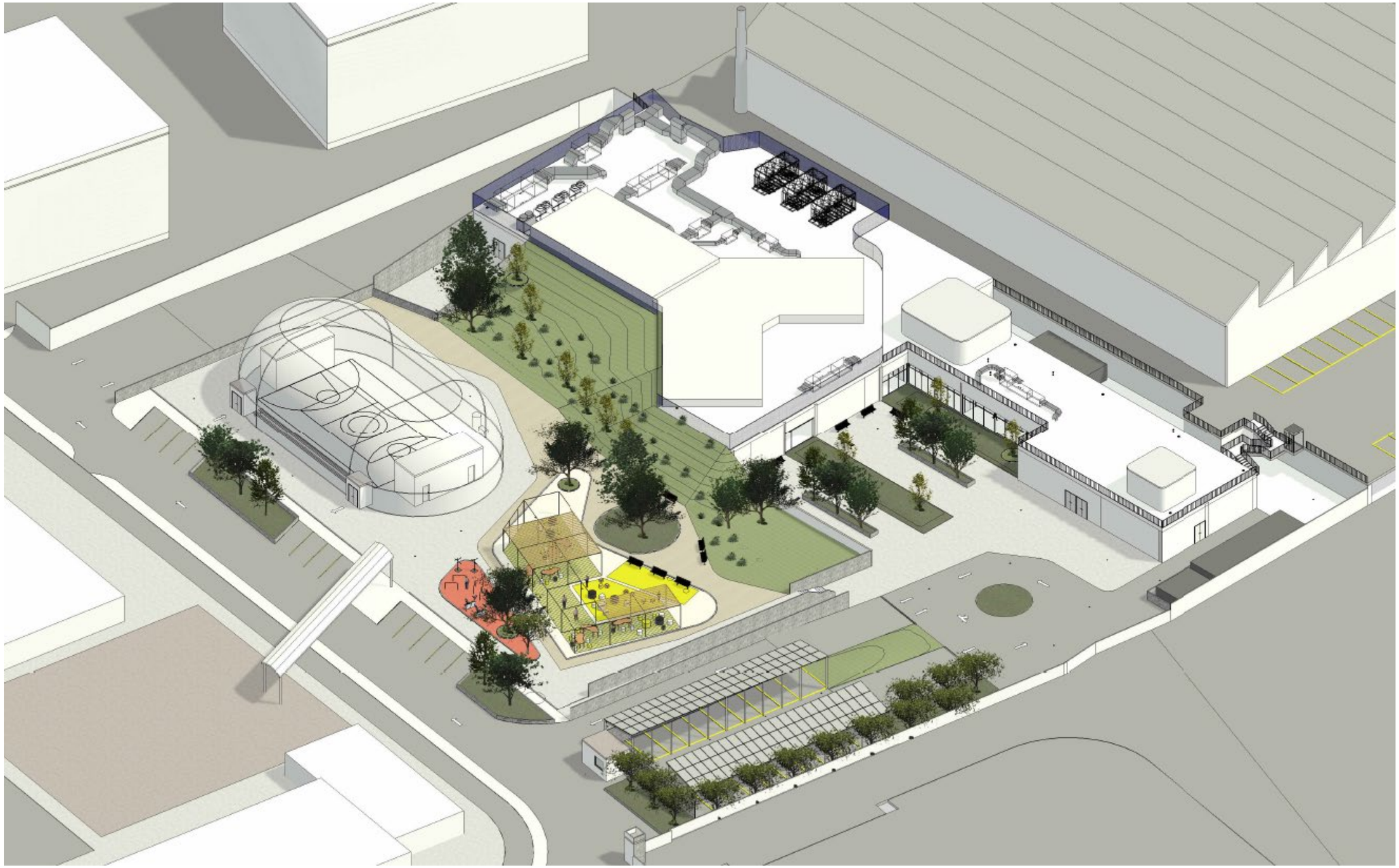
4 LAYOUT

RENDERING VIEW – PHASE 1



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4 LAYOUT

ZONING GROUND FLOOR – PHASE 2

- AREA INGRESSO / ATTESA / RECEPTION / ACCOGLIENZA / UFFICI / SICUREZZA
- AREA TECNICO - MEDICA
- PERCORSO TECNICI e MEDICI
- AREA PRE IRRAGGIAMENTO
- PERCORSO PAZIENTI PRE TRATTAMENTO
- AREA POST IRRAGGIAMENTO
- PERCORSO AREA POST IRRAGGIAMENTO
- LOCALI TECNICI
- IMPIANTI
- SALE DI TRATTAMENTO
- BUNKER

ABACO LOCALI		
N°	Destinazione d'uso	Superficie del locale
1	Spogliatoio Pazienti	30 m²
2	Preparazione paziente	30 m²
3	Simulazione	40 m²
4	Somministrazione farmaco	30 m²
5	Loc. medico	10 m²
6	1° soccorso	20 m²
7	Locale Misura Boro	40 m²
8	Post irraggiamento	60 m²
9	Area Ingresso	130 m²
10	Uffici / Segreteria Direzione	50 m²
11	Spogliatoi e S.I.	60 m²

ABACO LOCALI		
N°	Destinazione d'uso	Superficie del locale
12	Stanza fisici medici	50 m²
13	Deposito	30 m²
14	Sala riunioni	40 m²
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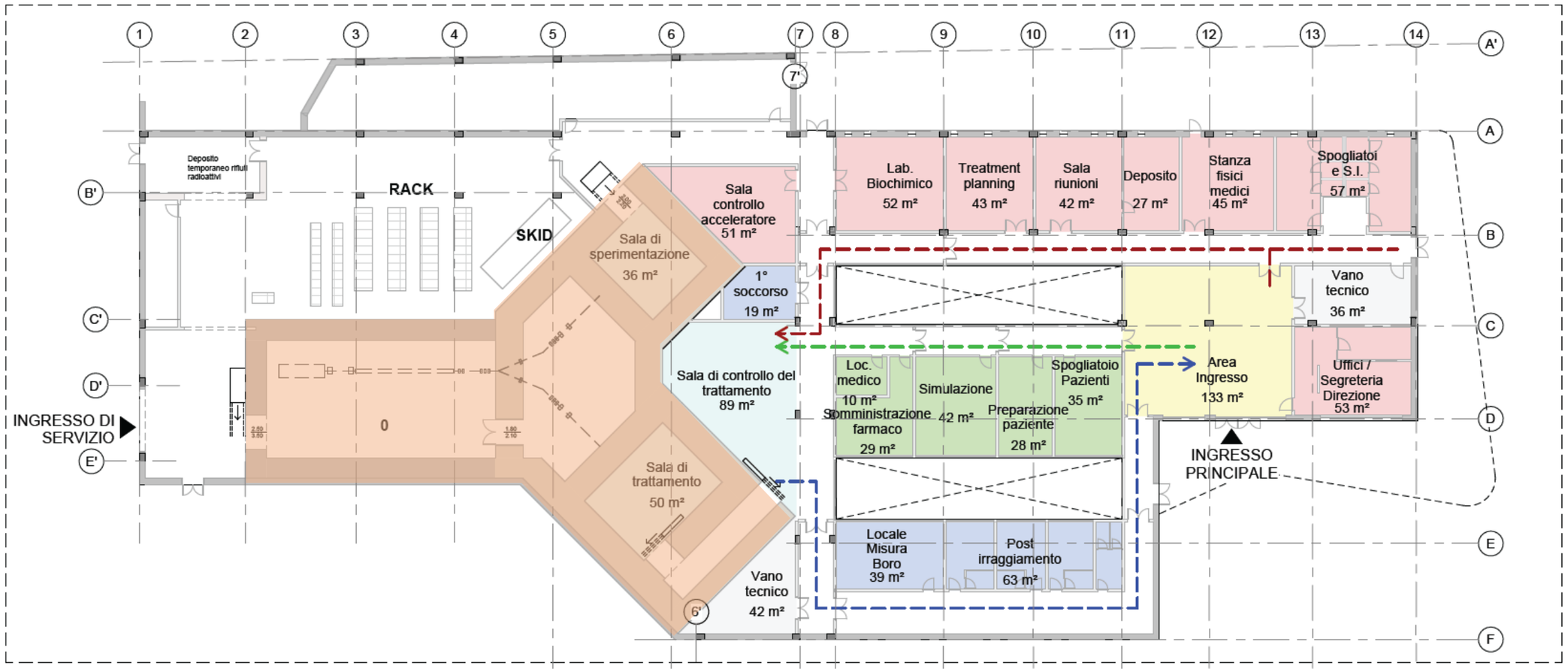
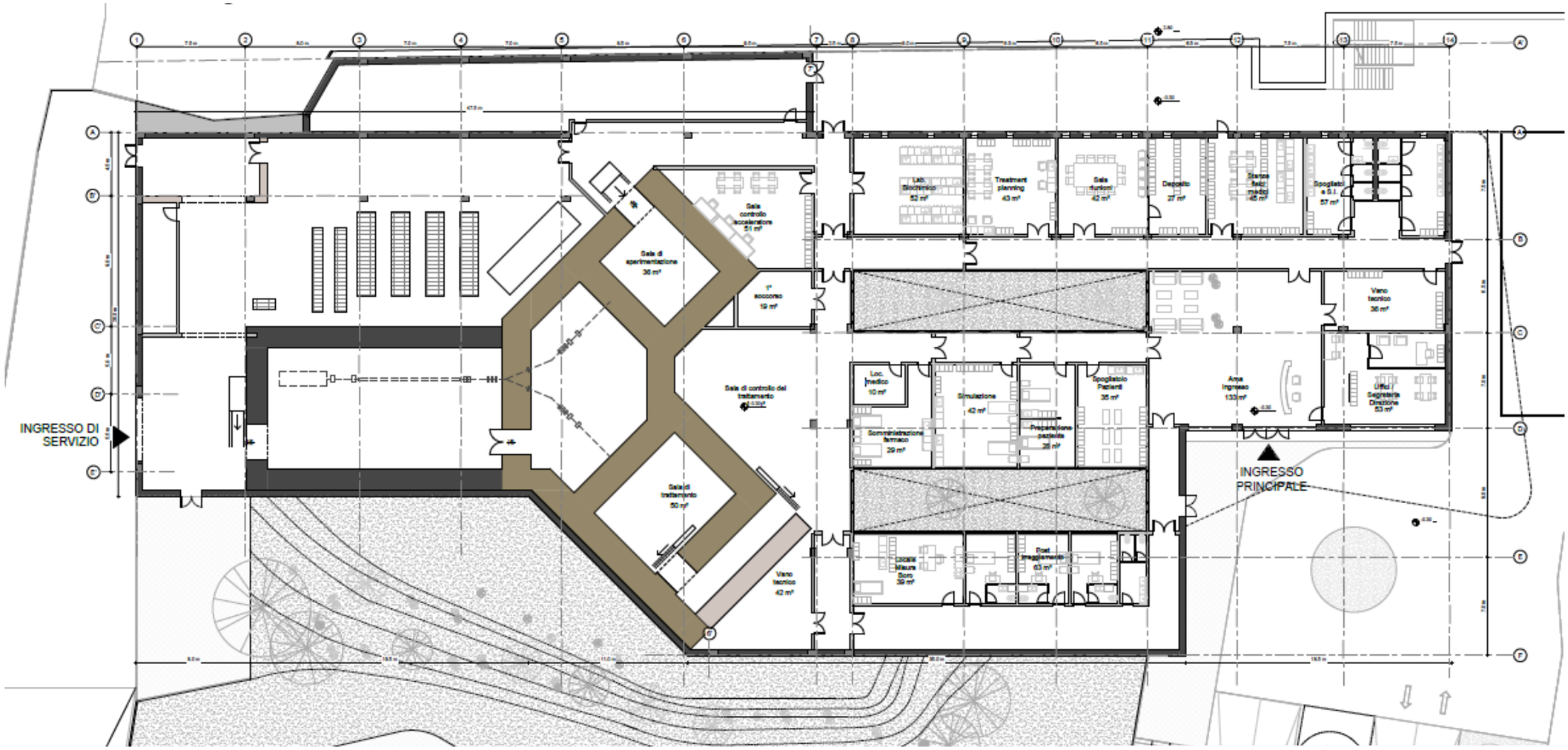
19	Sala di controllo del trattamento	100 m²
20	Sala di trattamento	50 m²
21	Vano tecnico	30 m²
22	Vano tecnico	40 m²



4 LAYOUT

FUNCTIONAL LAYOUT – PHASE 2



CALCESTRUZZO CON LASTRE DI PIOMBO INTERPOSTE E PANNELLI DI POLISTIRENE BORATO

MURI SCHERMATI PER RADIOPROTEZIONE

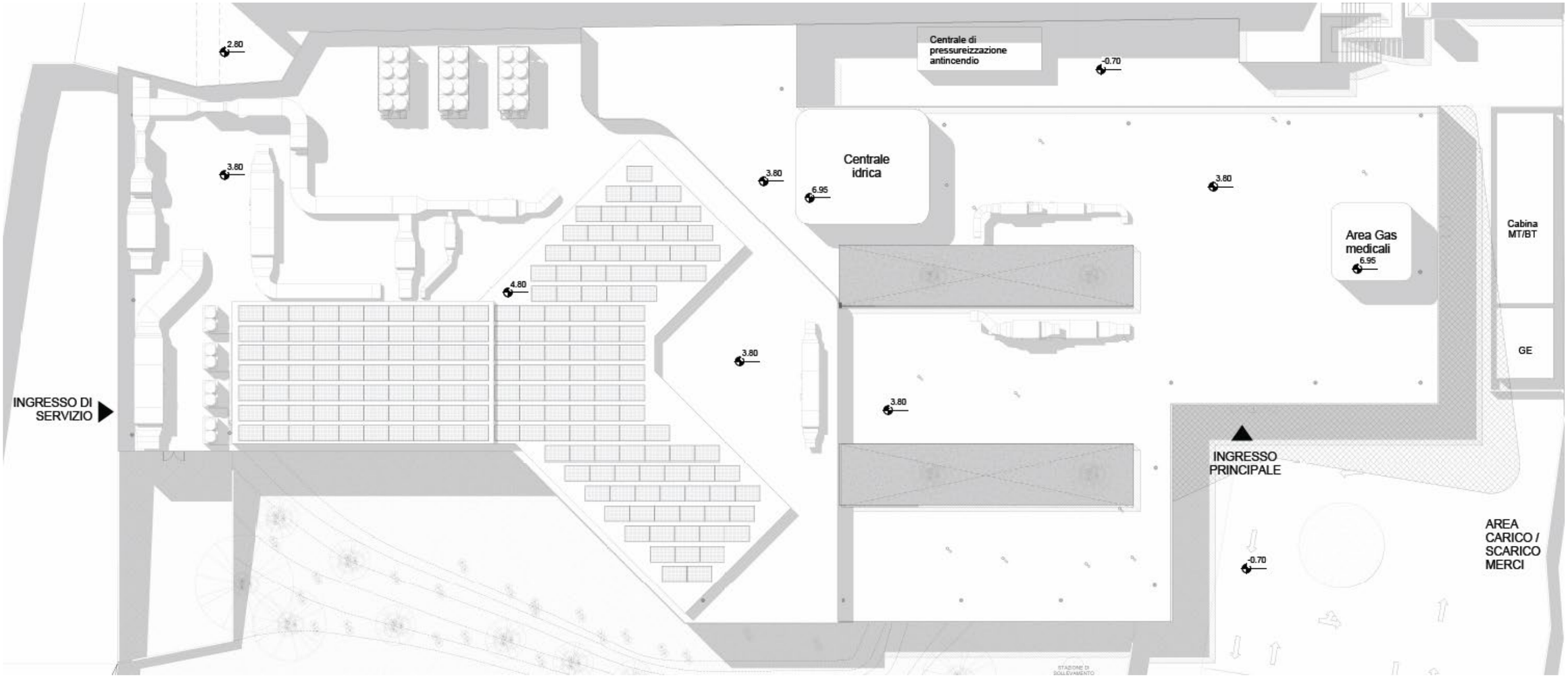
MURI IN CLS

MURI IN CARTONGESSO

The proposed *technical solutions* are intended to be indicative and will be carefully evaluated during the final and/or executive development phase of the project.

4 LAYOUT

ROOF PLAN – PHASE 2



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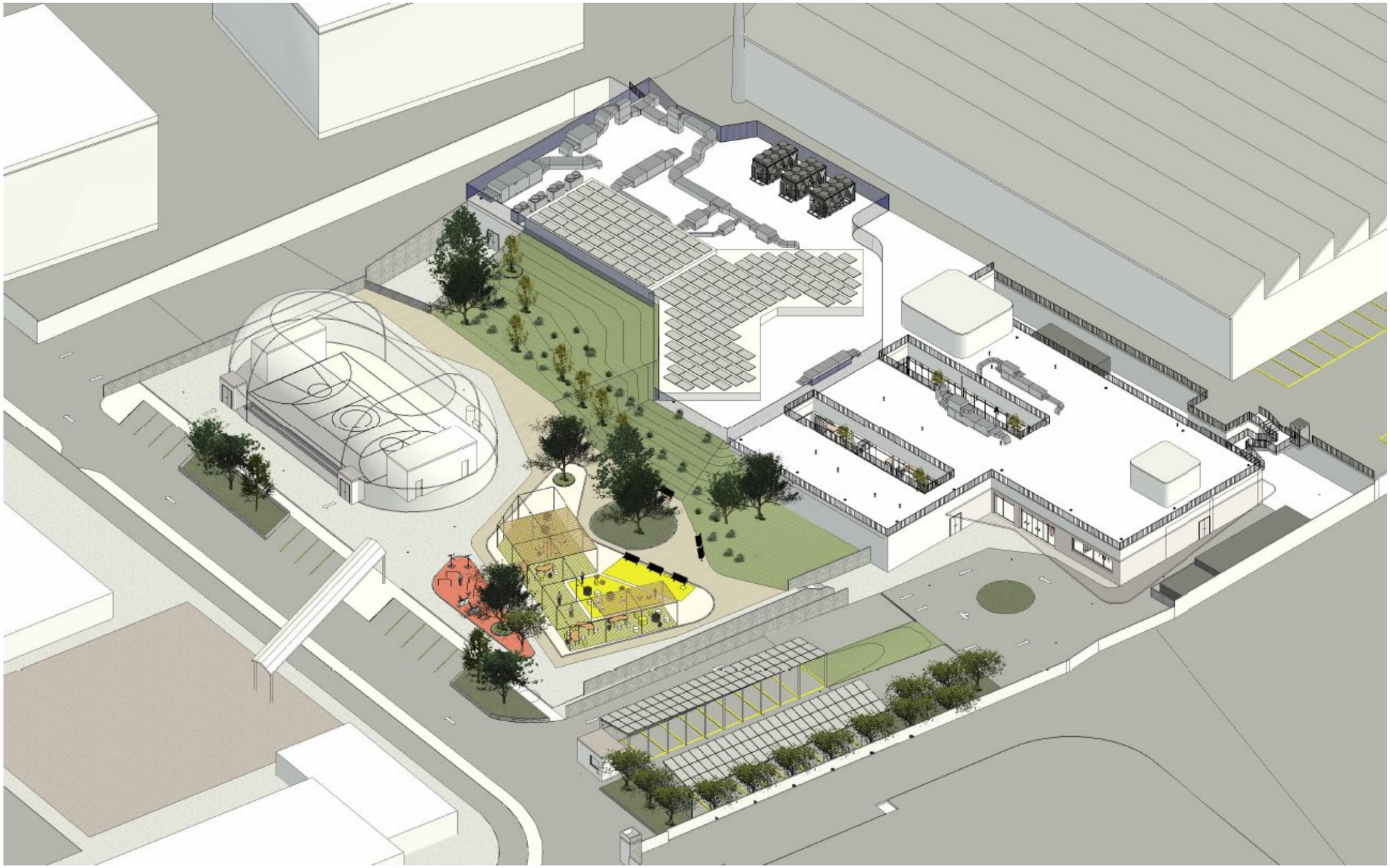
4 LAYOUT

RENDERING VIEW – PHASE 2



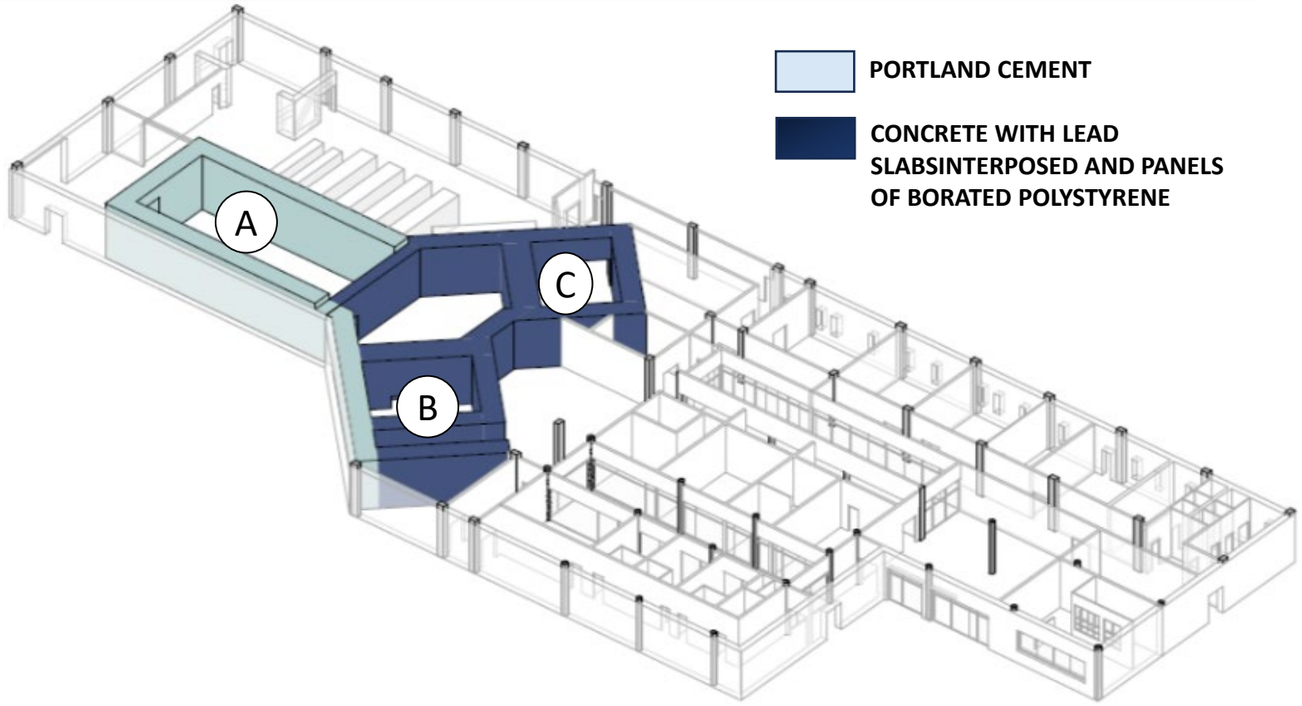
The proposed *technical solutions* are intended to be indicative and will be carefully evaluated during the final and/or executive development phase of the project.

5 DESIGN ISSUES

ANALYSIS OF THE BUNKER AREA

The Project concerns mainly the construction of the bunker to house the **particle accelerator for the production of neutron beams** and related equipment.

1. **<u>Structural issues</u>** - The type of walls and compatible geometries are derived from calculations provided by INFN for the containment of radiation from the use of radioactive sources. The structures will be composed of ordinary portland cement and concrete with interposed lead slabs and special barytic polystyrene panels with a minimum thickness of 2.00 m. Barytic concrete is a mixture of cement and barite, with a high density of 3,300 kg/m³. Due to its high radiation absorption power, barytic blocks are suitable for the construction of X-ray radiation shielding panels.



The Bunker will consist of 3 rooms:
***<u>A</u>** room where there the RFQ accelerator is located;*
***<u>B</u>** treatment room for research;*
***<u>C</u>** treatment room for medical activities with patients*

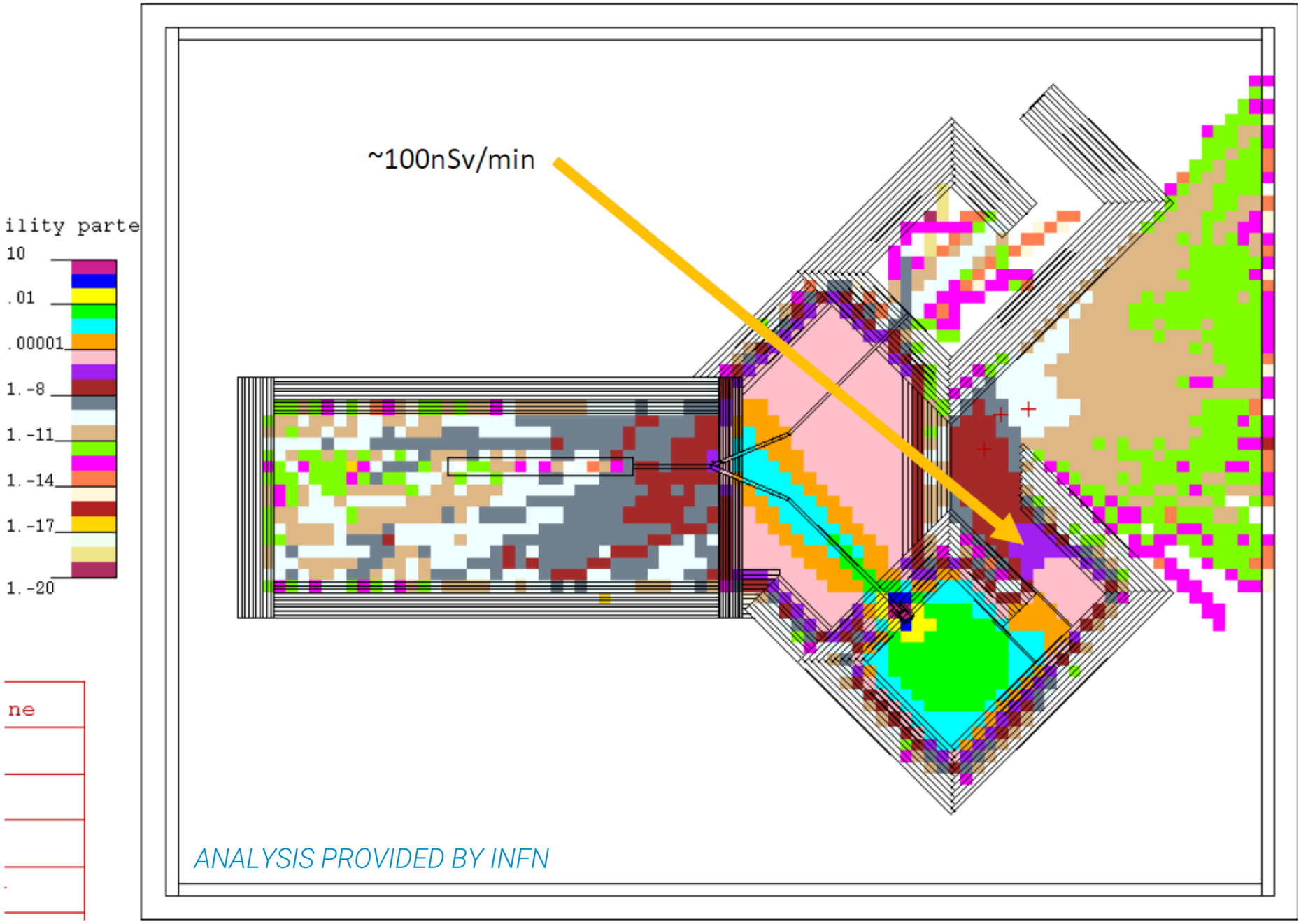
The proposed *technical solutions* are intended to be indicative and will be carefully evaluated during the final and/or executive development phase of the project.

5 DESIGN ISSUES

ANALYSIS OF THE BUNKER AREA

Labirinto con 2 porte

Rate di Dose **Fotoni** in Sv/min
Flux converted to Dose (kerma A 150 *) then to Equivalent Dose (Wr **)



The proposed *technical solutions* are intended to be indicative and will be carefully evaluated during the final and/or executive development phase of the project.

5 DESIGN ISSUES

ANALYSIS OF THE BUNKER AREA – COMPARISON AMONG STRUCTURAL SOLUTIONS

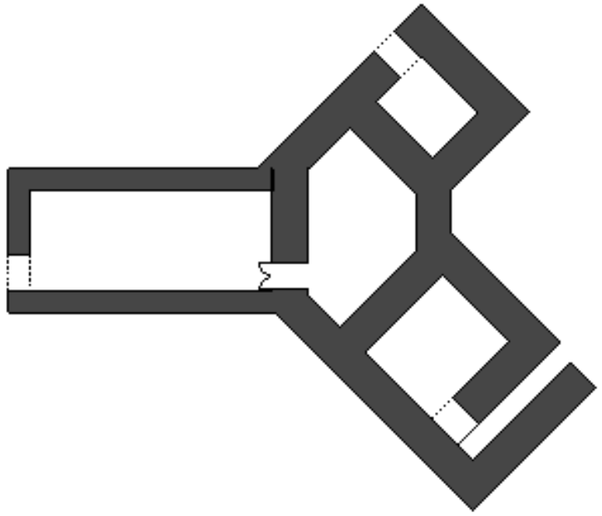
In all cases, for the area where the **RFQ machine is placed**, the use of Portland cement with a thickness of 1.5 m is considered.

Three different solutions are considered for the **treatment rooms**:

1. Solution **A** considers **ordinary Portland cement** with a thickness of 2.5 m is used. This solution **reduces the space available,** increasing the space required for the building.

2. Solution **B** considers **barytic cement** with a thickness of 2,00 m.

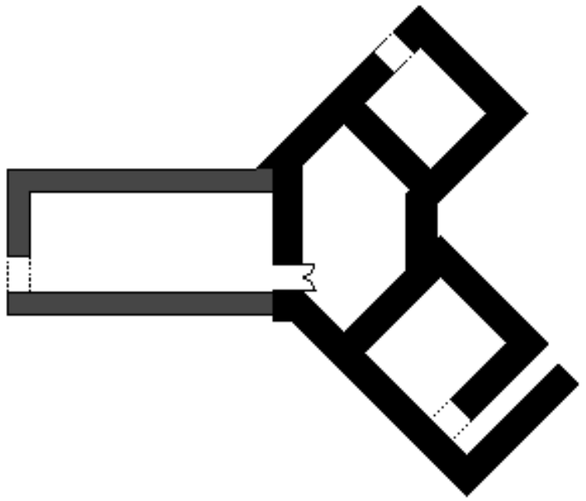
2. Solution **C** considers special **Baritic – Borated Cement** with a thickness of 1,50 m. This solution **reduces the space required.**



SOLUTION A

RFQ ROOM: Portland 1,5 m

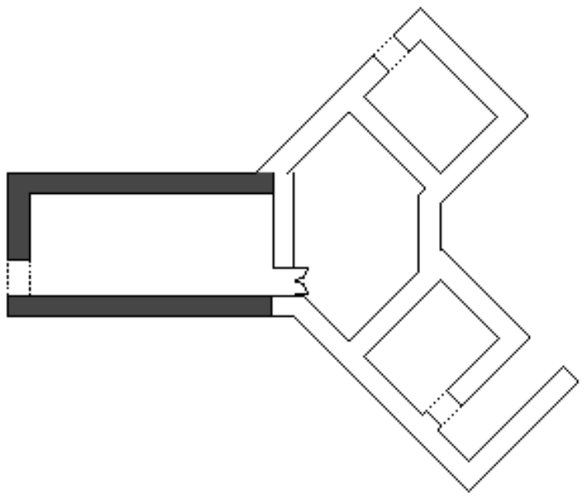
TREATMENT ROOM: Portland 2,5 m



SOLUTION B

RFQ ROOM: Portland 1,5 m

TREATMENT ROOM: Baritico 2 m



SOLUTION C

RFQ ROOM: Portland 1,5 m

TREATMENT ROOM: Baritico - Borato 1,5 m

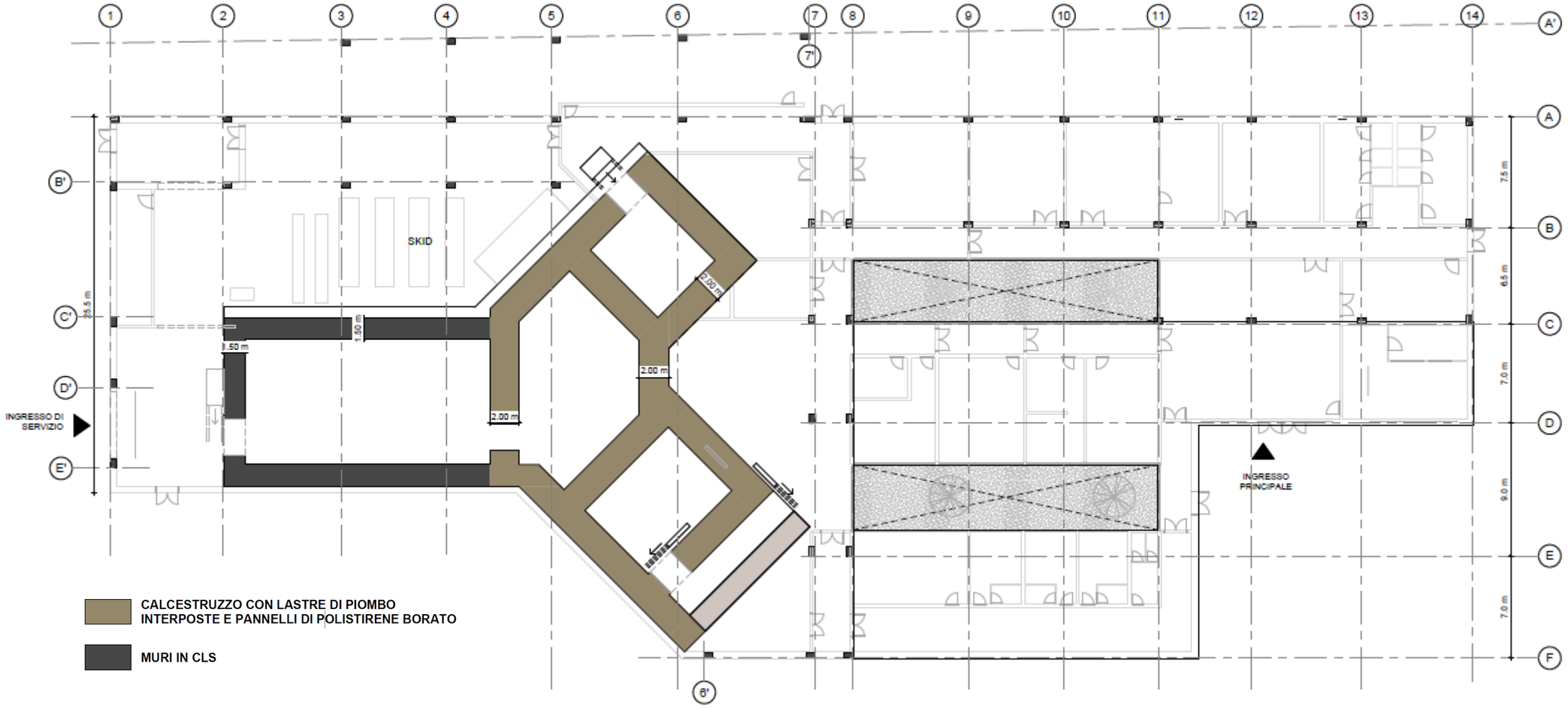
PORTLAND CEMENT

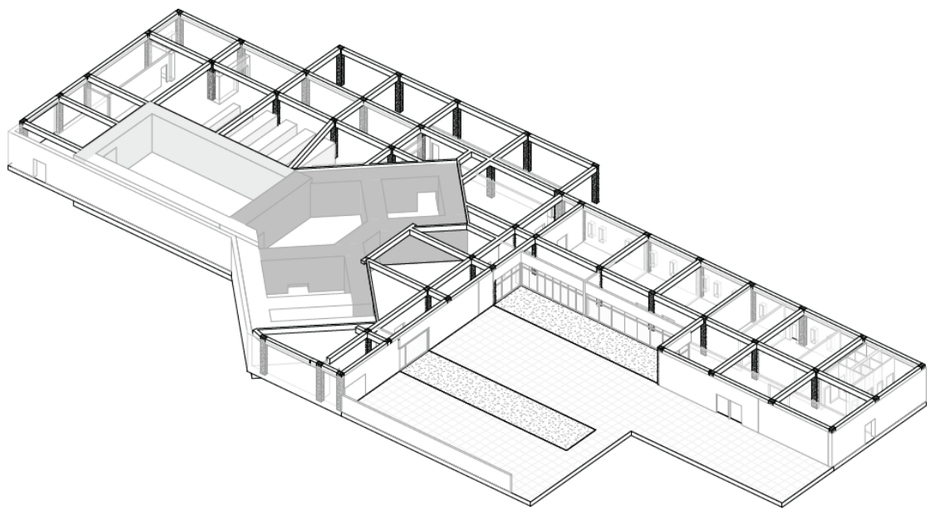
BARYTIC CEMENT

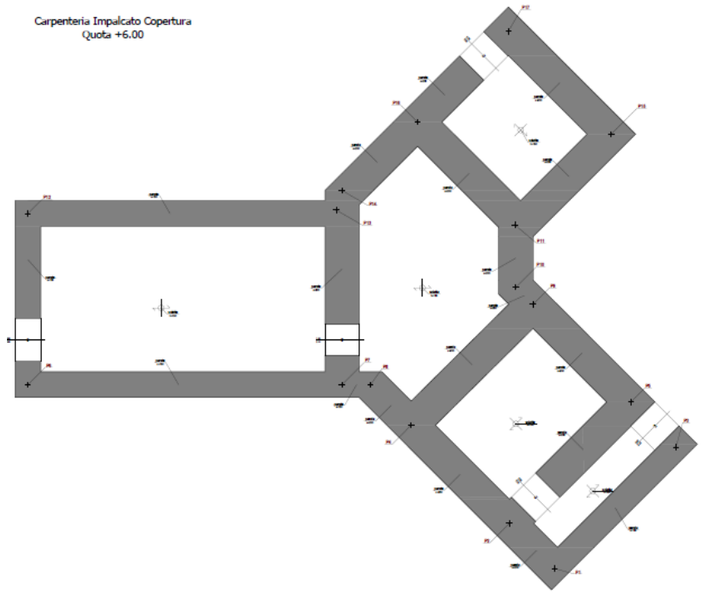
BORATED BARYTIC CEMENT

5 DESIGN ISSUES

STRUCTURAL DESIGN







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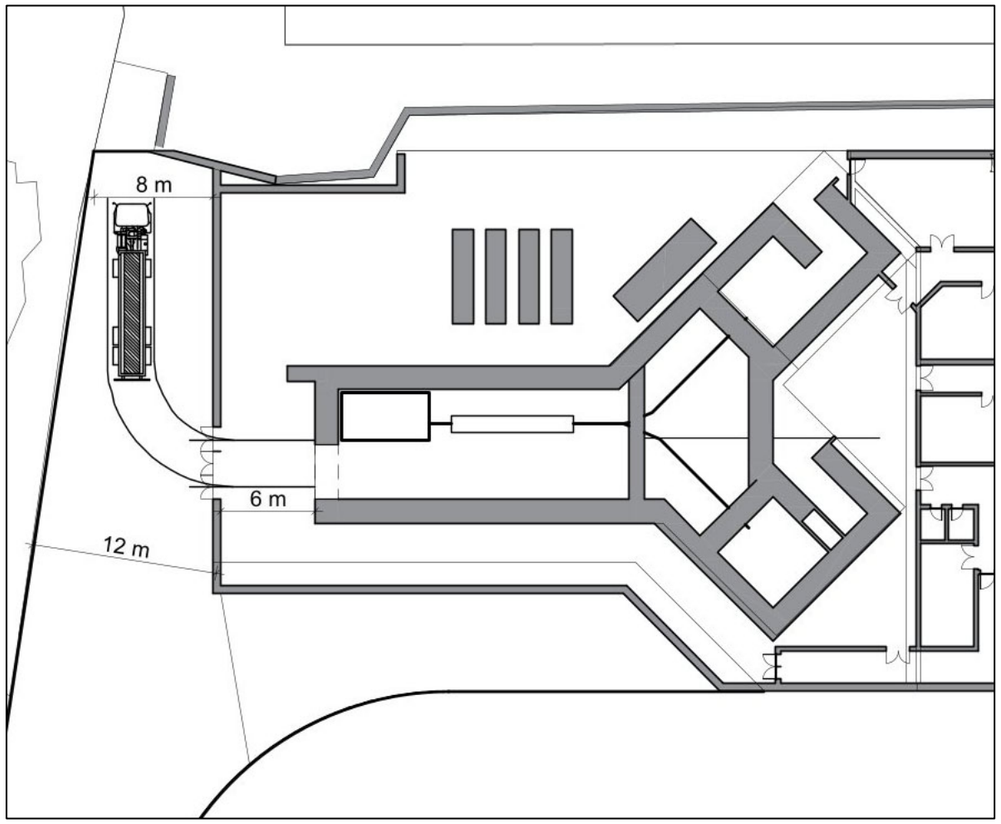
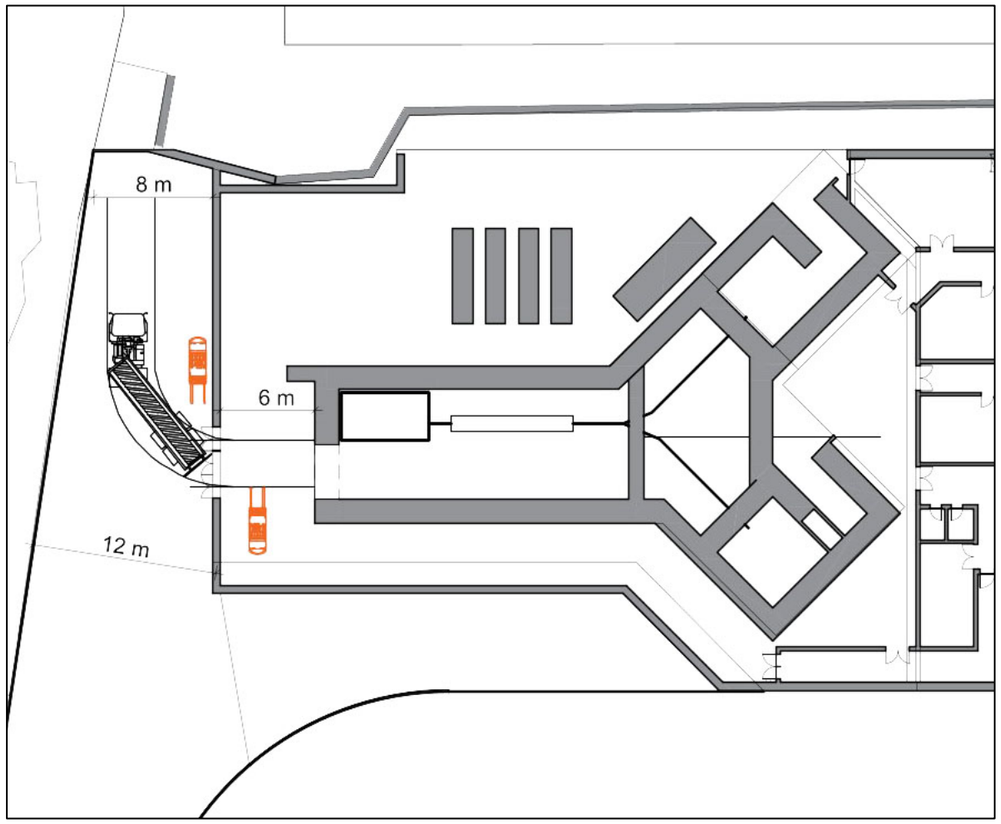
5 DESIGN ISSUES

RFQ ACCELERATOR POSITIONING

The assumed steps represented below describe the inserting of the RFQ accelerator (footprint 7,50x1,00m) with maximum height between 2,50m and 3,00m including frame and lifting sling bar.



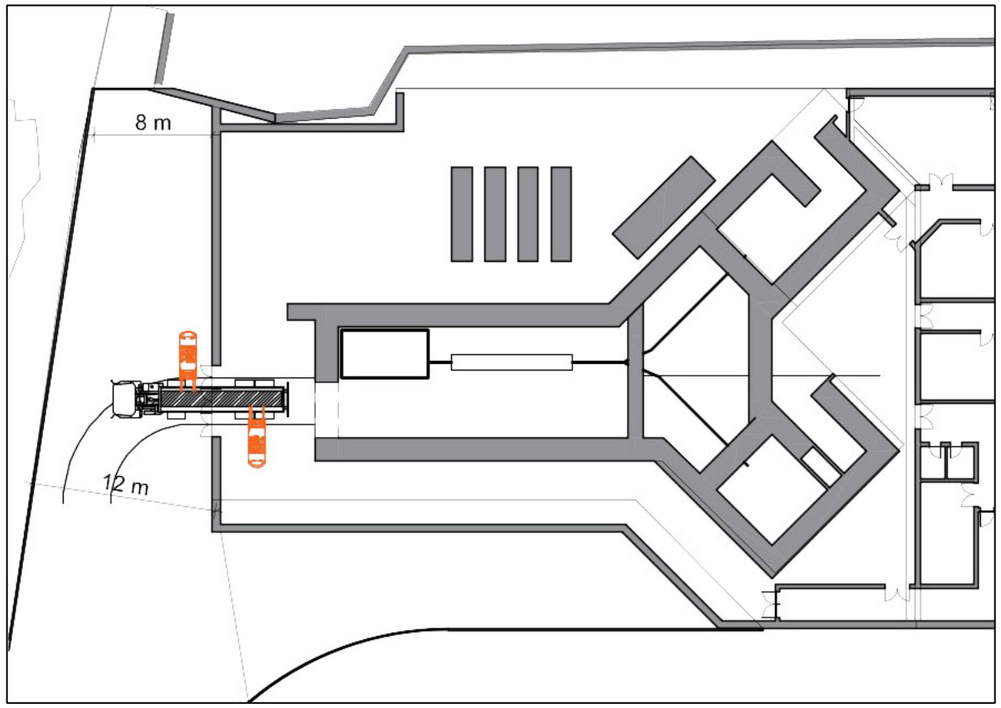


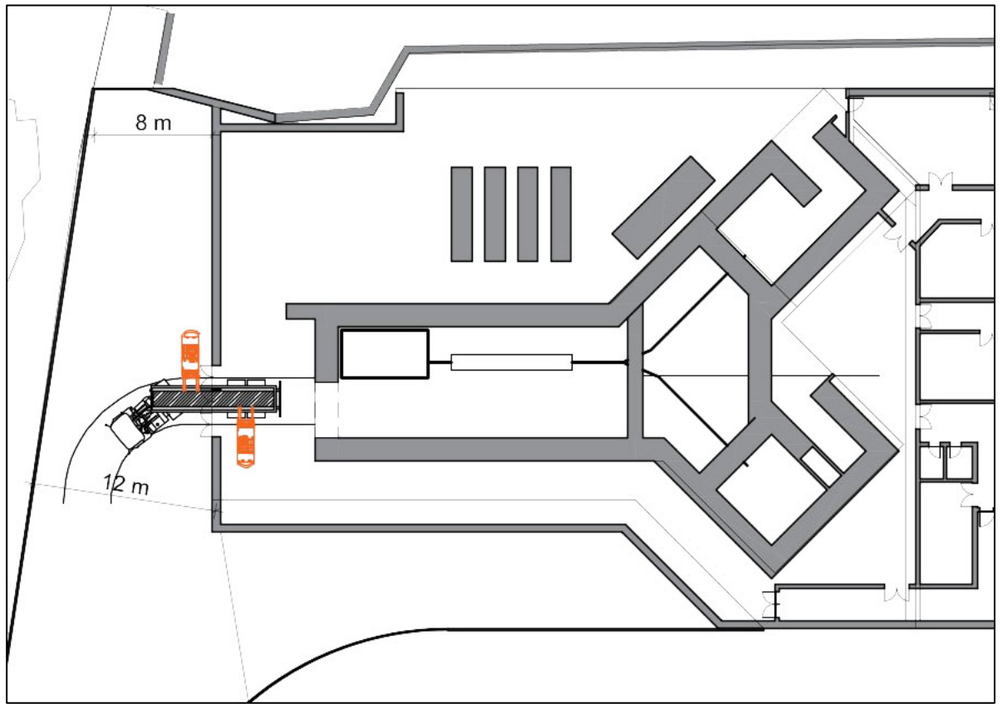
Phase 1: The accelerator will be transported by truck. The truck shall be positioned between the front door and the outside with a reverse maneuver.

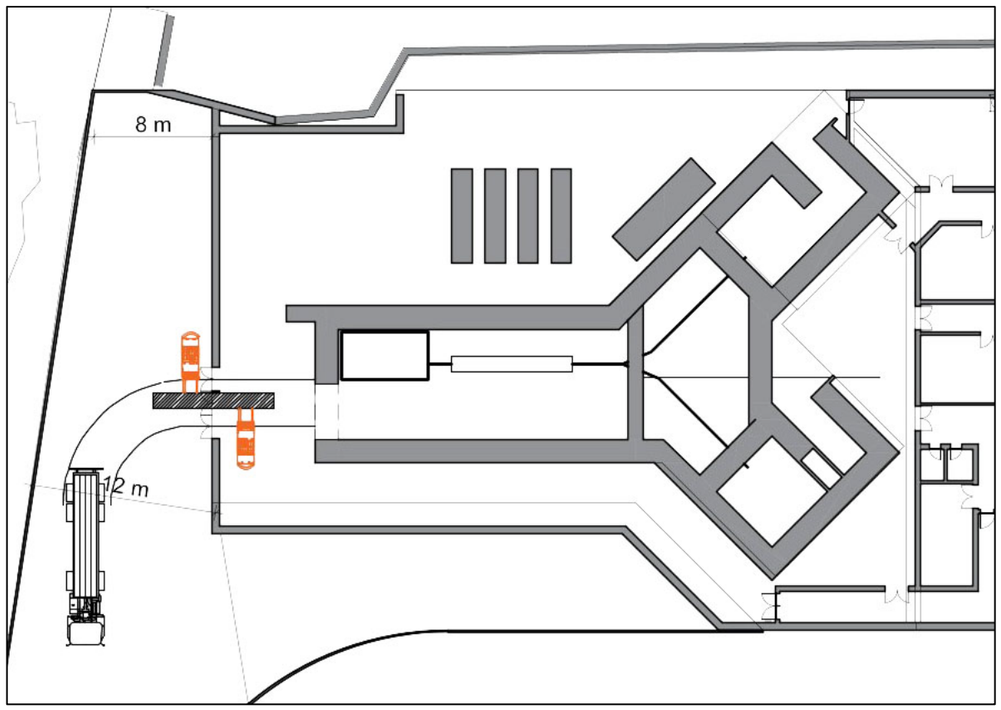
Truck dimensions: Length: 11,00m / Width: 2,40m

DESIGN ISSUES

RFQ ACCELERATOR POSITIONING



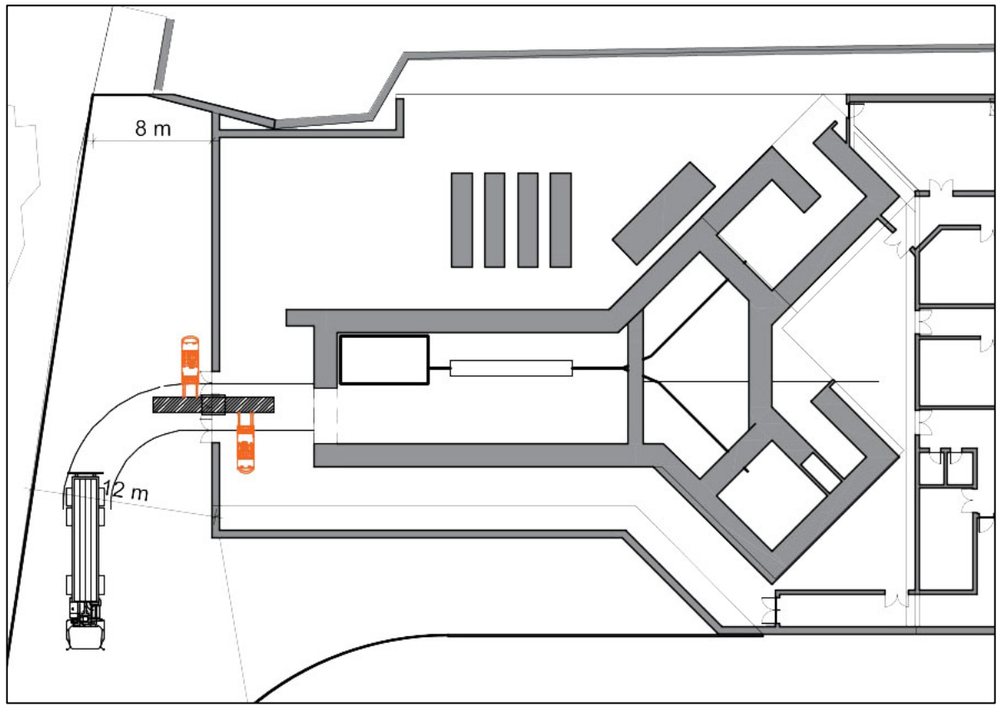


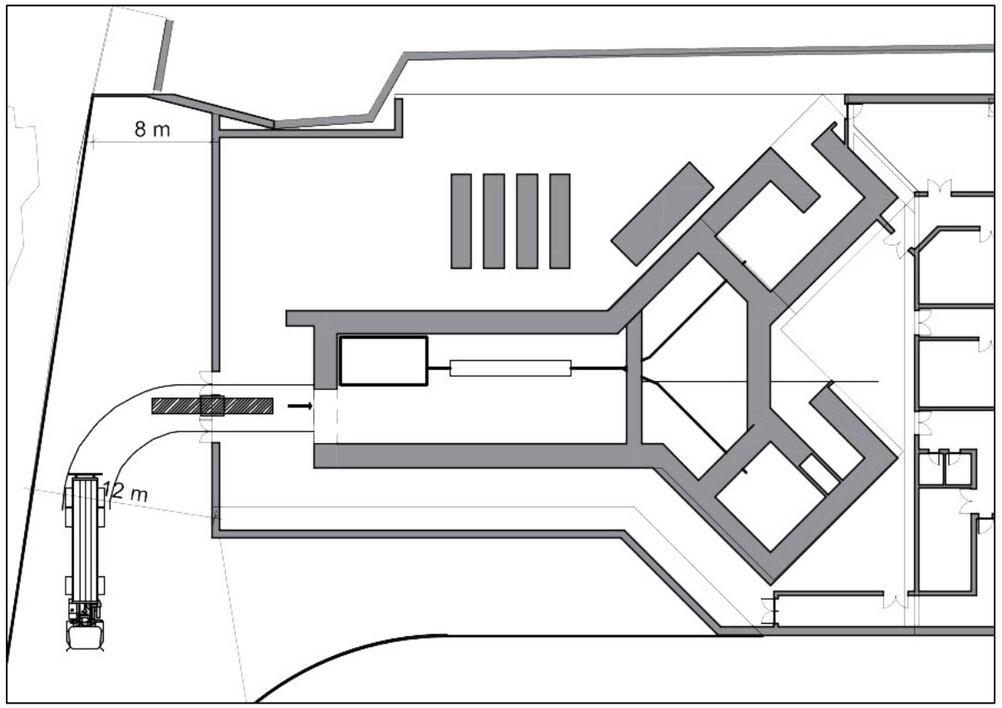


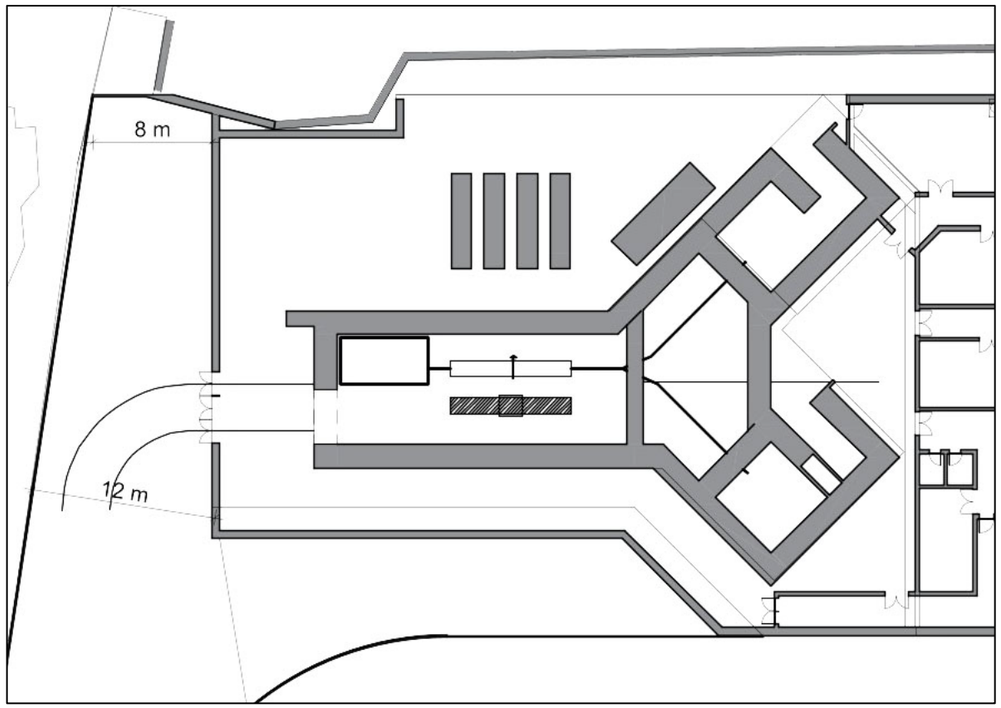
Phase 2: With the help of two forklifts, positioned one inside and one outside the building, minimal lifting of the RFQ accelerator will be performed to allow for its movement.

5 DESIGN ISSUES

RFQ ACCELERATOR POSITIONING







Phase 3: The accelerator on forklifts will then be laid on an AMR s-type robotic lifting system (data sheet attached) that will allow it to be moved and placed inside the bunker.
The number and size of the AMR s-type robotic system should be customized according to the specific need of the accelerator.

M1000 1500 kg - 10000 kg

LARS
AUTOMATED LOGISTICS

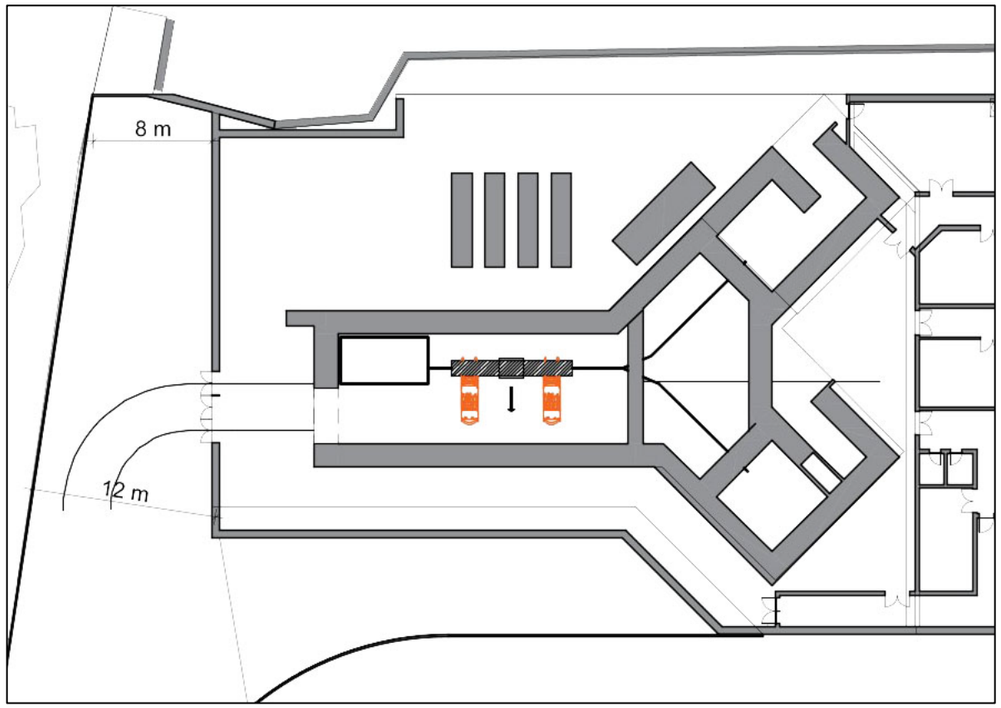
Robot designs suitable for your needs and high transport AMR Robot applications - Lars robot designs your robot for you and develops products with the qualities you need.

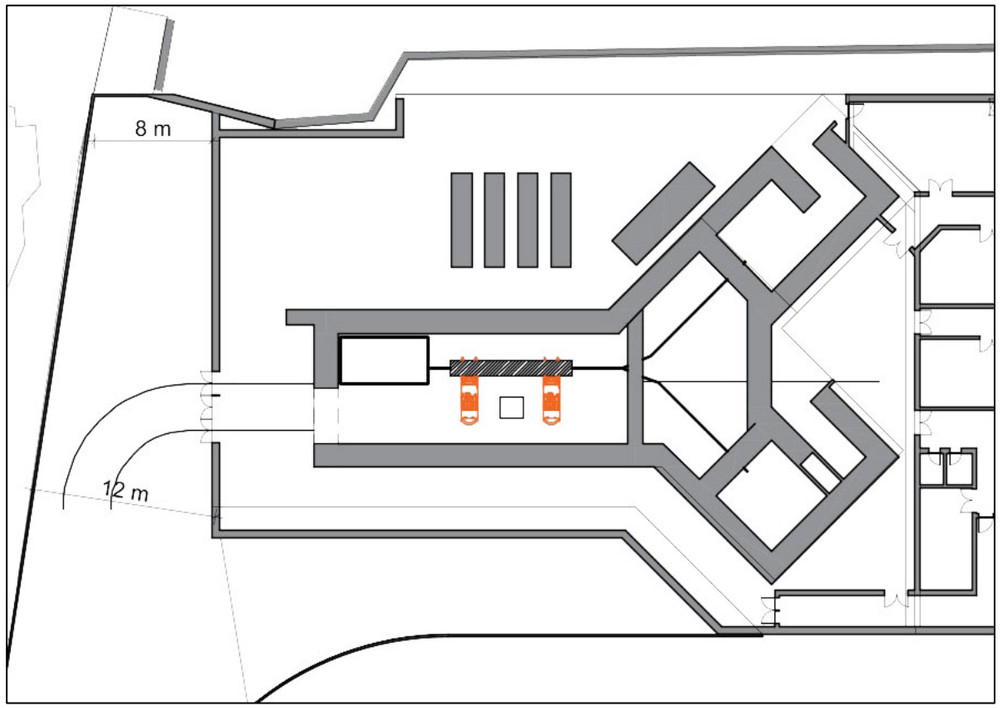
Performance	Parameter (mm; kg)
size	customizable
Rotation diameter	1476 mm
Self-respect	1000 kg
Rated load	1500-10.000 kg
Adapt to the largest bin size	customizable
Lifting Height	60 mm
Single pick and place time	8 s
Minimum pick-up bin height	customizable
Height of pick-and-place box	customizable
Carrying shelves	
No-load speed	< 1.0 m/s
Full load speed	< 0.8 m/s
positioning accuracy	±10 mm
Stop accuracy	±5 mm
Stop angle accuracy	±1°

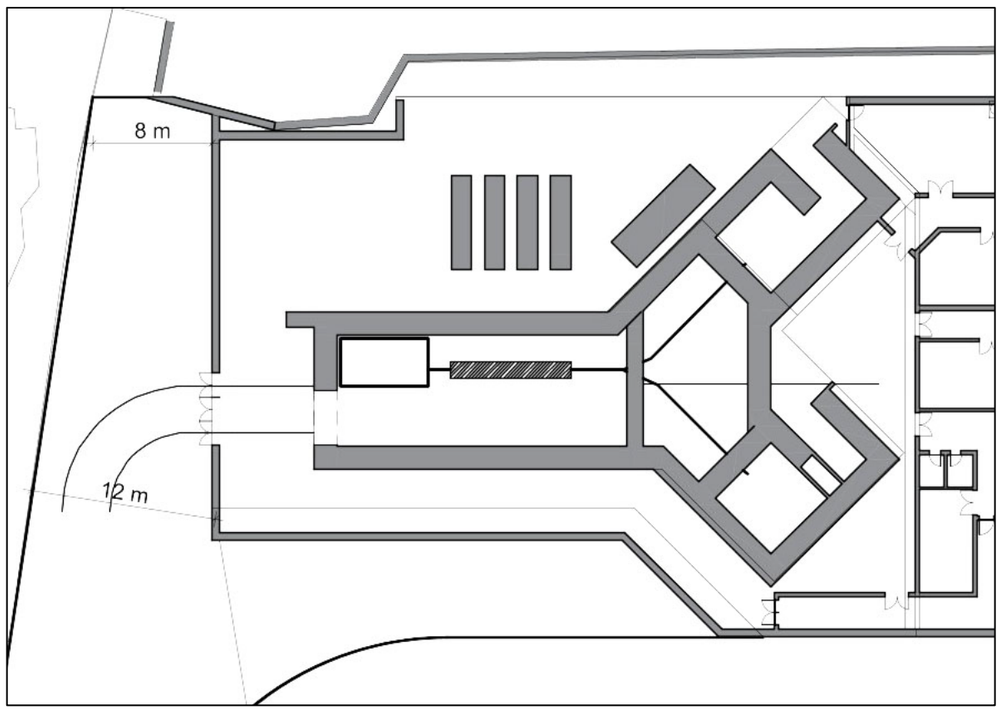
Navigation types	Laser Slam Natural Navigation
type of battery	Lithium Iron Phosphate (Lifepo4)
battery capacity	48V/65Ah
Rated battery life	8h
Charging time	1.5 h
Cycle life	Full 500 times
Crossing ability	<5 mm
Ability	< 3mm
Ability to cross the slope	< 3-5 %
Operating temperature	0-45 ℃
Lidar Obstacle Avoidance	Yes
Collision detection bar (optional)	Yes
Available e-stop	2 sides
Communication	Wifi/ 5G
Debugging Interface	Open API
noise	<70 dB

DESIGN ISSUES

RFQ ACCELERATOR POSITIONING



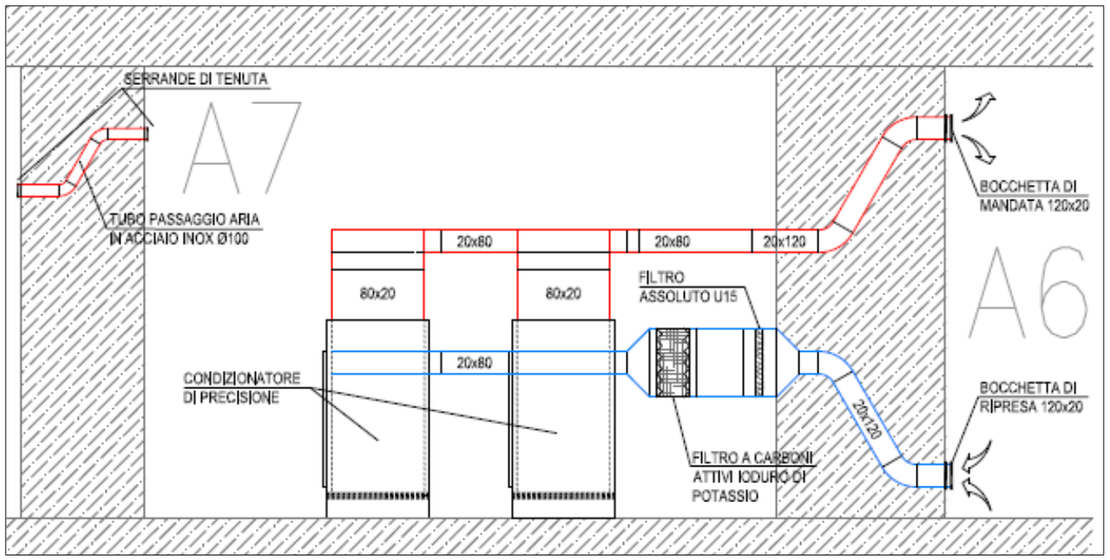




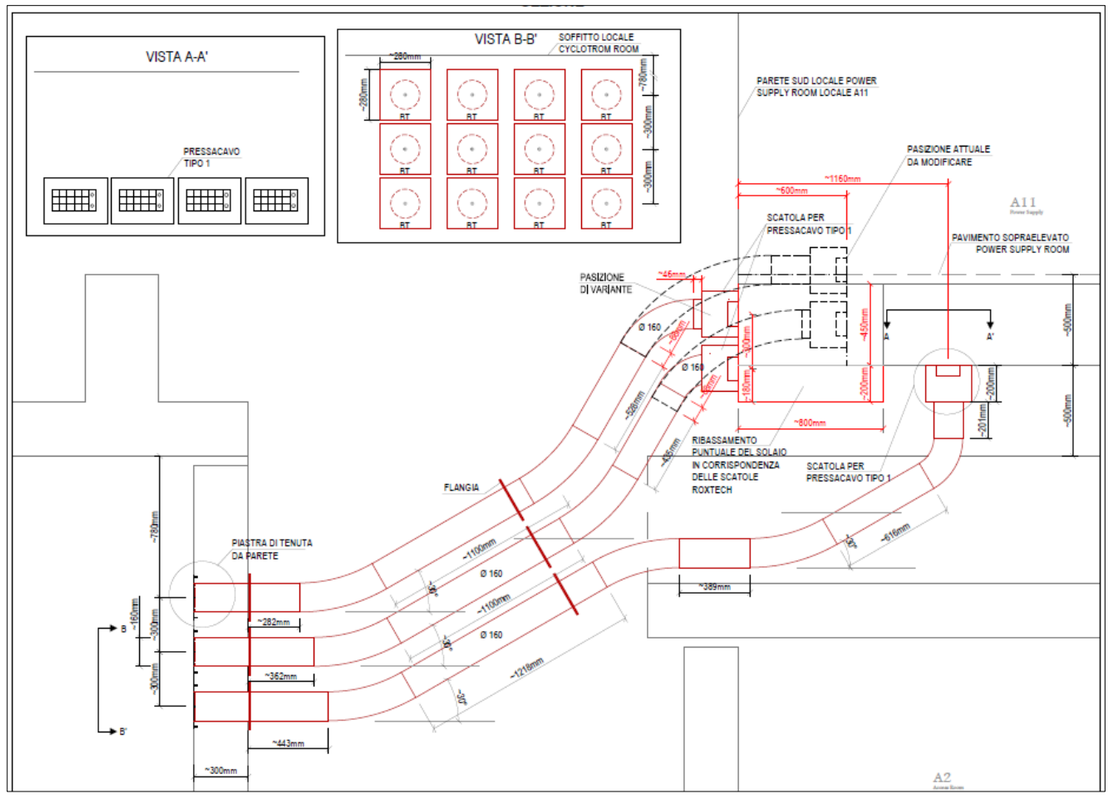
Phase 4: The accelerator will be placed via the robotic system in its final location. Then, the accelerator will be lifted via forklifts to allow the robotic system to exit and the accelerator to be placed on the ground.

5 DESIGN ISSUES

AIR CONDITIONING AND COOLING EQUIPMENT and ELETTRICAL INSTALLATIONS



Example of precision conditioner on target



example of pipeline crossing

Separate circuits are provided for air conditioning of rooms for areas with the presence of radioactivity and area swith absence of radioactivity. All facility crossings will be made with piping and ducting shall be made "gooseneck" so as to contain radiation.

For electrical installation, the crossing of walls and floors sizedfor the radiation protection effect, with a thickness of even more than 1.5 m, will no longer be possible if not already performed during the construction of the casting. The crossing of these walls will have to be carried out, taking care of:

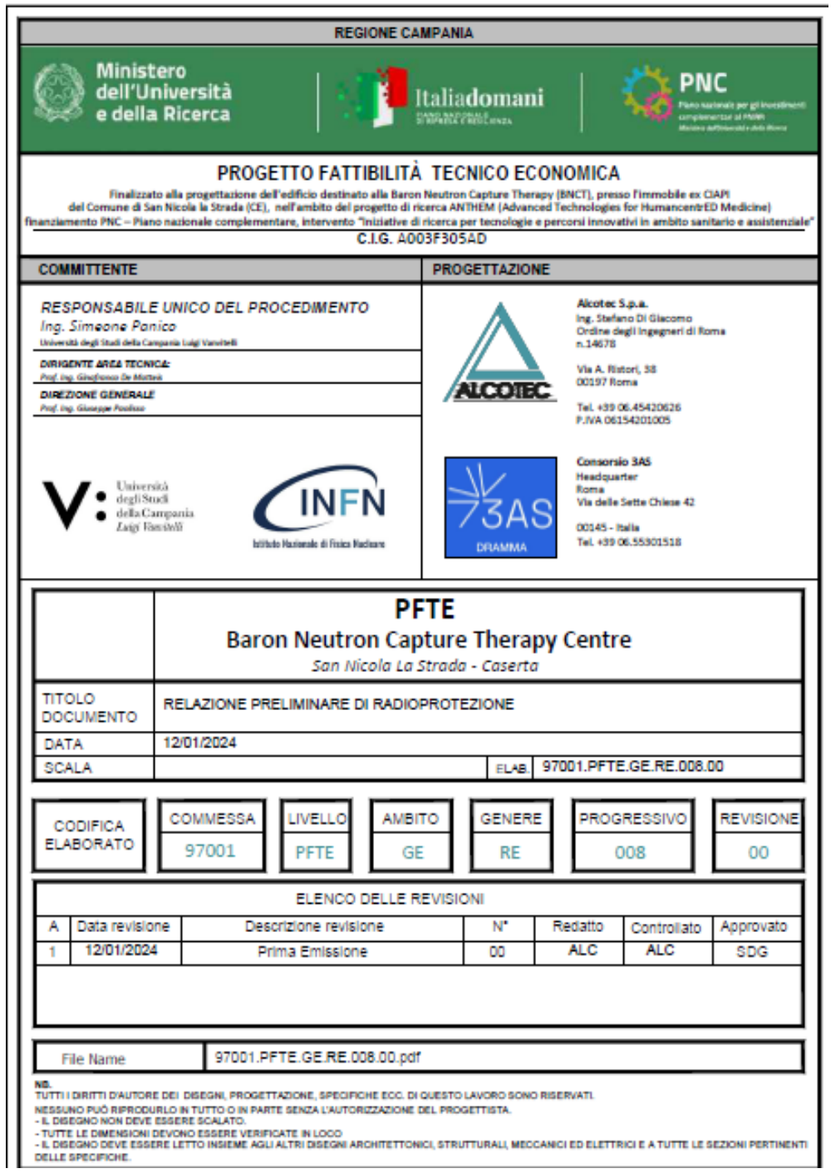
1) ***precautions to limit the passage of radioactive particles***
2) ***to maintain an airtight seal between the two separate rooms:***

- *for the first problem, a path is used that crosses the wall forming an "S," so that noradioactive particle can cross it, except by a series of bounces that attenuate its energy;*
- *for the second involves the use, on one of the two sides of the crossing, of special hollow press withrubber inserts which, when compressed, ensures the airtightness of the wall; these cable presses guarantee also a REI120 fire tightness.*

AMBIENTI PARTICOLARI

Gli ambienti nei quali per l'attività di ricerca e terapeutica, verrà prodotto un elevato tasso di radioattività: i locali saranno quindi mantenuti ad un elevato valore di depressione in Pa; mentre nei locali adiacenti nei locali filtro A3 e A6 sarà invece prodotto un tasso di radioattività più modesto: i locali saranno quindi mantenuti ad un valore di depressione di - 40 Pa; nel locale ciclotrone A1 potrebbero manifestarsi perdite di particelle per cui, prudenzialmente, si ritiene di mantenerlo ad un valore di depressione di - 50 Pa: tra tutti questi locali e nei confronti di tutti gli altri confinanti, è quindi presente un differenziale di pressione legato al fatto che più in un locale è elevato il tasso di radioattività e più il locale viene tenuto in depressione.

Come conseguenza, gli attraversamenti delle pareti di confinamento di questi ambienti particolari devono avere due caratteristiche sostanziali:



REGIONE CAMPANIA

Ministero dell'Università e della Ricerca — Italiadomani — PNC

PROGETTO FATTIBILITÀ TECNICO ECONOMICA

Finalizzato alla progettazione dell'edificio destinato alla Baron Neutron Capture Therapy (BNCT), presso l'immobile ex CIAPI del Comune di San Nicola la Strada (CE), nell'ambito del progetto di ricerca ANTHEM (Advanced Technologies for HumancentrED Medicine) finanziamento PNC – Piano nazionale complementare, intervento "Iniziative di ricerca per tecnologie e percorsi innovativi in ambito sanitario e assistenziale"

C.I.G. A003F305AD

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PFTE

Baron Neutron Capture Therapy Centre

San Nicola La Strada - Caserta

TITOLO DOCUMENTO	RELAZIONE PRELIMINARE DI RADIOPROTEZIONE
DATA	12/01/2024
SCALA	ELAB. 97001.PFTE.GE.RE.008.00

CODIFICA ELABORATO	COMMESSA	LIVELLO	AMBITO	GENERE	PROGRESSIVO	REVISIONE
	97001	PFTE	GE	RE	008	00

ELENCO DELLE REVISIONI

A	Data revisione	Descrizione revisione	N°	Redatto	Controllato	Approvato
1	12/01/2024	Prima Emissione	00	ALC	ALC	SDG

File Name	97001.PFTE.GE.RE.008.00.pdf

1. PORTE SCHERMANTI

Le aperture di accesso al locale "sala acceleratore" ed a una delle due sale di trattamento (dove non viene realizzato il labirinto, saranno protette da porte schermanti che dovranno rispondere alle seguenti caratteristiche

Le porte in oggetto dovranno essere realizzate al fine di contenere il livello di radiazioni ionizzanti generate nei locali e dovranno garantire la tenuta d'aria.

Il sistema di scorrimento e supporto degli elementi schermati in cls potrà essere realizzato mediante l'utilizzo di guide a ricircolazione di sfere installate a pavimento.

Dovrà essere presente in prossimità della porta una pulsantiera con chiave a 3 posizioni, estraibile in ognuna delle posizioni. In posizione di "personale presente" deve essere possibile eseguire le movimentazioni in manuale, ma non le operazioni da remoto; in posizione "movimentazione remota" deve essere possibile eseguire le movimentazioni solo da remoto e non dalla pulsantiera, mentre in posizione "3" dovrà essere possibile disattivare completamente entrambe le operazioni, quindi mantenere la porta bloccata sia dalle procedure remote che da quelle manuali.

2. SISTEMA DI TENUTA DELL'ARIA PER LE PORTE SCHERMANTI

Il sistema dovrà essere installato assieme alle porte schermanti, una volta aperte entrambe le porte dovrà essere garantita la continuità del pavimento tra i locali così come dovrà essere garantita l'intera luce di passaggio

Il sistema di tenuta d'aria dovrà essere realizzato mediante una doppia guarnizione gonfiabile preferibilmente fissato al muro adiacente la porta. Tra le due guarnizioni dovrà essere inserito un

sistema di pompaggio che consenta di misurare l'eventuale perdita della guarnizione più interna.

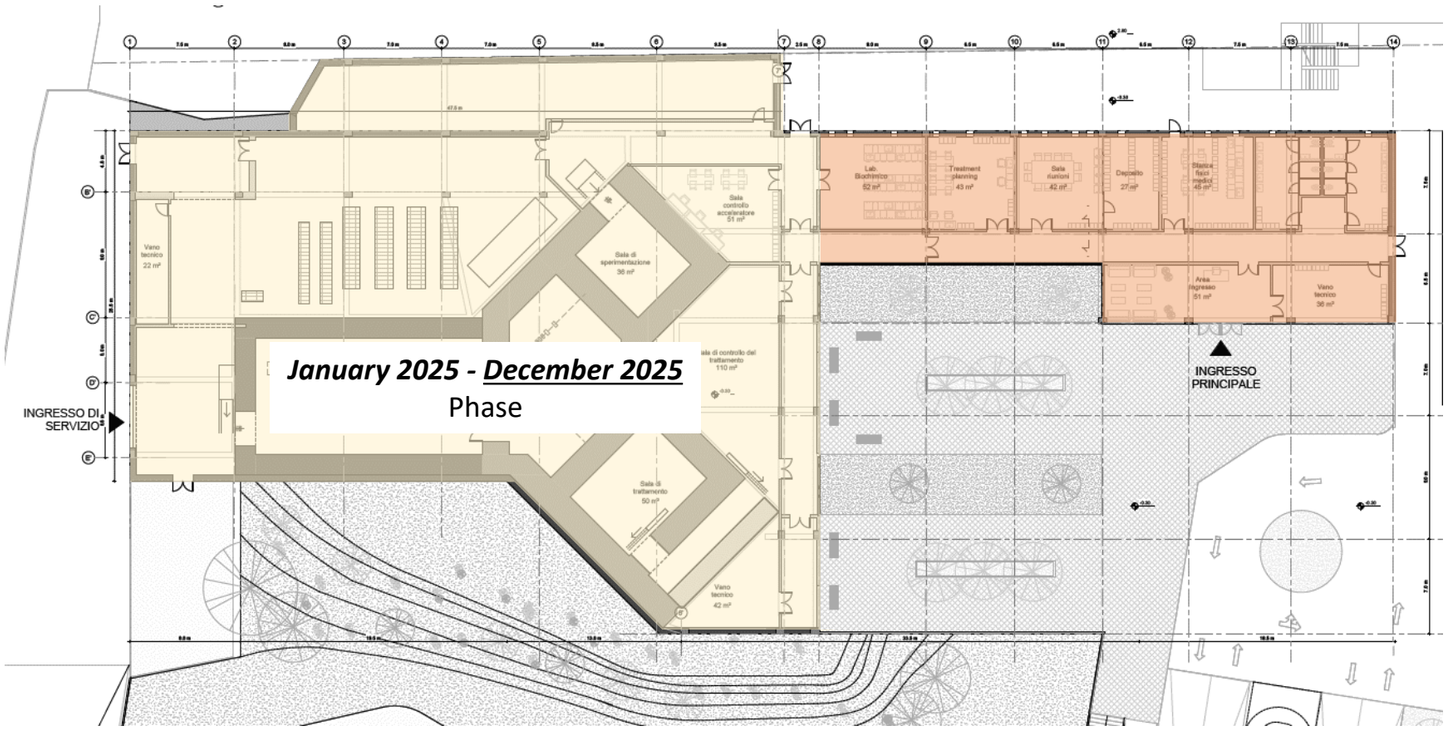
Il locale A1(acceleratore) è definito di classe 2 (-40 Pa), il locale A5 (sala trattamento) è mantenuto a pressione atmosferica (- 40 Pa),.

La perdita massima ammessa non potrà essere superiore allo 0.25% del volume del locale sulla quale viene installata.

Tutta la componentistica elettrica ed elettronica dovrà essere di tipo FAIL SAFE e dovrà essere garantita per un funzionamento non inferiore a 5 anni in un ambiente con un livello di radiazioni pari a 5 mSv/h.

6 PROJECT TIMETABLE

General (provisional) PROJECT TIMETABLE		
Technical and Economic Feasibility Project	***Done*** *Authorization request in progress*	*Due date:* ***April 2024***
Tender procedure for building execution	*Starting date*: ***April 2024***	*Due date:* ***July 2024***
Executive project	*Starting date:* **July 2024**	*Due date:* ***November 2024***
Acquisition of relevant authorizations and permissions	*In progress:*	*Due date:* ***December 2024***
Construction of the building (Phase I)	*Starting date:* ***January 2025***	*Due date:* ***July 2026***
Bunker Construction and start rfq testing (Phase Ia)	*Starting date:* ***January 2025***	*Due date:* ***December 2025***



Il centro BNCT ANTHEM a Caserta: stato del progetto e prospettive

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