BDF Service Cell design

ISIS/CERN collaboration progress workshop
1rst - 2nd June 2026

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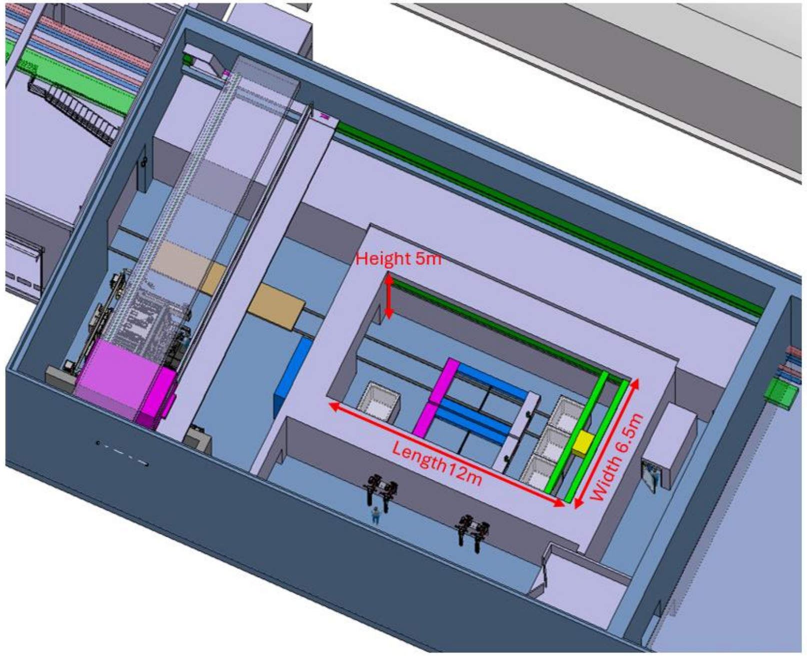
with the contribution of all the members of HI-ECN3 project

Service cell design

- Recall the initial motivation of the service cell
- Detail the original implementation
- Detail the process implemented to progress in the definition of the service cell
- Explain the equipment from BDF and legacy waste selected for the preliminary design study
- Present the outcome of the preliminary design study
- Concluding remarks and next steps

Initial justification for the need of BDF's own service cell in the target service building

- **BDF will host the most highly activated equipment ever operated at CERN**
- **Target design to be a replaceable component (5 y lifetime of the target compared to 15+ years of operation for the facility)**
- **Host states request a dismantling plan and elimination pathway for the BDF radioactive waste**
- **Extend the use of the BDF service cell to other CERN legacy radioactive wastes**



- **Target systems autopsies and equipment repairs shall be accounted**
  - Identifying **failure modes and possibly repair**, to ensure facility performance and improve future design and reduce operational costs

Target complex building - Service cell justification

- **Endorsed by NA-CONS and HI-ECN3 and RWMP steering boards**

Service cell justification: https://edms.cern.ch/document/3203029/0.1*

- **Design and process preliminary design study contract placed**
- **Service cell design study technical specification:** https://edms.cern.ch/document/3264680/1.0
- Develop further the design of the service cell
- Develop the processes associated to the cell

By having an experienced firm in design and construction of service cell

BiLFINGER

Kick-off
01/09/2025

Initial results of all studies
02/12/2025
→ Functional Analysis
→ General arrangement x 2
→ Waste Process Note x 3
→ Technical Note x 3

Intermediate/final results of all studies
22/12/2025
→ Final report
→ STEPs x 4

CERN Feedback
21/01/2026

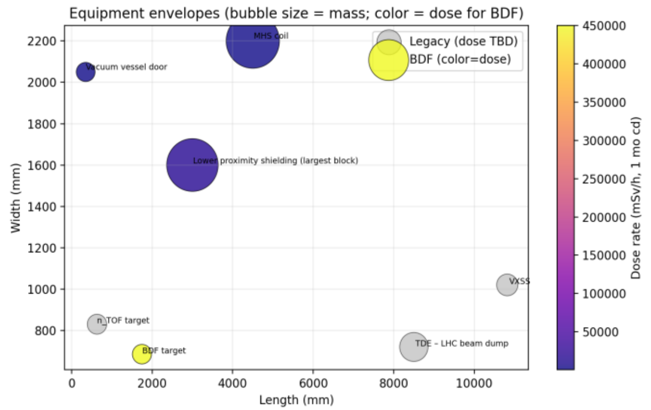
Final results of all studies
13/02/2026
→ Final report rev B
→ Technical Note rev B x 3
→ Kinematic simulation x 2

Wrap-up
17/02/2026

*A revision of the justification will be performed

Equipment to be processed in the Service Cell

Item	Envelope (L×W×H) mm	Mass	Container	Driver	Dose H*(10) @1 month cd (mSv/h)
BDF Target	1746×685×847	~2.3 t	KC-T12	Highest dose	4.5×10^5
MHS coil	4500×2200×1100	~30 t	ANDRA 10 m³	Widest & heaviest	5.4×10^2 (max)
Lower proximity shielding	3000×1600×1019	27.5 t	LC-86 (10 m³)	Heavy block	1.74×10^4
Vacuum vessel door	349×2050×3072	~2.2 t	ANDRA 10 m³	Tall element	6.3×10^2
TDE – LHC beam dump	8500×720×720	6.2 t	ANDRA 10 m³	Legacy fit check	TBD
VXSS	10820×1020×1260	3.0 t	ANDRA 10 m³	Longest item	TBD
n_TOF target	630×830×1600	2.4 t	KC-T12	Legacy fit check	TBD



Characteristics of the 7 items

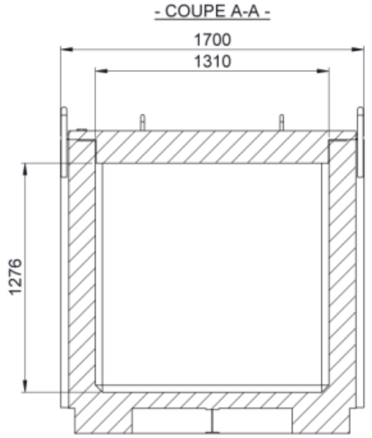
Dose rate of the 7 items

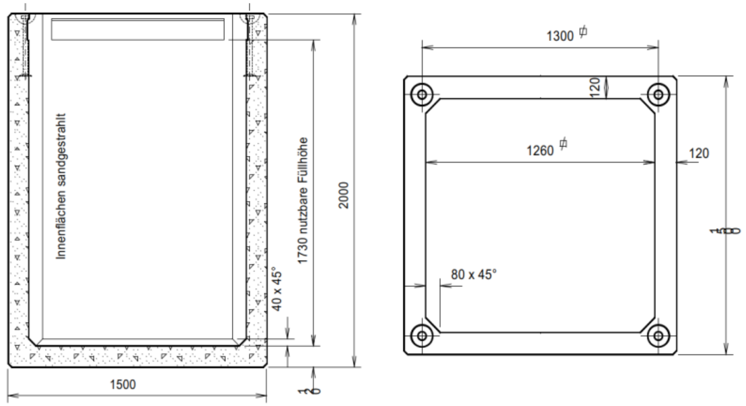
Disposal Containers & Operational Constraints

Container	External footprint (mm)	External height (mm)	SWL (kg)	Usable volume (m³)
KC-T12	1500×1500	2040	20000	2.71
ANDRA 10 m³	3400×1700	1812	32000	6.65
LC-86	2440×1980	1950	25000	4.99

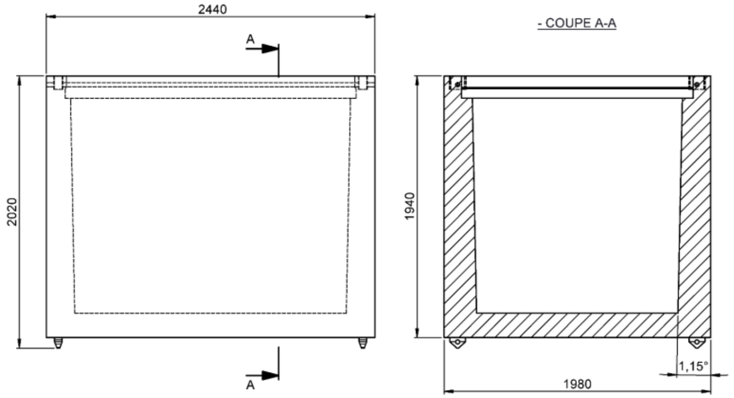
Operational rules (from process definition)

One lid removed at a time for loading.
Conditioned package masses must remain compatible with trolley, OHTC and floor limits.

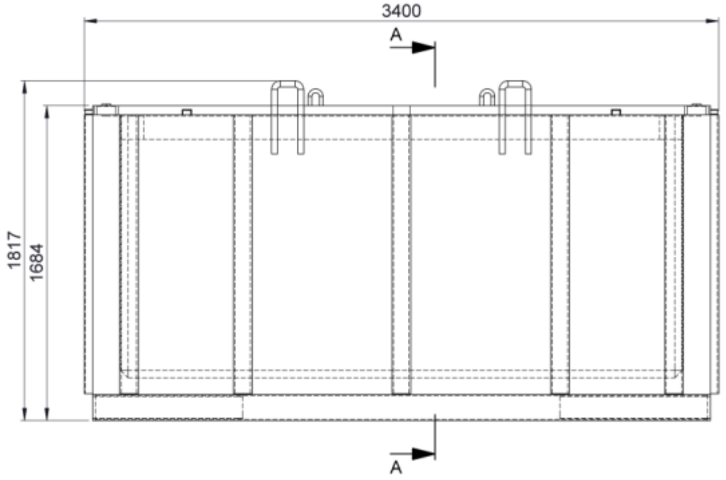




KC-T12 Disposal Container - PSI

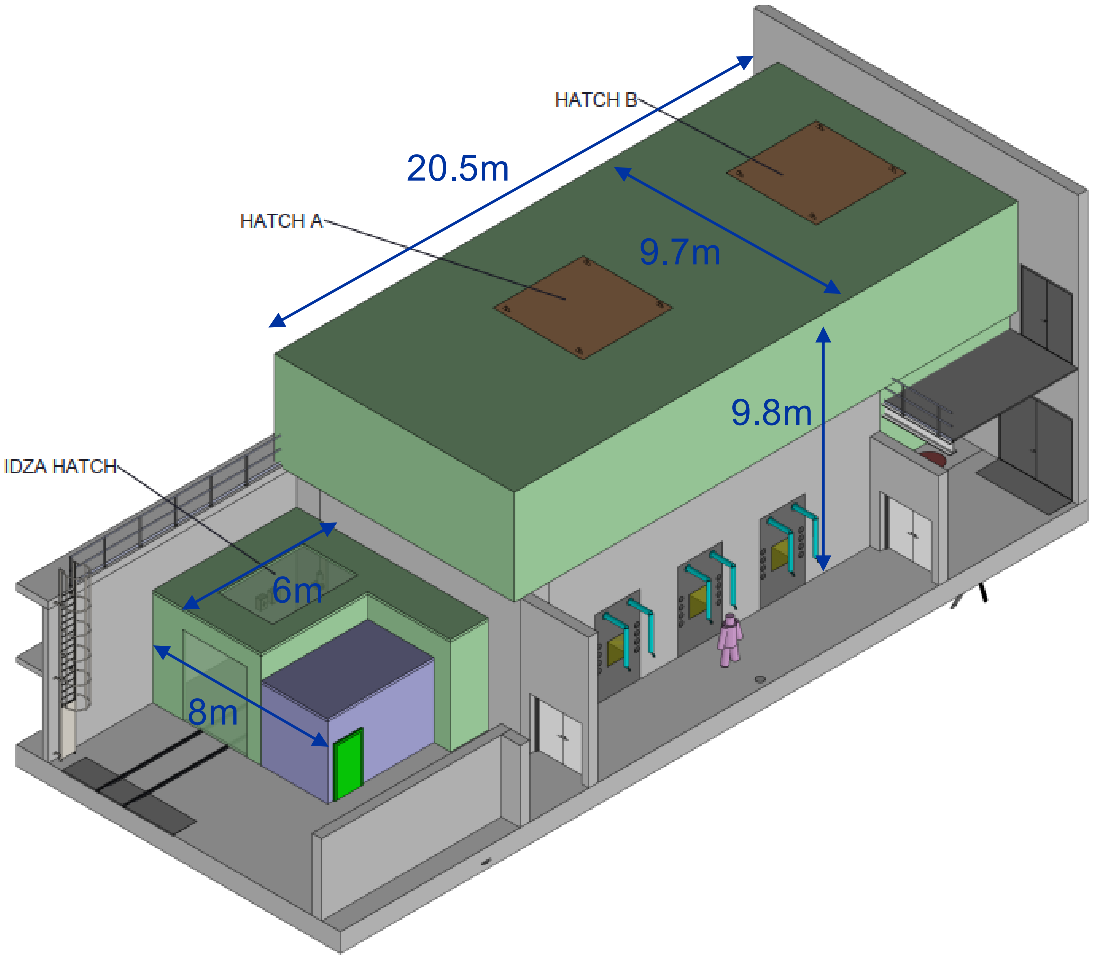


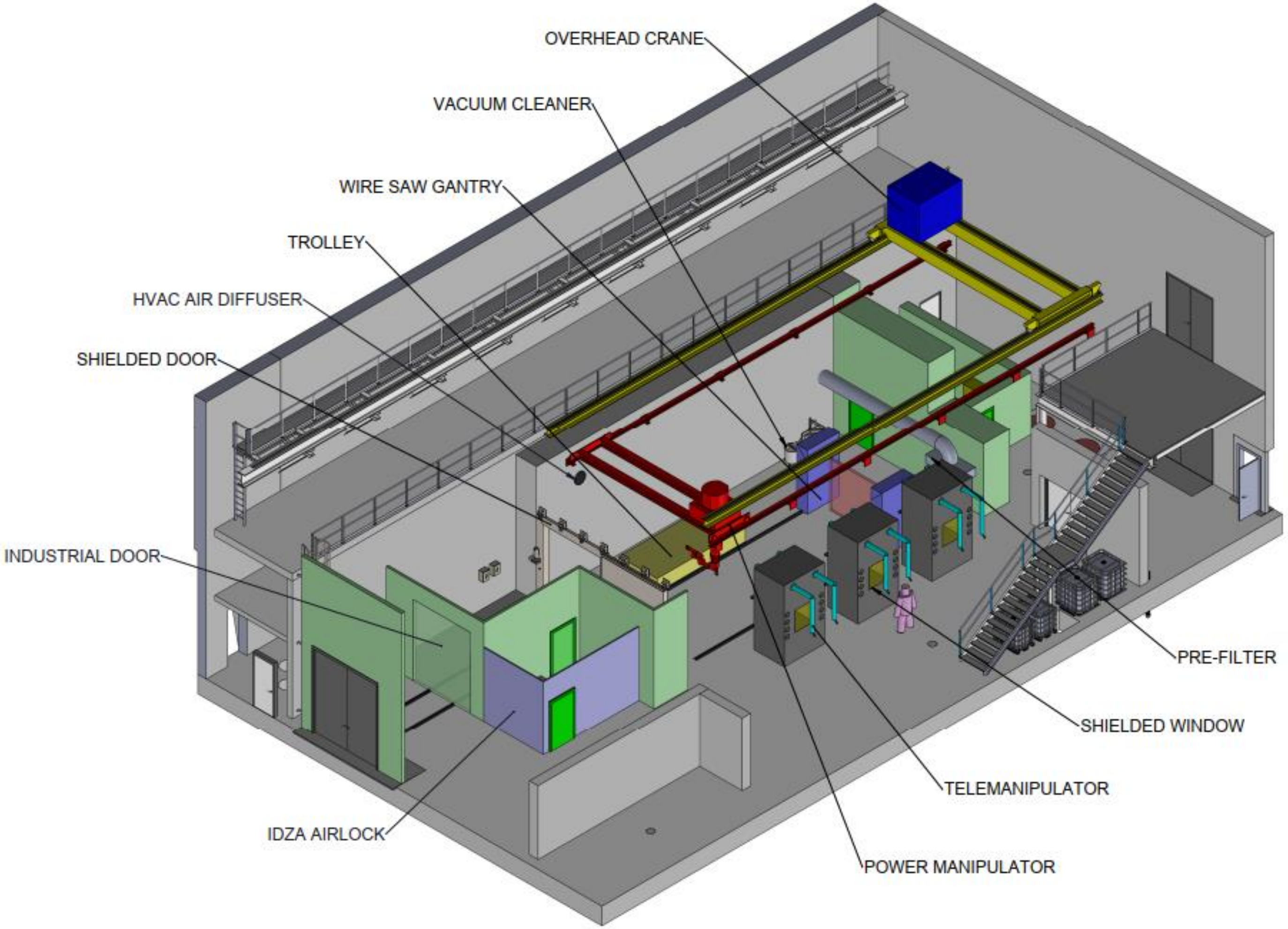
LC-86 Disposal Container - PSI



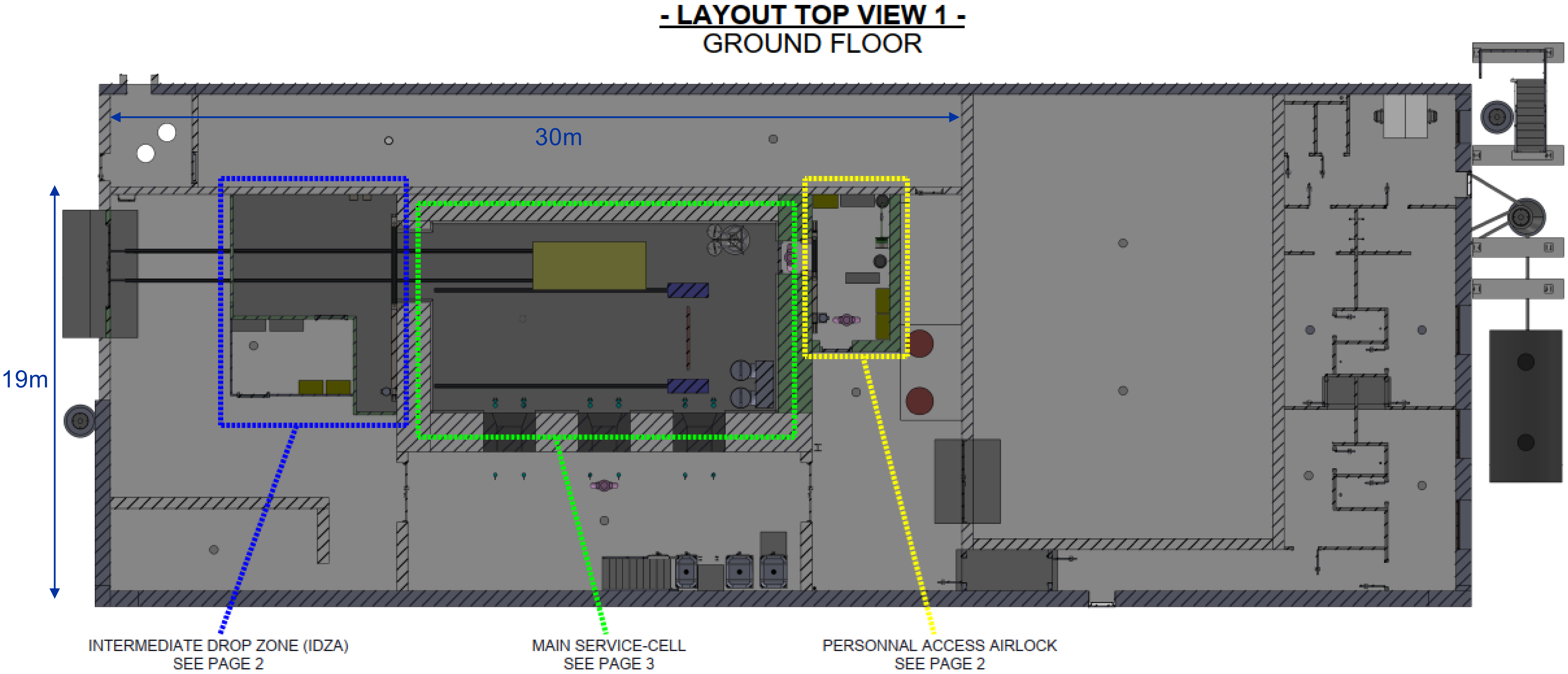
10m³ Disposal Container - ANDRA

Service cell design

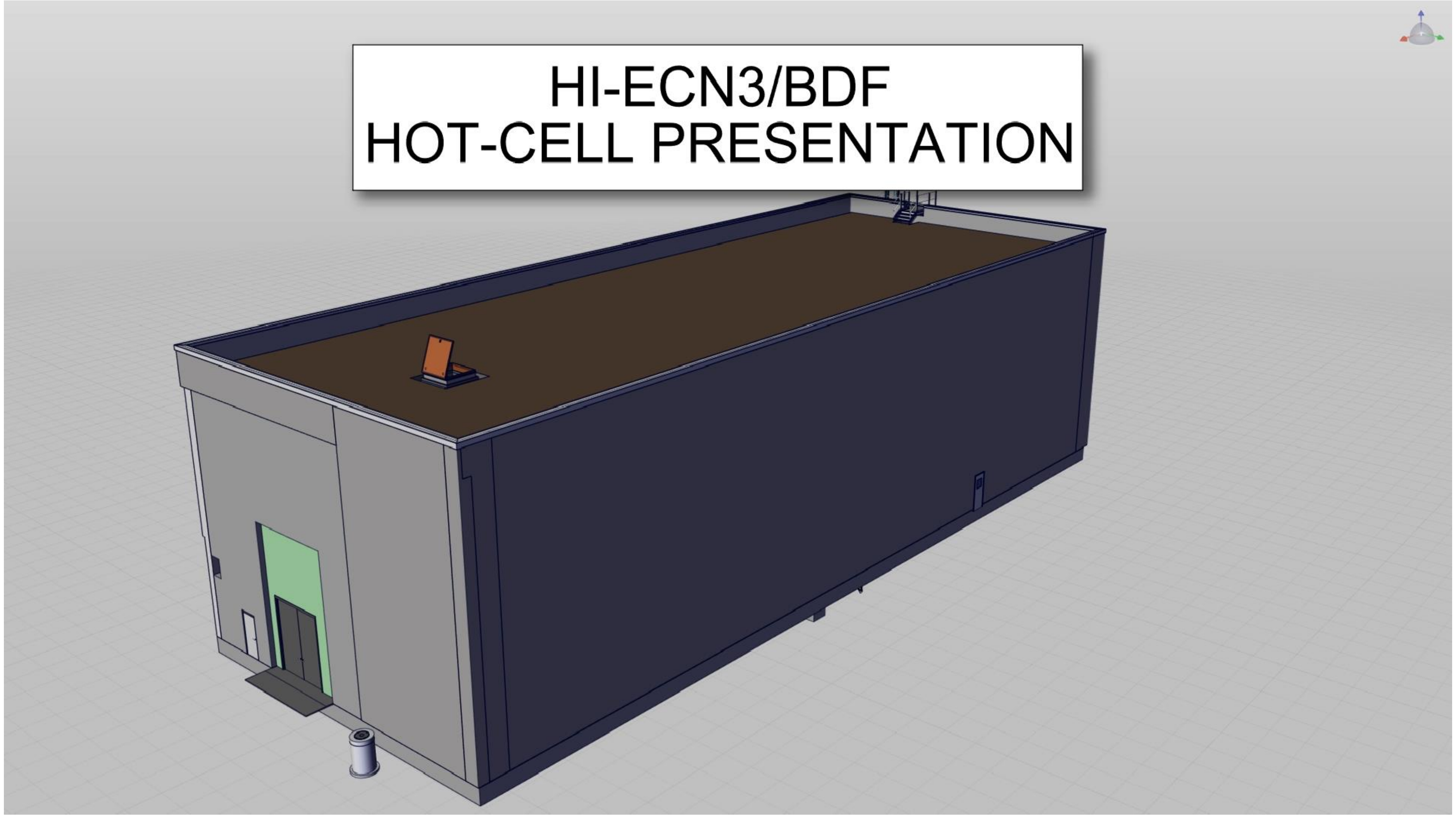




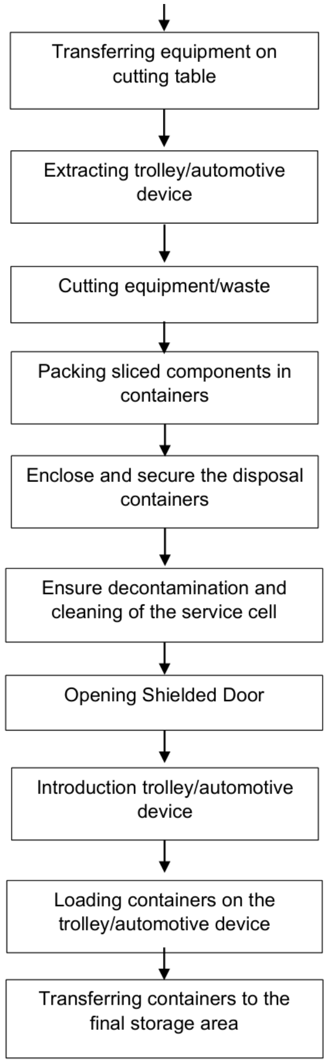
Service cell integration within building



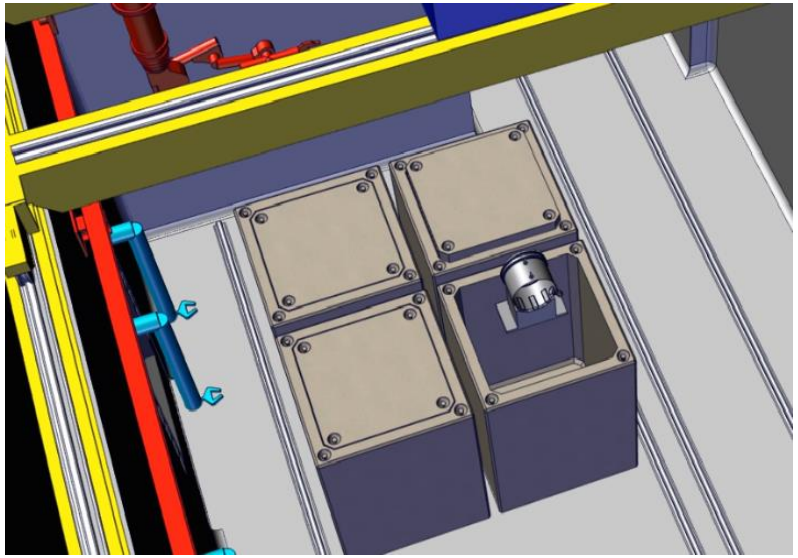
Service cell design – guided tour



BDF target process overview



BDF Target Process Flow Diagram

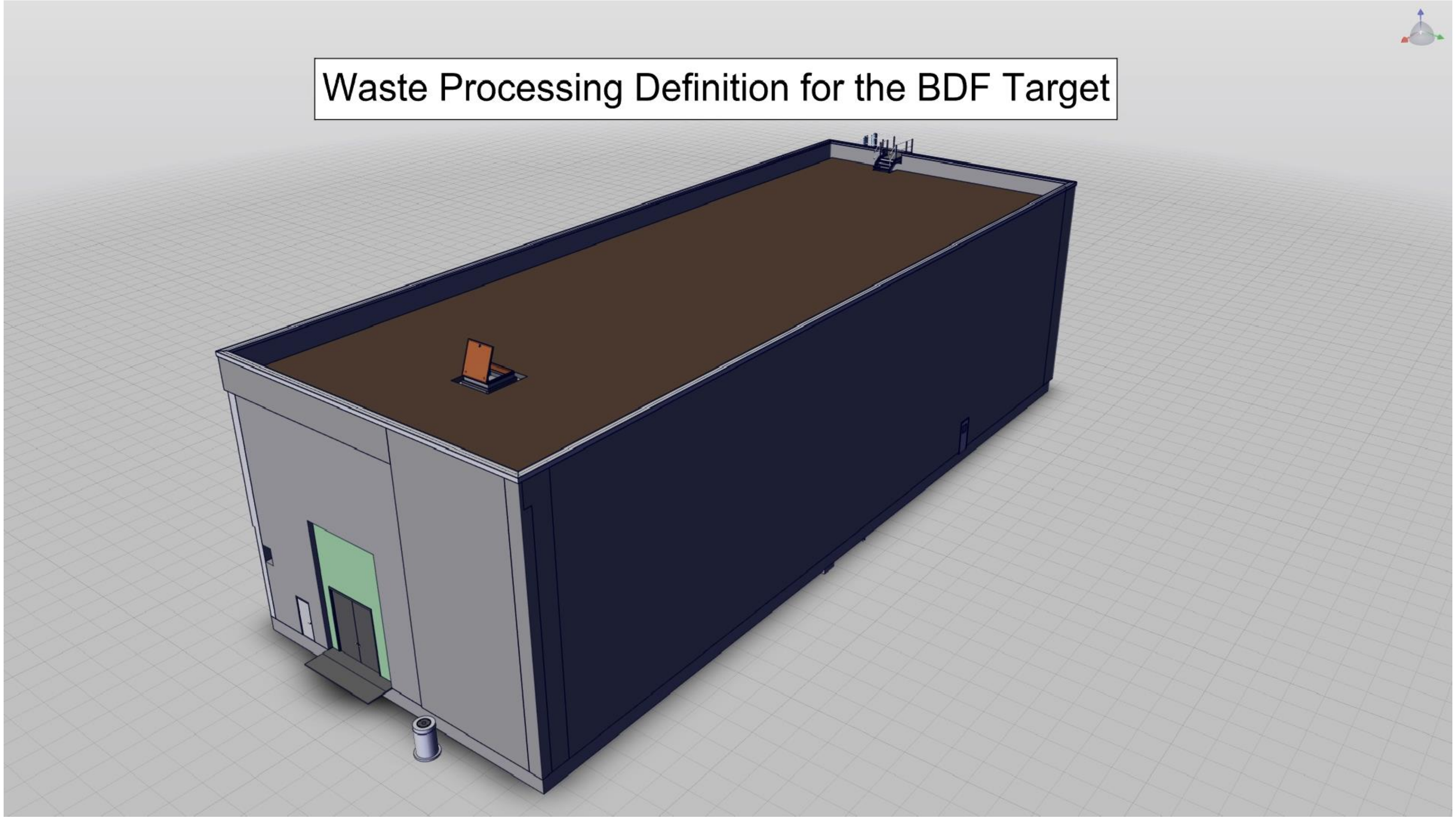


View of the Packing sliced target in containers process step

- Cell is not continuous-flow: each waste type has a specific configuration
- Transfers under dynamic confinement
- Cutting under local capture; swarf management; decontamination before door opening
- Container handling is sequenced to maintain safety and operability
- Components are sliced to fulfil final repository acceptance criteria*

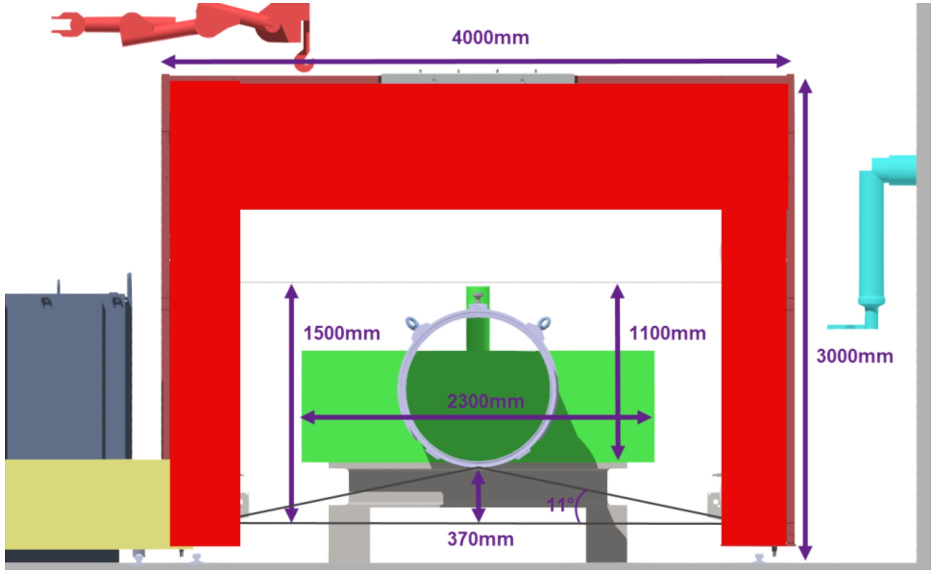
*criteria currently under revision

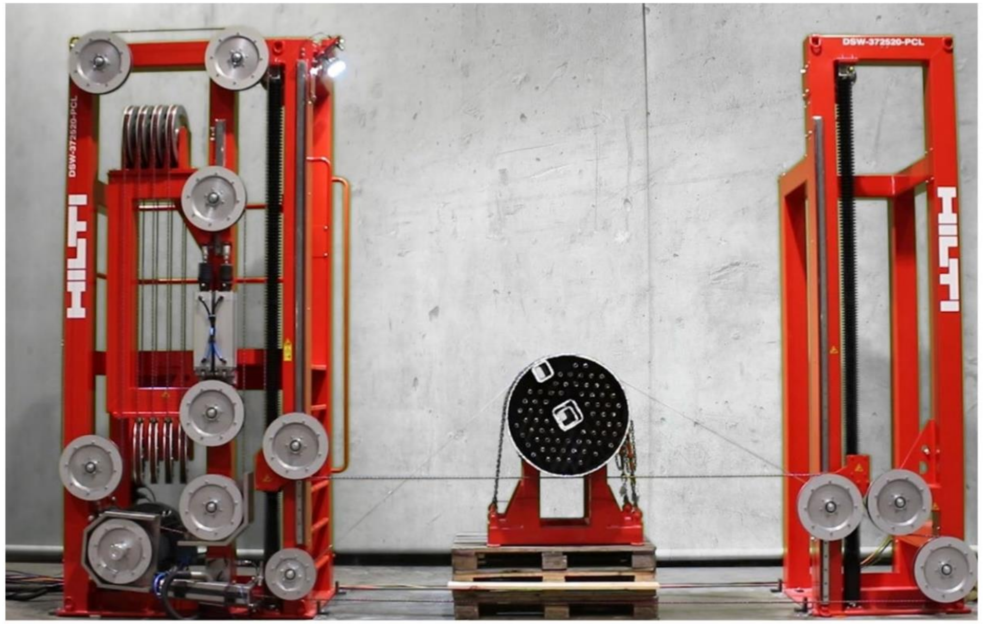
Kinematic simulation of BDF Target Process



Tentative process - Wire diamond saw

Giving major constrains



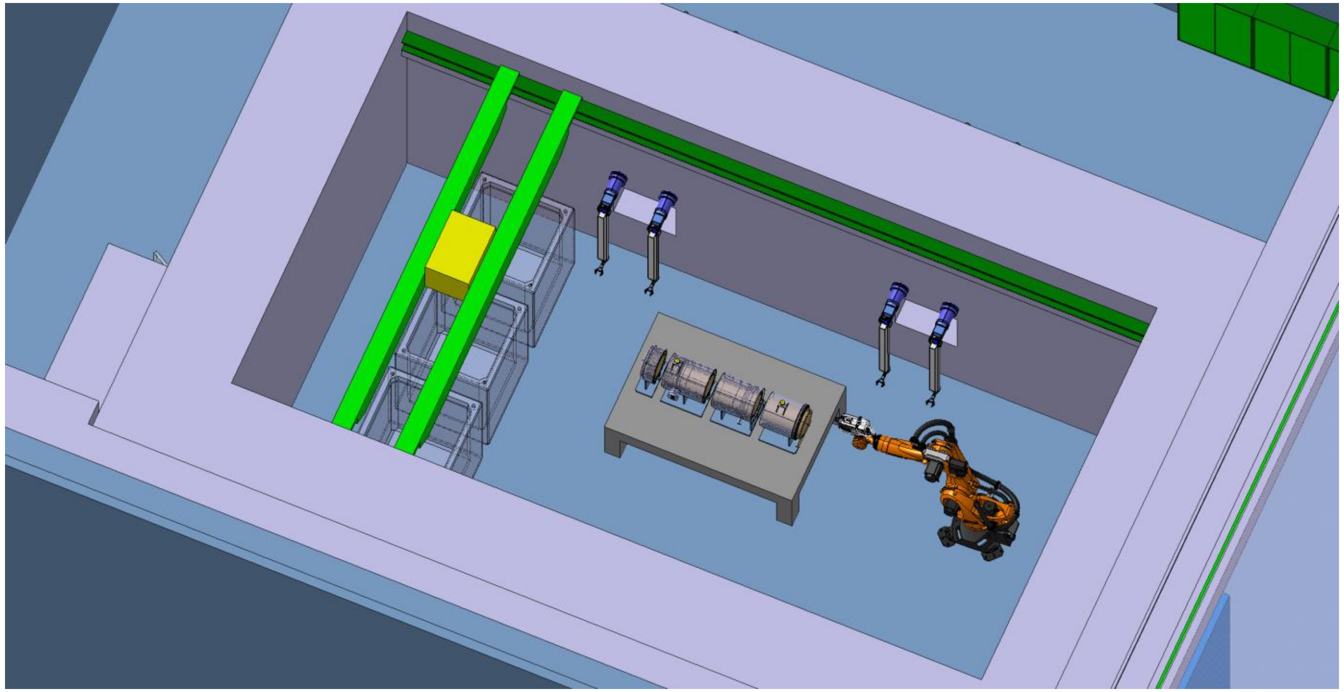


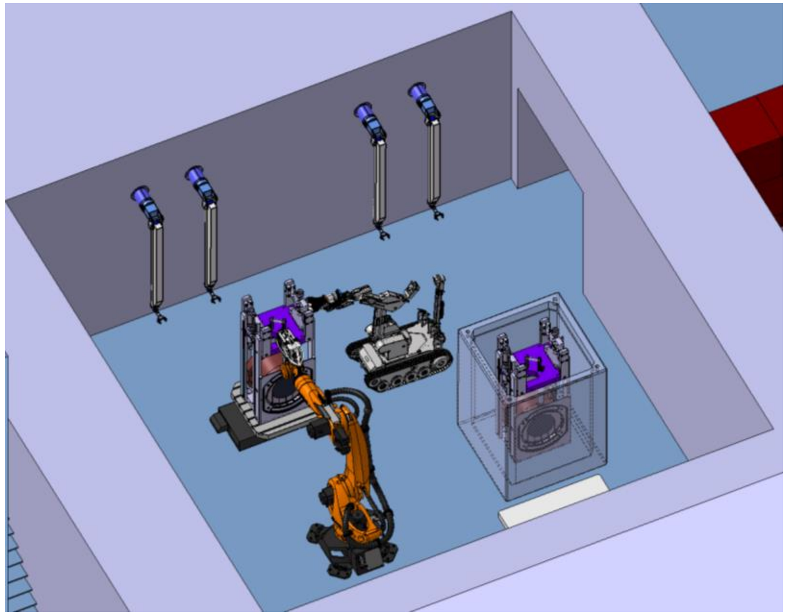
Some other parameters:

- Cutting gap: ~10.5mm
- Particle production: from ~0.6mm to >0,1mm
- Air cooled
- Possible sparkling during process(further investigations needed)
- ‘’particles’’ aspiration at source production needed
- Possibility to get a full remotely compatible wire diamond saw

Courtesy: Hilti

Tentative process – Alternative equipment

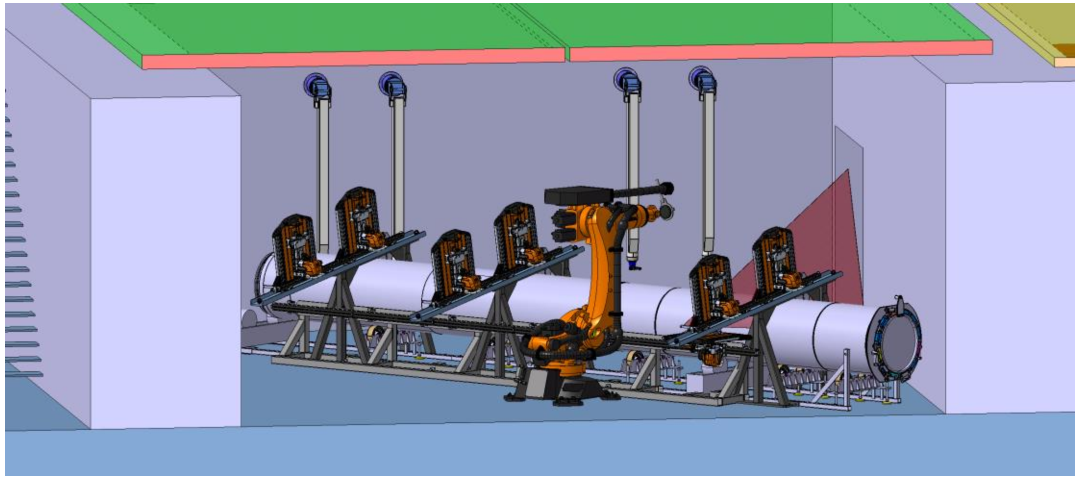




- Robots (fixed and mobile)
- Custom built machinery

Very well know systems at CERN used for previous radioactive packaging activities but recovery methods not yet/fully compliant with radiological constrains

Similar constrains as for wire diamond saw



Service cell Failure Recovery – Strategy

Failure mode (examples)	Safe state	Recovery / mitigation (integration level)
OHTC fault (hoist/drive)	Brakes set; load secured; park position	Redundant lifting provisions; recovery tools; maintenance access volumes
Manipulator failure	Freeze/park; safe tool release	Hot-swap strategy; retrieval hooks; cold-side replacement path
Transfer trolley fault	Stop; chock/lock; maintain confinement	Manual towing interface; access for intervention; recovery sequence via IDZA
Door/airlock malfunction	Door inhibited; maintain ΔP	Manual override strategy; seal inspection from cold side; contingency modes

Design principle

- Avoid single-point failures where feasible; otherwise provide remote recovery and maintainability paths.
- Reserve volumes and interfaces specifically for failure recovery tooling and sequences.
  - Maintenance cell
  - Hatches above the cell and airlock

Failures with associated mitigation measures are the sizing parameters for all the equipment part of the service cell

Impact of target design with final waste packaging

Initial requirement used for design of the service cell

- **Target need to be sliced in 4 parts to fulfill final repository acceptance criteria**
- **Overall target length (vessel) not fitting one final repository container**
- **Target packaging straight after removal from target station (~1 month cooldown)**

Cost of the service cell with the current requirement much higher than foreseen budget

➔ **Overall target length reduction will help with the final disposal requirements**

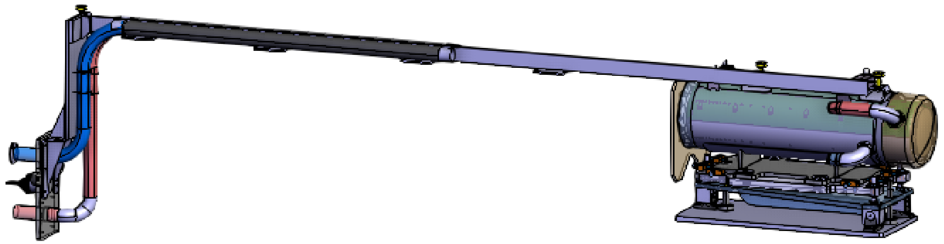
➔ **A minor reduction of target length ~2λ will not impact physics performances**

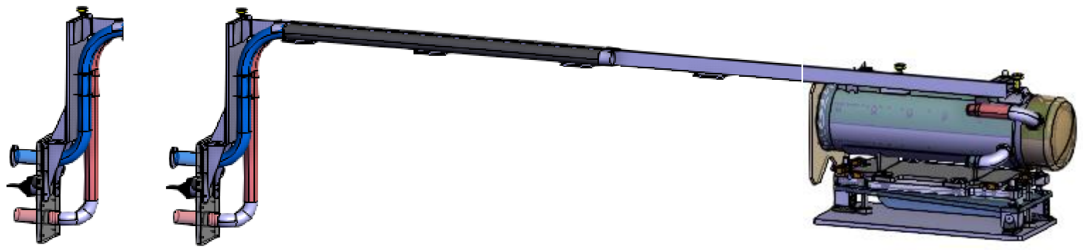
  ➔ Minimal cutting operation (only He pipes and thermocouples)

➔ **A different timeline line for waste disposal could allow radiation cooldown**

  ➔ Intermediate storage of target in the underground target area as mitigation plan

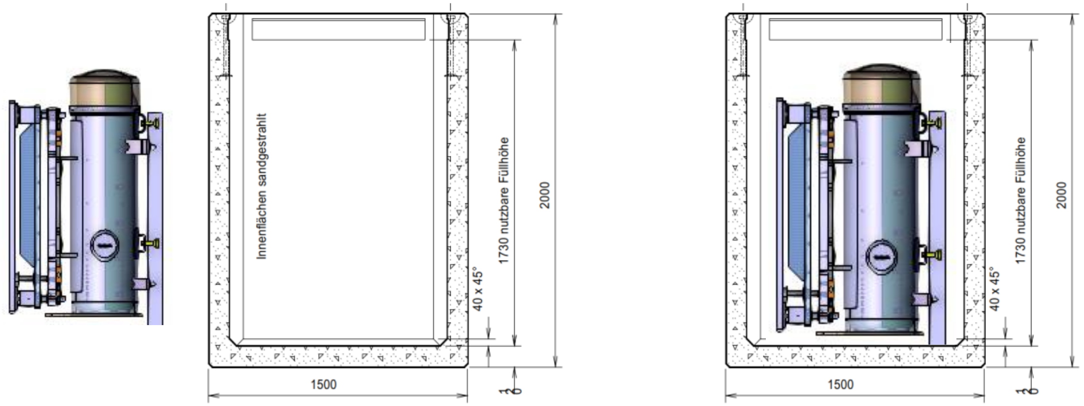
Final waste packaging baseline strategy





Way toward final disposal (baseline)

- Pipes and thermocouples shearing
- Rotation of target
- Insertion inside KC-T12 container



Container would need internal shielding to reduce dose rate

Filled with mortar to stabilize for long term storage

Implementation options evaluation

Construction of the service cell structure during building erection

- Would have been the ideal situation
- We would have needed to freeze the design of the service cell with their associated interfaces together with the design of the building

Construction of the service cell structure after building erection

- Would allow us for more time for a deeper thinking of our needs
- We would have to leave with the constrains we fixed today (footprint and load) and other interfaces

Retained option

Assessment performed with the help of a civil engineering design consultant specialised in design of nuclear facility

Is the volume secured inside the building coherent?

Example of the LHC beam dump (TDE)

Length: 8m Ø:0,7m

Weight: 8t

Space required to process the equipment:

- Tools (cutting, cleaning, dismounting)
- Shielding (including internal one)
- Recovery setup
- Accessibility with mobile robots
- Change over and airlock
- Space for container(s) and container lids

Bunker footprint 260m²

Overall area space 500m²

Service cell – Implementation strategy

The Service Cell will not be part of the BDF/SHiP baseline for installation and Run 4 operation, giving more time to refine requirements, optimize the design and reduce costs

- Options for post-irradiation examination of BDF systems are being studied and are increasingly important for long-term, cost-efficient operation
- The Service Cell detailed design will not be tendered with the main building works.
- Separating its procurement from the civil engineering schedule keeps open the possibility of installing a Service Cell later and reduce risks at this stage
- Safety and services provisions in the target complex building remain compatible with a future Service Cell
- The existing consultant design is used only as a reference for defining infrastructure needs, with staged installation where feasible
- Handling CERN legacy waste is an additional strong driver for a future Service Cell on the Prevessin site

Concluding remarks and next steps 1/2

- The Service Cell concept was developed in the HI-ECN3 context to support the BDF target, the Magnetized Hadron Stopper coil and proximity shielding waste packaging
- The preliminary design study clarified key processes, failure modes and recovery measures
- CERN legacy waste requirements were integrated into the design
- The study provided an essential step in understanding global implications
- The assessment of implementation options showed that the Service Cell structure can be decoupled from the main building
- **But resulting projected costs are more than expected values**
- A full revision of requirements is therefore needed, including:
  - Acceptance criteria for final disposal and road transport
  - Needs for PIE and the potential for equipment repair to reduce operational costs

Concluding remarks and next steps 2/2

- **A decision has been taken to decouple the service cell from the building tendering**
- Space is reserved in the service building for future infrastructure to prepare BDF target systems for final disposal, based on the preliminary design study.
- The design of this waste packaging infrastructure requires further development
- A mitigation plan for target disposal is being defined, using underground target-area space to store spent targets temporarily and then insert the target in an–hoc disposal container
- A staged approach is proposed for developing the waste packaging infrastructure, synergy with CERN's long-term radioactive waste management strategy
- **Target PIE inspection capabilities will not be available at the start of the facility**

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