ISOLDE-EPIC workshop

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ISOLDE beam dumps replacement: status and perspectives

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CERN | EN ENGINEERING DEPARTMENT

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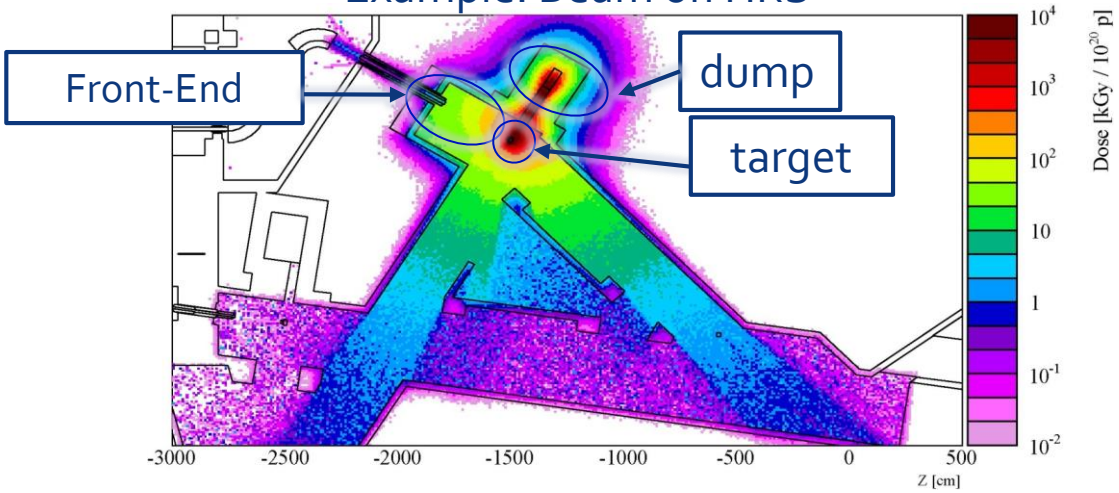
Introduction

- ISOLDE target area and beam dumps (BD)
- Historical notes on the ISOLDE BD
- Motivations to exchange beam dumps
- Beam dump designs
- Pre-study actions plans and perspectives
- Conclusions

Consideration about ISOLDE target areas

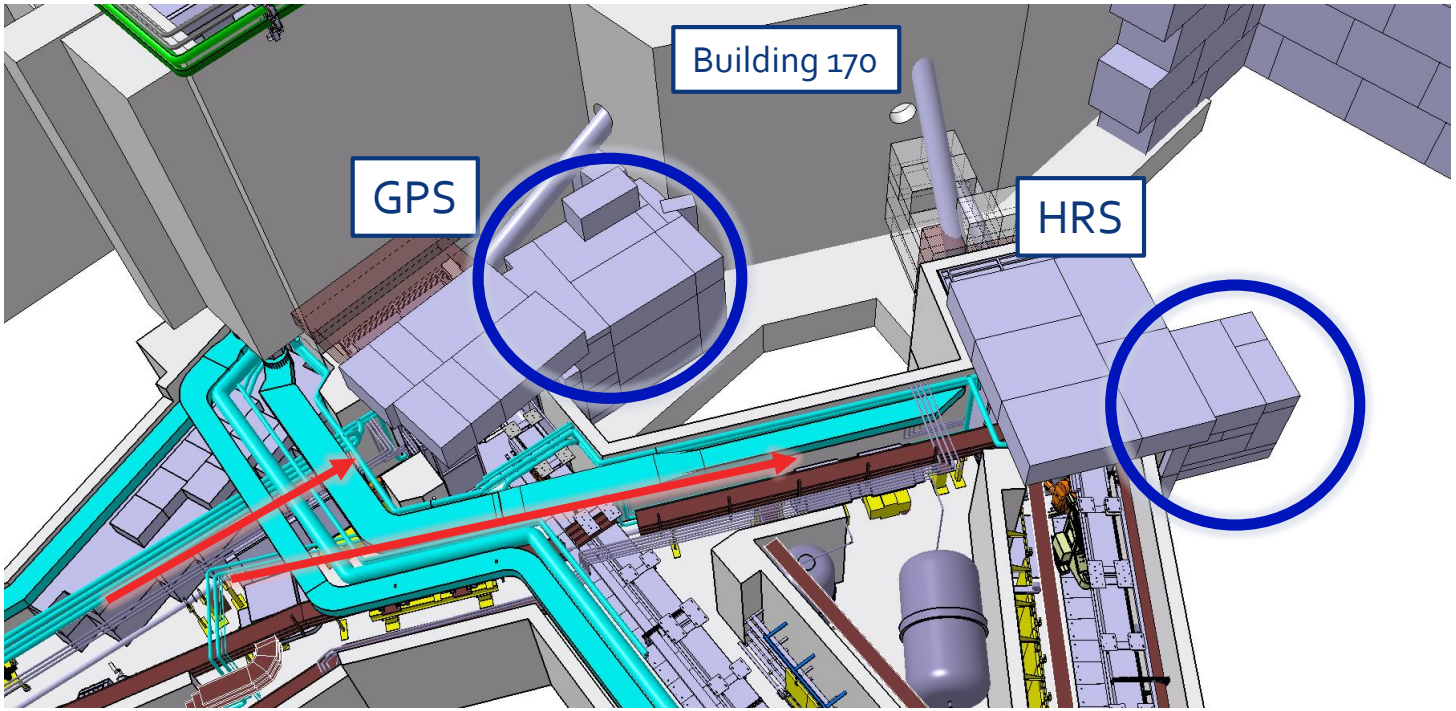
- Beam (and secondary particles) not interacting in the target (~70-85%) are intercepted in the dumps (GPS or HRS)
- Front Ends (target stations) are also exposed to high radiation levels limiting their lifetime (replaced **after ~5 years with beam**)
- Targets are replaced **several times** during the year
- **Dumps (GPS and HRS) have never been replaced (1992)**

Example: Beam on HRS



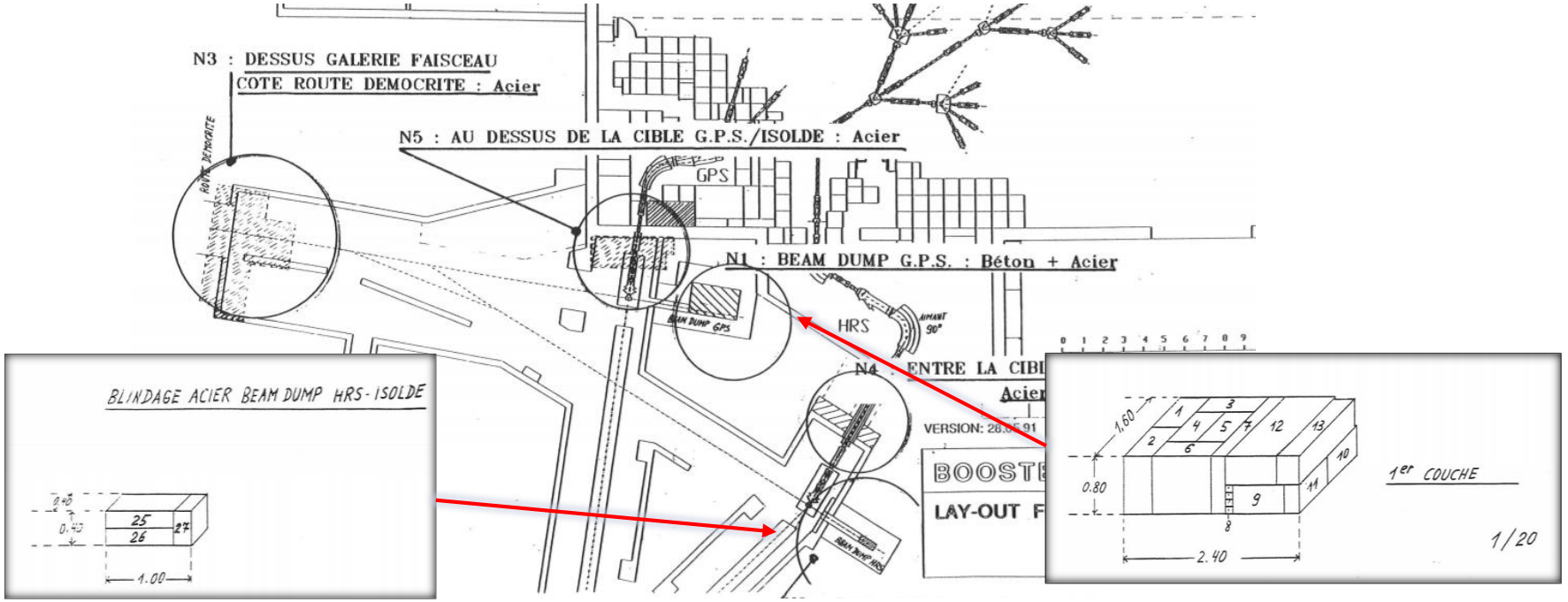
Historic notes about ISOLDE BD

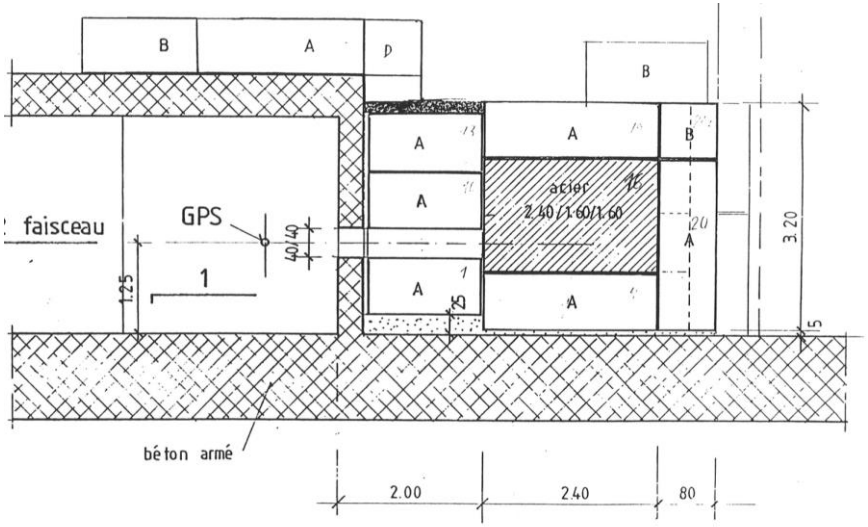
- Current ISOLDE configuration dates to 1991-1992 (ISOLDE 4)
- Beam dumps were designed for a proton beam of 1 GeV and lower (?) intensity

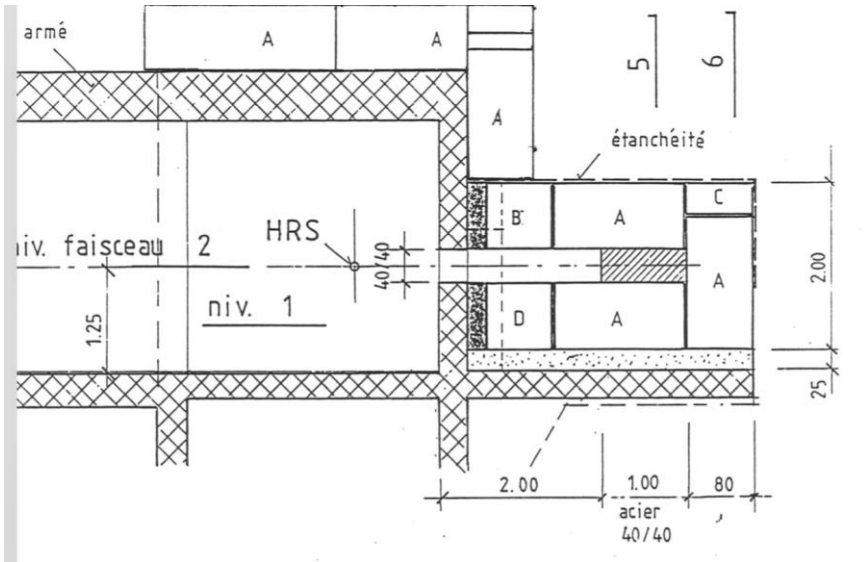


Historic notes about ISOLDE BD

- ISOLDE target area was covered with earth to serve as shielding
- Structures made of (already quite) radioactive blocks were used as complementary shielding (5 assemblies) in critical areas
  - Max dose rate max ~1 mSv/h at contact, >1 kBq/g specific activity…

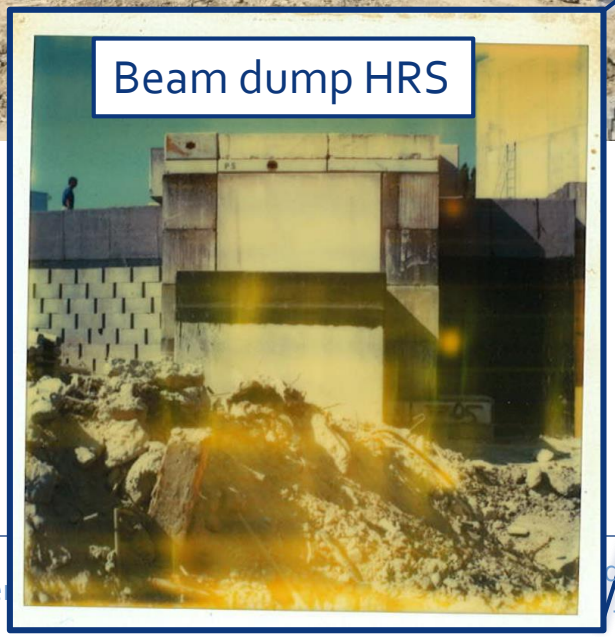




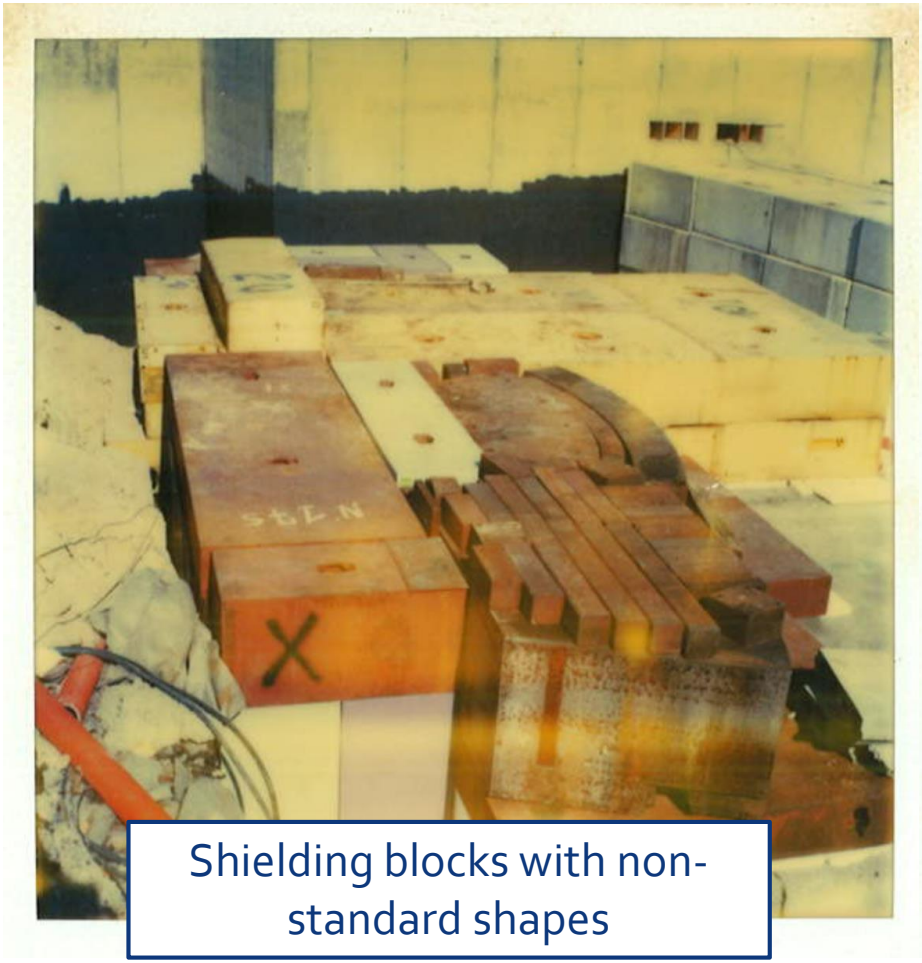


- Dump material not clearly defined → **carbon steel A36 (S275)**
- Dimensions (WxHxL) [m]:
  - HRS: 0.4 x 0.4 x 1
  - GPS: 1.6 x 1.6 x 2.4
- Shielding: **concrete** blocks
- **Not actively cooled,** relying on cooling via conduction on external blocks
- State of contact shielding/dump: unknown

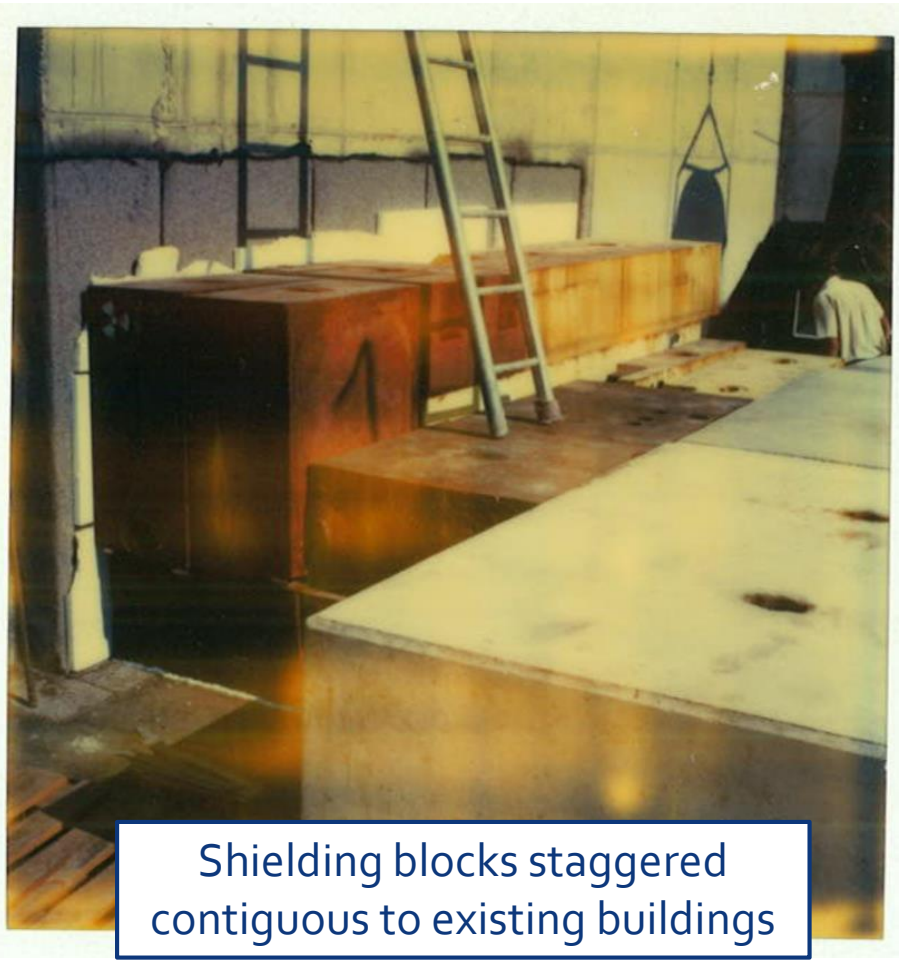
Historic notes about ISOLDE BD



Historical pictures of target area shielding

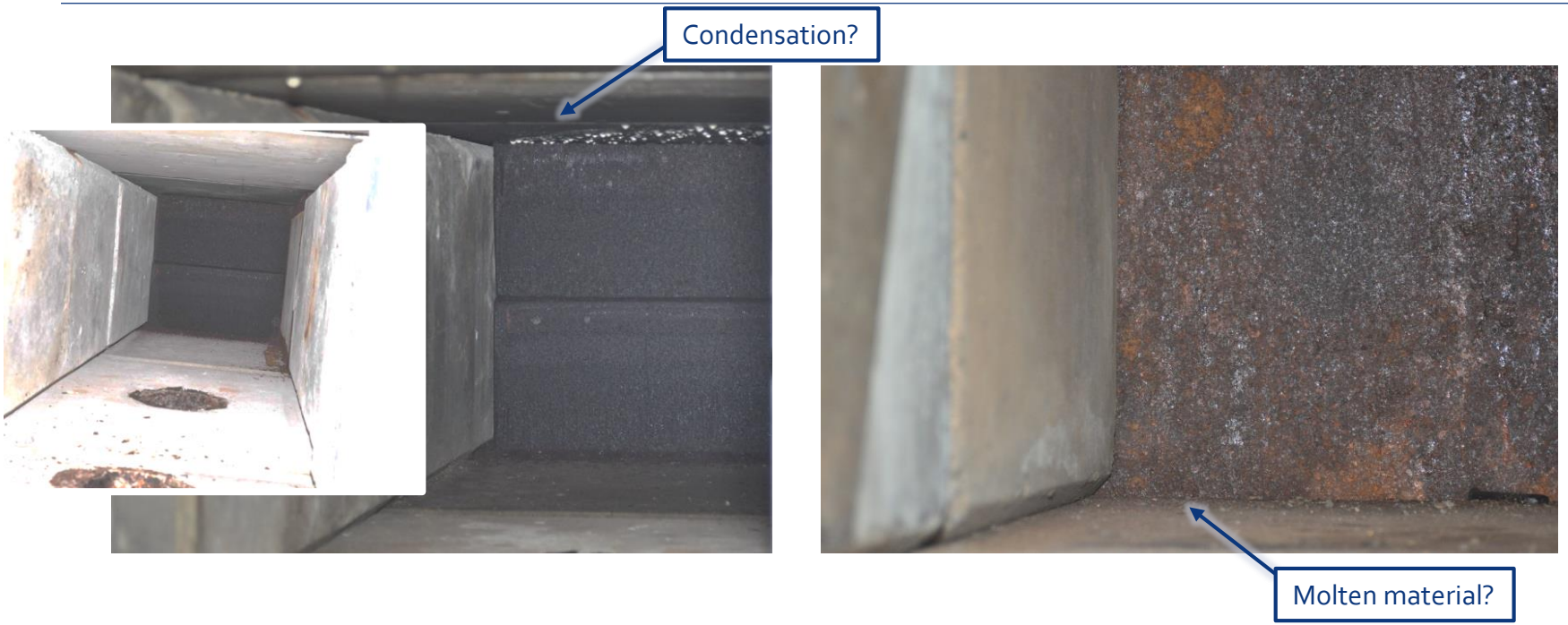


Shielding blocks with non-standard shapes



Shielding blocks staggered contiguous to existing buildings

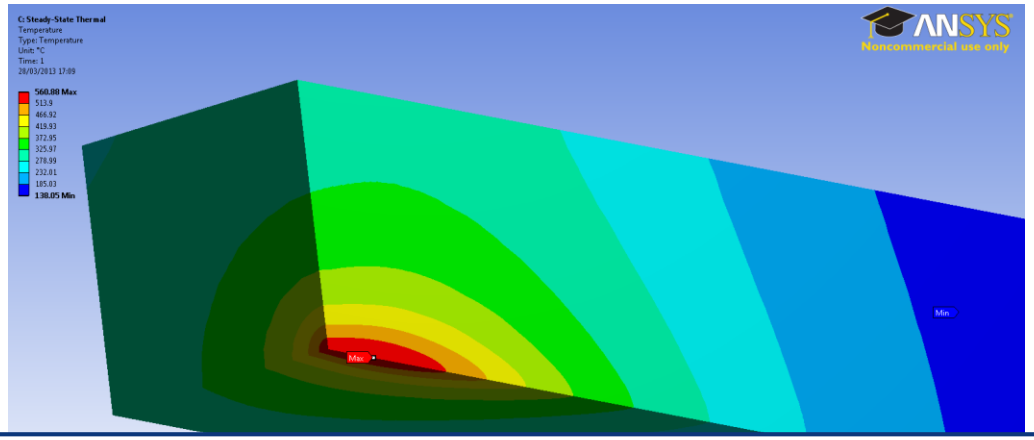
Motivations to exchange beam dumps (I/III)

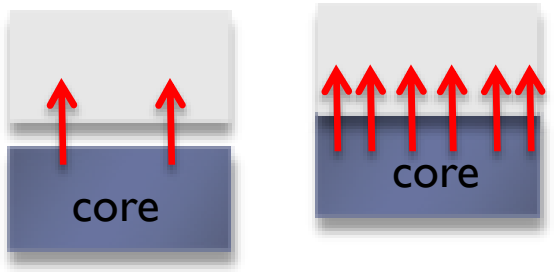


- Signs of corrosion and condensation on the visible face (accessible from target area)
  - Dump material not up to date with best practices in the field
- Unknown condition (neither access nor monitoring)

Motivations to exchange beam dumps (II/III)

- Current max beam 1.4 GeV/c at 2.5 μA is **3.5 kW (2.5-3 kW on dump)**
- Large uncertainty on the heat conduction coefficient between core and shielding assembly due to geometric and construction





560 °C steady state for HRS assuming ~3-5 W/m²K HTC

- Coupled FLUKA/thermo-mechanical analyses (EDMS 1277863, 1308217) are showing that the **dumps already operate at their limit in terms of temperature and mechanical stresses** → dangerous to go higher

Motivations to exchange beam dumps (III/III)

Radiation protection optimization

- Radiation measurements in accessible areas have shown the **need for shielding improvements around the target areas and beam dumps** (EDMS 1142606)
  - Exclusion area implemented (fence) but due to **sky shine still a source of exposure for the reference group** (proximity)
  - The **soil is radioactive around the beam dumps shielding** (samples were taken in 2013 before civil engineering work for MEDICIS)
- Beam dump integration could be further optimized to **limit air activation** and dose to equipment (back-scattering) and **lower personnel exposure** during interventions

Summary of BD exchange motivations

- **Advantages**
  - Allow for higher beam power for ISOLDE
  - Adapt beam dump to evolving needs
  - Take advantage to improve shielding around the facility
  - Reduction in air activation through new design
  - Reduction of environmental impact
- **Disadvantages**
  - Removal, storage and replacement of ~3500m^3 of earth, ~50% of which is activated - but this can be minimized by ad-hoc techniques
  - Handling and storage of radioactive beam dump(s) & blocks

Beam parameters

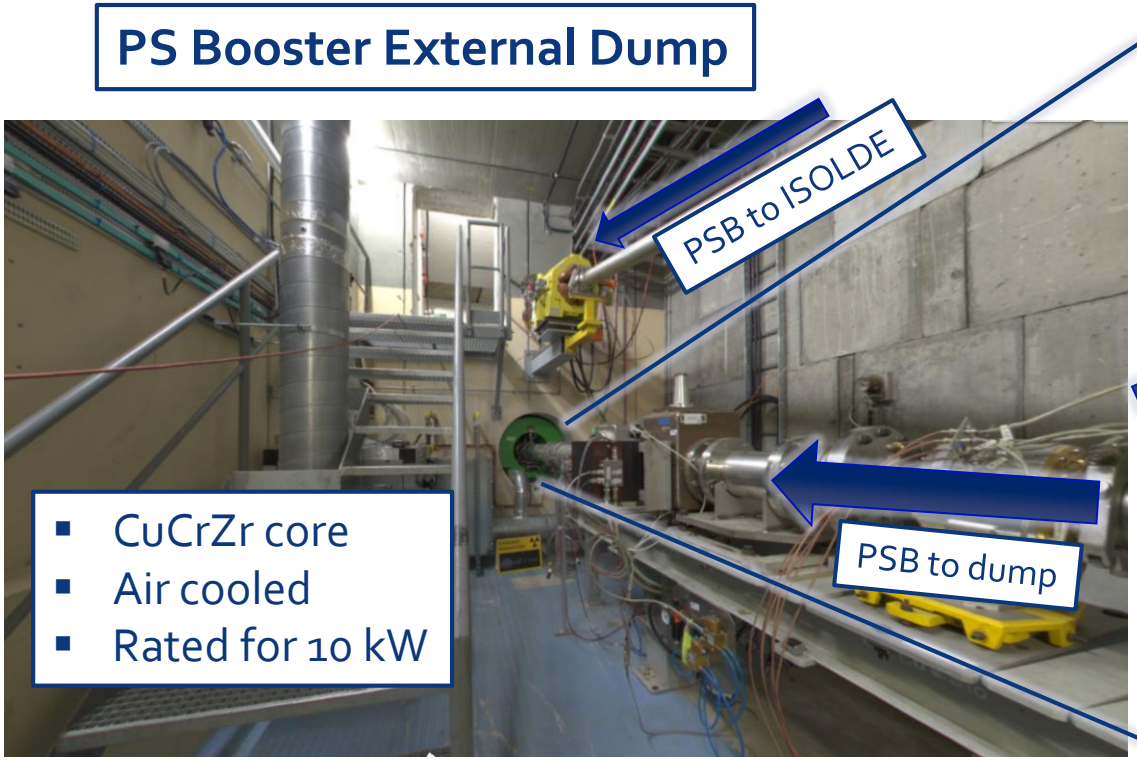
- Current max beam parameters (1.4 GeV/c, 2.5 μA) would yield **~3.5 kW beam power and 2.5-3.0 kW power on the dump**
- PS Booster external dump beam specifications (EDMS 1229493) indicated a maximum intensity of $8*10^{13}$ p/pulse every 1.2 seconds, equivalent to ~10.7 μA
- Considering 2.0 GeV/c operation, this would give a **theoretical** max of **~20 kW beam power, i.e. 15-18 kW on dump**

Current dumps are clearly not ready to cope with this potential **6x power** increase (melting, structural damage, environmental impact)

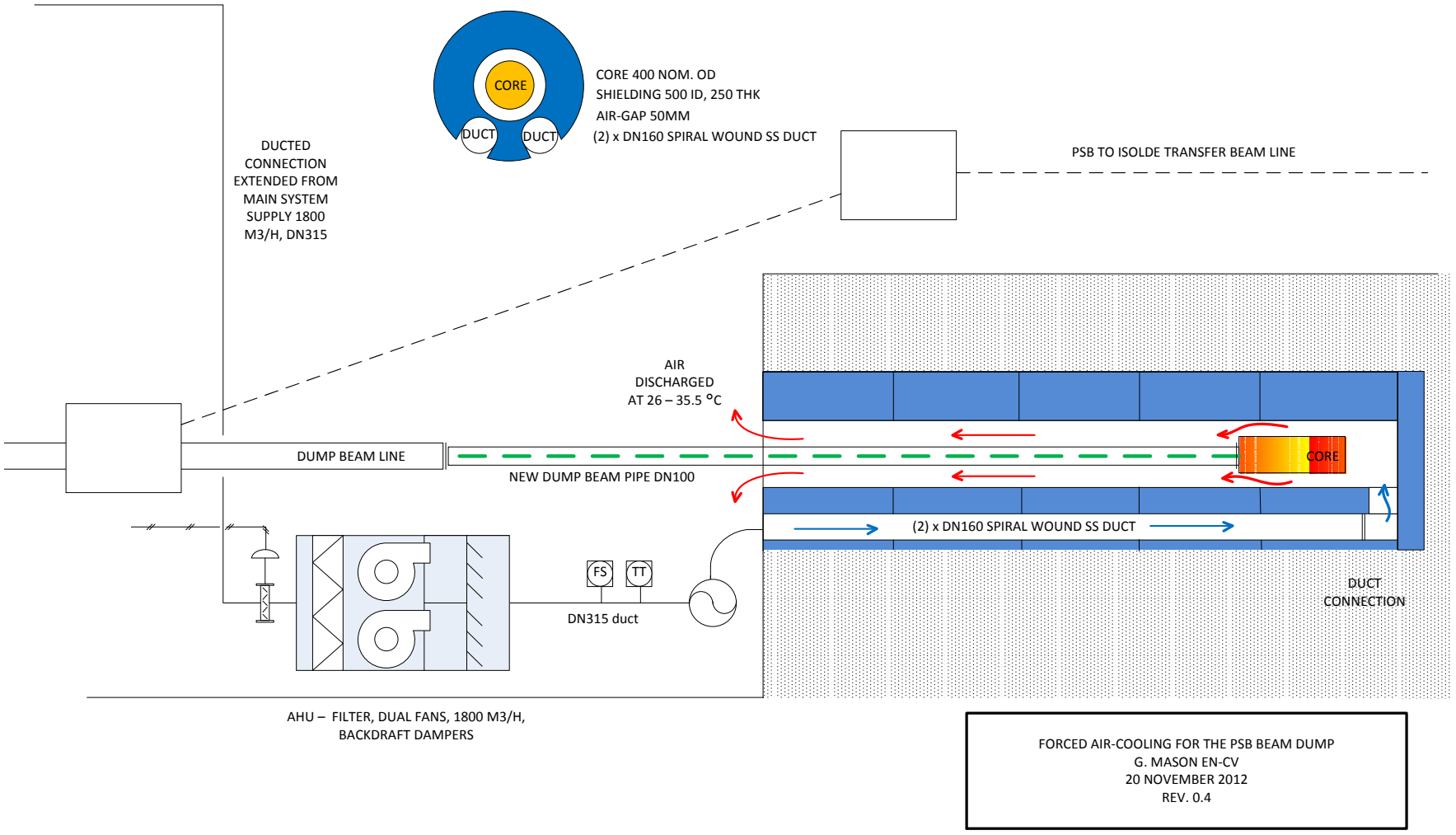
Potential beam dump designs (I/IV)

- CERN has large experience in building high intensity target and beam dumps and **O(20 kW) power can be managed with devices built for the LHC Injector Upgrade (LIU) Project**

PS Booster External Dump

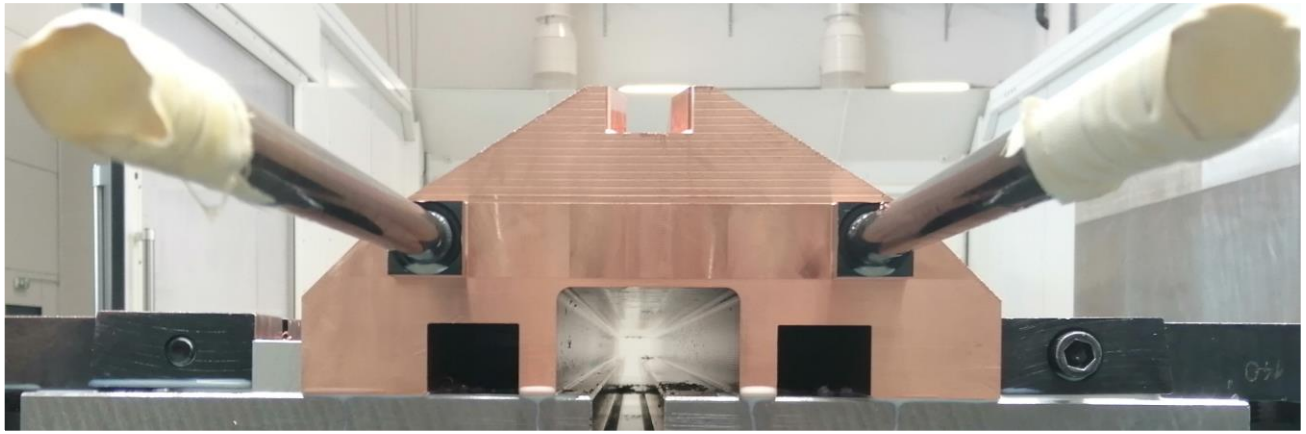


Potential beam dump designs (II/IV)



Potential beam dump designs (III/IV)

LIU-SPS Internal Beam Dump (TIDVG5)



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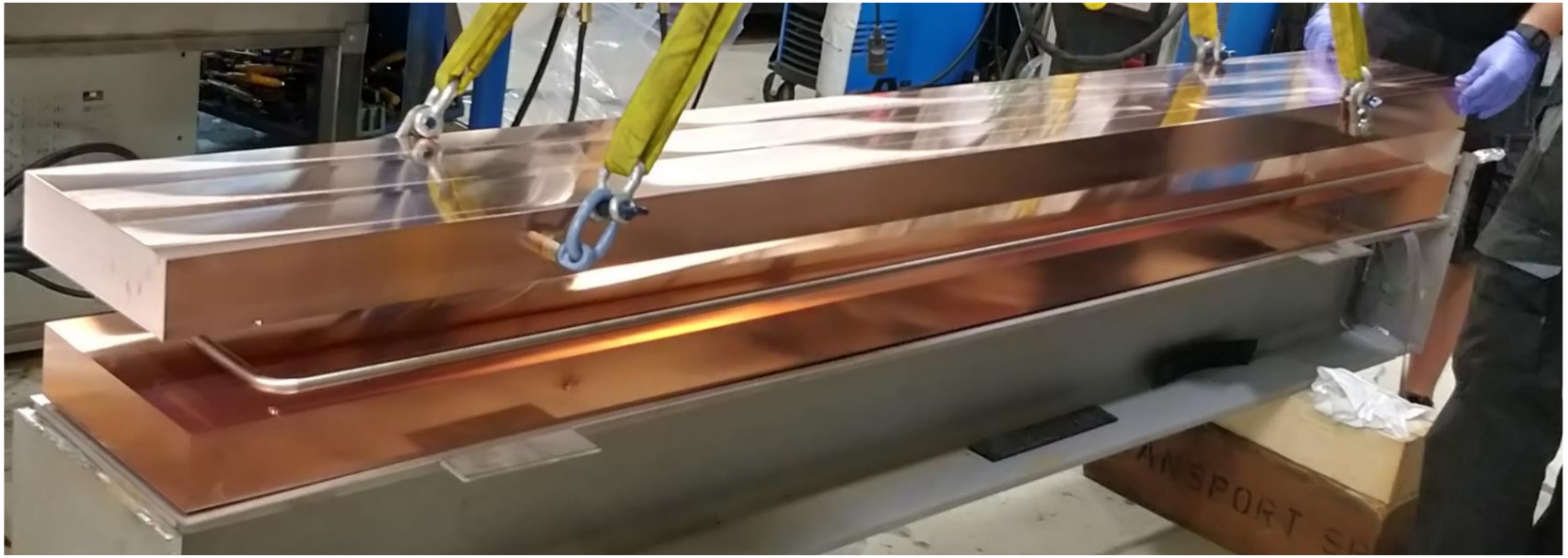

Potential beam dump designs (IV/IV)

Brainstorming ideas

- **CuCrZr cores**
  - to have good thermal conductivity and strength
- **Water cooled with HIPed tubes**
  - to efficiently extract heat from the core
- **Stainless steel cooling tubes** seamless until easily accessible areas
  - for high reliability and maintainability
- **Dump monitoring** (thermocouples (core) or Pt100)
- **Collimator(s)** located in the upstream direction in order to reduce backscattered neutrons
- **Remote exchange possibility** for operational flexibility as well as for easier dismantling in the (long-term) future
- Optimization for **radiation protection** point of view

Pre-study for beam dump exchange

- Budget requested (and approved) to perform a **feasibility study for the dump removal and a design proposal with two new dumps** meeting operational needs and modern radiation protection standards
- Activity to span over the **2020-2023 period**
  - Redaction of a **Project Implementation Plan during 2023**
  - **Definition of precise budget estimate required to carry out the Project**
- **Input from ISOLDE physics community essential!**

Dump exchange can be executed **only** during a Long Shutdown → **LS3**

Challenges and actions

1) Identification of the **best way of accessing the dump** is the priority (from the top - fully vertical handling – or from the side hill)
2) Management of **radioactive soil and radioactive blocks** identified also as significant constraint
3) Design of an **extremely robust and reliable dump(s)**, with no maintenance needs in the forbidden area close to the target area
4) Definition of **beam parameters** (intensity & optics)

Will start the study in 2020 with a few stakeholders (EN-STI, SMB, HSE-RP, EN-HE, BE-OP) and include other groups concerned later when designing the new system (EN-CV, EN-EL…)

Conclusions

- Current ISOLDE beam dumps are not capable of withstanding neither current (3.5 kW) and certainly not higher intensities (~20 kW)
- Dump designs capable of withstanding 20kW+ power are technically feasible (and proven)
- However, BD exchange is a complex endeavour
- Pre-study approved by ACC-CONS for 2020-2023, aiming at redacting a Project Implementation Plan with a detailed cost estimate by 2023, aiming at execution – if Project is approved – during LS3