Beam Dump Facility

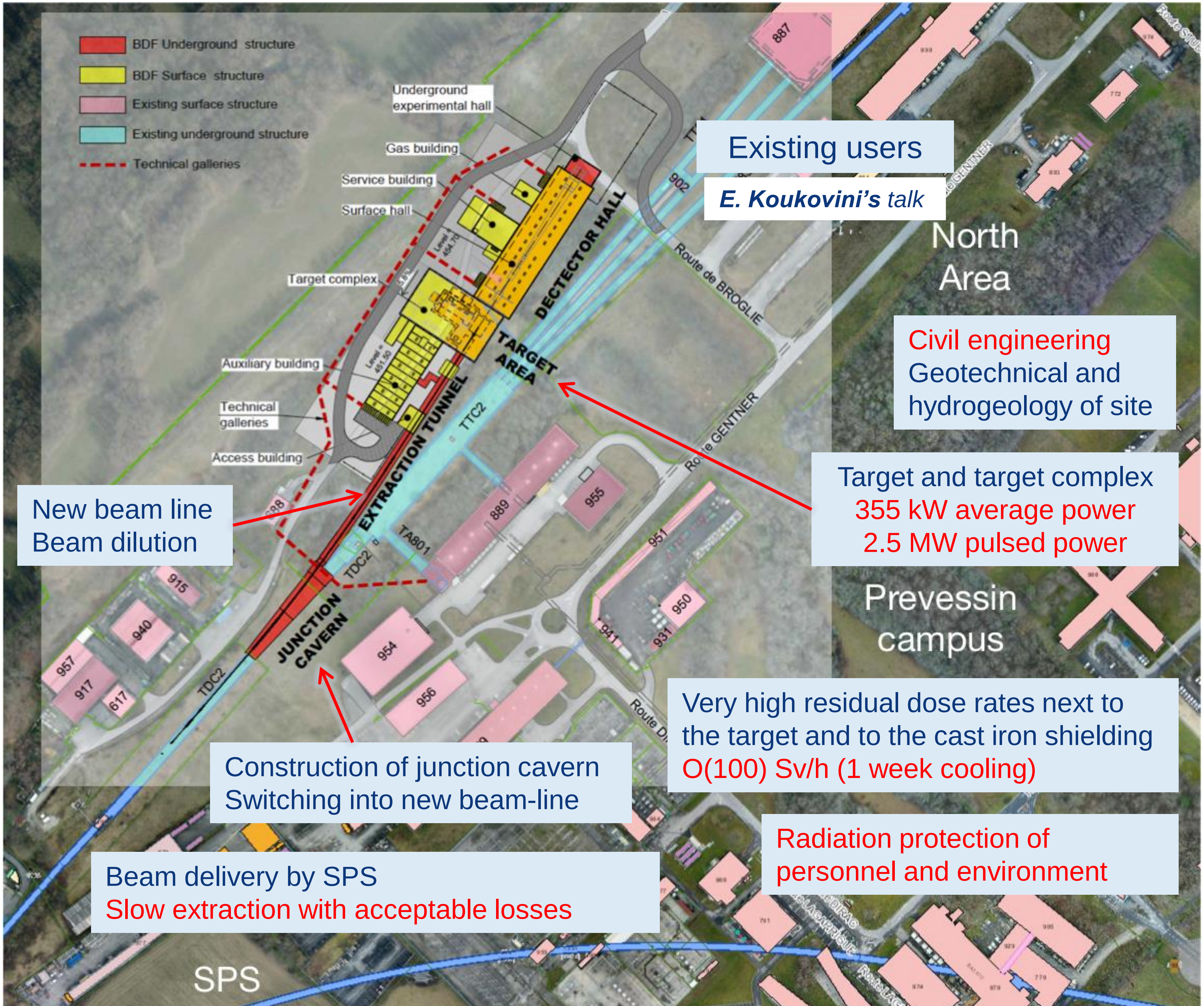
Edmundo Lopez Sola, Marco Calviani, Brennan Goddard, Richard Jacobsson, Mike Lamont

On behalf of the extended BDF team

Beam Dump Facility

BDF is a **planned high intensity fixed target facility** in the North Area of the SPS for beam dump experiments

- High intensity proton beam: **$4{\cdot}10^{13}$ p^+/pulse, $4{\cdot}10^{19}$ POT/year**, **355 kW** average beam power
- Slow extraction (~1 sec. flat top)
- O(400 GeV) optimal beam momentum
- Dense target/dump to **maximize production** and stop π and K before decay into $\mu+\nu$
- Minimal impact on running the North Area program

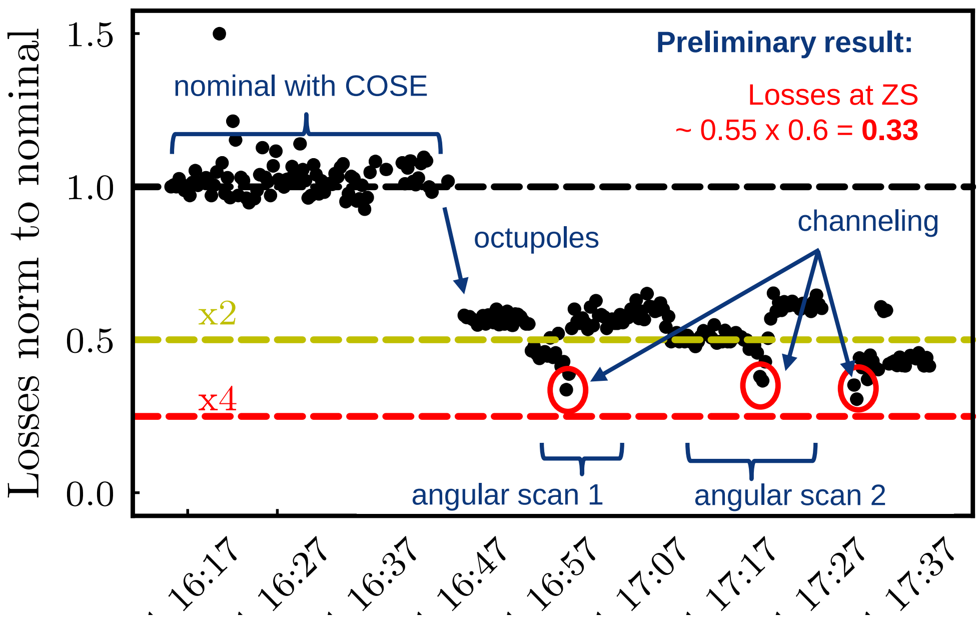

BDF Underground structure
BDF Surface structure
Existing surface structure
Existing underground structure
Technical galleries
Underground experimental hall
Gas building
Service building
Surface hall
Target complex
Auxiliary building
Technical galleries
Access building
DECTECTOR HALL
TARGET AREA
EXTRACTION TUNNEL
JUNCTION CAVERN
TTC2
TDC2
TA801
Route de BROGLIE
Route GENTNER
Existing users
E. Koukovini's talk
North Area
Civil engineering
Geotechnical and hydrogeology of site
Target and target complex
355 kW average power
2.5 MW pulsed power
Prevessin campus
New beam line
Beam dilution
Very high residual dose rates next to the target and to the cast iron shielding
O(100) Sv/h (1 week cooling)
Construction of junction cavern
Switching into new beam-line
Radiation protection of personnel and environment
Beam delivery by SPS
Slow extraction with acceptable losses
SPS

BDF work packages and working groups

- **Extraction and beam transfer** (Brennan Goddard)
  - SPS Losses and Activation WG (Matthew Fraser)
  - SPS Crystal-Assisted Slow Extraction WG (Matthew Fraser)
  - TT20 for BDF WG: splitters & transfer line design (Christoph Hessler)
- **Target and target complex** (Marco Calviani, Edmundo Lopez)
  - BDF target & target complex WG
- **Radiation protection** (Claudia Ahdida, Heinz Vincke, Mirko Casolino)
- **Civil engineering** (John Osborne, Jonathan Gall)
- **Infrastructure & integration** (Liam Dougherty, Yvon Muttoni, Francisco Sanchez Galan, Pablo Santos Diaz)
  - Junction cavern, beam-line, target complex, detector hall
- **Safety engineering** (Simon Marsh)

Extraction and beam transfer

- Beam losses from slow extraction challenging for the PoT requested
- Key developments for reduction of extraction losses in the ZS septa
  - **Constant Optics Slow Extraction** (COSE) in use since mid-2018
  - **Phase-space folding** – octupole fields
  - **Silicon crystal channeling**
  - **Automated ZS alignment**

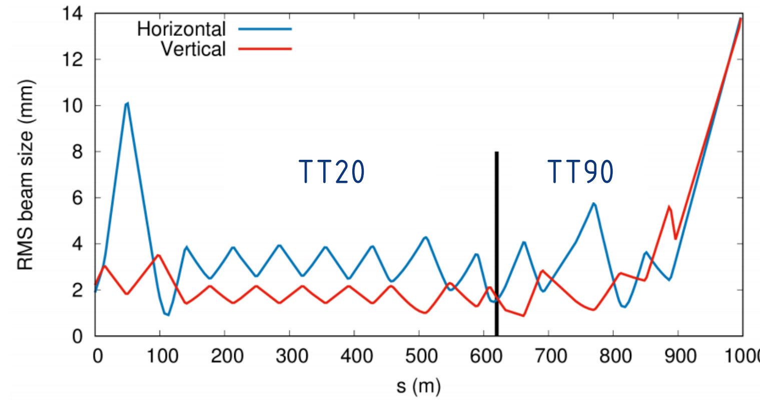


➢ Demonstrated factor of 3-4 loss reduction at ZS

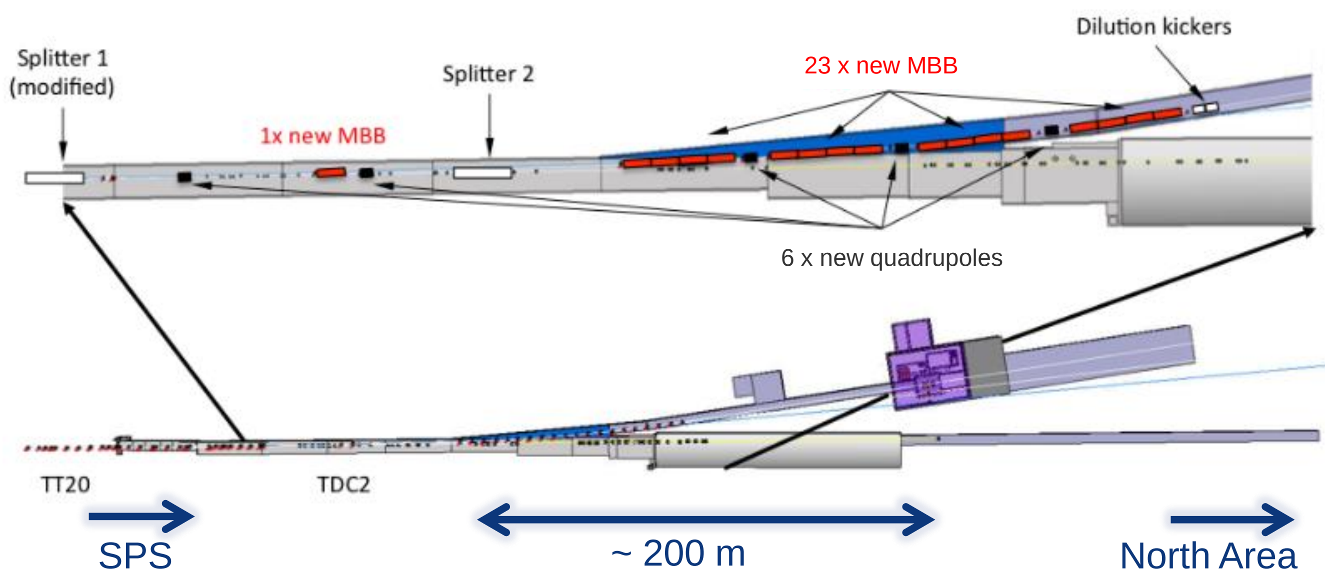
➢ Factor of 4 – 5 reduction to accommodate SHiP in BDF appears to be in reach

BDF beam line

- Beamline optics and design finalised
- Error studies completed, sub-system performance specifications updated
- Optics tested in MDs



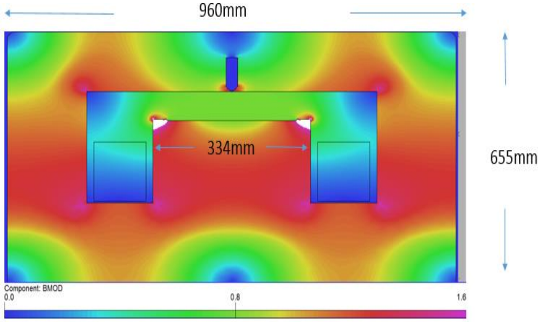
Beam size to target along TT20 and new TT90



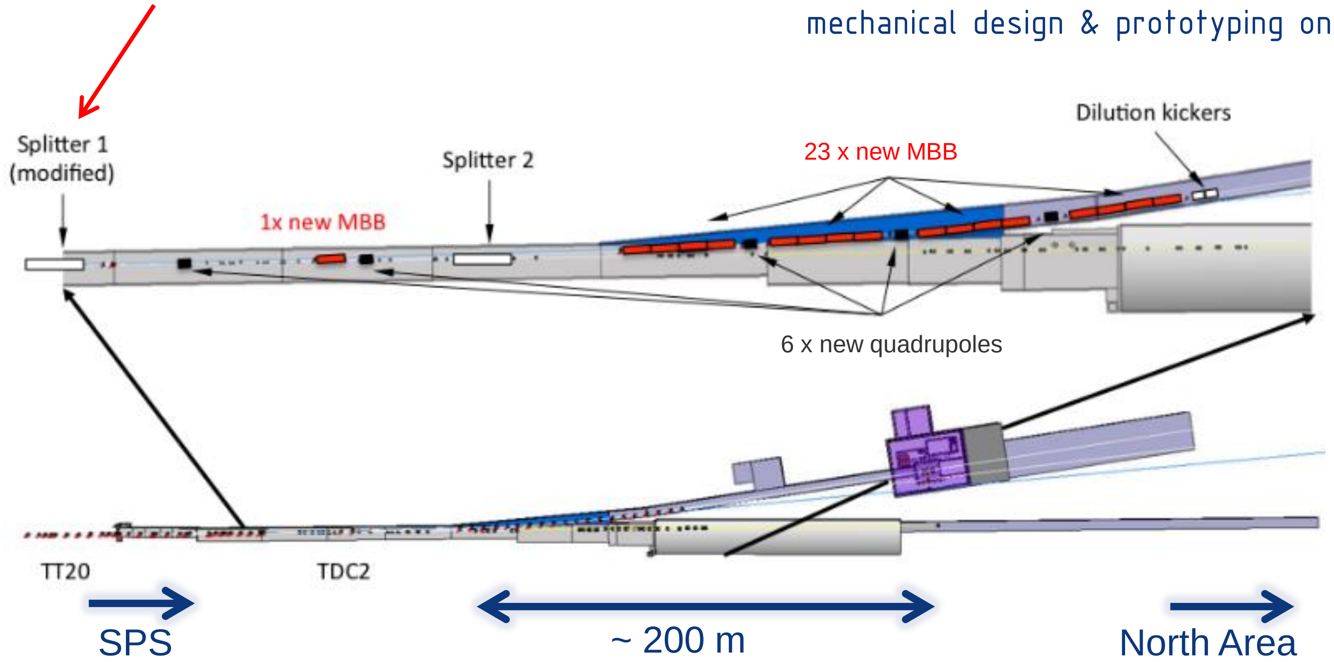
BDF beam line

- **New splitter magnet** → dual function:
  - Splitting the beam for NA targets (current operation)
  - Pulsing opposite field, deflection of entire beam to BDF
- Polarity switch requires **laminated** yokes

New MSSB splitter with reduced saturation



- Magnetic design of new splitter done, mechanical design & prototyping ongoing



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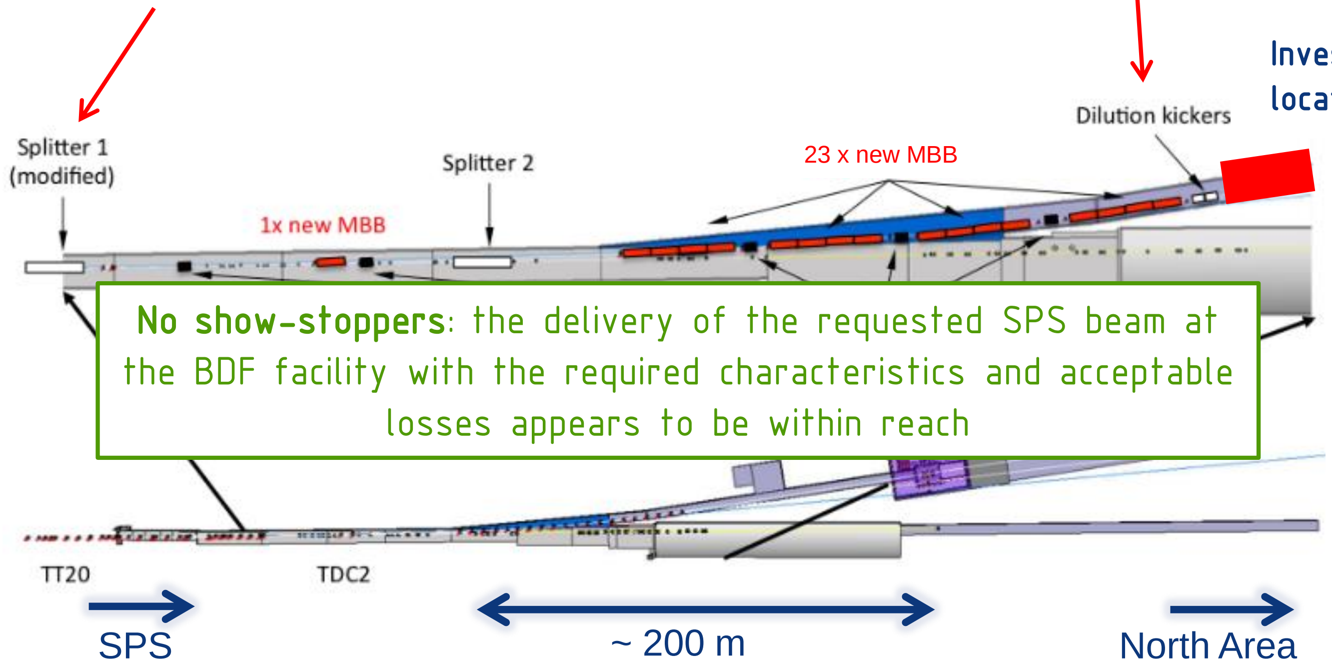
Beam dilution on target during the spill to reduce stress on target

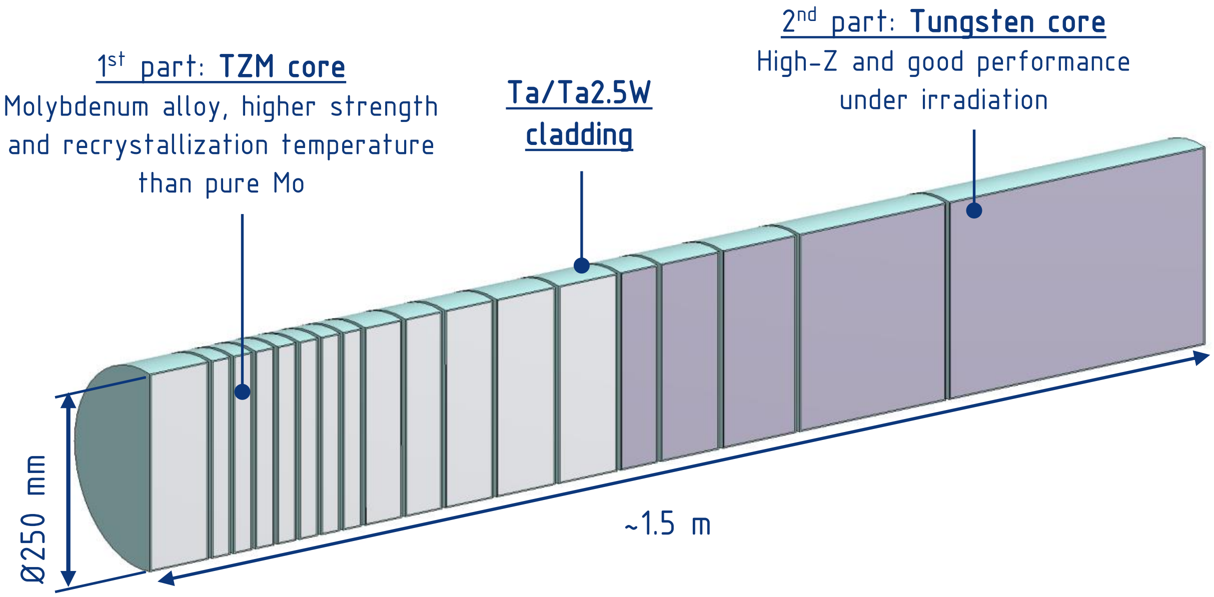
50 mm circular sweep at 4 Hz



No show-stoppers: the delivery of the requested SPS beam at the BDF facility with the required characteristics and acceptable losses appears to be within reach

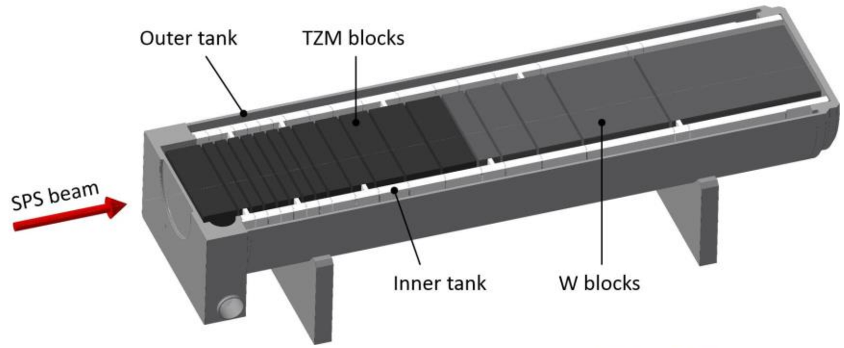
BDF target

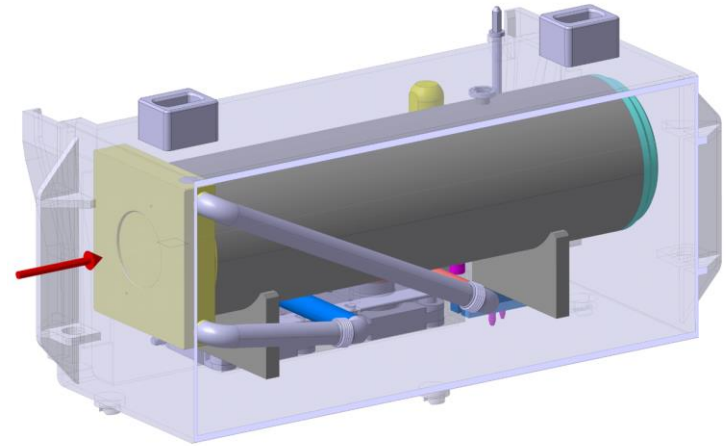
- High-Z and short nuclear interaction length
- Full absorption of SPS 400 GeV/c beam (12λ) → Target/dump
- Need to dissipate around **320 kW** of heating power (**~5 MW/m³**)
- Optimized segmentation, forced water cooling

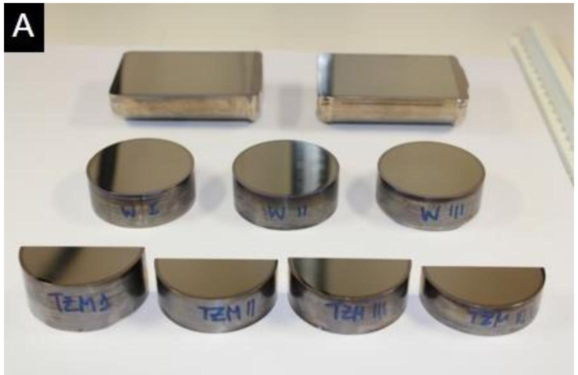


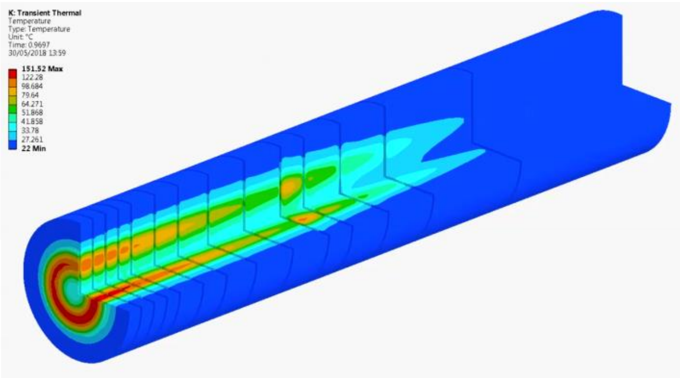
BDF target

- Target assembly design
- Complete thermo-mechanical calculations
- Extensive material R&D
  - Use of Ta2.5W + HIP – bonding







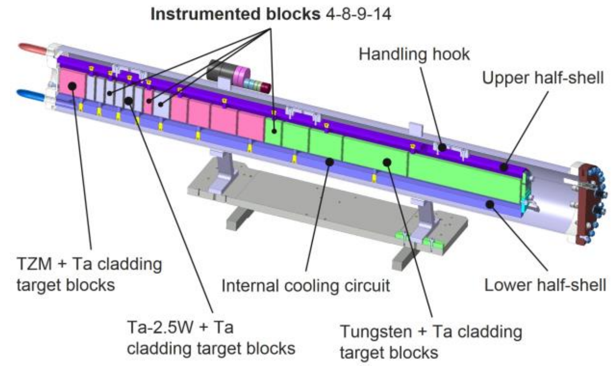


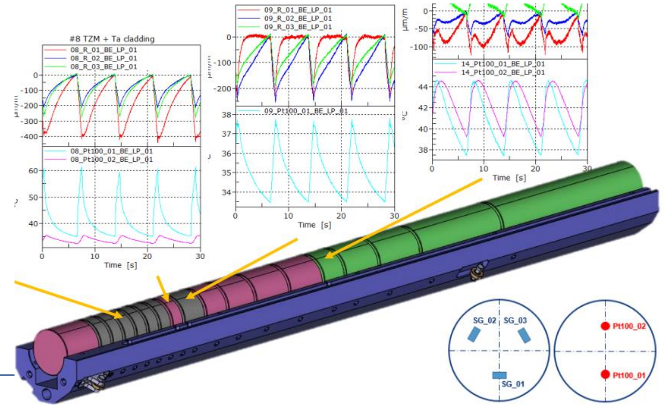
- Validation of the **technical feasibility and reliability of the BDF target**

BDF target prototype

- Reliability of the target is a critical aspect for the design of BDF
  - **Representative beam test suggested before LS2**
- **Reduced scale prototype**
  - Reduced diameter **(80 mm)**
  - TZM/W core, Ta/TaW cladding
- Experimental setup installed in **TCC2**, upstream T6 primary target
- **High intensity beam on target during >14 h (45 kW deposited ~6 MW/m³)**
  - Online measurements performed
  - Good correlation with simulations

Validation of the **future BDF target operational conditions**

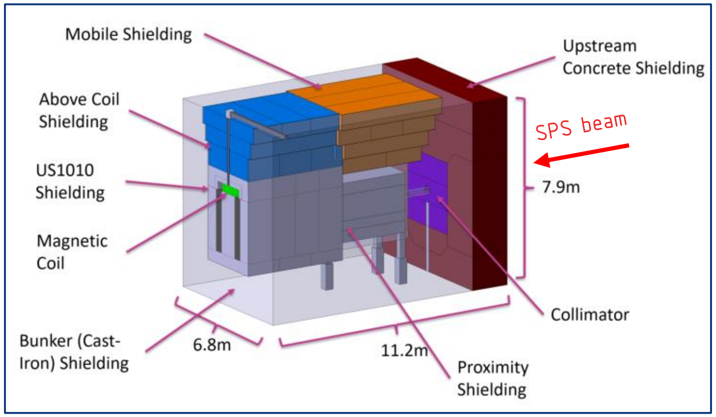




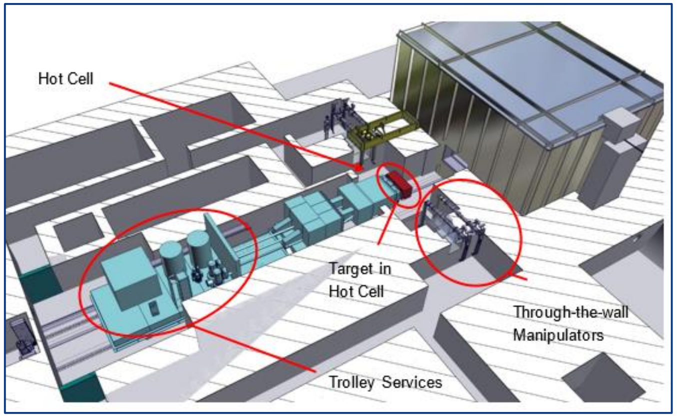
BDF target complex

- Target is located 15 m underground, relatively close to the CERN fence (~70 m)
- Cast-iron and steel shielding enclose production target (3700 tonnes)
- Target bunker inside an **active circulation He-vessel**
- Part of the hadron absorber is **magnetized** to act as initial muon filter
- **Fully remote handling/manipulation** during the lifetime of the facility

Crane handling concept
Shielding, supports, target, moved by crane

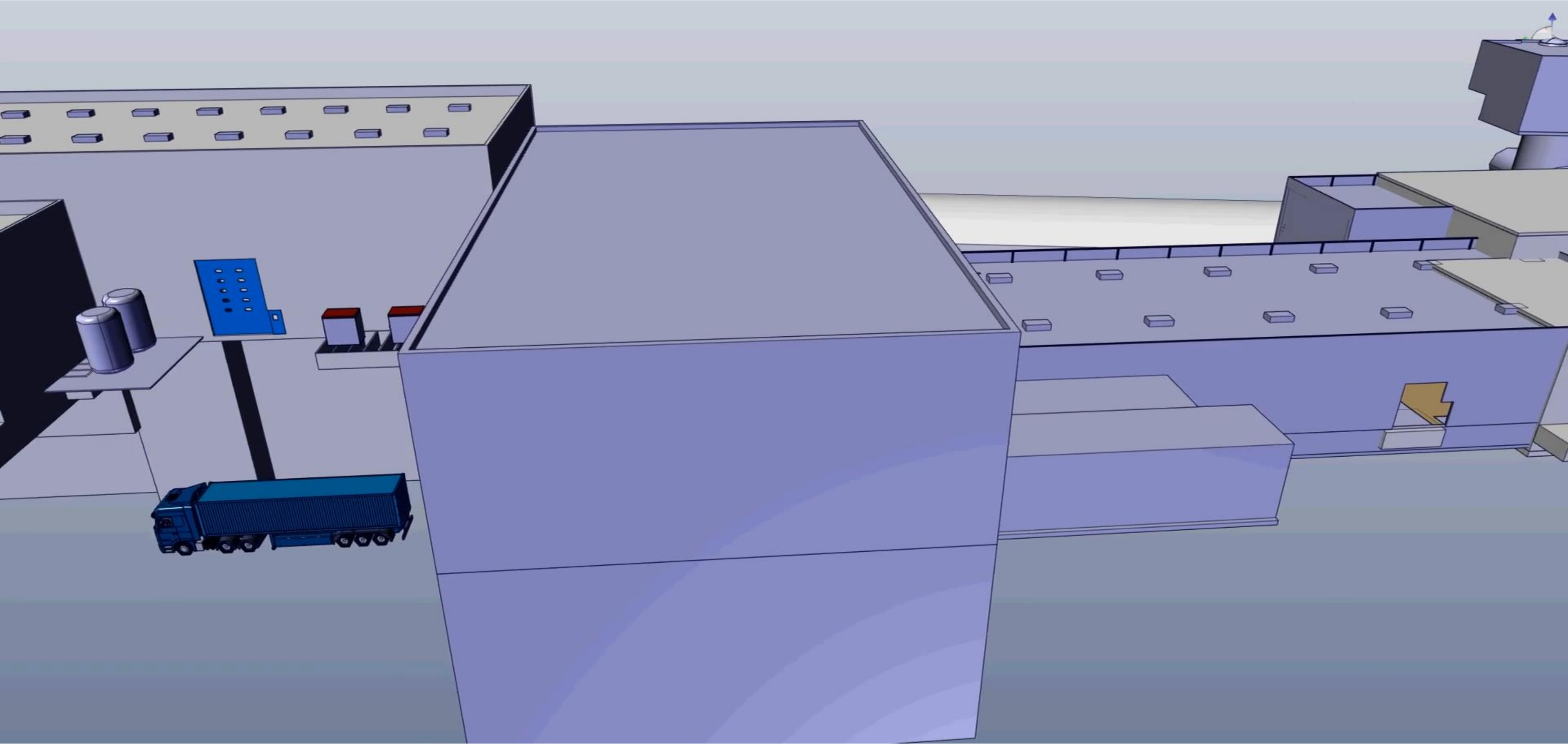


Trolley handling concept
Target and services on trolleys on rails

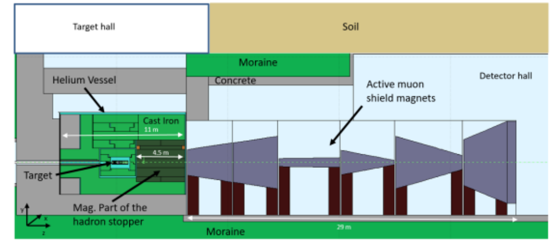


- Target complex design developed in detail → **demonstrated feasibility** of construction, operation, maintenance and decommissioning

BDF target complex

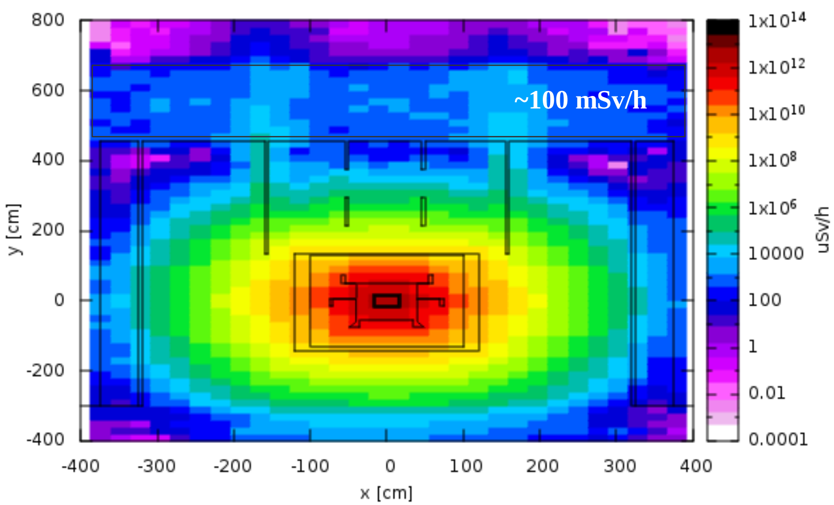


Radiation protection



- Detailed study of prompt and residual dose rates
- RP evaluation based on FLUKA Monte Carlo simulations
- Activation of air, helium and water + soil activation and radioactive waste
- BDF facility design optimized from RP perspective

Prompt dose rate for 4×10^{13} p / 7.2s



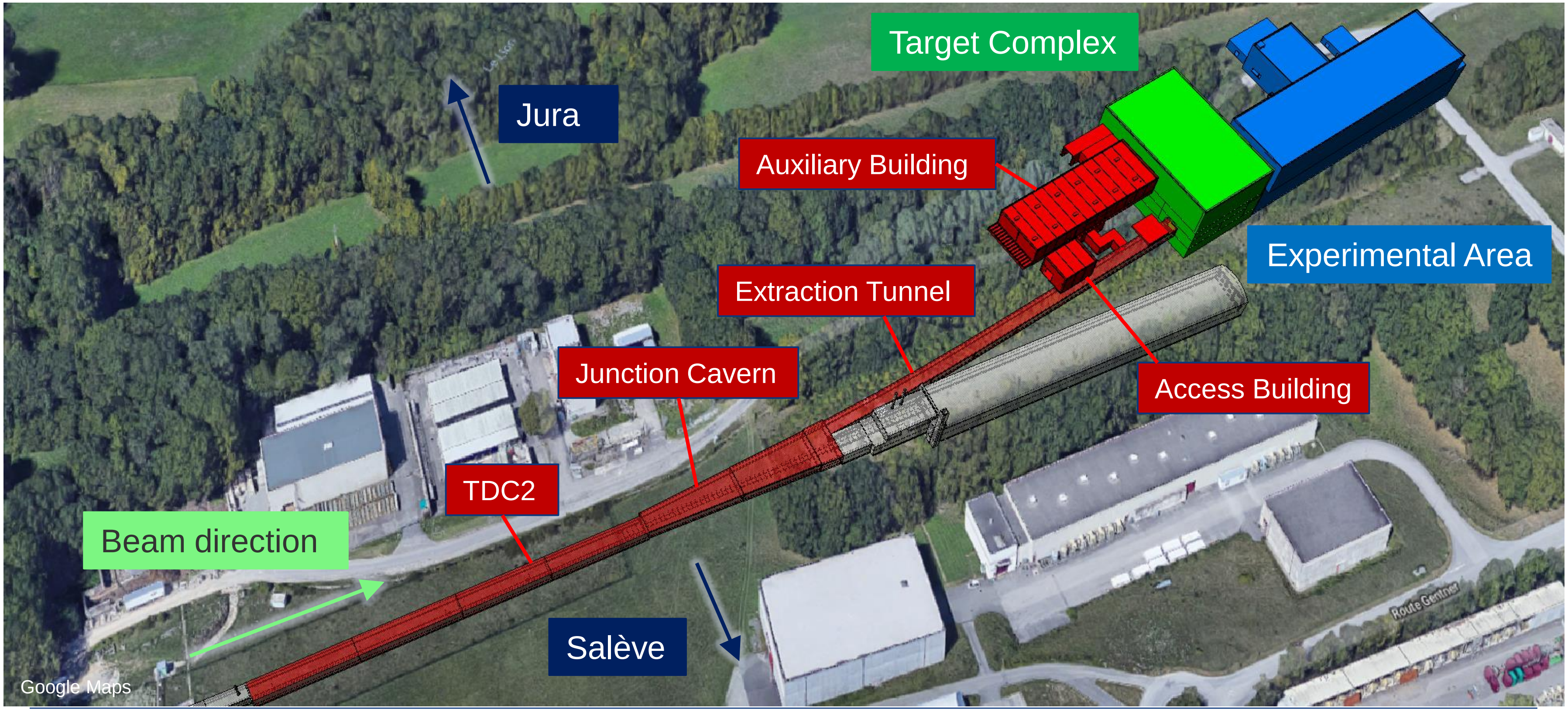
Prompt dose rates reach **~100 mSv/h** above He-vessel and drop down to **< 1 μSv/h** above top concrete shielding

→ Expected classification: **Supervised Radiation Area** (up to 2000h/year) **(< 3 μSv/h)** in the target hall

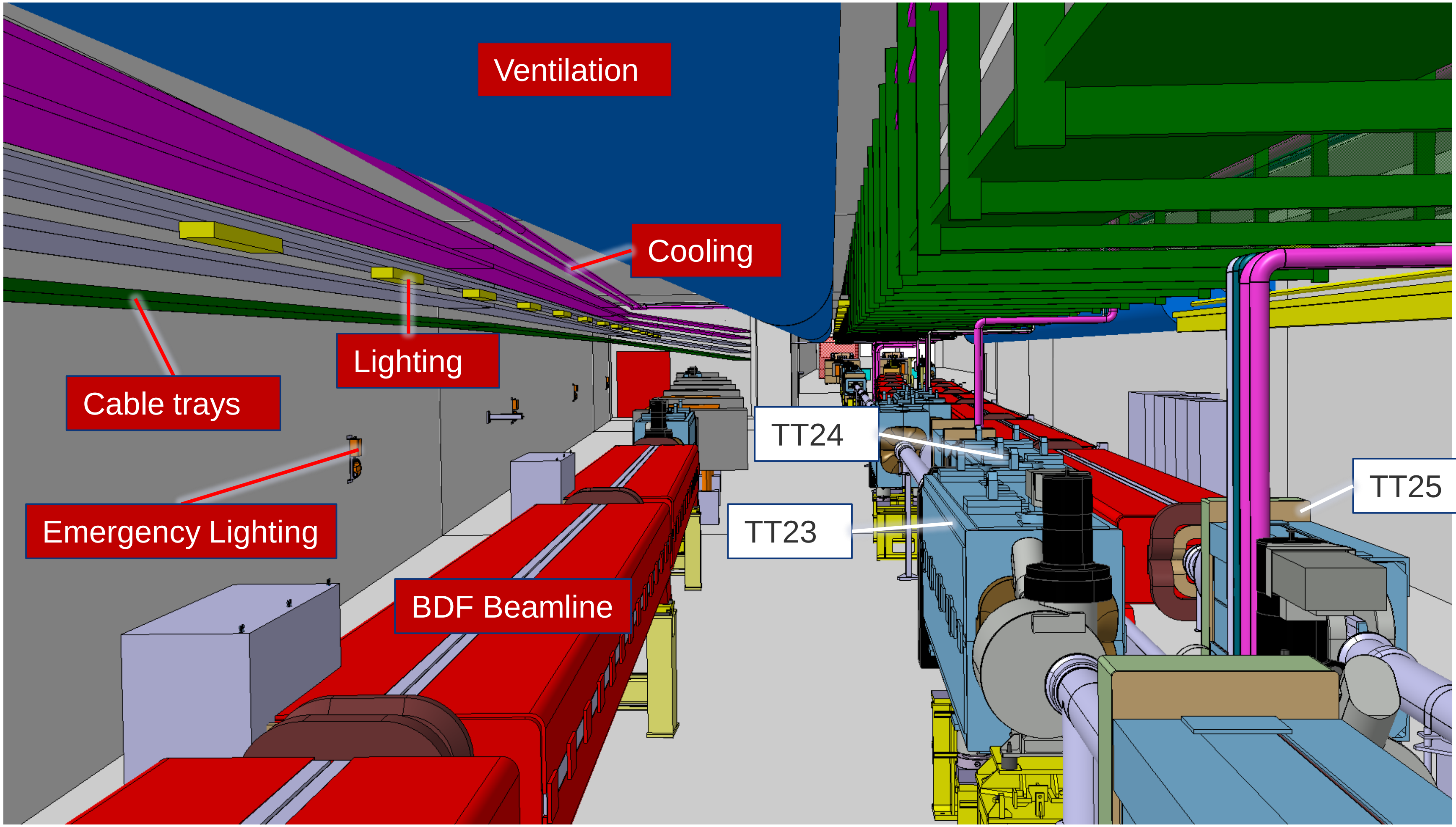
- **Preliminary RP evaluation showed the general feasibility of the project** in terms of exposure of persons to radiation and radiological impact

Integration

- **Integration from transfer line to experimental area**
- Locations of structures and services defined and optimized in terms of radiation protection, safety and accessibility.

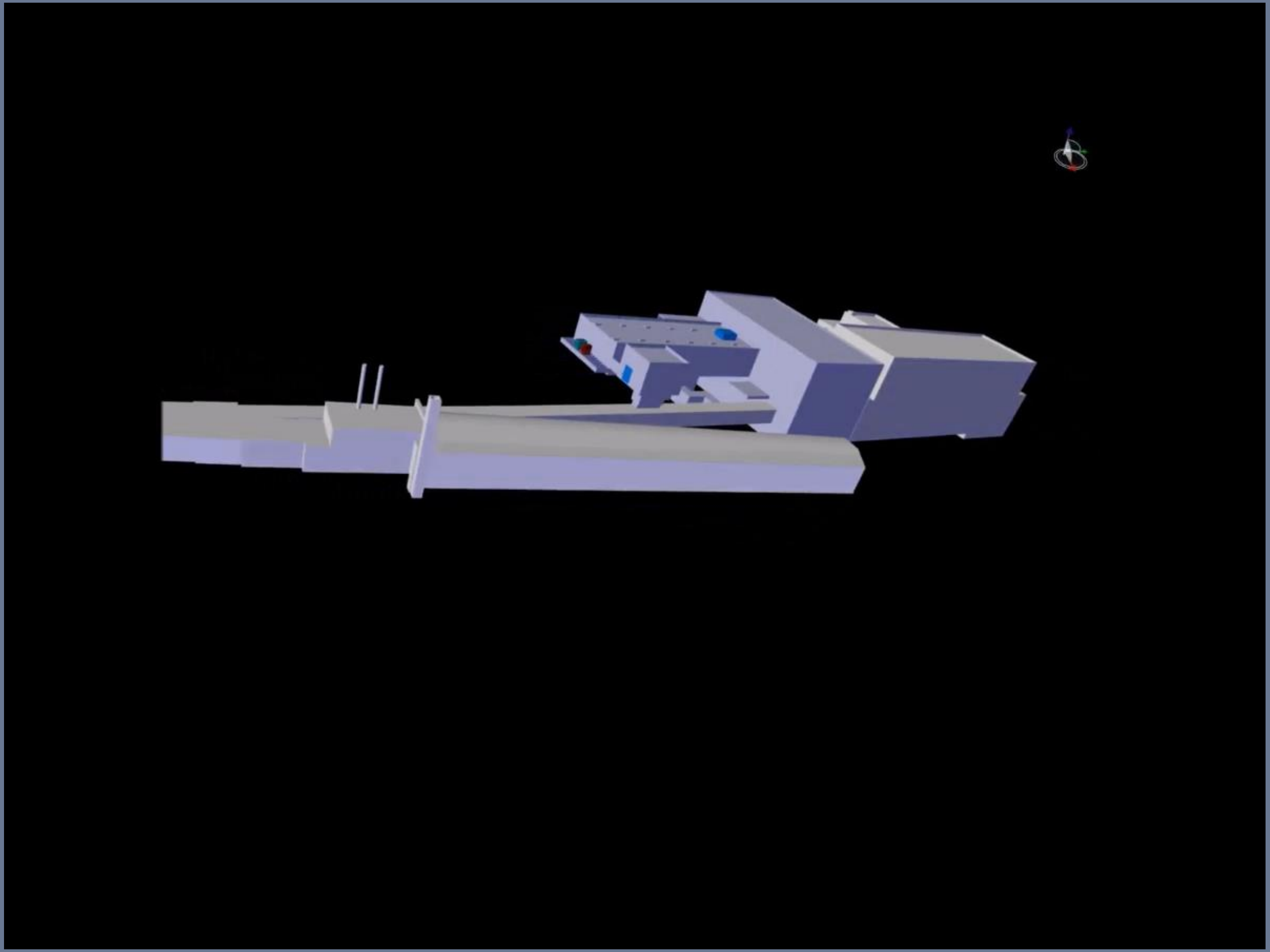


Integration – Junction Cavern



Liam Dougherty

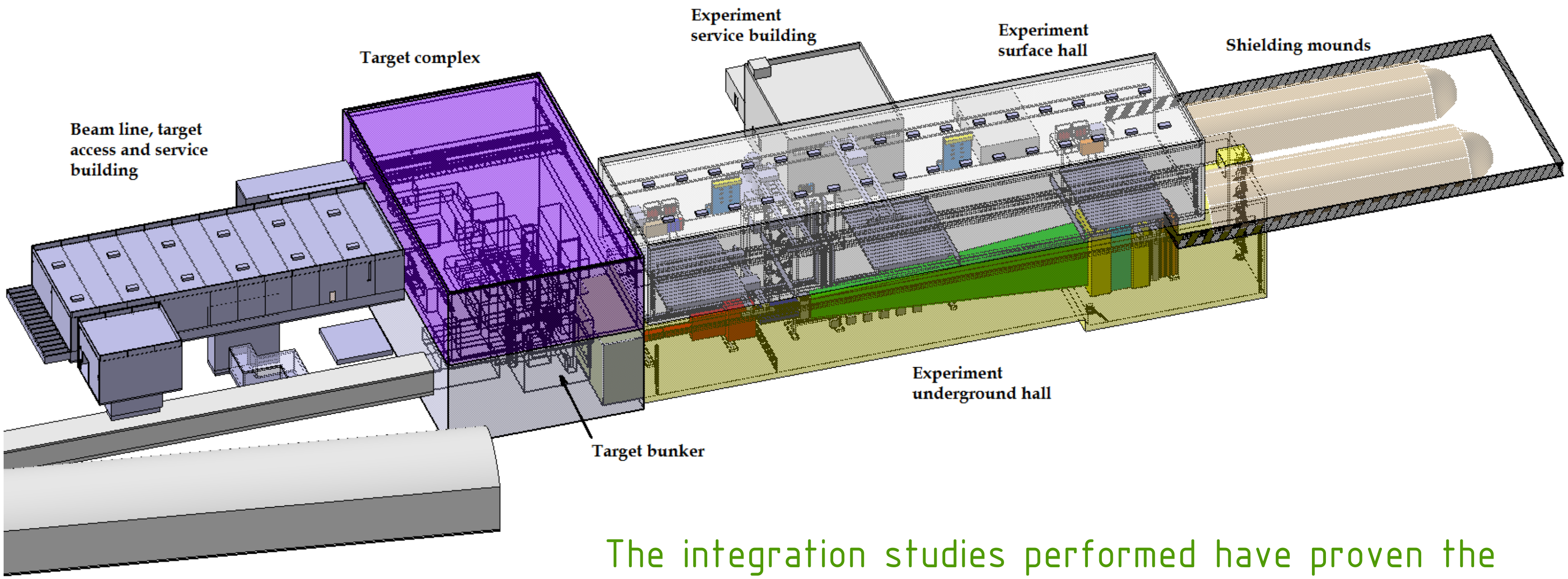
Integration – Video



Liam Dougherty

Integration – Experimental Area

- Detailed integration of the experimental area based on a detailed analysis of the implementation of SHiP detectors
- Surface and underground hall provide space for the assembly of the SHiP experiment

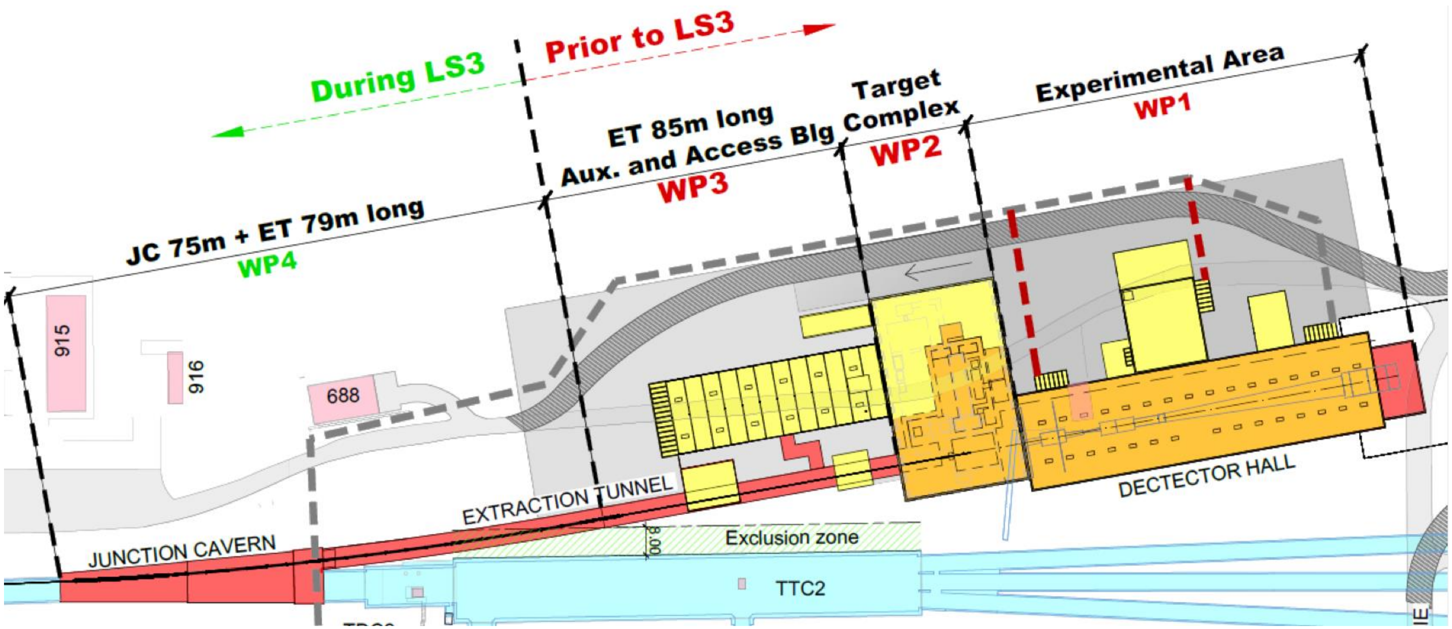


Pablo Santos Diaz

The integration studies performed have proven the **technical feasibility of the BDF facility**

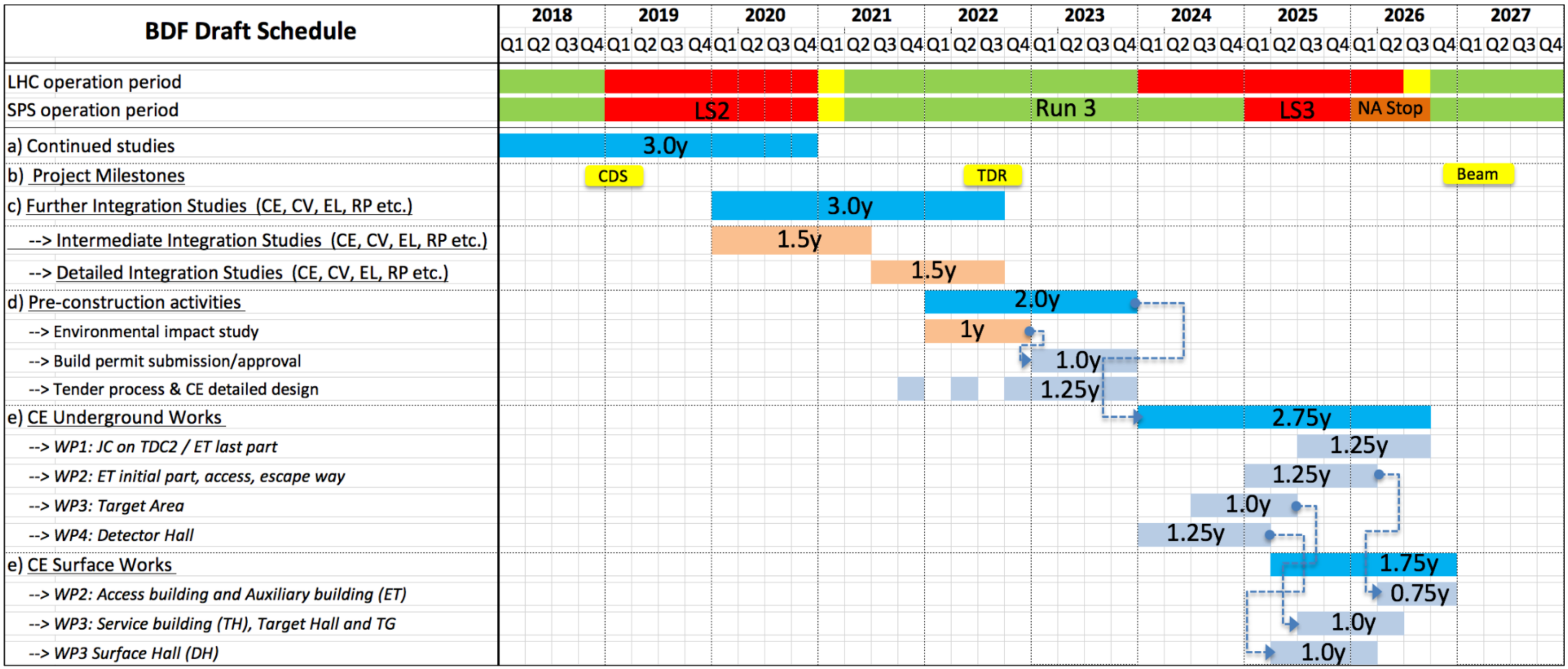
Civil Engineering

- Studied with external consultants: feasibility, optimized form of construction, robust cost estimation



- CE studies so far have revealed **no show-stoppers** despite the challenges of the project.

Provisional schedule



Cost breakdown

- Class 4 (intermediate – concept study or feasibility) cost estimate

Work Package/System	Estimate [MCHF]
Beam-line and junction cavern hardware	10.1
Target and Target Complex infrastructure	45.5
Civil Engineering	68.2
Cooling and ventilation	11.8
Electrical distribution	5.6
Survey and alignment	1.1
Access system	1.4
Fire safety system	3.5
Radiation monitoring	0.4
Transport (inc. cranes and lifts)	6.1
Installation	2.6
Total	156.3

- A full breakdown of the cost estimate will be published in the CDS.

Conclusions

- During the Comprehensive Design Phase, all pertinent technological challenges have been addressed.
- **In-depth studies and prototyping** have been performed or are already ongoing for all critical components.
- The **feasibility of the Beam Dump Facility has been proven**, and the technologies and techniques appear to be within CERN's established competencies.
- The project is **ready to move towards the detailed design and execution phase**.

Thanks to the Directorate for their support

CERN

Near timeline

- **2017-2018** ✓
  - Prototyping of key technologies
  - Preliminary infrastructure integration and CE designs
  - Preliminary cost estimates and schedule
- **Start 2019**
  - Delivery of CDS
- **2019-2020**
  - Continued design studies and prototyping
- **End 2020**
  - Approval to go ahead with TDR
- **2021-2020**
  - Engineering design studies towards TDR
  - Specification towards production
  - CE pre-construction activities
- **2022**
  - TDR delivery
- **2023**
  - Seek approval
  - Tender, component production, CE contracts