SPS Beam Dump Facility

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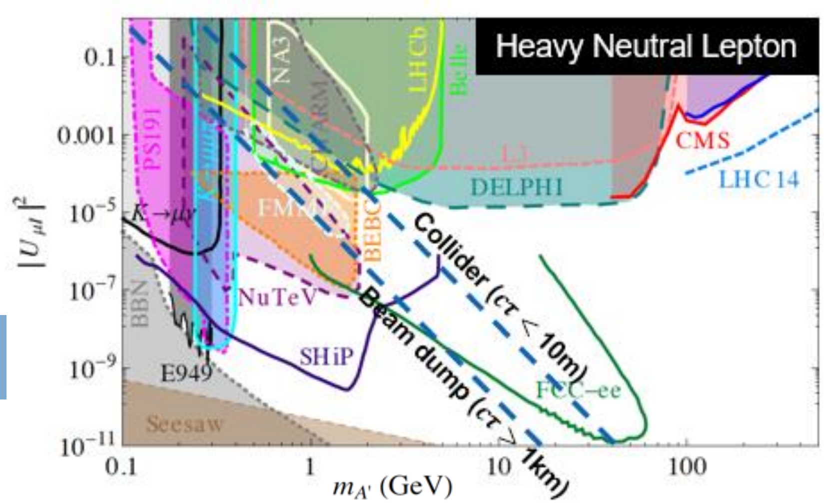
Beam Dump Facilities

- BDFs ideal for exploring light super-weakly interacting particles and Light Dark Matter
  - **Luminosity** (yield of π, K, D, B decay and photons):
    - HL-LHC: ~10^{35} cm^{-2}s^{-1} x 10^{7} s = **10^{42} cm^{-2}**
    - SPS (1 m long high A/Z target): 4*10^{13} x 6*10^{24} cm^{-3} x 10^{2} cm x 10^{6} ~ **2*10^{46} cm^{-2}**
    - Superior lumi compensate for lower energy (e.g. yield of charm hadrons ~10^{16}@HL-LHC vs ~10^{18}@SPS)
  - **Geometrical acceptance**
  - **Long lifetimes**
  - **Background suppression**

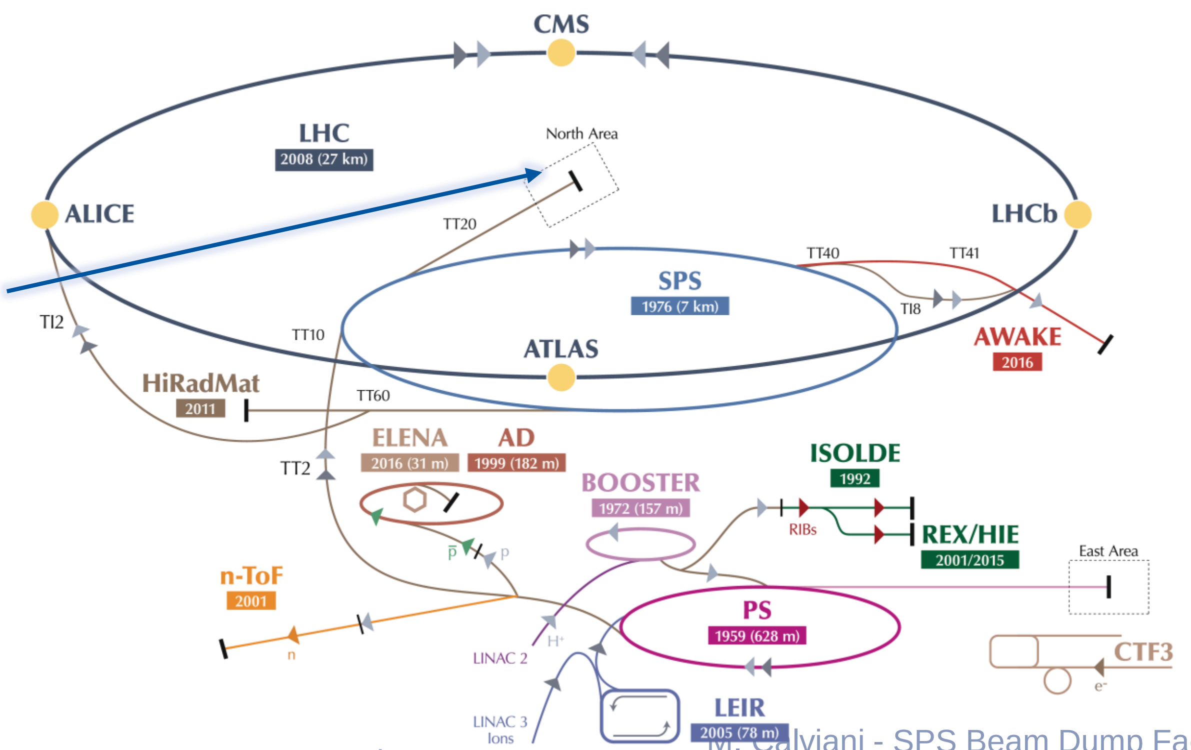


A. Golutvin talk

Conception of the facility

- Preliminary conceptual design of a general purpose fixed target facility for high intensity dump experiments in the SPS complex

Proposed siting of the SPS Beam Dump Facility



Requirements

- High intensity proton beam: **$4*10^{13}$ p^+/pulse, $4*10^{19}$ POT/year**, **355 kW** average beam power (CNGS ~500 kW)

G. Rumolo talk

- Slow extraction (~1 sec. flat top)
- O(400 GeV) optimal beam momentum
- Minimal impact on running the North Area program
- Dense target/dump to **maximize production** & stop π and K before decay into $\mu+\nu$

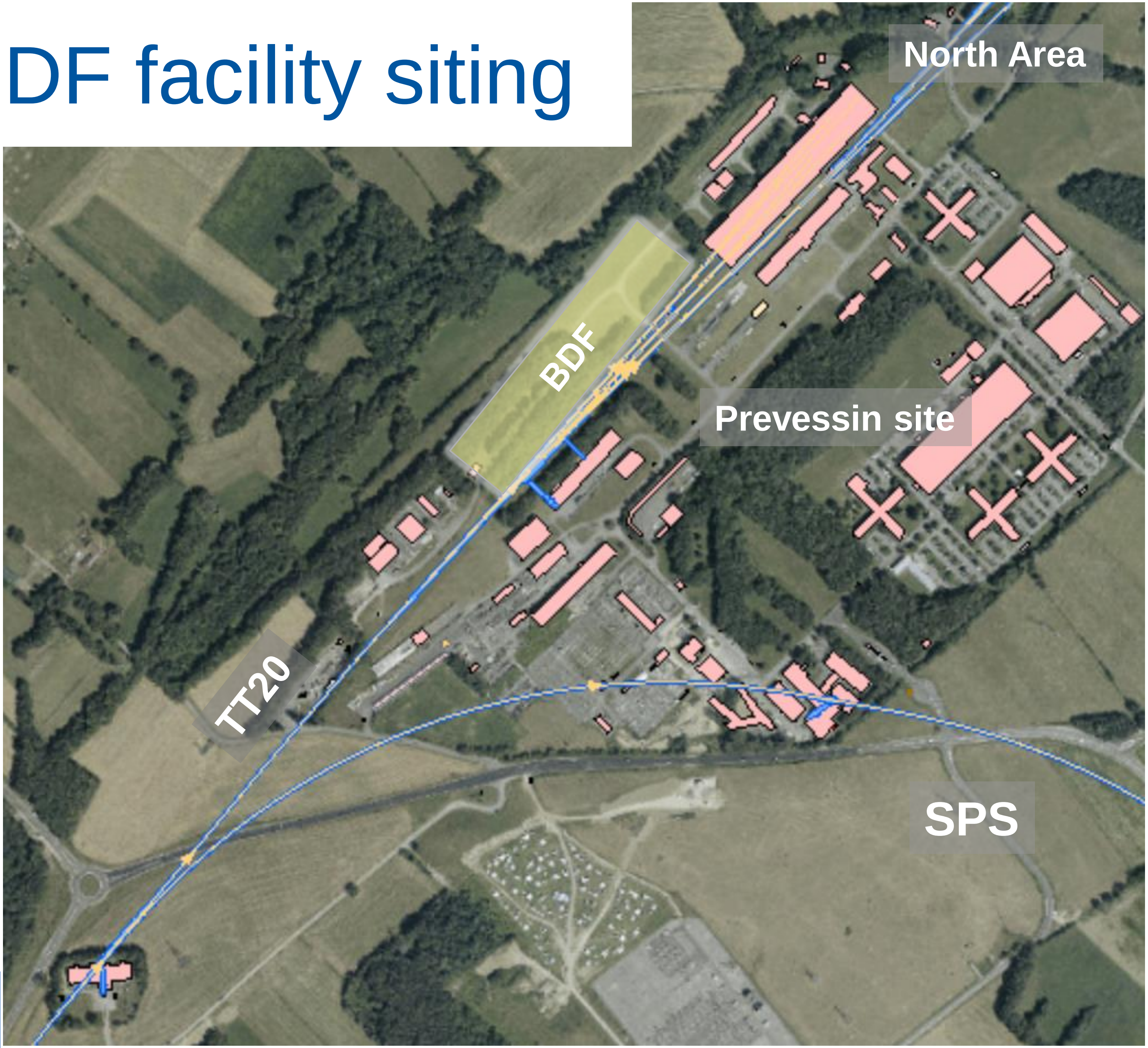
The proposed BDF is a **new permanent facility in the NA** with unprecedented average beam power

The main challenges for a BDF

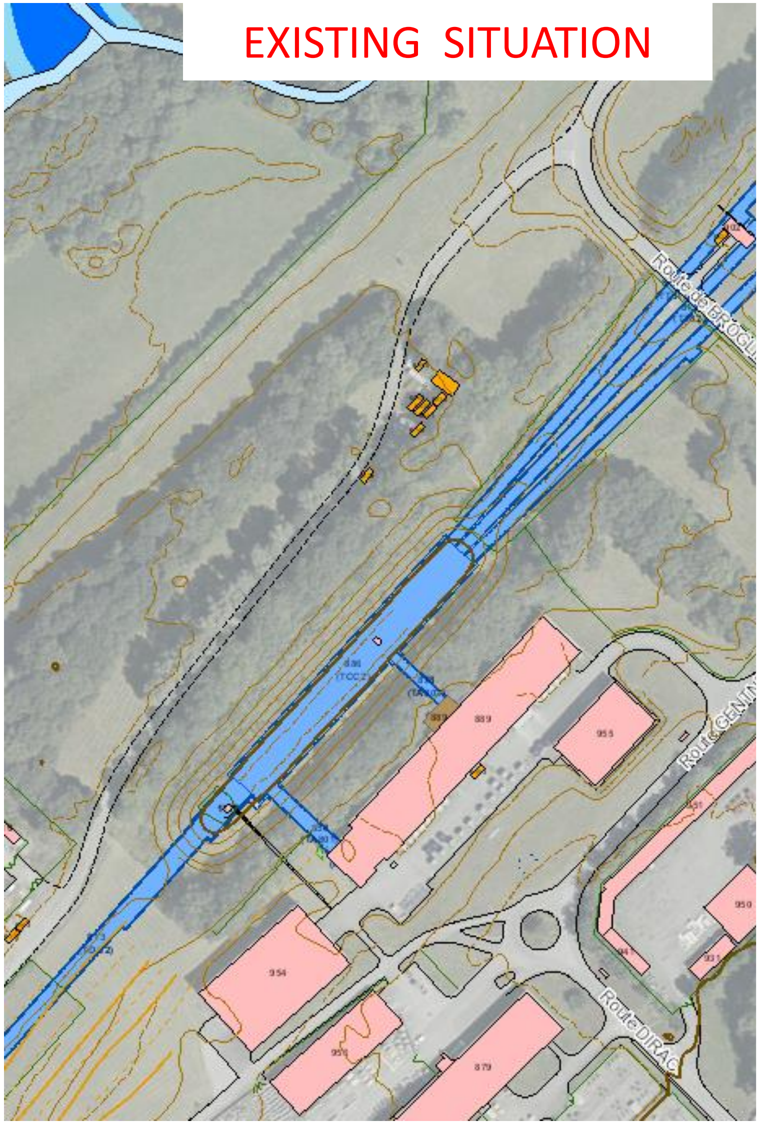
- Target design for longevity and reliability
- Extraction from SPS M. Fraser talk
- High cumulated radiation doses
  - Injectors, injection, extraction, target, etc…
- Radiation damage on materials
  - Extraction septa, target and target station
- Personnel and environmental protection
  - Close distance to the CERN site boundary
  - Detailed environmental study needed
- Good compatibility with North Area operation

G. Rumolo, L. Gatignon talk

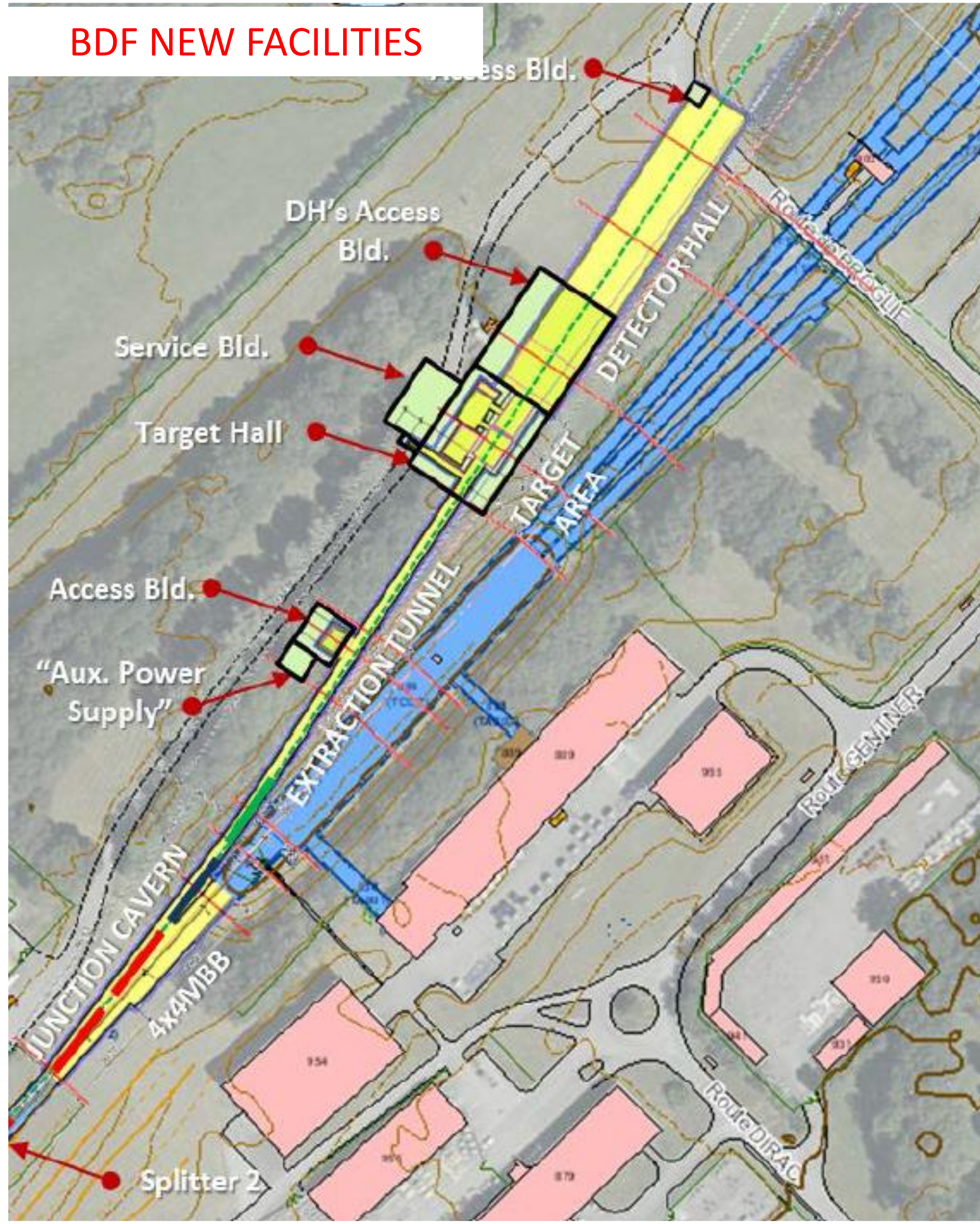
BDF facility siting



EXISTING SITUATION



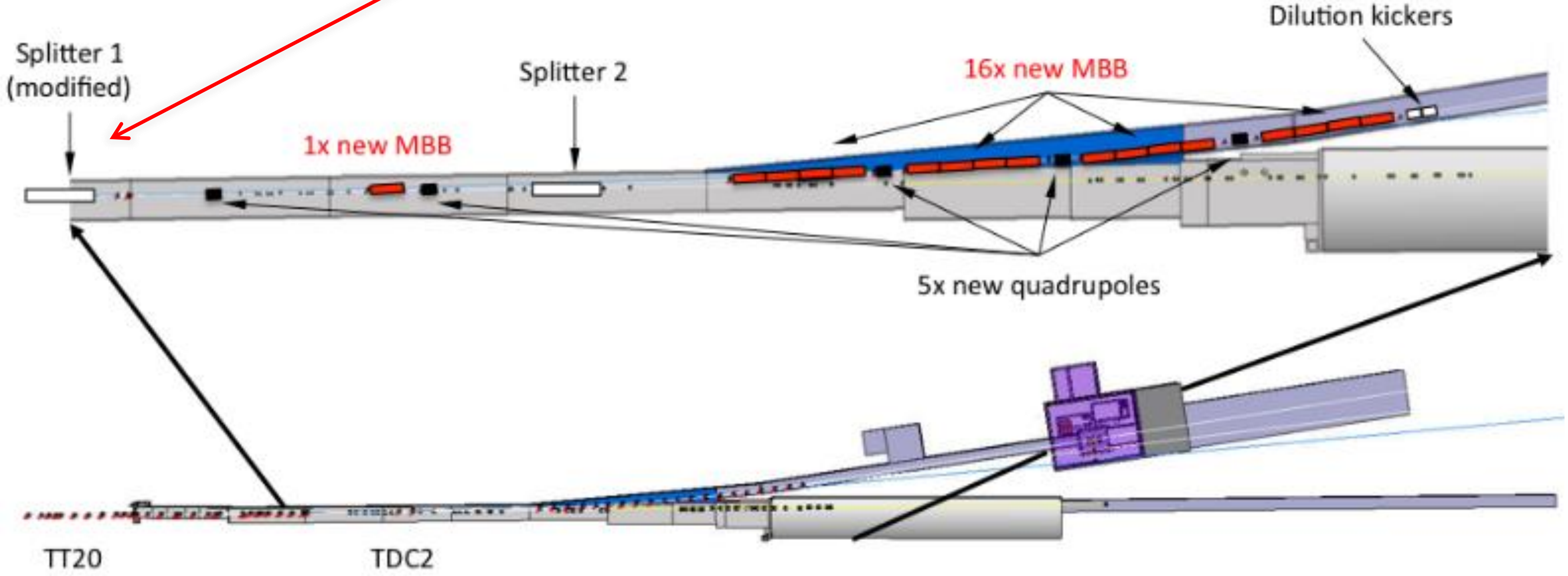
BDF NEW FACILITIES



BDF beam line

Beam to be painted on target during the spill to reduce stress on target

Splitter magnet need to be laminated: pulsing opposite field (deflection to left) and no splitting for BDF cycles



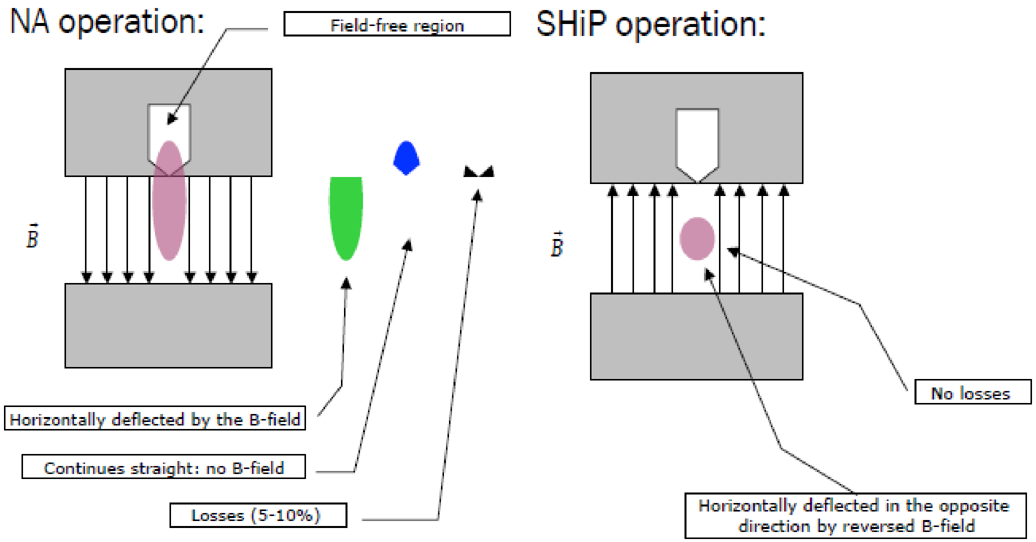
SPS

~ 200 m

North Area

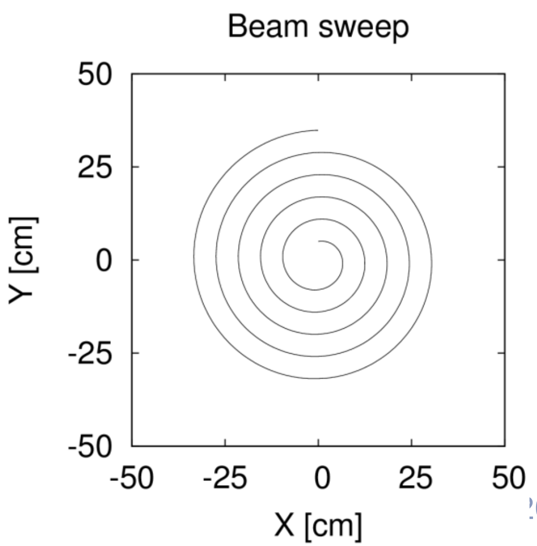
The extraction line to target

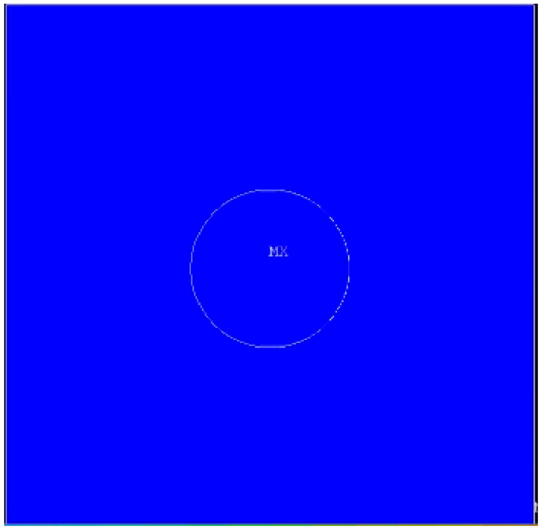
- Replace existing splitter Lambertson magnet with bi-polar laminated version with larger horizontal aperture
- Field polarity must flip for BDF cycles to deflect the beam, whilst keeping same functionality for NA FT
- TT20 require new optics, powering, upgraded instrumentation



Beam dilution to target

- In order to avoid damaging the target beam dilution on the target is required
- Magnets similar to SPS extraction bumpers suitable
  - Powering and interlocking to be studied
- Presently considered is an Archimedean spiral, 5-35 mm radius (1σ = 6 mm)



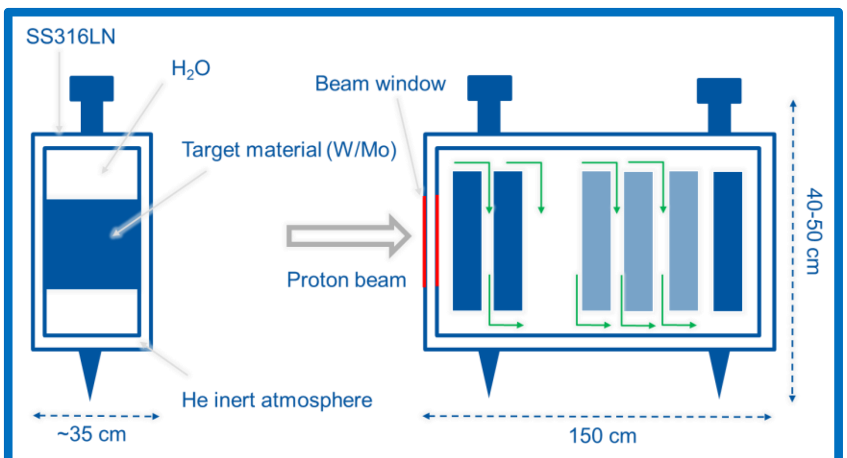


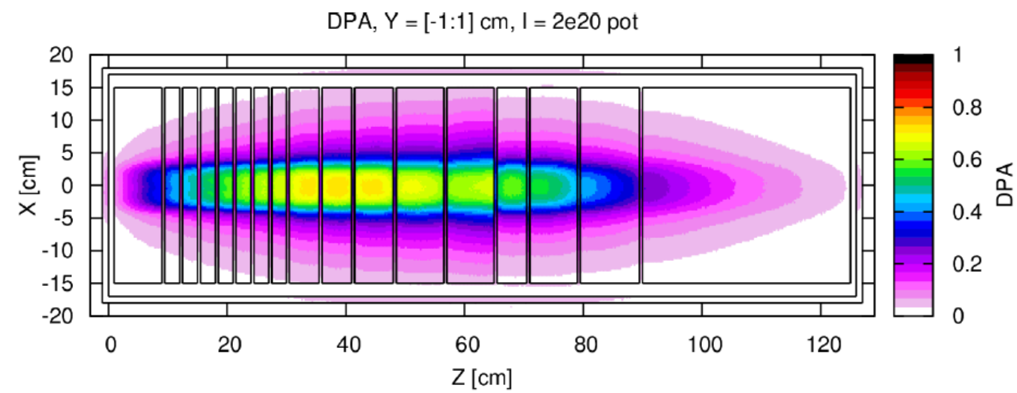
Target/Dump and Facility

- **Beam power 355 kW, 1 s spill up to 2.56 MW**
- Target must be as dense as possible to maximize production and reduce backgrounds
- High energy deposition per unit volume → significant **heating due to beam (320 kW)**
- Need of a challenging water cooling system
  - ~200 m^3/h, 20 bar
- Material damage due to cumulated radiation

The proposed BDF target

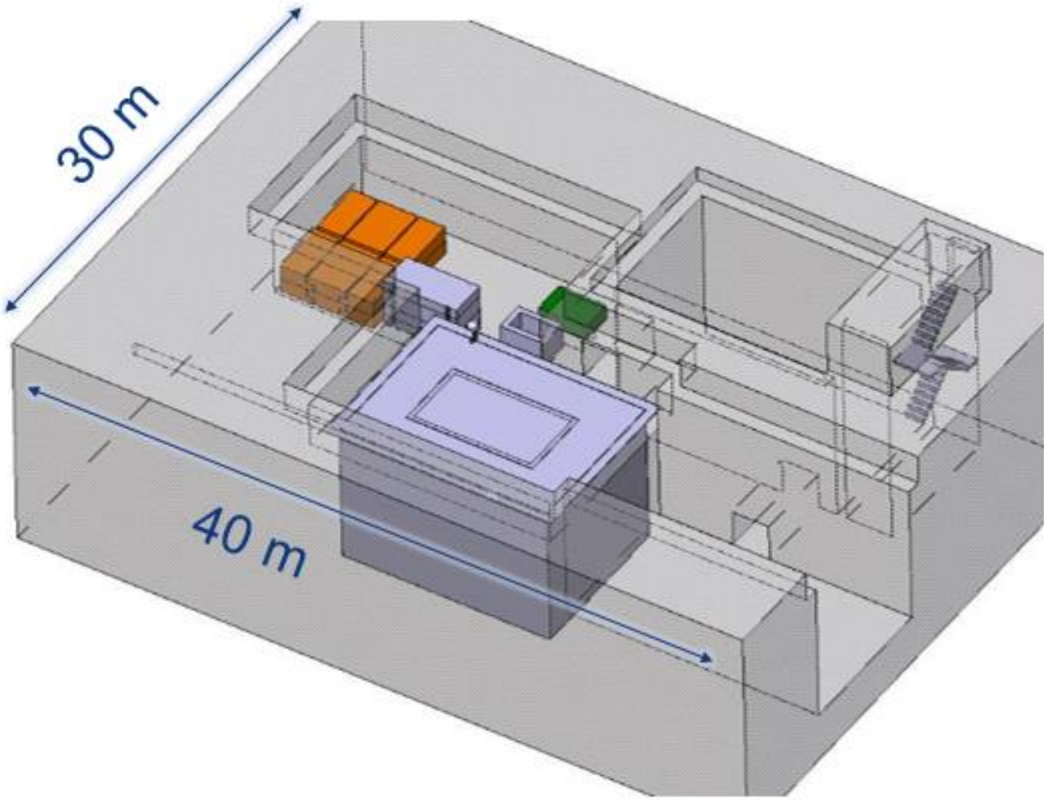
- 120 cm long, hybrid configuration
- 60 cm TZM (4λ) + 60 cm W (6λ), Ta cladded
- 40 x 40 cm^2 transversal size
- Target core in a double walled SS container
- Radiation damage effect on mechanical properties

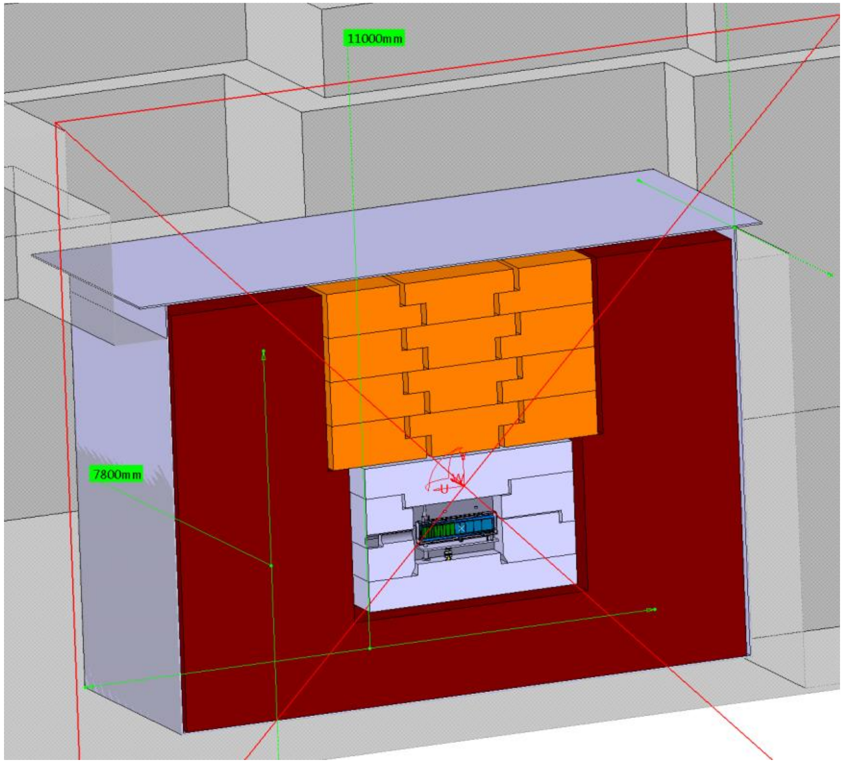




Target Complex

- Target is located 15 meters underground
- Cast-iron hadron absorber encloses production target (460 m^3)



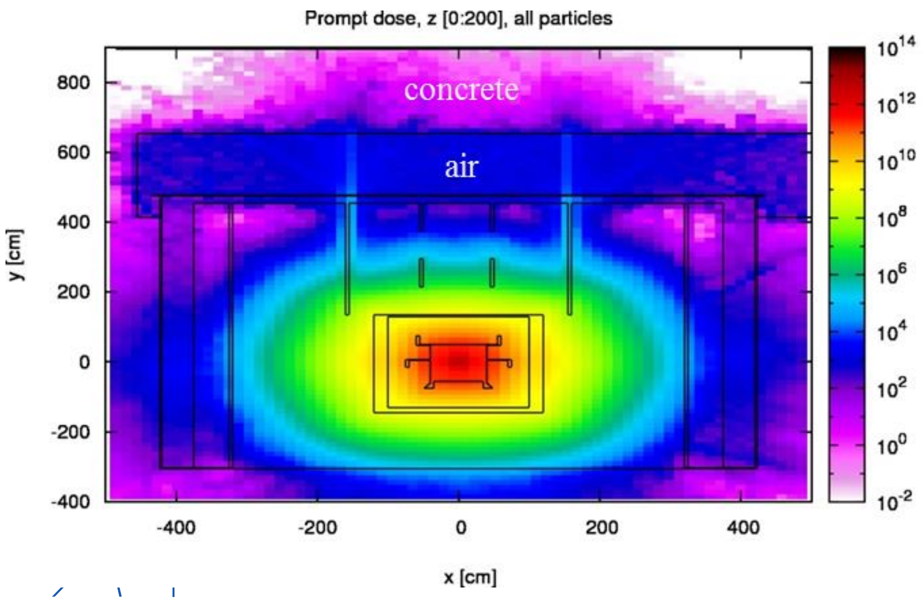


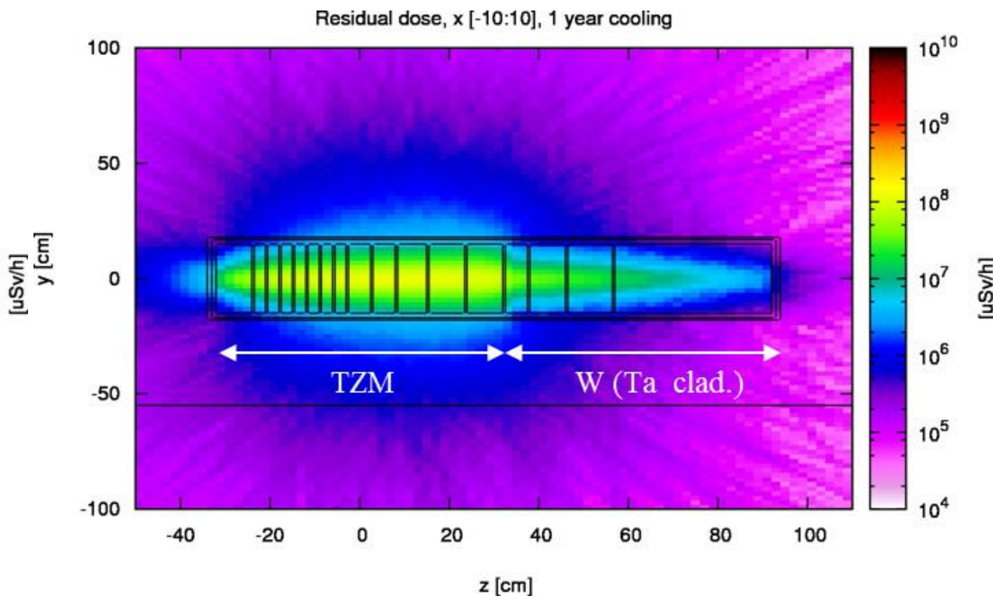
Radiation protection challenges

- 355 kW → RP dictates design of the facility
- High prompt & residual dose rates → shielding and remote interventions
- SPS extraction optimization crucial
- Target area particularly critical
- Environmental impact (gas releases)
- Constraints have been highlighted and design optimized in the conceptual design of the facility

Radiation protection

- Prompt dose rate under control in accessible areas
- Dump **residual dose rate ~10 Sv/h** after 1 week
  - Handling of the target an outstanding item
- Target station design adapted to configure the bunker for a **different dump design**

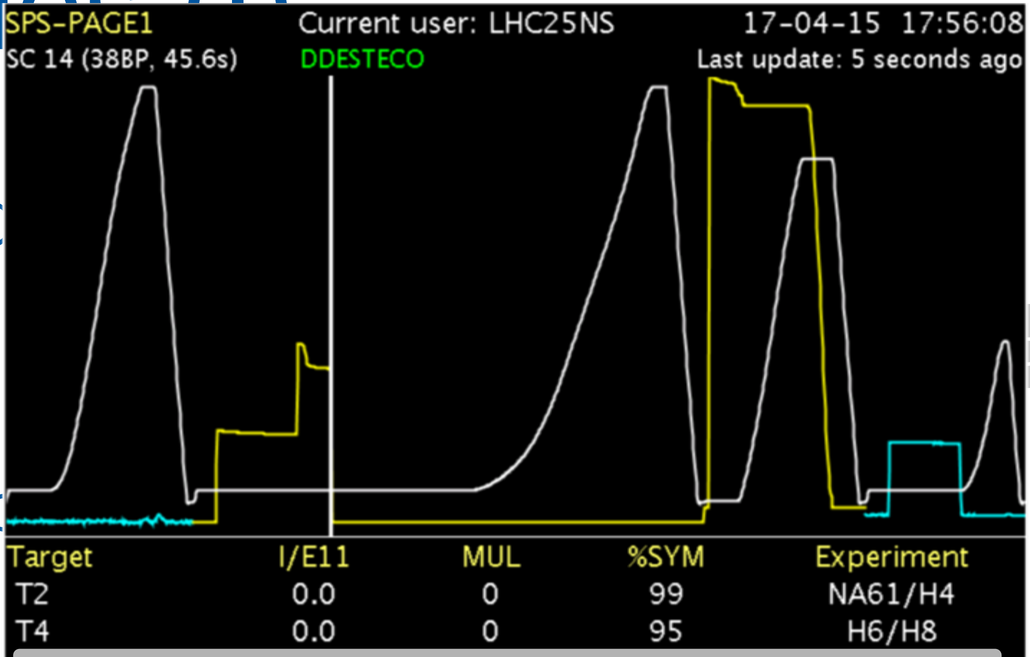




R&D activiti

1. Extraction anc

- SPS extractio
  minimization
- TT20 optics, p
  splitter
- Development
  magnets
- 1 s slow extraction spill quality
- Development of BDF-like cycle



SHiP MD 2015, $1.2*10^{12}$ ppp (low intensity), slowly extracted in 1.2 s

alk

R&D activities (II)

2. Target & Target complex
   - Pursue design of the production target towards a robust and reliable configuration & radiation damage
   - Development of gas-cooled target
   - Helium vessel purification system
   - Design of a fully remote handling system for the target area

- R&D (1+2) approved 2017-2019 within PBC

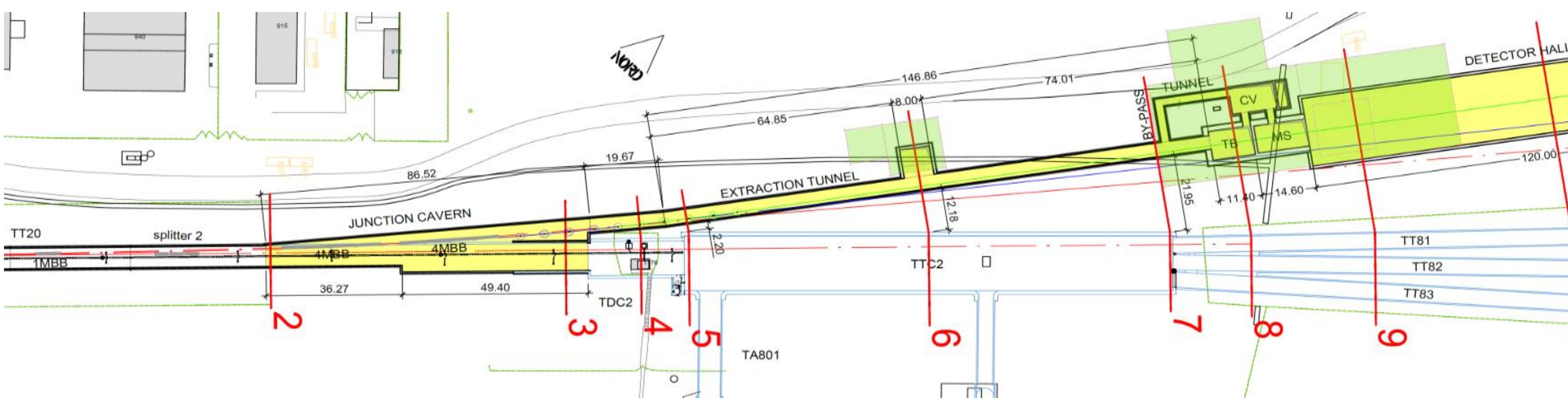
Summary

- Preliminary conceptual design of a general purpose SPS Beam Dump Facility presented
- Demonstrated it can be built with the requested performances, provided some key R&D are executed
- Realistic schedule has been drawn to start operation after LS3 (~2026)
- R&D plan foreseen for 2017-2019 as input to the European Strategy for Particle Physics

References

- EDMS 1369559 – “A new Experiment to Search for Hidden Particles (SHiP) at the SPS North Area” – 4 July 2015
- EDMS 1499253 – “Civil Engineering for the SHiP facility” – 19 March 2015
- EDMS 1498984 – “The SPS beam parameters, the operational cycle, and proton sharing with the SHiP facility” – 5 May 2015
- EDMS 1495859 – “Extraction and beam transfer for the SHiP facility” – 2 May 2015
- EDMS 1513294 – “Conceptual design of the SHiP Experiment Target and Target Complex” – 9 April 2015

CERN



NORD
DETECTOR HALL
TUNNEL
CV
TB
MS
BY-PASS
EXTRACTION TUNNEL
JUNCTION CAVERN
TT20
splitter 2
1MBB
4MBB
TDC2
TTC2
TA801
TT81
TT82
TT83
146.86
74.01
8.00
64.85
86.52
19.67
36.27
49.40
12.18
21.95
11.40
14.60
120.00
2.20
2
3
4
5
6
7
8
9

New MSSB magnet

- This is a significant piece of infrastructure, long-lead item:
  - Must be radiation-hard (~50 mSv/hr, inorganic coil insulation used, e.g. MgO)
  - High reliability
  - Laminated yoke, presently solid iron
  - Ramp cycle-to-cycle (in ~2 seconds)

Parameter	**MSSB**	**New MSSB-S**
Magnetic length [m]	4.7	4.7
Gap field [T]	0.8	0.8
Stacking factor [%]	100	98
Coil turns	48	48
Current [A]	994	1014
Vertical gap [mm]	75	75
Pole width [mm]	400	530
Magnet inductance [H]	~0.11	~0.14
Coil resistance [mΩ]	65	~66
Number of magnets in series	3	3
Minimum rise-time [s]	10 (?)	2
Maximum voltage to ground (3 magnets in series) [V]	~250	400