Consideration on MUC Target Complex

1st Muon Community Meeting, 20-21 May 2021

International MUON Collider Collaboration

CERN

by Marco CALVIANI
CERN – Systems Department
Sources Targets Interaction (STI)
Targets Collimators Dumps (TCD)

Introduction

- What are the challenges of a MUC Target Complex
- Requirements and constraints
- How are we going to tackle these challenges?
- How do we move forward?
- Points already raised during the MUC Testing Opportunities Workshop (link) and MUC design meetings (link)

MUC Target Complex considerations

- **Facility will need to comply with very stringent radiation and environmental protection considerations (→ C. Ahdida)**
  - Not only neutrino radiation, but neutron stray radiation, air activation at site boundary will be critical
  - Installation in the molasse (bedrock, as CNGS) will simplify many radiation protection constraints
- **Reminder: likely ±Sv/h dose rate on large volume components close to production target system/dump**
  - Fully remote handling of components is mandatory, no hands-on intervention
  - Should favour vertical handling (over side access, compliant with ITER remote handling code of practice)
  - Radioactive waste consideration (reuse as much as possible existing material, maximize reliability, etc.)

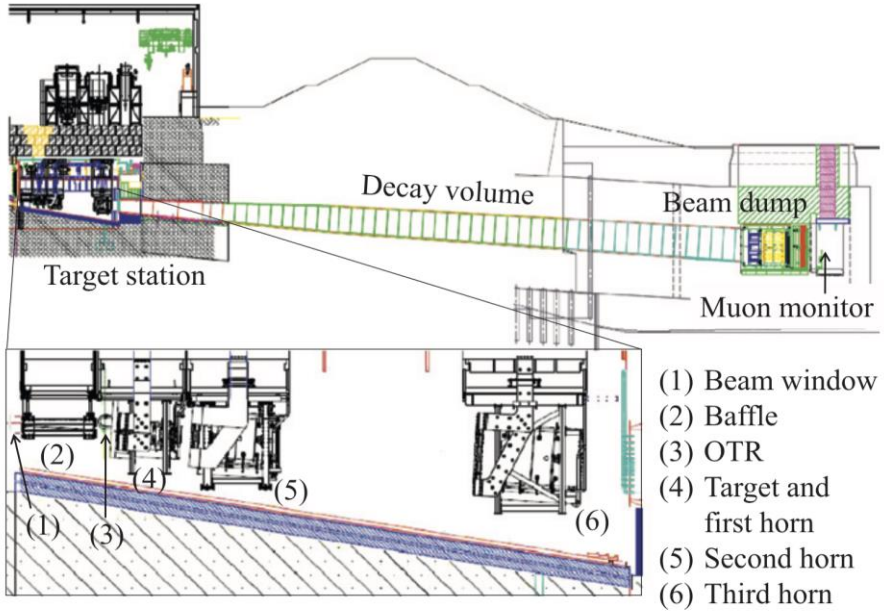
MUC Target Complex considerations

- Optimisation of ancillary services (cooling and ventilation, electrical, etc.) shall be though from the beginning
- Systems **will** fail during the lifetime of the installation → thinking about radioactive waste management from the start (morgue and interim storage for failed components)
- All points relevant and applicable to provide feasibility and a realistic cost estimate ballpark as part of the conceptual design

Challenges of Target Facilities for HEP

Couple of relevant examples

T2K – Japan
(operational)



doi:10.1016/j.nima.2011.06.067

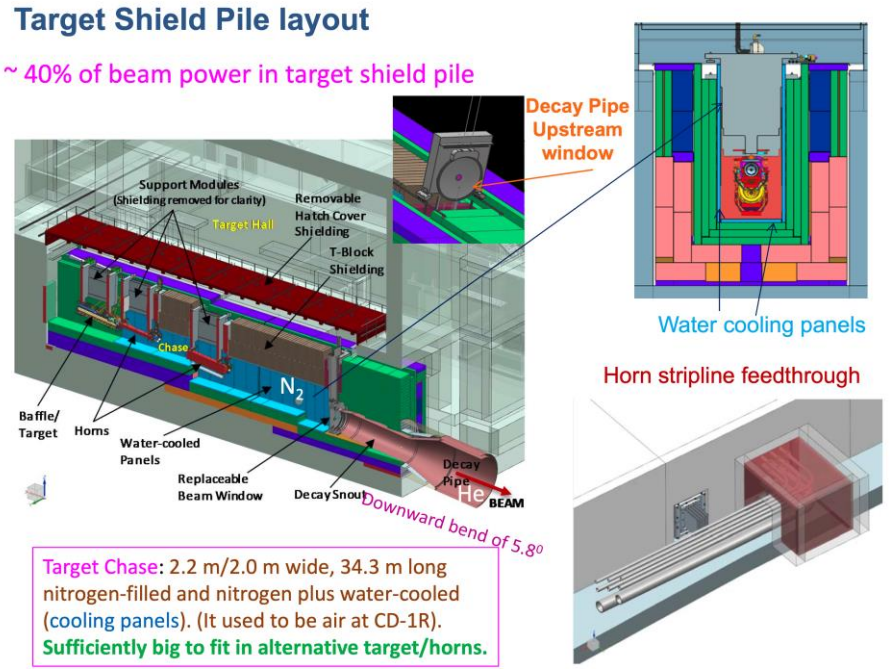
NUMI – US
(operational)

J. Hylen, NuMI Target Experience, NBI 2006

Challenges of Target Facilities for HEP

CNGS – CH (CERN)
(not operational)

LBNF – US
(±2028-2030)



V. Papadimitriou, NBI2017

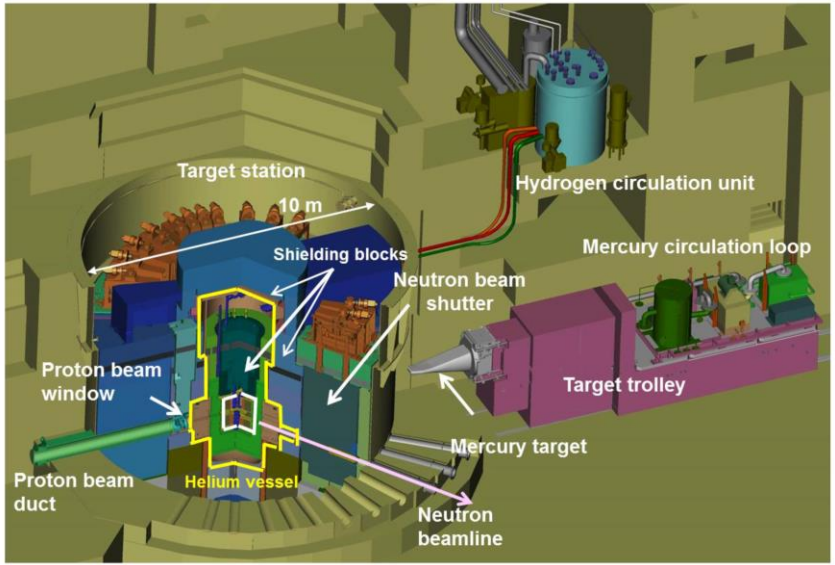
Challenges of Target Facilities for HEP

- Facilities running in the O(100 kW) level
  - heavy activation of large components due to the intrinsic structure of pion producing facilities (you want to focus large amount)
  - Fundamental differences if semi-shallow (like T2K), from deep (NuMI) or very deep (CNGS)
  - Experiences have shown that failures of components is real and determine the reliability of the infrastructure
- In the near future, break the barrier of 1 MW

Challenges of Target Facilities for Neutron

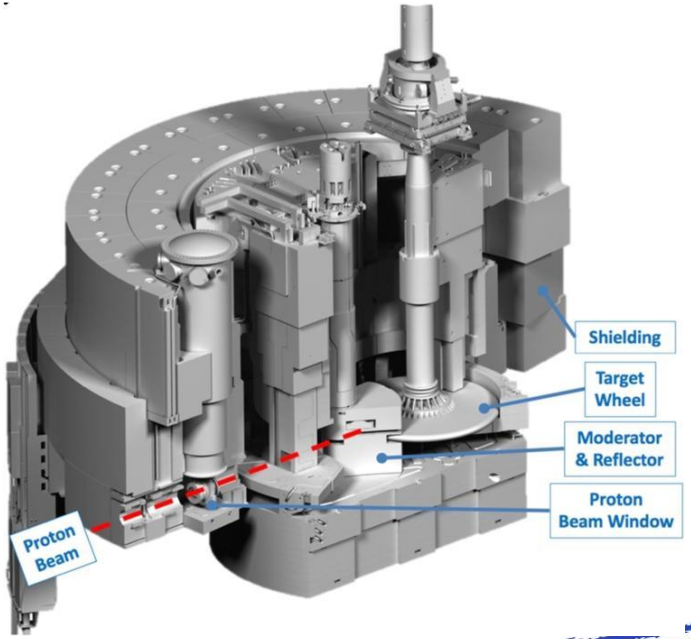
Couple of relevant examples

JSNS (JP) / SNS FTS (US)
(operational)



https://doi.org/10.3390/qubs1020008

ESS (SE)
(>2025)

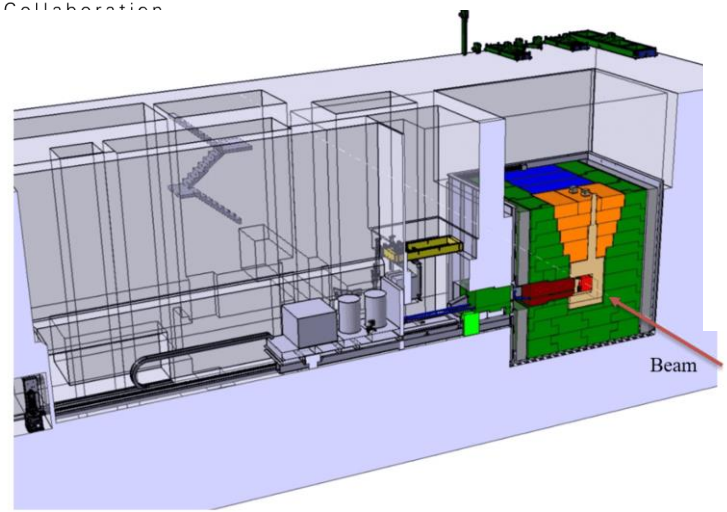


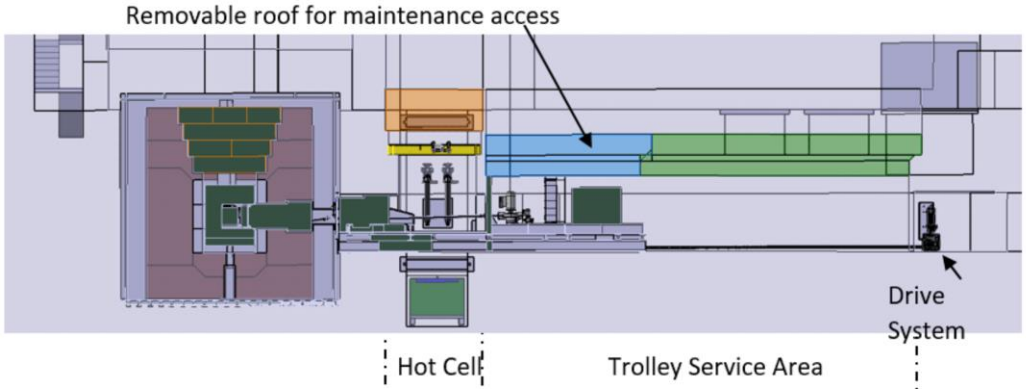
Lyngh, D. et al. 'Engineering and Prototyping of ESS Neutron Beam Extraction System'. 1 Jan. 2020 : 109 – 118.

Challenges of Target Facilities for Neutron

- Facilities running at the 0.5-1.4 MW level
  - Radiation is contained in the target monolith, with the exception of the neutron ports
  - Target Systems reliability >1 MW is challenging and require quite a lot of experience
  - Remote handling and hot-cell critical for the successes of the infrastructure

Recent studies for potential facilities at CERN



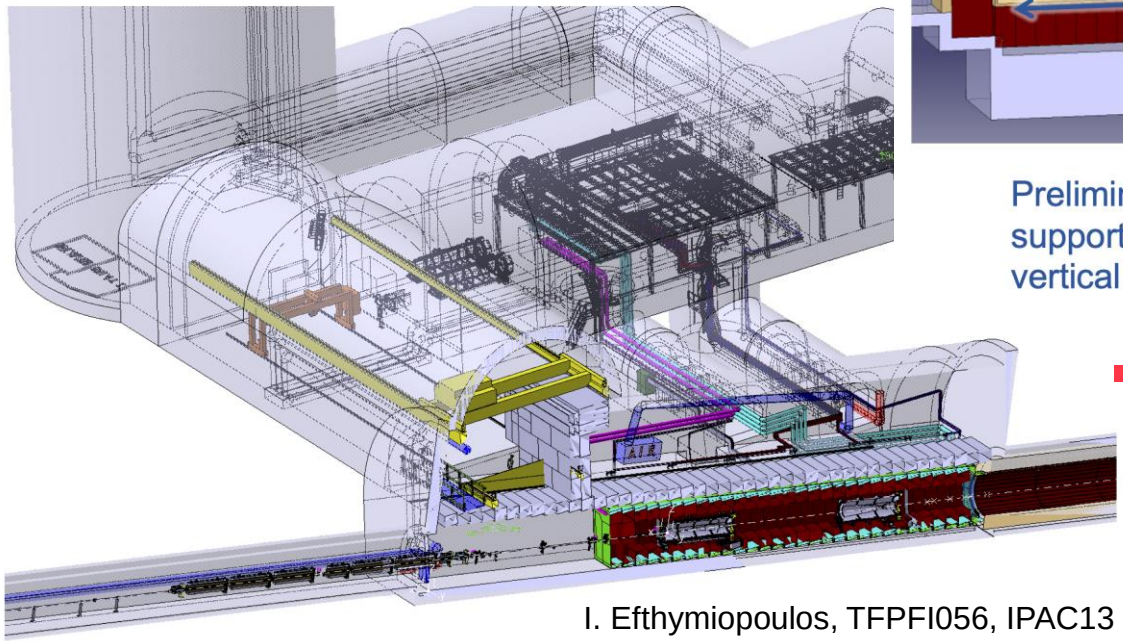


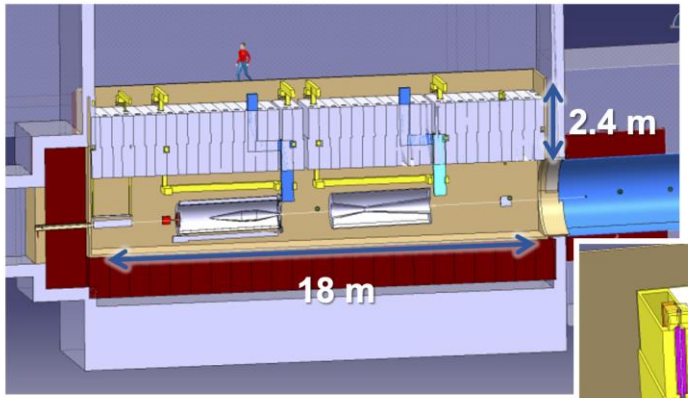
- Beam Dump Facility (BDF)

- 350 kW target/dump assembly, close to the design of a spallation source
- Detailed study (±2 “focused” years) for the comprehensive design study
- http://dx.doi.org/10.23731/CYRM-2020-002
- https://doi.org/10.1088/1748-0221/13/10/P10011

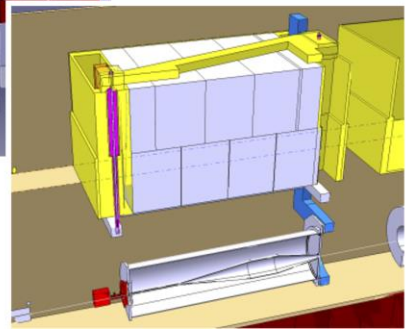
Recent studies for potential facilities at CERN

- CN2PY - LBNO





Integration of target trench, 3x3 m^2, matching DP diameters



Preliminary design of the support module, pure vertical movements

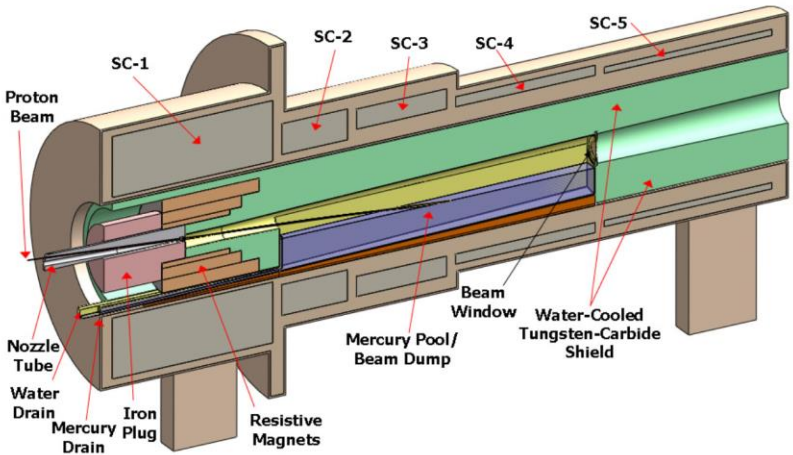
- CERN Neutrino Facility / SBN

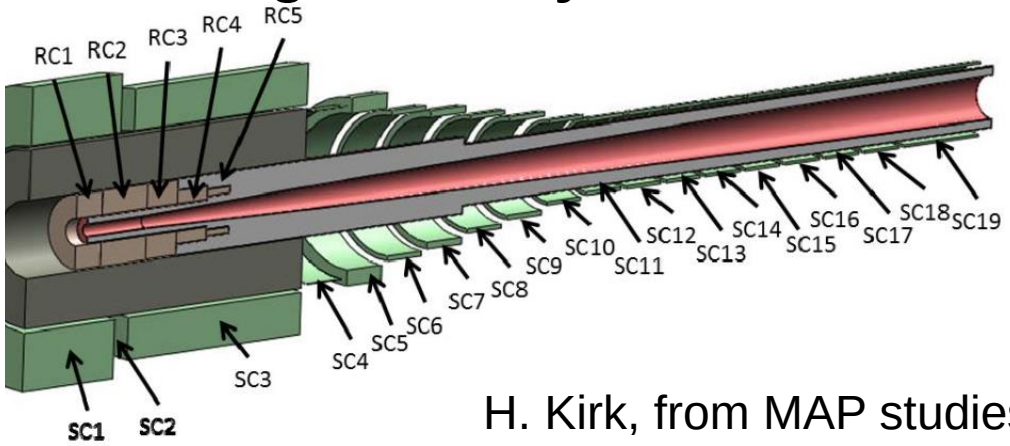
I. Efthymiopoulos, TFPFI056, IPAC13

Challenges of MUC Target Facility

- **MUC Target Facility is expected to merge the challenges of both infrastructures**
- (Very) high beam power, possibly liquid targets and very high residual dose rate (O(1000 Sv/h)) for beam line components
- Remote handling mandatory (including hot-cell for autopsies and post-mortem)
- Ready to exchange target/solenoids/horns quite frequently
- Proton beam dump inside the SC solenoid or in the capture channel → a (big) challenge as it will be the **main** stray radiation source

Challenges of MUC Target Facility





H. Kirk, from MAP studies

- All the production and capture section will have to be hosted in a well protected and shielded area; no human intervention possible
- Double target/horn(s) systems a possible alternative

How are we going to tackle these challenges?

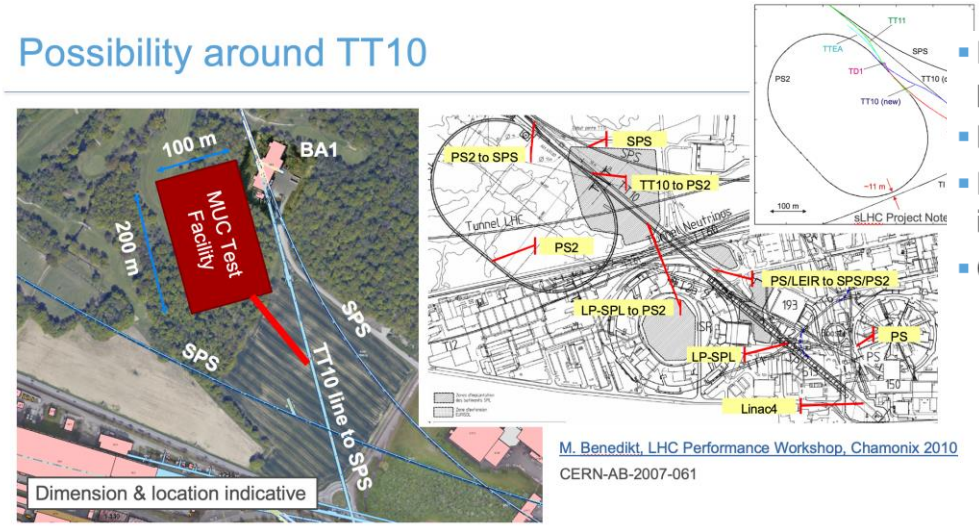
- Target Complex engineering design was not carried out within previous studies
- Understand that it is currently **not required to produce a conceptual design in the next 5 years** (and no resources will be available for that)
- However, if we want to provide a reasonable cost estimate, it is suggested to
  - Model in rough 3D the main components of the production, capture and cooling section of the MUC to understand integration/handling challenges
    - This is essential also for the development of the Test Facility / Demonstrator
    - **Input and feedbacks are essential to move on**
  - Execute a high-level RP assessment
  - CE pre-study to be able to understand overall costs of infrastructure

What is the role of the Test Facility / Demonstrator

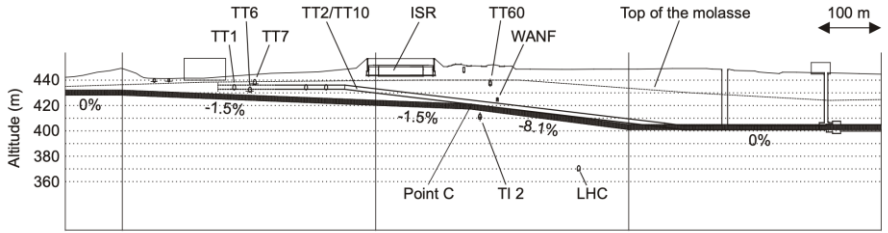
- Test Facility / Demonstrator could have an important role in the definition of the final Muon Collider Target Station
  - **Engineering** & **Cost (w/ "informed" scaling)**!
  - Demonstrator for the handling technologies and telemanipulation to be employed for the final facility
  - Should embed flexible design to be able to testing different target and production solenoid systems **or** multiple targets/horns systems
  - How to most efficiently introduce the different elements in the final Target Station (morgue, ancillaries, enclosure/confinements, etc.)?
- **Demonstrator Target Station development is likely to be essential in supporting the design of the final MUC Target Station!**

What is the role of the Test Facility / Demonstrator

- As reported by D. Schulte/R. Losito yesterday, proposition of couple of option at CERN (link), favouring “TT10” option



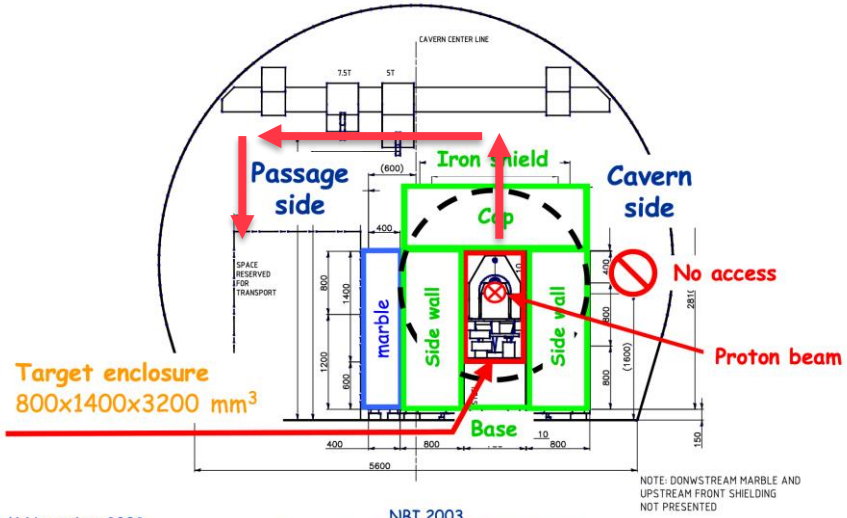
- Fully underground solution (±SPS level), reduced radiation protection concerns (facility well in the molasse)
- Maximum PS beam power (O(80) kW)
- Expandability guaranteed, as now expected limitations in terms of infrastructure appear to be present
- Common services around BA1?



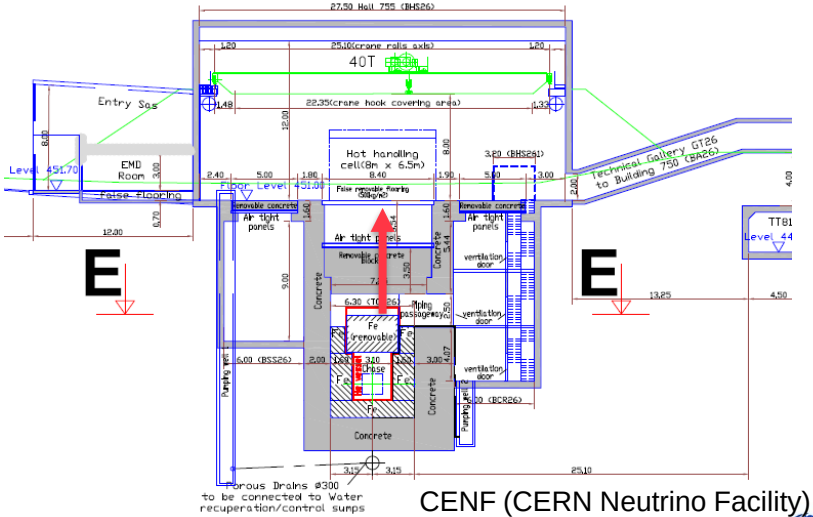
What is the role of the Test Facility / Demonstrator

- Options that could be envisaged/studied?
- And what is their impact for the final Target Station?

CNGS/WANF-like / lateral handling



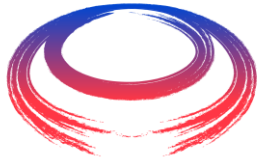
"Chase" / vertical handling



CENF (CERN Neutrino Facility)

Conclusions

- Design of the MUC Target Station (and related Systems) is a major challenge
- Advancement in the feasibility design is required in order to solve some specific technical challenges, address RP-specific questions and to allow a more precise costing
- **Target Facility / Demonstrator will place a major role in helping addressing design and technical challenges**



Thank you
very much for your support
and for your attention