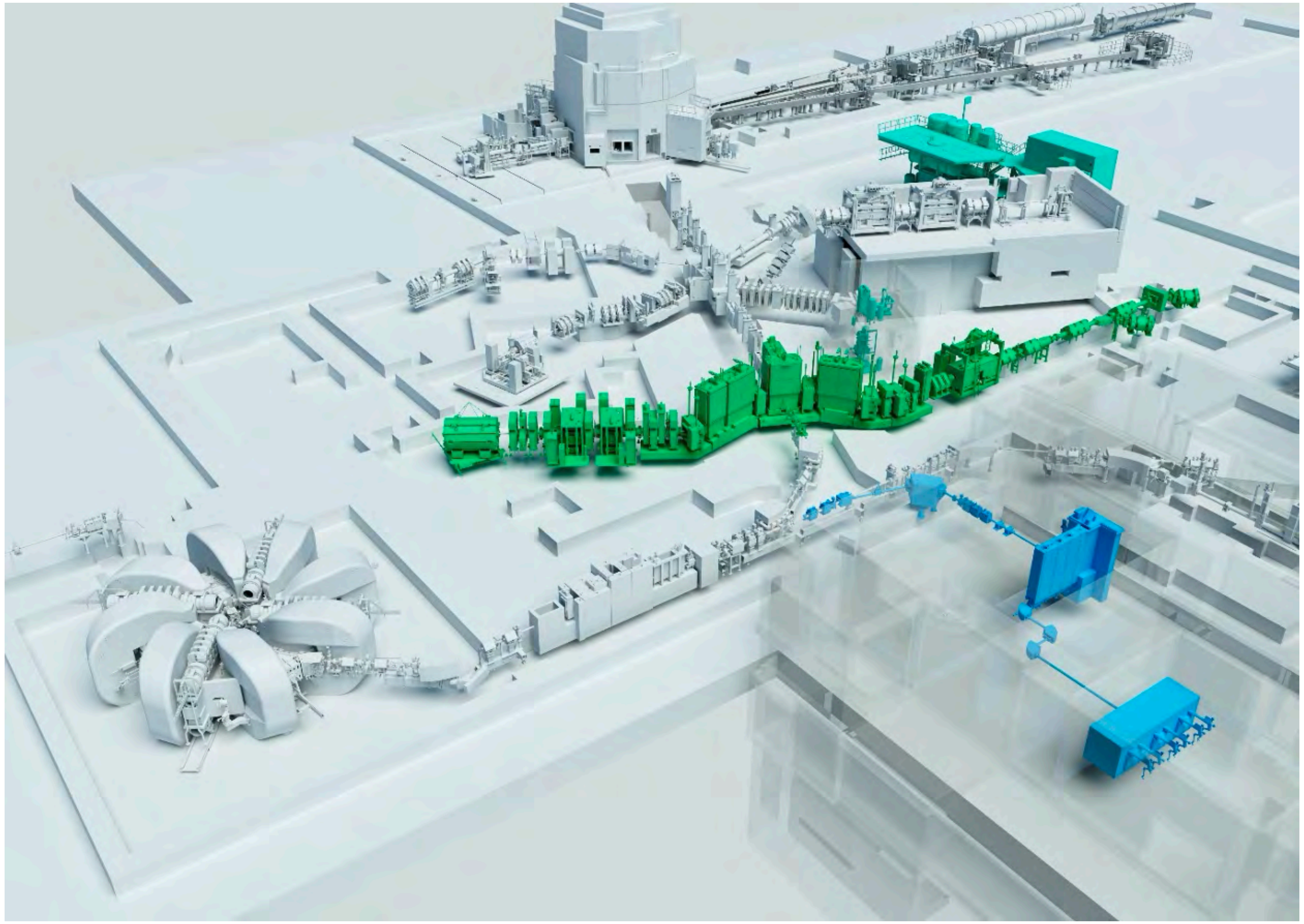
PSI Center for Neutron and Muon Sciences

Status of HIMB



Andreas Knecht for the HIMB project

cLFV2026, Rome, IT
19. June 2026

HIMB project in a nutshell

- Construction of new target station TgH at the place of the existing TgM
- Construction of two new solenoid-based beamlines for µSR and particle physics delivering 10^{10} surface muons per second

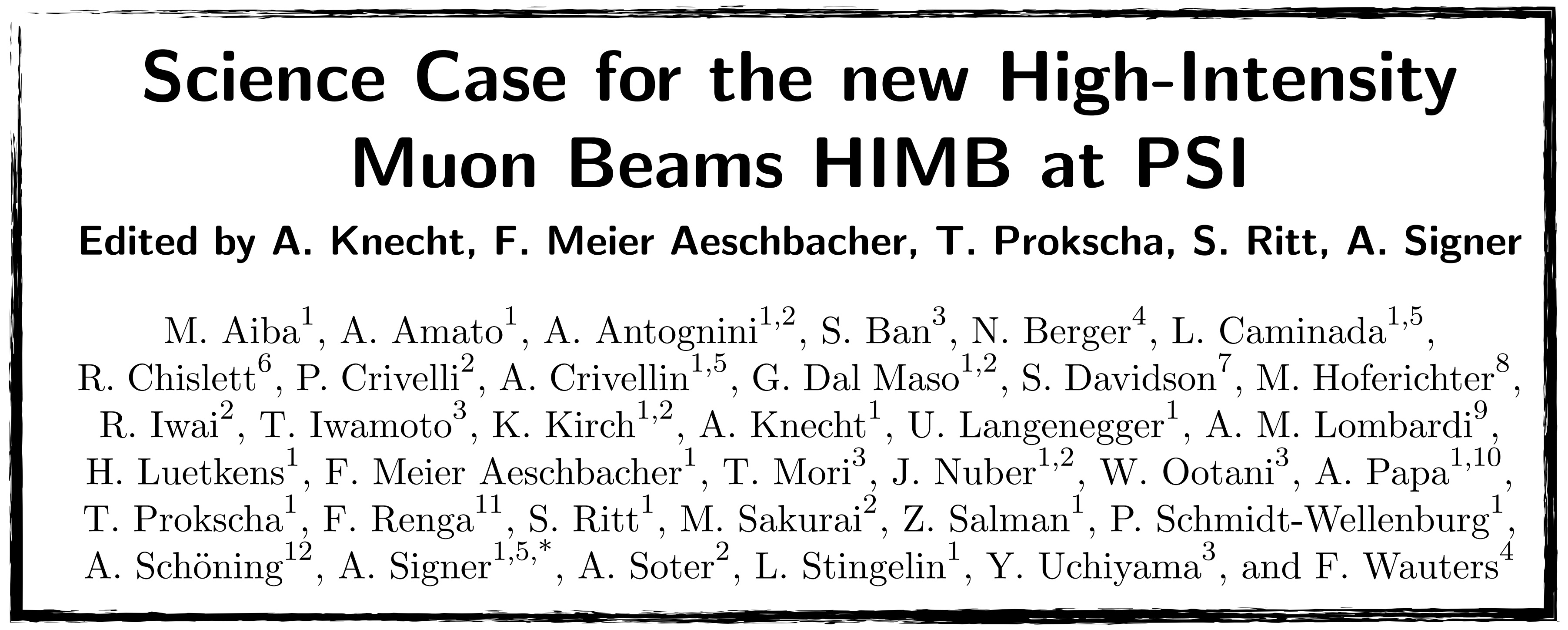
→ Enable ground-breaking muon research at PSI for the next 20+ years

HIMB Science Case Workshop & Document

Workshop held in April 2021 with 122 participants to gather and identify HIMB Science Case: arXiv:2111.05788v1

In short some highlights on what to do with 100x more muons:

- Higher-intensity muon rates for particle physics and μSR
- Better quality muon beams with muCool
- Pixel detector based μSR
- μSR with sub-surface muons



Science Case for the new High-Intensity Muon Beams HIMB at PSI

Edited by A. Knecht, F. Meier Aeschbacher, T. Prokscha, S. Ritt, A. Signer

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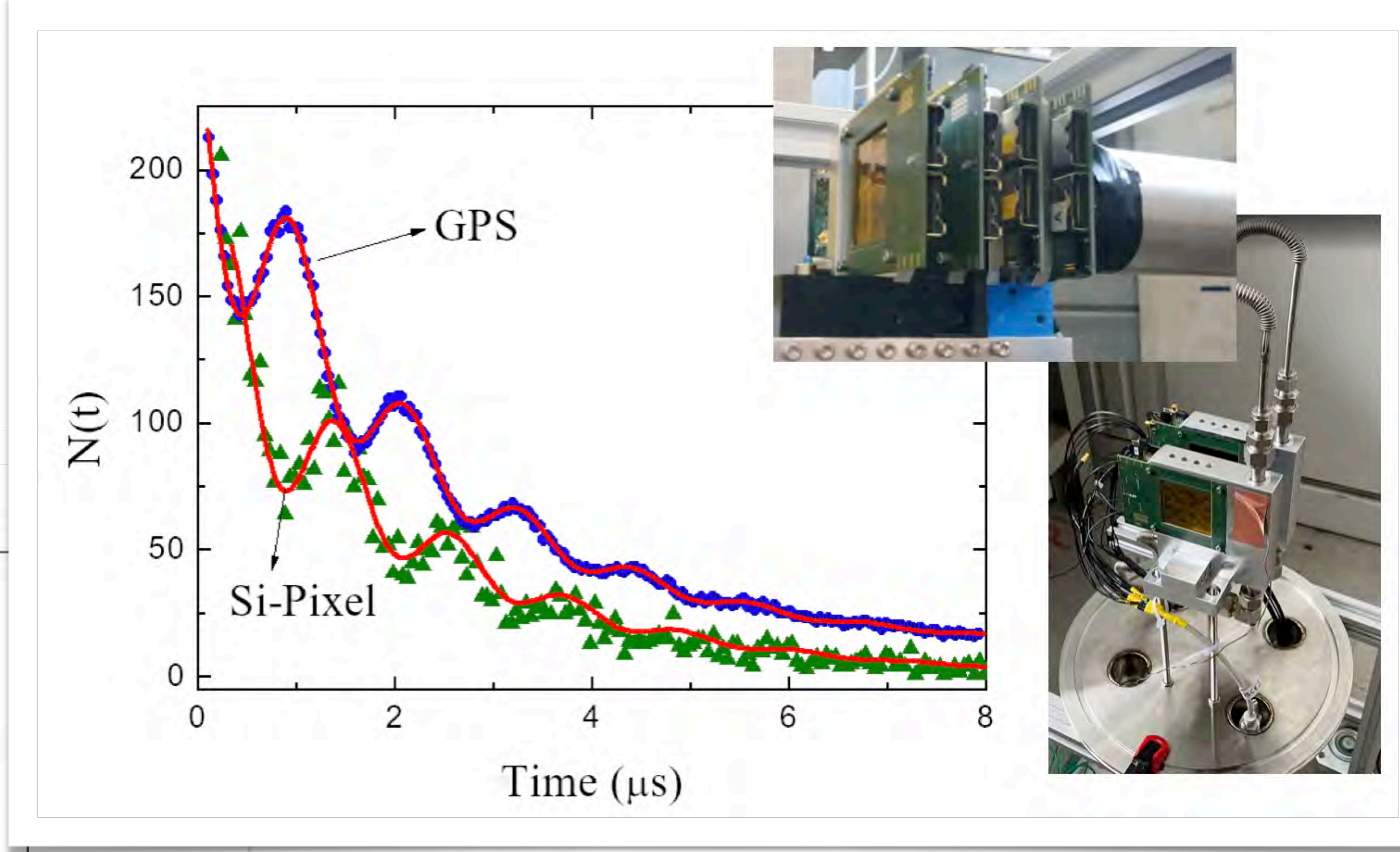
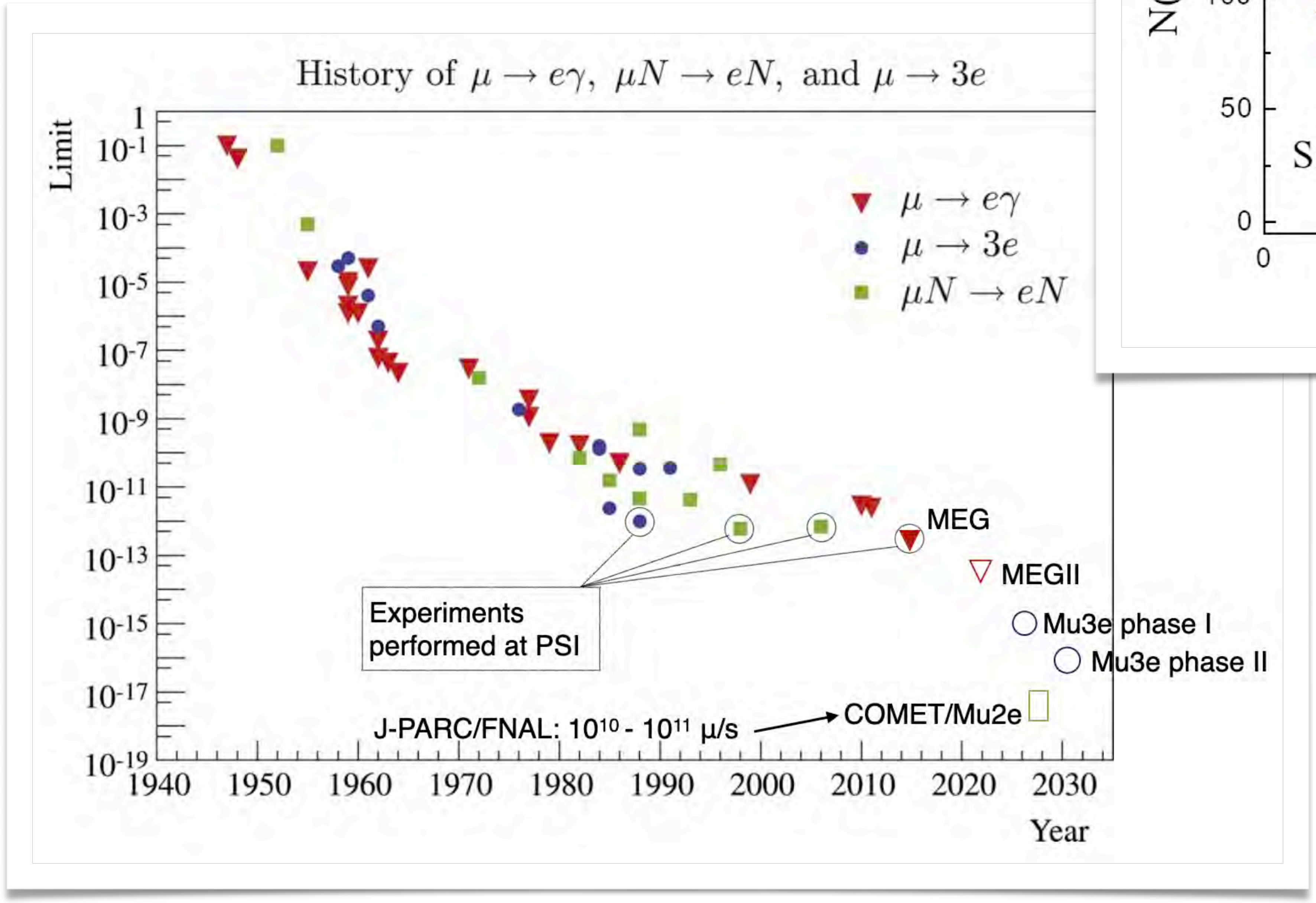


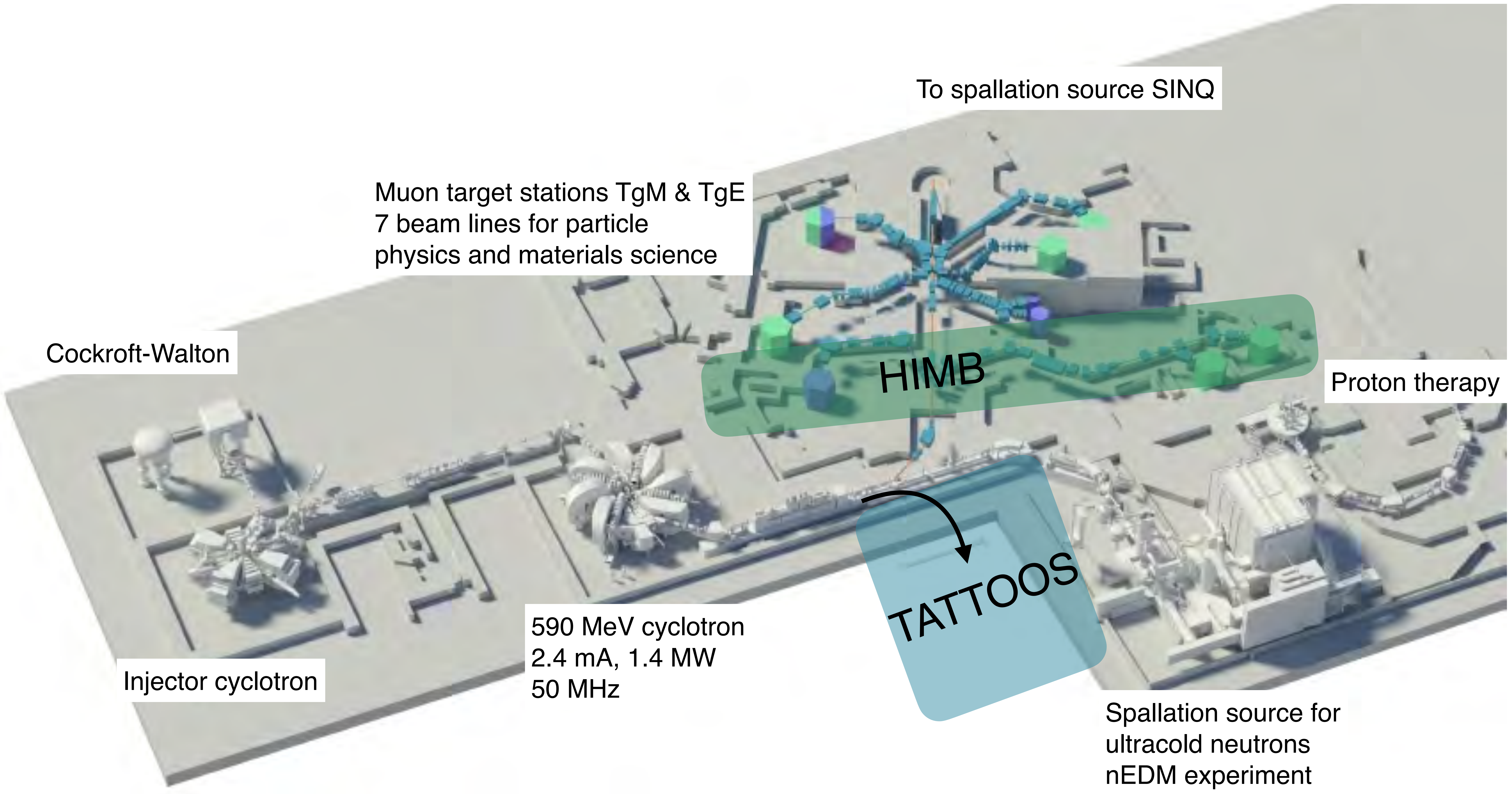
μSR with pixel detectors



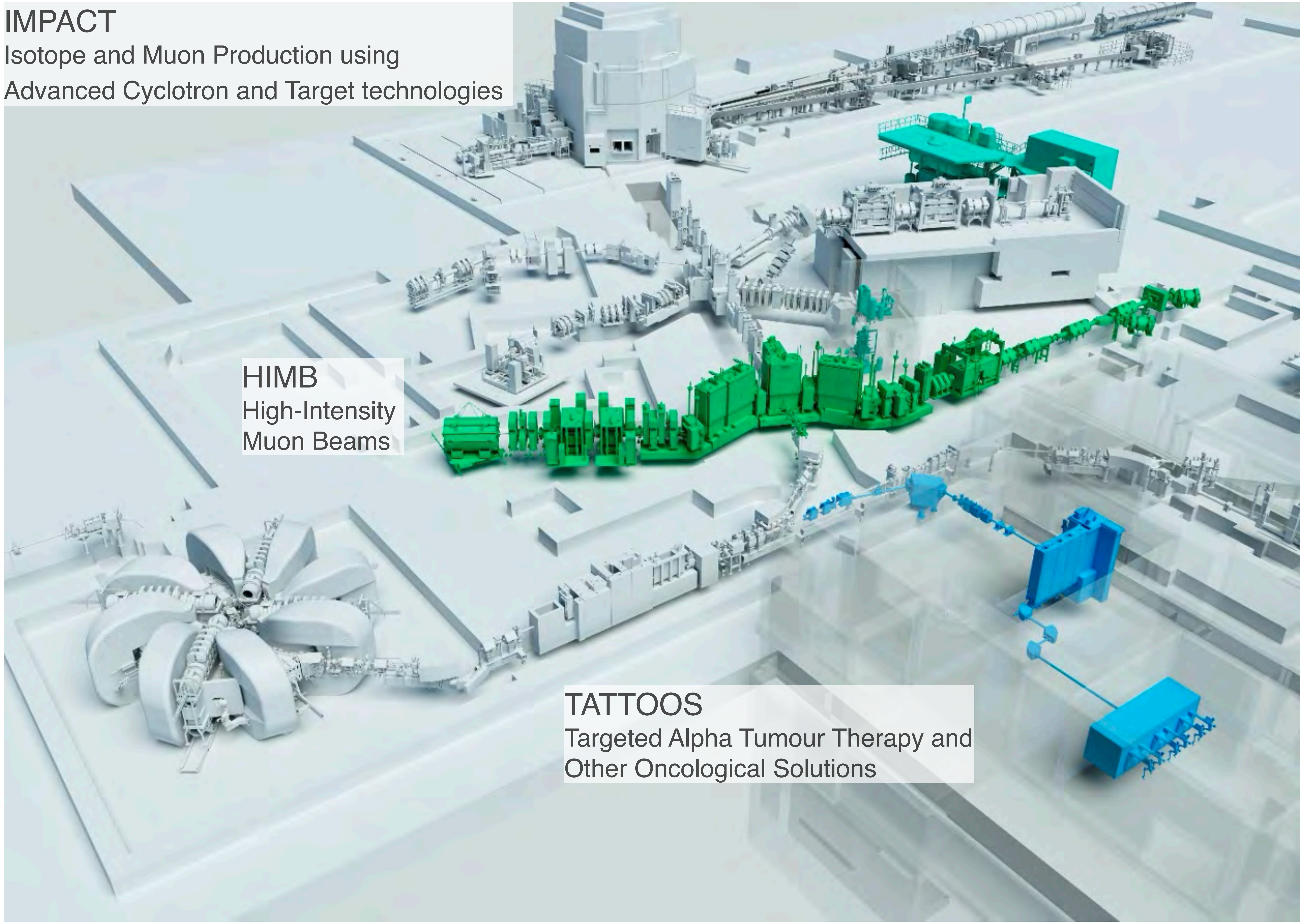
Rare muon decay searches

www.muoniverse.ch

PSI Proton Accelerator HIPA



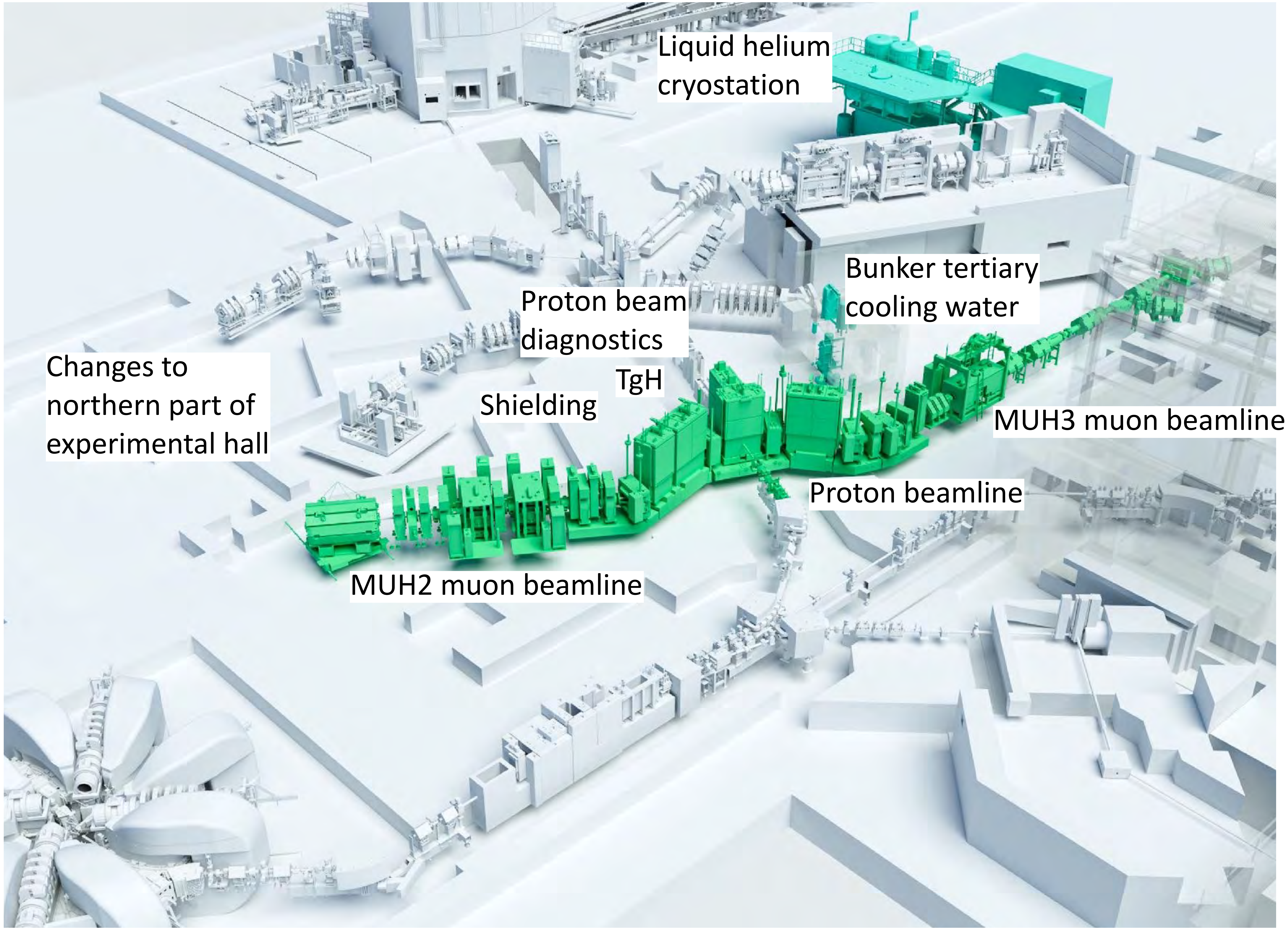
IMPACT: HIMB + TATTOOS



TgM area in experimental hall WEHA

To reach 100x more muons: new and optimized target station, capture solenoids close to target, beamline based on large-aperture solenoids and dipoles

HIMB components



Plus:

- Removal of existing TgM
- Removal and installation of infrastructure
- Equipment such as exchange flask, parking cells, etc.
- Logistics, planning
- Safety
- Approval process
- …

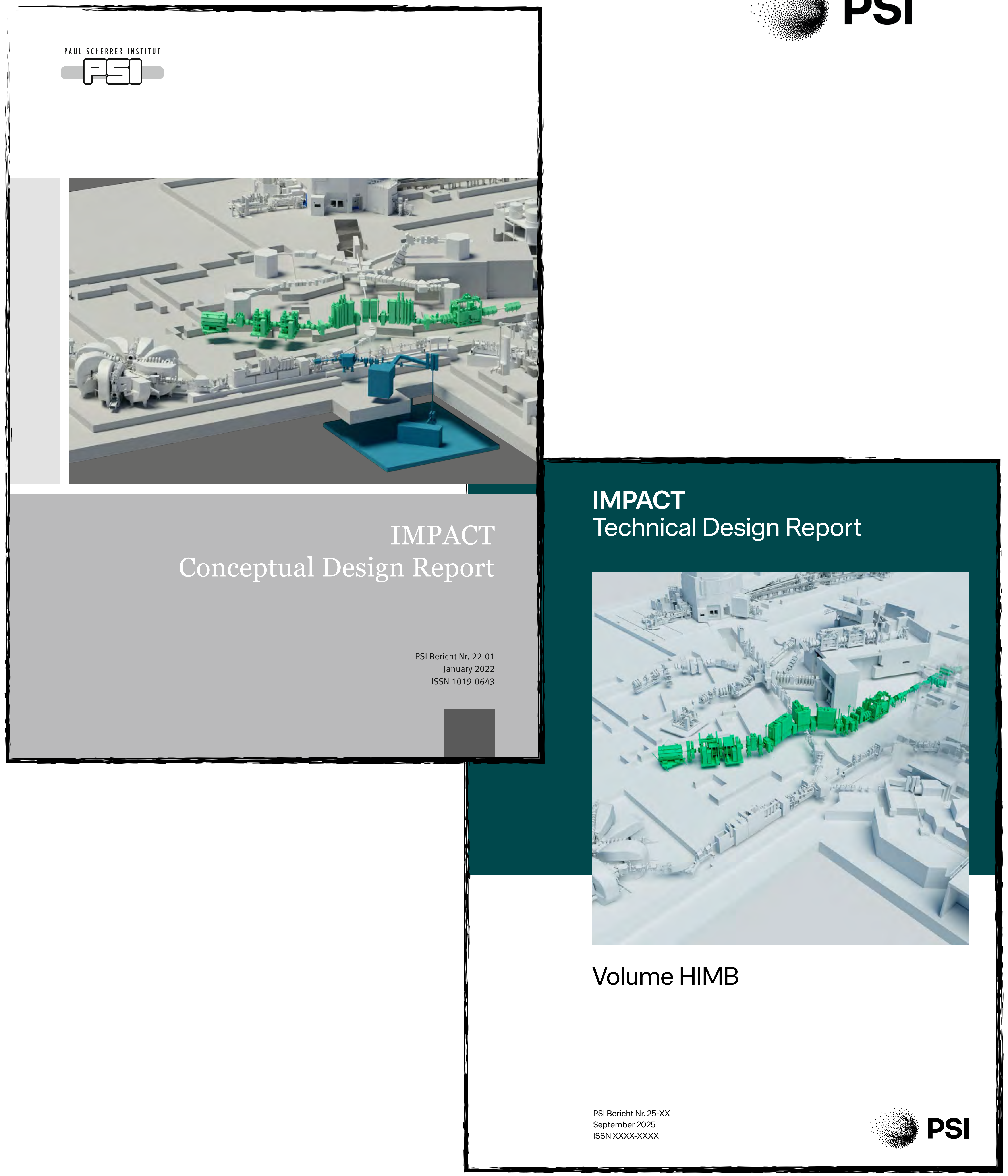
Design reports

Large effort by close to 100 authors and many more contributing

Basis of approval process (CDR) and start of procurement and manufacturing (TDR)

Available at:

https://www.psi.ch/en/impact/design-documents

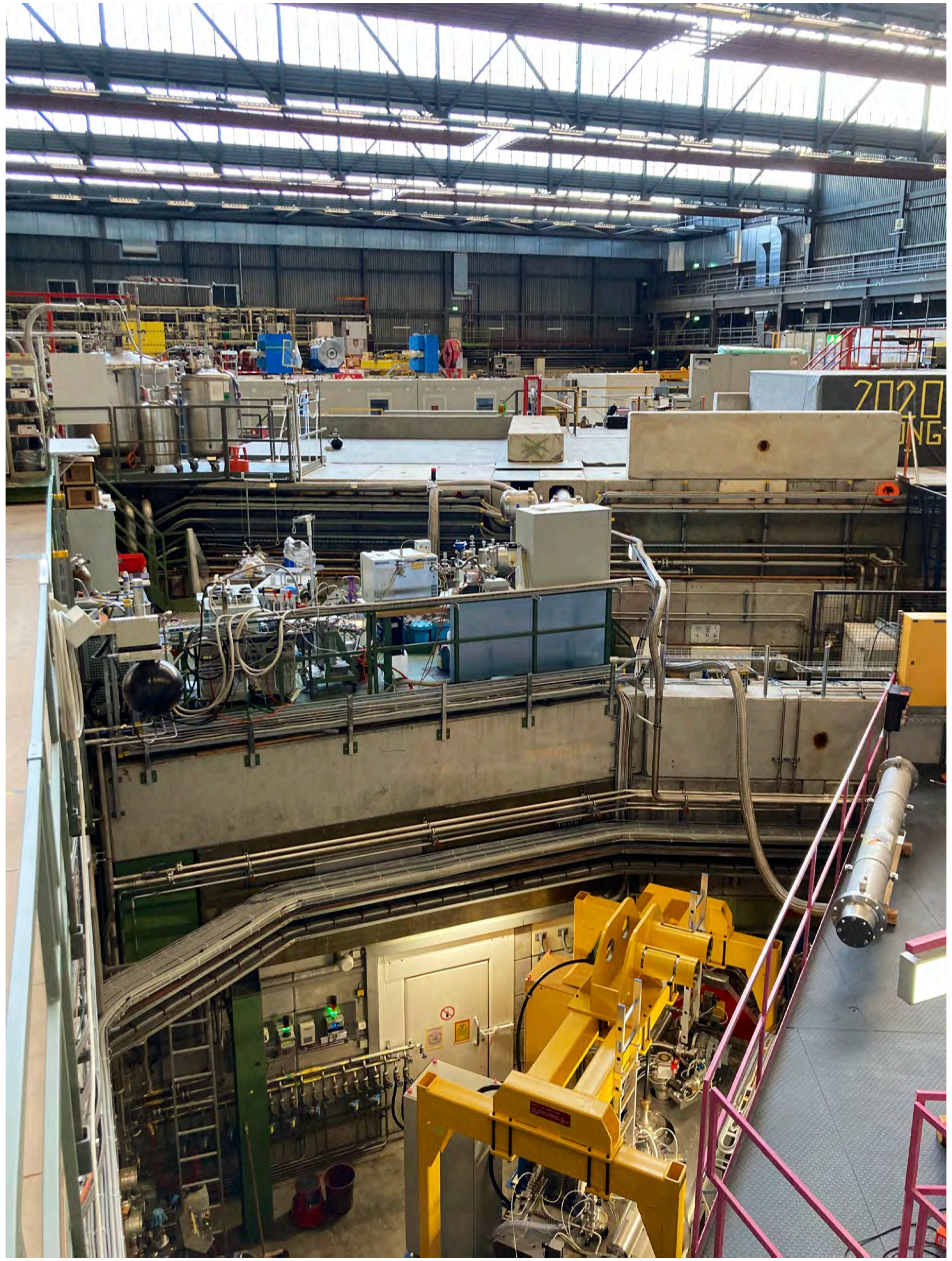


Building a new target station

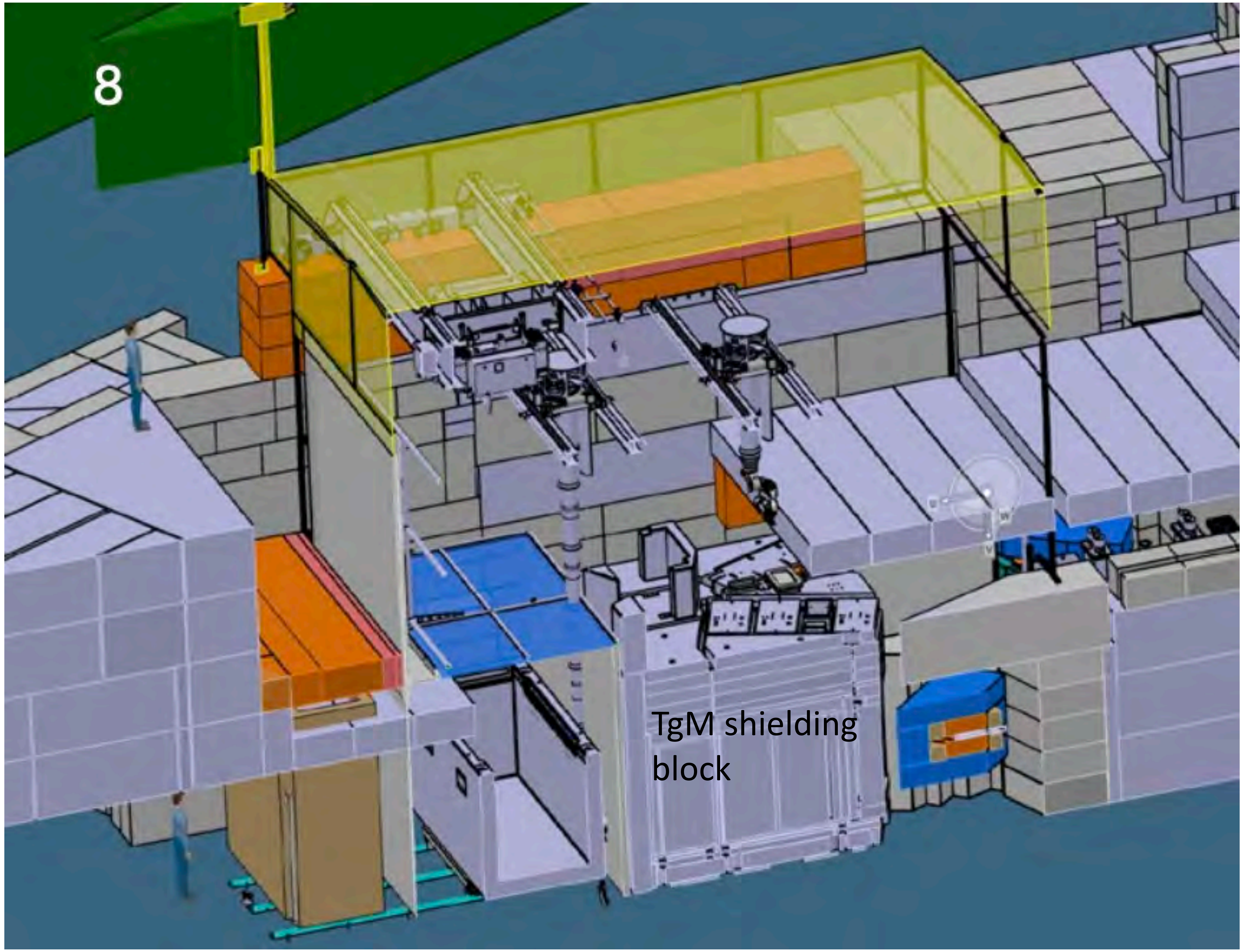
Challenging environment around TgM to change layout

Helium liquefier, tertiary cooling loop 7, lots of pipes, cables and conduits, power supply platforms, …

And of course in an environment with doses up to several Sv/h



TgM Dismantling



Several highly active components removed by exchange flask.

Installation of housing for contamination protection, remote-controlled crane, power manipulator and camera system.

Pieces to be packaged into containers and moved via lock system.

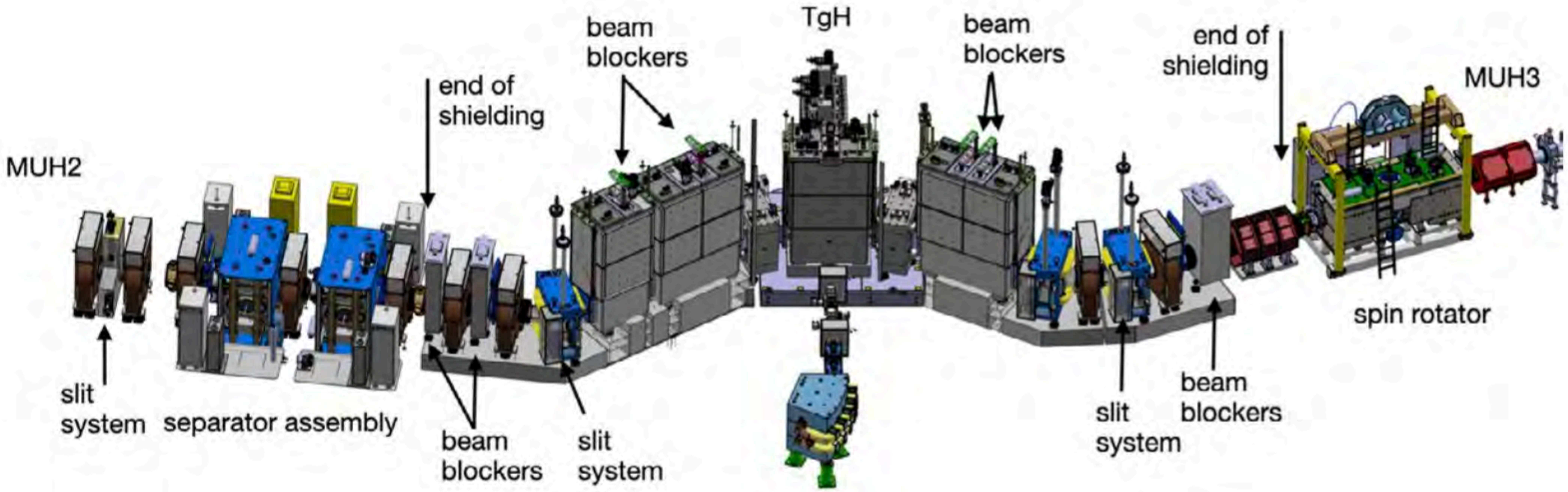
Several of the less activated shielding blocks to be reused in TgH shielding.

Layout MUH2 and MUH3

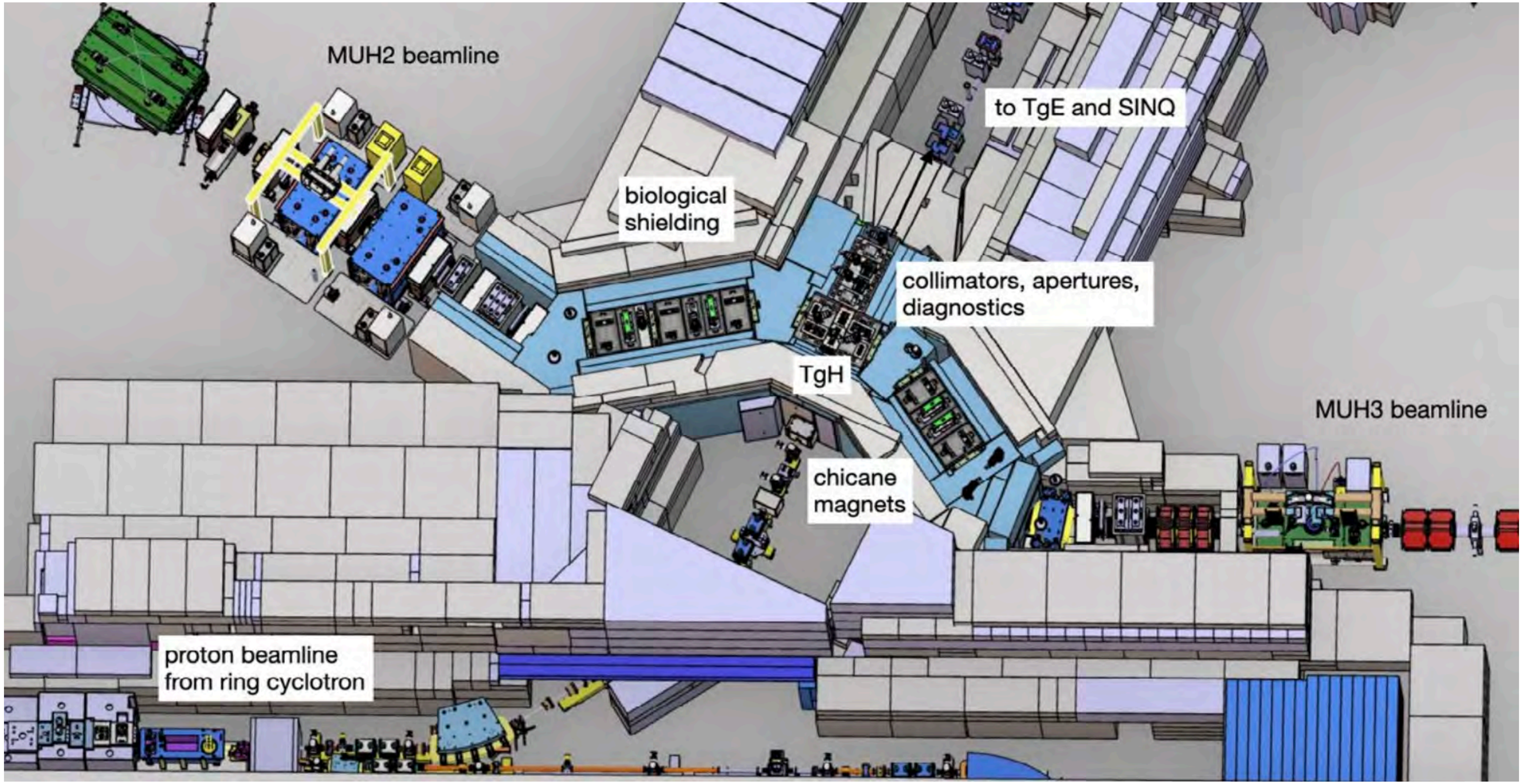
Two specialized capture solenoids at 250 mm to the slanted target. Beamlines at 90 degrees to proton beam consisting of large 500 mm aperture dipoles and solenoids.

MUH2 for particle physics. MUH3 for muSR coupling into the “existing” beamline.

Layout frozen with vast majority of components final and ordered or under construction or ready for construction.



Shielding layout



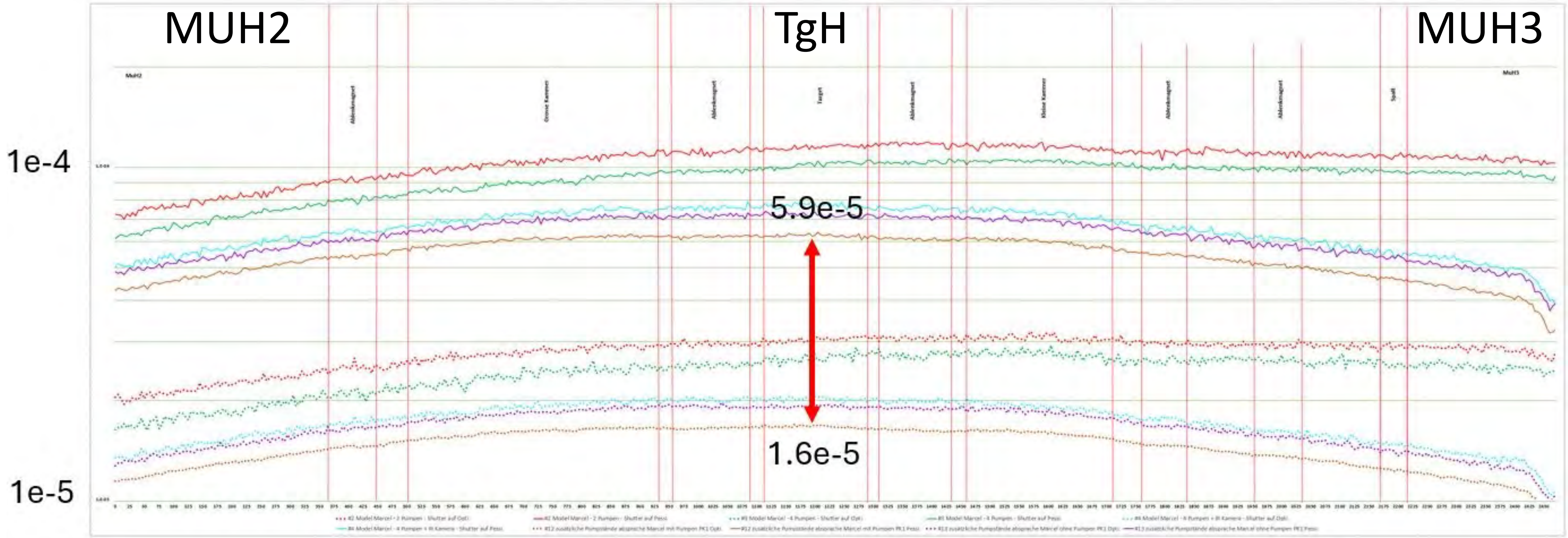
Many components of secondary beamlines MUH2 and MUH3 also realized as inserts. Services for these components located on service level with 2.5 m above beamline and protected by steel.

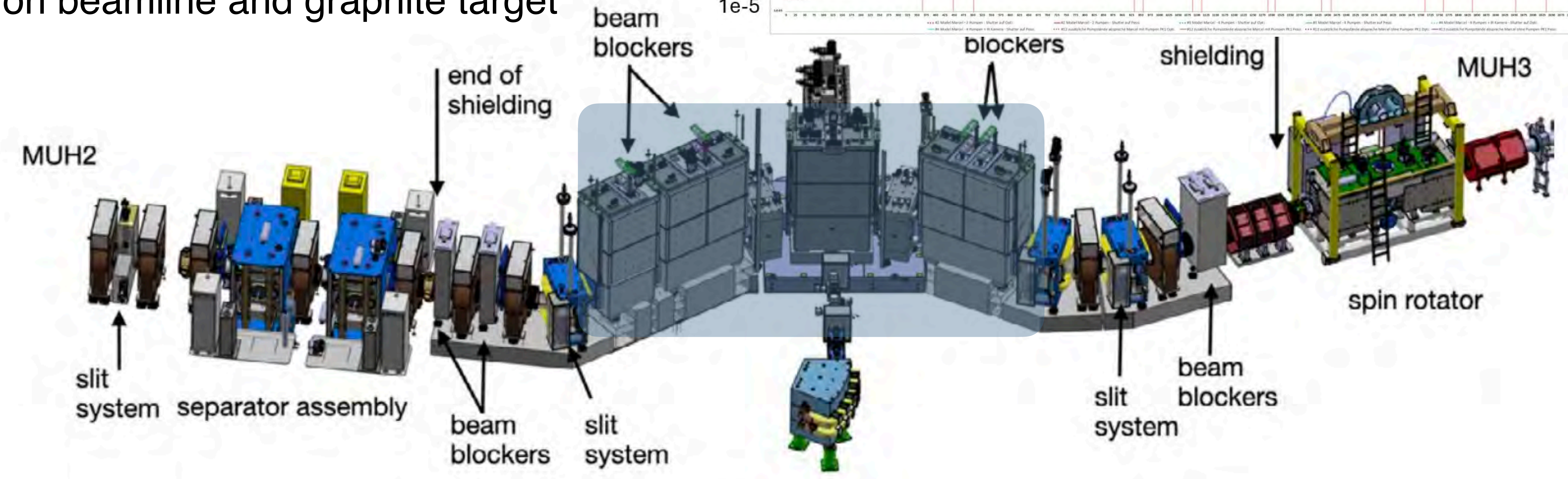
Large vacuum chambers

Central components are placed as inserts into 5 large vacuum chambers: TgH, PK2, 2xMUH2.1/3, MUH2.2

Large-scale vacuum simulations show that a pressure of a few 10^{-5} mbar can be achieved.

Acceptable level for operation of proton/muon beamline and graphite target



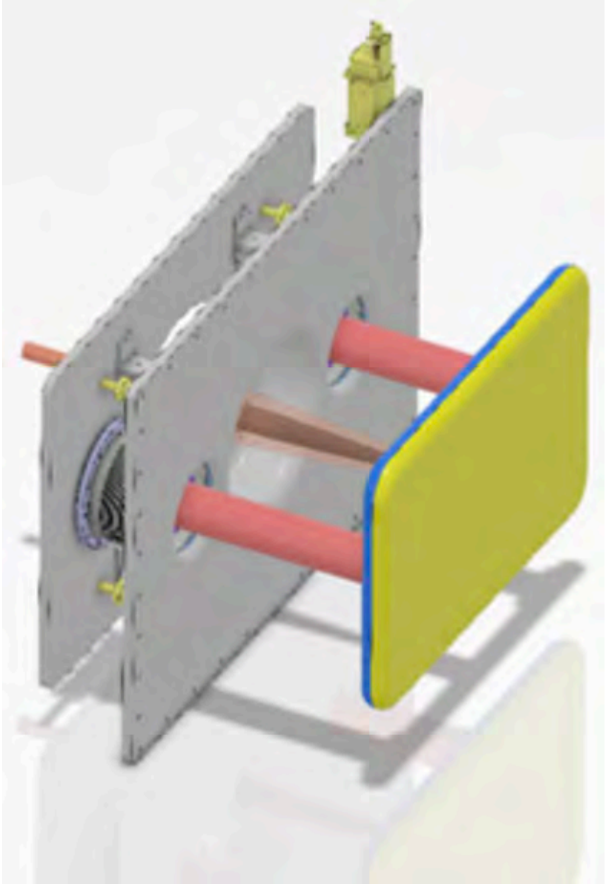


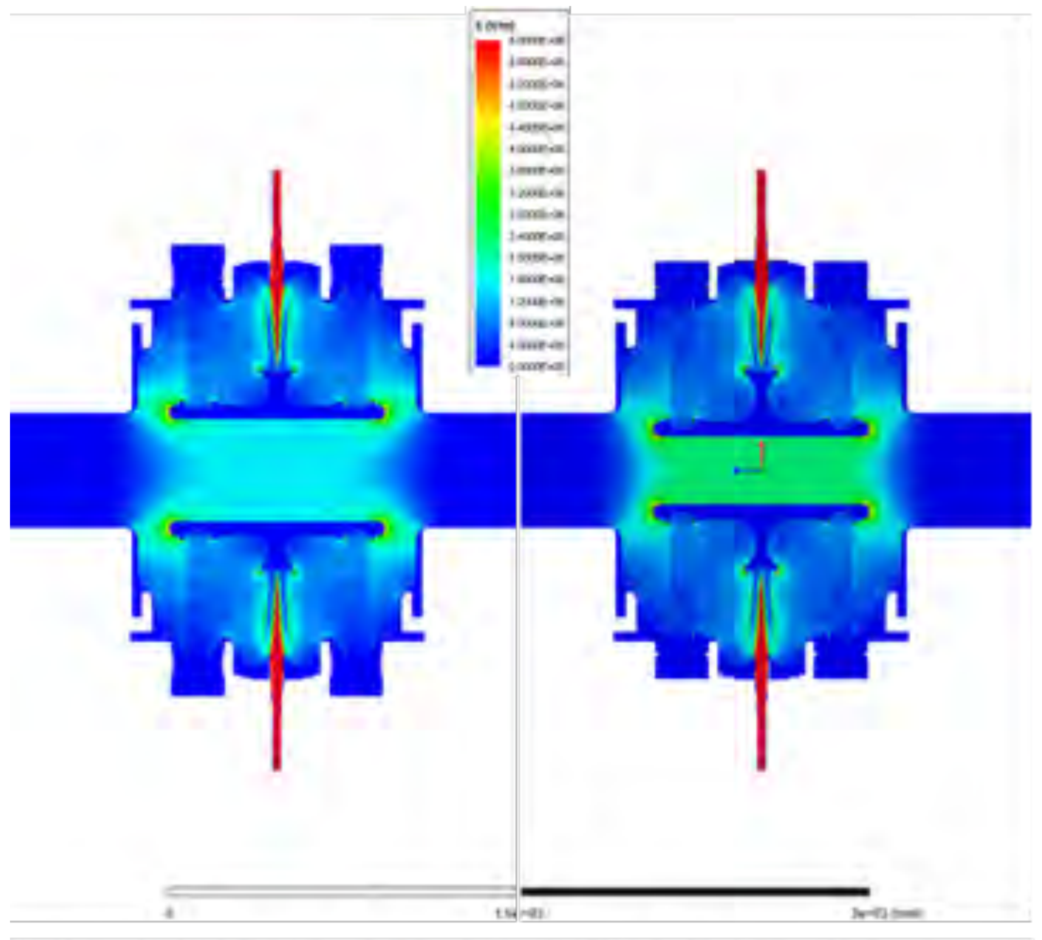
Variable plate Wien-filter assembly

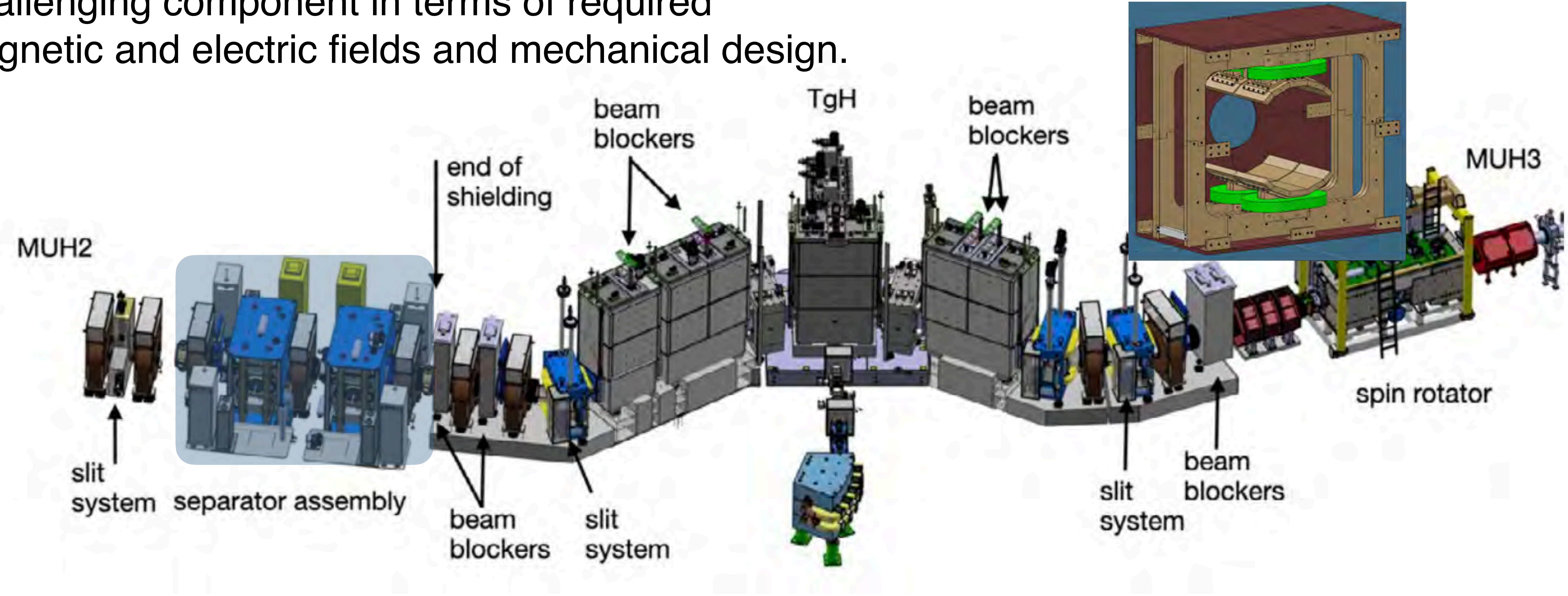
Separator needed to separate positrons from muons with the help of crossed electric and magnetic field.

Design of ±350 kV variable plate separator almost finished. Adjustability of plates allow for gaps between 300 and 450 mm.

Challenging component in terms of required magnetic and electric fields and mechanical design.





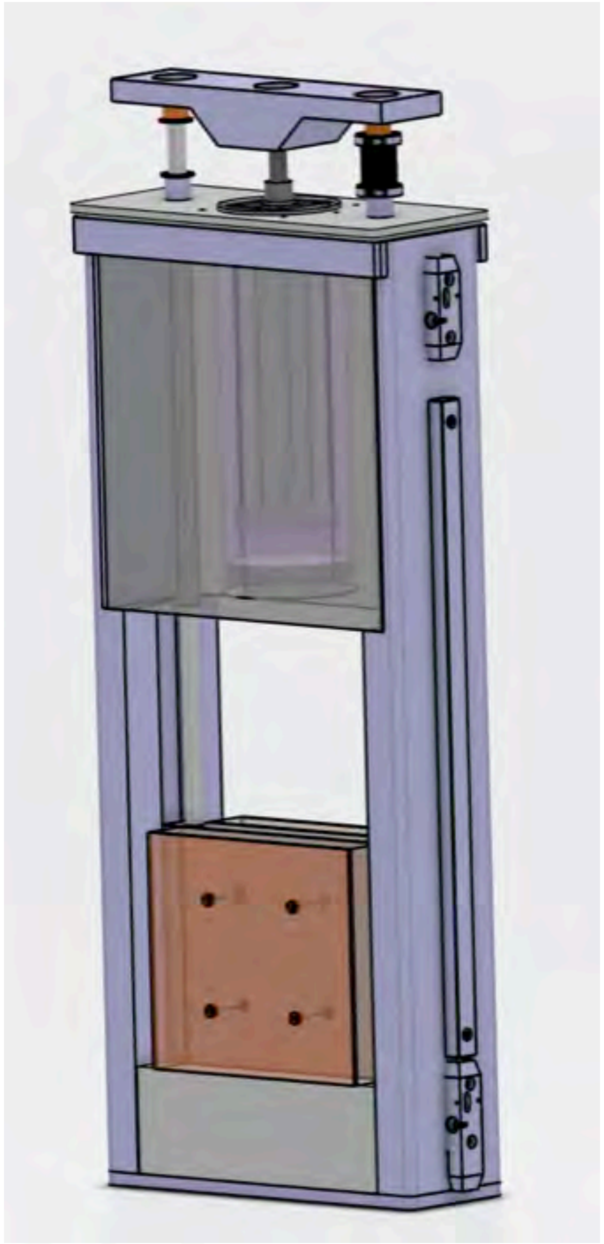


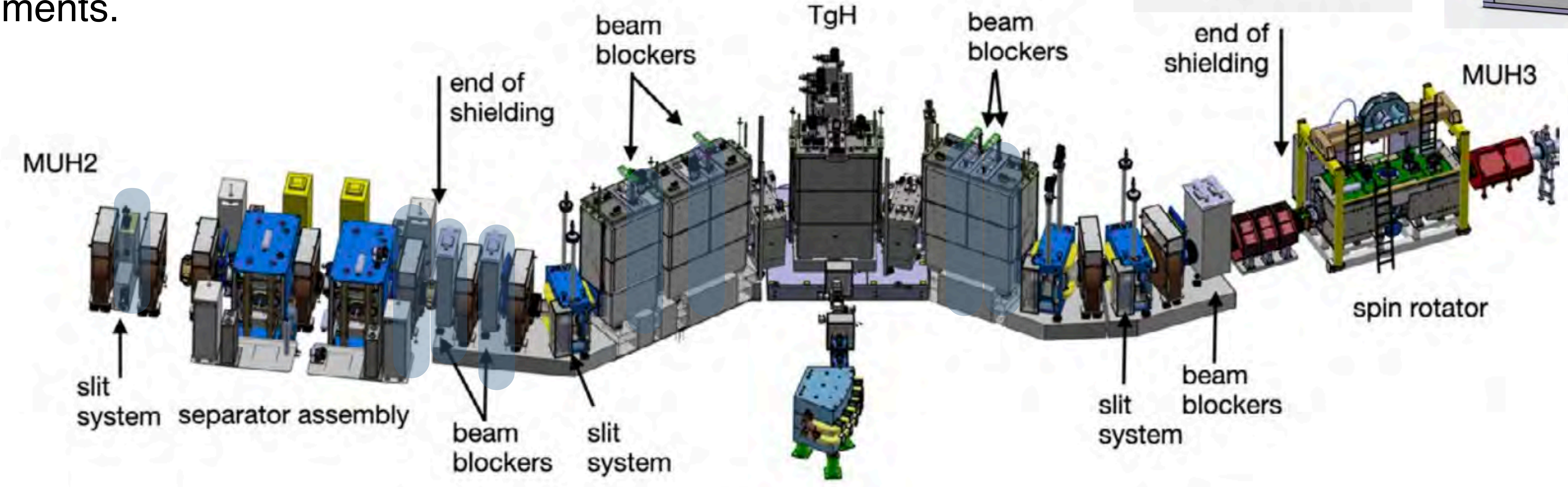
Beam blockers and slit systems

Four beam blockers per secondary beamline used to stop radiation dose from reaching experimental areas when accessible. Two made from copper and stainless steel and two from copper, polyethylene and stainless steel.

Slit systems to control muon rate, muon beam size and momentum distribution.

Beam blockers critical as need to be certified as safety elements.



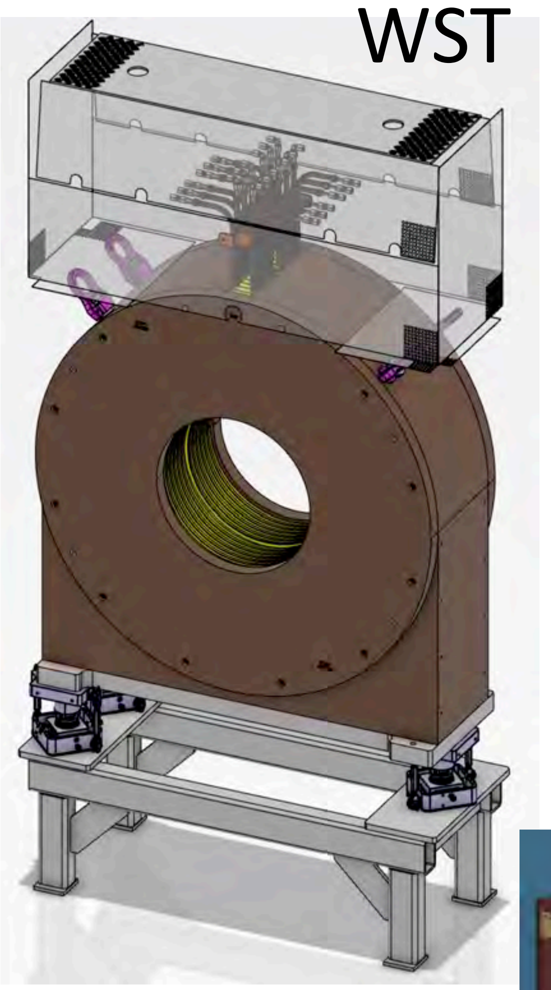


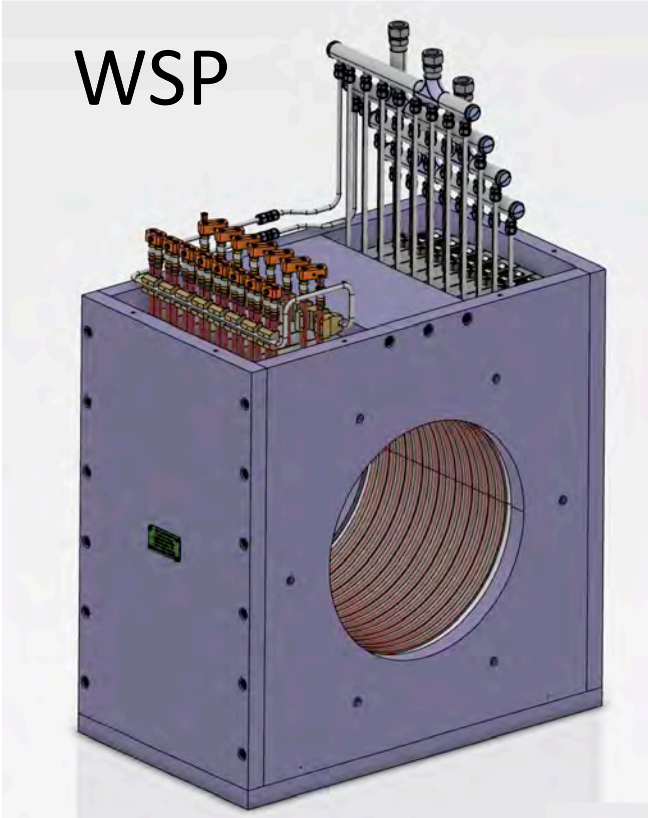
Magnets

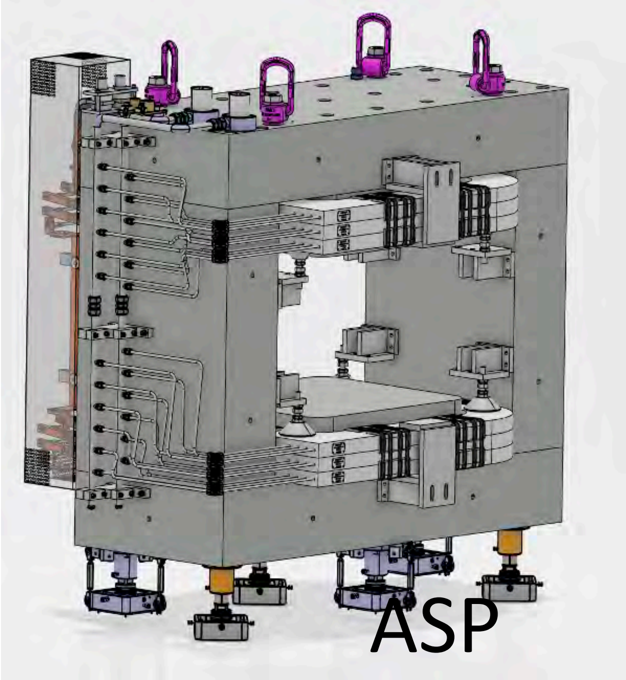
7 new magnet types developed from scratch.

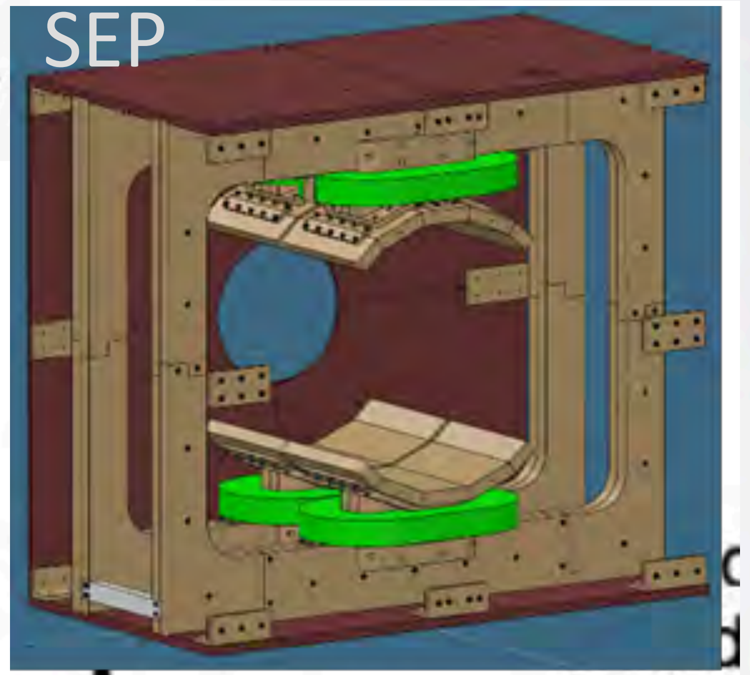
Huge effort with several of the magnets requiring >10 iterations.

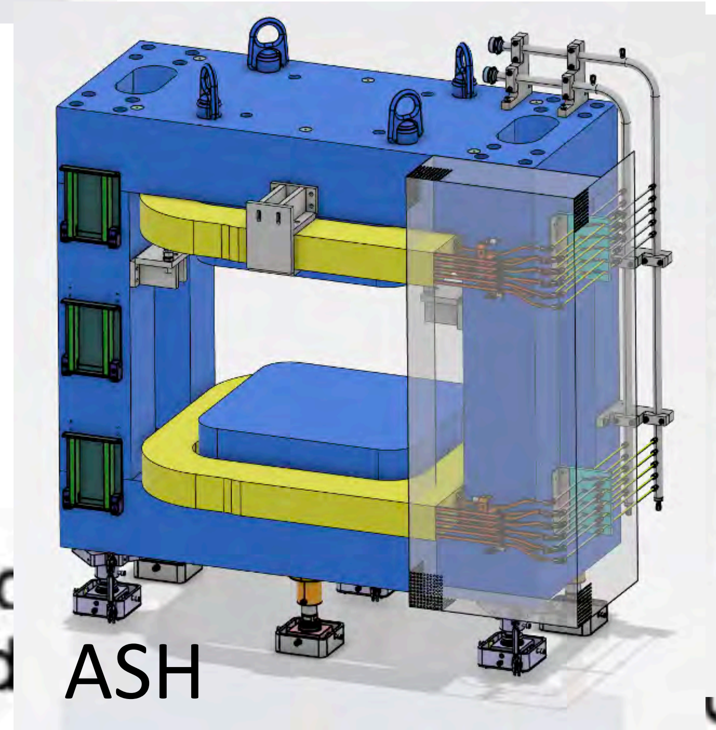
All of the magnets final and ordered. Final field maps calculated and available for simulation.

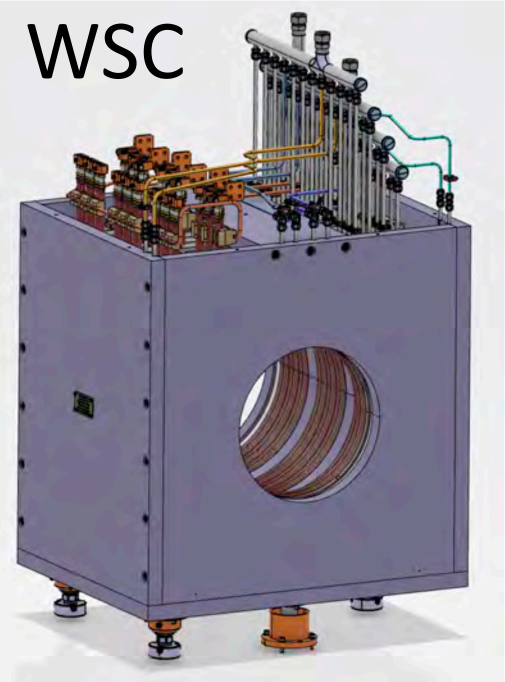


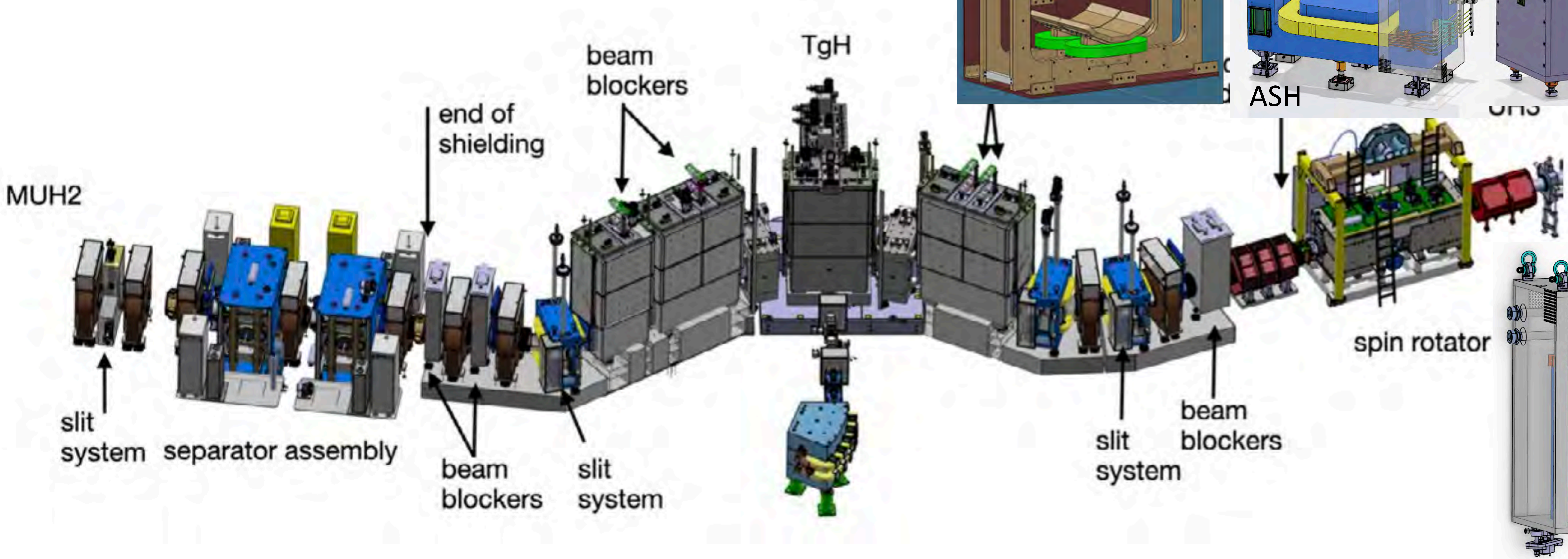


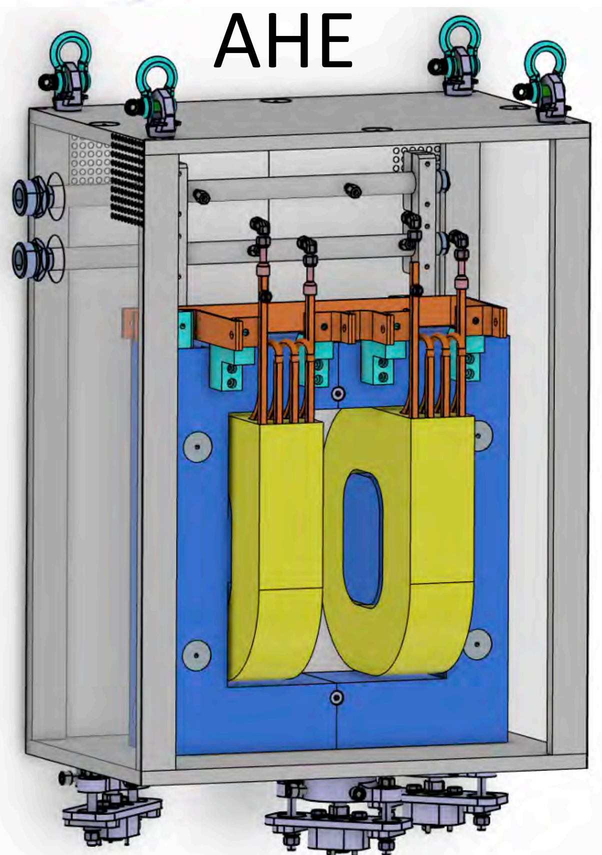








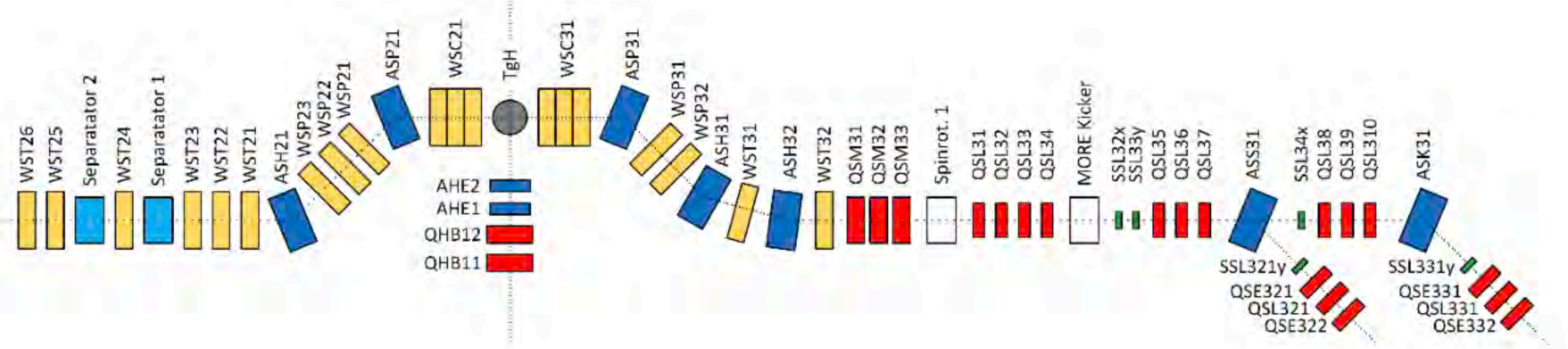


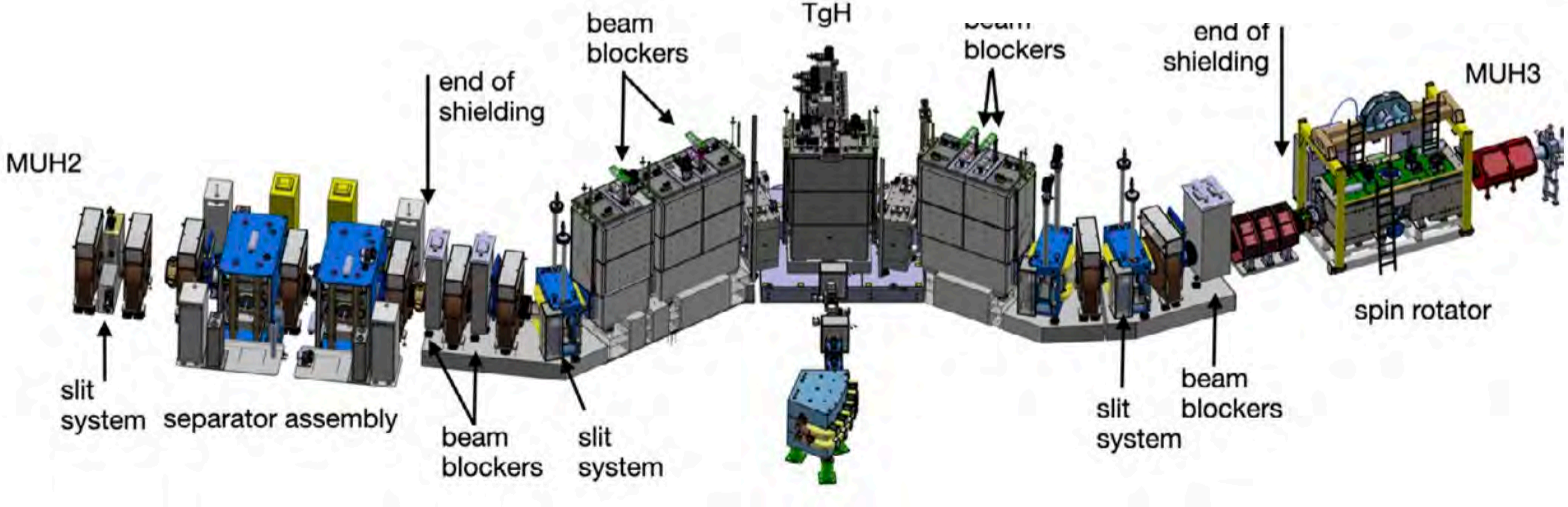


Power supplies

64 power supplies needed for all the magnets relevant to the HIMB project.

6 new variants to be developed and 21 new built. Others reused/reshuffled from existing beamlines.





Exchange flask

New exchange flask capable of extracting most of the new components of TgH, MUH2, MUH3.

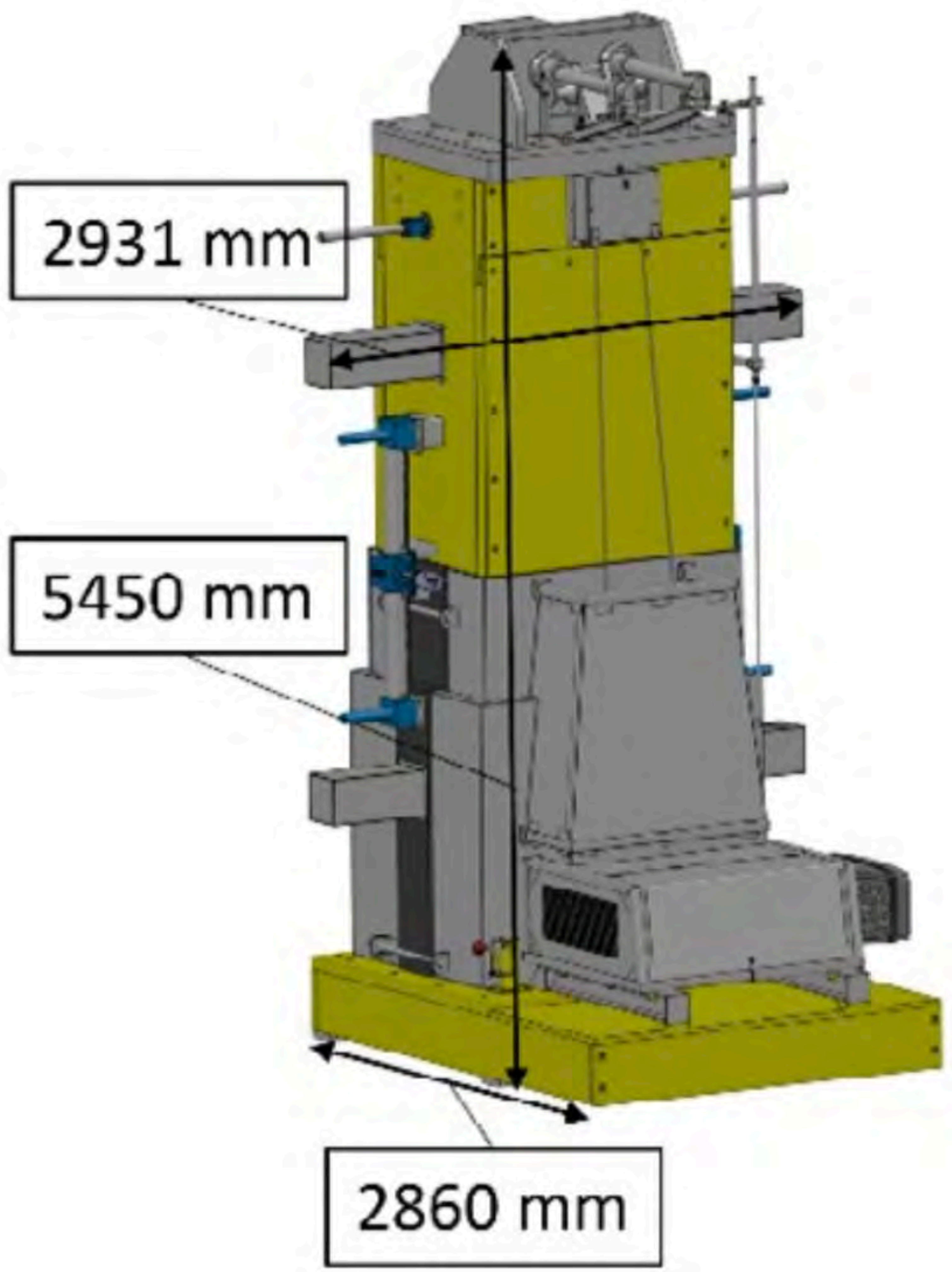
Different adapters (bridges) to mount to target or secondary beamline regions.

Challenges:

Extract capture solenoid including shielding of 14.5 t and stay within hall crane limit of 60 t.

Extract high-activity (40 Sv/h) items such as local shielding.

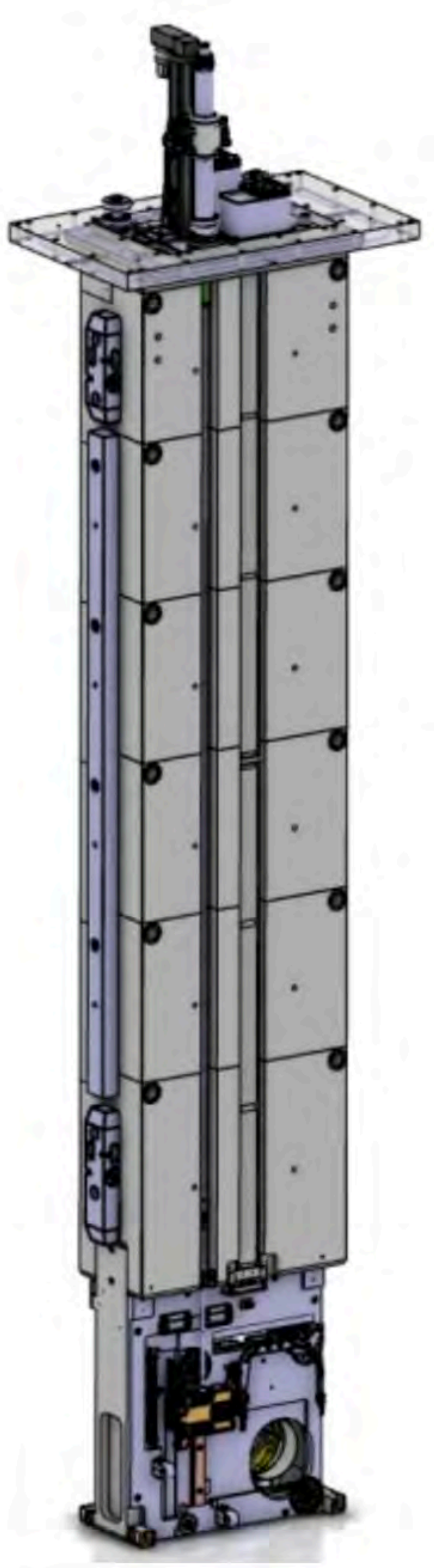
Additional shielding can be mounted to cope with the high-activity items

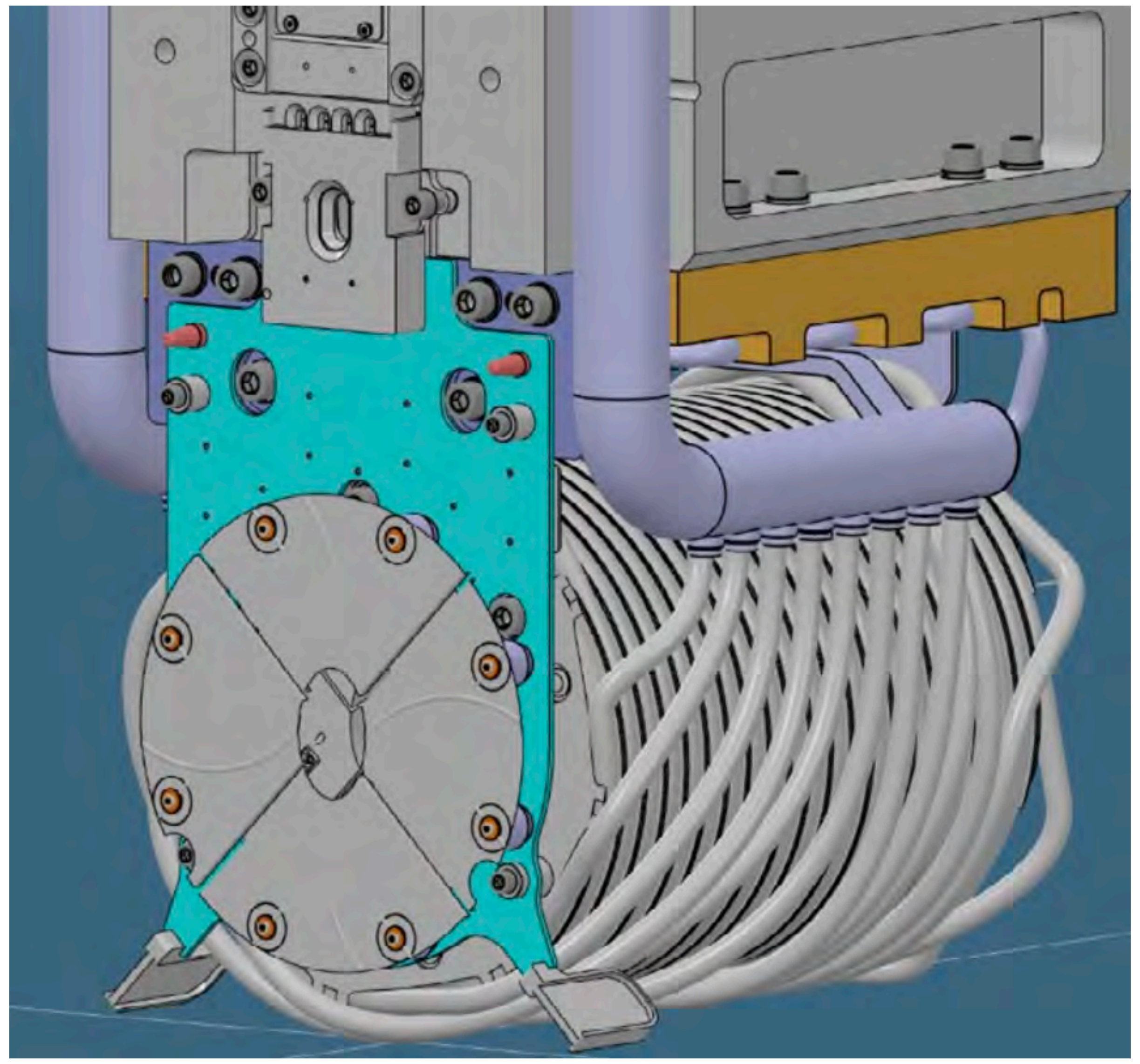


Proton beam diagnostics

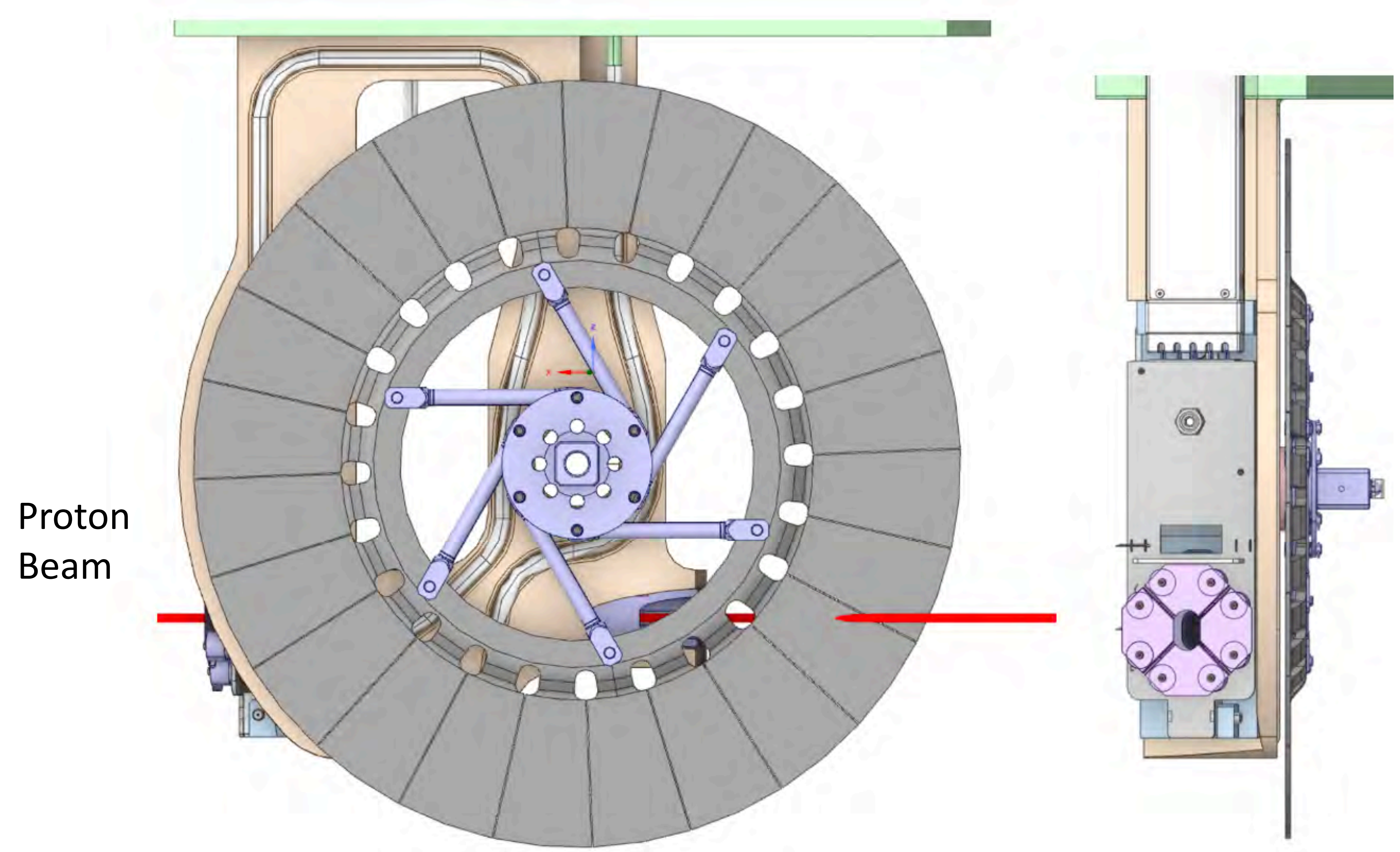
New proton beam diagnostics (beam position and profile monitors, aperture foils) upstream and downstream of TgH to control proton beam and ensure correct passage of beam through the target and further.

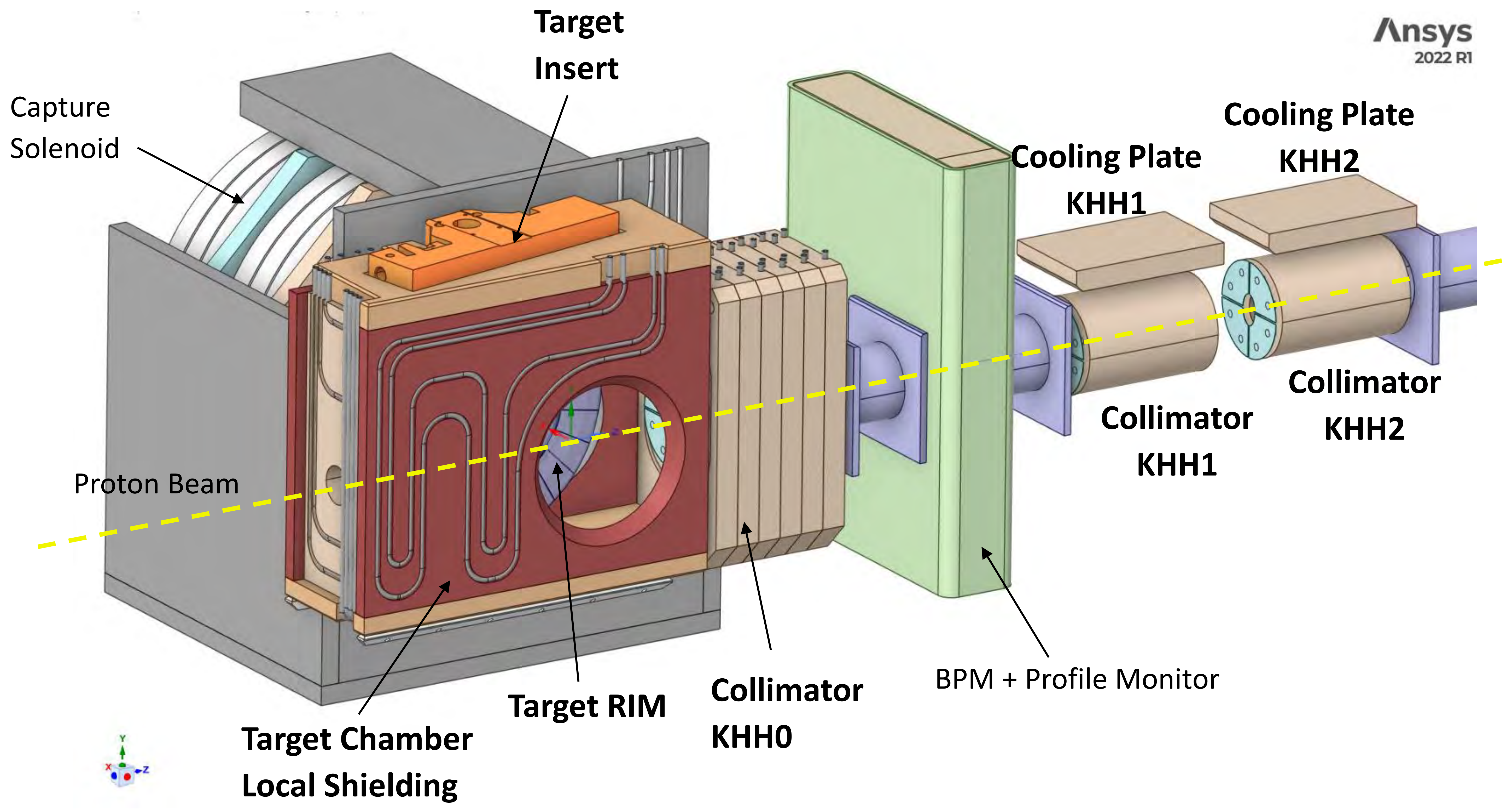
Additionally, read-out electronics is completely renewed.





New Target H





Challenging to fit target into small gap of <500 mm available between the two capture solenoids
Based on experience from TgM & TgE; same exchange concept as for TgE

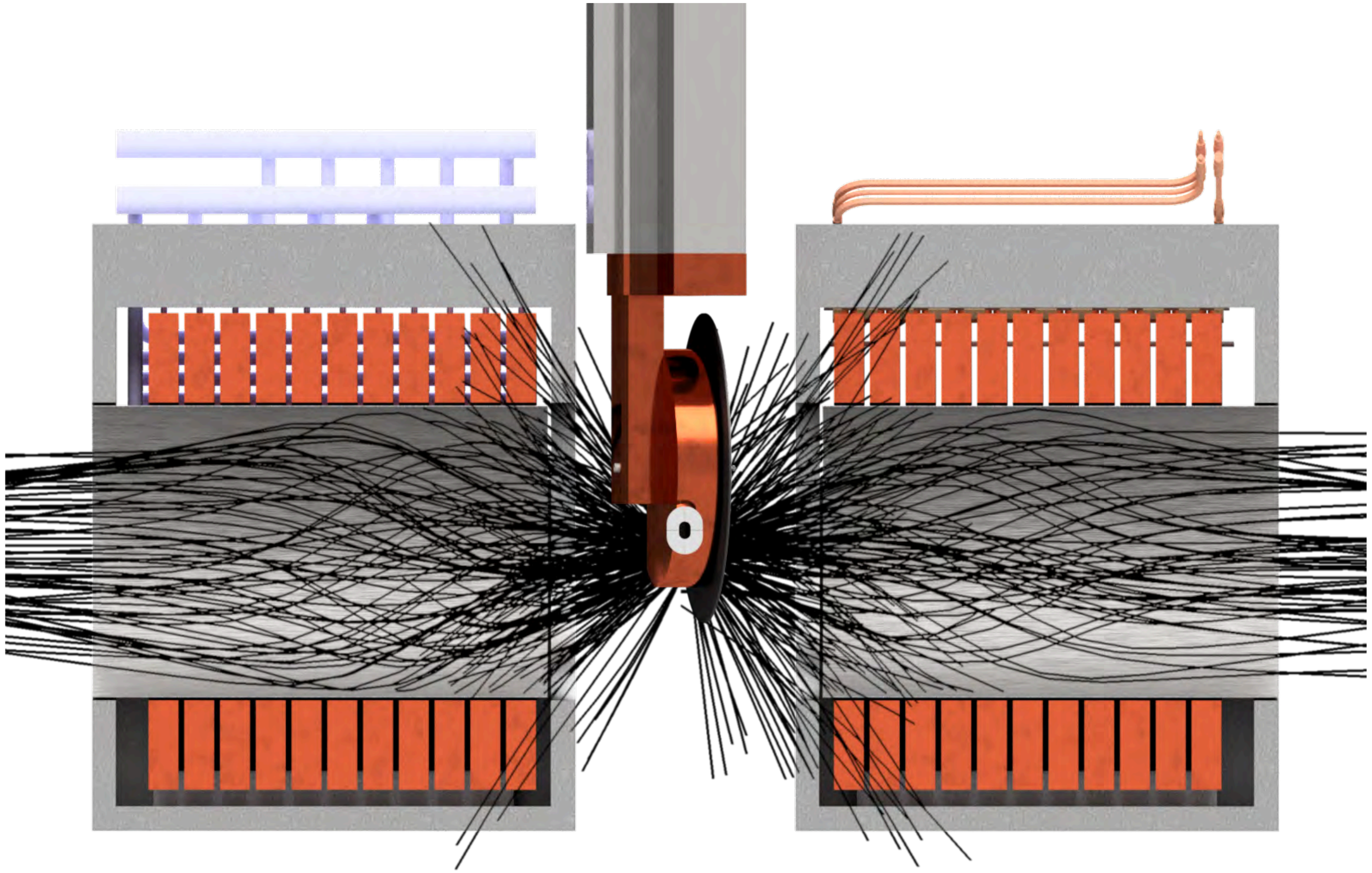
Split Capture Solenoids for Muon Collection

Two normal-conducting, radiation-hard solenoids 250 mm away from target to capture surface muons

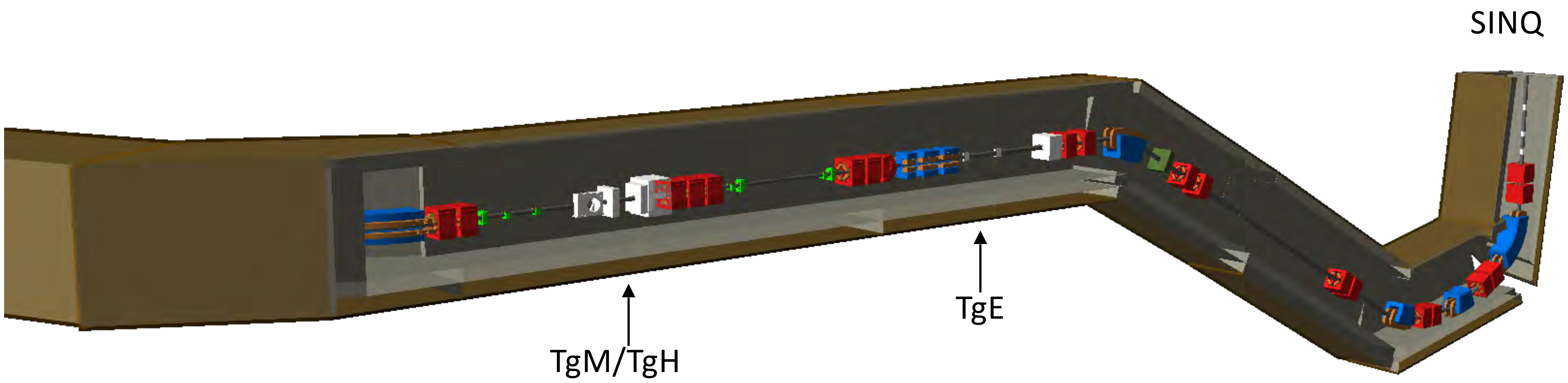
Central field of solenoids up to 0.45 T

Graded-field capture solenoid: stronger field at capture side, weaker at exit

Continue with high-aperture solenoids and dipoles for big increase in transmission over quadrupole based beamline



Proton beam simulations



Full simulation of high-energy proton beam line in BDSIM

Used to specify chicane magntes in fron of TgH to counteract fringe field of capture solenoids

Transmission to SINQ with TgH 67% compared to 69% with TgM

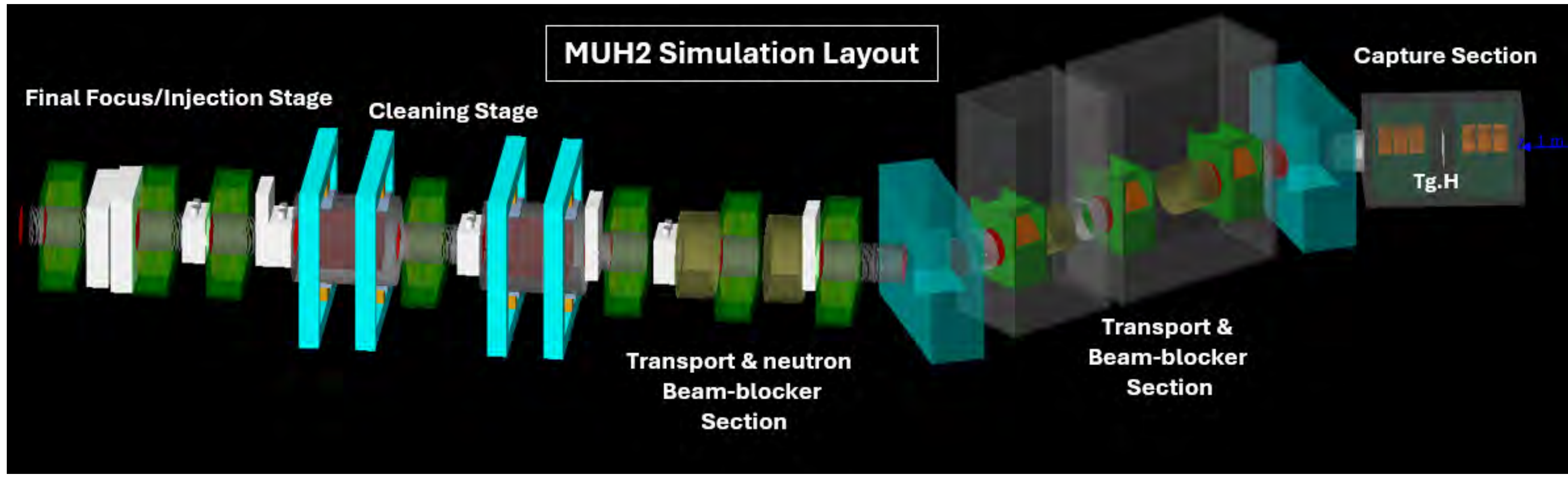
Can increase transmission back up to 69% when collimators after TgE are optimised

Beam shape at TgE and SINQ preserved

Simulated performance of muon beamlines

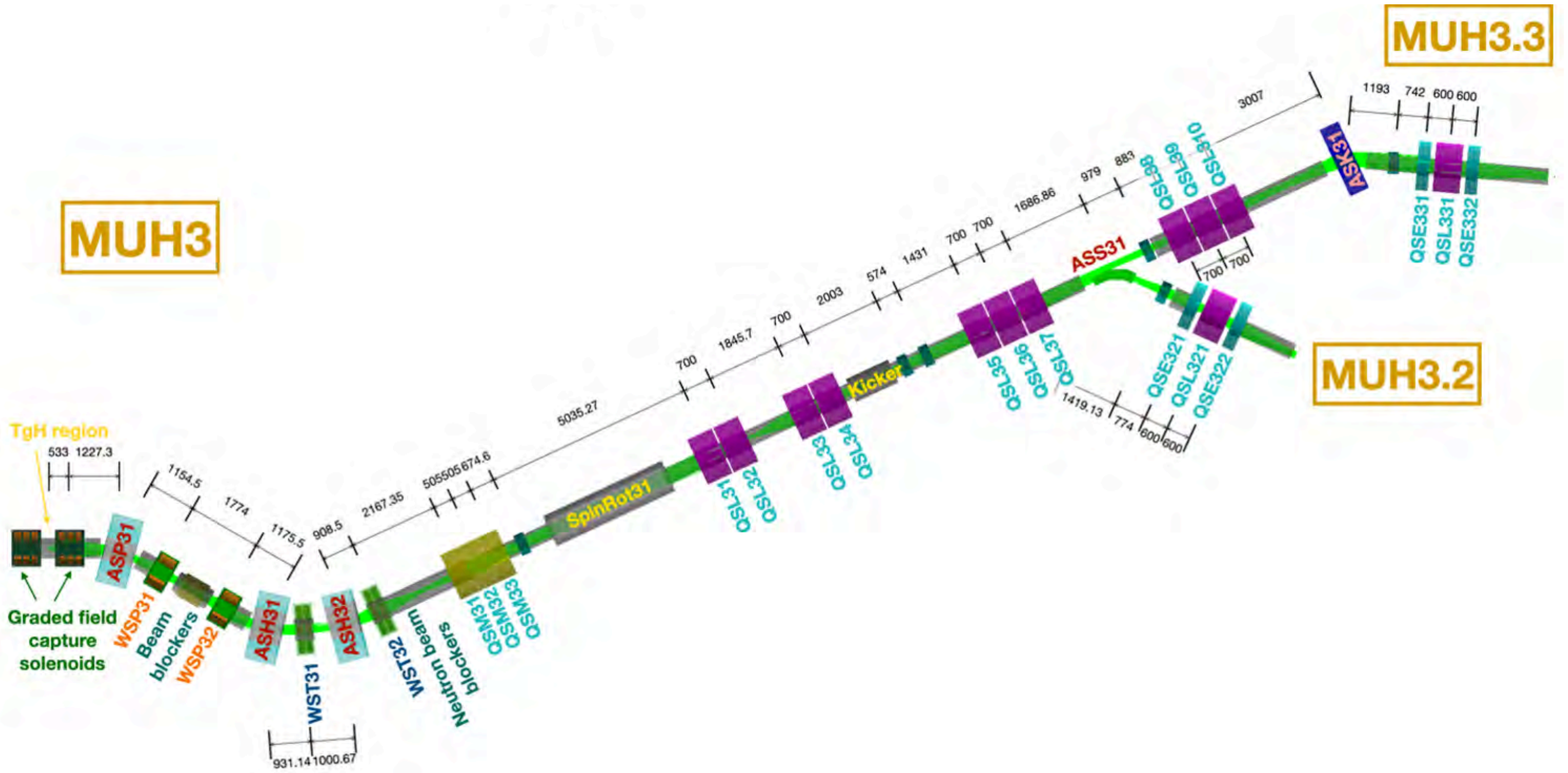
Transmitted rate to the end of the MUH2 beamline at 2.4 mA proton current (maximum rate):

- 1.06×10^{10} μ^+/s at 28 MeV/c
- Beam spot at final focus: $\sigma_x \sim \sigma_y \sim 37$ mm
- Positron contamination ~4%



Transmitted rates to the end of the MUH3 beamline at 2.4 mA proton current:

- More than 10^{10} μ^+/s at 28 MeV/c at the end of the solenoidal part
- More than a factor 10 higher muon rate on 8-mm µSR entrance detector than currently available: $\sim 4 \times 10^{6}$ μ^+/s
- Pixel detector technology crucial to go beyond the current maximum acceptable rate of $\sim 4 \times 10^{4}$ μ^+/s

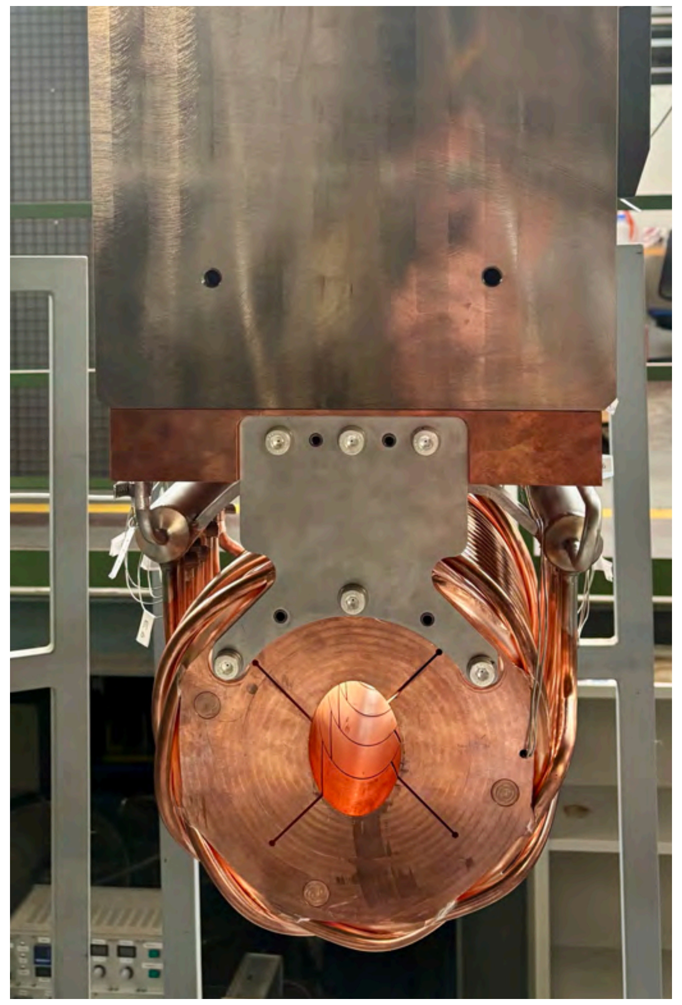


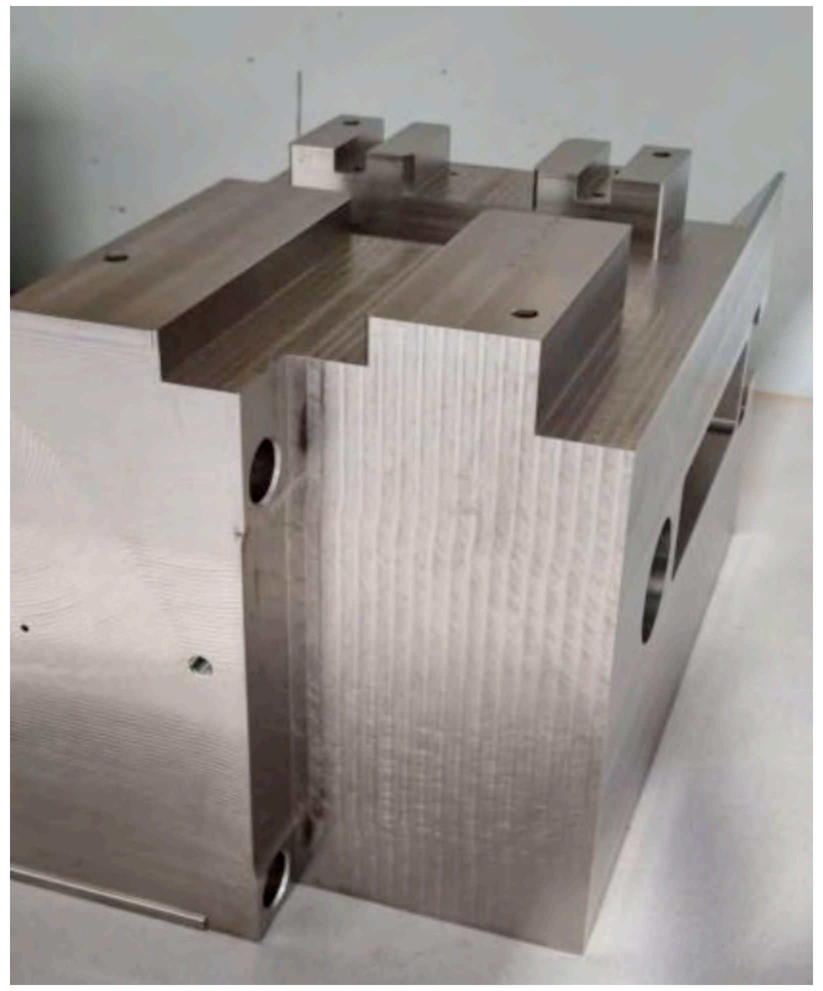
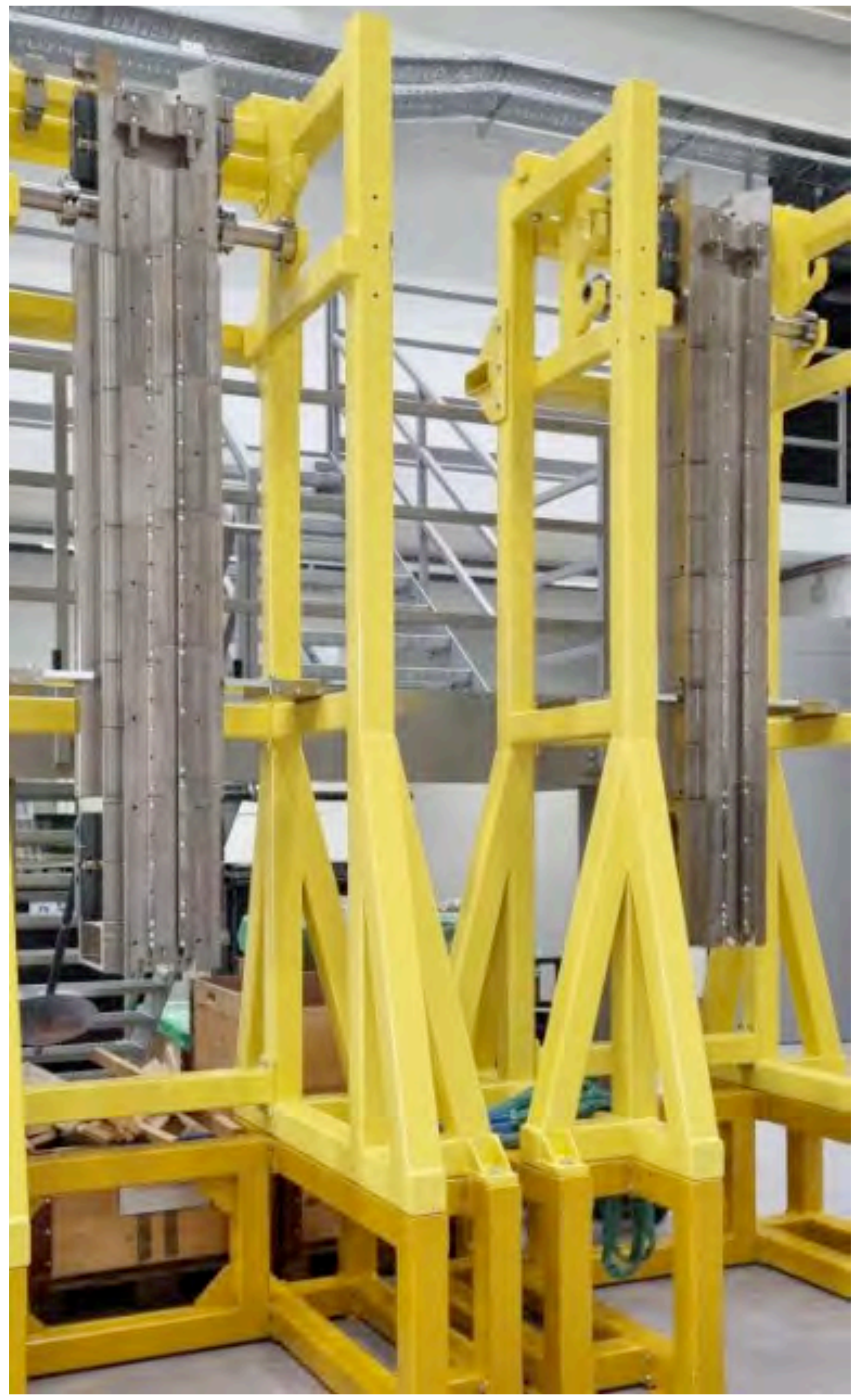
Continuously updated simulations show that we are still fulfilling specifications

HIMB under way!

First external components arriving and being tested

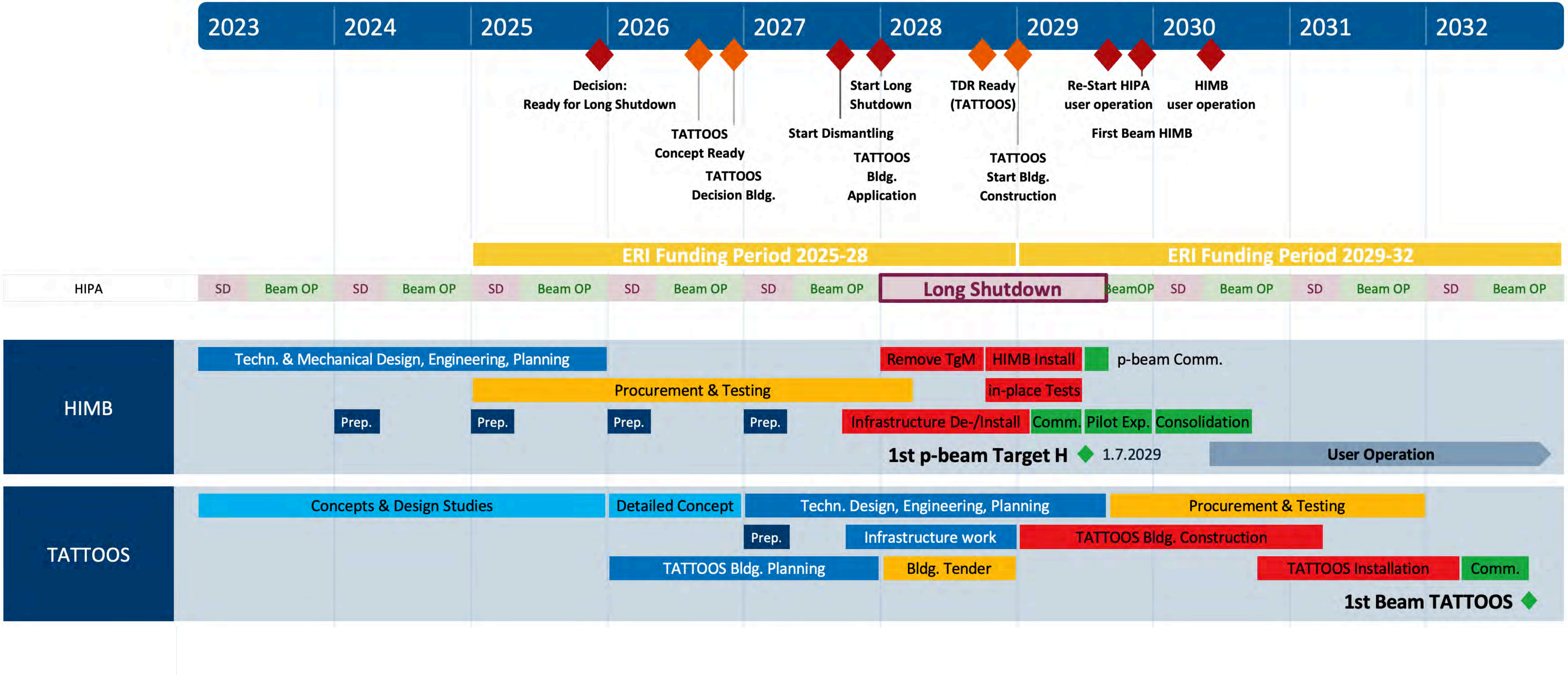
Internal production in full swing with full components being assembled, instrumented and tested





Time schedule IMPACT & Milestones



Timeline HIMB

2026:

- In-house manufacturing
- Prepare WEHA for pre-assembly of target station and first parts MUH2/MUH3

2027:

- Move of lHe cryoplant
- Pre-assembly of large vacuum chambers plus inserts
- Early shutdown of piM1, muE4, piM3
- Prepare and clear space in WEHA

2028:

- Start TgM dismantling
- Start installation HIMB

2029:

- ***1. 7.*** First proton beam on TgH
- ***3. 9.*** Start HIPA user operation; commissioning and pilot experiments MUH2/MUH3

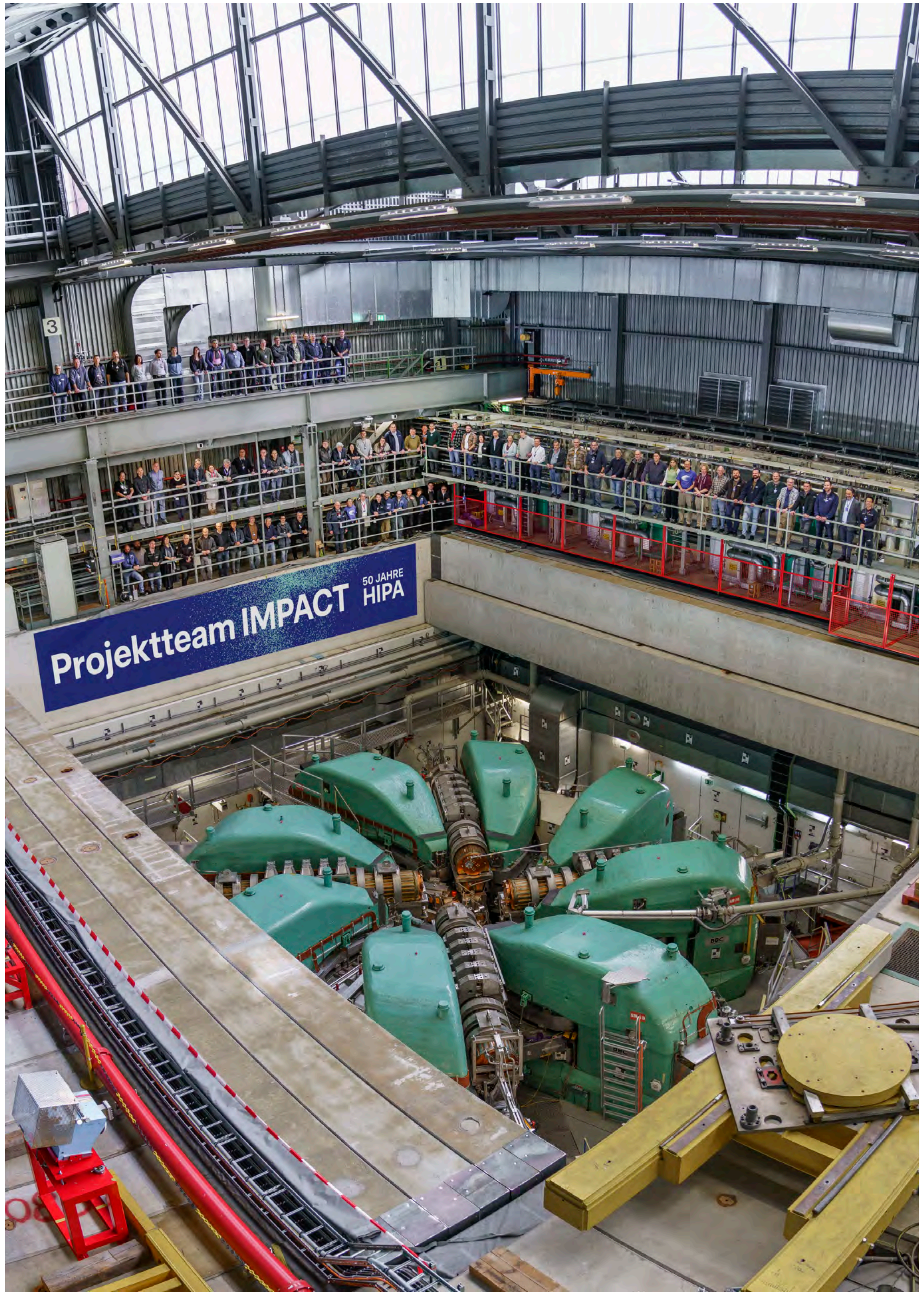
The WEHA in 3 years

Conclusions

PSI

Exciting times at PSI with much improved muon beams and radioisotopes in large quantities in the very near future!

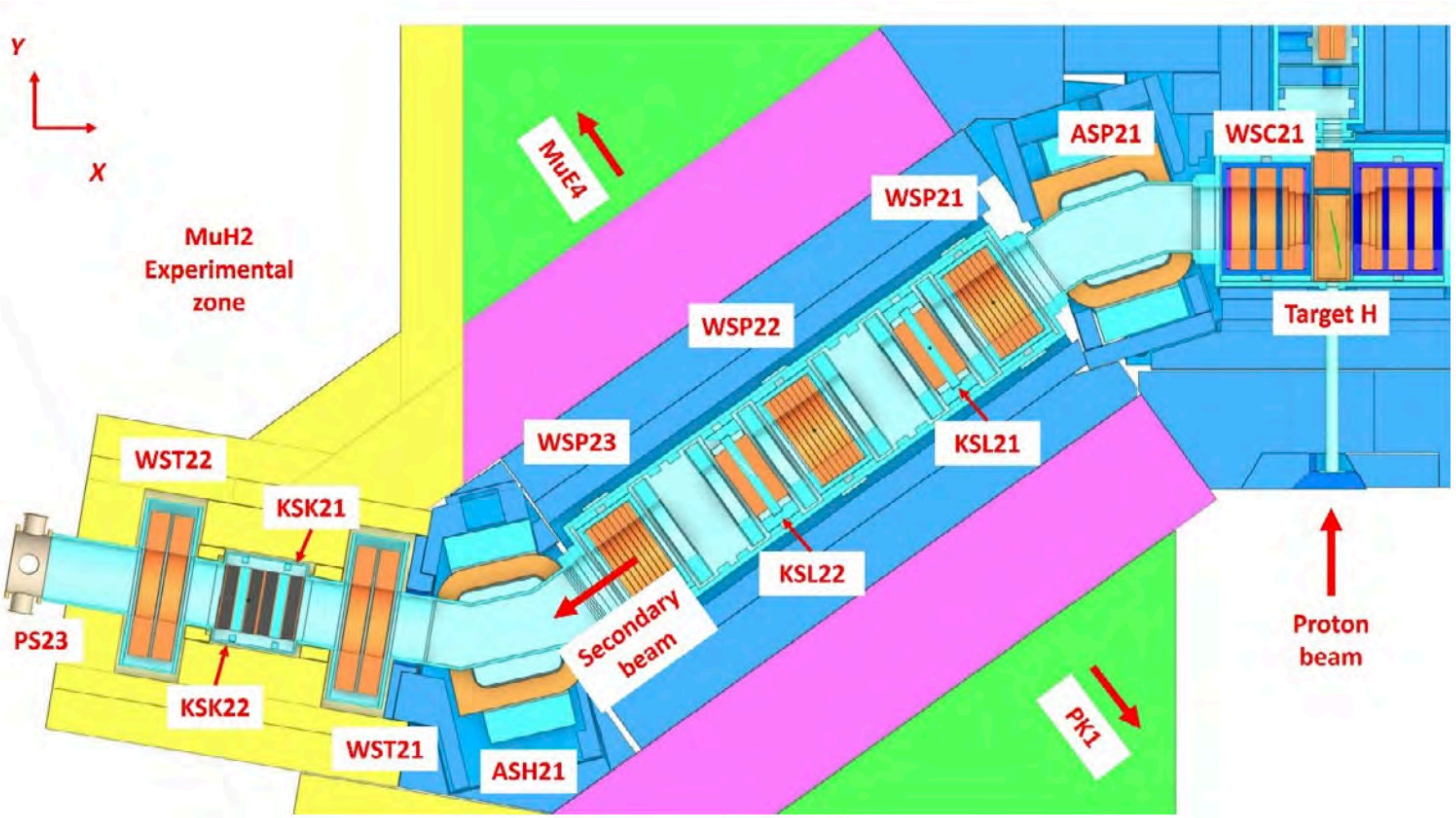
HIPA at the core of many facilities; investments confirmed to secure its further operation



Many thanks to everyone from the IMPACT project team for providing slides and input for this presentation!

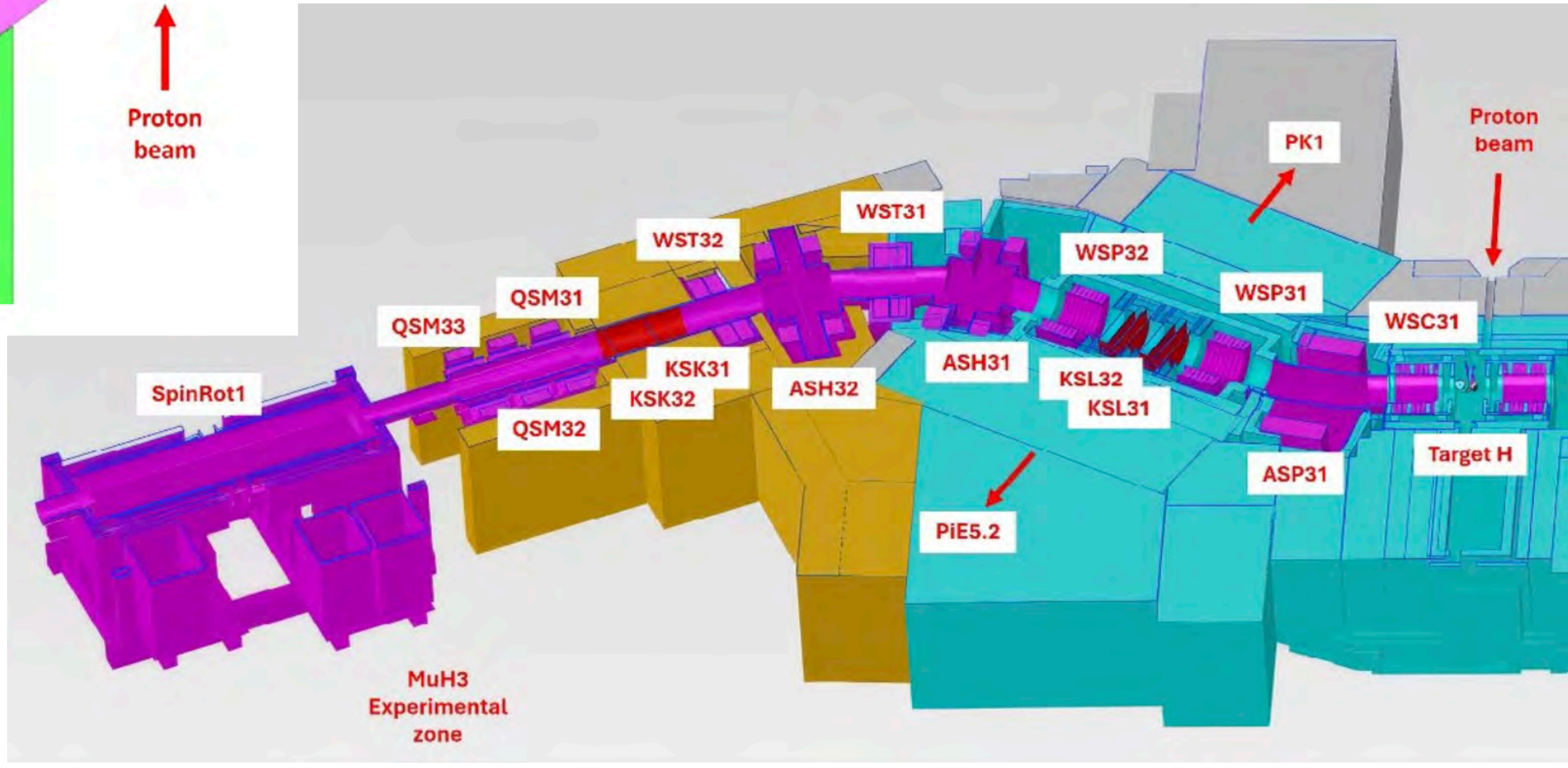
Backup

Shielding performance



MCNP models of MUH2 and MUH3

Doses in experimental areas < 10 µSv/h when all 4 beam blockers are closed



MUH2 large-scale optimisation

Maximum rates achievable for the different particles.

Additionally one can find good compromises in the full optimised parameter space between rate, beam spot and contamination.