



**MYRRHA phase 1
implementation**
MINERVA



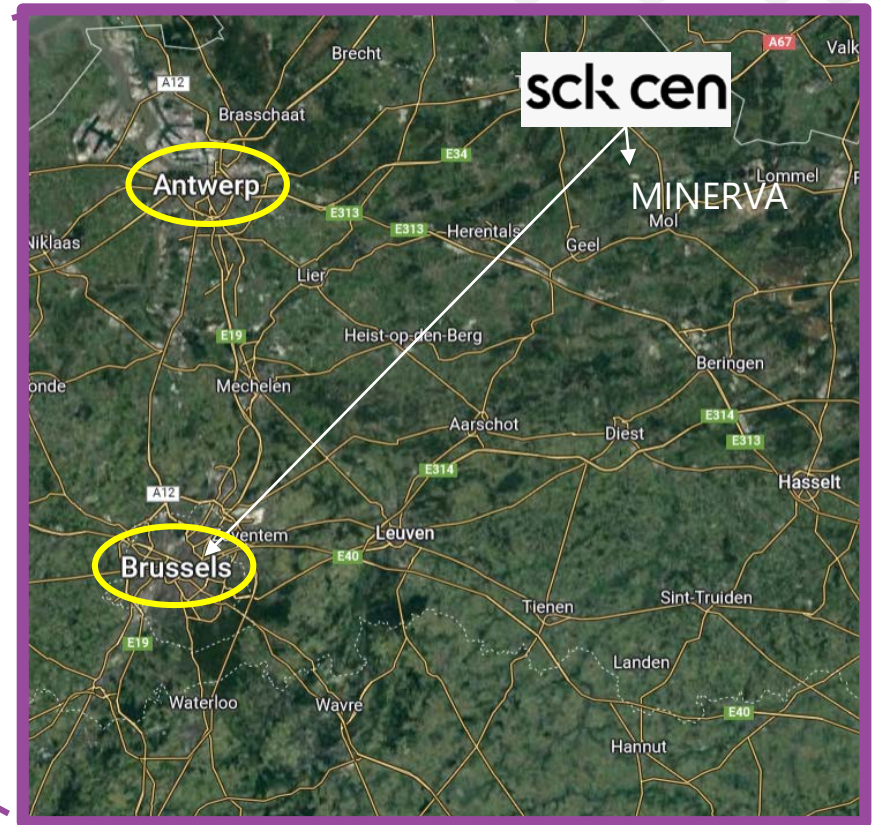
The MYRRHA- MINERVA project

Ulrich Dorda

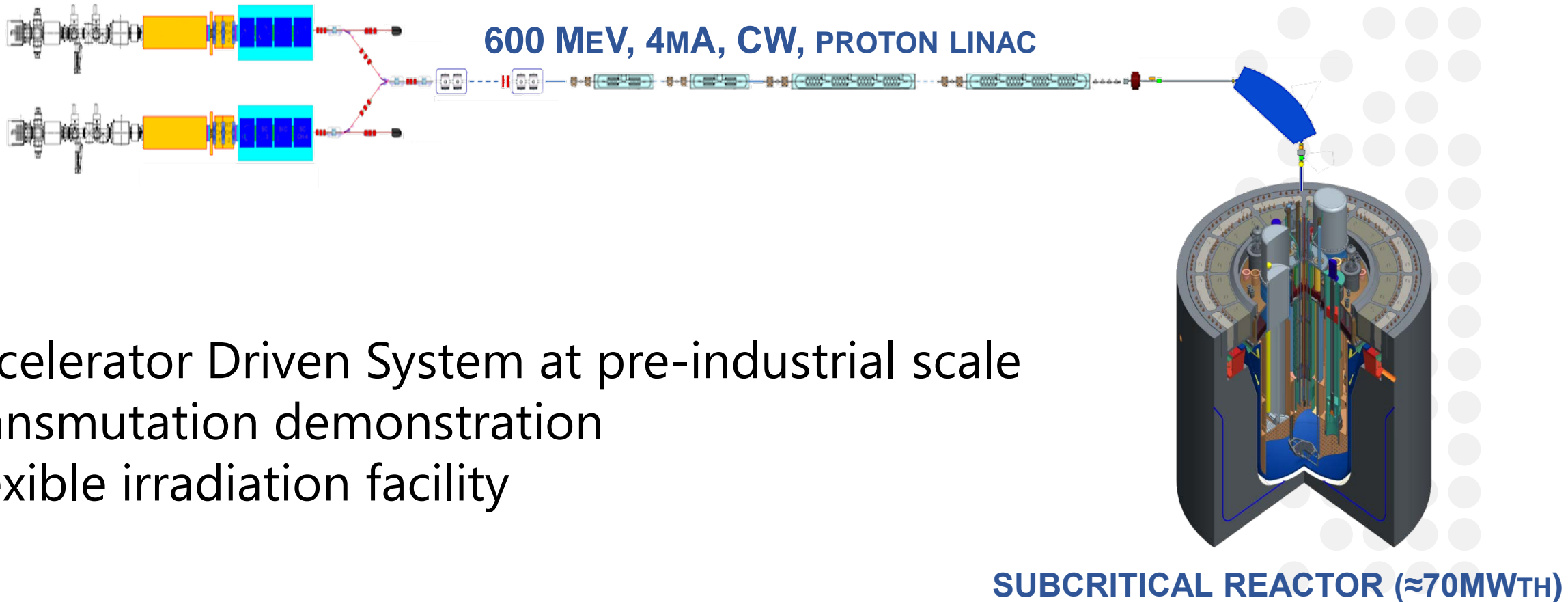
26.09.2022

SCK CEN

- Belgium nuclear research center established 1952
- 850+ staff members
- Currently operating 2 nuclear reactors for research and e.g. production of radio pharmaceuticals
- 25% directly funded by the Belgium state and 70% from contract work



The MYRRHA project



- ✓ Accelerator Driven System at pre-industrial scale
- ✓ Transmutation demonstration
- ✓ Flexible irradiation facility

Reliability requirements

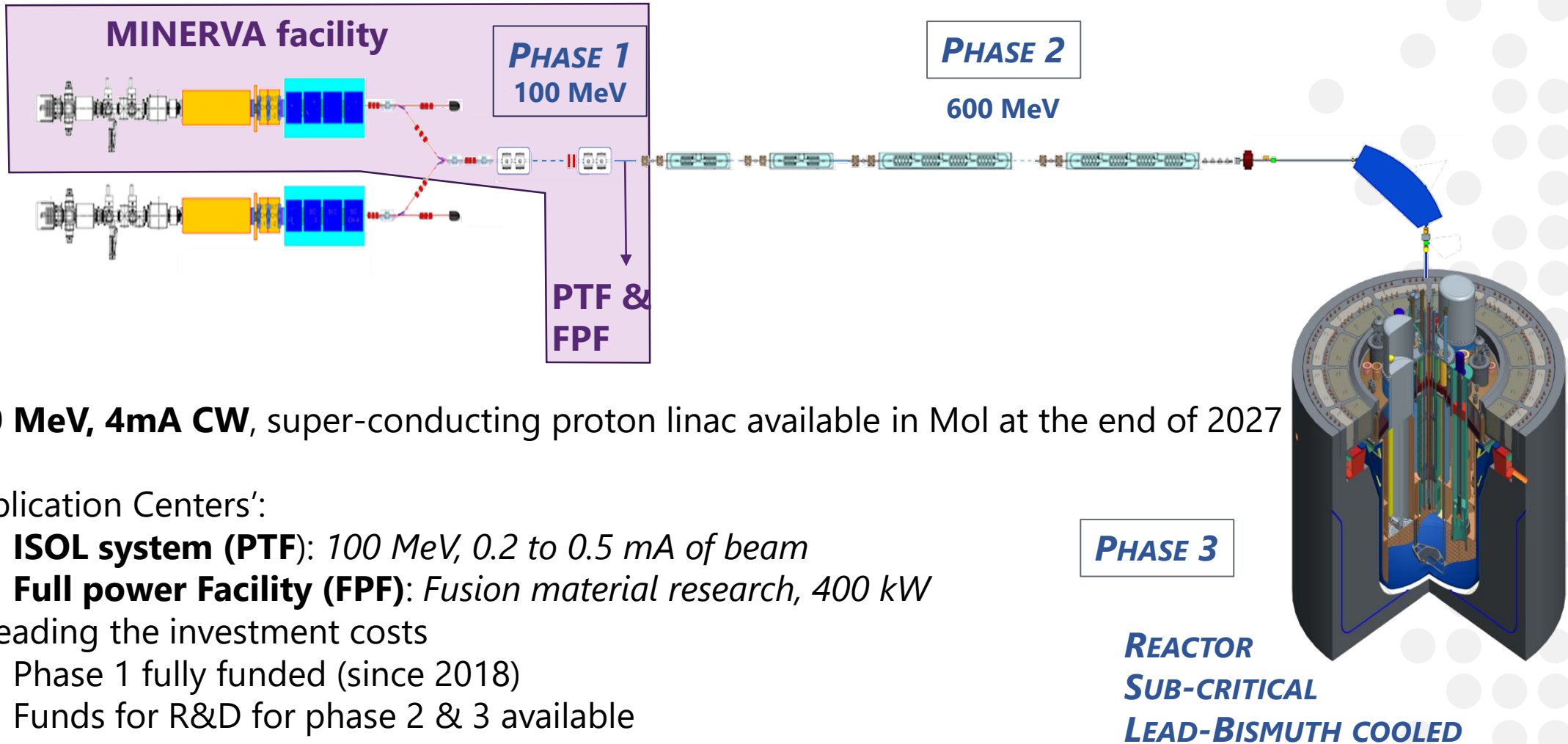
Beam trips

- imposing severe thermal stress on the reactor materials/components limiting its lifetime.
- lead to a time-consuming restart of the reactor limiting its availability.

→ Beam trips must be resolved within 3 seconds to be transparent to the reactor

→ Max 10 beam trips > 3s within 90 day operational run

The stages of the MYRRHA project

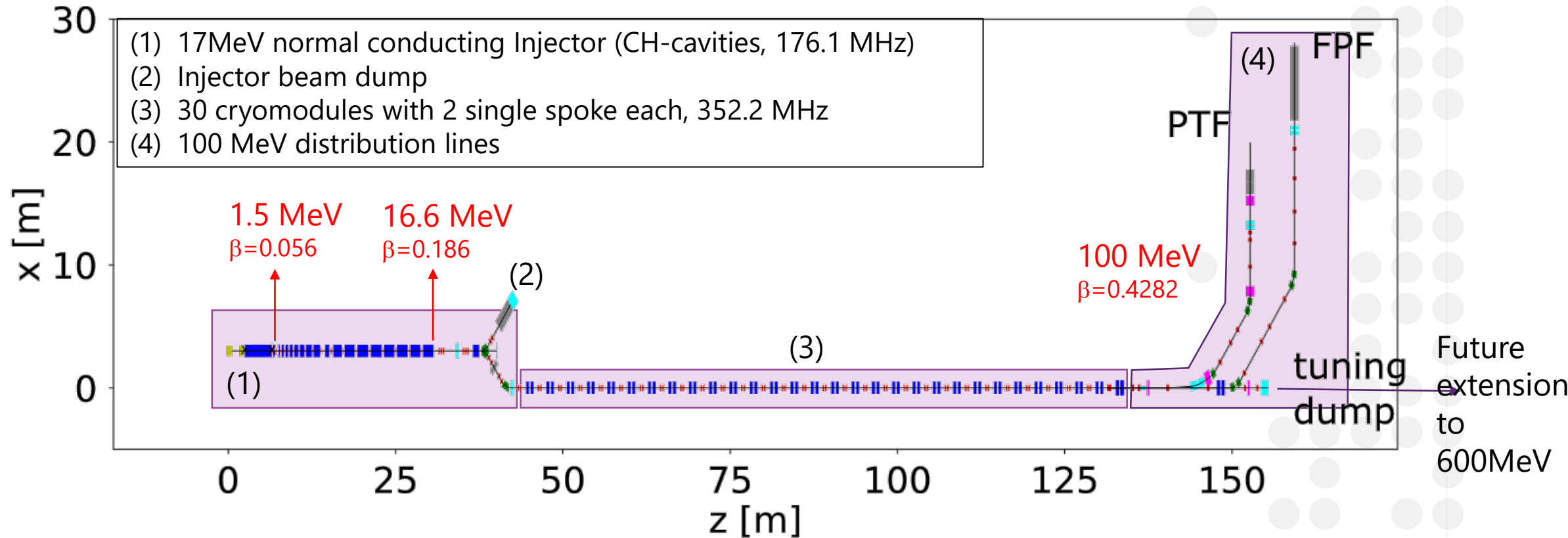


- ✓ **100 MeV, 4mA CW**, super-conducting proton linac available in Mol at the end of 2027
- ✓ 'Application Centers':
 - **ISOL system (PTF)**: 100 MeV, 0.2 to 0.5 mA of beam
 - **Full power Facility (FPF)**: Fusion material research, 400 kW
- ✓ Spreading the investment costs
 - ✓ Phase 1 fully funded (since 2018)
 - ✓ Funds for R&D for phase 2 & 3 available
 - ✓ Implementation of phase 2 & 3 subject to international funding

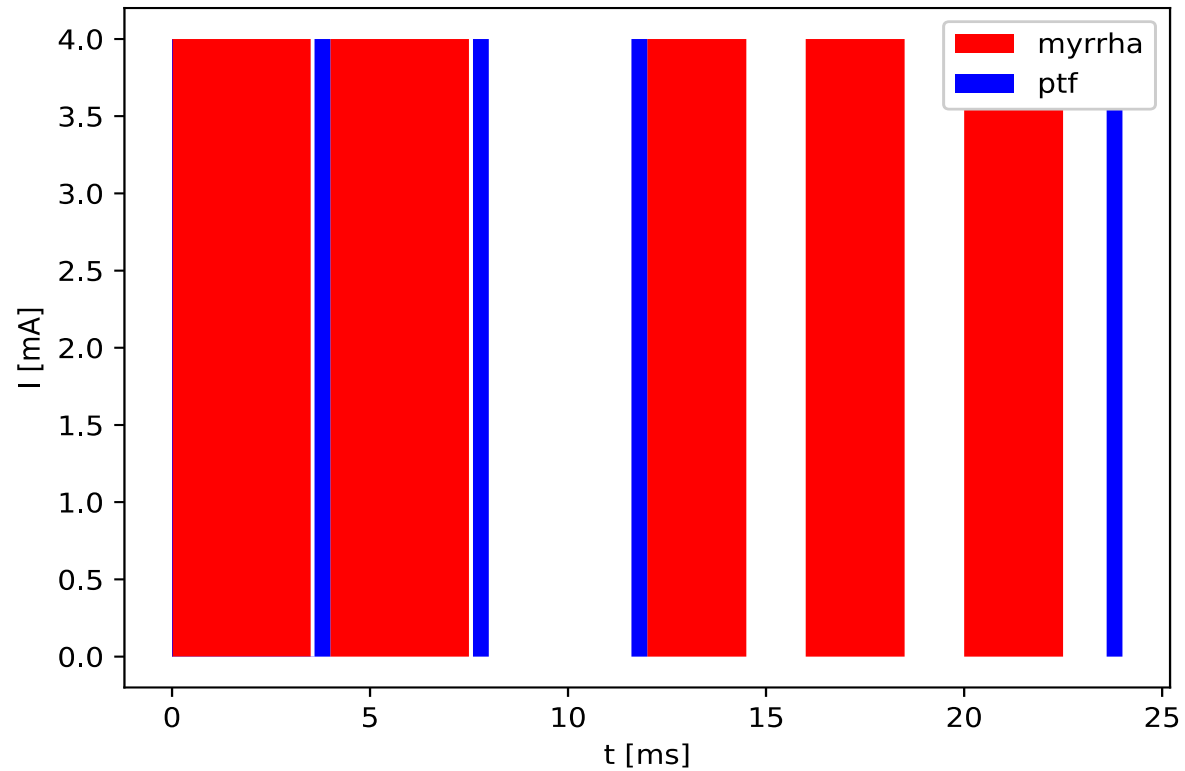
ACCELERATOR

a 100 MeV, superconducting proton linac

Linac layout

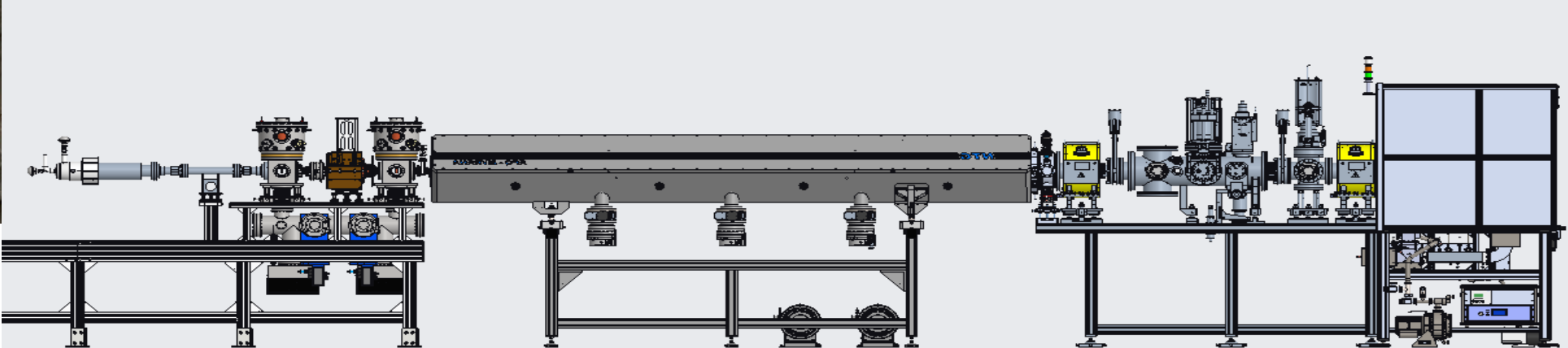
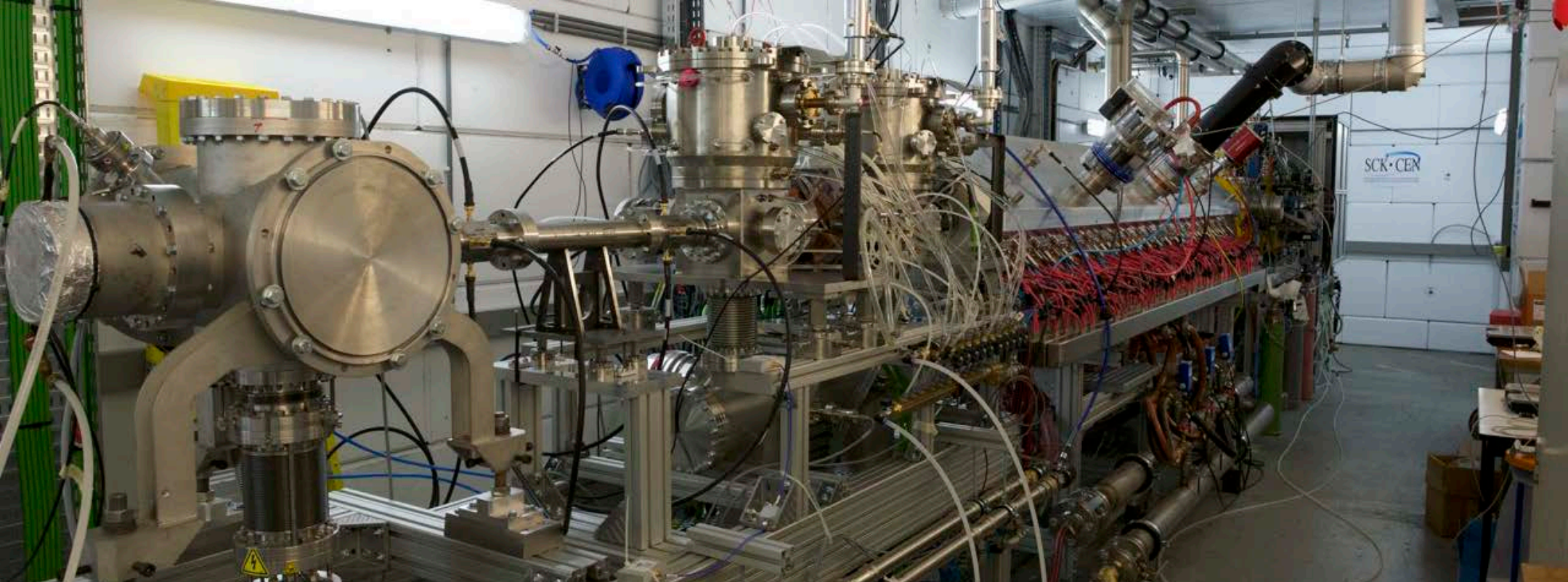


Fast target switching



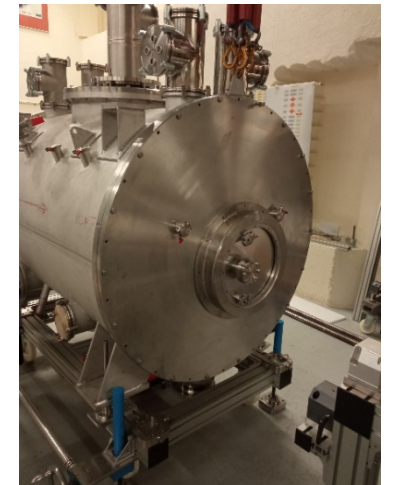
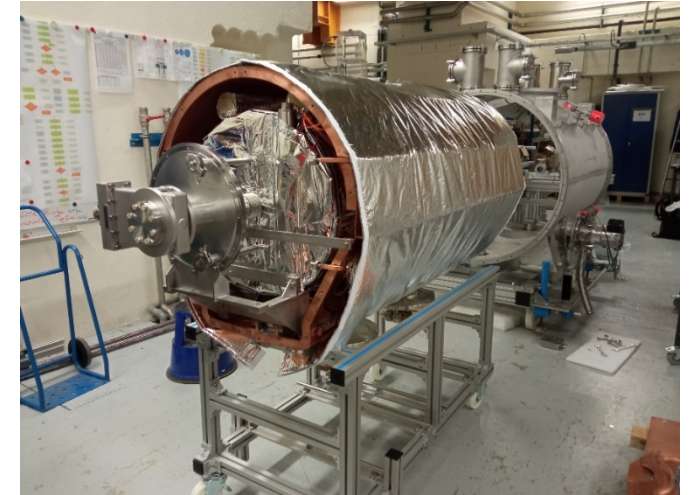
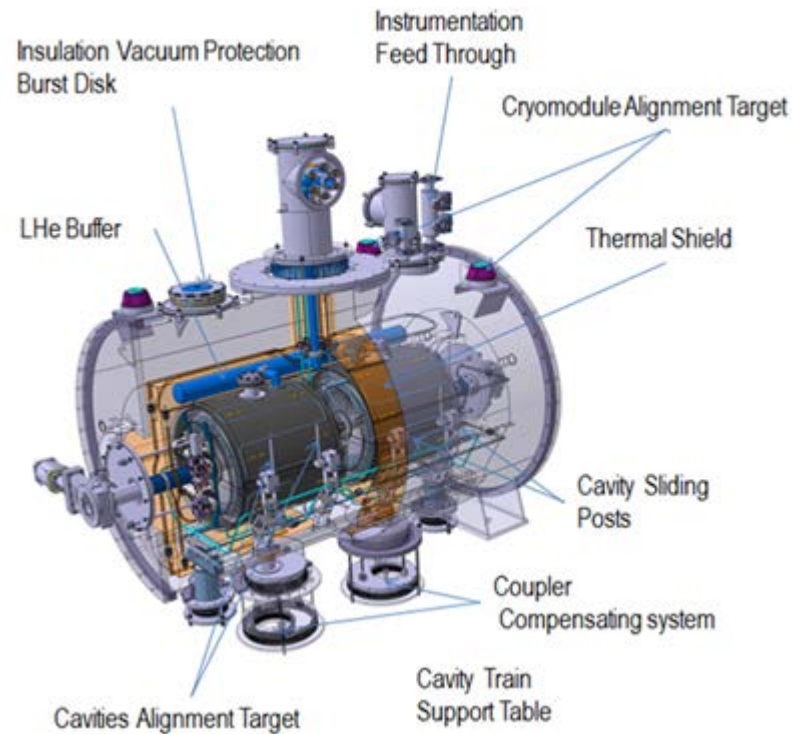
Fast switching between the target facilities: Two targets can be served within 4ms cycle

Injector Test Stand



Example: CRYOMODULE prototype

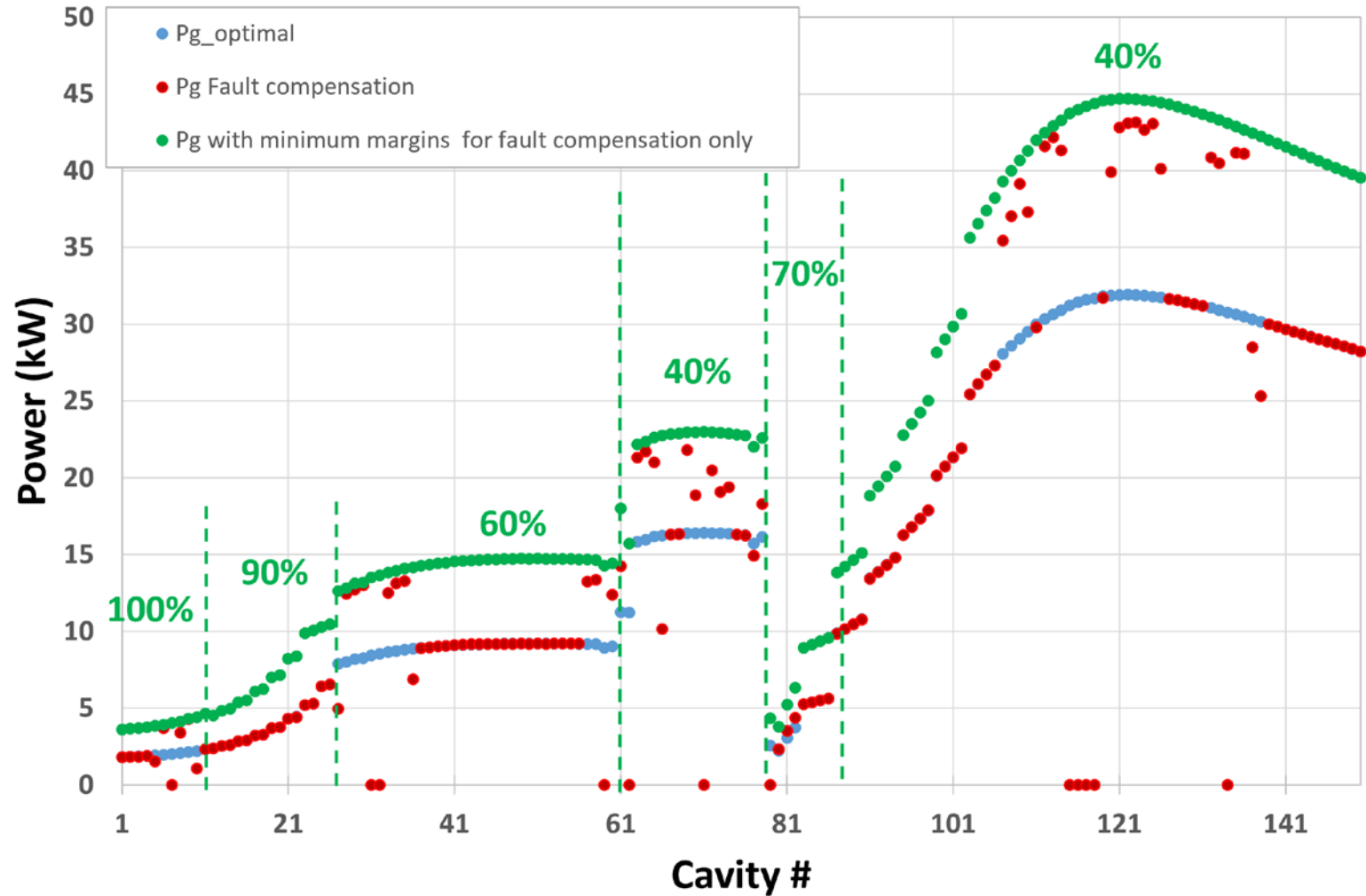
In collaboration with/at IJCLab



Series production: 30 cryomodules hosting 60 SC cavities, first series cavity expected this October

Fault tolerance

- Minimal beam trips of highest importance
- Parallel redundancy of injector
- Serial redundancy in SC-linac
- Failure detection, reconfiguration and full beam power ramp up within 3 seconds
- For RF-trips: Local and global compensation schemes being studied

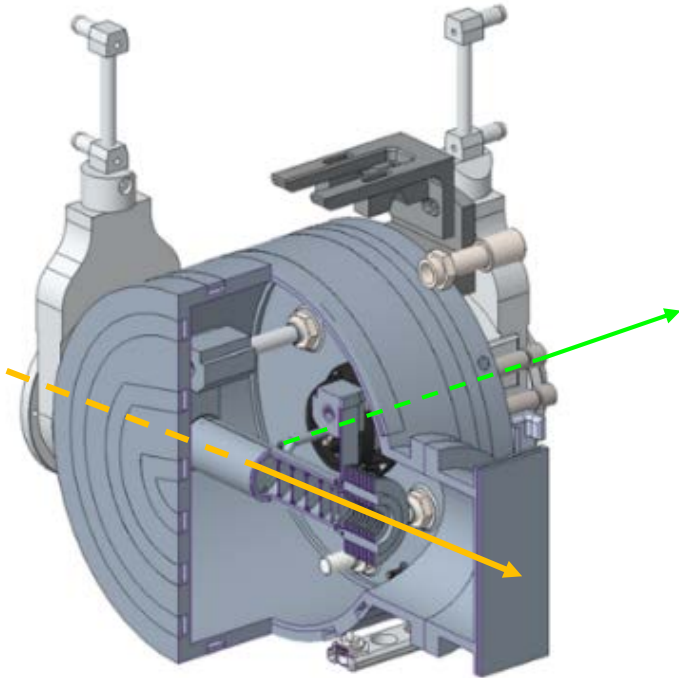


Proton Target Facility (PTF)

a 100 MeV proton driver high power ISOL facility

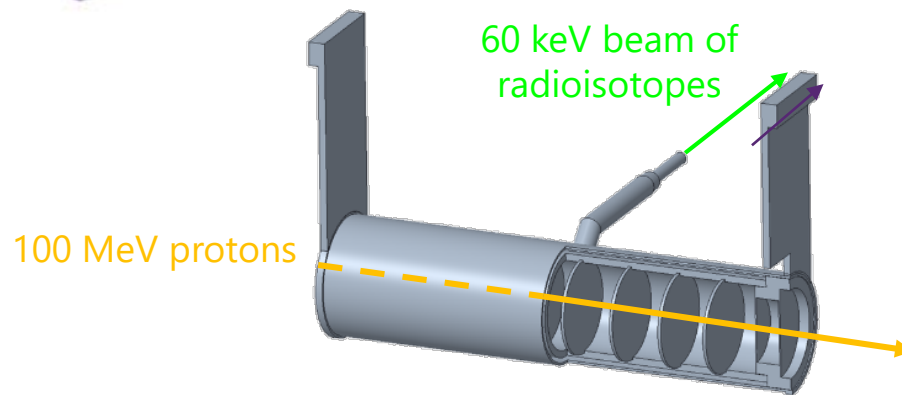
Based on the design of / thanks to the collaboration with the TRIUMF

The ISOL facility

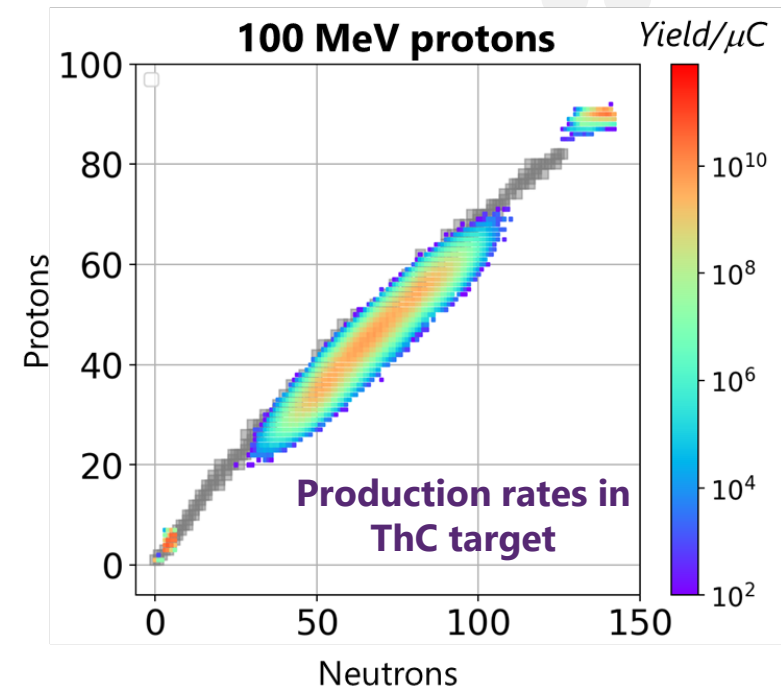


production target assembly

- ✓ Production, extraction and mass separation of radio-isotopes = Isotope Separation On-Line (ISOL)
- ✓ 100 MeV proton, 0.2 up to 0.5 mA average currents on production targets
- ✓ High-power ISOL facility, compared to existing ISOL facilities

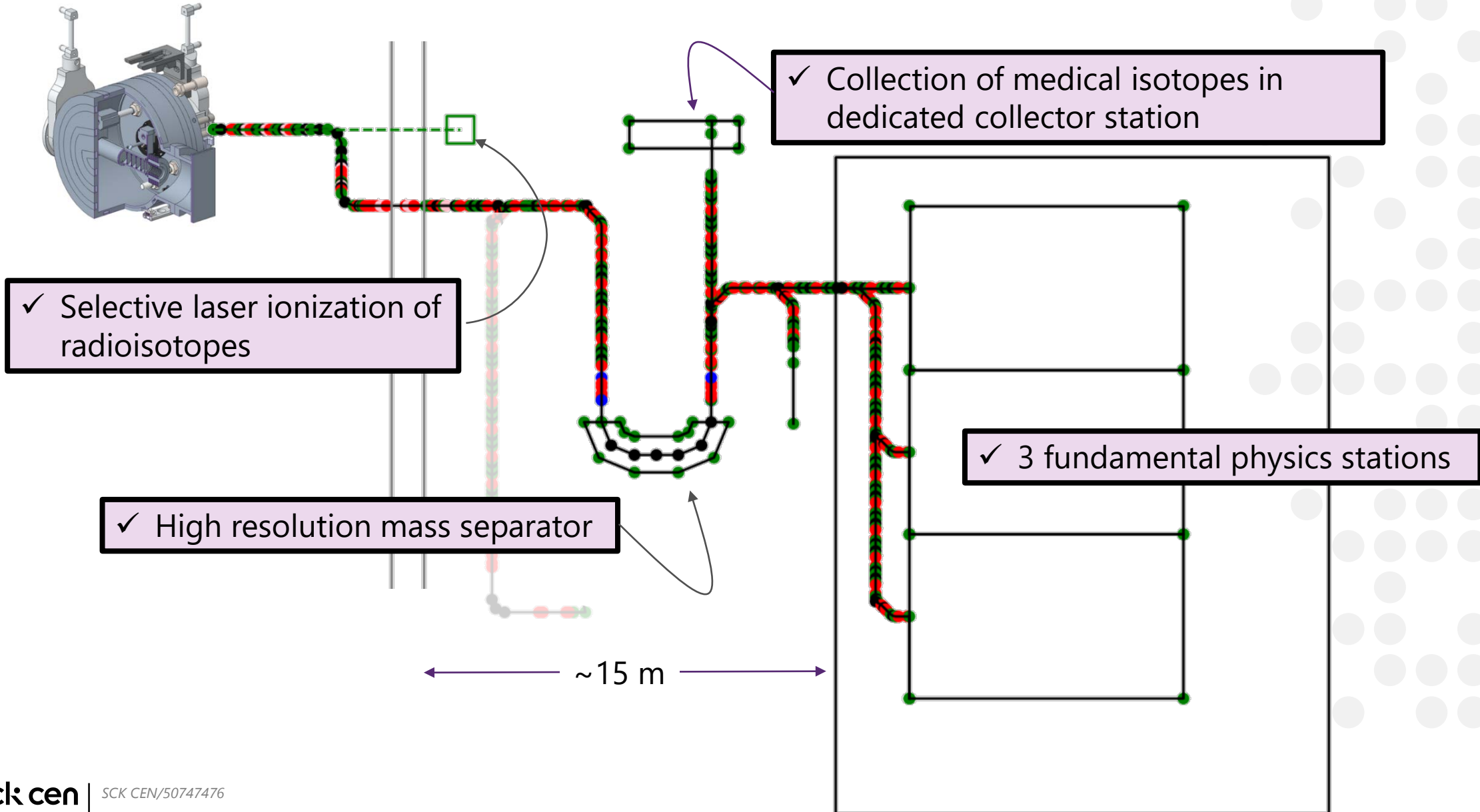


production target + radio-isotope transfer line



The ISOL facility layout

Based on the design of / thanks to the collaboration with the TRIUMF



Full Power Facility (FPF)

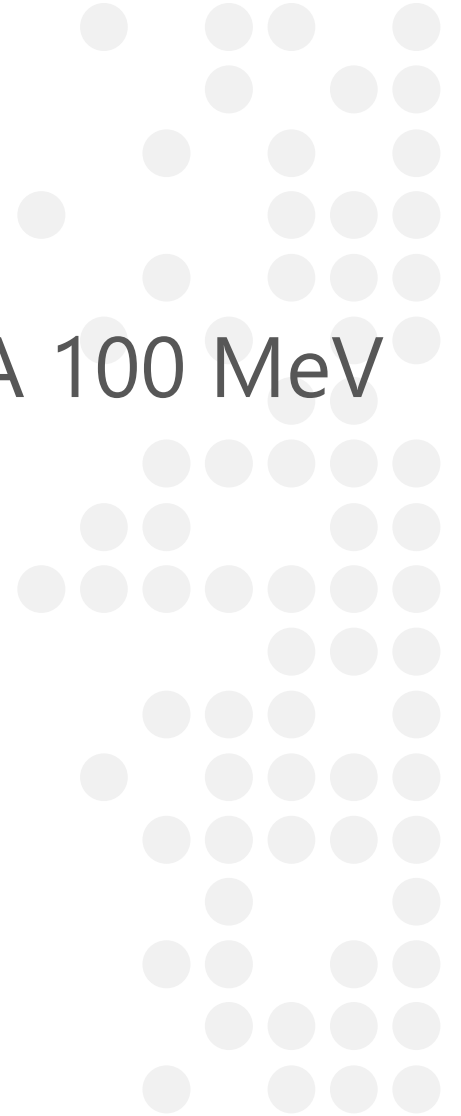
Fusion material research station

- also acting as full power beam dump for reliability studies

FPF (Full Power Facility)

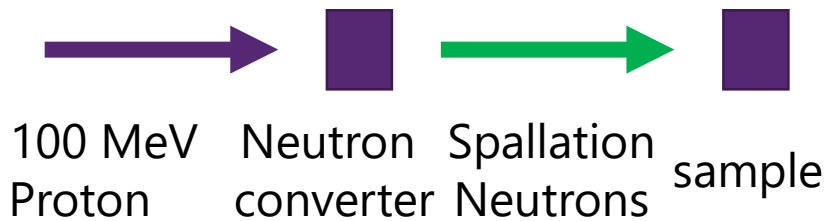
Dual purpose:

- Full power beam dump 400 kW nominal 4 mA 100 MeV (2027) for reliability studies
- Fusion material Research (2027+)

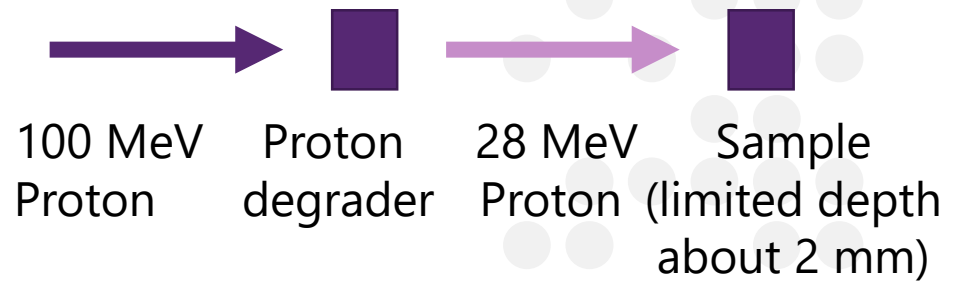


Fusion applications 100 MeV protons

Neutron irradiation

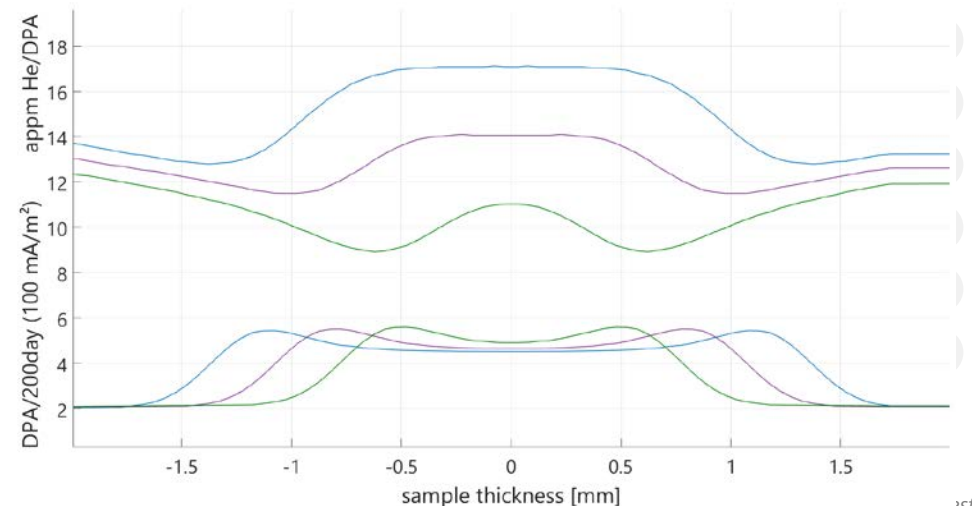
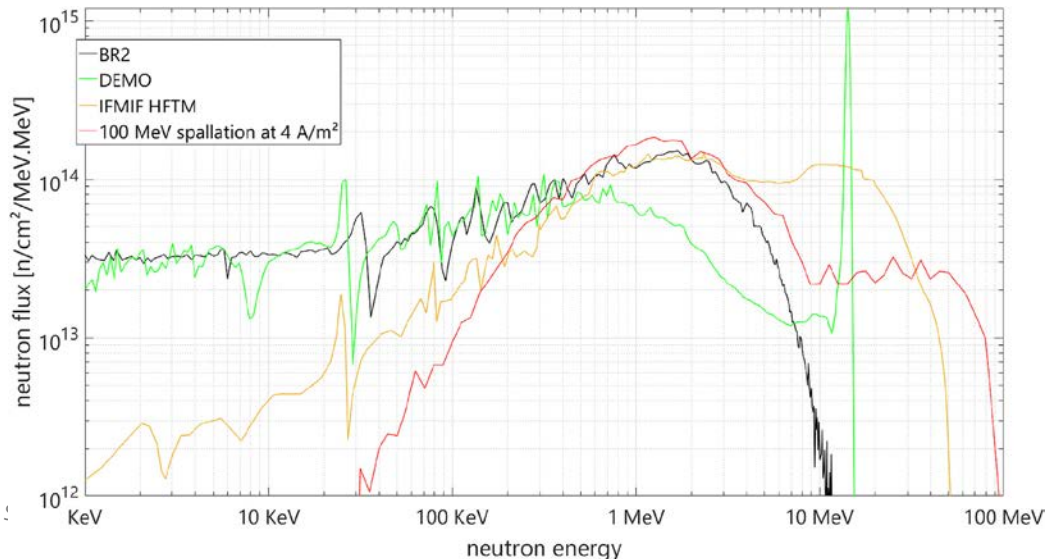


Proton irradiation



About 11 appmHe/DPA , 0,4 DPA / 200 days @ 100 mA/m²
 useful volume for experiments about 10 L

5 DPA / 200 days @ 100 mA/m² 400cm²
 (some cases even 50 DPA / 200 days (40 cm²))



Please find more details in:

Journal of Nuclear Materials 538 (2020) 152242



Contents lists available at [ScienceDirect](#)

Journal of Nuclear Materials

journal homepage: www.elsevier.com/locate/jnucmat



Short communication

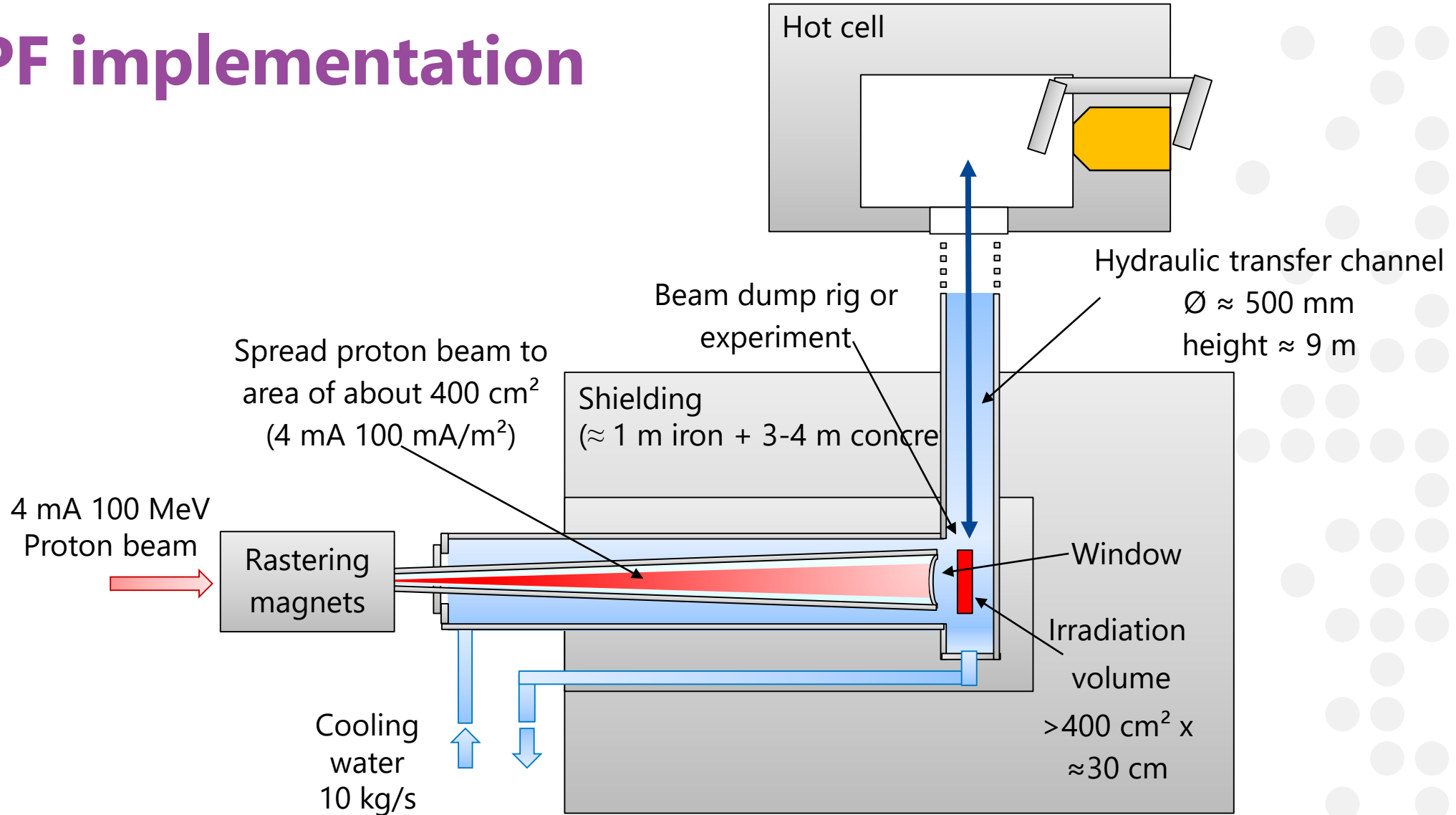
Fusion target station on MYRRHA facility: Baseline concept

Willem Leysen*, Dmitry Terentyev, Alexey Stankovskiy

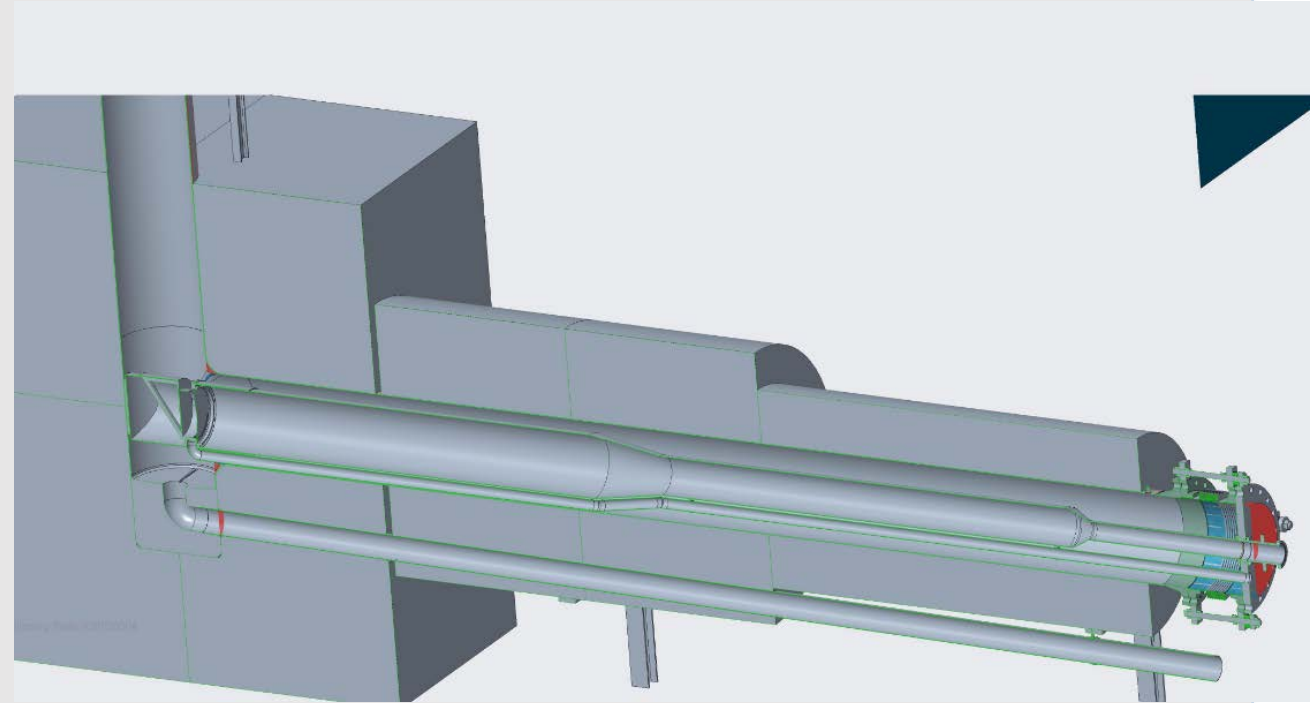
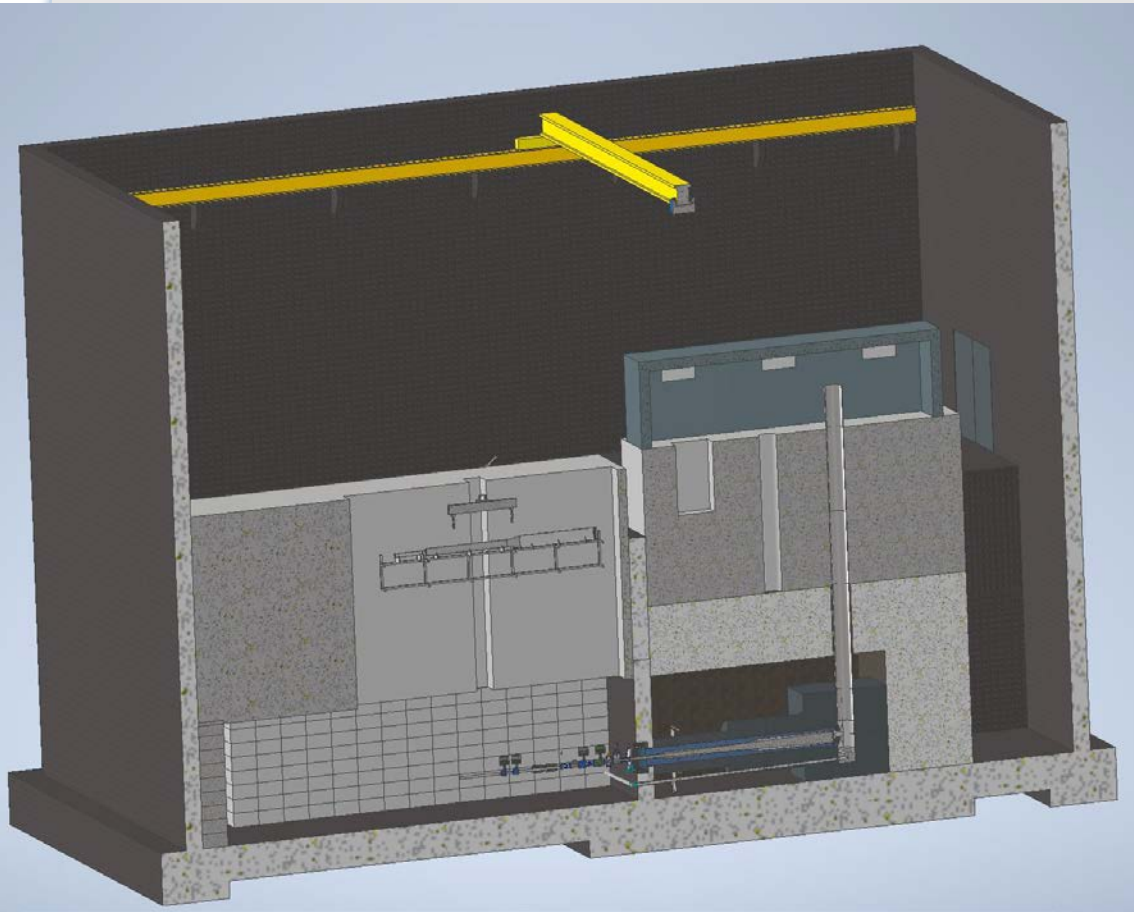
SCK CEN, Belgian Nuclear Research Centre, Boeretang 200, B-2400, Mol, Belgium



FPF implementation

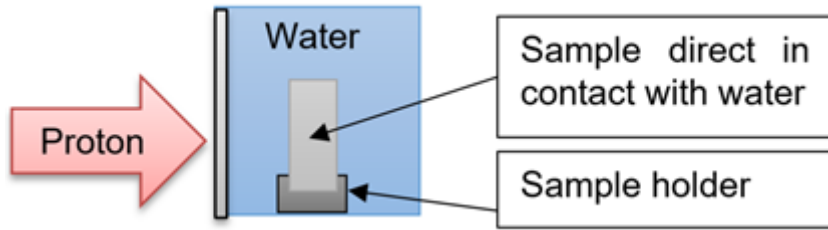


FPF design / integration

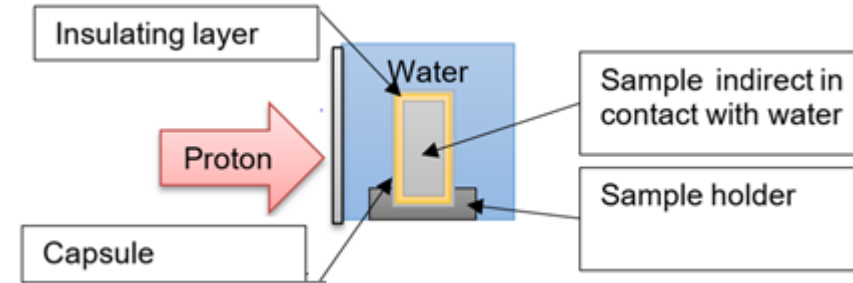


Principle of irradiation rigs

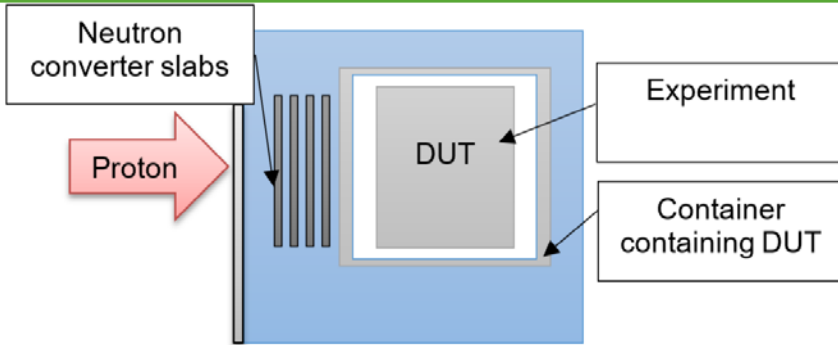
Proton



Low temperature experiment (sample in direct contact with primary water) → irradiation temp about 120°C

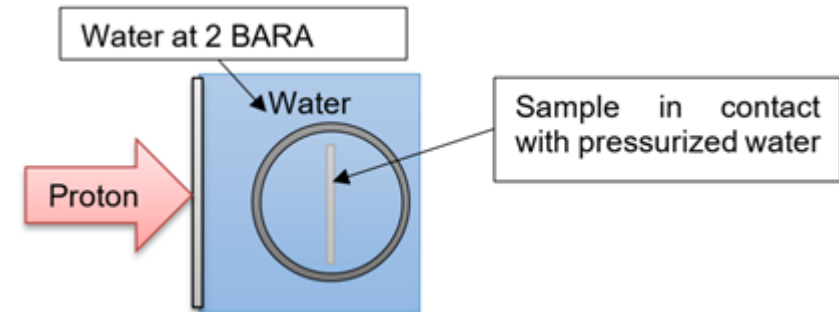


High temperature experiment (in helium filled capsule (Al, stainless steel) thermal gradient over the helium)



Neutron irradiation volume for various experiments (temperature control by use of heaters)

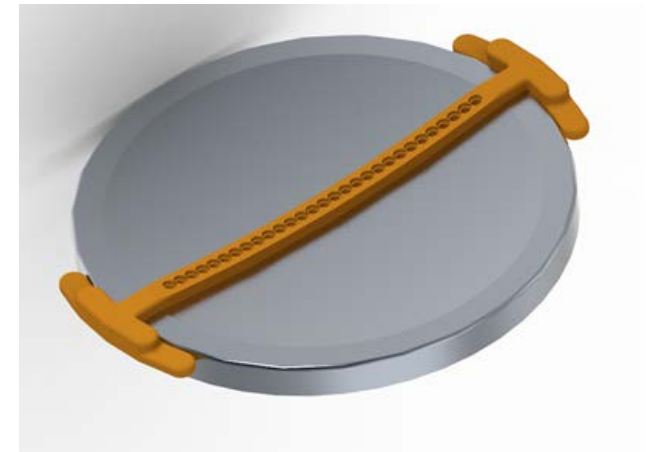
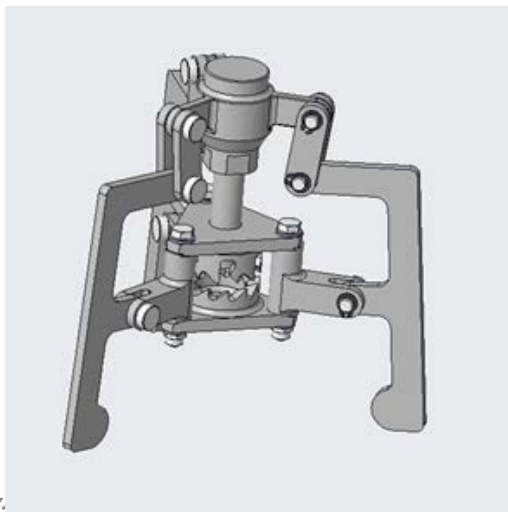
Neutron

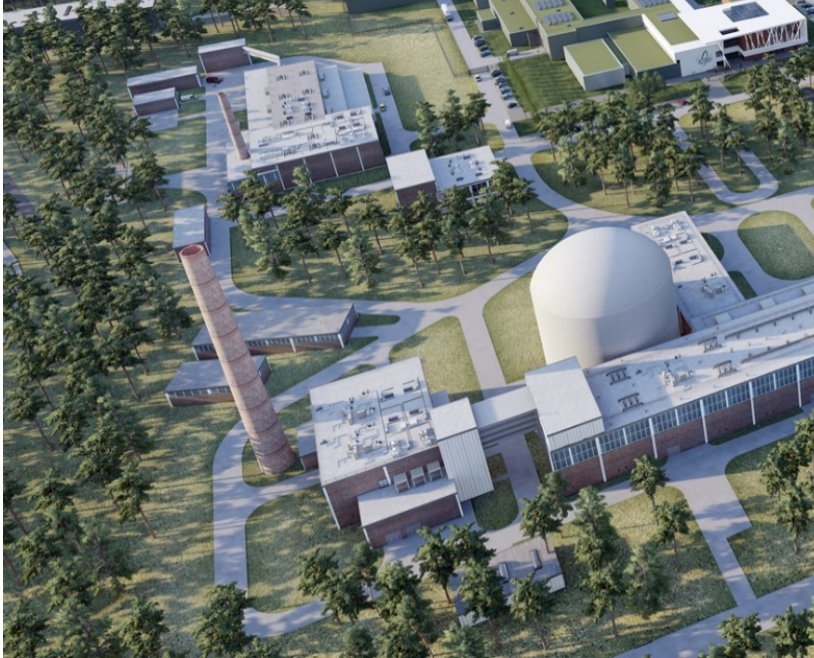


High temperature controlled experiment (variable pressure capsule in water) boiling regime temperature control.

FPF prototyping activities

- Beam window
 - Inconel prototype manufactured and measured
 - Ready for cold tests
- Irradiation rig clamp
 - 1st prototype proves concept
 - Refining design
 - Looking for alternatives on the market





towards MYRRHA

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MINERVA

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