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Introduction of a new test area for neutron detection instruments with a dominant high-energy neutron component at PSI

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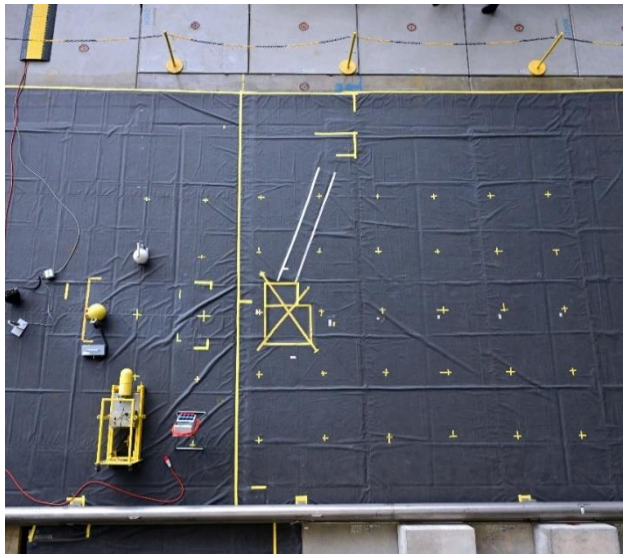

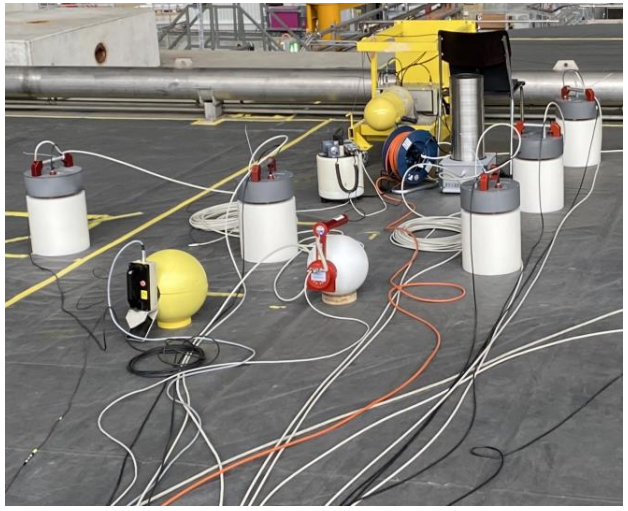

Paul Scherrer Institute - a federal research lab with focus on large scale research facilities

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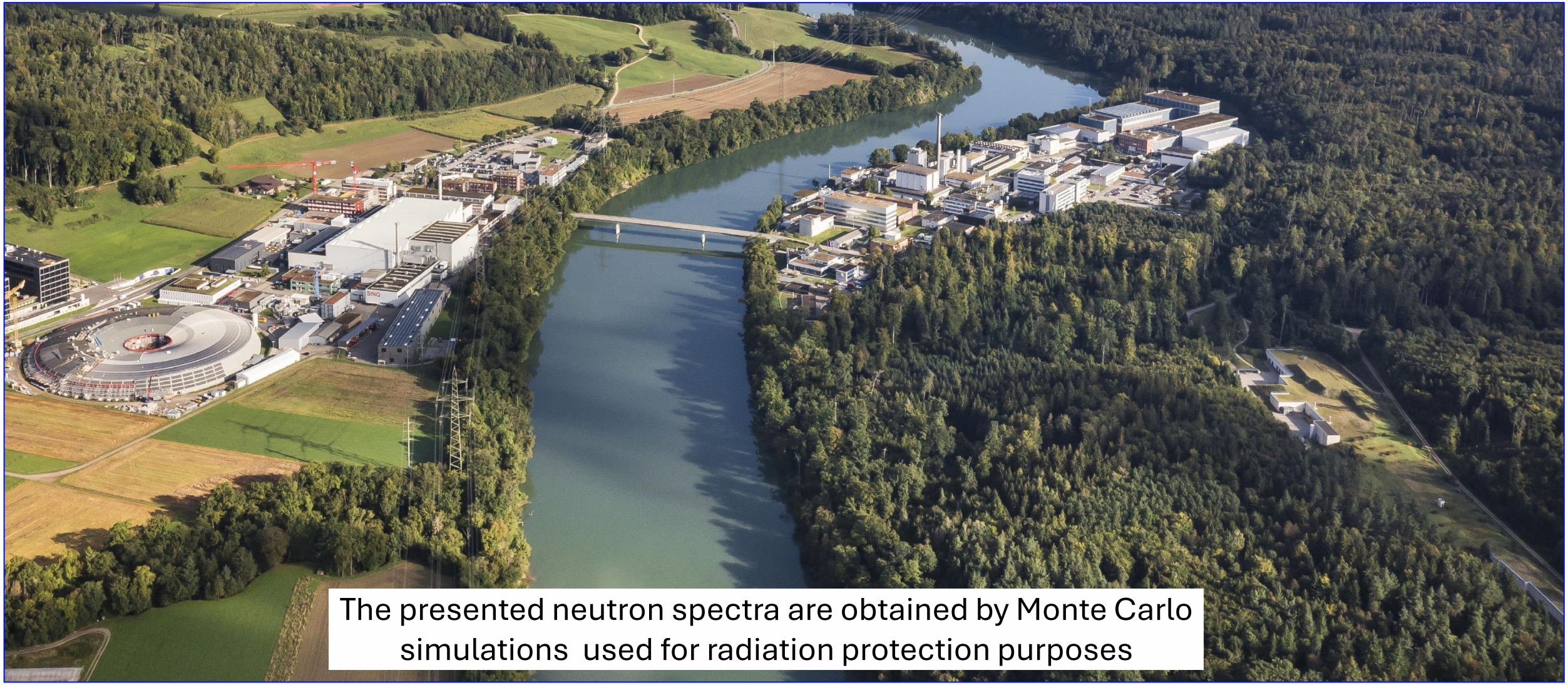
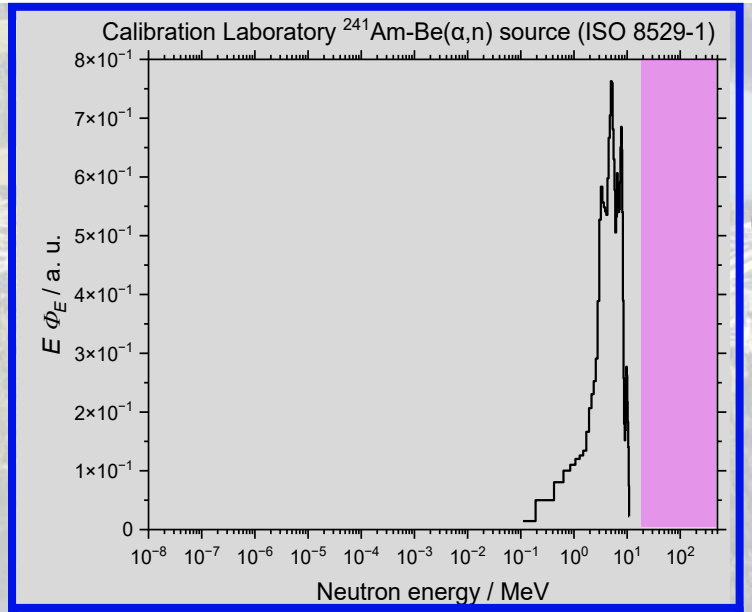


The presented neutron spectra are obtained by Monte Carlo simulations used for radiation protection purposes

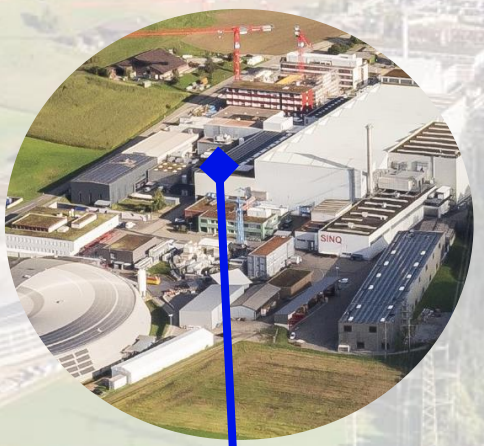
Paul Scherrer Institute - Neutron calibration facility



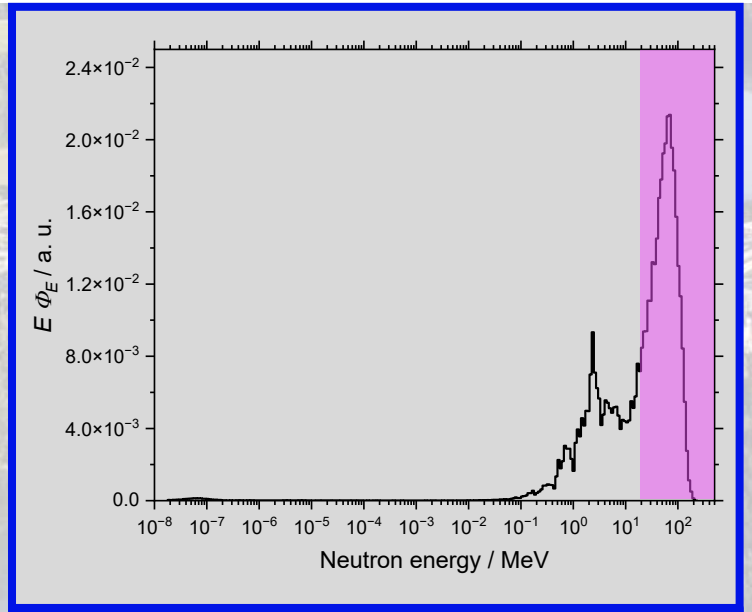
Calibration laboratory
^{241}AmBe source (ISO 8529-1)

Calibration laboratory
Neutron sources

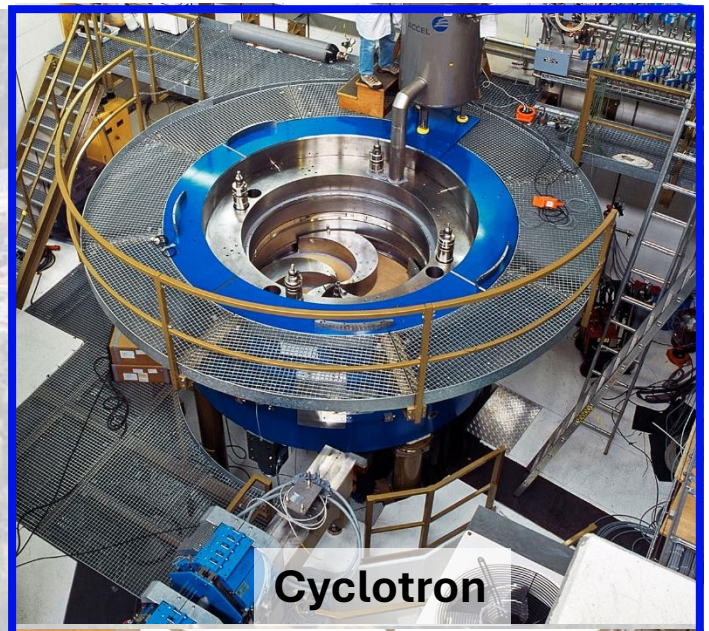
Paul Scherrer Institute - Proton accelerator I



Medical applications (PROSCAN), p(250 MeV)



p^+ (250 MeV) on a collimator in a treatment room

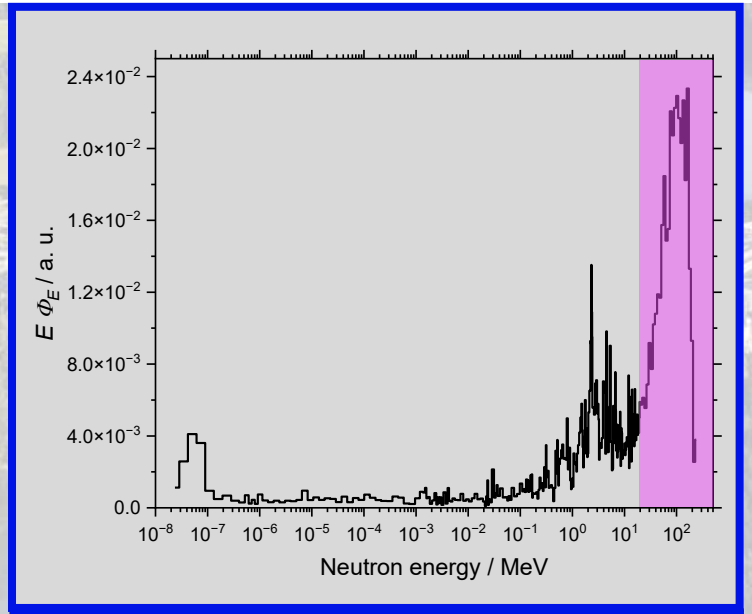


Cyclotron

Treatment room

Paul Scherrer Institute - Proton accelerator 2

High-intensity proton accelerator (HIPA) p(590 MeV)



p^+ (590 MeV) -) carbon outside shielding made of iron and concrete

Paul Scherrer Institute - Large scale research facilities

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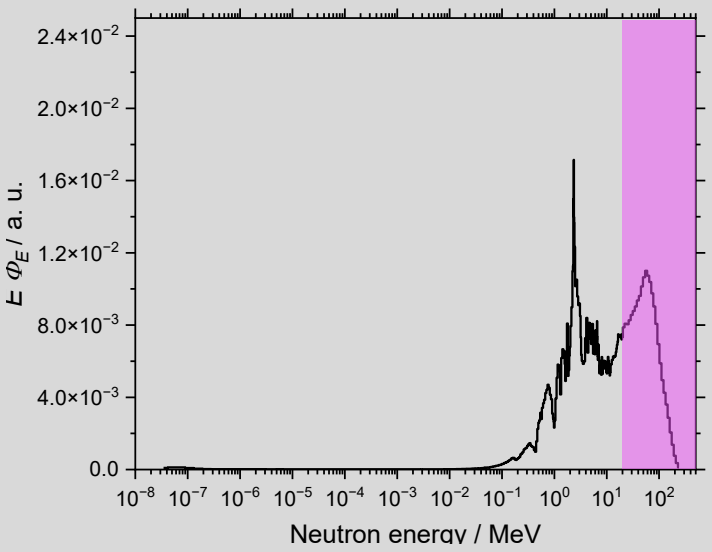
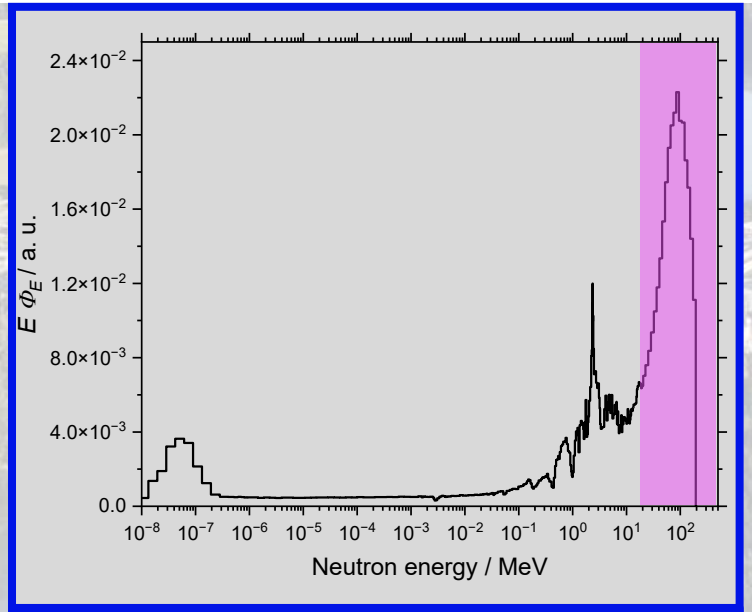


π^- (230 MeV) -) Behind concrete shielding of an experiment

High-intensity proton accelerator (HIPA), p(590 MeV)

- **CHRISP** - Swiss Research InfraStructure for Particle Physics

Paul Scherrer Institute - Electron accelerators



e⁻ (5800 MeV) -) Cu outside shielding made of iron and concrete

Free electron laser (SwissFEL), e(5.8 GeV)

Paul Scherrer Institute - Summary of neutron stray fields

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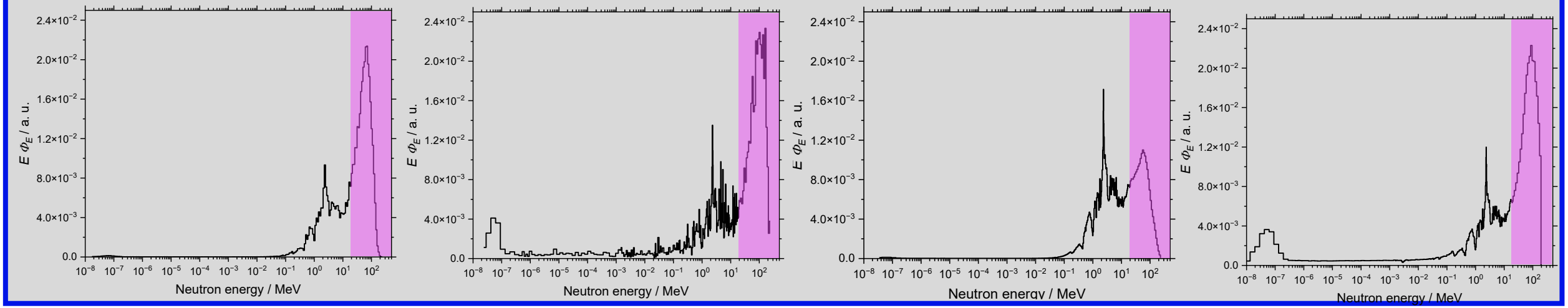
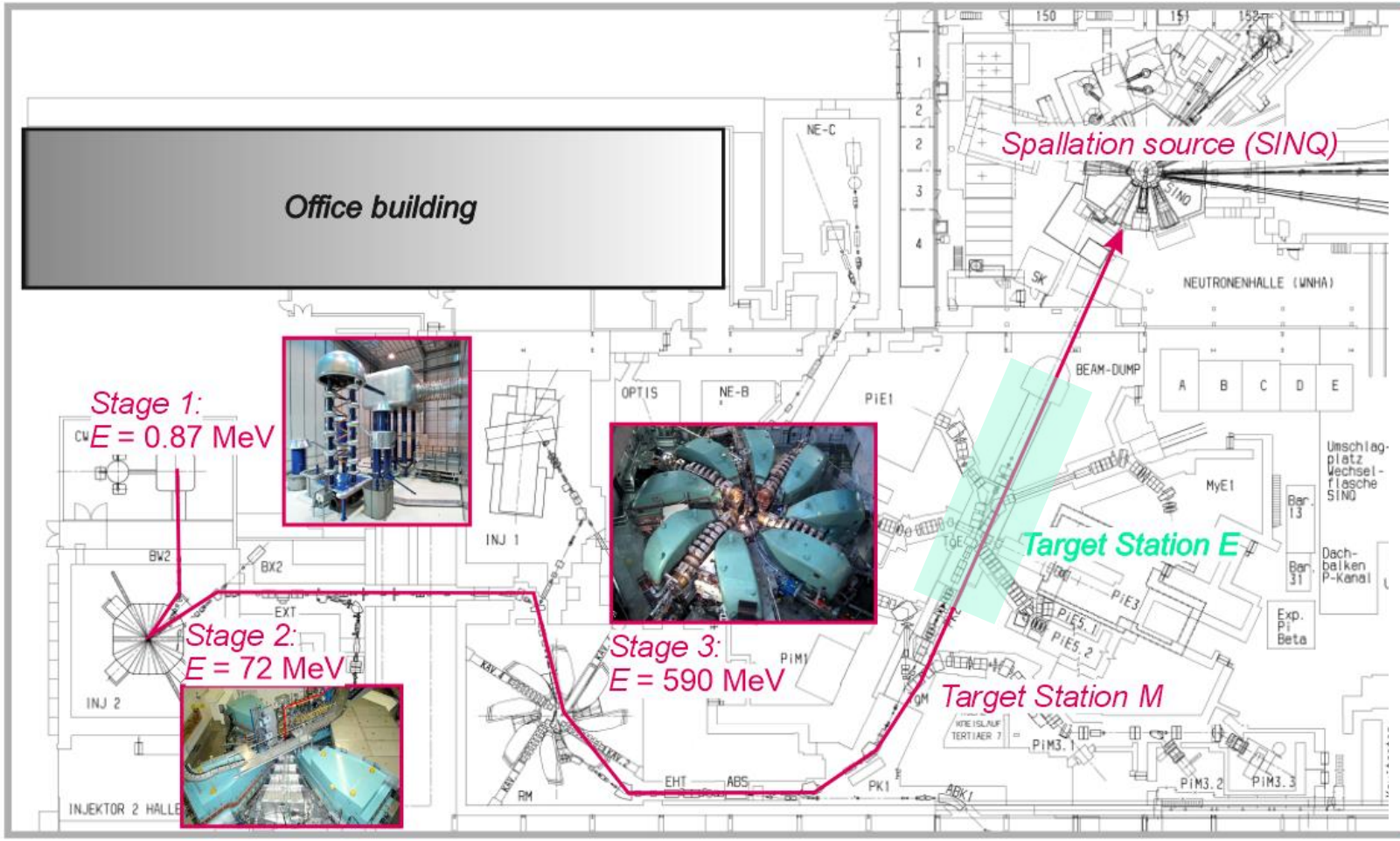
- Many neutron stray fields around PSIs high-energy accelerators and its applications have a significant component of neutons with energies greater 20 MeV
- Areas are accessible: personell need to surveyed adequately

- Easy accessible and timely available area for **development** and **calibration** of dosemeters and survey instruments



Location of the new reference facility

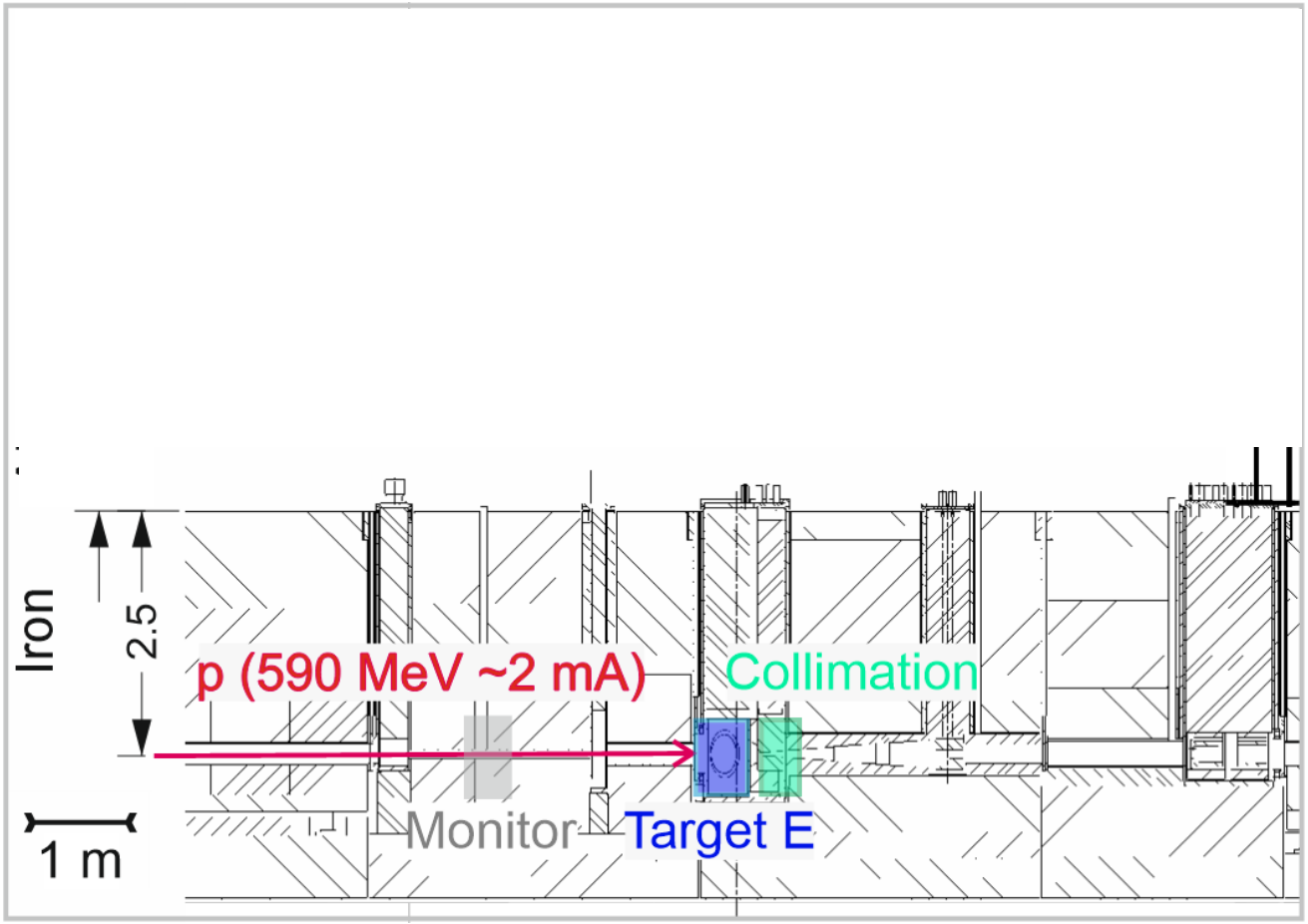


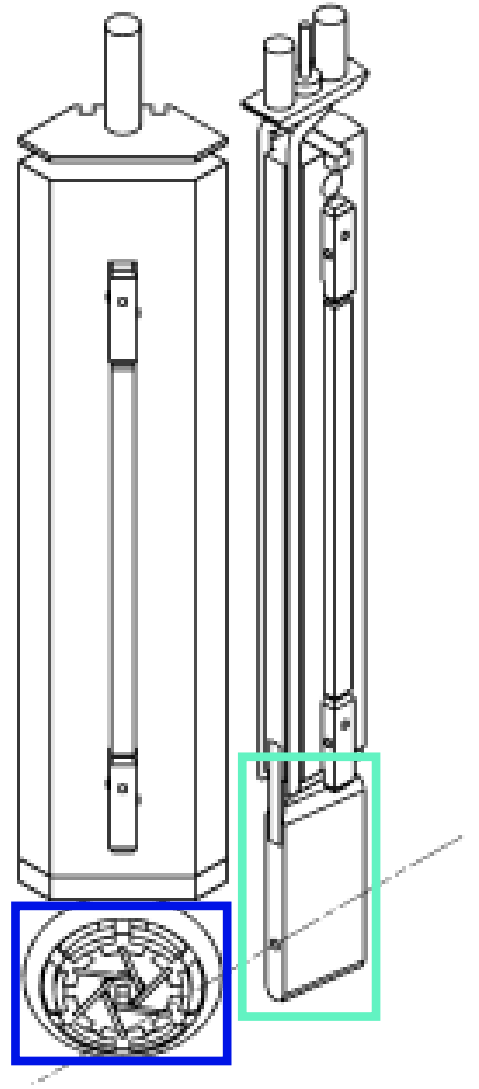
Accelerator operation schedule:

- May to December
- Mean Availability: 95%

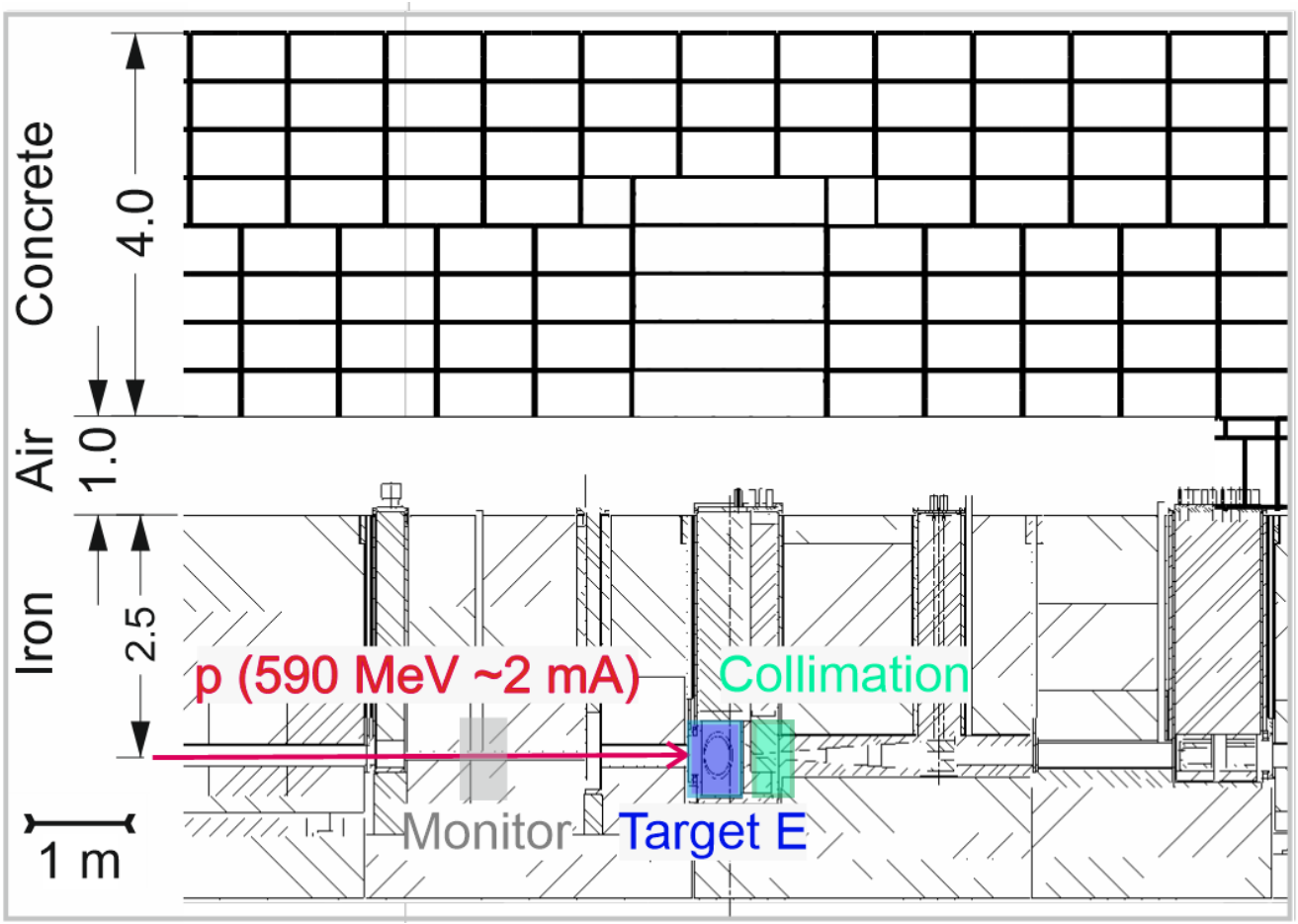
- **Area above the target station** is easily accessible

Facility layout: Side view

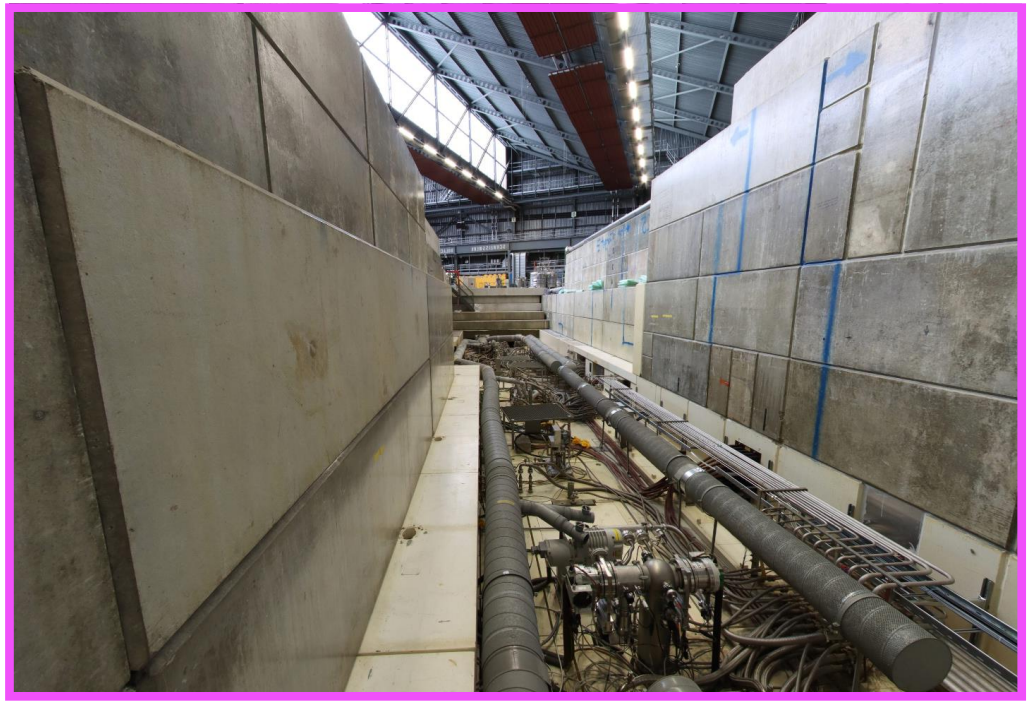




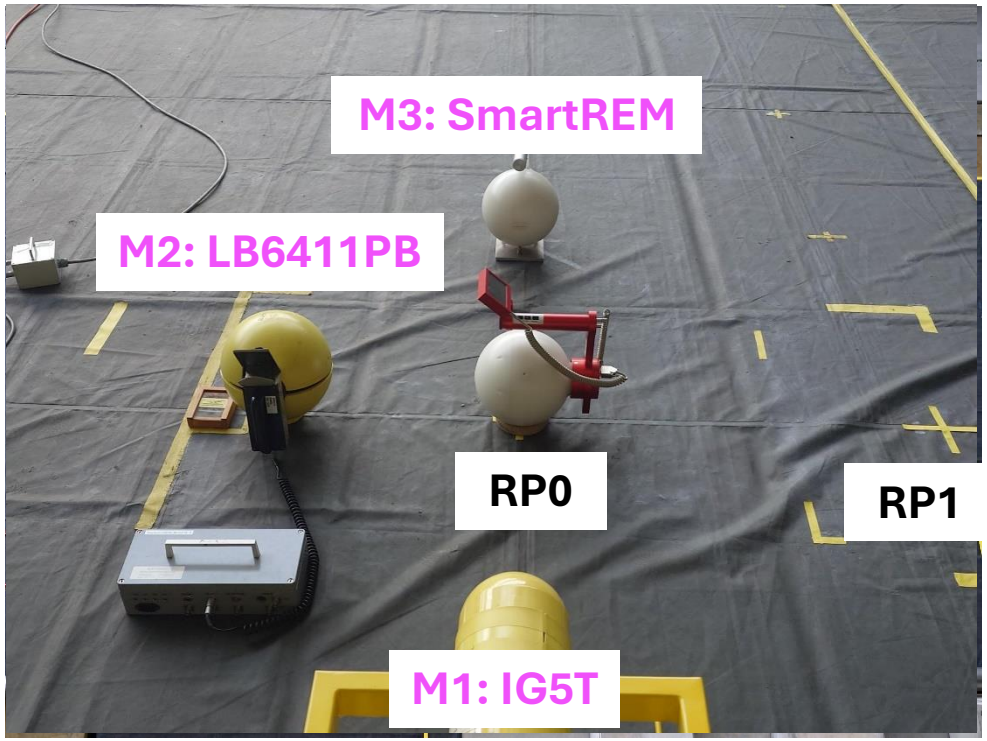
Facility layout: Side view

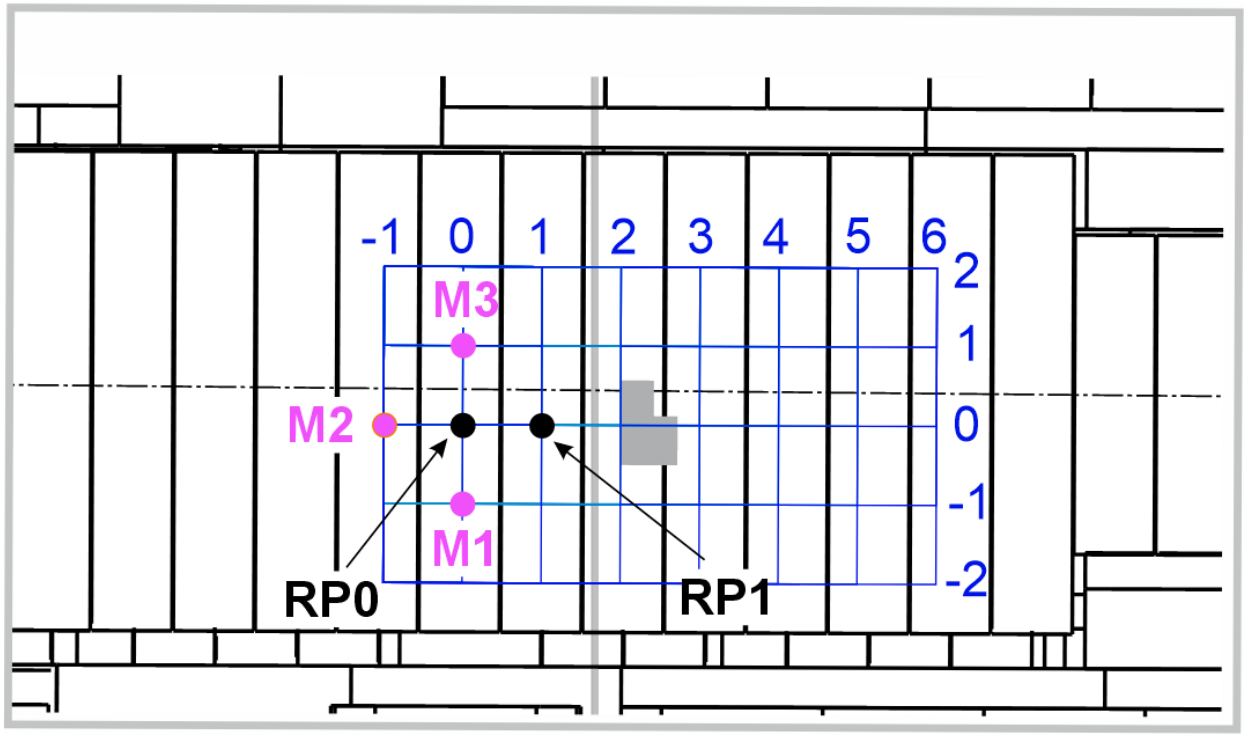


Beamline uncovered during the service period



Facility layout: Top view





- Field monitoring: **Three survey instruments**, Proton current monitor upstream the target
- **Two main reference positions RP** with spectral information
- **Additional positions available (only dose information)**
- **Position with reduced shielding available**

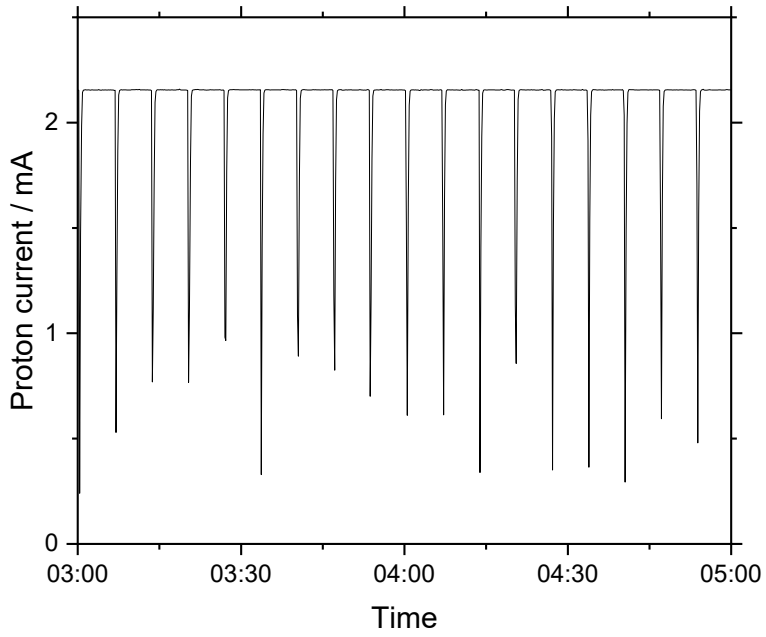
Beam properties and field monitoring

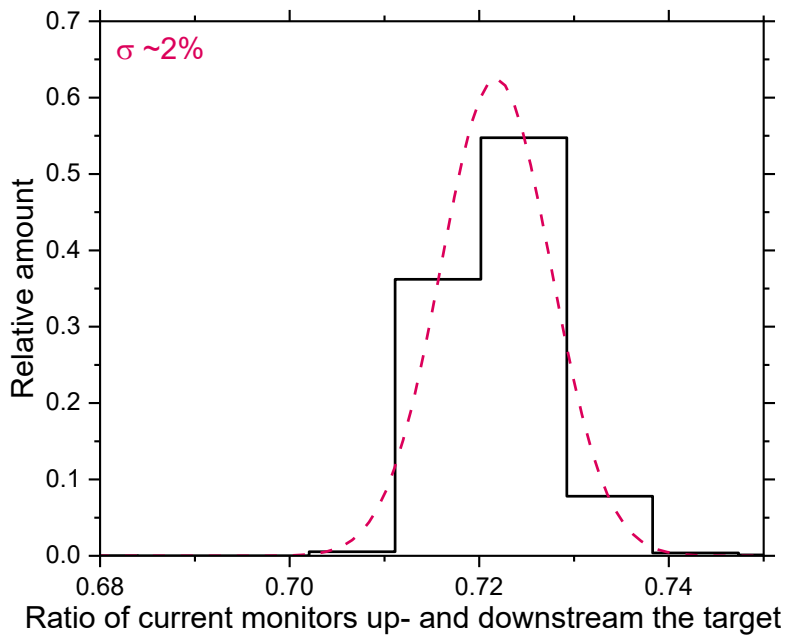
Proton current

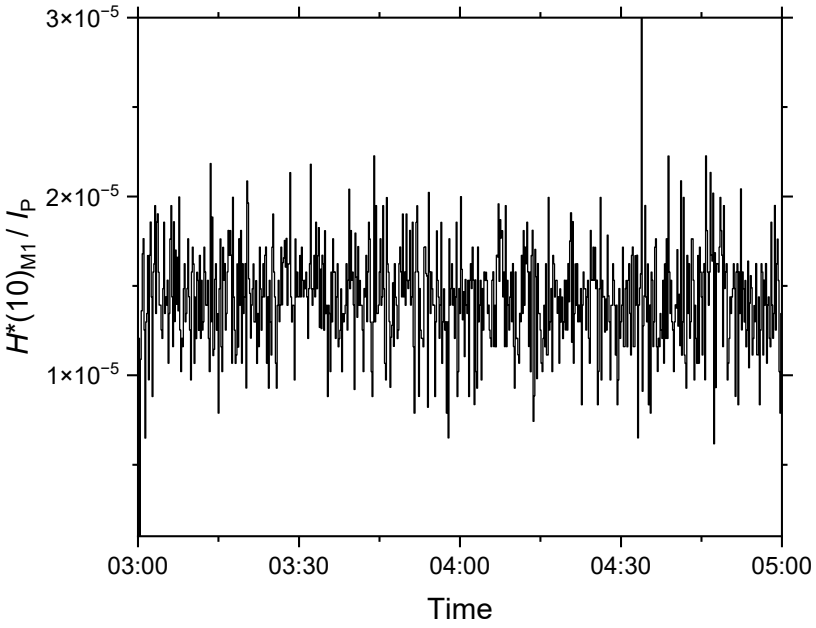
- Normal production conditions
- Periodically supplies a different experiment (5 s)
- Current indication up- and downstream the target varies with less than 2%

Neutron monitor readings

- Measurements ~60 days with an integration time of 10 s shows a stable indication







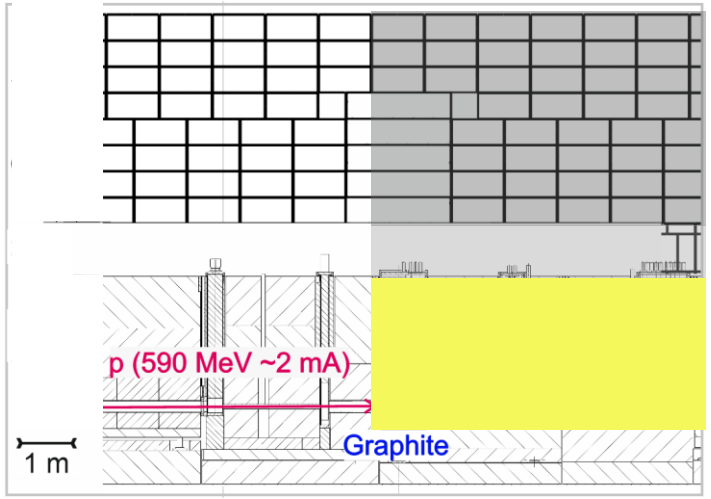
Characterization: Spectra Measurements and Calculation I

Measurement: PSI-Extended Range Bonner Sphere Spectrometer

- 10 PE moderator spheres and 4 with metal inlays [1]
- Characterized by Monte Carlo simulations, benchmarked in reference fields available at PTB and CERF [2]
- Data evaluation: Bayesian Parameter Estimation with a parametrized model or Maximum Entropy Unfolding [3]

Calculation: Simplified geometrical model using FLUKA [4]

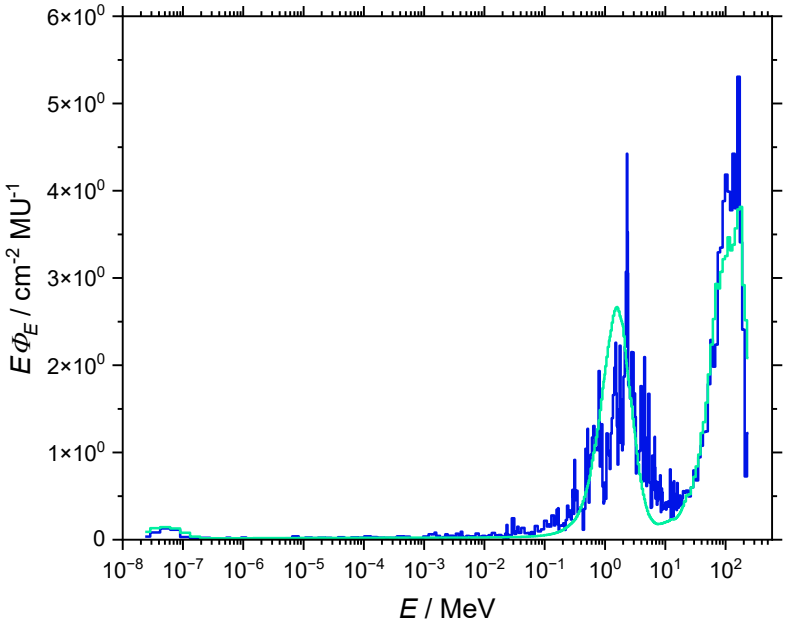
- Localized loss point: **Graphite Target** and Collimator
- First shielding layer: Iron without infrastructure openings
- Second layer: Air-filled service area
- Third layer: **Concrete**

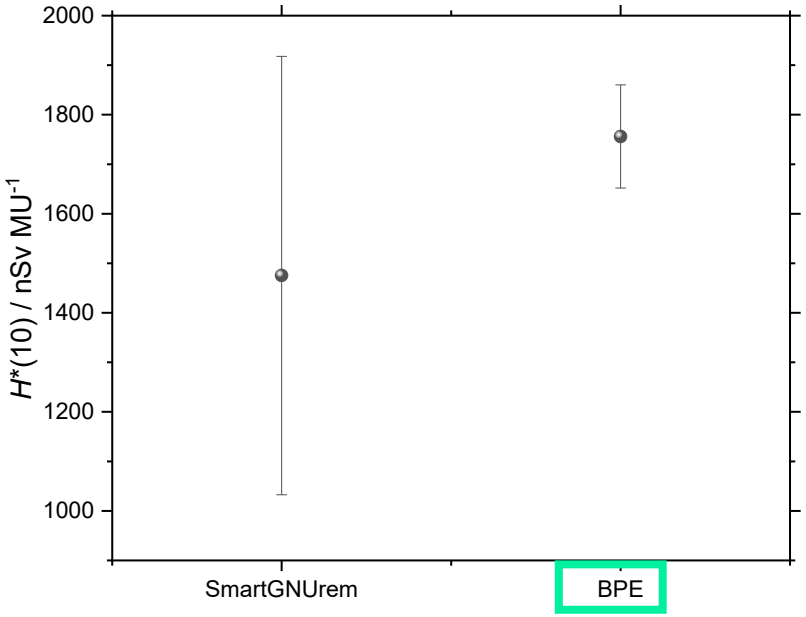


[1] B Wiegel, A.V Alevra. NEMUS—the PTB Neutron Multisphere Spectrometer: Bonner spheres and more, NIMA, 2002
[2] F. Pozzi, M. Silari. The CERN-EU high-energy Reference Field (CERF) facility: New FLUKA reference values of spectral fluences, present and newly proposed operational quantities, NIMA, 2020
[3] M. Reginatto. Overview of spectral unfolding techniques and uncertainty estimation, Radiation Measurements, 2010
[4] G. Battistoni et al. Overview of the FLUKA code, Annals of Nuclear Energy 82, 2015.

Characterization: Spectra Measurements and Calculation II

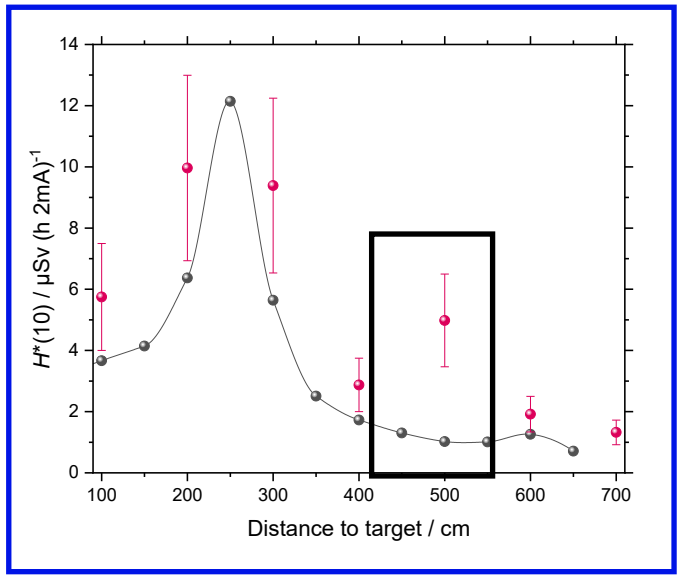
- The spectral neutron distribution for **Position RP0** obtained by **Bayesian Parameter Estimation (BPE)** and **Maximum Entropy Unfolding with calculations as pre-information** show good agreement
- Integral reference values for **Position RP0** as an example

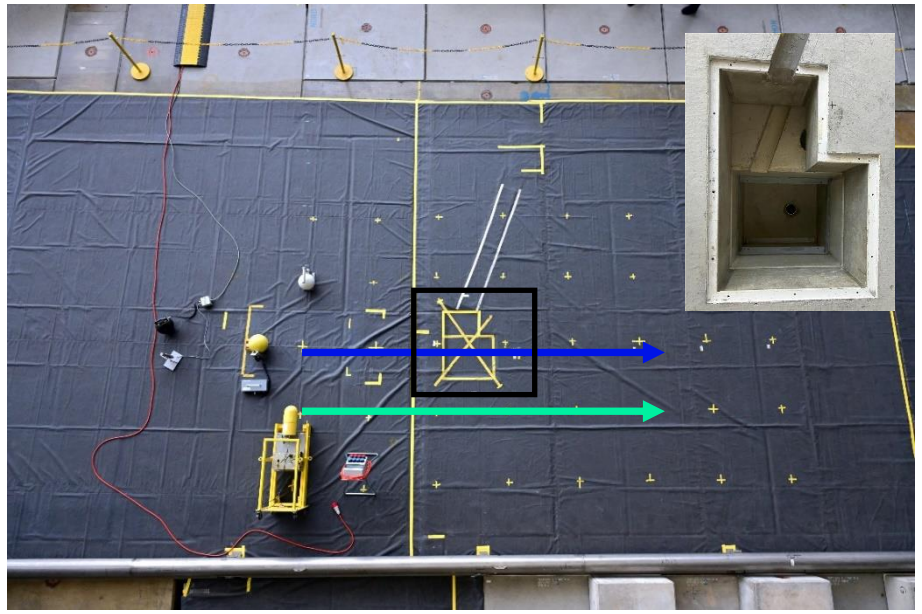




Characterization: Measured and calculated dose distribution

- Dose distribution was measured with Extended Range REM counters [5]
- Simplified geometrical model reproduces the gradient with acceptable agreement
- Introduction of more details necessary (**Reduced Shielding not included**)



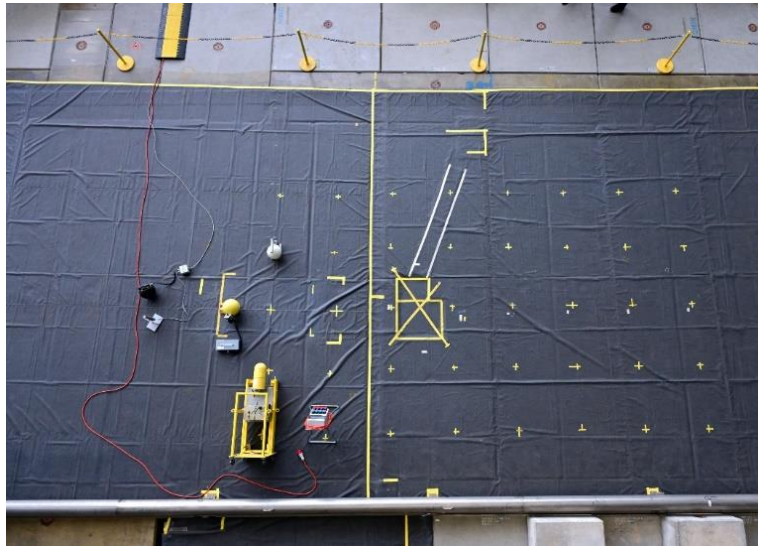


[5] Cirillo, Andrea Caresana, Marco. Experimental characterization of the LUPIN Rem counter in monoenergetic neutron fields. The European Physical Journal,. 2023

Summary and outlook

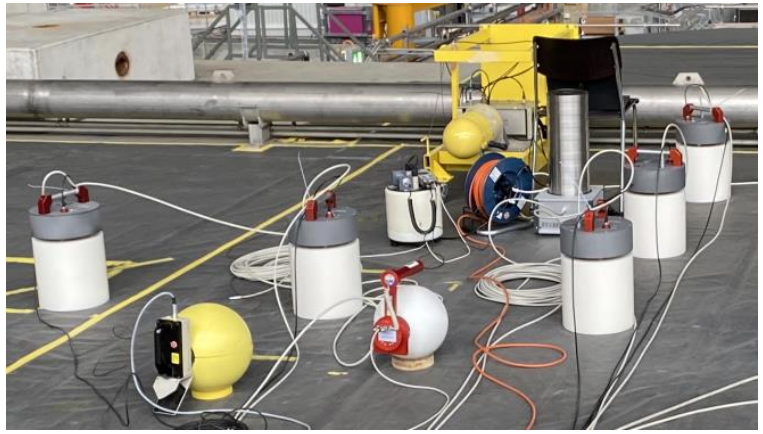
- Our new reference field above the PSI target E has a dominant contribution of neutrons with energies greater than 20 MeV
- The field was characterized by measurements and calculations
- The field monitoring was verified to be suitable by long term measurements
- The measurement positions are easy to access

Conclusion: The facility is suitable for calibrating and testing survey instruments and dosemeters



Outlook

- Investigating the position with reduced shielding in more detail
- Performing Monte Carlo simulations with a more detailed geometrical model
- Studying the dose gradient using passive detectors
- Conducting an intercomparison exercise with different REM-counters



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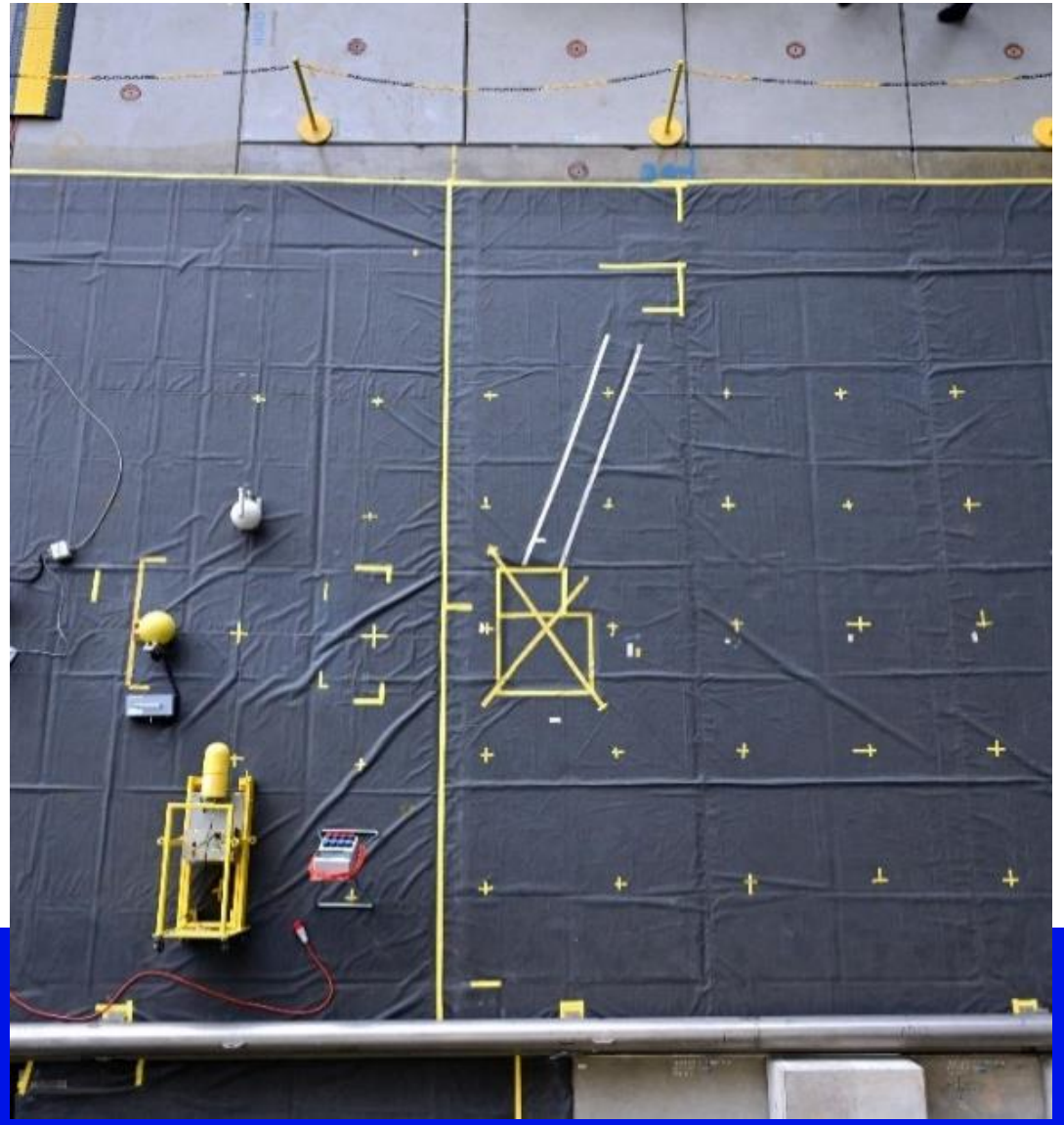
Thank you for your attention



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