

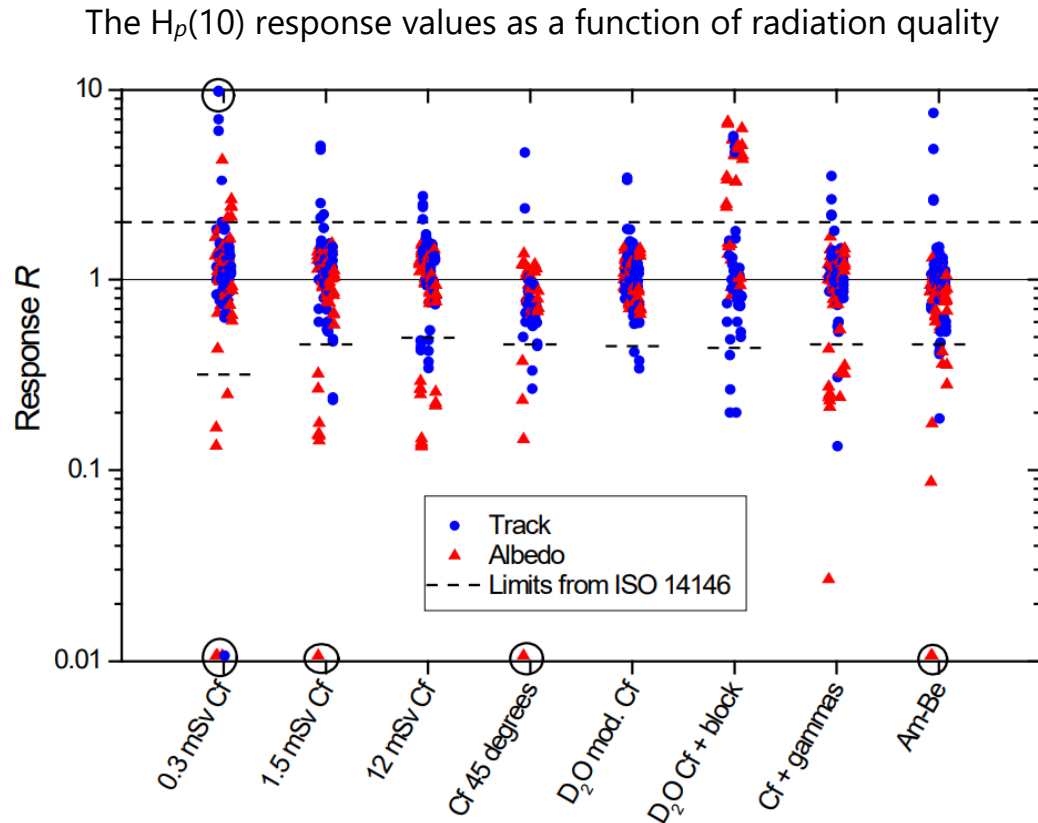


Computational neutron dosimetry at Budapest Research Reactor

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Motivation: The issue of physical neutron dosimeters

The response often deviates strongly from 1 with extremes of even 0.01 and 10.



European Radiation Dosimetry Group (EURADOS). (2021). *EURADOS report 2021-06: Technical recommendations for monitoring individuals for occupational exposure to external radiation*.

Why neutron dosimetry remains challenging in real workplaces?

Dosimeters are calibrated in ideal fields, but used in complex ones

- Well-known neutron spectrum
- Isotropic
- Minimal, controlled scattering
- Neutron only/neutron dominant

SCK CEN calibration field



SCK CEN workplace field (transport container)



O. Van Hoey et al., "Computational personal dosimetry at a realistic neutron workplace field," Radiation Measurements, vol. 159, p. 106867, Dec. 2022, doi: 10.1016/j.radmeas.2022.106867.

- Broad energy distribution
- Highly anisotropic, field gradients
- High scattering
- Mixed neutron-gamma common

Motivation: The issue of physical neutron dosimeters

General issues with personal neutron dosimeter

- ❑ **Forget to wear:** Workers tend to forget using multiple dosimeters.
- ❑ **Incomplete coverage:** One-point measurement. Not all body parts are covered
- ❑ **Inconsistent use:** Dosimeters are often worn incorrectly, affecting data accuracy.



Source: Radpro



Source: Thermo scientific

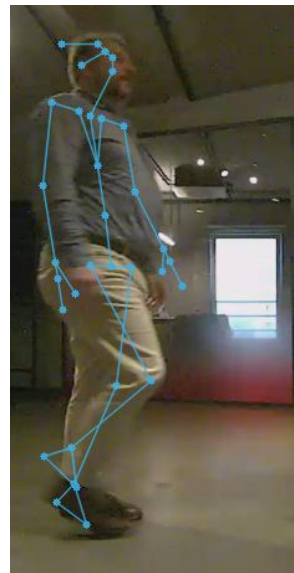


Source: SCK CEN

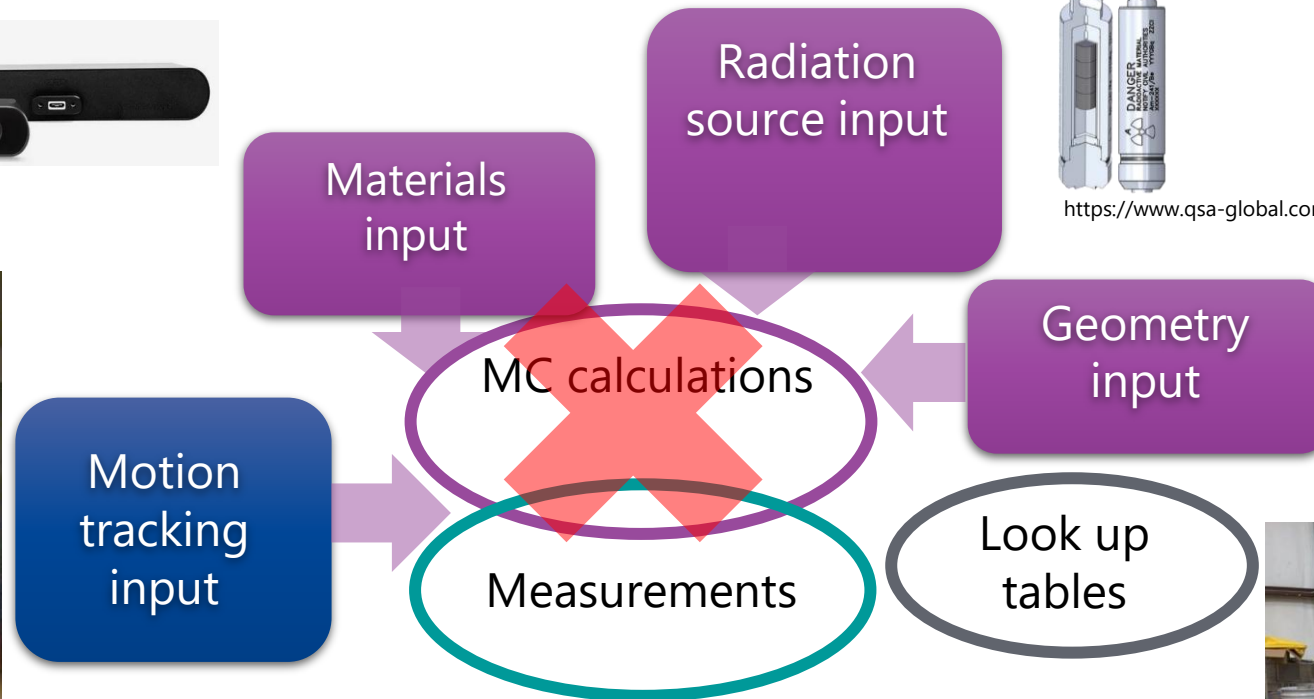
The concept of computational neutron dosimetry



<https://www.stereolabs.com>



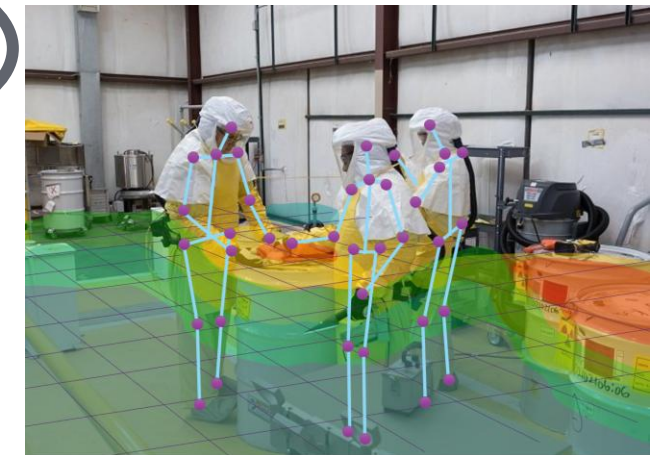
<https://community.stereolabs.com/>



<https://www.qsa-global.com>



<https://www.p-cure.com>



Adapted from <https://www.energy.gov/em/articles/los-alamos-establishes-new-processing-line-remediate-liquid-low-level-waste>

Adapted from M. Ginjaume, The PODIUM Project, 2020

The Budapest Research Reactor

- 10 MW tank-type research reactor
- Moderation & cooling: light water
- Rotatable core (affects field anisotropy)



View from the bridge

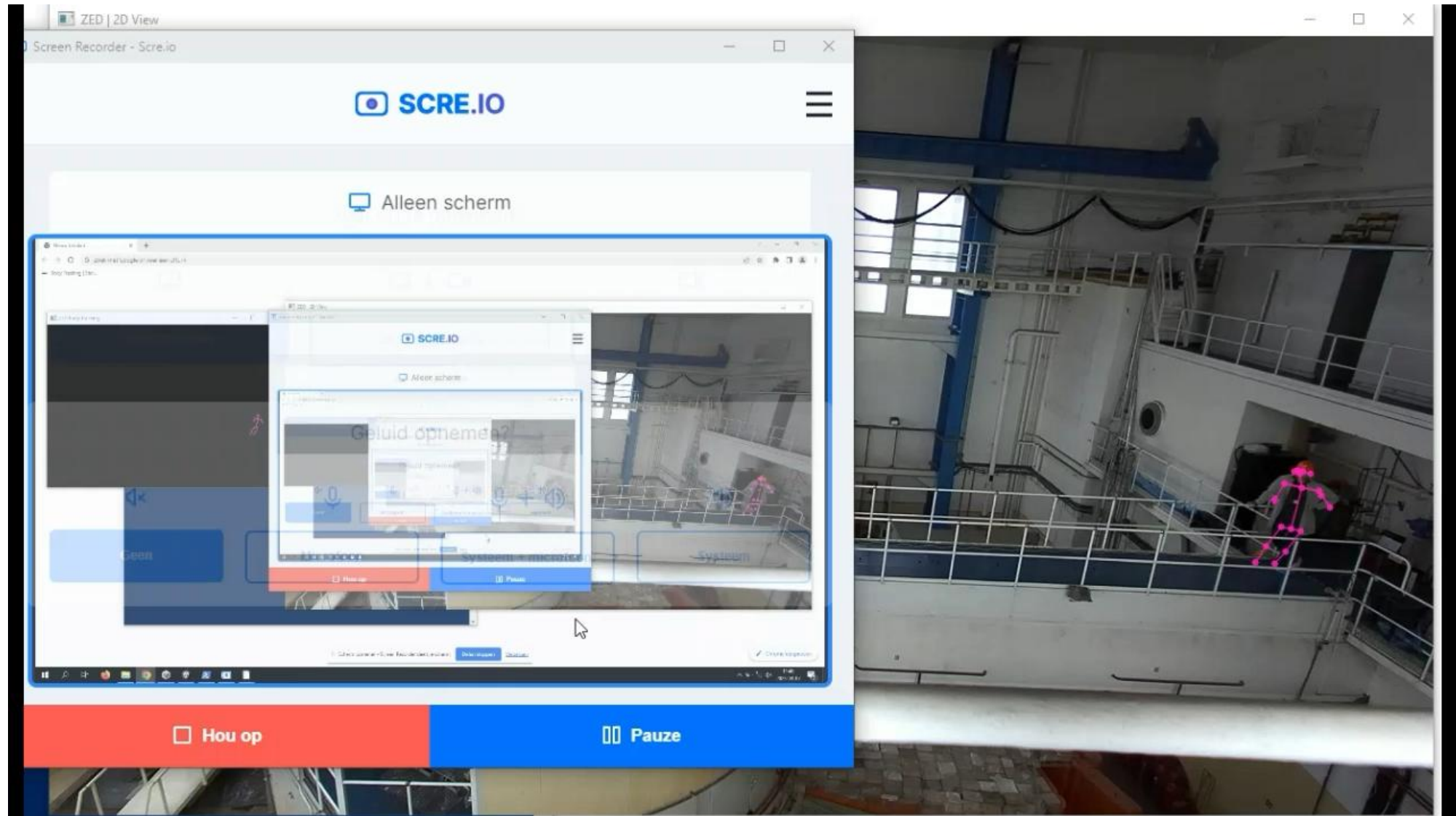


View from the corner of the room



Kasztovszky, Z., et.al., (2016). Applications of neutron-based and ion beam methods in Cultural Heritage research at the Budapest Neutron Centre. In *Technè* (Vol. 43, pp. 70–74).

Body tracking of a worker at Budapest Research Reactor



Measurement devices

- **Berthold LB6411:**

- Classic rem counter
- Large energy-dependent uncertainty (up to $\pm 30\%$)



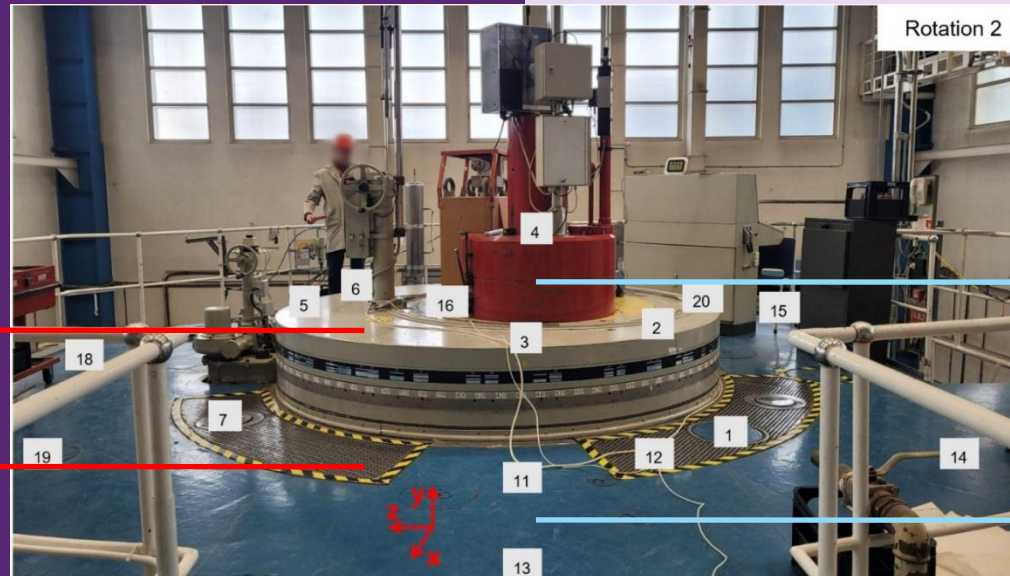
- **DIAMON Spectrometer:**

- Direction-aware, energy-resolved neutron fluence
- Real-time $H^*(10)$ and spectral data



Middle of reactor

Shafts

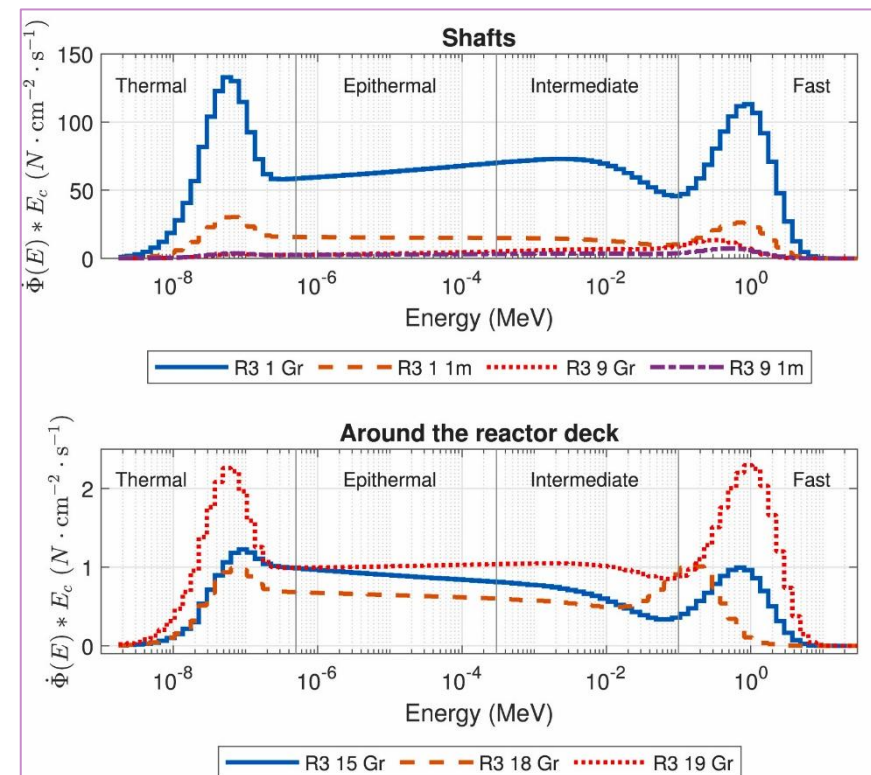
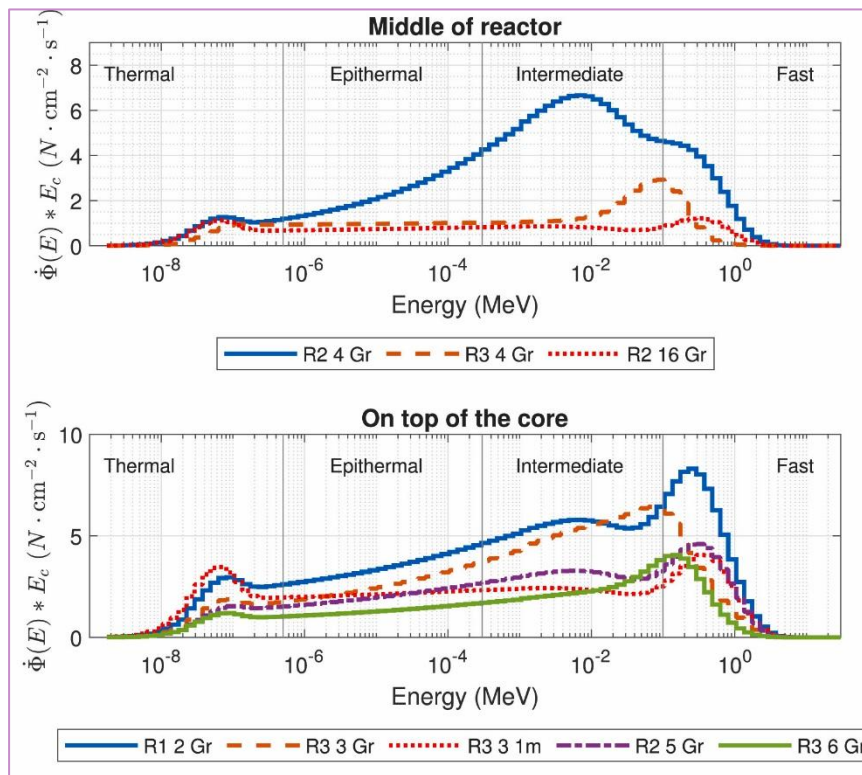


On top of the core

Around the reactor deck

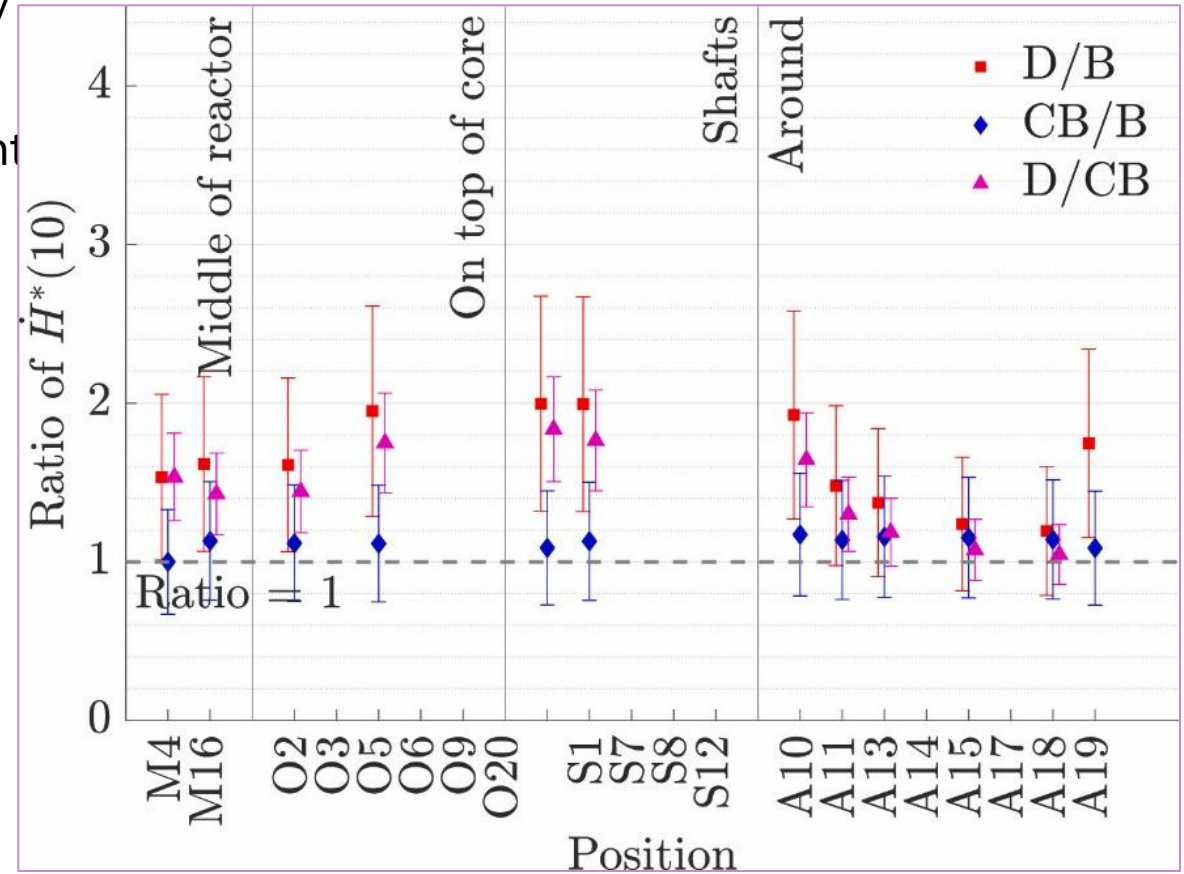
Neutron spectra variations

- DIAMON spectra show spatial & rotational variations
- Core vs. deck: Fast vs. thermal dominance
- Height matters: Strong vertical gradients near the core



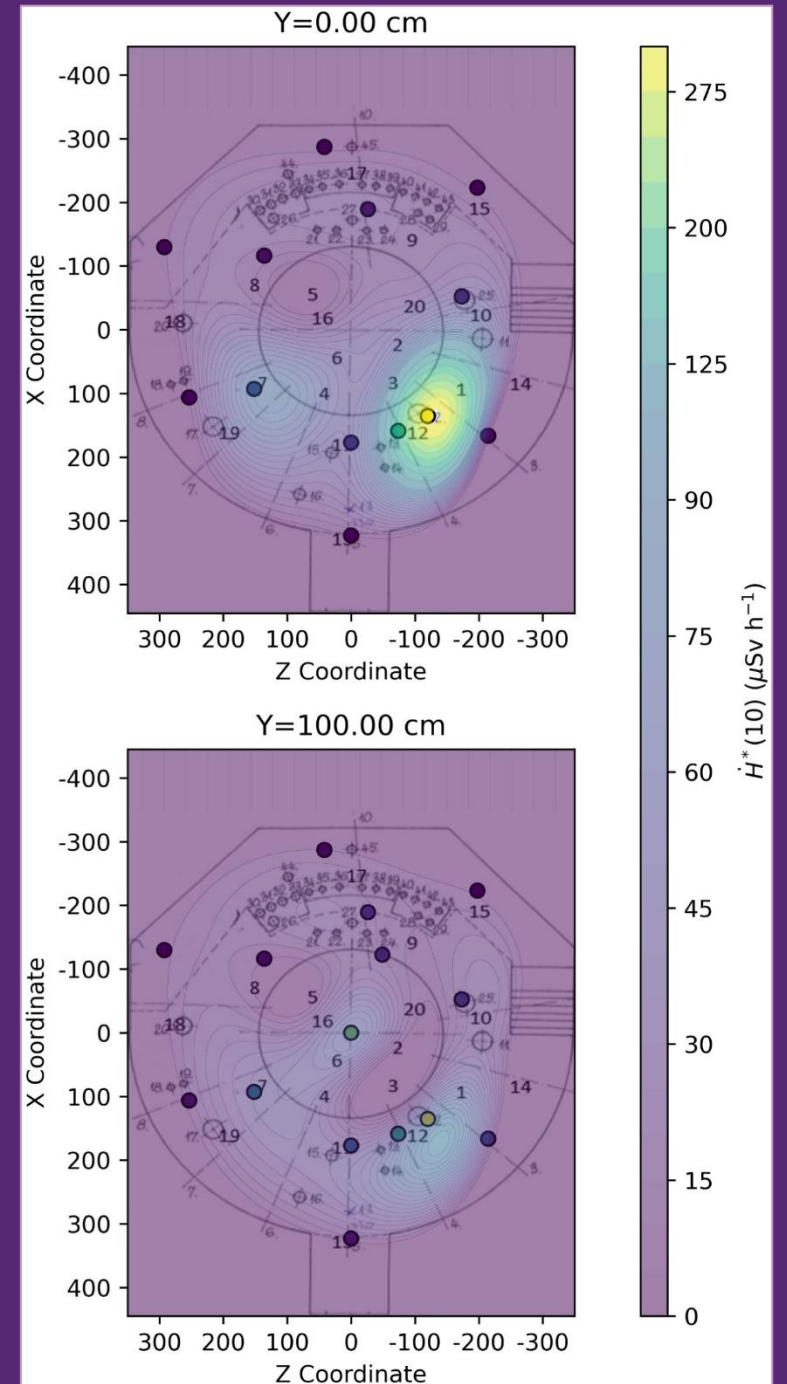
Device comparison & correction

- Berthold underestimates dose – limited energy response.
- Correction using DIAMON improves agreement



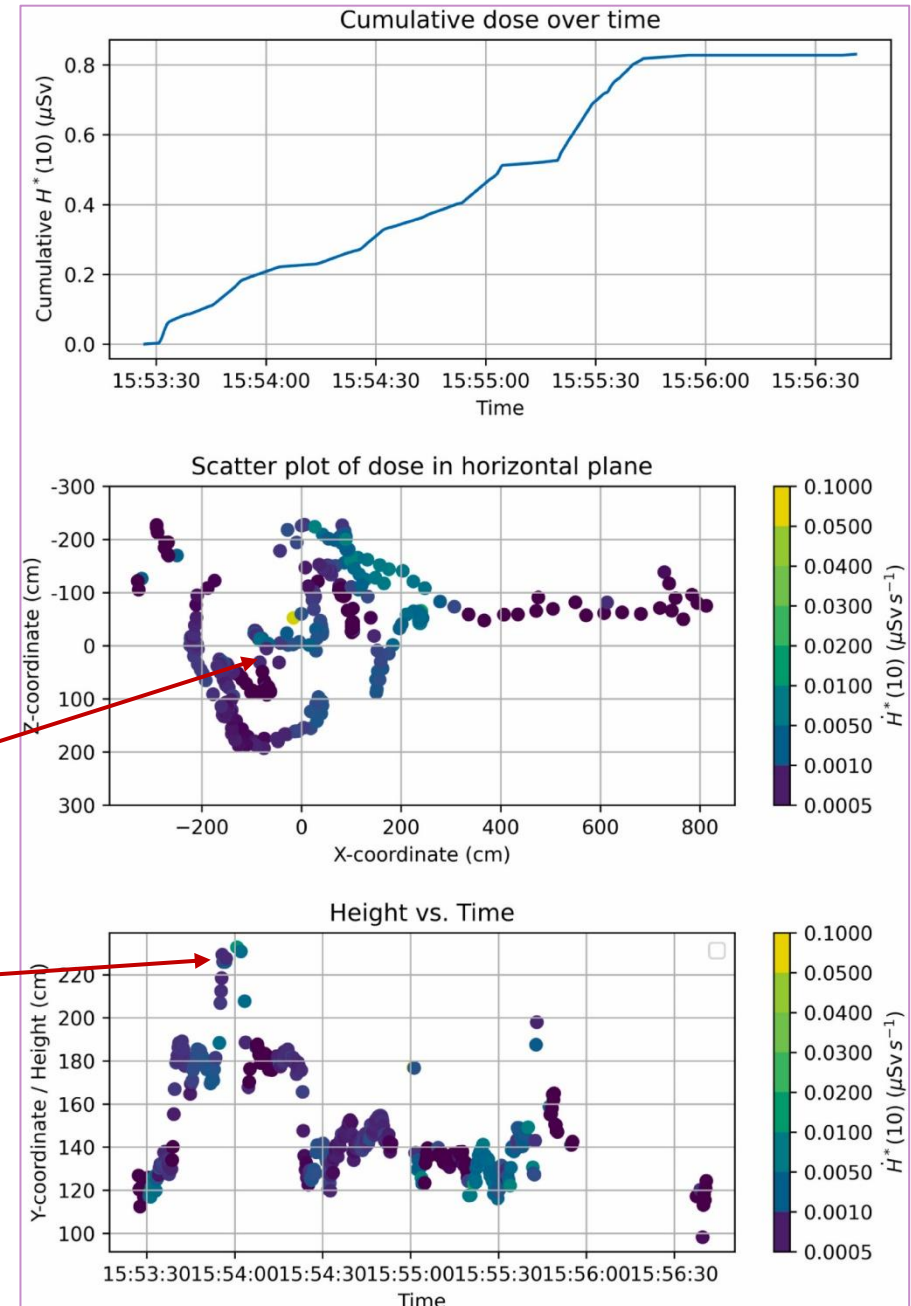
Establishment of the dose rate map

- Measurements at 40 locations (floor & 1 m)
- Corrected Berthold using DIAMON spectra weighted-integration.
- Interpolation via RBF (SciPy) → fine 3D dose rate map.



Computational dose results

Body tracks and accumulated dose



Comparison between the accumulated dose from computational dosimetry and electronic personal dosimeter (EPD)

- Computational dosimetry: 0.8 μSv over 3 minutes $\rightarrow$ 0.26 $\mu\text{Sv}/\text{min}$
- Personal neutron dosimeter:
36 μSv over $\pm$ 3 hours
 $\rightarrow$ $\sim$ 12 $\mu\text{Sv}/\text{hour}$
 $\rightarrow$ $\sim$ 0.2 $\mu\text{Sv}/\text{min}$
- Both results have the same order of magnitude.

Some notes:

- EPD is not considered sufficiently accurate to be used as a reference.
 - 3 minutes vs 3 **hours**
- $\rightarrow$ Further tests are needed

Conclusions:

- Computational dosimetry was validated in a real, complex neutron workplace field.
- Integration of DIAMON spectrometry and Berthold LB6411 improves neutron dose mapping.
- Real-time camera-based tracking accurately captured worker position if unobstructed.
- Computational dosimetry yielded neutron dose estimates comparable to physical dosimeters.
- Computational dosimetry may complement or replace neutron personal dosimeters.
- **Limitation:** Assumes field stability; estimates $H^*(10)$, not $H_p(10)$.

Outlook

- Apply DIAMON's angular data → to derive $H_p(10)$, E.
- Improve tracking ID & real-time processing.
- Extend to other neutron workplaces.
- **Vision:** Computational dosimetry as a standard tool.

Thank you for your attention!



Scan the code to read the article!

Pinasti, S. G., Van Hoey, O., Mihailescu, L.-C., Abdelrahman, M., Jakab, D., Pantya, A., Pázmándi, T., Rudas, C., Zagyvai, M., Vanhavere, F., & Pauly, N. (2025). Computational neutron personal dosimetry at the Budapest Research Reactor. Radiation Measurements. <https://doi.org/10.1016/j.radmeas.2025.107420>

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