

The ANTHEM BNCT clinical facility neutron moderation system design and materials characterisation

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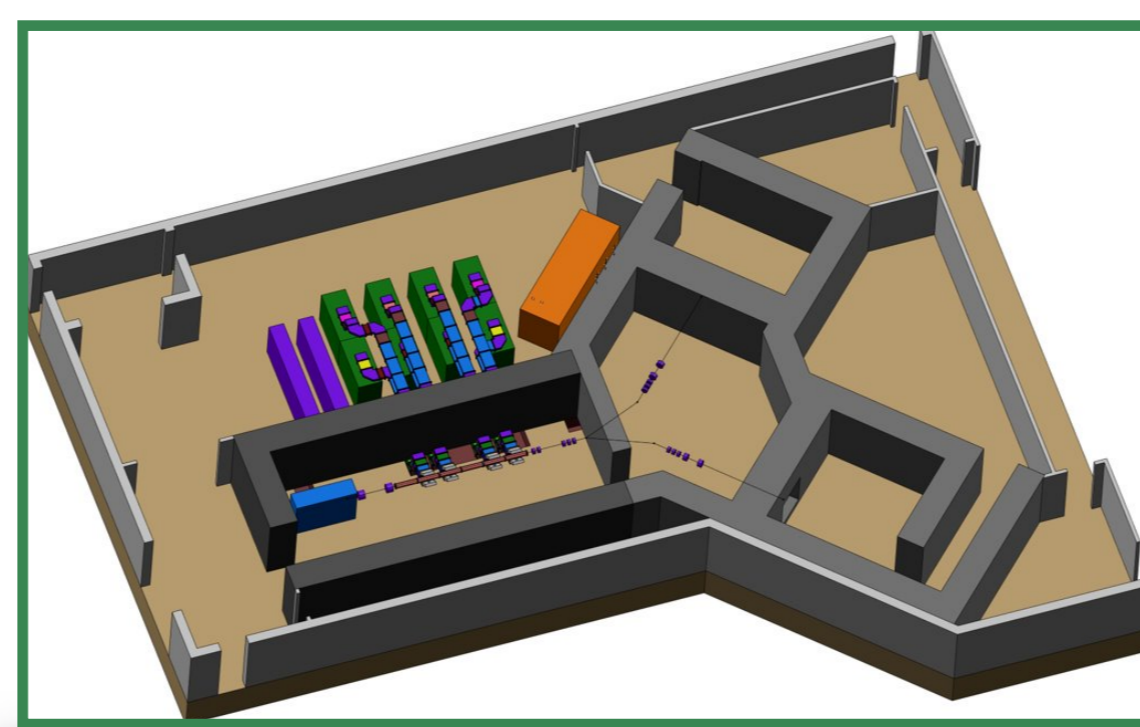
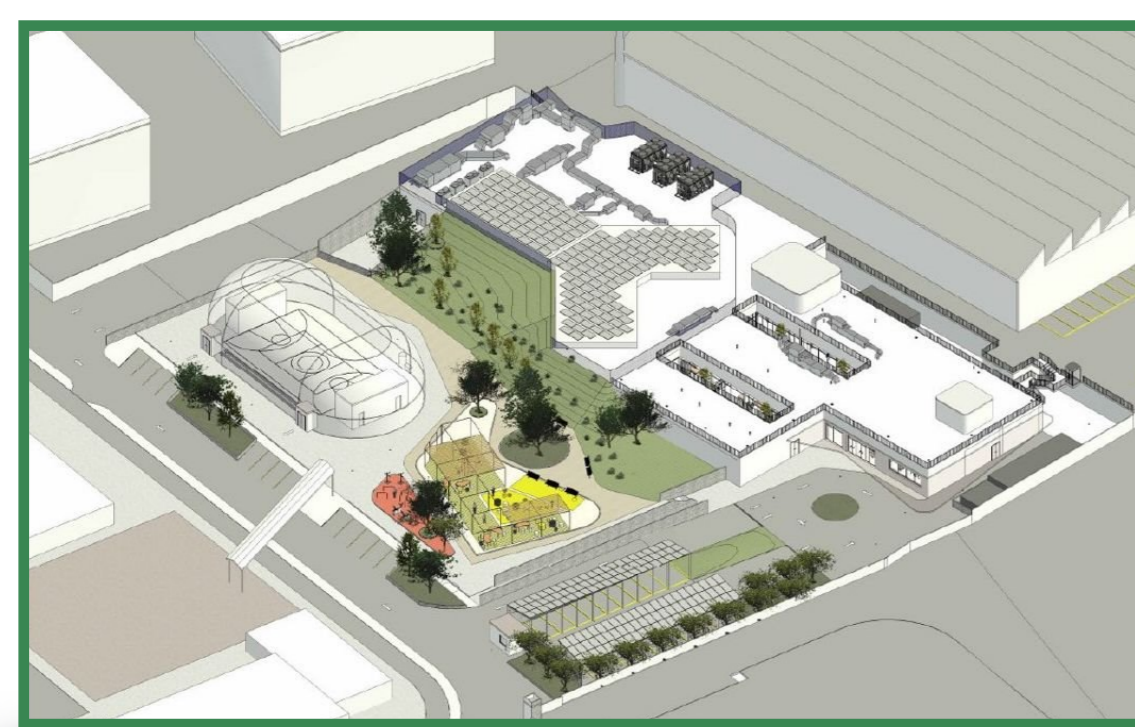
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ANTHEM - BNCT clinical facility

The project aims at building a **Boron Neutron Capture Therapy (BNCT) clinical facility** in Caserta. The area chosen for the centre is in San Nicola La Strada adjacent to the CIRCE laboratory of the University of Campania Luigi Vanvitelli and of INFN.

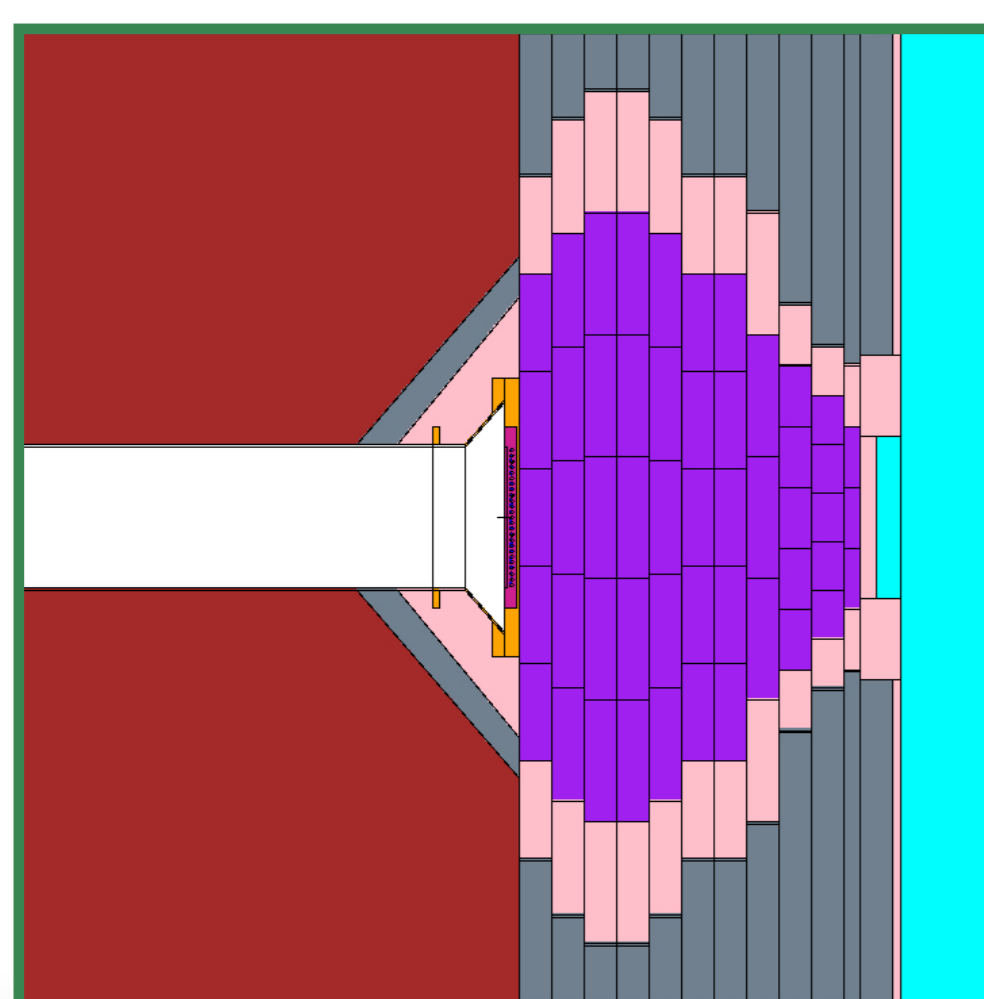
The clinical facility will employ a Radio Frequency Quadrupole (RFQ) proton accelerator with 5 MeV Energy and 30 mA current. Neutrons will be obtained by the protons impinging on a Beryllium target. Both the RFQ accelerator and the Be target have been designed and developed by the INFN Legnaro National Laboratories.

The neutron spectrum emerging from the target will have energy up to 3 MeV. To obtain a clinically efficient spectrum with a peak in the epithermal region, the neutron will need to be moderated and tailored.

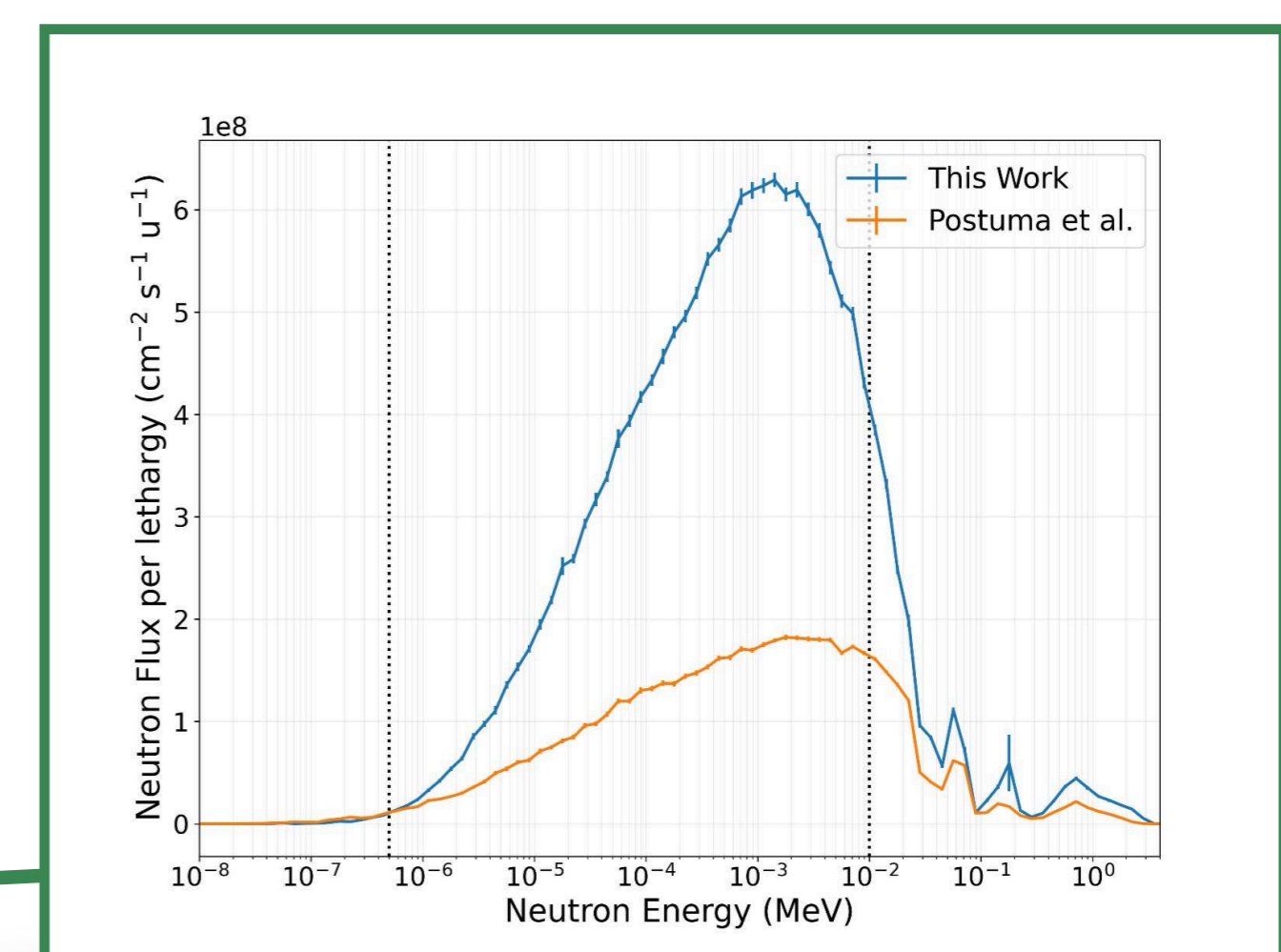
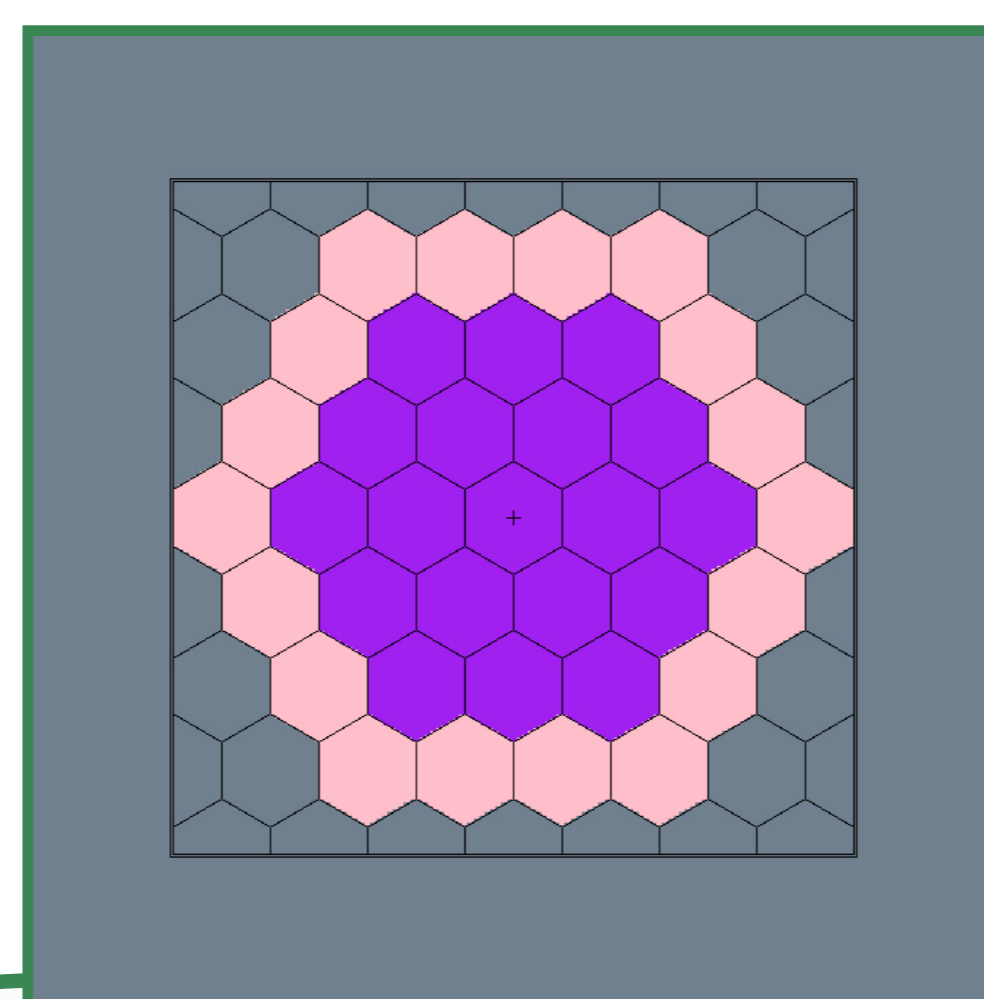


Neutron Moderation system

The neutron moderation system was designed by the INFN - Unit of Pavia. The Beam Shaping Assembly (BSA) shown in the figures below is mainly comprised of three materials. Borated Polyethylene will be used in the outer shell of the BSA to limit the thermal component of the beam exploiting the thermal capture cross-section of ¹⁰B and H present in the material. The lead in the middle shell will act both as a reflector for the neutrons and as shielding for the gamma rays due to the neutron capture reactions. Lastly the core of the BSA will be filled with Aluminium and Lithium Fluoride and Magnesium Fluoride to moderate the more energetic components of the spectrum. The new design will be 40 cm along the beam axis and have a maximum radius of 80 cm. The new design of the BSA was compared to the previous one published in 2021 and the plot shows the improved performances of the clinical beam.



Legend for BSA layers:
 - Borated Polyethylene (Grey)
 - Lead (Pink)
 - MgF₂ / AlF₃+LiF (Purple)



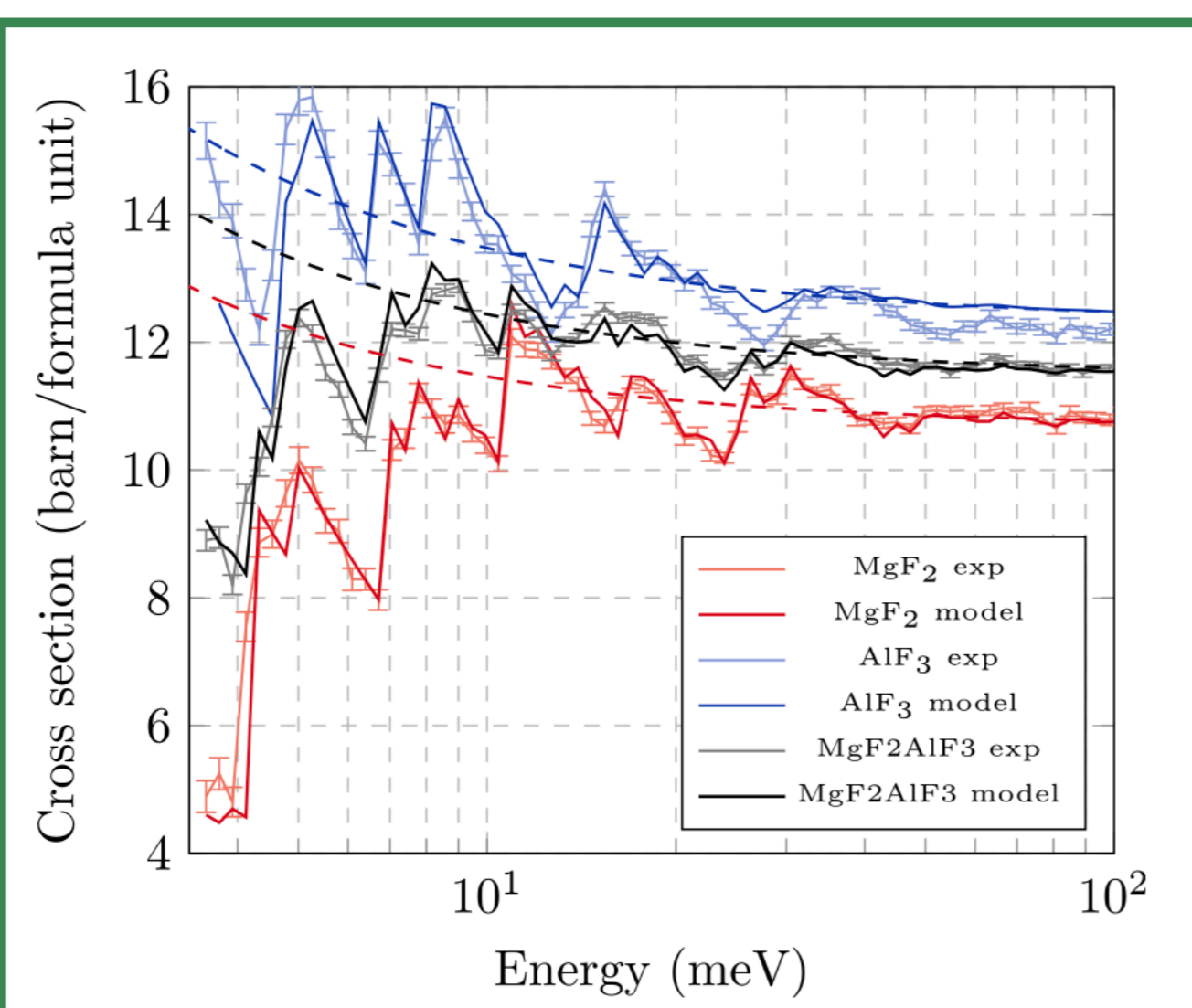
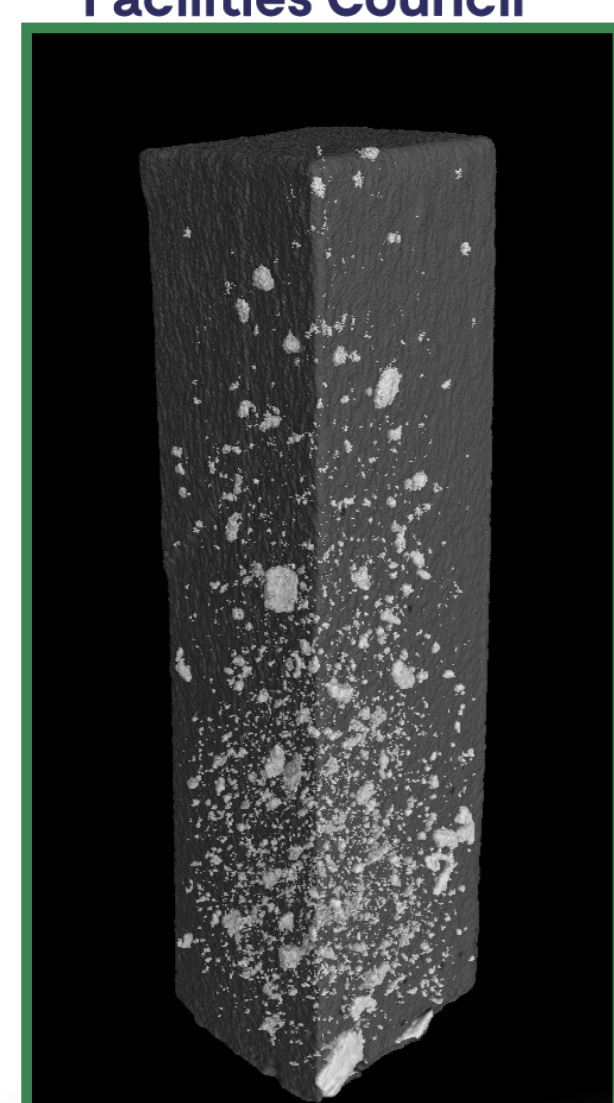
Postuma, Ian, et al. "A novel approach to design and evaluate BNCT neutron beams combining physical, radiobiological, and dosimetric figures of merit." *Biology* 10.3 (2021): 174.



Moderation materials production and characterisation

The neutron moderation core has been developed using AlF₃ and MgF₂. Both fluorides can be found in powder form but to reach a density useful for the moderation system the INFN Unit of Pavia through the TT SINTER project has developed a sintering machine that allows the creation of hexagonal bricks of the material with high density that can be stacked to create the BSA.

MgF₂, AlF₃ and AlF₃+LiF were characterised in a neutron field at the STFC Rutherford Appleton Laboratory in UK. The materials were studied both with neutron tomography to study the LiF distribution in the material and with neutron transmission and diffraction to study the Bragg-Edge peaks typical of the material structure and the thermal neutron cross sections.



Margherita Simoni et al. "Thermal neutron cross sections of aluminum and magnesium fluorides and quantum kinetic energy of fluorine." *J. Chem. Phys.* 28 October 2025; 163 (16): 164503. <https://doi.org/10.1063/5.0294270>

Acknowledgements

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