URANOS

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a voxel engine Neutron Transport Monte Carlo Simulation

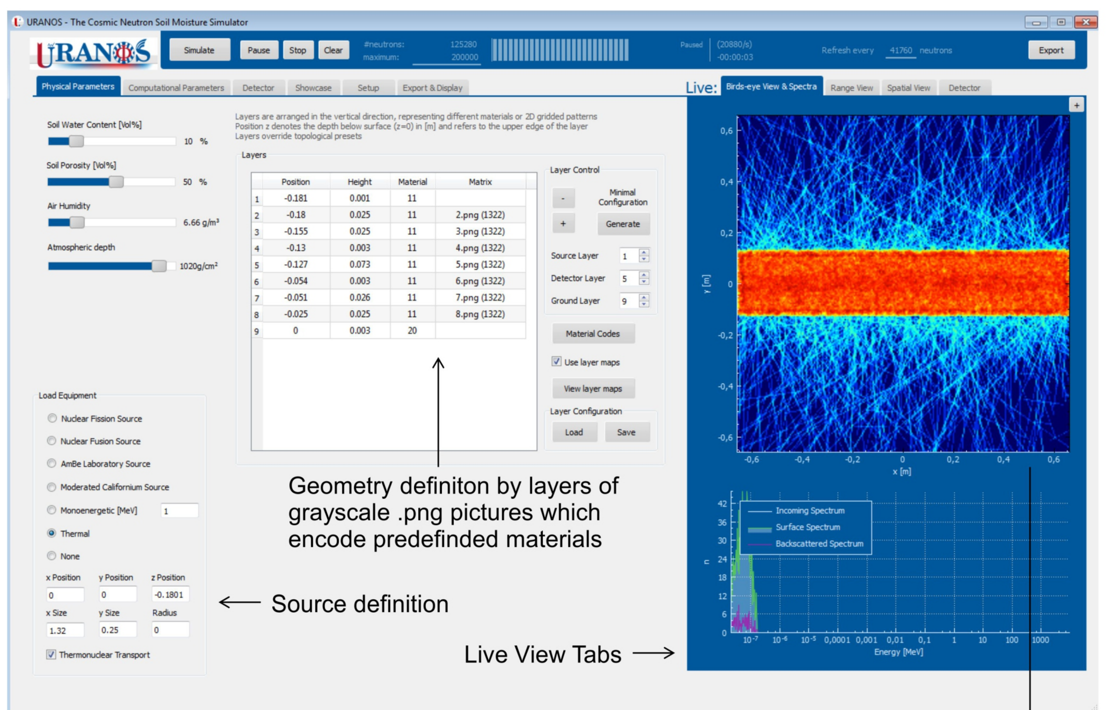
- •simple user interface
- •computationally efficient
- •New geometry concept of layers and voxels

URANOS (**U**ltra **RA**pid **N**eutron-**O**nly **S**imulation) is a newly developed 3D neutron transport Monte Carlo for the thermal to fast regime. Emerging from a problem solver for detector development in collaboration with environmental physics the project aims towards providing a fast computational workflow and an intuitive graphical user interface (GUI) for small to medium sized projects. It features a ray-casting algorithm based on a voxel engine. The simulation domain is defined layerwise, whereas the geometry is extruded from a pixel matrix of materials, identified by specific numbers. Therefore, input files are solely a stack of pictures, all other settings, including the configuration of predefined sources, can be adjusted by the GUI.

The scattering kernel features the treatment of elastic and inelastic collisions, absorption and emission-like processes like evaporation. Cross sections, energy distributions and angular distributions are taken from the data bases ENDF/B-VII.1 and JENDL/HE-2007. In order to simulate multi-layer boron detectors it also models the charged particle transport following the conversion by computing the energy loss in the boron and its consecutive layer. The electron track is then projected onto a readout unit by longitudinal and transversal diffusion.
URANOS is freely available and can be used to simulate the response function of boron-lined or epithermal neutron detectors, small-scale laboratory setups and especially transport studies of cosmic-ray induced environmental neutrons.

URANOS is freely available from the websites of the Physikalisches Institut Heidelberg and the UFZ Leipzig

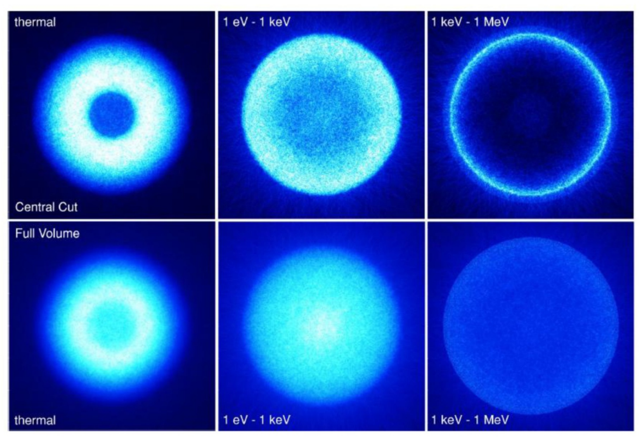
The User Interface



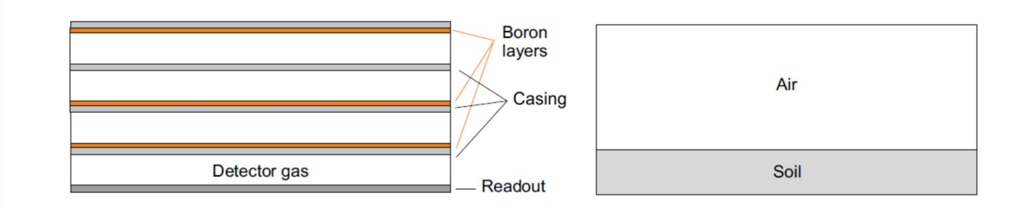
The URANOS GUI has been developed in collaboration with the UFZ Leipzig targeting environmental reseach. It allows for a direct and simple control over the settings of the computational domain. Therefore no editing of steering files is required.*

* Nerd disclaimer: URANOS also runs with batchfiles and ASCII matrices from the command line.

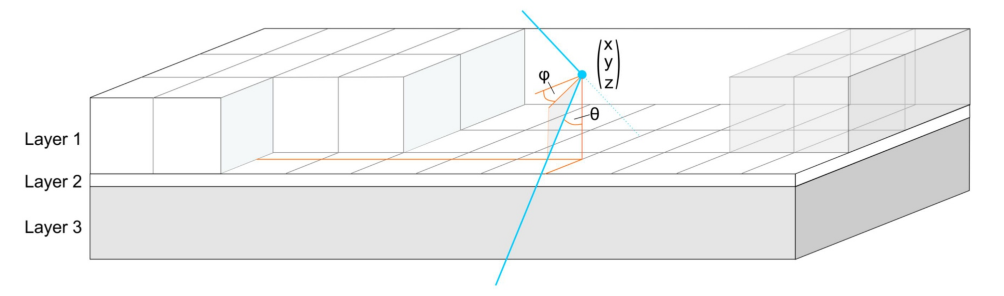
Live view example: tracks in a 3" Bonner Sphere

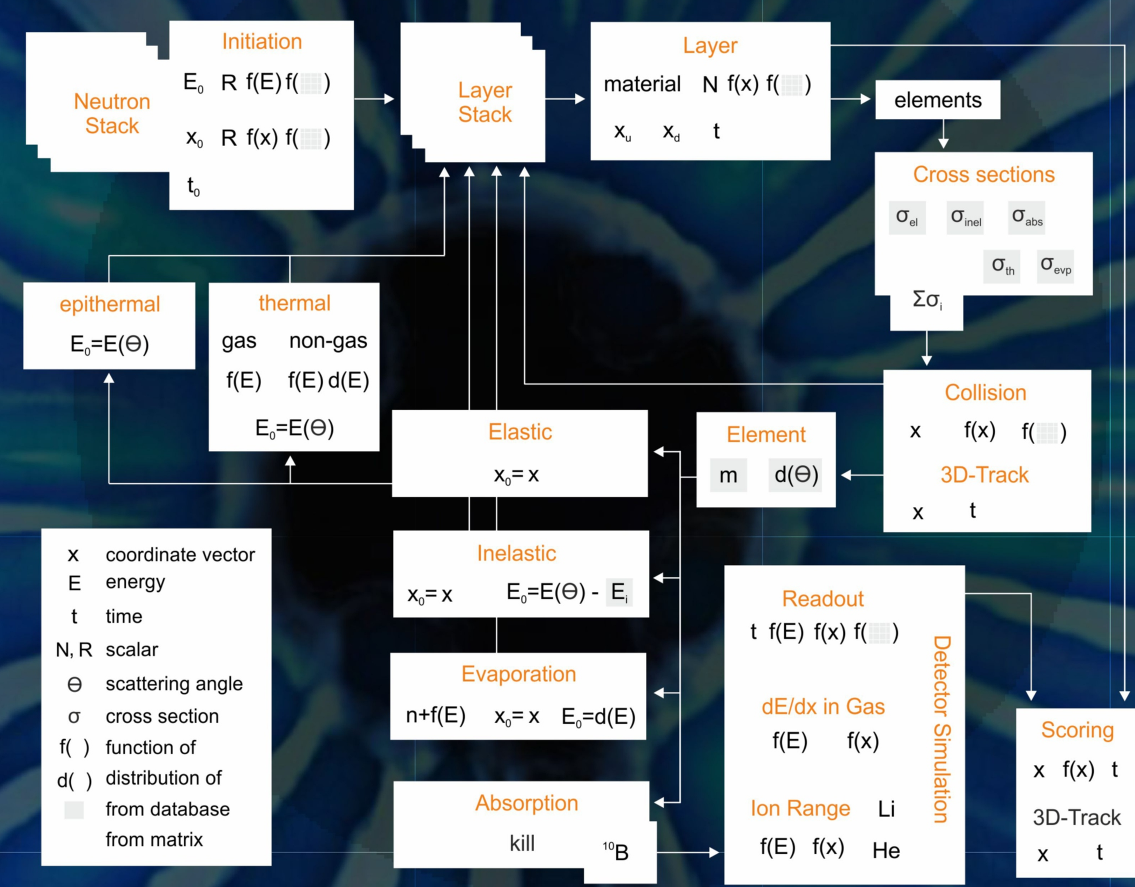


Layer and voxel geometry

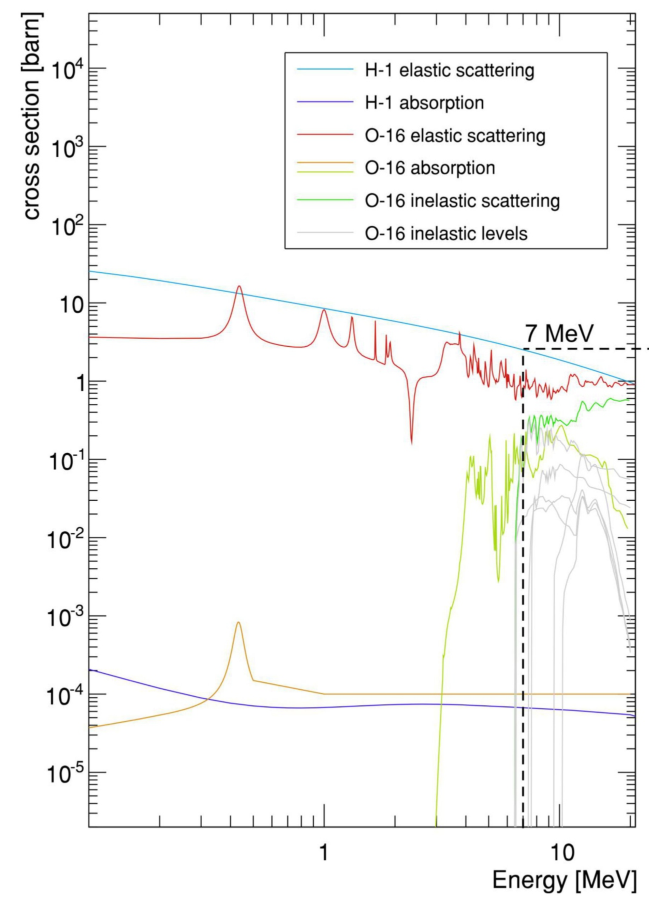


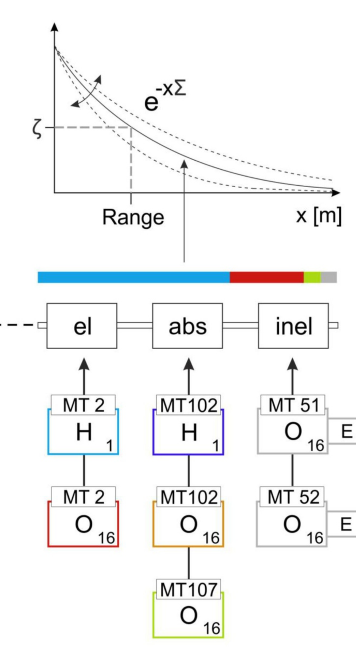
The geometry is organized in layers. This allows to easily build up a stack of homogenous materials with the main parameter being position and height of such a layer. Each layer furthermore can be sub-structured by twodimensional matrices into **voxels**.



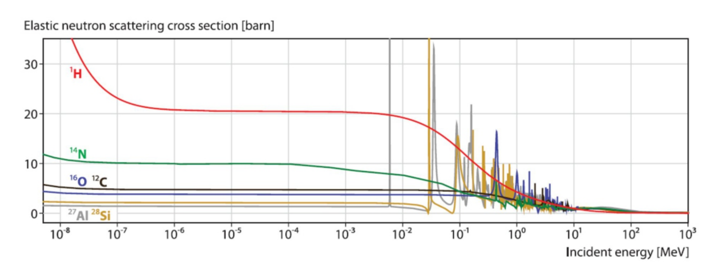


Cross Sections





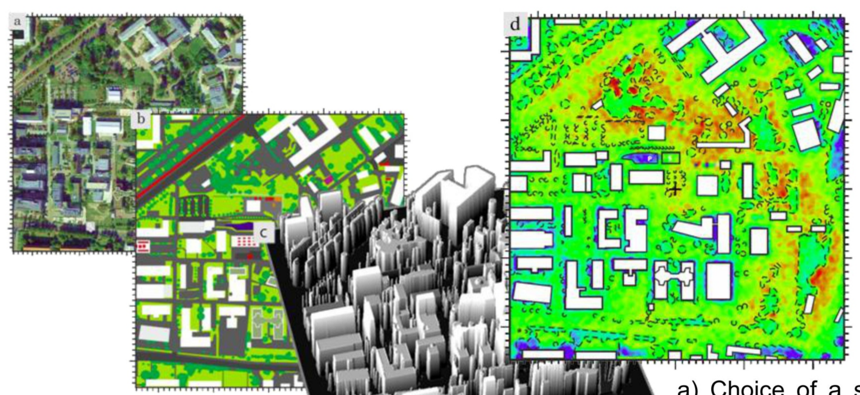
Only MT numbers with significant contributions are taken into account, which translates to omitting processes with overall less than 0.01 % of the total cross section.



Cross sections and angular distributions are read from tabulated ENDF files

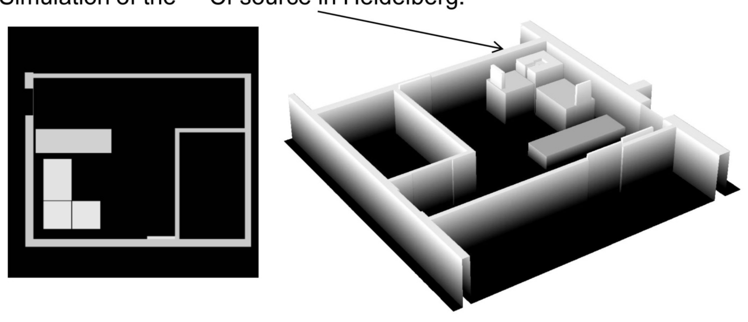
Neat Examples

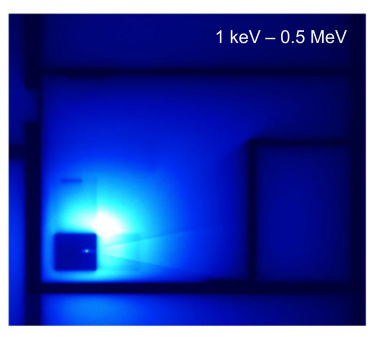
URANOS modeling process, exemplarily for a neutron density in an urban environment:



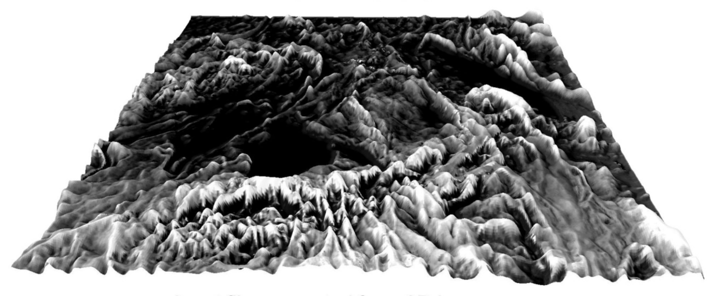
a) Choice of a simulation context, b) Transfer to a (layered) pixelated image, c) Extrusion of a voxel model by the geometry unit and d) Export of the neutron density.

Simulation of the ^{252}Cf source in Heidelberg:

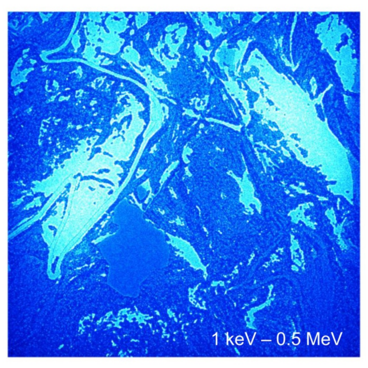




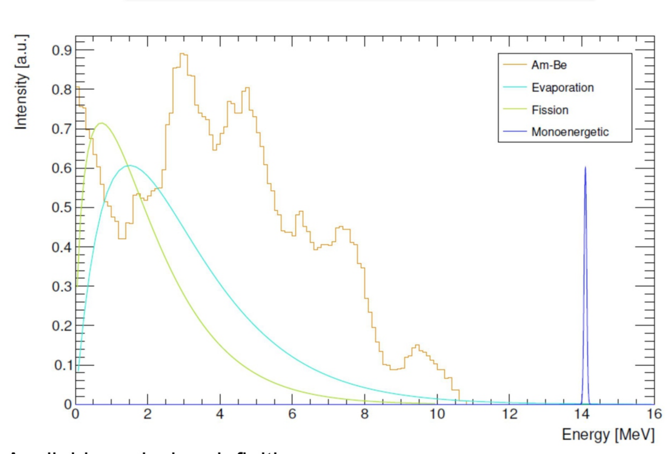
Snow cover at the Kaunertal glacier (Alps):



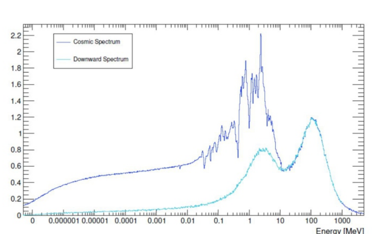
Input file generated from 3D laser scanner data provided by P. Schattan, University of Insbruck



Sources

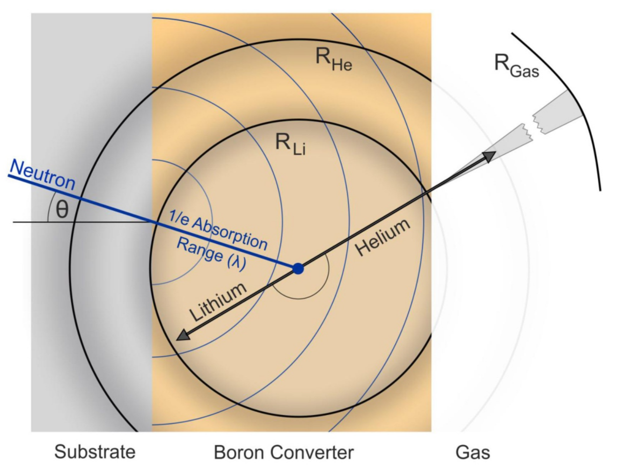


Available emission definitions:
- point source
- plane source
- volume source

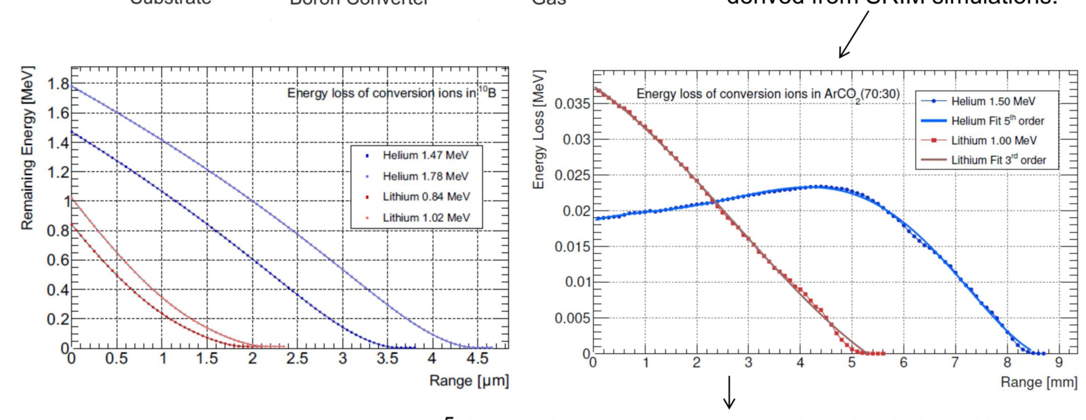


- Americium-Beryllium
- Fission
- Monoenergetic
- Thermal
- Cosmic Neutron Source

Conversion treatment

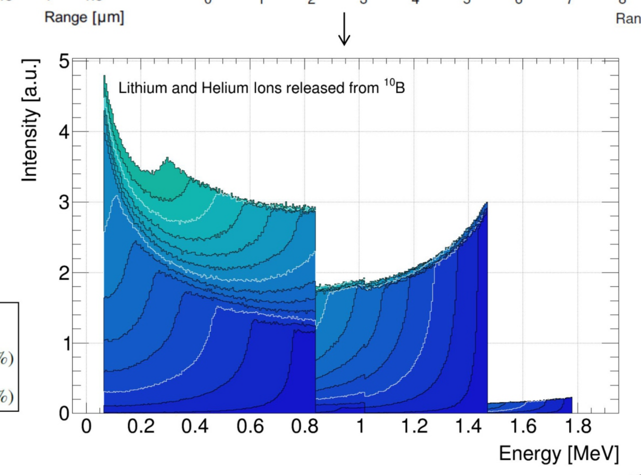


A neutron impinges with an angle normal to the surface of a converter (here: boron). By the conversion process lithium (Li) and helium (He) ions with fixed energies are created. In the medium itself they lose energy by collisions leading to a Bragg distributed range R, different for both agents. After reaching the gas an ionization track is produced with the remaining energy at the boundary. The material-specific energy loss (dE/dx) is analytically implemented by functions derived from SRIM simulations.

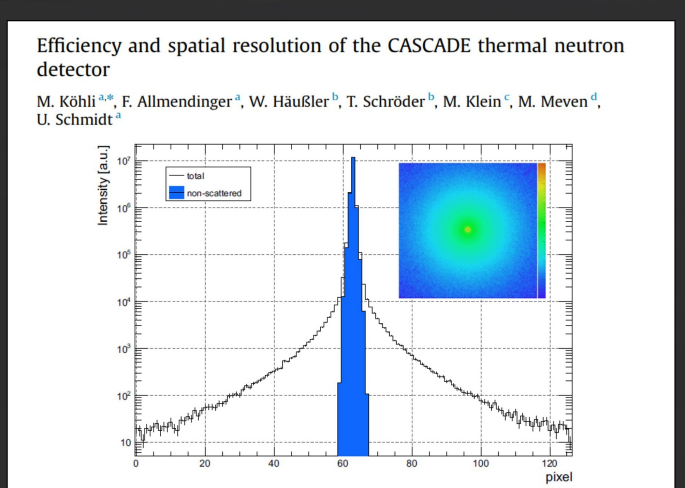


Conversion ion energy spectra for boron layers from 100 nm up to 2500 nm thickness in steps of 200 nm. The higher escape energies correspond to the helium ions whereas the lower correspond to the lithium ions.

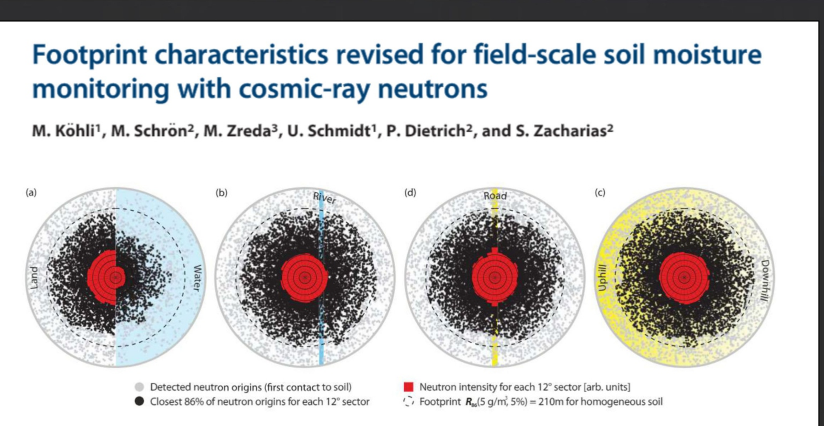
$^{10}B + n \rightarrow$
$^7Li(0.84\ MeV) + \alpha(1.472\ MeV) + \gamma(0.48\ MeV)$ (93.6 %)
$^7Li(1.013\ MeV) + \alpha(1.776\ MeV)$ (6.4 %)



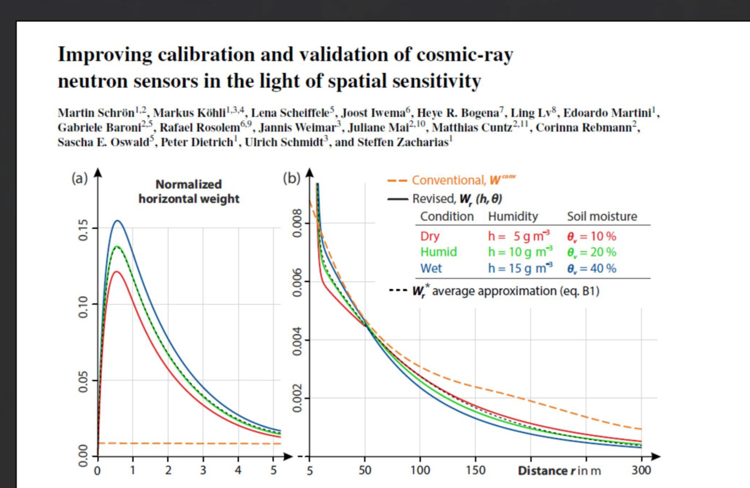
Publication Showcase



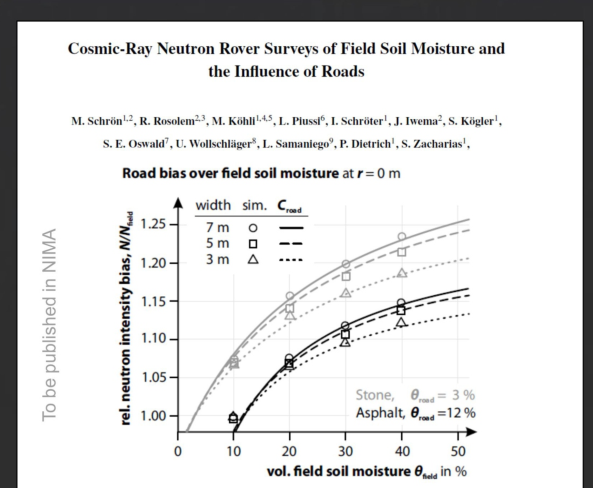
Detector Response of a multi-layer GEM detector with 0.9-1.2 μm ^{10}B-coating



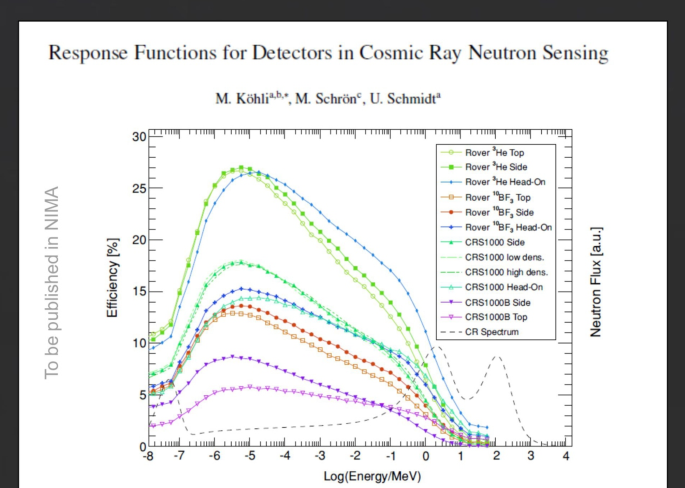
Transport studies for cosmic-ray induced albedo neutrons for soil moisture sensing. Determination of the footprint of the CRNS method and determining the range of influence for sensors in the epithermal to fast regime according to the environmental water content.



Full footprint description by cosmic neutron transport simulation studies



Determination of the road bias in mobile cosmic-ray surveys



Detector Response for moderated detectors in cosmic-ray neutron sensing

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