Physikalisches Institut
Heidelberg University
Germany

URANOS

a voxel engine Neutron Transport Monte Carlo Simulation

Position Sensitive Neutron Detectors 2024

10.4.2024

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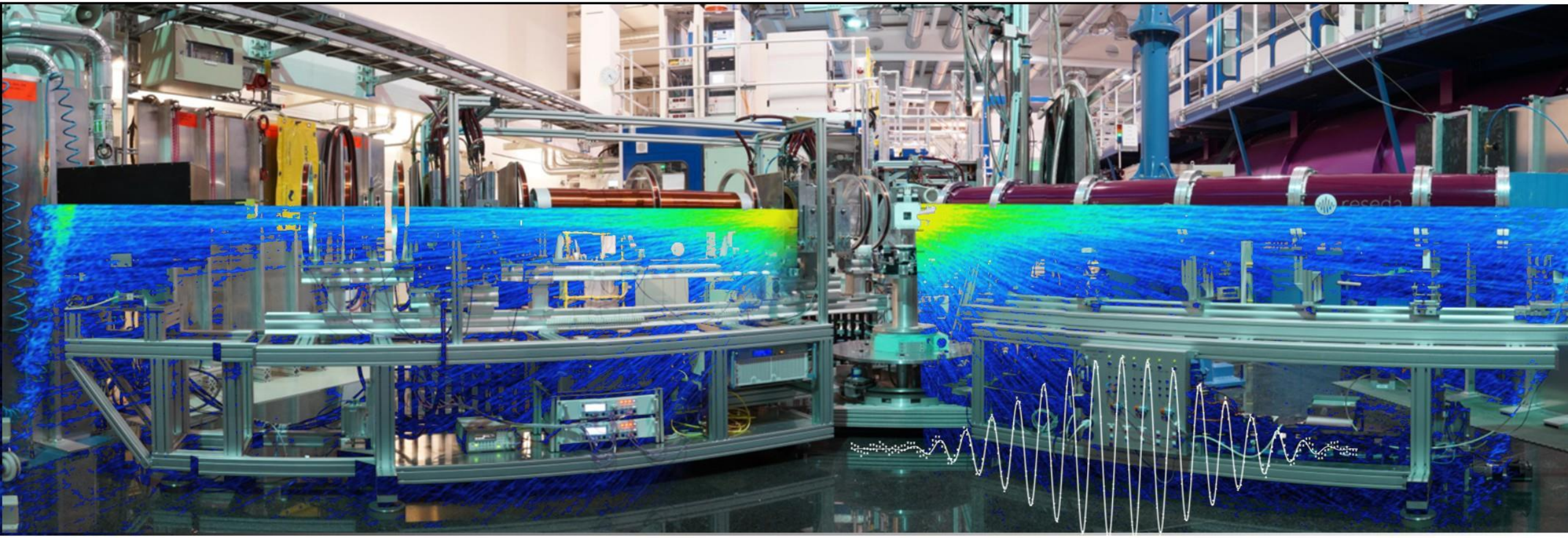
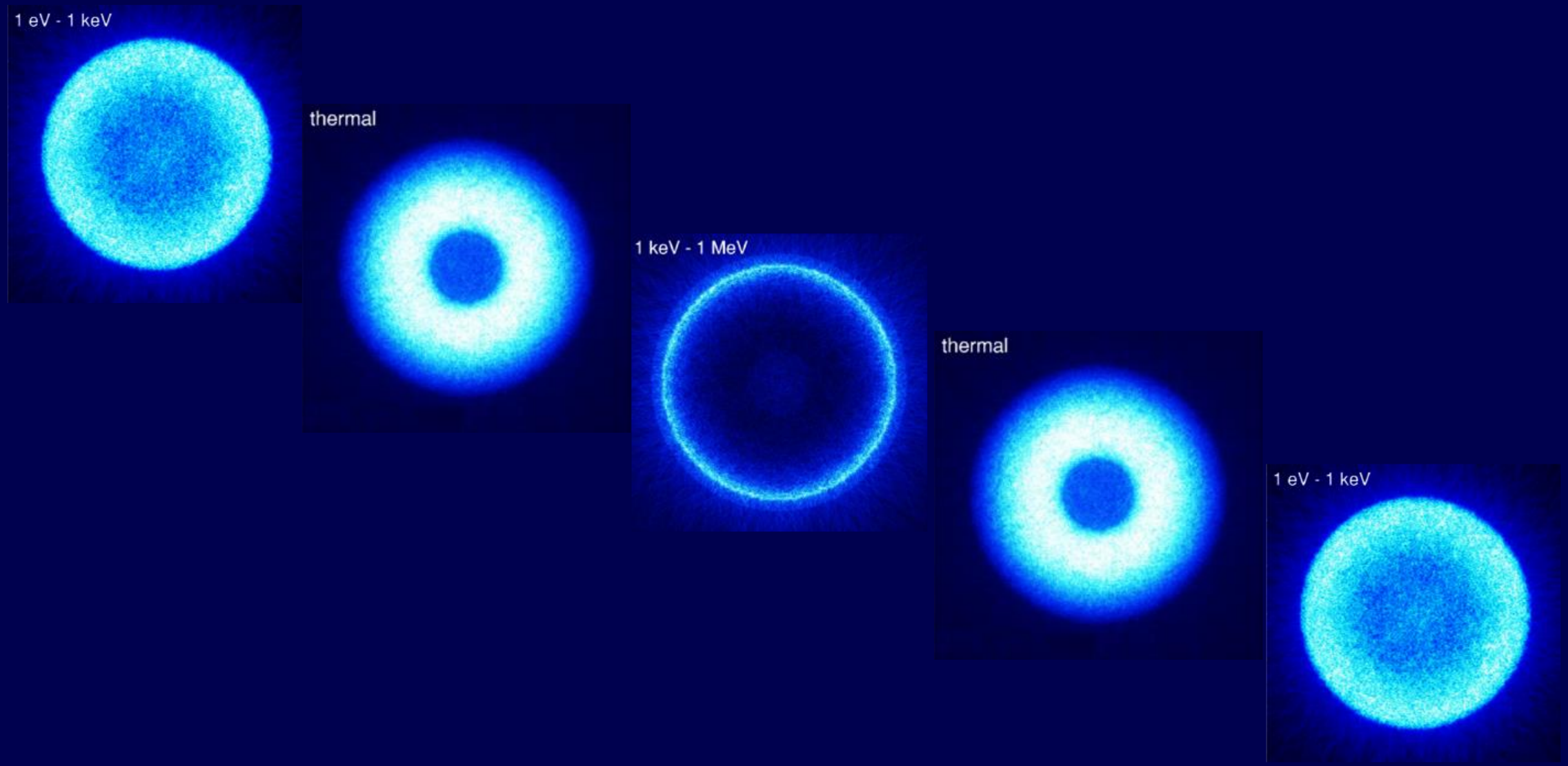
Bundesministerium für Bildung und Forschung

Gefördert durch DFG Deutsche Forschungsgemeinschaft




1 eV - 1 keV
thermal
1 keV - 1 MeV
thermal
1 eV - 1 keV

URANOS concepts

- written in C++

```
if (detectorEnergyModel2->Eval(TMath::Log10(energy)) > r.Rndm() )
{
    detectorRealisticallyHitted = true; layerRealisticallyHitted = true;
}
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URANOS concepts

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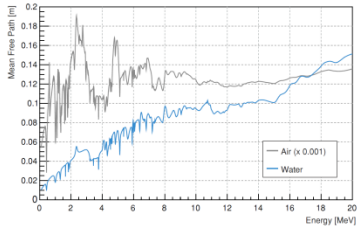
- written in C++

- linked against ENDF data bases



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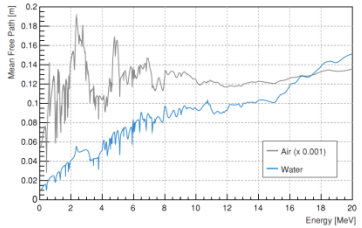

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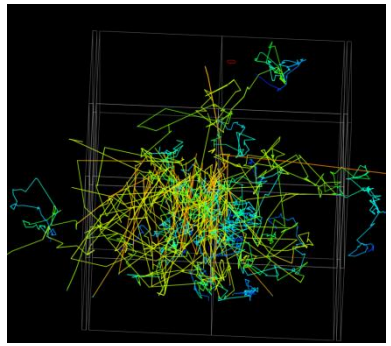

- Ray-Casting

URANOS concepts

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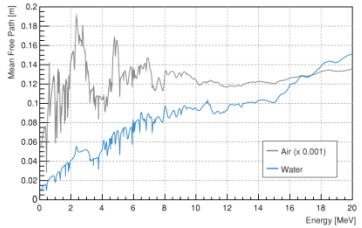
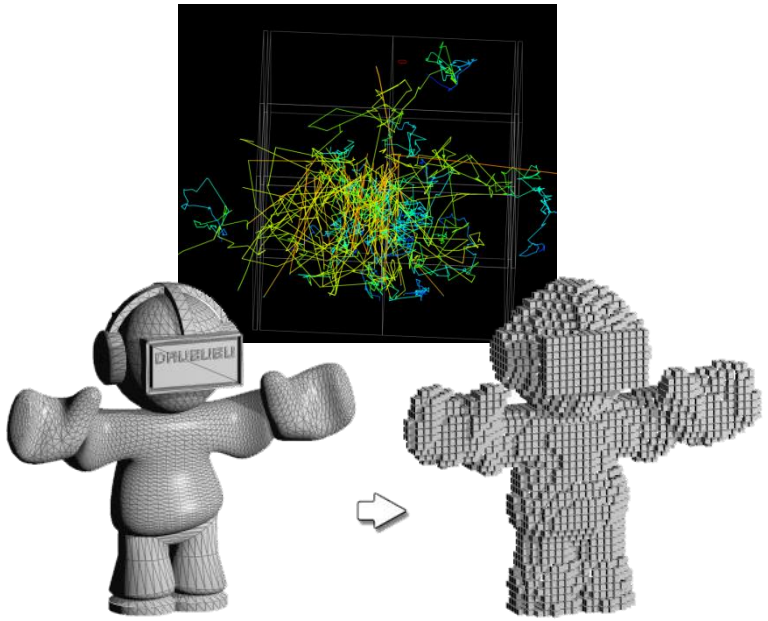


- linked against ENDF data bases
- Ray-Casting
- Voxel Engine



URANOS concepts

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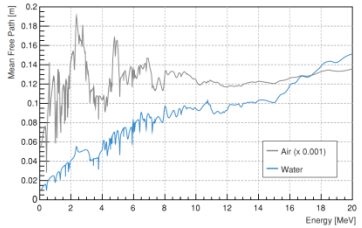

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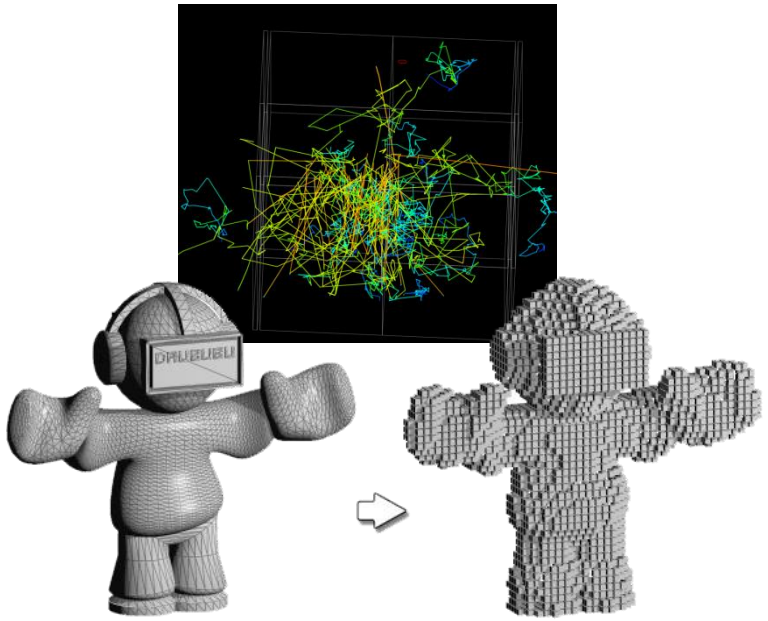
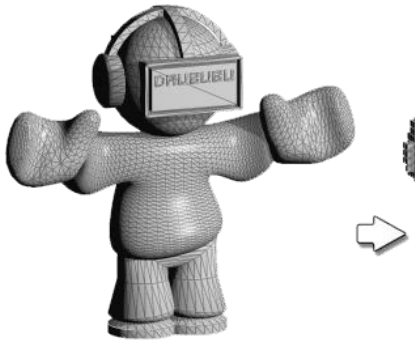
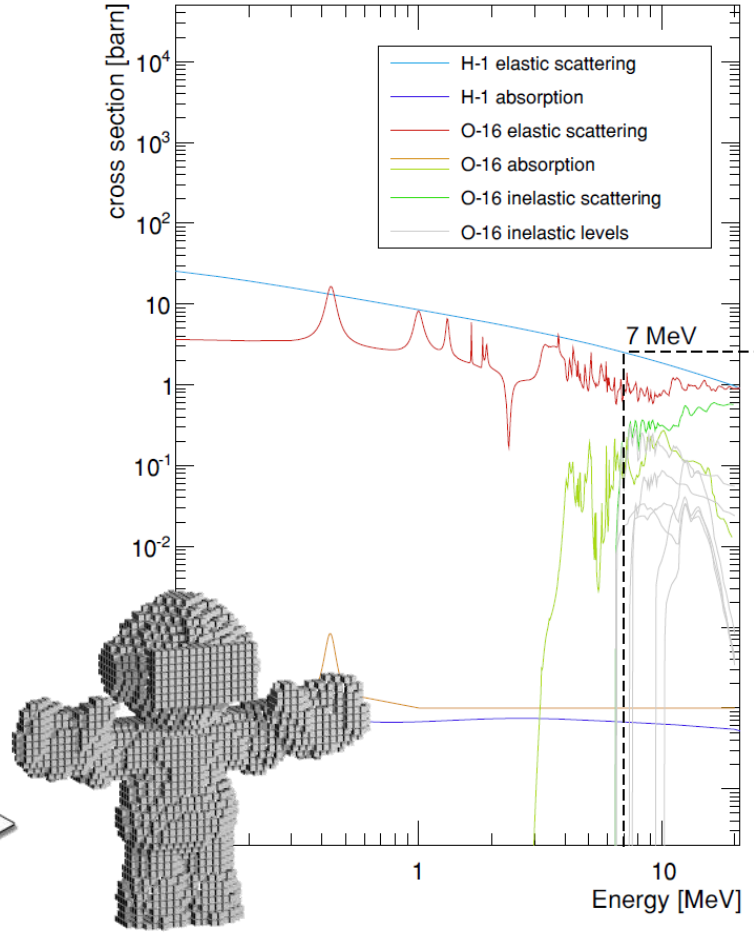
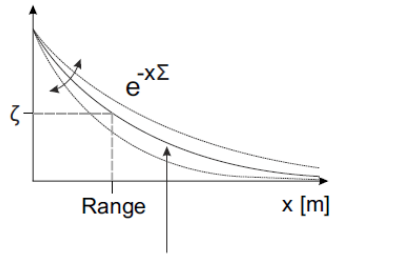


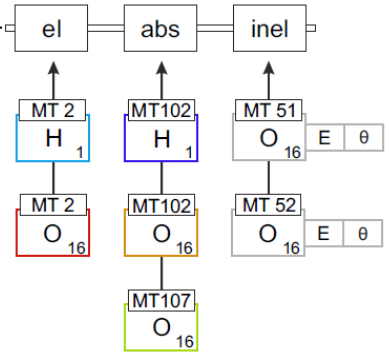
Neutrons interact with volumes, (typically) not with surfaces

Why a voxel engine?









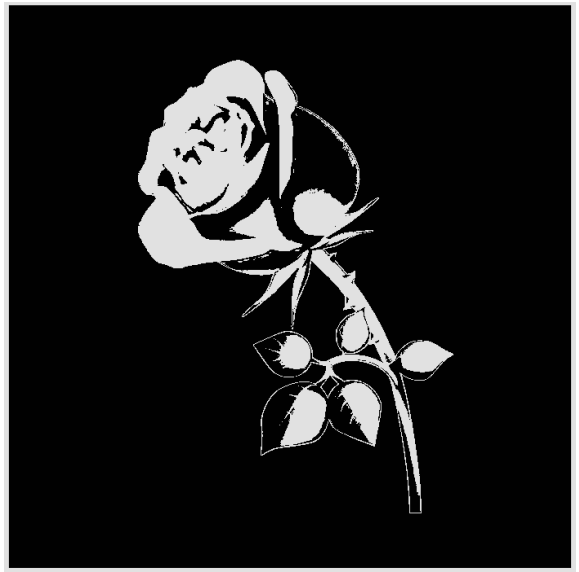
MCNP input file

File Edit Options Buffers Tools Help

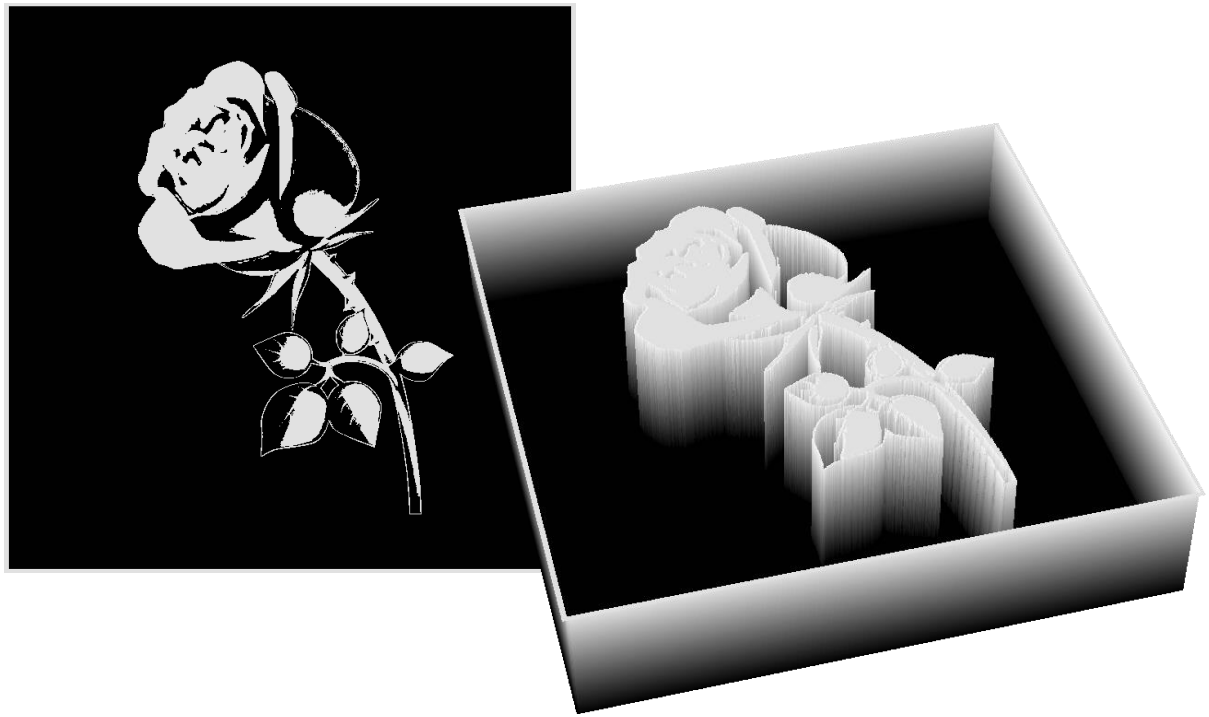
```
-*-mcnpgen-*- Pd-103 photon source,H2O phant filled w/cubes,1 cube has a sphere
c Cell Cards
1 1 -10. -1 2 -3              $ sr-90 source in silver foil
2 10 -2.7 -2 4 -3             $ Al filter
3 2 -8.02 -6 20 -5 (1:3:-4)   $ SS encapsulation
4 2 -8.02 -8 6 -7             $ SS rod
10 0 -20 21 -22 23 -24 25 fill=1     $ large water box
c 11 4 -1.0 -32 33 -34 35 -30 31 u=1 lat=1  $ water cubes
11 4 -1.0 -32 33 -34 35 -30 31 u=1 lat=1 fill=-1:1 -1:1 -1:1 &
        2 1 25r                              $ water cubes
12 3 -1.293e-3 -90 u=2               $ air sphere inside cube
13 2 -8.02 90 u=2                   $ SS surrounding sphere inside cube
90 3 -1.293e-3 -100 -21                      $ air below box
91 3 -1.293e-3 -100 -20 21 (22:-23:24:-25)   $ air around box
92 3 -1.293e-3 -100 20 #1 #2 #3 #4           $ air outside src/rod
100 0 100                                      $ bounding region

c SURFACE CARDS
1 pz .03574                          $ source top plane
2 pz .03074                          $ source bottom plane
3 cz .475                            $ source outer radius
4 pz .00574                            $ Al filter bottom plane
5 cz .525                         $ SS encapsulation outer radius
6 pz 1.4                          $ SS encapsulation top plane
7 cz .2                                 $ rod outer radius
8 pz 2.4                                $ rod top plane
20 pz 0.                          $ large box top plane
21 pz -1.2                        $ large box bottom plane
22 px .6                          $ large box xmax
23 px -.6                         $ large box xmin
24 py .6                          $ large box ymax
25 py -.6                         $ large box ymin
30 pz -.4                            $ cube top plane
31 pz -.8                            $ cube bottom plane
32 px .2                             $ cube xmax
33 px -.2                            $ cube xmin
-:--  sampl          (Mcnpgen)--L29--C0--Top----------------------------------
```

URANOS voxel engine

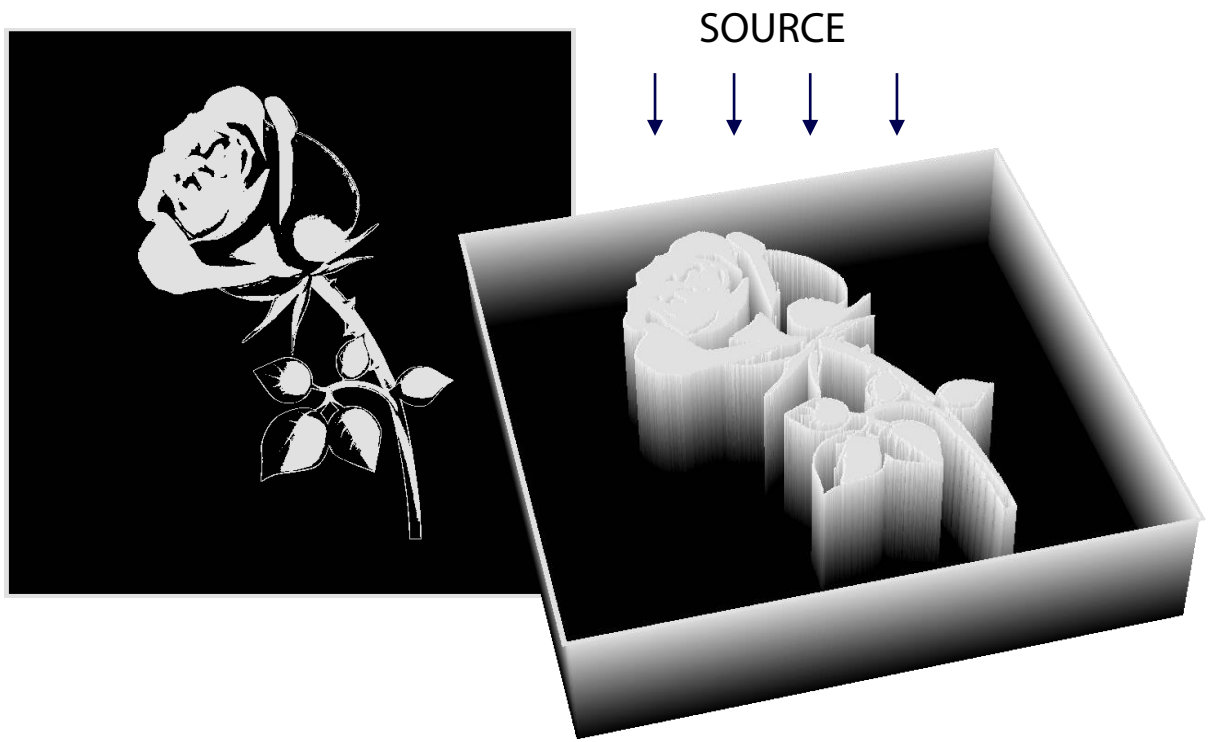


URANOS voxel engine



polyethylene rose in a box

URANOS voxel engine



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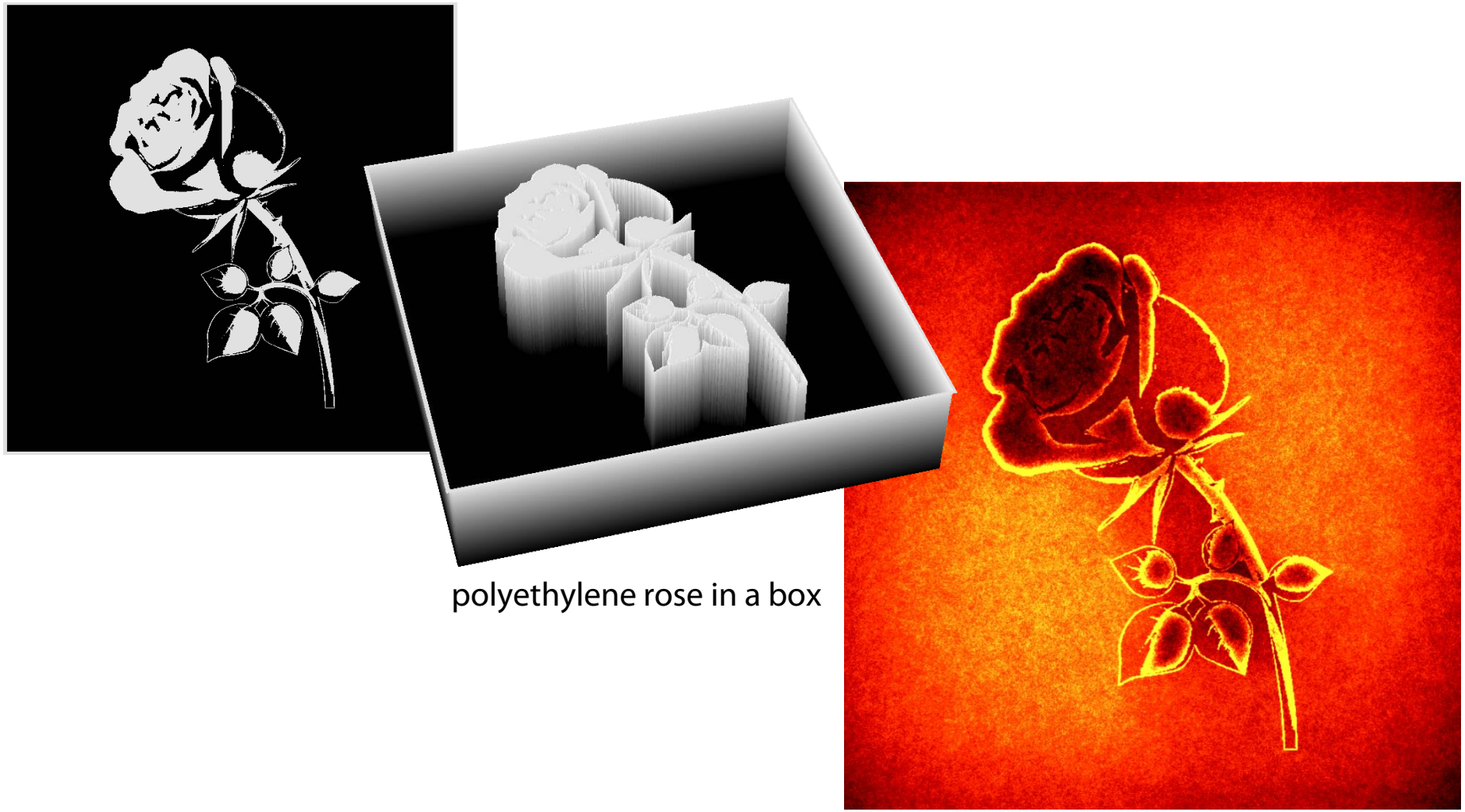
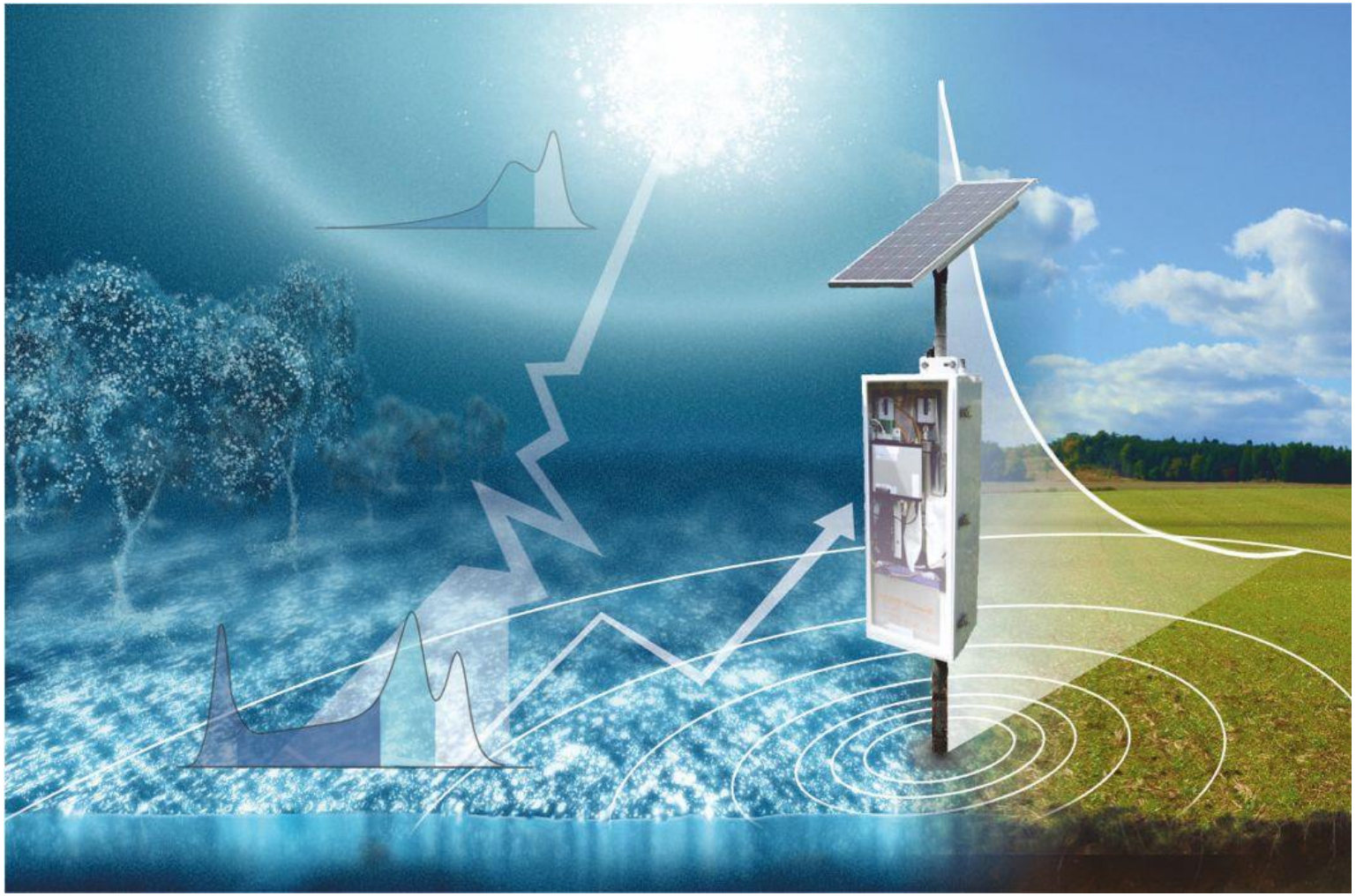


polyethylene rose in a box

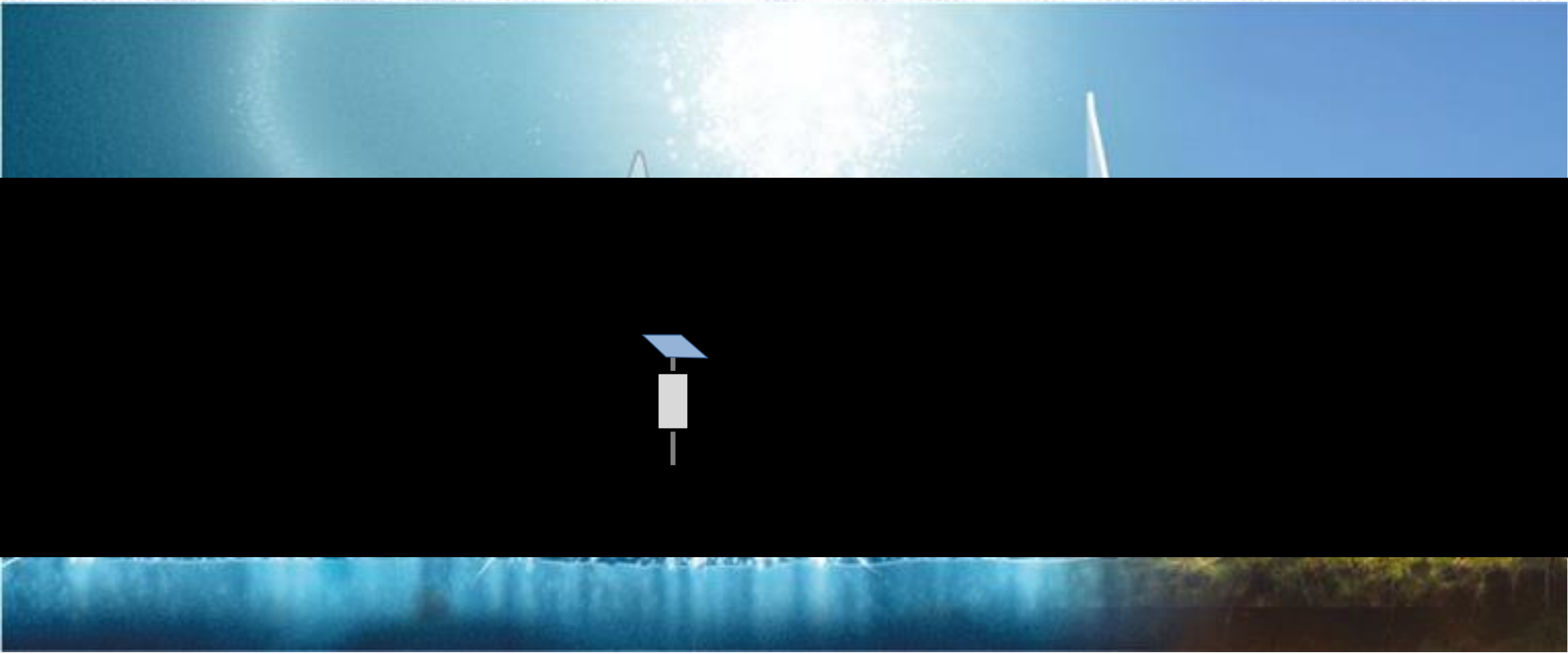
URANOS

Neutron tool developed in collaboration with environmental sciences

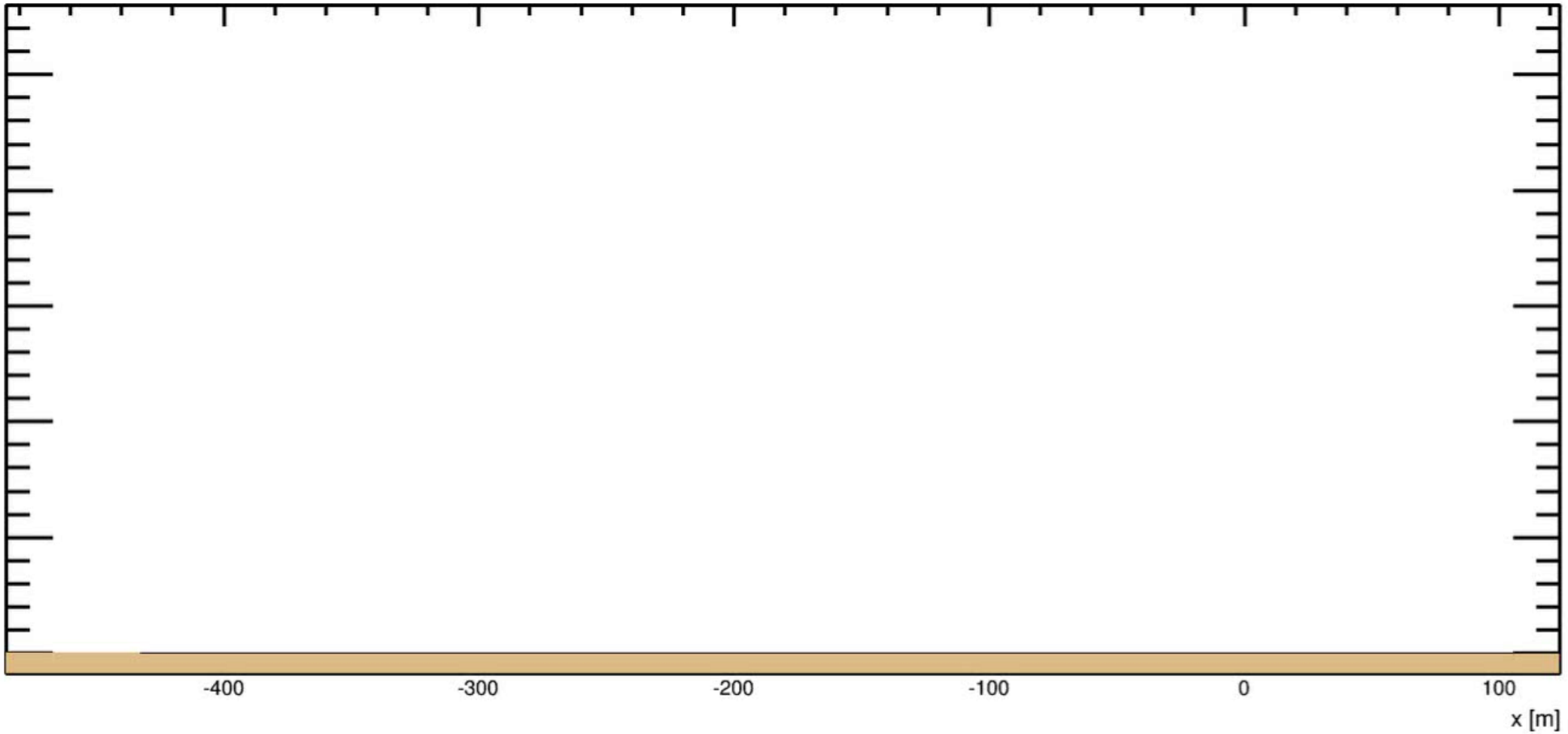


HELMHOLTZ
ZENTRUM FÜR
UMWELTFORSCHUNG
UFZ

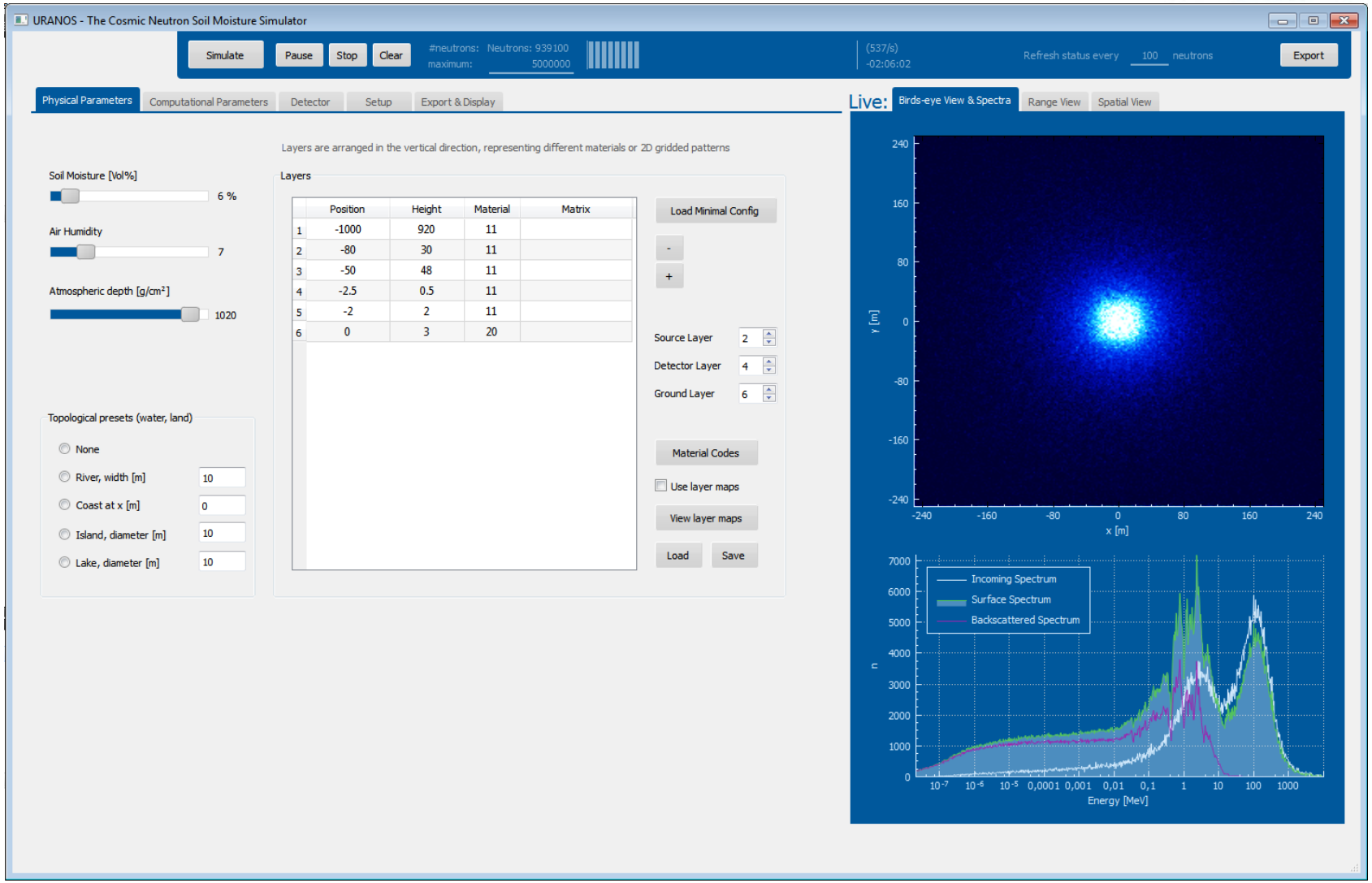
Neutrons on soil and water



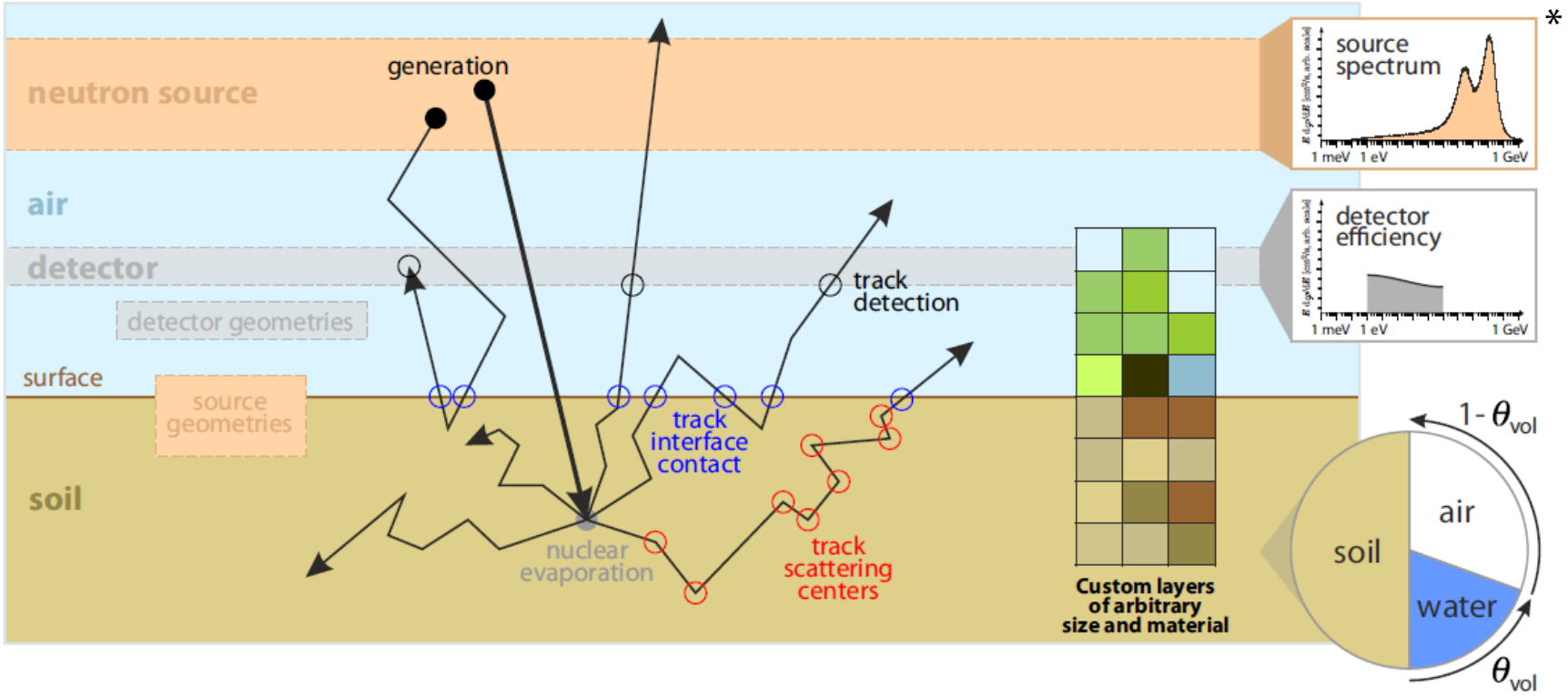
Neutron Animation (Evaporation)



USER Interface



URANOS Buildup



* T. Sato
Features and applications of the analytical model for estimating terrestrial cosmic-ray fluxes: PARMA/EXPACS

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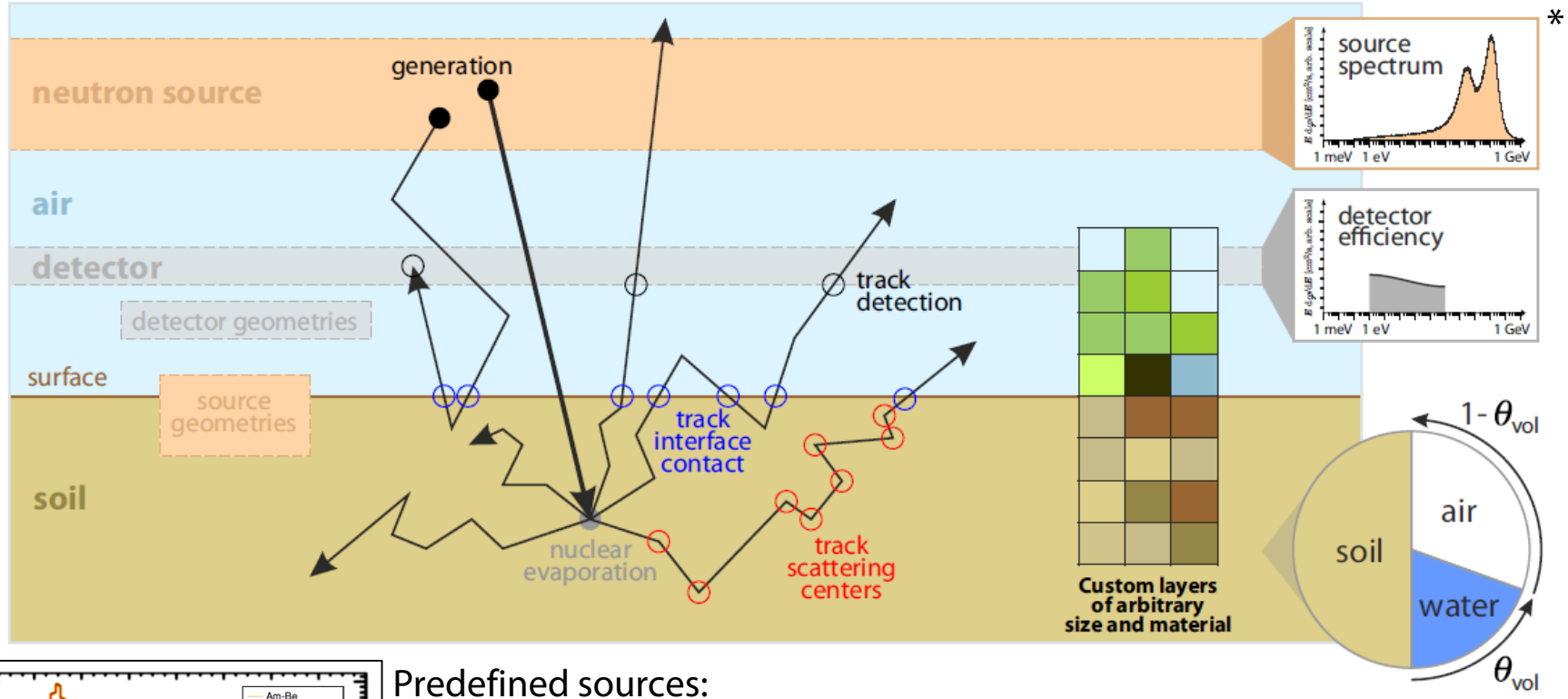

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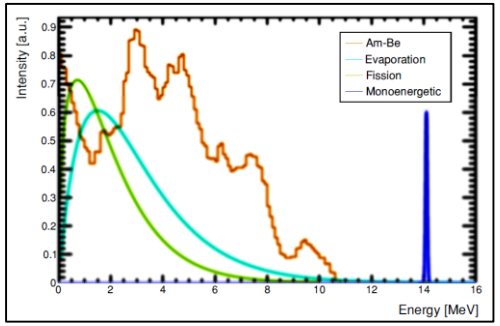

Predefined sources:

- Thermal
- Fusion
- Fission
- AmBe
- Moderated Cf

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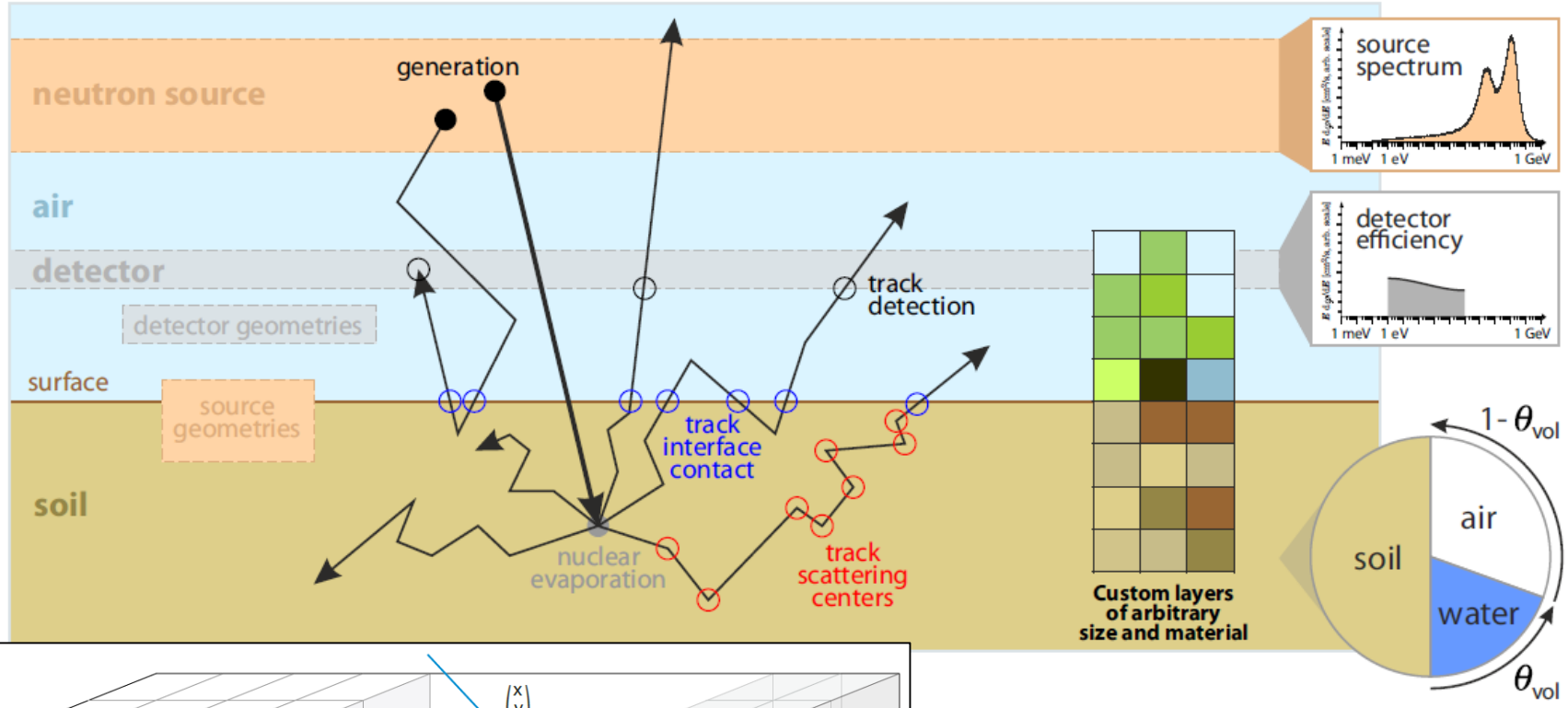

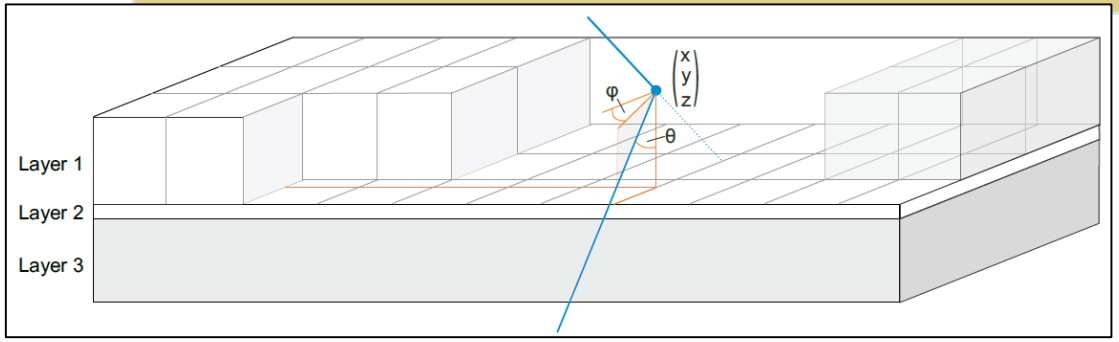

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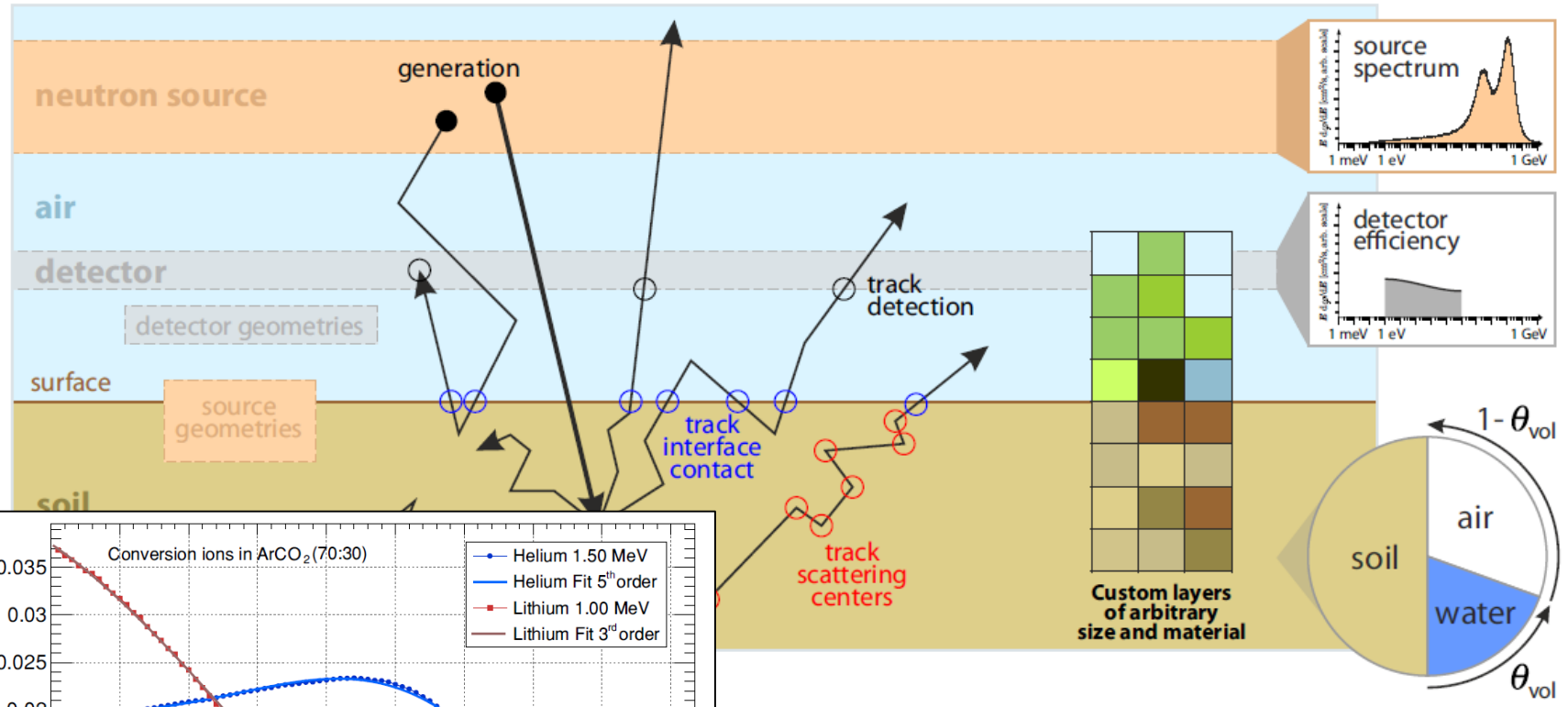

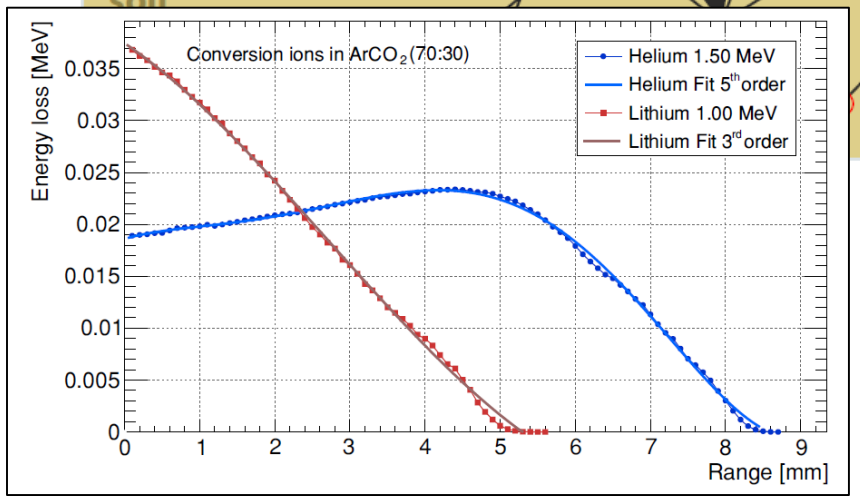

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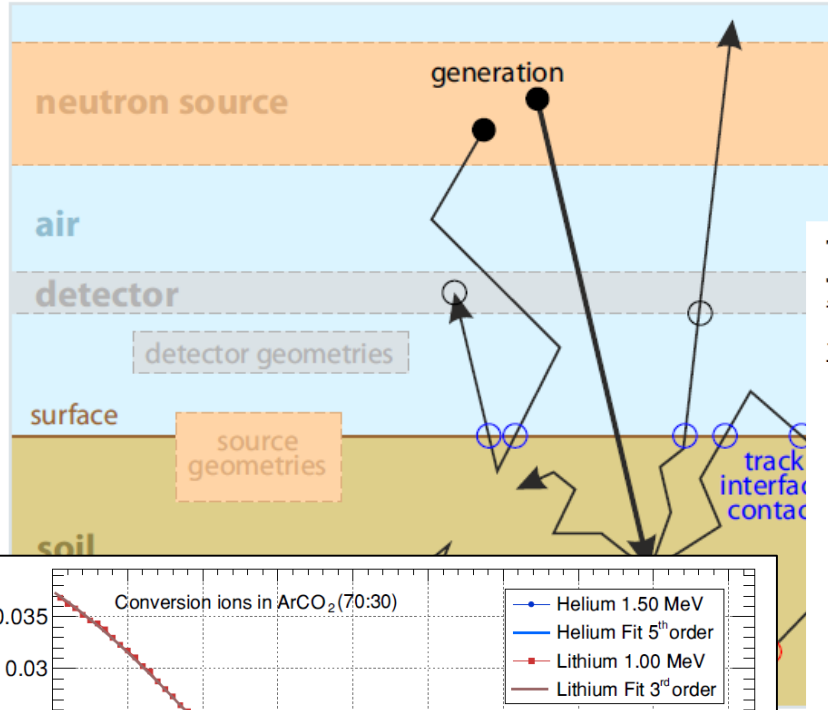

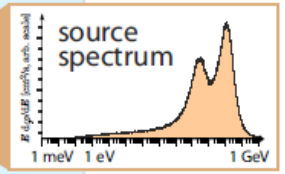

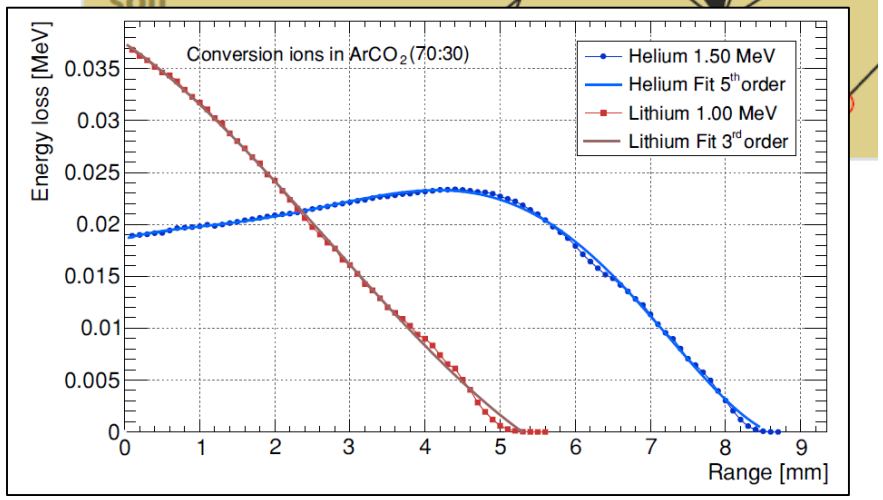

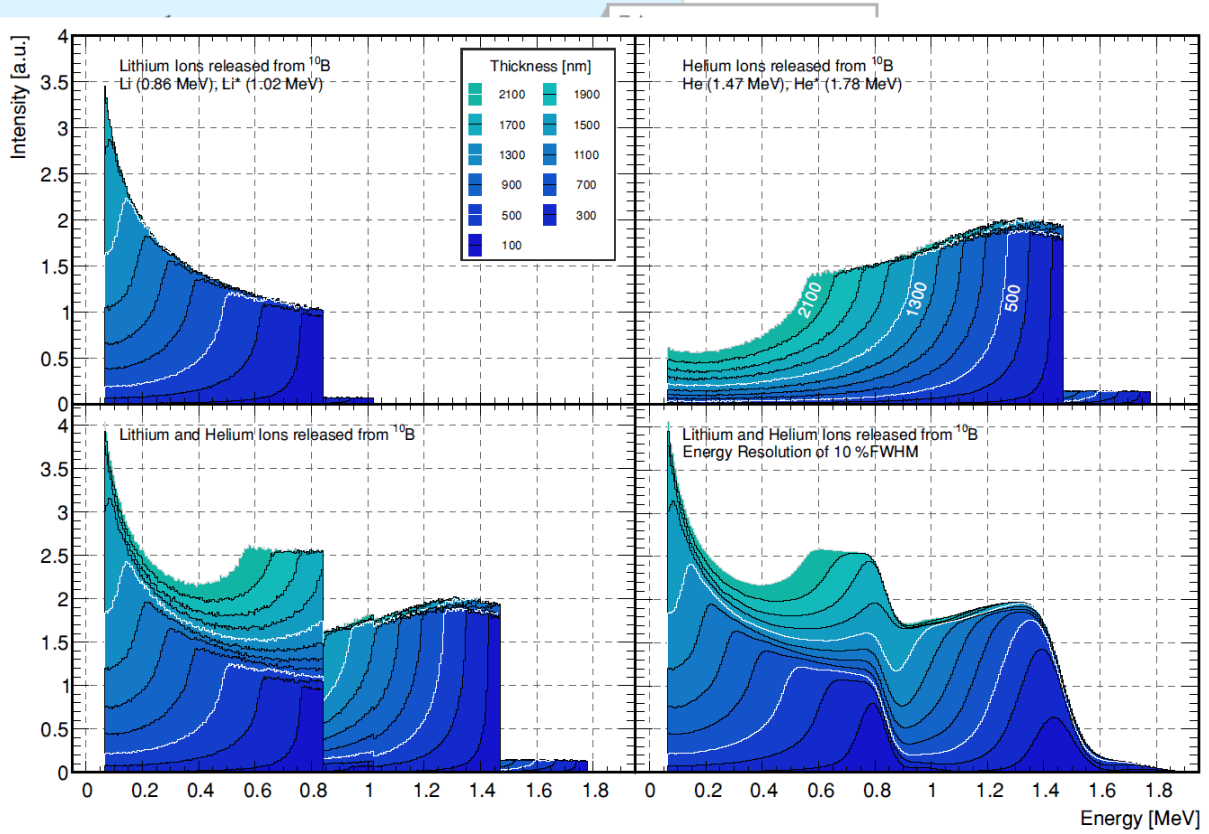

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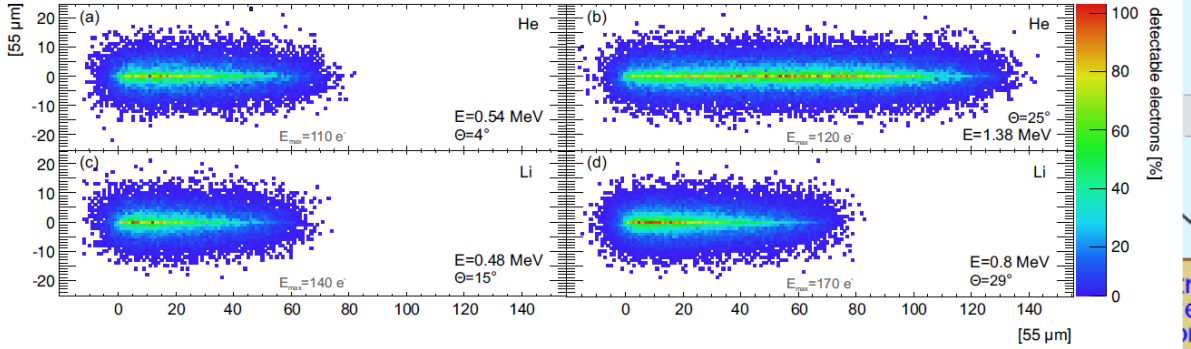
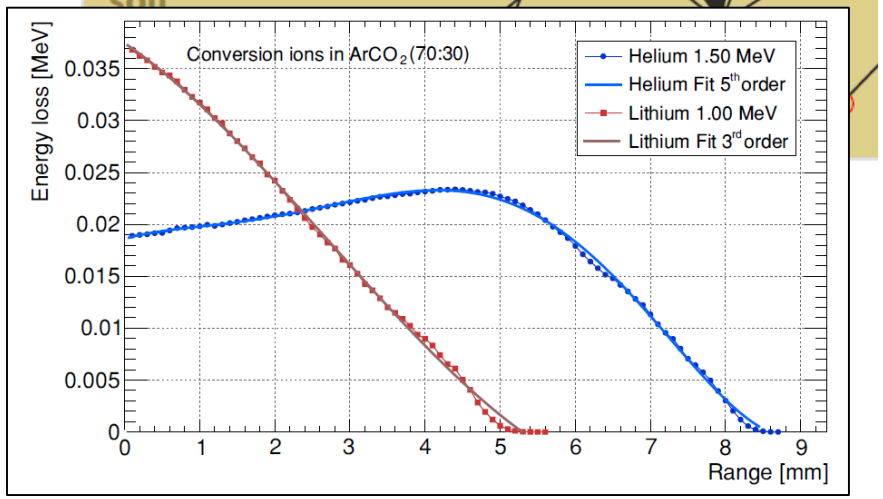
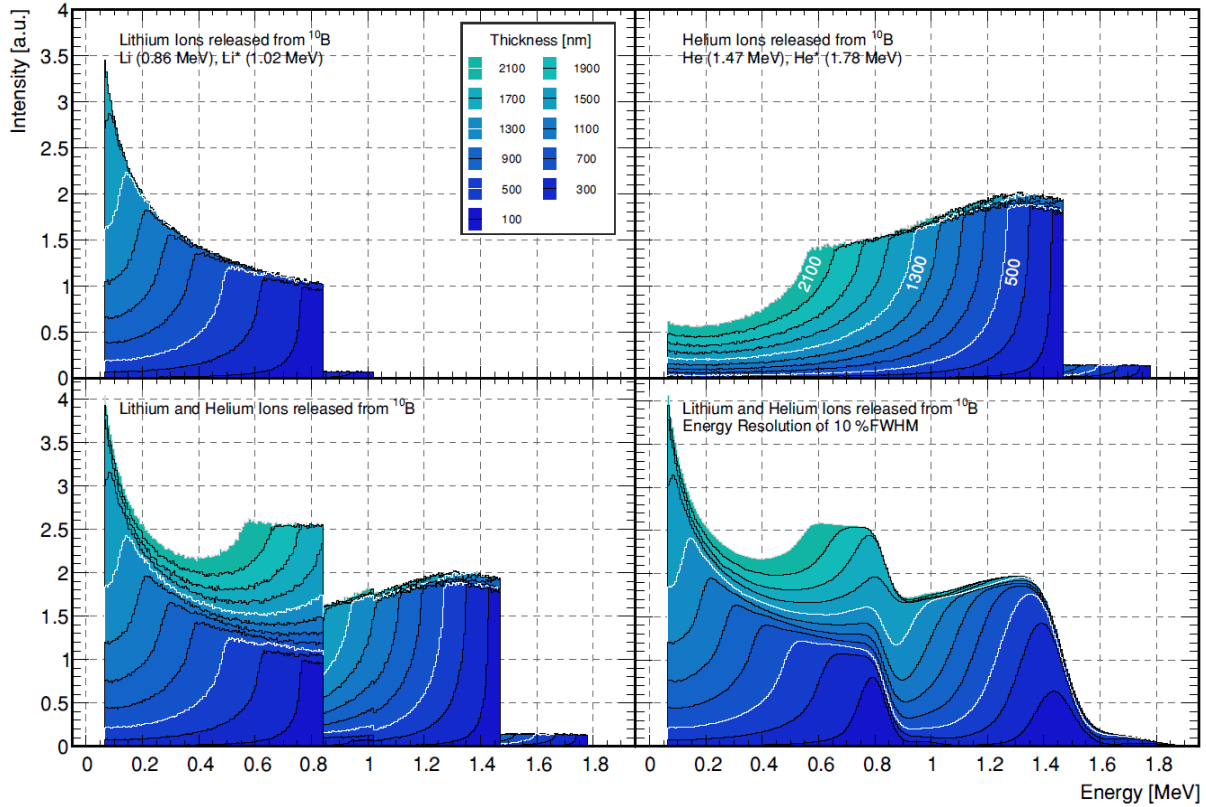






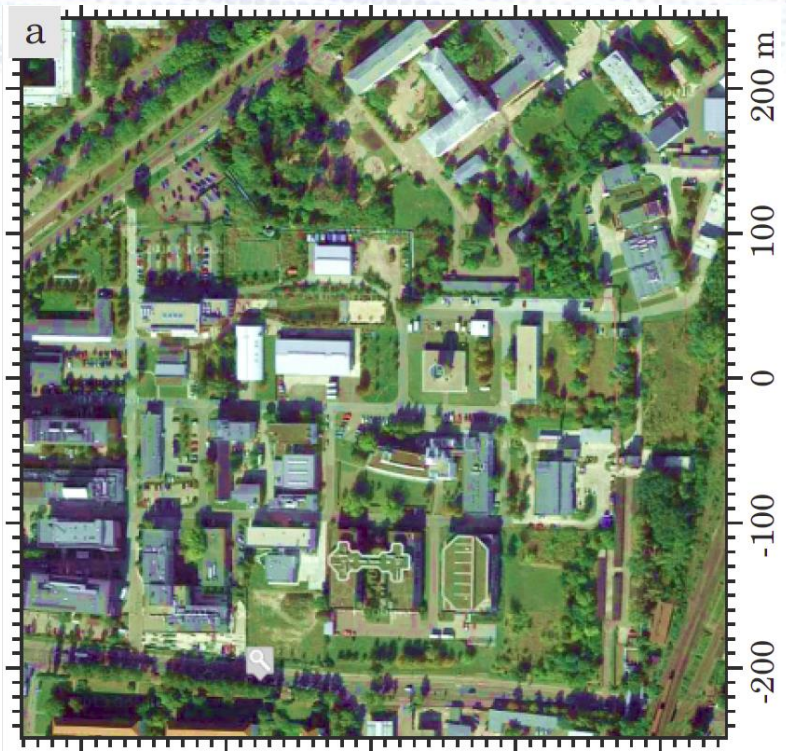
Performance

Nº	name	description	Performance [n/(s·GHz·core)] URANOS	MCNP6	GEANT4
1	std. setup	water body, 5 g/m^3 air humidity NTP	930	300	70
2	std. setup	ground with 10 % soil moisture, 5 g/m^3 air humidity NTP	450		31
3	std. setup	ground with 1 % soil moisture, 5 g/m^3 air humidity NTP	265	250	17
4	std. setup	like Nº 1, with full domain tracking enabled	710		
5	std. setup	like Nº 1, with thermal transport enabled	260	260	16
6	std. setup	like Nº 3, with thermal transport enabled	130	220	9
7	std. setup	like Nº 3, with thermal transport and full domain tracking enabled	120		
8	UFZ site	with 10 % soil moisture	500		
9	UFZ site	like Nº 8, without voxel geometry but same layering	420		
10	detector	thermal spectrum onto a side face with $\vartheta = 0°$	9170		
11	detector	like Nº 10, with an americium-beryllium spectrum	4060		

Epithermal & Fast & High Energy

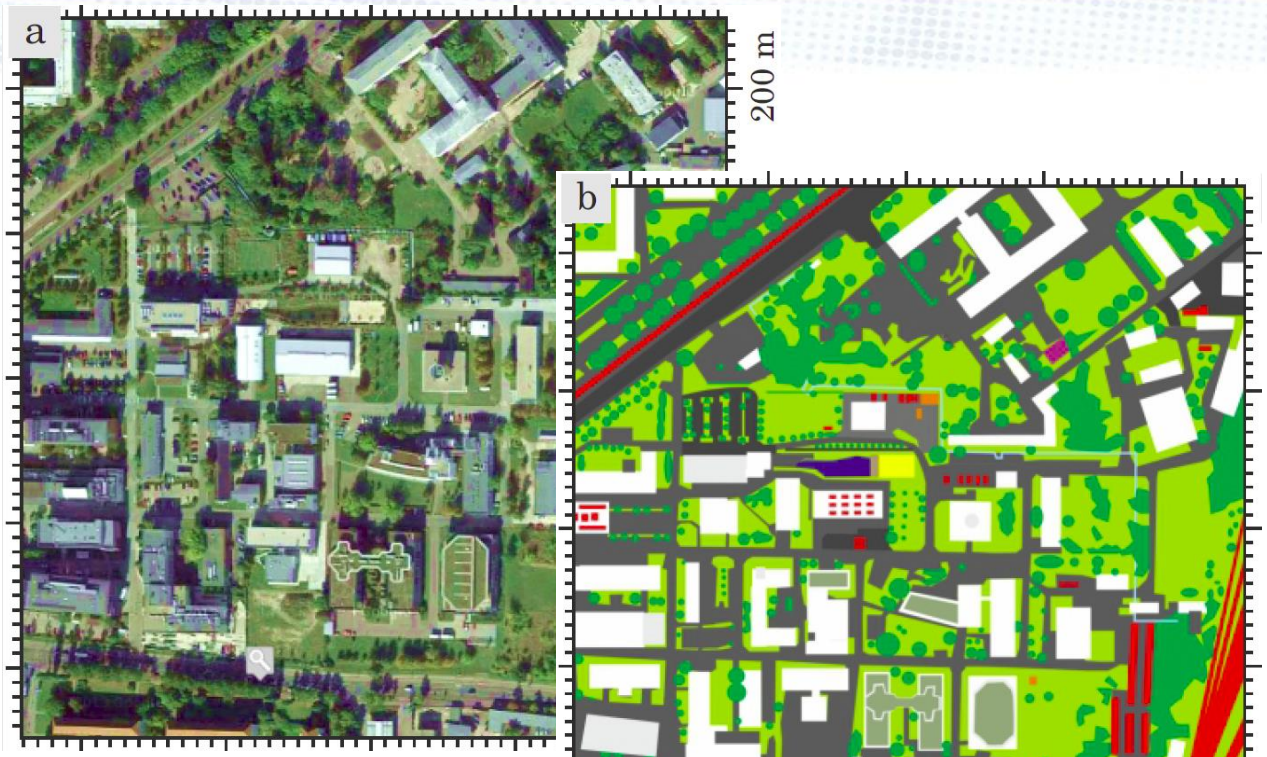
With Thermal

Modeling steps



topography

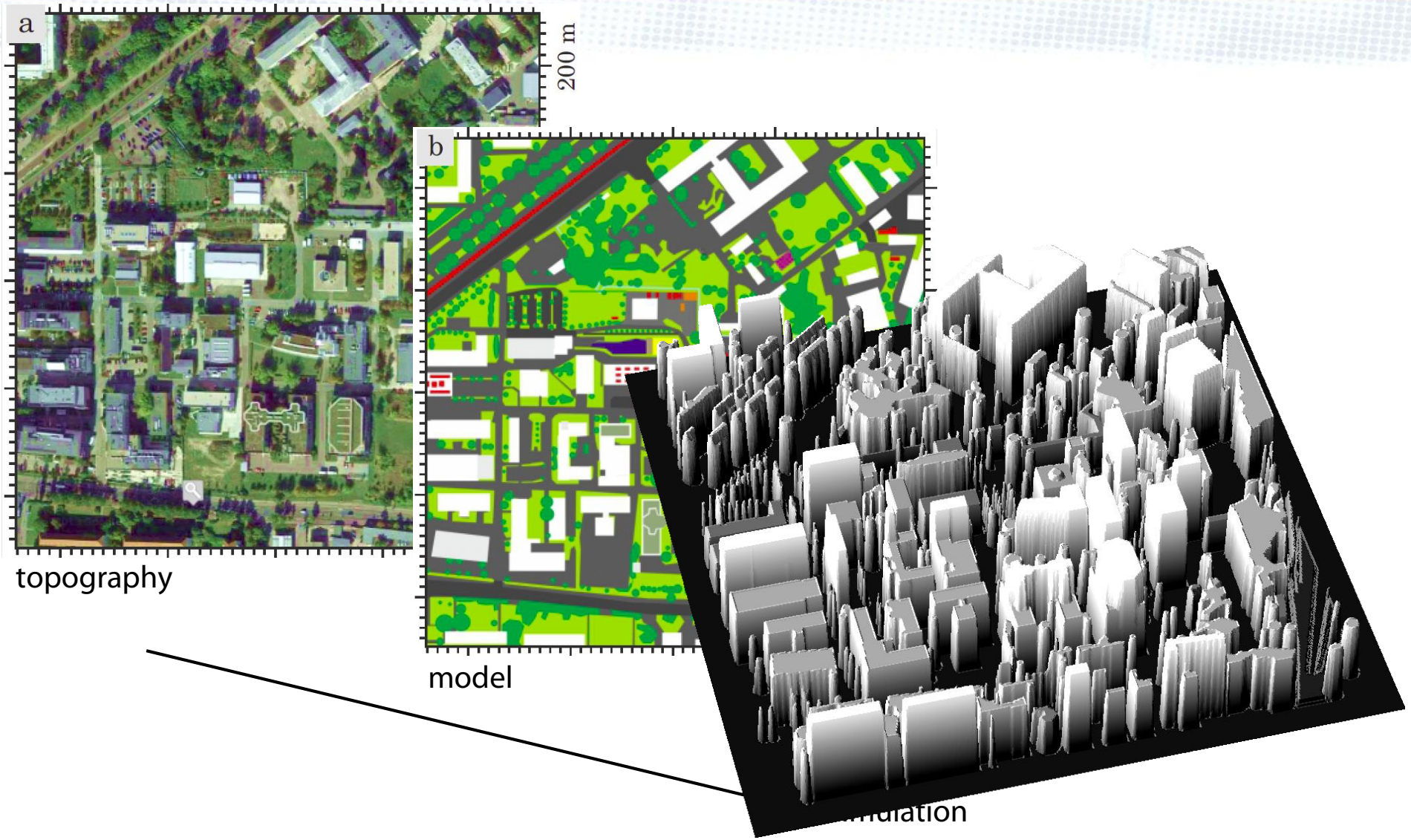
Modeling steps



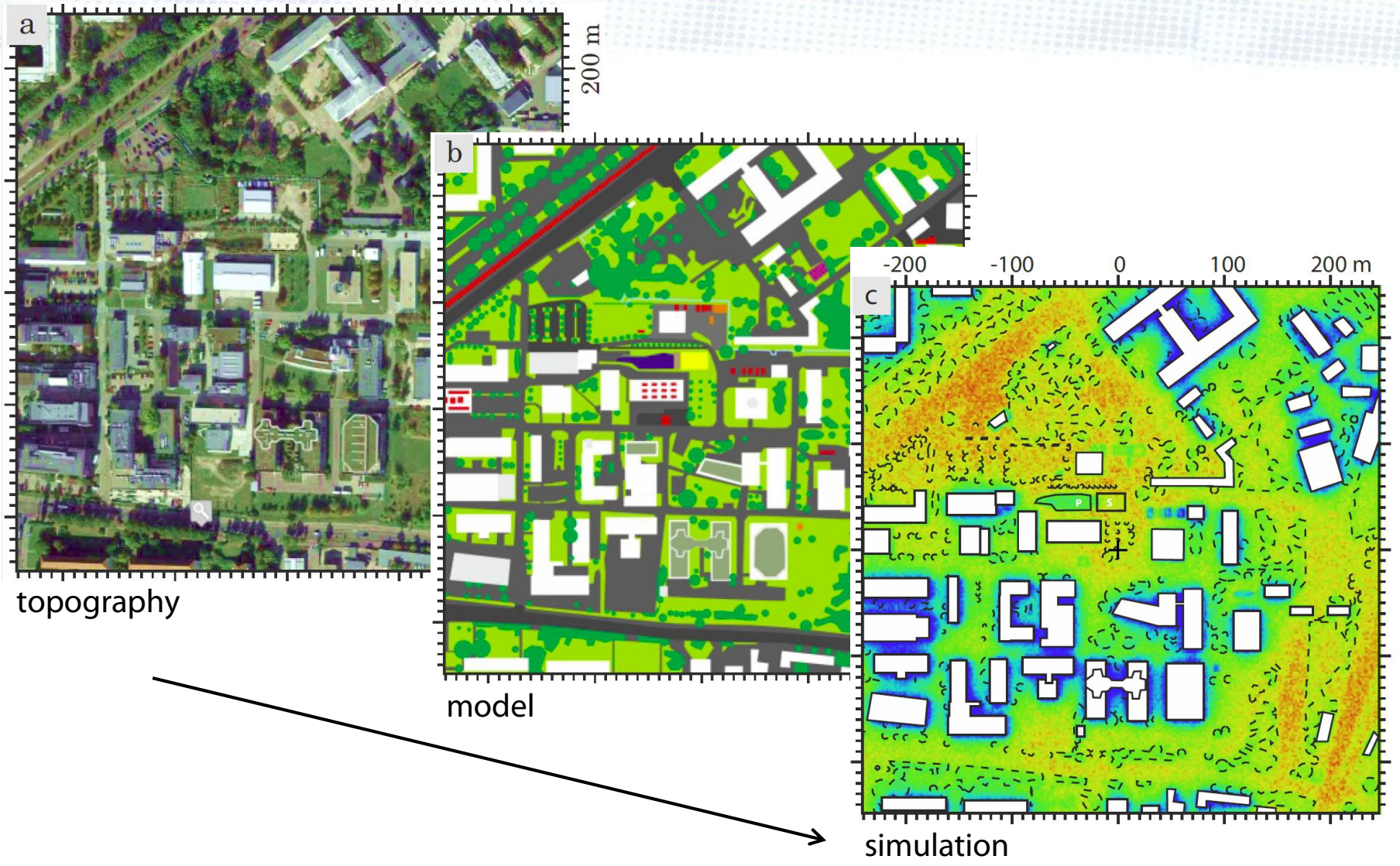
topography

model

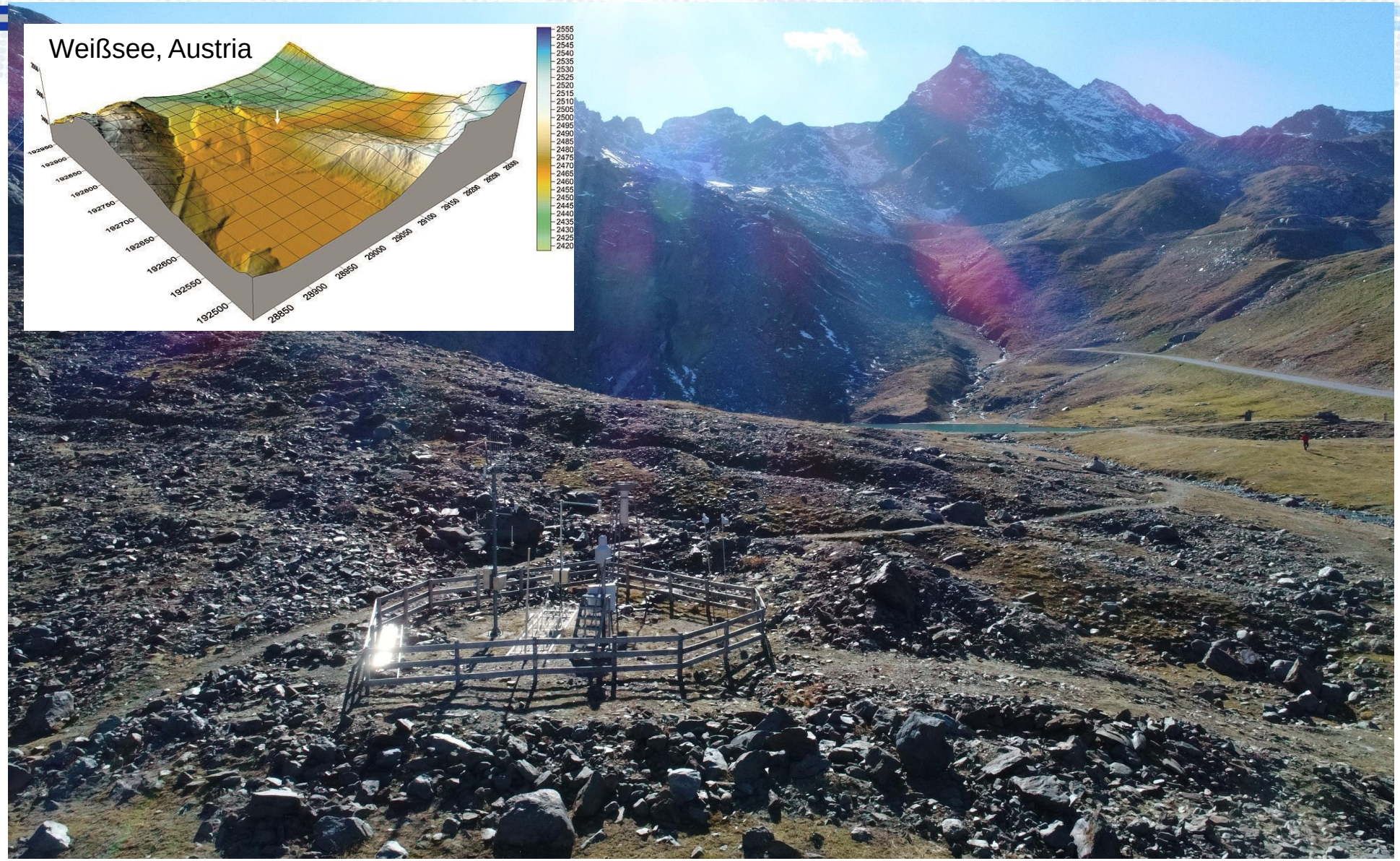
Modeling steps



Modeling steps



Snow Water Equivalent



P. Schattan et al., to be published

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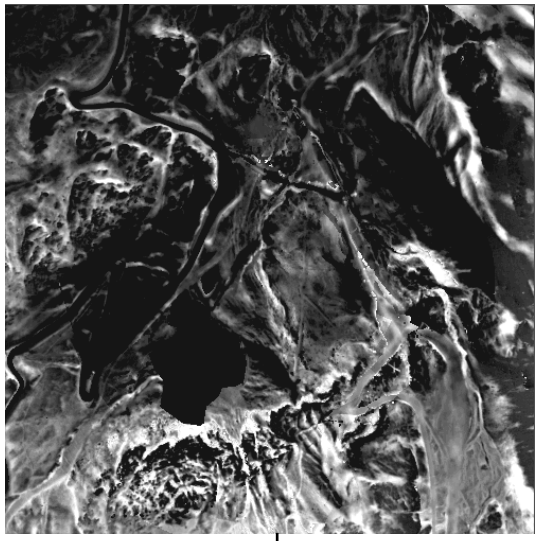
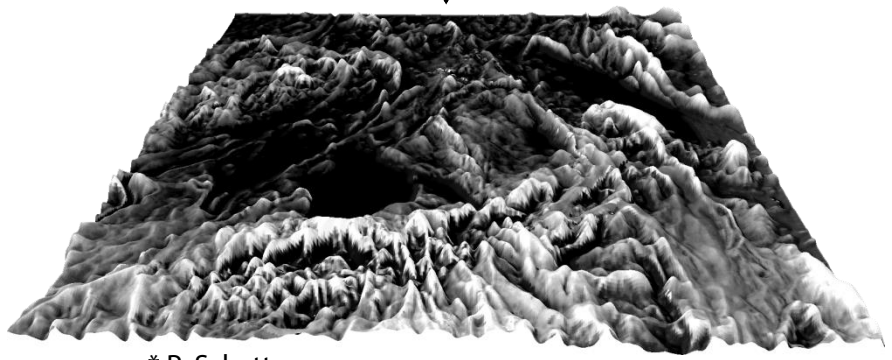
3D Laser Scanner



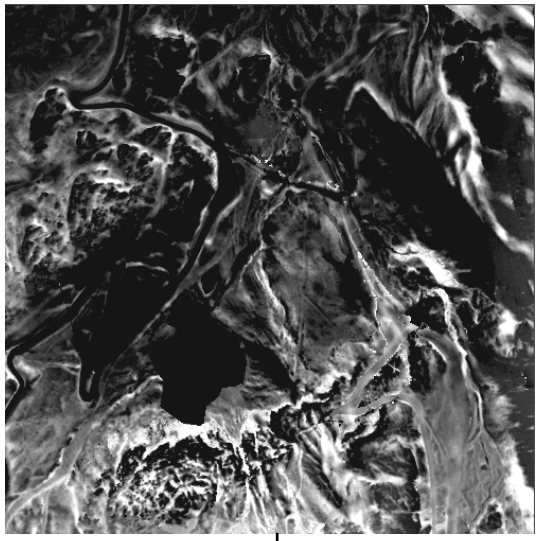
P. Schattan – Kaunertal Glacier at N46° 52.2 E10 °42.6



* P. Schattan
Cosmic-ray neutron sensing of snow water equivalent in heterogeneous alpine terrain

URANOS voxel engine

3D Laser Scanner



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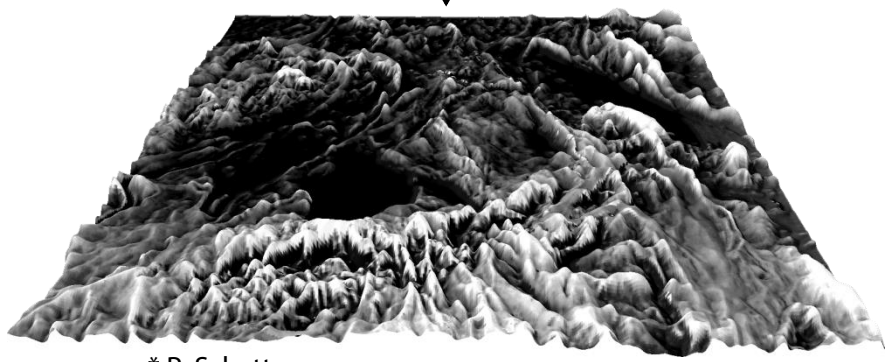

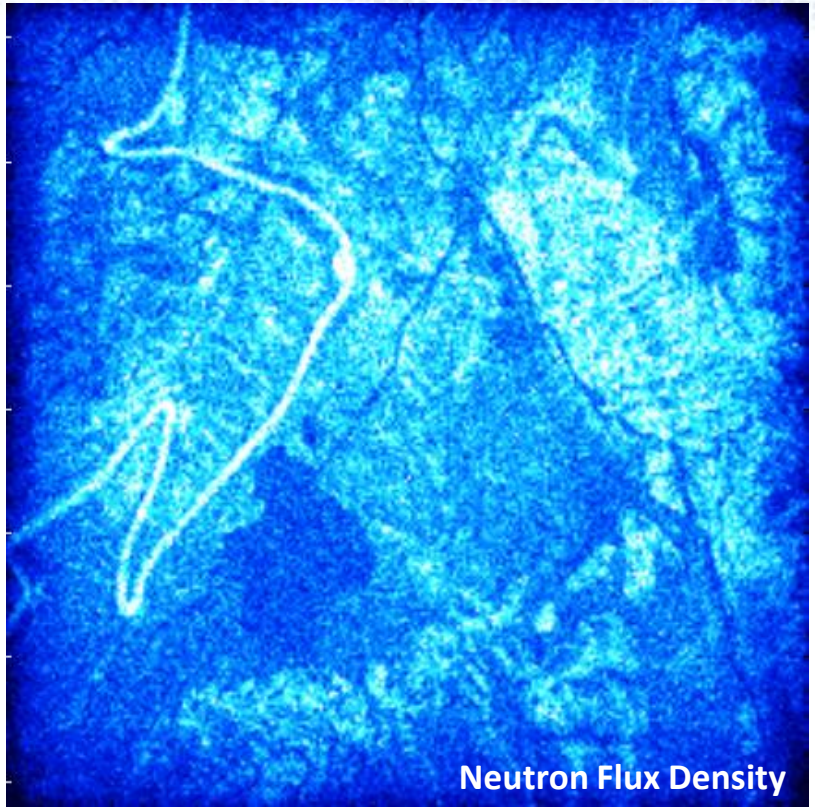

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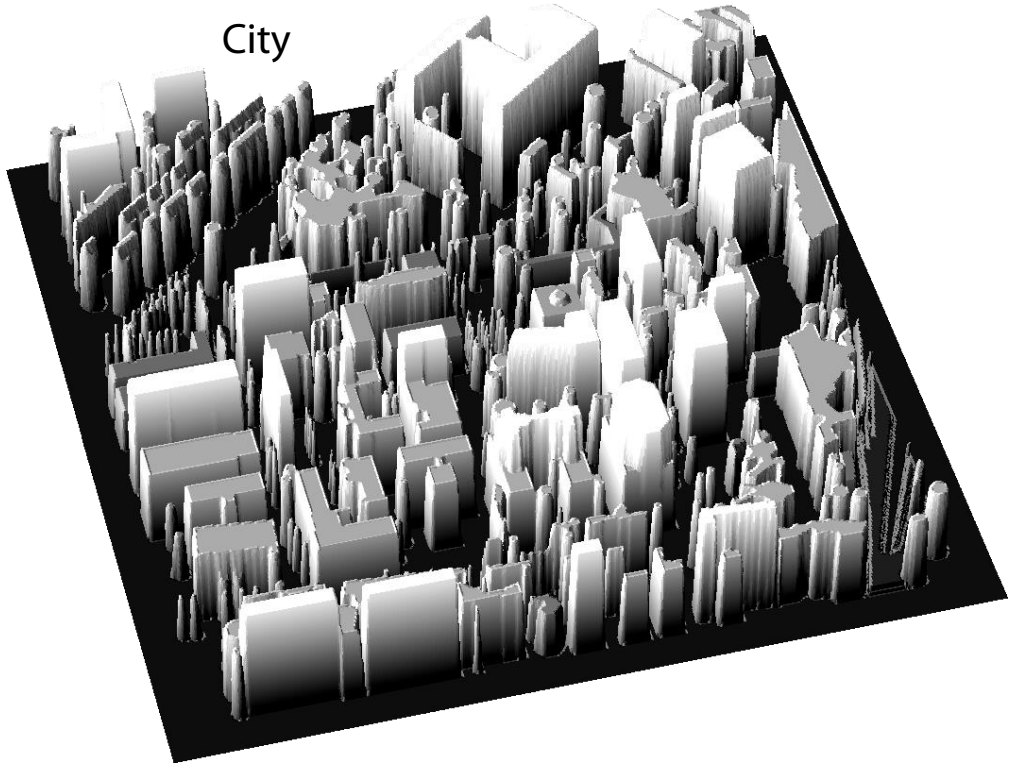
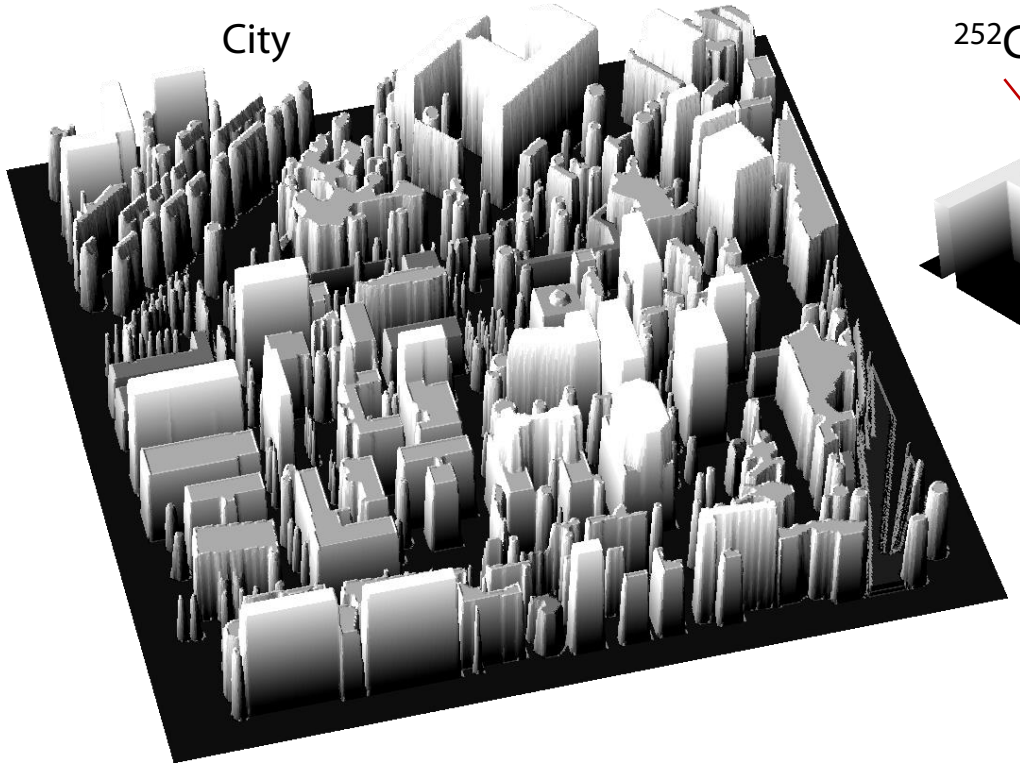
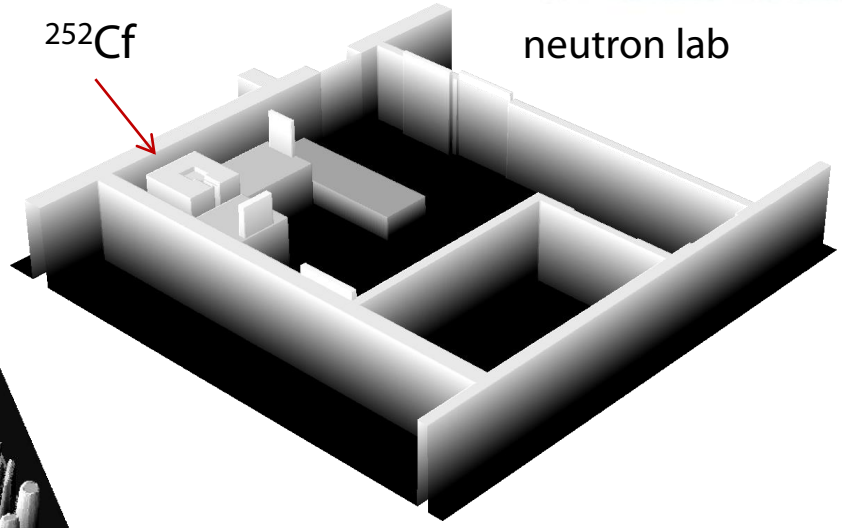
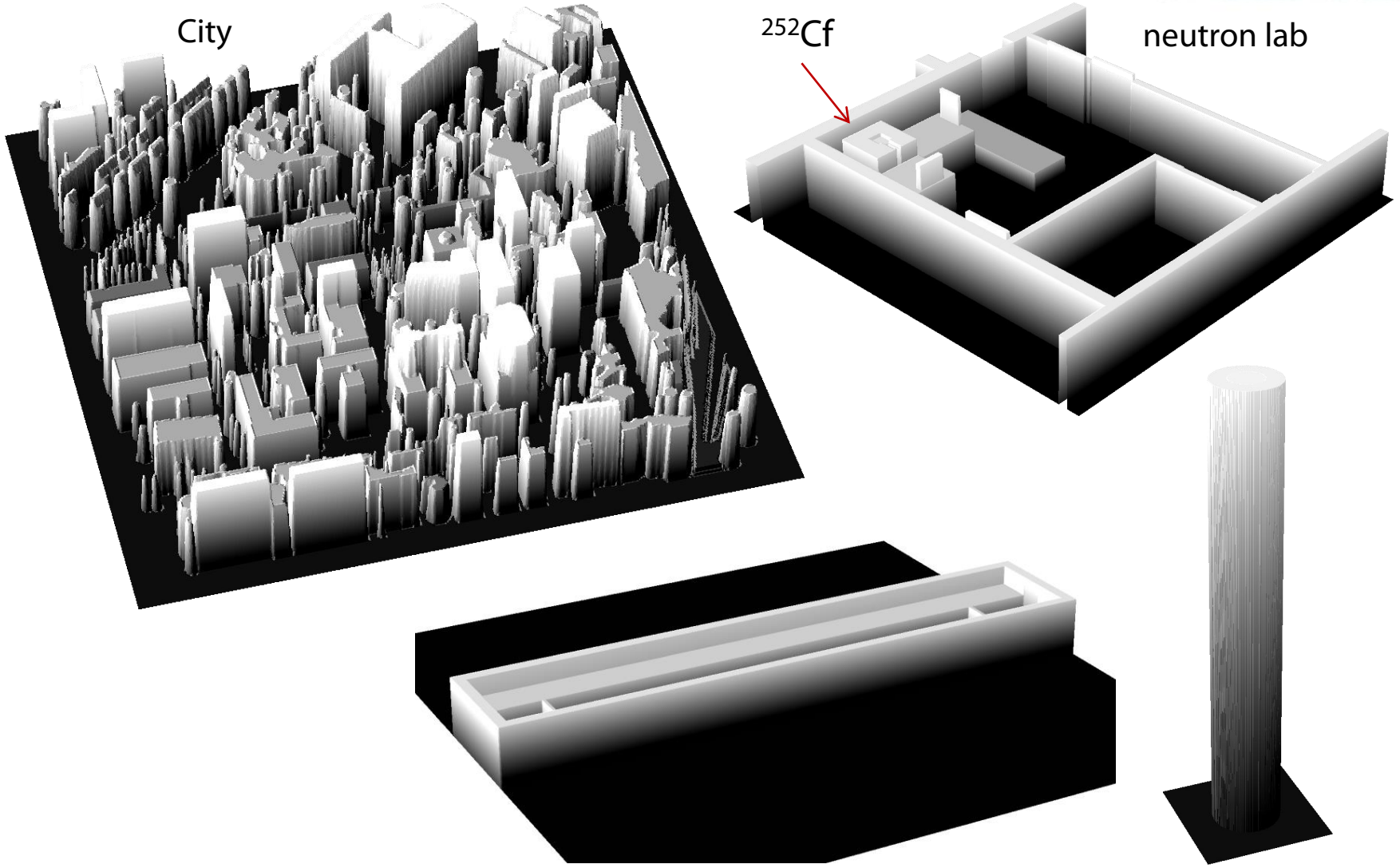


URANOS voxel engine



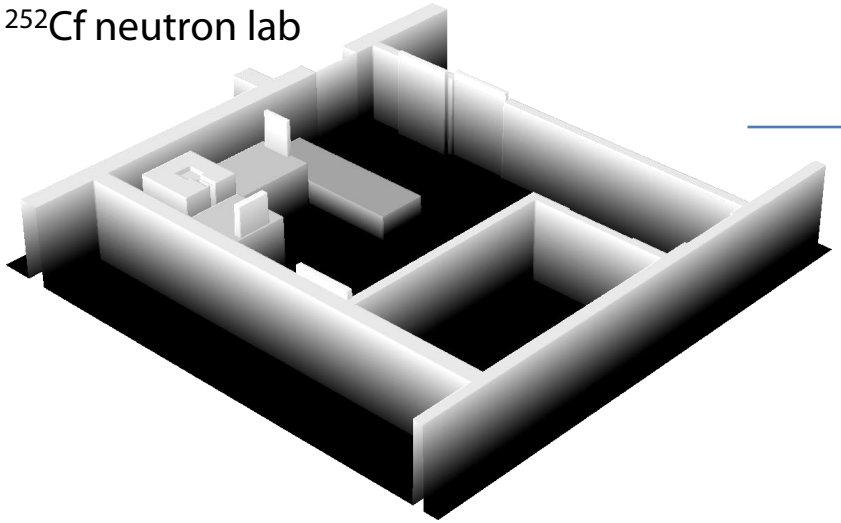


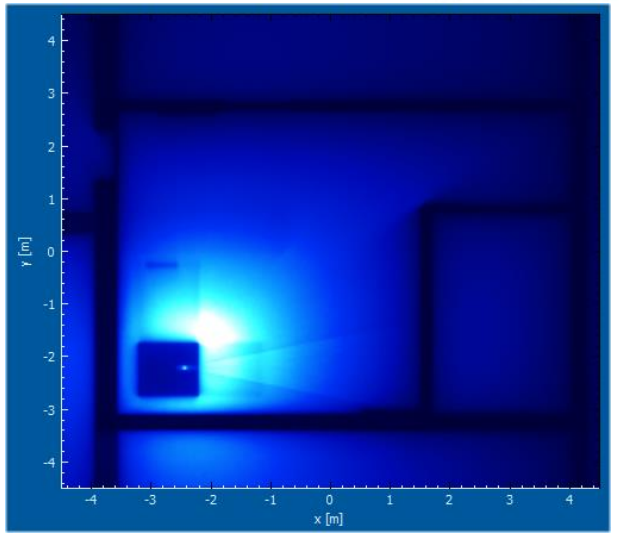
URANOS voxel engine



URANOS voxel engine

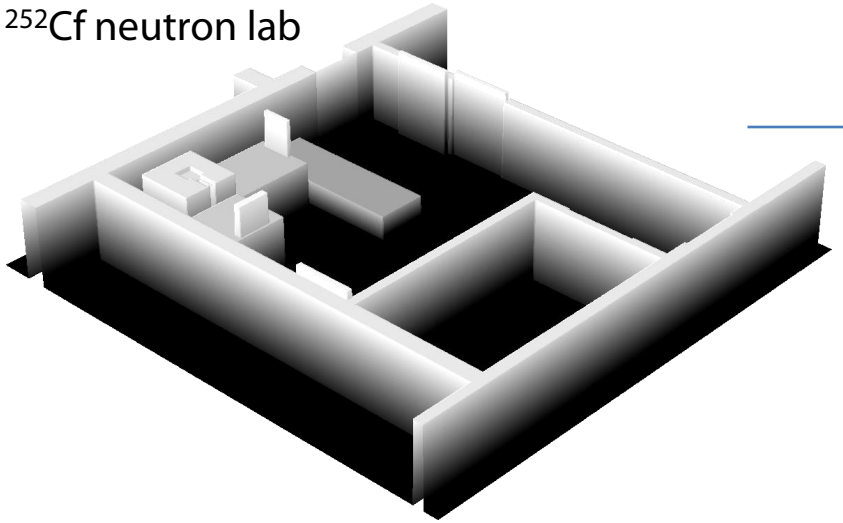
^{252}Cf neutron lab

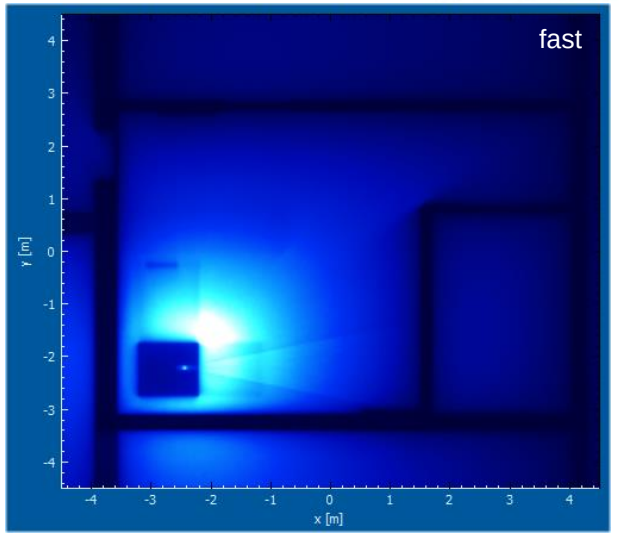




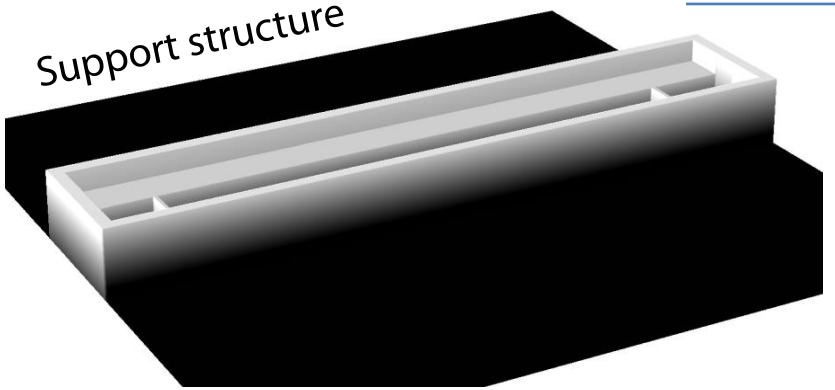
URANOS voxel engine

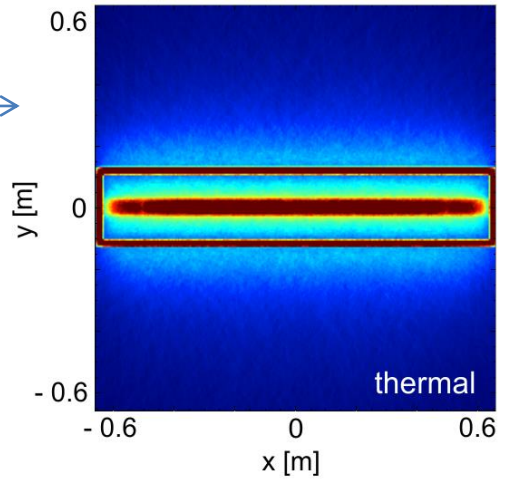
^{252}Cf neutron lab



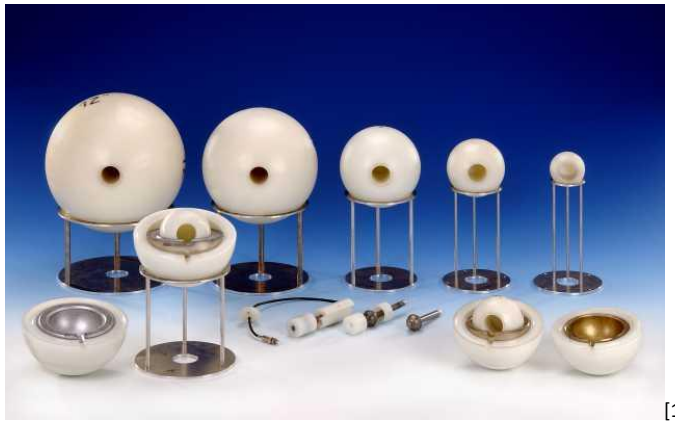


Support structure

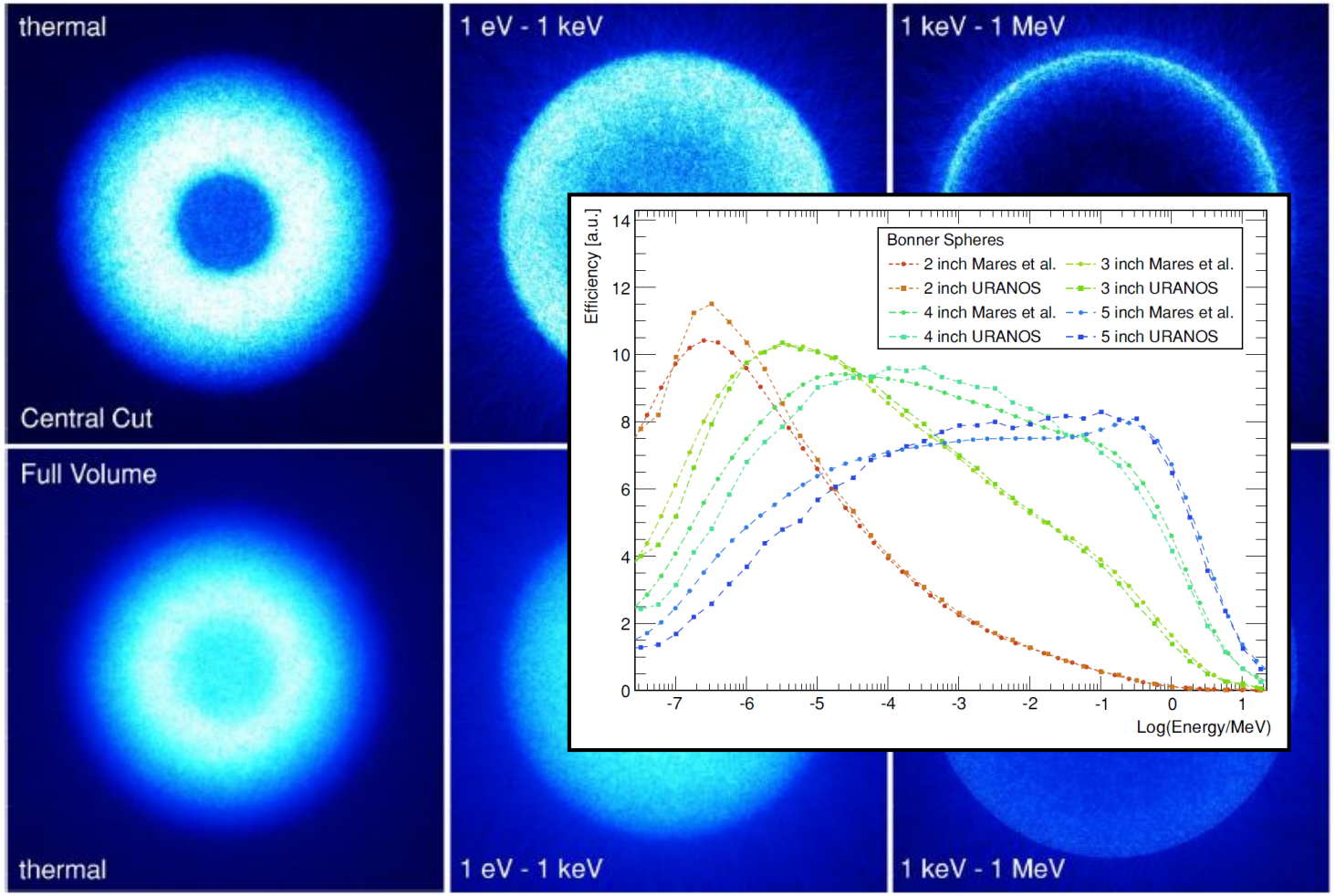




Bonner Spheres

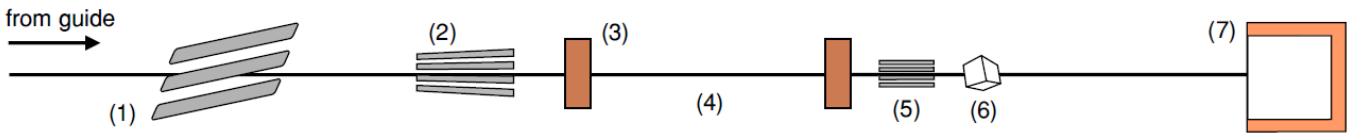


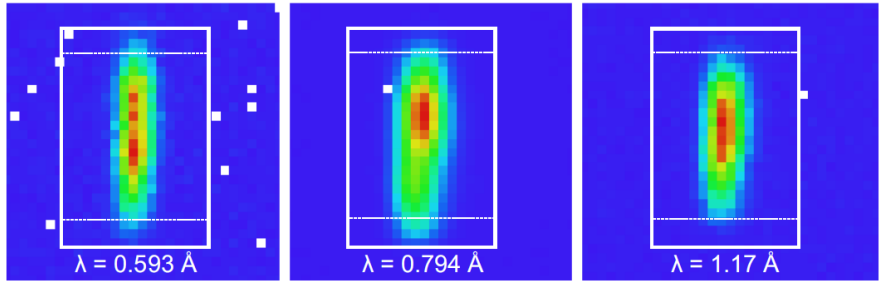
[1]

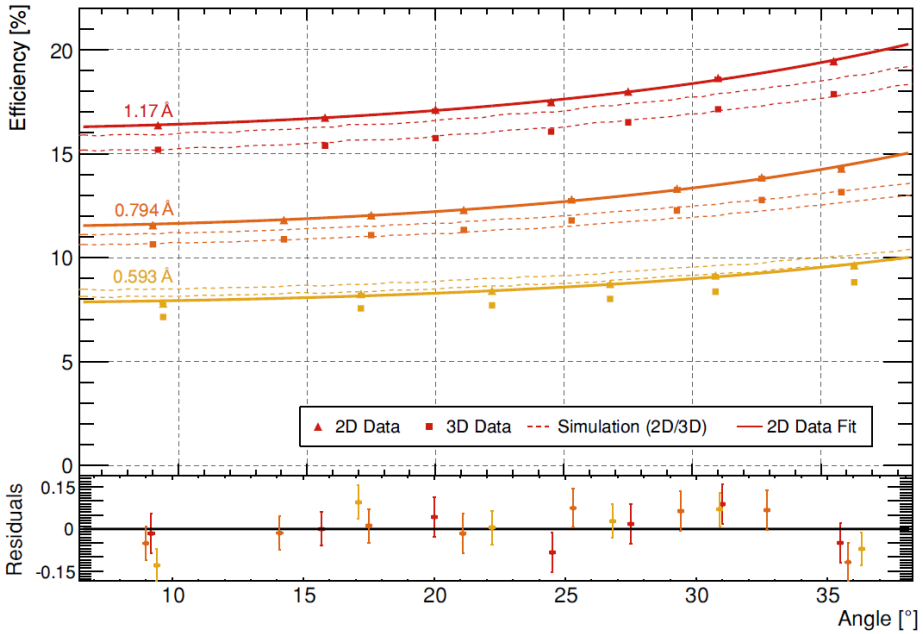


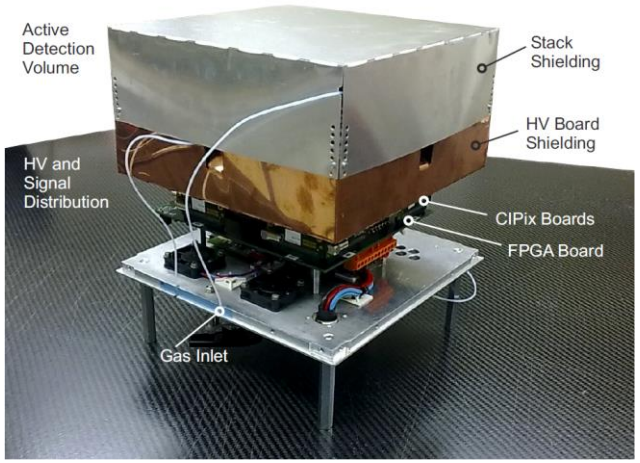
[1] https://www.ptb.de/cms/en/ptb/fachabteilungen/abt6/fb-64/643-neutron-spectrometry/nemus/neutron-spektrometer-nemus-neutron-multisphere-spectrometer.html

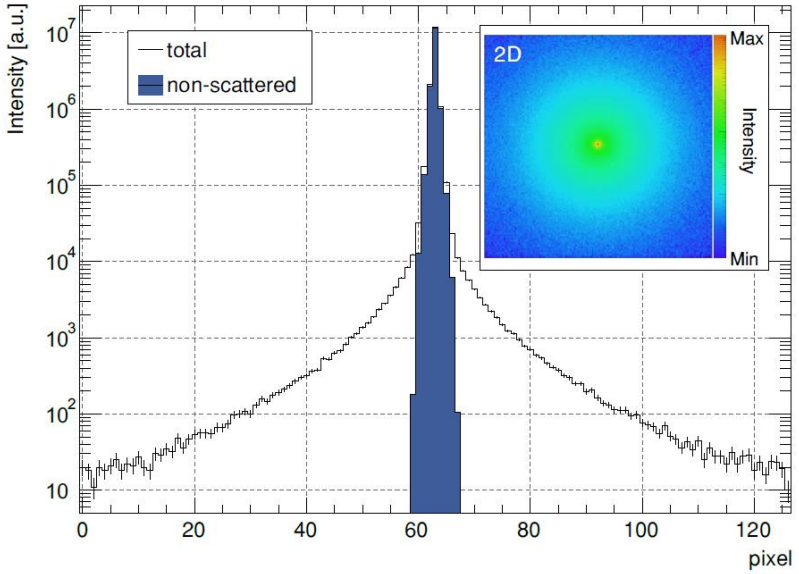
Detector efficiency calculation





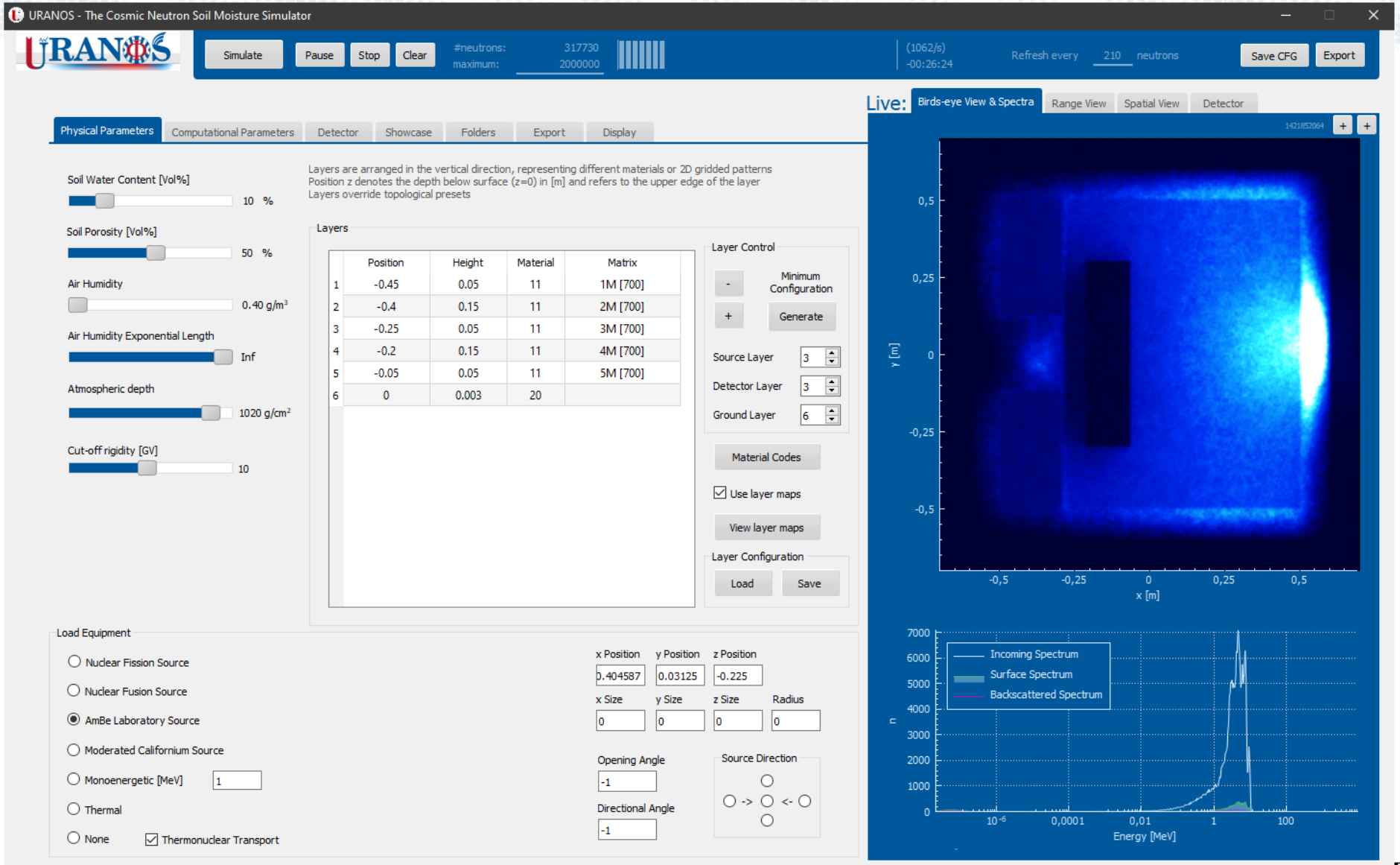




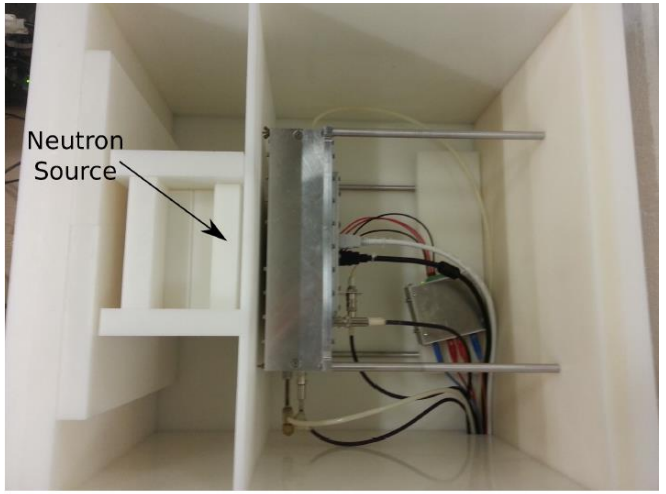


URANOS Demonstration

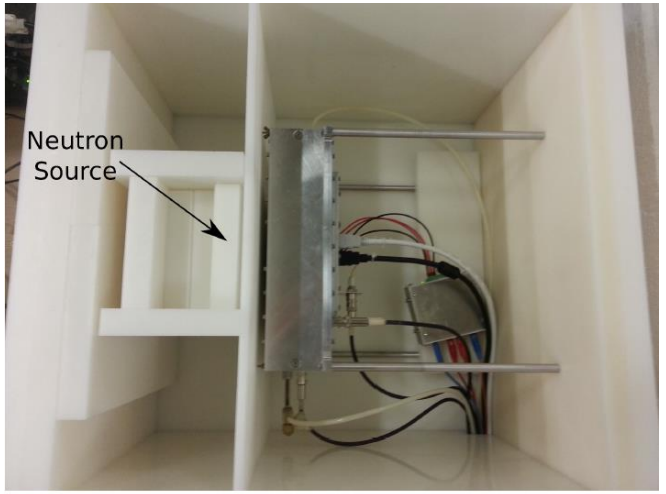
User interface

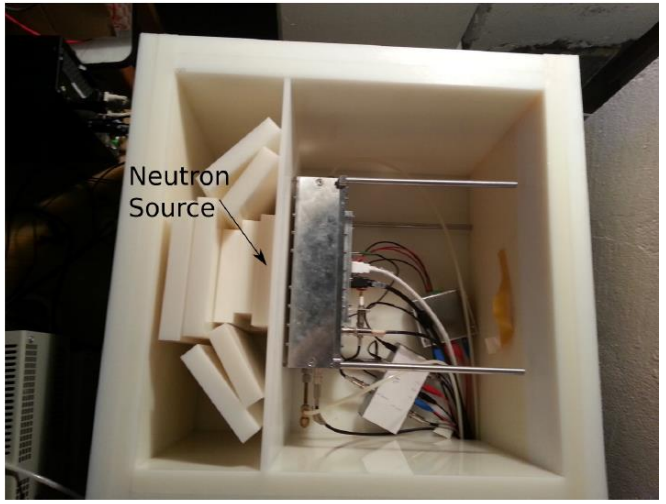


Small-scale detector test



Small-scale detector test





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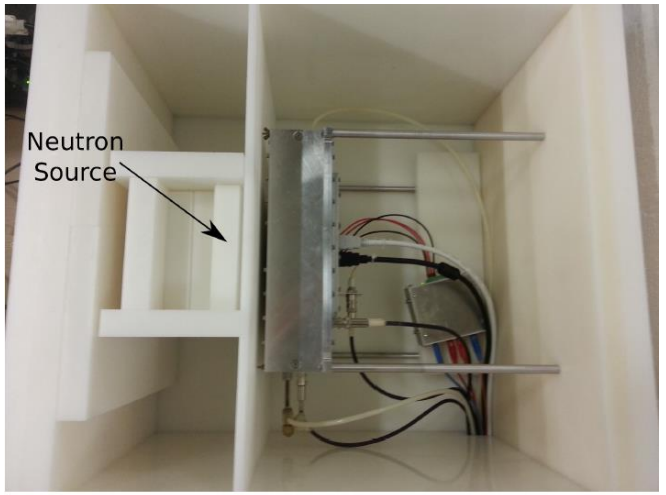
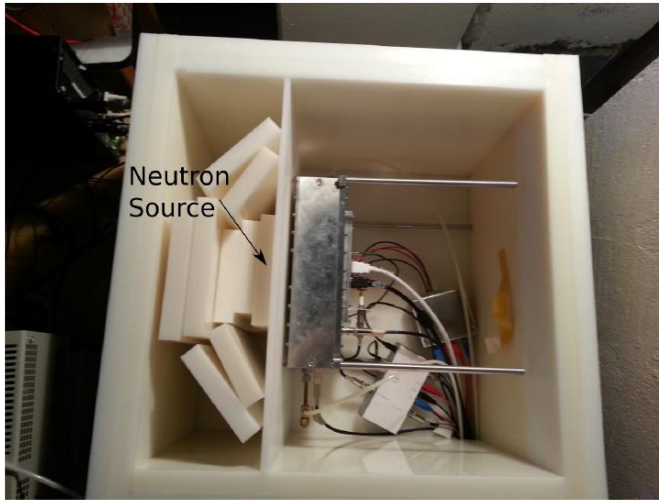
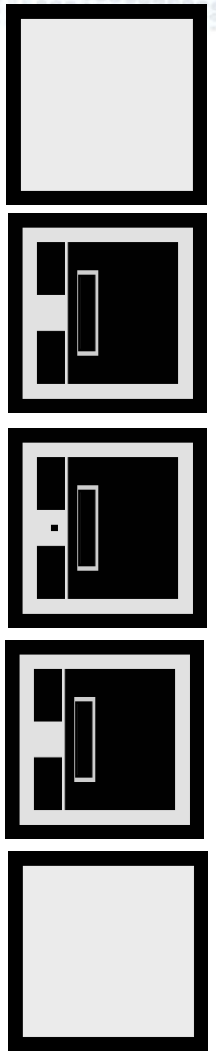
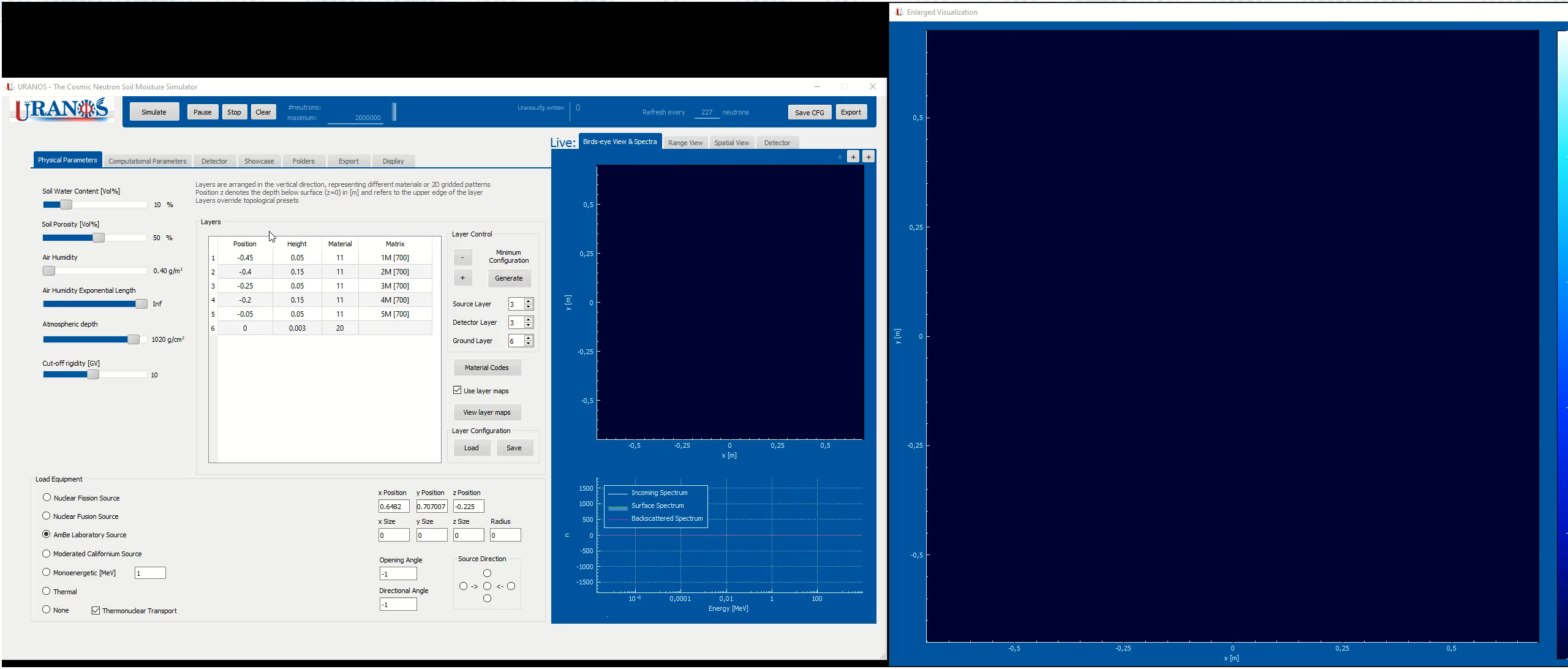


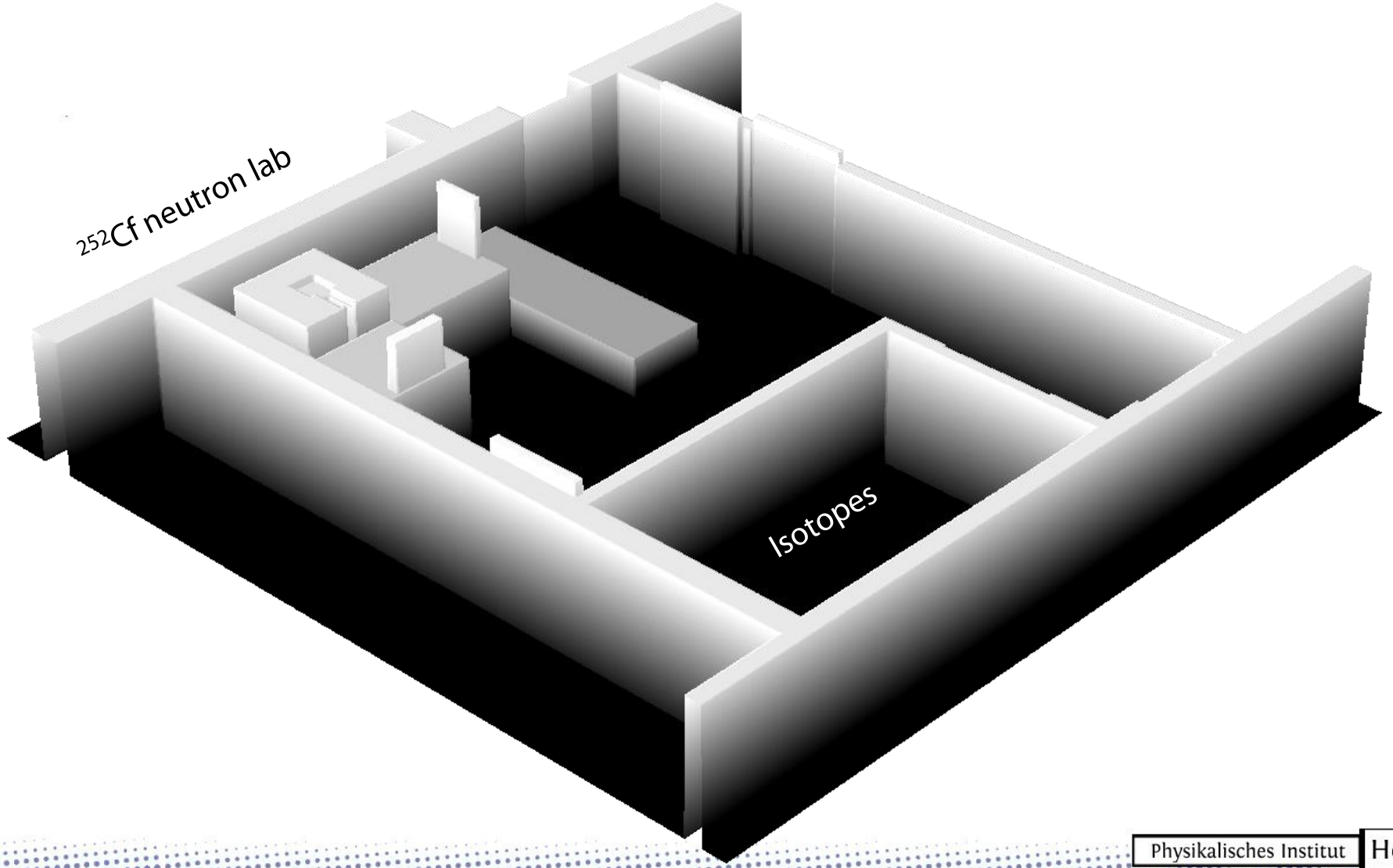




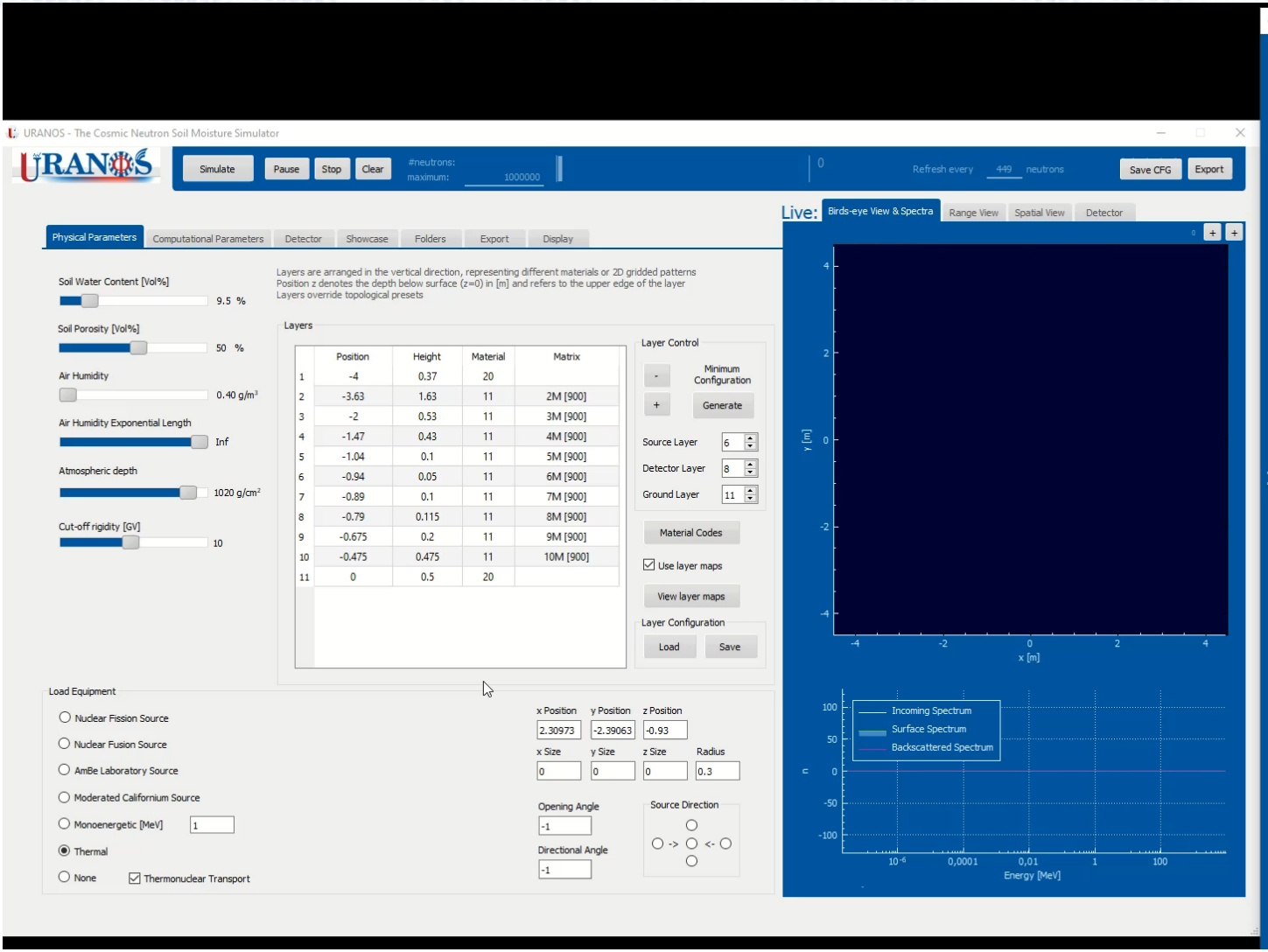
Small-scale detector test

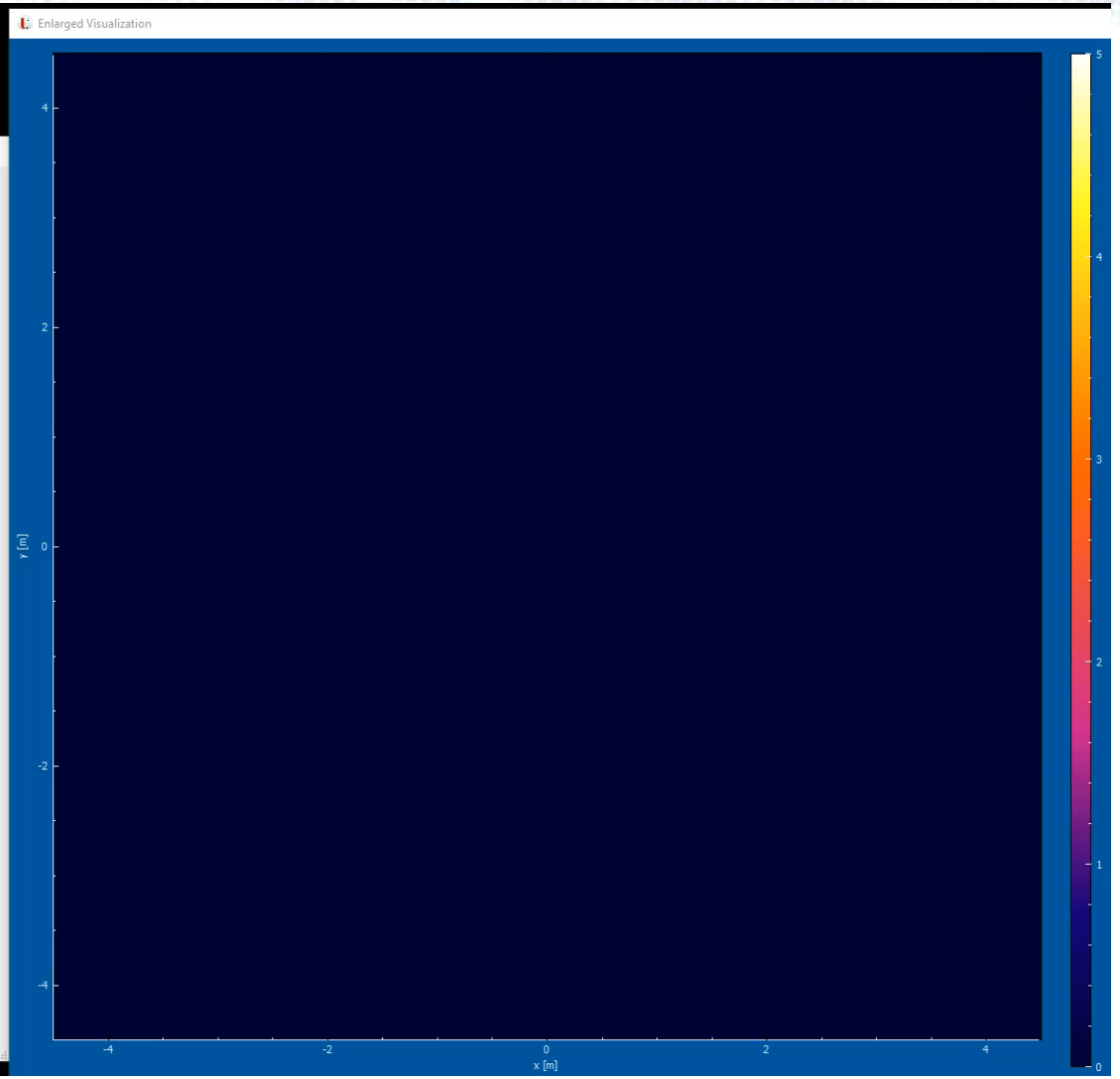


Small-scale laboratory test



Small-scale laboratory test





URANOS model paper 2023

Paper:

Articles / Volume 16, issue 2 / GMD, 16, 449–477, 2023

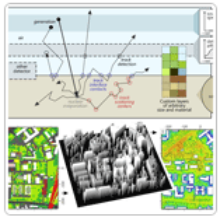
https://doi.org/10.5194/gmd-16-449-2023

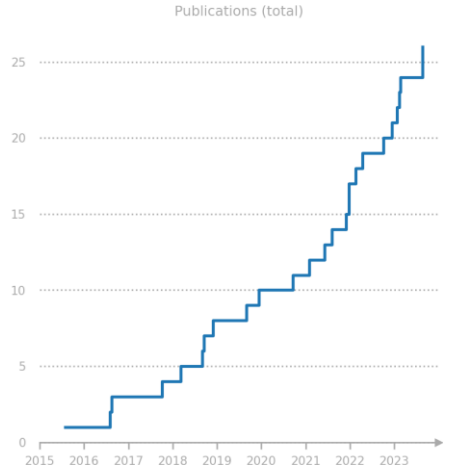
Article | Assets | Peer review | Metrics | Related articles

Model description paper | 23 Jan 2023

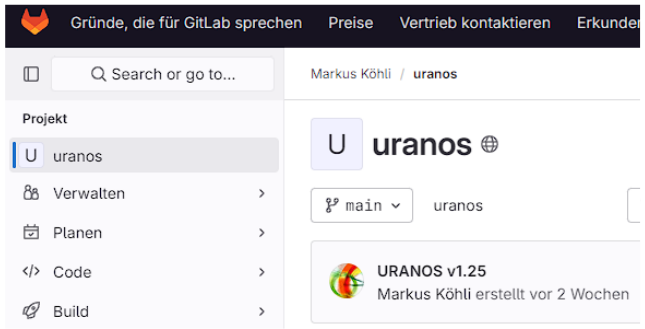
URANOS v1.0 – the Ultra Rapid Adaptable Neutron-Only Simulation for Environmental Research

Markus Köhli, Martin Schrön, Steffen Zacharias, and Ulrich Schmidt

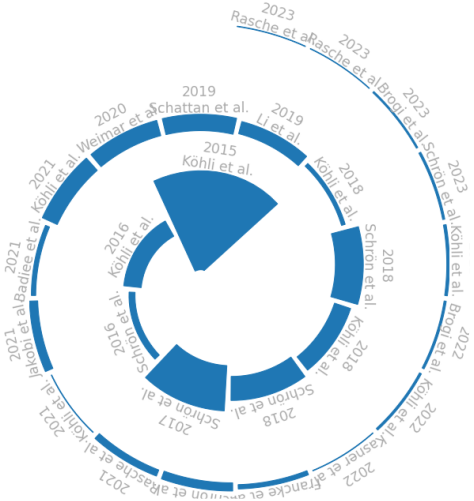




Public repository (Sources, Wiki, Windows, Linux):



file	OS	requires
`URANOS*`	Windows	ROOT 6.22.08
`URANOS64bit`	Windows	ROOT 6.30.02
`URANOS-Ubuntu20-*`	Linux/Ubuntu 20	ROOT 6.30.02, QT 5.14.2
`URANOS-Ubuntu22-*`	Linux/Ubuntu 22	ROOT 6.30.02, QT 5.15.3
`URANOS-Ubuntu23-*`	Linux/Ubuntu 23	ROOT 6.30.02, QT 5.14.2
`URANOS-CentOS7-*`	Linux/CentOS 7	ROOT 6.22.08, QT 5.9.7, QT 5.13.1



https://gitlab.com/mkoehli/uranos

URANOS

- Novel neutron Monte Carlo tool

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- Ready-to-use User Interface

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