Markus Köhli Martin Schrön Steffen Zacharias Ulrich Schmidt

13.04.2018

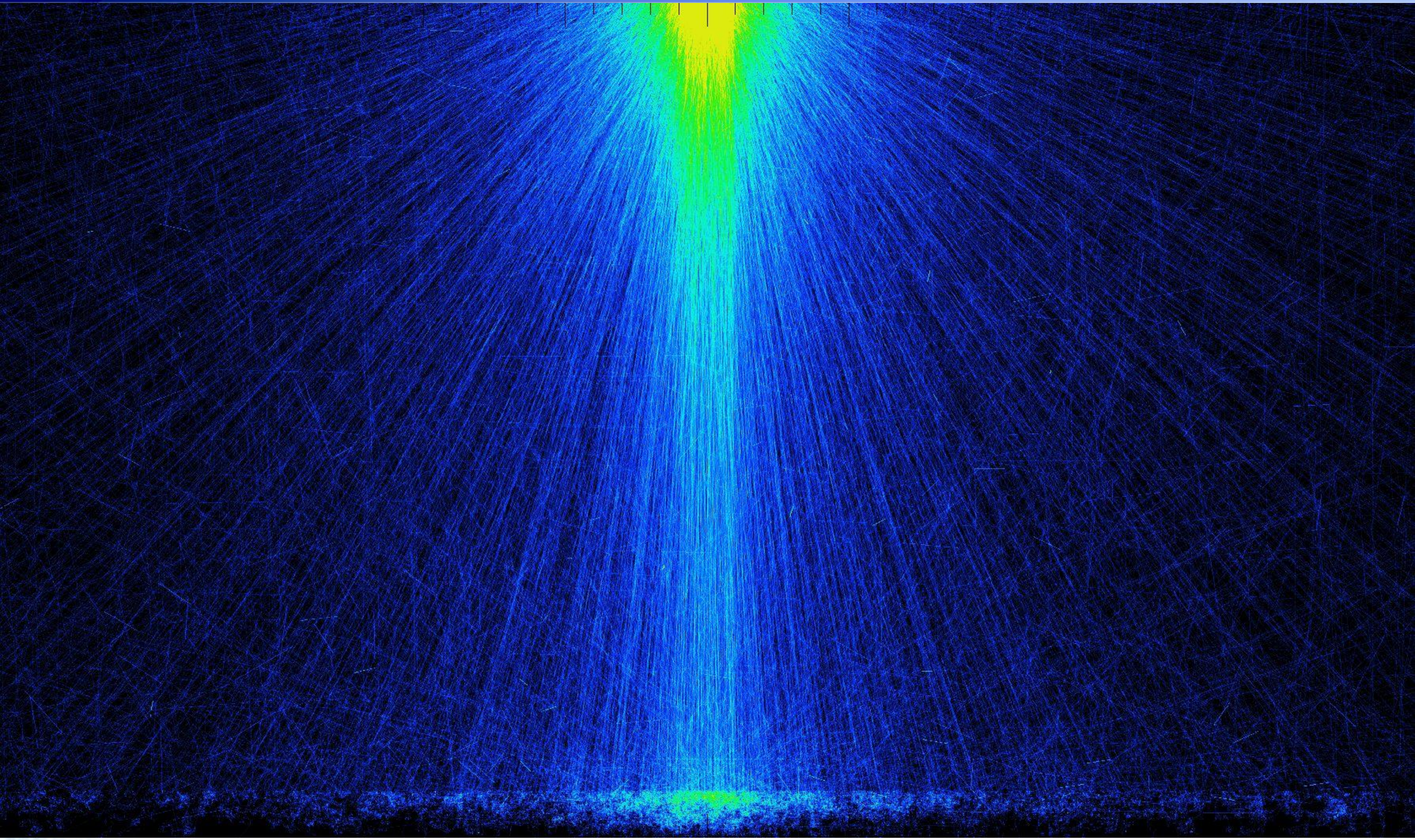
URANOS
-
the
Cosmic Ray Monte Carlo tool

EGU 2018

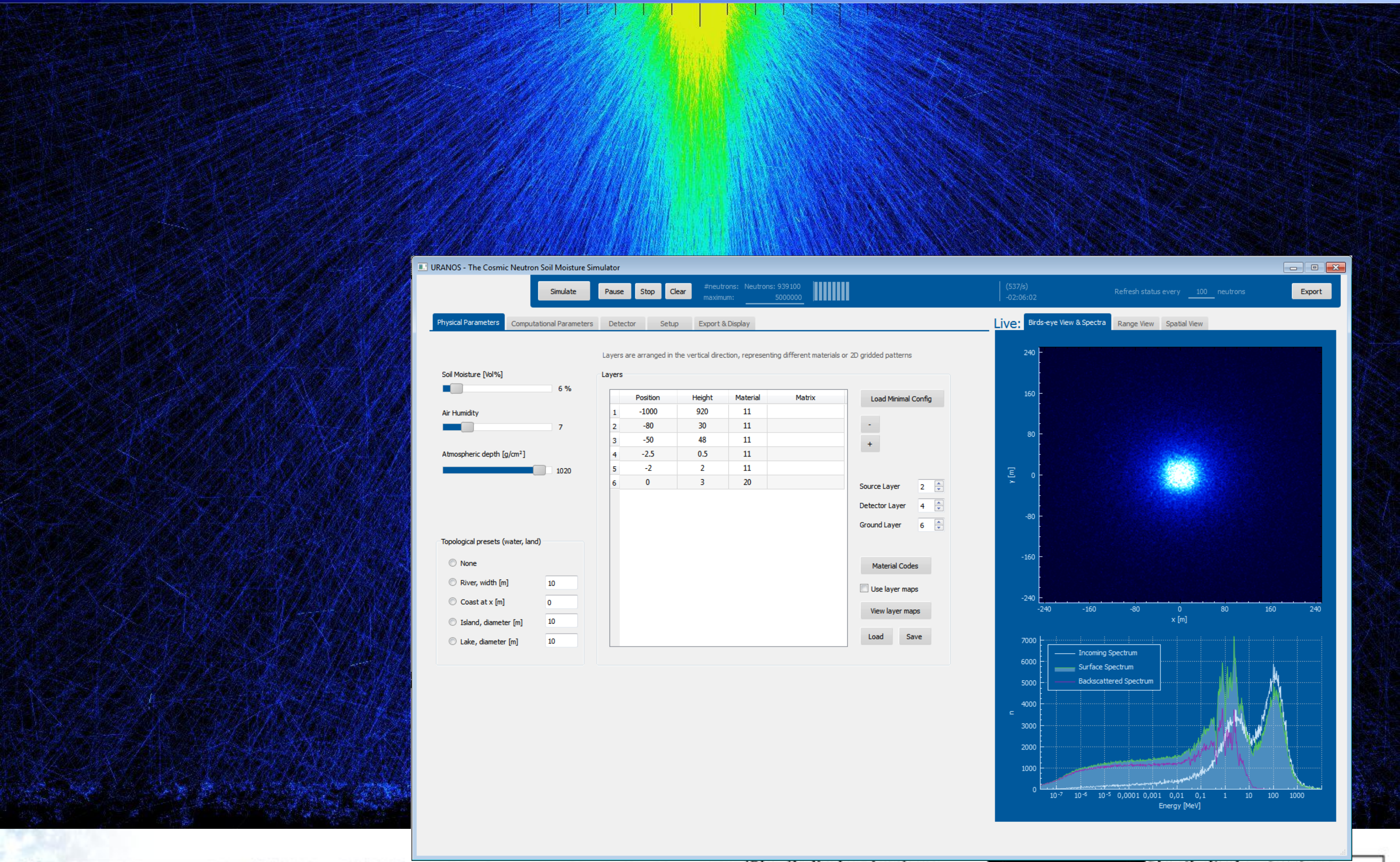
UNIVERSITÄT HEIDELBERG ZUKUNFT SEIT 1386

HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

URANOS



URANOS


URANOS - The Cosmic Neutron Soil Moisture Simulator
Simulate
Pause
Stop
Clear
#neutrons: Neutrons: 939100
maximum: 5000000
(537/s)
-02:06:02
Refresh status every 100 neutrons
Export
Physical Parameters
Computational Parameters
Detector
Setup
Export & Display
Layers are arranged in the vertical direction, representing different materials or 2D gridded patterns
Soil Moisture [Vol%]
6 %
Air Humidity
7
Atmospheric depth [g/cm²]
1020
Layers
Position Height Material Matrix
1 -1000 920 11
2 -80 30 11
3 -50 48 11
4 -2.5 0.5 11
5 -2 2 11
6 0 3 20
Load Minimal Config
Source Layer 2
Detector Layer 4
Ground Layer 6
Material Codes
Use layer maps
View layer maps
Load
Save
Topological presets (water, land)
None
River, width [m] 10
Coast at x [m] 0
Island, diameter [m] 10
Lake, diameter [m] 10
Live:
Birds-eye View & Spectra
Range View
Spatial View
y [m]
x [m]
Incoming Spectrum
Surface Spectrum
Backscattered Spectrum
n
Energy [MeV]

WRR Paper 2015

AGU PUBLICATIONS

Water Resources Research

RESEARCH ARTICLE

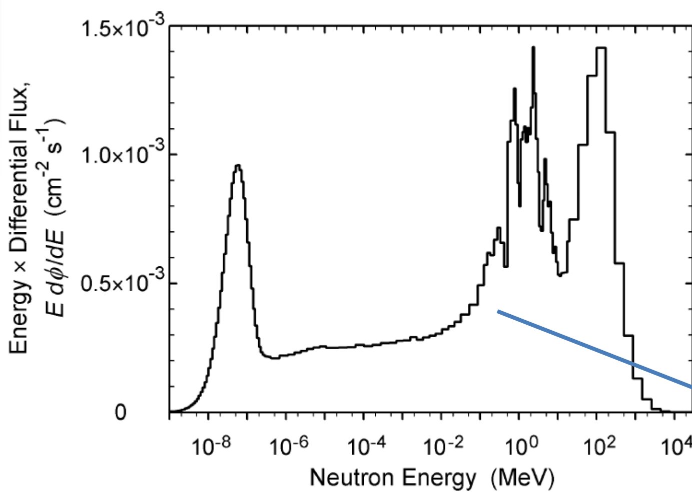
10.1002/2015WR017169

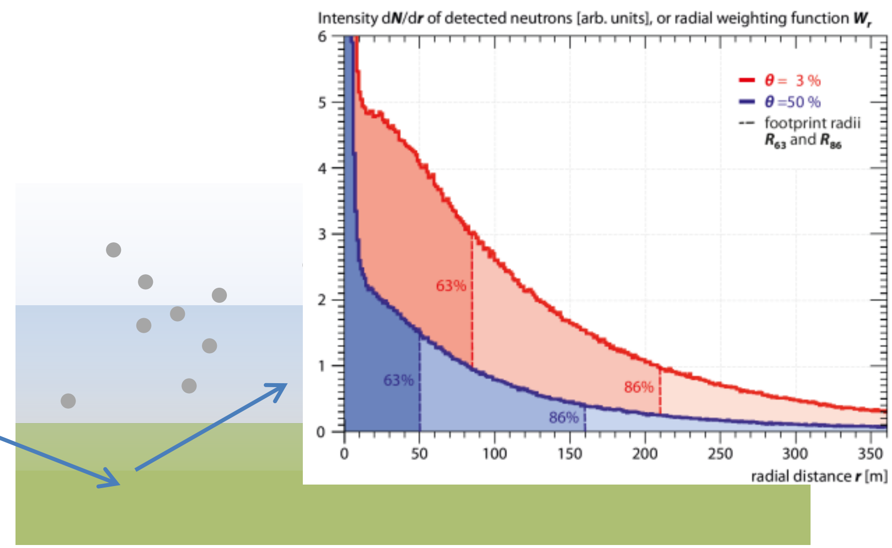
Footprint characteristics revised for field-scale soil moisture monitoring with cosmic-ray neutrons

M. Köhli and M. Scl
equally to this worl

Key Points:
- Neutron transpor

$$W_r(h,\theta) \approx \begin{cases} F_1\, e^{-F_2 r} + F_3\, e^{-F_4 r}\,, & r \le 50\,\mathrm{m} \\ F_5\, e^{-F_6 r} + F_7\, e^{-F_8 r}\,, & r > 50\,\mathrm{m} \end{cases}$$





WRR Paper 2015

AGU PUBLICATIONS

Water Resources Research

RESEARCH ARTICLE

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Footprint characteristics revised for field-scale soil moisture monitoring with cosmic-ray neutrons

M. Köhli and M. Schrön contributed equally to this work.

M. Köhli[1], M. Schrön[2], M. Zreda[3], U. Schmidt[1], P. Dietrich[2], and S. Zacharias[2]

...ploration Technologies,
and Water Resources,

Key Points:
- Neutron transpo...

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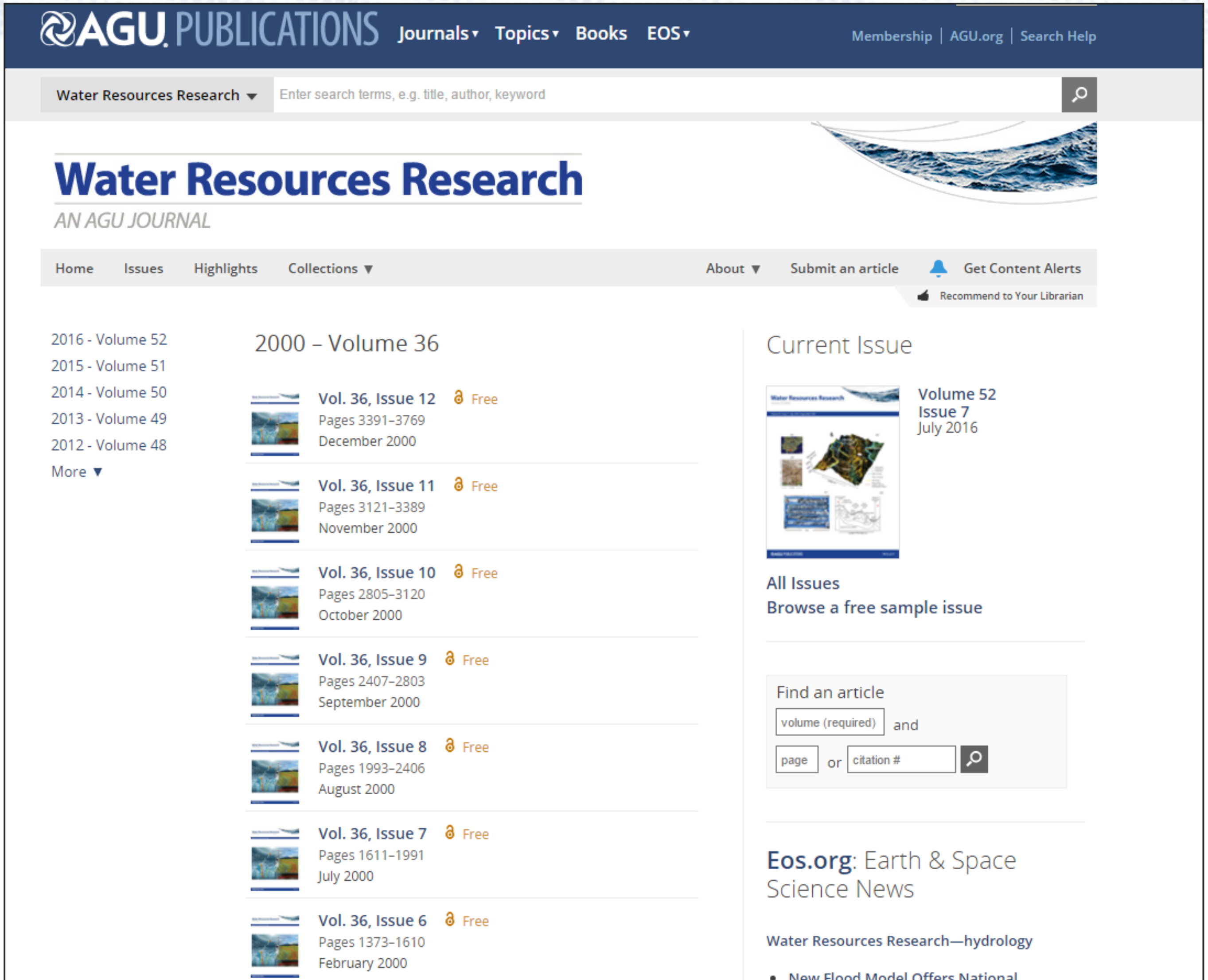
HEIDELBERG UNIVERSITY

WRR Paper 2015



HESS Paper 2017

Improving calibration and validation of cosmic-ray neutron sensors in the light of spatial sensitivity

Martin Schrön[1,2], Markus Köhli[1,3,4], Lena Scheiffele[5], Joost Iwema[6], Heye R. Bogena[7], Ling Lv[8], Edoardo Martini[1], Gabriele Baroni[2,5], Rafael Rosolem[6,9], Jannis Weimar[3], Juliane Mai[2,10], Matthias Cuntz[2,11], Corinna Rebmann[2], Sascha E. Oswald[5], Peter Dietrich[1], Ulrich Schmidt[3], and Steffen Zacharias[1]

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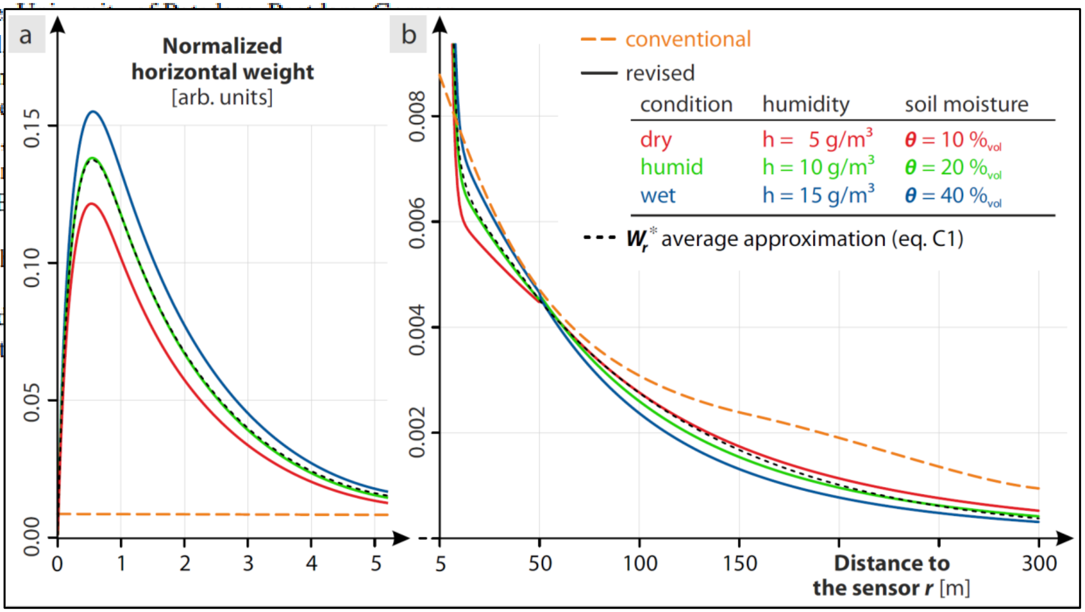
[2]Dept. Computational Hydrosystems, Helmholtz Centre for Environmental Research – UFZ, Leipzig, Germany
[3]Physikalisches Institut, Heidelberg University, Heidelberg, Germany
[4]Physikalisches Institut, University of Bonn, Bonn, Germany
[5]Institute of Earth and Environmental Science
[6]Faculty of Engineering, University of Bristol
[7]Agrosphere Institute (IBG-3), Forschungszen
[8]Dept. of Plants, Soils and Climate, Utah State
[9]Cabot Institute, University of Bristol, Bristol
[10]Dept. of Civil and Environmental Engineeri
[11]INRA, Université de Lorraine, UMR1137, E

Correspondence to: Martin Schrön (martin.sc

Received: 14 March 2017 – Discussion started
Revised: 24 June 2017 – Accepted: 26 August



HESS Paper 2017

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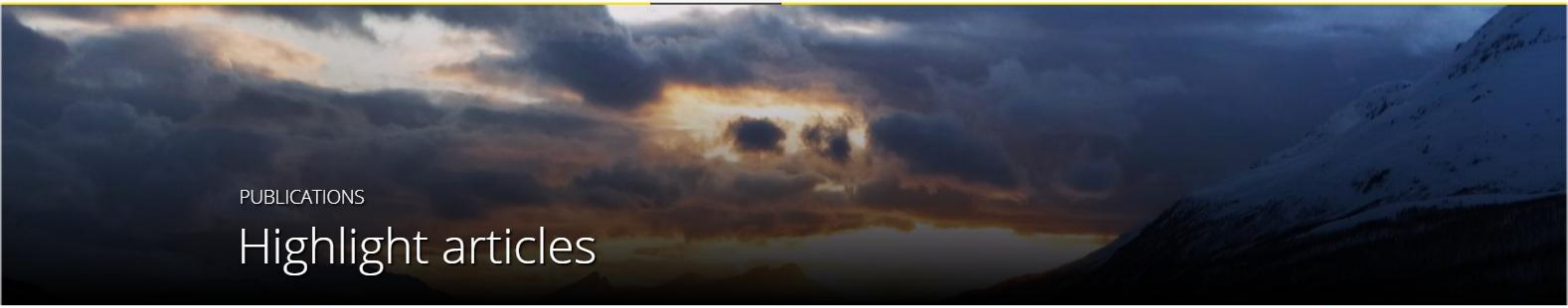

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SEARCH

Keywords

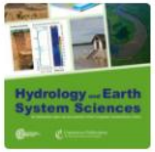
JOURNALS

All

657 ITEMS FOUND — 10 | 20 | 50

Improving calibration and validation of cosmic-ray neutron sensors in the light of spatial sensitivity

Hydrology and Earth System Sciences DOI 10.5194/hess-21-5009-2017 6 October 2017



A field-scale average of near-surface water content can be sensed by cosmic-ray neutron detectors. To interpret, calibrate, and validate the integral signal, it is important to account for its sensitivity to heterogeneous patterns like dry or wet spots. We show how point samples contribute to the neutron signal based on their depth and distance from the detector. This approach robustly improves the sensor performance and data consistency, and even reveals otherwise hidden hydrological features.

Read more

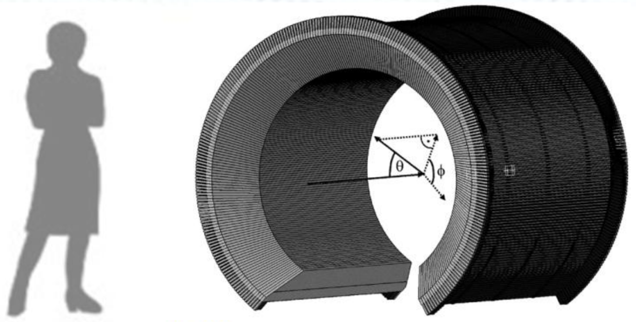
URANOS principles

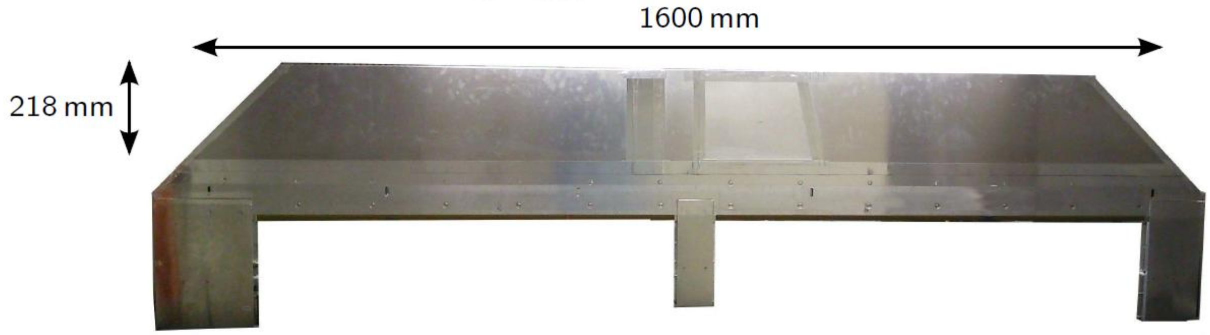
- bitter roots
  - sweet fruits*

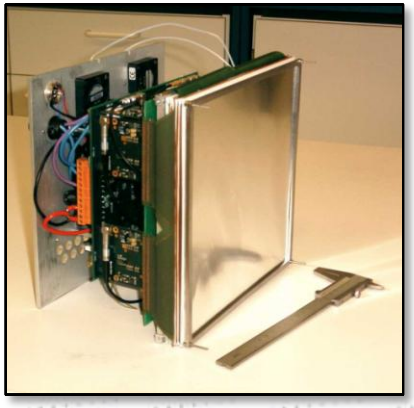
*supposedly ARISTOTELE

Heidelberg Neutron Detectors

The JALOUSIE system

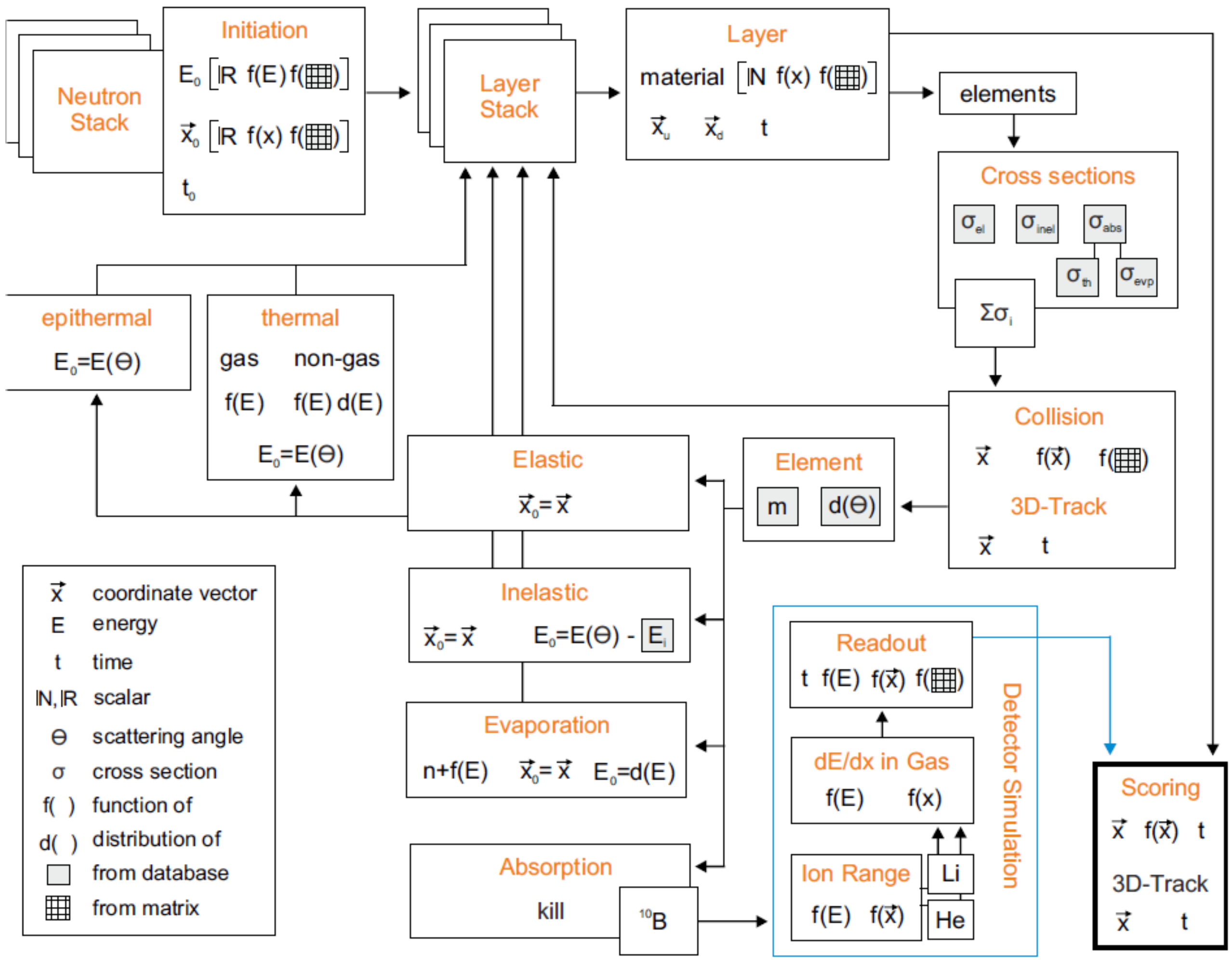




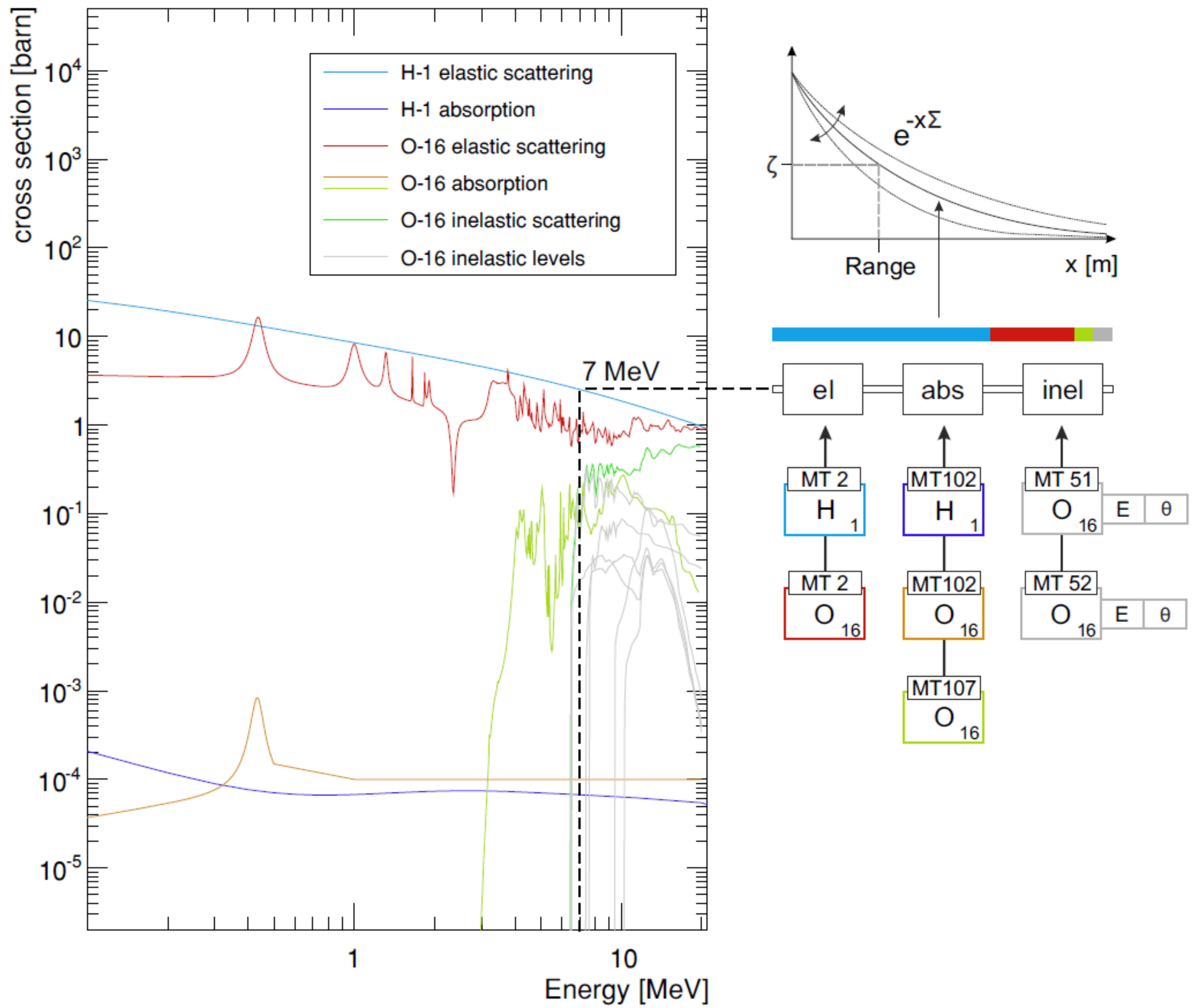


The CASCADE detector

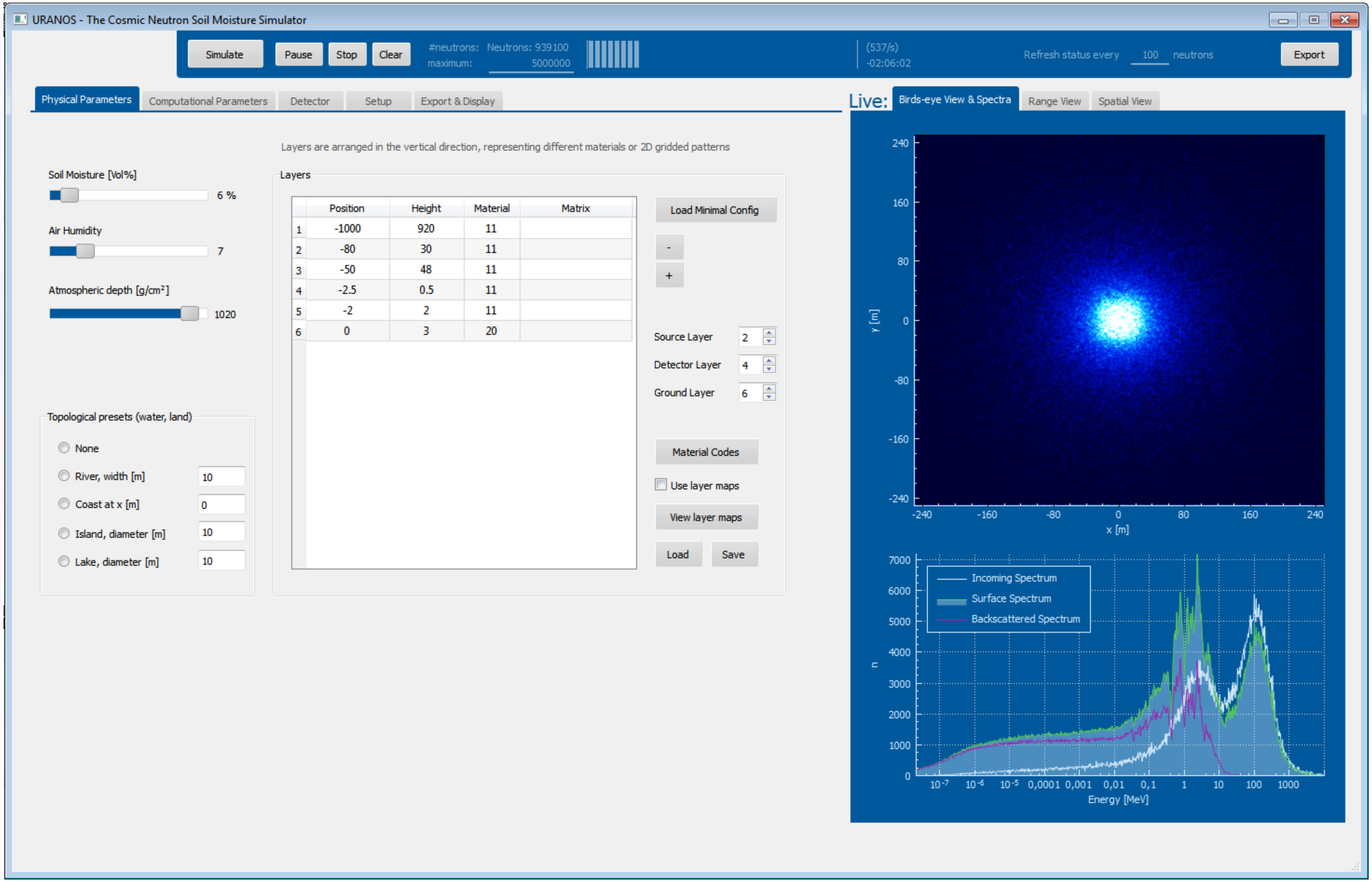
URANOS Buildup



URANOS Buildup



USER Interface



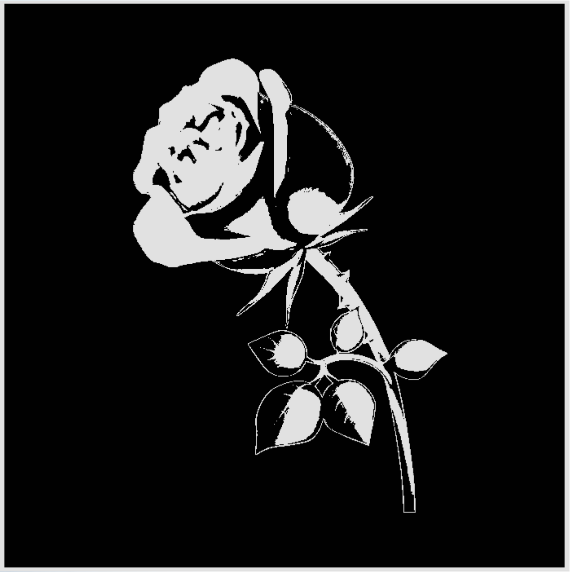
MCNP input file

File Edit Options Buffers Tools Help

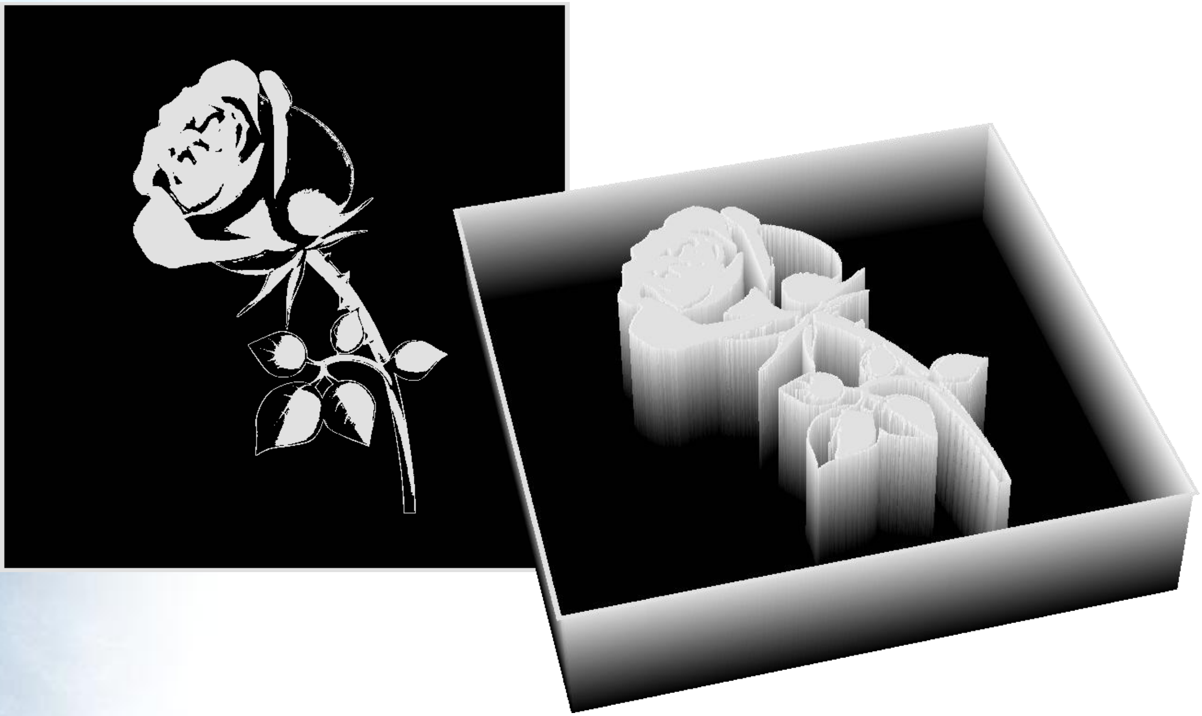
```
-*-mcnpgen-*- Pd-103 photon source,H20 phant filled w/cubes,1 cube has a sphere
c Cell Cards
1 1 -10. -1 2 -3              $ sr-90 source in silver foil
2 10 -2.7 -2 4 -3             $ Al filter
3 2 -8.02 -6 20 -5 (1:3:-4)   $ SS encapsulation
4 2 -8.02 -8 6 -7             $ SS rod
10 0 -20 21 -22 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

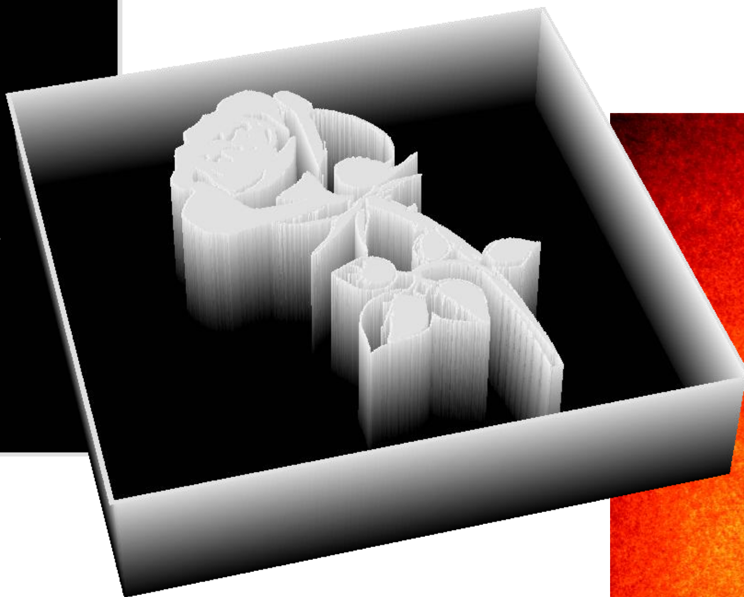


URANOS voxel engine



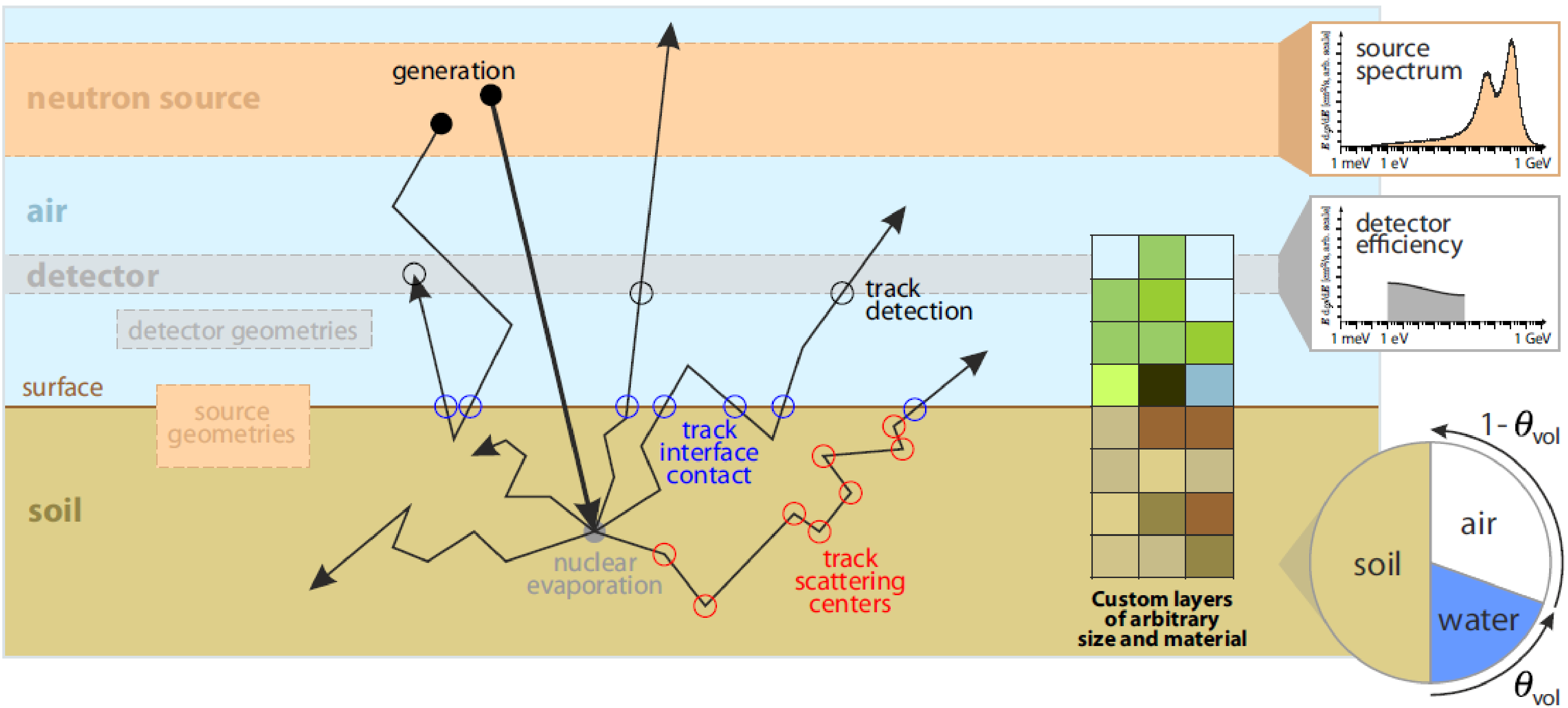
polyethylene rose in a box

URANOS voxel engine



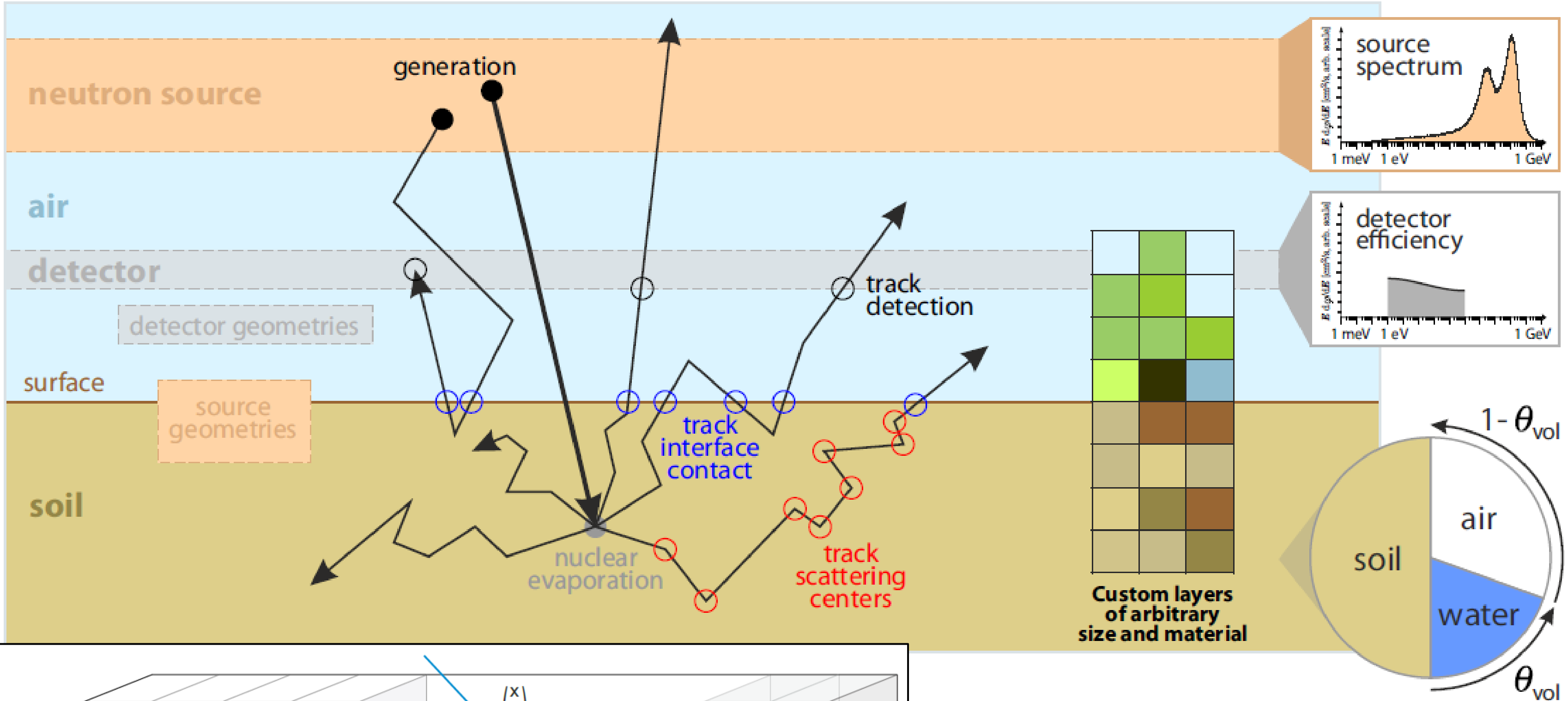
polyethylene rose in a box

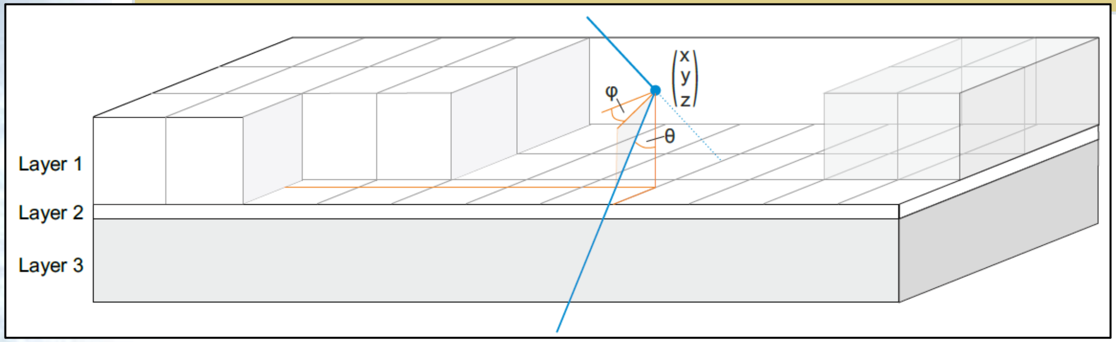
URANOS Buildup



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

URANOS Buildup





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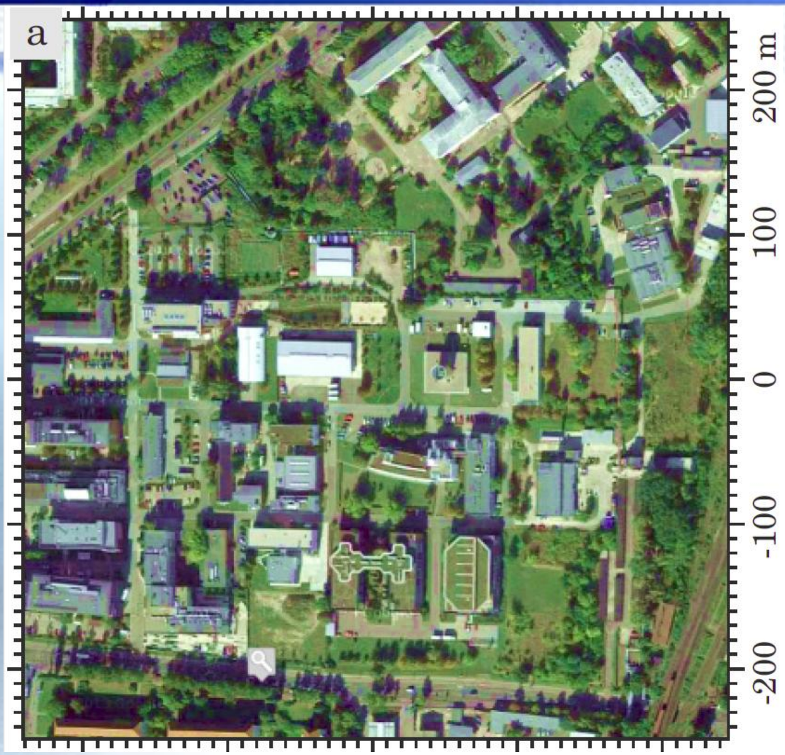
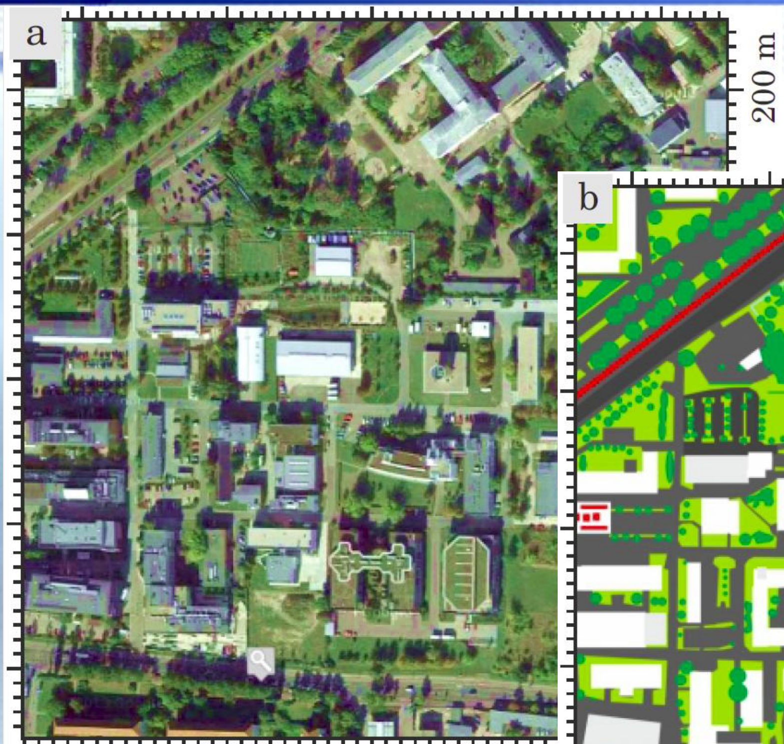
Features and applications of the analytical model for estimating terrestrial cosmic-ray fluxes: PARMA/EXPACS

Modeling steps

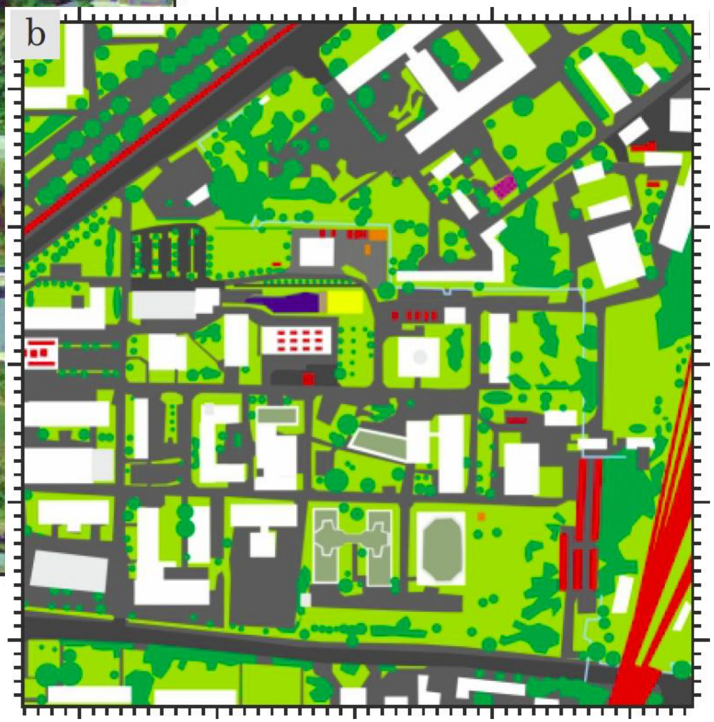


topography

Modeling steps

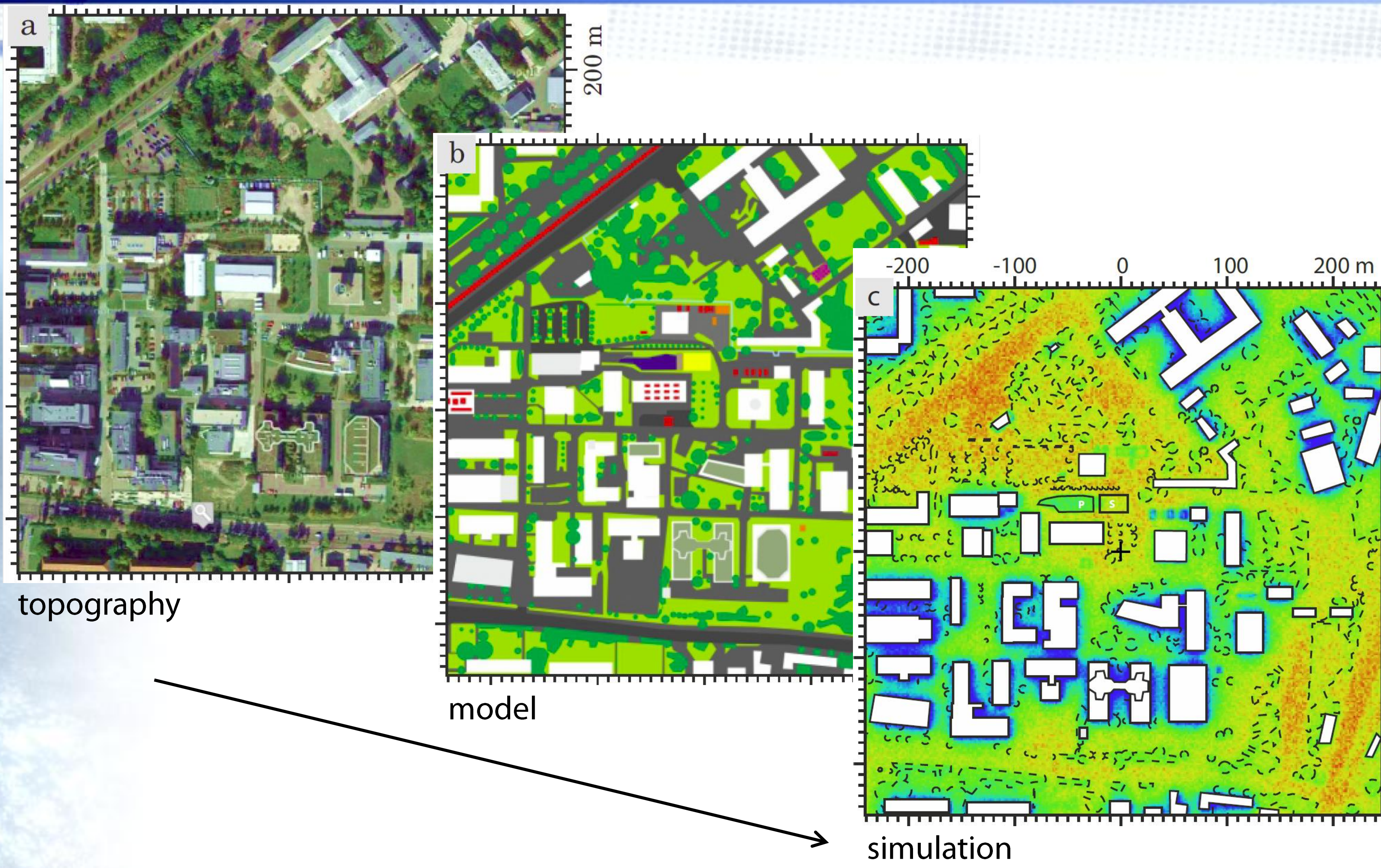


topography



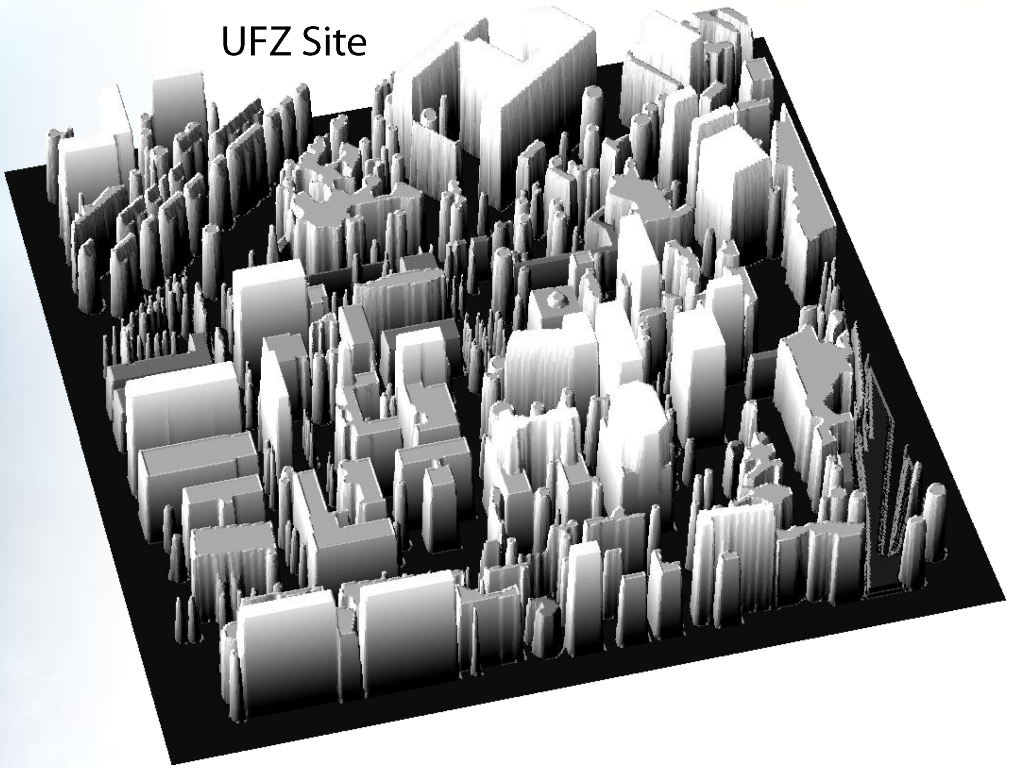
model

Modeling steps

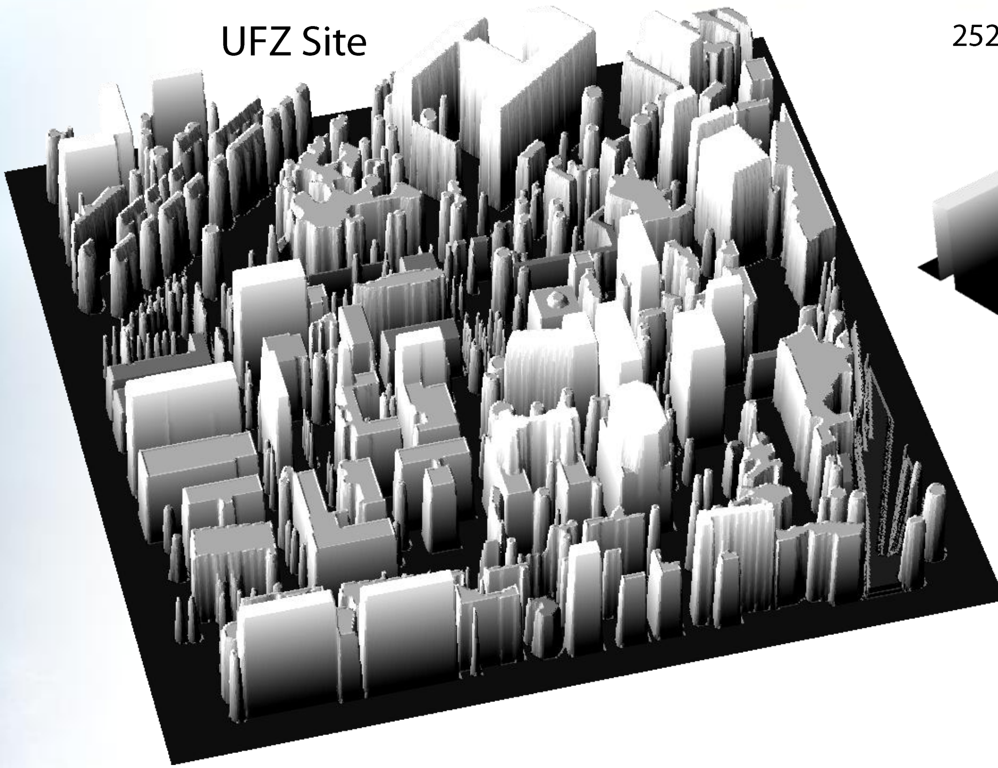


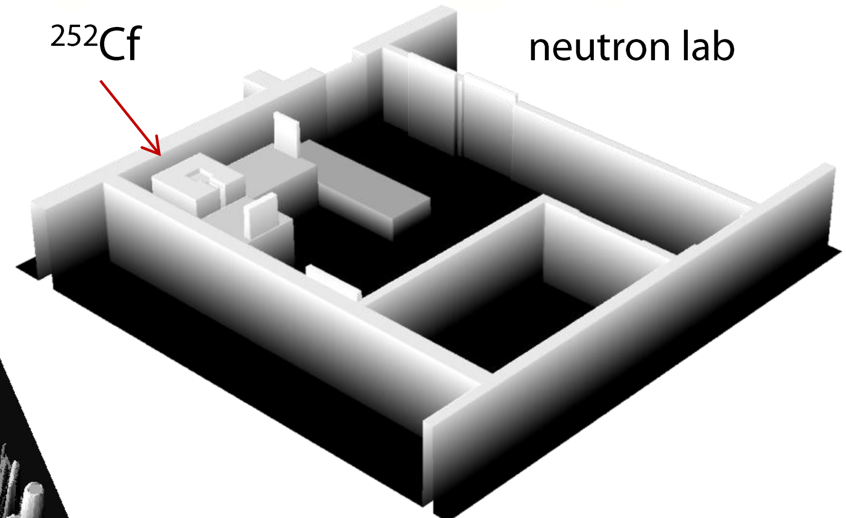
URANOS voxel engine

UFZ Site

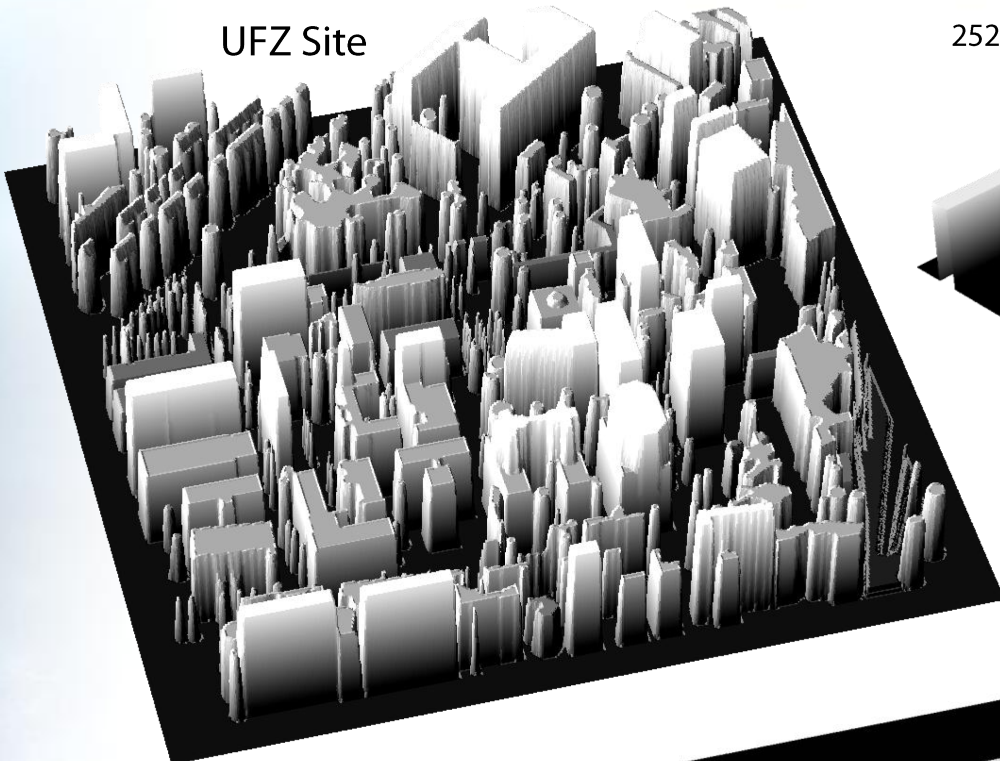


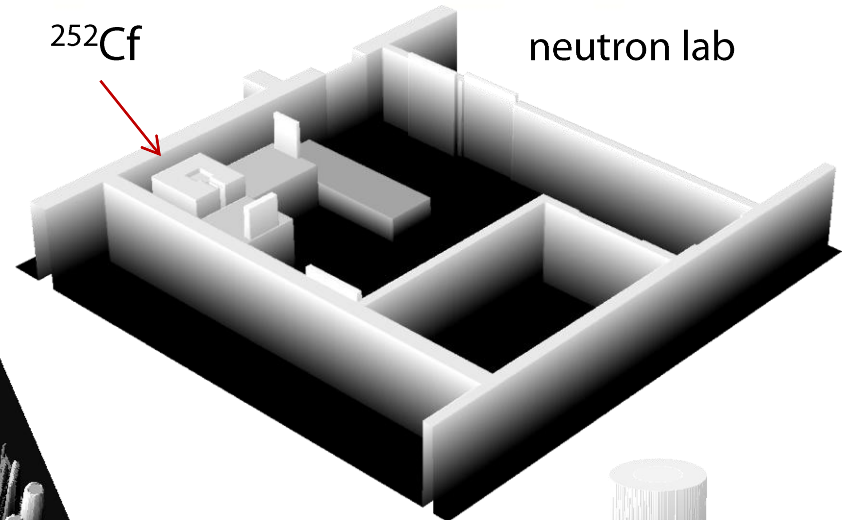
URANOS voxel engine

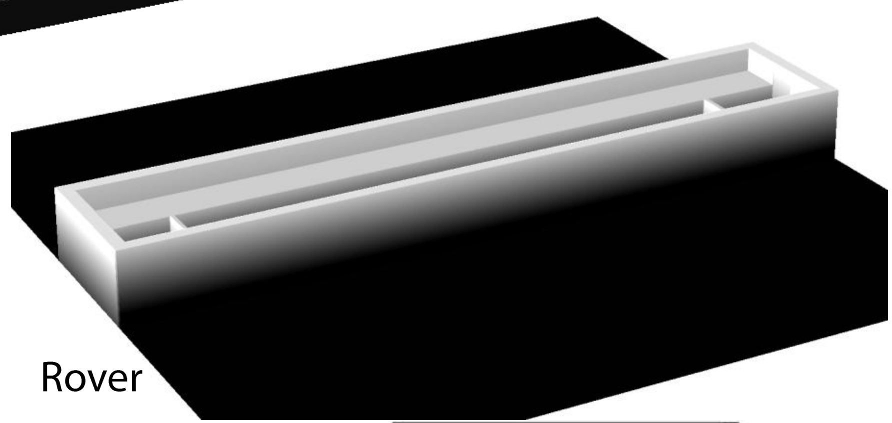


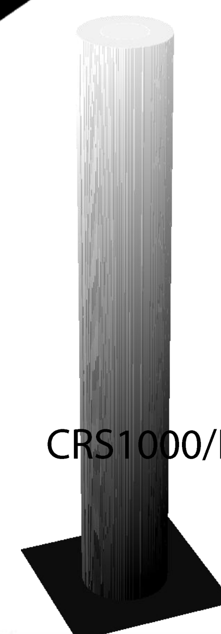


URANOS voxel engine



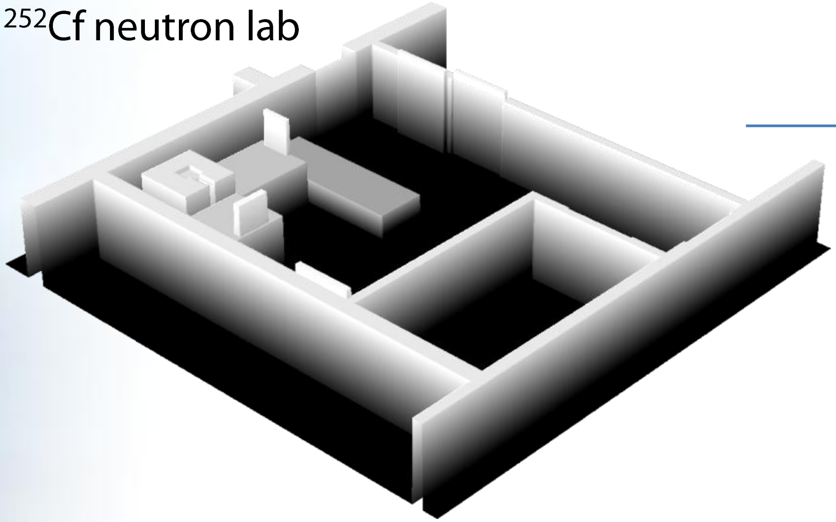


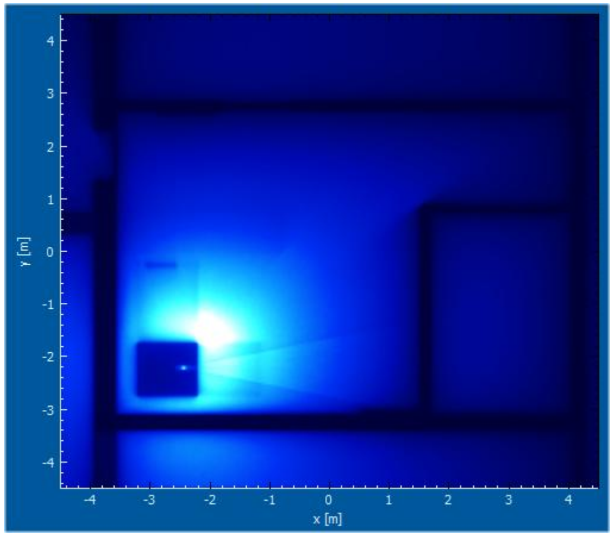




URANOS voxel engine

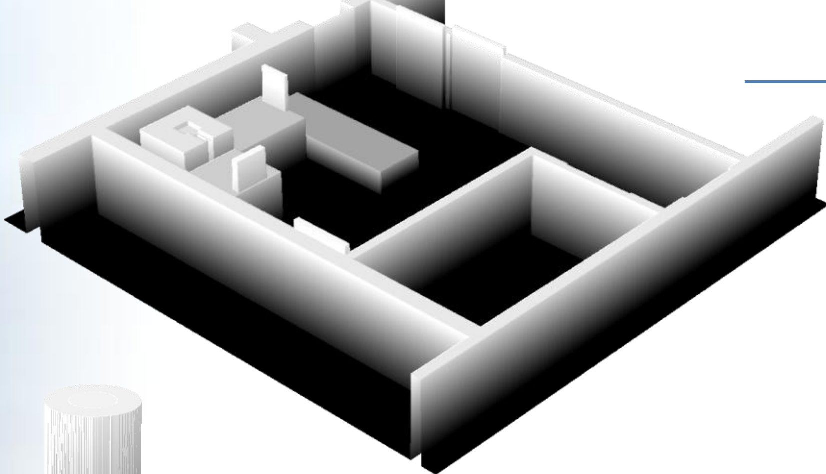
^{252}Cf neutron lab

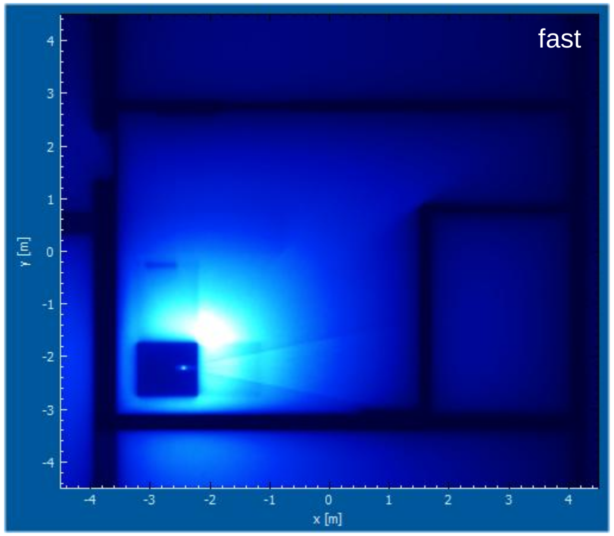




URANOS voxel engine

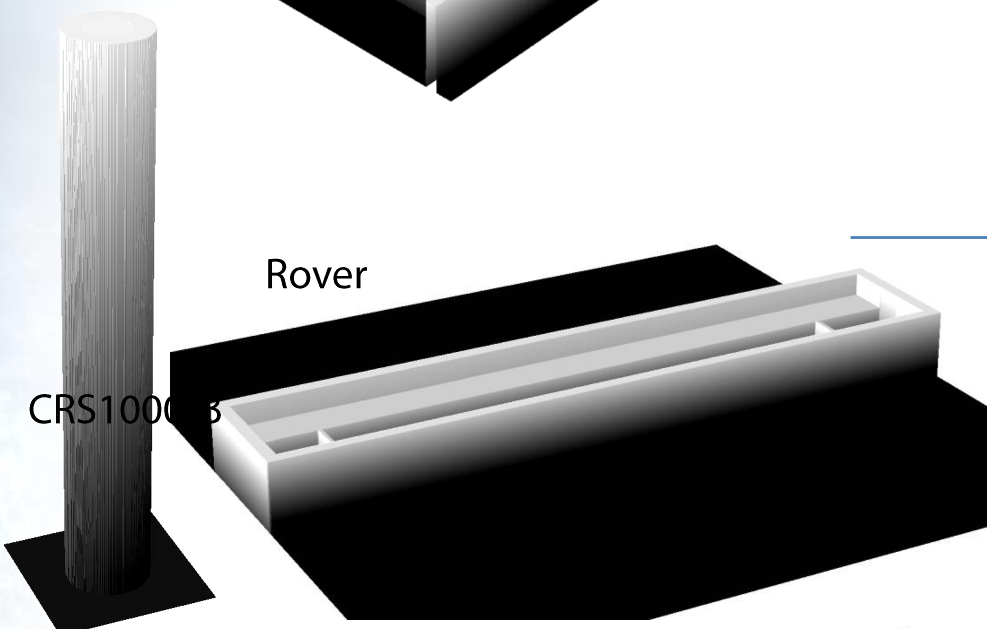
^{252}Cf neutron lab

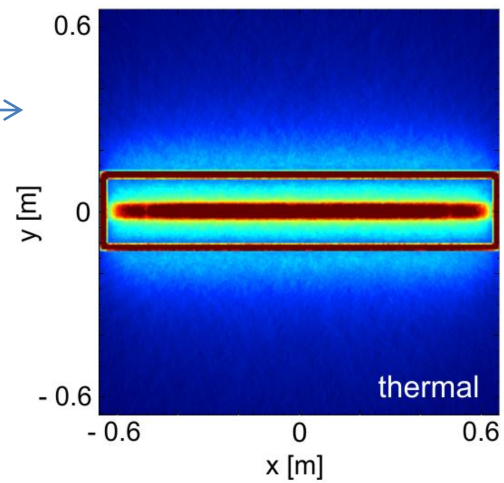




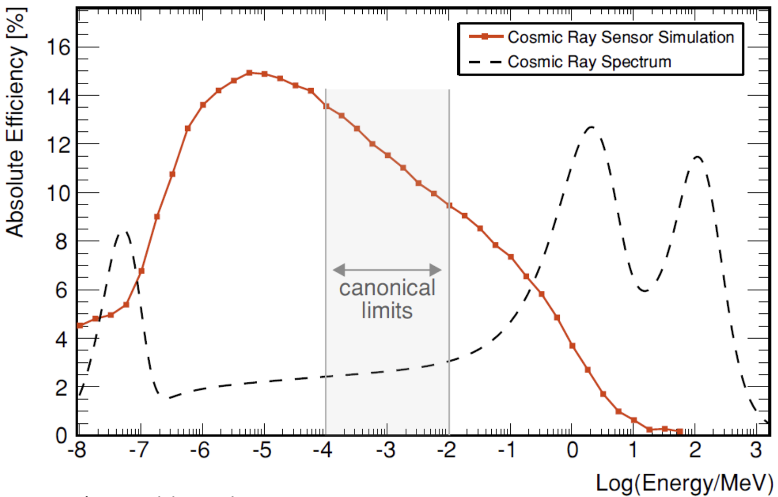
Rover

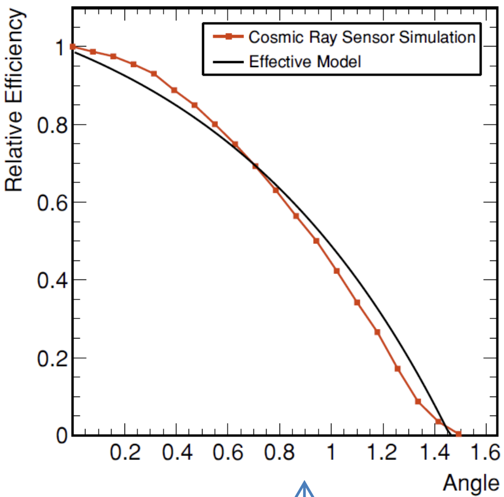
CRS1000



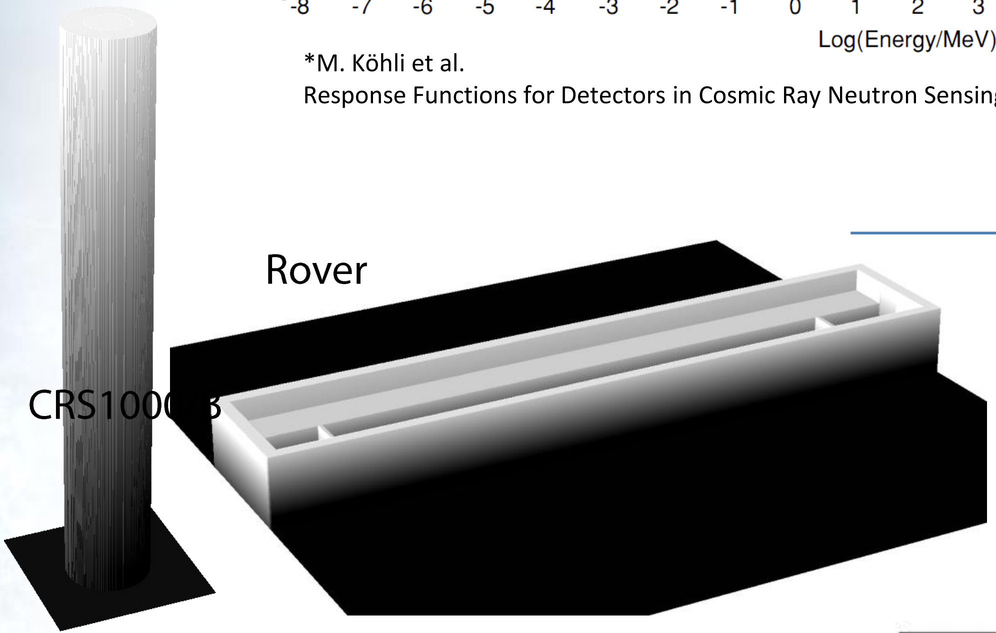


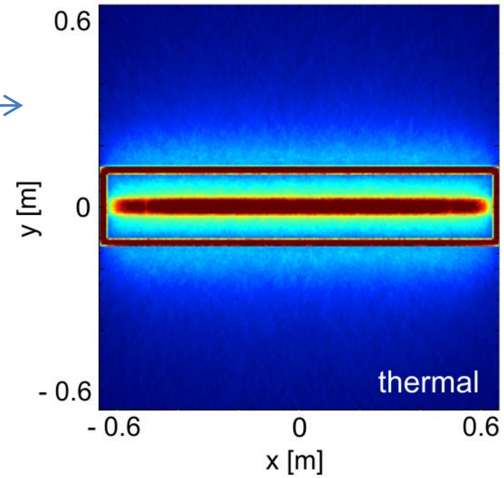
URANOS voxel engine





*M. Köhli et al.
Response Functions for Detectors in Cosmic Ray Neutron Sensing

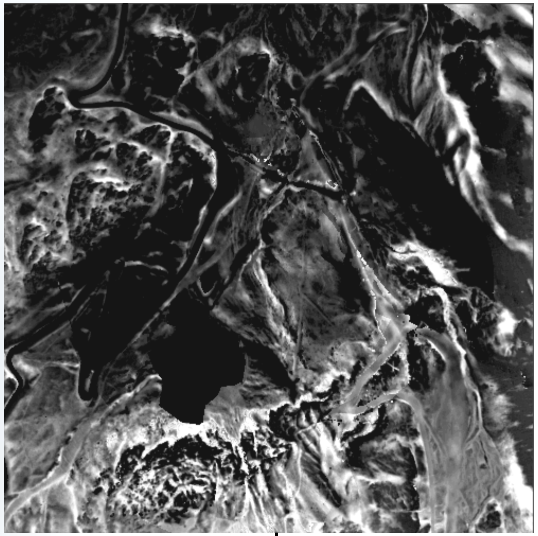


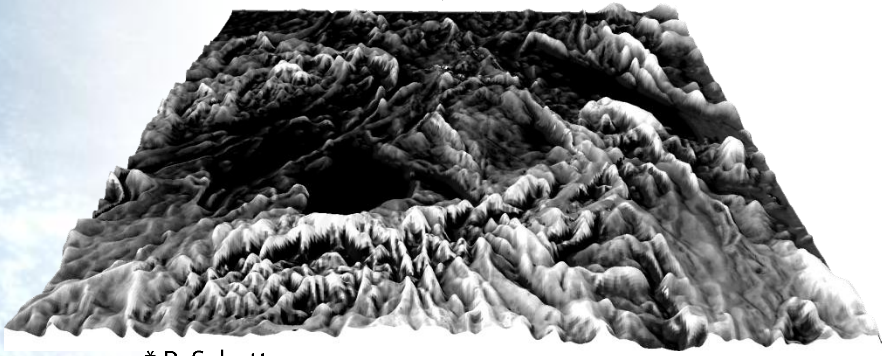


URANOS voxel engine

3D Laser Scanner

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

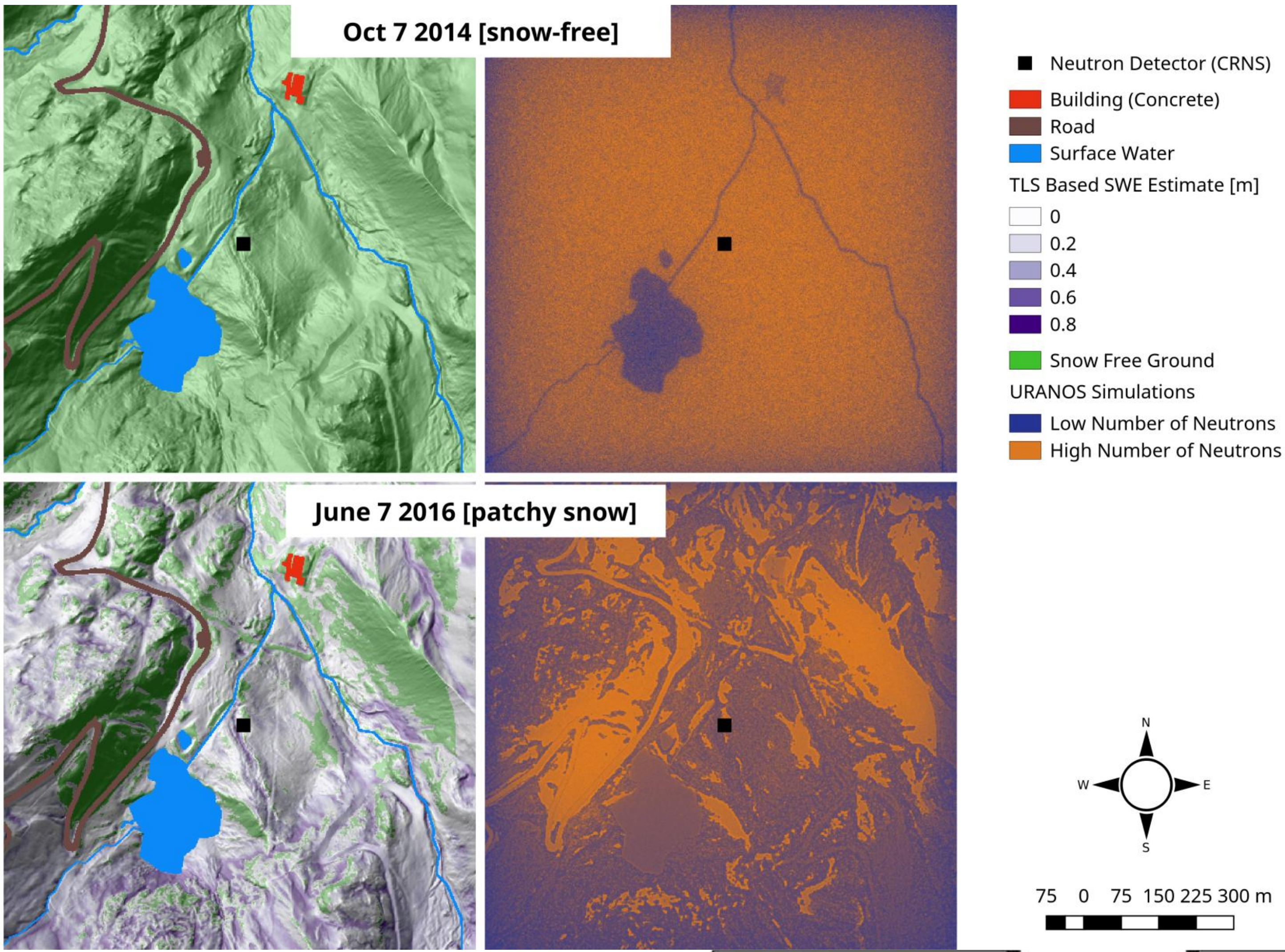




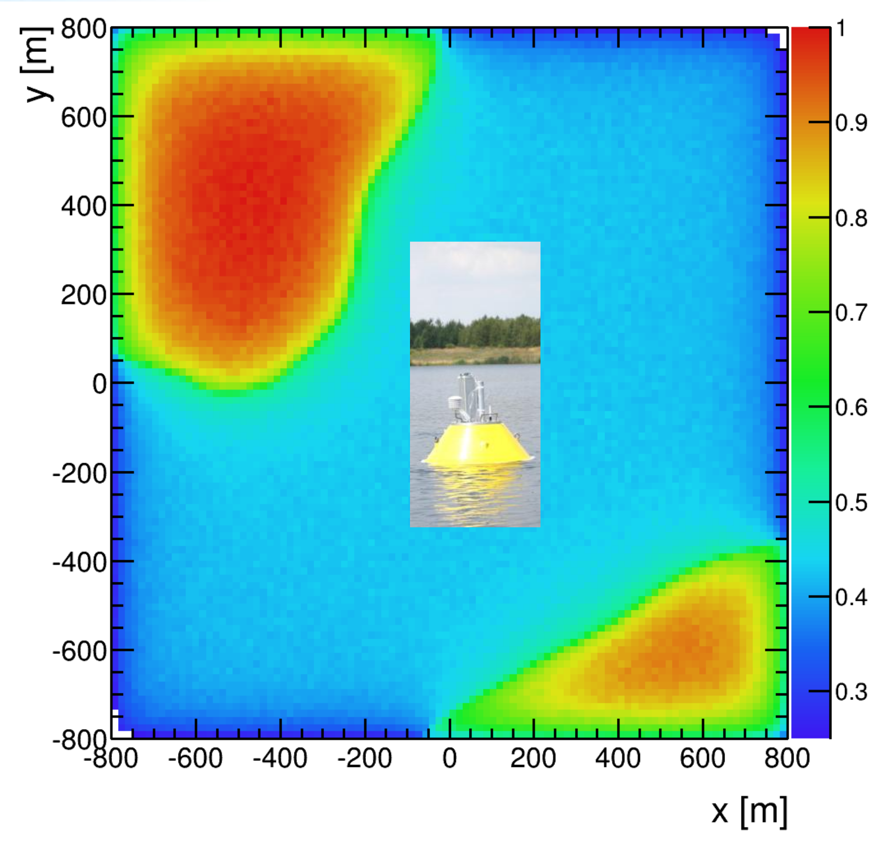
* P. Schattan
Cosmic-ray neutron sensing of snow water equivalent in heterogeneous alpine terrain

URANOS Snow Cover

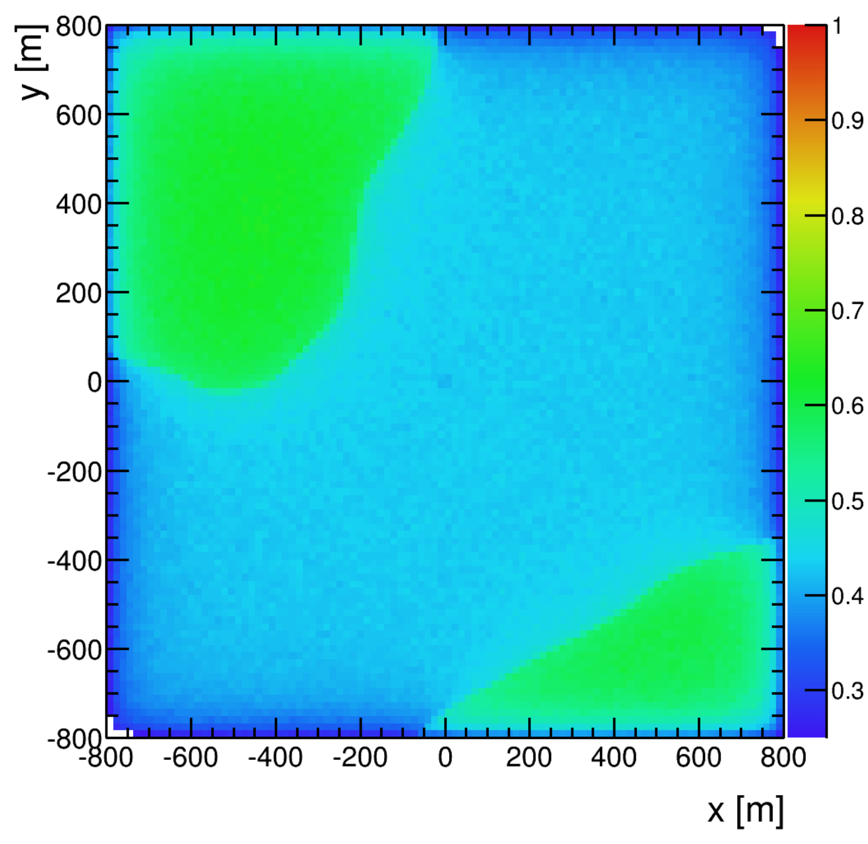
P. Schattan – Kaunertal Glacier at N46° 52.2 E10 °42.6



Buoy on a lake



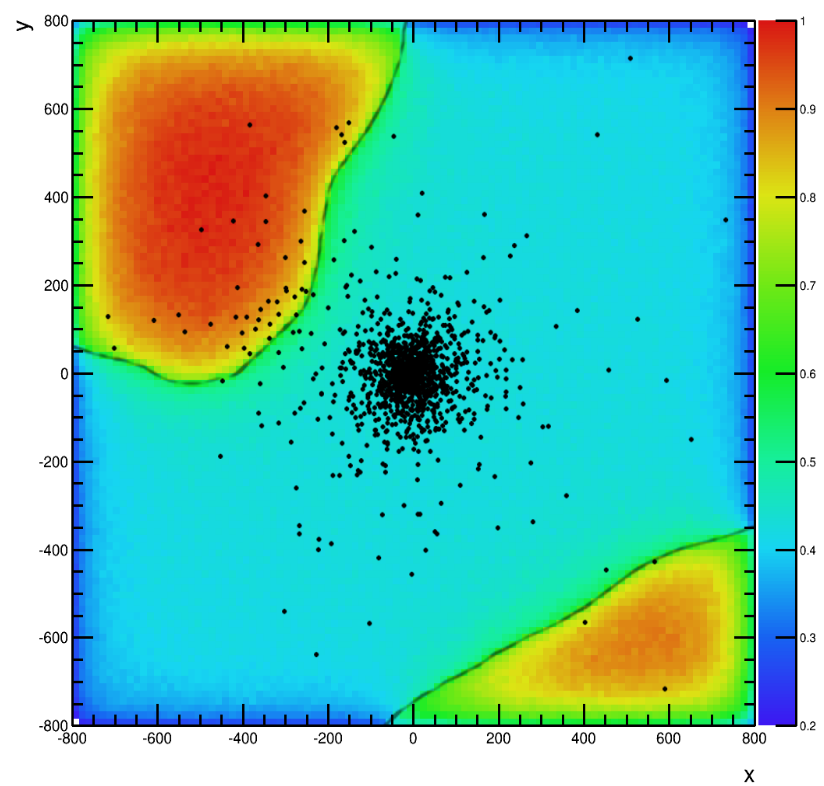
dry coast



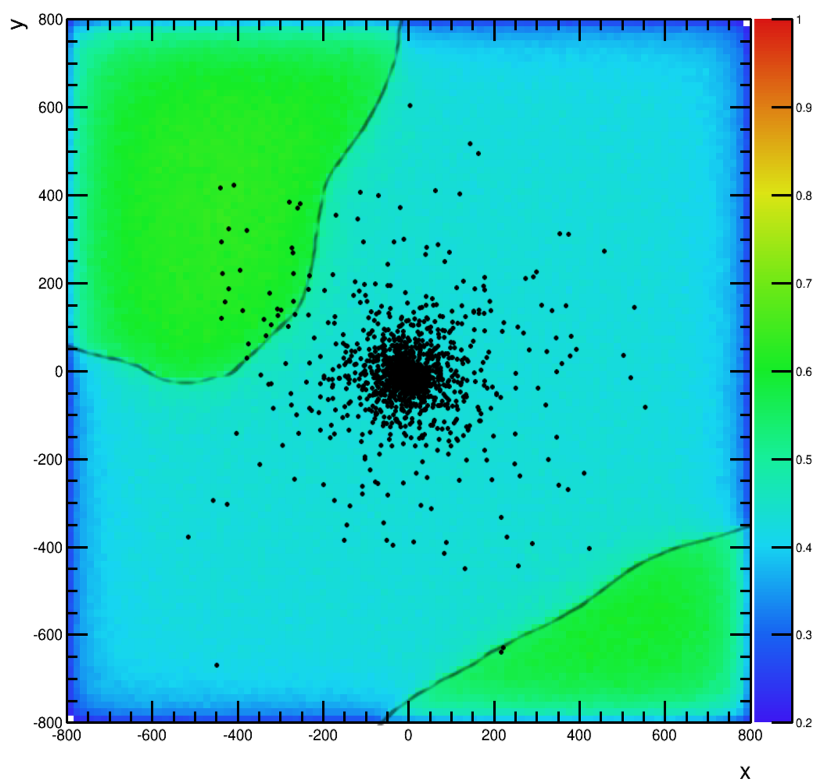
wet coast

*M. Schrön
Correction of near-surface neutron measurements using incoming cosmic-ray fluxes from neutron monitors

Buoy on a lake



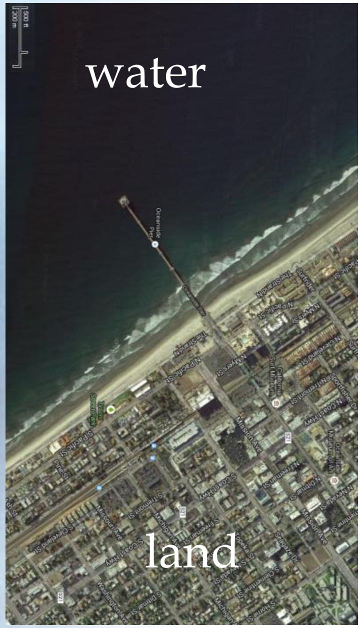
dry coast

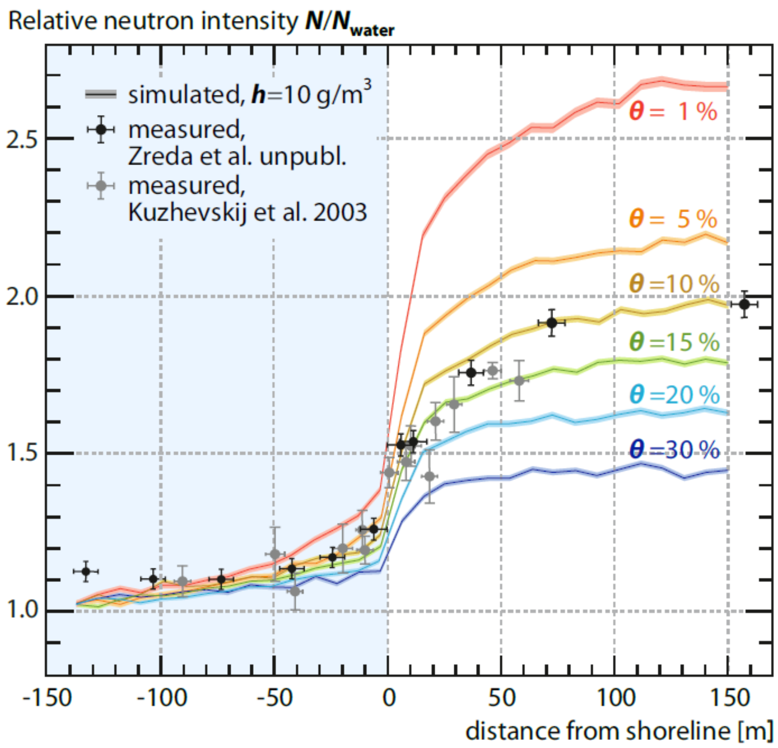


wet coast

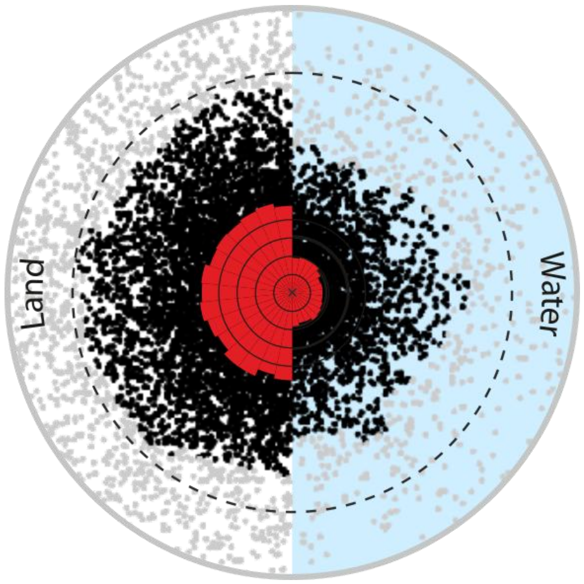
*M. Schrön
Correction of near-surface neutron measurements using incoming cosmic-ray fluxes from neutron monitors

Transects and detector Options





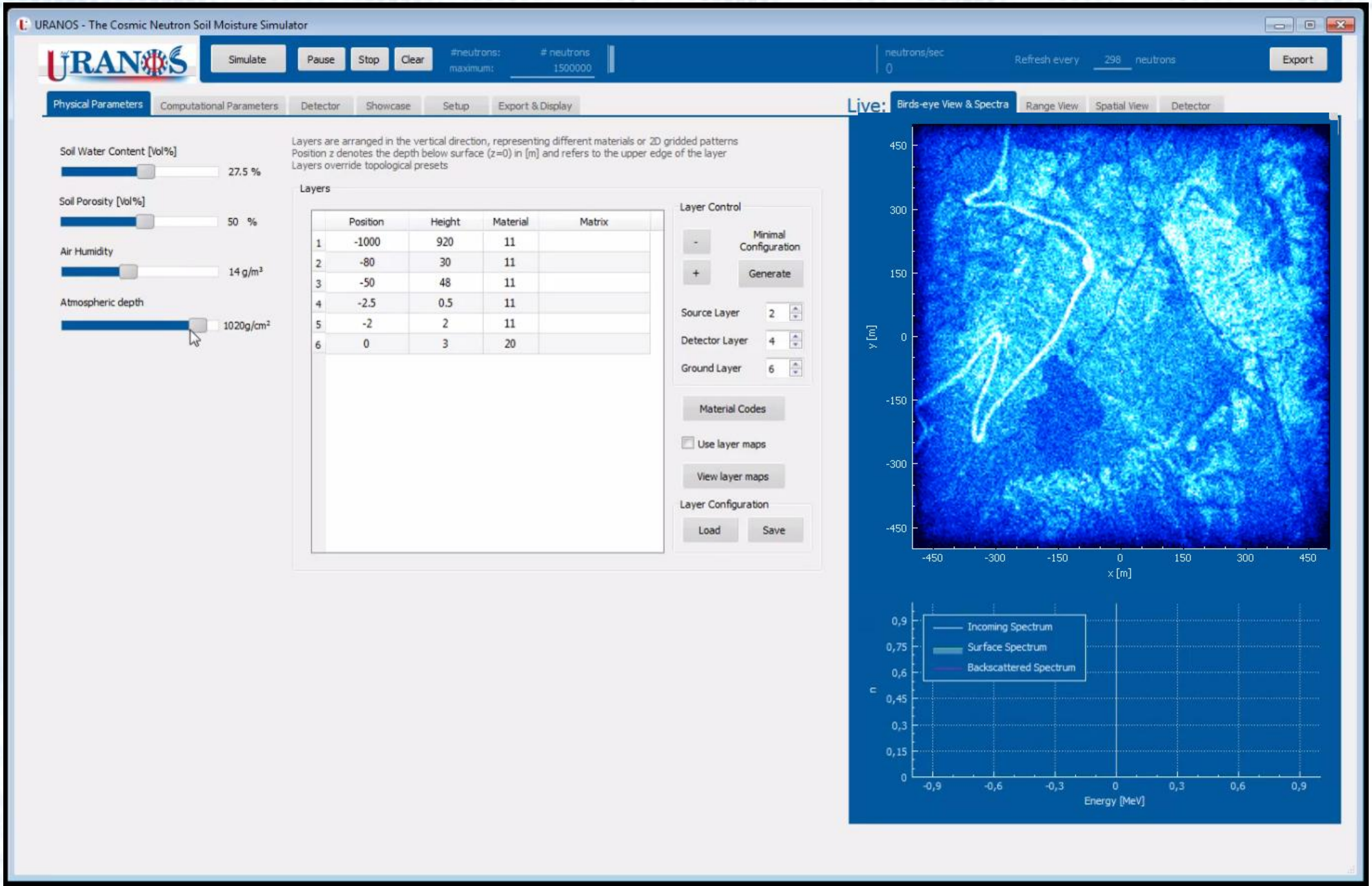
water land



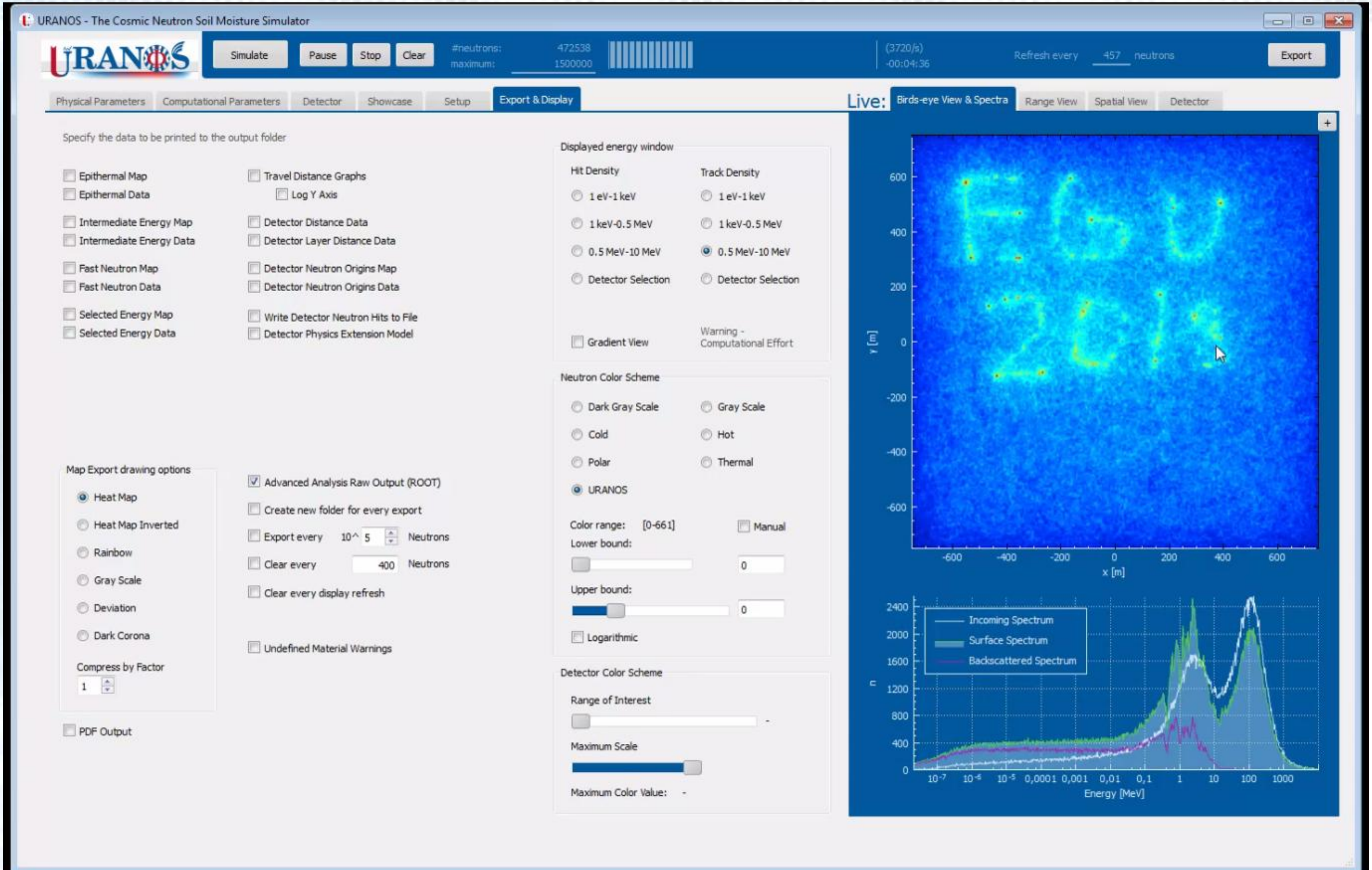
Detected neutron origins (first contact to soil)
Closest 86% of neutron origins for each 12° sector
Neutron intensity for each 12° sector [arb. units]
Footprint R_{86}(5g/m³, 5 %)=210m for homogeneous soil

URANOS Demonstration

Physikalisches Institut Heidelberg University
UFZ Leipzig
Physikalisches Institut University of Bonn


URANOS - The Cosmic Neutron Soil Moisture Simulator
URANOS
Simulate
Pause
Stop
Clear
#neutrons:
maximum:
neutrons
1500000
neutrons/sec
0
Refresh every
298
neutrons
Export
Physical Parameters
Computational Parameters
Detector
Showcase
Setup
Export & Display
Live:
Birds-eye View & Spectra
Range View
Spatial View
Detector
Soil Water Content [Vol%]
27.5 %
Soil Porosity [Vol%]
50 %
Air Humidity
14 g/m³
Atmospheric depth
1020g/cm²
Layers are arranged in the vertical direction, representing different materials or 2D gridded patterns
Position z denotes the depth below surface (z=0) in [m] and refers to the upper edge of the layer
Layers override topological presets
Layers
Position | Height | Material | Matrix
1 | -1000 | 920 | 11
2 | -80 | 30 | 11
3 | -50 | 48 | 11
4 | -2.5 | 0.5 | 11
5 | -2 | 2 | 11
6 | 0 | 3 | 20
Layer Control
Minimal Configuration
Generate
Source Layer
2
Detector Layer
4
Ground Layer
6
Material Codes
Use layer maps
View layer maps
Layer Configuration
Load
Save
y [m]
x [m]
Incoming Spectrum
Surface Spectrum
Backscattered Spectrum
Energy [MeV]

- video removed -


URANOS - The Cosmic Neutron Soil Moisture Simulator
URANOS
Simulate
Pause
Stop
Clear
#neutrons: 472538
maximum: 1500000
(3720/s)
-00:04:36
Refresh every 457 neutrons
Export
Physical Parameters
Computational Parameters
Detector
Showcase
Setup
Export & Display
Live:
Birds-eye View & Spectra
Range View
Spatial View
Detector
Specify the data to be printed to the output folder
Epithermal Map
Epithermal Data
Intermediate Energy Map
Intermediate Energy Data
Fast Neutron Map
Fast Neutron Data
Selected Energy Map
Selected Energy Data
Travel Distance Graphs
Log Y Axis
Detector Distance Data
Detector Layer Distance Data
Detector Neutron Origins Map
Detector Neutron Origins Data
Write Detector Neutron Hits to File
Detector Physics Extension Model
Map Export drawing options
Heat Map
Heat Map Inverted
Rainbow
Gray Scale
Deviation
Dark Corona
Compress by Factor
PDF Output
Advanced Analysis Raw Output (ROOT)
Create new folder for every export
Export every 10^ 5 Neutrons
Clear every 400 Neutrons
Clear every display refresh
Undefined Material Warnings
Displayed energy window
Hit Density
Track Density
1 eV-1 keV
1 keV-0.5 MeV
0.5 MeV-10 MeV
Detector Selection
Gradient View
Warning - Computational Effort
Neutron Color Scheme
Dark Gray Scale
Gray Scale
Cold
Hot
Polar
Thermal
URANOS
Color range: [0-661]
Manual
Lower bound:
Upper bound:
Logarithmic
Detector Color Scheme
Range of Interest
Maximum Scale
Maximum Color Value: -
y [m]
x [m]
Incoming Spectrum
Surface Spectrum
Backscattered Spectrum
n
Energy [MeV]

URANOS

- Novel neutron Monte Carlo tool for Environmental Physics

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  - Ready-to-use User Interface
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  - Fast Calculation using an analytical spectrum above the ground

- URANOS Community Version: Now available!
  (and in development)

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to be continued