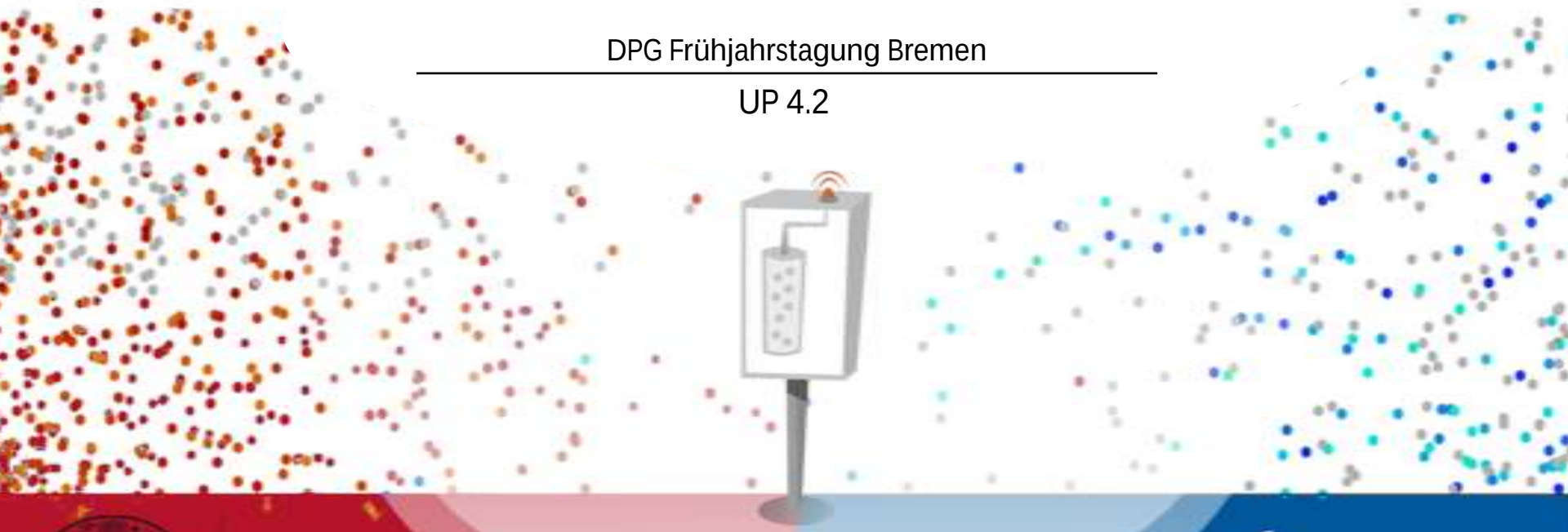
Soil Moisture measurement
at the
hectometer scale
with
cosmic-ray neutrons

DPG Frühjahrstagung Bremen

UP 4.2



UNIVERSITÄT HEIDELBERG ZUKUNFT SEIT 1386

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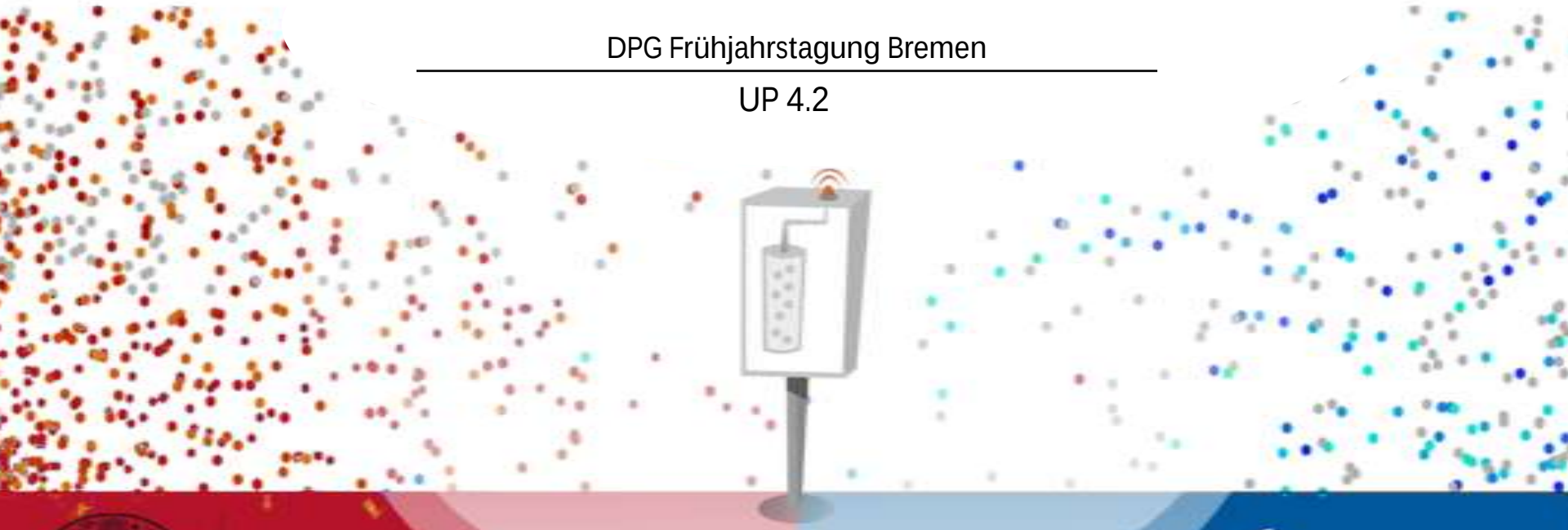
UP 4.3

Soil Moisture measurement at the hectometer scale with cosmic-ray neutrons

DPG Frühjahrstagung Bremen

UP 4.2



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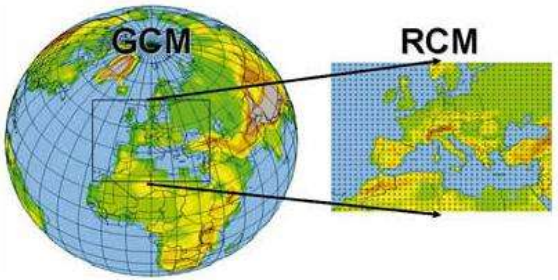
[1]

[1] http://www.iso.org/iso/2012_iso-in-action_water_vignette.jpg

[3]

[2]

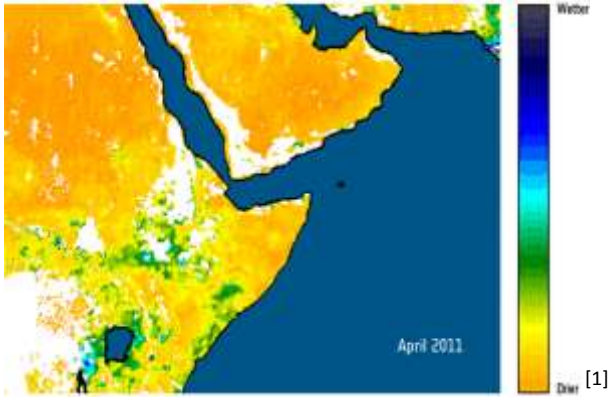


[1]

[1] http://www.wmo.int/pages/themes/climate/images/figures/ClimateModelnesting.jpg
[2] http://www.livetradingnews.com/wp-content/uploads/2014/04/precisionag.jpg
[3] http://upload.wikimedia.org/wikipedia/commons/3/37/Nam_steppe.jpg

The Measurement Gap

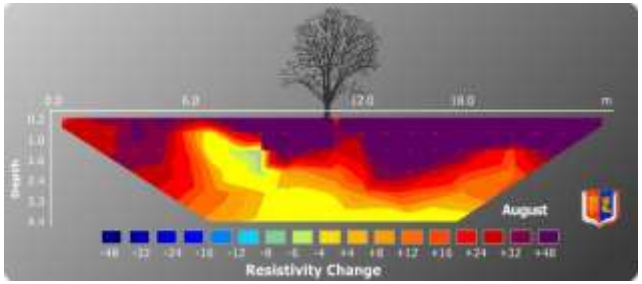
> 1 km



[1]

via
satellite remote sensing
(optical, microwave)

< 10 m



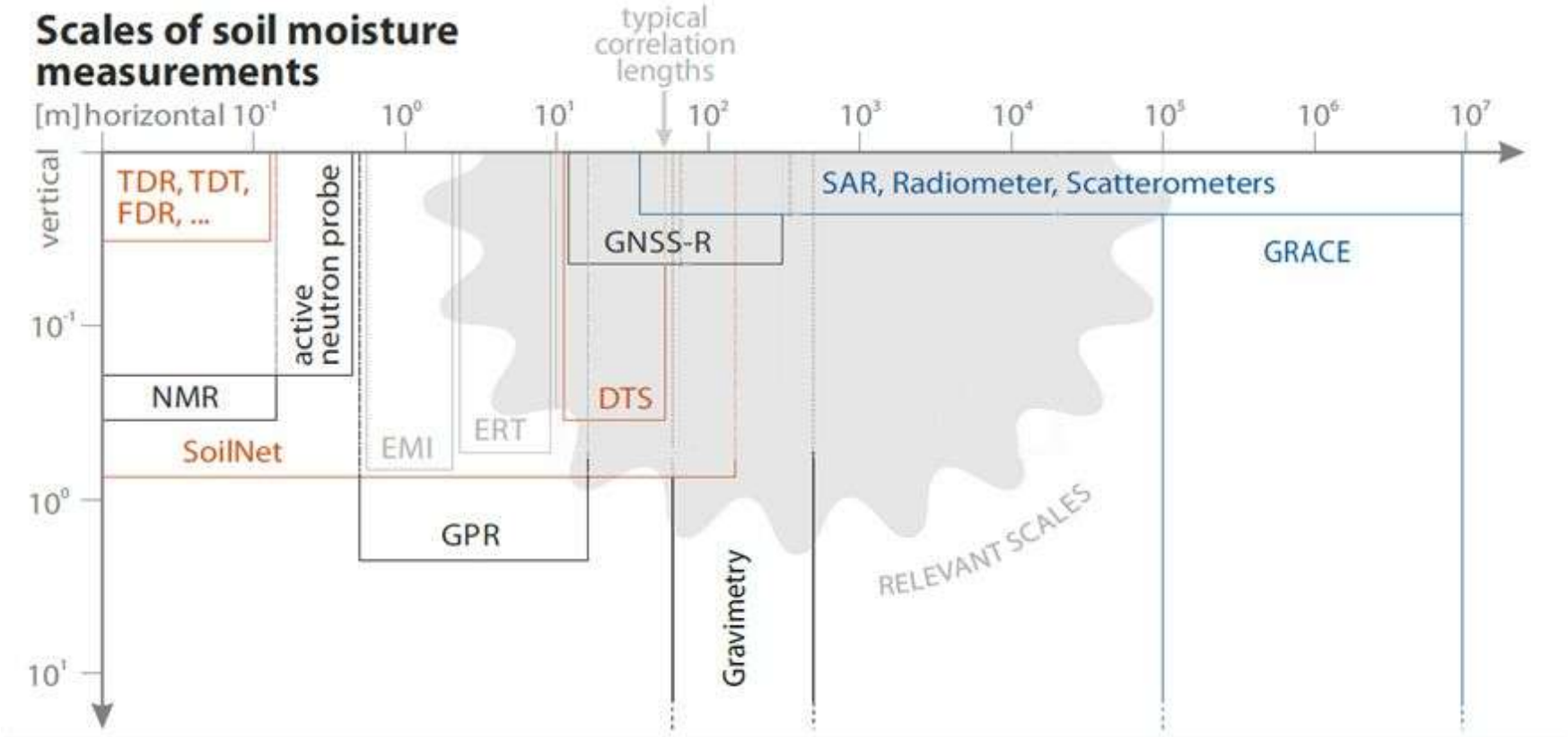
[2]

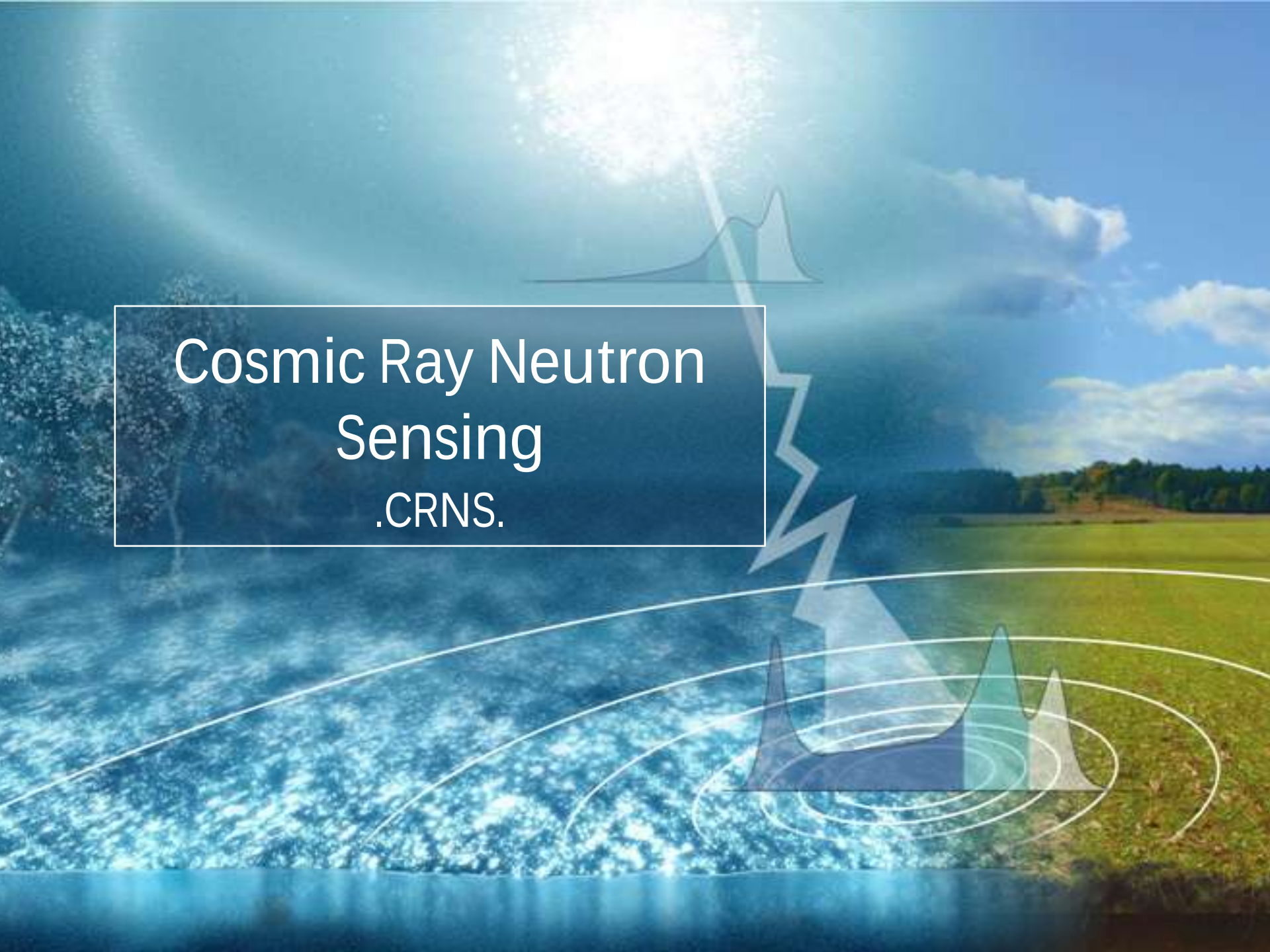
via
local techniques
(electrical resistivity, capacitance, etc)
(even neutrons…)

[1] ESA SMOS (http://www.esa.int/Our_Activities/Observing_the_Earth/SMOS/Horn_of_Africa_drought_seen_from_space)
[2] The Clay Research Group (http://www.theclayresearchgroup.org/images/ert.jpg)

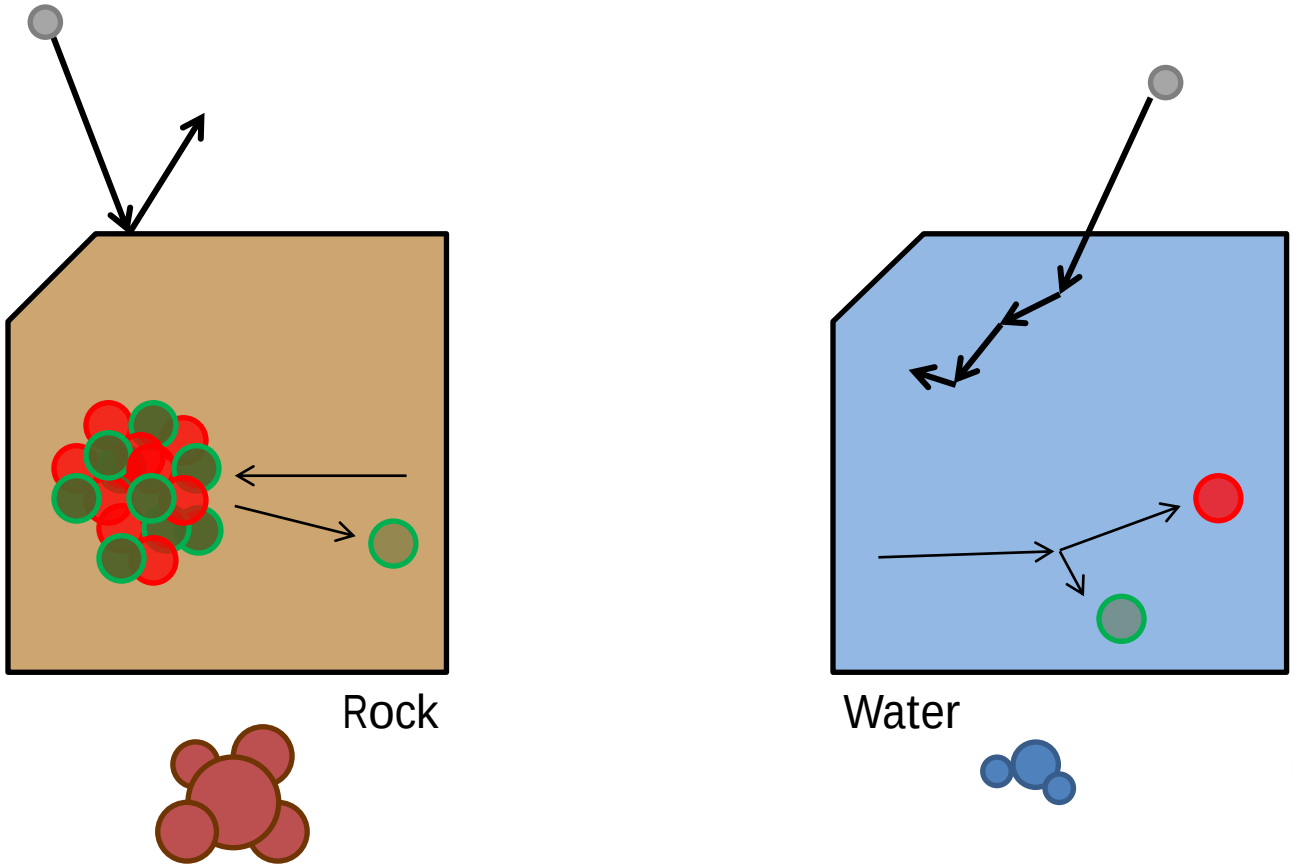
The Measurement Gap

1




Cosmic Ray Neutron Sensing
.CRNS.

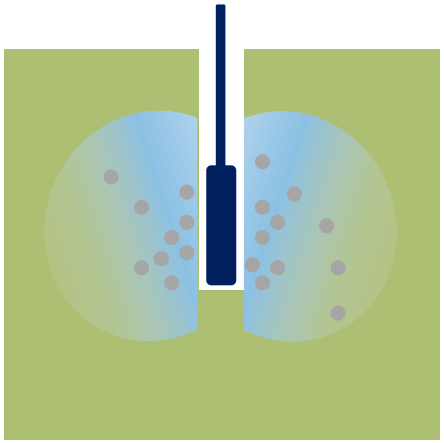
Neutron Response to Water



Neutron Response to Water

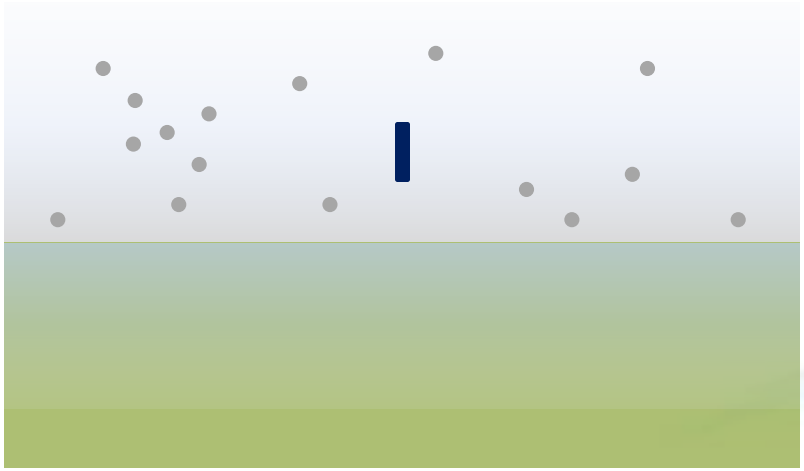
active

small distinct domain
thermalization



passive

large area, diffusive
reflection



Neutron Response to Water

passive

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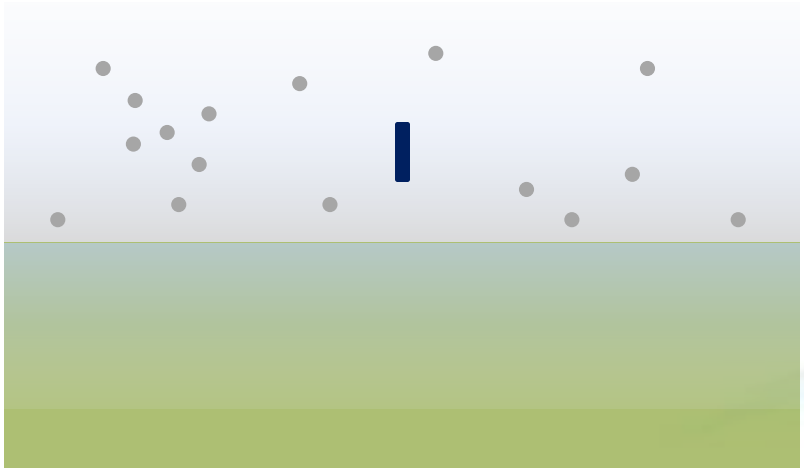
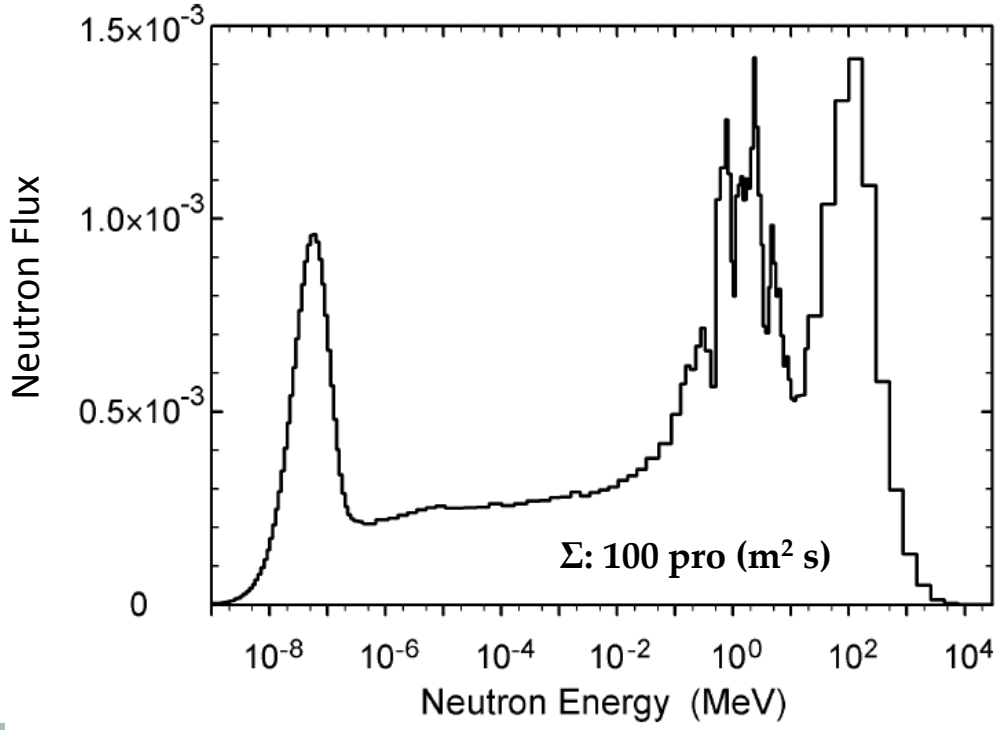


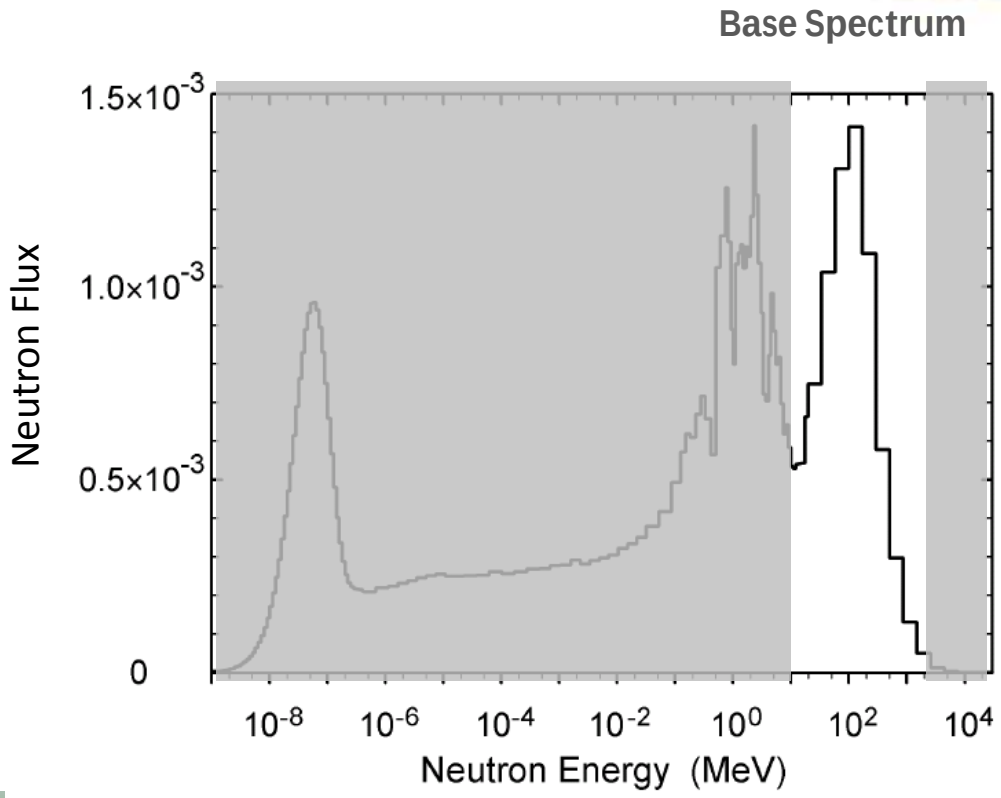
The Cosmic Neutron Spectrum

soil

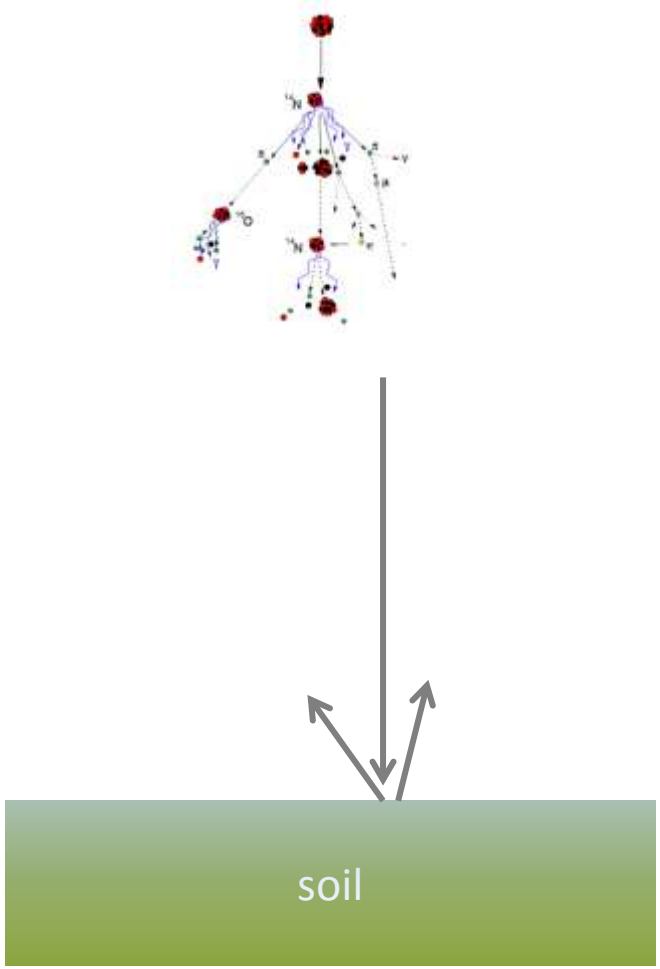


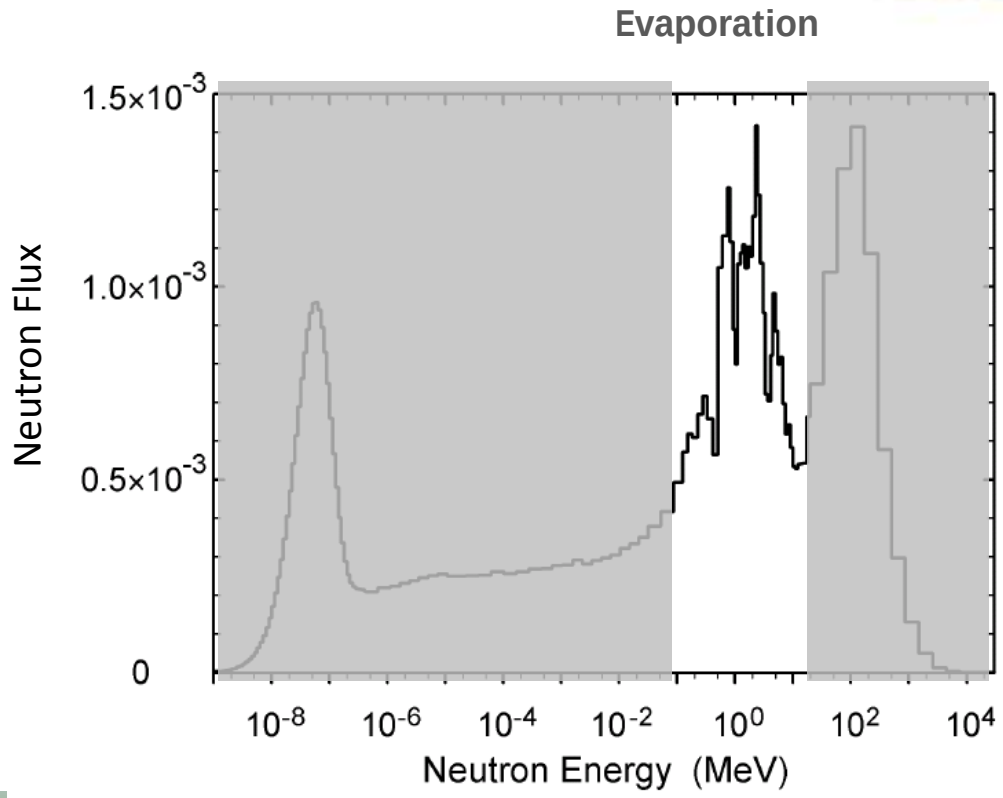
The Cosmic Neutron Spectrum

soil

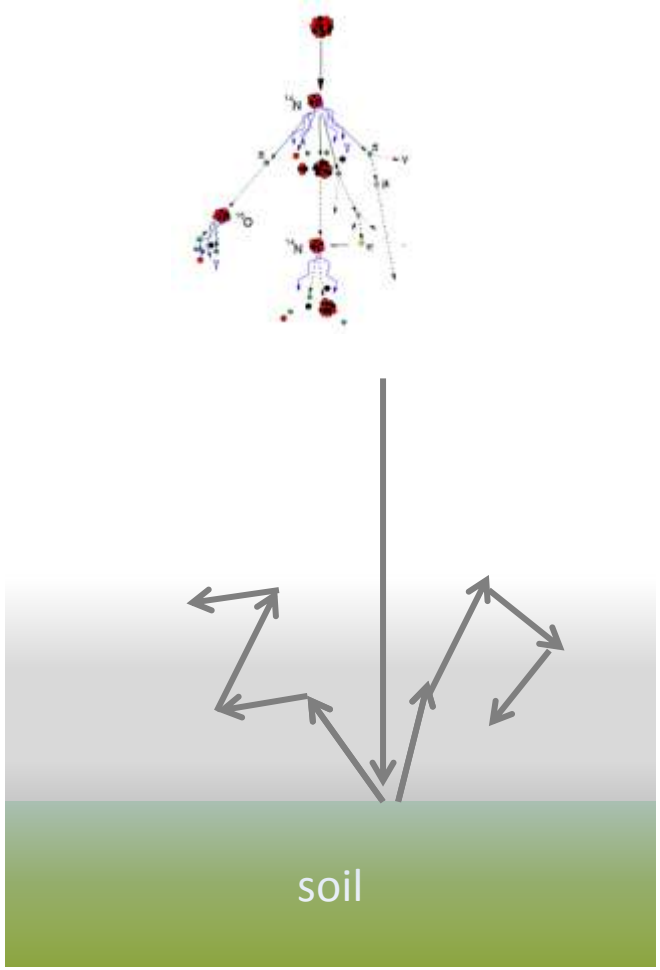


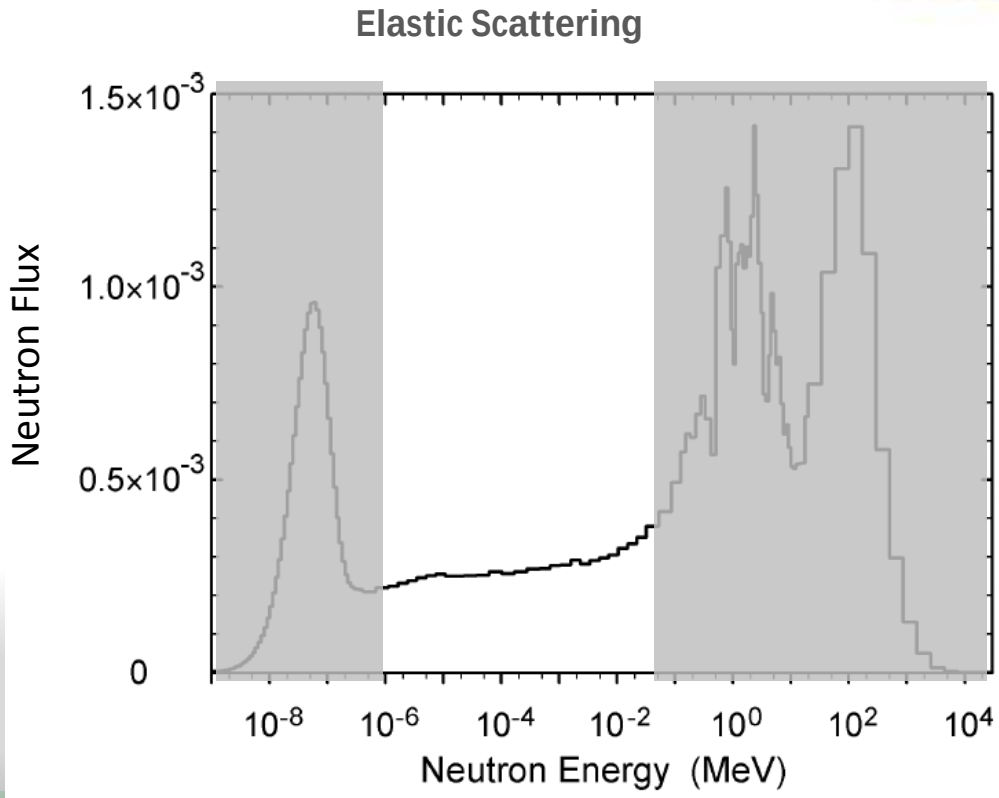
The Cosmic Neutron Spectrum



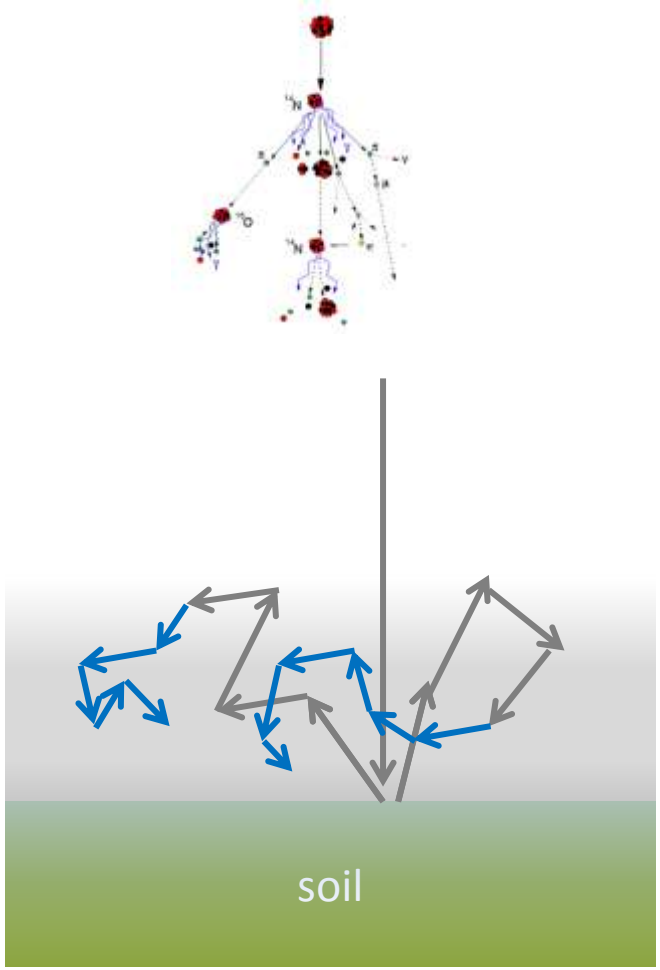


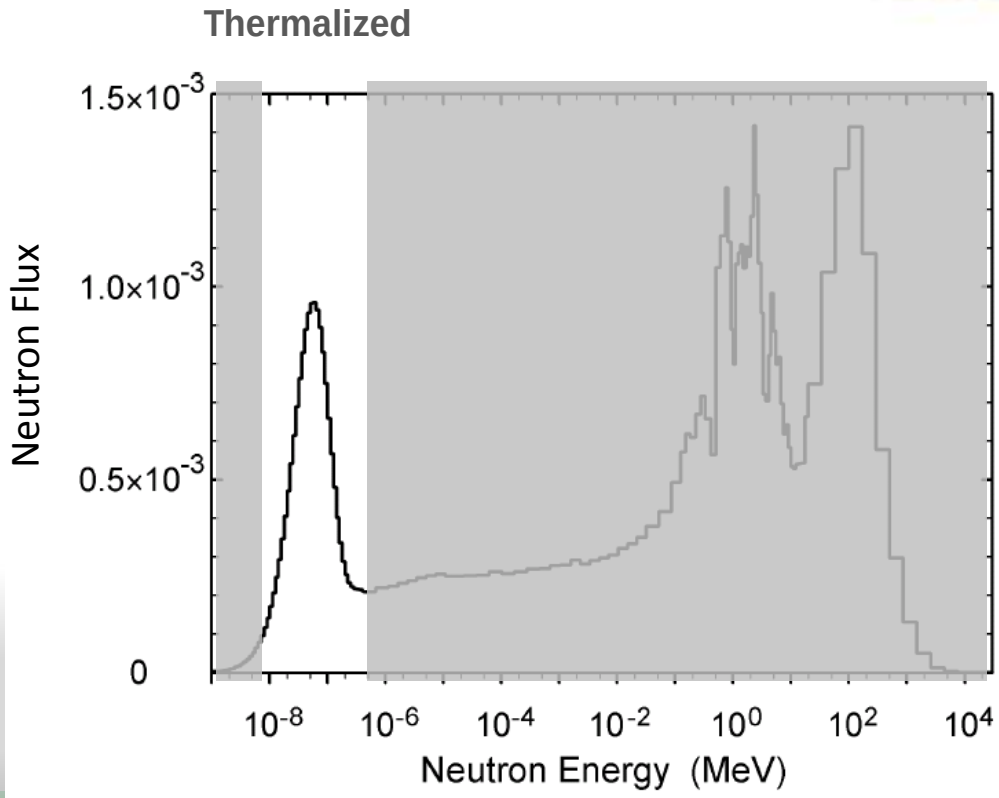
The Cosmic Neutron Spectrum



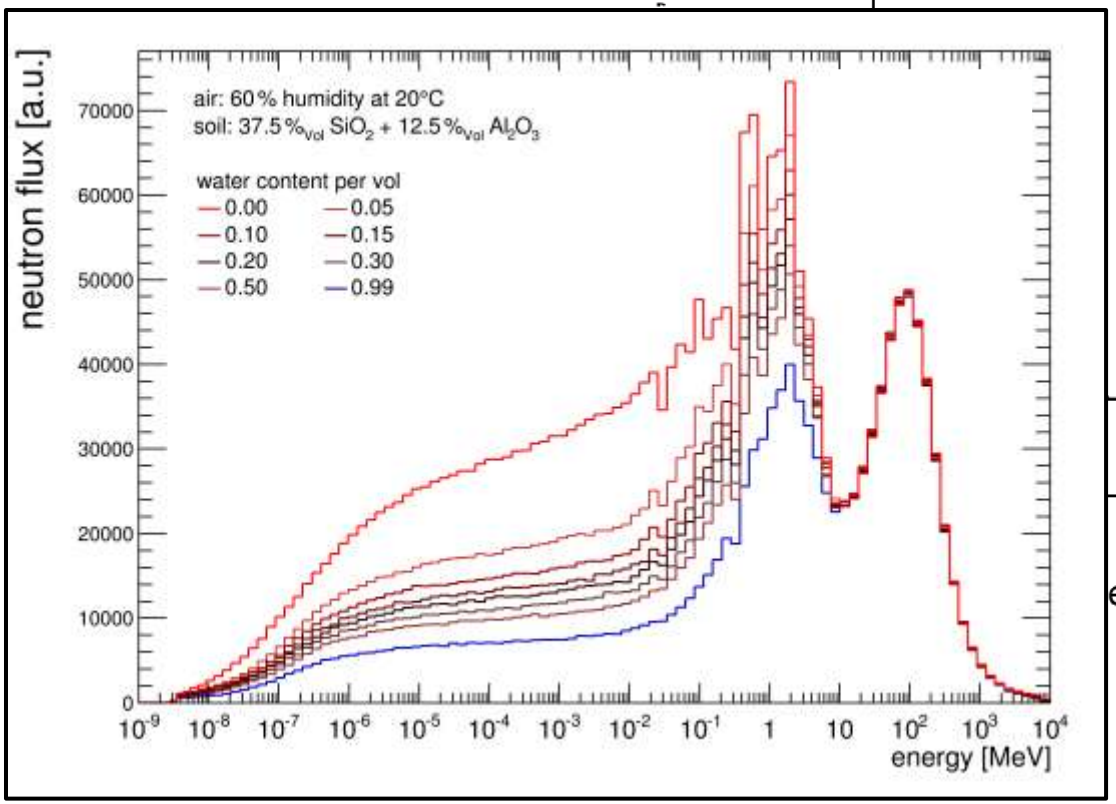


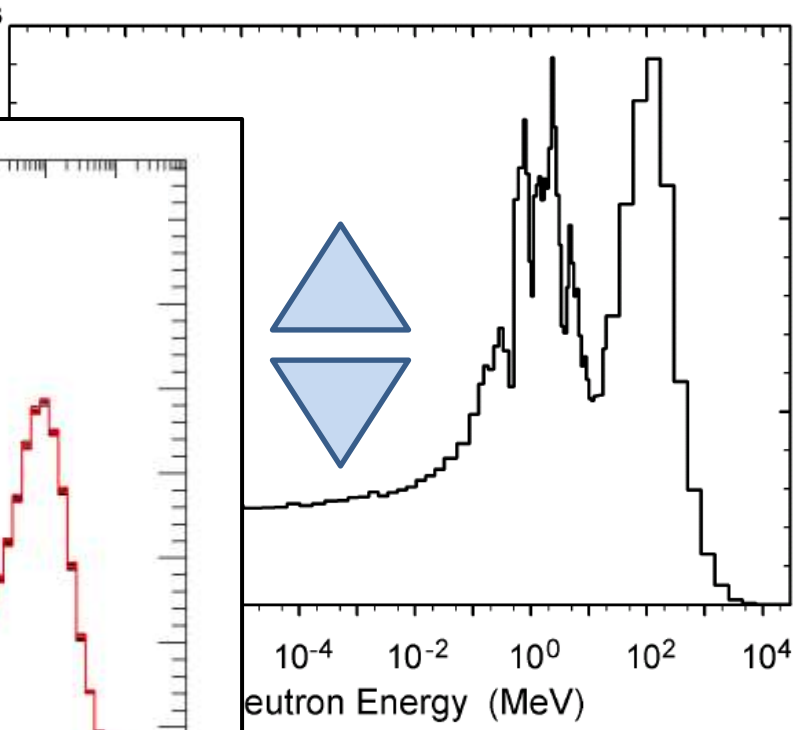
The Cosmic Neutron Spectrum



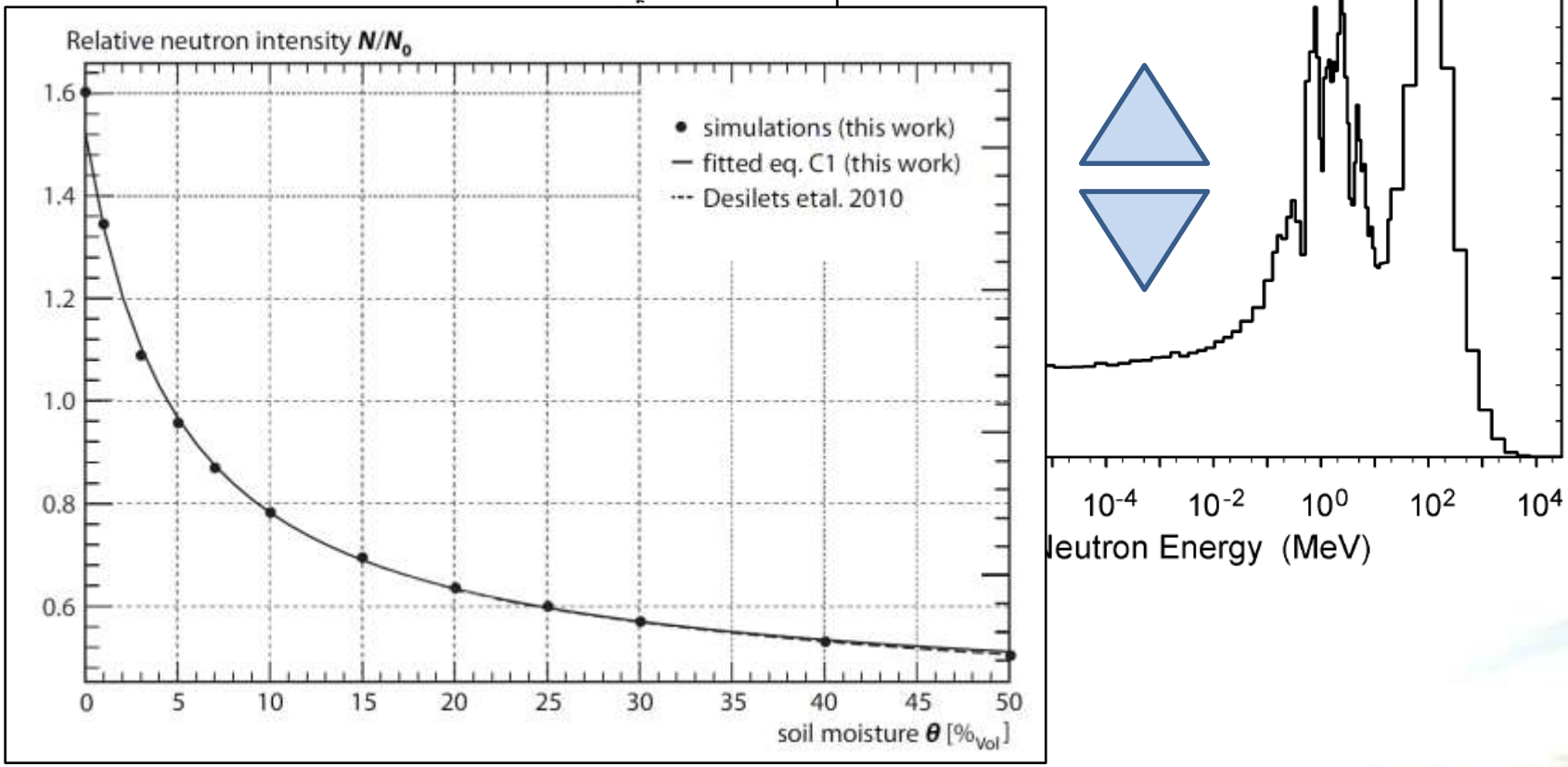


The Cosmic Neutron Spectrum





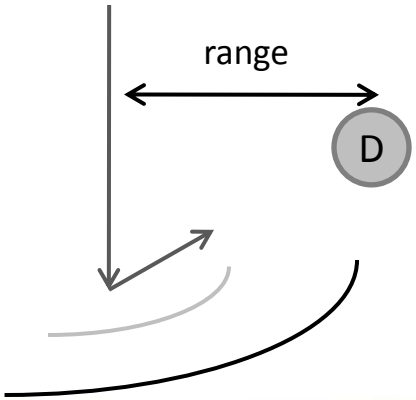
The Cosmic Neutron Spectrum



The Footprint

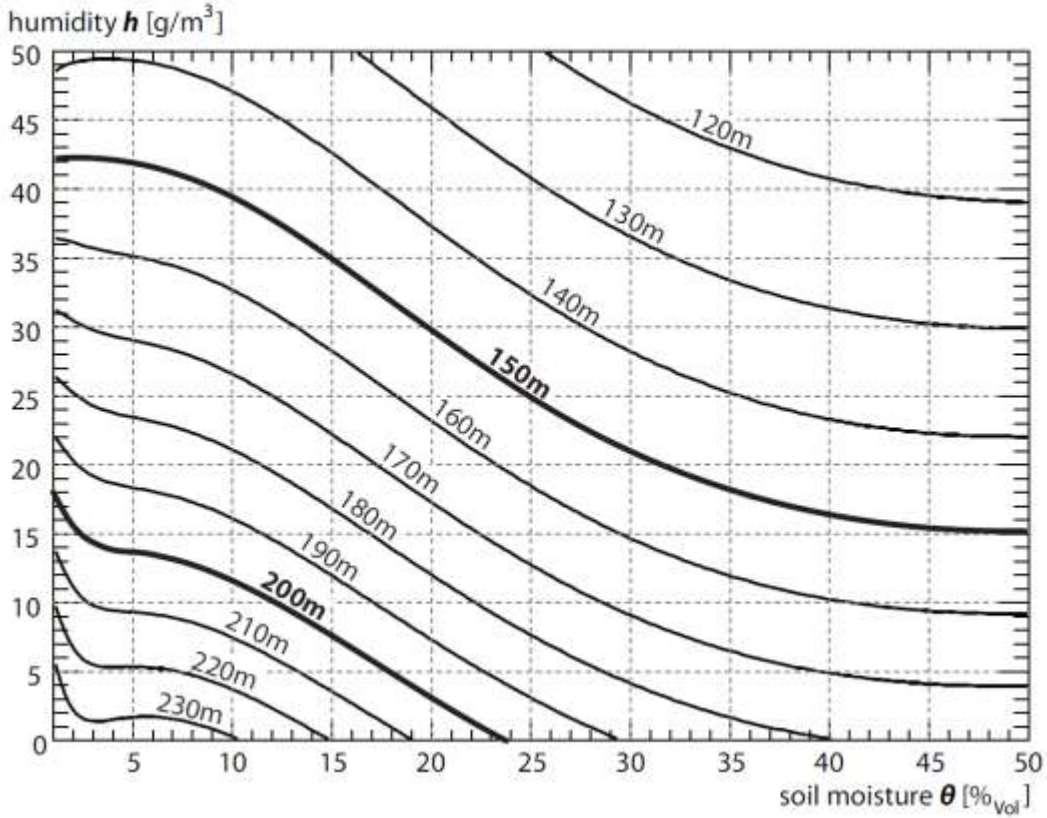
How far do reflected neutrons travel?

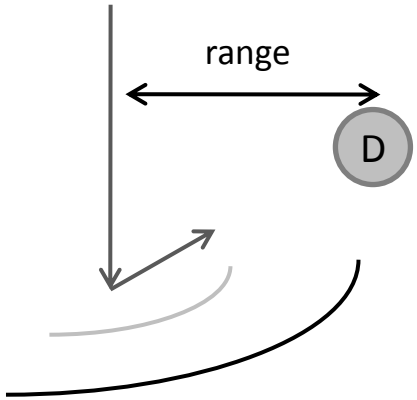
- Movie removed -



The Footprint in 2015

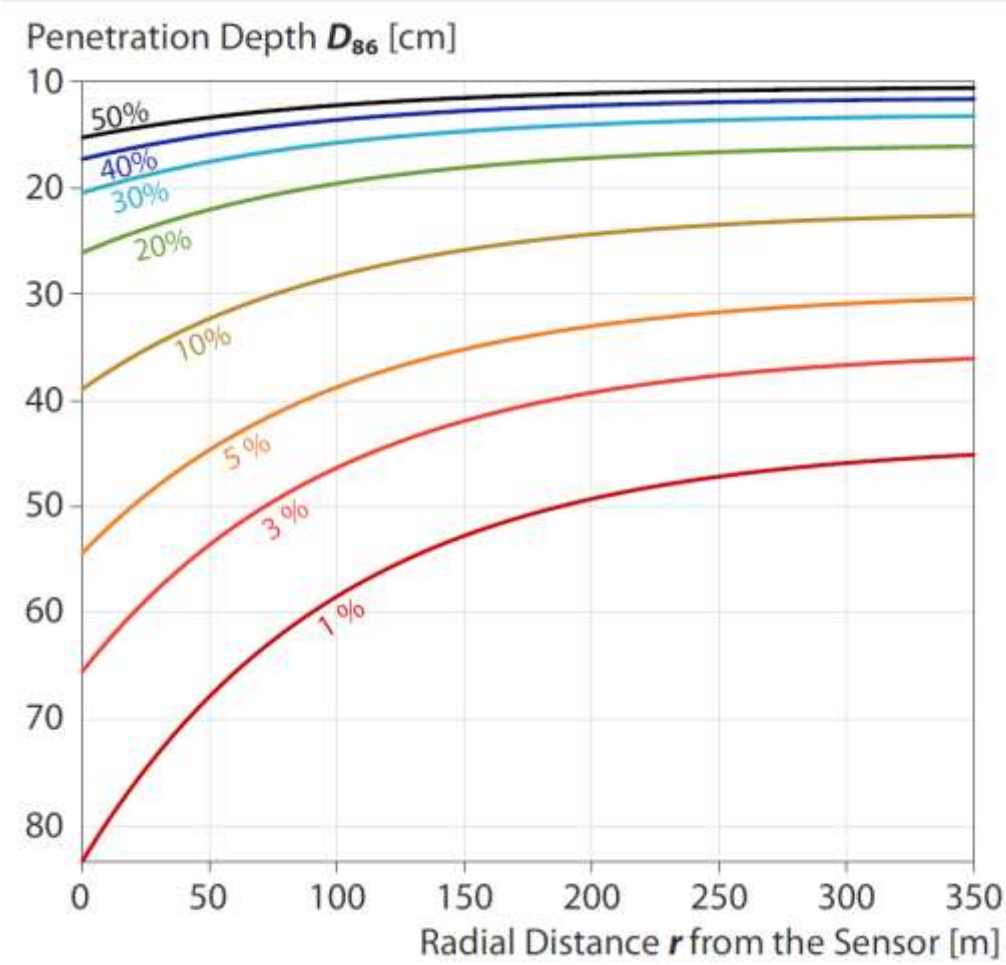
How far do reflected neutrons travel?

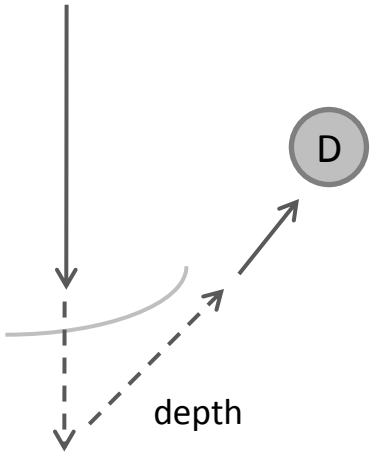




Köhli et Schrön et al.
Footprint characteristics revised for field-scale soil moisture monitoring with cosmic-ray neutrons
Water Resources Research, **51**, 5772-5790

Penetration Depth





Precipitation Events

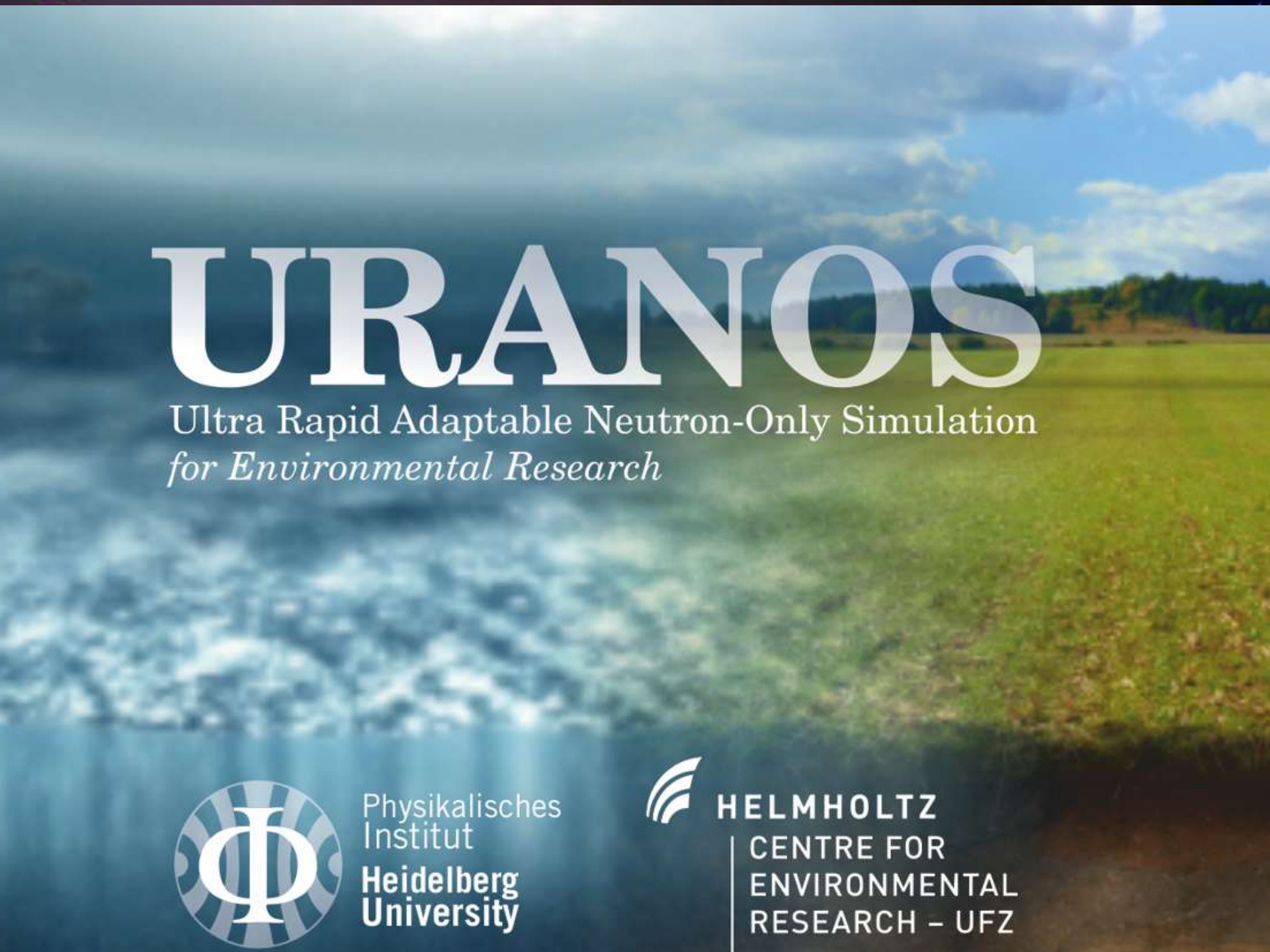
raw data from T. Franz, Santa Rita Site, refined by URANOS

The Equipment

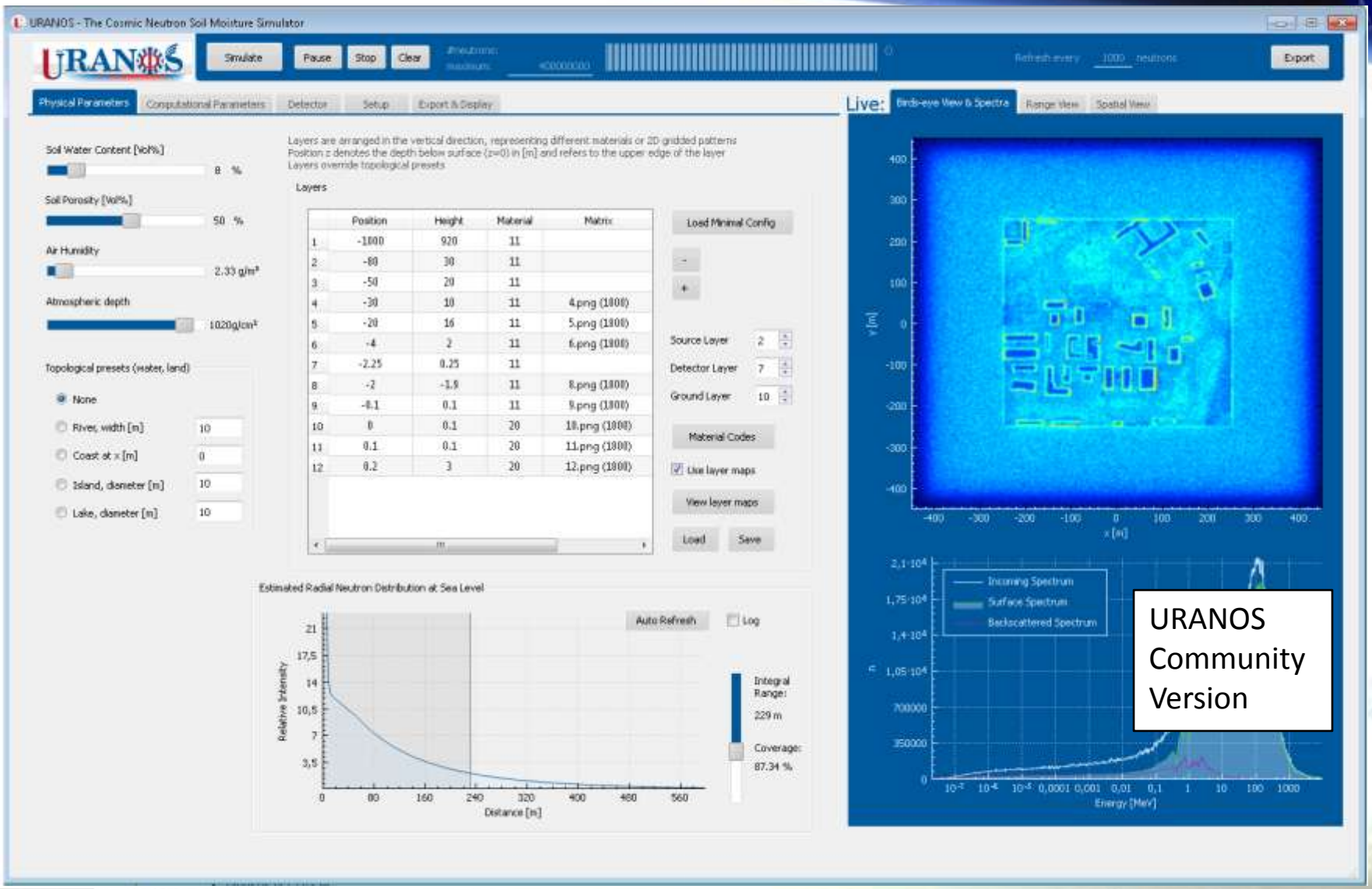
The CRNS Sensor

The CRNS Sensor

M. Zreda et al. (CRNS Website)


URANOS
Ultra Rapid Adaptable Neutron-Only Simulation
for Environmental Research
Physikalisches Institut
Heidelberg University
HELMHOLTZ
CENTRE FOR
ENVIRONMENTAL
RESEARCH – UFZ

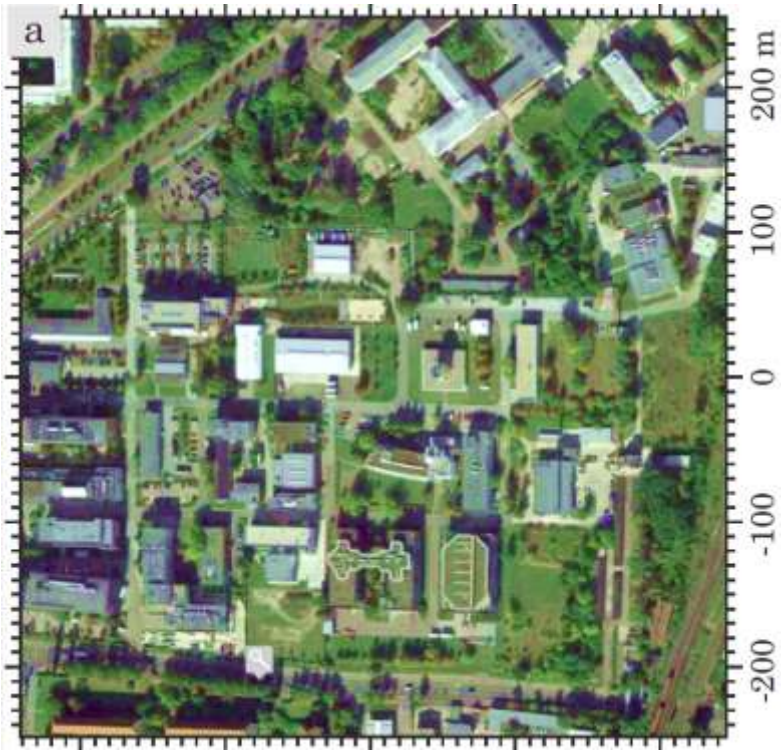
URANOS



URANOS Community Version

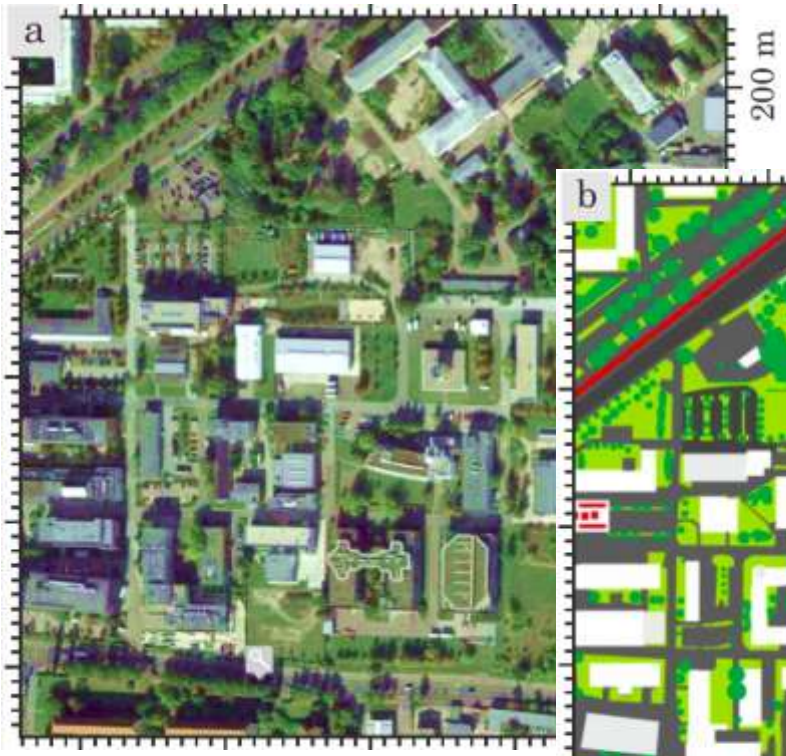
Inhomogeneous Terrain

9

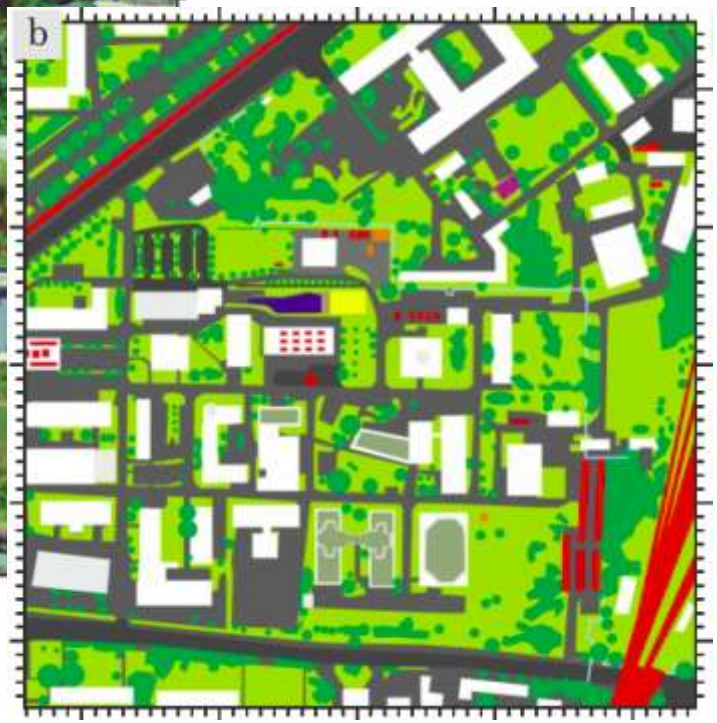


topography

Inhomogeneous Terrain

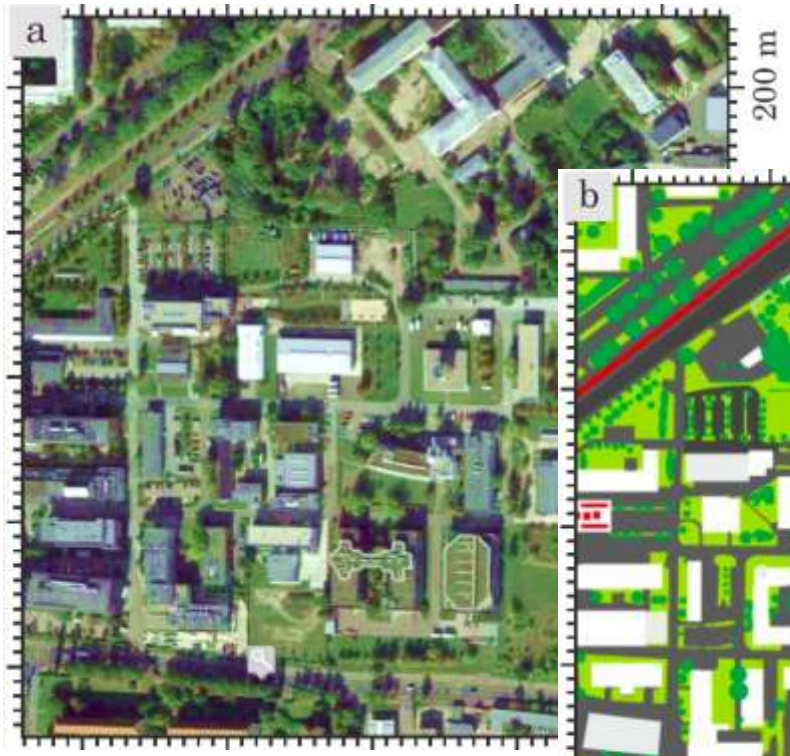


topography

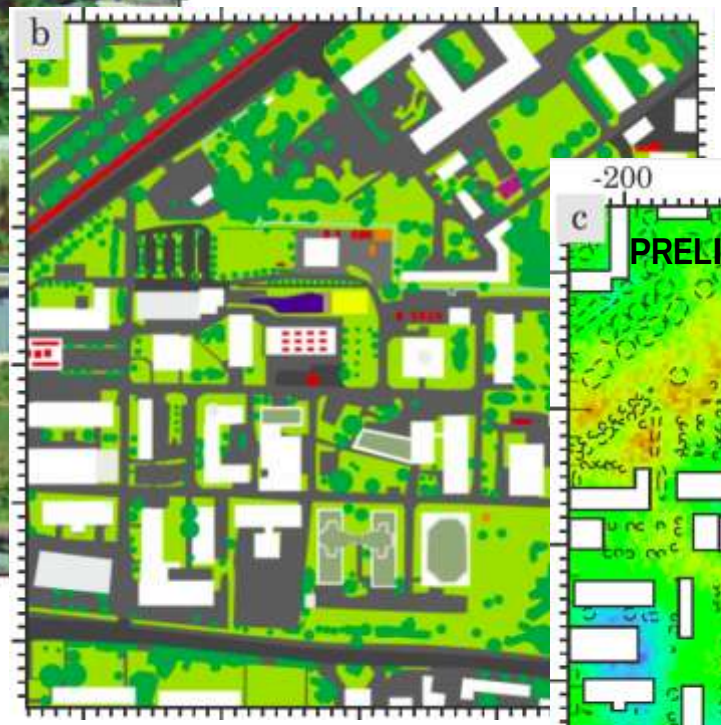


model

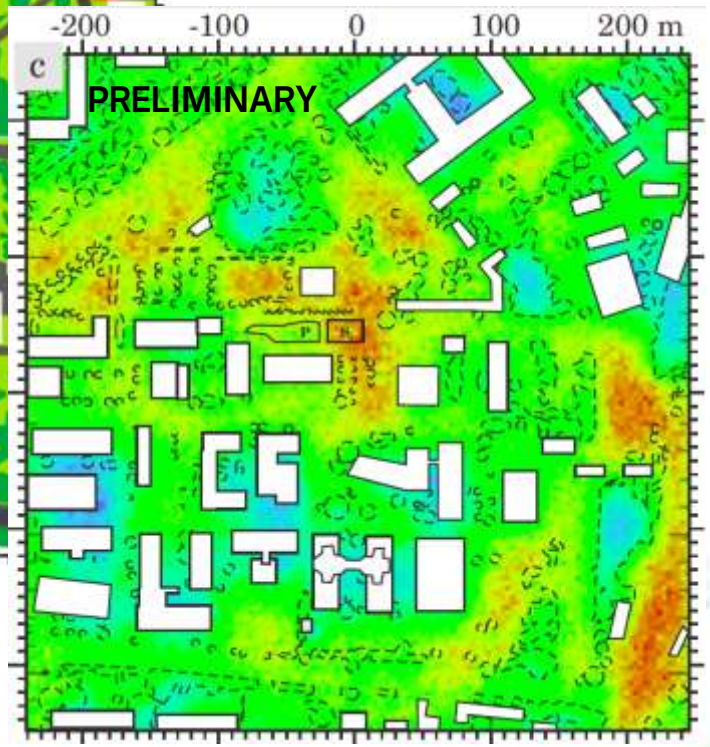
Inhomogeneous Terrain



topography



model

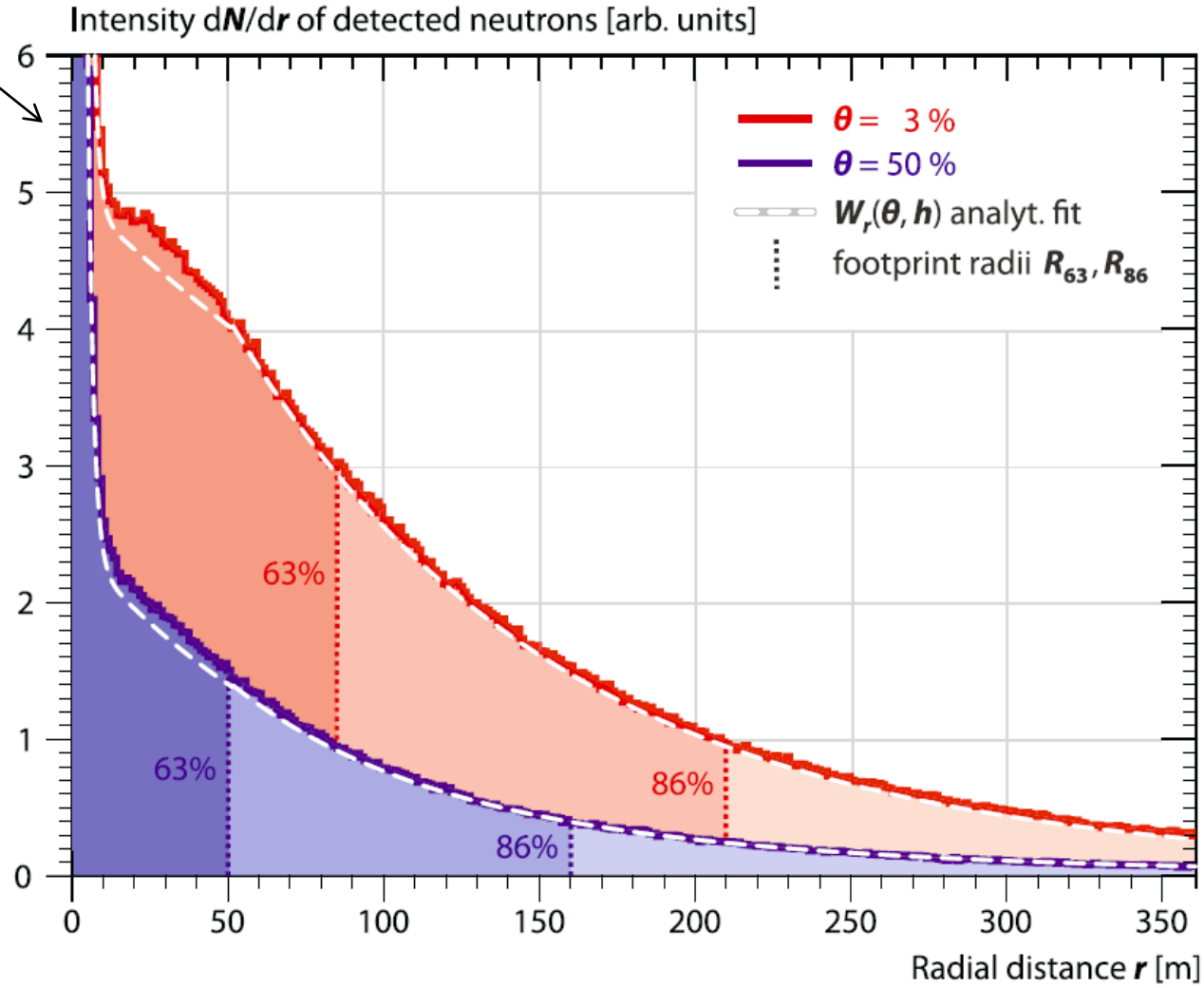


simulation

Local Effects

Local Effects

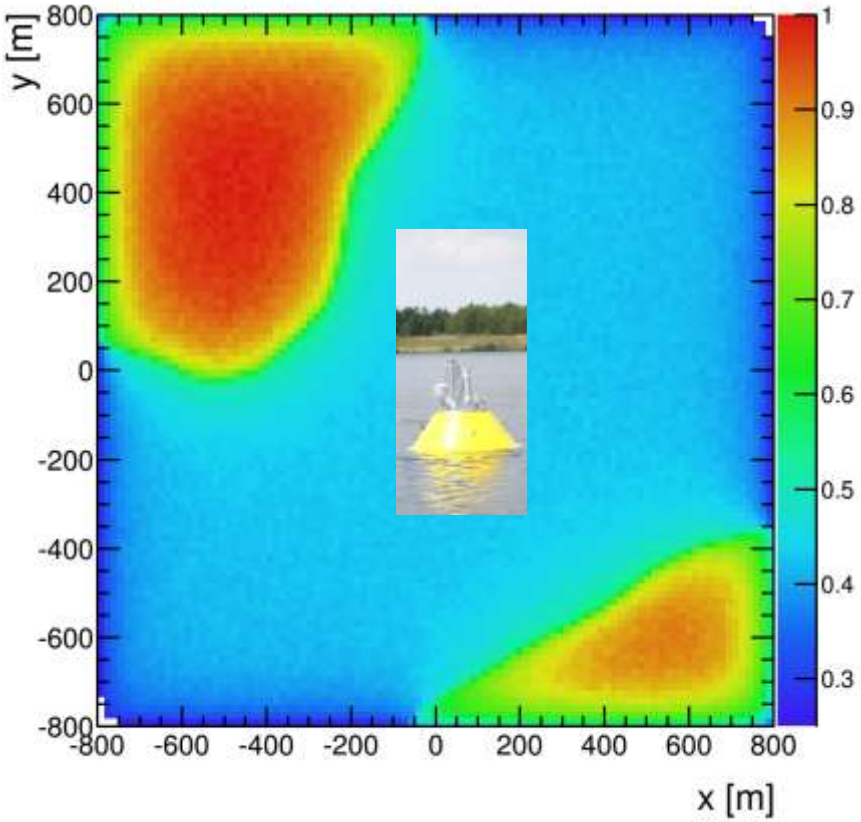
near field peak



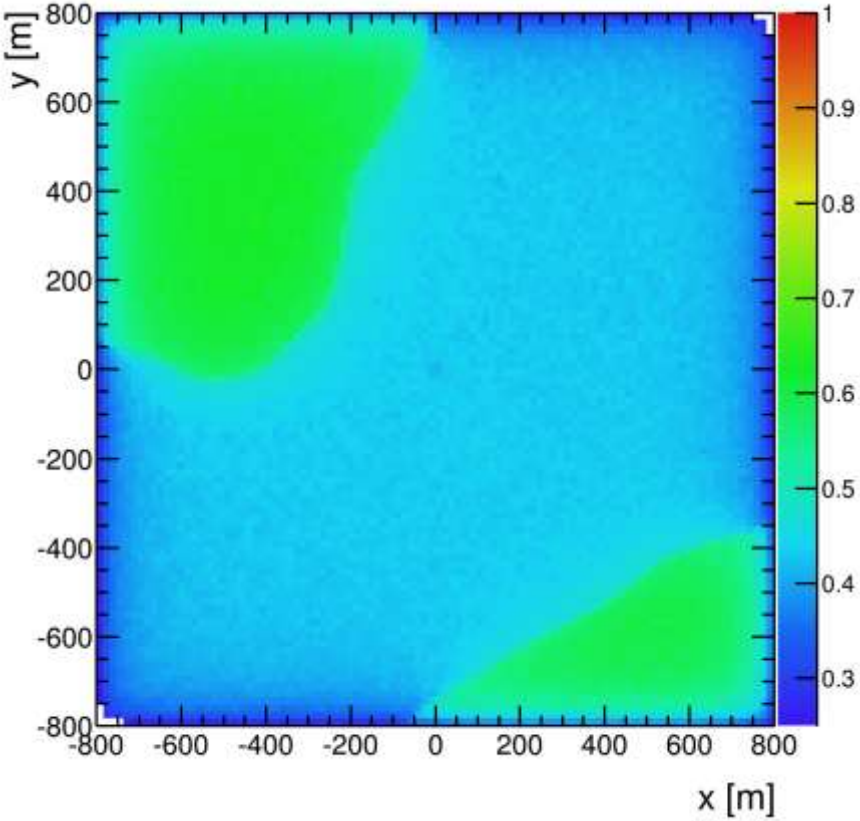
long tail

Buoy on a lake

Buoy on a lake

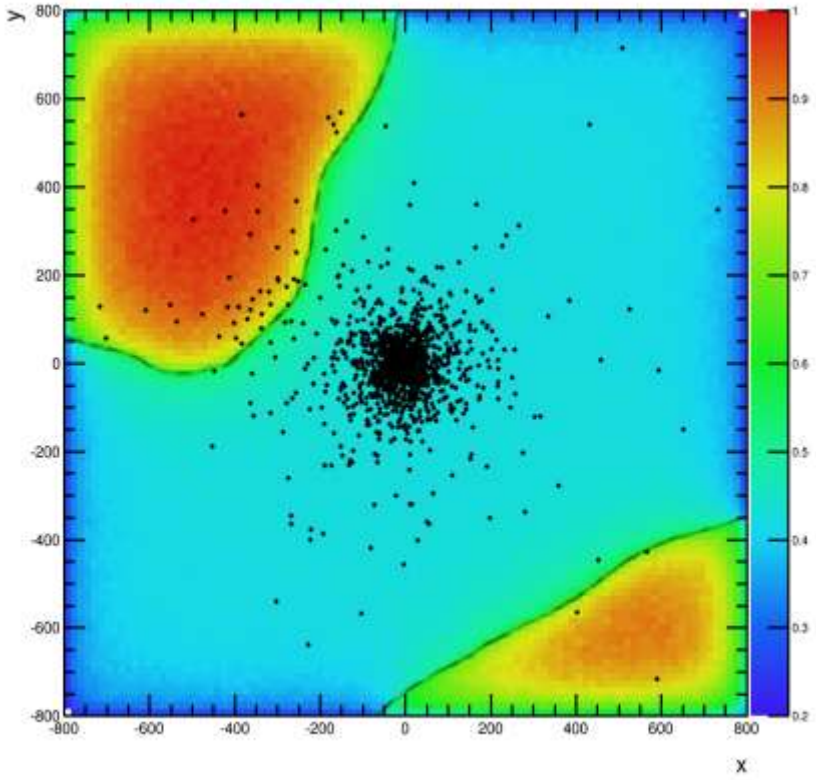


dry coast

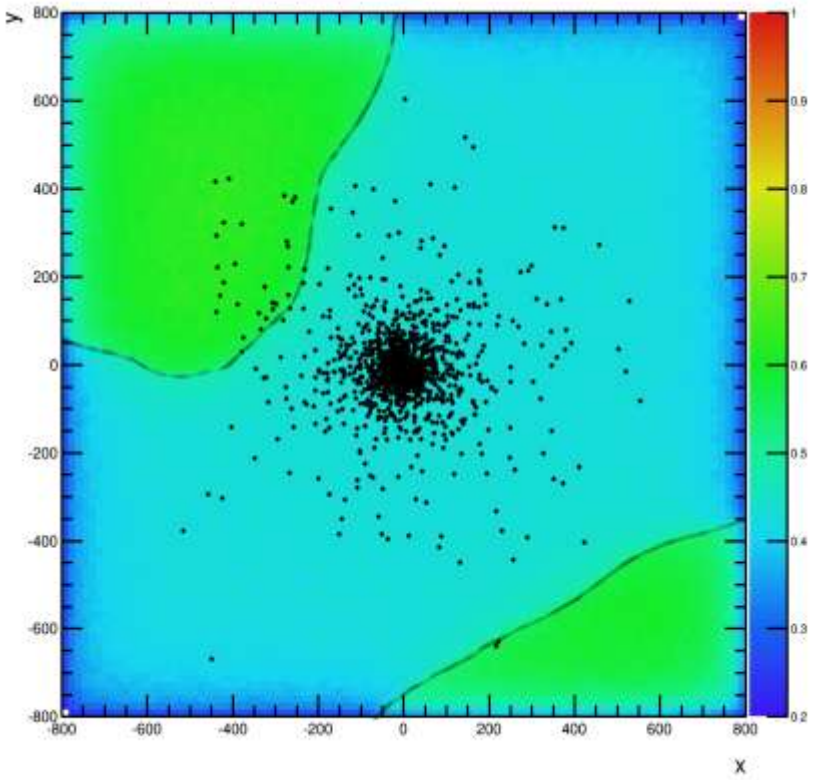


wet coast

Buoy on a lake



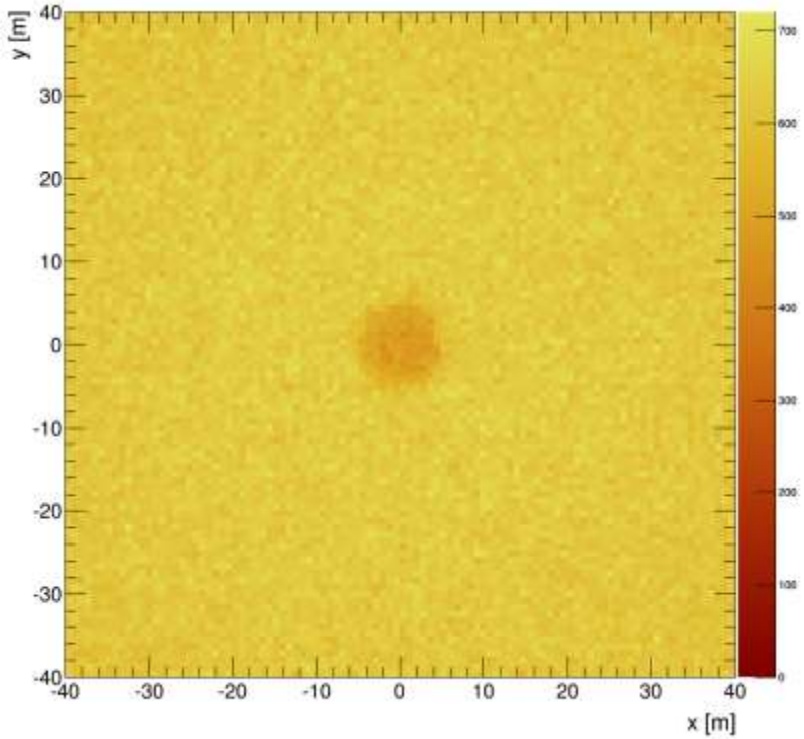
dry coast

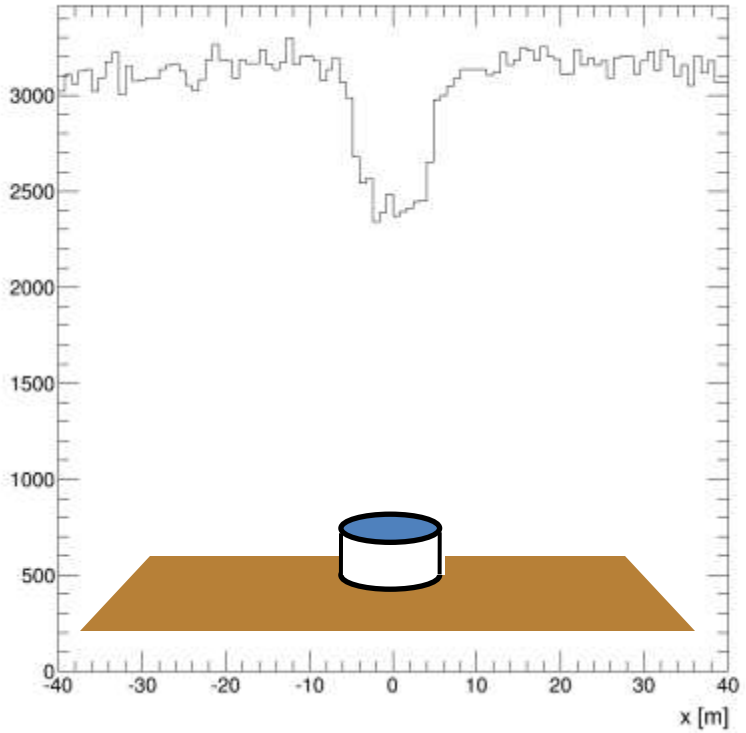


wet coast

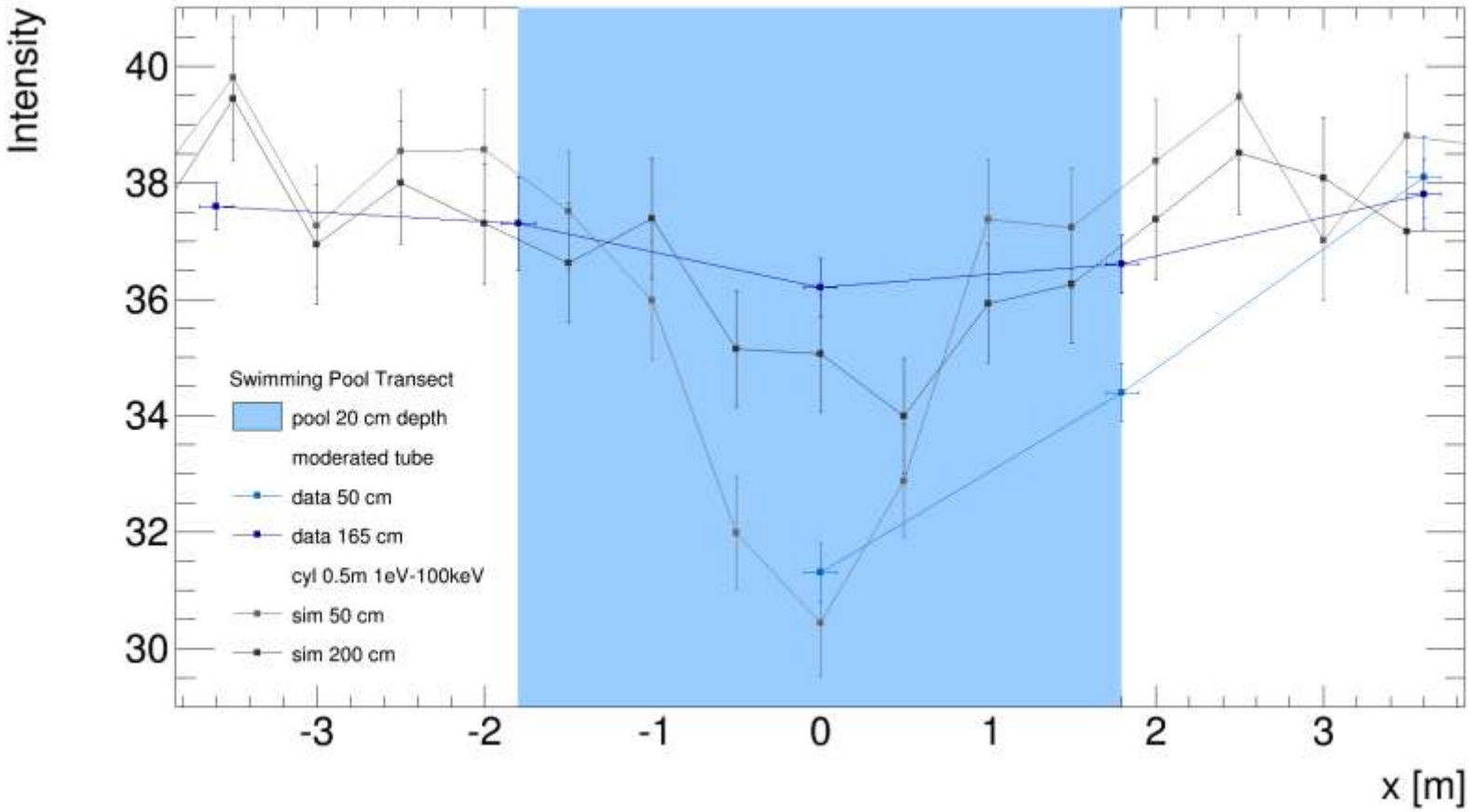
Local Effects

Pool Transect



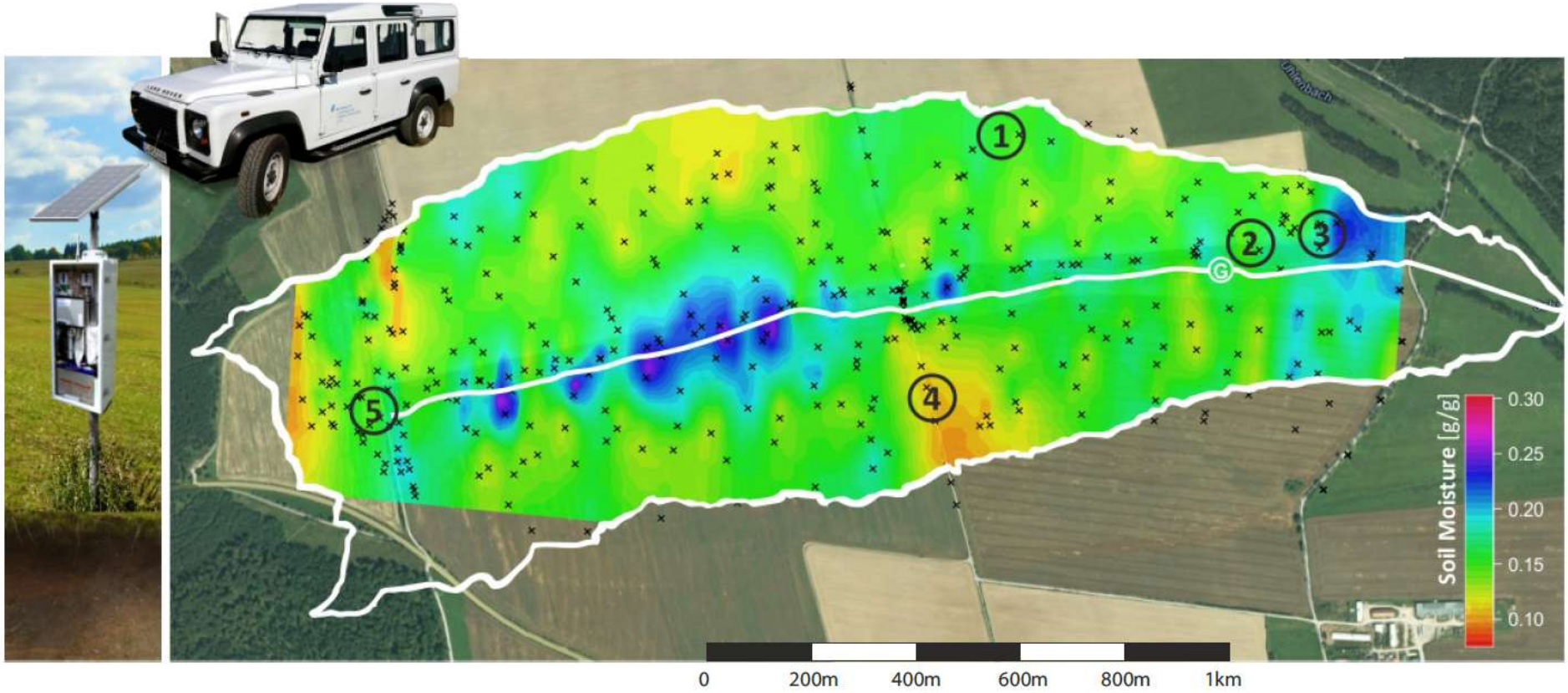


Local Swimming Pool Effects



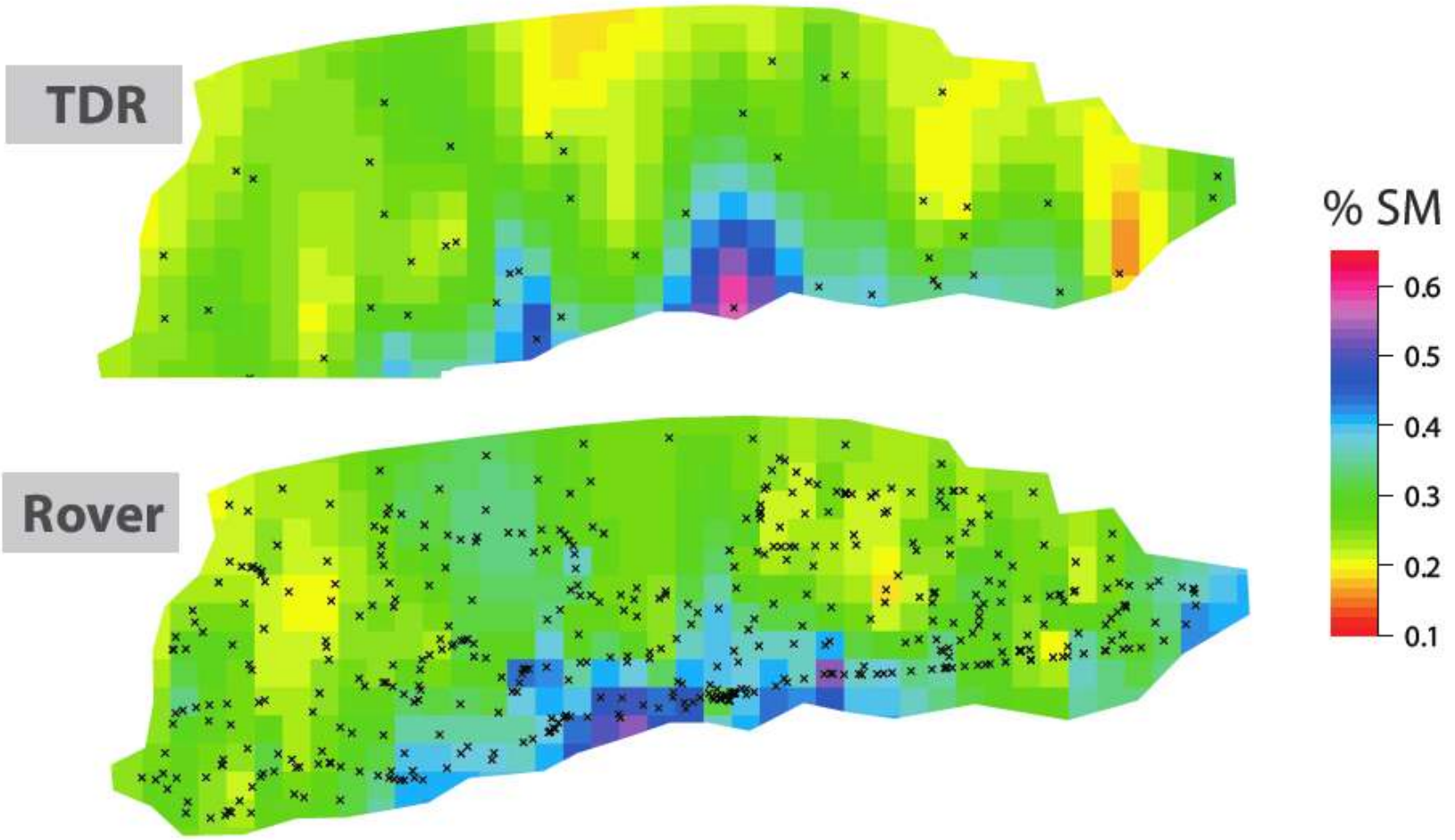
Mobile CRNS

Mobile CRNS

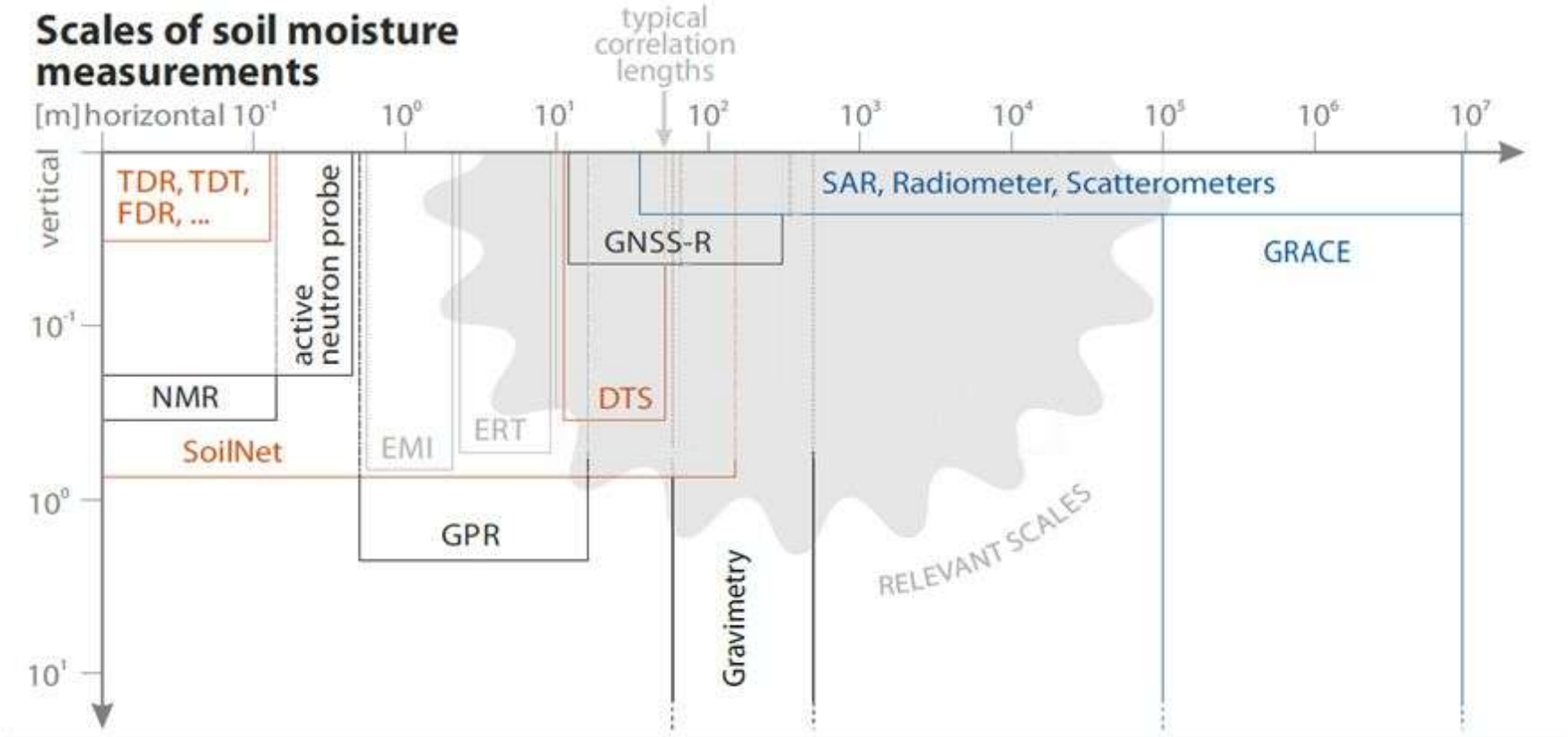


UFZ Site Schäfertal

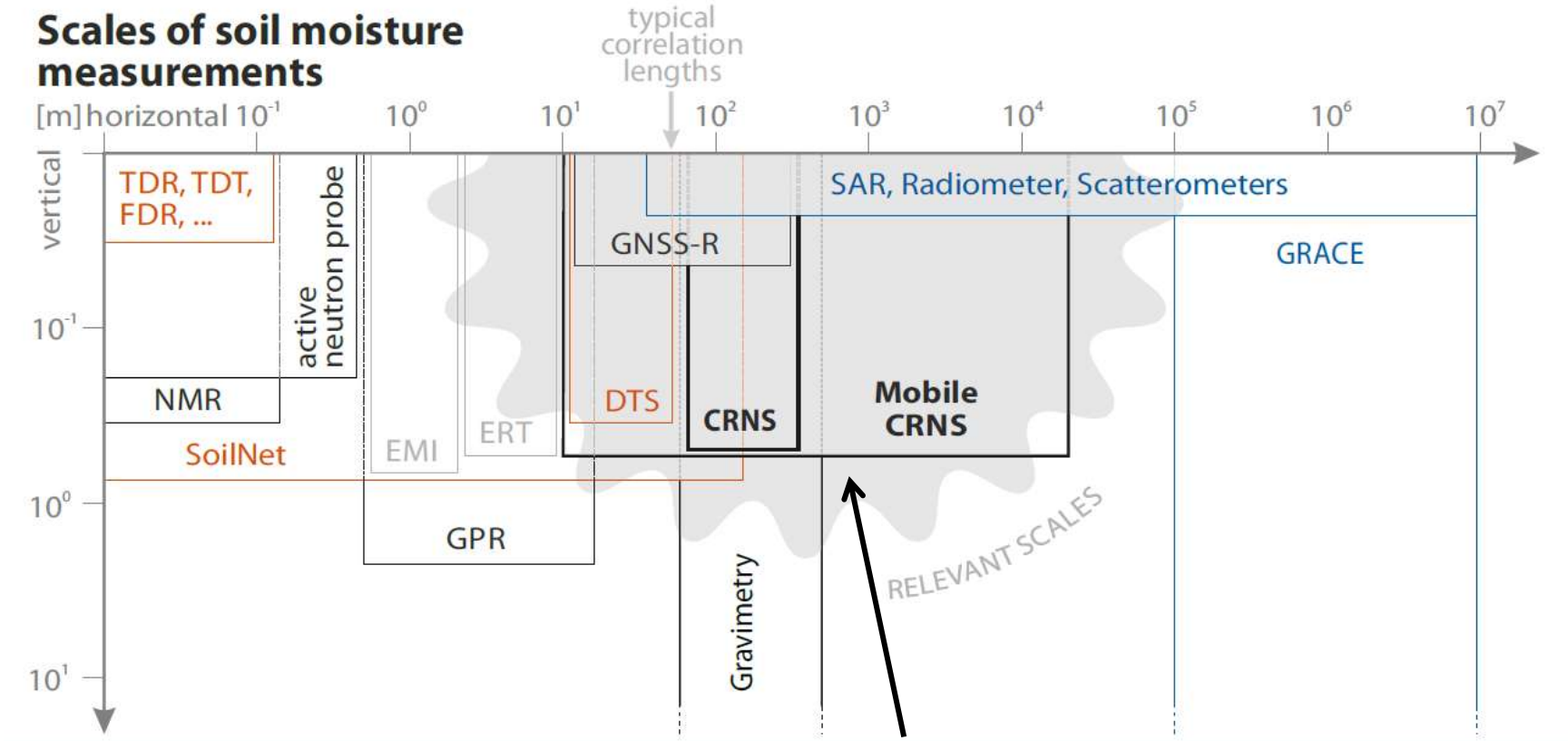
Mobile CRNS



The Measurement Gap



The Measurement Gap



And now here

Summary

- **Cosmic-Ray Neutron Detection**

- Outlook:

Summary

Cosmic-Ray Neutron Detection

- provides an average soil moisture measurement over **several hectares** and **0.5 m in depth**
- can be understood by Monte-Carlo transport modelling
- road effect, small scale variations, inhomogeneous soil moisture patterns can now be explained

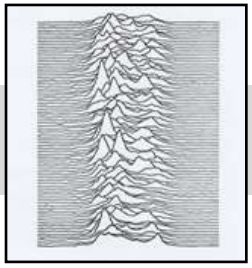
Outlook:

Summary

Cosmic-Ray Neutron Detection

- provides an average soil moisture measurement over **several hectares** and **0.5 m in depth**
- can be understood by Monte-Carlo transport modelling
- road effect, small scale variations, inhomogeneous soil moisture patterns can now be explained

Outlook: Development of mobile technologies



to be continued
J. Weimar

UP 4.3