



# Spatially resolved soil moisture sensing

Markus Köhli<sup>1,2</sup>, Martin Schrön<sup>3</sup>, Steffen Zacharias<sup>3</sup>, and Ulrich Schmidt<sup>1</sup>

<sup>1</sup>Physikalisches Institut, Universität Heidelberg

<sup>2</sup>Physikalisches Institut, Universität Bonn

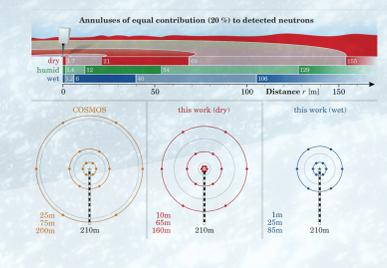
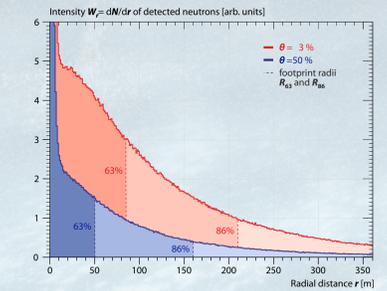
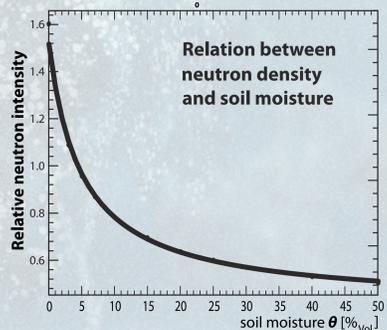
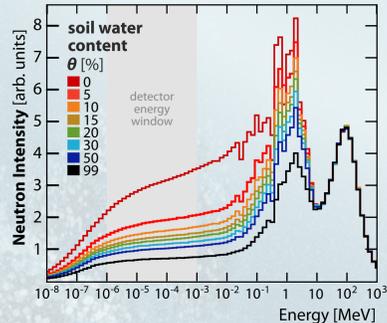
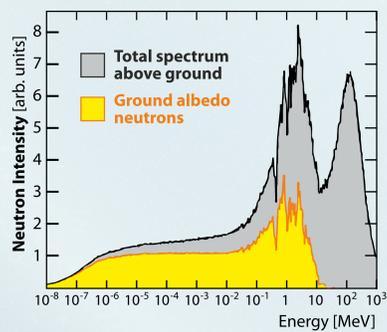
<sup>3</sup>Helmholtz-Zentrum für Umweltforschung - UFZ, Leipzig

an interdisciplinary collaboration

by Cosmic Ray Induced Neutrons

- nuclear physics
- particle physics
- environmental physics

## Measurement Principle



Cosmic Ray neutrons are a permanent source of radiation in the environment. The sensitivity of 10 eV - 100 keV neutrons to hydrogen is extraordinarily high. Thus, the intensity of ground albedo neutrons strongly relates to its water content. Transport in air leads to the density being representative for several hectares.

## Sensitivity to Water

**High-energy** neutrons are comparatively insensitive to water. At lower energies, particularly in the **blue** domain, hydrogen can effectively moderate neutrons. **Thermal** neutrons are slow and sensitive also to other chemical components.

## Mixing in Air

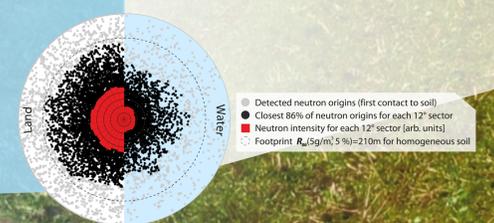
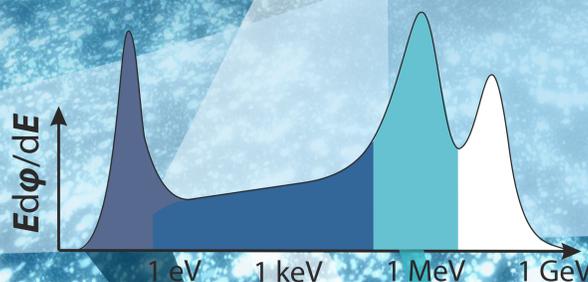
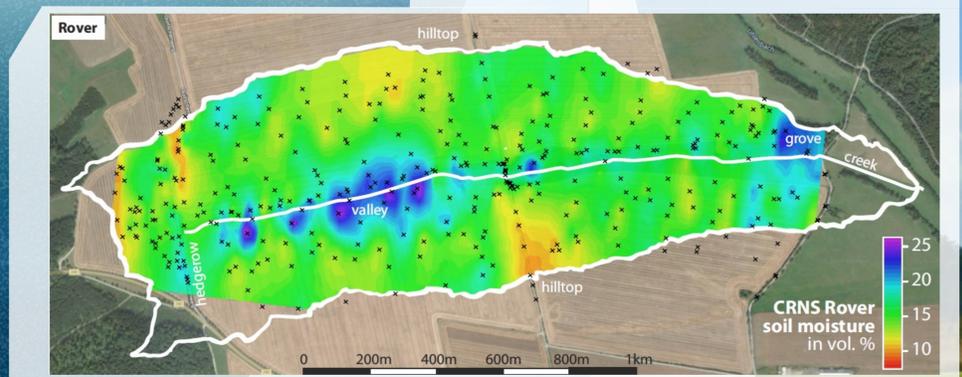
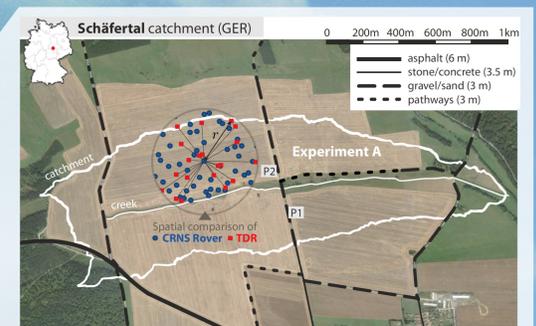
Neutrons are able to travel hundreds of meters from origin (contact with the soil) to detection.

## Detection

A moderated He detector counts **low-energy** neutrons.

## New and unrivaled technology for soil moisture monitoring

	Spatial resolution	Penetration depth	Temporal resolution
conventional point sensors	few cm	5-30 cm	snapshot/continuous
satellite remote sensing	4-24 km	0-5 cm	daily
airborne remote sensing	10-50 m	2-8 cm	irregular
Cosmic-Ray neutron sensor	100-200 m	10-80 cm	continuous/snapshot (mobile)



## Applications

- **Hydrological and Climate Models:** Soil Water Storage is a key variable for accurate prediction of weather, floods and drought
- **Irrigation management in agriculture:** Knowledge of soil moisture can save irrigation water
- **Snow height** measurements
- **Crop water** content / **yield** prediction
- **Forest water** storage, **ground water** recharge
- **Validation** of satellite products

