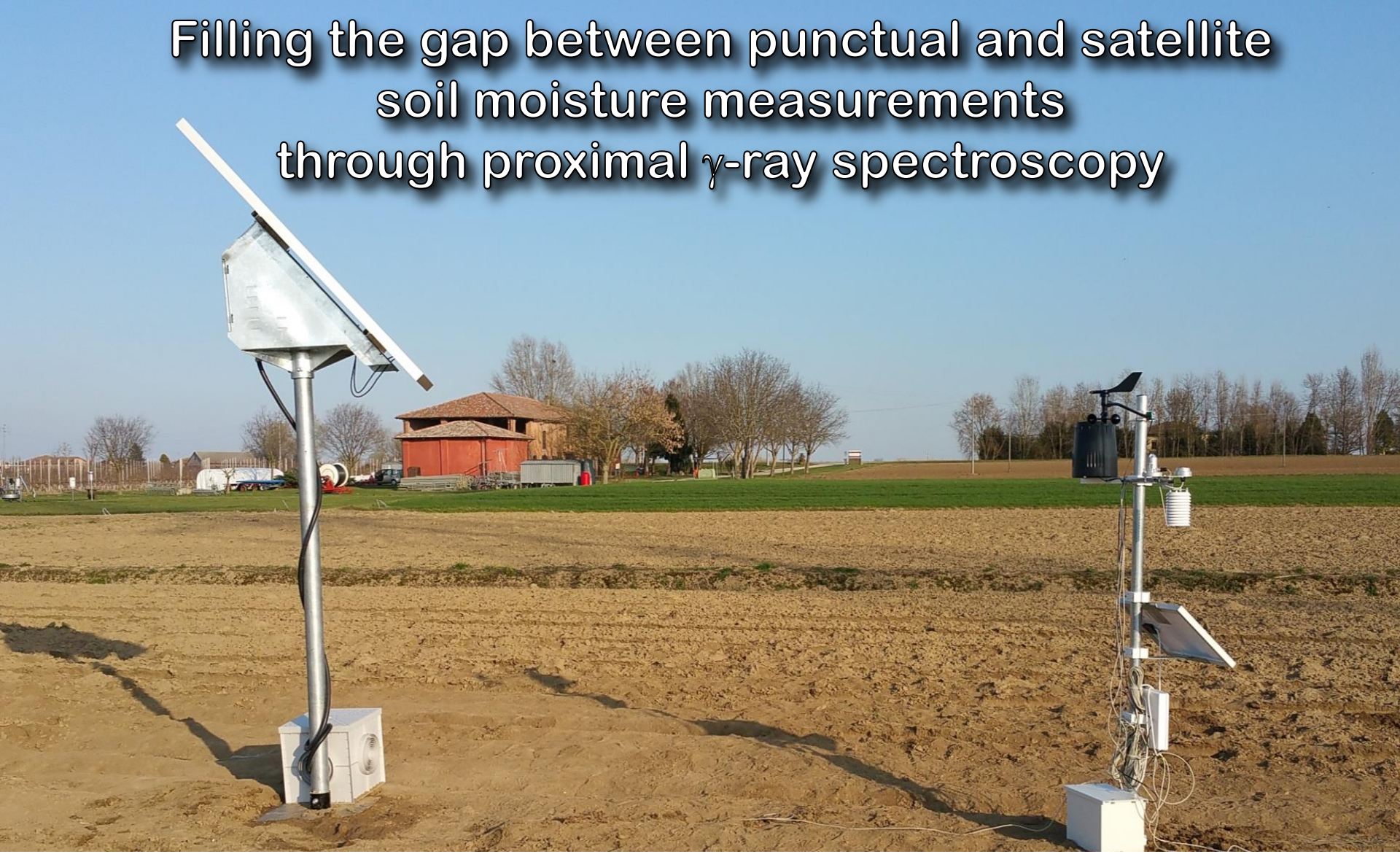
Filling the gap between punctual and satellite soil moisture measurements through proximal γ-ray spectroscopy



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Istituto Nazionale di Fisica Nucleare

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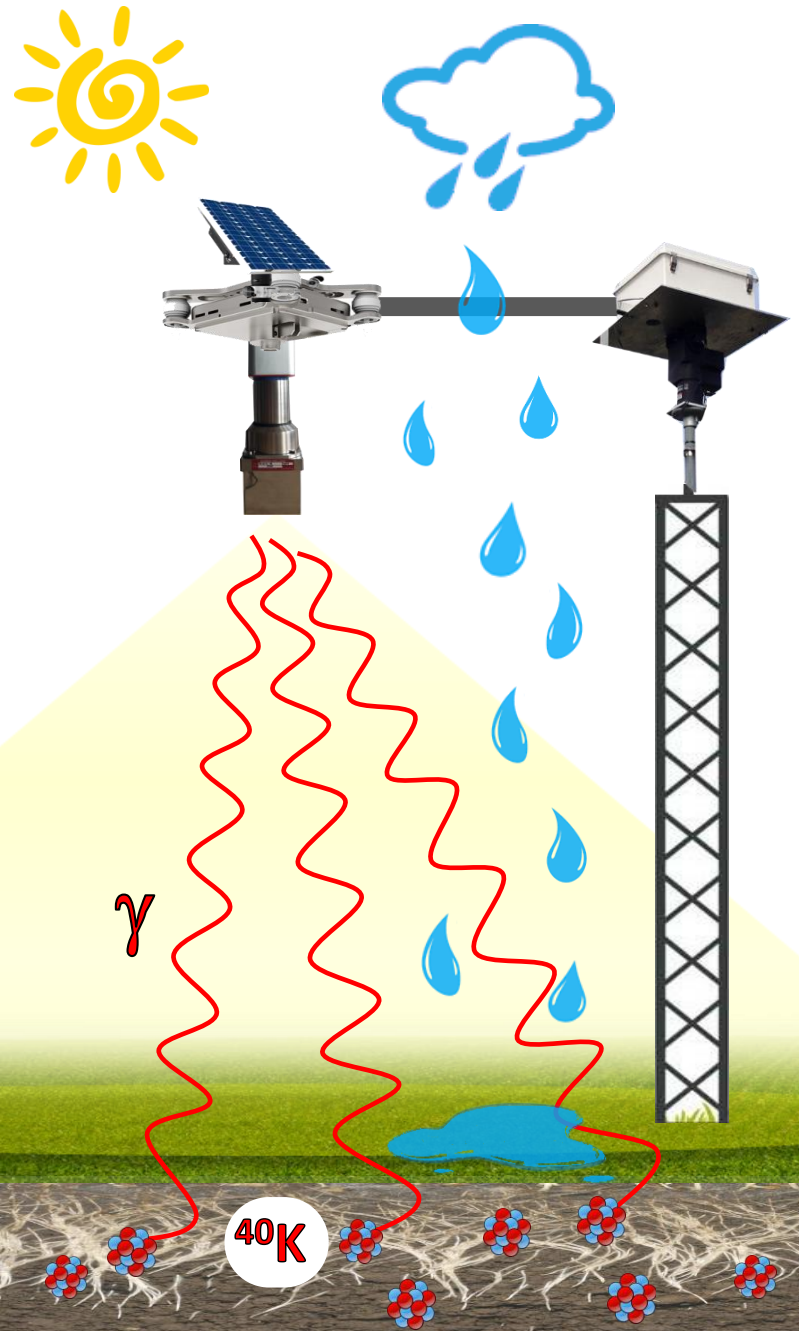
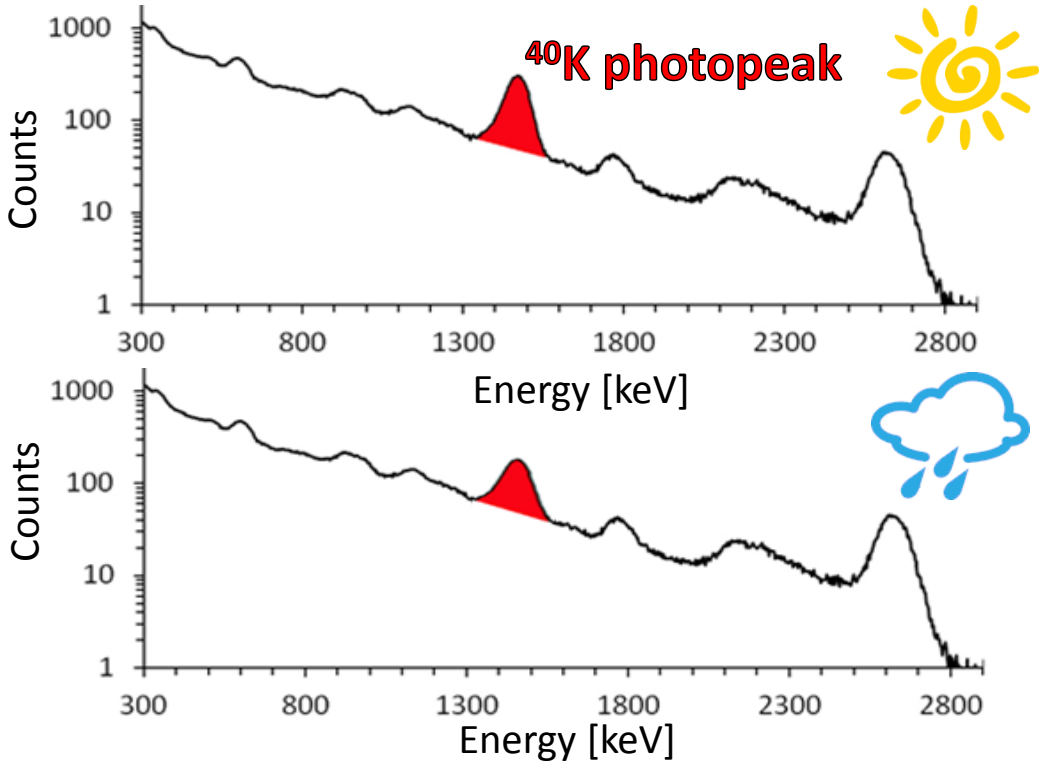
The rationale





^{40}K is everywhere (a_K~0.02 g/g) and homogenously distributed in soils

^{40}K is radioactive and decays by emitting a single gamma-ray (E_γ = 1460 keV)

From a cartoon to an actual experiment

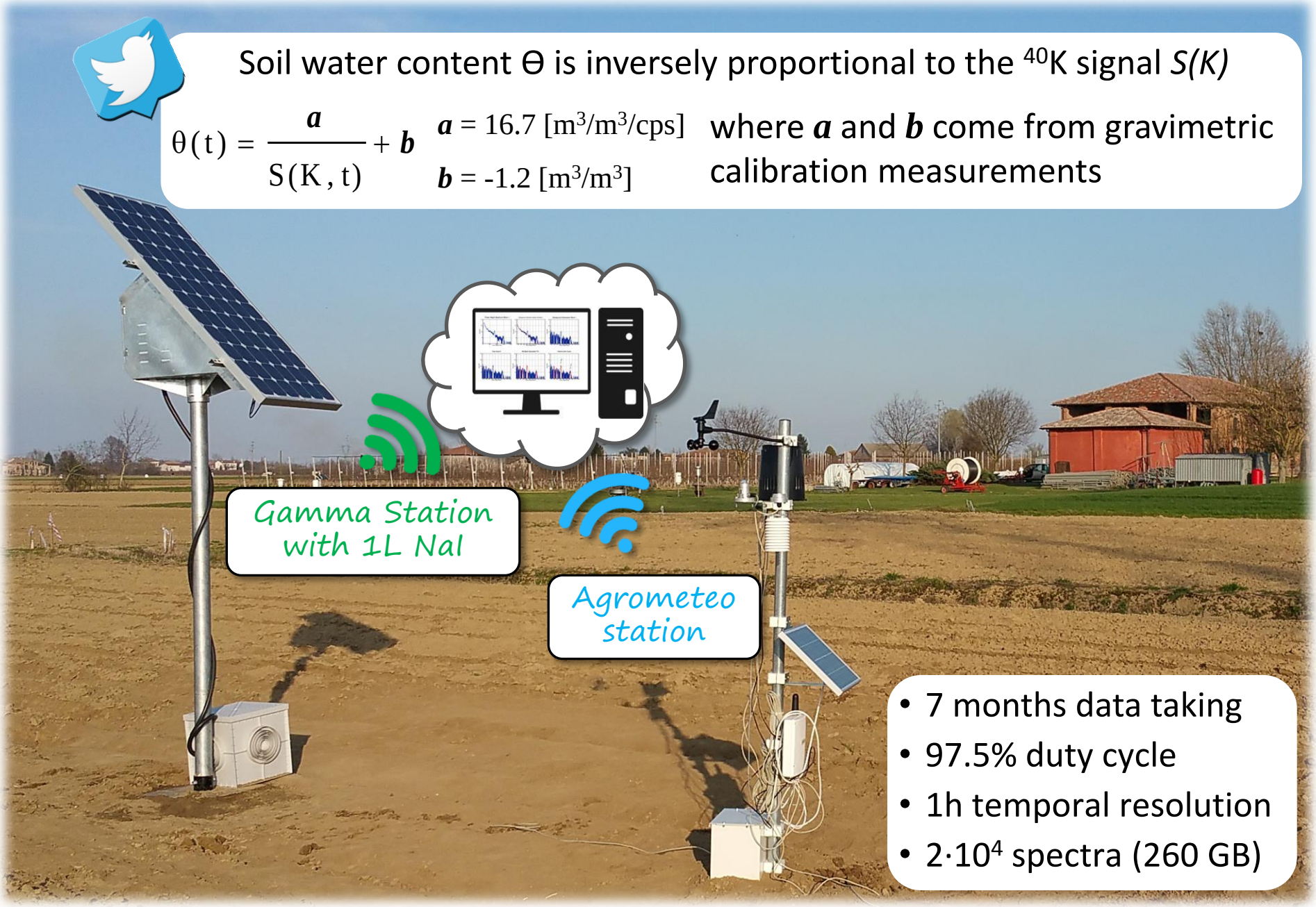
Soil water content Θ is inversely proportional to the ^{40}K signal *S(K)*

$$\theta(t) = \frac{a}{S(K,t)} + b$$

$a = 16.7\ [m^3/m^3/cps]$

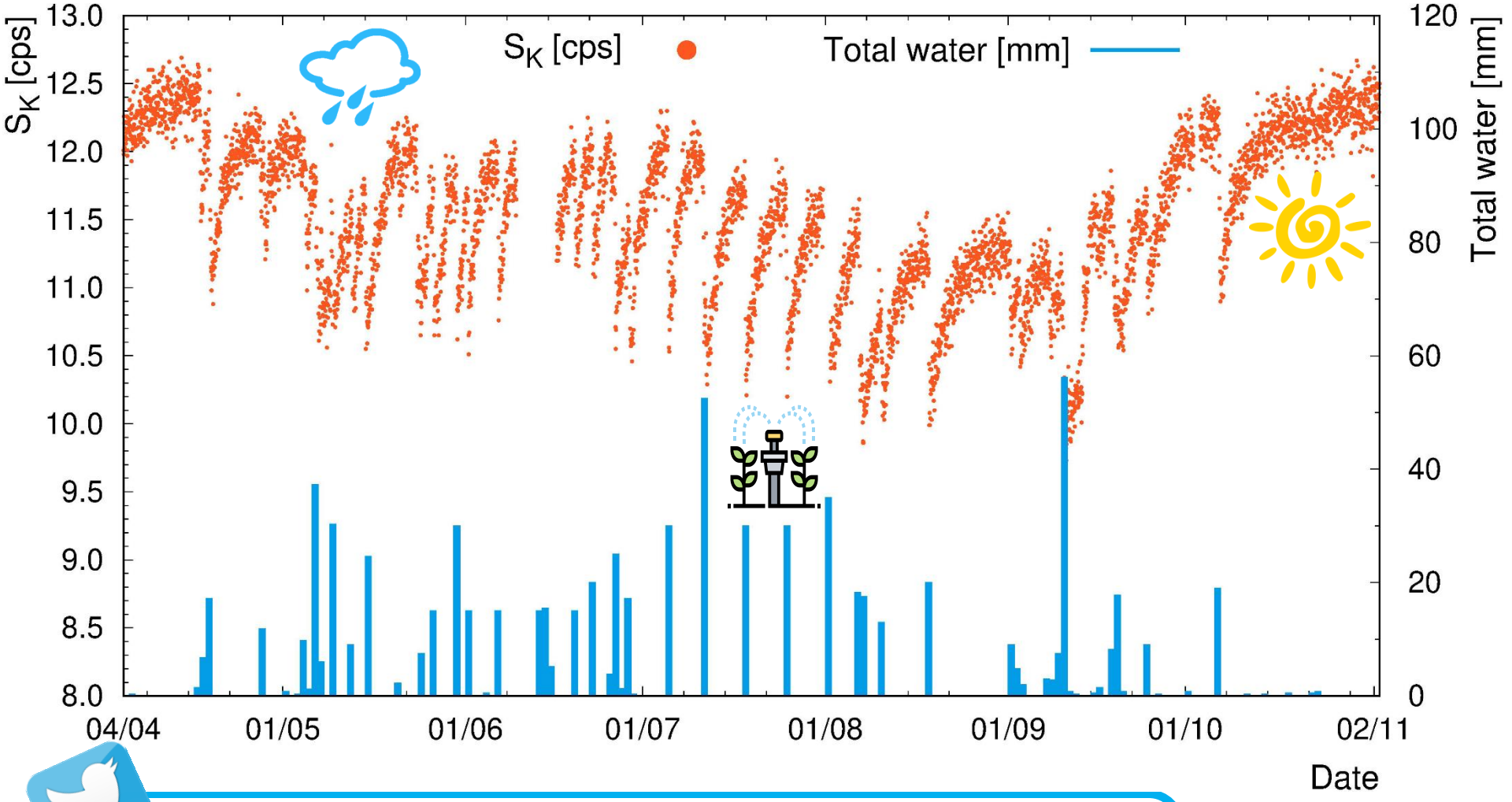
$b = -1.2\ [m^3/m^3]$

where ***a*** and ***b*** come from gravimetric calibration measurements



- 7 months data taking
- 97.5% duty cycle
- 1h temporal resolution
- $2 \cdot 10^4$ spectra (260 GB)

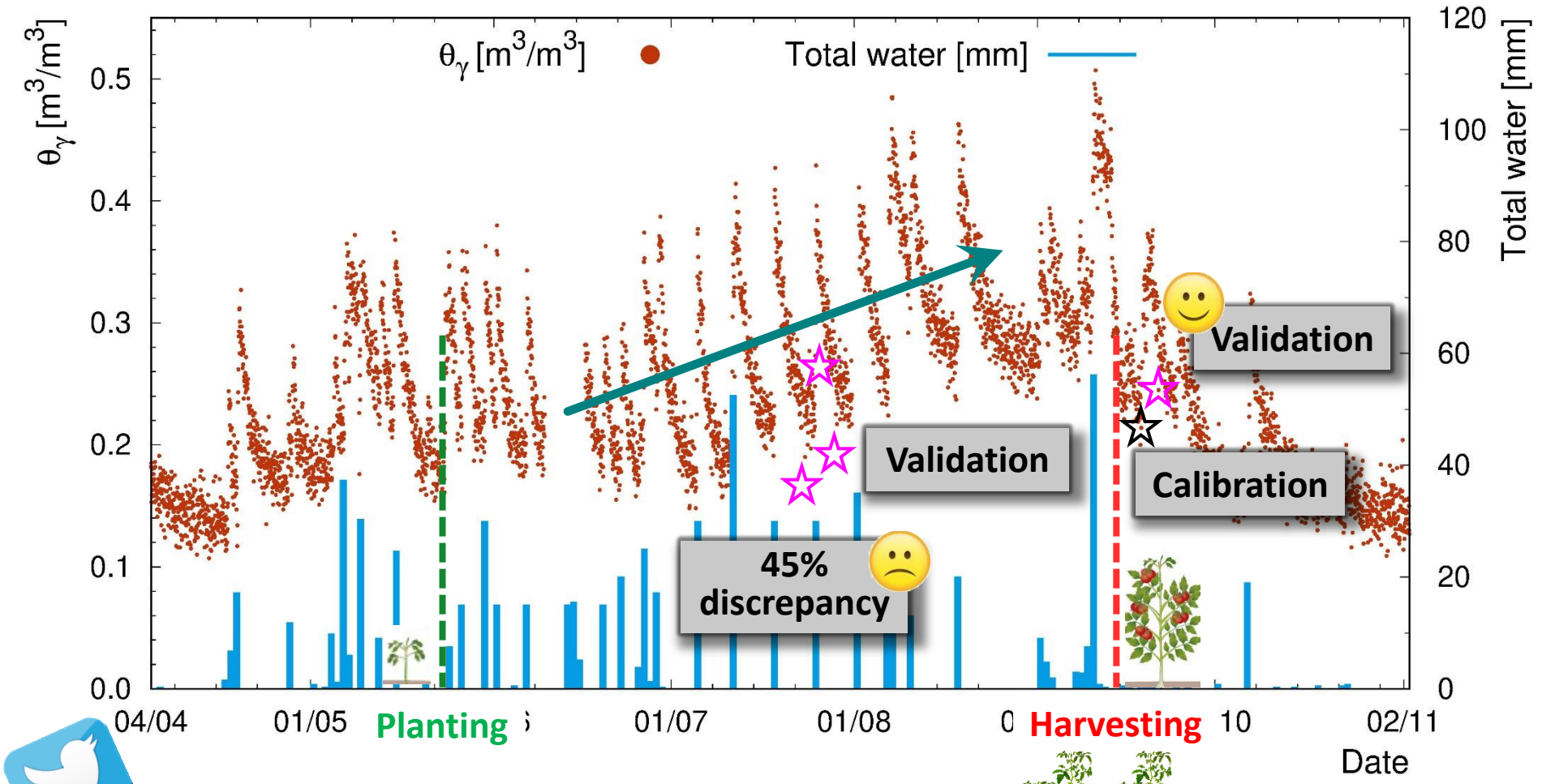
A 7 months experiment at a tomato test field



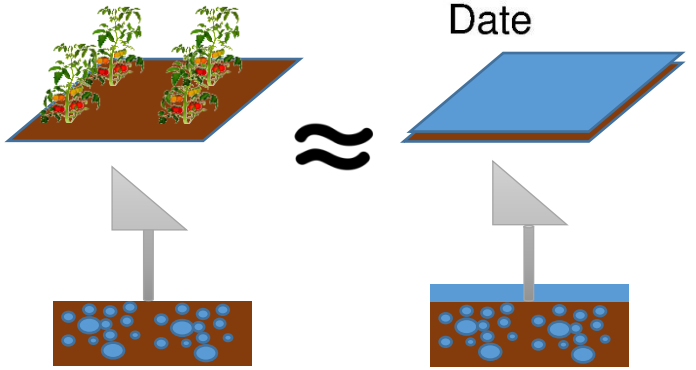
Evident temporal correlation between the reduction of the raw ^{40}K signal and the occurrence of rainfall and/or irrigation events

Come to PICO «Radon daughters rain-induced activity" PICO 4.11, Thursday 08.30 – 10.15

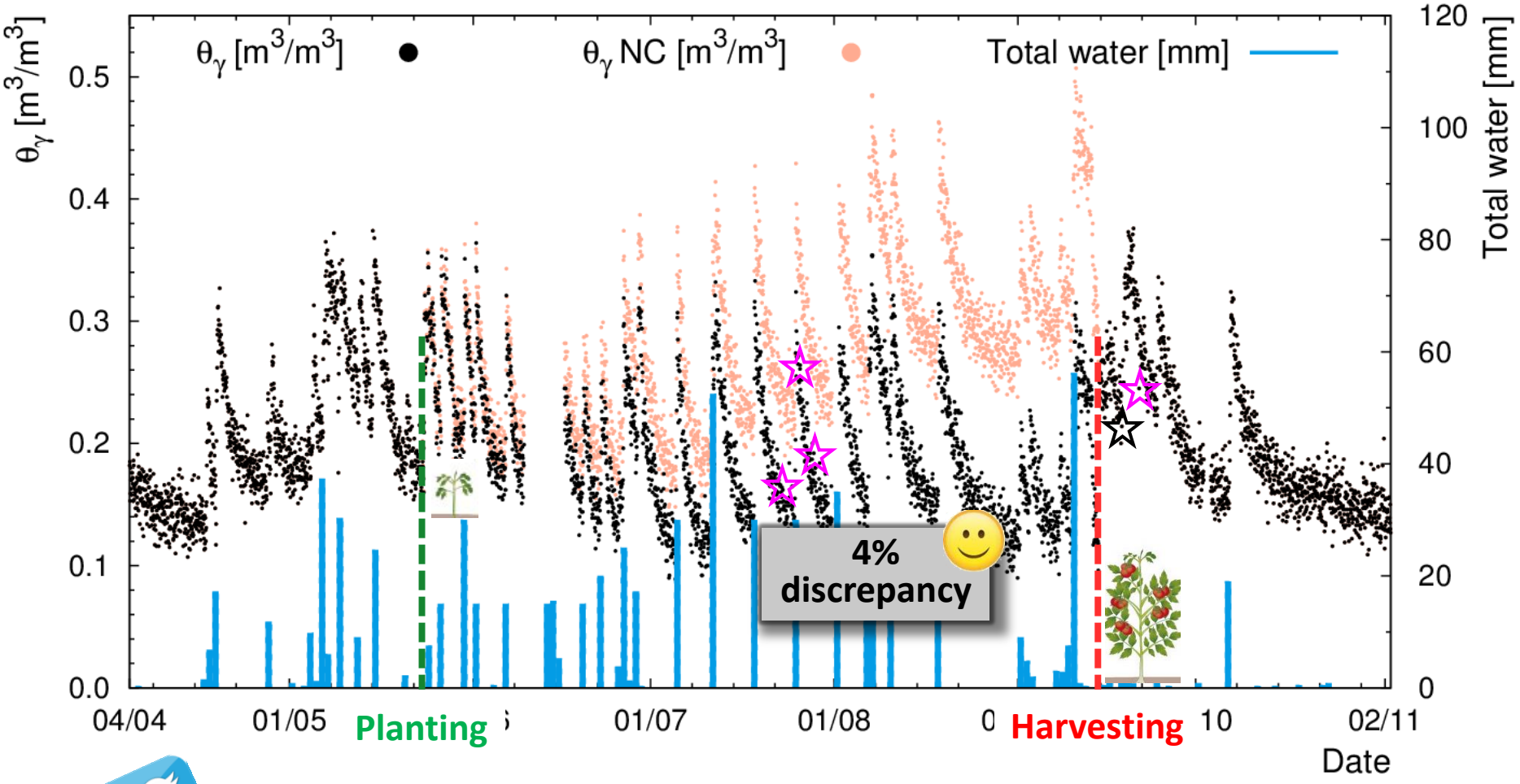
From ^{40}K signal to soil water content



The presence of growing biomass introduces an extra attenuation which gives a strong positive bias on Θ_γ values

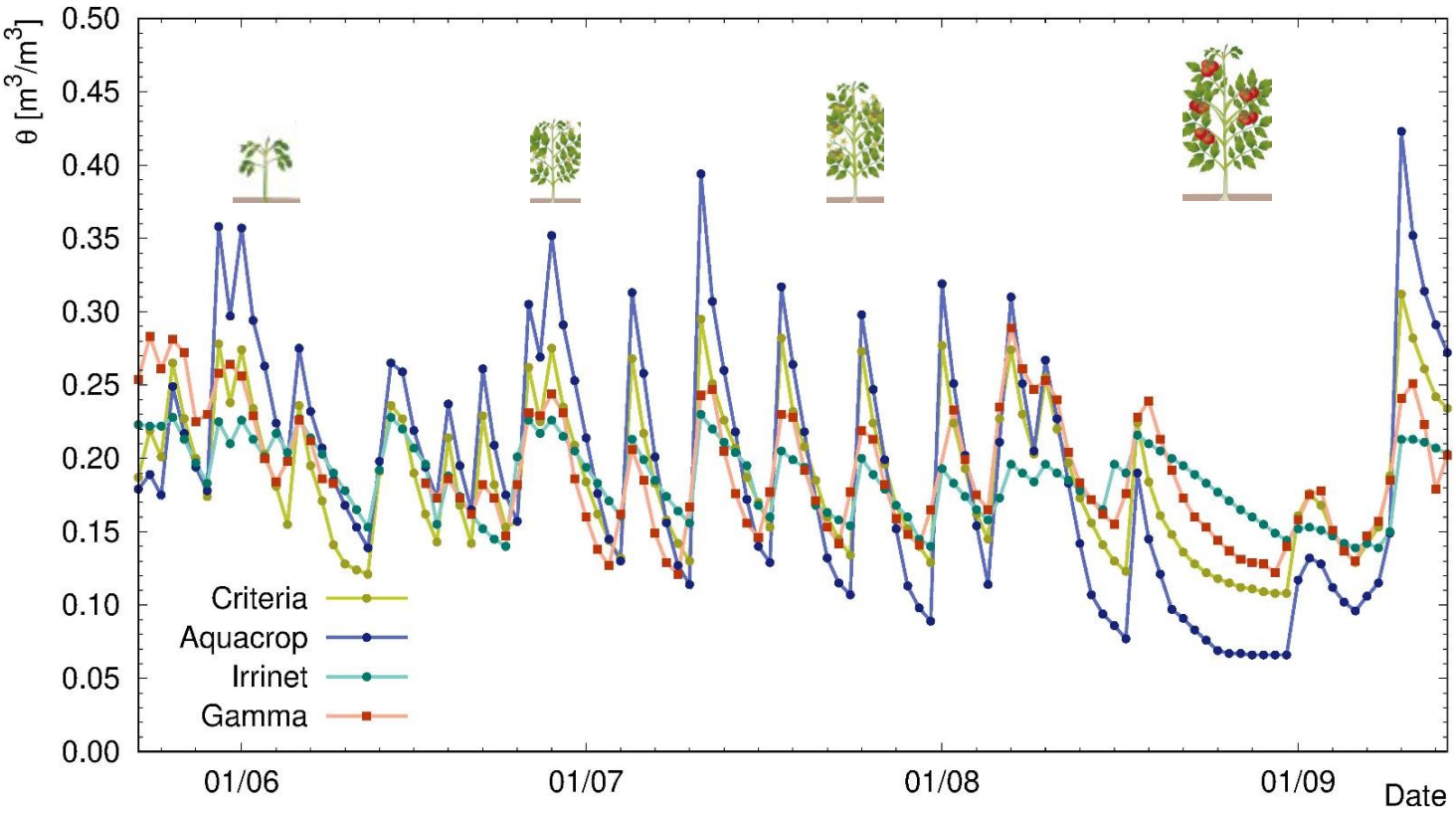


Correcting for the bias due to growing biomass



Θ_γ values are compatible at 1σ level with gravimetric measurements with a 8% maximum discrepancy

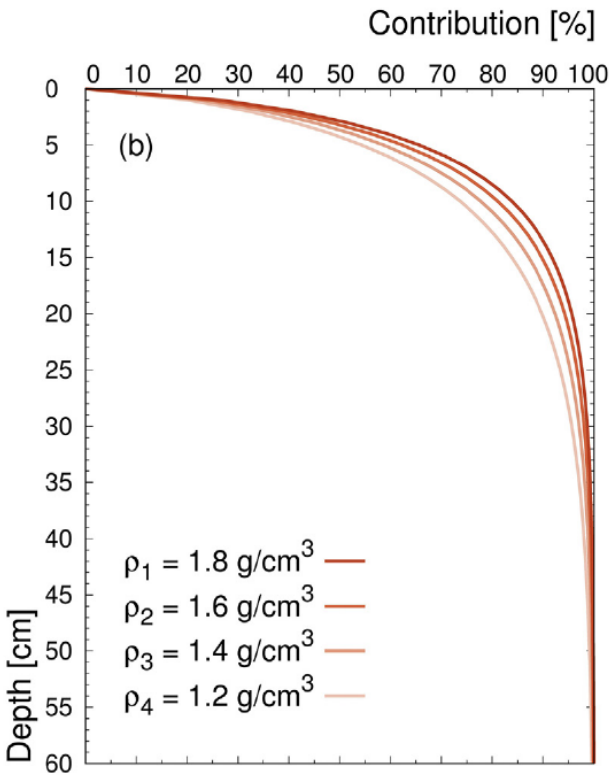
Does it really work?



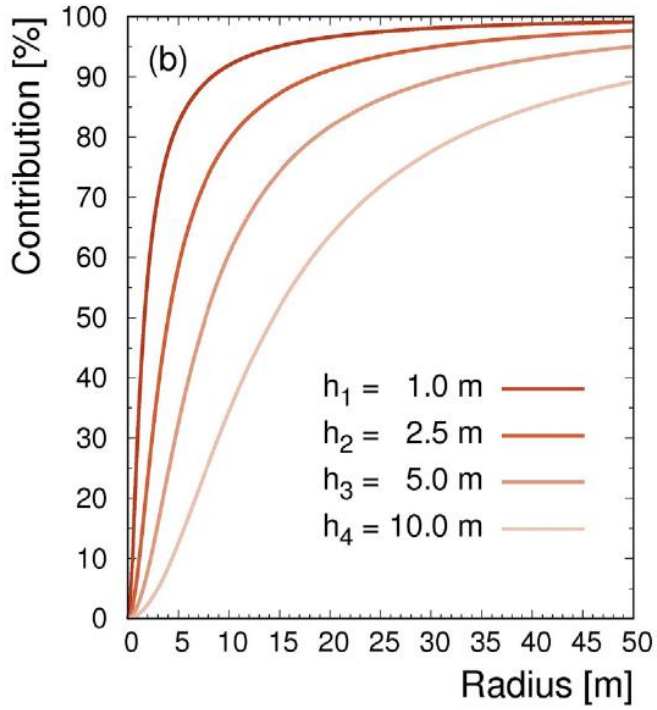
- **CRITeRIA** is a physically-based numerical model for simulating soil water balance
- **AquaCrop** is the FAO tipping-bucket conceptual model for soil water transport based on soil hydraulic properties and crop water demand
- **Irrinet** is a model for irrigation management that implements economic calculation of the crop-tailored irrigation profitability

Vertical and horizontal fields of view of proximal γ-ray spectroscopy

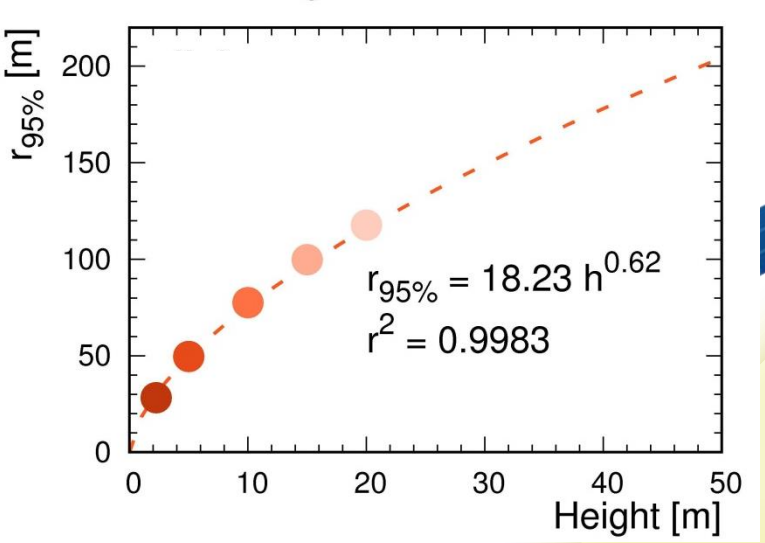
In a typical soil ~95% of the detected γ radiation is emitted from the top ~30 cm



Cumulative percentage contribution of γ flux detected at 2.3 m height reaches ~95% at ~25 m radial distance

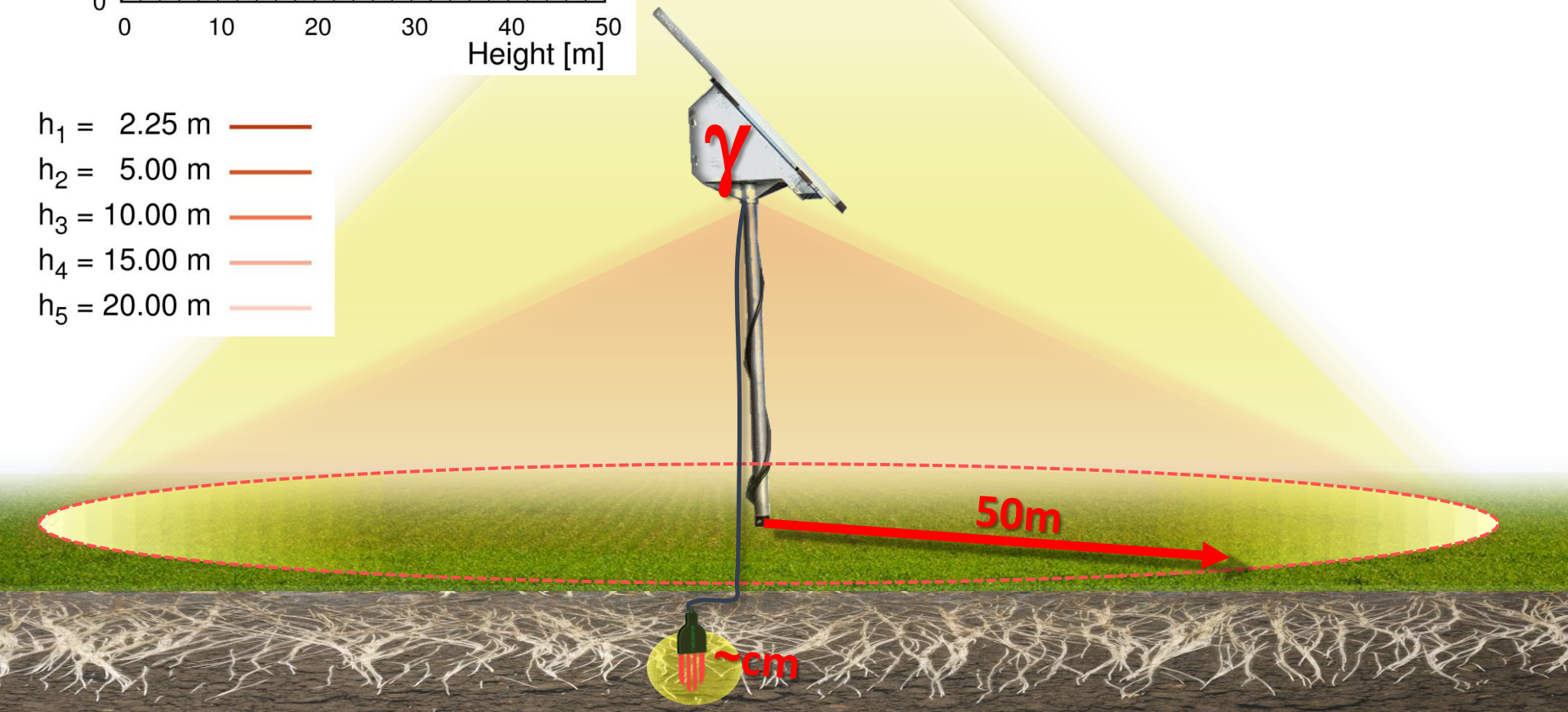


Proximal γ-ray spectroscopy for filling the gap at field-scale

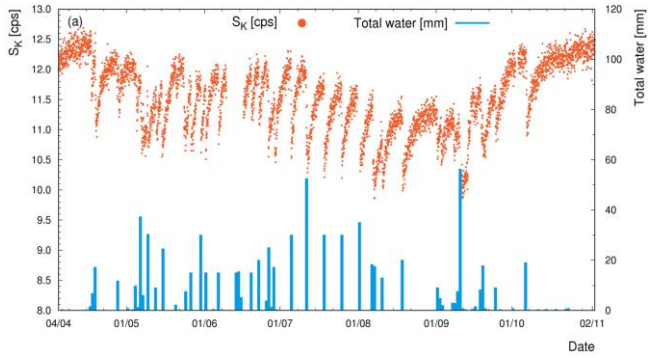


h_1 = 2.25 m
h_2 = 5.00 m
h_3 = 10.00 m
h_4 = 15.00 m
h_5 = 20.00 m

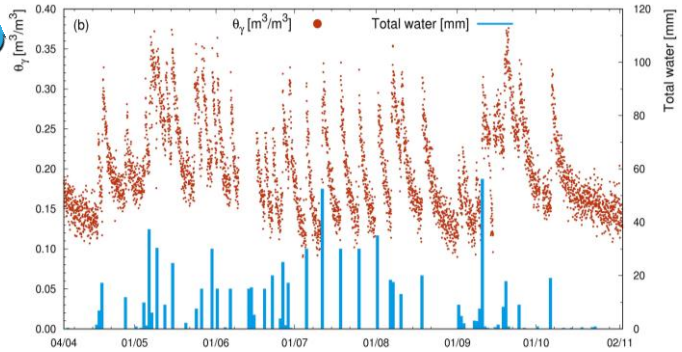
Proximal γ-ray spectroscopy can be an ideal ground truthing technique for the calibration of satellite data



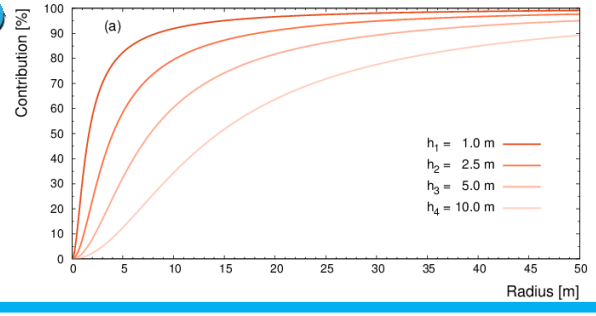
Take away highlights



The **attenuation** of the ^{40}K gamma signal coming from the ground is an unequivocal **smoking gun** for a **soil water content increase after rainfalls and/or irrigations**



Provided a (single) soil **gravimetric calibration** measurement and biomass samplings, **soil water content** can be assessed via proximal γ-ray spectroscopy at the level of **5%**



Proximal γ-ray spectroscopy has a **field scale areal horizon** which makes it a promising technique in view of **satellite data calibration**

Baldoncini et al., "**Investigating the potentialities of Monte Carlo simulation for assessing soil water content via proximal gamma-ray spectroscopy**" *Journal of Environmental Radioactivity*, 2018

Strati et al., "**Modelling Soil Water Content in a Tomato Field: Proximal Gamma Ray Spectroscopy and Soil–Crop System Models**" *Agriculture*, 2018

Baldoncini et al., "**Biomass water content effect on soil moisture assessment via proximal gamma-ray spectroscopy**" *Geoderma*, 2019