

Cosmic Ray Neutron Sensor (Cosmic-SMM)



CosmicSMM-xx-xx-xx-xx

The Cosmic Ray Soil Moisture Monitor

An emerging technology is the Cosmic Ray Neutron Sensor (CRNS). These systems measure naturally occurring neutrons from cosmic rays to understand the moisture levels in soil below the surface, which can help to better understand the impact to plant root systems and nutrients. With such information, we can make better irrigation decisions, conserve energy, and provide better predictive ecological models and warnings for events such as drought and flood conditions. The RDT Cosmic Soil Moisture Monitor (Cosmic-SMM), provides accurate measurements of the water content in soil, providing real-time, critical data to decision makers in irrigation, water management, agriculture, and climate monitoring.

The Neutron Sensor

Li-Foil Multi-wire Proportional Counter (MWPC) Neutron Detectors provide an affordable large-area alternative to the ^3He -based and BF_3 detectors, maintaining a high thermal-neutron detection efficiency.

- γ -reject: $<1:10^{-8}$
- $E_{\text{thermal}} : 40(\pm 1)\%$
- CTS/sec/nv: 79.5
- $V_{\text{input}} : 2.7 - 4.5 \text{ V}$
- $V_{\text{output}} : \text{TTL or output driven}$
- Temp. Range: -40°C to 85°C
- Power: $\sim 150\text{mW}$ total
- Weight: $\sim 1.6\text{lbs}$
- Standard Size: $19.625'' \times 2.25'' \times 1.38''$

Cosmic-SMM Specifications

- Standard Device Dimensions $24'' \times 9.5'' \times 5.4''$ for a 2-device Li-Foil MWPC configuration (1" thick HDPE weather tight enclosure).
 - 700 – 800 neutron counts per hour (cph) per Li-Foil MWPC device*
 - 2-device configuration: 1400 – 1600 cph*
 - 3-device configuration: 2100 – 2400 cph*

**Altitude: 350 m a.s.l., Mean air relative humidity: 70%, Mean atmospheric pressure: 977 kPa*

- 10 – 40-Watt solar configurations, with a solar controller and battery
- Weather-proof enclosure for all the peripherals
- Reach back data logging via LTE, 3g or 2g networks
- Optional weather sensor provides temperature, pressure, humidity measurements
- Mounting equipment for 2-inch pole mast
- Optional tripod mast



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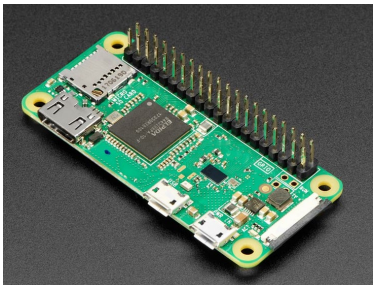
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Data Loggers



Boron Particle

- LTE, 3g, 2g network connectivity
- Data can be pulled conveniently through a network connection



Raspberry Pi

- Includes an SD card
- Data is stored on the SD card can be physically retrieved

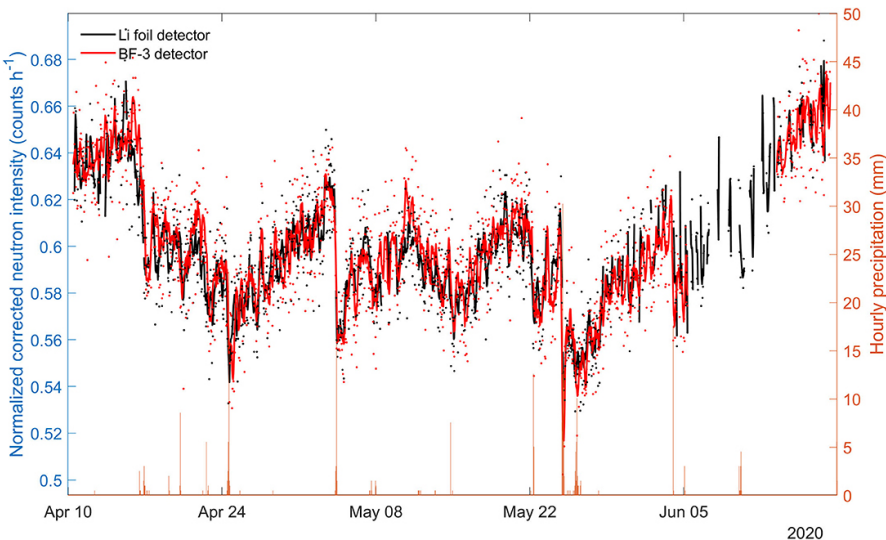
Ordering Information

Number of Neutron Sensors	Weather Sensor	Data Logger	Mounting
XX	XX	XX	XX
01 - 1 sensor 02 - 2 sensors 03 - 3 sensors	MG - Meter Group Atmos14 CS - Campbell Scientific MetSens NA - None	BP - Boron Particle Pi - Raspberry Pi NA - None	T - Tripod NA - None

Technology comparison:

- The normalized (N/N_0) corrected cosmic-ray neutron counts from the Cosmic-SMM (Li Foil MWPC devices) and a BF-3 based system
- Li-Foil: \$4.4 per average uncorrected hourly count*
- BF3: \$8.4 per average uncorrected hourly count*
- 3He: \$26.5. per average uncorrected hourly count*

**within the reported study*



Ref: A. Patrignani, T. E. Ochsner, B. Montag, and S. Bellinger, "A Novel Lithium Foil Cosmic-Ray Neutron Detector for Measuring Field-Scale Soil Moisture," (in English), *Frontiers in Water*, Original Research vol. 3, 2021-July-07 2021, doi: 10.3389/frwa.2021.673185