



# Boron-lined neutron detectors for mobile soil moisture measurements

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## A <sup>3</sup>He alternative for environmental applications

## Innovative Neutron Detection

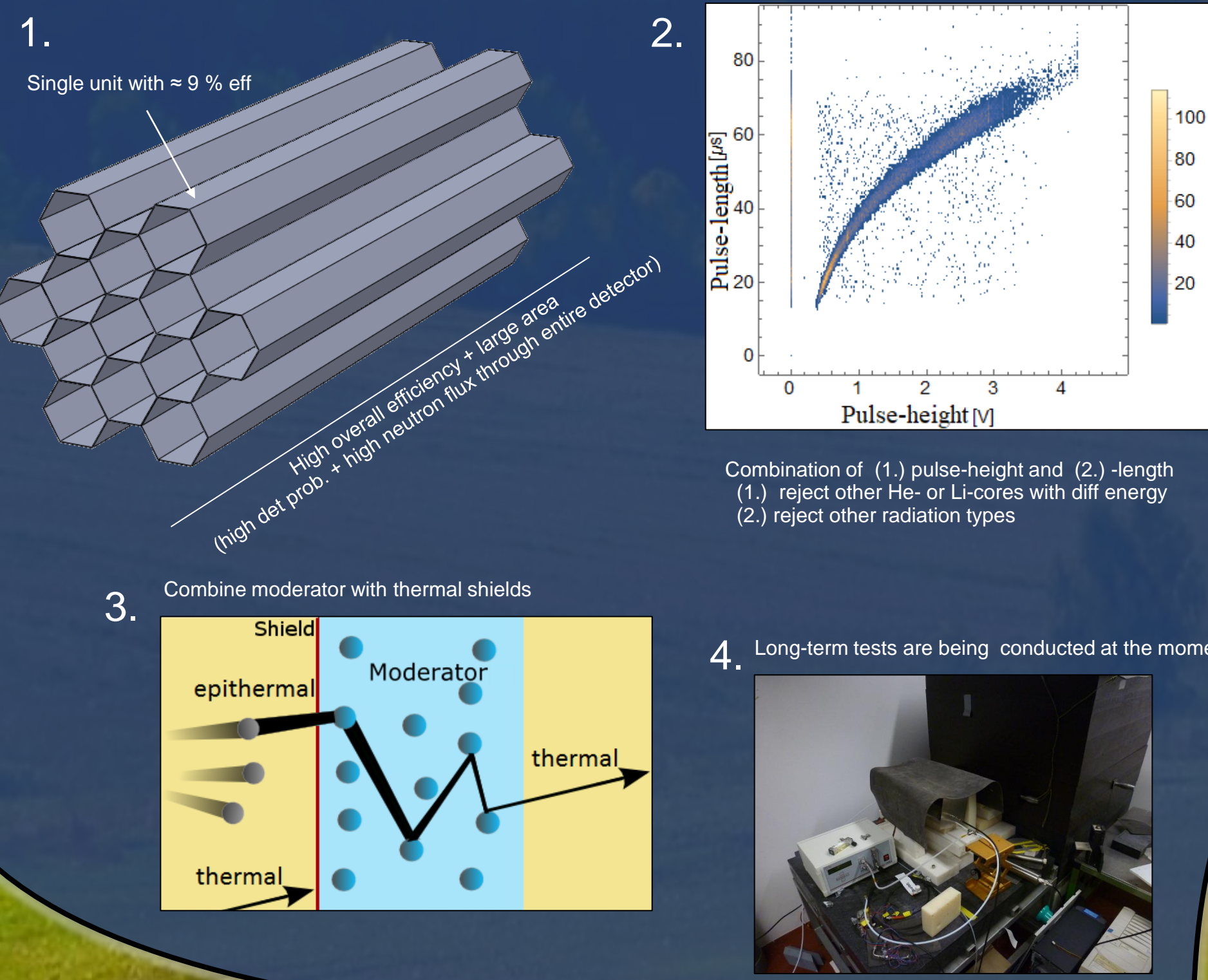
- radiation type & background discrimination
- low cost & low power consumption
- lightweight and modular

We present a boron-lined proportional counter for mobile and especially air-borne detection of environmental neutrons. The choice for solid boron as neutron converter limits the efficiency of single proportional counters to roughly 12 %. This is why we propose a modular detection system composed of a multitude of hexagonal-shaped counting tubes. Each tube can work as a standalone neutron detector but also can be combined with others to form a high-count rate detection system especially suitable for mobile measurements where high temporal resolution is the primary criterion.

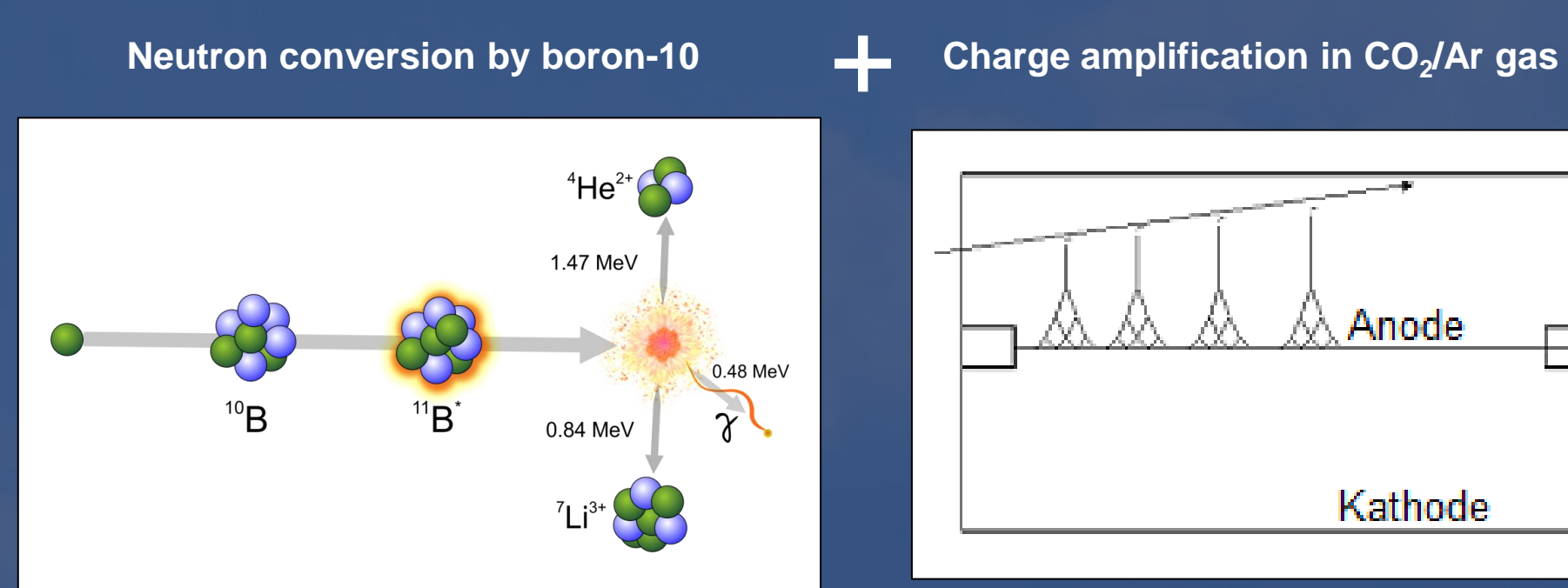
The walls of the counting tubes are composed of 300 µm thick aluminum sheets making them very light and most suitable for airborne applications. Moreover, the system will feature all important measurement devices for the application in soil moisture sensing but will still have lower power consumption as comparable systems. By combining pulse-height and pulse-shape information of detection events, the read-out electronics is capable of differentiating between different radiation types. This allows for a high signal-to-noise ratio and thus for precise soil moisture evaluation.

### Concept

- Demands in environmental neutron detection
- High count rate  
→ high temporal resolution
  - Appropriate energy dependent efficiency
  - Efficient discrimination of radiation types  
→ high signal-to-noise ratio, precise soil moisture monitoring
  - Low power consumption
  - Robust and weatherproof  
→ long-term use

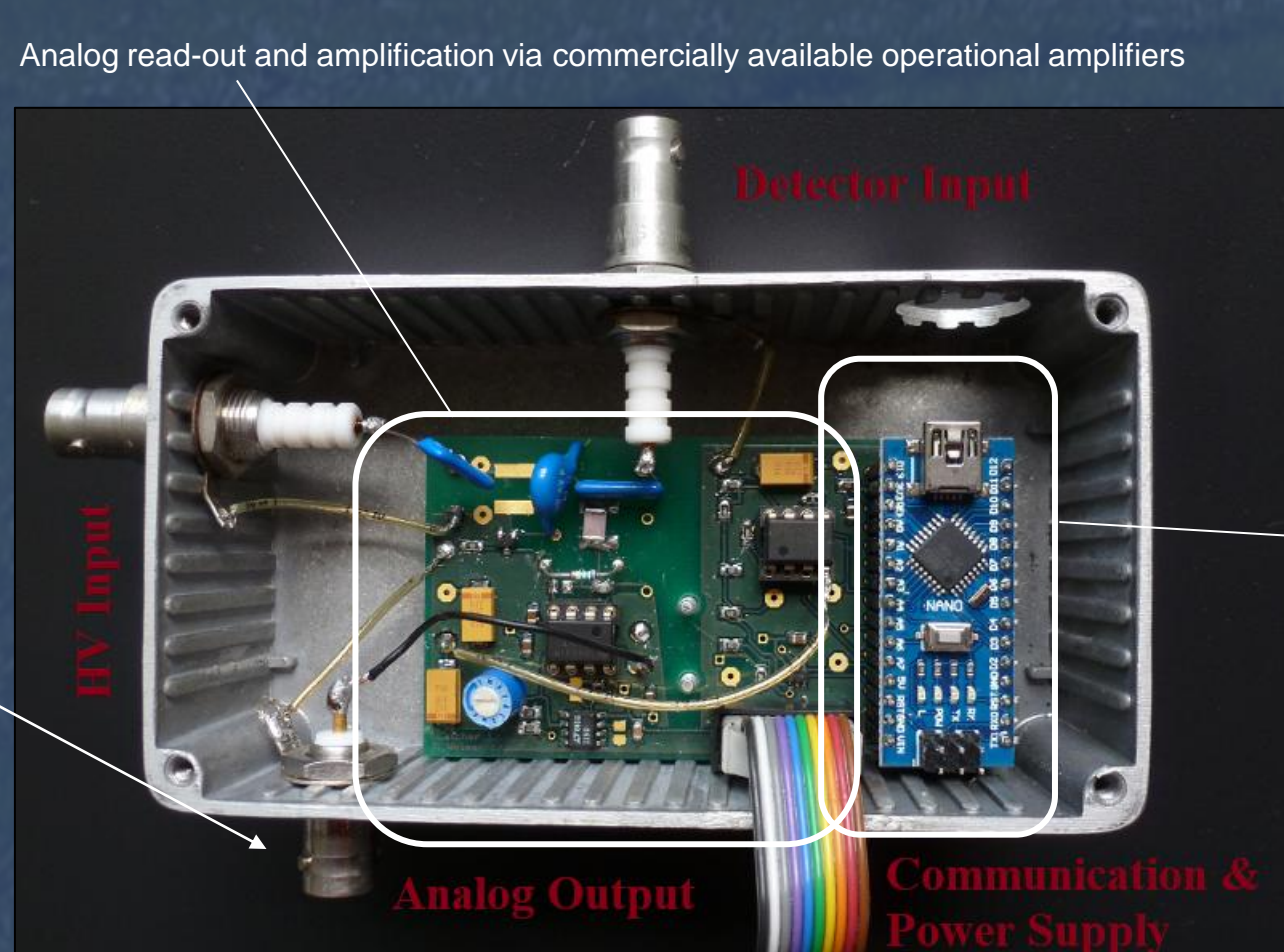


### Detection Method

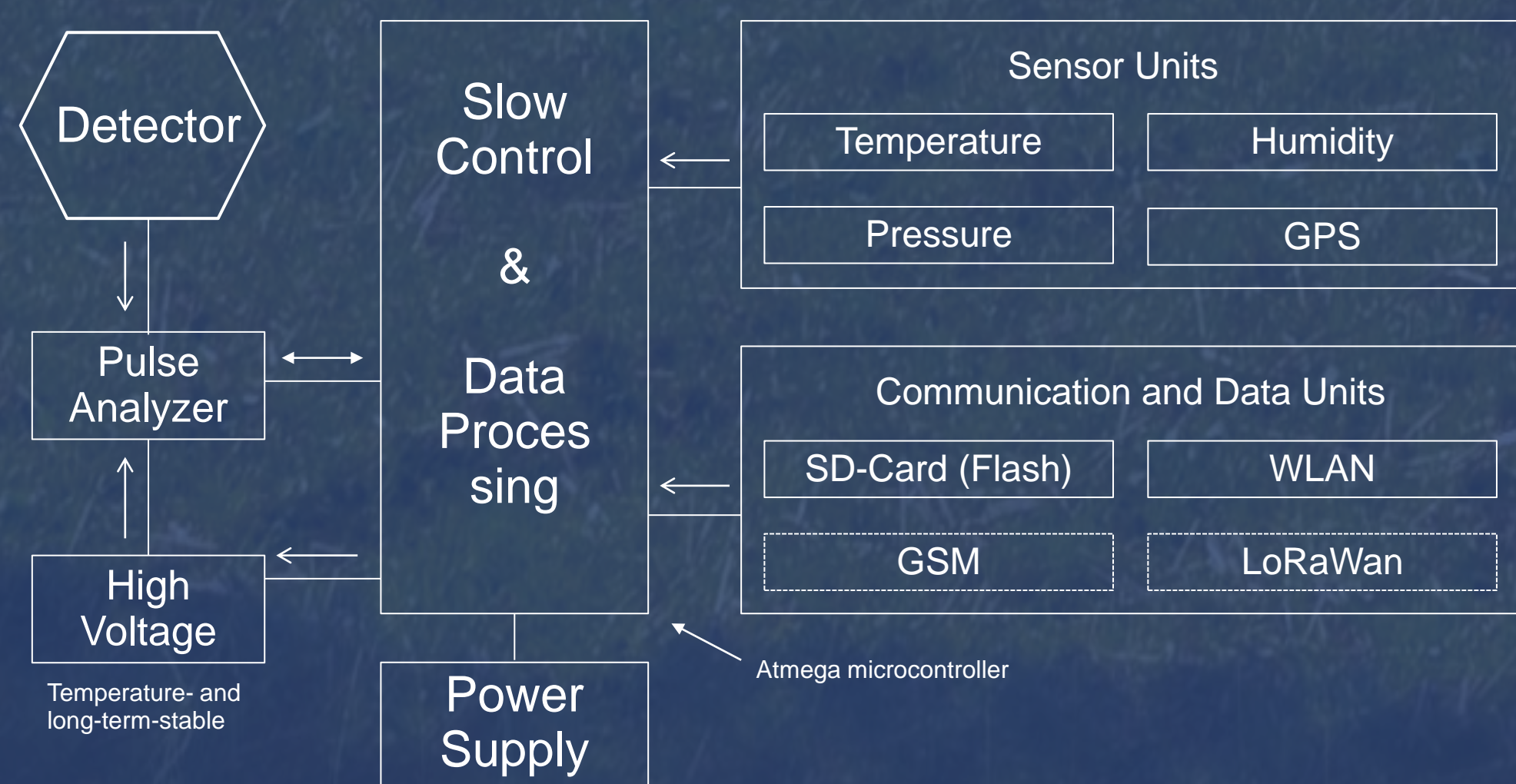


### Electronics

#### Read-out unit (Pulse Analyzer)



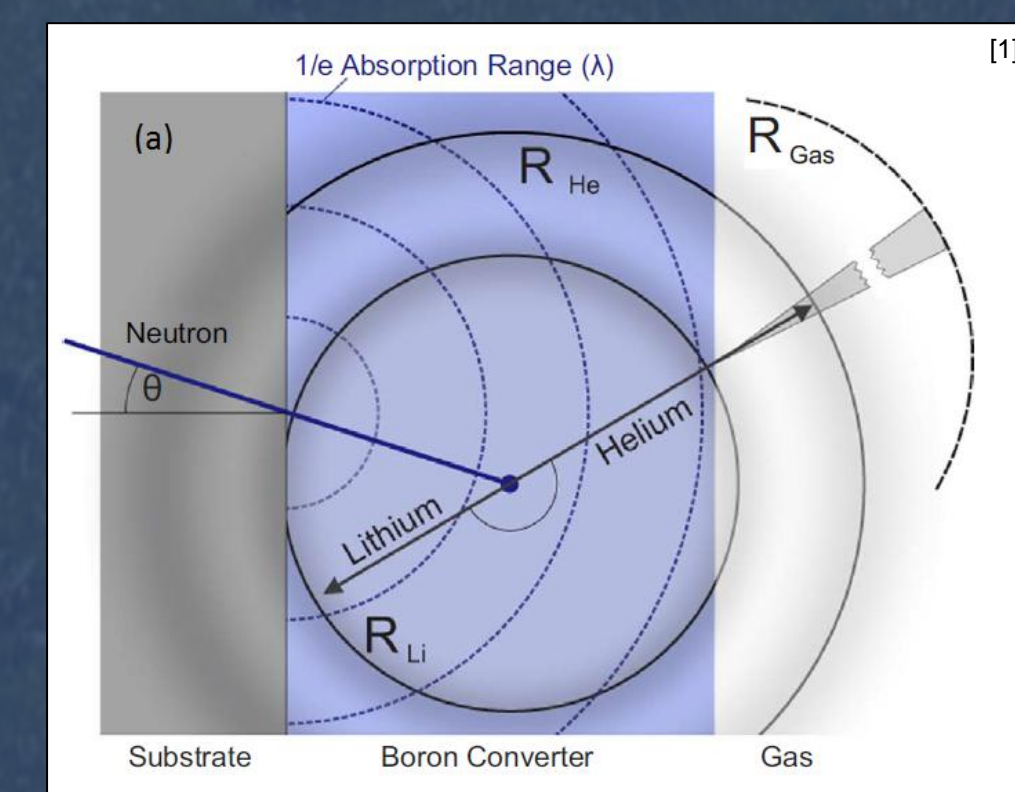
#### Entire electronics setup



### Summary/Advantages

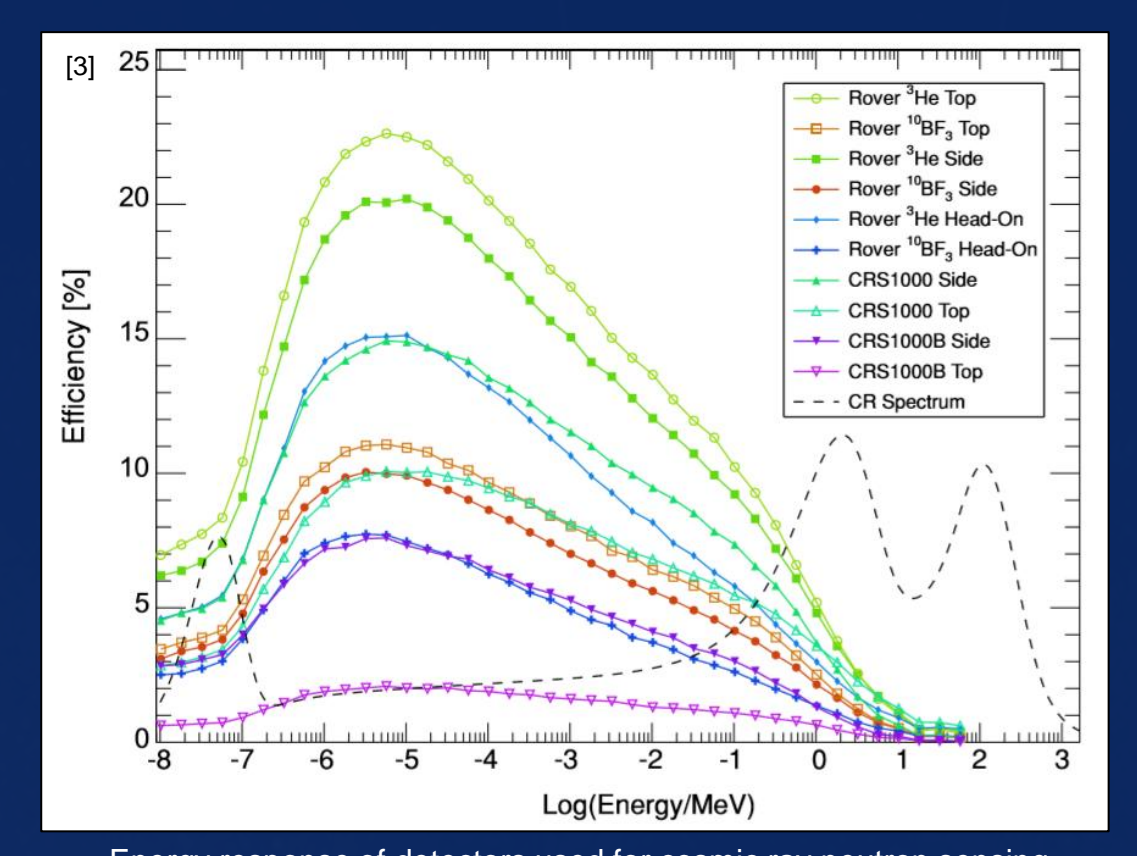
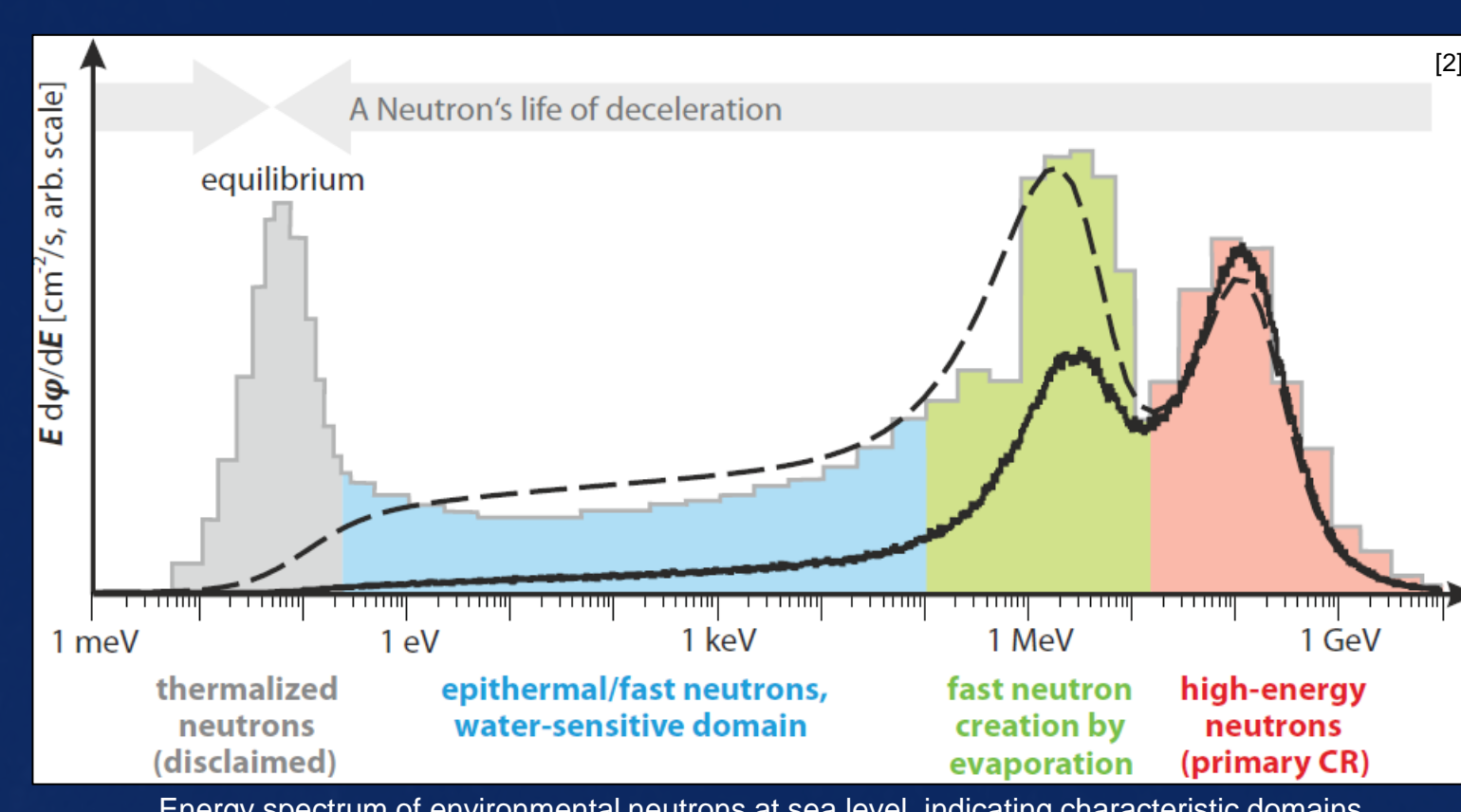
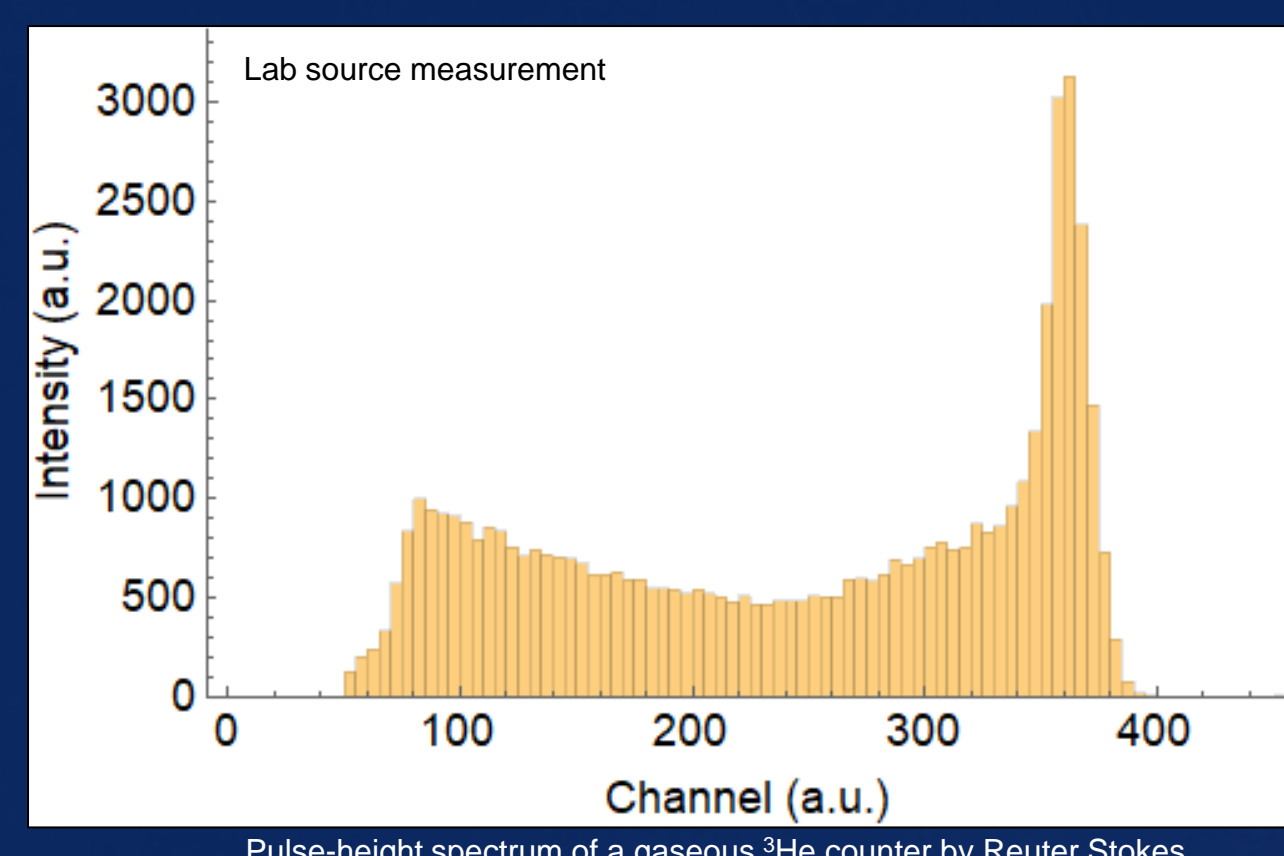
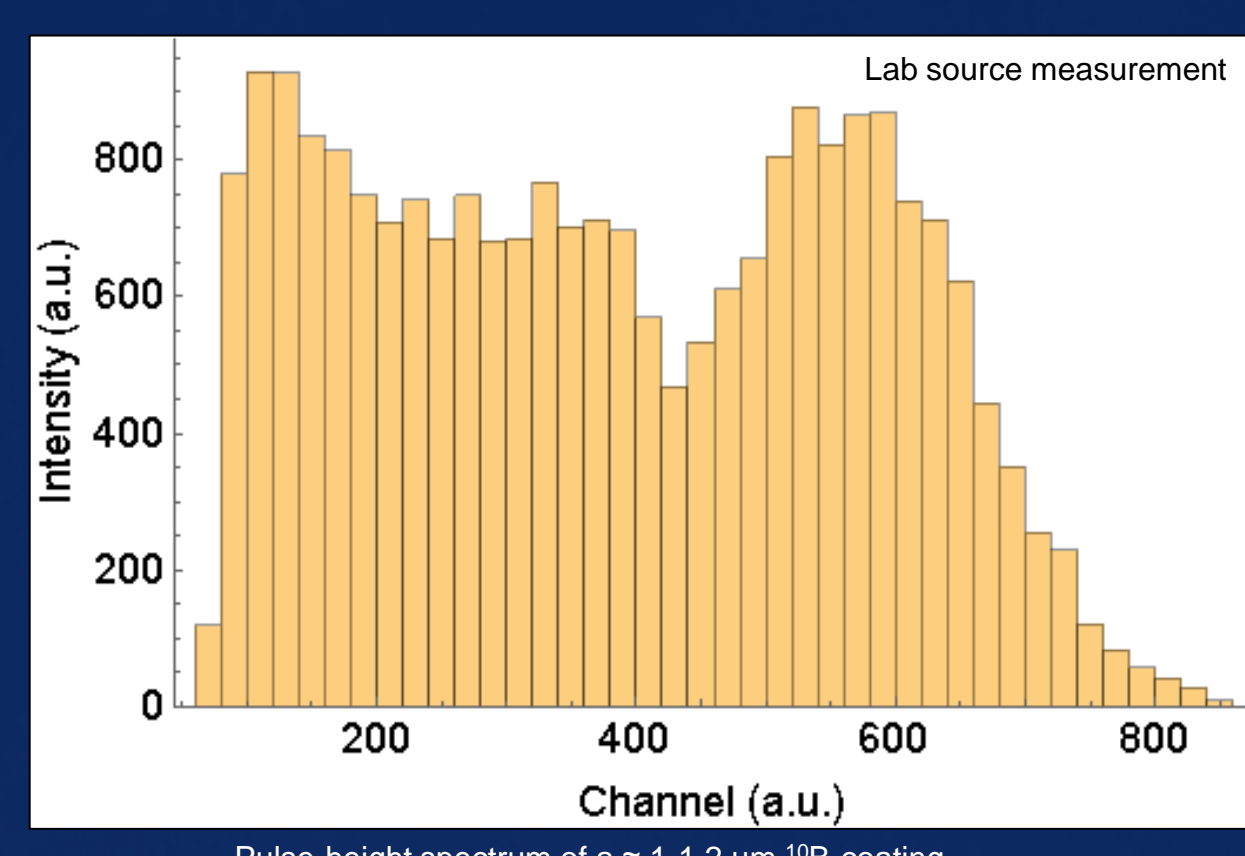
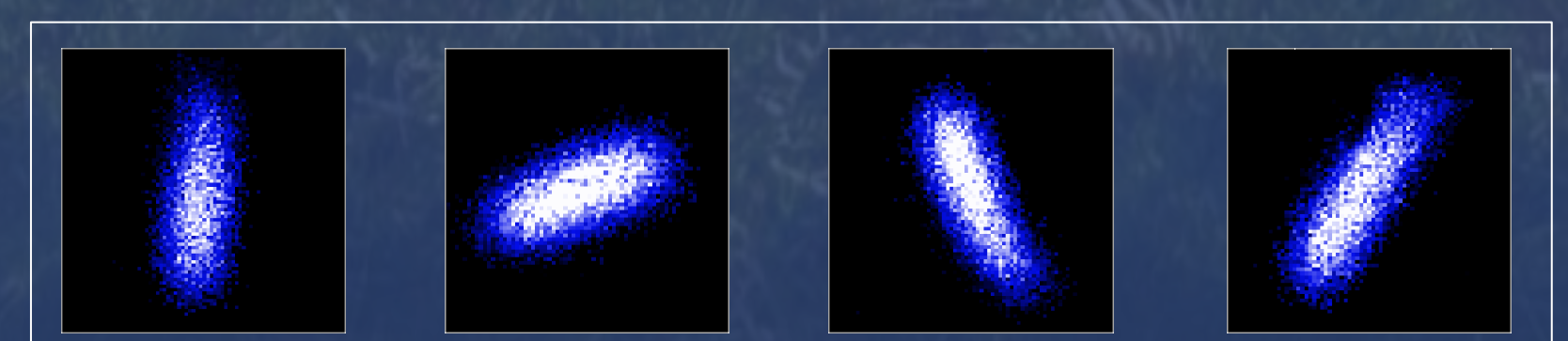
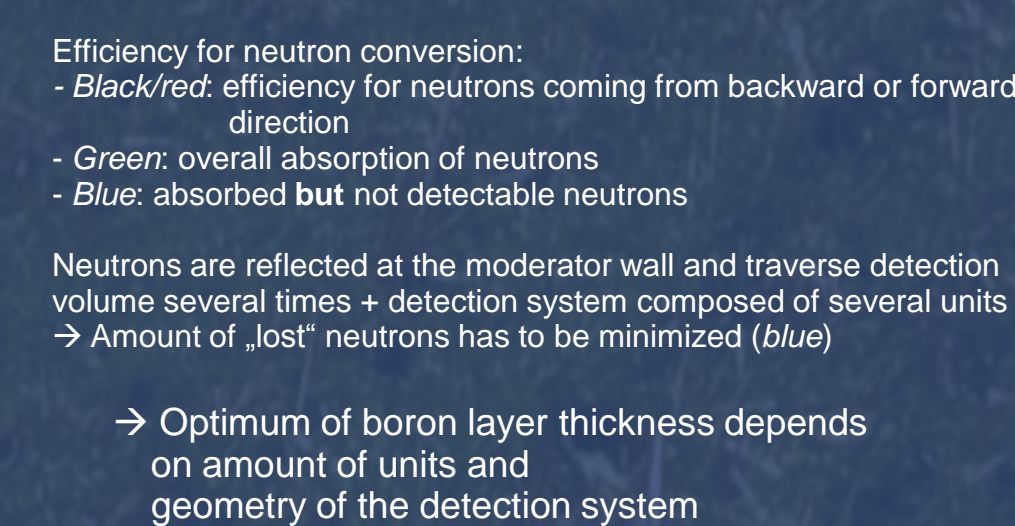
- Modular detection system of boron-lined proportional chambers
- Simple, robust and temperature-stable electronics (based on open hardware)
- High count rate by
  1. large effective area
  2. overall high efficiency
- Modular system allows for easily upgrading/downgrading the system if detectors are needed elsewhere
- Lightweight: future application for airborne neutron detection
- Advanced discrimination of background radiation
- Shielding against thermal neutron leakage
- Ar/CO<sub>2</sub> counting gas: cheap and hazard-free

### Physics: Neutron Conversion in solid Boron



- Nuclear reaction takes place inside solid coating
- reaction products lose energy on their path through boron layer
- only energy deposited in gas volume can be detected
- Critical compromise between neutron absorption and absorption range of reaction products determines efficiency of detection unit

→ Limited efficiency of a single boron-lined detection unit (boron layer thickness is the crucial parameter)



### Additional Information

[1] Köhli et al.: Efficiency and spatial resolution of the CASCADE thermal neutron detector. In: Nuclear Instruments and Methods 828 (2016)  
[2] Köhli et al.: Footprint characteristics revealed for fast-neutron soil moisture monitoring with cosmic ray neutrons. In: WRR 51 (2015)  
[3] Köhli et al.: Response Functions for Detectors in Cosmic-Ray Neutron Sensing. In: WRR 51 (2015)

