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Next generation Portable Neutron detector

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Nuclear Security Detection
STFC knowledge exchange workshop
Nuclear Security Science Network

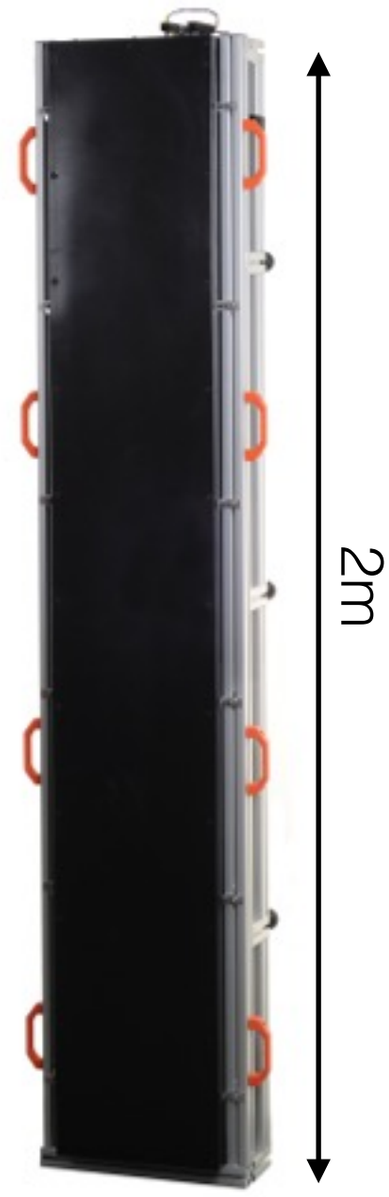
Science & Technology Facilities Council

Detection sensor networks

- Detection of nuclear threats can be greatly enhanced by radiation sensor networks
  - demand a large number of devices that connects to the network
  - can be transported for wider coverage
- Particularly well suited for
  - Special events with no port of entry and no facility available
  - Urban settings which covers even greateer area
- They could also improve screening at Border crossing and Ports of Entry
- Combined with other data sets and algorithmic, this approach can solve some of the very hard problems facing the community

Our approach

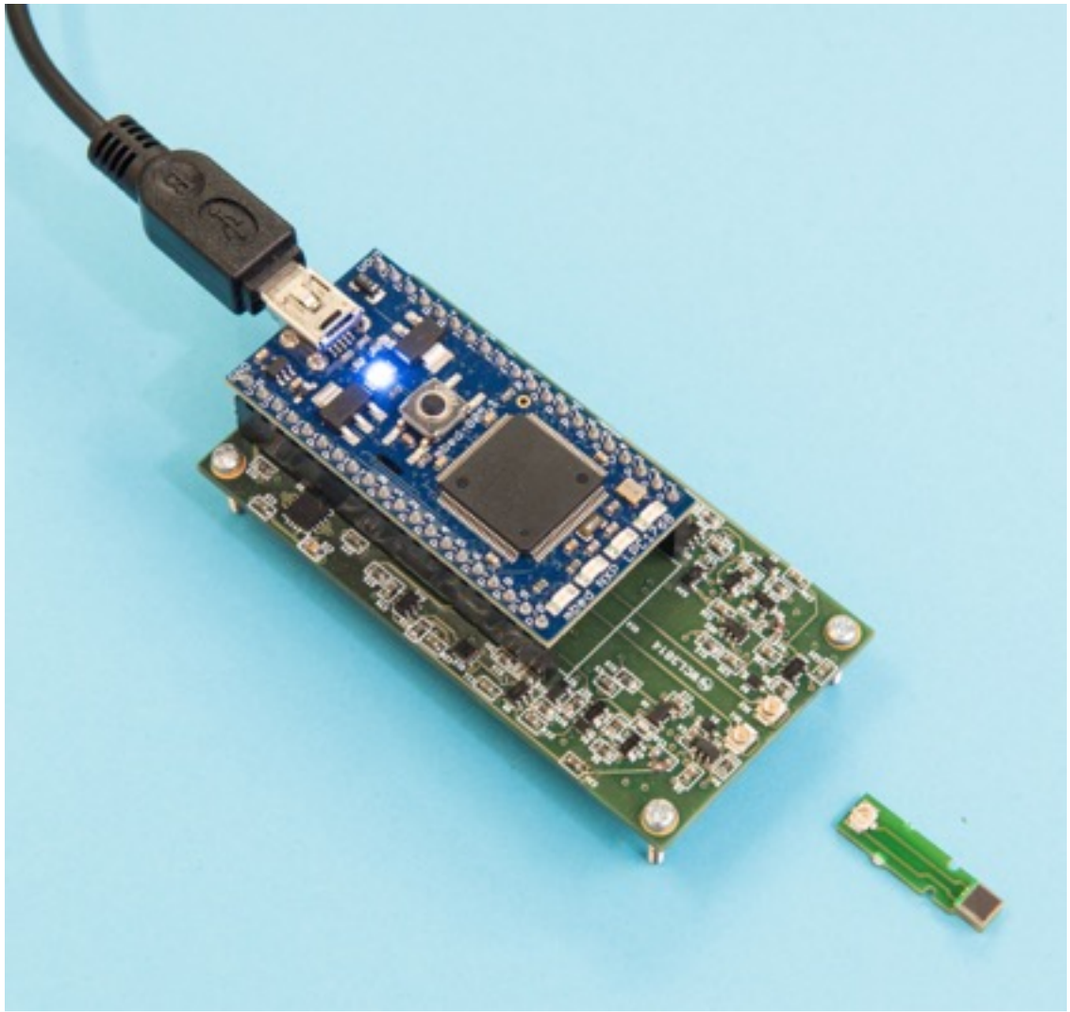
- technology based on LiF:ZnS(Ag) for neutron detection (WO/2013/027069)
  - First SiPM-based large system (RPM prototype) was validated in 2013
    - high efficiency and high discrimination achievable (3.05cps/ng, Garrn ~ 1.01)
      - compact read out
- multi-channel system
  - combine segmentation with gamma-ray and neutron signature to improve identification
- Built in “intelligence” i.e. front-end processing
  - reduce data size



Performance of a Prototype Large Area Neutron Detector Based on (LiF)-Li-6:ZnS(Ag) with MPPC Read-out
2013 IEEE NSS-MIC 10.1109/NSSMIC.2013.6829532

Handheld : signal processing unit

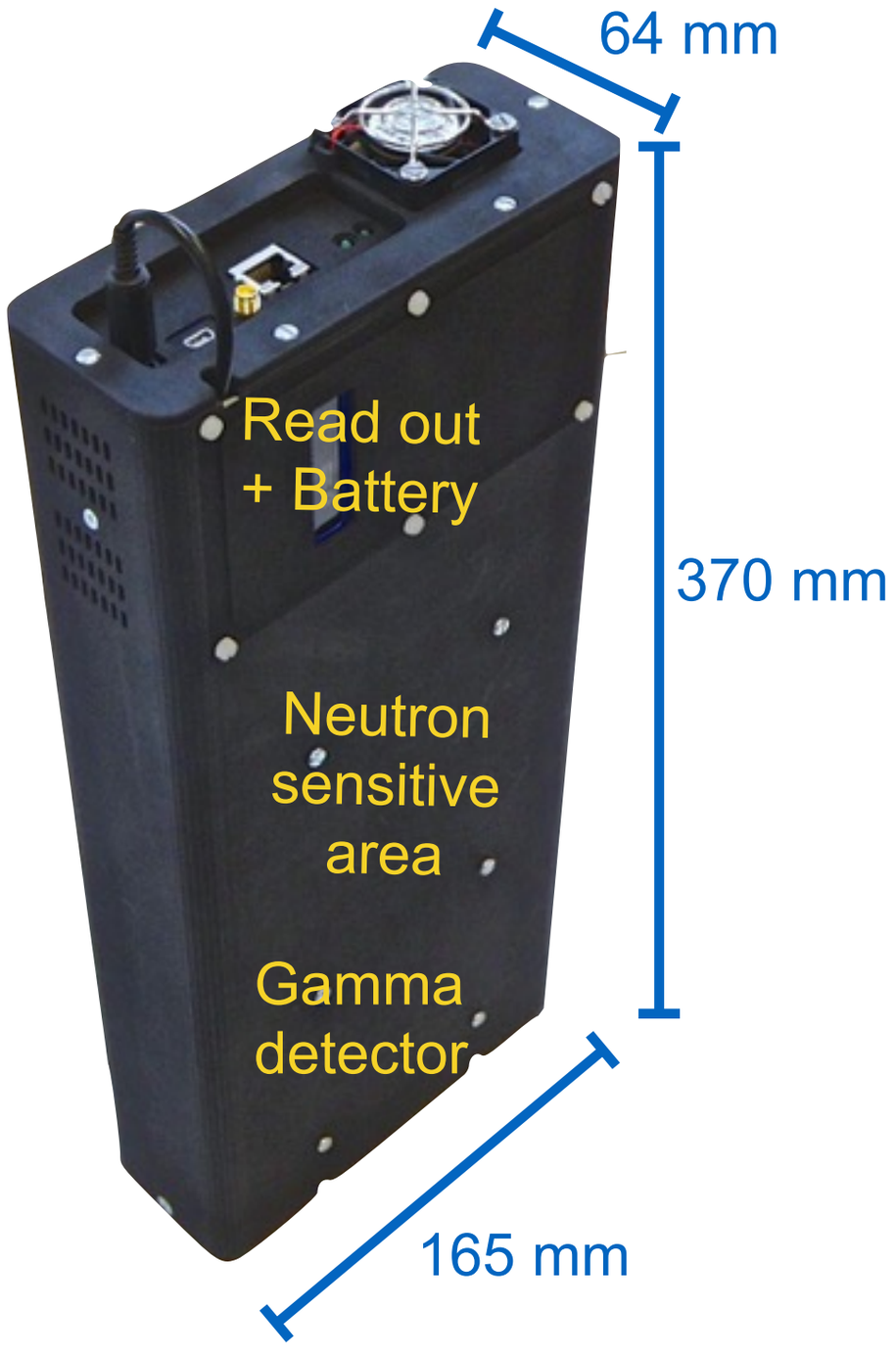
- reduce cost per channel / low power
- Use ARM mbed CORTEX-M3 platform LP1768
    - Connect via USB / Bluetooth
    - Programmable firmware for signal processing
    - Sampling rate up to 10kHz
- Front-end board for sensor signal amplification and triggering
- temperature sensors for gain drift correction
- Can connect to a variety of radiation sensor and connect to computers / phones



“backpack” portable unit

- Single “generic” unit with integrated electronics to fit in backpack
- Bare system : additional moderator added for specific applications
- LiF:ZnS(Ag) & CsI(Tl)
- units can be mounted as an “array” or used standalone
    - USB/ETH connectivity

“backpack” portable unit



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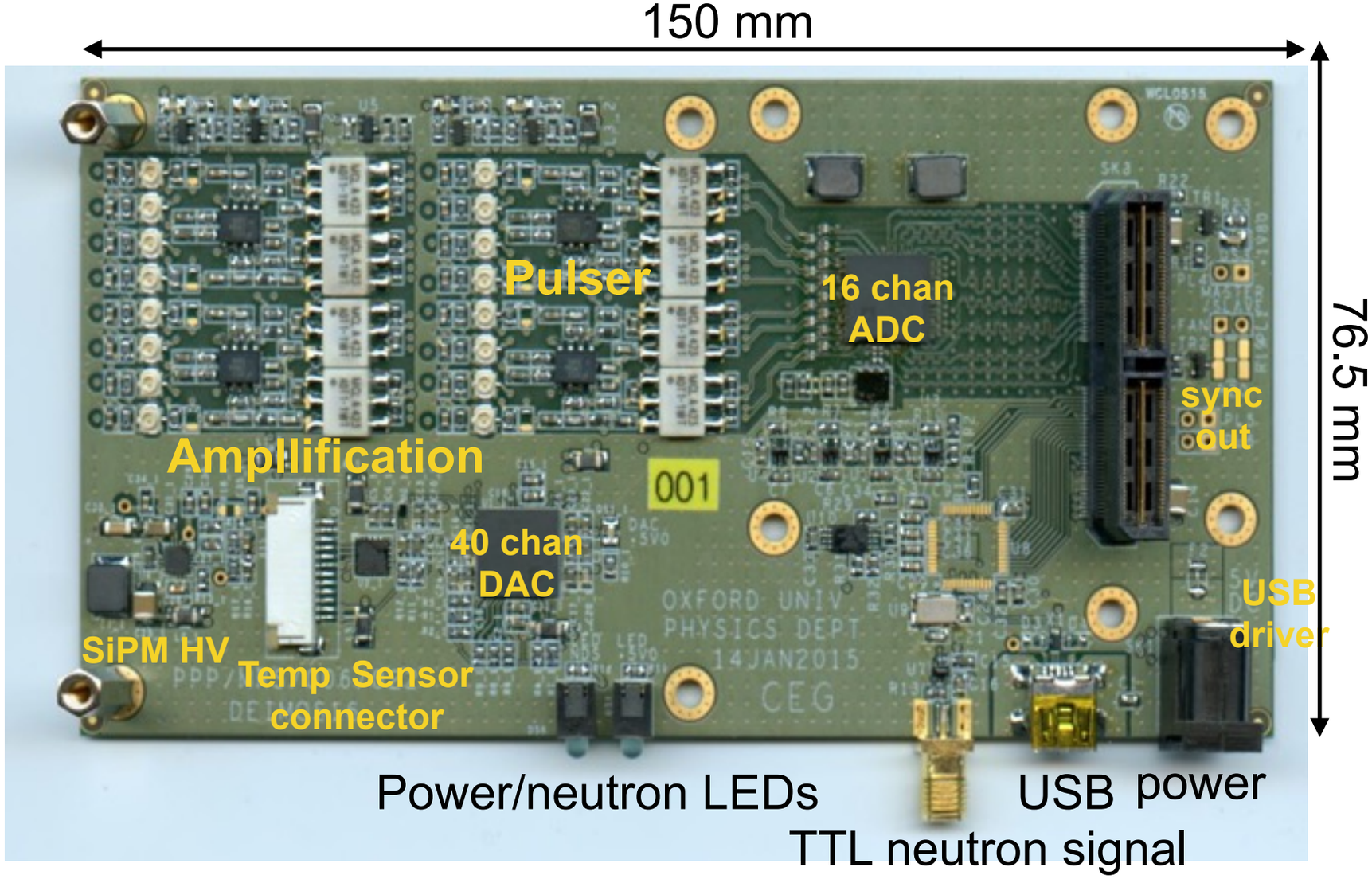
Electronics



Orange Tree
ZESTET1 board

Gbit ETH

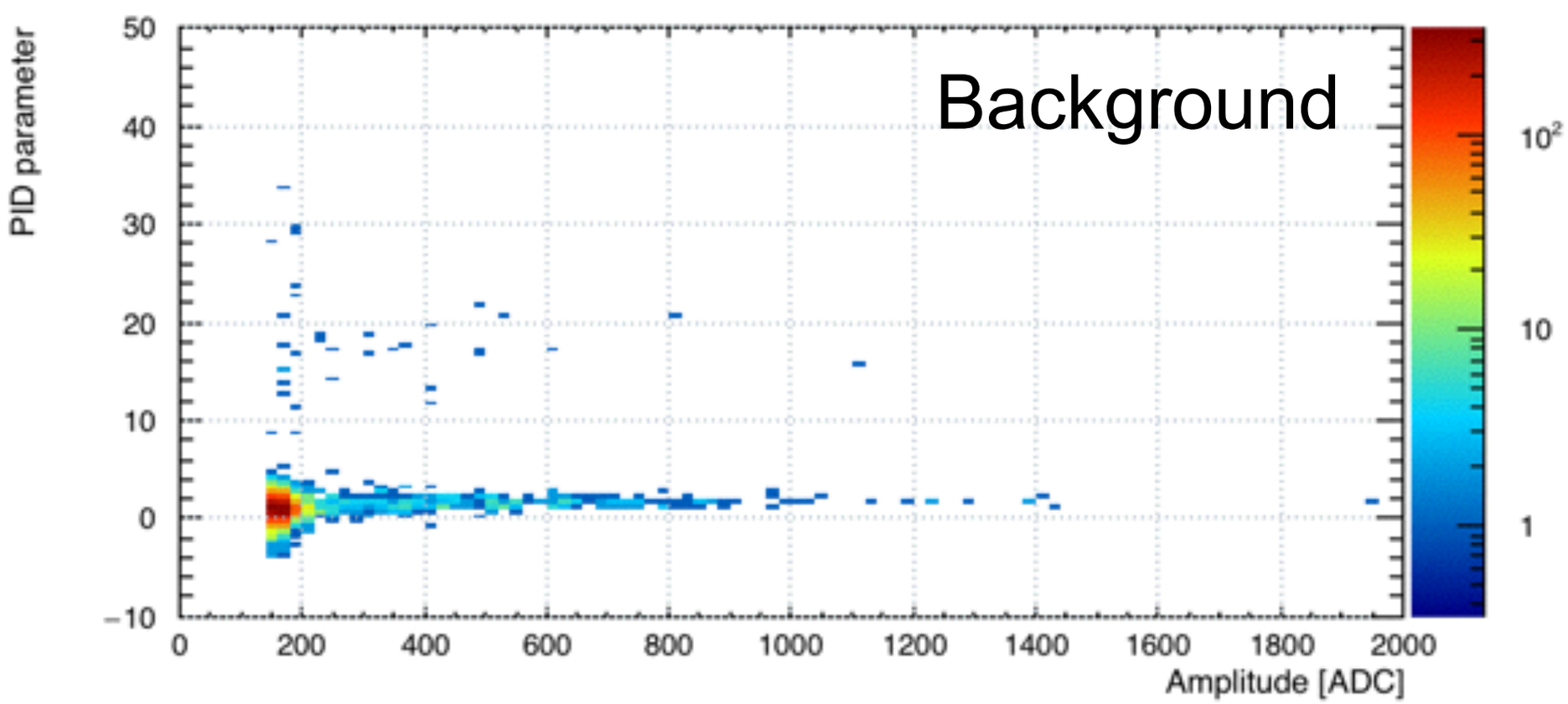
- Compact design, 16 channels Dual ETH/USB
- On board SiPM voltage supply and external temperature sensor connector
- ZESTET1 Spartan3 FPGA, Trigger and waveform digitisation at 33 MS/S
- Max rate ~ 4kHz currently limited by DAQ software, 1AmpH power consumption

Measurements

- First measurements with neutrons sources
  - AmBe
- tested system at NPL neutron facility
- Cf and AmLi

Neutron identification

- Use pulse shape characteristics to identify neutrons
  - not optimised, for demonstration only
- Efficiency currently limited by threshold at low energy



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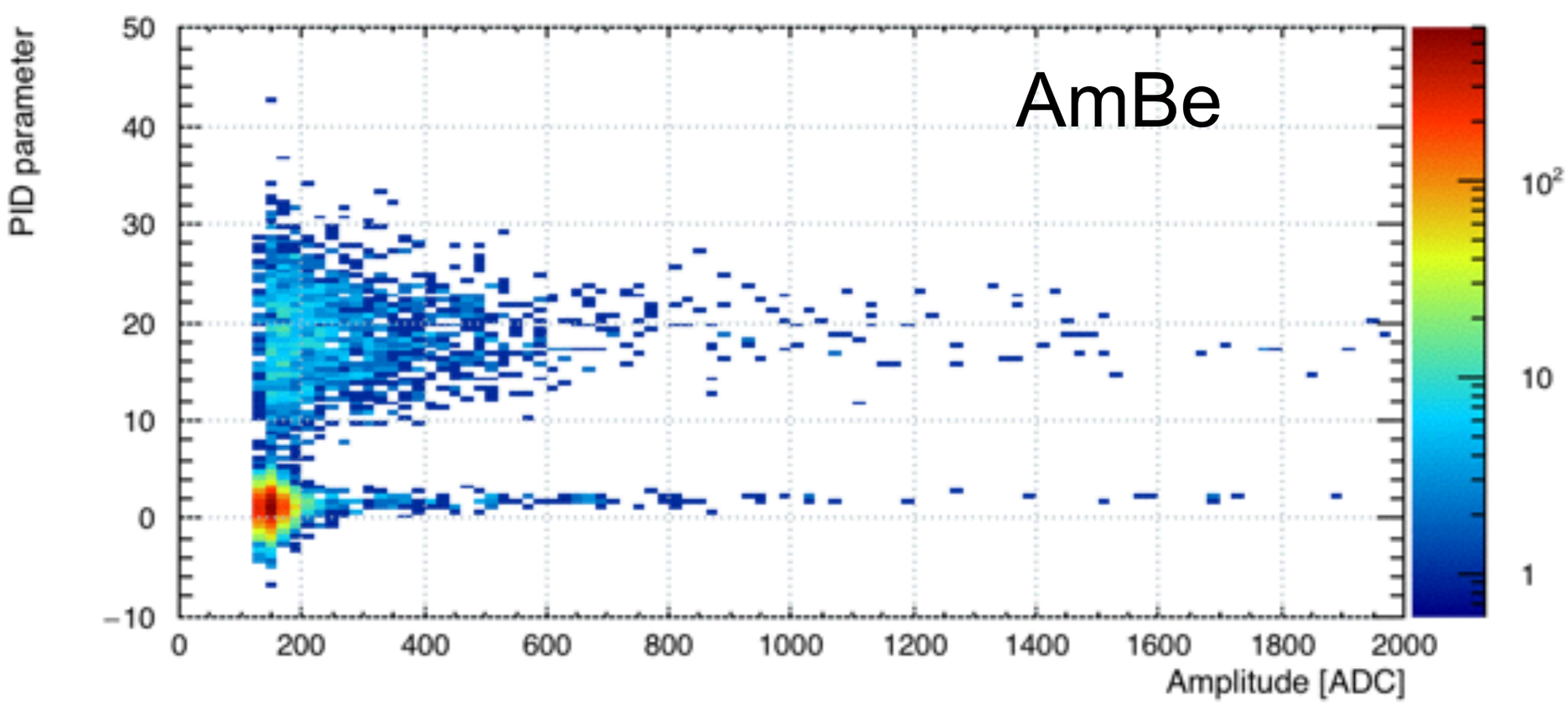
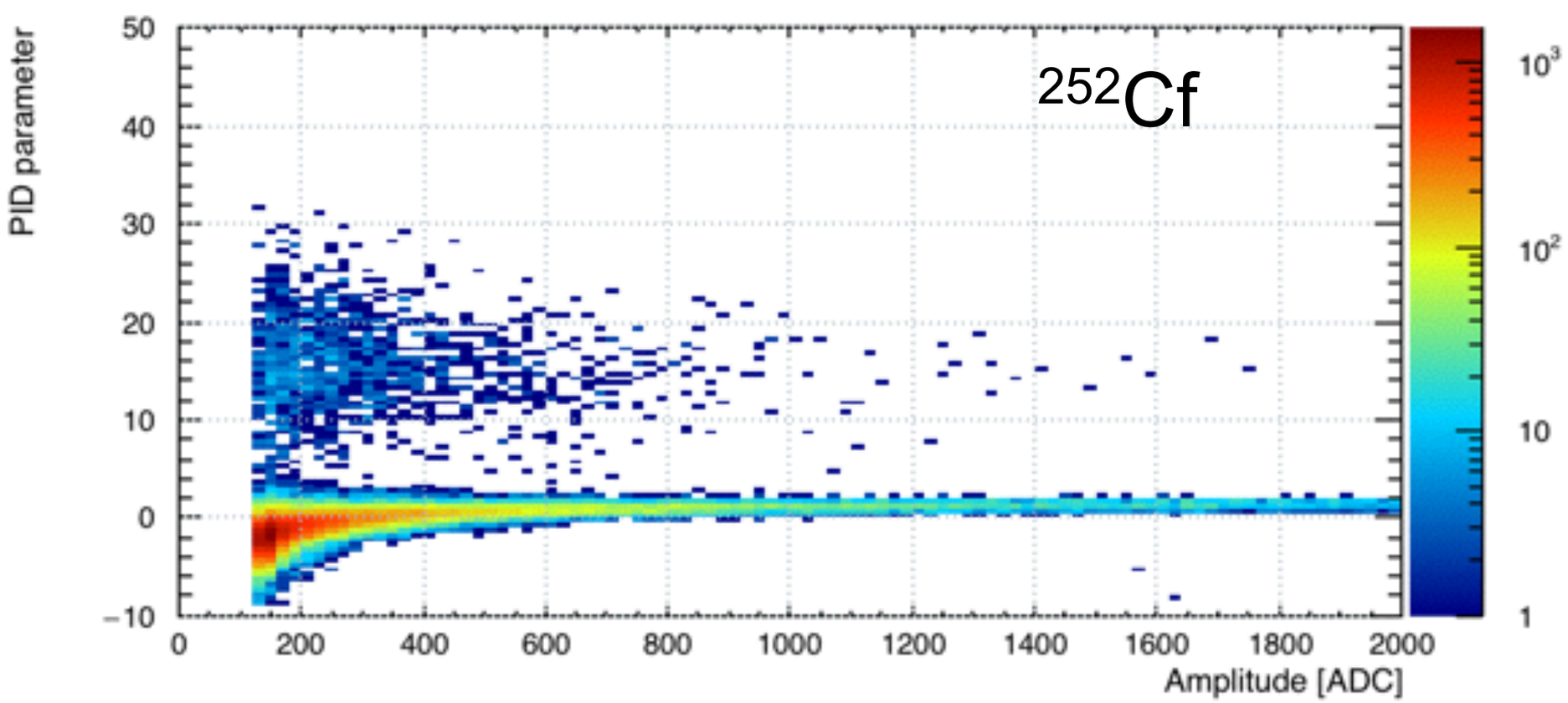


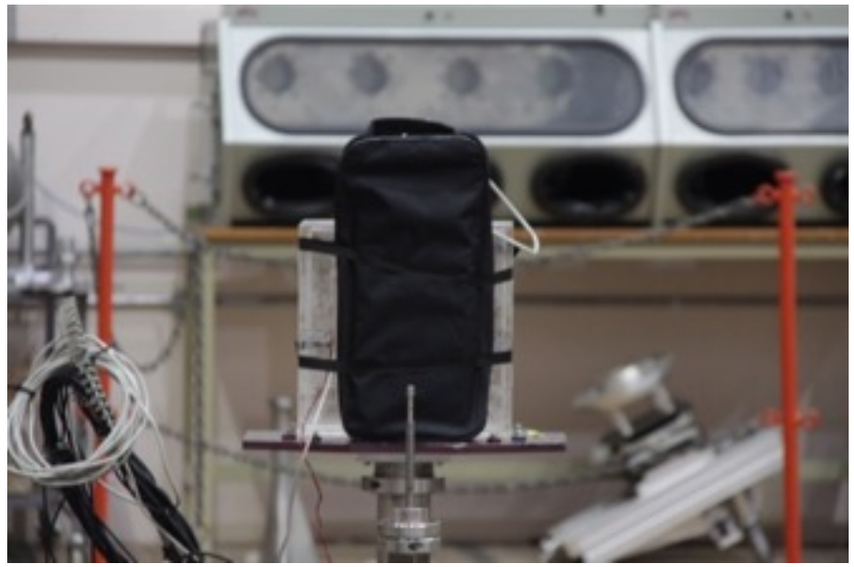
Neutron identification LiF:ZnS + PVT plastic

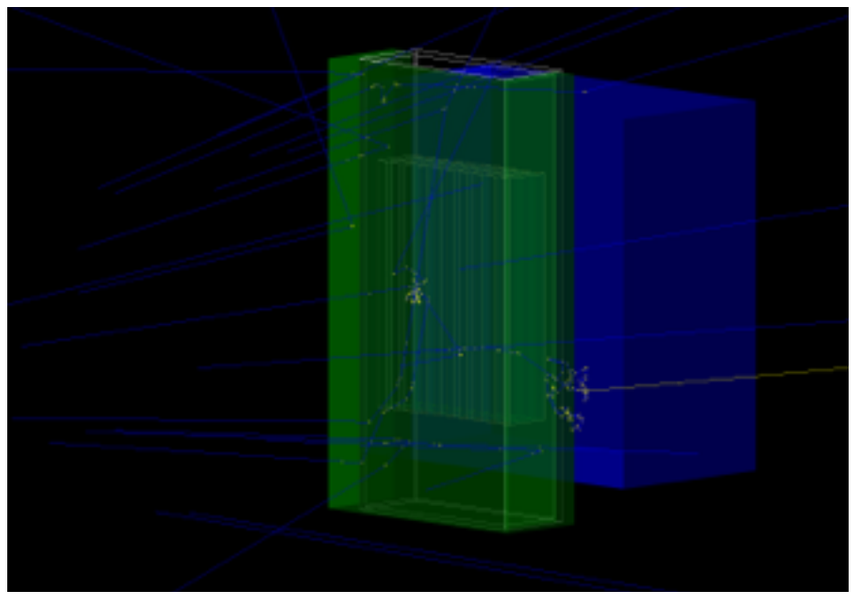
- System with added PVT scintillator read out by same Sensor
  - doesn’t affect PID



Effect of “body”

- Tested the variation of efficiency due to presence of moderator



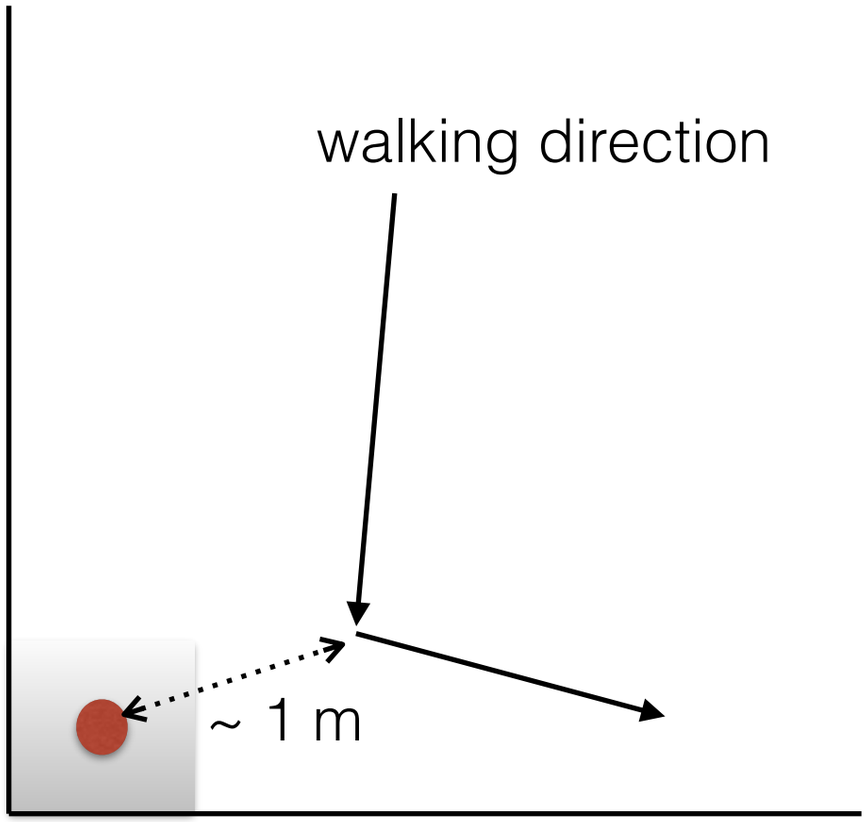


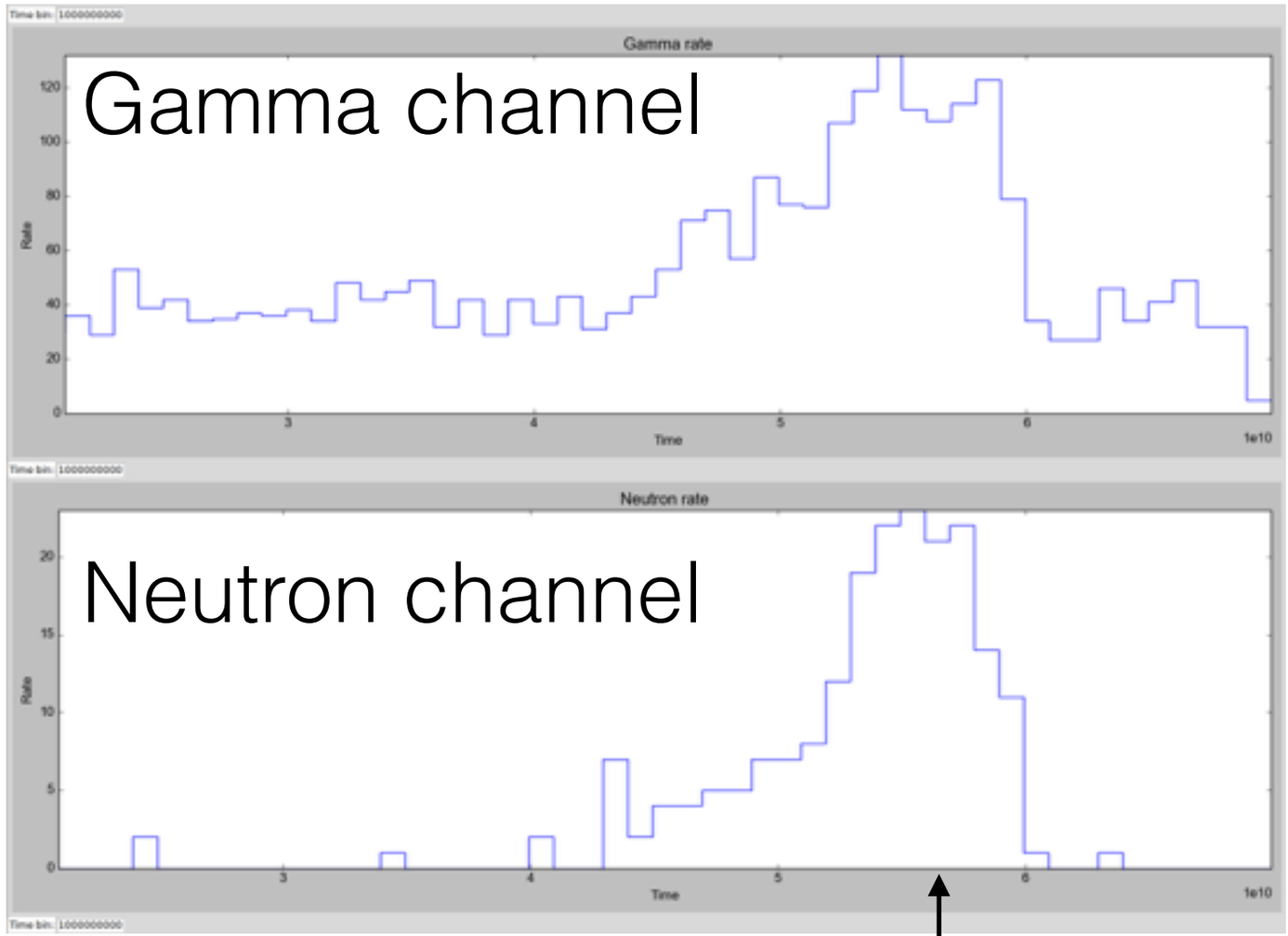
Geant4 MC simulation

Phantom body	Data	Sim
none	1	1
Back	4.2	6.7
Back with 1.5 cm front moderator	N/A	10

Neutron source detection

- detection of PE shielded AmBe source at proximity of detector





Summary

- a portable neutron detector and a signal processing units for the sensor network era have been succesfully developed and tested
  - based on robust LiF:ZnS(Ag) neutron detection
  - combine segmentation and gamma-ray detection to improve identification
- future work
  - complete testing of a handheld system
  - improve firmware for backpack unit (increase sensitivity)
  - develop network management software
- open to new collaboration and interest
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