

Arduino-based readout electronics for particle detectors

University projects



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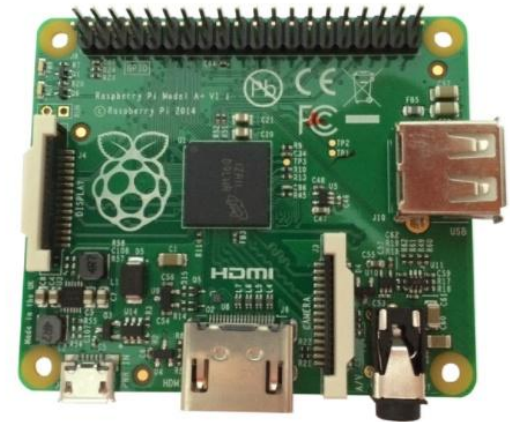
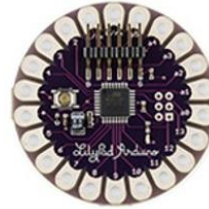
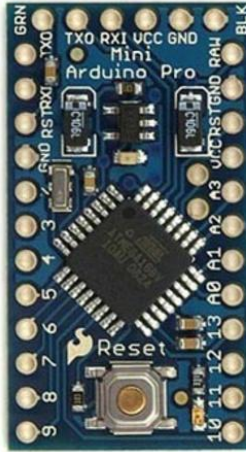
25.03.2019

Markus Köhli

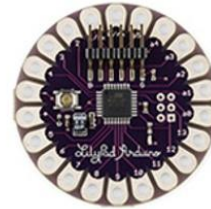
Jannis Weimar, Fabian Allmendinger, Fabian Schmidt,
Klaus Desch, Ulrich Schmidt

DPG Frühjahrstagung
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Pocket Computers

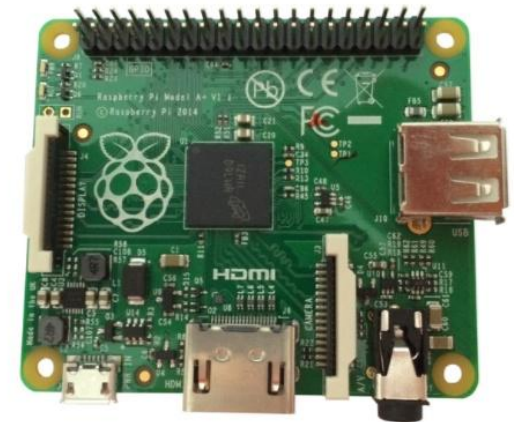


Pocket Computers



Arduino
(Microcontroller)

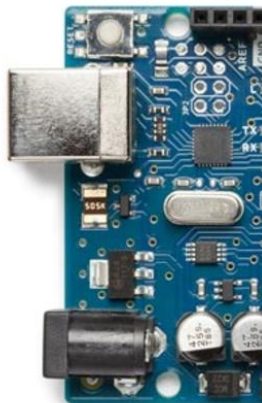
Raspberry Pi
(Single Board Computer)



Arduino vs Raspberry

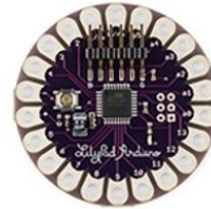
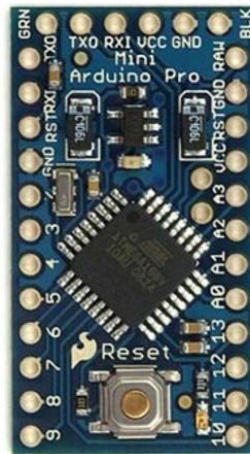
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	Arduino Uno	Raspberry Pi Model B
Price	\$30	\$35
Size	7.6 x 1.9 x 6.4 cm	8.6cm x 5.4cm x 1.7cm
Memory	0.002MB	512MB
Clock Speed	16 MHz	700 MHz
On Board Network	None	10/100 wired Ethernet RJ45
Multitasking	No	Yes
Input voltage	7 to 12 V	5 V
Flash	32KB	SD Card (2 to 16G)
USB	One, input only	Two, peripherals OK
Operating System	None	Linux distributions
Integrated Development Environment	Arduino	Scratch, IDLE, anything with Linux support





Why are they so popular?

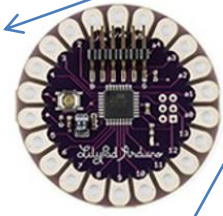
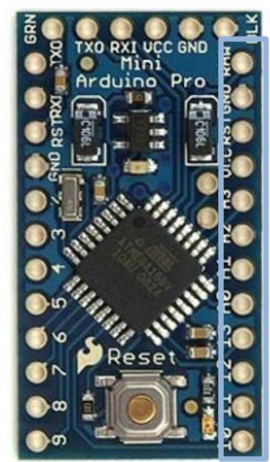


Arduino
(Microcontroller)

Raspberry Pi
(Single Board Computer)



Why are they so popular?



GPIO Pins
General Purpose
Input Output

Arduino
(Microcontroller)

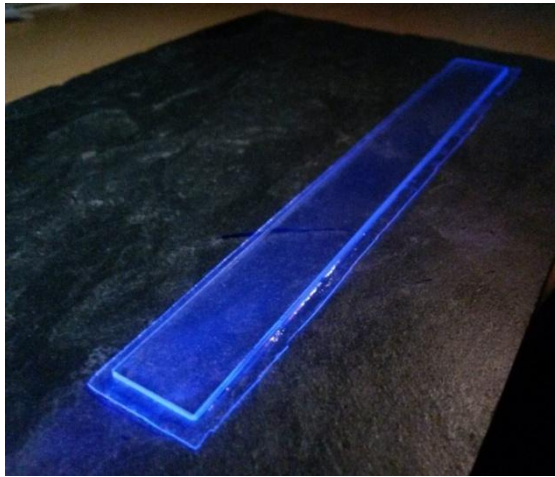
Raspberry Pi
(Single Board Computer)



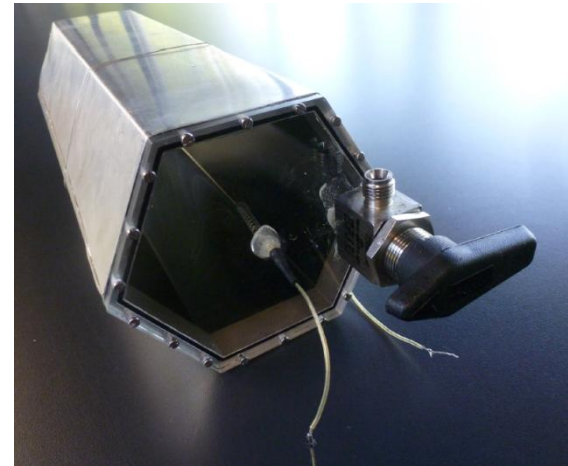


Scientific Research Projects

Scintillators

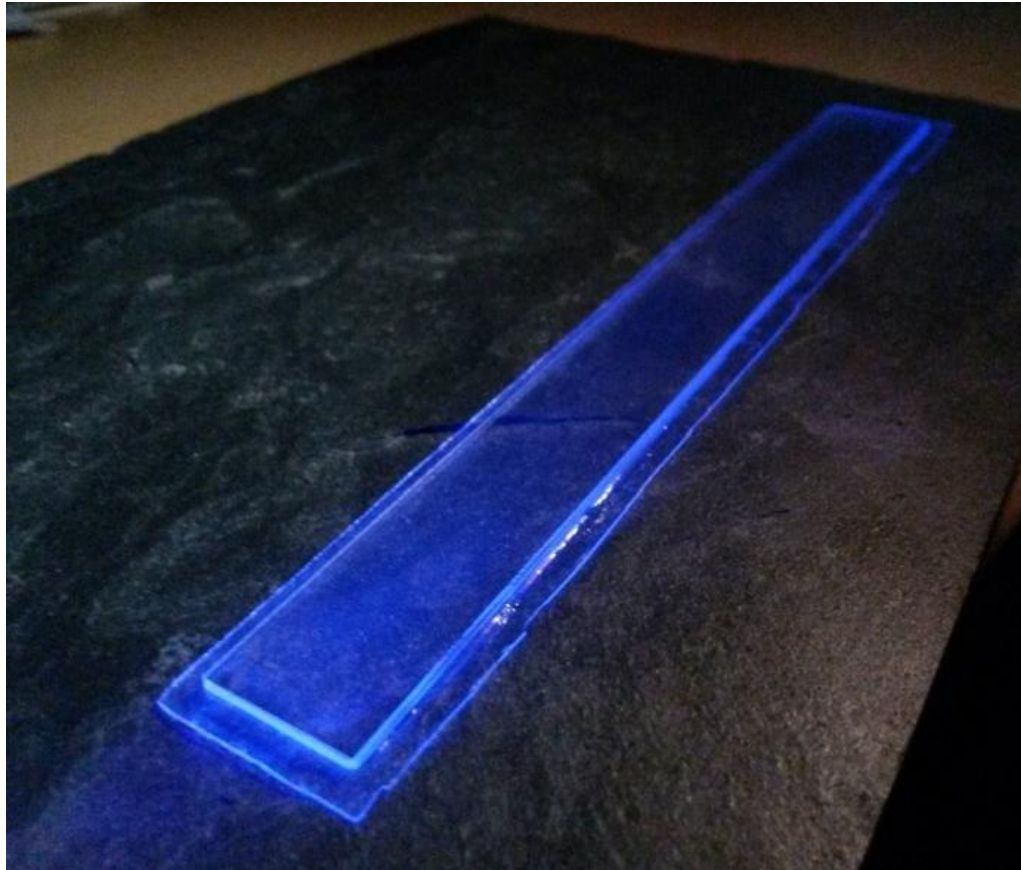


Proportional counter



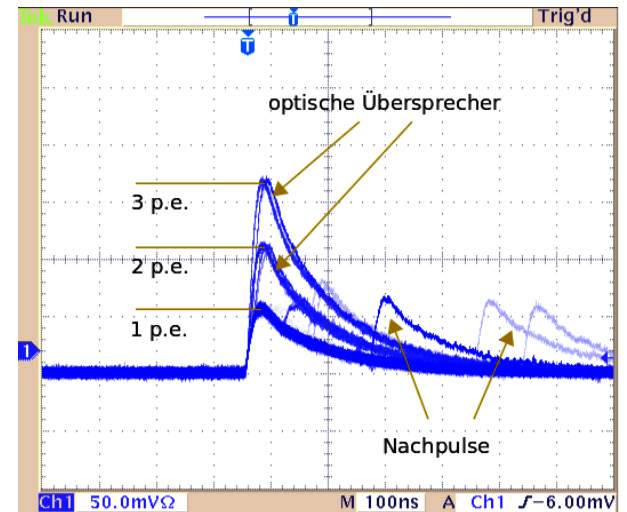
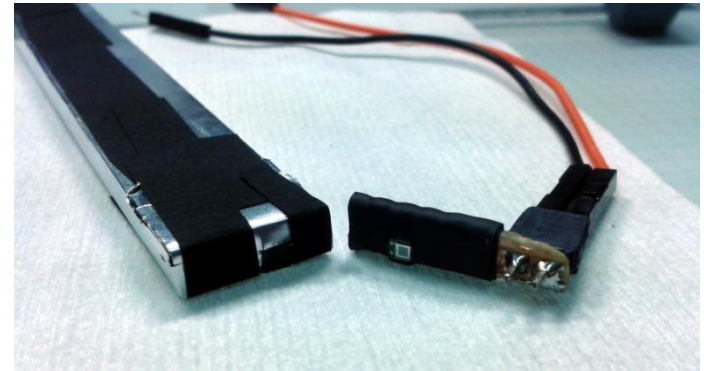
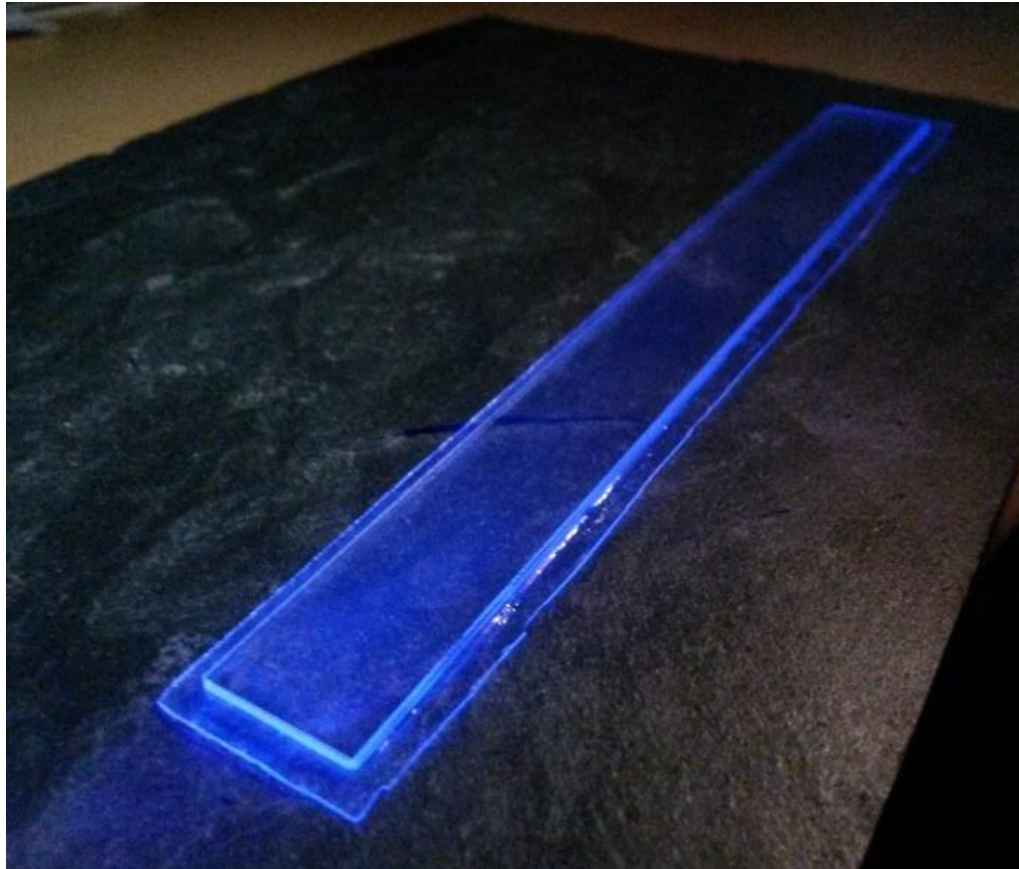


In Medias Res I



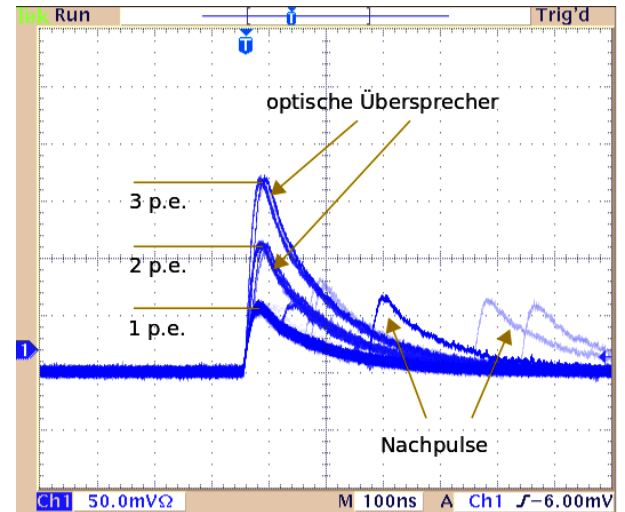
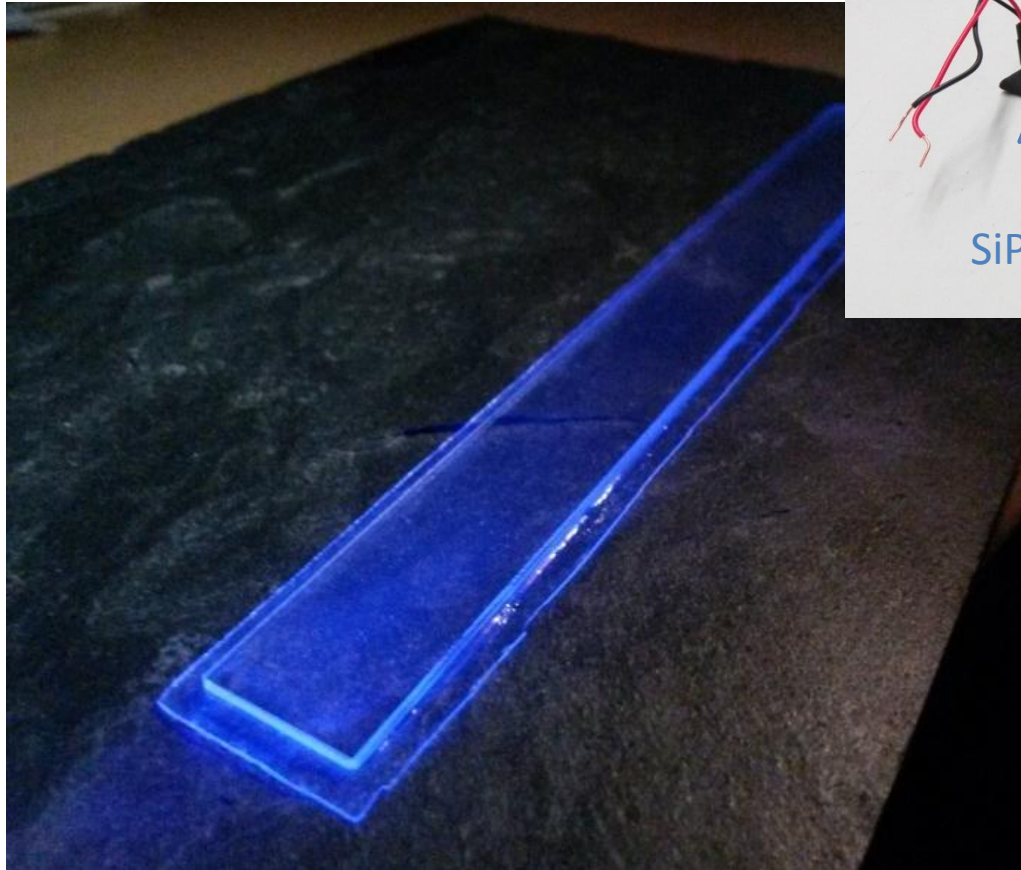


In Medias Res I



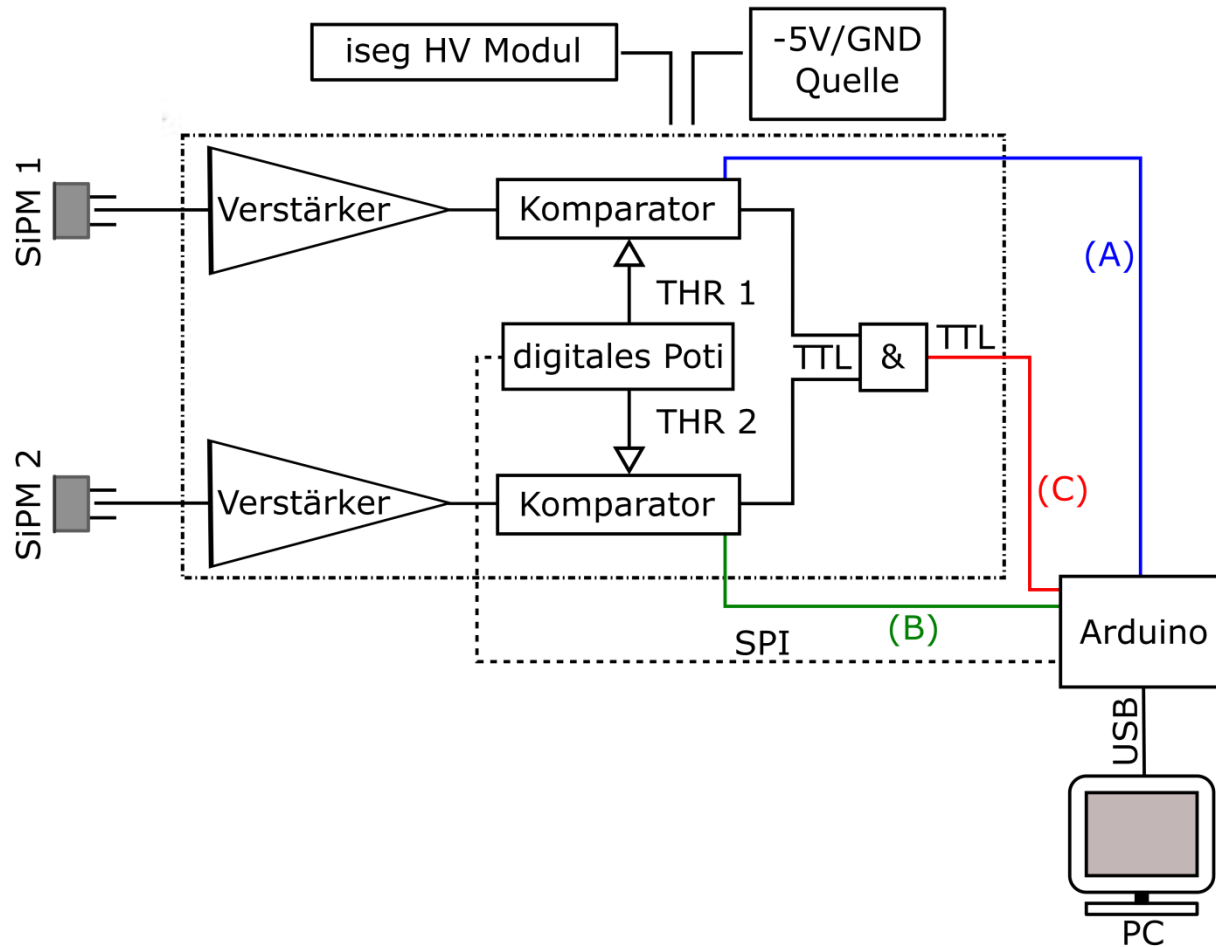


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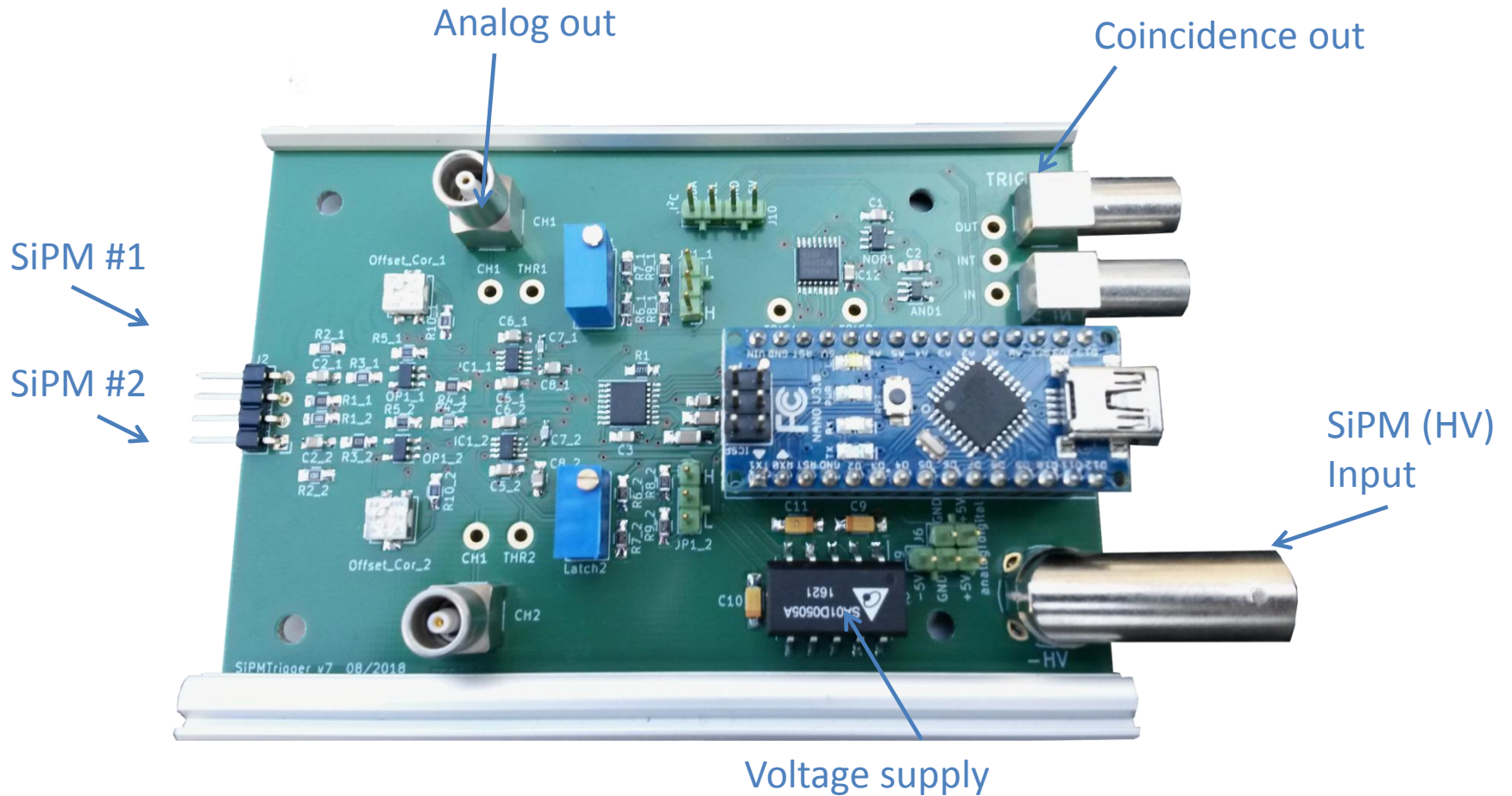


Electronic Schematic

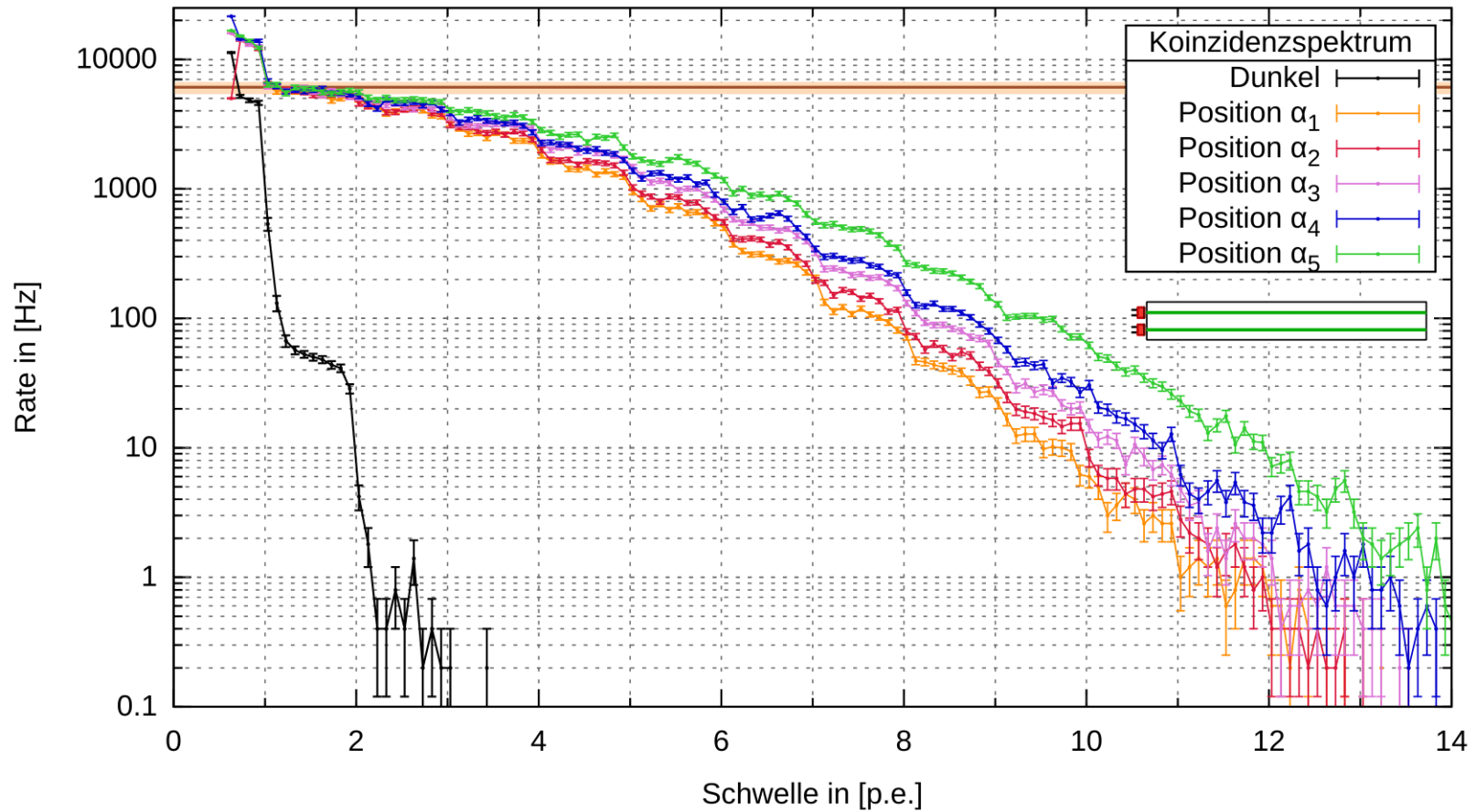
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SiPM Board



Measurements





SiPM Board Features

It's a Single Channel Analyzer:

- Designed to read out Silicon Photomultipliers
- Featuring:
 - Preamplifier + Mainamplifier
 - Digital Comparator
 - Arduino Nano
 - Counter

It's a Coincidence Counter:

- Comparator triggers nano's Input Capture Unit (ICU) if both pulses $>$ a THL voltage
- The full coincidence pulse height spectrum can be obtained by a THL Scan

Cost Calculation

Main Components:

PCB: ~20 €

PCB Components: ~28 €

Arduino NANO: ~10 €

Arduino Box: ~10 €

SiPM ~80 € (x2)

Optional:

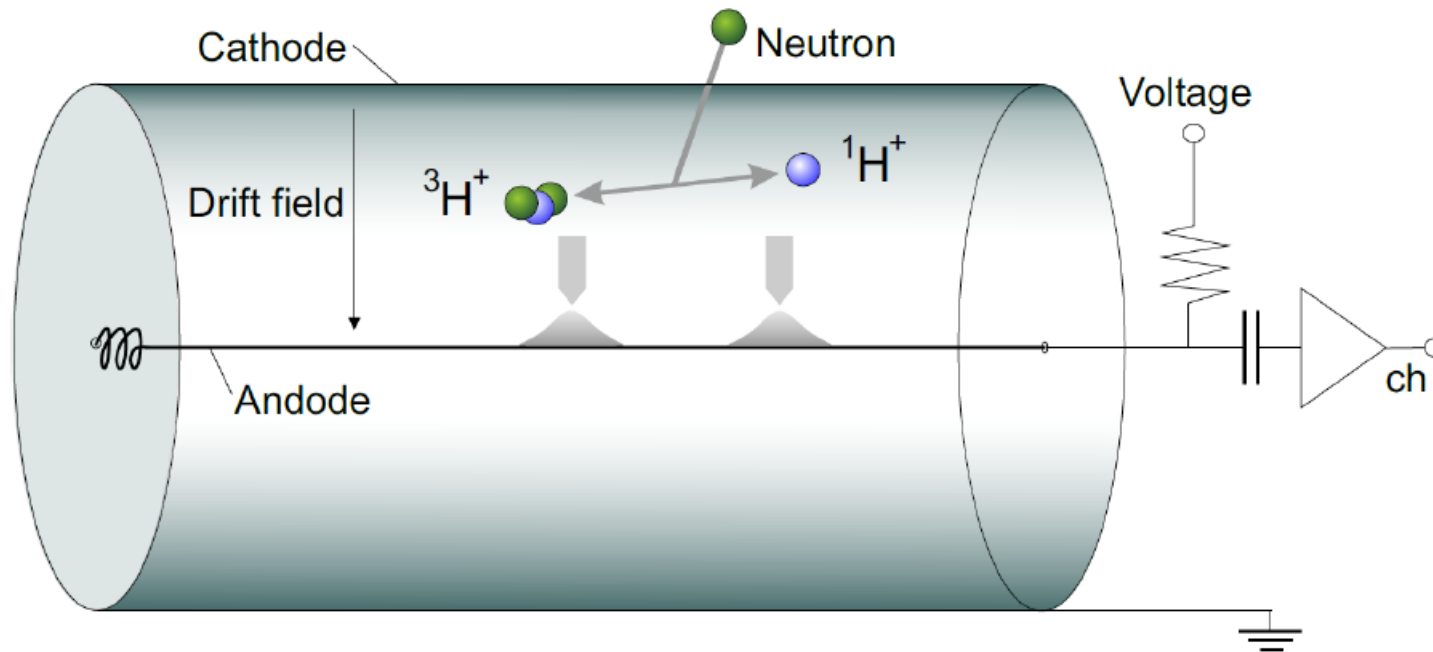
Coaxial Cable/Jacks: ~30 €

SD Card and RTC Shield: ~ 25 €

DC-DC Converter: ~ 15€



In Medias Res II





The neutron detector

nCatcher:
Pulse analyzer



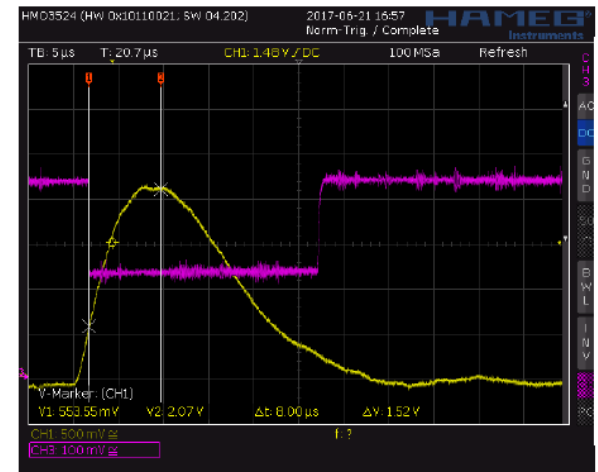
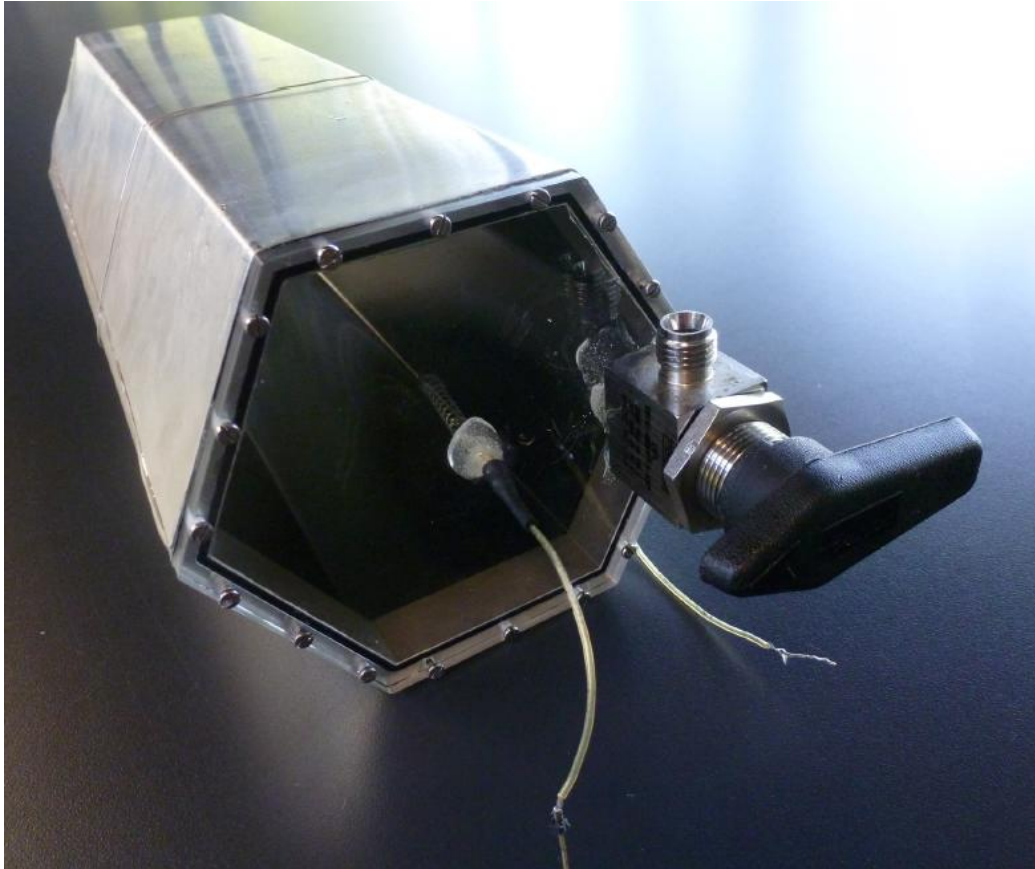
High Voltage
supply

Slow-control &
Data processing

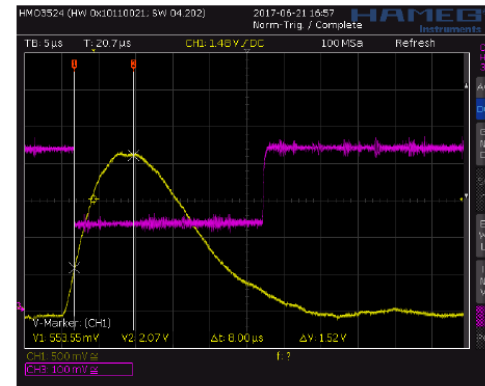
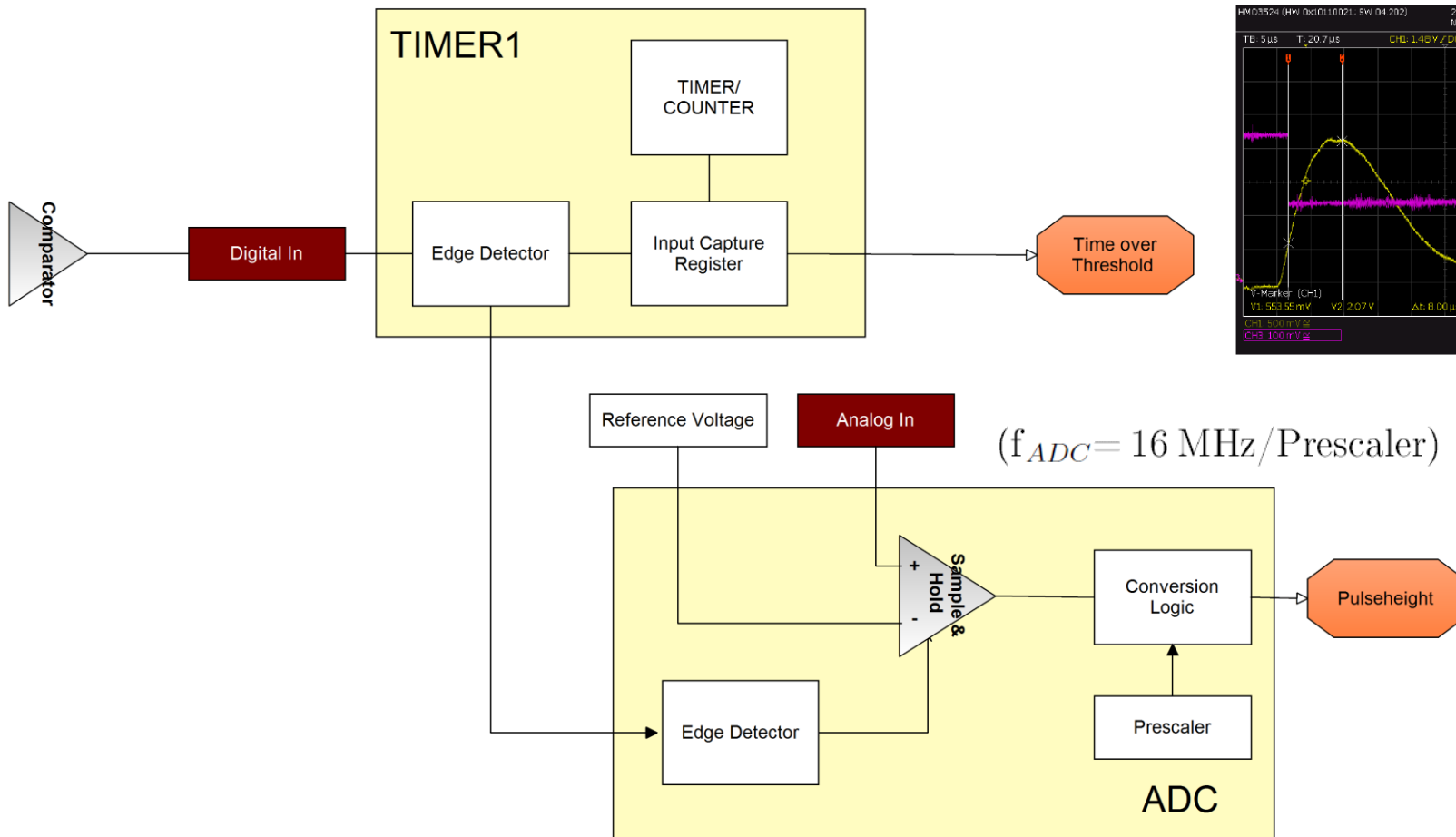
Detector unit



A proportional counter



The Single Channel Analyser

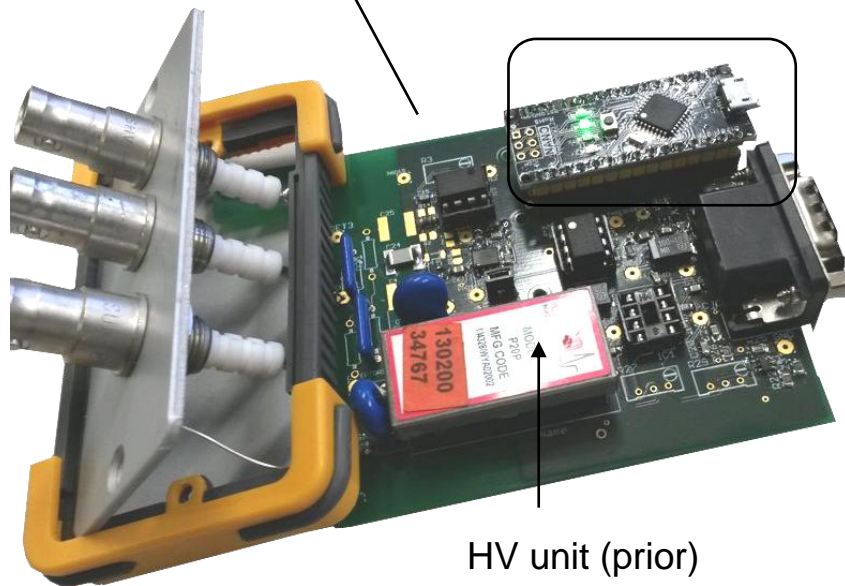


$$[\mu s] = \text{PRE}/16 * 13,5 + 3/16$$



nCatcher Board

nCatcher (Pulse Analyzer + Digitizer)



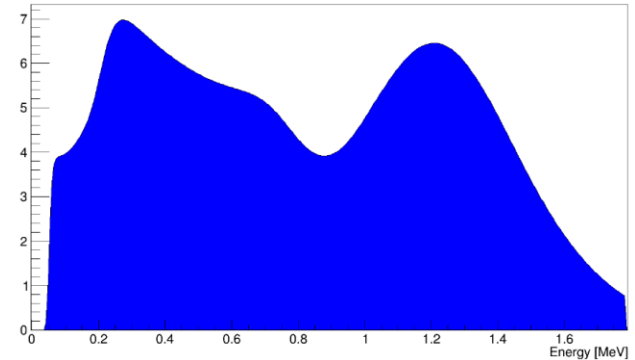
Arduino Nano

- ADC: pulse height measurement
- Time over threshold: pulse length measurement
- Communication with data loggers possible via I²C

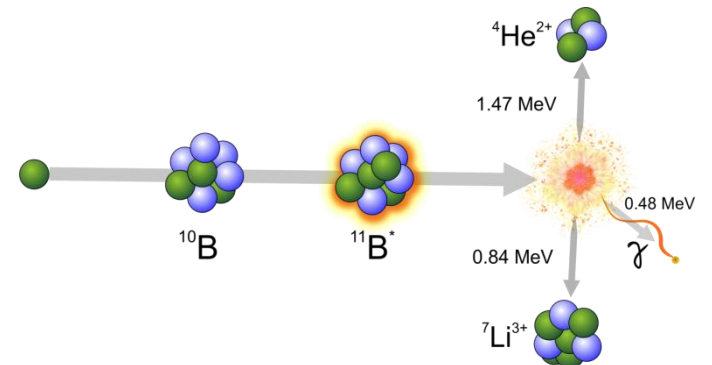
Analog output and serial communication allows for read-out and control

HV unit (prior)

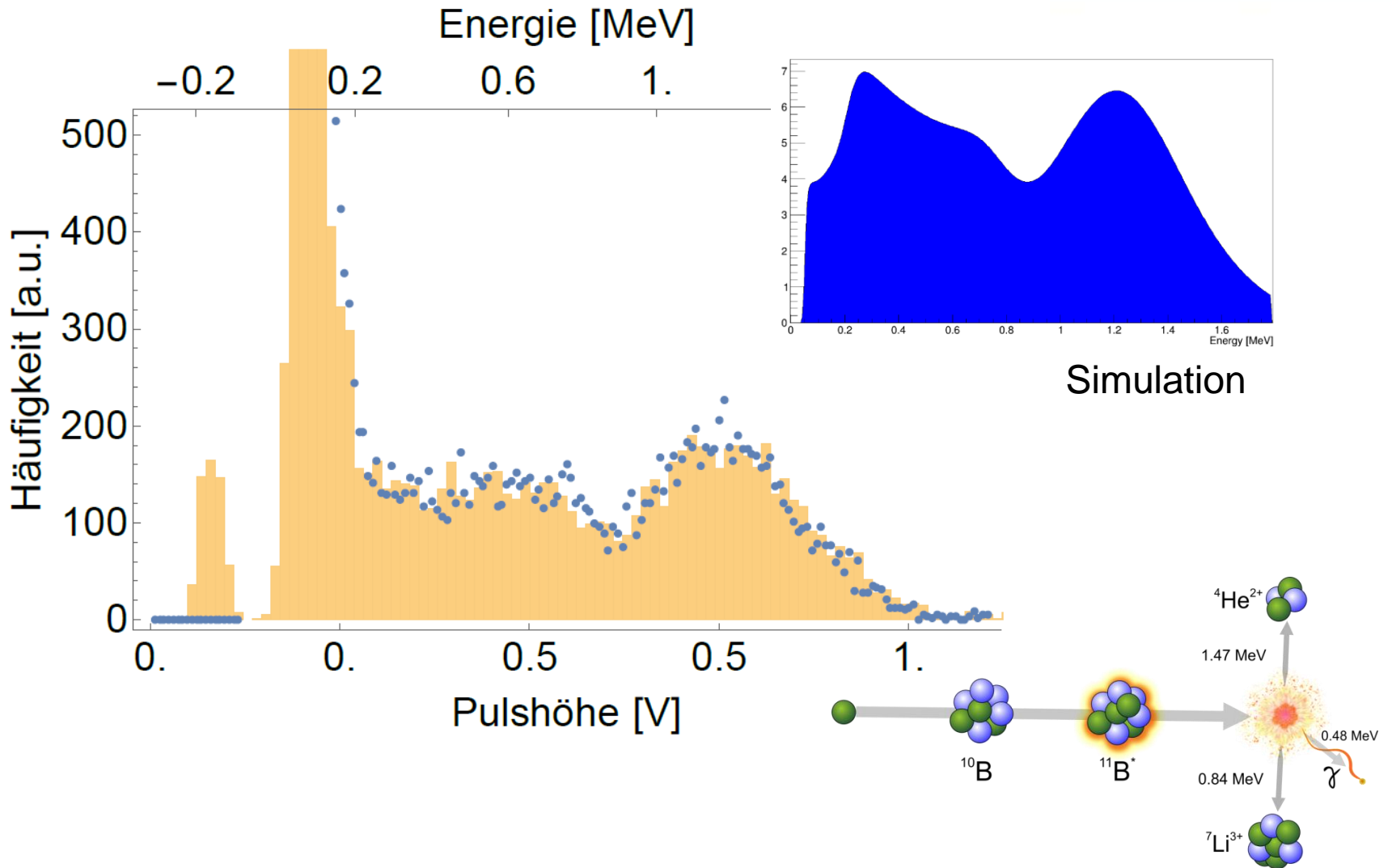
Comparison: B-10 spectrum



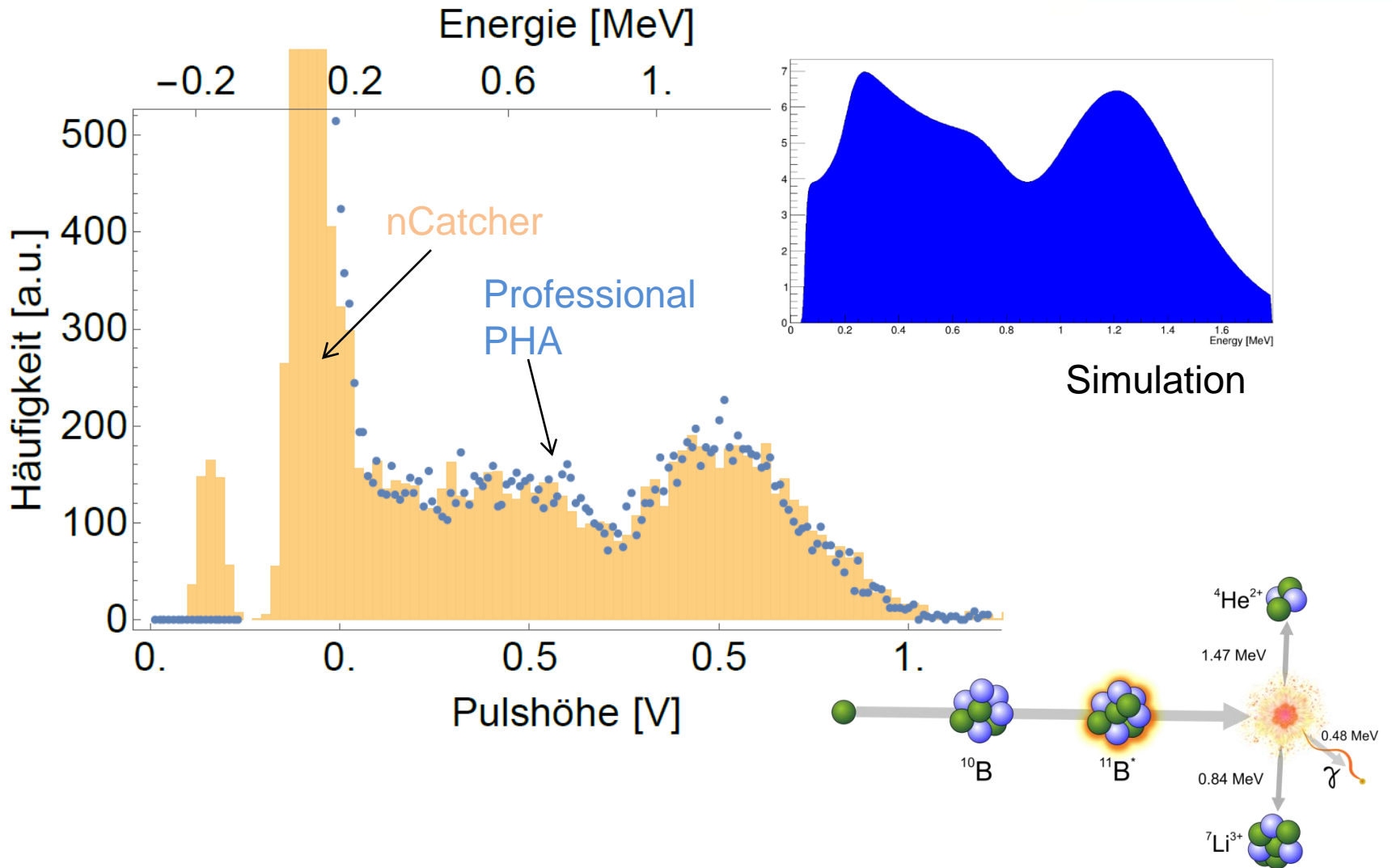
Simulation



Comparison: B-10 spectrum



Comparison: B-10 spectrum





It's a Pulse Height Analyzer:

- Designed to read out proportional chambers
- Featuring:
 - Integrating Preamplifier + Mainamplifier
 - Comparator (Schmitt-Trigger)
 - Arduino nano
 - Pulse length and pulse height measurements via time over threshold and internal 10-bit ADC
 - Schmitt-Trigger threshold configuration via 12-bit DAC

It's a Single Channel Analyzer:

- Comparator triggers nano's Input Capture Unit (ICU) if a pulse $>$ a THL voltage
- The ICU measures the time for which the THL voltage is exceeded (Pulselength)
- The ICU also triggers the ADC which needs between 250 ns and 16mus to sample the Pulseheight

Cost Calculation

Main Components:

PCB: ~20 €

PCB Components: ~15 €

Arduino Nano: ~10 €

Arduino MEGA: ~15 €

Arduino Box: ~10 €

Optional:

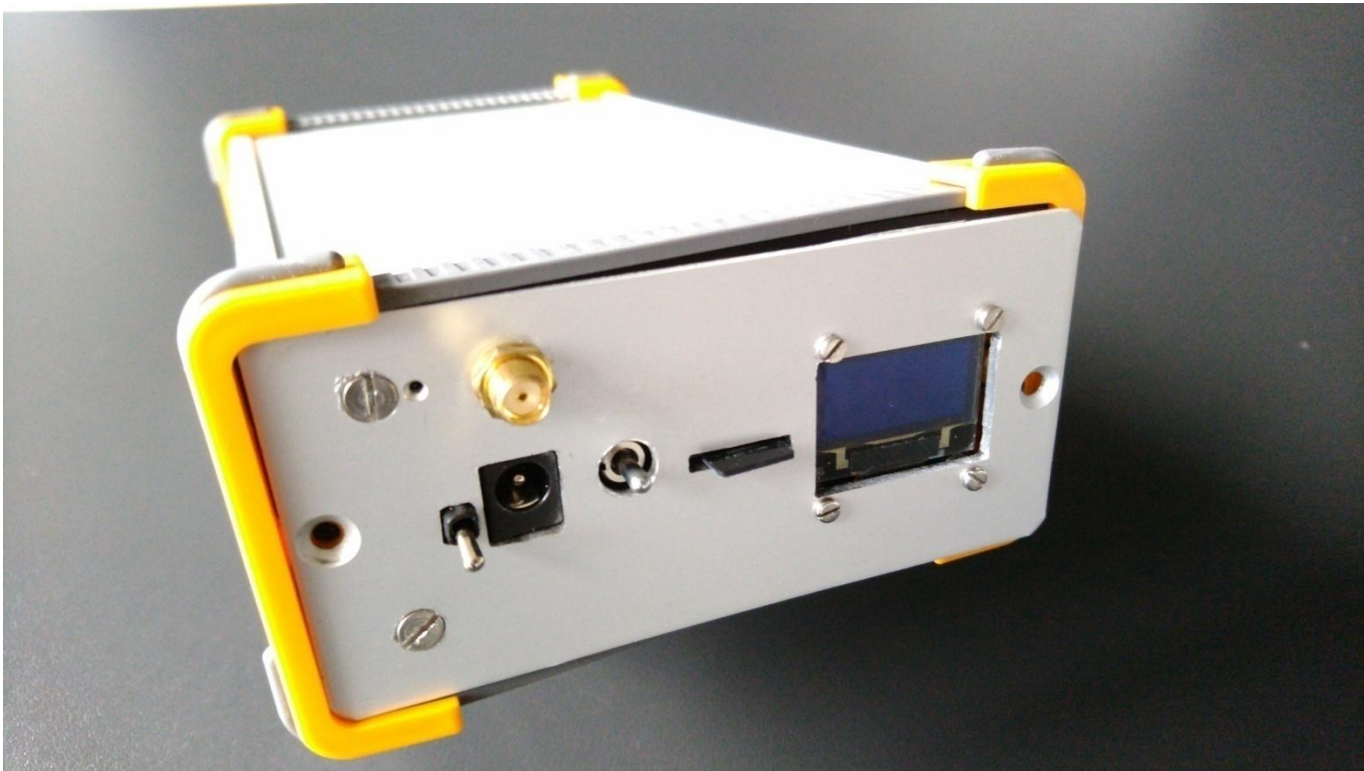
Coaxial Cable/Jacks: ~30 €

SD Card and RTC Shield: ~ 25 €

DC-DC Converter: ~ 15€

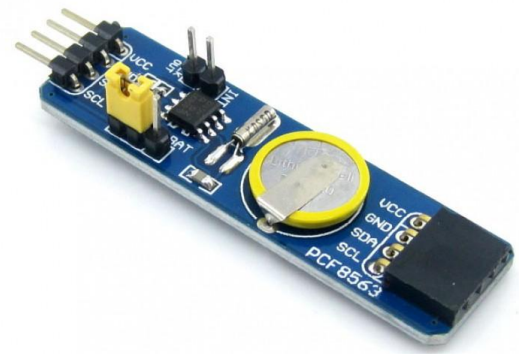


Data Logger



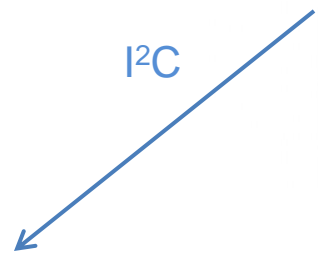
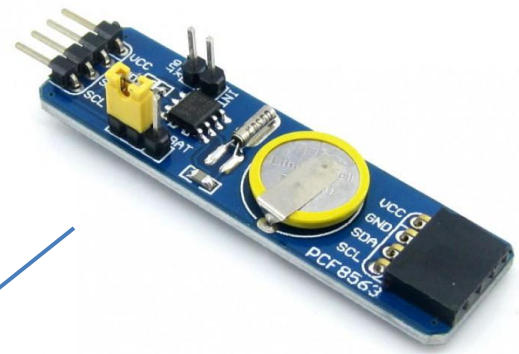
Sensors and Data

PFC8563 RTC



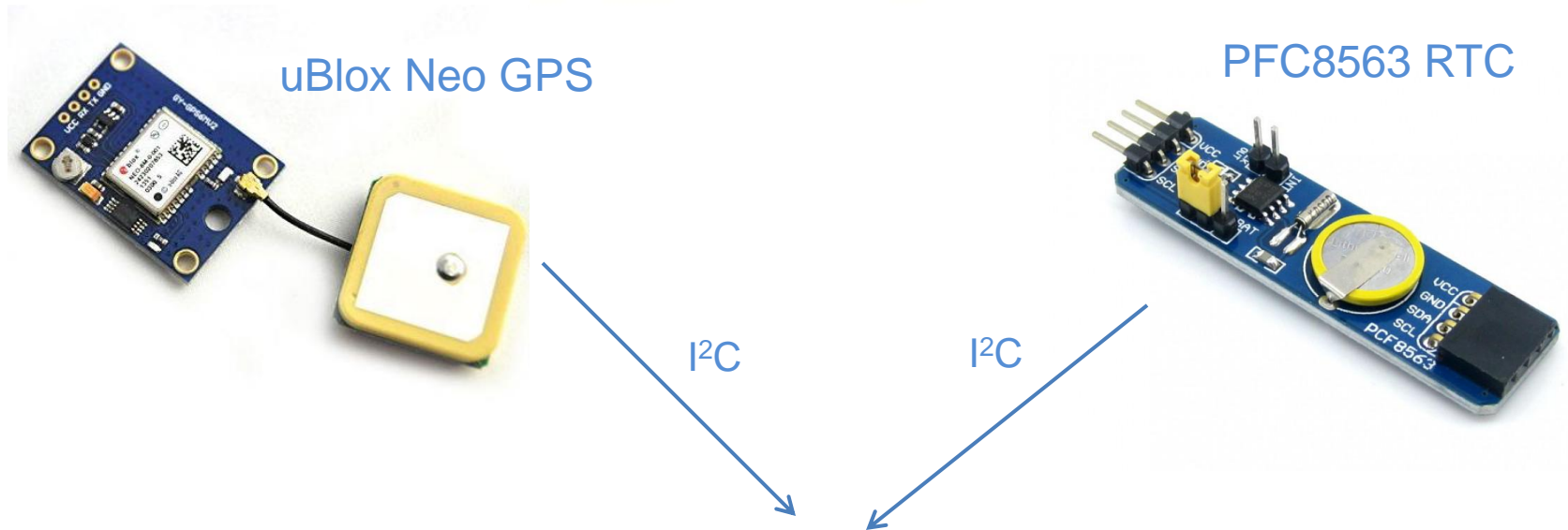
Sensors and Data

PFC8563 RTC

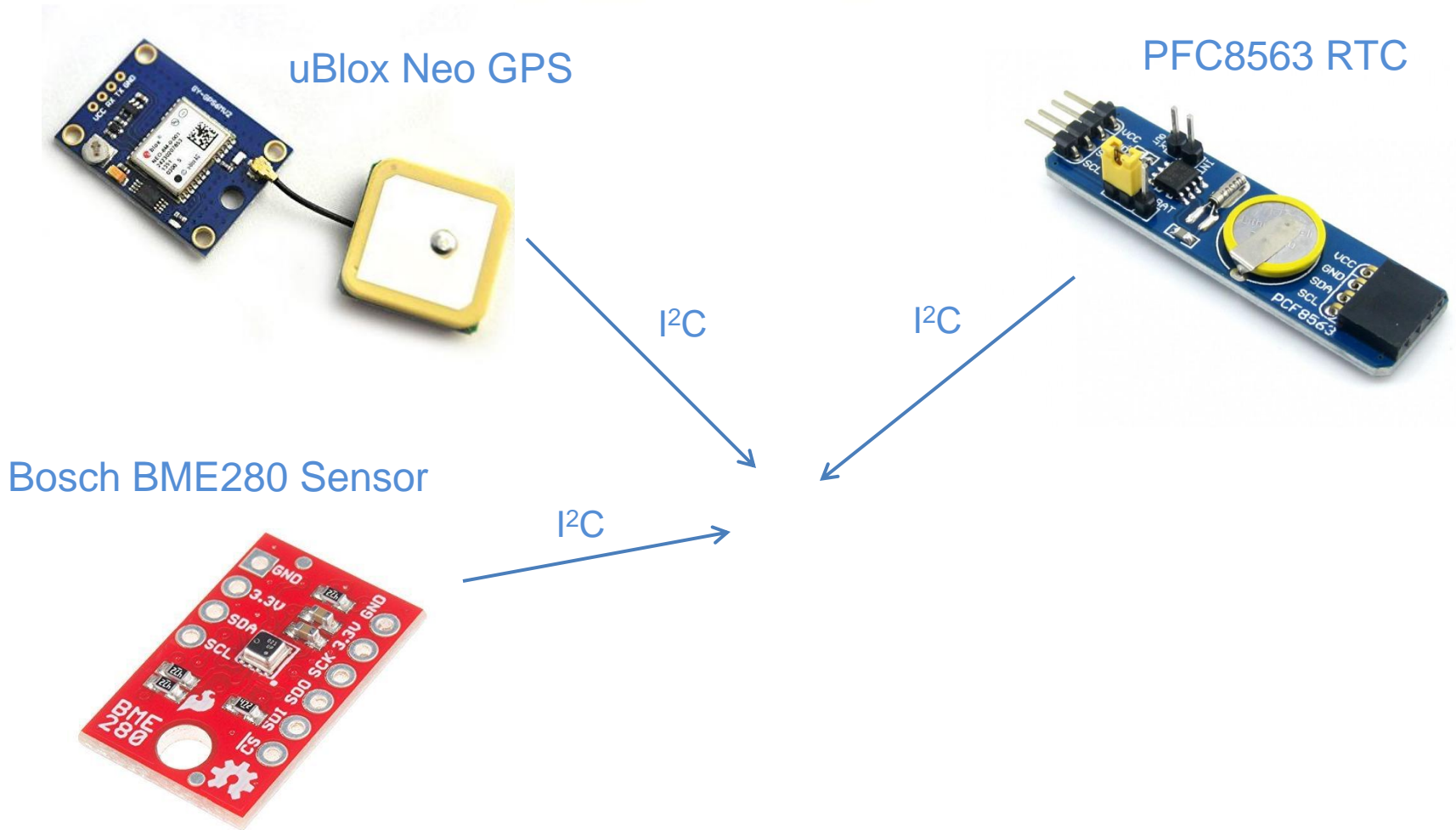


I²C

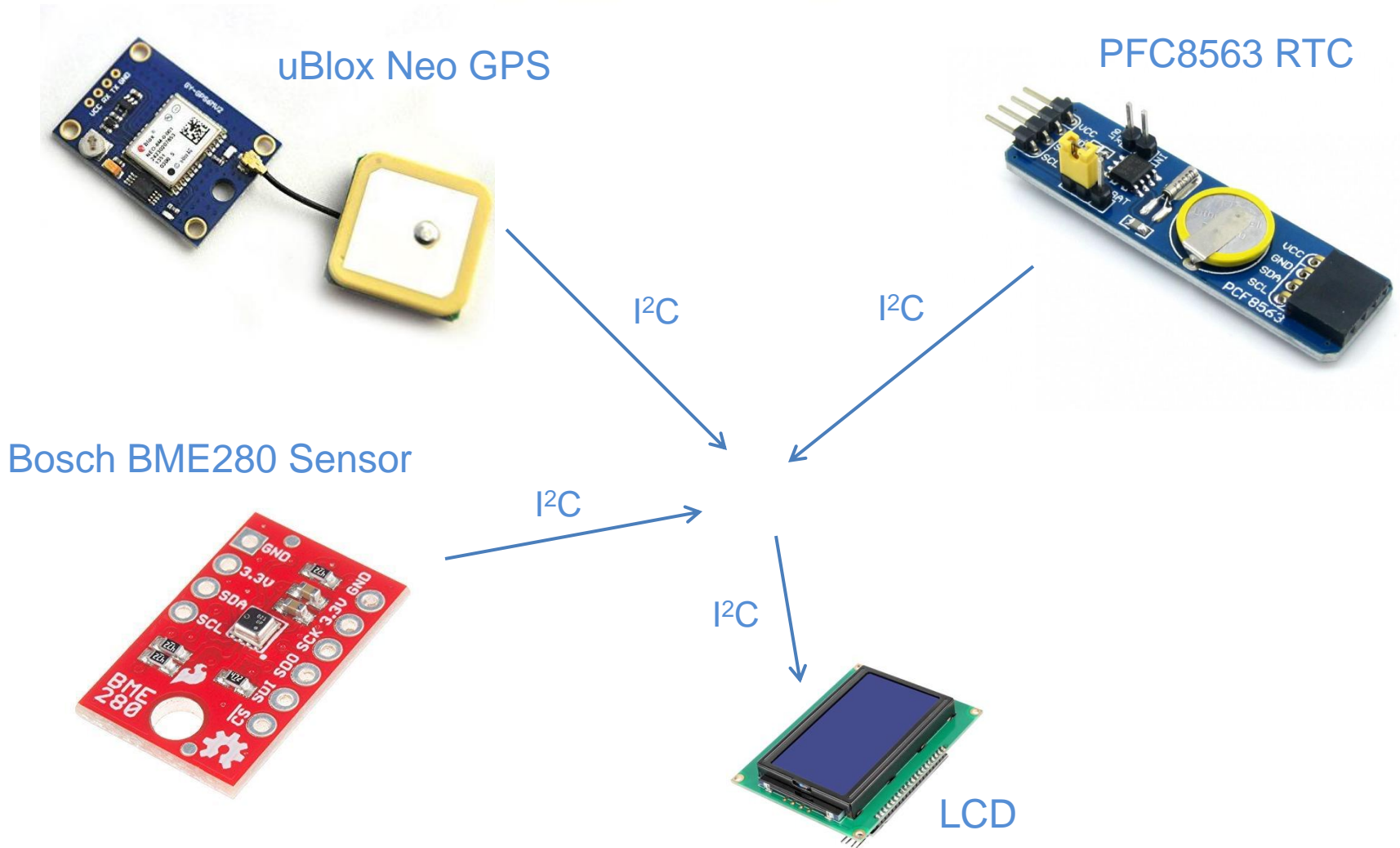
Sensors and Data



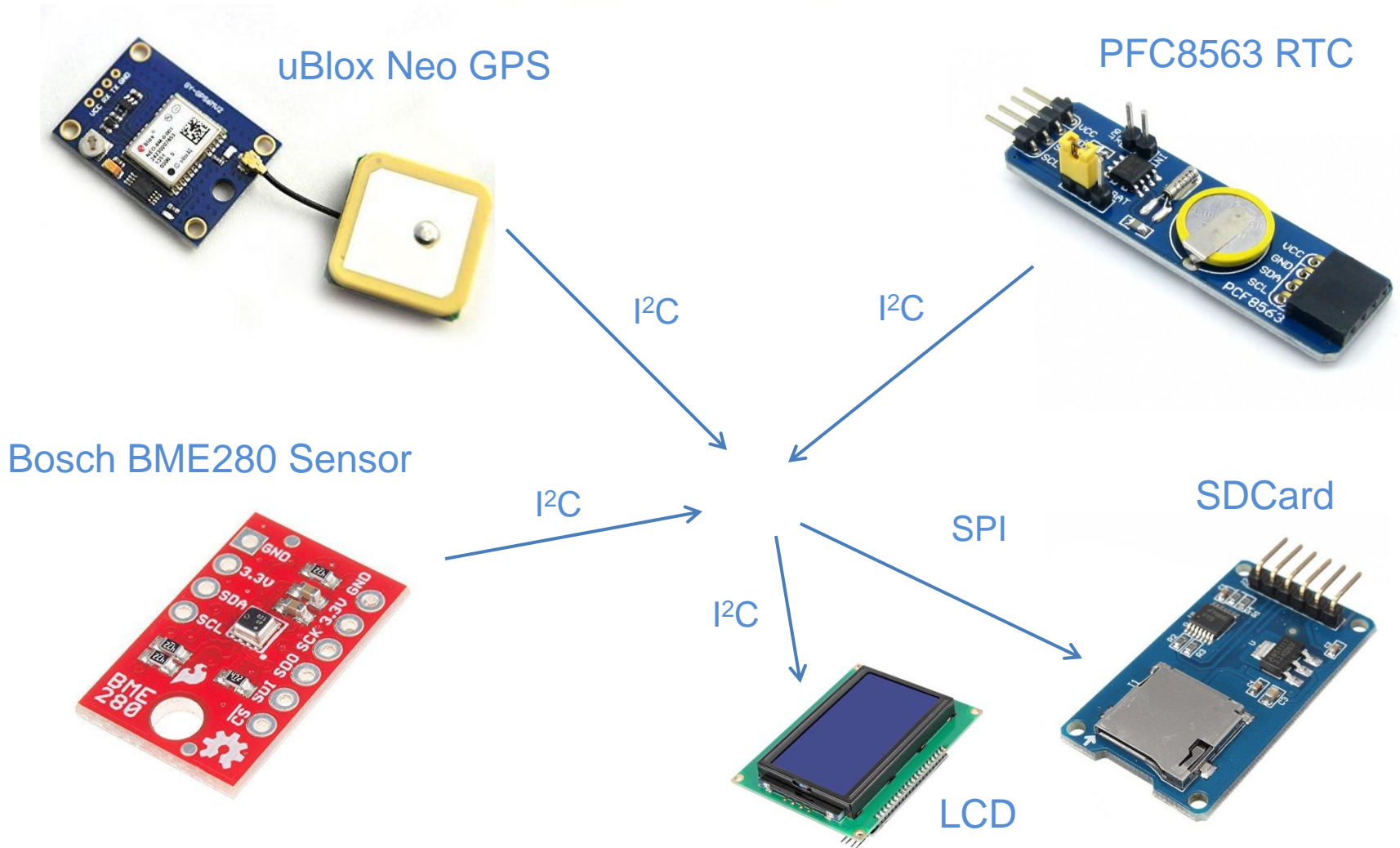
Sensors and Data



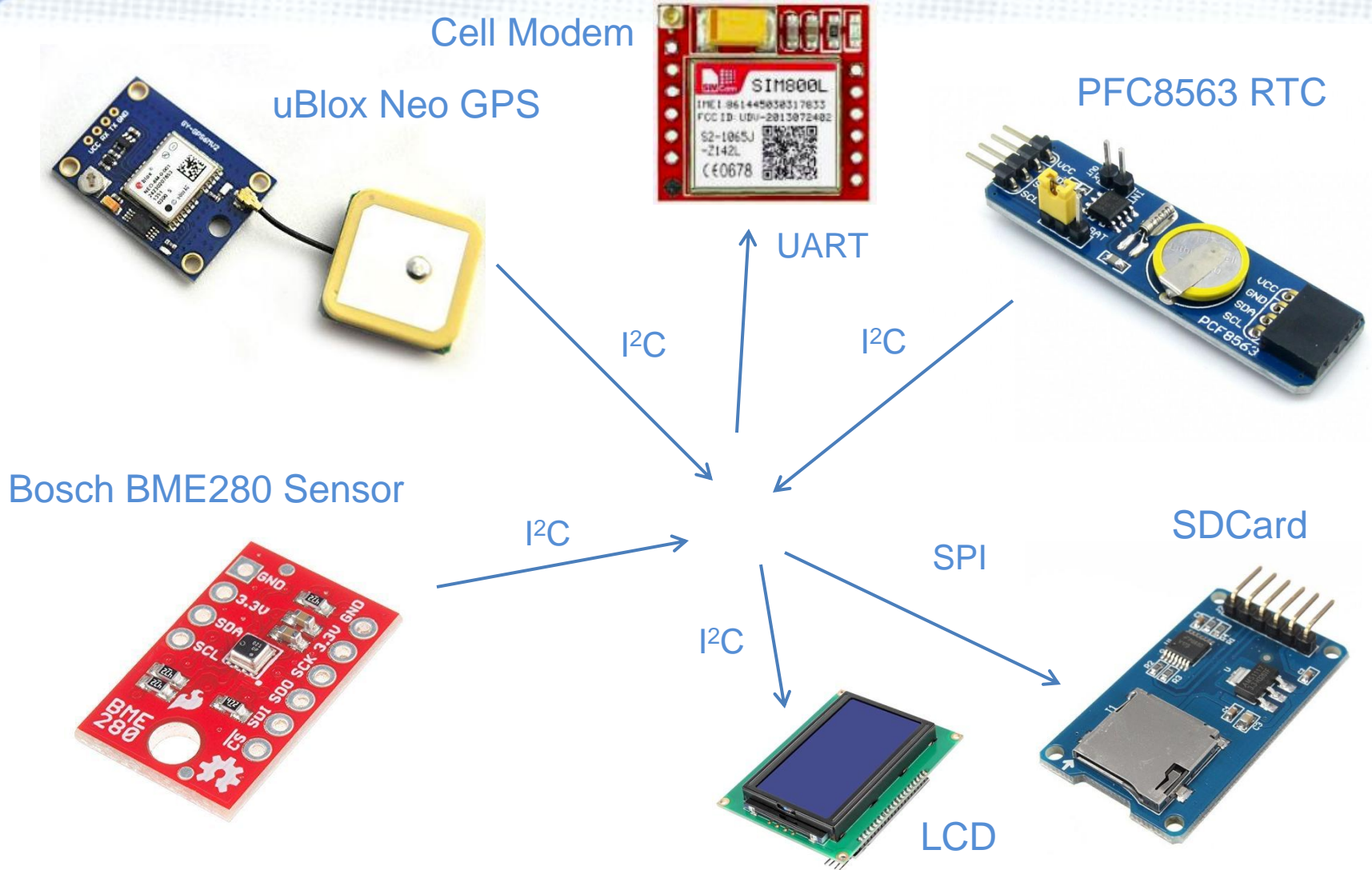
Sensors and Data



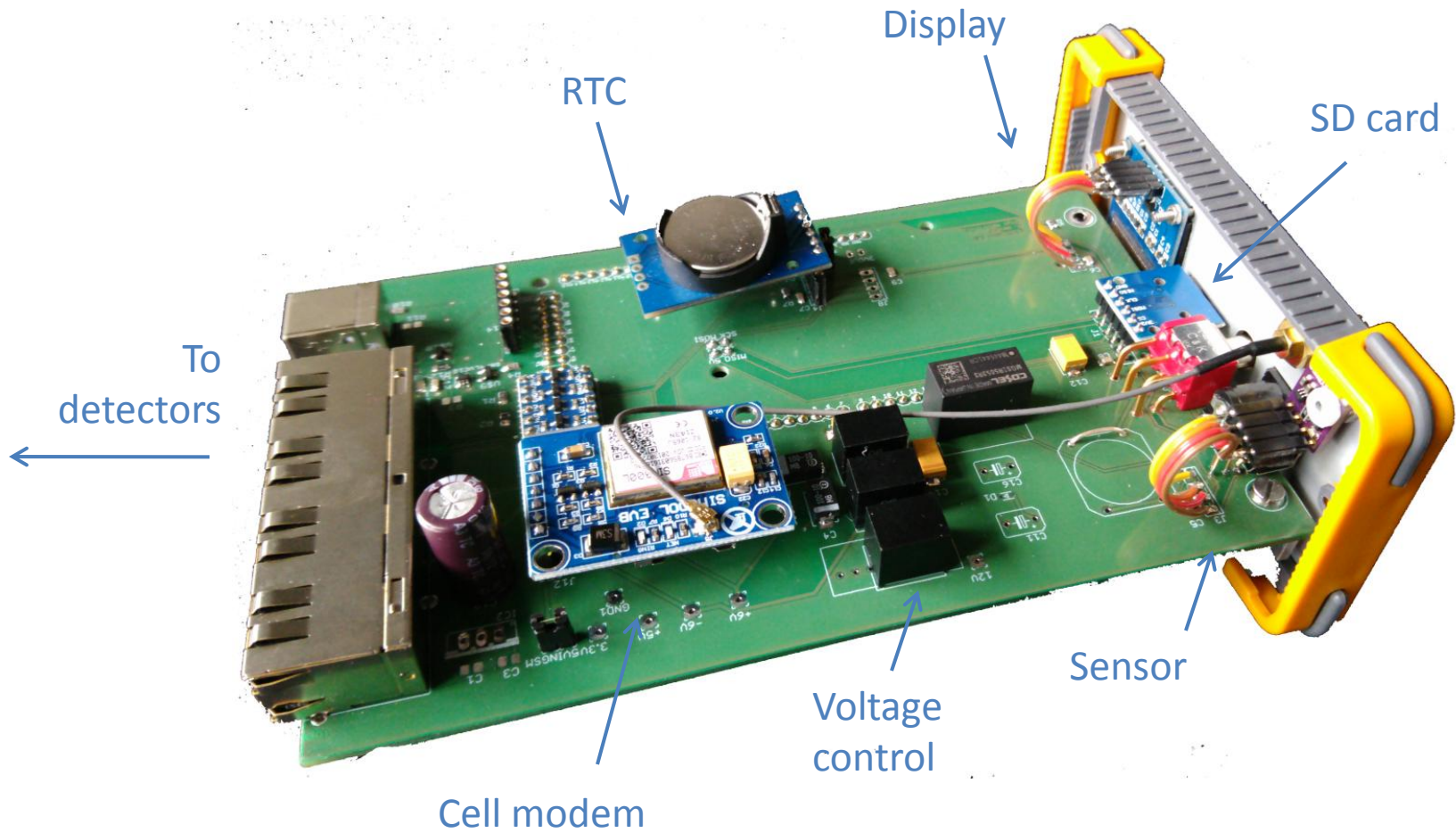
Sensors and Data



Sensors and Data

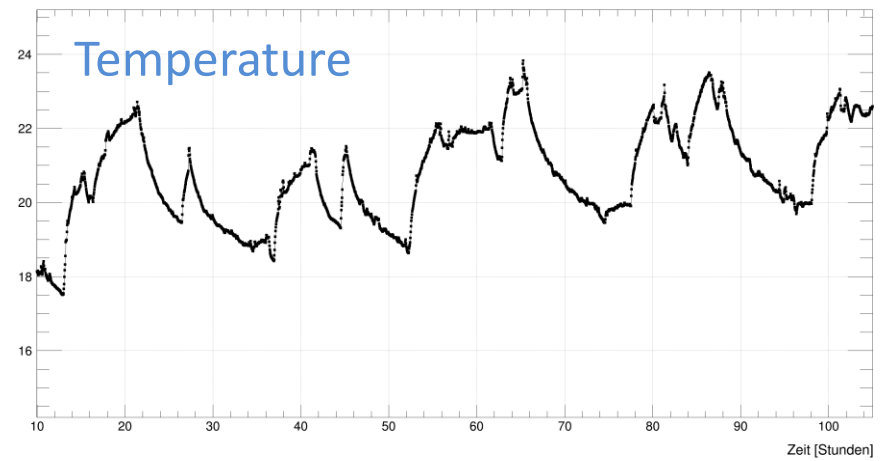
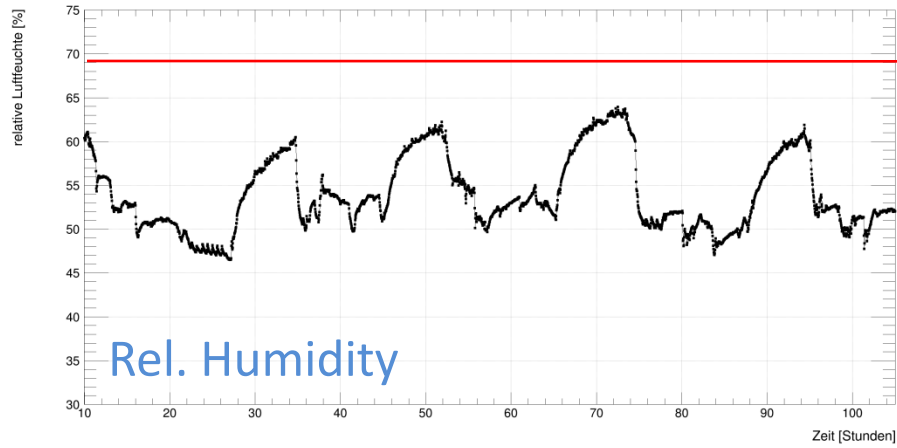


Data logger

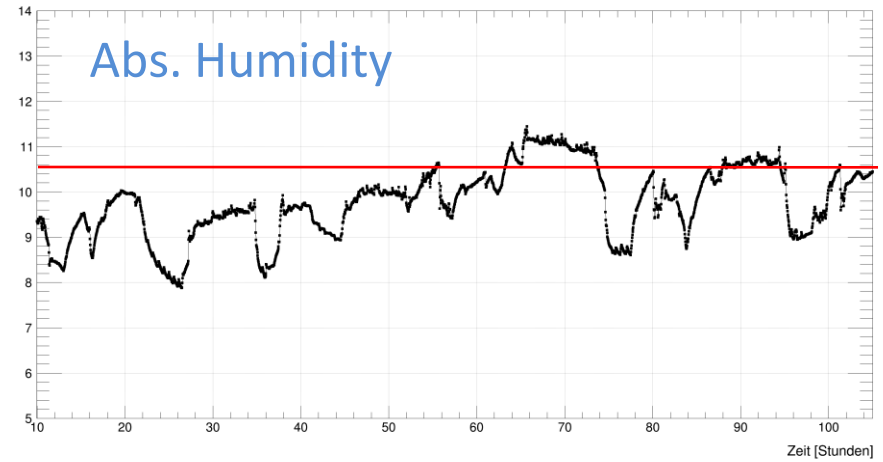
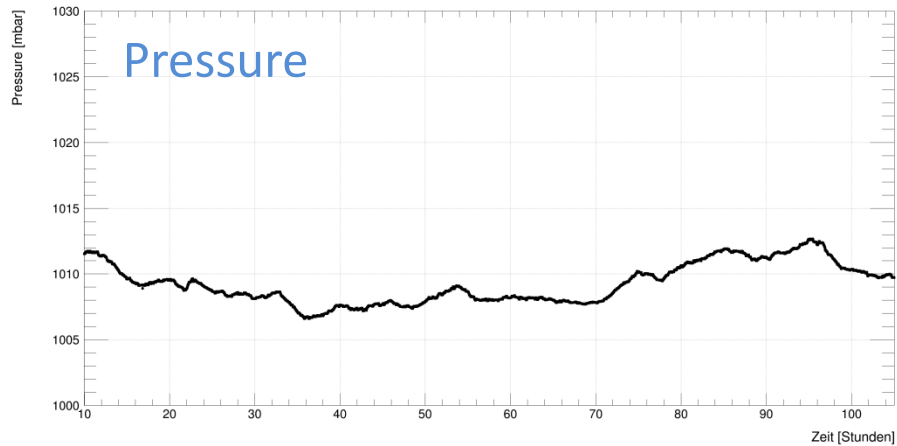




data logging



[100h 30 s average]





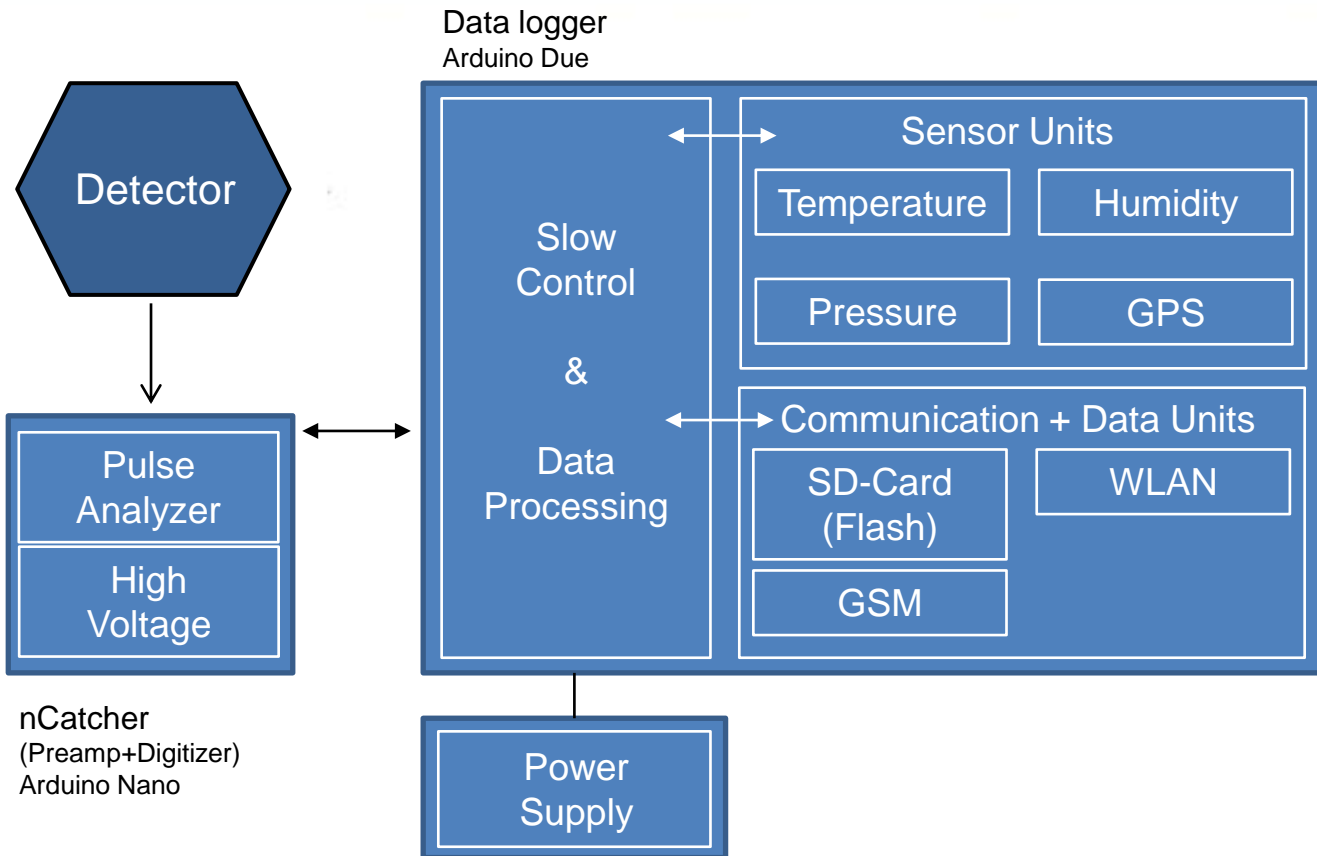
GSM data transmission

Live-Display for Webbrowser



- GSM-Modem
- + MQTT-Server (Internet of Things)
- + Influx-DB (Time series data base)
- + Grafana (Frontend)

Detector and Logger



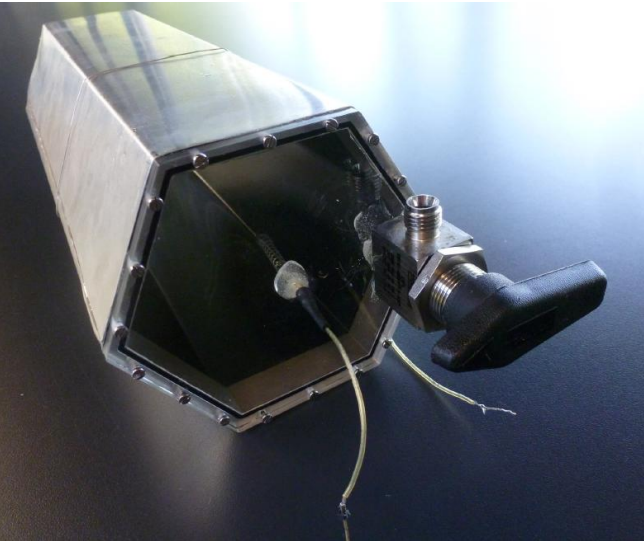
- New:
- upgrade to Due (larger)
 - GSM Modem
 - shielded design for nCatcher



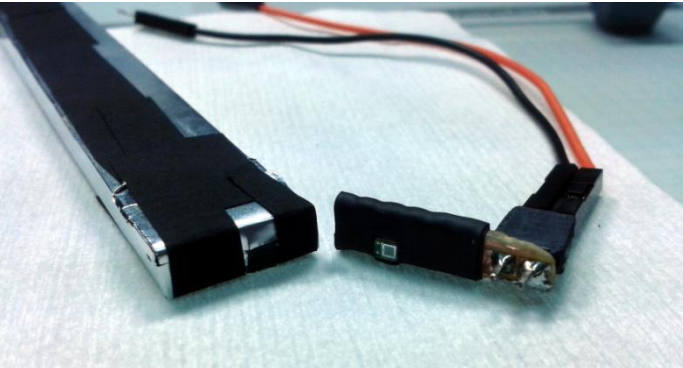


Summary

Proportional Counter

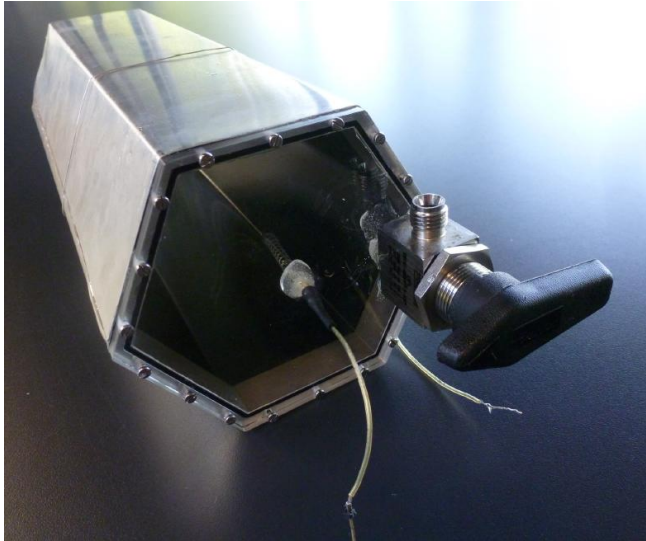


Scintillation Counter

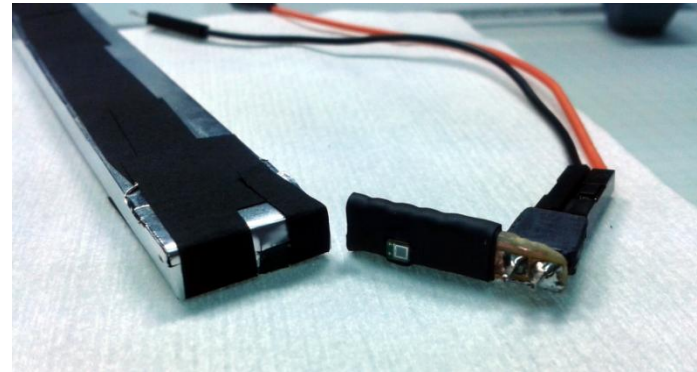


Summary

Proportional Counter



Scintillation Counter



Arduino-up your lab!



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