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An open source detector for cosmic rays

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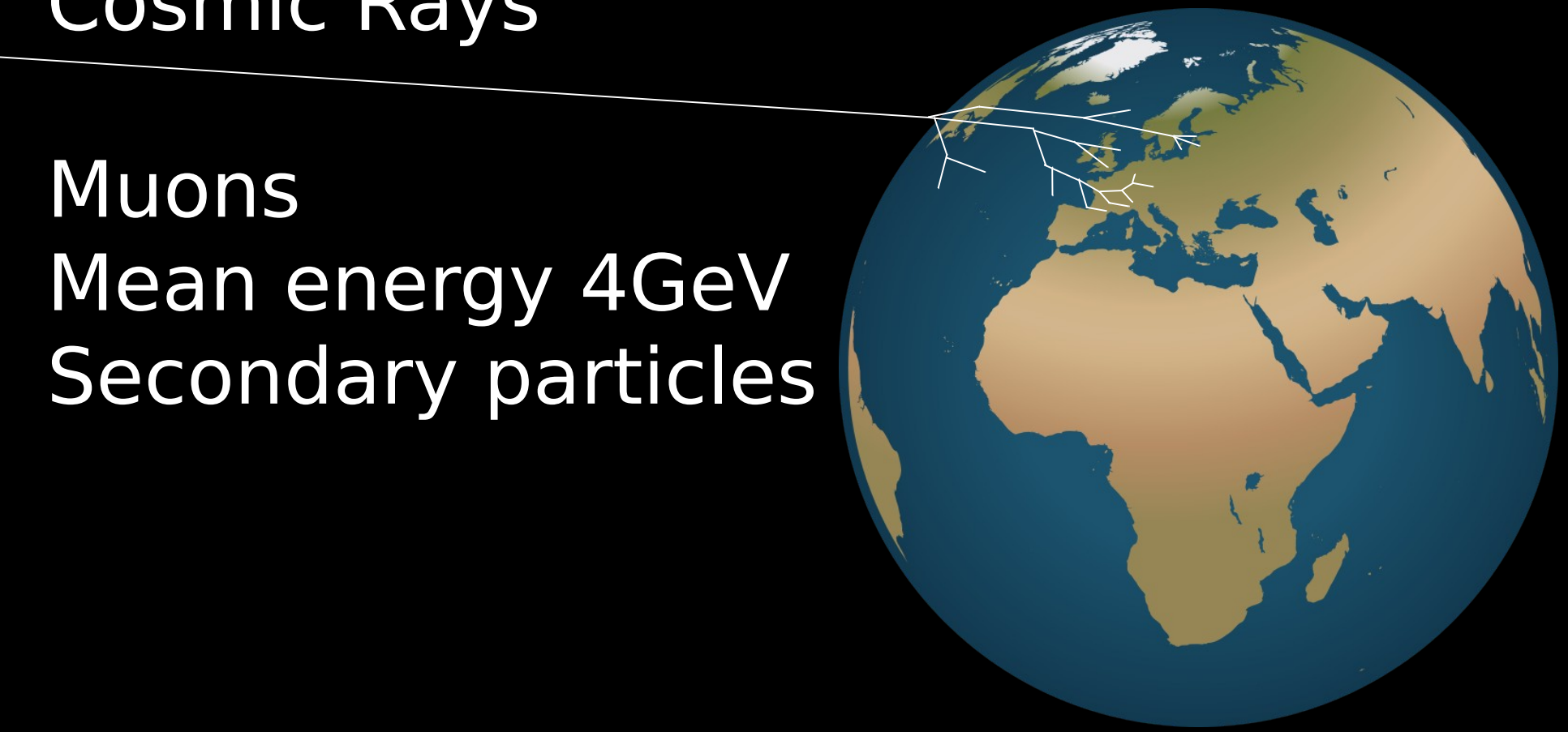
Agenda

What is it?
Science goals
Architecture
Current status
What's next...

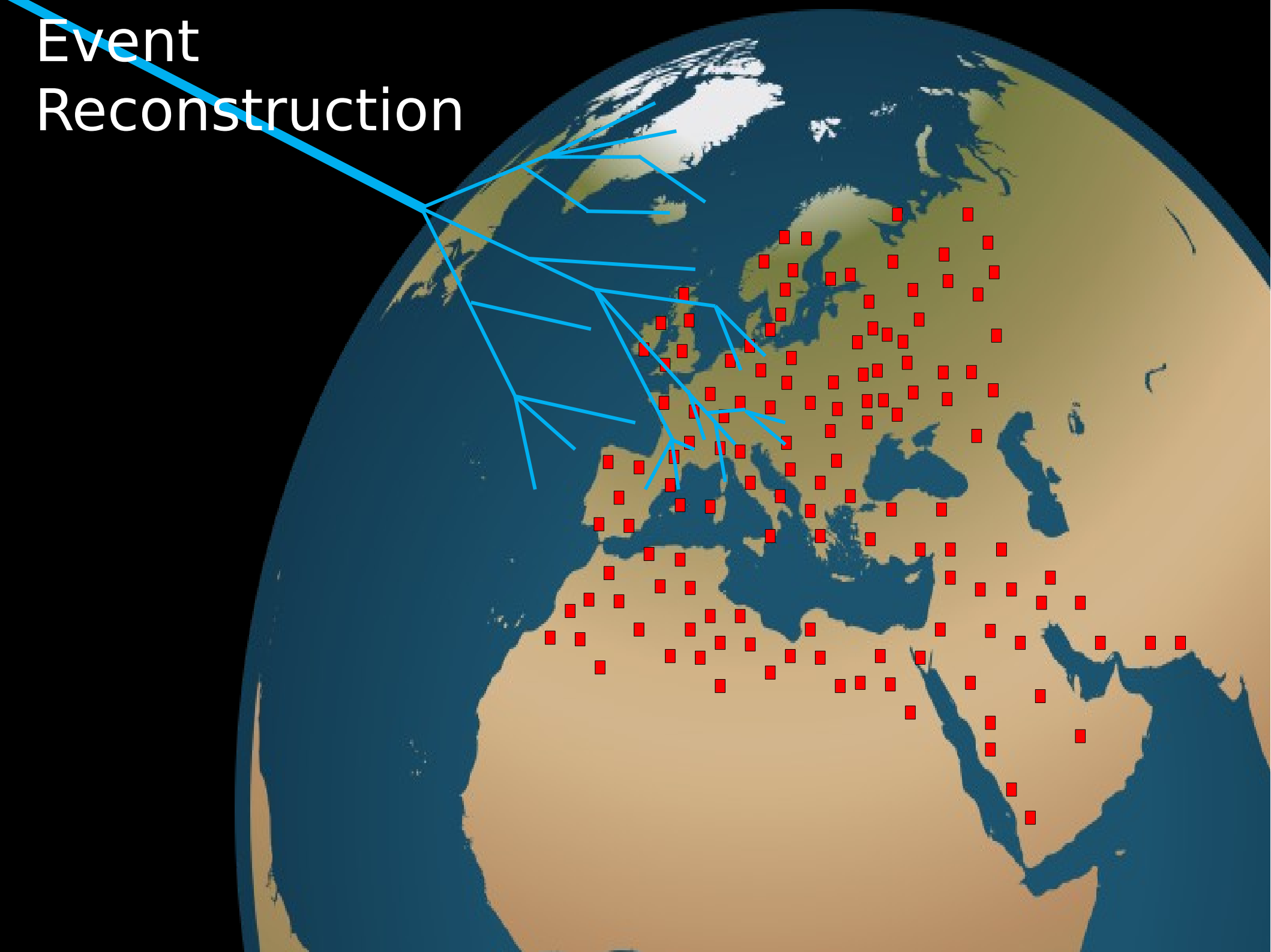
An open hardware detector
that anyone can
buy or build
to detect cosmic rays individually,
and connect to a network
creating a cosmic ray telescope.

The Science bit...

Cosmic Rays



Muons
Mean energy 4GeV
Secondary particles

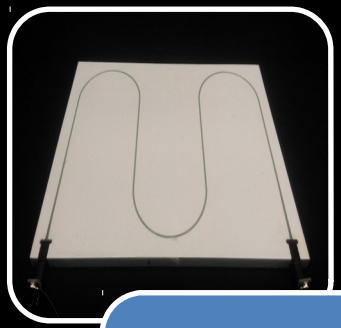

Event
Reconstruction

Hardware challenges:

High stability HV Power (70V)
High gain amplifiers (>1e6)
Trigger generation
High speed timing & ADC synch.
Integration of other sensors

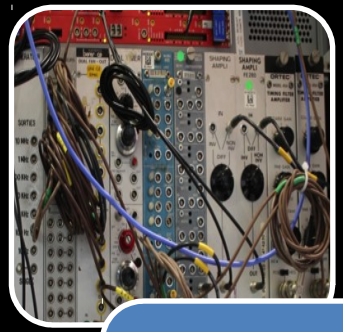
All in a USB Device

Hardware model



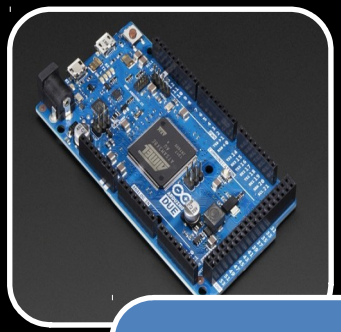
Detector module

- scintillator tile
- two SiPM
- light tight enclosure



Analog Processing

- trigger generation
- signal amplification
- signal shaping



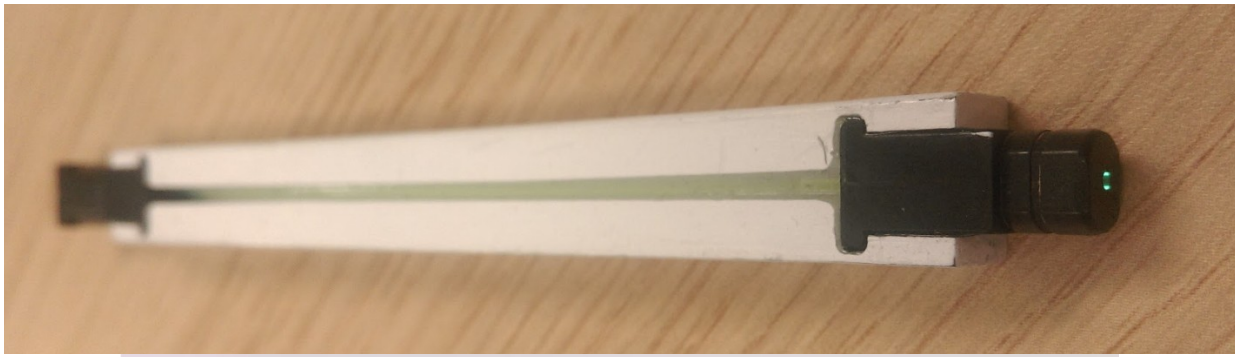
Digital Processing

- analog signal digitization
- sensors readout
- data organization
- power supply control
- Communication and data display via touchscreen

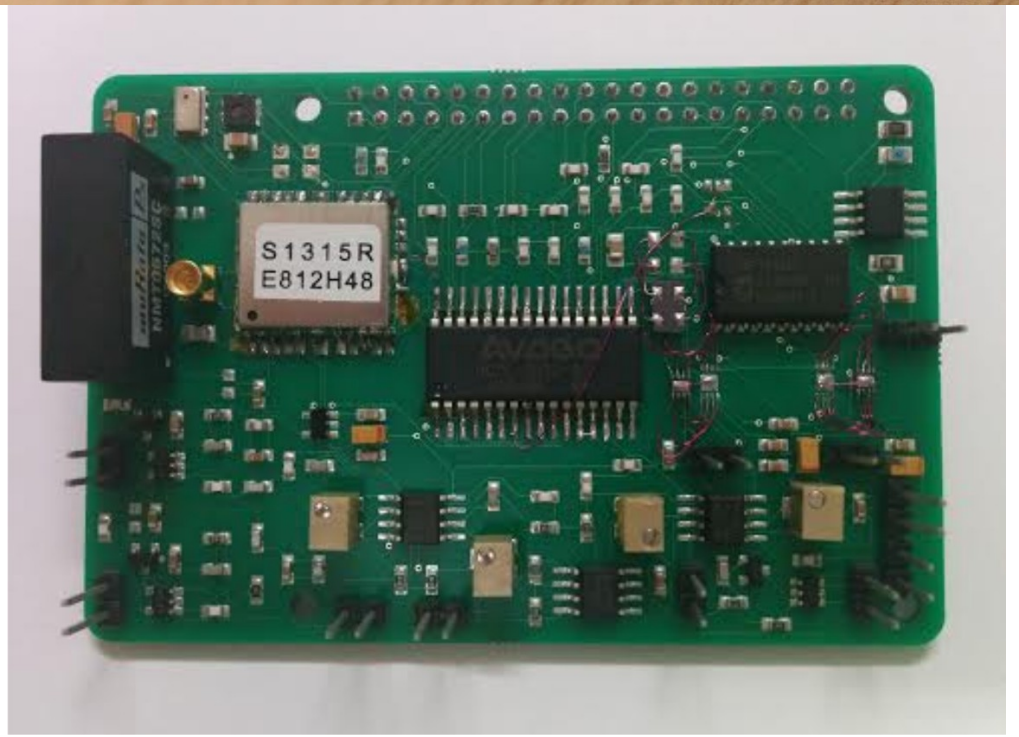
Data Processing

- data acquisition
- data storage
- data analysis
- communication with central server or local computer
- data visualization

Hardware (Version 1, Oct 2014)

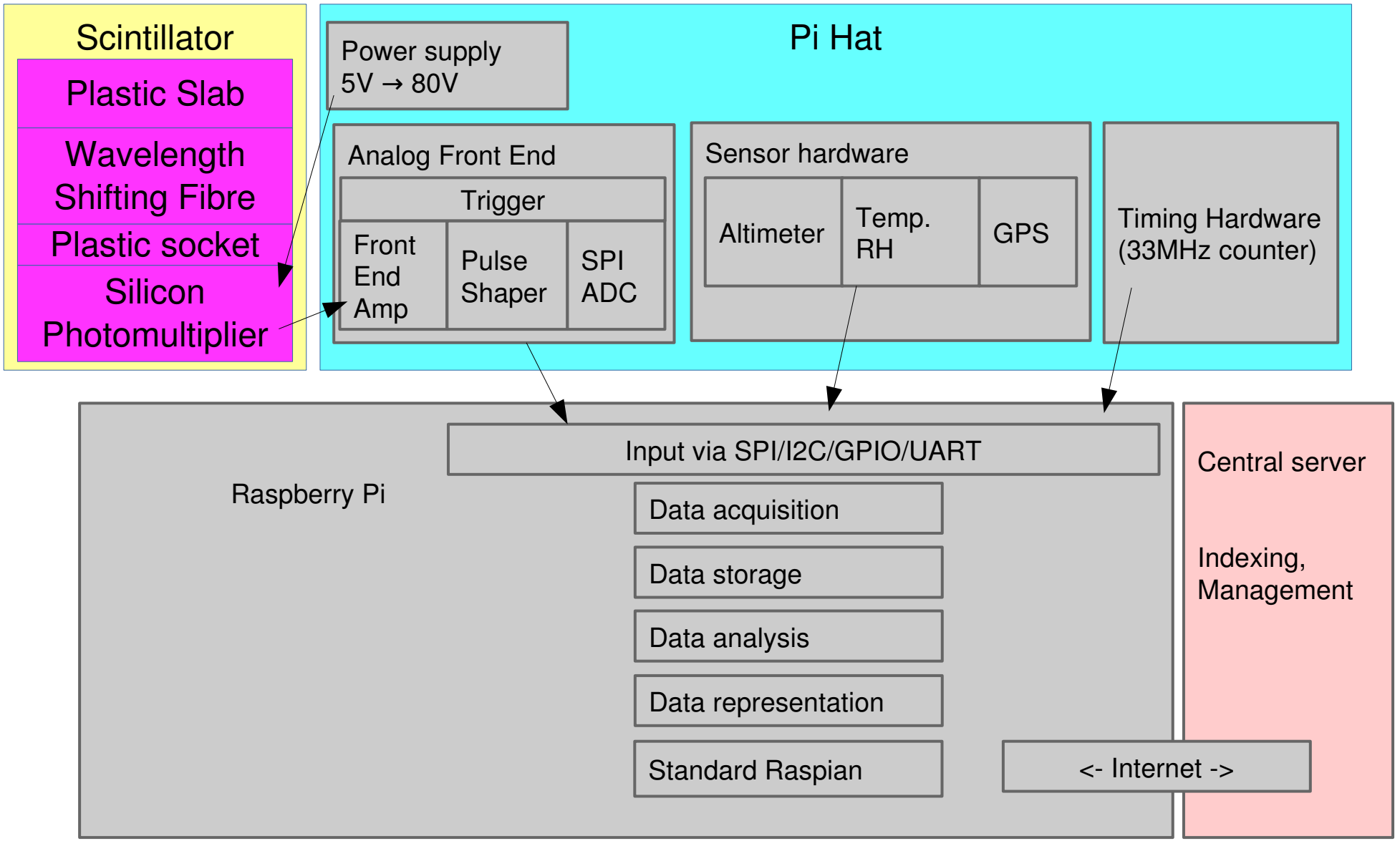


Scintillator



Pi Hat

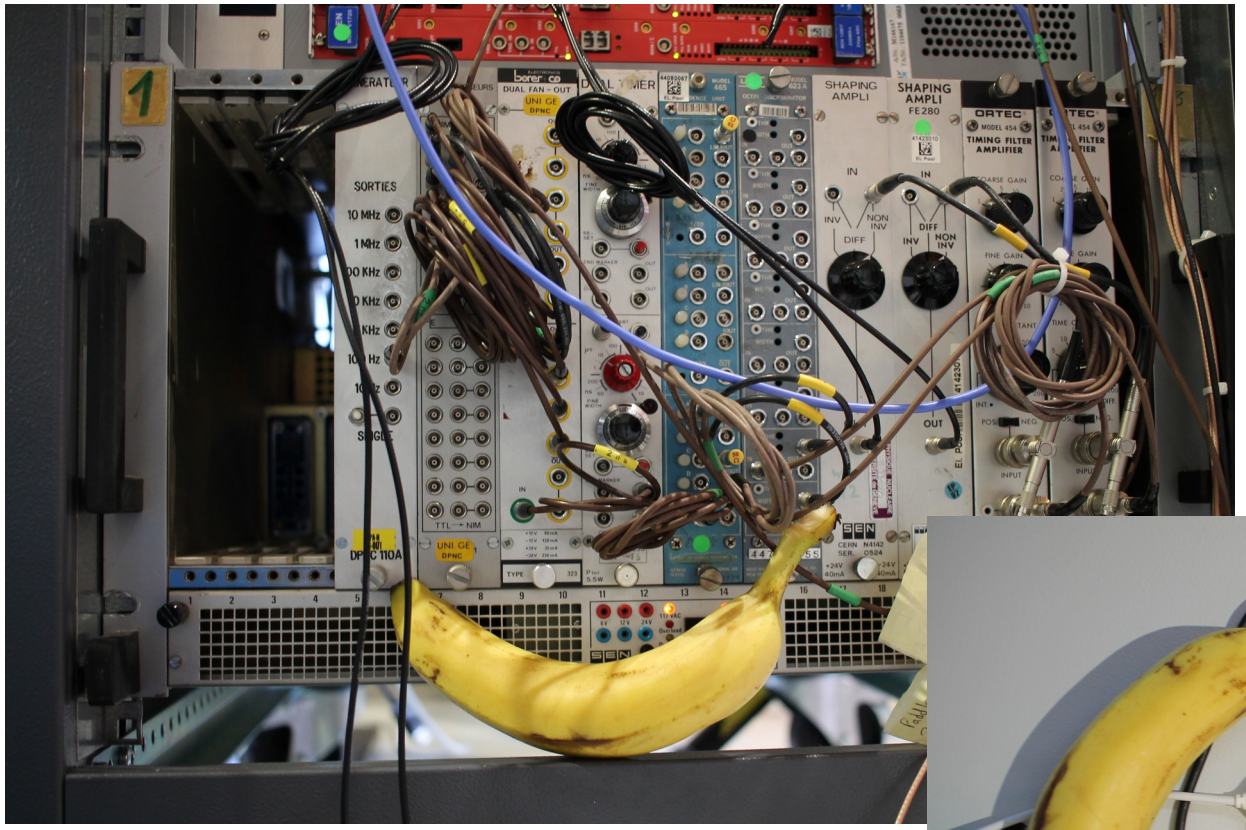
Architecture (Version 1)



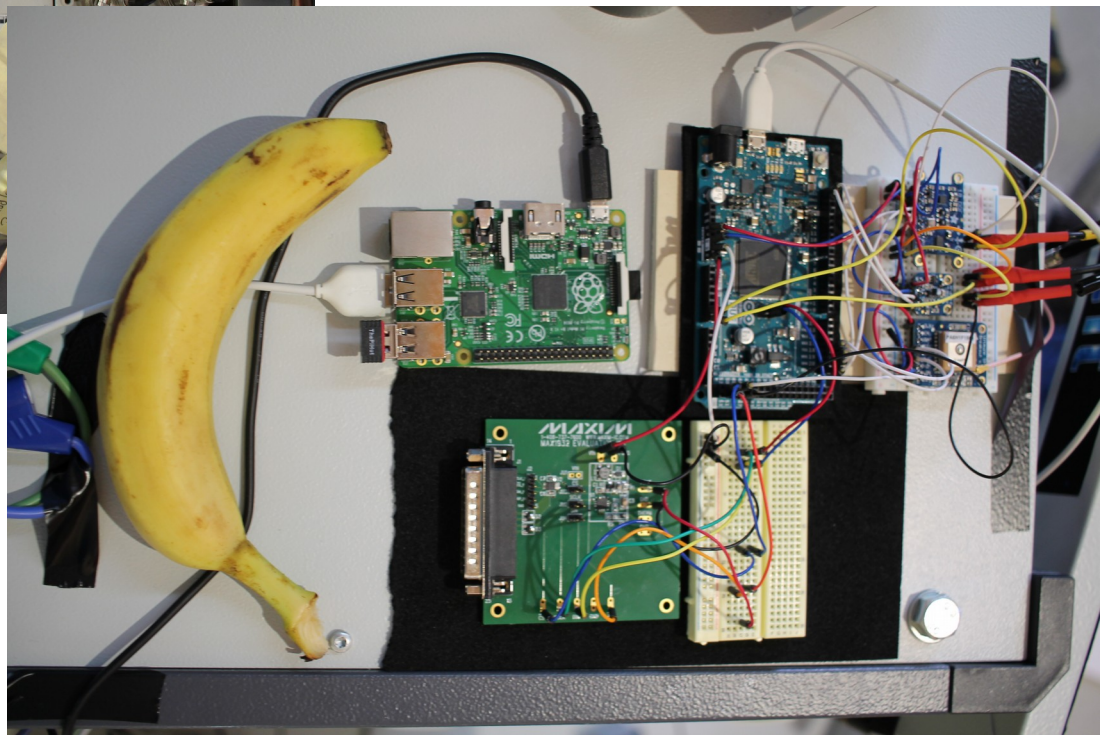
Lessons Learned (Version 1)

- Raspberry Pi too slow (non RT-PREEMPT)
- Hardware timing limits event rate to 1Hz
- Lots of effort into choosing ADC, wasted!
- HV PSU too noisy
- Analog Front End needs matching to SiPM

Hardware (Version 1.1, Oct 2015)

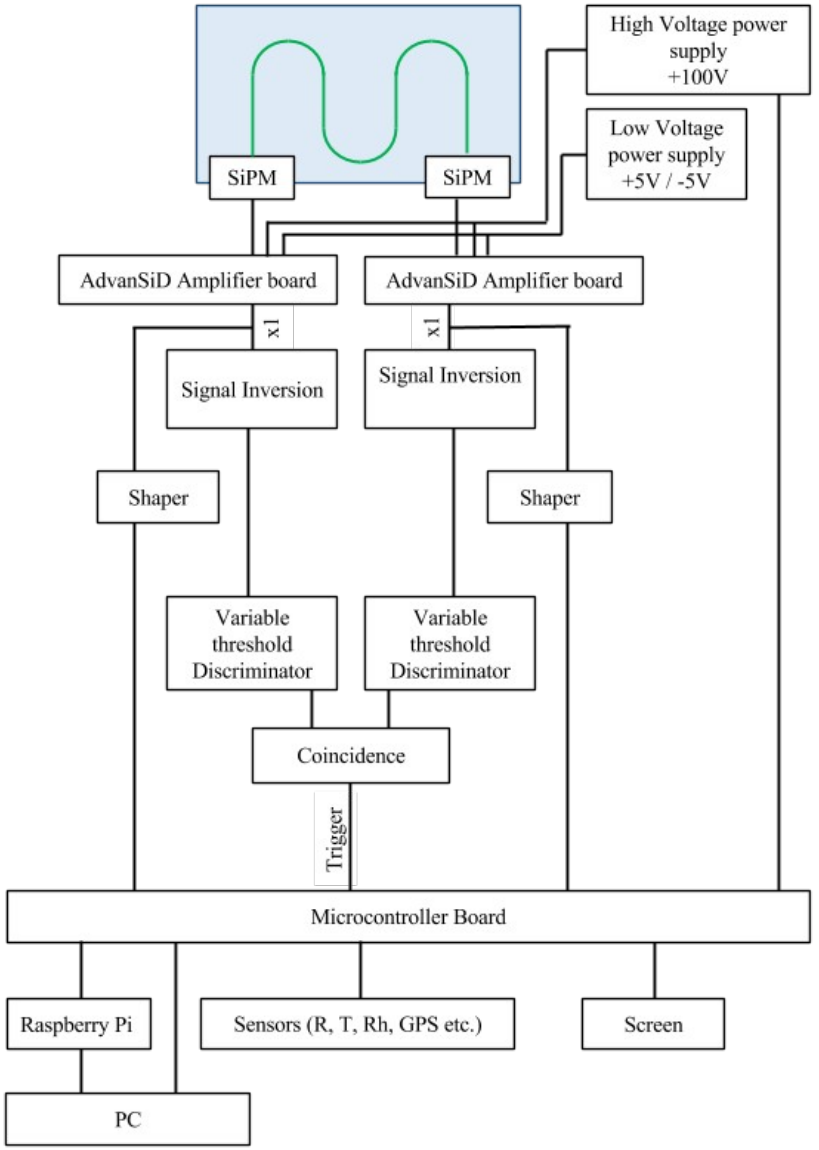


Modular Approach: Dev Boards NIM Crate



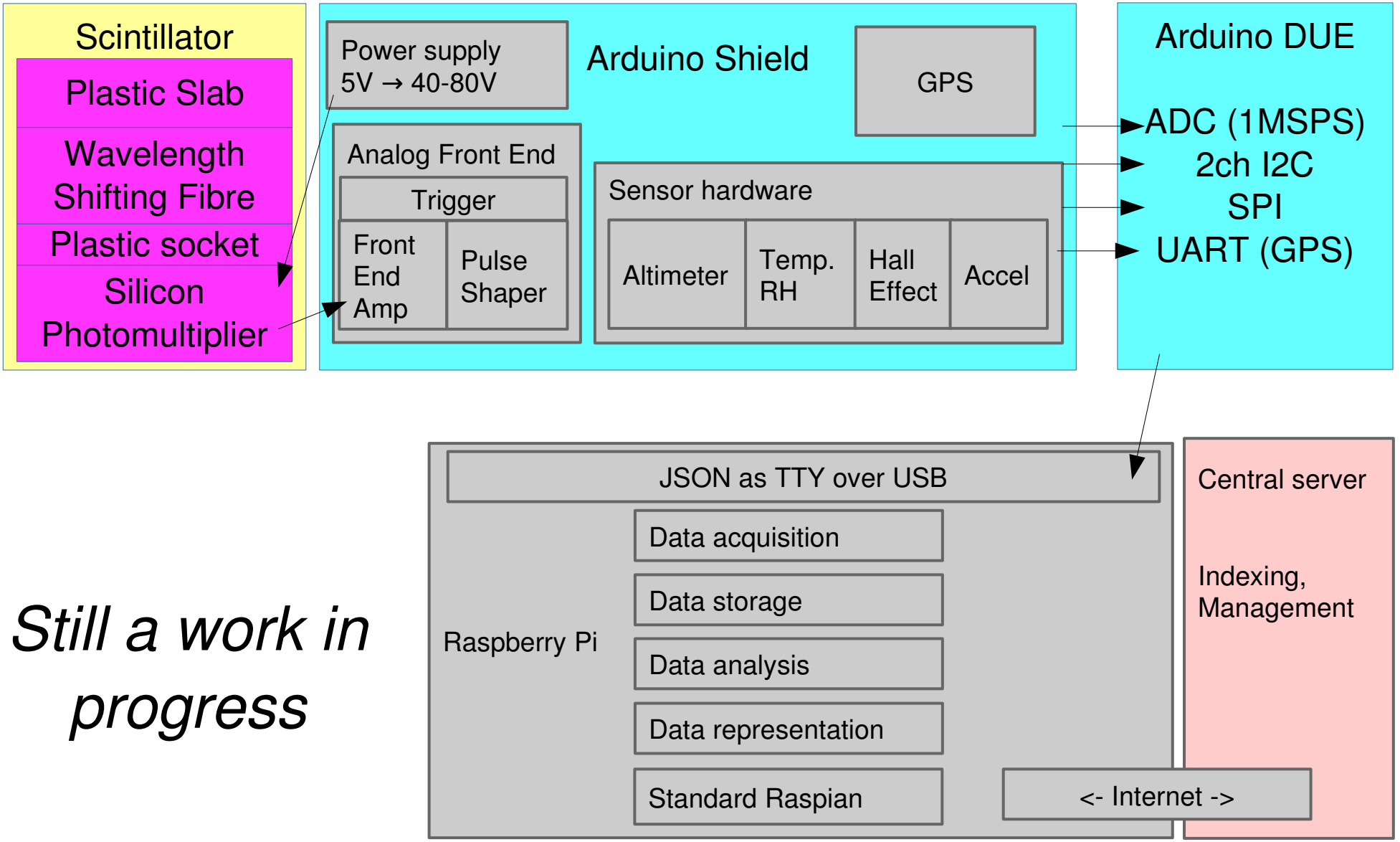
Integrate components into circuit & firmware one at a time

Analog Architecture Prototype



- Based on real world detectors
- 2 channels required for coincidence
- Raw output SiPM = 5ns pulse, mV range
- Pulse shaper
- Simple trigger

Architecture (Version 1.1)

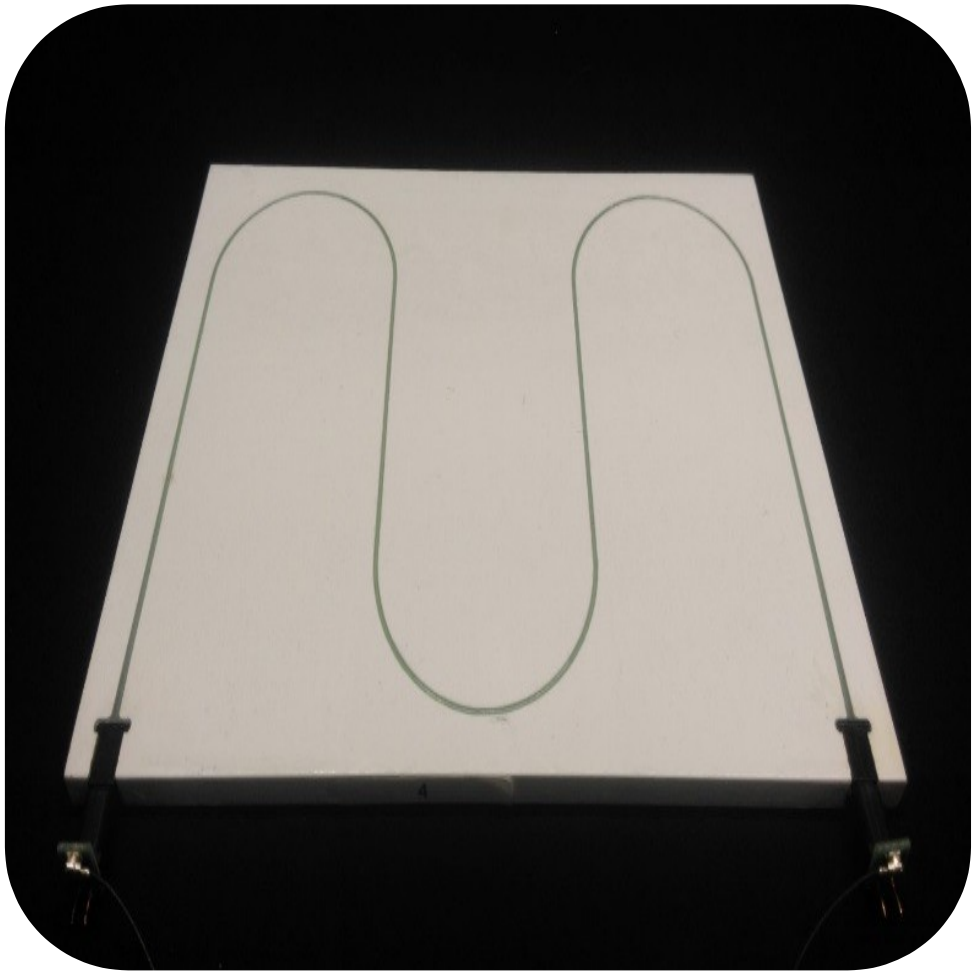


Still a work in progress

Lessons Learned (Version 1.1)

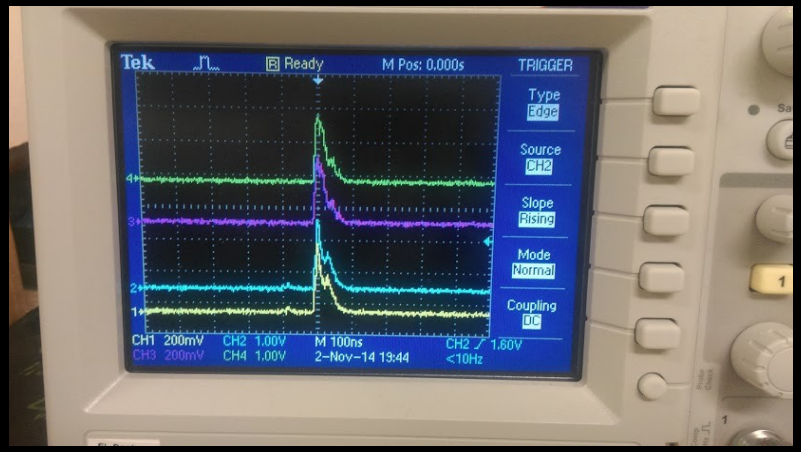
- Single core is challenging when communicating over serial
- Integrated ADC in Arduino DUE (SAM3X8E M3 - 32 bit ARM) is adequate, 1 MSPS
- ADC continuous read and buffering essential
- Operational stability/reliability work in progress
- JSON is quite heavyweight for Arduino

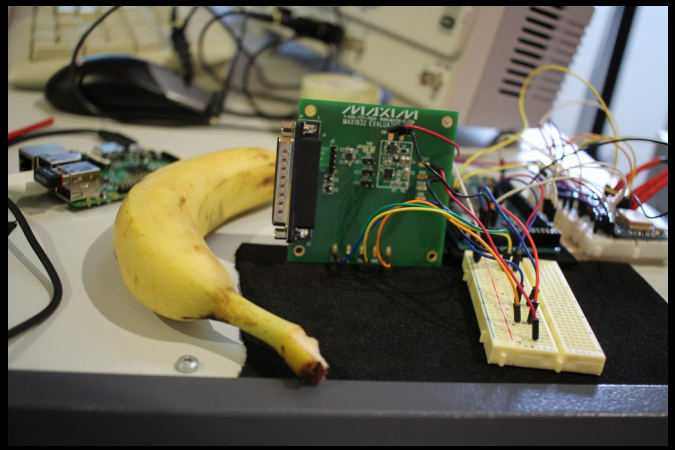
Mechanical Hardware: Scintillator tiles



- Extruded plastic with a chemical additive, few manufacturers
- Light reflective coating on the outside
- Detector specific geometry
- Wavelength shifting fibre → for silicon detector
- High mechanical precision & alignment

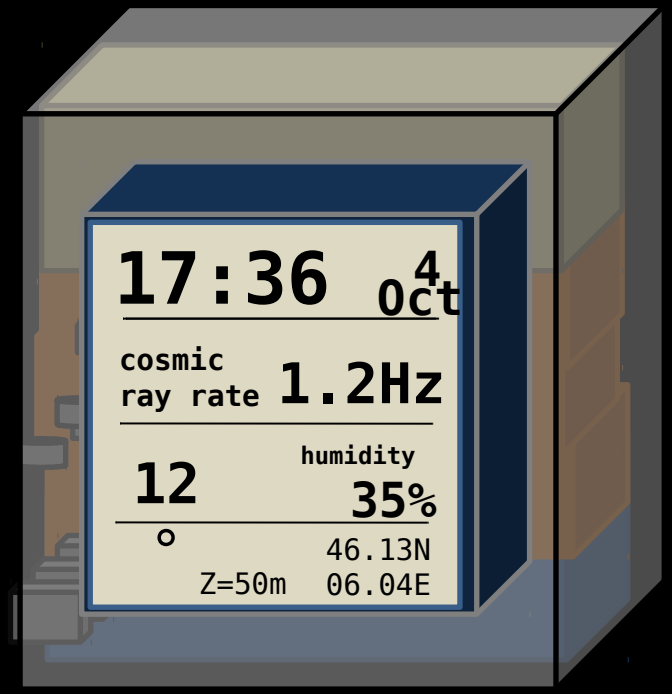
Current Status





- Able to detect cosmic rays using our prototype
- Maxim 1932 Boost IC integrated last week for high voltage
- Analog Front End needs moving from a 19” Rack to a PCB
- Open format for Cosmic Ray data exchange
- Prototype Version 2!

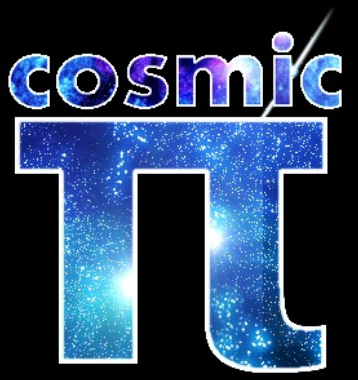
What's next?



A finished product?

- Fully integrated prototype
- Firmware robustness
- Improve software stack
- Open source scintillator design?
- Design → Production

Follow us at



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Coming soon on KICKSTARTER