LOW-COST COSMIC RAY DETECTORS - FIRST STEPS

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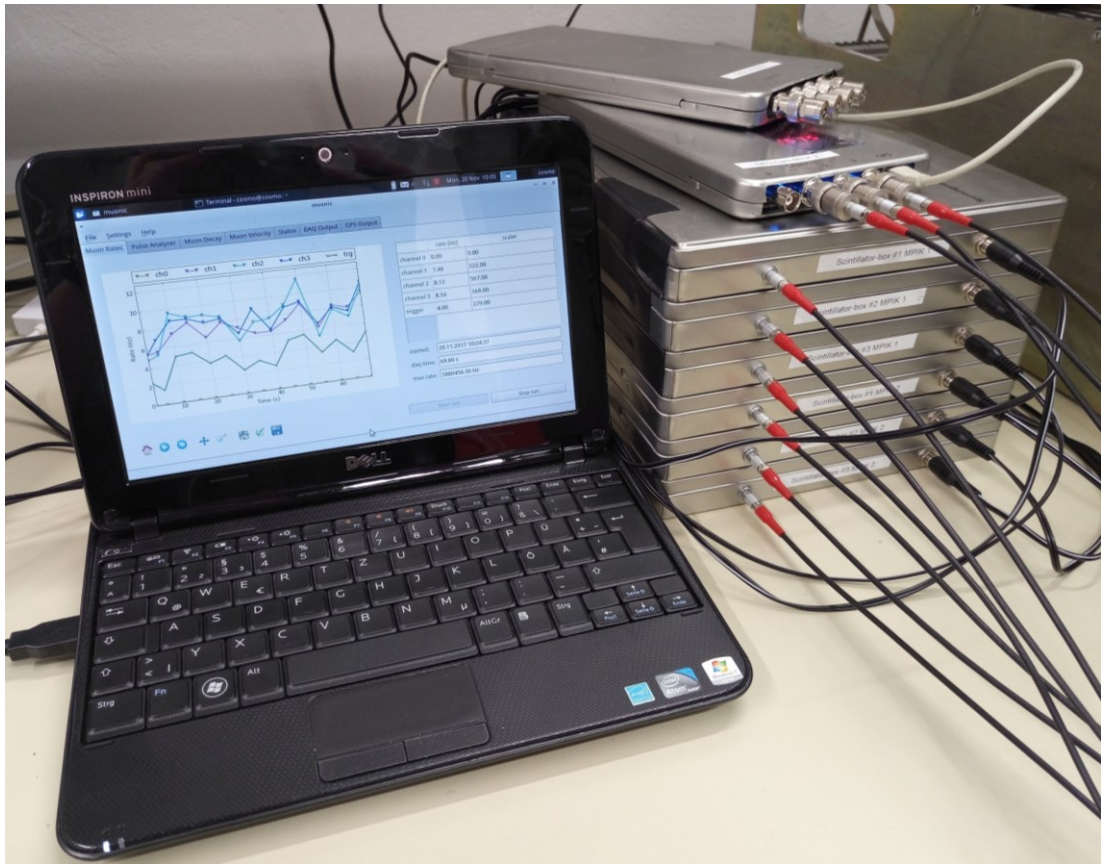
GOALS AND RESOURCES

- **Test and verify a low cost silicon detector**
  - Targeting: Enthusiast, schools, outreach
  - Research opportunities
    - Large scale cosmic ray flux data
    - Observation of showers
    - Better understanding of the impact of cosmic rays on cloud formation
    - Collaboration with CREDO for data collection
- Resources
  - Two CosMO scintillator detectors from the “Netzwerk Teilchenwelt”
  - Two prototype µTelescope silicon detectors
  - NIM-Crate
  - Oscilloscope and resources from the lab

COSMO-DETECTOR

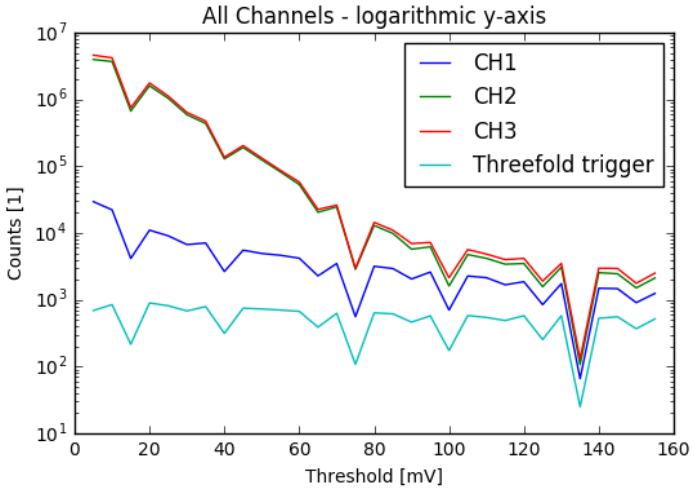
- Two units available
- Parts: DAQ-Card, Laptop, 3x scintillator boxes with SiPMs
- Detector area: 400 cm^2
- 4 Channels
- Timing precision: < 24 ns
- Port for external GPS
- Cost: ~ 2000€



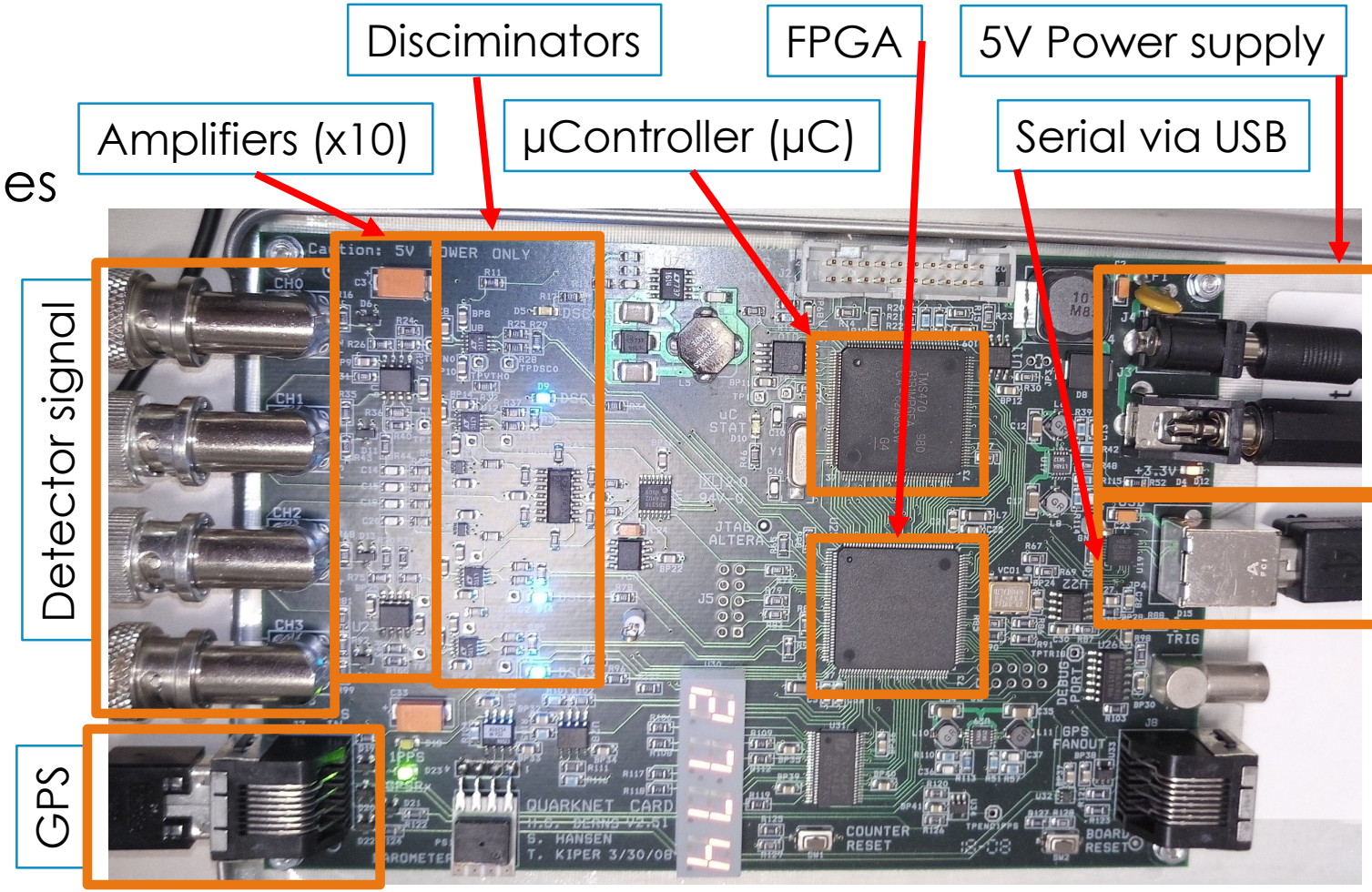
CosMO-Detectors 1 and 2; only one available laptop is being used

COSMO-DETECTOR: DAQ

- Precise pulse edge measurements
- Different channel and trigger modes
- Control via Serial interface
- Internal amplifier
- Non obvious auto reset



Threshold scan with automatic reset



DAQ-Card of the CosMO-Detector; Important parts are highlighted in red

COSMO-DETECTOR: DAQ

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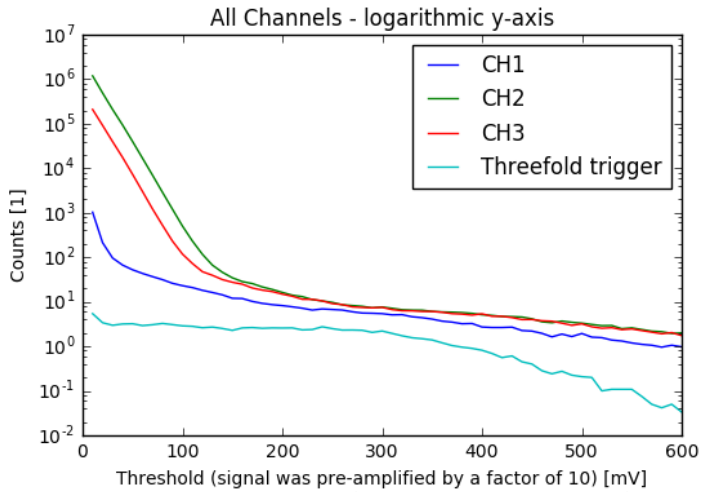
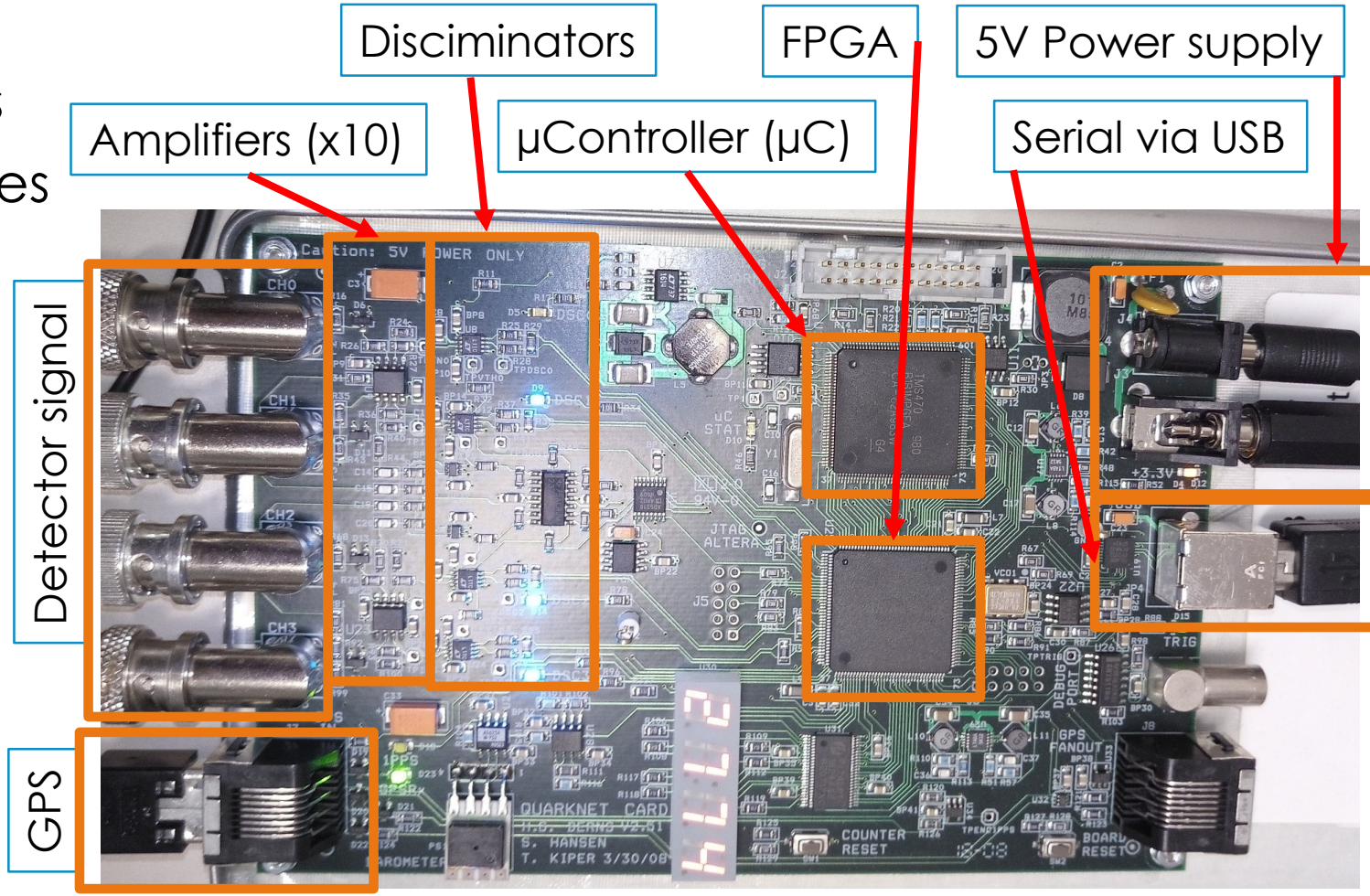


Threshold scan without automatic reset

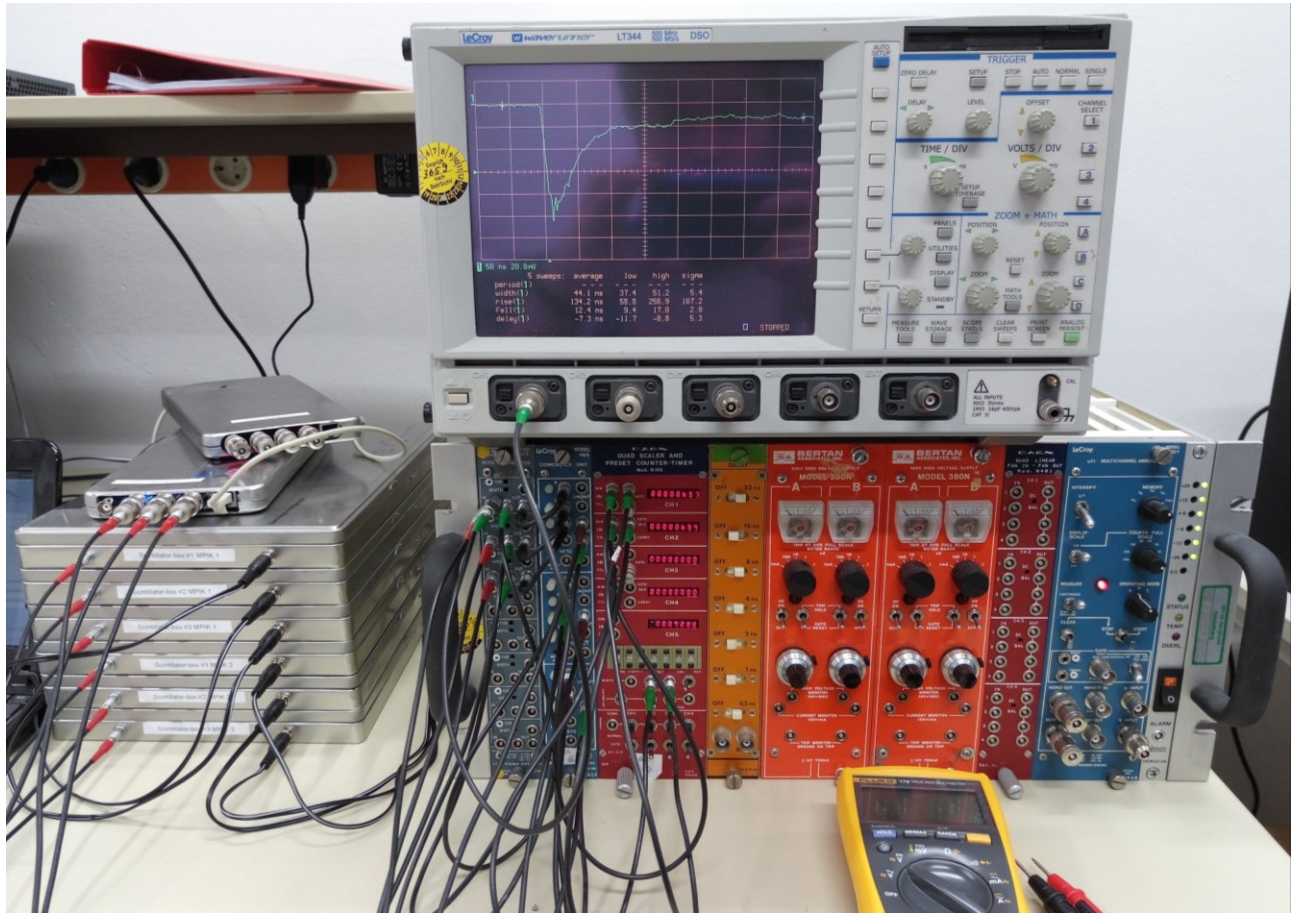


DAQ-Card of the CosMO-Detector; Important parts are highlighted in red

EFFICIENCY MEASUREMENTS

- Measurable via DAQ-Card and NIM-Crate
- On all tested scintillators efficiencies > 98%
- The NIM-Crate seems to perform significantly better

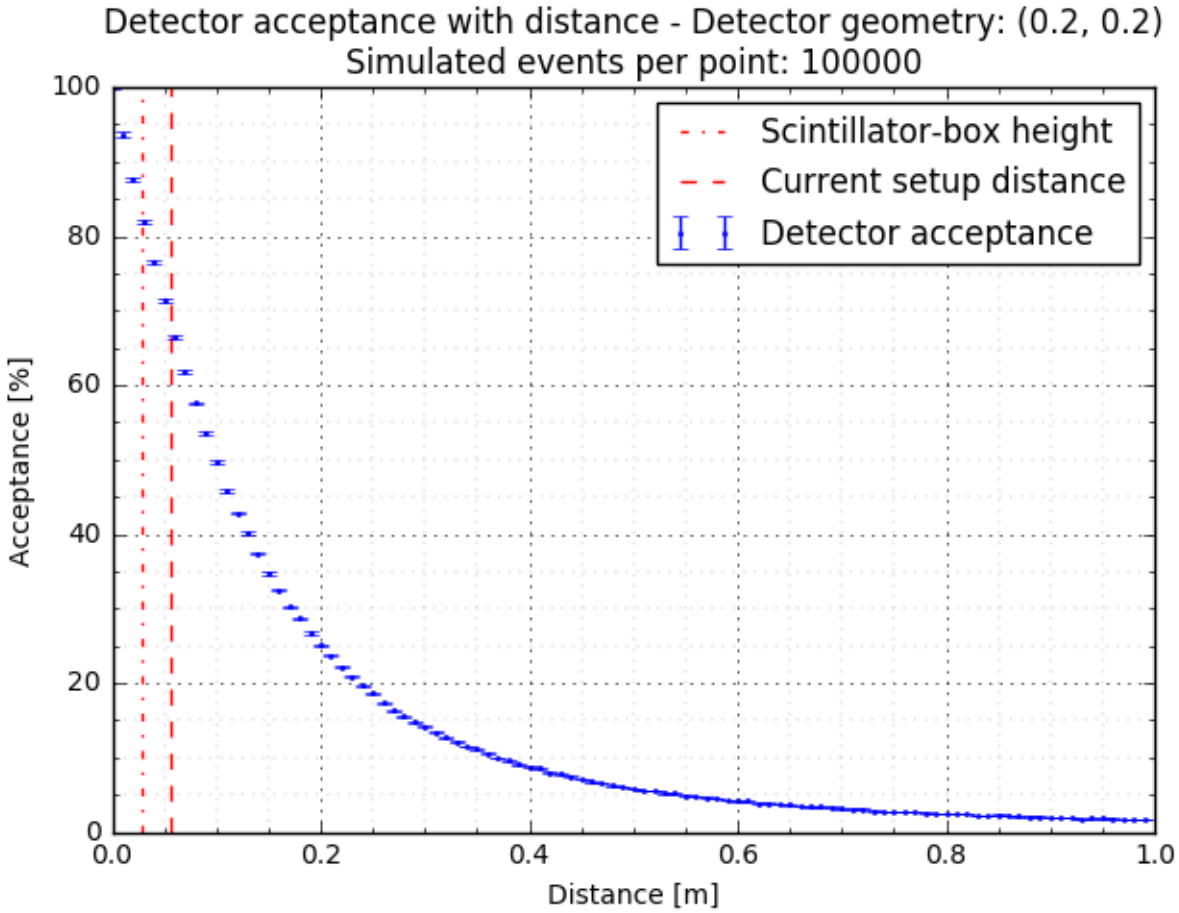
Tested detector	DAQ	Efficiency [%]
Scintillator-box #1 MPIK1	NIM	98.972 ± 0.001
Scintillator-box #2 MPIK1	NIM	99.345 ± 0.001
Scintillator-box #2 MPIK1	DAQ-Card	98.507 ± 0.002
Scintillator-box #3 MPIK1	NIM	99.572 ± 0.001



NIM-Crate setup for the CosMO-Detector

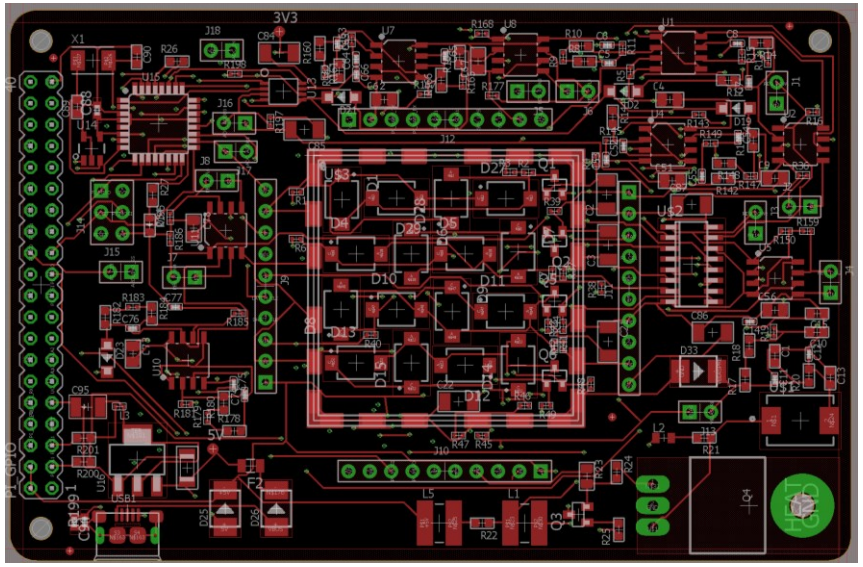
SIMULATIONS: ACCEPTANCE WITH DETECTOR DISTANCE

- Geometric simulation of cosmic ray flux
- Geometric simulation of a twofold detector
- Current setup should already have a significant acceptance loss
- Detector size adjustable
- >2 Million events per second on one thread
- Written with: Python, numpy, Jupyter



µTELESCOPE-DETECTOR

- Two units available
- Parts: Detector prototype PCB, noise shields, Raspberry Pi
- 32 PIN-Diodes as a matrix and row/column readout (expandable)
- Detector area: 1.4 cm^2
- Timing precision goal: < 60 µs (~100 clock cycles)
- Additional are addressable (Accelerometer, Magnetometer, GPS)
- User interface via WiFi
- Pocket-sized
- Cost per prototype: ~220€ (Design goal: < $500)
- Designed by: James Devine and Hendrik Borras



Schematics of the µTelescope (top layer)

µTELESCOPE: HARDWARE

µController (µC) ATMEL328 (Arduino Uno)

12-Bit ADC

Expansion headers (four in total)

µC programming port

Raspberry Pi Pin-header

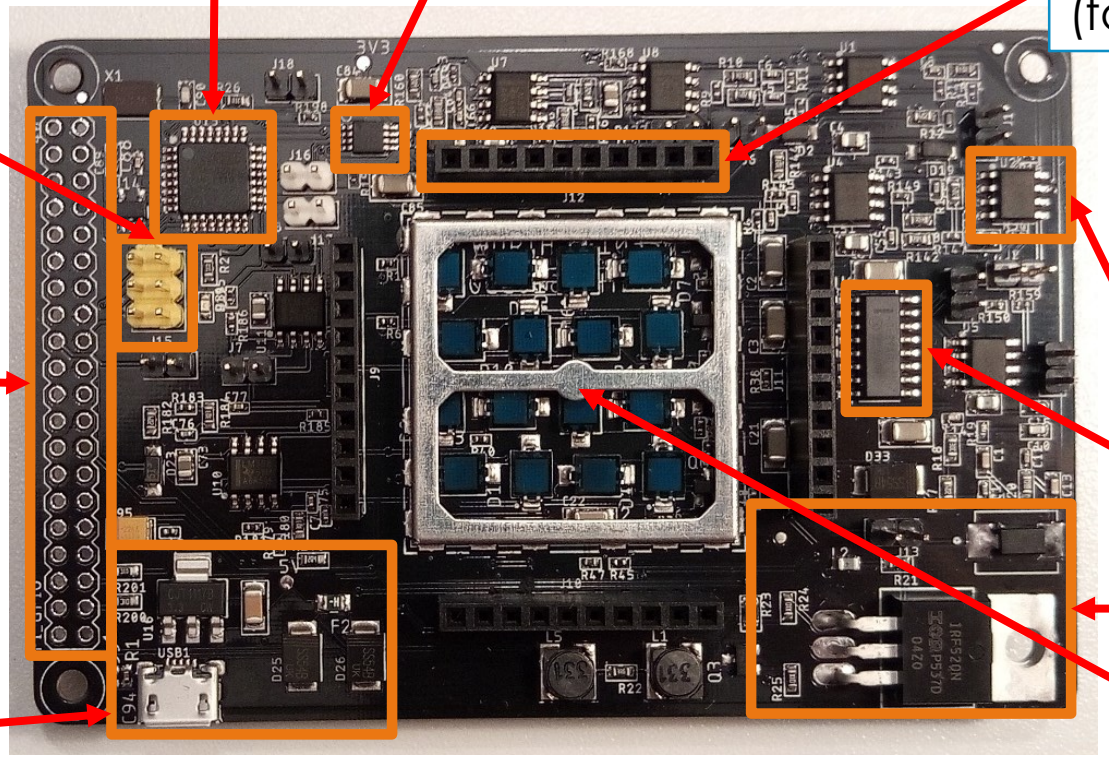
Operational amplifiers (all IC's with this package)

Parallel to Serial Converter

Low-noise HV supply

5V supply

16 PIN-Diodes per side



µTelescope: Prototype PCB (front); Important parts are highlighted in red

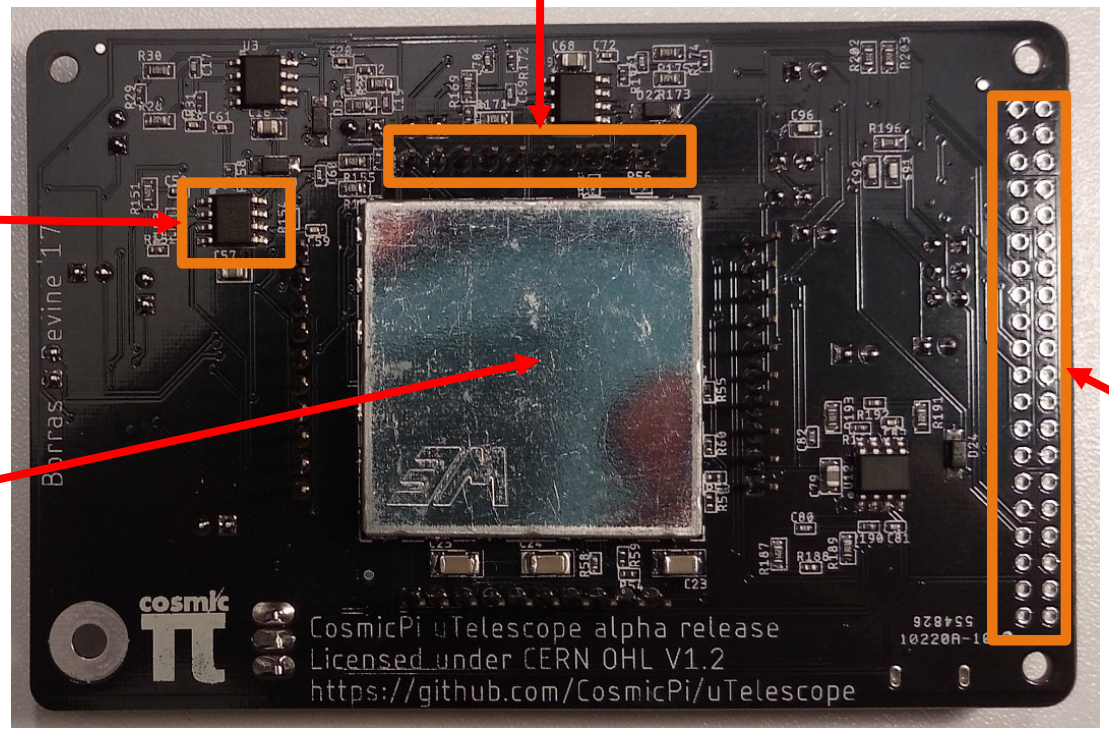
µTELESCOPE: HARDWARE

Expansion headers (four in total)

Operational amplifiers (all IC‘s with this package)

16 PIN-Diodes per side with noise shield

Raspberry Pi Pin-header



µTelescope: Prototype PCB (back); Important parts are highlighted in red

COSMICPI – E.G. A BIT OF HISTORY

- CERN based project aiming to build low-cost cosmic ray detectors
- Mostly voluntary CERN staff/affiliates and summer students
- Worked there as a summer student
  - Improvement of the CosmicPi V1 -> V1.5; a scintillator/SiPM based detector
  - Testing and verification of the CosmicPi V1.5
  - Designing of the µTelescope
    - Intresting as an alternative to the scintillator based approach
    - Uses off-the-shelf components
    - Easy to optimize for manufacturing
    - Designed for higher spatial resolution

NEXT STEPS

- Monte-carlo simulation
  - Verify acceptance results
  - Include measured detector efficiencies
  - Simulate how a rotating detector behaves
- CosMO-Detector
  - Longer efficiency measurements
  - Measurements at increasing detector distances
- µTelescope-Detector
  - Verify components placement
  - Smoke test
  - Component testing
  - µC-programming
  - Efficiency testing