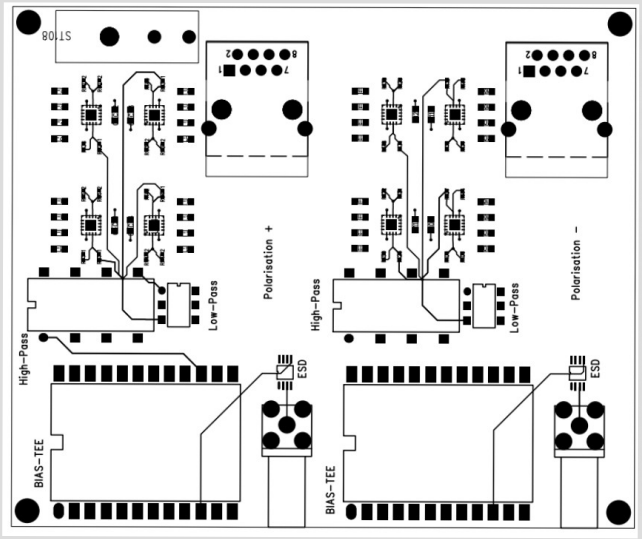
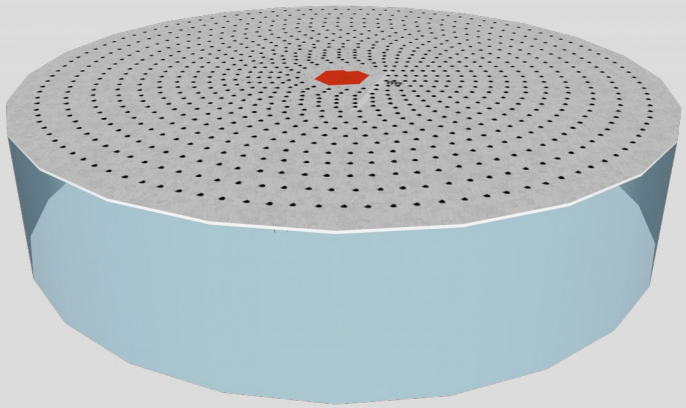
Karlsruher Institut für Technologie

IceCube GEN2

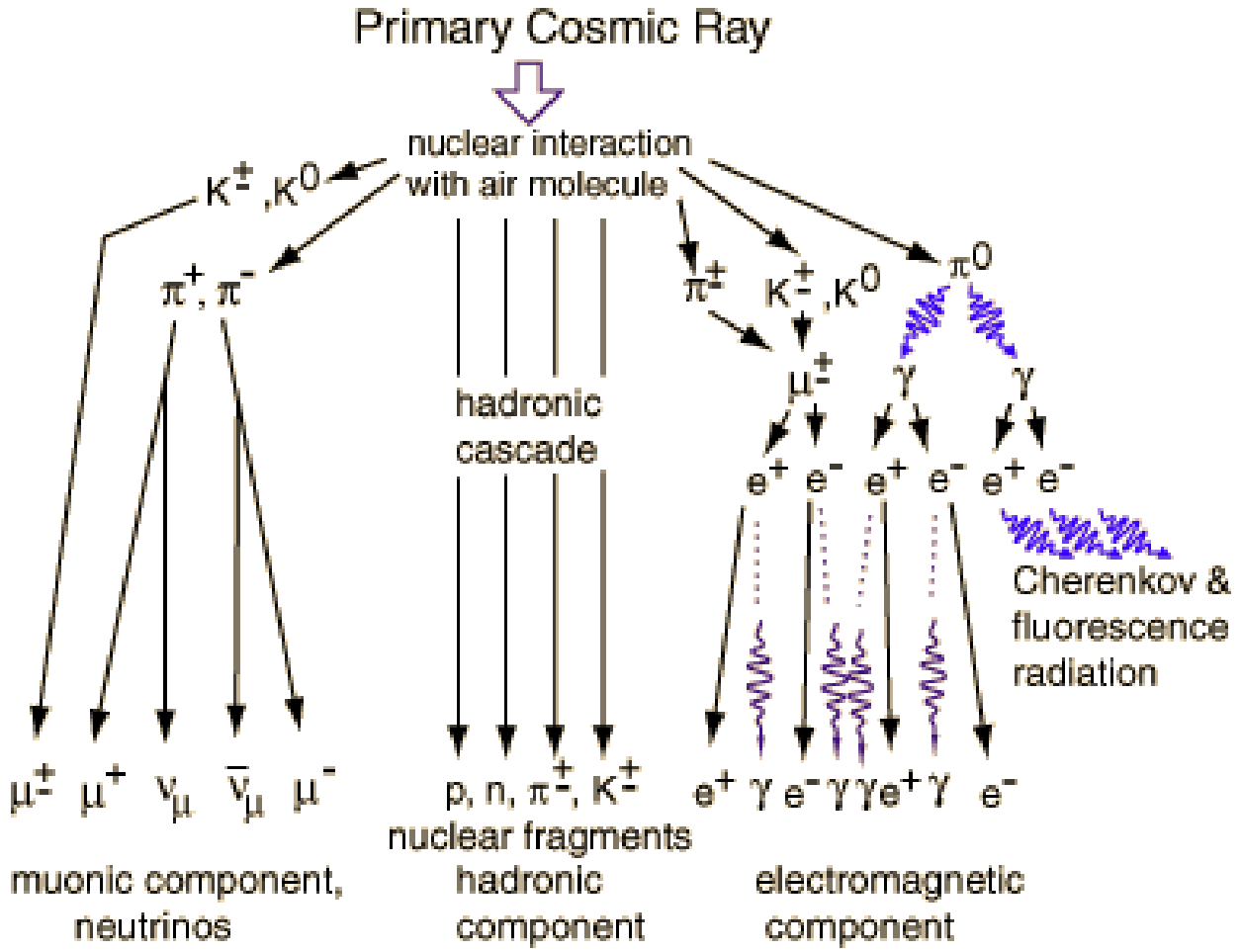
Integration of radio surface antennas into the scintillator upgrade of IceTop at IceCube

Institut für Kernphsik (IKP)
Karlsruhe Institut für Technologie





Cosmic Ray Showers



http://hyperphysics.phy-astr.gsu.edu/hbase/Astro/cosmic.html

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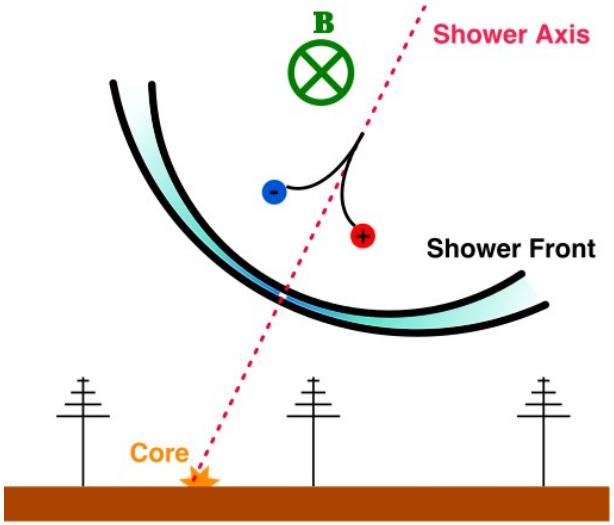
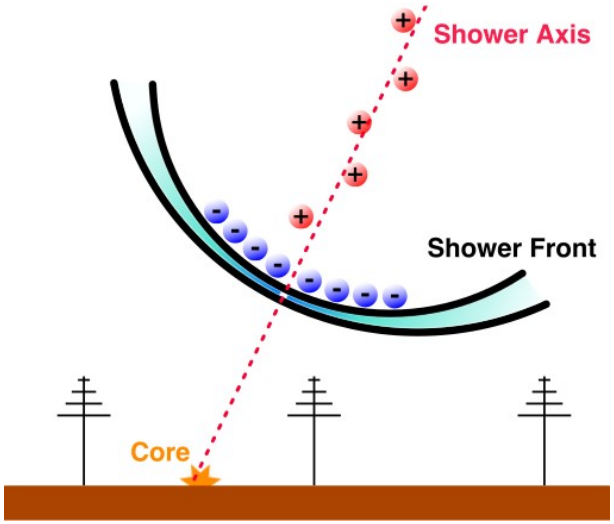
Radio emissions during an air shower





[Auger Col.]

Geomagnetic effect

- Separation of e^+/e^- due to the Earth magnetic field
- Primary effect for particle showers in air

Askaryan radiation

- Charge excess due to e^- in the shower front
- Secondary effect for particle showers in air
- Shifts the maximum of radio away from the core

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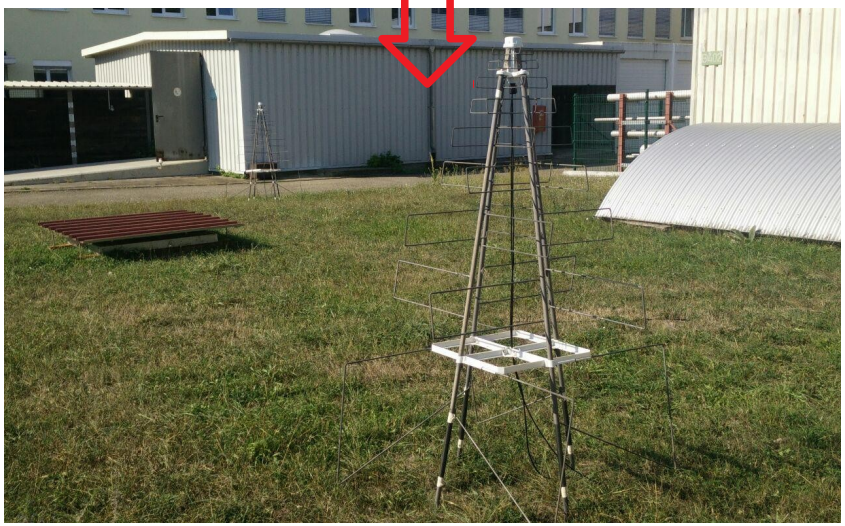
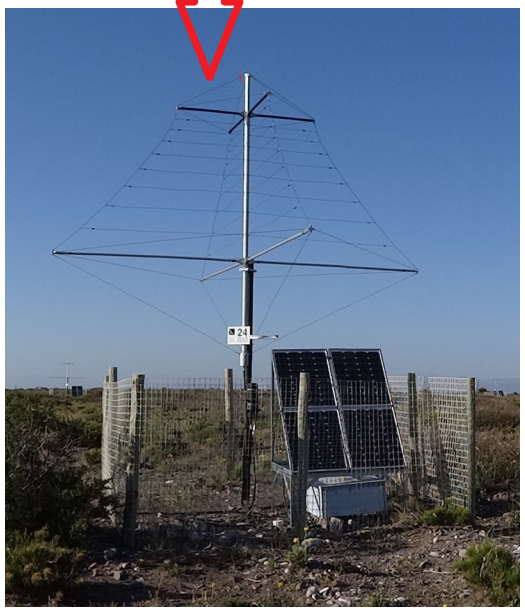
Radio arrays for Astro Particle Physics

- LOPES at CASCADE-Grande (Shutdown in 2013)
- AERA at Auger Observatory (153 radio stations, 6 km²)
- Tunka-Rex (63 antenna, 1 km², E~1 Eev)
- Square Kilometer Array (Africa/Australia, 130k up to 1 million antennas)





LOPES: https://commons.wikimedia.org/wiki/File:LOPES_Antenna.JPG?uselang=de
AERA: https://www.auger.org/images/Projects/AERA_panorama

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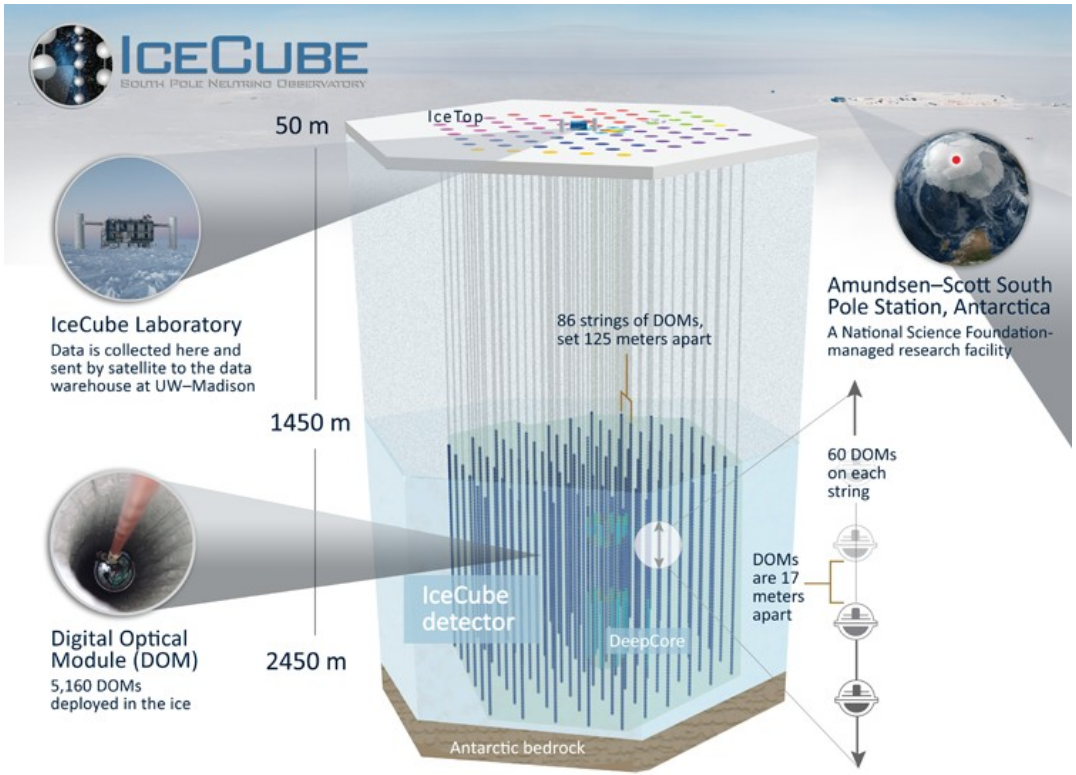
IceCube-Gen2

- IceCube-Gen2 upgrade
- First step: IceTop-Gen2
- Development of a hybrid particle and radio detector for IceTop
  - Improved veto capabilities
  - Investigation of snow accumulation on new detectors
  - IceTop as CR-Detector
  - Search for PeV gamma rays from the Galactic center



https://icecube.wisc.edu/science/icecube/detector

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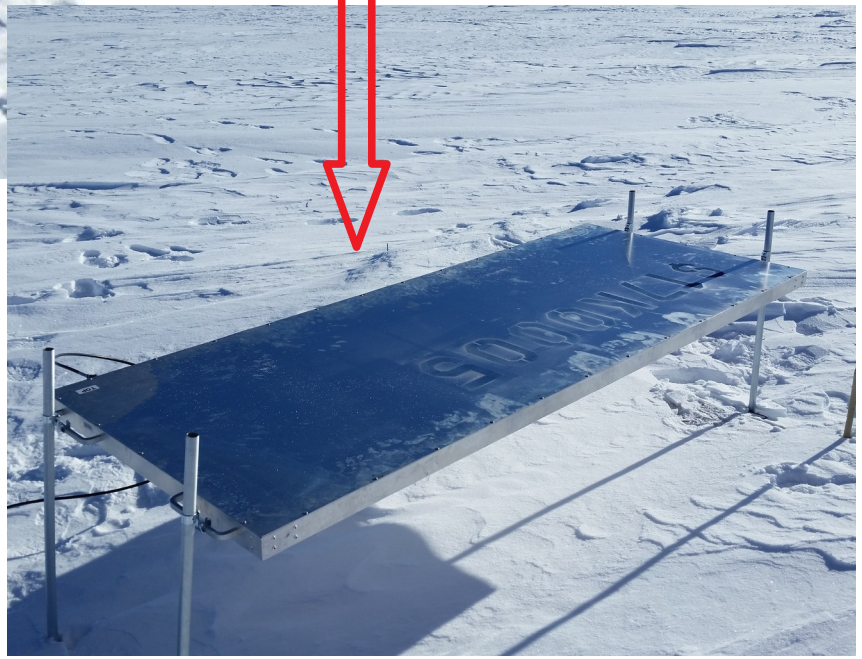
IceScint and IceAct deployed at the southpole

IceScint



IceAct

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The SKALA antenna

- Developed for the Square Kilometer array
- Frequency bandwidth of 50-350MHz (target 100-190 MHz)
- Low-Noise LNA

- Simple structure for harsh conditions
- Integration of radio into existing IceTAXI DAQ, which is in use at the southpole, possible

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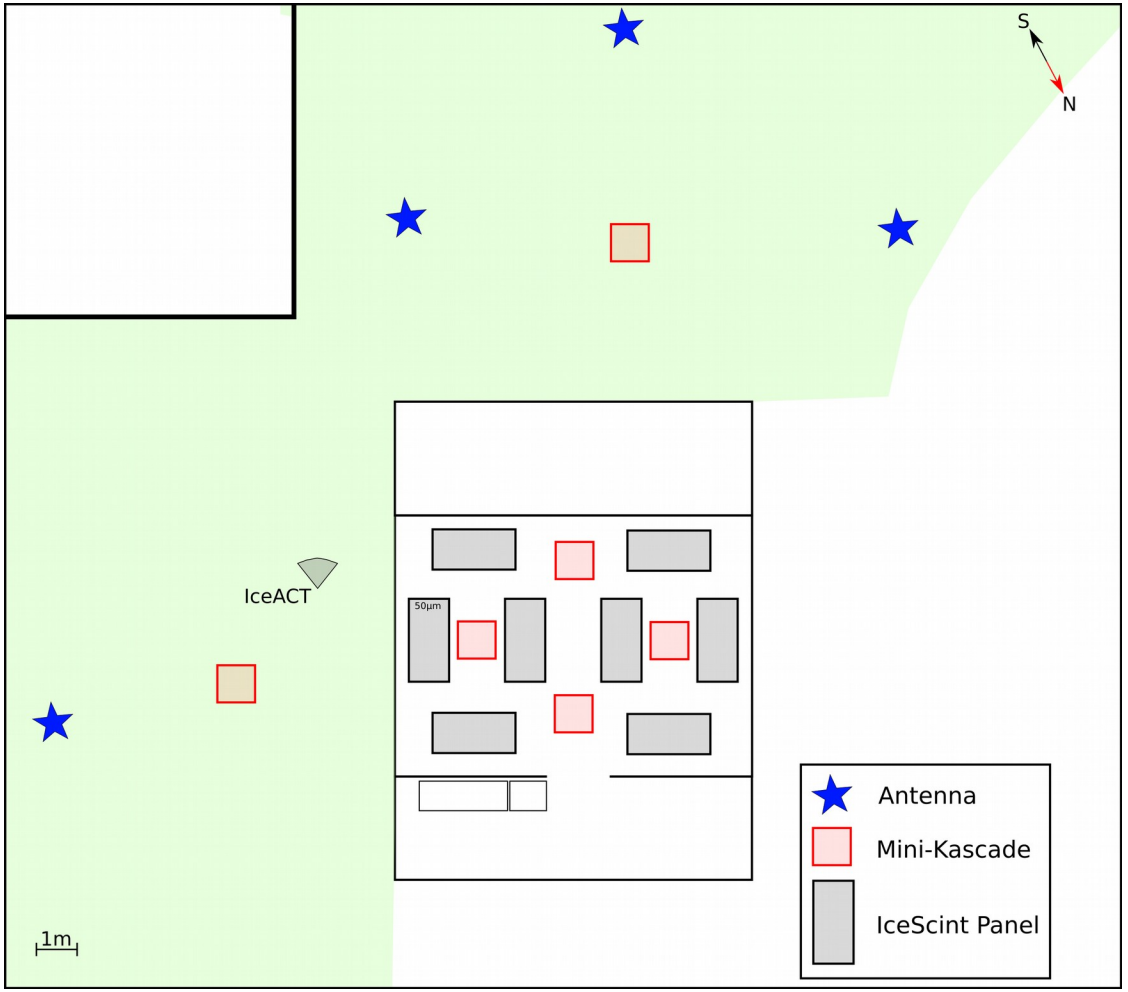
Hybrid engineering array at KIT

- 6 Mini-KASCADE particle detectors
- 8 IceScint detectors
- 4 SKA radio antennas
- IceTAXI DAQ
- White Rabbit network

- Test and calibration of IceScint detectors
- Tests and first measurement with radio antennas



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Pictures - Array

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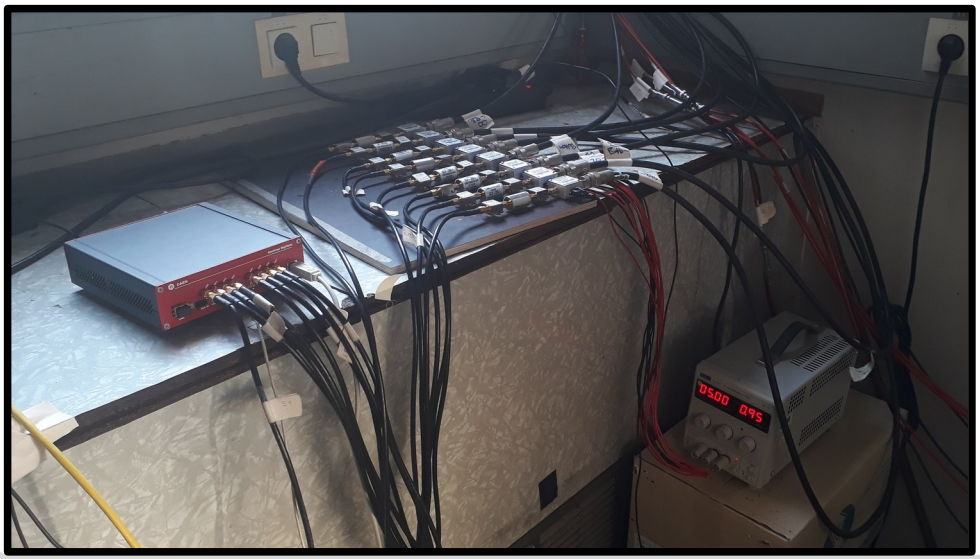
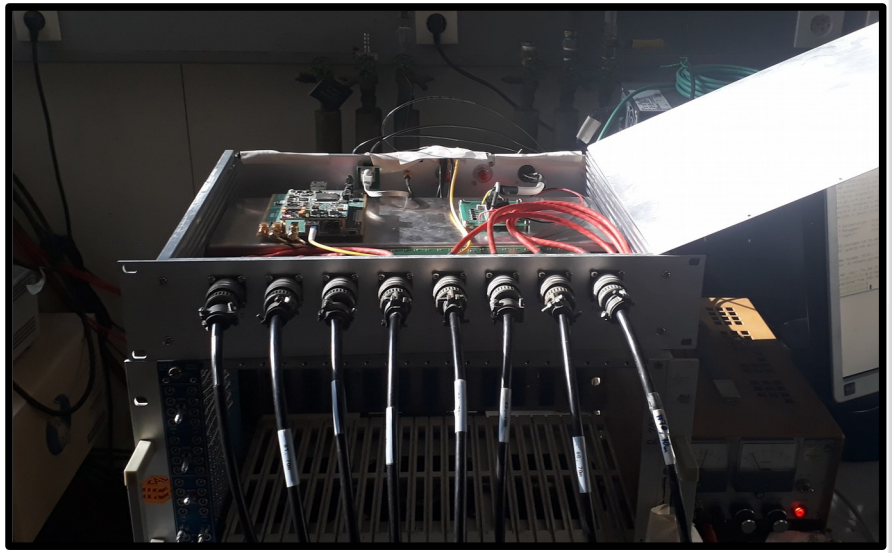
Pictures - DAQ





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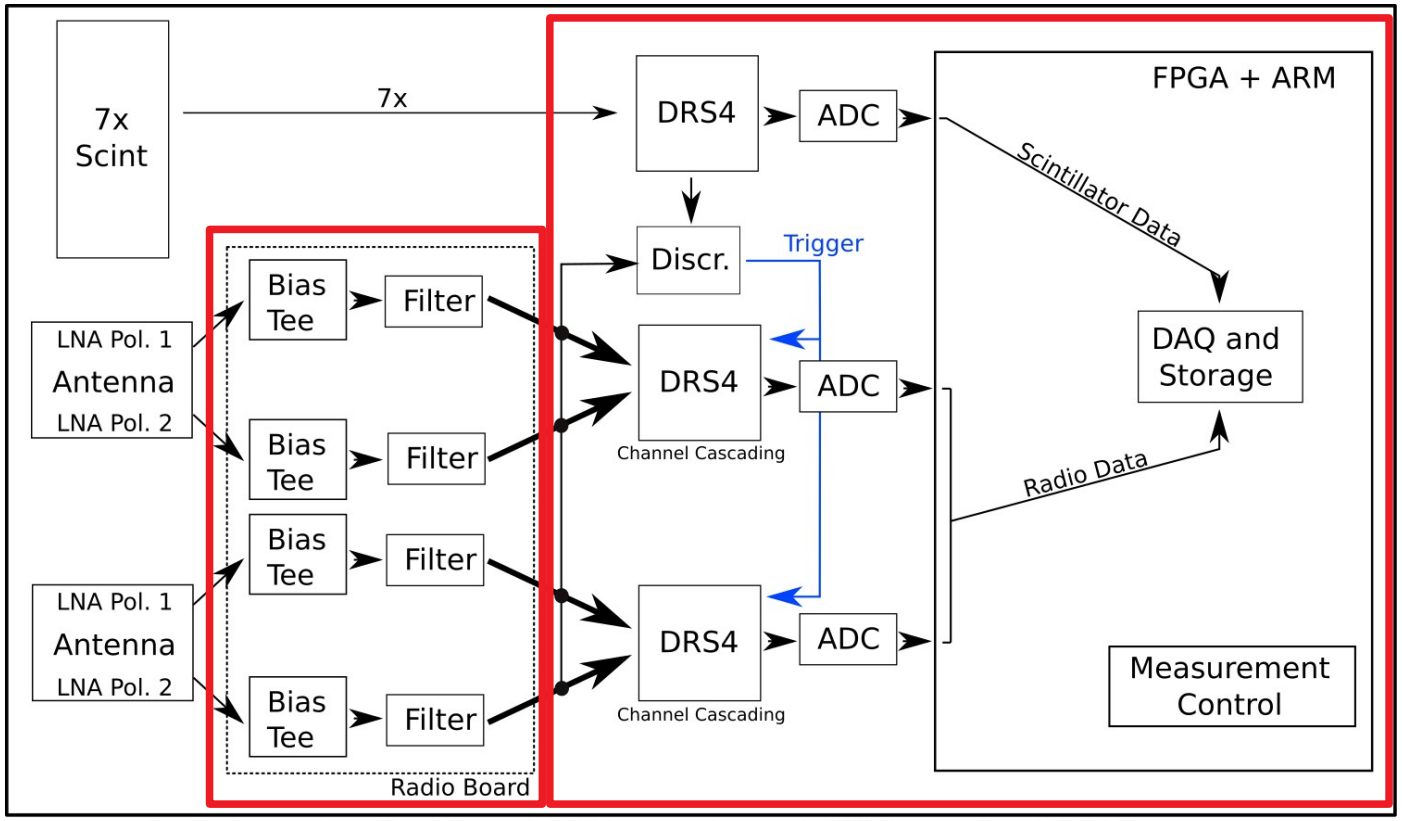
PCB for radio integration

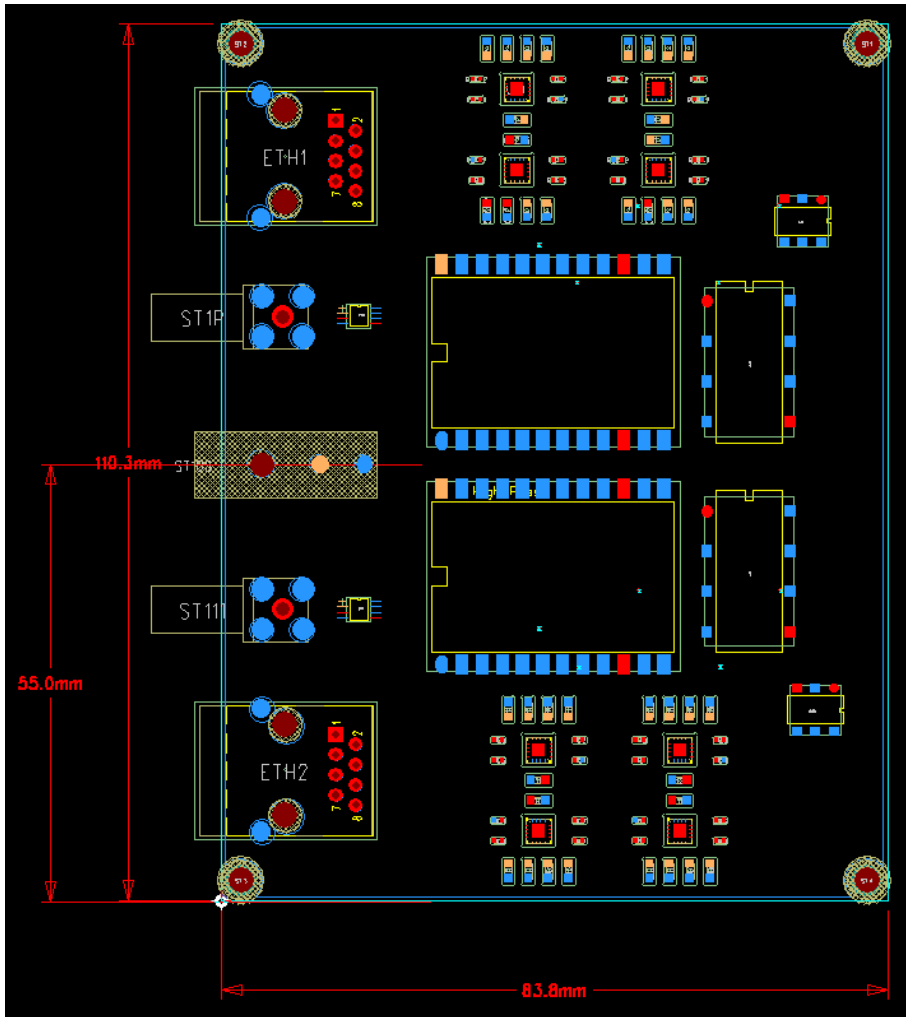


Radio trace length: 4.1µs @ 1GHz per channel, 4096 samples á 14 bit

- One DRS4 samples scintillation detectors, two DRS4 sample two radio antennas
- DRS4 in channel cascading mode for radio: trace length of ~4us
- Internal trigger for radio based on scintillation detector events

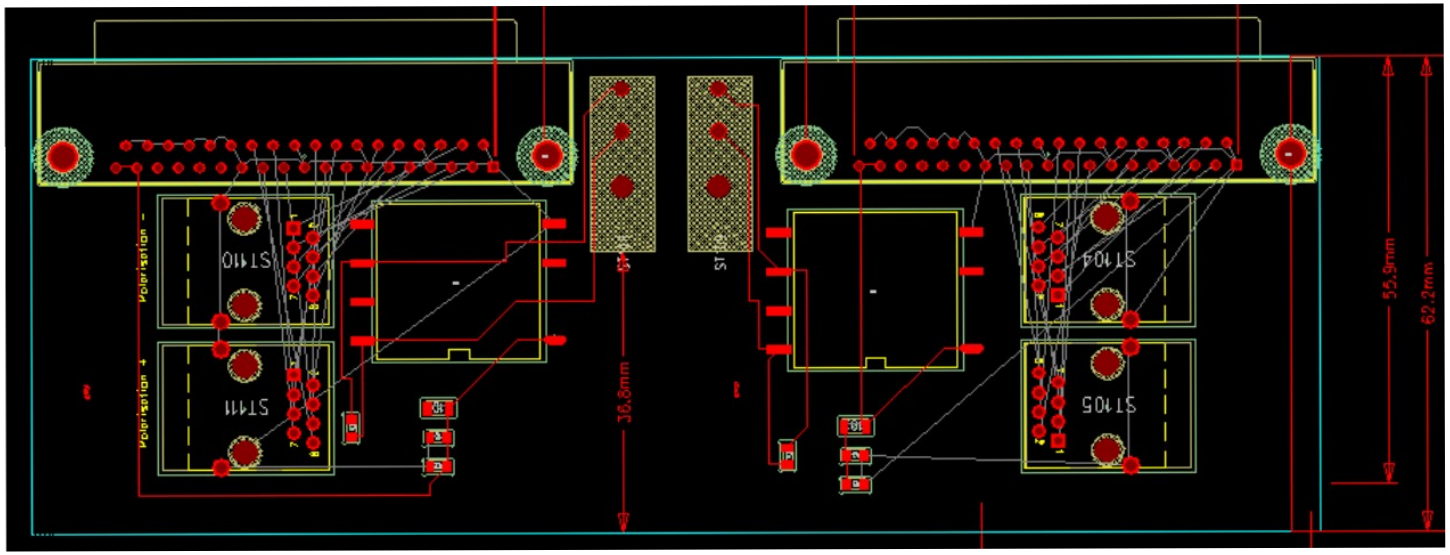
PCB for radio integration

- Input via SMA-connectors
- ESD as spark protection
- BIAS-TEE for power supply of the antennas
- High- and Low-Pass-Filter for frequency bandwidth
- Amplifier for amplification and conversion from single-ended to differential signals
- Output via 8Pin Ethernet



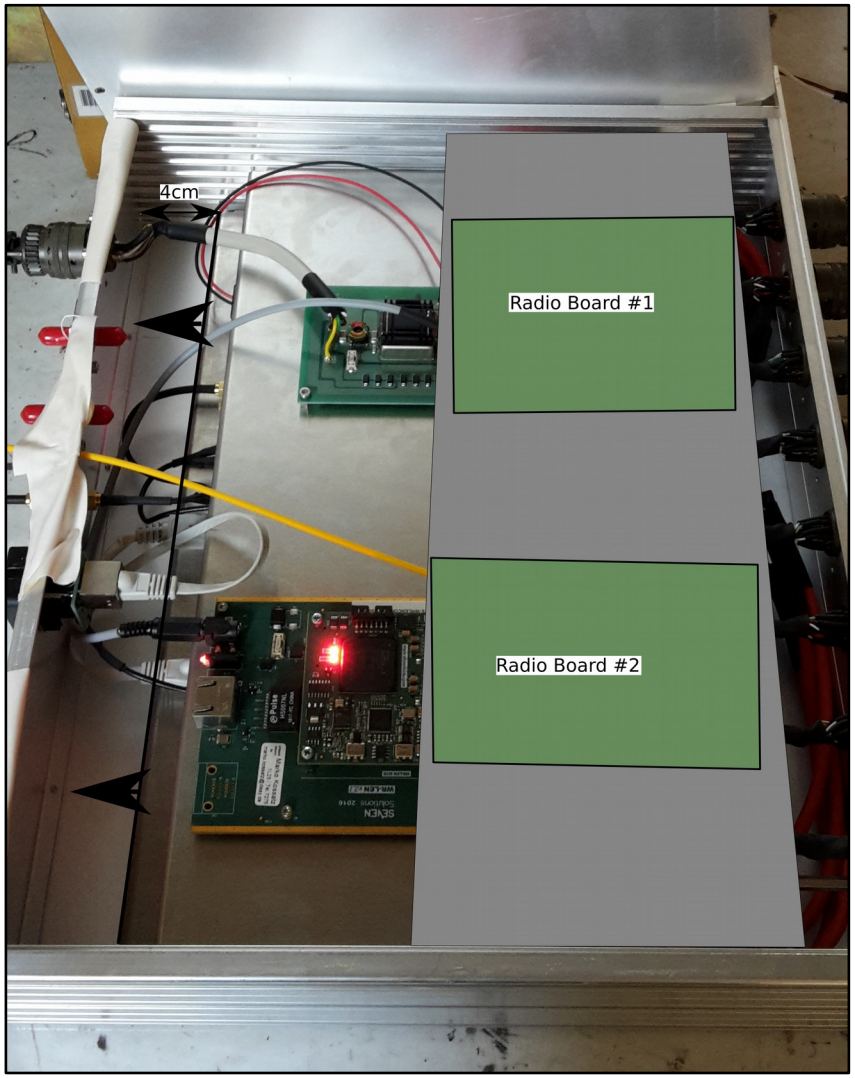
Connector to TAXI

- Input of Ethernet Signal (differential) into TAXI
- Converting 24V DC to 5V DC for Power supply
- Connection for two antenna
  - Separated circuit for each antenna



Prospect

- Production of the PCB by external institute
- Ordering of all necessary parts
- Mounting of all parts and first test with at KIT
- Planing and production of housing for RFI protection



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Prospect

- End of October: deployment of three antenna to New Zeeland and further to the South Pole
- Beginn of November: finishing a new TAXI, provided by DESY Zeuthen with radio board and send to South Pole as hand luggage
- Improvement of the board at KIT
  - Integration into the existing array
  - Stress testing of the board down to -70°C
- Planing of mass production for up to 100 antennas

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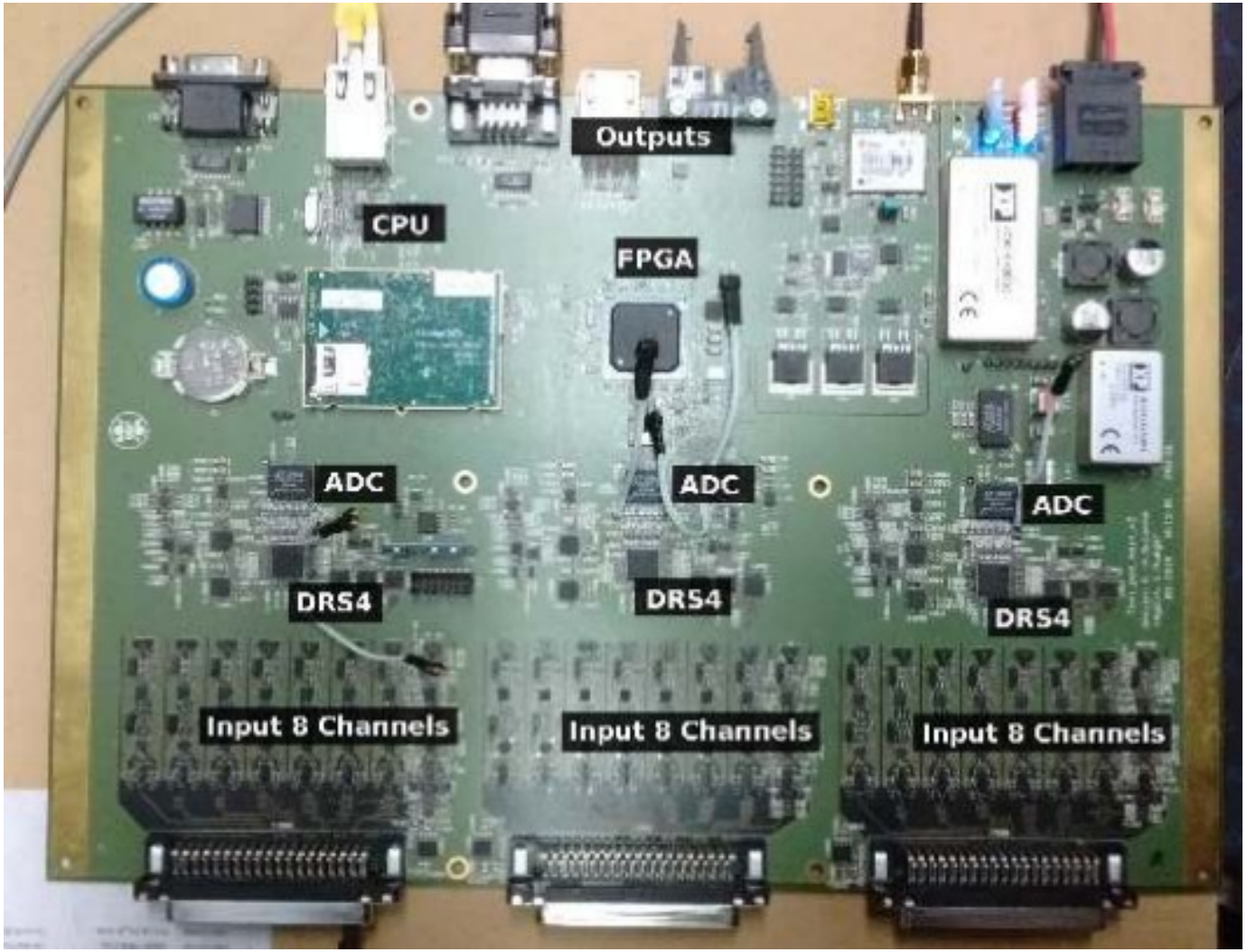
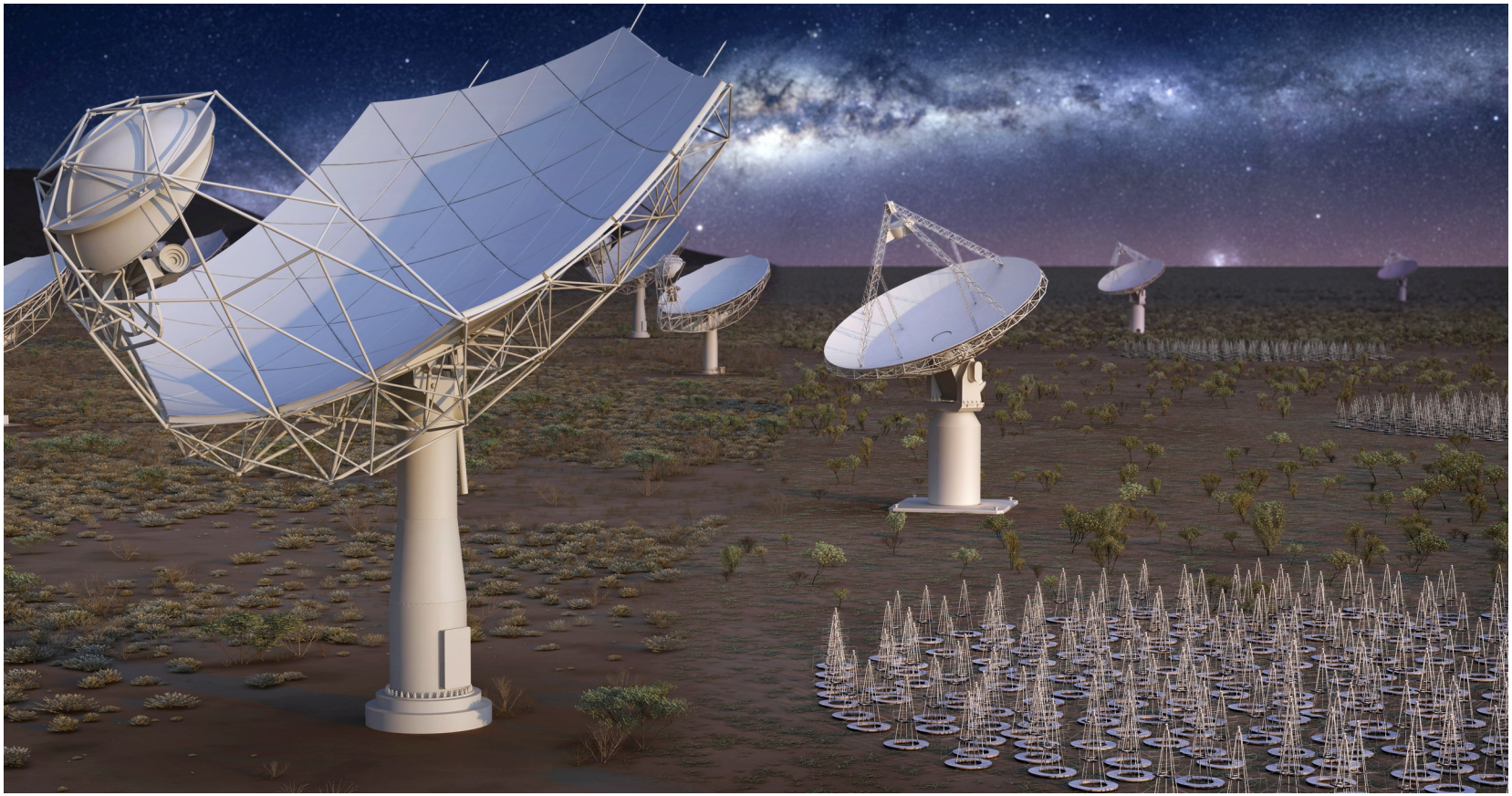
IceTAXI


Outputs
CPU
FPGA
ADC
ADC
ADC
DRS4
DRS4
DRS4
Input 8 Channels
Input 8 Channels
Input 8 Channels

SKA at night



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