Development of a Scintillation and Radio Hybrid Detector Array at the South Pole

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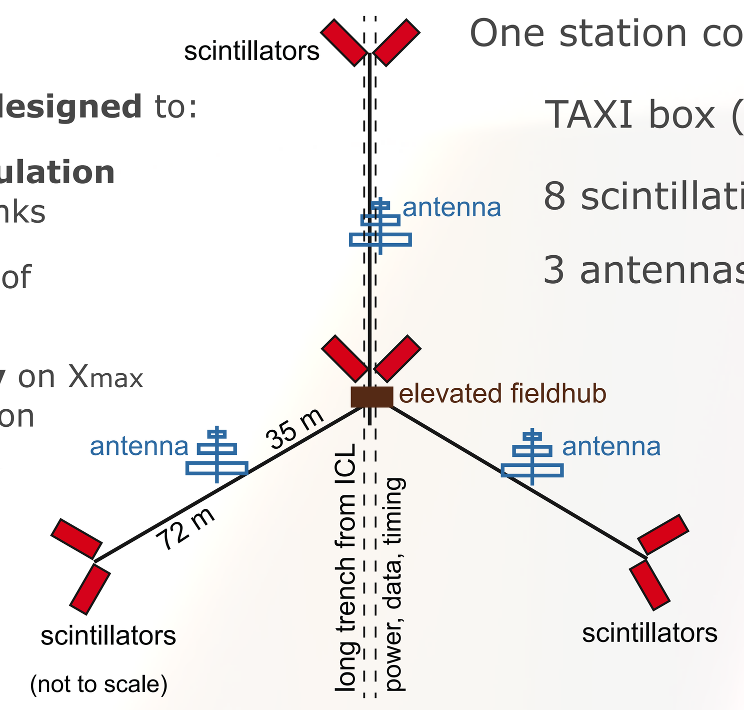
STATION

Enhanced surface array is **designed** to:

- **Mitigate snow accumulation** effects on the IceTop tanks
- **Veto the background** of the in-ice detector
- **Increase the accuracy** on Xmax and energy reconstruction

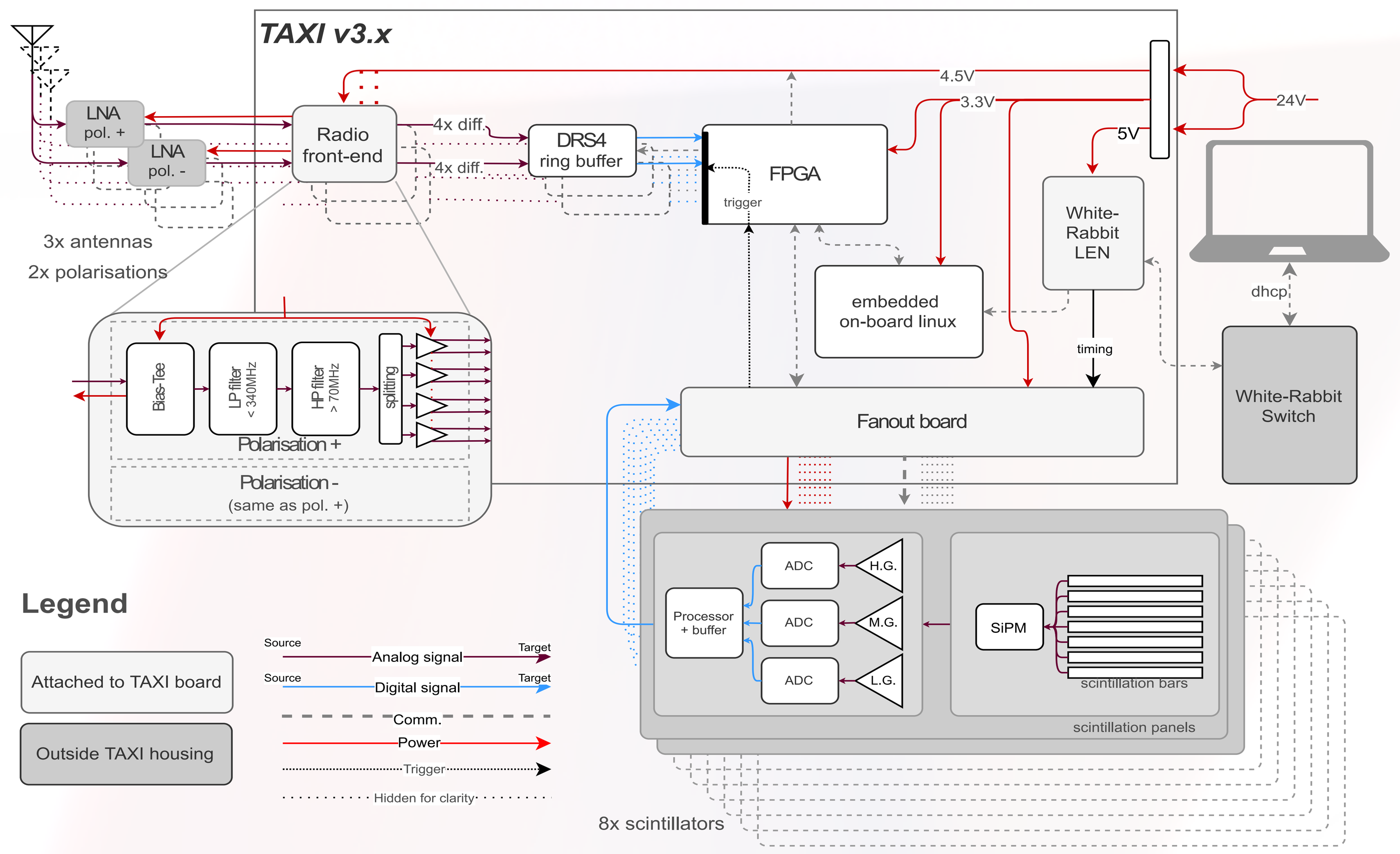
A **prototype station** was deployed in January 2020

Confirming the design



One station comprises :

- TAXI box (in the fieldhub)
- 8 scintillation detectors
- 3 antennas



Picture credit: Y. Makino, IceCube/NSF

The TAXI board has an embedded Linux operating system running on a microprocessor for processing the signals and provides power, communication and timing for the scintillation detectors

The White Rabbit (WR) system provides nanosecond timing

The DRS4 sampling chip is a 8+1 channel ring buffer chip with 1024 sampling cells each.

Radio signal is digitized by 8-channels, 14 bit ADCs

Possibility of trace lengths of 1024 ns, 2048 ns or 4096 ns

Sampling rate of 1GHz

The radio and scintillator data is sent via a 1 Gb fiber link to the IceCube Lab (ICL) using a WR layer

PROTOTYPE STATION

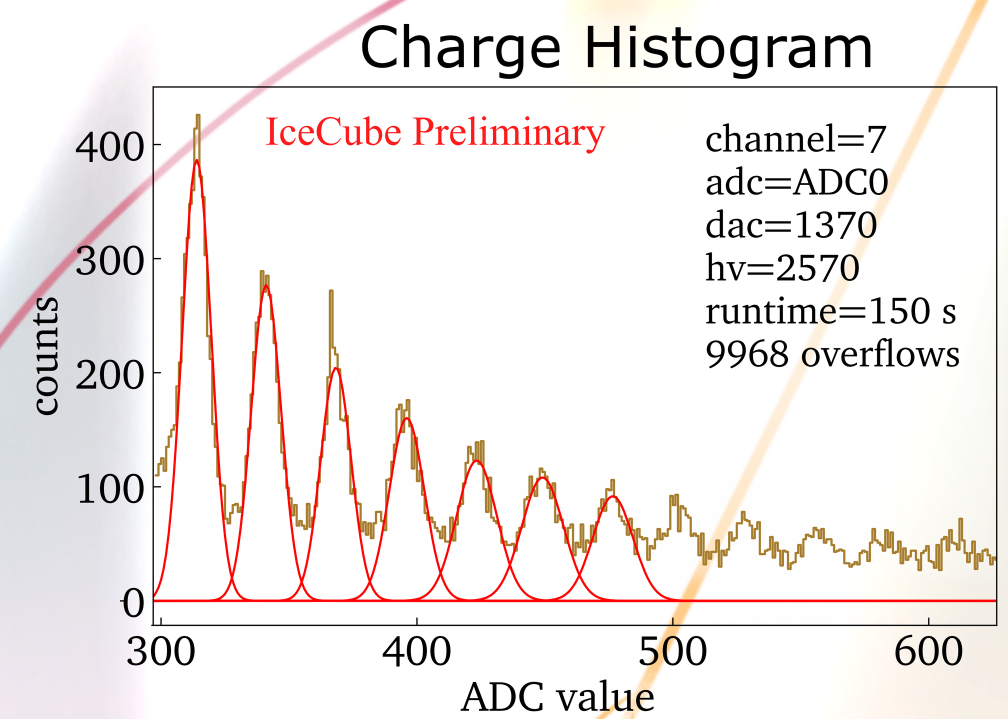
SCINTILLATOR

Each scintillator panel has a sensitive area of 1.5 m² and weights less than 50 kg

16 extruded plastic scintillation bars with a height of 1 cm polystyrene with a TiO_2 reflective layer

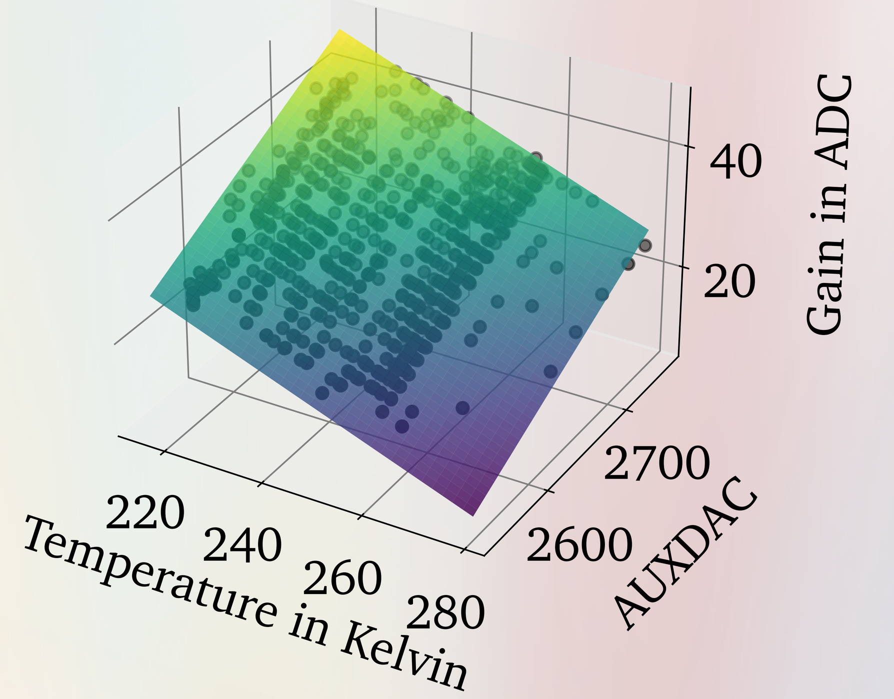
Wavelength shifting fibers are routed through the bars and are read out by a SiPM

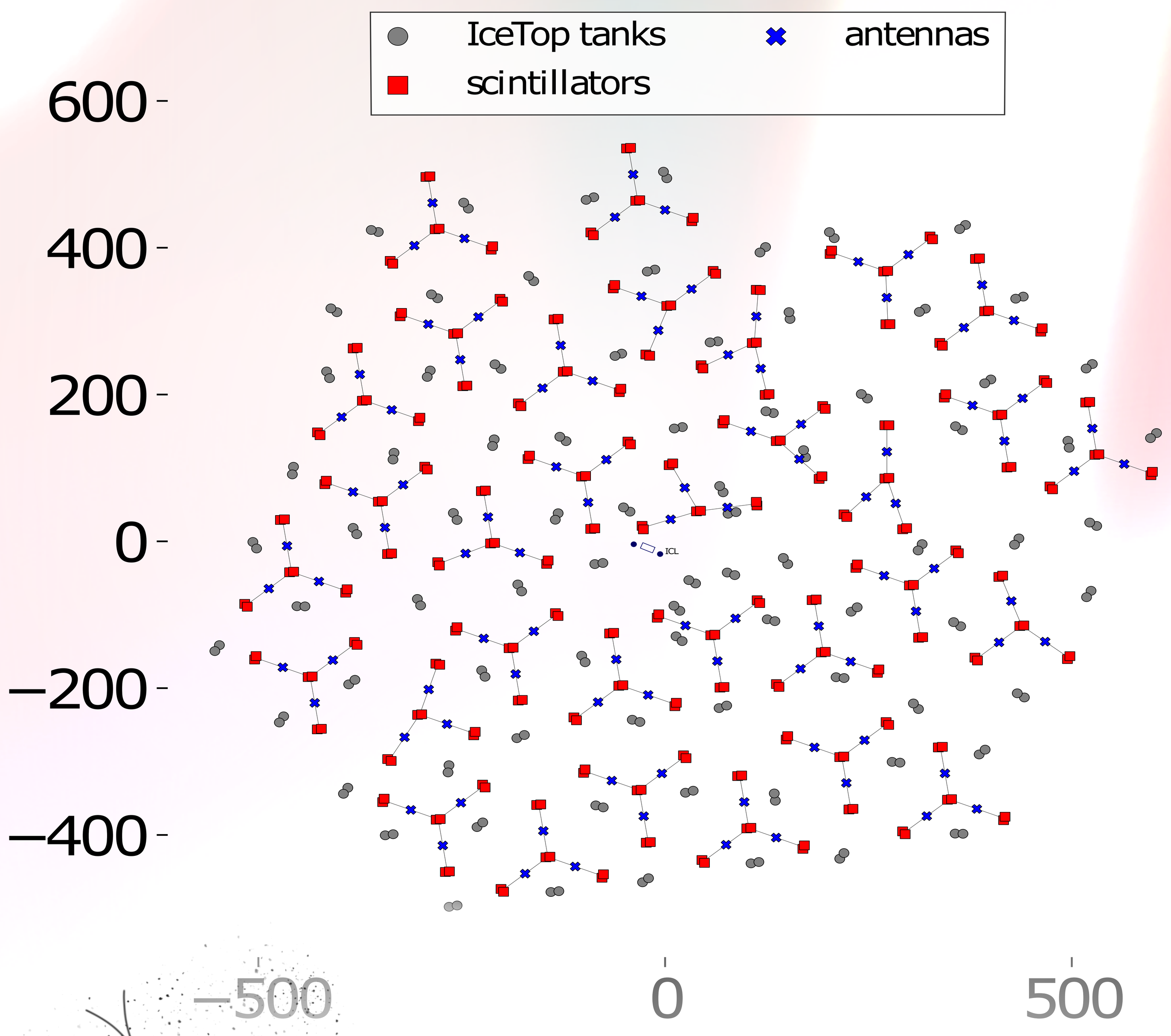
Scintillator MicroDAQ v4.1 sends data in a digitized format



SiPM gain depends on temperature, to stabilize it:

1. Gain is calculated from the distance of the single P.E. peaks in the charge histogram (see left plot)
2. Voltage can then be adjusted as function of the temperature for constant gain (see right plot)





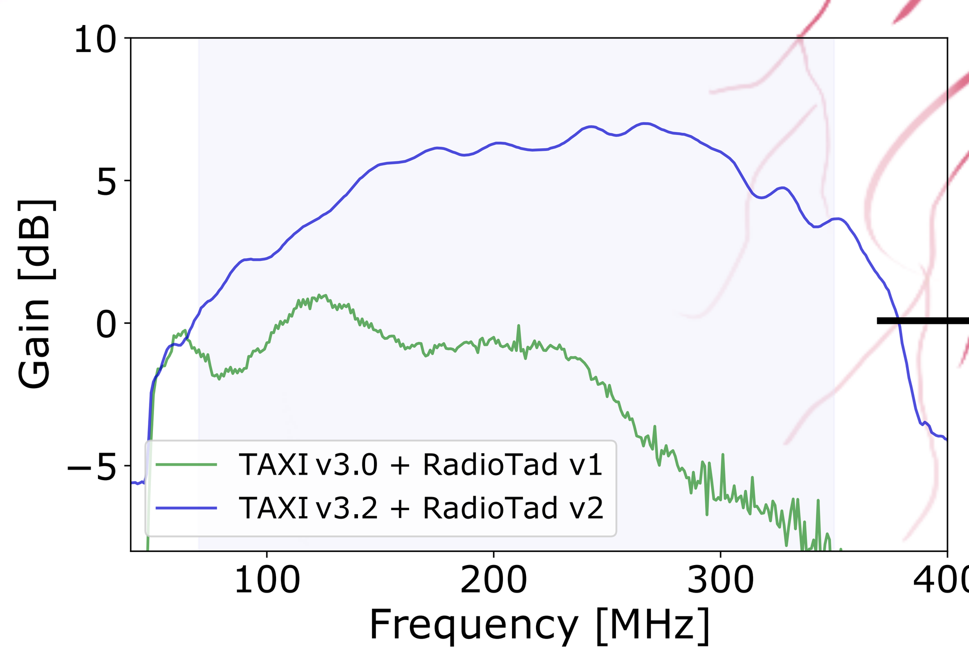
DEPLOYMENT

Final array : 32 stations by 2026

1 km² of instrumented area

Electronics optimized

The gain for the radio signal is higher and more uniform throughout the band of interest. The deviation between the channels of the radioTads is below 10%



RADIO

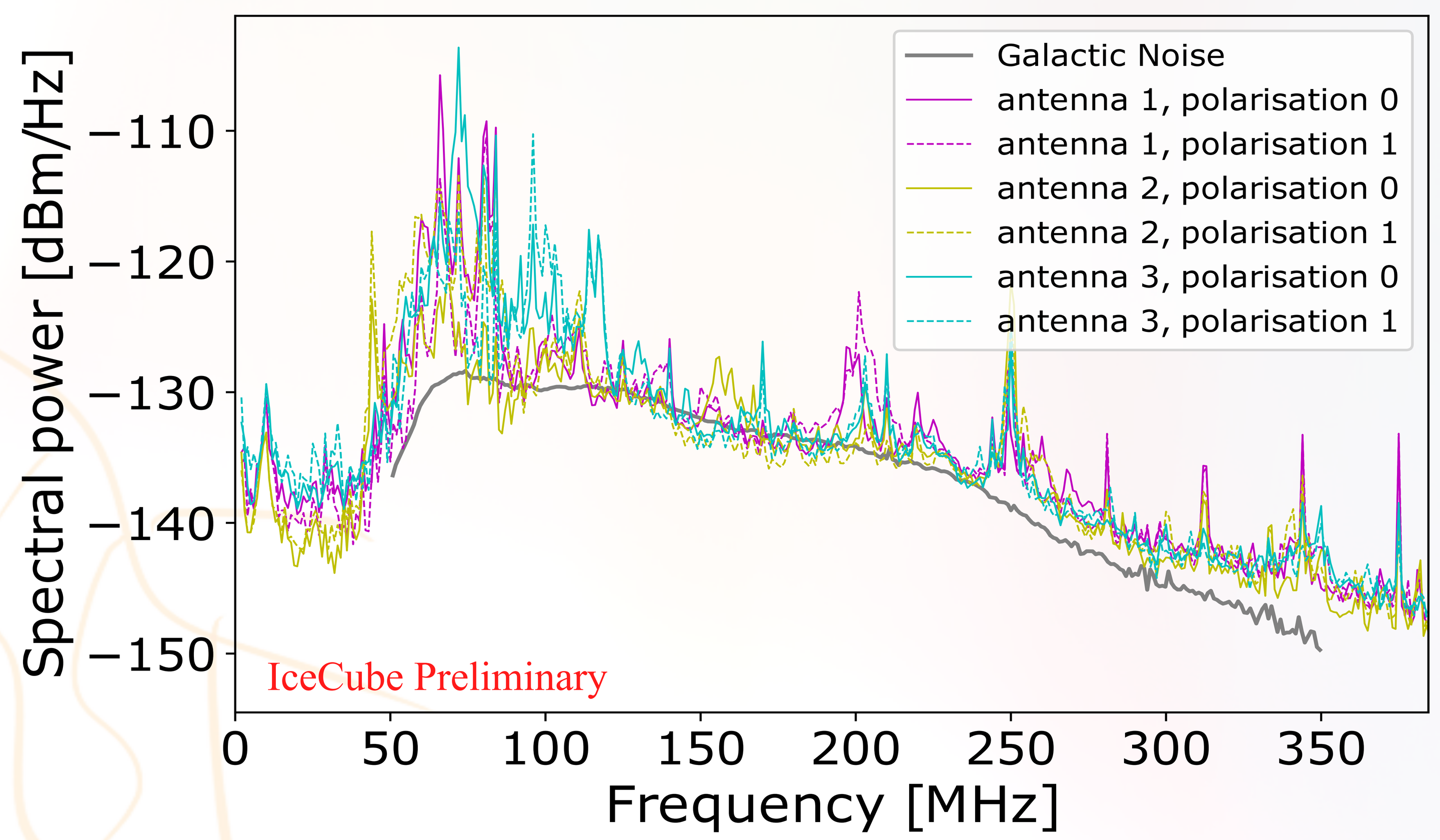
SKALA-2 antennas with dual arms

Pre-processing board: filtering (70-350 MHz) and amplifying the signal

Median spectrum of one day of radio background data

The black line is the galactic noise based on the Cane model and convoluted with the electronic chain

The galactic noise is, as wanted, the noise floor of the radio electronics



References

[1] IceCube Collaboration, A. Leszczyńska, and M. Plum PoSICRC2019(2019) 332.

[2] IceCube Collaboration and M. Renschler PoSICRC2019(2019) 401.

[3] IceCube Collaboration, M. Kauer, T. Huber, D. Tosi, and C. Wendt PoSICRC2019(2019)309.

Surface Array Enhancement

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