

SWIFT-SAT: COEXISTENCE OF REMOTE ASTRONOMICAL INSTRUMENTS SUSCEPTIBLE TO INTERFERENCE WITH LARGE COMMUNICATION SATELLITE CONSTELLATIONS

Cosmin Deaconu (UChicago) <cozzyd@kicp.uchicago.edu>

Introduction: Instruments at the South Pole



The Dark Sector at Amundsen-Scott South Pole Station is a radio-quiet zone hosting several instruments that are susceptible to radio interference. The **South Pole Telescope** and **BICEP Array** are Cosmic-Microwave Background (CMB) observatories, measuring the fluctuations in the primordial light left over from the big bang.

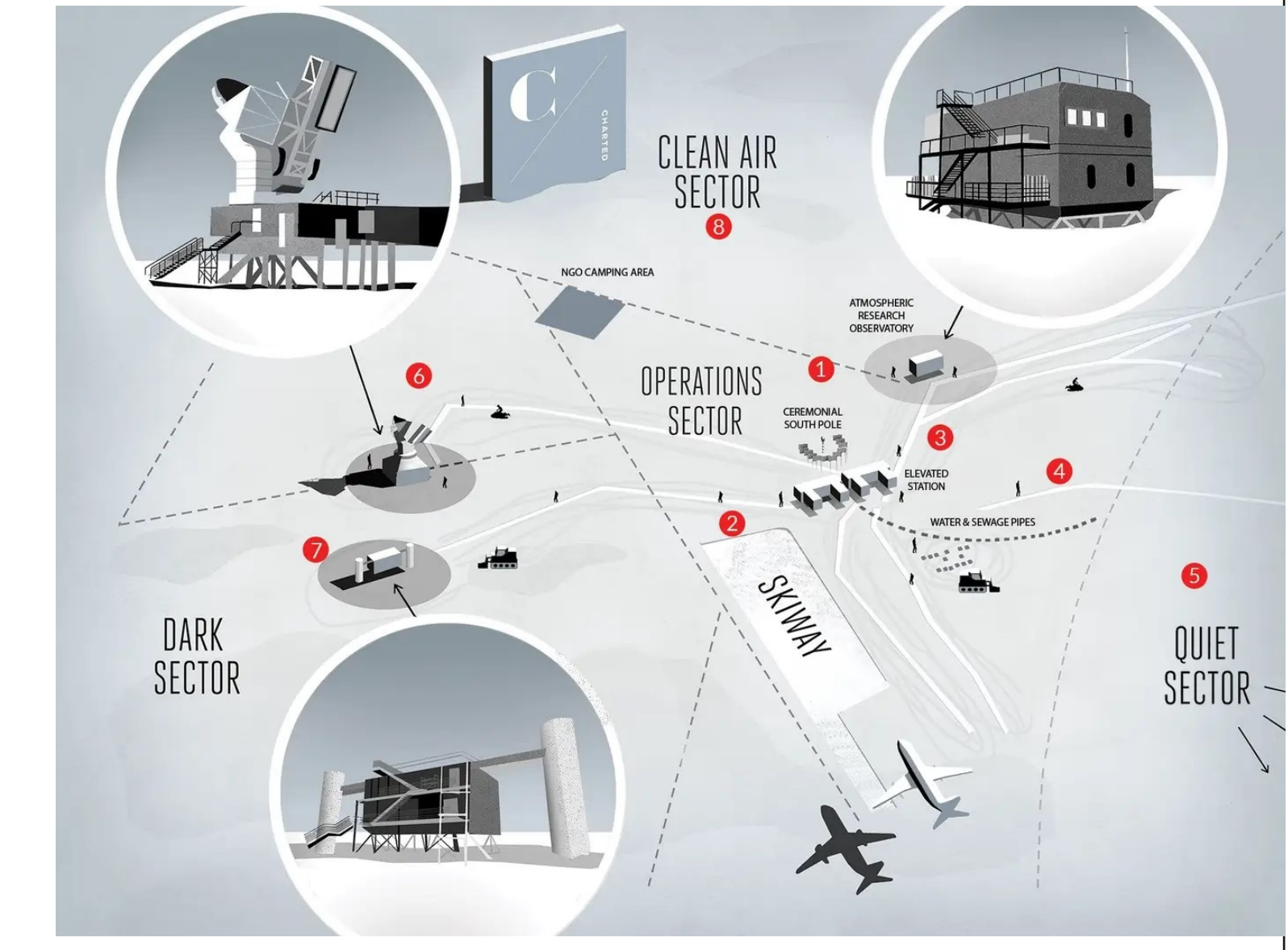
They employ thousands of individual cryogenic bolometric detectors observing in several bands between ~30 and ~400 GHz. Each detector measures the total incident power in its band and polarization. Due to the tiny signal being measured, CMB telescopes repeatedly scan the same region of sky to reduce errors.

The South Pole is an ideal place for CMB measurements due to the dry atmosphere allowing transmission of the frequencies of interest as well as a low RFI environment present in the Dark Sector. Bolometric detectors measure the sum of photons at frequencies they are sensitive to, making RFI more difficult to deal with than with most radio detectors as it cannot be notched. Due to the highly sensitive nature of the electronics used for the multiplexed sensor readout, out-of-band RFI can also couple into the measurement stream through intermediate readout stages in difficult to predict ways.

Also in the Dark Sector is the **Askaryan Radio Array** (ARA), a detector looking for radio pulses from ultrahigh-energy neutrinos interacting in the glacial ice. The Askaryan Radio Array observes from 150-700 MHz and is especially sensitive to transient impulses.

Owing to its remoteness, communications at the South Pole are limited. While Iridium is available at all times, normal internet and high-speed data transfer are only available about half the time with satellites (TDRSS and DSCS) that are near end of life and may become unavailable as soon as next year. Replacing or augmenting communications with low-earth-orbit satellites is therefore an urgent priority for the station. However, any impacts on the science must be understood and necessary mitigations devised to avoid jeopardizing the science done at Pole.

Above: CMB Telescopes at Pole from ICL (Jan, 2020)
Below: Map of sectors at the South Pole.

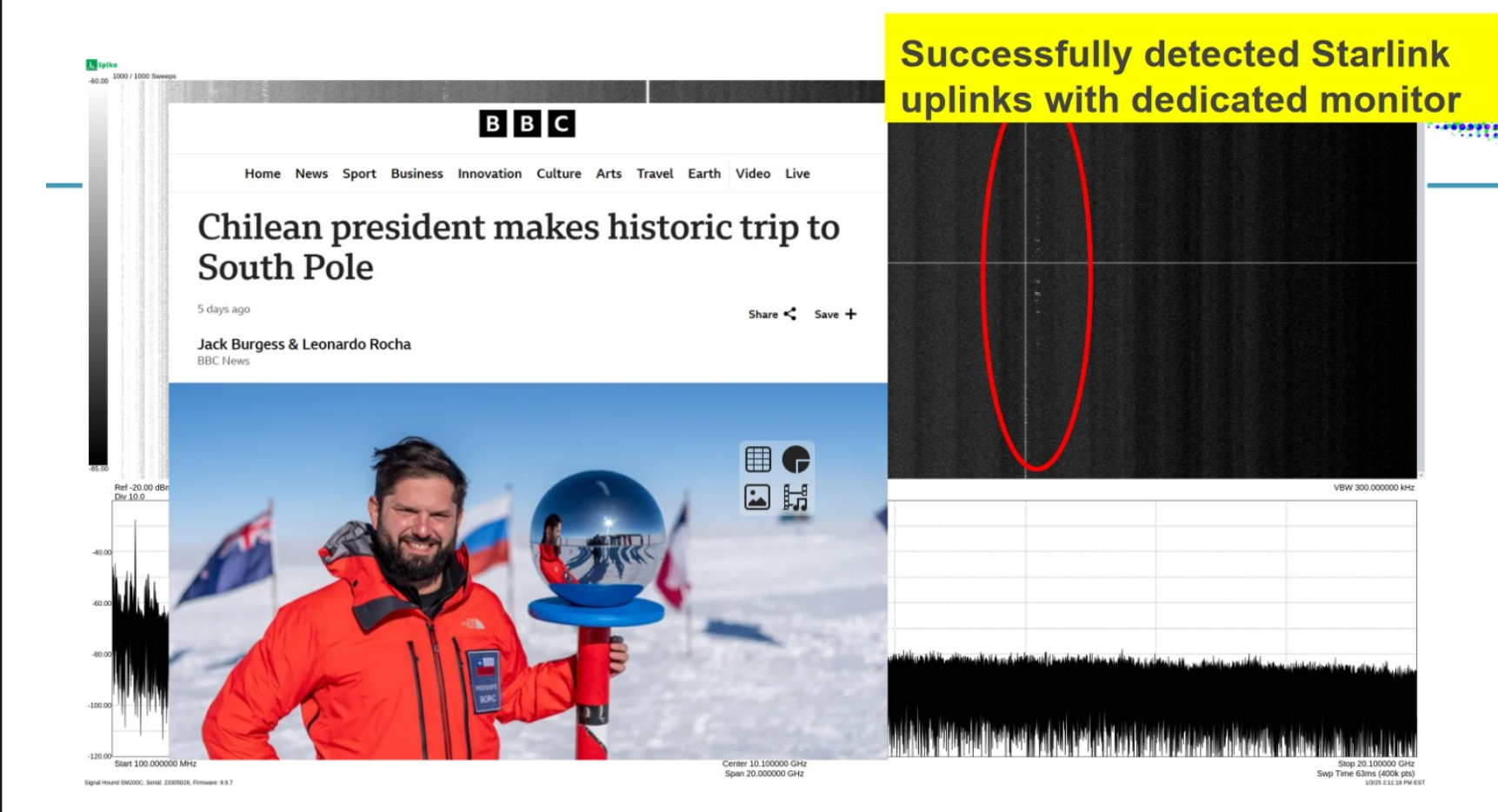


Improved RFI Monitoring at the South Pole

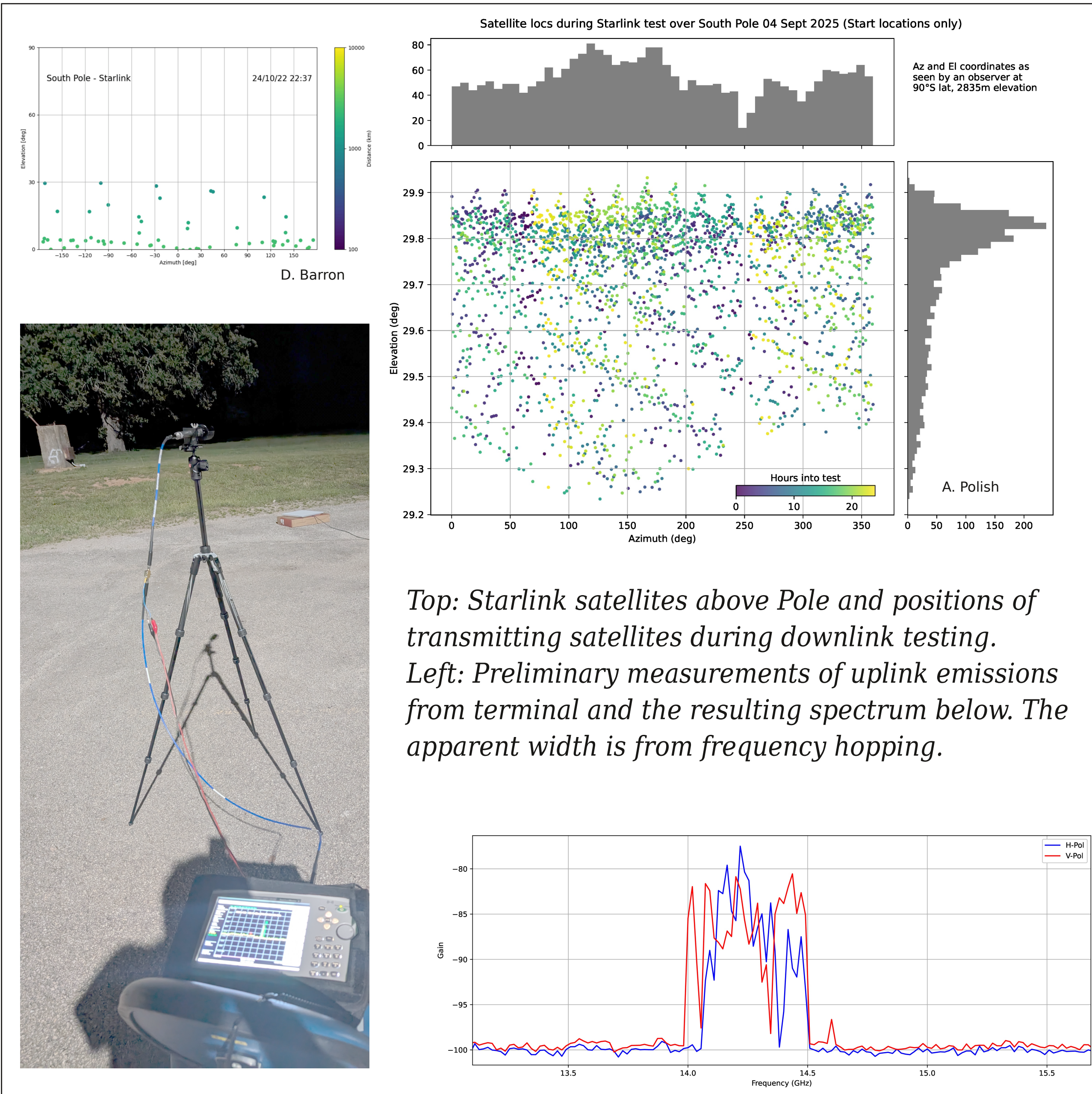
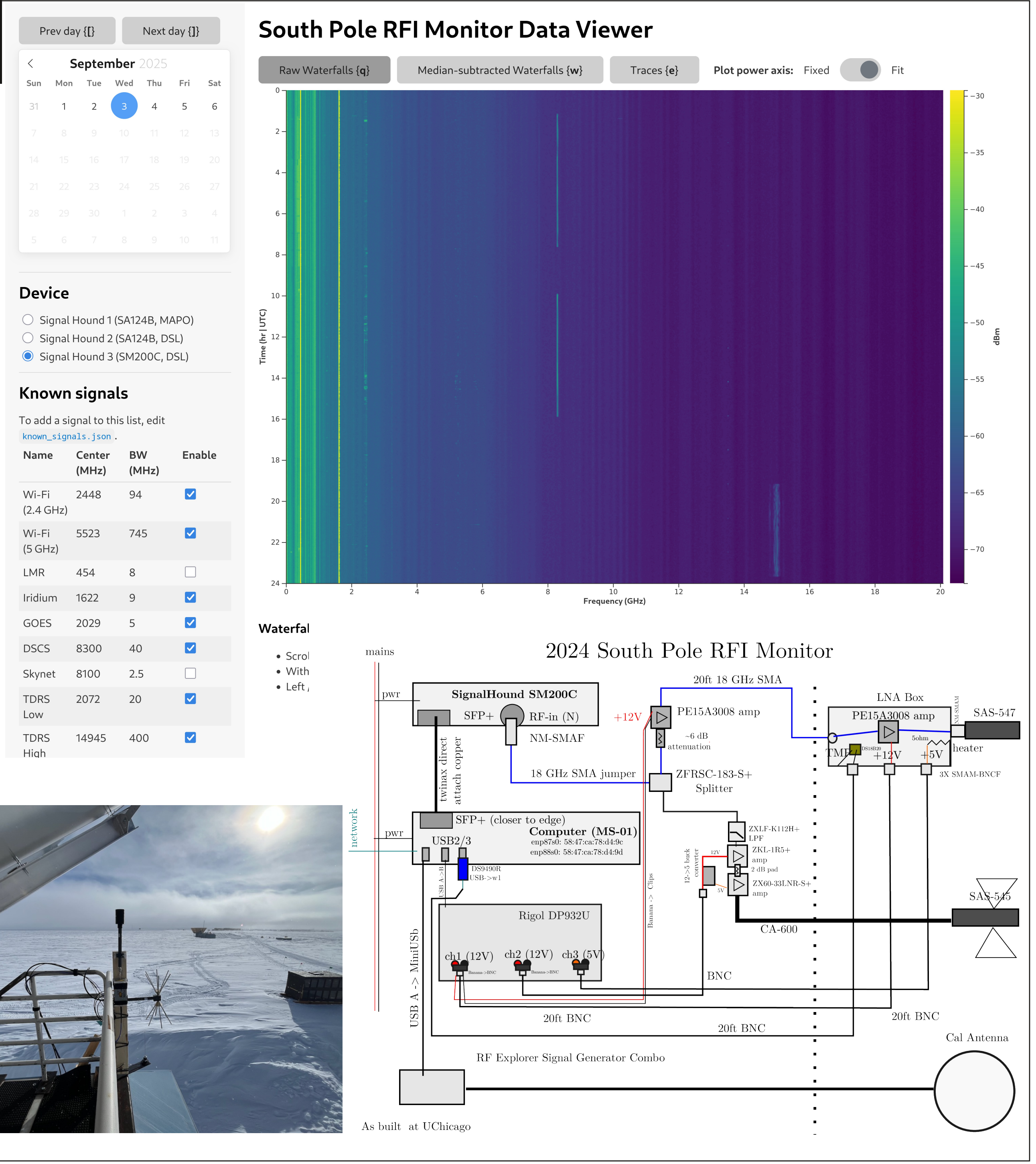
We have designed and built an improved RFI monitor for the South Pole, based on the SignalHound SM200C and covering 30 MHz-18 GHz. Two antennas and amplifier chains are used to achieve this wide bandwidth with a sensitivity limit close to thermal noise (total noise figure around 4 dB). This system was deployed last austral summer and has been operational ever since. Monitor data is uploaded north every day and can be investigated using an interactive web display.

Using the monitor system, RFI can be correlated with any patterns or irregularities in South Pole instruments. When the Chilean president visited the South Pole in early 2025 with a Starlink terminal, this system was easily able to pick up associated Starlink uplinks.

Work is underway to eventually integrate spectra measured with ARA stations into monitoring streams as well.



Top right: RFI Monitoring web interface
Right: RFI Monitor system diagram and installed antennas at Pole
Left: Chilean President visit to Pole and resulting Starlink uplinks.



Starlink Terminal and Downlink Testing

The expected demise of South Pole TDRSS data transfer next year has increased the urgency of efforts to install Starlink terminals at the South Pole. Both the uplink terminal and satellite downlinks are potential sources of interference with experiments.

Emissions from the uplink terminal may be mitigated by sufficient shielding (though care must be taken due to sidelobes) or by placing the terminal farther away from station (though that presents operational difficulties). To understand what might be needed, measurements of uplink emissions have begun. A complementary campaign of lab RFI susceptibility measurements is also underway at Harvard.

Downlink emissions are harder to mitigate due to the large size of the beams projected onto Pole. While it should be possible to turn off transmissions from satellites within CMB experiment fields of view, signals may still affect data. This month, we have started initial downlink tests with cooperation of SpaceX. Starlink satellite transmitters were turned on and off at a 15-second cadence for a 24-hour period while CMB experiments were running normally in order to study data contamination levels from satellite downlinks. Analysis is ongoing.