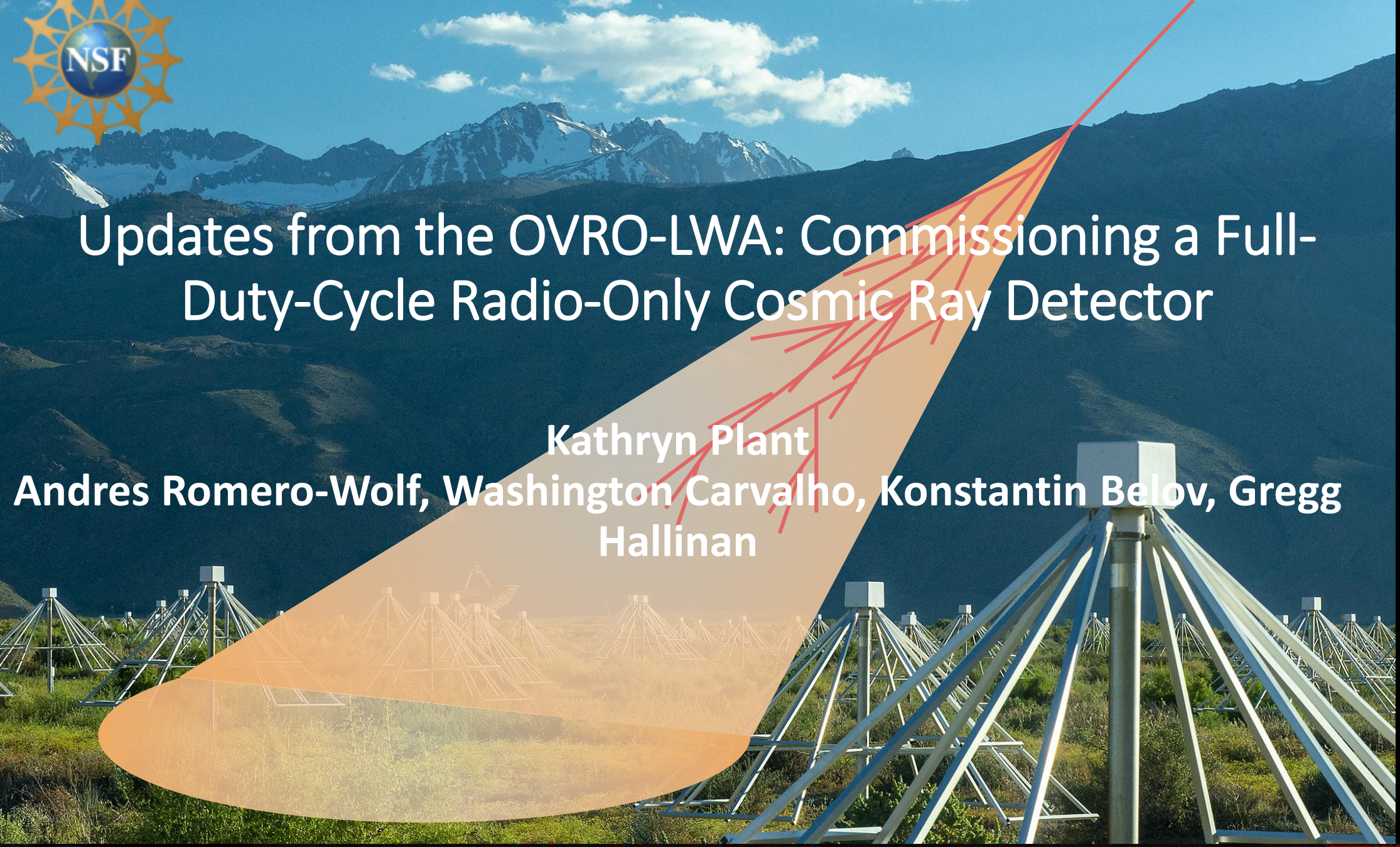
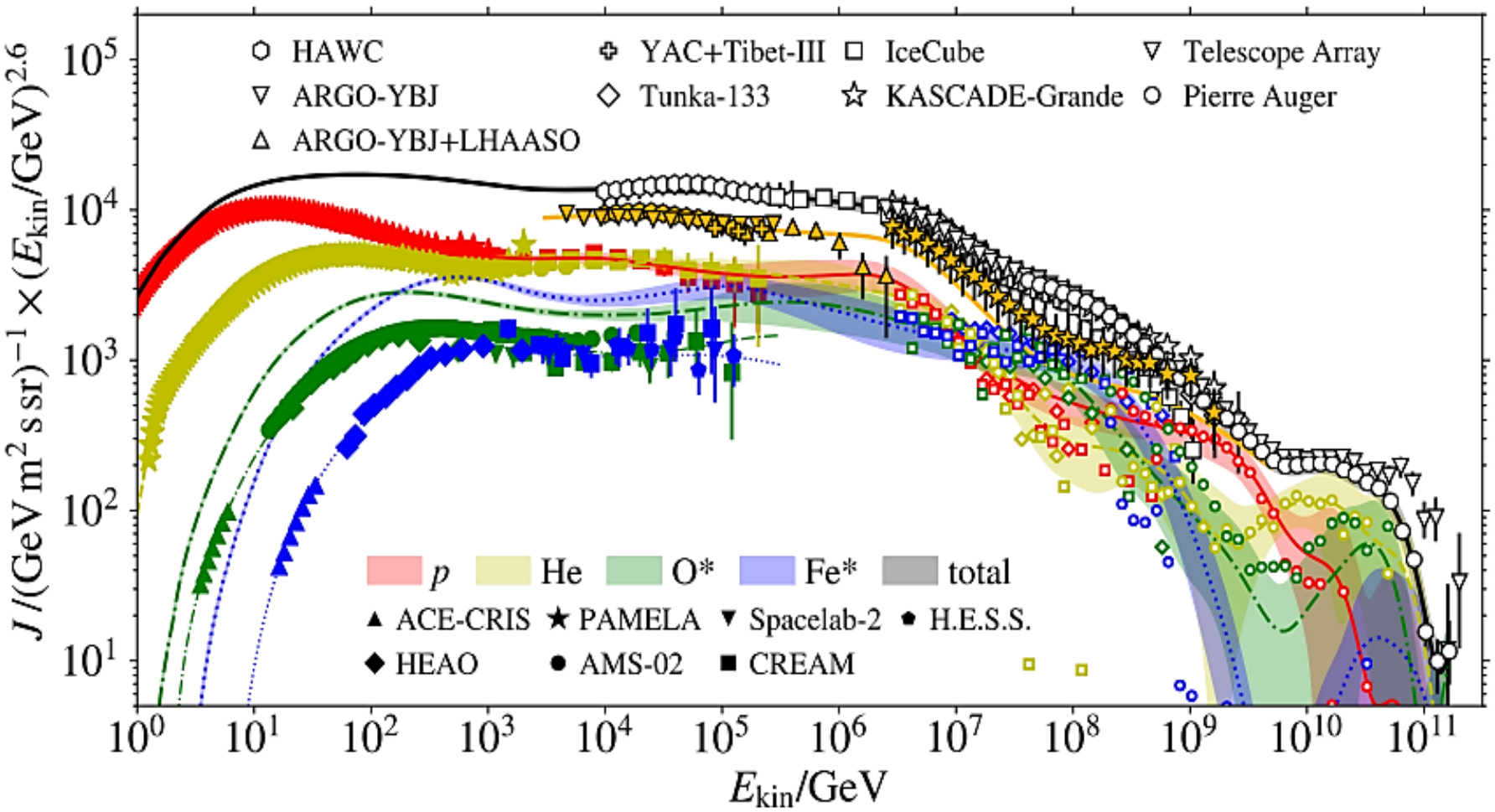


Updates from the OVRO-LWA: Commissioning a Full-Duty-Cycle Radio-Only Cosmic Ray Detector

Kathryn Plant
Andres Romero-Wolf, Washington Carvalho, Konstantin Belov, Gregg Hallinan

Motivation:

- Objective: use composition across the second knee to probe Galactic to extragalactic transition
- OVRO-LWA 2000 cosmic rays per year, 10^17-10^18 eV
- Expect Xmax uncertainty <20g/cm^2



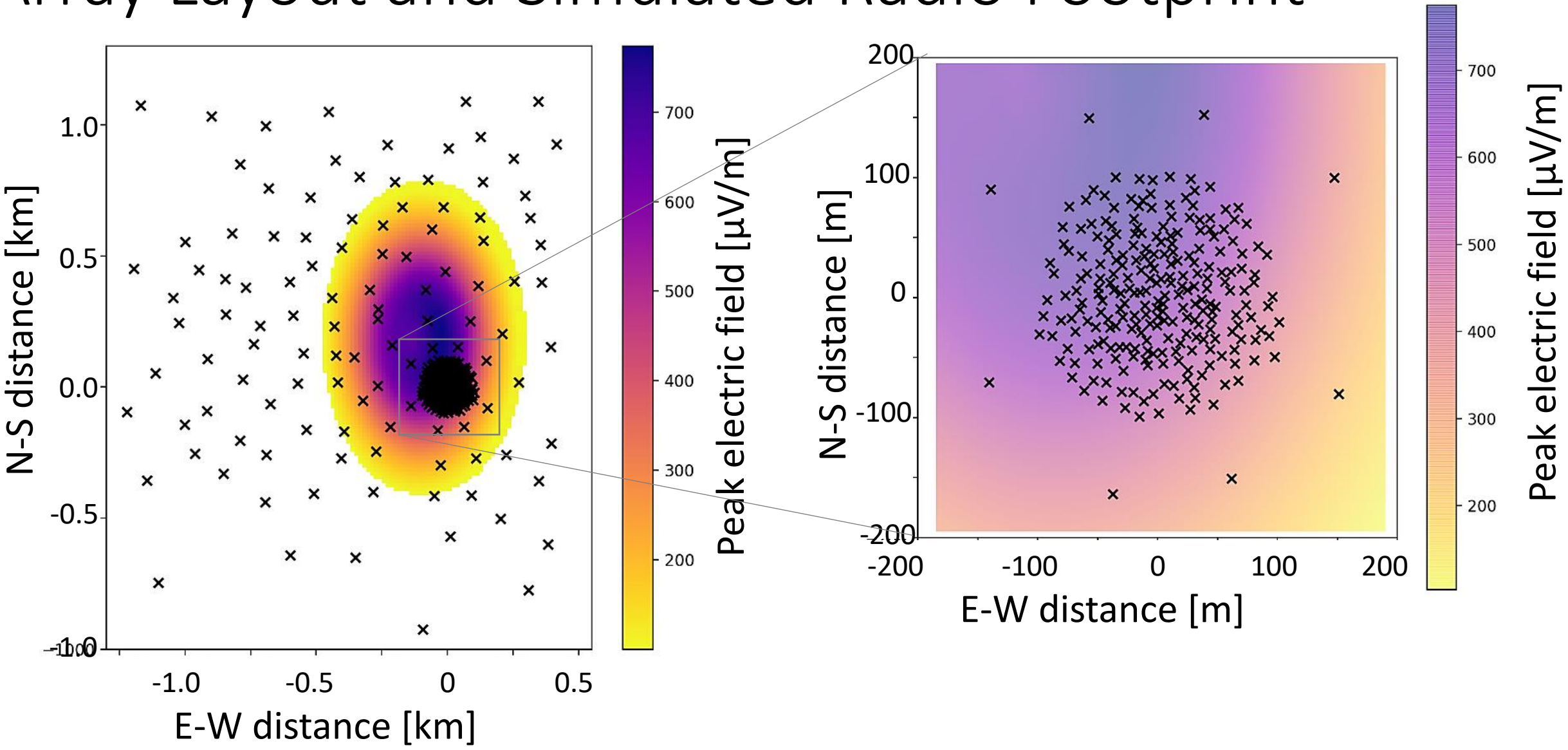
Plot: H. Dembinski ICRC 2019 in F. Schroeder rapporteur summary.

The Long Wavelength Array at the Owens Valley Radio Observatory

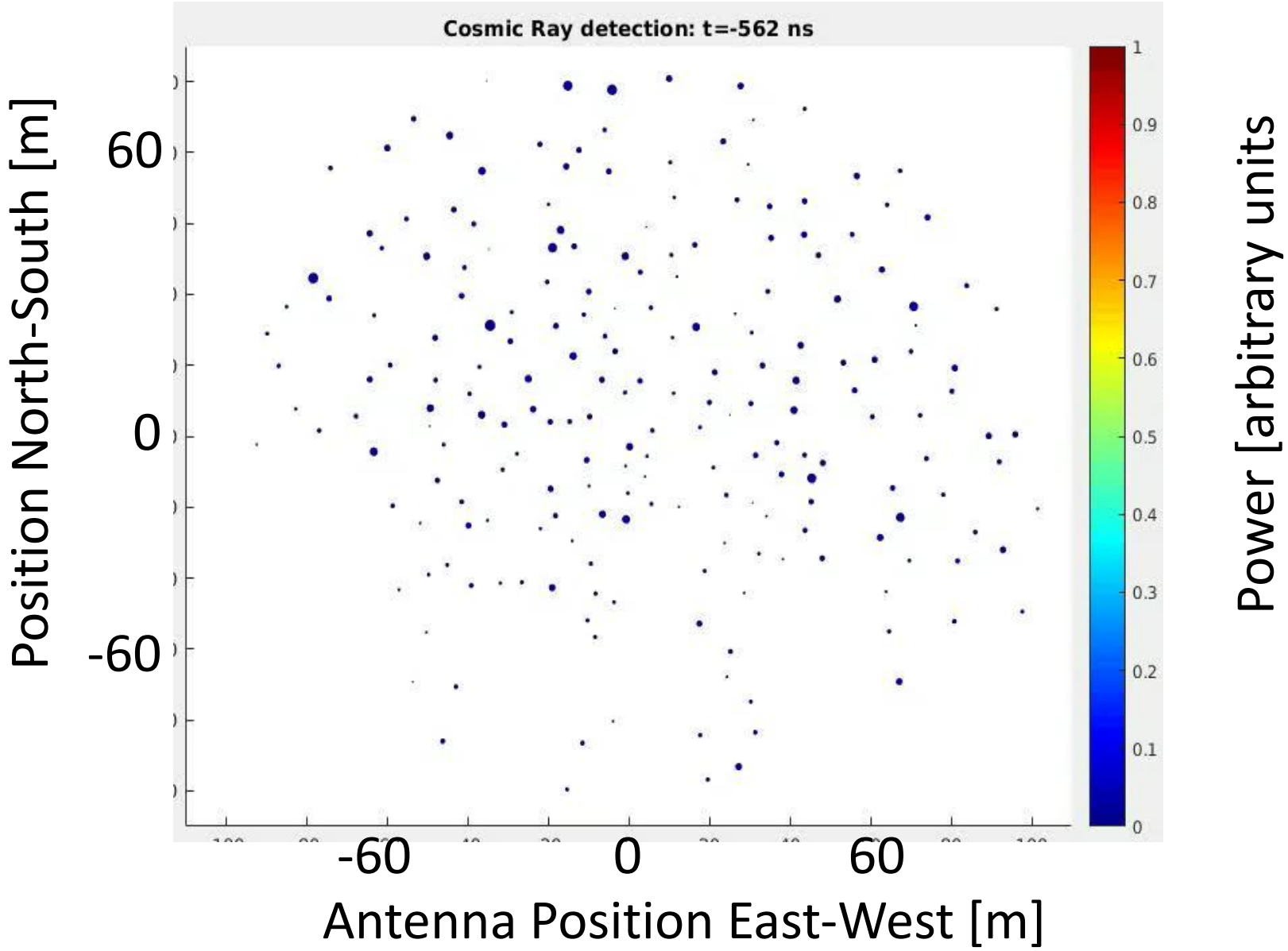
- 256 dual polarization antennas → 352 antennas
- Baselines up to 1.5 km →2.4 km
- 12—85 MHz

- Extrasolar space weather, cosmic dawn, solar flares, cosmic rays and more

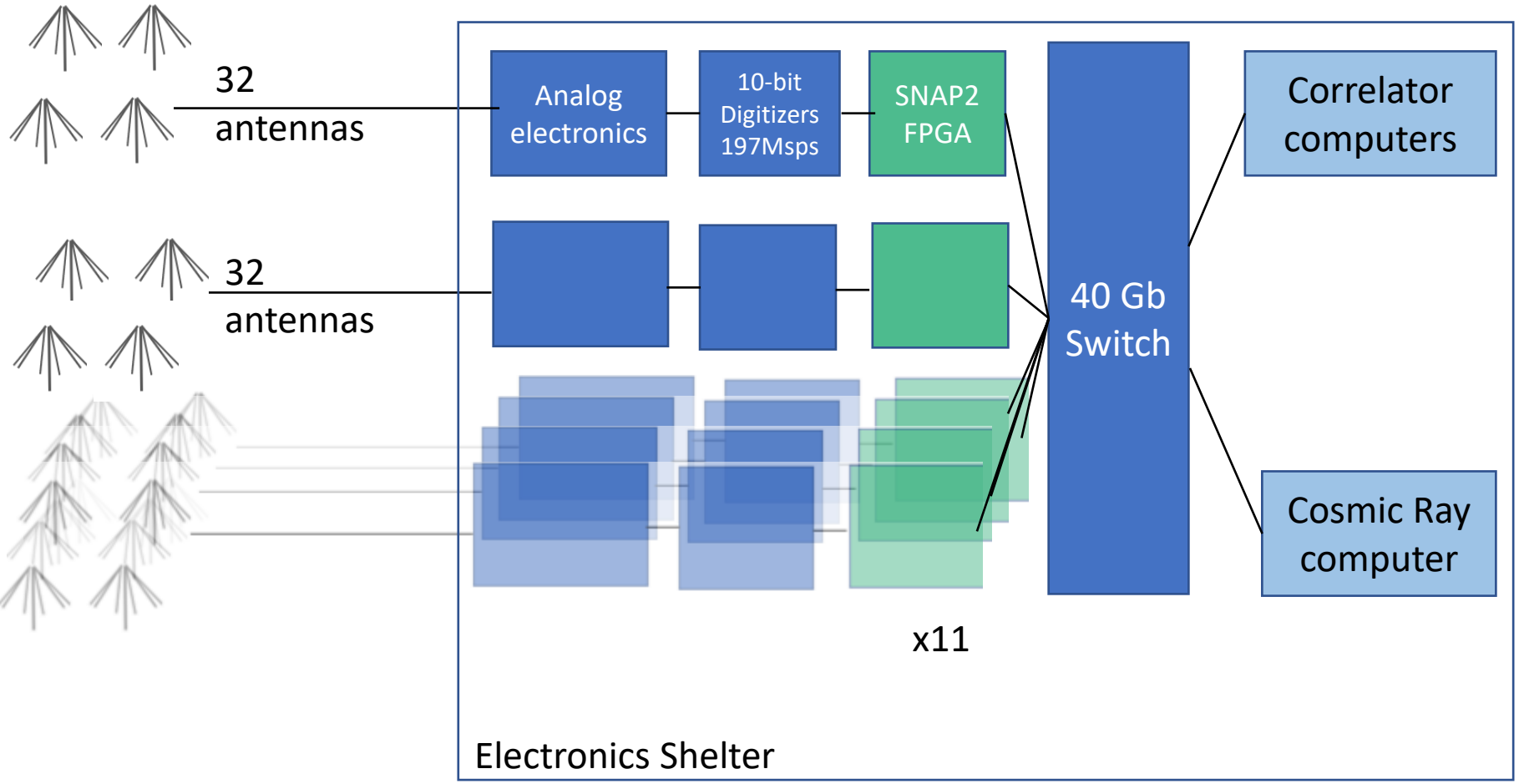
Array Layout and Simulated Radio Footprint



With the stage II array, Monroe et al. 2020 detected 8 cosmic rays with 40 hours of observing.

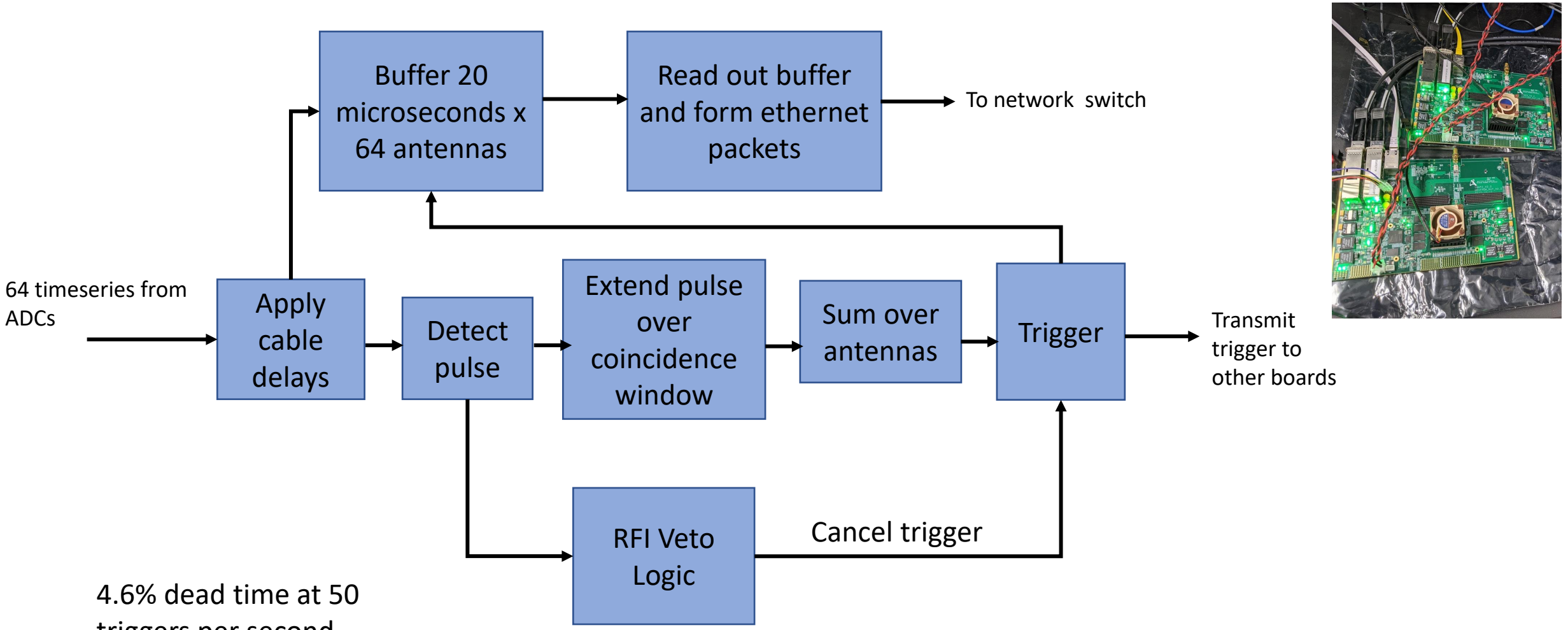


The array upgrade involves all new digital signal processing hardware.



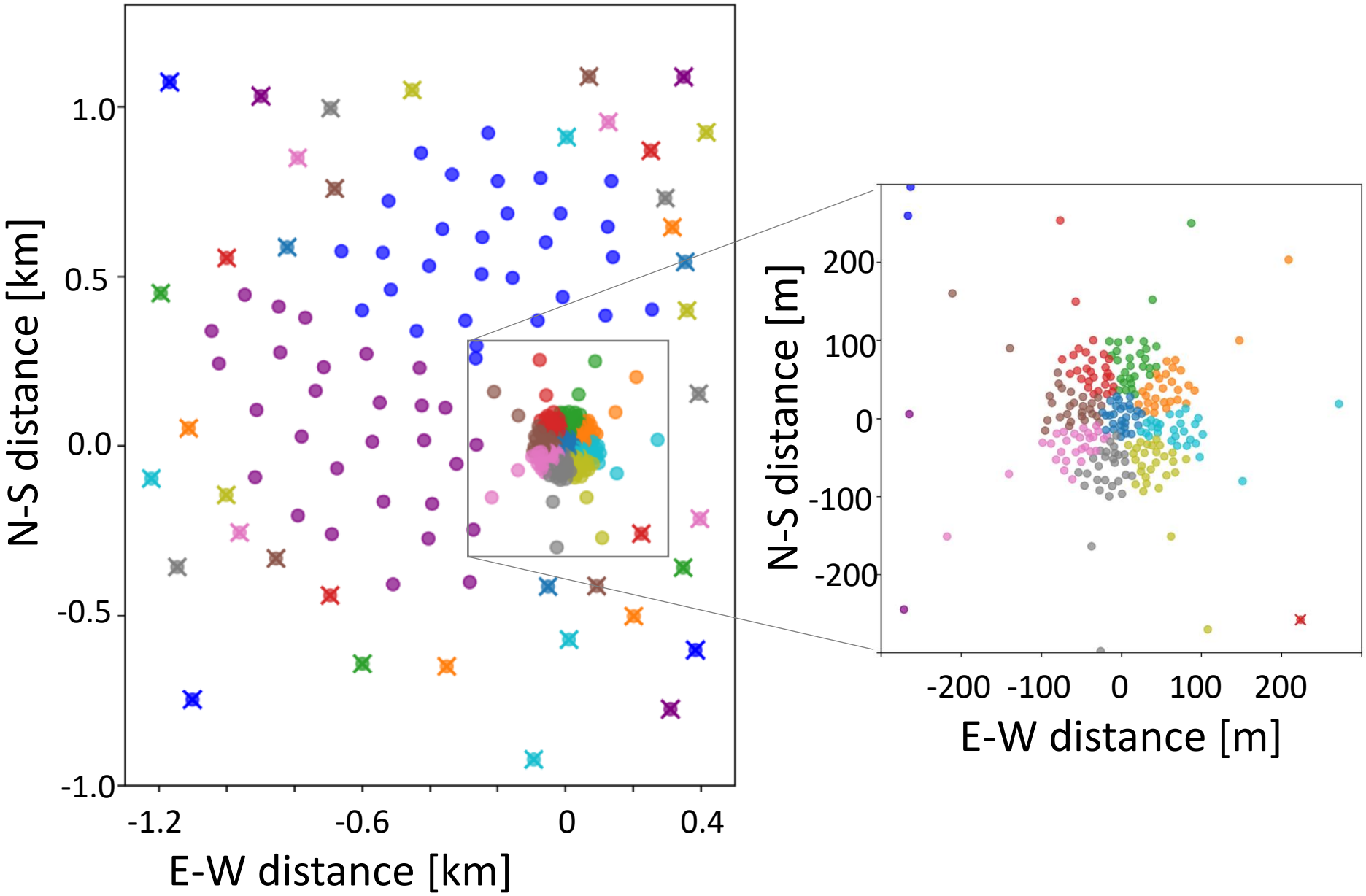
SNAP2 boards with Xilinx Kintex Ultrascale+ FPGAs

Each board triggers on radio signal from its subset of antennas, then transmits trigger to all the other boards.



4.6% dead time at 50 triggers per second

RFI Mitigation strategy uses distant antennas to veto.



-- Color indicates FPGA group

-- x indicates veto

Remaining RFI Rejection will be performed on CPU

Timeseries from all FPGAs

Get:
- Peak power
- Arrival time
- Noise power

Wavefront fit

Fit fails (thermal noise)

Discard

Good fit

Check arrival direction

ok

Check for airplane track

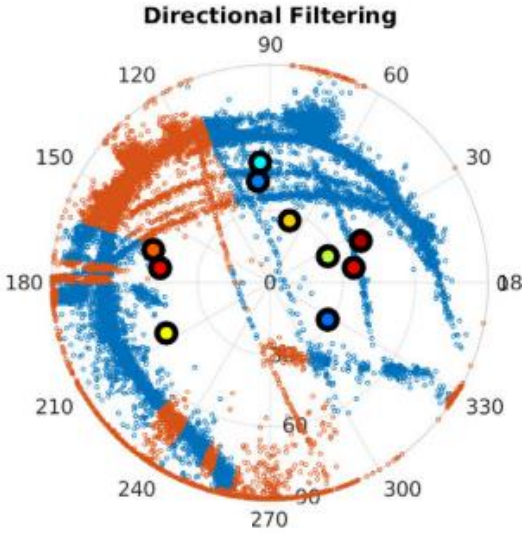
NO

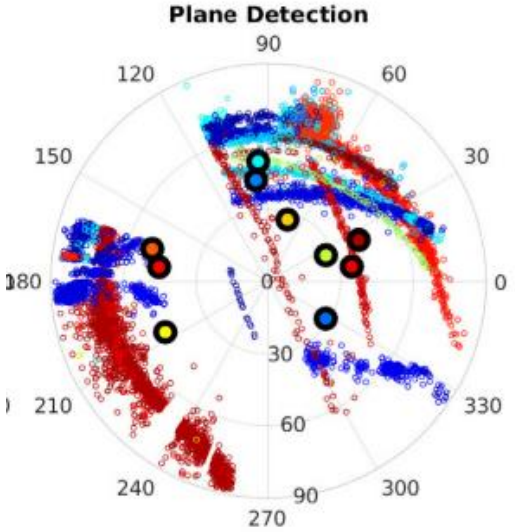
Verify cosmic ray:
- spatial power distribution
- polarization

YES

Specific RFI source

Discard





Monroe et al. 2020

Summary of Radio-Only System

Detection Part 1

1. Detect impulse signal.
2. Compare nearby antennas.
3. Reject events seen by distant antennas.
4. Trigger whole array to read out buffered data.

FPGA

Detection Part 2

1. Estimate direction and core position.
2. Reject events that are badly fit by model wavefront.
3. Reject events from known key RFI directions.
4. Reject events from airplane tracks.
5. Confirm power LDF and polarization.

CPU

Analysis

Compare data to simulations to estimate:
-- energy
-- Xmax

CPU

Future Outlook

- Beam mapping to 1%
- Scintillators in subarray

Summary of Upgrade

Before Upgrade		Upgrade
• Ryan Monroe demonstrated that radio-only detection is possible, with dedicated 40 hour observing run	→	• Real-time commensal observing mode of the array, thousands of cosmic rays per year
• Reconstructed arrival directions	→	• Reconstruct Xmax and energy for composition study
• Required special RFI-quiet times	→	• RFI mitigation with distant antennas