

Distinguishing Between Two Types of Cosmic Ray Signals Observed by ARIANNA Stations

Anbarasi Thangamani, Cheng Han Tang, Dr. Steven Barwick
 Department of Physics and Astronomy, University of California, Irvine
 ARIANNA Collaboration



Introduction & Background

- Antarctic Ross Ice Shelf Antenna Neutrino Array (ARIANNA) utilizes radio-frequency sensors buried in the Antarctic ice to detect high-energy neutrinos.
- ARIANNA researchers have possibly identified cosmic ray signals reflected producing radio pulses resembling neutrino signals.
- The aim is to collect a clean sample of cosmic ray events that are reflected off internal layers in the ice to develop techniques for distinguishing them from true neutrino events.

RCR = reflected cosmic rays

Back lobe CR = cosmic rays entering through the back lobe of downward-facing antennas

Focus: Differentiating between RCR events and back lobe CR events

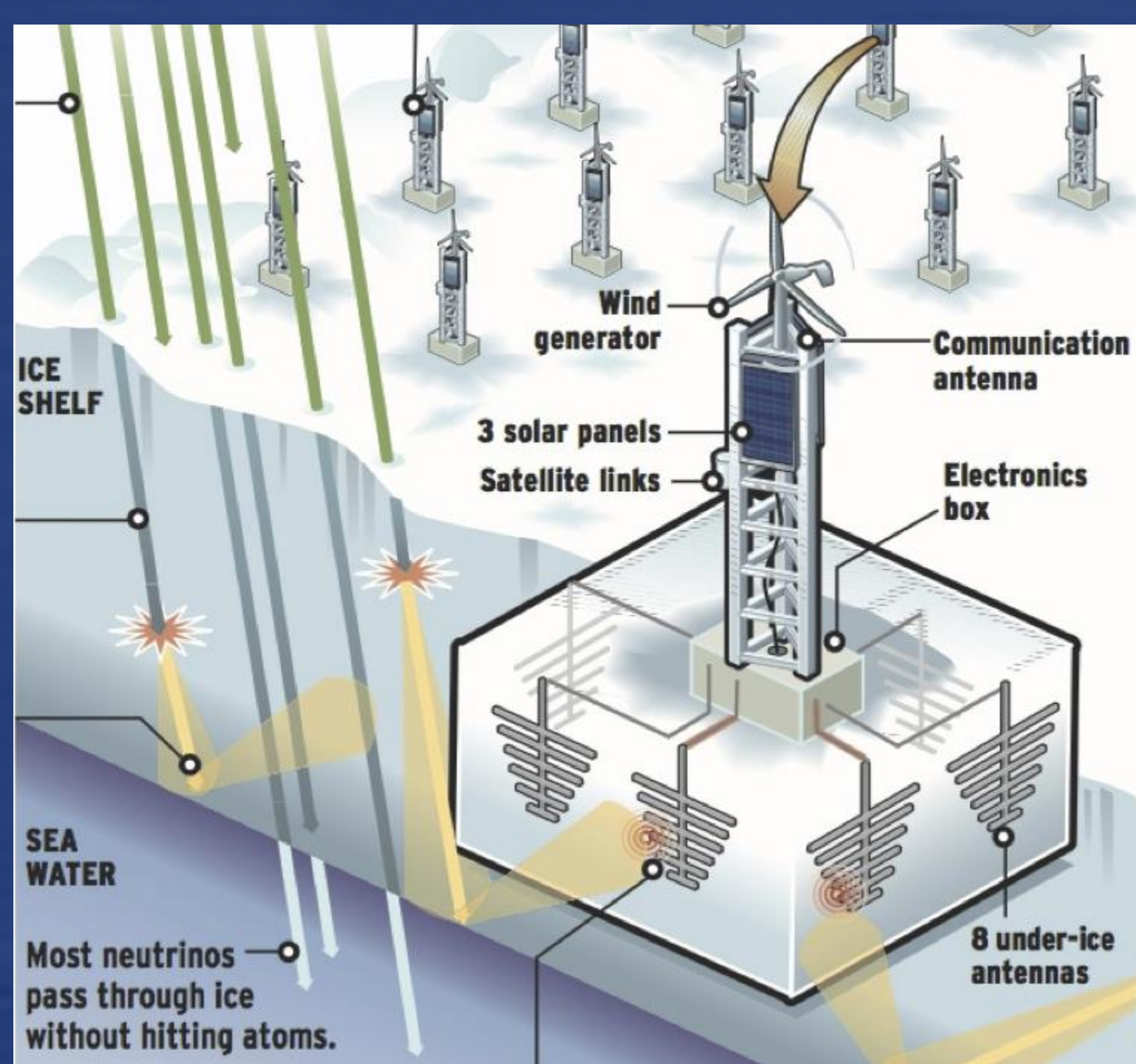


Figure 1 ARIANNA stations on the Ross Ice-Shelf at Moore's Bay in Antarctica

Methodology

- Events collected from stations 14, 17, 19, & 30 which pass deep learning and time cuts
- Events are then sorted by Chi-value and Signal-to-Noise ratio
- Visual comparison of collected data with simulated back lobe and RCR events
- Cross-comparison of observation with peer

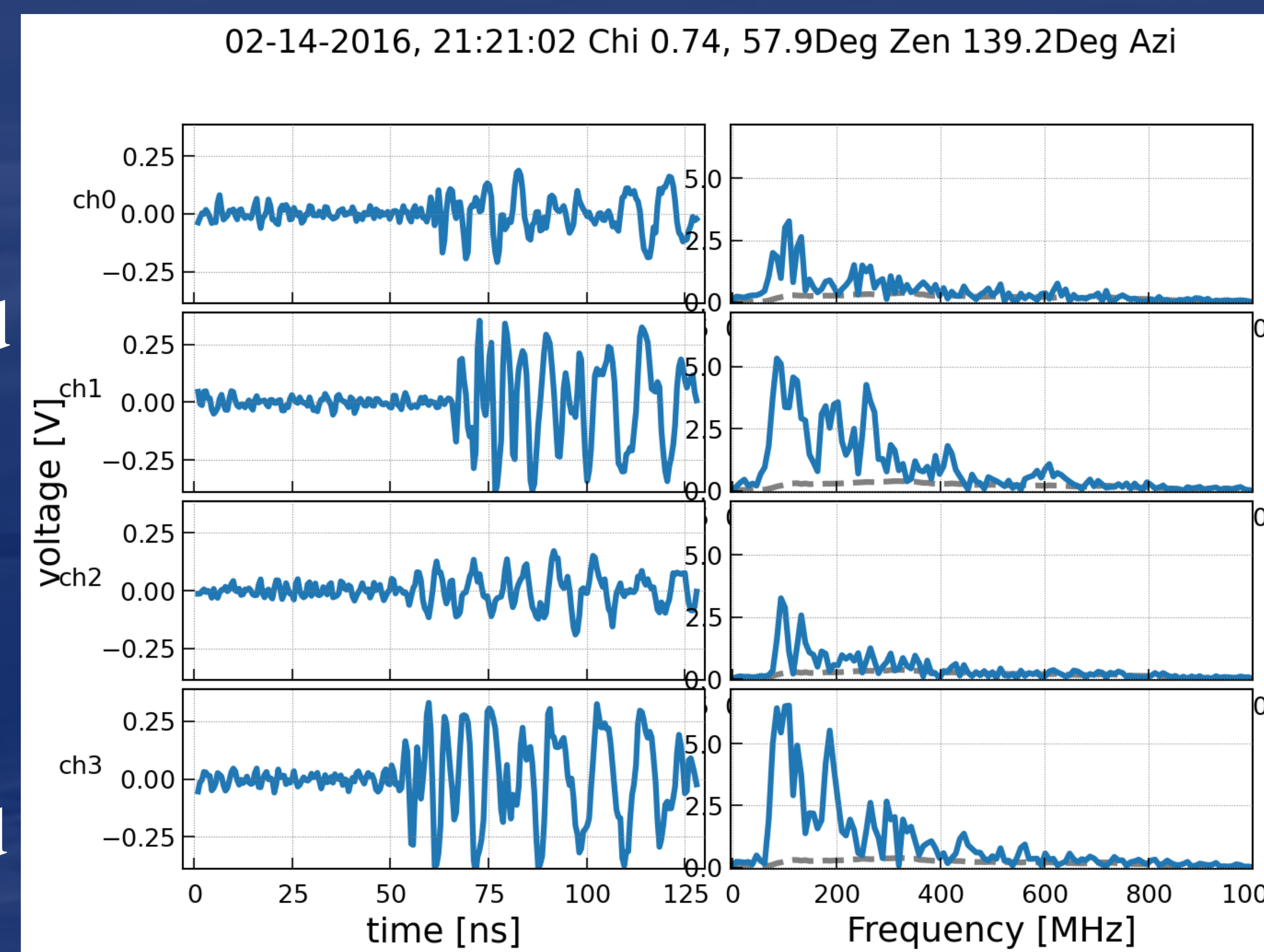


Figure 2 Suspected RCR signal from Station 30

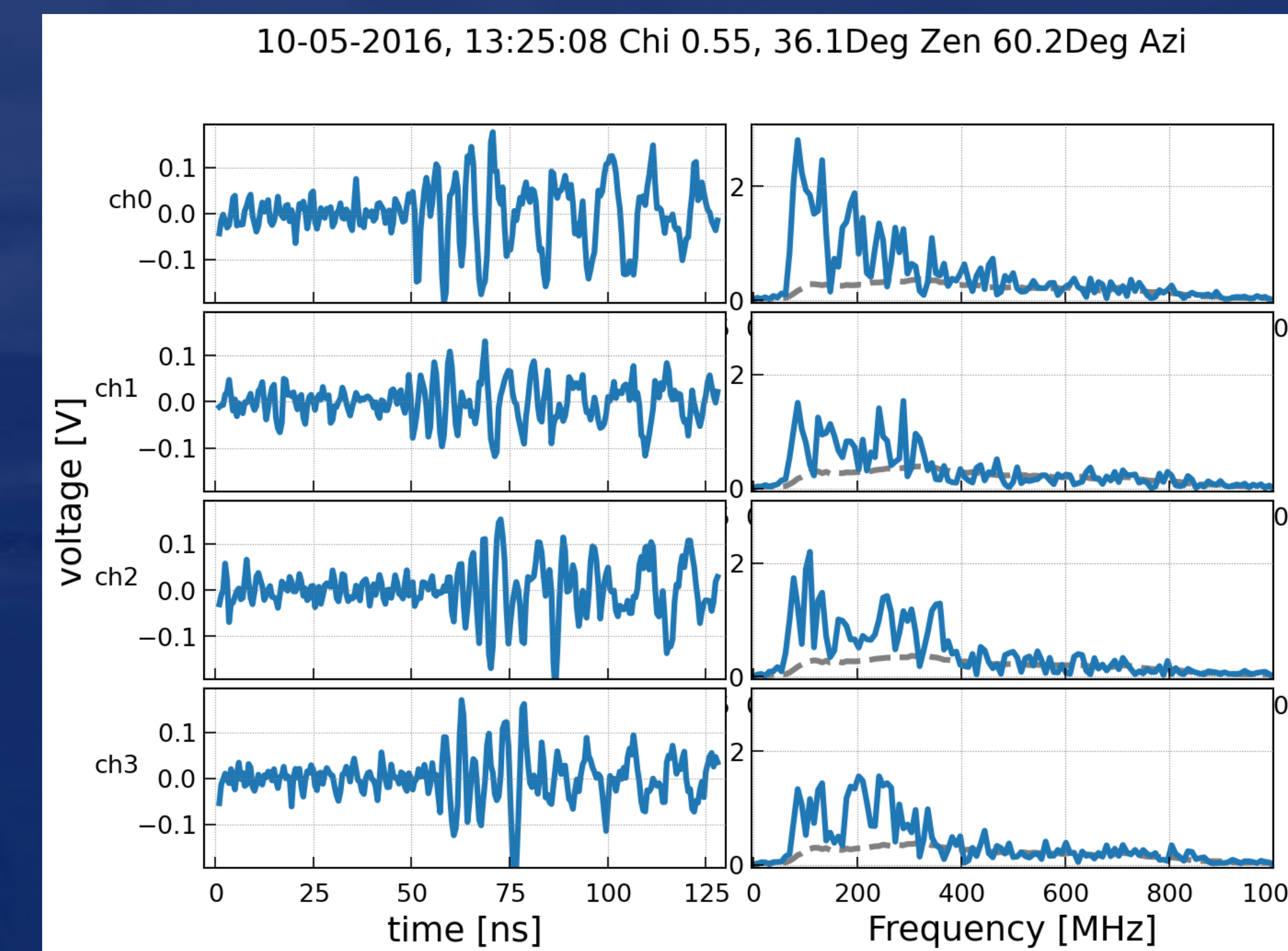


Figure 3 Suspected back lobe CR signal from Station 30

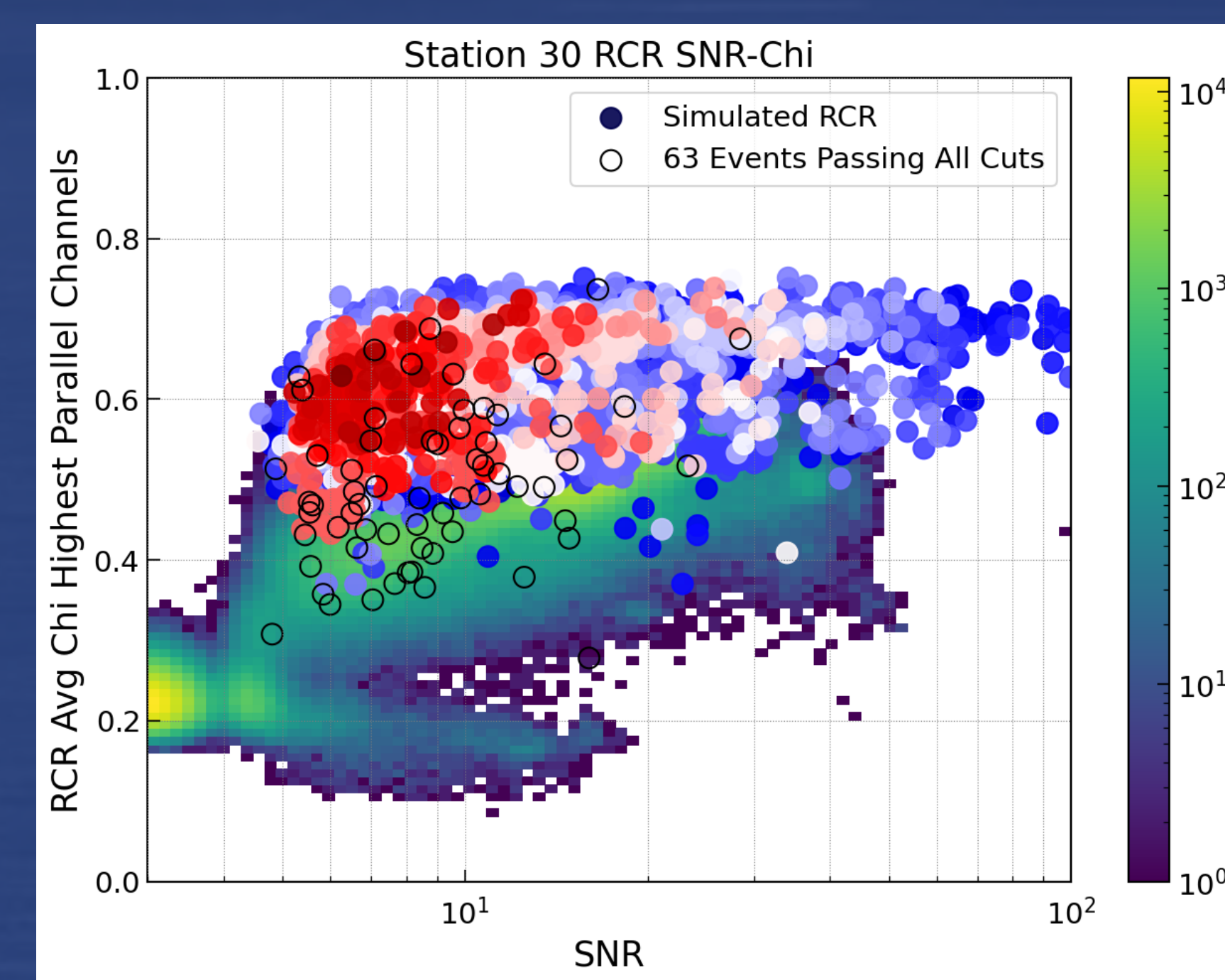


Figure 4 Station 30 Signal-to-Noise Ratio to Chi value graph

Simulated Events	Time	Channels	Waveform	Frequency
Reflected Cosmic Rays (RCR)	<ul style="list-style-type: none"> • Delay between two parallel channels ≈ 15ns 	<ul style="list-style-type: none"> • Parallel channels • All channels when signal approaches the antennas diagonally 	<ul style="list-style-type: none"> • High to low frequency as signal proceeds 	<ul style="list-style-type: none"> • One high peak • Exponential decay
Back lobe Cosmic Rays	<ul style="list-style-type: none"> • Inconclusive 	<ul style="list-style-type: none"> • One channel or three channels 	<ul style="list-style-type: none"> • Noticeable high frequency at the start of the signal 	<ul style="list-style-type: none"> • Two high peaks • No noticeable exponential decay

Table 1 Characteristics of RCR and back lobe CR signals collected from simulated data

Future Developments

- Utilization of key characteristics of back lobe events to extend and further improve the existing neural network's ability to distinguish between the two types of signals.

Acknowledgement

Ryan Rice-Smith

References

- [1] S. W. Barwick, C. Glaser, arXiv:2208.04971v2 (2022)
- [2] A. Anker, S. W. Barwick, et al., arXiv:1909.00840v3 (2019)