2022 Asilomar Conference on Signals, Systems, and Computers
High-Resolution Spectral Analysis and Signal Segregation Using the Polyphase Channelizer
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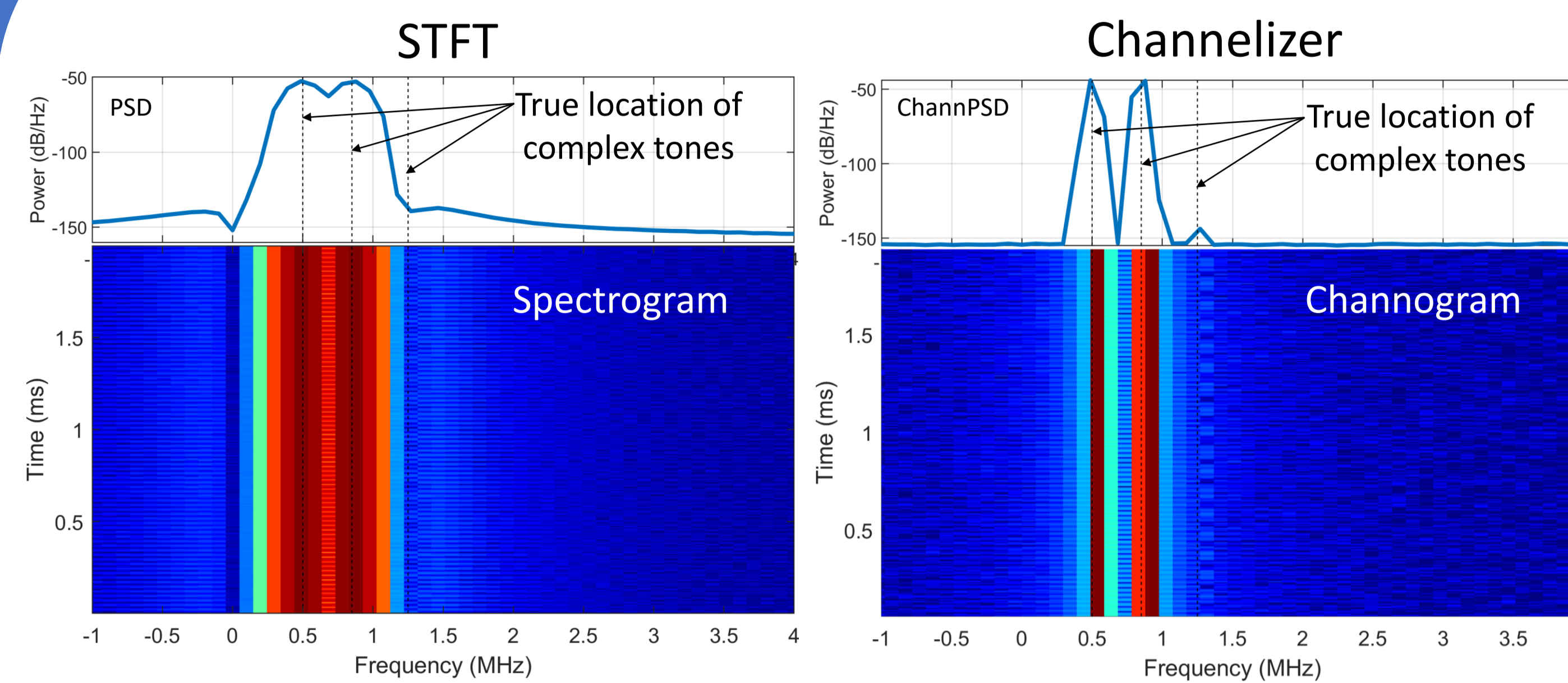
Securing Spaces from Wireless Threats

Video/Audio Recording

Audio Recording

Processing Flow

Focus

Channogram → Detect and Bound → Segregate

Classify Anomalies (Future Work)

Concealed Device

Requirements

- Continuous Monitoring
- No Prior Signal Knowledge
- High Frequency Resolution
- Large Dynamic Range

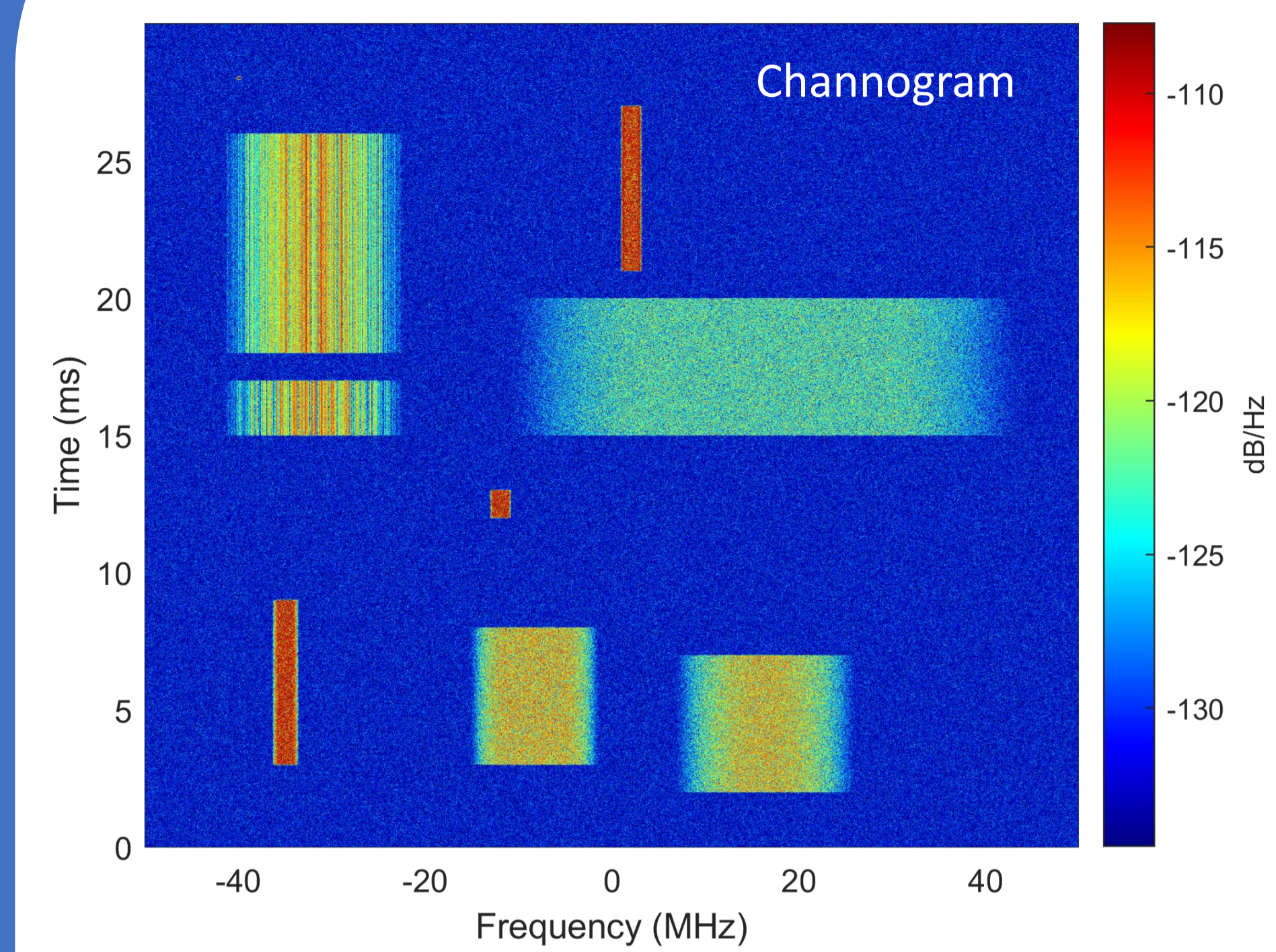**FFT Based Techniques do not meet these requirements**

Overview: Improved Resolution and Dynamic Range

STFT

Channelizer

STFT Properties: 1024 Point Kaiser window with beta 10, 50% overlap, 1024 Point FFT

Channelizer Properties: 1024 Channels, 24576 Length Prototype Filter, Beta 5

Three complex tones centered at 0.5 MHz, 0.85 MHz and 1.25 MHz are to be estimated. The first two tones are equal power while the third tone has 100 dB less power. No window exists that allows the STFT to resolve all three tones simultaneously. The polyphase channelizer can increase the prototype filter length indefinitely until the tones are resolvable while using 1024 channels

The polyphase channelizer resolves all tones!
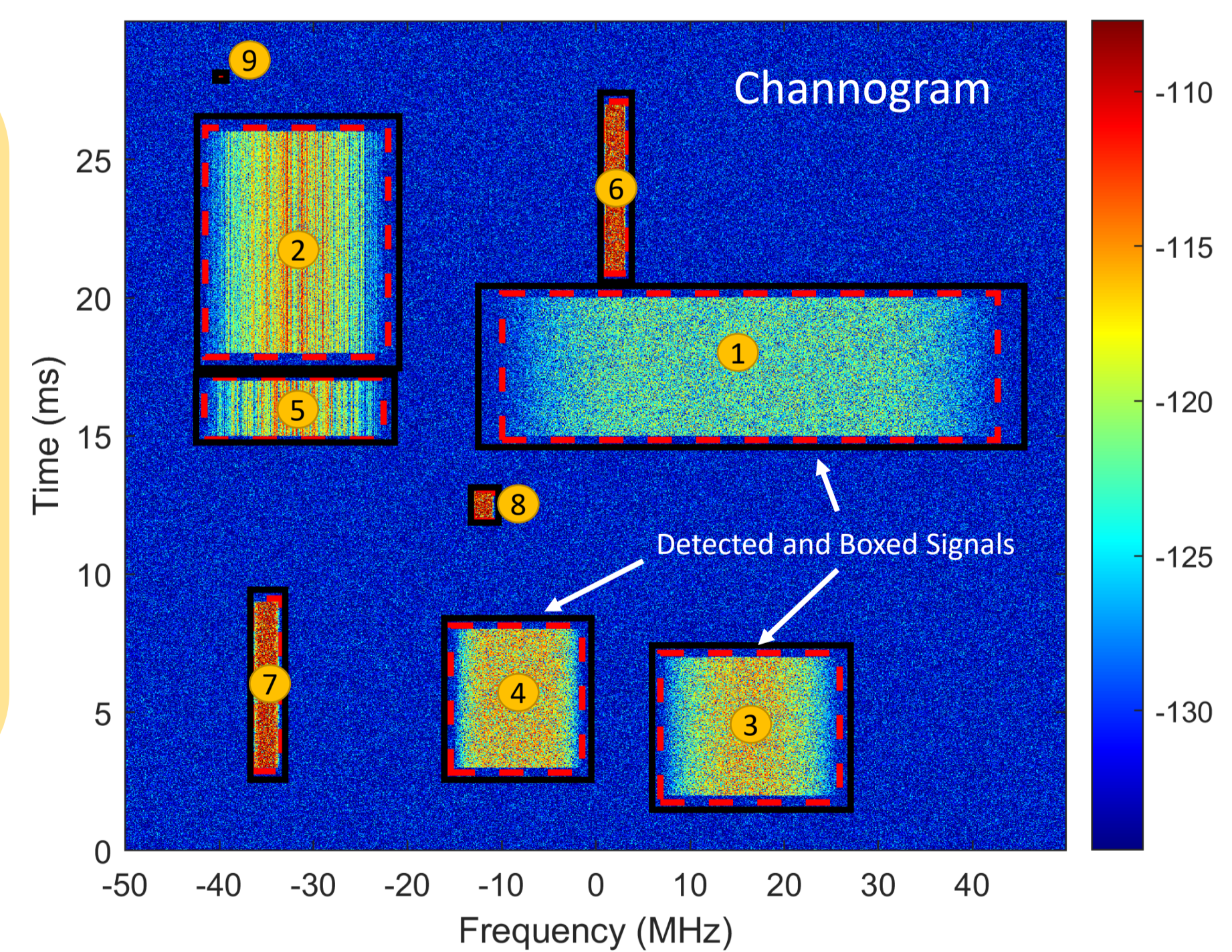
Estimating the Channogram

Channogram

The **polyphase channelizer** is used to create the analog of a spectrogram, which we call the **channogram**. This inherits the improved frequency resolution and dynamic range performance without requiring any prior knowledge of the signals we wish to detect and box.

Estimating the channogram requires no additional knowledge about the signals

Detecting Signals Using the Channogram

Channogram

A 2D convolution based energy detector is applied to the channogram to distinguish between areas that contain signal and areas of noise only.
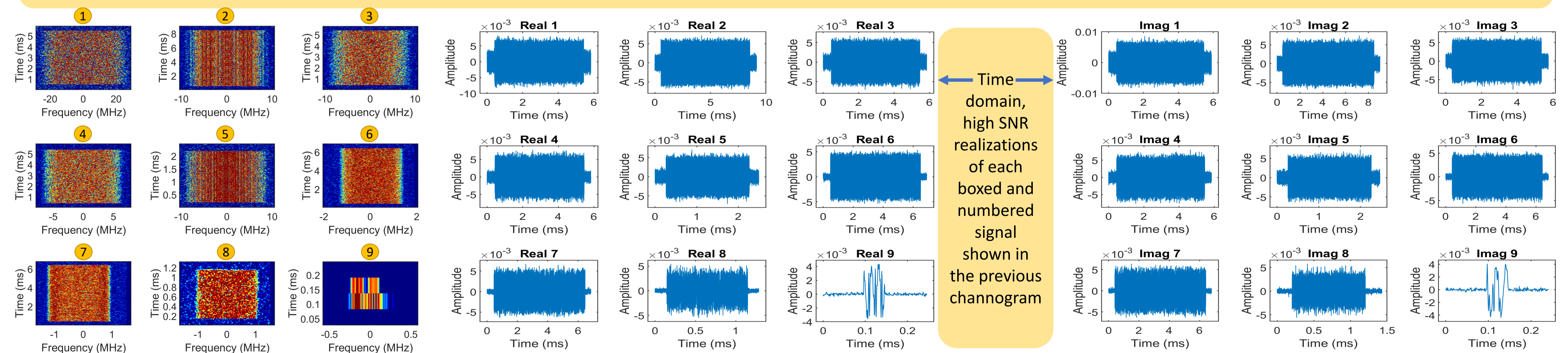
Signal isolation and noise rejection is an important step for continuous monitoring because the overall required throughput is lowered

Detected and Boxed Signals

Signal modulations shown are QAM, PSK, DSSS, FSK and GFSK. The modulation type does not affect the performance of the channelizer or the boxing. This information is not required.

Identifying Anomalous Signals – Frequency and Time Domain Segregations

The process of identifying anomalous signals requires a baseline that defines what is normal. Creating the baseline requires classification and association of each energy bursts with a modulation, modality or protocol as well as an association with previously seen energy bursts that constitute some larger idea of a signal. To support these various levels of classification, the signals should be available in either the frequency domain or time domain with the highest SNR possible. Creating the time domain version of the boxed signals is achieved using a synthesis channelizer as shown below.

Real 1, Real 2, Real 3, Real 4, Real 5, Real 6, Real 7, Real 8, Real 9

Imag 1, Imag 2, Imag 3, Imag 4, Imag 5, Imag 6, Imag 7, Imag 8, Imag 9

Time domain, high SNR realizations of each boxed and numbered signal shown in the previous channogram

The polyphase channelizer enables, high performance, high throughput, signal detection and segregation to support automatic classification systems. This is an important and often overlooked part of these systems.

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Summary: The polyphase channelizer enables the resolution of closely spaced signals at large dynamic ranges. It also supports automatic classification systems by generating isolated time domain realizations of boxed regions of the channogram for further processing by classification algorithms.

Future Work: Combining the polyphase channelizer with cyclostationary techniques for improved signal detection and classification

https://wcsng.ucsd.edu/channogram