Spectrum use in US License-exempt Frequency Bands

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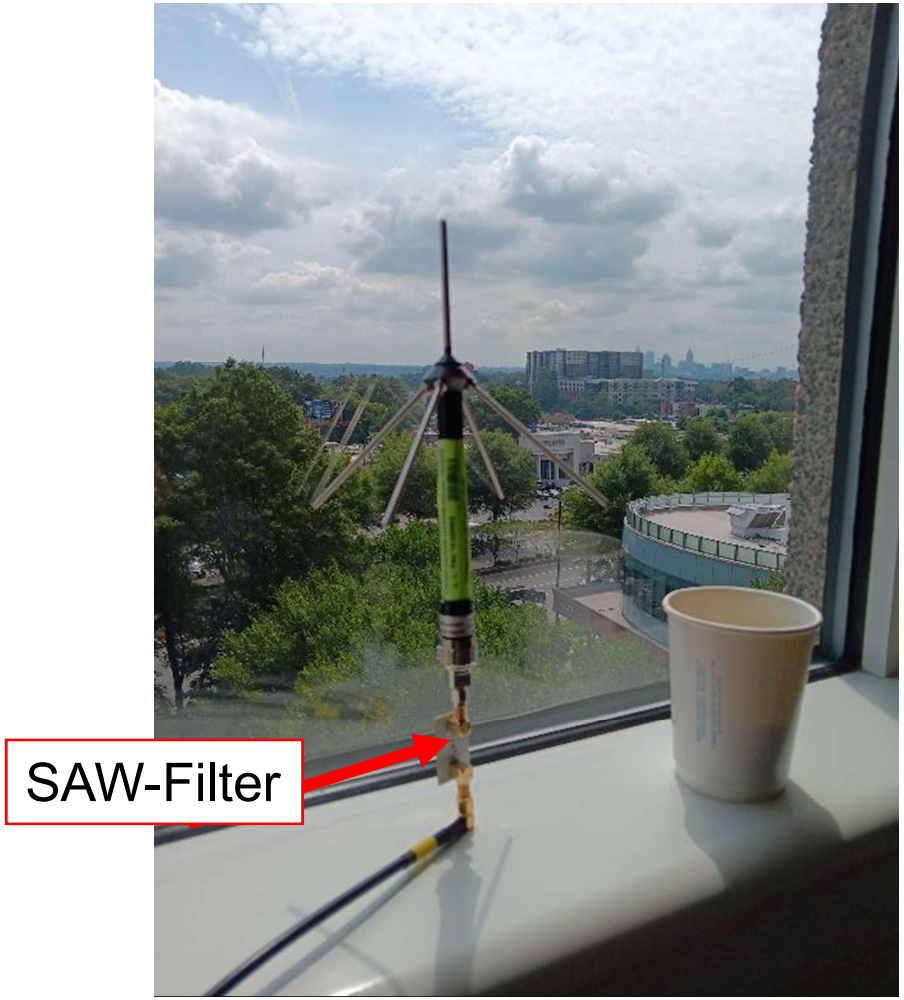
Abstract

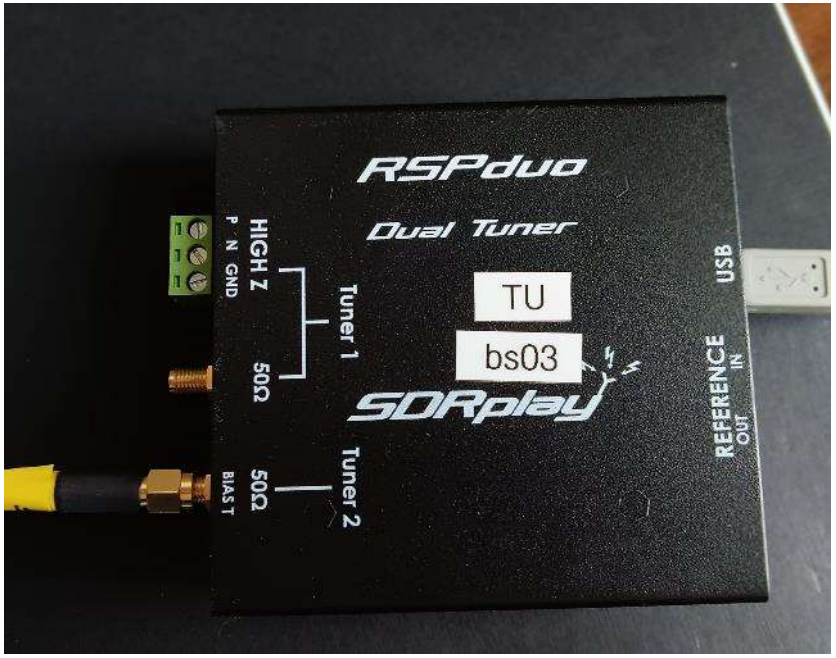
- This presentation shows some measurement results showing the channel use in license exempt frequency bands
- The measurements were done during the IEEE 802 Wireless Interim in September 2023 in the Hyatt Regency Atlanta in Buckhead

Measurement Location



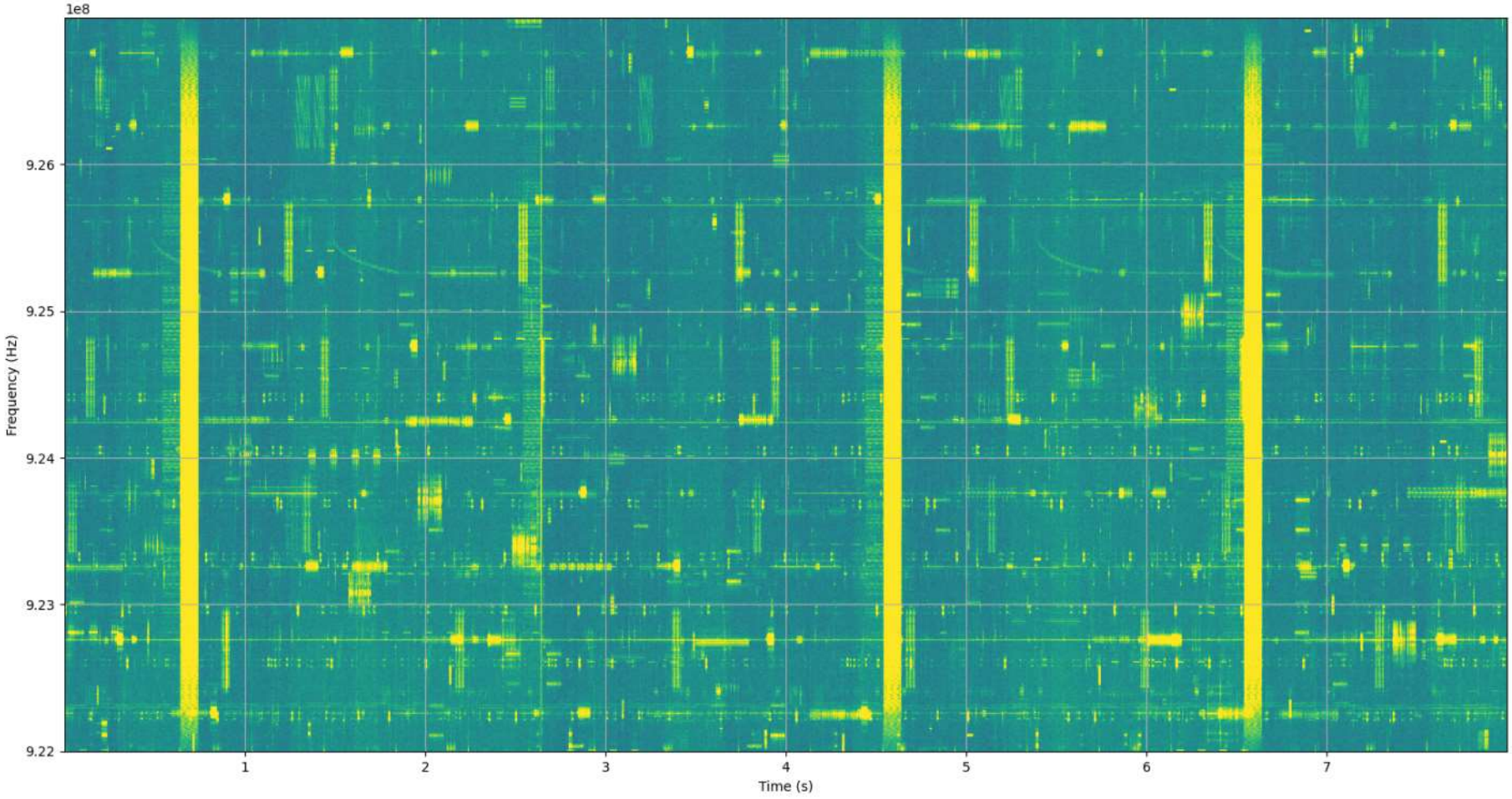
- 0 dBd measurement antenna located next to the window in the 9th floor or the Hyatt in Buckhead, view towards downtown Atlanta
- A SAW filter (924.5 MHz, 5 MHz bandwidth, ~2 dB attenuation) below the antenna avoid non-linear effects of the pre-amplifiers (very strong cellular and broadcast signals)
- Metallized window may reduce RX level by 30 dB

SDR Frontend

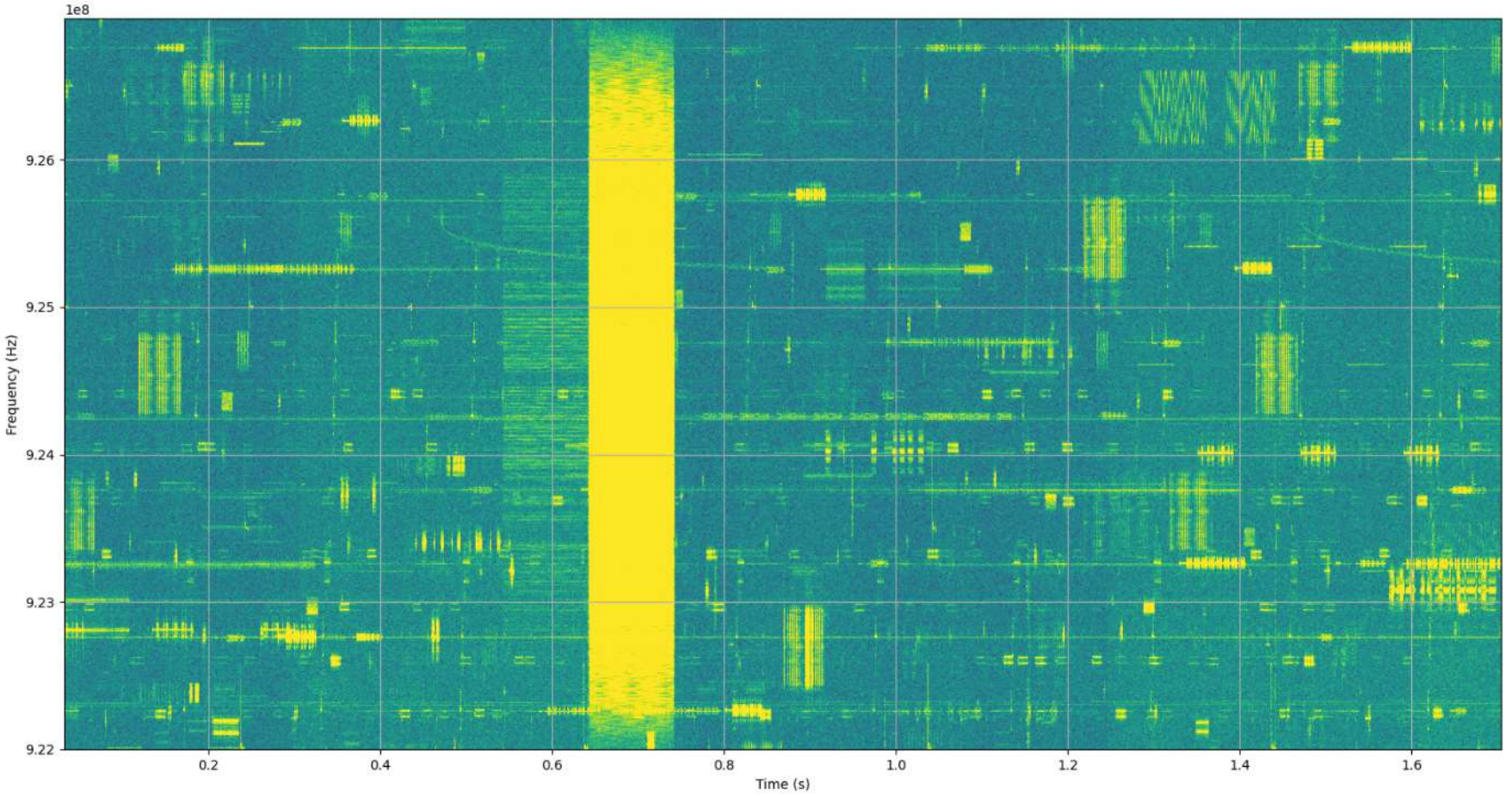


- An RSPduo Software-Defined Radio Frontend (~250$) equipped sampled the band width 14 bit A/D resolution and 10MS/s
- The bandwidth for the later plot is limited to 5 MHz (SAW filter bandwidth of 5 MHz)
- Levels are not calibrated yet

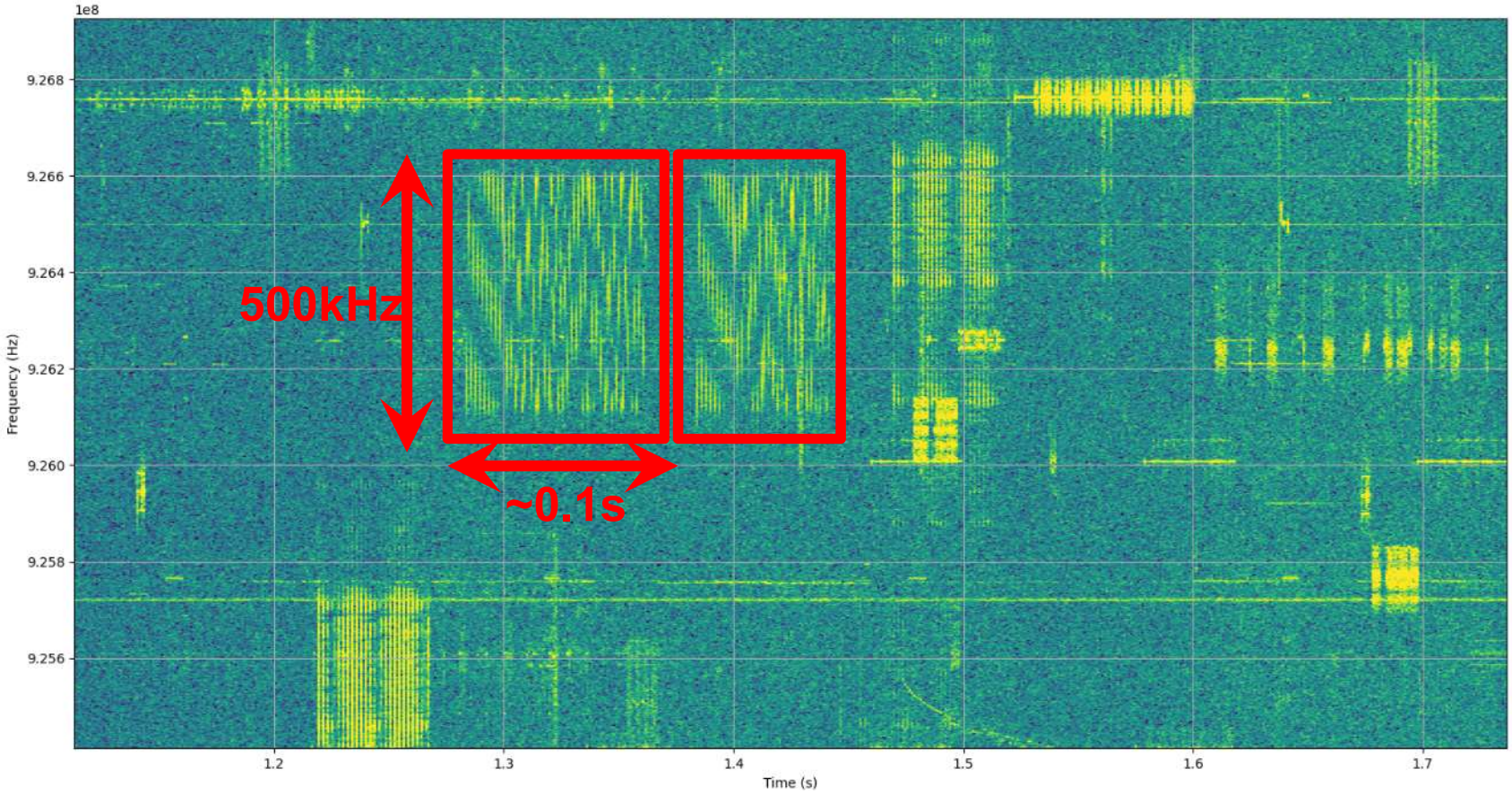
Measured Spectrogram (922 … 927 MHz, length 8s)



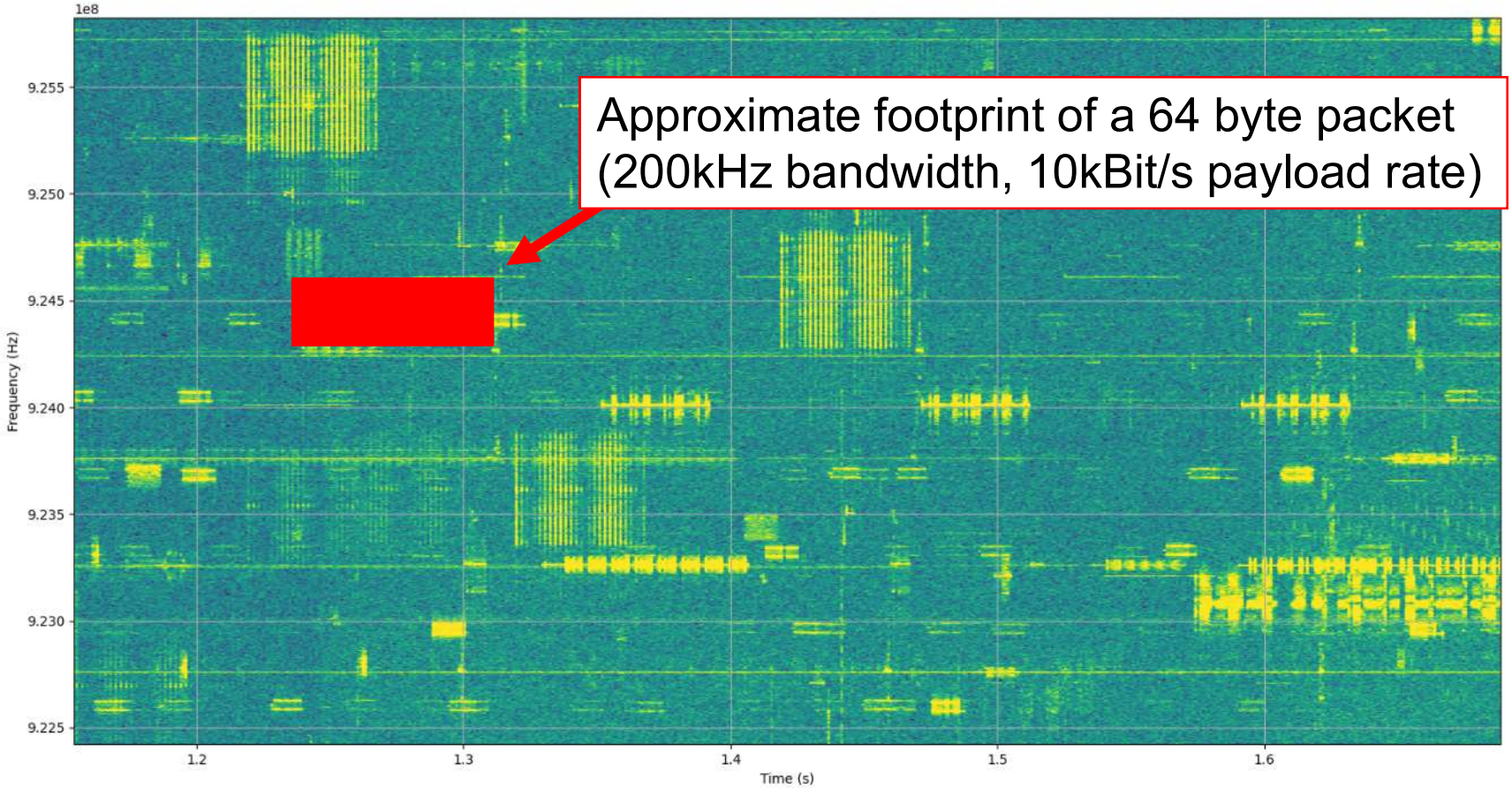
Measured Spectrogram (922 … 927 MHz, length 1.5s)



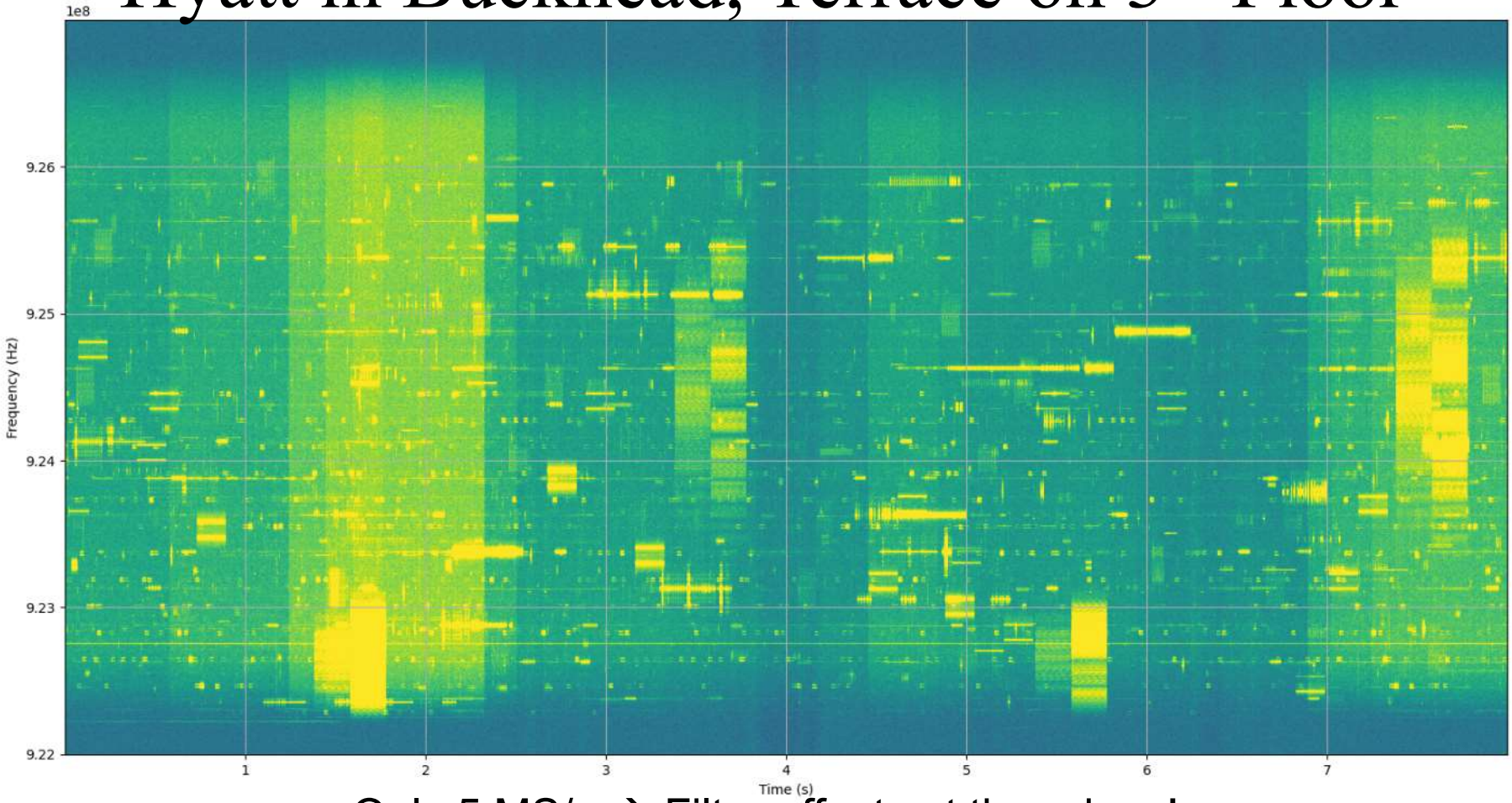
Measured Spectrogram 500kHz LoRa Signals



Footprint of a Typical Low-Rate Packet



Outdoor Measurements
Hyatt in Buckhead, Terrace on 3rd Floor



Only 5 MS/s → Filter effects at the edges!

Interference Models

- Problems due to interference were already addressed during the development of IEEE 802.15.4w
- An interference model is given in:
  - J. Robert, S. Rauh, H. Lieske and A. Heuberger, "IEEE 802.15 Low Power Wide Area Network (LPWAN) PHY Interference Model," 2018 IEEE International Conference on Communications (ICC), Kansas City, MO, USA, 2018

- BUT: Interference characteristics may have to be updated to reflect the increased use of license-exempt frequency bands

Important Findings and Summary

- Spreading is bad and consumes more spectrum than actually required
- Ensure precise signal generation with minimized out-of-band emissions
- Improve the FEC and ensure robustness in interfered channels by means of diversity in time and frequency
- High bandwidth signals will always face interference

Thank You!

Time for some demonstrations.