TECHNISCHE UNIVERSITÄT WIEN

# The 2.4 GHz ISM band Interference Analysis

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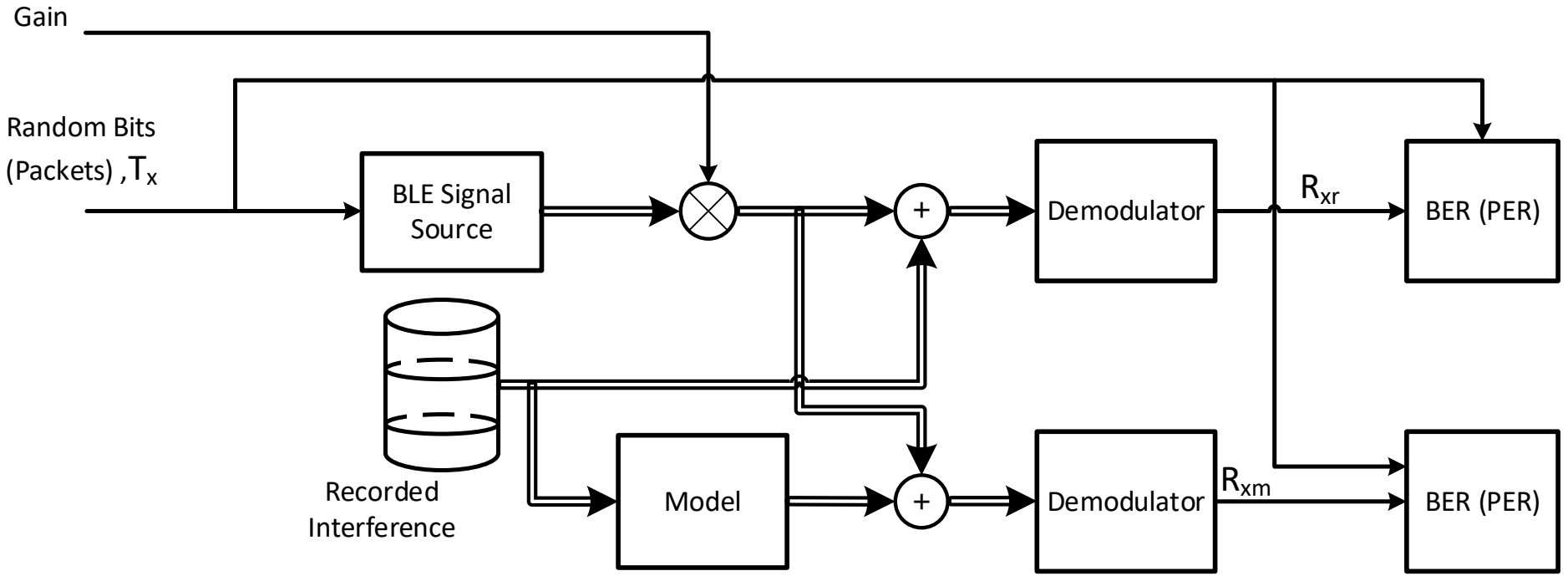
# Content

- A basic framework for interference analysis
- Goal and application
- Modeling interference based on measurement data
- Conclusion

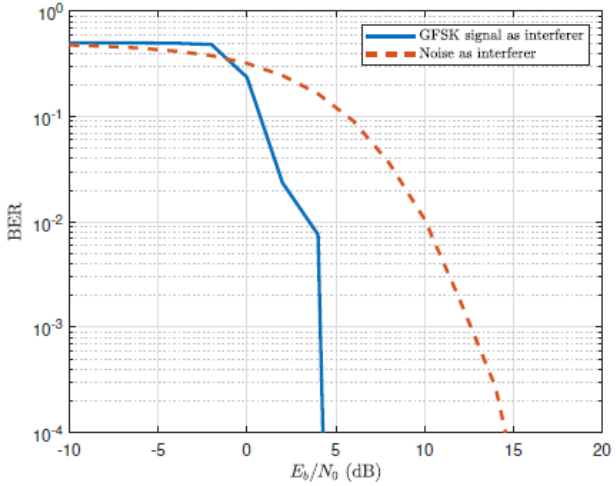
# A basic framework for interference analysis

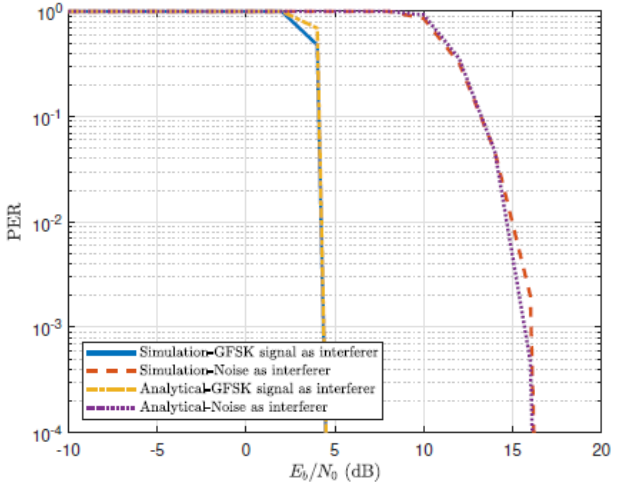
- Analyze BLE performance against recorded and modeled interference
  - BLE signal source
  - Recorded interference
  - demodulator



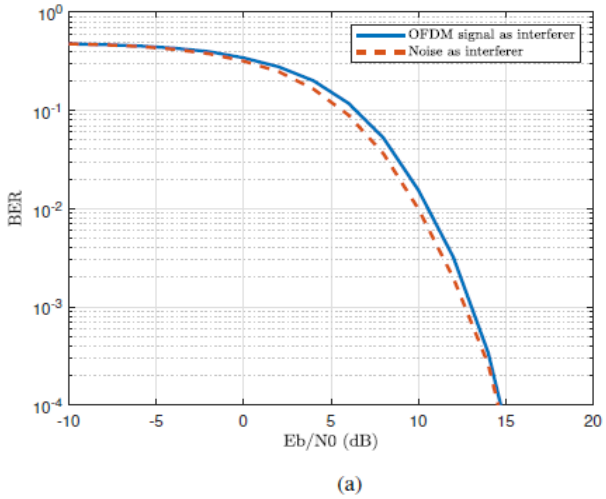
# A basic framework for perform interference analysis

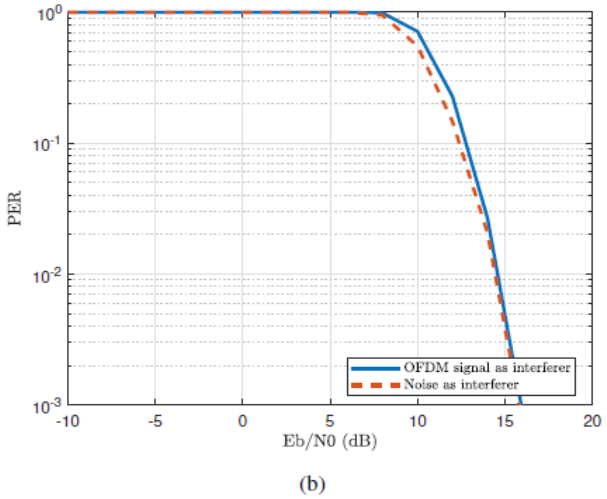
- BLE performance against typical interference sources
  - GFSK modulated signals




  - OFDM modulated signals



# Goal and application

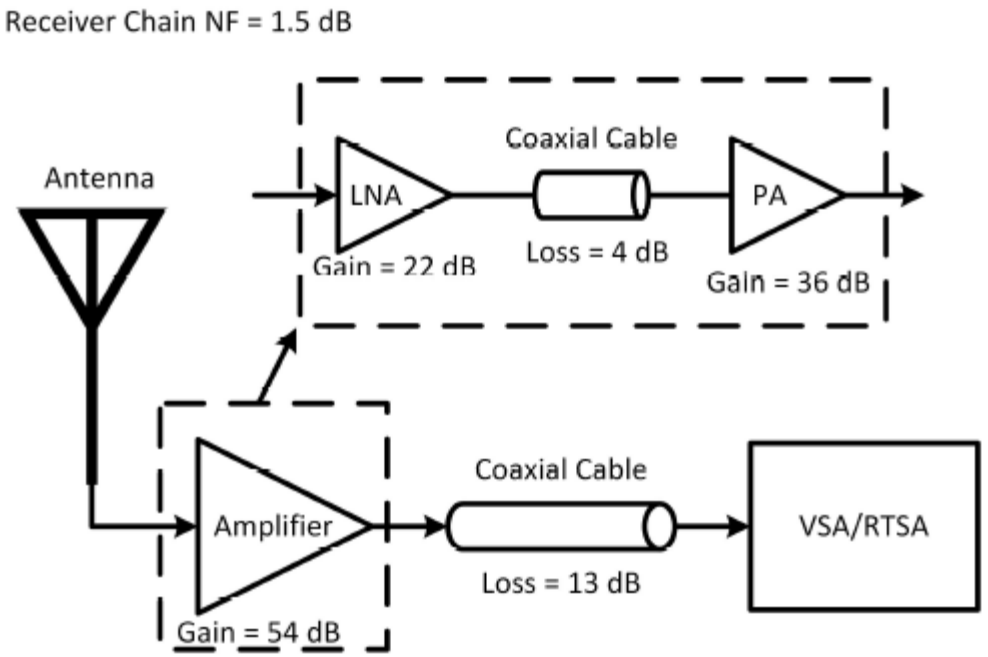
- Two research works
  - Improving the Timeliness of Bluetooth Low Energy in Noisy RF Environments [1]
    - Nine Rpi3 equally distributed
    - Generating Bluetooth and WLAN interference using their on board radio chip
  - Modeling the Coexistence of Co-located BLE and TSCH Networks [2]
    - Two CC2650 launchpads to generate Bluetooth interference
- Problems
  - Non-realistic
  - Complicated
- A simple tool to provide quality of each BLE channel
  - Ignore AFH algorithm



1 Spörk, Michael, Carlo Alberto Boano, and Kay Römer. "Improving the Timeliness of Bluetooth Low Energy in Noisy RF Environments." *EWSN*. 2019.

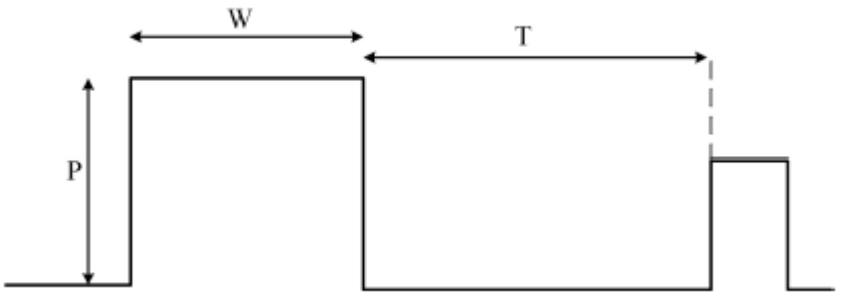
# Modeling interference based on measurement data

- Modeling approach
  - Measurement campaign
  - Interference characterization
  - Emulator



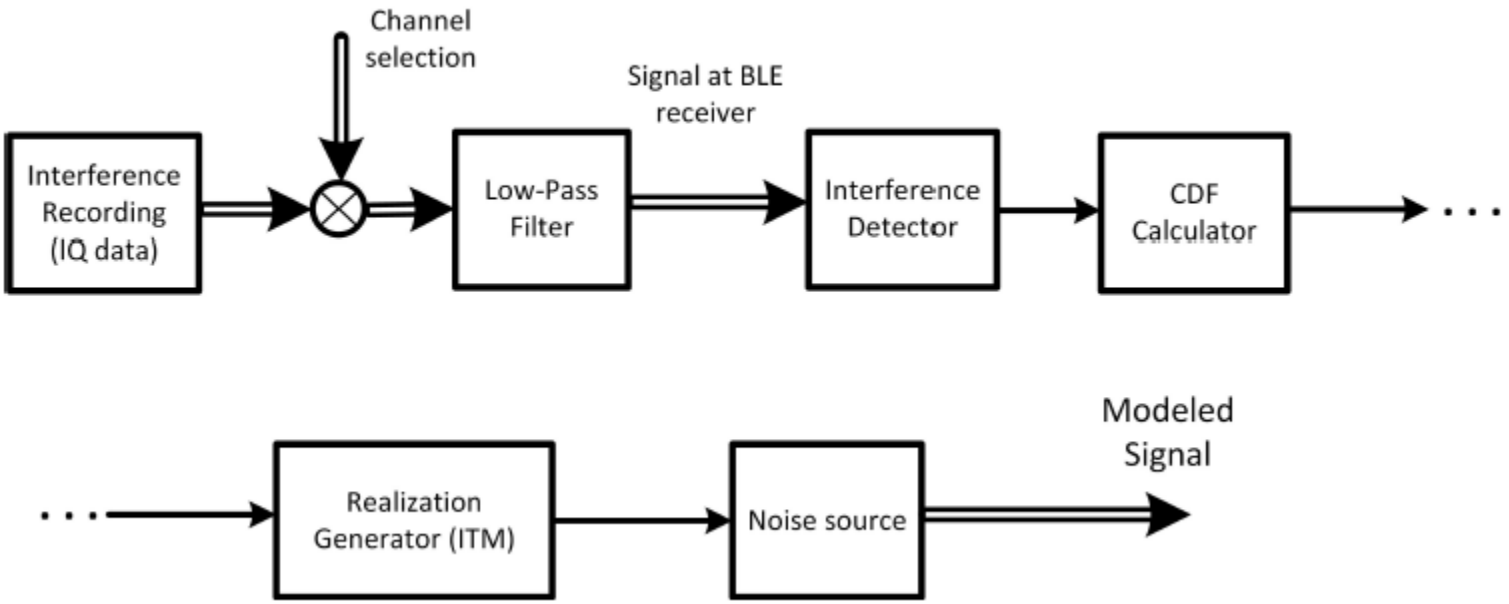

- Models
  - IQ based model
  - Spectrum based model

- Interference characterization



# Modeling interference based on measurement data

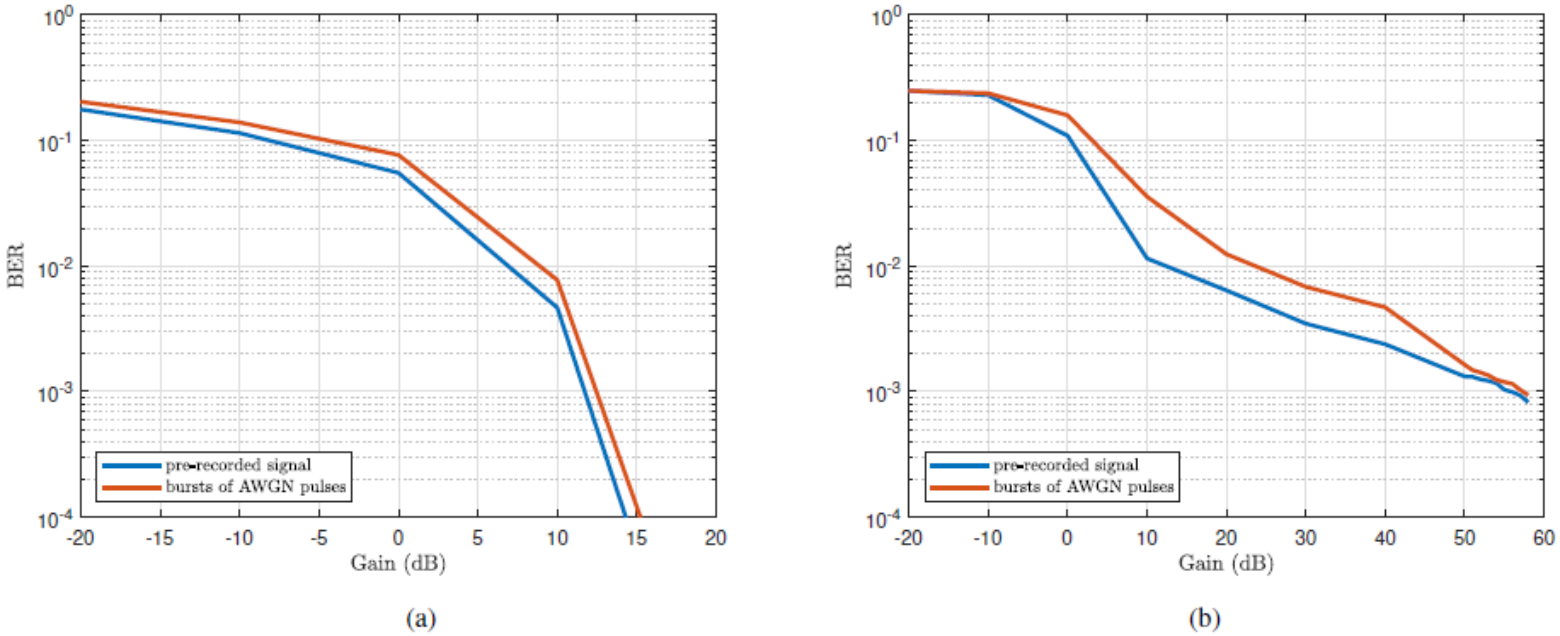
- IQ based models




  - High memory is required to capture reference interference
  - Frequency characteristics are excluded
    - Single channel analysis
  - Poor performance in dominant Bluetooth environments

# Modeling interference based on measurement data

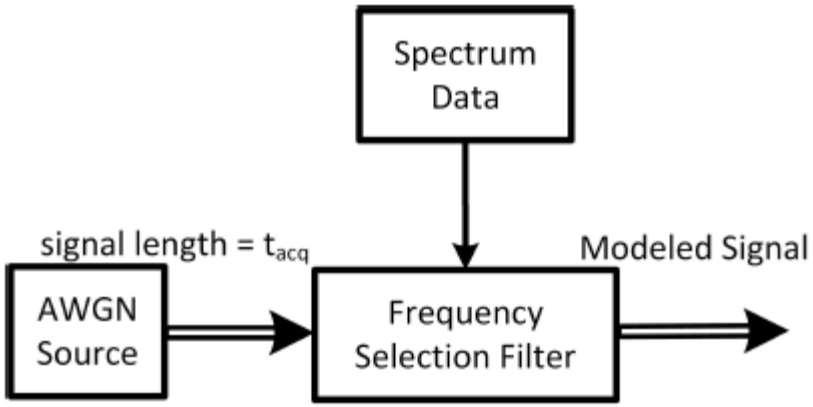
- IQ based model results



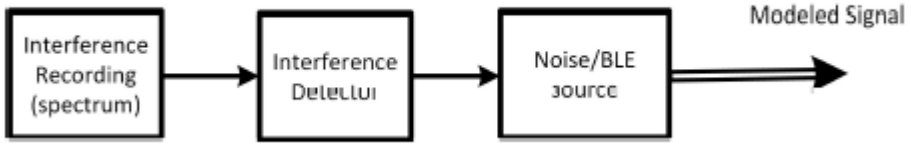

  - Good performance in WLAN dominant environments (IEEE 802.11 channel 1)
  - Poor performance in BLE advertising channel (BLE channel 39)

# Modeling interference based on measurement data

- Spectrum based models
  - IFFT approach



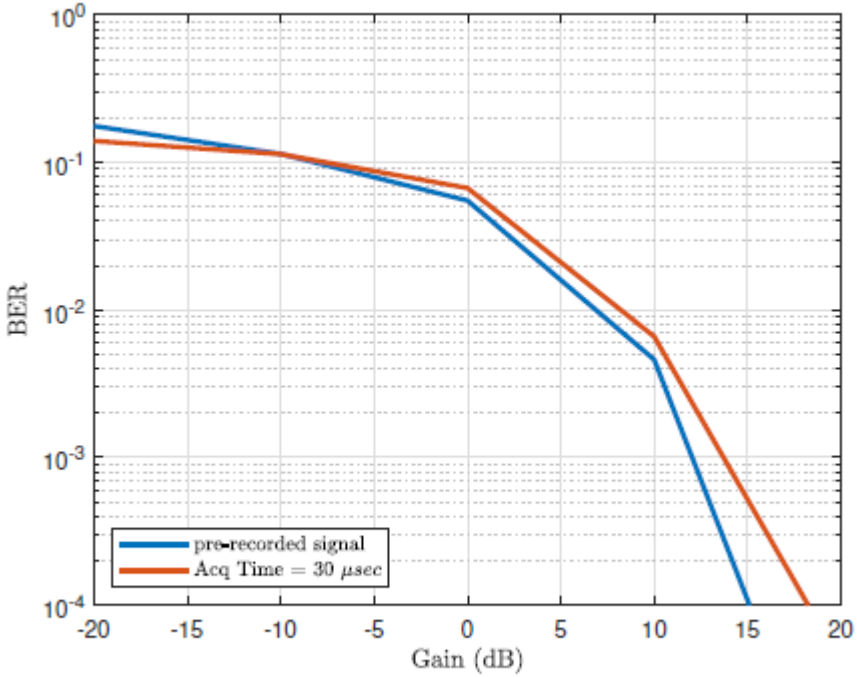

  - Train of events



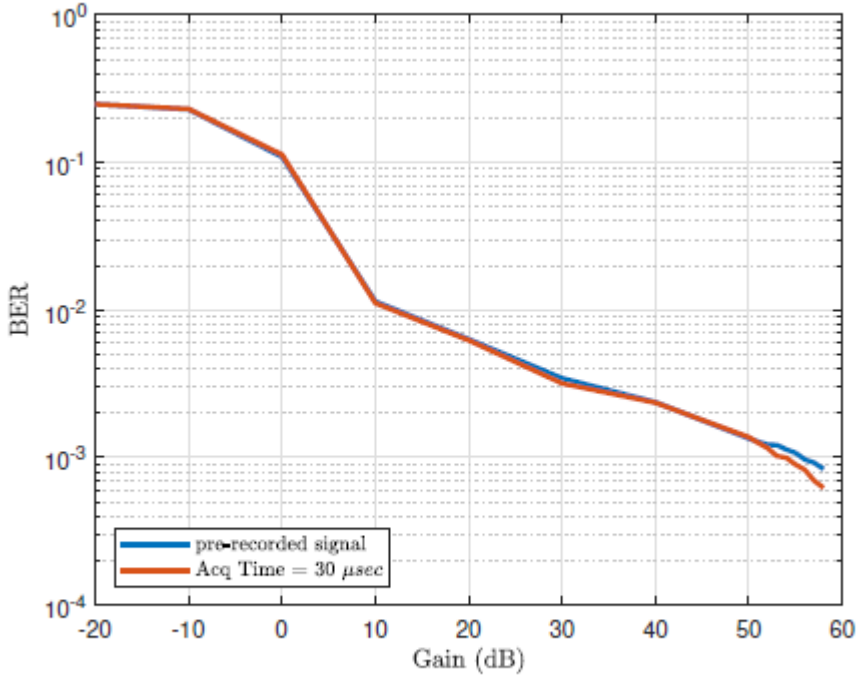

- Properties
  - Less memory is required in capturing interference
  - Frequency properties included in characterization
    - More complicated detection algorithm
- Minimum requirements
  - Acquisition time of 40 μs in a typical university room
  - 256 number of frequency bins over the whole ISM band

# Modeling interference based on measurement data

- Spectrum based model results




(a)



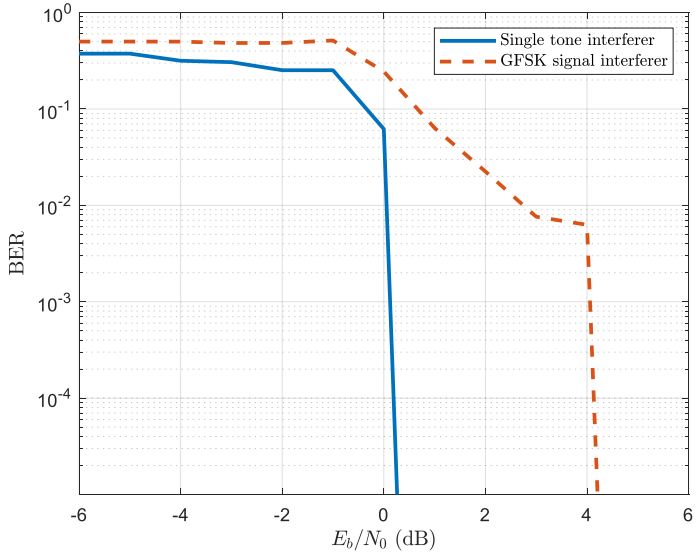

(b)

  - Addresses the problem of modeling Bluetooth interfering signals
  - Degradation in detection algorithm due to high number of detected events
    - Increase number of frequency bins
    - Decrease acquisition time period
    - AI algorithms?

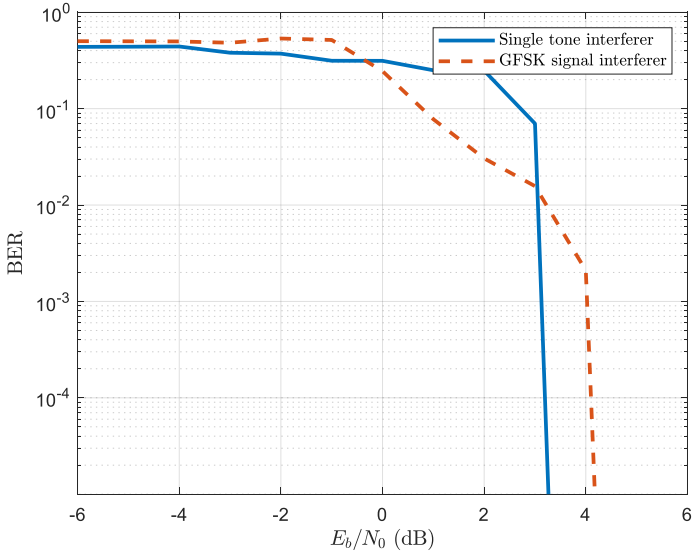
# Modeling interference based on measurement data

- It is difficult to implement BLE signal source in emulator
  - Single tone versus GFSK modulated signal

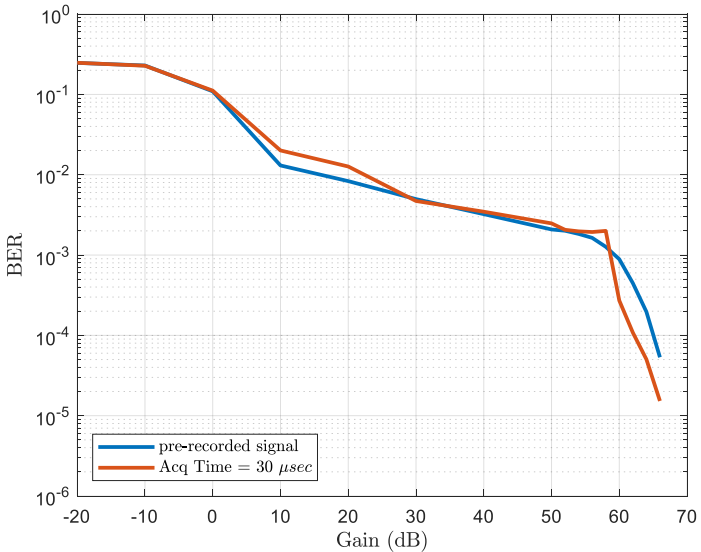
Before gain compensation




After gain compensation




  - Results



# Conclusion

- Conclusion
  - High decimation in data required for interference analysis
    - Using spectrum data
    - Representing interference by train of events
  - Quantifying interference
    - Dominant WLAN environments
    - Dominant Bluetooth environments
  - Emulate interference using simple signal sources

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# Thank You For Your Attention!


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