



KRATOS
READY FOR WHAT'S NEXT™

Methods of Detecting Electromagnetic Interference in Passive Radio Frequency Data

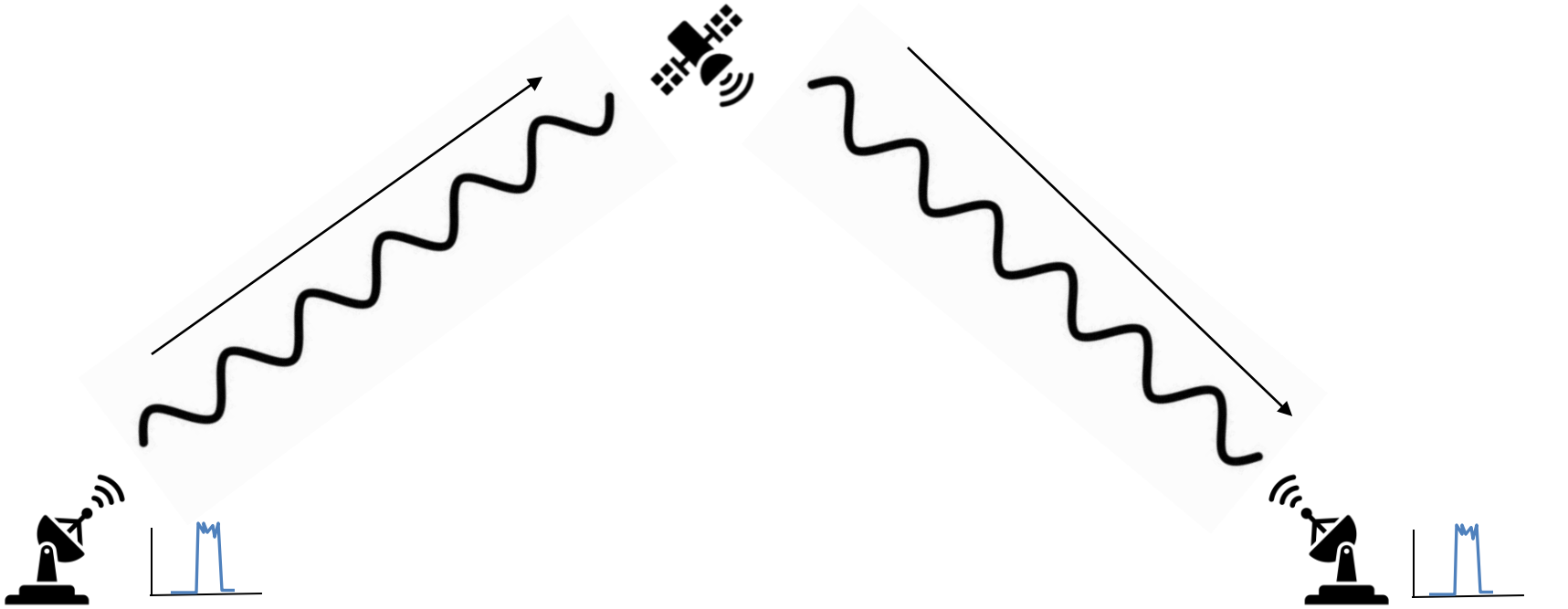
Harris Mohamed

GSAW 2025

Introduction

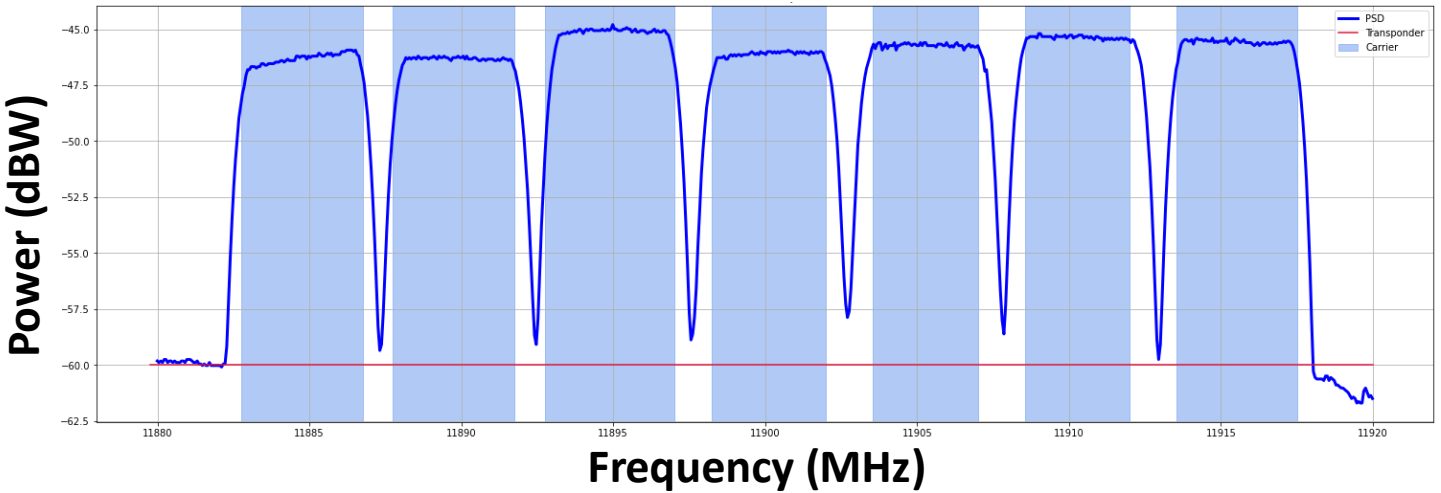
- Radio Frequency (RF) and Electromagnetic Interference (EMI) Overview
- Statistical approaches to EMI Detection
- Machine Learning (ML) approaches to EMI Detection
- Conclusion and Future Work

RF Overview (Nominal)



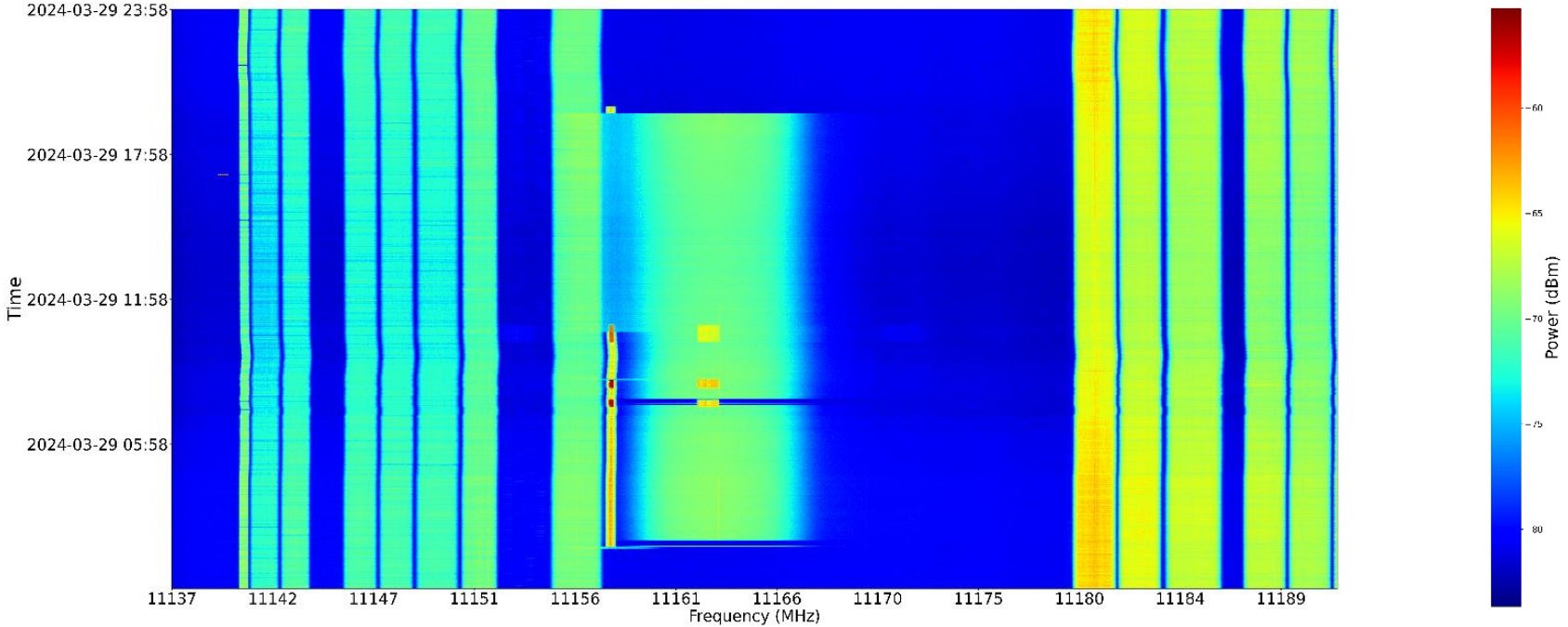
RF Overview

- **Transponder:** A communication unit that receives data from an antenna and then transmits that data to a different antenna
- **Carrier:** Carriers are modulated signals that carry data between ground stations
- **Power Spectral Density (PSD):** A way to visualize RF data



RF Overview

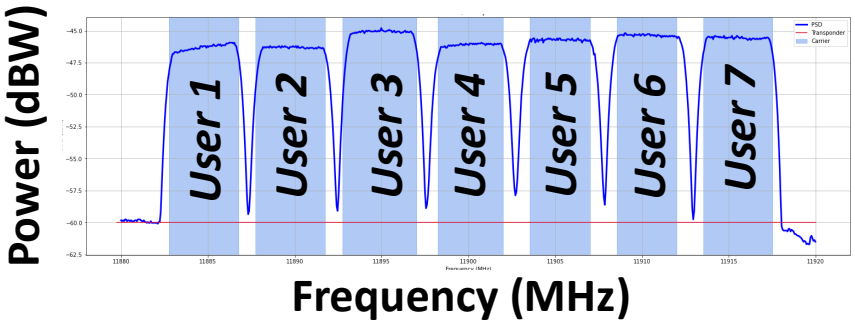
Example waterfall plot



KRATOS
READY FOR WHAT'S NEXT™

RF Overview

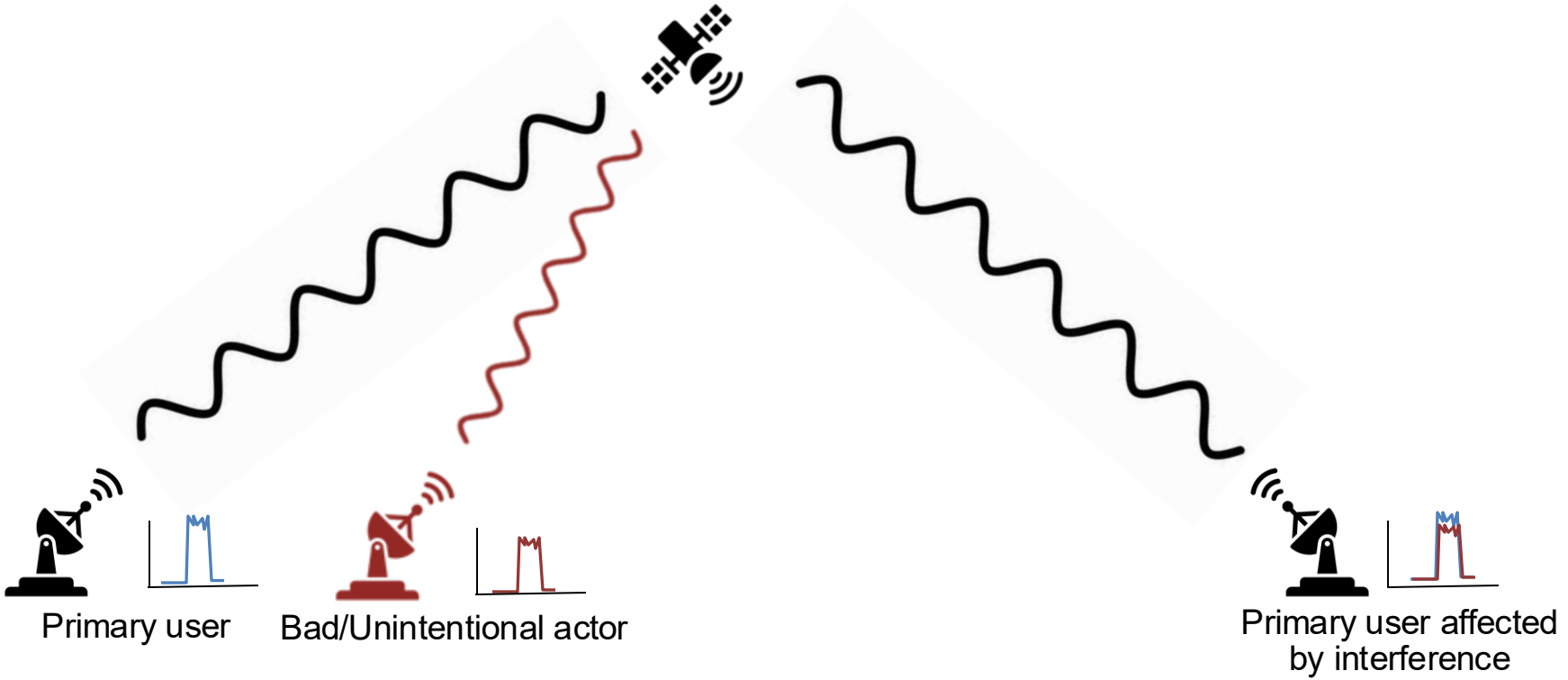
- Transmission plans: Allocation of how spectrum will be used



- Might correspond to:

Carrier	Center Frequency (MHz)	Bandwidth (KHz)	Modulation	..
0	11885	5	8PSK	..
1	11890	5	8PSK	.
…	..	..	..	..

EMI Overview (Uplink)

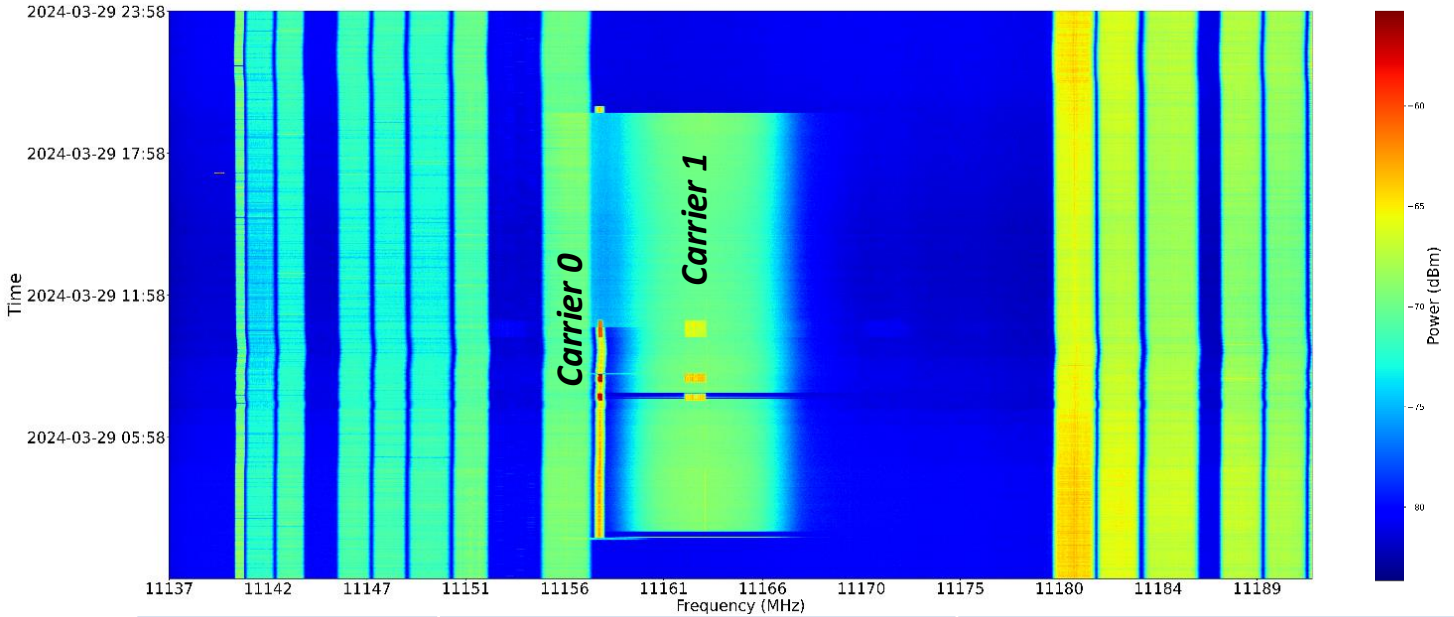


**Note that we are not exploring environmental, hardware-based, or unintentional interference in this work*

The goal

- Given a time series of PSDs, look for abrupt temporal anomalies that are **most likely highly visible EMI**
  - Statistical approaches
    - Mean Squared Error (MSE)
    - Euclidean Distance
    - Maximum hold
  - ML approaches
    - K-means clustering
    - One-shot learning for image-based object detection

Statistical approaches to EMI detection

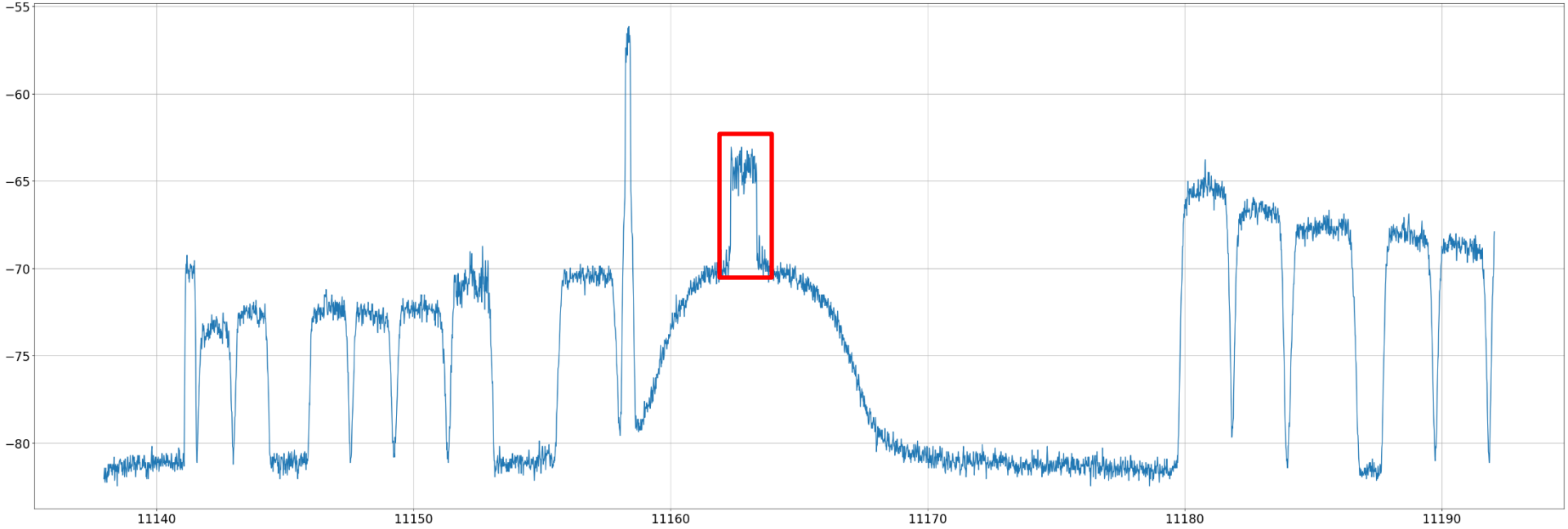


Carrier	Center Frequency (MHz)	Bandwidth (MHz)
0	11156	2
1	11162	10

Statistical approaches to EMI detection

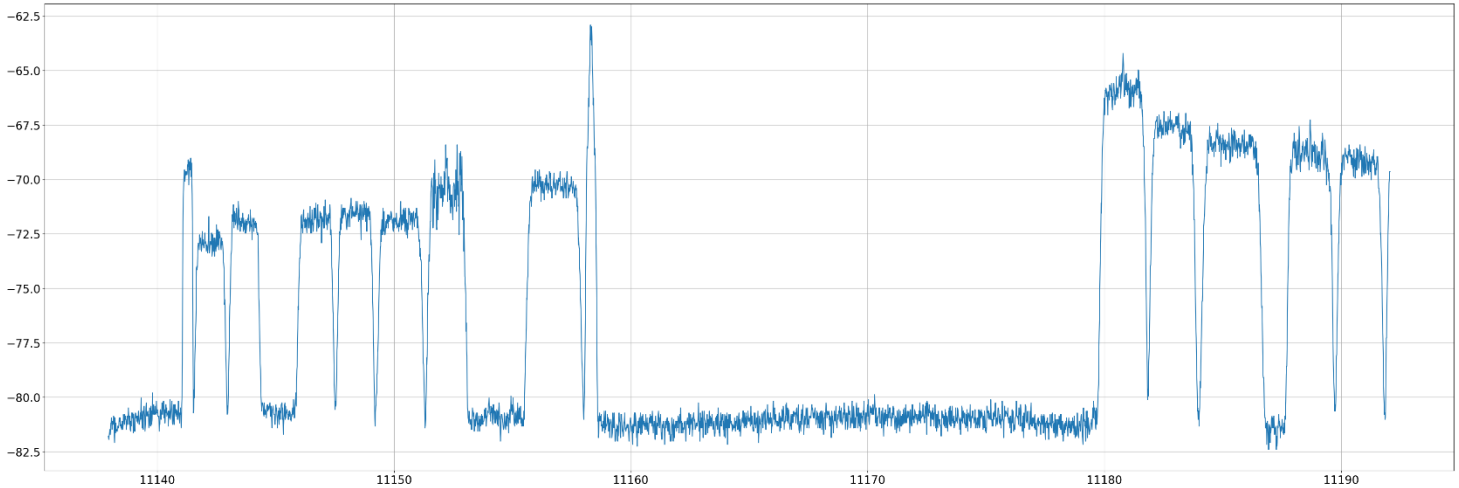
- All methods find the potential EMI

MSE (α=0.8), Euclidean Distance (α=0.75), Max Hold (α=0.6)



Statistical approaches to EMI detection

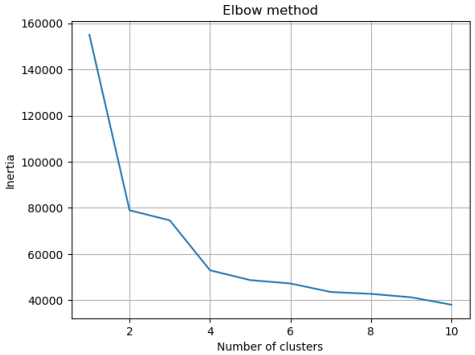
- … But they also find a bunch of false positives



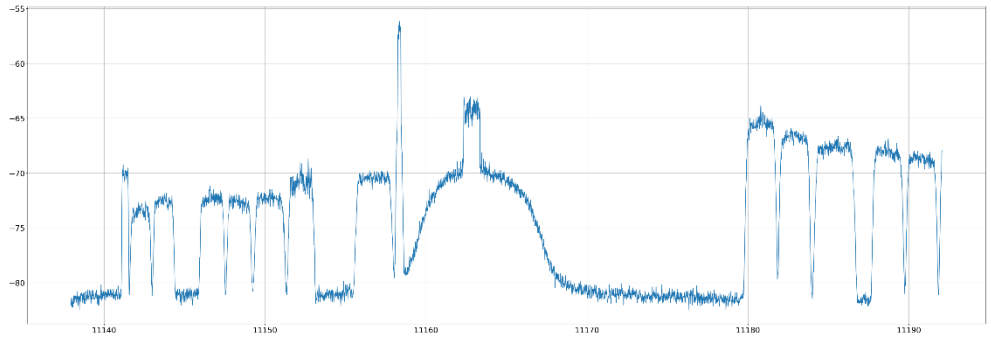
- Hard to account for noise fluctuations and artifacts
- False positive counts: MSE (7), Euclidean Distance (5), Max Power (14)
- This problem gets worse at scale and without a transmission plan

ML approaches to EMI detection

- K-means Clustering
  - Unsupervised approach to group PSDs by their features, define each with a centroid and minimize variance in each cluster



Cluster 1 contains the potential EMI

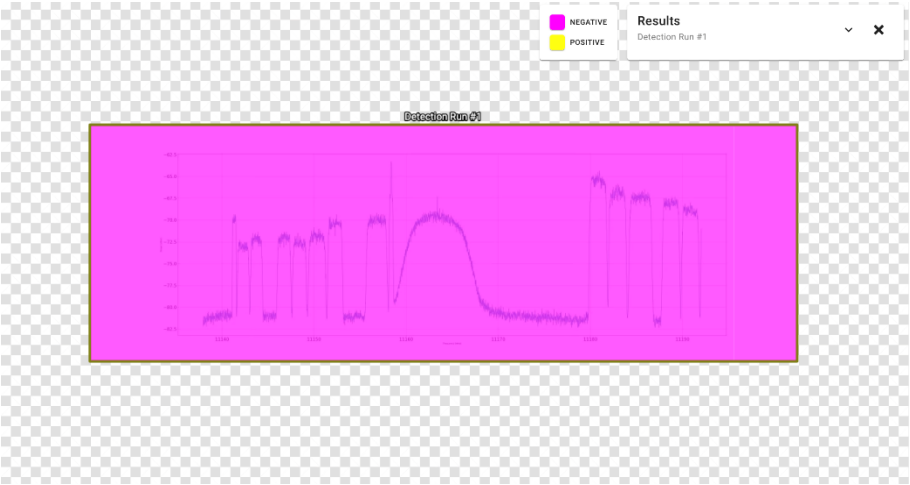


- Performs well with human-in-the-loop labeling
- Offline approach will require batch processing and frequent reprocessing

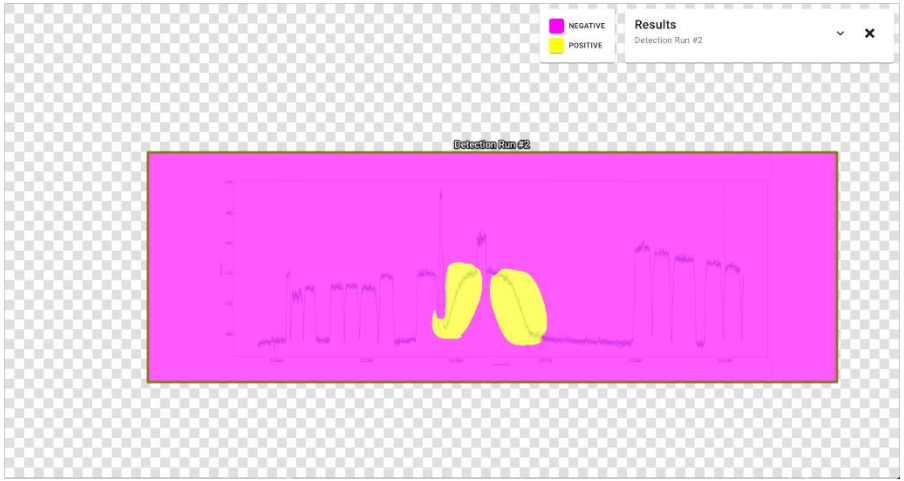
ML approaches to EMI detection

- One-shot learning treating each PSD as an image
  - Train an image segmentation model from a few EMI examples

Nominal trace



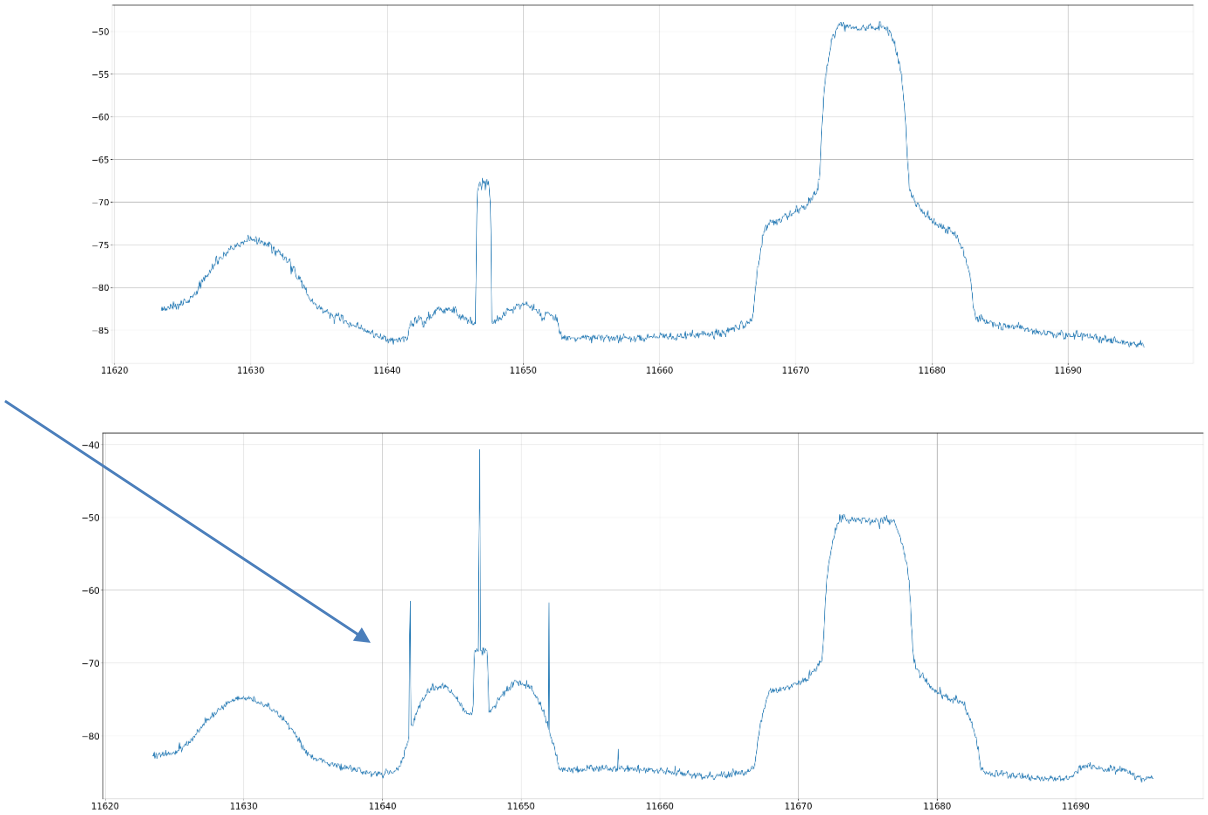
PSD with Interference detected



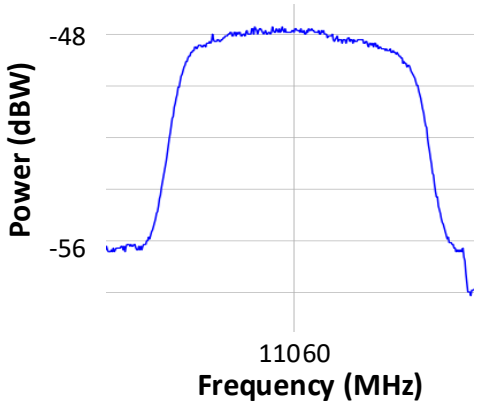
- More sophisticated approach but still suffers from same drawbacks

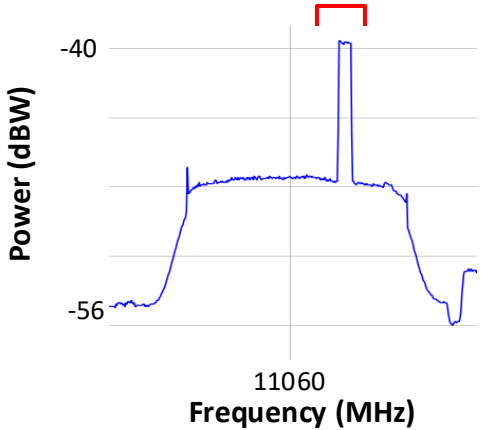
Applications

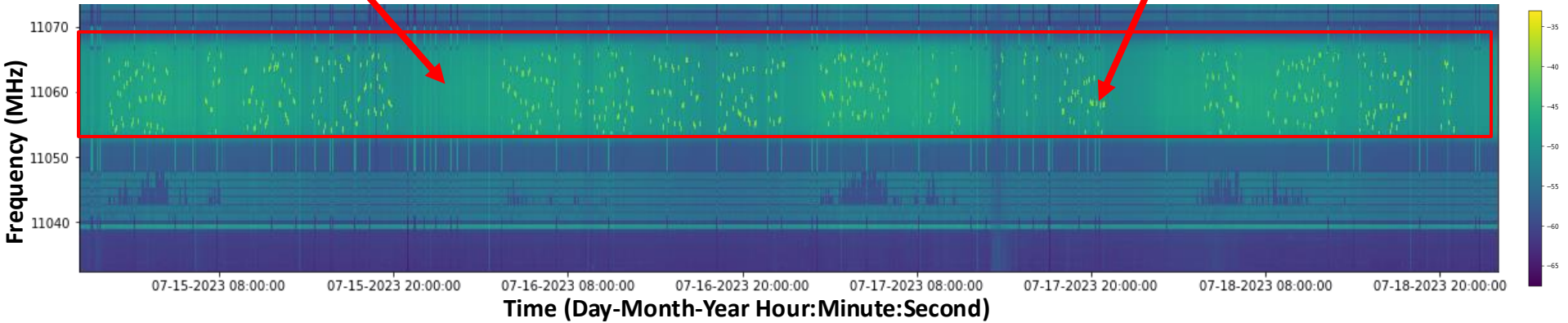
Interference causes artifacting and the noise floor to raise



Yamal 401


-48
-56
Power (dBW)
11060
Frequency (MHz)


-40
-56
Power (dBW)
11060
Frequency (MHz)


11070
11060
11050
11040
Frequency (MHz)
07-15-2023 08:00:00
07-15-2023 20:00:00
07-16-2023 08:00:00
07-16-2023 20:00:00
07-17-2023 08:00:00
07-17-2023 20:00:00
07-18-2023 08:00:00
07-18-2023 20:00:00
Time (Day-Month-Year Hour:Minute:Second)

Conclusion & Future Work

- Conclusion
  - Need to have human-in-the-loop approach
  - PSD-only datasets are limiting
- Future work
  - Multivariate analysis
    - Carrier characterization limits
  - Dataset generation

Thank You