# PANSY Mode Detection

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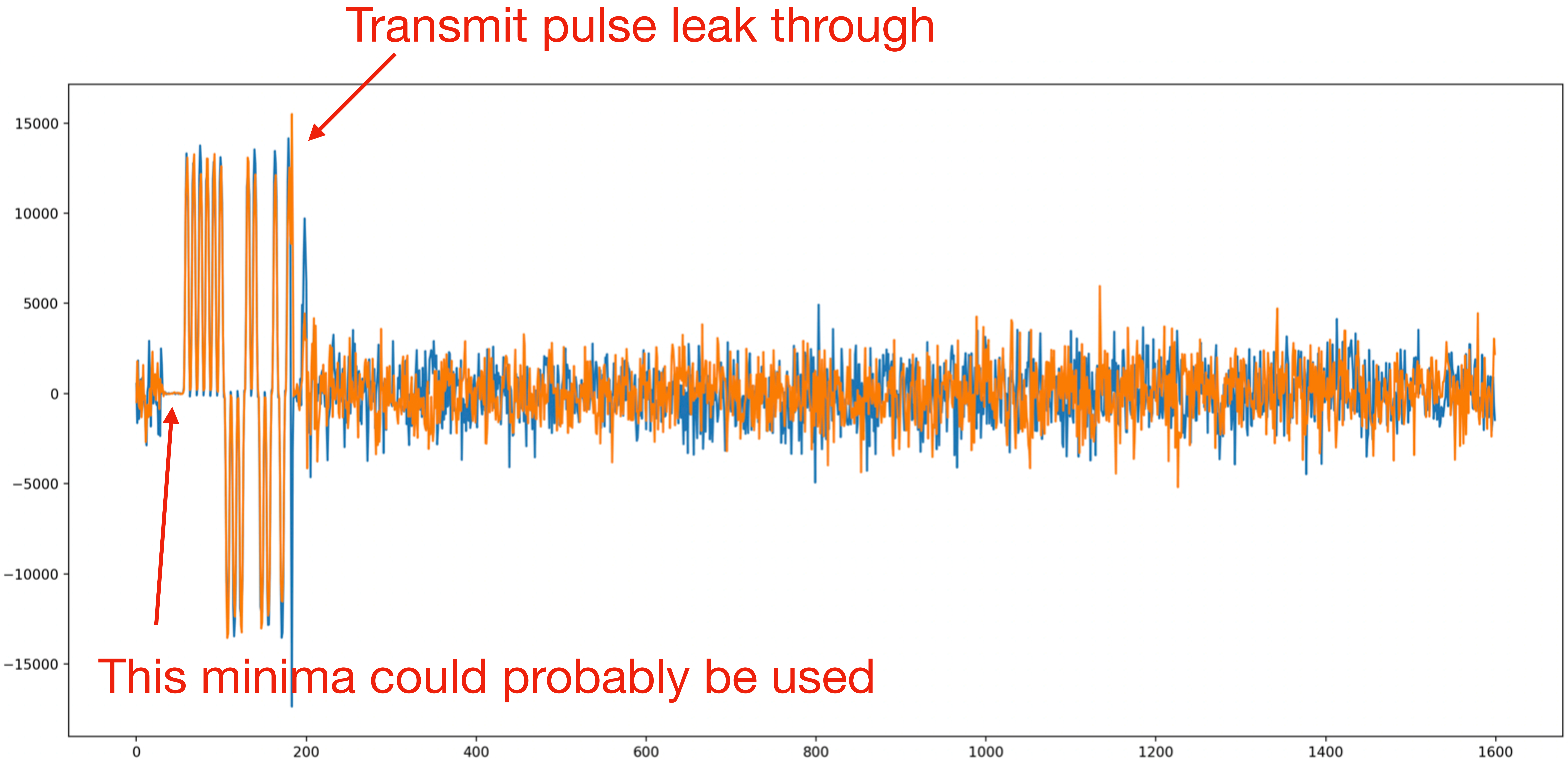
# Mode detection need

- Pansy Meteor Extension (PAMEX) is locked to GPS reference, while PANSY is locked to its own free running internal reference
- Based on the testing at Shigaraki, the PANSY clock is within about 1 ppm of the GPS reference
- This means that within a few pulses, the phase doesn't change significantly at 47 MHz
- The interpulse period will also not significantly deviate over a tenth of a second or so with a 1 MHz sample rate
- We need to use the transmit sample to detetermine what beam pointing is currently used, and which part of the sequence we are currently in.

# Example Raw Voltage



# Strategy

- The code sequence for the mesosphere mode only has a repeated  A-code when starting a new sequence.
- The sequecy -BB would also work, but let’s try AA first

```
.0.0.0.0.0.0.1.1.1.0.0.1.1.0.1.0,#1      A
.0.0.0.0.1.1.0.0.1.0.0.1.0.1.0.1,#2      B
.1.1.1.1.1.1.0.0.0.1.1.0.0.1.0.1,#-1    -A
.1.1.1.1.0.0.1.1.0.1.1.0.1.0.1.0,#-2    -B
.1.1.1.1.1.1.0.0.0.1.1.0.0.1.0.1,#-1    -A
.0.0.0.0.1.1.0.0.1.0.0.1.0.1.0.1,#2      B
.1.1.1.1.1.1.0.0.0.1.1.0.0.1.0.1,#-1    -A
.0.0.0.0.1.1.0.0.1.0.0.1.0.1.0.1,#2      B
.1.1.1.1.1.1.0.0.0.1.1.0.0.1.0.1,#-1    -A
.1.1.1.1.0.0.1.1.0.1.1.0.1.0.1.0,#-2    -B
.0.0.0.0.1.1.0.0.1.0.0.1.0.1.0.1,#2      B
.1.1.1.1.1.1.0.0.0.1.1.0.0.1.0.1,#-1    -A
.1.1.1.1.0.0.1.1.0.1.1.0.1.0.1.0,#-2    -B
.0.0.0.0.0.0.1.1.1.0.0.1.1.0.1.0,#1      A
.0.0.0.0.1.1.0.0.1.0.0.1.0.1.0.1,#2      B
.0.0.0.0.0.0.1.1.1.0.0.1.1.0.1.0,#1      A
.0.0.0.0.1.1.0.0.1.0.0.1.0.1.0.1,#2      B
.0.0.0.0.0.0.1.1.1.0.0.1.1.0.1.0,#1      A
.0.0.0.0.1.1.0.0.1.0.0.1.0.1.0.1,#2      B
.0.0.0.0.0.0.1.1.1.0.0.1.1.0.1.0,#1      A
.0.0.0.0.0.0.1.1.1.0.0.1.1.0.1.0,#1      A
.0.0.0.0.1.1.0.0.1.0.0.1.0.1.0.1,#2      B
.1.1.1.1.1.1.0.0.0.1.1.0.0.1.0.1,#-1    -A
.1.1.1.1.0.0.1.1.0.1.1.0.1.0.1.0,#-2    -B
.1.1.1.1.1.1.0.0.0.1.1.0.0.1.0.1,#-1    -A
.0.0.0.0.1.1.0.0.1.0.0.1.0.1.0.1,#2      B
.1.1.1.1.1.1.0.0.0.1.1.0.0.1.0.1,#-1    -A
.0.0.0.0.1.1.0.0.1.0.0.1.0.1.0.1,#2      B
.1.1.1.1.1.1.0.0.0.1.1.0.0.1.0.1,#-1    -A
.1.1.1.1.0.0.1.1.0.1.1.0.1.0.1.0,#-2    -B
.0.0.0.0.1.1.0.0.1.0.0.1.0.1.0.1,#2      B
.1.1.1.1.1.1.0.0.0.1.1.0.0.1.0.1,#-1    -A
.1.1.1.1.0.0.1.1.0.1.1.0.1.0.1.0,#-2    -B
.0.0.0.0.0.0.1.1.1.0.0.1.1.0.1.0,#1      A
.0.0.0.0.1.1.0.0.1.0.0.1.0.1.0.1,#2      B
.0.0.0.0.0.0.1.1.1.0.0.1.1.0.1.0,#1      A
.0.0.0.0.1.1.0.0.1.0.0.1.0.1.0.1,#2      B
.0.0.0.0.0.0.1.1.1.0.0.1.1.0.1.0,#1      A
.0.0.0.0.1.1.0.0.1.0.0.1.0.1.0.1,#2      B
.0.0.0.0.0.0.1.1.1.0.0.1.1.0.1.0,#1      A
```

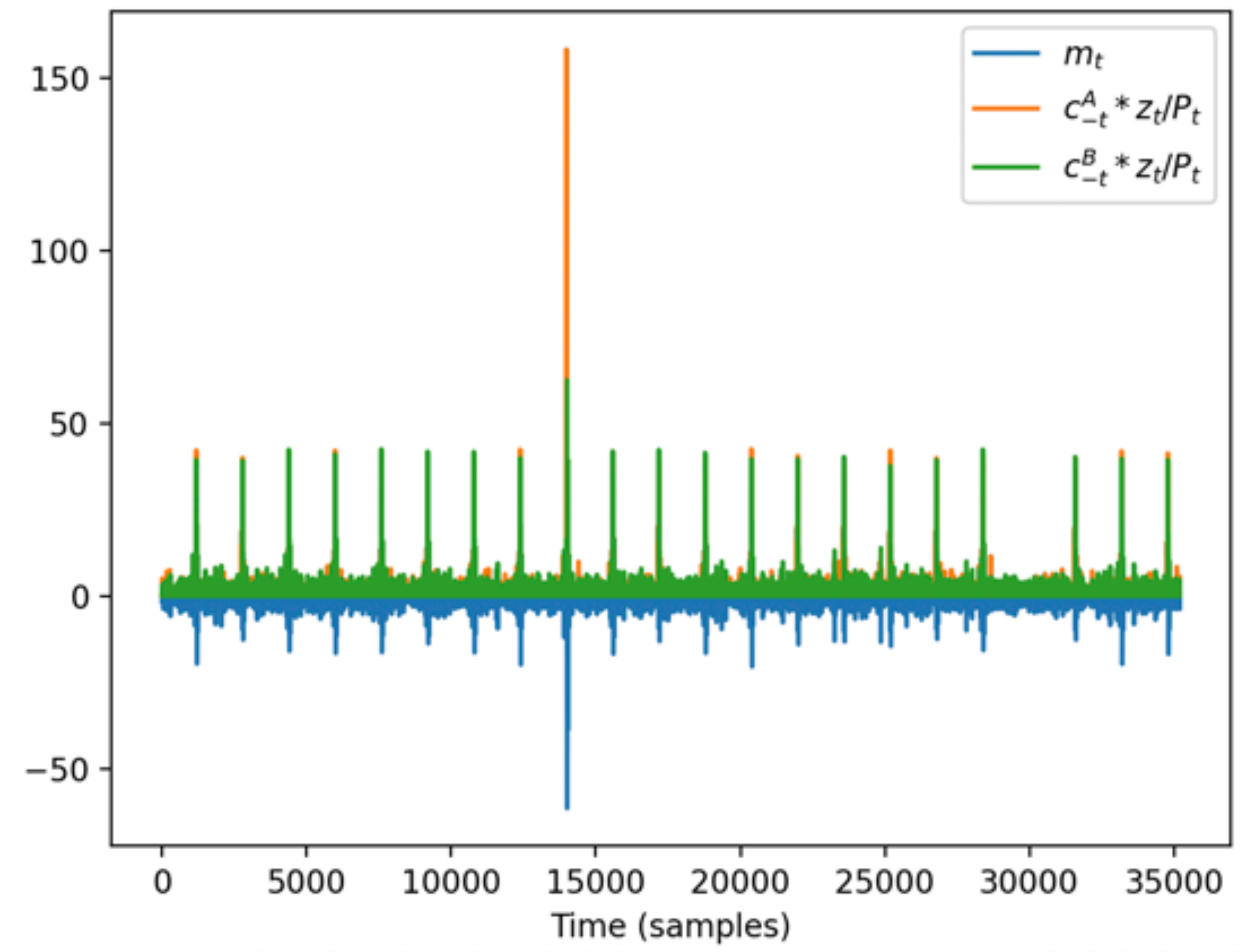
# Strategy

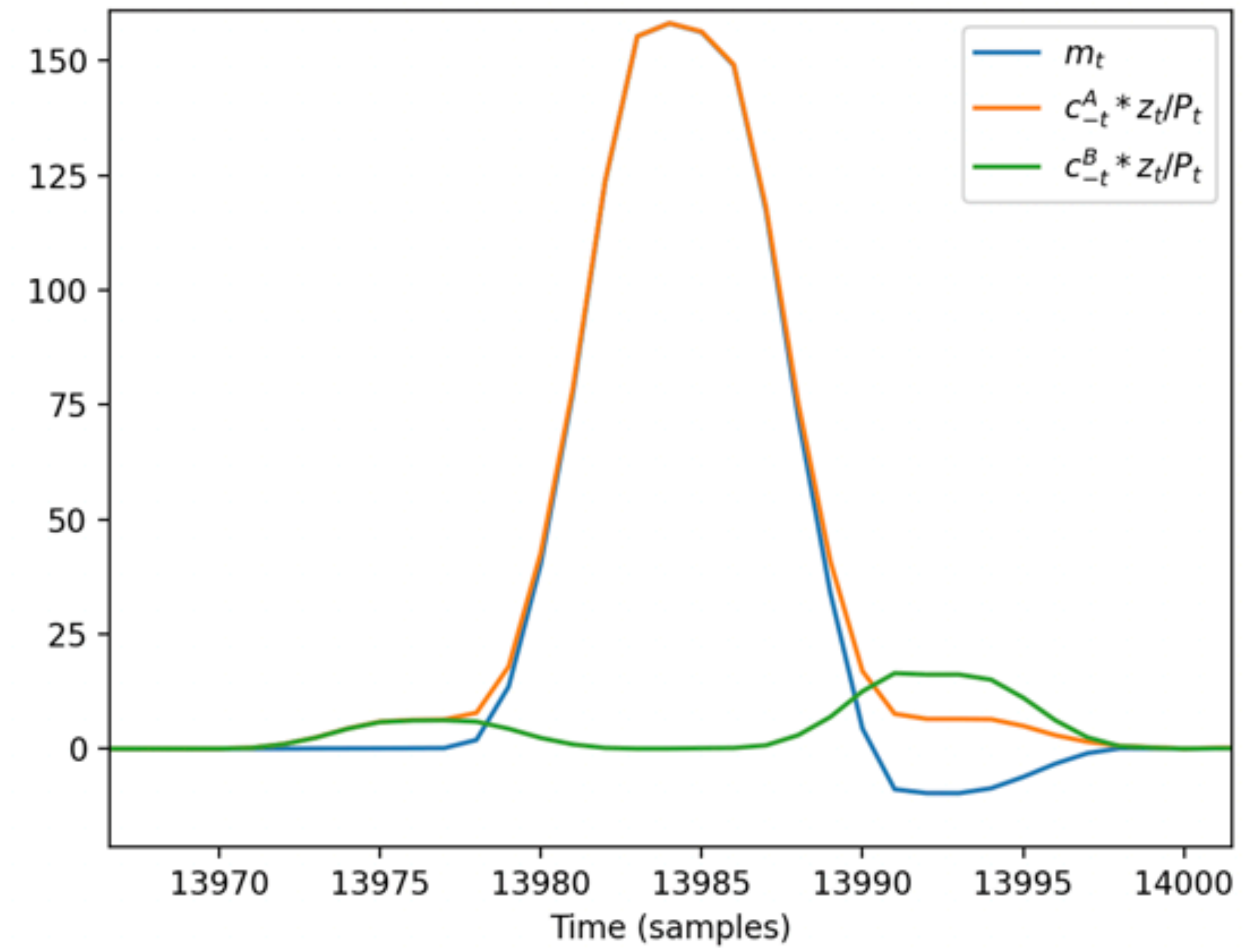
- The cross-correlation $c^A_{-t} * c^A_t$ is maximized when $c^B_{-t} * c^A_t$ is minimized. Here $c^A_t$ is 16-bit complementary code A and $c^B_t$ is code B

- Normalize with power within pulse length $P_t = r_{-t} * |z_t|^2 + \epsilon$ with $r_t$ a rectangular window of length of transmit pulse

- Metric: $m_t = (c^A_{-t} * z_t - c^B_{-t} * z_t)/P_t$

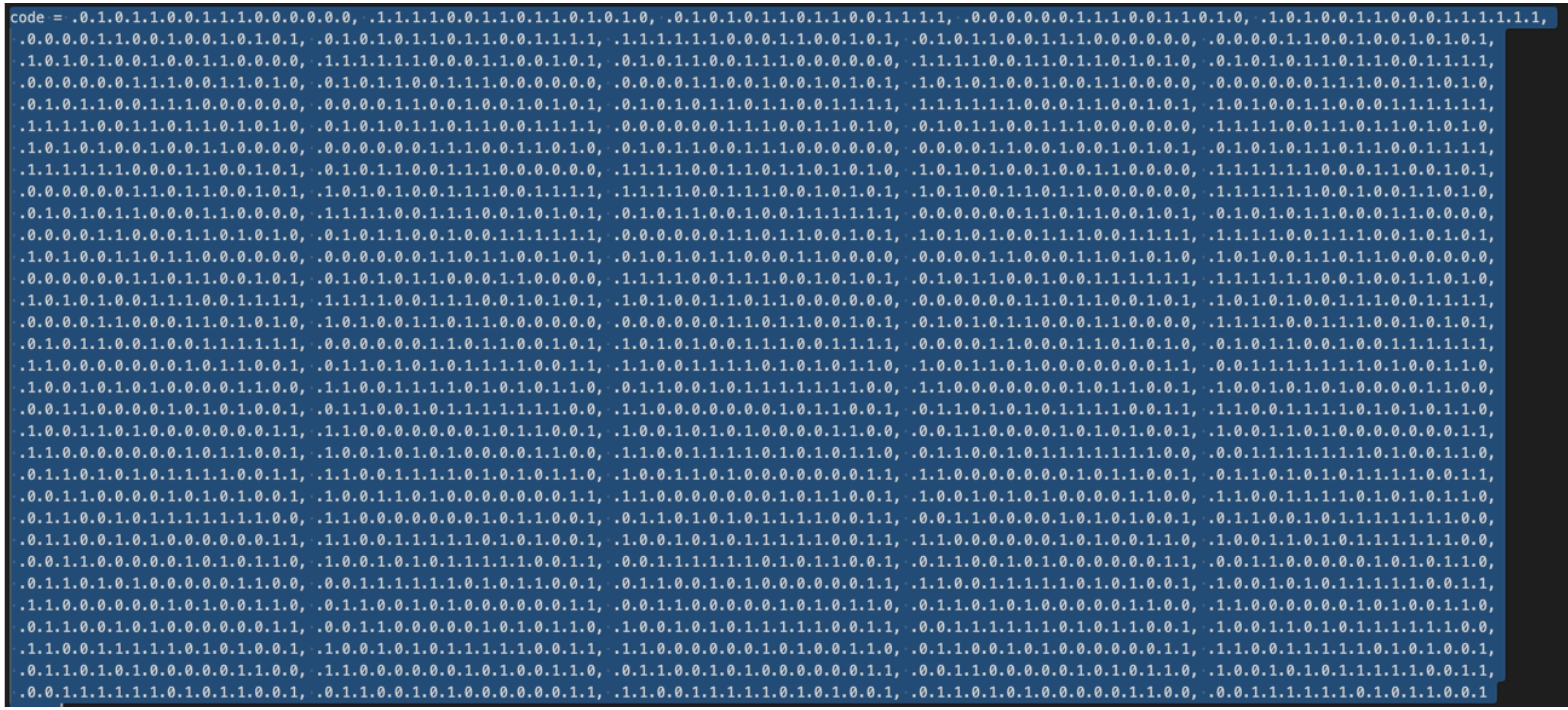
- Avoid $P_t = 0$ with small number $\epsilon$

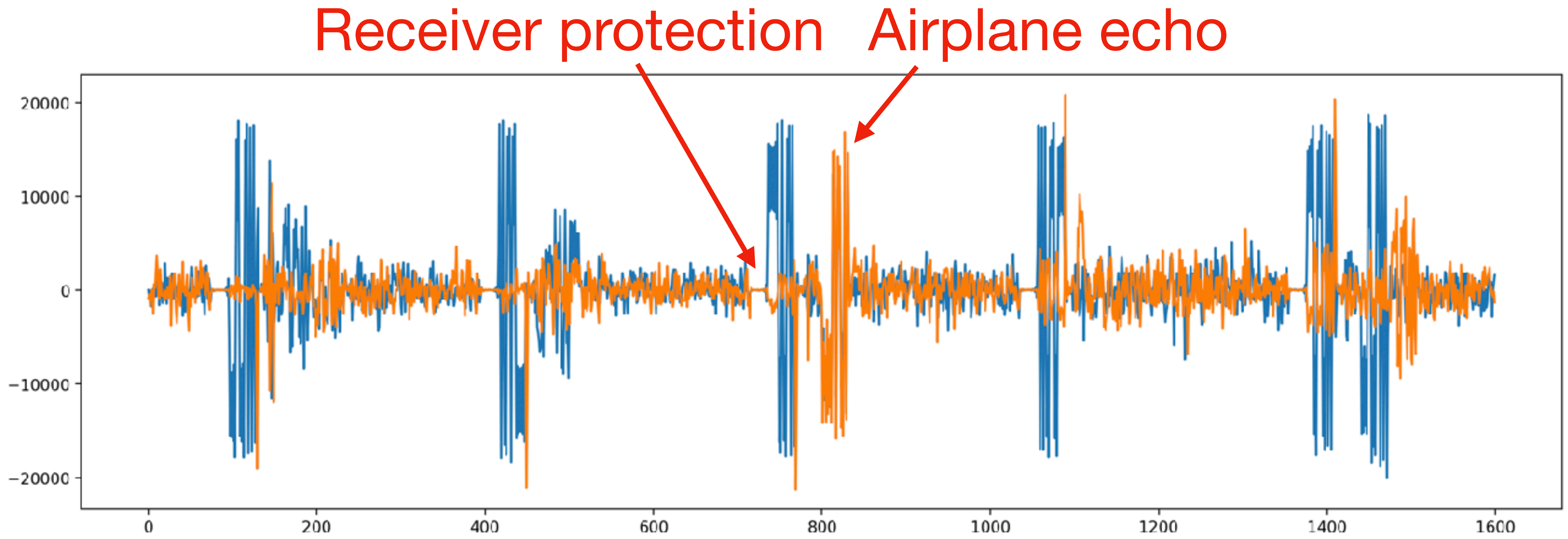


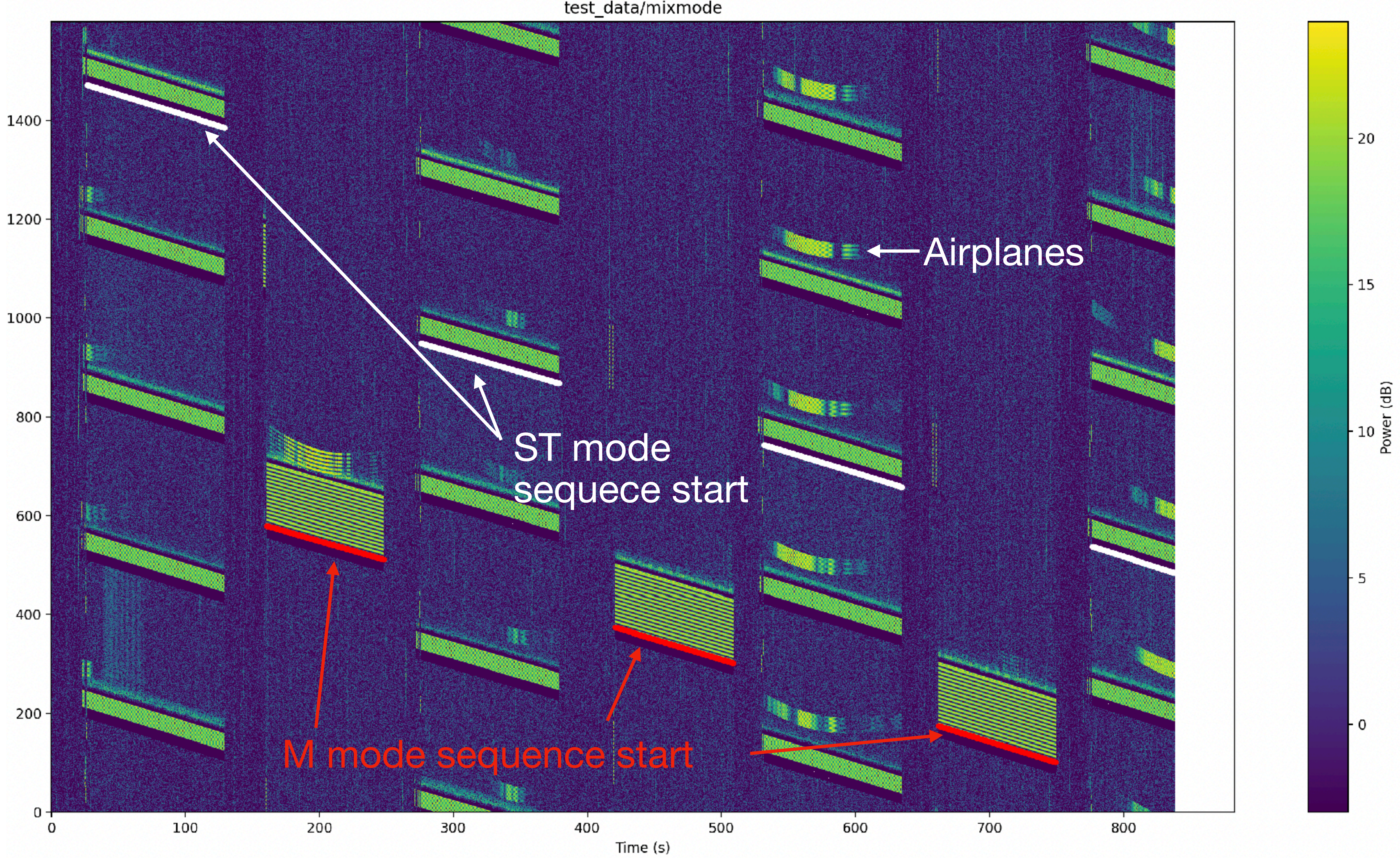



# Strategy

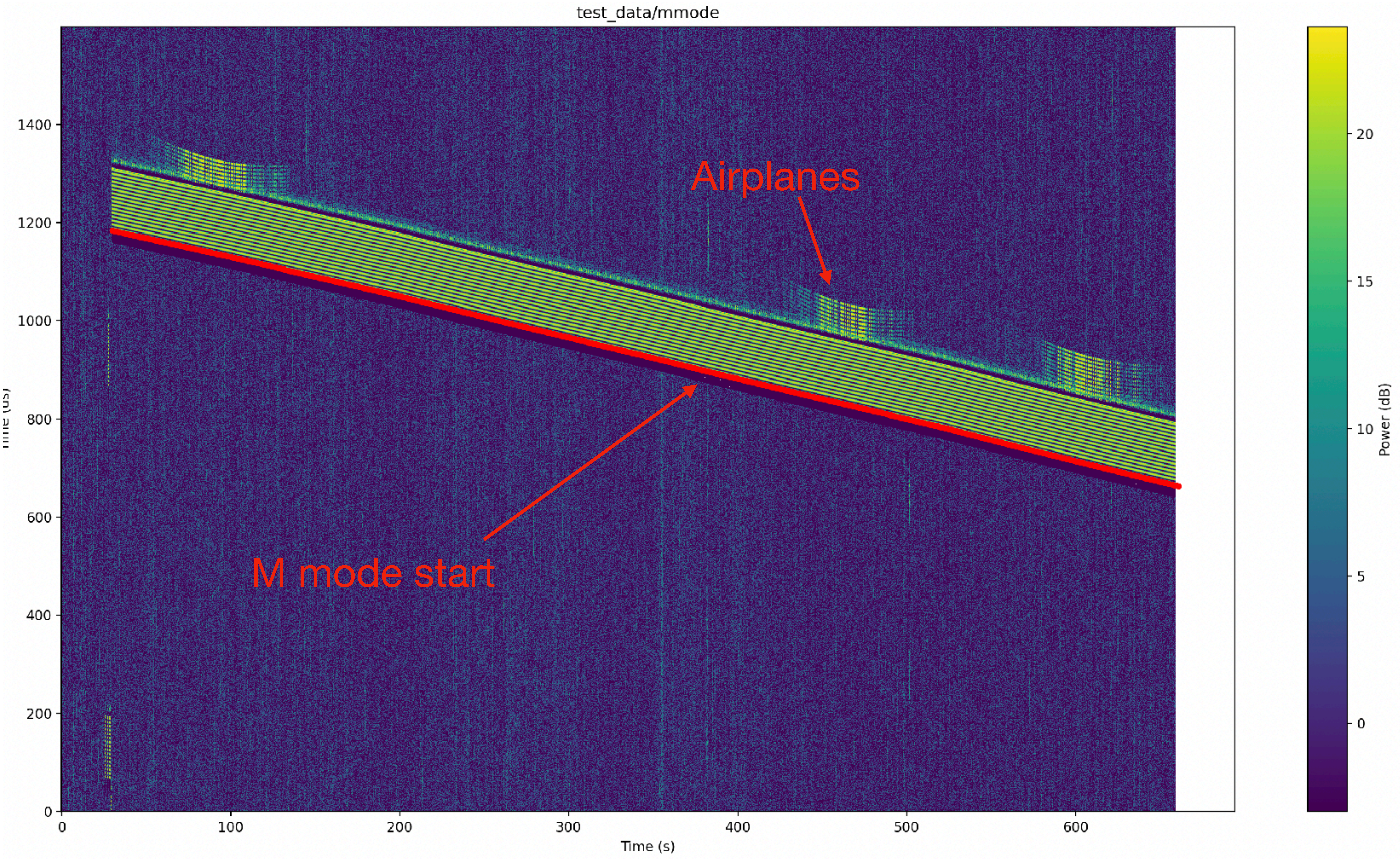
- For the ST mode, we can detect based on the first 10 pulses only occurring once in the beginning of the 160 pulse sequence
- We also need to find the receiver protect minima before the transmit pulse to make sure that we don't accidentally detect strong airplane echoes as transmit pulses

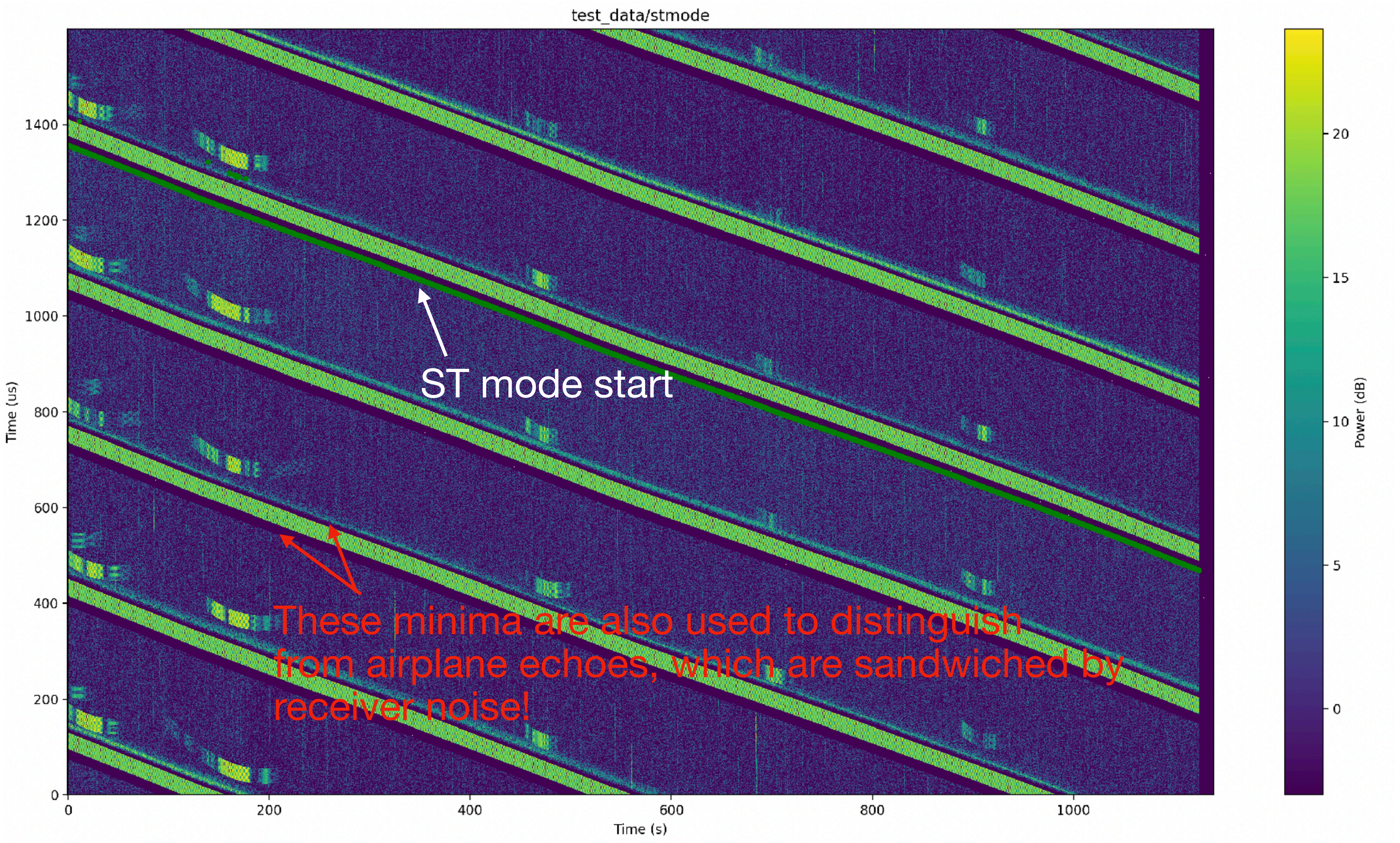






test_data/mixmode
Airplanes
ST mode
sequece start
M mode sequence start
Time (s)
Power (dB)
0
100
200
300
400
500
600
700
800
1000
1200
1400
20
15
10
5


test_data/mmode
Airplanes
M mode start
Time (s)
Power (dB)
0
100
200
300
400
500
600
200
400
600
800
1000
1200
1400
0
5
10
15
20


test_data/stmode
ST mode start
These minima are also used to distinguish from airplane echoes, which are sandwiched by receiver noise!
Time (us)
Time (s)
Power (dB)
0
200
400
600
800
1000
1200
1400
0
200
400
600
800
1000
0
5
10
15
20

# TODO

- Test against various signal levels and airplane echo amplitudes
- Airplanes will be more challenging for the ST mode, because they are near zero Doppler shift and can be stronger than the transmit sample