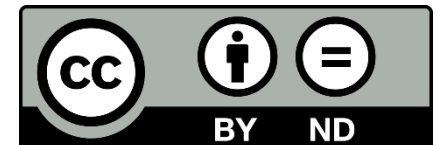


# The RPW Time Domain Sampler (TDS) on Solar Orbiter: In-flight performance and first data

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# RPW: Radio and Plasma Waves instrument on Solar Orbiter

*PI: Milan Maksimovic (LESIA, Paris)*

## Electric field

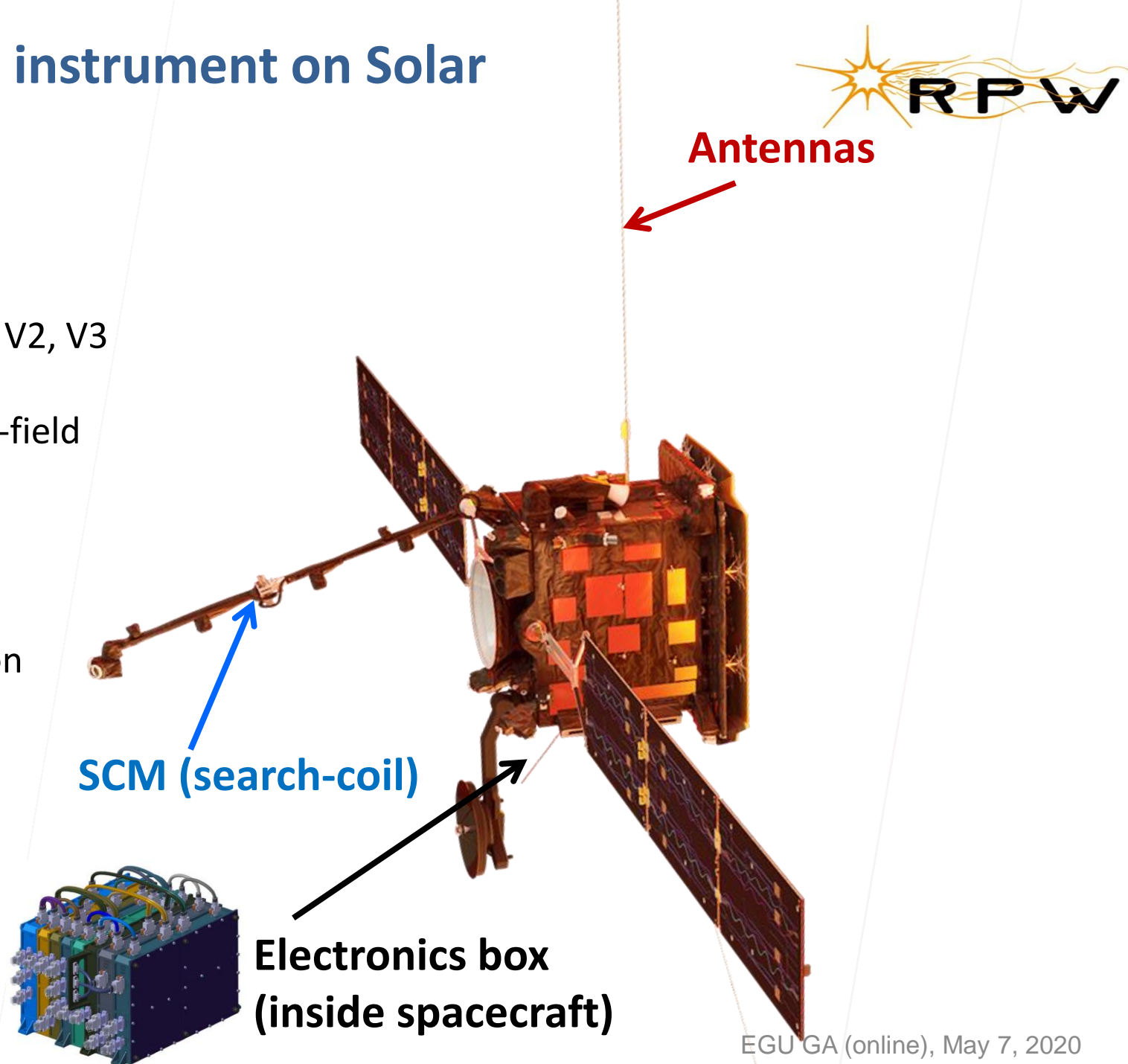
- 3 stacer antennas (6 meters long): V1, V2, V3
- DC to 16 MHz
- Biased antennas, first low frequency E-field measurements in inner heliosphere)

## Magnetic field

- 0.1 Hz to 200 kHz
- Magnetic measurements up to electron plasma frequency

## Electronics box:

- Low Frequency Receiver (LFR)
- Time Domain Sampler (TDS)
- Thermal noise & High Frequency Receiver (TNR/HFR)





# Time Domain Sampler – TDS



- ❑ Waveform receiver designed to capture waves and dust impacts
- ❑ Up to **4 simultaneously sampled E/B field components** chosen from:
  - monopole antenna voltages ( $V_x$ )
  - differential antenna voltages ( $V_x - V_y$ )
  - AC magnetic field from the high frequency search coil
- ❑ Possible sampling frequencies: 65.5 kHz, 131 kHz, 262 kHz, 542 kHz ( $2^n$  Hz)
  - ❑ TDS analog bandwidth is 100 Hz – 200 kHz
- ❑ TDS is a waveform receiver, capturing high resolution waveform snapshots
  - ❑ Implements on-board signal analysis, designed to classify observed data and identify wave and dust impacts.
  - ❑ TDS downlinks triggered snapshots (auto-detected “best” events) as well as statistical data about all the observed events.



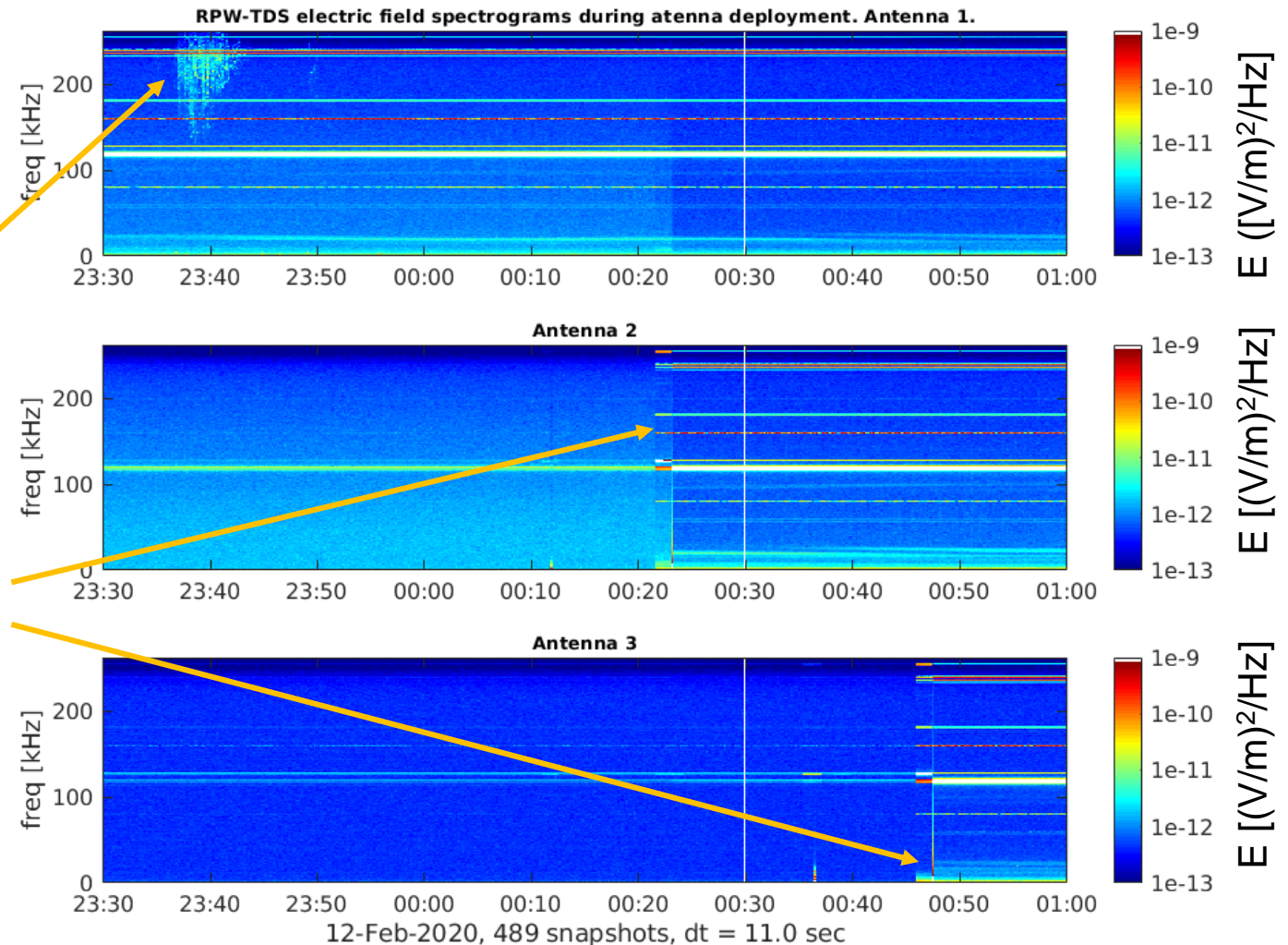
# Early operations of RPW/TDS



- ❑ TDS was first powered on on February 12<sup>th</sup> during antenna deployment
- ❑ Deployment of antennas successful, marked by an increase in spacecraft interference.
- ❑ Commissioning started on February 25<sup>th</sup>

AKR

Antenna deployments





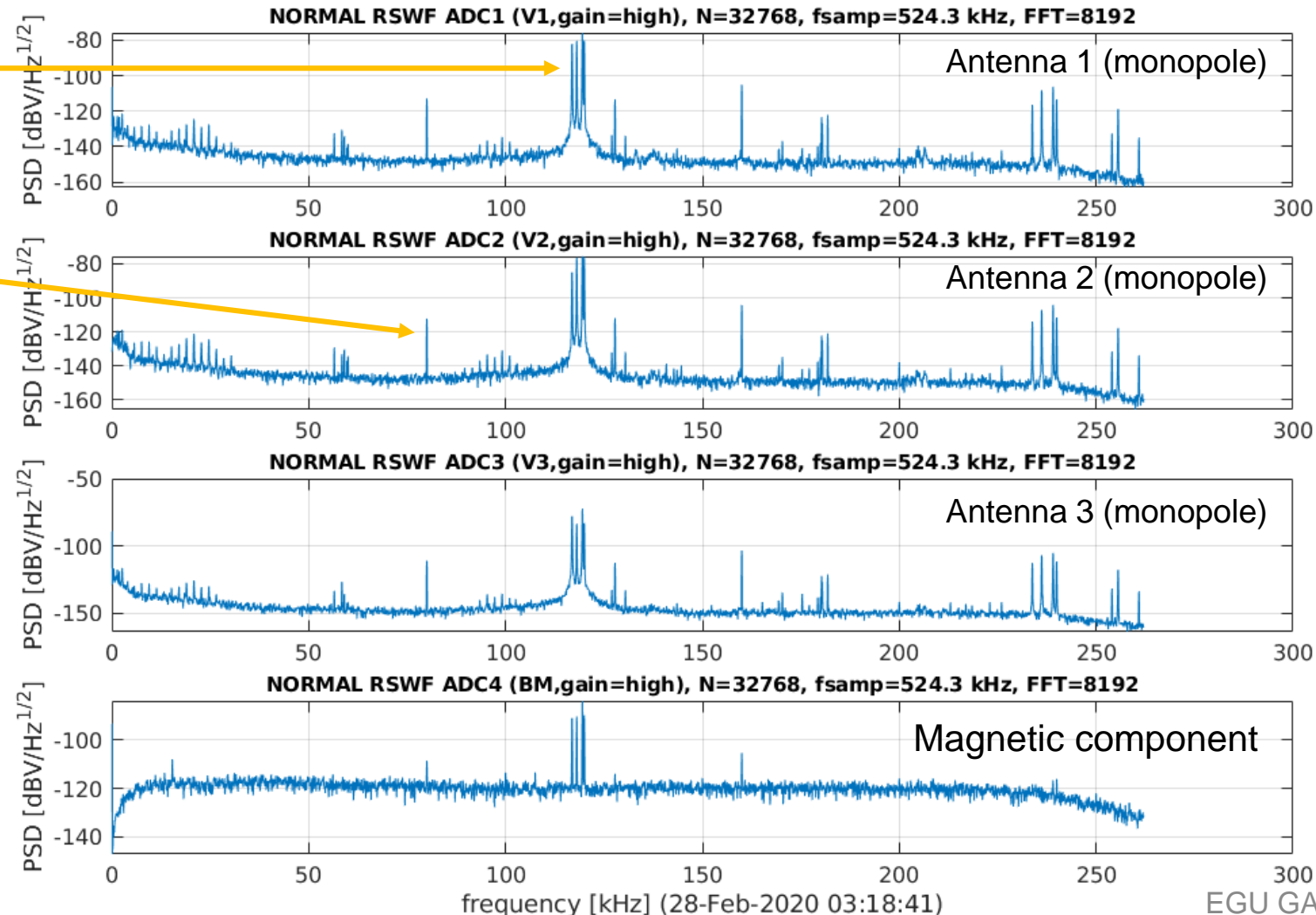
# First look at data - interference



- ❑ The data looks good, but unfortunately, we see a lot of spacecraft interference.
- ❑ Worst by far is the solar panel DC/DC converter at 120 kHz

Solar panel power converter

Reaction wheel DC/DC converter





# TDS data products



The following data products are produced by TDS:

Data products	What data	Cadence
Regular snapshots	Waveform: 4 components (3E+1B) sampled at 262 ksps or 524 ksps.	4k points every 5 minutes.
Triggered snapshots	Waveform: 4 components (3E+1B) sampled at 262 ksps or 524 ksps. Autodetected.	16k points 64 snapshots per day.
Statistics	Maximum /average amplitude, frequency etc.	Every 10 seconds.
1D histograms	Dust amplitude, wave amplitude, peak frequency	4 histogram every 10 minutes
2D histograms	Dust: amplitude vs. ramp Waves: amplitude vs. bandwidth	1 or 2 histograms every 30 minutes.
Max. amplitude (MAMP)	A waveform of max $ E(t) $ taken over $2^N$ data samples.	Only used in Burst mode or during high rate. Typically 16 sps.



# Usual modes of operation



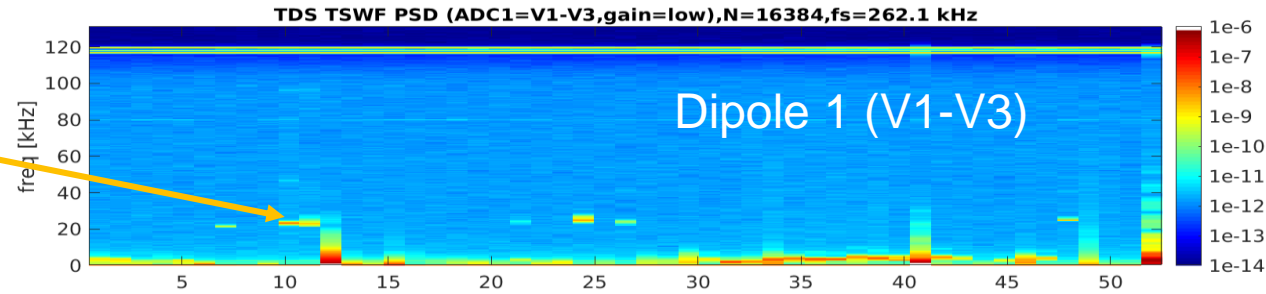
- ❑ During commissioning, we run a variety of modes, but the usual operational modes are:
  - Sampling 524 ksps, monopole antenna configuration (V1, V2, V3 and B)
  - Sampling 524 ksps, dipole antenna configuration (V1-V3, V2-V1, V3-V2 and B)
  - Sampling 262 ksps, monopole antenna configuration (V1, V2, V3 and B)
  - Sampling 262 ksps, dipole antenna configuration (V1-V3, V2-V1, V3-V2 and B).
  - 262 ksps modes are clean and adequate for larger heliocentric distances
- ❑ Data taken (current operation)
  - ❑ Regular snapshots of 4096 samples, every 5 minutes
  - ❑ Triggered snapshots of 16k samples. About 64 per day, but varies
  - ❑ Statistical data, once every 16 seconds (preliminary, this depends on the wave selection algorithm settings)
  - ❑ Histograms of wave and dust properties (same as above, still needs tuning)



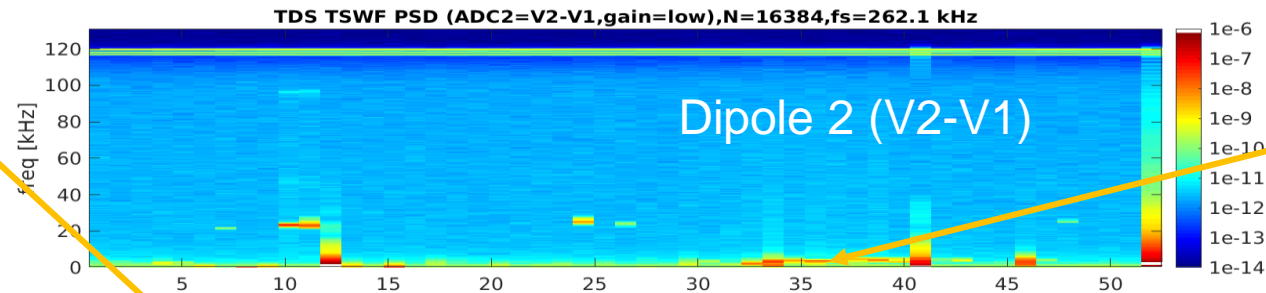
# RPW TDS data examples



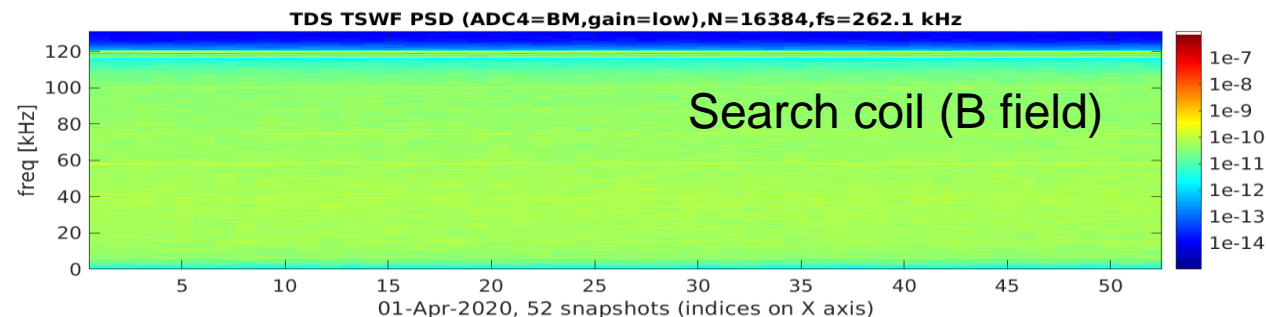
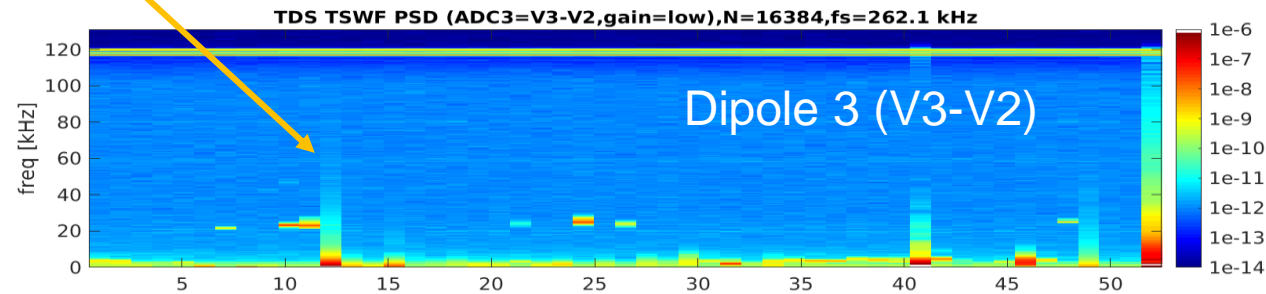
Langmuir waves



Dust impact



LF waves



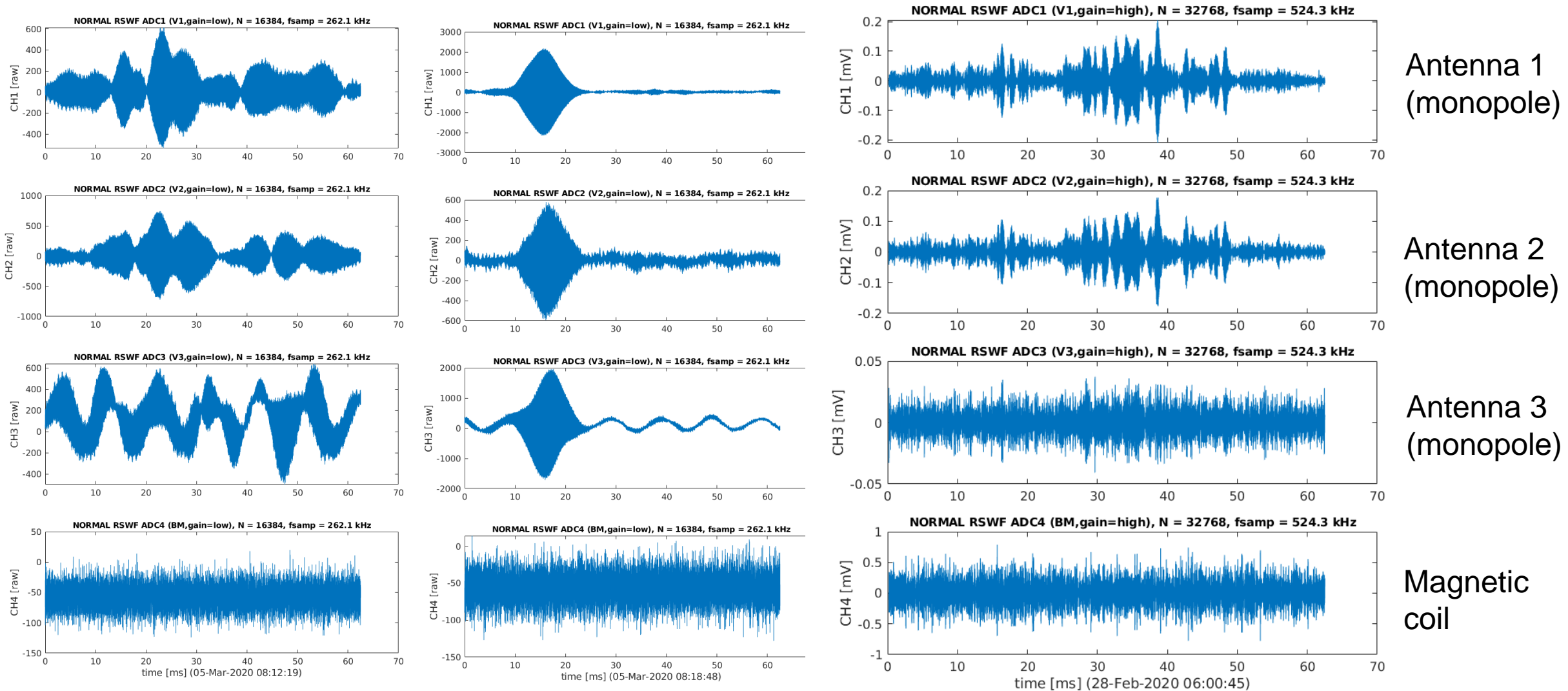
- ☐ Dipole mode, 262 ksps
- ☐ Spectra calculated from snapshots.
- ☐ Example of 1 day of triggered snapshots (x axis is the snapshot index)



# Langmuir waves



TDS observes a lot of Langmuir waves and these are successfully detected by the onboard algorithm.

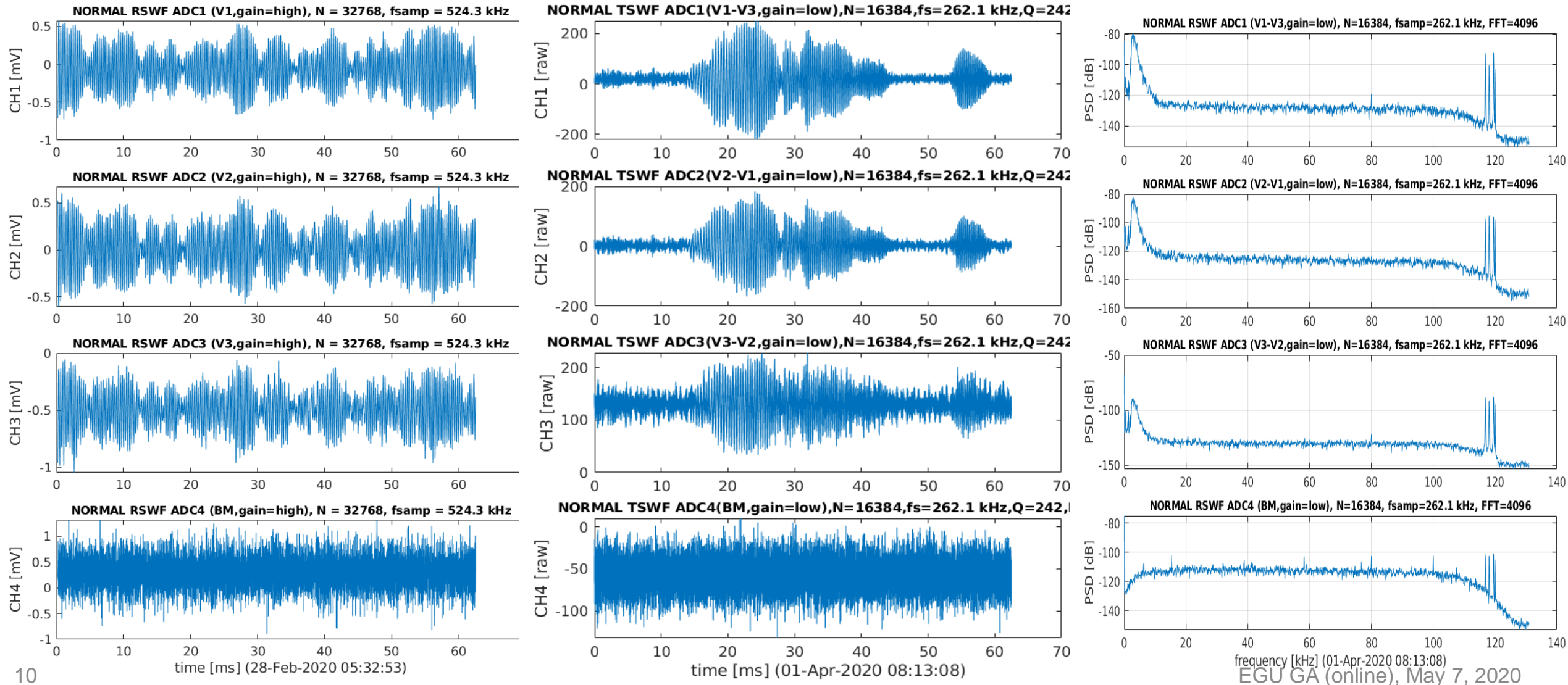




# Low frequency waves



Low frequency waves at kHz frequencies (ion acoustic, electron-acoustic).

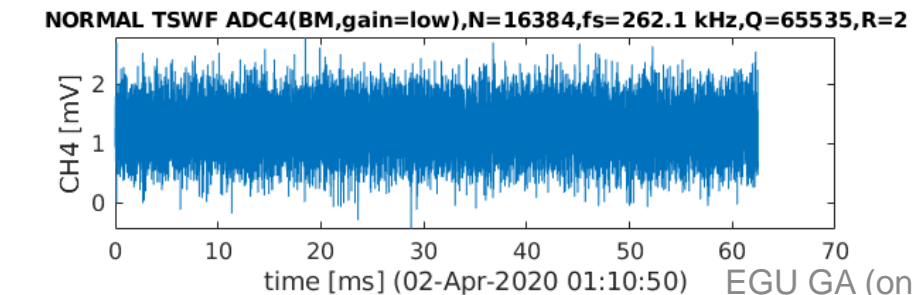
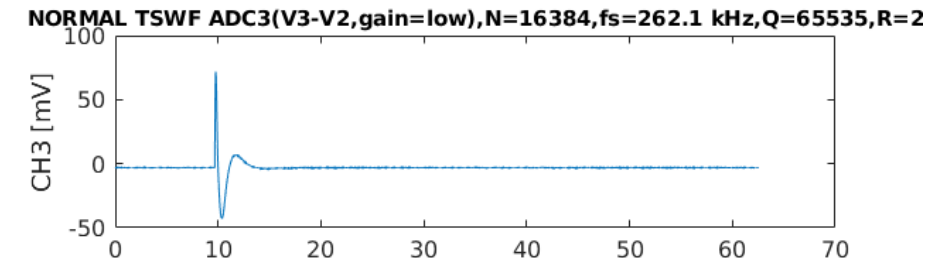
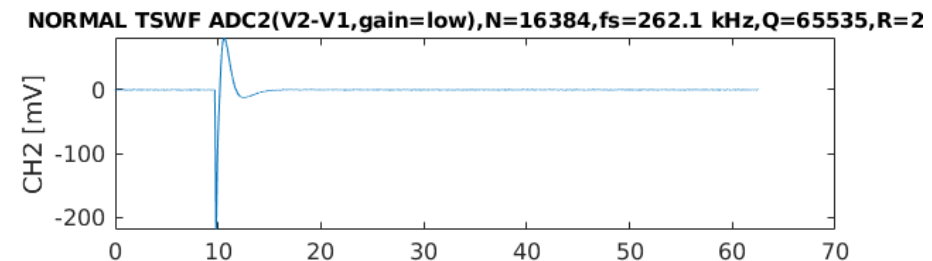
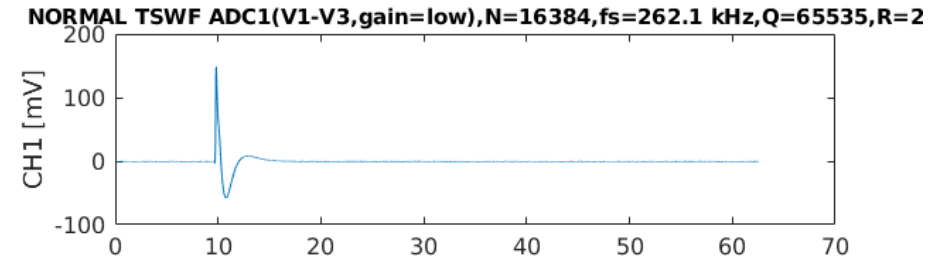
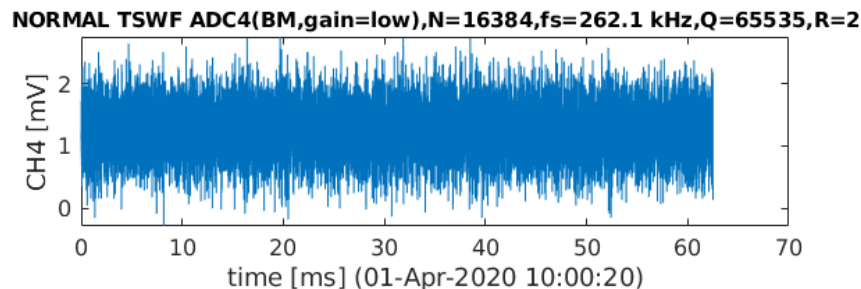
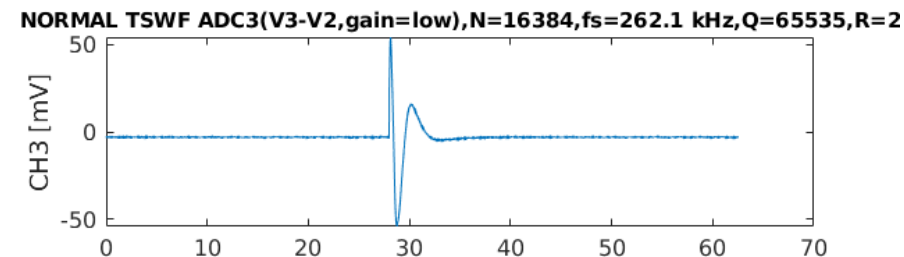
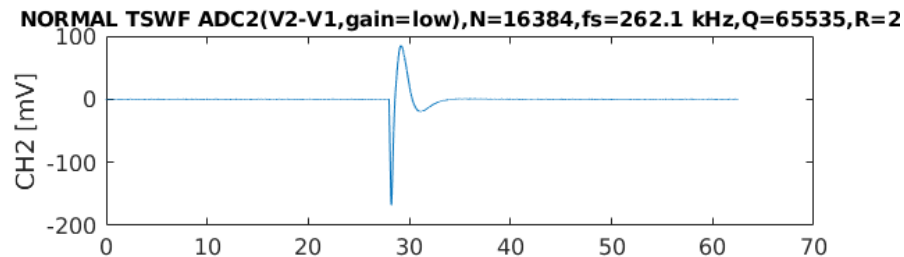
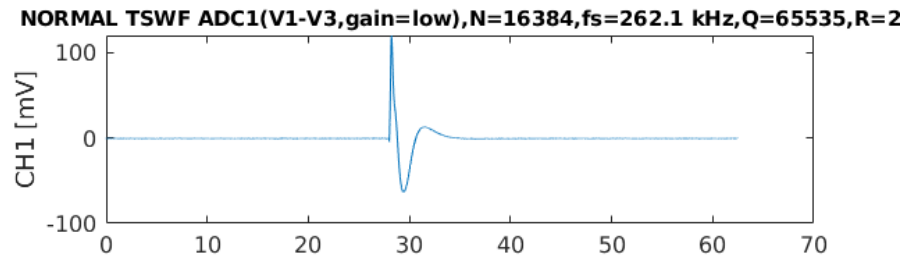




# Dust impacts



- ❑ Voltage spikes associated with impacts of dust on the Spacecraft body are observed. Automatic detection works, but parameters being updated.



Antenna 1  
(dipole)

Antenna 2  
(dipole)

Antenna 3  
(dipole)

Magnetic  
coil



# Summary



- ❑ The RPW TDS module works properly and produces valid data.
- ❑ Automatic wave and dust detection works, but is somehow biased by strong electromagnetic interference from the spacecraft.
  - The detection is a work in progress and a software update will be uploaded to mitigate the interference bias.
- ❑ We have already observed the phenomena TDS is designed to study:
  - Langmuir waves around plasma frequency
  - Other waves at lower frequencies
  - Dust impact spikes