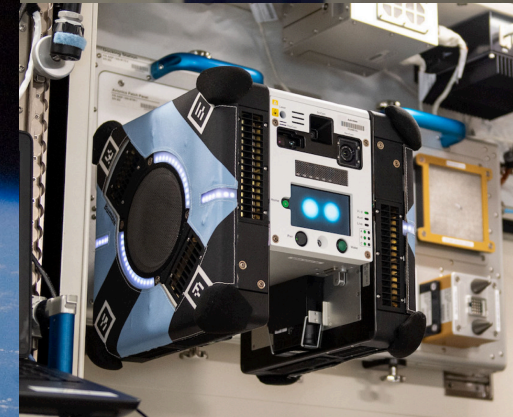
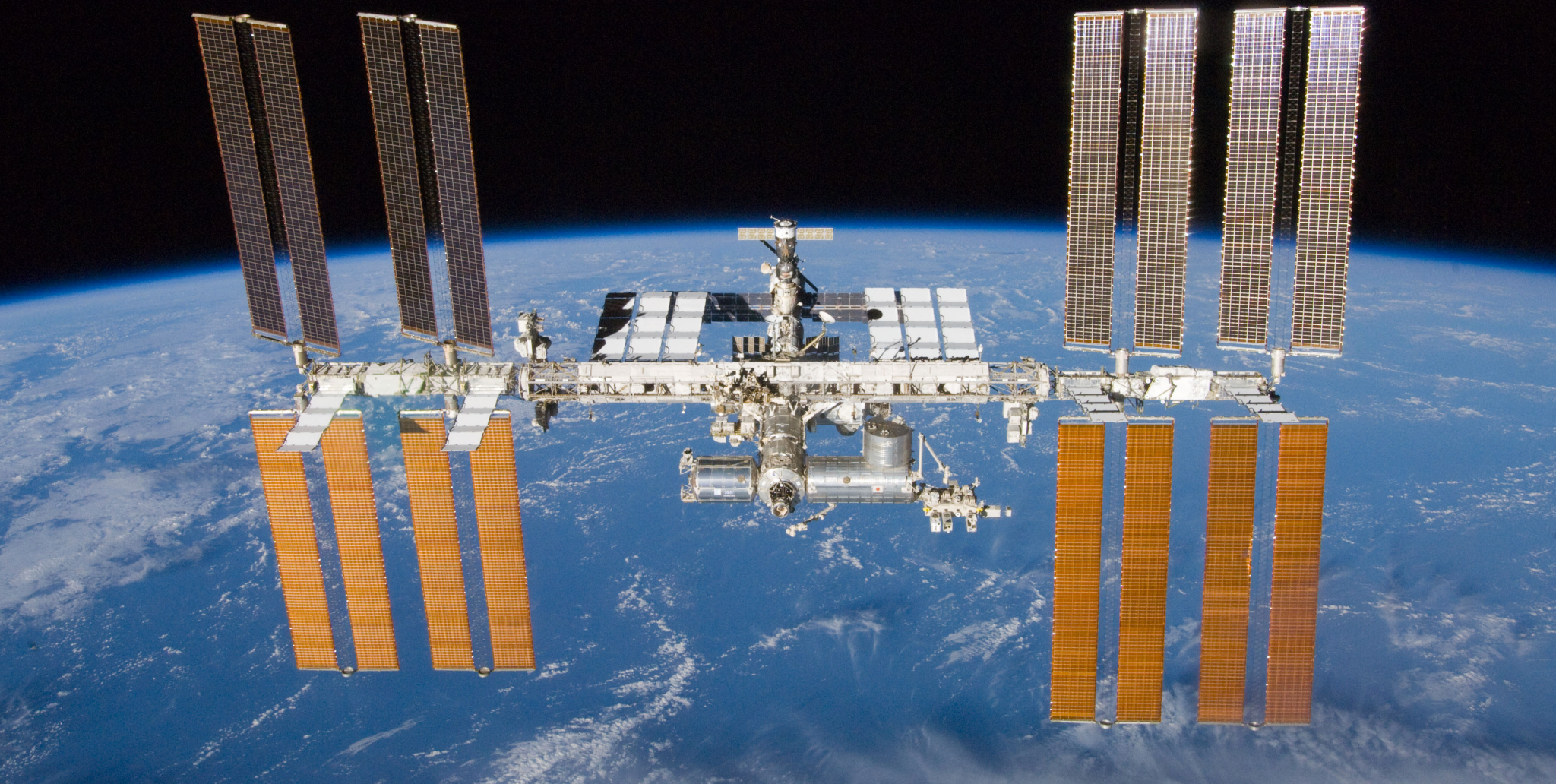


SoundSee: Towards Autonomous Acoustic Monitoring of the ISS

Luca Bondi, Gabriel Chuang, Christopher Ick, Adarsh Dave, Charles Shelton, Brian Coltin, Trey Smith, Samarjit Das

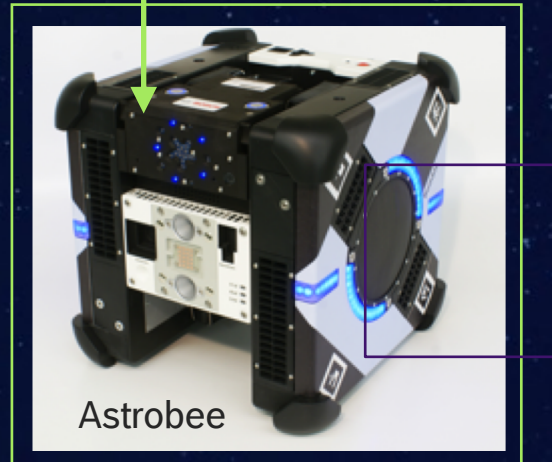
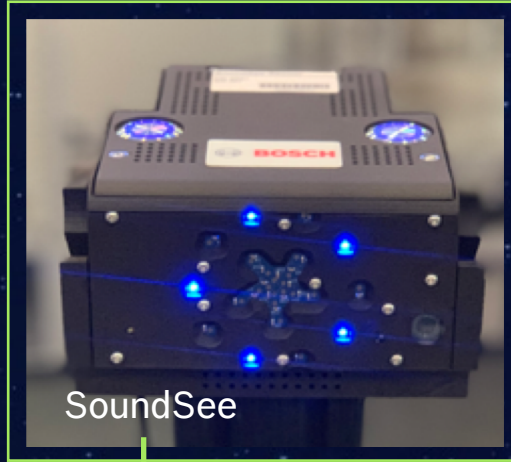


Presenter: Samarjit Das (PI), Bosch Research Pittsburgh

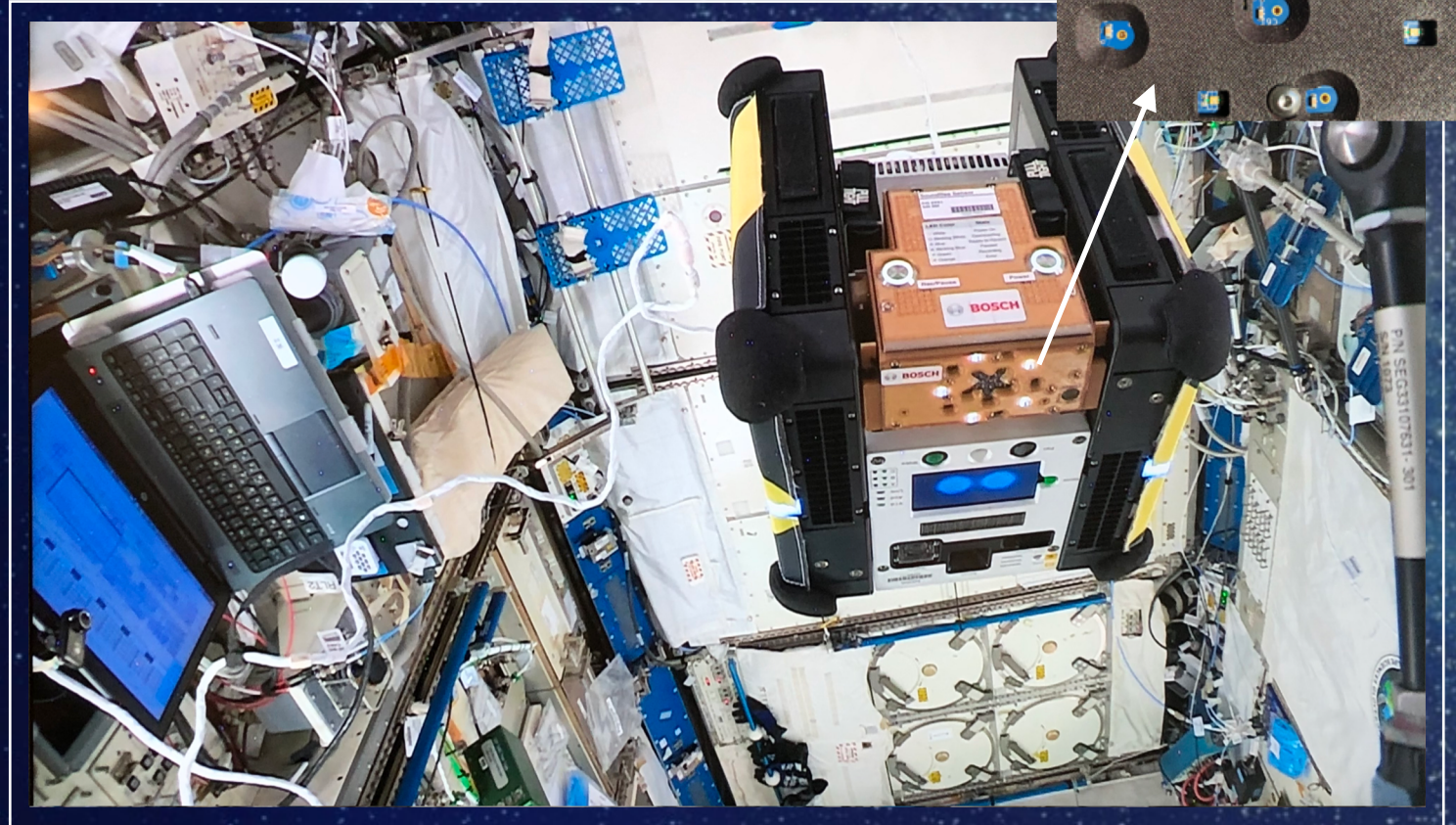


BOSCH

Bosch SoundSee and NASA's Astrobee

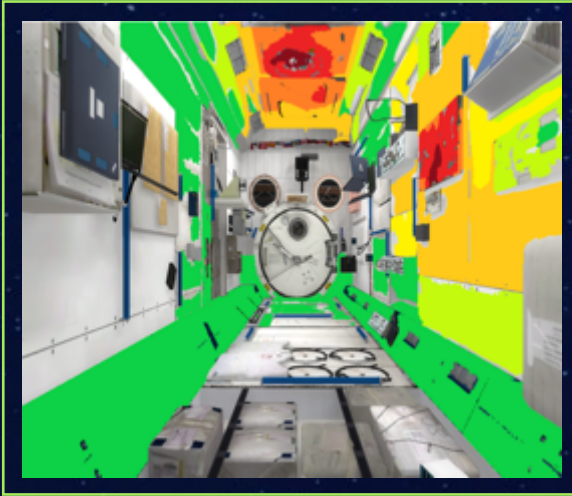


SoundSee is a guest-science payload
on the Astrobee



The Astrobee robot has been developed by NASA Ames Research Center

SoundSee's Primary Mission Objectives



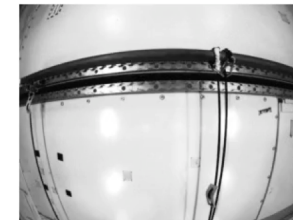
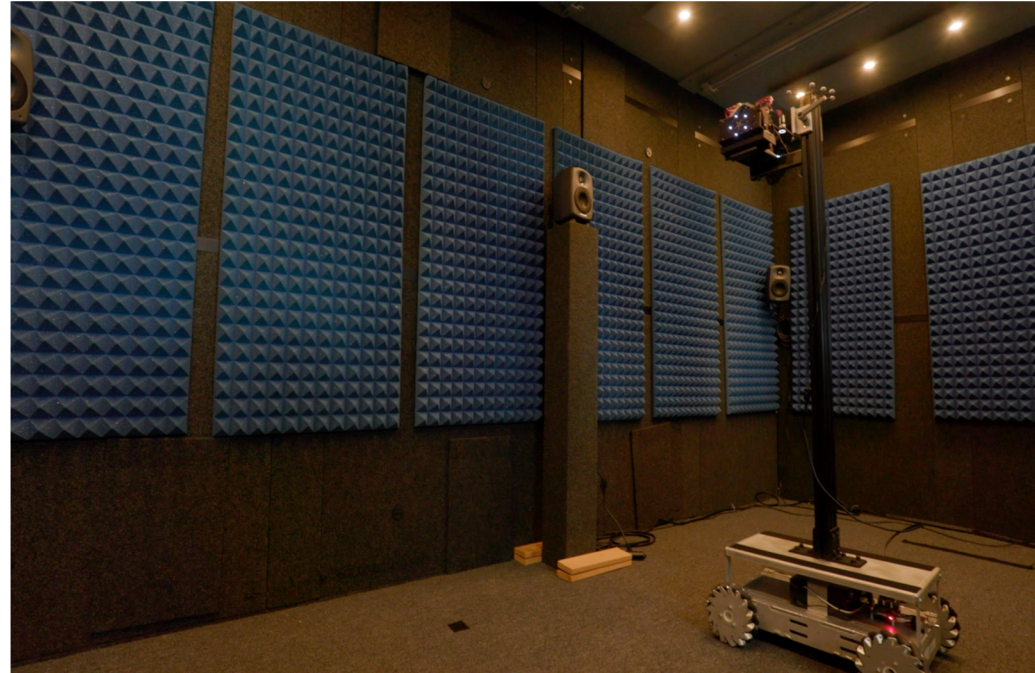
Acoustic mapping



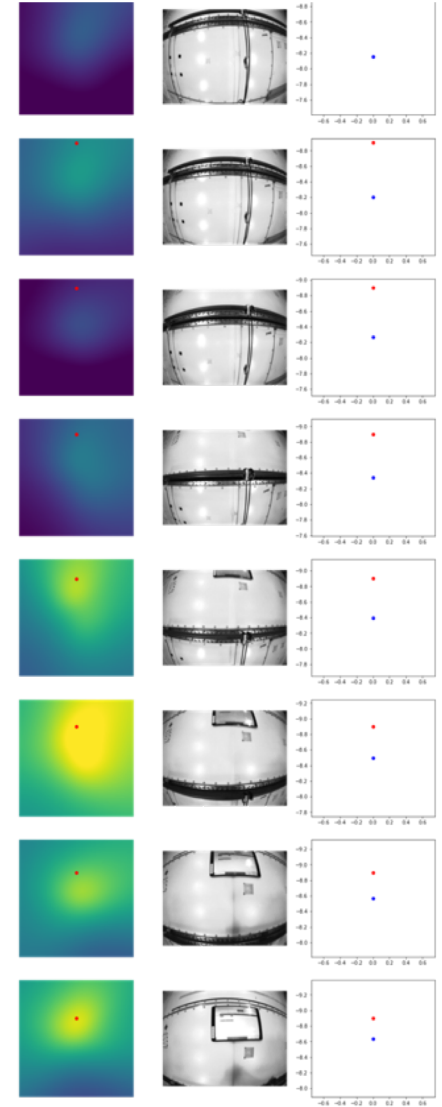
Audio AI for machine health monitoring



SoundSee ISS Mission Operations and Research

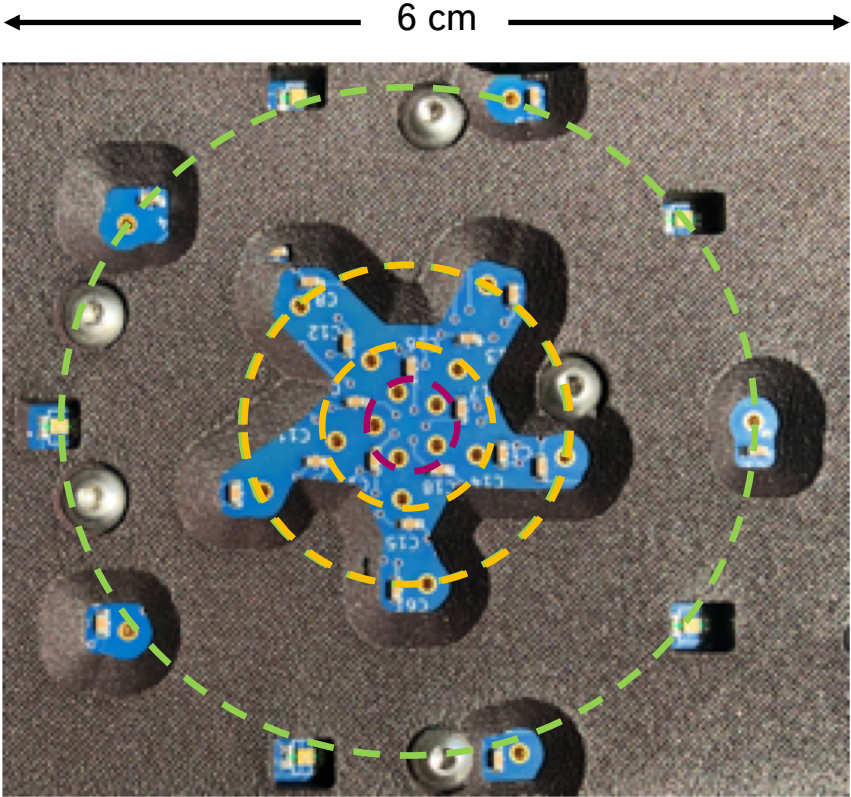


Published at IEEE ICASSP 2022 (with NASA)

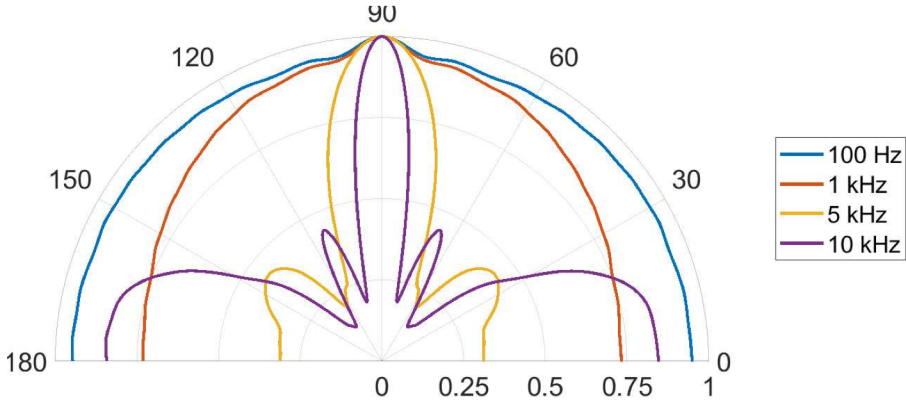


SoundSee Sensor Capabilities

Operating modes and executing on-orbit recording experiments

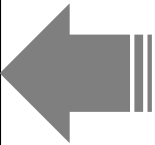
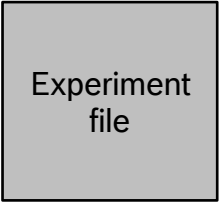
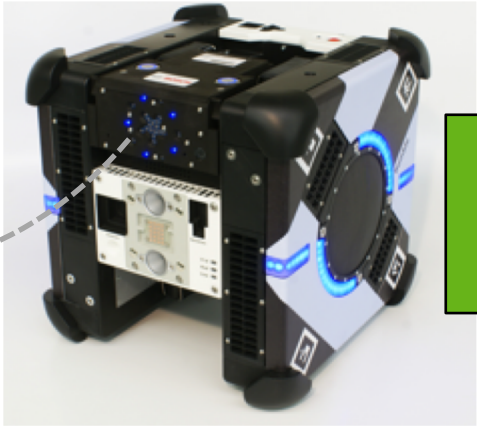


20 microphones spiral array
100 Hz – 80kHz frequency range



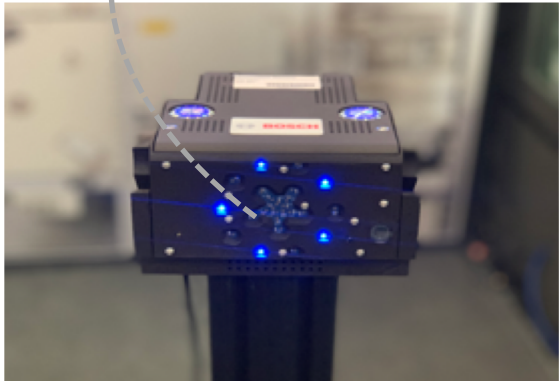
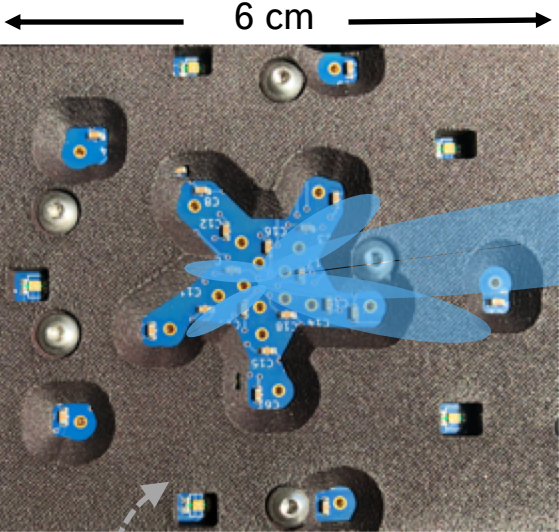
On-orbit

Ground

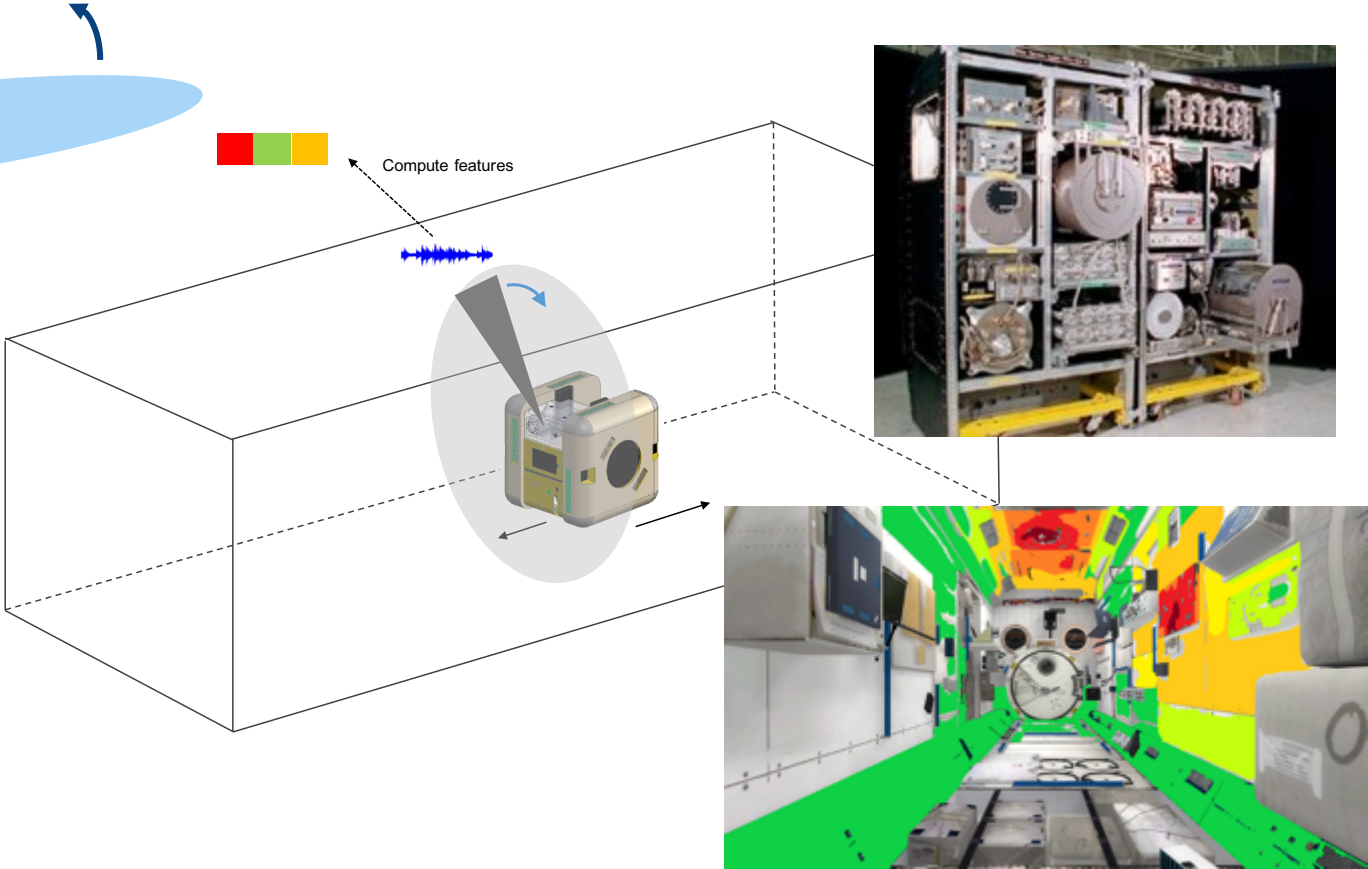


SoundSee Sensor Capabilities

Basic mapping mechanisms



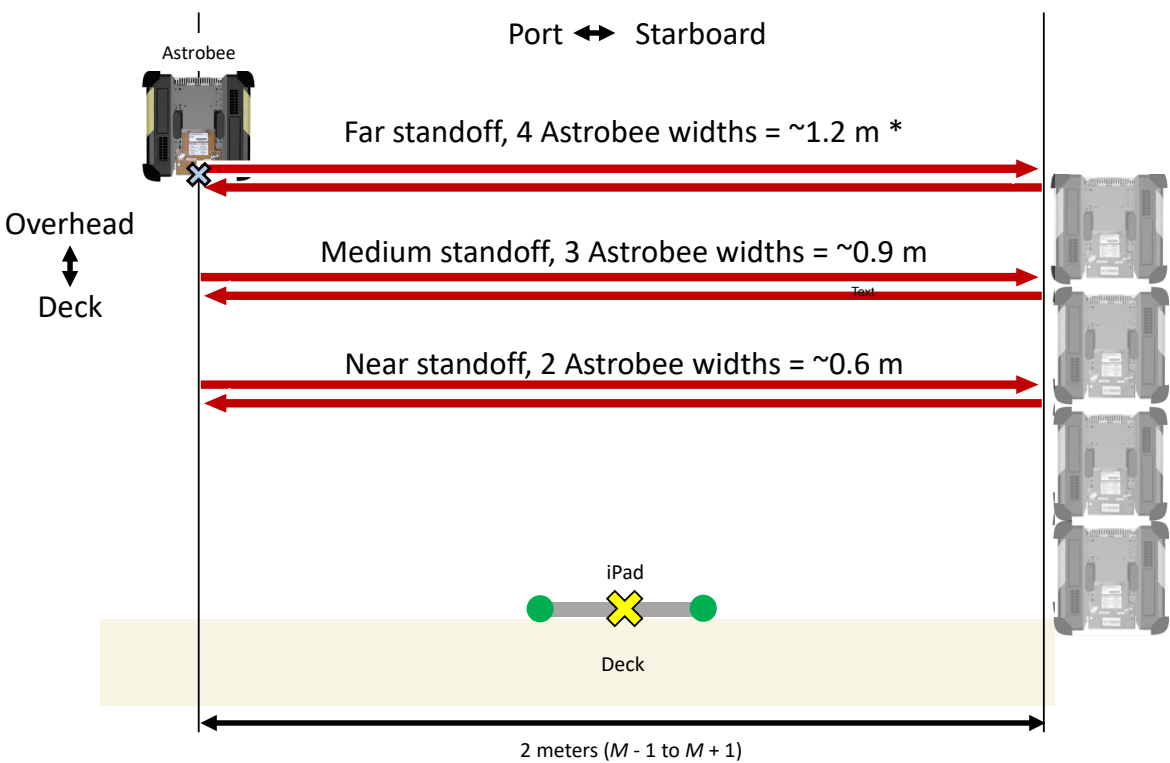
100 Hz – 80kHz [innermost ring for ultrasonic]



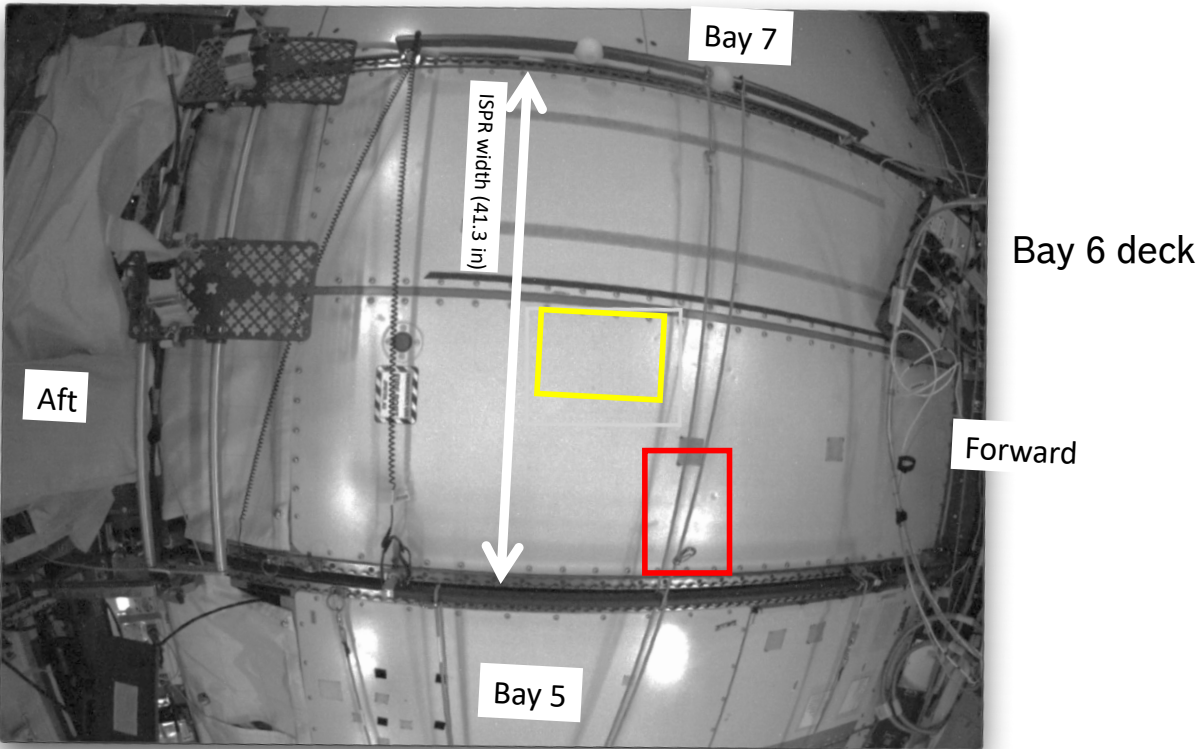
20 MEMS microphones (spiral array, 4 rings)

Experimental Setup Aboard the ISS

Collaboration between Bosch SoundSee and NASA-ARC ISAAC team



Astrobees + SoundSee transacts

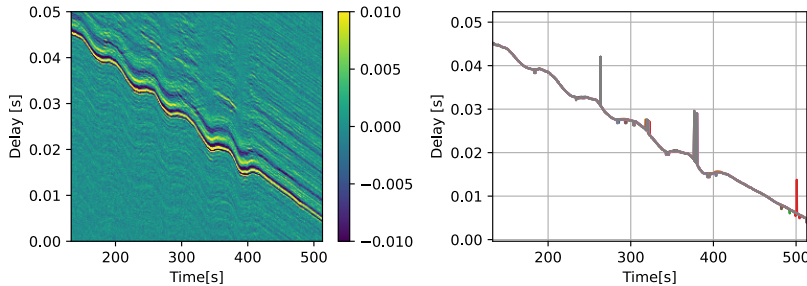


Location of simulated sound sources @JEM

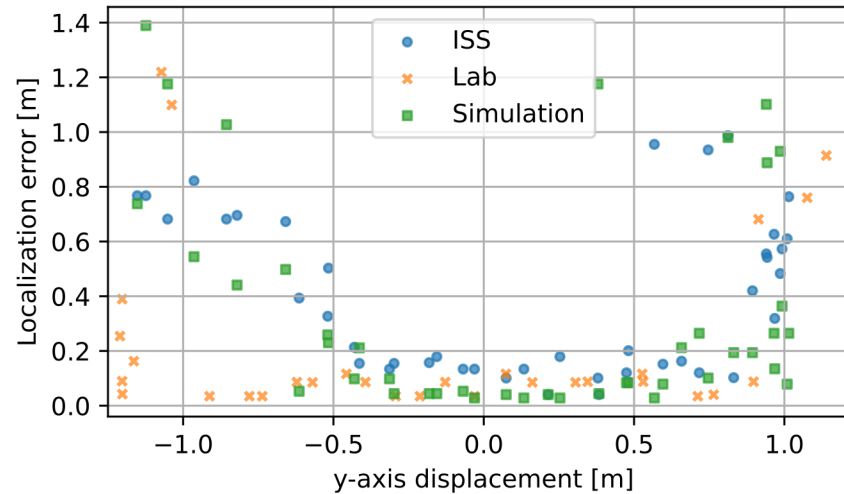
SoundSee Data Ops + Ground Experiments + Simulation

Challenges of acoustic imaging from a flying robotic platform

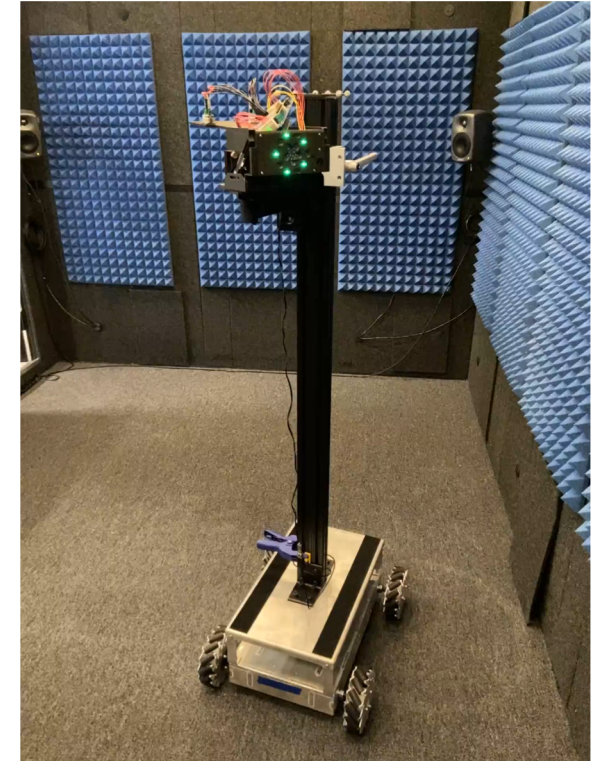
- ▶ Asynchronous systems
 - ▶ video-cameras
 - ▶ robot telemetry
 - ▶ SoundSee recordings
 - ▶ sound sources
- ▶ Synchronization is vital for acoustic imaging
- ▶ First attempt to match simulation, lab measurements, ISS acquisitions



Time-varying delay between stimulus signal and microphone signal



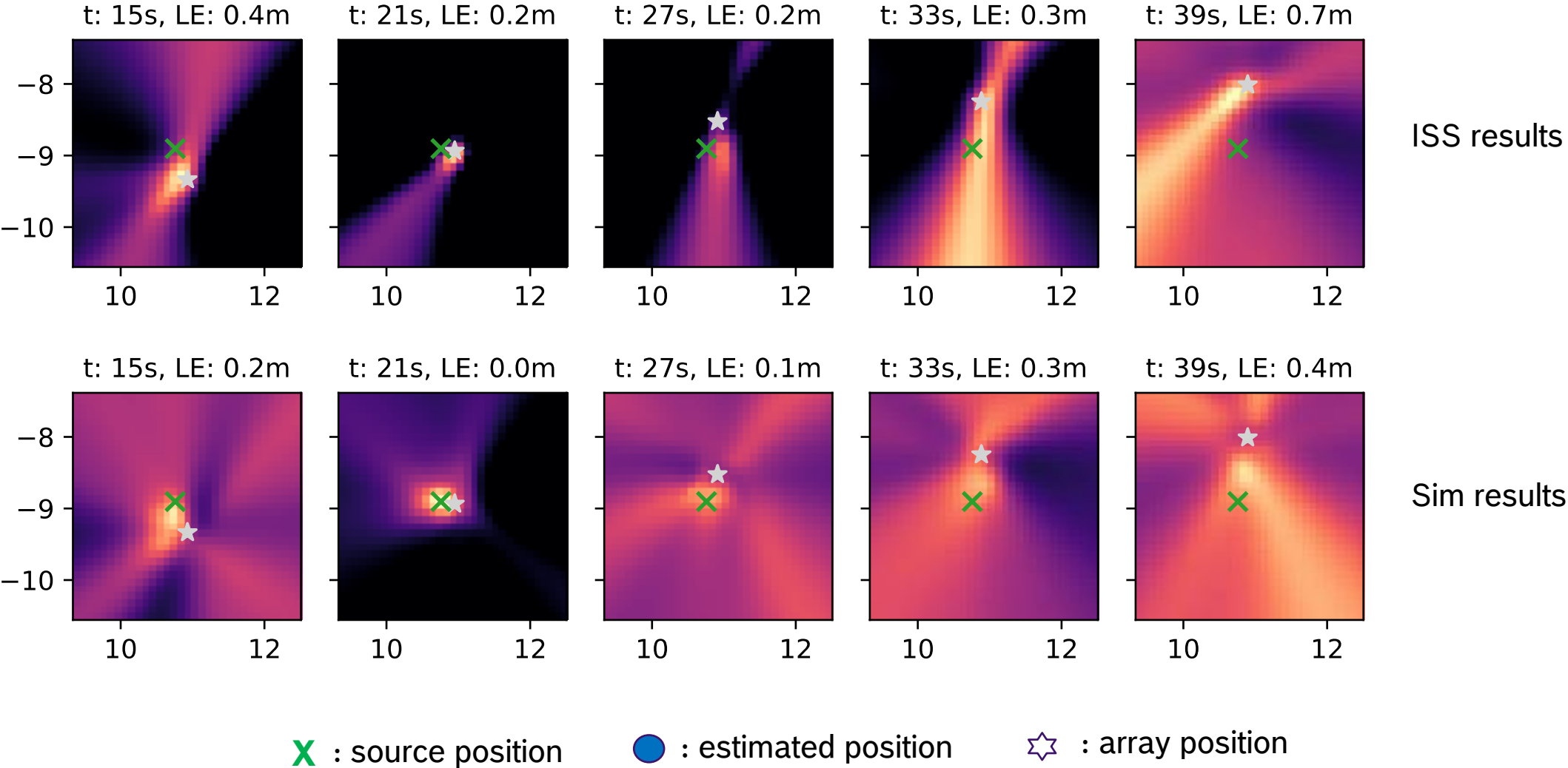
Localization error as a function of displacement between microphone array and source along y-axis



Ground experiment setup at Bosch

SoundSee Data Ops + Ground Experiments + Simulation

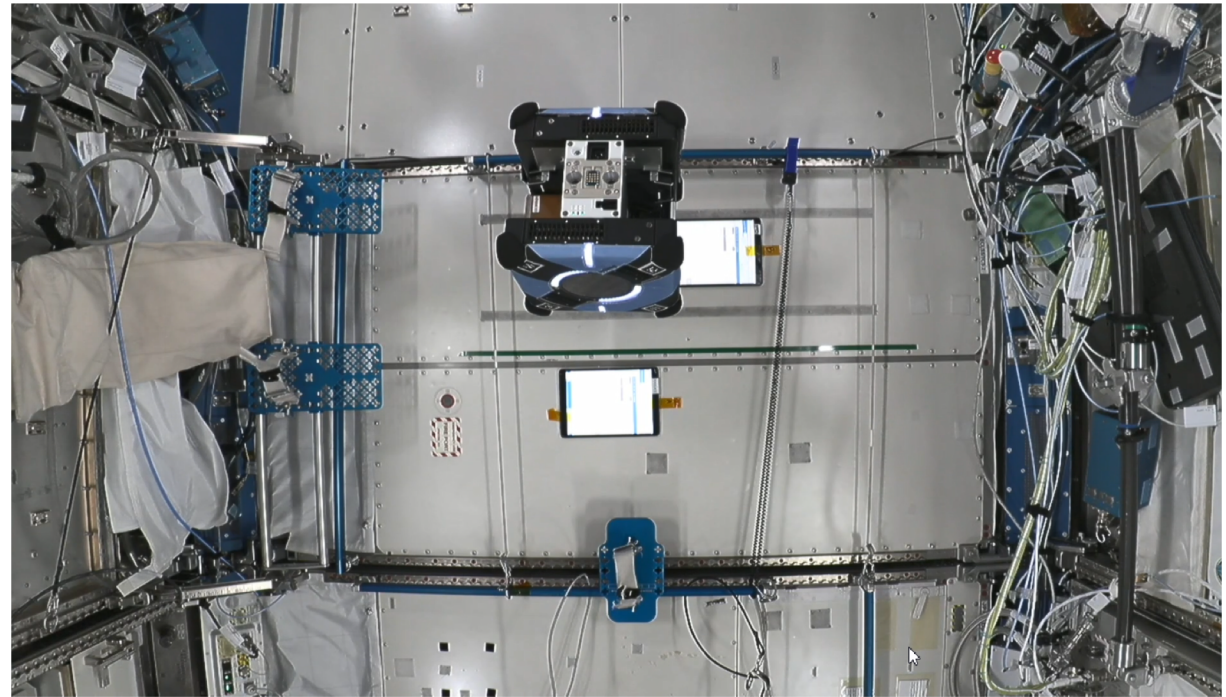
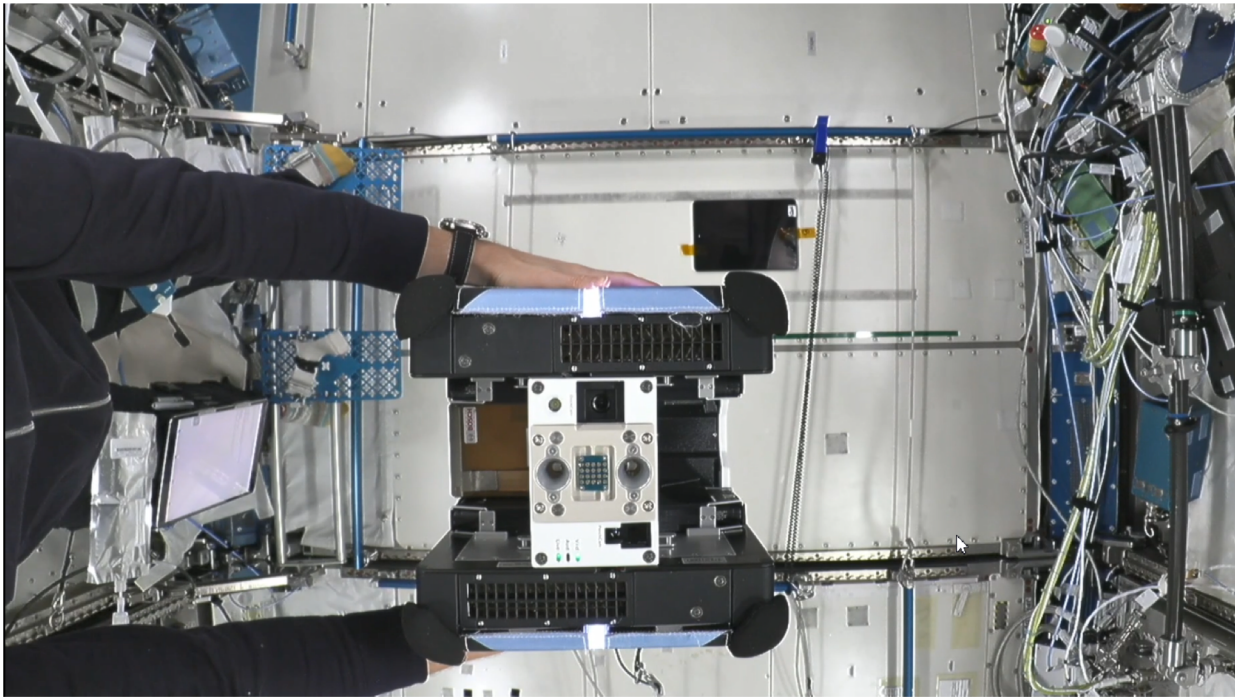
Comparing ISS results with ground simulation



Moving Forward: Simulated Leak Audio Data Collection

Towards autonomous leak detection and acoustic anomaly detection

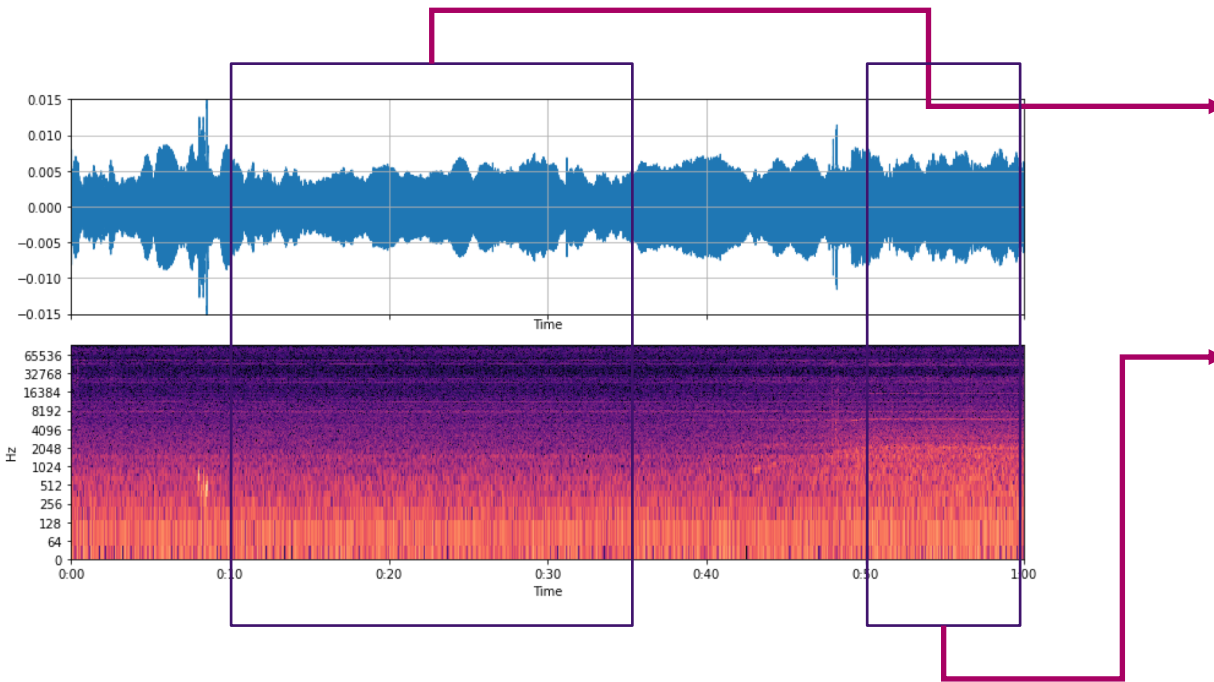
- ▶ Two iPads play audio files to simulate noise and leak audio signals
- ▶ Record audio with SoundSee with Astrobees being moved manually by astronaut, and with Astrobees navigating autonomously (to measure the impact of observation platform noise)
- ▶ Data Analysis in progress



SoundSee Ultrasonic recording

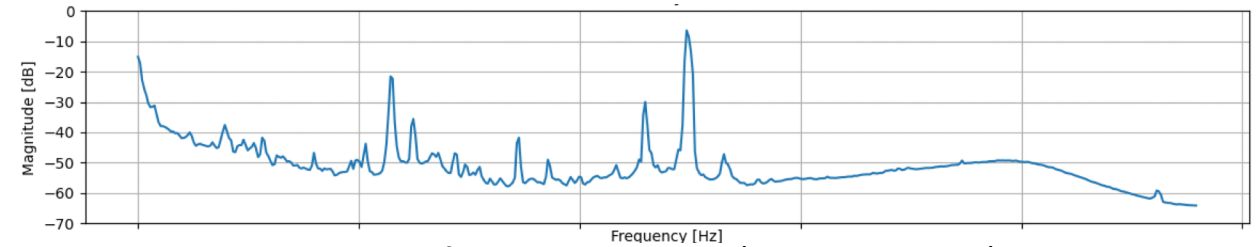
Experiments with sampling frequencies 96 kHz and 196 kHz

1 minute recording, in front of AstroBee bay
AstroBee fan activated at second 40, steady
from second 52 onward

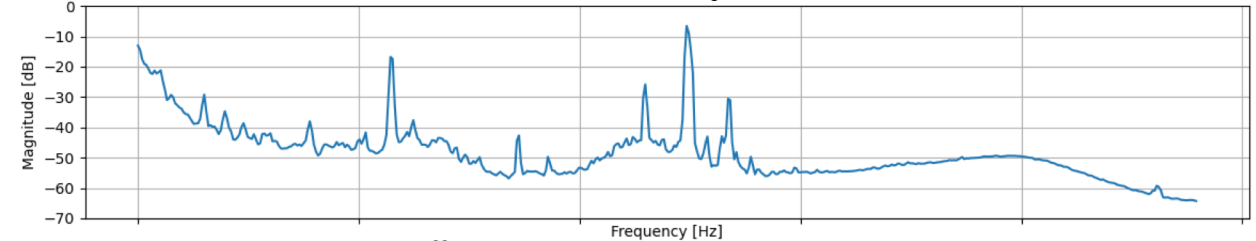


Power Spectral Density

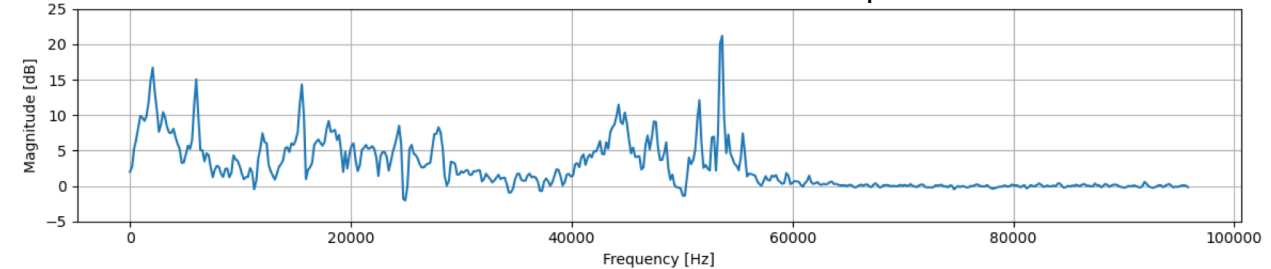
Background sounds at bay (seconds 10 to 35)



Astrobee fan turned on at bay (seconds 52 to 60)



Difference between middle and top



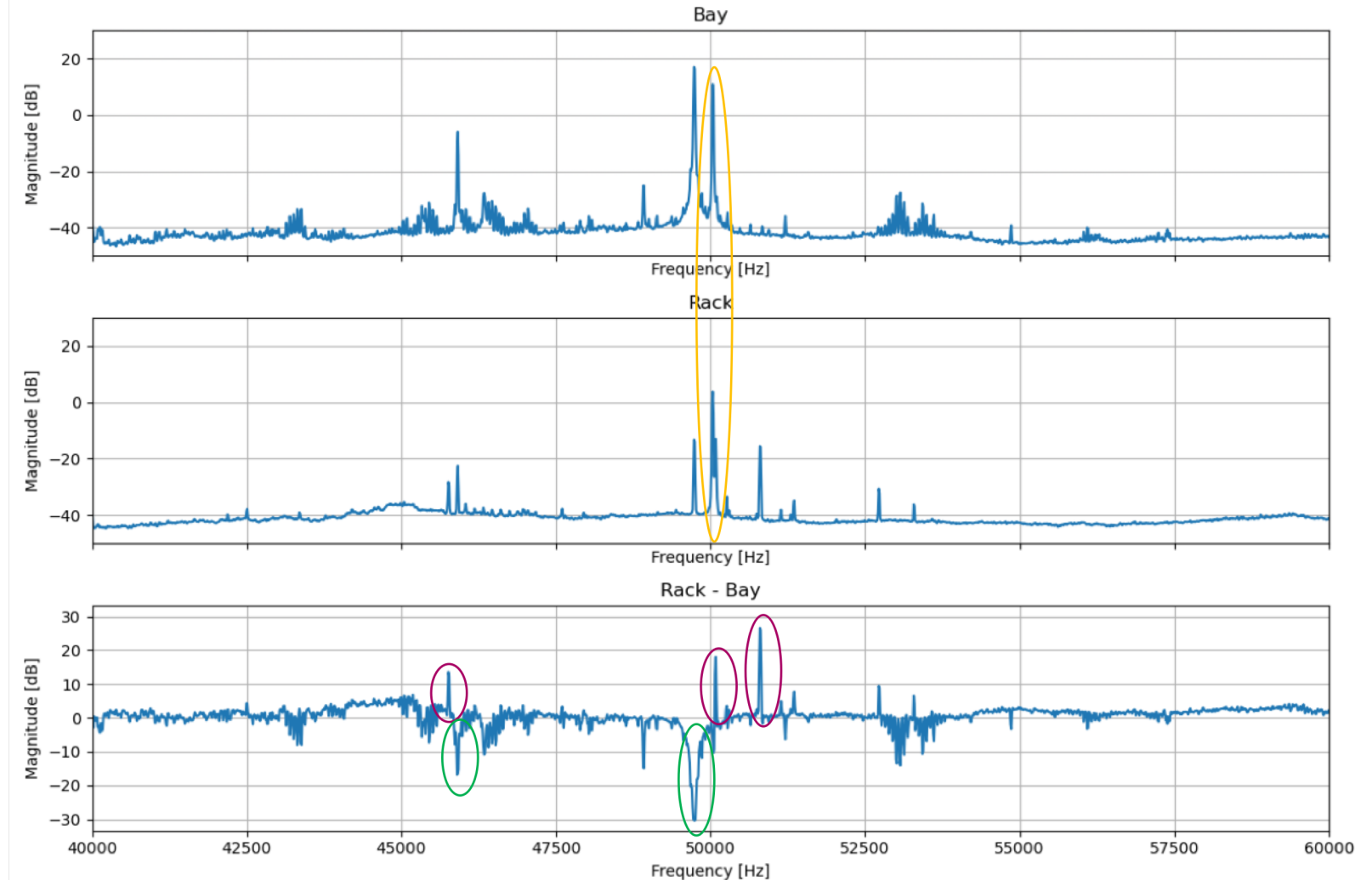
SoundSee Ultrasonic recording

Comparisons between Bay and Rack, 192kHz, 40kHz – 60kHz

○ HF components that appear close to both bay and rack. EMC interference or real acoustic signal?

○ HF components that appeared close to the rack, not present close to bay

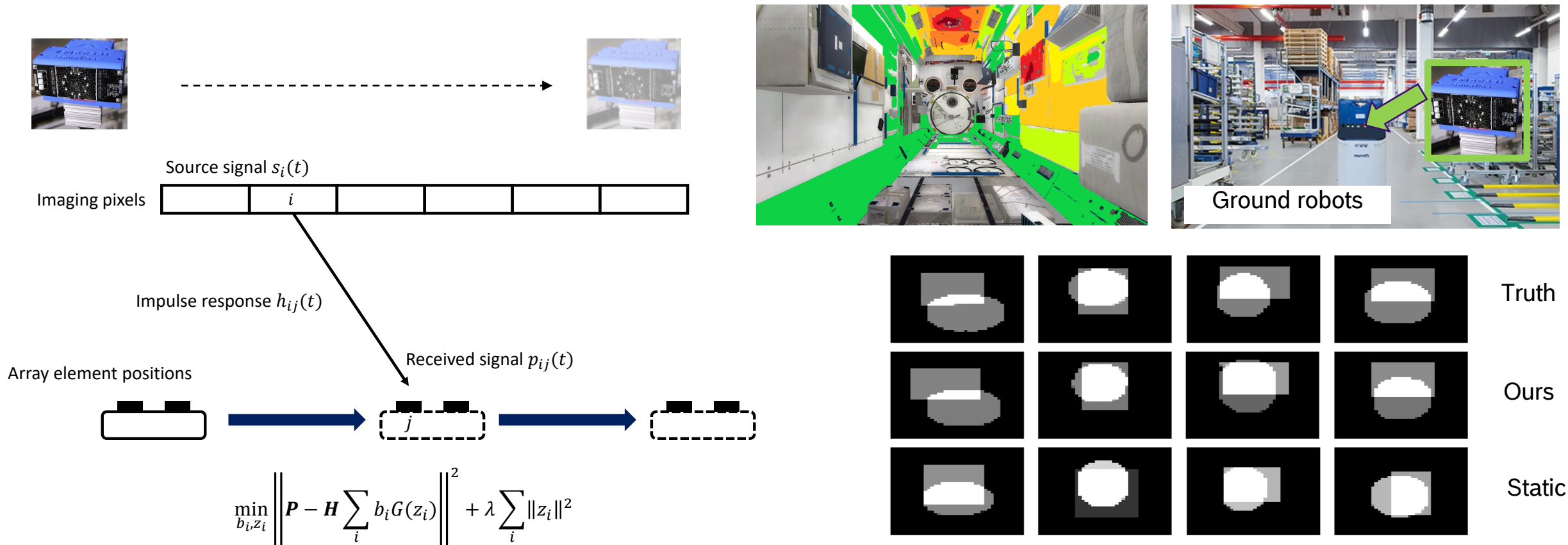
○ HF components present close to bay, not present close to rack



Fusing deep generative models with Phased-array processing

Novel imaging, dynamics reconstruction exploiting scene map

- **Synthetic Aperture Acoustic imaging** with Compressive Sensing + deep generative model-based priors on acoustic scenes/source distribution



Thank you!