Beamforming Results for the Initial Multi-Sensor Towbody Field Tests

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2019 | Enhancing DoD's Mission Effectiveness

Overview

- Multi-Sensor Towbody
- BOSS system and SAS processing
- Lake Washington tests: example data products and lessons learned
- Sequim Bay tests: example data products and lessons learned

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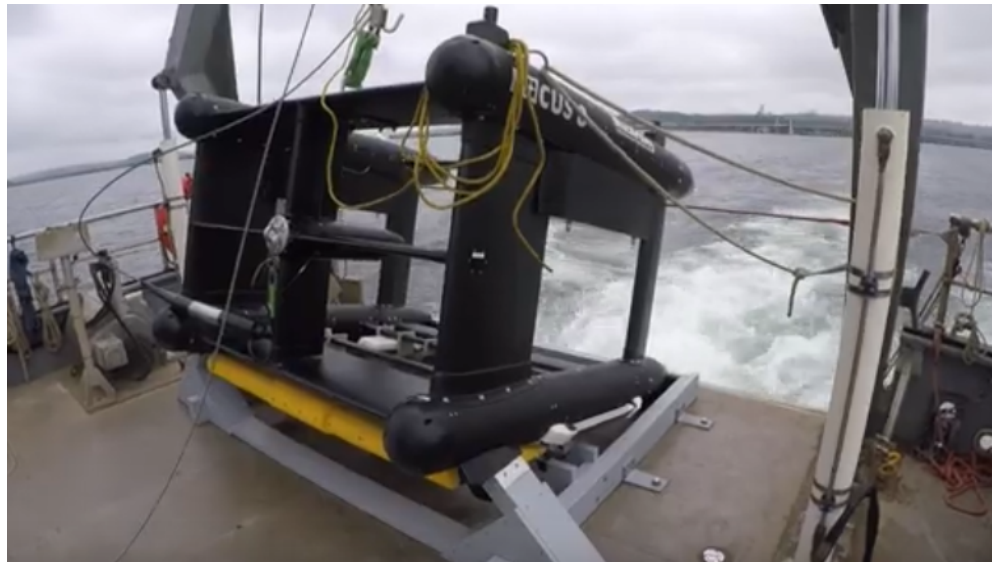
Multi-Sensor Towbody (MuST)

- An APL designed platform with high data rate communication and power supplies capable of supporting multiple sensors
- MacCartney Focus-3 Towfish
- Current sensors:
  - EdgeTech 2205 dual frequency sidescan sonar
  - **B**uried **O**bject **S**canning **S**onar (BOSS)
- Designed to detect and ID UXO



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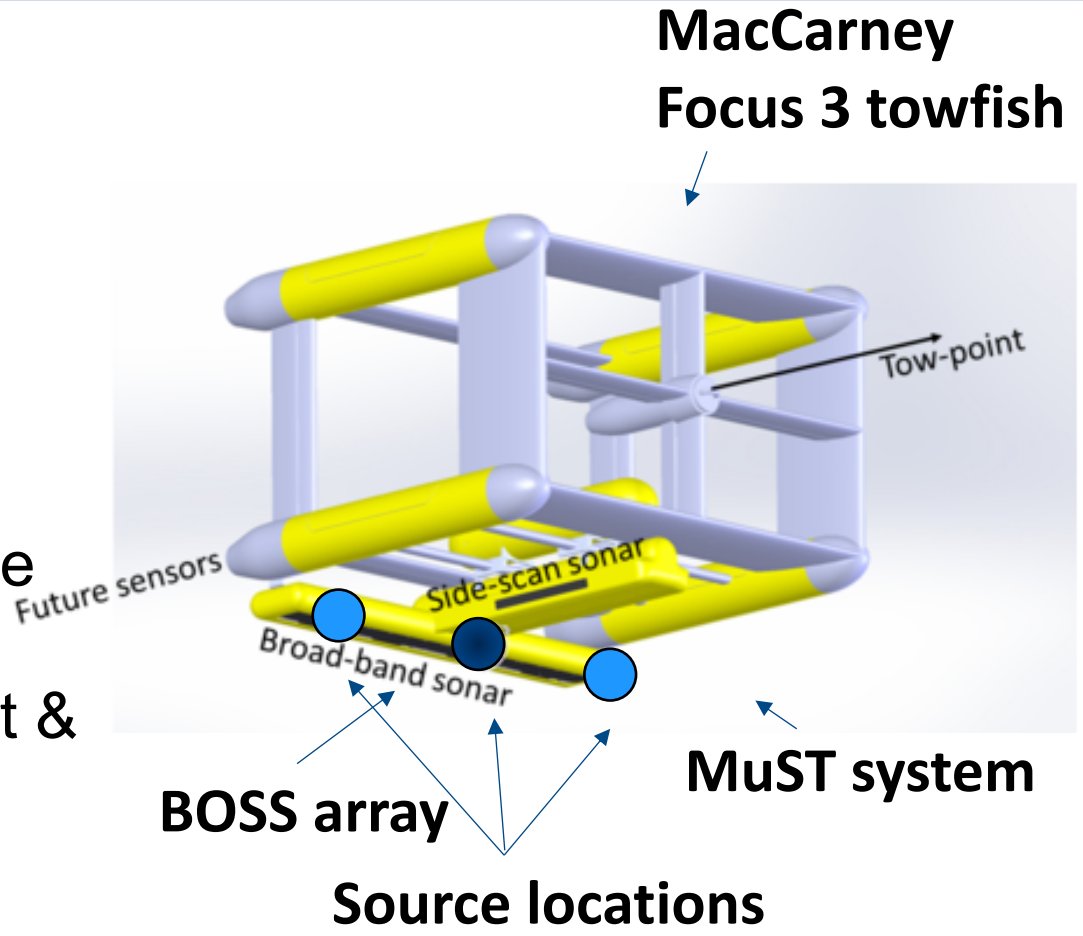
Buried Object Scanning Sonar (BOSS)

- Downlooking low-frequency sonar with across-track array
- ~1.6 meter long array with 64 elements
- 64 receiver elements (~1 x 2 inches)
- Two transmitter configurations:
  - Directional source (VLA) located behind the center of the array
  - Alternating omni-directional sources at port & starboard sides the array
- Useable bandwidth: ~5 to 25 kHz



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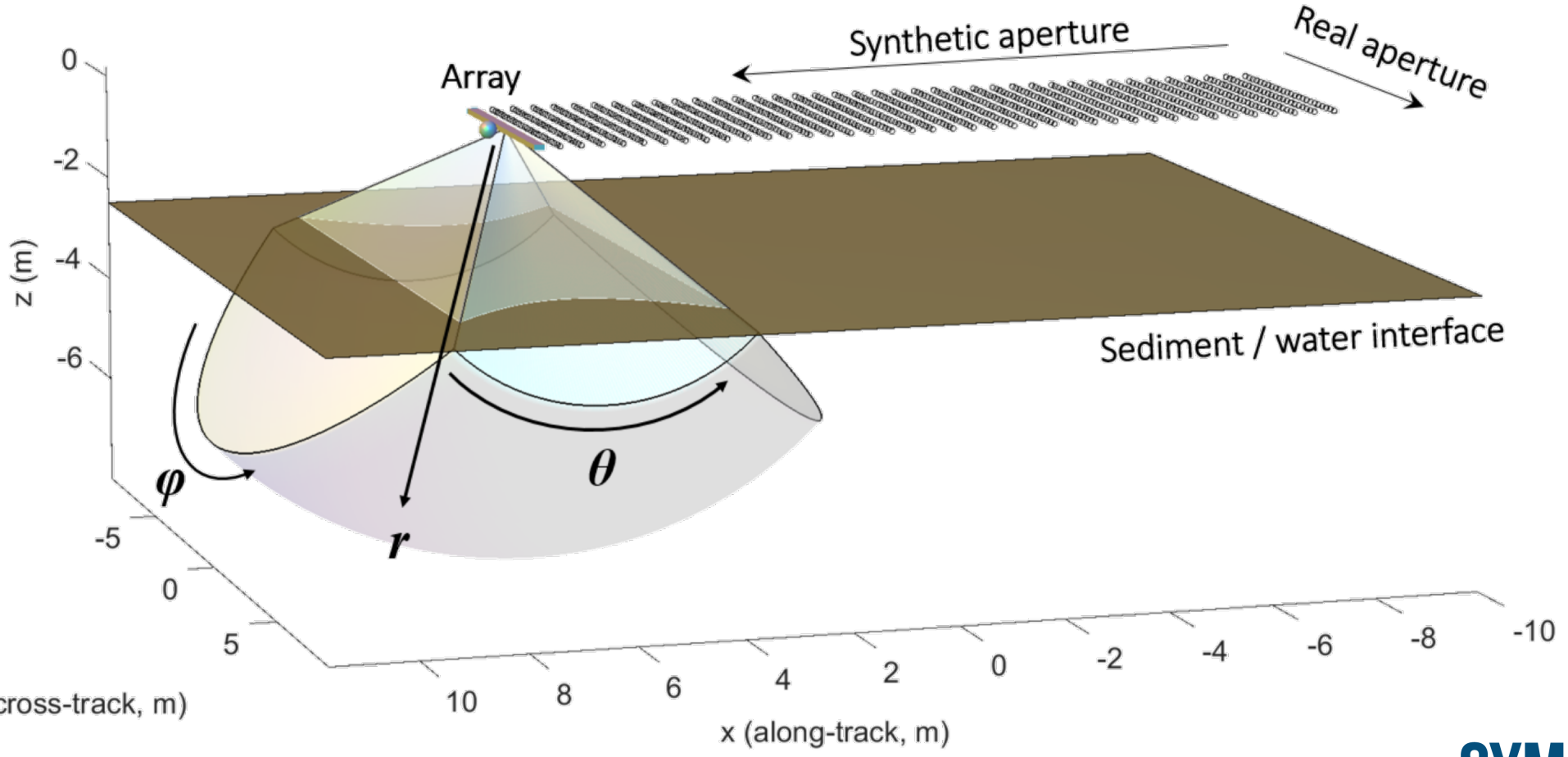
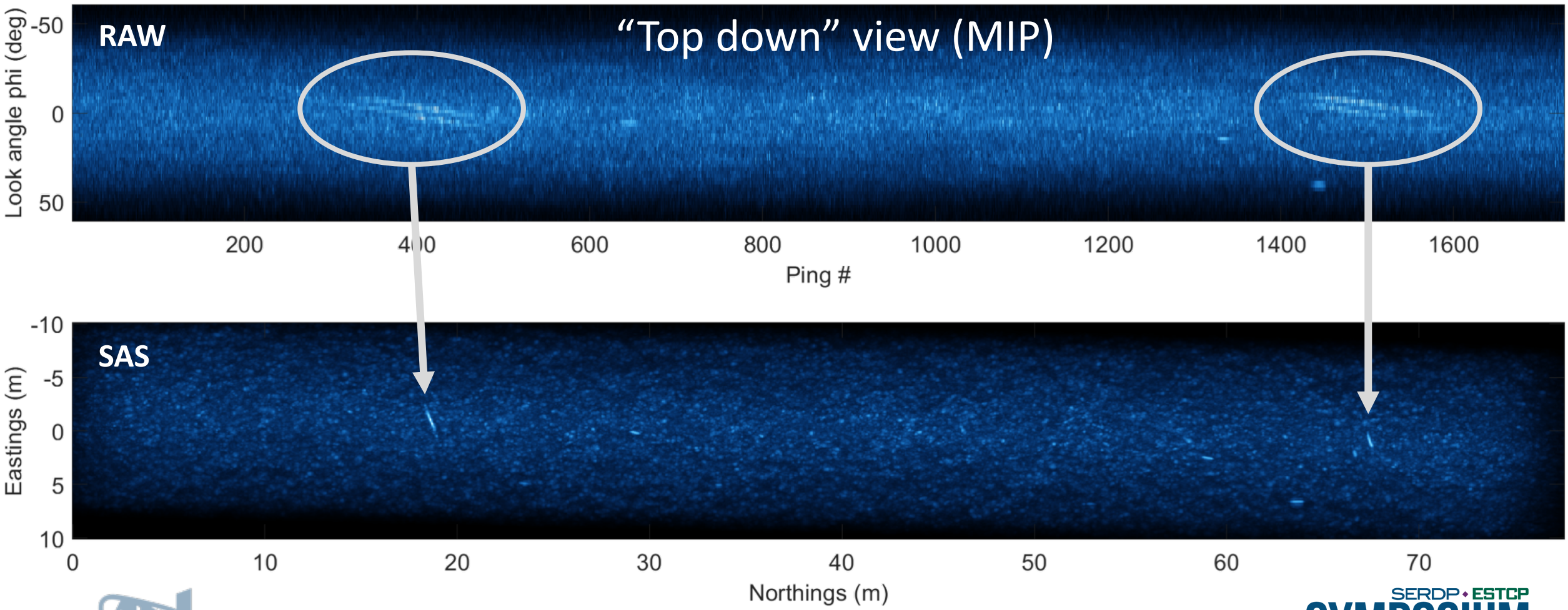
BOSS: SAS array generation

Synthetic *planar* array creates 3D volumetric images



BOSS: SAS processing example



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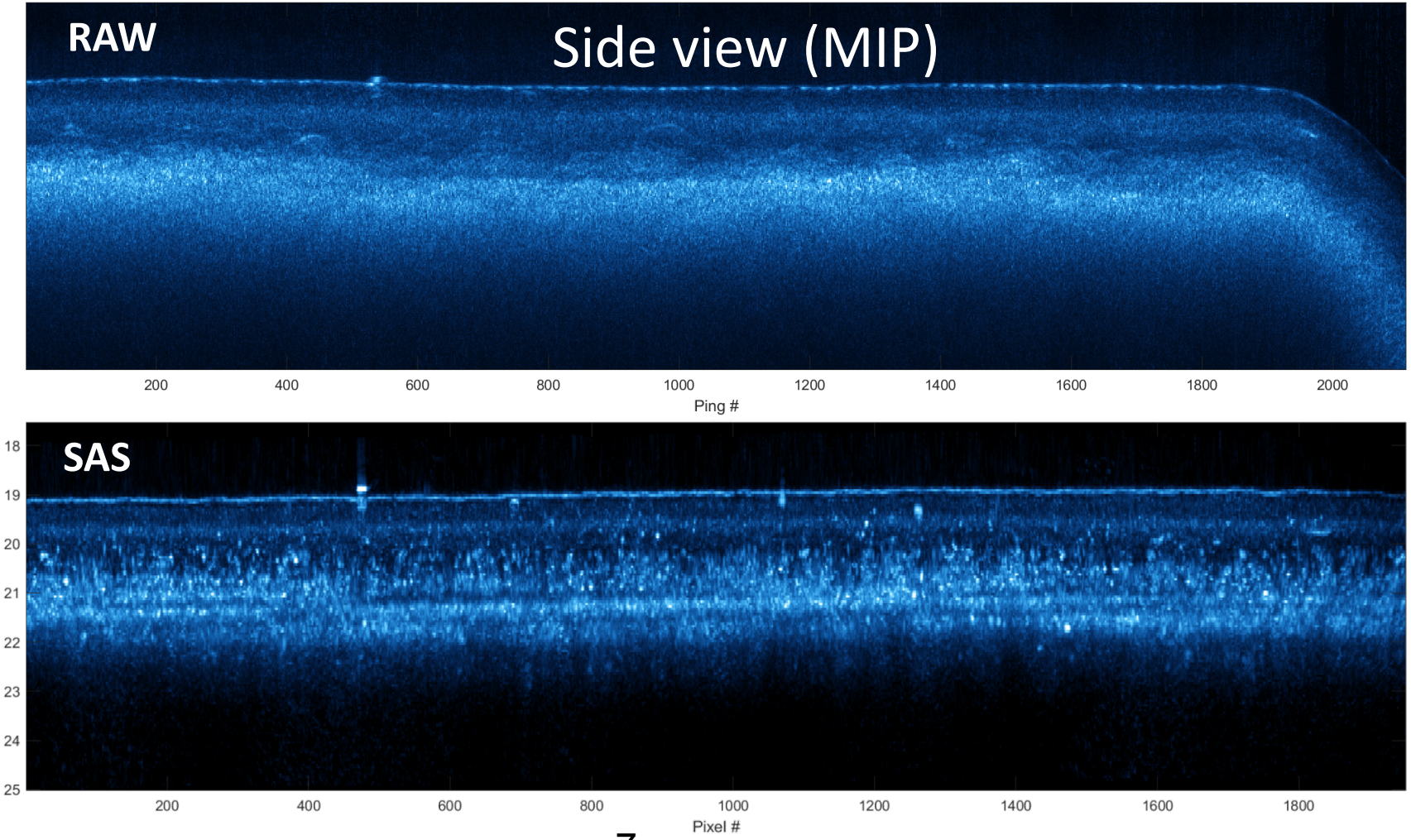
BOSS: SAS processing example



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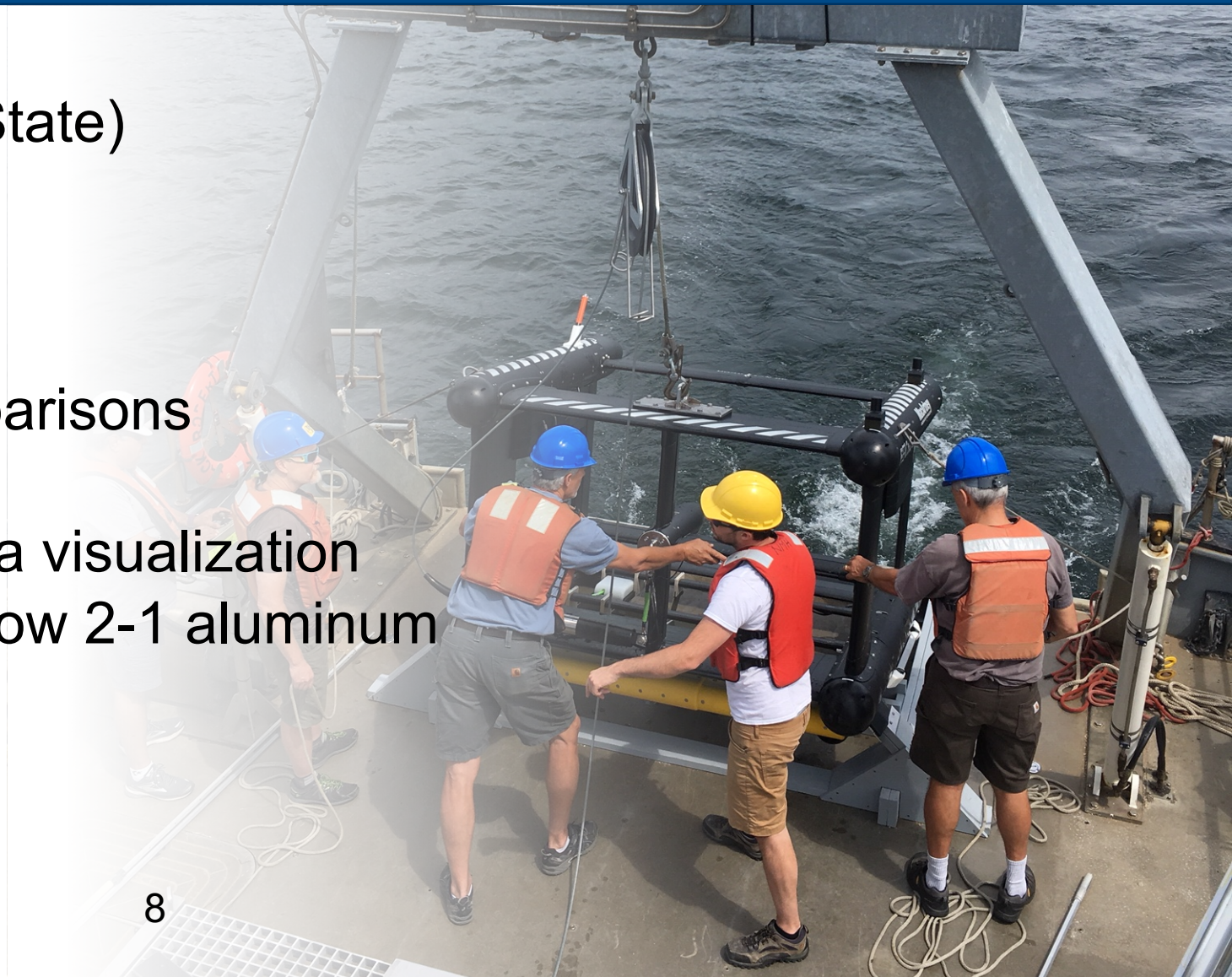
Lake Washington tests (Aug. 2 – 8th, 2019)

Location:

- North Lake Washington (WA. State)

Goals:

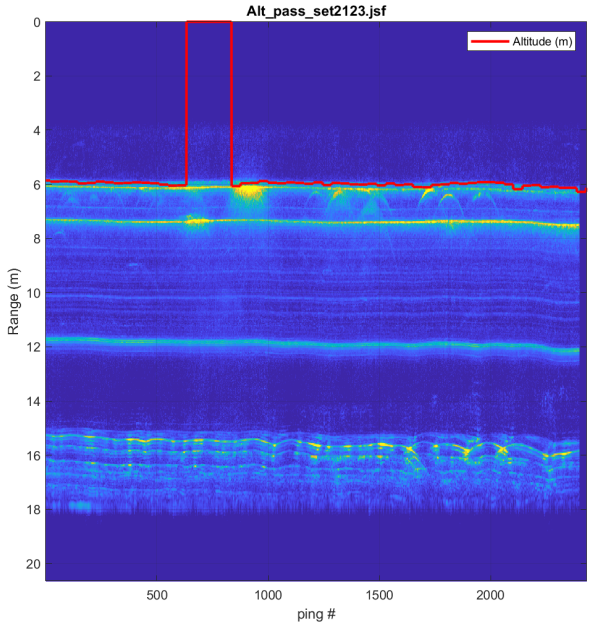
- BOSS sensor & system test
- Transmitter configuration comparisons
- Ping rate selection
- Data streaming tests & live data visualization
- Target detection (solid and hollow 2-1 aluminum cylinders)
- DVL and MEM's INS test

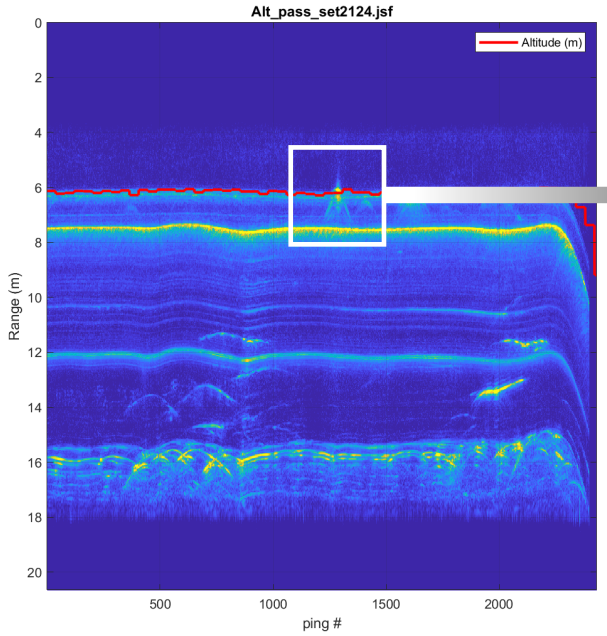


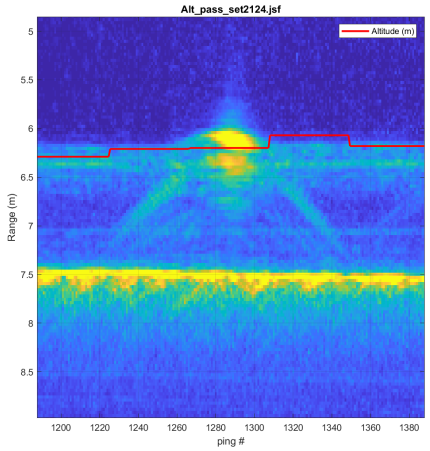
Lake Washington tests (Aug. 2 – 8th, 2019)

Sensor test

- Example sediment profile and target signature captured by the BOSS







Hollow aluminum cylinder target arc

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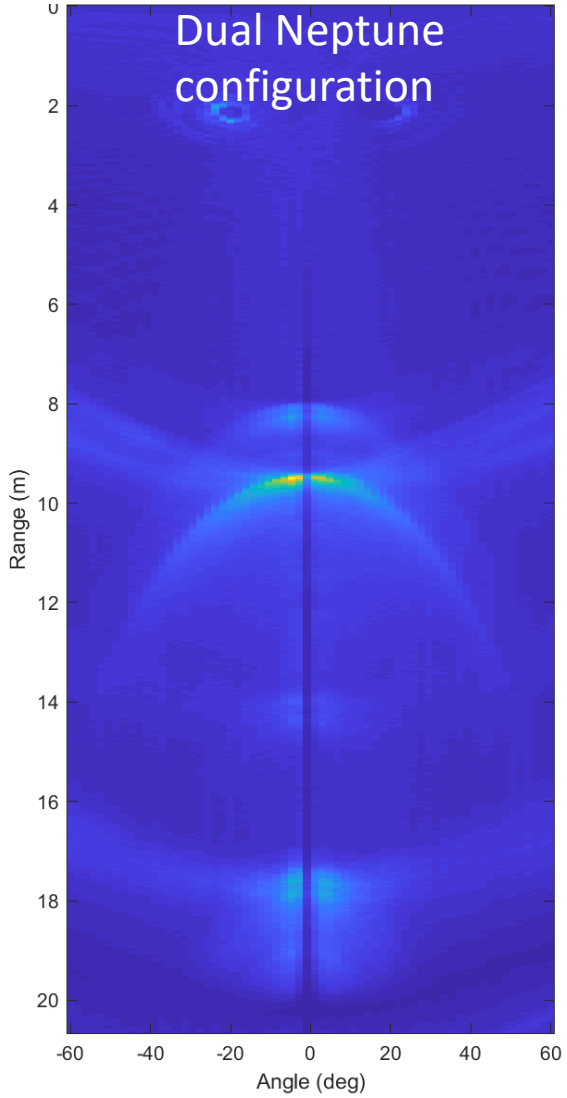
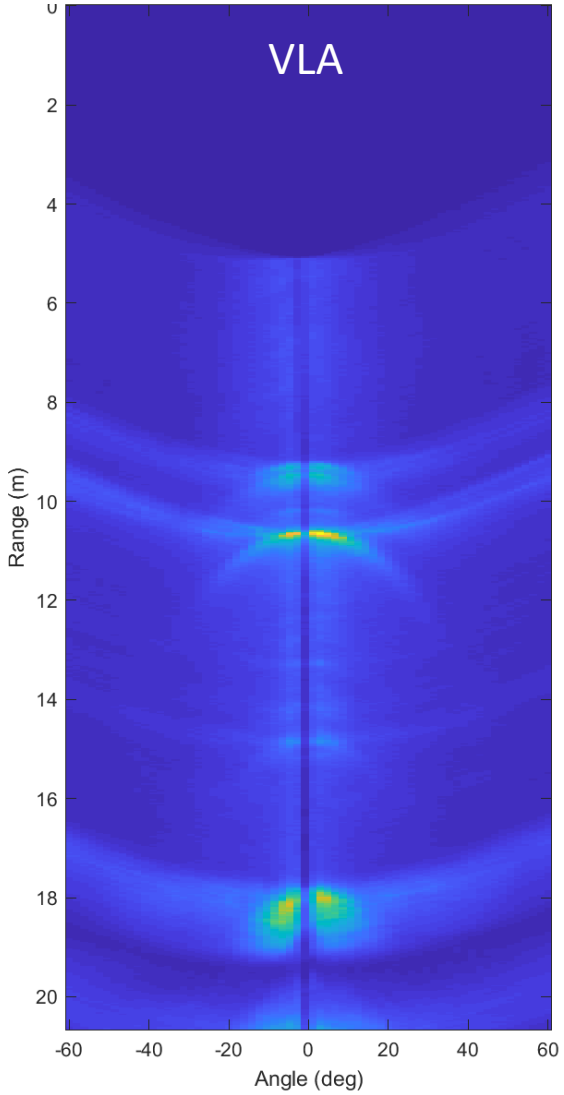
Lake Washington tests (Aug. 2 – 8th, 2019)

Transmitter configuration tests

- VLA system had narrower beam, but also lower signal level
- VLA samples faster
- Neptunes ensonified larger area (wider swath) but also can double across-track resolution

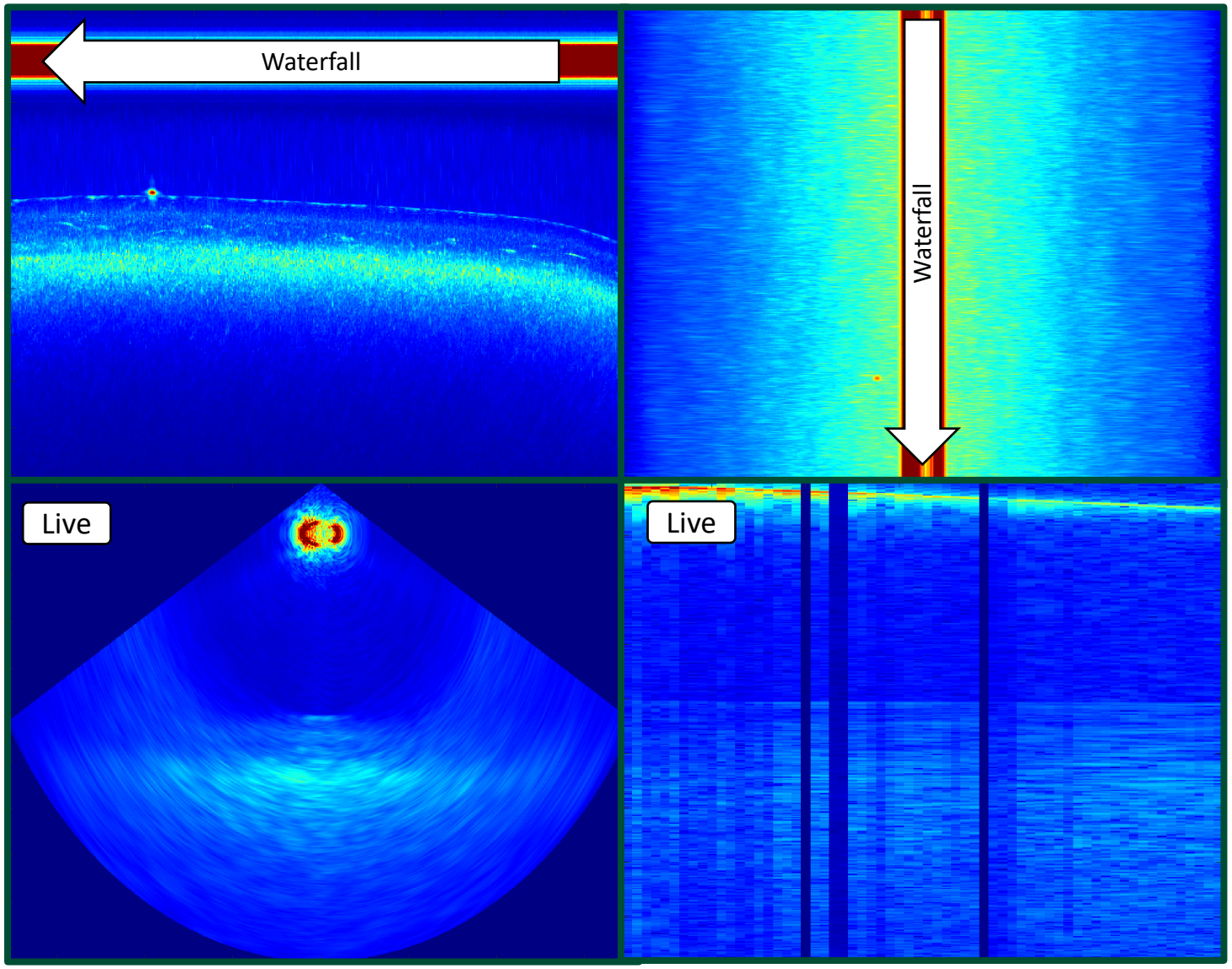




Lake Washington tests (Aug. 2 – 8th, 2019)

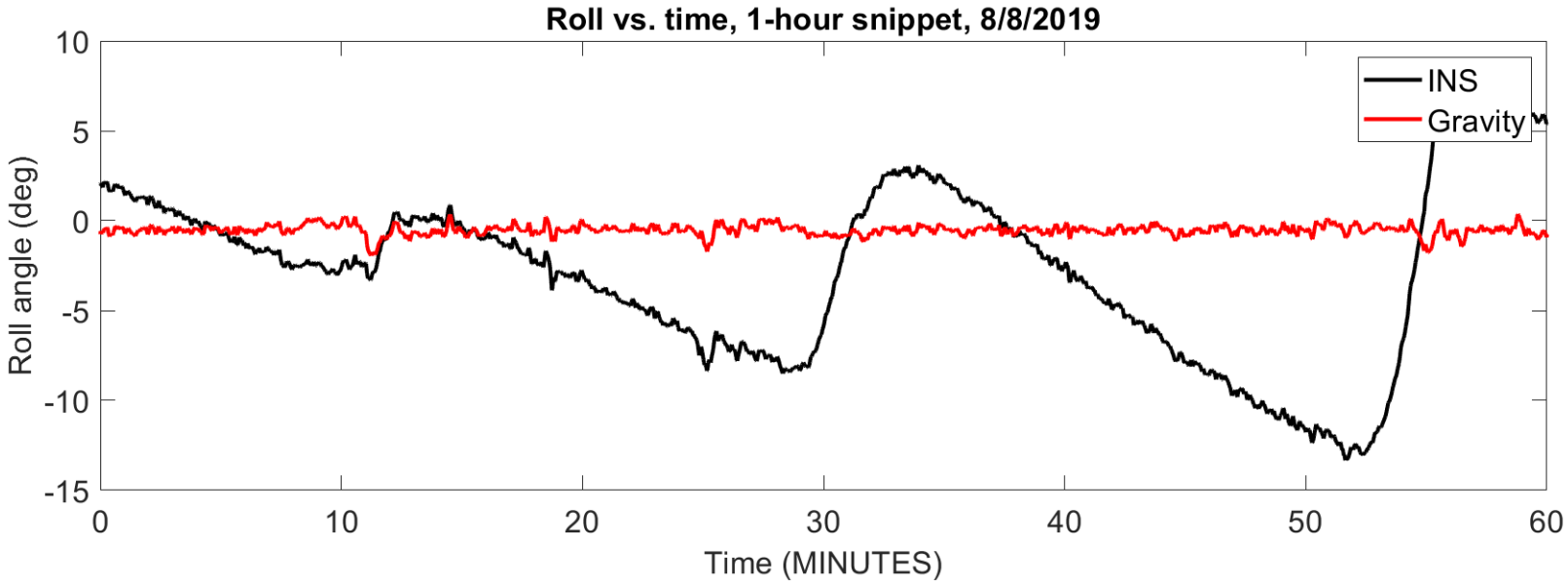
Data live-streaming

- TCP/IP connection tests (Python / Matlab)
- Data quality assessment
- JSF grabbing
- Real aperture beamforming



Lake Washington lessons learned

- Dual-Neptunes were in general more useful than the VLA source
- Not ready to beamform yet: INS experiencing major problems
  - “fusion” with DVL not working (bouncing between 48th and 49th parallel…)
  - Roll and pitch also walking around erratically



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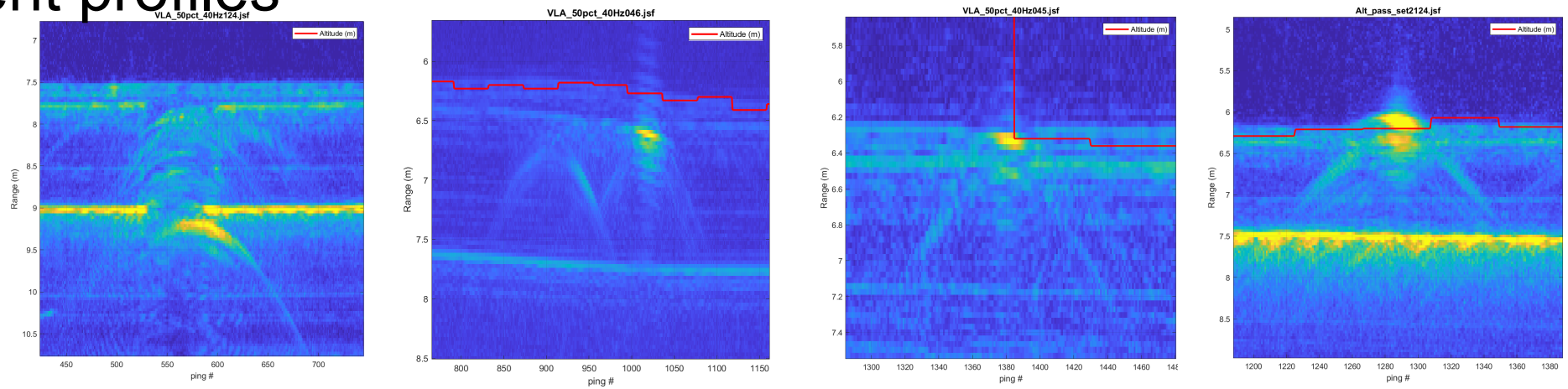
Lake Washington lessons learned

- Live streaming works pretty decently / BOSS accepts only one TCIP/IP connection per time for data streaming
- 40 Hz sampling: range and swath preferred to sampling ambiguity
- Could see > 13 meters into the sediment!
- Target arcs showed up nicely in many of the pulse-compressed sediment profiles



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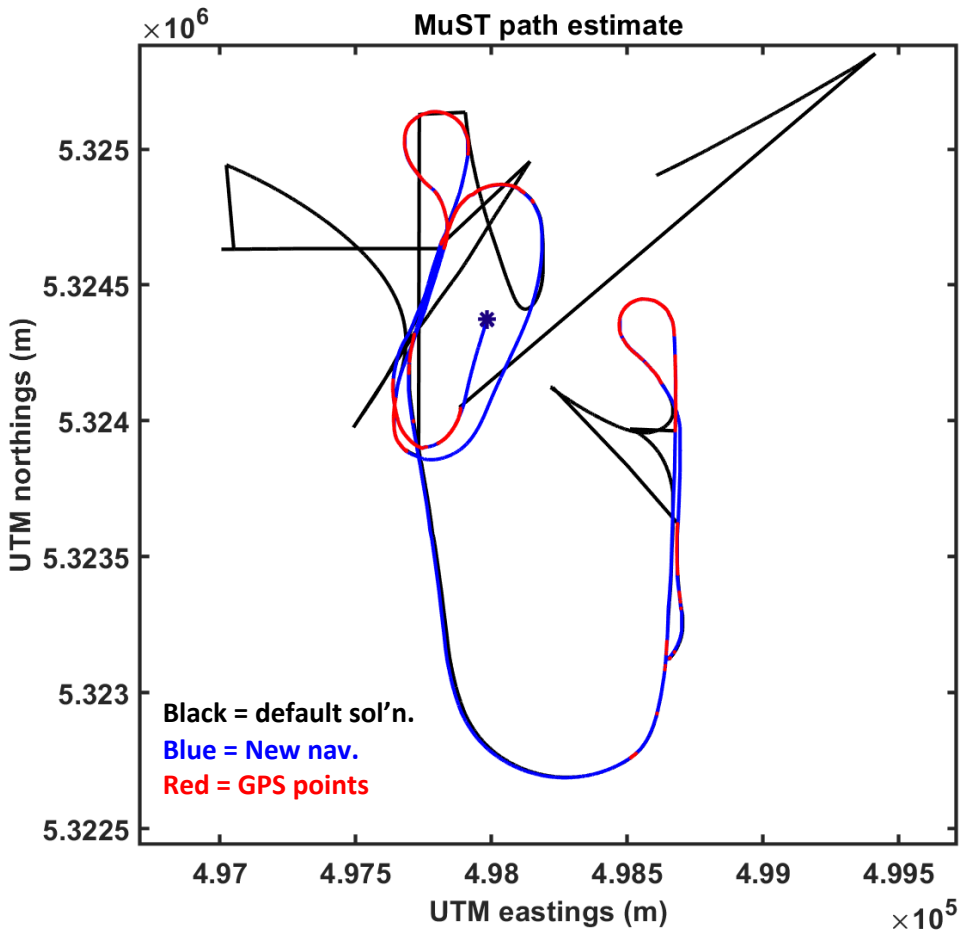
Interim period: improve INS solution

INS solution recalculation:

- Posed as a giant sparse iterative WNLSQ problem
- Fuses raw INS accelerometer, DVL, and pressure sensor data with GPS (when available)
- Smooth, gap-filled solution
- Collaborated with Ocean Engineering group create a new file-type containing all the relevant NAV info in a single binary package, live-streamed over TCP/IP



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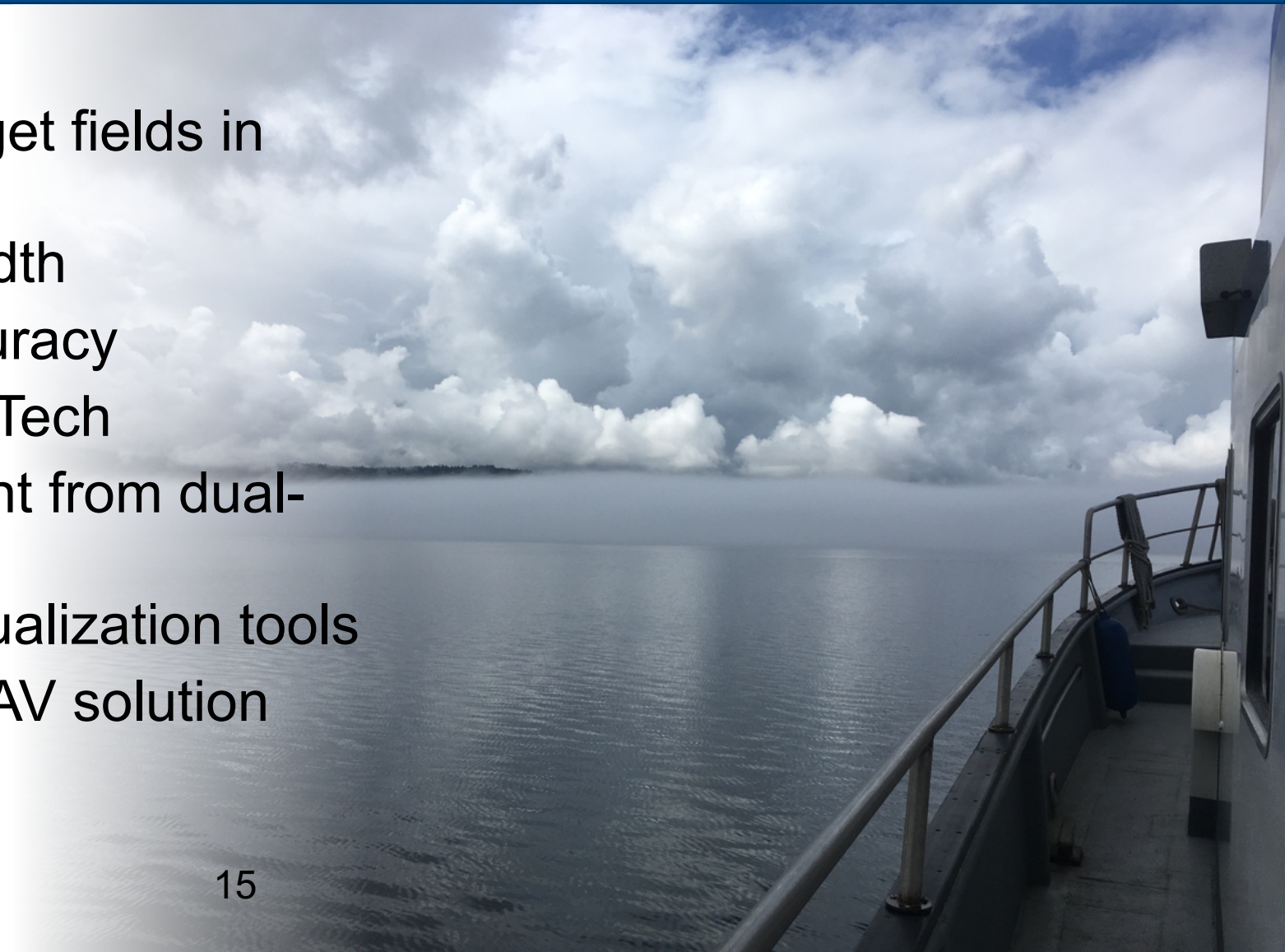
Sequim Bay (Sept. 9 – 12th, 2019)

Goals:

- Acquire good data over target fields in different sediment types
- Determine sensor swath width
- Determine geolocation accuracy
- Test new panels from EdgeTech
- Test resolution enhancement from dual-transmitter design
- Test upgraded live data-visualization tools
- Test new INS format and NAV solution processing

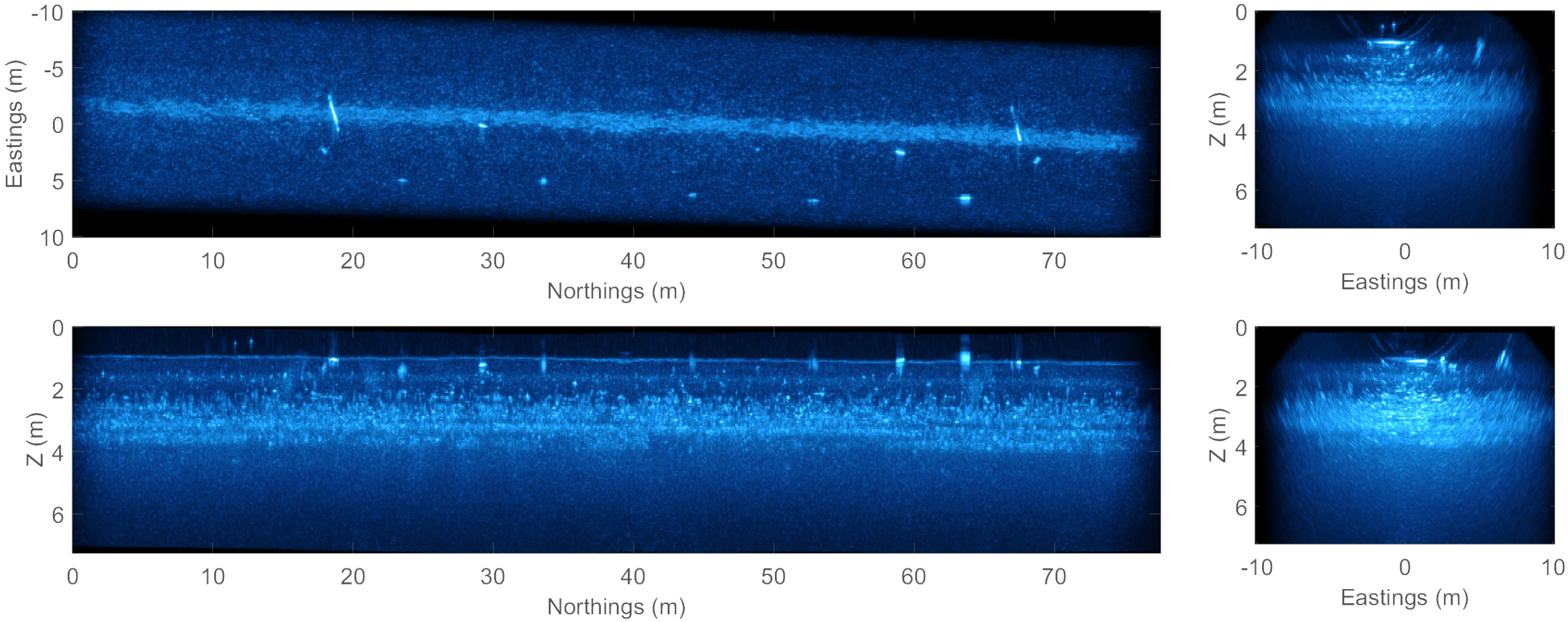


Sequim Bay (Sept. 9 – 12th, 2019)

General results:

- Lots of *very good* data captured over sandy and muddy target fields
- Swath width ~15m. for 5 m. altitude
- New EdgeTech panels are greatly improved
- Live-visualization proved very useful the entire time
- The dual-source configuration was very successful
- Geolocation accuracy not yet assessed
- Beamforming with new nav. solution works very well…

Mud site: Buried Targets / Layered Medium



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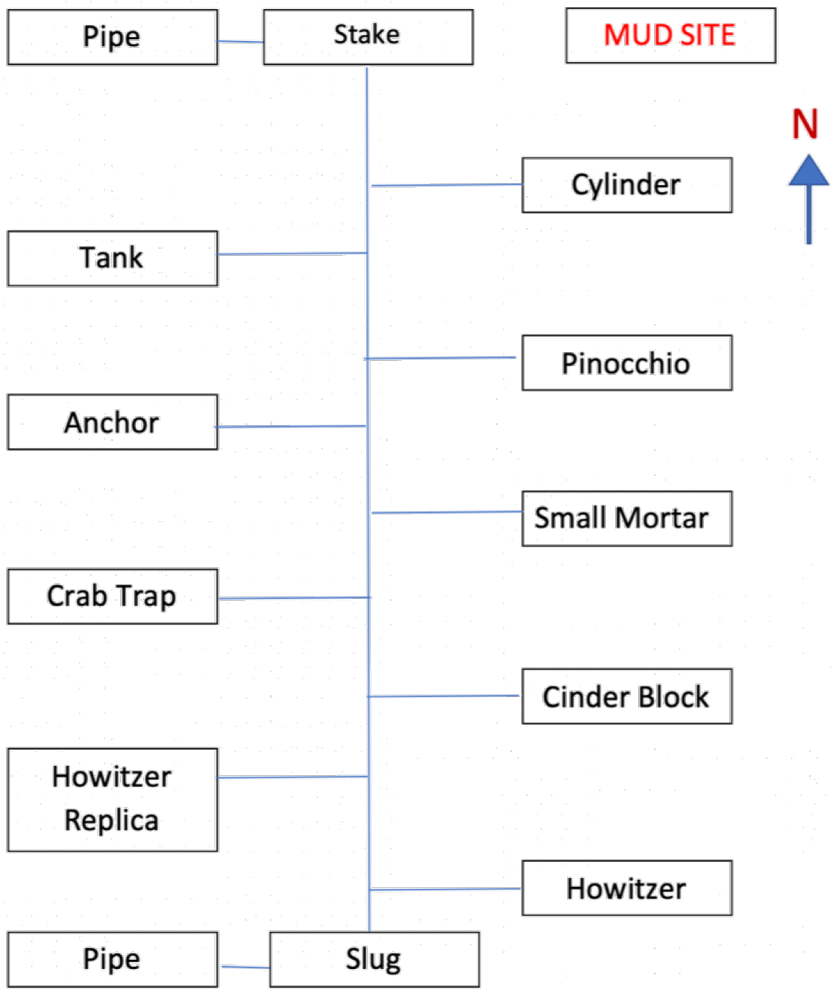
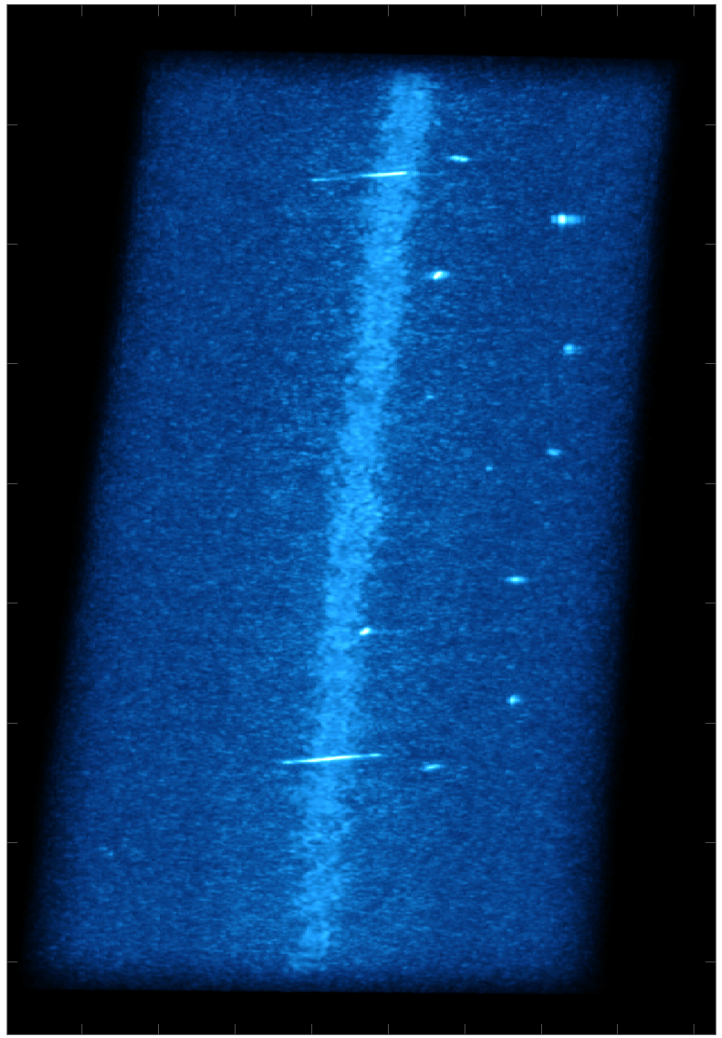
Mud site: Buried Targets / Layered Medium





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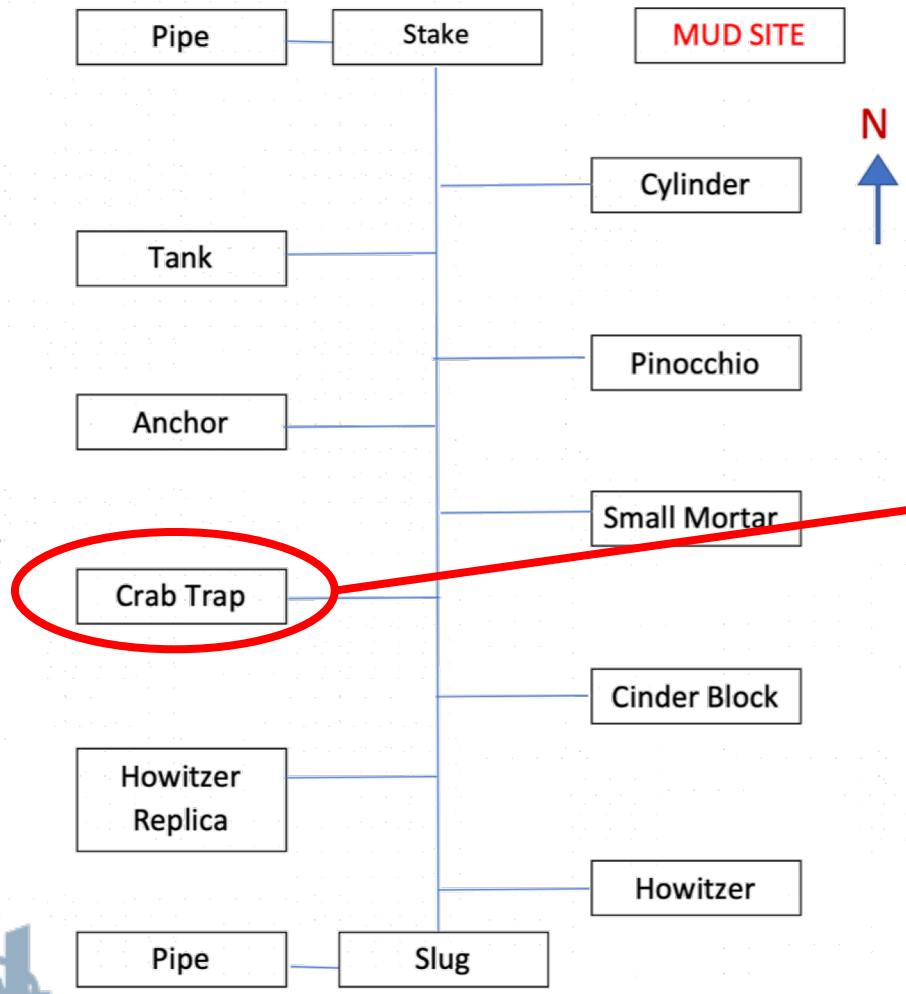
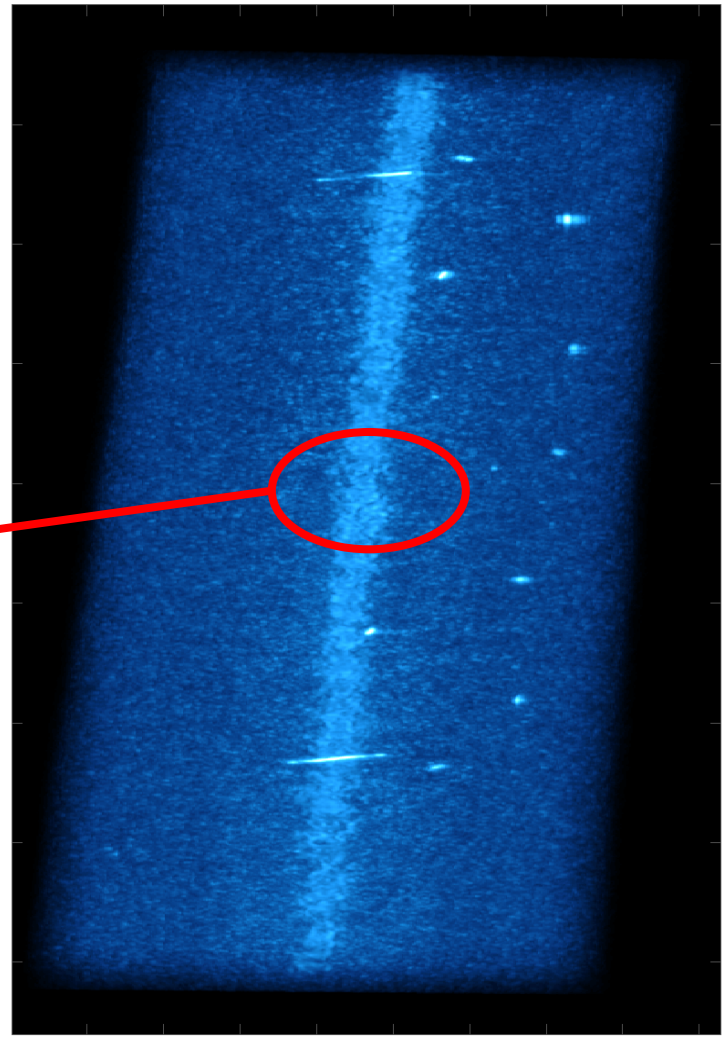
Mud site: Buried Targets / Layered Medium



Only missing target…



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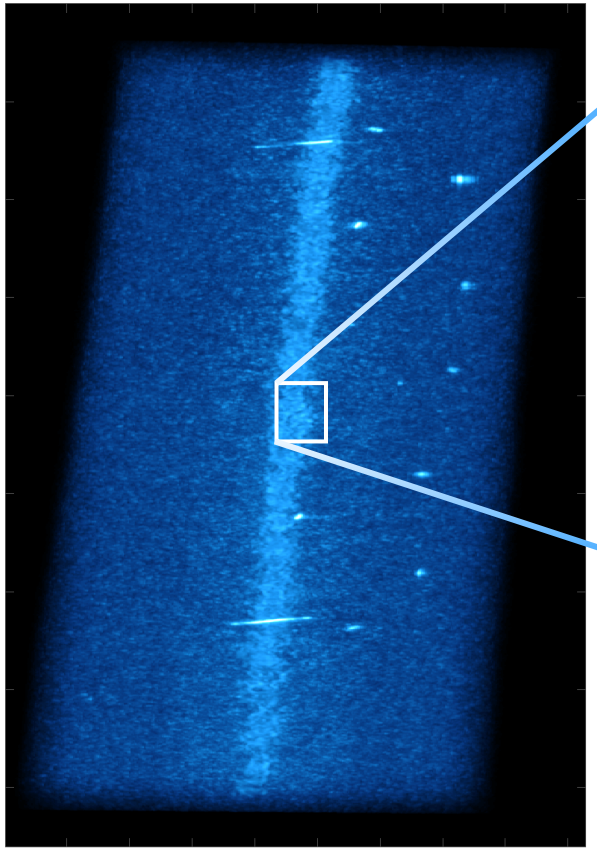
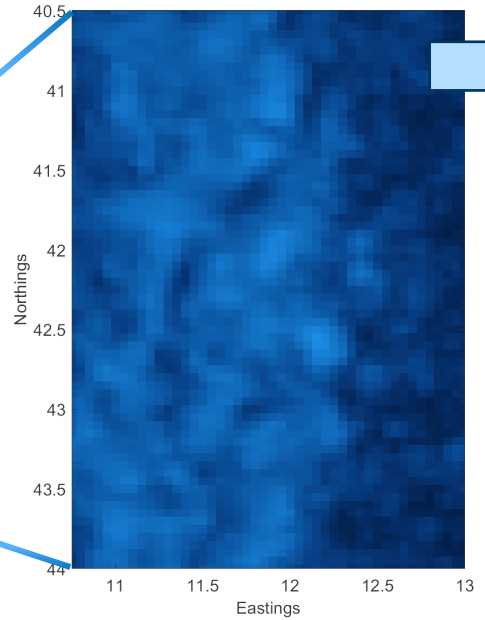
Mud site: Buried Targets / Layered Medium

MIP point of failure: weak targets

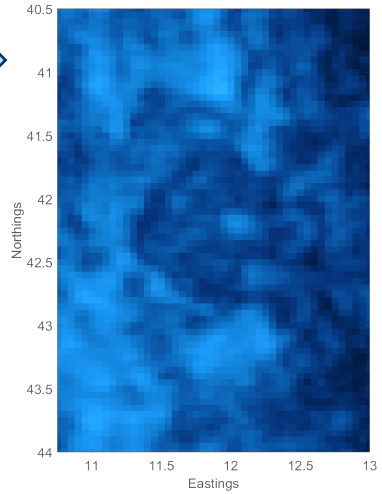




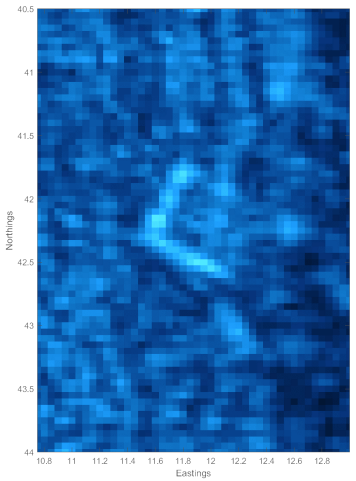
No target in MIP…

Slices…

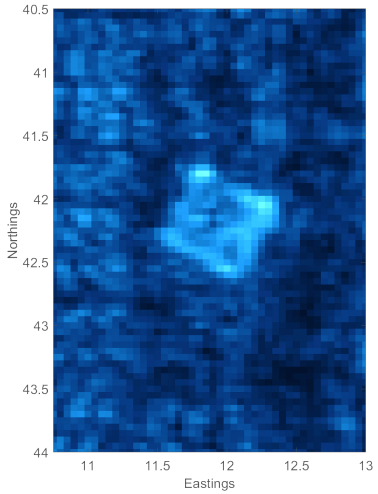
+ 0 m.



+ 0.1 m.



+ 0.25 m.



Crab-pot and sediment disturbance visible in volume slices…

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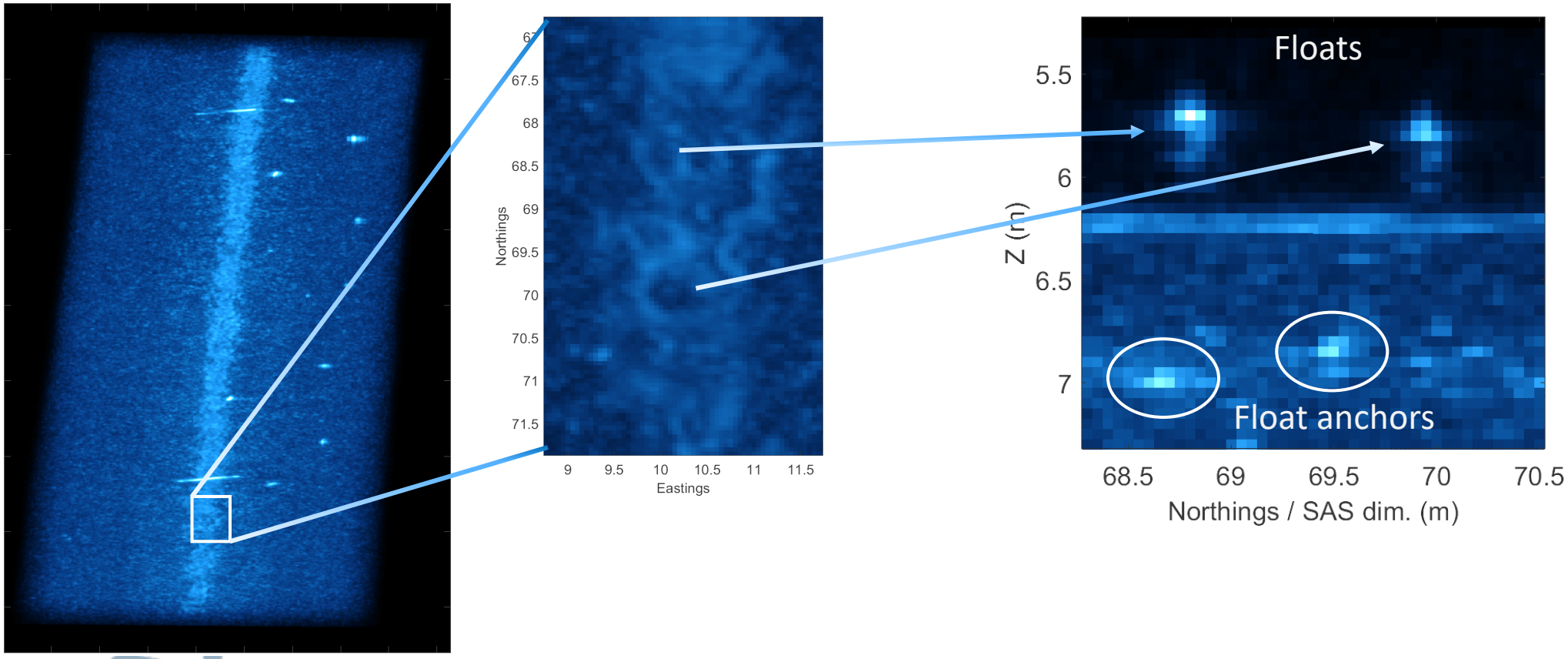
Mud site: Buried Targets / Layered Medium

Floating end markers: focus validation



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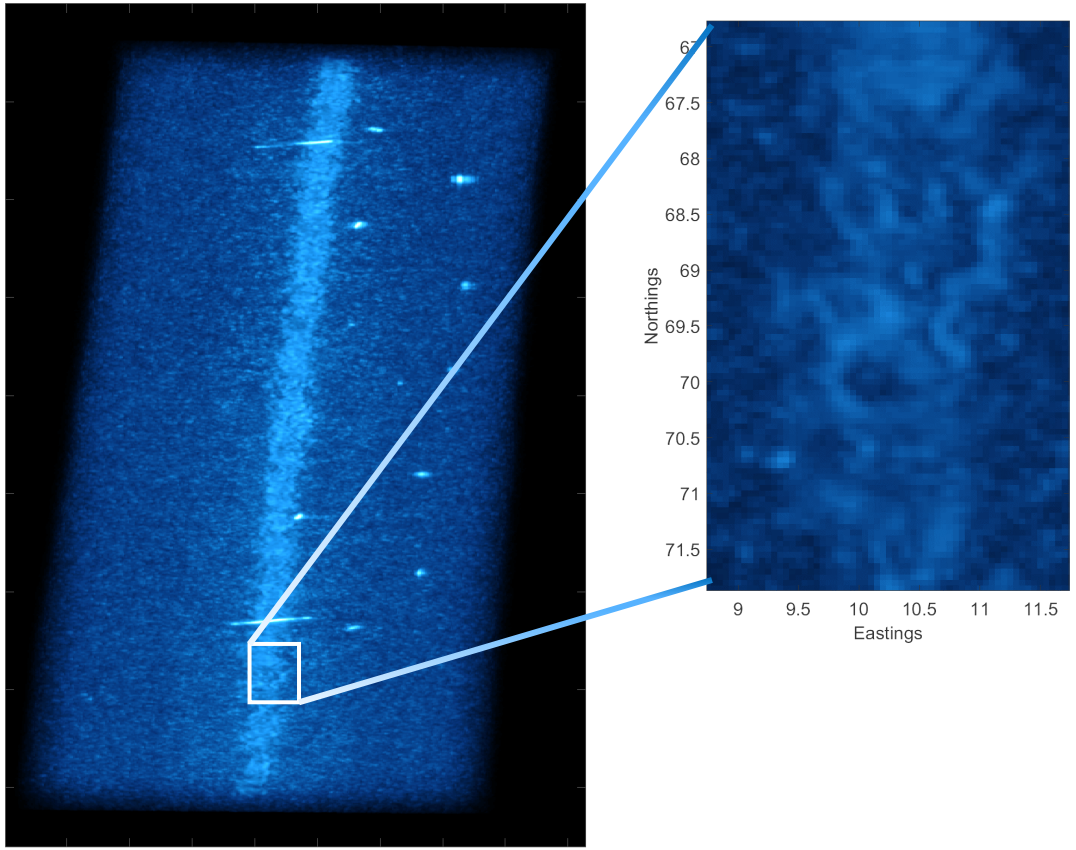
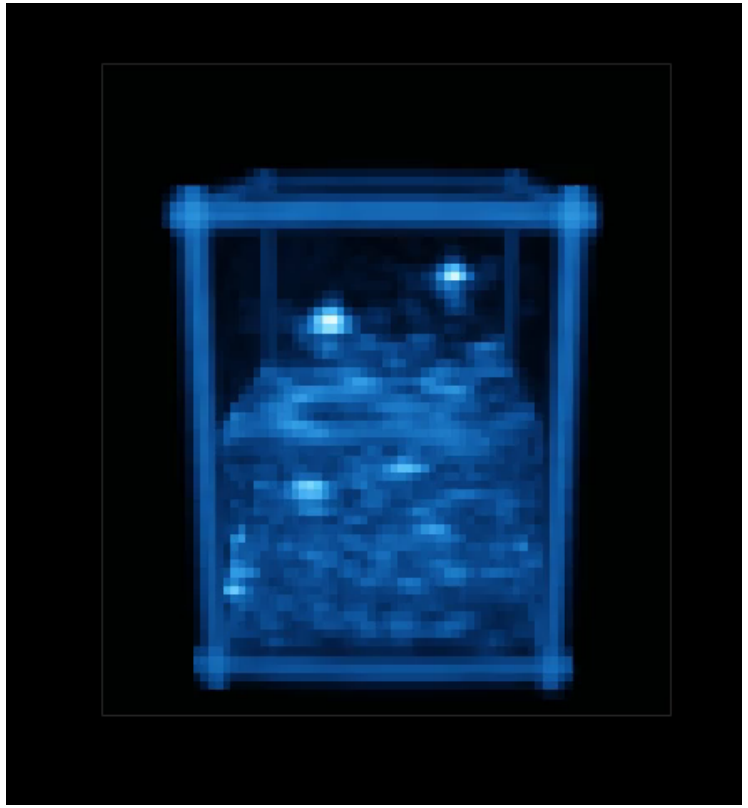
Mud site: Buried Targets / Layered Medium

Floating end markers, 3D visualization: rotating MIPs





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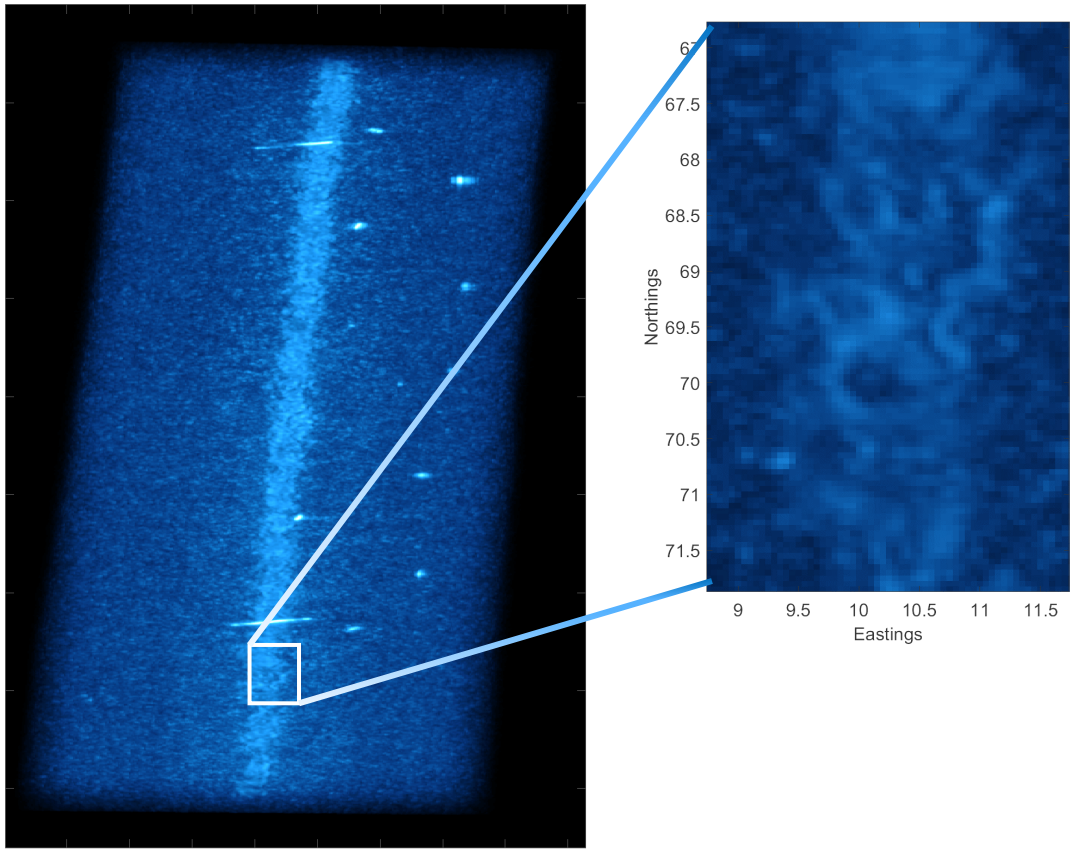
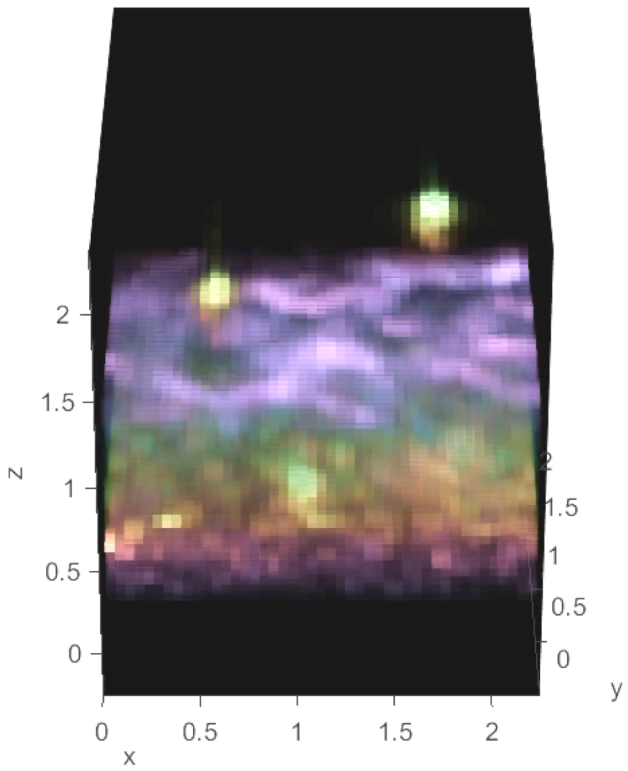
Mud site: Buried Targets / Layered Medium

Floating end markers, 3D visualization: rotating voxels w/alpha





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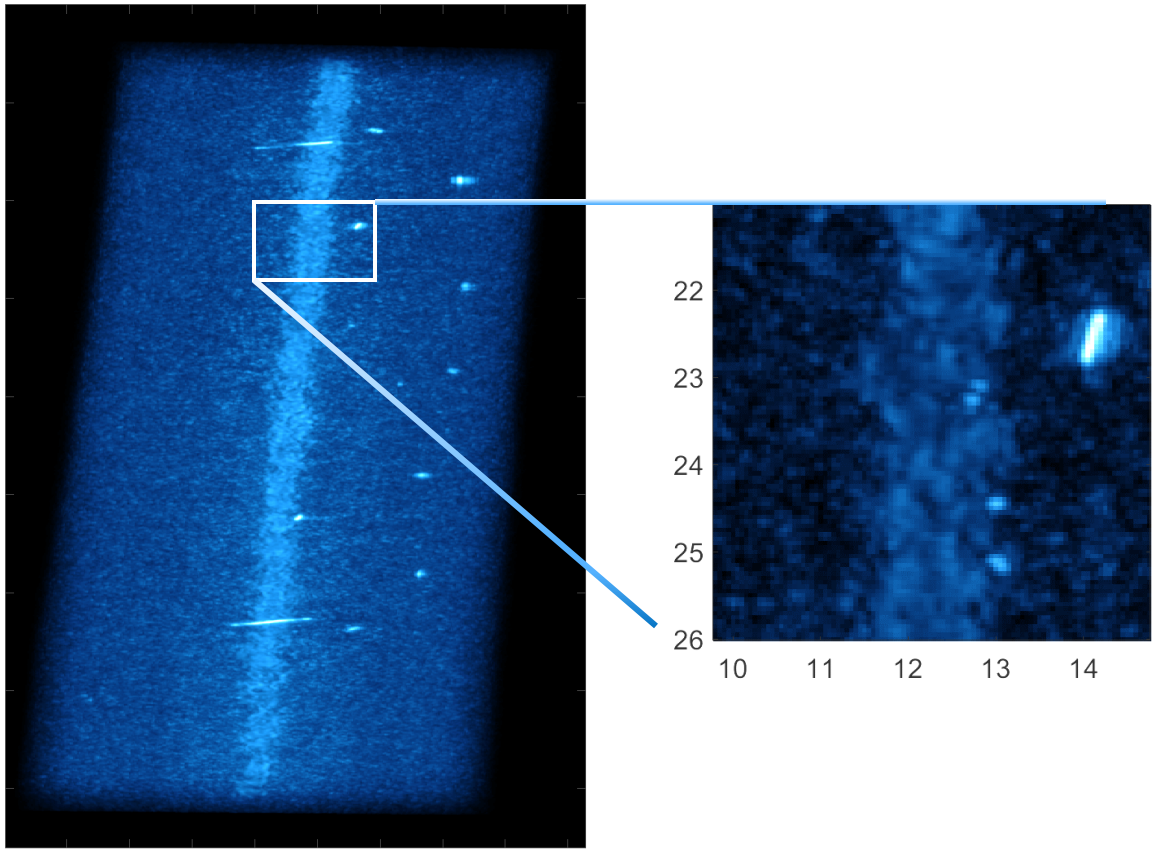
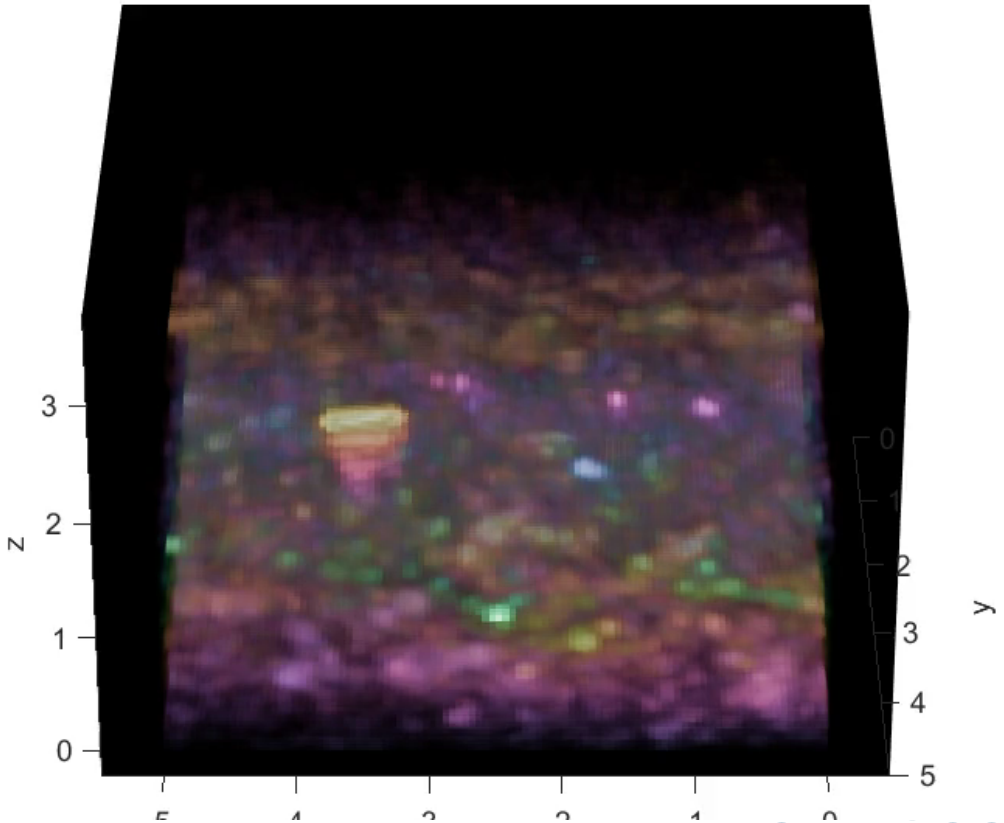
Mud site: Buried Targets / Layered Medium

Scuba tank & context: rotating voxels w/alpha





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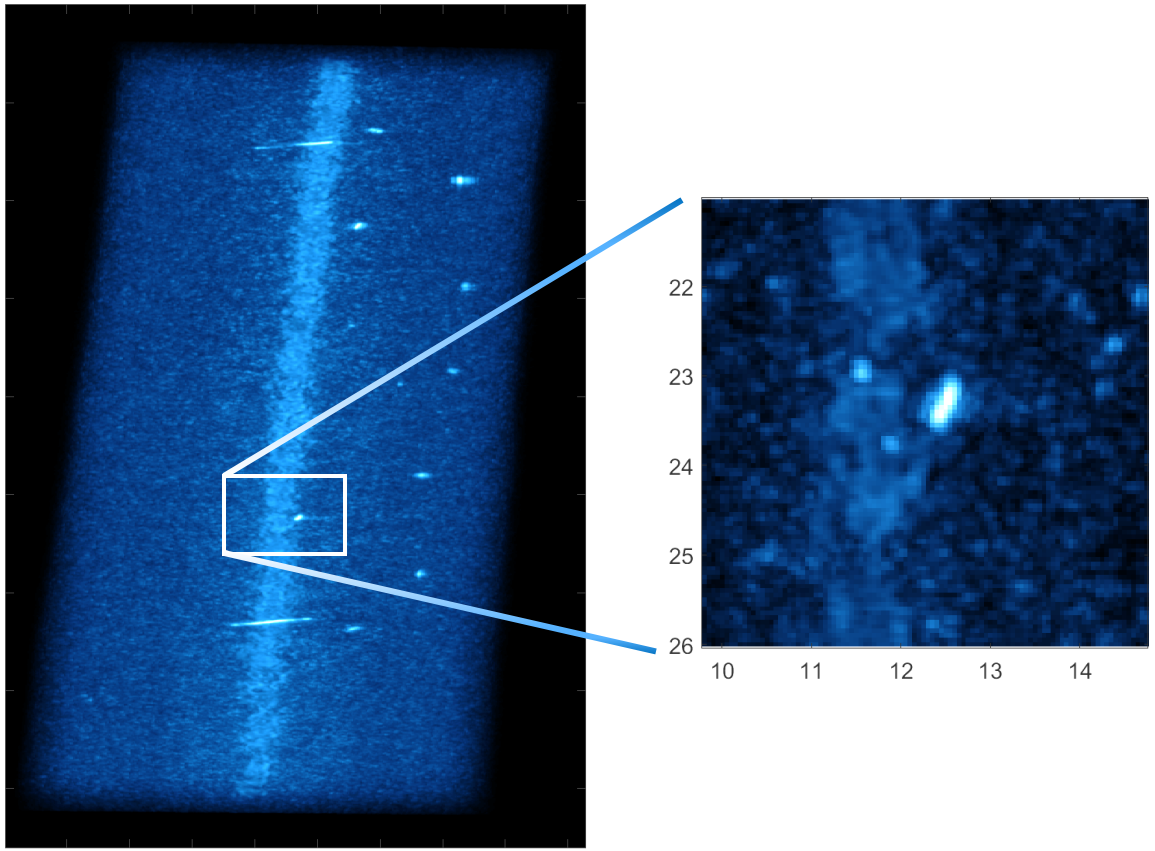
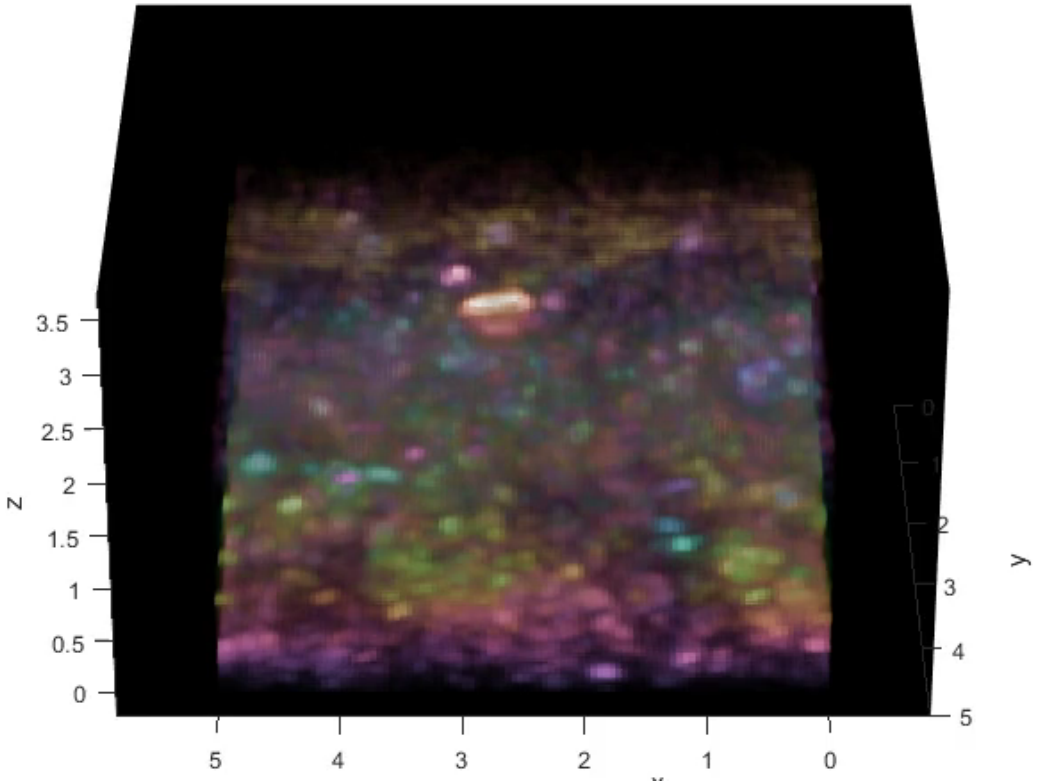
Mud site: Buried Targets / Layered Medium

Buried UXO & context: rotating voxels w/alpha





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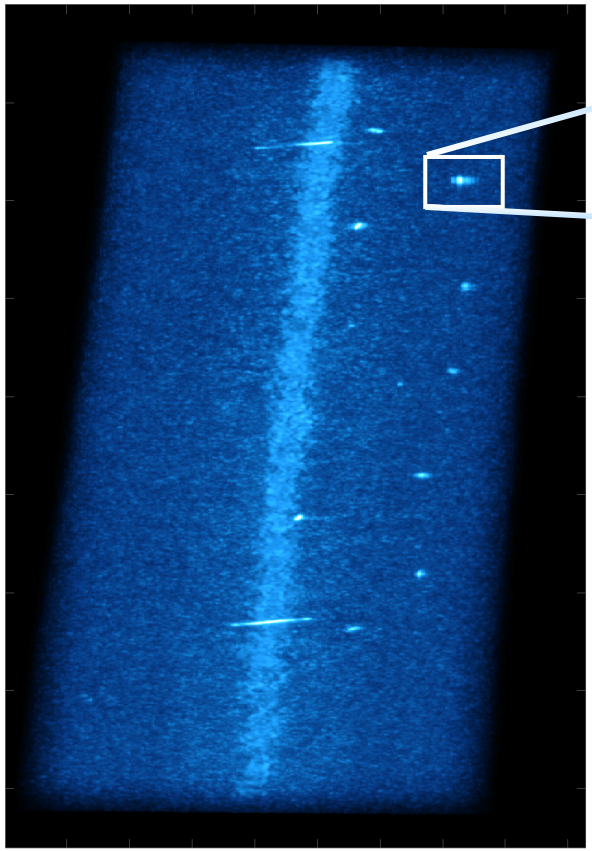
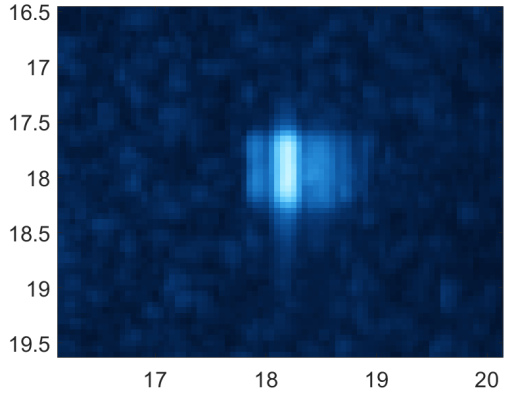
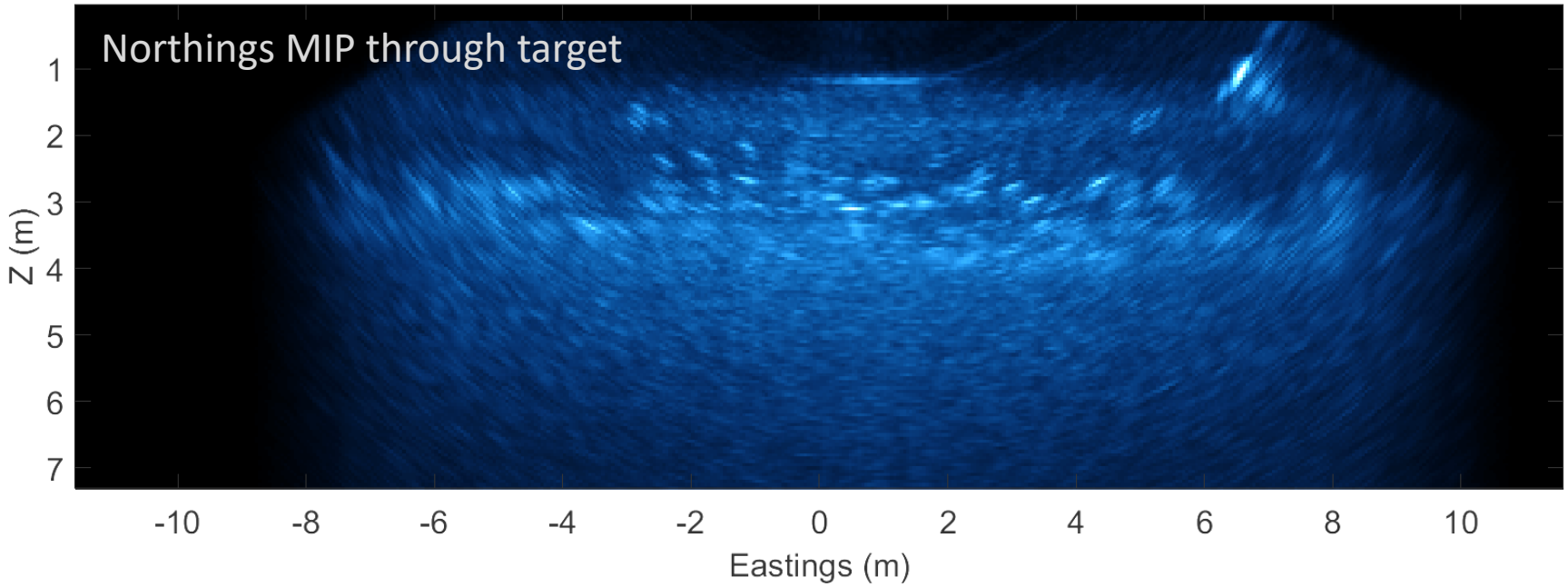
Mud site: Buried Targets / Layered Medium

2 by 1 hollow Al. cylinder

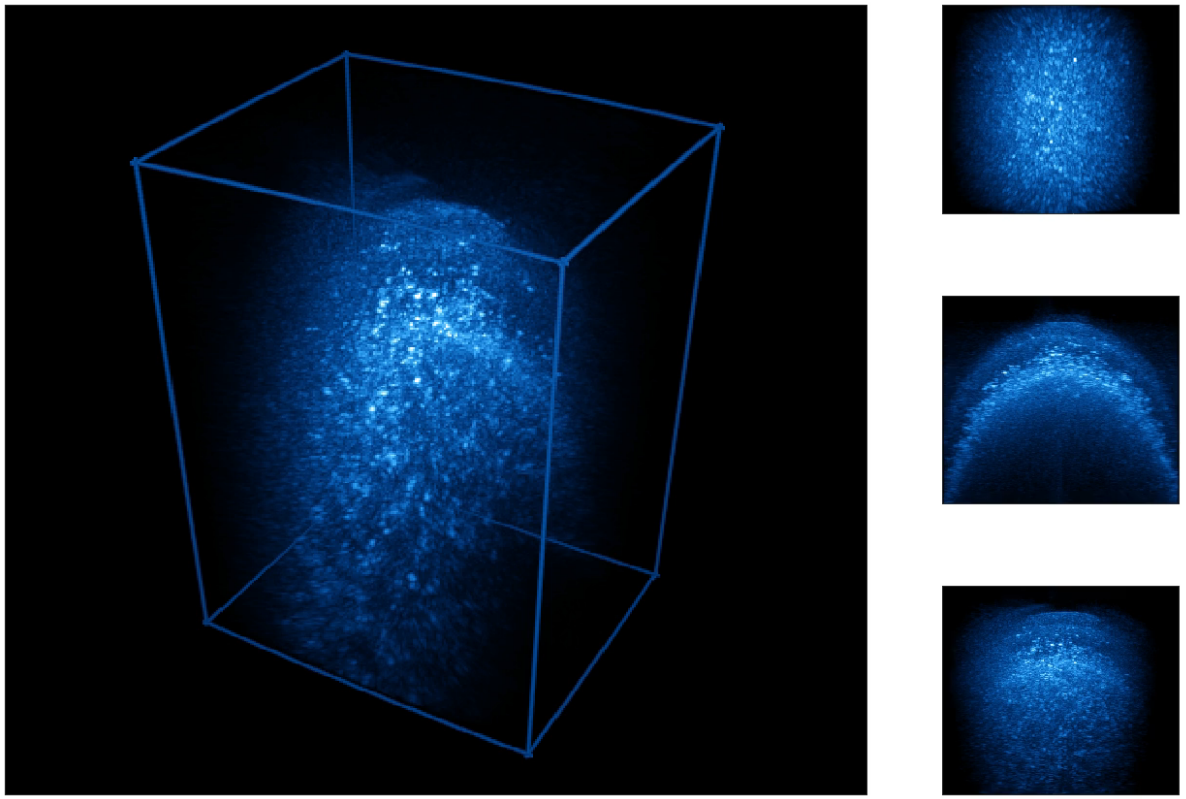






Acoustic Camera imaging

- Local image products in region under sensor
- Spherical coordinate view (flat surfaces look curved)
- Hoping to implement in real time for a future deployment



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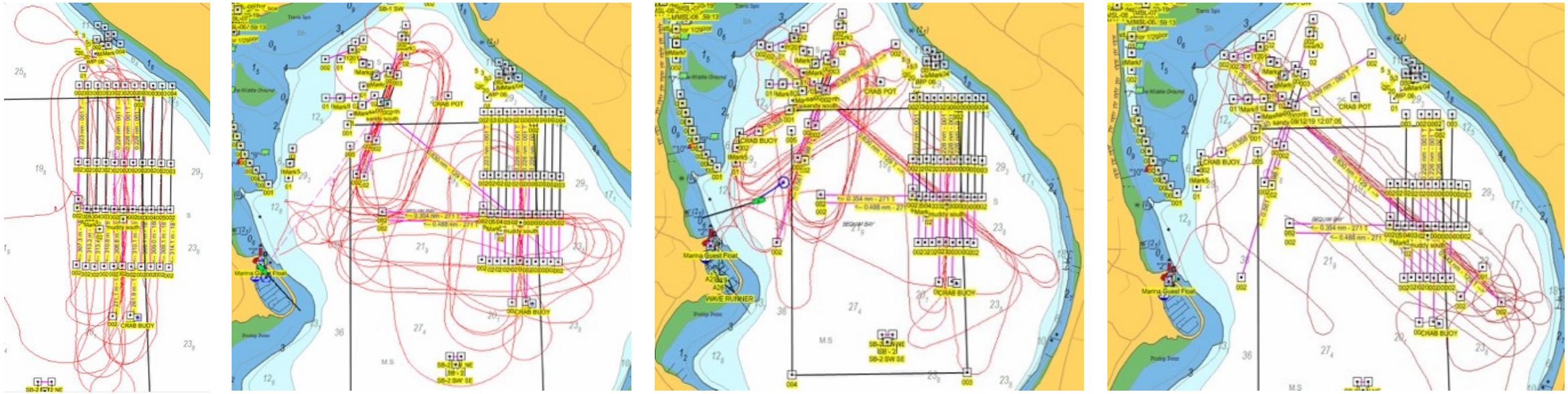
Sequim Bay summary

- This was one of many scans! Ship GPS by day:



Next steps:

- Beamform the rest of the data
- Compare target location repeatability (Geolocation precision)
- Acoustic color extraction: extract 3D impulse response info from ROI's

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Questions?

Acknowledgements:

- SERDP / ESTCP
- APL-UW Ocean Engineering
- EdgeTech
- Mike Lesnikowski
- PNNL