Arecibo
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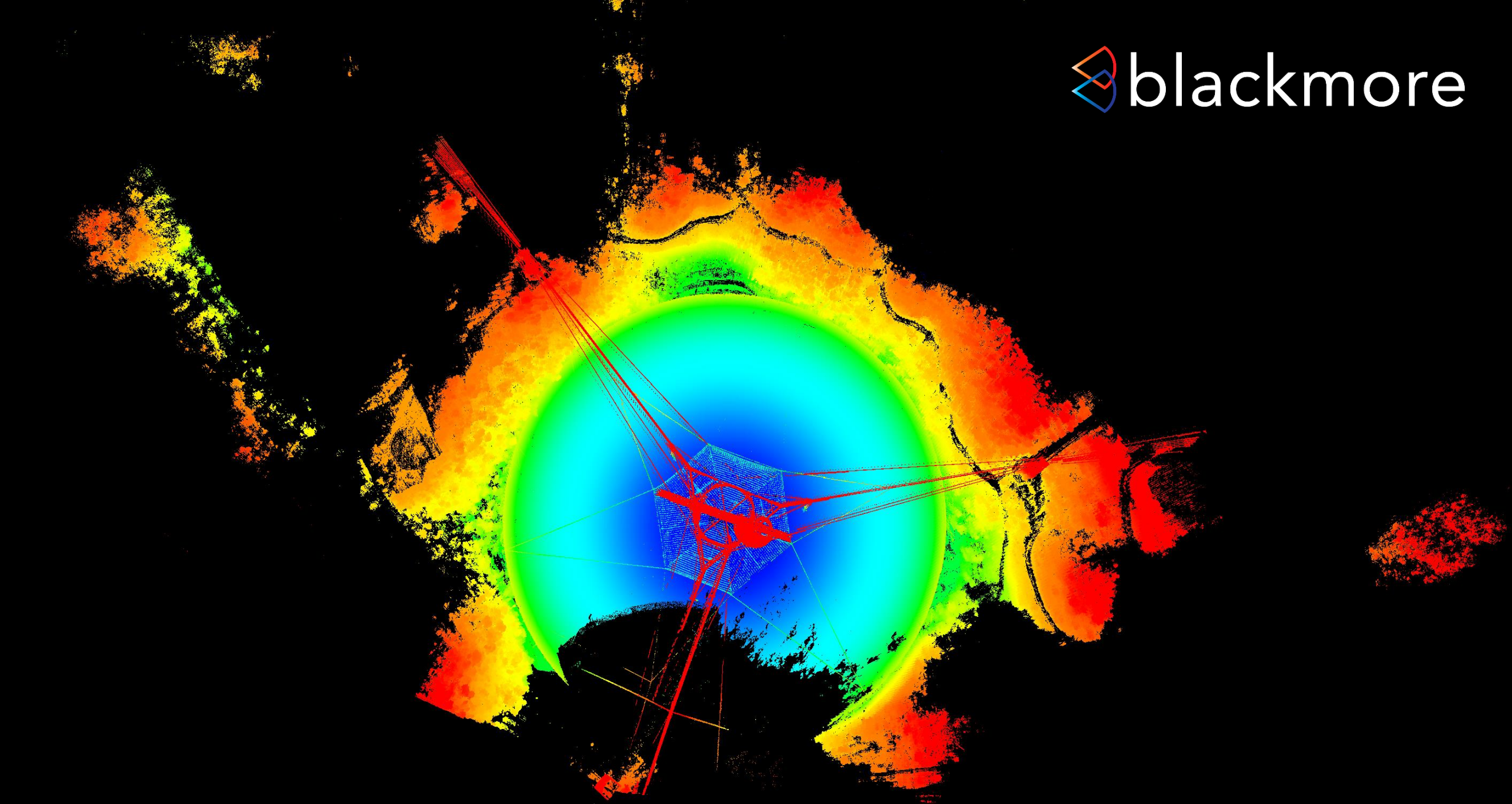

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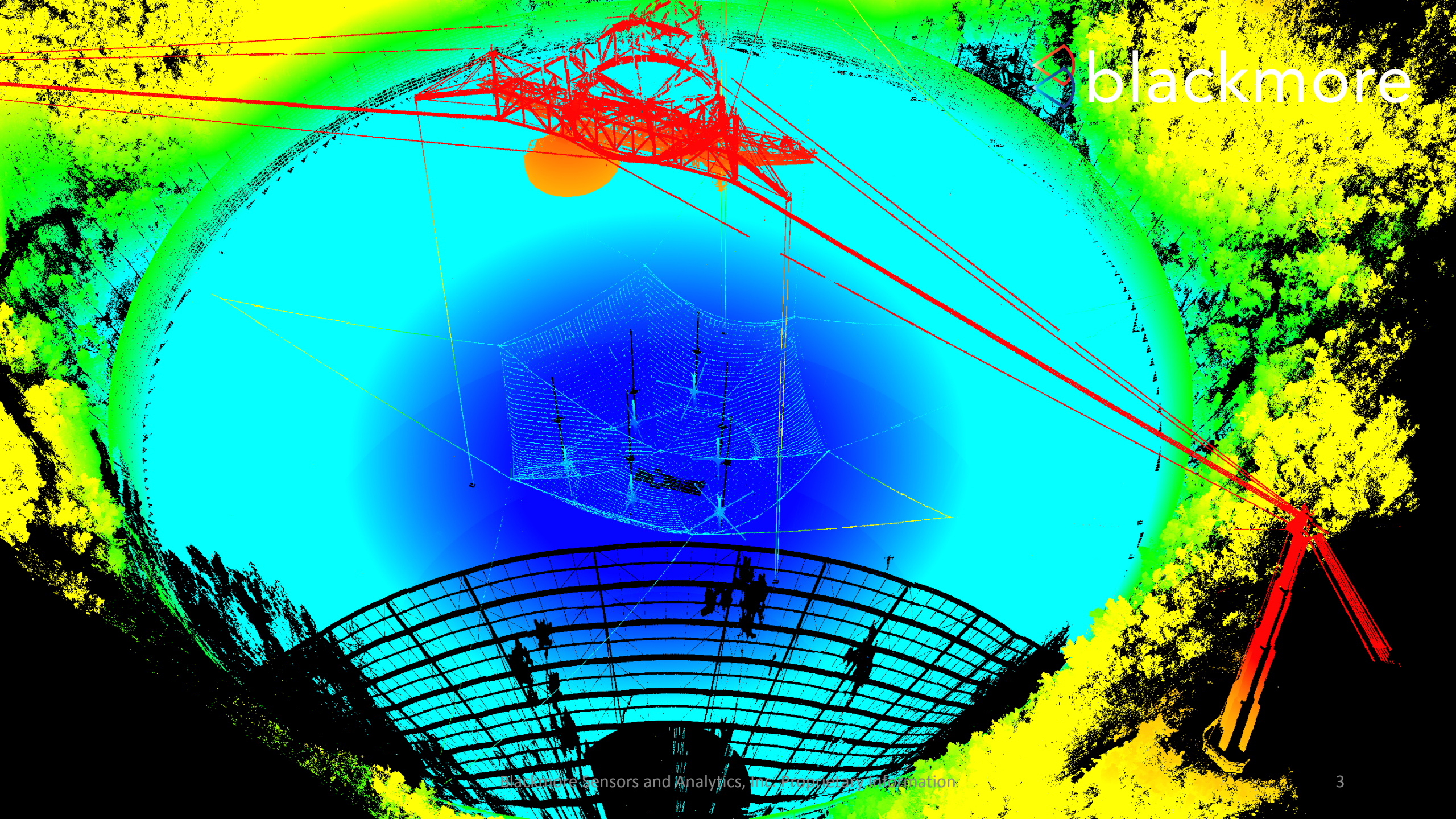
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Previous Results

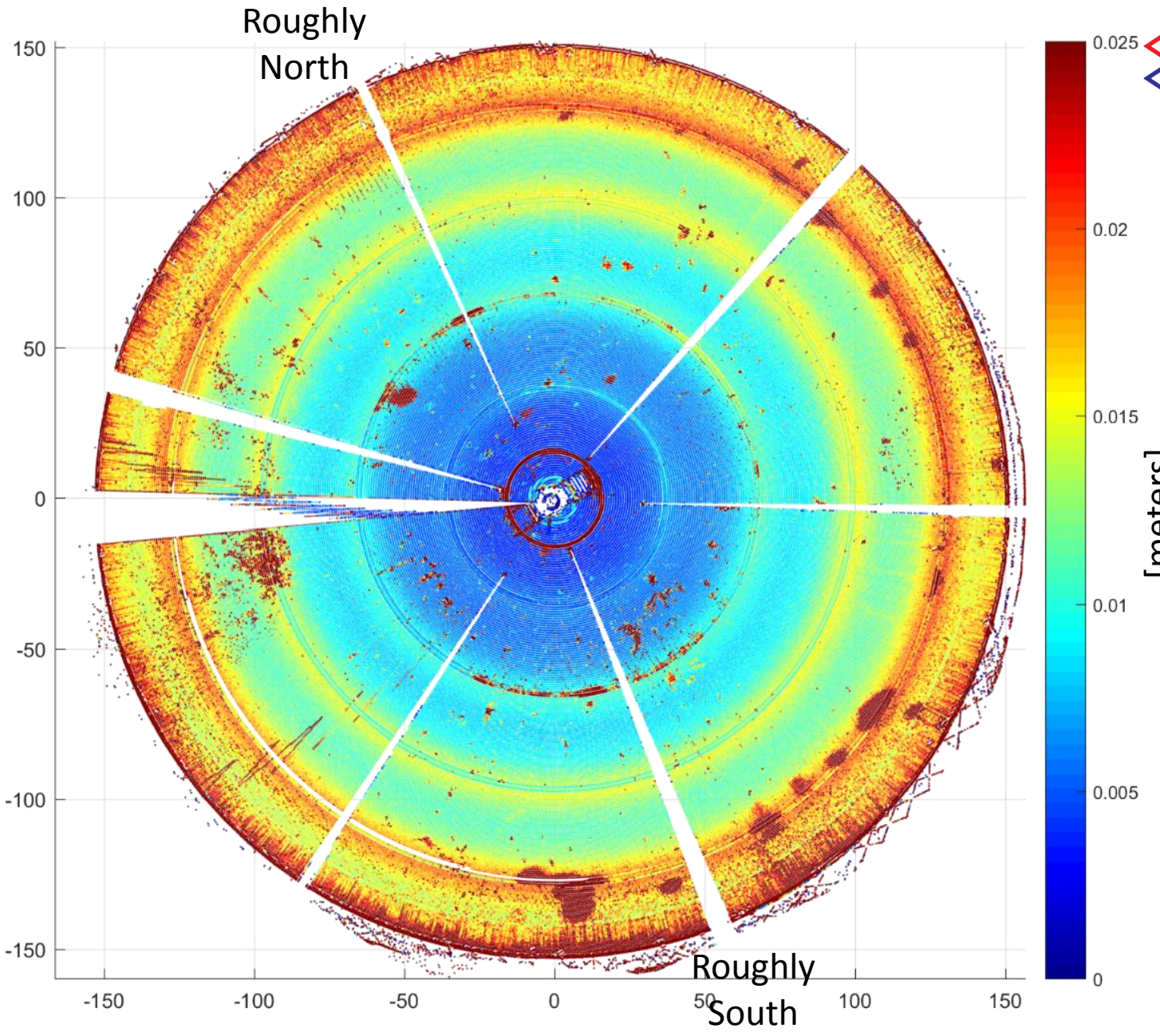
Analysis

- Analysis focused on radial deviation from the focal point of the spherical receiver
- This allows the lidar data to produce a “heat map” of possible aberrations
- Data product would ultimately be converted into re-calibration instructions
  - i.e. “turn bolt #xx by ¼ revolution clockwise…”
  - Underlying tensioning cables would then correct the dish shape

Basic Approach

- Points “on the dish” filtered to remove vegetation, ground, etc.
- Points voxelized in spherical coordinate system and averaged to reduce noise
  - Voxel patch size ~75cm x 75cm or about ¼ of panel surface area
- Distance from dish focal point used as surface error metric

Noise



Standard deviation of the point by point radial estimates within each voxel

Counts

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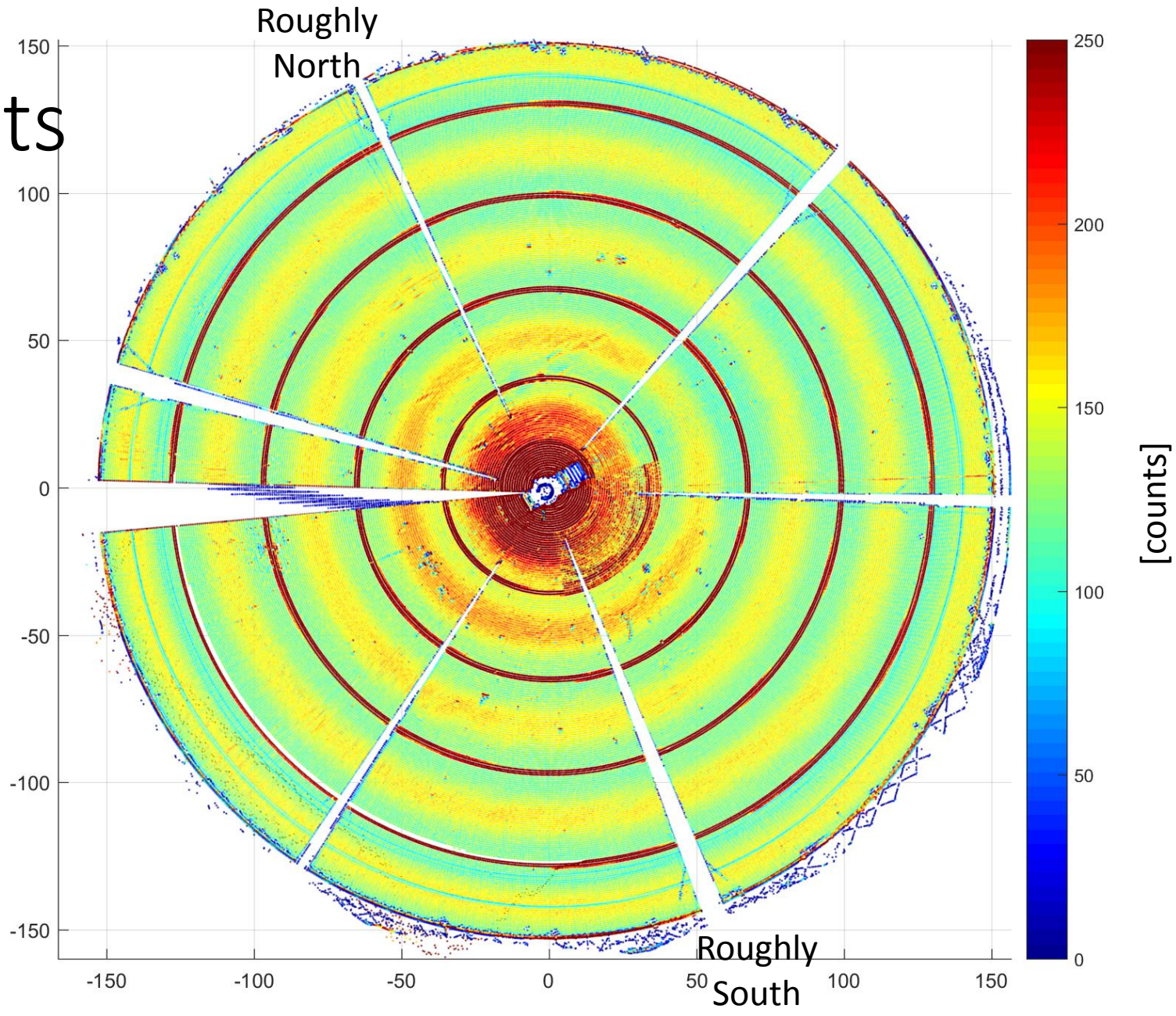
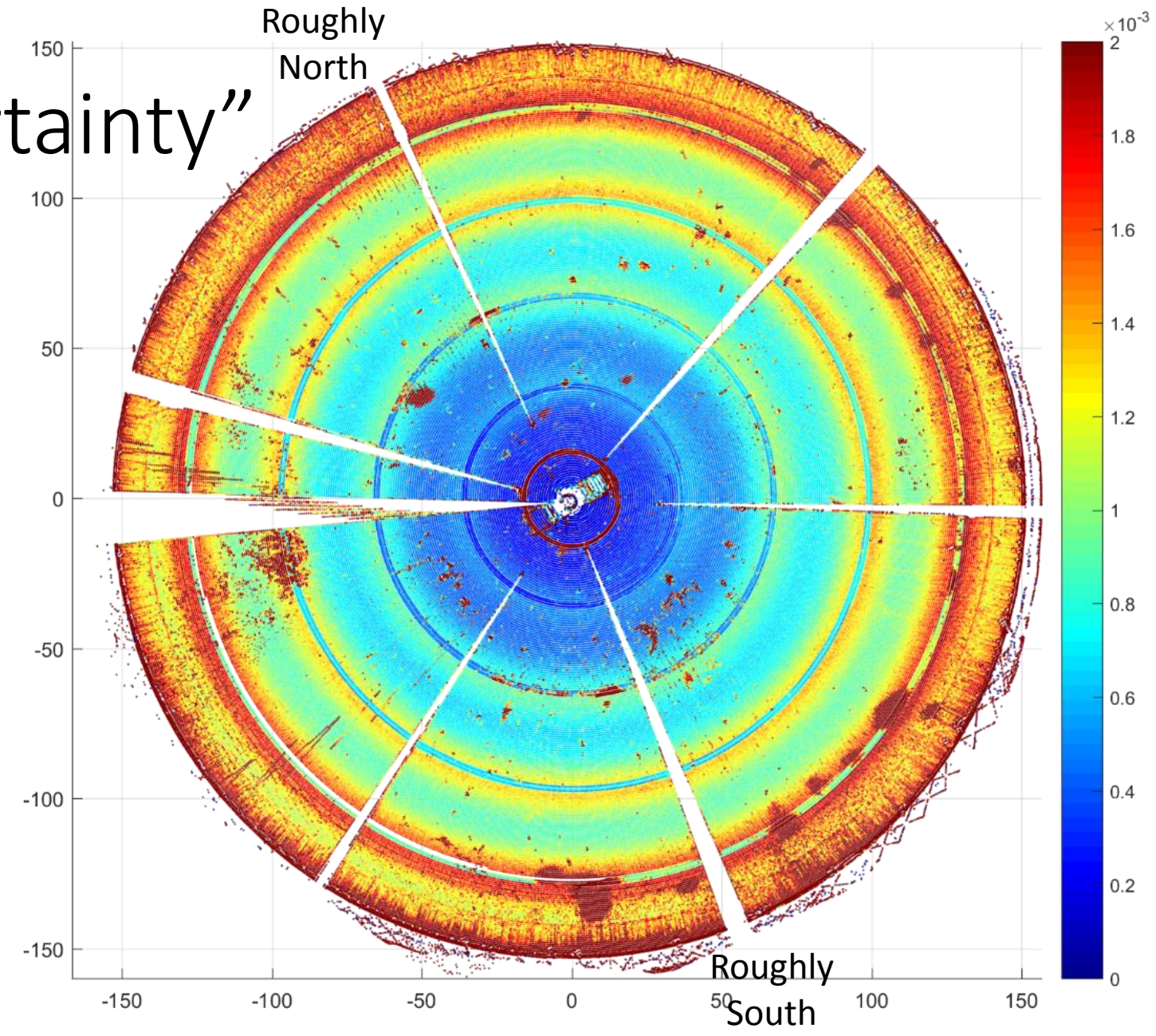


Number of points per voxel (~0.5m^2 patches)

“Uncertainty”



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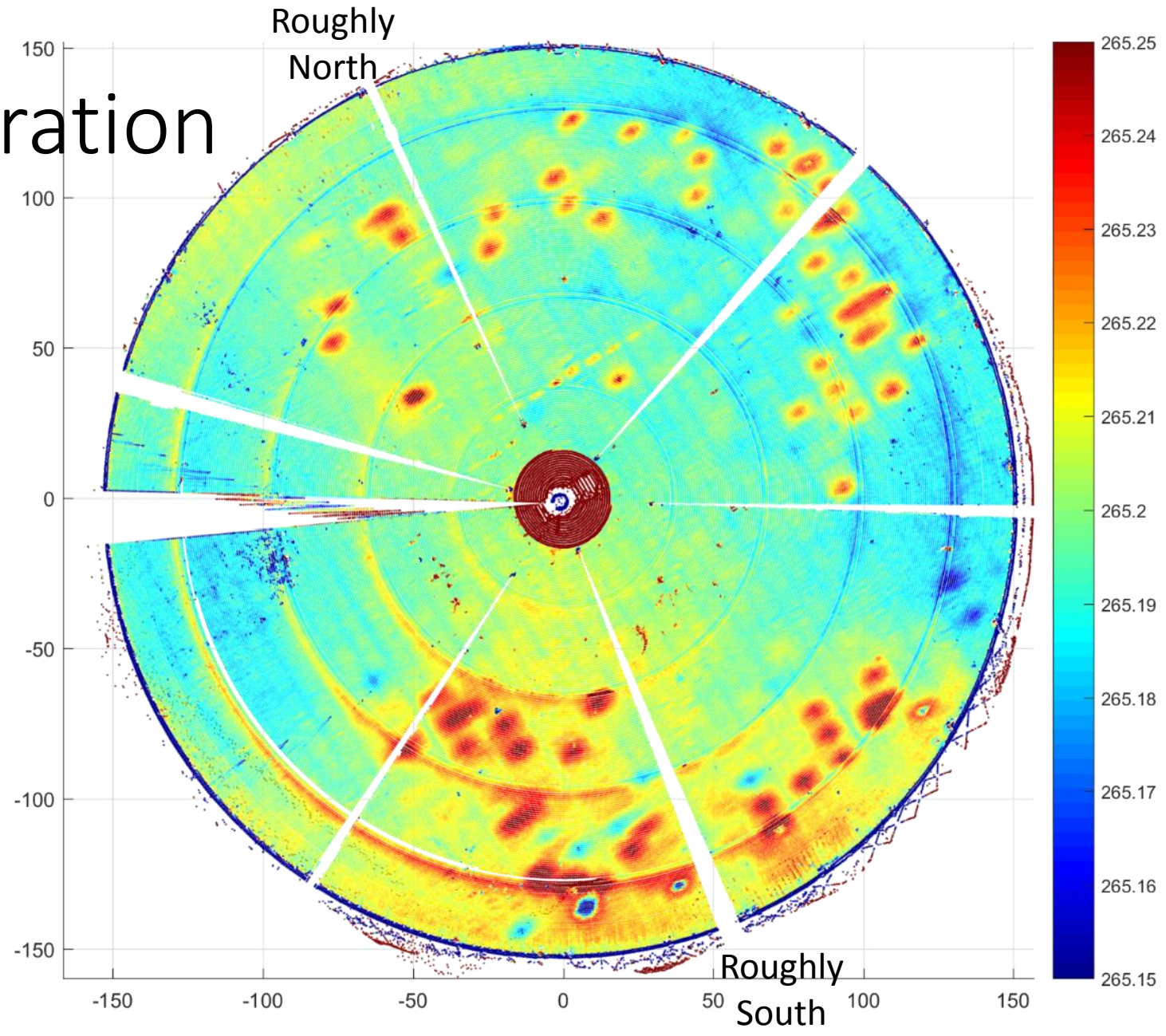
Standard deviation of point by point radial estimates within each voxel divided by the square root of the number of measurements with each voxel

Aberration



Average deviation from 265.2m radius for each voxel

Takeaways

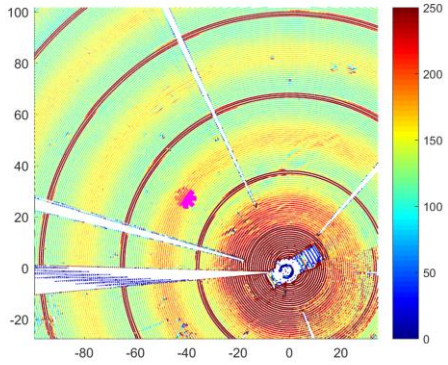
- Calibration still needs to be fine tuned

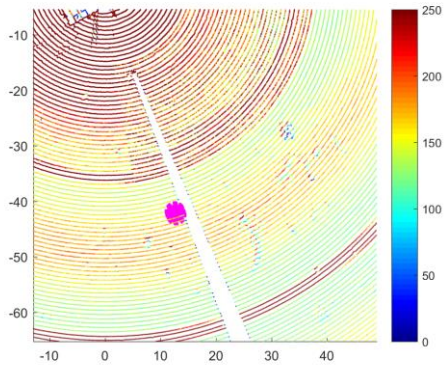
- “Hot spots” correspond to vegetation in a few cases, but the majority seem to be real deviations
  - Would be good to understand if the pattern of hot spots corresponds to underlying cable structure / tie points

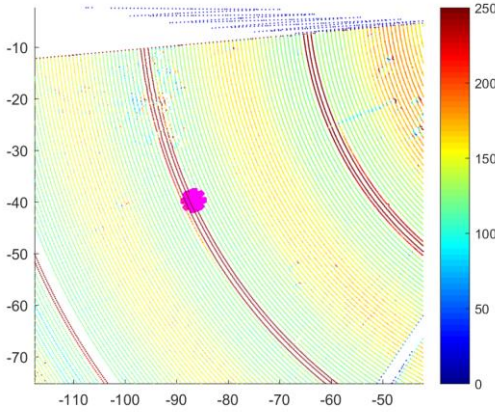
- 4GHz with this scan density is a good start
  - Denser spatial sampling and higher bandwidth would further reduce the noise, but structure is clearly present in the aberrations as it stands

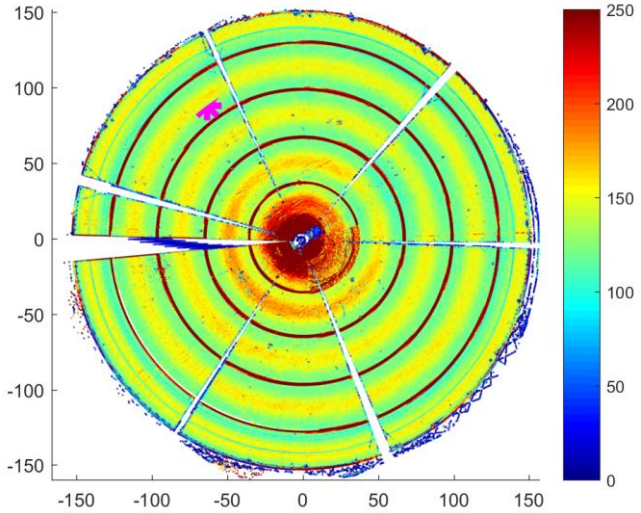
…Follow Up Questions

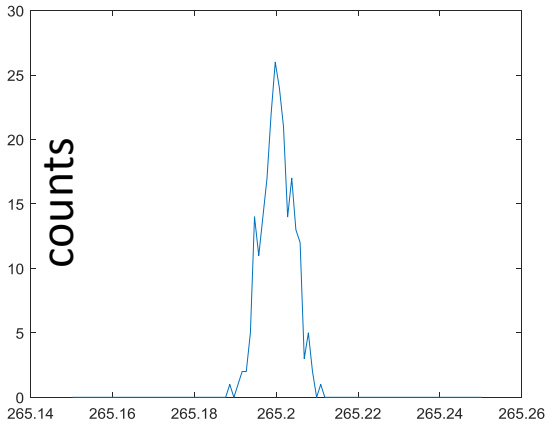
- Are points w/in voxels radially Gaussian?
  - …For the most part, yes

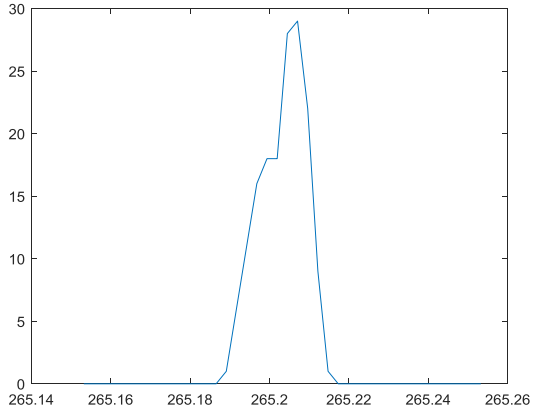


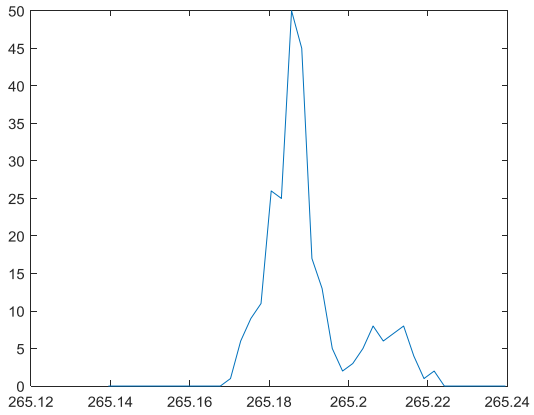


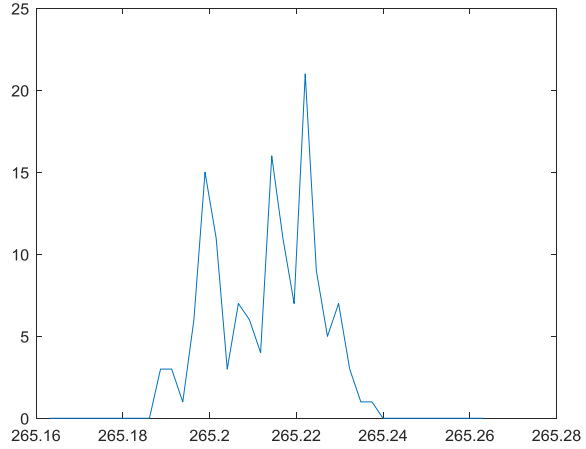












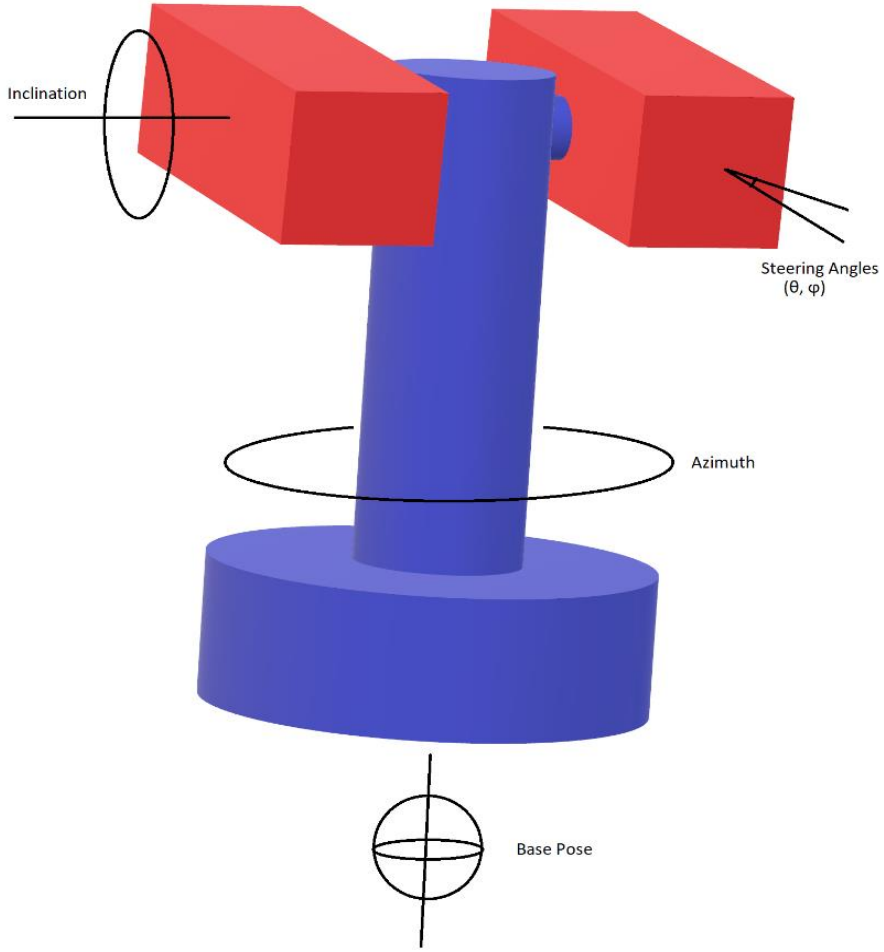
Looking Ahead

Company Update

- Dedicated team of 10 engineers now assigned to HRS tasks
- Revisions to HRS being driven by DoD customers, this engagement will benefit from continued support, testing, etc.
- Blackmore is motivated to supply and support a sensor for Arecibo

Calibration

- Complicated lever arm geometry based on pan tilt unit at heart of calibration problem
- The dedicated HRS team now starting to make this a priority
- Models for sensor calibration can be shared
  - Dual quaternion with other assumptions
- Data driven approach under investigation to minimize calibration error
  - Currently being refined for use in online calibration of mobile lidar extrinsic parameters
  - Uses an occupancy minimization approach and retro-reflective targets of opportunity to self calibrate



Bandwidth Update

- New processing and control chip will allow larger ranging bandwidths
  - 4G maximum now extend to maximum of 15G ranging bandwidth – the approach has been tested w/ this hardware
  - Greater bandwidth = better range precision (possibly sub mm)
  - Better resolution will also help dodge vegetation clutter
- New Xilinx chips are in-house and first rev of new board is undergoing testing
- Processing algorithms are a direct port as underlying FPGA / MPSoC architecture is identical
  - Tweaks to algorithms can be considered to better address this application

Update

- Mechanical modifications are planned for September/October timeframe
  - Reduce system weight
  - Improve manufacturability / serviceability
- Modifications will also remove undue complications to the calibration
- Firmware bug discovered that limited observation of retro-reflective targets
  - New data can demonstrate this improvement for use in survey of sensor position

Cost and Timeline, Other

- Price point driven by DoD customer
- Unit cost can be offset by inclusion of support / training / control software
- Possible follow up test by November, dedicated unit delivery by Q1 2019
- Interest from local director in documentary

Proposed Calibration Workflow

- Semi-permanent installation at A09 will provide the best overall vantage point
  - HRS used to monitor dish calibration “in situ”
  - HRS could also track receiver position
- Data processing is very efficient
  - All shared results processed on business laptop…
  - Highly automated workflow could guide dish adjustment in real time
  - System operated from control room over dedicated network connection
  - Routines programmed through API
- Blackmore would like to include Arecibo employees and students in a possible effort