MAPPING THE LWA POWER PATTERN

D. JACOBS – ARIZONA STATE UNIVERSITY

LWA USERS MEETING, JULY 30 2020

AST-1711179

THE ECHO TEAM

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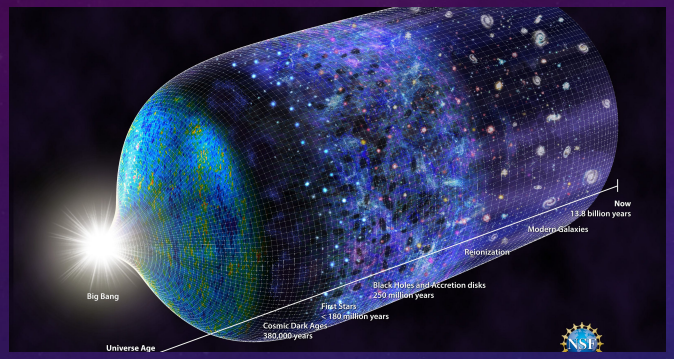
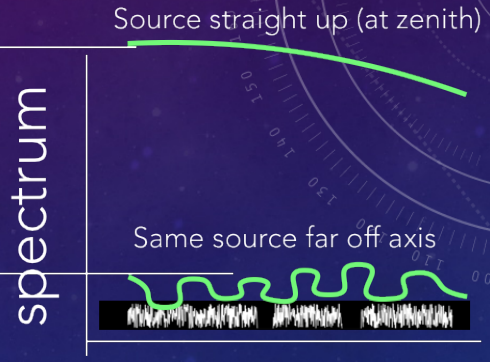
(ASU Engineer)

MOTIVATION #1: COSMIC DAWN FOREGROUNDS

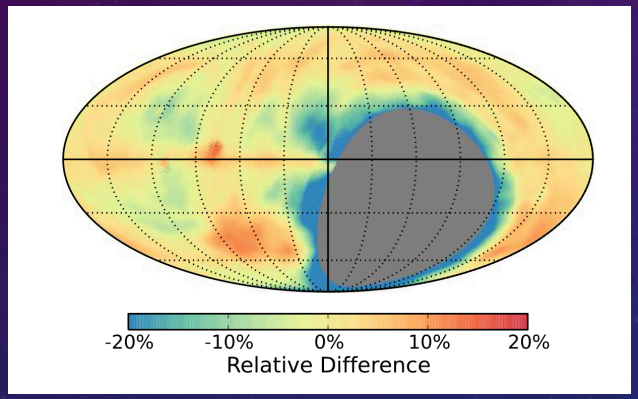




Requirement: Accurate map of in-situ beam pattern to 1% in FWHM, 10% outside (Ewall-wice et al 2017)

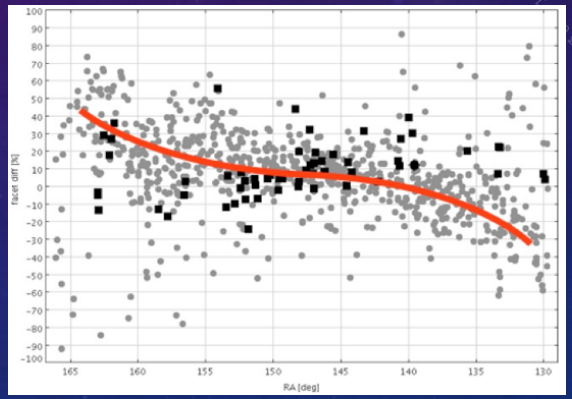
MOTIVATION #2: IMAGING

LWA Sky Survey % difference from GSM



Dowell et al 2017

% Flux Difference between two MWA pointings

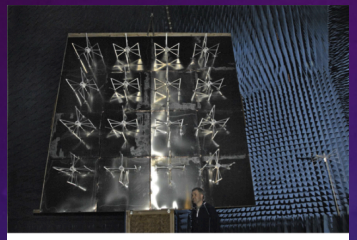


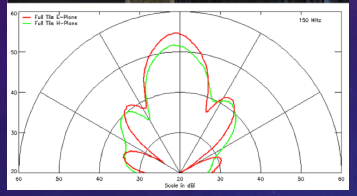
Jacobs et al 2013

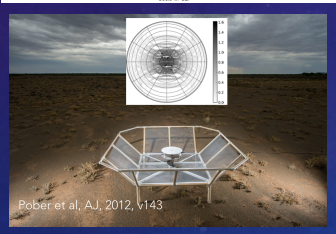
Requirement: (whatever you want your flux or polarization accuracy to be)

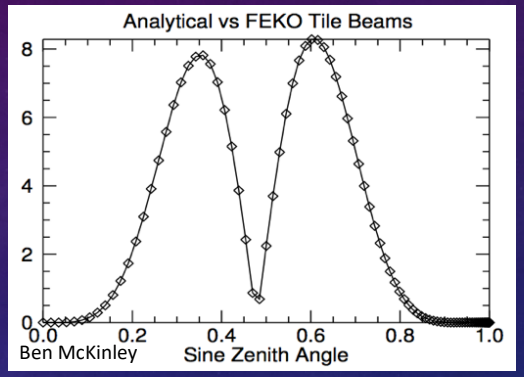
HISTORY OF BEAM MAPPING (BRIEF)

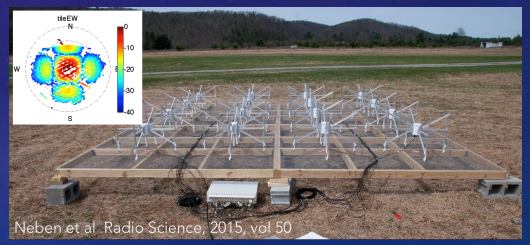
- Anechoic Chambers
- Range testing
- E&M models
- Sky sources
- Satellites
- Helicopters (real ones)
- **Drones**











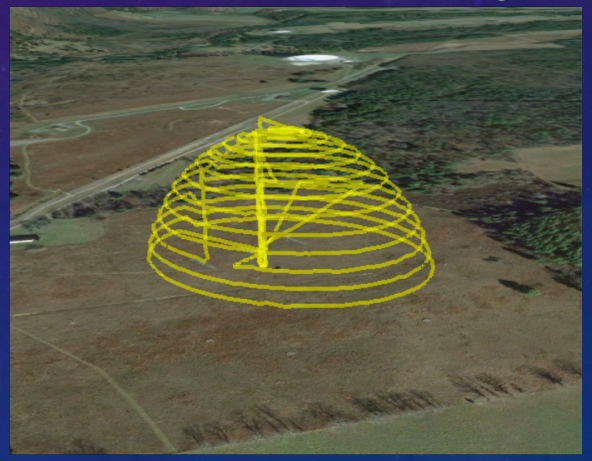
Requirement: Map beam voltage pattern to better than 1% to horizon.
Goal: Improve on previous methods in terms of speed, reliability, repeatability, spectral coverage, polarization, etc

EXTERNAL CALIBRATOR FOR HYDROGEN OBSERVATORIES

Transmits known Calibration signal

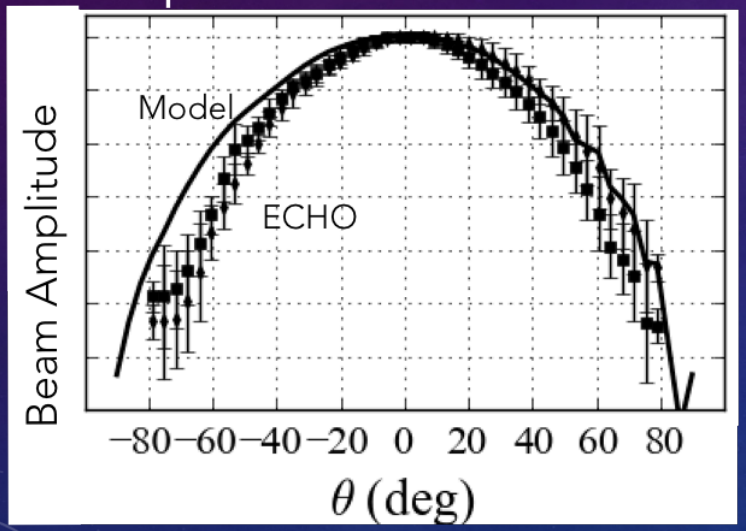
record amplitude as a function of GPS position

Complete spatial coverage



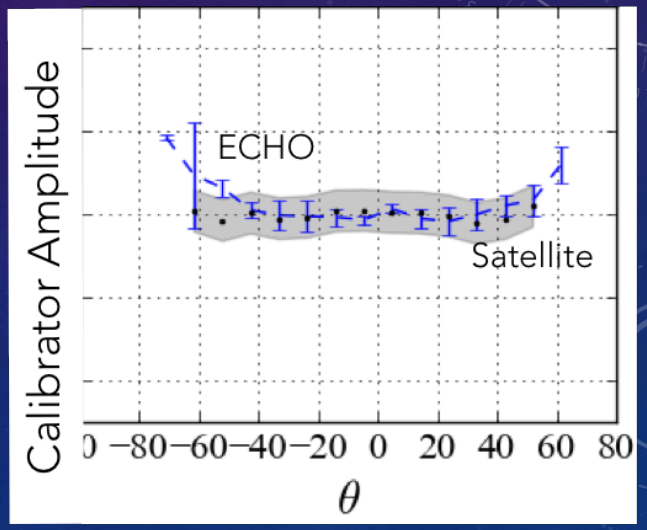
ECHO TEST PERFORMANCE

Comparison with Model



angle from zenith

Comparison with other data

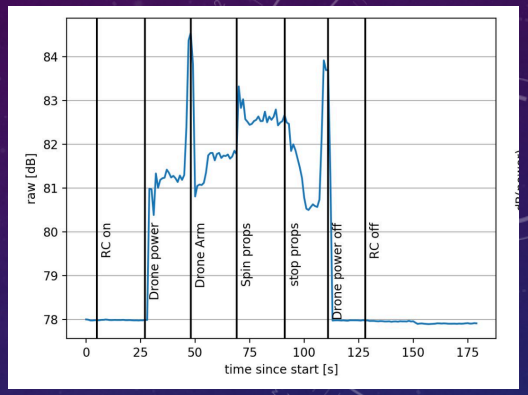


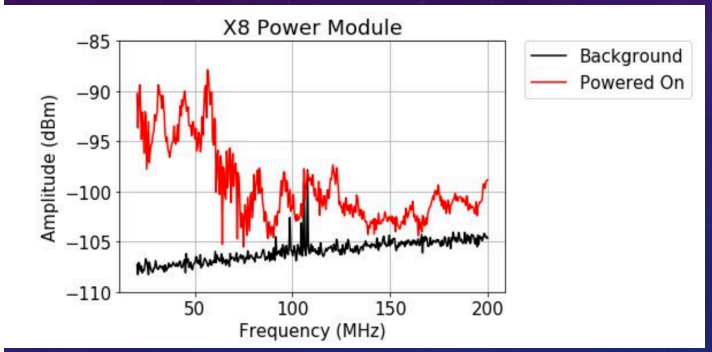
angle from zenith

Jacobs et al 2017

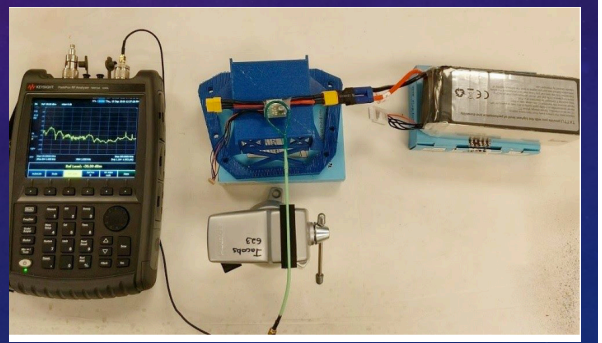
MITIGATING SELF INTERFERENCE

Power supply radiation, discovered in testing at OVRO

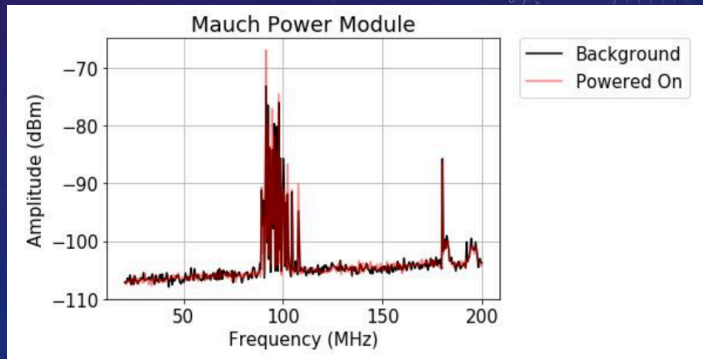




Noisy Power supply



H Probe test setup

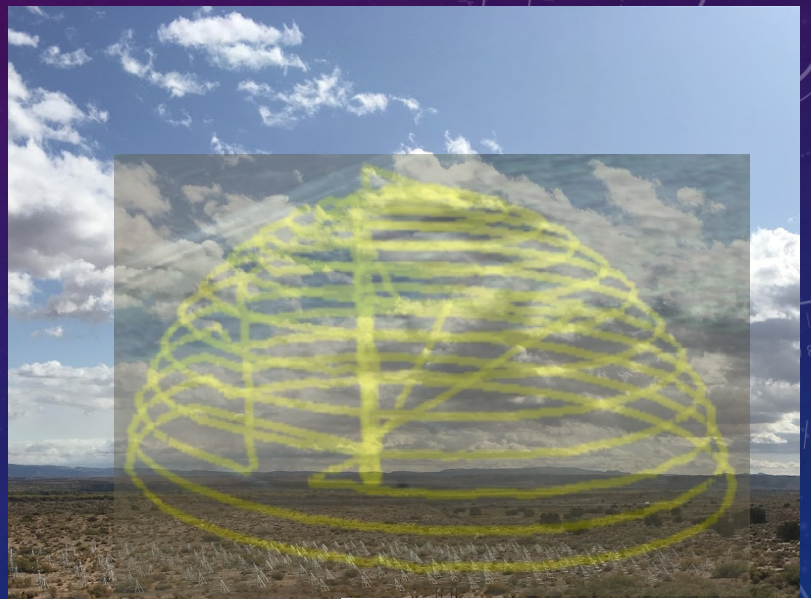


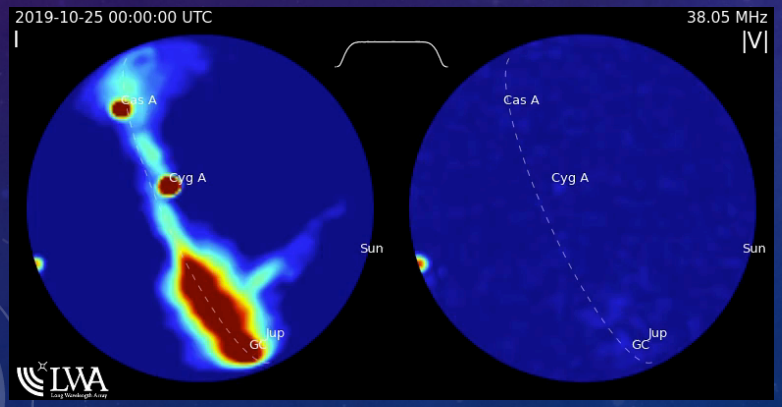
Best power supply

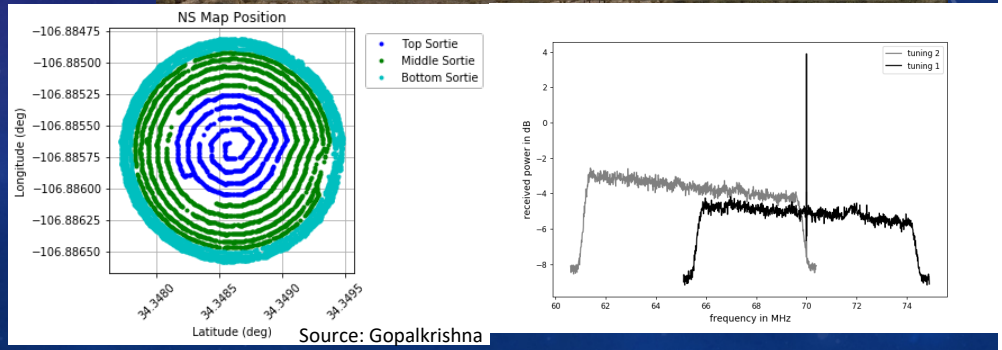
See ECHO Memo #30 danielcjacobs.com/echo/memos

SEVILLETA MAPPING CAMPAIGN

- October 2019
- Mapped single central antenna
- Beamformer mode (with all other ants x0)
- Recorded Spectra every 0.1s
- Transmitter: tone at 70MHz, -15dBm



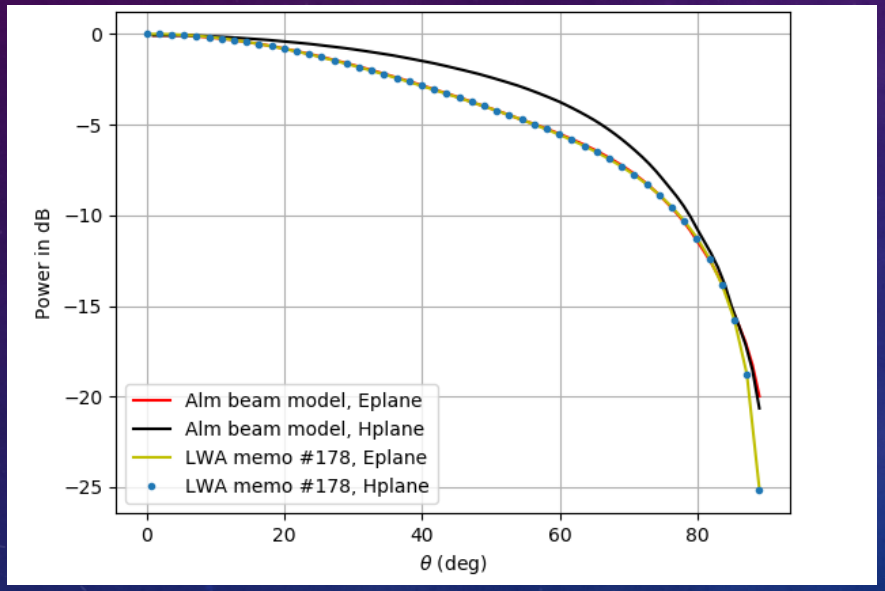




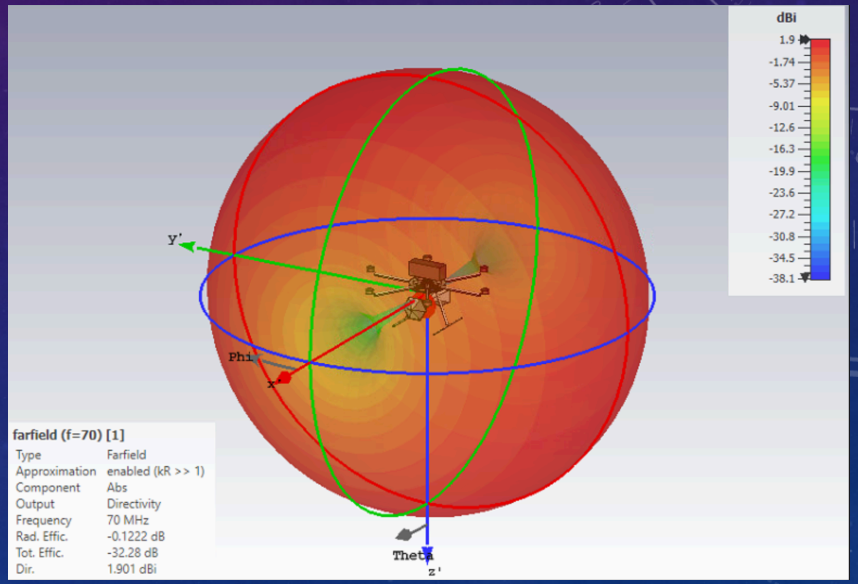
Source: Gopalkrishna

MODEL (RX BEAM + TX BEAM + PATH LOSS)

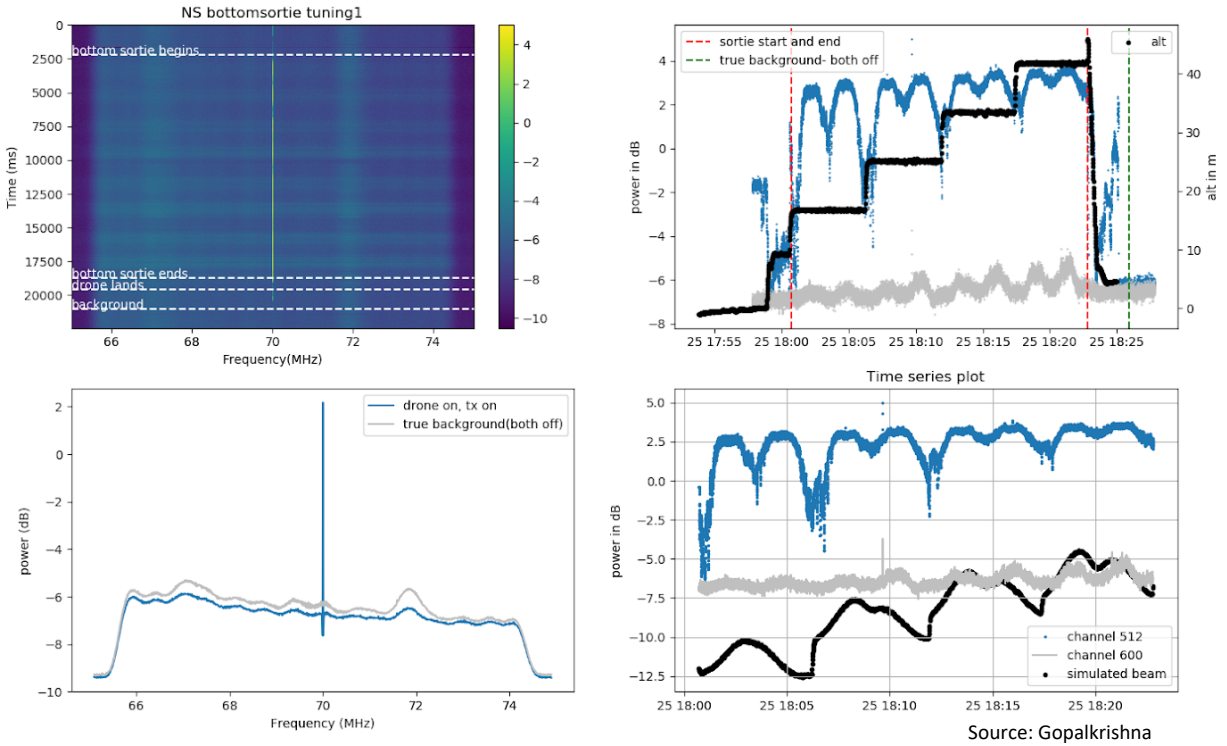
LWA Beam Model



CST Drone Model

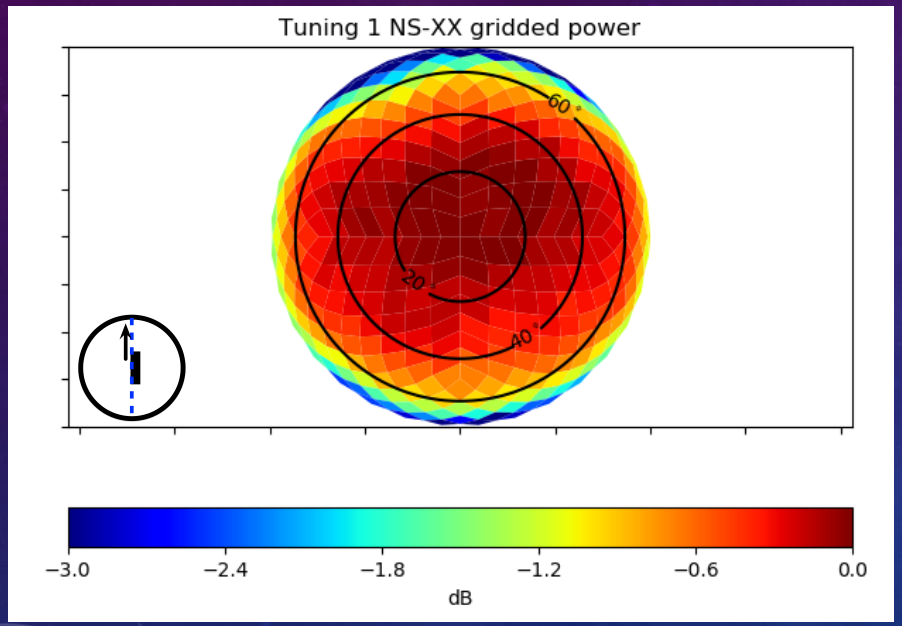


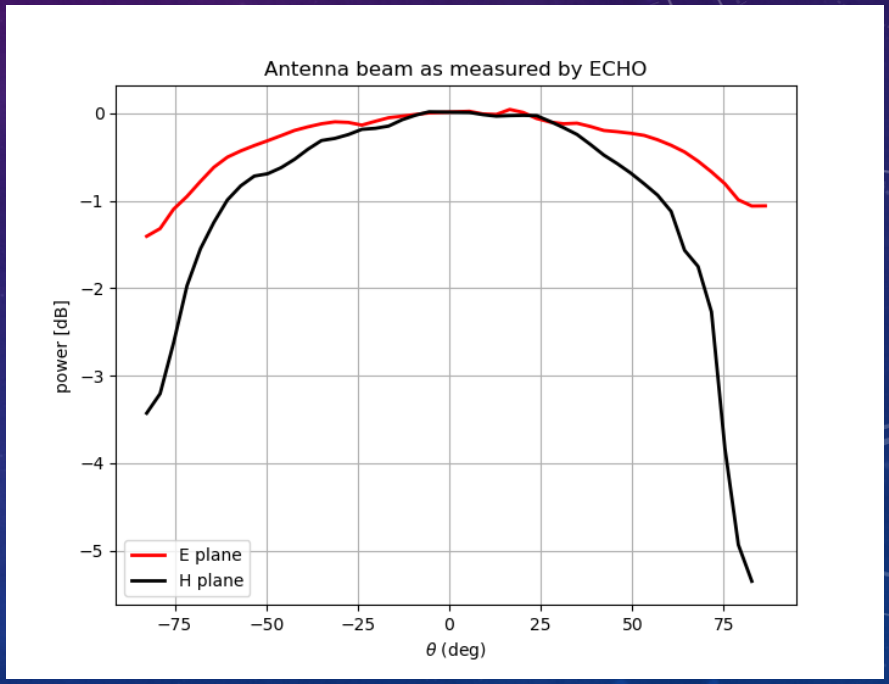
EXAMPLE DATA



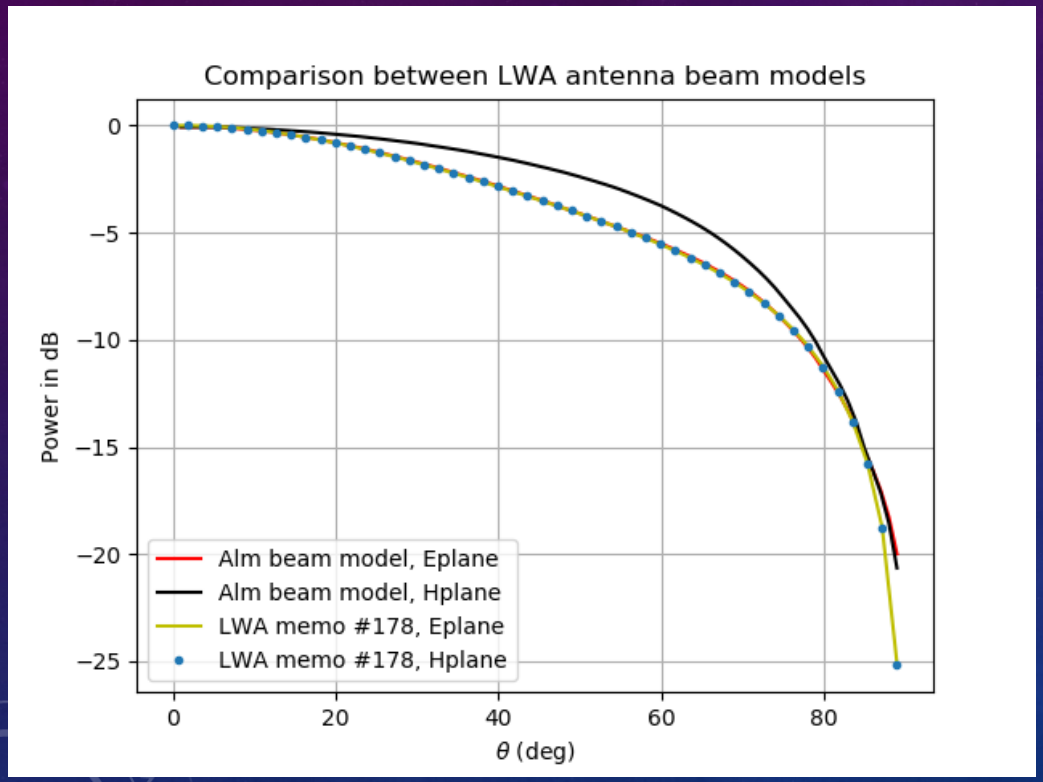
Source: Gopalkrishna

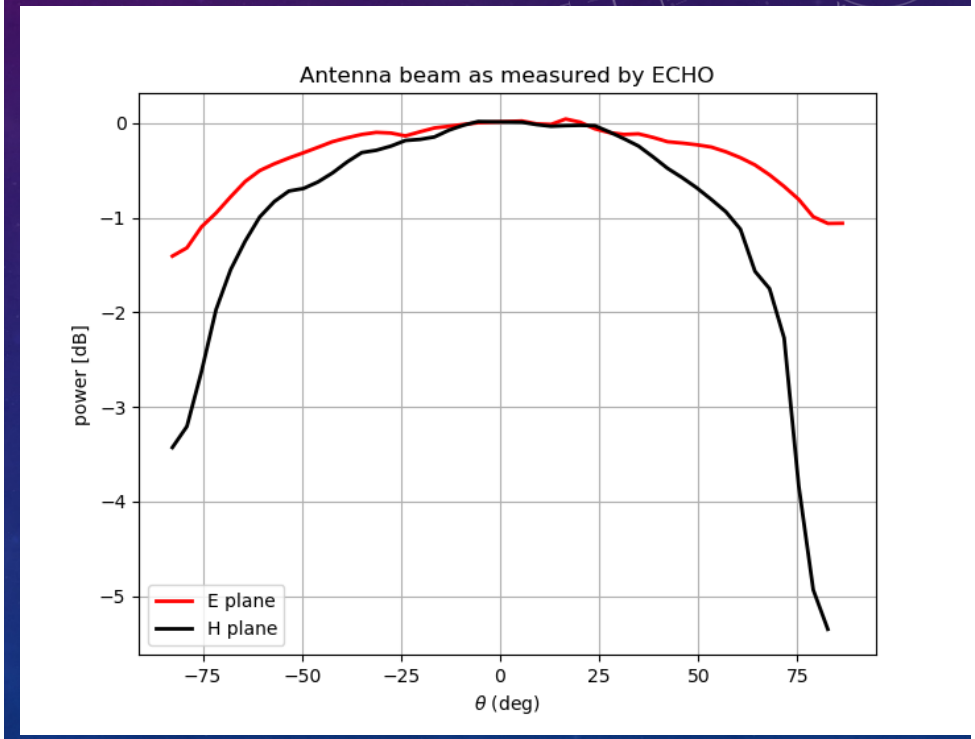
RESULTING BEAM MAP





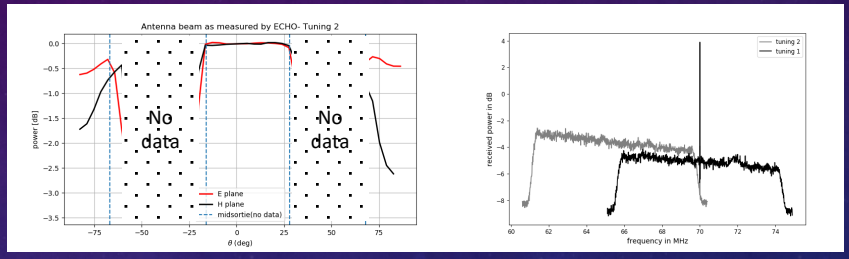
COMPARISON TO MODEL (SOMETHINGS A BIT OFF…)



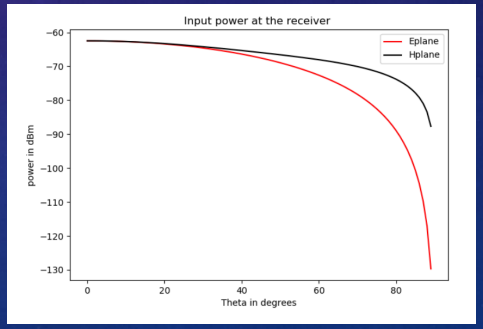


POTENTIAL ISSUES EXAMINED

- Digital compression/clipping
- Analog compression
- Tx power drift
- Analysis Bug

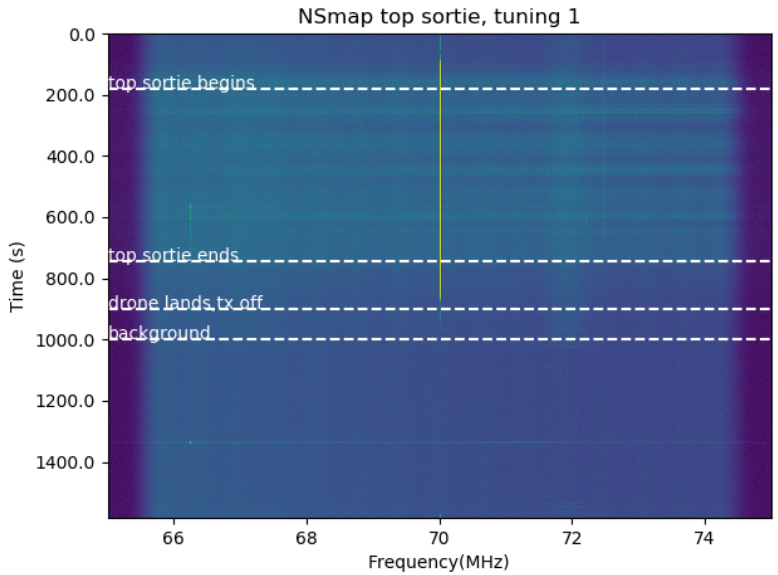


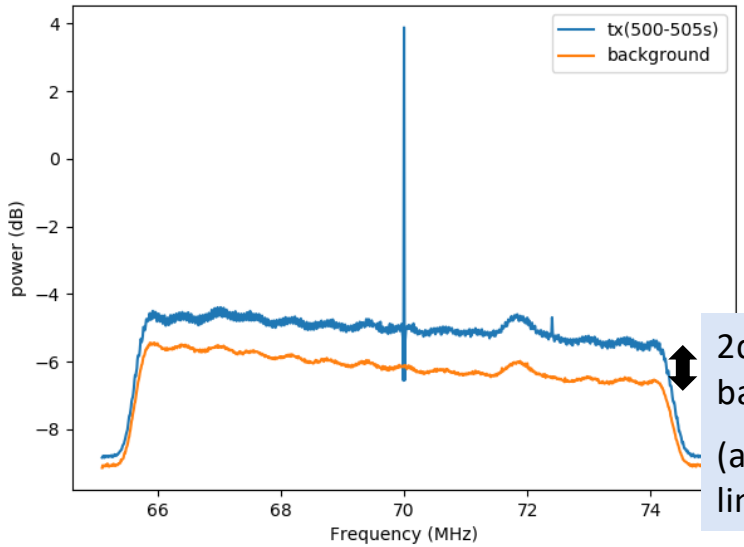
Tuning 2 with tone in digital passband rolloff, still compressed.
Probably not digital compresion



Simulated power level at LNA <-60dBm
Well below compression point -18dB
(Ellingson 2013)

SELF EMI ASSESSMENT

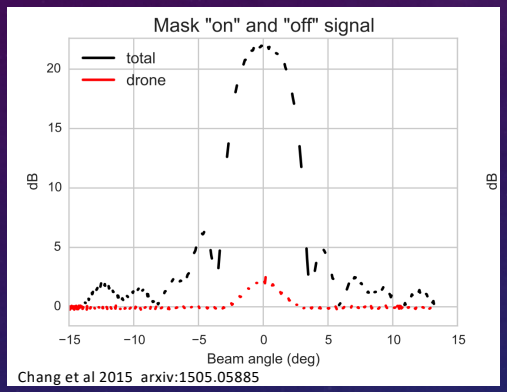




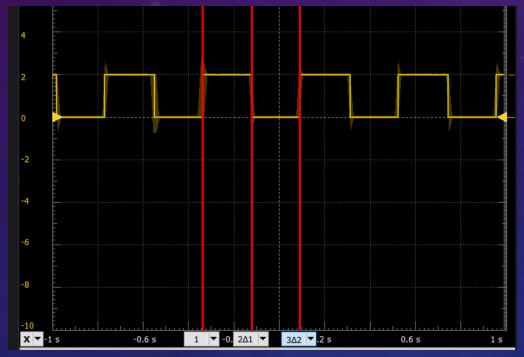
2dB above background?

(assuming linearity prevails)

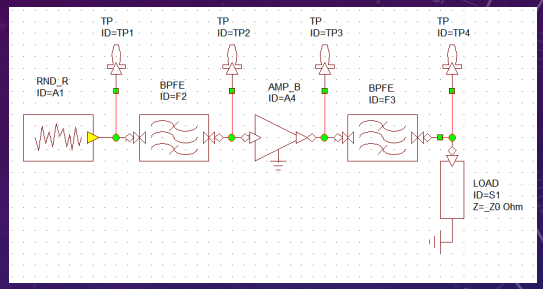
CURRENT WORK

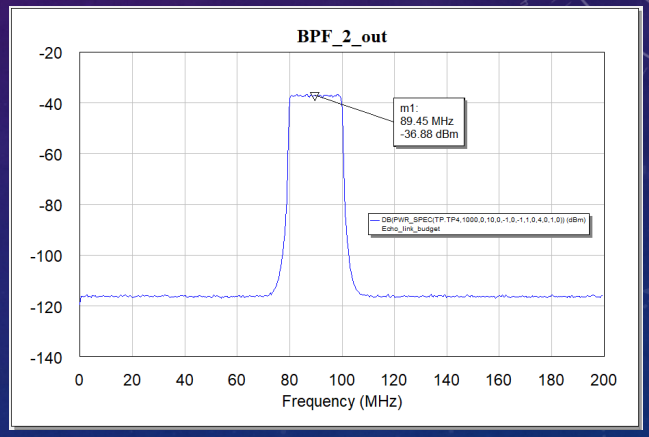


Transmitter Chopper



Status: Breadboard prototype
(Mickey Horn)

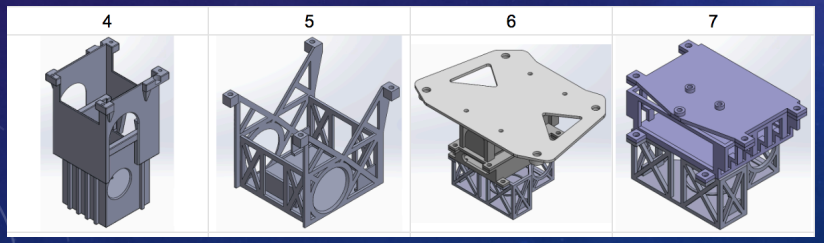


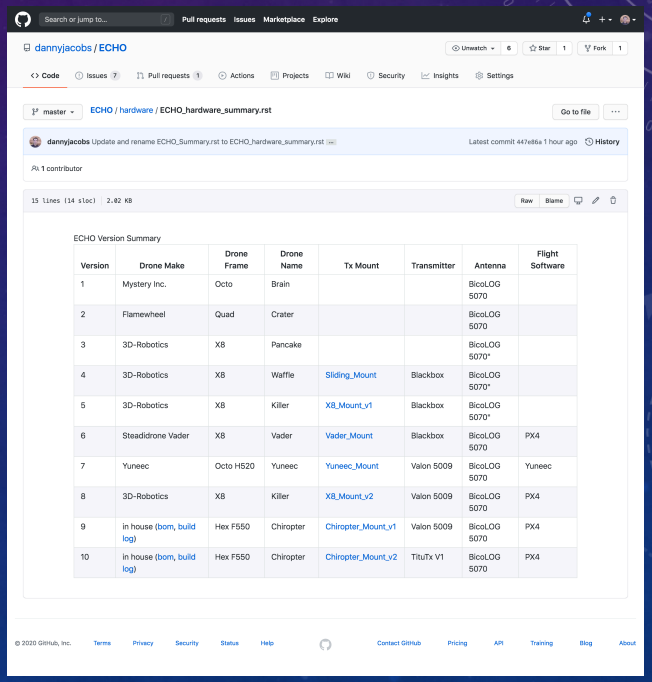


Wideband noise source
V1 prototype ordered (Titu Samson)

ECHO IS OPEN SOURCE HARDWARE AND SOFTWARE!

github.com/dannyjacobs/ECHO | danielcjacobs.com/research/ECHO





dannyjacobs / ECHO

ECHO / hardware / ECHO_hardware_summary.rst

ECHO Version Summary

Version	Drone Make	Drone Frame	Drone Name	Tx Mount	Transmitter	Antenna	Flight Software
1	Mystery Inc.	Octo	Brain			BicoLOG 5070	
2	Flamewheel	Quad	Crater			BicoLOG 5070	
3	3D-Robotics	X8	Pancake			BicoLOG 5070*	
4	3D-Robotics	X8	Waffle	Sliding_Mount	Blackbox	BicoLOG 5070*	
5	3D-Robotics	X8	Killer	X8_Mount_v1	Blackbox	BicoLOG 5070*	
6	Steadidrone Vader	X8	Vader	Vader_Mount	Blackbox	BicoLOG 5070	PX4
7	Yuneec	Octo H520	Yuneec	Yuneec_Mount	Valon 5009	BicoLOG 5070	Yuneec
8	3D-Robotics	X8	Killer	X8_Mount_v2	Valon 5009	BicoLOG 5070	PX4
9	in house (bom, build log)	Hex F550	Chiropter	Chiropter_Mount_v1	Valon 5009	BicoLOG 5070	PX4
10	in house (bom, build log)	Hex F550	Chiropter	Chiropter_Mount_v2	TituTx V1	BicoLOG 5070	PX4

THANKS!

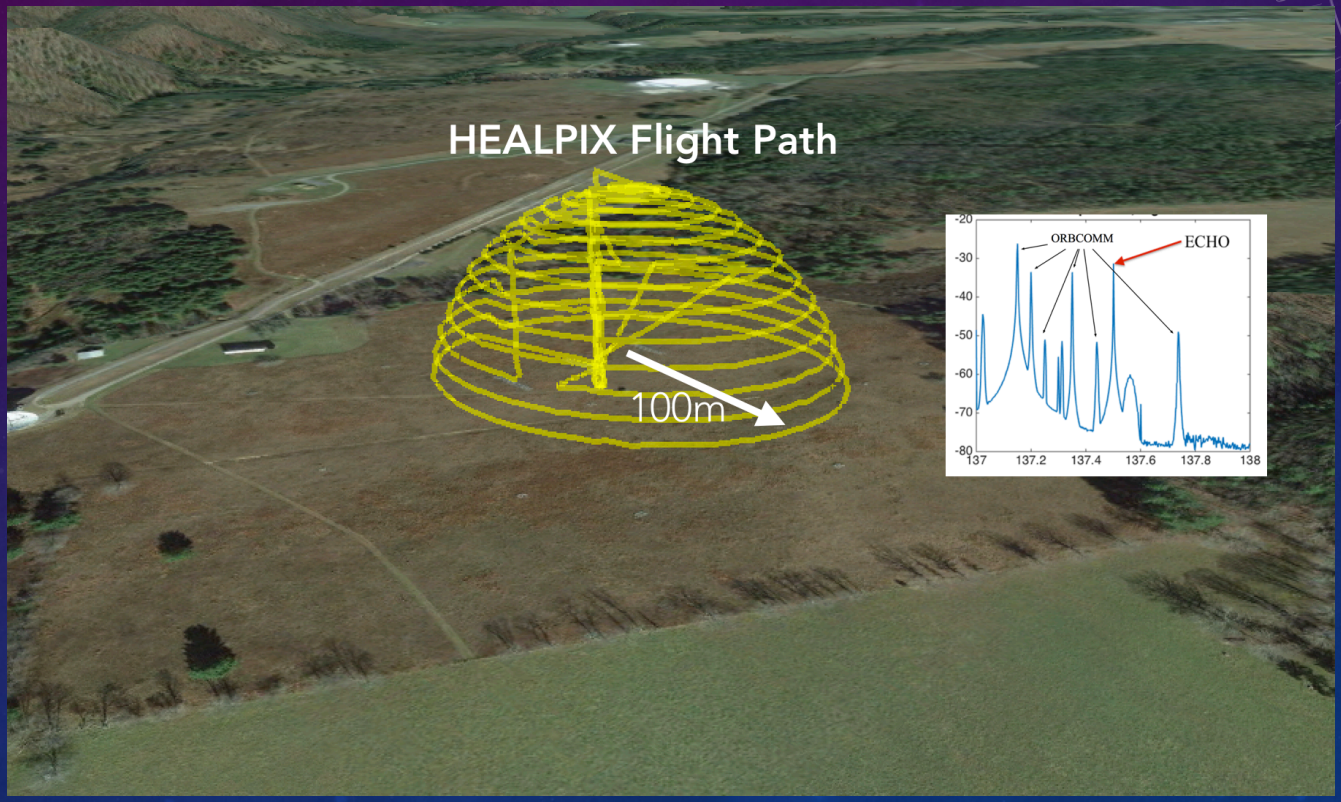
My contact: daniel.c.jacobs@asu.edu

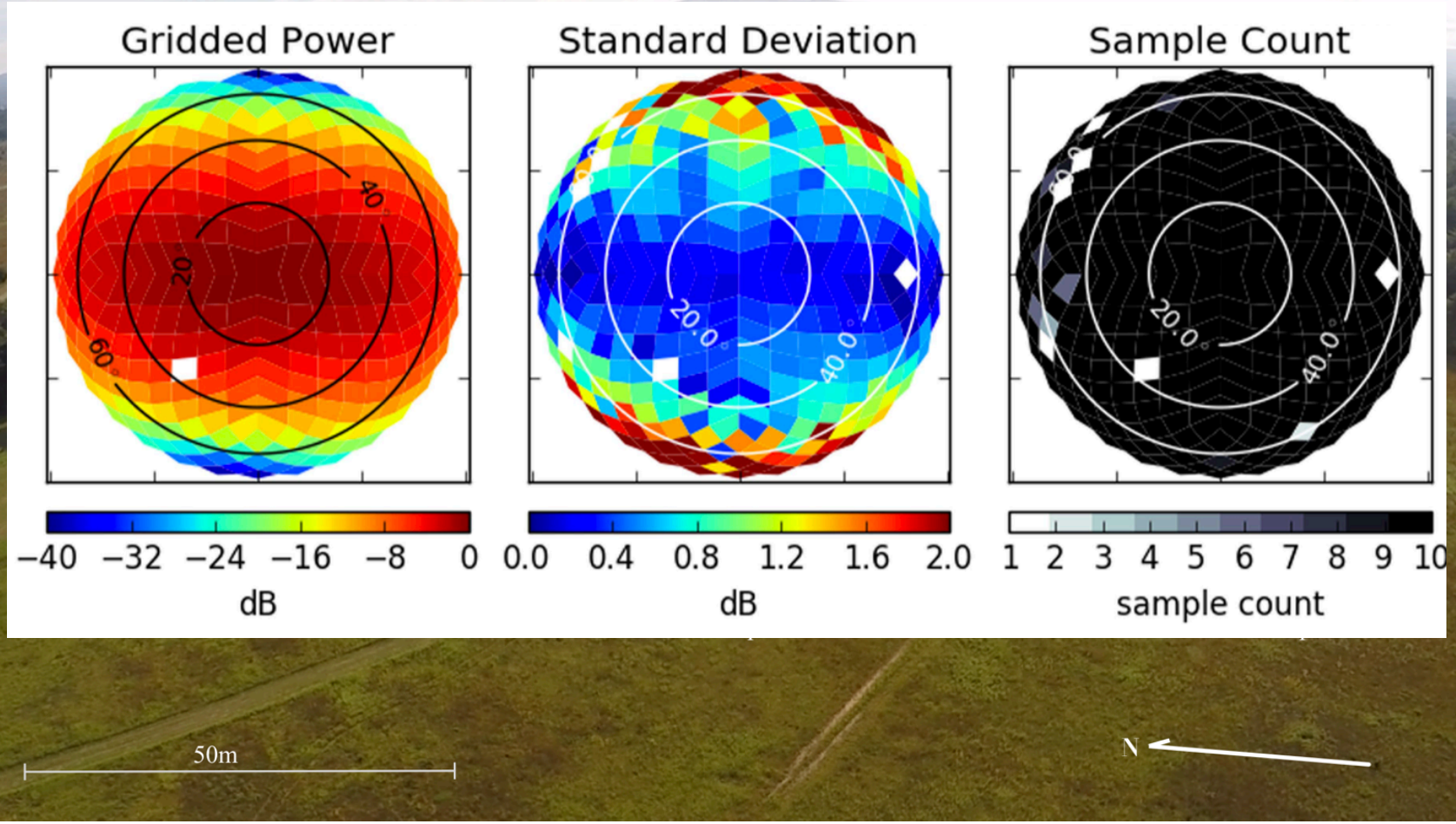
Web: danielcjacobs.com/research/ECHO

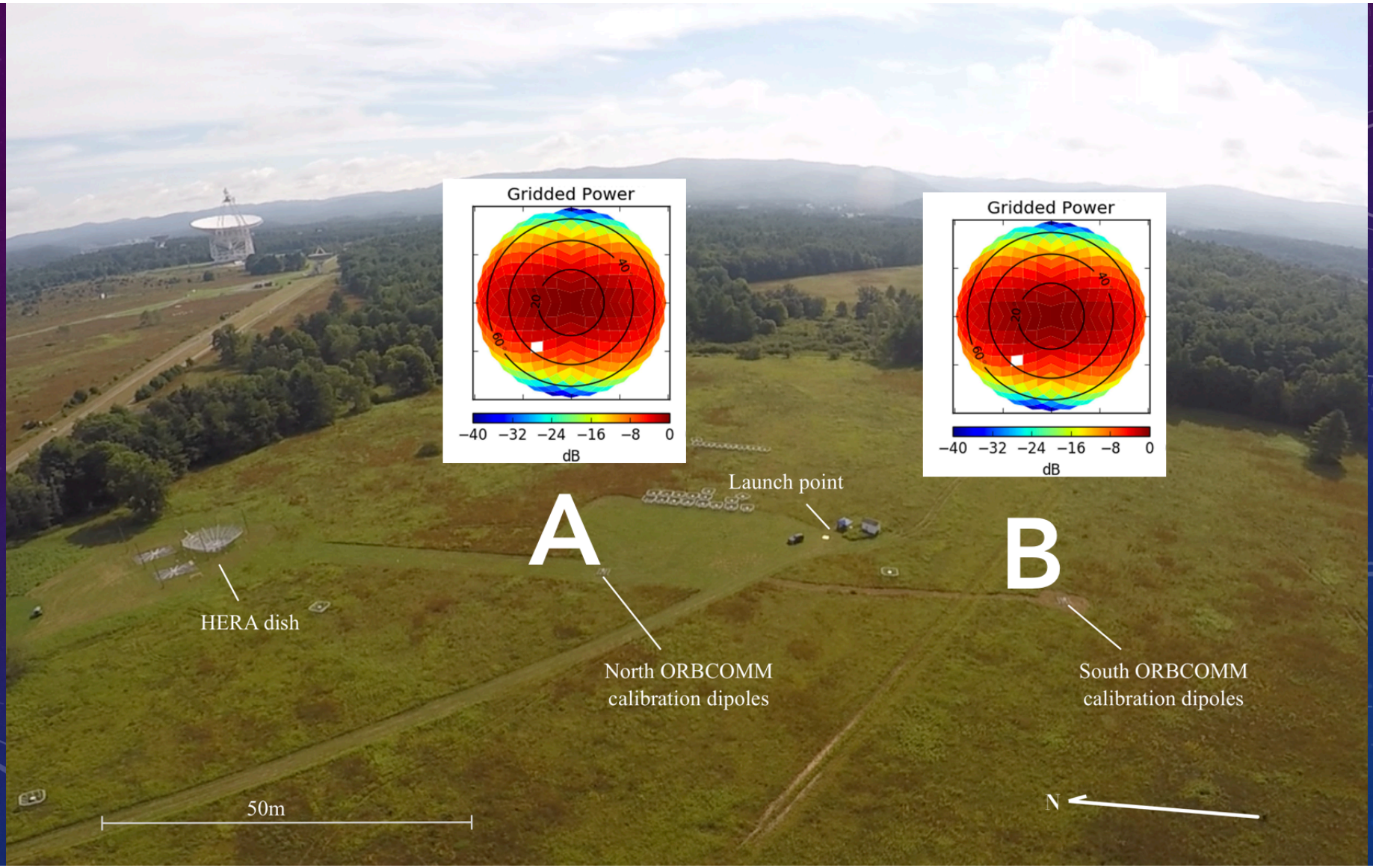
Code and Hardware: github.com/dannyjacobs/ECHO

Docs: external-calibrator-for-hydrogen-arrays-echo.readthedocs.io

FIRST DEMONSTRATION: SINGLE DIPOLE




Gridded Power
Standard Deviation
Sample Count
20
40
60
20.0°
40.0°
−40 −32 −24 −16 −8 0
dB
0.0 0.4 0.8 1.2 1.6 2.0
dB
1 2 3 4 5 6 7 8 9 10
sample count
50m
N


Gridded Power
40
20
60
−40 −32 −24 −16 −8 0
dB
Gridded Power
40
20
60
−40 −32 −24 −16 −8 0
dB
Launch point
A
B
HERA dish
North ORBCOMM
calibration dipoles
South ORBCOMM
calibration dipoles
50m
N