New SeaSonde Features for Remote Operations: Low Power Systems and Automated Antenna Patterns from AIS Vessels

Chad Whelan
CODAR Ocean Sensors

RIAM Workshop
Kyushu University
18 December 2013

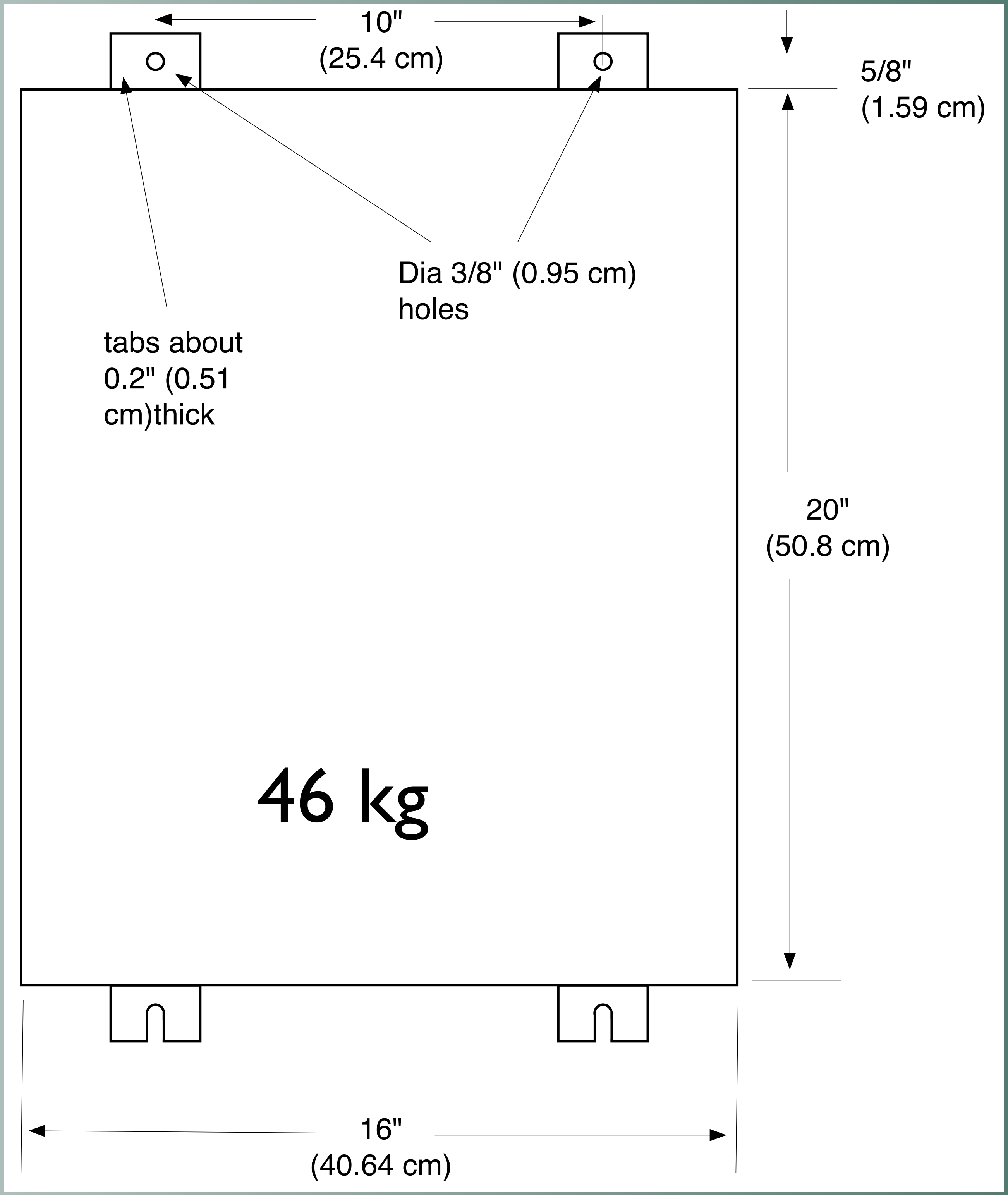
Low Power SeaSonde

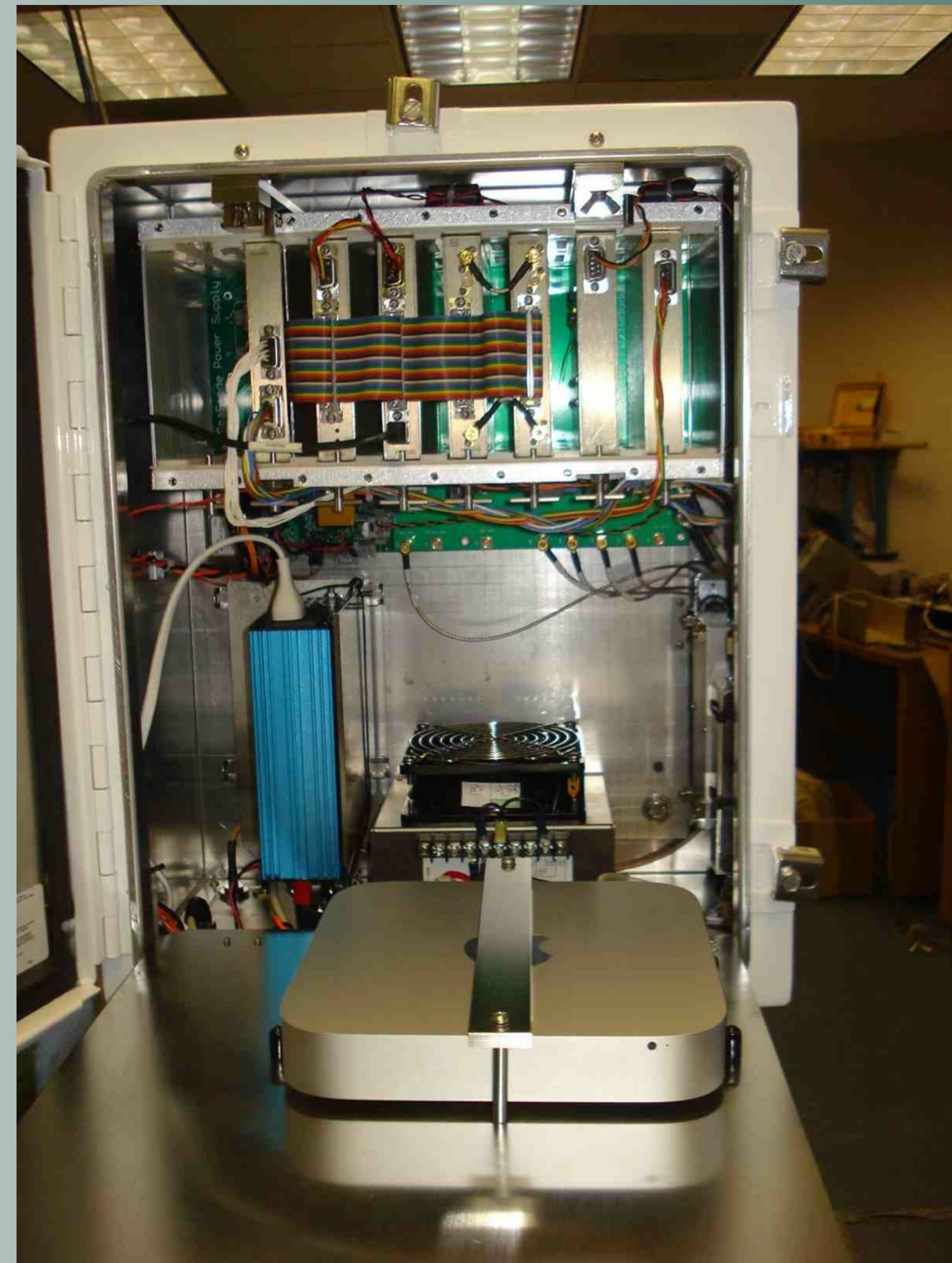
- Low Power (150-200 W)
- All-in-one weatherproof chassis
- Designed for remote & off-grid power solutions

Low Power SeaSonde

- Class E amplifier up to 85% efficient (Standard systems ~25% efficient)
- Small volume to cool
- ~150 W *Total Power* for < 27 C ambient air temp
- ~250 W *Total Power* for ~ 40C ambient air temp
- 24 V DC input (120/220 V AC input with adapter)
- Compatible with all frequencies & antennas
- Same performance as standard chassis Seasonde


SeaSonde LP
CODAR
OCEAN SENSORS


10"
(25.4 cm)
5/8"
(1.59 cm)
Dia 3/8" (0.95 cm)
holes
tabs about
0.2" (0.51
cm)thick
20"
(50.8 cm)
46 kg
16"
(40.64 cm)



CODAR Ocean Sensors
www.codar.com

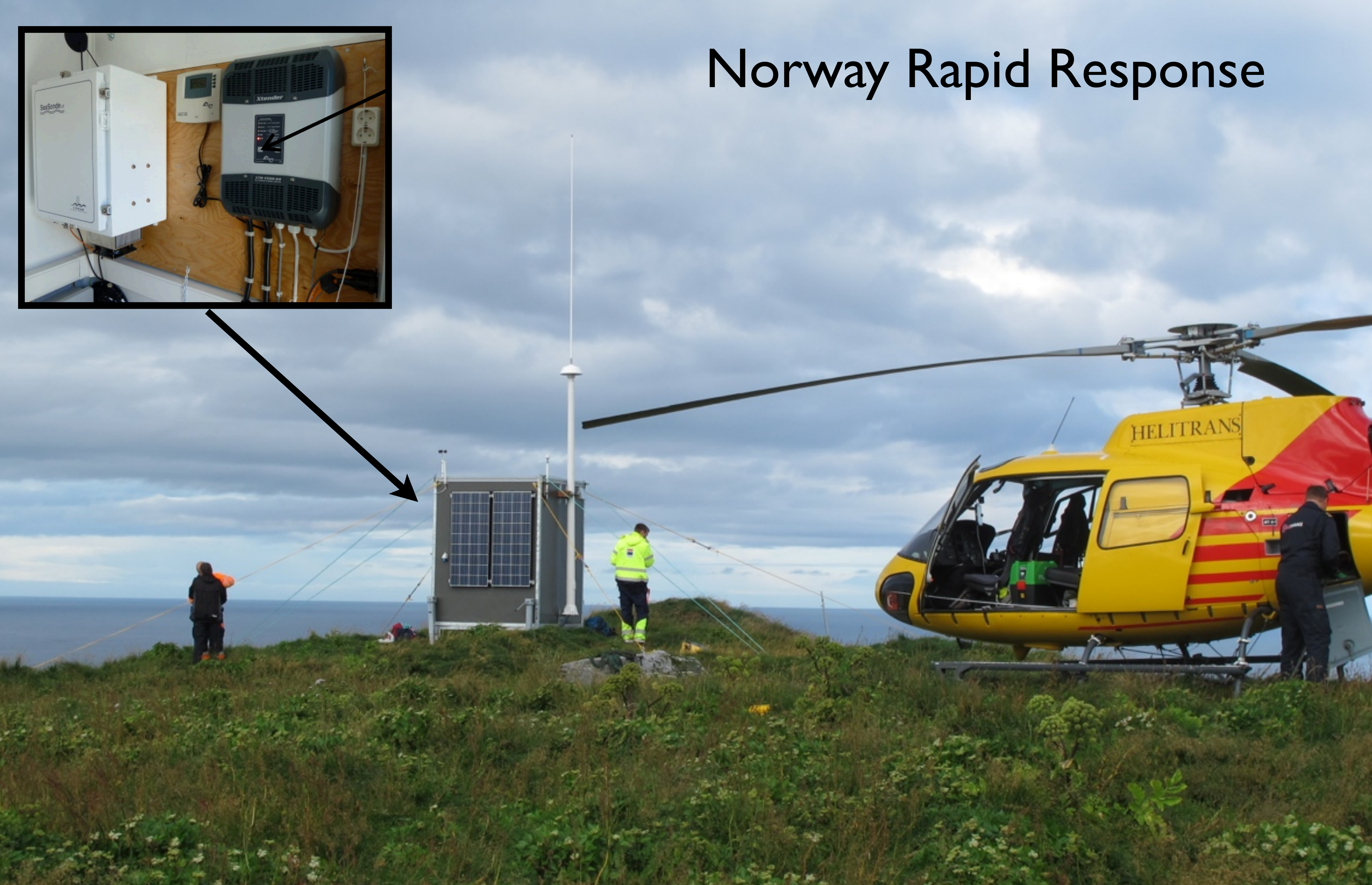
RIAM Workshop
Kyushu University
18 December 2013

Easy-Swap Modules

Wall-mountable

Norway Rapid Response

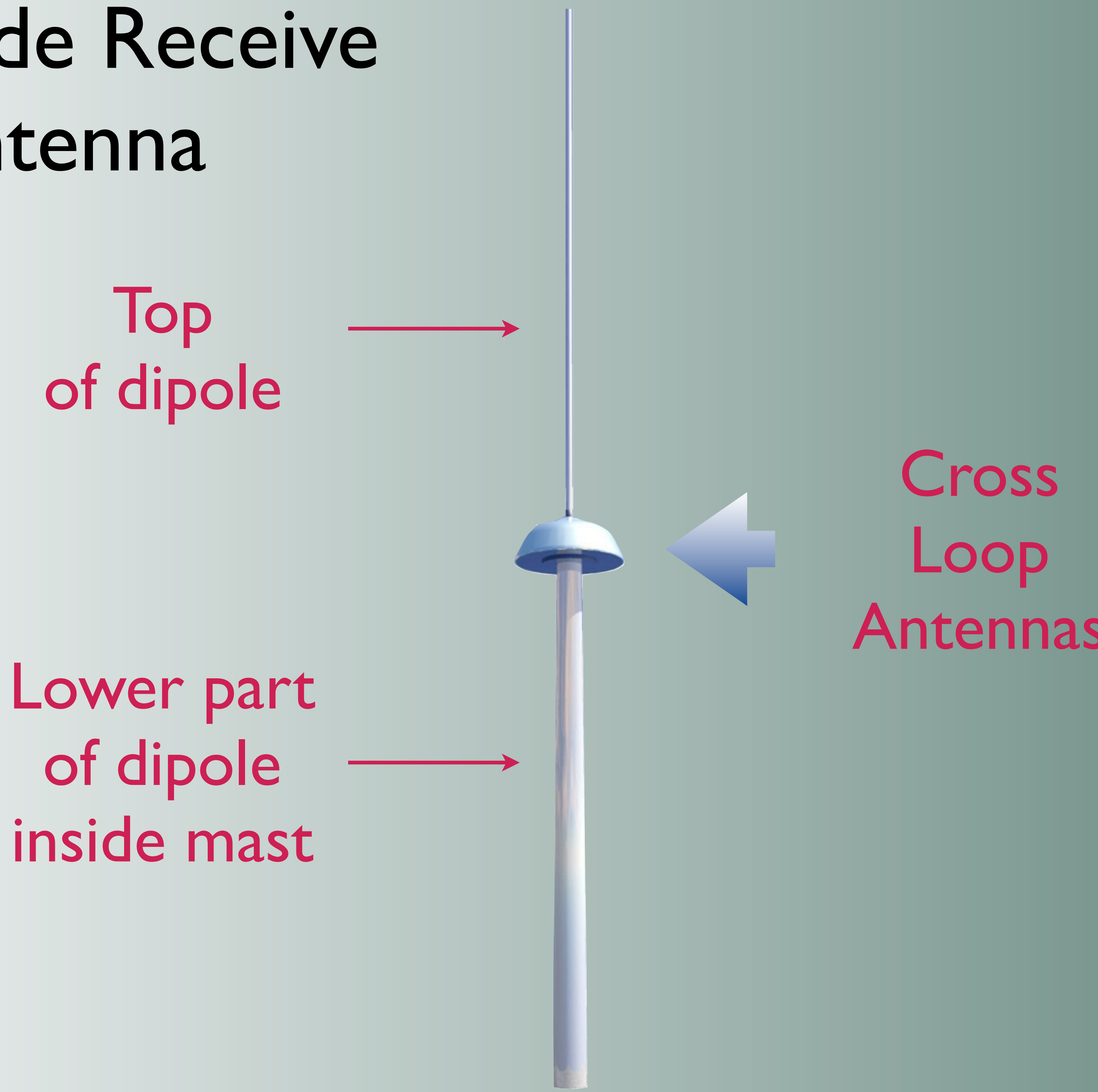
Norway Rapid Response



Use Vessel Echoes to Calibrate Antenna Pattern

Funding provided by 2011 NOAA
Small Business Innovative Research (SBIR)
Phase II Award

SeaSonde Receive Antenna



Compact Crossed Loop Omnidirectional Antenna

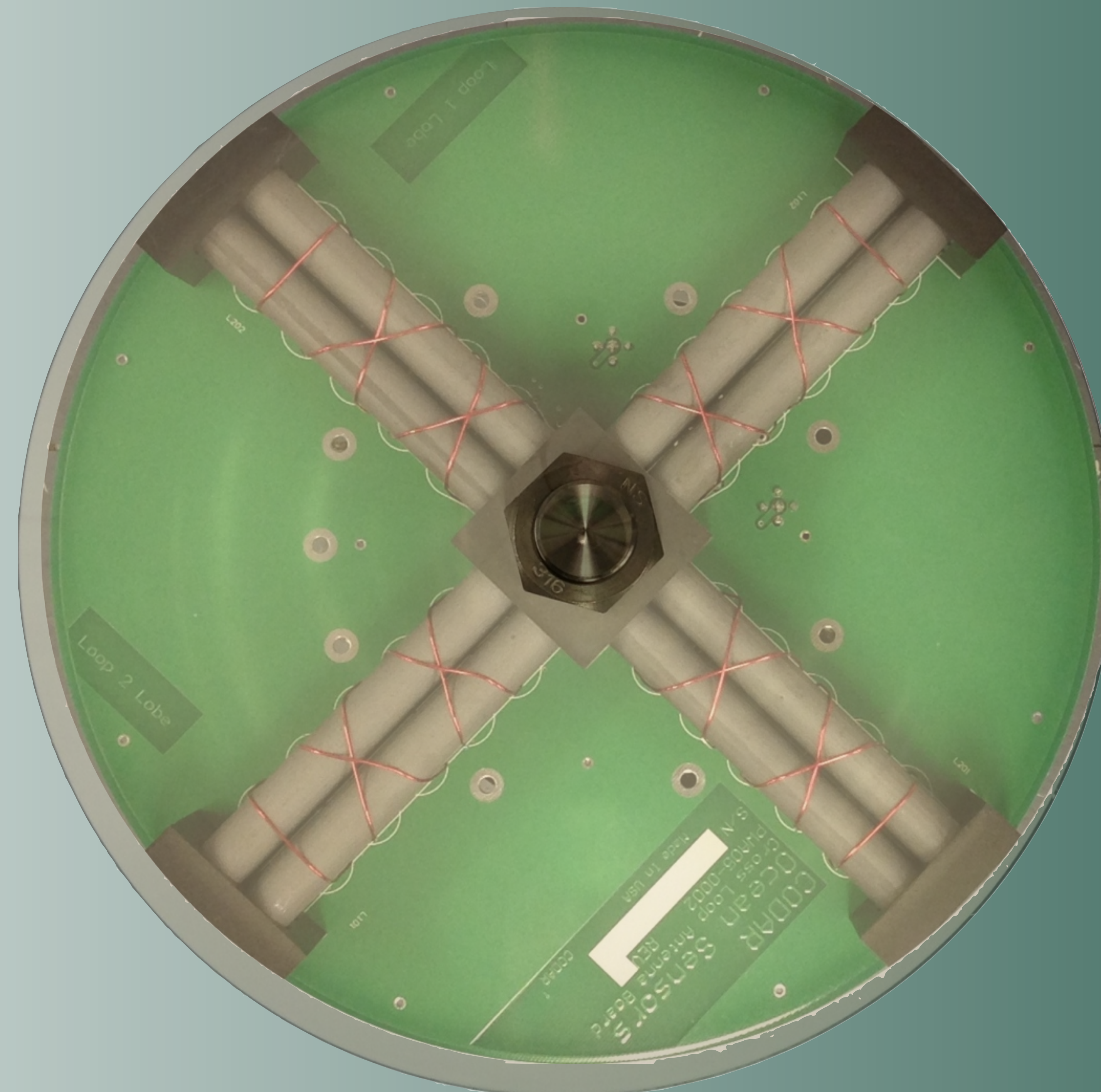
- *3 co-located antennas*
- *Unique combination of amplitude & phase for each antenna = 6 parameters for each bearing*
- *MUSIC Direction Finding on each Doppler bin*

Compact Crossed Loop Omnidirectional Antenna

- *3 co-located antennas*

- *Unique combination of amplitude & phase for each antenna = 6 parameters for each bearing*

- *MUSIC Direction Finding on each Doppler bin*

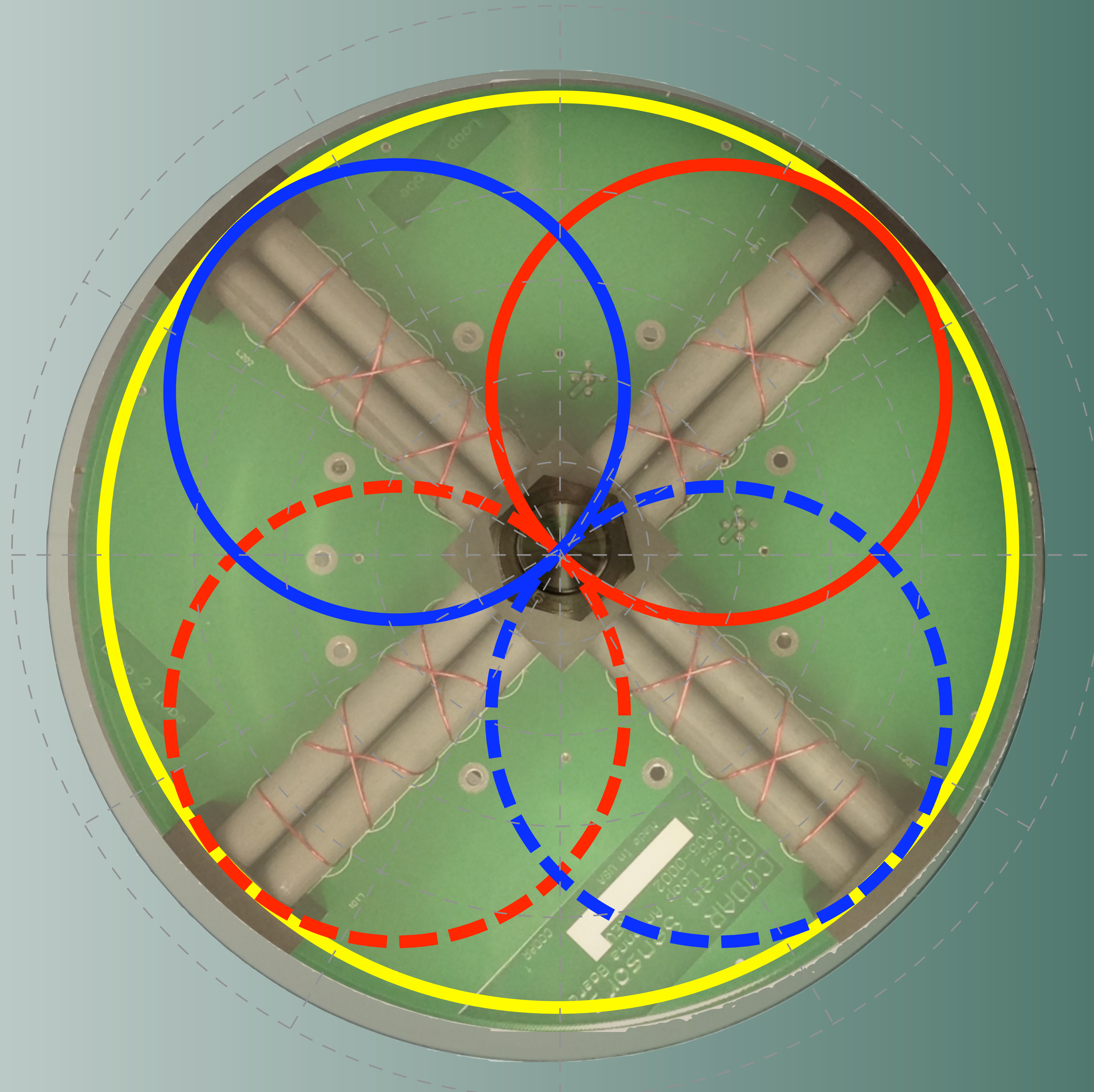


Compact Crossed Loop Omnidirectional Antenna

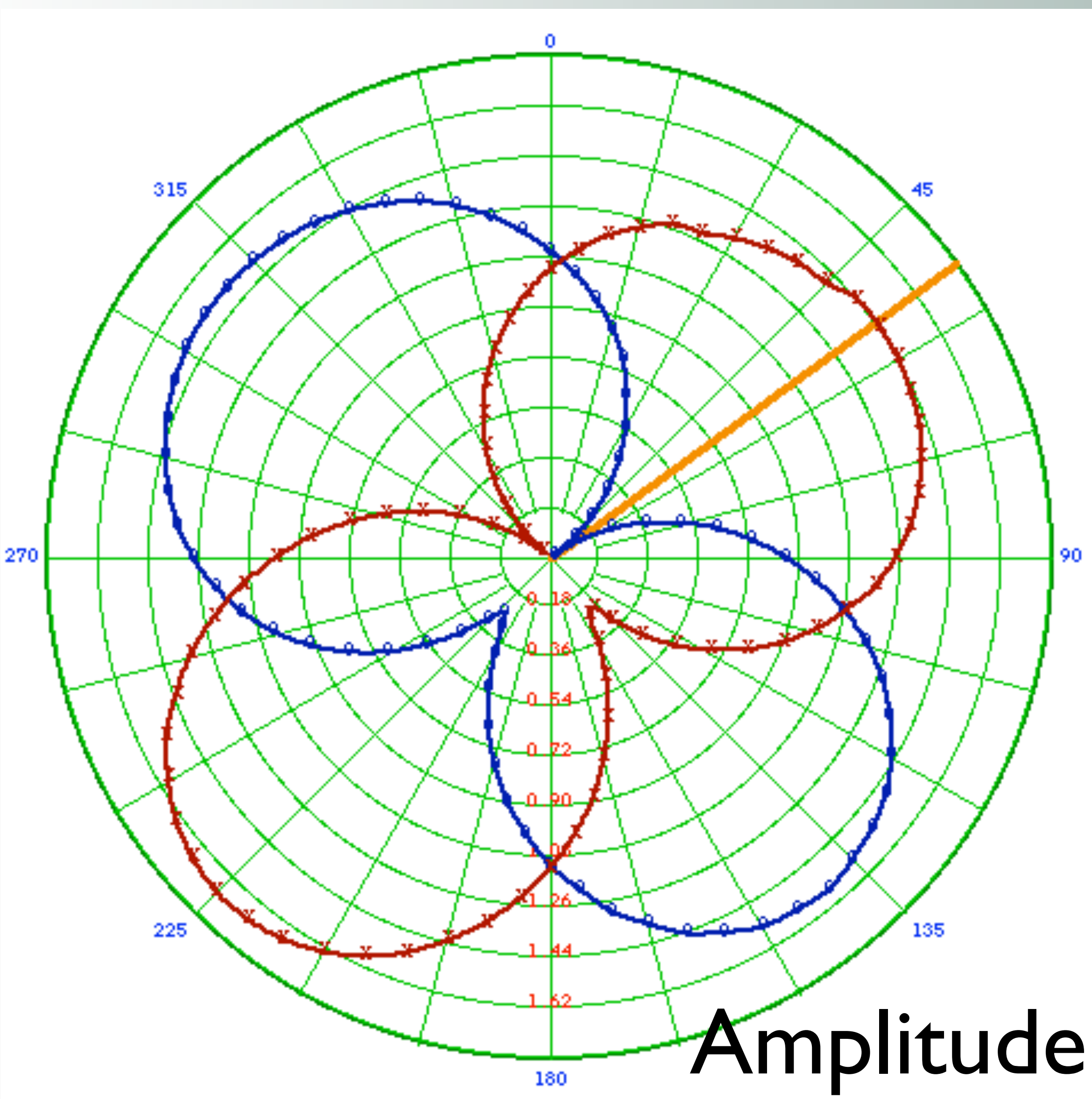
- *3 co-located antennas*

- *Unique combination of amplitude & phase for each antenna = 6 parameters for each bearing*

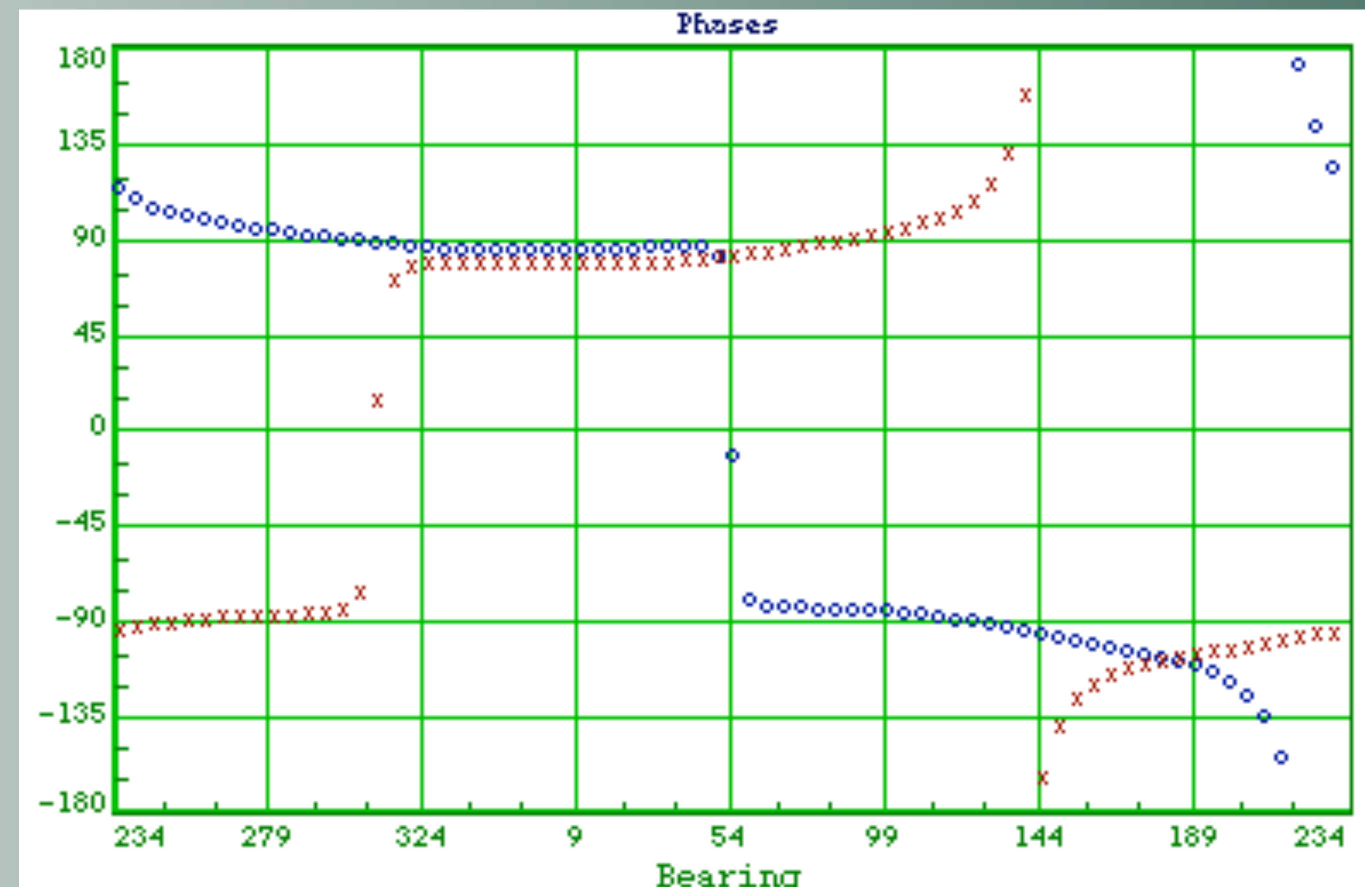
- *MUSIC Direction Finding on each Doppler bin*



SeaSonde Antenna Pattern



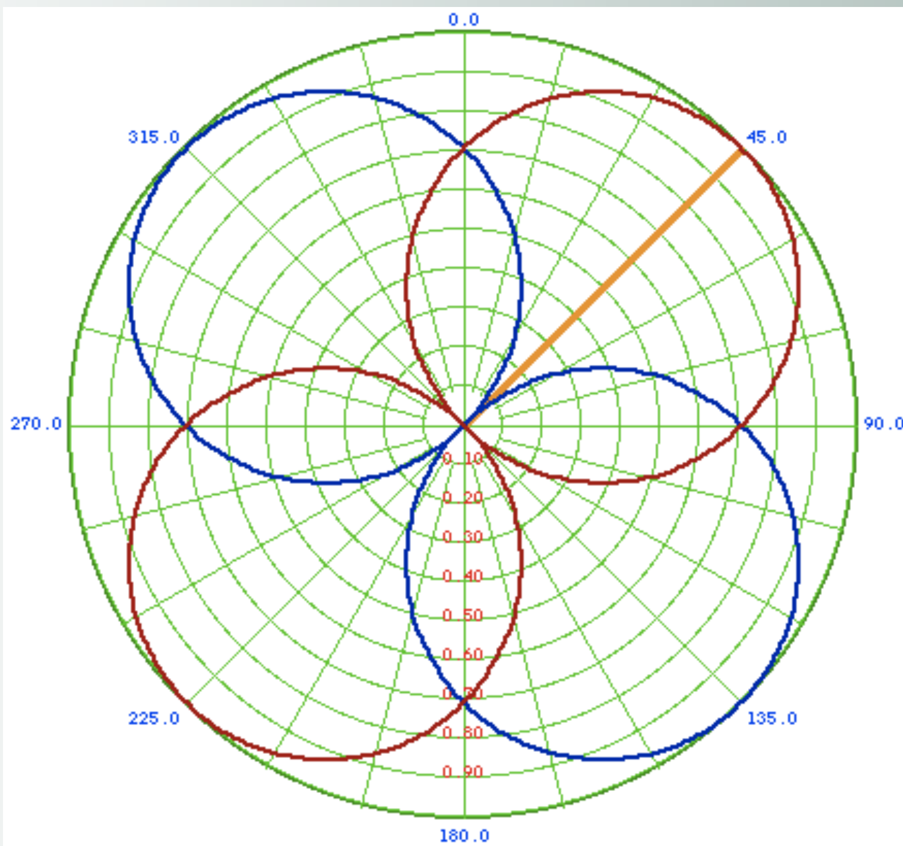
Amplitude



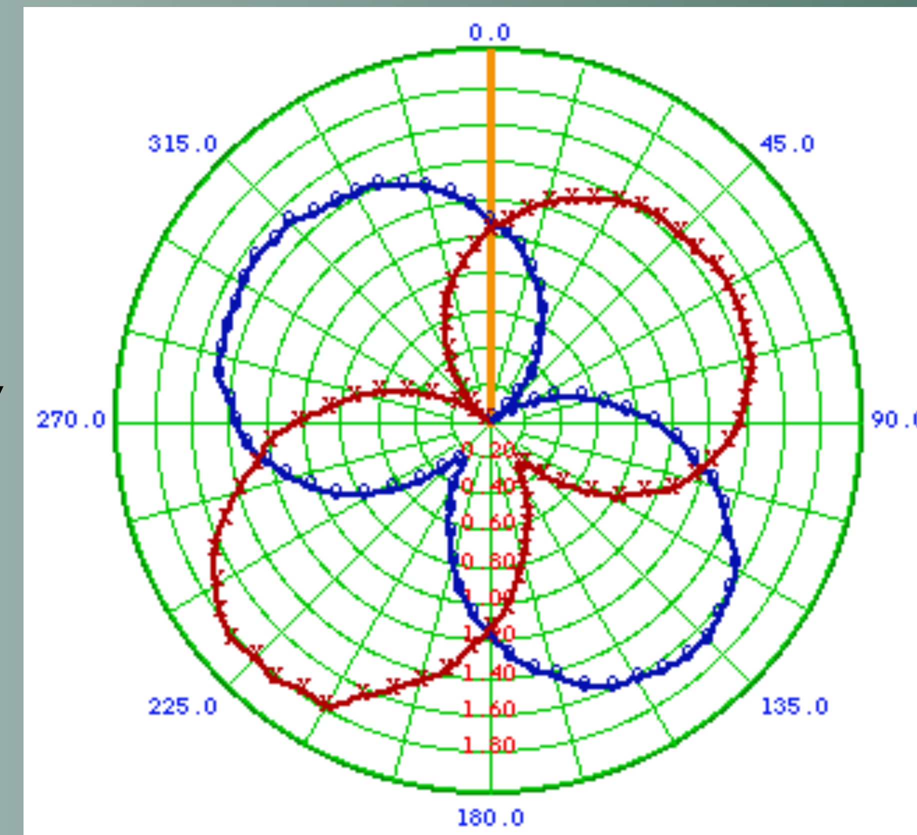
Phase

Antenna Pattern Distortions

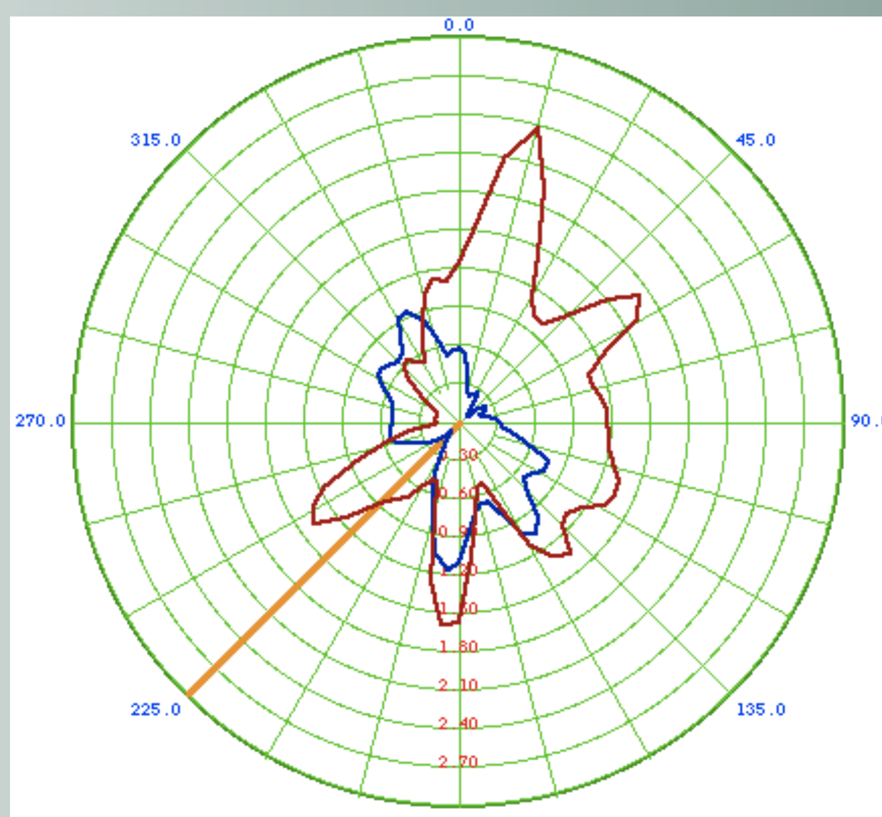
Ideal



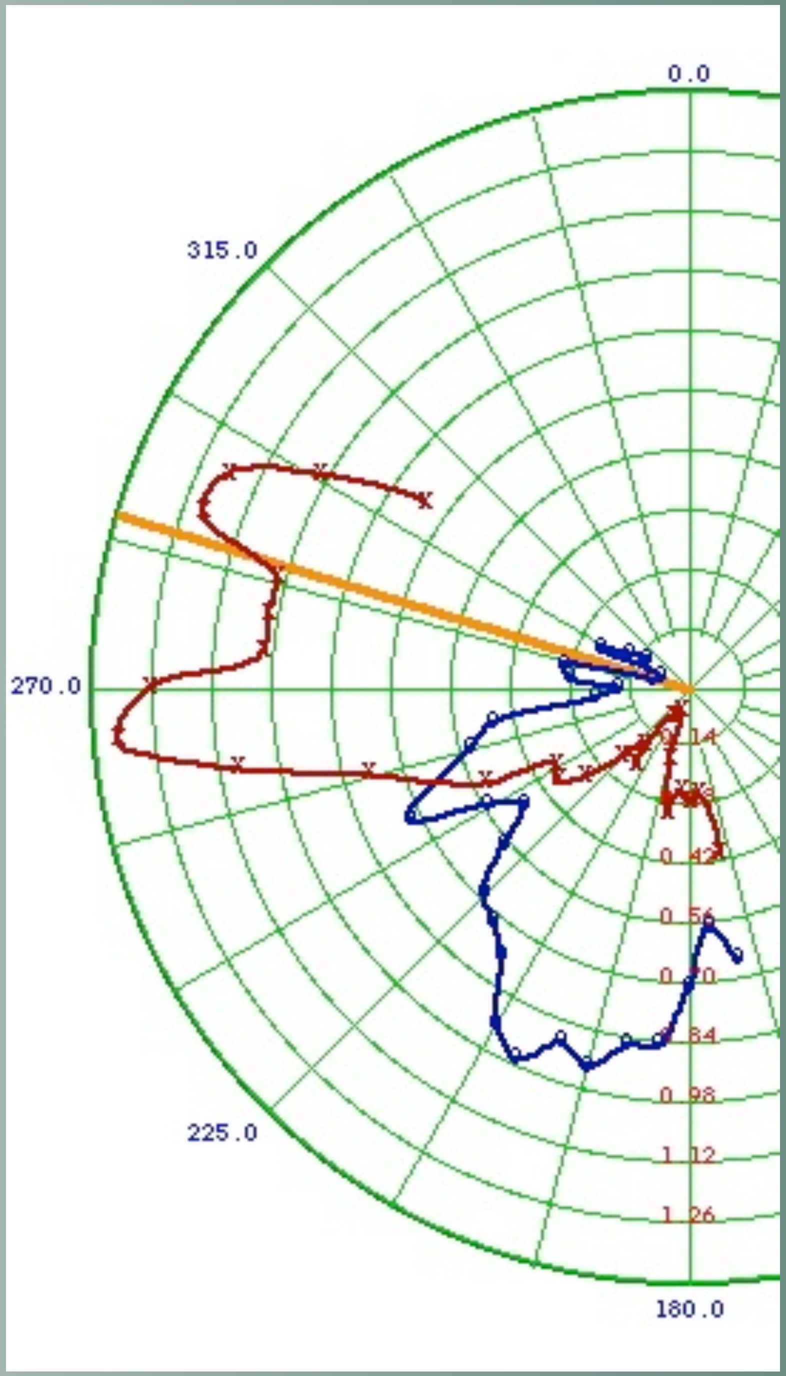
Nearly ideal



Not so Ideal



Distorted Antenna Patterns



CODAR Ocean Sensors
www.codar.com

RIAM Workshop
Kyushu University
18 December 2013

Measuring Patterns Improves Accuracy

1. de Paolo, T. and E. Terrill (2007), Properties of HF radar compact antenna arrays and their effect on the MUSIC algorithm, eScholarship U. of California Report, Scripps Institution of oceanography.

2. Laws, K., J.D. Paduan, and J. Vesecky (2010). Estimation and assessment of errors related to antenna pattern distortion in CODAR SeaSonde high-frequency radar ocean current measurements, J. Atmos. & Oceanic Technology, vol. 27, pp. 1029-1043.

3. Barrick, D., (2003), "Bearing Accuracy against Hard Targets with SeaSonde DF Antennas", CODAR Report, September 26.

4. Kohut, J., et. al., Calibration of HF radar surface current measurements using measured antenna beam patterns, J. Atmos. Ocean Tech., pp. 1303 - 1316, 2003.

5. Jeff Paduan, Don Barrick, Dan Fernandez, Zack Hallock, and Cal Teague, Improving the accuracy of coastal HF radar current mapping, Hydro International, vol. 5, no. 1, 2001.

6. Barrick, D.E., Lipa, B.J., Using antenna patterns to improve the quality of SeaSonde HF radar surface current maps, Current Measurement, 1999. Proceedings of the IEEE Sixth Working Conference on, 11-13 March 1999, pp. 5-8, DOI 10.1109/CCM.1999.755204.

7. K. E. Laws, D. M. Fernandez, J. D. Paduan, C. C. Teague, and J. F. Vesecky, Simulation studies of errors in HF radar ocean surface current measurements, in IGARSS'98 Sensing and Managing the Environment, New York, Jul 1998, IEEE, vol. I, pp. A08.09.1-A08.09.3, IGARSS'98, Seattle, Washington.

8. Barrick, D.E. and B.J. Lipa (1996), Comparison of direction-finding and beam-forming in HF radar ocean surface currentmapping, Phase 1 SBIR Final Report. Contract No. 50-DKNA-5-00092. National Oceanic and Atmospheric Administration, Rockville, MD.

Measuring Patterns Improves Accuracy

- Any ground discontinuities or vertical conductive structures (poles, buildings, power lines) can cause pattern distortions, which can cause bearing errors if not included in processing
- HF Radar wavelengths are long (10-100 m), so it is difficult to isolate receive antenna from parasitic structures
- Good measurement is done from an external far-field source
- This is true for *both* Phased Array & Compact Cross Loop Antenna systems

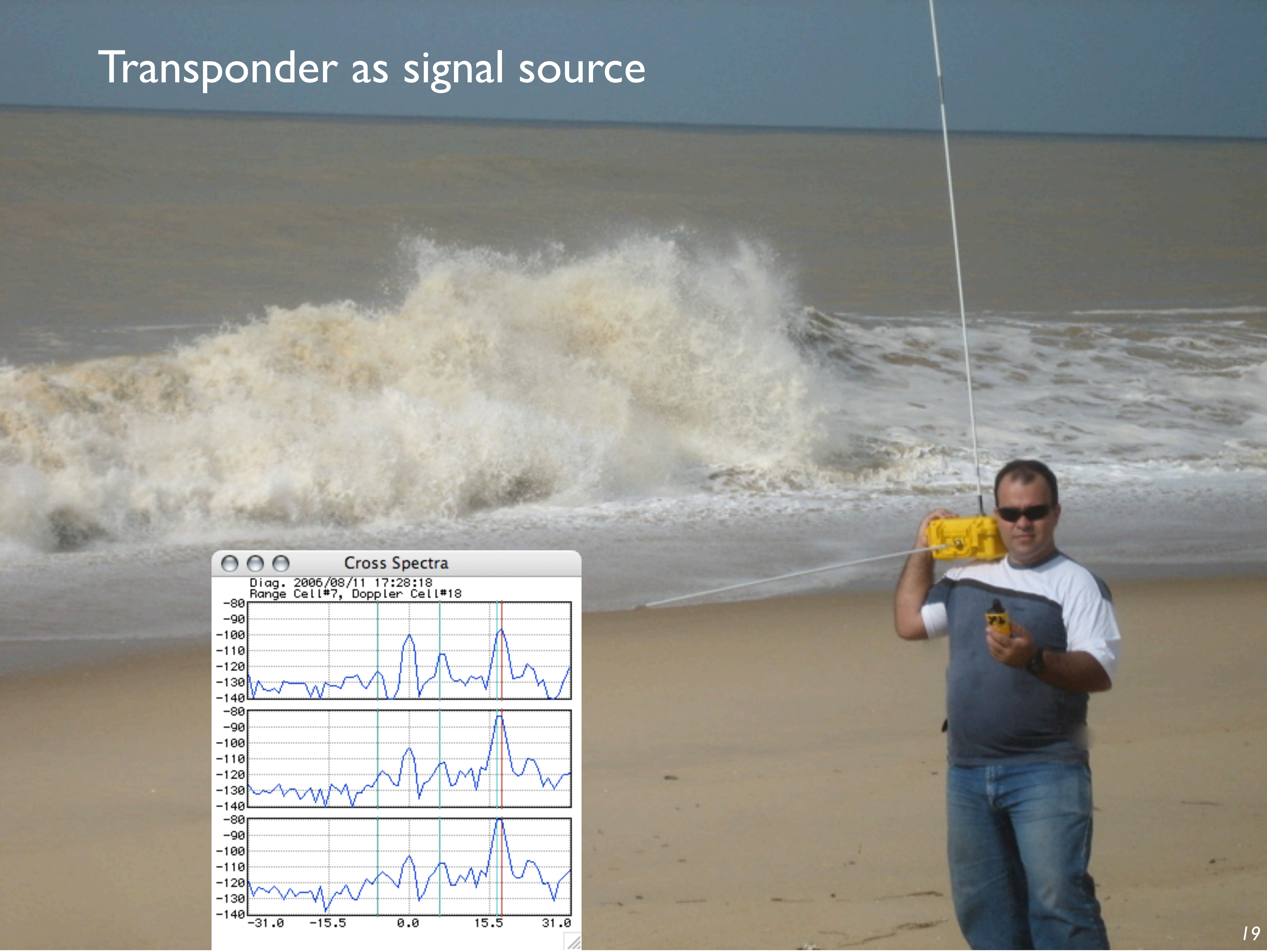
Current Calibration Method

CODAR Ocean Sensors
www.codar.com

RIAM Workshop
Kyushu University
18 December 2013

Transponder as signal source

Transponder as signal source




Transponder on
a boat
20

15 MAR 2007
4:59pm
Long Marine Lab
UC Santa Cruz
transponder
on land
Additional
Coverage
Rx
Tx
Image © 2007 DigitalGlobe
Image AMBAG
©2007 Goog
36°56'55.66" N 122°03'56.38" W
Streaming 100%
Eye alt


Or by Helicopter!
22

Planning, setup and execution can be costly and time-consuming

23

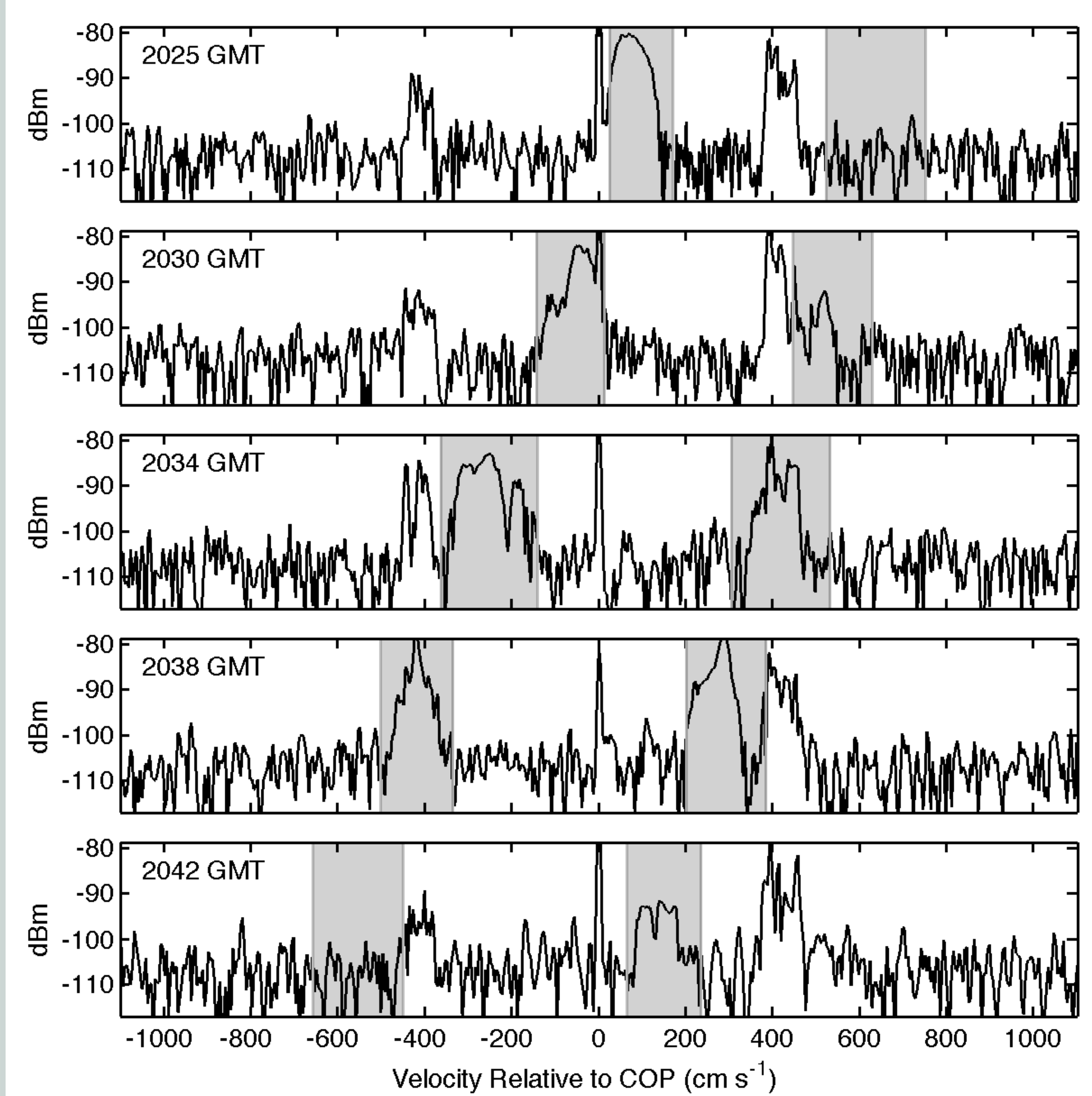
New Solution:
Use AIS & Ship Echoes

Ship Echoes in Doppler Spectra

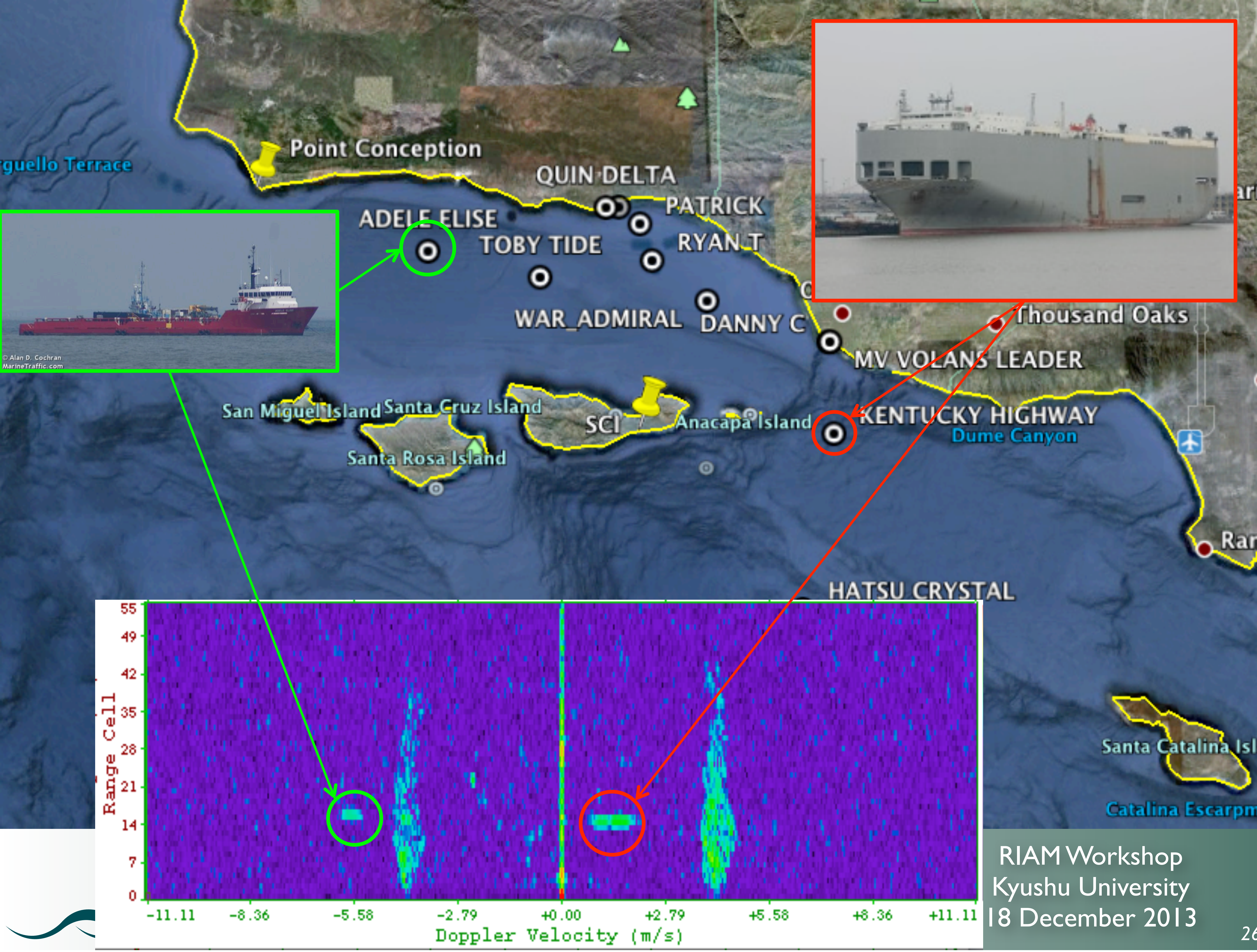
Provides a calibration signal from direction of vessel

Need to get bearing of vessel to use in APM

Use range from AIS position & Doppler from AIS velocity to find peak



25


Point Conception
rguello Terrace
QUIN DELTA
PATRICK
ADELE ELISE
TOBY TIDE
RYAN T
WAR_ADMIRAL
DANNY C
Thousand Oaks
MV VOLANS LEADER
KENTUCKY HIGHWAY
Dume Canyon
San Miguel Island
Santa Cruz Island
SCI
Anacapa Island
Santa Rosa Island
HATSU CRYSTAL
Santa Catalina Isla
Catalina Escarpme
© Alan D. Cochran
MarineTraffic.com
Range Cell
55
49
42
35
28
21
14
7
0
-11.11
-8.36
-5.58
-2.79
+0.00
+2.79
+5.58
+8.36
+11.11
Doppler Velocity (m/s)

What is AIS?

CODAR Ocean Sensors
www.codar.com

RIAM Workshop
Kyushu University
18 December 2013

What is AIS?

Automatic Identification System

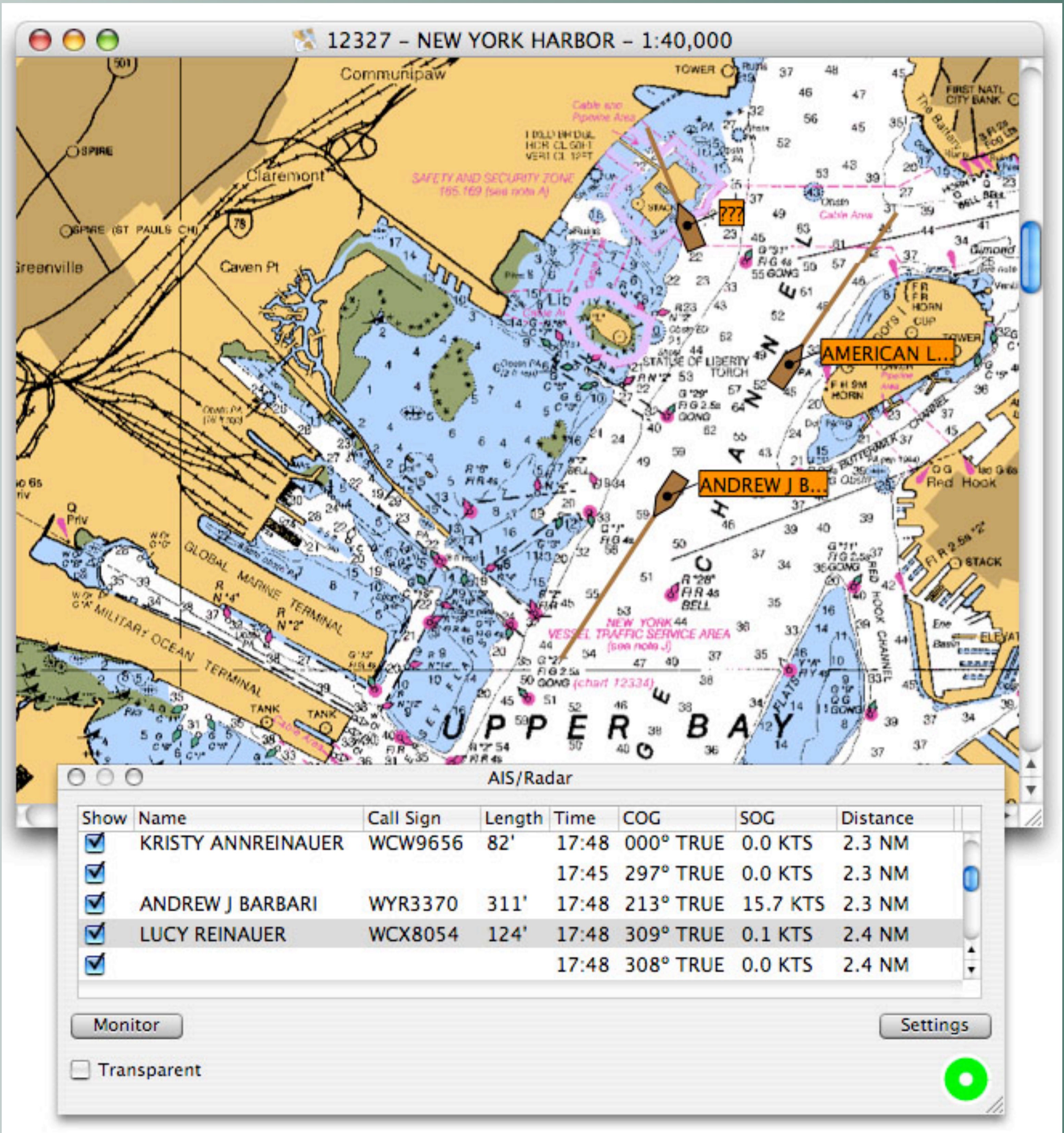
Ship-to-ship & Ship-to-shore anti-collision transponder system

Two VHf Marine Bands: 161.975 and 162.025 MHz

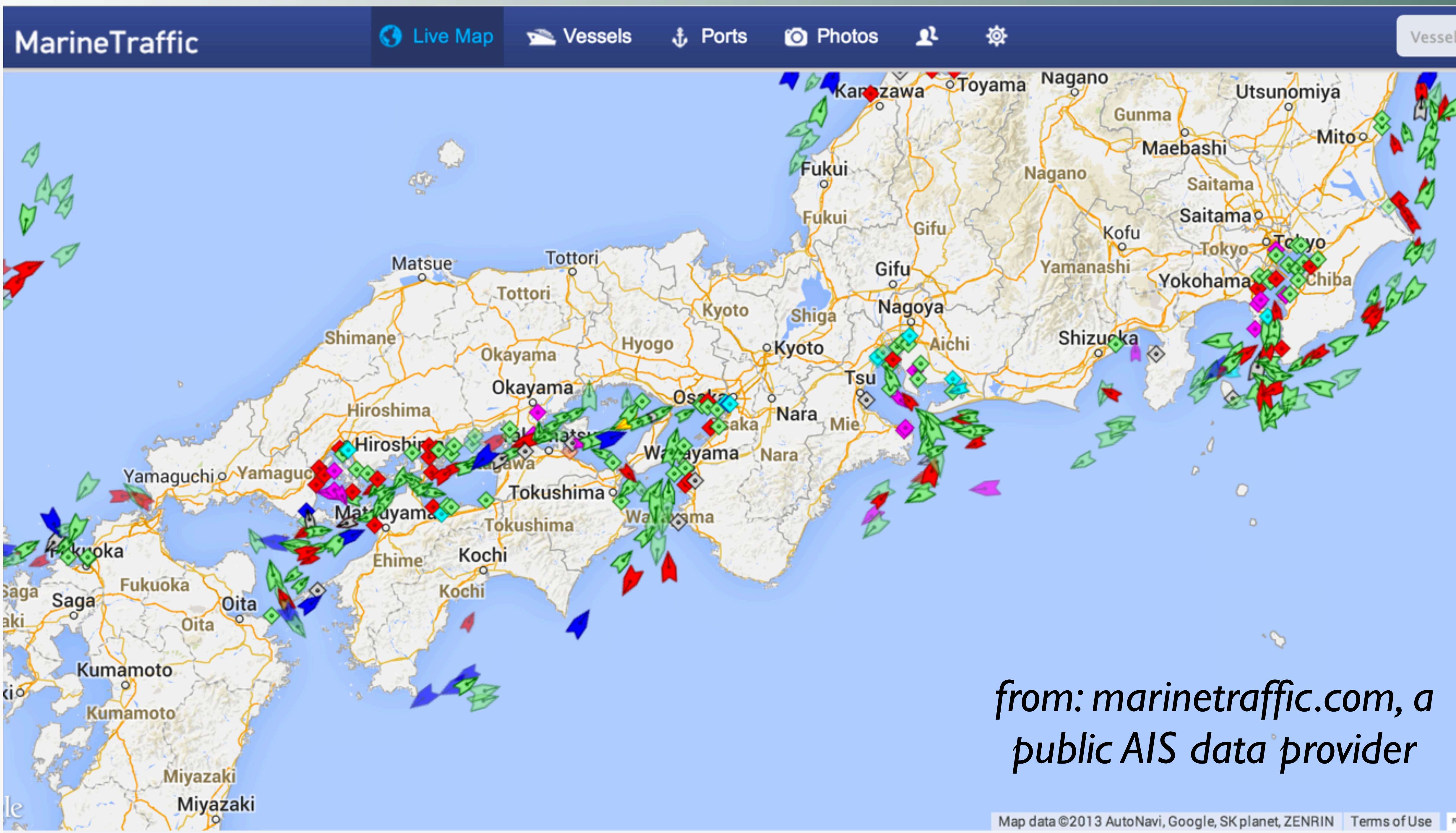
Required on all ships over 300 tons and all passenger ships

For each vessel, AIS provides:

Time-Stamped
Position
Bearing
Speed



AIS in Japan



from: marinetraffic.com, a public AIS data provider

AIS in Japan

from: marinetraffic.com, a public AIS data provider

AIS Data Flow

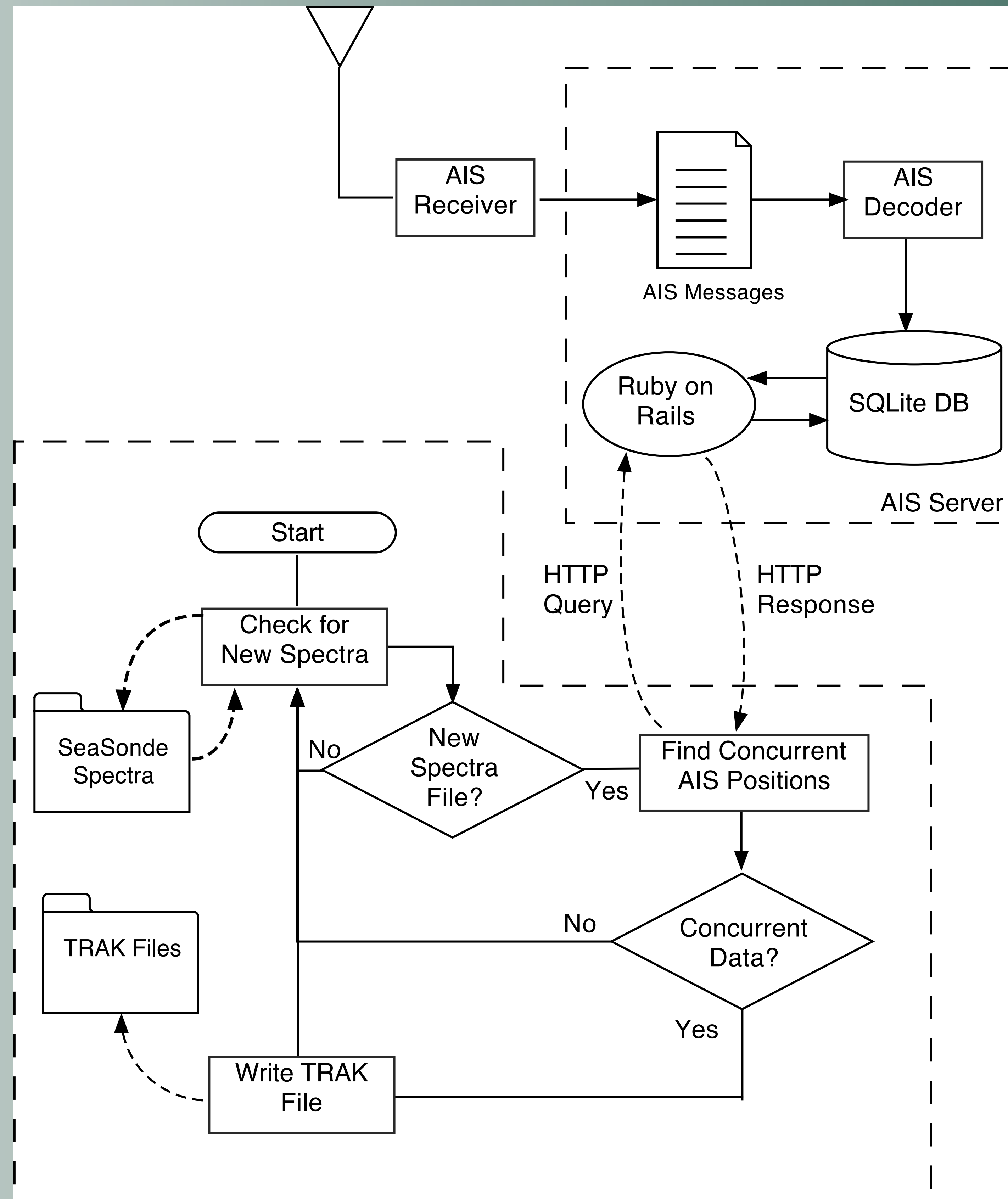
Collect AIS messages on radial site computer via AIS receiver

Match AIS messages with raw spectra

AIS Receiver can be separated from SeaSonde computer

AIS receiver can be moved to a nearby building for better range

AIS APM processing operates in parallel with radial procesing



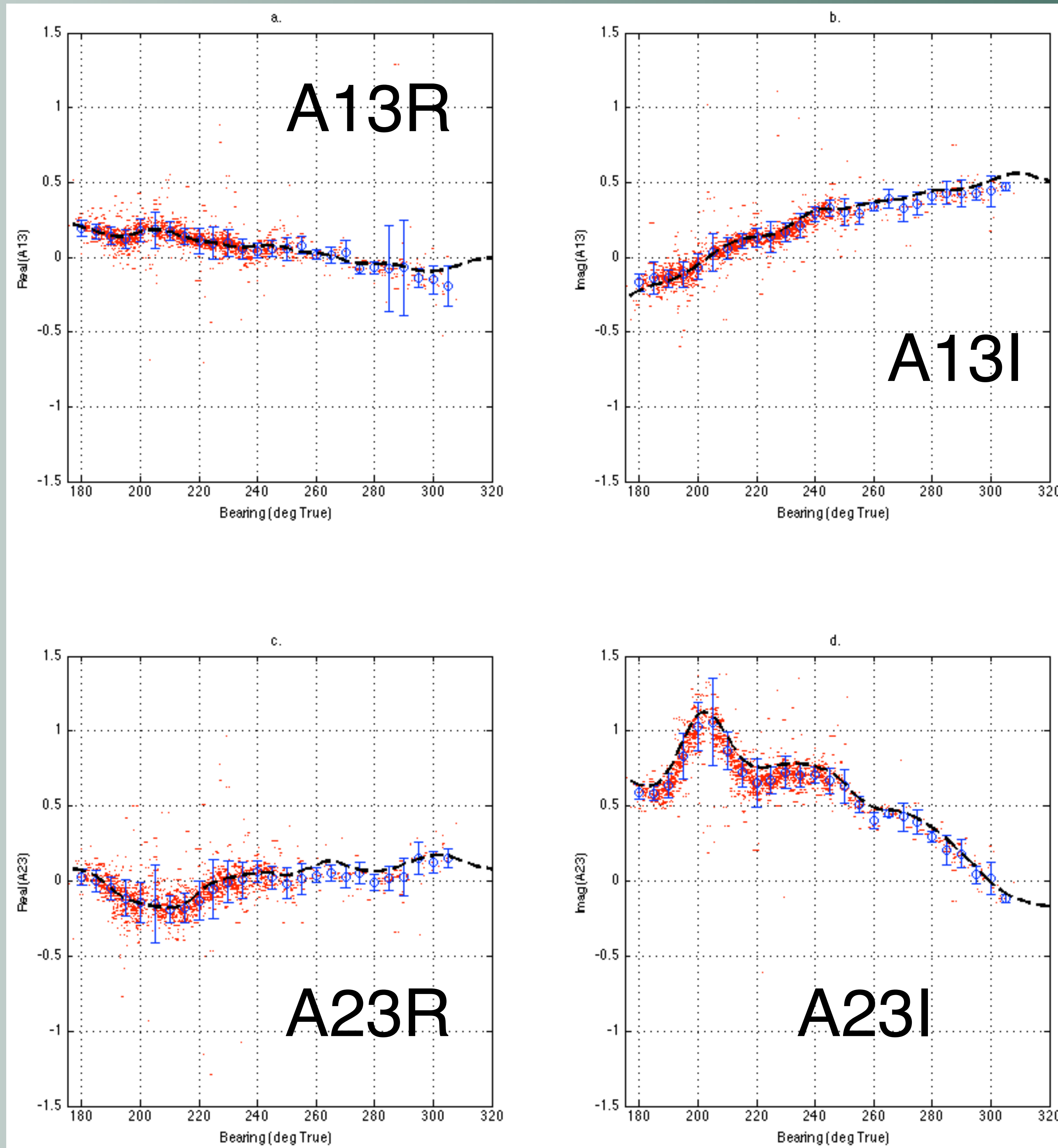
Results

Bodega Marine Lab

Normalized Antenna Patterns: Real & Imaginary Components

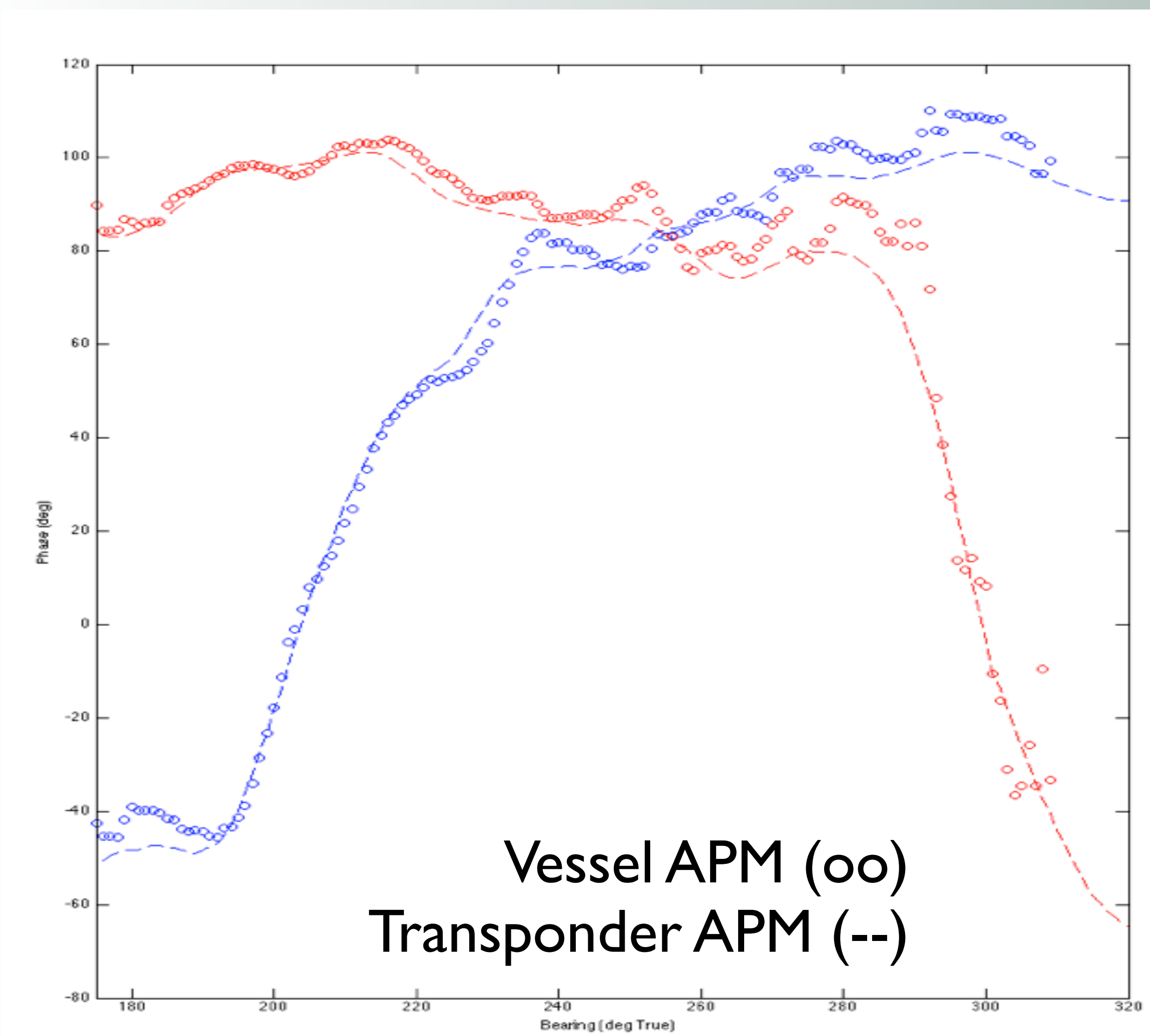
Median filter sorted by bearing

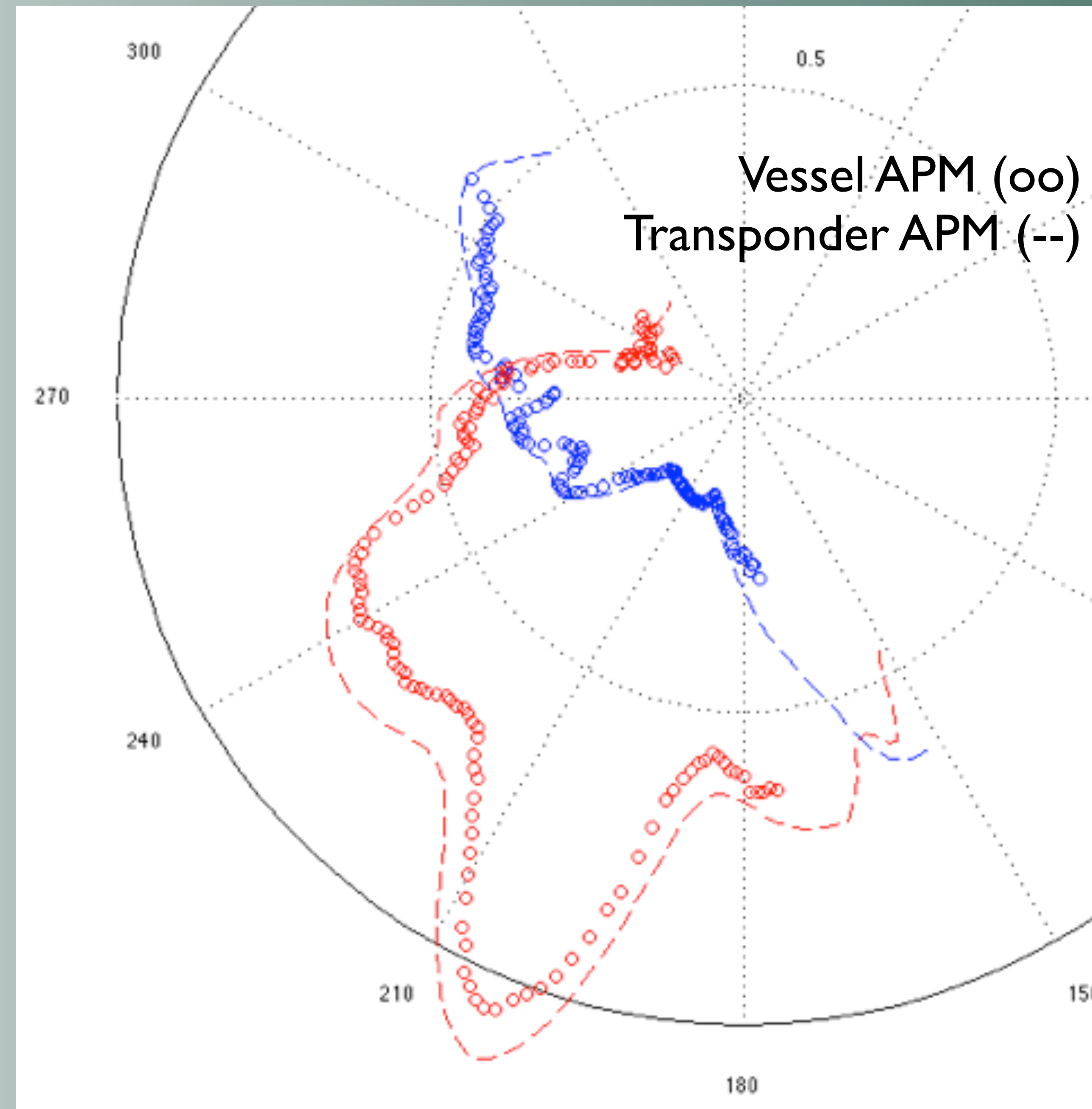
Previous transponder pattern (---)



Bodega Marine Lab

Normalized Antenna Patterns: Amplitude & Phase





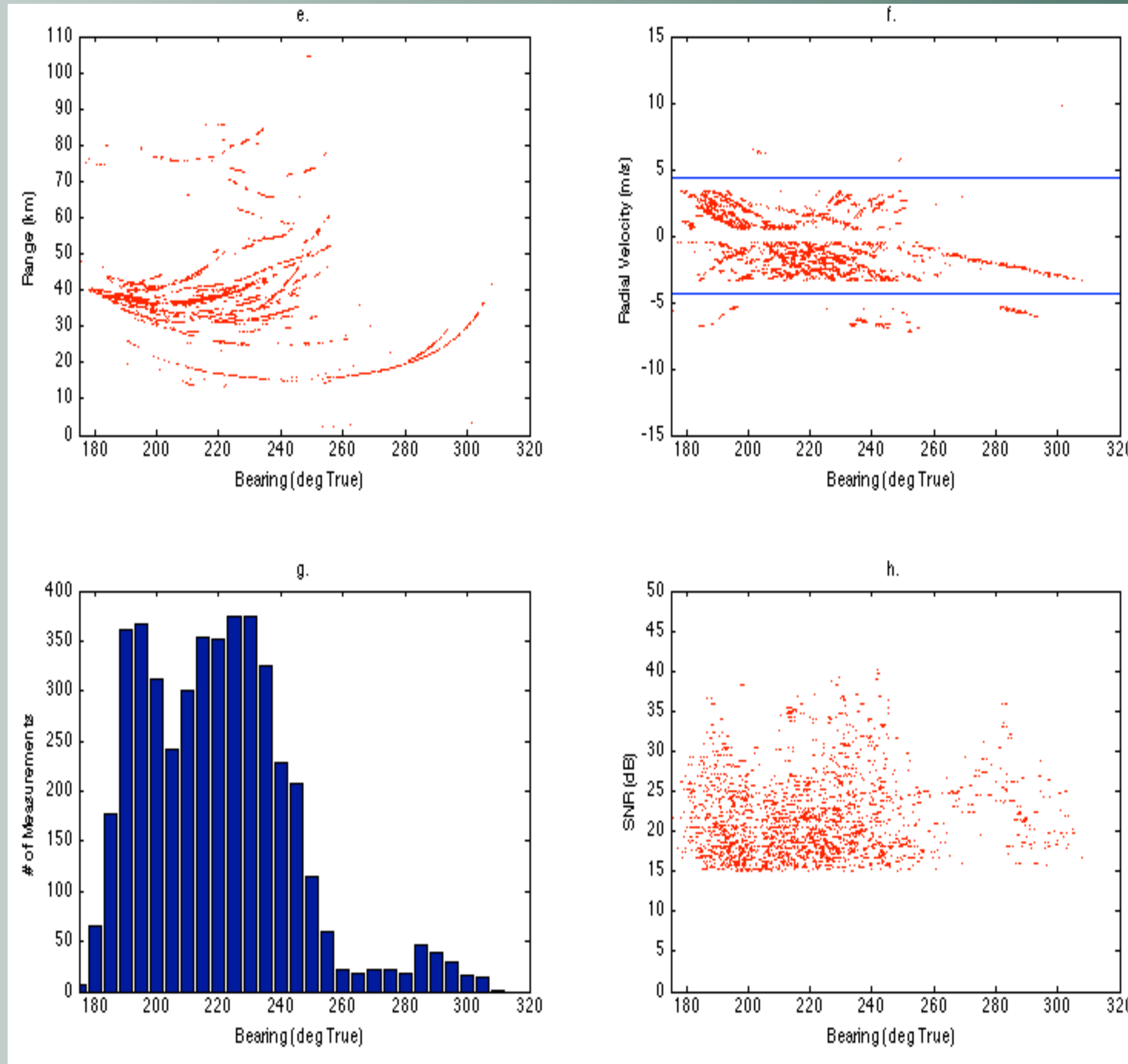
35

Bodega Marine Lab

Metadata Collected:

- S/N ratio
- Peak width
- Doppler
- Range
- Bearing

Pattern update rate depends on vessel activity (varies vs. bearing)

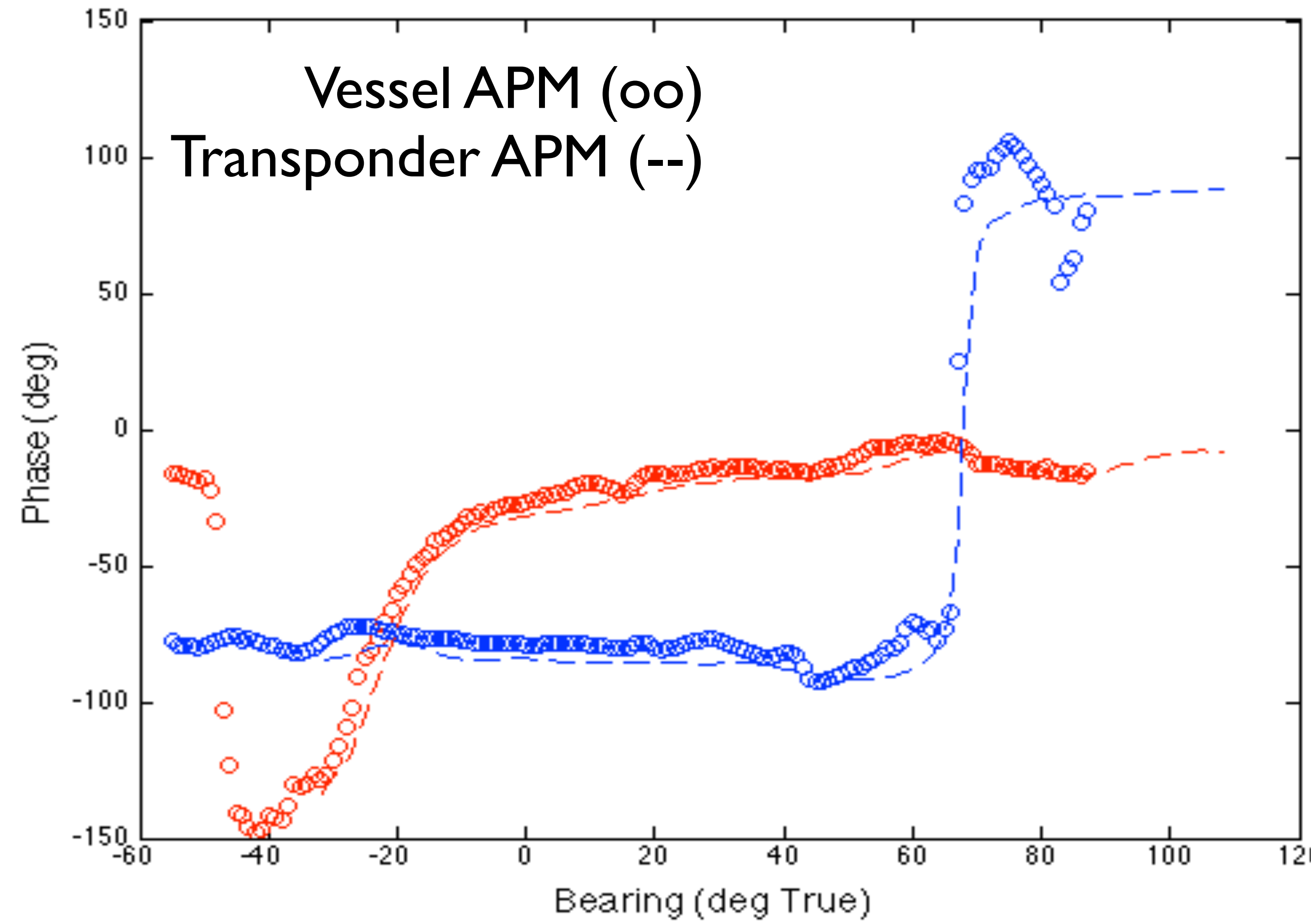


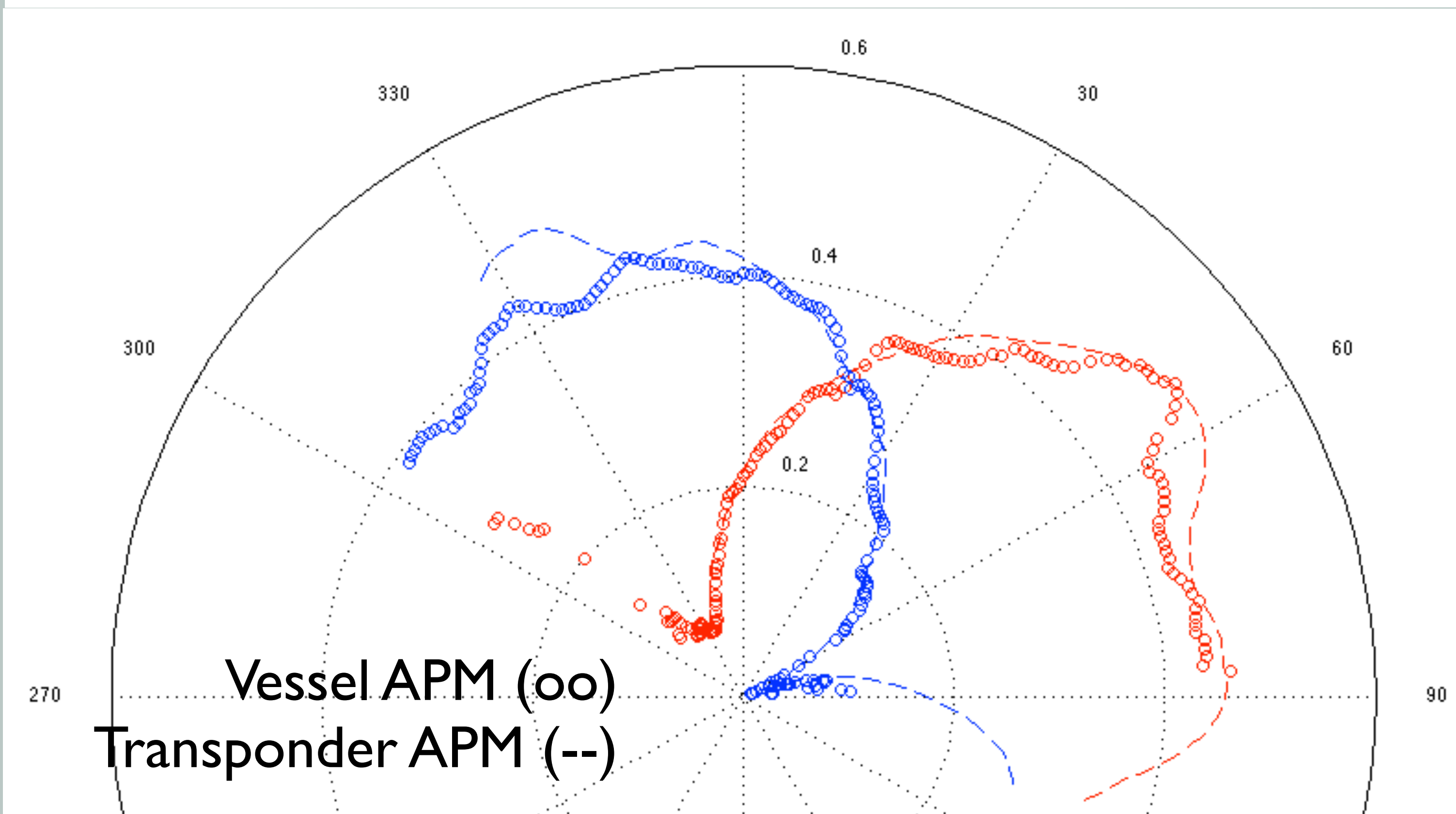
Old Dominion University

(VIEW site)

Antenna pattern measured in a few days from vessel echoes

Vessels provide a far-field signal source





37

Benefits

Significantly reduced cost of calibration

Improved surface current data quality assurance

Continuous measurements allow antenna pattern to be processed over different time periods & lengths

Inexpensive software addition and AIS hardware

Compatible with all SeaSonde hardware