Brief on the Vector Quantity **Circularity** Θ and its application to geoacoustic inversion

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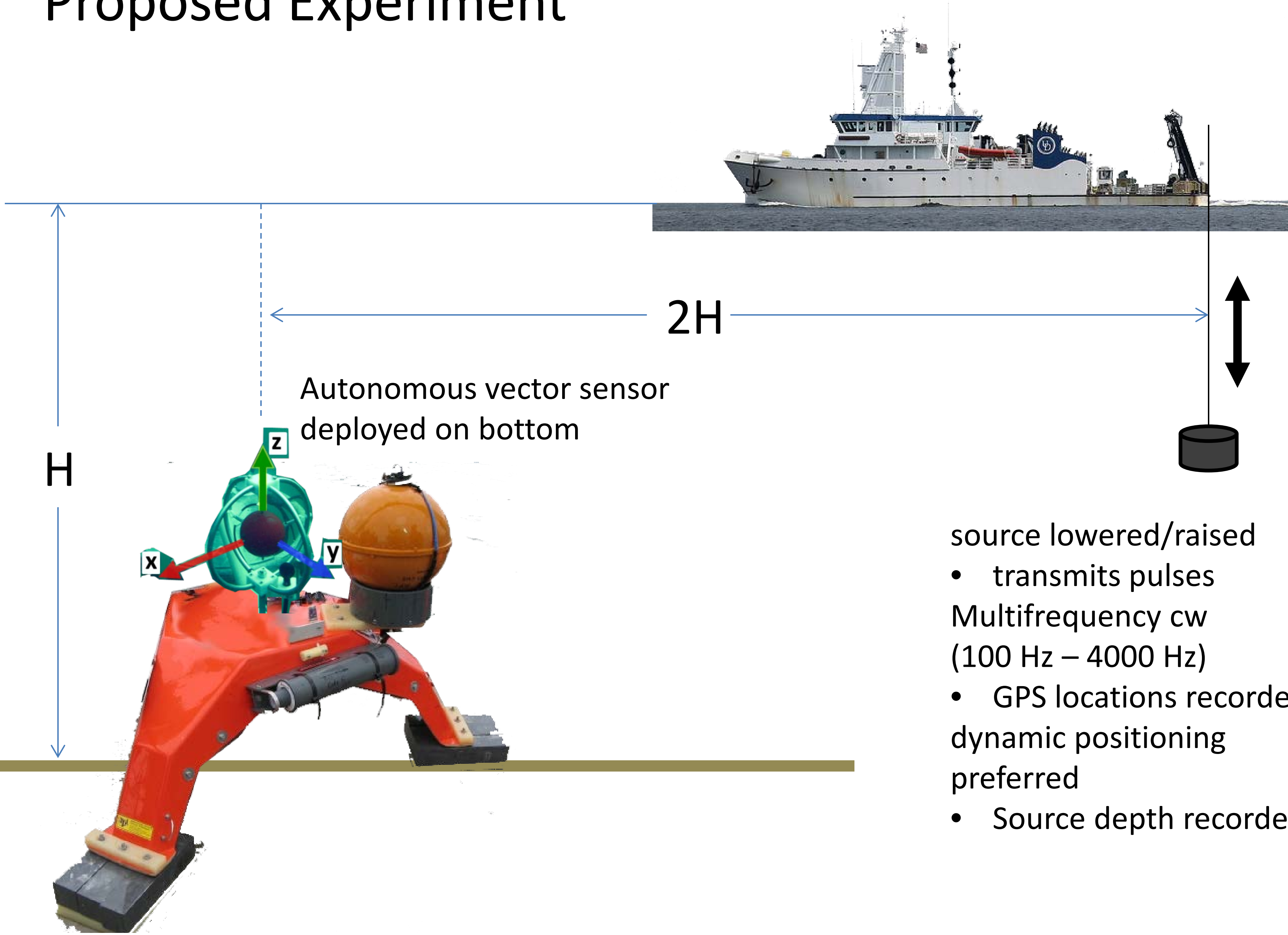
Proposed Experiment



source lowered/raised

- transmits pulses

Multifrequency cw
(100 Hz – 4000 Hz)

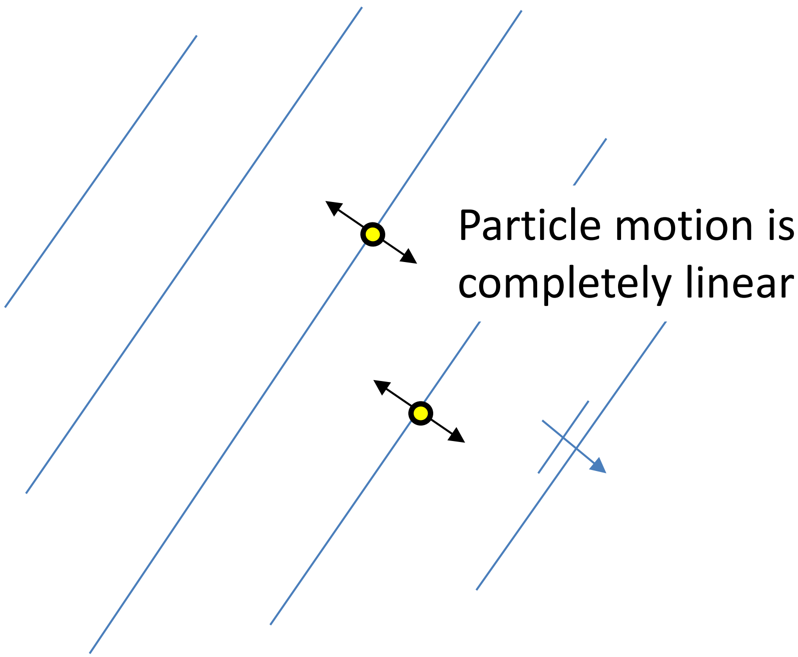
- GPS locations recorded

dynamic positioning
preferred

- Source depth recorded

Linear and circular particle motion

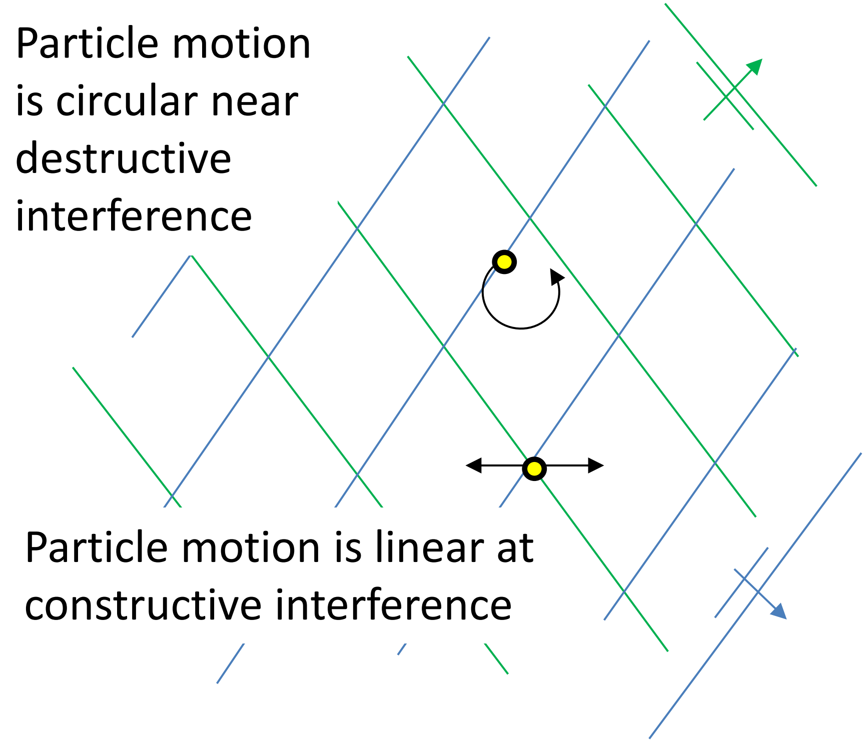
Single Plane Wave Field



$$\Theta = 0$$

Circularity is zero everywhere

Two Plane Waves



$$-1 < \Theta < 1$$

Circularity has spatial dependence

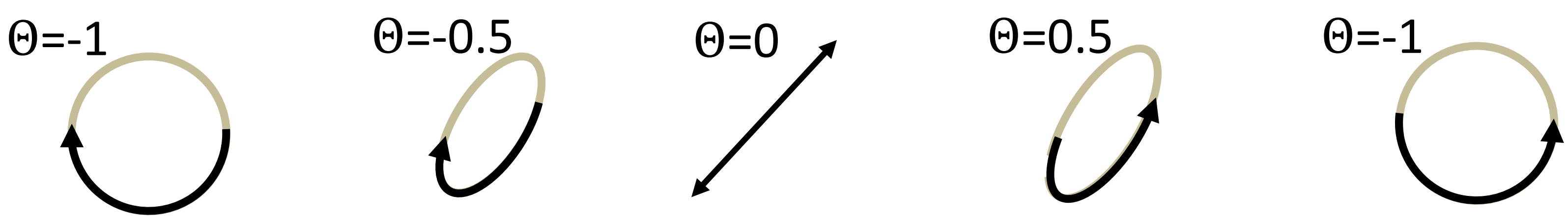
The degree of circularity, Θ

The resultant of vector components associated with different wavefronts, or multipaths may show a phase between the vertical and horizontal particle velocity

The degree of circularity, Θ, quantifies this vector-phase relationship

$$\vec{\Theta} = 2\frac{Im\{\vec{v}\times\vec{v}^{*}\}}{\vec{v}\cdot\vec{v}^{*}}$$

Θ describes the path of fluid particle, which can be directly measured by a vector sensor

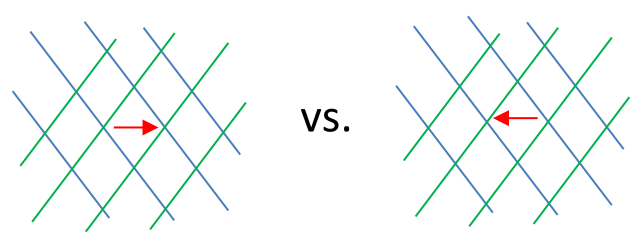


circular, clockwise motion

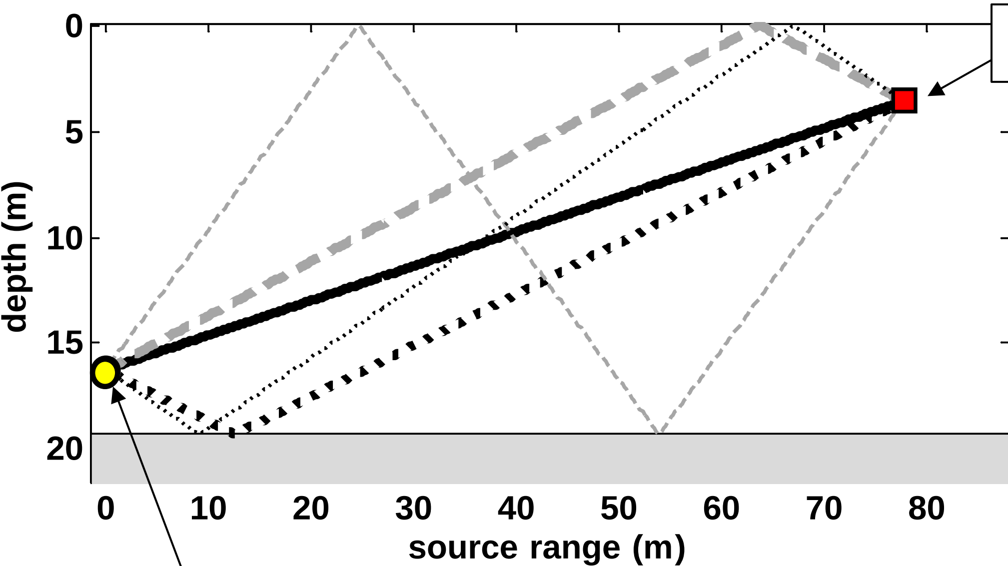
motion on a line (or no motion)

circular, counterclockwise motion

Sign of circularity will change with the direction of propagating waves



TREX Circularity Experiment



Source transmits 100 ms tone at 1025 Hz

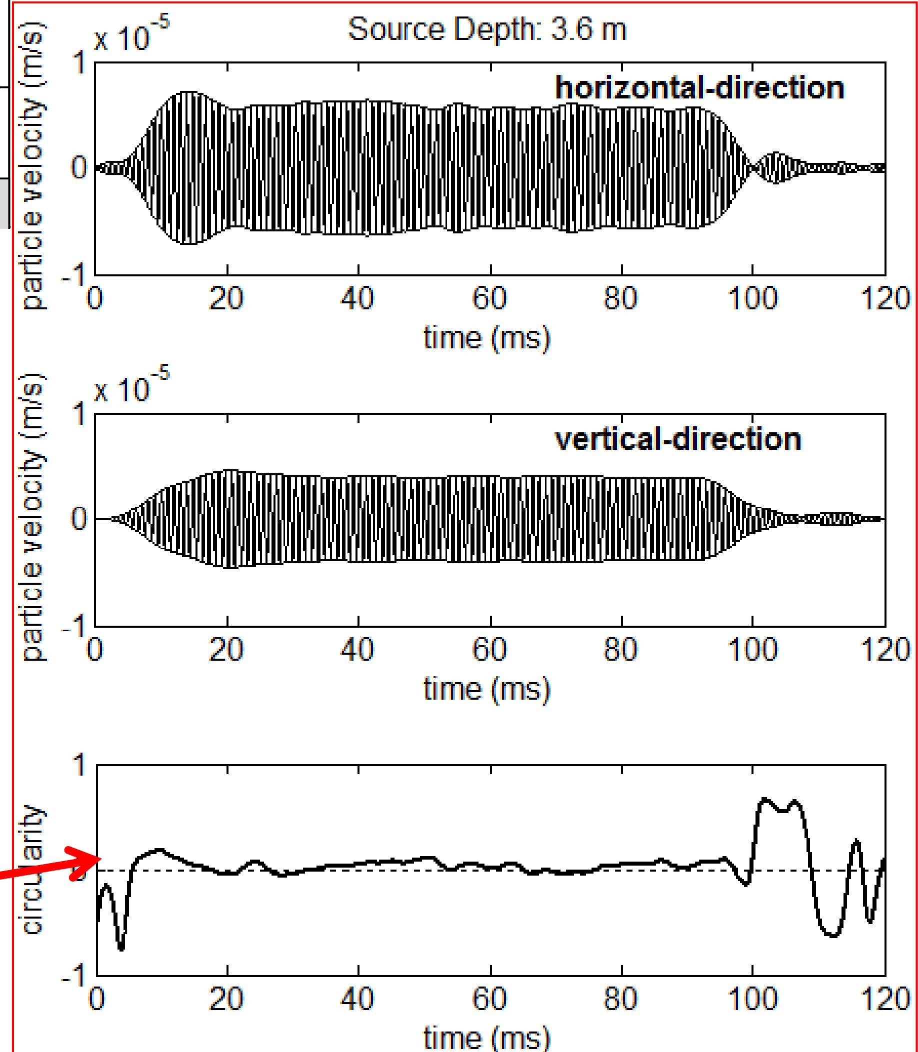
Fixed vector sensor records particle velocity

Horizontal and vertical components of particle velocity are used to compute circularity

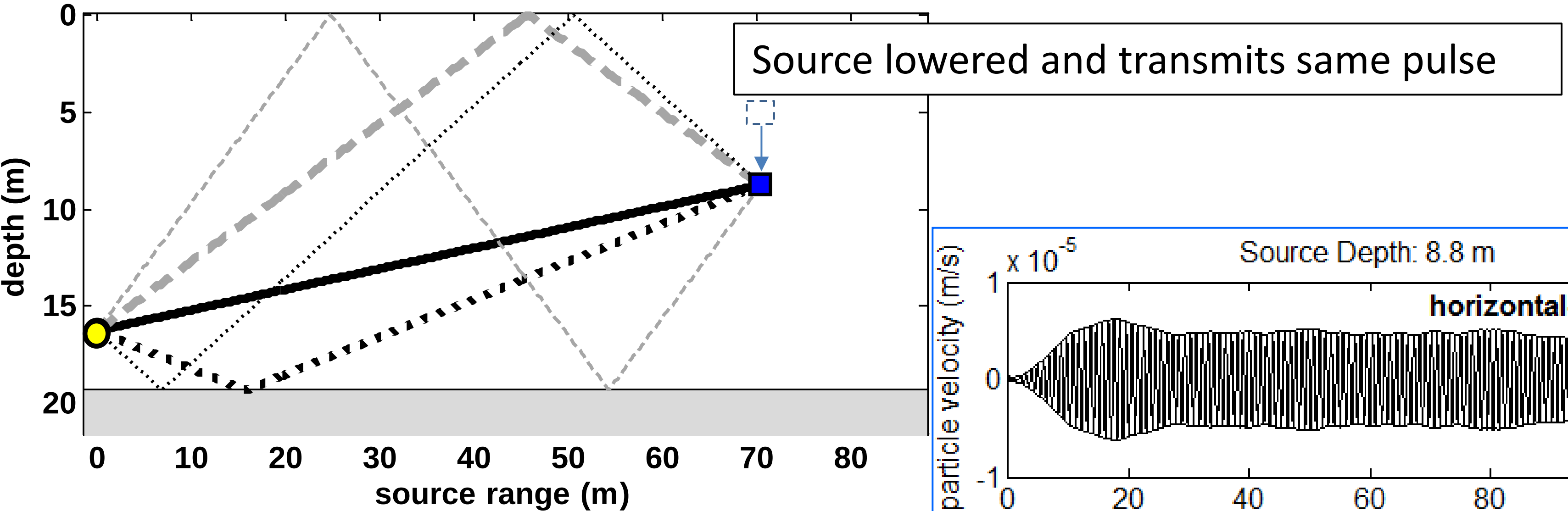
Steady state is reached obtained after 20 ms

Steady state circularity is 0 for 3.6 source depth

Corresponding time series of **Circularity**



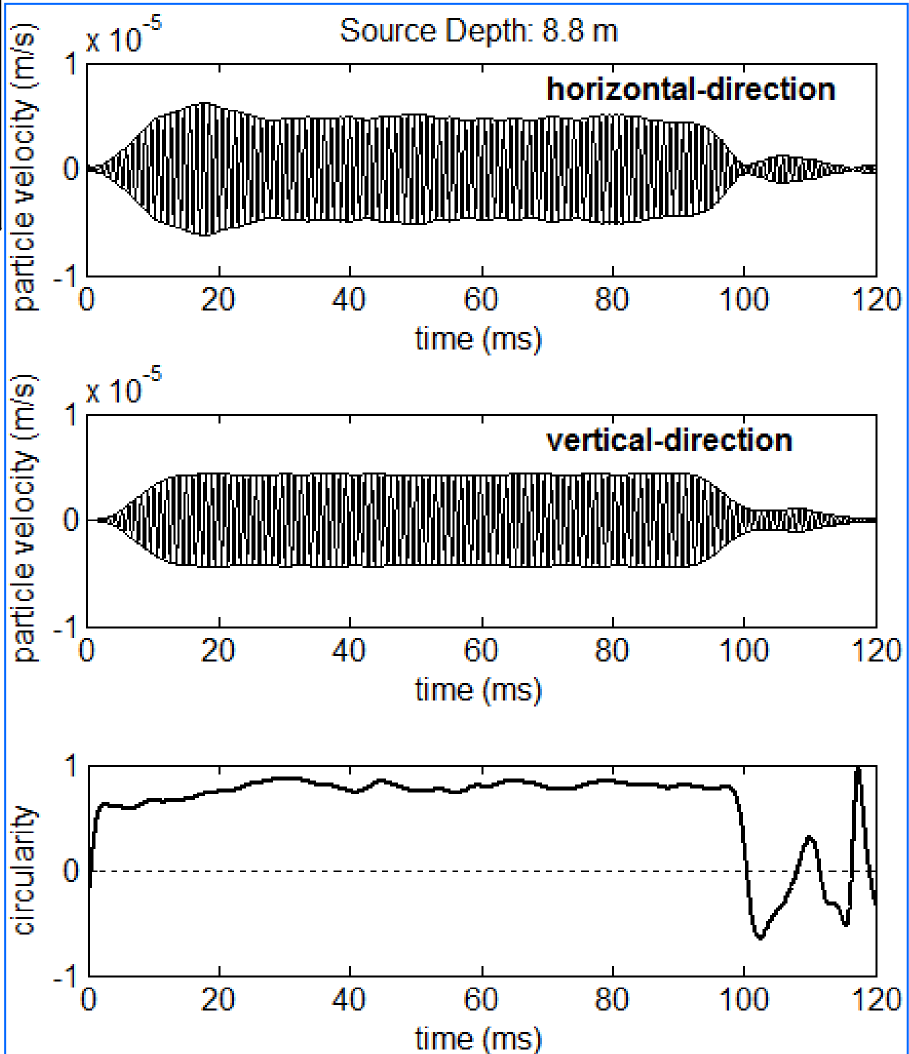
TREX Circularity Experiment



Similar amplitudes of horizontal and vertical components of particle velocity particle velocity can result in very different circularity

Steady state circularity is 0.8 for 8.8 m source depth

The build-up of circularity to its steady-state value also depends on source depth

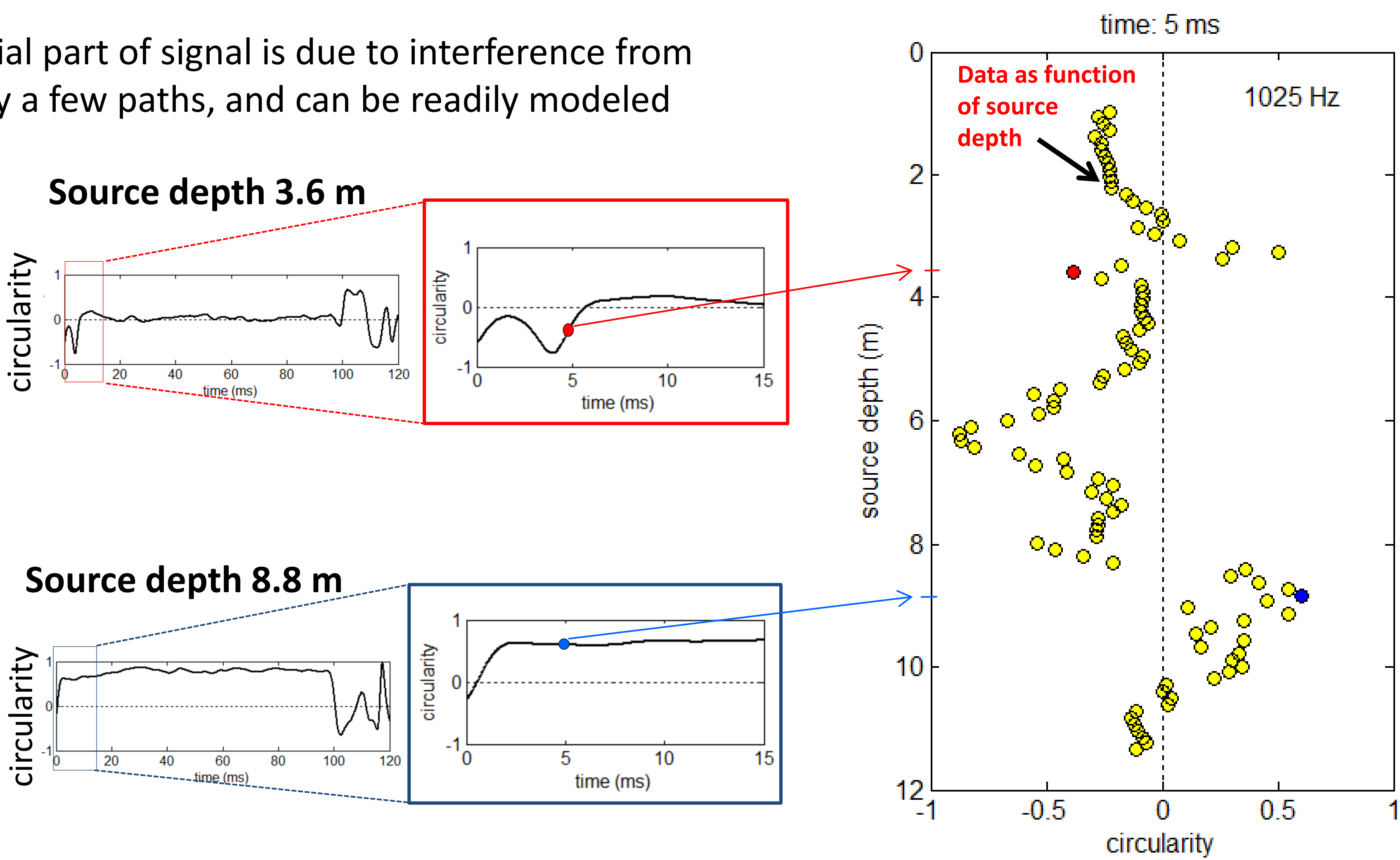


TREX13 measurement of Θ

Build up of circularity field contains many looks at the data

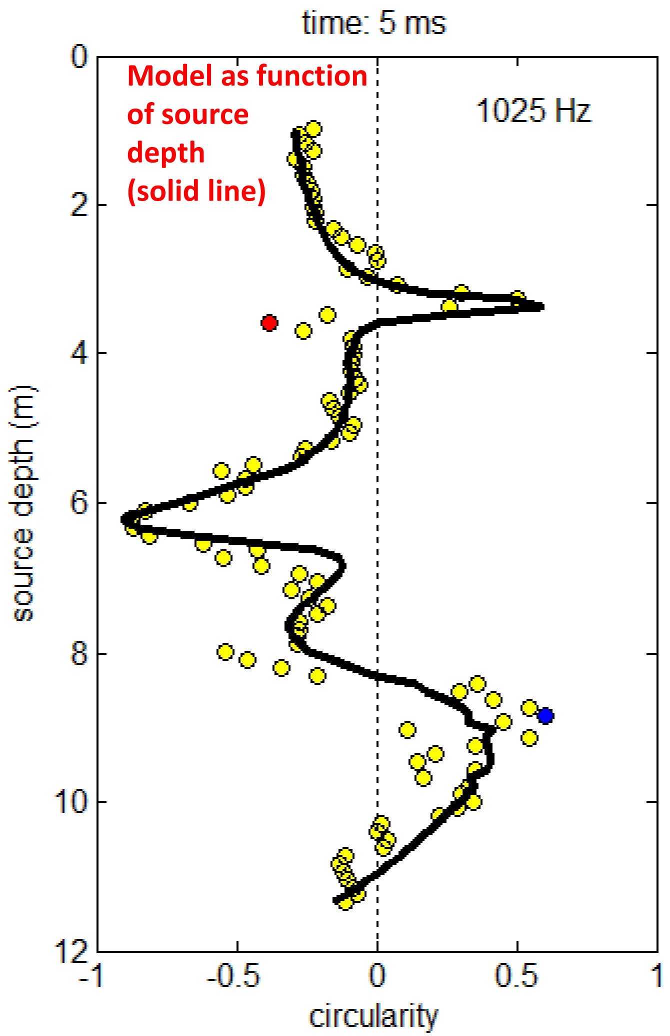
Initial part of signal is due to interference from only a few paths, and can be readily modeled

Snapshots of circularity in time for source depths 1-12 m



Comparison of Data to Modeled Field

Model computed from addition of first 5 bottom-interacting paths



Model Requires:

Bottom soundspeed: **1595** m/s

Bottom density: 2150 kg/m^3

Bottom attenuation: 0.35 dB/m

Comparison of Data to Modeled Field

Circularity is highly dependent on the **phase** of the bottom reflected paths and bottom sound speed and gradient

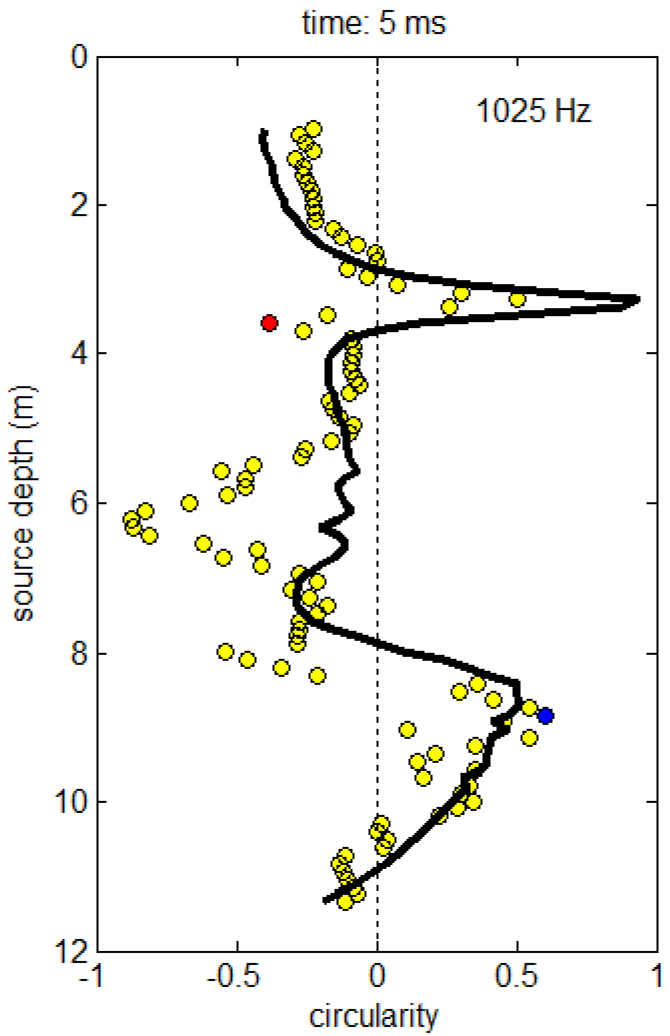
A poor bottom model has the wrong magnitude or sign of circularity for some source depths

Poor Fit:

Bottom soundspeed: **1640** m/s

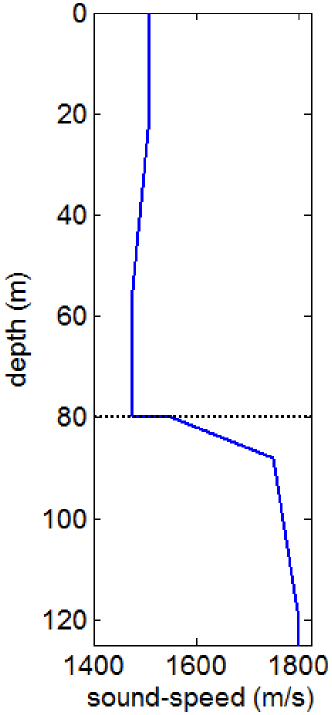
Bottom density: 2150 kg/m^3

Bottom attenuation: 0.35 dB/m



Simulated Result for Geoacoustics Exp 2016
Depth 80 m (near Primer site)

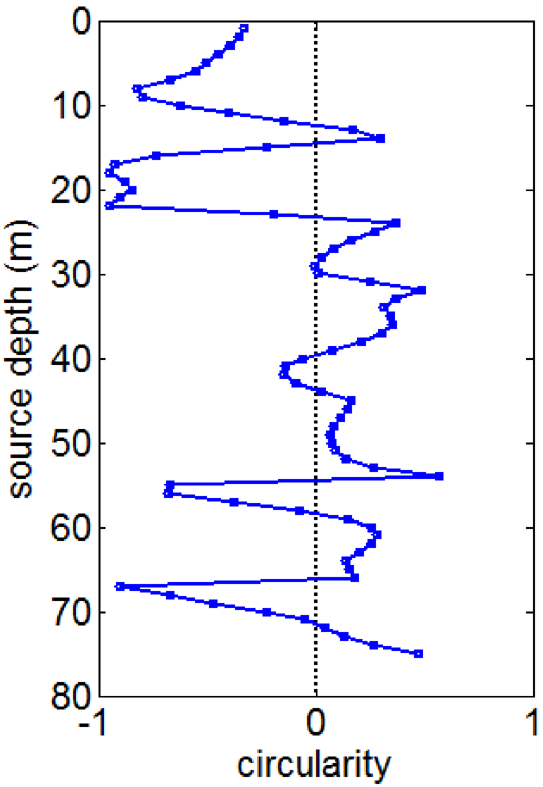
Primer Conditions, Depth 80 m



New England Shelfbreak PRIMER Experiment JOE Oct. (2004)

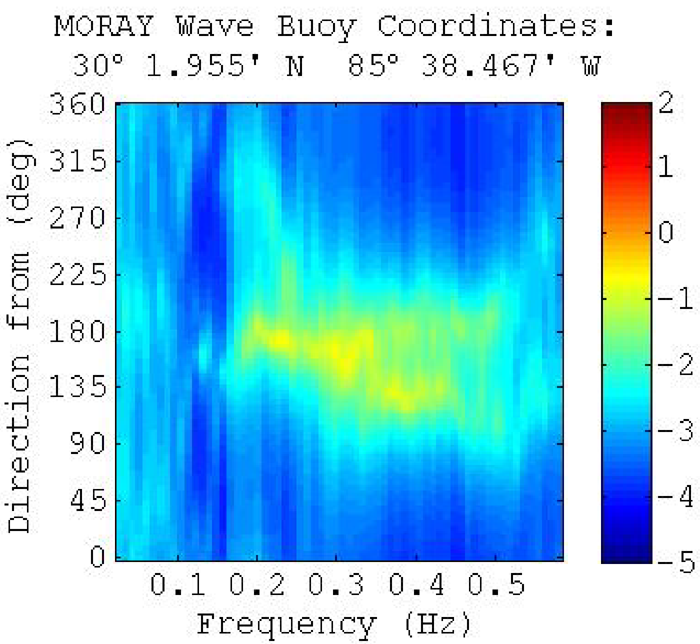
- **Vector sensor placed on bottom**
- **Source at range 250 m, is raised (lowered) through water column**
- **Using Primer site conditions (left) a simulated (PE) result shown on right**
- **doable measurement amenable to piggy backing on other source assets**

Simulated Result

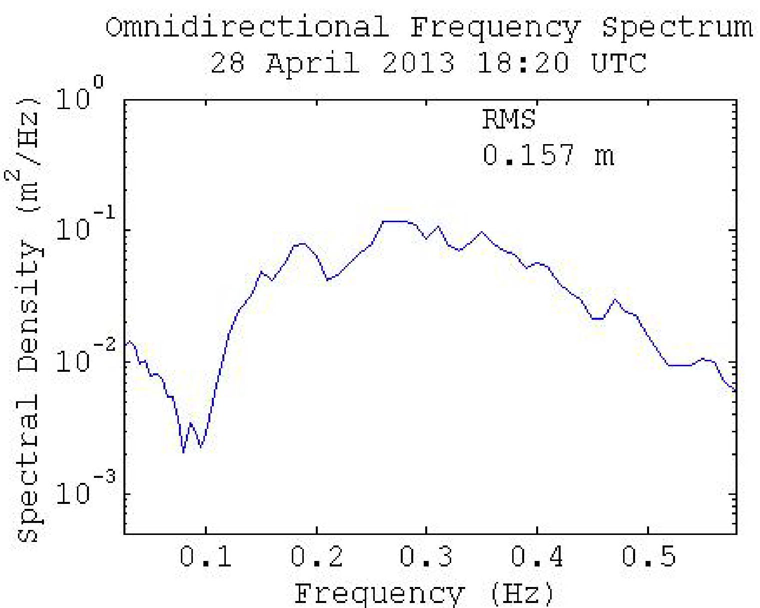


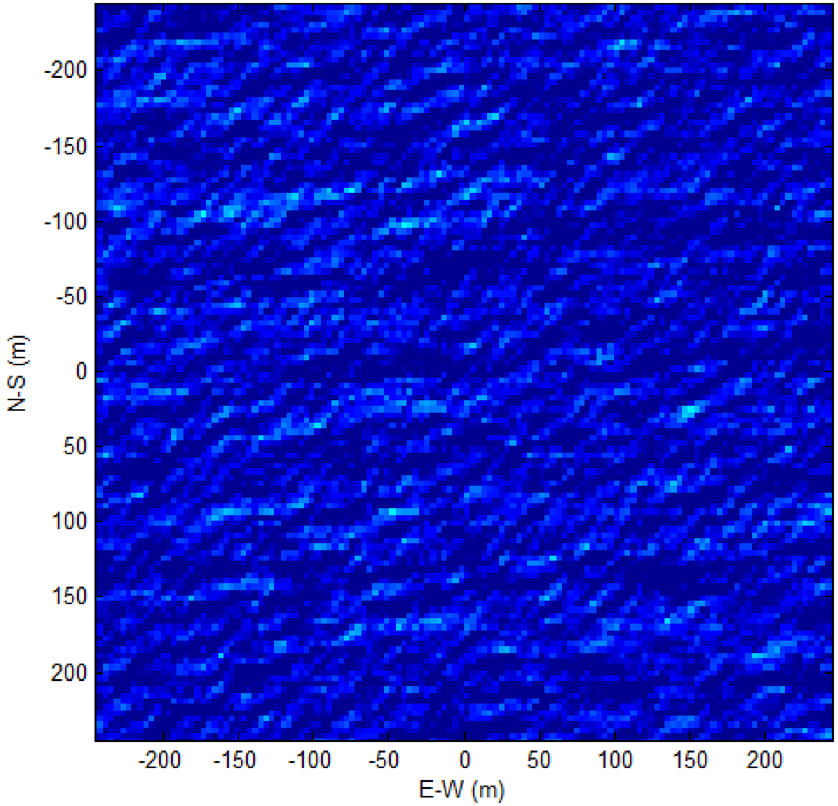
Summary: Circularity is doable measurement sensitive to bottom parameters and amenable to piggy backing with other sources and deployment schemes : (1) changing source depth, or (2) changing source range

Waverider Buoy Assets



Input spectrum to simulate surfaces





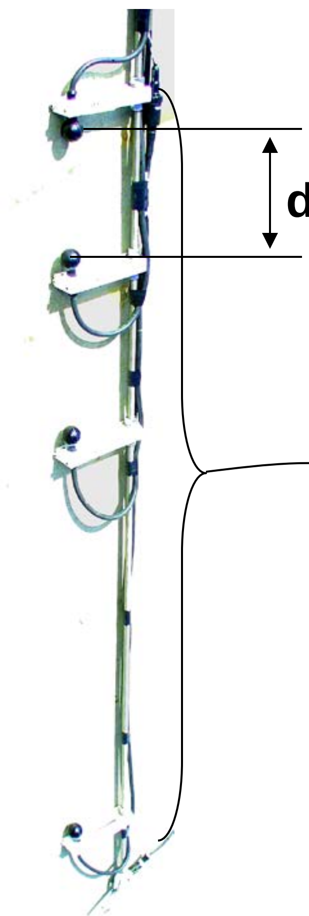
Properties the bottom-reflected field

Experimental Data from Shallow Water 2006:

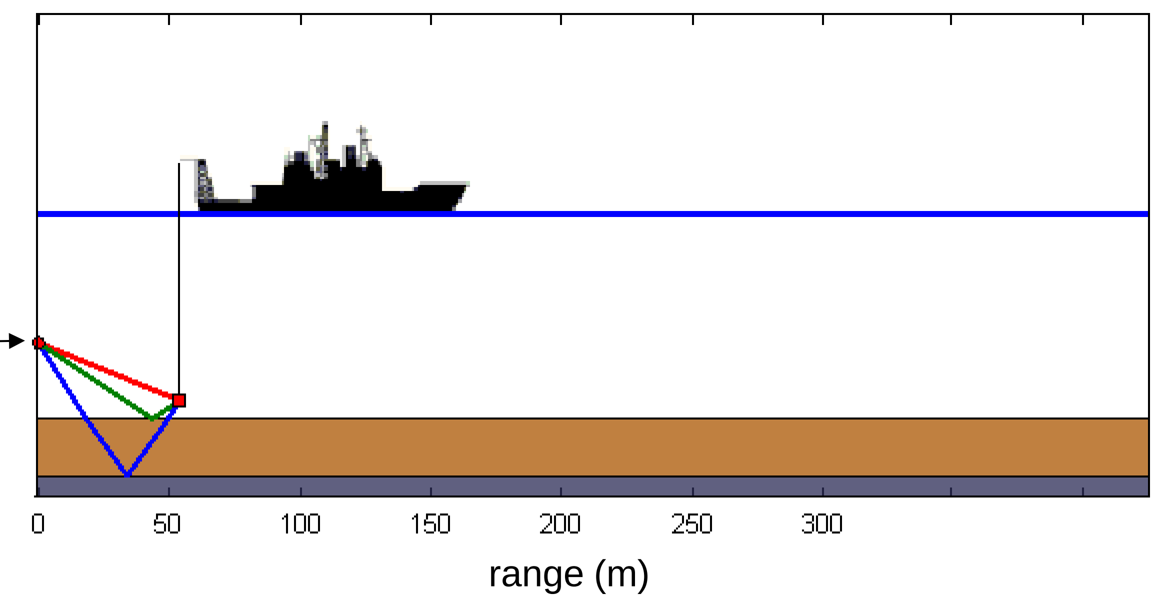
R/V Knorr: Towed near-bottom (~5 m) source from 50-300 m range
Transmit: 3-ms pulse (ctr freq 1000 Hz) every 1 m

VLA

Compute Complex Intensity via Finite Difference

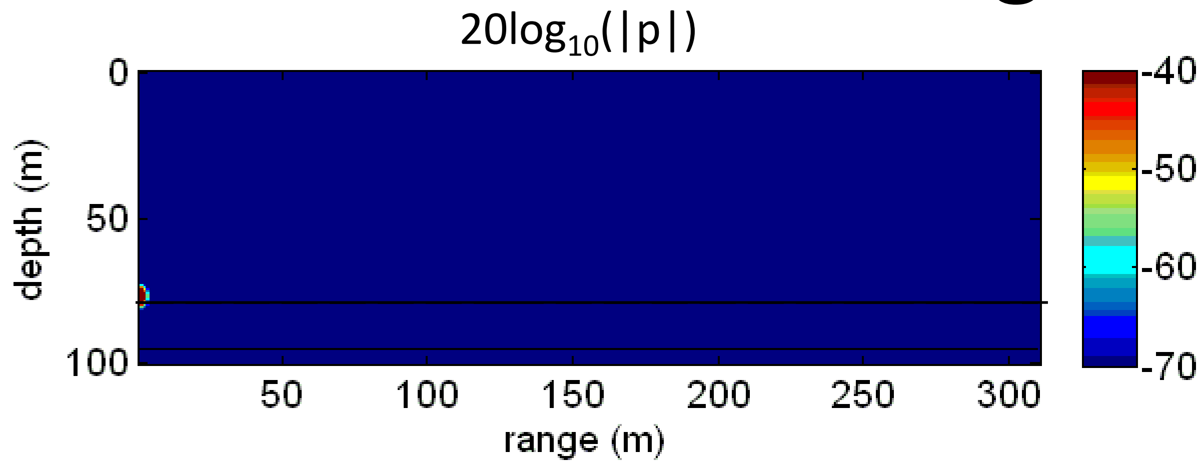


d = 20 cm Separation



Θ as a function of range

Compute Θ during the direct arrival



As a function of range, Θ exhibits characteristic oscillations in range