Acoustic Horizontal Coherence and Beamwidth Variability Observed in ASIAEX (SCS)

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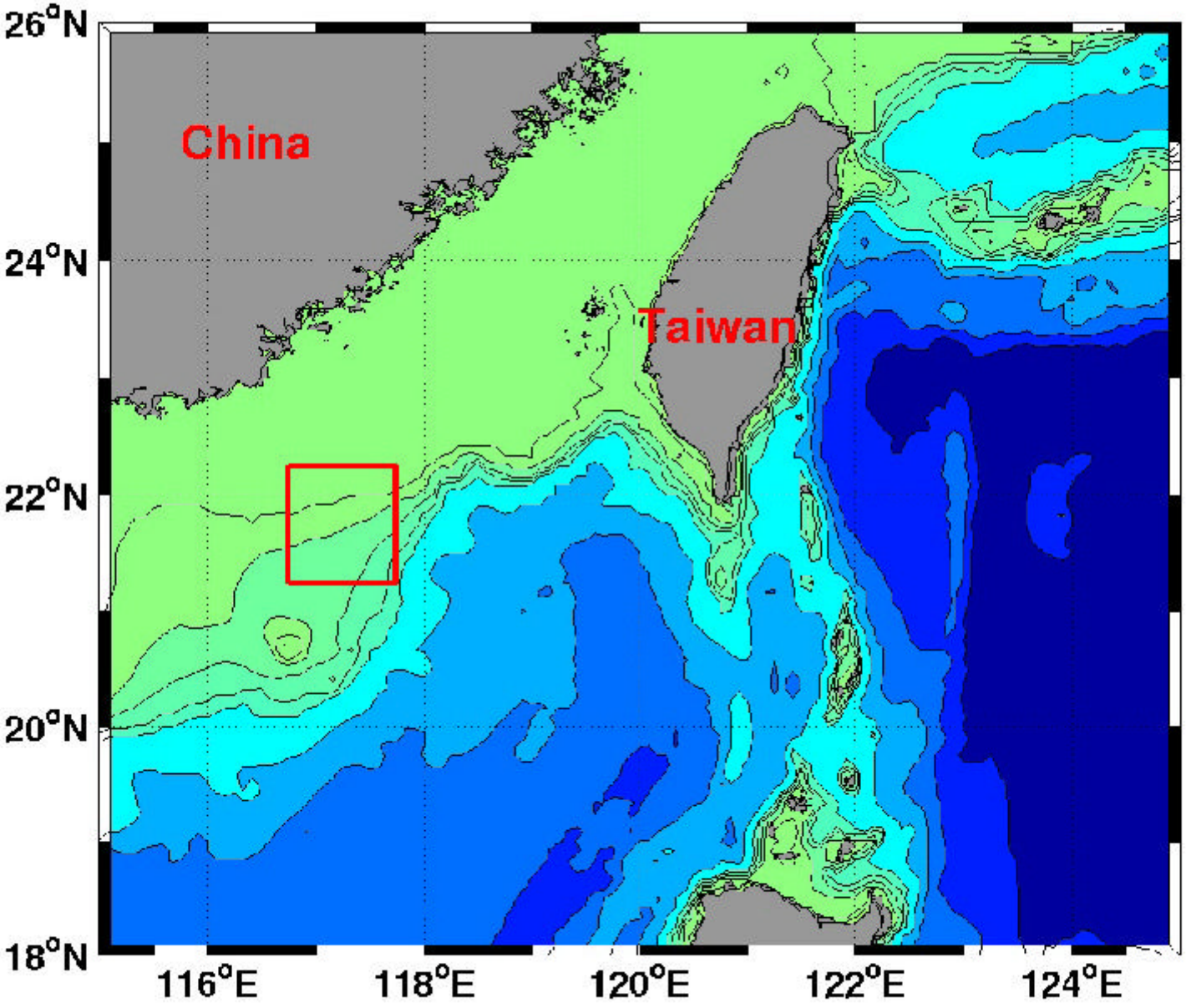

26°N
24°N
22°N
20°N
18°N
116°E
118°E
120°E
122°E
124°E
China
Taiwan

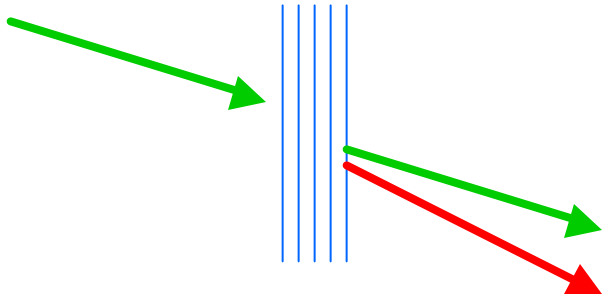
GOALS

Relate Acoustic Coherence to Water Column Inhomogeneity and Anisotropy

Contrast Coherence under Isotropic and Anisotropic Conditions

Coupling-induced Refraction

Independent of array orientation
Strongly dependent on IW orientation

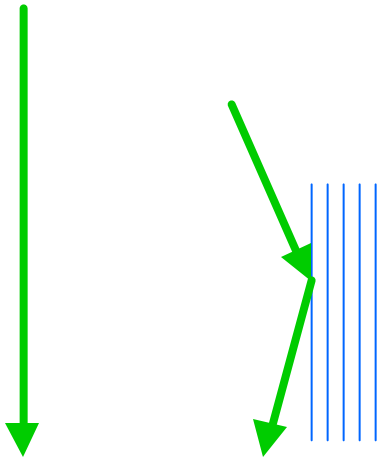


Large Incidence Angle:
Coupling to mode with
different phase speed

$\sin \phi_2 = \sin \phi_1 \, C_2 / C_1$

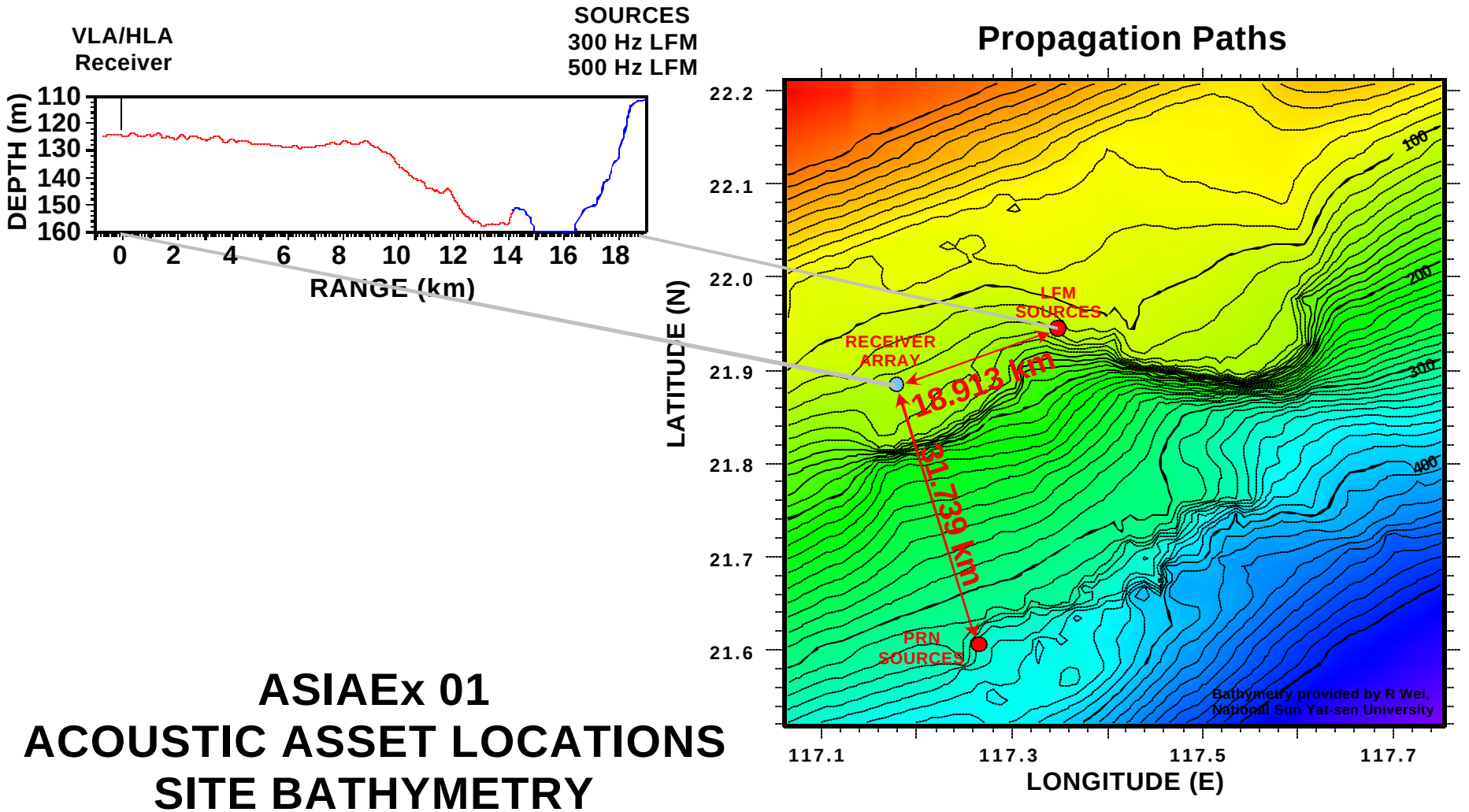
$\delta\phi \sim (C_2/C_1) - 1$

Adiabatic Refraction – near grazing incidence

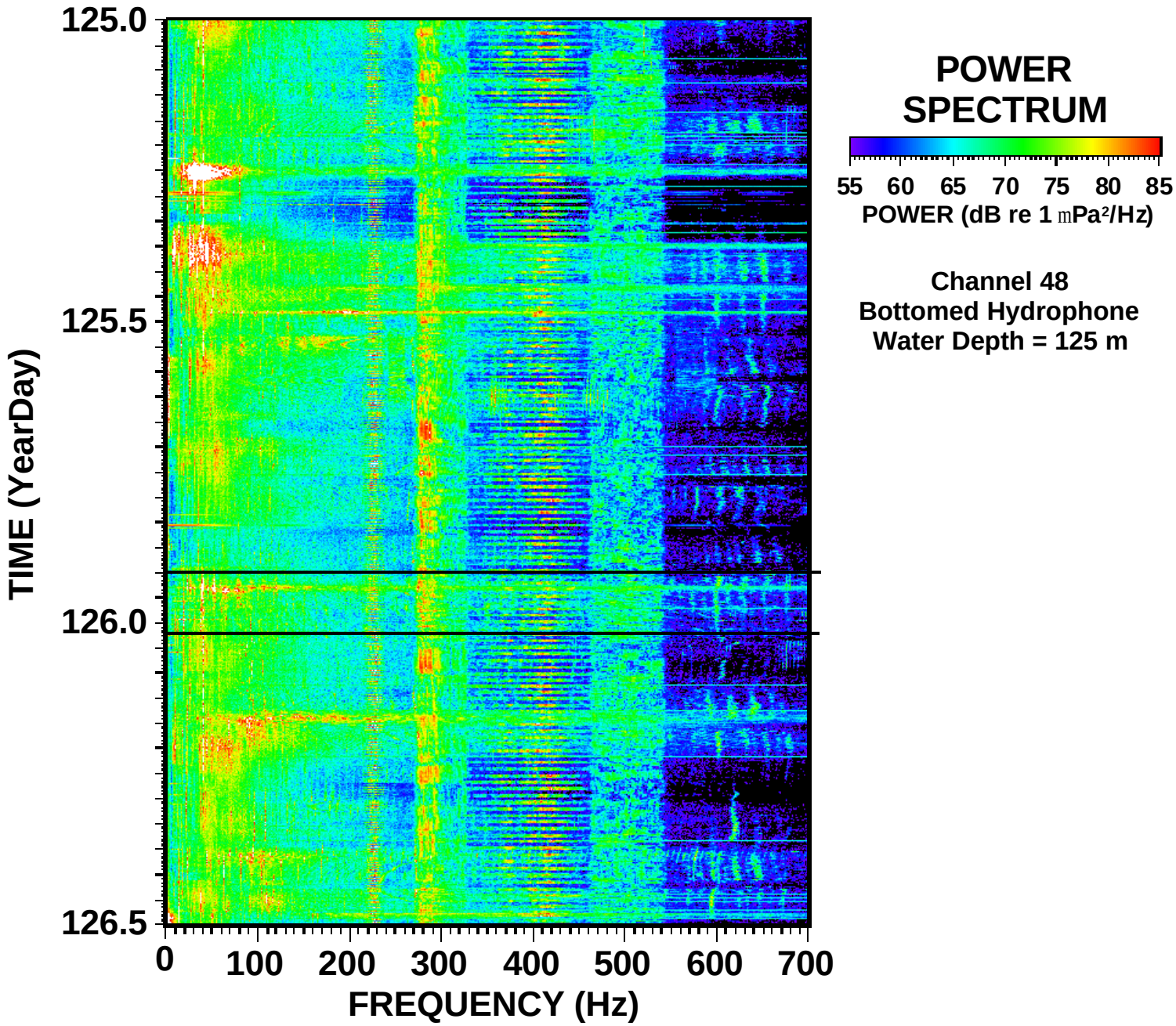


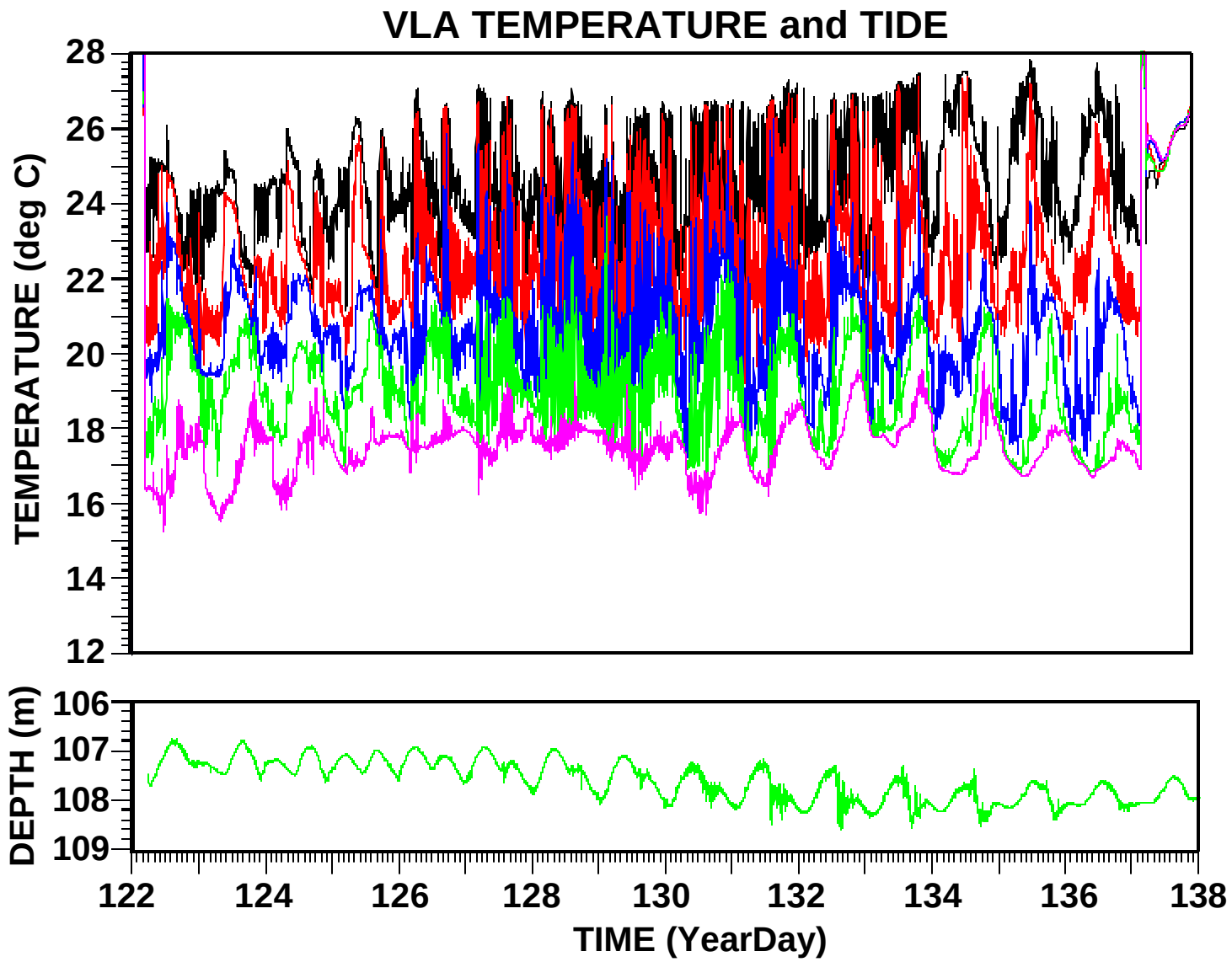
Small Incidence Angle:
Refraction due to local change in modal phase speed

$\cos(\delta\phi/2) < C_1 / C'_1 ; C' > C$

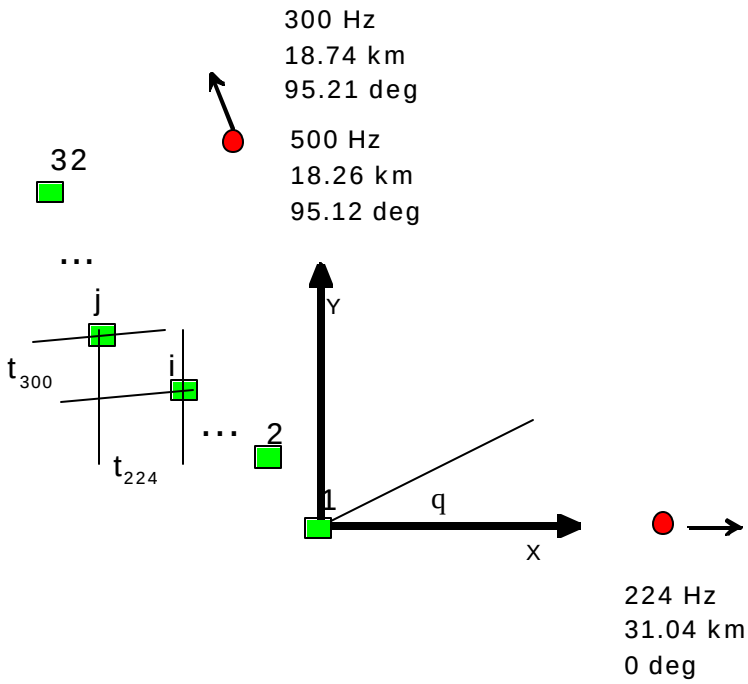


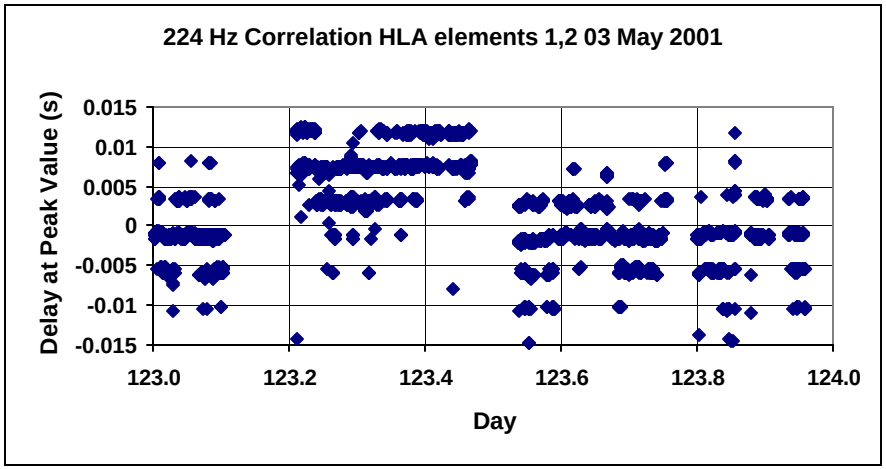
ASIAEx 01
ACOUSTIC ASSET LOCATIONS
SITE BATHYMETRY

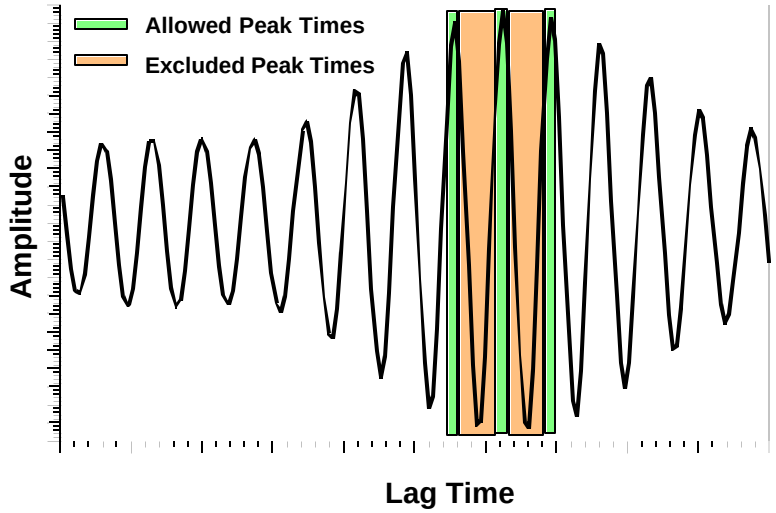

125.0
125.5
126.0
126.5
TIME (YearDay)
0
100
200
300
400
500
600
700
FREQUENCY (Hz)
POWER SPECTRUM
55 60 65 70 75 80 85
POWER (dB re 1 mPa²/Hz)
Channel 48
Bottomed Hydrophone
Water Depth = 125 m

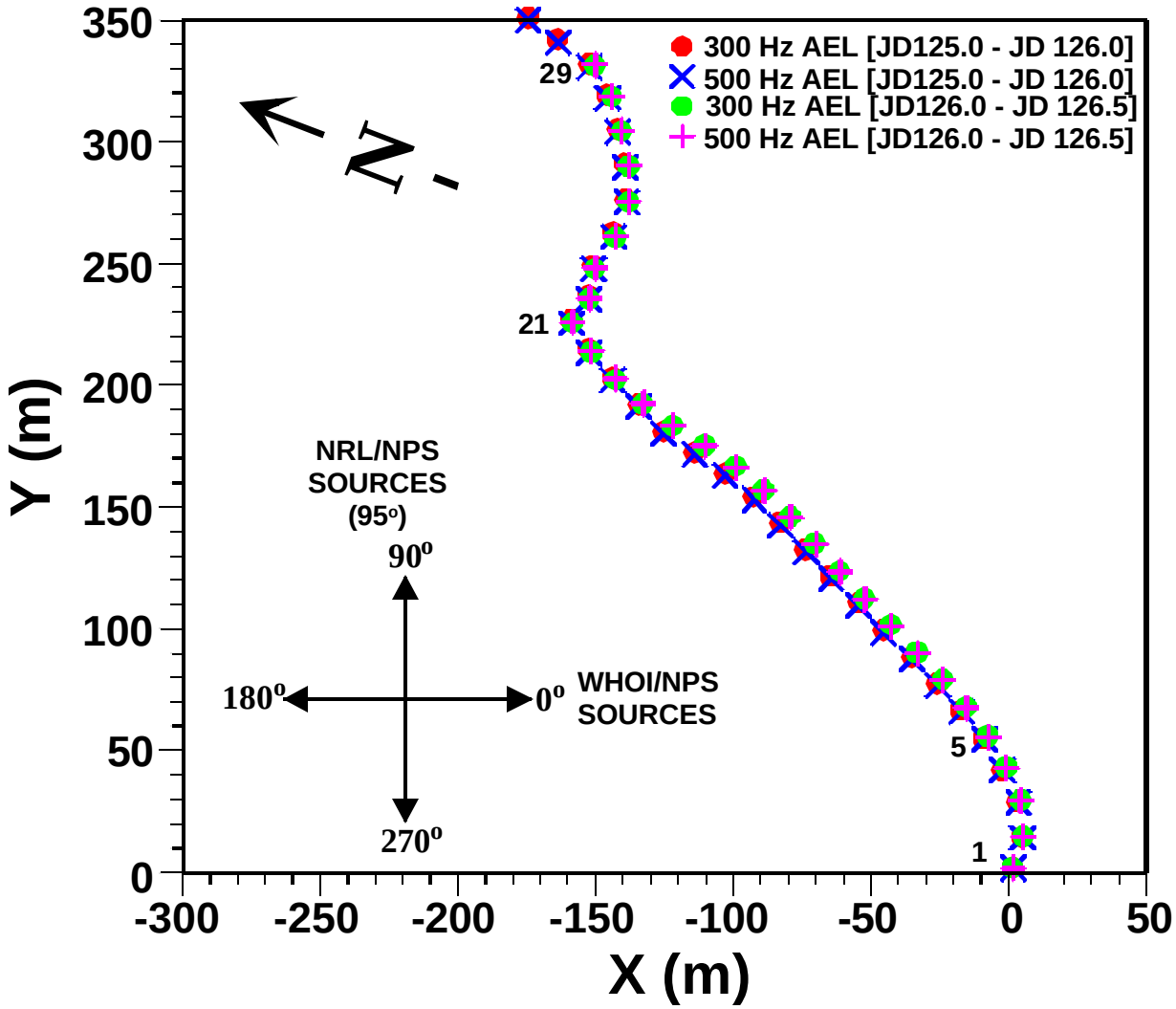

VLA TEMPERATURE and TIDE
TEMPERATURE (deg C)
28
26
24
22
20
18
16
14
12
DEPTH (m)
106
107
108
109
122
124
126
128
130
132
134
136
138
TIME (YearDay)

Array Element Localization









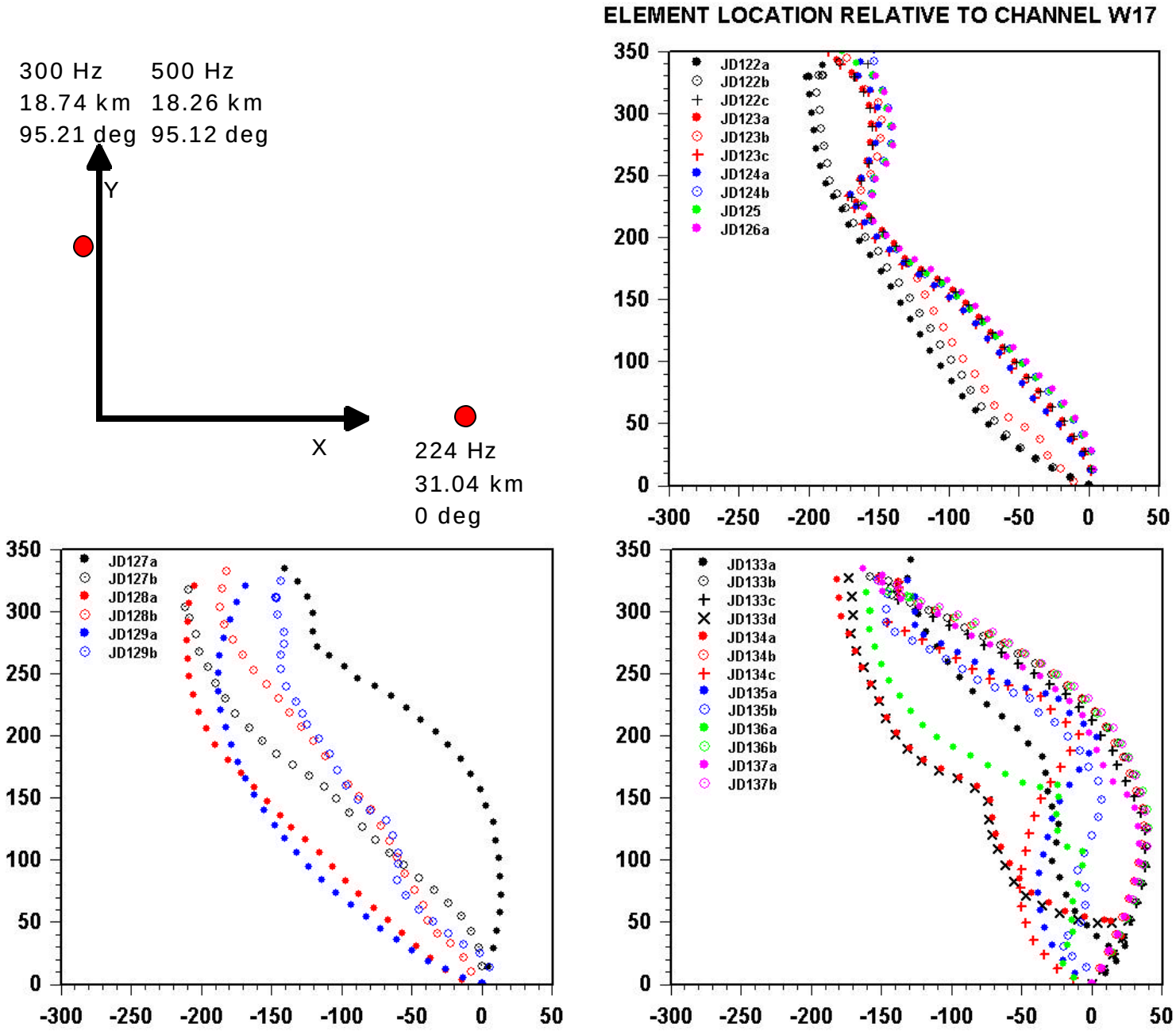
Localizations valid for periods of hours to ~ 1 day

Good (0.4 m typical) agreement at 300/500 Hz

Agreement with light bulb implosion localization

Motion smallest early in recording period

300 Hz
18.74 km
95.21 deg
500 Hz
18.26 km
95.12 deg
Y
X
224 Hz
31.04 km
0 deg


ELEMENT LOCATION RELATIVE TO CHANNEL W17
JD122a
JD122b
JD122c
JD123a
JD123b
JD123c
JD124a
JD124b
JD125
JD126a
JD127a
JD127b
JD128a
JD128b
JD129a
JD129b
JD133a
JD133b
JD133c
JD133d
JD134a
JD134b
JD134c
JD135a
JD135b
JD136a
JD136b
JD137a
JD137b
350
300
250
200
150
100
50
0
-300
-250
-200
-150
-100
-50
0
50

Numerical Testing

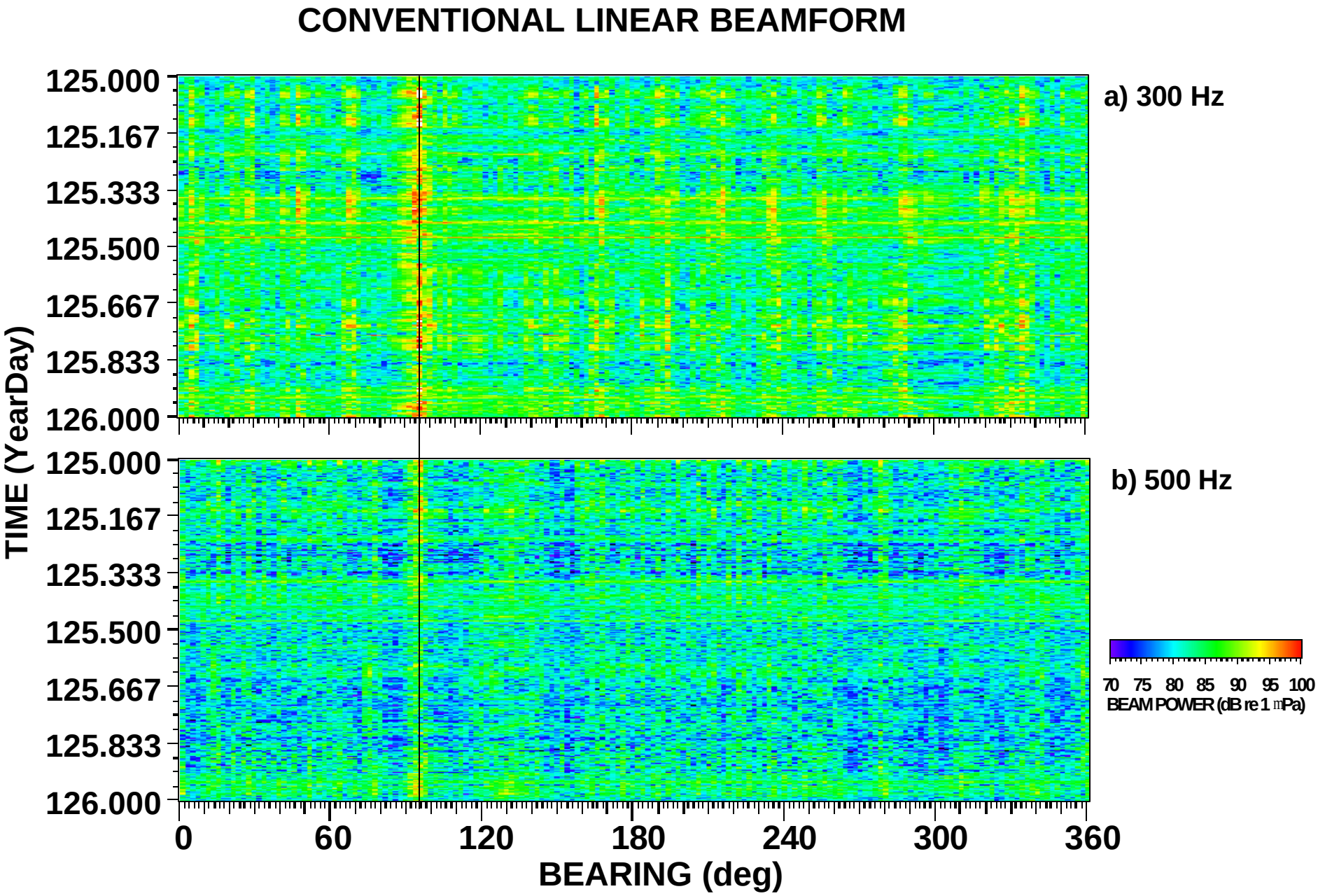
Nearfield corrections not required

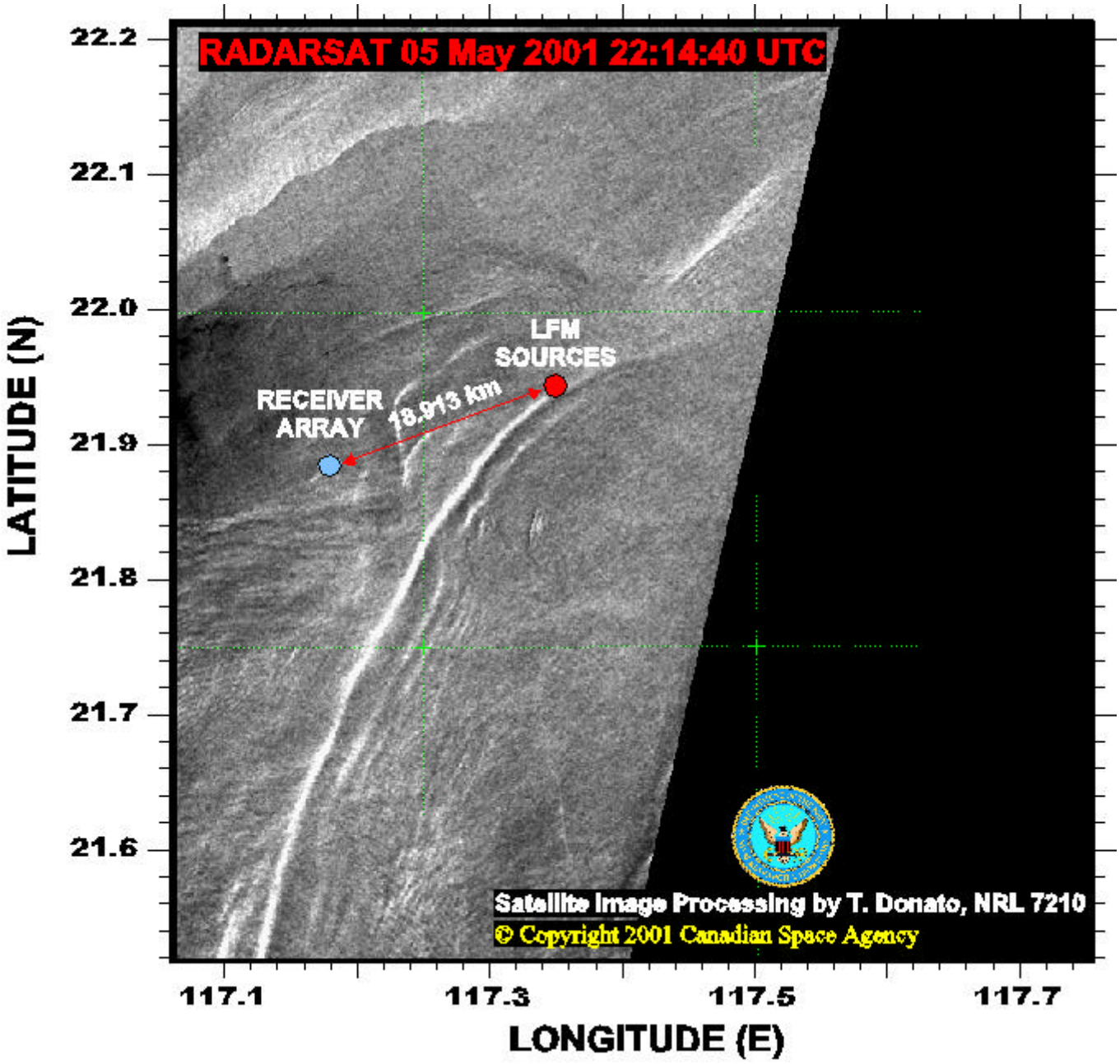
- ASG and resolution can be calculated using plane wave field

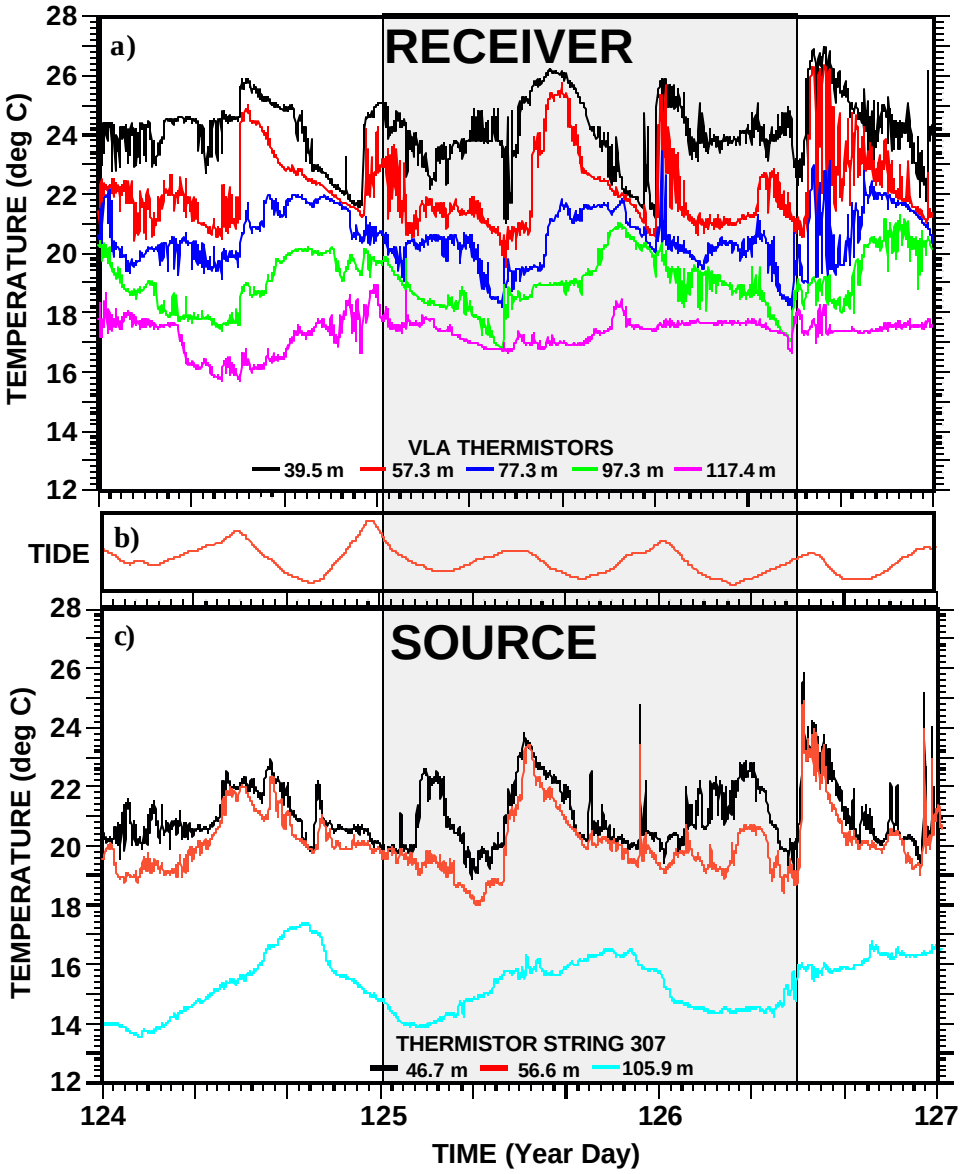
Bearing bias due to phase speed mismatch

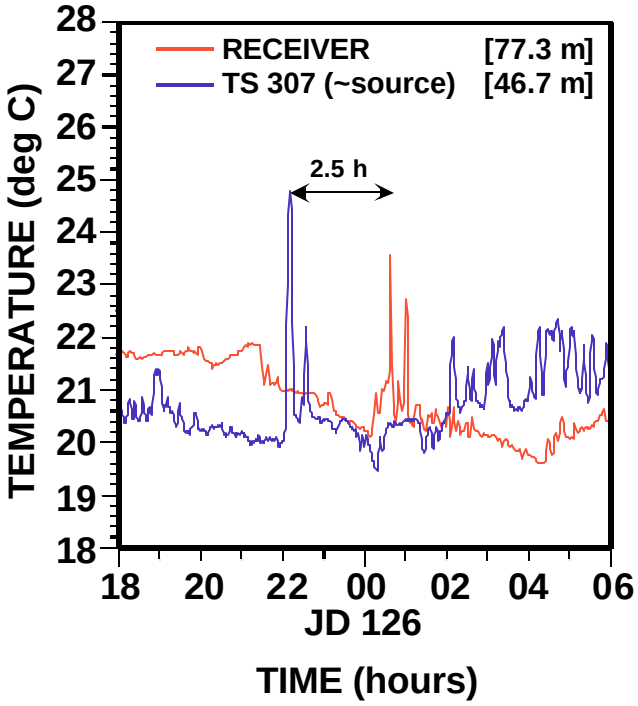
- Can use plane wave field calculation

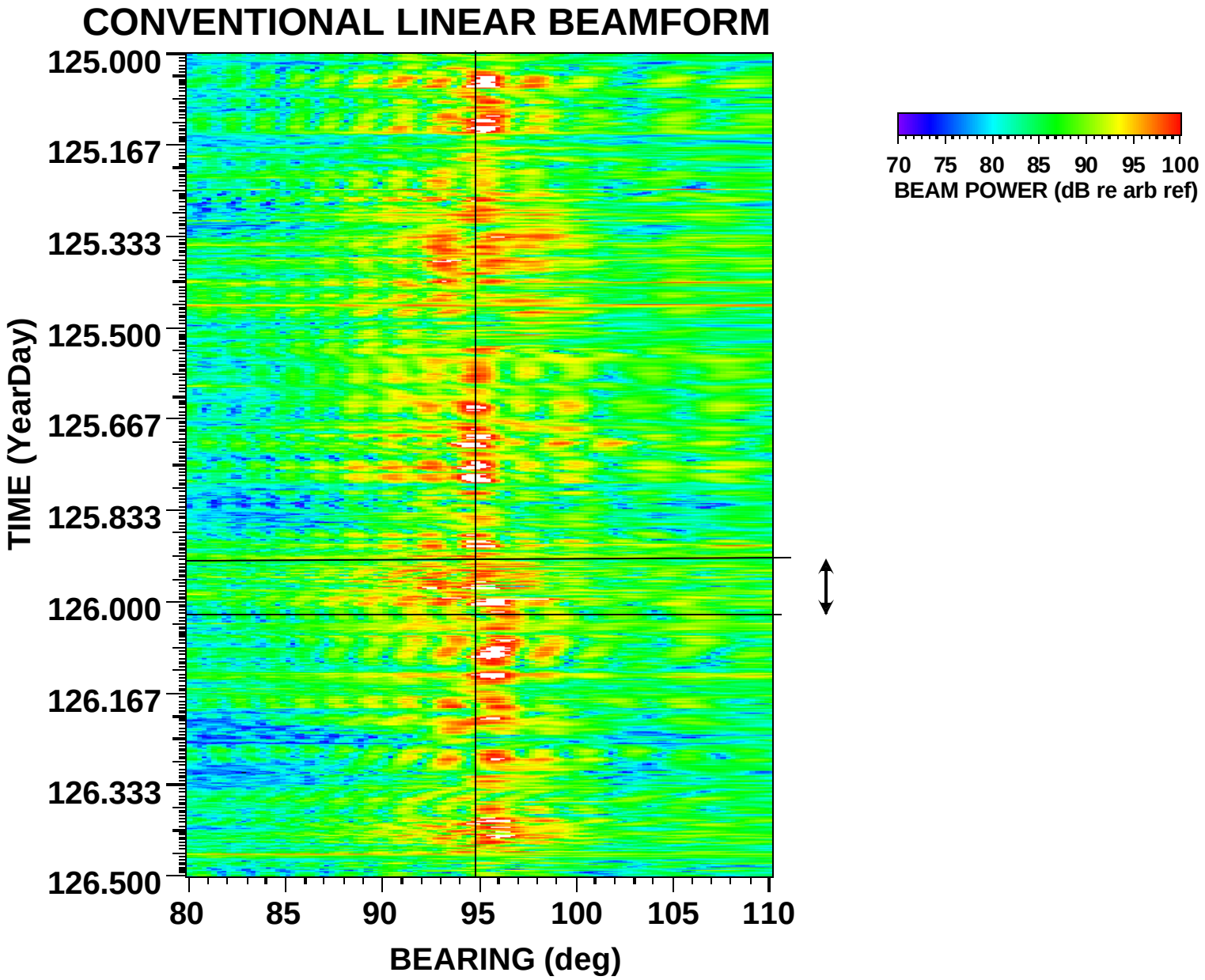
Planar shape removes grating lobe ambiguity

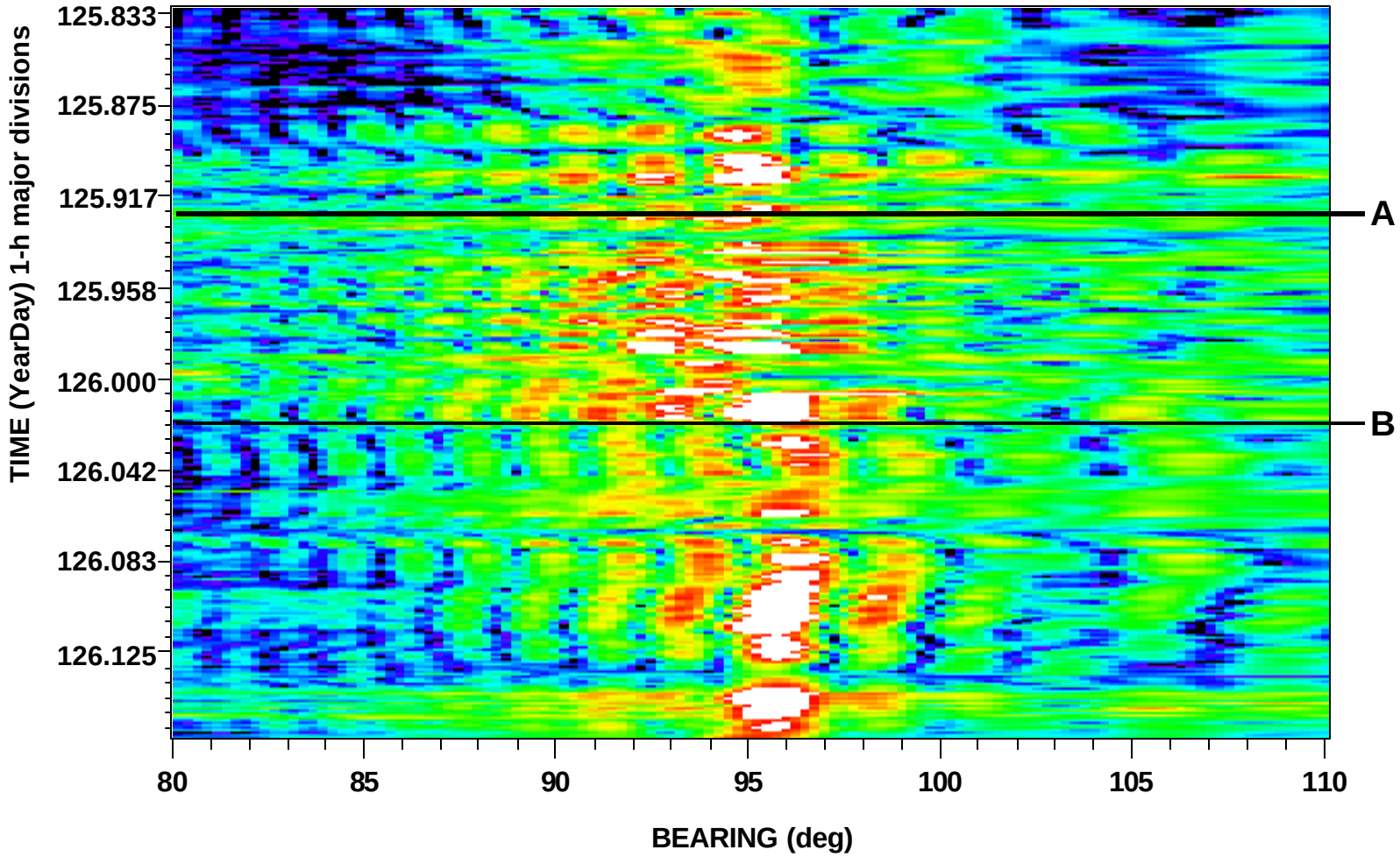

CONVENTIONAL LINEAR BEAMFORM
TIME (YearDay)
125.000
125.167
125.333
125.500
125.667
125.833
126.000
a) 300 Hz
b) 500 Hz
0
60
120
180
240
300
360
BEARING (deg)
70 75 80 85 90 95 100
BEAM POWER (dB re 1 mPa)

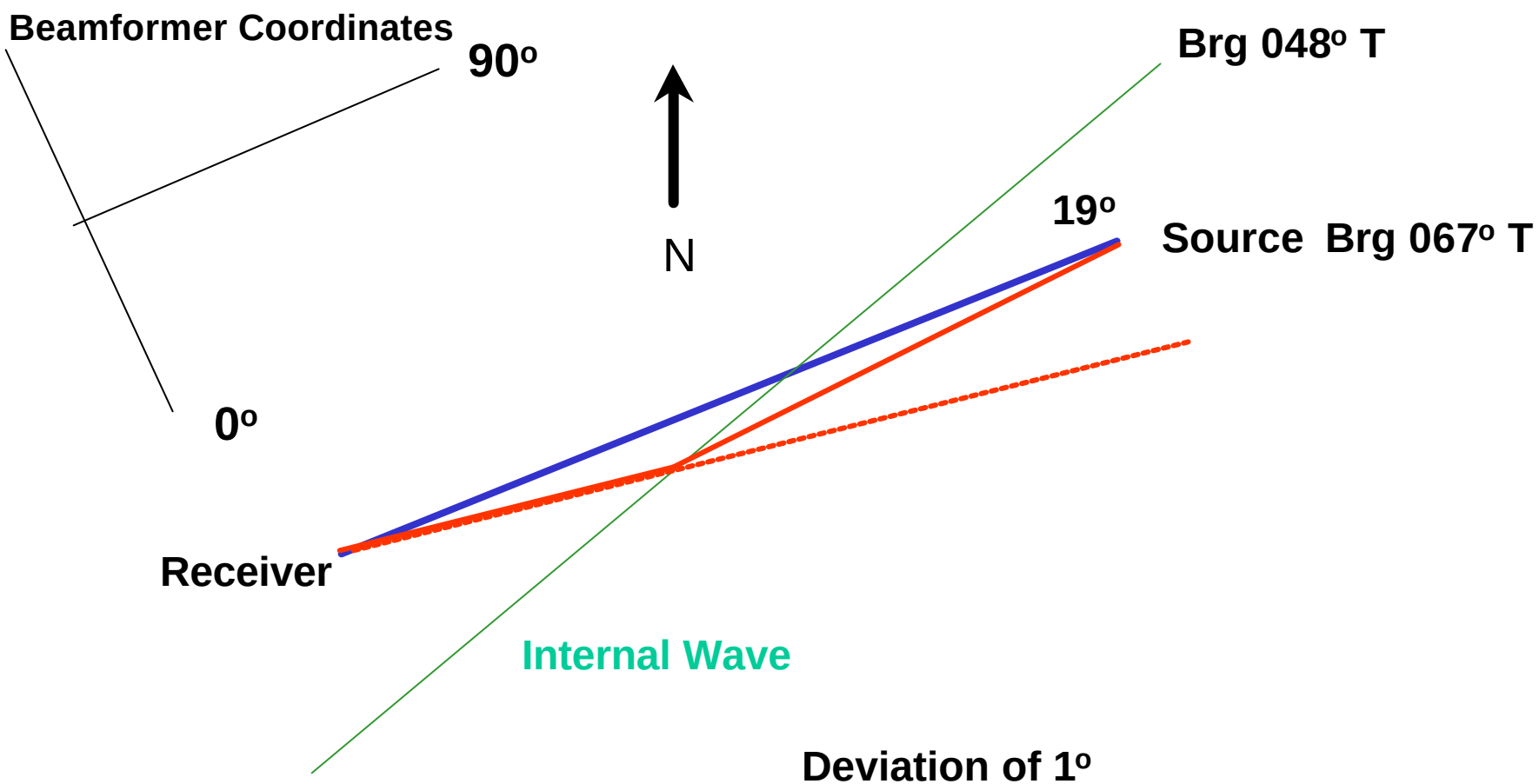

RADARSAT 05 May 2001 22:14:40 UTC
LFM SOURCES
RECEIVER ARRAY
18.913 km
LATITUDE (N)
22.2
22.1
22.0
21.9
21.8
21.7
21.6
117.1
117.3
117.5
117.7
LONGITUDE (E)
Satellite Image Processing by T. Donato, NRL 7210
© Copyright 2001 Canadian Space Agency


a)
RECEIVER
TEMPERATURE (deg C)
VLA THERMISTORS
39.5 m
57.3 m
77.3 m
97.3 m
117.4 m
b)
TIDE
c)
SOURCE
THERMISTOR STRING 307
46.7 m
56.6 m
105.9 m
124
125
126
127
TIME (Year Day)

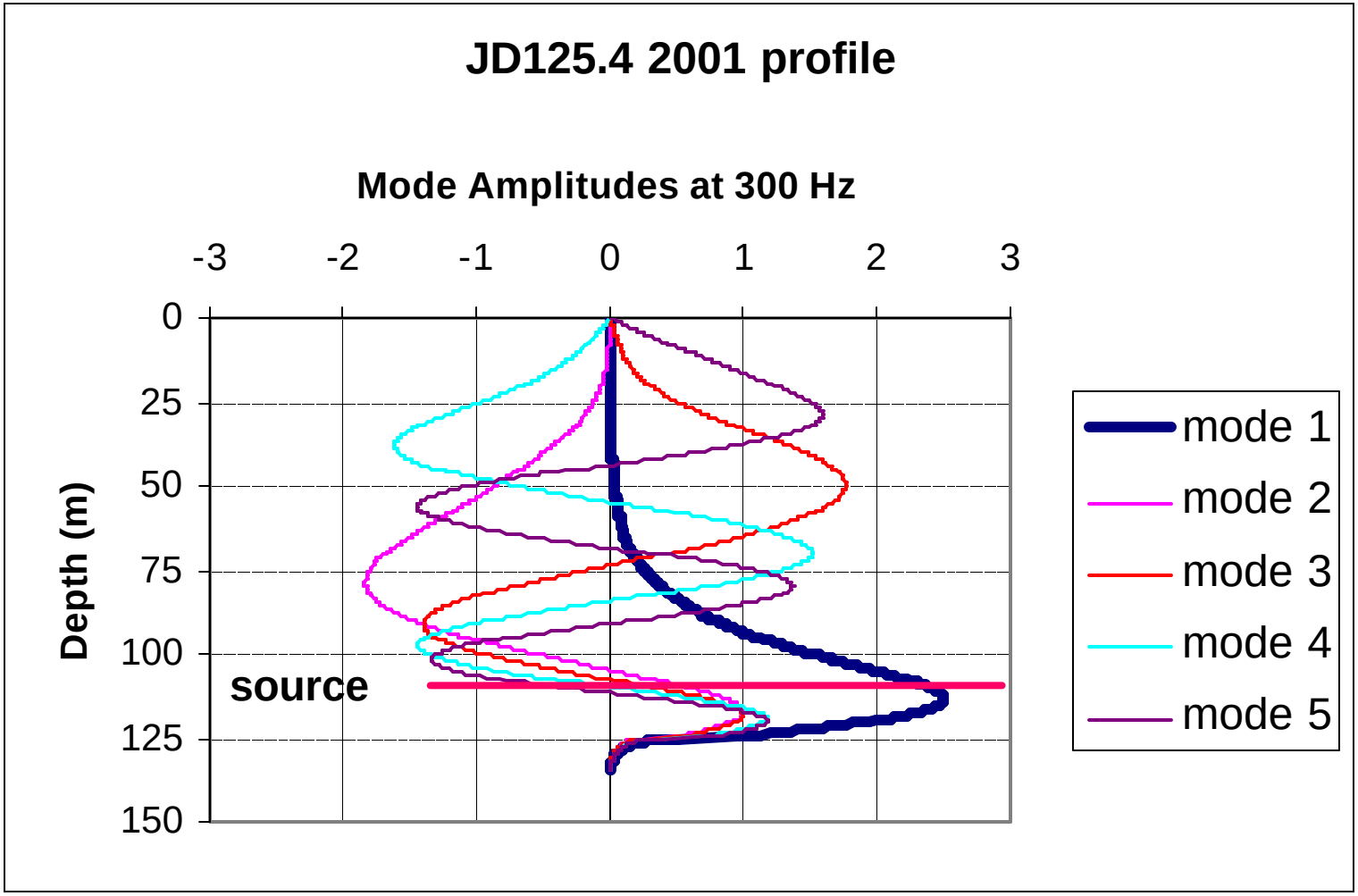

RECEIVER [77.3 m]
TS 307 (~source) [46.7 m]
2.5 h
TEMPERATURE (deg C)
18
20
22
00
02
04
06
JD 126
TIME (hours)

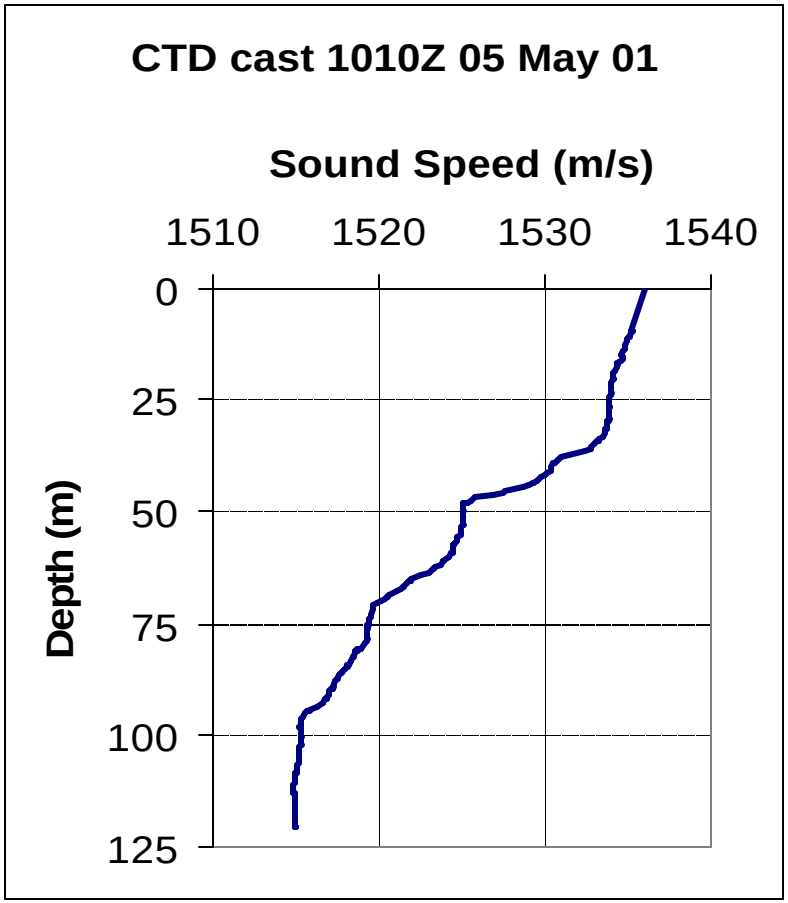

CONVENTIONAL LINEAR BEAMFORM
125.000
125.167
125.333
125.500
125.667
125.833
126.000
126.167
126.333
126.500
TIME (YearDay)
80
85
90
95
100
105
110
BEARING (deg)
70
75
80
85
90
95
100
BEAM POWER (dB re arb ref)

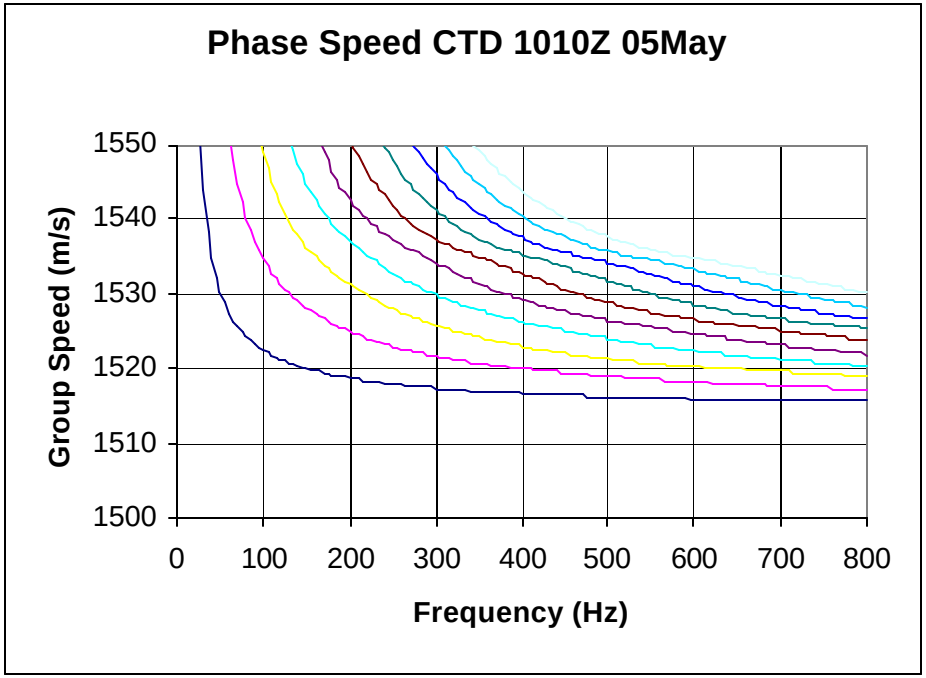

TIME (YearDay) 1-h major divisions
125.833
125.875
125.917
125.958
126.000
126.042
126.083
126.125
A
B
80
85
90
95
100
105
110
BEARING (deg)



Deviation of 1°
Observed at 2300Z
5 May 2001
Requires ~10 m/s
Phase Speed Decrease


JD125.4 2001 profile
Mode Amplitudes at 300 Hz
-3
-2
-1
0
1
2
3
0
25
50
75
100
125
150
Depth (m)
source
mode 1
mode 2
mode 3
mode 4
mode 5


CTD cast 1010Z 05 May 01
Sound Speed (m/s)
1510
1520
1530
1540
Depth (m)
0
25
50
75
100
125


Phase Speed CTD 1010Z 05May
Group Speed (m/s)
1550
1540
1530
1520
1510
1500
0
100
200
300
400
500
600
700
800
Frequency (Hz)

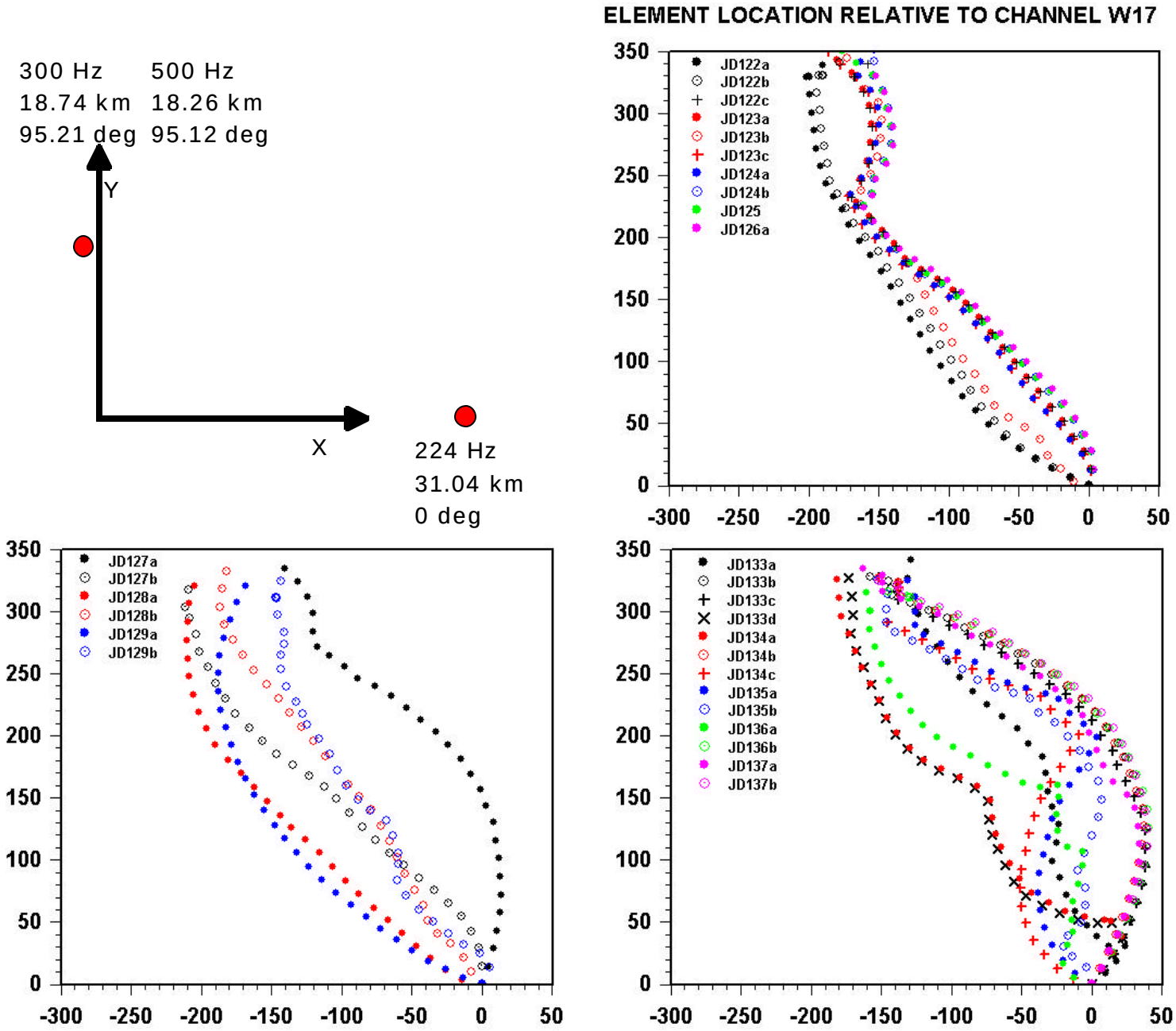
Preliminary Interpretation

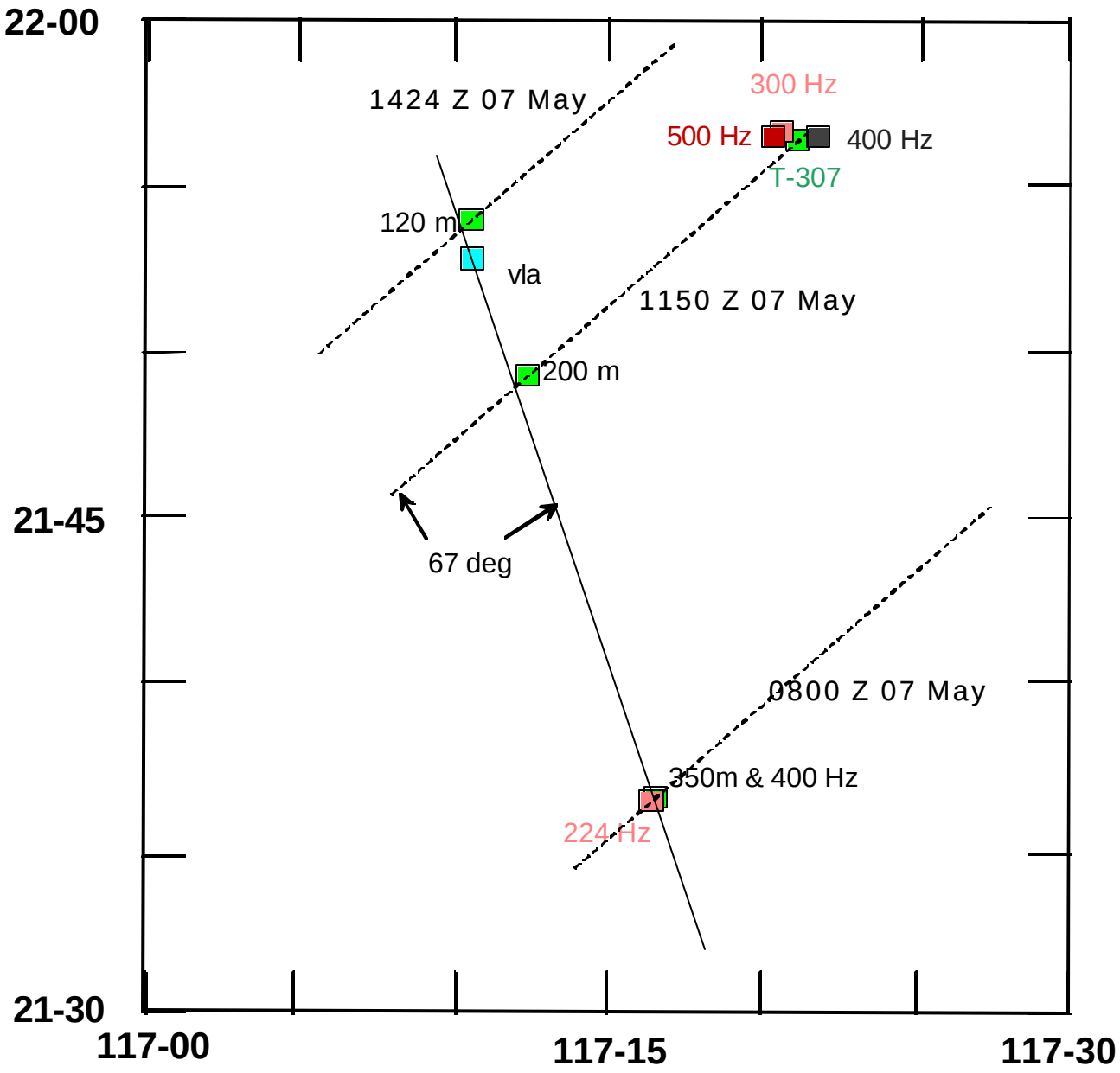
Most of energy in NB beam broadening can be attributed to biases associated with multimode (multiple phase-speed) propagation and non-broadside array

Some data may indicate refraction during coupling – work ongoing

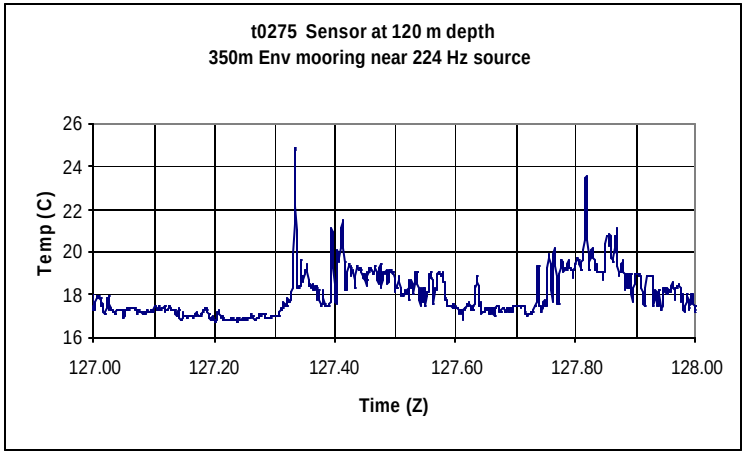
Issues complicating observations would disappear at array broadside

300 Hz
18.74 km
95.21 deg
500 Hz
18.26 km
95.12 deg
Y
X
224 Hz
31.04 km
0 deg

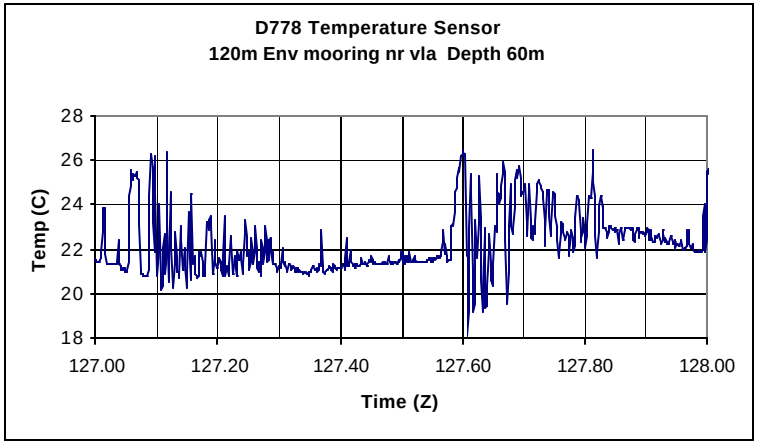

ELEMENT LOCATION RELATIVE TO CHANNEL W17
JD122a
JD122b
JD122c
JD123a
JD123b
JD123c
JD124a
JD124b
JD125
JD126a
JD127a
JD127b
JD128a
JD128b
JD129a
JD129b
JD133a
JD133b
JD133c
JD133d
JD134a
JD134b
JD134c
JD135a
JD135b
JD136a
JD136b
JD137a
JD137b
350
300
250
200
150
100
50
0
-300
-250
-200
-150
-100
-50
0
50


22-00
21-45
21-30
117-00
117-15
117-30
1424 Z 07 May
300 Hz
500 Hz
400 Hz
T-307
120 m
vla
1150 Z 07 May
200 m
67 deg
0800 Z 07 May
350m & 400 Hz
224 Hz

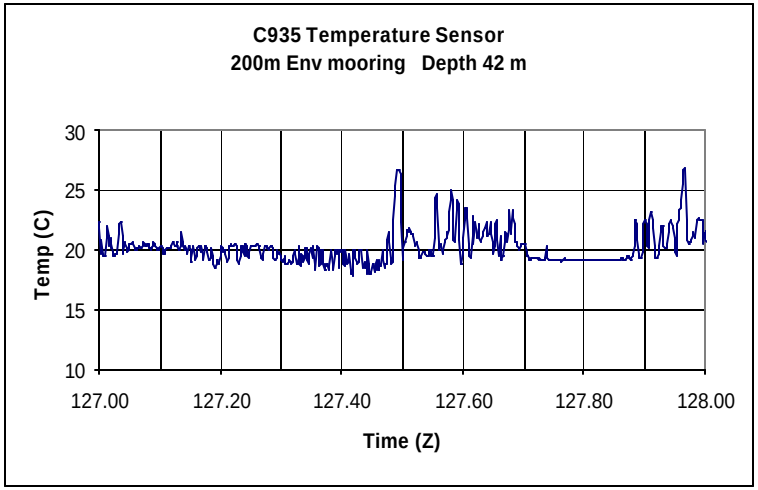
Source



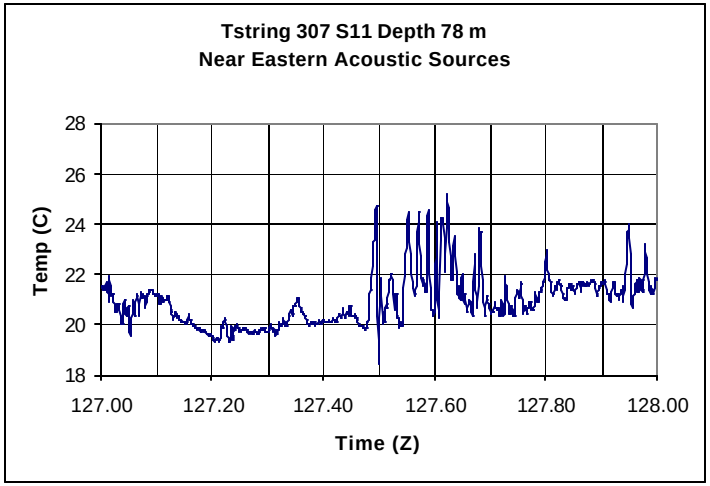
Receiver

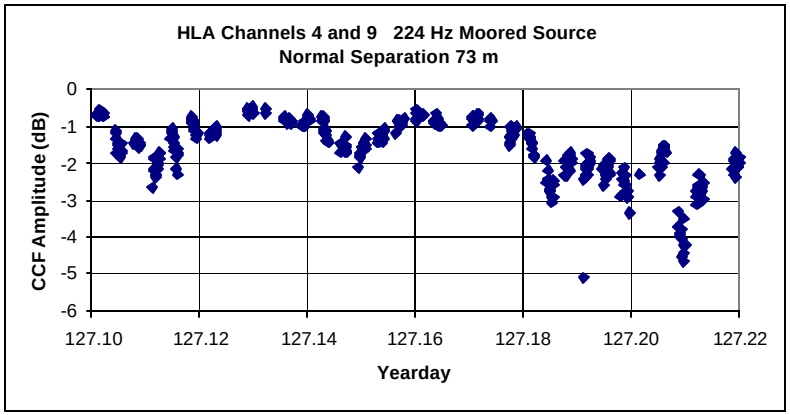


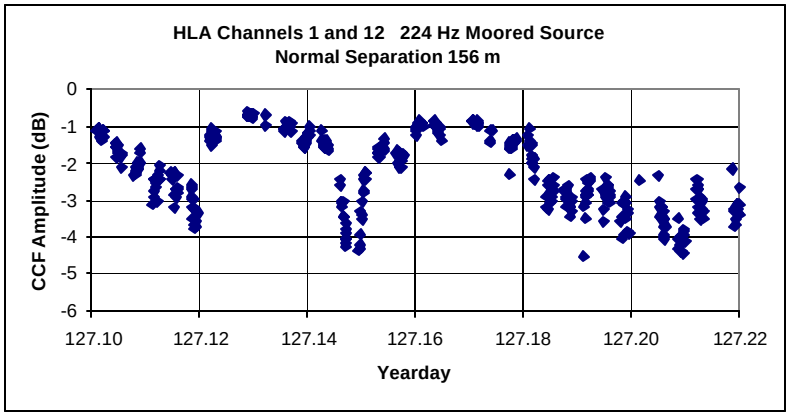
200 m Env

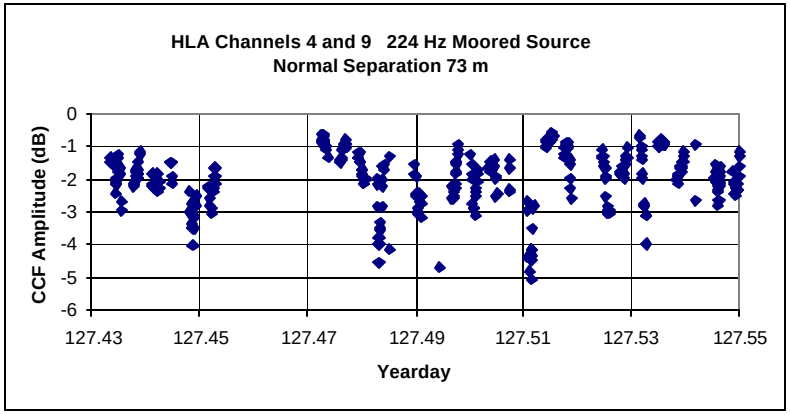


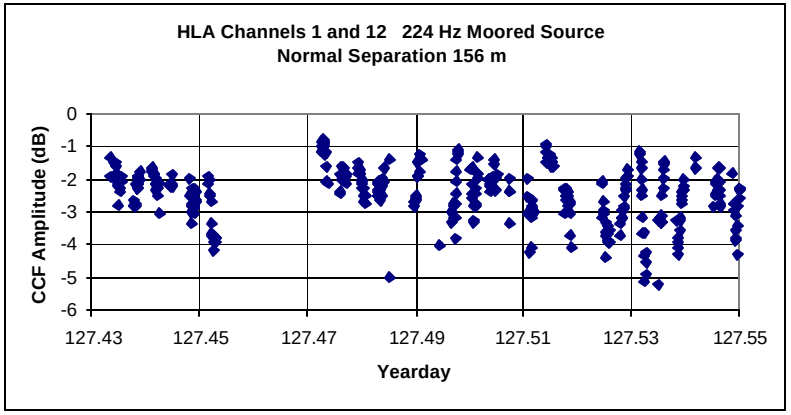
T-string 307




HLA Channels 4 and 9 224 Hz Moored Source
Normal Separation 73 m
CCF Amplitude (dB)
0
-1
-2
-3
-4
-5
-6
127.10
127.12
127.14
127.16
127.18
127.20
127.22
Yearday


HLA Channels 1 and 12 224 Hz Moored Source
Normal Separation 156 m
CCF Amplitude (dB)
0
-1
-2
-3
-4
-5
-6
127.10
127.12
127.14
127.16
127.18
127.20
127.22
Yearday


HLA Channels 4 and 9 224 Hz Moored Source
Normal Separation 73 m
CCF Amplitude (dB)
0
-1
-2
-3
-4
-5
-6
127.43
127.45
127.47
127.49
127.51
127.53
127.55
Yearday


HLA Channels 1 and 12 224 Hz Moored Source
Normal Separation 156 m
CCF Amplitude (dB)
0
-1
-2
-3
-4
-5
-6
127.43
127.45
127.47
127.49
127.51
127.53
127.55
Yearday

SUMMARY

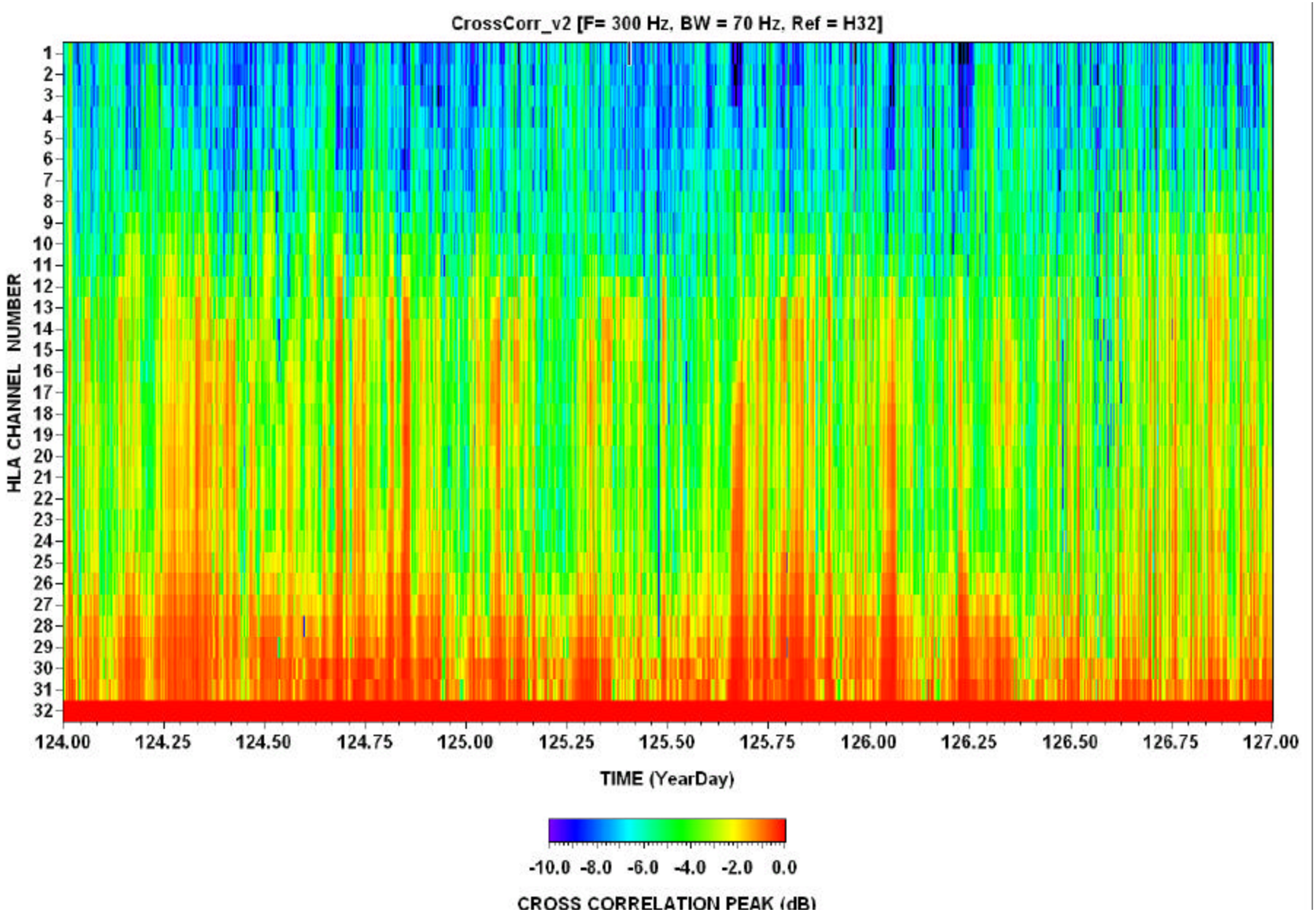
Array element localizations and beam processing completed for 17 day data set

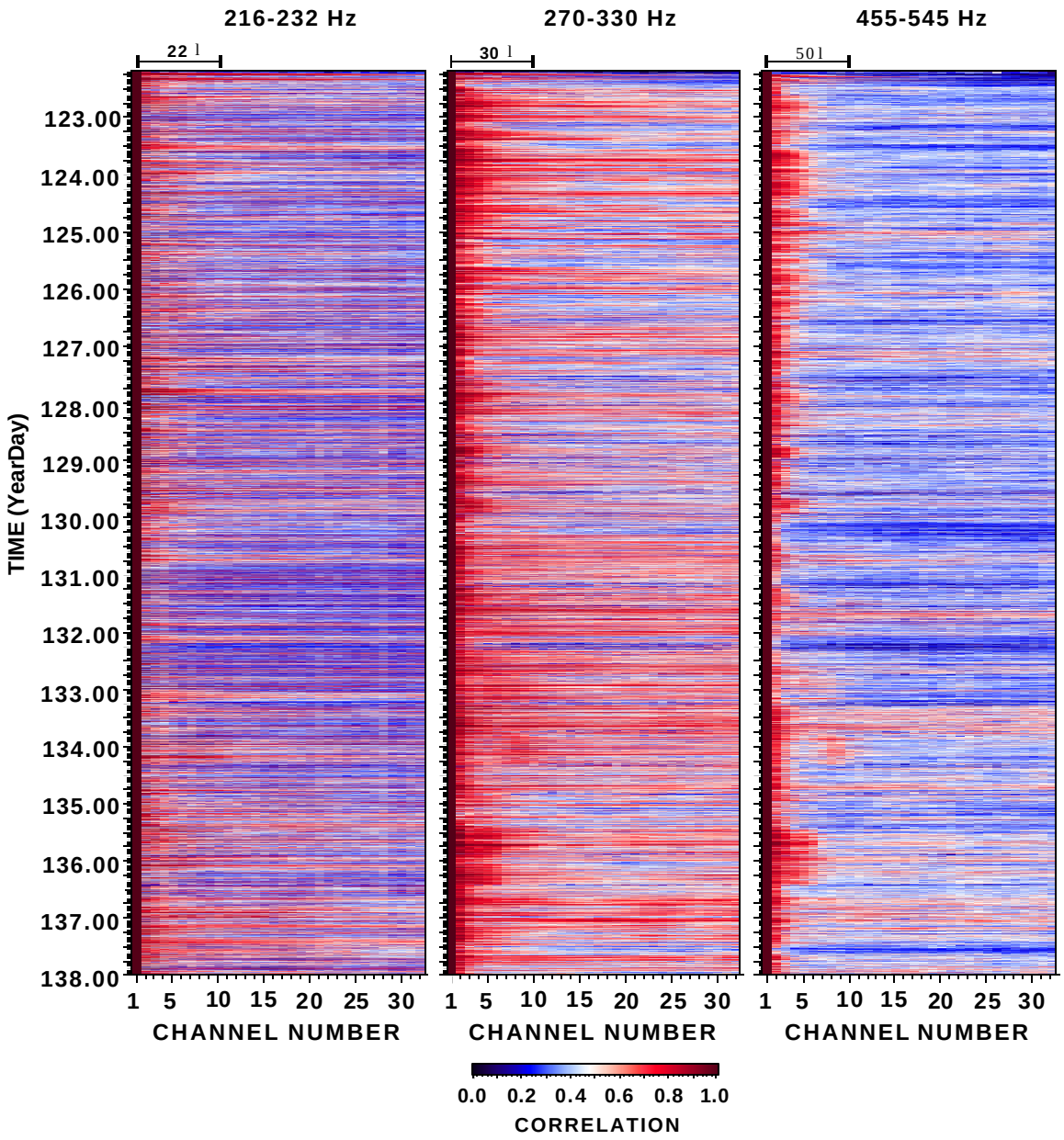
Aperture-limited beamwidths, near-ideal array signal gain found much of the time

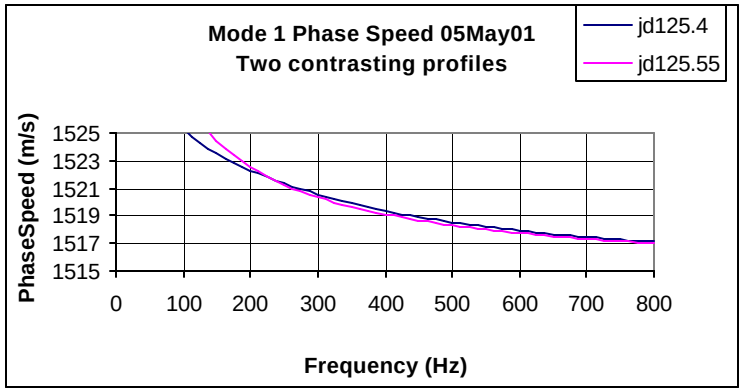
Off-broadside narrowband beam broadening appears to be primarily due to multipath wave number differences

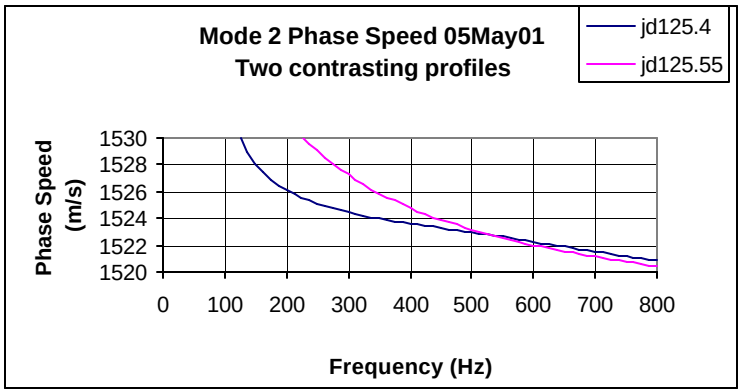
Some events may be due to horizontal refraction

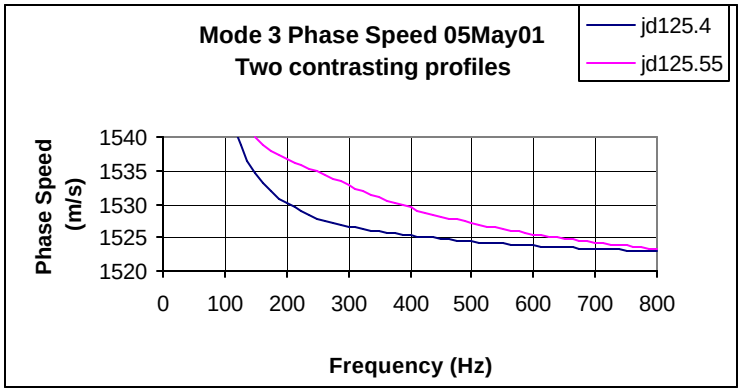
Broadside-element cross-correlation suggests long coherence lengths with some fading due to internal waves

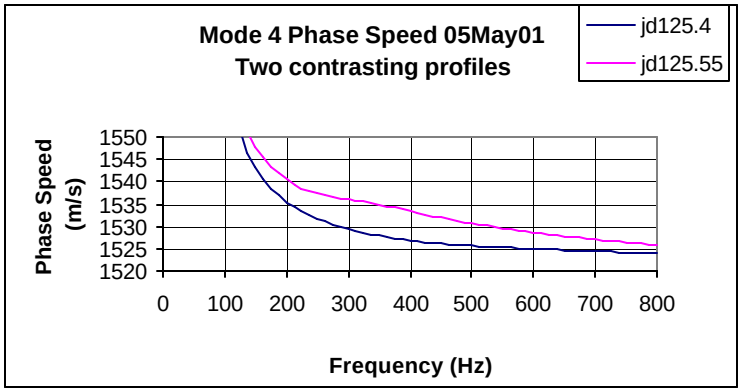

CrossCorr_v2 [F= 300 Hz, BW = 70 Hz, Ref = H32]
HLA CHANNEL NUMBER
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
124.00
124.25
124.50
124.75
125.00
125.25
125.50
125.75
126.00
126.25
126.50
126.75
127.00
TIME (YearDay)
-10.0 -8.0 -6.0 -4.0 -2.0 0.0
CROSS CORRELATION PEAK (dB)

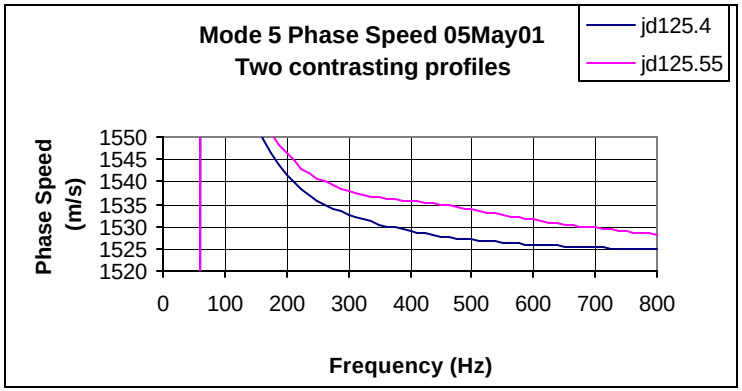

216-232 Hz
270-330 Hz
455-545 Hz
22
30
50
TIME (YearDay)
123.00
124.00
125.00
126.00
127.00
128.00
129.00
130.00
131.00
132.00
133.00
134.00
135.00
136.00
137.00
138.00
1 5 10 15 20 25 30
CHANNEL NUMBER
0.0 0.2 0.4 0.6 0.8 1.0
CORRELATION


Mode 1 Phase Speed 05May01
Two contrasting profiles
jd125.4
jd125.55
PhaseSpeed (m/s)
1525
1523
1521
1519
1517
1515
0
100
200
300
400
500
600
700
800
Frequency (Hz)


Mode 2 Phase Speed 05May01
Two contrasting profiles
jd125.4
jd125.55
Phase Speed (m/s)
1530
1528
1526
1524
1522
1520
0
100
200
300
400
500
600
700
800
Frequency (Hz)


Mode 3 Phase Speed 05May01
Two contrasting profiles
jd125.4
jd125.55
Phase Speed (m/s)
1540
1535
1530
1525
1520
0
100
200
300
400
500
600
700
800
Frequency (Hz)


Mode 4 Phase Speed 05May01
Two contrasting profiles
jd125.4
jd125.55
Phase Speed (m/s)
1550
1545
1540
1535
1530
1525
1520
0
100
200
300
400
500
600
700
800
Frequency (Hz)


Mode 5 Phase Speed 05May01
Two contrasting profiles
jd125.4
jd125.55
Phase Speed (m/s)
1550
1545
1540
1535
1530
1525
1520
0
100
200
300
400
500
600
700
800
Frequency (Hz)