 <b>SINTEF</b>  <b>SINTEF Telecom and Informatics</b>  Address: NO-7465 Trondheim NORWAY Location Trondheim: S.P. Andersens v 15 Location Oslo: Forskningsveien 1 Telephone: +47 73 59 30 00 Fax: +47 73 59 43 02  Enterprise No.: NO 948 007 029 MVA		<b>MEMO</b>						
		MEMO CONCERNS <b>Aircraft directivity</b>			FOR YOUR ATTENTION	COMMENTS ARE INVITED	FOR YOUR INFORMATION	AS AGREED
		DISTRIBUTION Kåre H. Liasjø, Luftfartsverket Knut Holen, Oslo Lufthavn A/S Nils Ivar Nilsen, Forsvarsbygg Odd Kr. Ø. Pettersen Svein Ådne Storeheier Herold Olsen Idar L. N. Granøien Asbjørn Ustad			X X X		X   X X X X X	
		FILE CODE 40-NO 020043  CLASSIFICATION Unclassified  ELECTRONIC FILE CODE 40-NO 020043.doc						
PROJECT NO. 403129.07	DATE 2002-05-02	PERSON RESPONSIBLE / AUTHOR Herold Olsen		NUMBER OF PAGES 372				

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## 2 Introduction

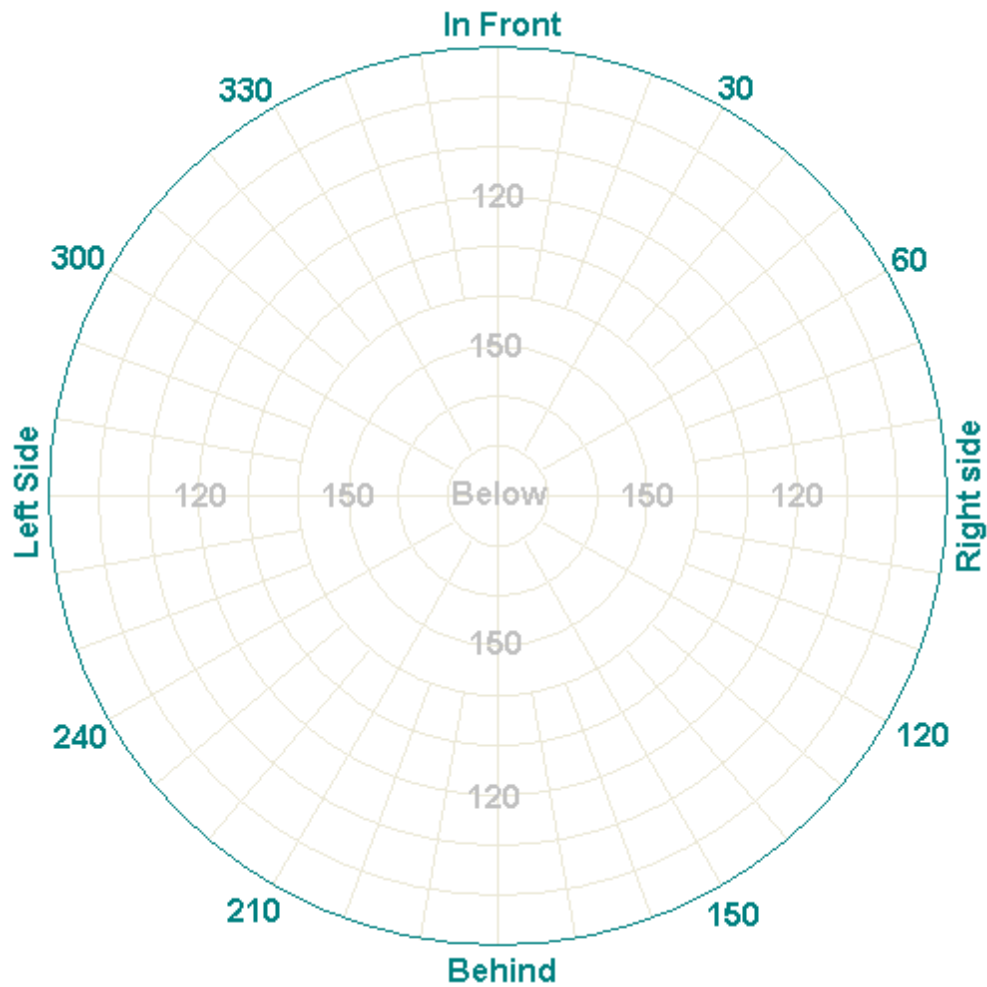
Noise data from 155 flights have been measured at Gardermoen airport. The measurement procedures and subsequent data processing are described in the main report.

This memo presents the directivity of the measured aircraft types, separated each 1/3 octave frequency band from 25 to 10000 Hz. The directivity is calculated from the measured data, using a propagation model (Nord 2000) that eliminates the influence from distance, ground surface and weather, thus giving the actual sound emission from the aircraft.

## 3 Analysis tools

Every measurement sample (2 per second) is propagated back to the source, using the model Nord 2000. This is a modern ray-tracing model, which accounts for the influence of topography, ground impedance, wind- and temperature gradients, and turbulence effects in the atmosphere. The calculations are done in a special developed Matlab program. To describe the 3D directivity as precise as possible, the program accounts for all aircraft angles (heading, pitch and roll), as well as the full source-to-receiver geometry.

A separate computer program is developed to visualise the source directivity. It is displayed as a colour map of the hemisphere below the aircraft, projected to a plane. The hemisphere above the aircraft is disregarded in these analyses. The projection is a kind of polar projection with *sideangle in the wing-plane* (Theta) along the projection circle, and *azimuth angle* (Phi) displayed as radius. Theta is set to 0 in front, 90 degrees to the right, 180 degrees behind etc. Phi is 0 straight above the aircraft, 90 degrees in the wing-plane, and 180 degrees straight below (see figure 1). This projection is chosen because it preserves the real area of any shape projected from the hemisphere to the plane, which means that grouping, smoothing, and other statistical analyses can be based on the x,y co-ordinates of the projection plane. The projection however does not preserve the shape of any object.



*Figure 1: Directivity projection. Theta angles in blue (outside circle). Phi angles in grey (inside circle).*

To help visualise any axis-symmetry in the directivity, lateral lines are added to the diagram (see red lines in figure 2). These connect points in the projection with constant angle to the flight heading vector. Any axis-symmetry in the data set will display as coloured areas parallel to these lines.

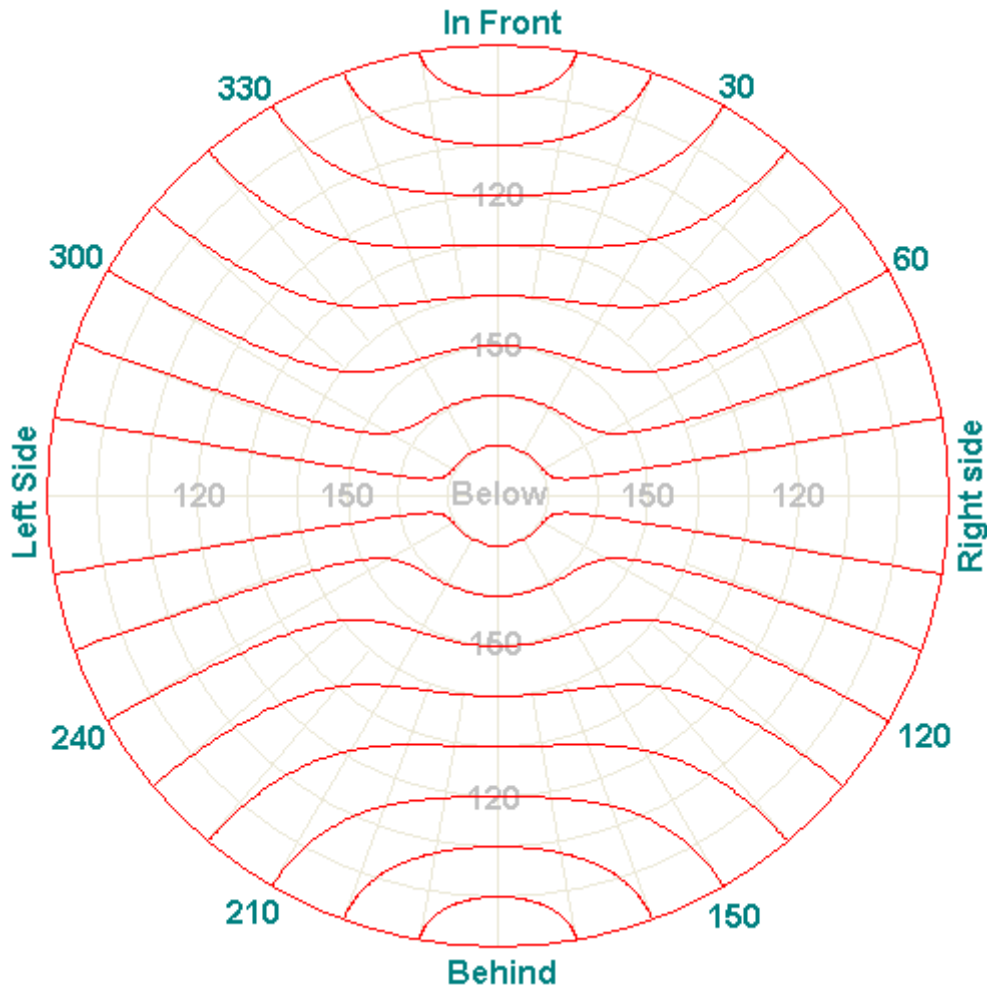


Figure 2: Lateral lines (axis-symmetric). Displays equal angle to flight vector.

In the source directivity program all source data for one aircraft type can be displayed. Different filters can be added to the data to investigate how the directivity changes due to operation (arrival and departure), thrust interval, frequency, measurement position and microphone height. In addition data can be excluded based on user defined parameters for background noise floor, source – receiver distance, aircraft elevation angle, and quality indicators in the propagation model.

Finally the program is able to calculate statistics for a resulting averaged source directivity, and produce report files containing source spectra, directivity plots and tables. Directivity parameters are averaged according to a grid, covering the projection as shown in figure 3. In this project we assume symmetry between right and left side of the aircraft. Thus all data are transferred to the right-hand side of the aircraft before statistical analyses. If a gridcell contains less than 10 samples, the data in it is replaced by the data from the closest cell containing 10 samples or more. In this way, the resulting directivity diagram will cover all angles below the aircraft.



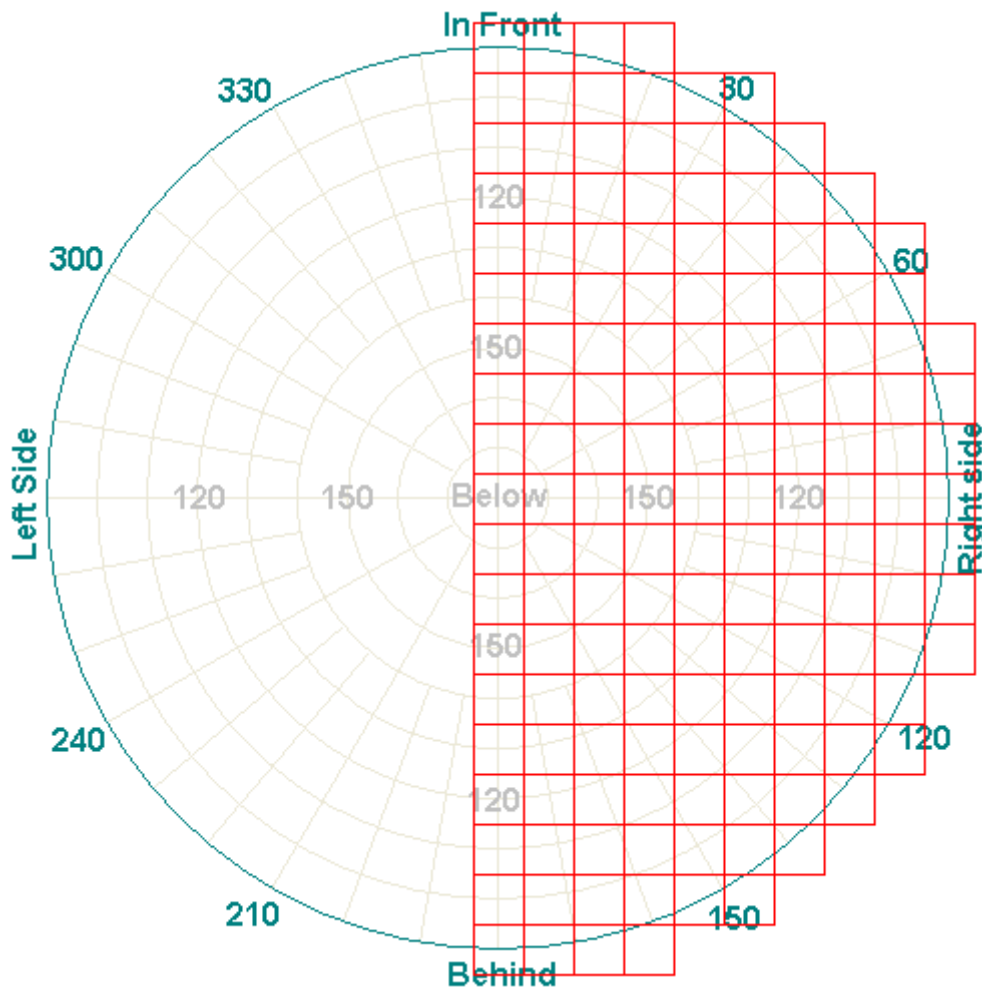


Figure 3: Grid for statistical analyses of directivity

#### 4 Backward propagation parameters

The backward propagation from receiver to source are based on:

- Nord 2000 algorithms
- Actual geometry including flight position and orientation sampled every 0.5 second
- Actual ground impedance measured close to the receiver
- Air absorption based on actual measured temperature and humidity, smoothed over 7 minutes.
- Actual wind speed and direction smoothed over 30 minutes.
- Temperature gradient is set to  $-1$  degrees per 100 meter, in accordance with measured meteorology and expert judgement of the total weather situation.
- No topography corrections (horizontal ground assumed)
- After backward propagation, the data for departures are normalised to a fixed thrust setting of 10000 Lbs. This is done by subtracting 1.1 dB per 1000 Lbs thrust exceeding 10000 Lbs. Arrival data are not normalised by thrust.

#### 5 Data filtering

A series of test calculations of source directivity is done to verify the quality, and find optimum settings for filtering parameters. The goal was to exclude suspicious data, and gain highest possible statistic strength in the results. It seems that the directivity does not change much with

varying thrust, so we decided to display it as an average for all measured thrust settings, after separation between arrival and departure.

Other filter settings where:

- No specific adjustment for background noise other than what was done by the raw measurement data.
- All departure data propagated more than 2 km where excluded, as well as all arrival data propagated more than 1 km.
- On departures, all data propagated at an elevation angle less than 15 degrees where excluded. On arrivals no data where excluded due to elevation angle.
- All data with normalised propagation (air and ground attenuation) less than  $-30$  dB where excluded.

## 6 Directivity results

Section 7 through 20 below show the directivity plots for each aircraft type. The data is organised as one spectrum table, and 27 directivity plots. The table covers all measured directions from the aircraft, and has the following columns:

- Freq: 1/3 octave center frequency from 25 to 10000 Hz
- Num: Number of 0.5 second measurement samples
- Avg: Average sound level 1 meter from a point representing the aircraft
- Std: Standard deviation of the 0.5 second sound levels
- 95%Avg: the +/- deviation for the average sound level, within 95% confidence interval
- P1, ...P6: Average level for each engine power setting, grouped according to the NPD table

The directivity plots show all 0.5 second samples as sound pressure levels 1 meter from a point representing the aircraft. They are plotted in the projection of the hemisphere below the aircraft, described above, as one small circle per sample. The colour of the circle indicates the deviation from the average of all samples, according to a colour scale of  $\pm 15$  dB. Black circles indicate that the sample is outside the colour scale.

At the top of both tables and directivity plots, the aircraft type is indicated, along with the one letter indicator “A” for arrival and “D” for departure. In the plots, the 1/3 octave centre frequency, and average sound level is indicated.

The resulting averaged source directivities with corresponding statistics are tabulated in ASCII text files. They are not included in this memo due to space limitations. A printout would take approx 2000 pages. Corresponding binary files are created to hold the averaged data. The file *acDir\_D.bin* contains data for departures, and *acDir\_A.bin* contains data for arrivals. The file is a binary dump of a 6 dimensional array of single precision real (4 bytes).

The dimensions of this array are:

- Dimension 1: 8 indexes corresponding to the aircraft type:
  - 1 = B737 600
  - 2 = B737 700
  - 3 = B737 800
  - 4 = MD81

- 5 = MD82
- 6 = MD83
- 7 = MD87
- 8 = MD90
- Dimension 2: 7 indexes corresponding to thrust category:
  - 0 = Average for all thrusts (after normalisation to 10000 Lbs at takeoffs)
  - 1 = Average for INM NPD thrust setting 1 (no normalisation)
  - 2 = Average for INM NPD thrust setting 1 (no normalisation)
  - 3 = Average for INM NPD thrust setting 1 (no normalisation)
  - 4 = Average for INM NPD thrust setting 1 (no normalisation)
  - 5 = Average for INM NPD thrust setting 1 (no normalisation)
  - 6 = Average for INM NPD thrust setting 1 (no normalisation)
- Dimension 3: 10 indexes for indication of gridcell X (horizontal position ref. figure 3)
- Dimension 4: 19 indexes for indication of gridcell Y (vertical position ref. figure 3)
- Dimension 5: 27 indexes for 1/3 octave frequency band from 25 Hz to 10000 Hz
- Dimension 6: 4 indexes for data type:
  - 1 = Number of data points in the cell
  - 2 = Average sound pressure level 1 meter from a point representing the source
  - 3 = Corresponding standard deviation
  - 4 = Corresponding 95% confidence interval

In Visual Basic the array can be declared and loaded from the file this way:

```
Dim acDir(1 To 8, 0 To 6, 1 To 10, 1 To 19, 1 To 27, 1 To 4) As Single
Open "acDir_D.bin" For Binary Access Write As #1
Get #1, , acDir
Close #1
```

A similar procedure can be used to read the file into a FORTRAN array.

An algorithm to calculate gridcell index (iX = dimension 3 and iY = dimension 4) from *Theta* and *Phi*, may look like this in Visual Basic:

```
T = Pi / 2 - Theta
F = Pi - Phi
X = F * Cos(T)
Y = F * Sin(T)
iX = Fix(X / Pi * 19) + 1
iY = Fix(Y / Pi * 19) + 10
```

## 7 Findings

The directivity analyses can be summarised in the following main results:

- The directivity is strongly dependent on frequency. This means that it will also depend on distance between source and receiver, since sound propagation is strongly frequency dependent too.
- The directivity is fundamental different between the tail-engine aircraft (MD8x, MD90) and wing-engine aircraft (B73x). This is especially the case below 1000 Hz, which is the

dominating range in noise zoning situations. Tail-engine aircraft has a very distinct directivity lobe behind the aircraft at mid and low frequencies, while wing-engine aircraft are more omnidirectional.

- The present data set shows no clear difference in directivity between MD8x and MD90, even though the engine bypass ratio is different.
- There is a clear difference in the directivity between B73x and MD90, even though the engine type is similar. Connected to the above two points, this indicates that major differences in directivity depend more on engine placement than engine bypass ratio.
- The sound radiation downwards is generally higher than to the side. This is clearly most evident behind tail-engine aircraft, at mid and lower frequencies.
- The directivity does not change significantly by the thrust intervals covered by the measurements.

## 8 B737 600 directivity at departure

SPECTRUM  
Source Emission  
B736  
D

Freq	Num	Avg	Std	95%Avg	P1	P2	P3	P4	P5	P6
25	7426	120.2	6.7	0.2	-1.0	-1.0	119.4	120.3	-1.0	-1.0
31.5	8568	121.9	6.0	0.1	-1.0	-1.0	121.1	121.9	-1.0	-1.0
40	8738	122.5	5.6	0.1	-1.0	-1.0	121.9	122.6	-1.0	-1.0
50	9146	123.1	5.2	0.1	-1.0	-1.0	122.1	123.2	-1.0	-1.0
63	9345	124.2	5.0	0.1	-1.0	-1.0	122.5	124.4	-1.0	-1.0
80	9799	125.4	4.7	0.1	-1.0	-1.0	122.9	125.6	-1.0	-1.0
100	9982	125.3	4.3	0.1	-1.0	-1.0	122.5	125.6	-1.0	-1.0
125	10195	124.6	4.3	0.1	-1.0	-1.0	122.0	124.8	-1.0	-1.0
160	10203	123.6	4.6	0.1	-1.0	-1.0	120.7	123.9	-1.0	-1.0
200	10298	123.0	5.0	0.1	-1.0	-1.0	119.5	123.3	-1.0	-1.0
250	10331	122.5	4.9	0.1	-1.0	-1.0	120.0	122.7	-1.0	-1.0
315	10365	121.4	5.3	0.1	-1.0	-1.0	118.0	121.7	-1.0	-1.0
400	10344	120.5	5.6	0.1	-1.0	-1.0	117.1	120.8	-1.0	-1.0
500	10330	119.9	6.0	0.1	-1.0	-1.0	116.0	120.3	-1.0	-1.0
630	10286	119.0	5.7	0.1	-1.0	-1.0	115.1	119.3	-1.0	-1.0
800	10254	118.1	5.3	0.1	-1.0	-1.0	113.9	118.5	-1.0	-1.0
1000	10210	117.5	5.4	0.1	-1.0	-1.0	113.2	117.9	-1.0	-1.0
1250	10219	117.2	5.5	0.1	-1.0	-1.0	112.8	117.5	-1.0	-1.0
1600	10188	117.3	5.6	0.1	-1.0	-1.0	112.8	117.7	-1.0	-1.0
2000	9856	118.2	6.1	0.1	-1.0	-1.0	114.1	118.6	-1.0	-1.0
2500	9198	119.0	5.2	0.1	-1.0	-1.0	116.7	119.2	-1.0	-1.0
3150	7390	120.7	5.2	0.1	-1.0	-1.0	120.1	120.8	-1.0	-1.0
4000	4334	121.2	5.4	0.2	-1.0	-1.0	121.2	121.2	-1.0	-1.0
5000	1772	121.1	5.2	0.2	-1.0	-1.0	120.8	121.1	-1.0	-1.0
6300	463	120.7	5.8	0.5	-1.0	-1.0	121.6	120.6	-1.0	-1.0
8000	81	119.5	7.2	1.6	-1.0	-1.0	122.0	119.1	-1.0	-1.0
10000	7	111.6	7.4	5.5	-1.0	-1.0	-1.0	111.6	-1.0	-1.0

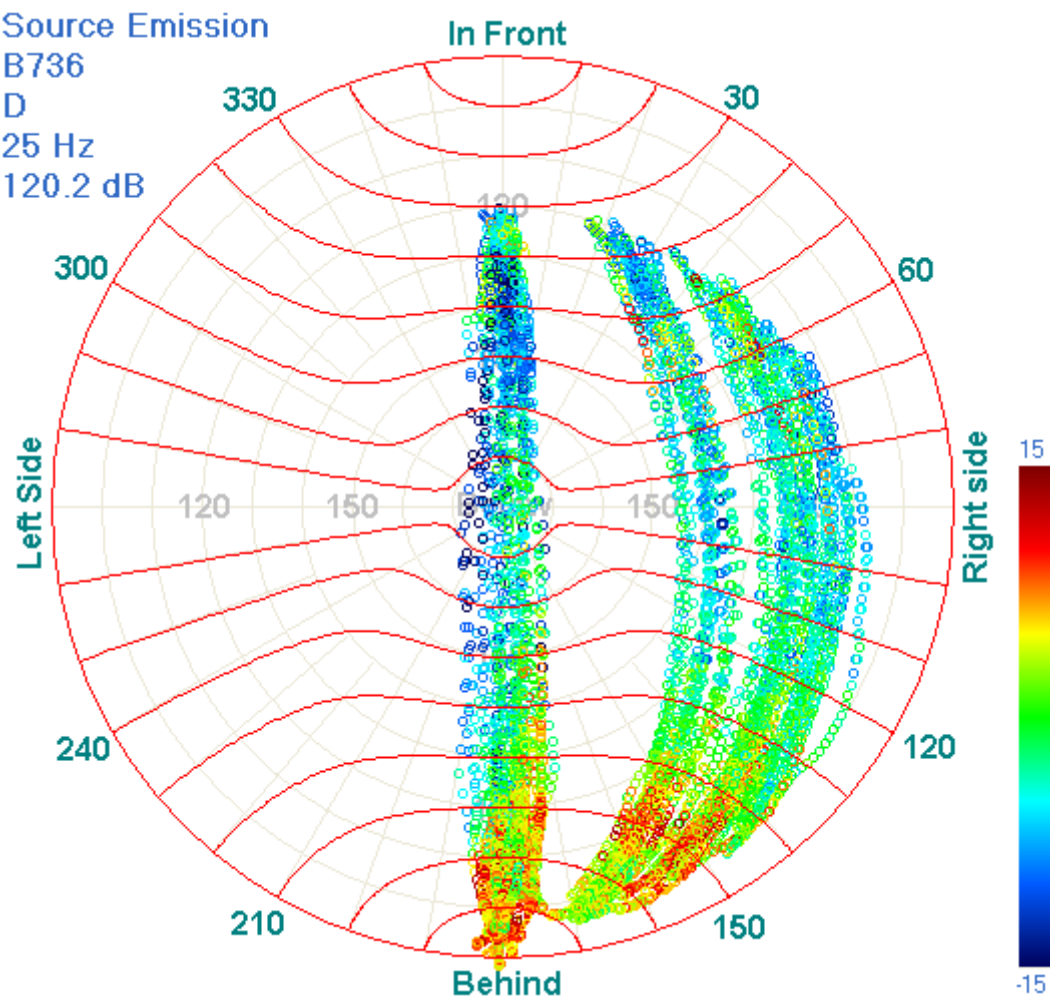
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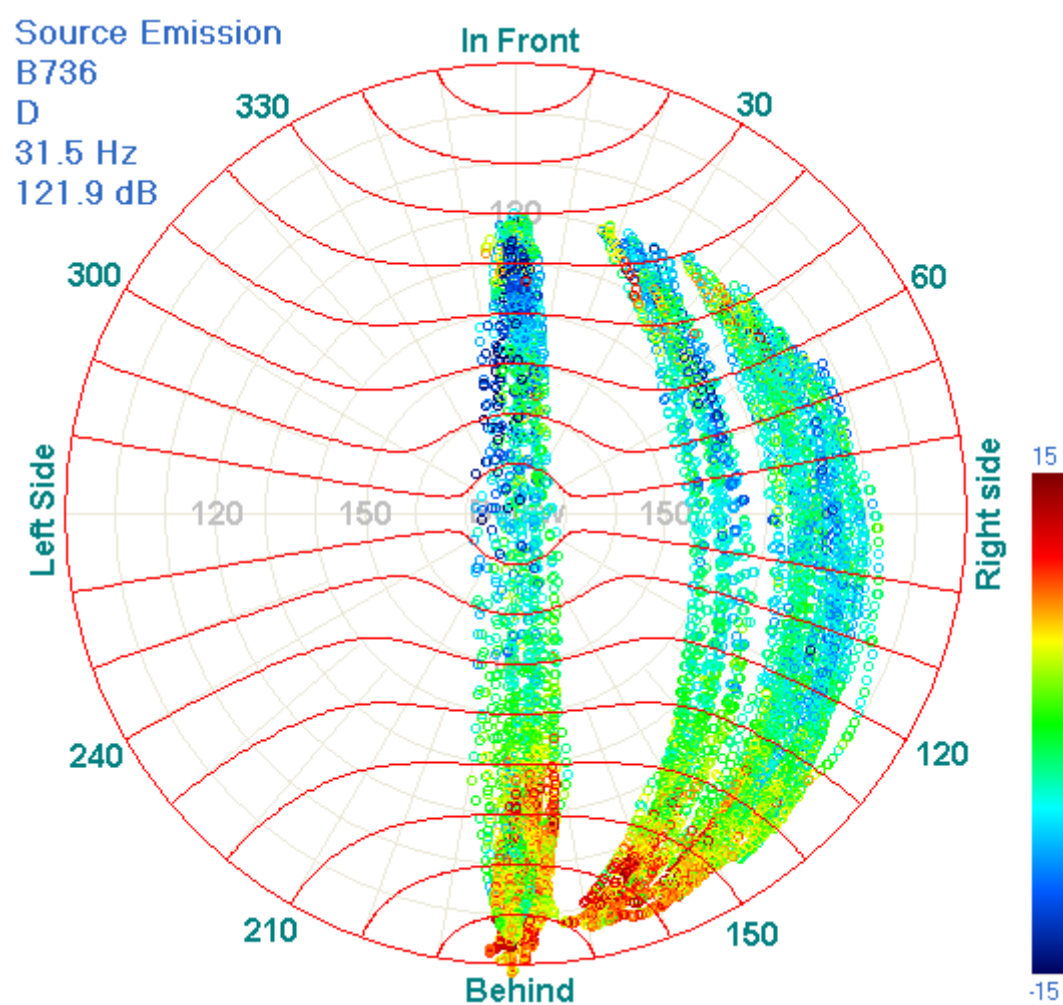
B736

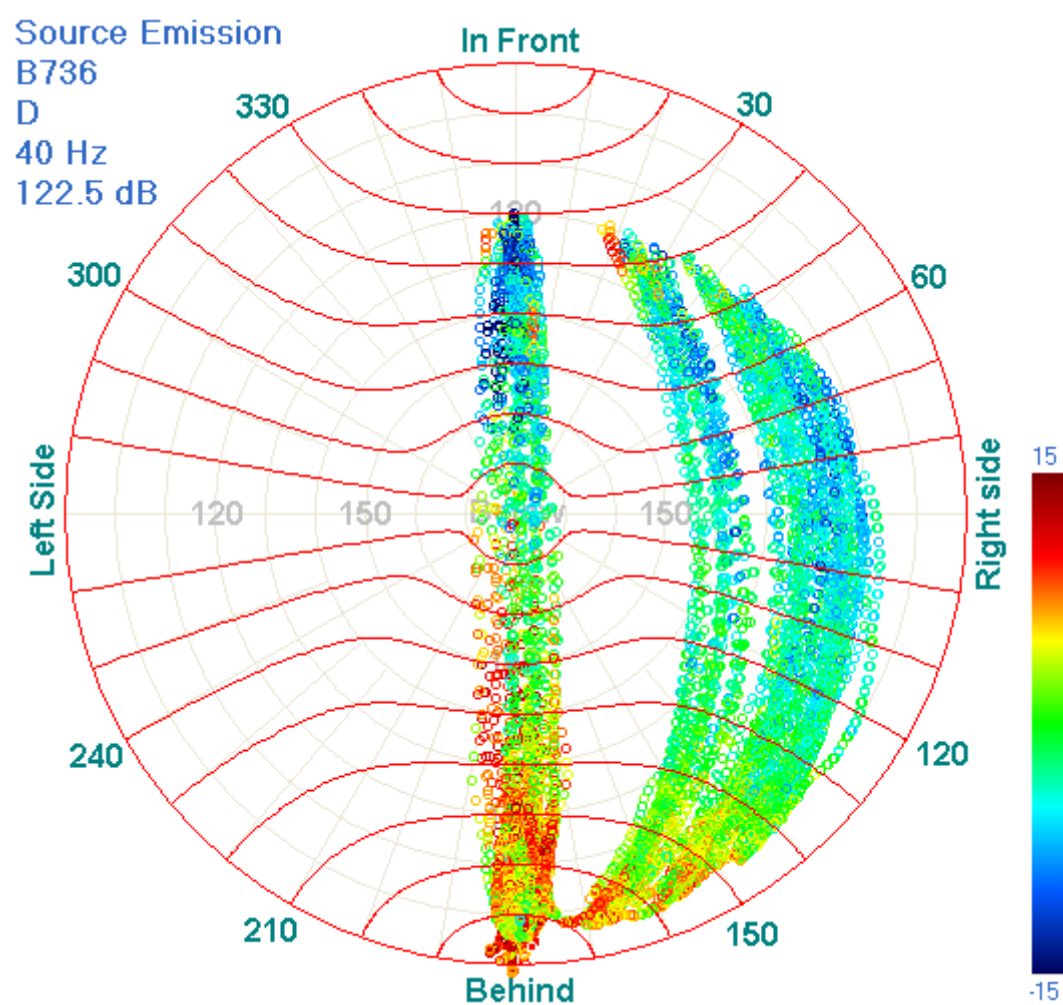
D

25 Hz

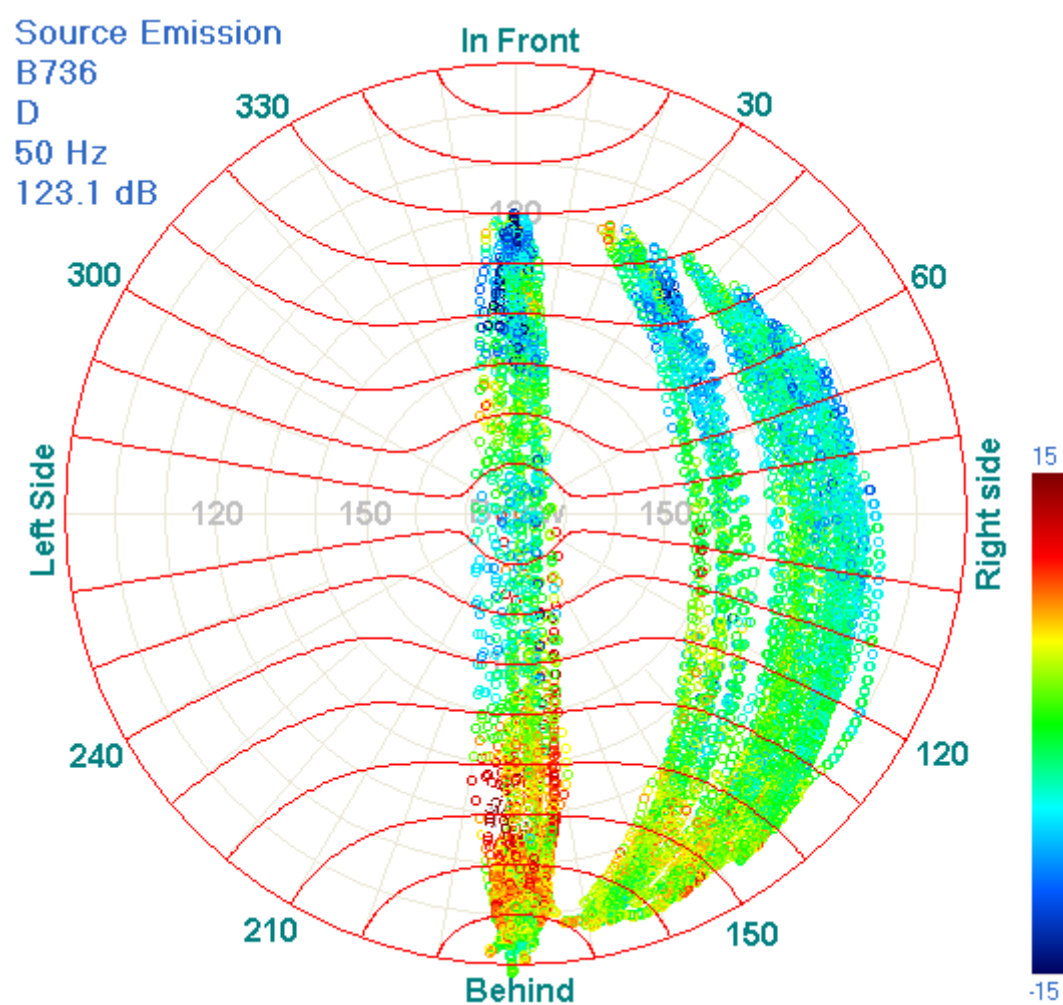
120.2 dB

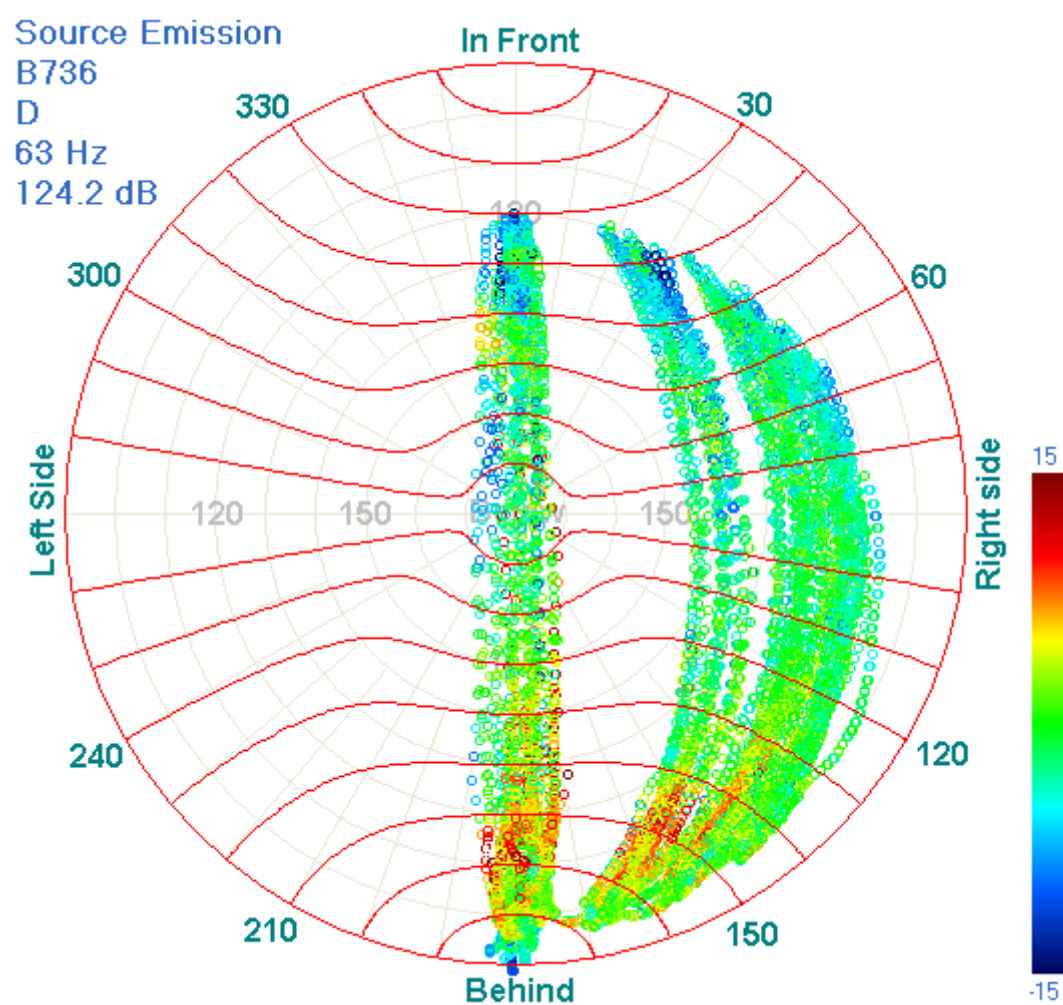


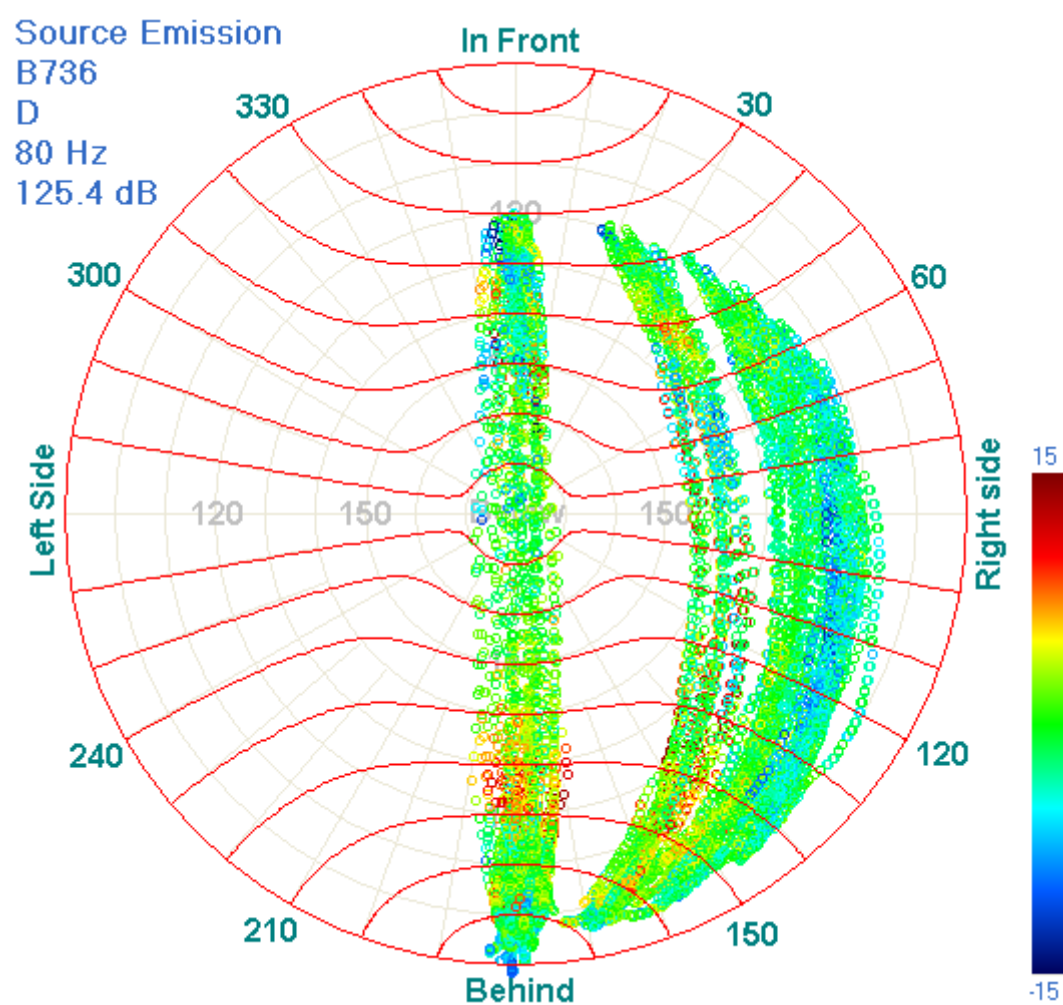


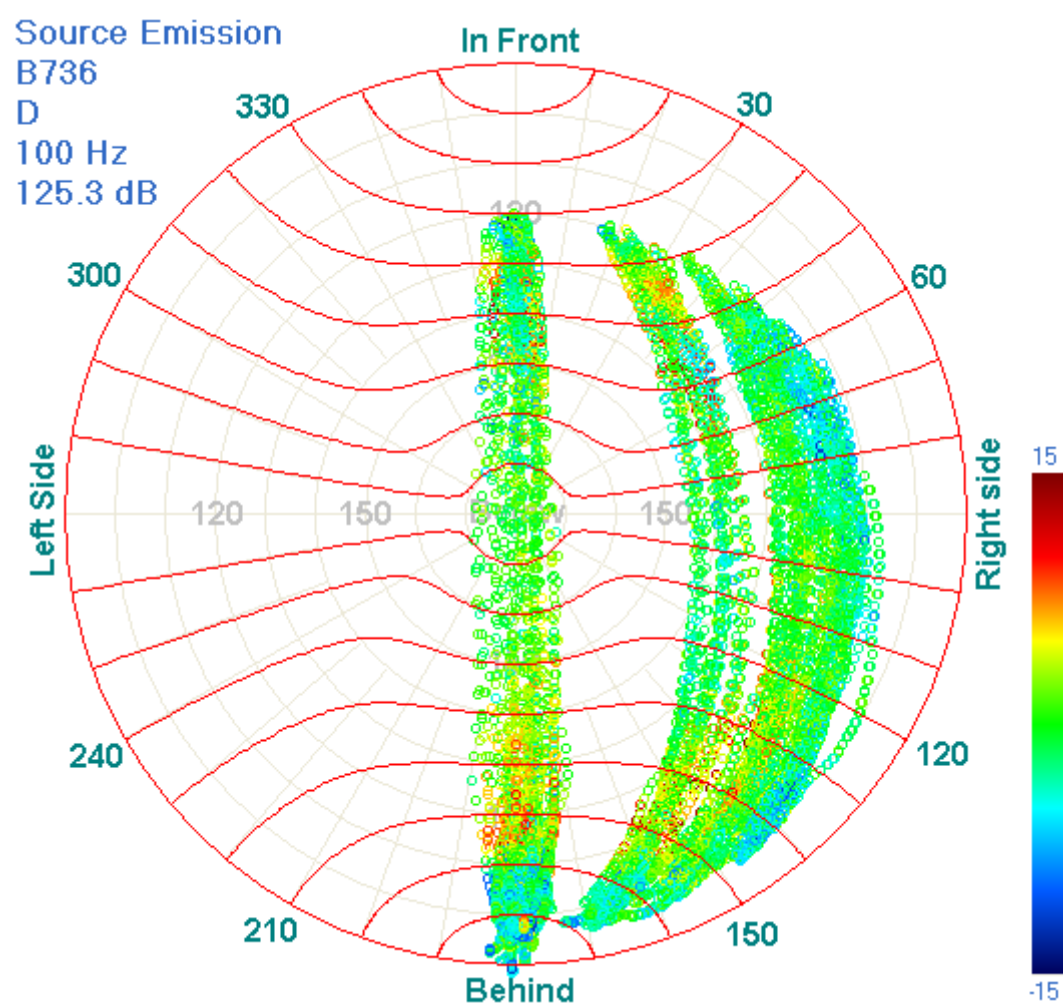


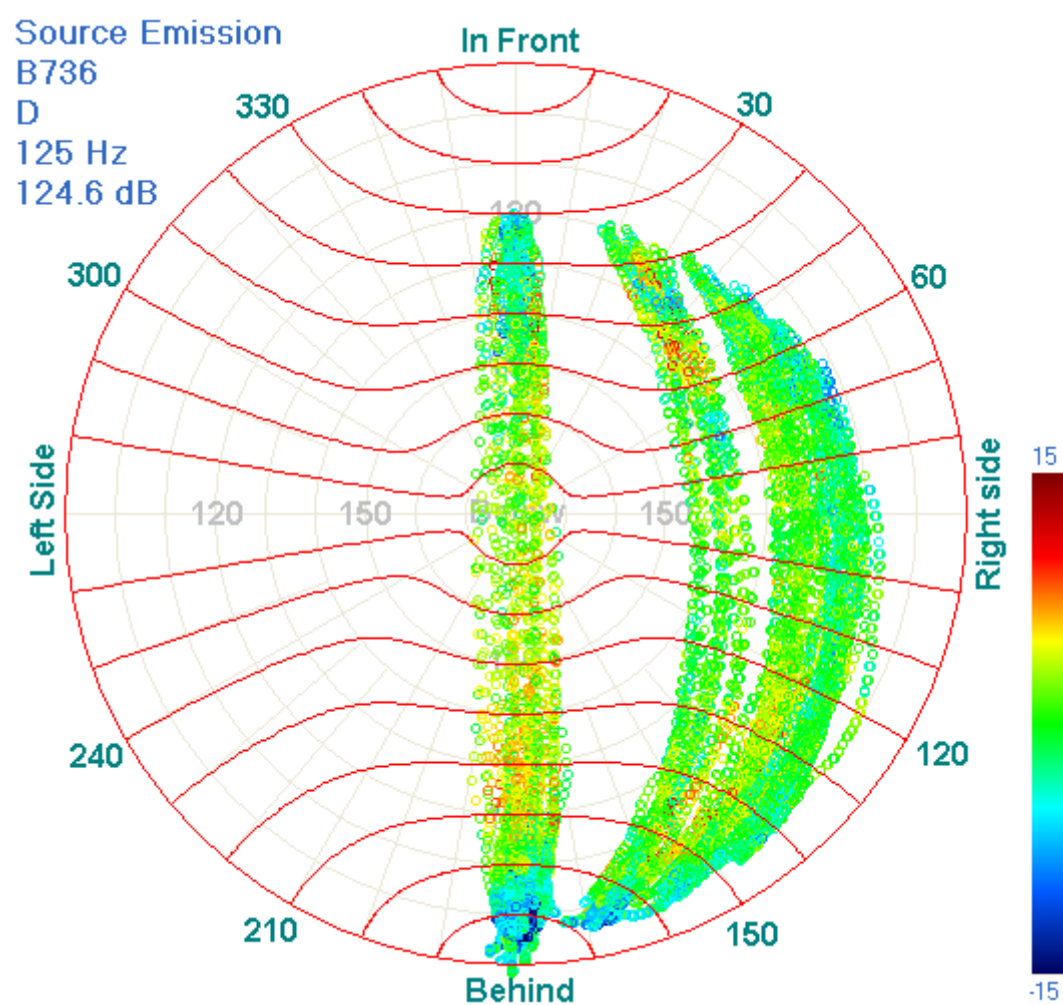


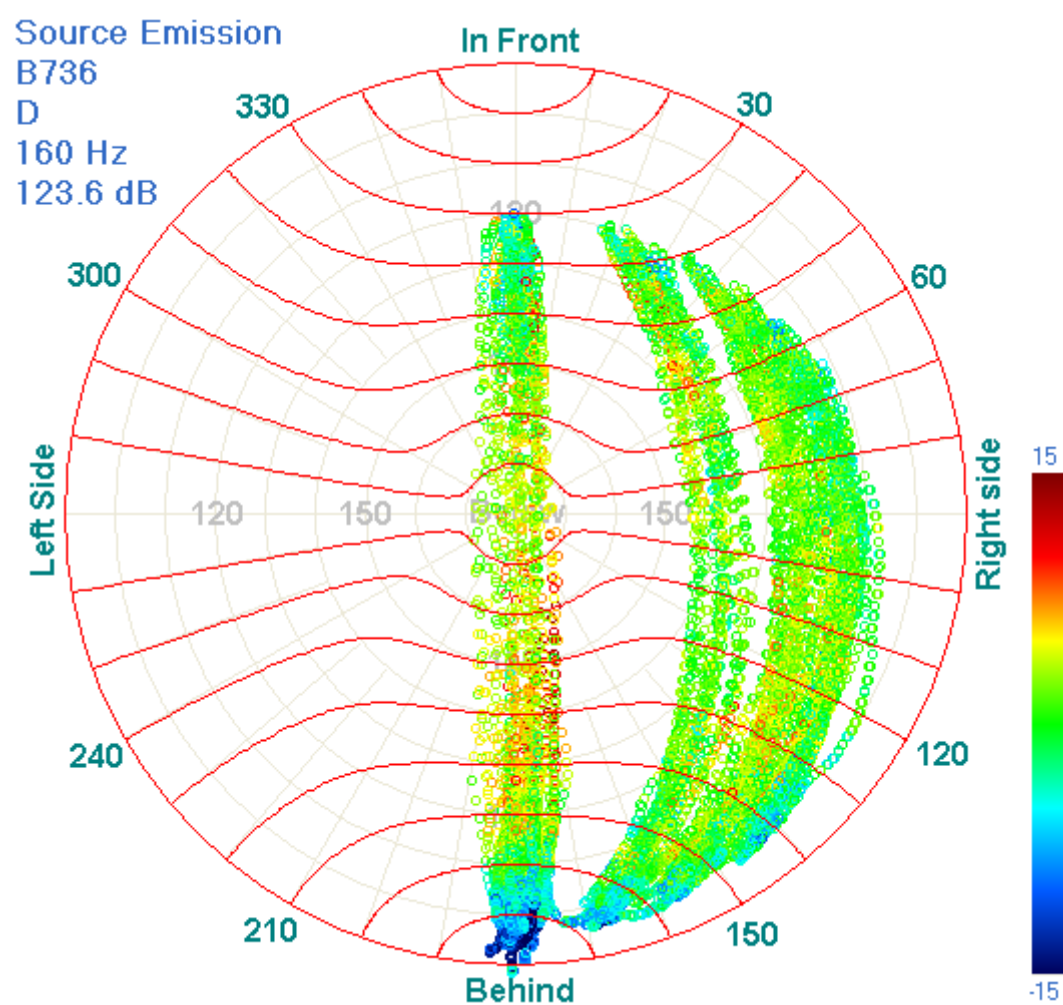


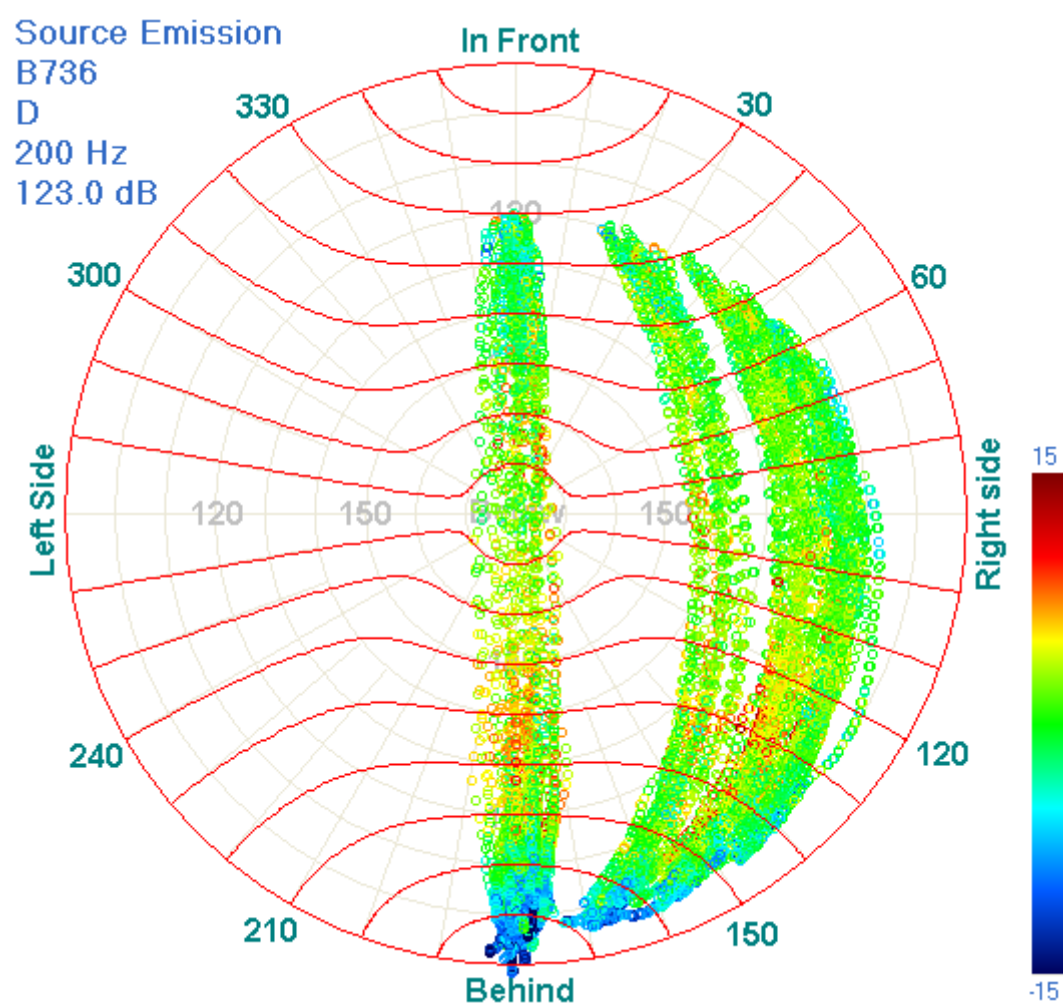






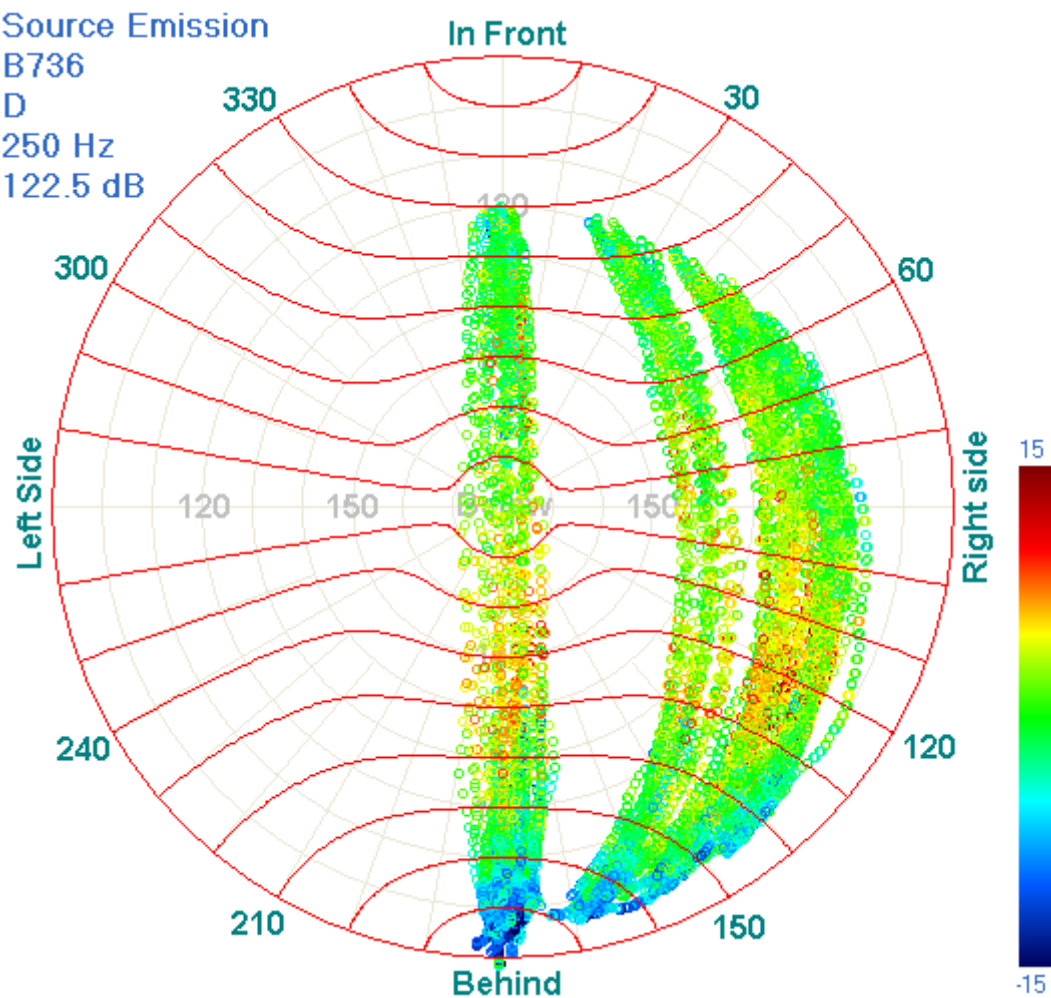




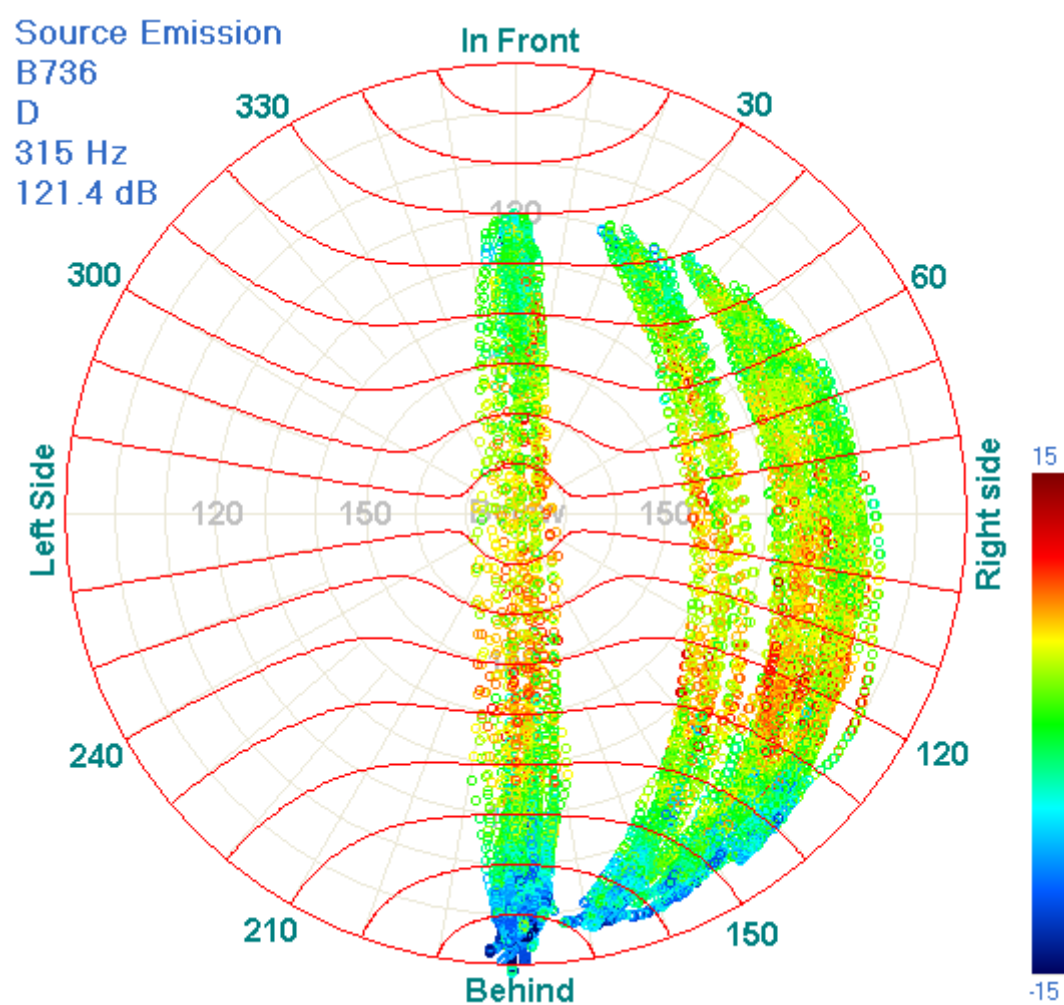


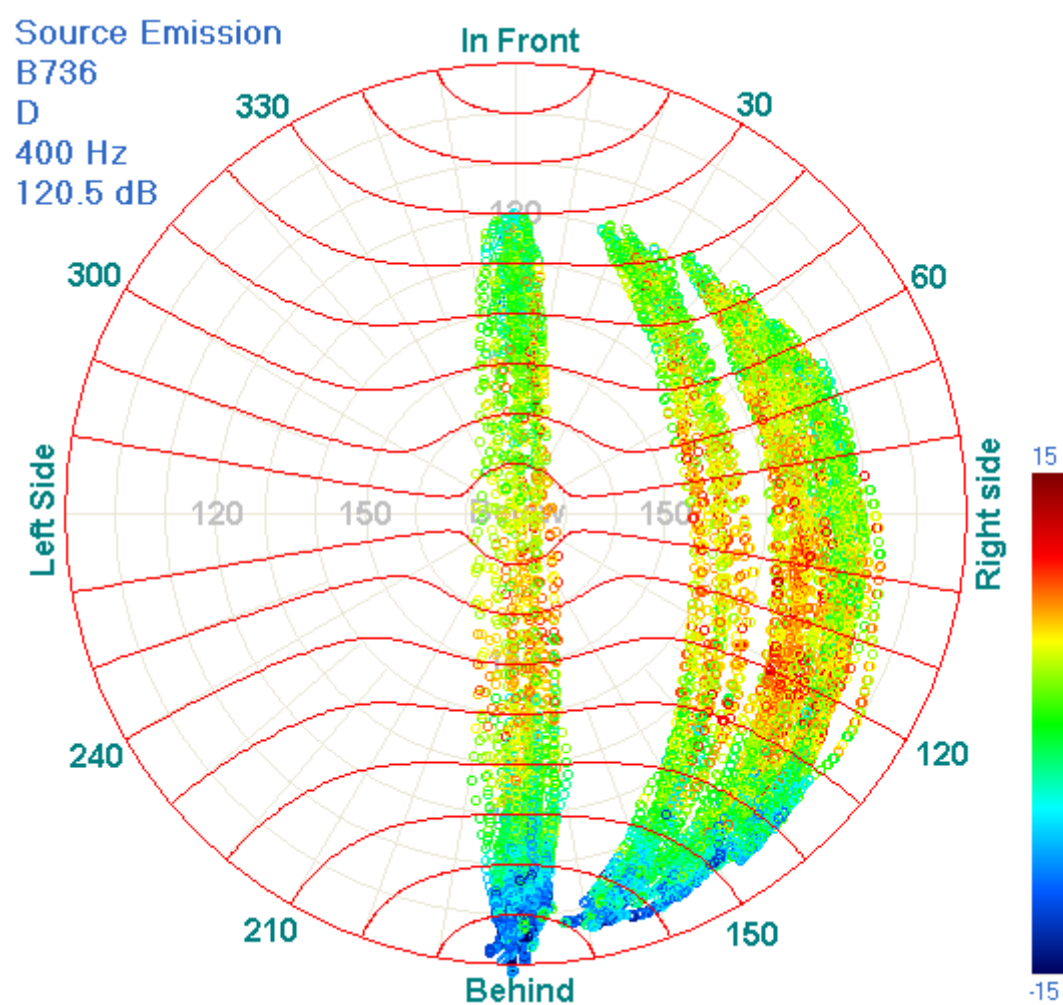


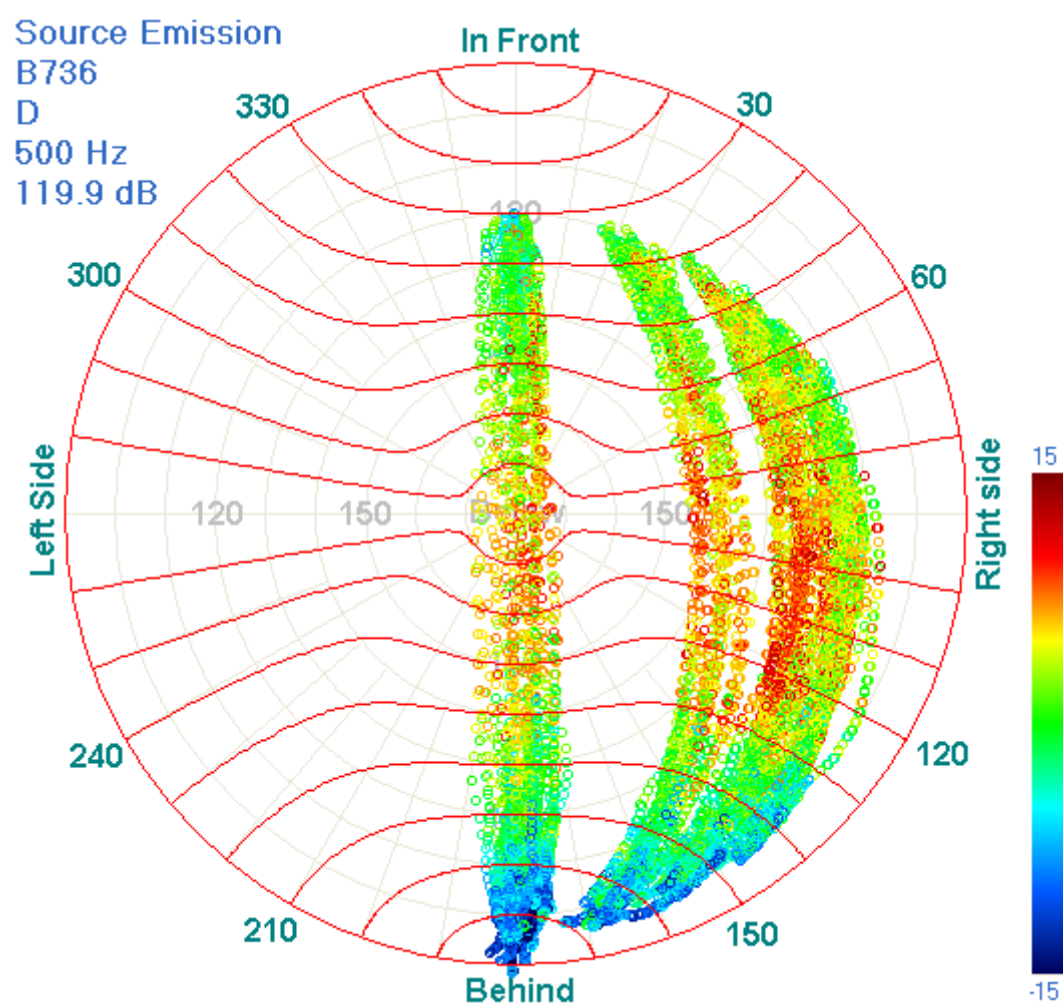
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B736  
D  
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122.5 dB

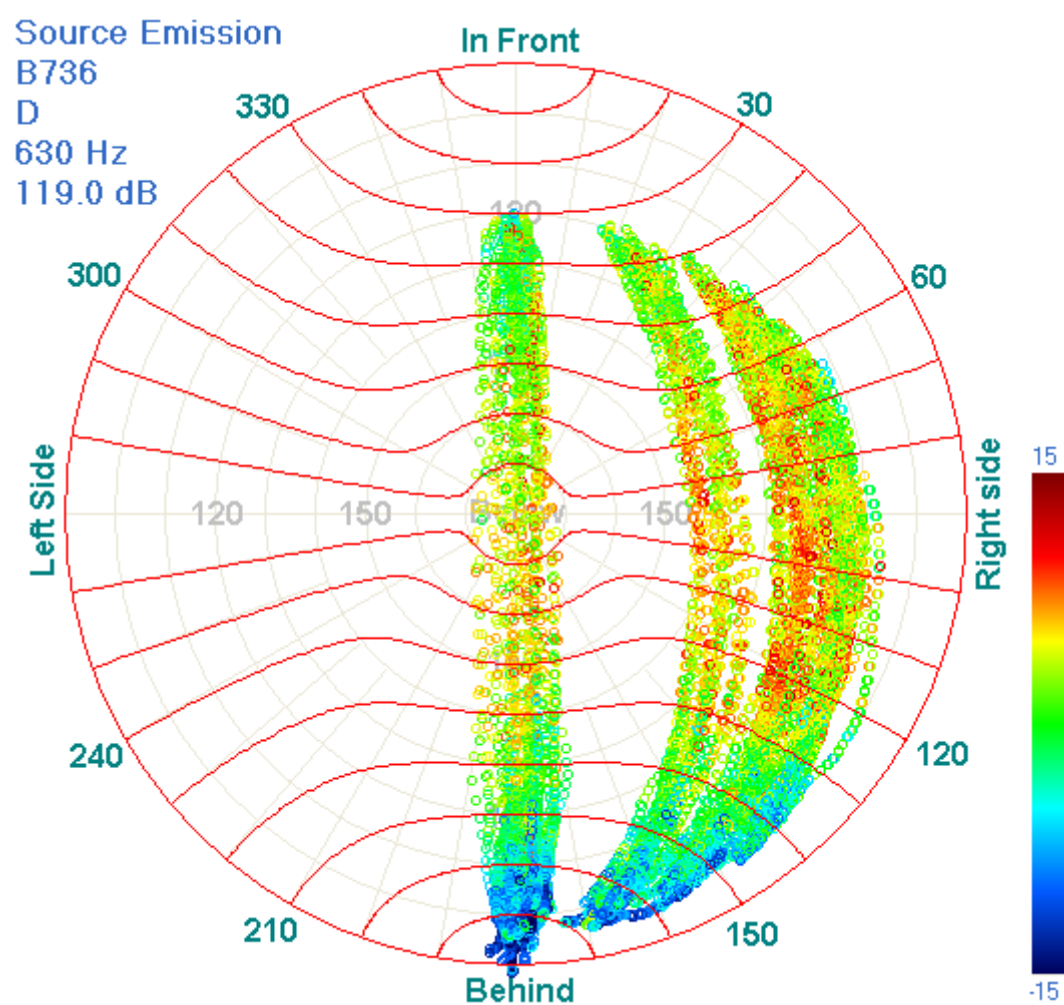


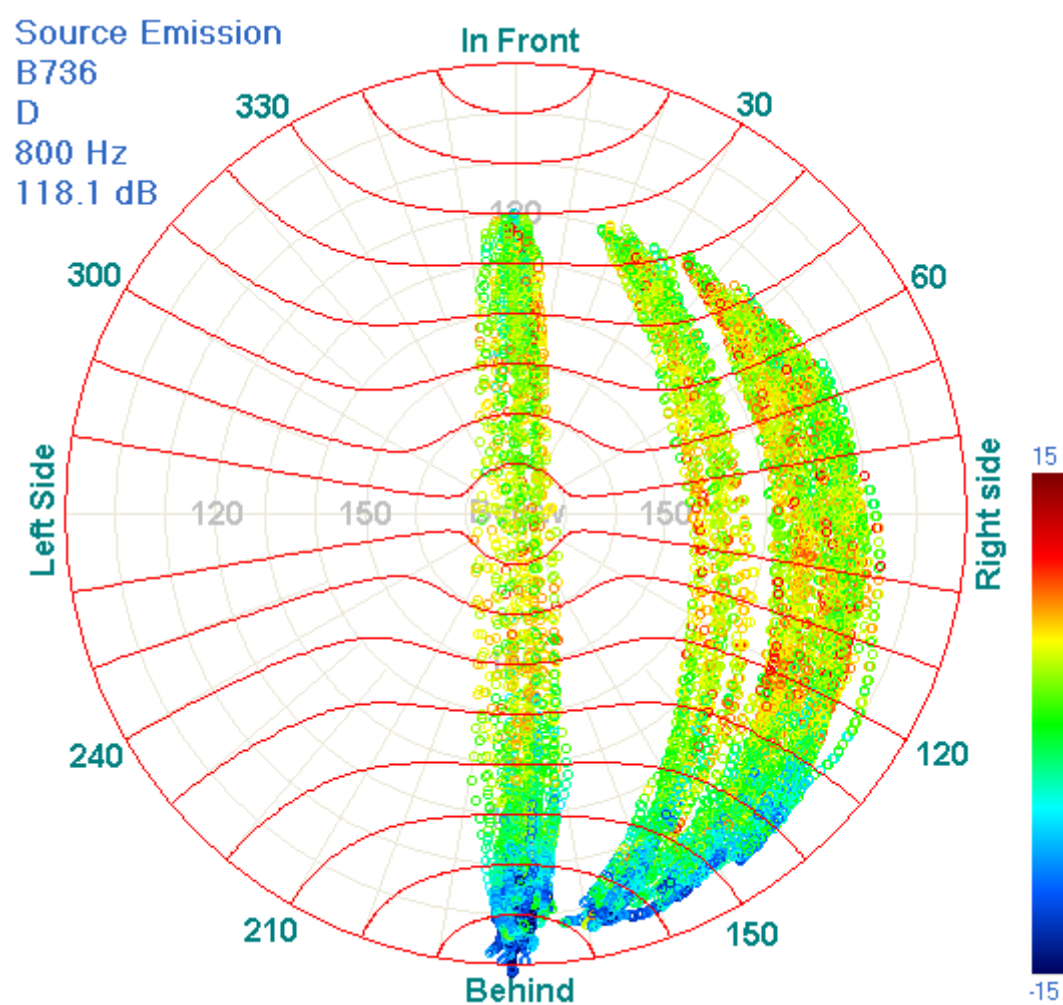


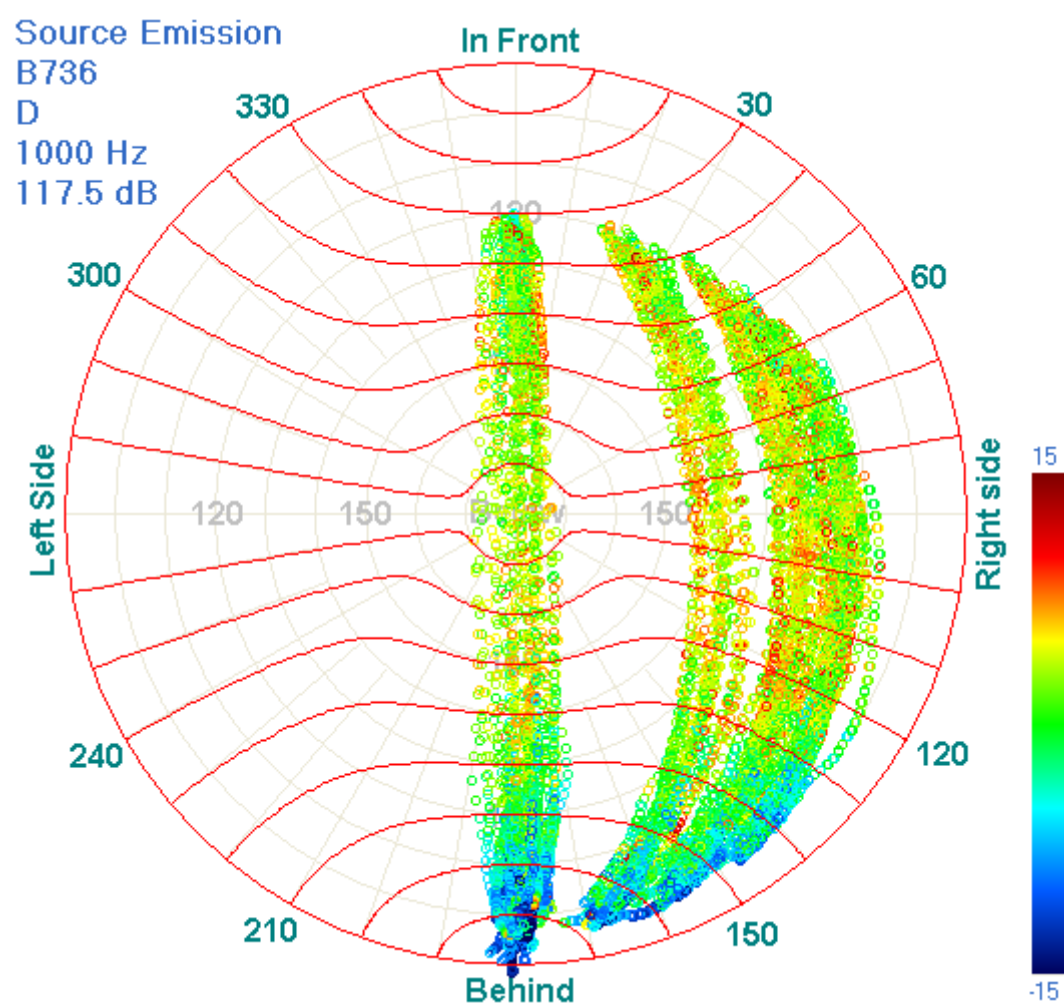












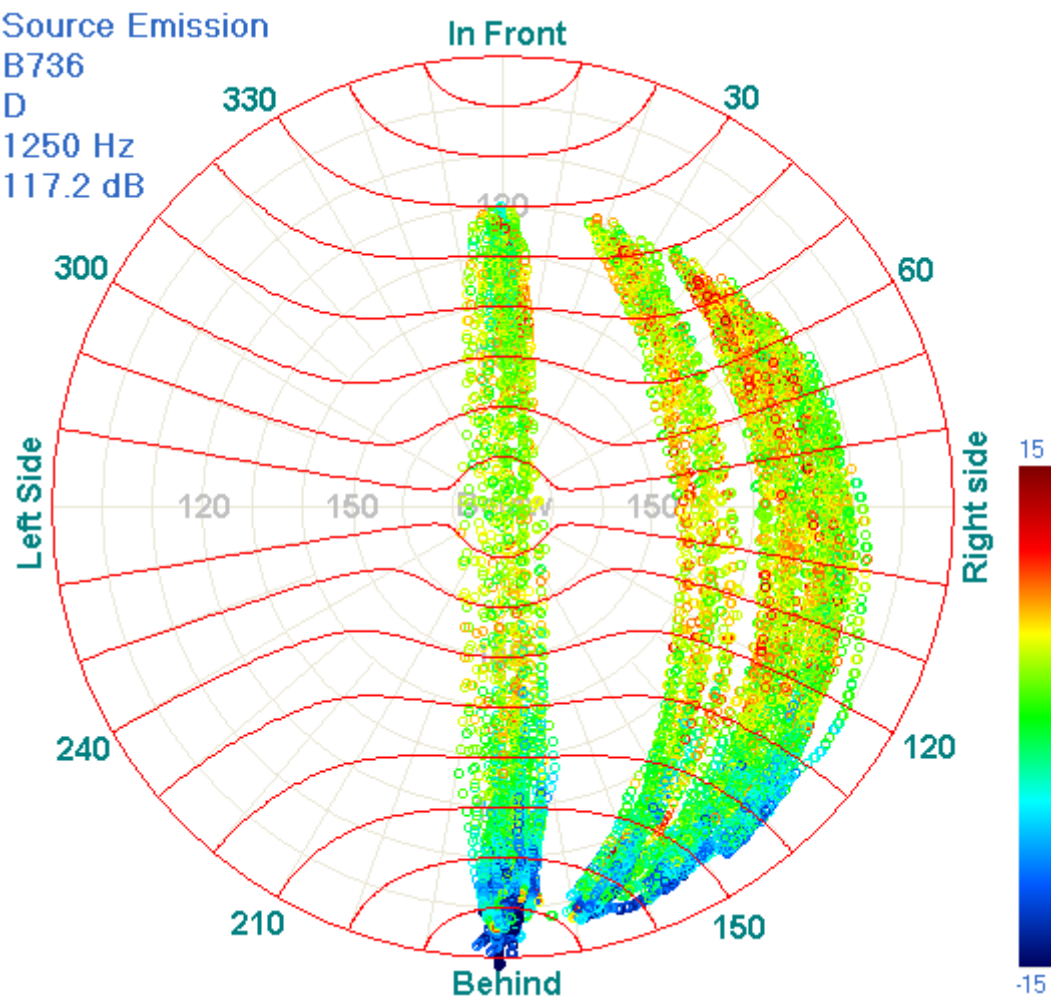
Source Emission

B736

D

1250 Hz

117.2 dB





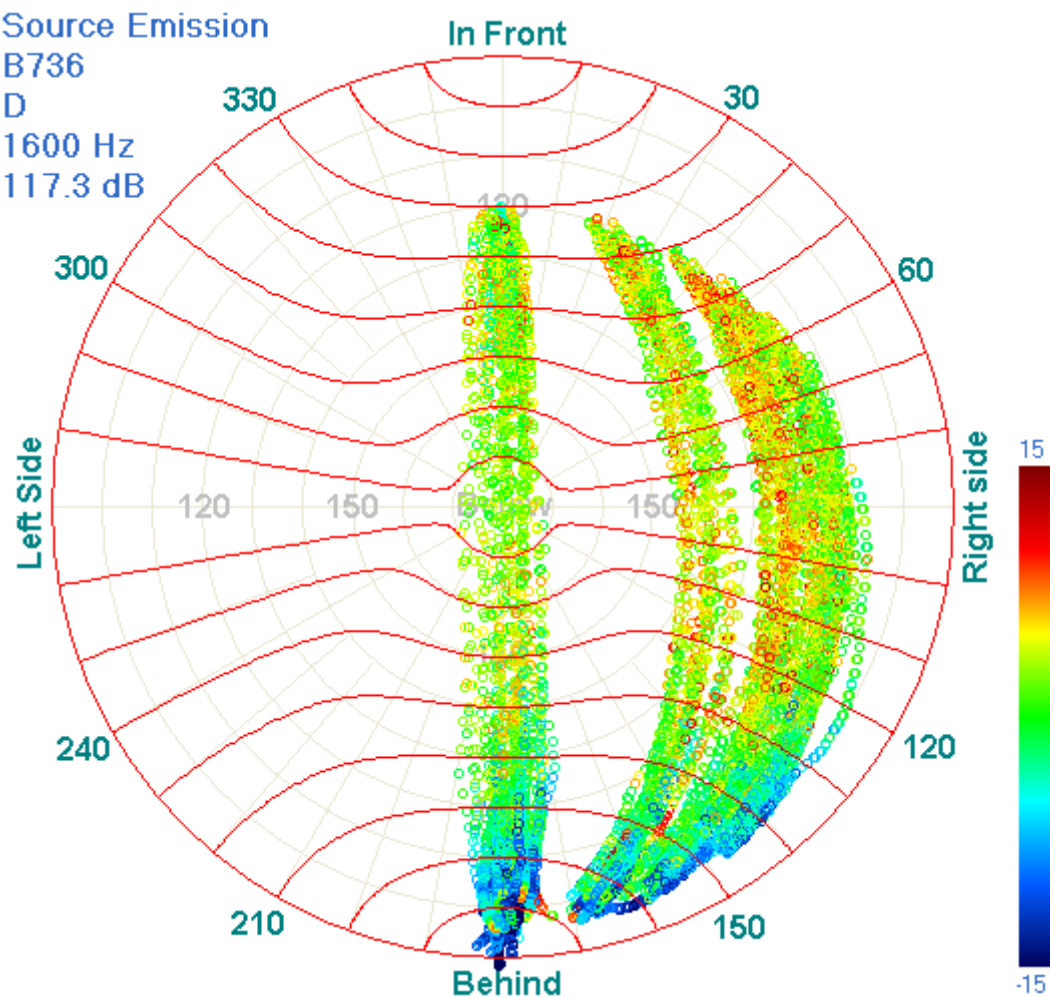
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B736

D

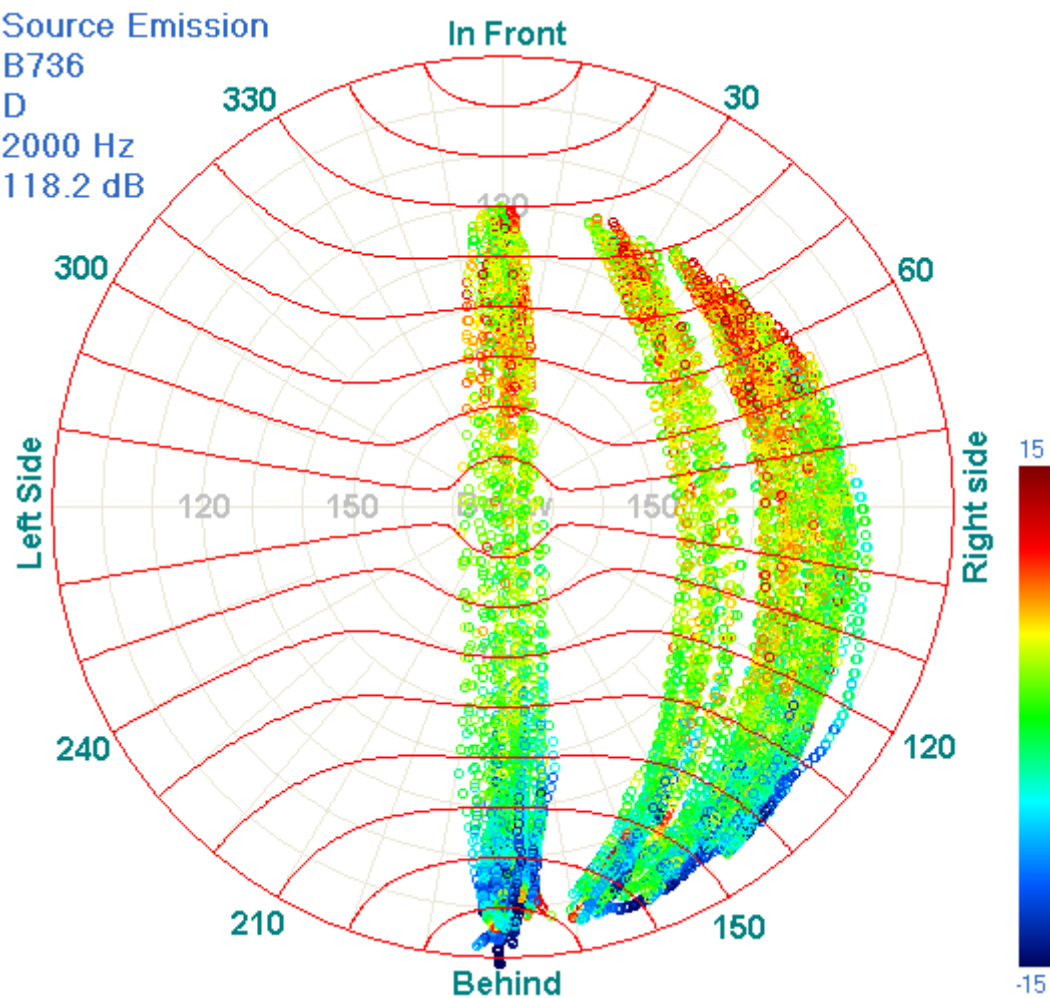
1600 Hz

117.3 dB

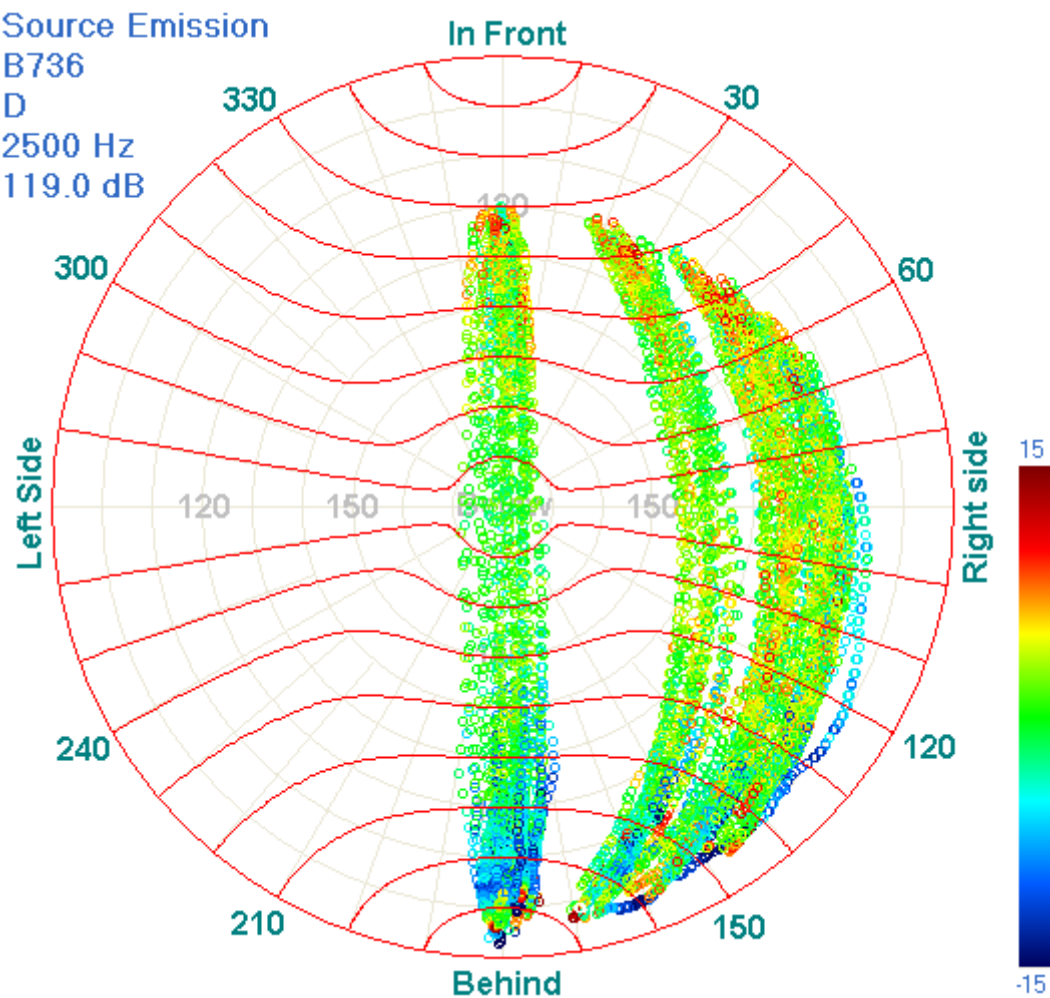




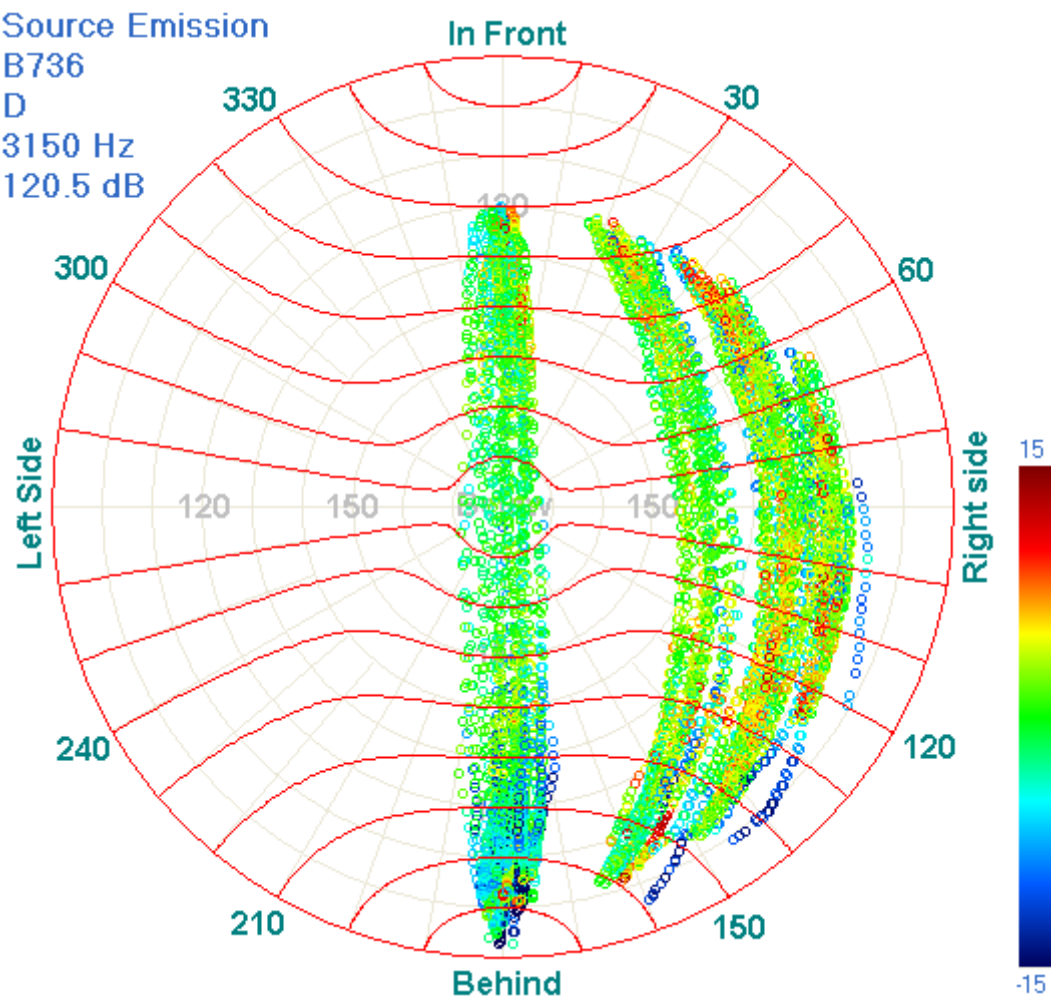
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B736  
D  
2000 Hz  
118.2 dB



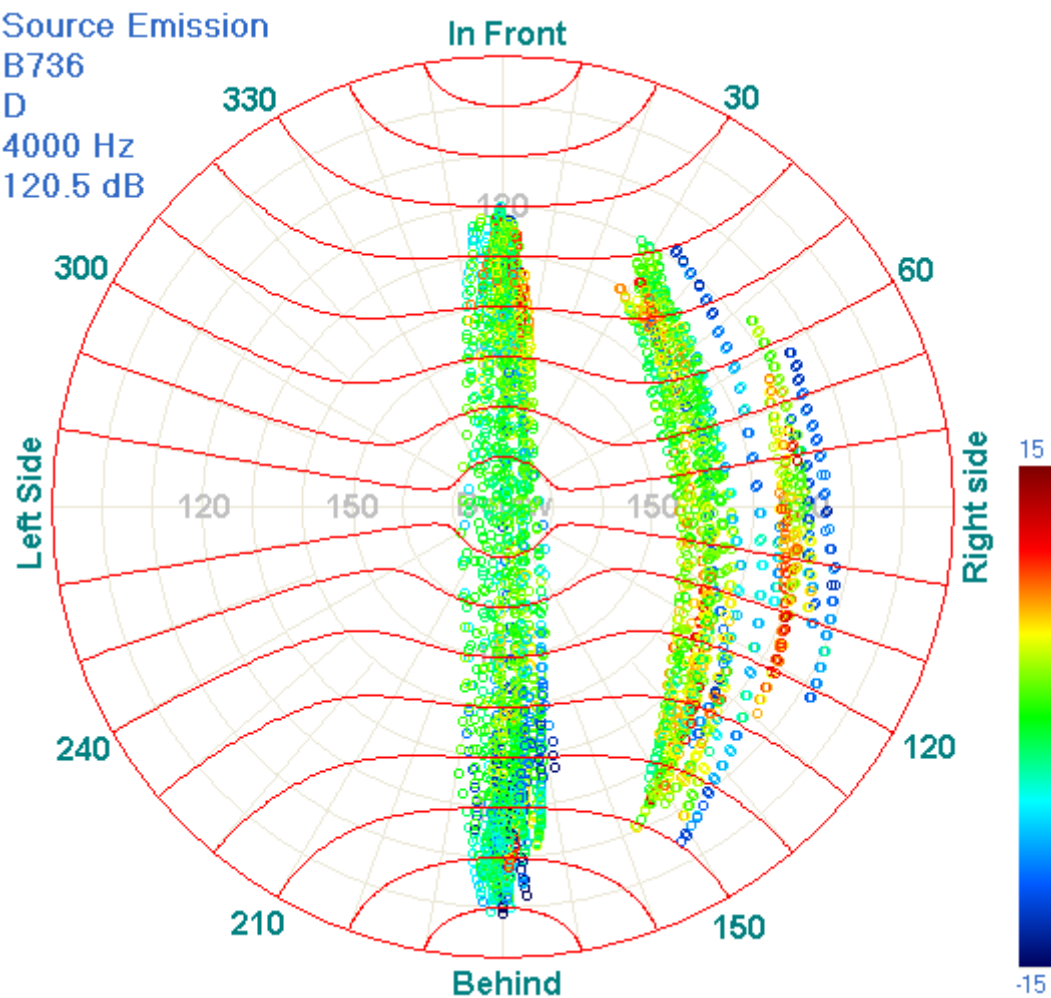
Source Emission  
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D  
2500 Hz  
119.0 dB

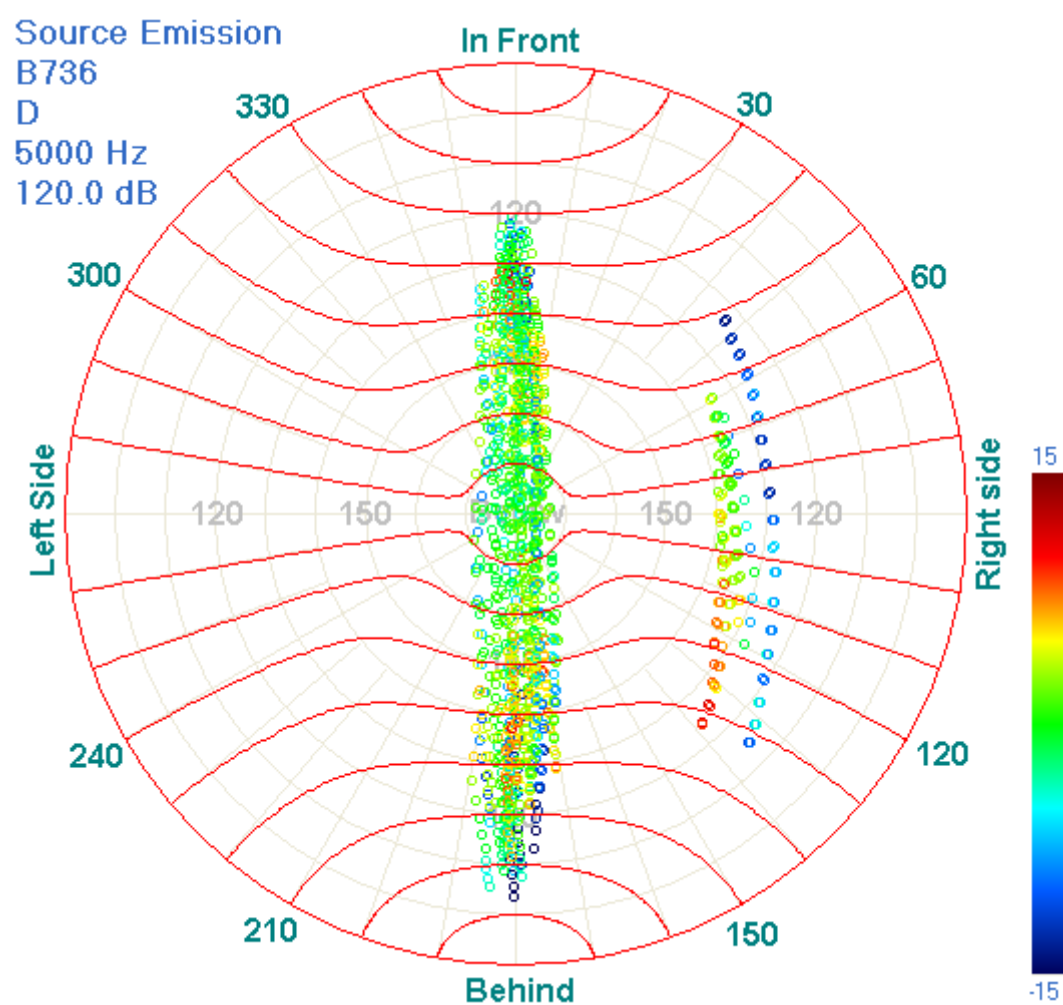


Source Emission  
B736  
D  
3150 Hz  
120.5 dB



Source Emission  
B736  
D  
4000 Hz  
120.5 dB





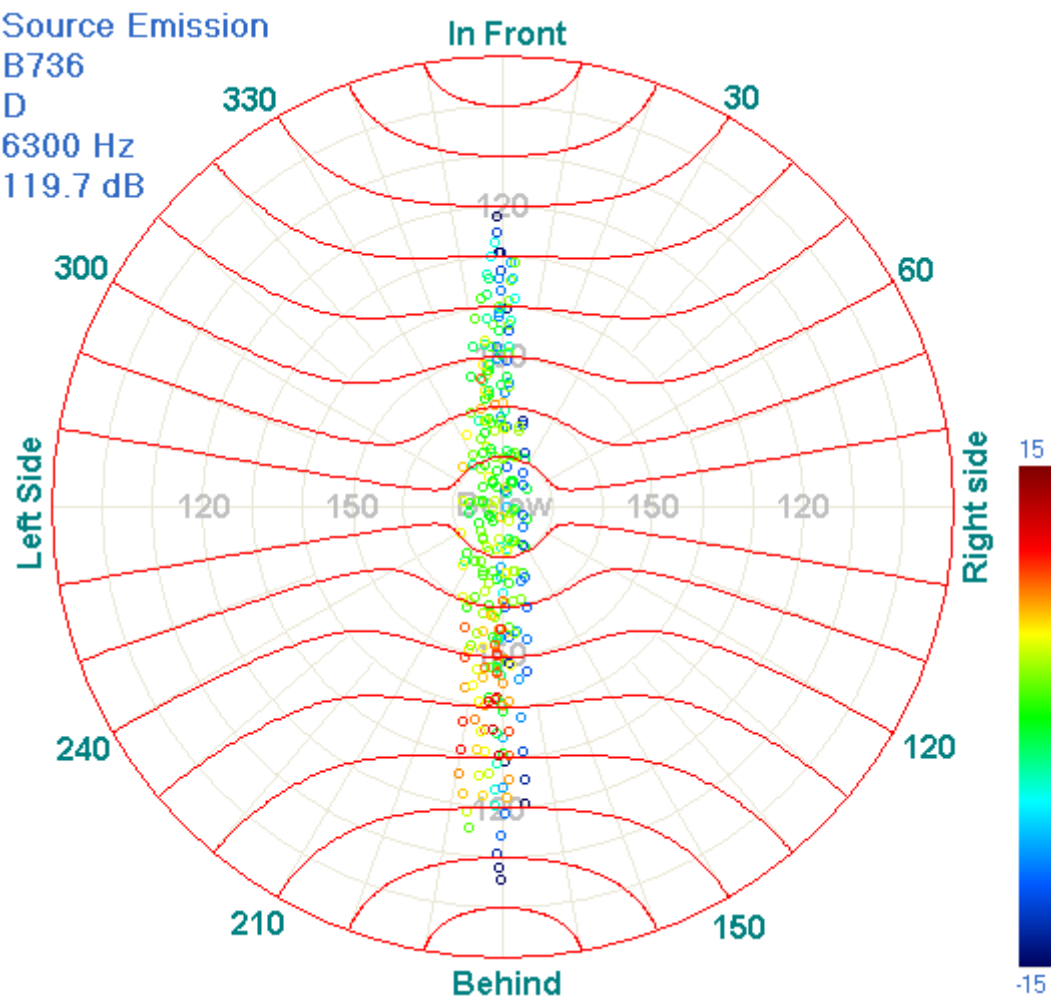
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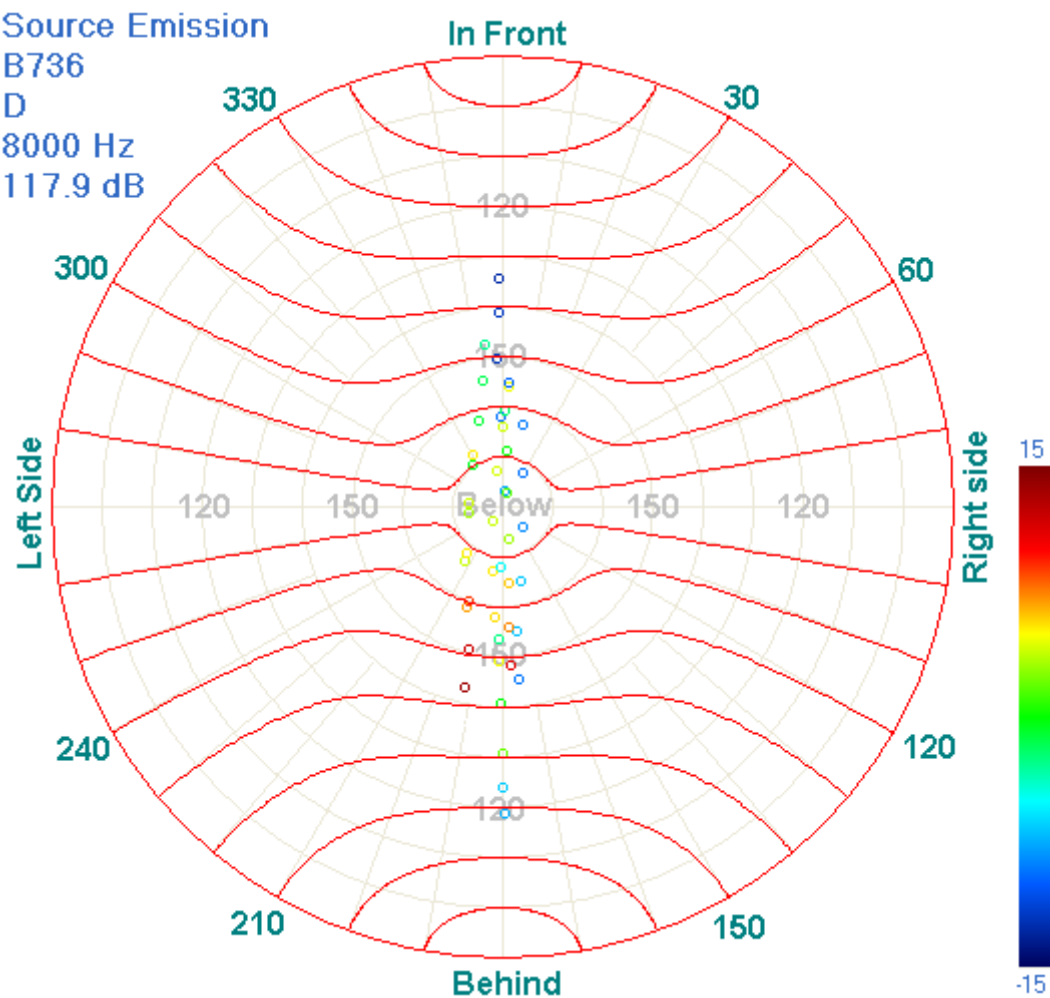
D

6300 Hz

119.7 dB



Source Emission  
B736  
D  
8000 Hz  
117.9 dB



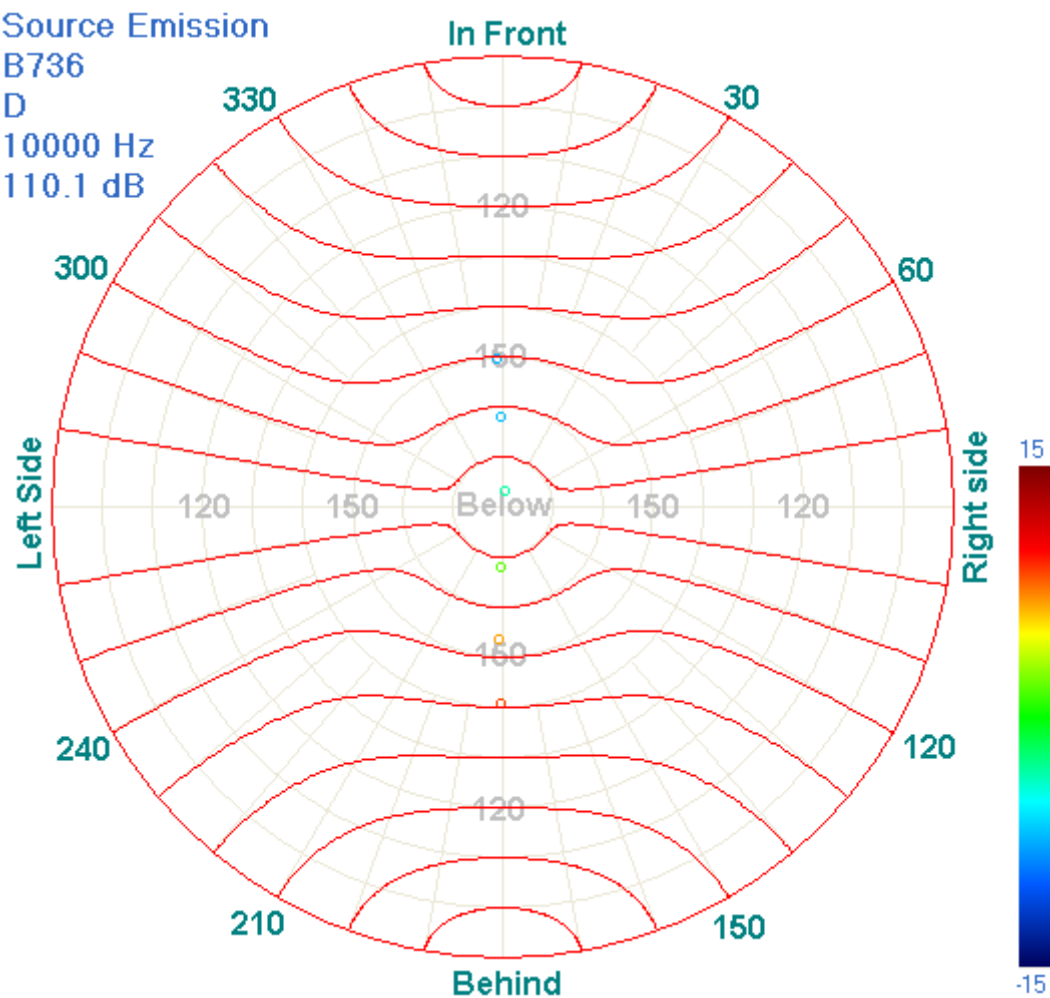
Source Emission

B736

D

10000 Hz

110.1 dB

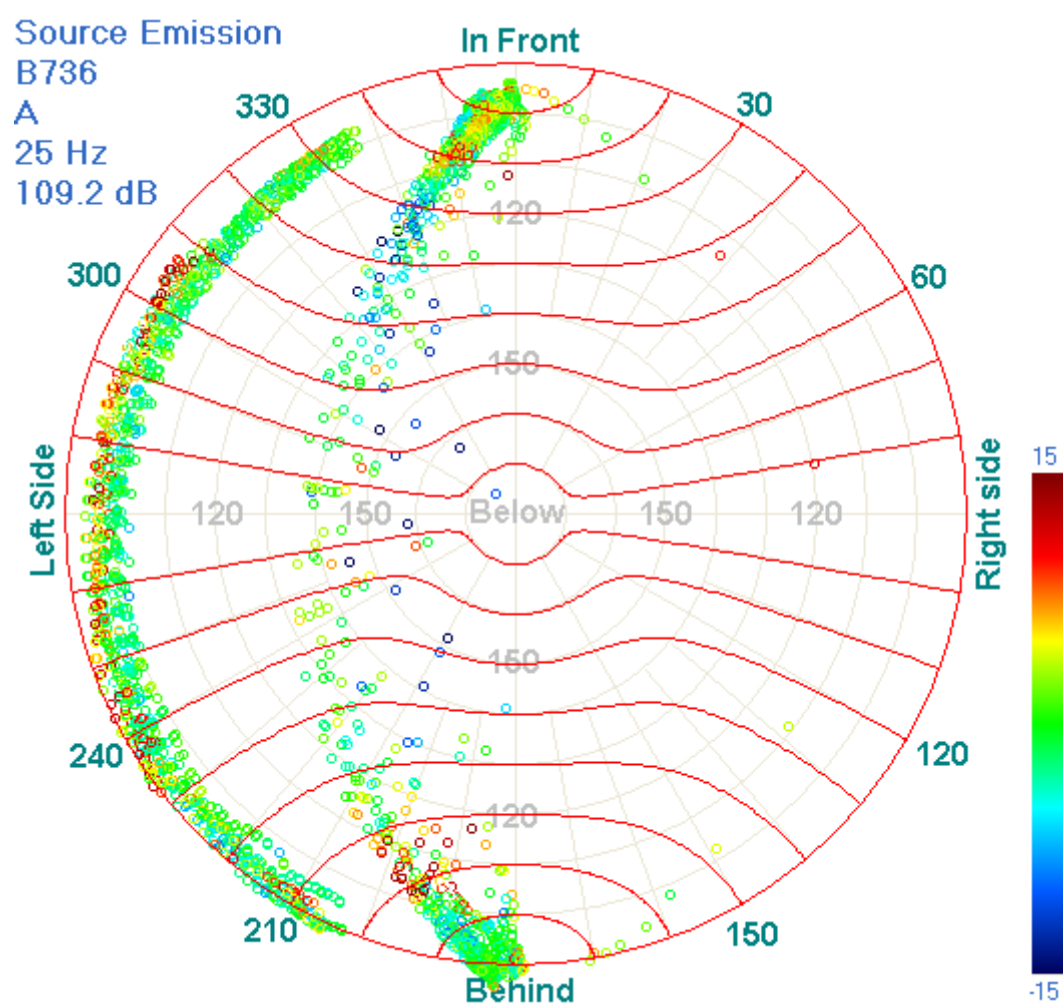


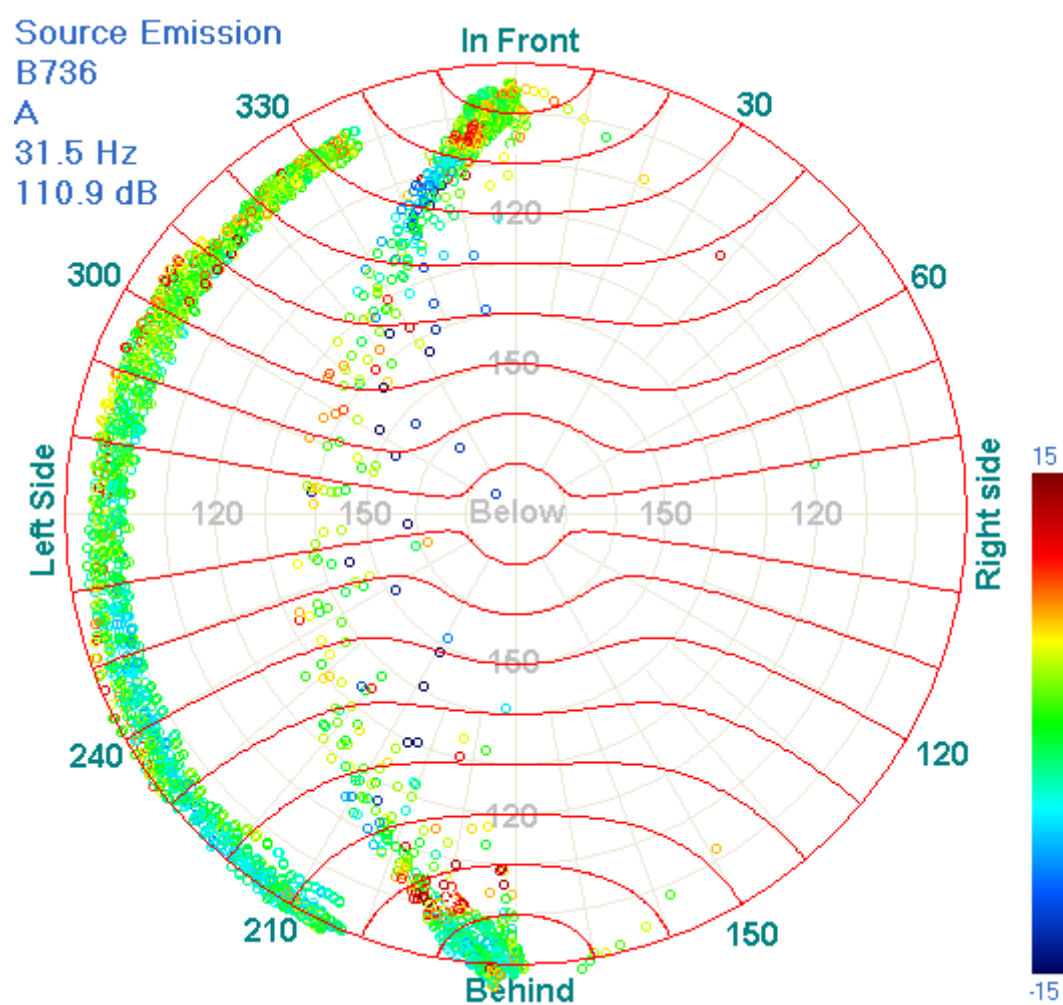


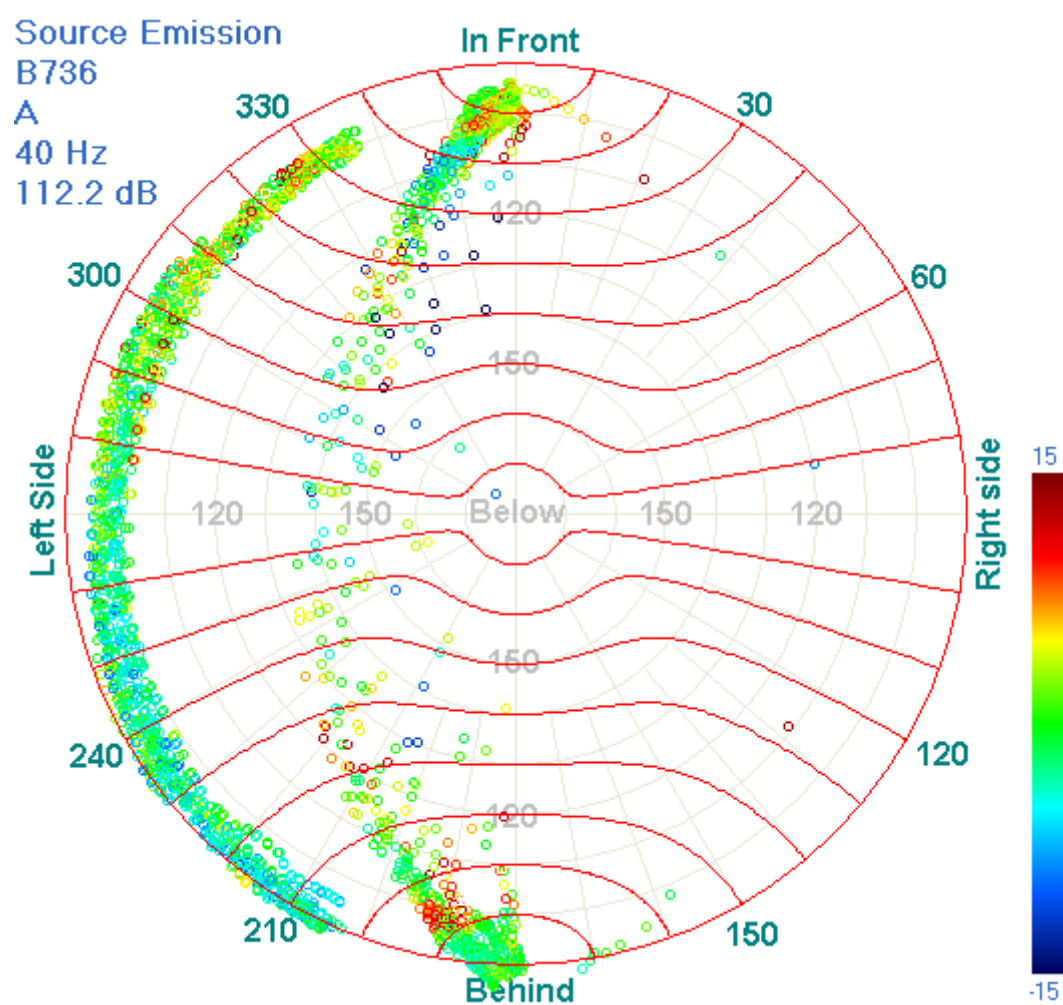
## 9 B737 600 directivity at arrival

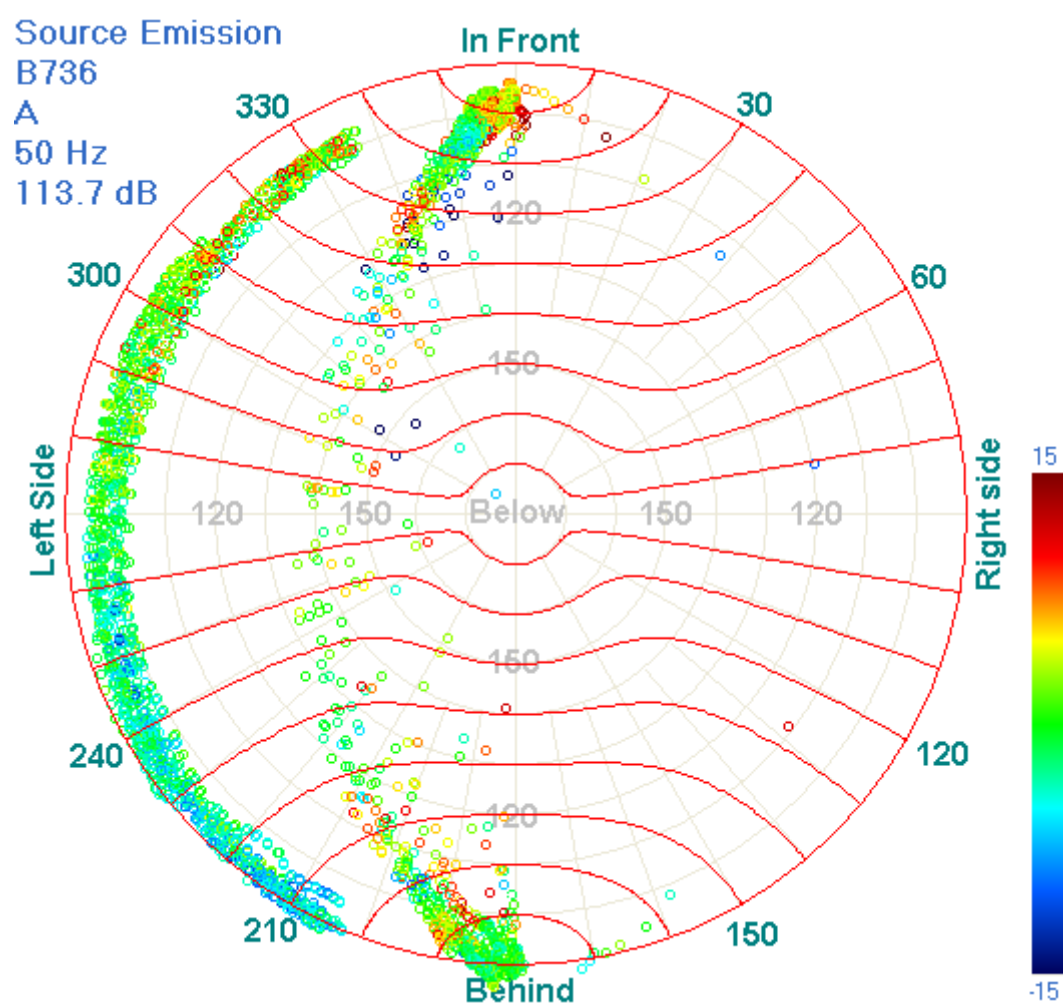
SPECTRUM  
Source Emission  
B736  
A

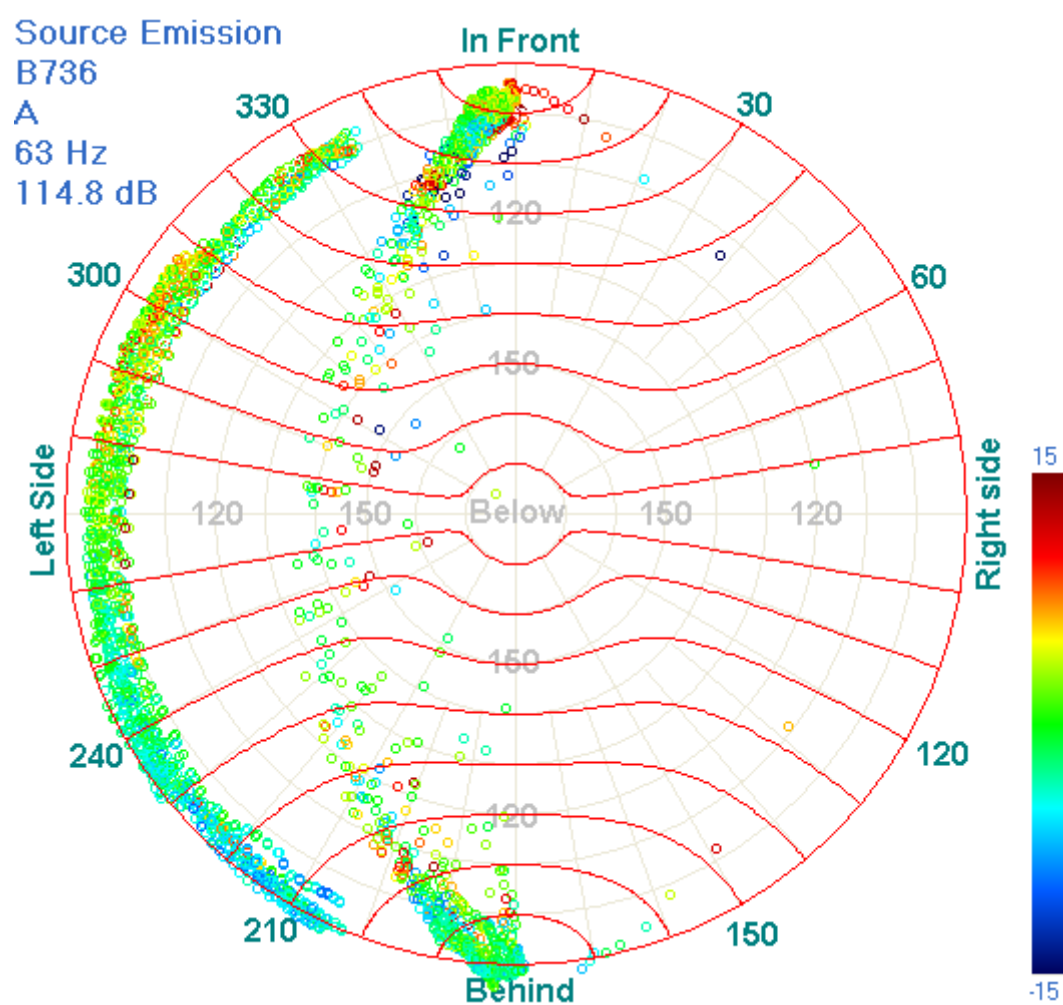
Freq	Num	Avg	Std	95%Avg	P1	P2	P3	P4	P5	P6
25	2569	109.2	4.7	0.2	109.1	110.9	-1.0	-1.0	-1.0	-1.0
31.5	3143	110.9	4.5	0.2	110.8	112.7	-1.0	-1.0	-1.0	-1.0
40	2995	112.2	4.8	0.2	112.1	114.1	-1.0	-1.0	-1.0	-1.0
50	3103	113.7	4.8	0.2	113.6	115.9	-1.0	-1.0	-1.0	-1.0
63	3037	114.8	5.2	0.2	114.6	117.8	-1.0	-1.0	-1.0	-1.0
80	3527	114.8	5.6	0.2	114.6	118.8	-1.0	-1.0	-1.0	-1.0
100	3657	114.1	5.7	0.2	113.9	118.4	-1.0	-1.0	-1.0	-1.0
125	3855	113.2	4.8	0.2	113.1	117.7	-1.0	-1.0	-1.0	-1.0
160	3781	112.6	4.6	0.1	112.5	116.6	-1.0	-1.0	-1.0	-1.0
200	3859	112.4	4.8	0.2	112.3	116.5	-1.0	-1.0	-1.0	-1.0
250	3933	111.9	5.0	0.2	111.8	115.6	-1.0	-1.0	-1.0	-1.0
315	3820	111.7	4.8	0.2	111.6	114.5	-1.0	-1.0	-1.0	-1.0
400	3883	112.5	4.7	0.1	112.4	114.3	-1.0	-1.0	-1.0	-1.0
500	3866	113.1	4.8	0.2	113.1	114.8	-1.0	-1.0	-1.0	-1.0
630	3857	112.9	4.7	0.1	112.9	114.5	-1.0	-1.0	-1.0	-1.0
800	3934	112.8	4.6	0.1	112.8	114.0	-1.0	-1.0	-1.0	-1.0
1000	3930	112.1	4.6	0.1	112.1	113.4	-1.0	-1.0	-1.0	-1.0
1250	3892	111.2	5.1	0.2	111.2	113.0	-1.0	-1.0	-1.0	-1.0
1600	3929	109.9	5.1	0.2	109.8	112.7	-1.0	-1.0	-1.0	-1.0
2000	3928	109.4	5.5	0.2	109.3	112.6	-1.0	-1.0	-1.0	-1.0
2500	3899	109.4	5.9	0.2	109.3	113.2	-1.0	-1.0	-1.0	-1.0
3150	3682	110.0	6.1	0.2	109.8	114.2	-1.0	-1.0	-1.0	-1.0
4000	3064	112.0	6.5	0.2	111.8	115.4	-1.0	-1.0	-1.0	-1.0
5000	1669	112.4	6.9	0.3	112.2	116.3	-1.0	-1.0	-1.0	-1.0
6300	972	113.6	6.3	0.4	113.3	118.6	-1.0	-1.0	-1.0	-1.0
8000	533	113.0	6.3	0.5	112.5	122.2	-1.0	-1.0	-1.0	-1.0
10000	344	110.9	8.0	0.8	110.3	121.9	-1.0	-1.0	-1.0	-1.0

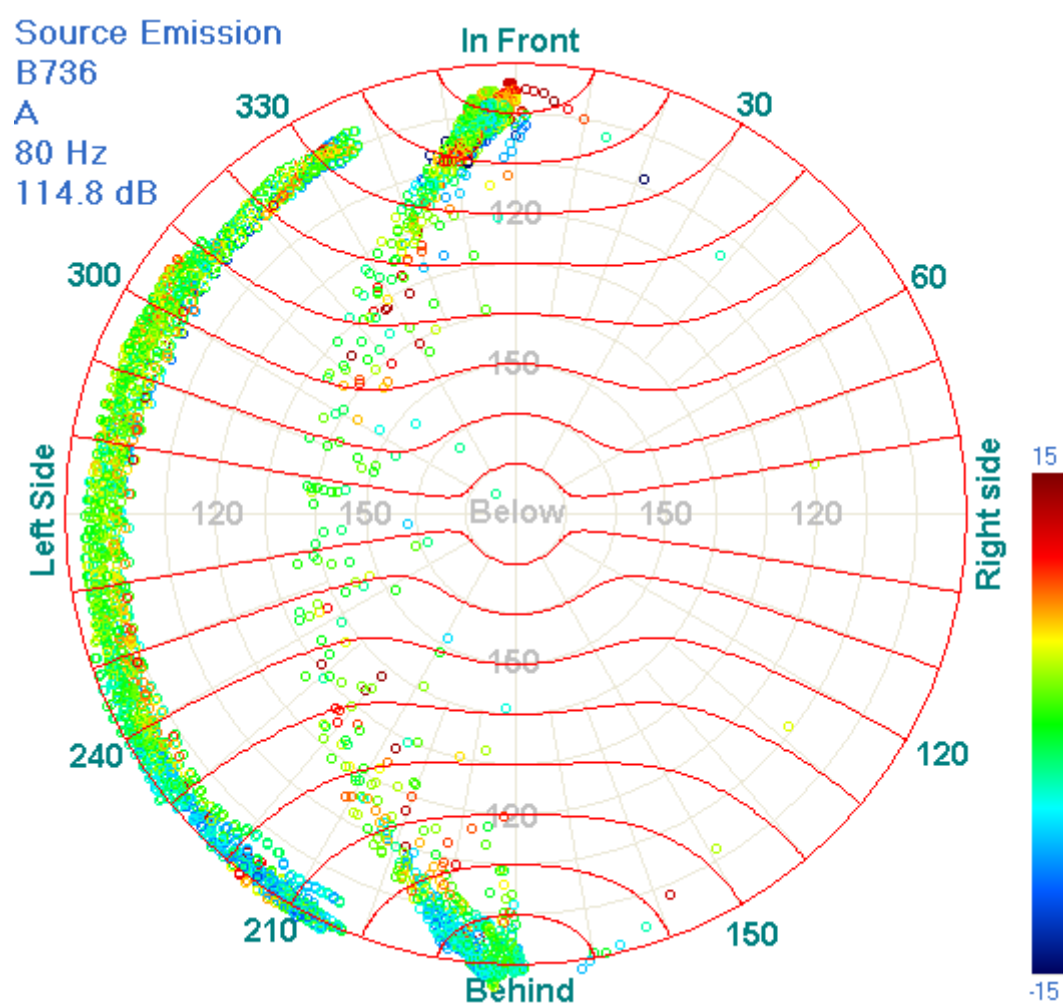


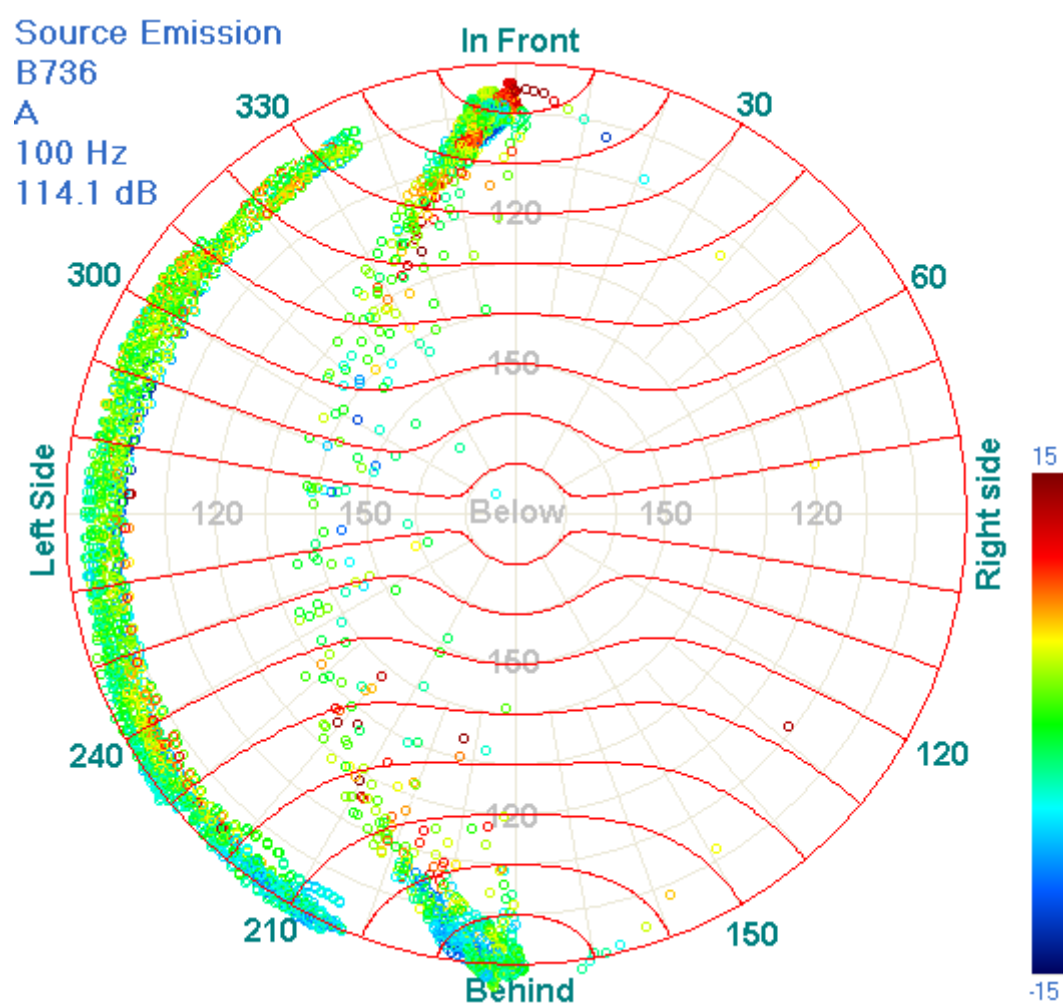






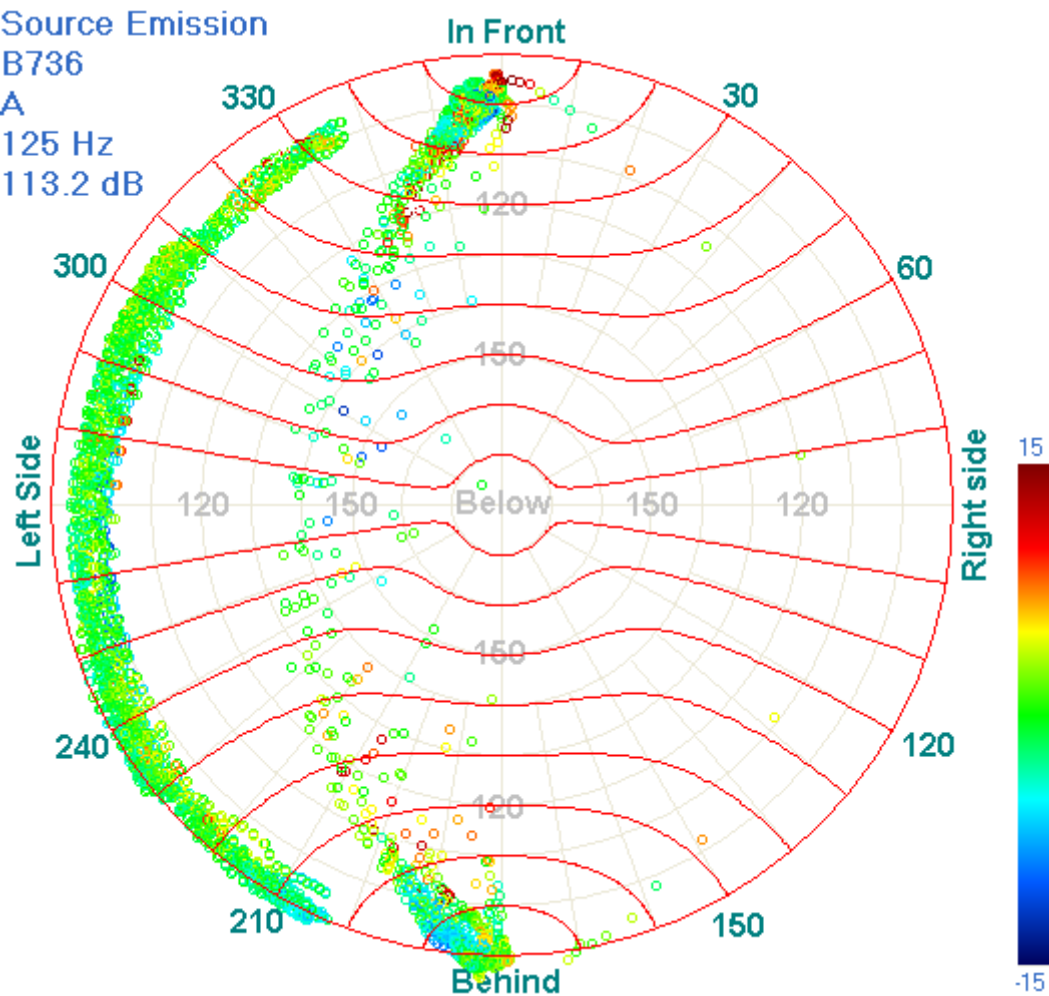


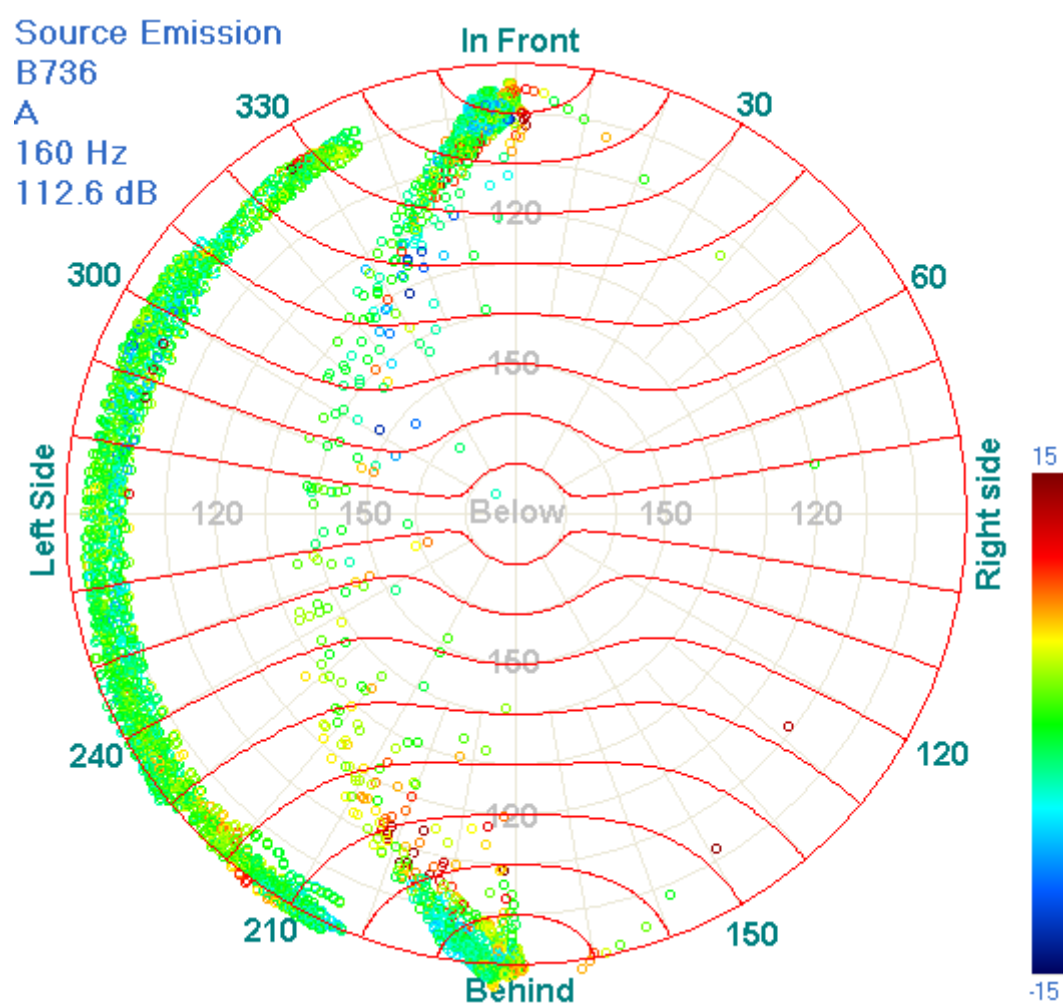


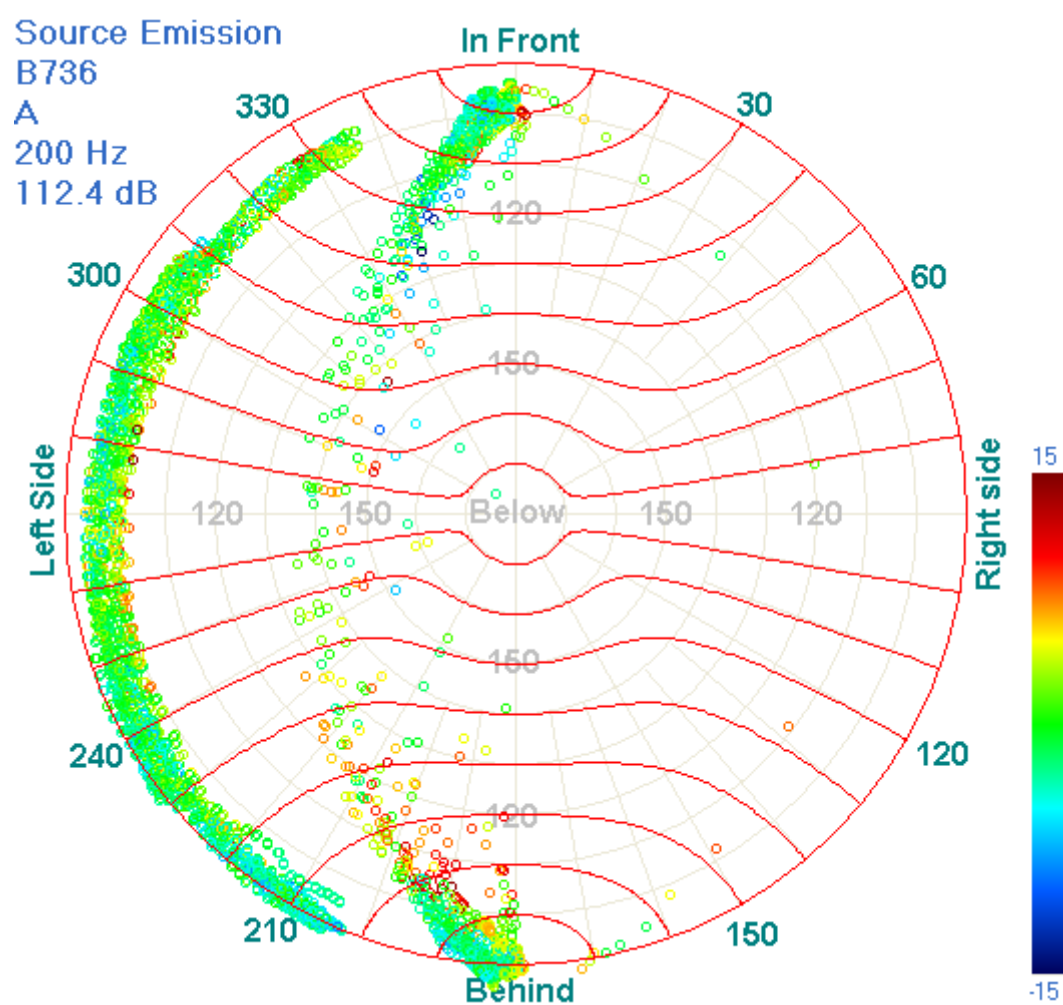


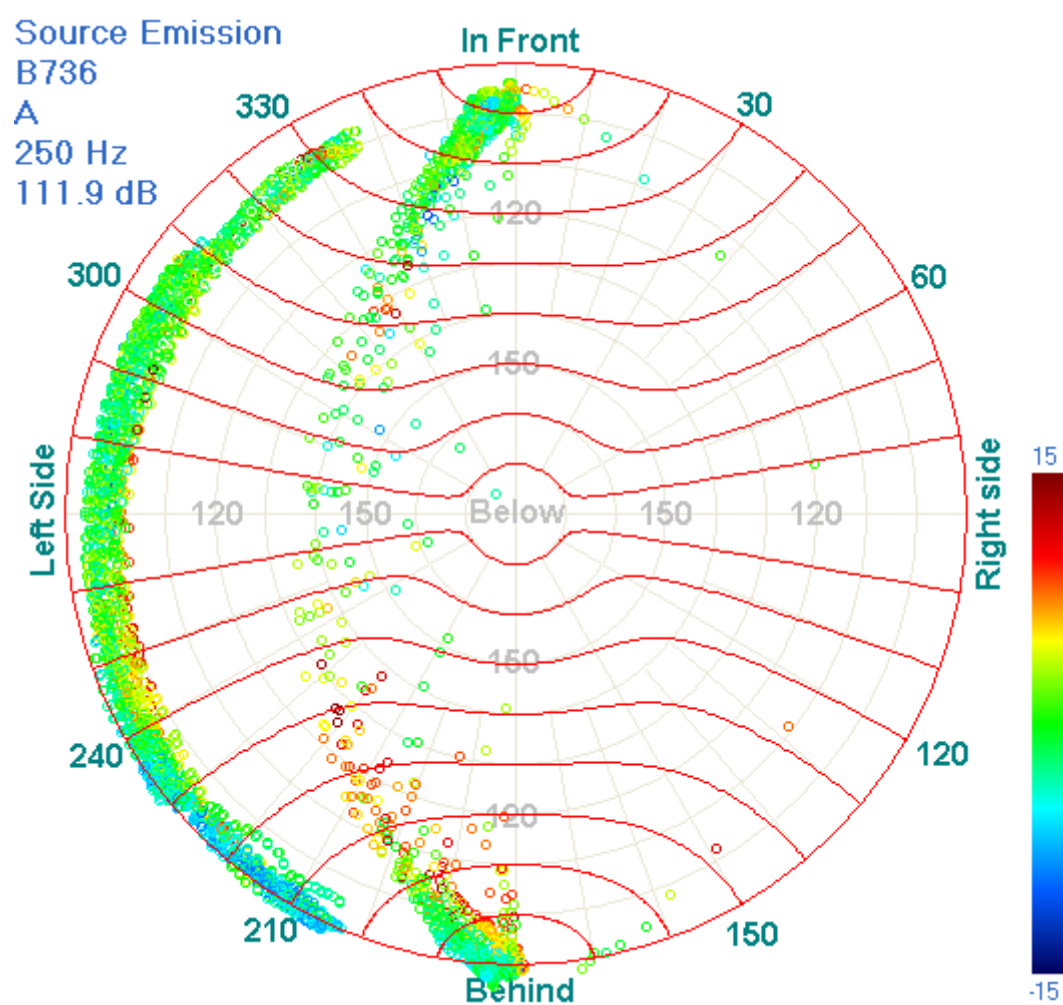


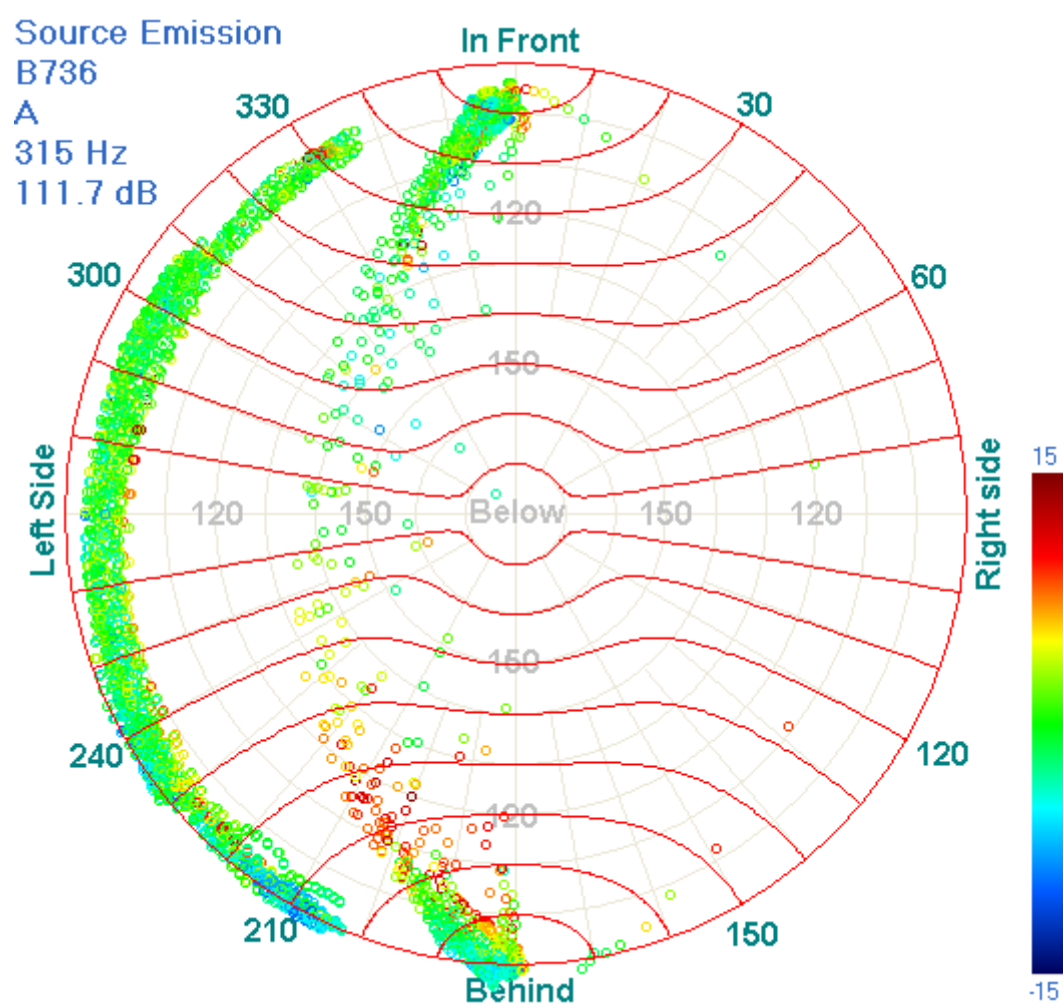
Source Emission  
B736  
A  
125 Hz  
113.2 dB

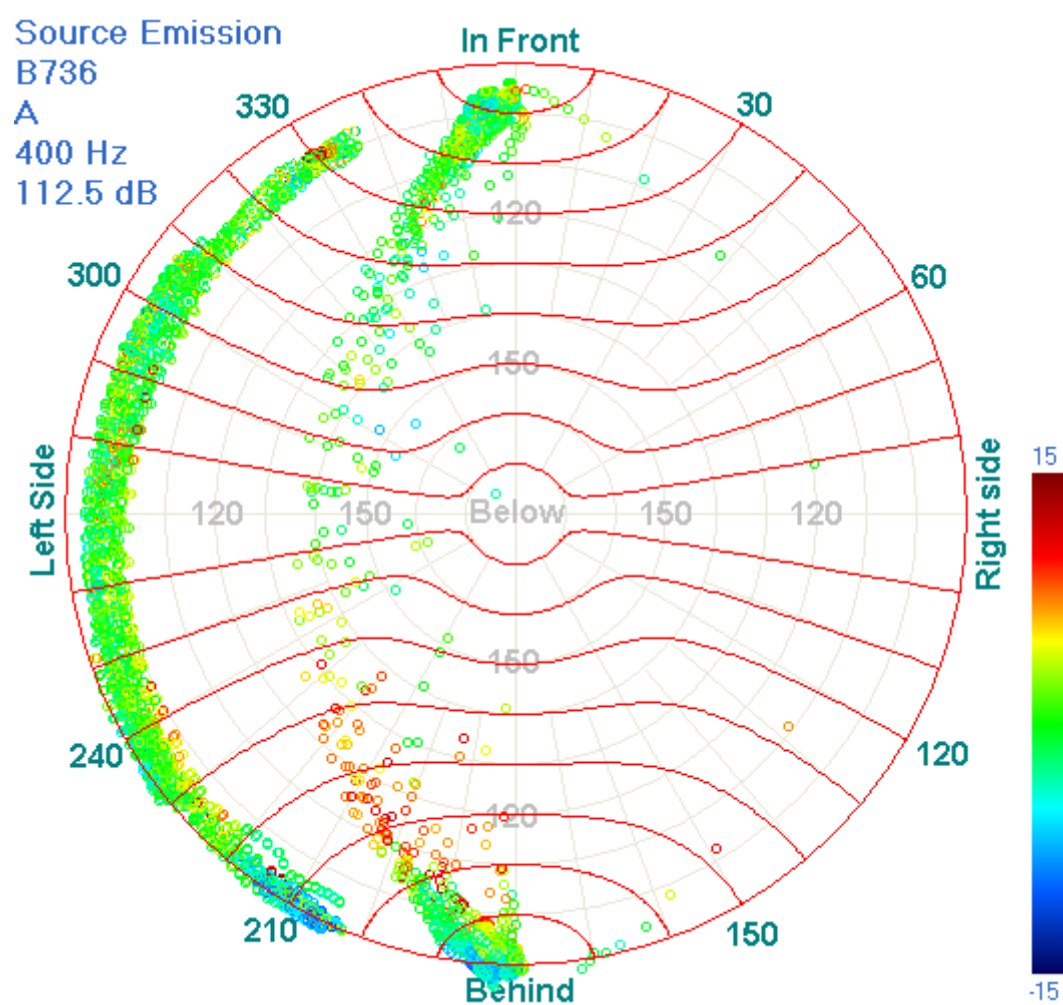


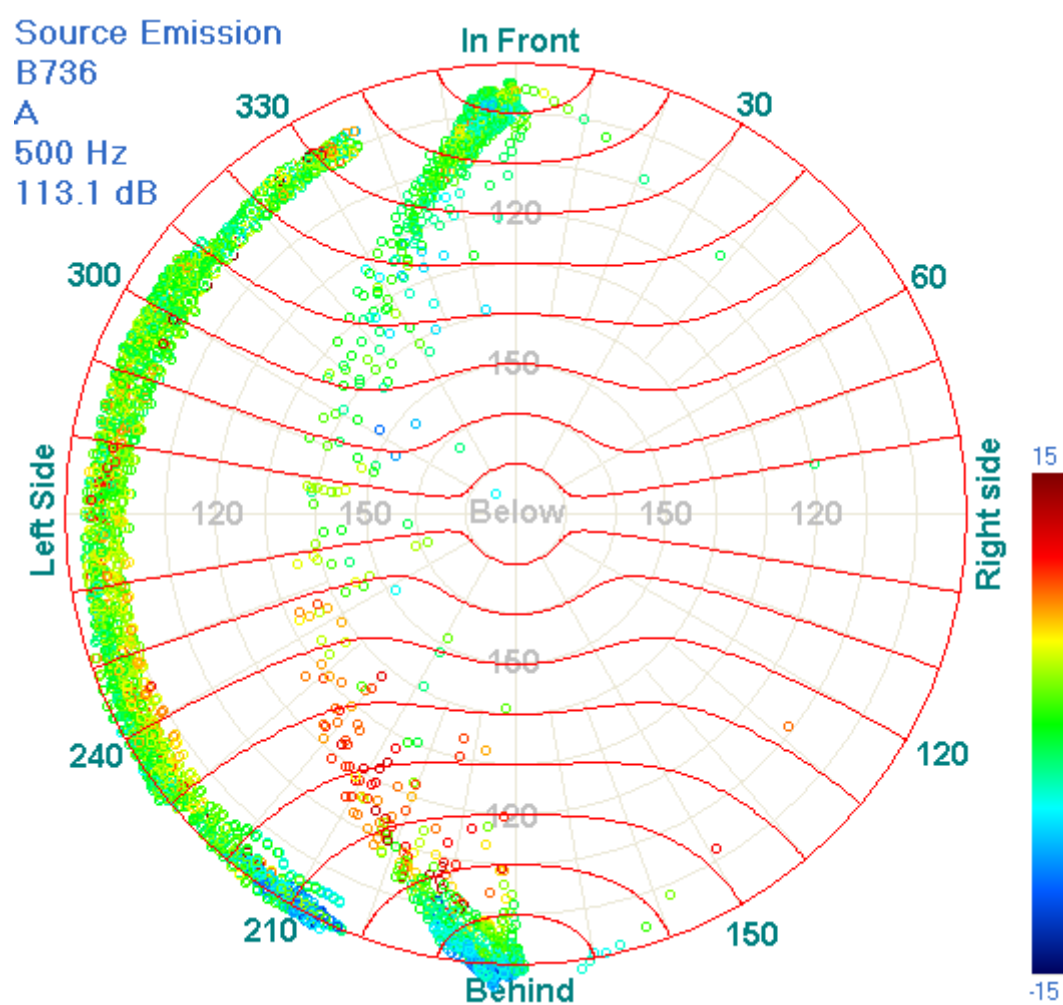


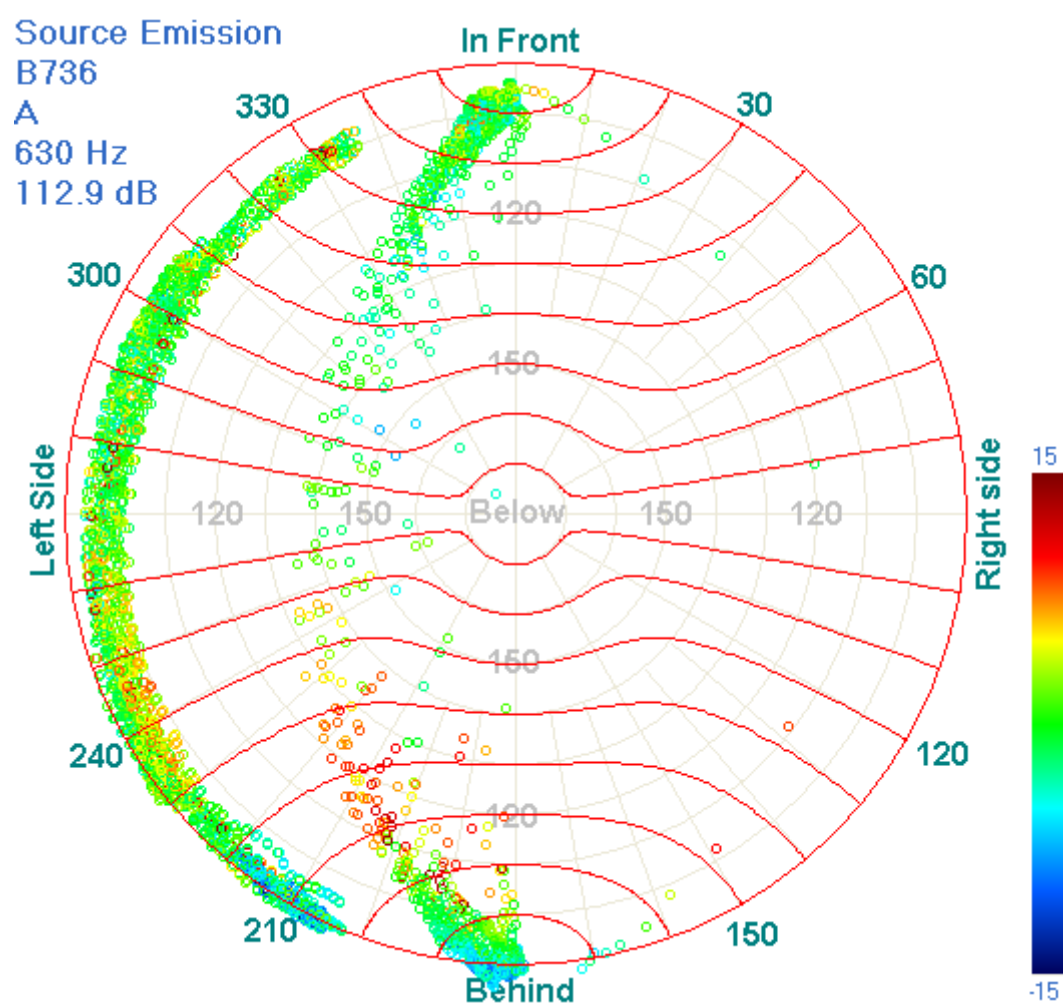




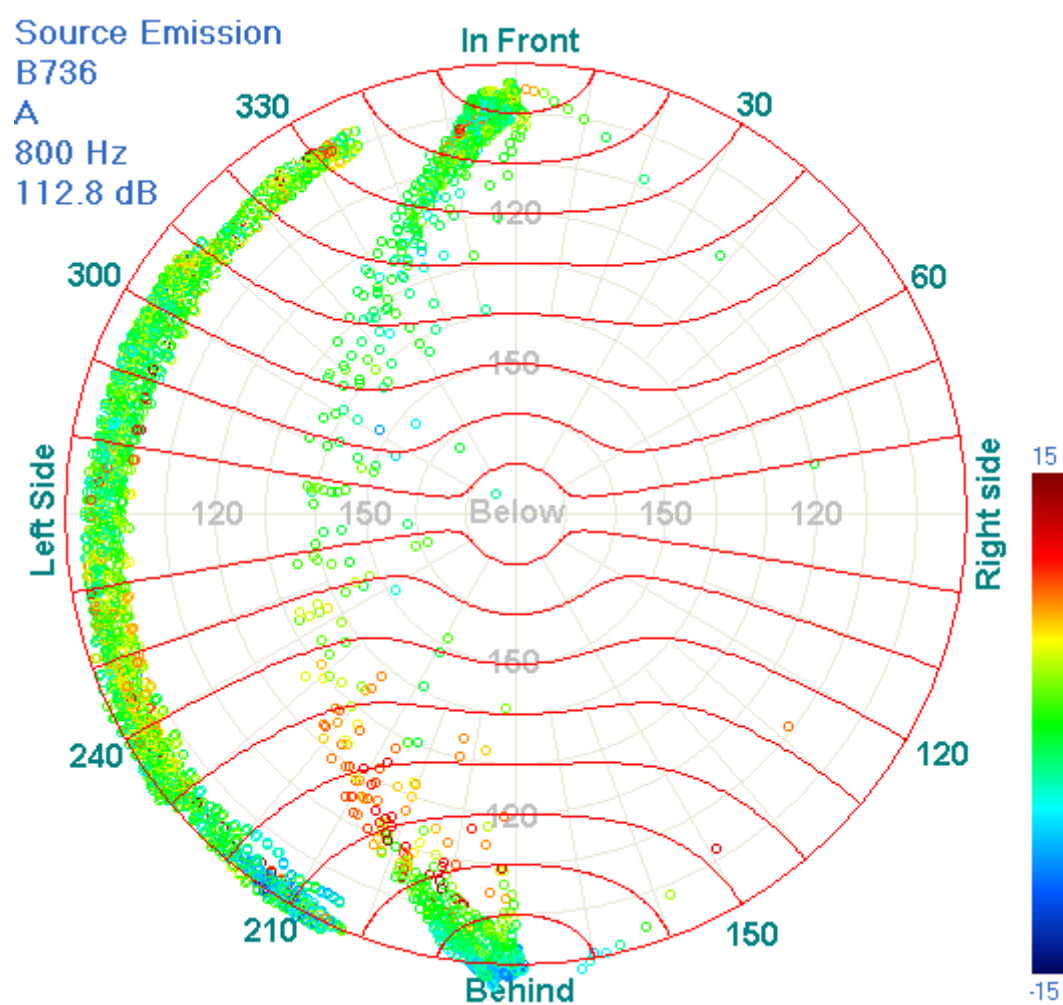


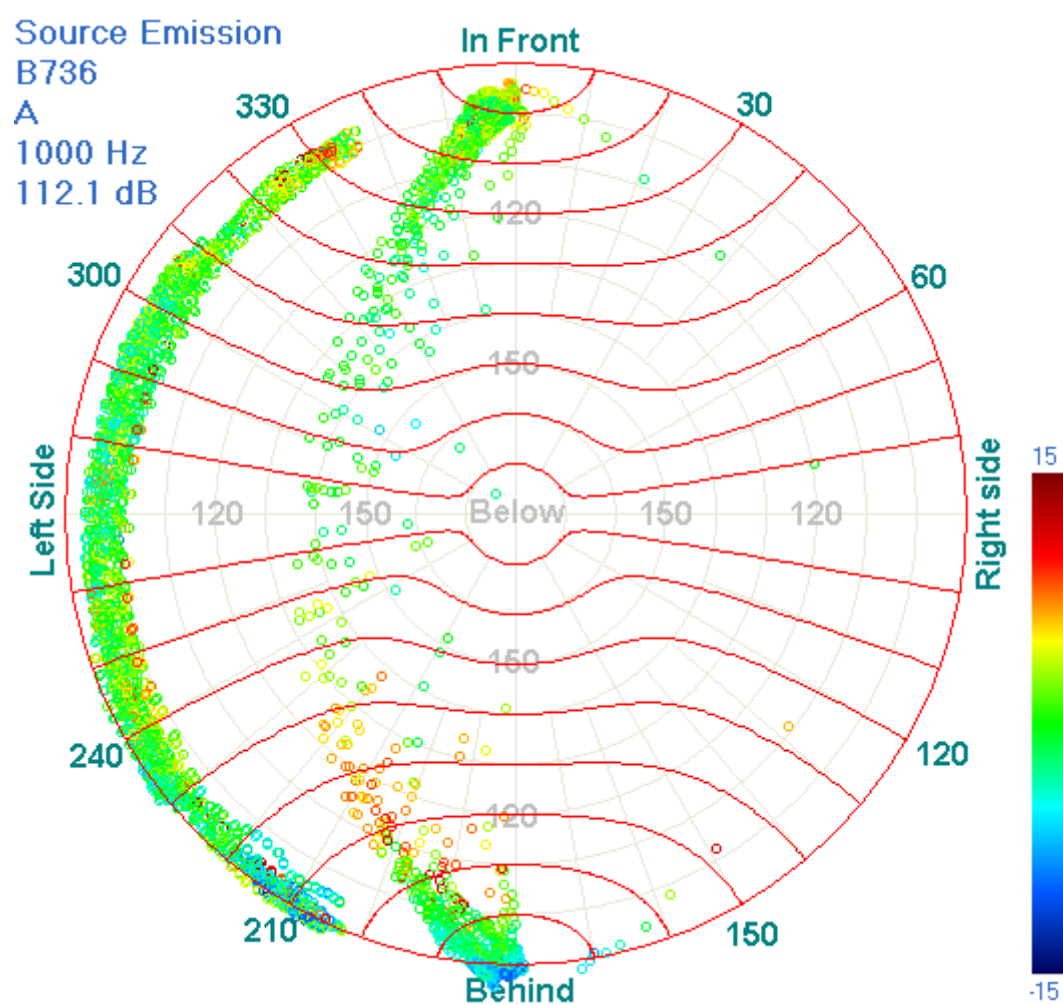


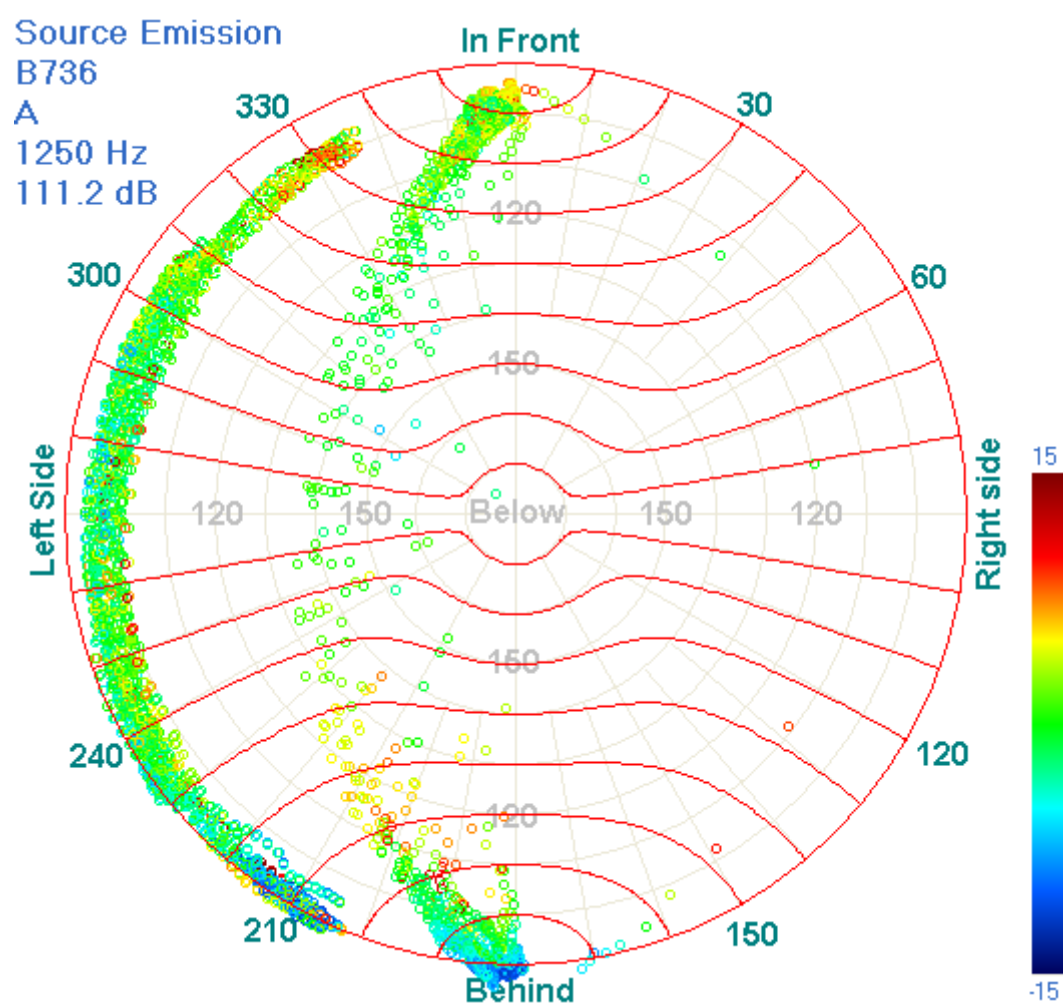


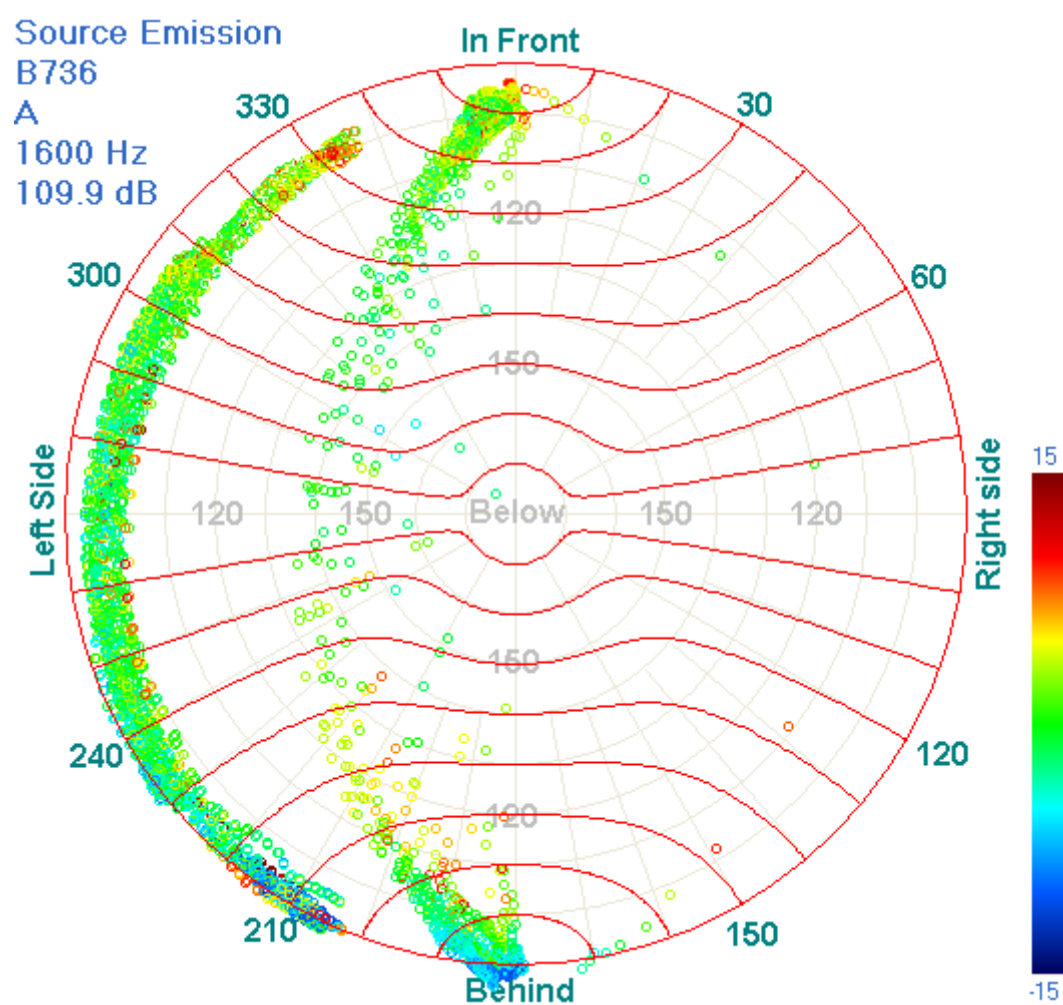


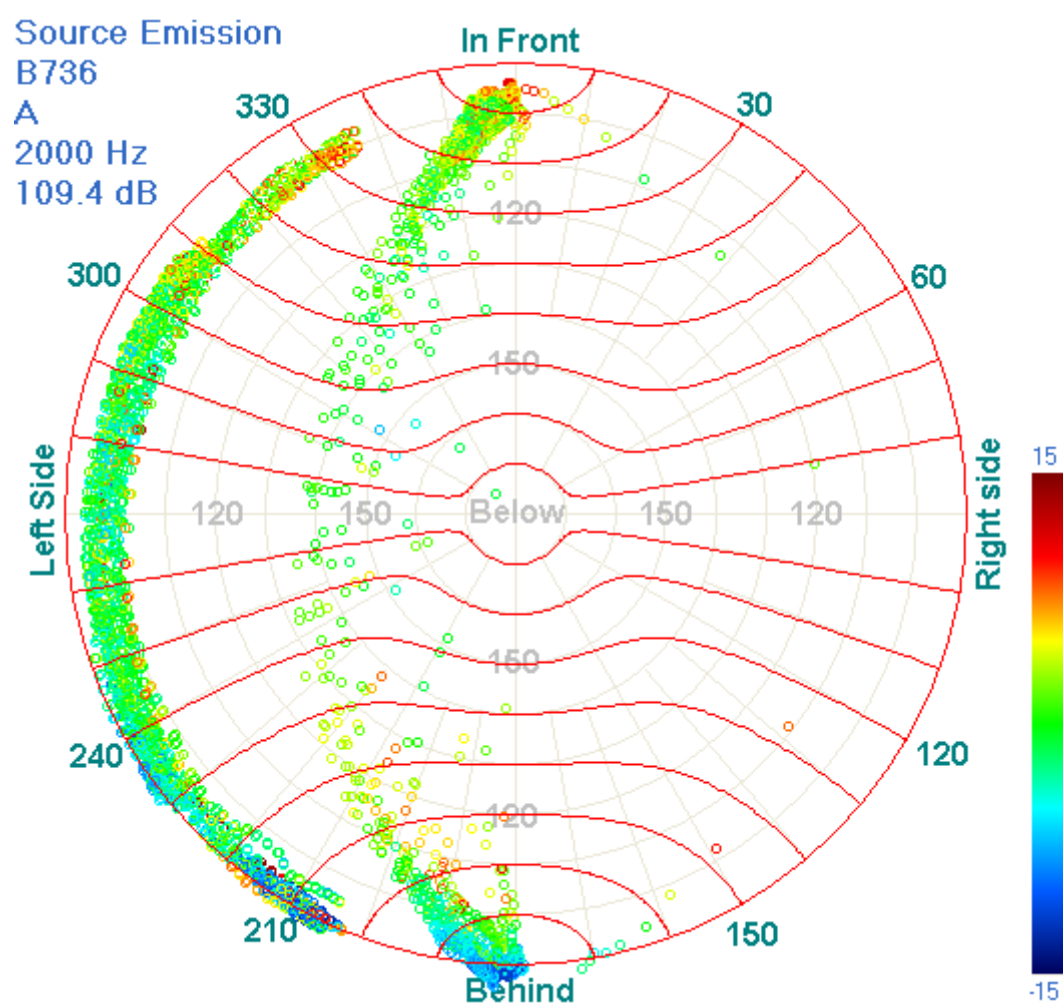


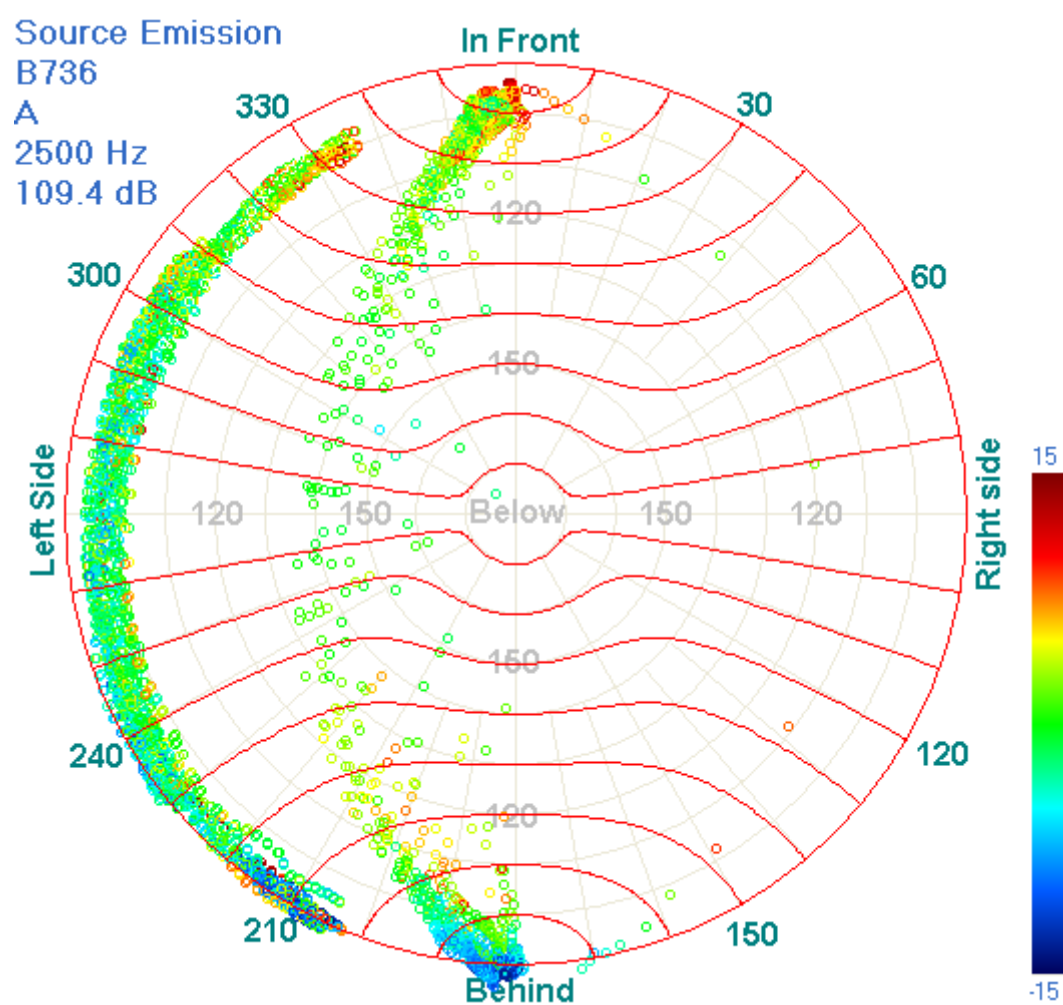


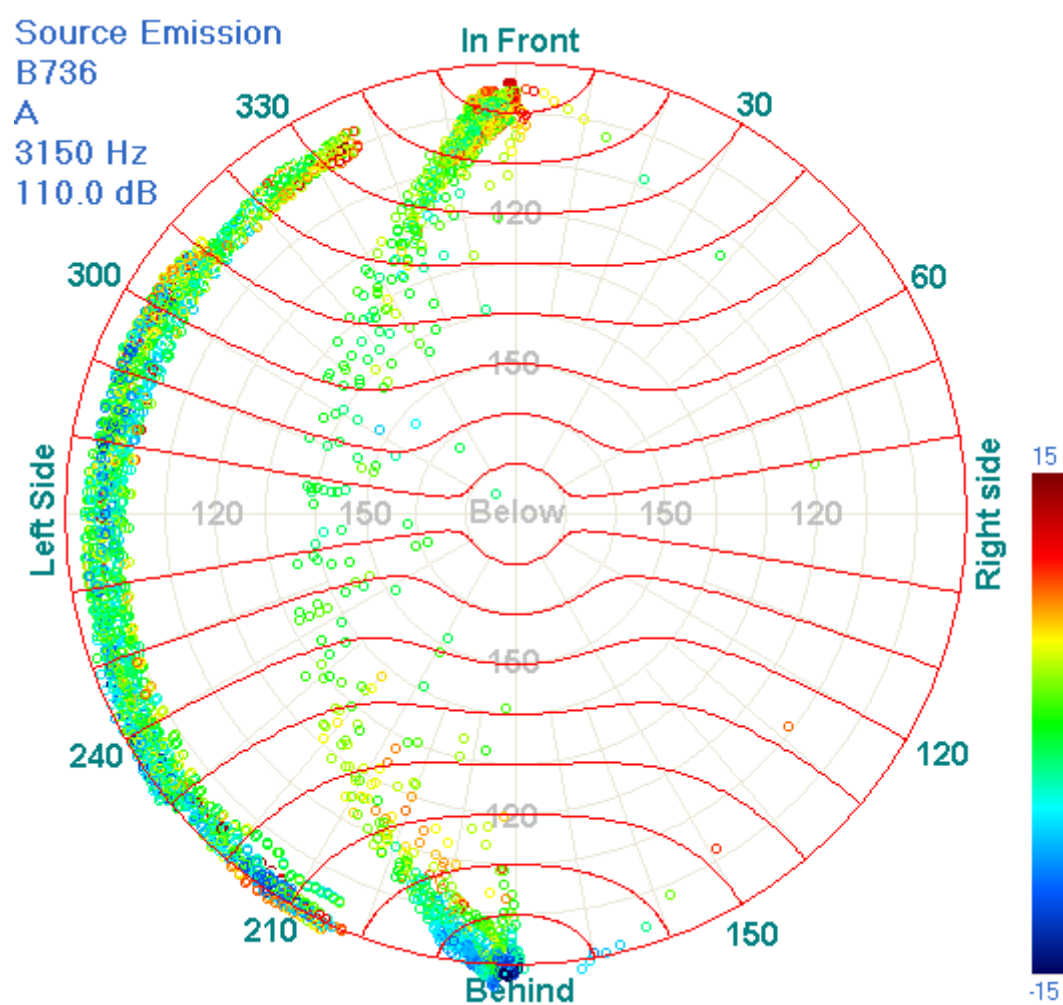




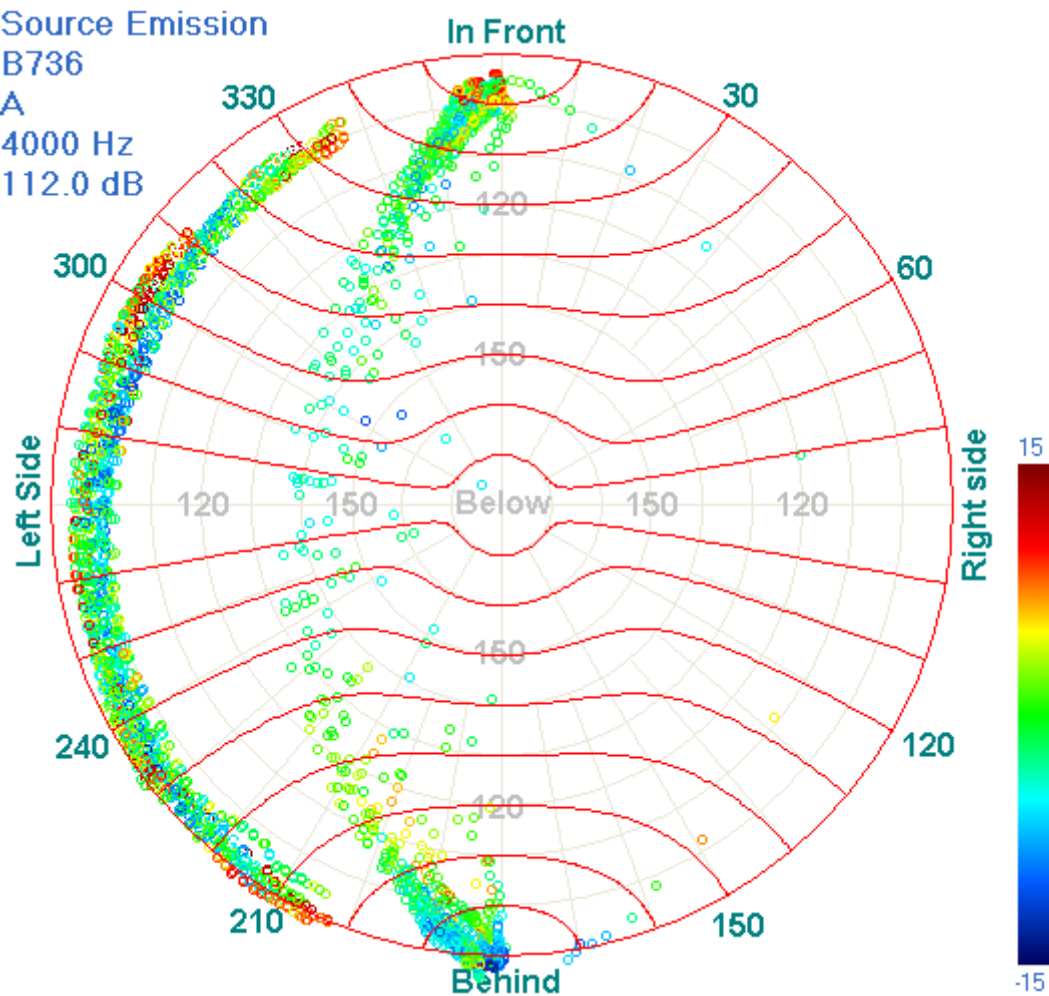




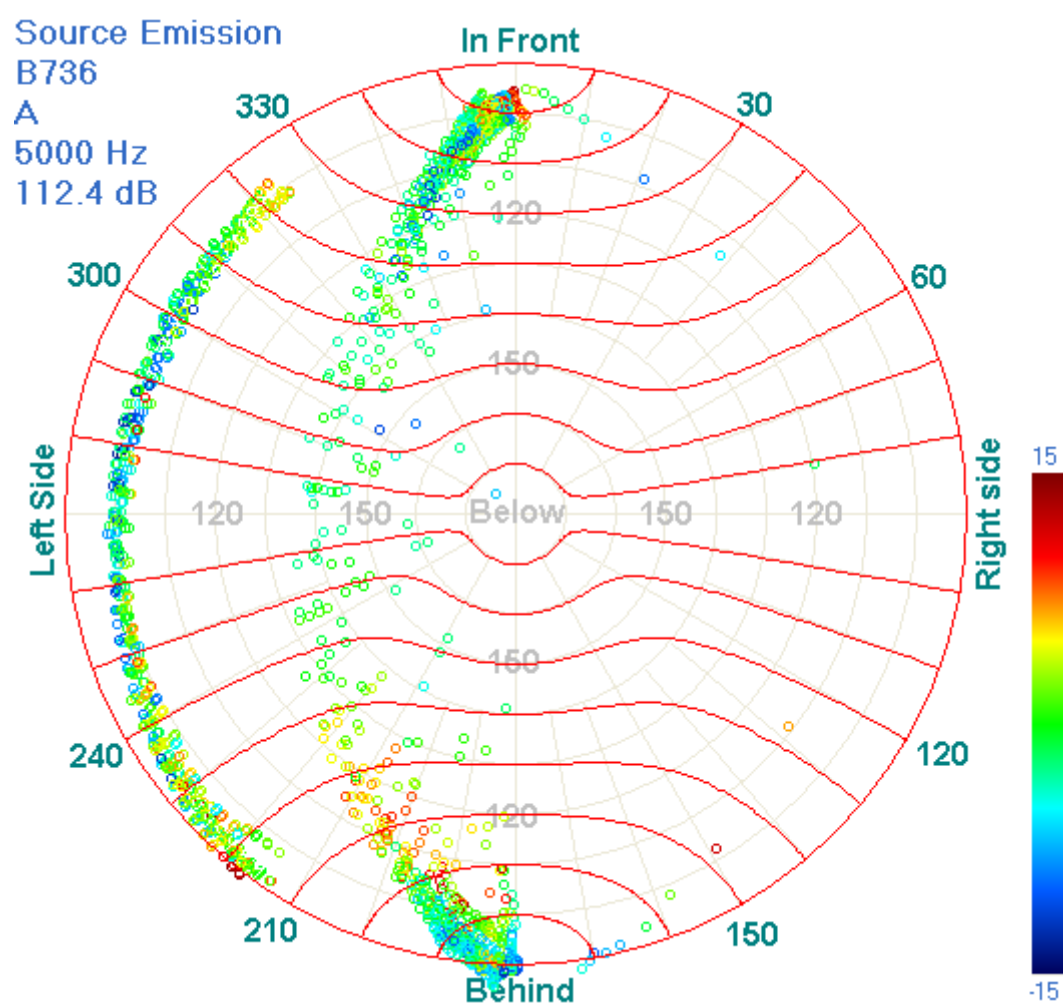




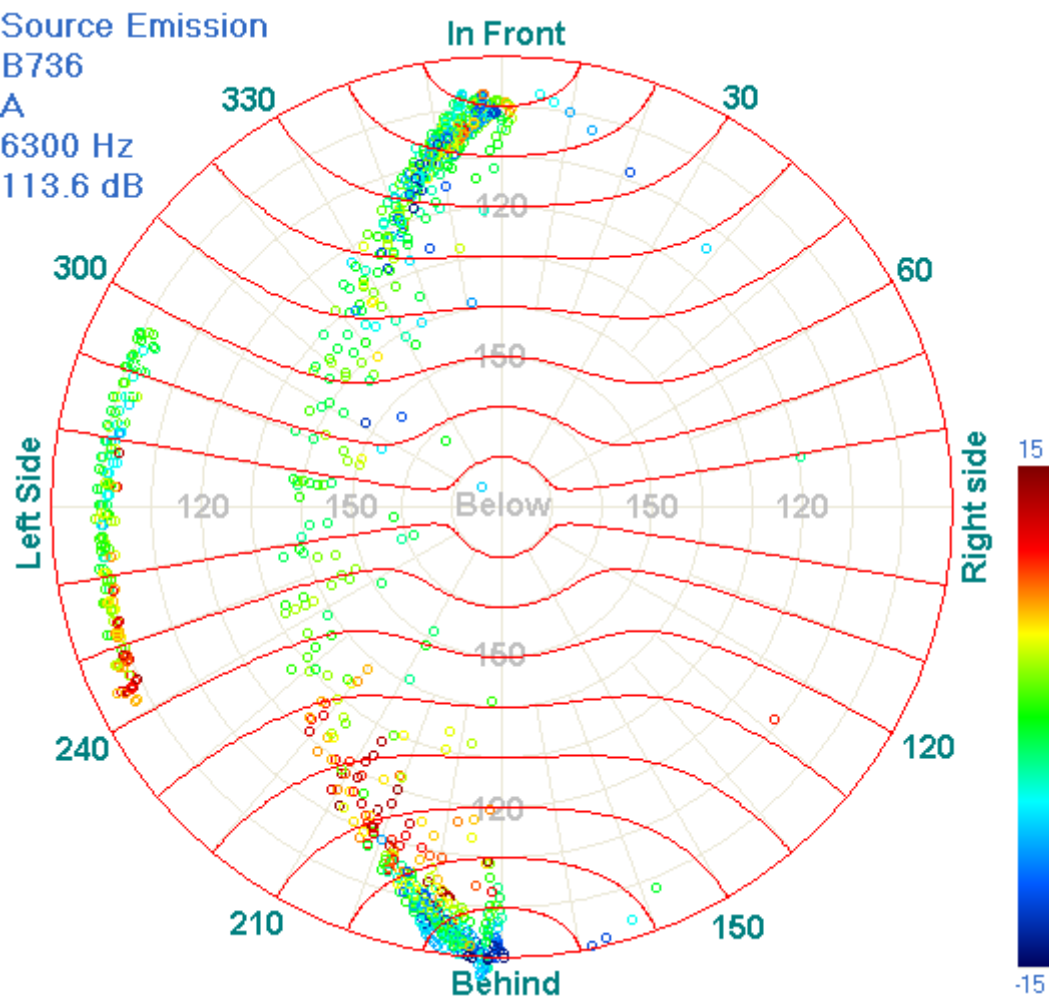
Source Emission  
B736  
A  
4000 Hz  
112.0 dB

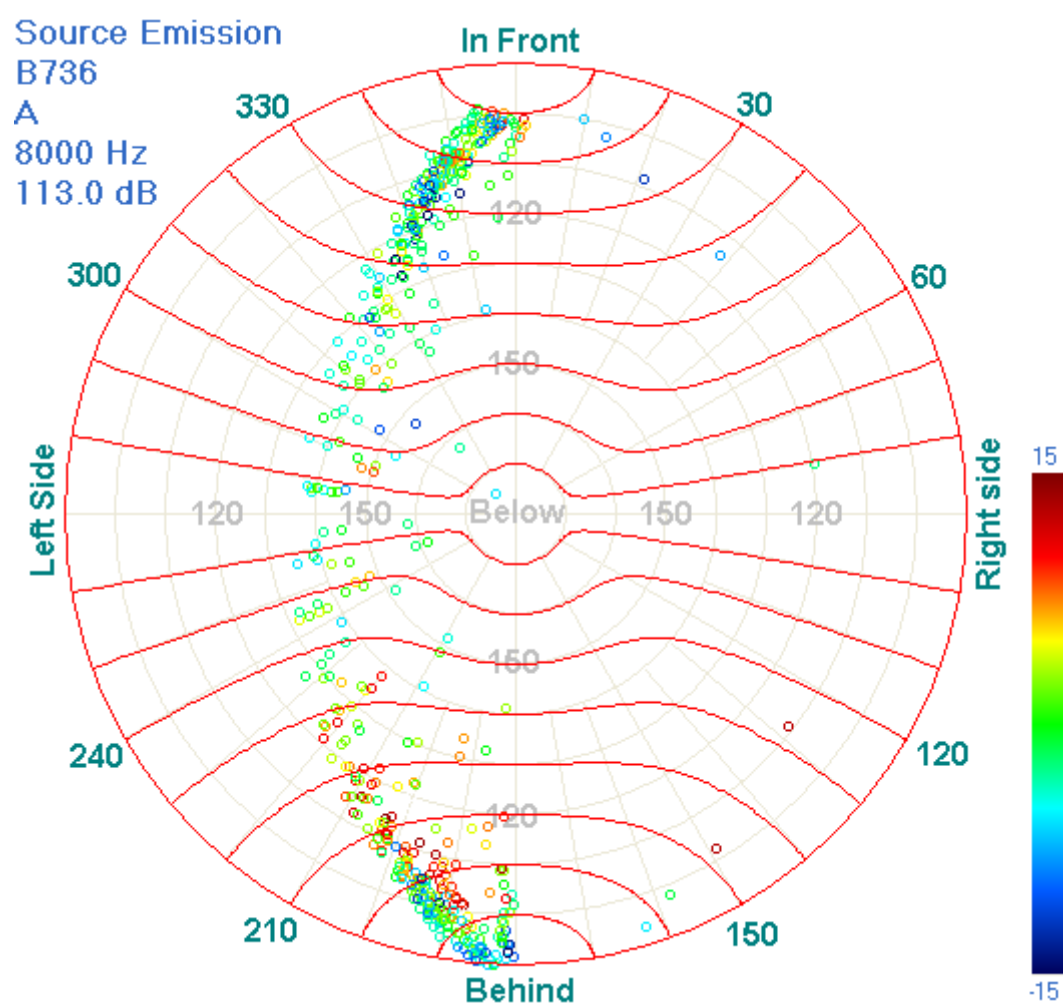


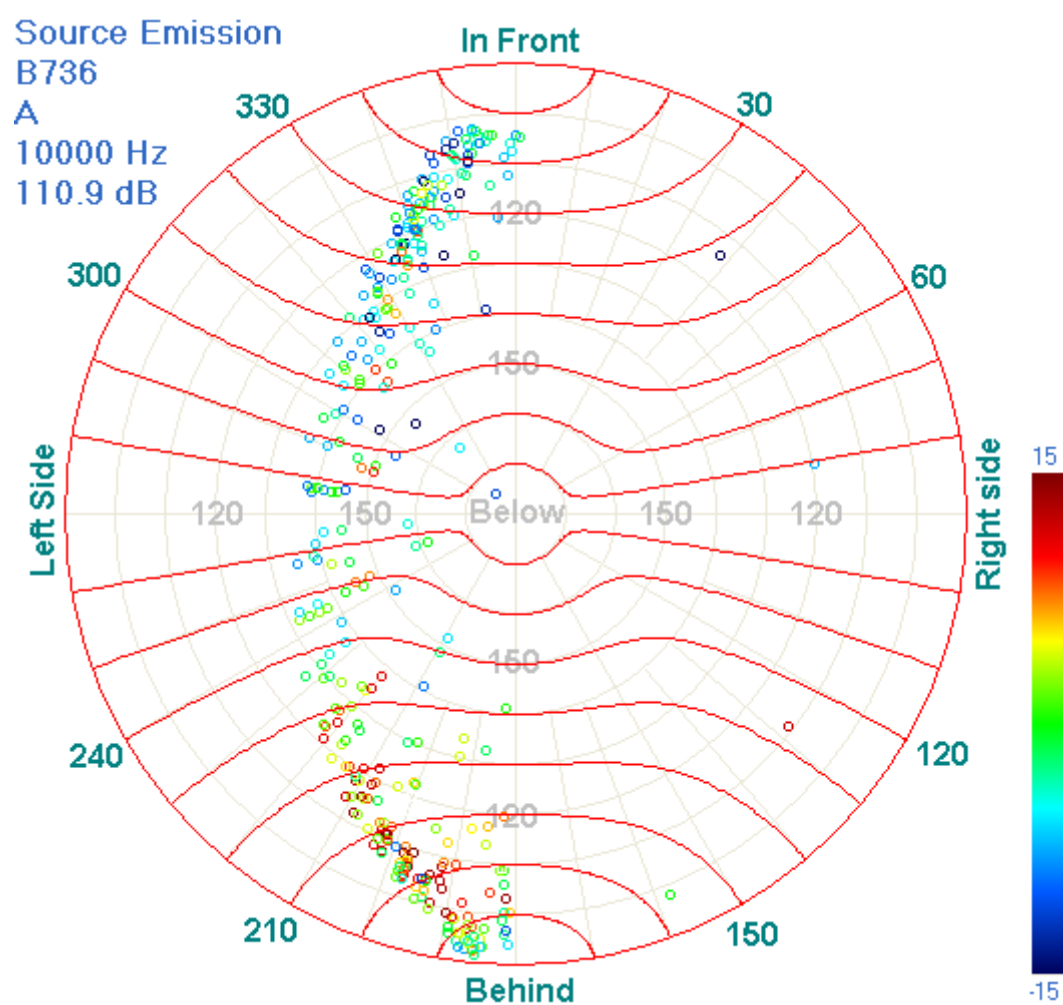




Source Emission  
B736  
A  
6300 Hz  
113.6 dB





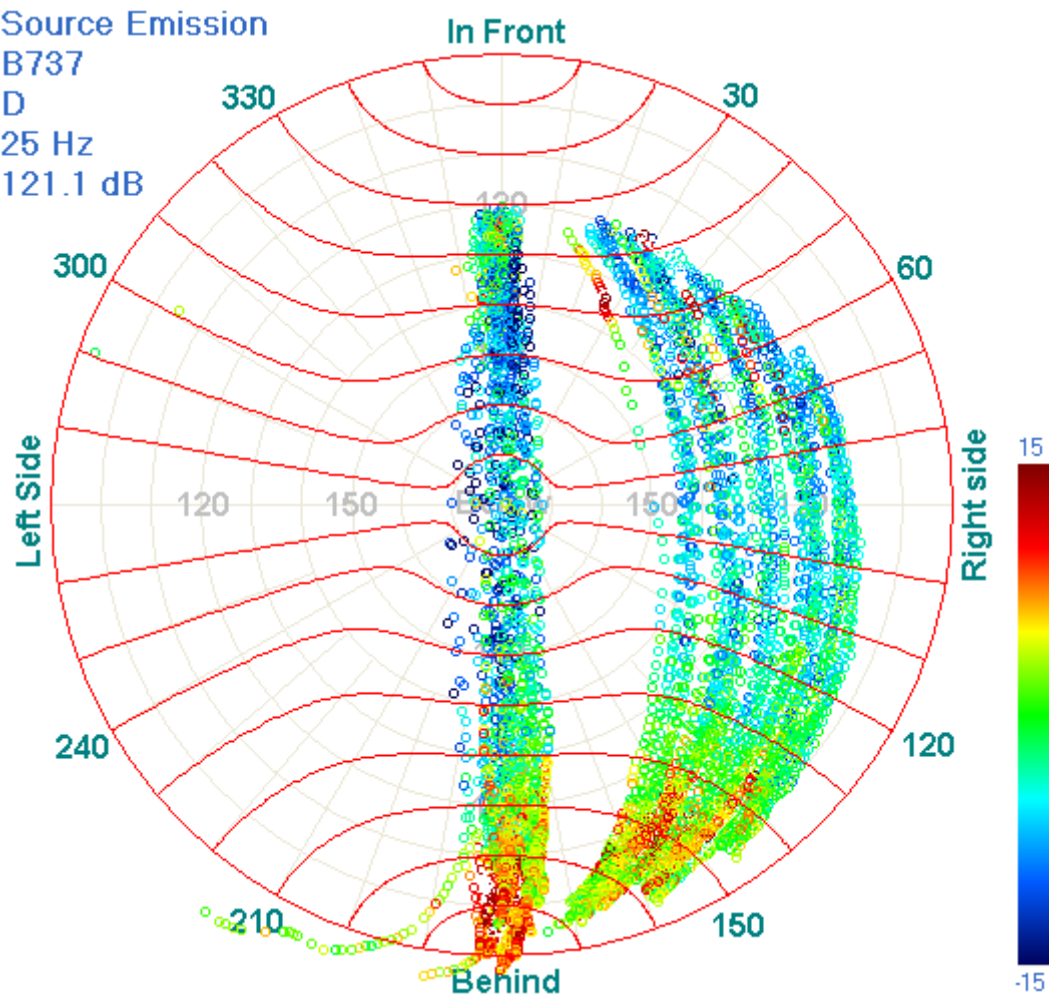


## 10 B737 700 directivity at departure

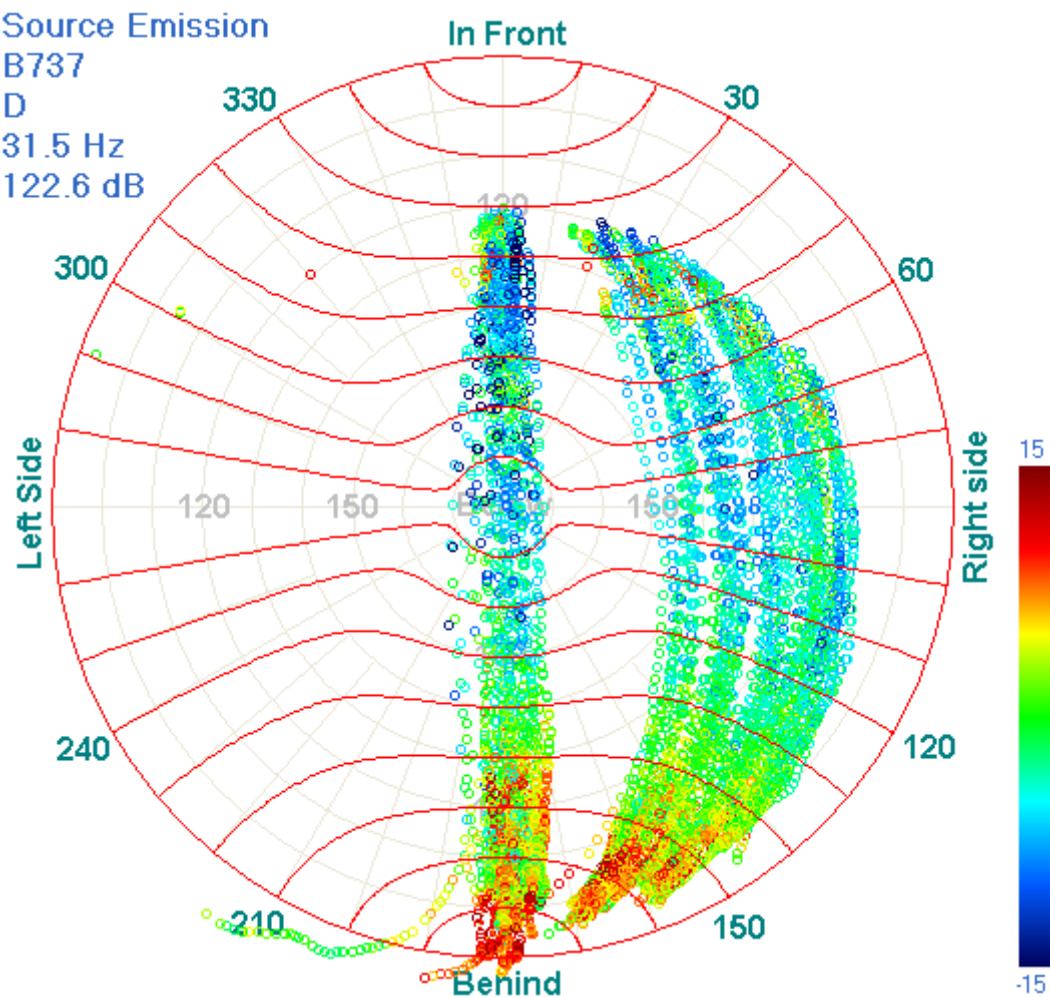
SPECTRUM  
Source Emission  
B737  
D

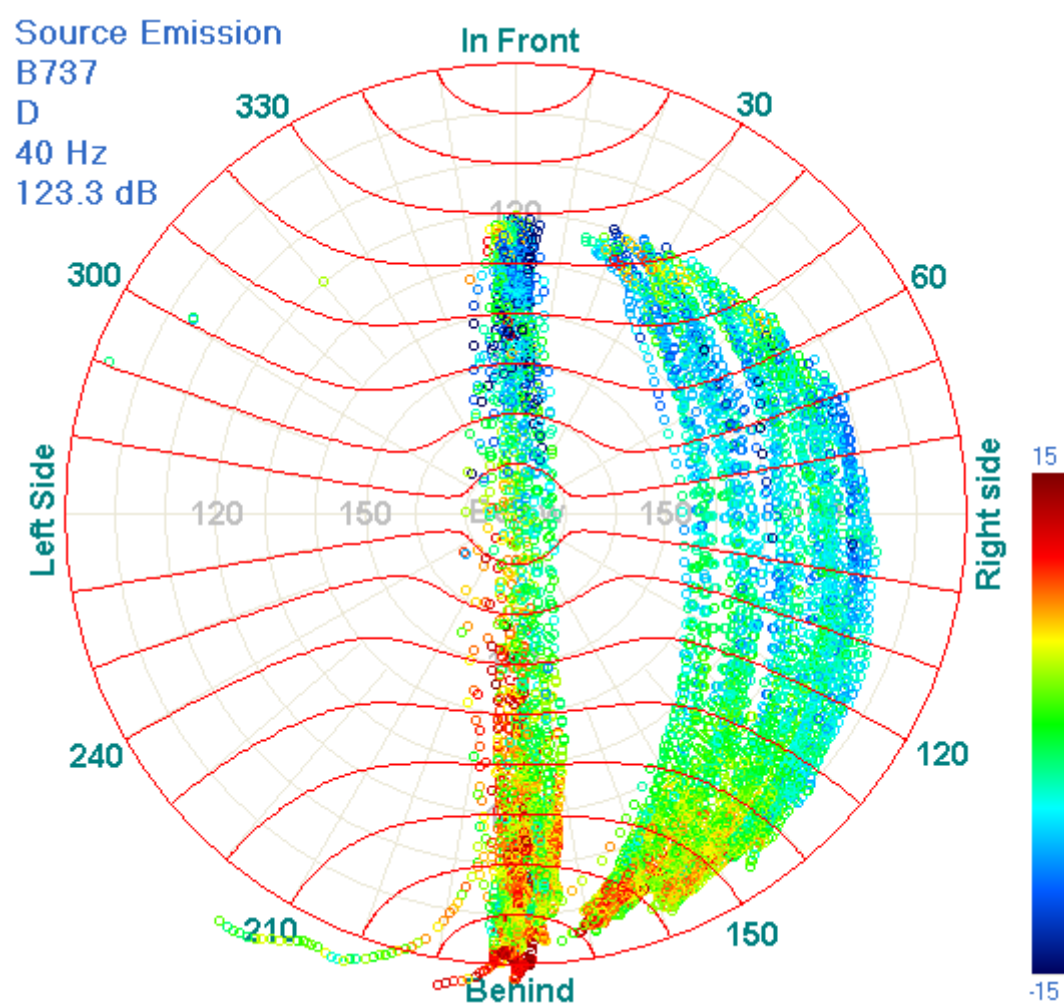
Freq	Num	Avg	Std	95%Avg	P1	P2	P3	P4	P5	P6
25	6805	121.1	7.1	0.2	-1.0	-1.0	124.4	121.1	122.0	-1.0
31.5	8089	122.6	6.2	0.1	-1.0	-1.0	123.4	122.6	122.4	-1.0
40	8248	123.3	5.7	0.1	-1.0	-1.0	124.0	123.3	123.3	-1.0
50	8191	123.8	5.3	0.1	-1.0	-1.0	125.2	123.7	124.7	-1.0
63	8128	124.5	5.3	0.1	-1.0	-1.0	125.2	124.5	125.7	-1.0
80	9694	125.7	4.8	0.1	-1.0	-1.0	125.0	125.7	127.5	-1.0
100	10240	125.6	4.5	0.1	-1.0	-1.0	124.7	125.6	127.6	-1.0
125	10838	124.7	4.3	0.1	-1.0	-1.0	123.3	124.7	126.4	-1.0
160	10914	123.5	4.7	0.1	-1.0	-1.0	122.0	123.5	125.9	-1.0
200	11001	122.5	5.1	0.1	-1.0	-1.0	122.7	122.4	125.4	-1.0
250	11107	122.4	5.1	0.1	-1.0	-1.0	120.6	122.3	125.6	-1.0
315	11000	121.1	5.5	0.1	-1.0	-1.0	120.2	121.1	124.7	-1.0
400	11032	120.3	5.7	0.1	-1.0	-1.0	119.1	120.3	124.0	-1.0
500	10974	119.6	6.1	0.1	-1.0	-1.0	119.2	119.6	123.3	-1.0
630	10782	118.7	5.8	0.1	-1.0	-1.0	118.4	118.6	122.3	-1.0
800	10739	117.9	5.5	0.1	-1.0	-1.0	118.5	117.8	121.1	-1.0
1000	10711	117.3	5.6	0.1	-1.0	-1.0	118.7	117.2	120.1	-1.0
1250	10737	116.8	5.9	0.1	-1.0	-1.0	118.0	116.7	119.9	-1.0
1600	10673	116.8	6.0	0.1	-1.0	-1.0	118.5	116.7	119.9	-1.0
2000	10349	117.4	6.5	0.1	-1.0	-1.0	119.5	117.2	120.4	-1.0
2500	9369	118.0	5.8	0.1	-1.0	-1.0	121.7	117.9	119.9	-1.0
3150	7461	119.3	5.9	0.1	-1.0	-1.0	124.4	119.2	120.5	-1.0
4000	4385	119.7	6.4	0.2	-1.0	-1.0	124.0	119.6	122.4	-1.0
5000	1800	119.0	6.4	0.3	-1.0	-1.0	-1.0	118.9	123.5	-1.0
6300	565	118.7	7.1	0.6	-1.0	-1.0	-1.0	118.7	123.0	-1.0
8000	113	118.6	7.5	1.4	-1.0	-1.0	-1.0	118.6	-1.0	-1.0
10000	8	110.9	6.3	4.4	-1.0	-1.0	-1.0	110.9	-1.0	-1.0

Source Emission  
B737  
D  
25 Hz  
121.1 dB



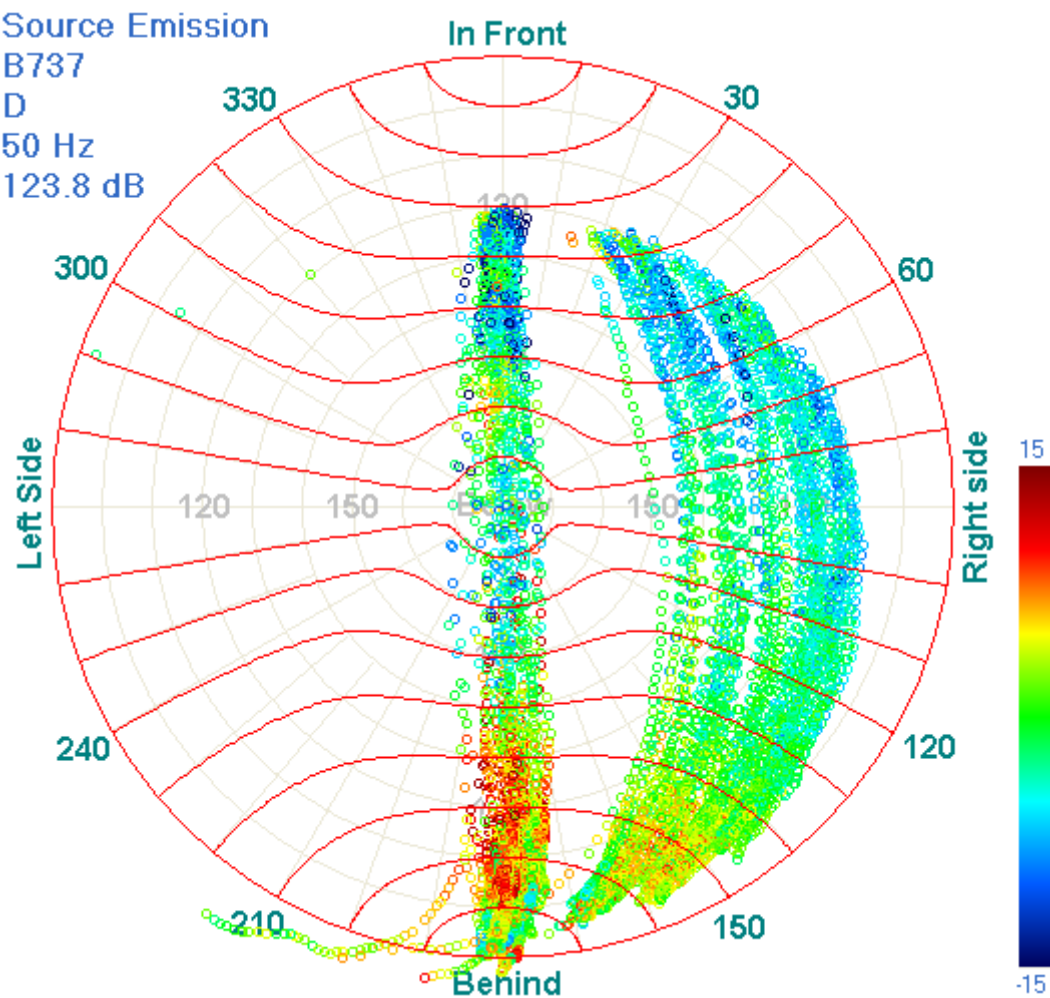
Source Emission  
B737  
D  
31.5 Hz  
122.6 dB



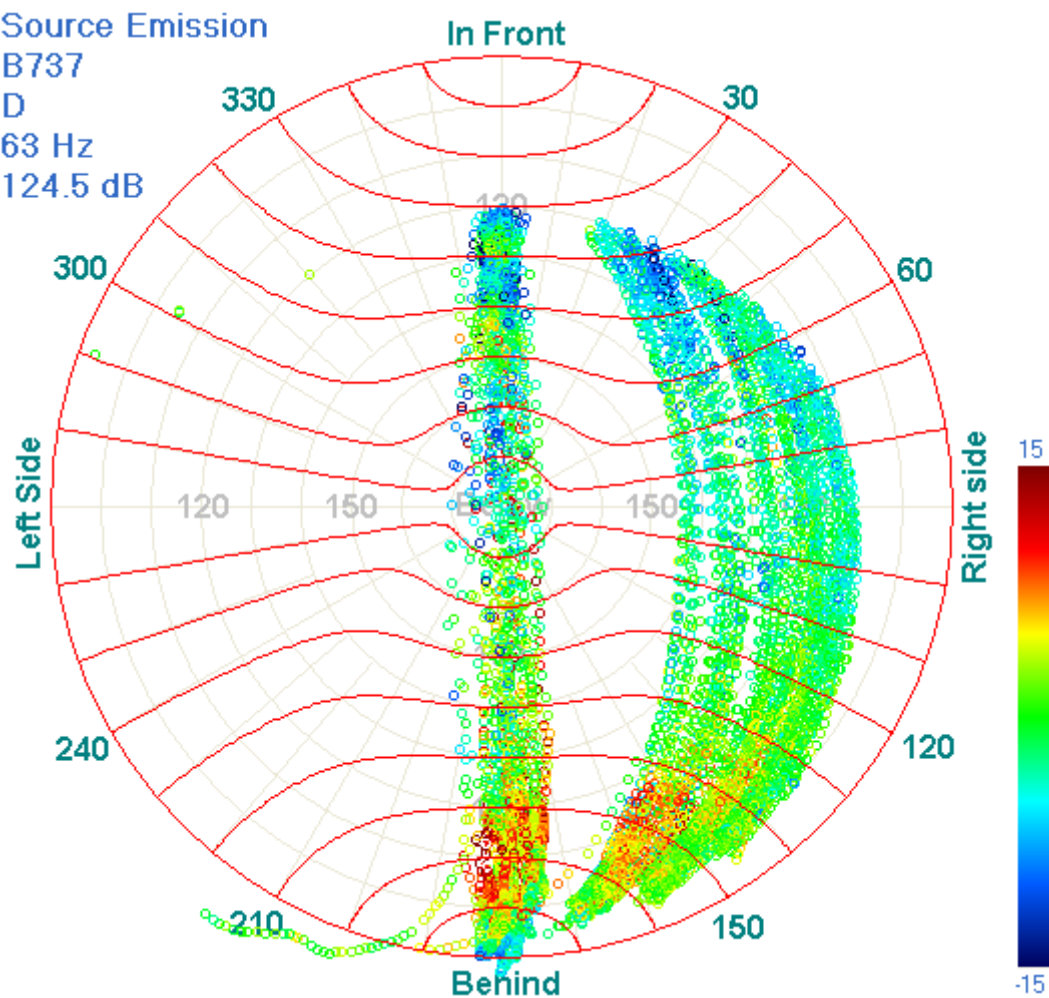




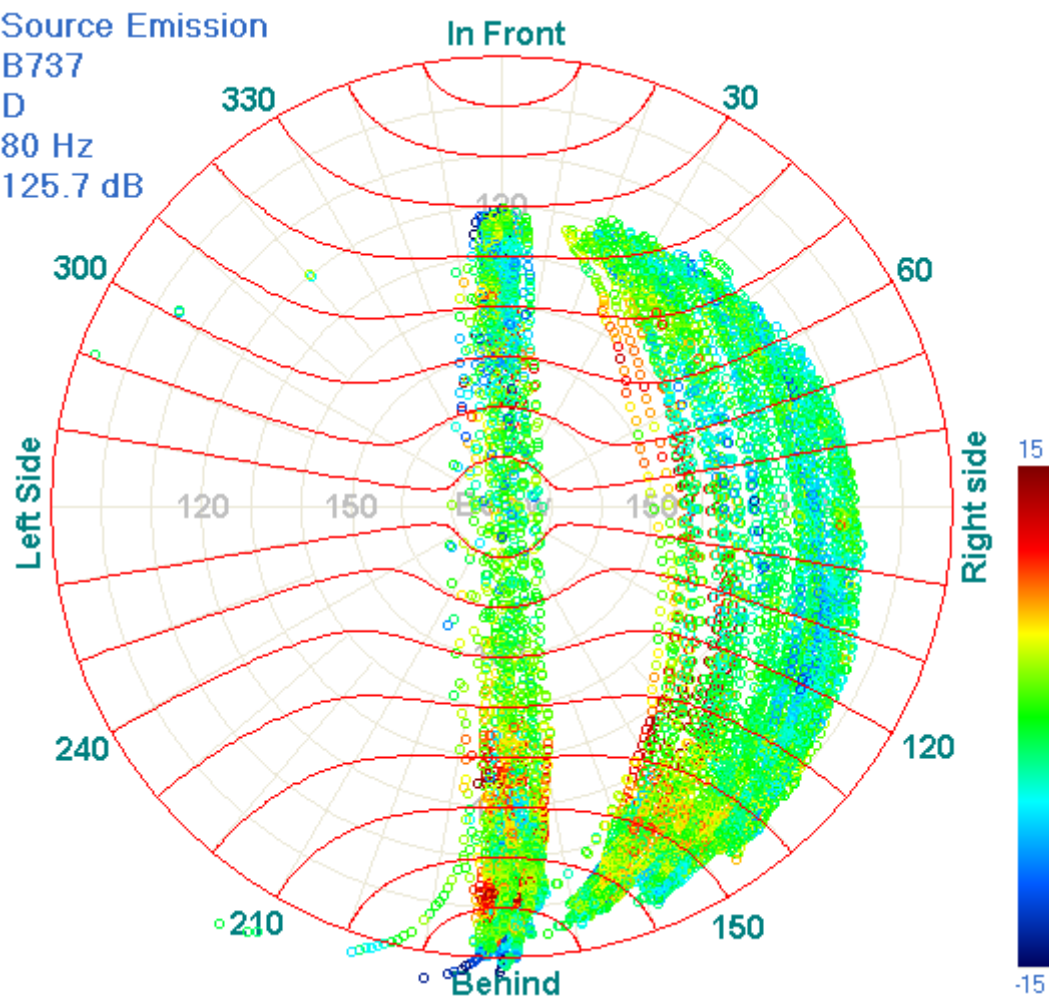
Source Emission  
B737  
D  
50 Hz  
123.8 dB



Source Emission  
B737  
D  
63 Hz  
124.5 dB



Source Emission  
B737  
D  
80 Hz  
125.7 dB



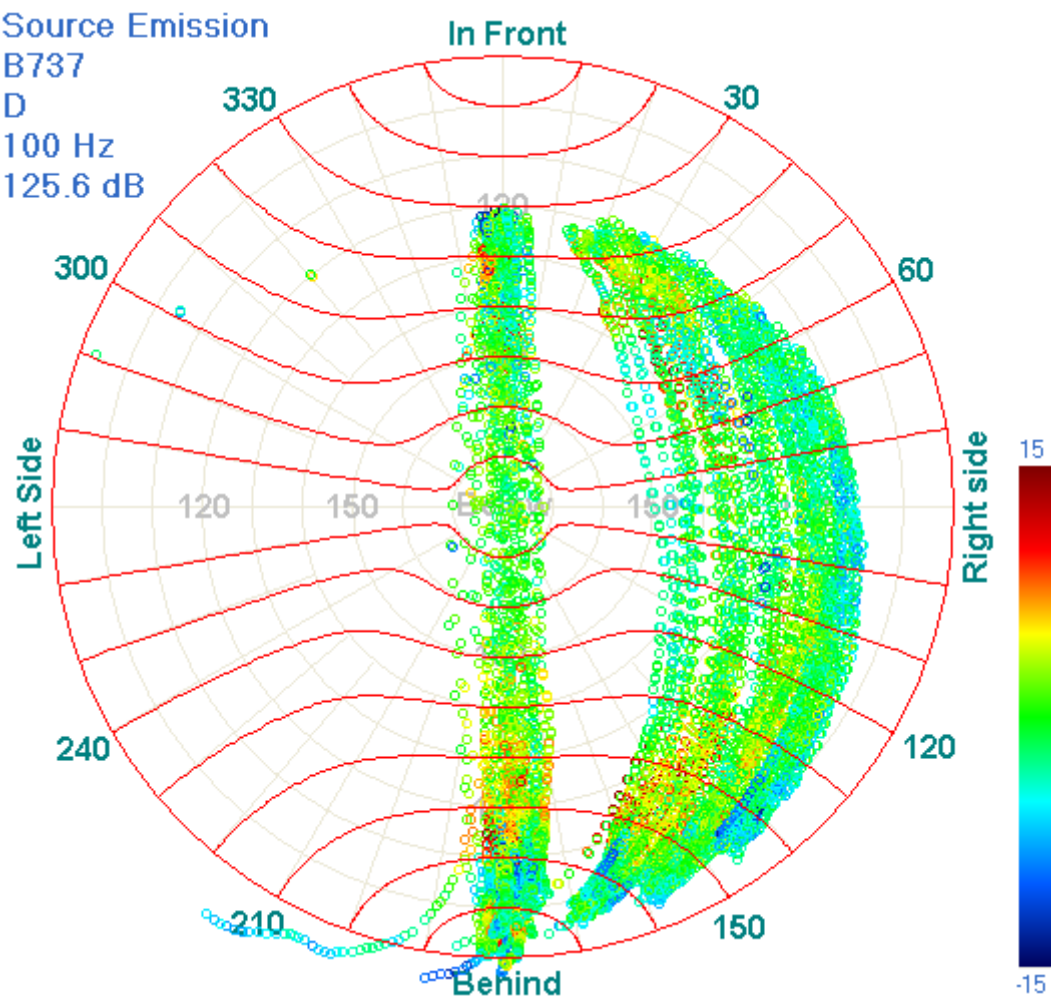
Source Emission

B737

D

100 Hz

125.6 dB



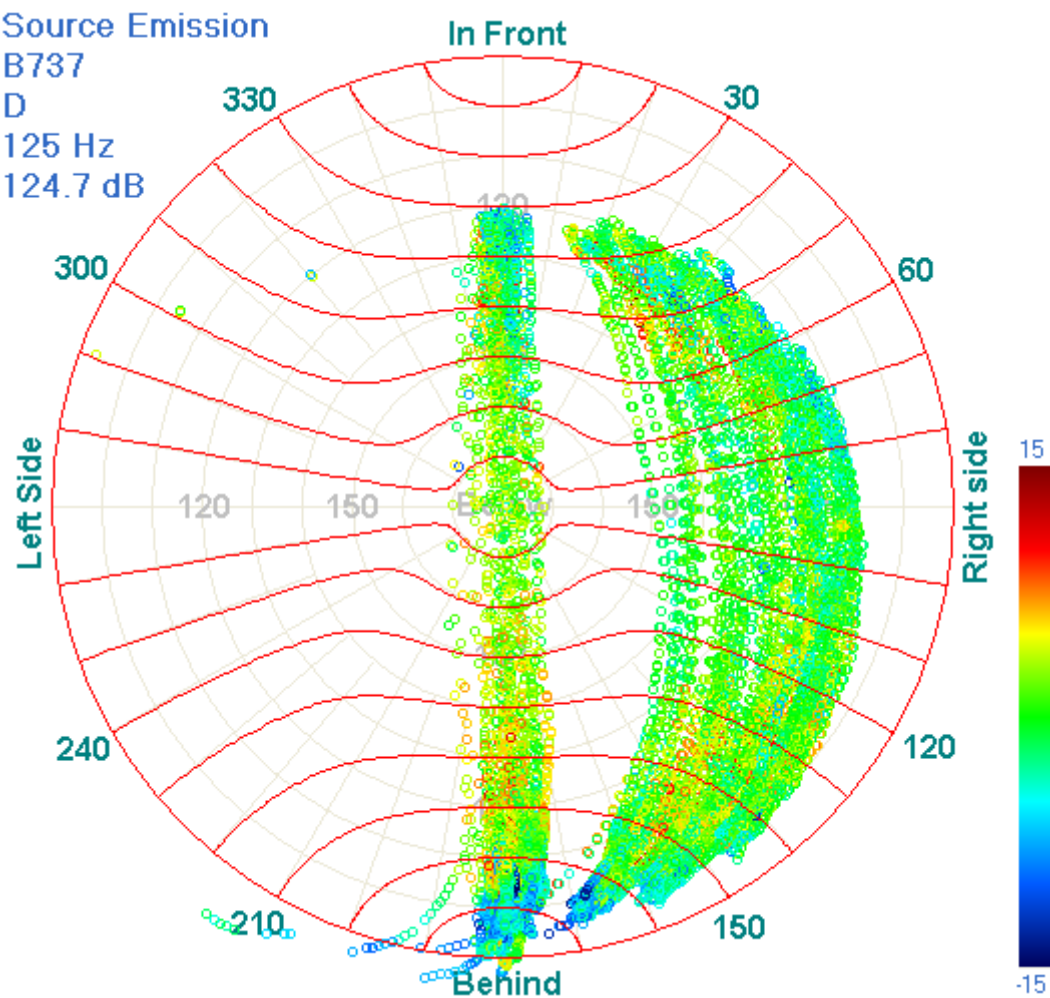
Source Emission

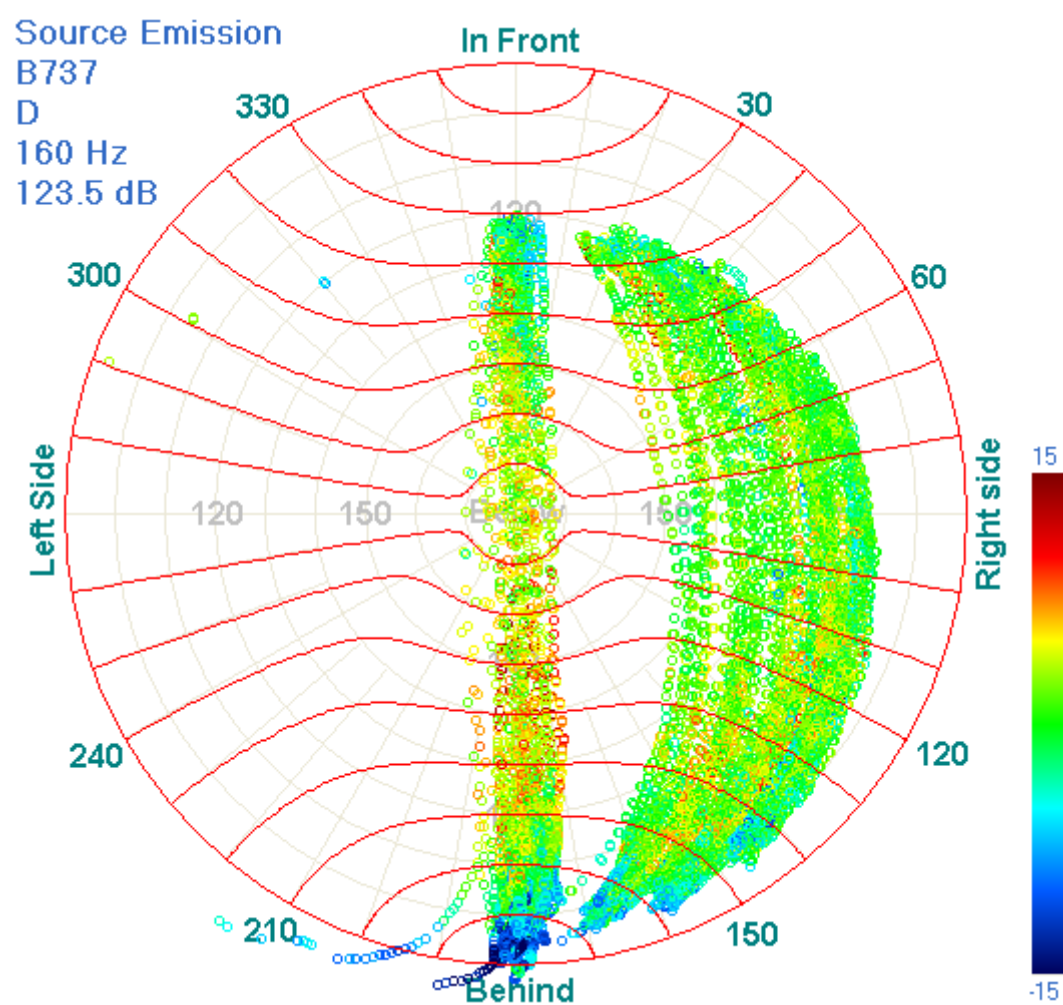
B737

D

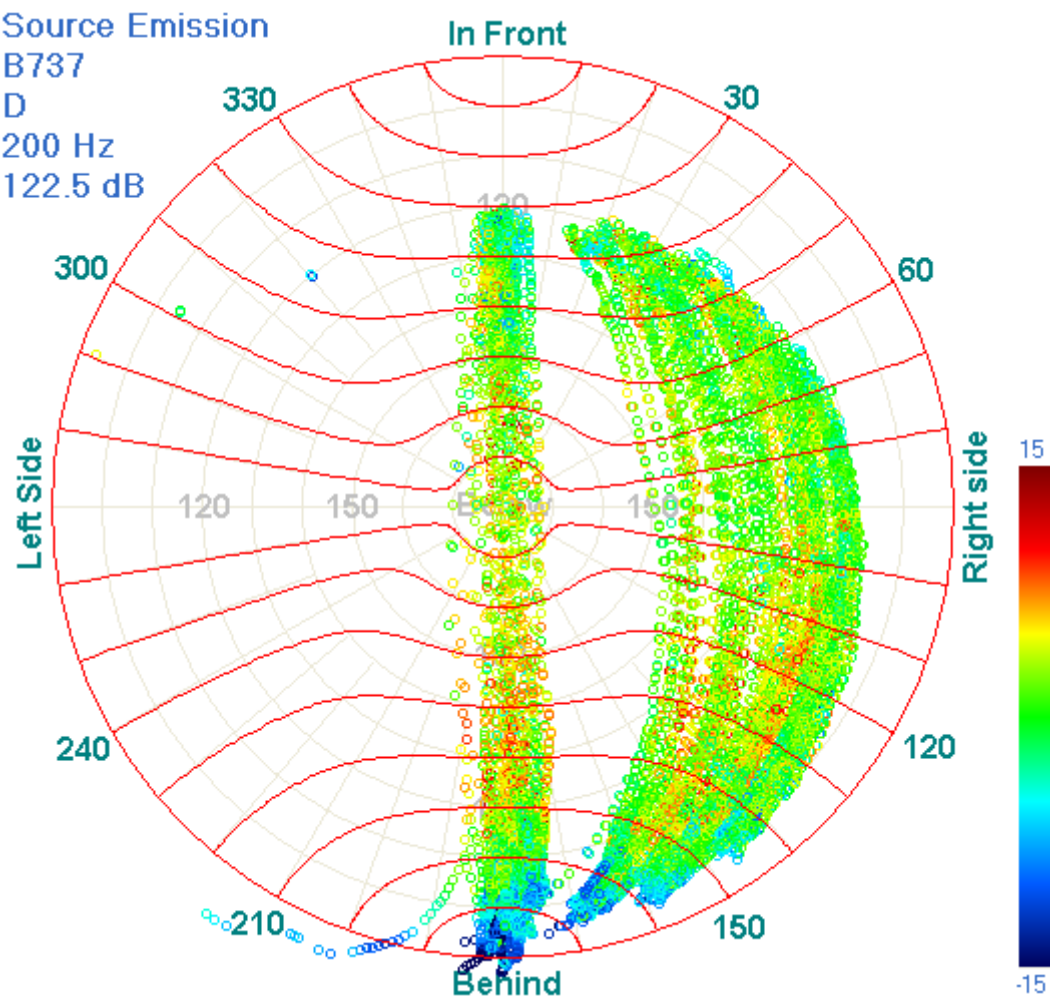
125 Hz

124.7 dB



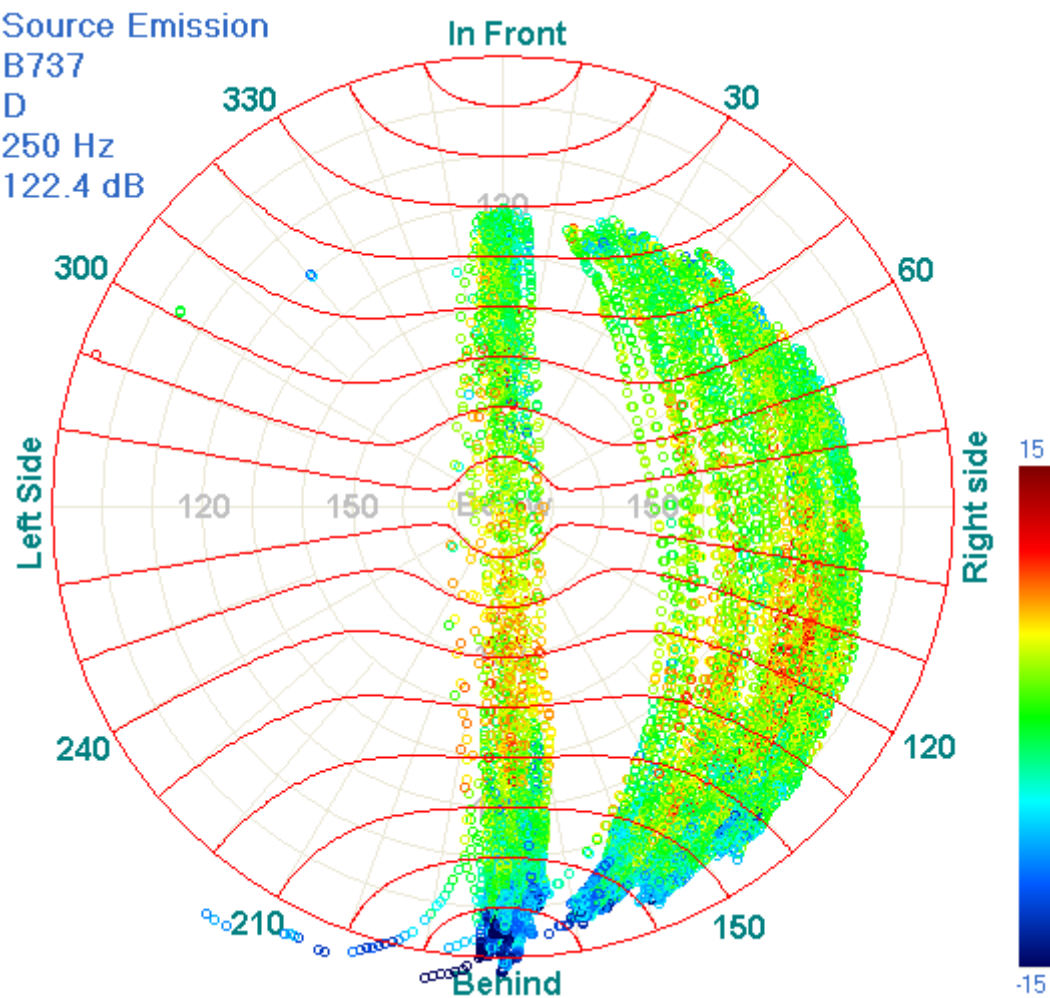


Source Emission  
B737  
D  
200 Hz  
122.5 dB



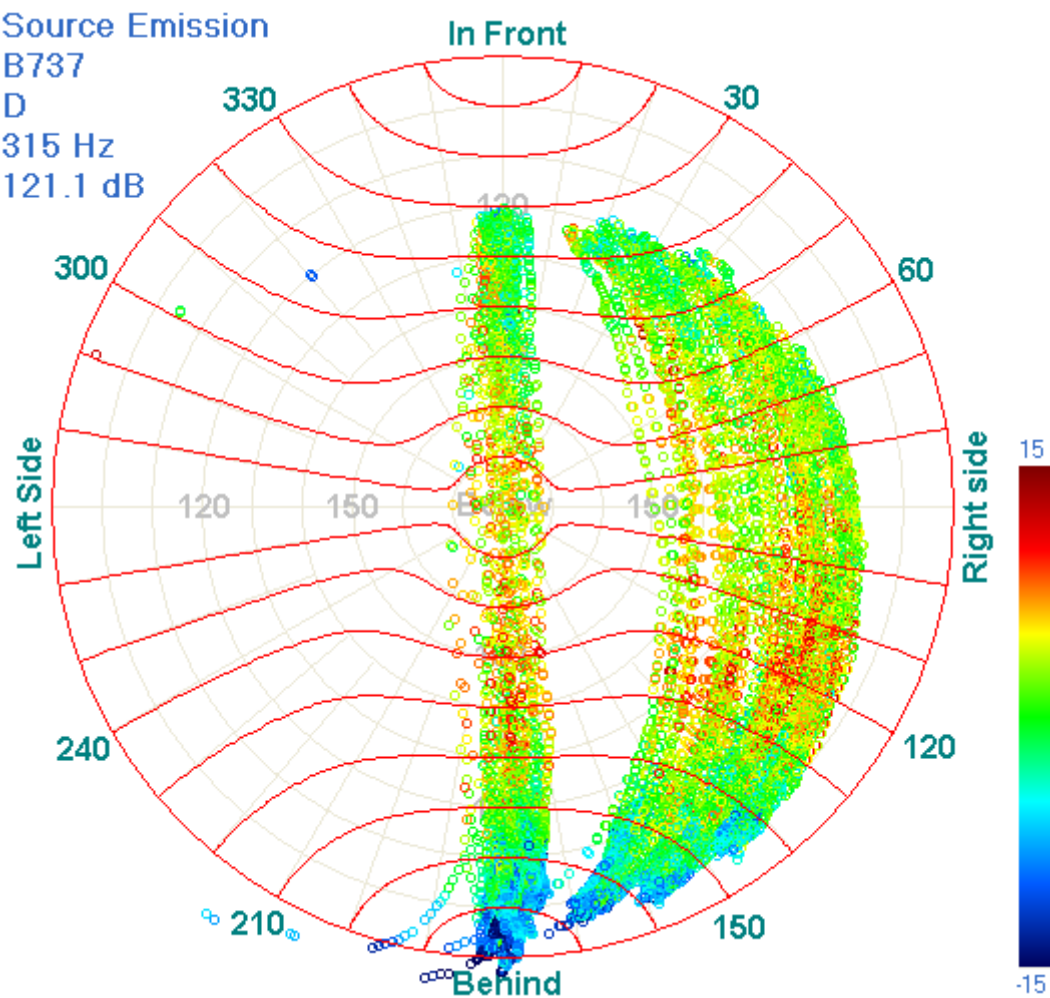


Source Emission  
B737  
D  
250 Hz  
122.4 dB





Source Emission  
B737  
D  
315 Hz  
121.1 dB



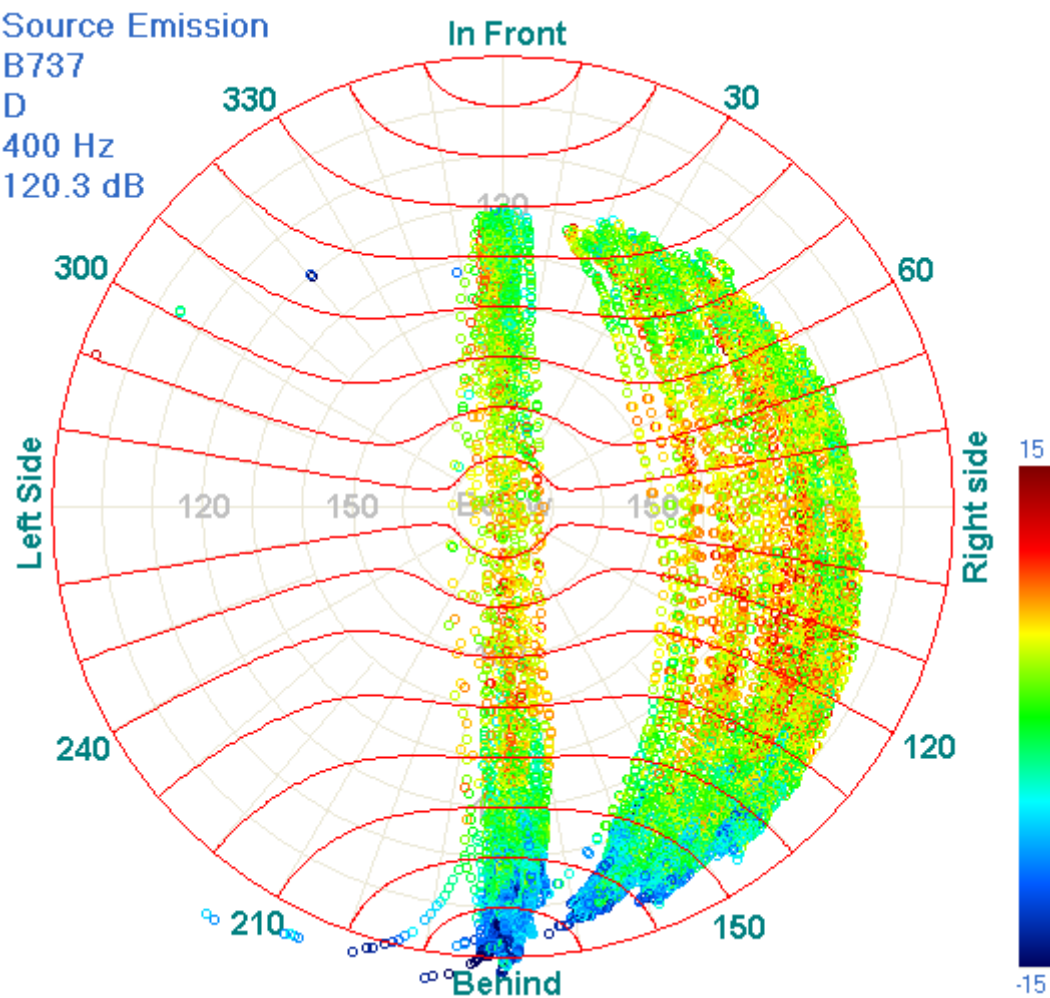
Source Emission

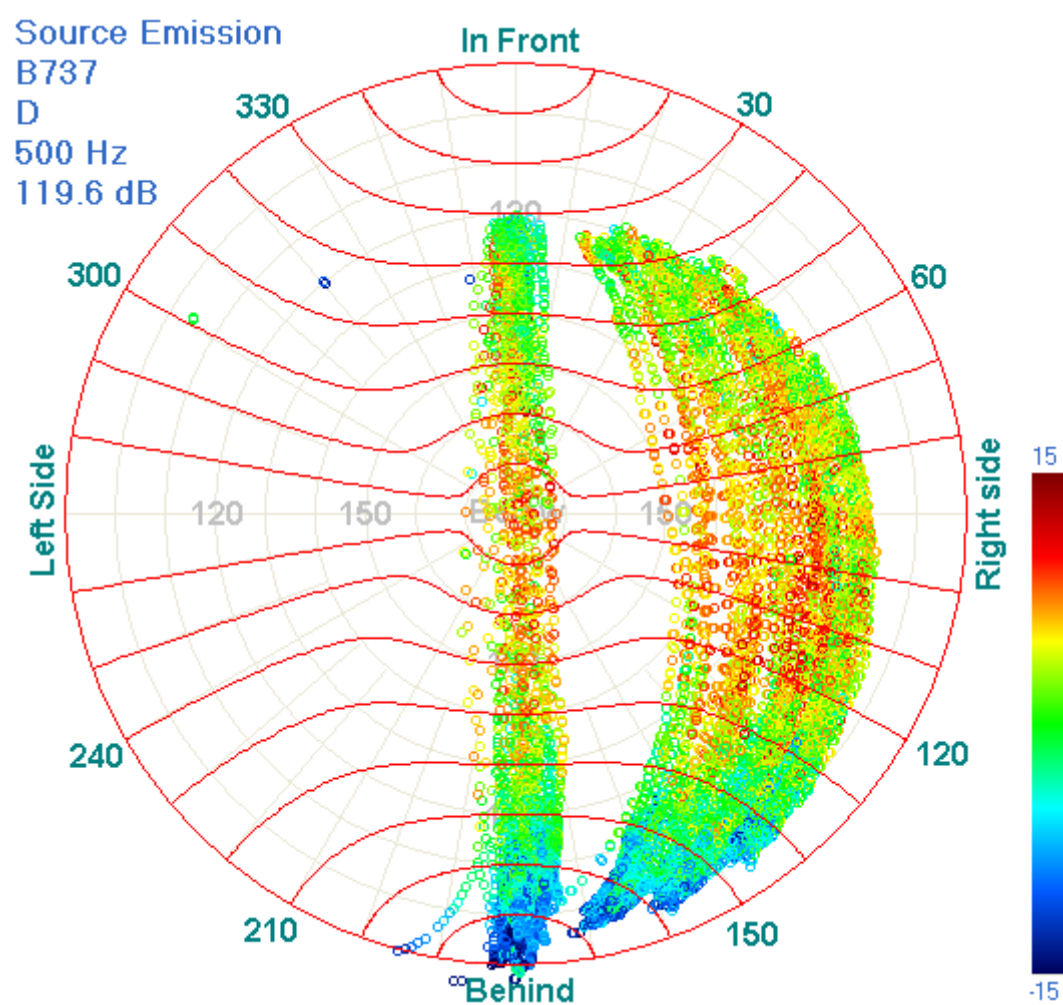
B737

D

400 Hz

120.3 dB





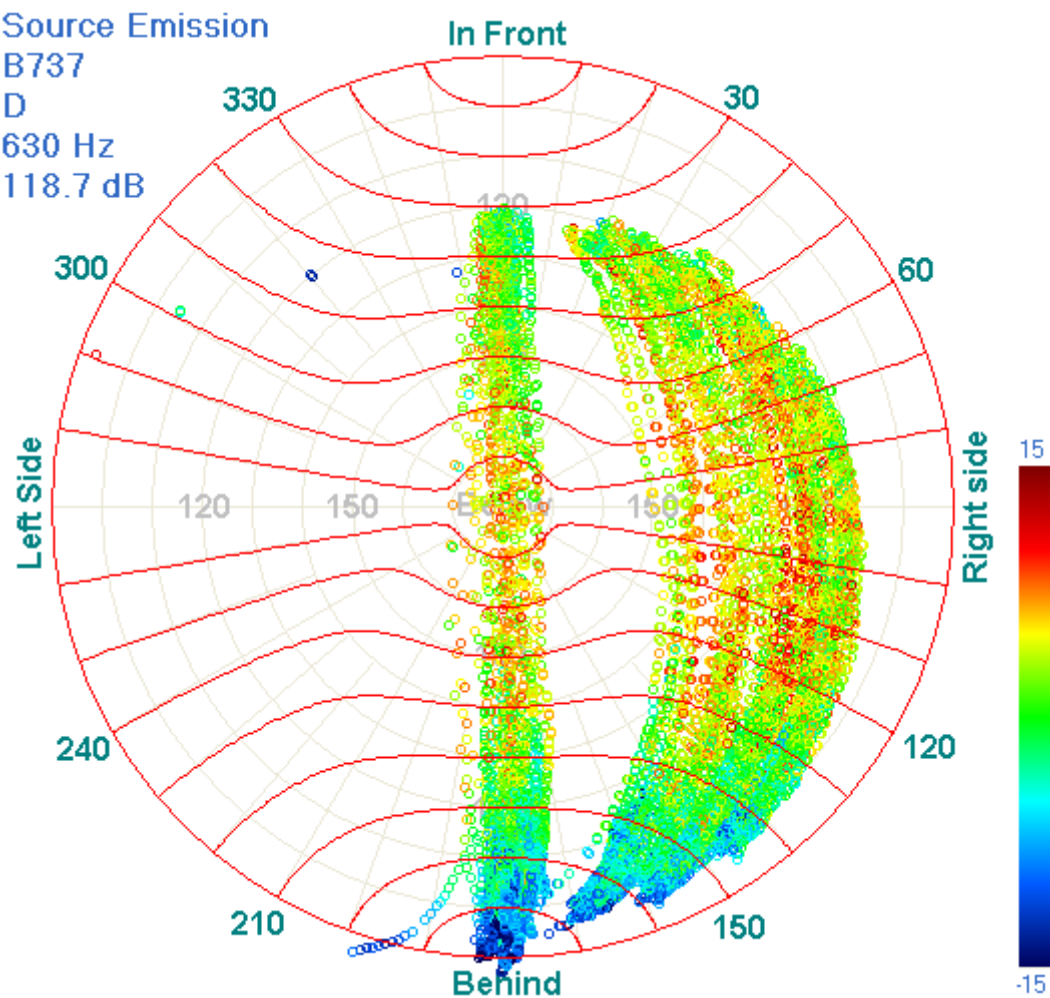
Source Emission

B737

D

630 Hz

118.7 dB



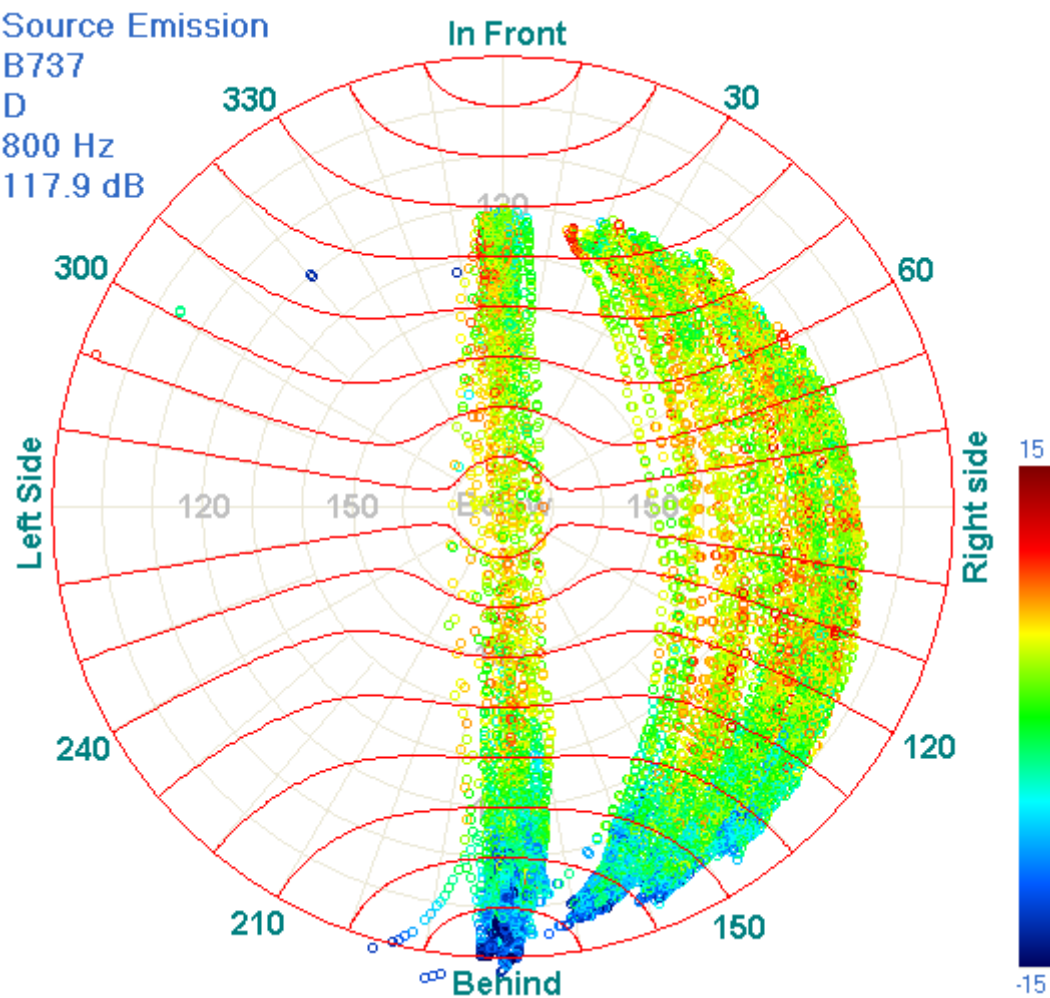
Source Emission

B737

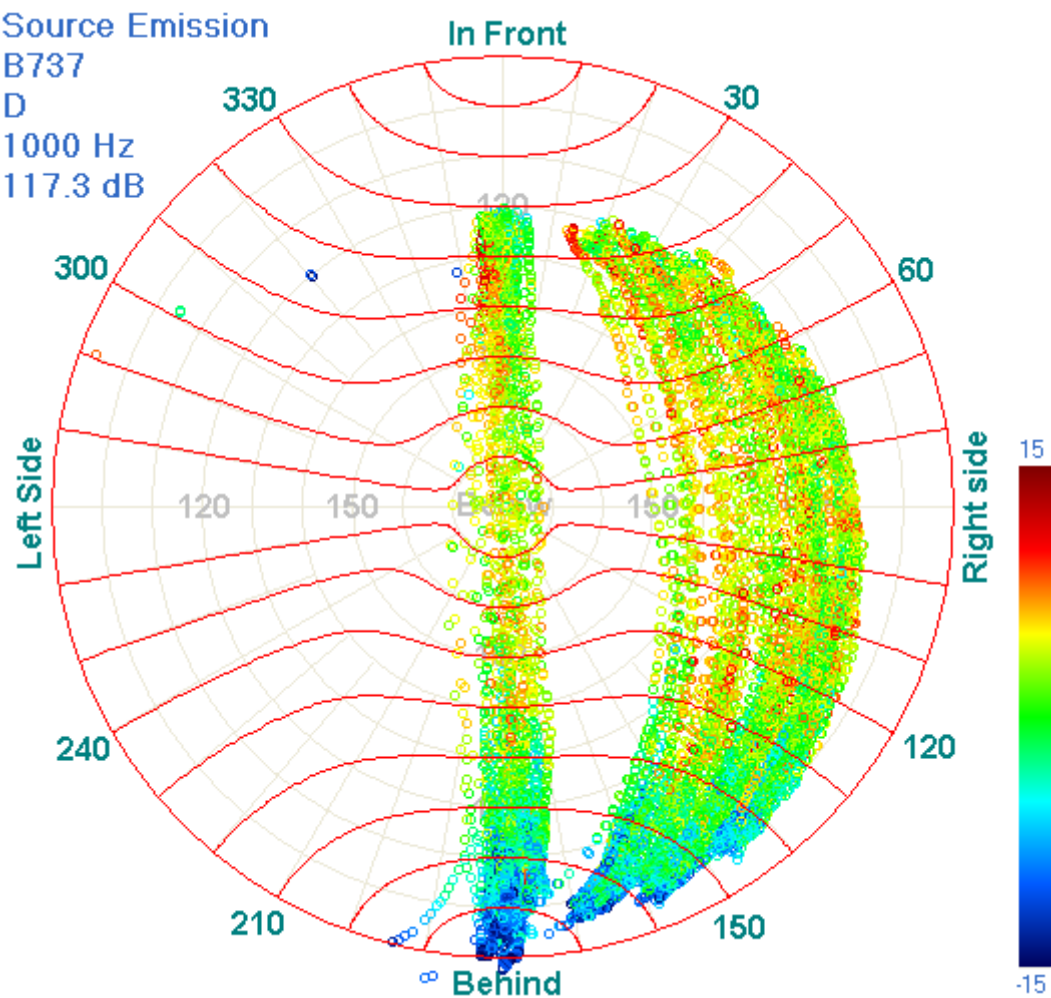
D

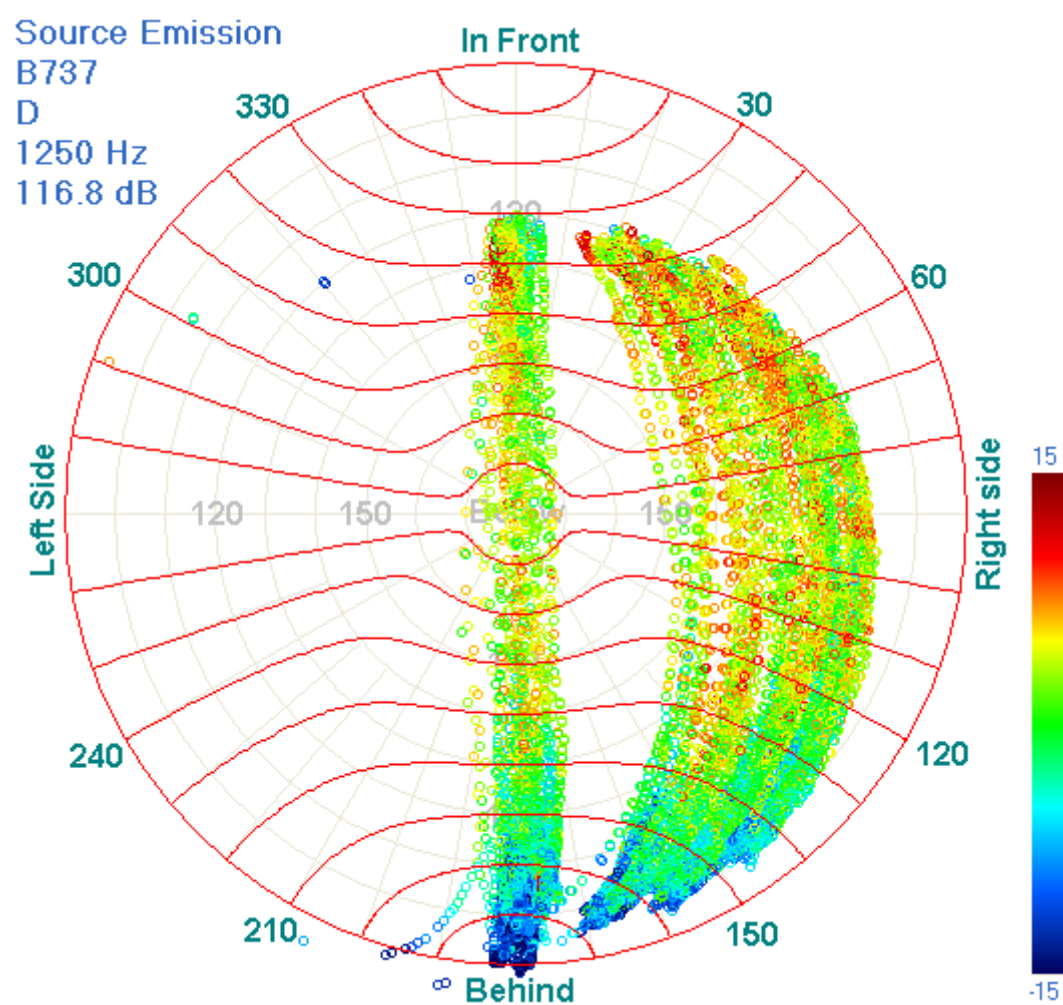
800 Hz

117.9 dB

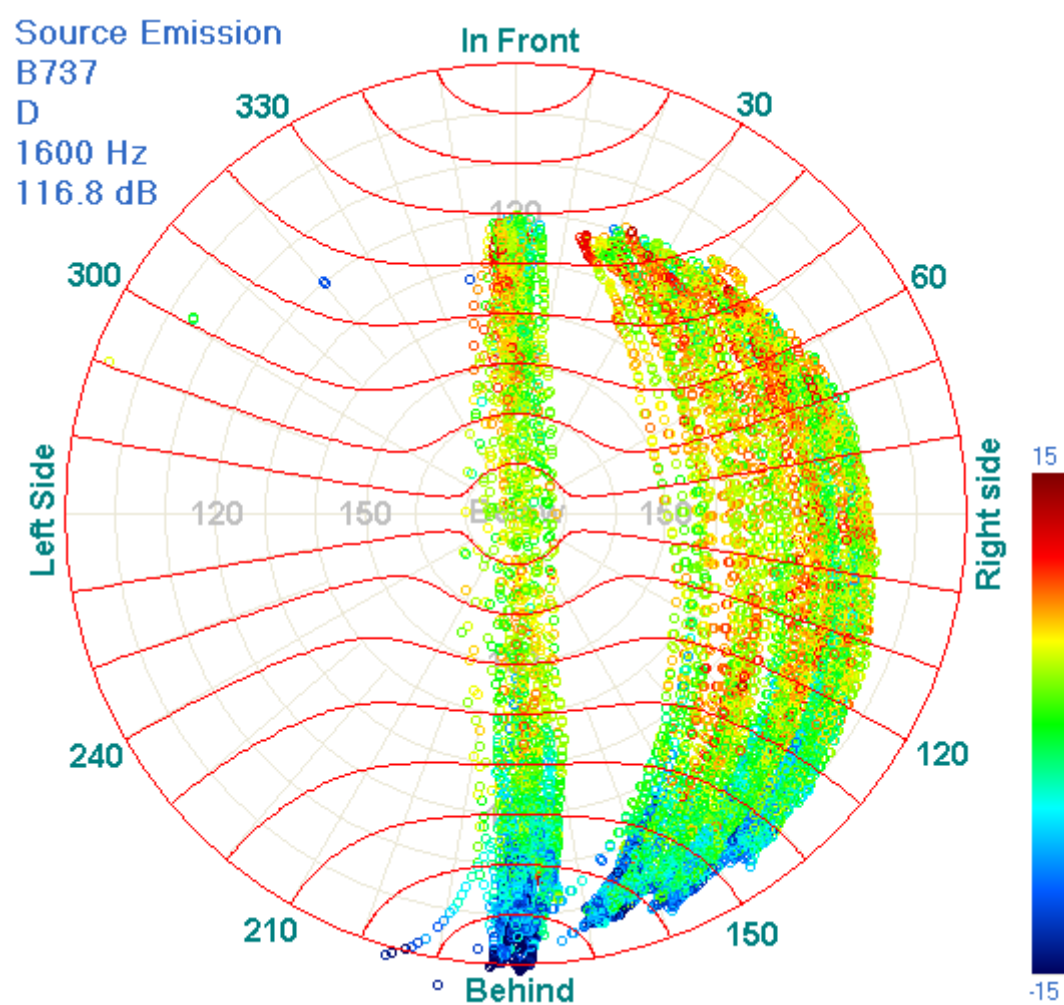


Source Emission  
B737  
D  
1000 Hz  
117.3 dB











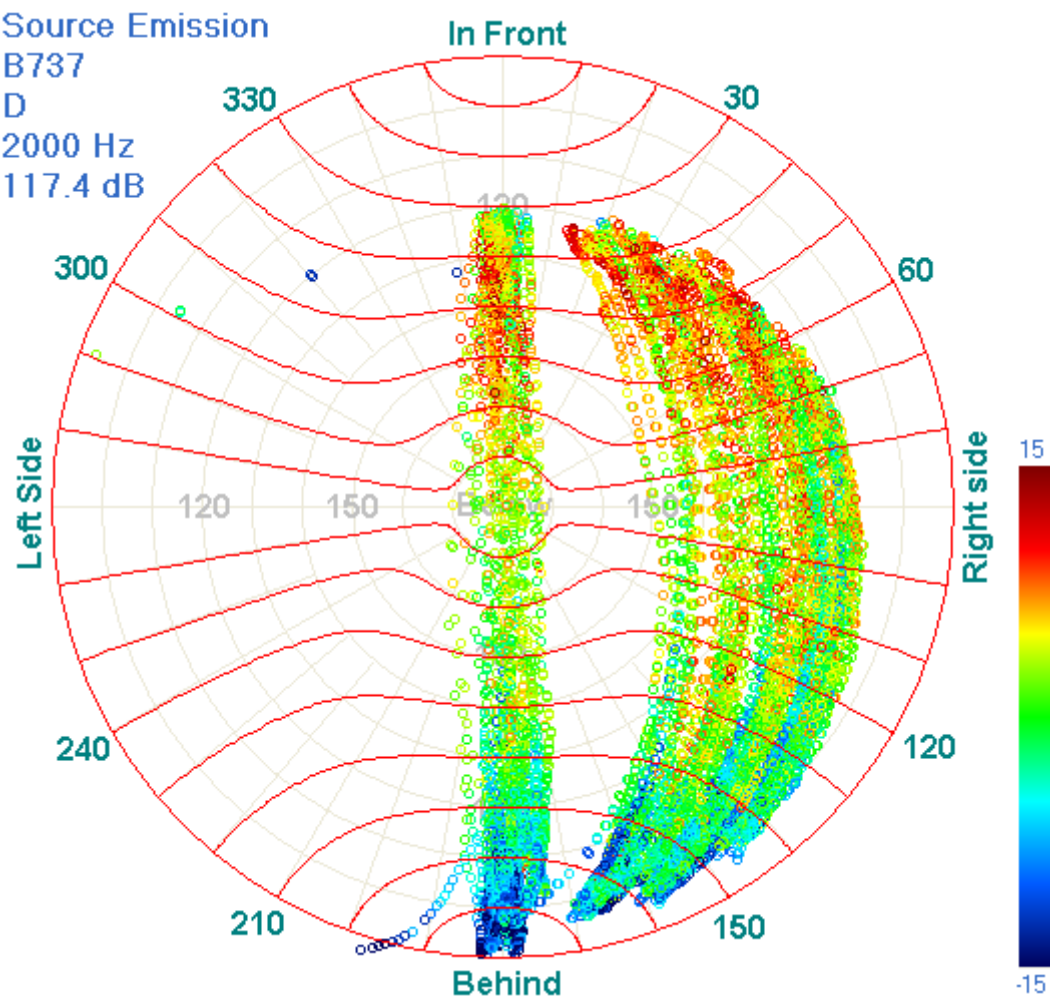
Source Emission

B737

D

2000 Hz

117.4 dB



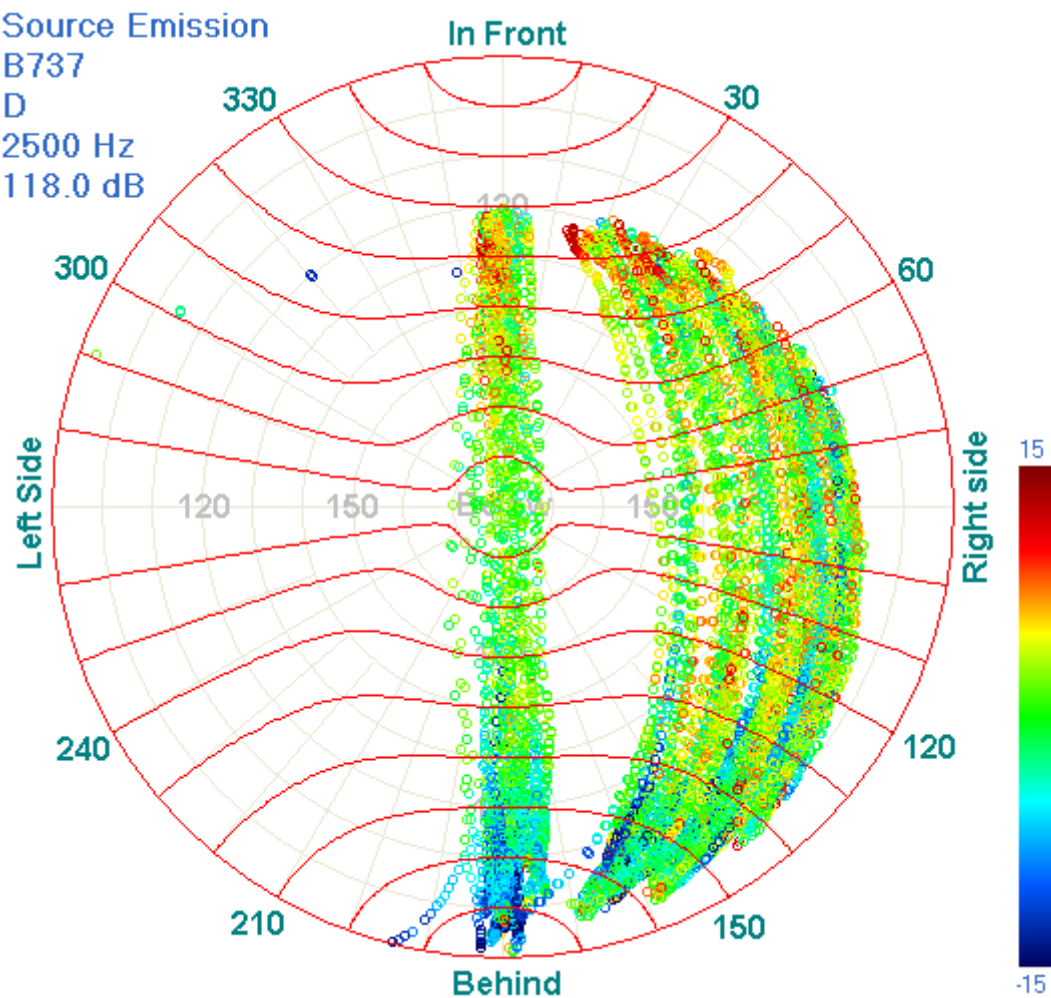
Source Emission

B737

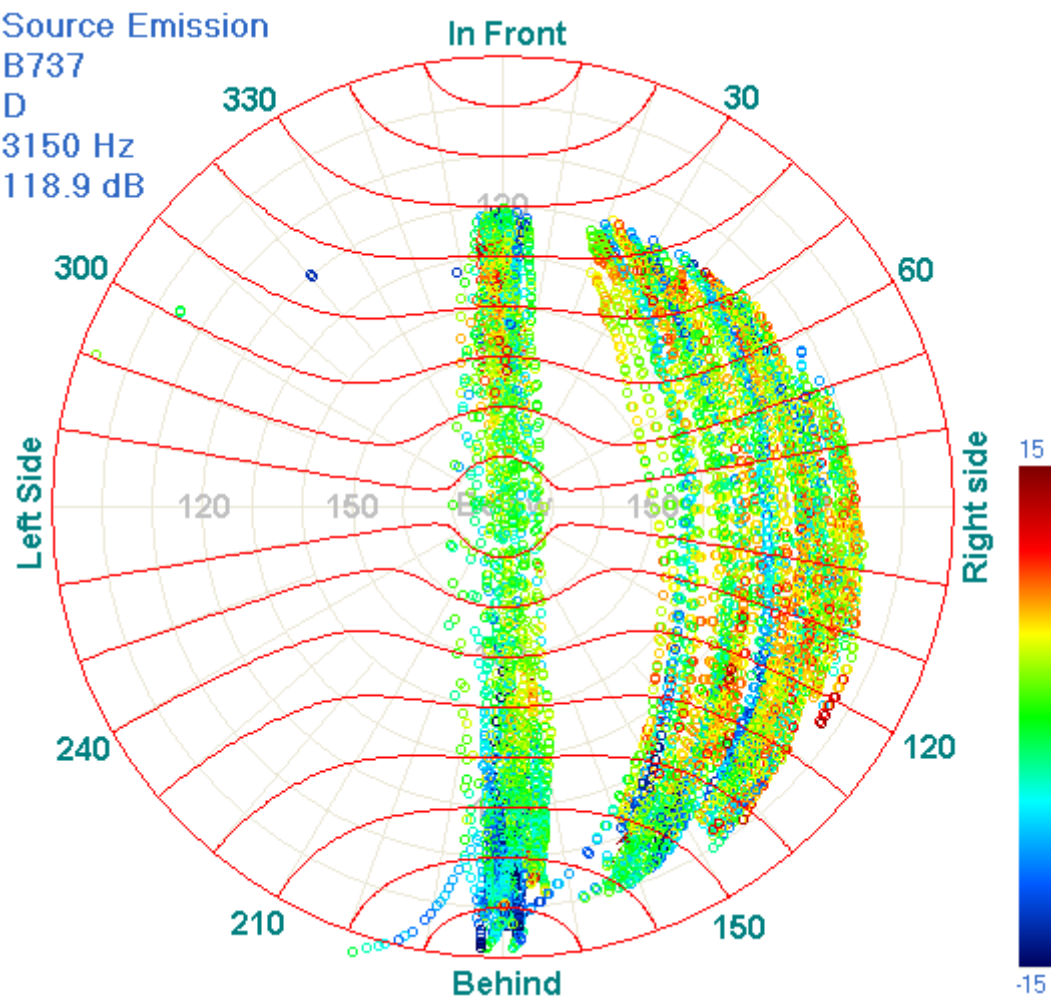
D

2500 Hz

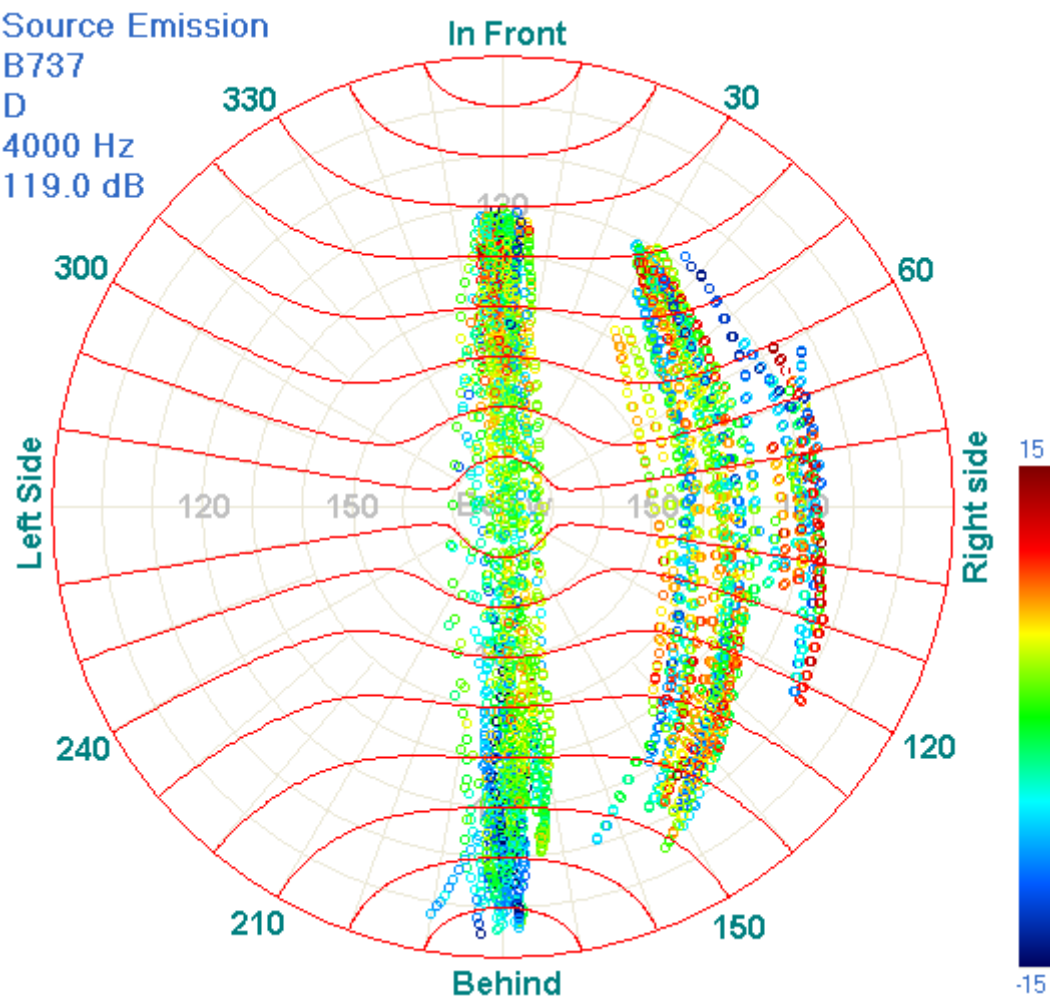
118.0 dB



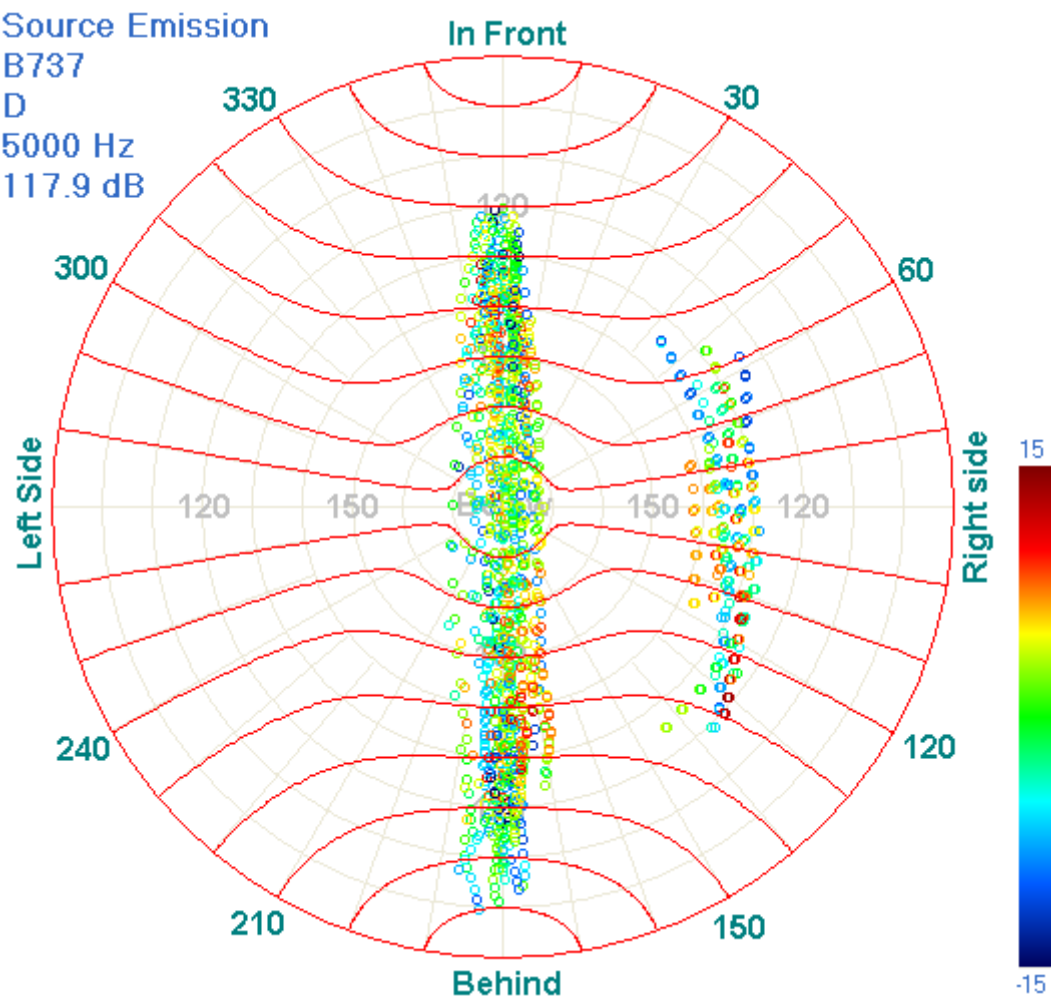
Source Emission  
B737  
D  
3150 Hz  
118.9 dB



Source Emission  
B737  
D  
4000 Hz  
119.0 dB



Source Emission  
B737  
D  
5000 Hz  
117.9 dB



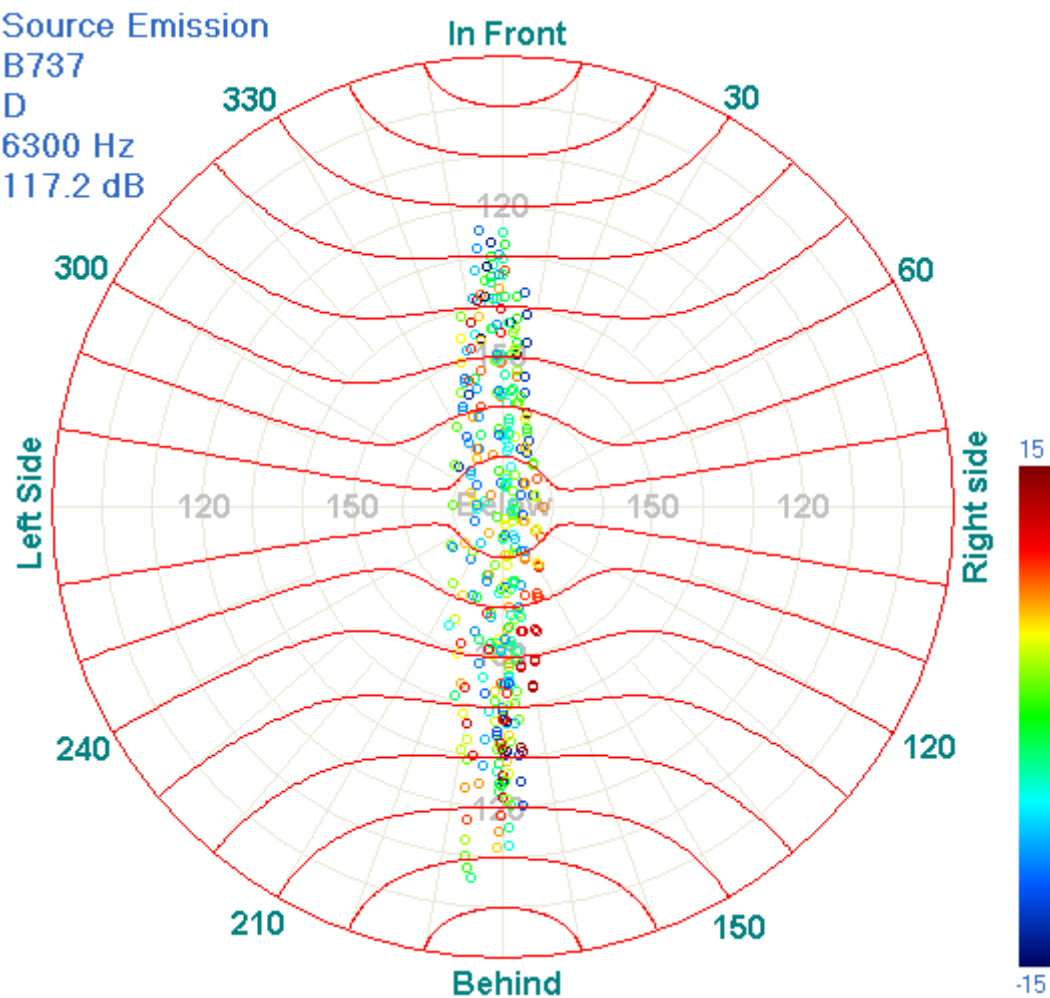
Source Emission

B737

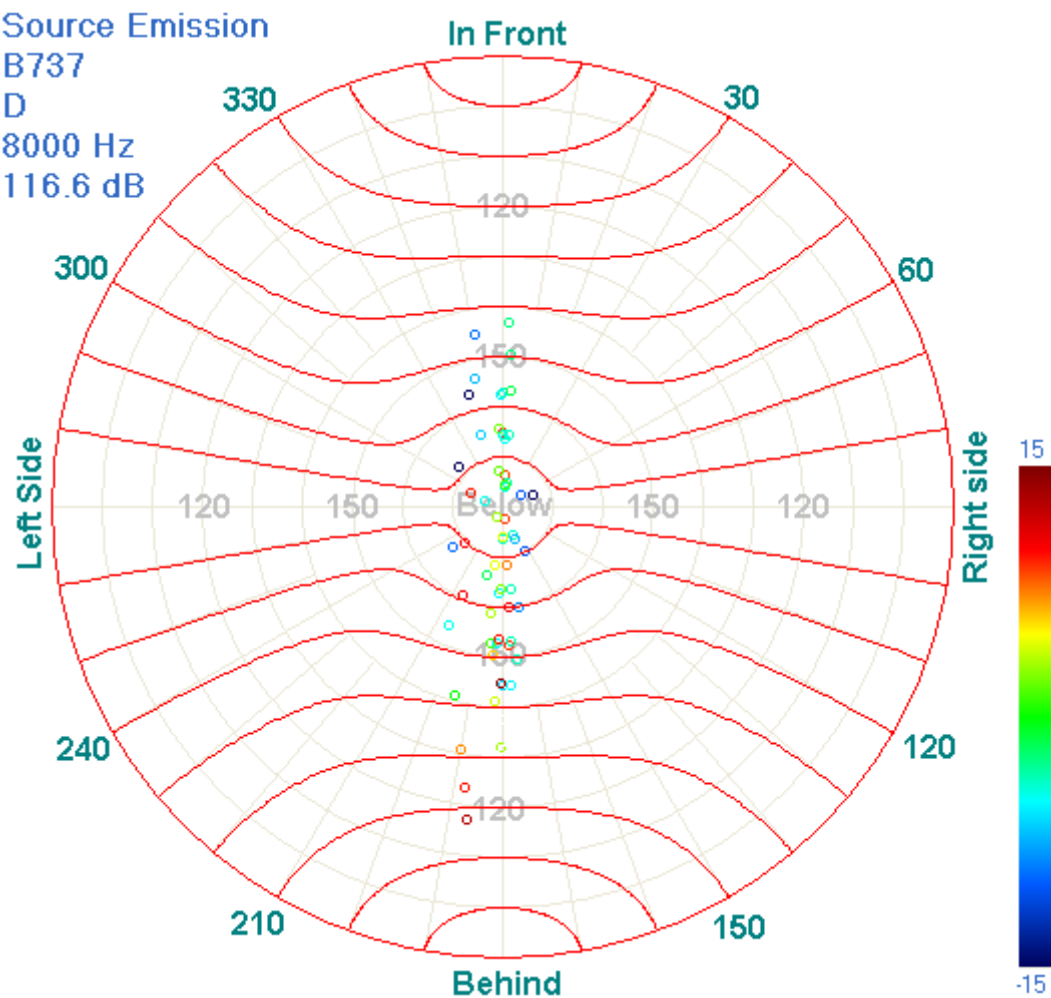
D

6300 Hz

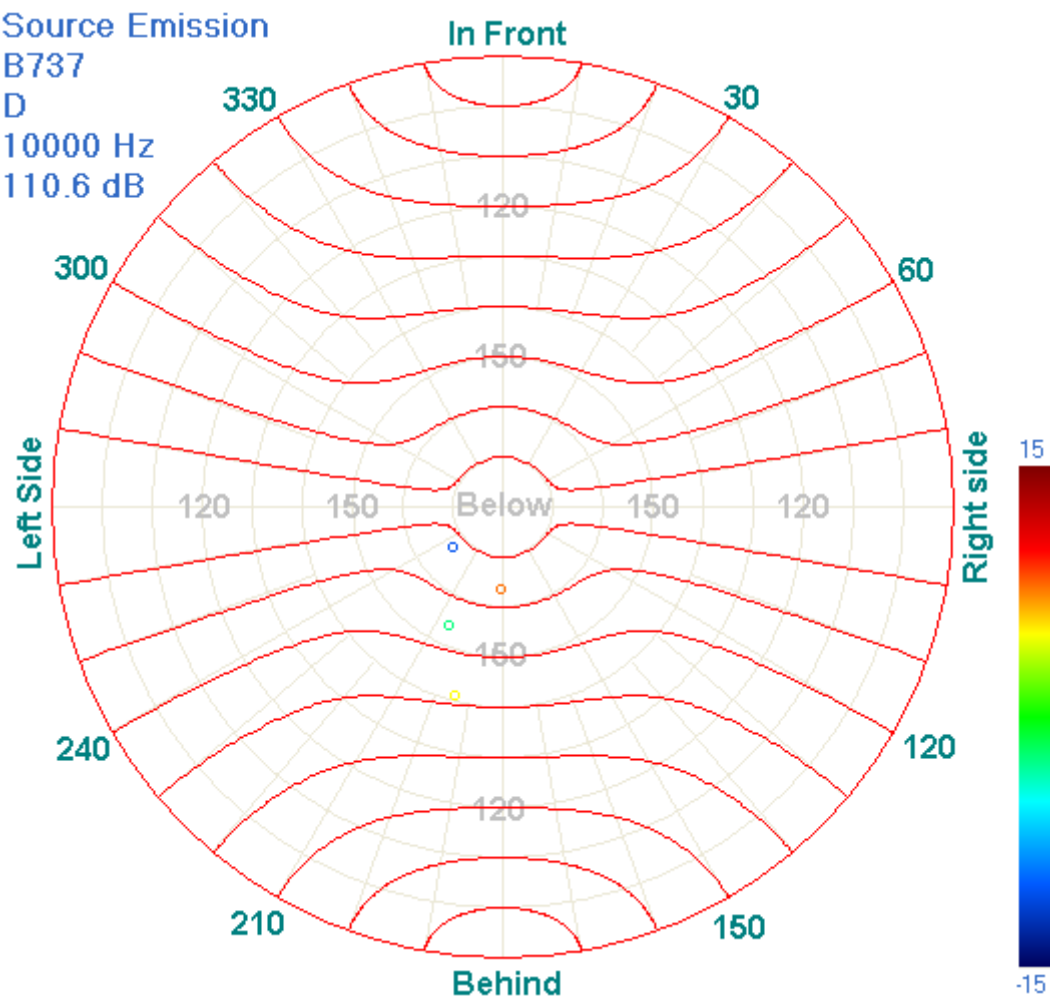
117.2 dB



Source Emission  
B737  
D  
8000 Hz  
116.6 dB



Source Emission  
B737  
D  
10000 Hz  
110.6 dB

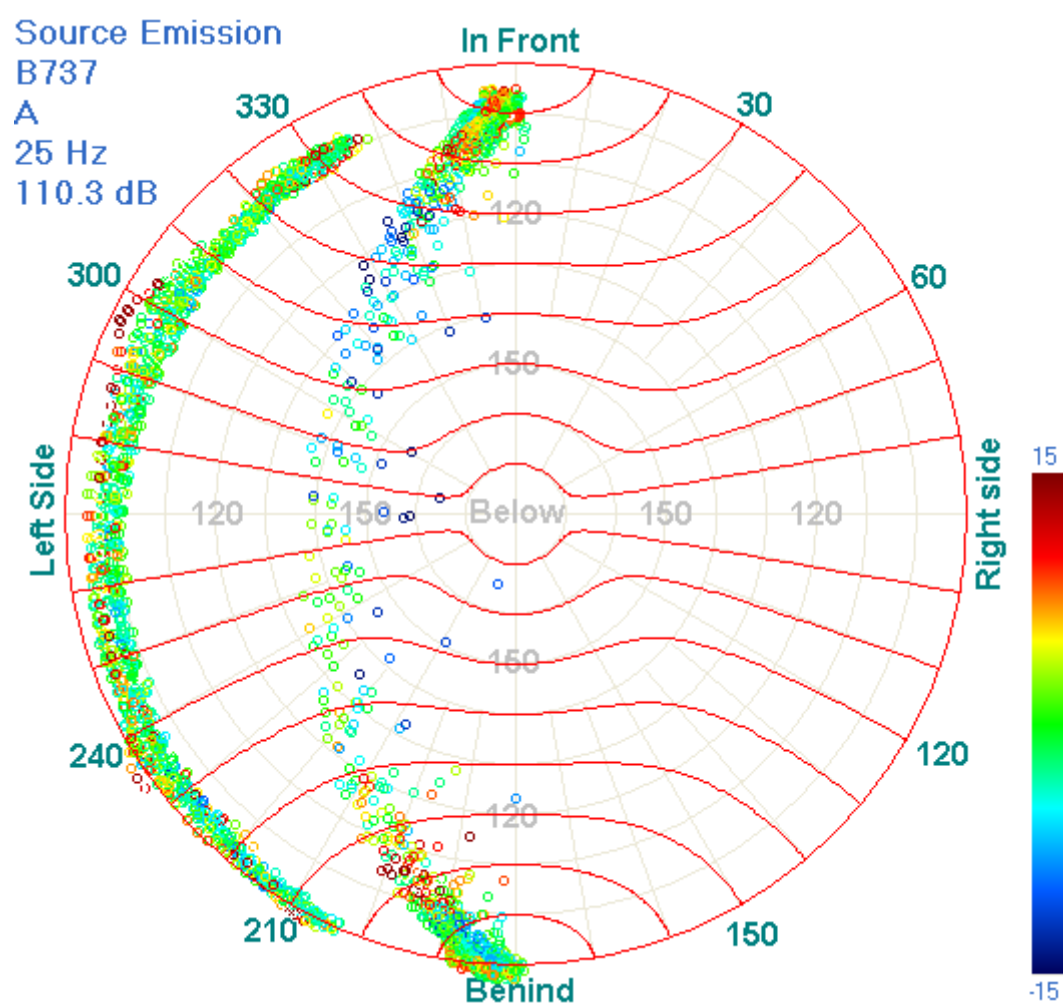


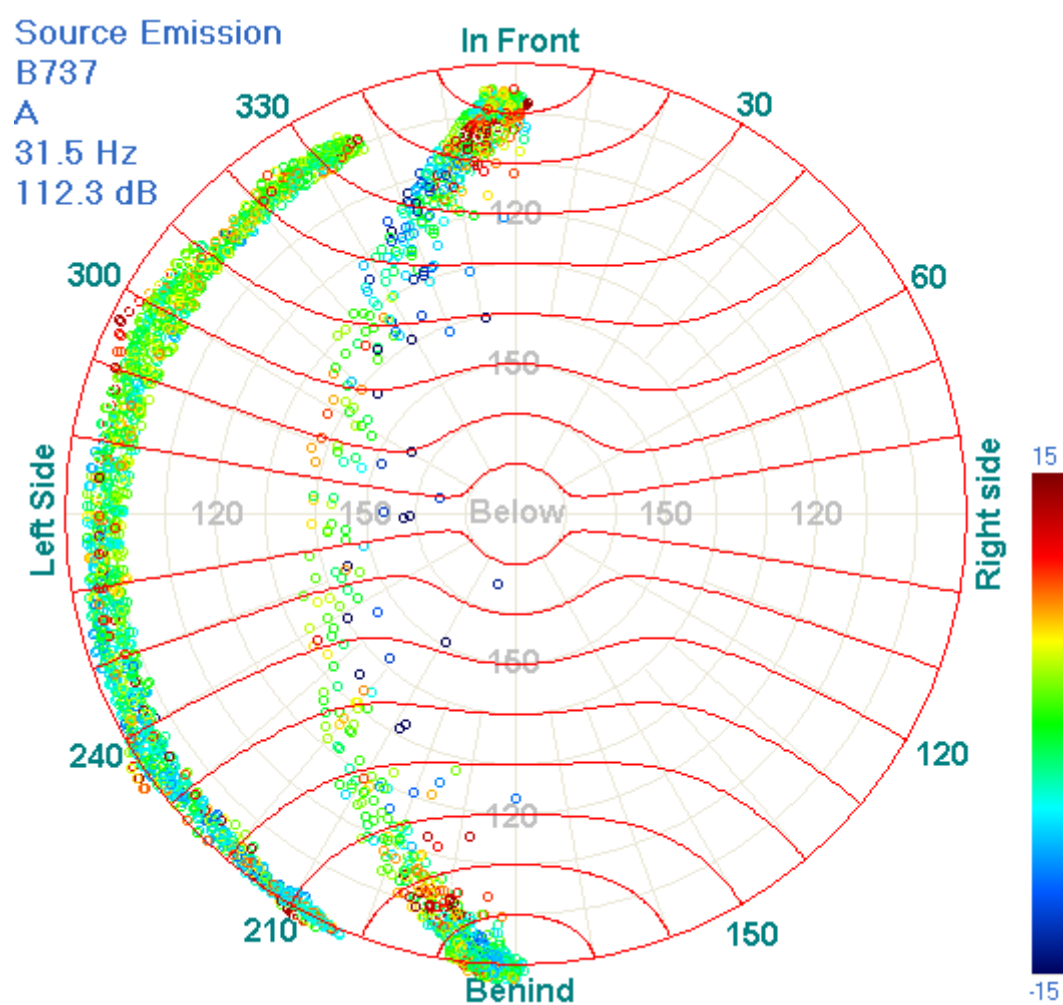


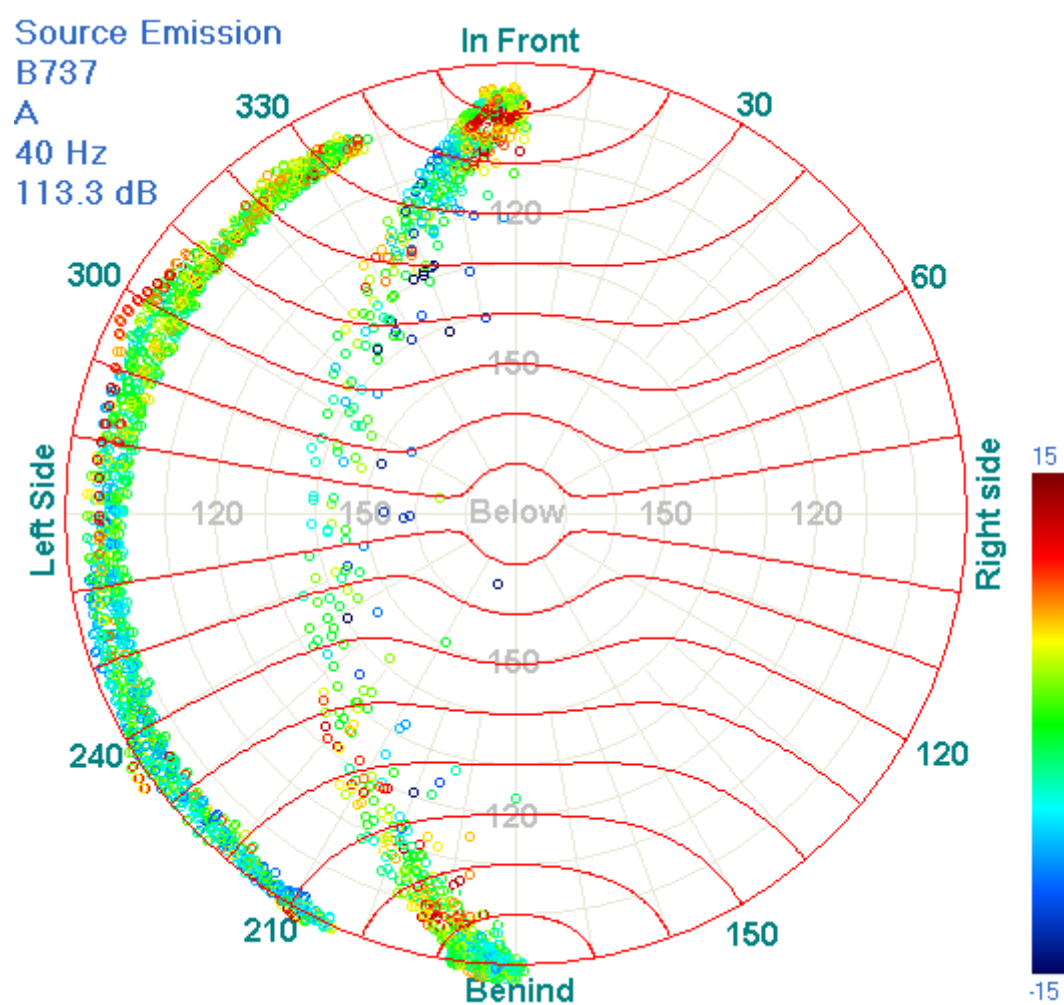
## 11 B737 700 directivity at arrival

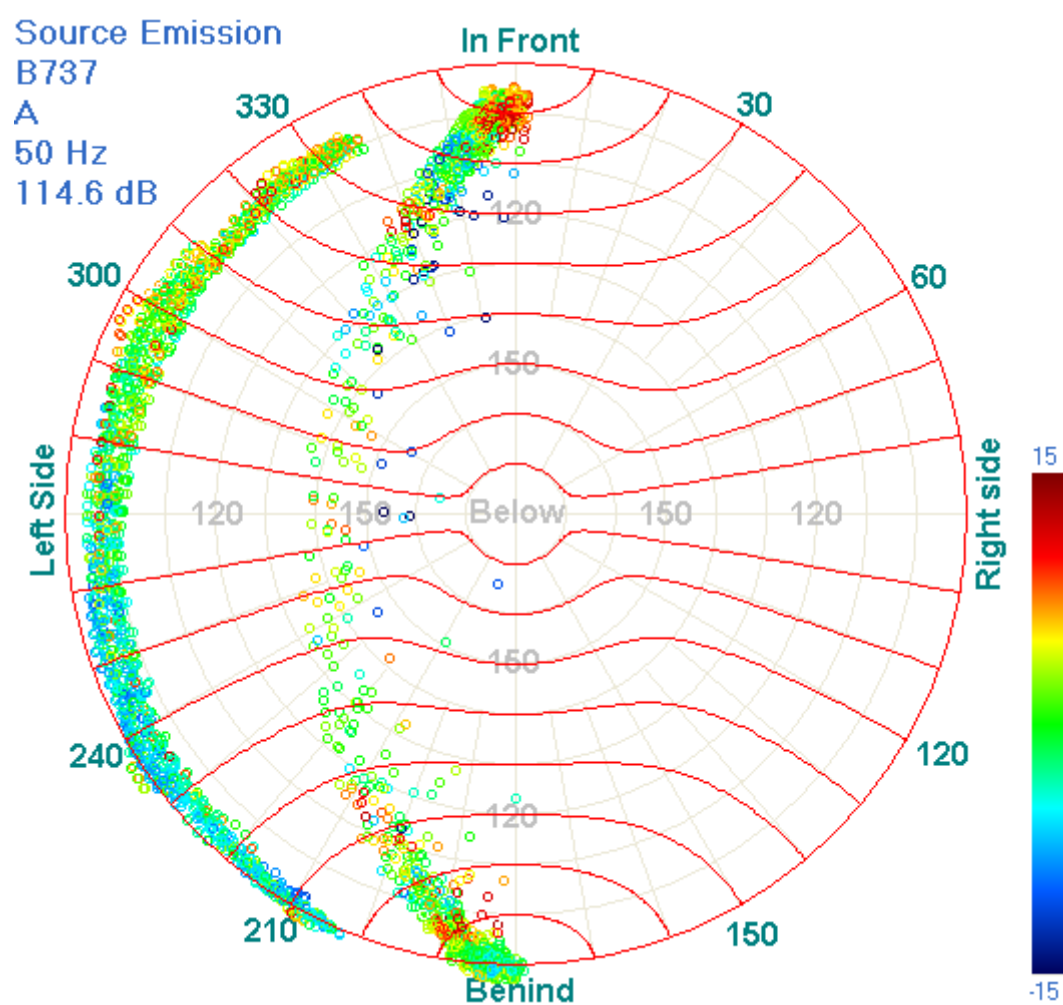
SPECTRUM  
Source Emission  
B737  
A

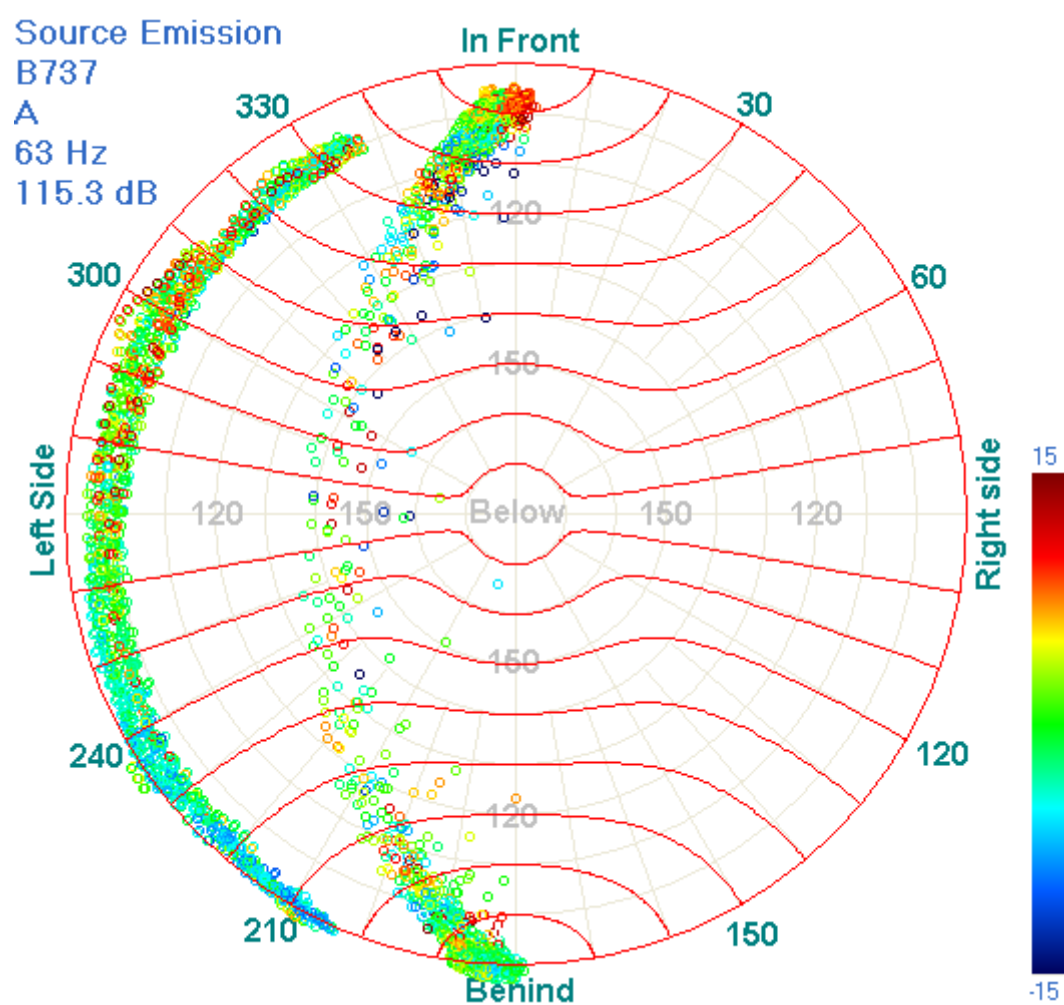
Freq	Num	Avg	Std	95%Avg	P1	P2	P3	P4	P5	P6
25	2869	110.3	5.6	0.2	109.8	111.2	-1.0	-1.0	-1.0	-1.0
31.5	3168	112.3	5.5	0.2	111.5	113.4	-1.0	-1.0	-1.0	-1.0
40	3139	113.3	5.2	0.2	112.6	114.2	-1.0	-1.0	-1.0	-1.0
50	3214	114.6	5.1	0.2	113.8	115.7	-1.0	-1.0	-1.0	-1.0
63	3203	115.3	5.4	0.2	114.3	116.5	-1.0	-1.0	-1.0	-1.0
80	3548	115.3	5.5	0.2	114.5	116.4	-1.0	-1.0	-1.0	-1.0
100	3747	114.8	5.1	0.2	113.9	116.0	-1.0	-1.0	-1.0	-1.0
125	3783	113.9	4.5	0.1	113.1	115.0	-1.0	-1.0	-1.0	-1.0
160	3835	113.2	4.0	0.1	112.5	114.1	-1.0	-1.0	-1.0	-1.0
200	3800	113.0	4.2	0.1	112.4	113.8	-1.0	-1.0	-1.0	-1.0
250	3878	112.7	4.3	0.1	112.0	113.5	-1.0	-1.0	-1.0	-1.0
315	3887	112.4	4.1	0.1	111.9	113.2	-1.0	-1.0	-1.0	-1.0
400	3885	112.8	4.1	0.1	112.4	113.2	-1.0	-1.0	-1.0	-1.0
500	3843	113.3	4.5	0.1	113.1	113.5	-1.0	-1.0	-1.0	-1.0
630	3910	113.2	4.4	0.1	113.1	113.3	-1.0	-1.0	-1.0	-1.0
800	3939	113.2	4.3	0.1	113.0	113.4	-1.0	-1.0	-1.0	-1.0
1000	3835	112.6	4.3	0.1	112.3	113.1	-1.0	-1.0	-1.0	-1.0
1250	3807	111.7	4.5	0.1	111.2	112.2	-1.0	-1.0	-1.0	-1.0
1600	3901	110.5	4.6	0.1	109.6	111.7	-1.0	-1.0	-1.0	-1.0
2000	3903	109.8	4.7	0.1	109.0	110.9	-1.0	-1.0	-1.0	-1.0
2500	3854	109.9	5.3	0.2	108.9	111.2	-1.0	-1.0	-1.0	-1.0
3150	3728	110.5	5.3	0.2	109.1	112.2	-1.0	-1.0	-1.0	-1.0
4000	3212	112.1	5.4	0.2	110.8	113.7	-1.0	-1.0	-1.0	-1.0
5000	1956	113.0	5.5	0.2	111.9	114.1	-1.0	-1.0	-1.0	-1.0
6300	1102	115.3	6.9	0.4	114.7	115.9	-1.0	-1.0	-1.0	-1.0
8000	591	115.7	8.1	0.7	114.5	117.2	-1.0	-1.0	-1.0	-1.0
10000	370	113.1	10.0	1.0	111.6	115.1	-1.0	-1.0	-1.0	-1.0

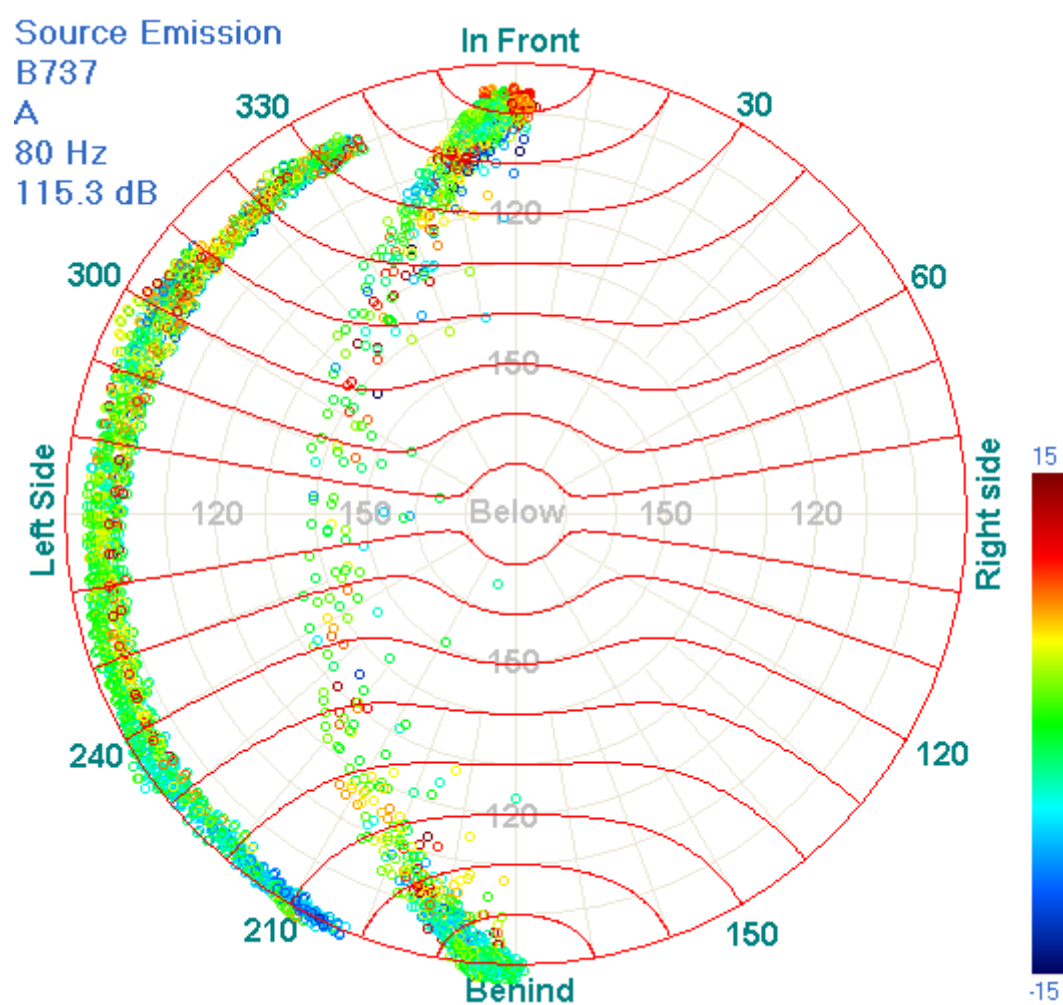


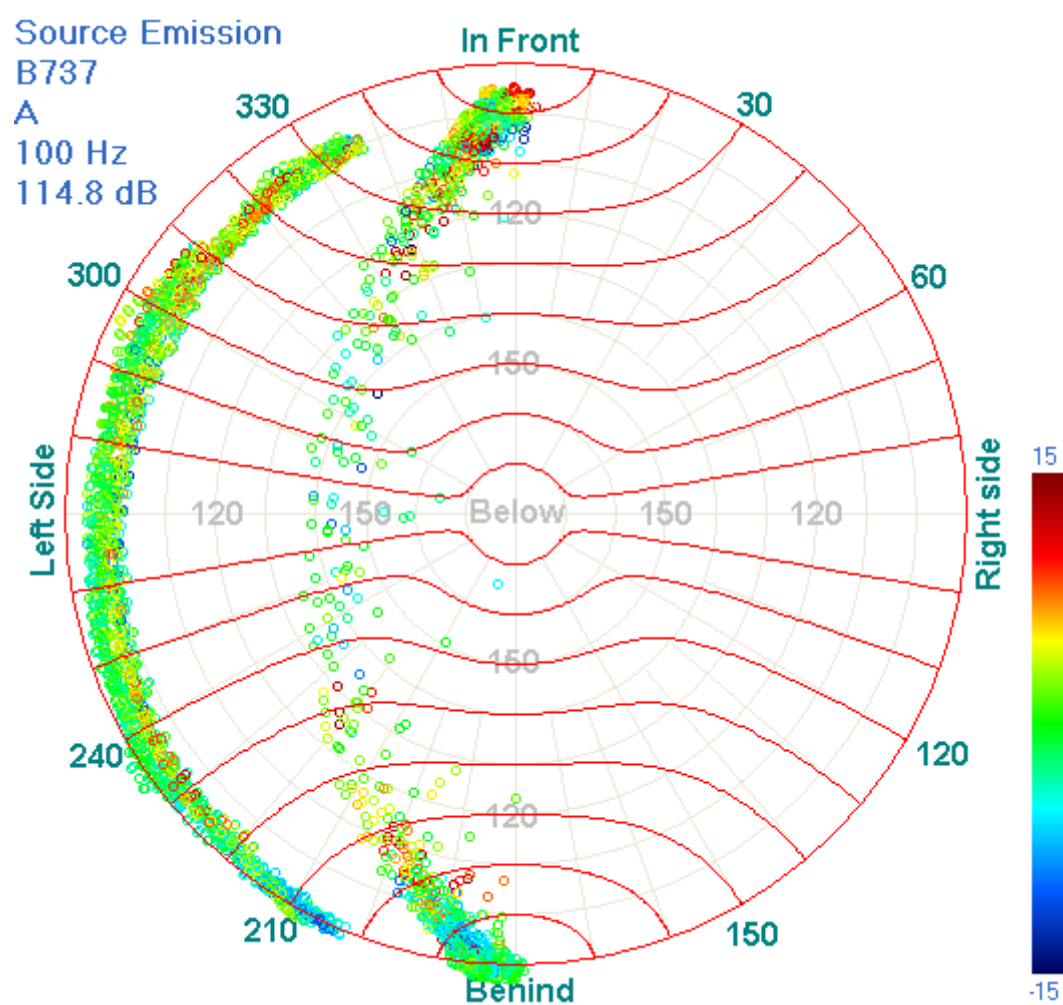




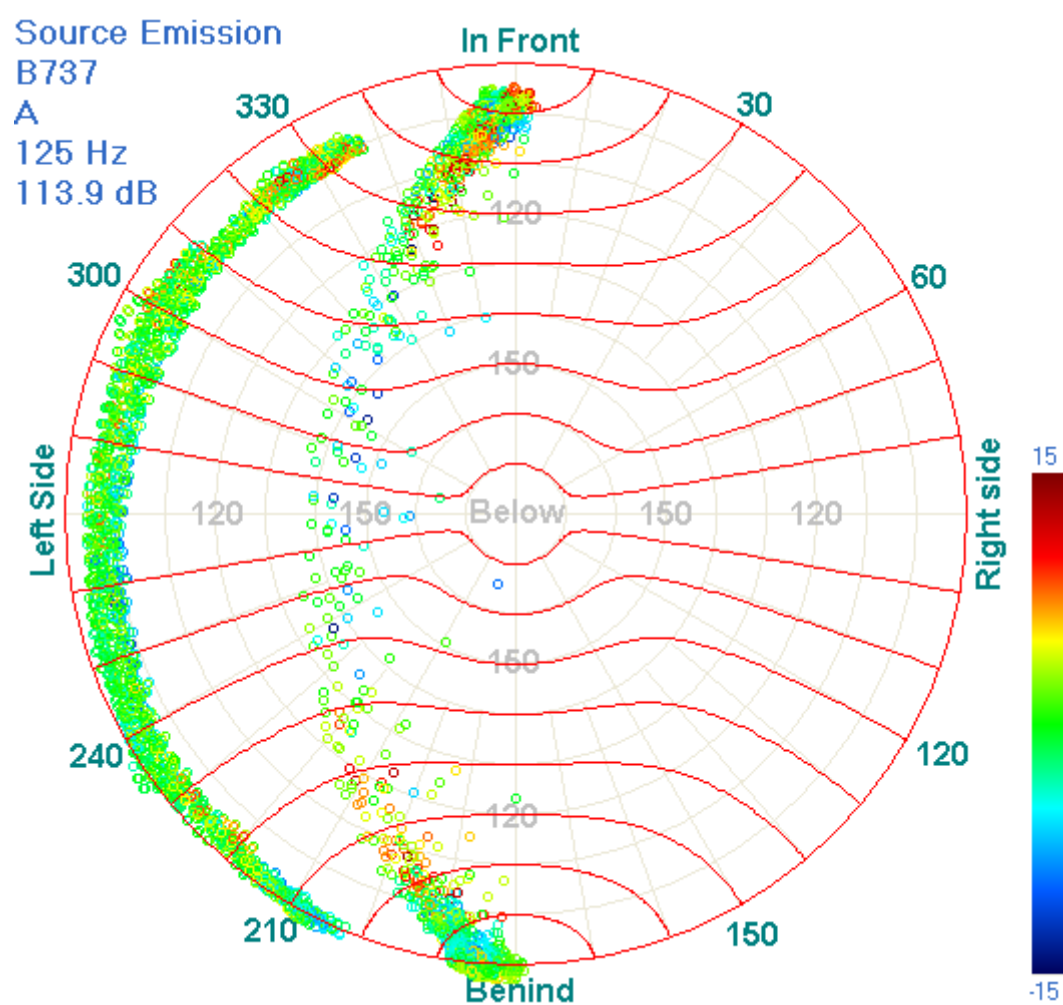


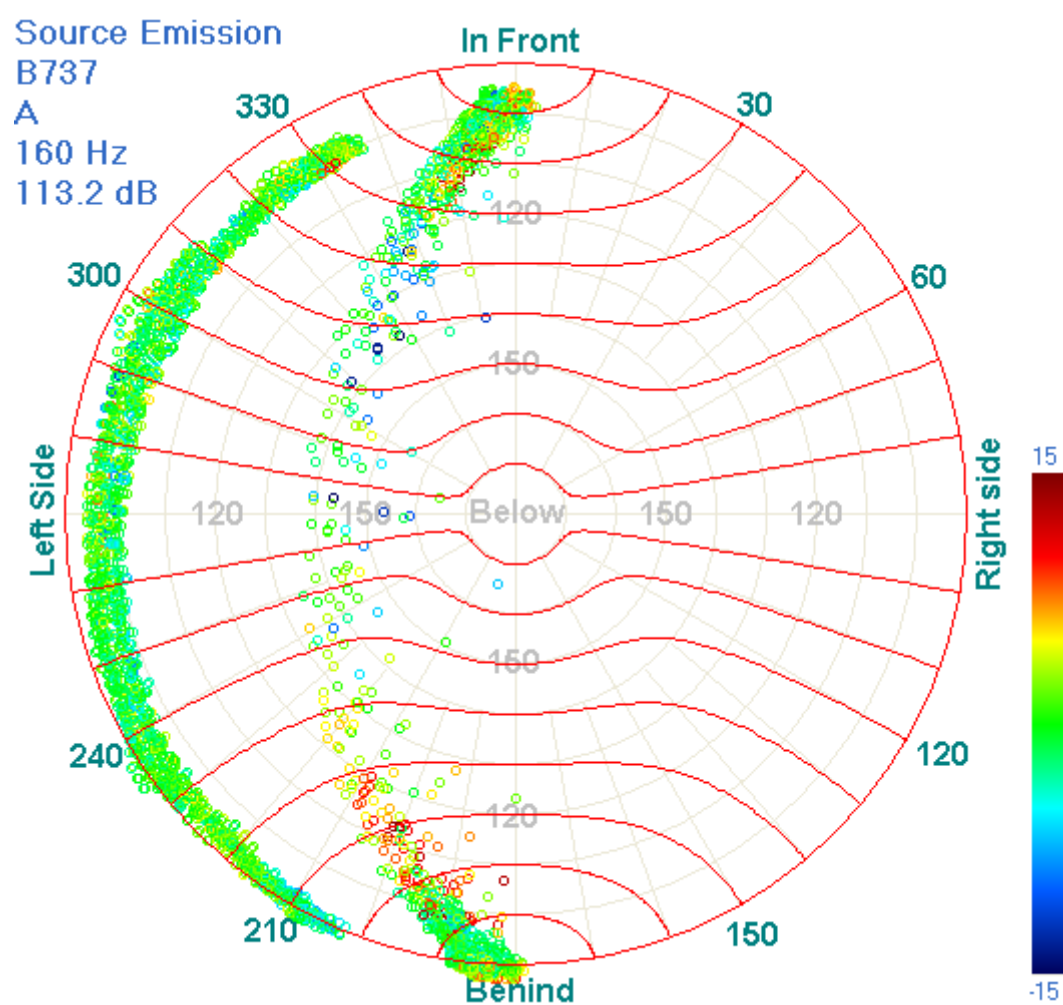


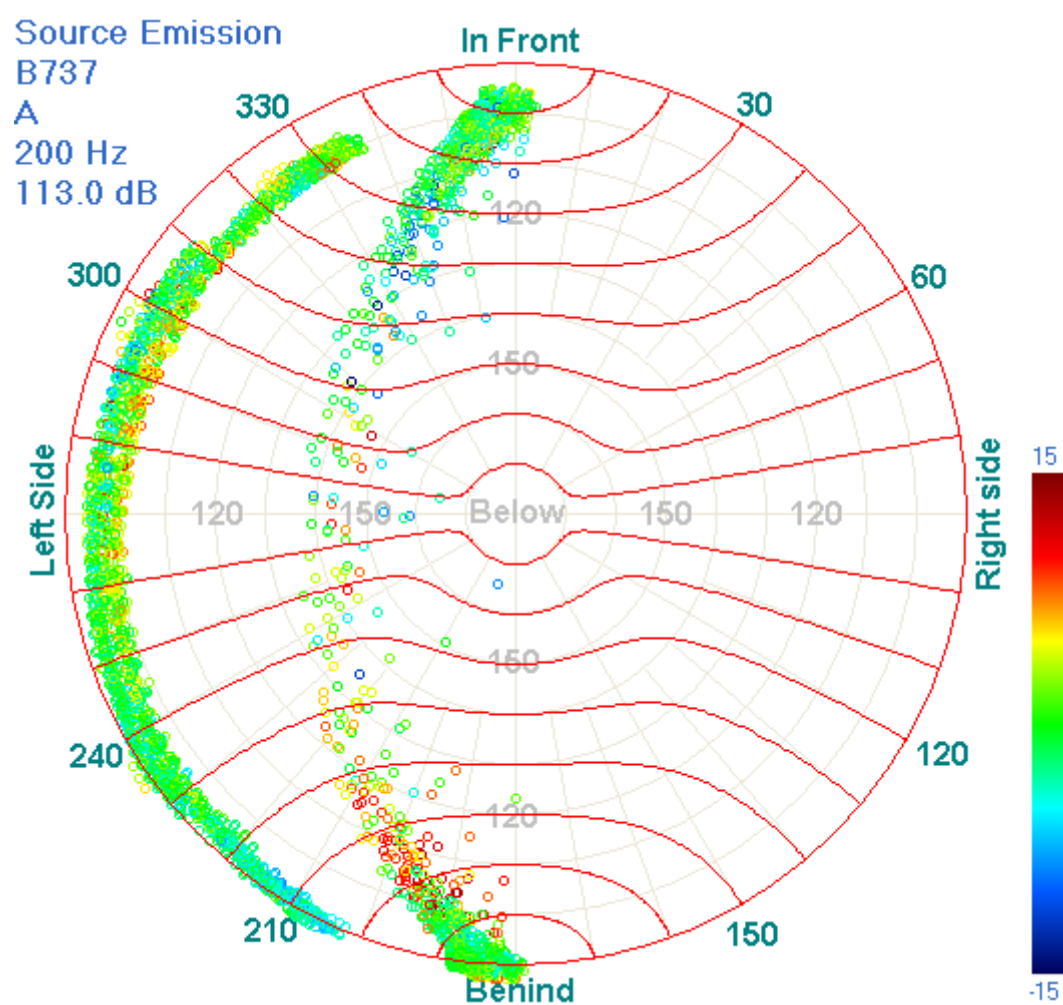


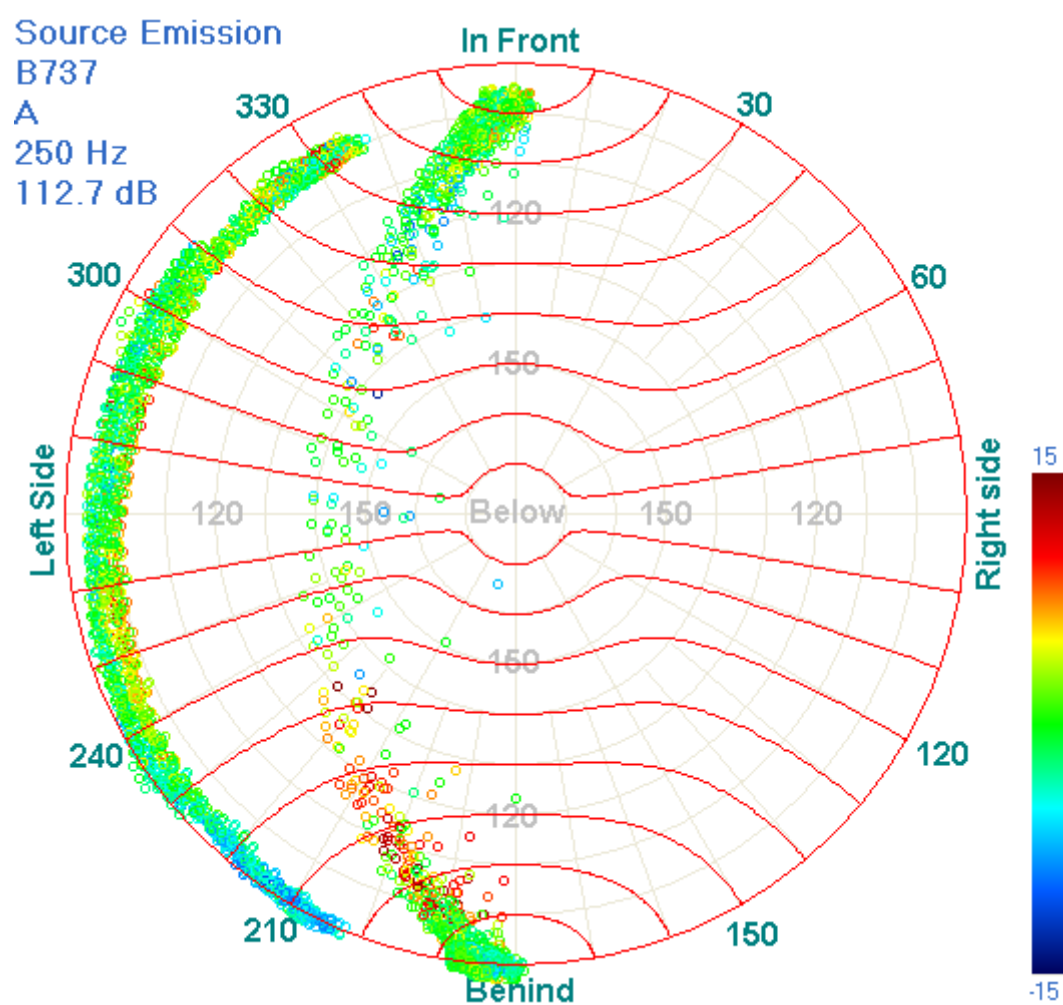


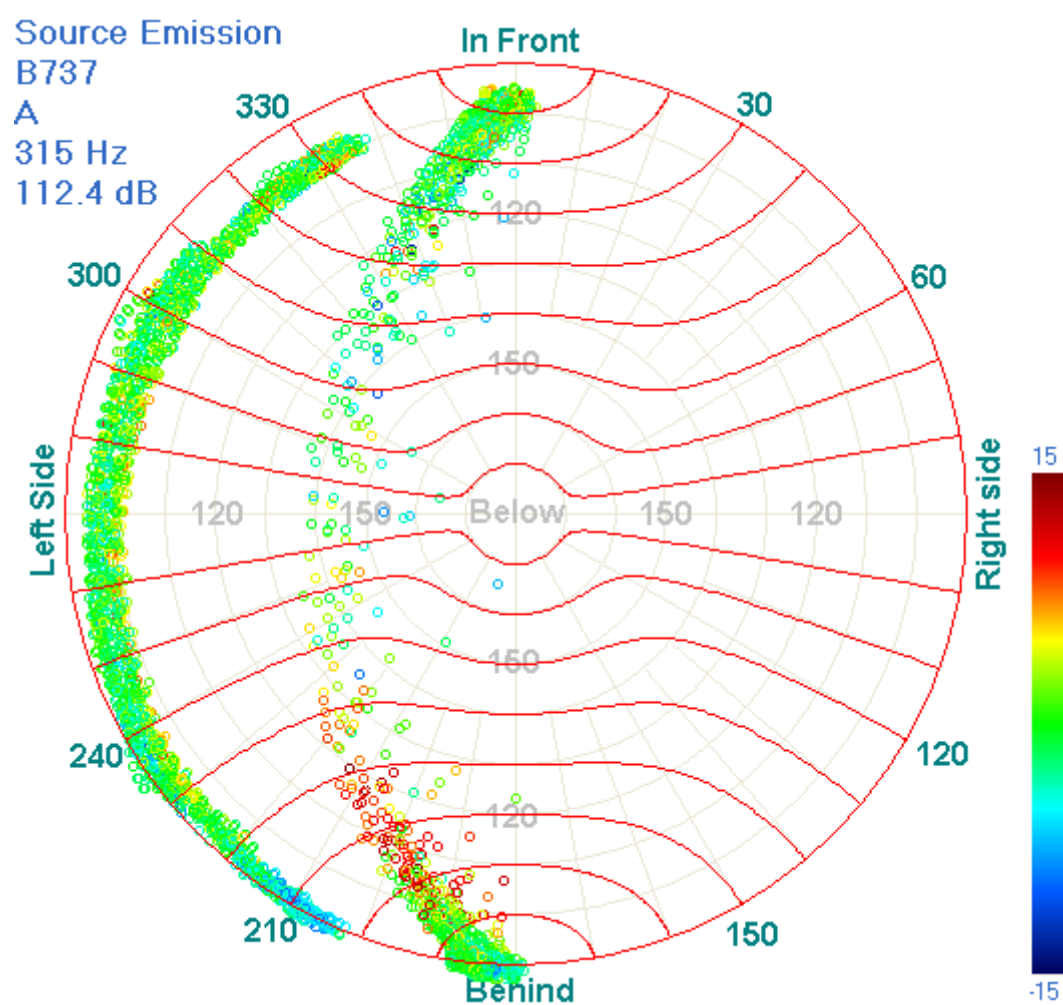


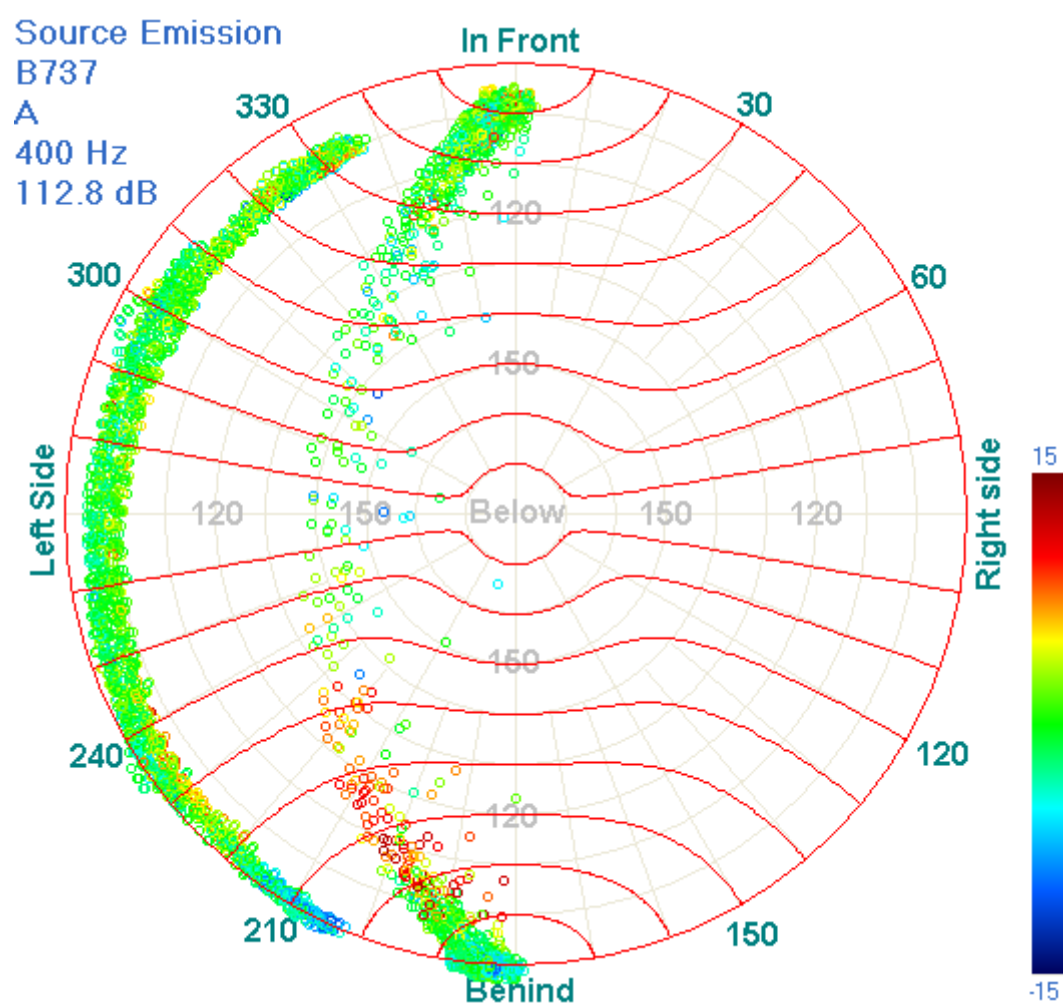


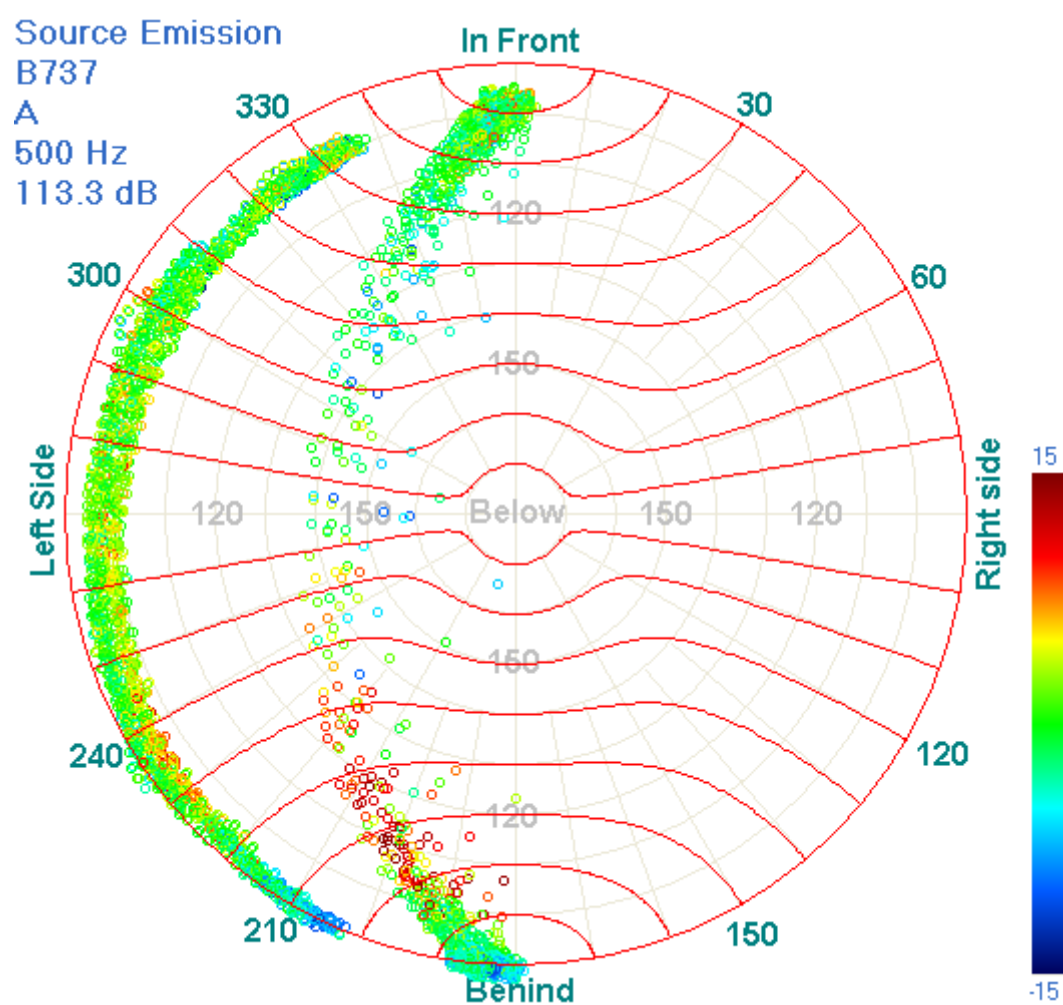


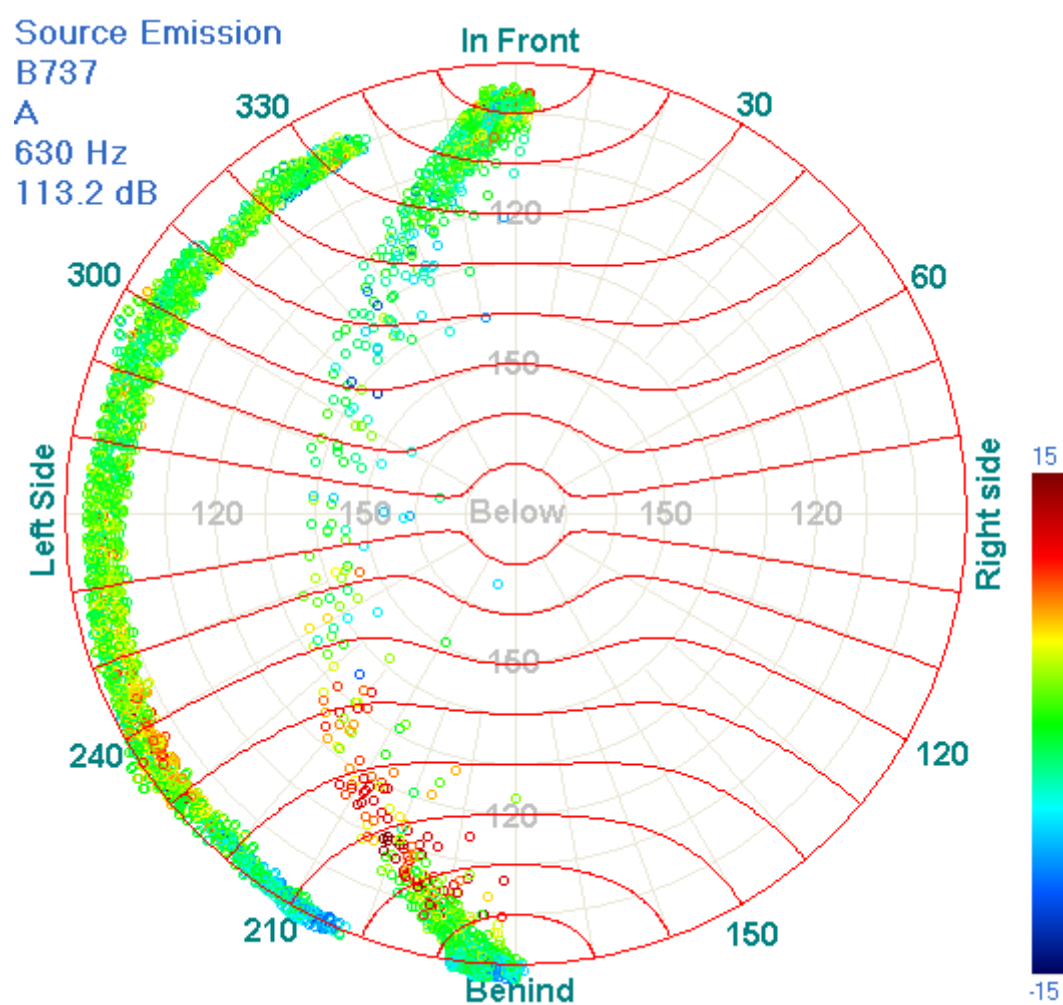




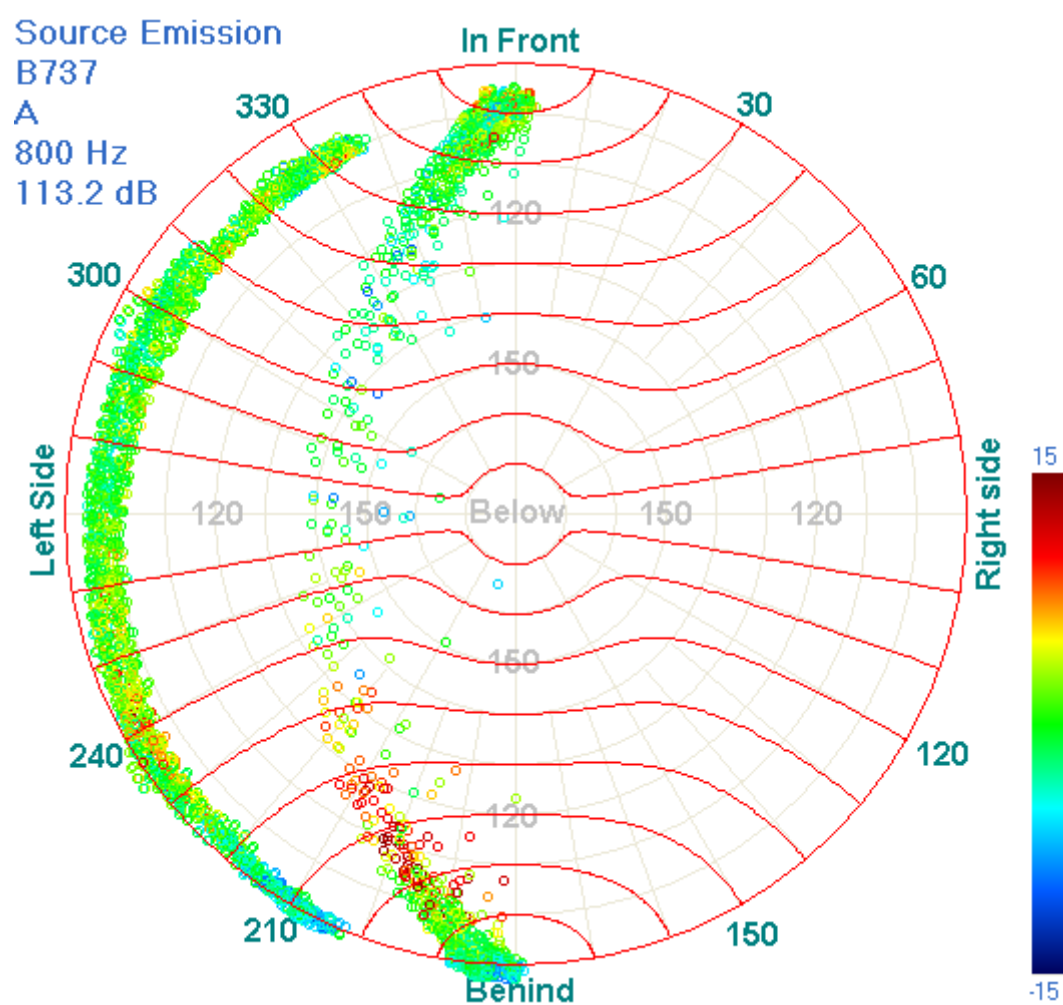


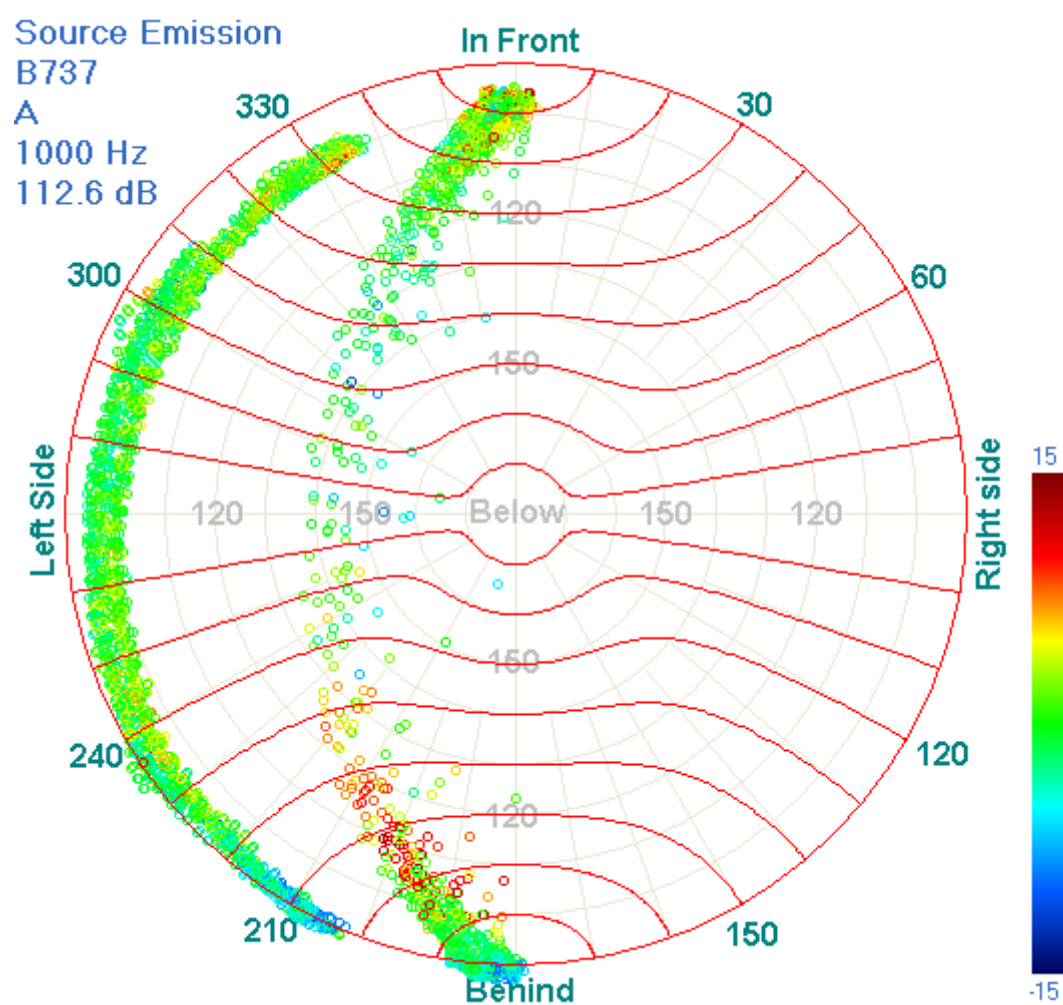


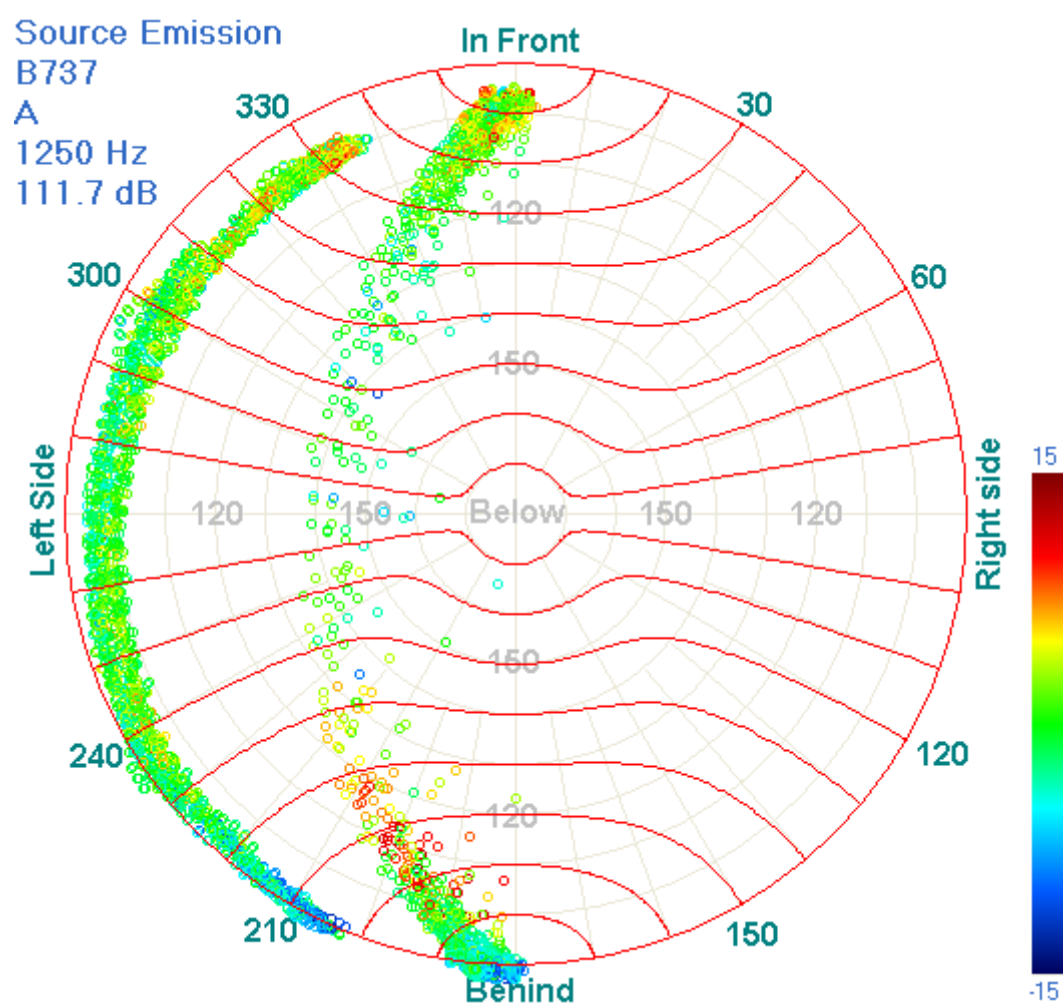


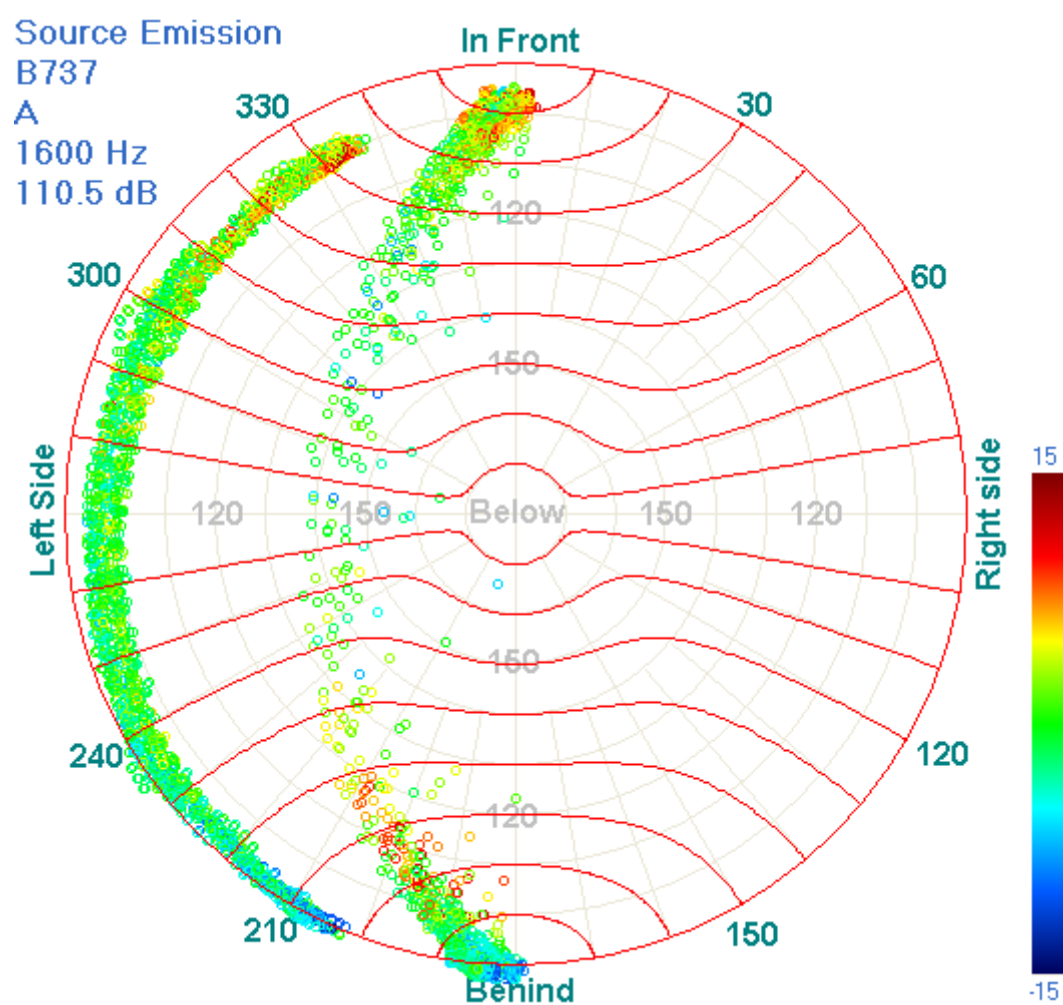


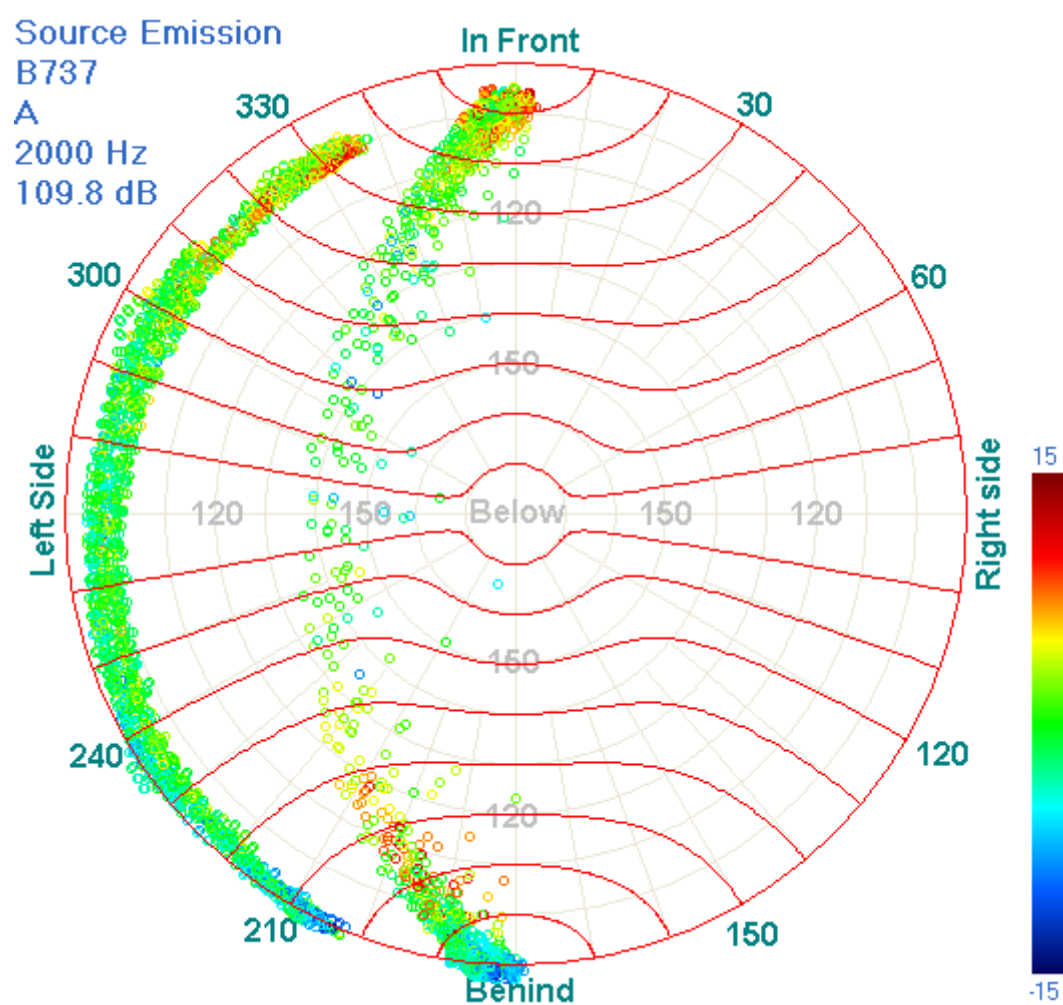


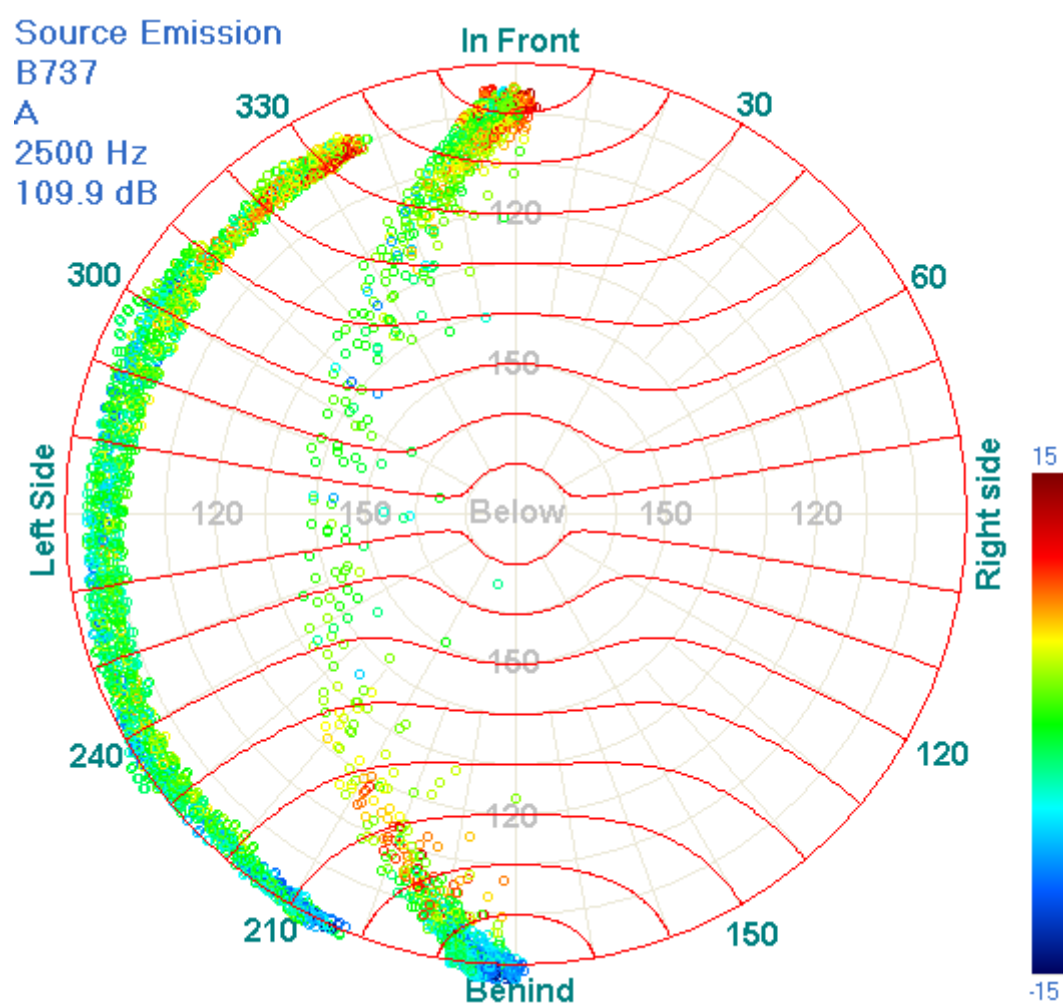


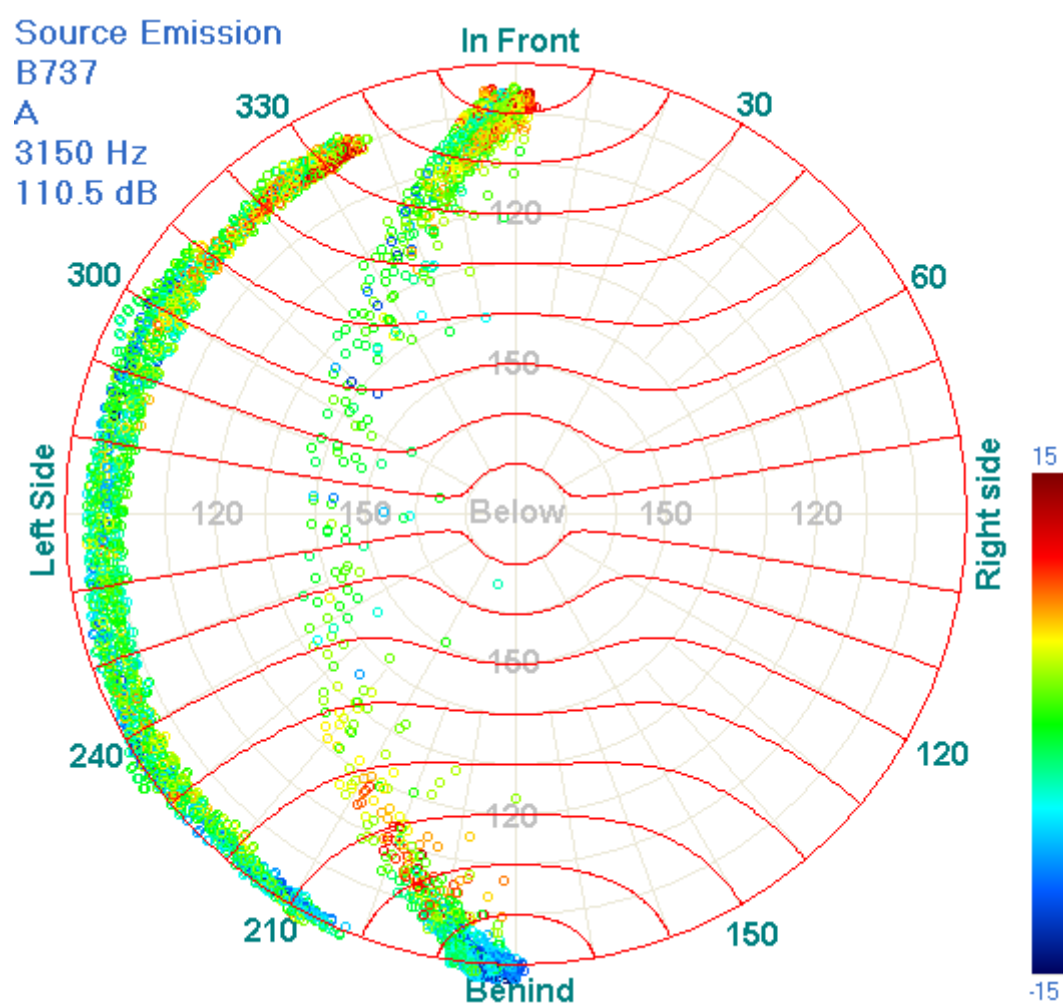


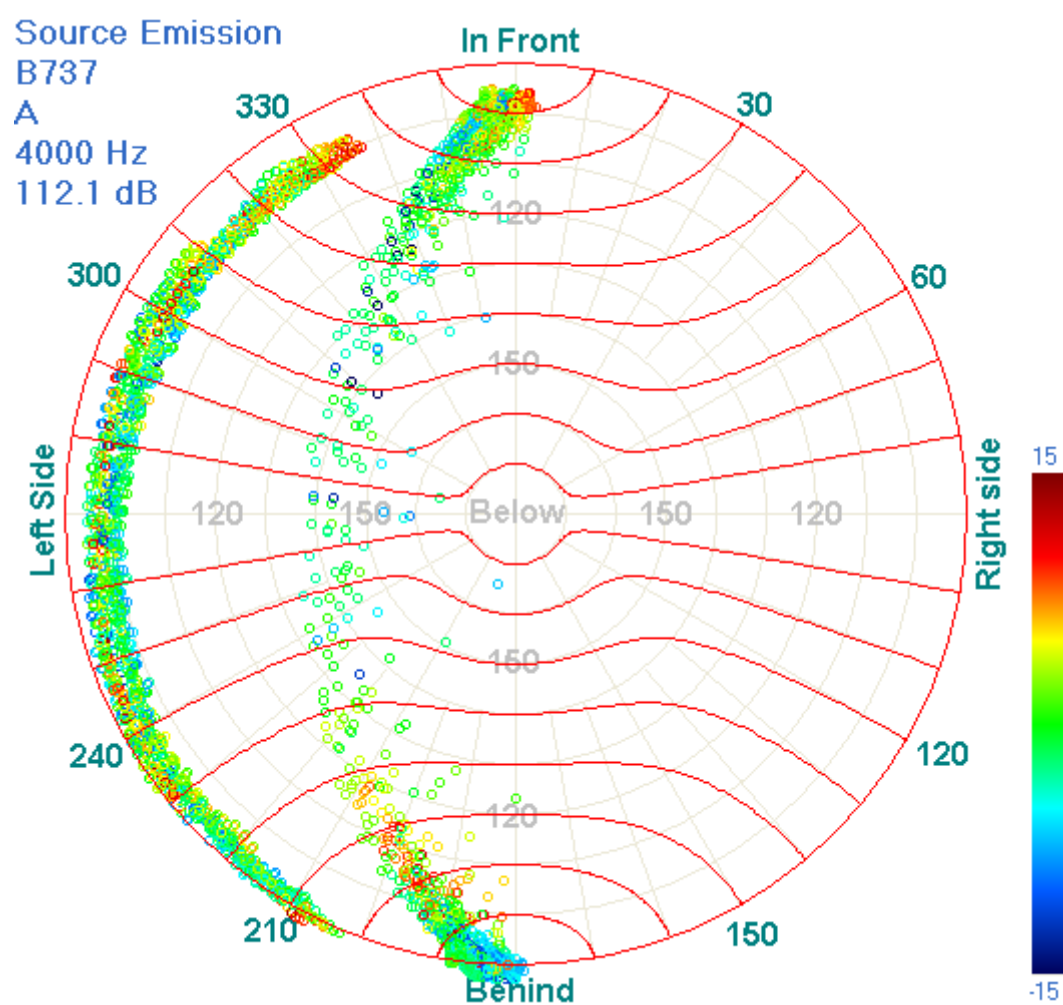




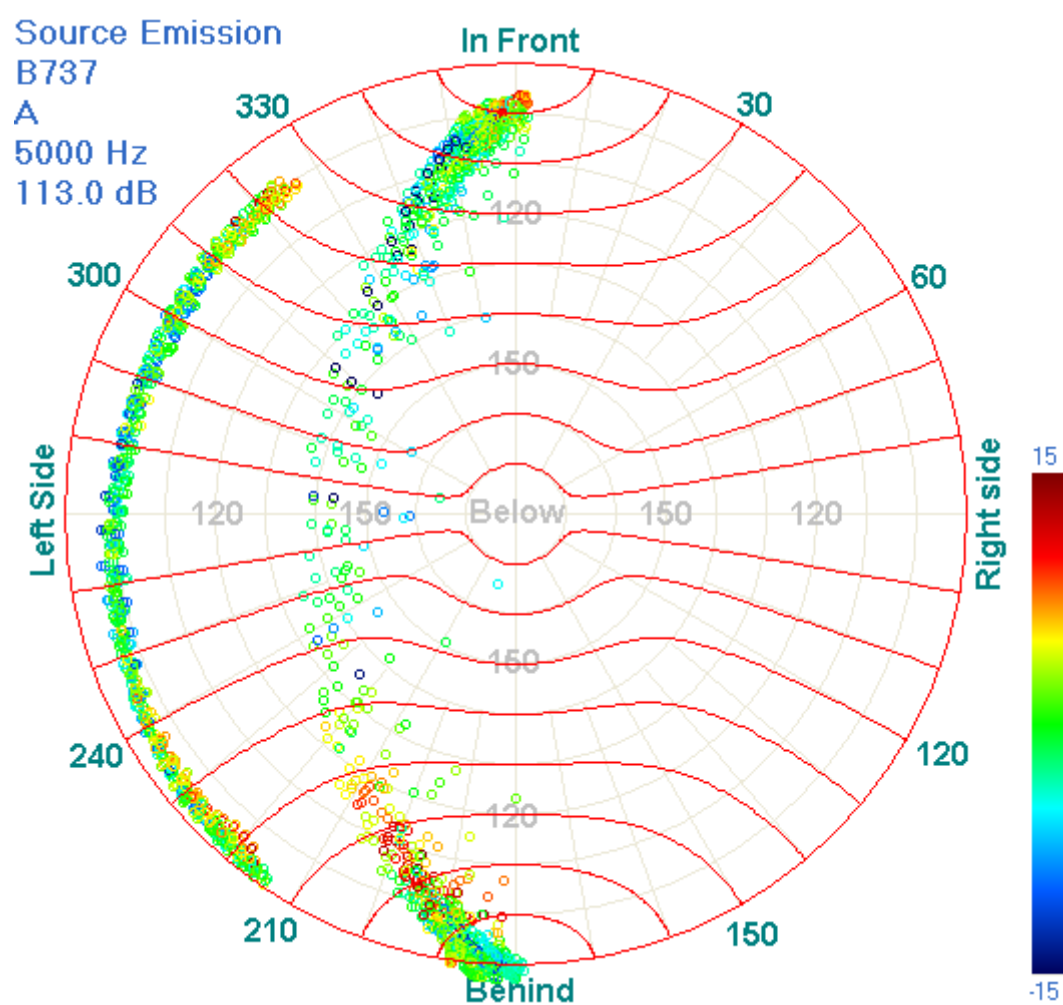


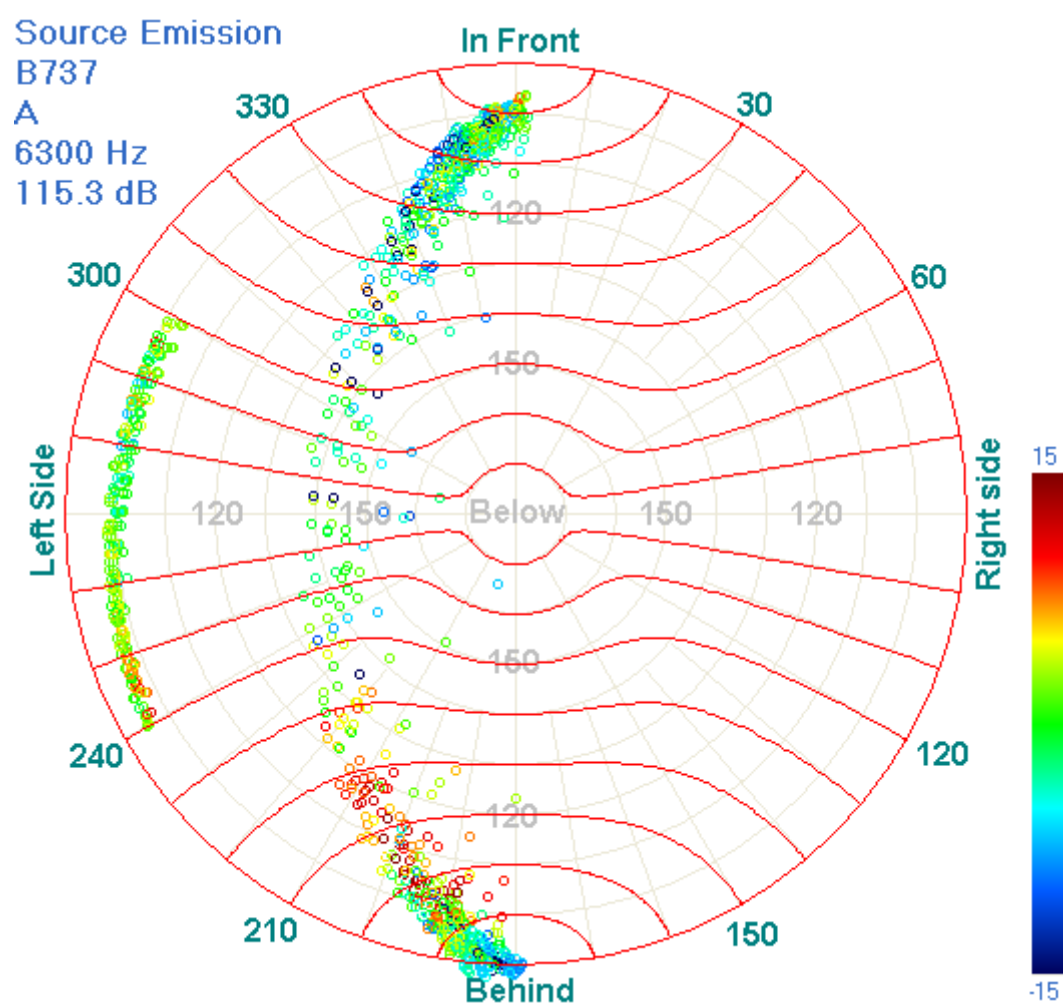


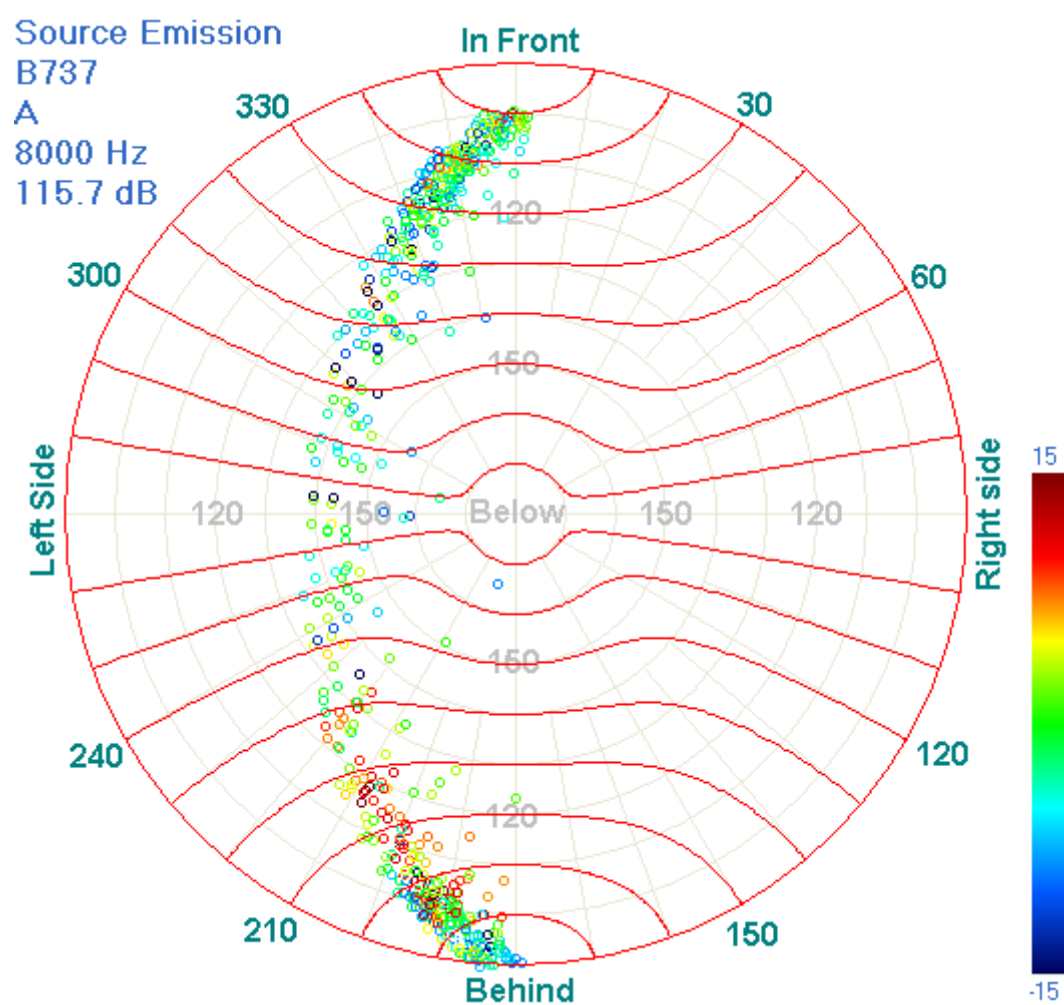


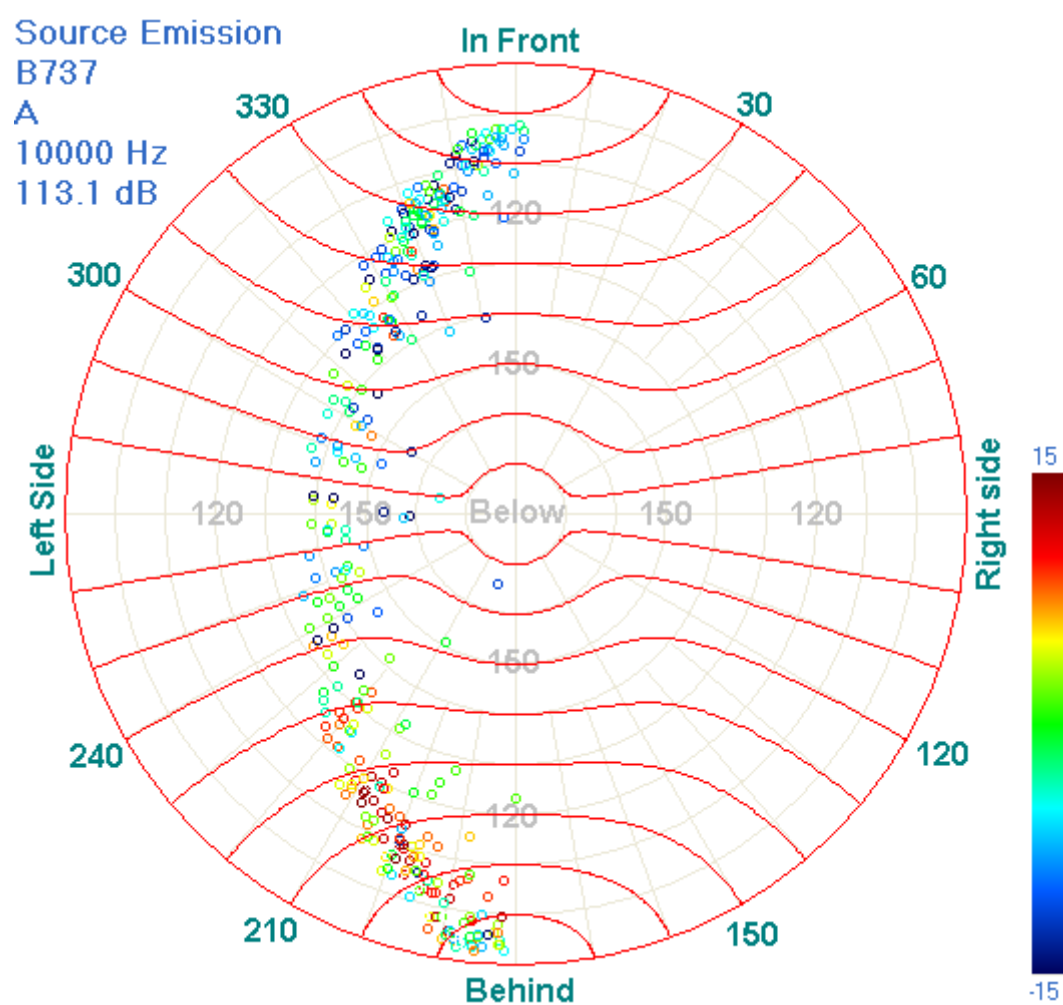








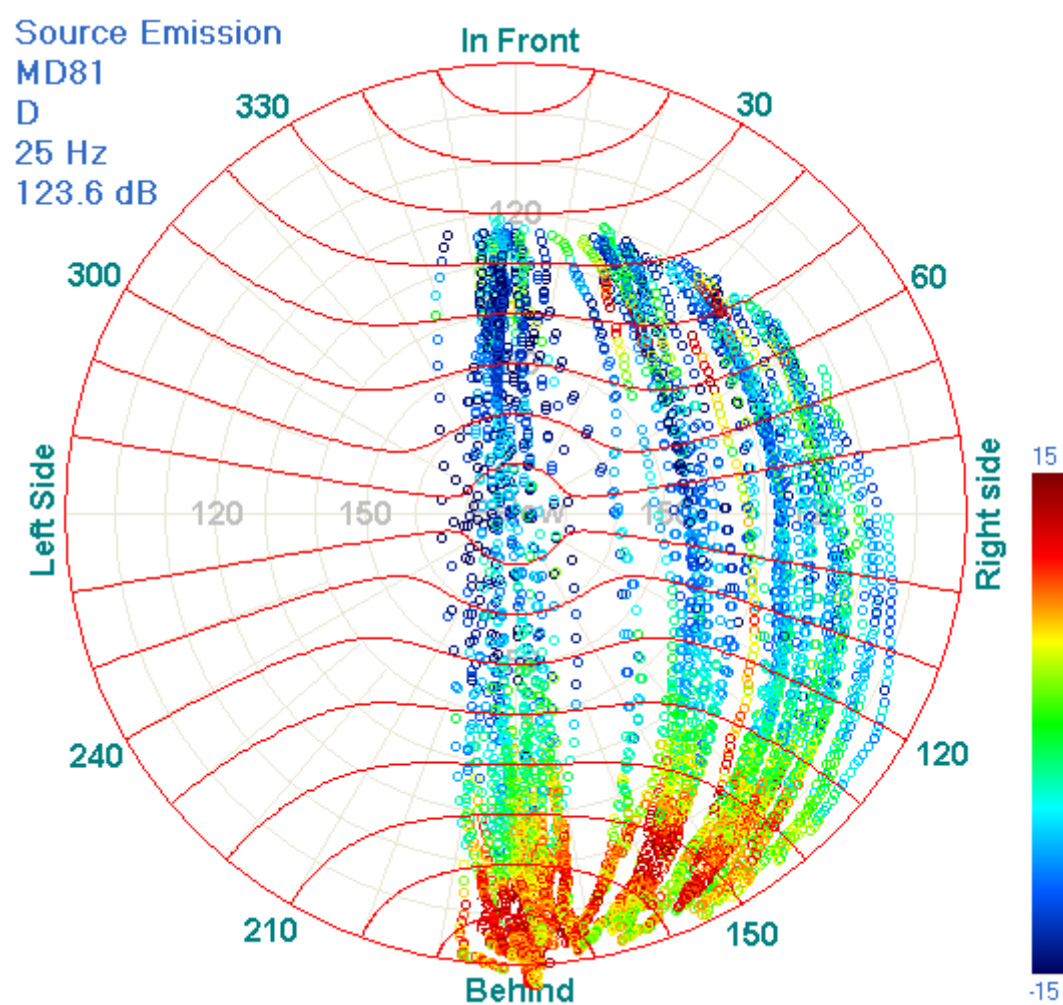




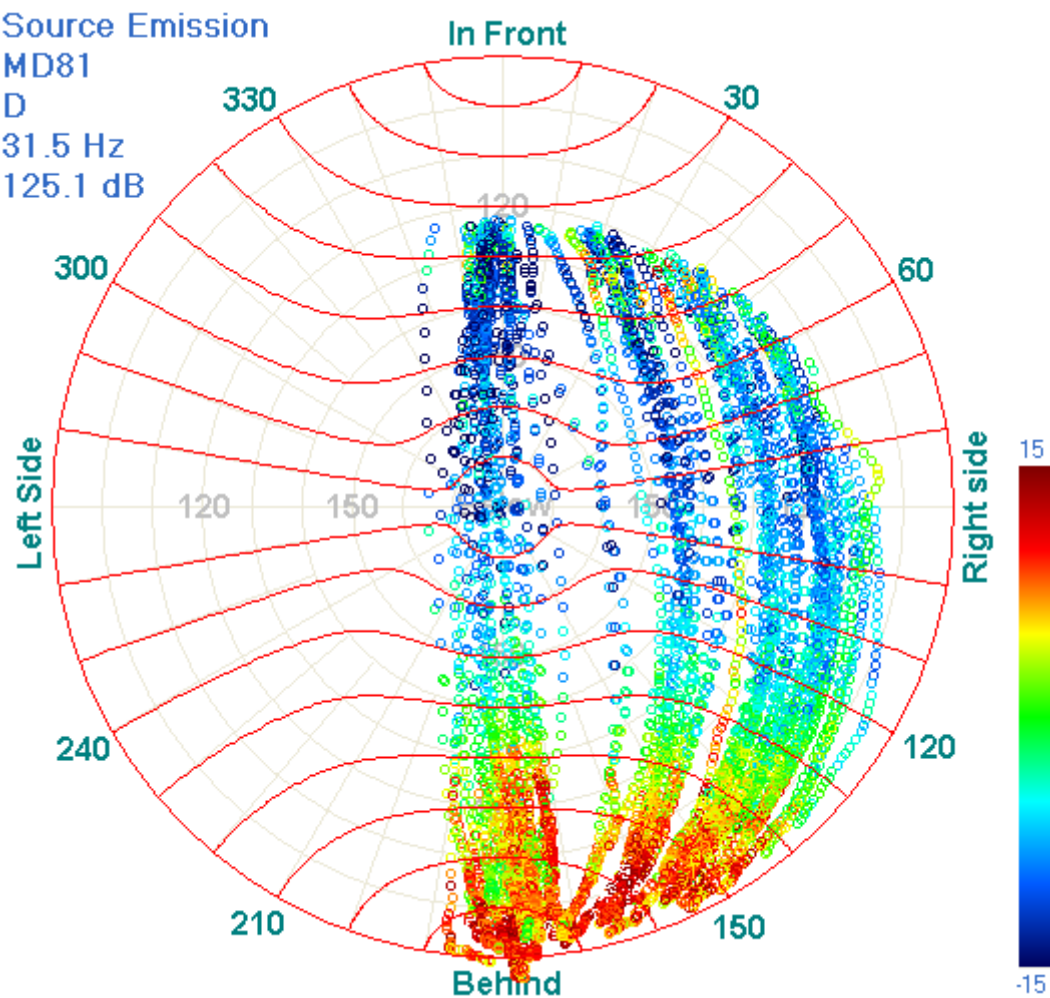
## 12 MD 81 directivity at departure

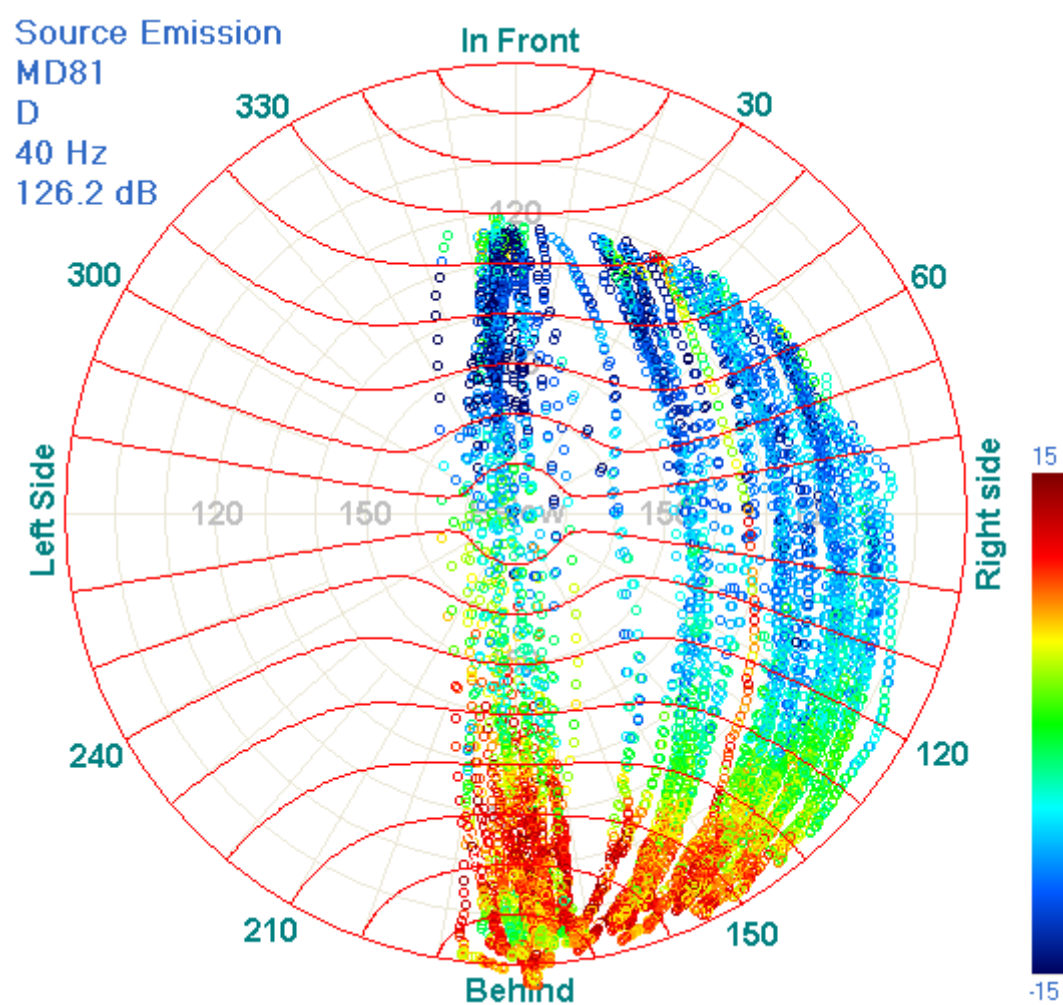
SPECTRUM  
Source Emission  
MD81  
D

Freq	Num	Avg	Std	95%Avg	P1	P2	P3	P4	P5	P6
25	6524	123.6	8.5	0.2	-1.0	-1.0	-1.0	-1.0	124.2	-1.0
31.5	7413	125.1	8.3	0.2	-1.0	-1.0	-1.0	-1.0	125.8	-1.0
40	7351	126.2	8.2	0.2	-1.0	-1.0	-1.0	-1.0	126.8	-1.0
50	7294	127.6	8.2	0.2	-1.0	-1.0	-1.0	-1.0	128.3	-1.0
63	7296	129.5	8.4	0.2	-1.0	-1.0	-1.0	-1.0	130.2	-1.0
80	7482	131.1	8.0	0.2	-1.0	-1.0	-1.0	-1.0	131.7	-1.0
100	8562	130.8	7.3	0.2	-1.0	-1.0	-1.0	-1.0	131.2	-1.0
125	9411	130.1	6.1	0.1	-1.0	-1.0	-1.0	-1.0	130.4	-1.0
160	9594	129.7	5.6	0.1	-1.0	-1.0	-1.0	-1.0	130.0	-1.0
200	9591	129.9	5.8	0.1	-1.0	-1.0	-1.0	-1.0	130.2	-1.0
250	9582	129.7	5.3	0.1	-1.0	-1.0	-1.0	-1.0	129.9	-1.0
315	9582	129.7	5.4	0.1	-1.0	-1.0	-1.0	-1.0	129.8	-1.0
400	9577	129.2	5.5	0.1	-1.0	-1.0	-1.0	-1.0	129.2	-1.0
500	9563	128.8	5.3	0.1	-1.0	-1.0	-1.0	-1.0	128.8	-1.0
630	9555	128.5	5.1	0.1	-1.0	-1.0	-1.0	-1.0	128.5	-1.0
800	9578	128.2	5.1	0.1	-1.0	-1.0	-1.0	-1.0	128.1	-1.0
1000	9577	127.6	5.2	0.1	-1.0	-1.0	-1.0	-1.0	127.5	-1.0
1250	9578	126.8	5.3	0.1	-1.0	-1.0	-1.0	-1.0	126.8	-1.0
1600	9564	126.1	5.3	0.1	-1.0	-1.0	-1.0	-1.0	126.0	-1.0
2000	9476	125.7	5.3	0.1	-1.0	-1.0	-1.0	-1.0	125.6	-1.0
2500	9106	125.8	5.2	0.1	-1.0	-1.0	-1.0	-1.0	125.7	-1.0
3150	6978	125.3	5.4	0.1	-1.0	-1.0	-1.0	-1.0	125.2	-1.0
4000	3840	125.0	5.7	0.2	-1.0	-1.0	-1.0	-1.0	124.8	-1.0
5000	1629	123.6	5.9	0.3	-1.0	-1.0	-1.0	-1.0	123.2	-1.0
6300	429	119.5	7.1	0.7	-1.0	-1.0	-1.0	-1.0	118.3	-1.0
8000	84	115.8	7.9	1.7	-1.0	-1.0	-1.0	-1.0	115.8	-1.0
10000	18	113.1	7.9	3.7	-1.0	-1.0	-1.0	-1.0	115.4	-1.0

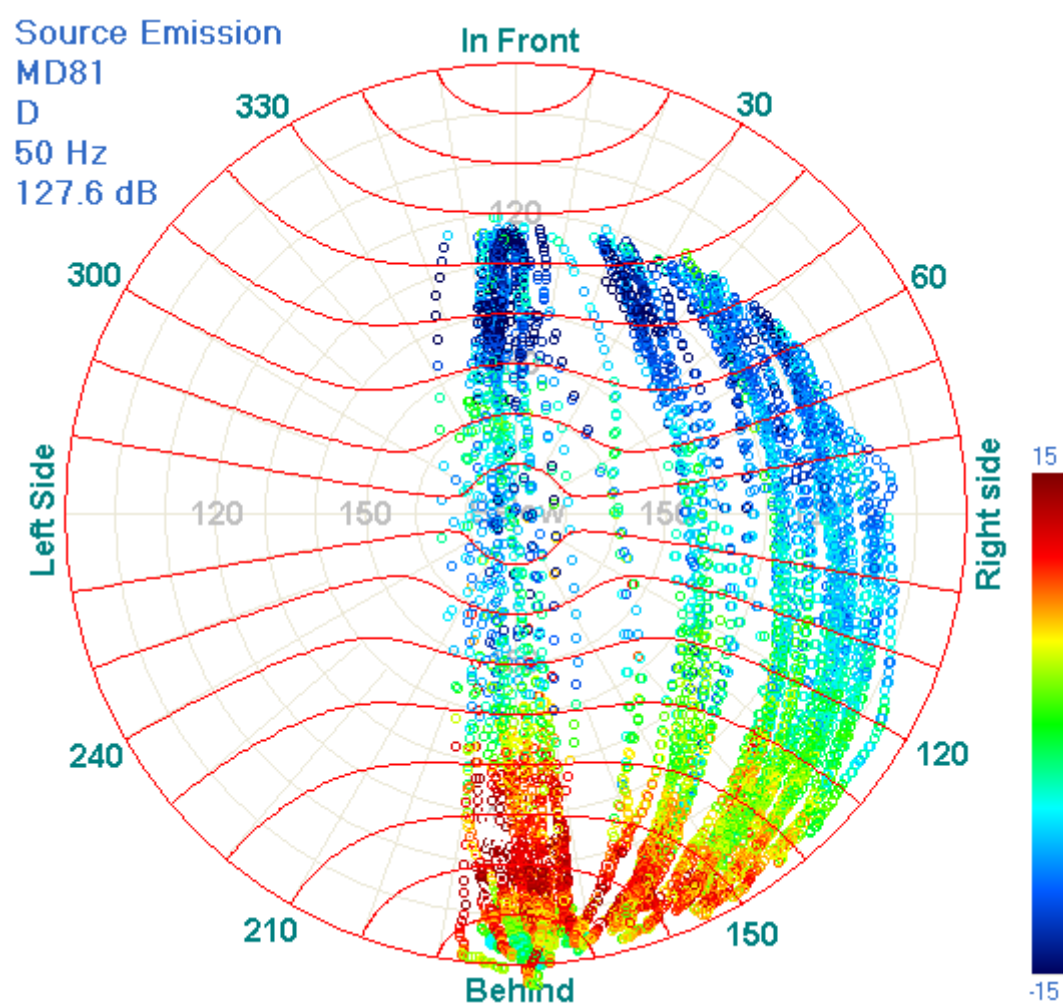


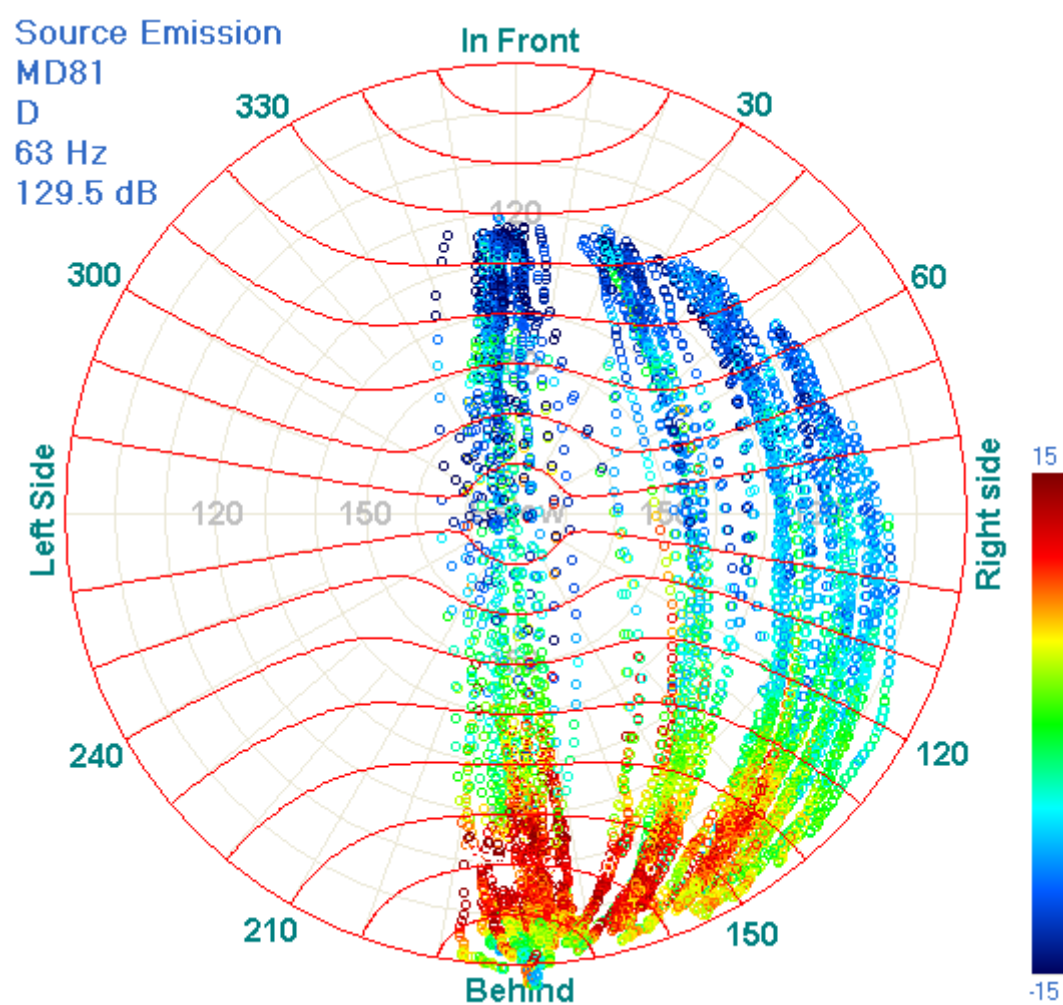
Source Emission  
MD81  
D  
31.5 Hz  
125.1 dB

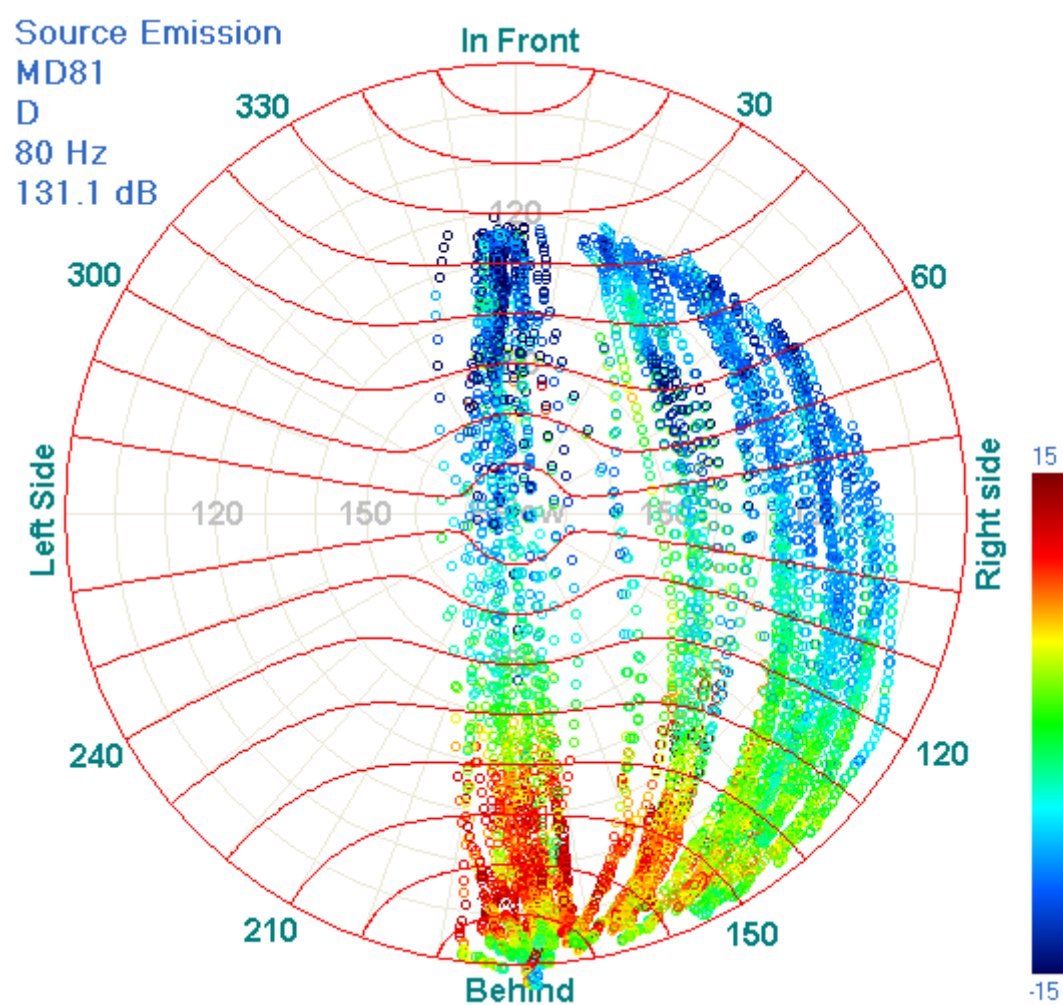


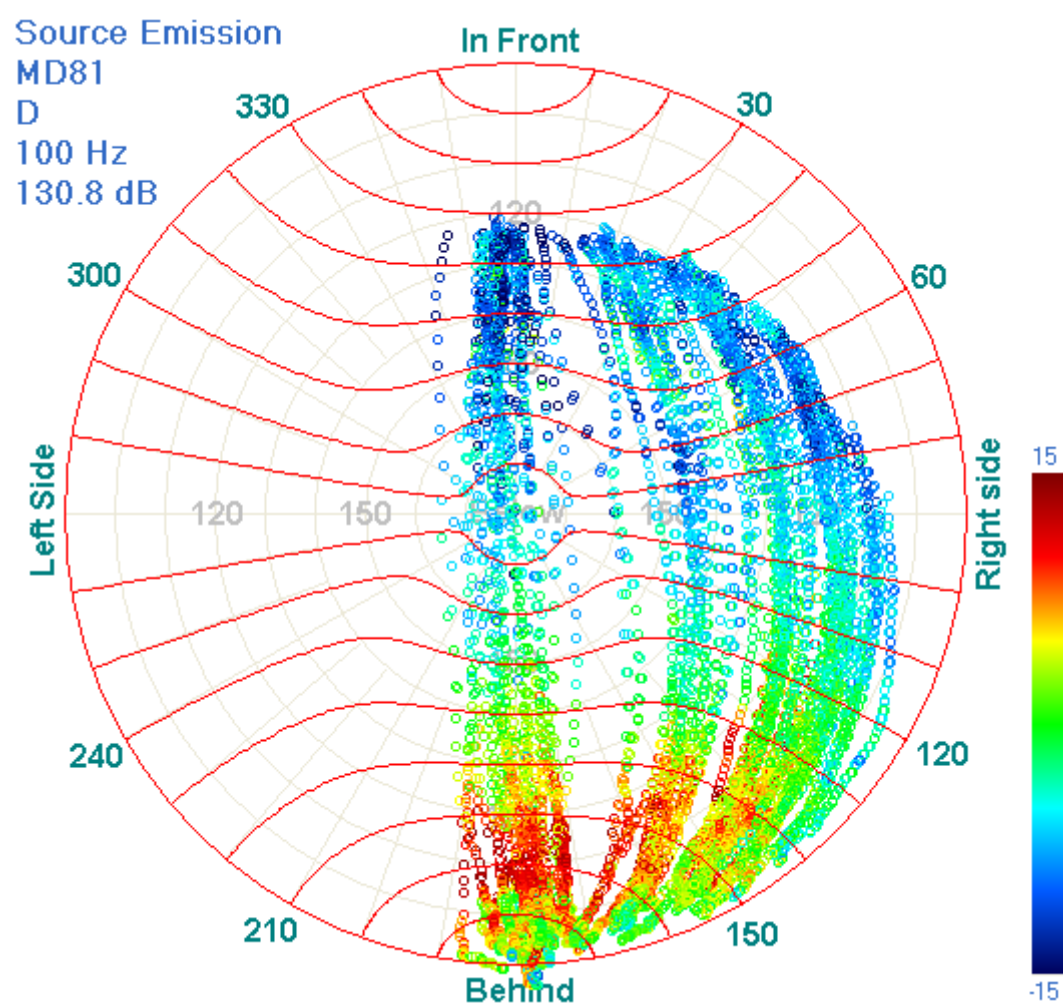


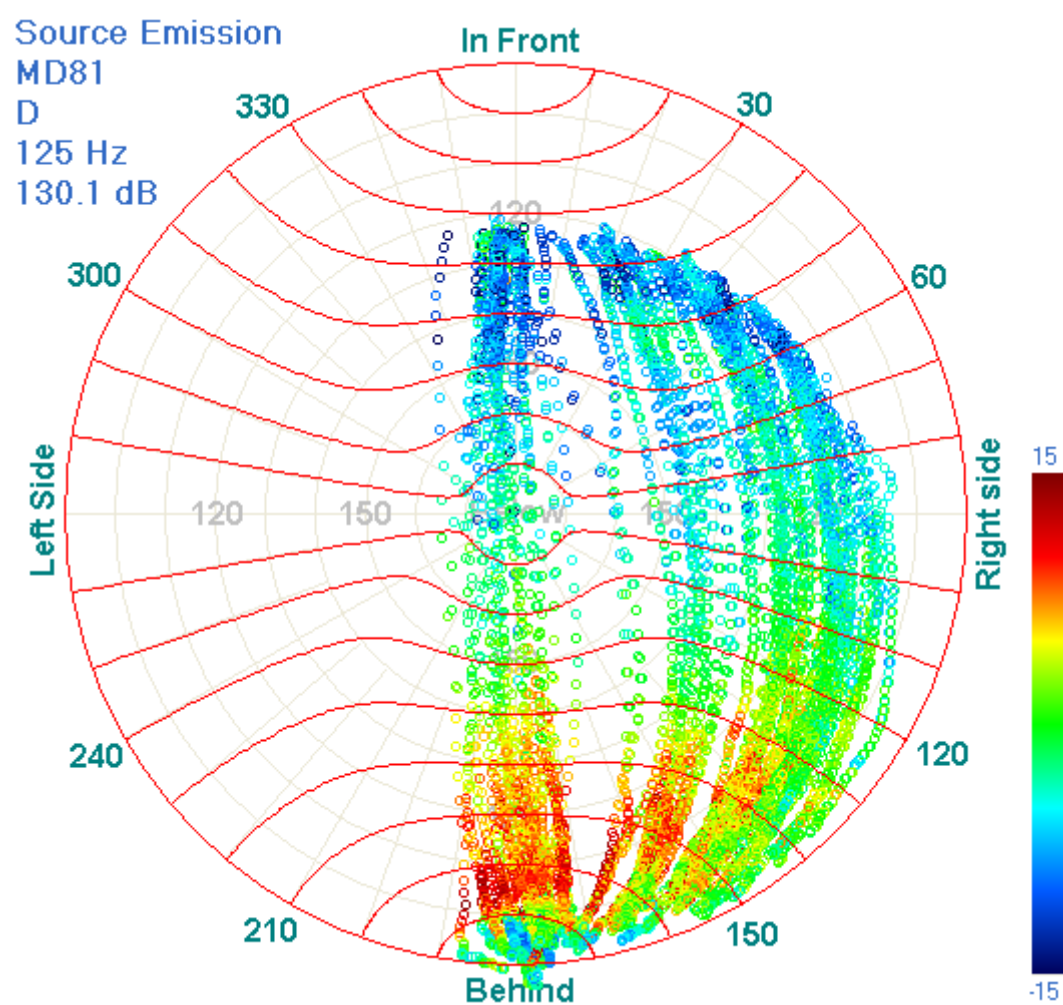


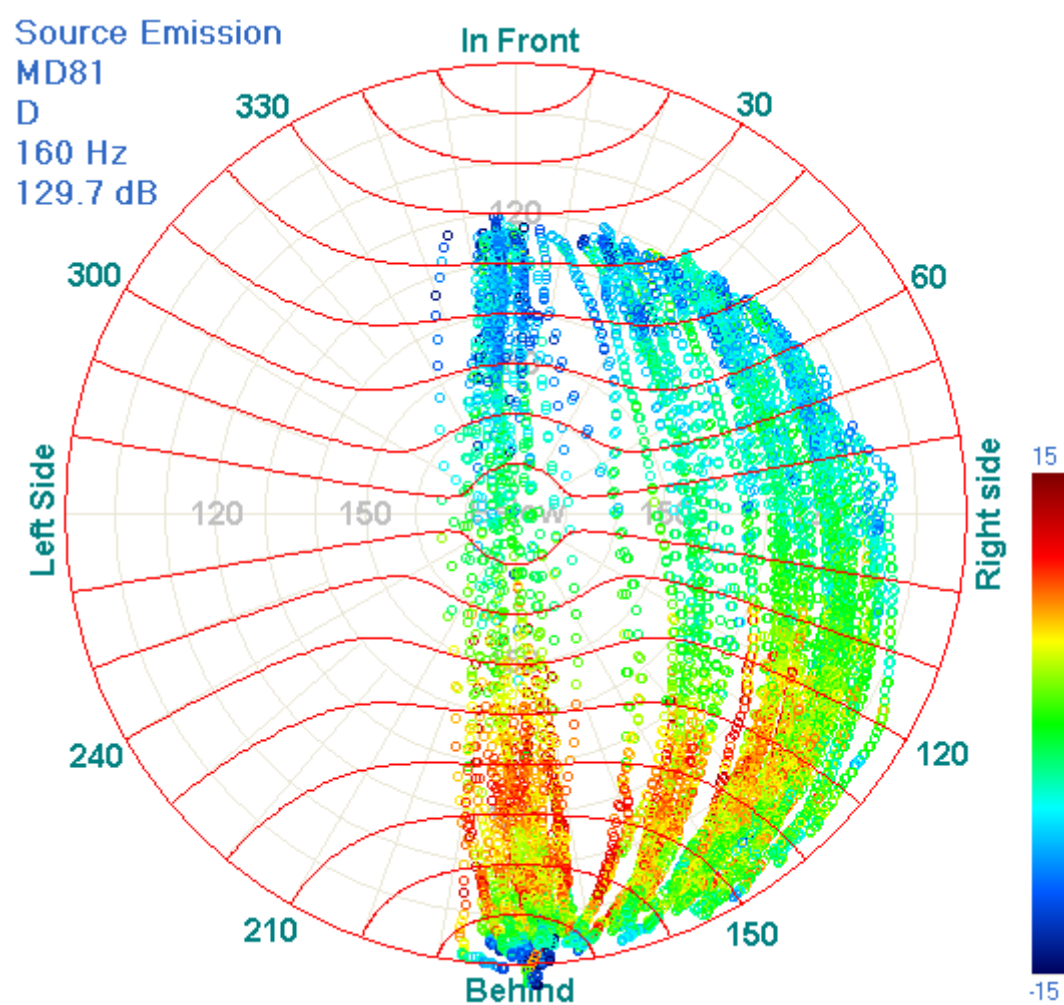




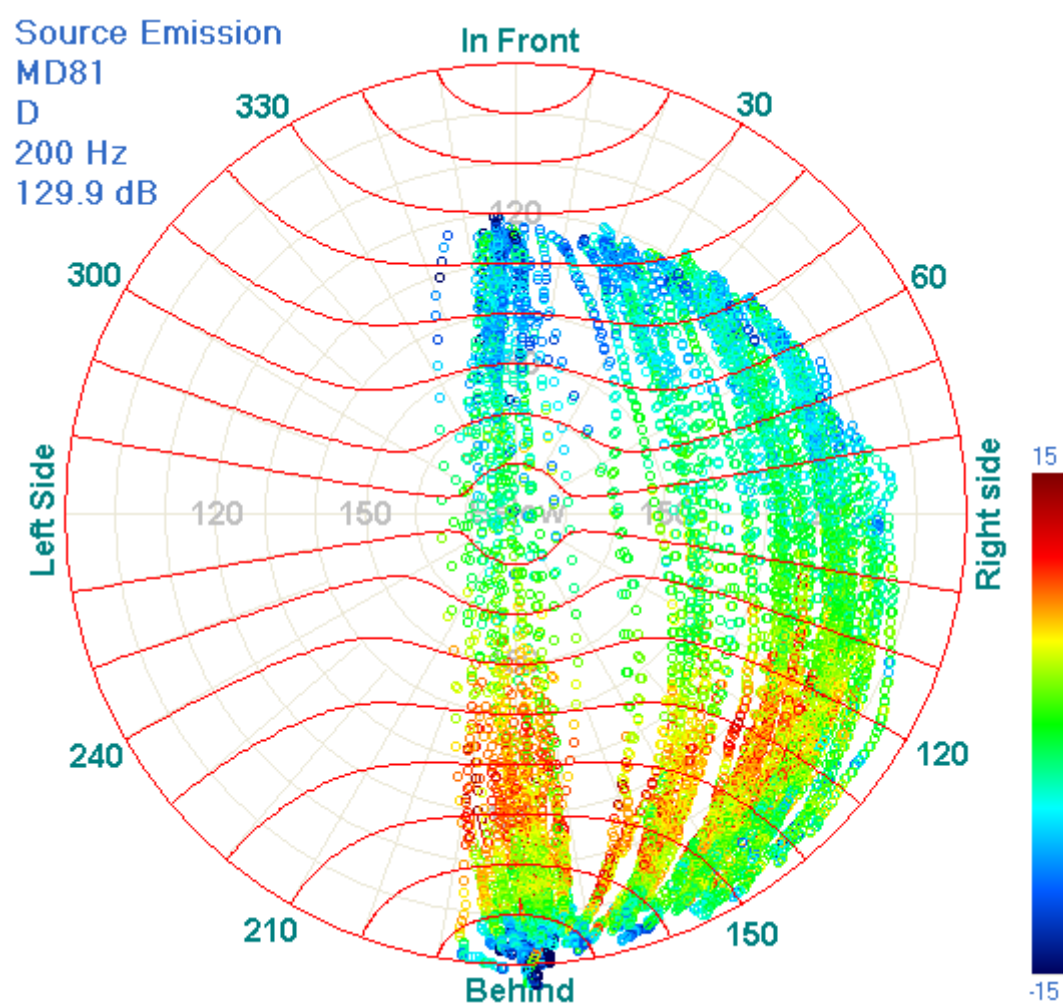




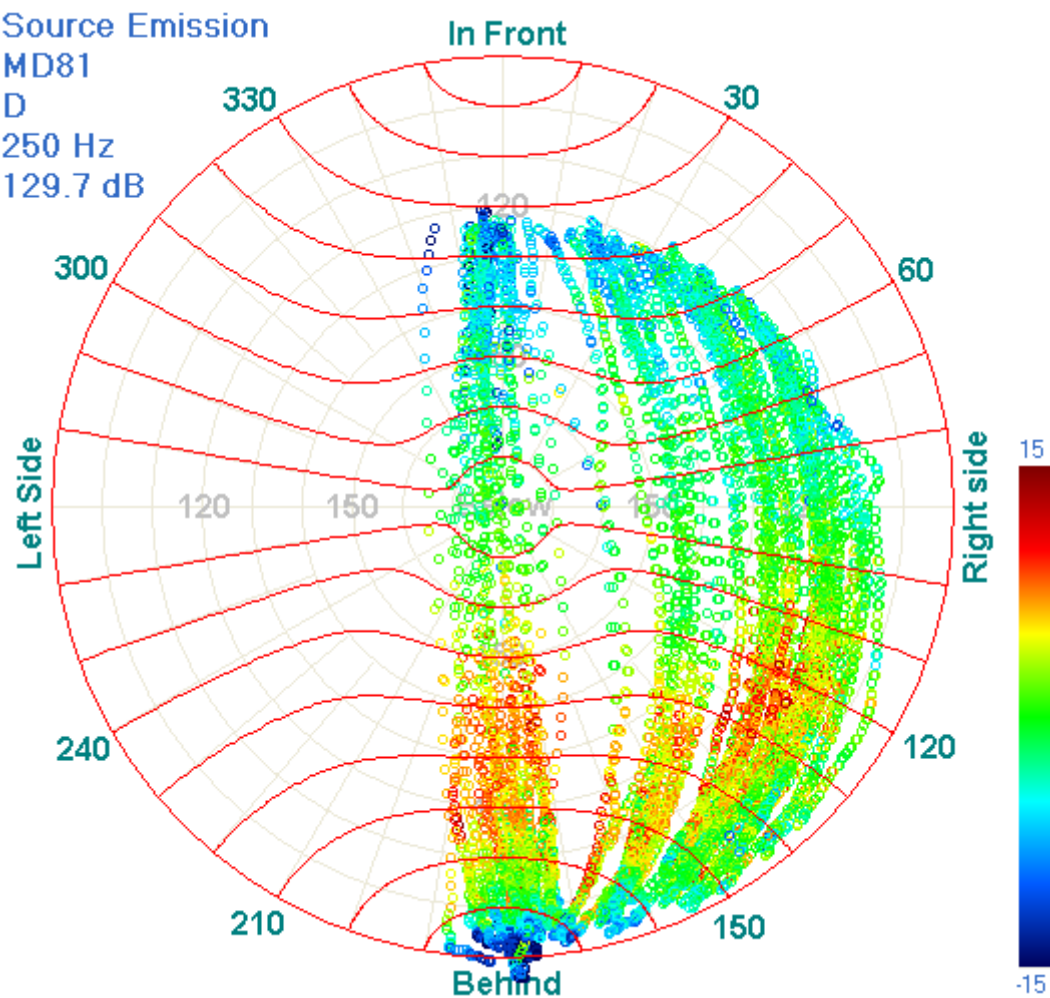






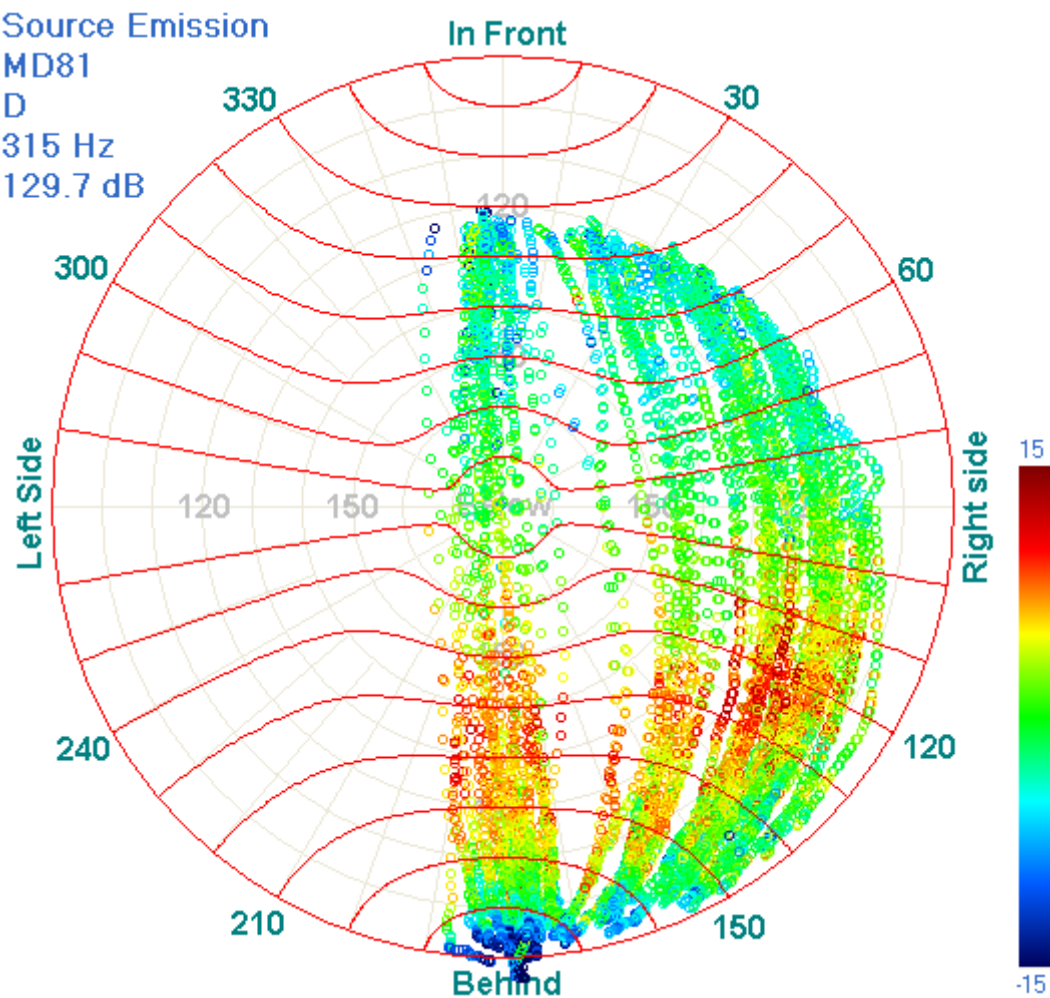


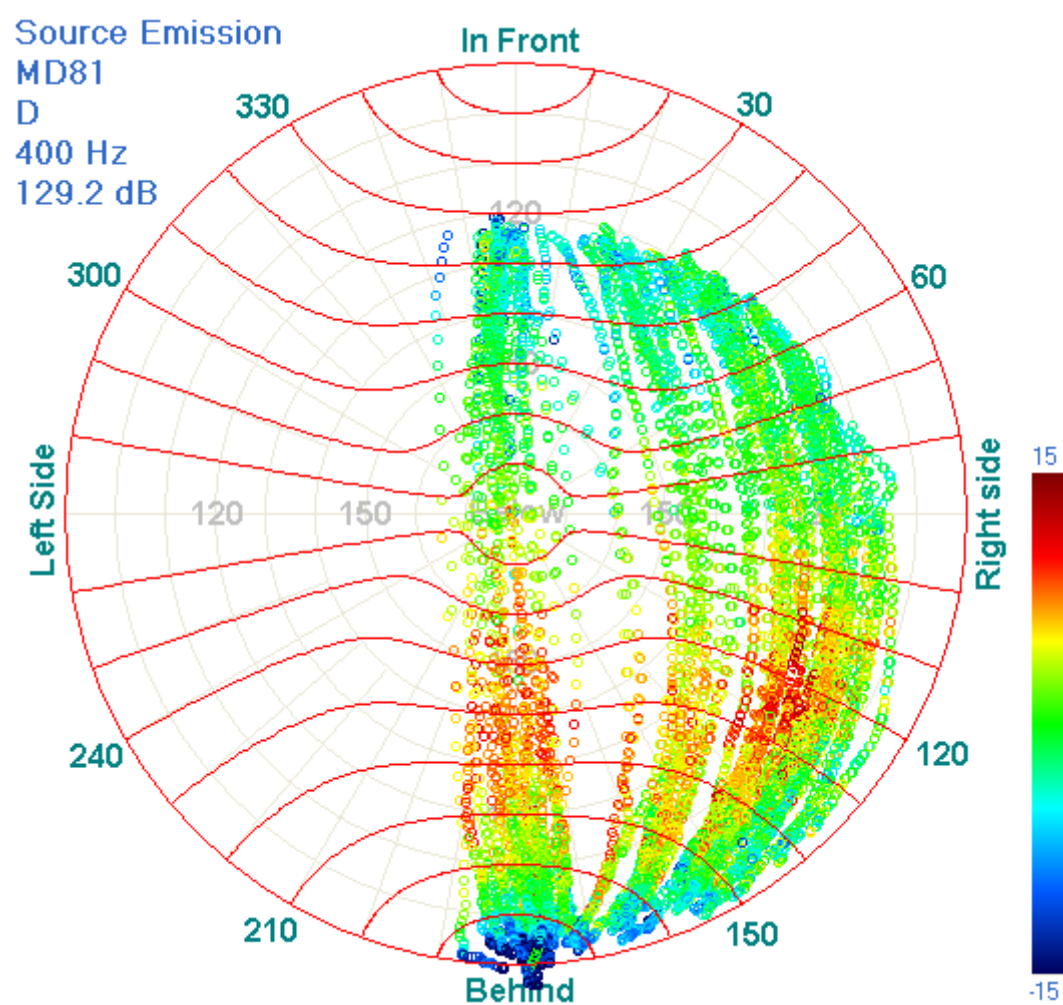
Source Emission  
MD81  
D  
250 Hz  
129.7 dB

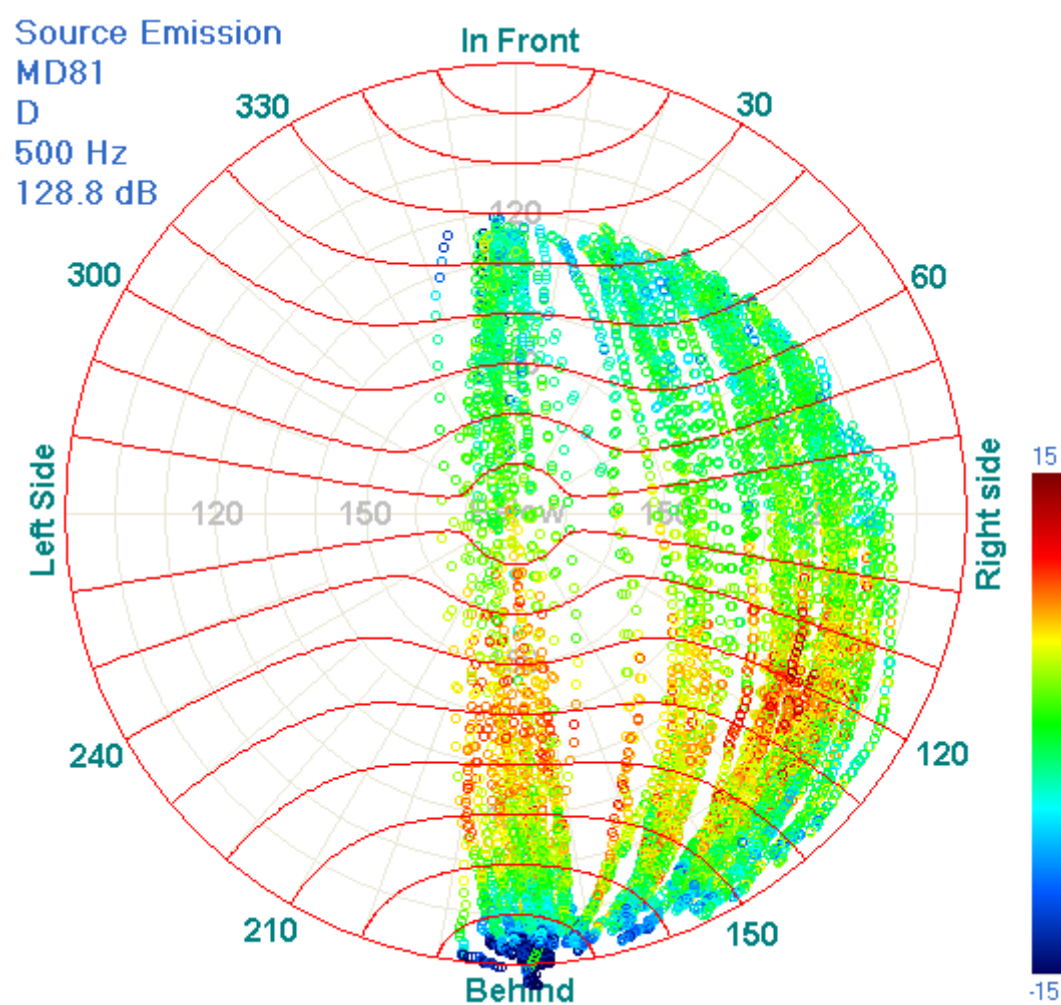


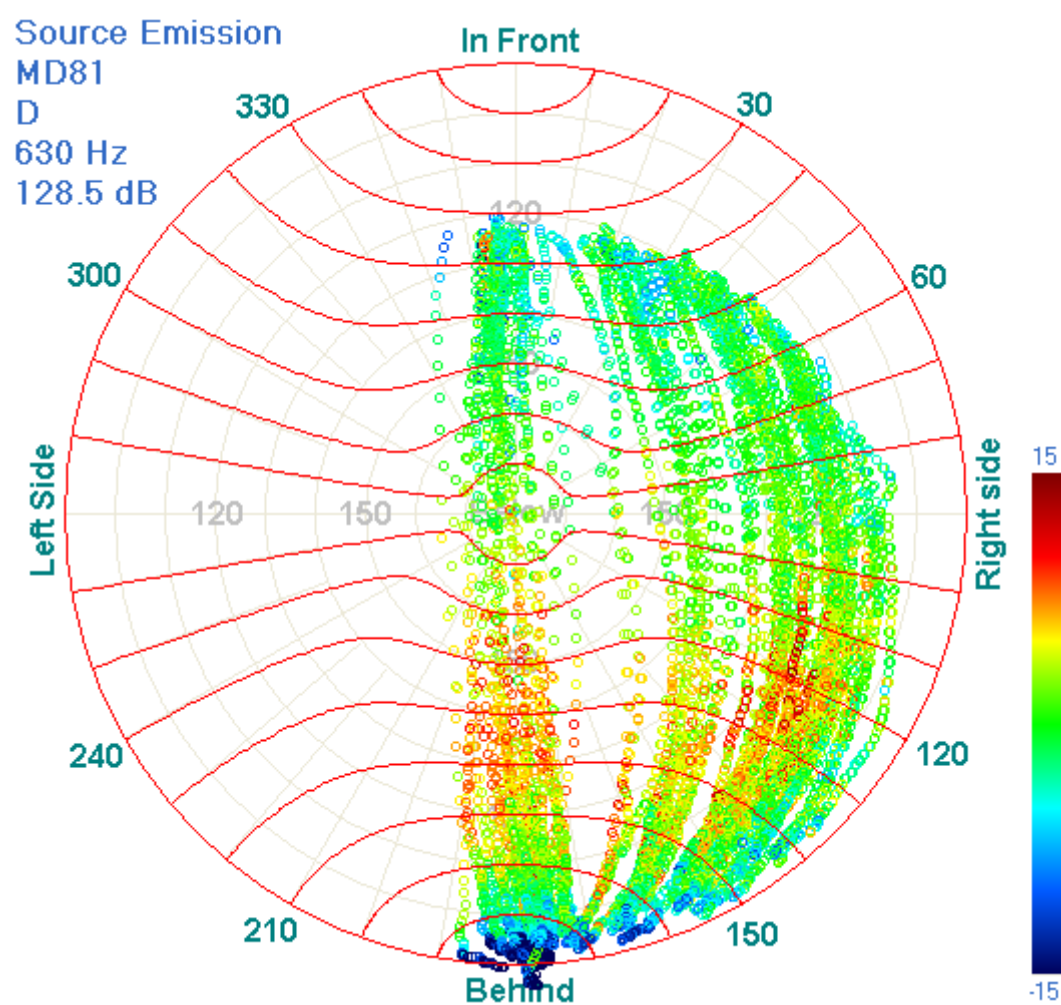


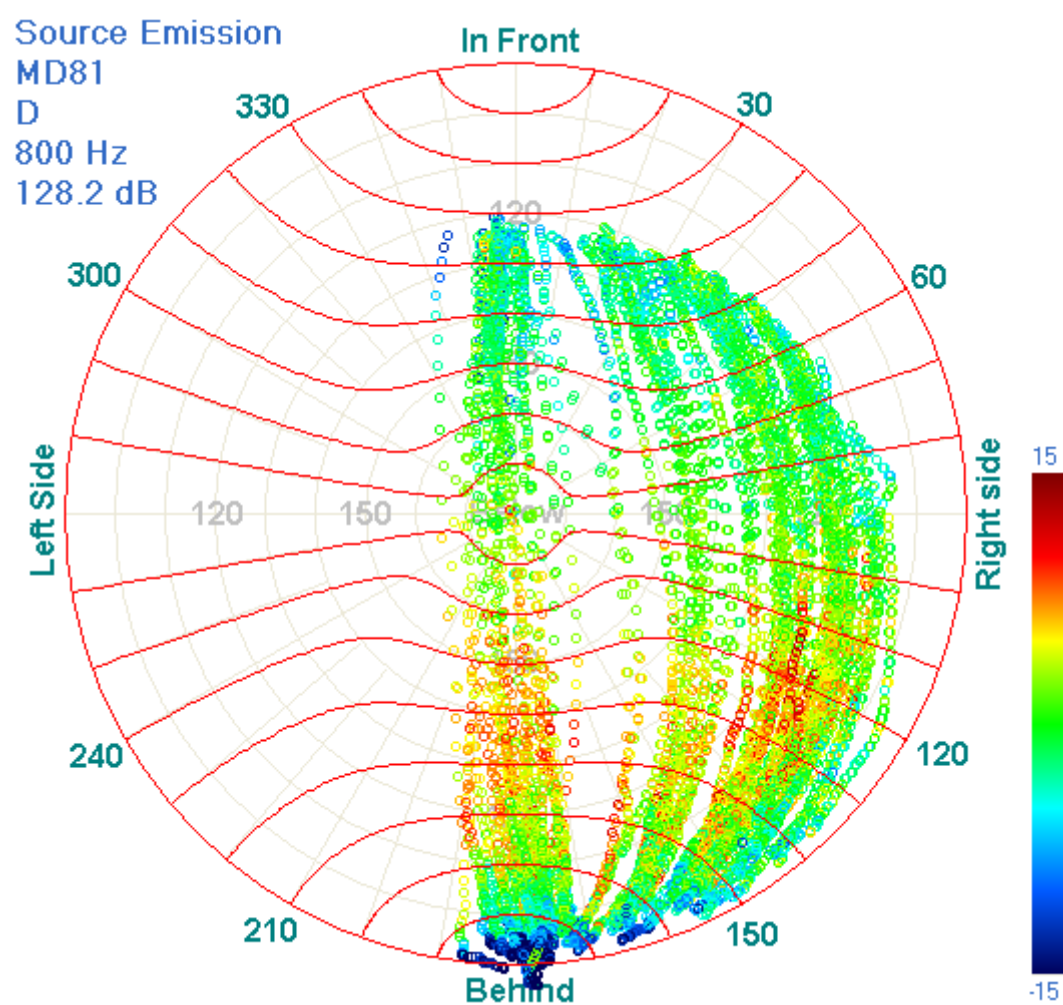
Source Emission  
MD81  
D  
315 Hz  
129.7 dB

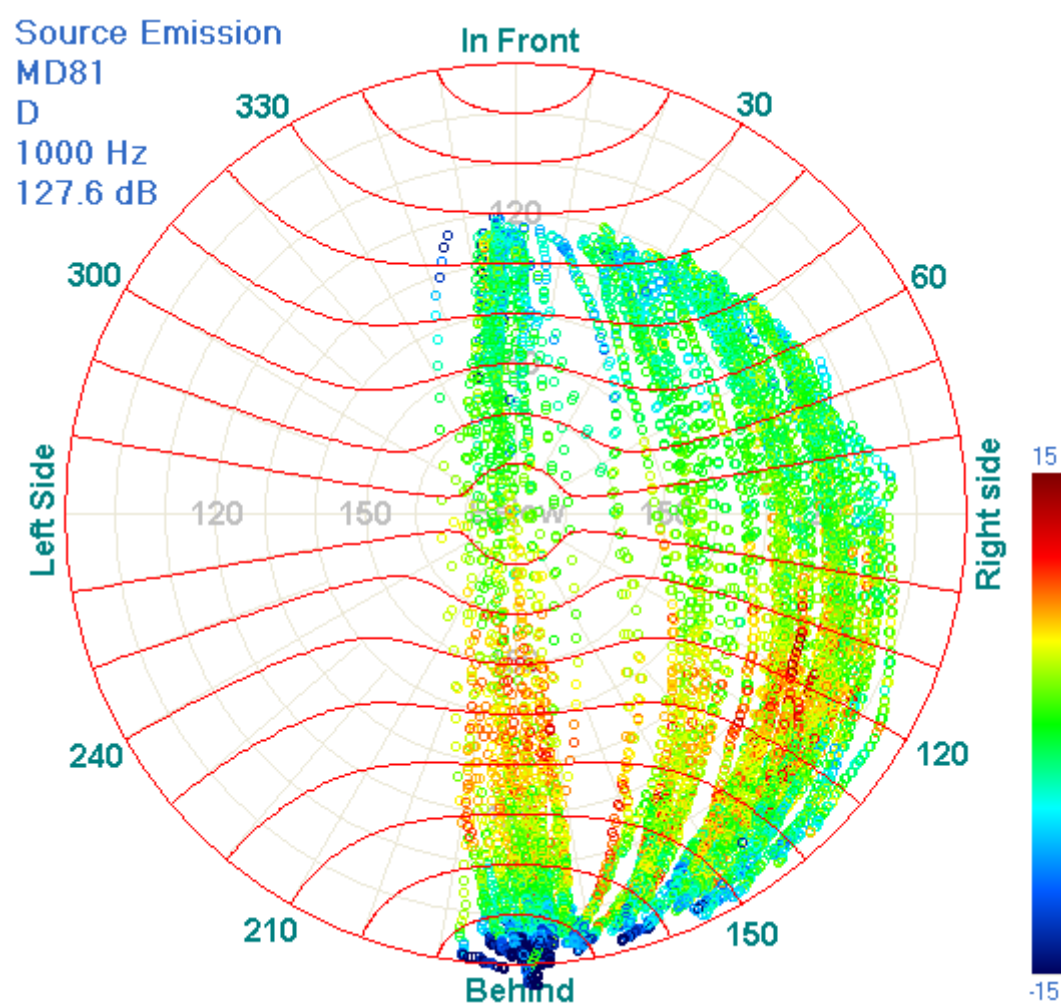




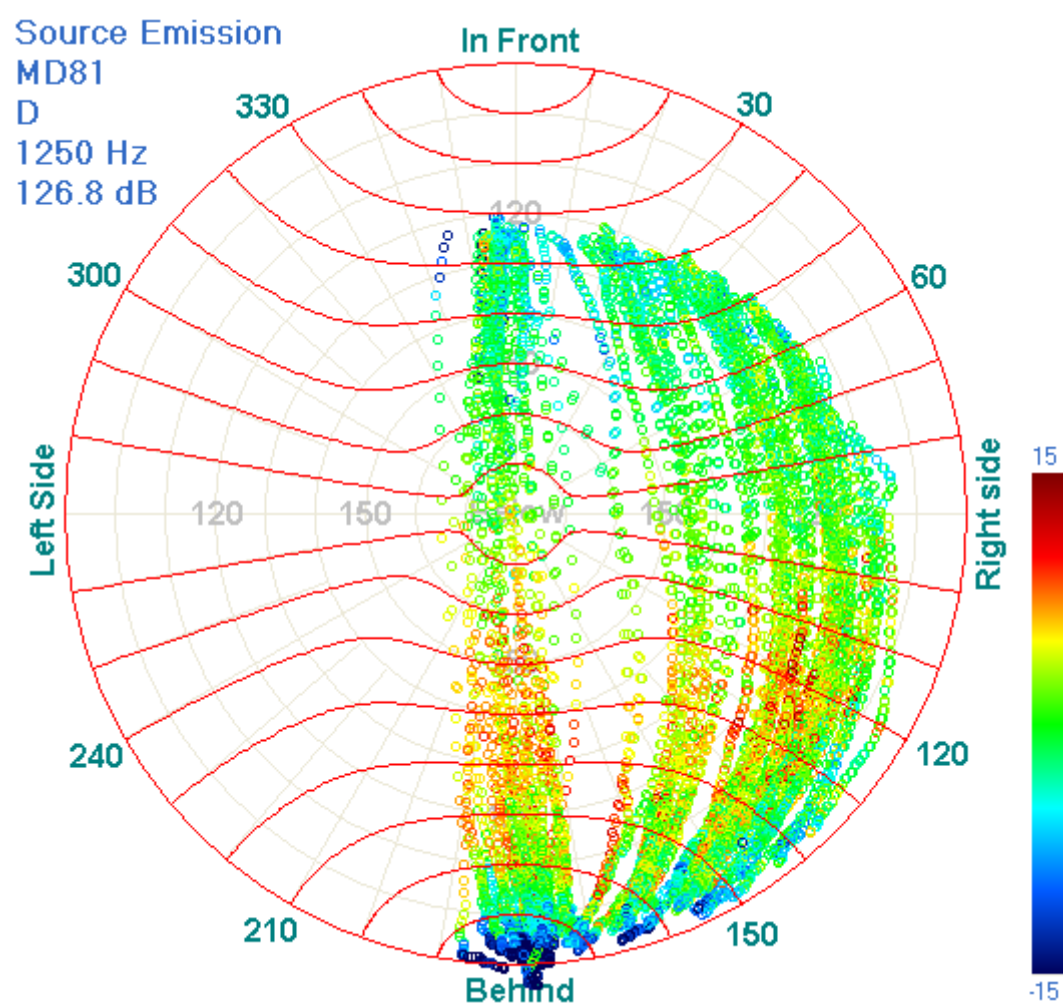


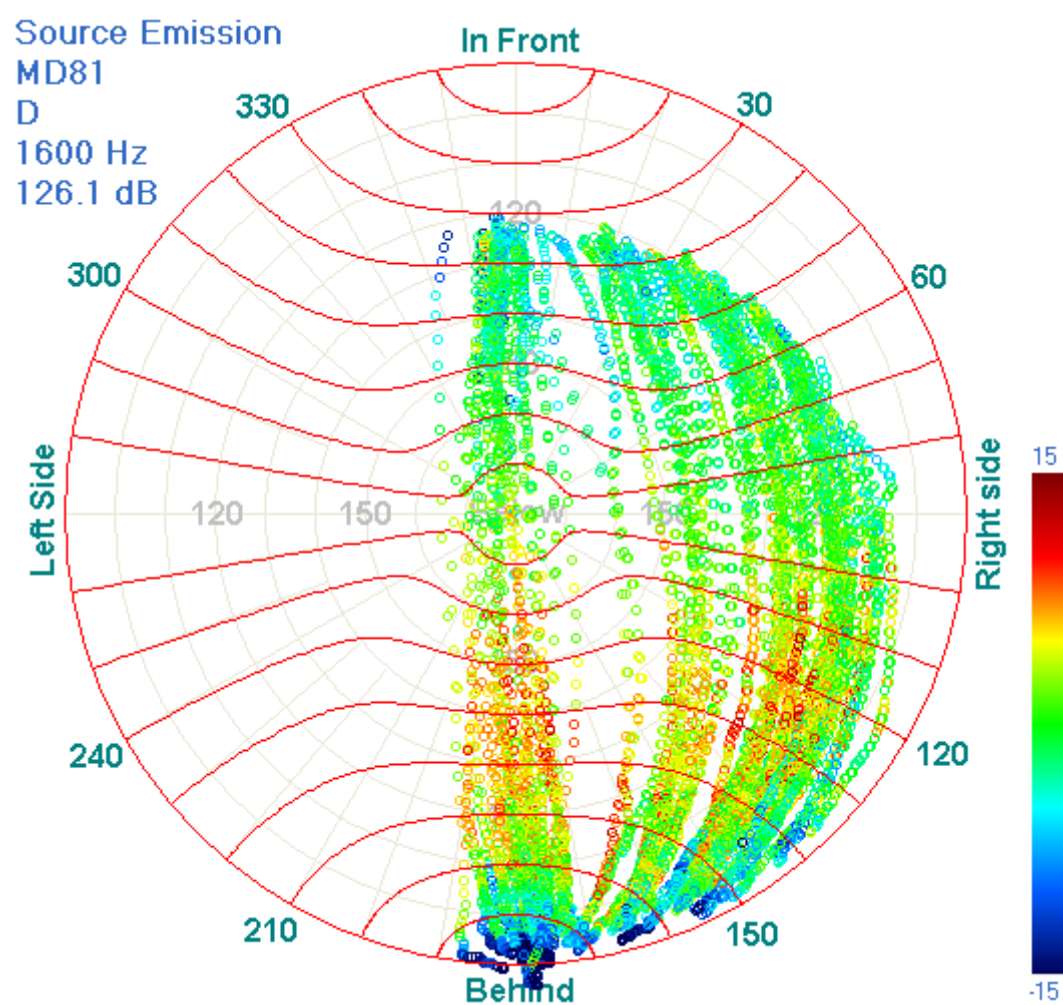




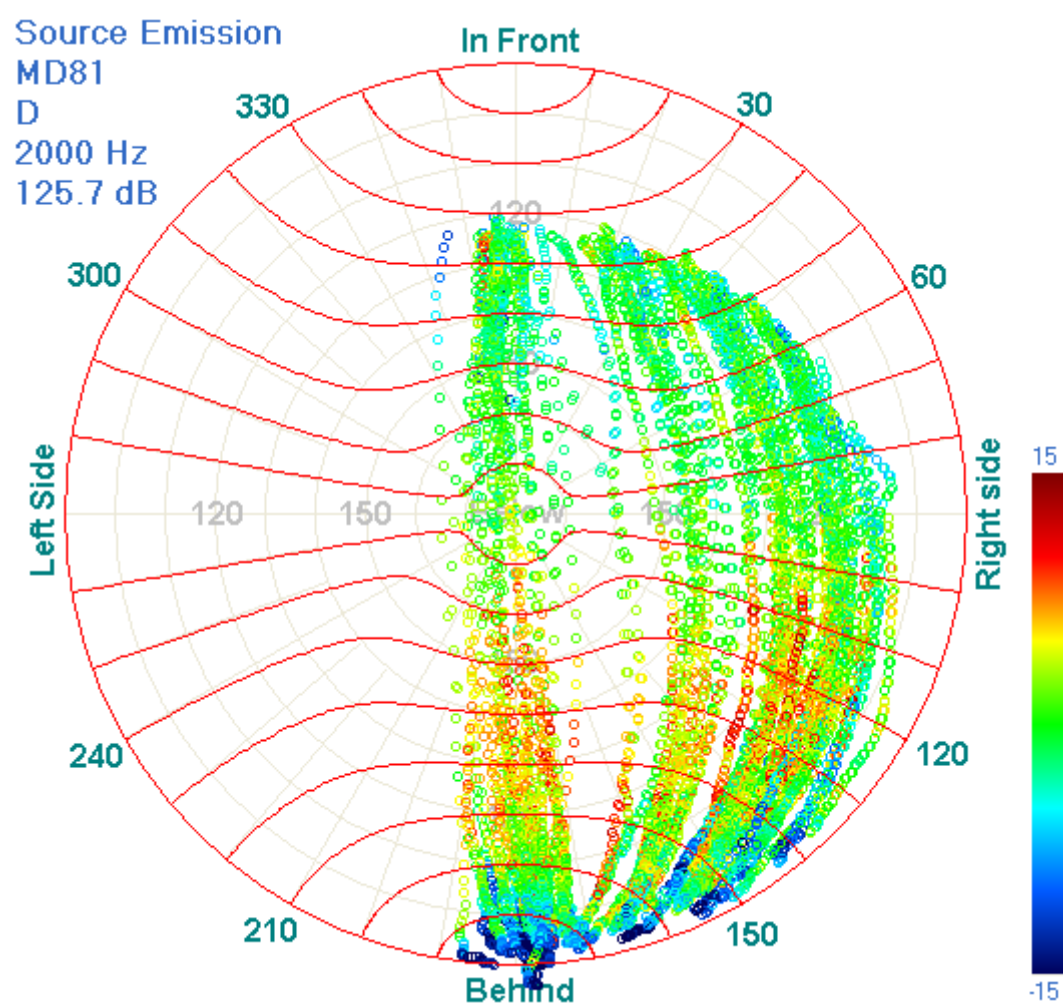


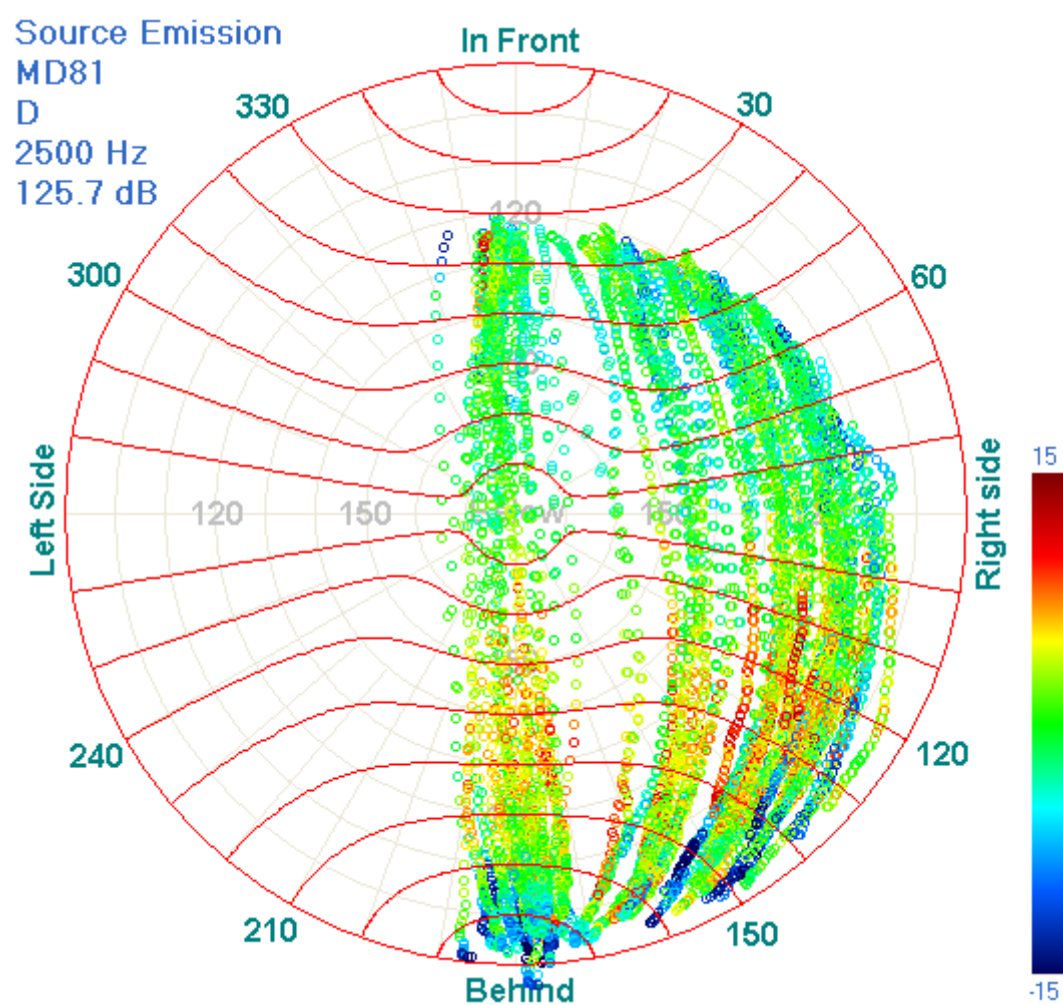




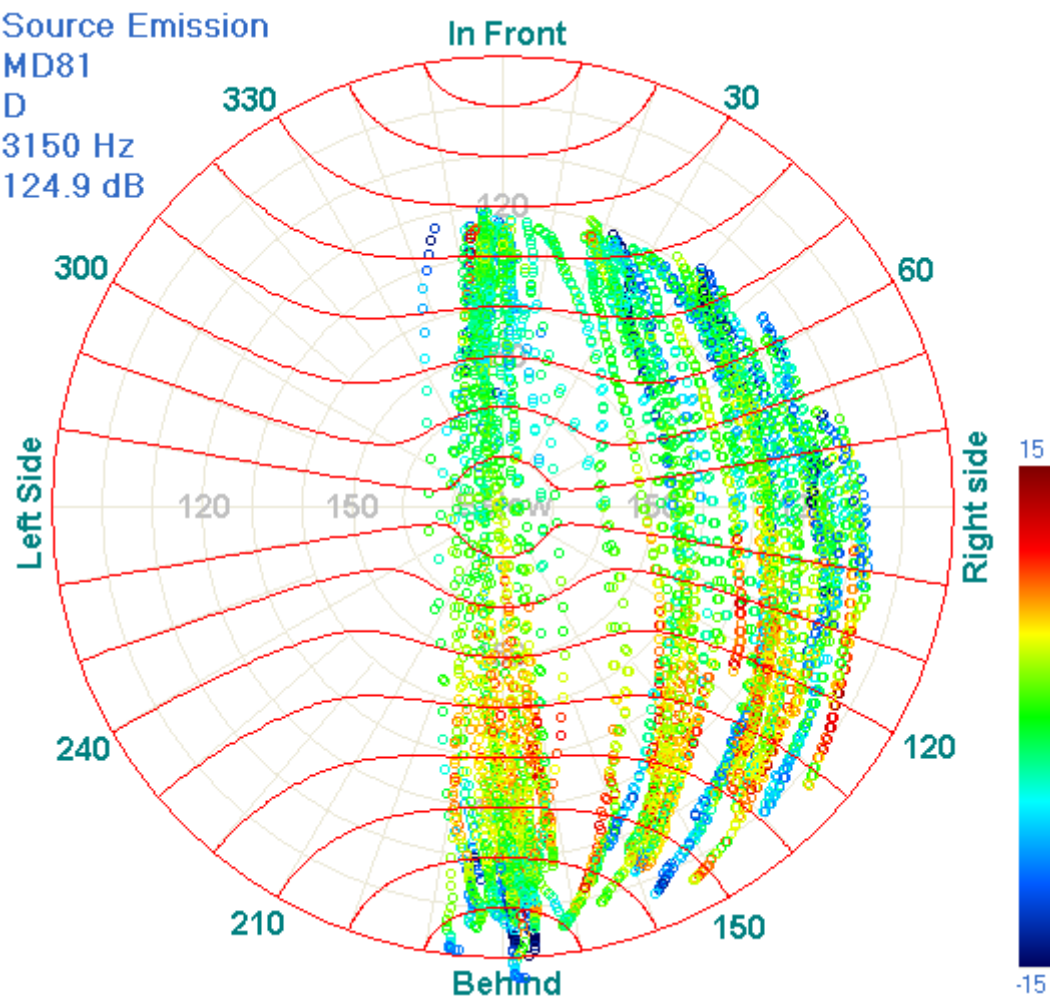




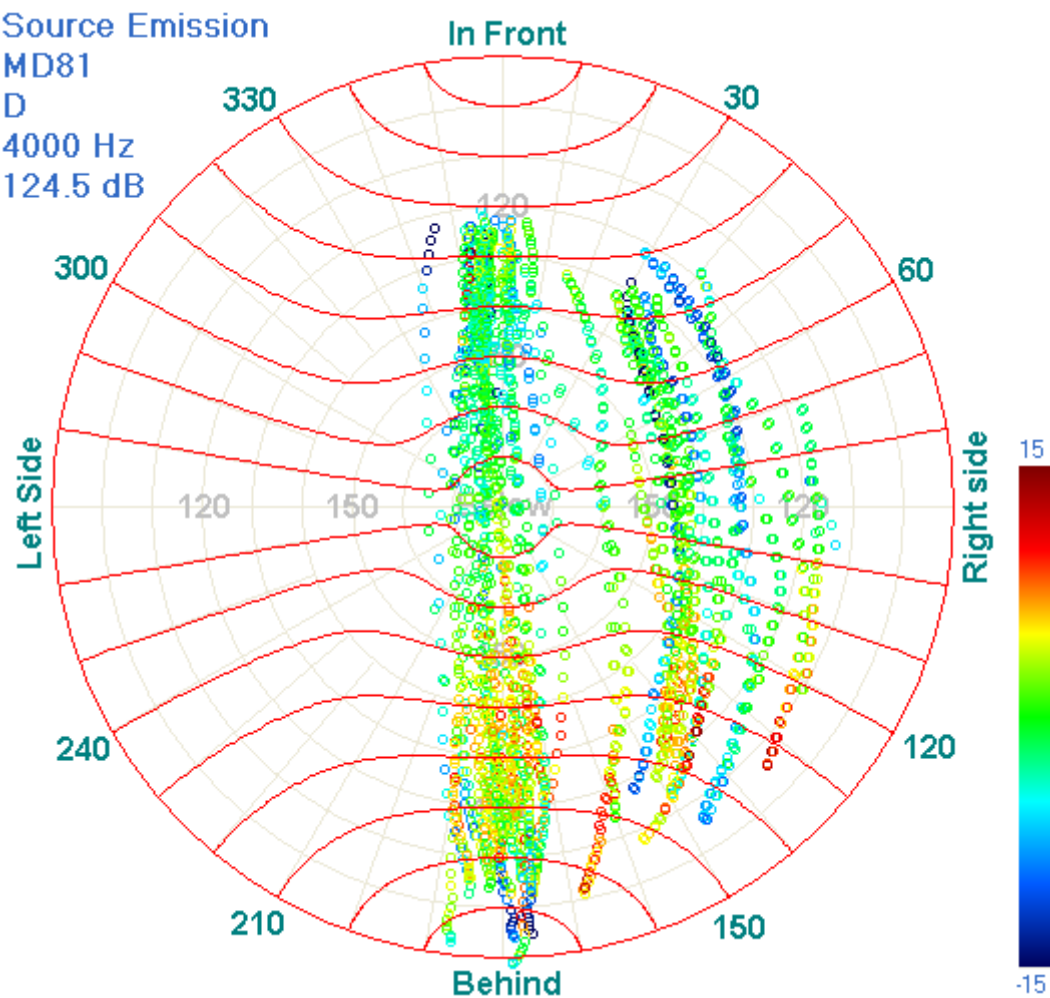




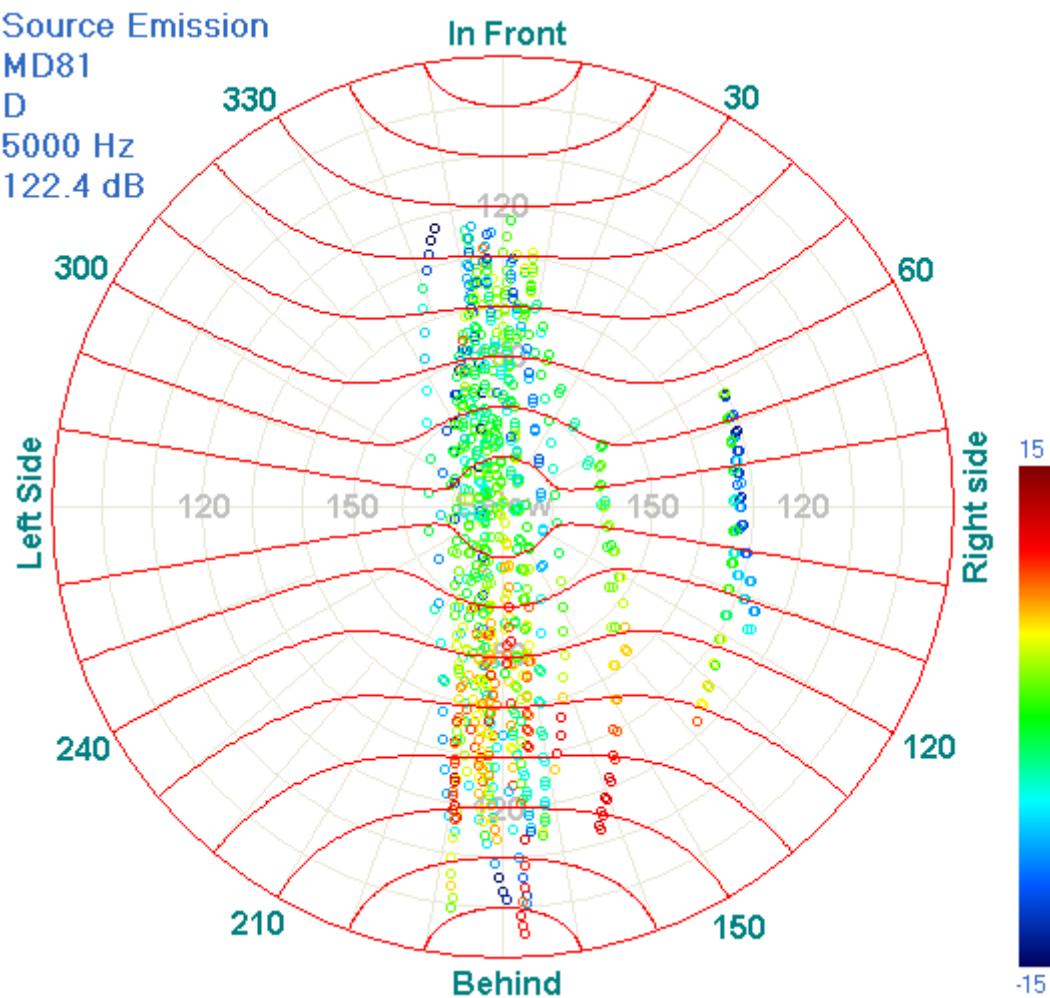
Source Emission  
MD81  
D  
3150 Hz  
124.9 dB

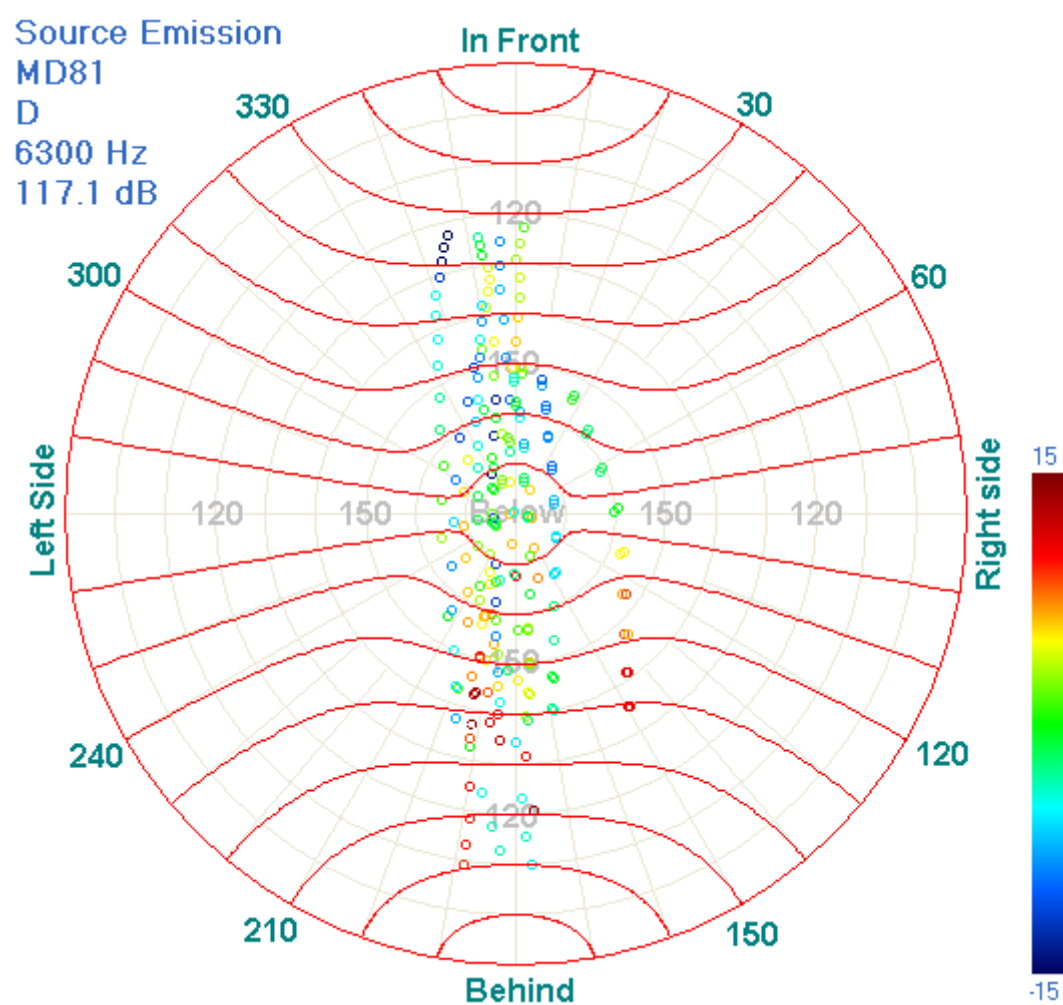


Source Emission  
MD81  
D  
4000 Hz  
124.5 dB

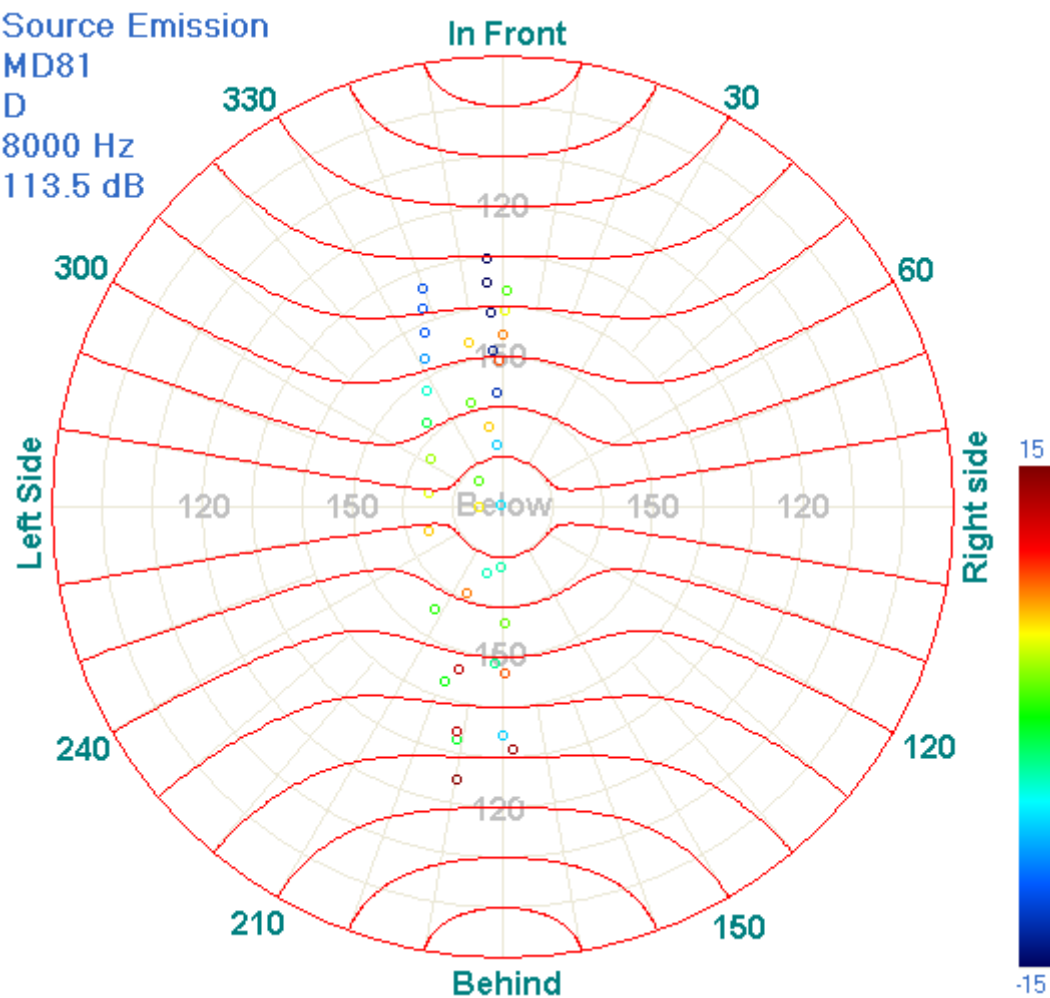


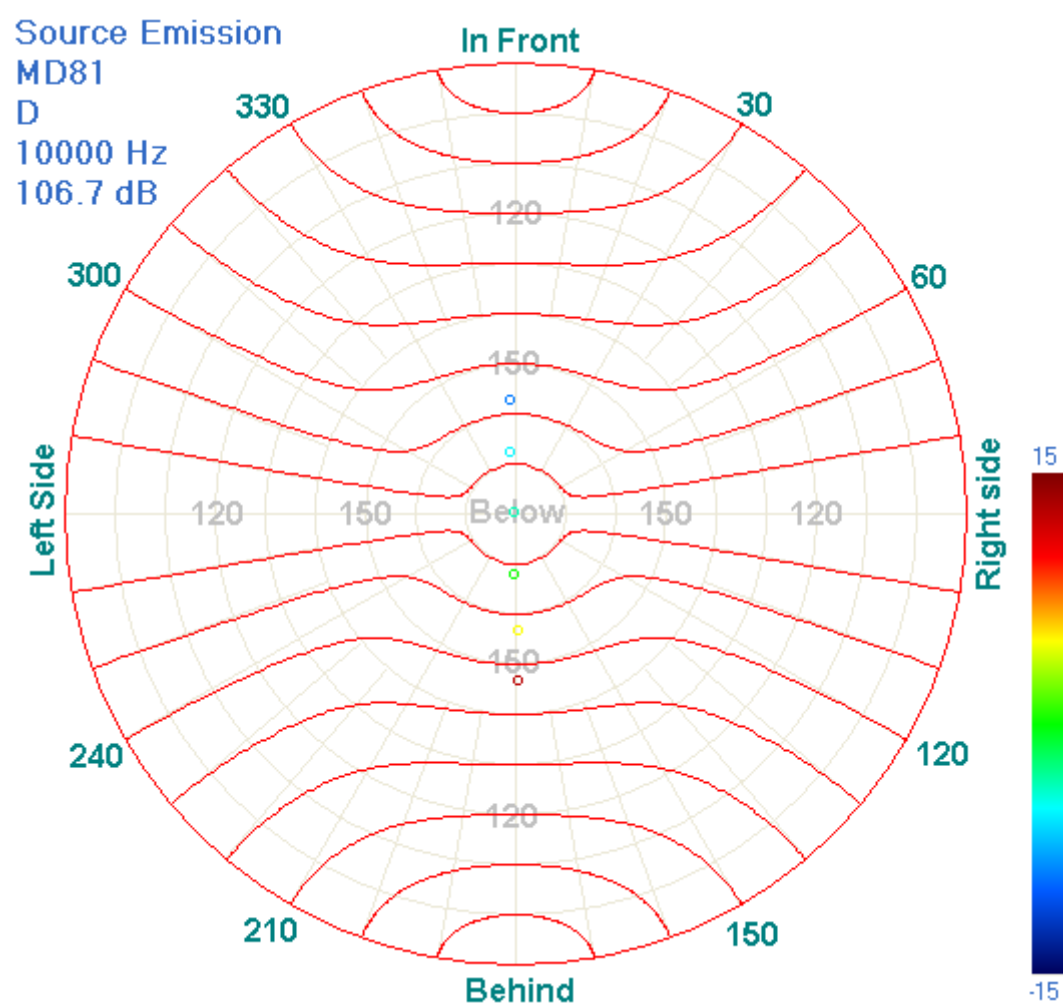
Source Emission  
MD81  
D  
5000 Hz  
122.4 dB





Source Emission  
MD81  
D  
8000 Hz  
113.5 dB





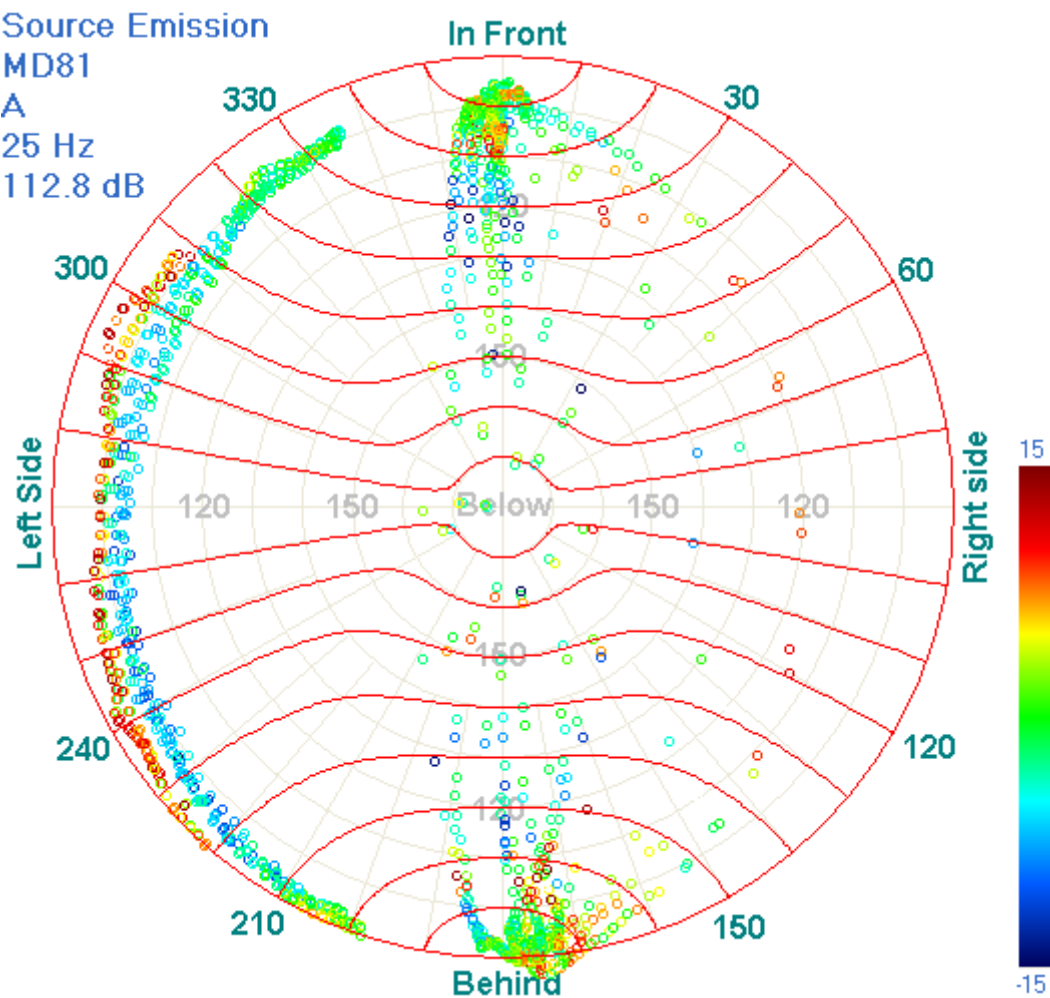


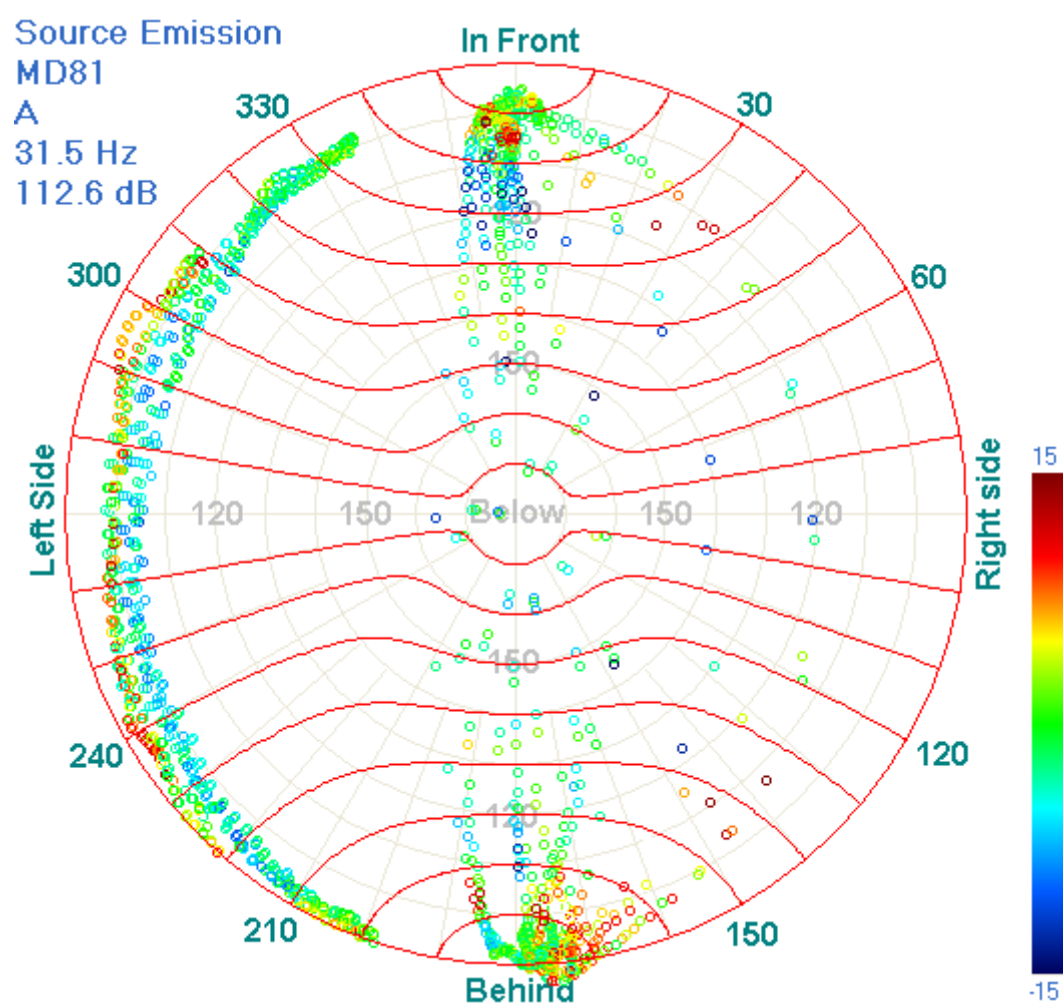
### 13 MD 81 directivity at arrival

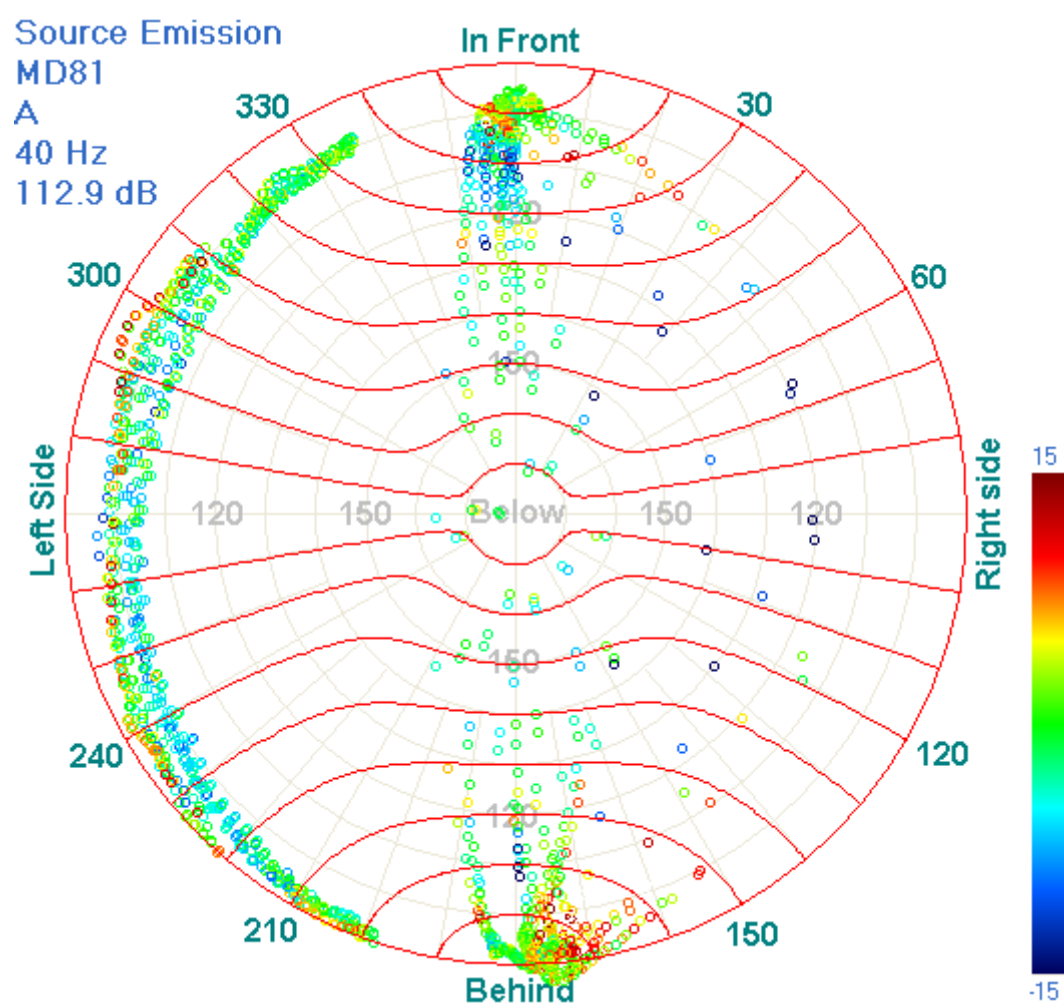
SPECTRUM  
Source Emission  
MD81  
A

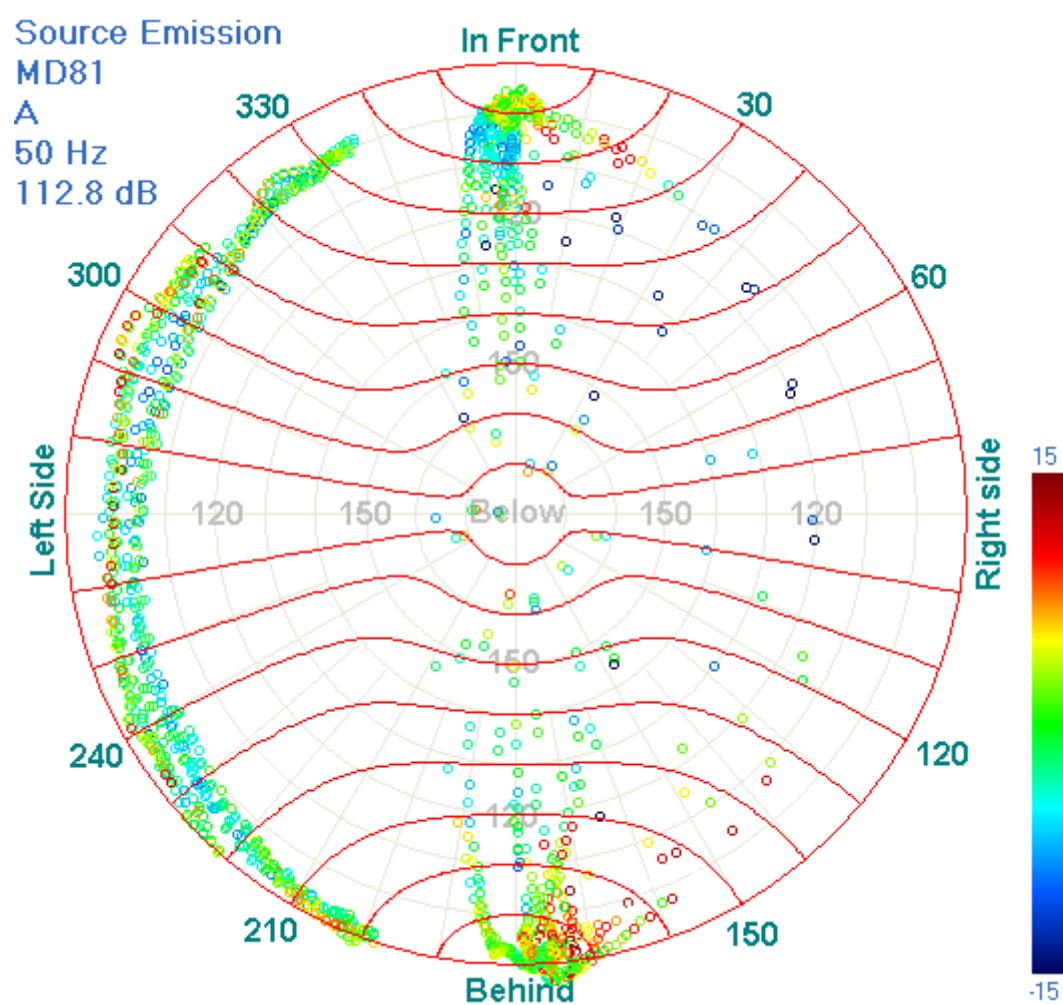
Freq	Num	Avg	Std	95%Avg	P1	P2	P3	P4	P5	P6
25	1617	112.7	5.8	0.3	111.5	113.2	114.6	-1.0	-1.0	-1.0
31.5	1710	112.6	5.6	0.3	111.6	112.8	114.2	-1.0	-1.0	-1.0
40	1730	112.8	5.7	0.3	111.6	113.2	115.2	-1.0	-1.0	-1.0
50	1689	112.7	5.5	0.3	111.7	113.0	115.3	-1.0	-1.0	-1.0
63	1775	112.0	5.5	0.3	110.7	112.5	114.8	-1.0	-1.0	-1.0
80	1992	112.1	6.0	0.3	110.5	112.7	114.2	-1.0	-1.0	-1.0
100	2065	111.6	5.7	0.2	110.3	112.3	113.5	-1.0	-1.0	-1.0
125	2102	112.2	5.6	0.2	111.1	112.7	114.5	-1.0	-1.0	-1.0
160	2220	113.3	5.4	0.2	112.0	113.9	115.2	-1.0	-1.0	-1.0
200	2201	113.6	4.8	0.2	112.4	114.1	115.2	-1.0	-1.0	-1.0
250	2243	113.2	4.9	0.2	112.1	113.7	114.5	-1.0	-1.0	-1.0
315	2237	112.9	5.1	0.2	111.9	113.5	114.0	-1.0	-1.0	-1.0
400	2228	111.6	4.8	0.2	110.7	112.0	112.7	-1.0	-1.0	-1.0
500	2189	110.9	4.5	0.2	109.9	111.4	112.4	-1.0	-1.0	-1.0
630	2231	111.1	4.4	0.2	110.0	111.6	112.5	-1.0	-1.0	-1.0
800	2196	110.8	4.3	0.2	109.7	111.3	111.9	-1.0	-1.0	-1.0
1000	2191	110.1	4.4	0.2	109.2	110.6	111.0	-1.0	-1.0	-1.0
1250	2226	109.7	4.6	0.2	108.7	110.2	110.5	-1.0	-1.0	-1.0
1600	2225	109.1	4.6	0.2	108.2	109.6	109.8	-1.0	-1.0	-1.0
2000	2225	108.8	5.0	0.2	108.0	109.2	109.8	-1.0	-1.0	-1.0
2500	2204	109.0	5.4	0.2	108.2	109.3	110.0	-1.0	-1.0	-1.0
3150	2099	110.5	6.2	0.3	110.0	110.7	111.4	-1.0	-1.0	-1.0
4000	1748	112.6	7.1	0.3	111.1	112.9	116.5	-1.0	-1.0	-1.0
5000	1052	112.7	7.0	0.4	113.7	112.5	110.4	-1.0	-1.0	-1.0
6300	596	115.1	8.5	0.7	114.7	115.6	112.1	-1.0	-1.0	-1.0
8000	332	116.9	11.1	1.2	116.6	117.3	112.8	-1.0	-1.0	-1.0
10000	207	118.0	15.1	2.1	118.5	117.6	135.0	-1.0	-1.0	-1.0

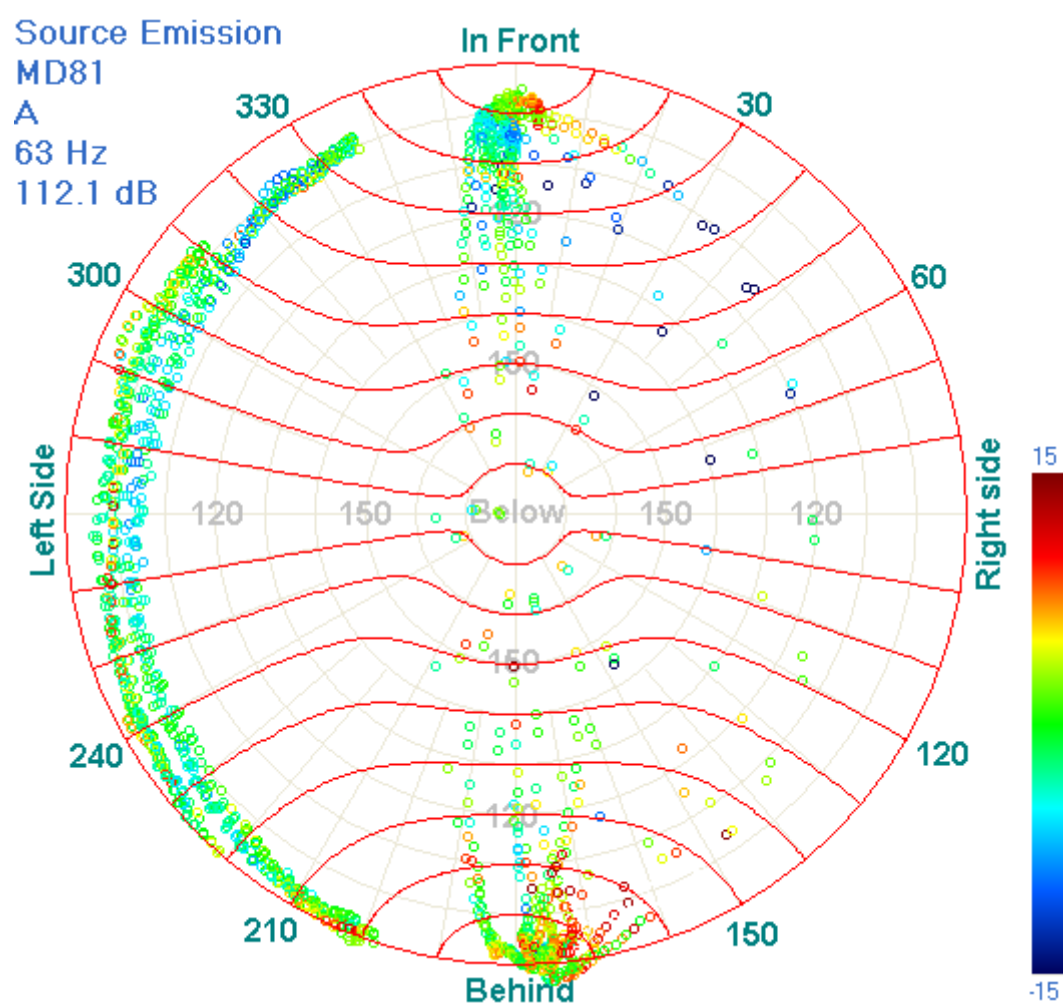
Source Emission  
MD81  
A  
25 Hz  
112.8 dB

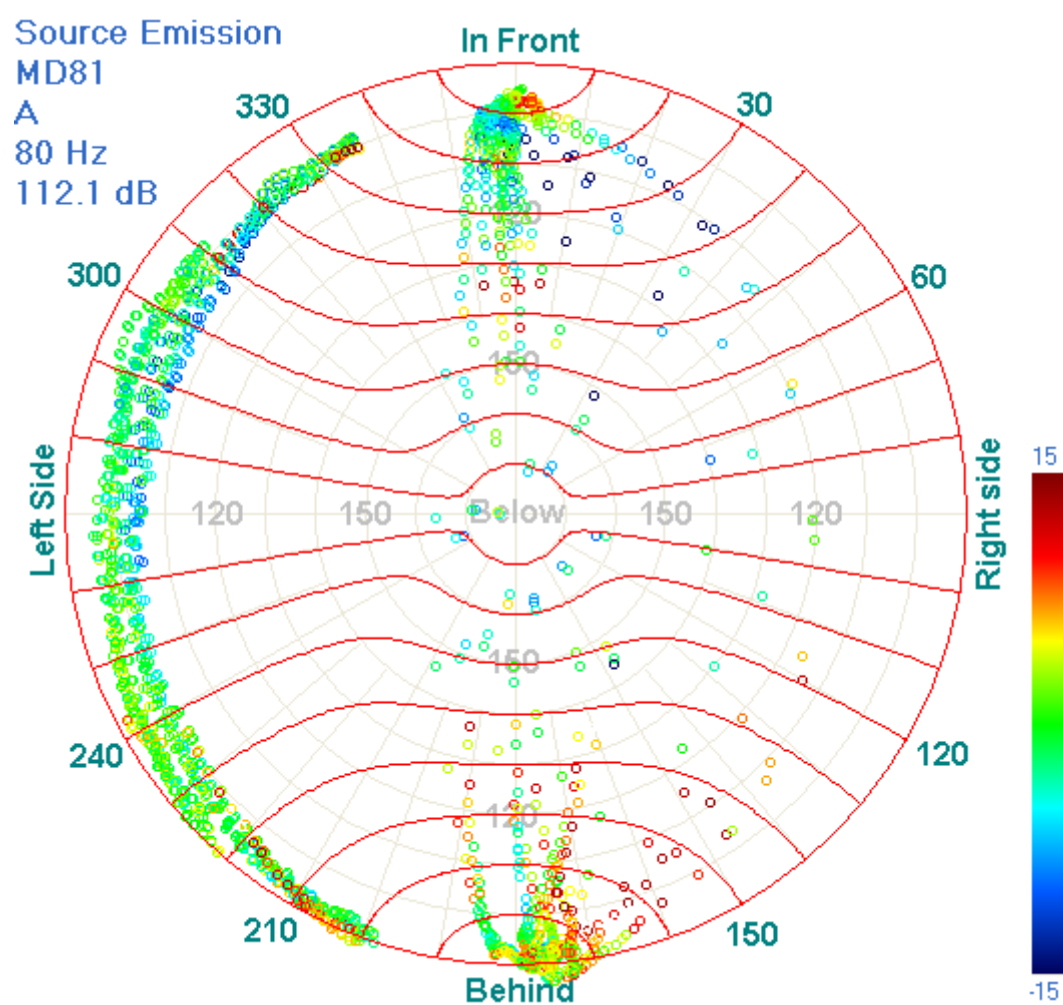


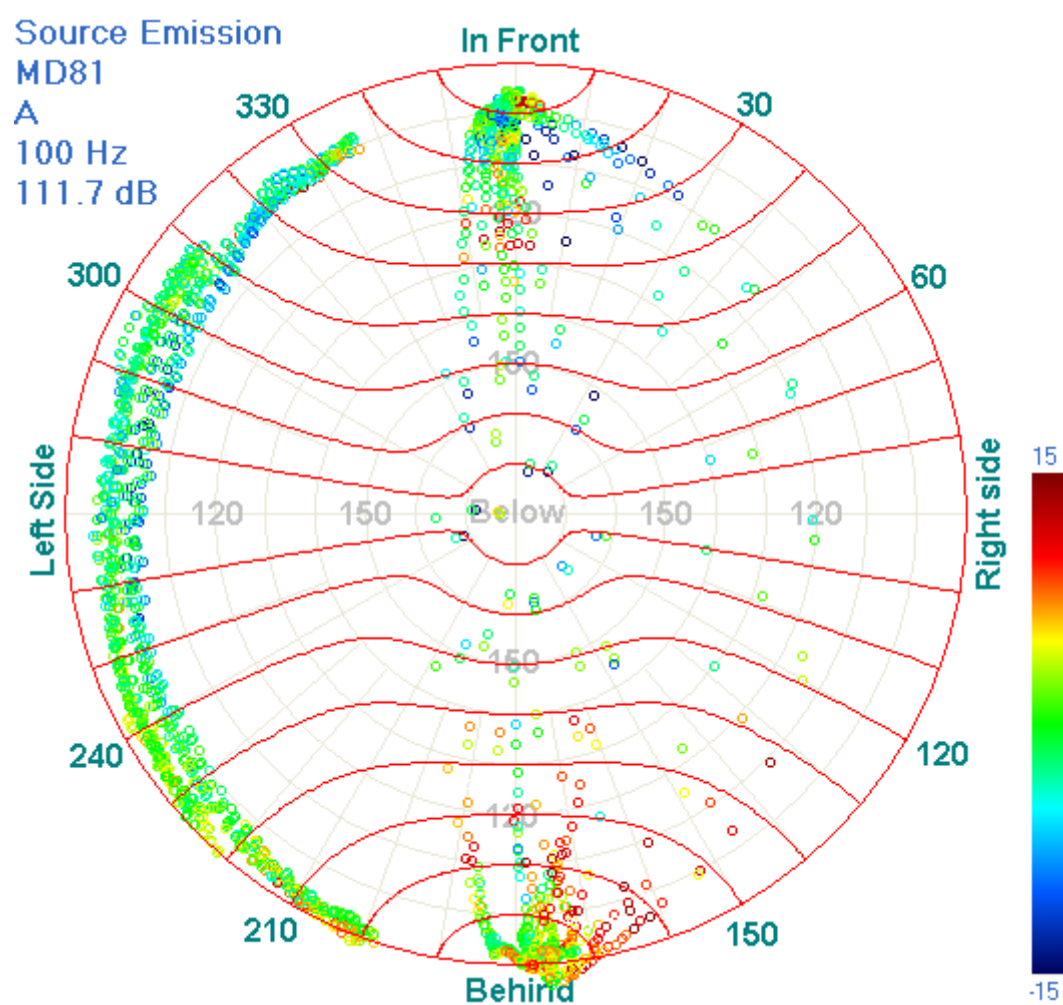






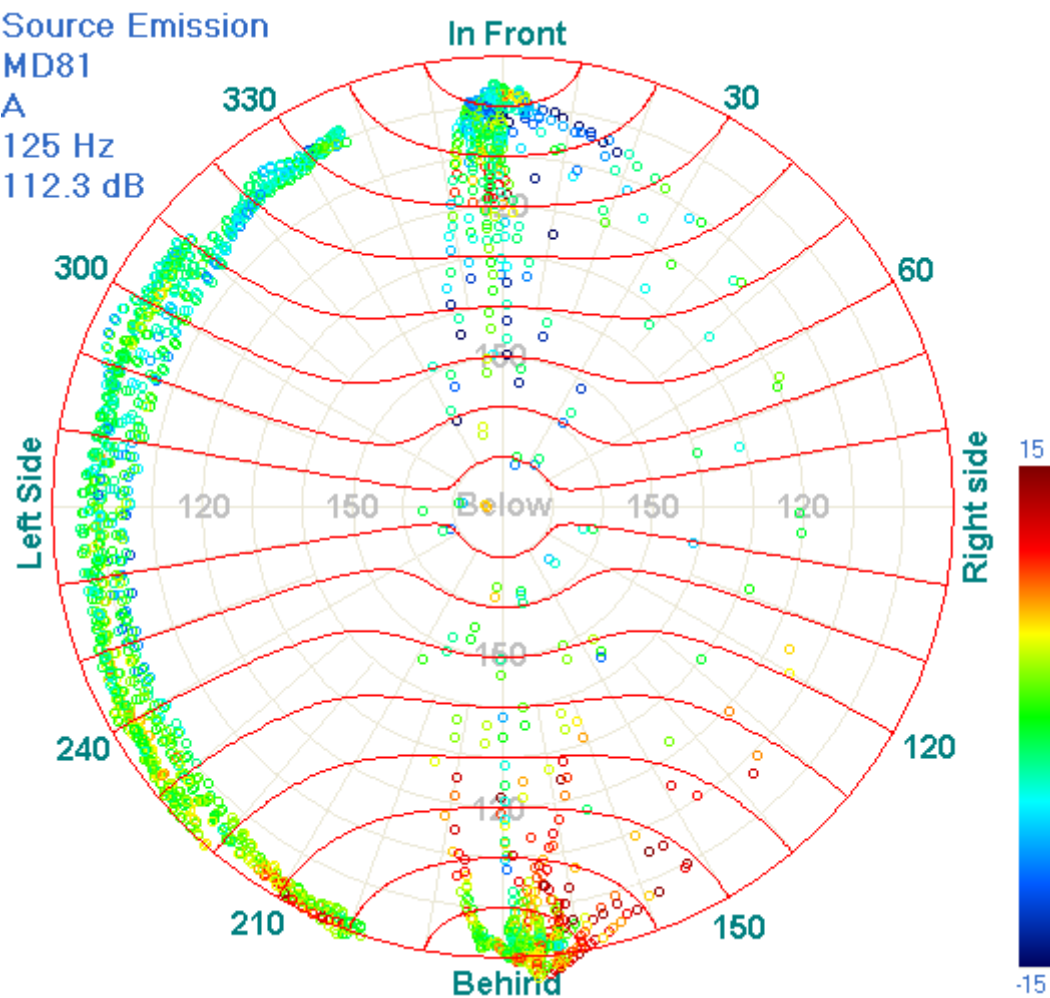


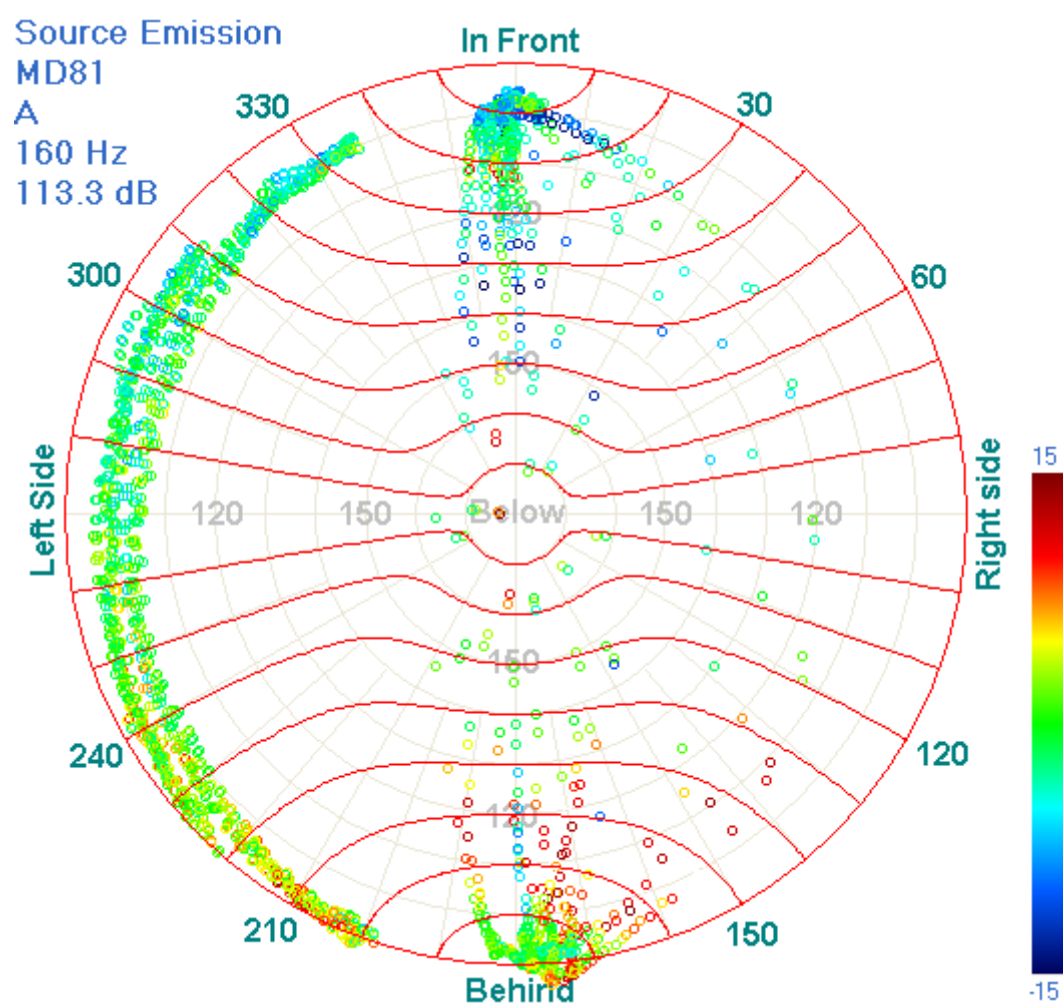


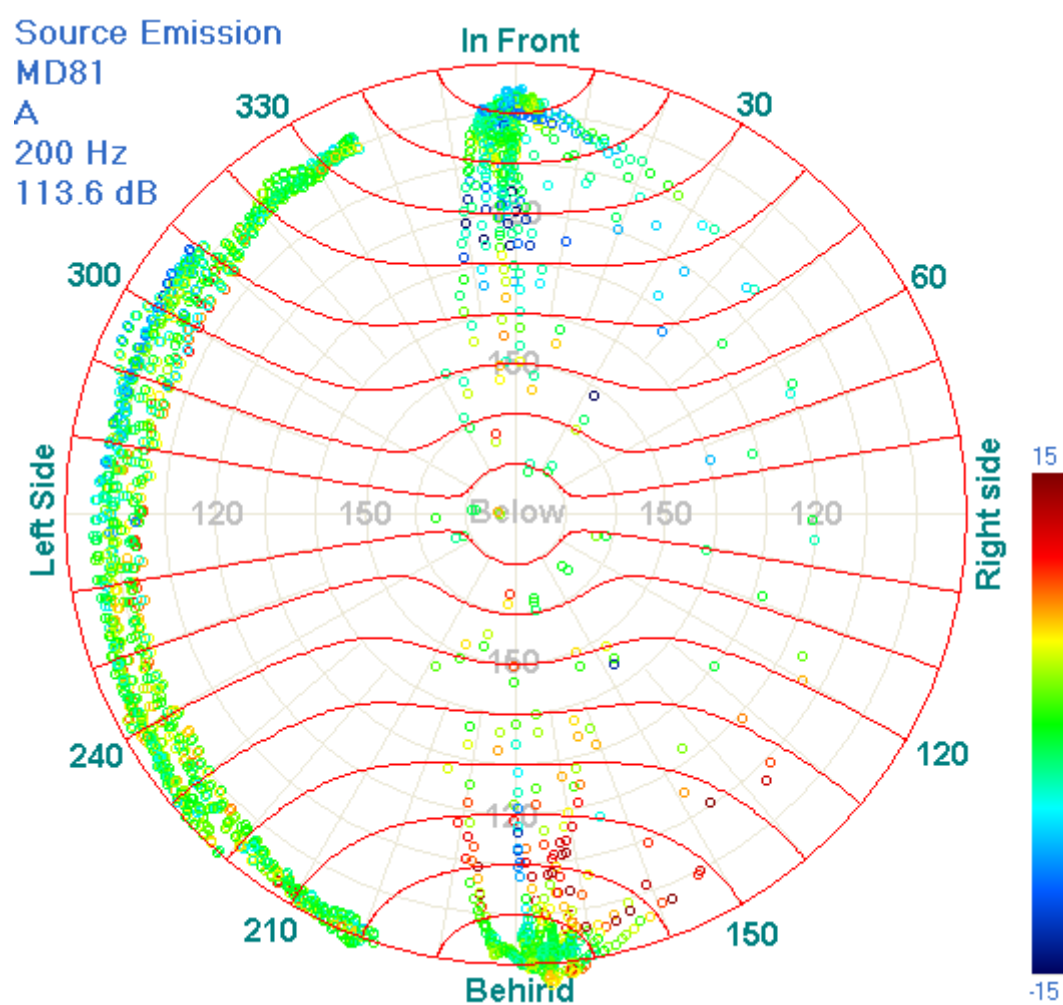


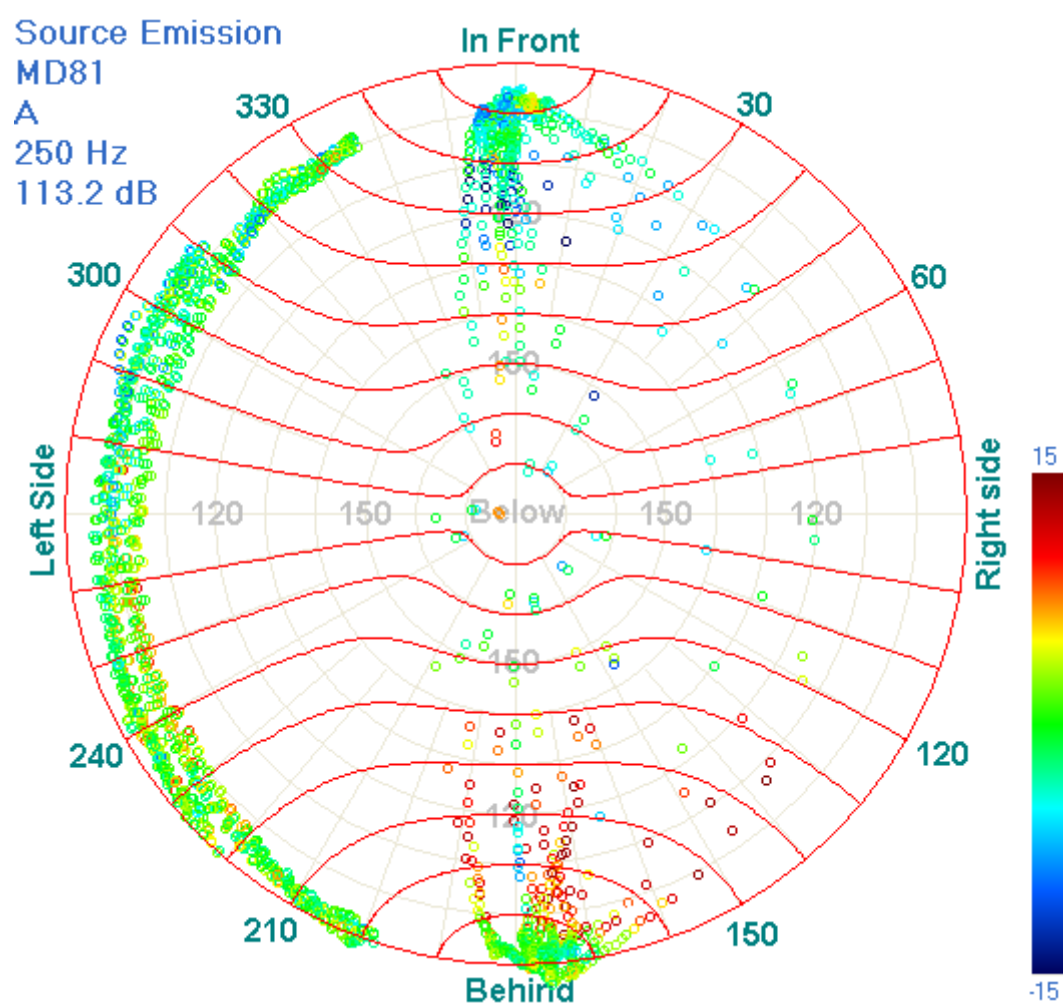


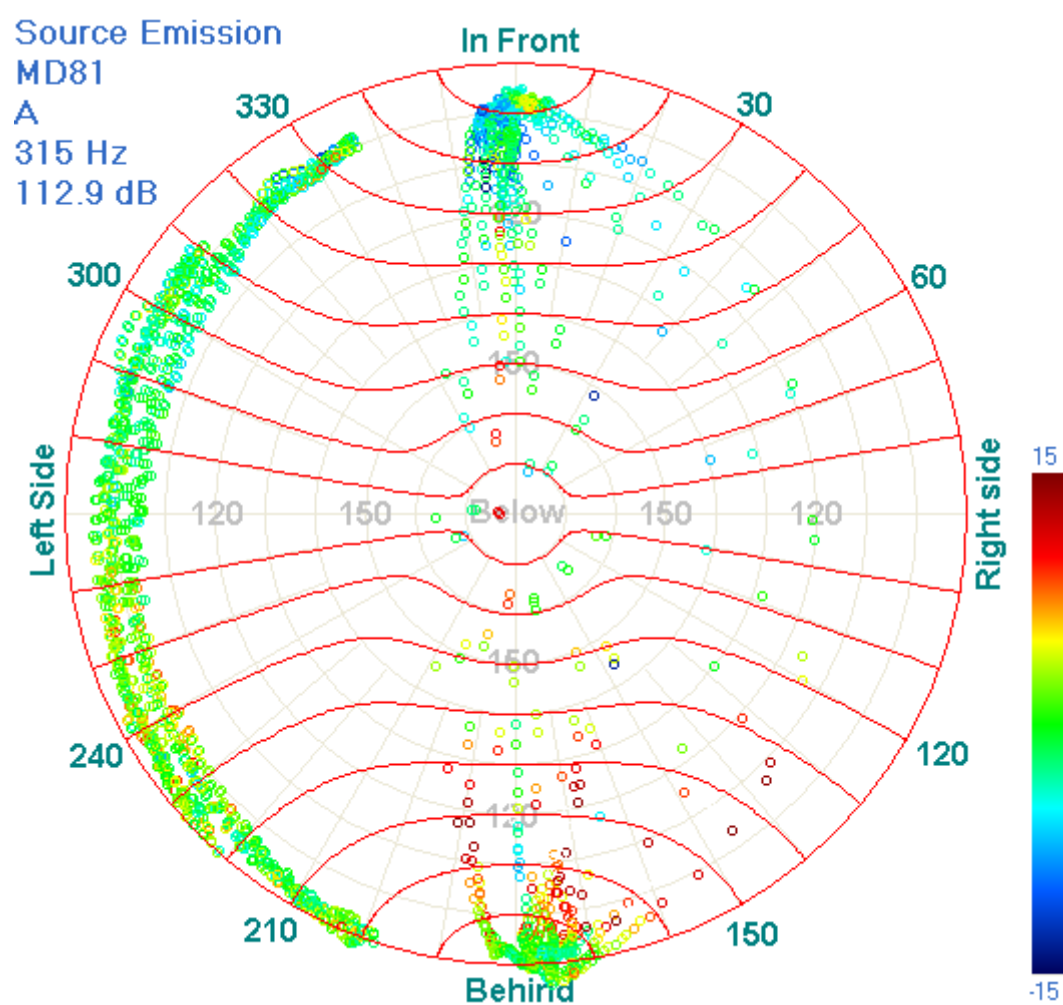
Source Emission  
MD81  
A  
125 Hz  
112.3 dB

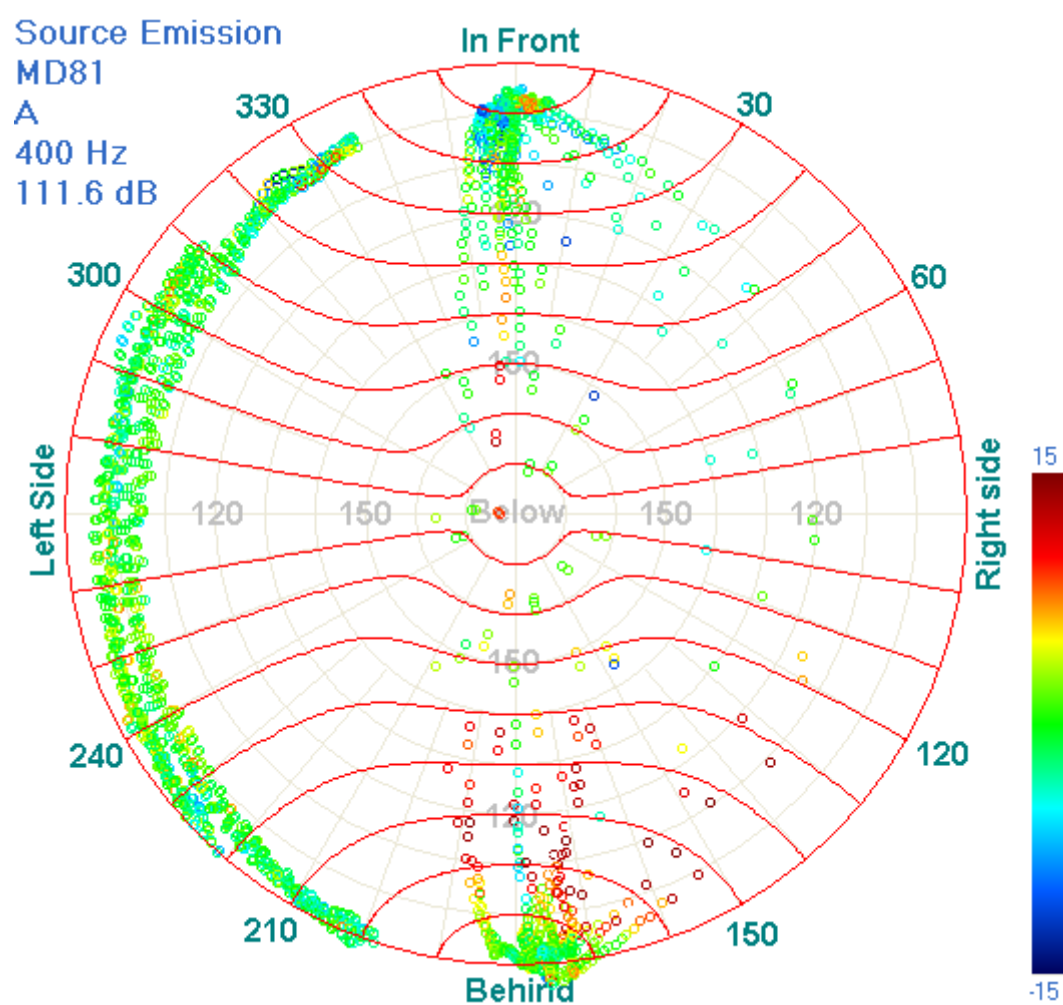


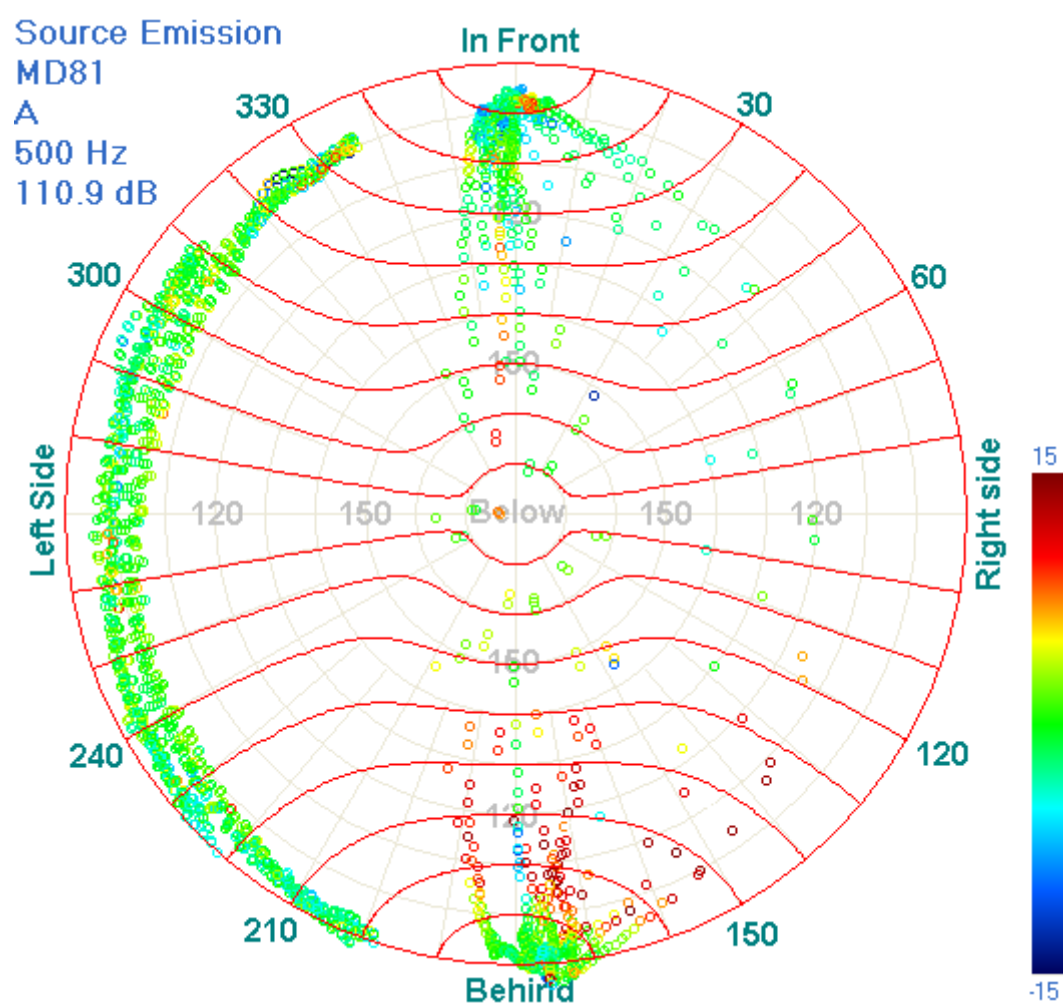


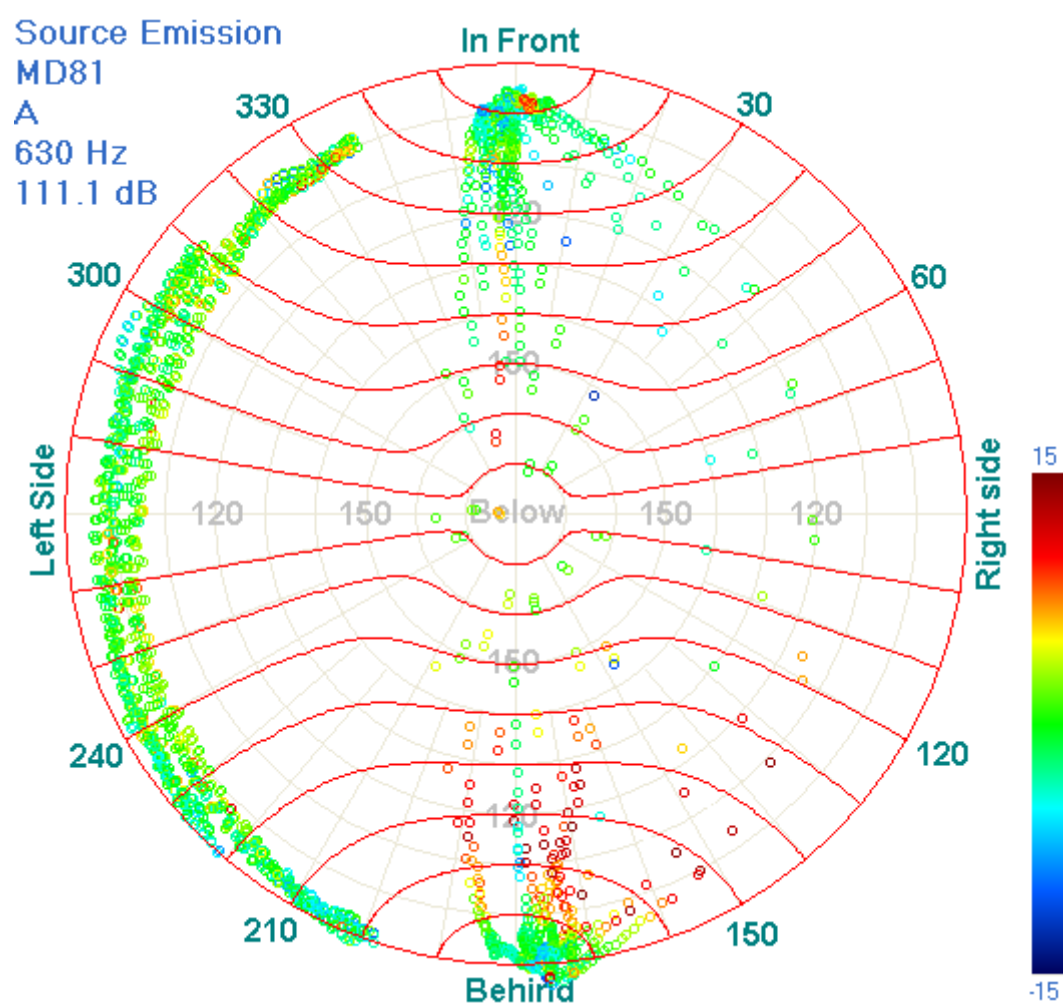




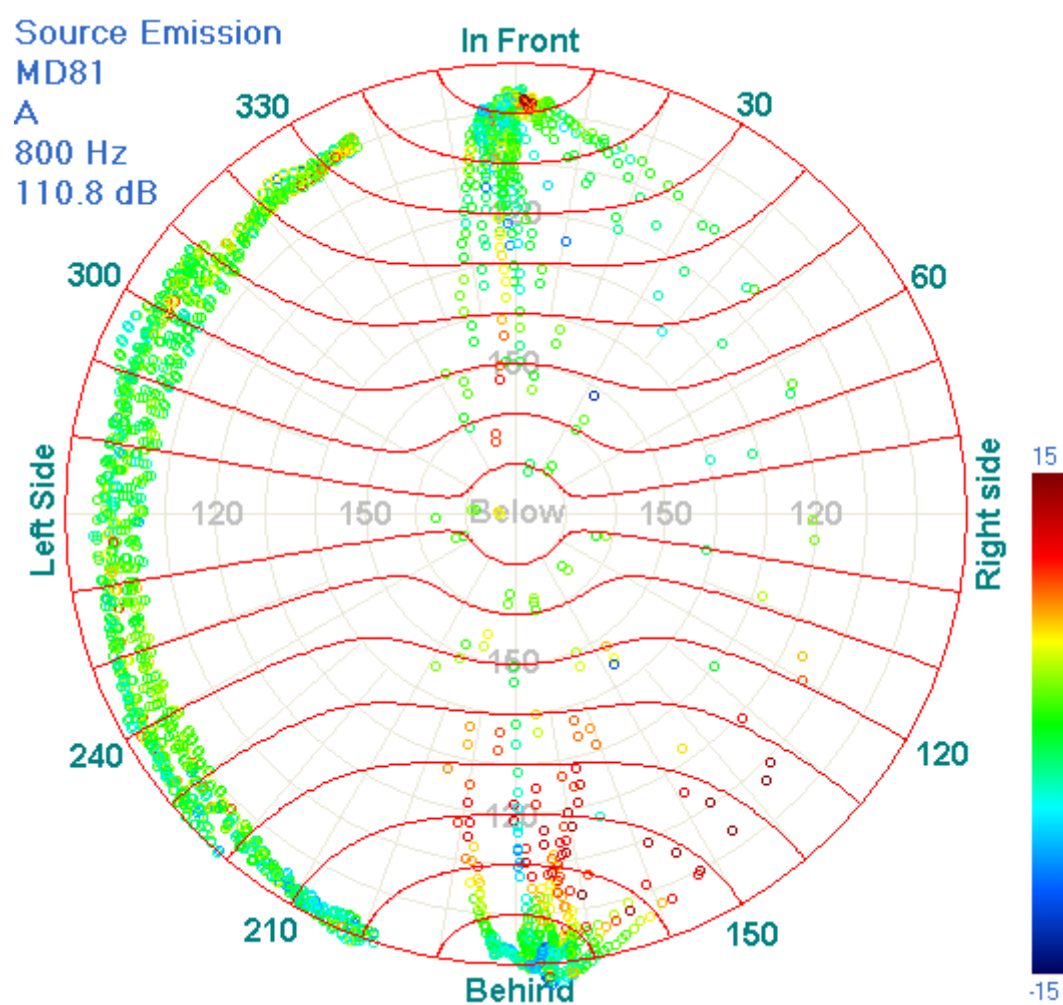


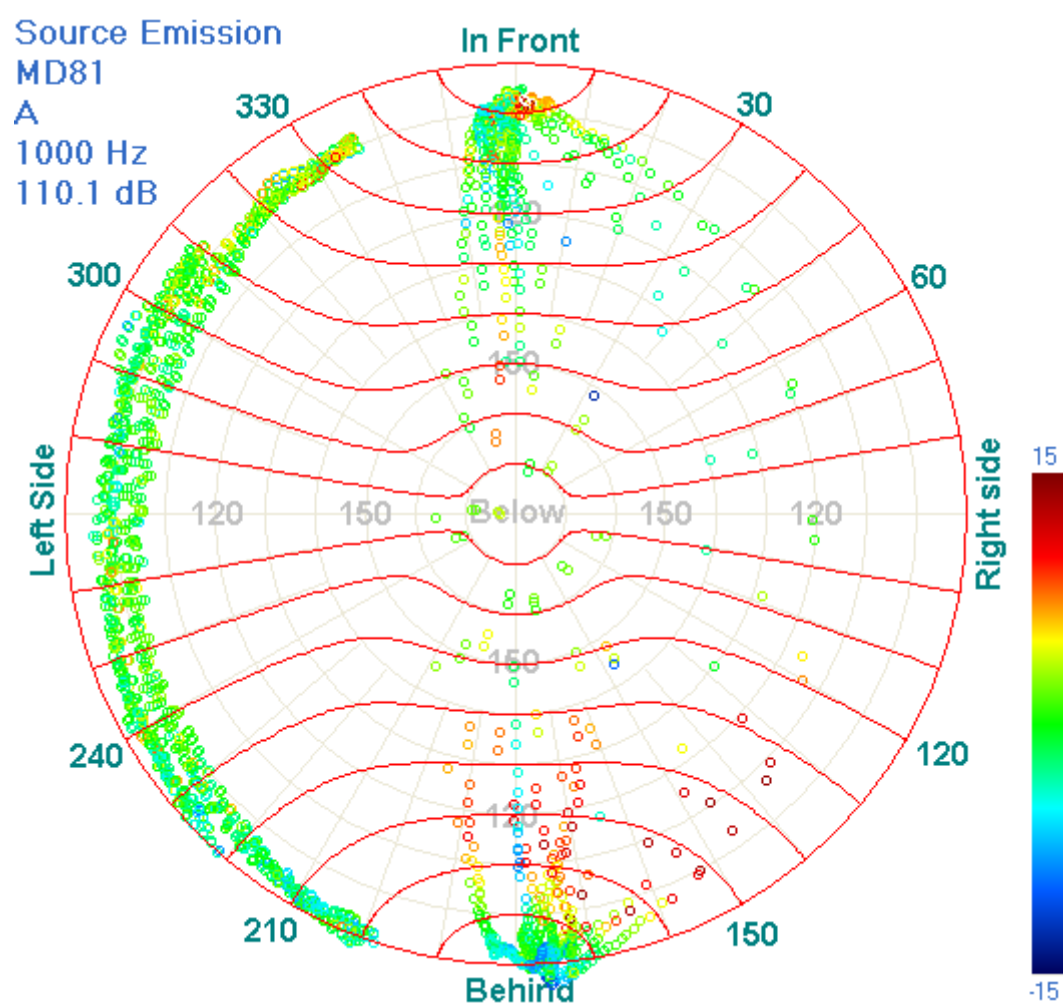


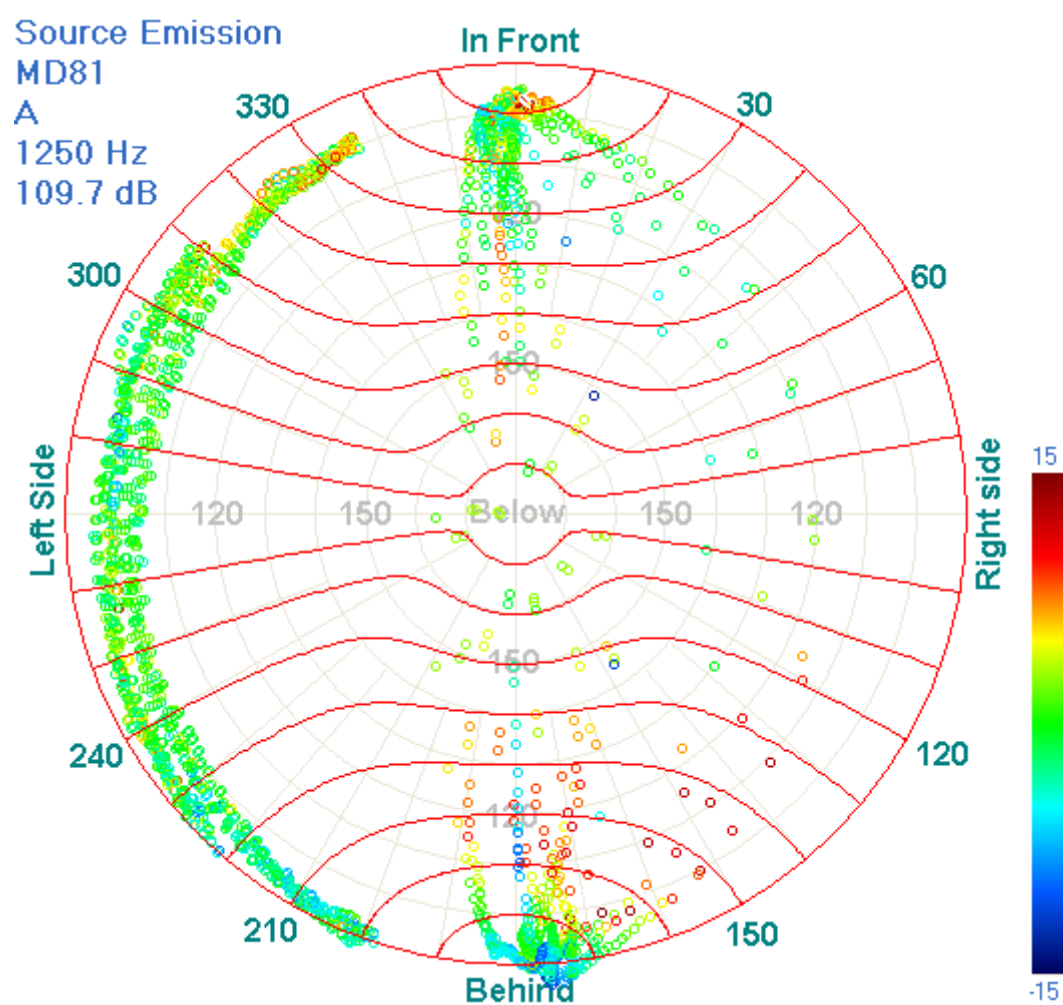


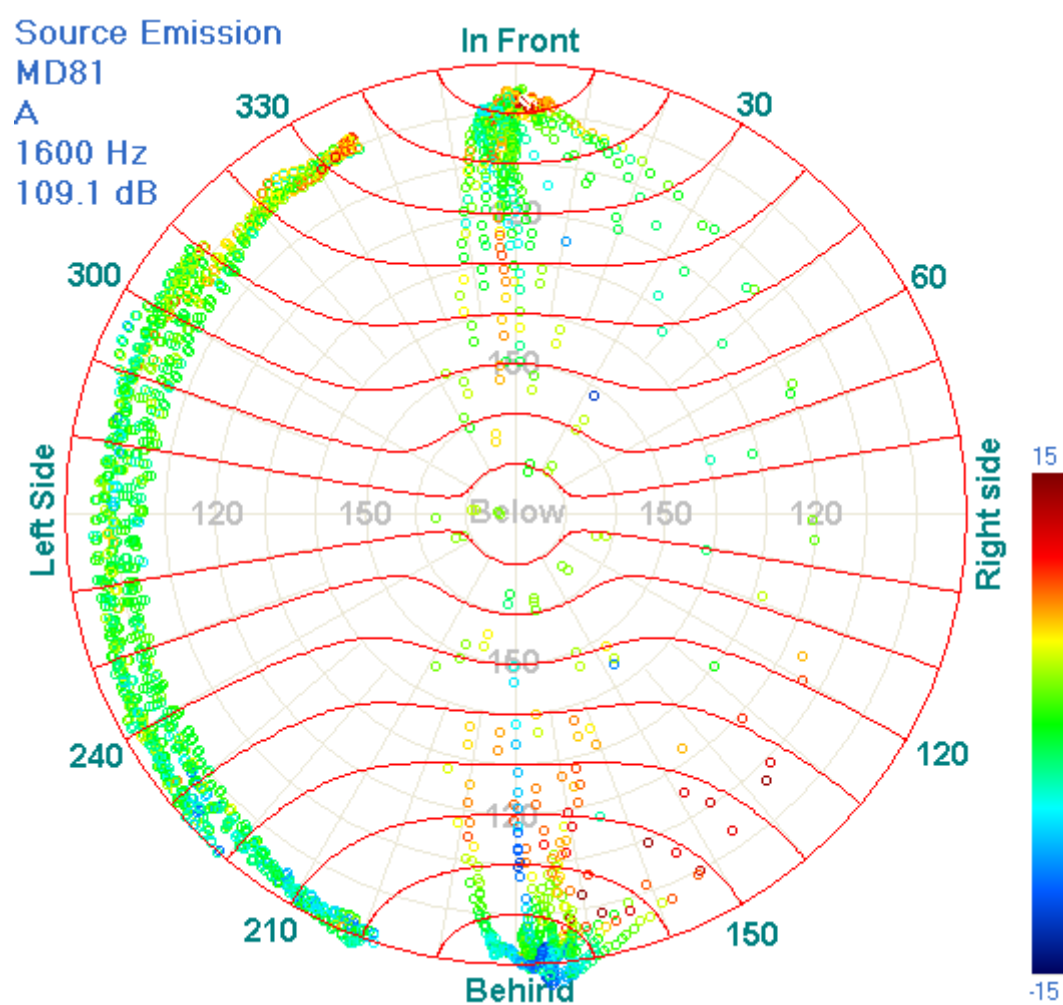


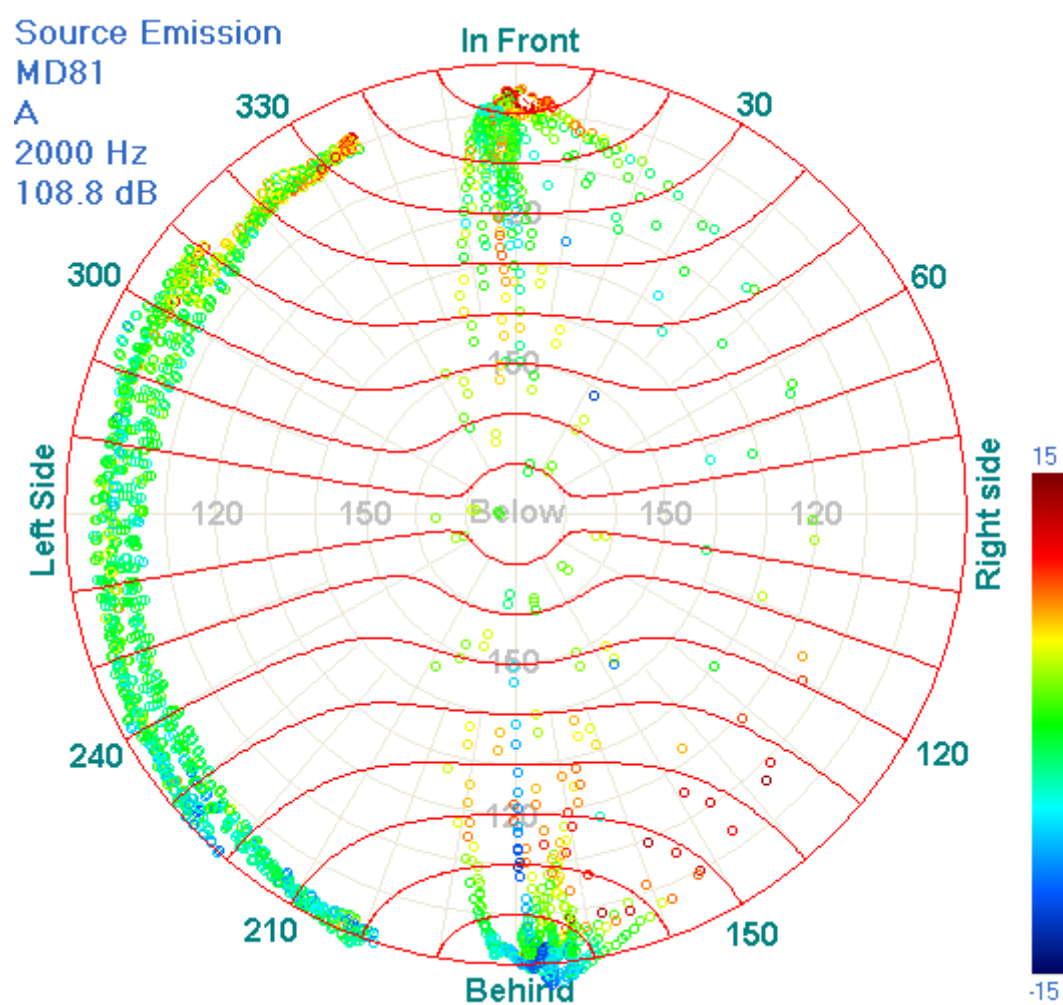


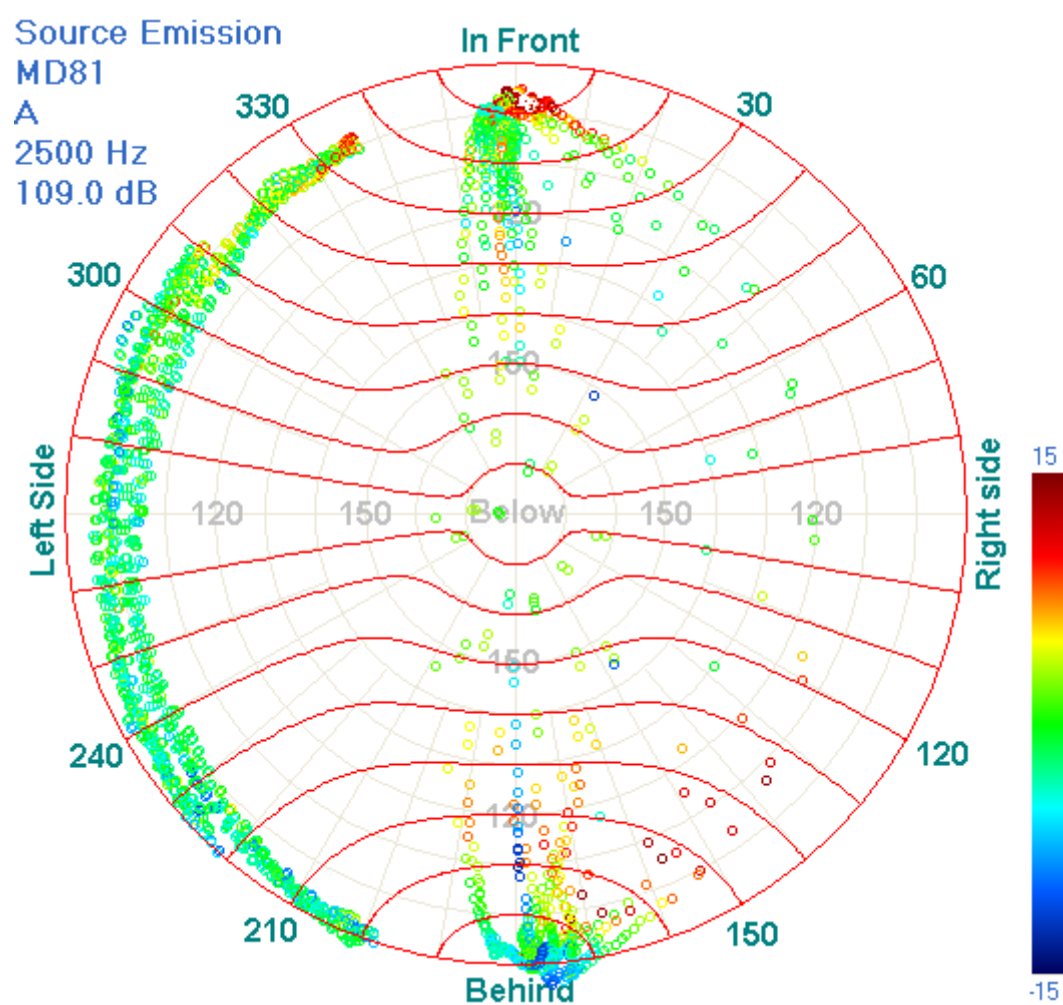


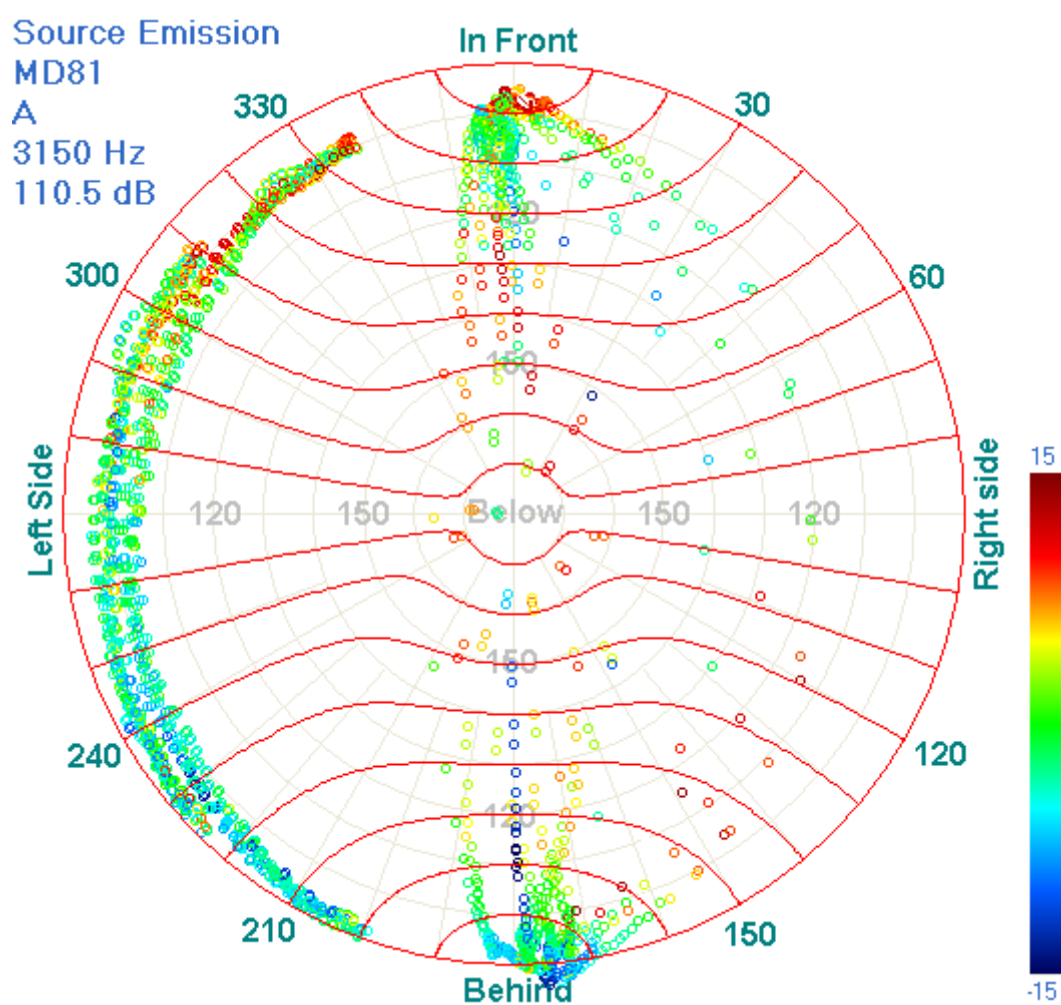


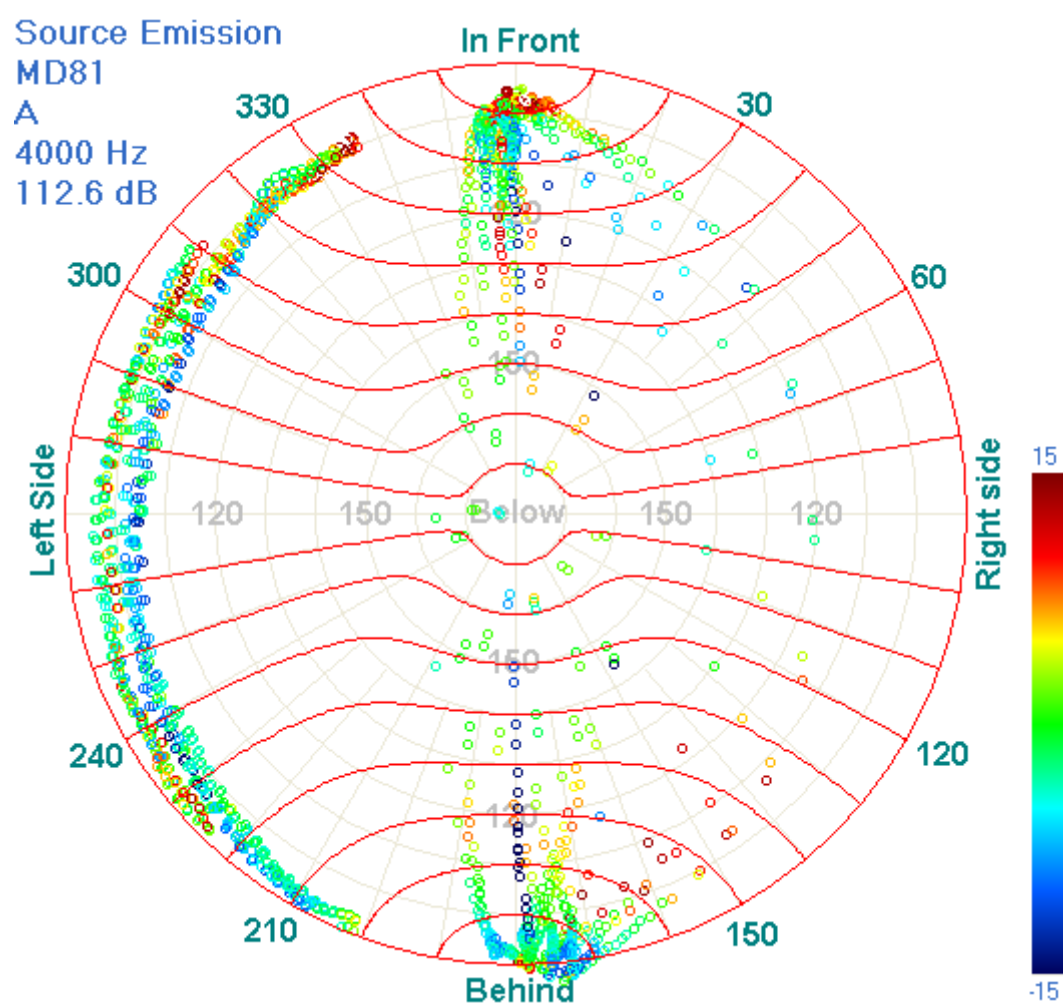




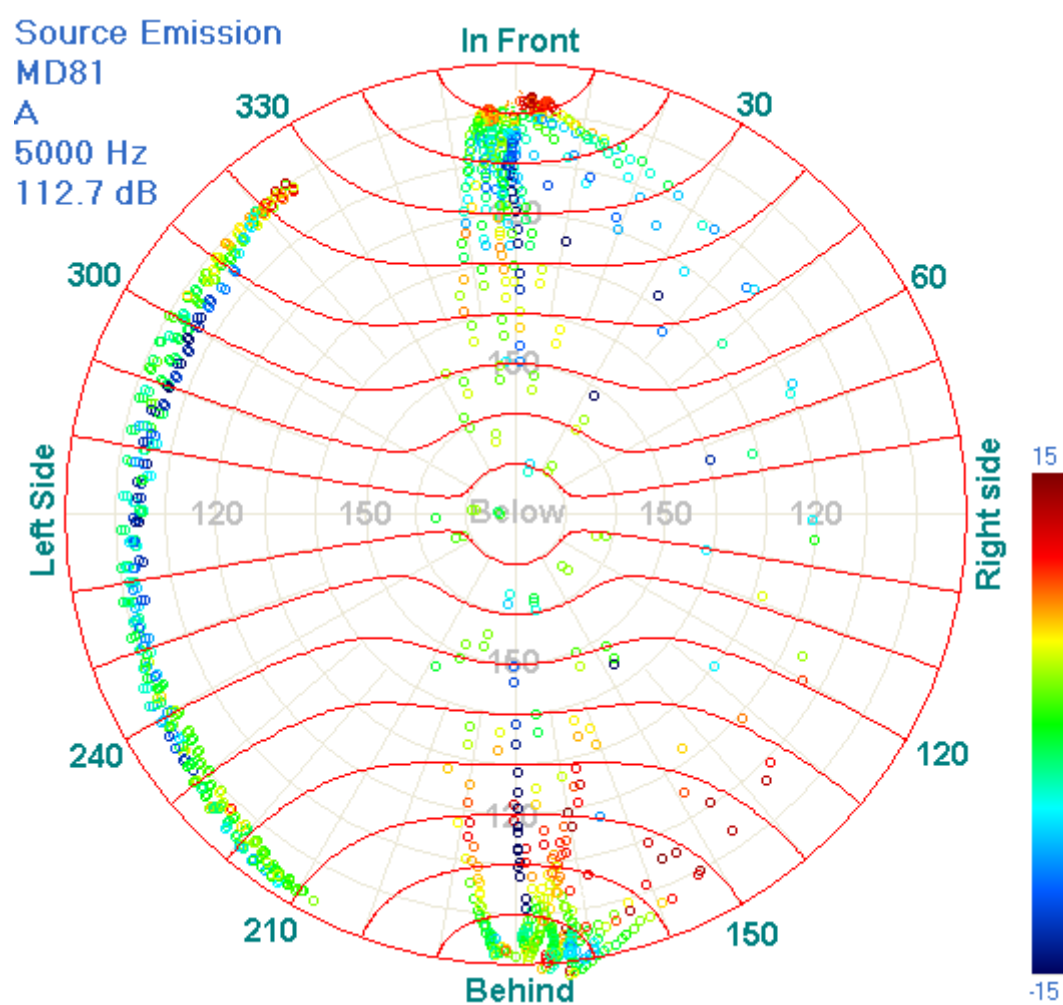


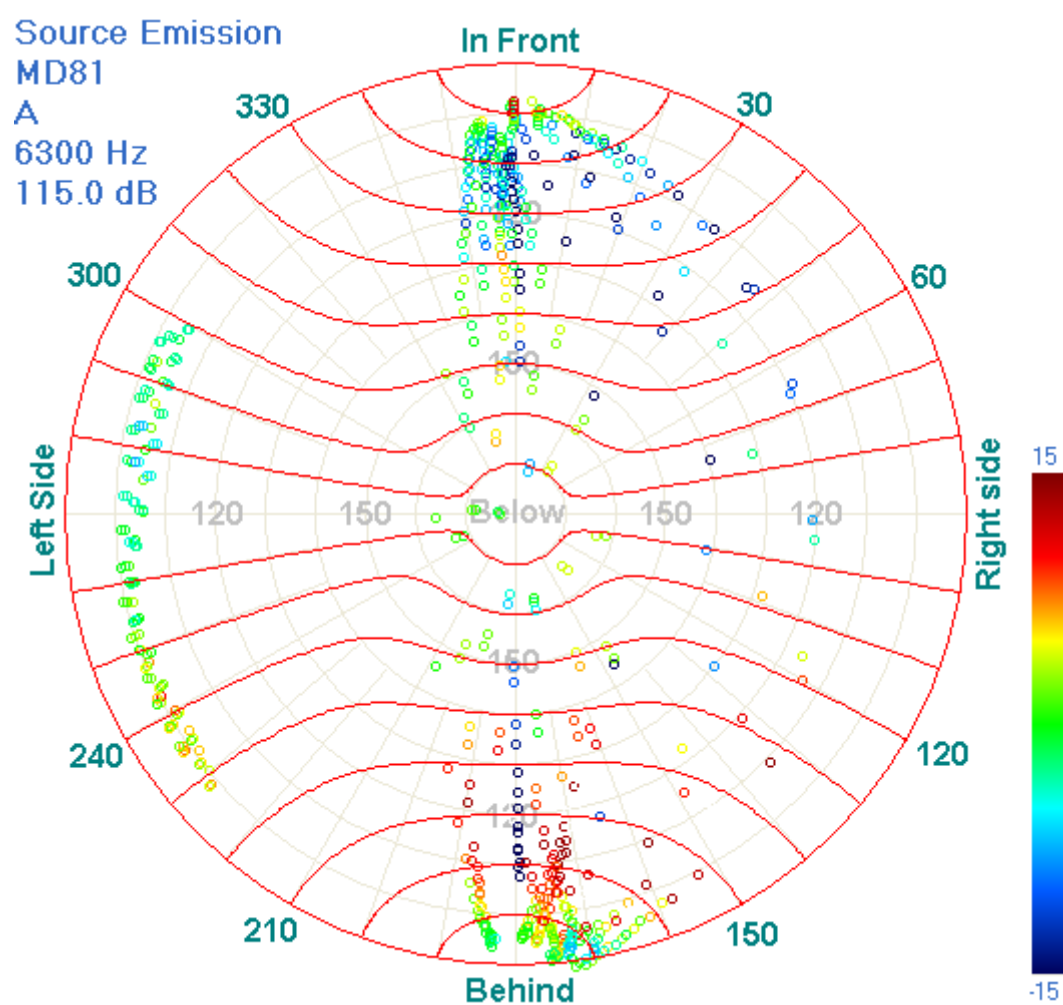


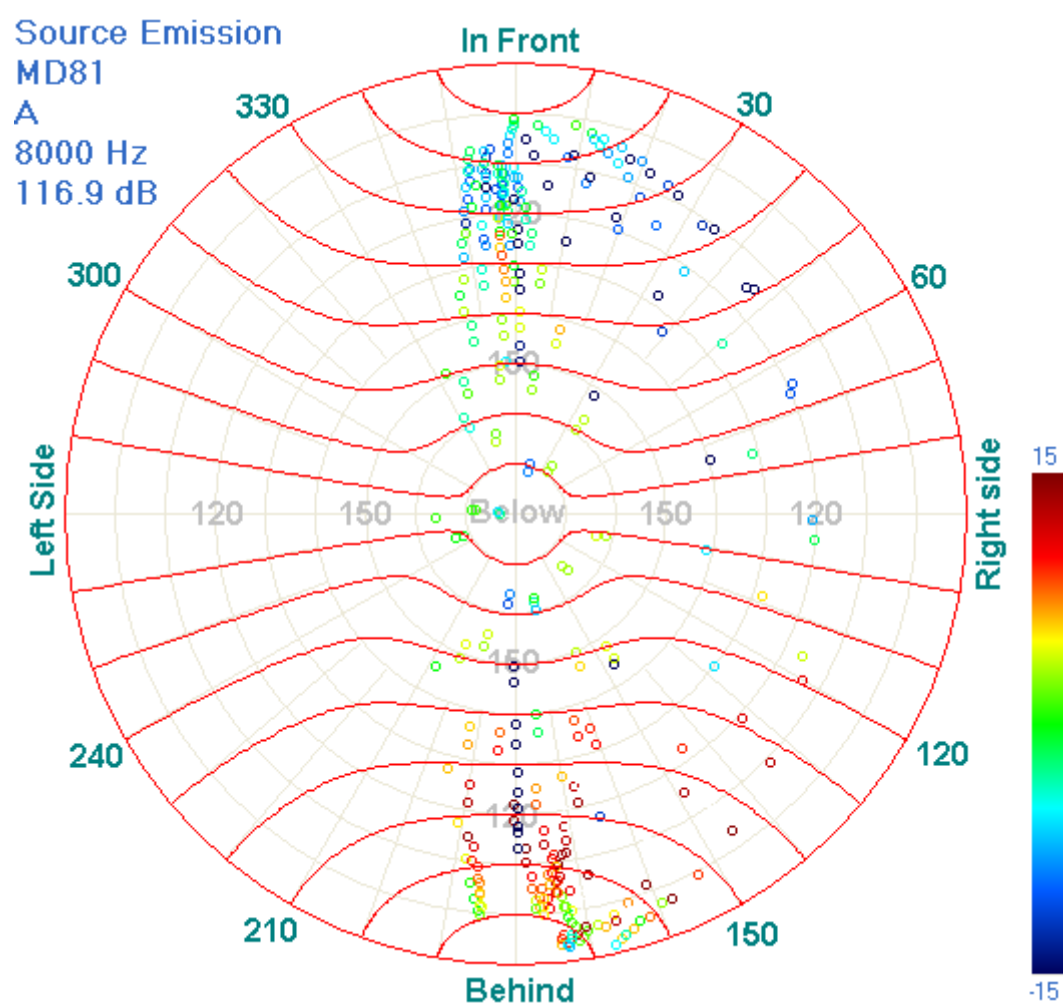


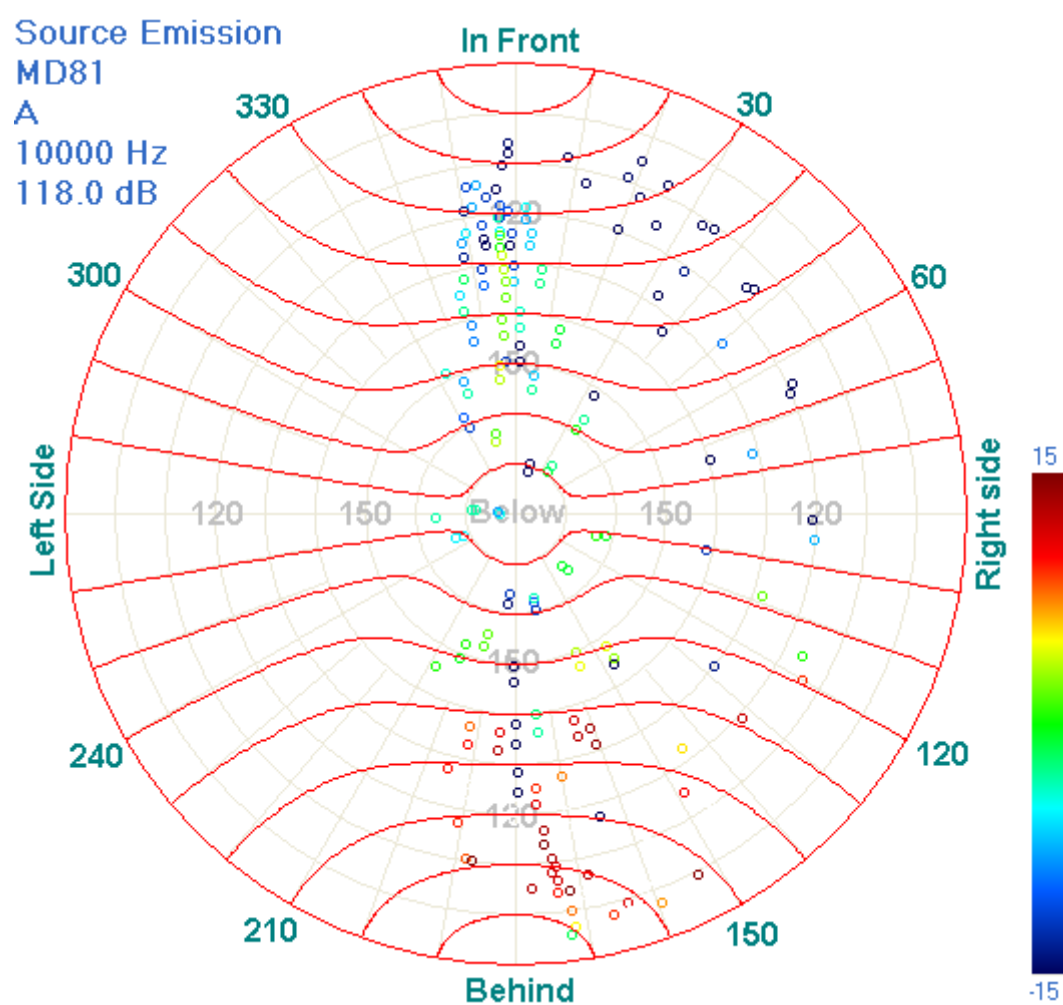










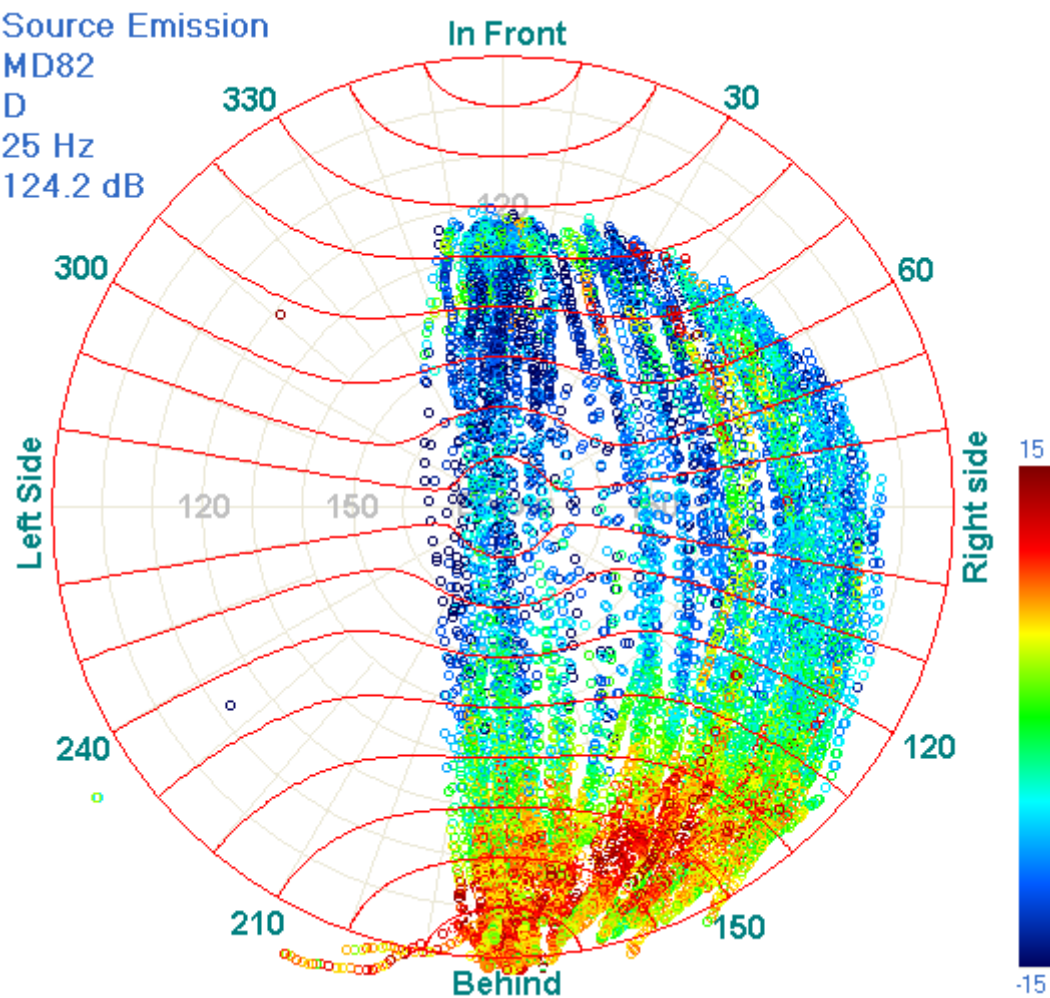


## 14 MD 82 directivity at departure

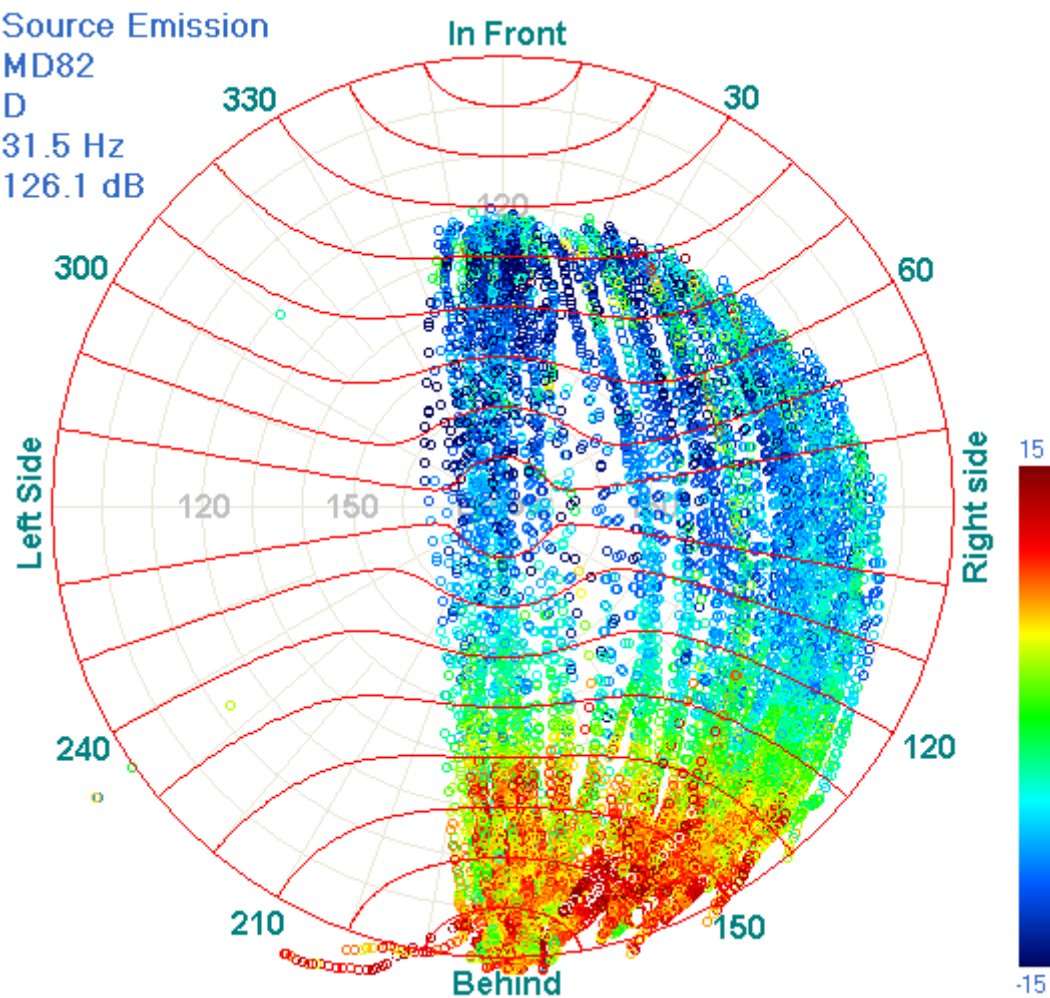
SPECTRUM  
Source Emission  
MD82  
D

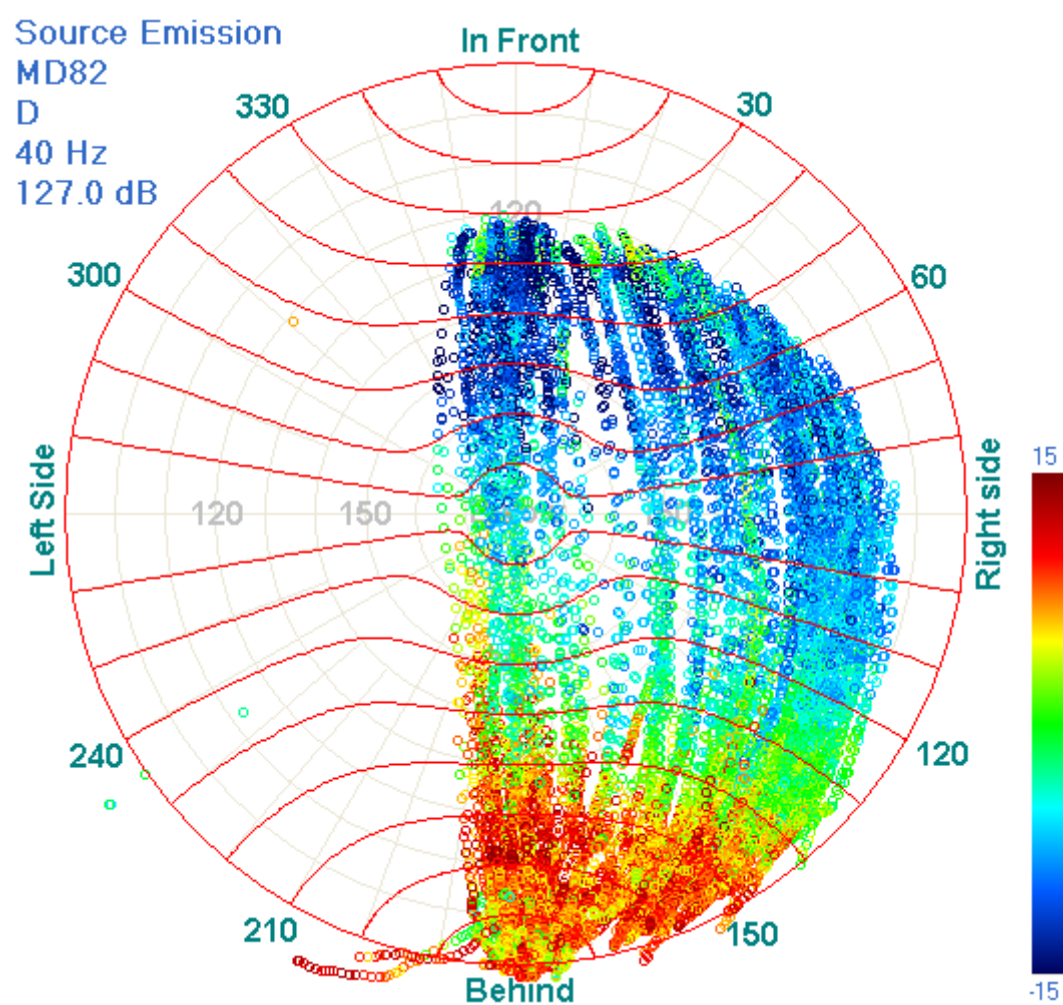
Freq	Num	Avg	Std	95%Avg	P1	P2	P3	P4	P5	P6
25	13546	124.2	8.3	0.1	-1.0	-1.0	-1.0	-1.0	125.2	-1.0
31.5	14365	126.1	8.1	0.1	-1.0	-1.0	-1.0	-1.0	127.1	-1.0
40	15589	127.0	8.0	0.1	-1.0	-1.0	-1.0	-1.0	128.0	-1.0
50	15535	128.3	8.2	0.1	-1.0	-1.0	-1.0	-1.0	129.3	-1.0
63	15698	130.0	8.5	0.1	-1.0	-1.0	-1.0	-1.0	131.0	-1.0
80	16139	131.4	8.1	0.1	-1.0	-1.0	-1.0	-1.0	132.4	-1.0
100	17310	131.5	7.4	0.1	-1.0	-1.0	-1.0	-1.0	132.3	-1.0
125	18411	131.0	6.3	0.1	-1.0	-1.0	-1.0	-1.0	131.6	-1.0
160	18694	130.6	5.8	0.1	-1.0	-1.0	-1.0	-1.0	131.0	-1.0
200	18727	130.4	5.9	0.1	-1.0	-1.0	-1.0	-1.0	130.8	-1.0
250	18716	130.4	5.6	0.1	-1.0	-1.0	-1.0	-1.0	130.7	-1.0
315	18689	130.2	5.7	0.1	-1.0	-1.0	-1.0	-1.0	130.3	-1.0
400	18745	129.8	5.8	0.1	-1.0	-1.0	-1.0	-1.0	129.8	-1.0
500	18690	129.3	5.6	0.1	-1.0	-1.0	-1.0	-1.0	129.2	-1.0
630	18749	129.1	5.5	0.1	-1.0	-1.0	-1.0	-1.0	129.0	-1.0
800	18610	128.8	5.4	0.1	-1.0	-1.0	-1.0	-1.0	128.7	-1.0
1000	18695	128.3	5.5	0.1	-1.0	-1.0	-1.0	-1.0	128.3	-1.0
1250	18687	127.6	5.6	0.1	-1.0	-1.0	-1.0	-1.0	127.6	-1.0
1600	18675	126.9	5.7	0.1	-1.0	-1.0	-1.0	-1.0	126.9	-1.0
2000	18504	126.6	5.7	0.1	-1.0	-1.0	-1.0	-1.0	126.6	-1.0
2500	17610	126.8	5.6	0.1	-1.0	-1.0	-1.0	-1.0	126.9	-1.0
3150	13494	126.5	5.6	0.1	-1.0	-1.0	-1.0	-1.0	127.0	-1.0
4000	7188	126.0	5.7	0.1	-1.0	-1.0	-1.0	-1.0	126.7	-1.0
5000	2948	124.4	6.5	0.2	-1.0	-1.0	-1.0	-1.0	124.7	-1.0
6300	803	121.0	7.6	0.5	-1.0	-1.0	-1.0	-1.0	121.5	-1.0
8000	150	117.1	8.5	1.4	-1.0	-1.0	-1.0	-1.0	117.1	-1.0
10000	19	110.9	10.4	4.7	-1.0	-1.0	-1.0	-1.0	117.2	-1.0

Source Emission  
MD82  
D  
25 Hz  
124.2 dB

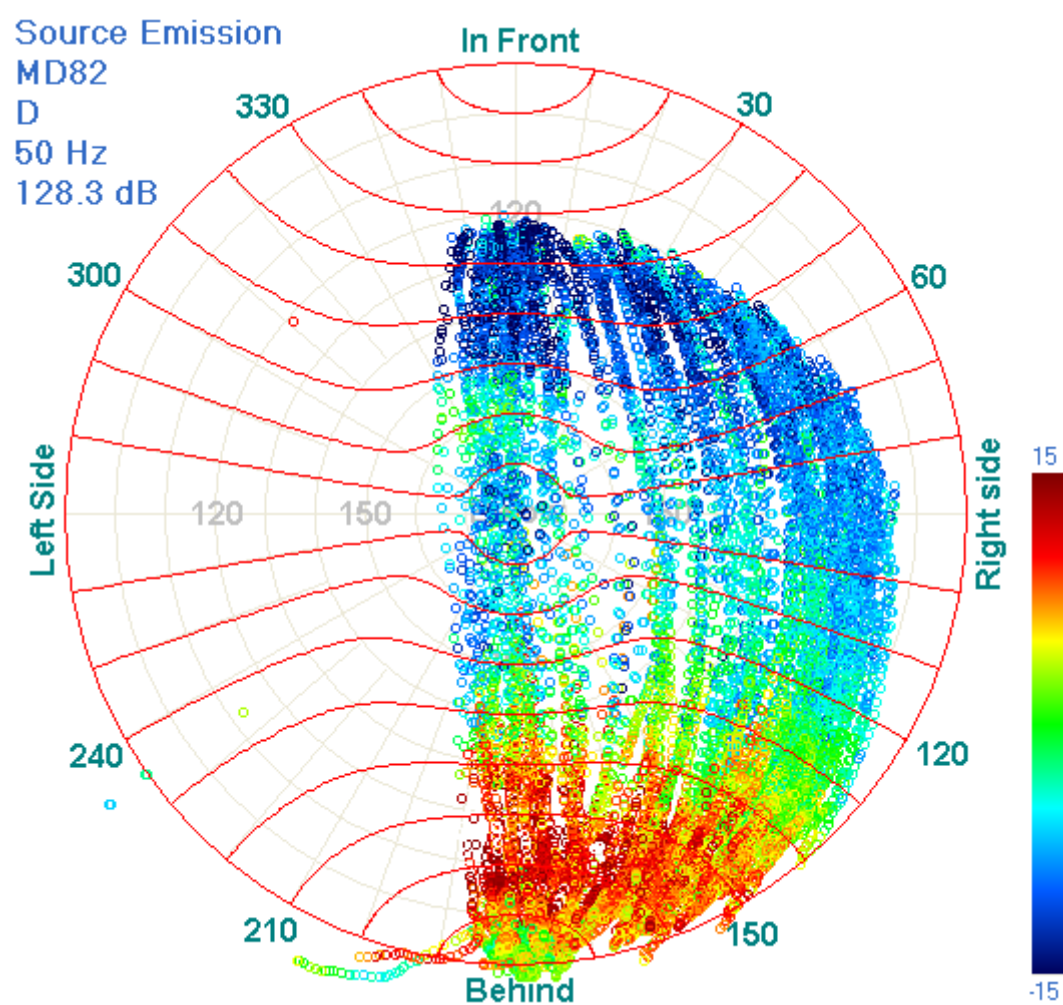


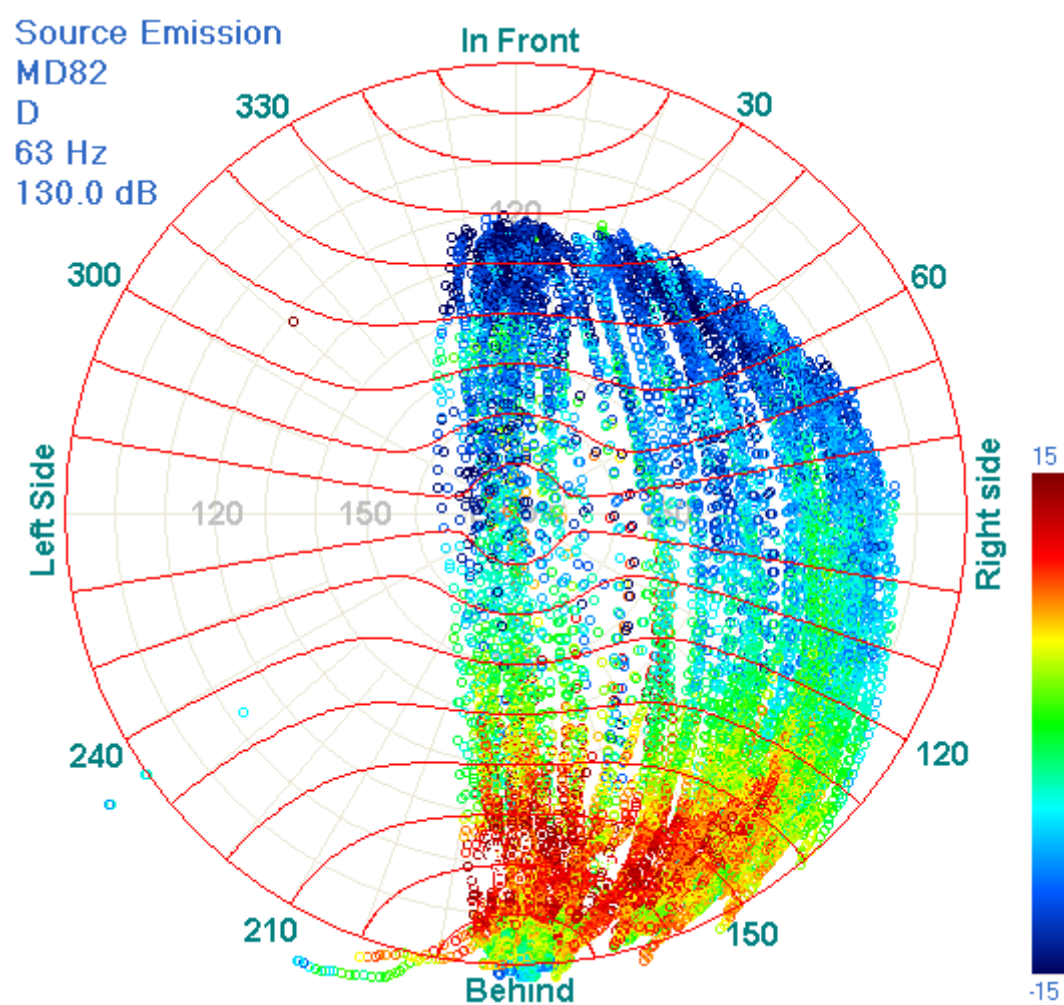
Source Emission  
MD82  
D  
31.5 Hz  
126.1 dB

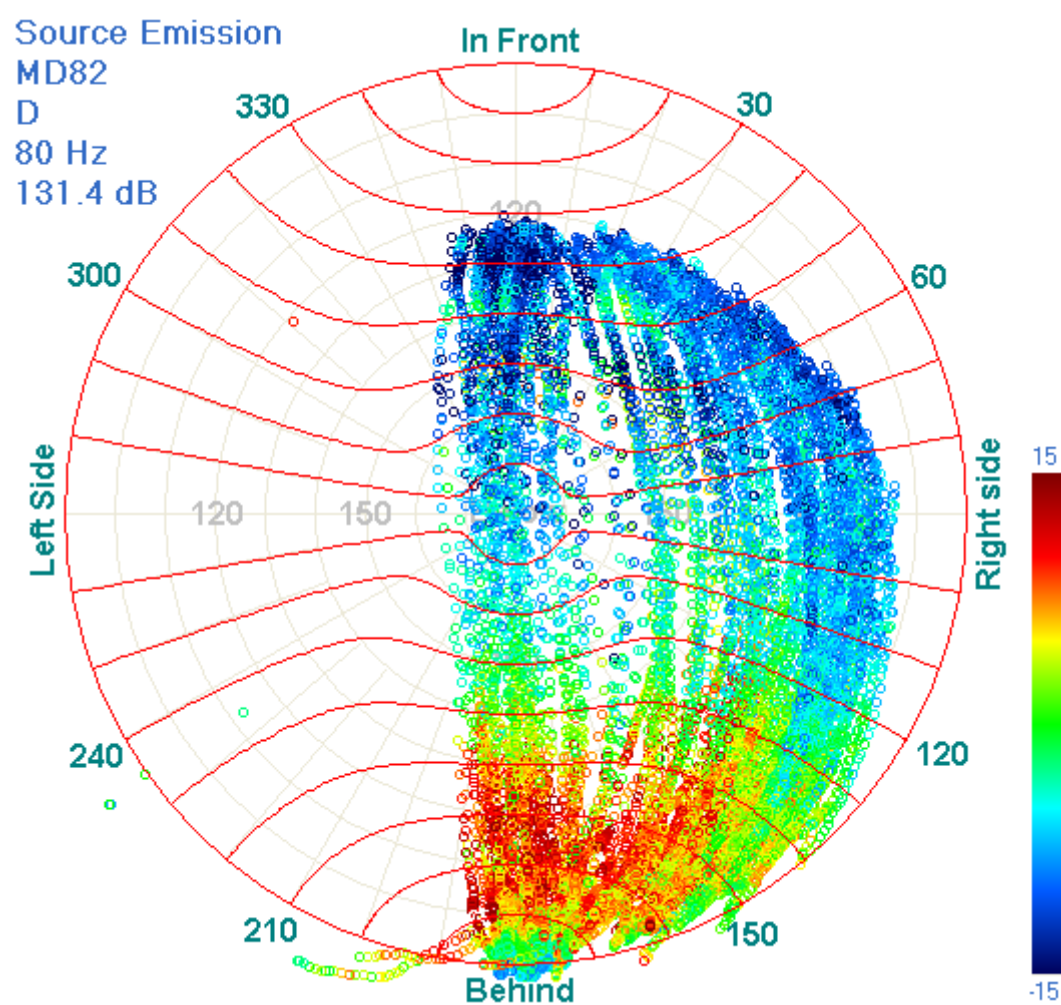


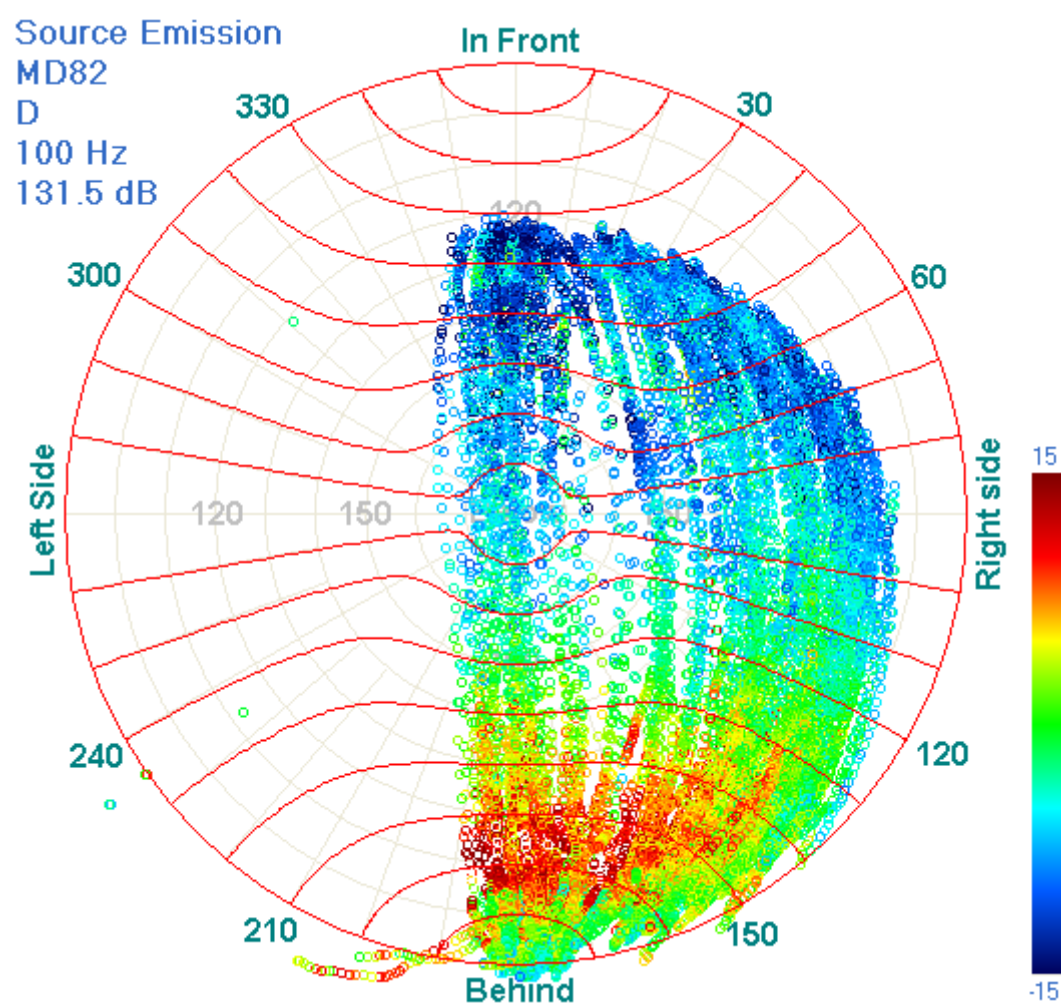




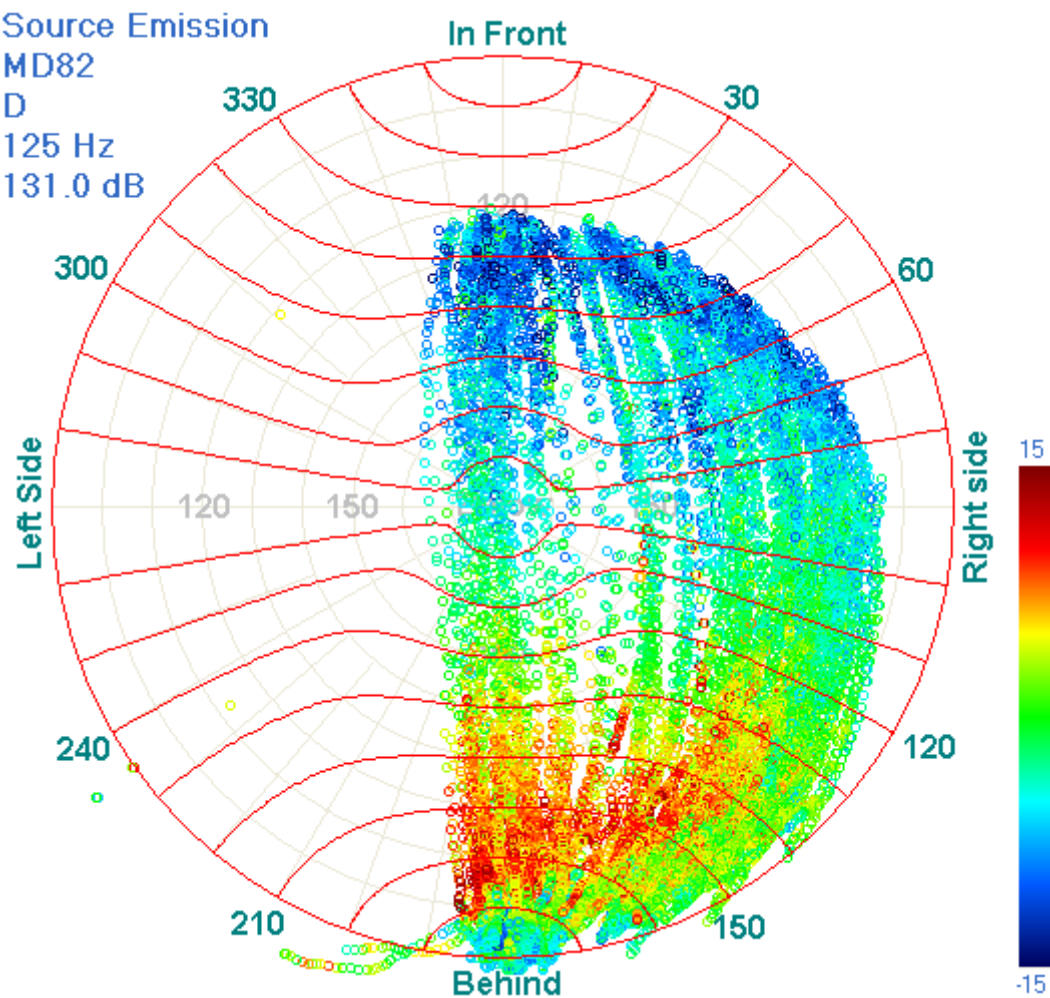




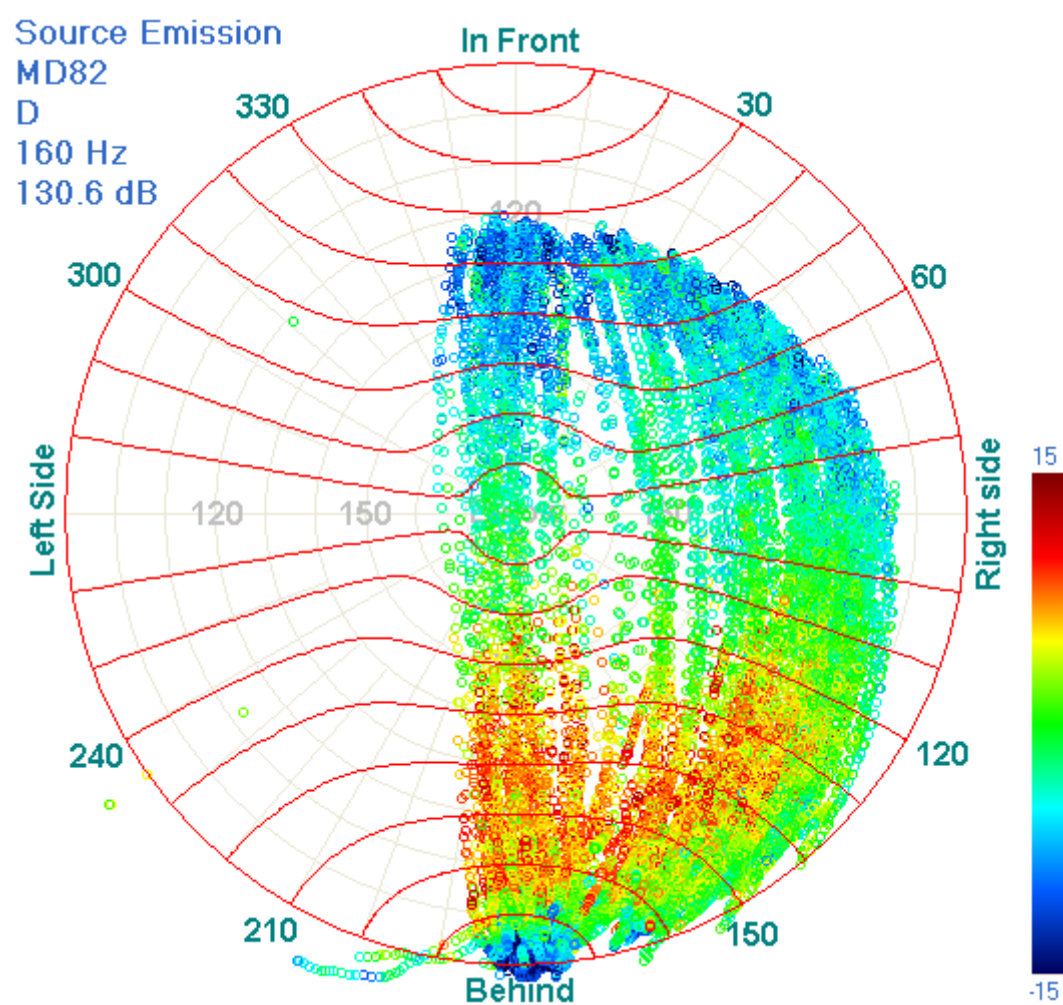


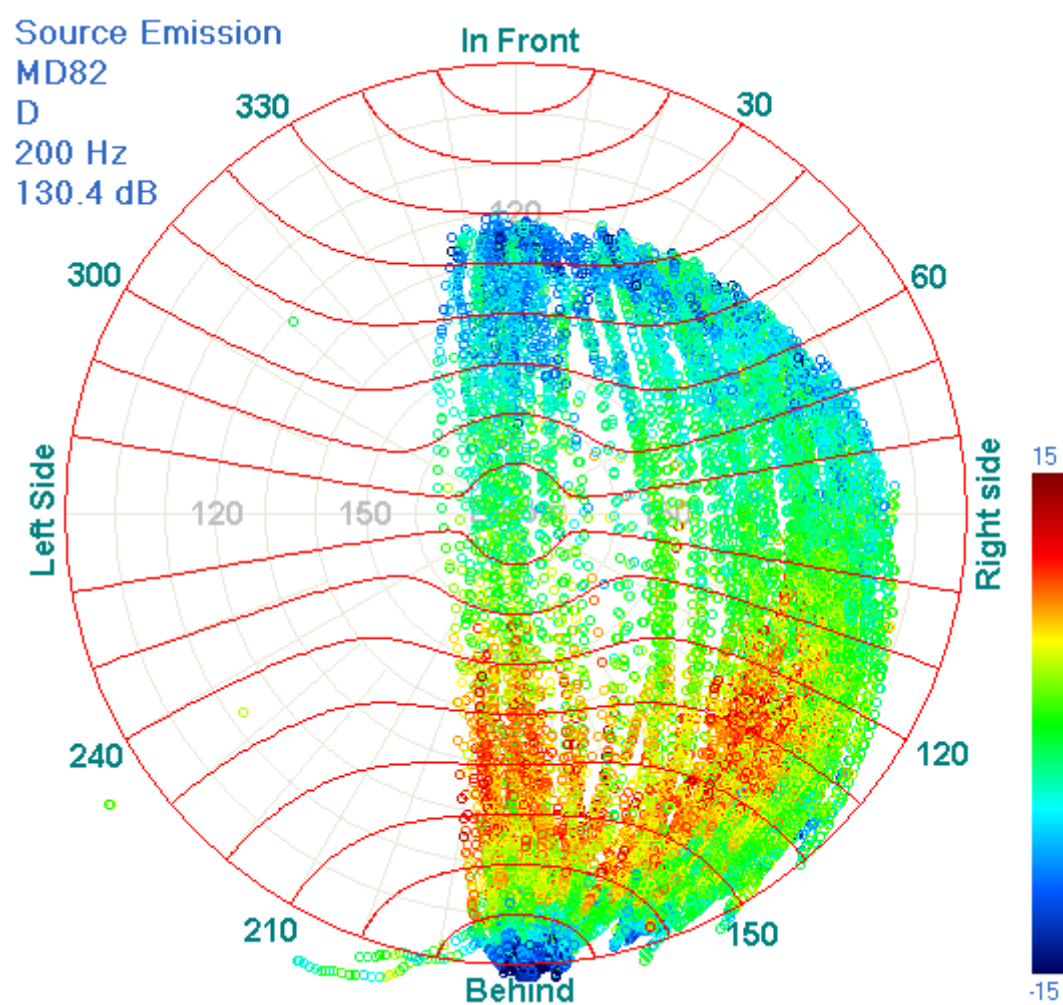


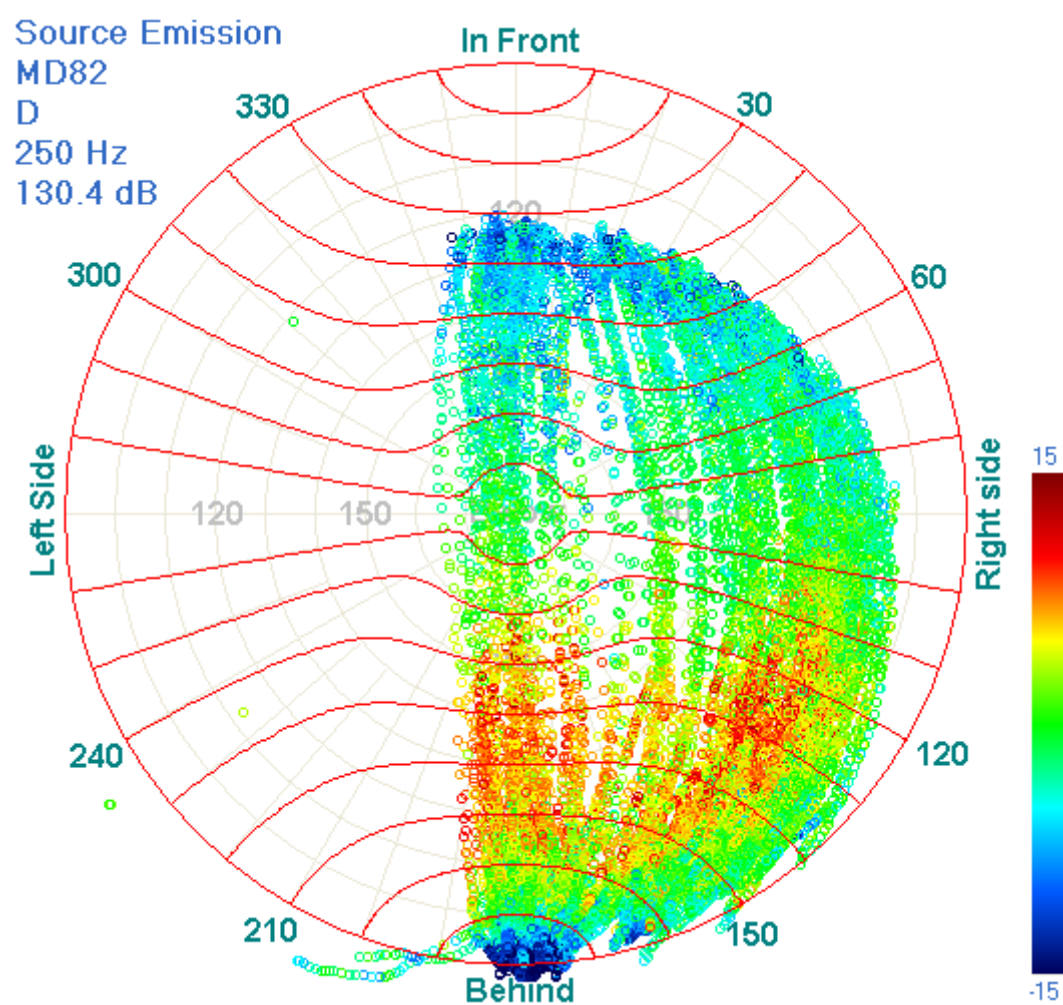
Source Emission  
MD82  
D  
125 Hz  
131.0 dB



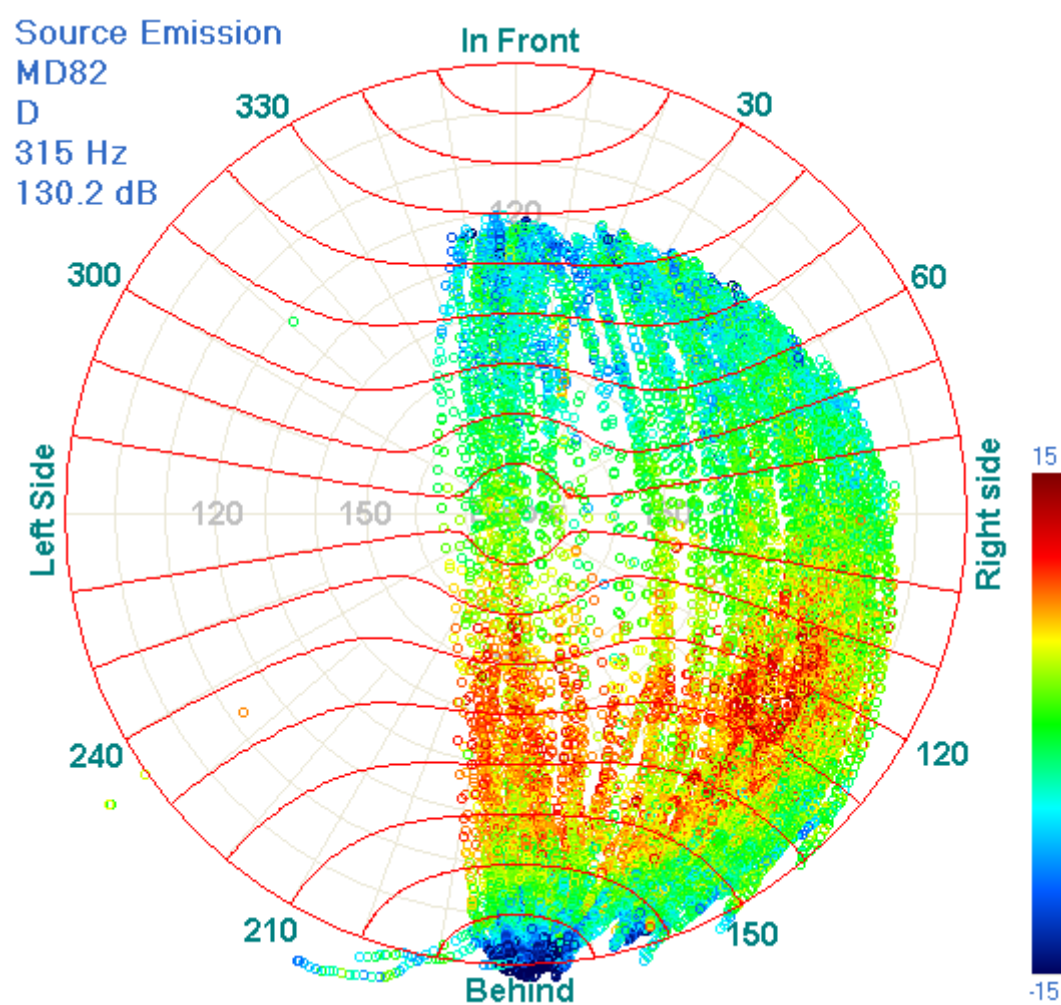


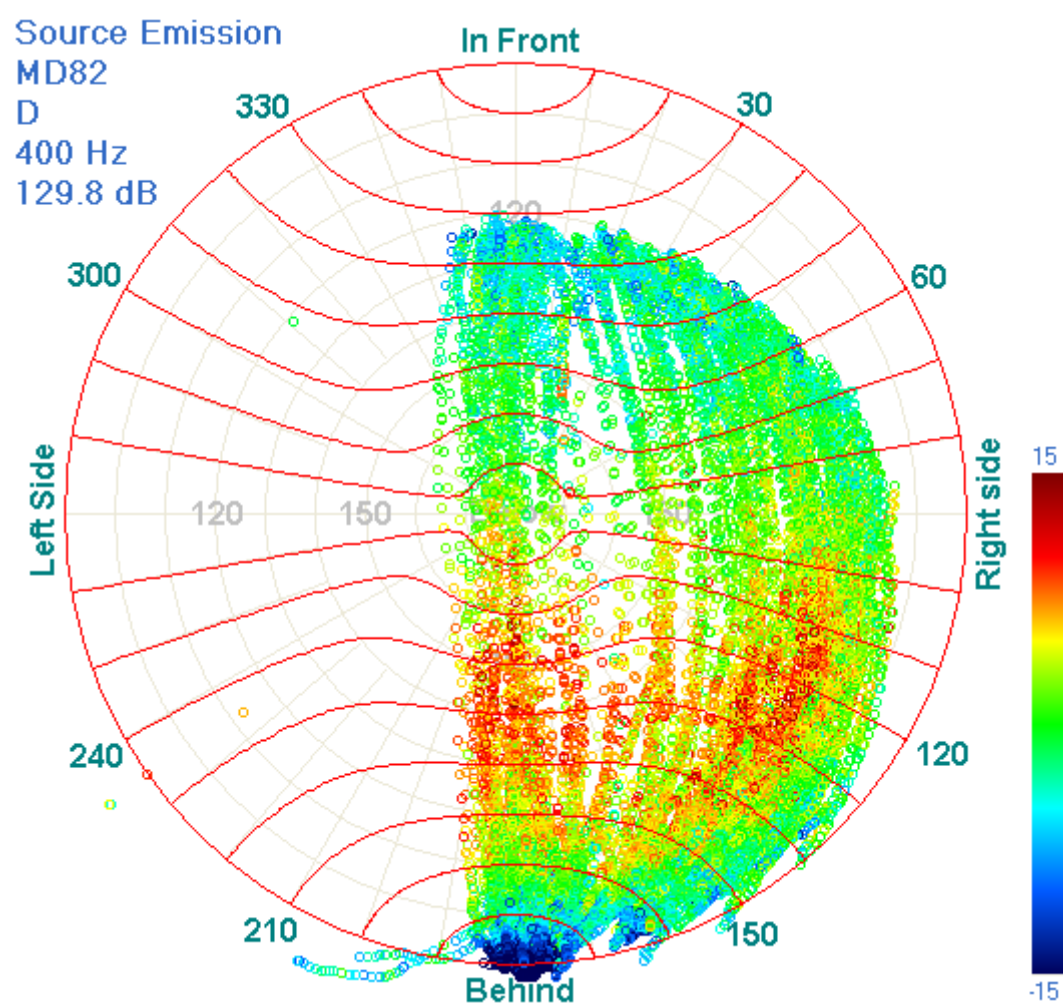


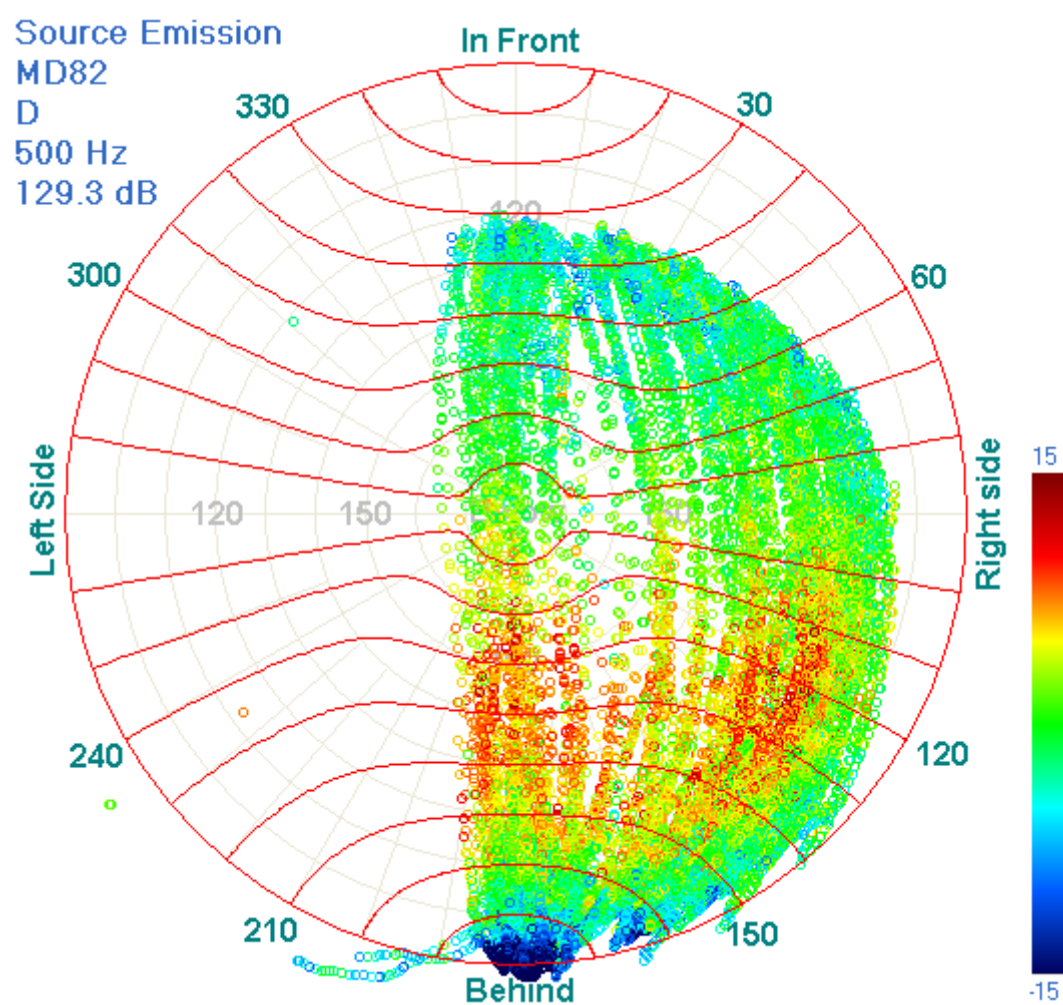


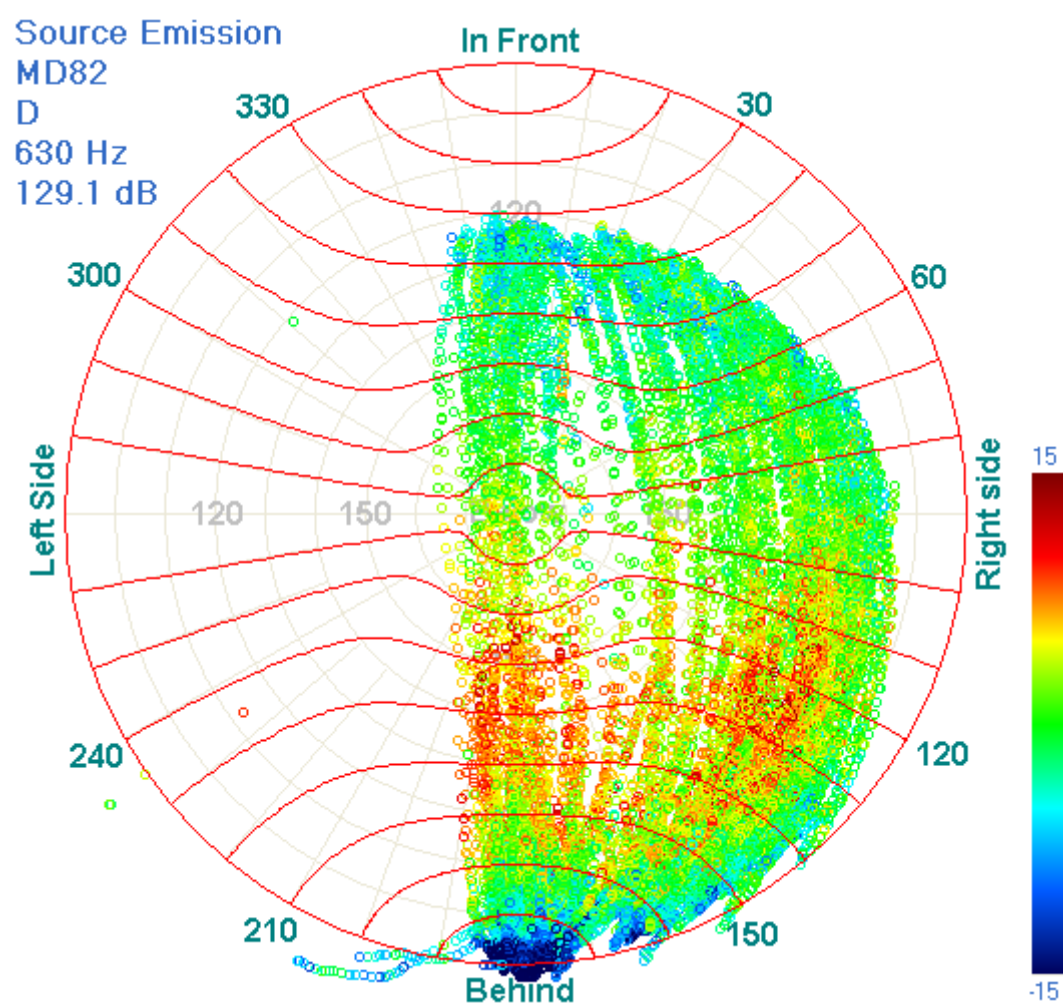


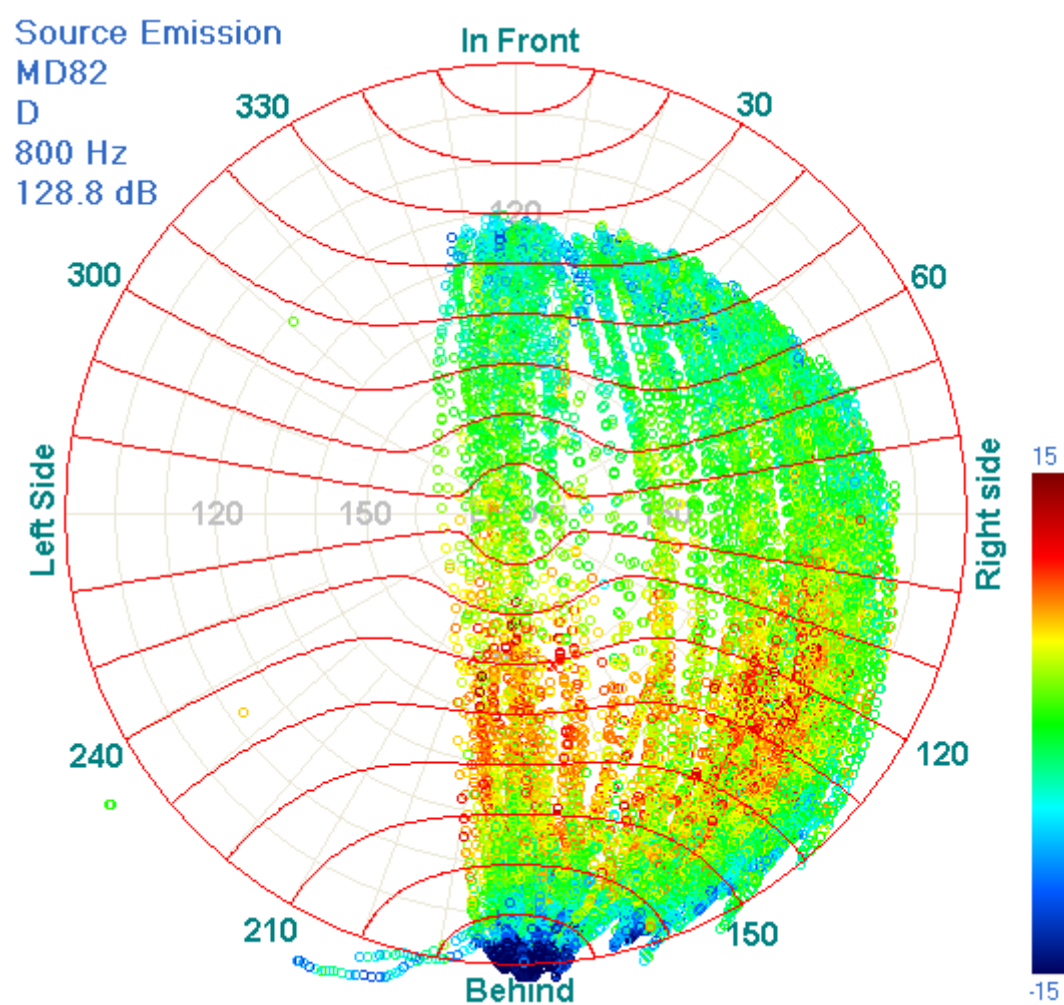




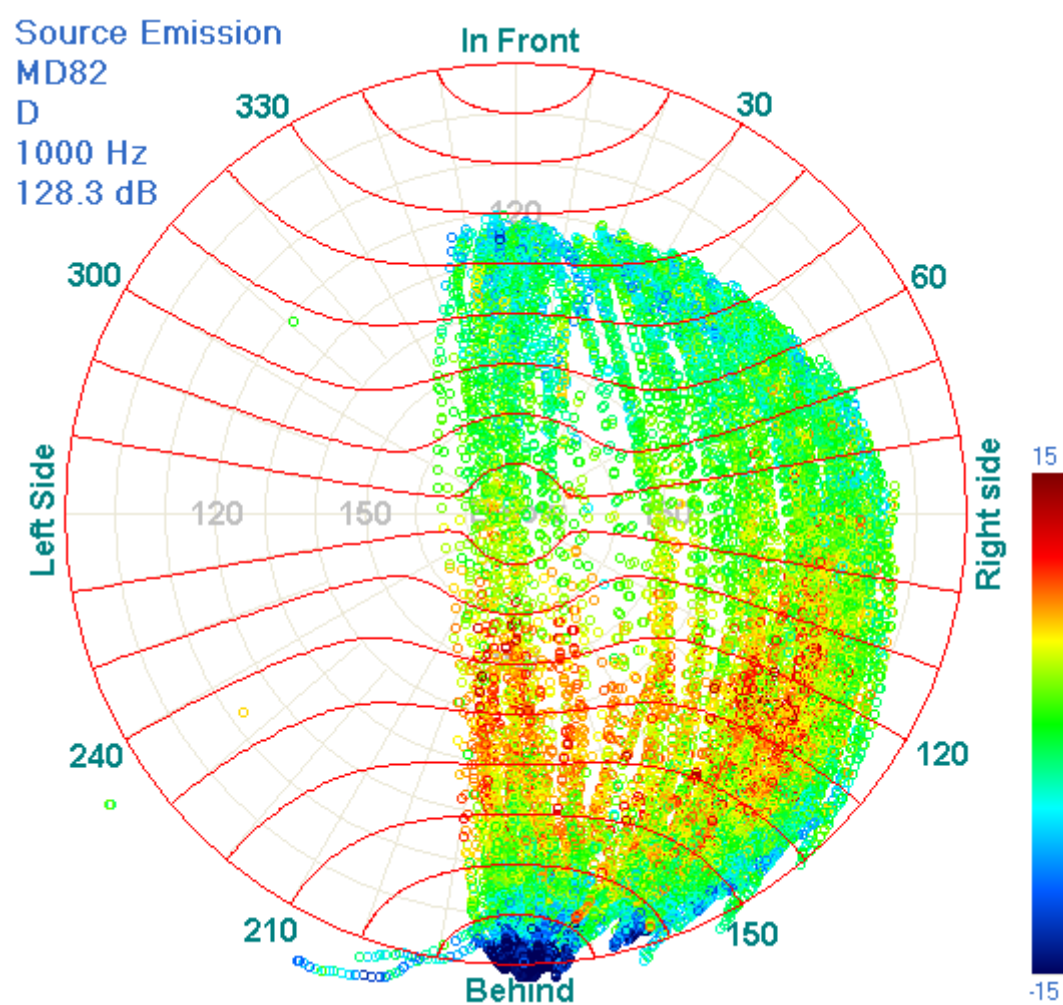


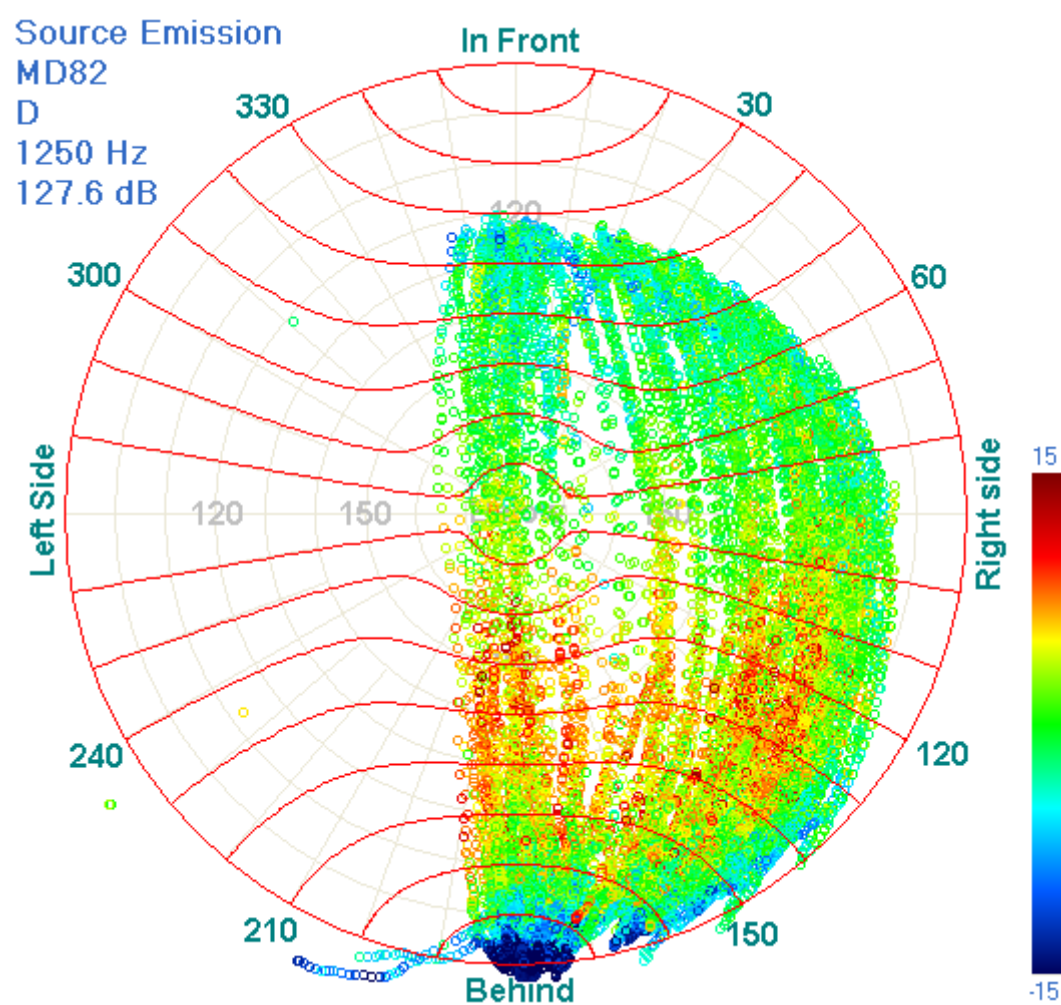


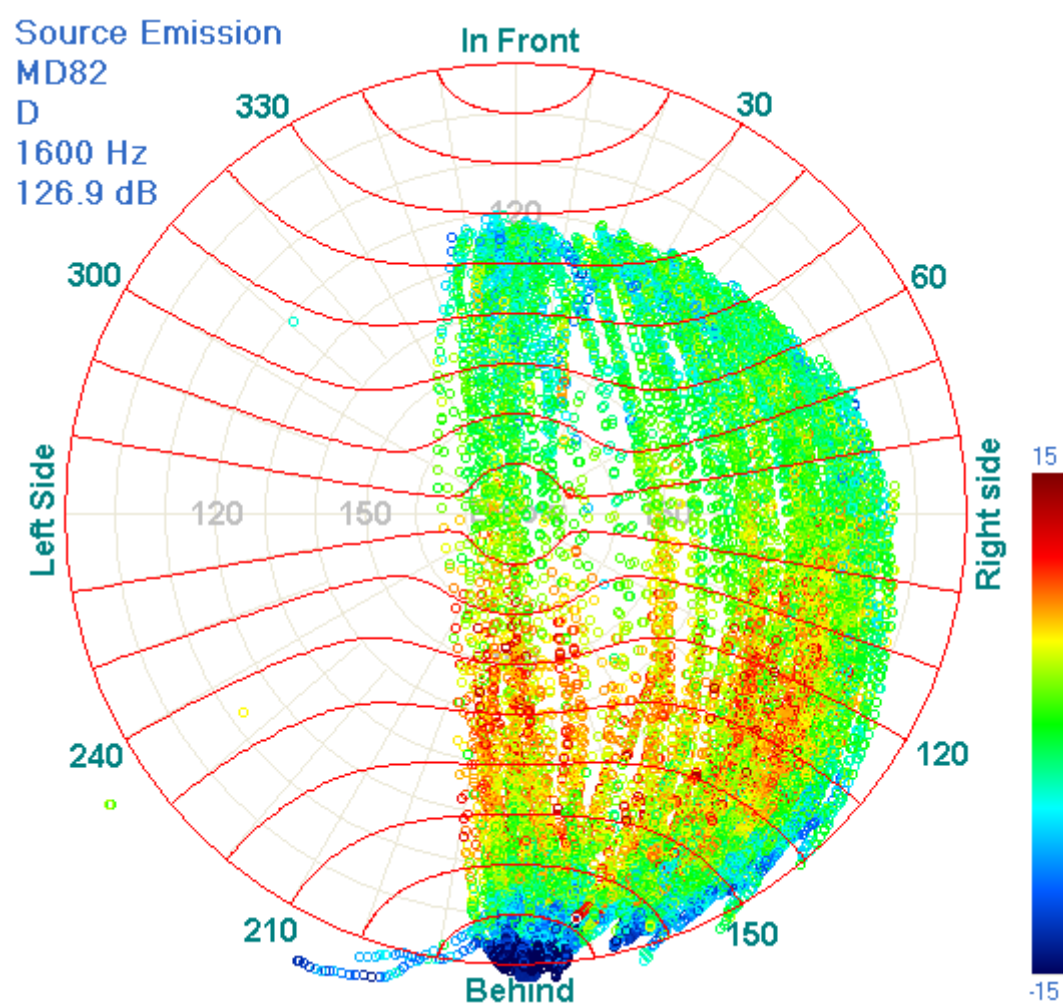




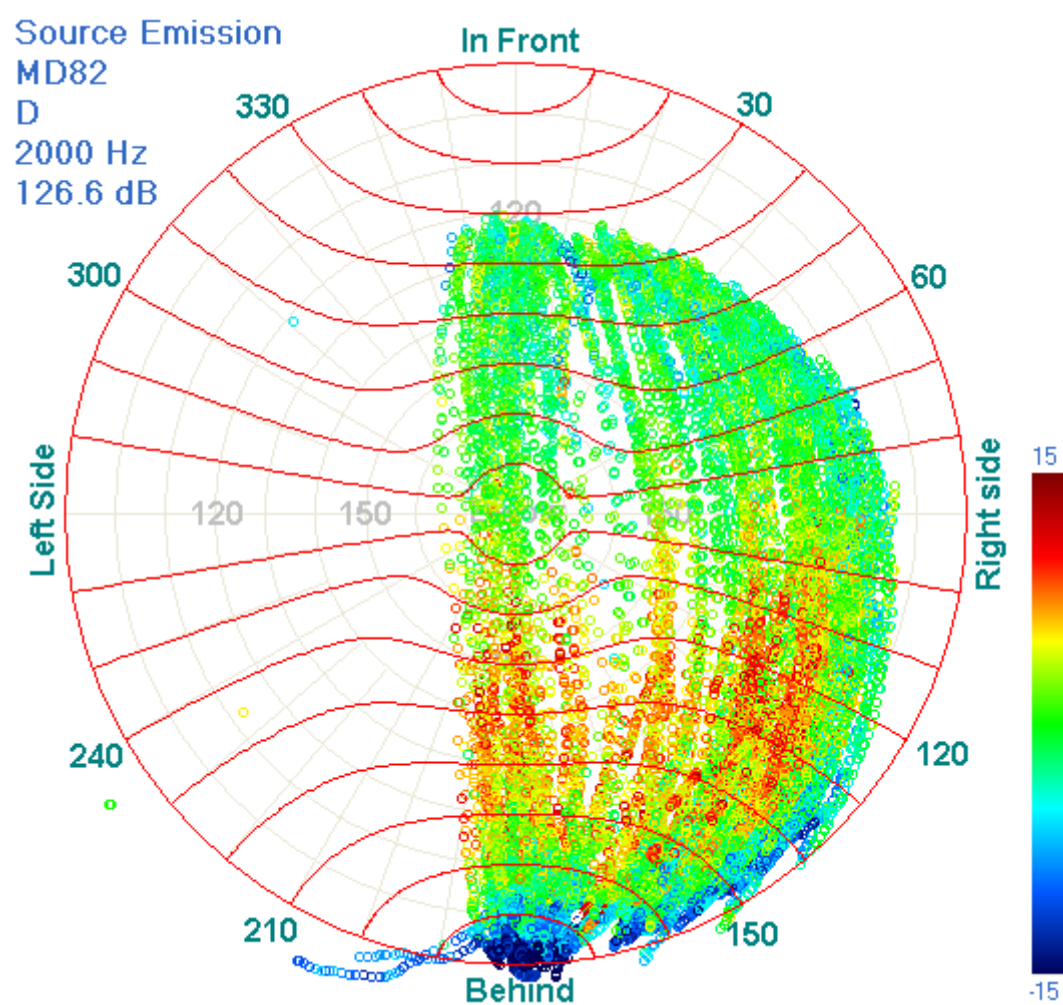


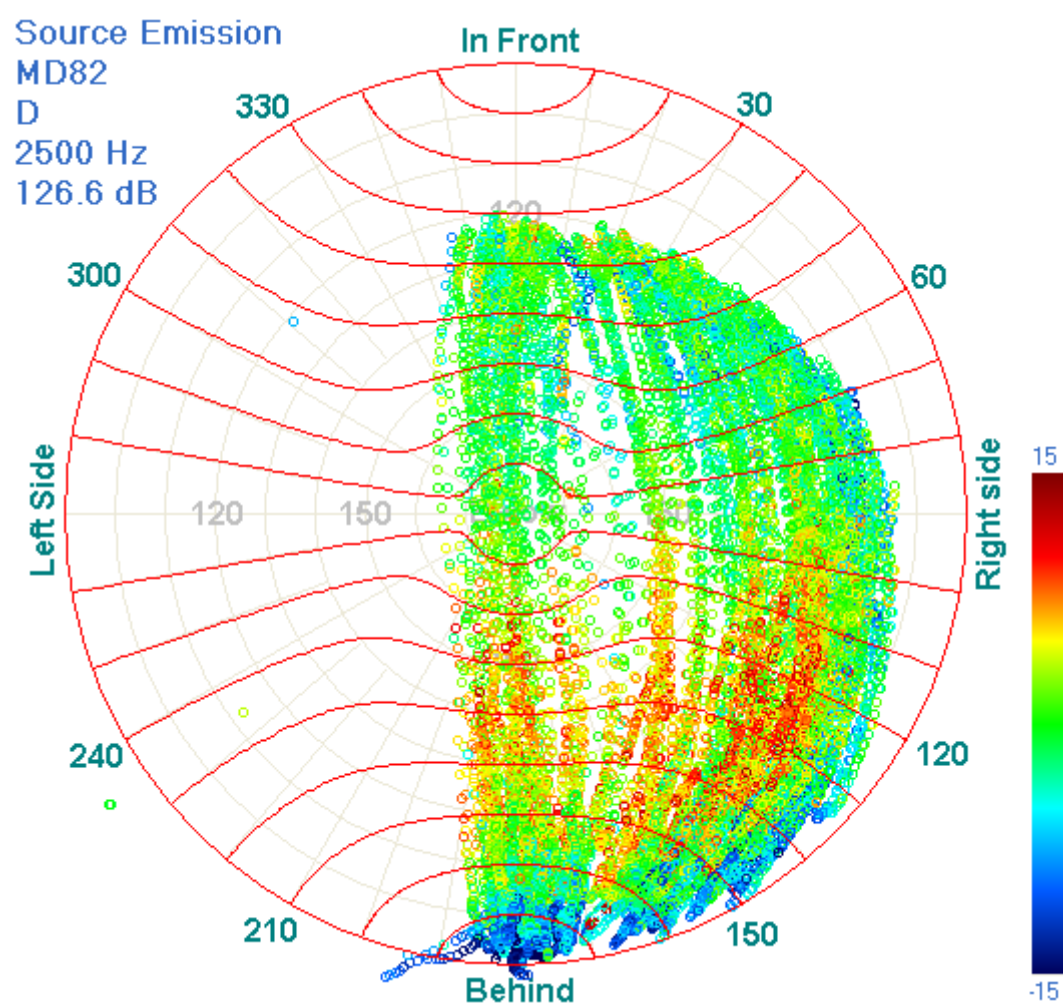




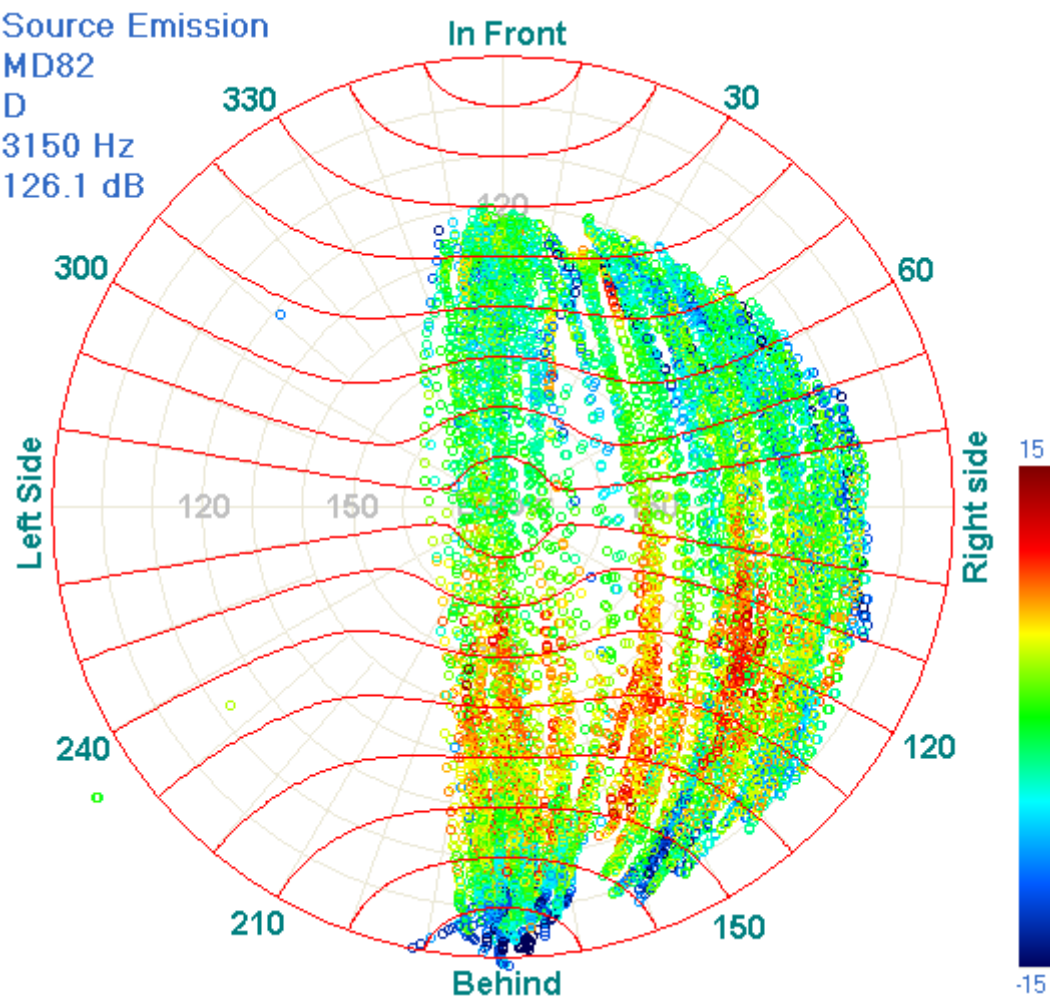




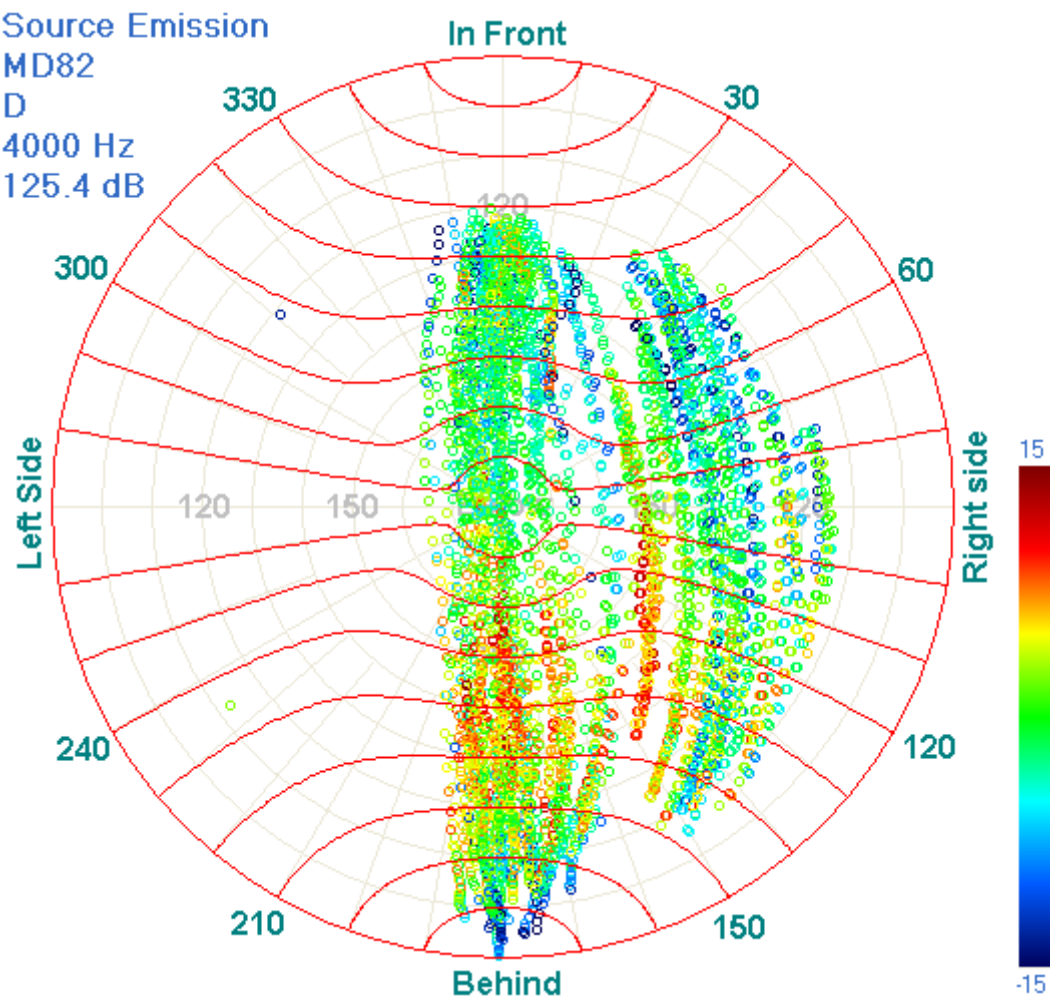




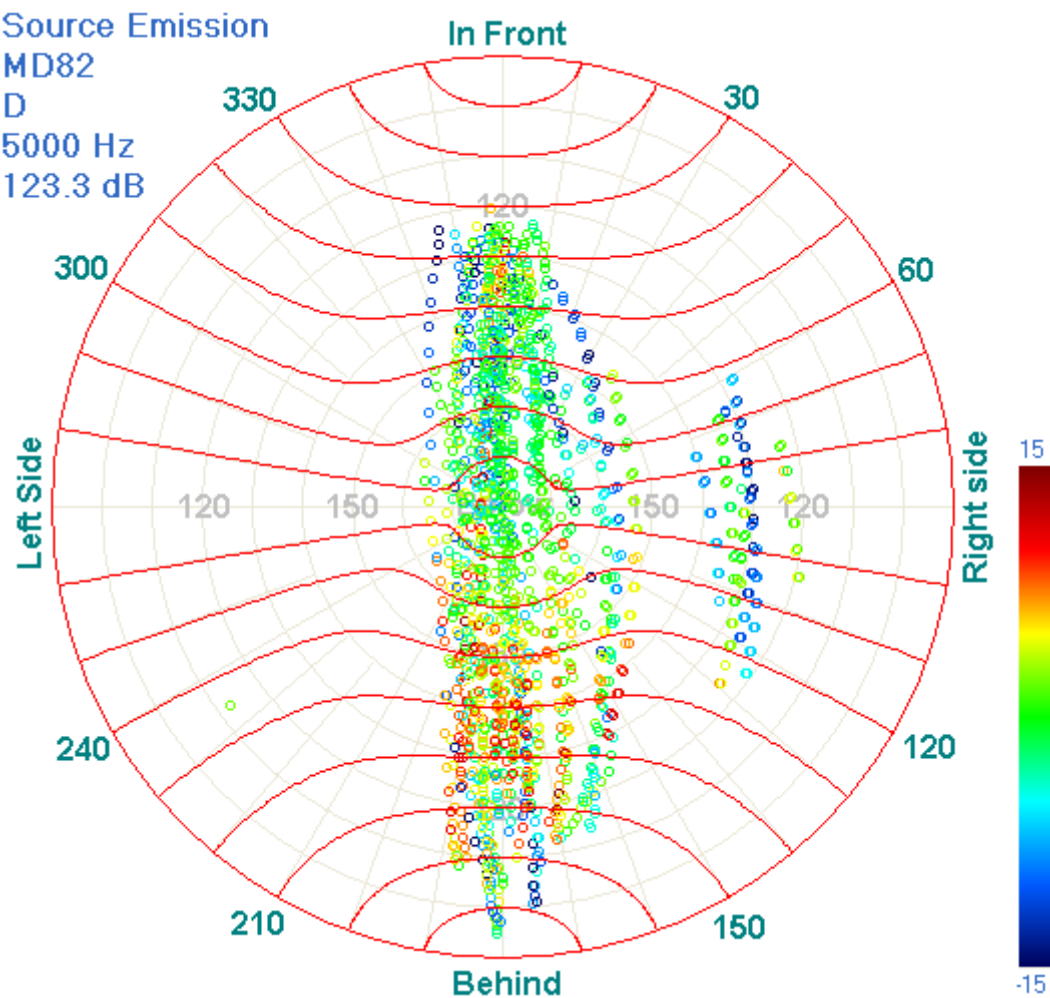
Source Emission  
MD82  
D  
3150 Hz  
126.1 dB



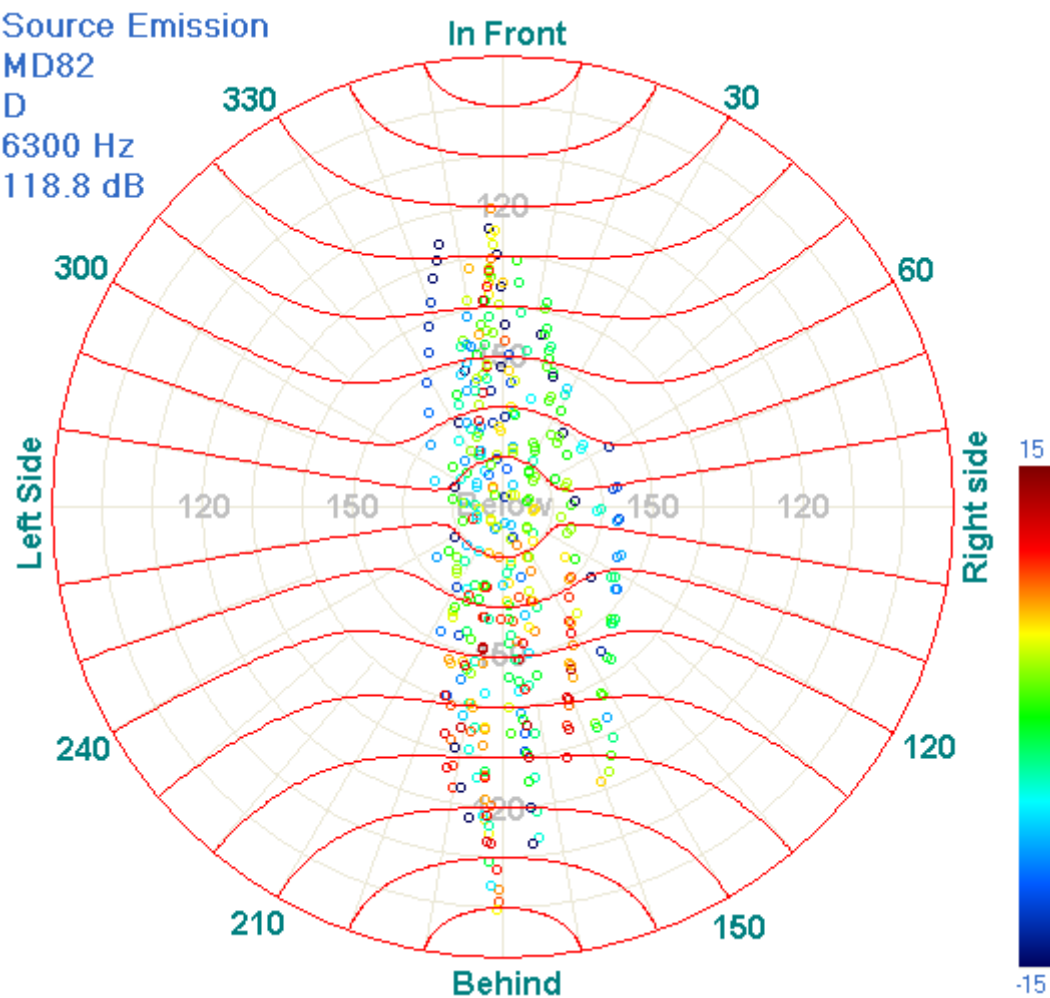
Source Emission  
MD82  
D  
4000 Hz  
125.4 dB



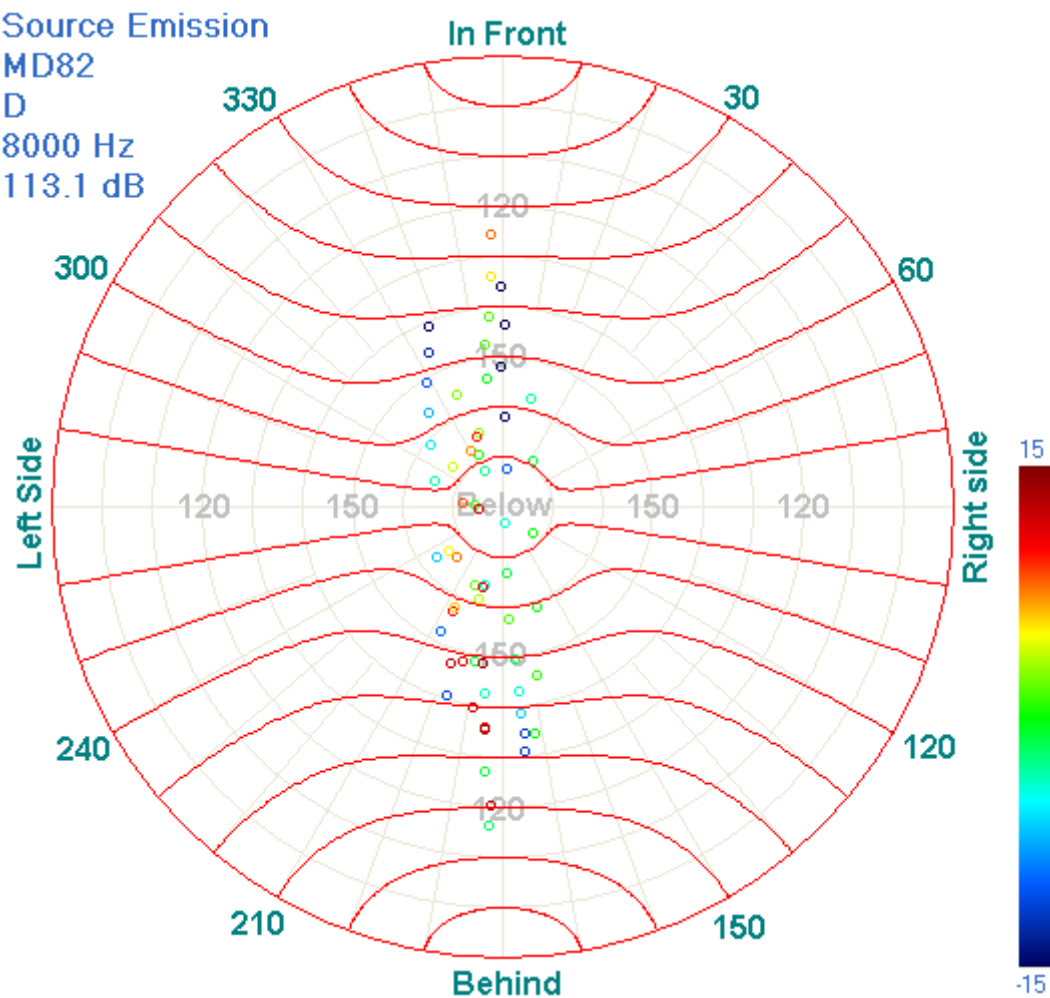
Source Emission  
MD82  
D  
5000 Hz  
123.3 dB



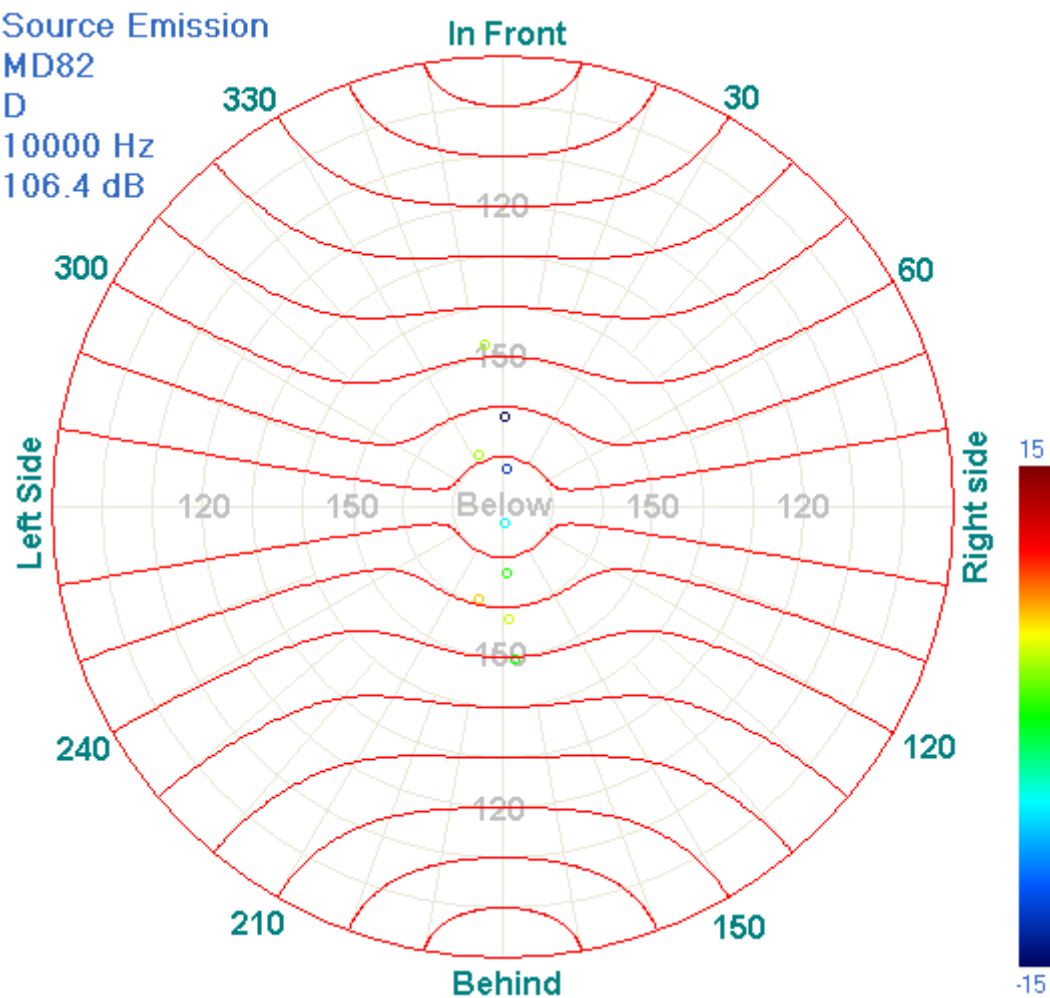
Source Emission  
MD82  
D  
6300 Hz  
118.8 dB



Source Emission  
MD82  
D  
8000 Hz  
113.1 dB



Source Emission  
MD82  
D  
10000 Hz  
106.4 dB

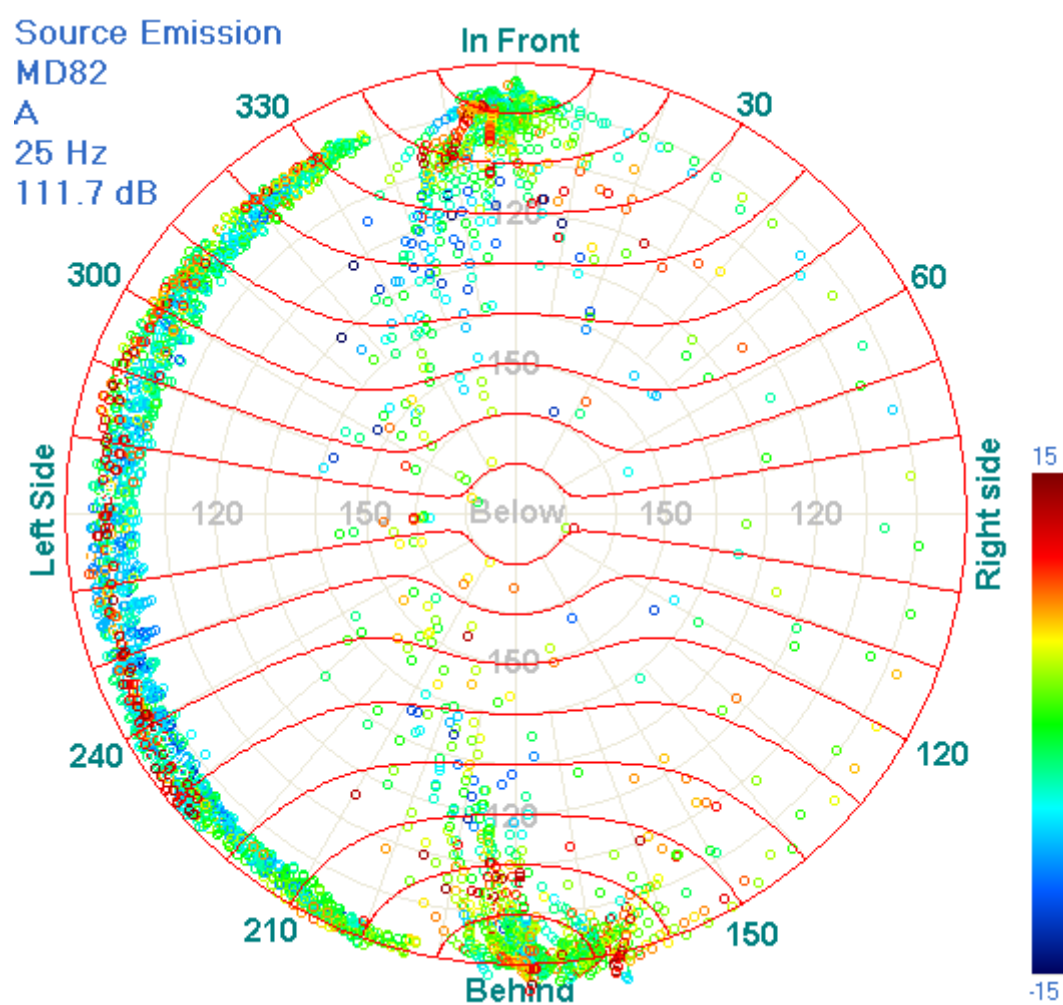


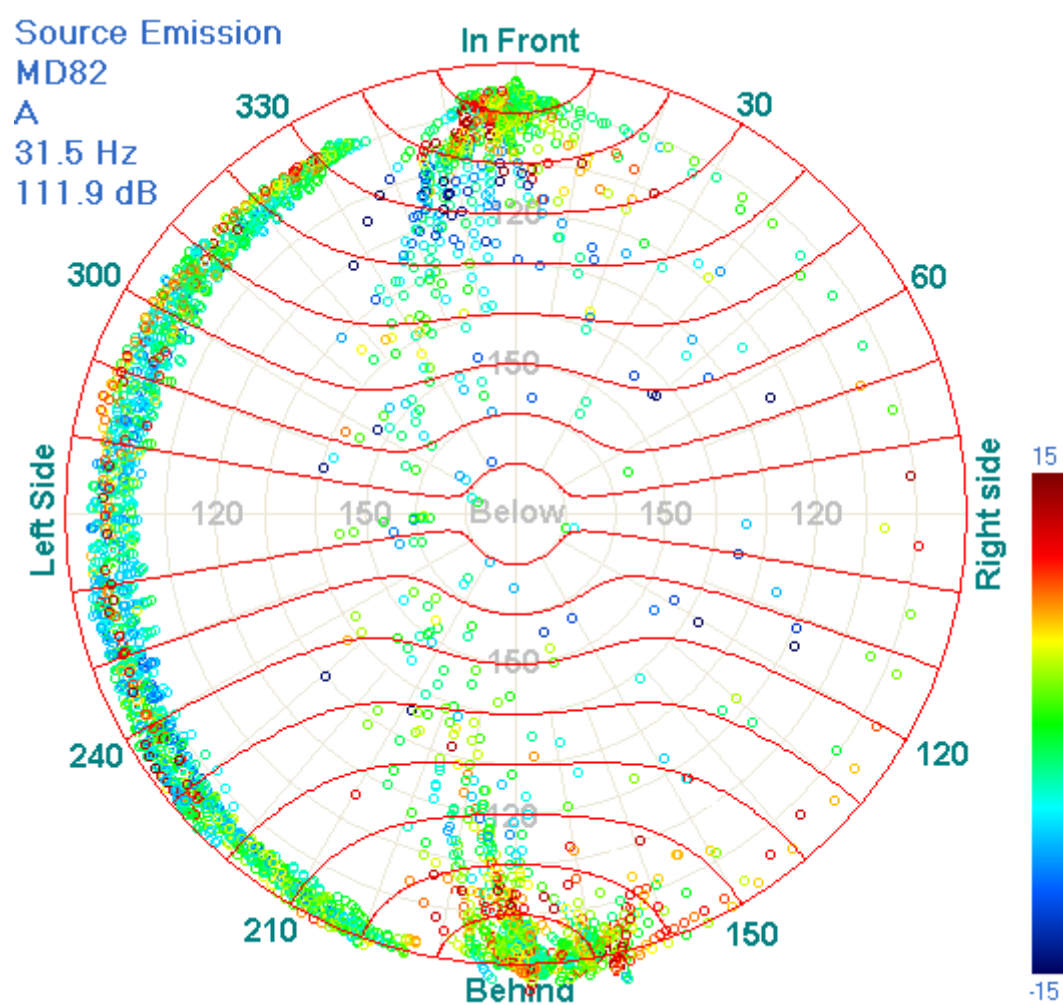


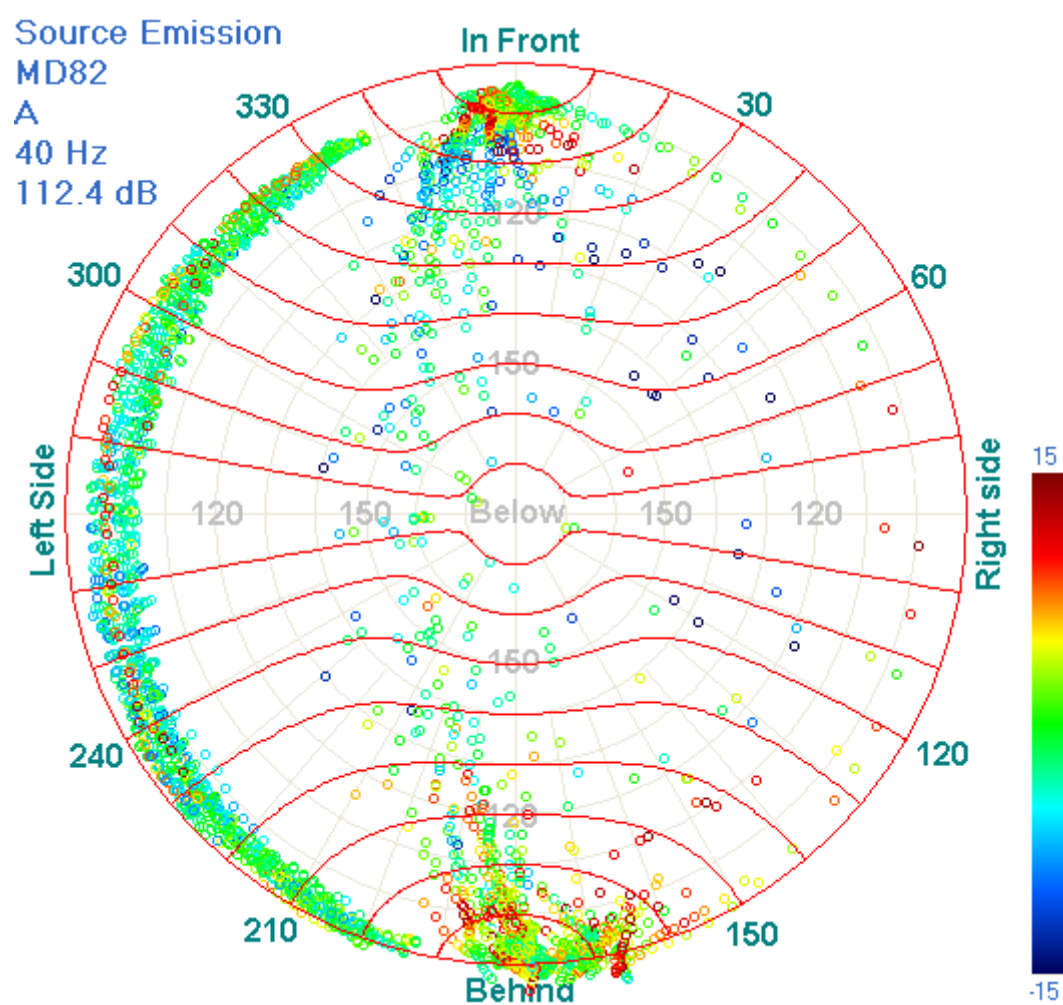
## 15 MD 82 directivity at arrival

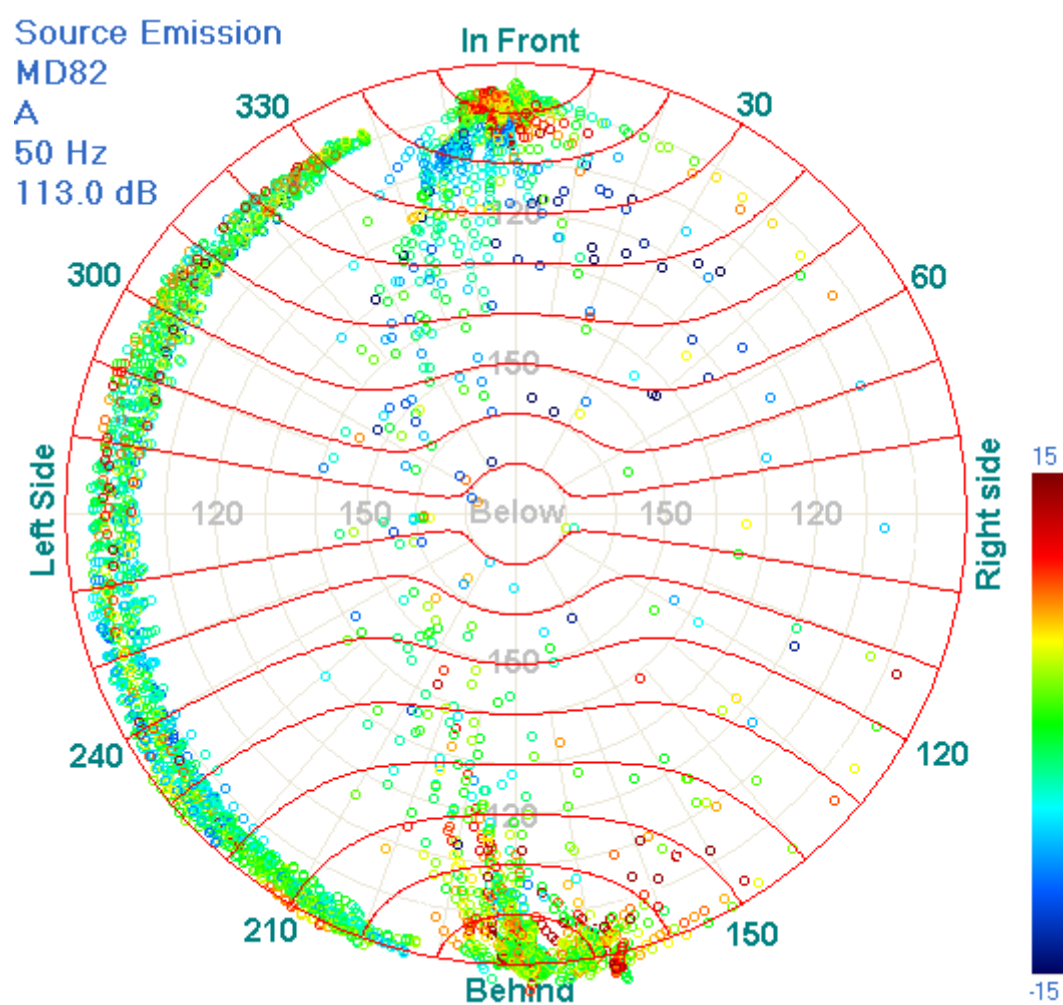
SPECTRUM  
Source Emission  
MD82  
A

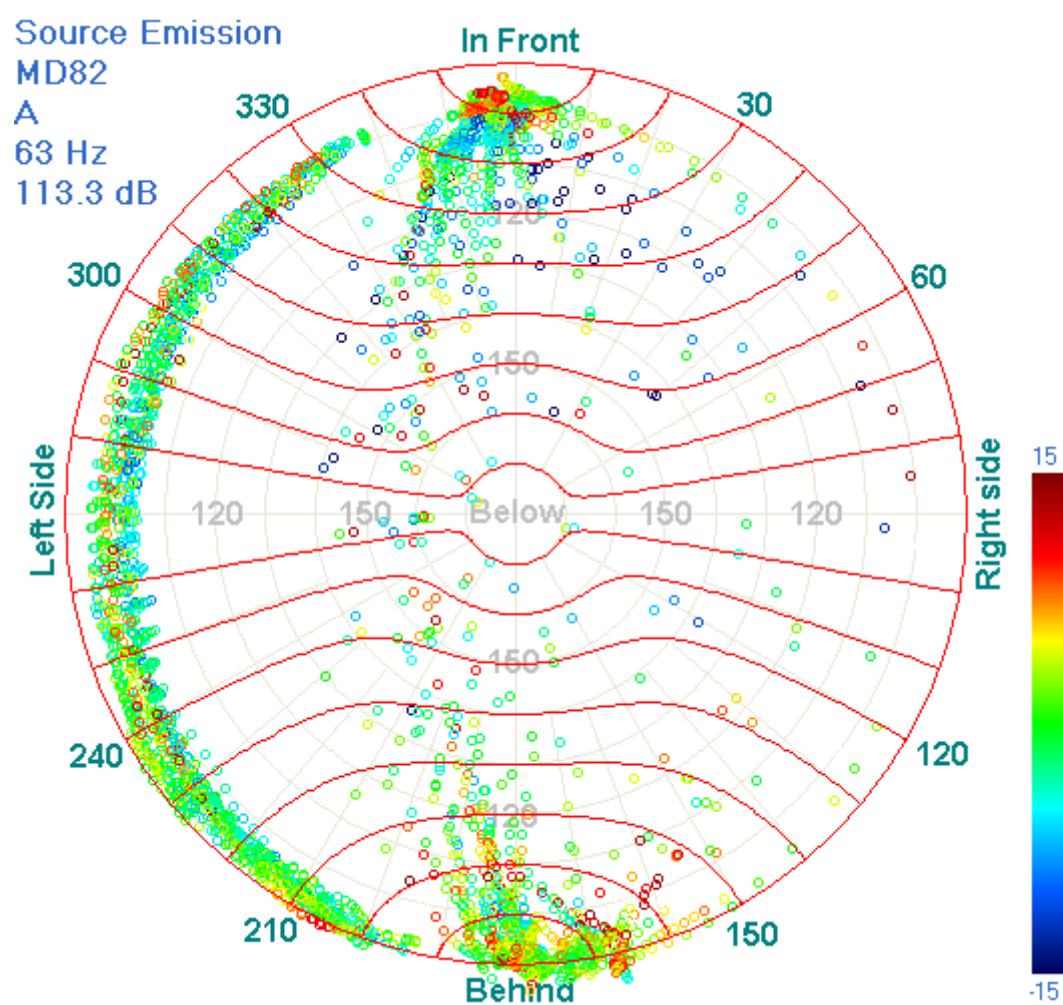
Freq	Num	Avg	Std	95%Avg	P1	P2	P3	P4	P5	P6
25	3432	111.7	5.8	0.2	111.8	111.3	112.8	-1.0	-1.0	-1.0
31.5	3444	111.9	5.9	0.2	111.0	111.5	113.7	-1.0	-1.0	-1.0
40	3254	112.4	5.7	0.2	111.1	112.2	114.2	-1.0	-1.0	-1.0
50	3356	113.0	5.7	0.2	112.1	112.7	114.5	-1.0	-1.0	-1.0
63	3181	113.3	5.9	0.2	112.8	112.7	115.2	-1.0	-1.0	-1.0
80	3595	112.7	5.8	0.2	112.2	112.3	114.3	-1.0	-1.0	-1.0
100	4078	112.3	5.6	0.2	111.4	111.8	114.3	-1.0	-1.0	-1.0
125	4328	112.8	5.4	0.2	112.1	112.4	114.6	-1.0	-1.0	-1.0
160	4296	113.5	5.4	0.2	112.8	113.3	114.8	-1.0	-1.0	-1.0
200	4470	113.7	4.8	0.1	112.7	113.4	115.2	-1.0	-1.0	-1.0
250	4510	113.5	4.9	0.1	112.4	113.3	115.2	-1.0	-1.0	-1.0
315	4567	113.7	5.1	0.1	112.5	113.5	115.5	-1.0	-1.0	-1.0
400	4553	112.4	4.7	0.1	111.1	112.2	113.9	-1.0	-1.0	-1.0
500	4482	111.5	4.4	0.1	110.4	111.4	112.9	-1.0	-1.0	-1.0
630	4492	111.4	4.5	0.1	110.7	111.3	112.4	-1.0	-1.0	-1.0
800	4411	111.1	4.4	0.1	110.5	111.0	112.1	-1.0	-1.0	-1.0
1000	4358	110.7	4.4	0.1	110.0	110.5	111.7	-1.0	-1.0	-1.0
1250	4458	110.2	4.5	0.1	109.3	110.1	111.2	-1.0	-1.0	-1.0
1600	4423	109.5	4.5	0.1	108.6	109.5	110.5	-1.0	-1.0	-1.0
2000	4472	109.3	4.8	0.1	108.3	109.3	110.1	-1.0	-1.0	-1.0
2500	4403	109.2	5.1	0.2	108.2	109.3	109.9	-1.0	-1.0	-1.0
3150	4273	110.7	5.6	0.2	109.0	111.1	110.6	-1.0	-1.0	-1.0
4000	3779	113.0	6.7	0.2	110.5	113.3	114.1	-1.0	-1.0	-1.0
5000	2194	112.6	6.7	0.3	112.0	112.8	112.4	-1.0	-1.0	-1.0
6300	1293	114.0	8.3	0.4	113.3	114.6	112.8	-1.0	-1.0	-1.0
8000	644	116.4	10.8	0.8	114.9	117.3	114.9	-1.0	-1.0	-1.0
10000	395	117.4	14.7	1.4	117.4	118.1	114.7	-1.0	-1.0	-1.0

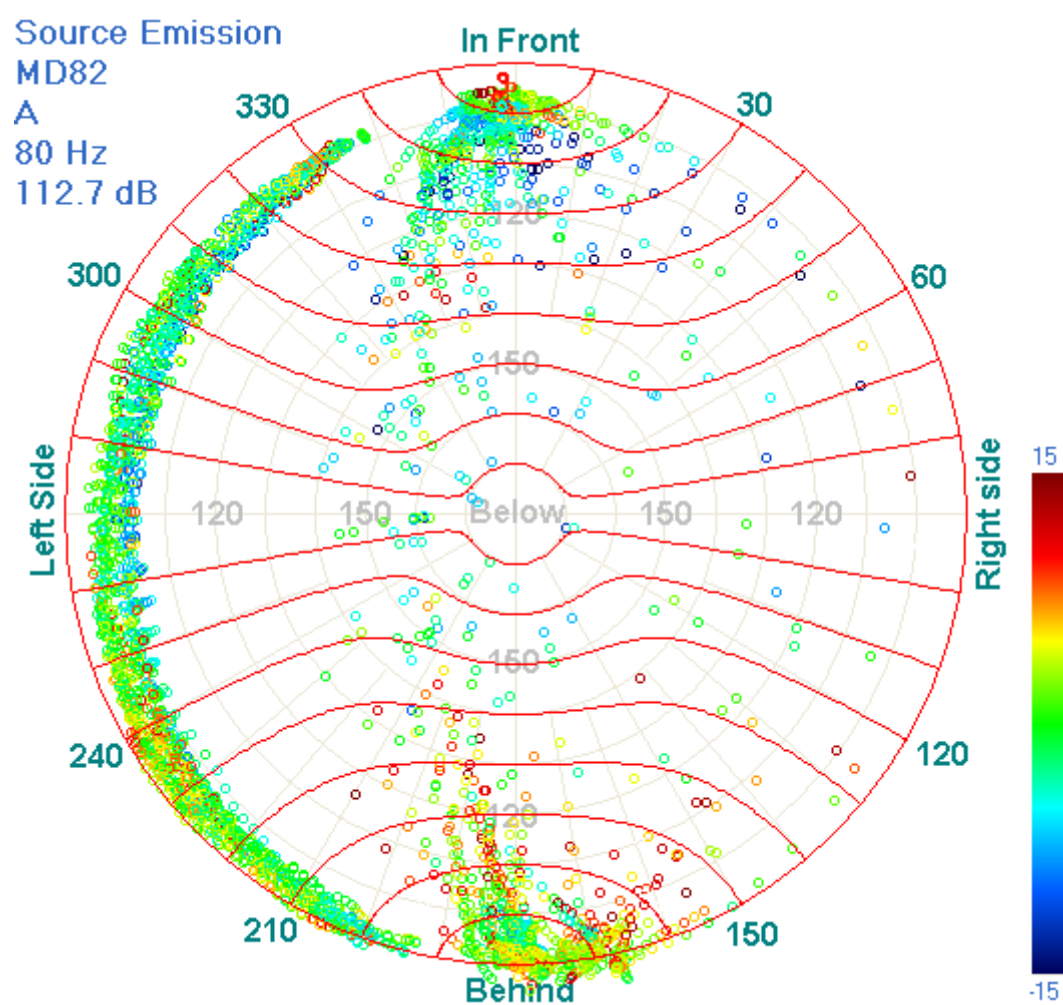


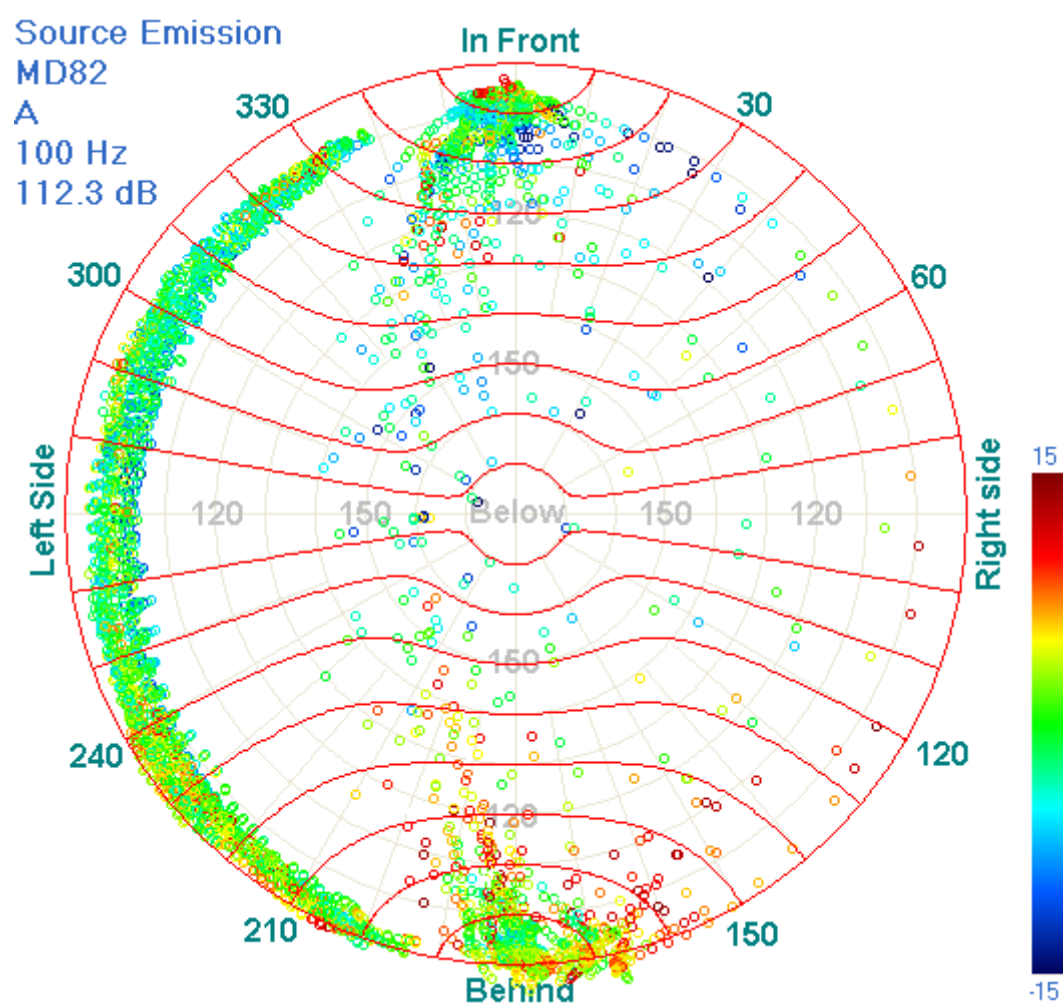




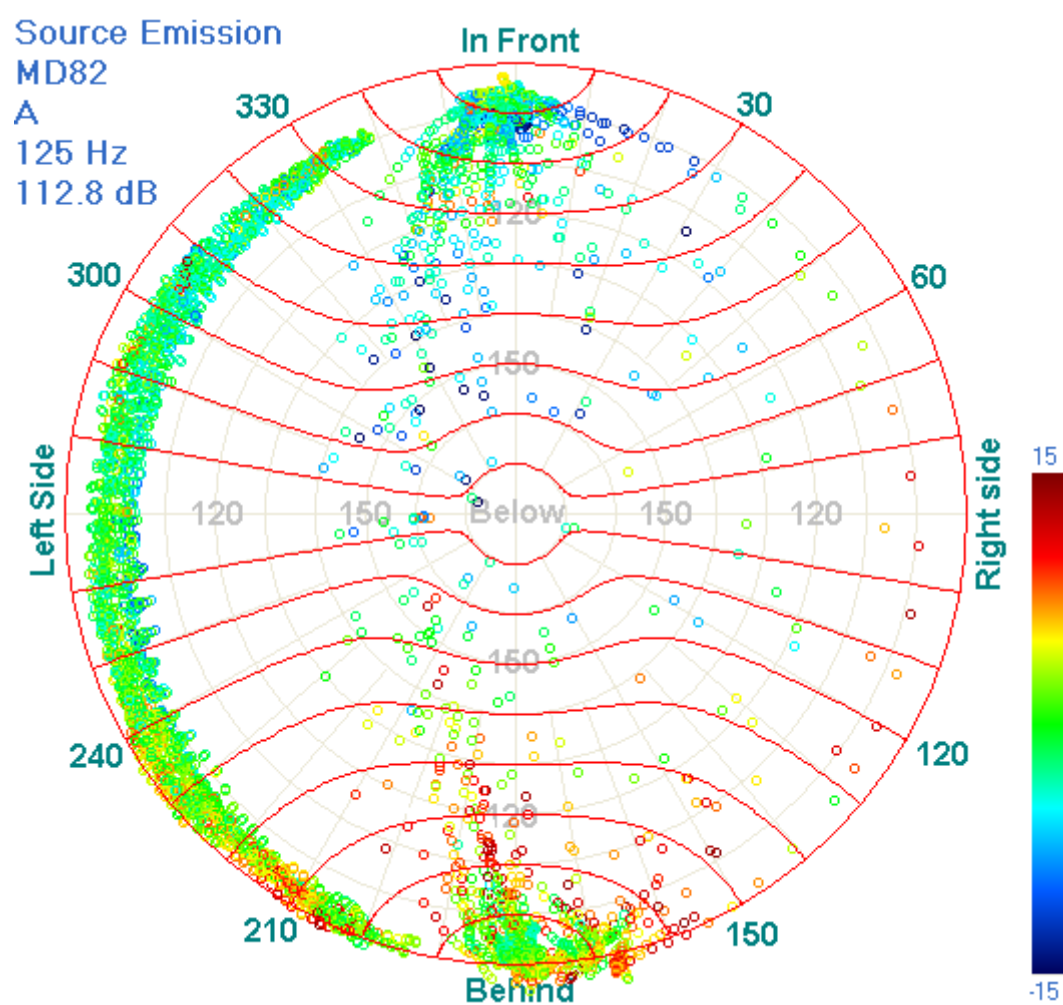


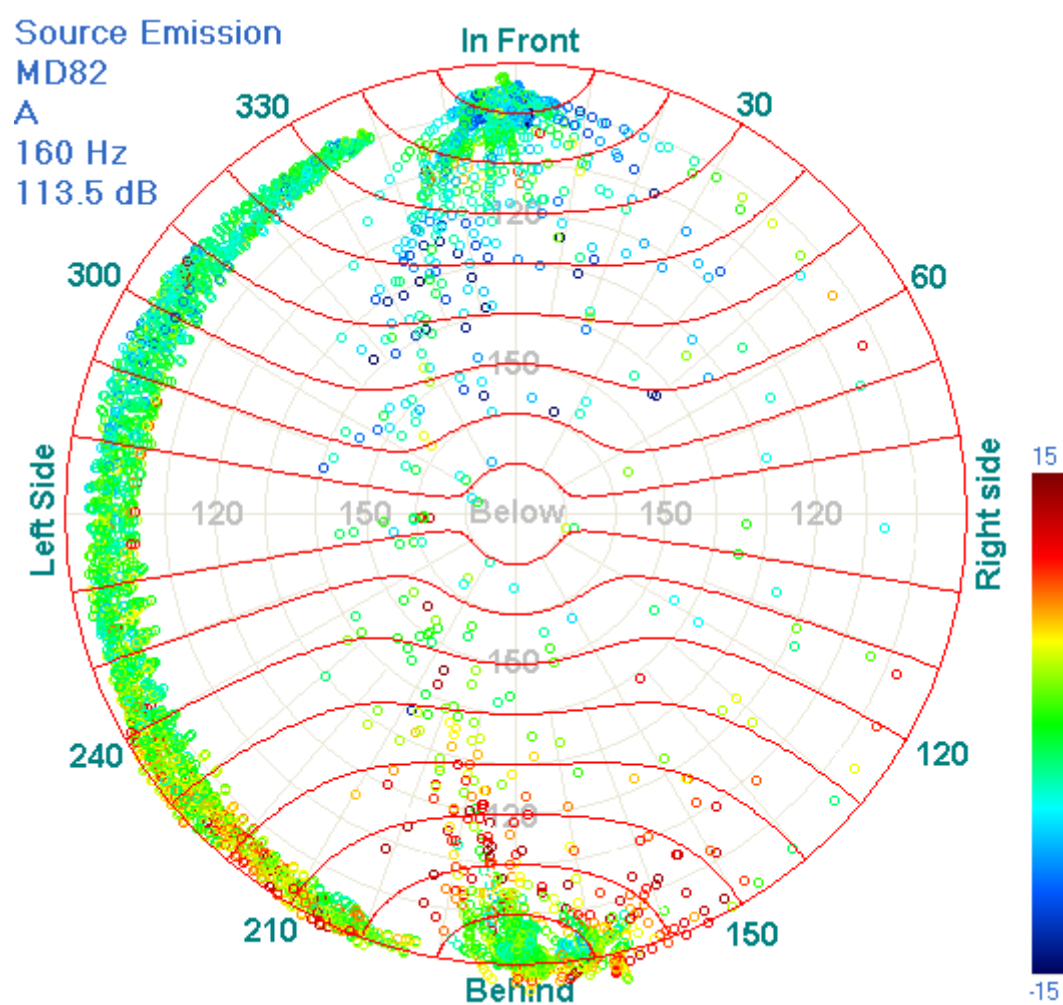


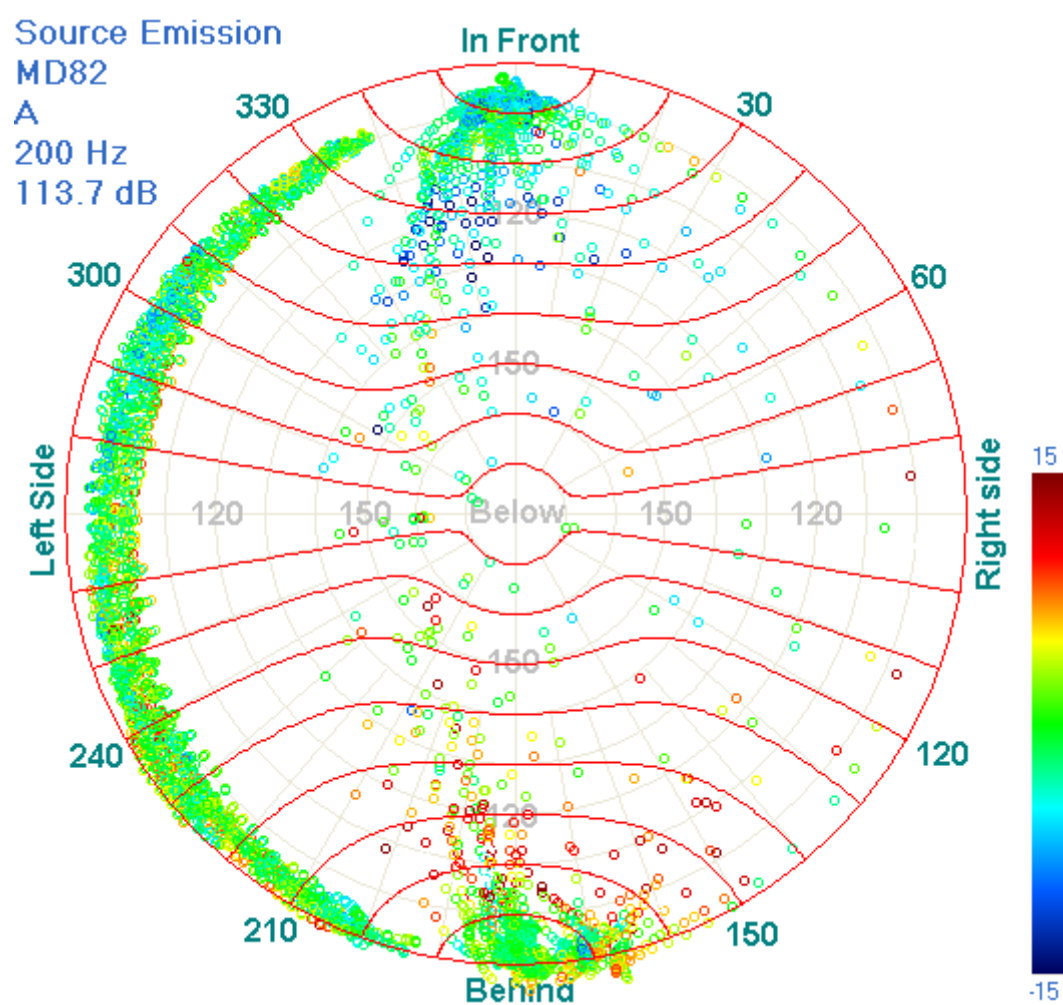


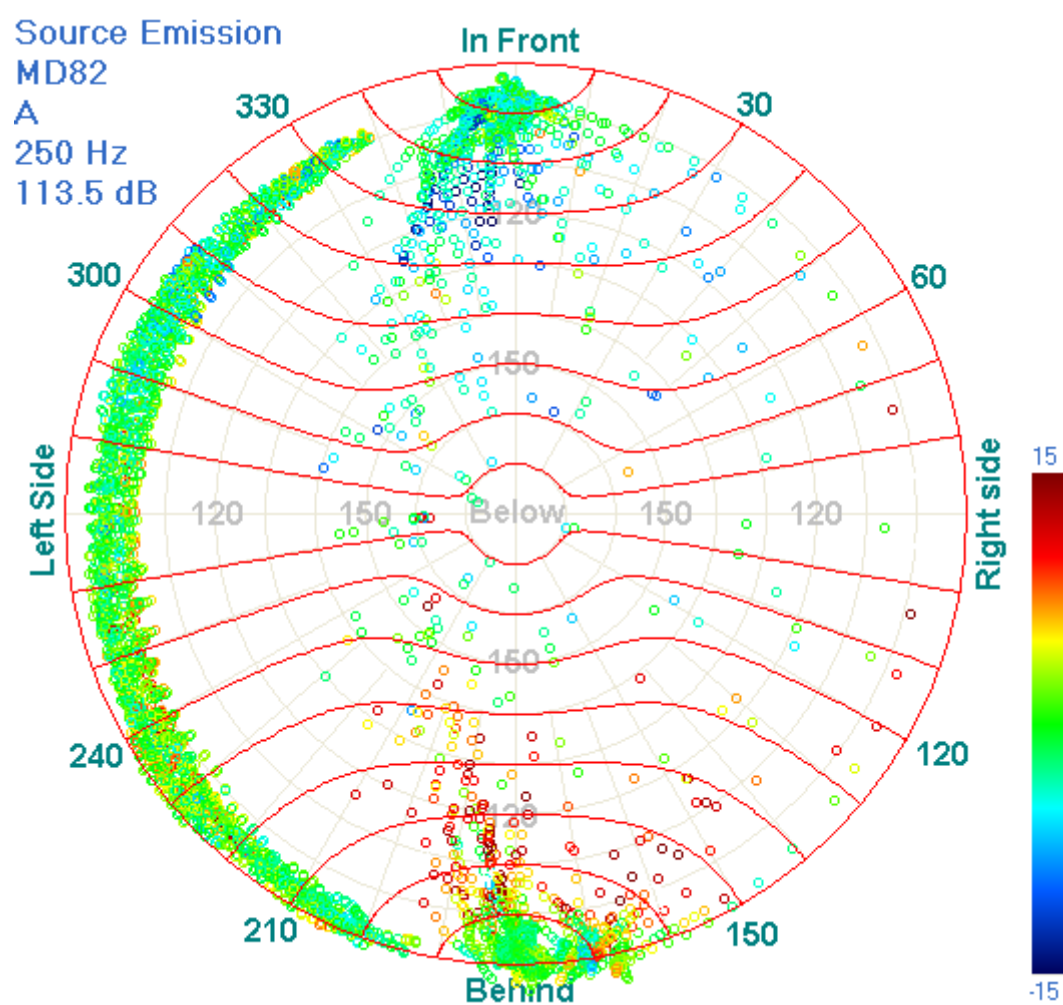


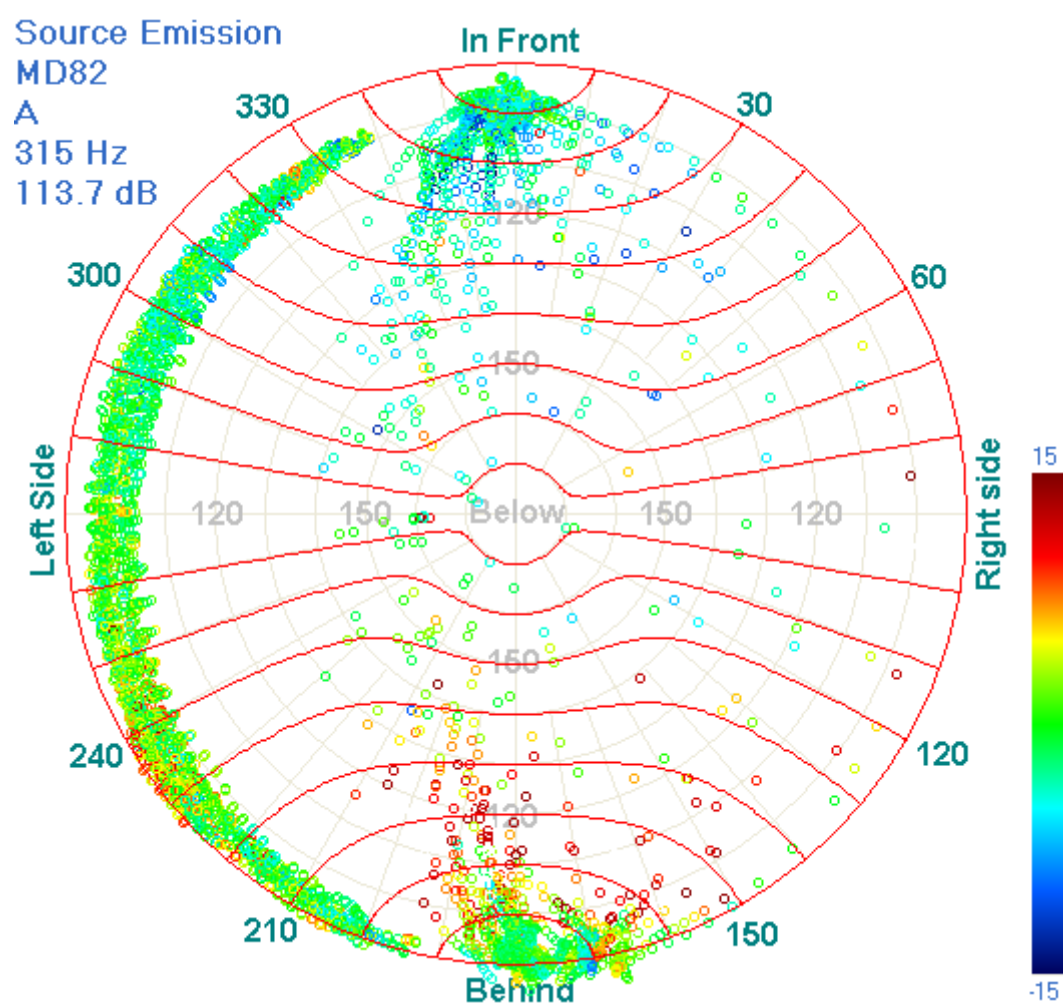


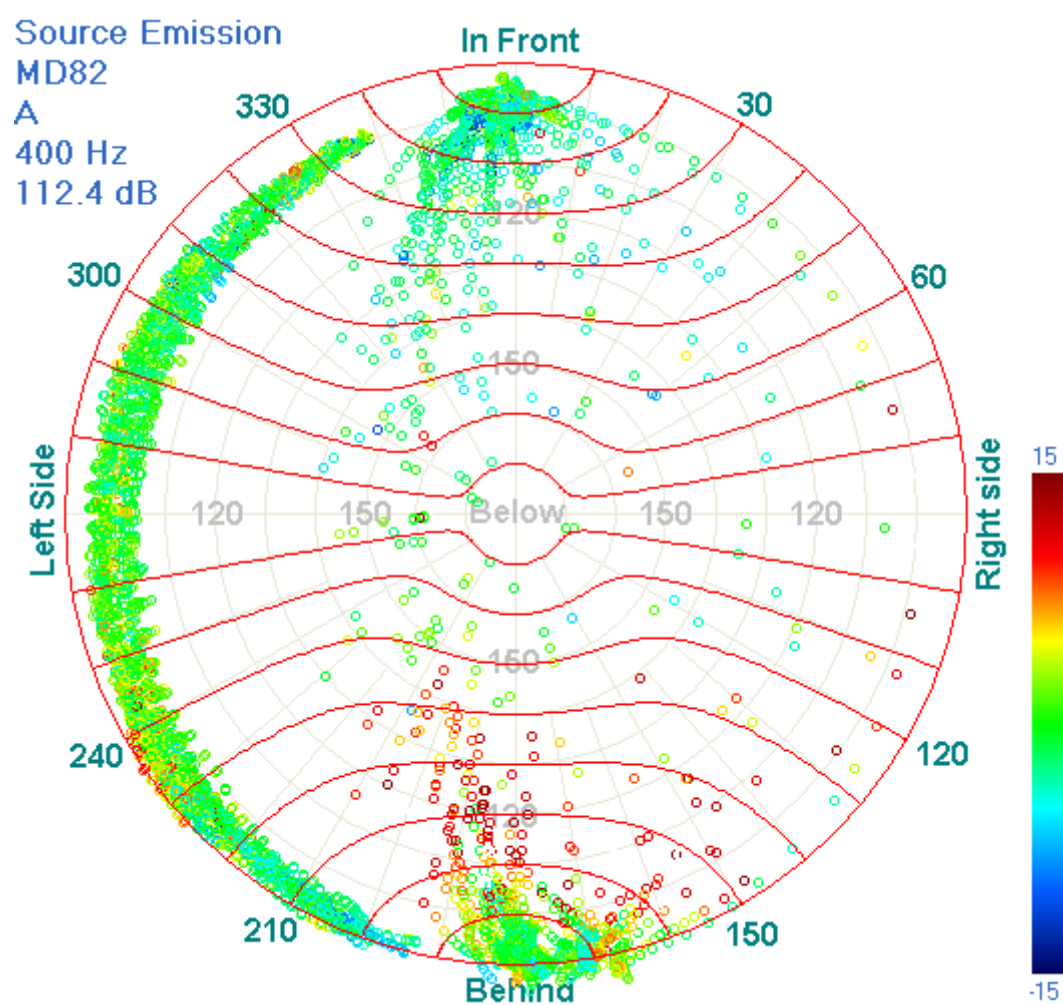


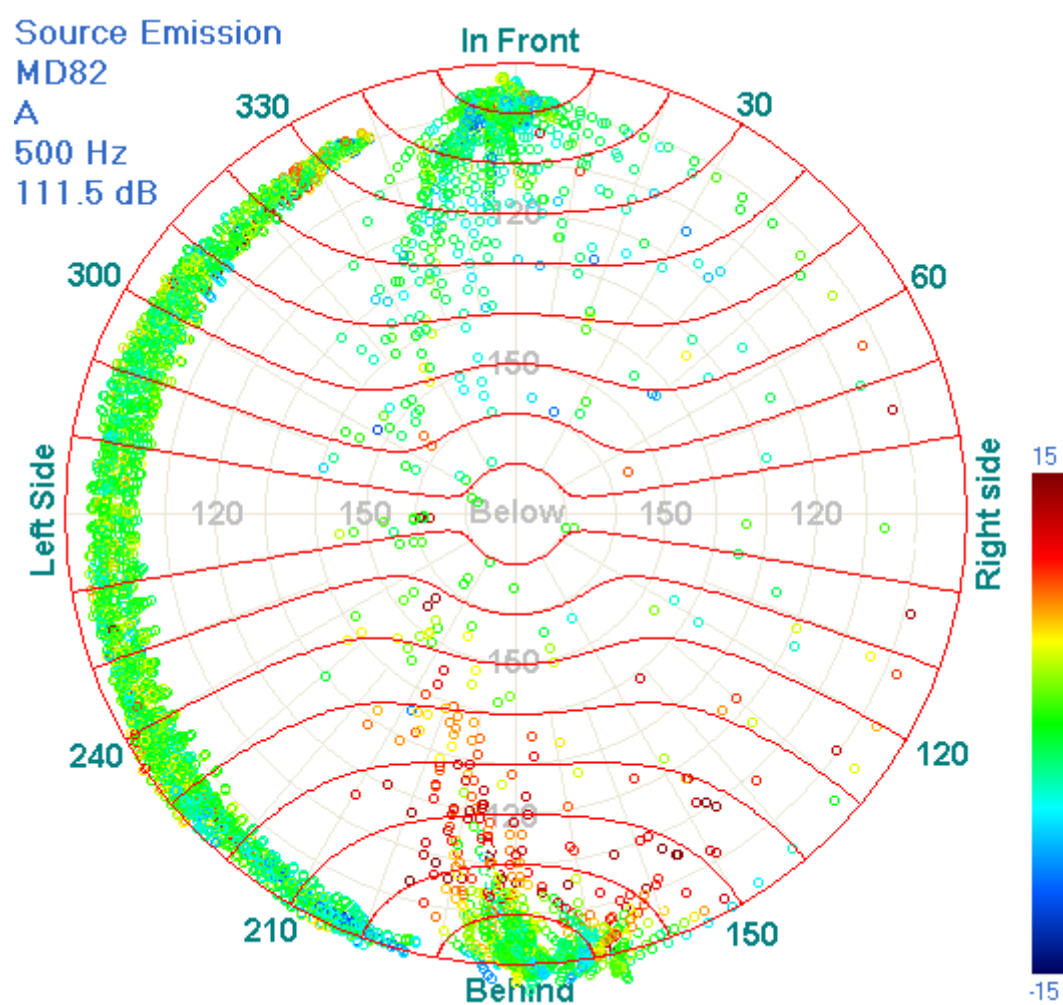


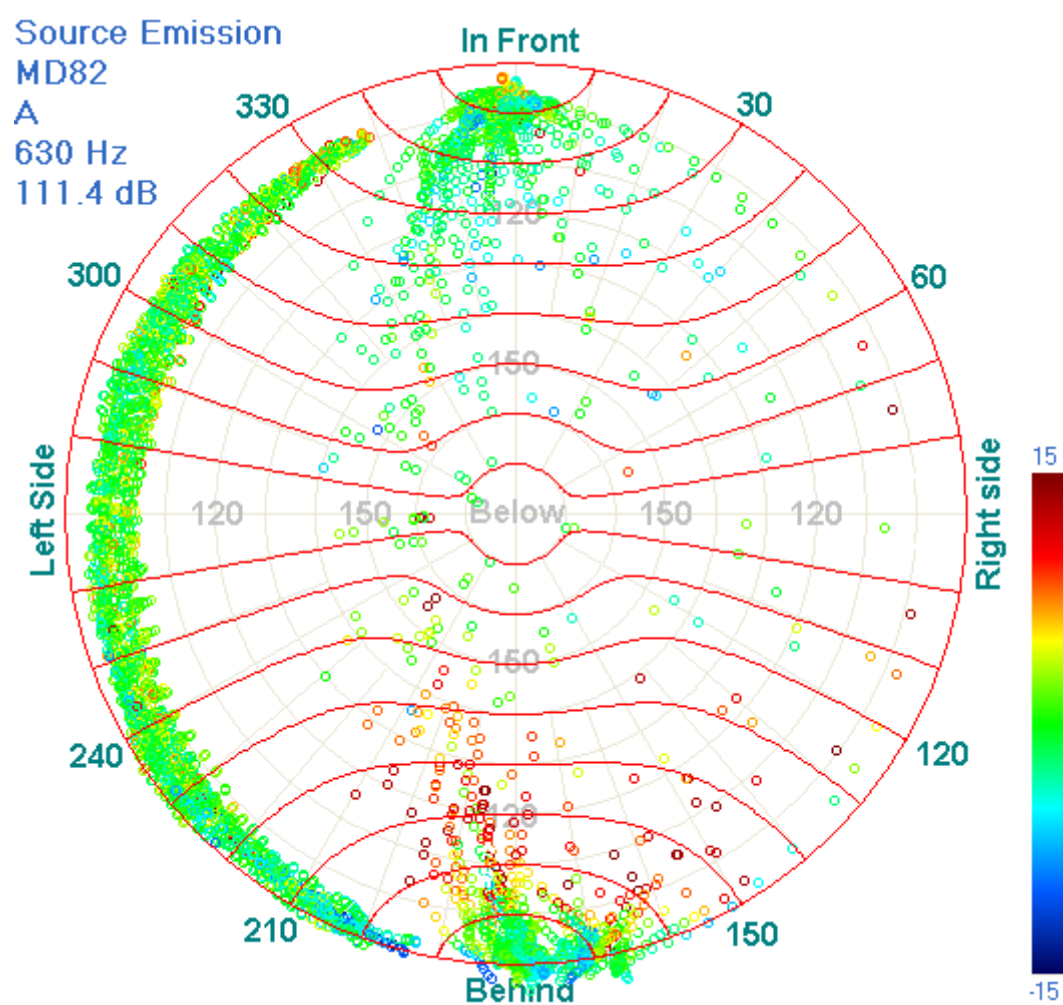




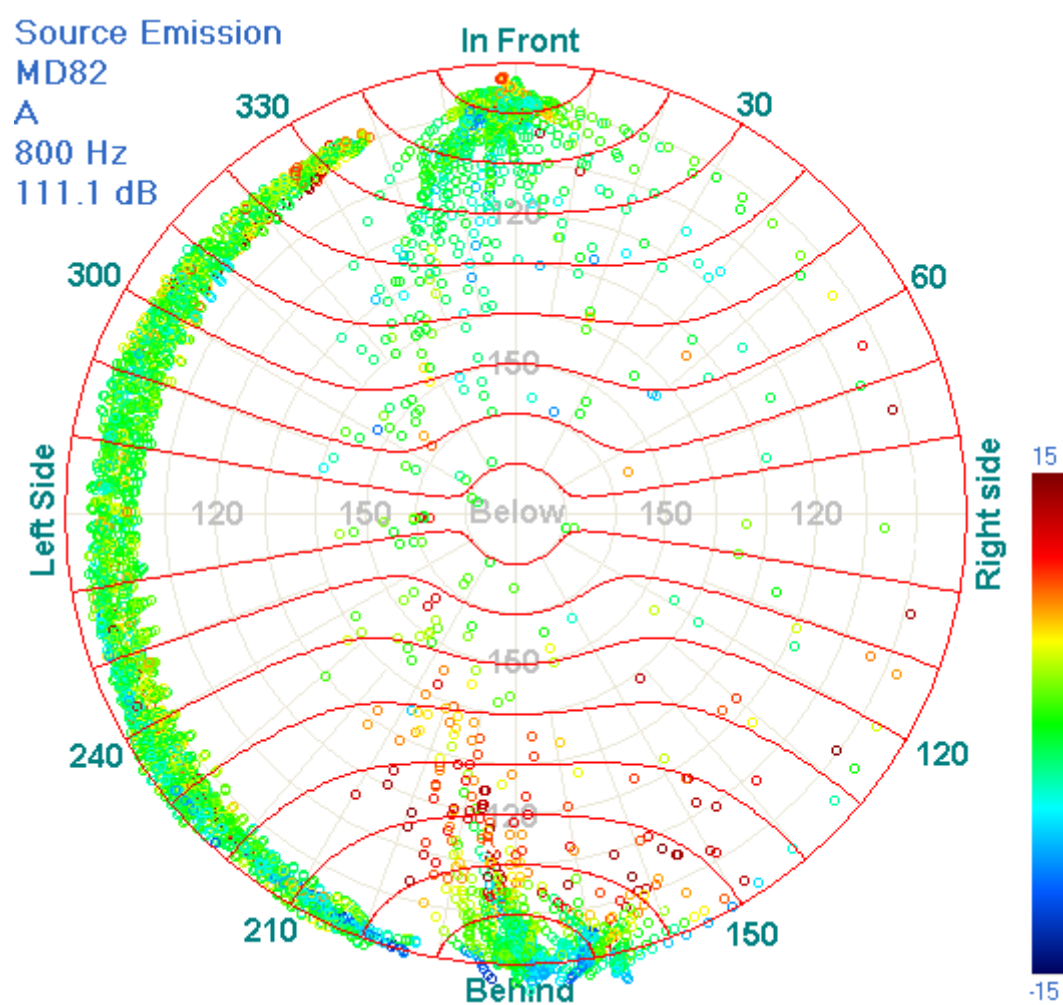


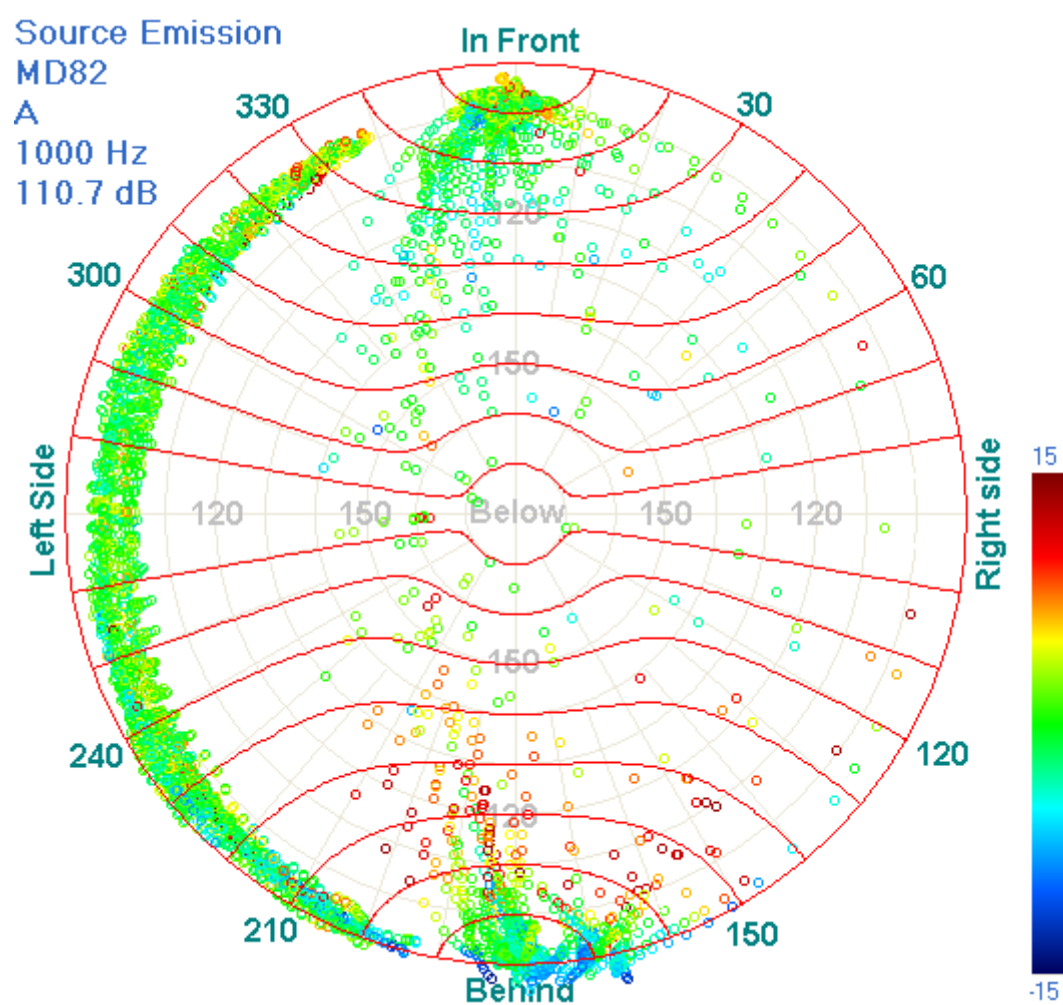


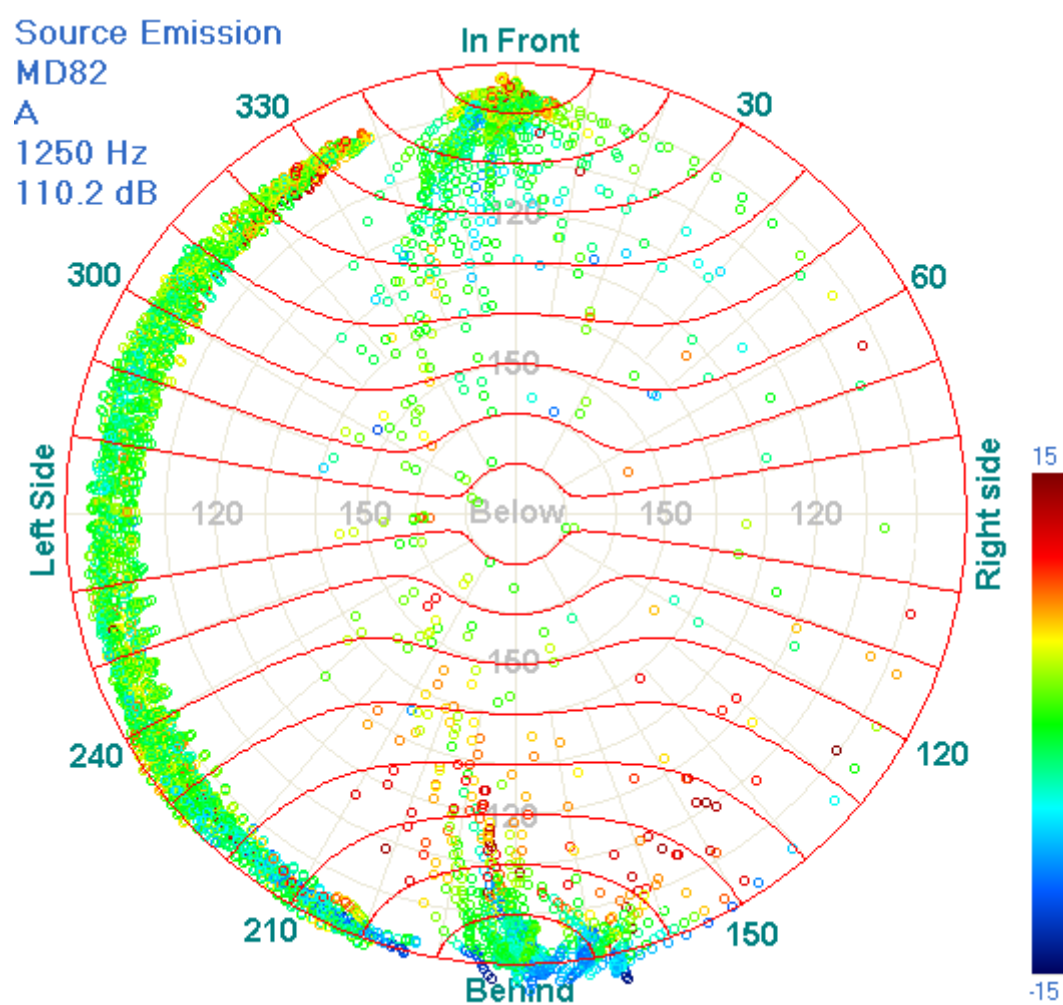


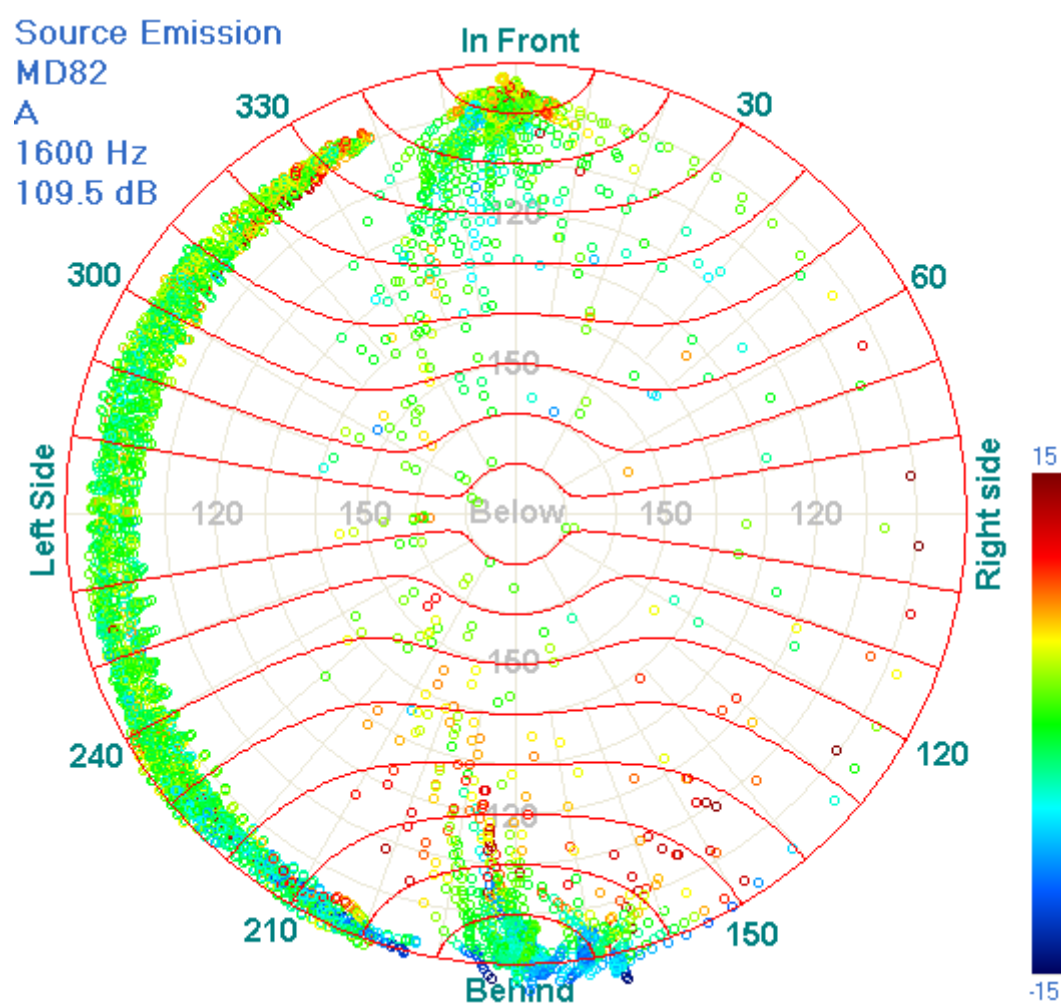


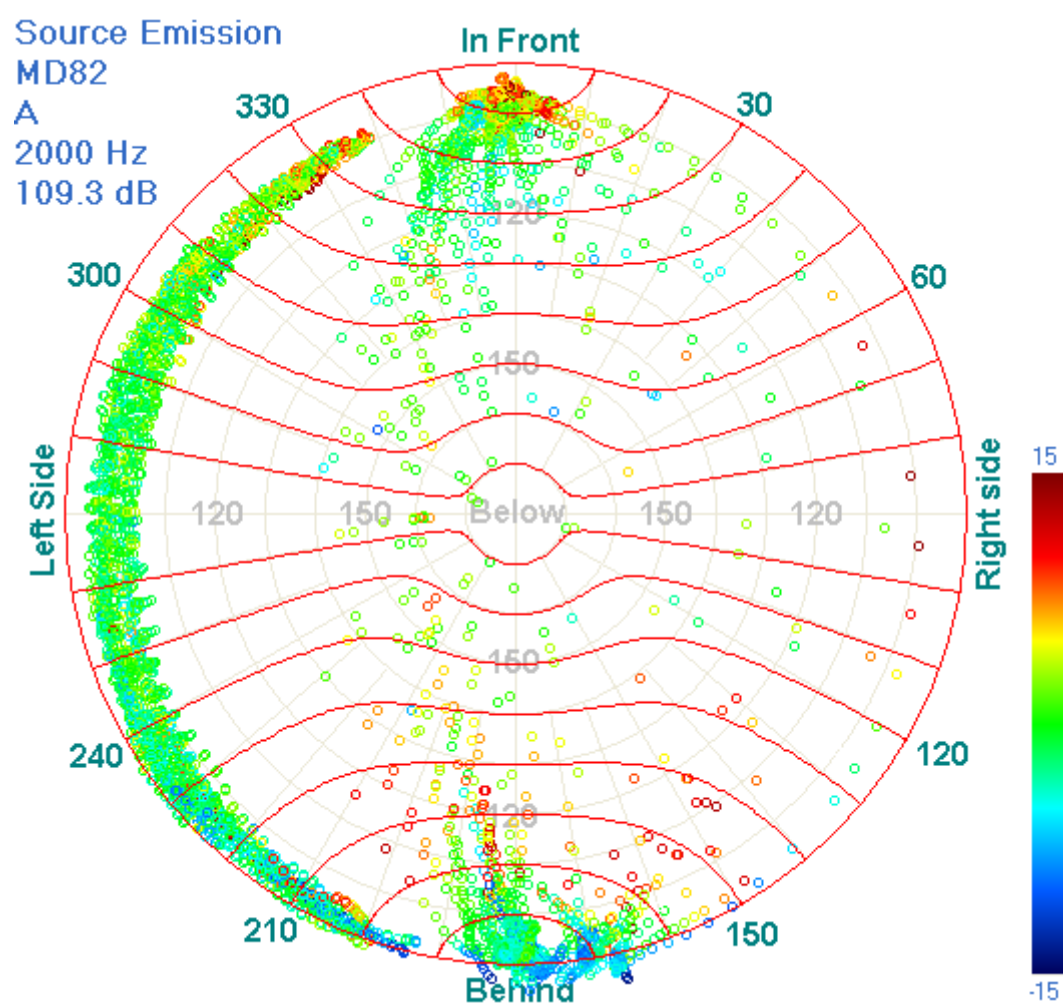


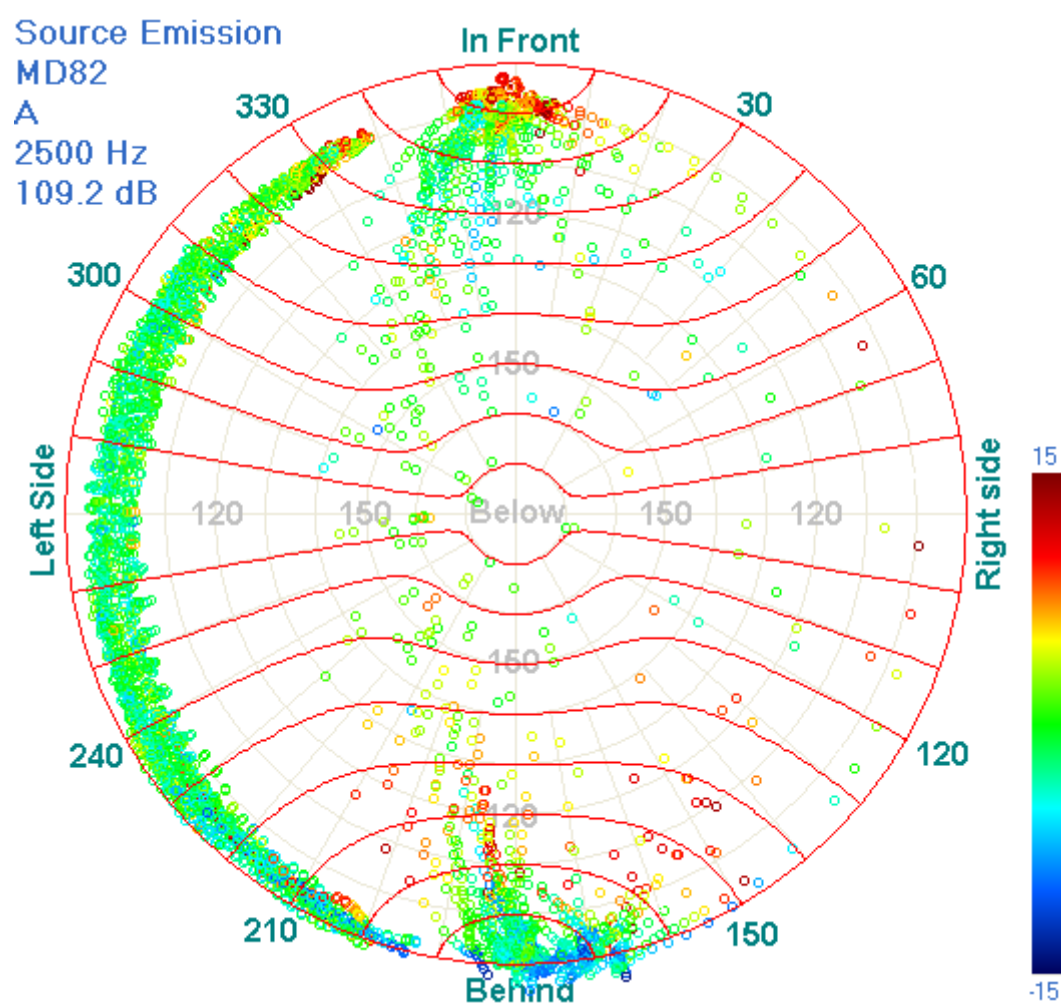




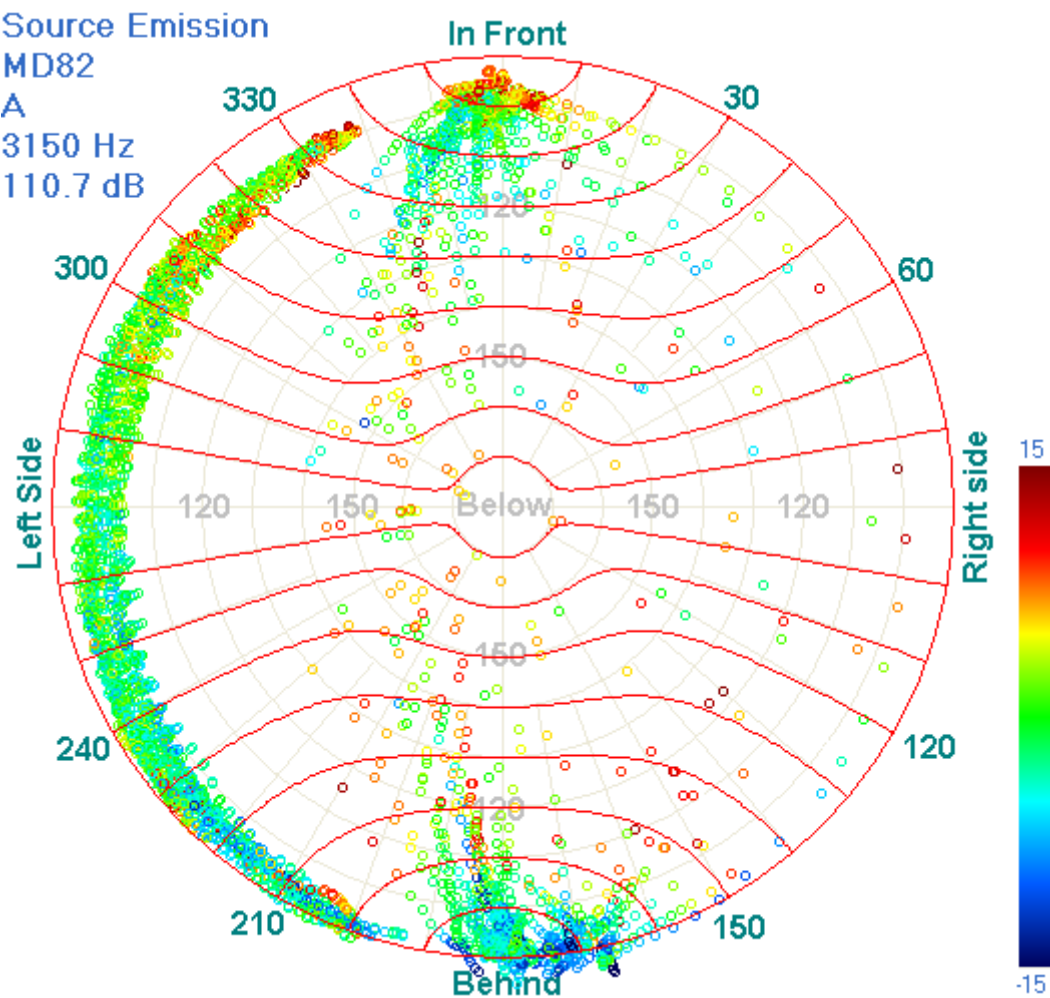


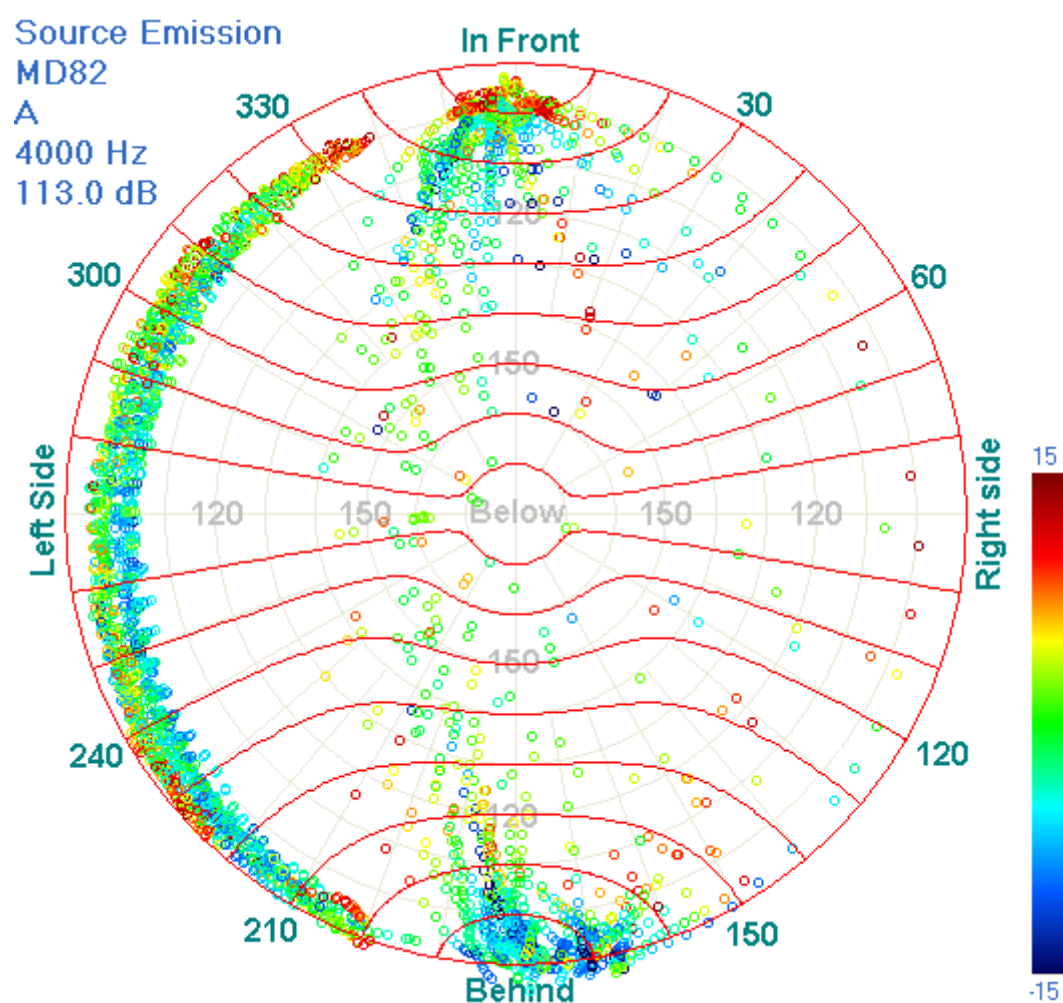




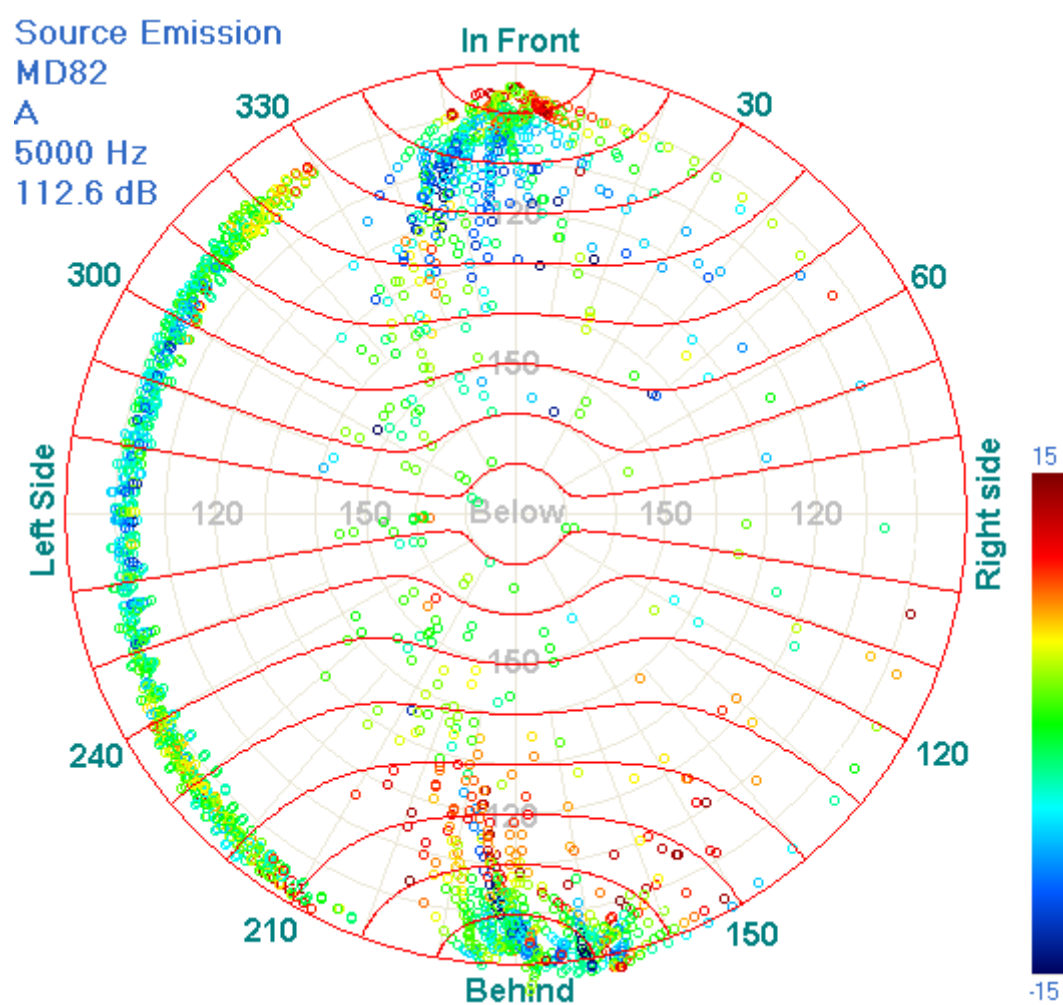


Source Emission  
MD82  
A  
3150 Hz  
110.7 dB

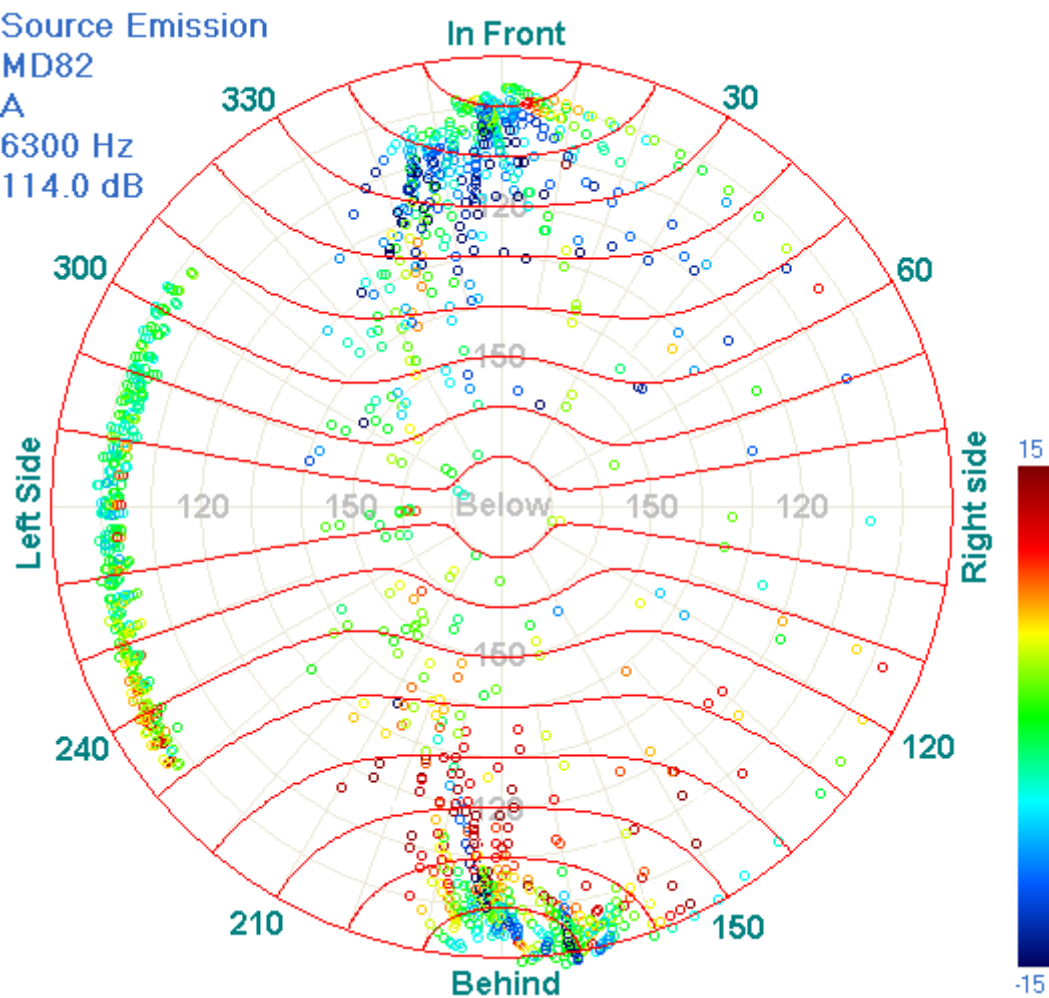


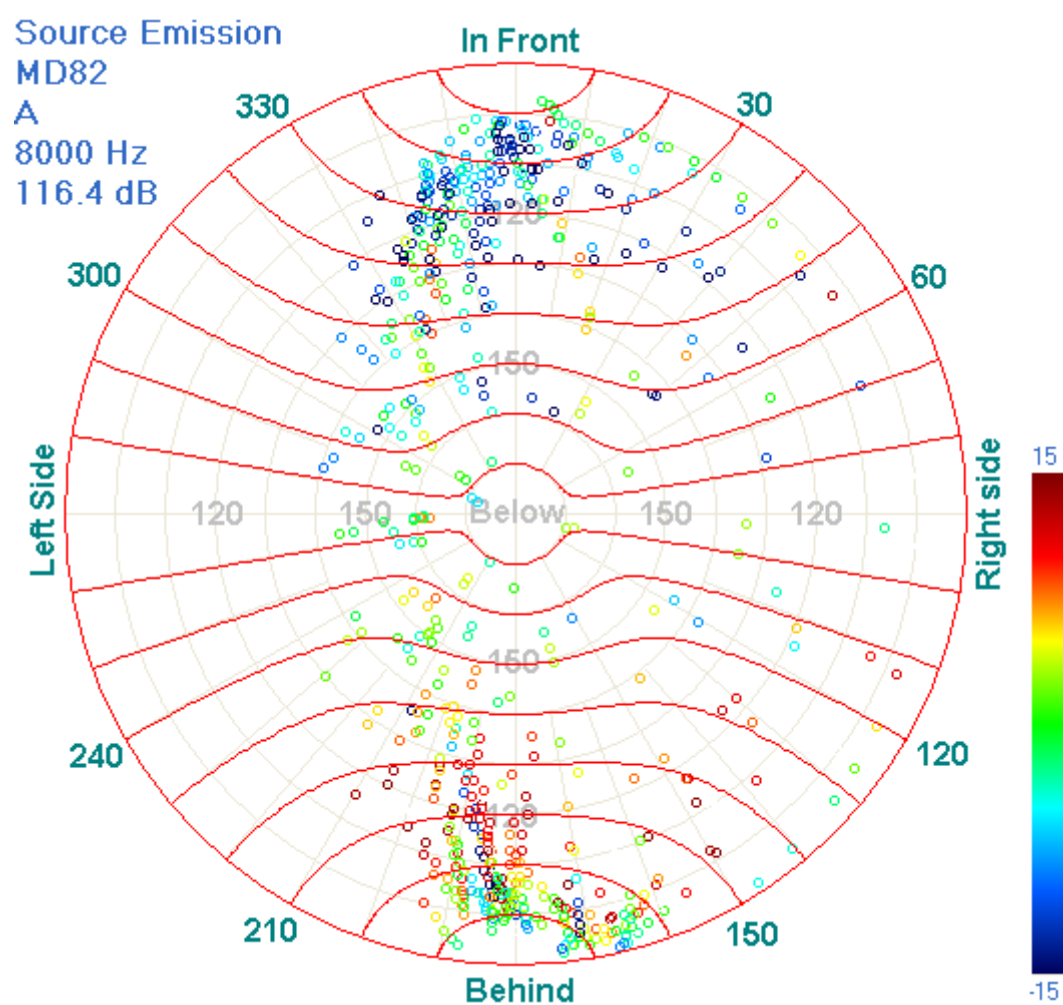


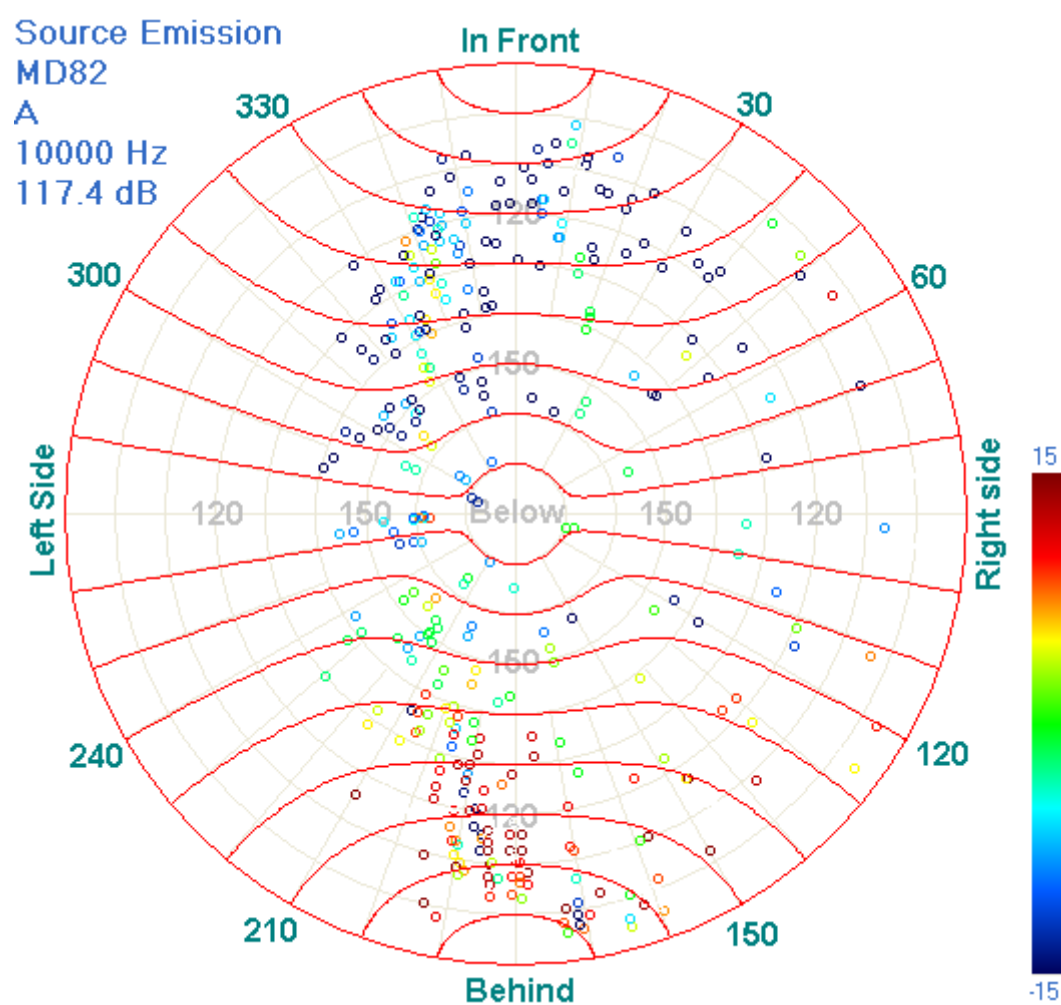




Source Emission  
MD82  
A  
6300 Hz  
114.0 dB





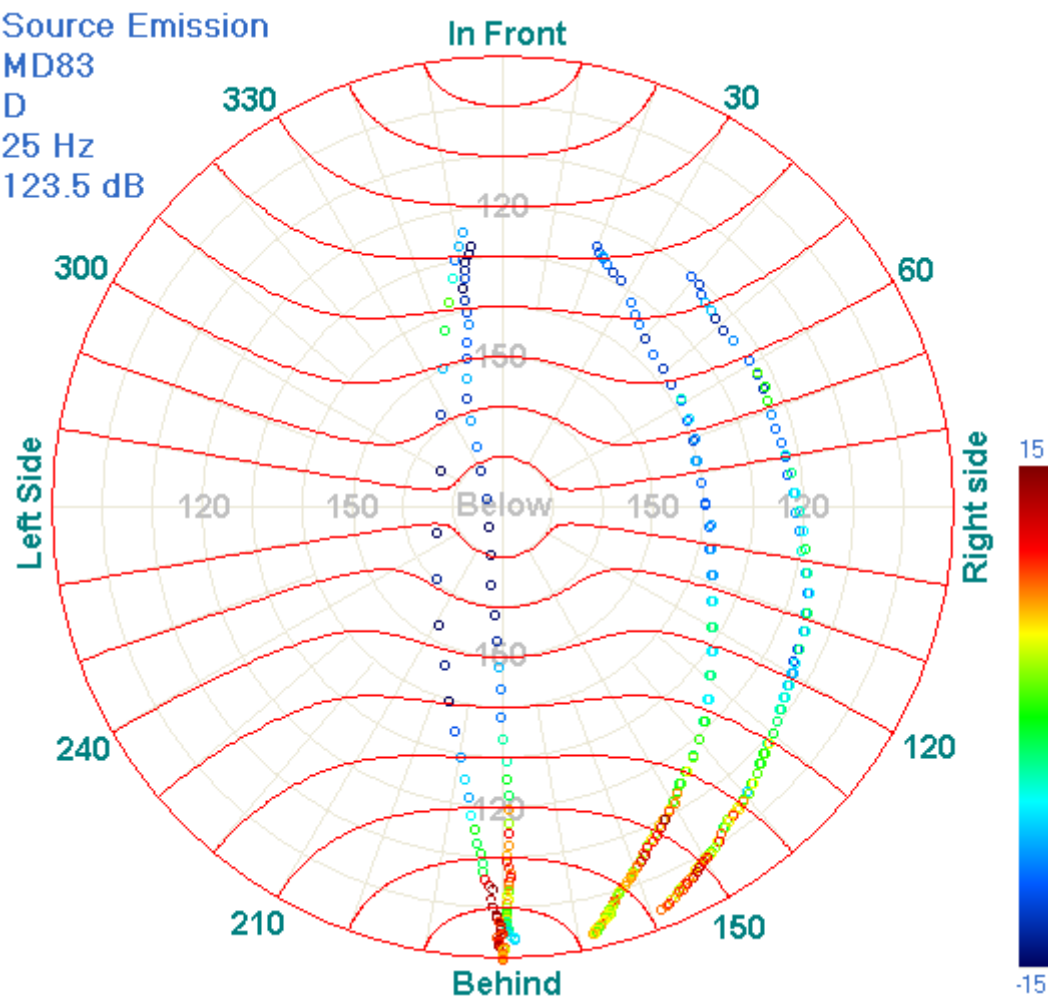


## 16 MD 83 directivity at departure

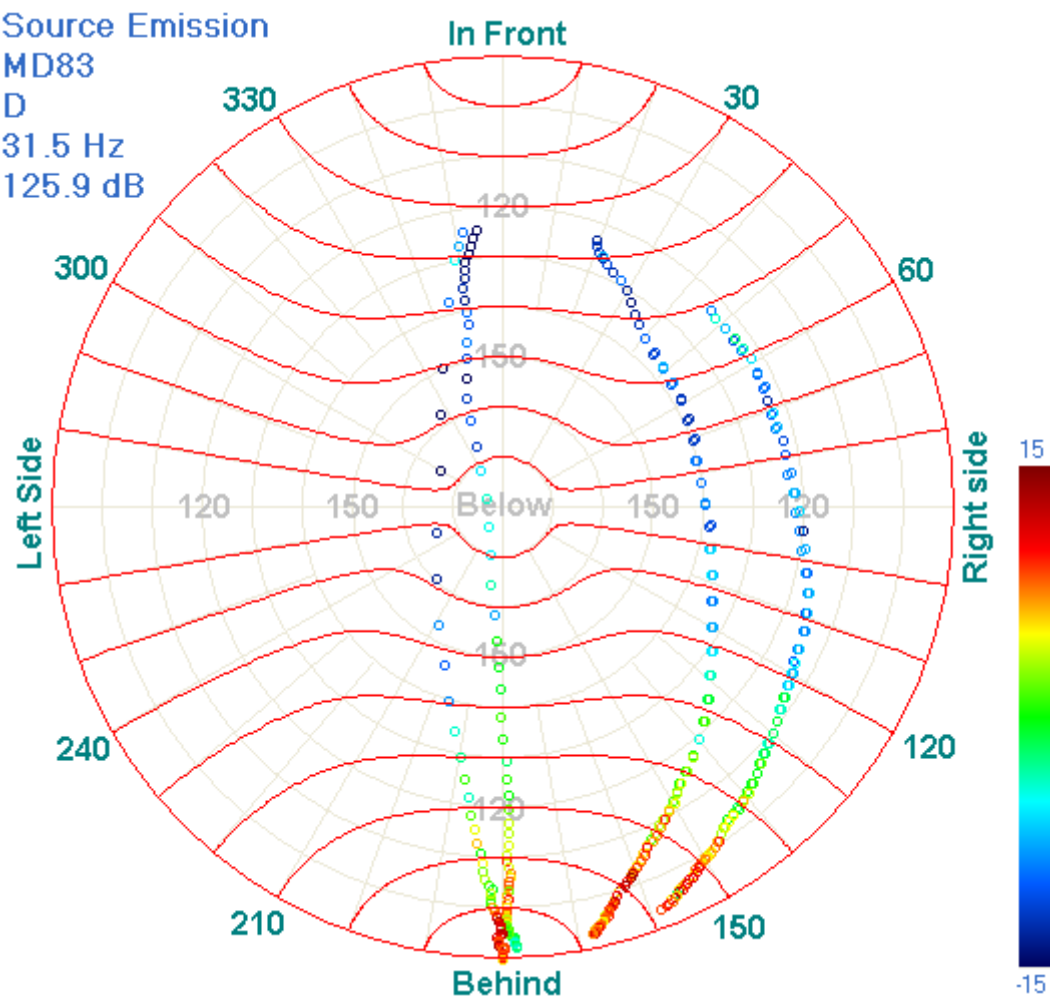
SPECTRUM  
Source Emission  
MD83  
D

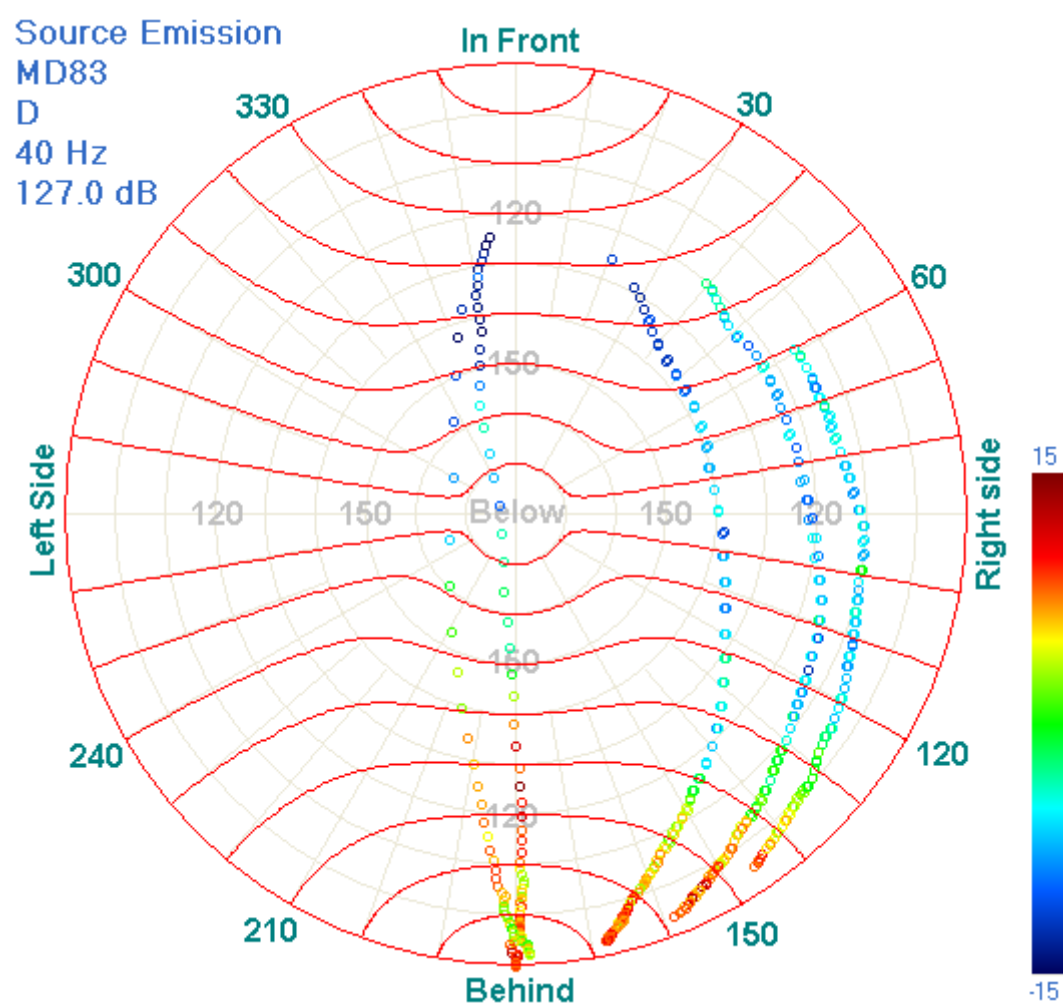
Freq	Num	Avg	Std	95%Avg	P1	P2	P3	P4	P5	P6
25	354	123.5	8.1	0.8	-1.0	-1.0	-1.0	-1.0	128.3	-1.0
31.5	367	125.9	8.1	0.8	-1.0	-1.0	-1.0	-1.0	131.6	-1.0
40	471	127.0	7.1	0.6	-1.0	-1.0	-1.0	-1.0	131.4	-1.0
50	468	128.0	7.2	0.7	-1.0	-1.0	-1.0	-1.0	131.9	-1.0
63	492	129.5	7.8	0.7	-1.0	-1.0	-1.0	-1.0	132.9	-1.0
80	433	131.1	8.1	0.8	-1.0	-1.0	-1.0	-1.0	133.5	-1.0
100	440	131.7	7.4	0.7	-1.0	-1.0	-1.0	-1.0	134.6	-1.0
125	505	130.9	5.9	0.5	-1.0	-1.0	-1.0	-1.0	133.9	-1.0
160	503	130.1	4.7	0.4	-1.0	-1.0	-1.0	-1.0	131.4	-1.0
200	505	129.6	5.1	0.4	-1.0	-1.0	-1.0	-1.0	129.5	-1.0
250	505	130.2	5.4	0.5	-1.0	-1.0	-1.0	-1.0	130.9	-1.0
315	502	129.4	5.6	0.5	-1.0	-1.0	-1.0	-1.0	128.4	-1.0
400	503	129.3	5.7	0.5	-1.0	-1.0	-1.0	-1.0	127.8	-1.0
500	501	128.0	5.5	0.5	-1.0	-1.0	-1.0	-1.0	126.6	-1.0
630	501	128.0	5.5	0.5	-1.0	-1.0	-1.0	-1.0	126.6	-1.0
800	499	127.4	5.3	0.5	-1.0	-1.0	-1.0	-1.0	126.1	-1.0
1000	500	126.8	5.4	0.5	-1.0	-1.0	-1.0	-1.0	125.2	-1.0
1250	497	125.5	5.7	0.5	-1.0	-1.0	-1.0	-1.0	123.8	-1.0
1600	499	123.9	5.6	0.5	-1.0	-1.0	-1.0	-1.0	122.0	-1.0
2000	488	122.6	5.2	0.5	-1.0	-1.0	-1.0	-1.0	120.5	-1.0
2500	461	121.2	4.7	0.4	-1.0	-1.0	-1.0	-1.0	119.2	-1.0
3150	379	119.9	4.1	0.4	-1.0	-1.0	-1.0	-1.0	119.7	-1.0
4000	213	118.6	4.3	0.6	-1.0	-1.0	-1.0	-1.0	121.7	-1.0
5000	89	116.3	3.8	0.8	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
6300	27	112.8	3.8	1.4	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
8000	0	999.0	999.0	999.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
10000	0	999.0	999.0	999.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0

Source Emission  
MD83  
D  
25 Hz  
123.5 dB

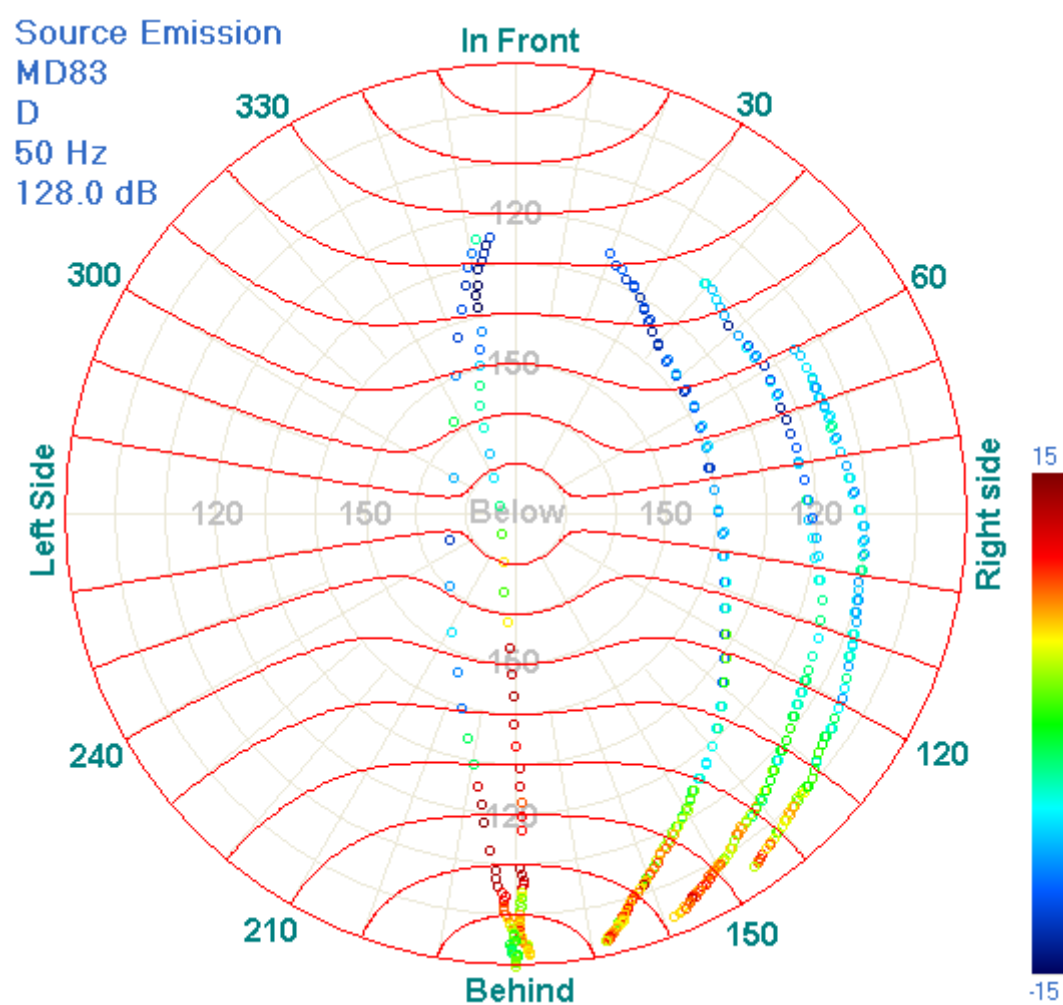


Source Emission  
MD83  
D  
31.5 Hz  
125.9 dB

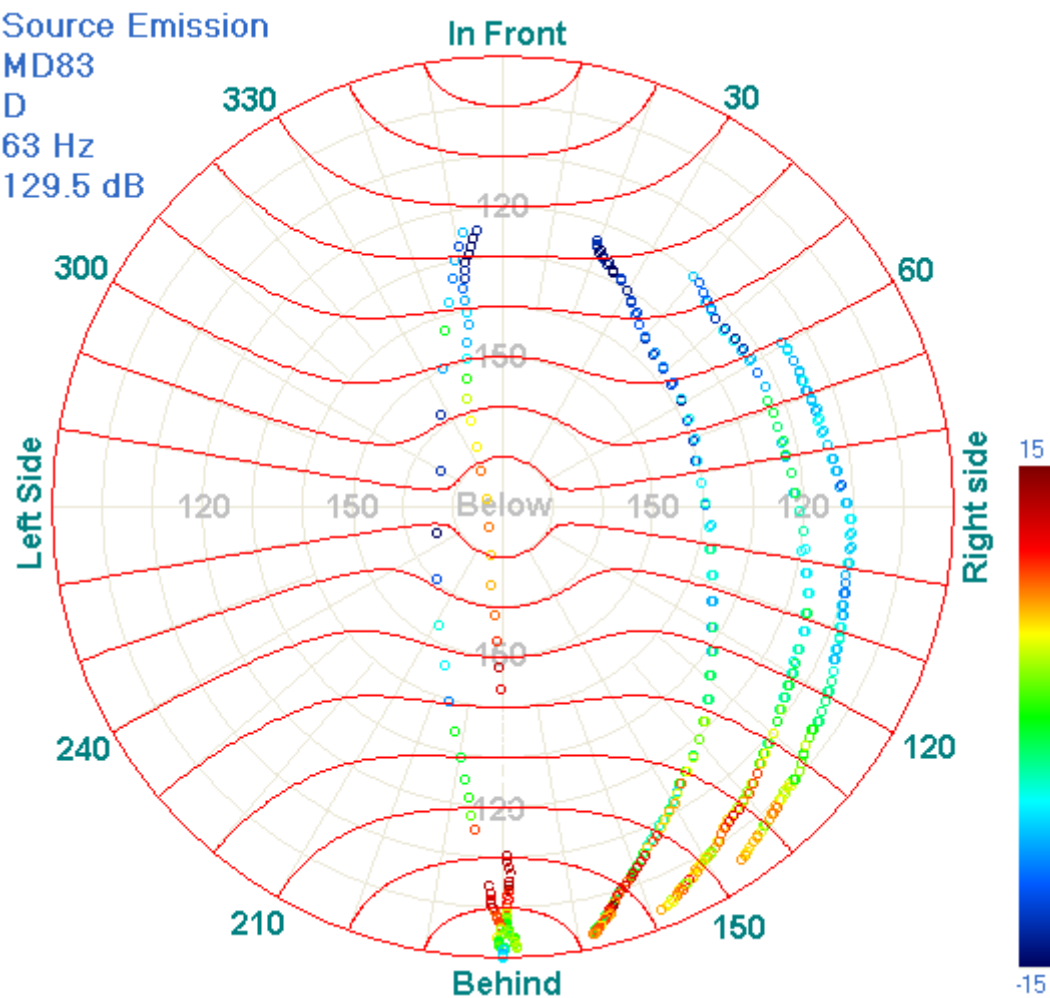


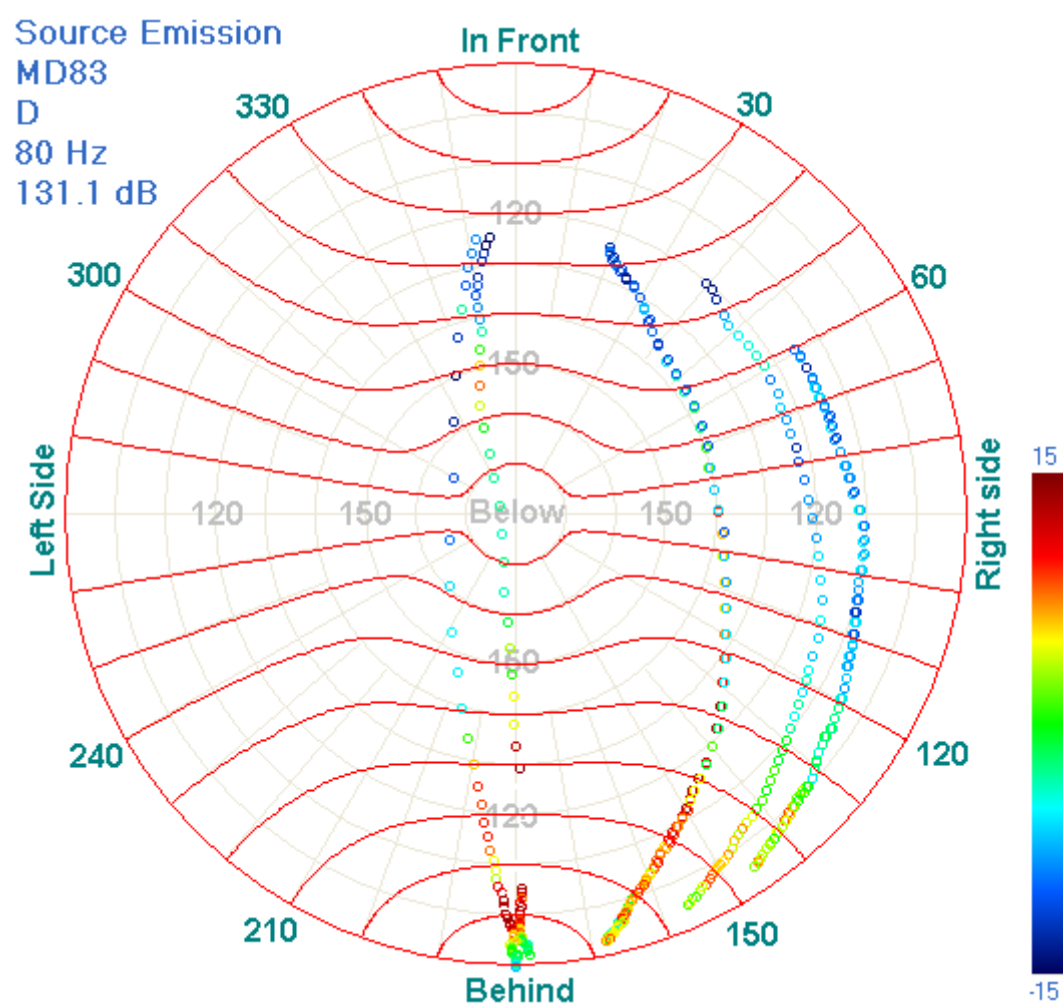


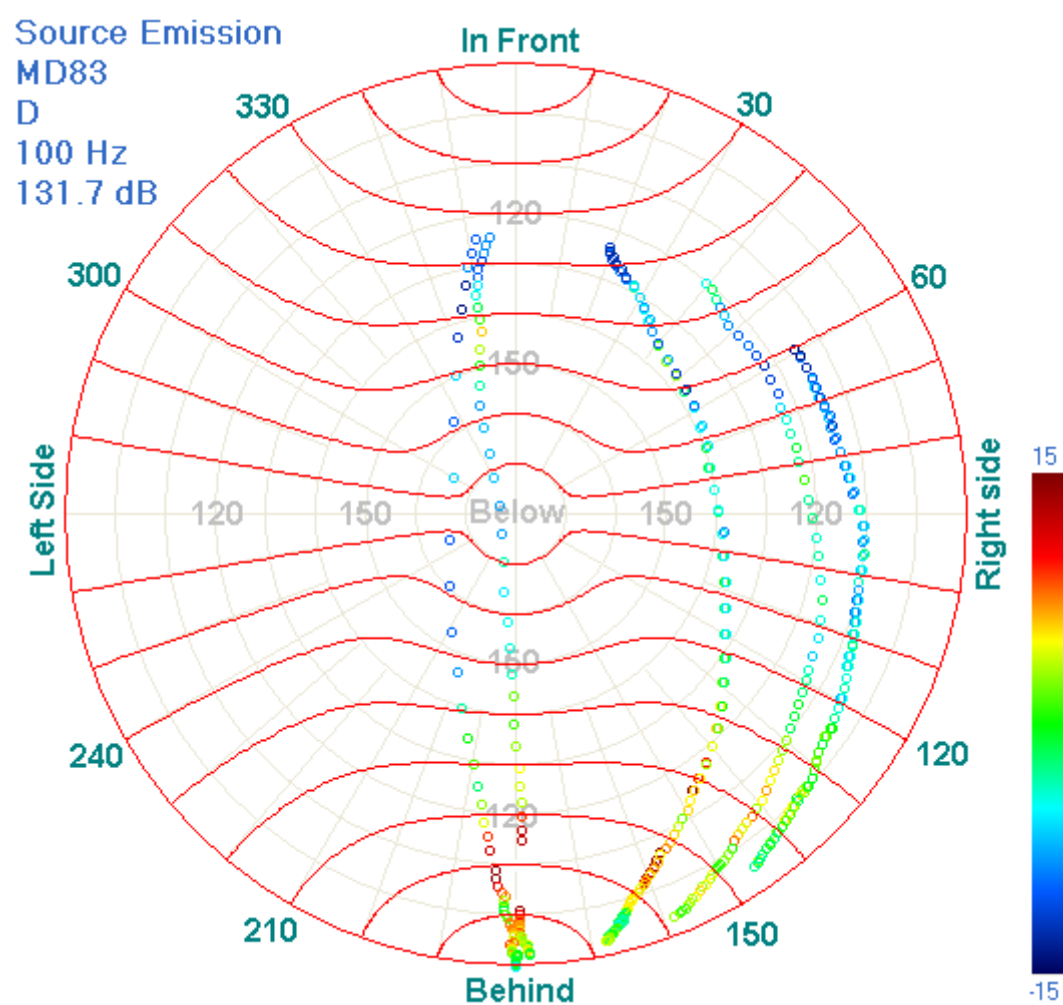




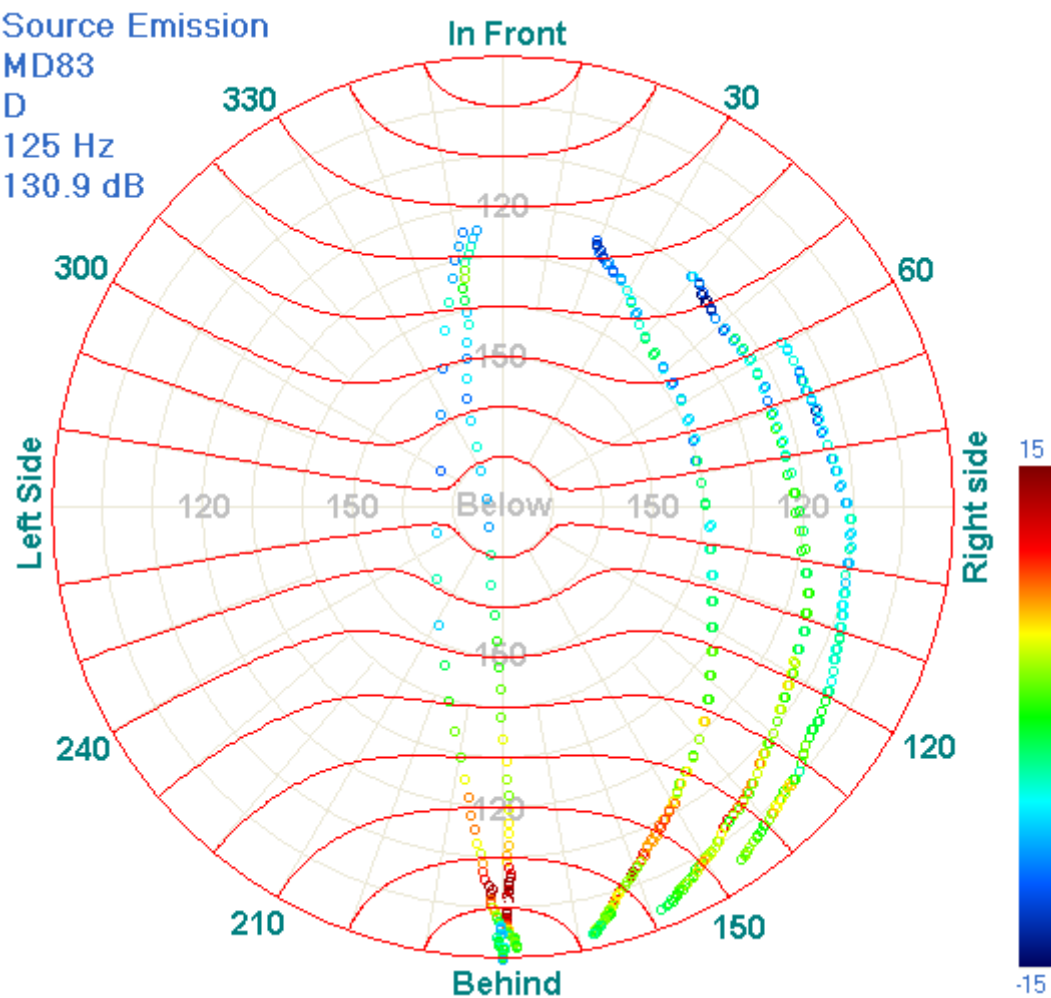
Source Emission  
MD83  
D  
63 Hz  
129.5 dB



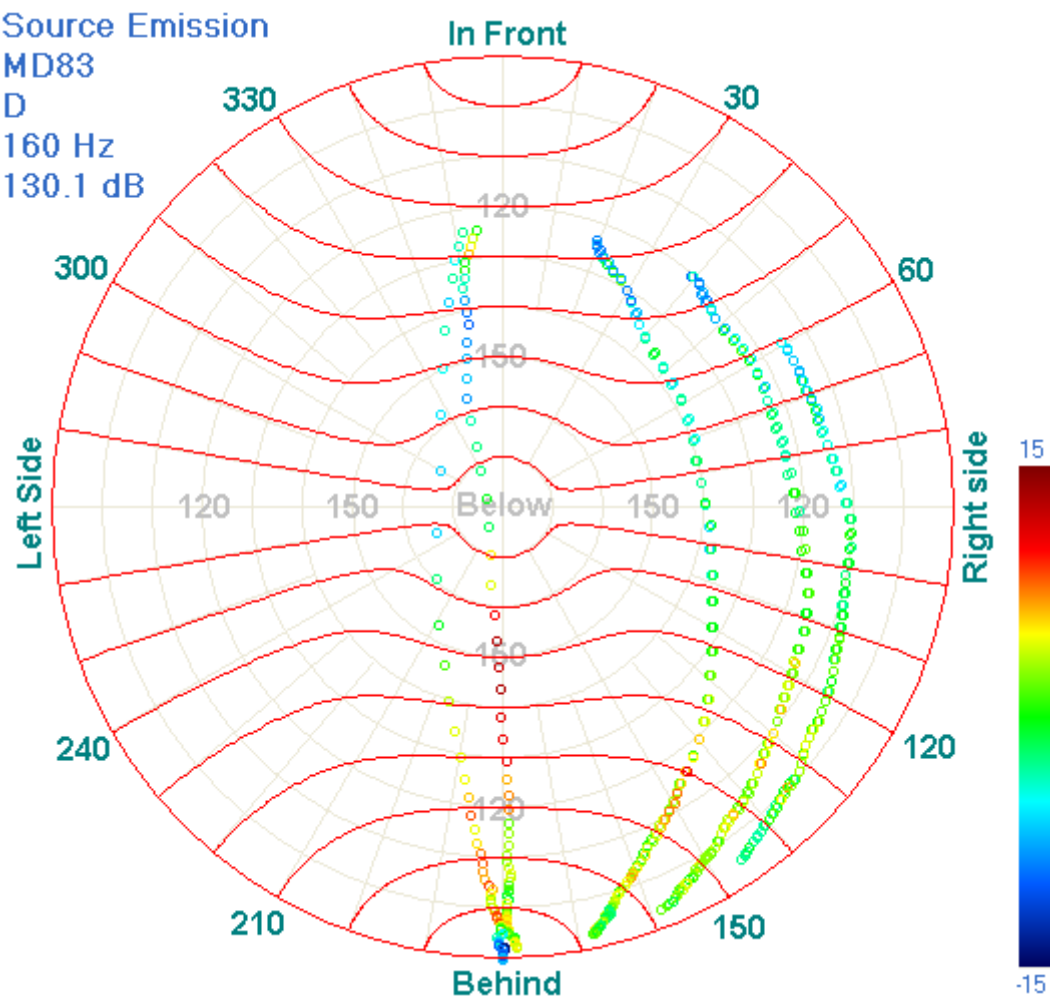




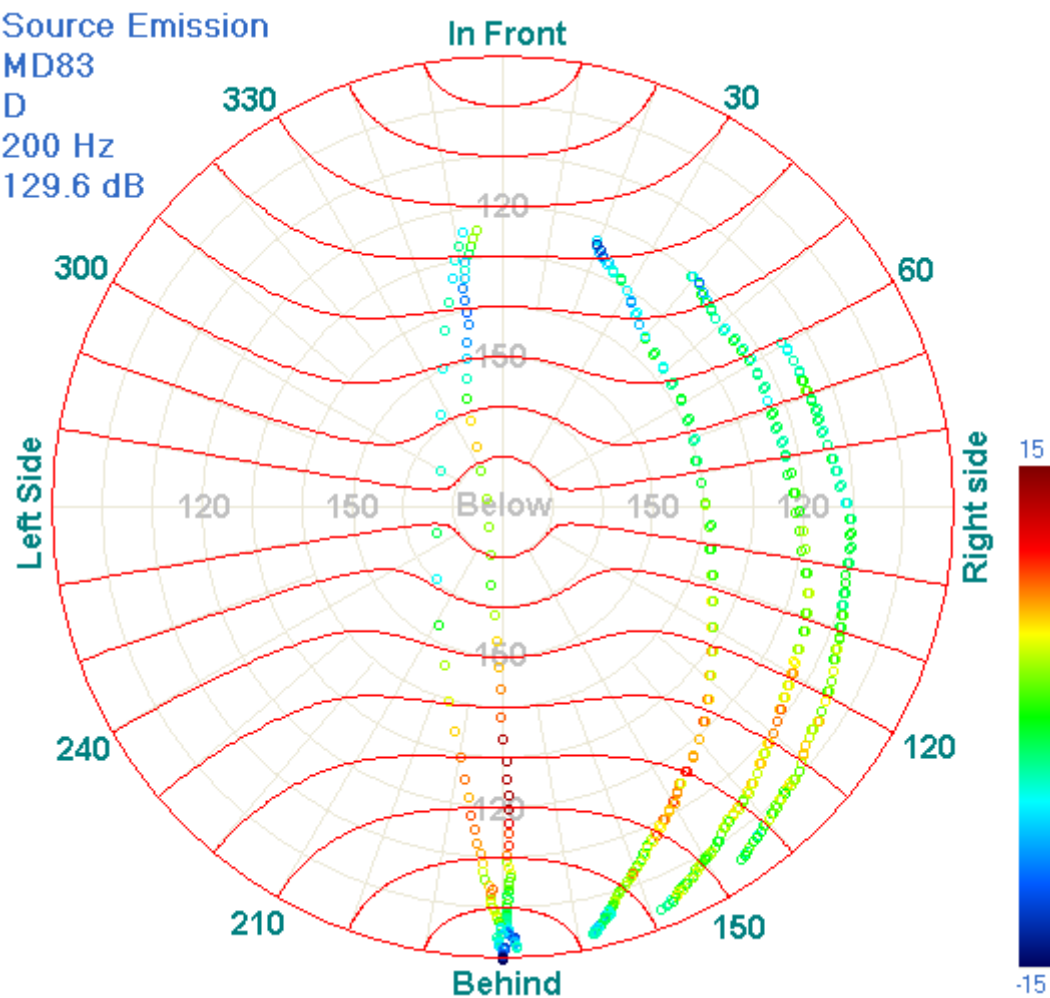
Source Emission  
MD83  
D  
125 Hz  
130.9 dB



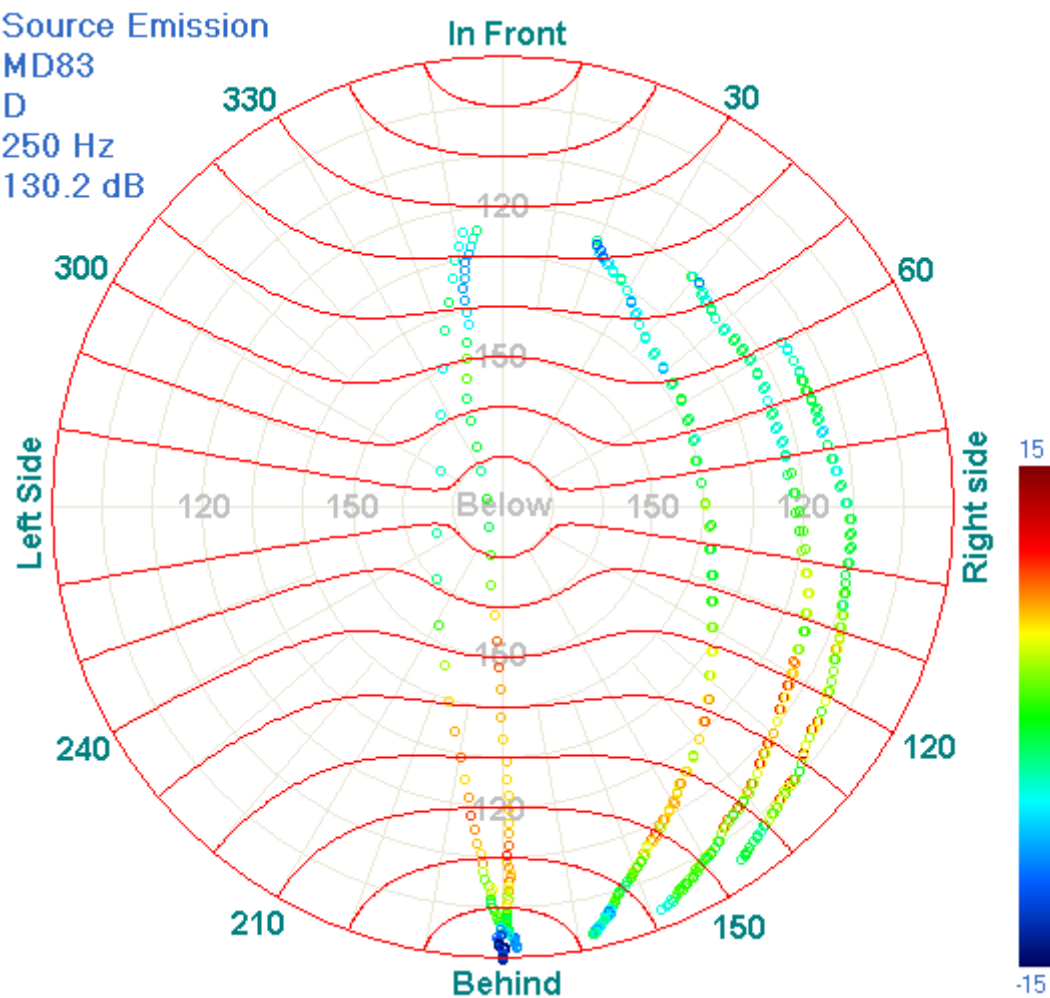
Source Emission  
MD83  
D  
160 Hz  
130.1 dB



Source Emission  
MD83  
D  
200 Hz  
129.6 dB

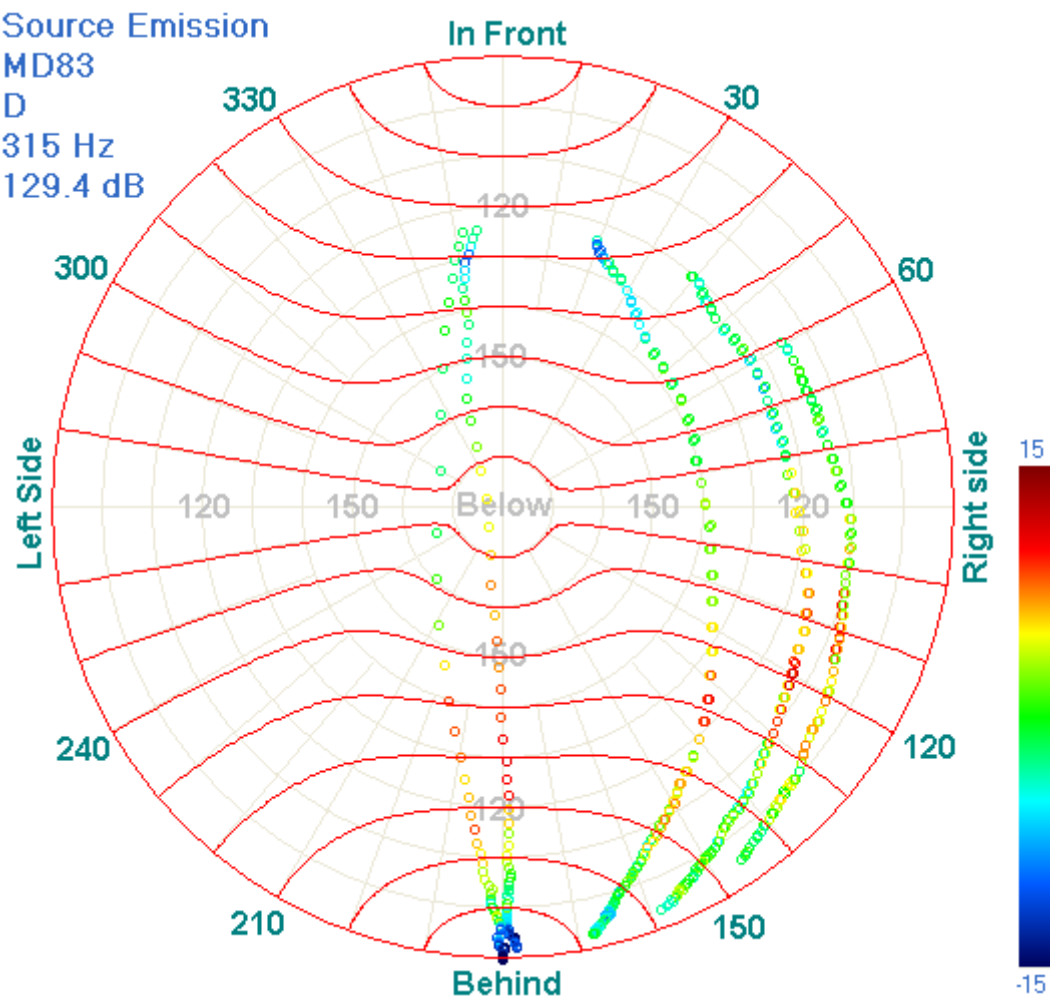


Source Emission  
MD83  
D  
250 Hz  
130.2 dB

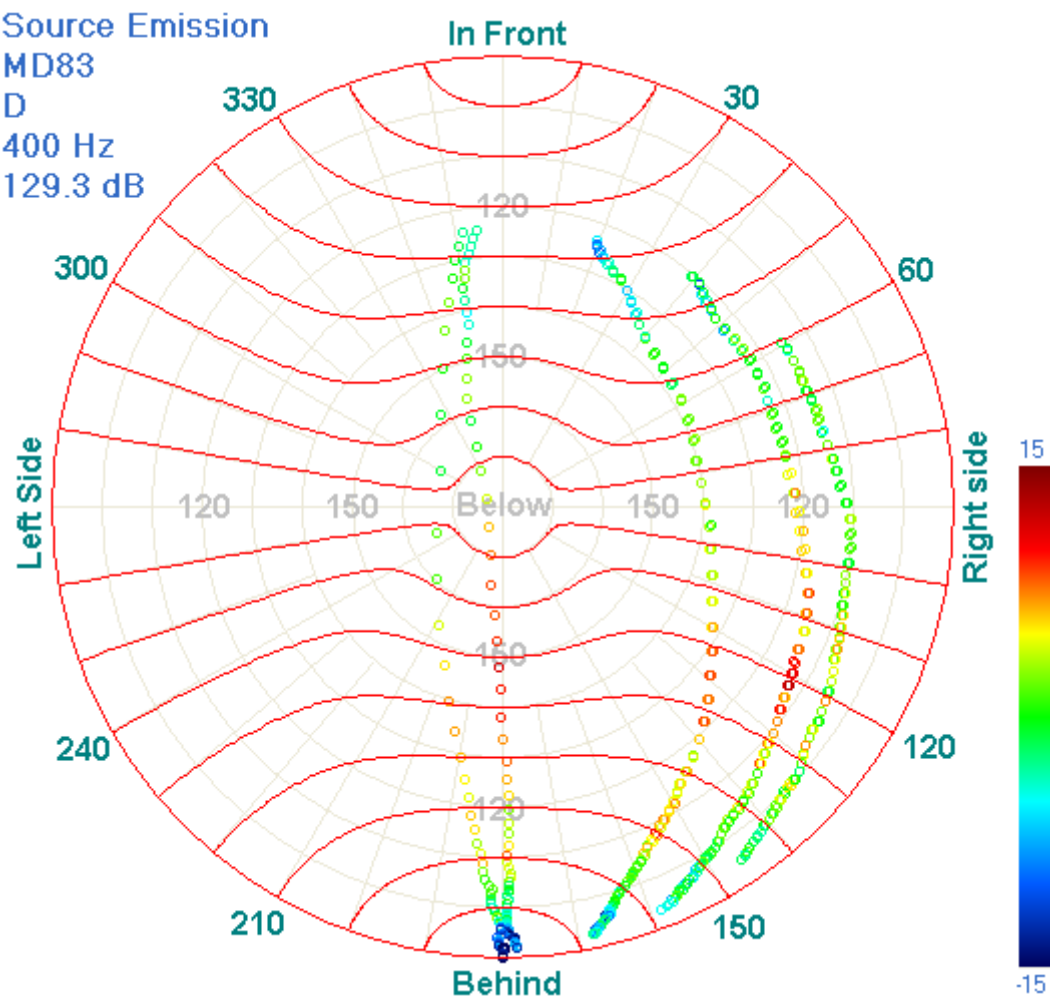




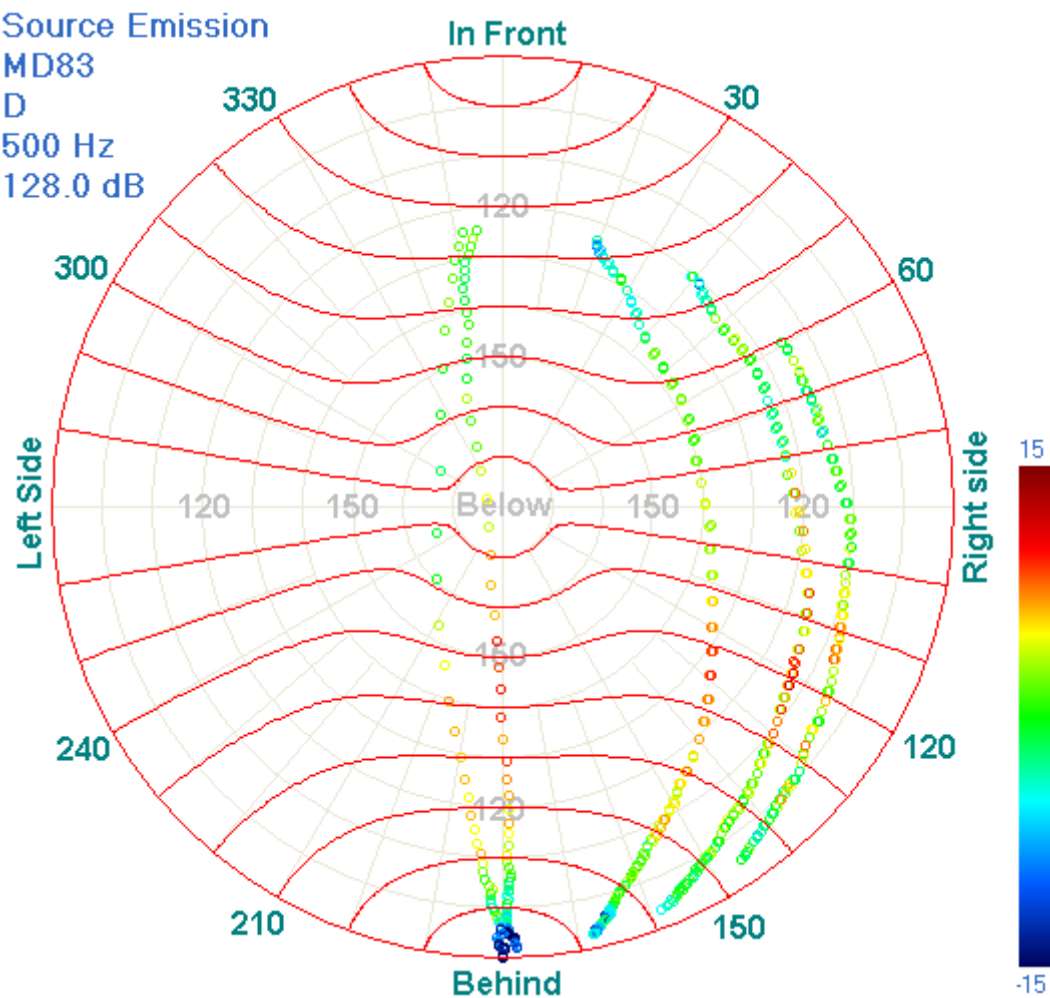
Source Emission  
MD83  
D  
315 Hz  
129.4 dB



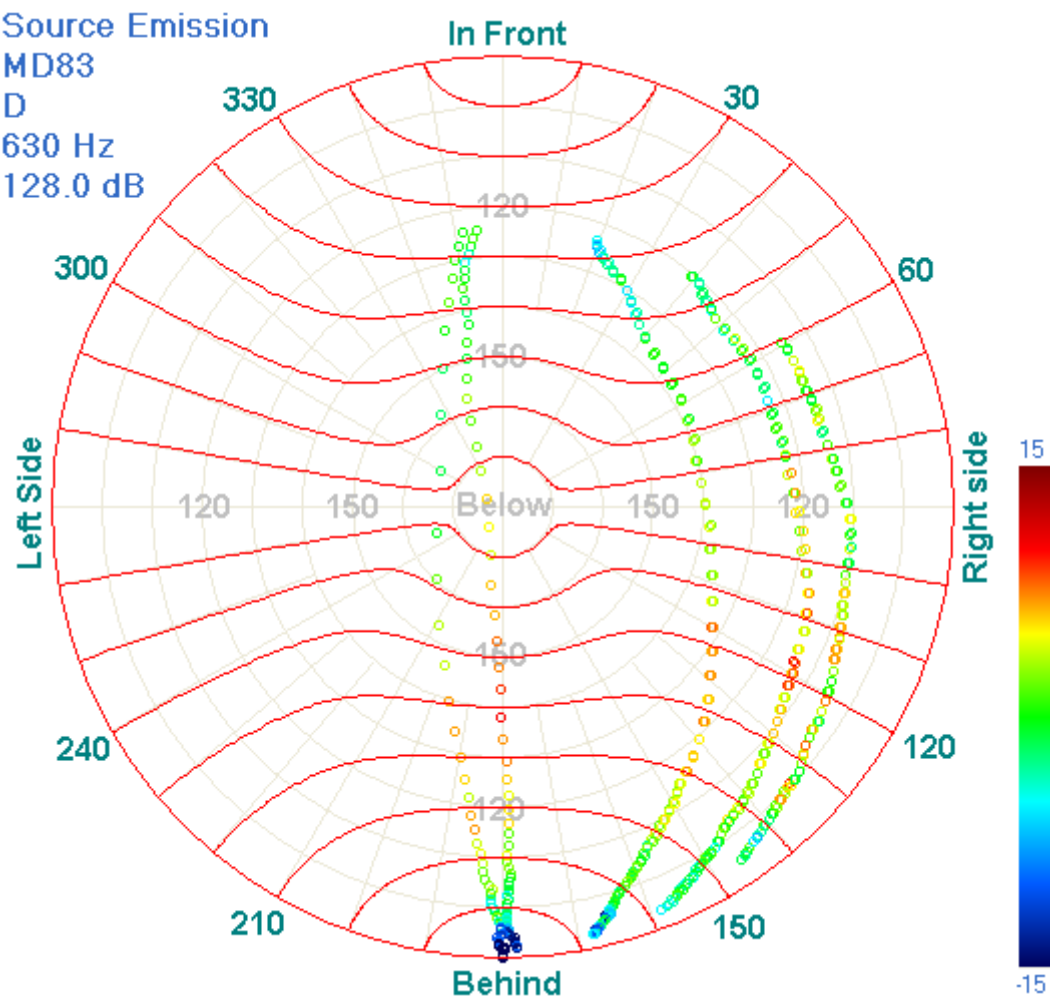
Source Emission  
MD83  
D  
400 Hz  
129.3 dB



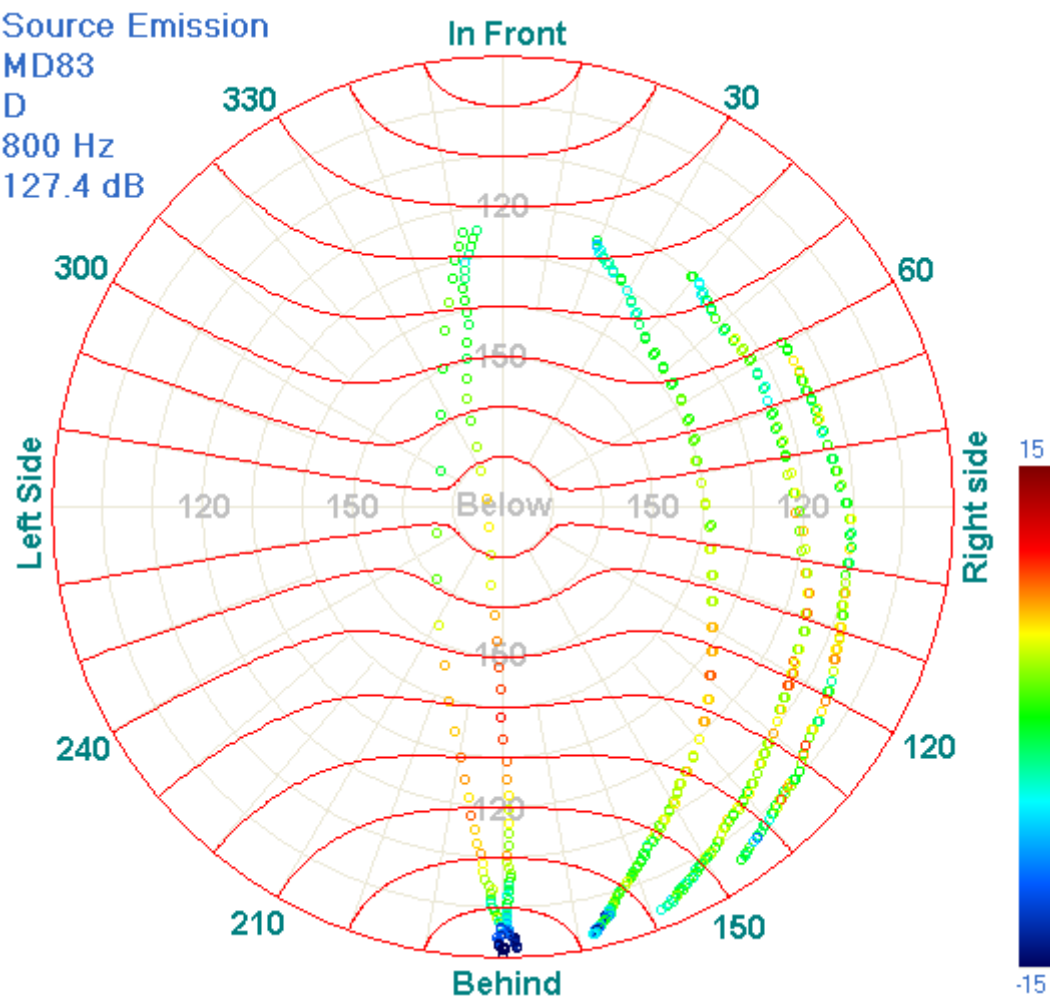
Source Emission  
MD83  
D  
500 Hz  
128.0 dB



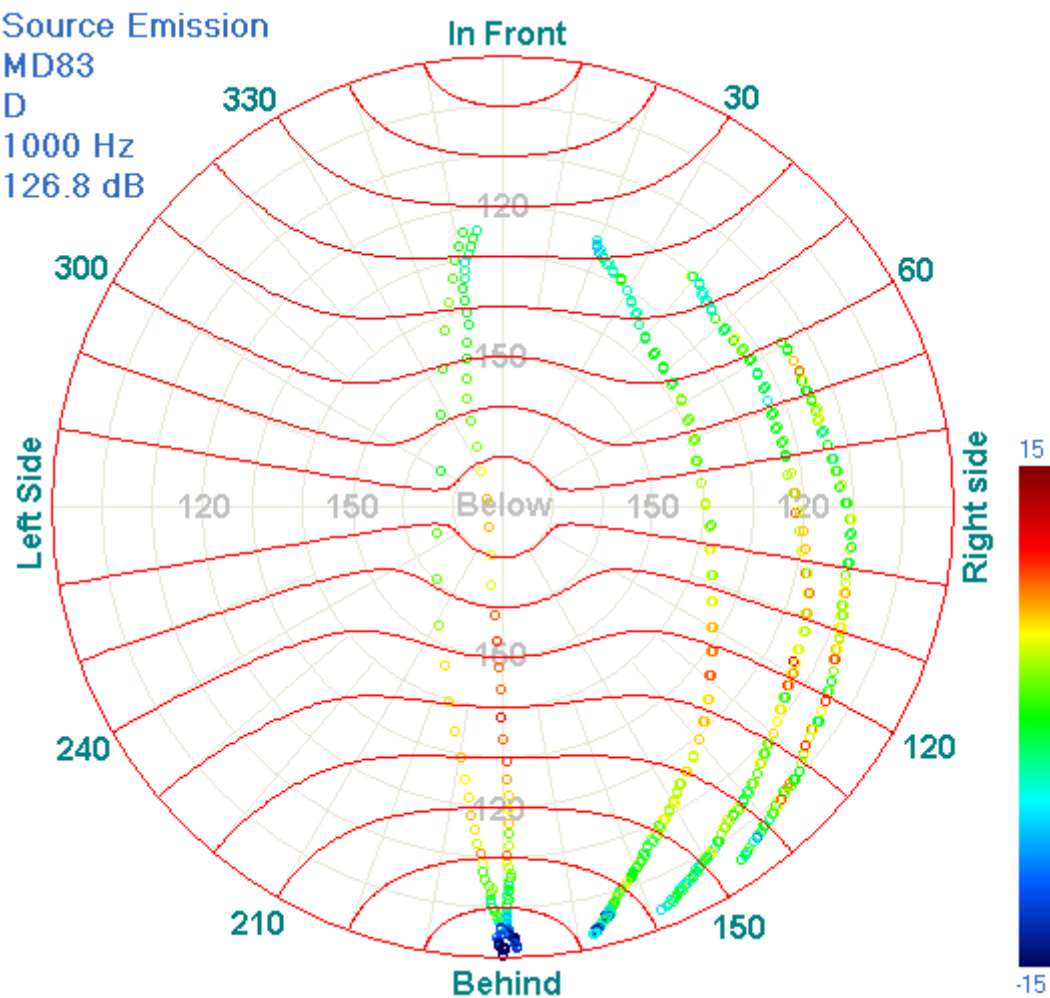
Source Emission  
MD83  
D  
630 Hz  
128.0 dB



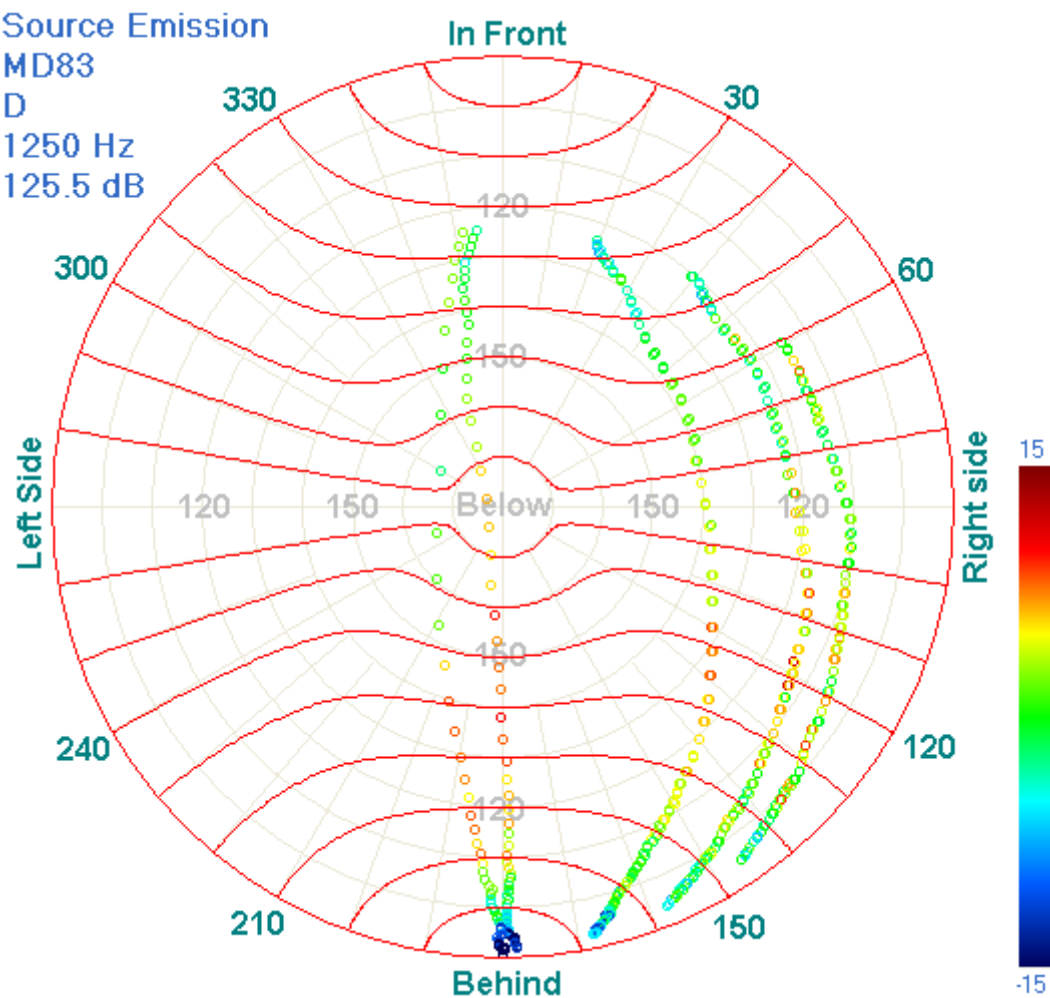
Source Emission  
MD83  
D  
800 Hz  
127.4 dB



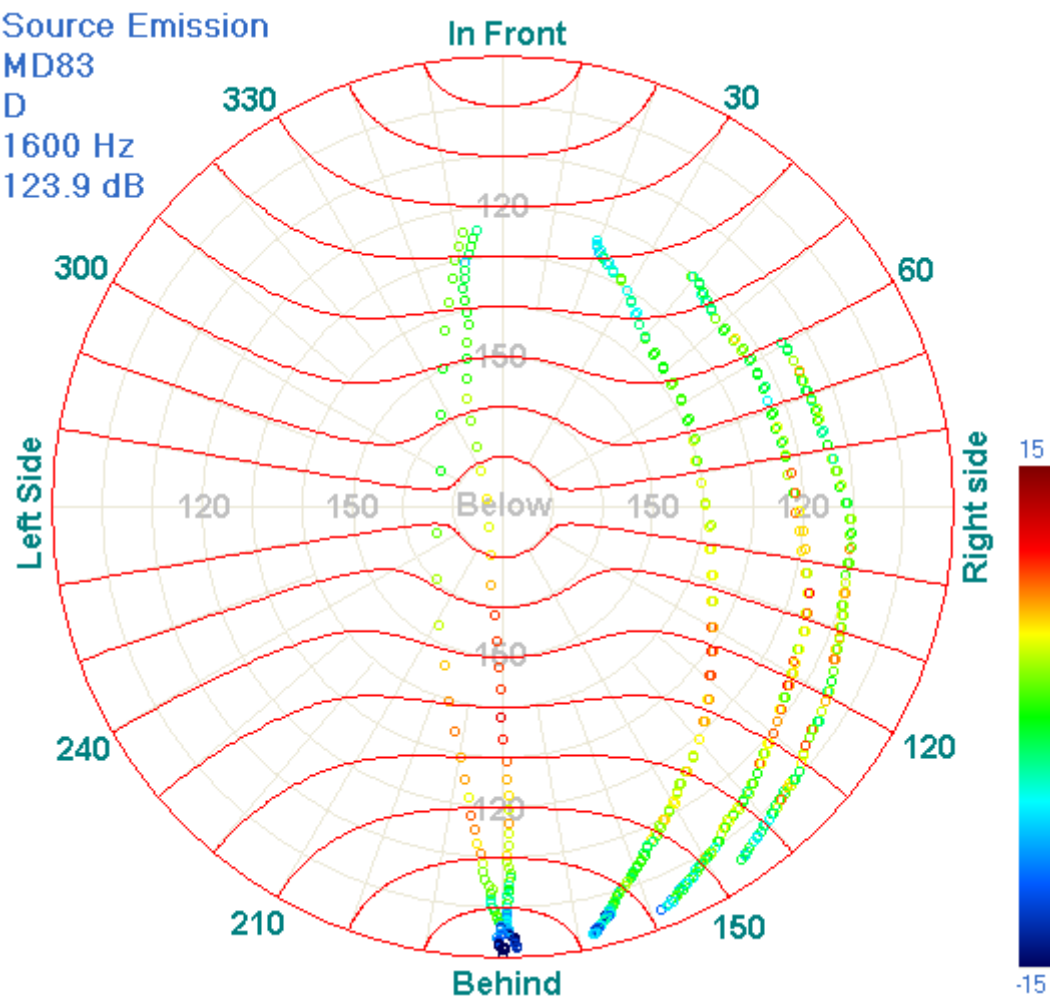
Source Emission  
MD83  
D  
1000 Hz  
126.8 dB



Source Emission  
MD83  
D  
1250 Hz  
125.5 dB

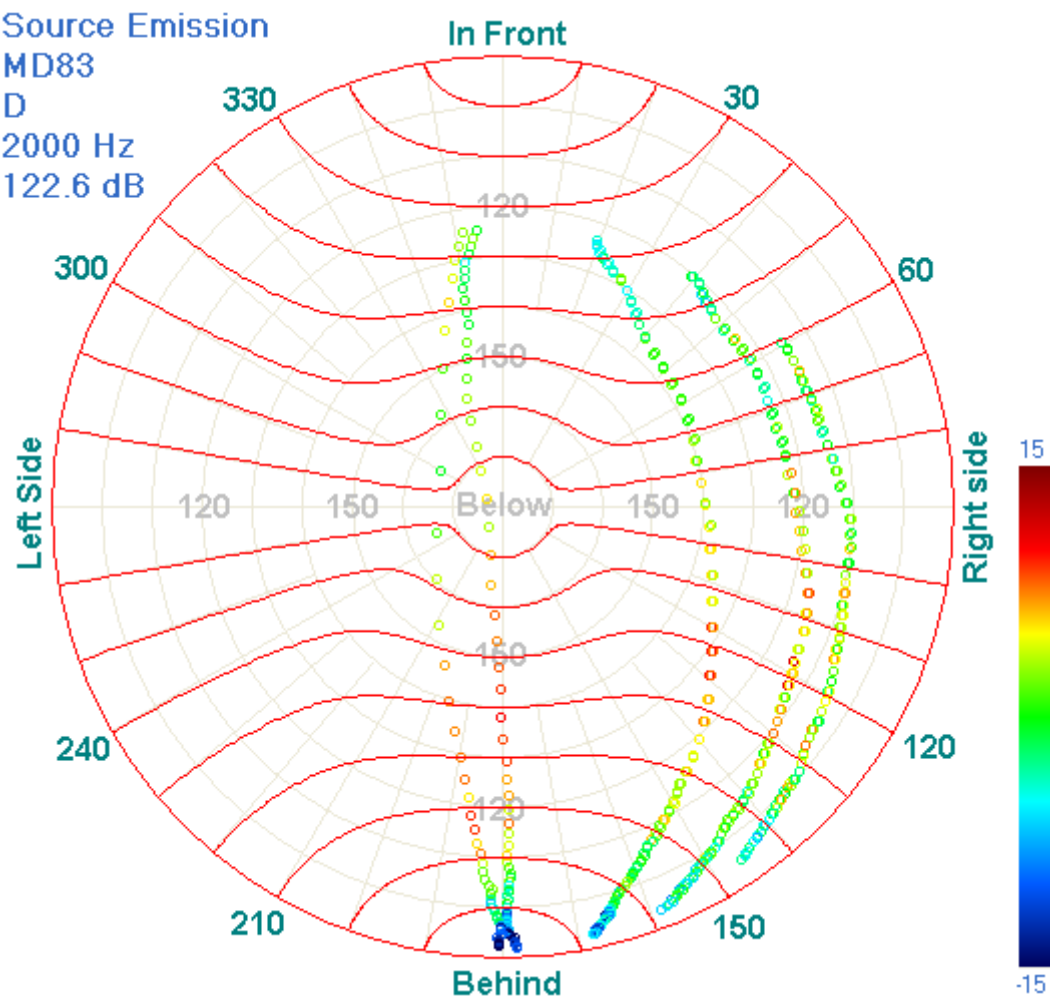


Source Emission  
MD83  
D  
1600 Hz  
123.9 dB

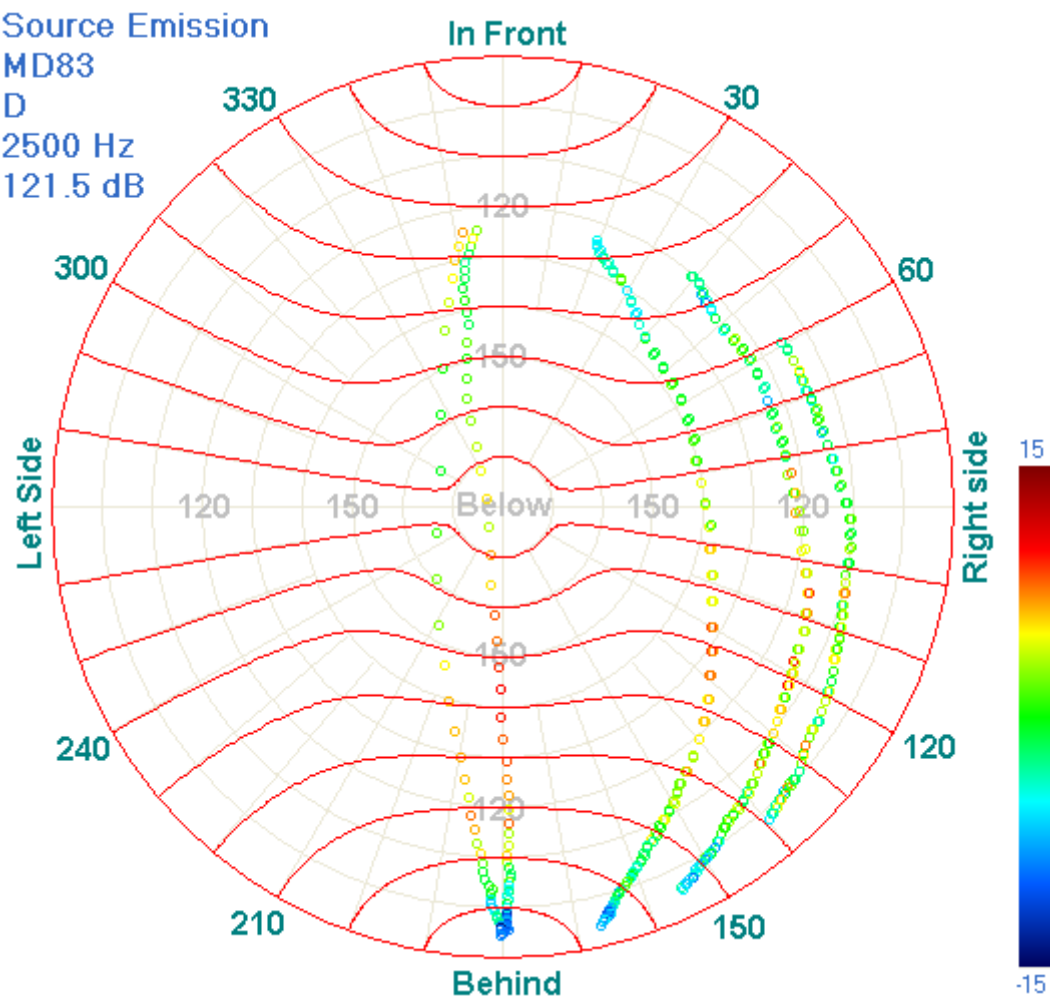




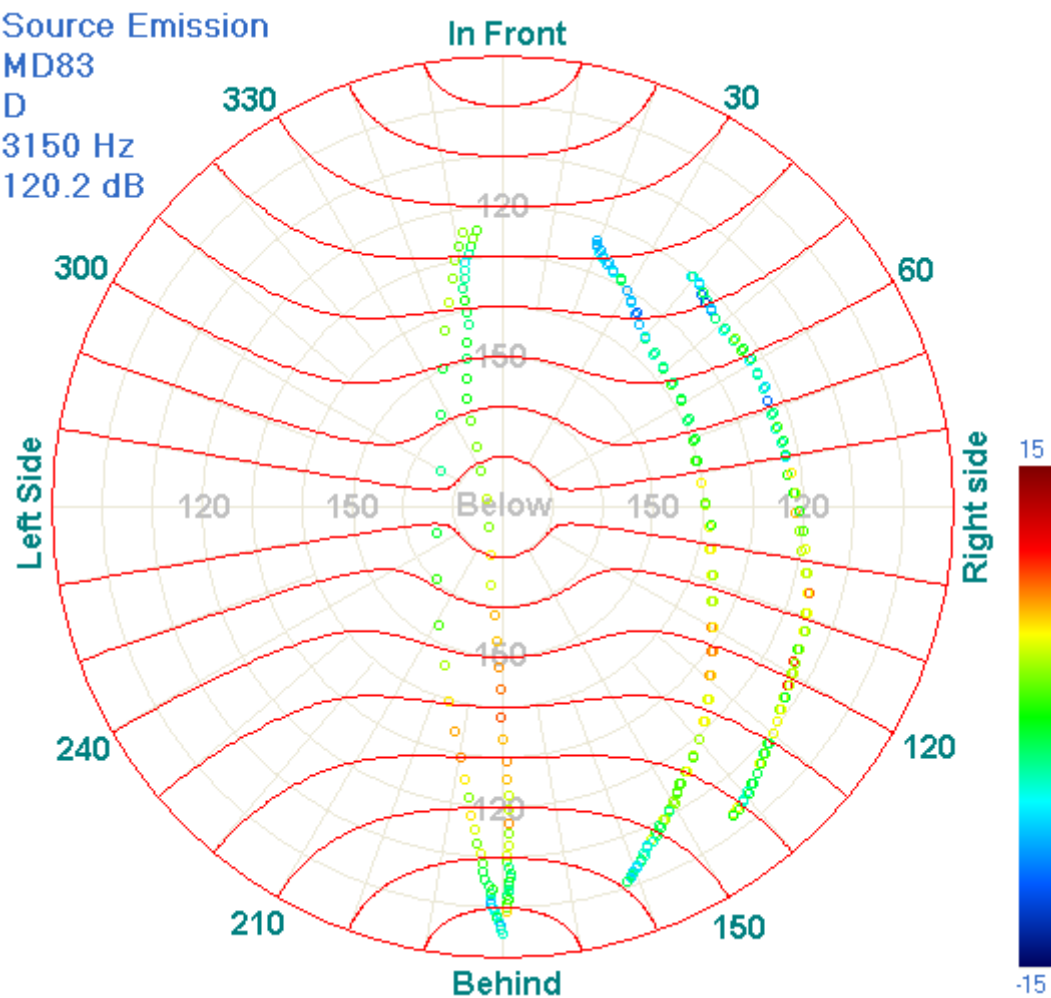
Source Emission  
MD83  
D  
2000 Hz  
122.6 dB



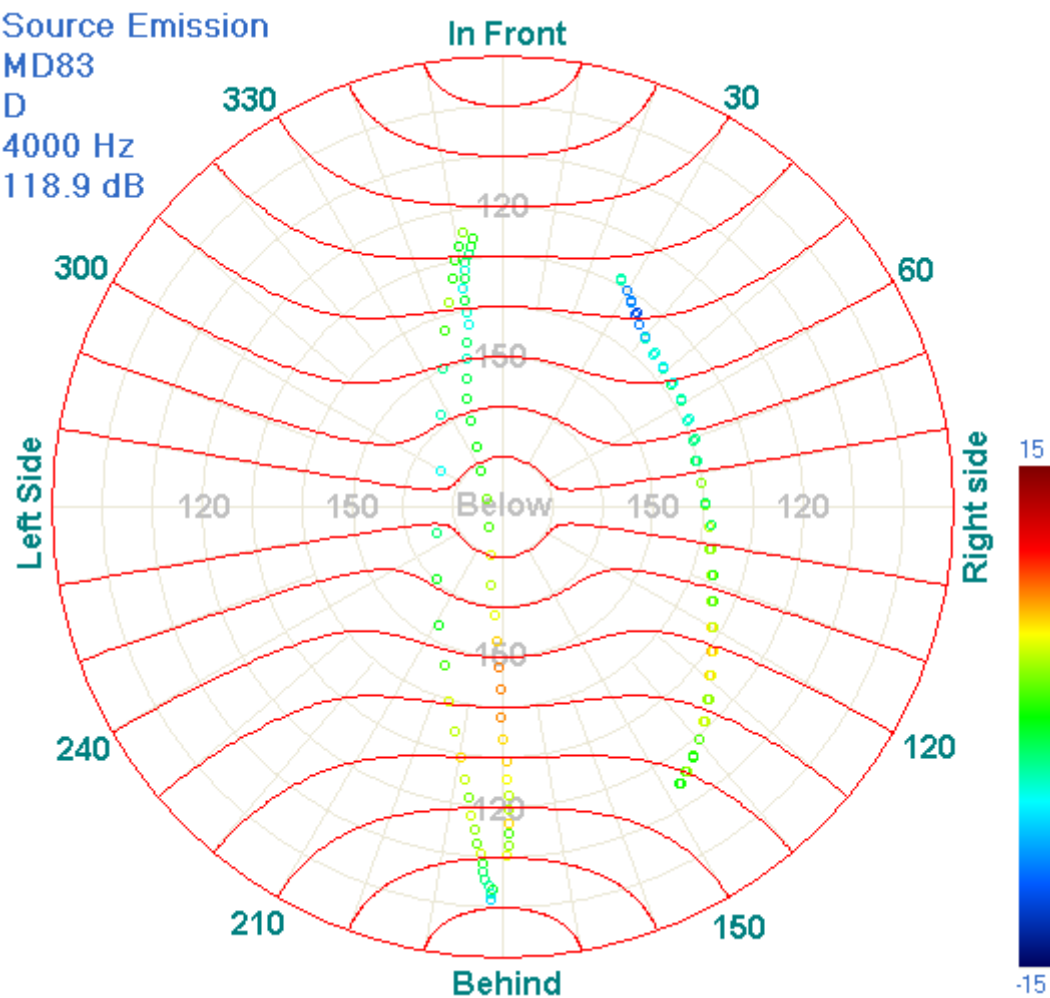
Source Emission  
MD83  
D  
2500 Hz  
121.5 dB



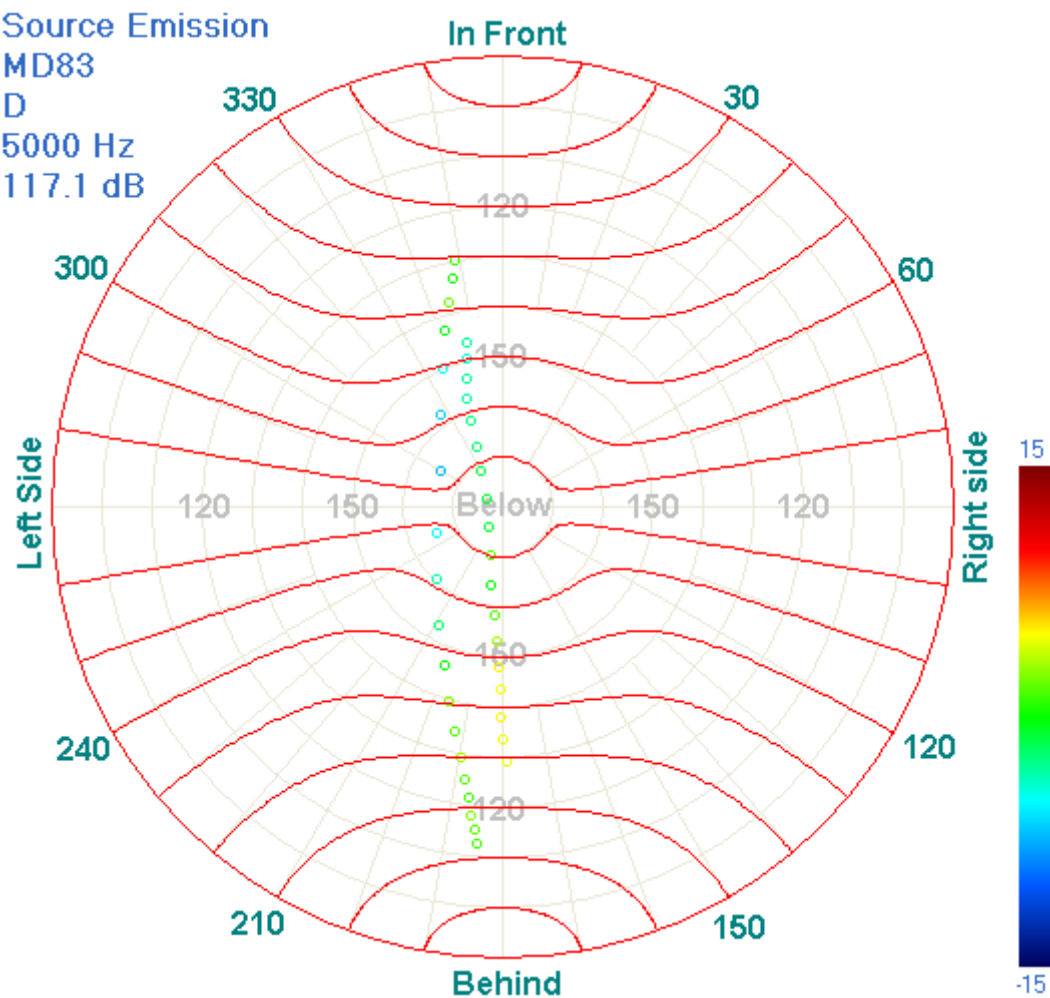
Source Emission  
MD83  
D  
3150 Hz  
120.2 dB



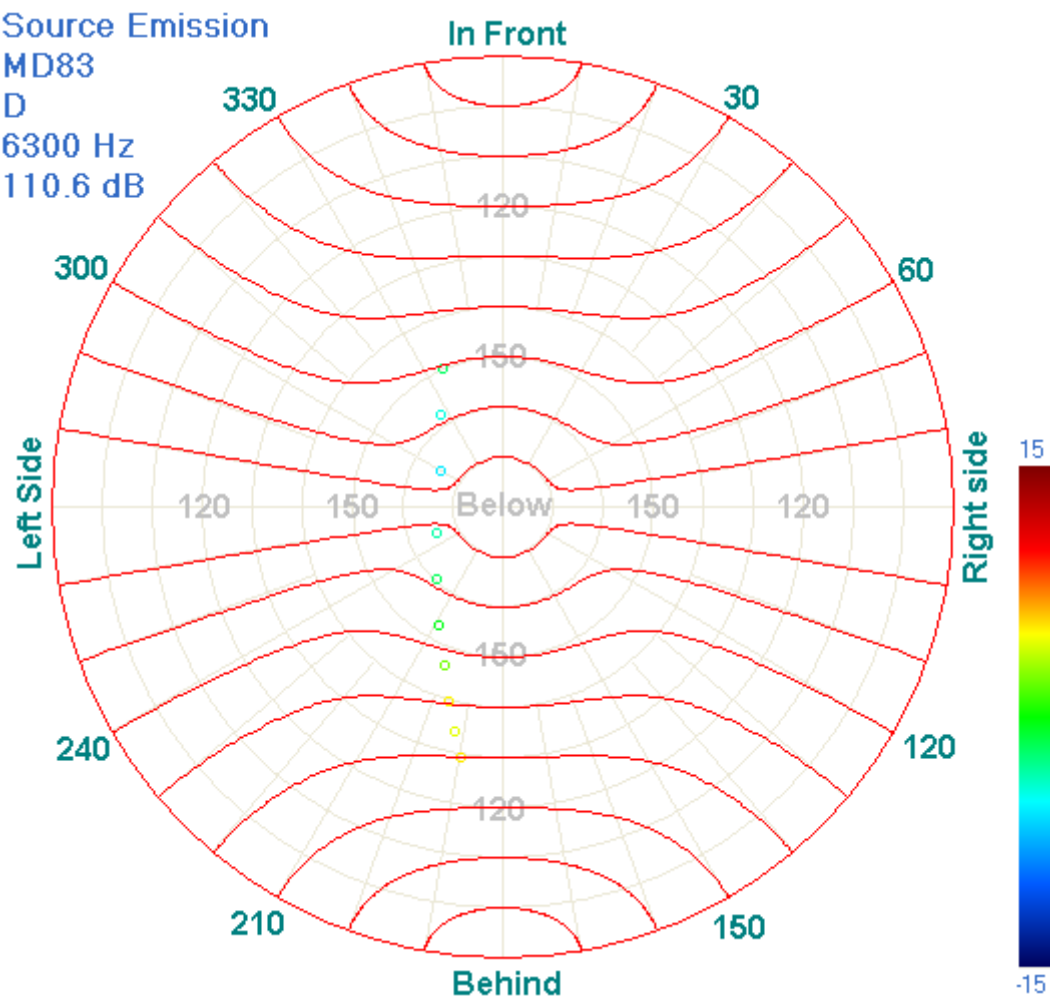
Source Emission  
MD83  
D  
4000 Hz  
118.9 dB



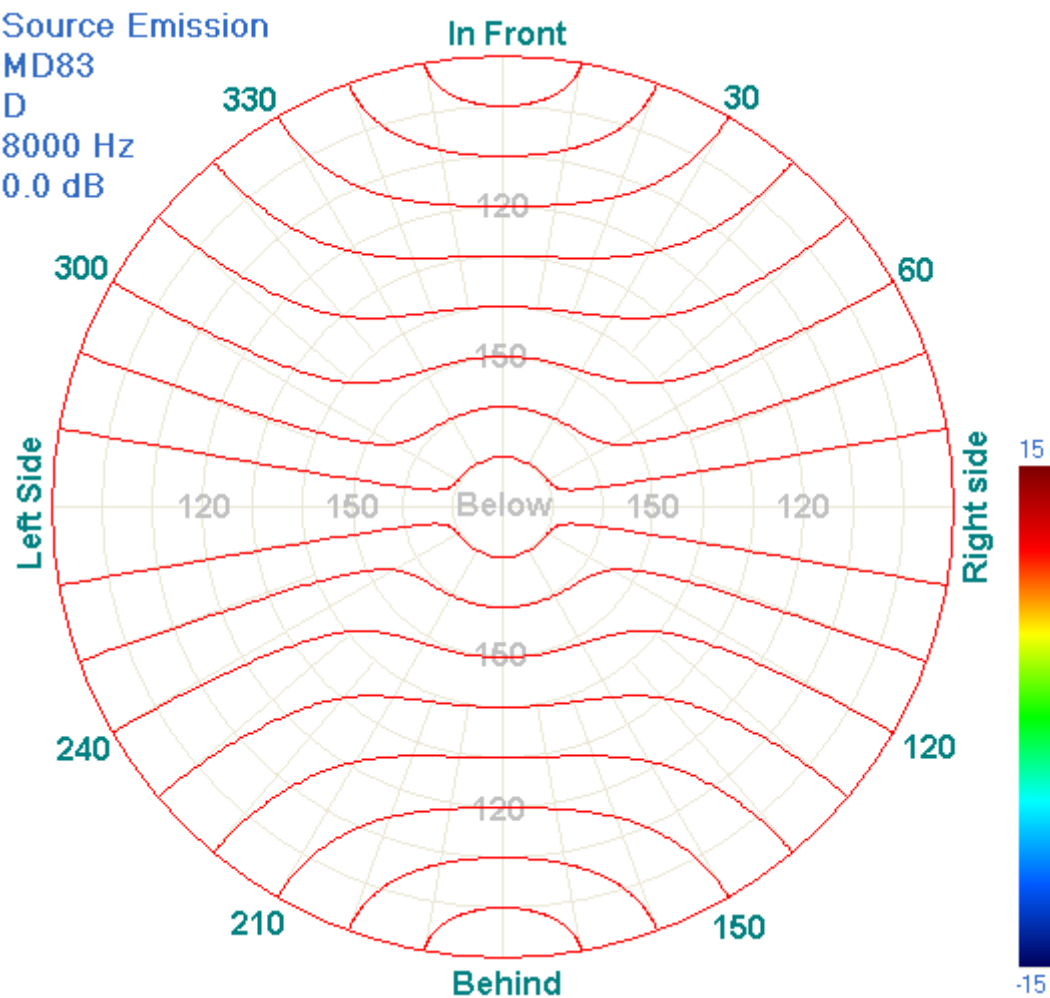
Source Emission  
MD83  
D  
5000 Hz  
117.1 dB

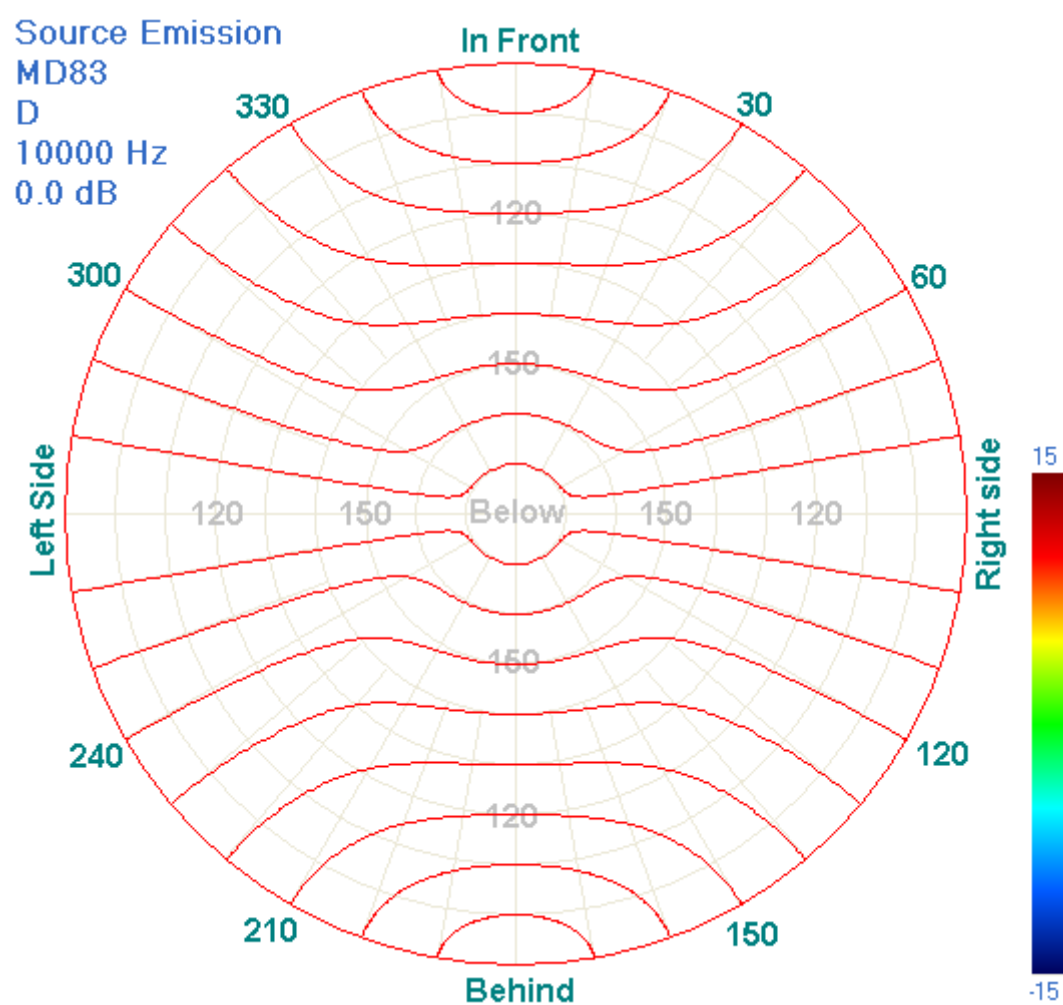


Source Emission  
MD83  
D  
6300 Hz  
110.6 dB



Source Emission  
MD83  
D  
8000 Hz  
0.0 dB





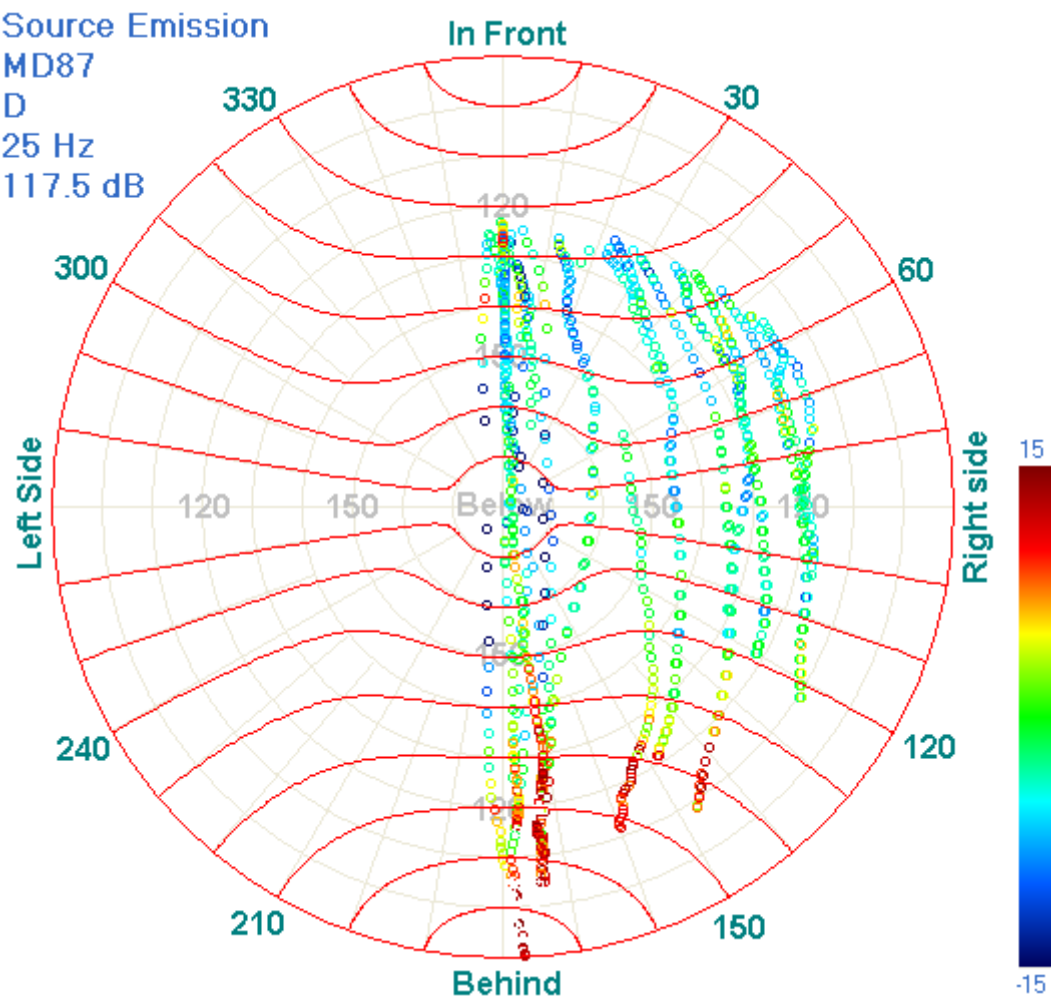


## 17 MD 87 directivity at departure

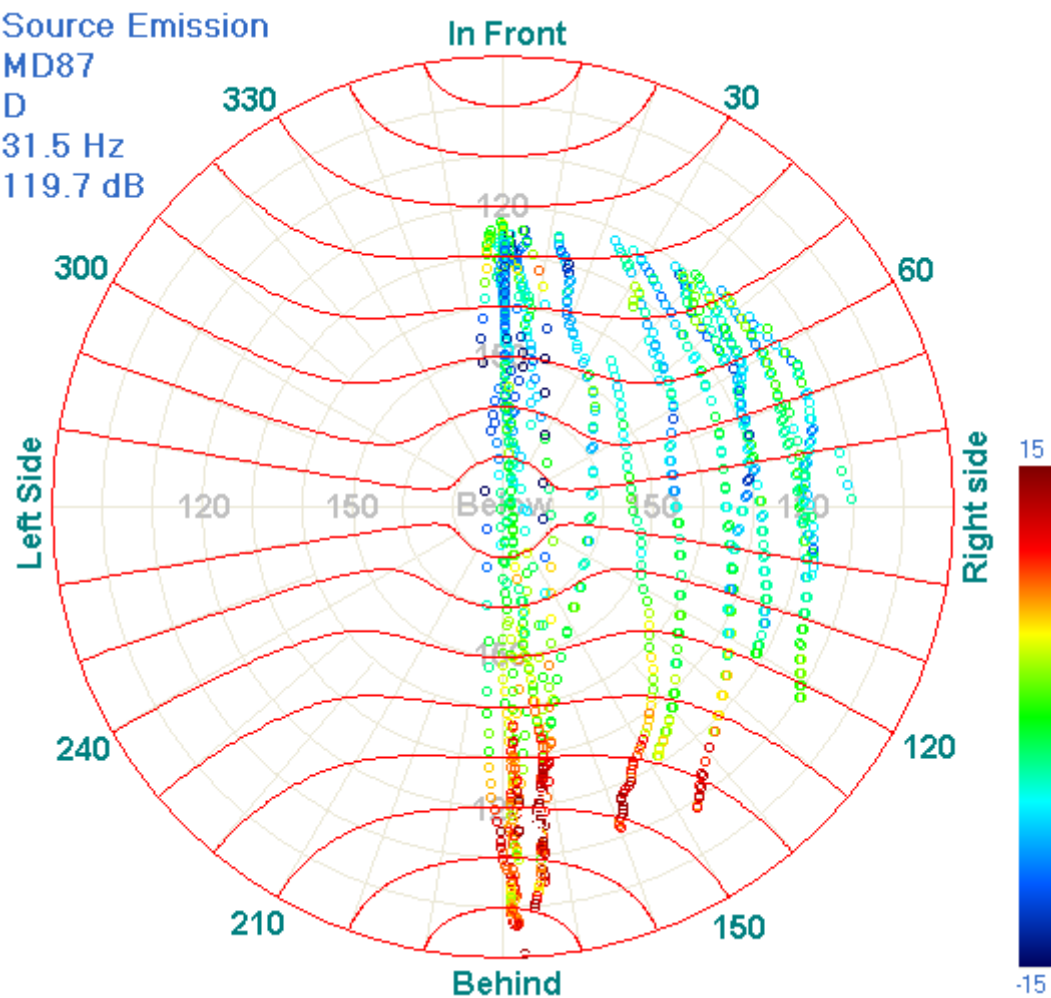
SPECTRUM  
Source Emission  
MD87  
D

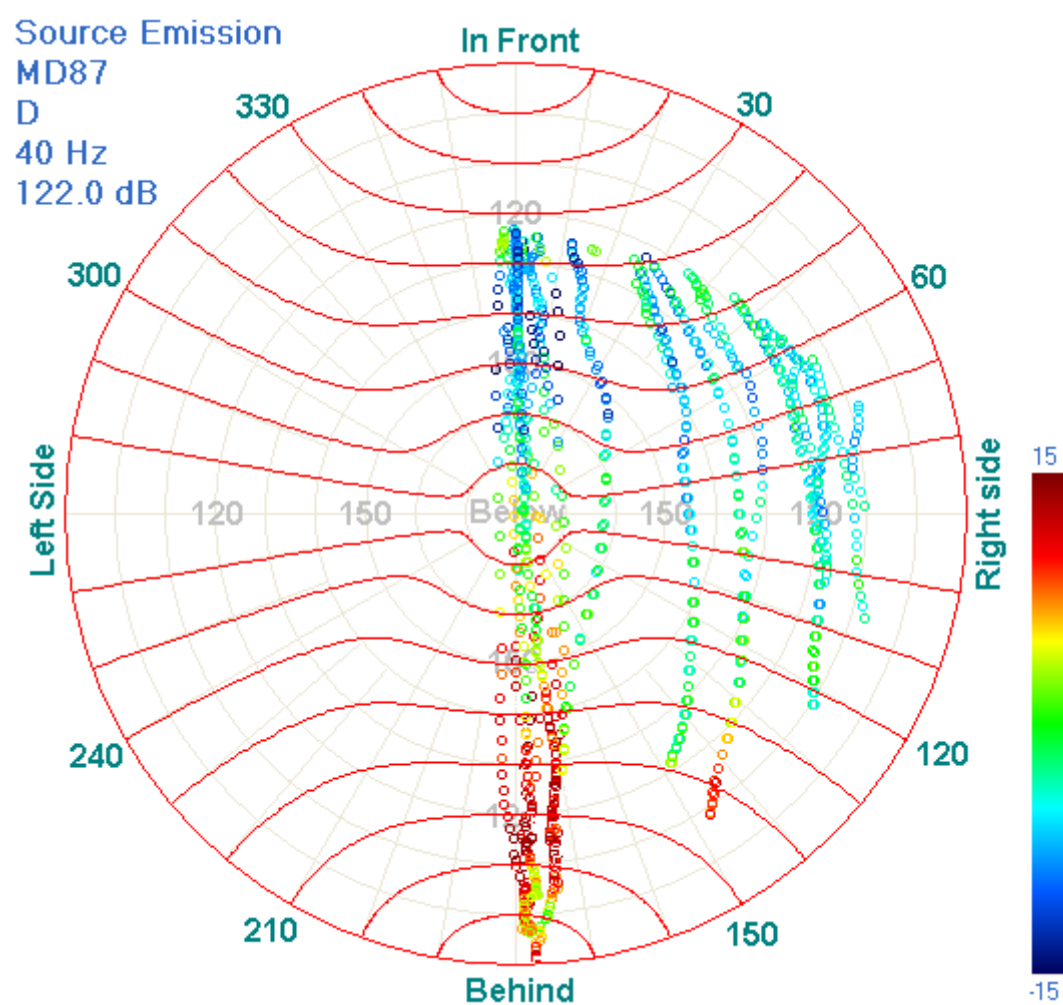
Freq	Num	Avg	Std	95%Avg	P1	P2	P3	P4	P5	P6
25	1015	117.5	7.8	0.5	-1.0	-1.0	-1.0	-1.0	117.5	-1.0
31.5	1105	119.7	7.4	0.4	-1.0	-1.0	-1.0	-1.0	119.7	-1.0
40	1052	122.0	8.1	0.5	-1.0	-1.0	-1.0	-1.0	122.0	-1.0
50	1066	122.8	8.9	0.5	-1.0	-1.0	-1.0	-1.0	122.9	-1.0
63	1138	125.1	9.5	0.6	-1.0	-1.0	-1.0	-1.0	125.3	-1.0
80	1185	127.4	8.8	0.5	-1.0	-1.0	-1.0	-1.0	127.6	-1.0
100	1321	127.3	7.3	0.4	-1.0	-1.0	-1.0	-1.0	127.4	-1.0
125	1567	127.7	6.8	0.3	-1.0	-1.0	-1.0	-1.0	127.8	-1.0
160	1740	128.3	6.0	0.3	-1.0	-1.0	-1.0	-1.0	128.5	-1.0
200	1739	128.6	5.4	0.3	-1.0	-1.0	-1.0	-1.0	128.7	-1.0
250	1823	129.8	5.2	0.2	-1.0	-1.0	-1.0	-1.0	130.0	-1.0
315	1742	129.7	5.1	0.2	-1.0	-1.0	-1.0	-1.0	129.9	-1.0
400	1820	129.5	5.0	0.2	-1.0	-1.0	-1.0	-1.0	129.6	-1.0
500	1743	128.9	4.7	0.2	-1.0	-1.0	-1.0	-1.0	129.0	-1.0
630	1743	129.0	4.5	0.2	-1.0	-1.0	-1.0	-1.0	129.1	-1.0
800	1814	128.6	4.4	0.2	-1.0	-1.0	-1.0	-1.0	128.7	-1.0
1000	1814	127.9	4.5	0.2	-1.0	-1.0	-1.0	-1.0	128.0	-1.0
1250	1814	127.3	4.7	0.2	-1.0	-1.0	-1.0	-1.0	127.4	-1.0
1600	1815	126.4	4.9	0.2	-1.0	-1.0	-1.0	-1.0	126.6	-1.0
2000	1812	126.1	4.9	0.2	-1.0	-1.0	-1.0	-1.0	126.3	-1.0
2500	1795	125.7	5.1	0.2	-1.0	-1.0	-1.0	-1.0	125.9	-1.0
3150	1442	124.7	5.2	0.3	-1.0	-1.0	-1.0	-1.0	124.9	-1.0
4000	866	124.1	5.4	0.4	-1.0	-1.0	-1.0	-1.0	124.3	-1.0
5000	316	123.0	5.7	0.6	-1.0	-1.0	-1.0	-1.0	123.0	-1.0
6300	59	121.5	5.7	1.4	-1.0	-1.0	-1.0	-1.0	121.5	-1.0
8000	3	120.7	2.3	2.6	-1.0	-1.0	-1.0	-1.0	120.7	-1.0
10000	0	999.0	999.0	999.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0

Source Emission  
MD87  
D  
25 Hz  
117.5 dB

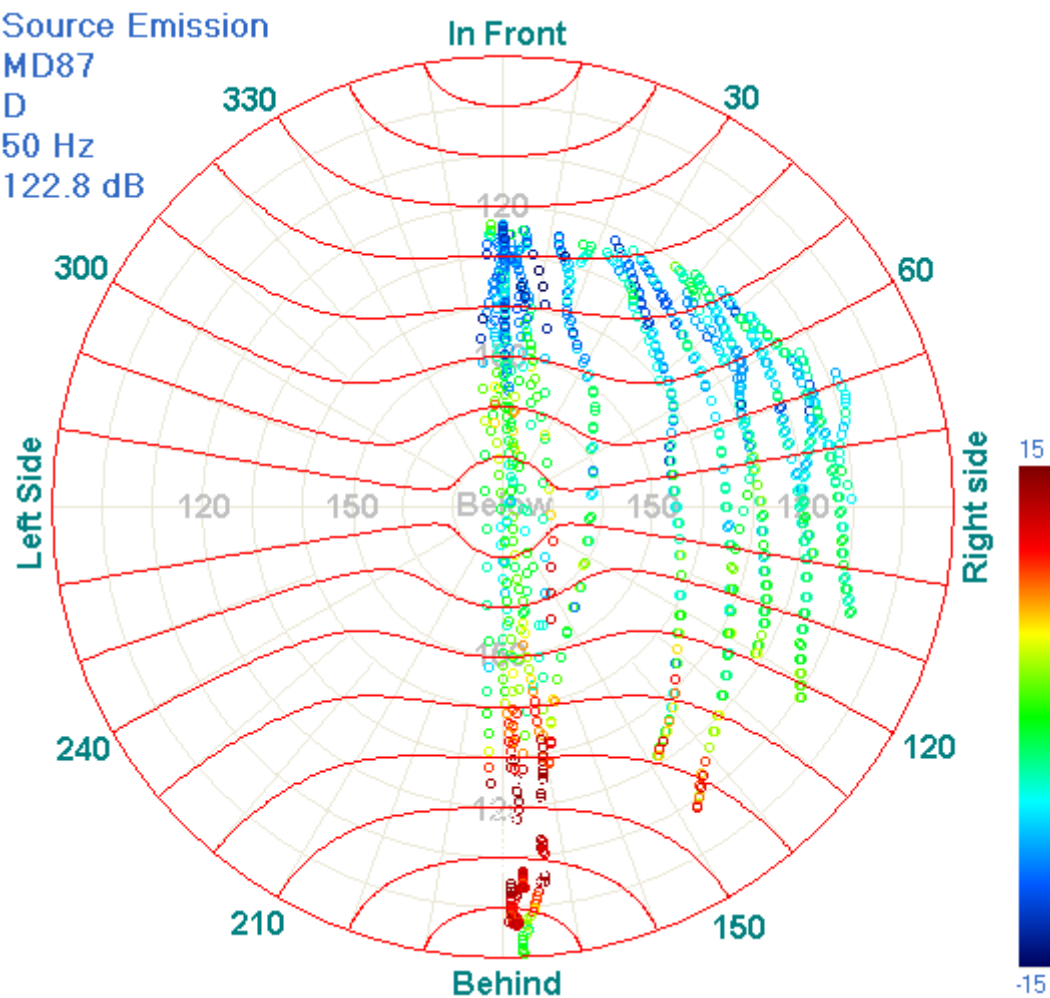


Source Emission  
MD87  
D  
31.5 Hz  
119.7 dB

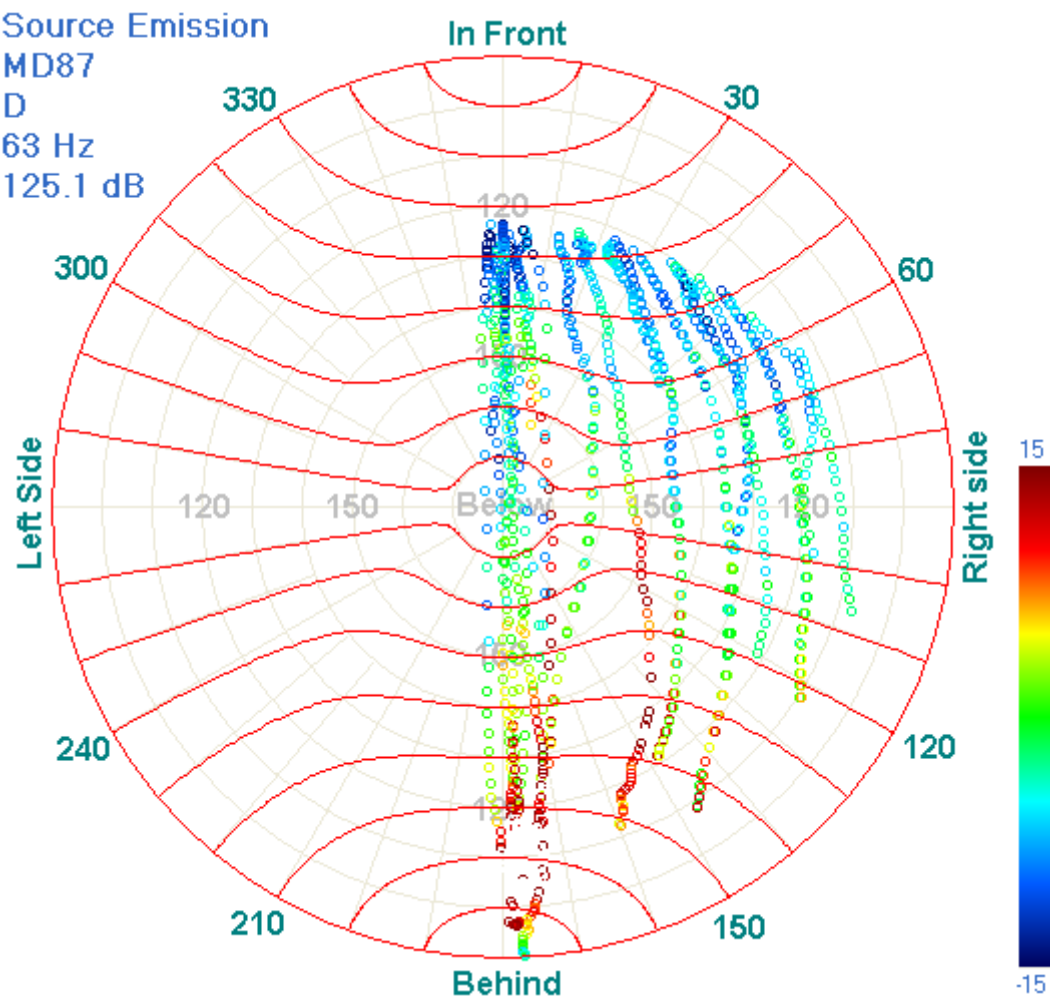


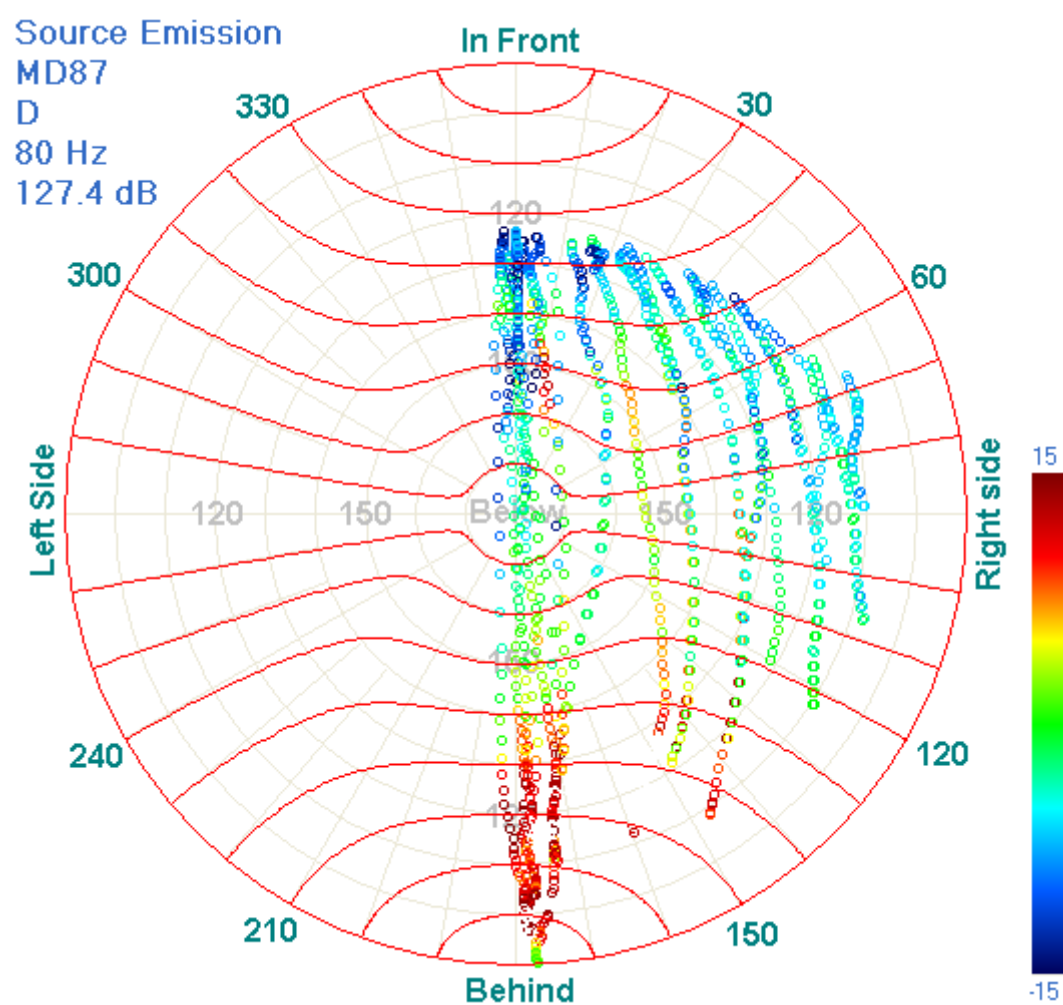


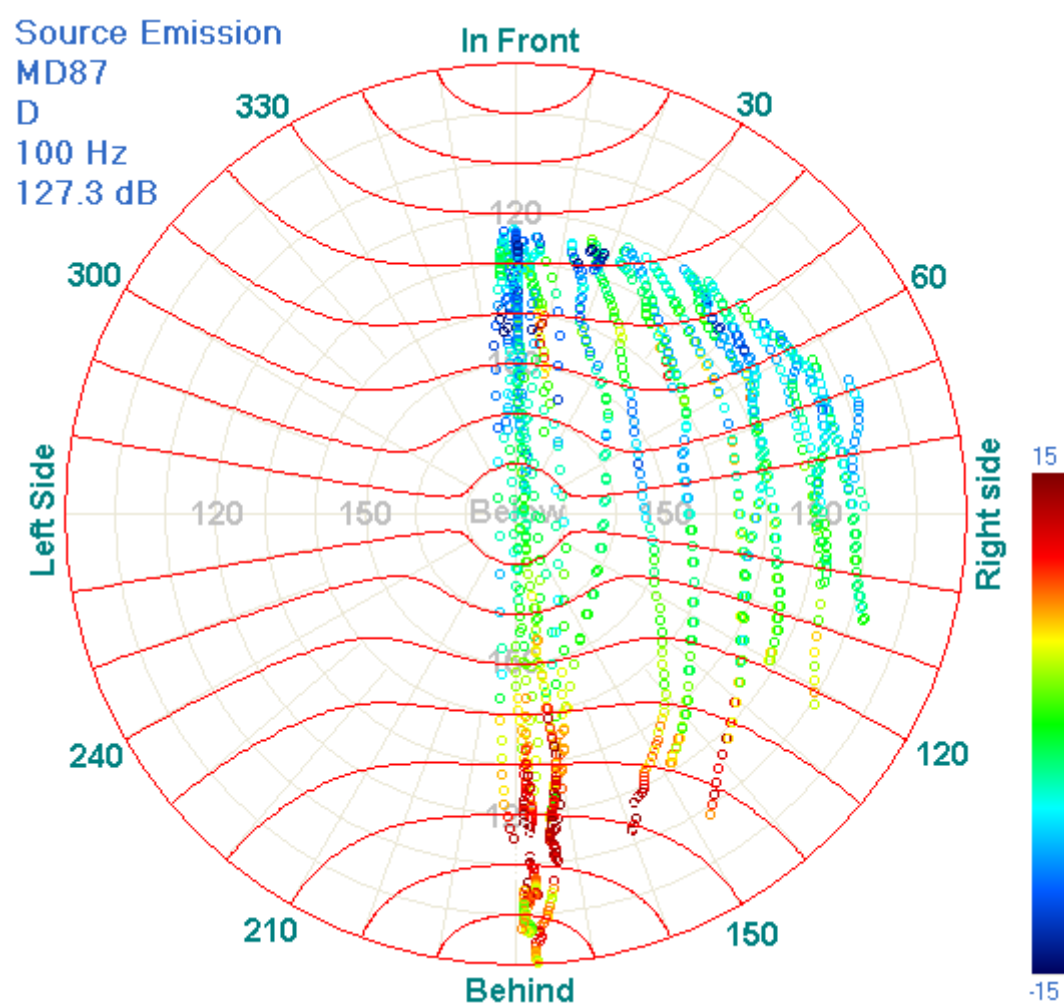
Source Emission  
MD87  
D  
50 Hz  
122.8 dB



Source Emission  
MD87  
D  
63 Hz  
125.1 dB

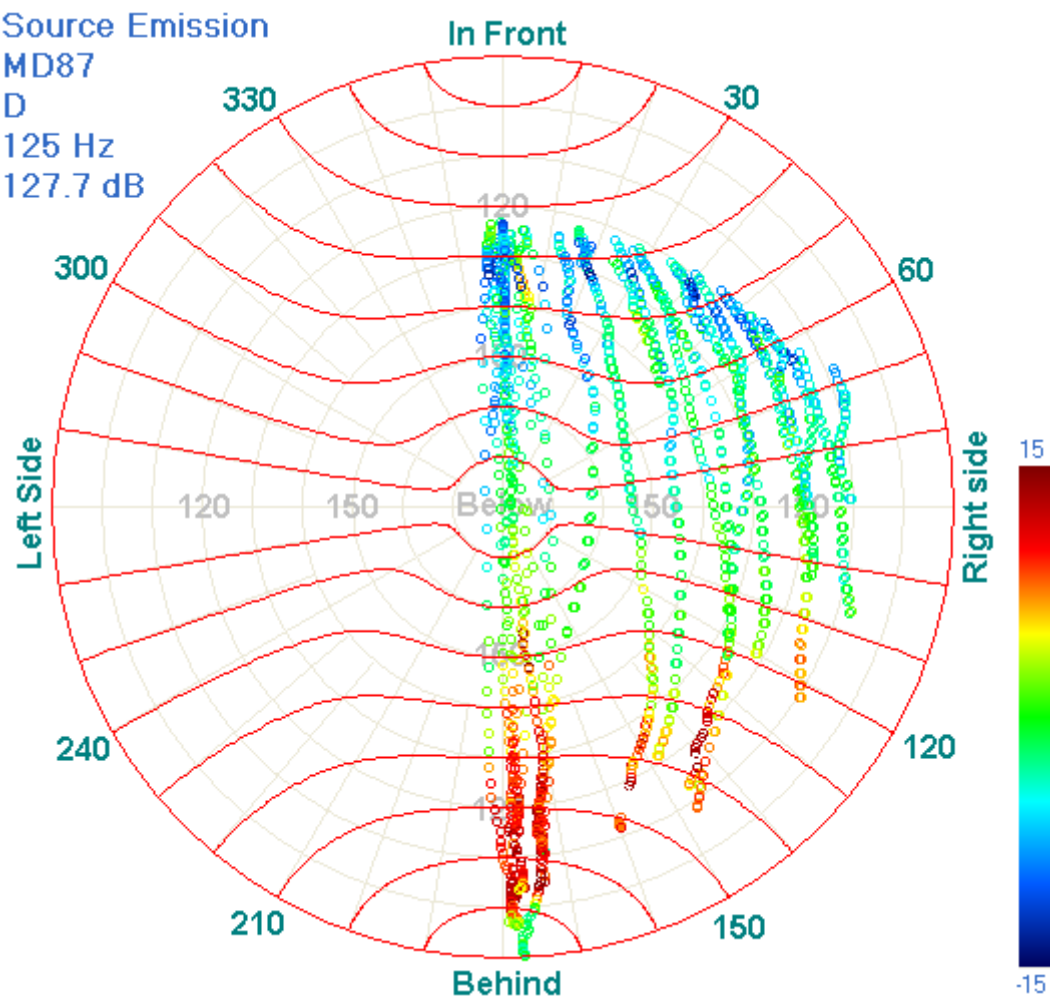




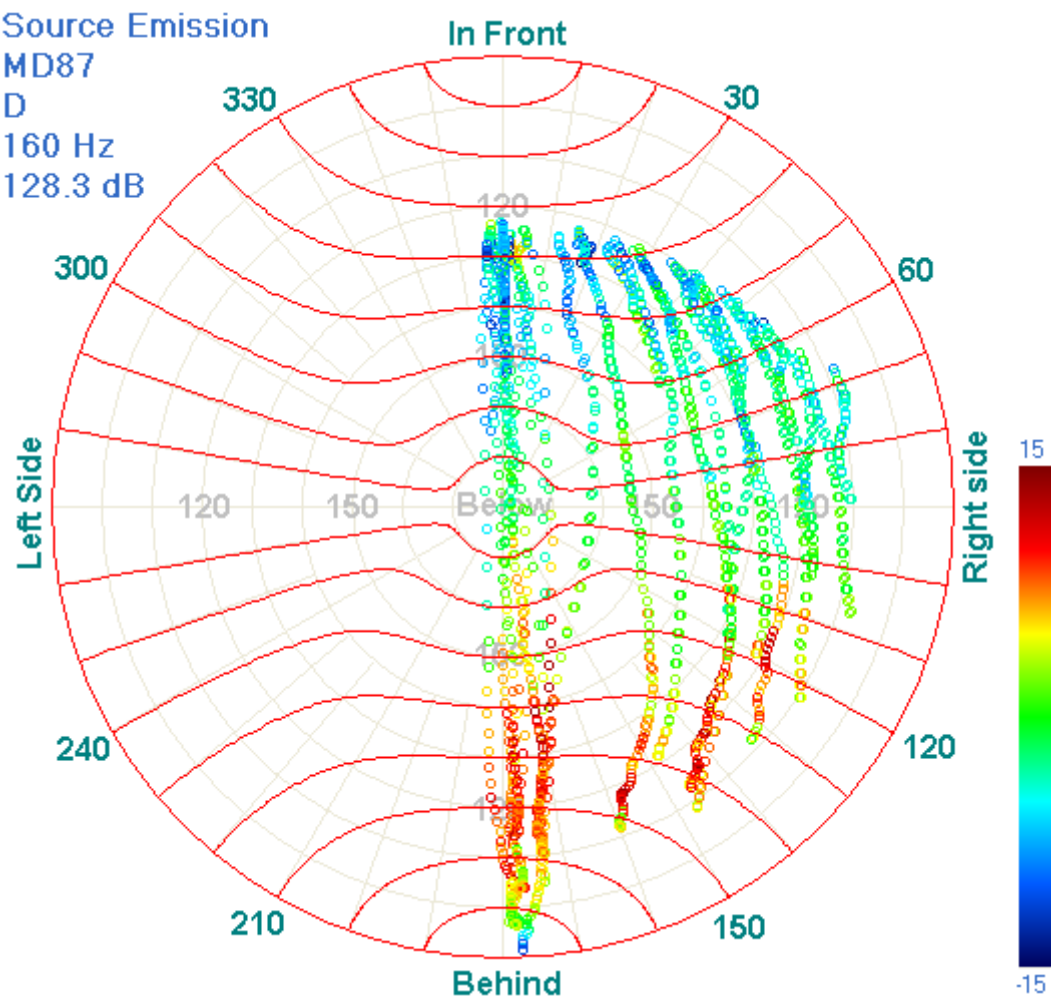


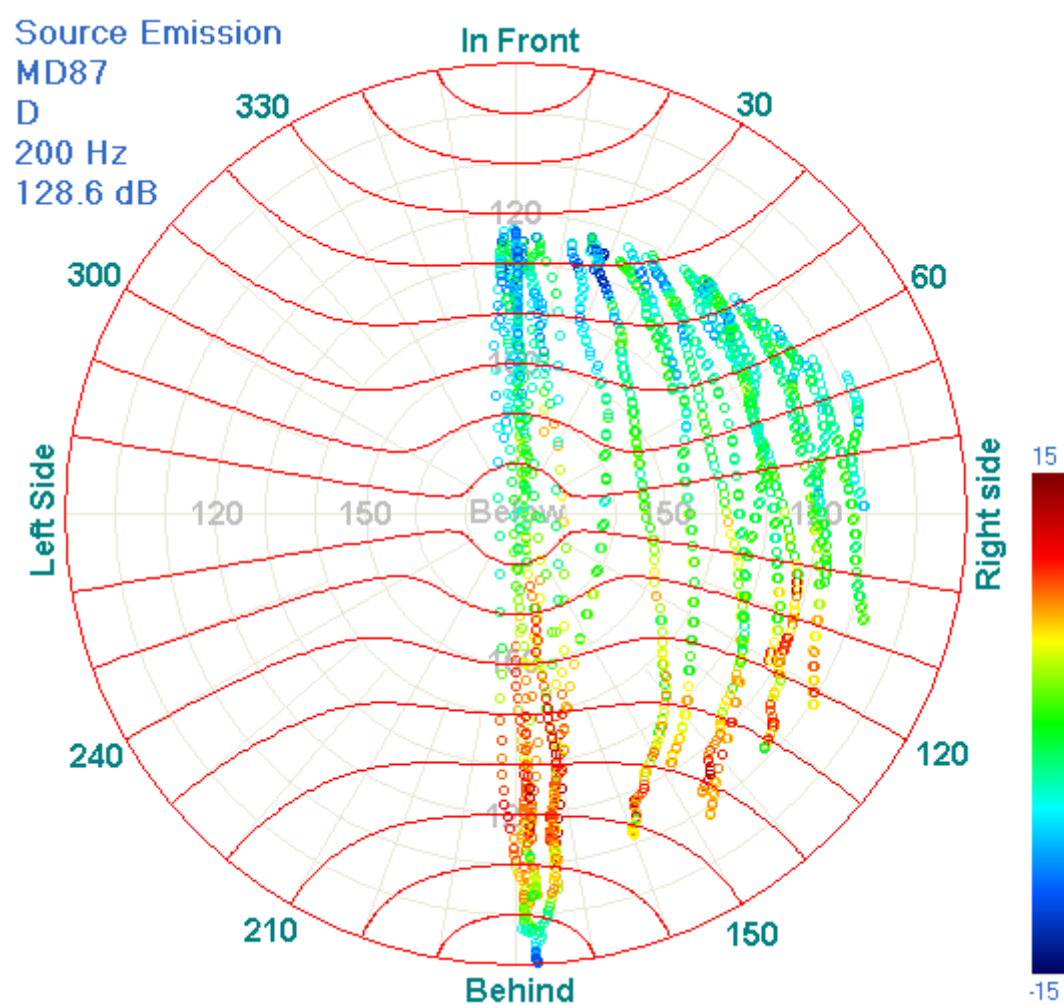


Source Emission  
MD87  
D  
125 Hz  
127.7 dB

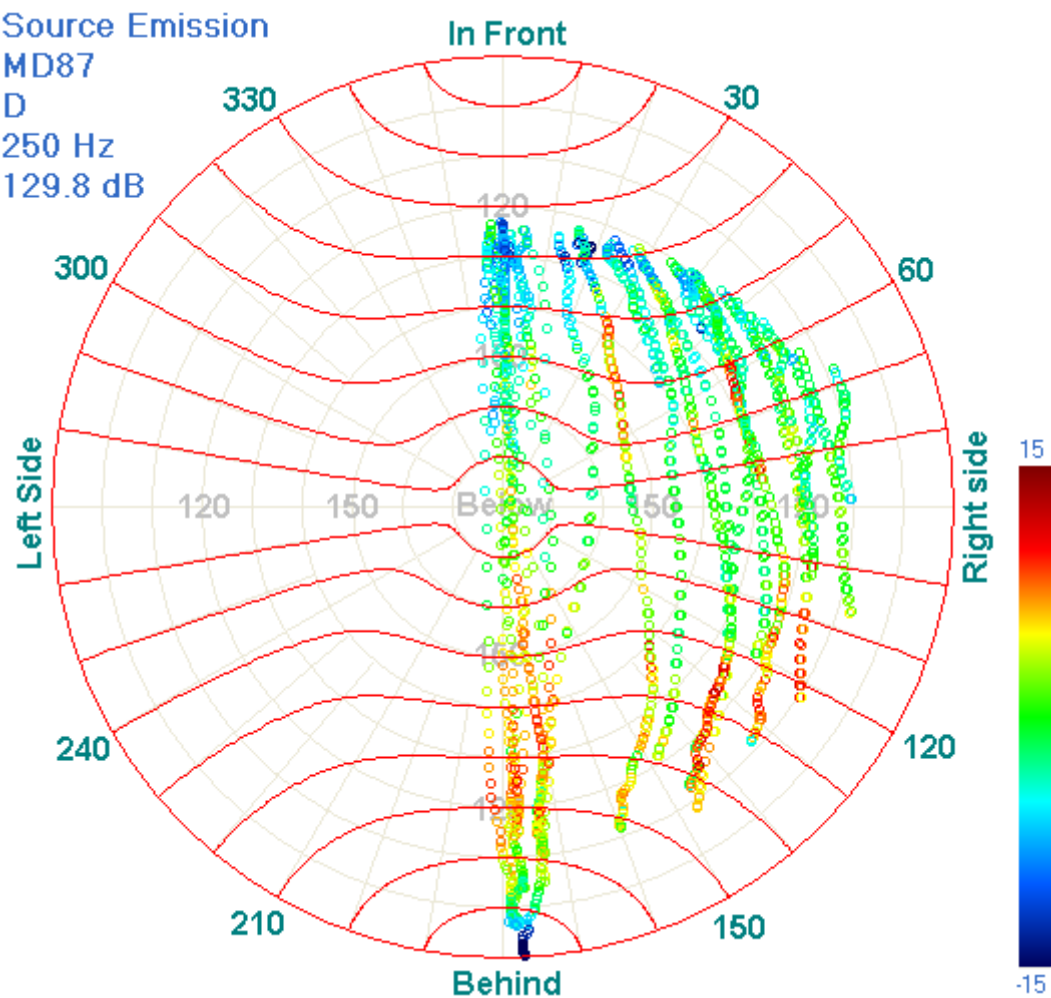


Source Emission  
MD87  
D  
160 Hz  
128.3 dB

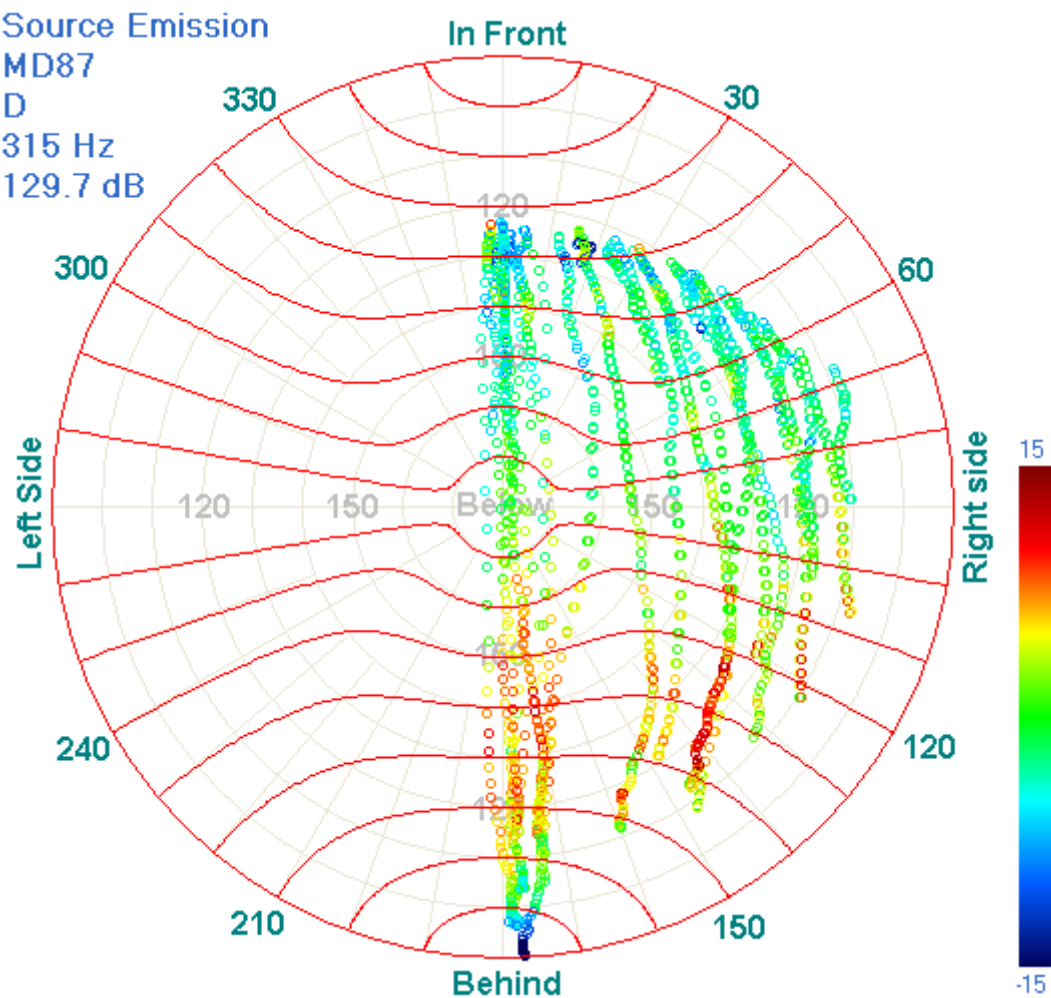




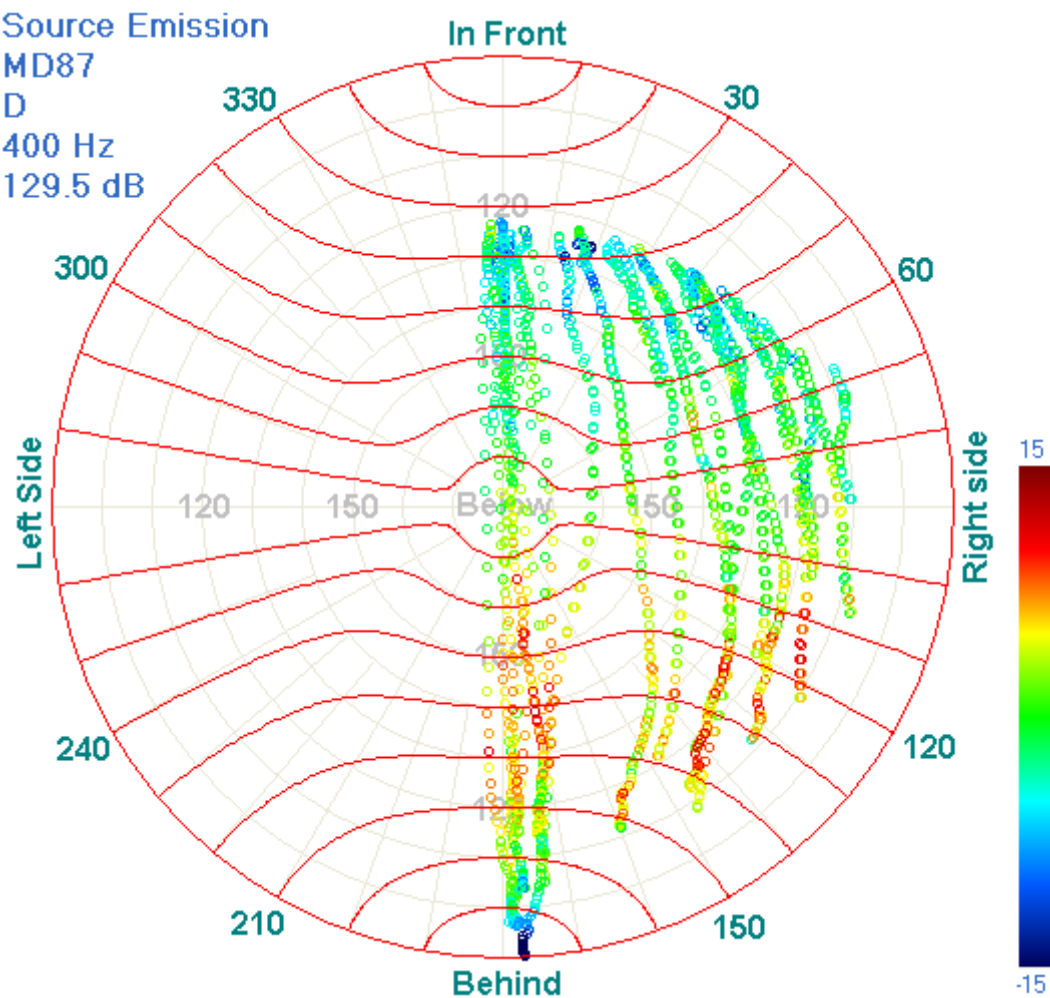
Source Emission  
MD87  
D  
250 Hz  
129.8 dB



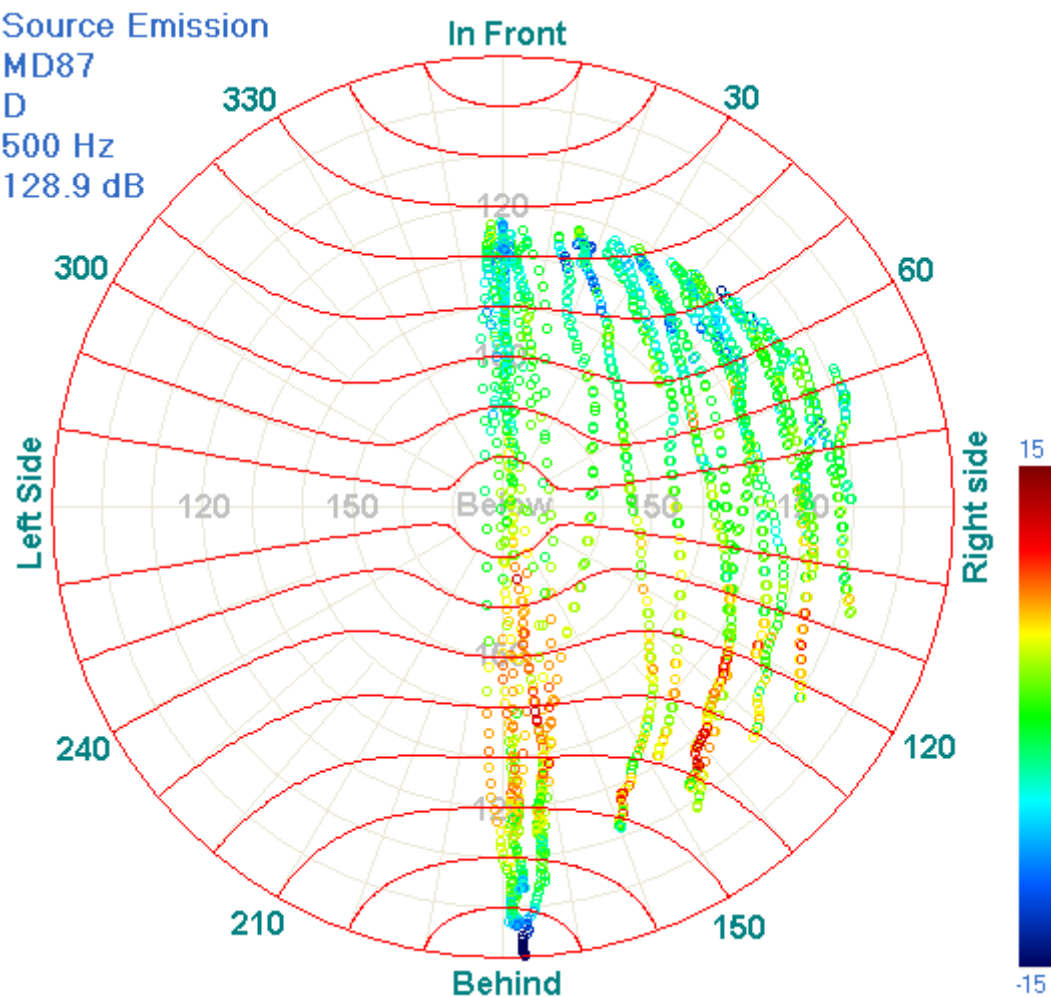
Source Emission  
MD87  
D  
315 Hz  
129.7 dB



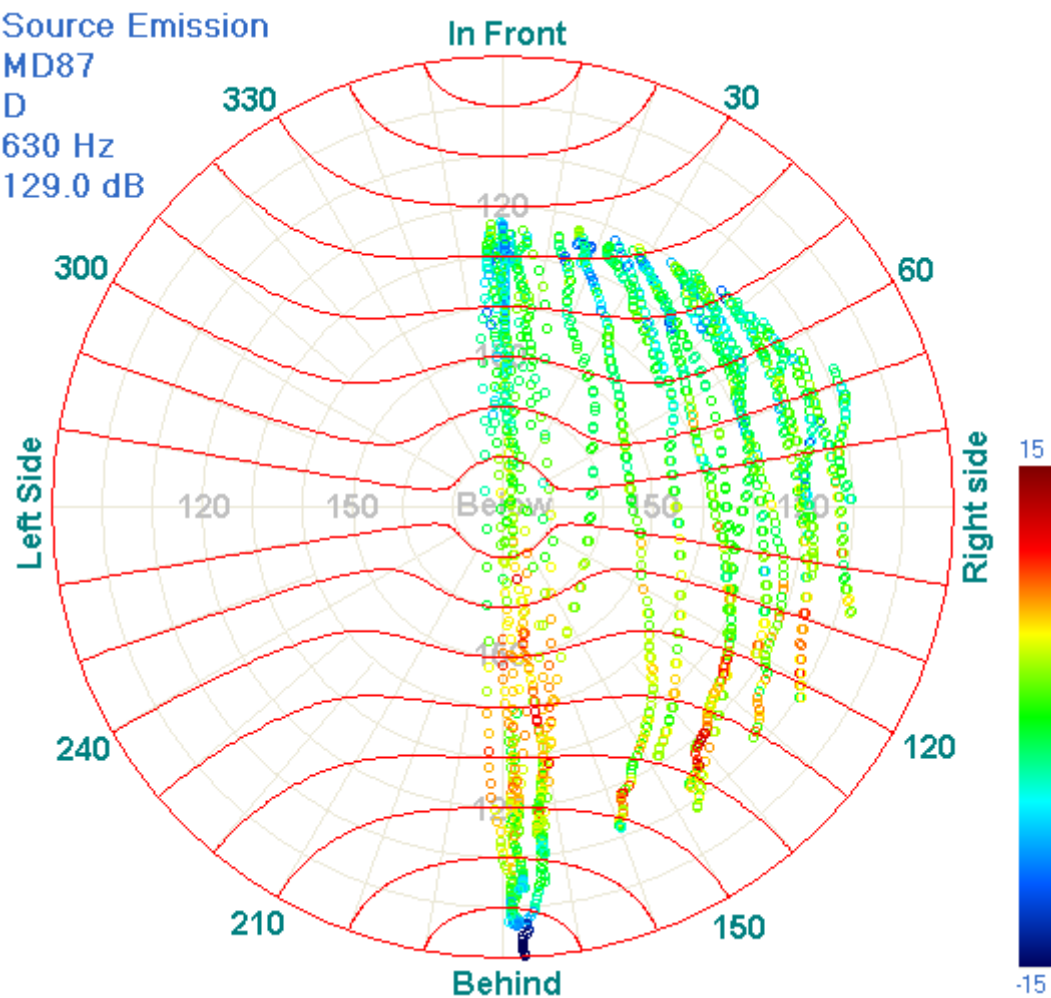
Source Emission  
MD87  
D  
400 Hz  
129.5 dB



Source Emission  
MD87  
D  
500 Hz  
128.9 dB

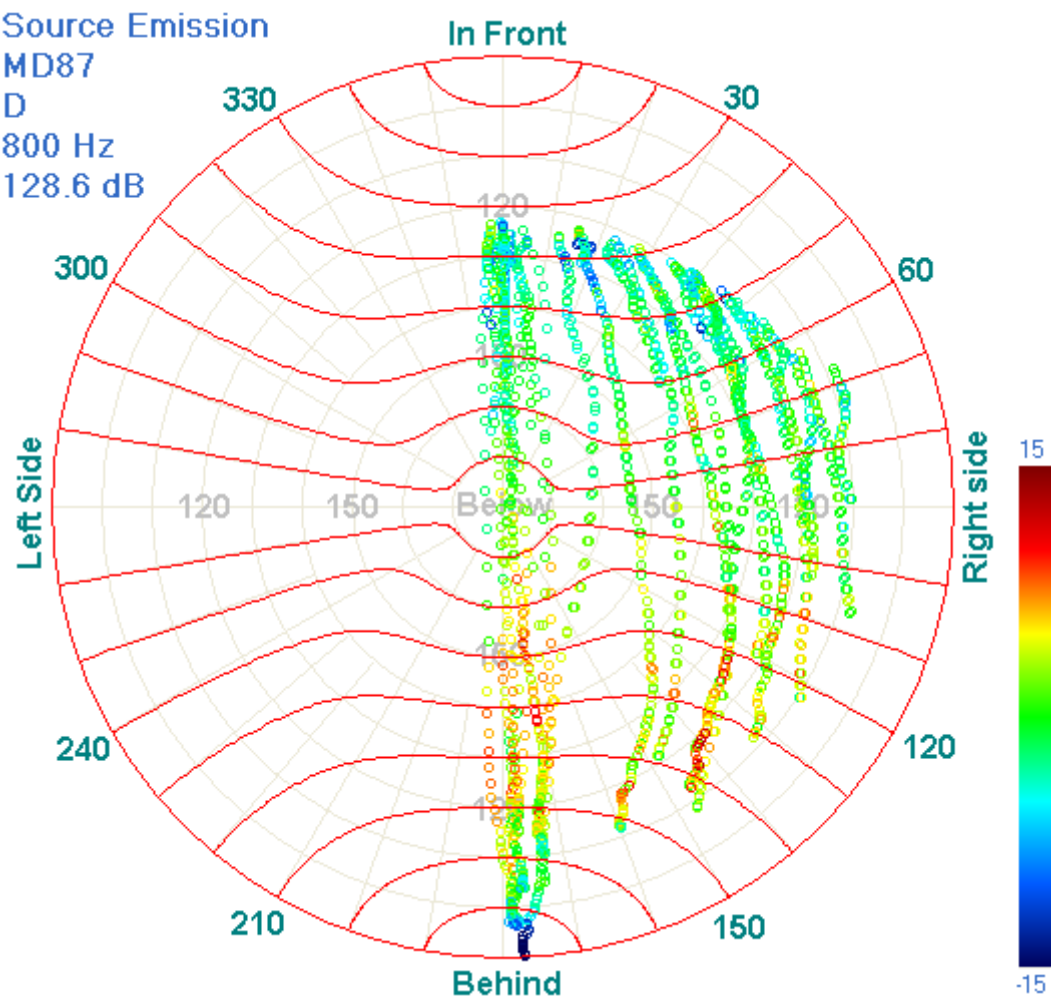


Source Emission  
MD87  
D  
630 Hz  
129.0 dB

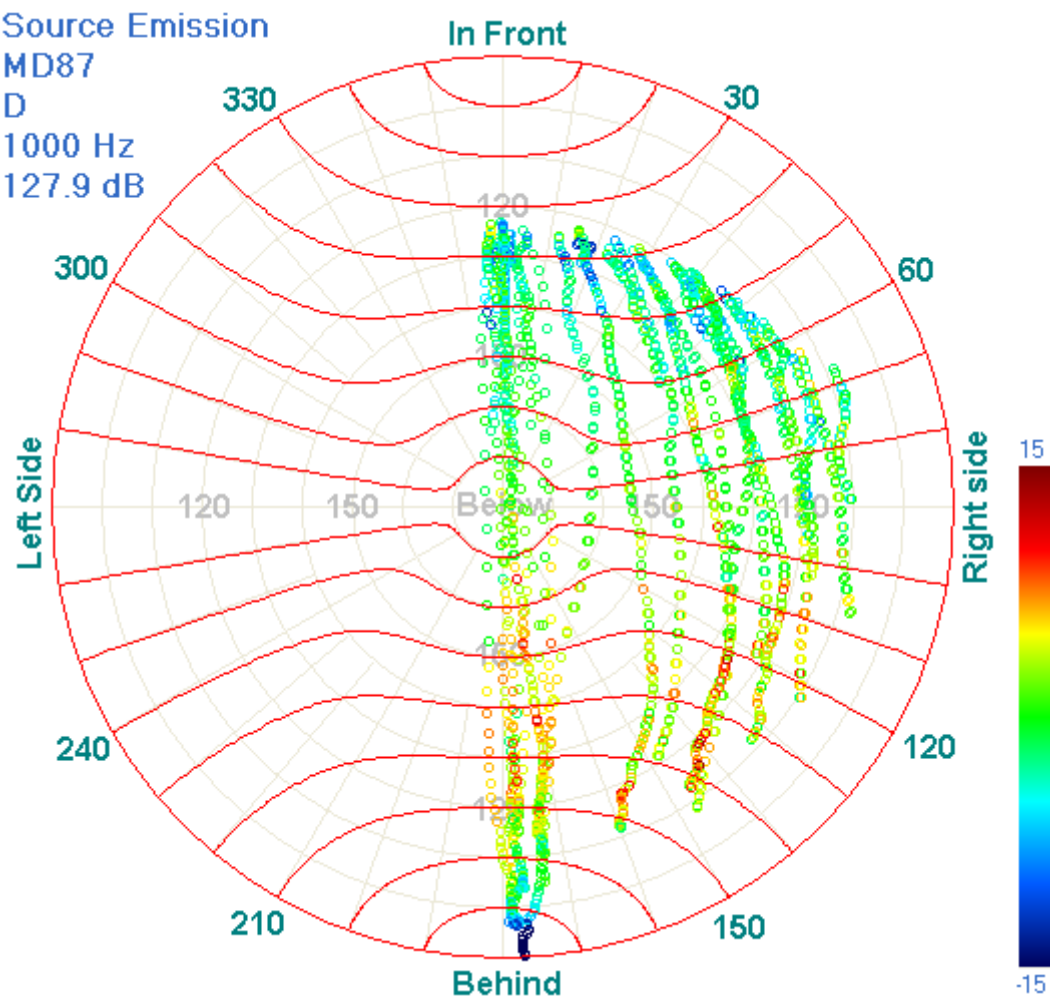




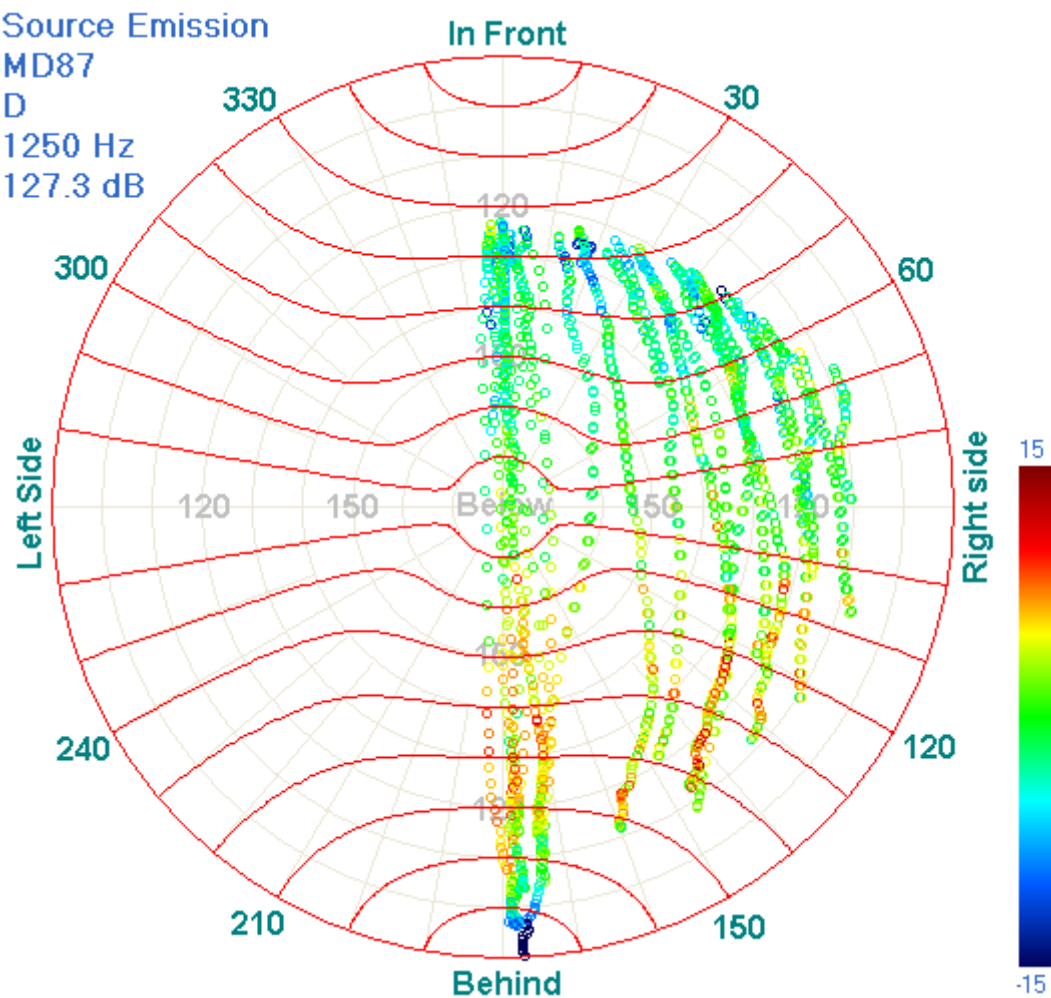
Source Emission  
MD87  
D  
800 Hz  
128.6 dB



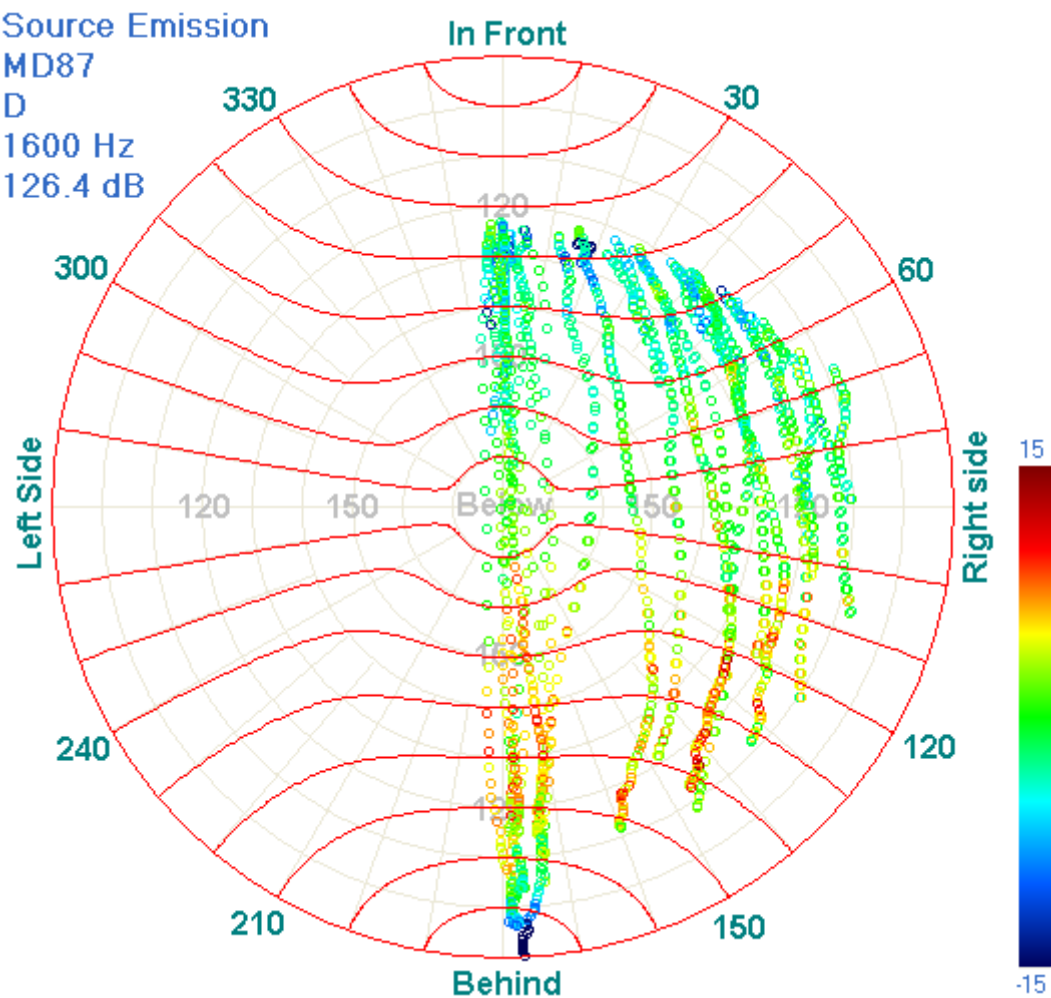
Source Emission  
MD87  
D  
1000 Hz  
127.9 dB



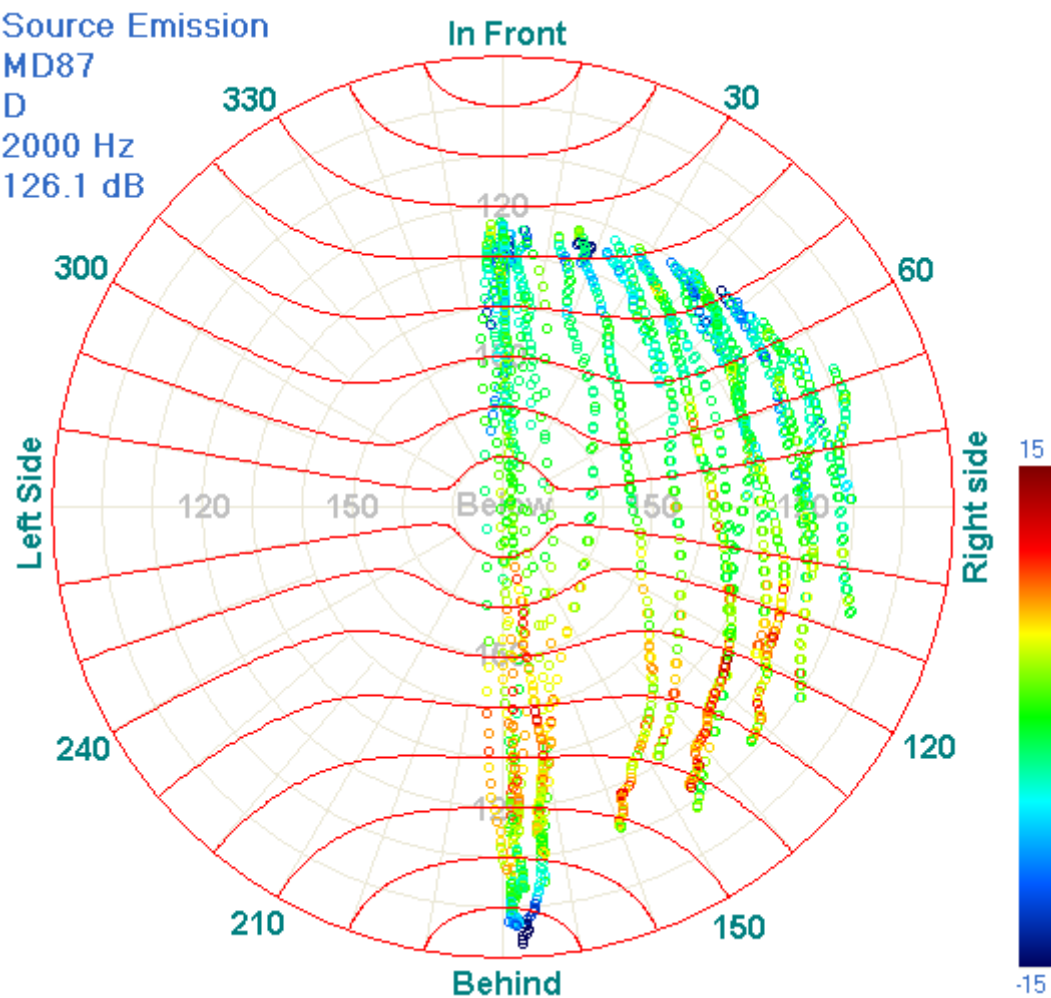
Source Emission  
MD87  
D  
1250 Hz  
127.3 dB



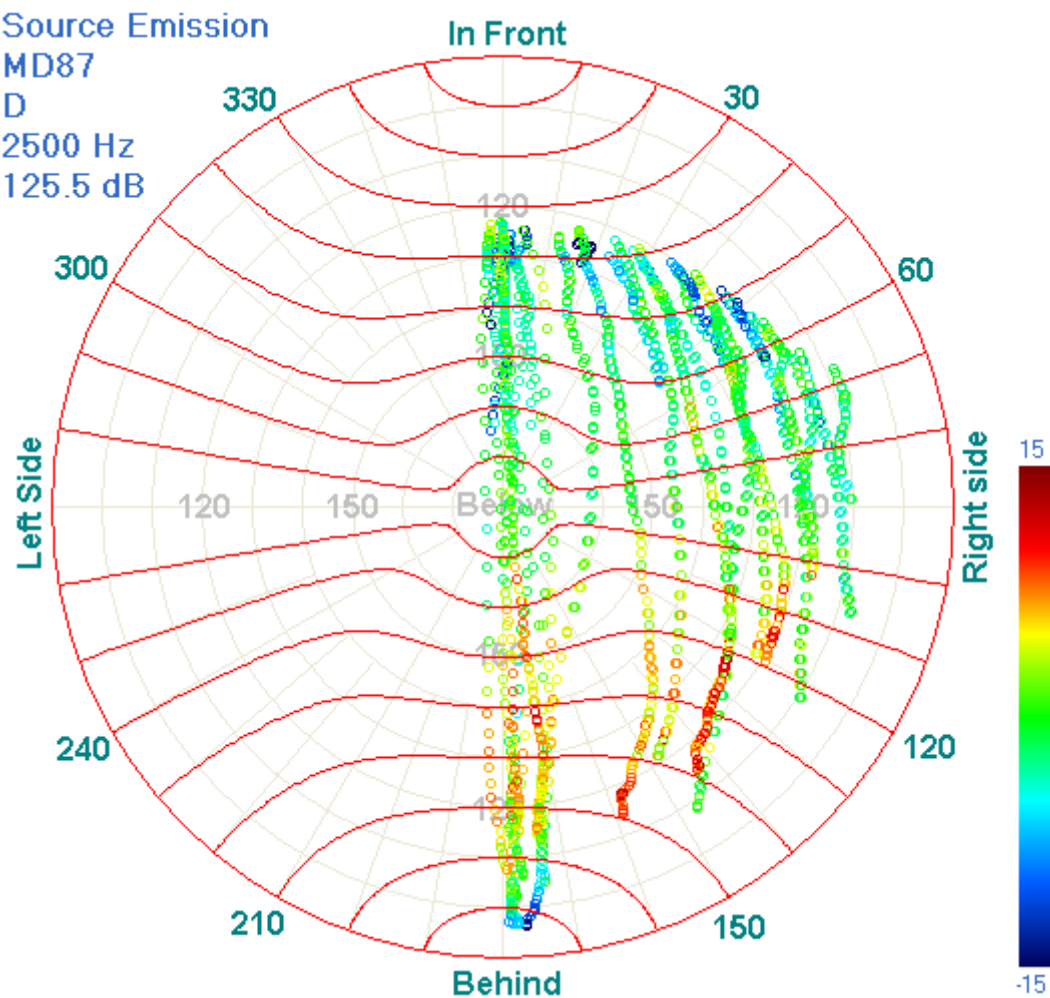
Source Emission  
MD87  
D  
1600 Hz  
126.4 dB



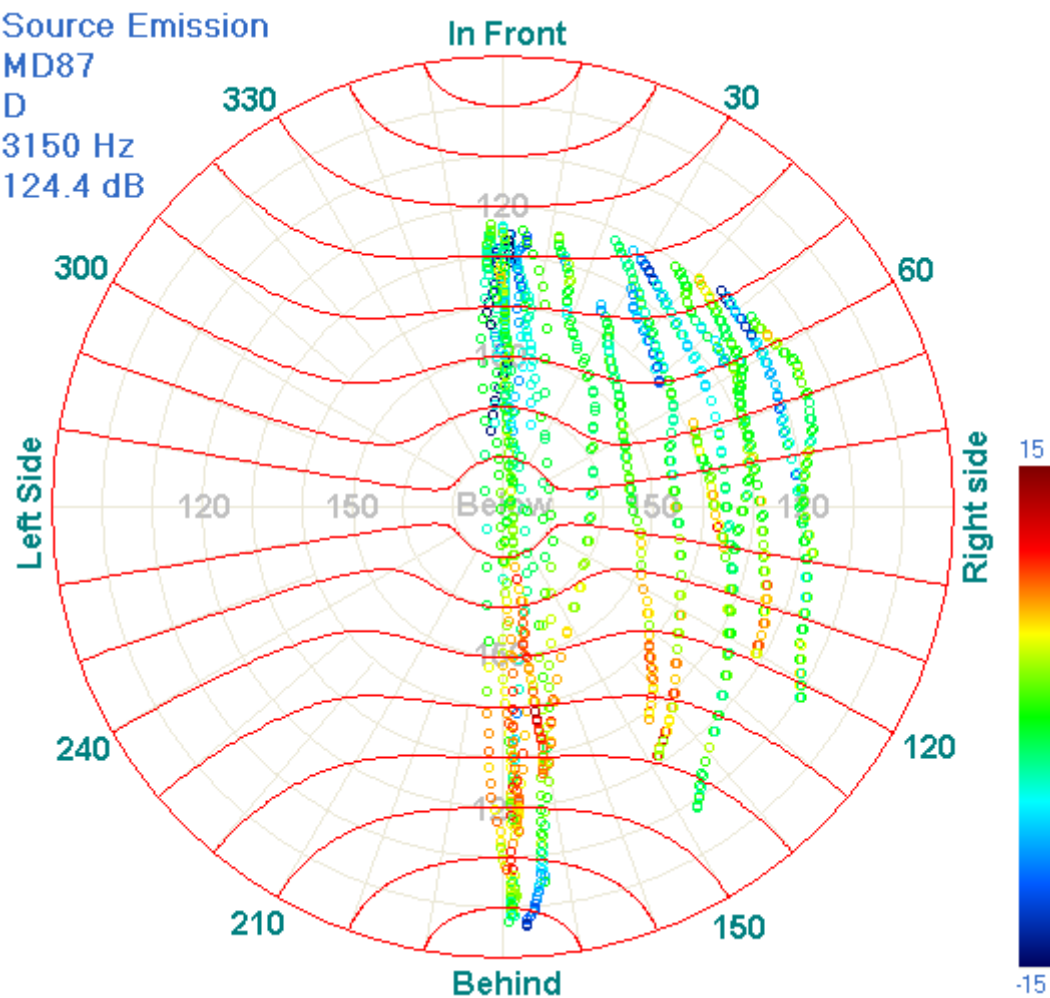
Source Emission  
MD87  
D  
2000 Hz  
126.1 dB

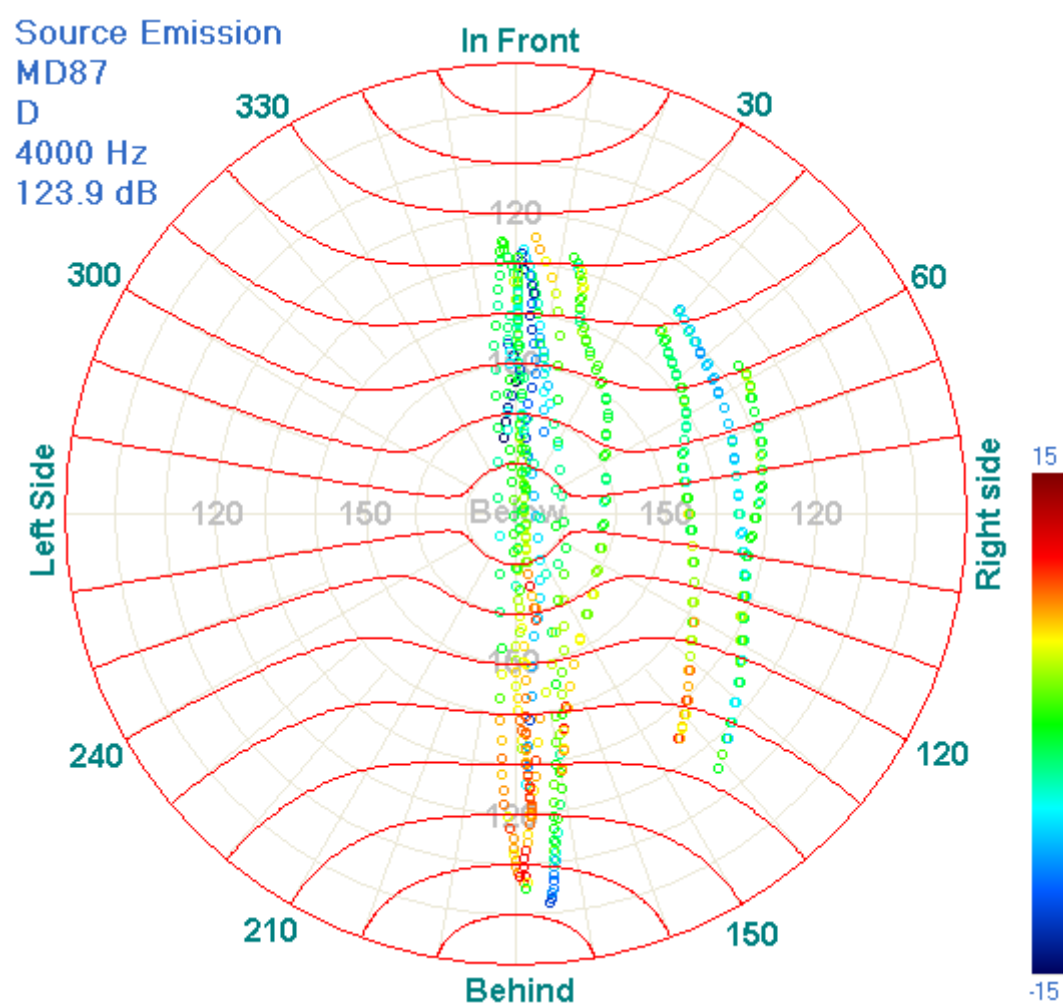


Source Emission  
MD87  
D  
2500 Hz  
125.5 dB



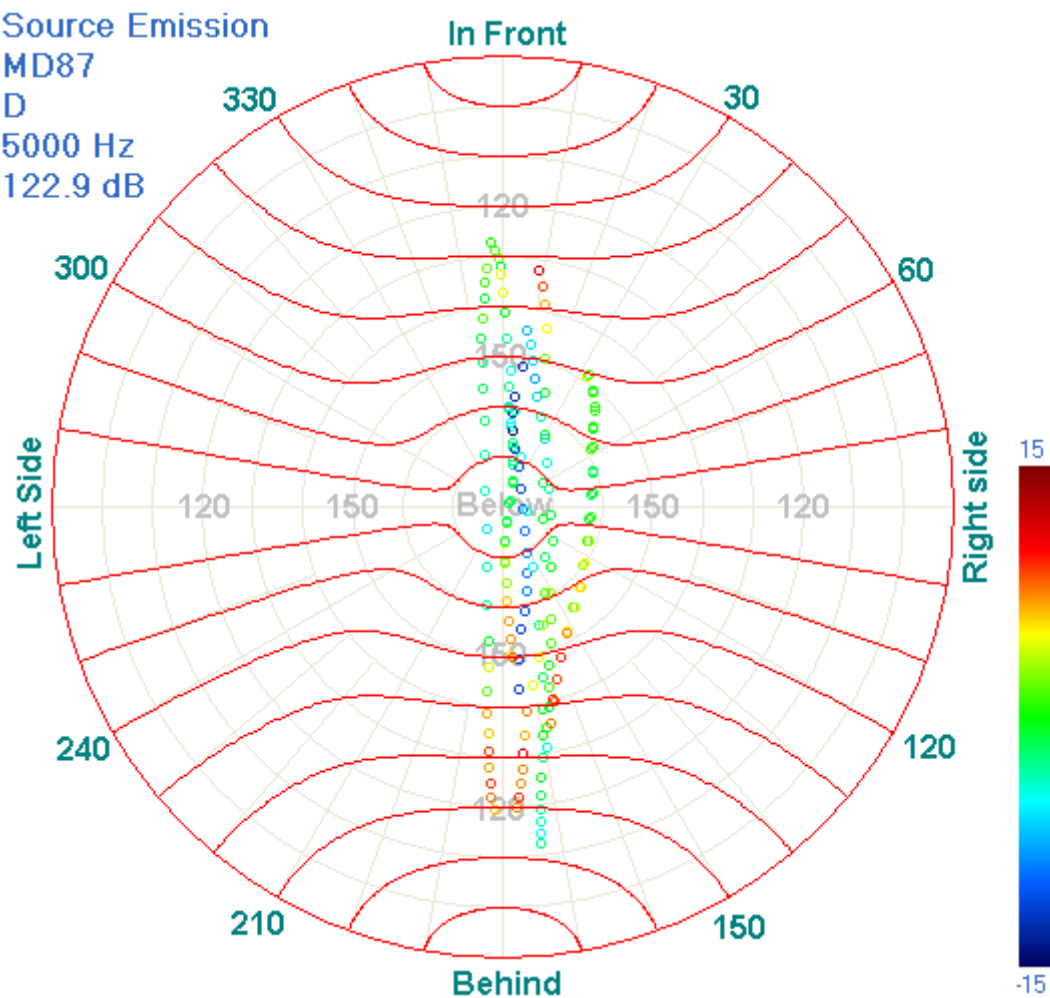
Source Emission  
MD87  
D  
3150 Hz  
124.4 dB



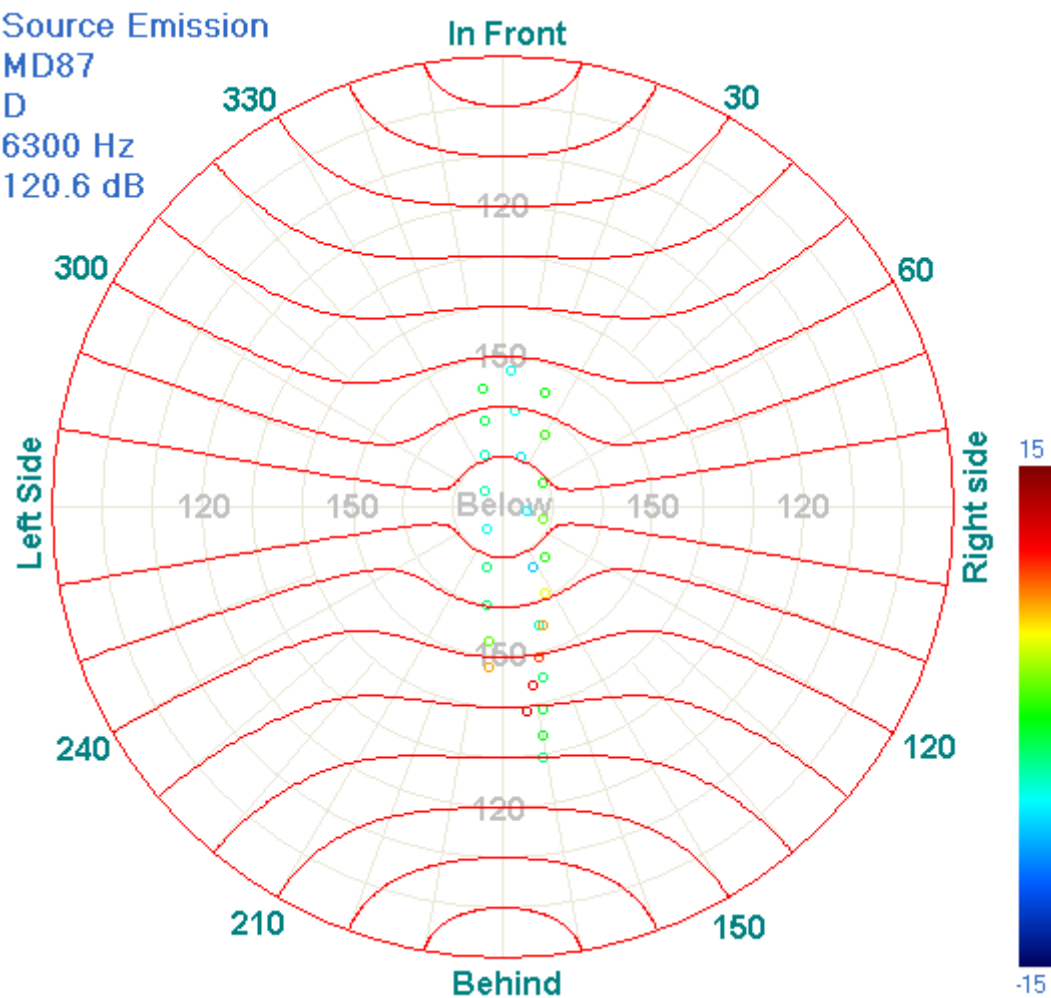




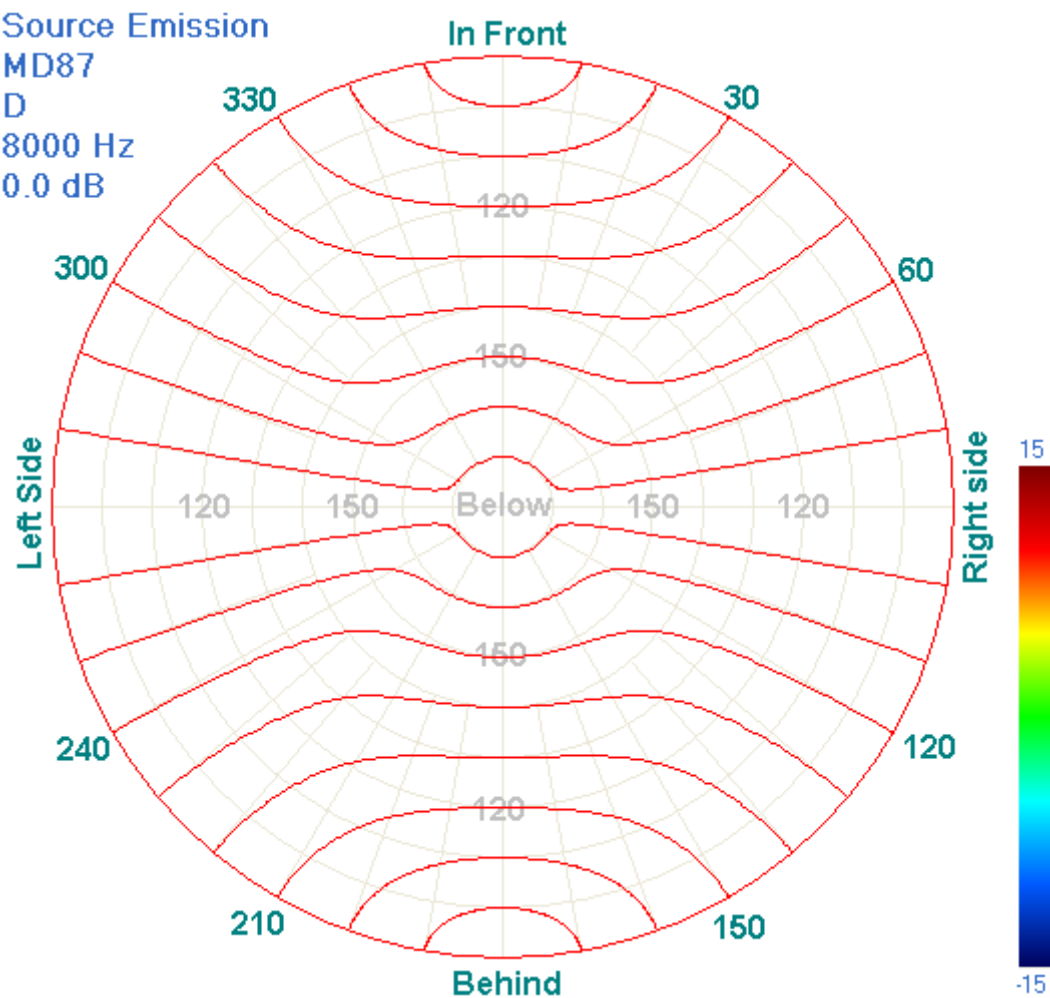
Source Emission  
MD87  
D  
5000 Hz  
122.9 dB



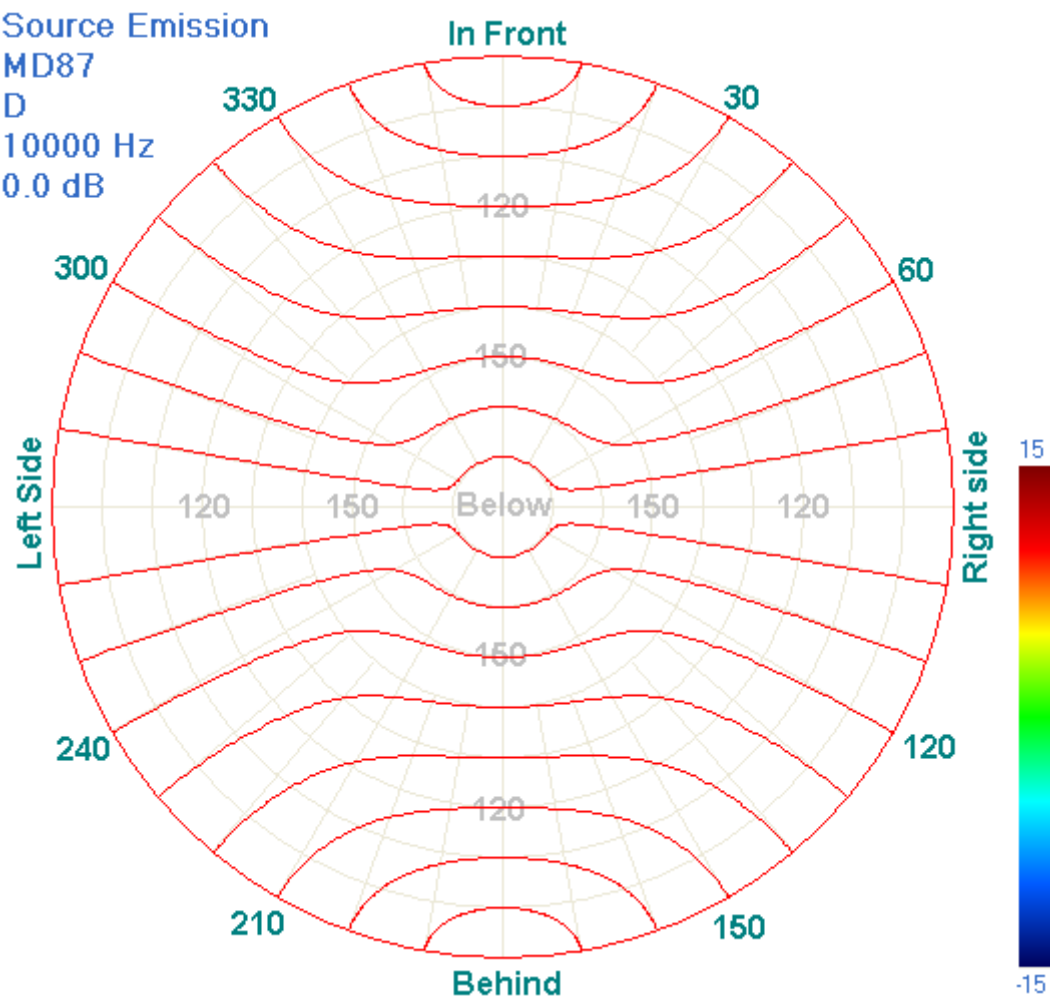
Source Emission  
MD87  
D  
6300 Hz  
120.6 dB



Source Emission  
MD87  
D  
8000 Hz  
0.0 dB



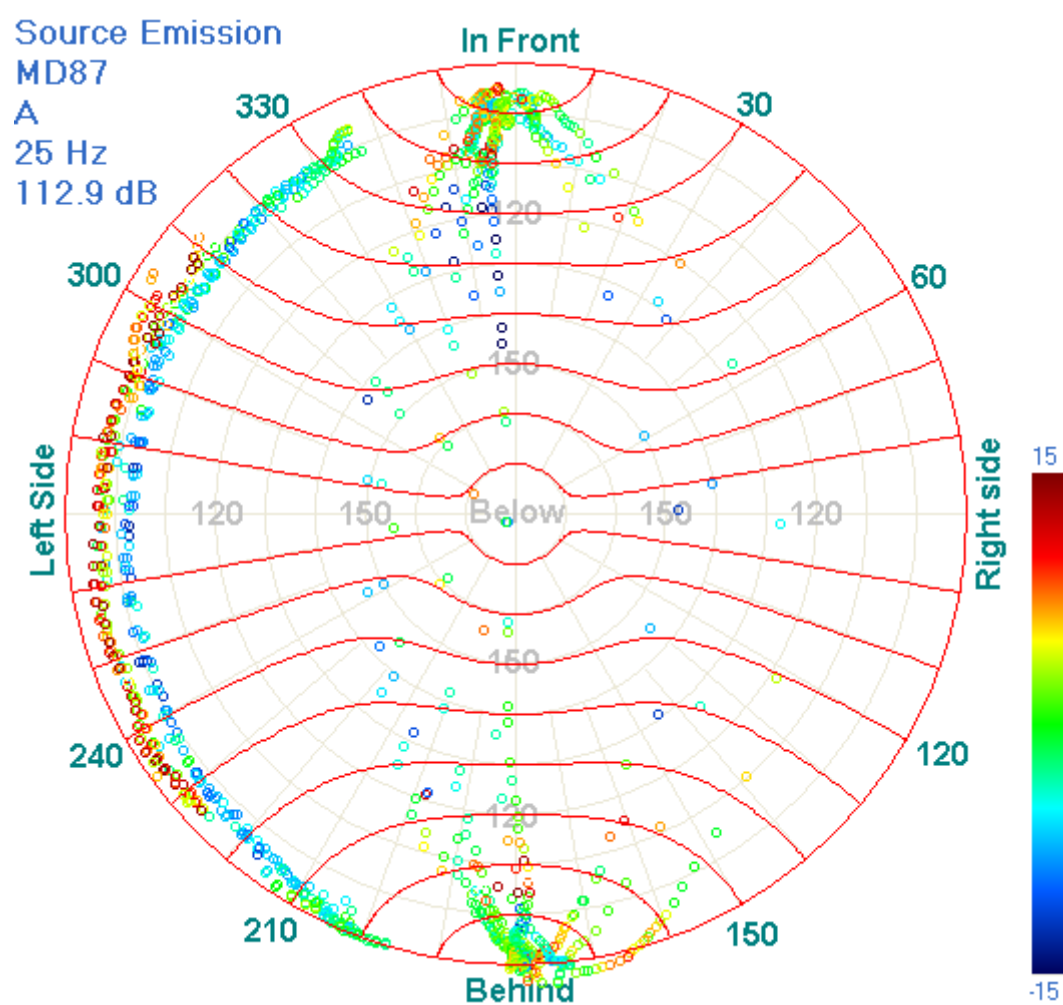
Source Emission  
MD87  
D  
10000 Hz  
0.0 dB

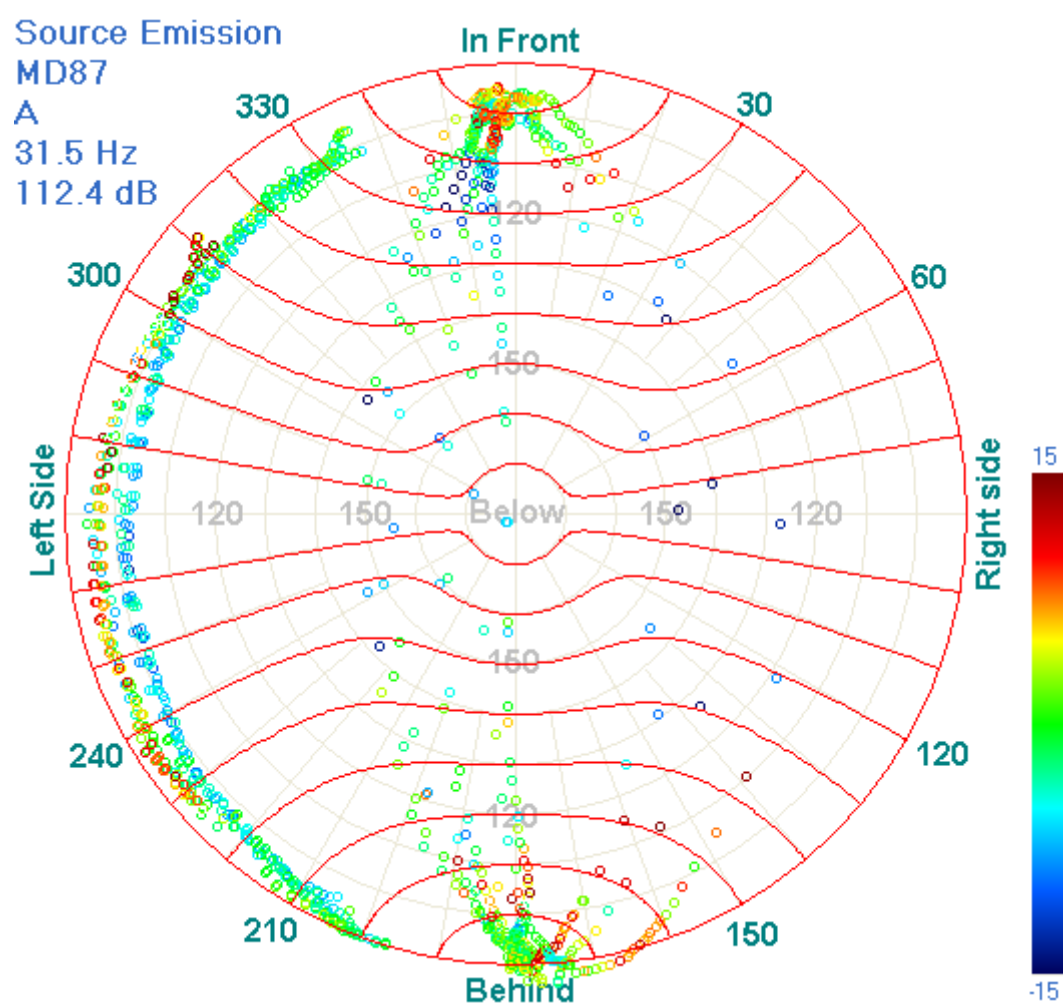


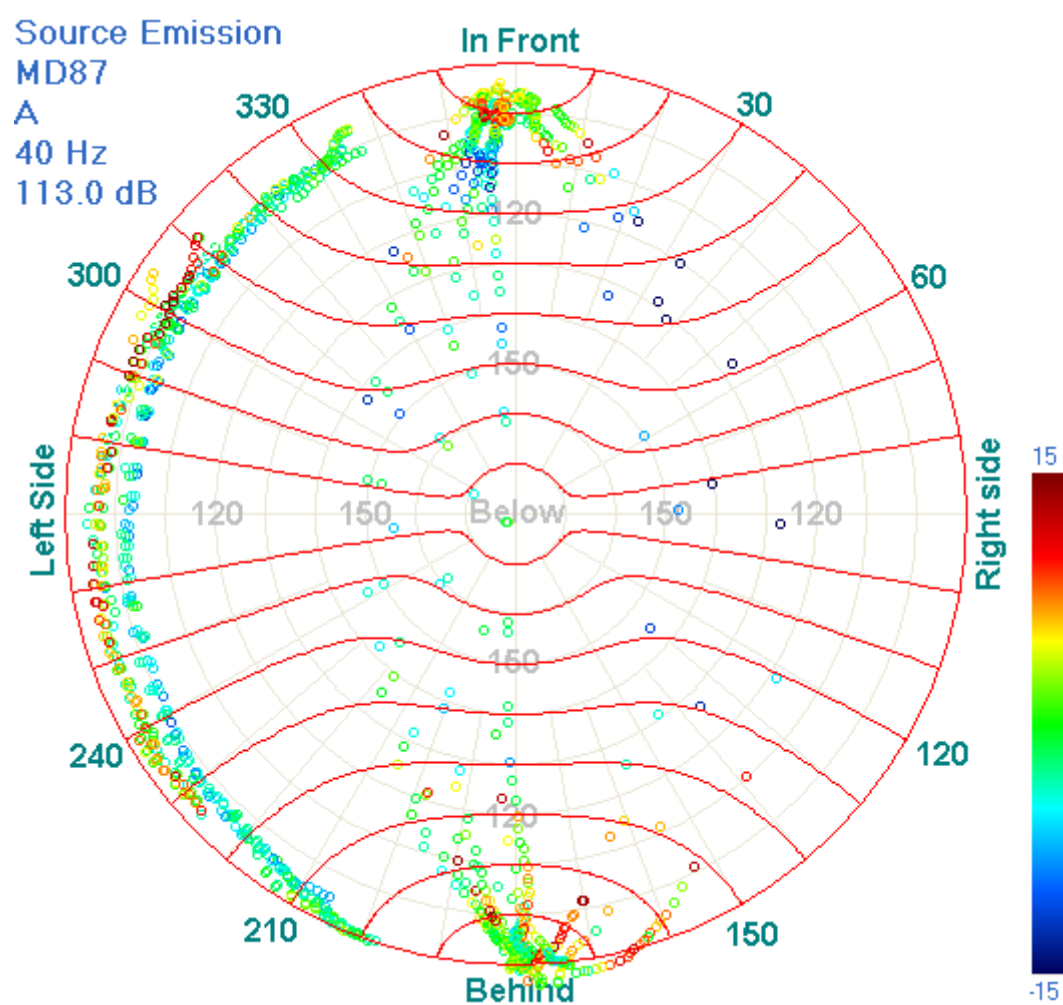
## 18 MD 87 directivity at arrival

SPECTRUM  
Source Emission  
MD87  
A

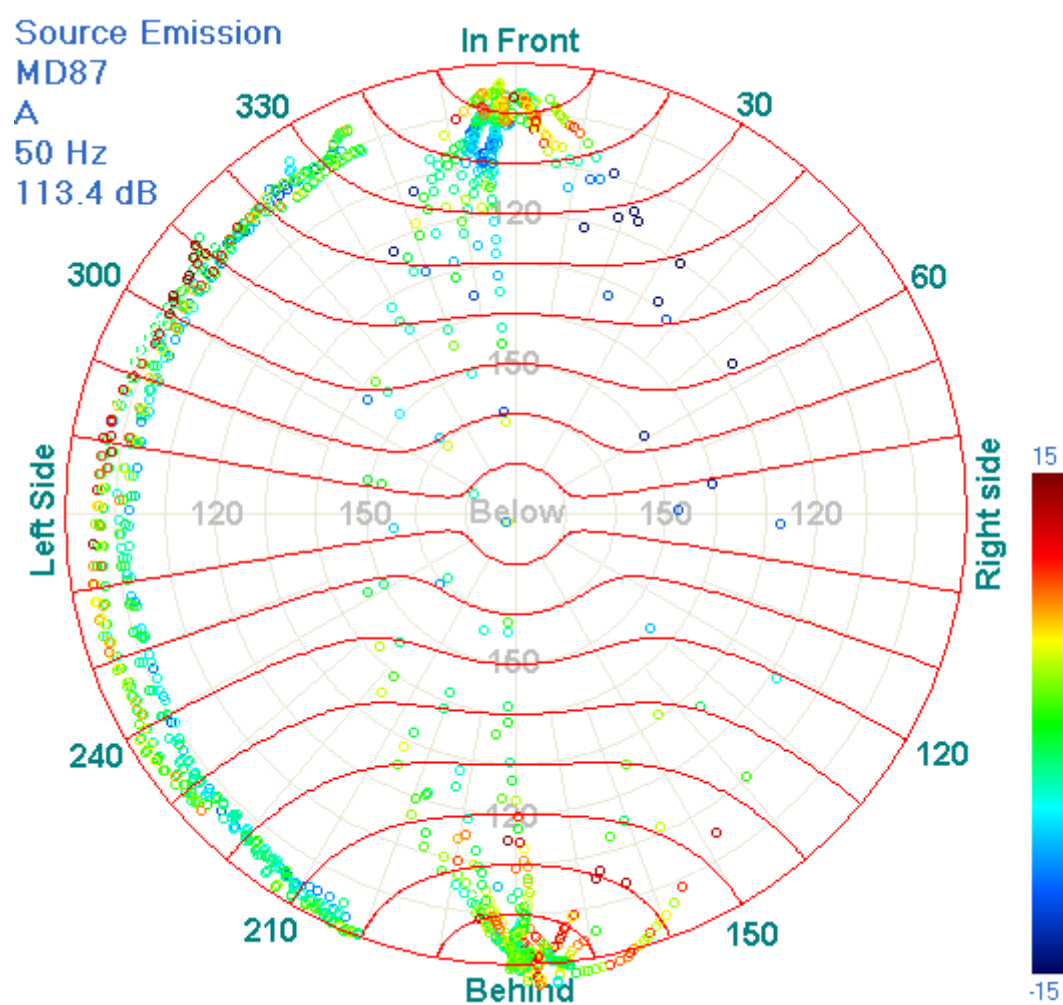
Freq	Num	Avg	Std	95%Avg	P1	P2	P3	P4	P5	P6
25	1165	112.9	6.5	0.4	112.0	113.4	114.9	-1.0	-1.0	-1.0
31.5	1210	112.4	6.1	0.3	111.9	112.3	113.9	-1.0	-1.0	-1.0
40	1191	113.0	5.8	0.3	112.6	113.3	114.0	-1.0	-1.0	-1.0
50	1116	113.4	6.0	0.3	113.0	113.4	114.1	-1.0	-1.0	-1.0
63	1067	113.1	5.8	0.3	112.4	113.5	113.9	-1.0	-1.0	-1.0
80	1259	111.9	5.3	0.3	111.4	112.6	111.7	-1.0	-1.0	-1.0
100	1388	111.4	5.1	0.3	110.7	112.6	111.0	-1.0	-1.0	-1.0
125	1415	112.2	5.0	0.3	111.4	113.3	112.4	-1.0	-1.0	-1.0
160	1600	113.0	5.1	0.2	112.1	114.2	113.0	-1.0	-1.0	-1.0
200	1577	113.7	4.4	0.2	112.6	114.7	114.5	-1.0	-1.0	-1.0
250	1626	113.2	4.4	0.2	112.5	113.8	114.3	-1.0	-1.0	-1.0
315	1618	113.5	4.7	0.2	112.9	114.2	114.1	-1.0	-1.0	-1.0
400	1582	112.4	4.4	0.2	111.5	113.1	113.7	-1.0	-1.0	-1.0
500	1569	111.2	4.1	0.2	110.5	111.7	112.5	-1.0	-1.0	-1.0
630	1482	111.1	4.2	0.2	110.3	111.7	112.9	-1.0	-1.0	-1.0
800	1506	110.8	4.3	0.2	110.3	111.2	112.1	-1.0	-1.0	-1.0
1000	1559	110.3	4.4	0.2	109.8	110.5	111.5	-1.0	-1.0	-1.0
1250	1629	109.6	4.5	0.2	108.9	110.1	111.1	-1.0	-1.0	-1.0
1600	1648	108.6	4.5	0.2	108.1	109.0	109.7	-1.0	-1.0	-1.0
2000	1630	107.9	4.6	0.2	107.4	108.2	108.8	-1.0	-1.0	-1.0
2500	1577	107.5	4.8	0.2	107.2	107.8	107.5	-1.0	-1.0	-1.0
3150	1447	108.1	5.4	0.3	108.5	107.6	107.3	-1.0	-1.0	-1.0
4000	1071	109.6	6.1	0.4	110.2	108.7	110.2	-1.0	-1.0	-1.0
5000	646	109.5	7.0	0.5	111.5	108.1	106.7	-1.0	-1.0	-1.0
6300	329	110.5	8.4	0.9	110.9	110.8	107.2	-1.0	-1.0	-1.0
8000	200	111.3	10.7	1.5	110.8	112.2	109.8	-1.0	-1.0	-1.0
10000	117	113.3	15.5	2.8	111.3	116.2	111.6	-1.0	-1.0	-1.0

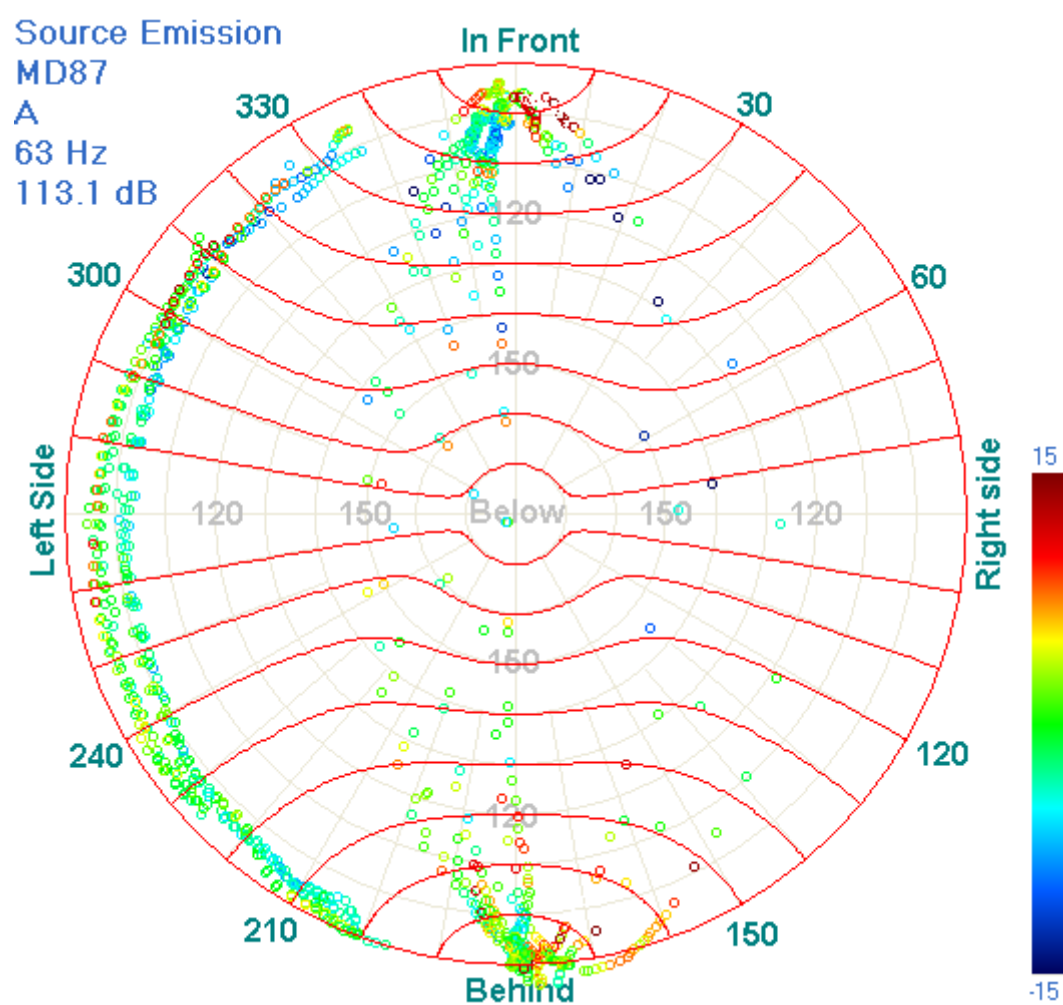


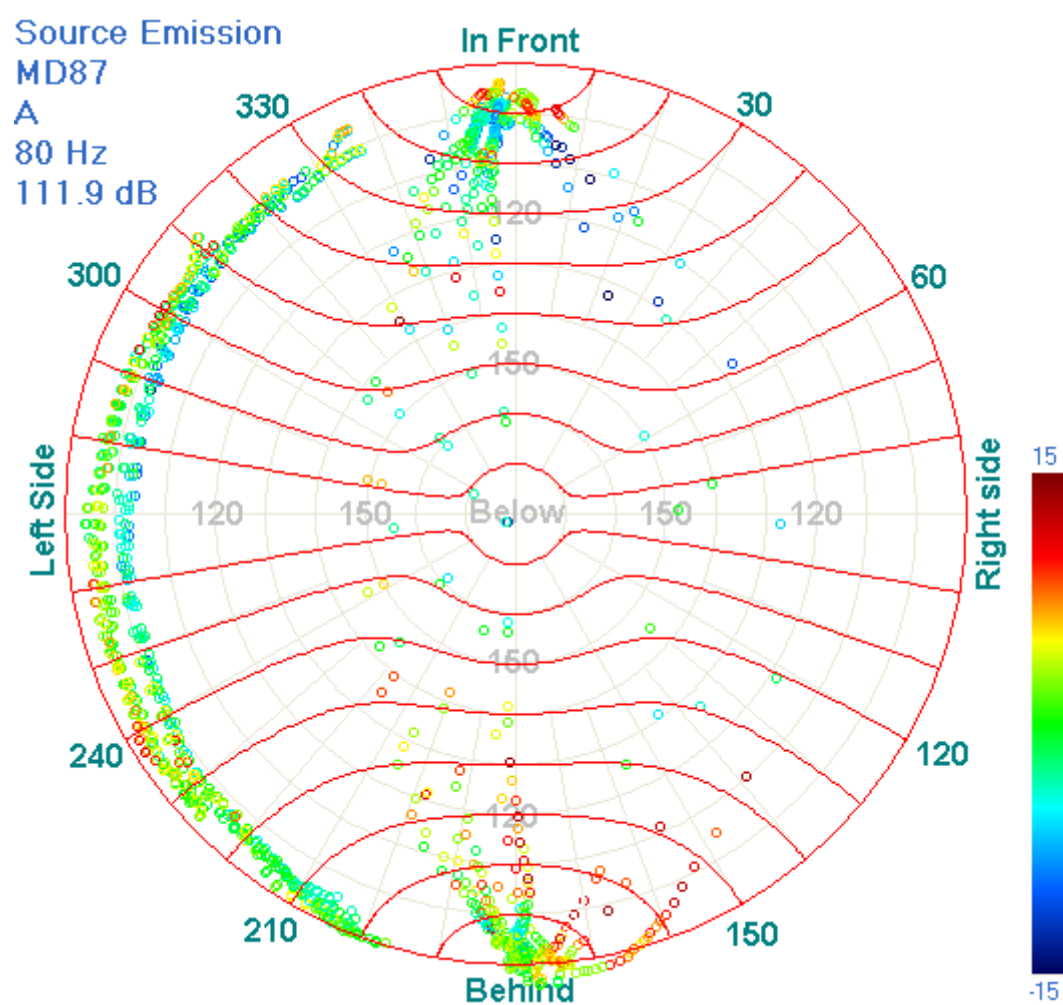


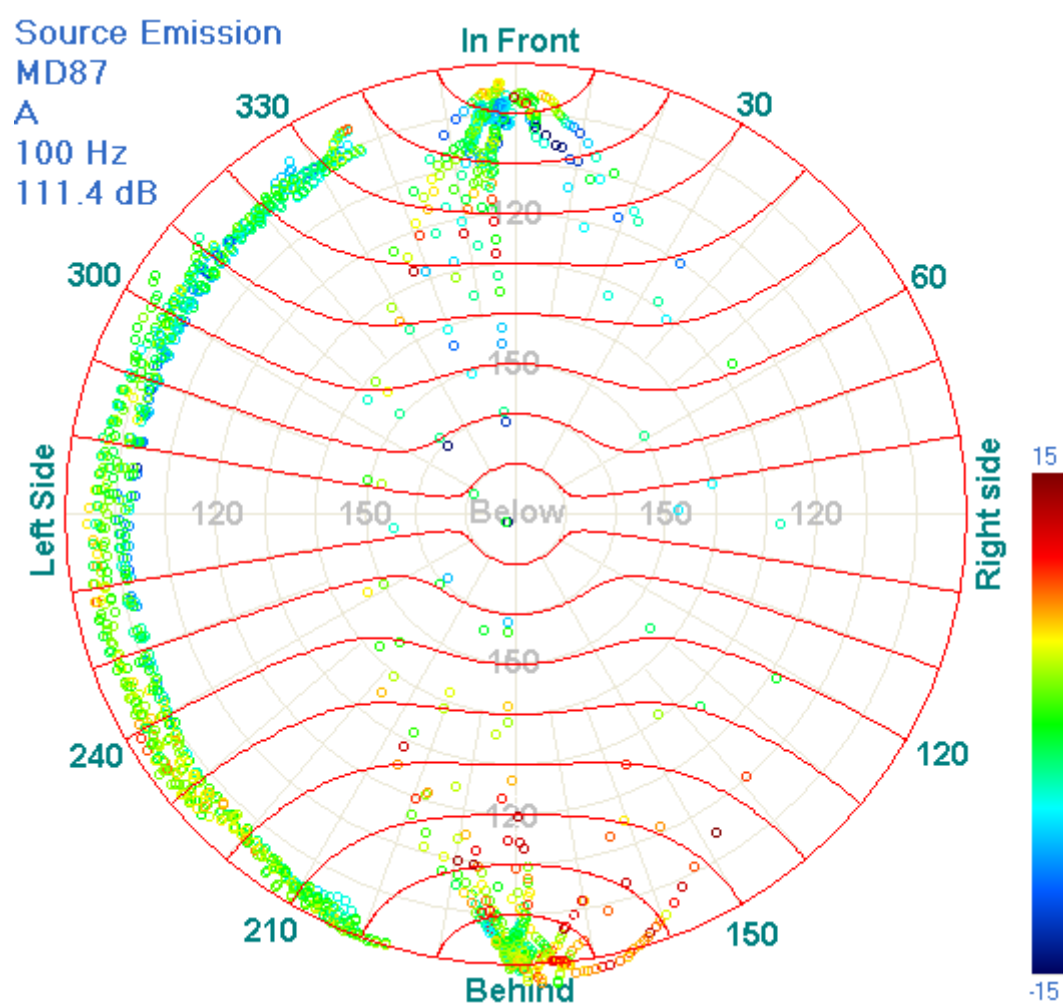


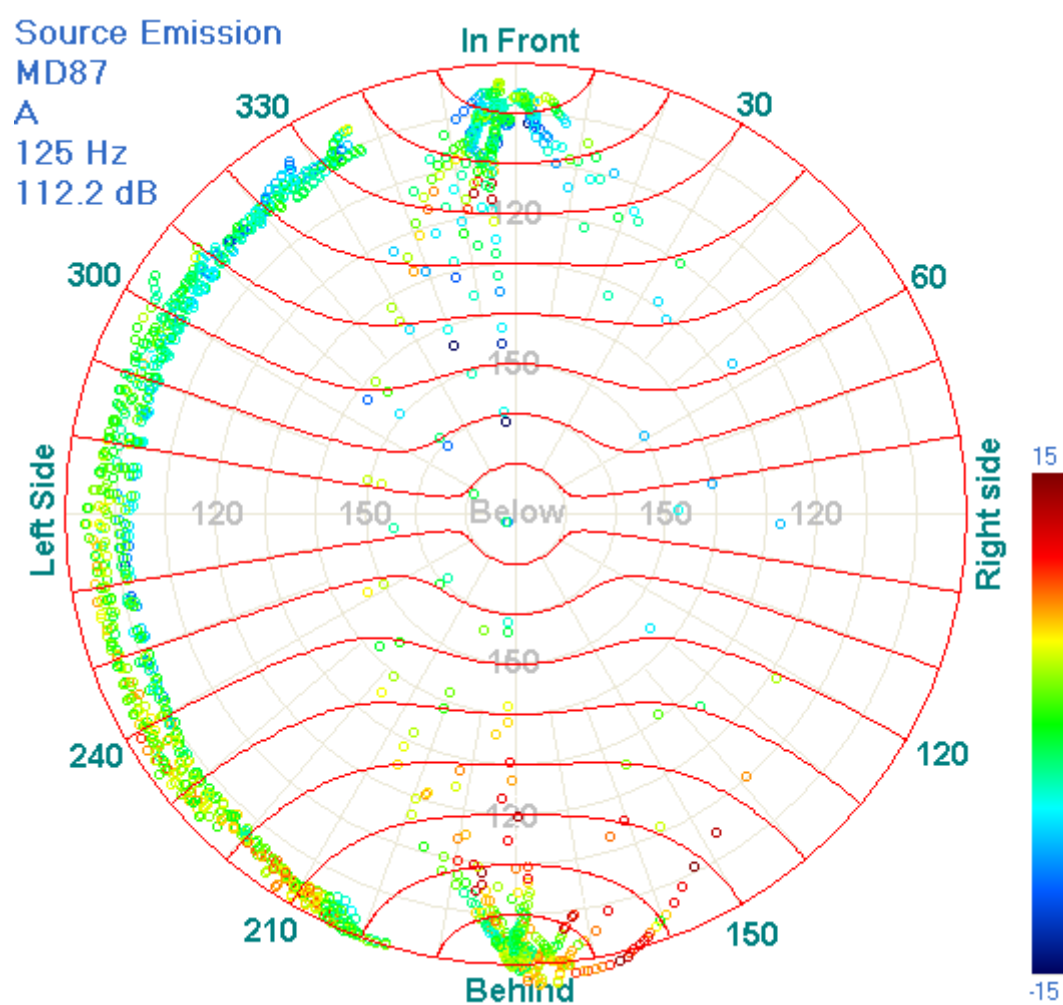


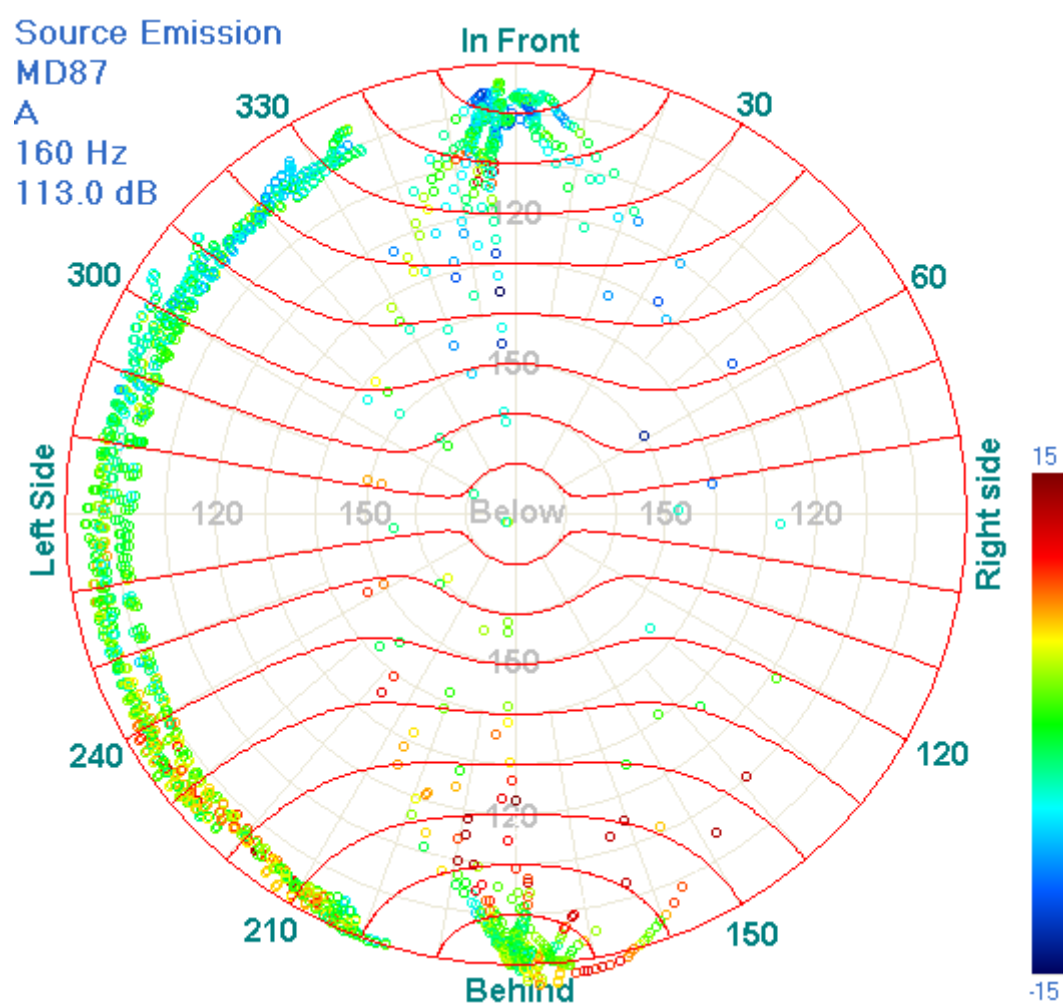


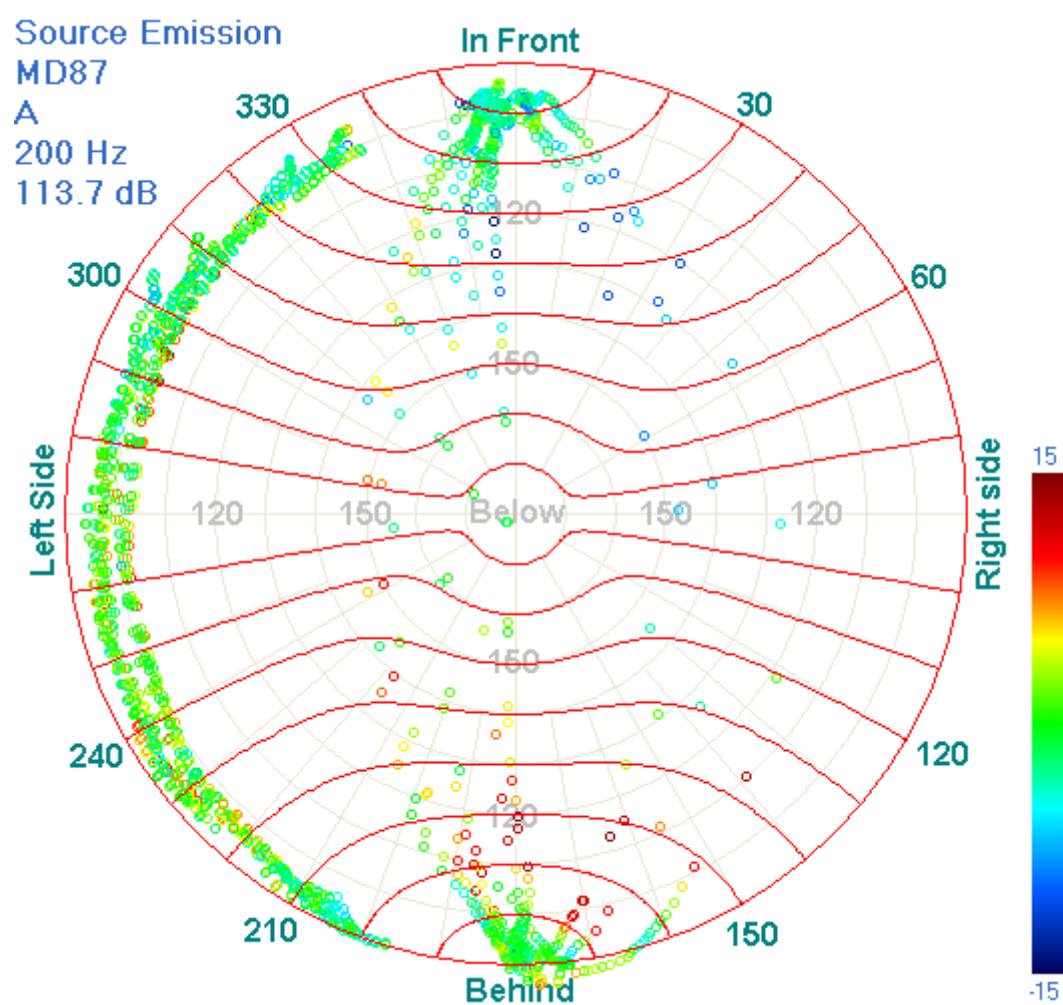


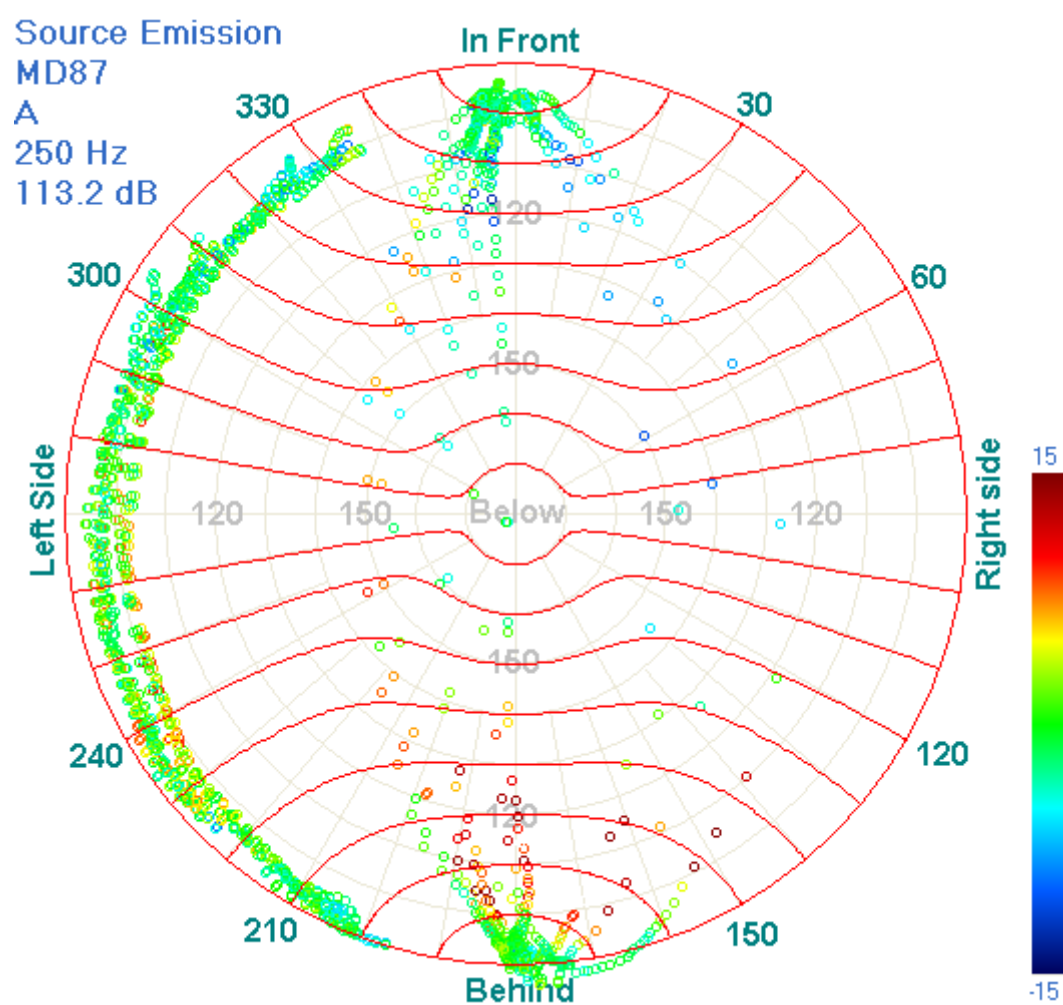




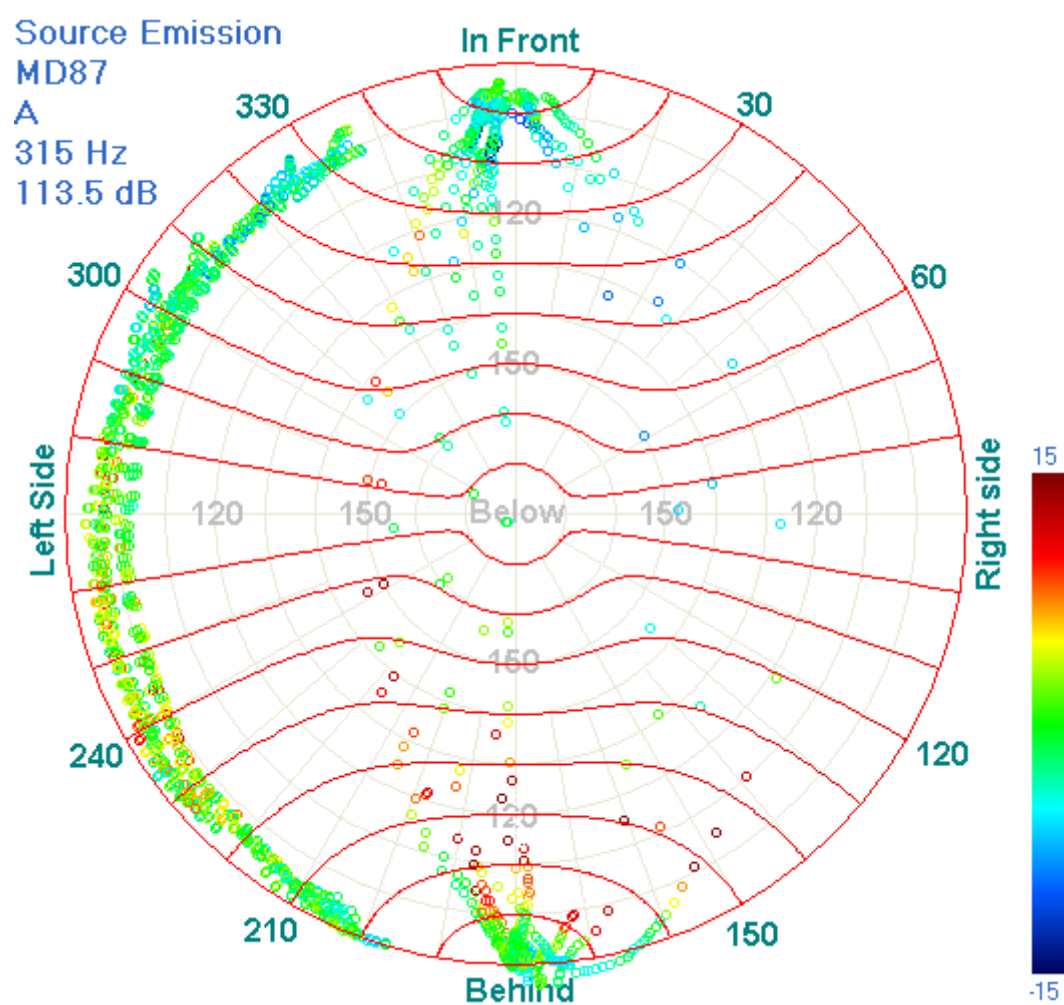


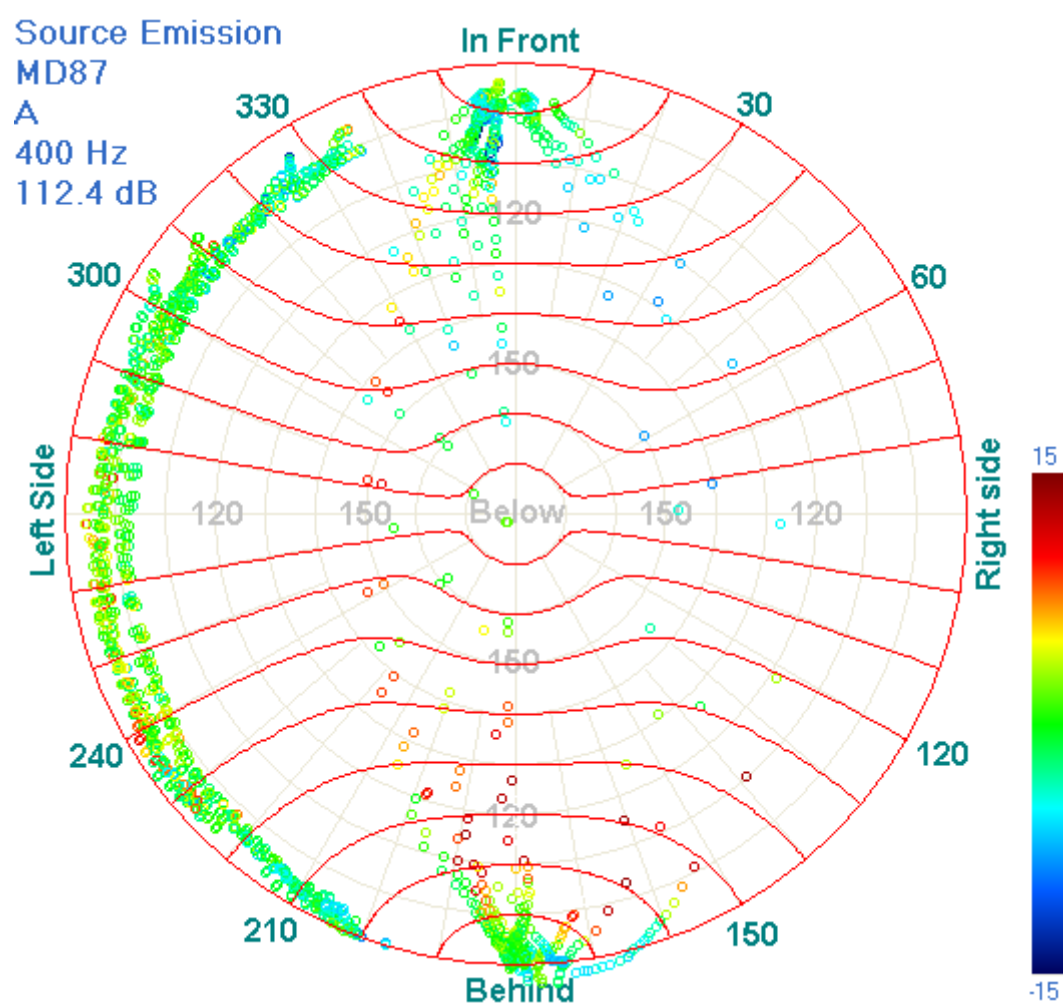


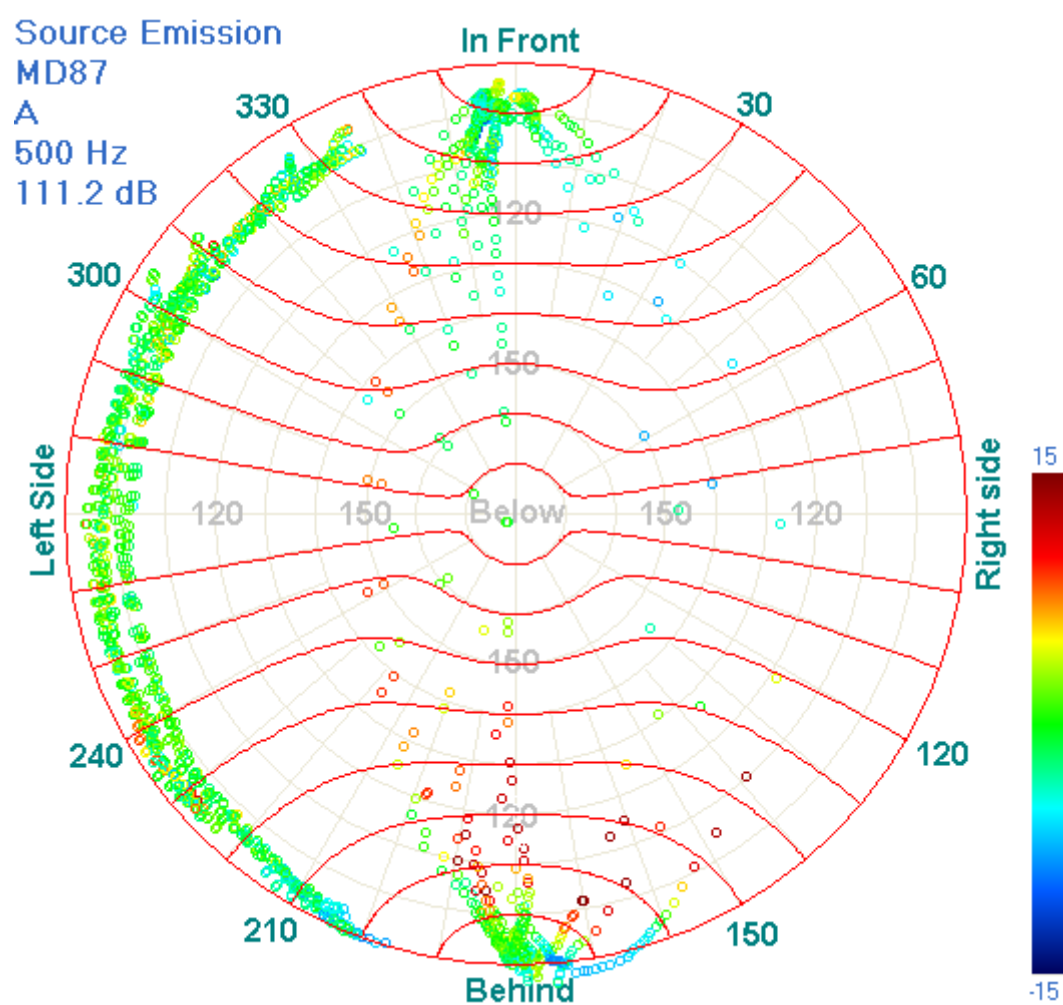


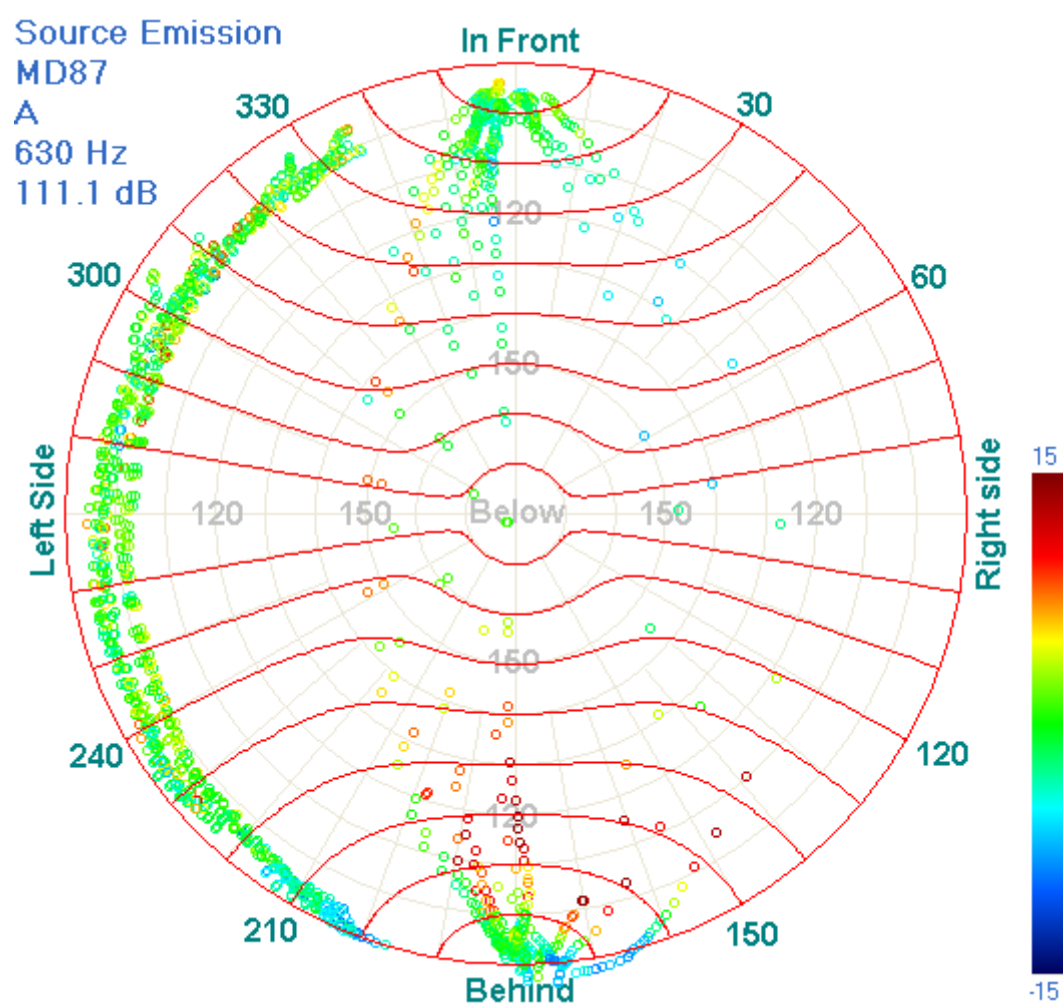


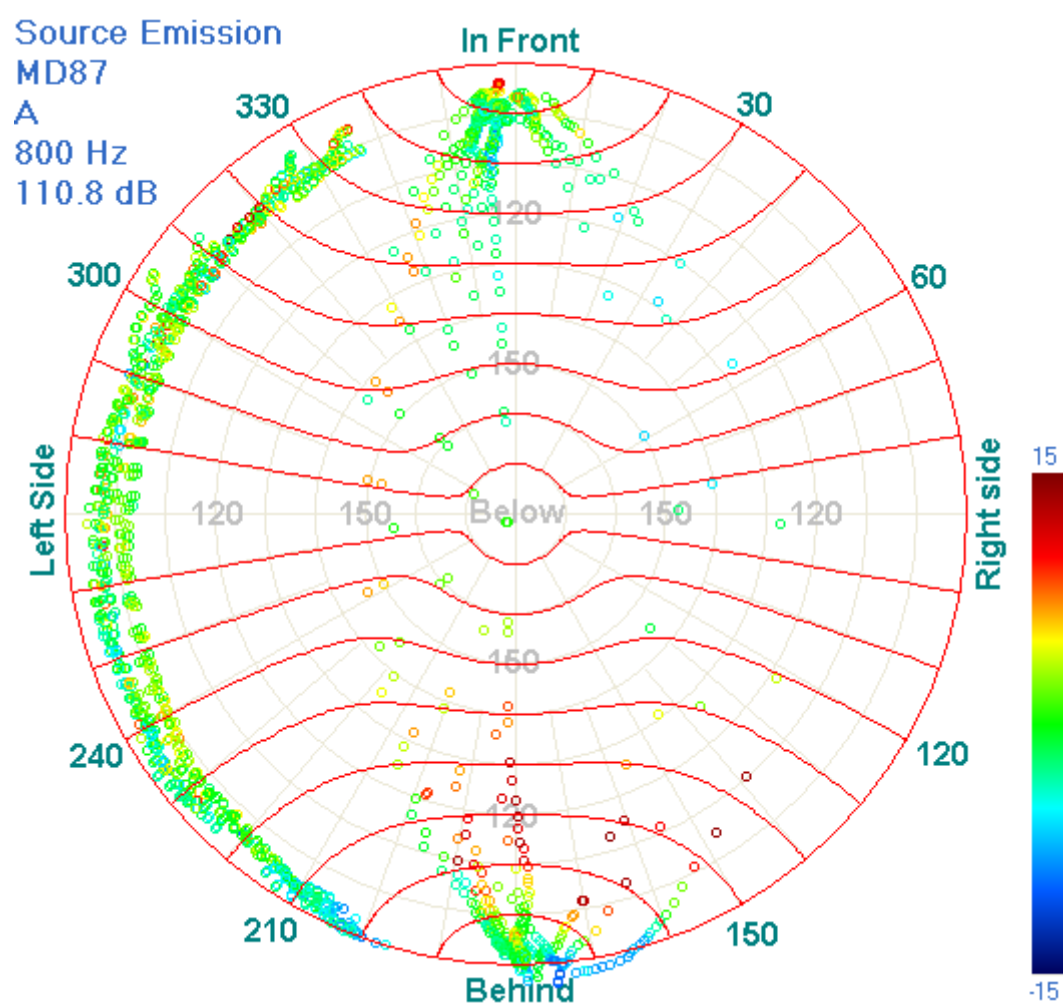


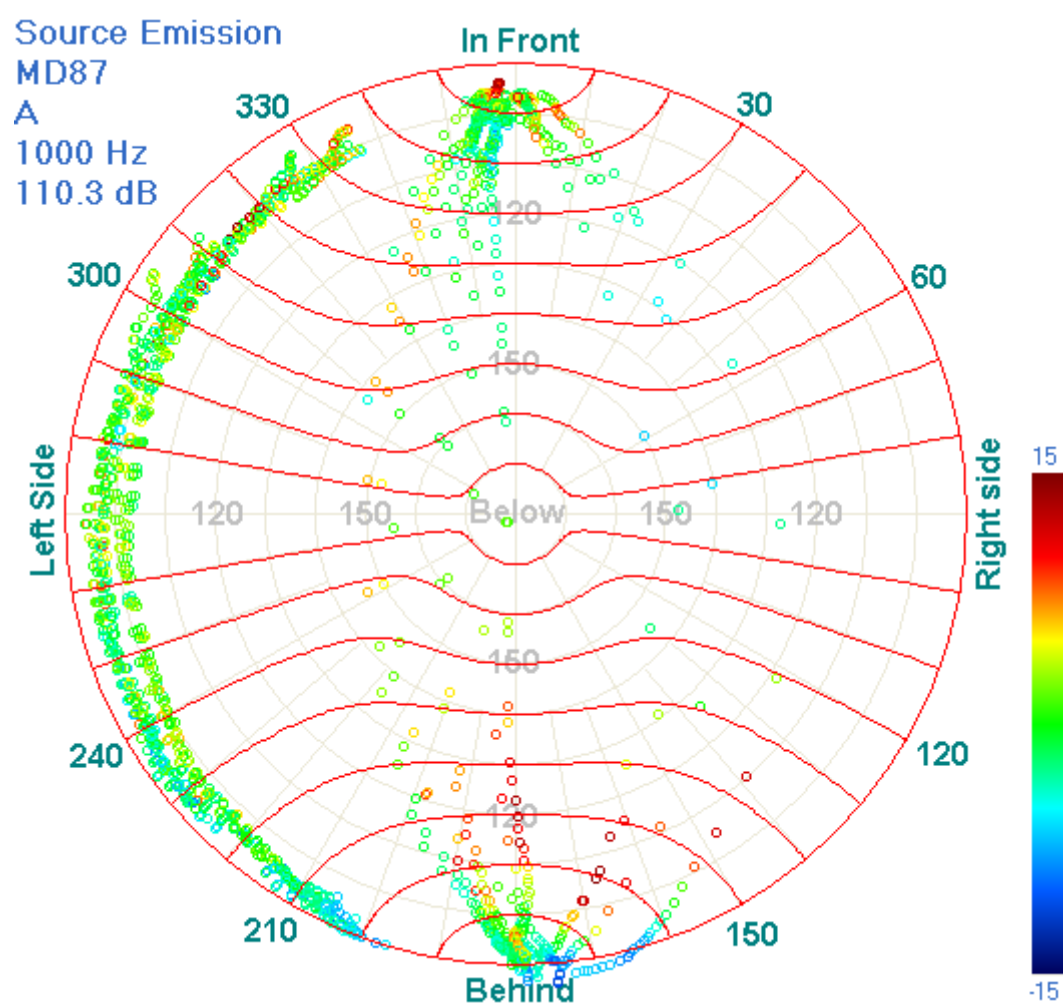


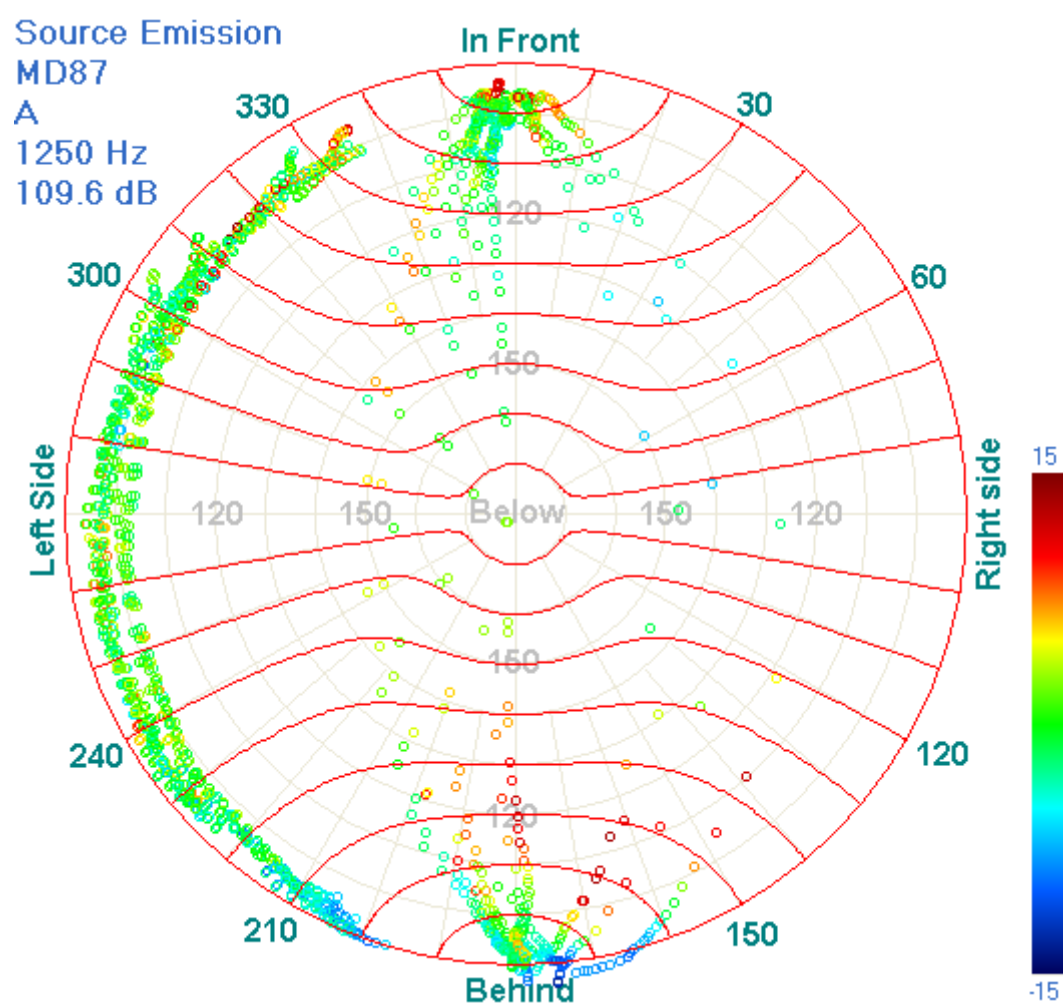


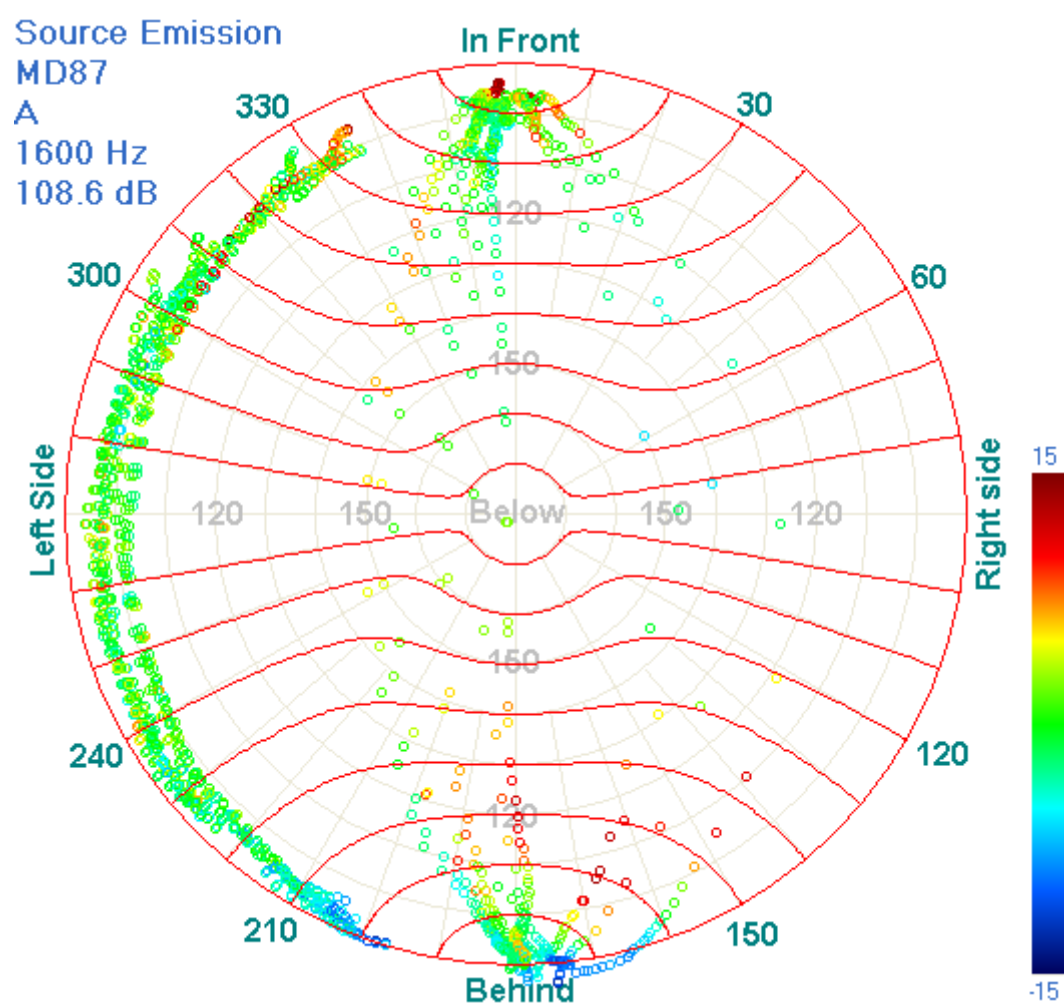




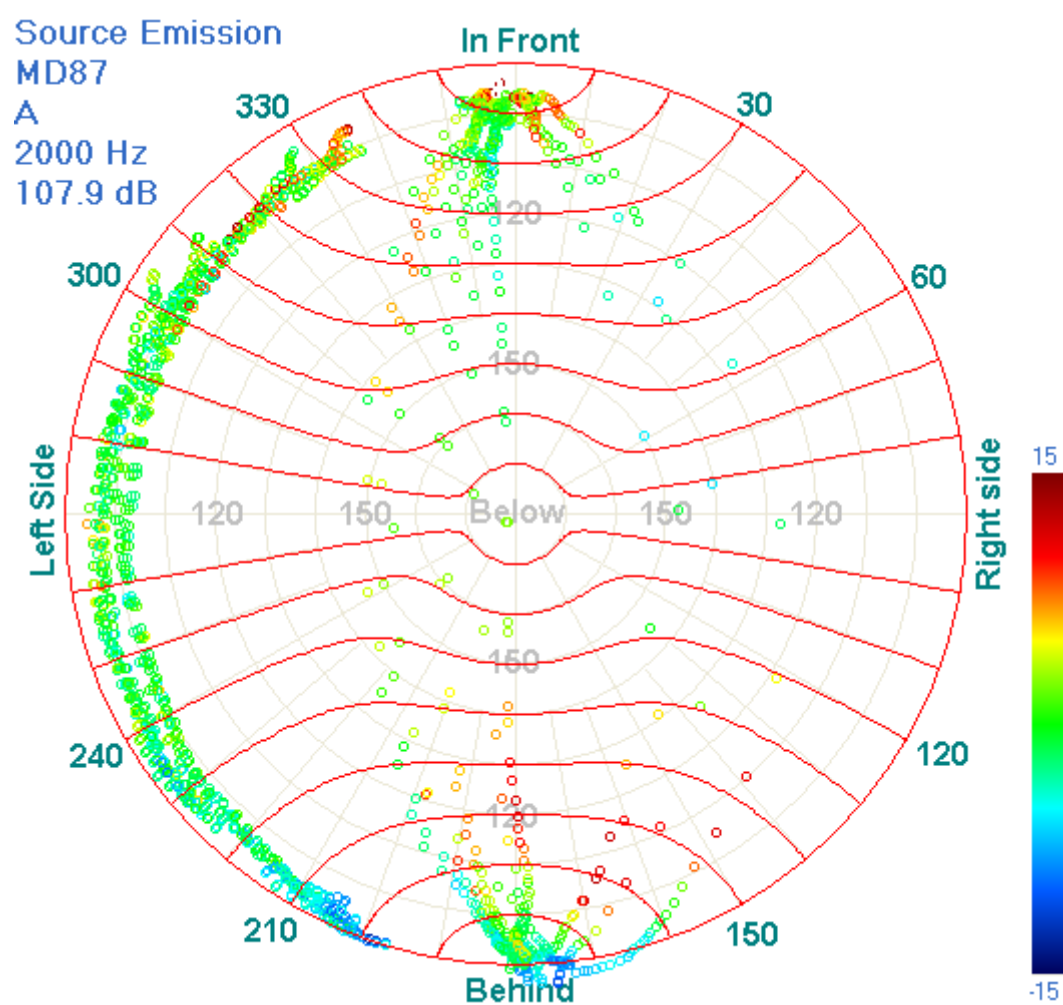


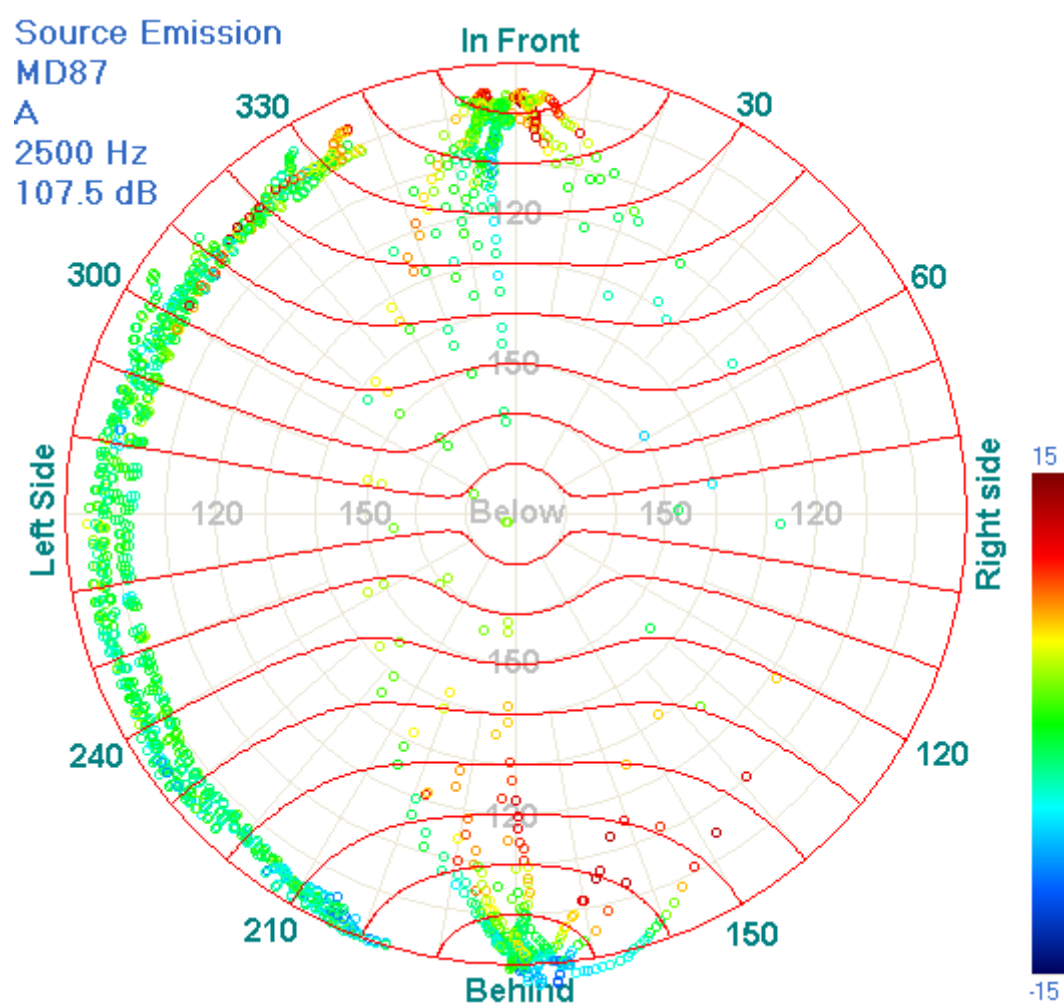


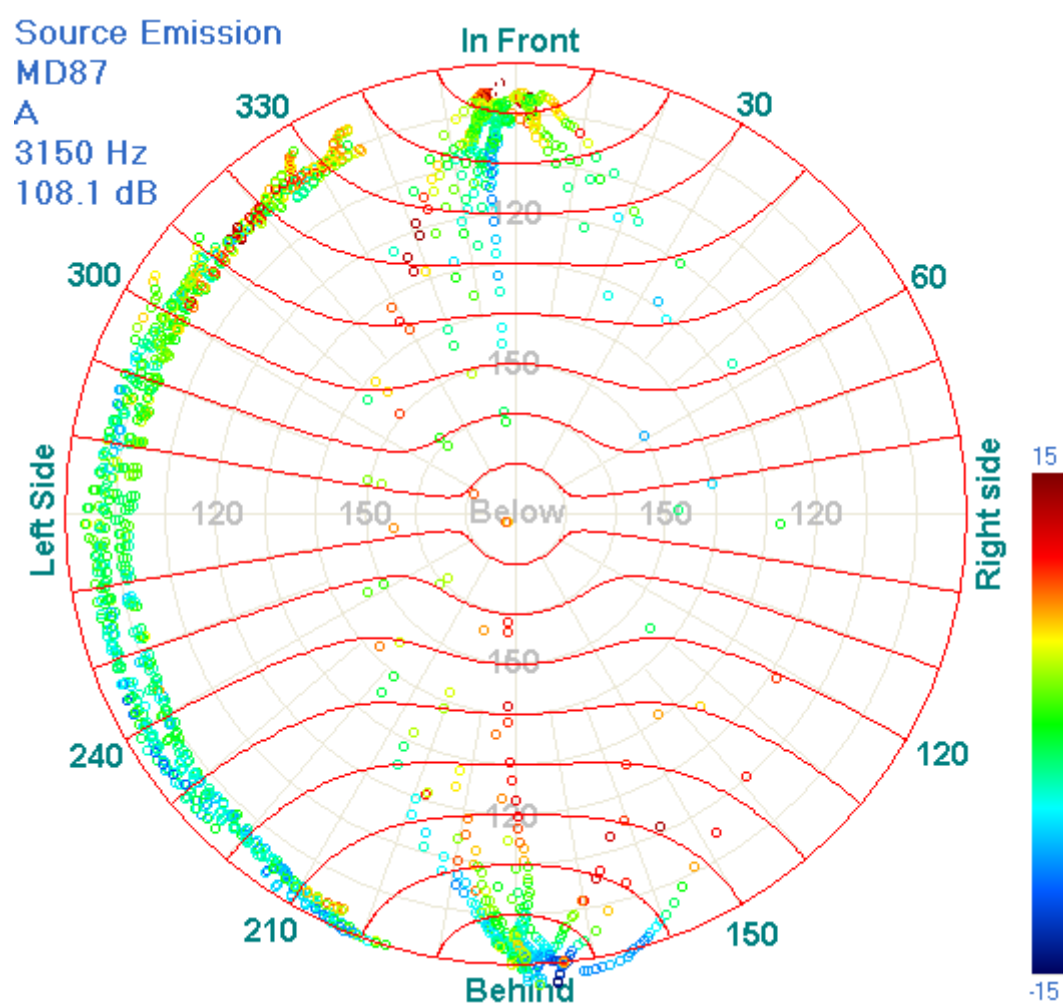


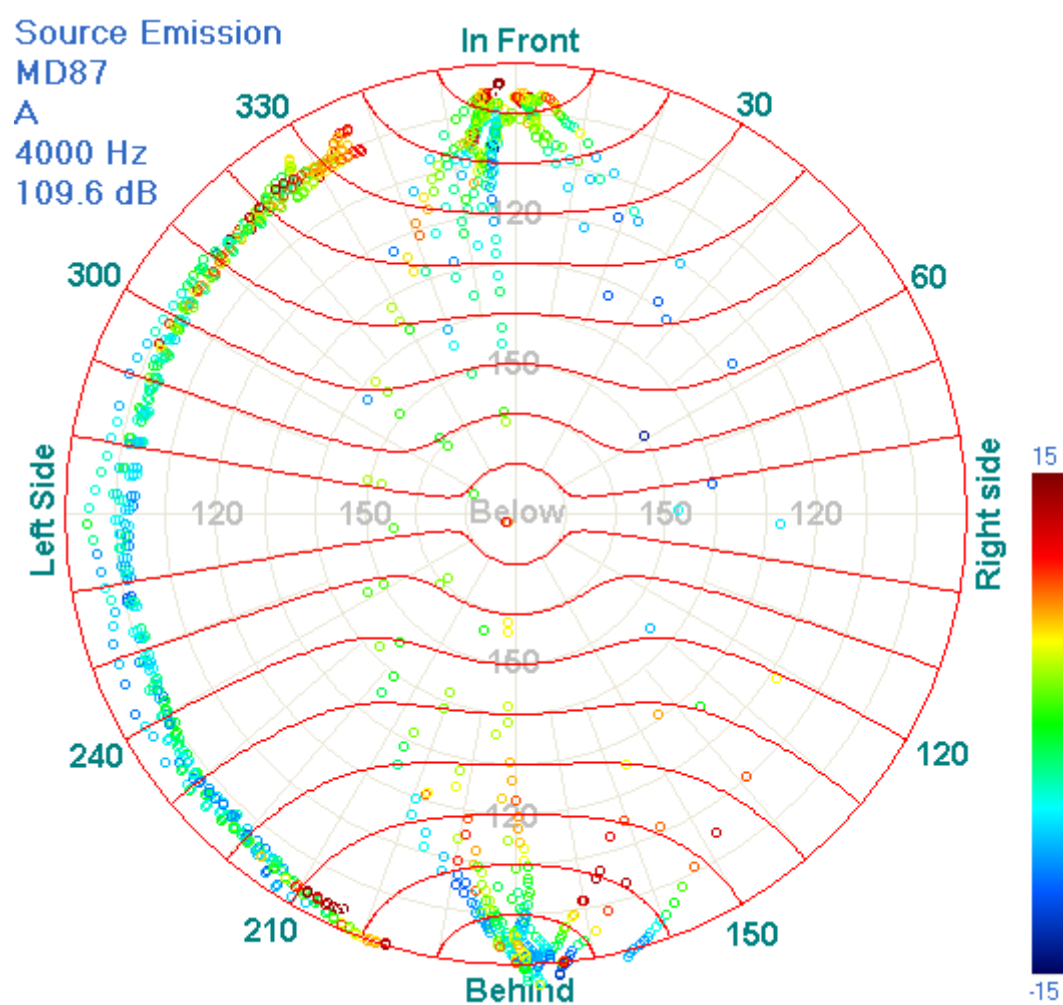


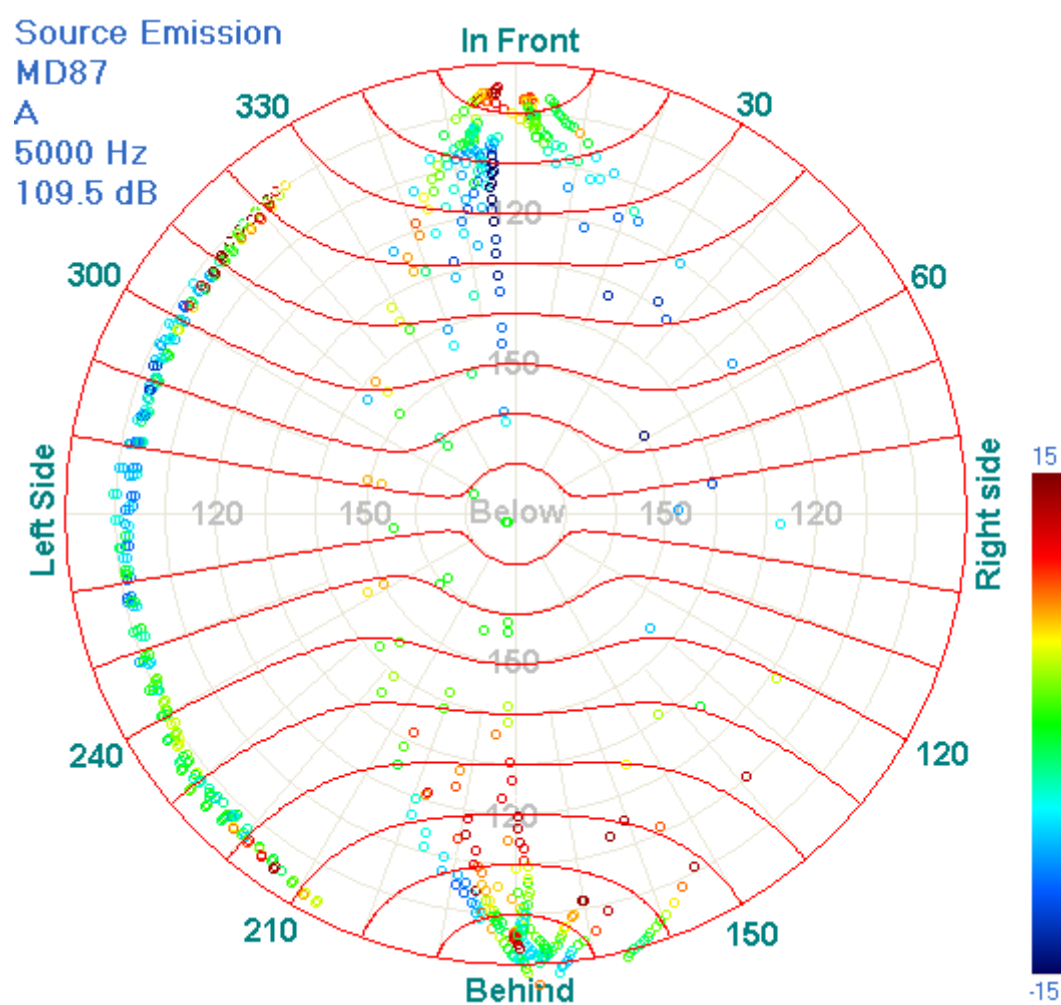


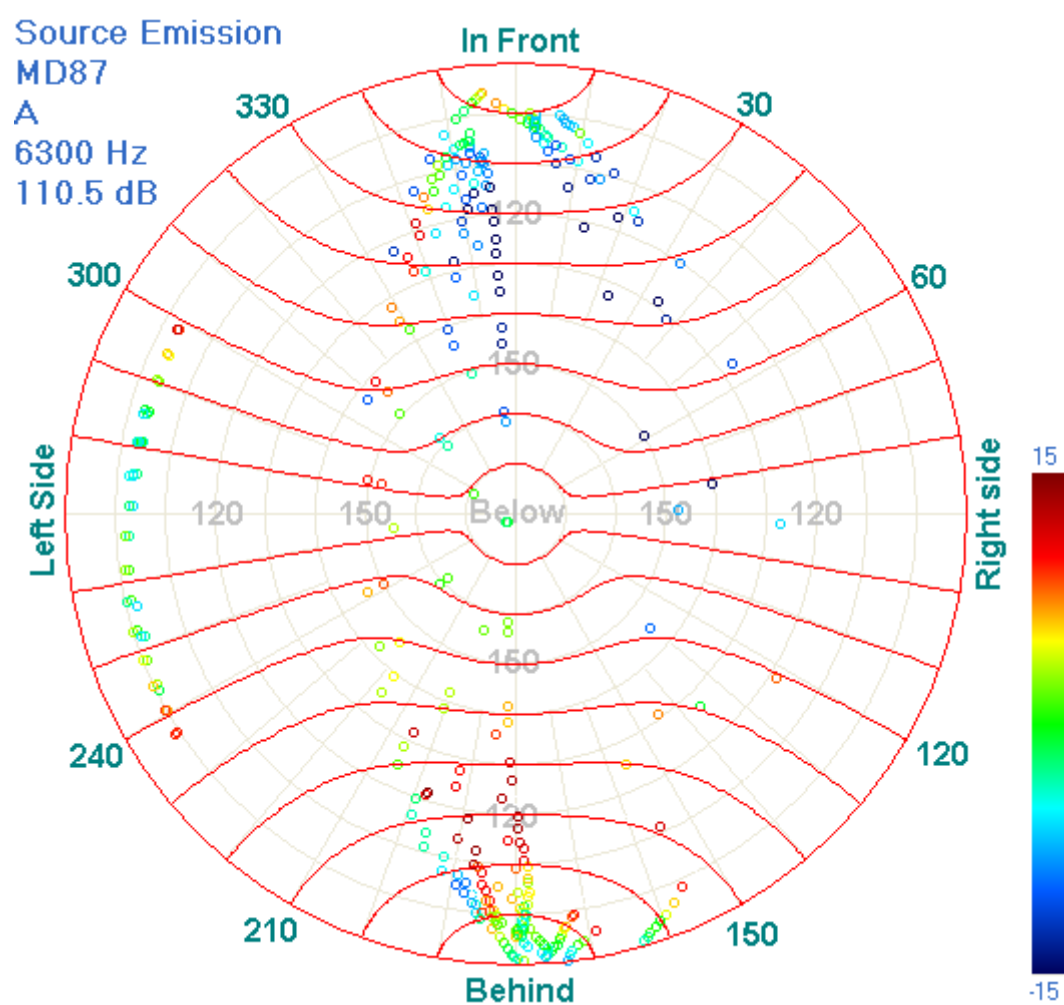


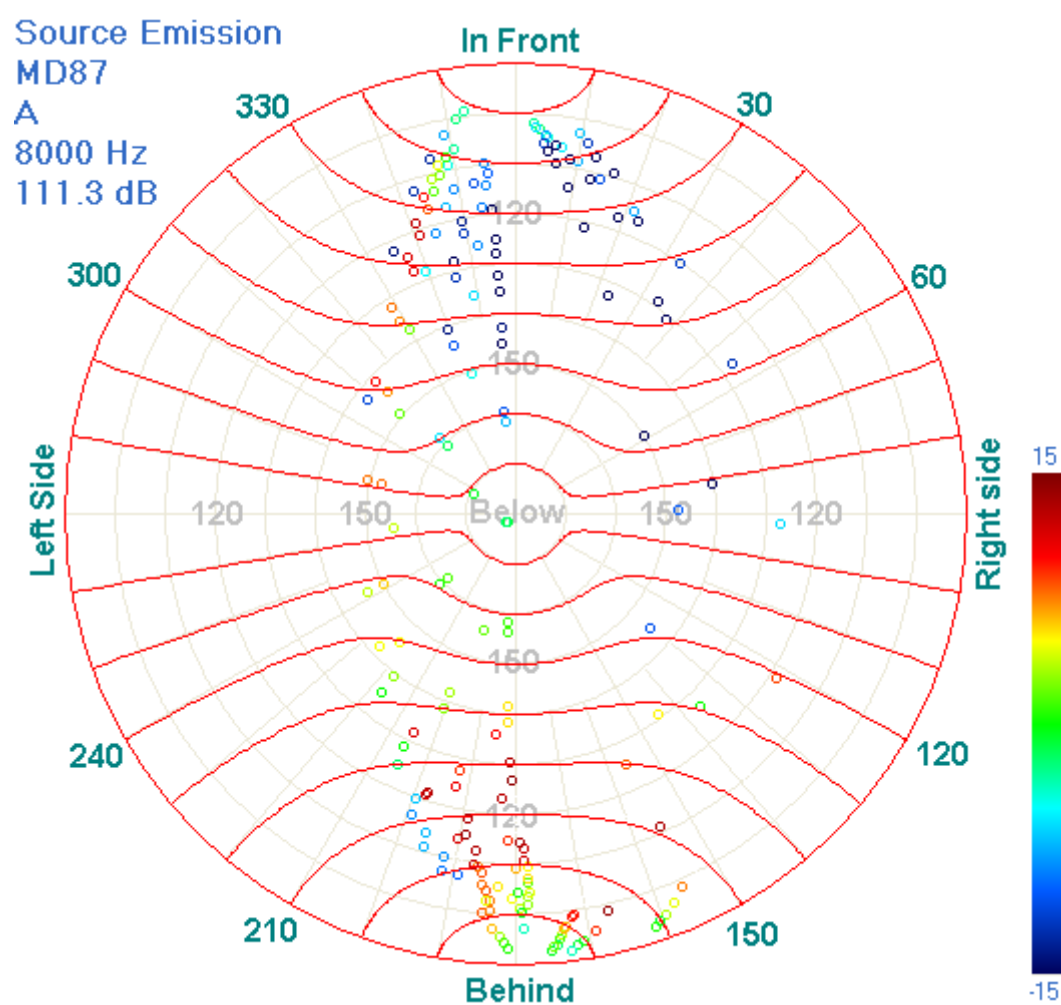


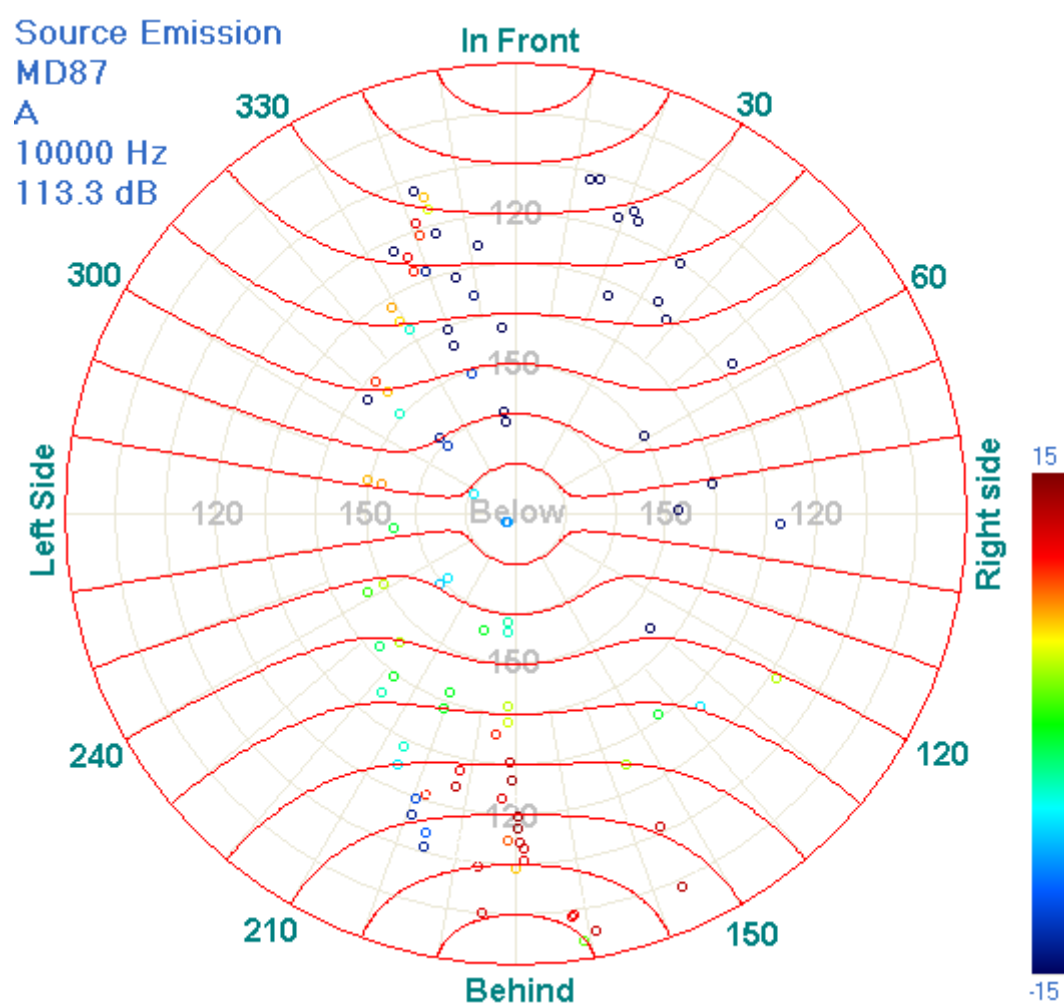










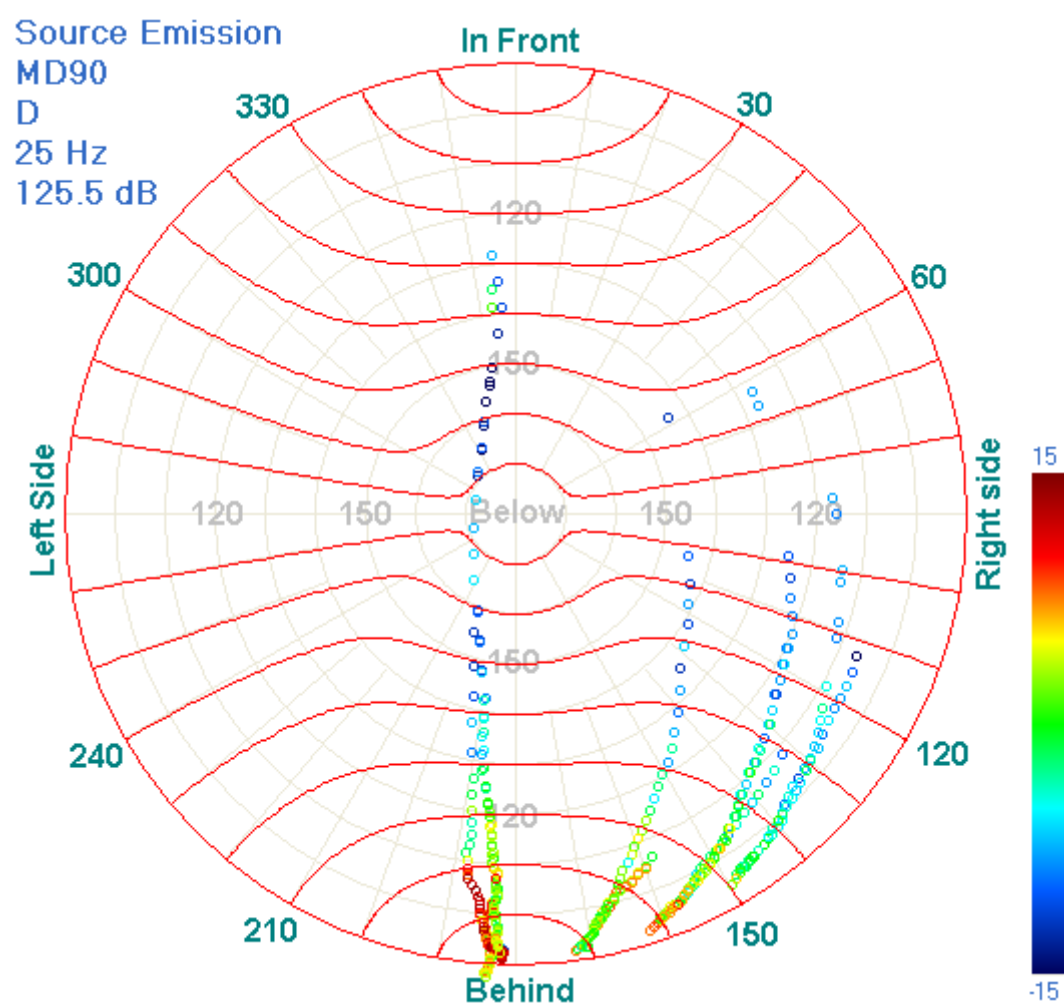


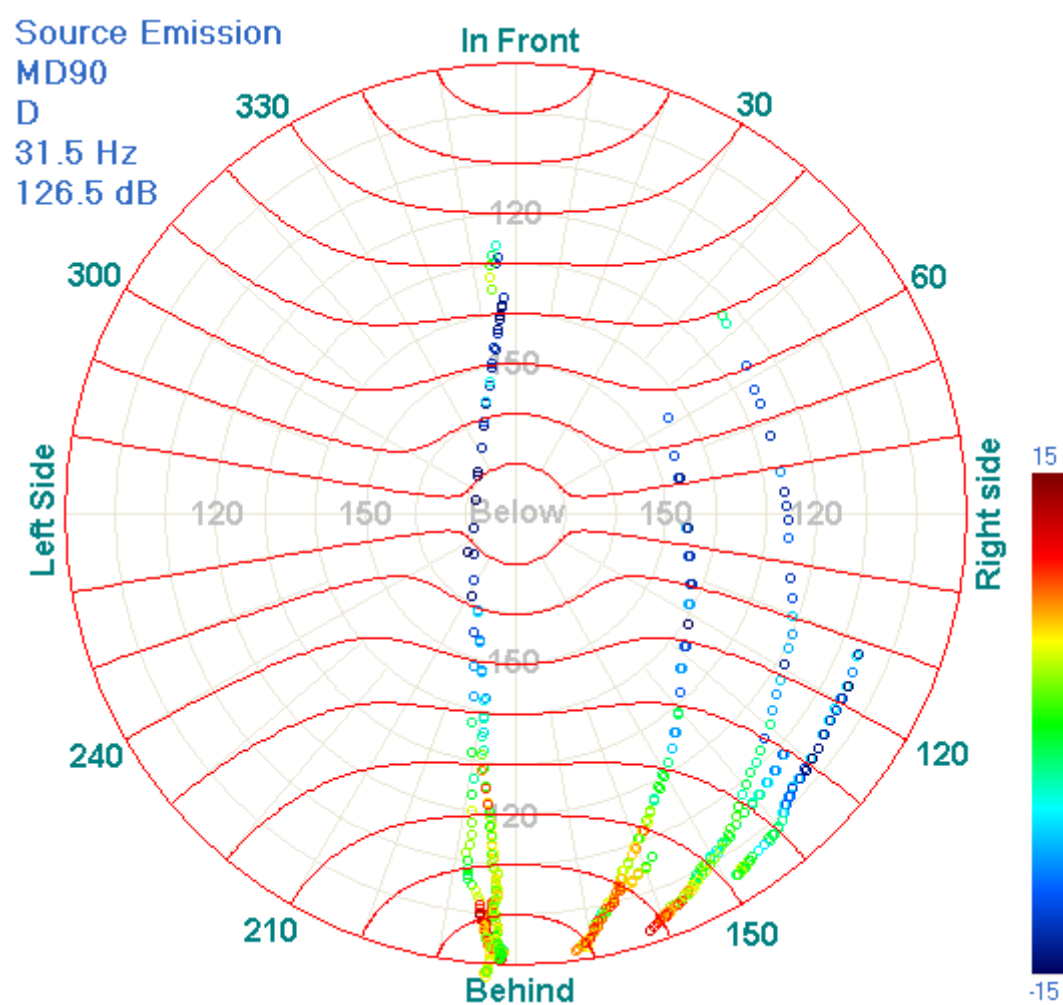


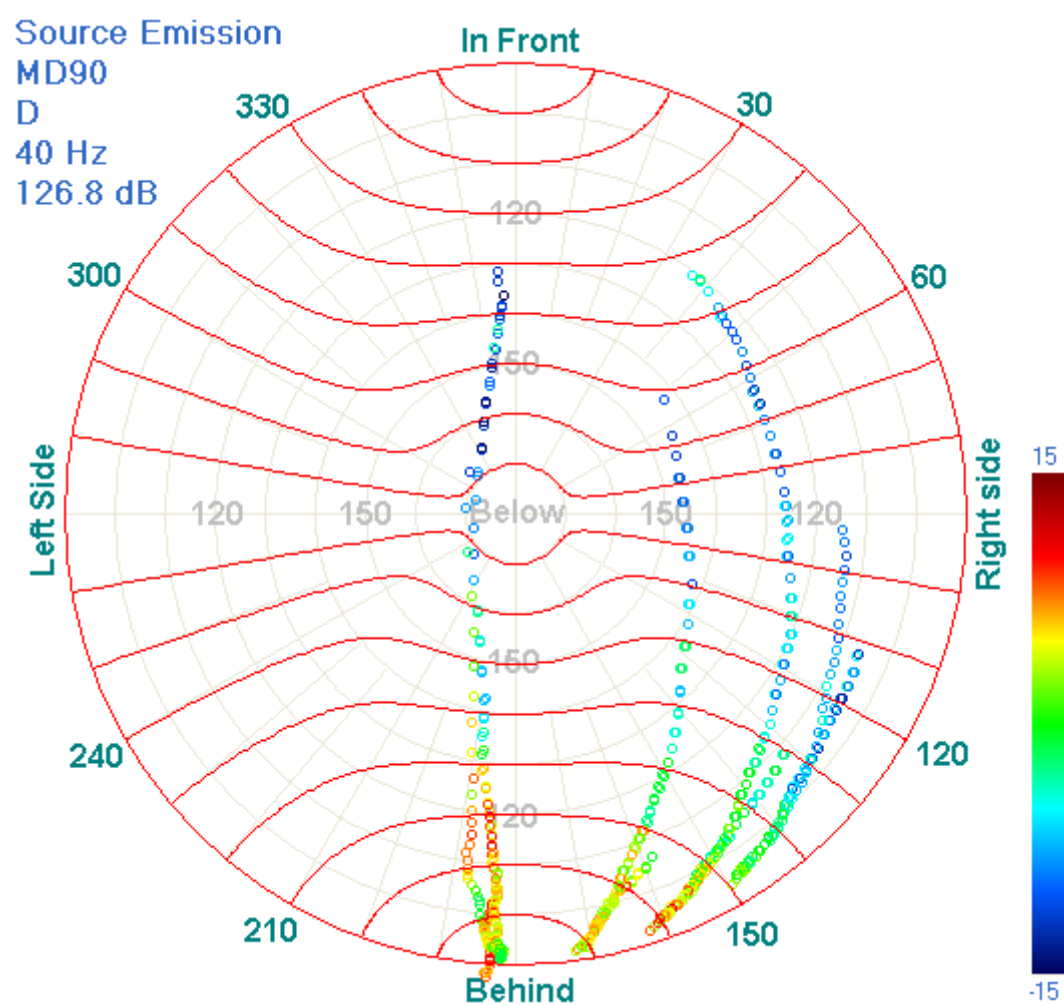
## 19 MD 90 directivity at departure

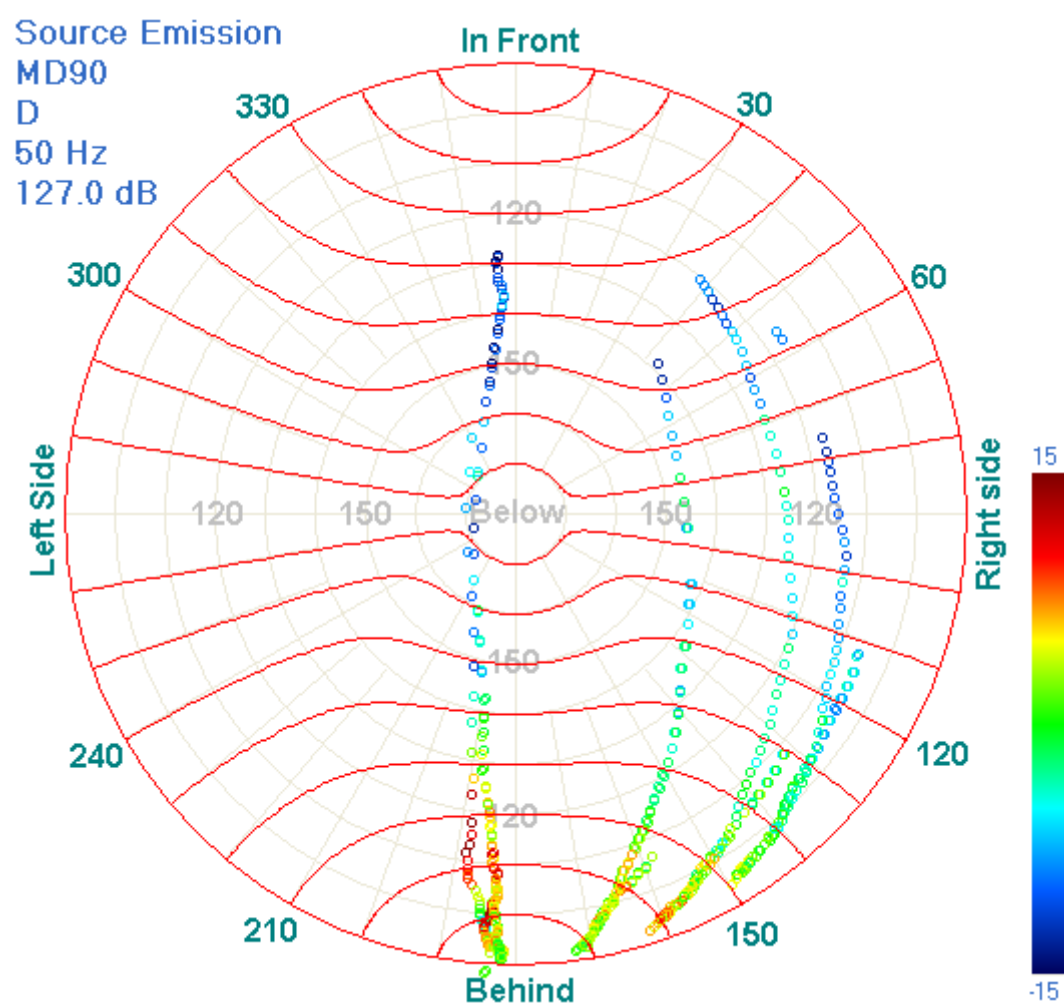
SPECTRUM  
Source Emission  
MD90  
D

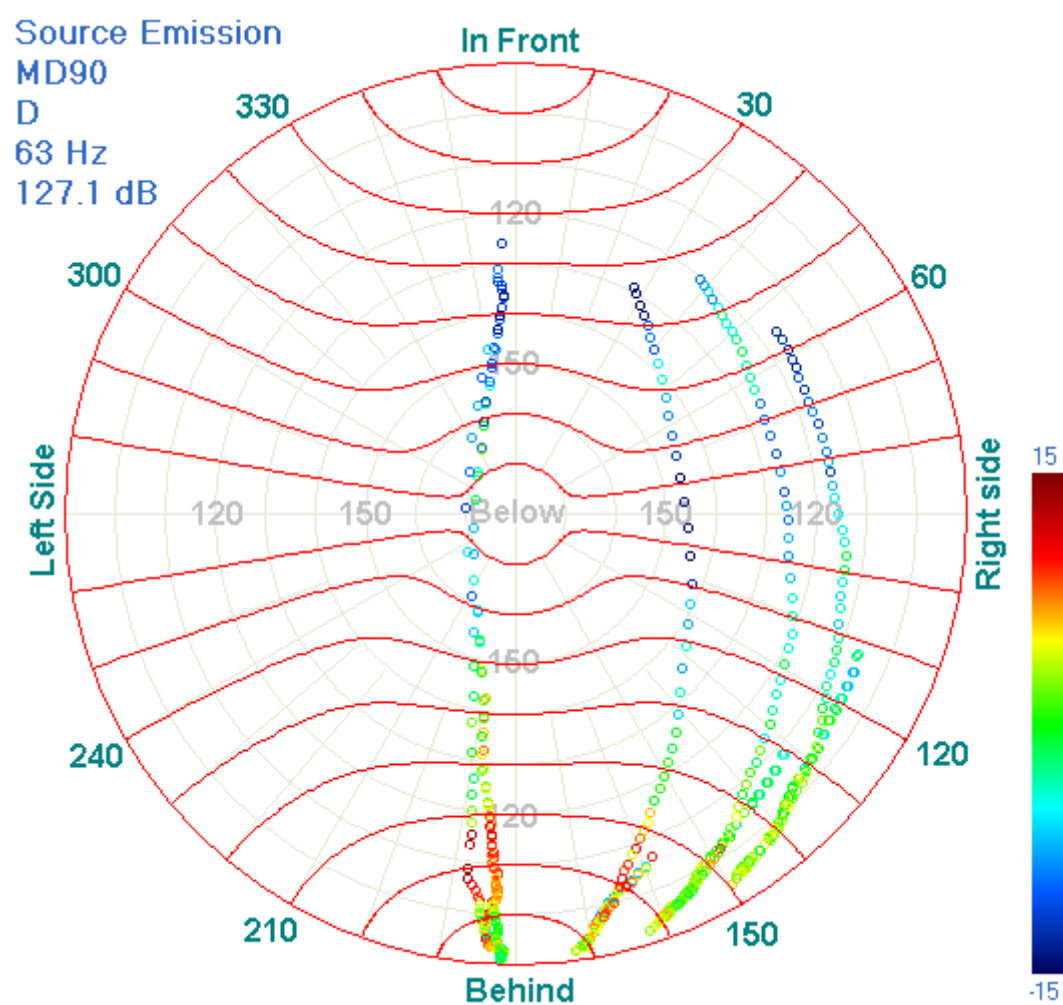
Freq	Num	Avg	Std	95%Avg	P1	P2	P3	P4	P5	P6
25	444	125.5	6.6	0.6	-1.0	-1.0	-1.0	-1.0	125.5	-1.0
31.5	504	126.5	6.9	0.6	-1.0	-1.0	-1.0	-1.0	126.5	-1.0
40	587	126.8	6.1	0.5	-1.0	-1.0	-1.0	-1.0	126.8	-1.0
50	559	127.0	5.8	0.5	-1.0	-1.0	-1.0	-1.0	127.0	-1.0
63	537	127.1	6.2	0.5	-1.0	-1.0	-1.0	-1.0	127.1	-1.0
80	673	126.5	6.0	0.4	-1.0	-1.0	-1.0	-1.0	126.5	-1.0
100	692	126.0	5.7	0.4	-1.0	-1.0	-1.0	-1.0	126.0	-1.0
125	746	125.5	5.5	0.4	-1.0	-1.0	-1.0	-1.0	125.5	-1.0
160	736	123.9	5.0	0.4	-1.0	-1.0	-1.0	-1.0	123.9	-1.0
200	738	123.9	5.5	0.4	-1.0	-1.0	-1.0	-1.0	123.9	-1.0
250	741	123.9	5.4	0.4	-1.0	-1.0	-1.0	-1.0	123.9	-1.0
315	737	122.1	5.1	0.4	-1.0	-1.0	-1.0	-1.0	122.1	-1.0
400	733	120.5	5.2	0.4	-1.0	-1.0	-1.0	-1.0	120.5	-1.0
500	721	119.6	5.0	0.4	-1.0	-1.0	-1.0	-1.0	119.6	-1.0
630	713	119.0	5.1	0.4	-1.0	-1.0	-1.0	-1.0	119.0	-1.0
800	720	118.4	5.1	0.4	-1.0	-1.0	-1.0	-1.0	118.4	-1.0
1000	723	117.8	5.2	0.4	-1.0	-1.0	-1.0	-1.0	117.8	-1.0
1250	736	117.5	5.4	0.4	-1.0	-1.0	-1.0	-1.0	117.5	-1.0
1600	739	117.6	5.4	0.4	-1.0	-1.0	-1.0	-1.0	117.6	-1.0
2000	721	118.6	5.6	0.4	-1.0	-1.0	-1.0	-1.0	118.6	-1.0
2500	634	119.9	5.3	0.4	-1.0	-1.0	-1.0	-1.0	119.9	-1.0
3150	486	122.0	4.7	0.4	-1.0	-1.0	-1.0	-1.0	122.0	-1.0
4000	250	125.5	3.0	0.4	-1.0	-1.0	-1.0	-1.0	125.5	-1.0
5000	104	127.0	2.8	0.5	-1.0	-1.0	-1.0	-1.0	127.0	-1.0
6300	18	133.0	4.3	2.0	-1.0	-1.0	-1.0	-1.0	133.0	-1.0
8000	0	999.0	999.0	999.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
10000	0	999.0	999.0	999.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0

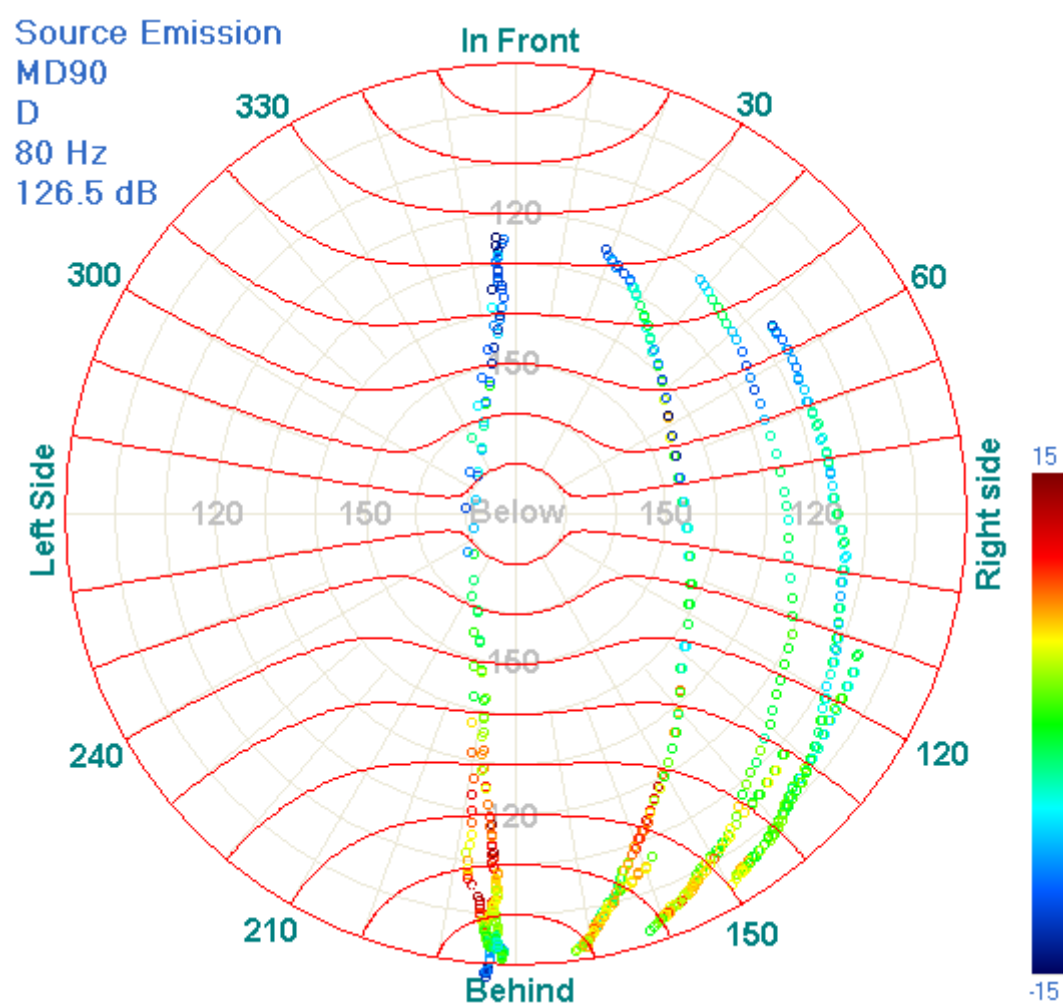


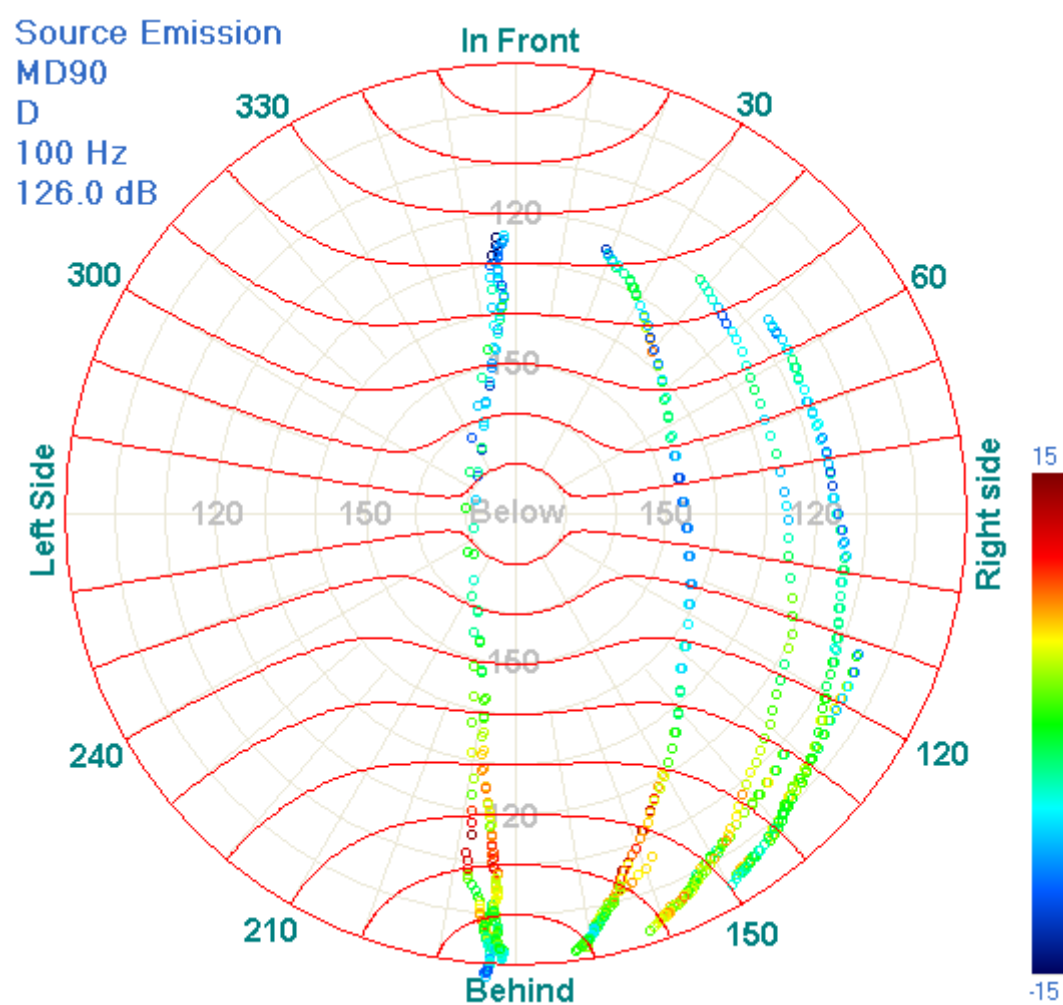




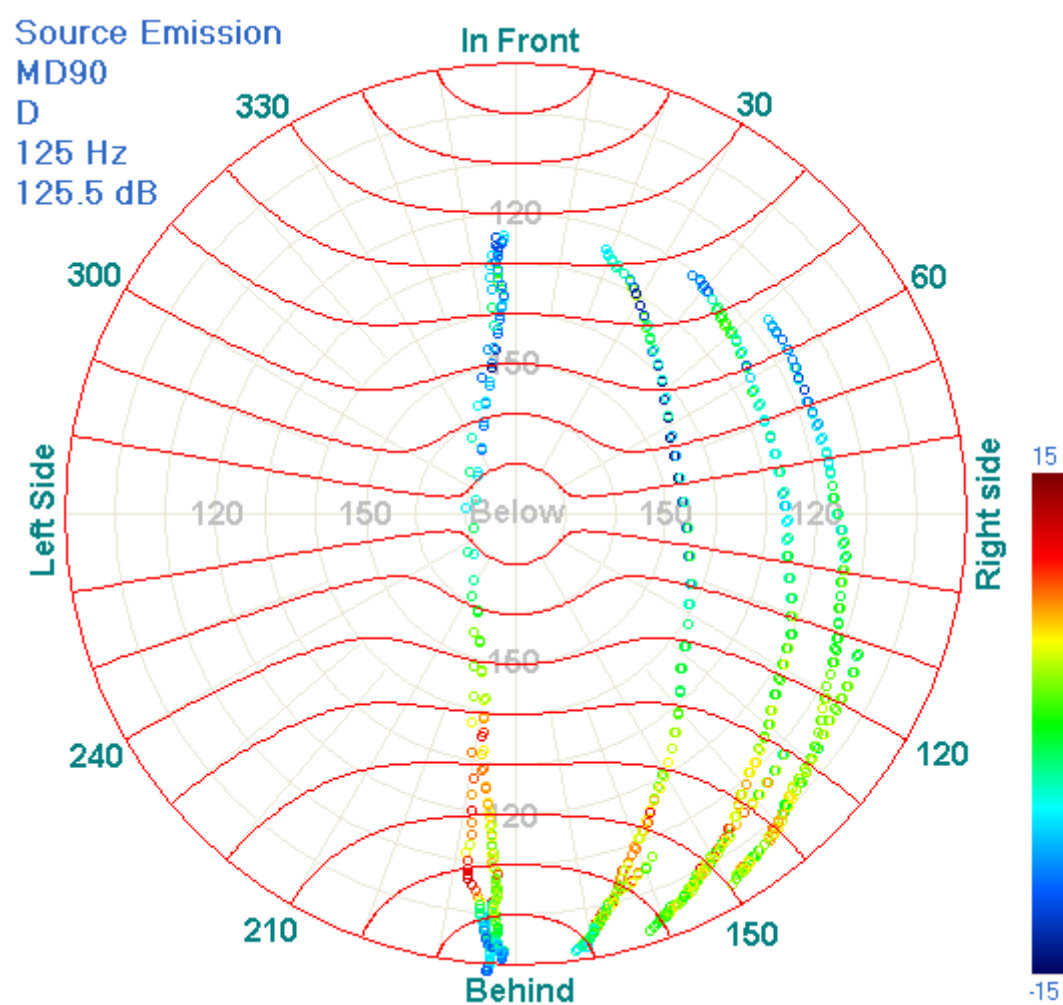


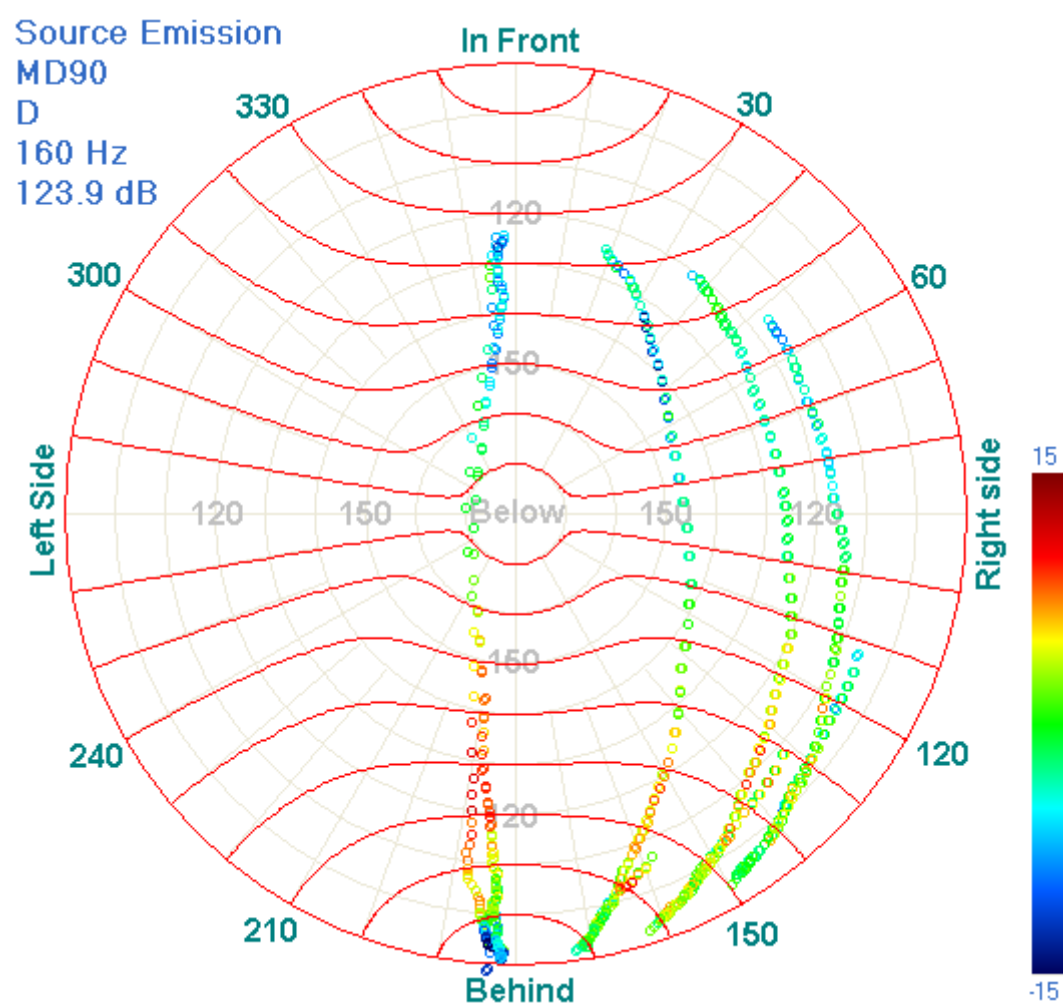


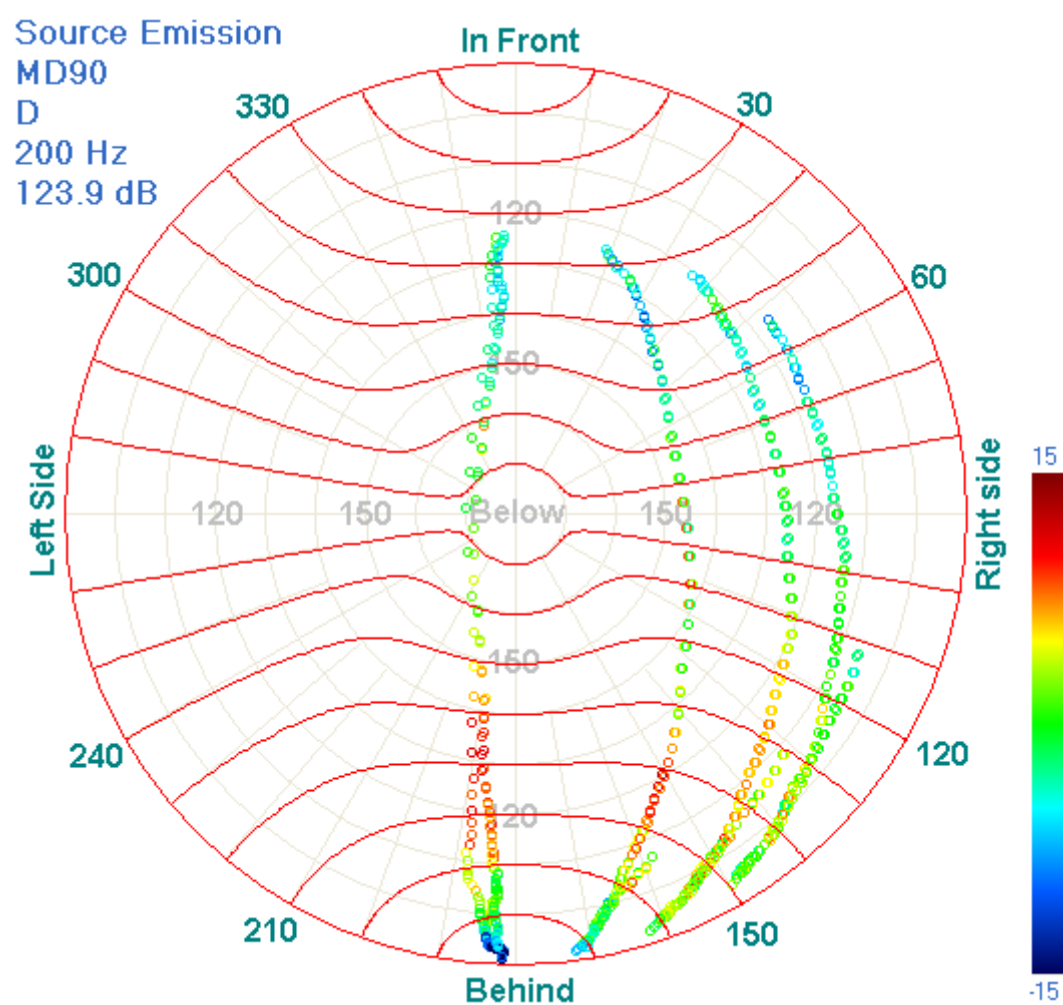


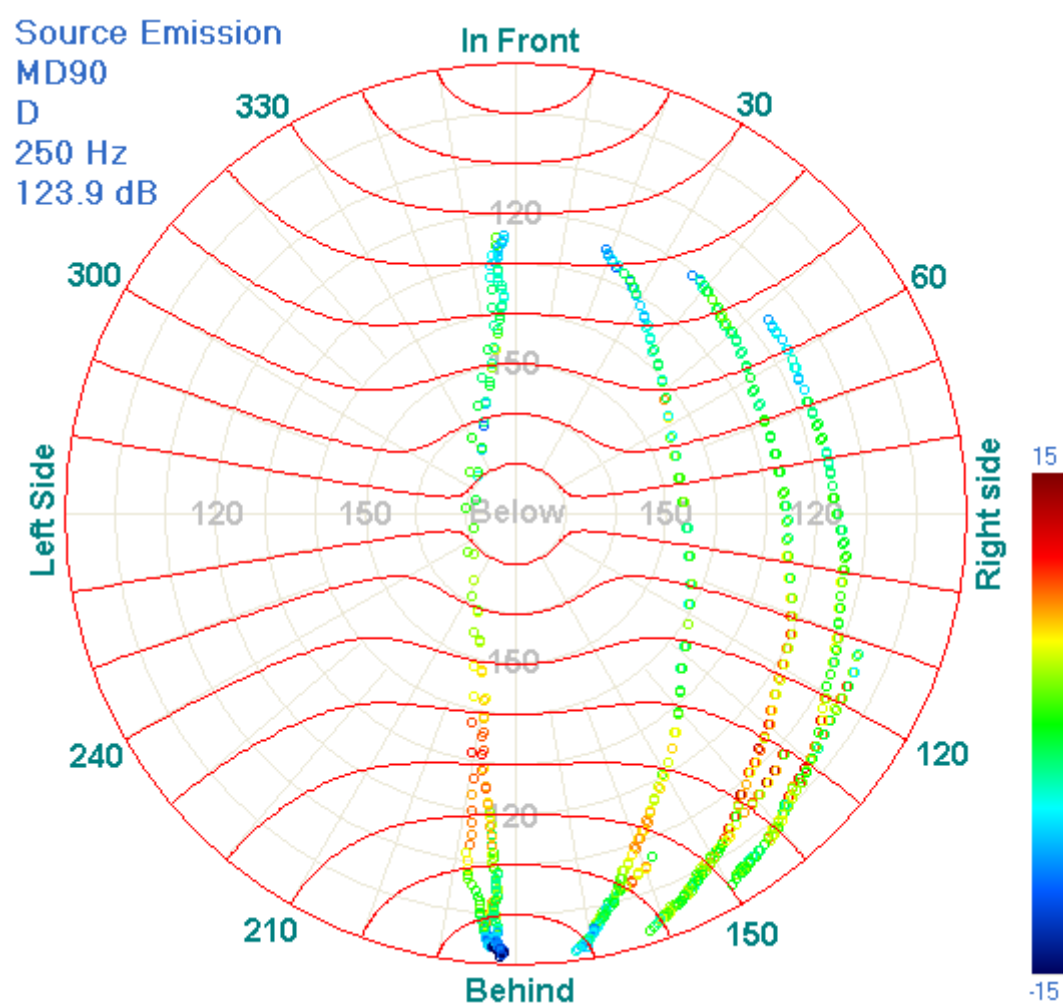


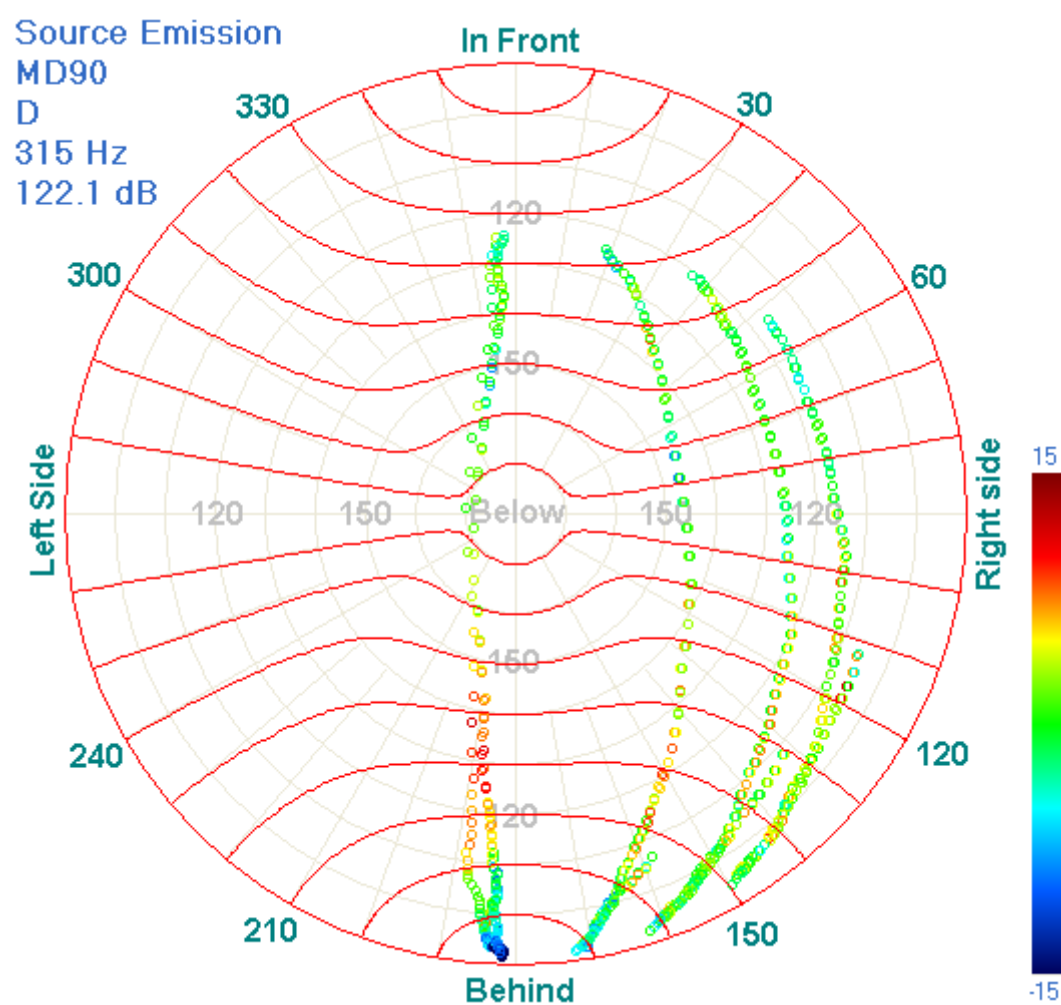


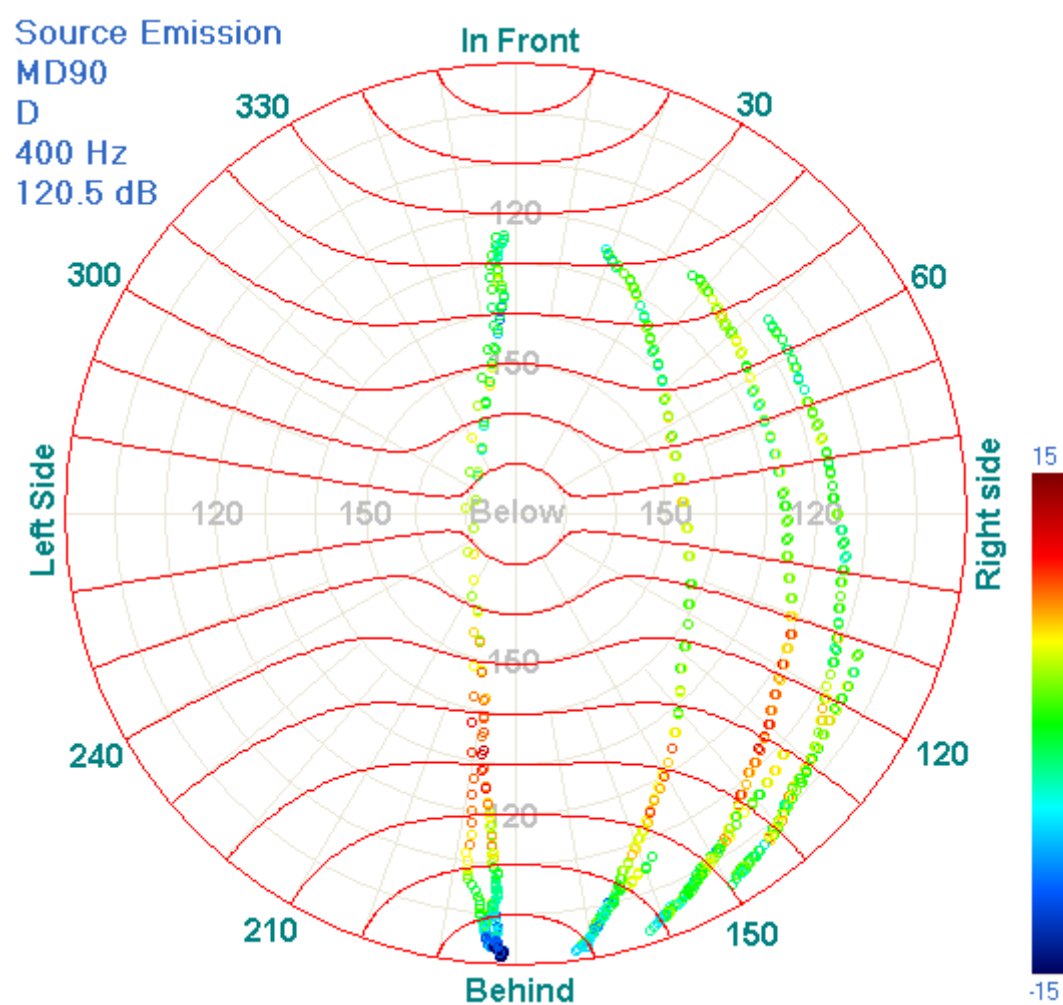


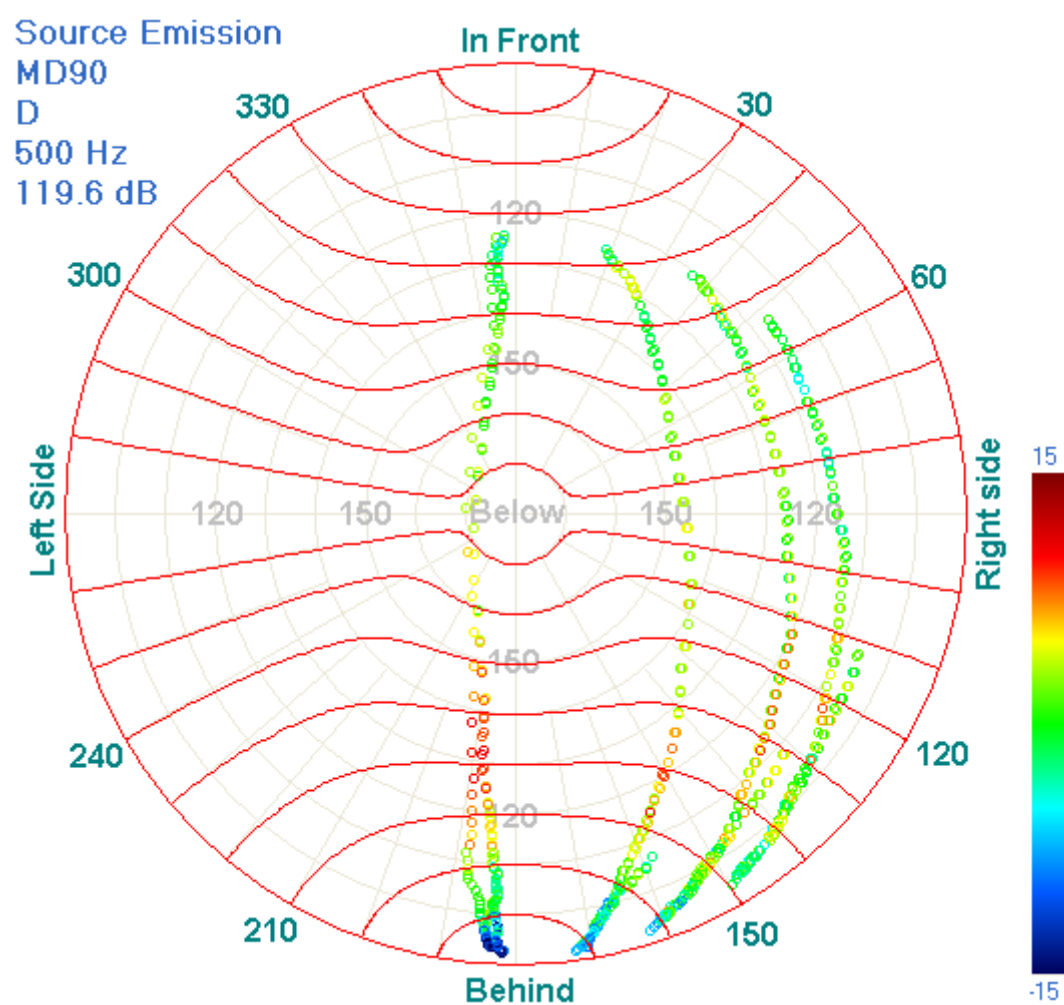


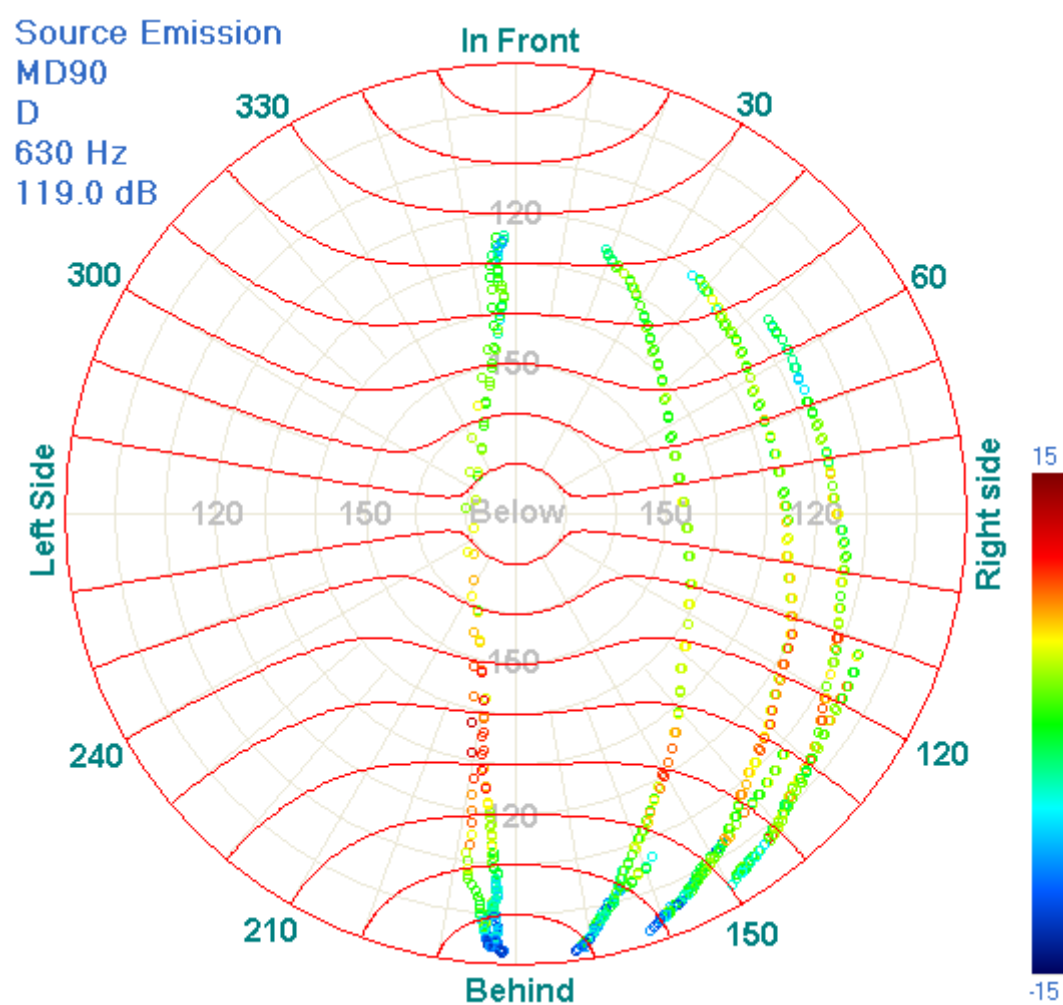




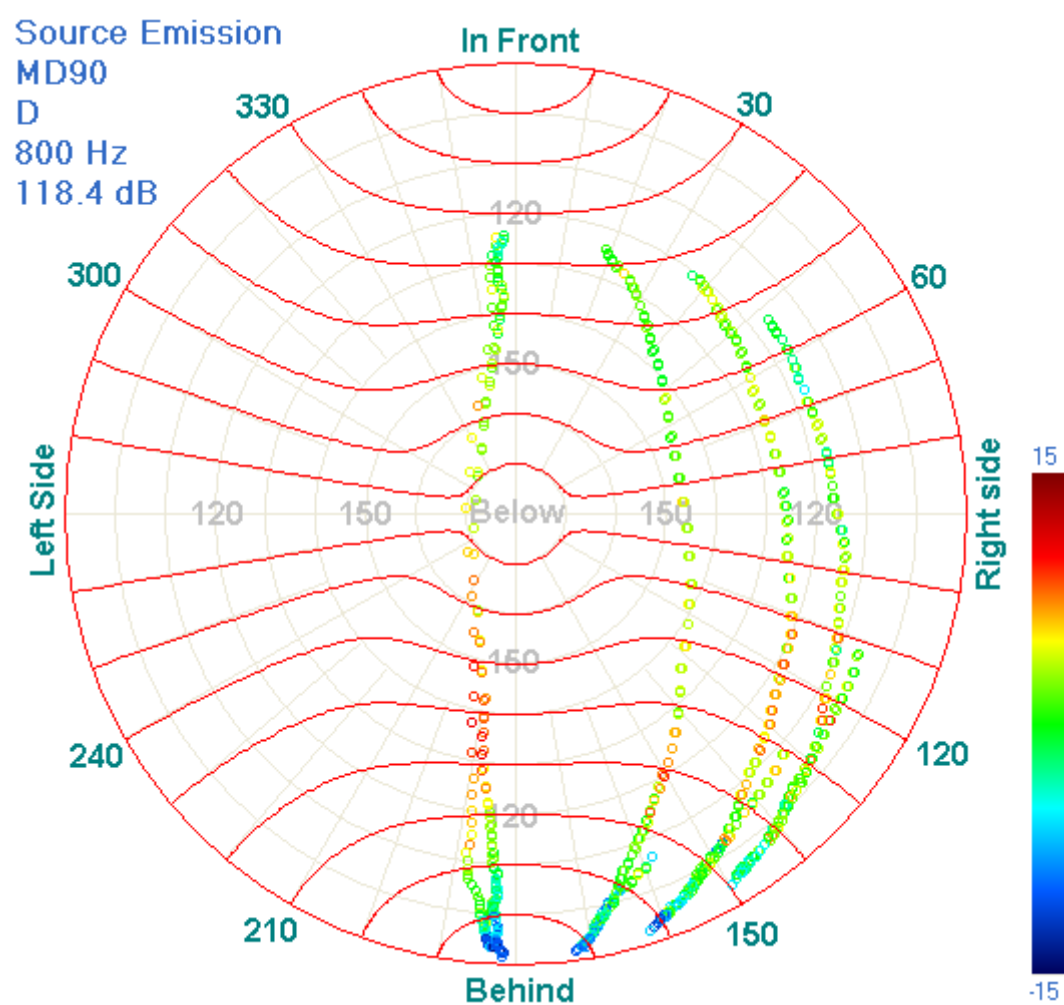


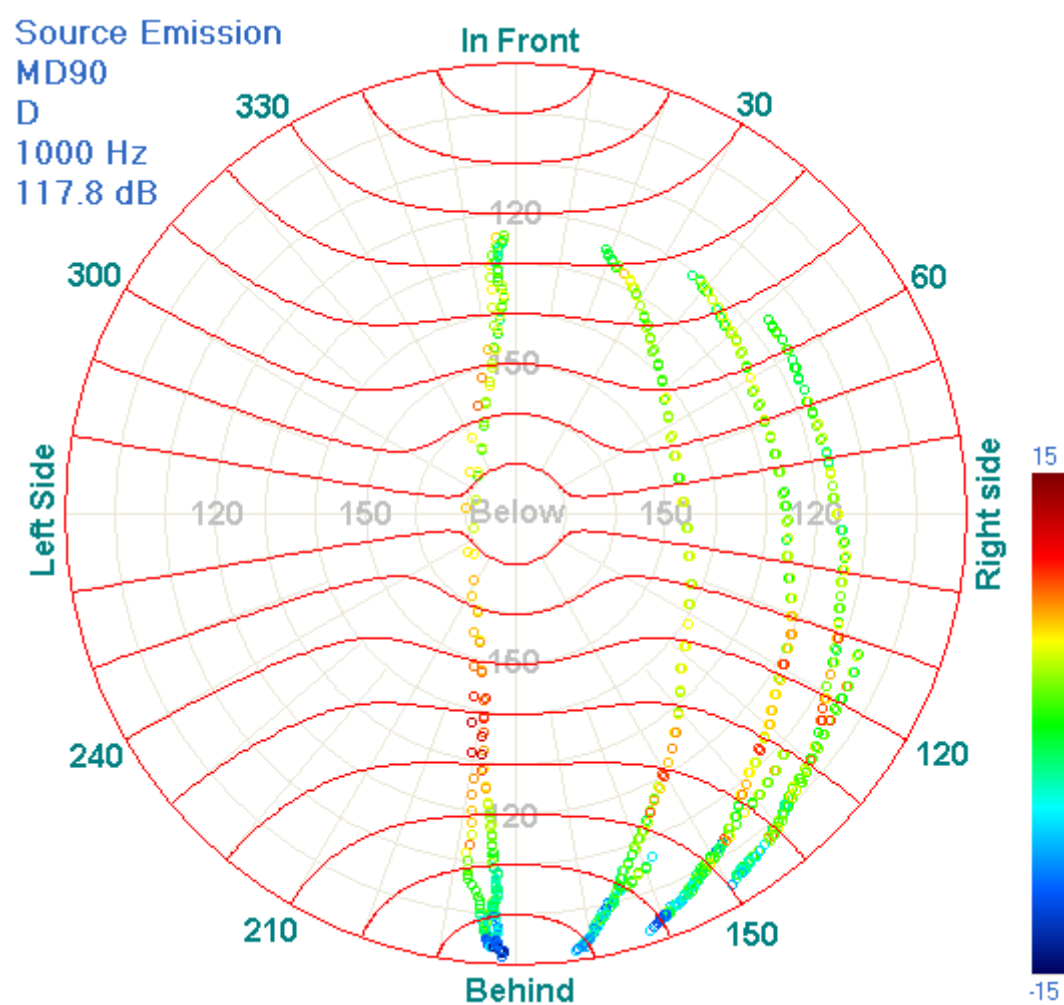


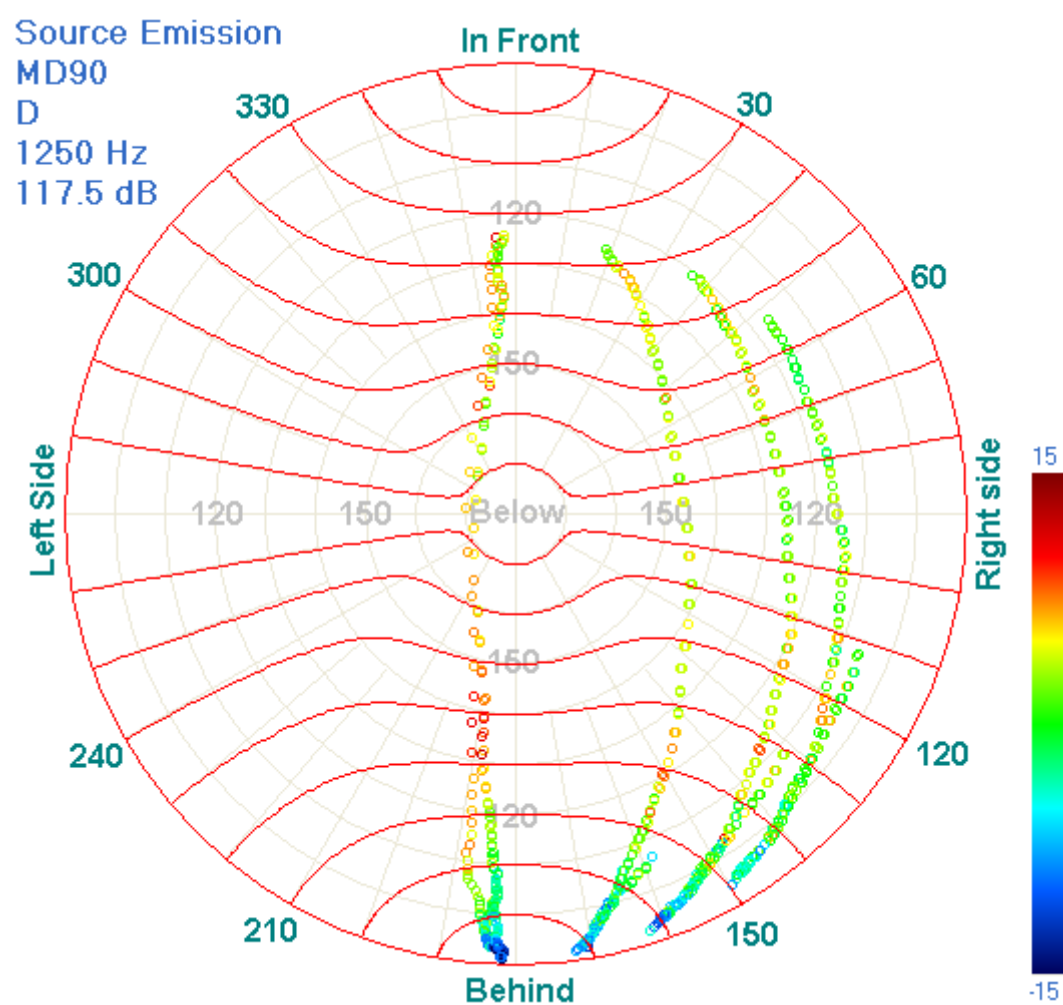


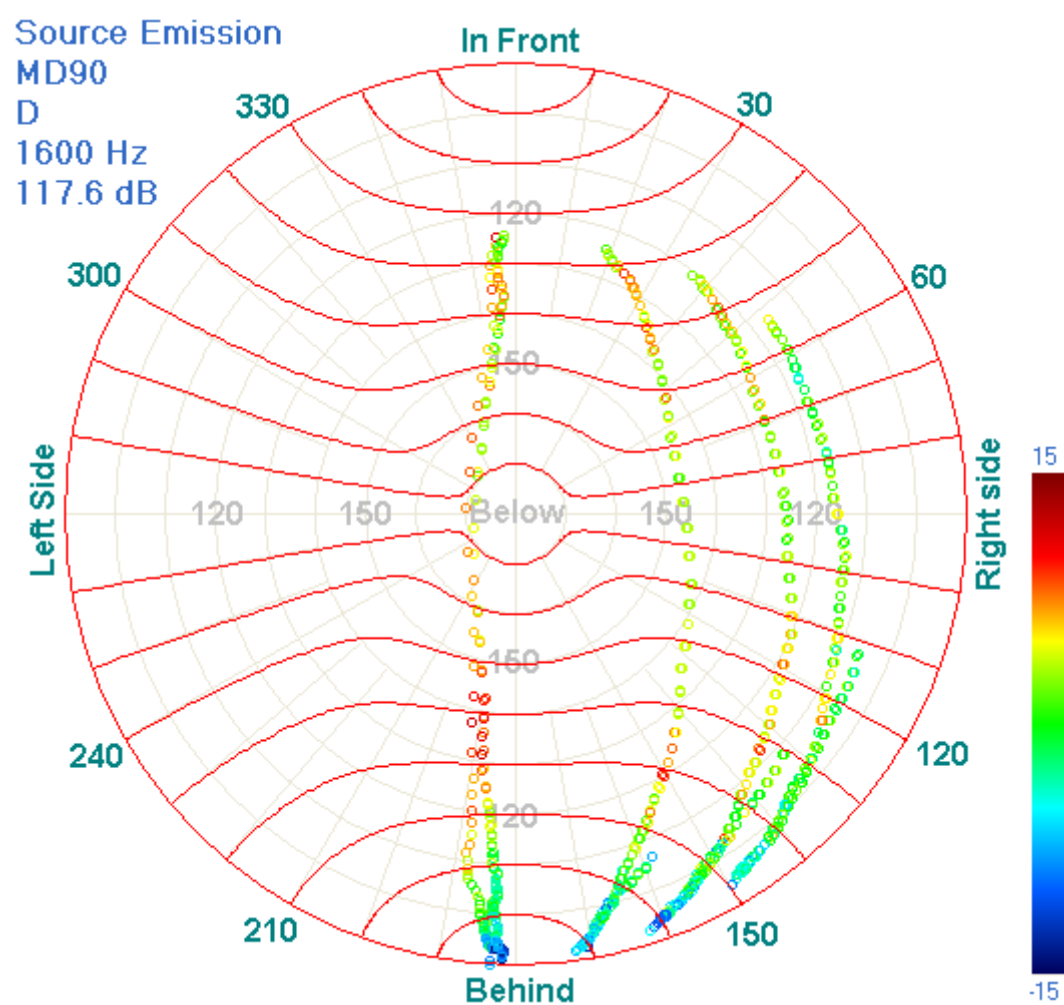


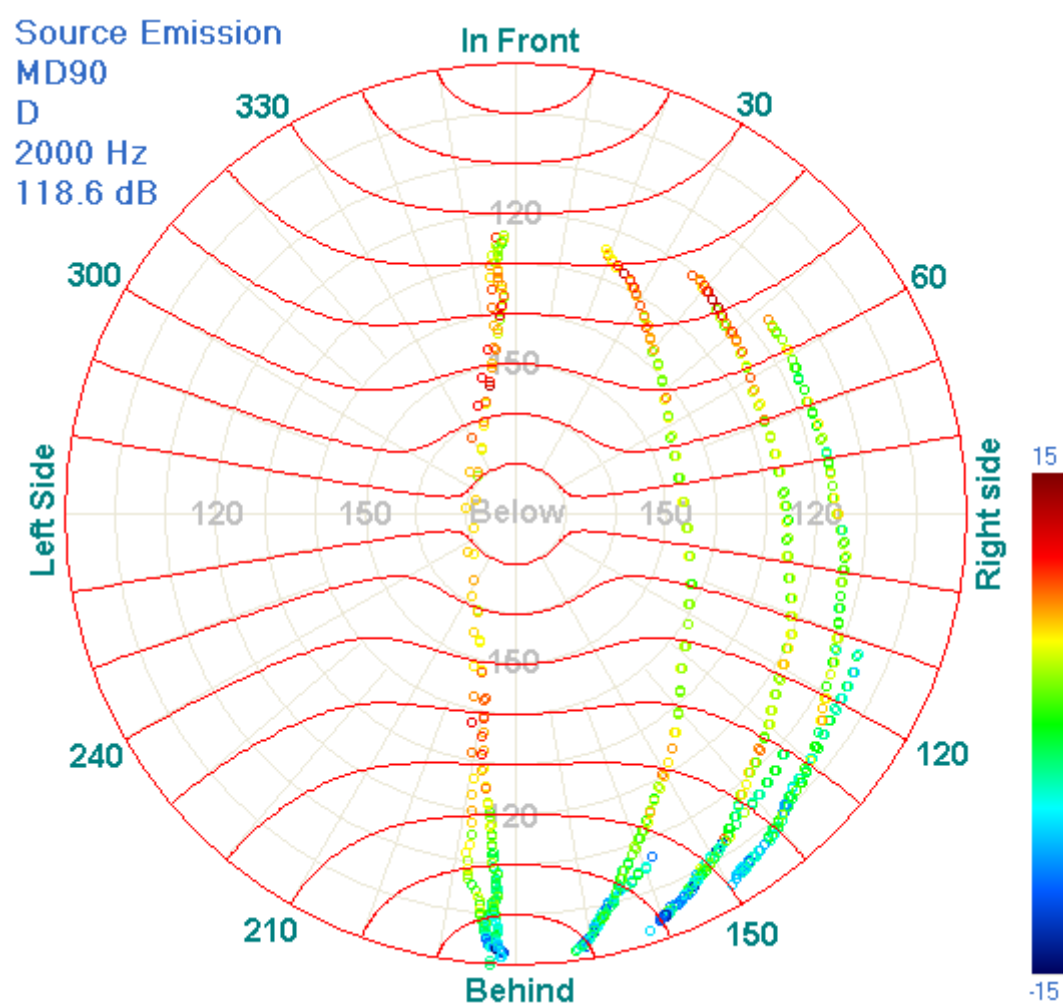


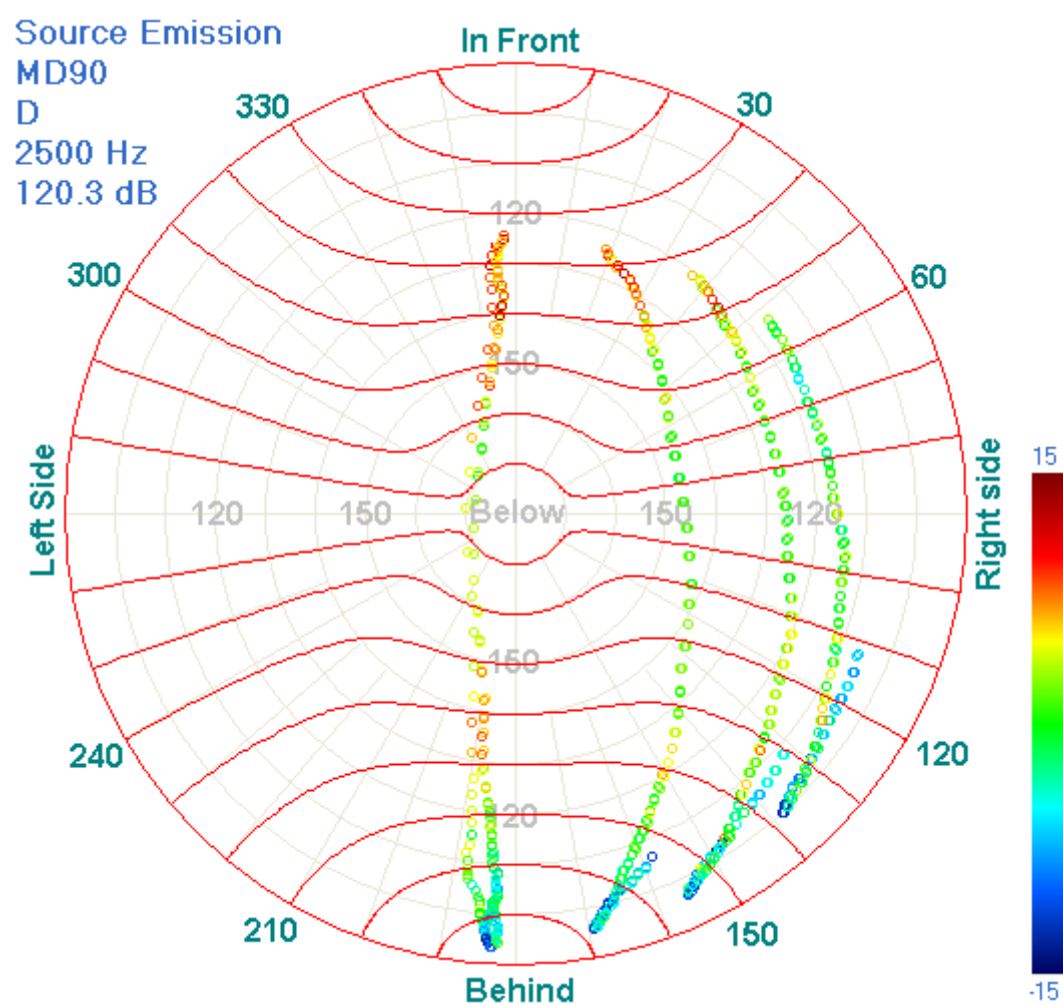




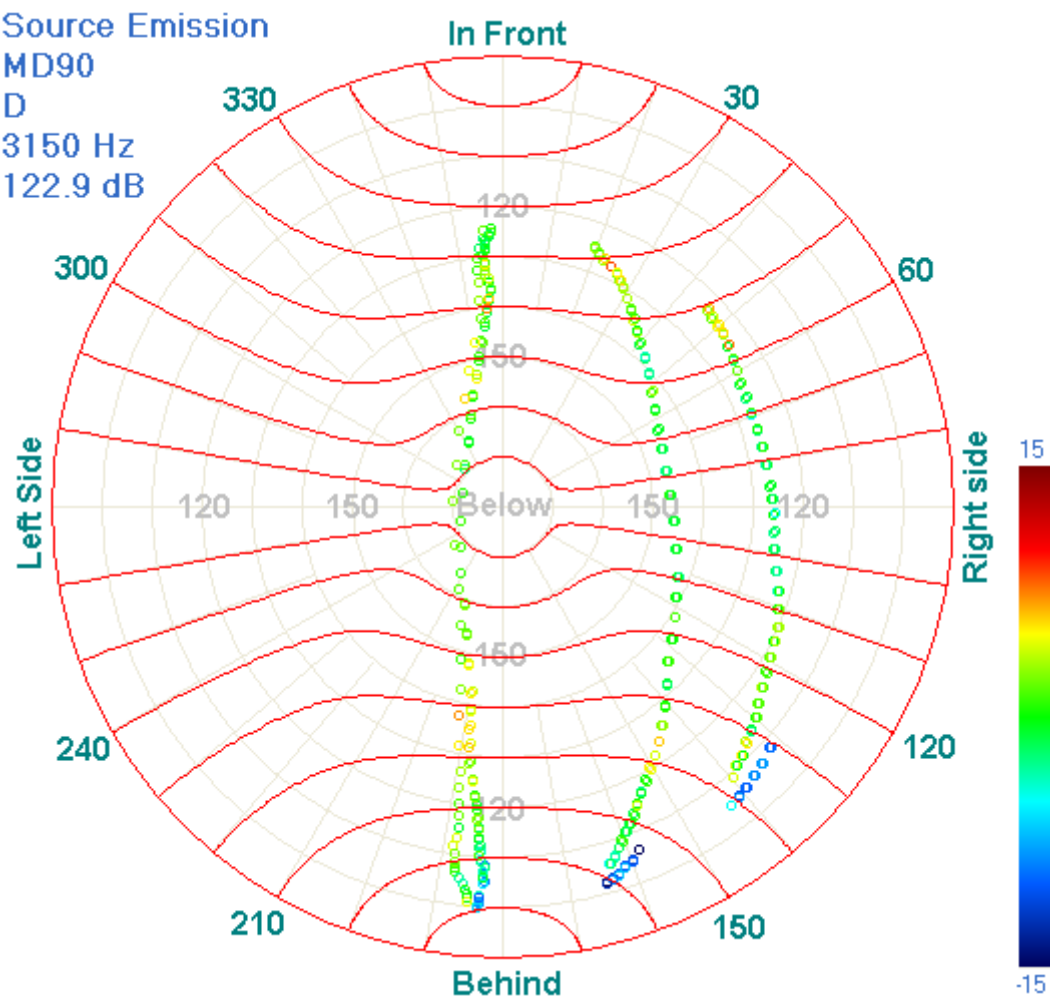




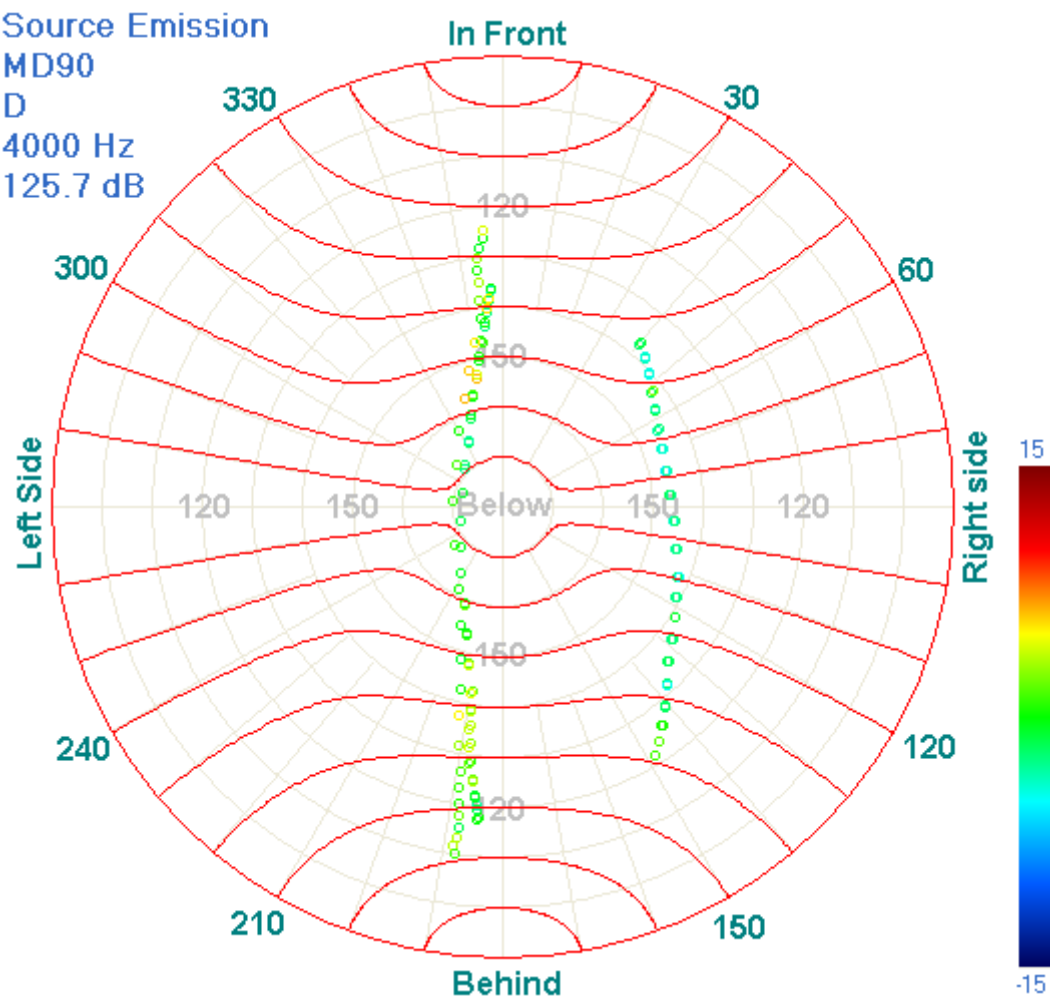




Source Emission  
MD90  
D  
3150 Hz  
122.9 dB

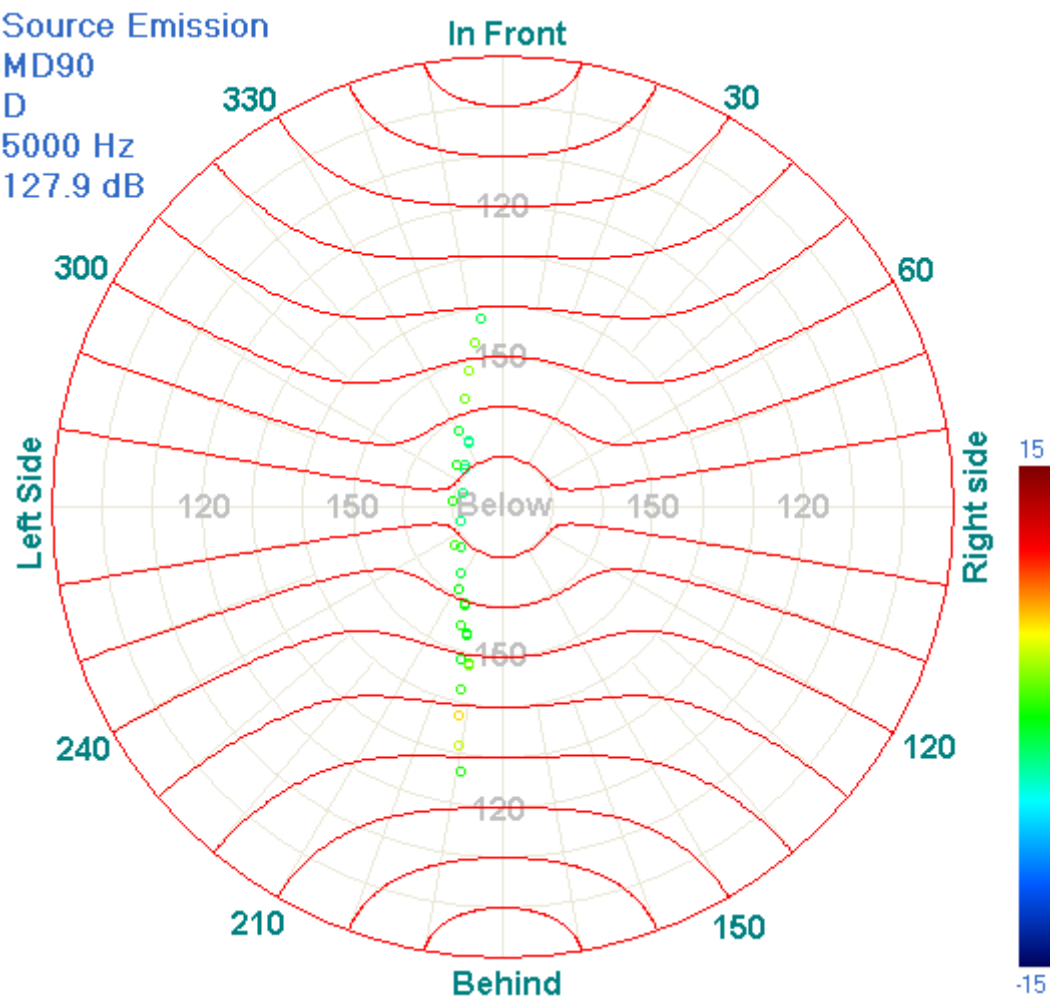


Source Emission  
MD90  
D  
4000 Hz  
125.7 dB

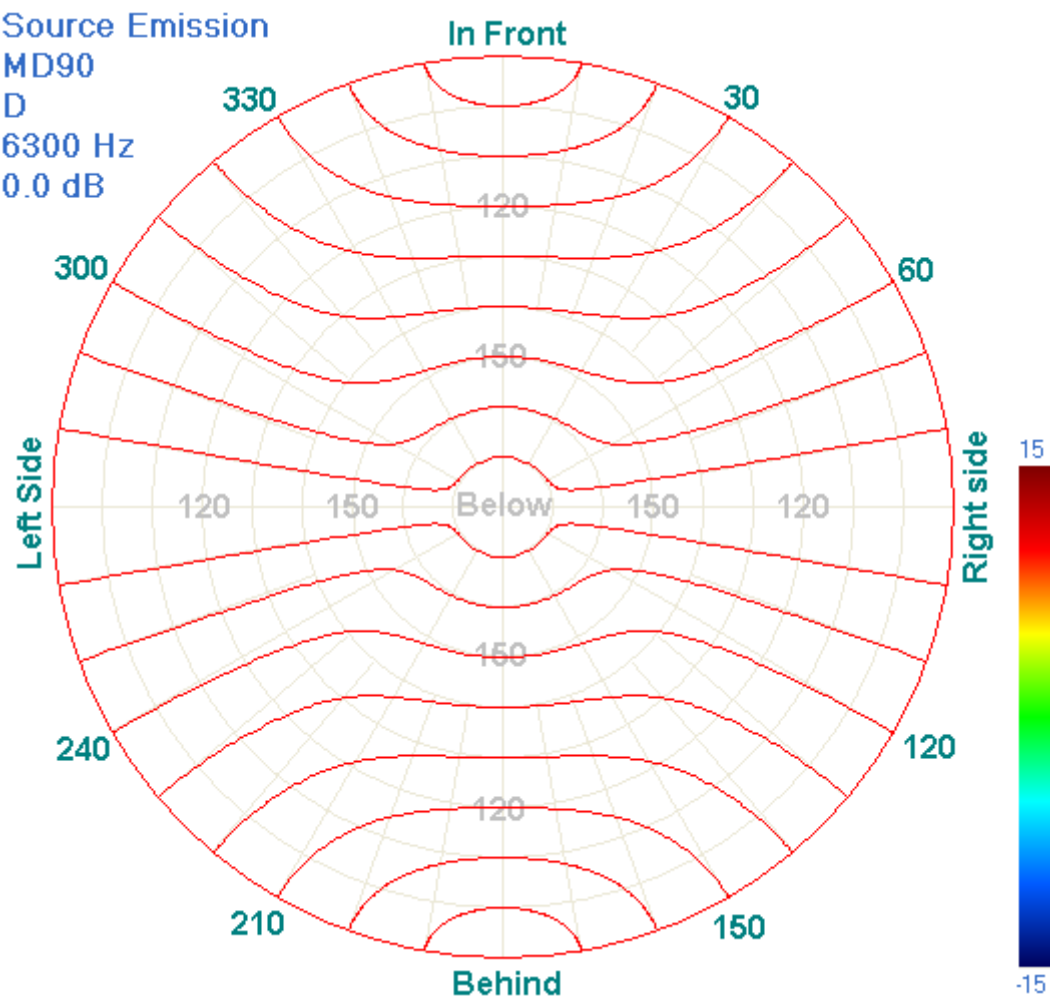




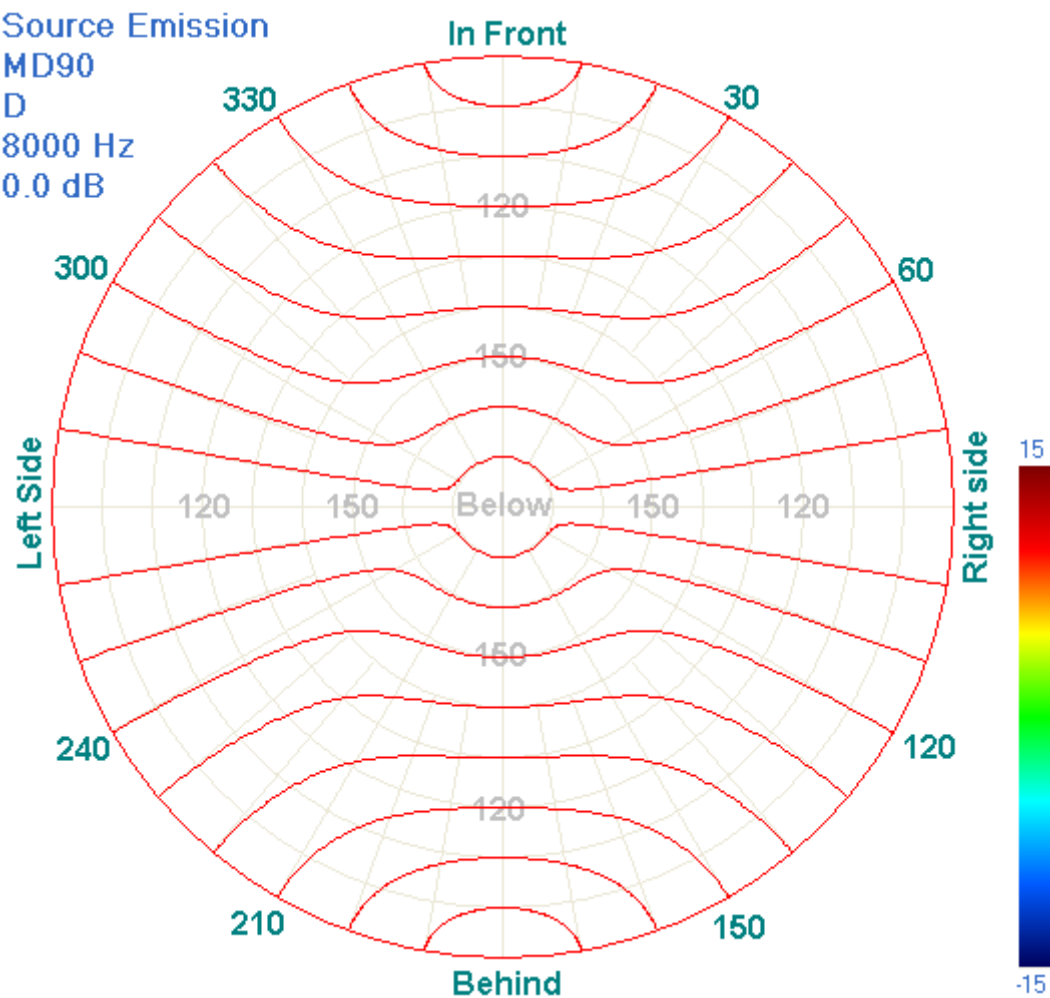
Source Emission  
MD90  
D  
5000 Hz  
127.9 dB



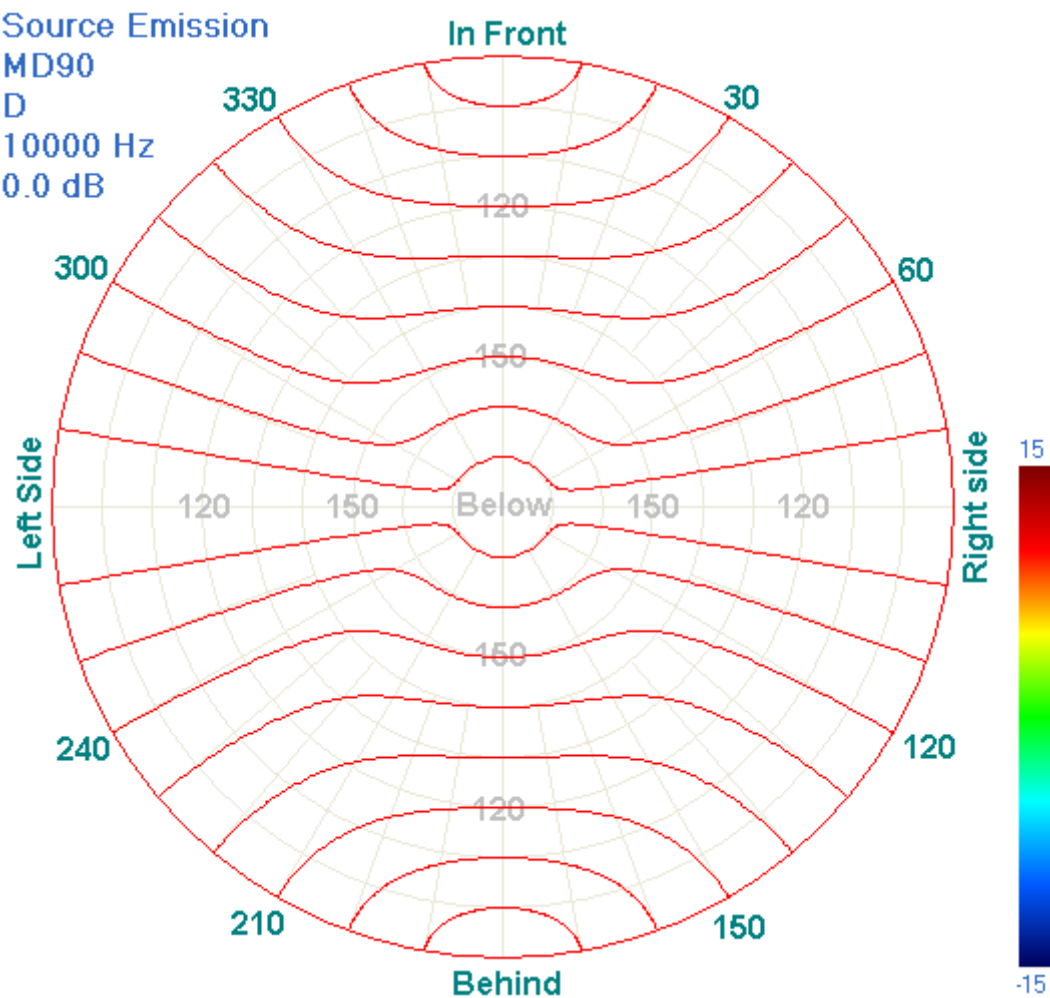
Source Emission  
MD90  
D  
6300 Hz  
0.0 dB



Source Emission  
MD90  
D  
8000 Hz  
0.0 dB



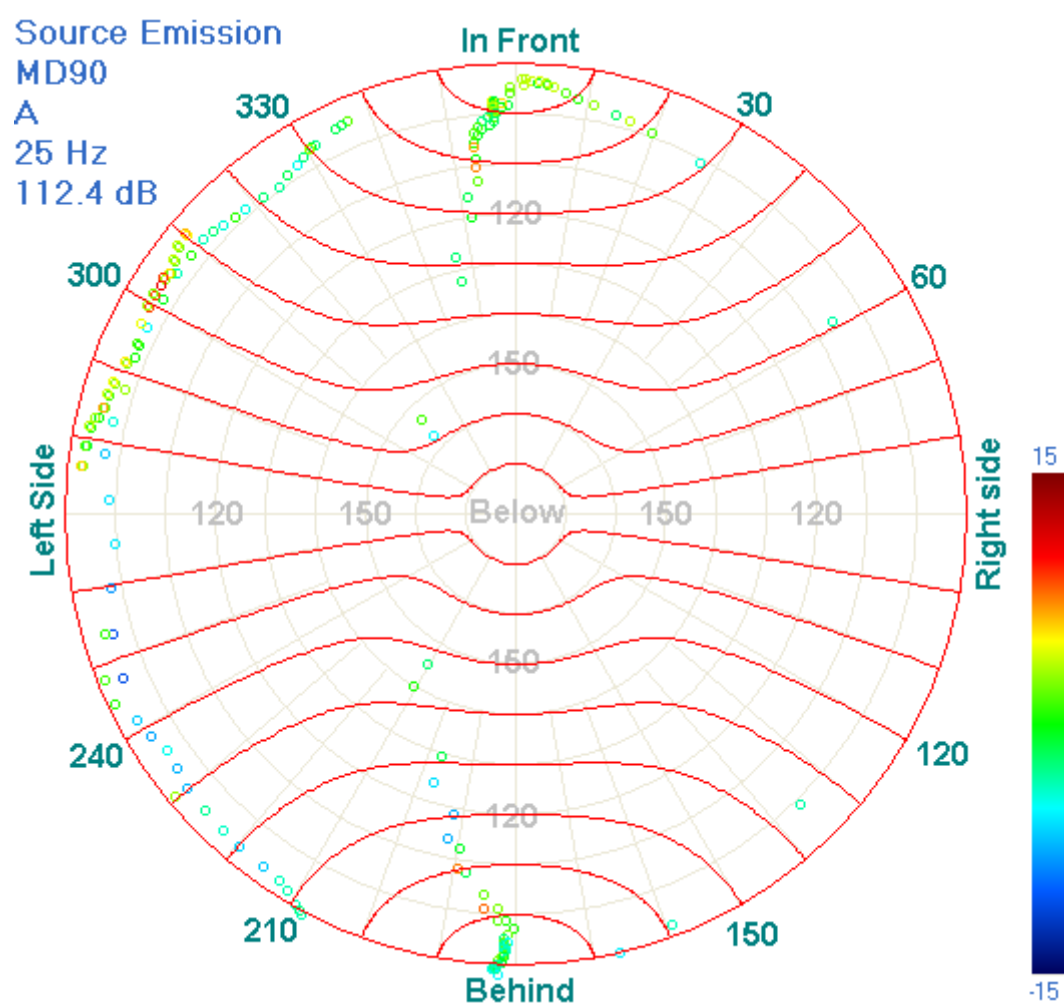
Source Emission  
MD90  
D  
10000 Hz  
0.0 dB



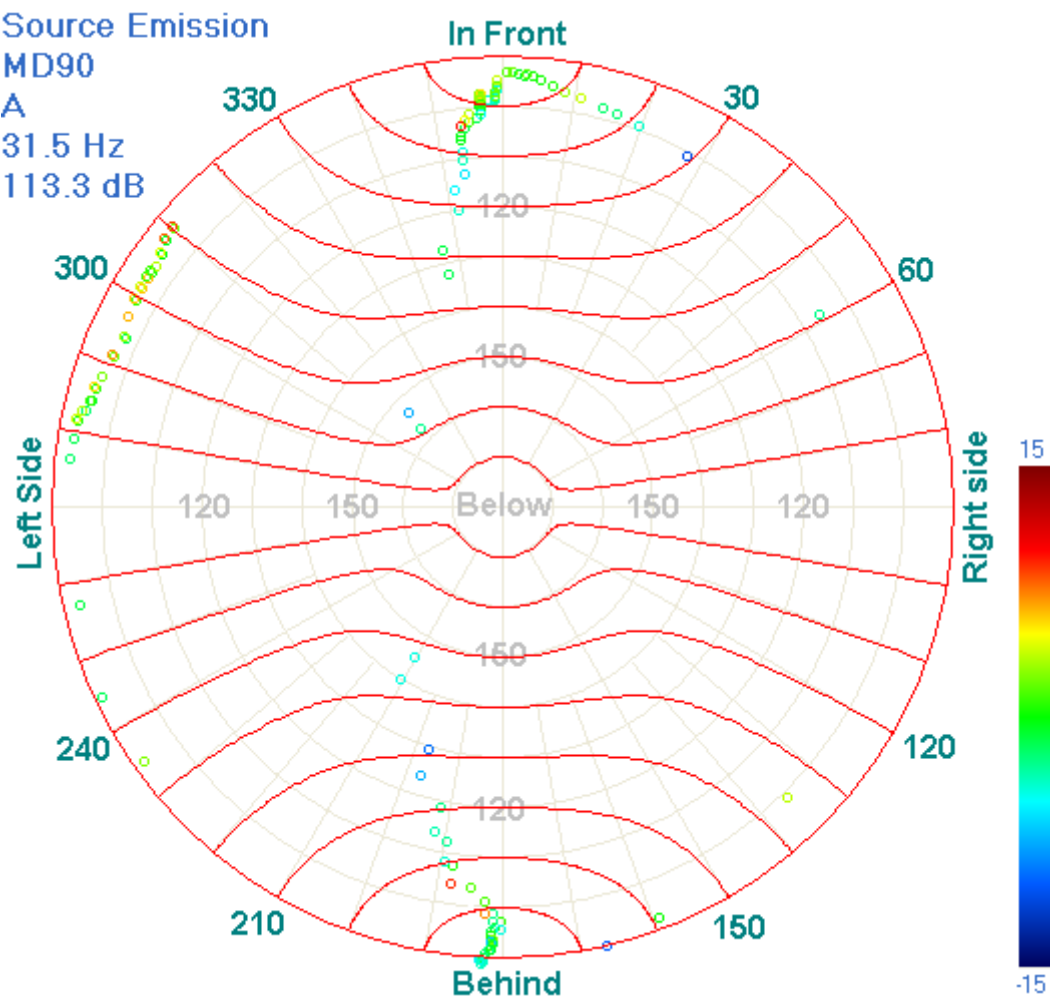
## 20 MD 90 directivity at arrival

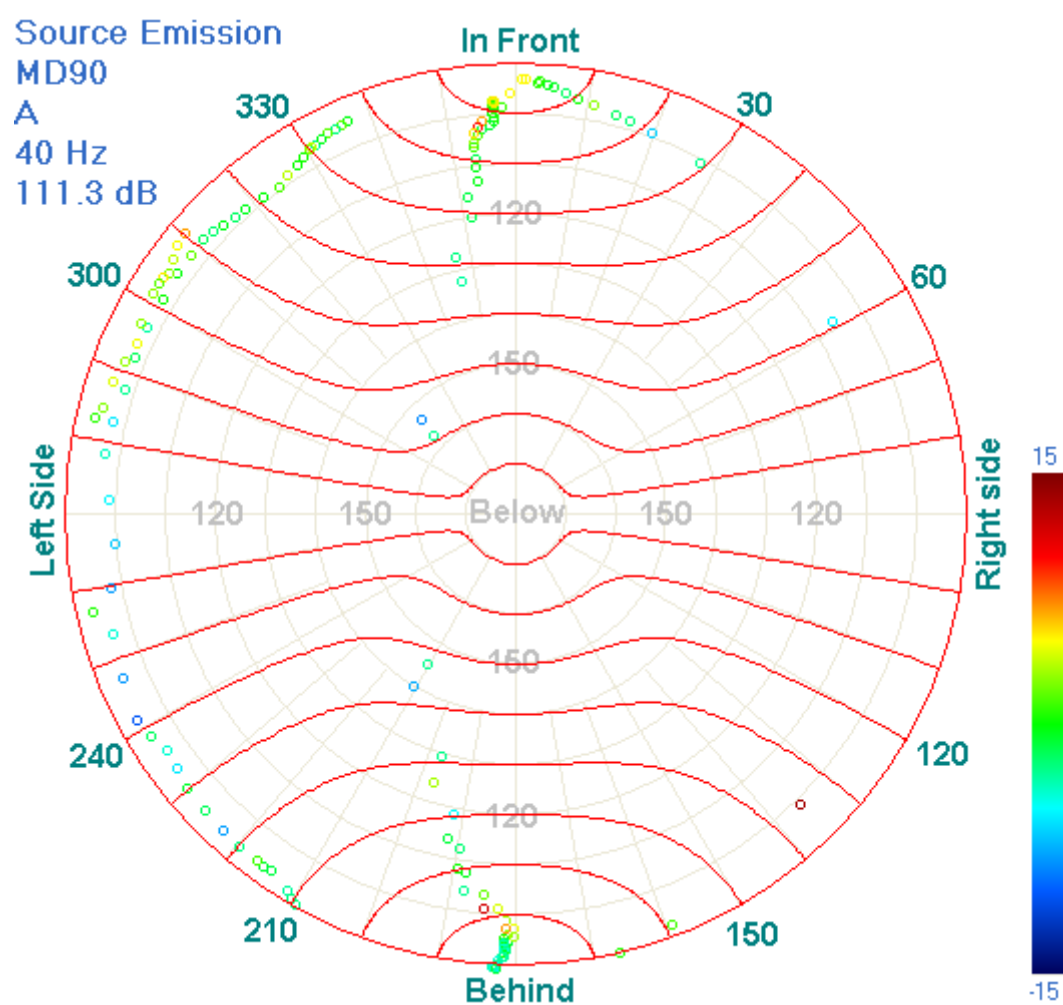
SPECTRUM  
Source Emission  
MD90  
A

Freq	Num	Avg	Std	95%Avg	P1	P2	P3	P4	P5	P6
25	180	112.4	4.2	0.6	113.6	112.3	112.6	-1.0	-1.0	-1.0
31.5	127	113.3	4.2	0.7	114.1	113.2	-1.0	-1.0	-1.0	-1.0
40	143	111.3	4.2	0.7	113.5	111.2	112.1	-1.0	-1.0	-1.0
50	83	111.6	3.7	0.8	111.8	111.6	-1.0	-1.0	-1.0	-1.0
63	117	112.1	4.2	0.8	110.5	112.2	-1.0	-1.0	-1.0	-1.0
80	108	112.6	5.3	1.0	119.1	112.3	-1.0	-1.0	-1.0	-1.0
100	112	112.5	4.5	0.8	110.4	112.6	-1.0	-1.0	-1.0	-1.0
125	232	112.8	4.3	0.5	113.3	112.7	-1.0	-1.0	-1.0	-1.0
160	193	112.4	3.8	0.5	112.6	112.4	-1.0	-1.0	-1.0	-1.0
200	224	112.1	3.5	0.5	113.8	112.0	-1.0	-1.0	-1.0	-1.0
250	231	112.2	3.2	0.4	115.1	112.0	-1.0	-1.0	-1.0	-1.0
315	192	111.8	3.0	0.4	115.1	111.6	-1.0	-1.0	-1.0	-1.0
400	190	111.3	3.1	0.4	113.6	111.2	-1.0	-1.0	-1.0	-1.0
500	190	110.9	3.2	0.5	113.8	110.8	-1.0	-1.0	-1.0	-1.0
630	190	110.5	3.3	0.5	113.9	110.4	-1.0	-1.0	-1.0	-1.0
800	189	110.6	3.5	0.5	114.9	110.4	-1.0	-1.0	-1.0	-1.0
1000	183	110.6	3.5	0.5	114.6	110.4	-1.0	-1.0	-1.0	-1.0
1250	188	109.8	3.8	0.5	112.8	109.6	-1.0	-1.0	-1.0	-1.0
1600	233	109.6	3.4	0.4	112.4	109.4	113.8	-1.0	-1.0	-1.0
2000	244	109.0	3.9	0.5	110.7	108.8	111.7	-1.0	-1.0	-1.0
2500	252	108.2	4.7	0.6	109.7	108.1	115.5	-1.0	-1.0	-1.0
3150	225	106.7	3.6	0.5	109.1	106.6	-1.0	-1.0	-1.0	-1.0
4000	150	105.9	4.1	0.6	106.1	105.9	-1.0	-1.0	-1.0	-1.0
5000	98	105.5	5.5	1.1	-1.0	105.5	-1.0	-1.0	-1.0	-1.0
6300	47	106.0	7.2	2.1	-1.0	106.0	-1.0	-1.0	-1.0	-1.0
8000	40	106.0	8.6	2.7	-1.0	106.0	-1.0	-1.0	-1.0	-1.0
10000	25	102.0	11.5	4.5	-1.0	102.0	-1.0	-1.0	-1.0	-1.0

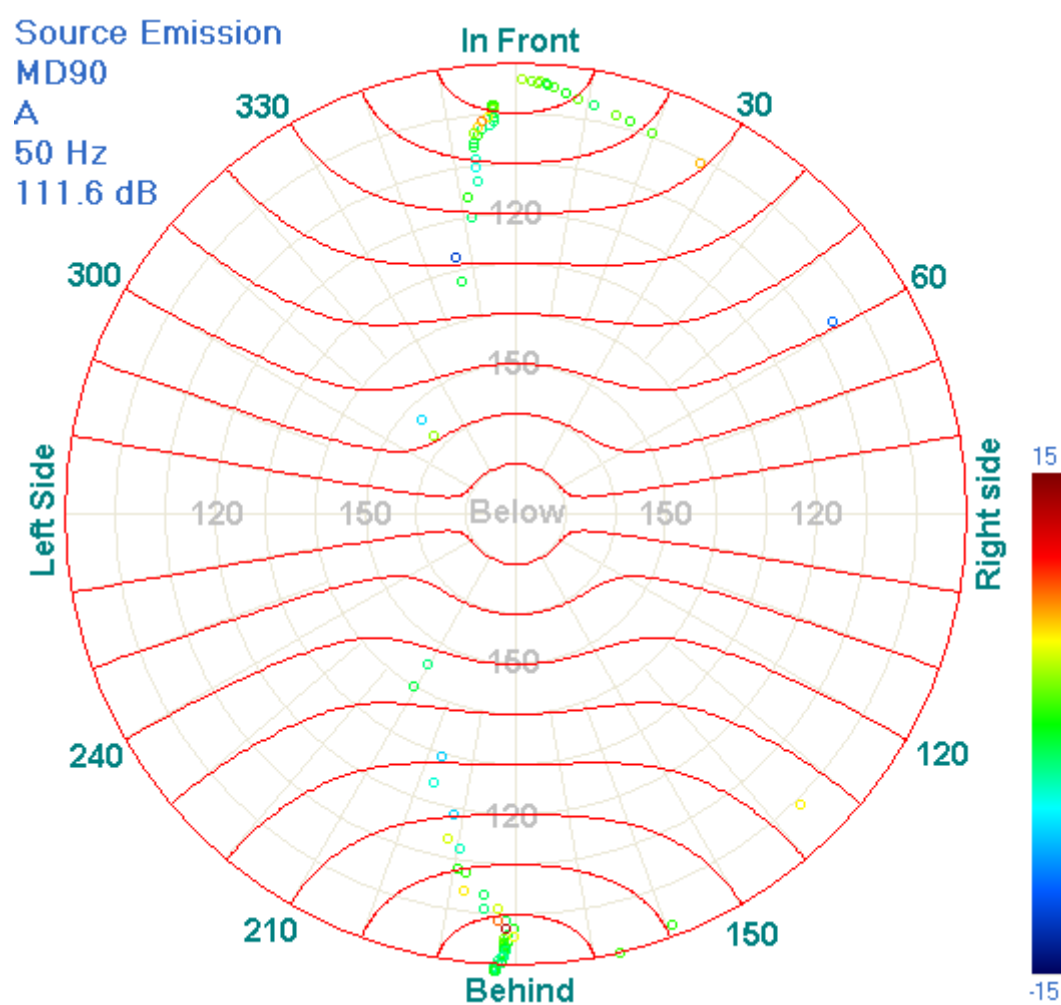


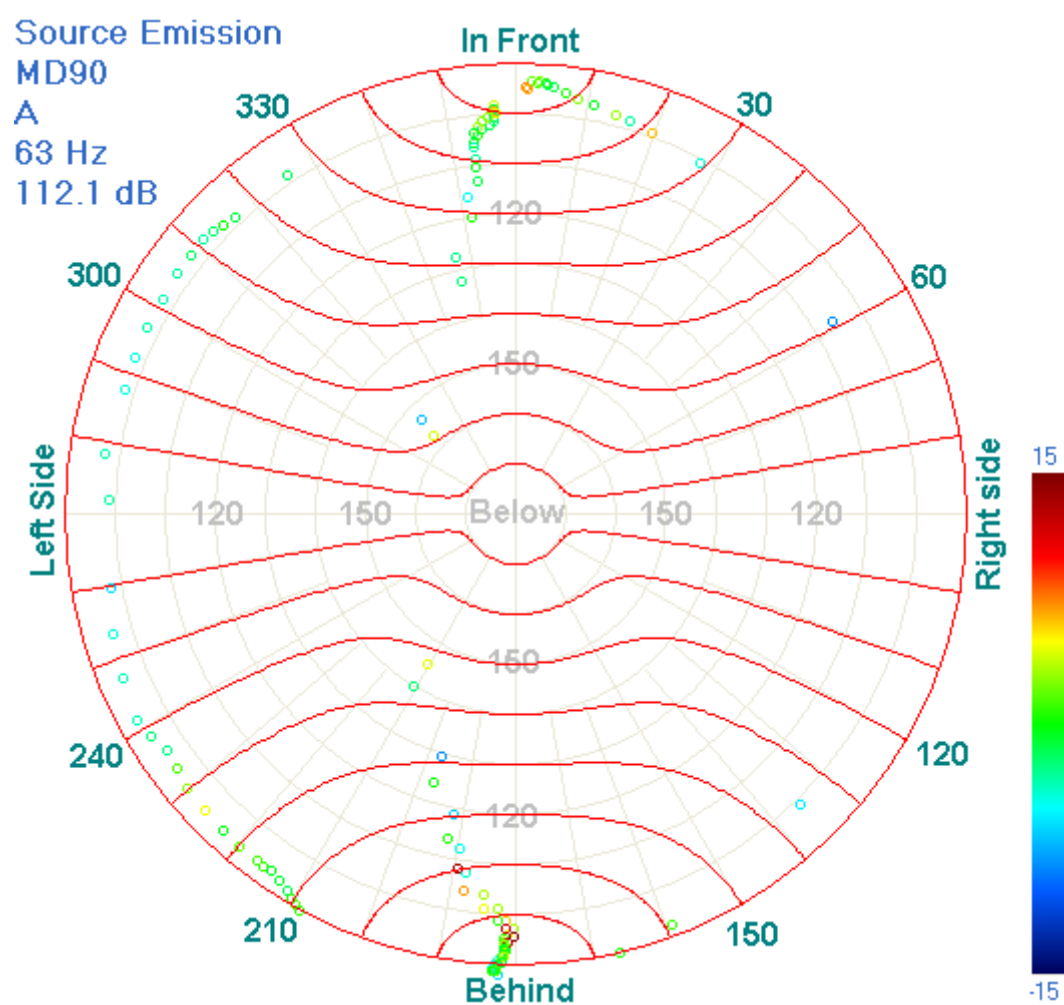
Source Emission  
MD90  
A  
31.5 Hz  
113.3 dB

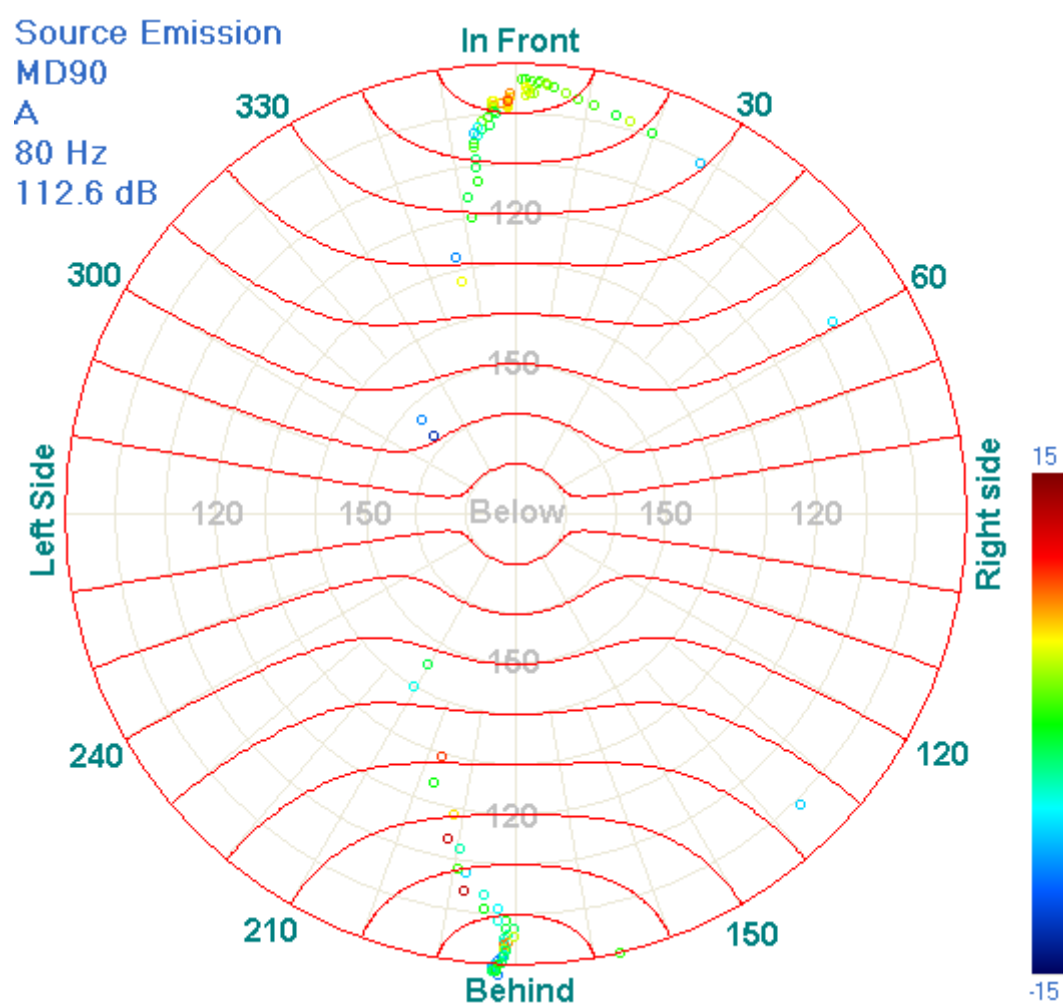


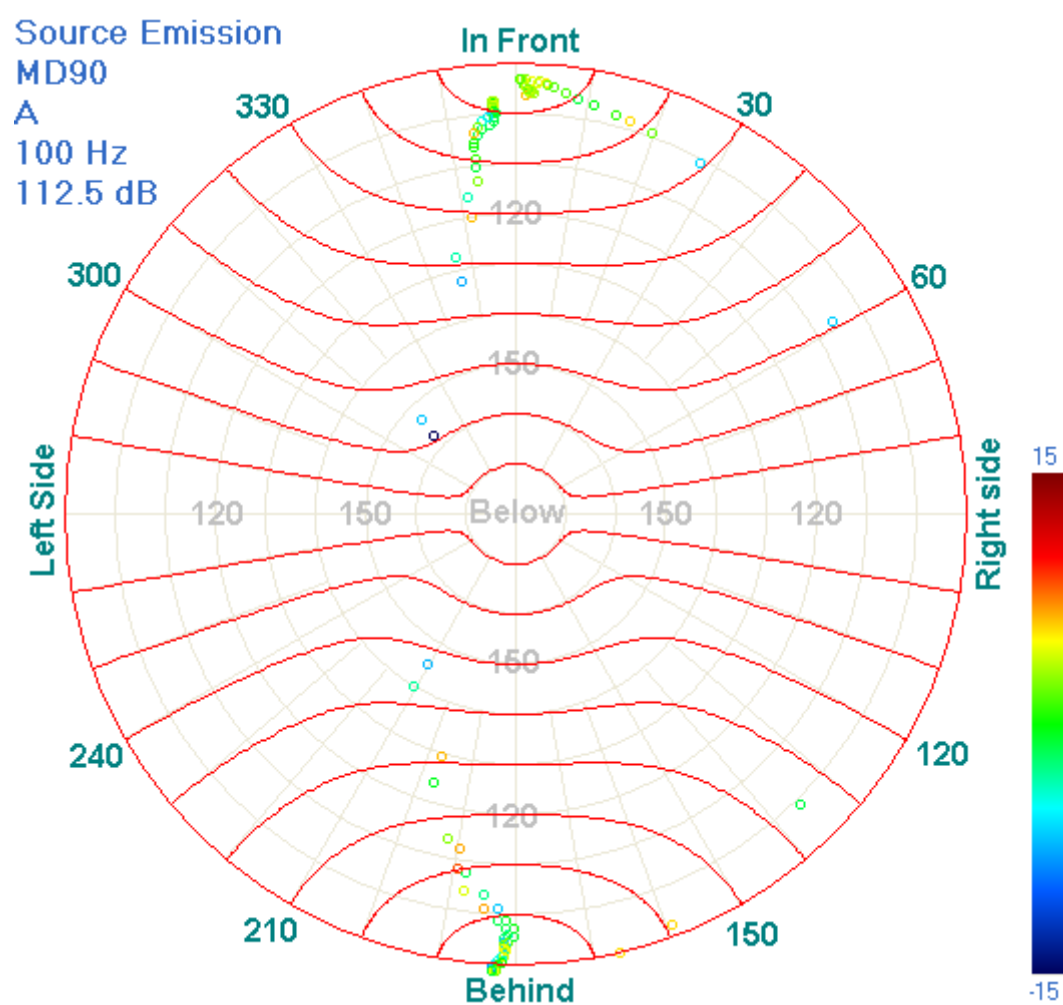




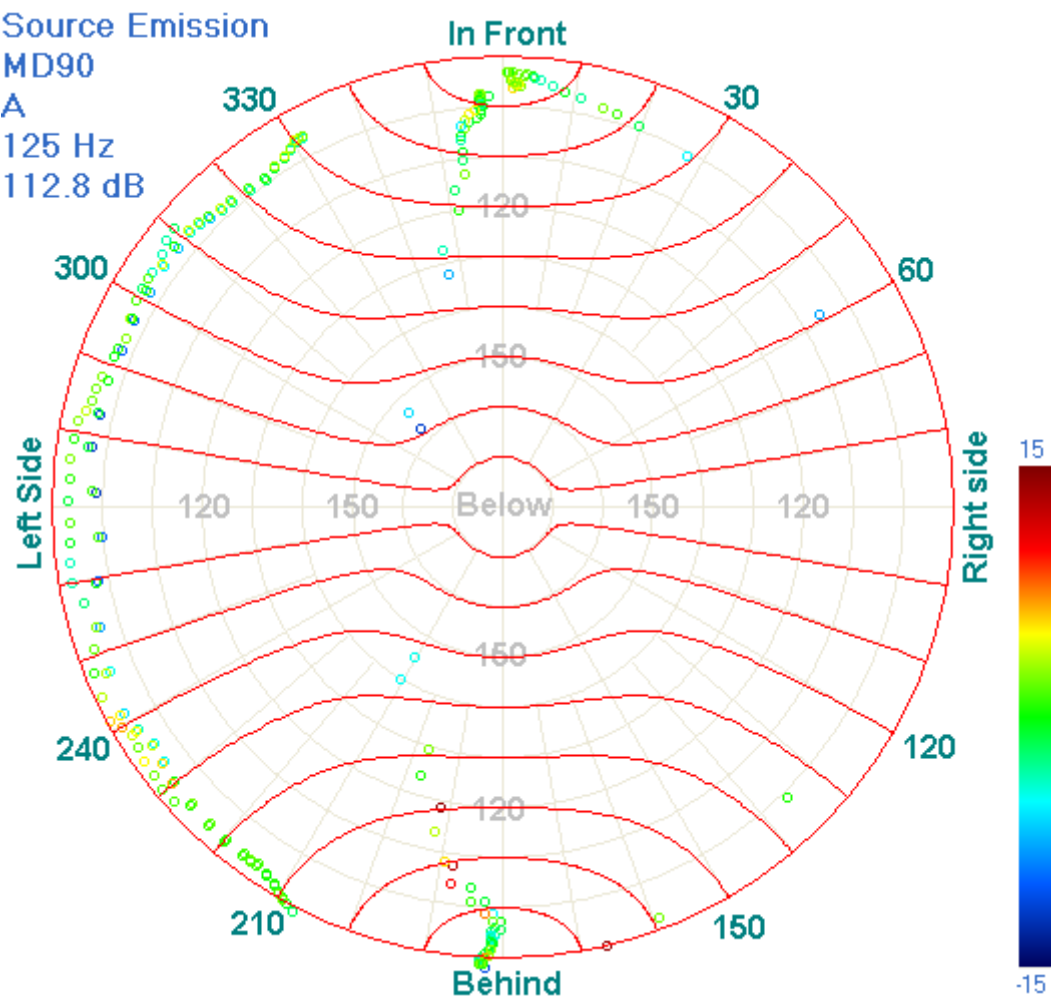


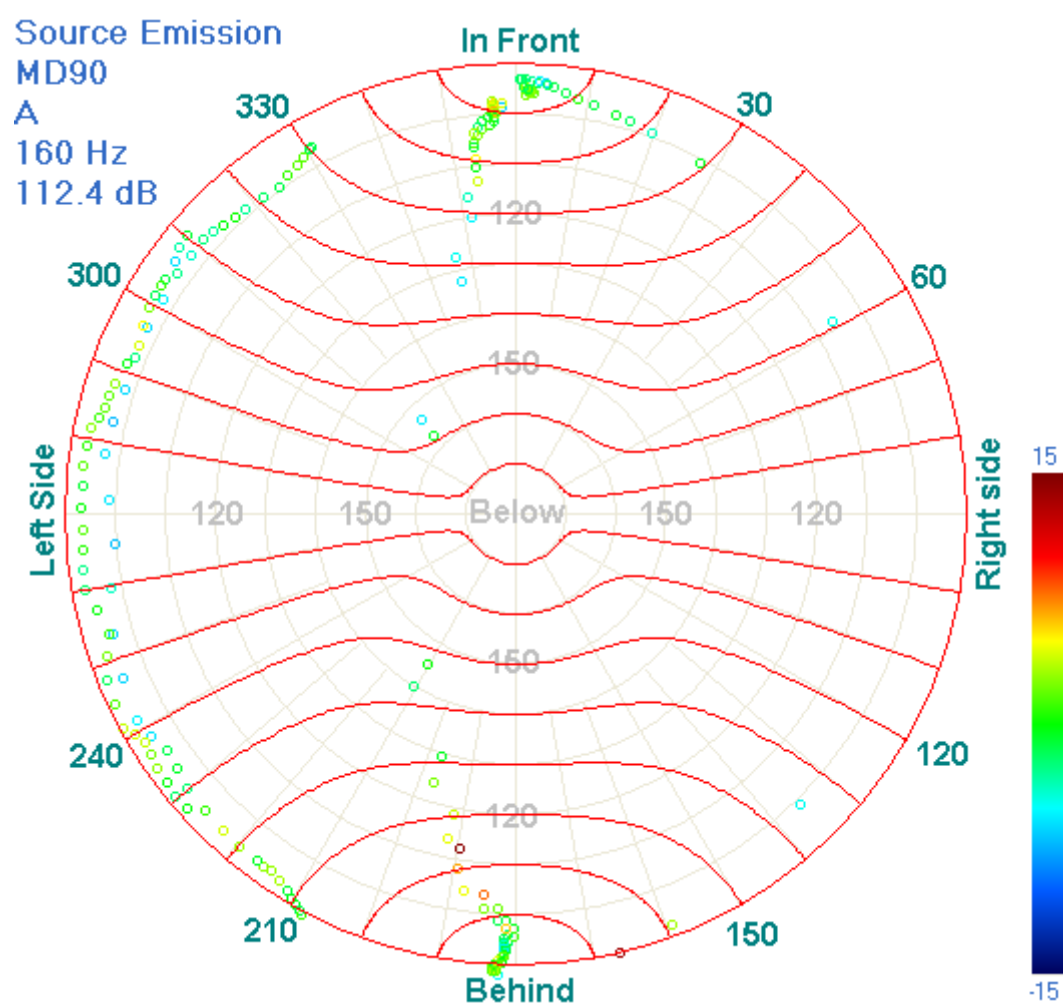


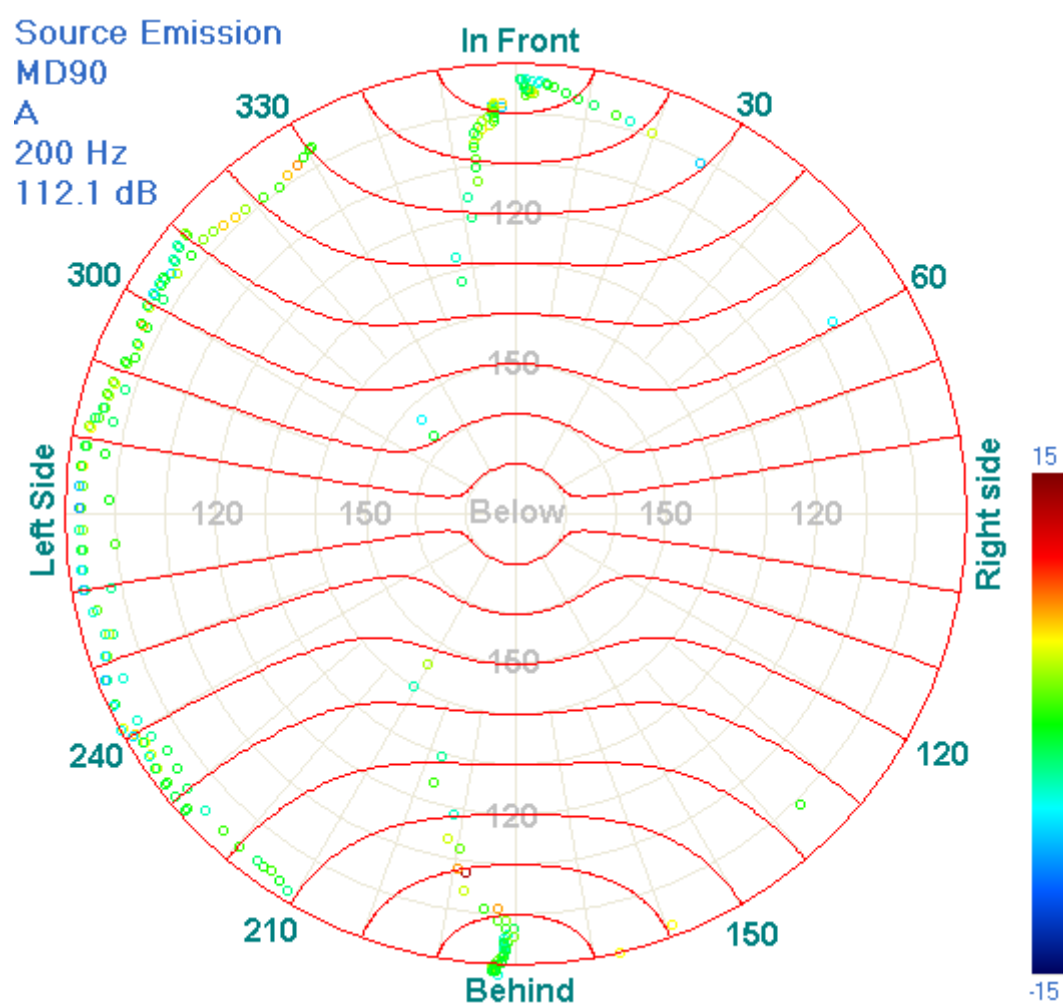


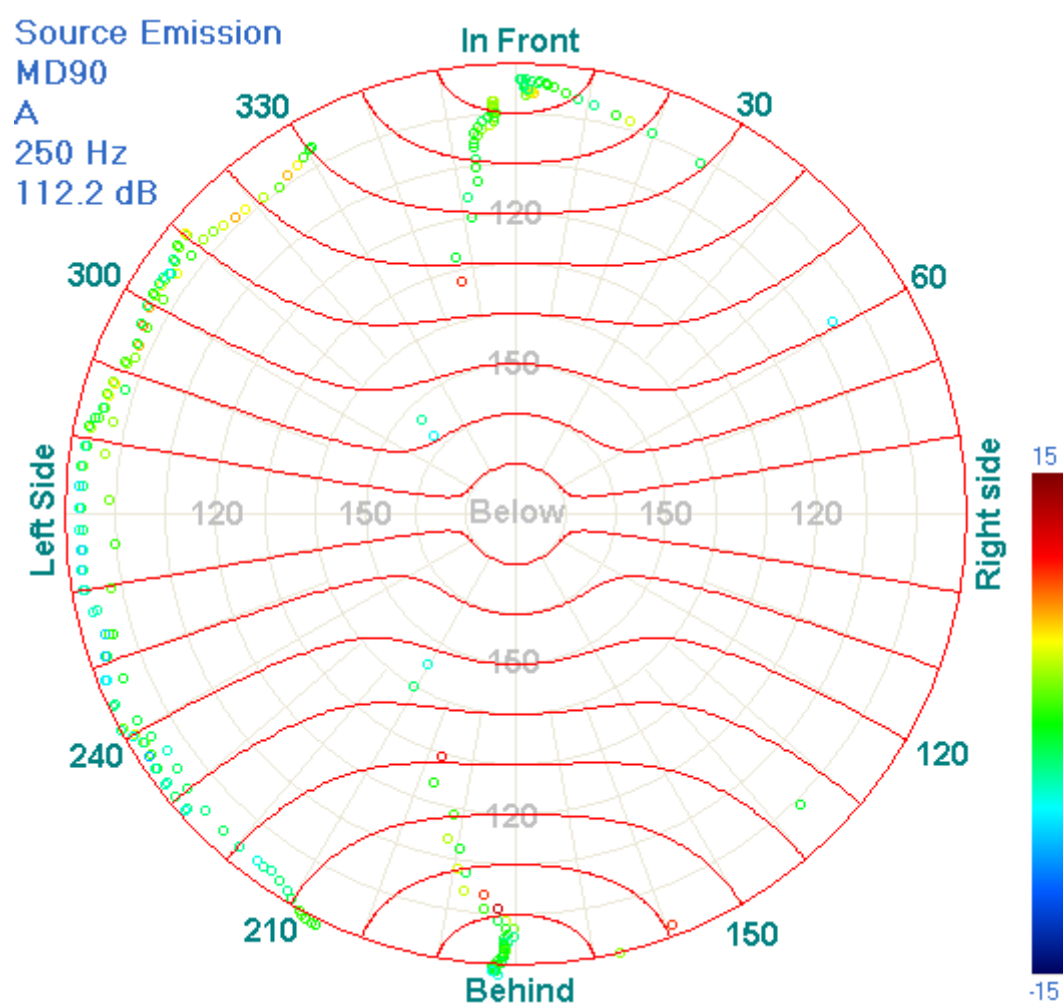


Source Emission  
MD90  
A  
125 Hz  
112.8 dB

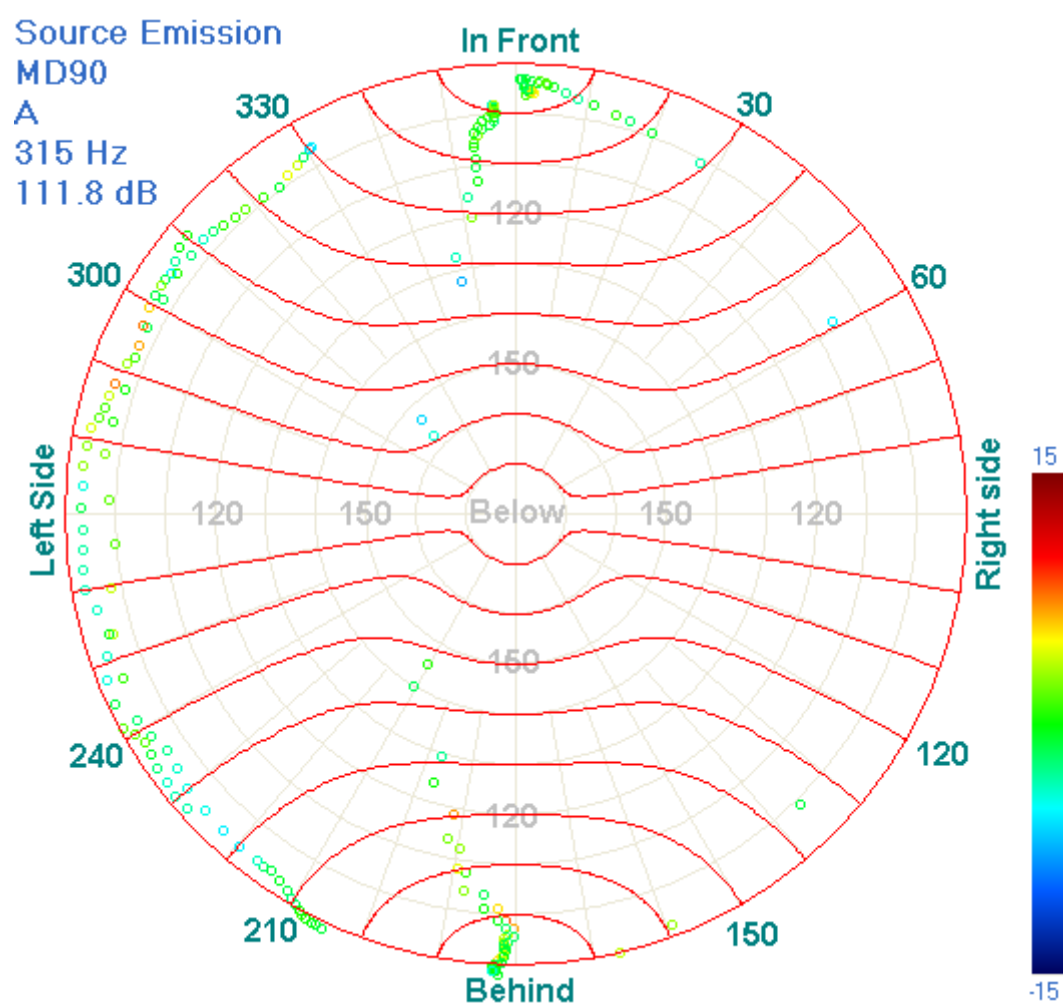


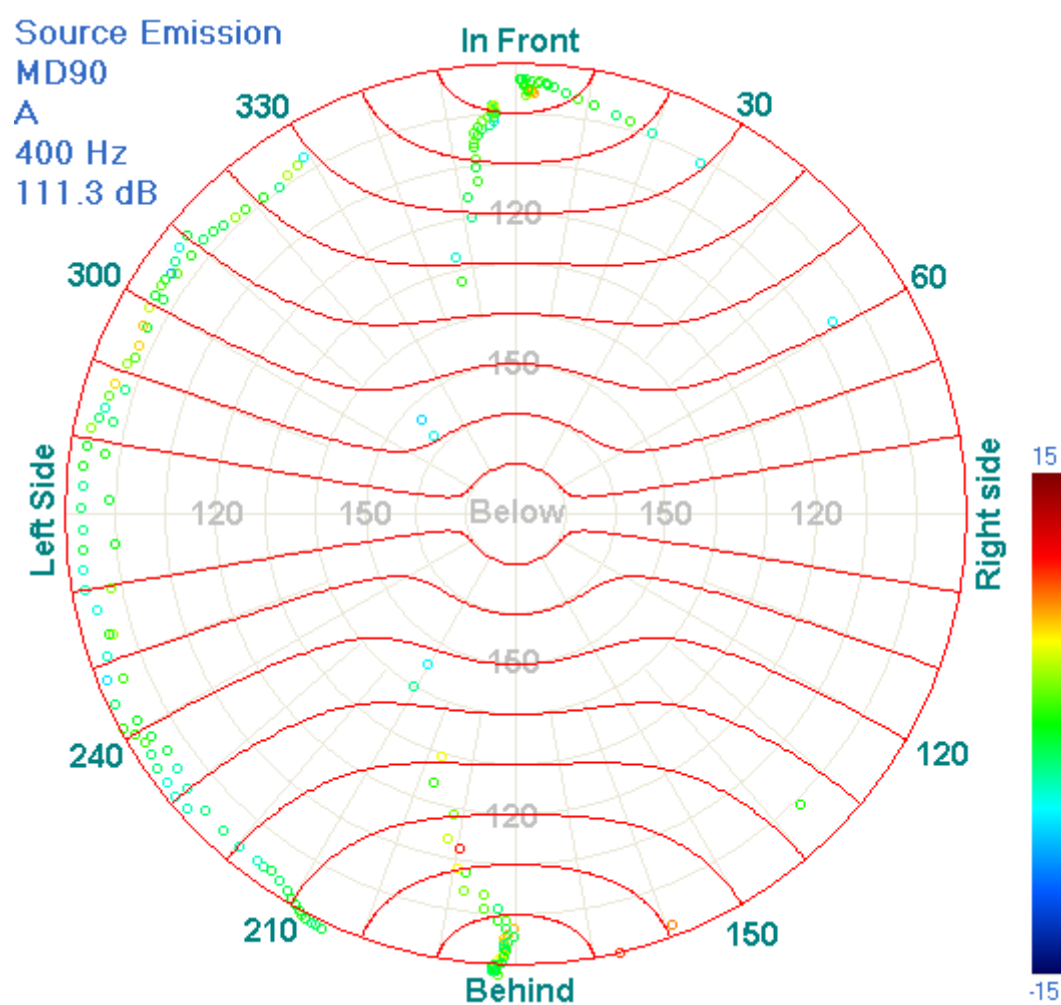


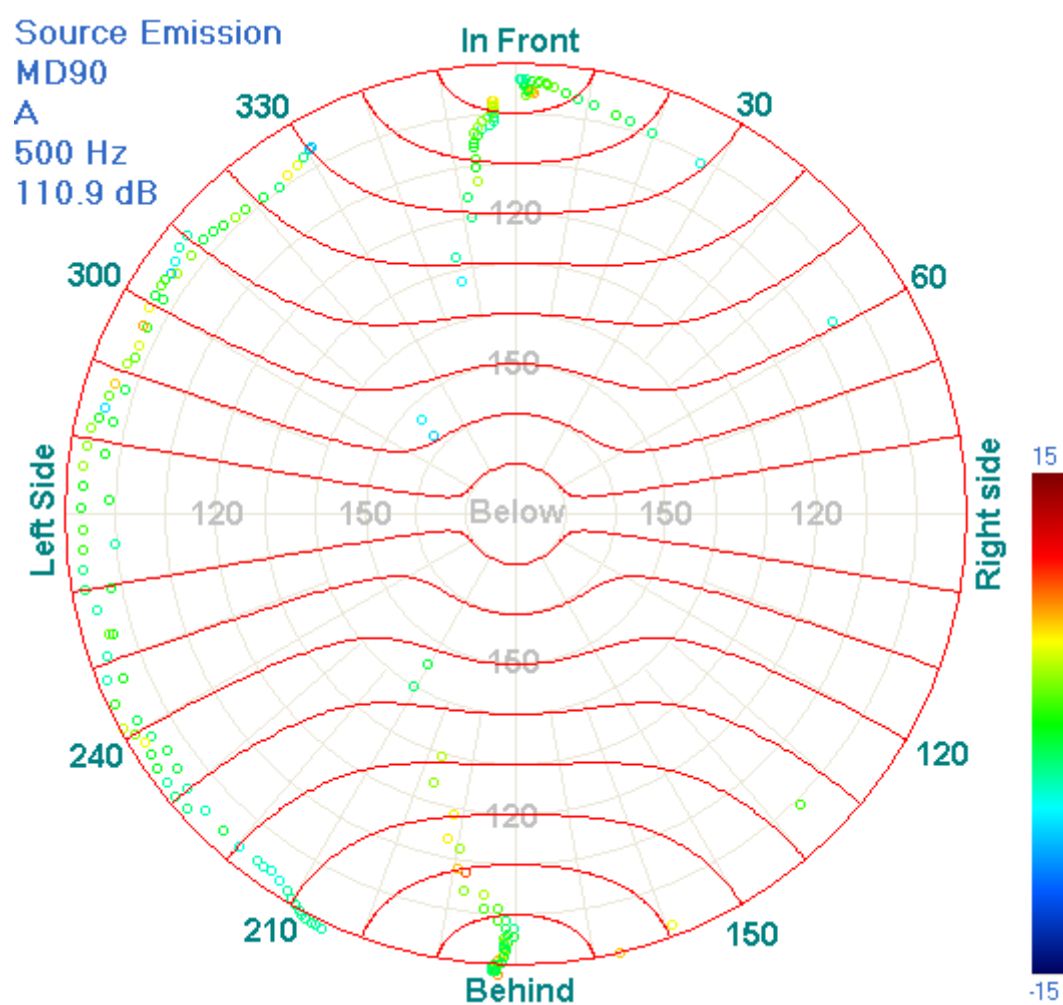


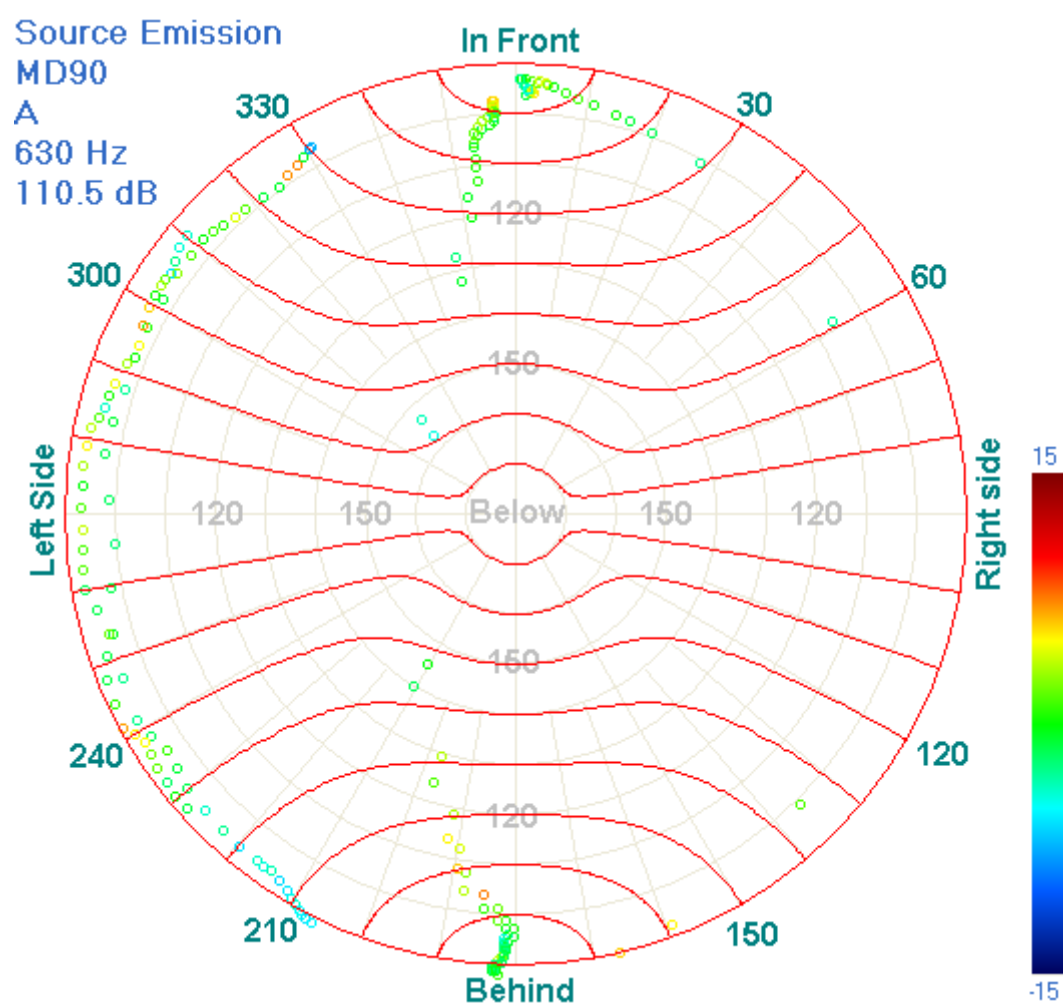


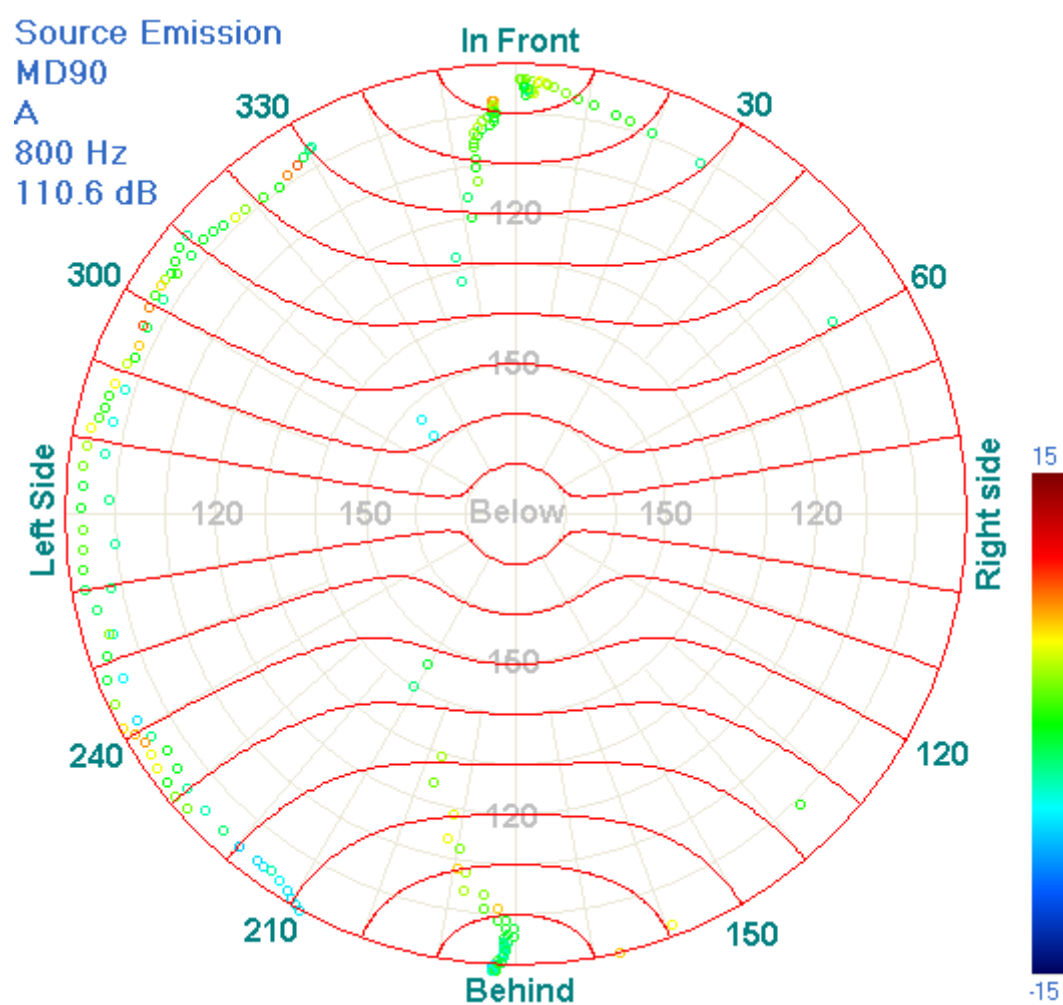


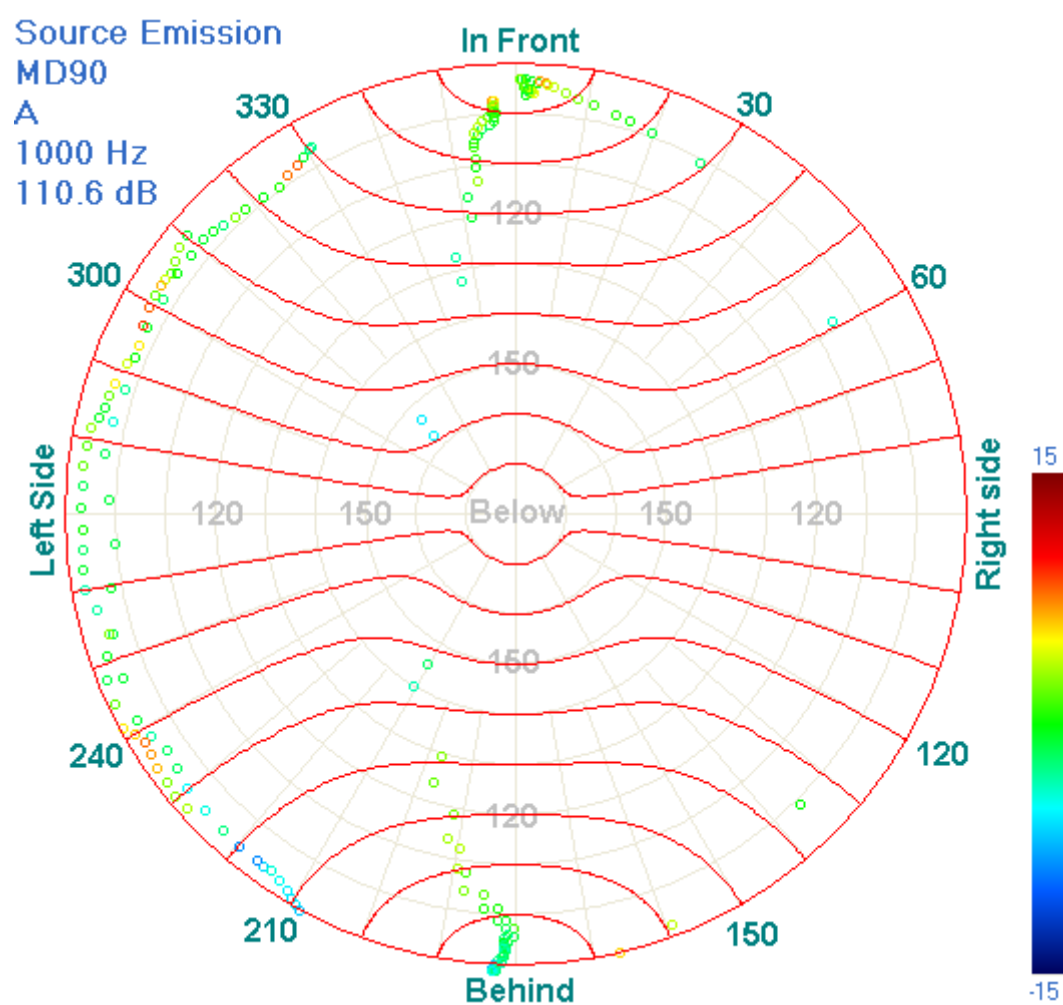




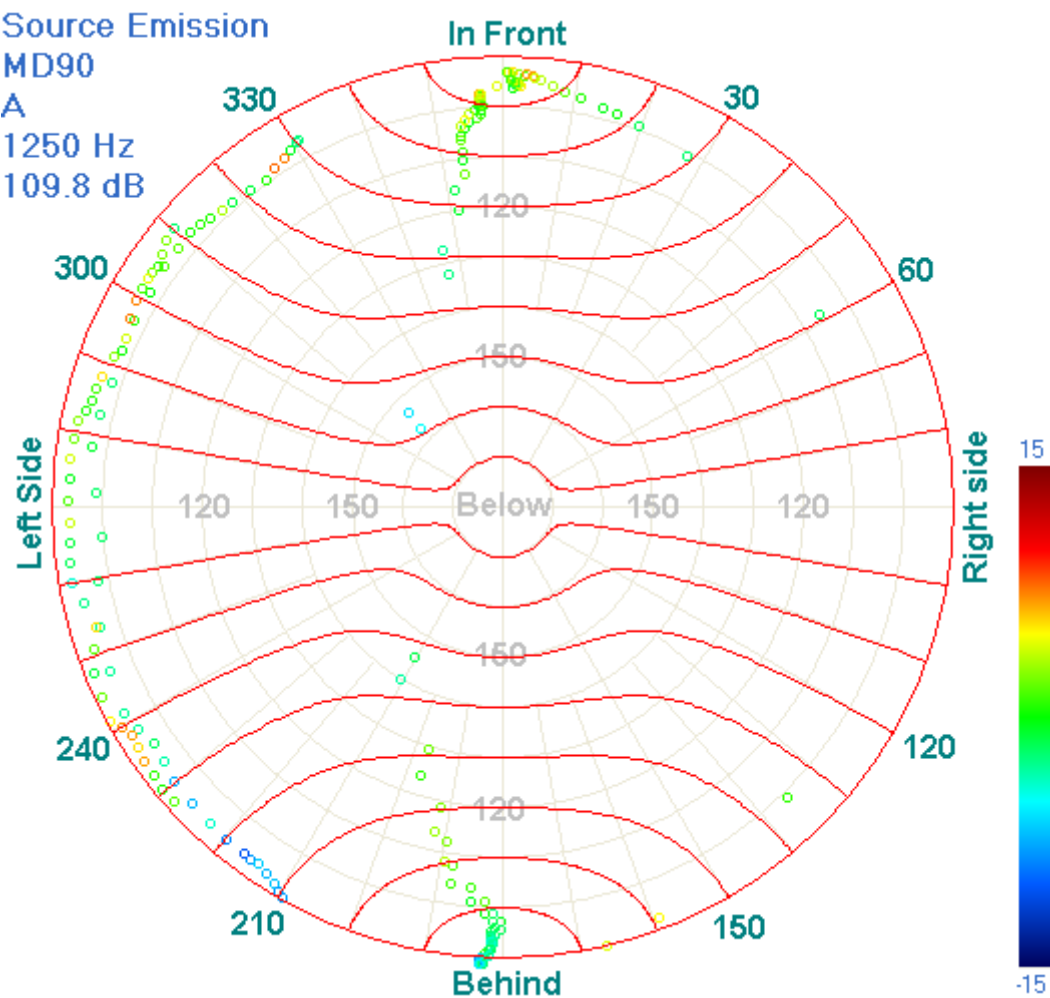




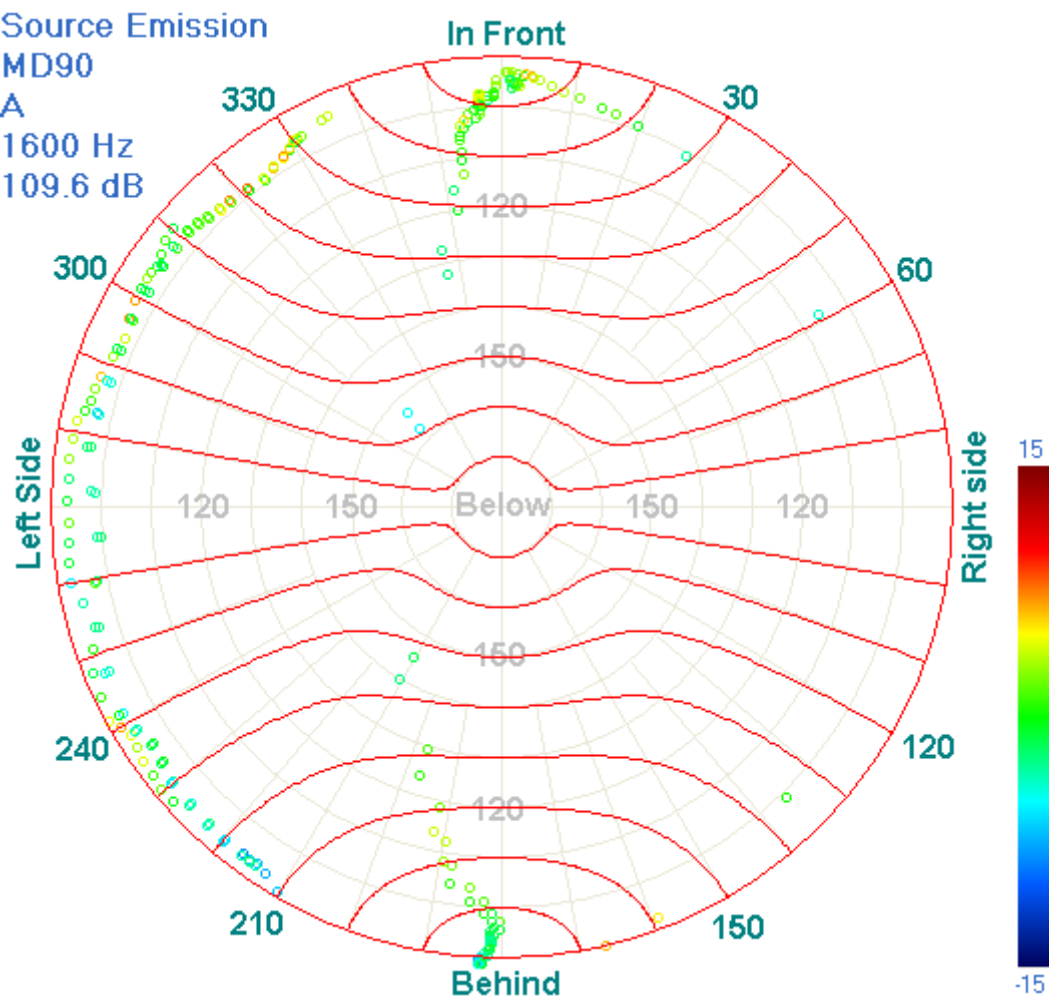




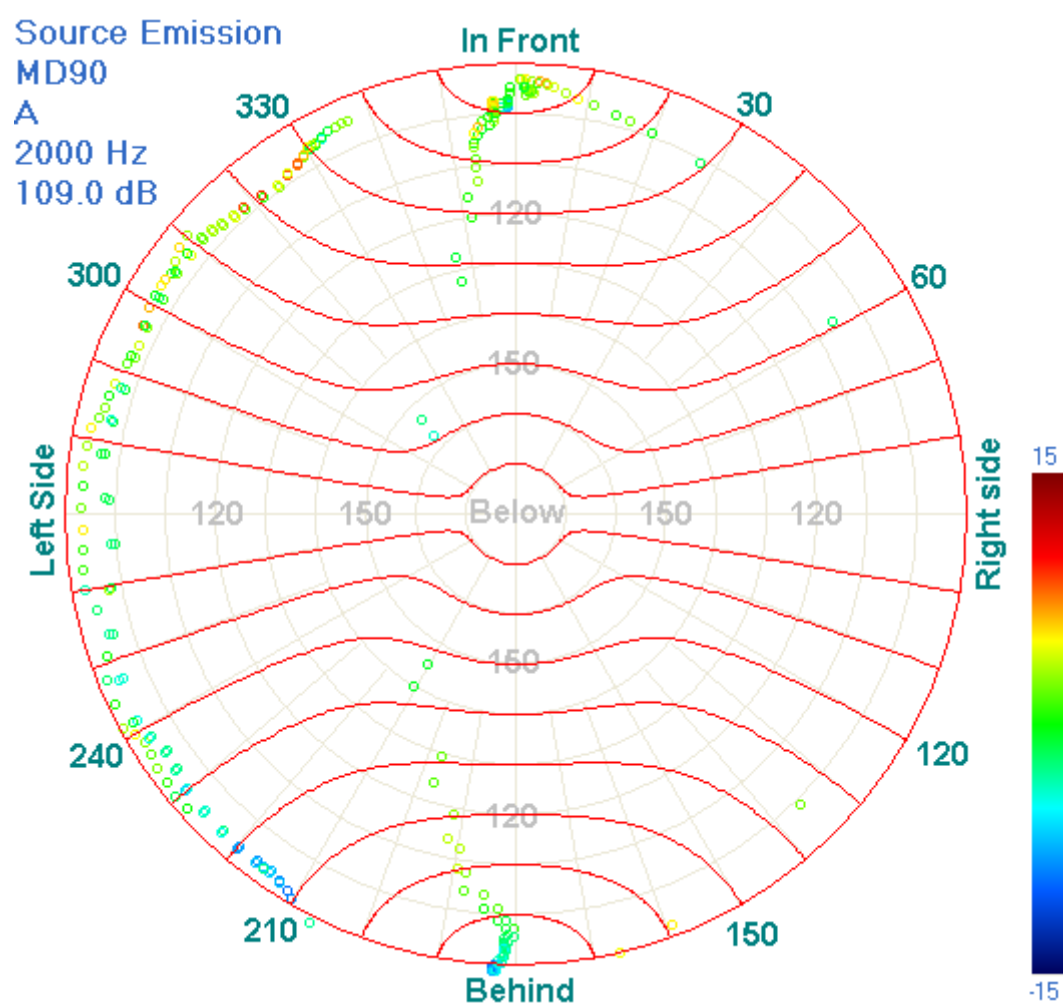
Source Emission  
MD90  
A  
1250 Hz  
109.8 dB

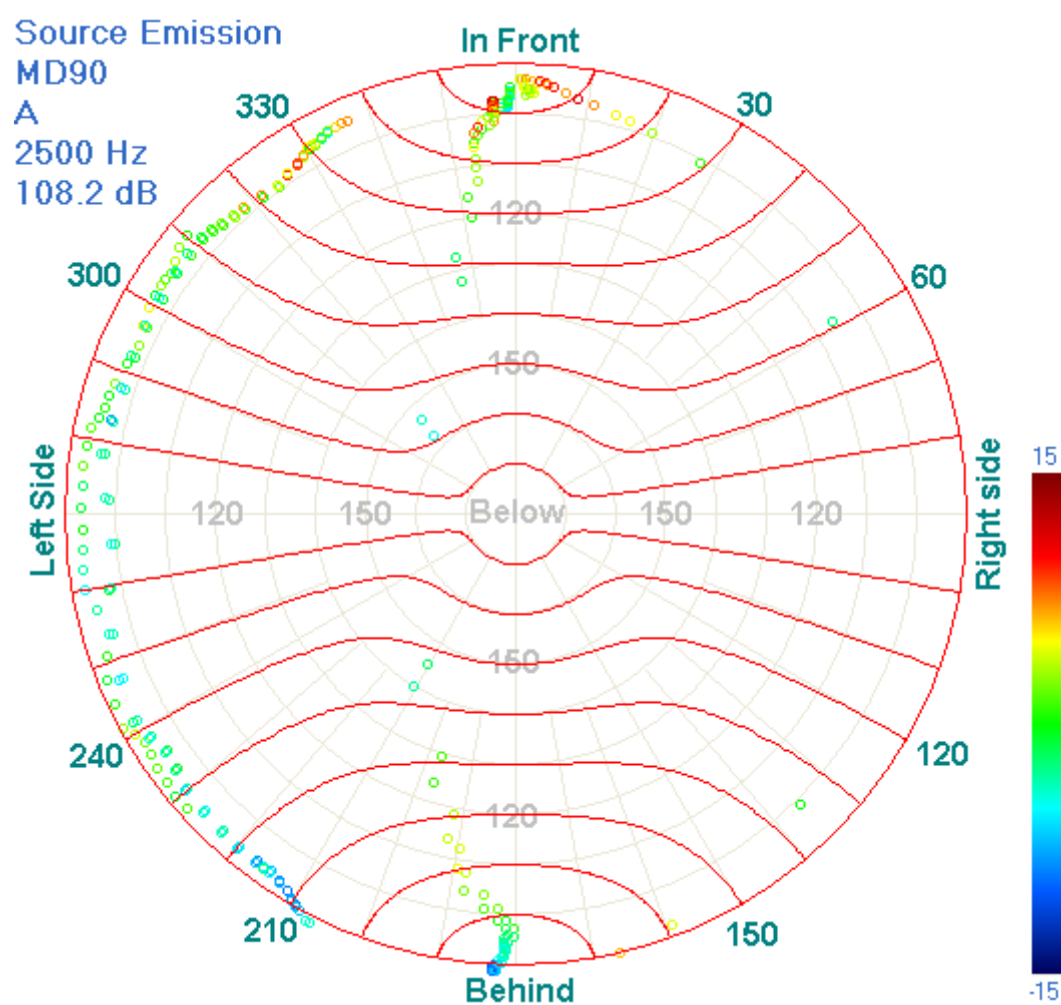


Source Emission  
MD90  
A  
1600 Hz  
109.6 dB

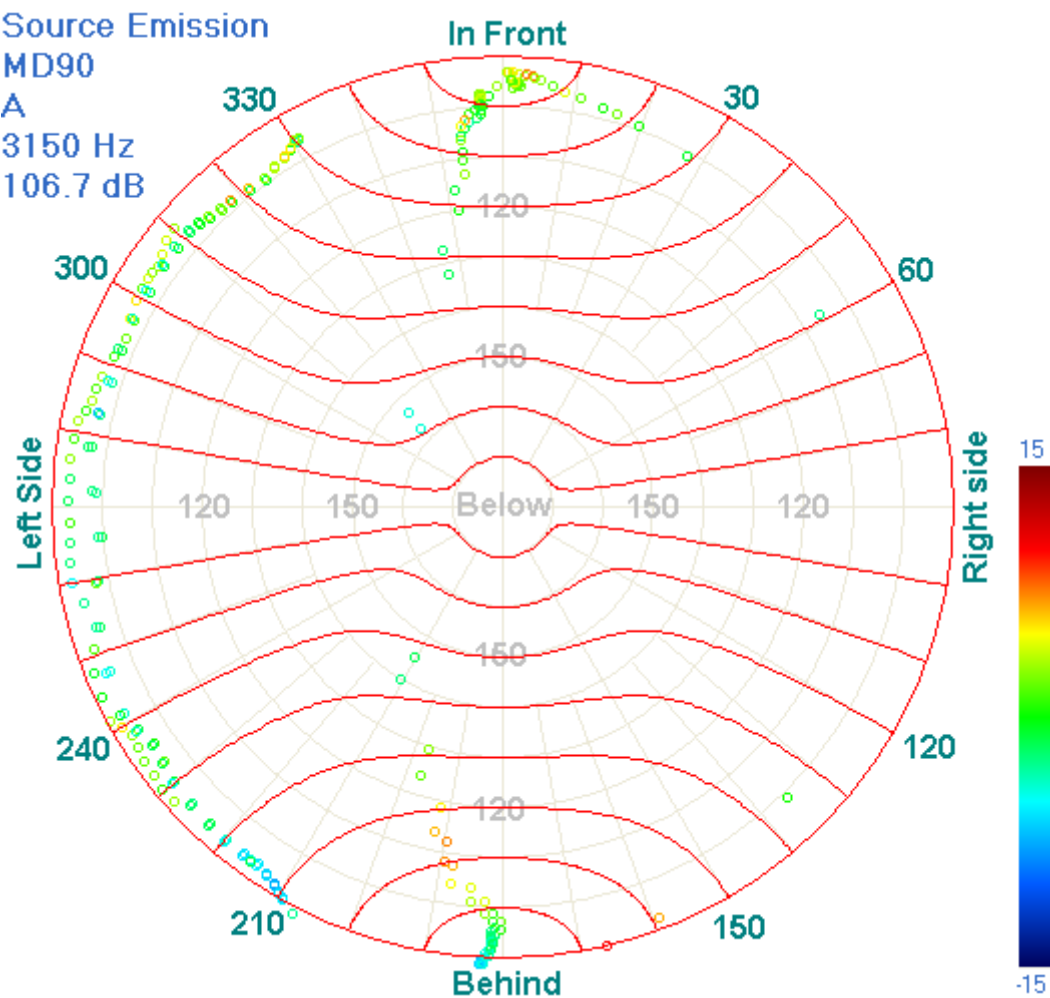




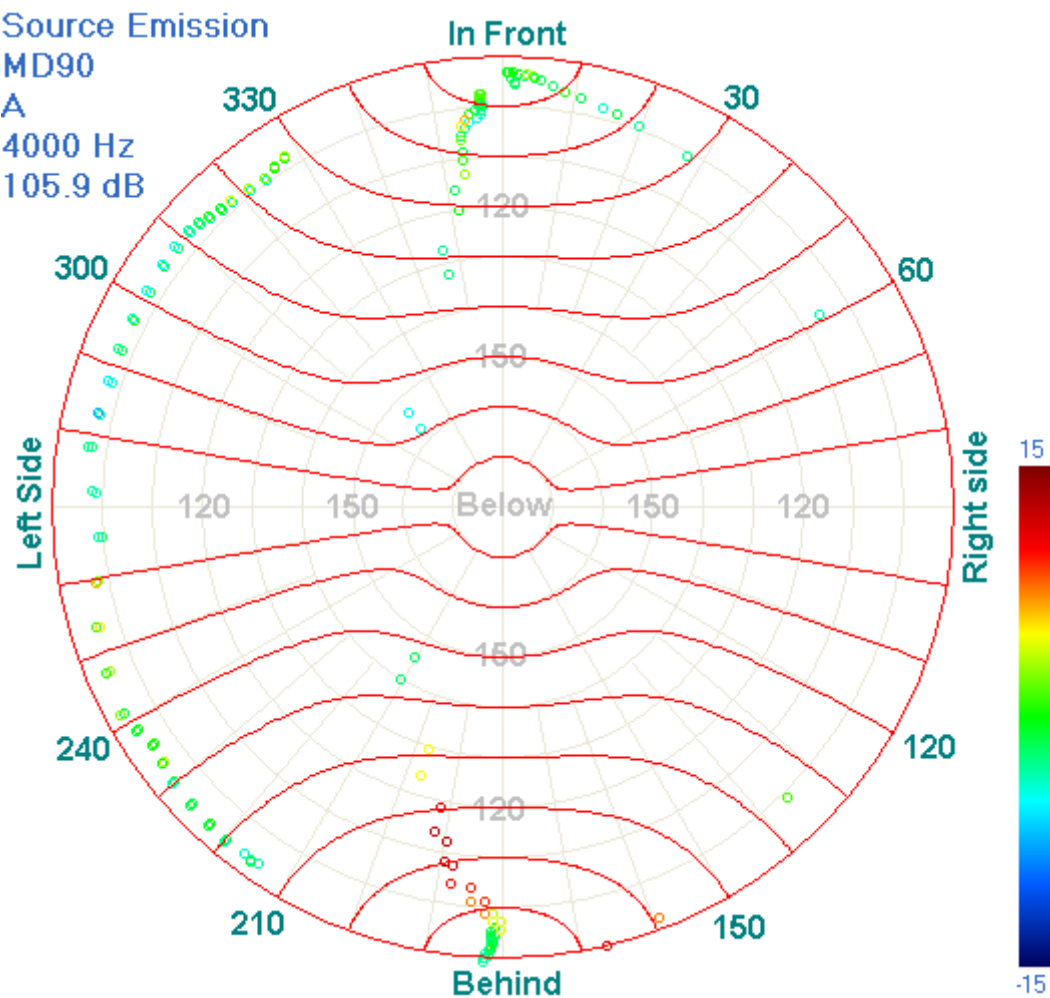




Source Emission  
MD90  
A  
3150 Hz  
106.7 dB



Source Emission  
MD90  
A  
4000 Hz  
105.9 dB



Source Emission  
MD90  
A  
5000 Hz  
105.5 dB

