Array Methods: DLR 1

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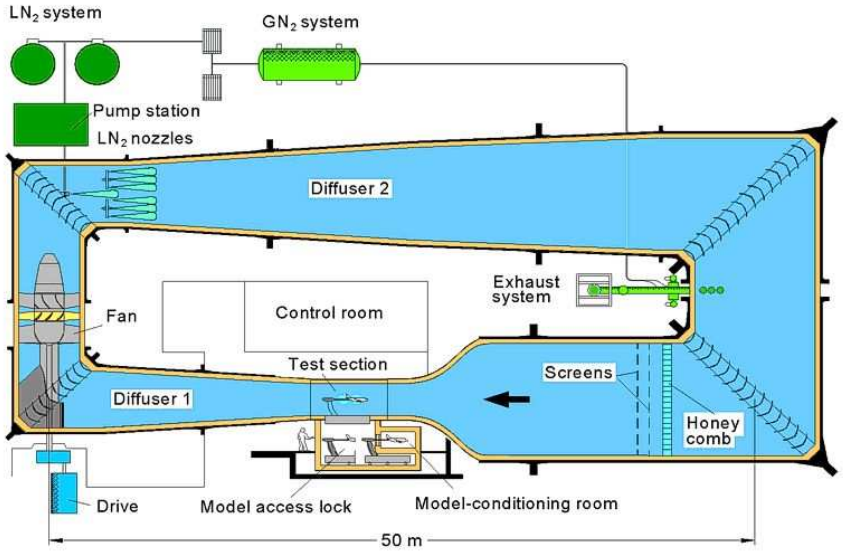
Overview

- Measurement Setup
- Model Details and Potential Sources
- Comparison of Contributions
- Conclusion

Measurement Setup: Wind Tunnel

- Cryogenic wind tunnel located at the DLR Cologne Site (DNW-KKK)



- Göttingen type wind tunnel
- 2.4 m x 2.4 m closed test section
- 300 K > T > 100 K ; 0.1 < Ma < 0.38

Measurement Setup: Array and Model

Microphone array

- 144 microphones (135 used)
- arranged in spiral arms

DO–728 half model

- scale: 1 : 9.24
- ½ - spanwidth: 1.44 m
- chord length: 0.338 m
- no transition fixation on slat

Measurement parameter

- angle of attack: 3°, 5°, 9°
- Mach number: 0.125, 0.2, 0.25
- temperature: ~ 290 K

DO-728 half-model at landing configuration

Model Details and Potential Noise Sources

flap

flap track

flap side edge/flap tip

leading edge slat

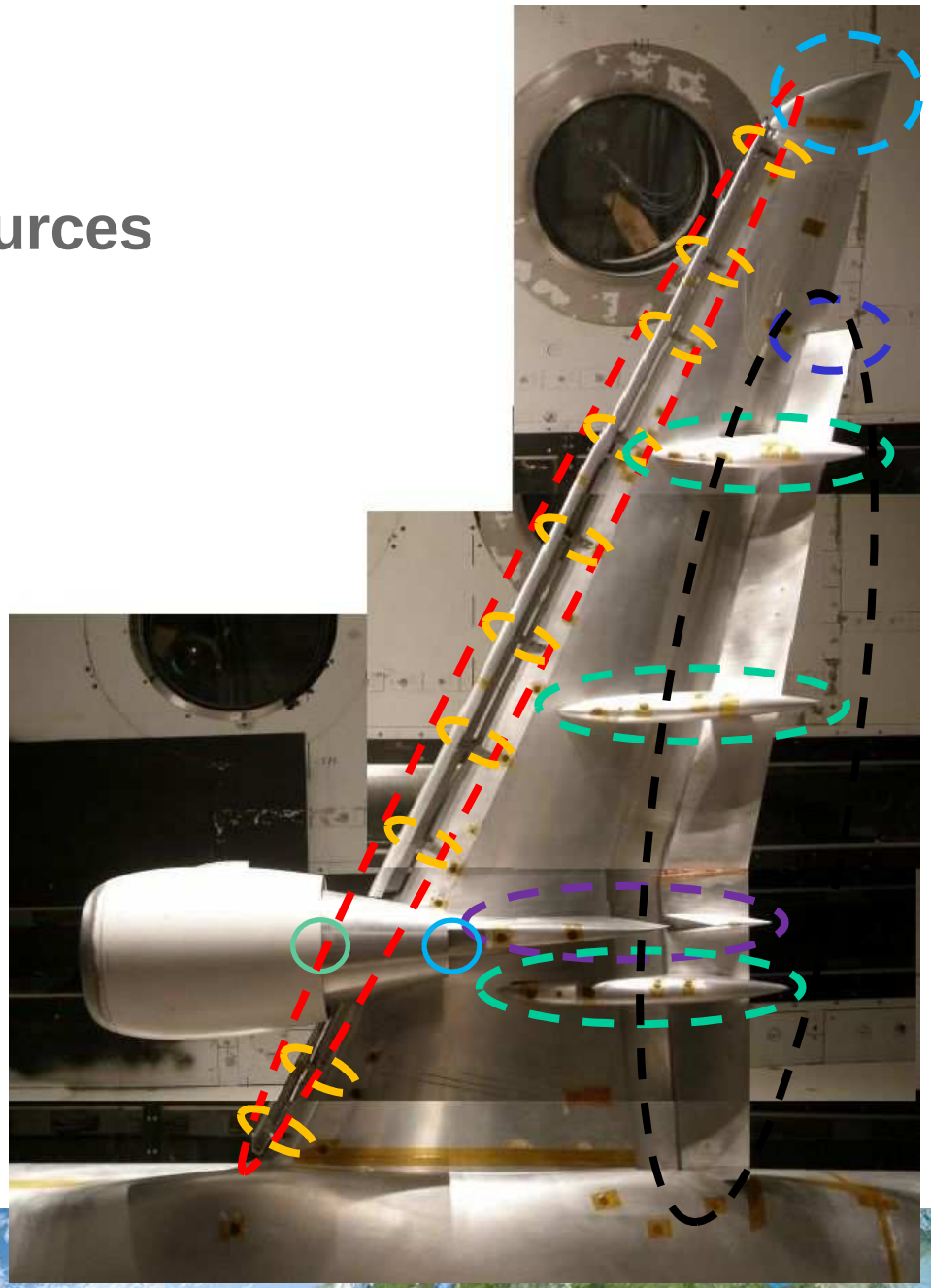
slat track

wing tip

core noozle

fan noozle

engine mount

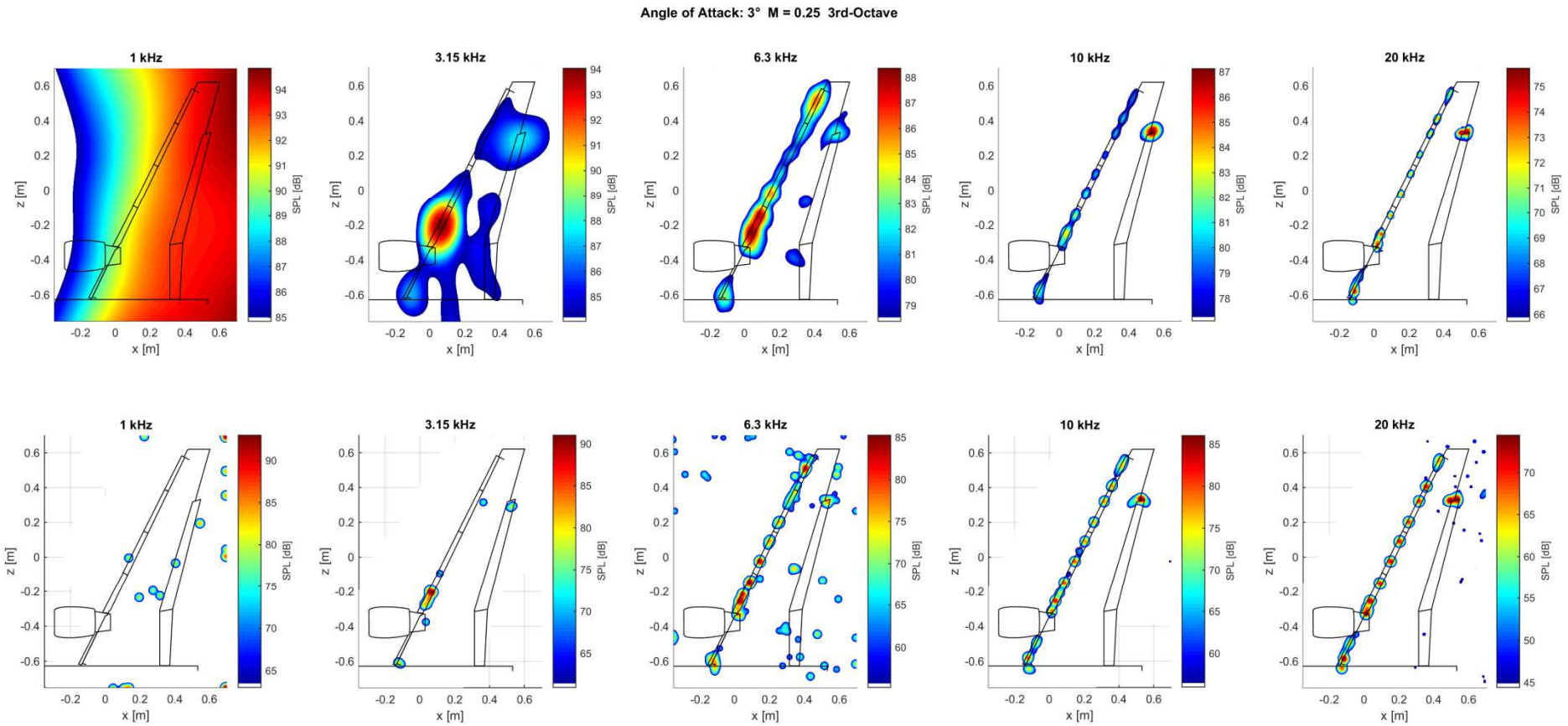


Available Data at TU-Cottbus Server

1) Data
   - Time Data (*_TimeSeriesEssential.h5)
   - CSM Data (*. _CsmEssential.h5)

2) Results
   - Standard Dirty Maps (*_CsmOptional_dx_0.01_DirtyMap.h5)
   - CleanSC Maps (*_CsmOptional_dx_0.01_CleanSC.h5)
   - Resolution
     $\Delta x = 0.01m\ (\sim 15k\ Pts.), 0.02m\ (\sim 4k\ Pts.), 0.05m\ (\sim 700\ Pts)$

Overview of Sources

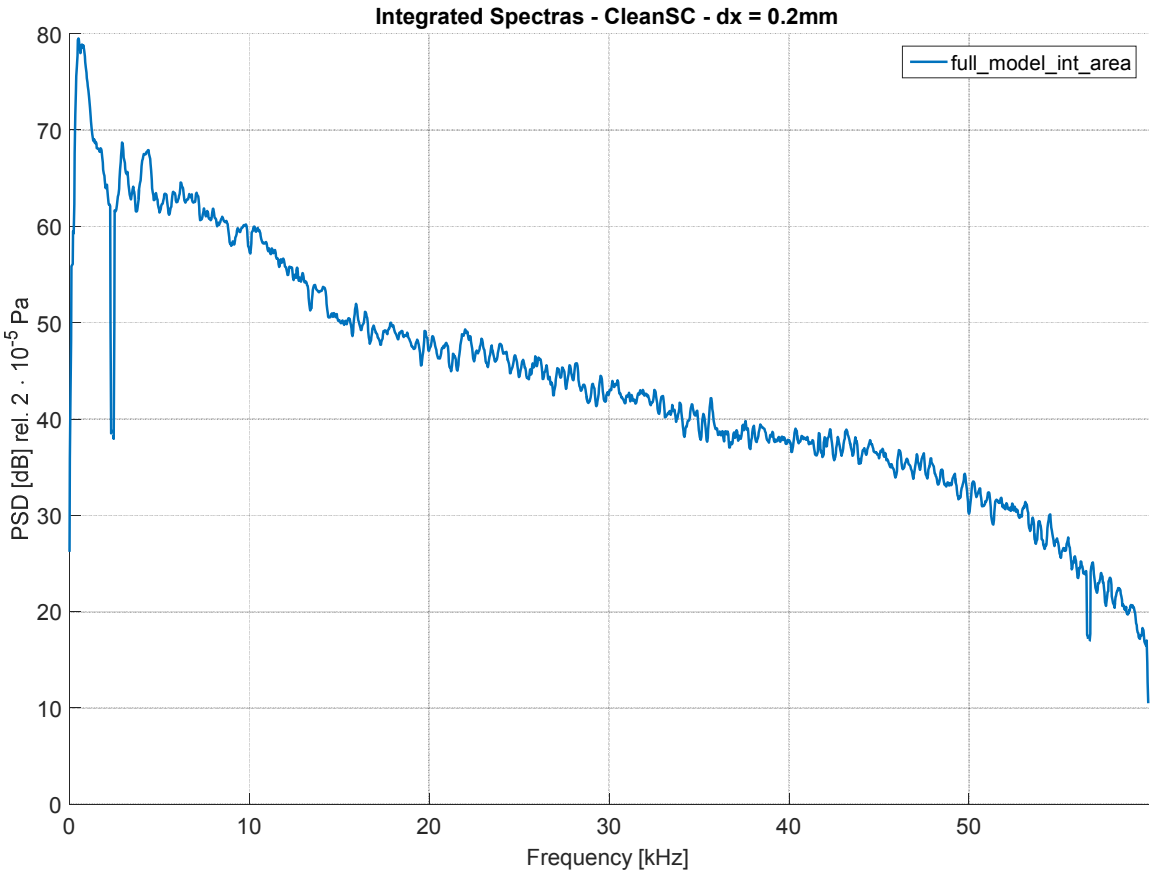


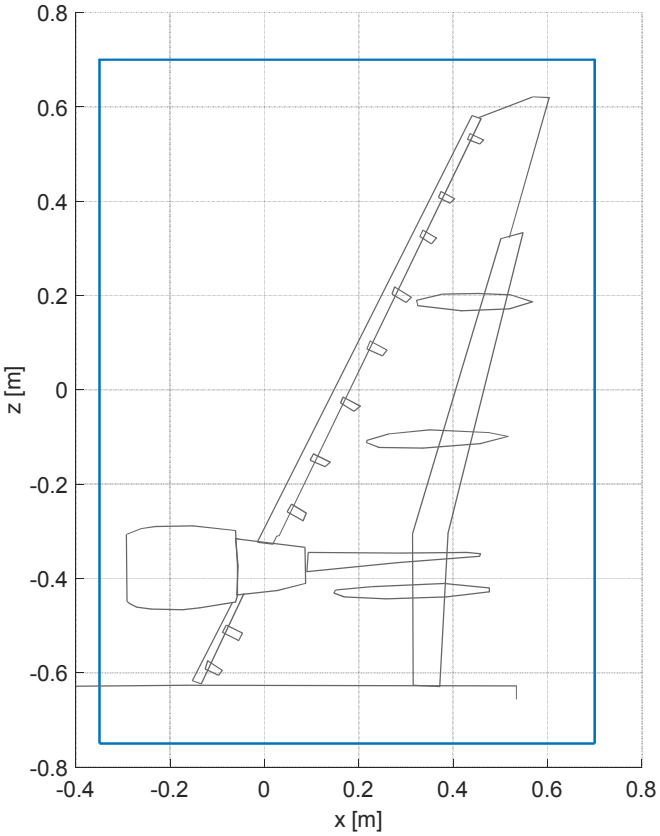
Upper row: Frequency-domain beamforming (Dynamic: 10 dB)

Lower row: CleanSC (Dynamic: 30 dB)

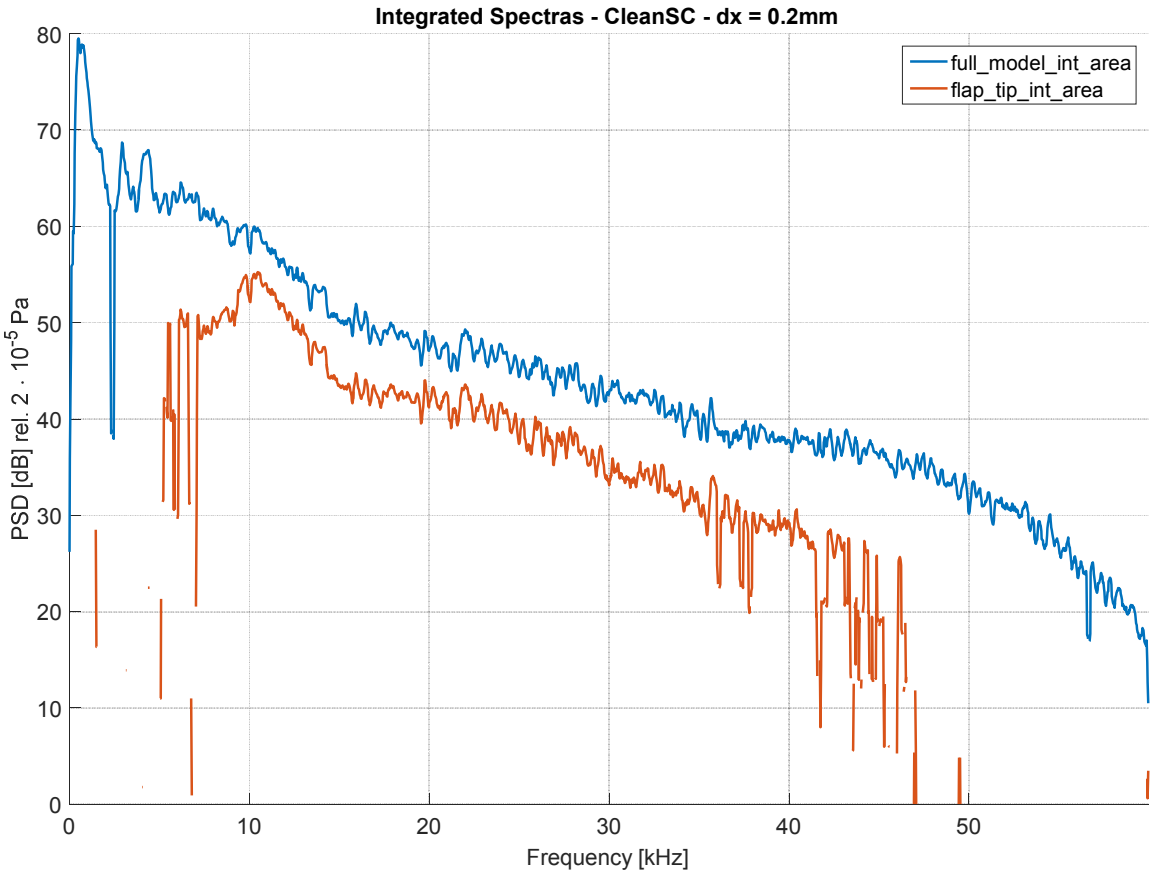
Resolution $\Delta x = 0.01m$

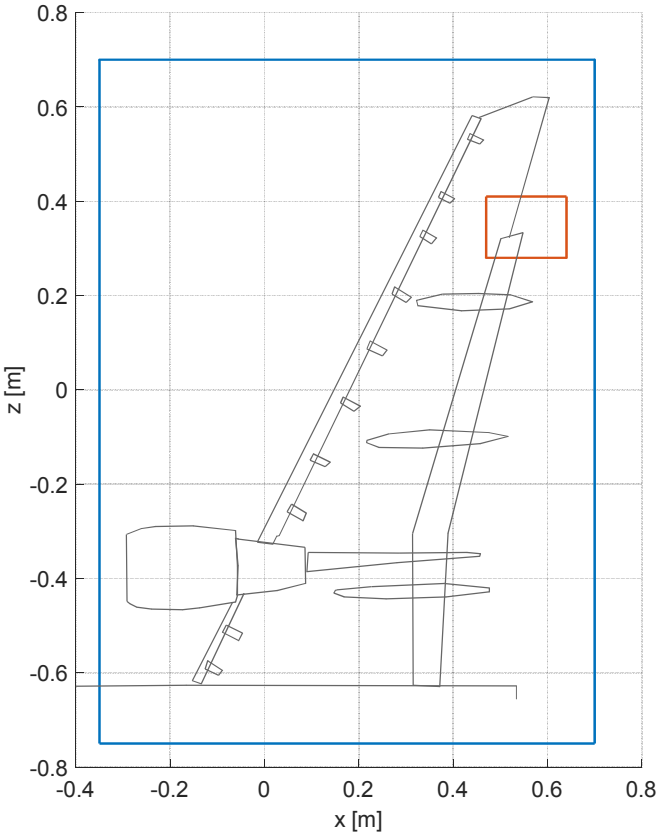
Integrated Spectra of Deconvoluted Source Maps





Integrated Spectra of Deconvoluted Source Maps





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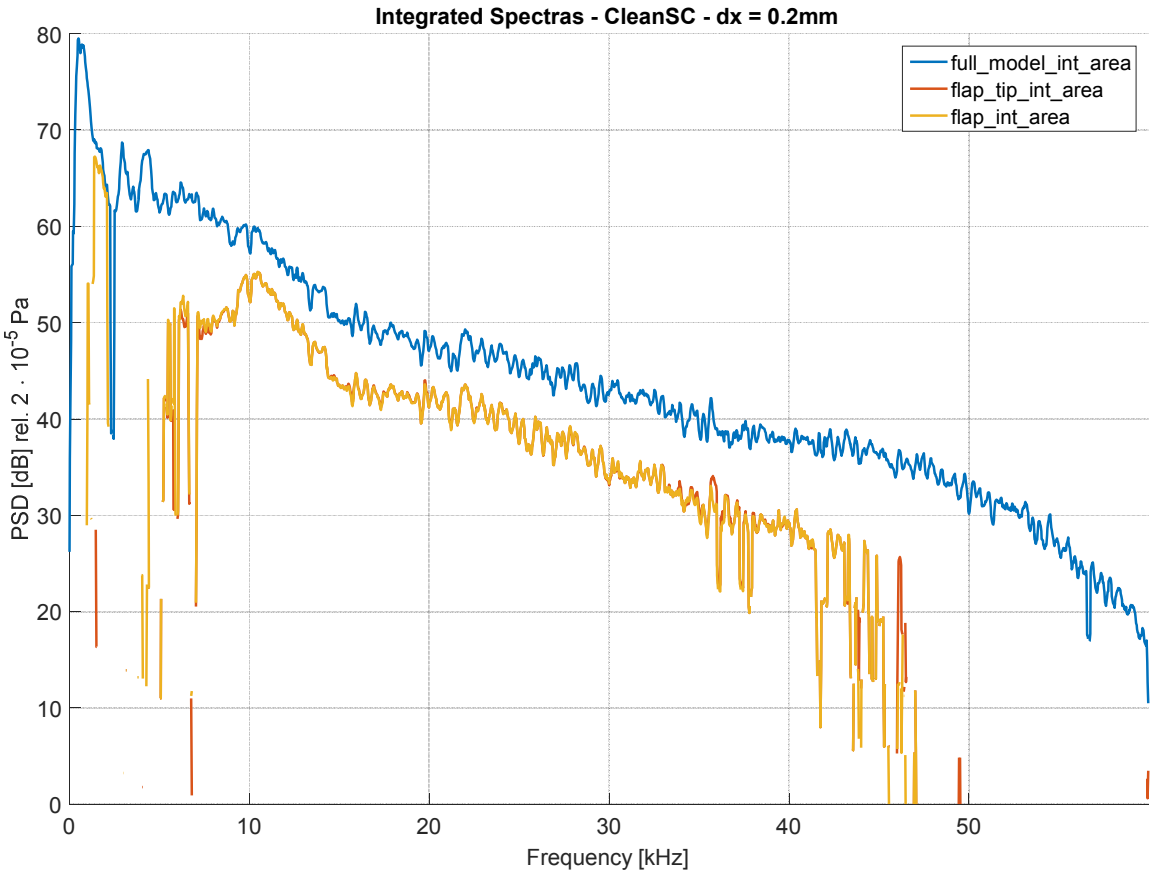
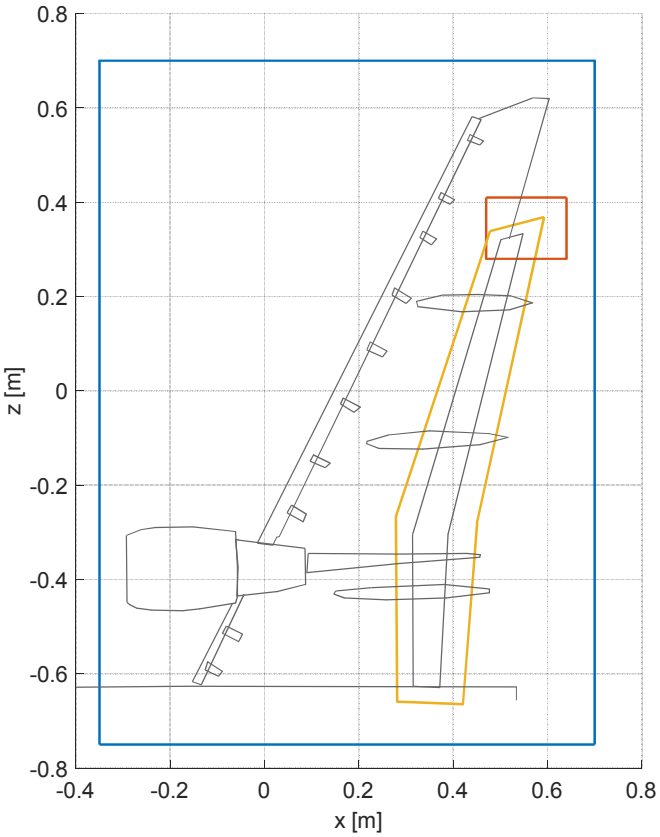
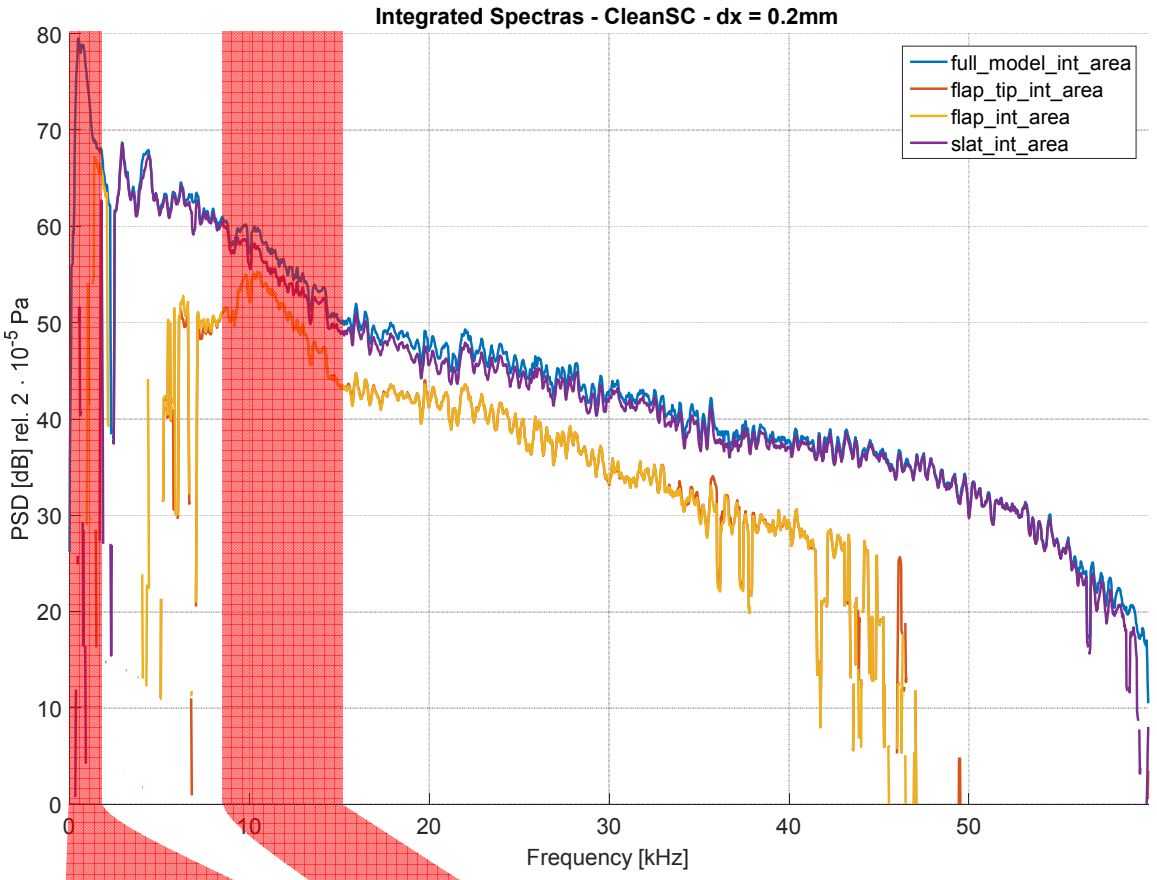
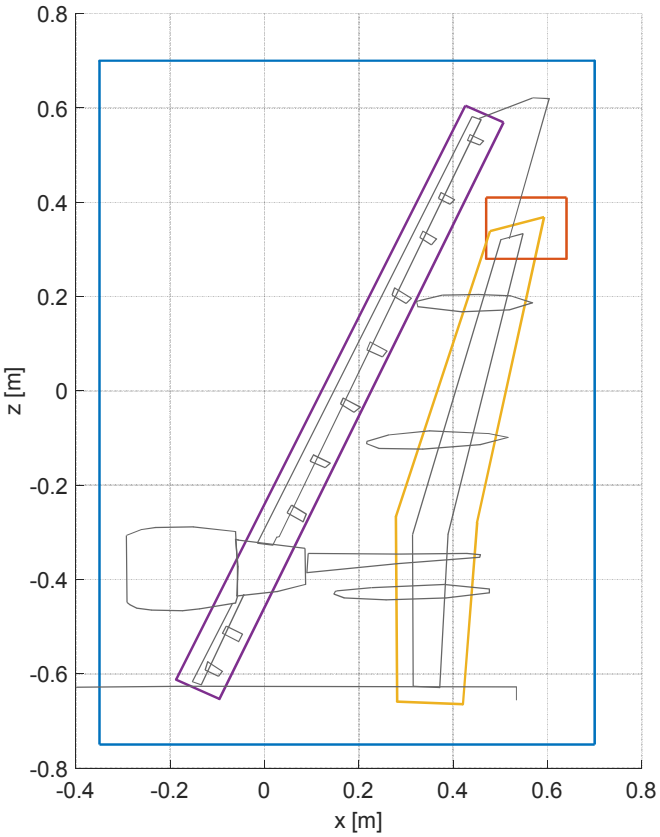




Integrated Spectra of Deconvoluted Source Maps





Windtunnel noise

Flap tip

Beamforming Maps

low resolution (high computational effort due to deconvolution)

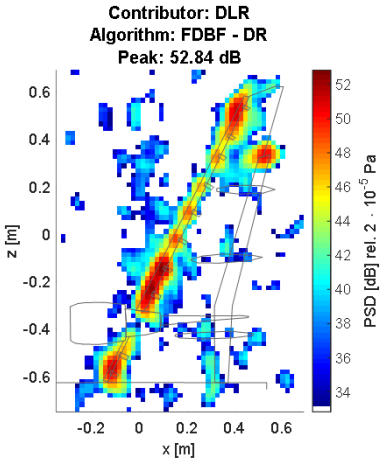
Contributors:

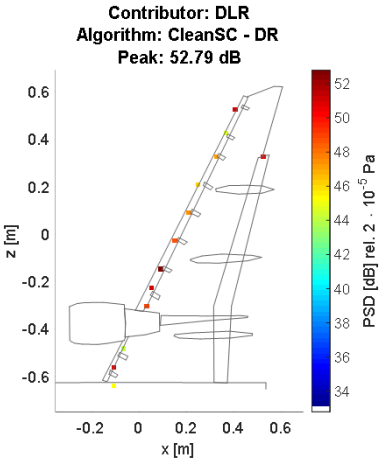
Chris Bahr, *NASA*
DAMAS and derivatives

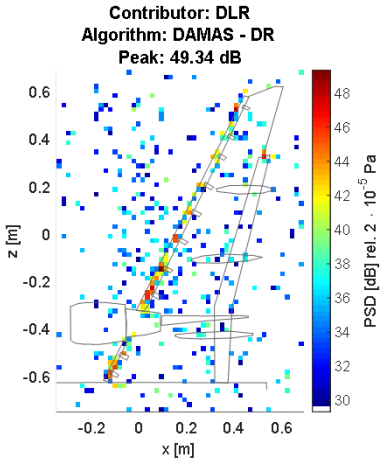
Antonio Pereira, *University of Lyon*
NNLS, Bayes

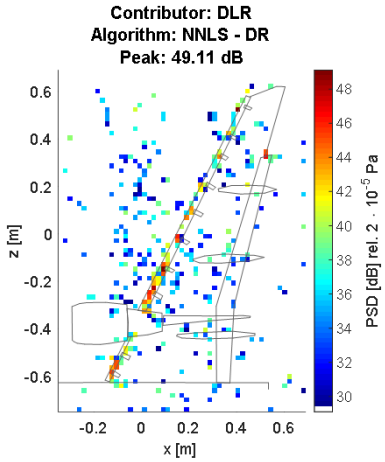
Daniel Ernst, *DLR*
DAMAS, FDBF, Functional, CleanSC, NNLS

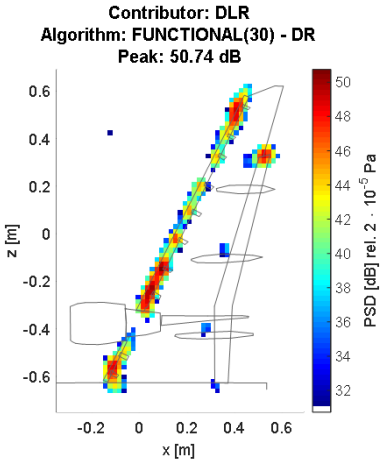
DLR

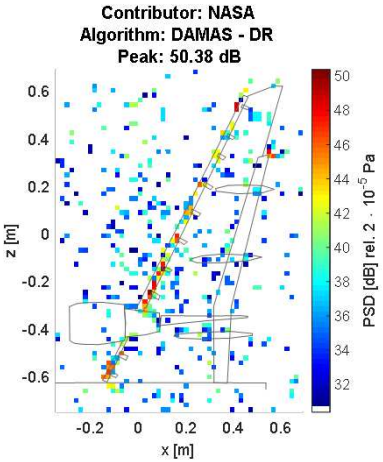


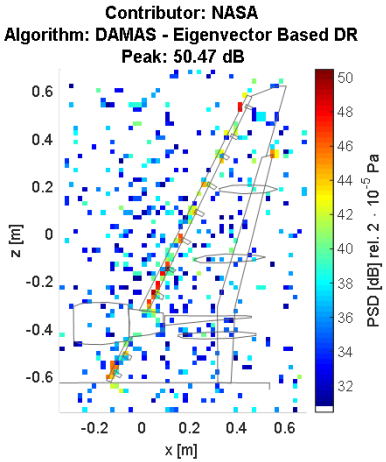


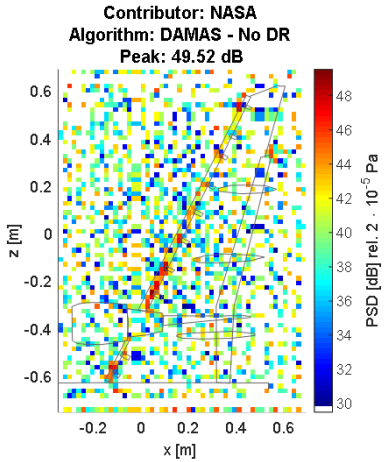


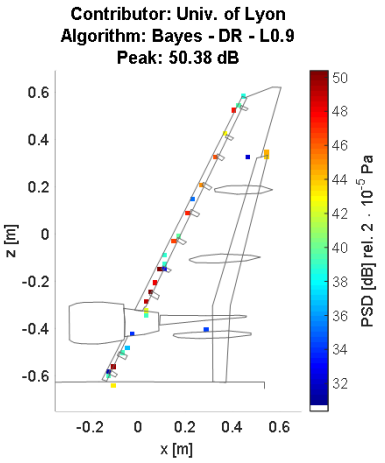


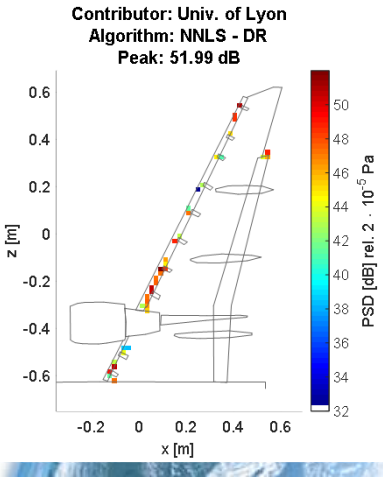










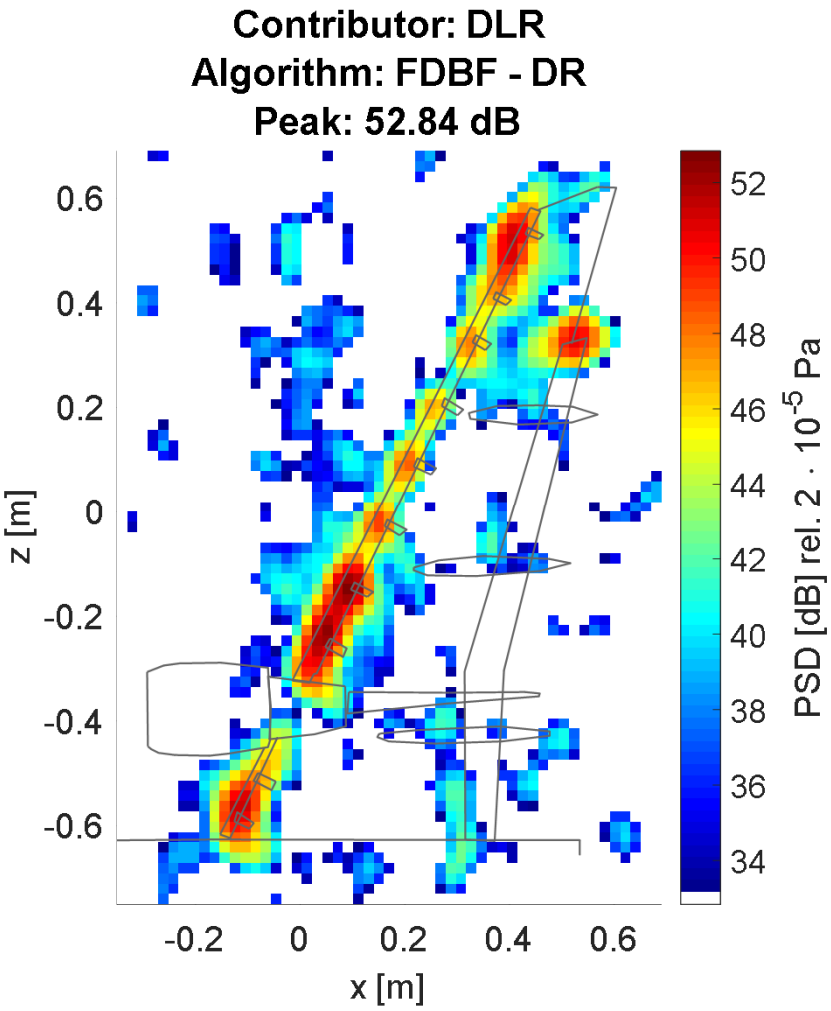


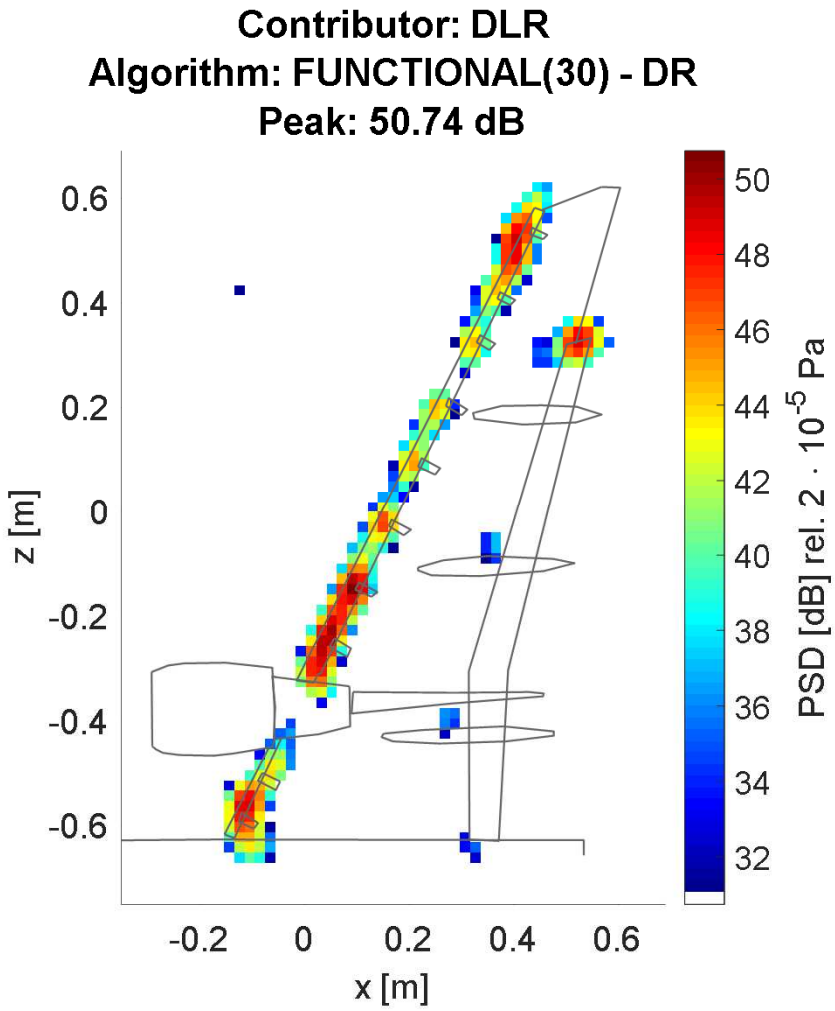
Narrow band source maps @ 8496 Hz

Dynamic range = 20 dB

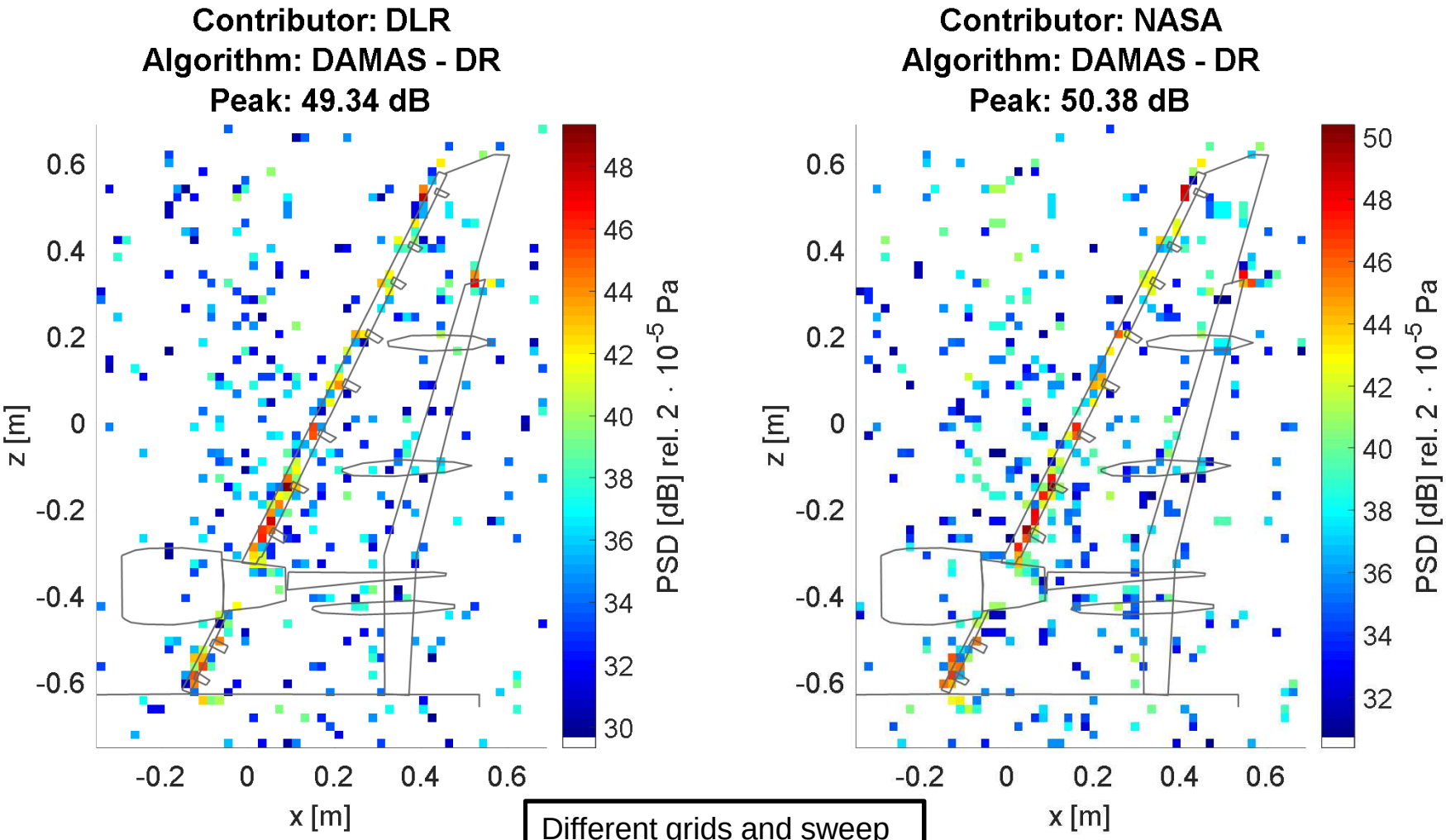
Grid resolution = 20 mm

Narrow Band Source Maps @ 8496 Hz
Dynamic Range = 20 dB
Grid Resolution = 20 mm





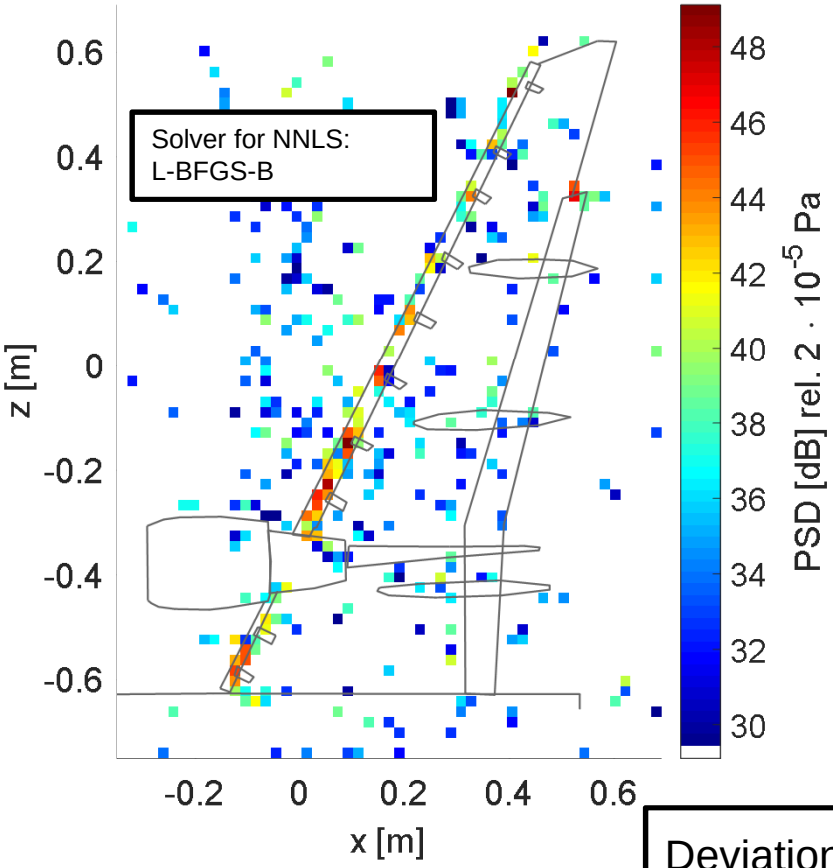
Narrow Band Source Maps @ 8496 Hz
Dynamic Range = 20 dB
Grid Resolution = 20 mm



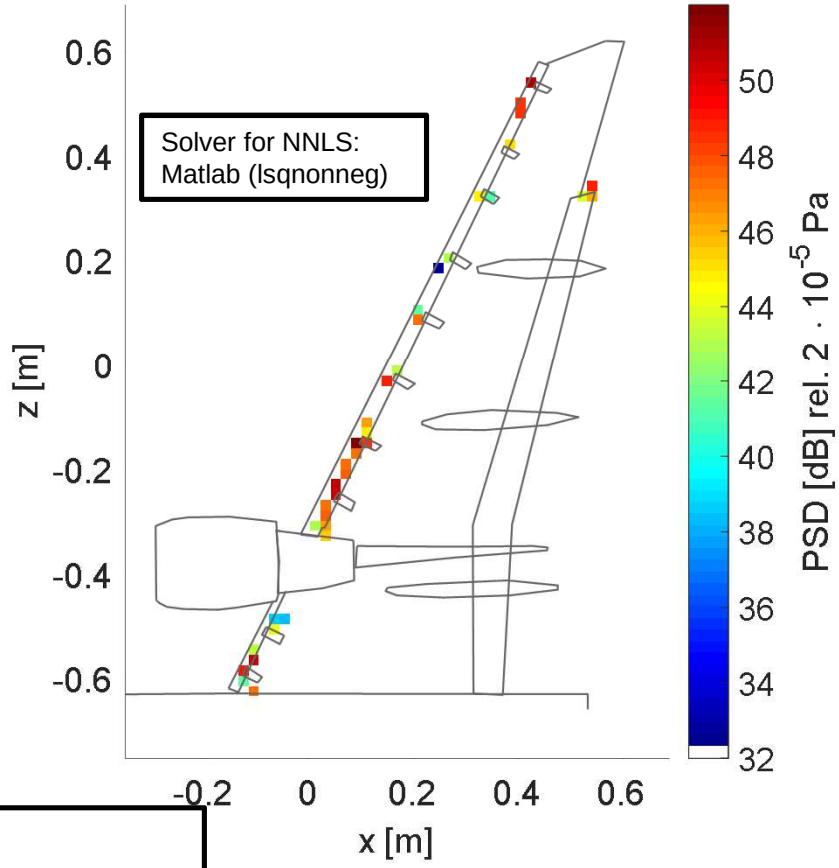
Different grids and sweep strategies where used.
Both 200 Iterations.

Narrow Band Source Maps @ 8496 Hz
Dynamic Range = 20 dB
Grid Resolution = 20 mm

Contributor: DLR
Algorithm: NNLS - DR
Peak: 49.11 dB



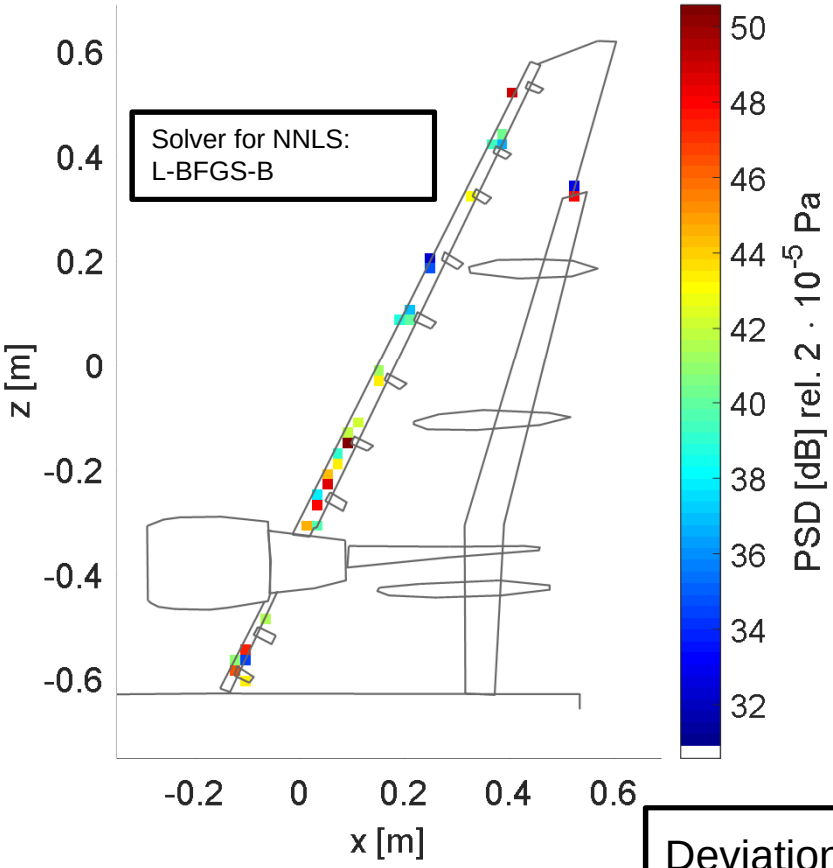
Contributor: Univ. of Lyon
Algorithm: NNLS - DR
Peak: 51.99 dB



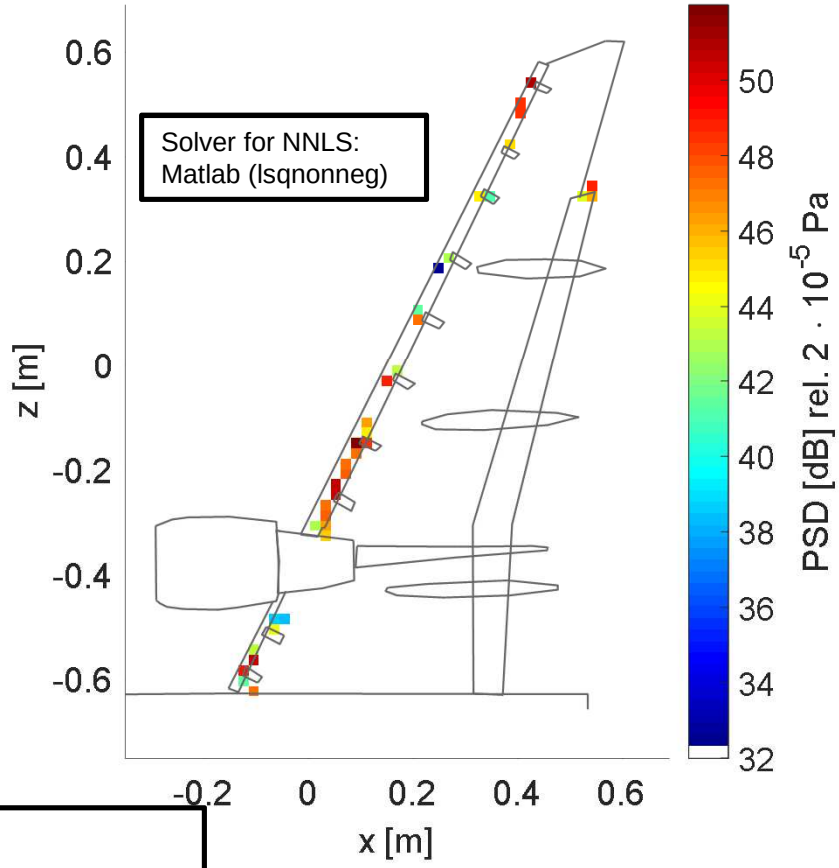
Deviations:
Maybe slightly different approach to compute the psf

Narrow Band Source Maps @ 8496 Hz
Dynamic Range = 20 dB
Grid Resolution = 20 mm

Contributor: DLR
Algorithm: NNLS - DR PSF>0 NoPsfDR
Peak: 50.58 dB



Contributor: Univ. of Lyon
Algorithm: NNLS - DR
Peak: 51.99 dB



Deviations:
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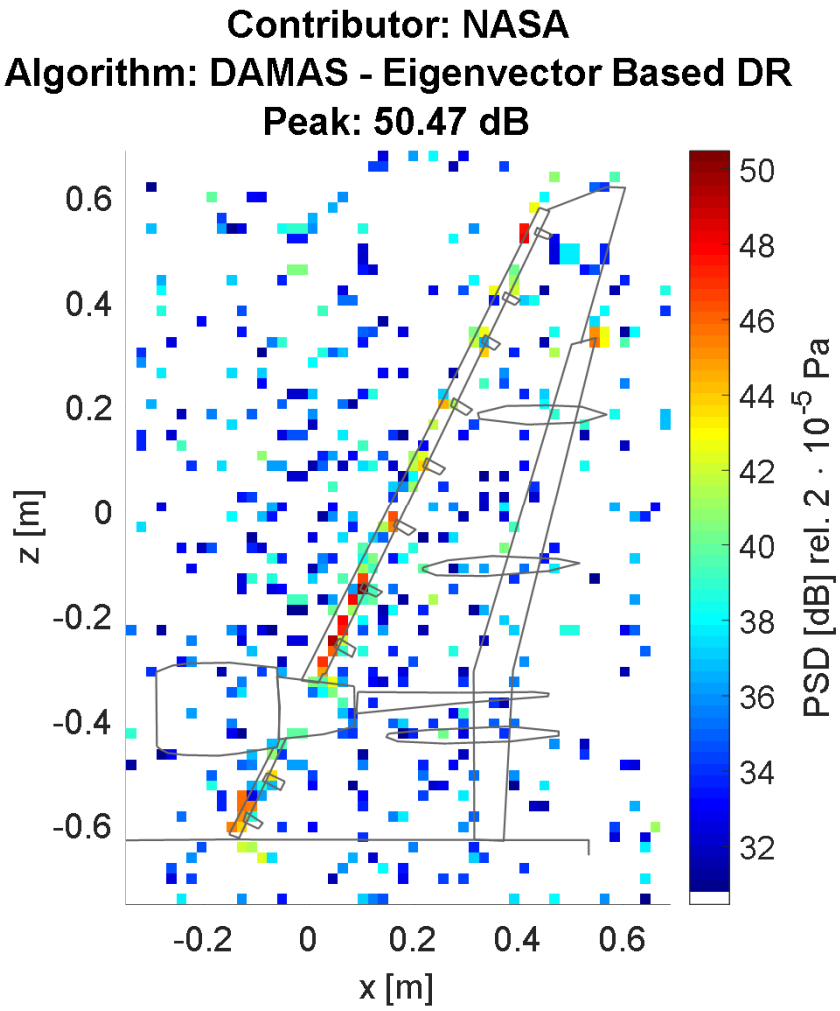
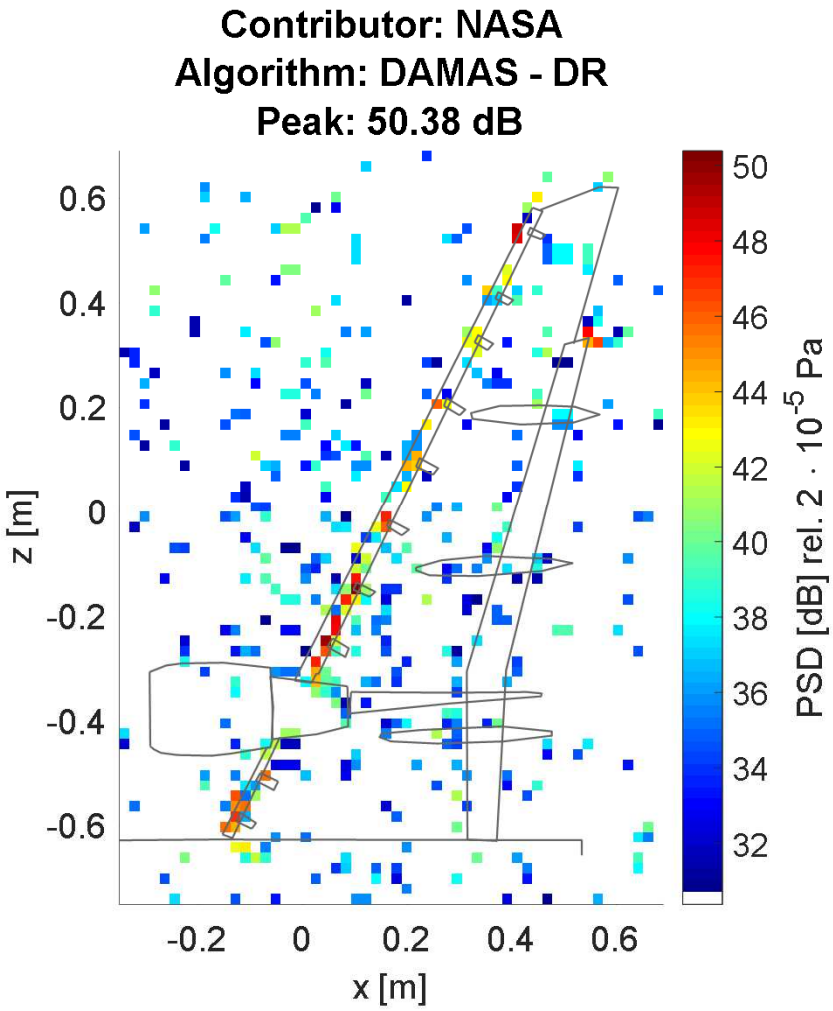
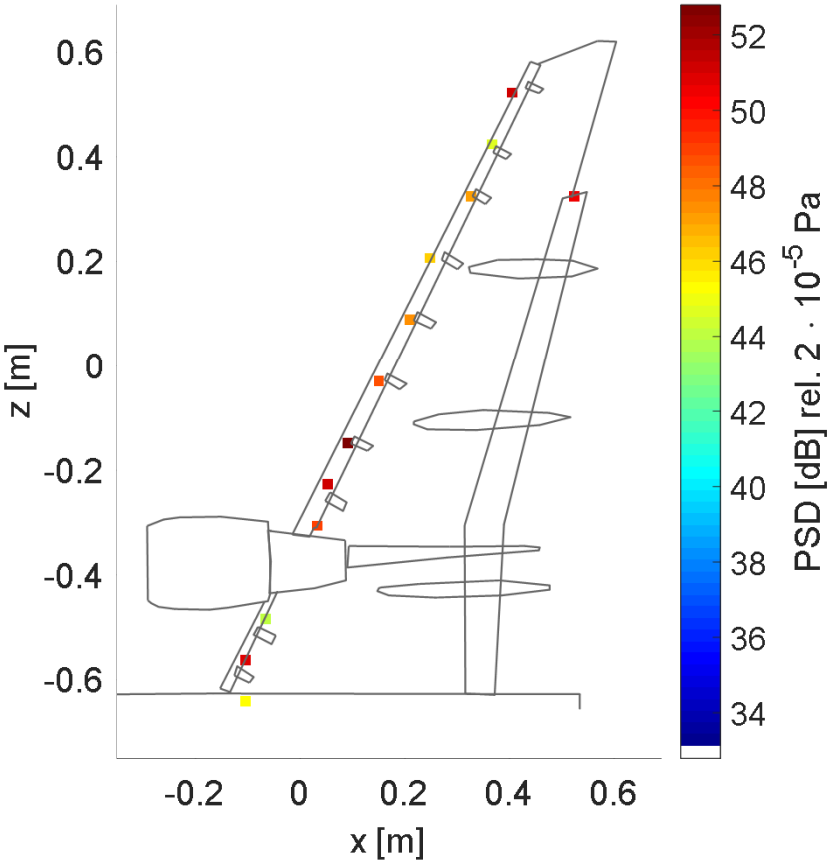
Narrow Band Source Maps @ 8496 Hz
Dynamic Range = 20 dB
Grid Resolution = 20 mm



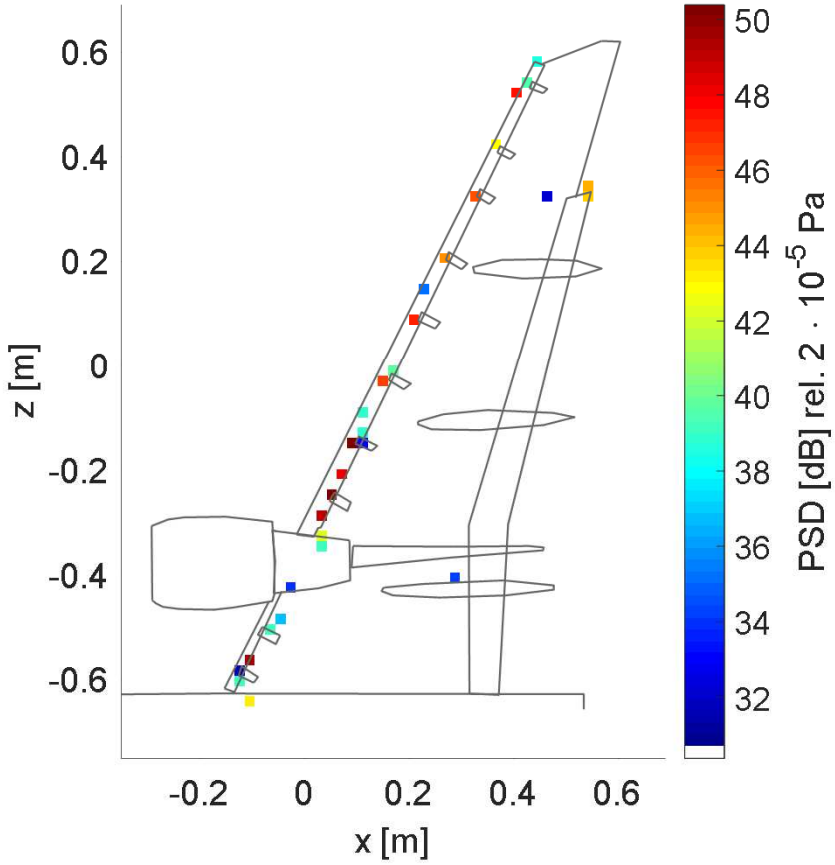


Narrow Band Source Maps @ 8496 Hz
Dynamic Range = 20 dB
Grid Resolution = 20 mm

Contributor: DLR
Algorithm: CleanSC - DR
Peak: 52.79 dB

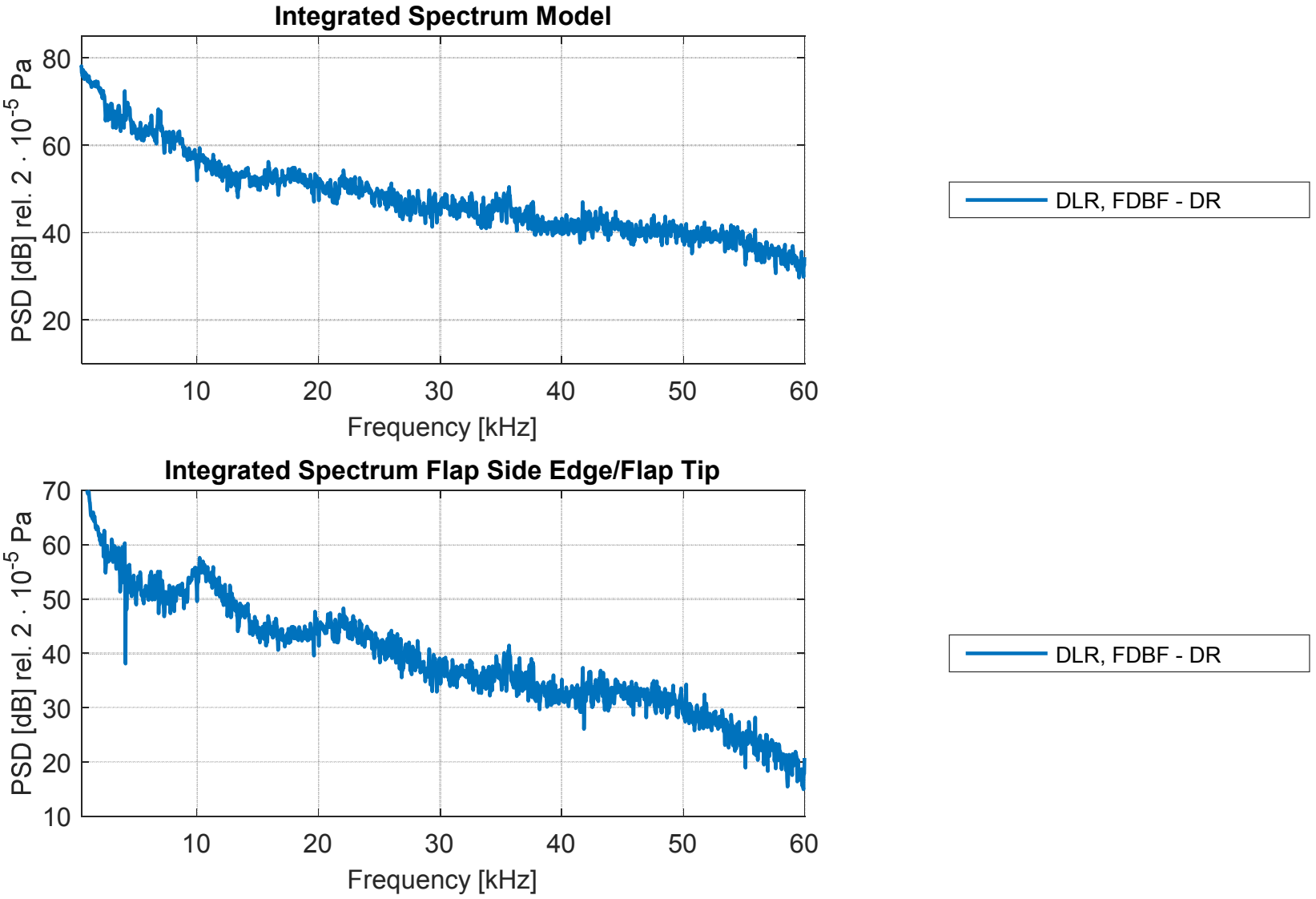


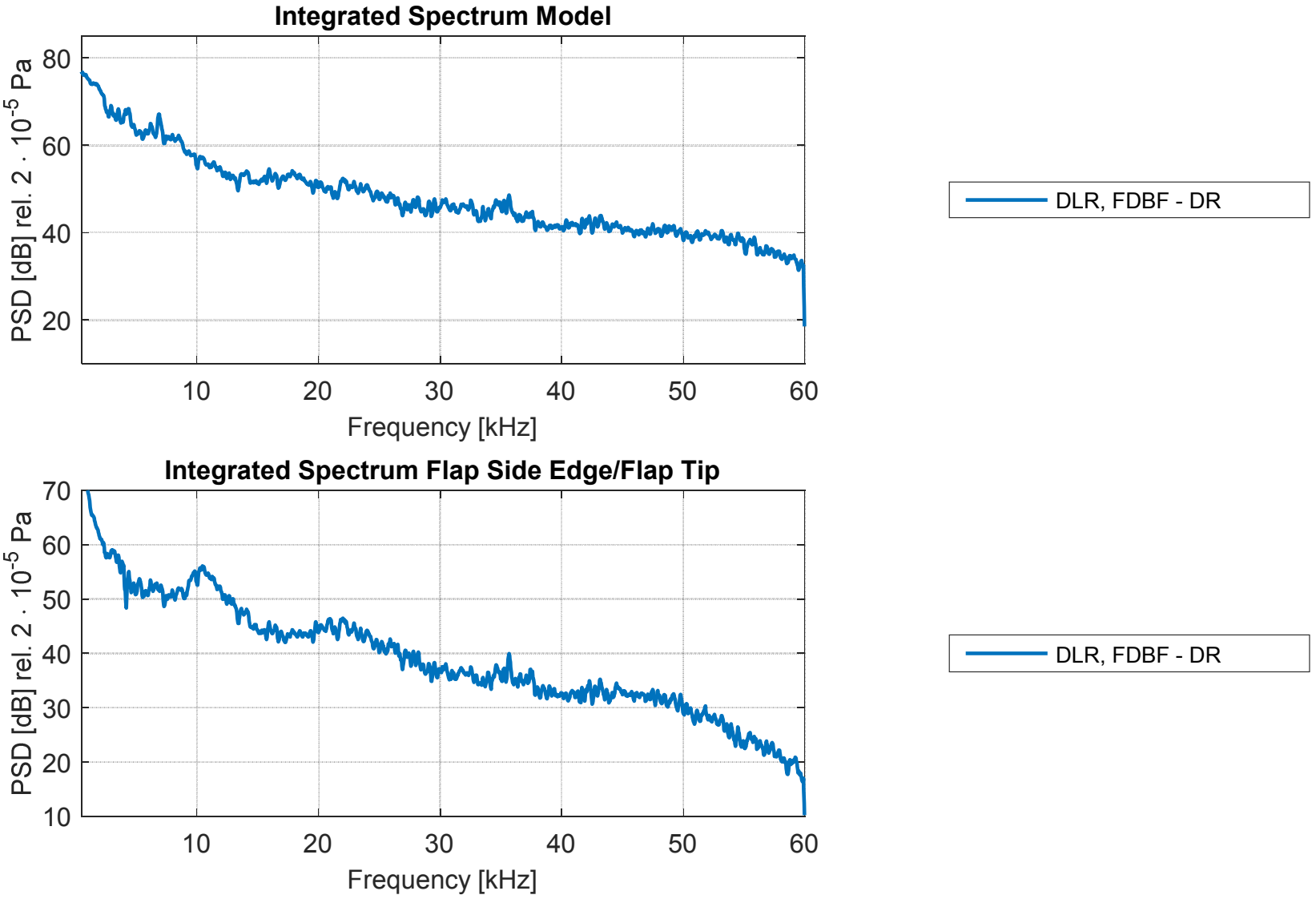
Contributor: Univ. of Lyon
Algorithm: Bayes - DR - L0.9
Peak: 50.38 dB



DLR

Integrated Spectra


Integrated Spectrum Model
PSD [dB] rel. 2 · 10^-5 Pa
80
60
40
20
10
20
30
40
50
60
Frequency [kHz]
DLR, FDBF - DR
Integrated Spectrum Flap Side Edge/Flap Tip
PSD [dB] rel. 2 · 10^-5 Pa
70
60
50
40
30
20
10
10
20
30
40
50
60
Frequency [kHz]
DLR, FDBF - DR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Frequency [kHz]
DLR, FDBF - DR
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30
20
10
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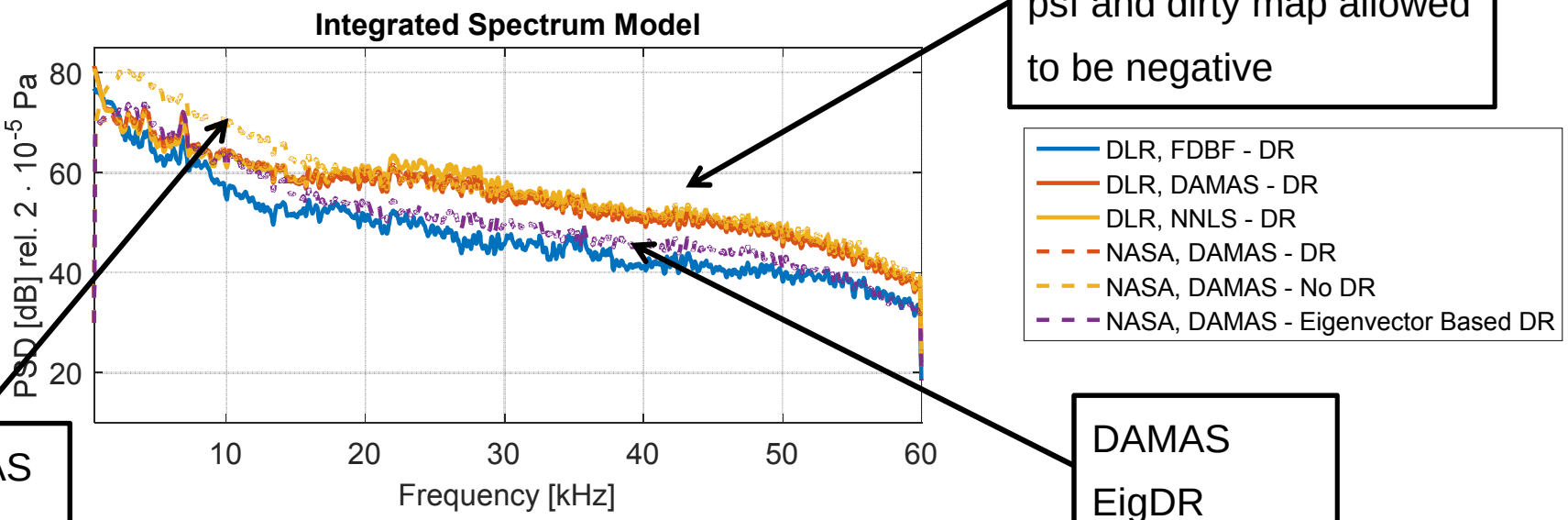
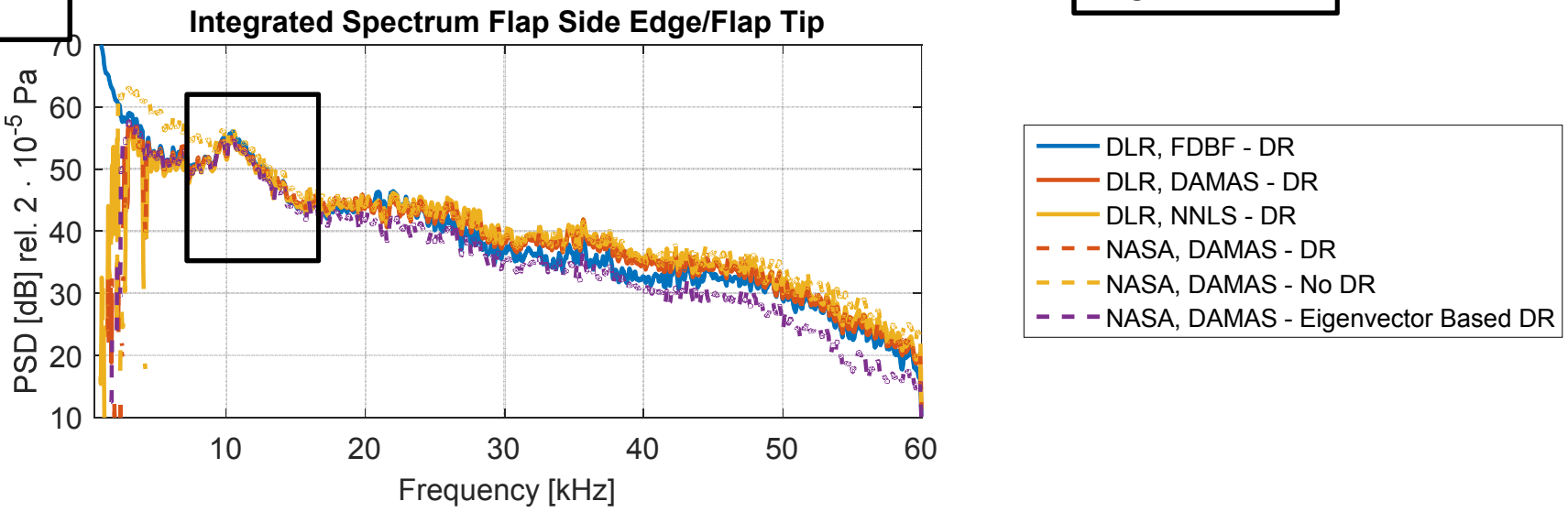
20
30
40
50
60
Frequency [kHz]
DLR, FDBF - DR

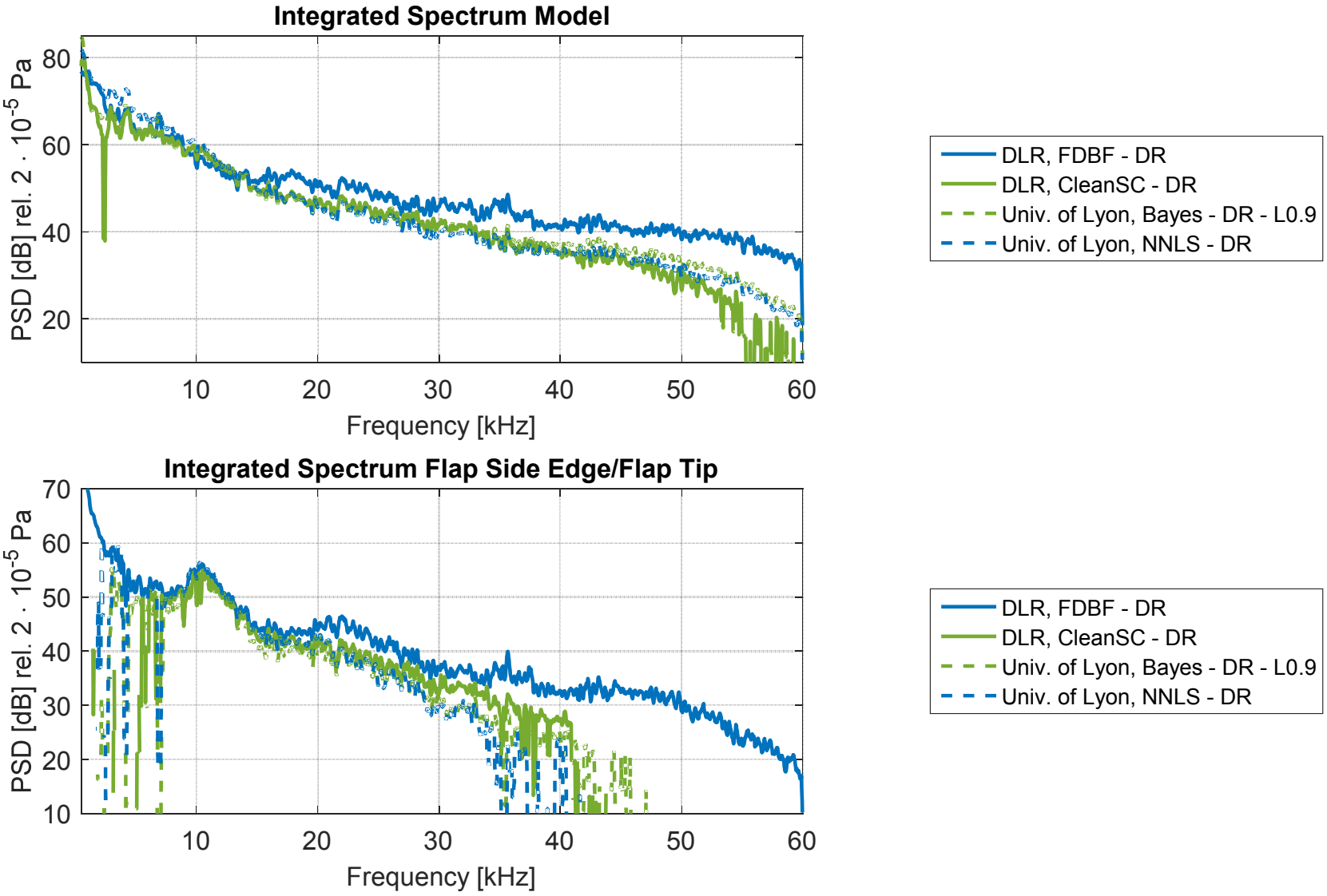
DAMAS NASA/DLR
psf and dirty map allowed
to be negative

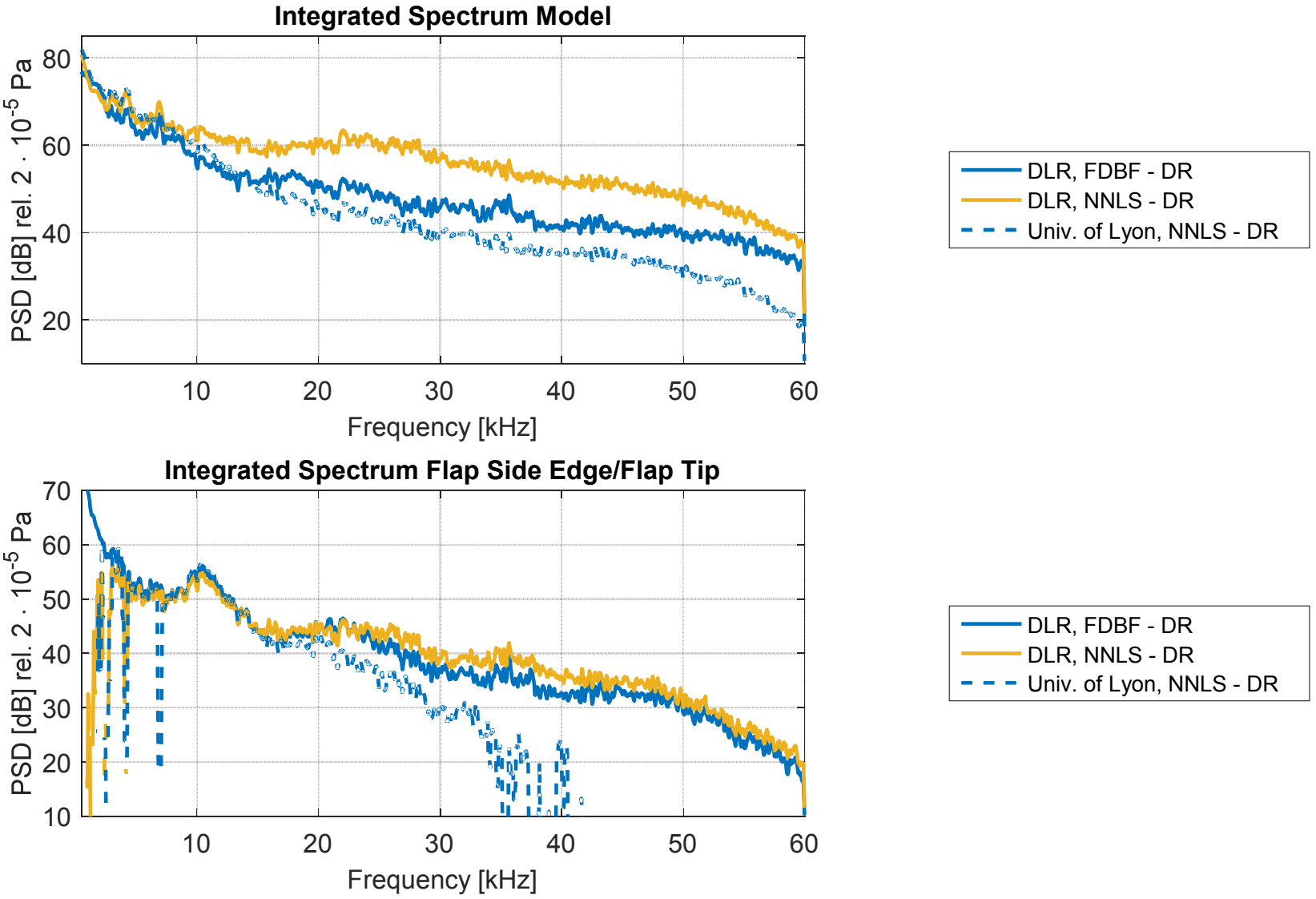


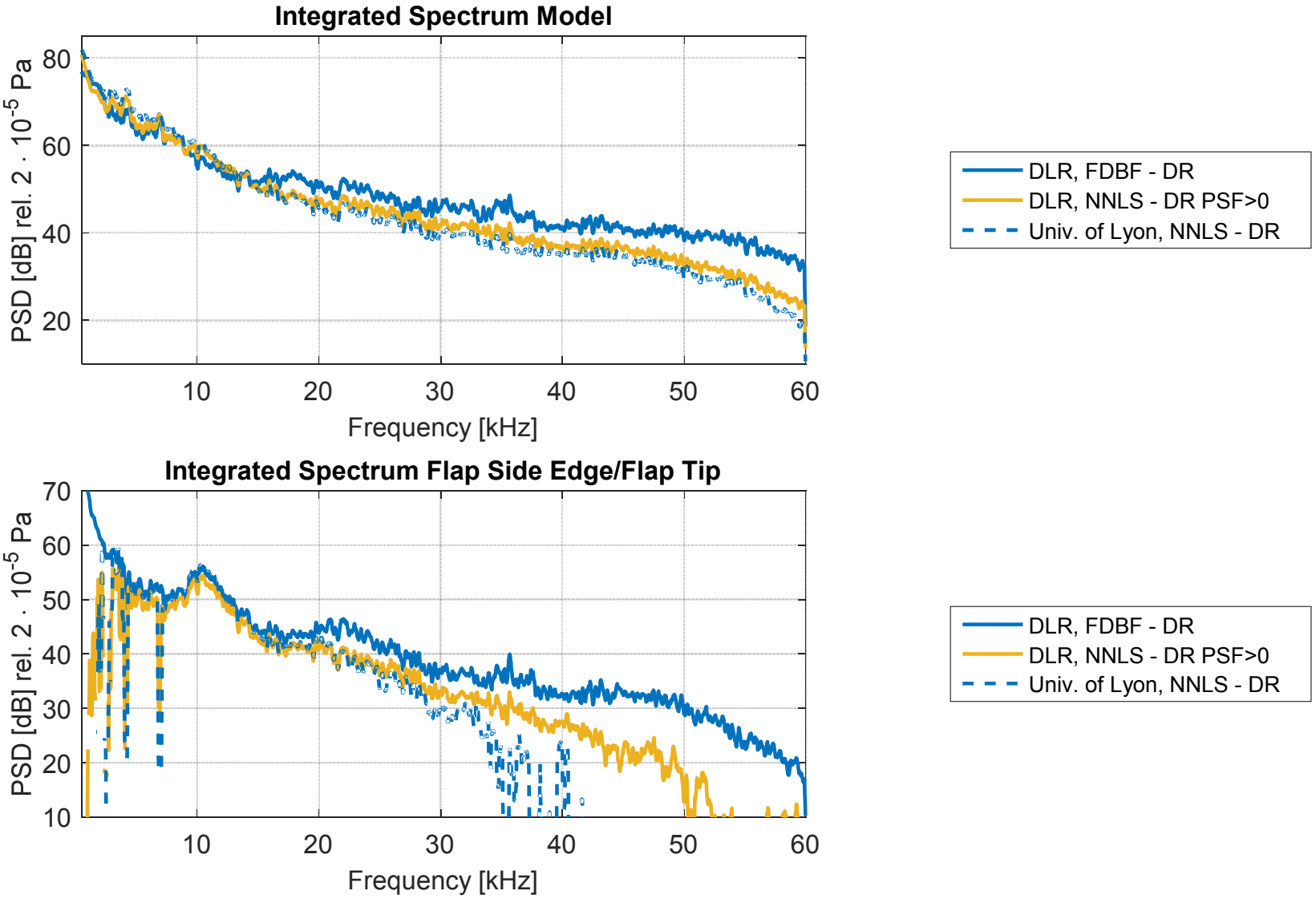
DAMAS
NoDR

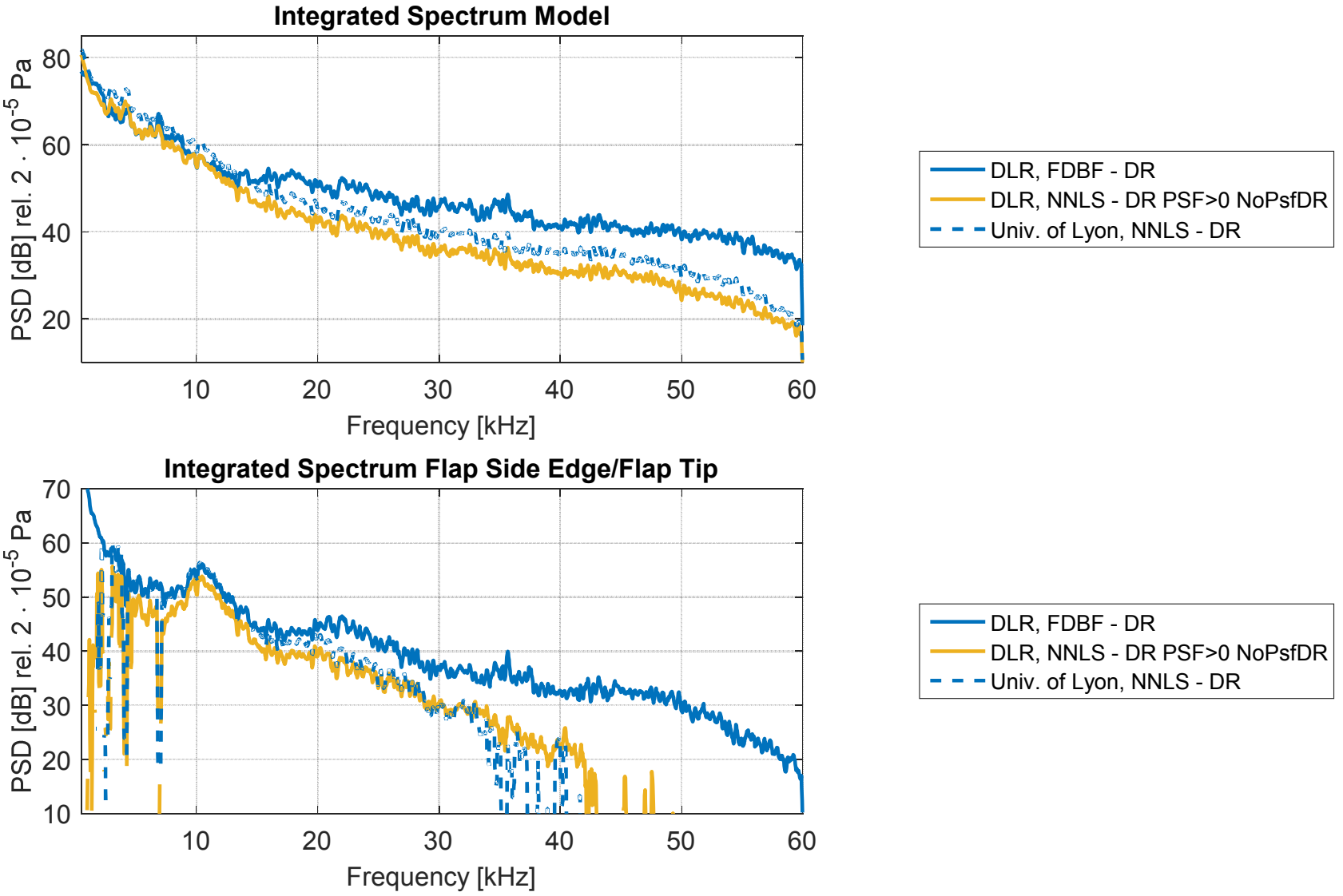
DAMAS
EigDR

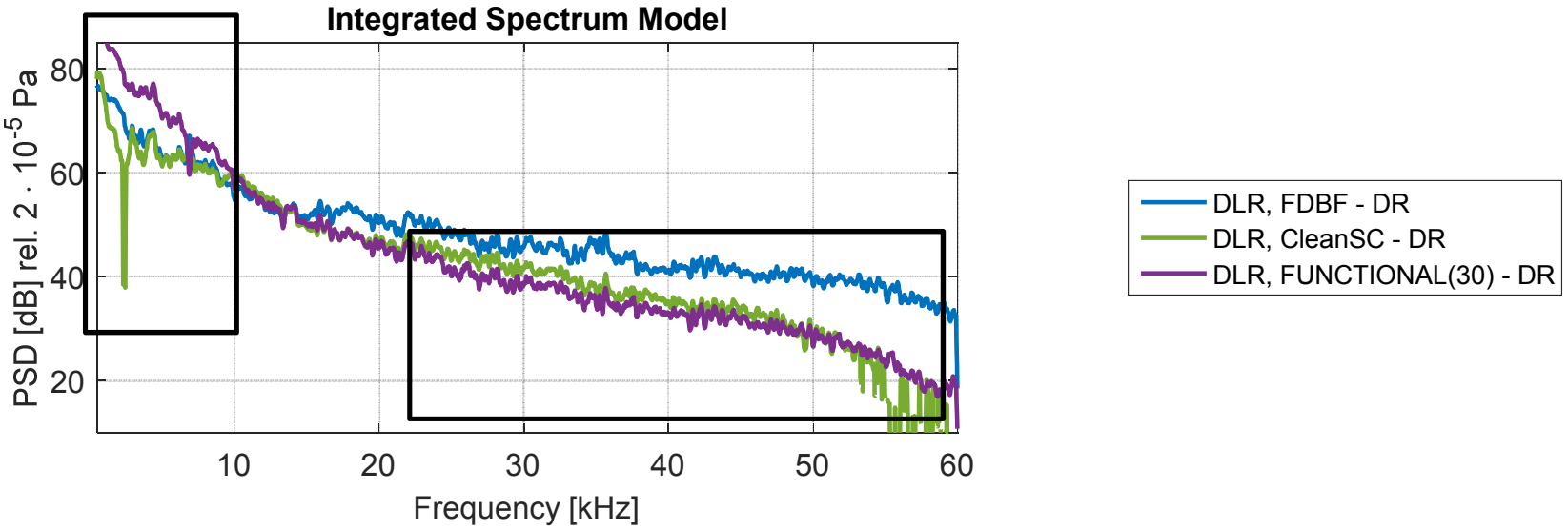


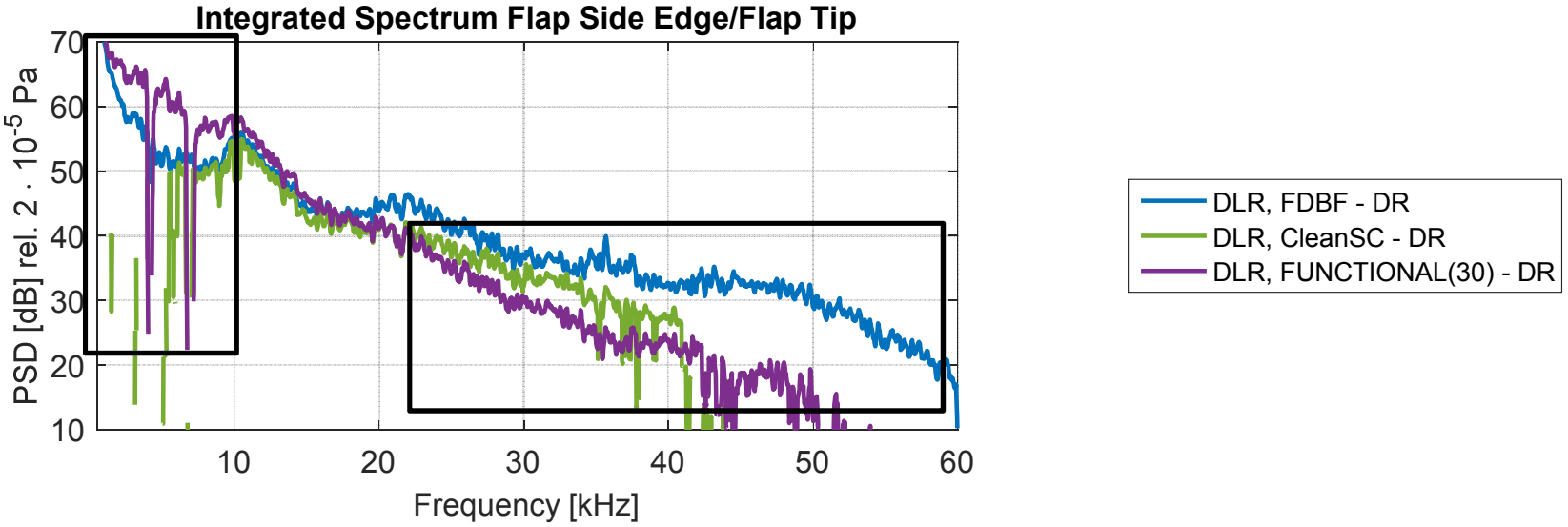

Integrated Spectrum Model
PSD [dB] rel. 2 · 10^-5 Pa
Frequency [kHz]
DLR, FDBF - DR
DLR, CleanSC - DR
Univ. of Lyon, Bayes - DR - L0.9
Univ. of Lyon, NNLS - DR
Integrated Spectrum Flap Side Edge/Flap Tip
PSD [dB] rel. 2 · 10^-5 Pa
Frequency [kHz]
DLR, FDBF - DR
DLR, CleanSC - DR
Univ. of Lyon, Bayes - DR - L0.9
Univ. of Lyon, NNLS - DR


Integrated Spectrum Model
PSD [dB] rel. 2 · 10^-5 Pa
Frequency [kHz]
DLR, FDBF - DR
DLR, NNLS - DR
Univ. of Lyon, NNLS - DR
Integrated Spectrum Flap Side Edge/Flap Tip
PSD [dB] rel. 2 · 10^-5 Pa
Frequency [kHz]
DLR, FDBF - DR
DLR, NNLS - DR
Univ. of Lyon, NNLS - DR


Integrated Spectrum Model
PSD [dB] rel. 2 · 10^-5 Pa
Frequency [kHz]
DLR, FDBF - DR
DLR, NNLS - DR PSF>0
Univ. of Lyon, NNLS - DR
Integrated Spectrum Flap Side Edge/Flap Tip
PSD [dB] rel. 2 · 10^-5 Pa
Frequency [kHz]
DLR, FDBF - DR
DLR, NNLS - DR PSF>0
Univ. of Lyon, NNLS - DR

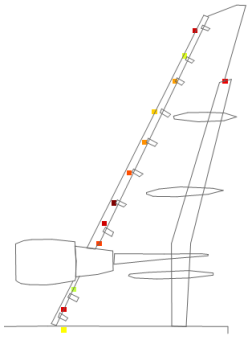

Integrated Spectrum Model
PSD [dB] rel. 2 · 10^-5 Pa
Frequency [kHz]
DLR, FDBF - DR
DLR, NNLS - DR PSF>0 NoPsfDR
Univ. of Lyon, NNLS - DR
Integrated Spectrum Flap Side Edge/Flap Tip
PSD [dB] rel. 2 · 10^-5 Pa
Frequency [kHz]
DLR, FDBF - DR
DLR, NNLS - DR PSF>0 NoPsfDR
Univ. of Lyon, NNLS - DR

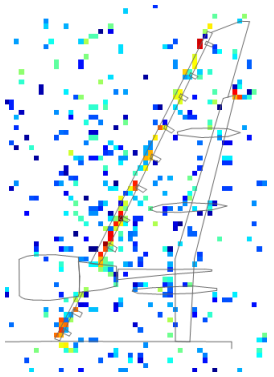

Integrated Spectrum Model
PSD [dB] rel. 2 · 10^-5 Pa
80
60
40
20
10
20
30
40
50
60
Frequency [kHz]
DLR, FDBF - DR
DLR, CleanSC - DR
DLR, FUNCTIONAL(30) - DR


Integrated Spectrum Flap Side Edge/Flap Tip
PSD [dB] rel. 2 · 10^-5 Pa
70
60
50
40
30
20
10
10
20
30
40
50
60
Frequency [kHz]
DLR, FDBF - DR
DLR, CleanSC - DR
DLR, FUNCTIONAL(30) - DR

Conclusion

- CleanSC/Bayes/NNLS
  show similar results
  source position and amplitude
  as expected (based on experience)

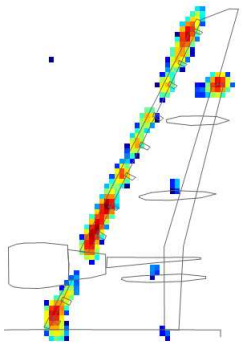




- DAMAS/NNLS: difficulties at high frequencies
  (without non-negativity constraint on the psf)

- Definition of the psf and dirty-map is more important than the algorithm

- Functional Beamforming:
  fastest algorithm,
  all sources can be identified
  psf artifacts highly reduced



Submission to Testcase DLR 1

Create a HDF5 – CsmOptional File with your beamforming result

Testcase: 2009_DO728_dp59
M = 0.25
Angle of Attack: 3°

and **provide this File to** one of the following

Daniel Ernst Daniel.Ernst@dlr.de
Thomas Ahlefeldt Thomas.Ahlefeldt@dlr.de
Carsten Spehr Carsten.Spehr@dlr.de

We can provide transfer for large files upon request!

We will

1. Check your submission
2. Calculate the integrated spectra
3. Upload your solution

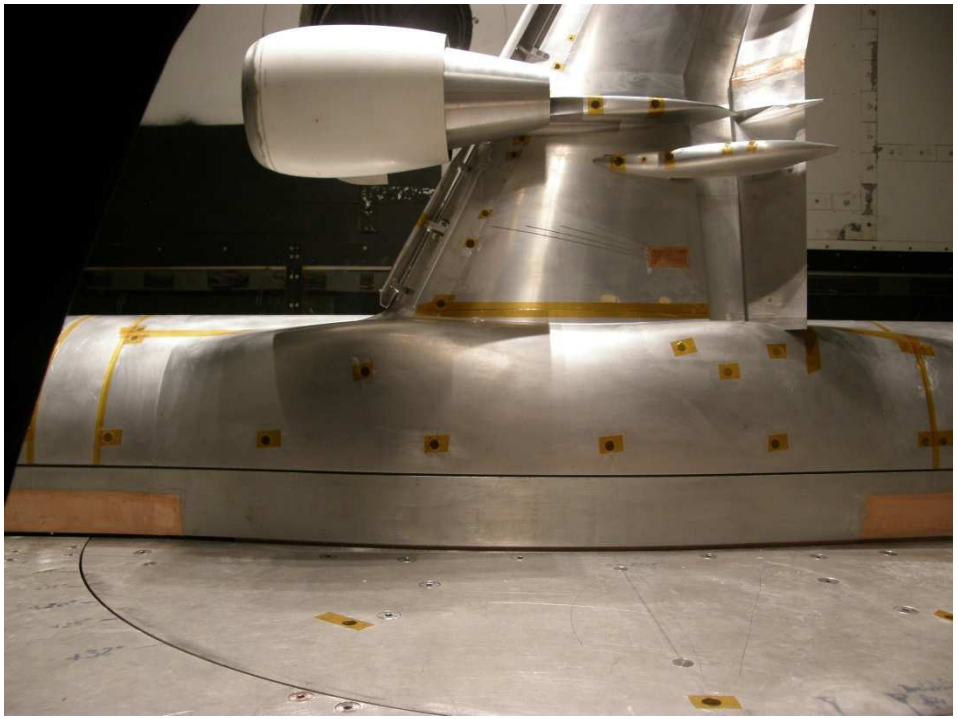
Appendix

1) Integrated Spectra „Full Model“ and „Flap Tip“

2) 3rd Octave - Source Maps

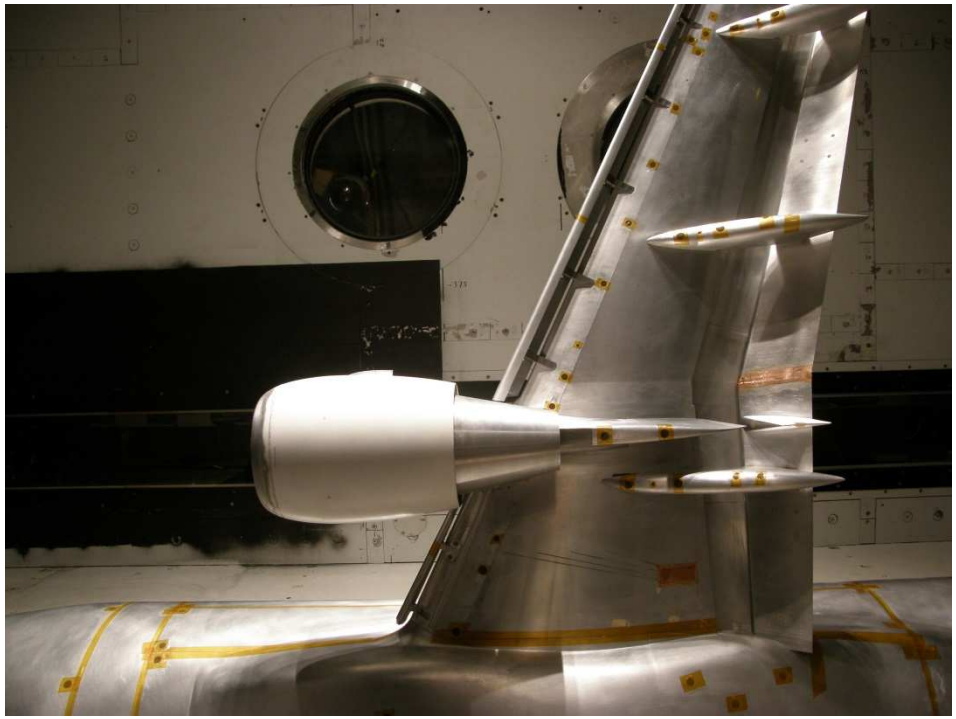
Detail Pictures of the DO-728 Model

view from microphone array

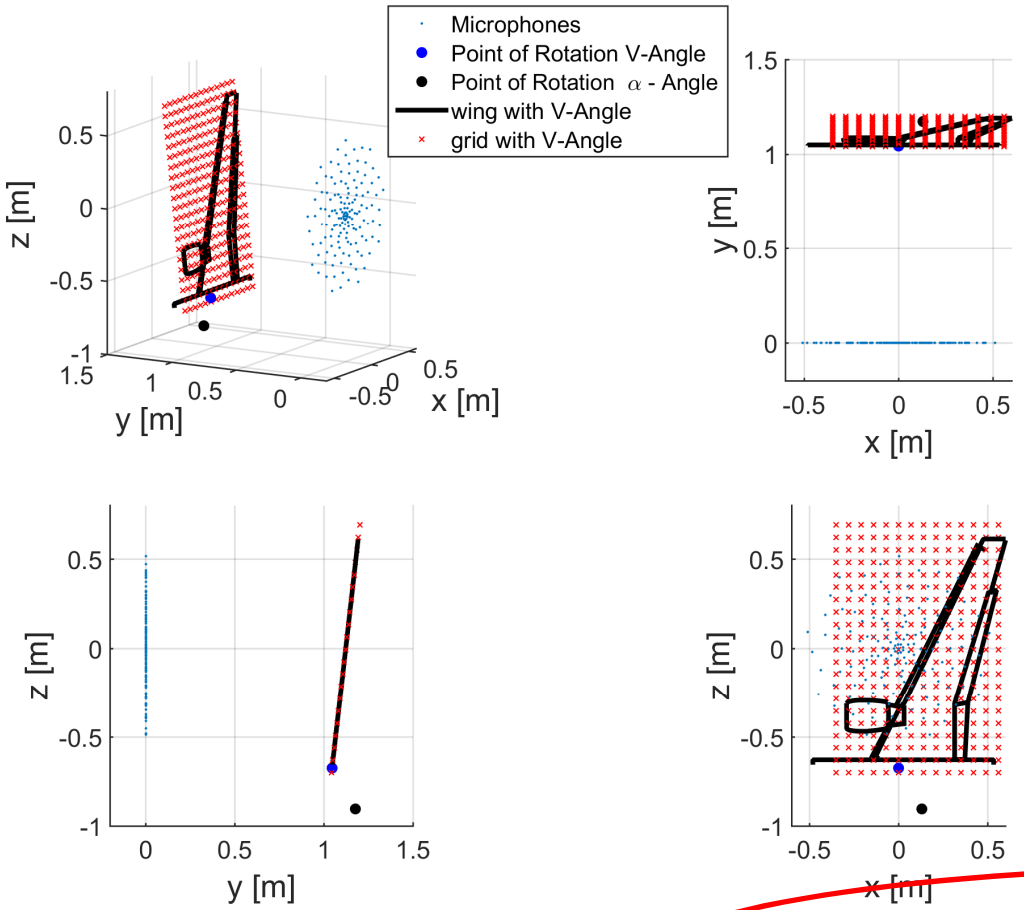


Detail Pictures of the DO-728 Model

view from microphone array



Focus-Grid Rotation



Focus grid

x = -0.35, … , 0.7 m

y = 1.045 m

z = - 0.75, … , 0.7 m

V-angle: - 6.5°

Rotation axis: x (right hand rule)

Point of rotation:

x = 0m, y = 1.045m, z = -0.675m

Angle of attack (negative): - 3°

Rotation axis: z (right hand rule)

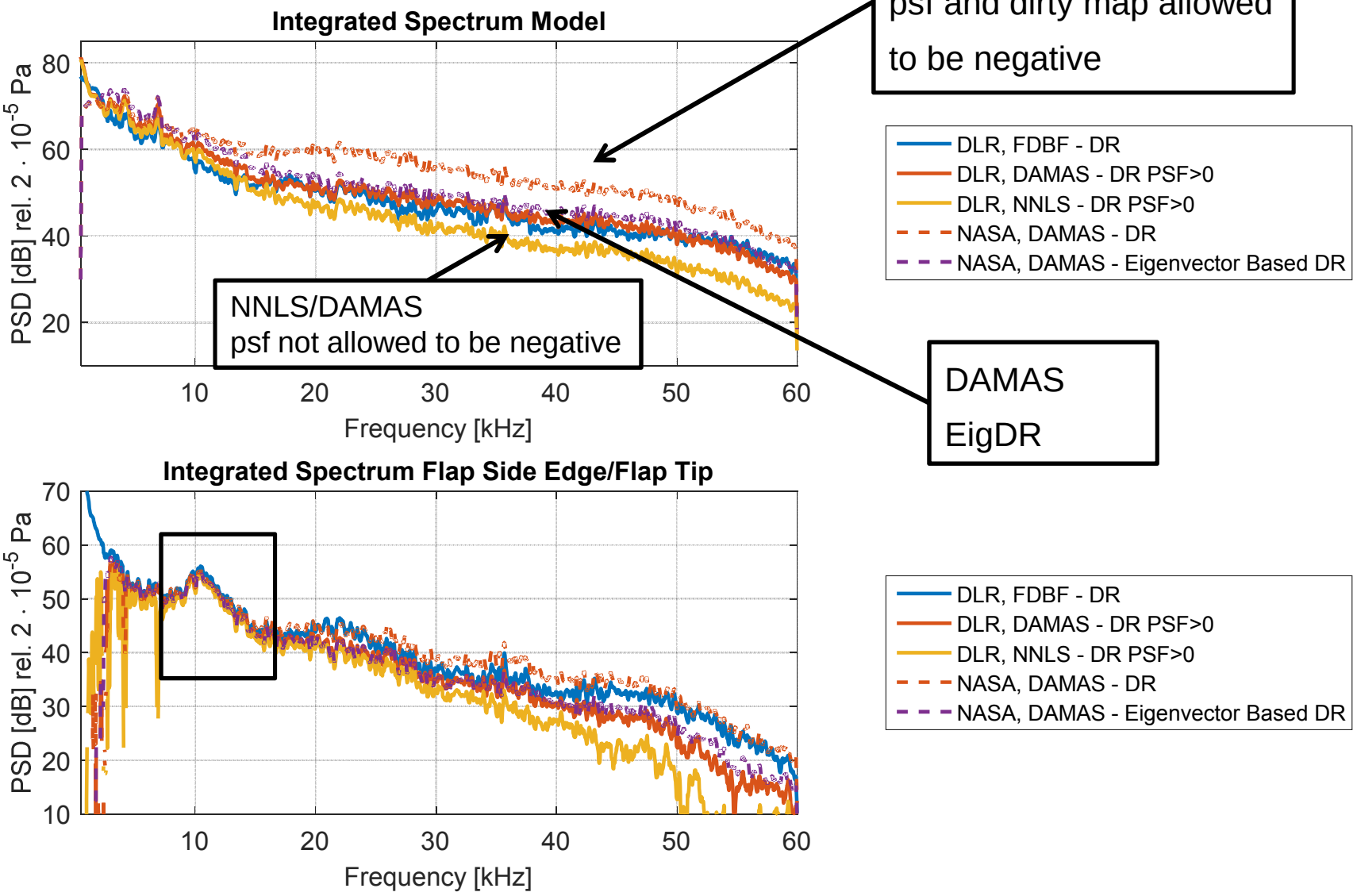
Point of rotation:

x = 0.13m, y = 1.175m, z = -0.675m

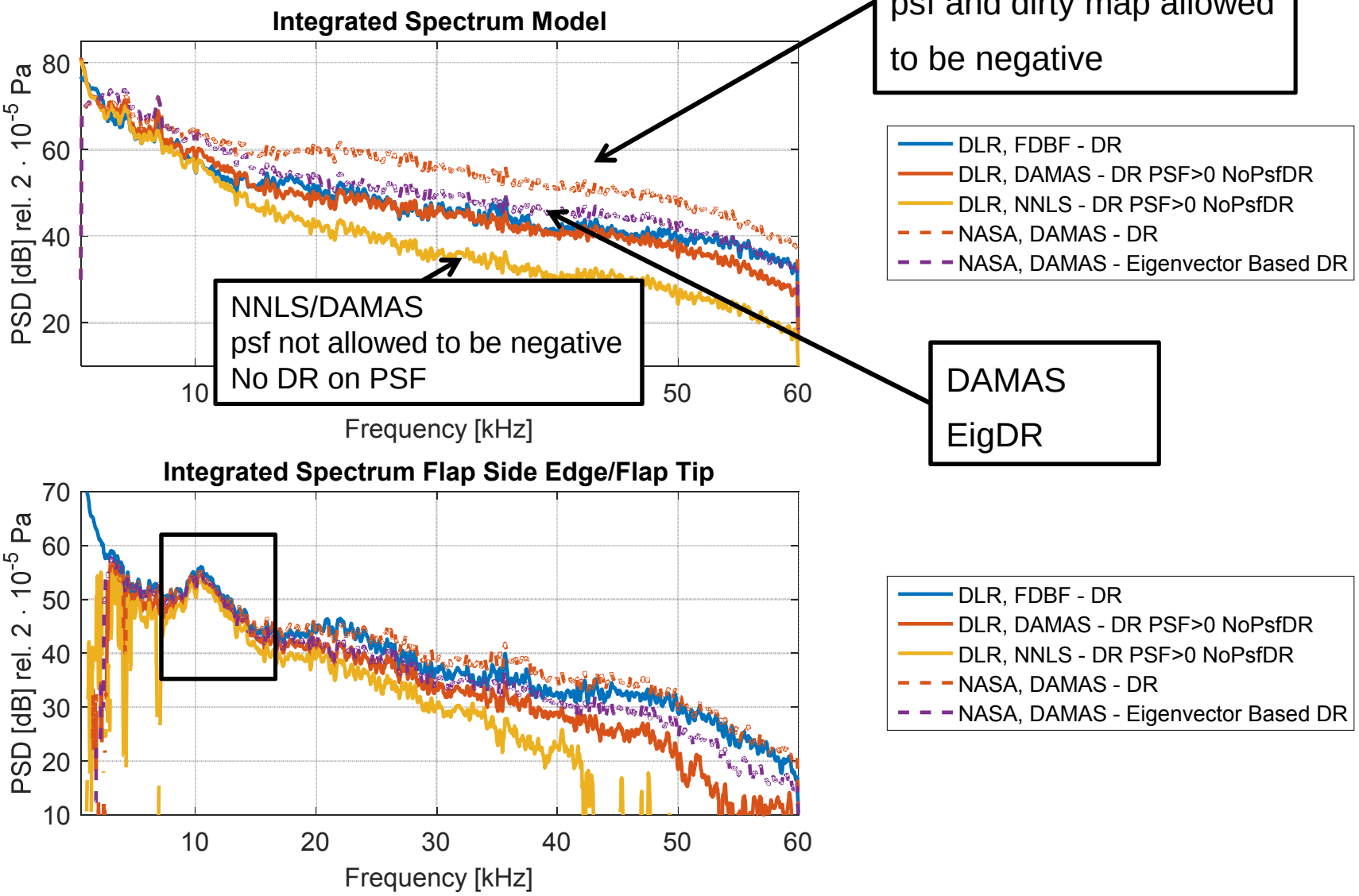
Rotated Focus Grids available @ TU-Cottbus Server

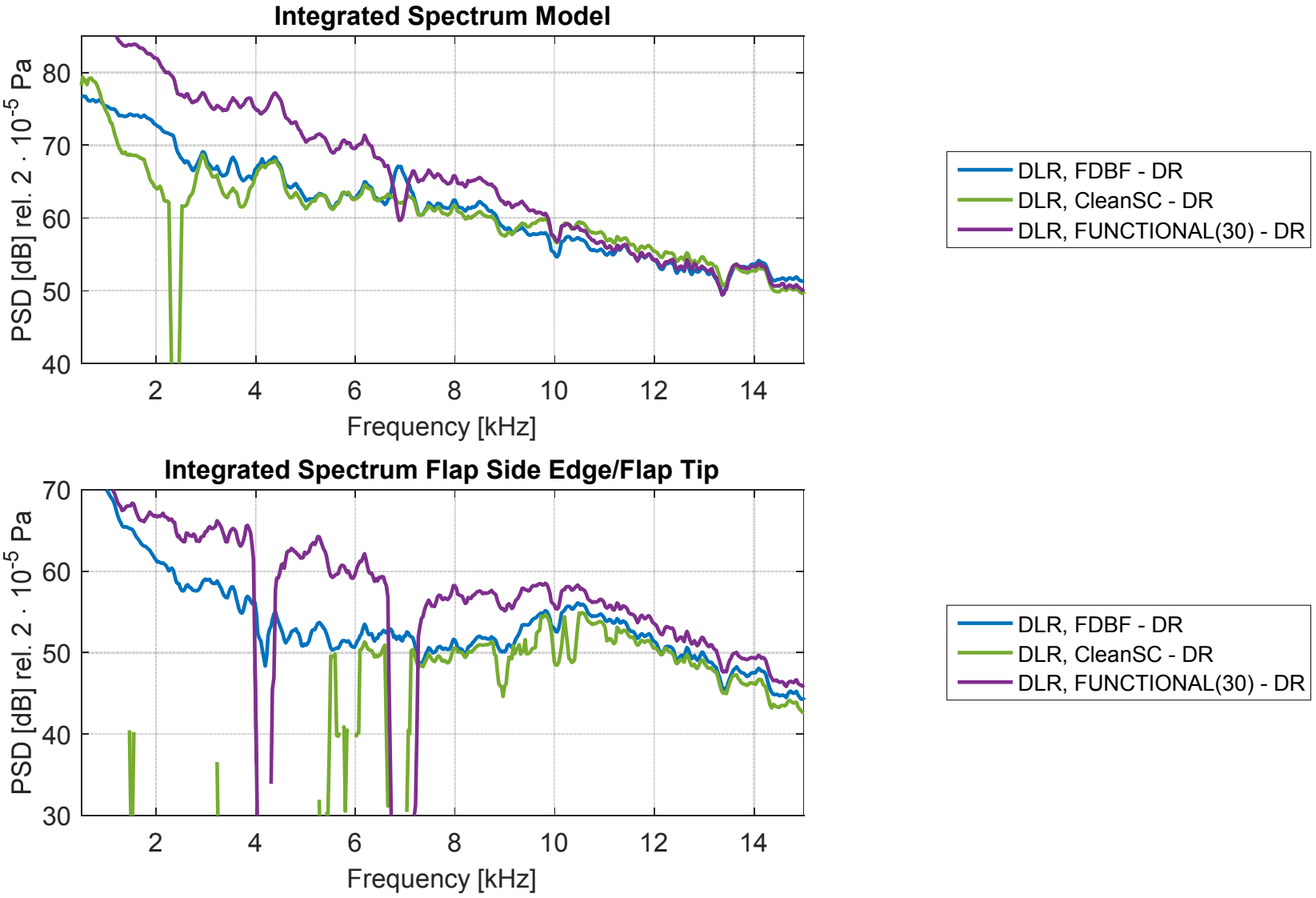
DLR

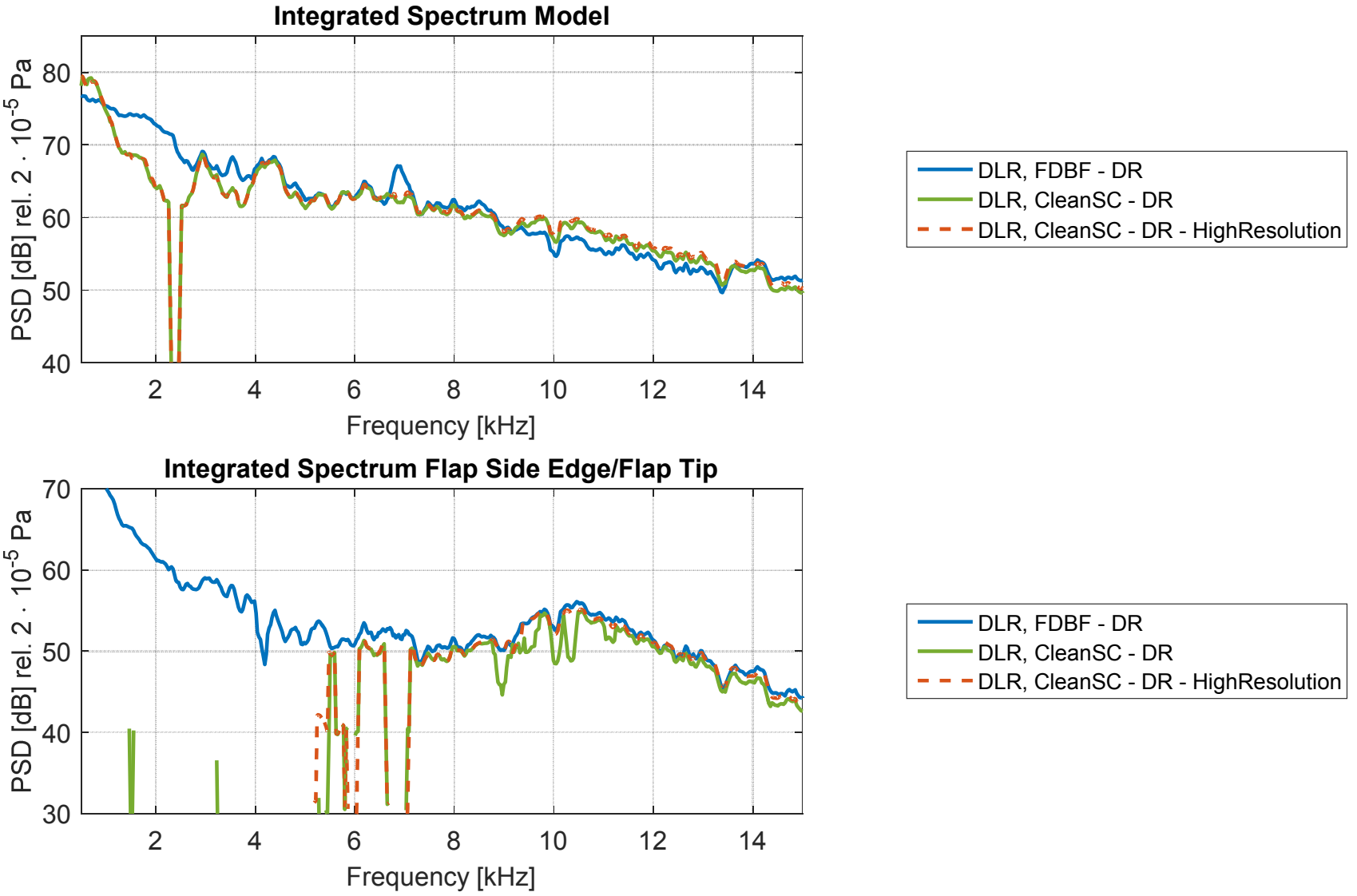
DAMAS NASA
psf and dirty map allowed
to be negative

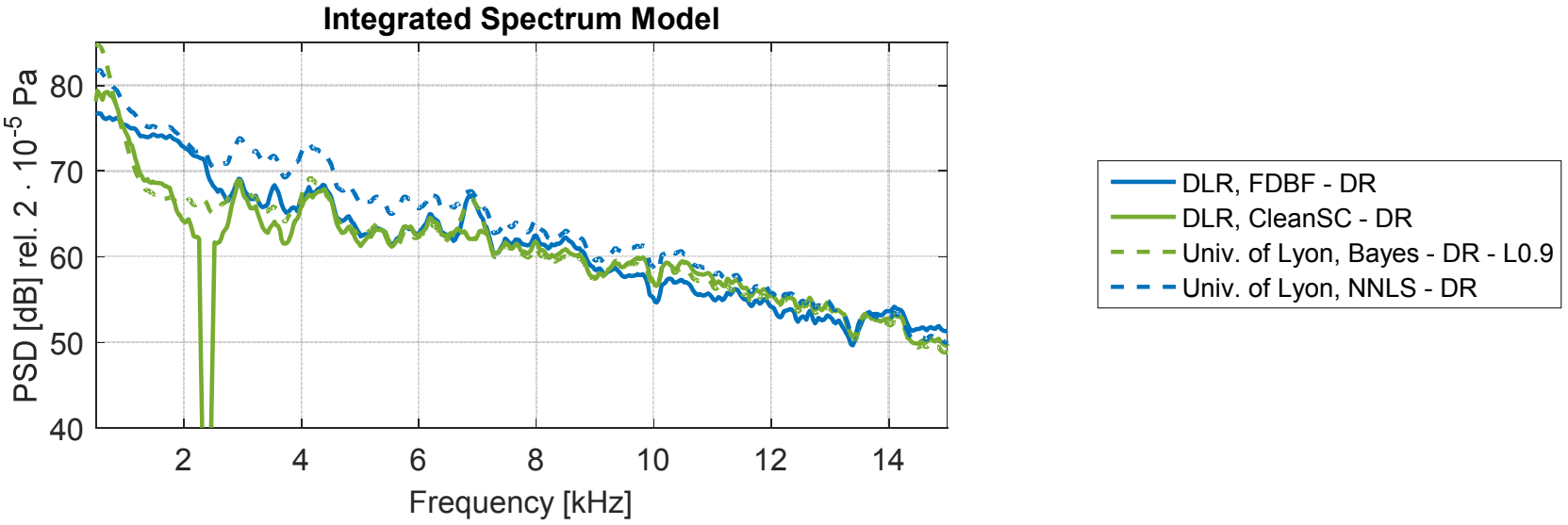


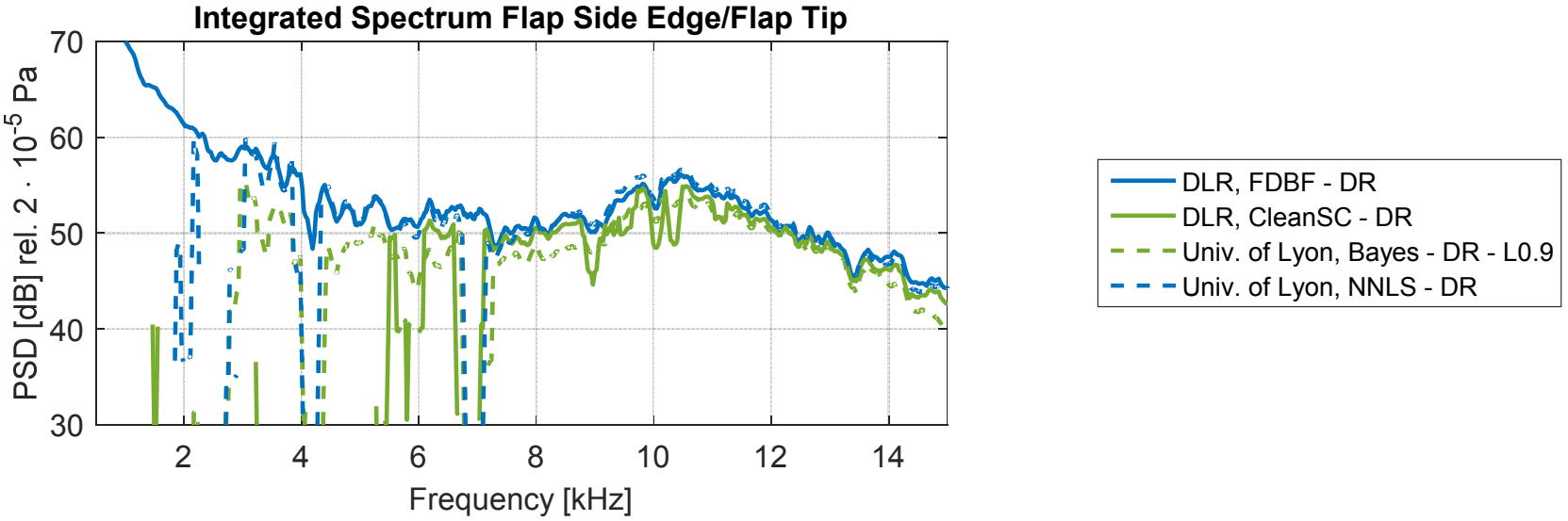
DAMAS NASA
psf and dirty map allowed
to be negative

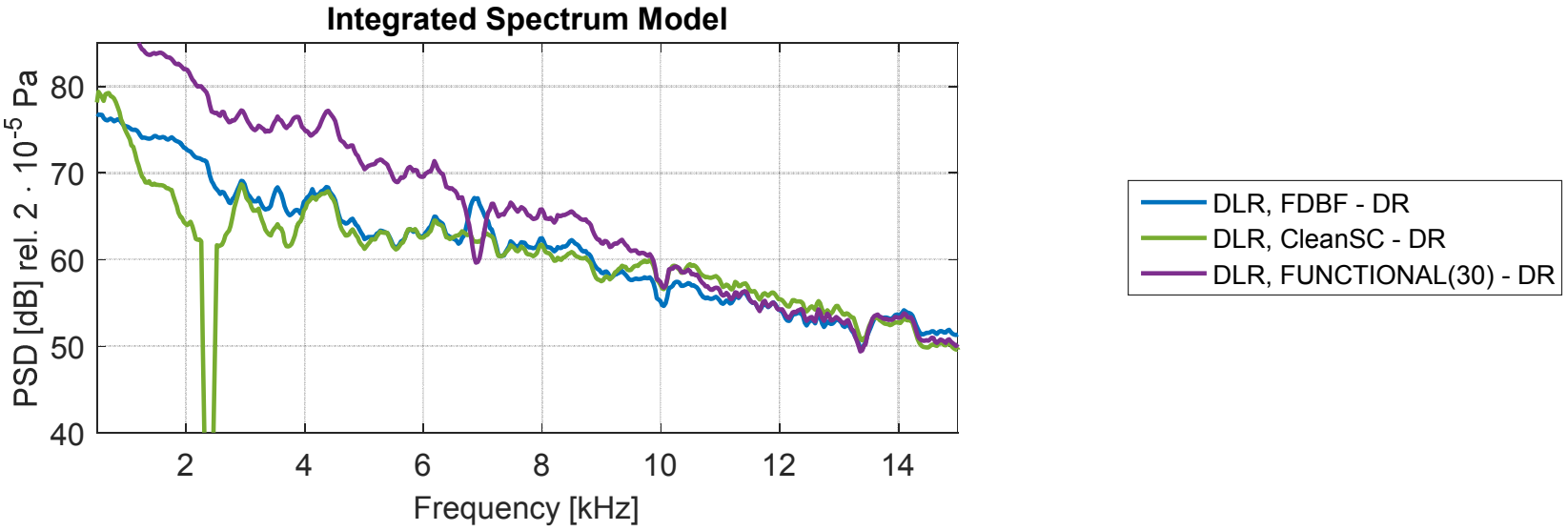


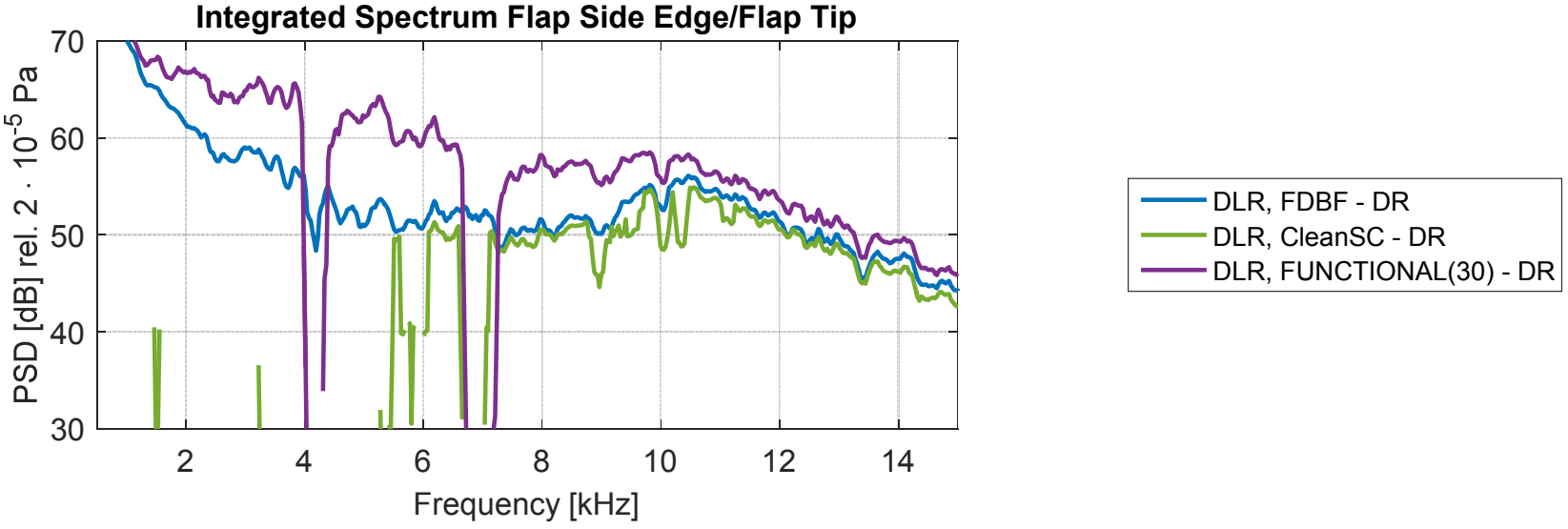

Integrated Spectrum Model
PSD [dB] rel. 2 · 10^-5 Pa
80
70
60
50
40
2
4
6
8
10
12
14
Frequency [kHz]
DLR, FDBF - DR
DLR, CleanSC - DR
DLR, FUNCTIONAL(30) - DR
Integrated Spectrum Flap Side Edge/Flap Tip
PSD [dB] rel. 2 · 10^-5 Pa
70
60
50
40
30
2
4
6
8
10
12
14
Frequency [kHz]
DLR, FDBF - DR
DLR, CleanSC - DR
DLR, FUNCTIONAL(30) - DR

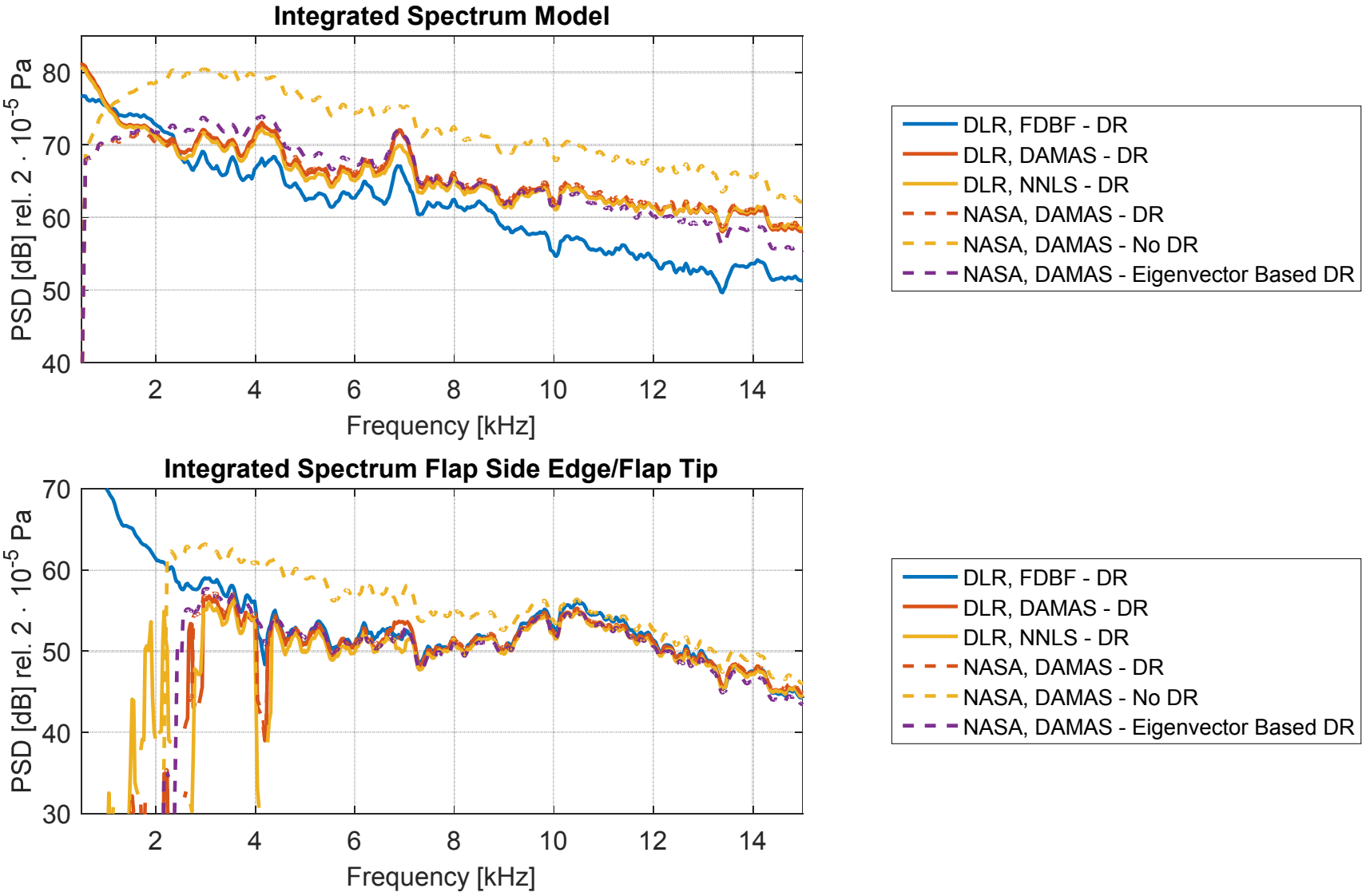

Integrated Spectrum Model
PSD [dB] rel. 2 · 10^-5 Pa
80
70
60
50
40
2
4
6
8
10
12
14
Frequency [kHz]
DLR, FDBF - DR
DLR, CleanSC - DR
DLR, CleanSC - DR - HighResolution
Integrated Spectrum Flap Side Edge/Flap Tip
PSD [dB] rel. 2 · 10^-5 Pa
70
60
50
40
30
2
4
6
8
10
12
14
Frequency [kHz]
DLR, FDBF - DR
DLR, CleanSC - DR
DLR, CleanSC - DR - HighResolution

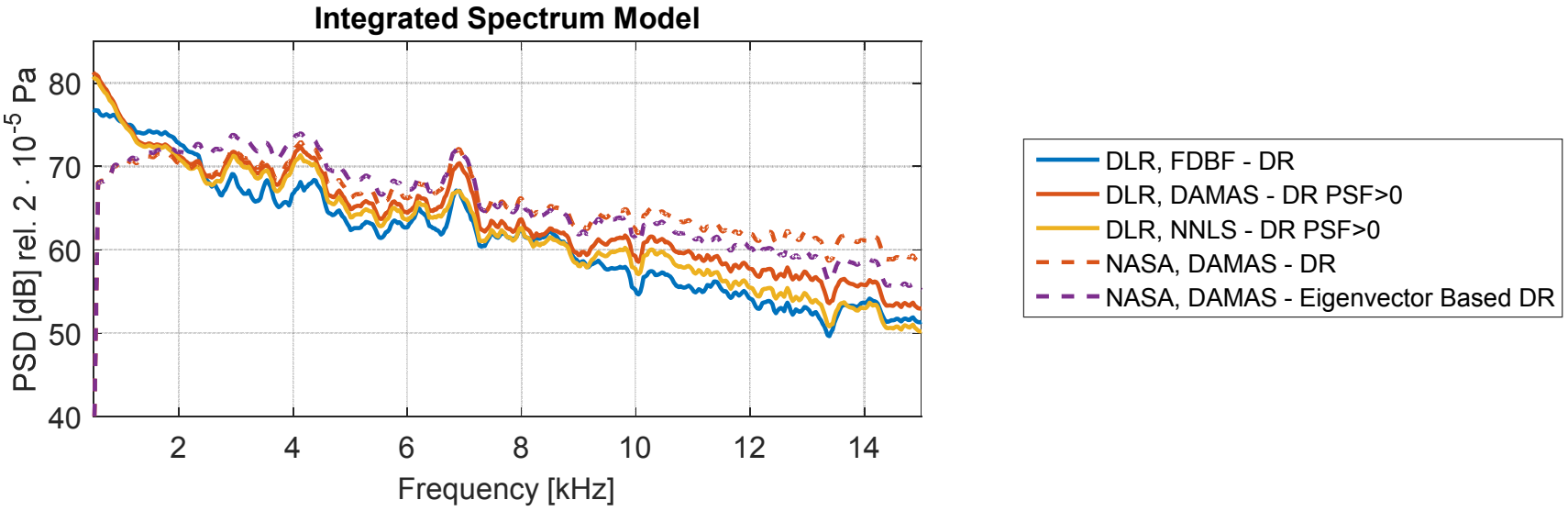

Integrated Spectrum Model
PSD [dB] rel. 2 · 10^-5 Pa
80
70
60
50
40
2
4
6
8
10
12
14
Frequency [kHz]
DLR, FDBF - DR
DLR, CleanSC - DR
Univ. of Lyon, Bayes - DR - L0.9
Univ. of Lyon, NNLS - DR

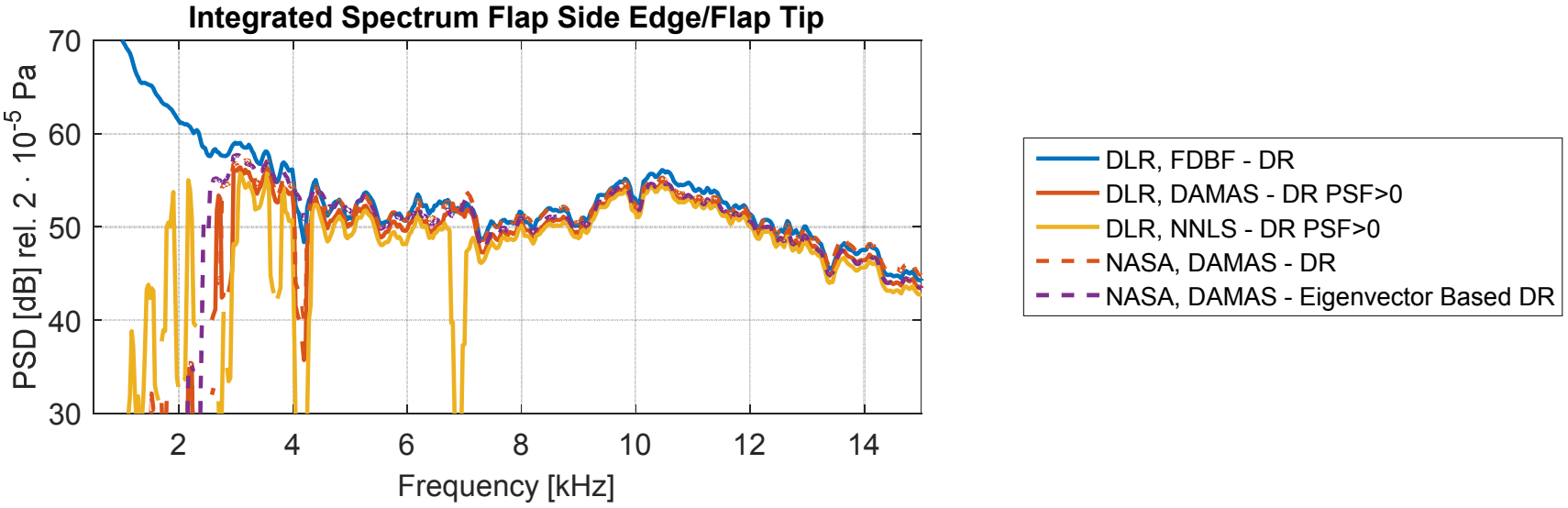

Integrated Spectrum Flap Side Edge/Flap Tip
PSD [dB] rel. 2 · 10^-5 Pa
70
60
50
40
30
2
4
6
8
10
12
14
Frequency [kHz]
DLR, FDBF - DR
DLR, CleanSC - DR
Univ. of Lyon, Bayes - DR - L0.9
Univ. of Lyon, NNLS - DR

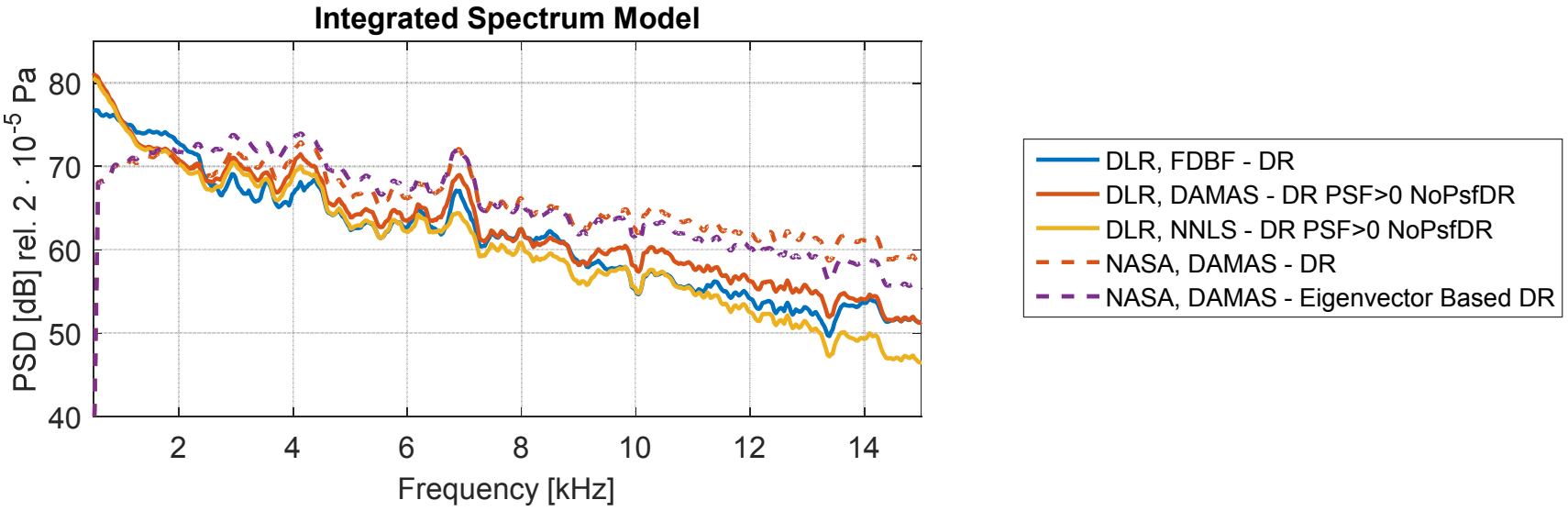

Integrated Spectrum Model
PSD [dB] rel. 2 · 10^-5 Pa
80
70
60
50
40
2
4
6
8
10
12
14
Frequency [kHz]
DLR, FDBF - DR
DLR, CleanSC - DR
DLR, FUNCTIONAL(30) - DR

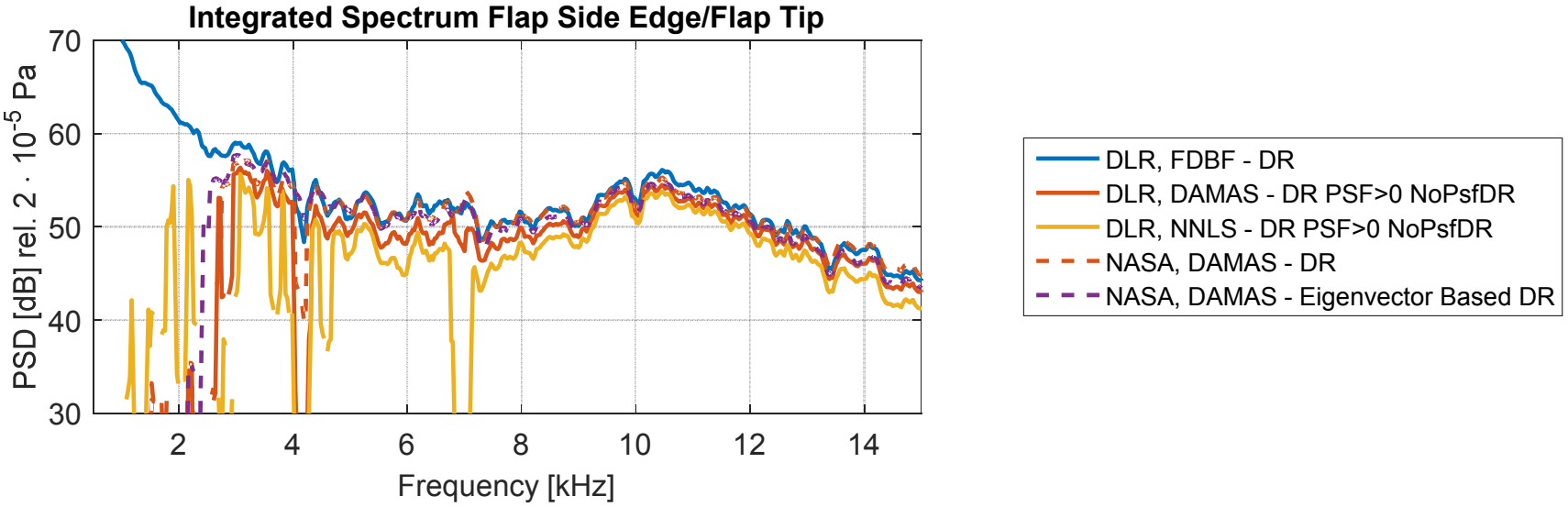

Integrated Spectrum Flap Side Edge/Flap Tip
PSD [dB] rel. 2 · 10^-5 Pa
70
60
50
40
30
2
4
6
8
10
12
14
Frequency [kHz]
DLR, FDBF - DR
DLR, CleanSC - DR
DLR, FUNCTIONAL(30) - DR

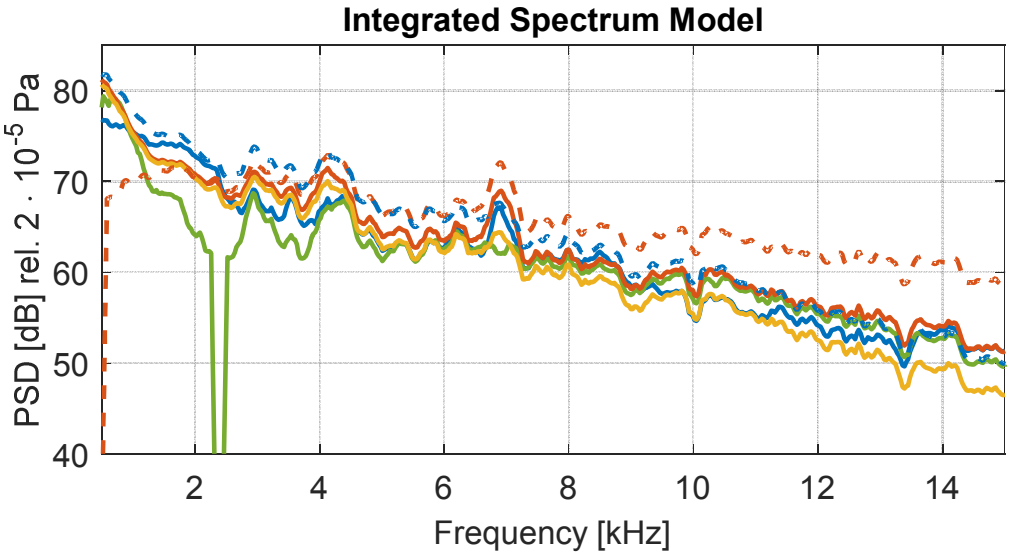

Integrated Spectrum Model
PSD [dB] rel. 2 · 10^-5 Pa
Frequency [kHz]
DLR, FDBF - DR
DLR, DAMAS - DR
DLR, NNLS - DR
NASA, DAMAS - DR
NASA, DAMAS - No DR
NASA, DAMAS - Eigenvector Based DR
Integrated Spectrum Flap Side Edge/Flap Tip
PSD [dB] rel. 2 · 10^-5 Pa
Frequency [kHz]
DLR, FDBF - DR
DLR, DAMAS - DR
DLR, NNLS - DR
NASA, DAMAS - DR
NASA, DAMAS - No DR
NASA, DAMAS - Eigenvector Based DR


Integrated Spectrum Model
PSD [dB] rel. 2 · 10^-5 Pa
80
70
60
50
40
2
4
6
8
10
12
14
Frequency [kHz]
DLR, FDBF - DR
DLR, DAMAS - DR PSF>0
DLR, NNLS - DR PSF>0
NASA, DAMAS - DR
NASA, DAMAS - Eigenvector Based DR


Integrated Spectrum Flap Side Edge/Flap Tip
PSD [dB] rel. 2 · 10^-5 Pa
70
60
50
40
30
2
4
6
8
10
12
14
Frequency [kHz]
DLR, FDBF - DR
DLR, DAMAS - DR PSF>0
DLR, NNLS - DR PSF>0
NASA, DAMAS - DR
NASA, DAMAS - Eigenvector Based DR


Integrated Spectrum Model
PSD [dB] rel. 2 · 10^-5 Pa
80
70
60
50
40
2
4
6
8
10
12
14
Frequency [kHz]
DLR, FDBF - DR
DLR, DAMAS - DR PSF>0 NoPsfDR
DLR, NNLS - DR PSF>0 NoPsfDR
NASA, DAMAS - DR
NASA, DAMAS - Eigenvector Based DR


Integrated Spectrum Flap Side Edge/Flap Tip
PSD [dB] rel. 2 · 10^-5 Pa
70
60
50
40
30
2
4
6
8
10
12
14
Frequency [kHz]
DLR, FDBF - DR
DLR, DAMAS - DR PSF>0 NoPsfDR
DLR, NNLS - DR PSF>0 NoPsfDR
NASA, DAMAS - DR
NASA, DAMAS - Eigenvector Based DR


Integrated Spectrum Model
PSD [dB] rel. 2 · 10^-5 Pa
80
70
60
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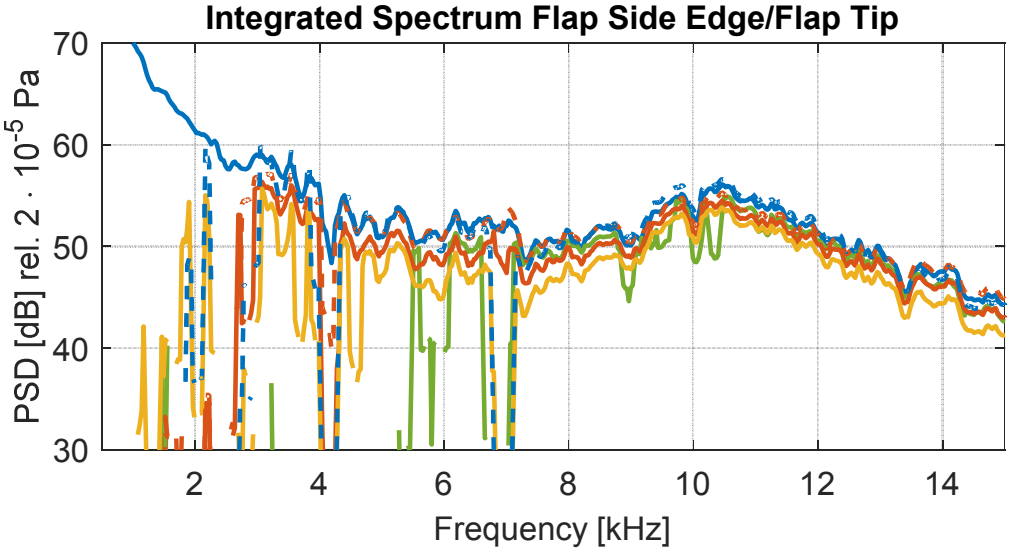
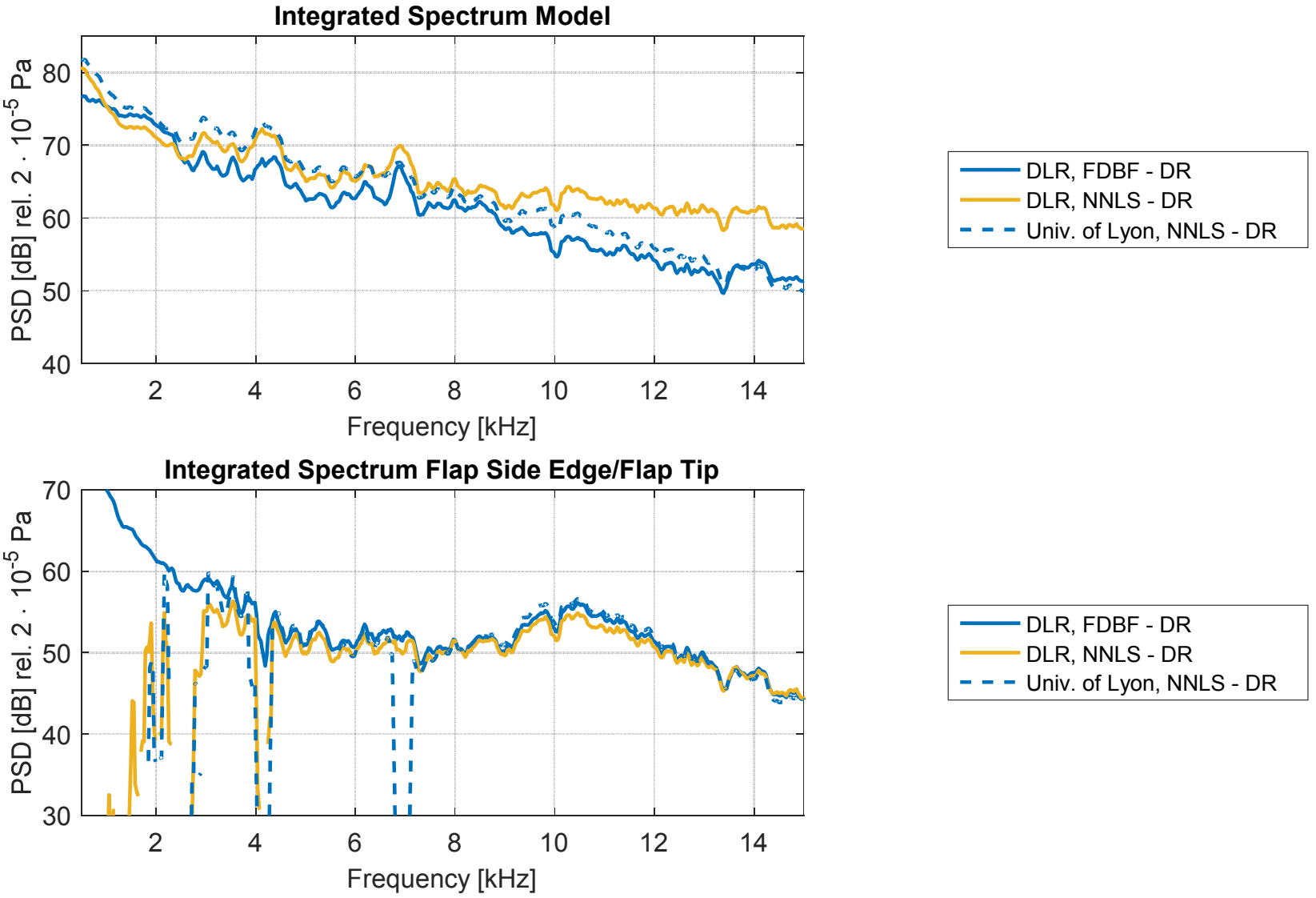
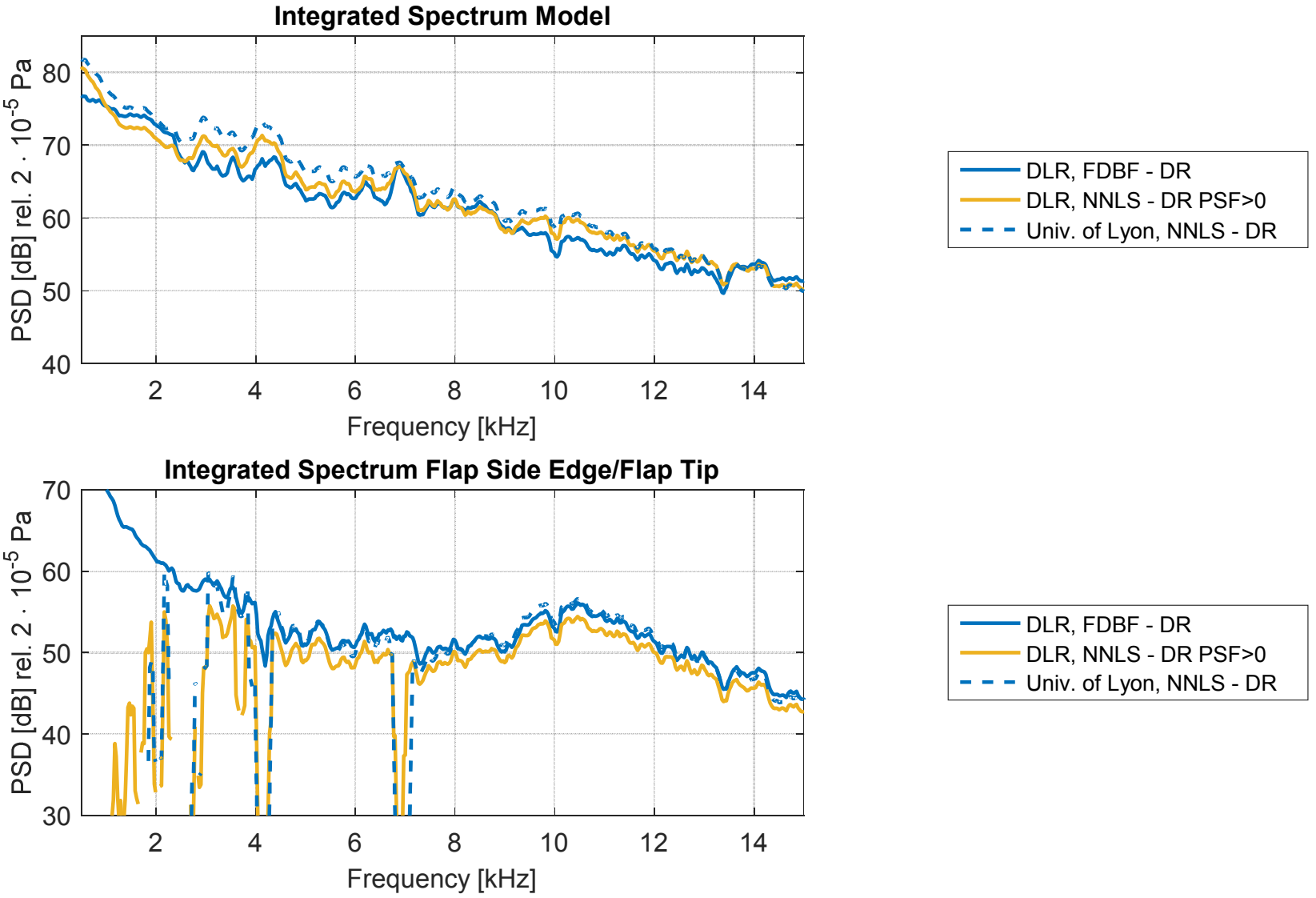
40
2
4
6
8
10
12
14
Frequency [kHz]

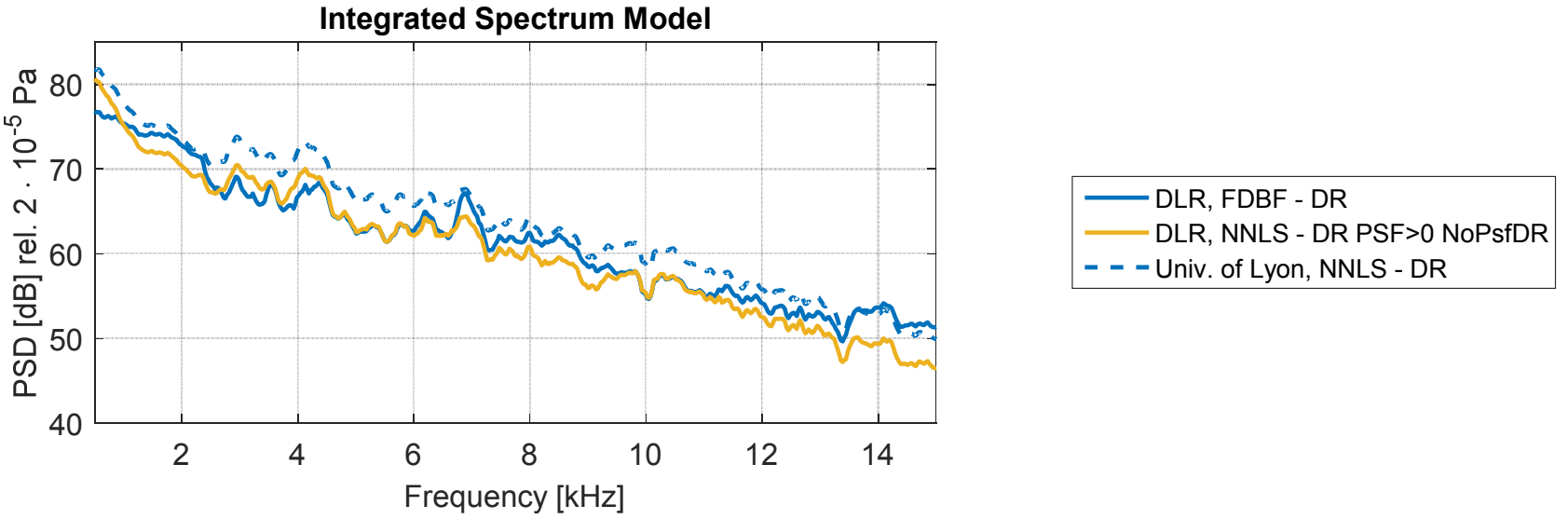

DLR, FDBF - DR
DLR, CleanSC - DR
DLR, DAMAS - DR PSF>0 NoPsfDR
DLR, NNLS - DR PSF>0 NoPsfDR
NASA, DAMAS - DR
Univ. of Lyon, NNLS - DR

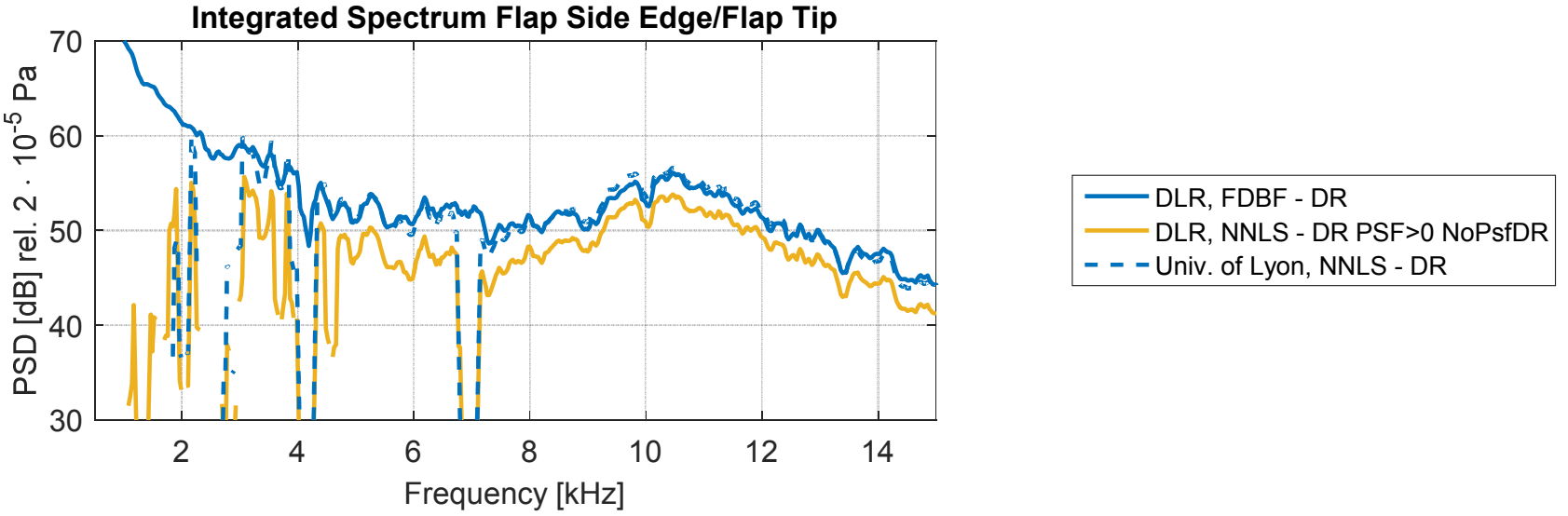

Integrated Spectrum Flap Side Edge/Flap Tip
PSD [dB] rel. 2 · 10^-5 Pa
70
60
50
40
30
2
4
6
8
10
12
14
Frequency [kHz]

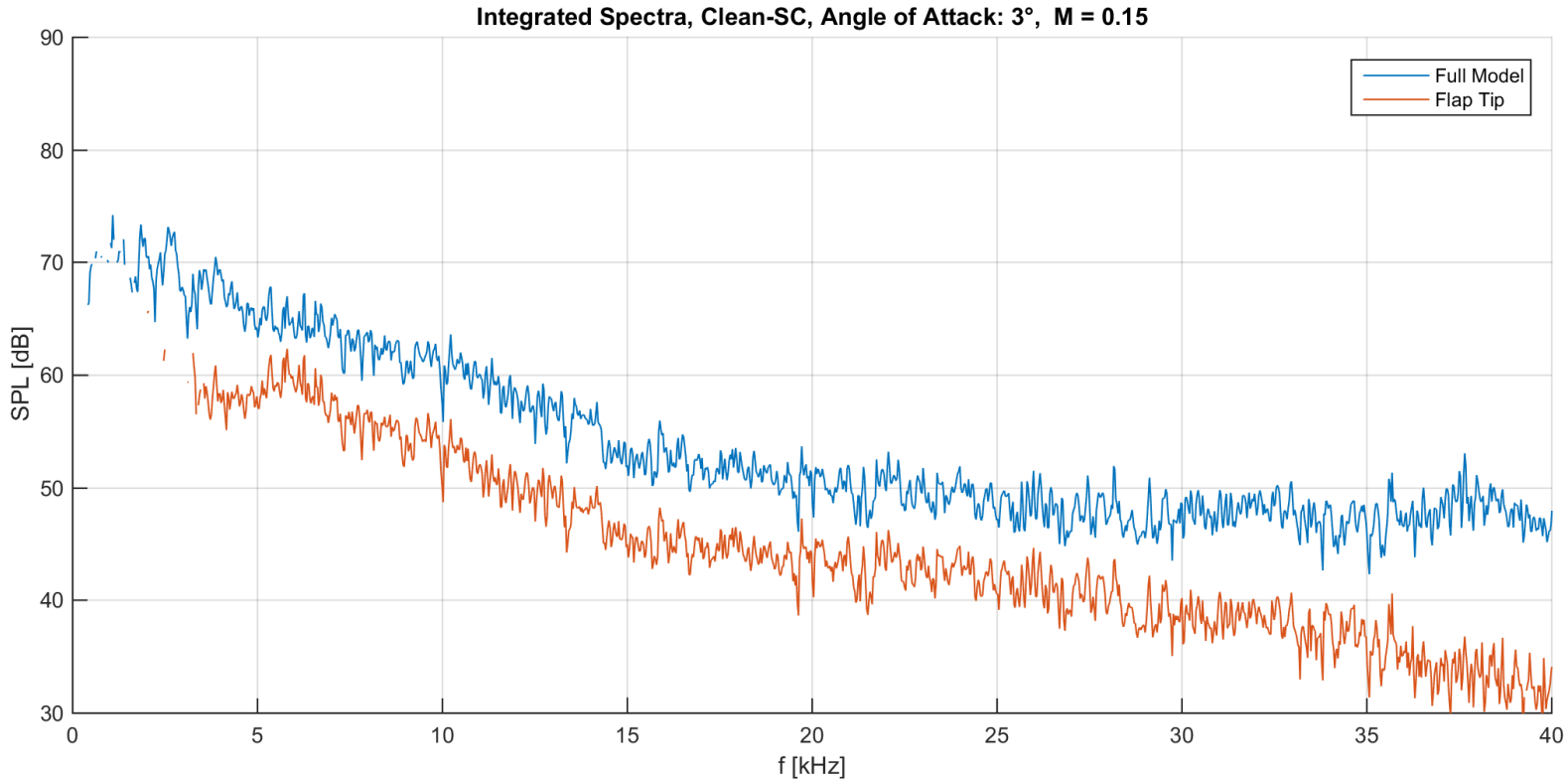

DLR, FDBF - DR
DLR, CleanSC - DR
DLR, DAMAS - DR PSF>0 NoPsfDR
DLR, NNLS - DR PSF>0 NoPsfDR
NASA, DAMAS - DR
Univ. of Lyon, NNLS - DR

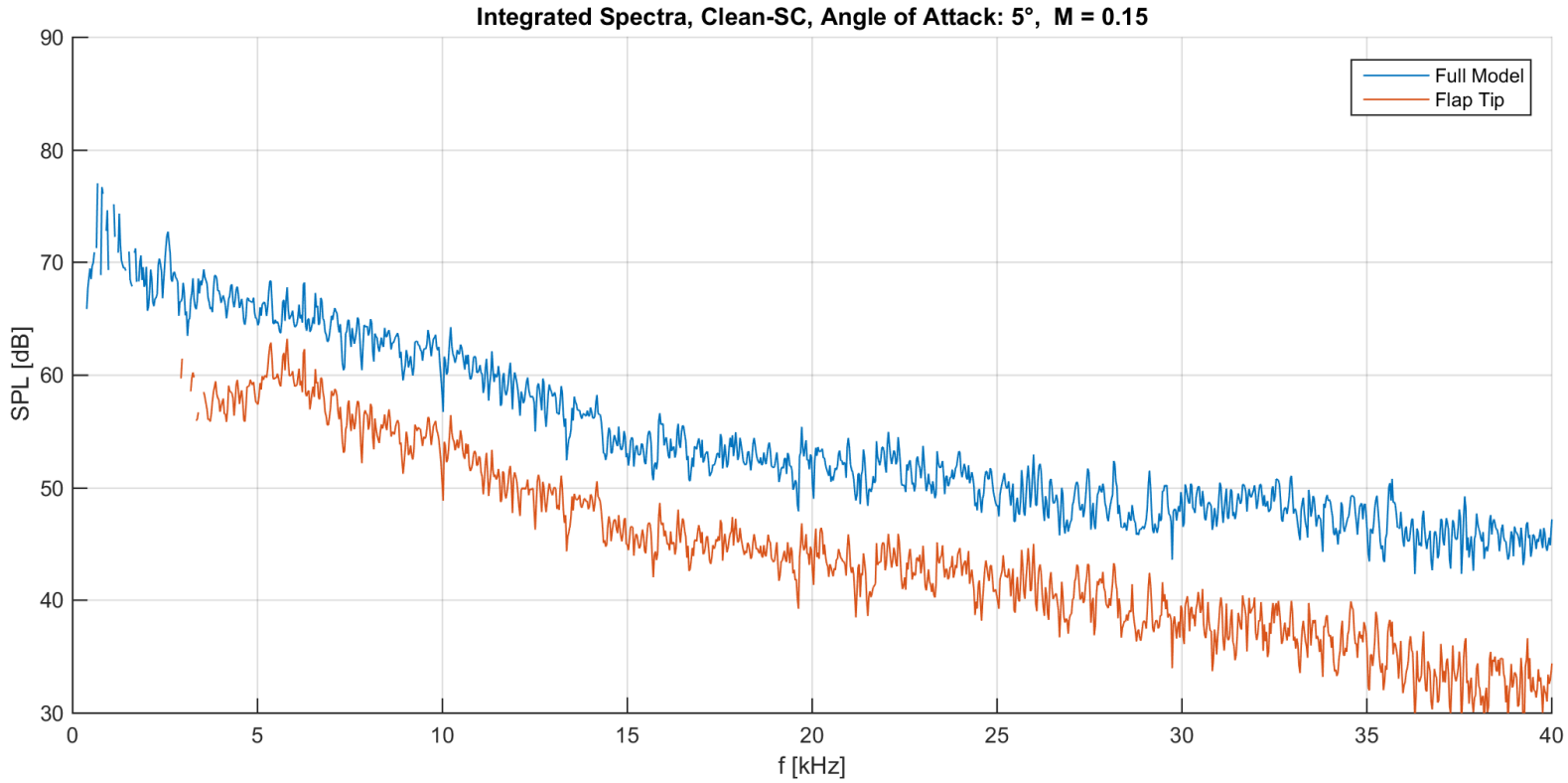

Integrated Spectrum Model
PSD [dB] rel. 2 · 10^-5 Pa
Frequency [kHz]
DLR, FDBF - DR
DLR, NNLS - DR
Univ. of Lyon, NNLS - DR
Integrated Spectrum Flap Side Edge/Flap Tip
PSD [dB] rel. 2 · 10^-5 Pa
Frequency [kHz]
DLR, FDBF - DR
DLR, NNLS - DR
Univ. of Lyon, NNLS - DR

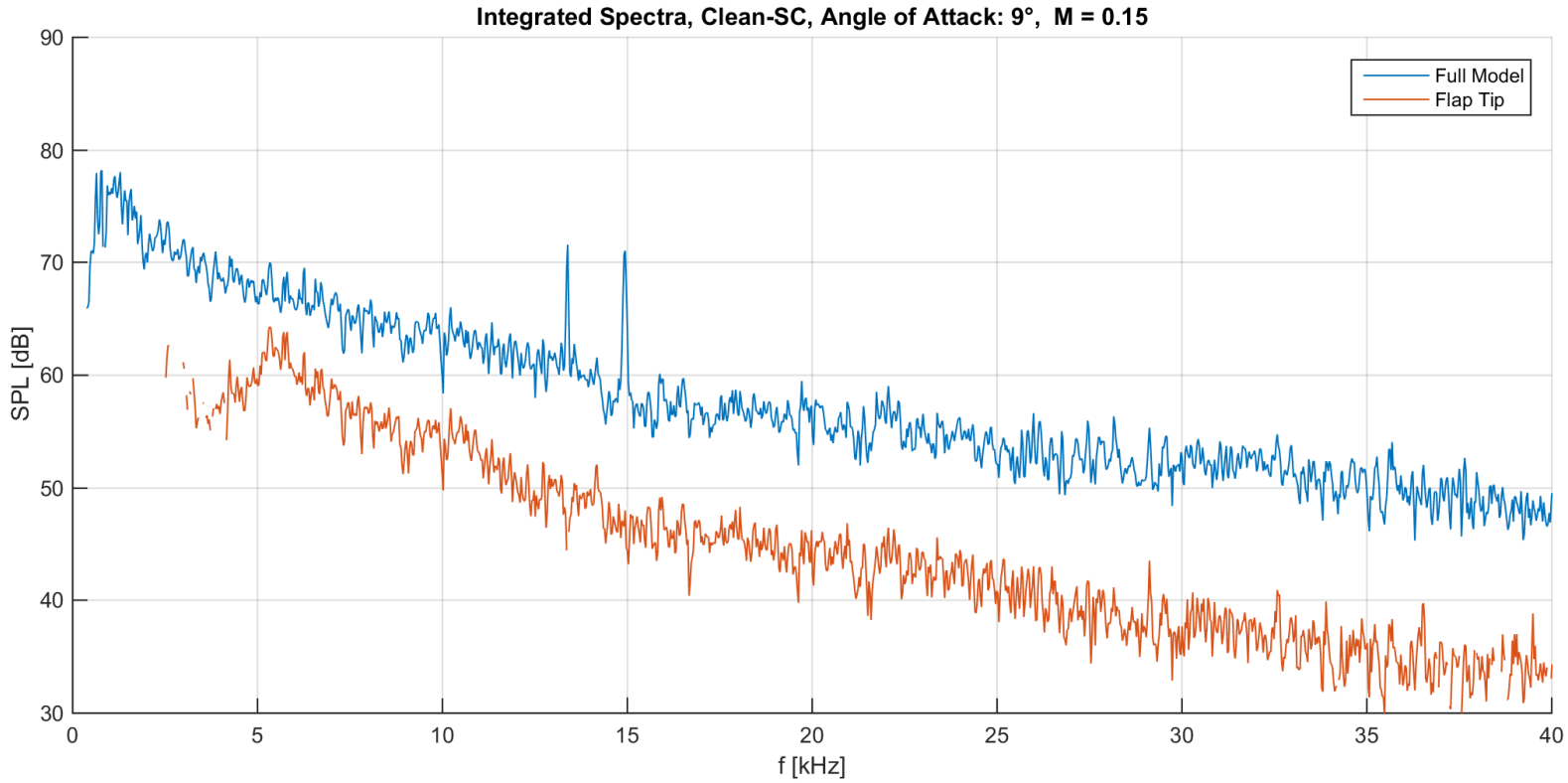

Integrated Spectrum Model
PSD [dB] rel. 2 · 10^-5 Pa
Frequency [kHz]
DLR, FDBF - DR
DLR, NNLS - DR PSF>0
Univ. of Lyon, NNLS - DR
Integrated Spectrum Flap Side Edge/Flap Tip
PSD [dB] rel. 2 · 10^-5 Pa
Frequency [kHz]
DLR, FDBF - DR
DLR, NNLS - DR PSF>0
Univ. of Lyon, NNLS - DR

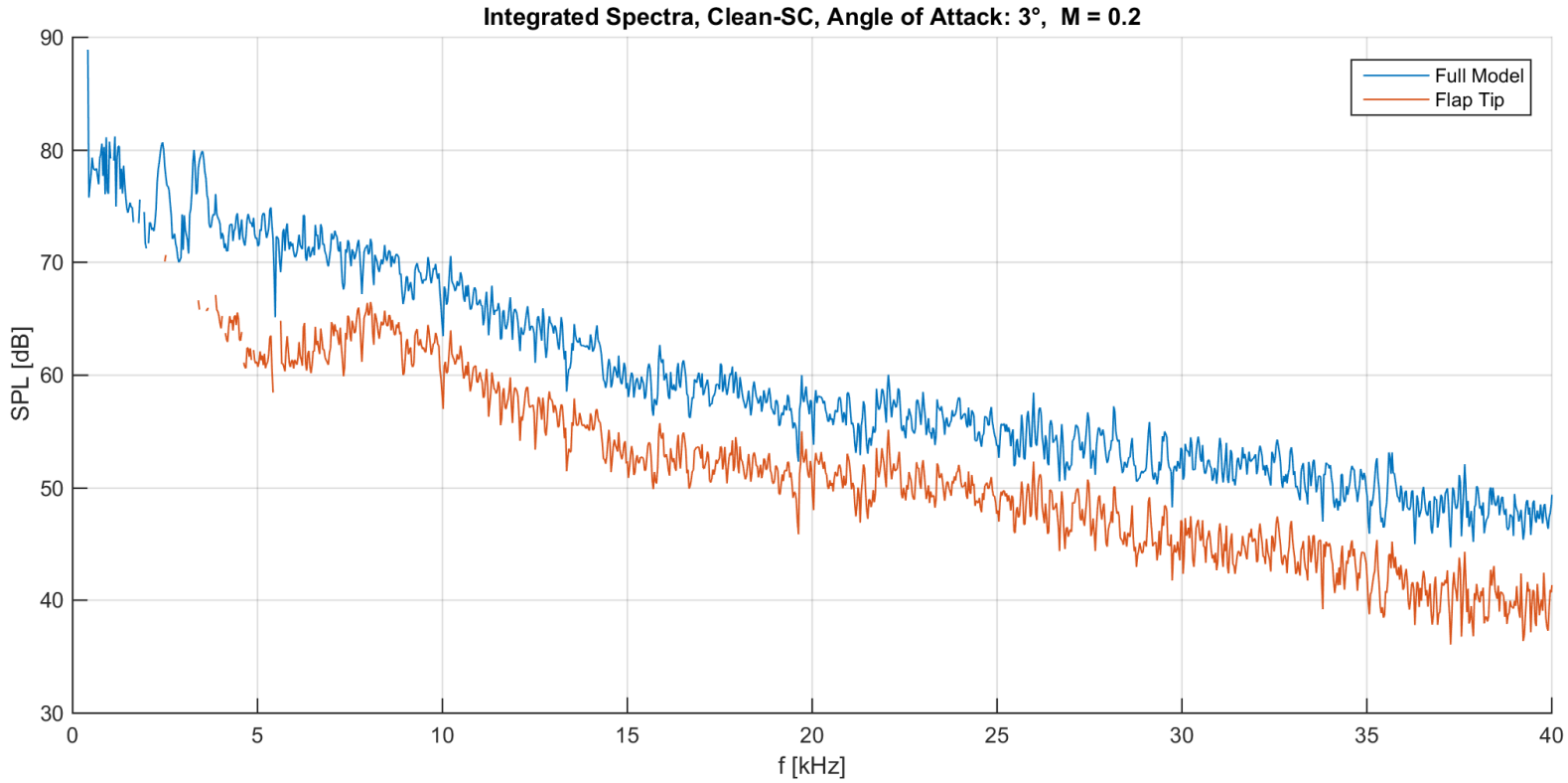

Integrated Spectrum Model
PSD [dB] rel. 2 · 10^-5 Pa
80
70
60
50
40
2
4
6
8
10
12
14
Frequency [kHz]
DLR, FDBF - DR
DLR, NNLS - DR PSF>0 NoPsfDR
Univ. of Lyon, NNLS - DR

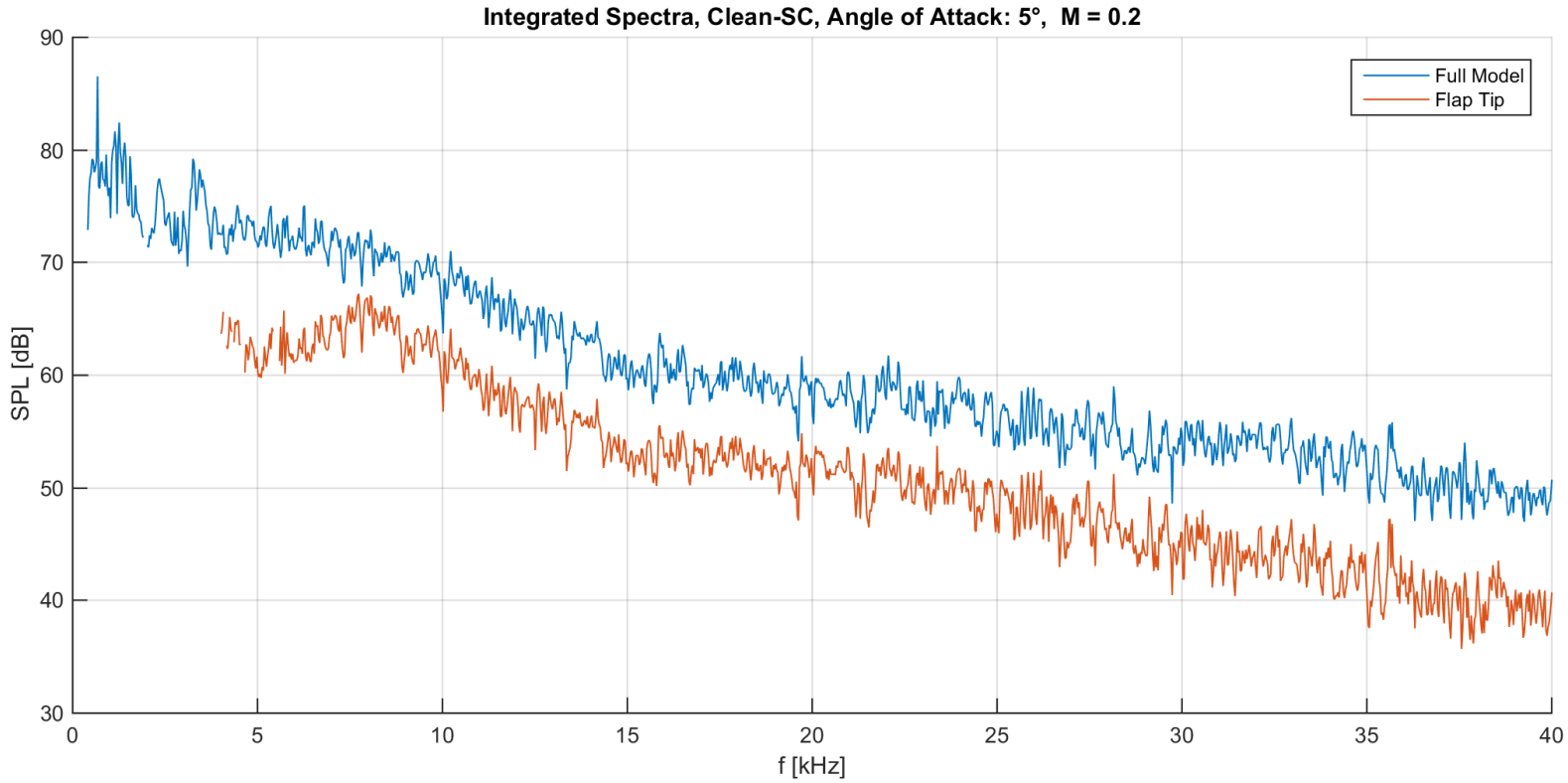

Integrated Spectrum Flap Side Edge/Flap Tip
PSD [dB] rel. 2 · 10^-5 Pa
70
60
50
40
30
2
4
6
8
10
12
14
Frequency [kHz]
DLR, FDBF - DR
DLR, NNLS - DR PSF>0 NoPsfDR
Univ. of Lyon, NNLS - DR

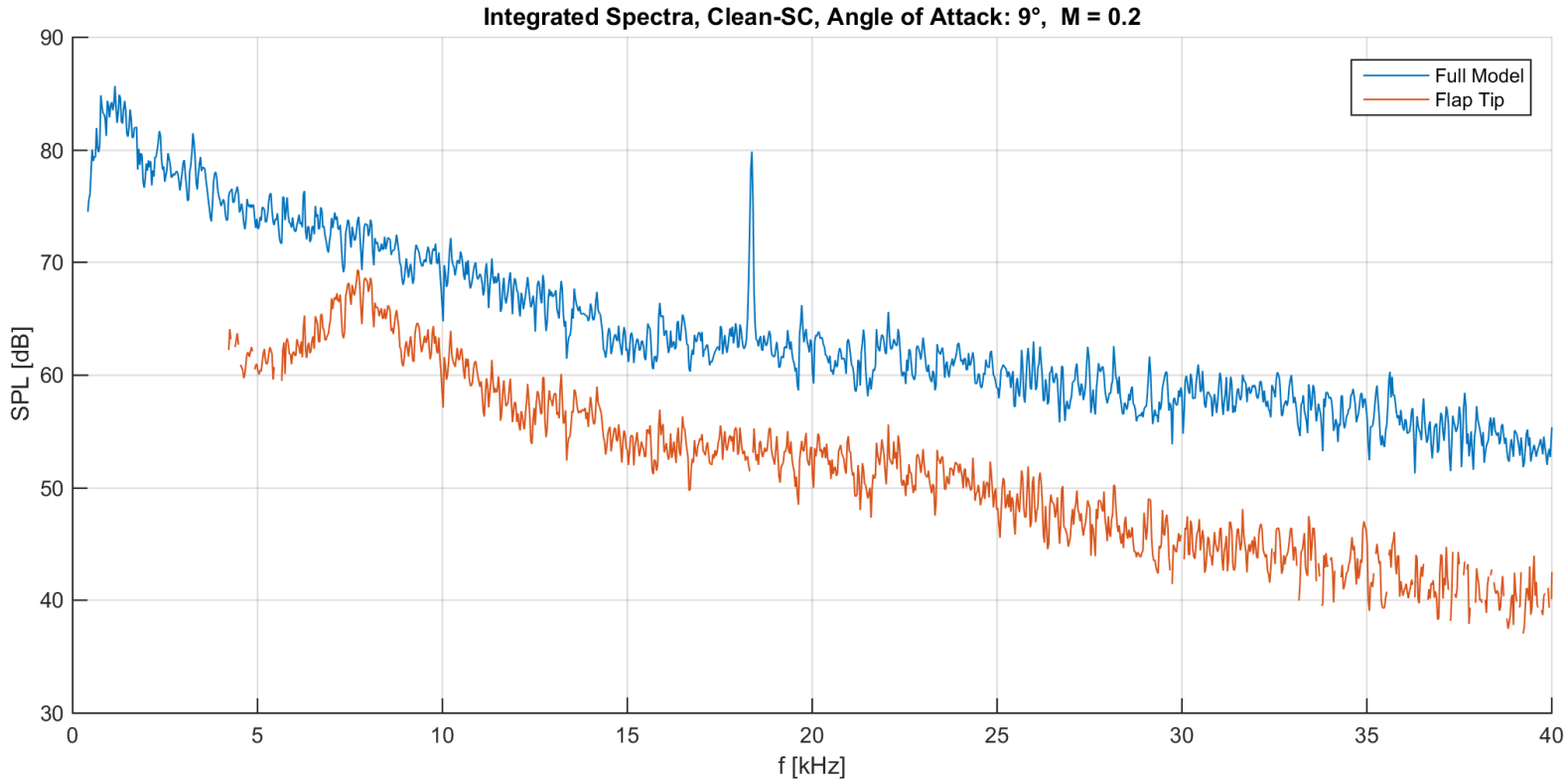

Integrated Spectra, Clean-SC, Angle of Attack: 3°, M = 0.15
Full Model
Flap Tip
SPL [dB]
f [kHz]
90
80
70
60
50
40
30
0
5
10
15
20
25
30
35
40

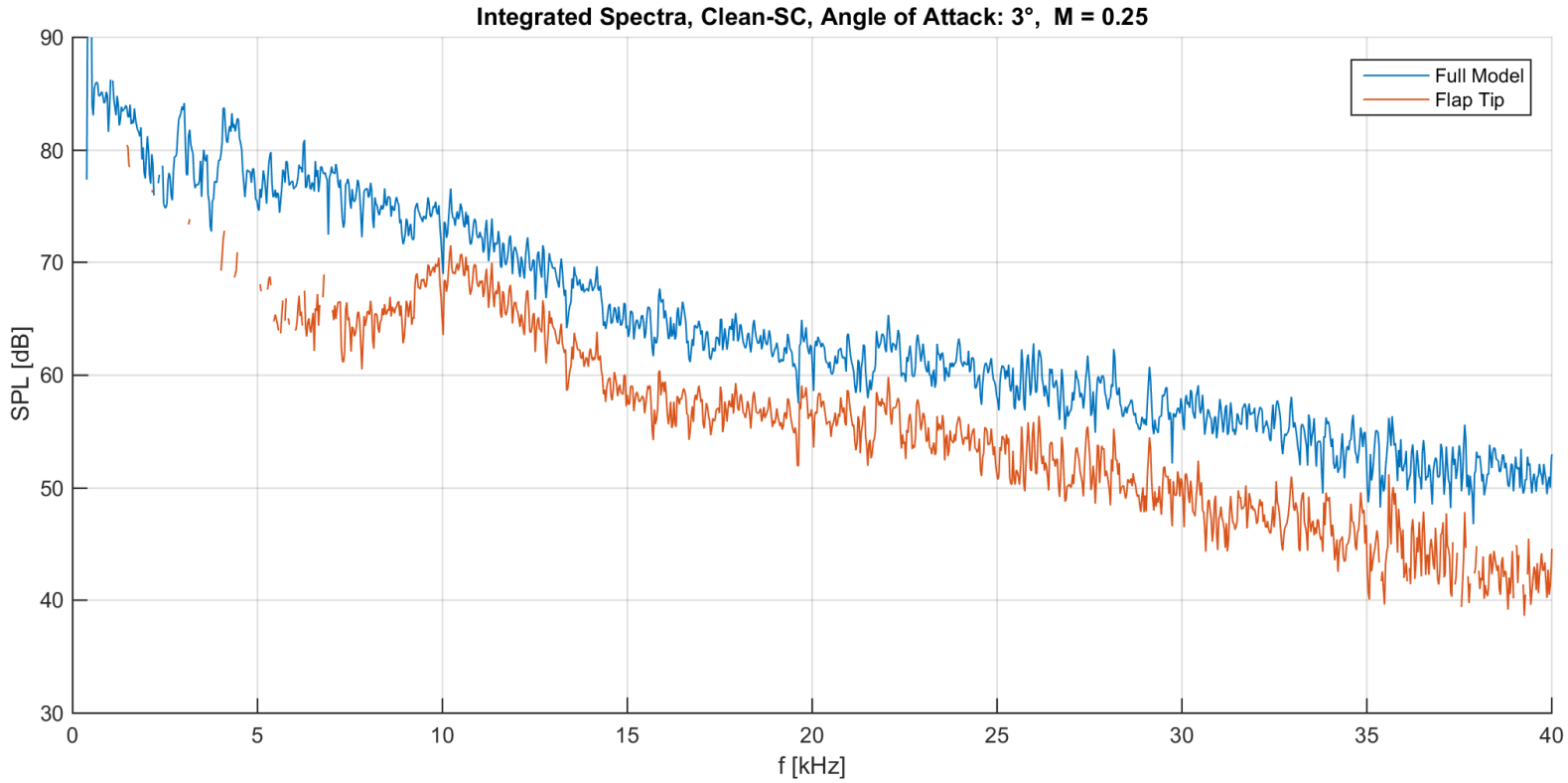

Integrated Spectra, Clean-SC, Angle of Attack: 5°, M = 0.15
Full Model
Flap Tip
SPL [dB]
f [kHz]
90
80
70
60
50
40
30
0
5
10
15
20
25
30
35
40

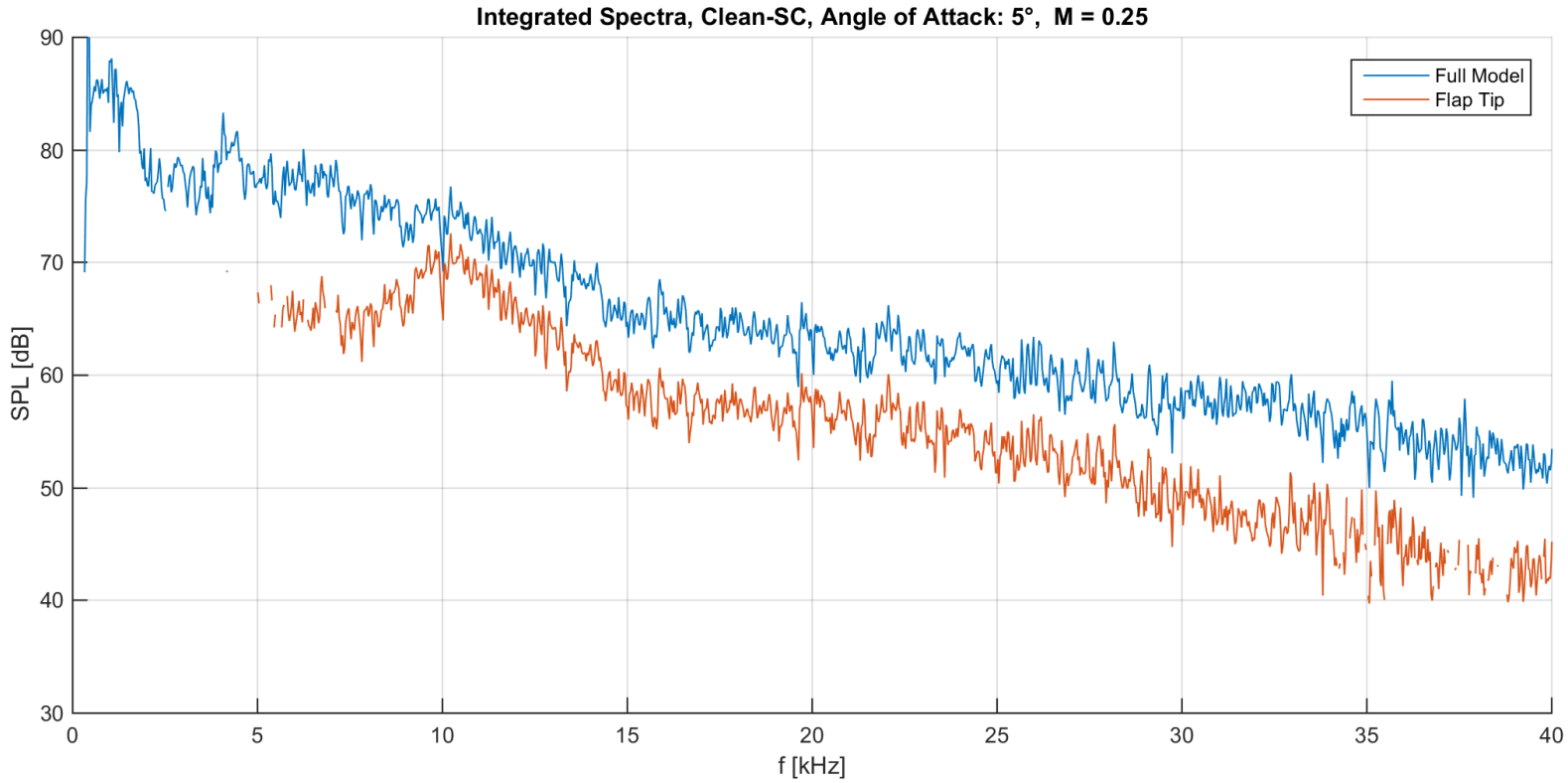

Integrated Spectra, Clean-SC, Angle of Attack: 9°, M = 0.15
Full Model
Flap Tip
SPL [dB]
f [kHz]
90
80
70
60
50
40
30
0
5
10
15
20
25
30
35
40

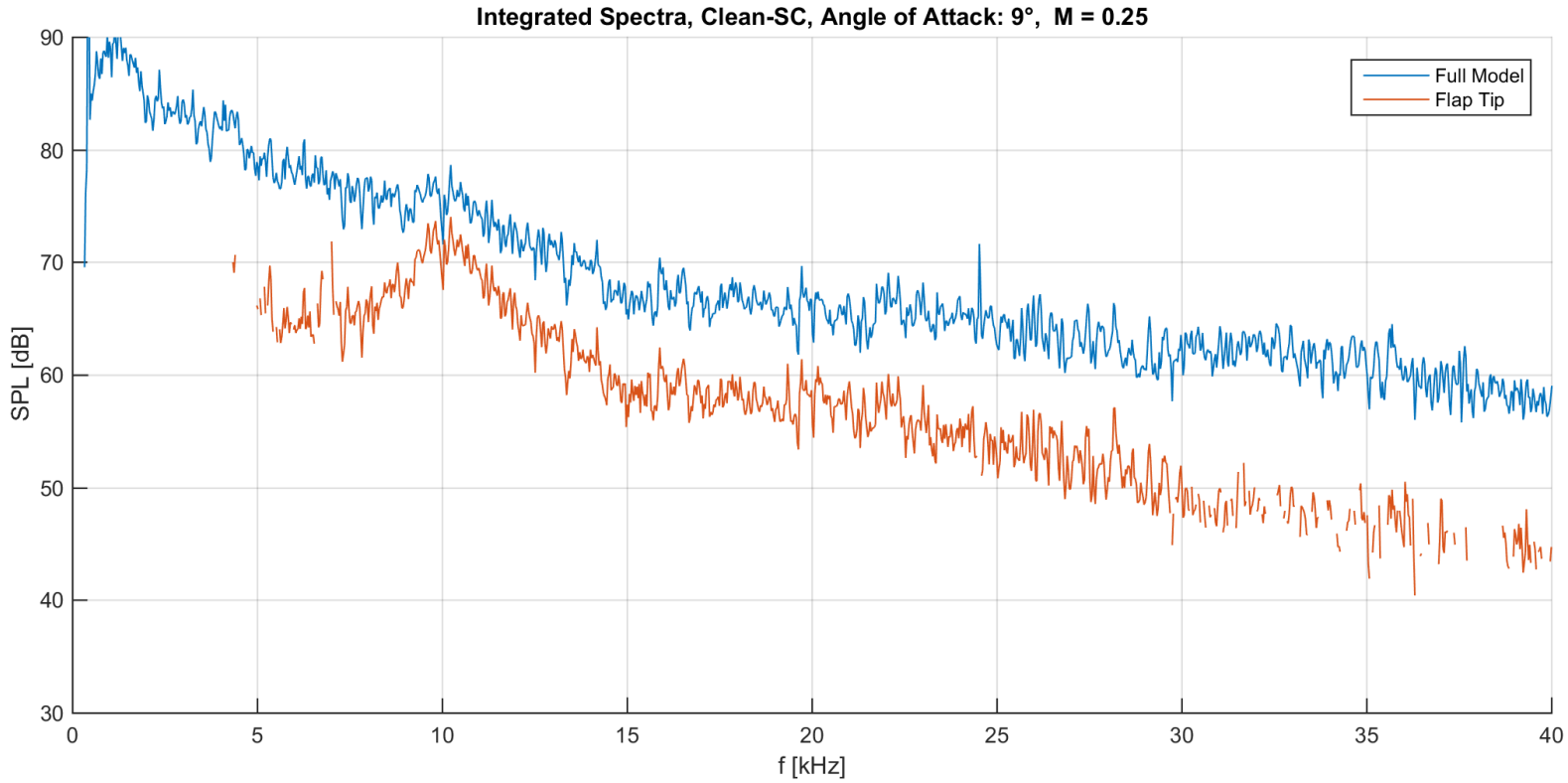

Integrated Spectra, Clean-SC, Angle of Attack: 3°, M = 0.2
Full Model
Flap Tip
SPL [dB]
f [kHz]
90
80
70
60
50
40
30
0
5
10
15
20
25
30
35
40

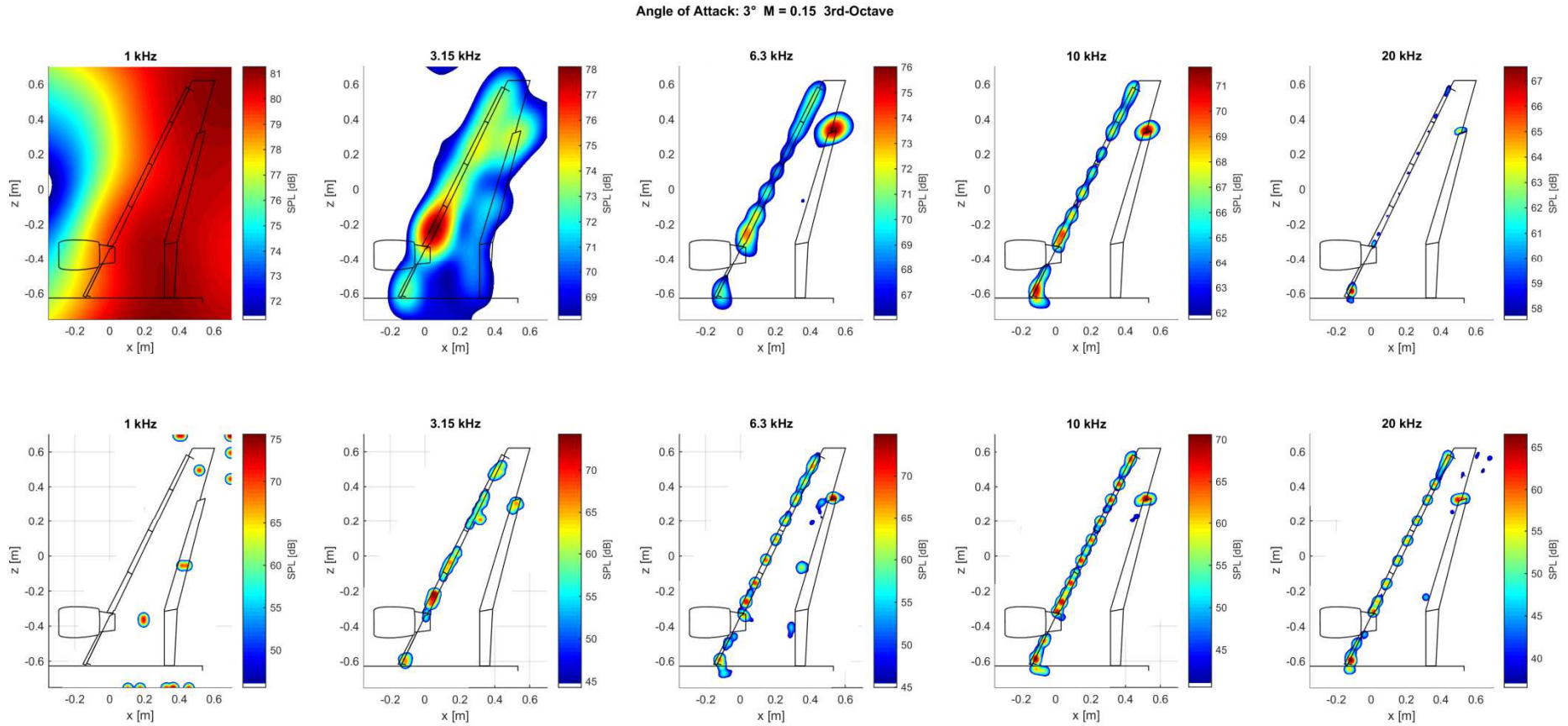

Integrated Spectra, Clean-SC, Angle of Attack: 5°, M = 0.2
Full Model
Flap Tip
SPL [dB]
f [kHz]
90
80
70
60
50
40
30
0
5
10
15
20
25
30
35
40


Integrated Spectra, Clean-SC, Angle of Attack: 9°, M = 0.2
Full Model
Flap Tip
SPL [dB]
f [kHz]
90
80
70
60
50
40
30
0
5
10
15
20
25
30
35
40


Integrated Spectra, Clean-SC, Angle of Attack: 3°, M = 0.25
SPL [dB]
f [kHz]
Full Model
Flap Tip
90
80
70
60
50
40
30
0
5
10
15
20
25
30
35
40


Integrated Spectra, Clean-SC, Angle of Attack: 5°, M = 0.25
SPL [dB]
f [kHz]
Full Model
Flap Tip
90
80
70
60
50
40
30
0
5
10
15
20
25
30
35
40

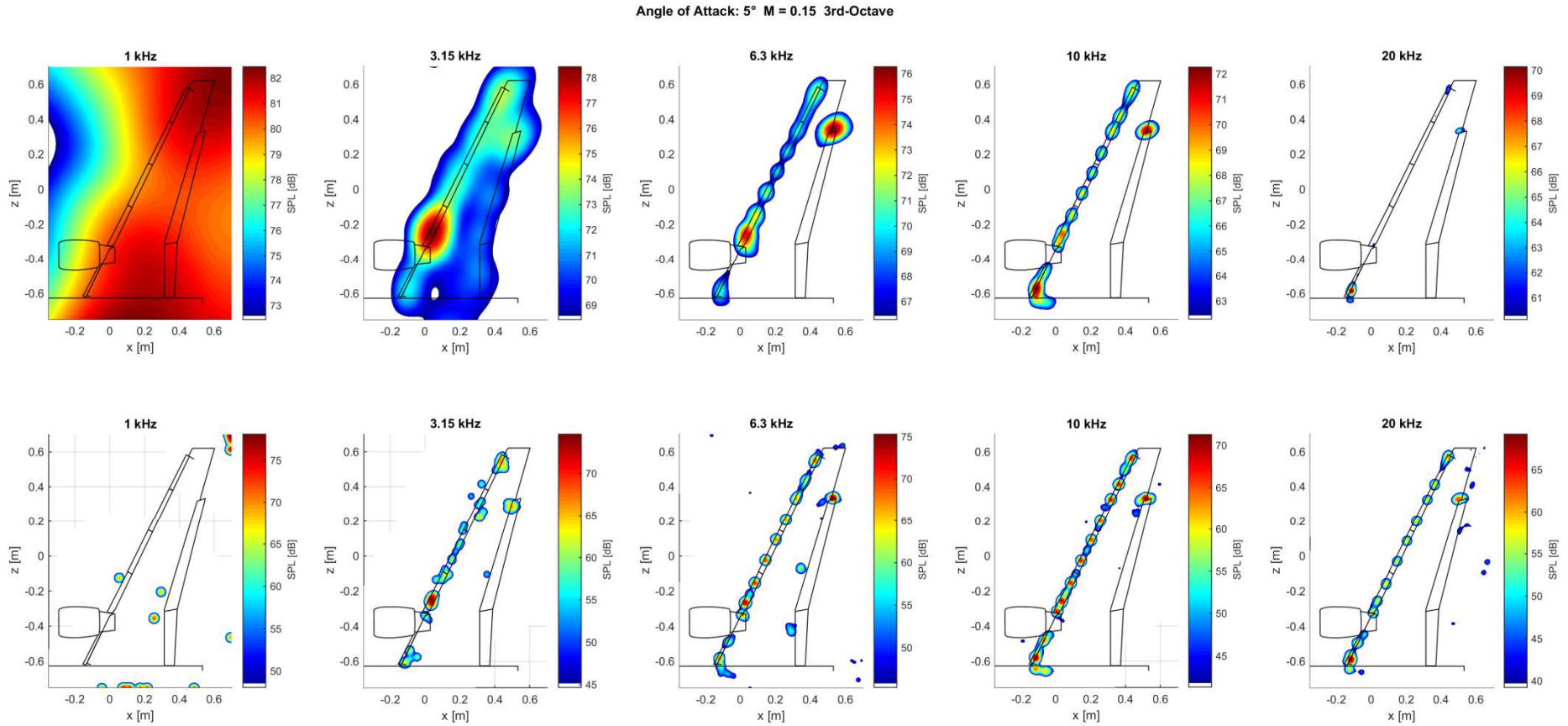

Integrated Spectra, Clean-SC, Angle of Attack: 9°, M = 0.25
Full Model
Flap Tip
SPL [dB]
f [kHz]
90
80
70
60
50
40
30
0
5
10
15
20
25
30
35
40



Upper Row: FDBF

Lower Row: CleanSC

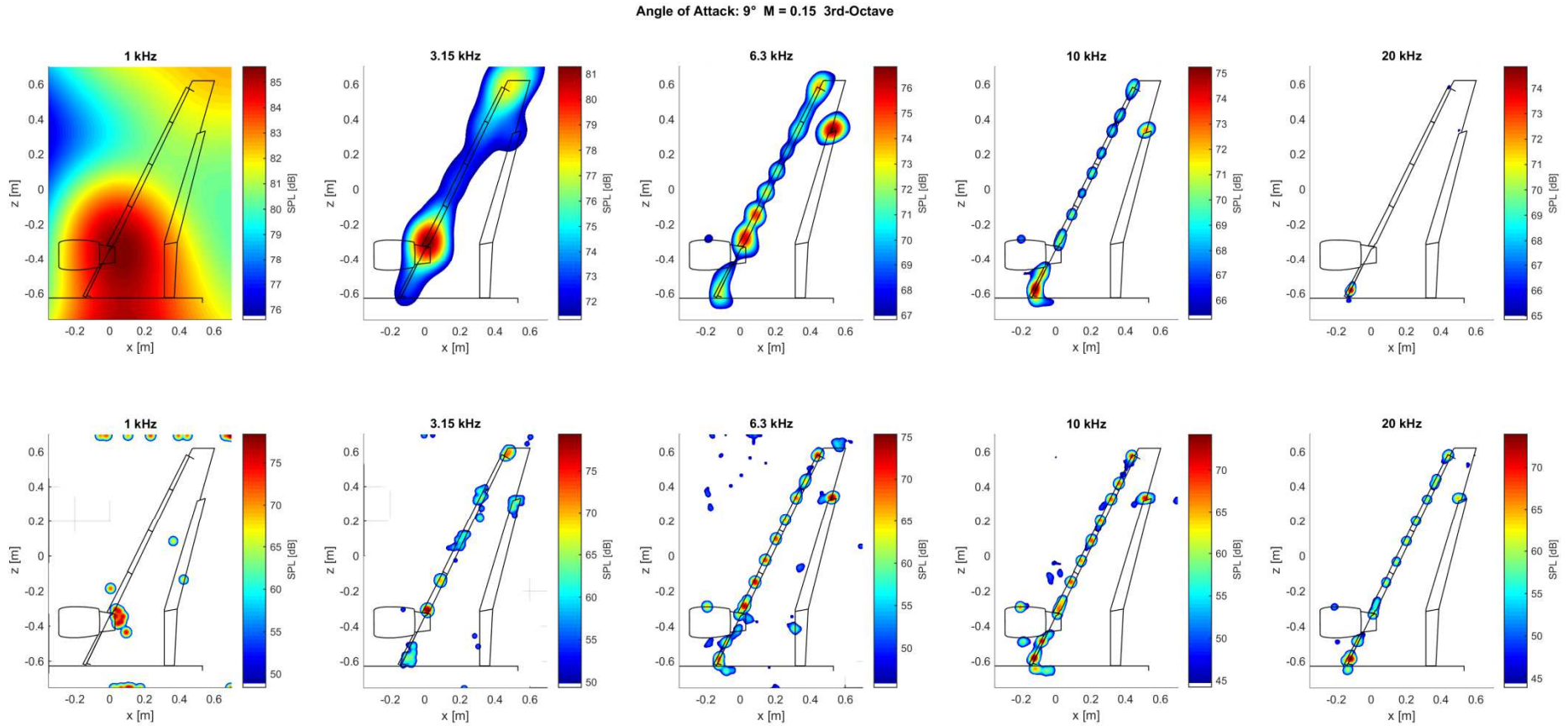
Resolution $\Delta x = 0.01m$



Upper Row: FDBF

Lower Row: CleanSC

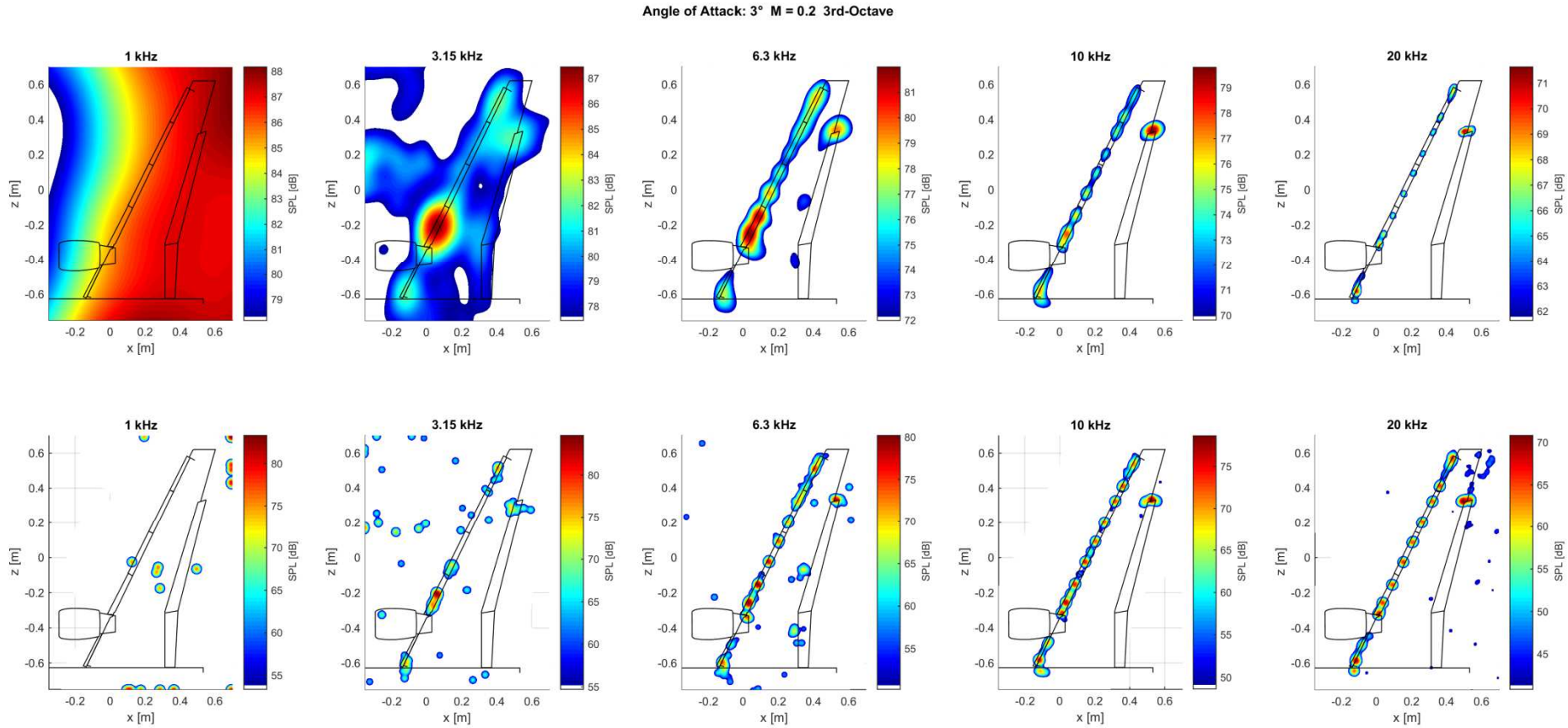
Resolution $\Delta x = 0.01m$



Upper Row: FDBF

Lower Row: CleanSC

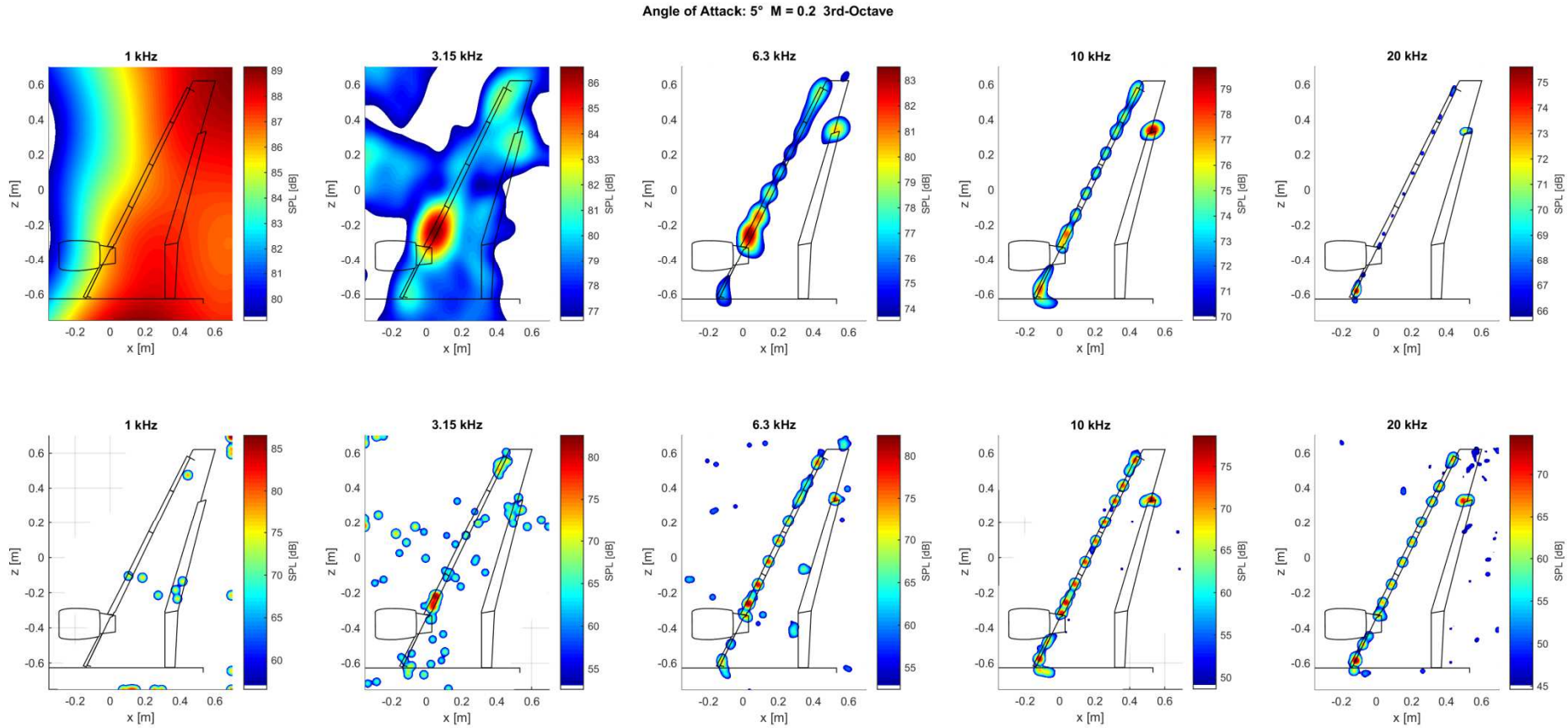
Resolution $\Delta x = 0.01m$



Upper Row: FDBF

Lower Row: CleanSC

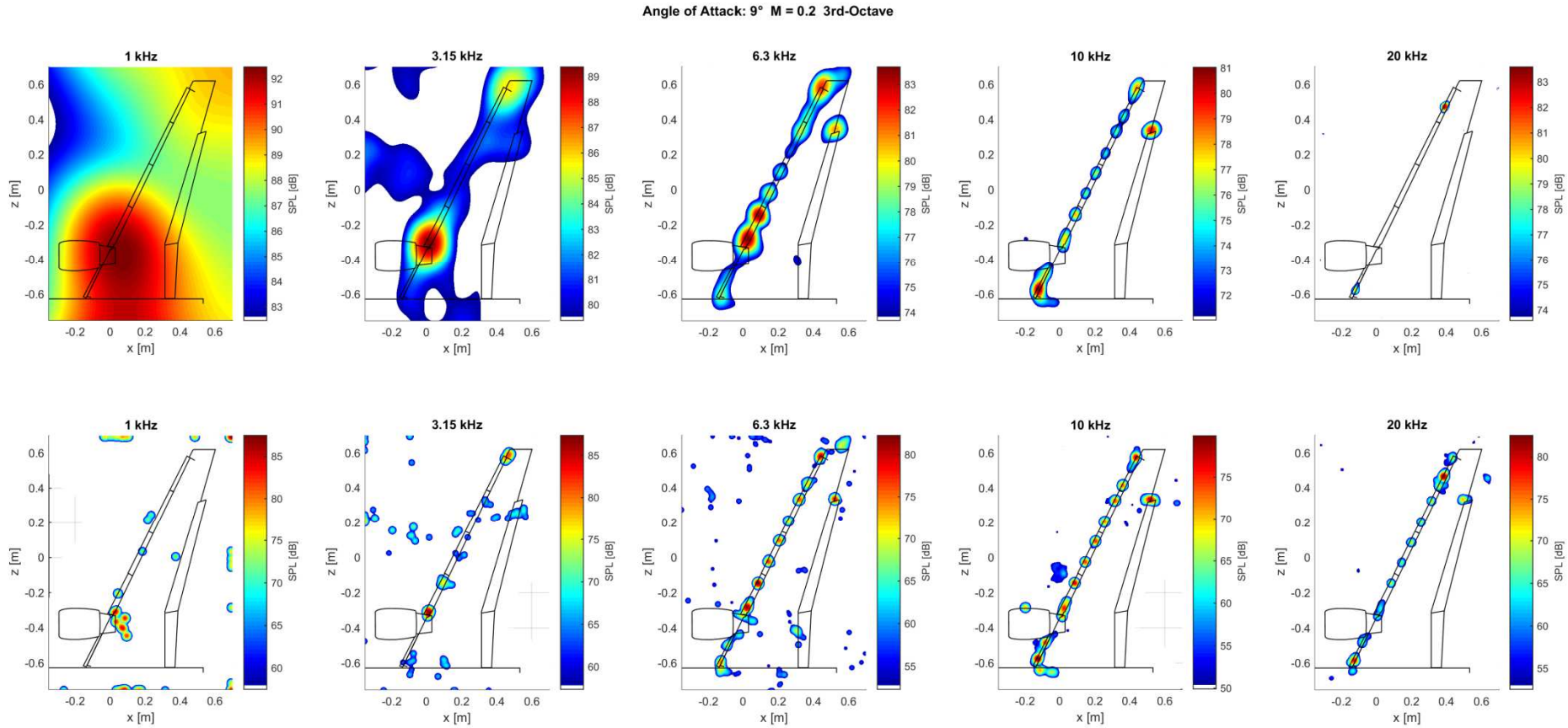
Resolution $\Delta x = 0.01m$



Upper Row: FDBF

Lower Row: CleanSC

Resolution $\Delta x = 0.01m$

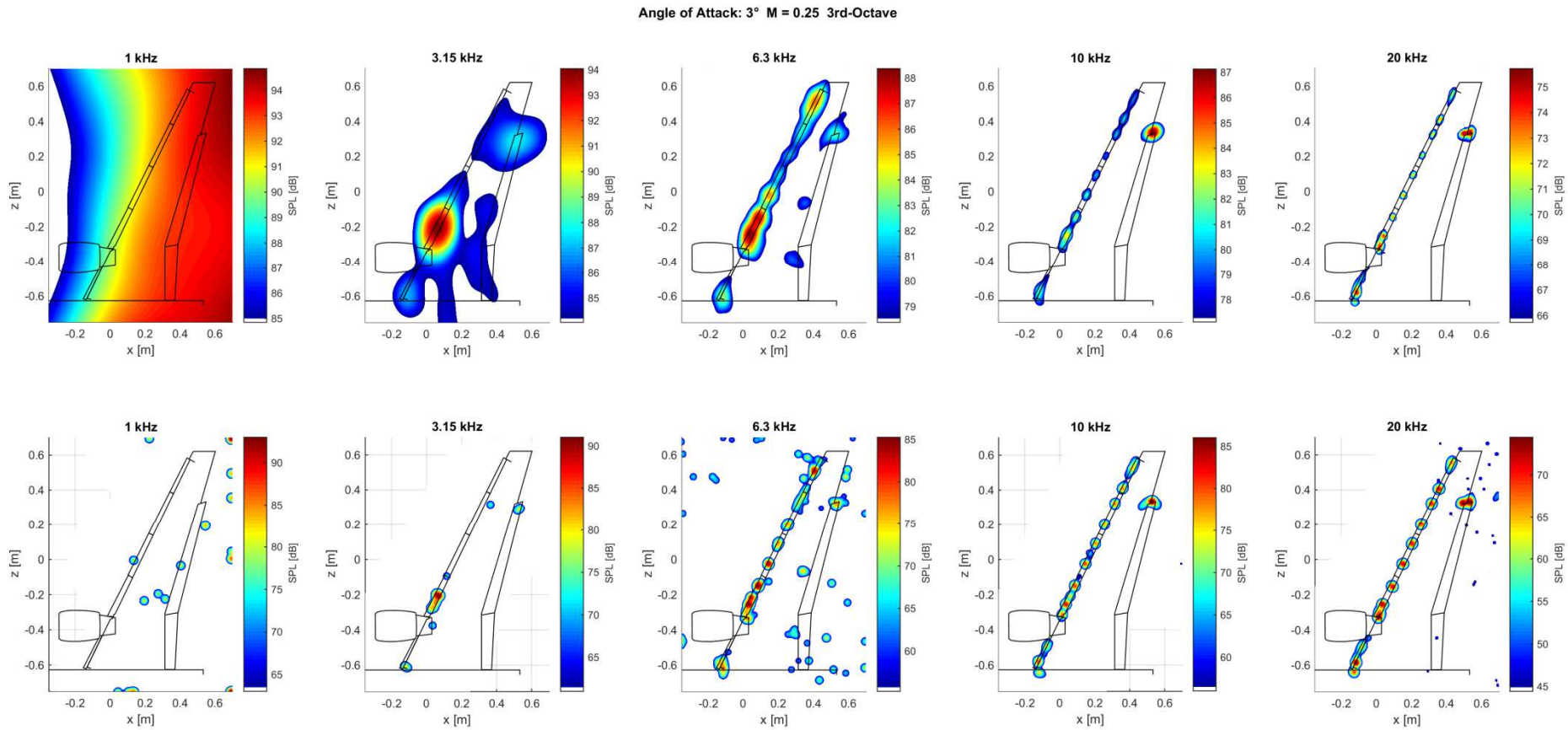


Upper Row: FDBF

Lower Row: CleanSC

Resolution $\Delta x = 0.01m$

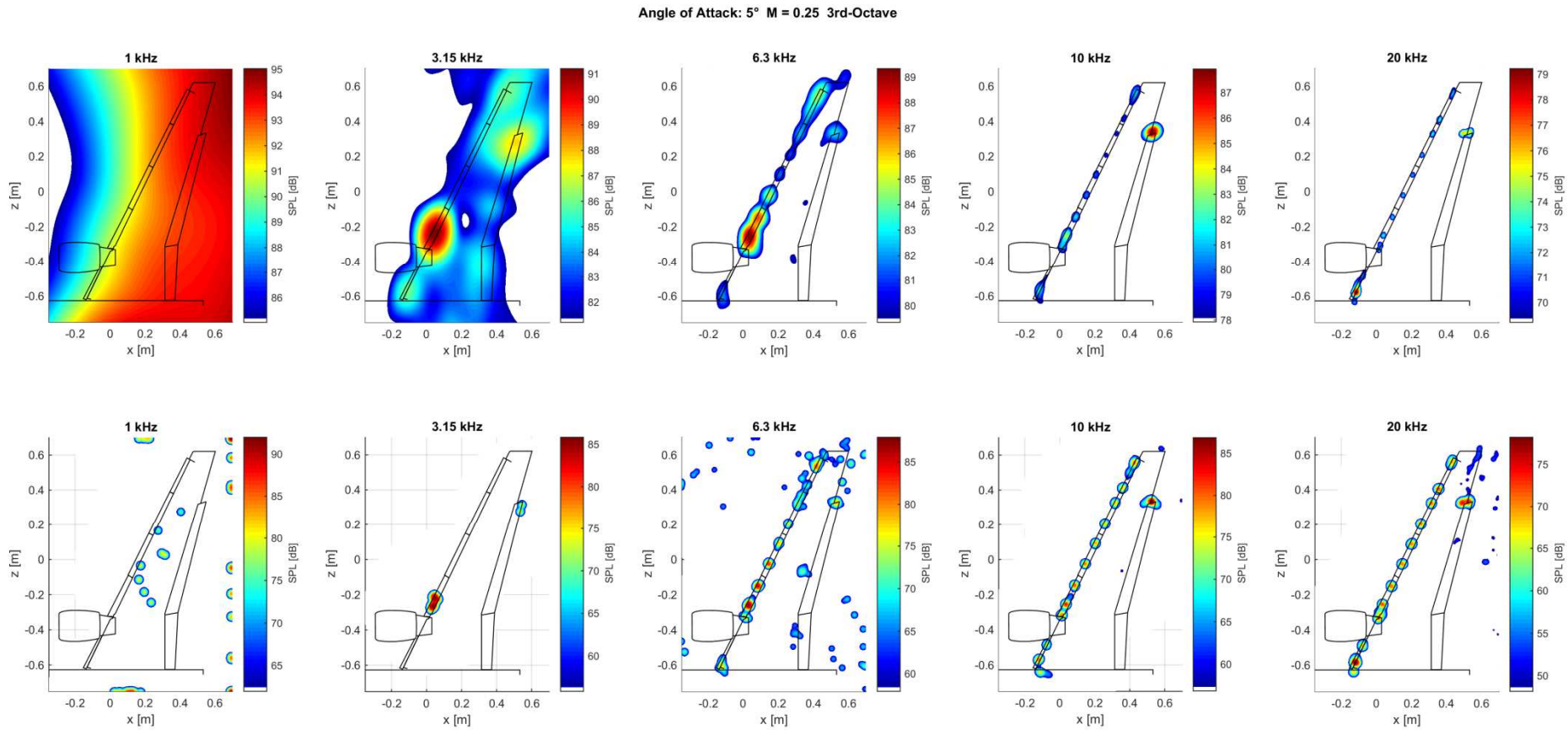
DLR



Upper Row: FDBF

Lower Row: CleanSC

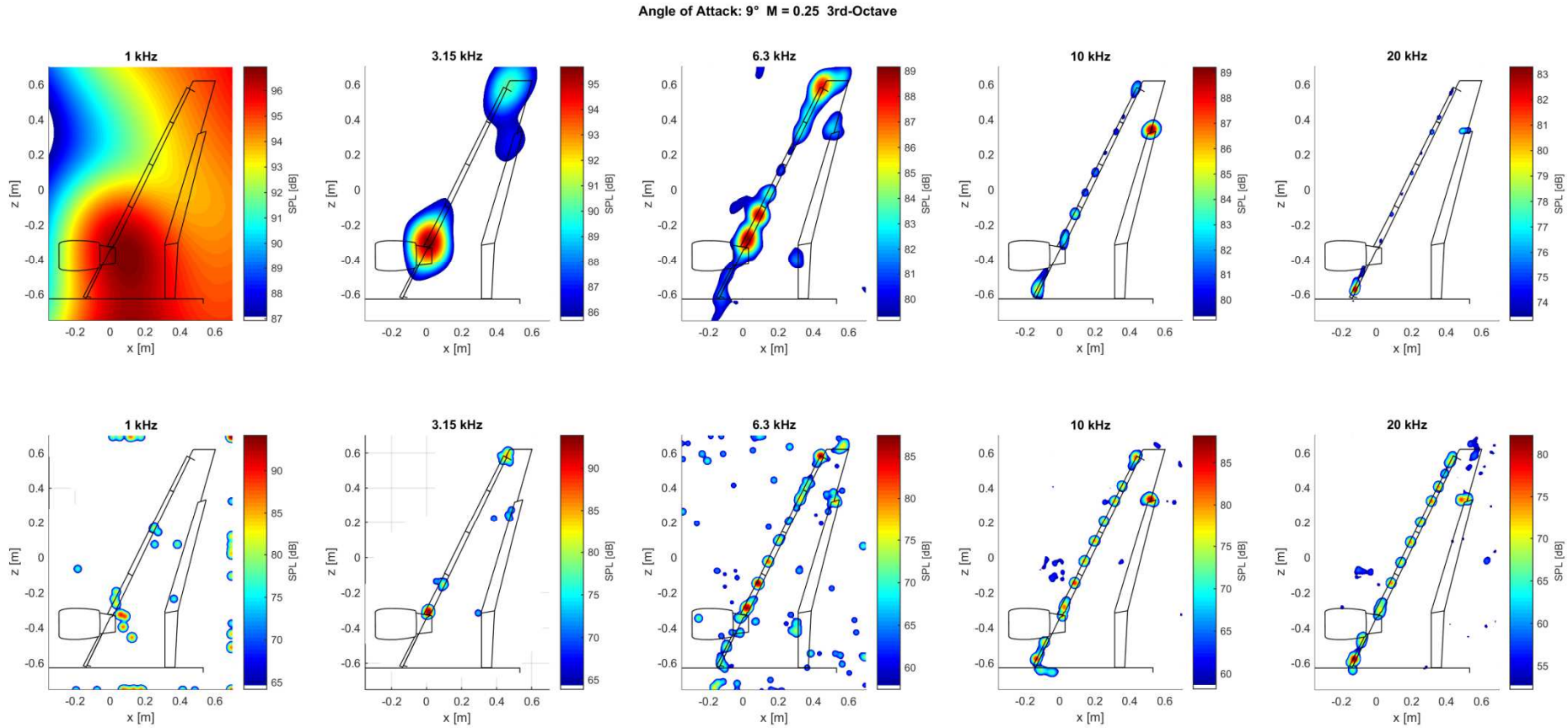
Resolution $\Delta x = 0.01m$



Upper Row: FDBF

Lower Row: CleanSC

Resolution $\Delta x = 0.01m$



Upper Row: FDBF

Lower Row: CleanSC

Resolution $\Delta x = 0.01m$

DLR