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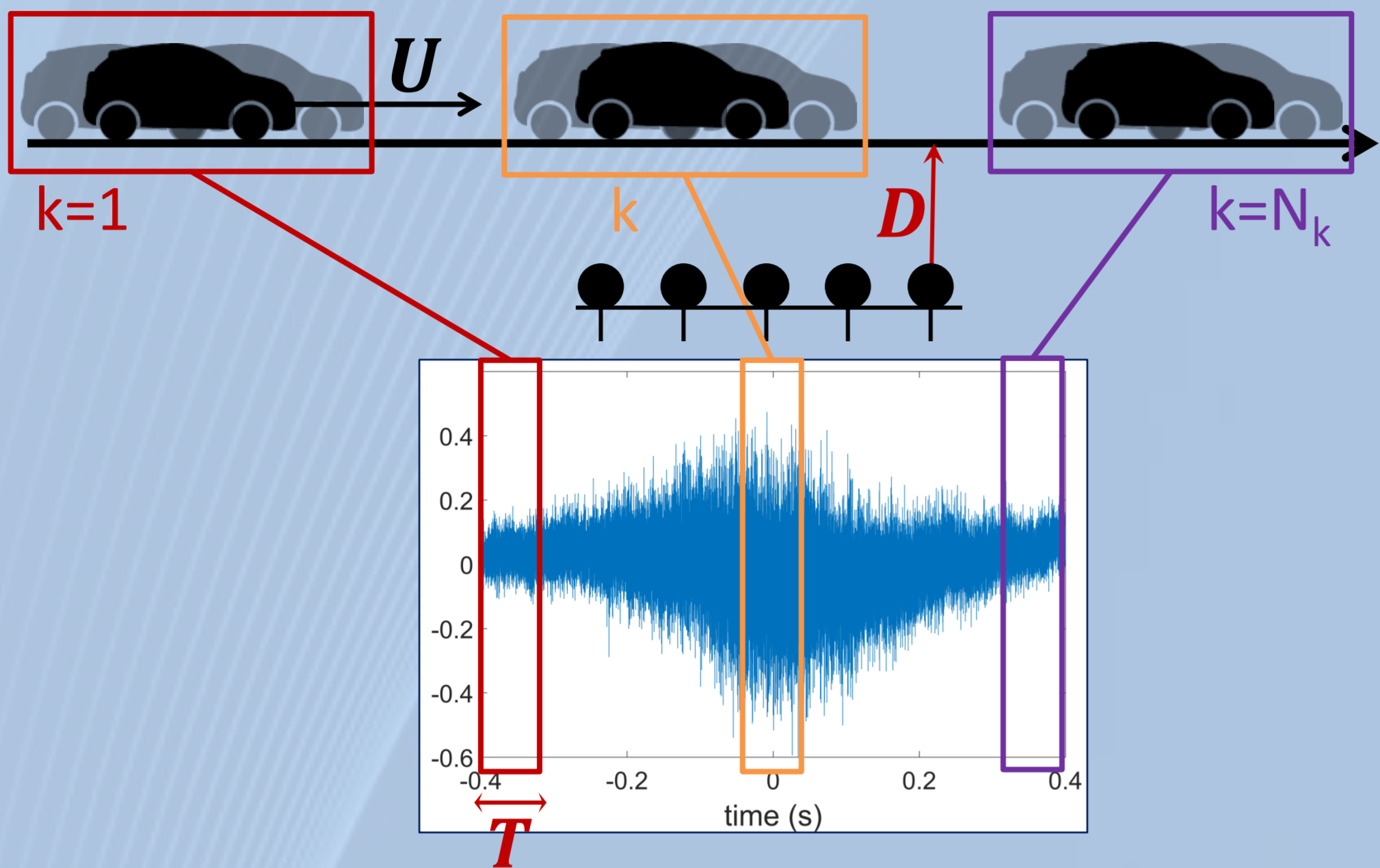
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Identification of acoustic moving sources in the context of a road vehicle at pass-by: a numerical and experimental comparison

METHOD DESCRIPTION: MOVING SOURCE ADAPTED - PSF



Assumptions:

- Uncorrelated sources
- Monopoles linearly moving at constant speed U
- $UT \ll D$
- Ergodic random sources
- Differences in dopplerized frequencies $< \Delta f (= \frac{1}{T})$

Snapshot k ($k=1..N_k$):

$$\text{Beamforming at frequency } f_{dopp}^{(k)} = \frac{f}{1 - M \cos \theta_k}$$

$$\text{PSF calculated at } f_{dopp}^{(k)}$$

- Averaged BF output over N_k
- Averaged PSF over N_k
- Deconvolution

$$\tilde{H}(\omega_p) \mathbf{s}(\omega_p) = \mathbf{b}(\omega_p)$$

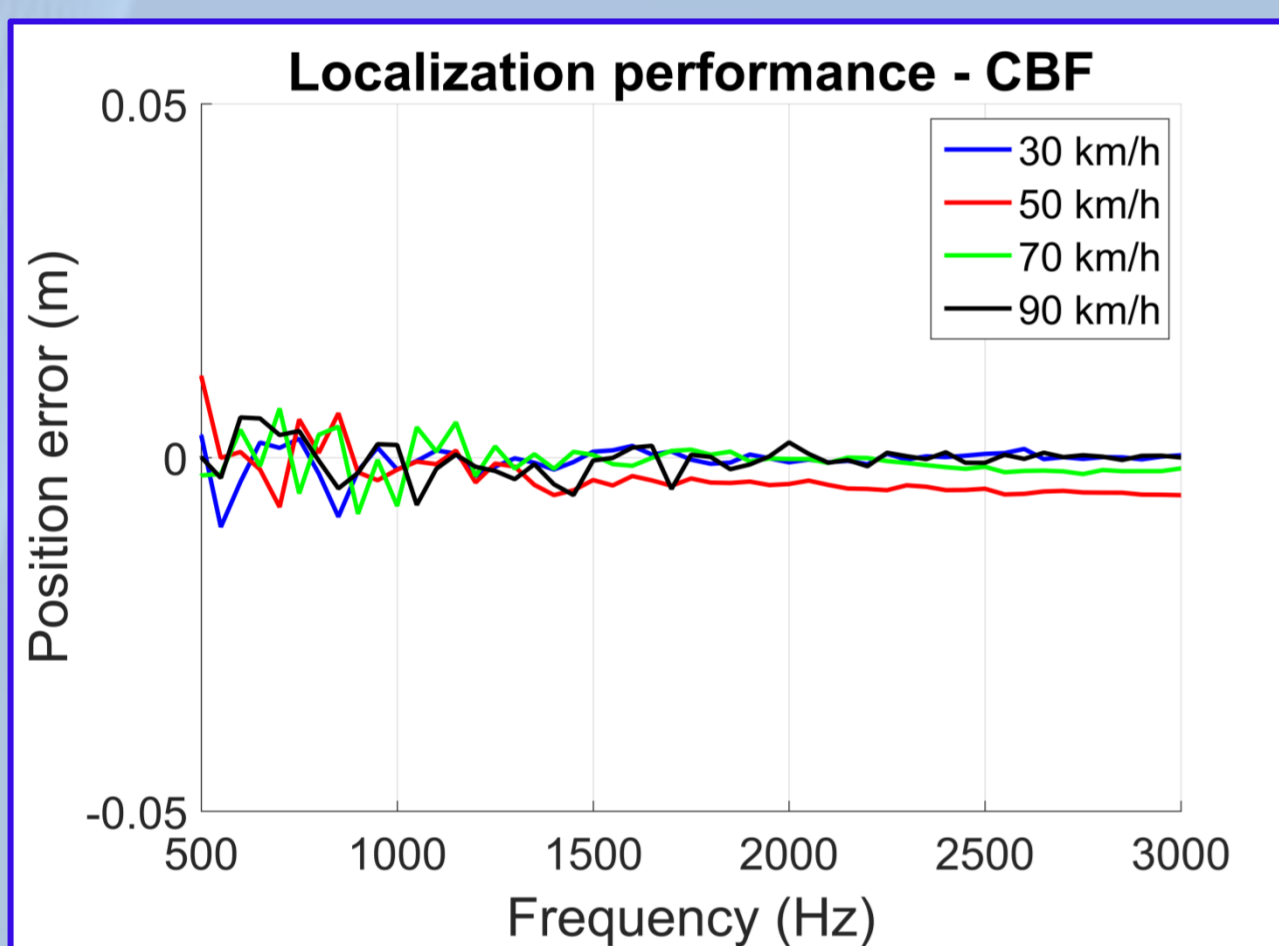
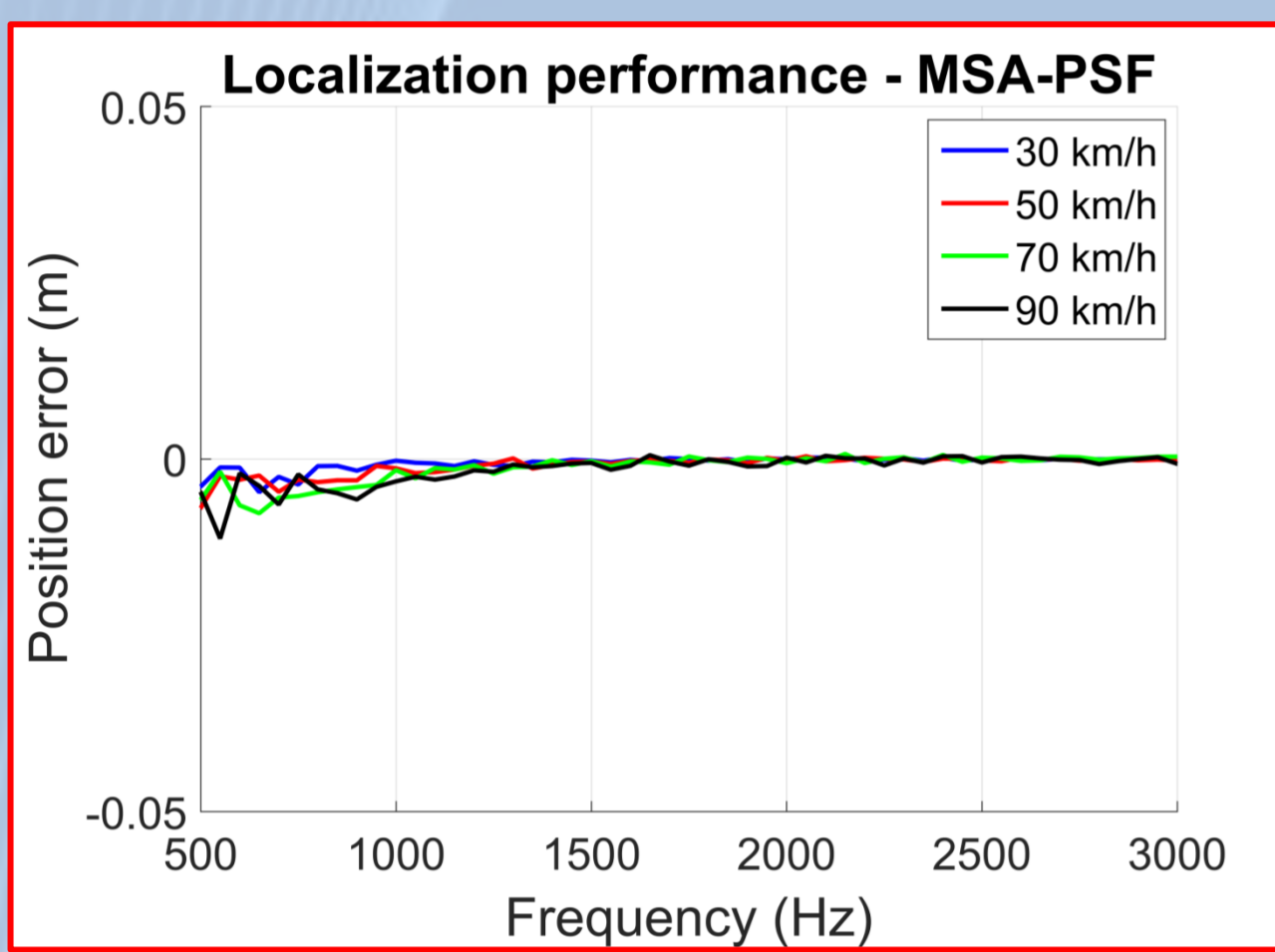
$$b_i(\omega_p) \approx \sum_{m,n=1}^{N_M} \tilde{G}_{i,m}^* \left(\frac{\omega_p}{1 - M_{i,m}^{(k)}} \right) \tilde{G}_{i,n}^{(k)} \left(\frac{\omega_p}{1 - M_{i,n}^{(k)}} \right)$$

$$\tilde{H}_{i,j}(\omega_p) = \left| \sum_{m=1}^{N_M} \tilde{G}_{i,m}^* \left(\frac{\omega_p}{1 - M_{i,m}^{(k)}} \right) \tilde{G}_{j,m} \left(\frac{\omega_p}{1 - M_{i,m}^{(k)}} \right) \right|^2$$

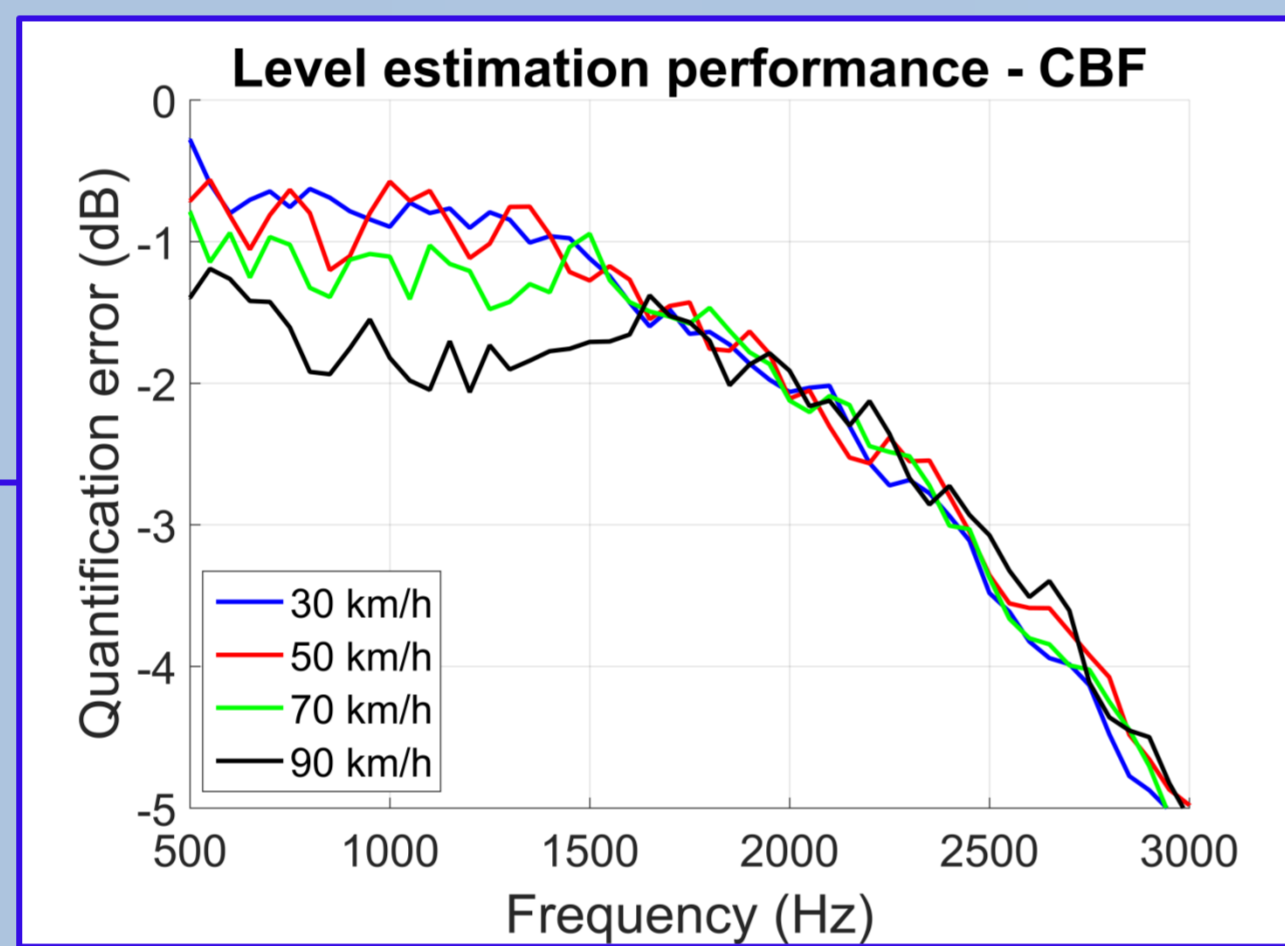
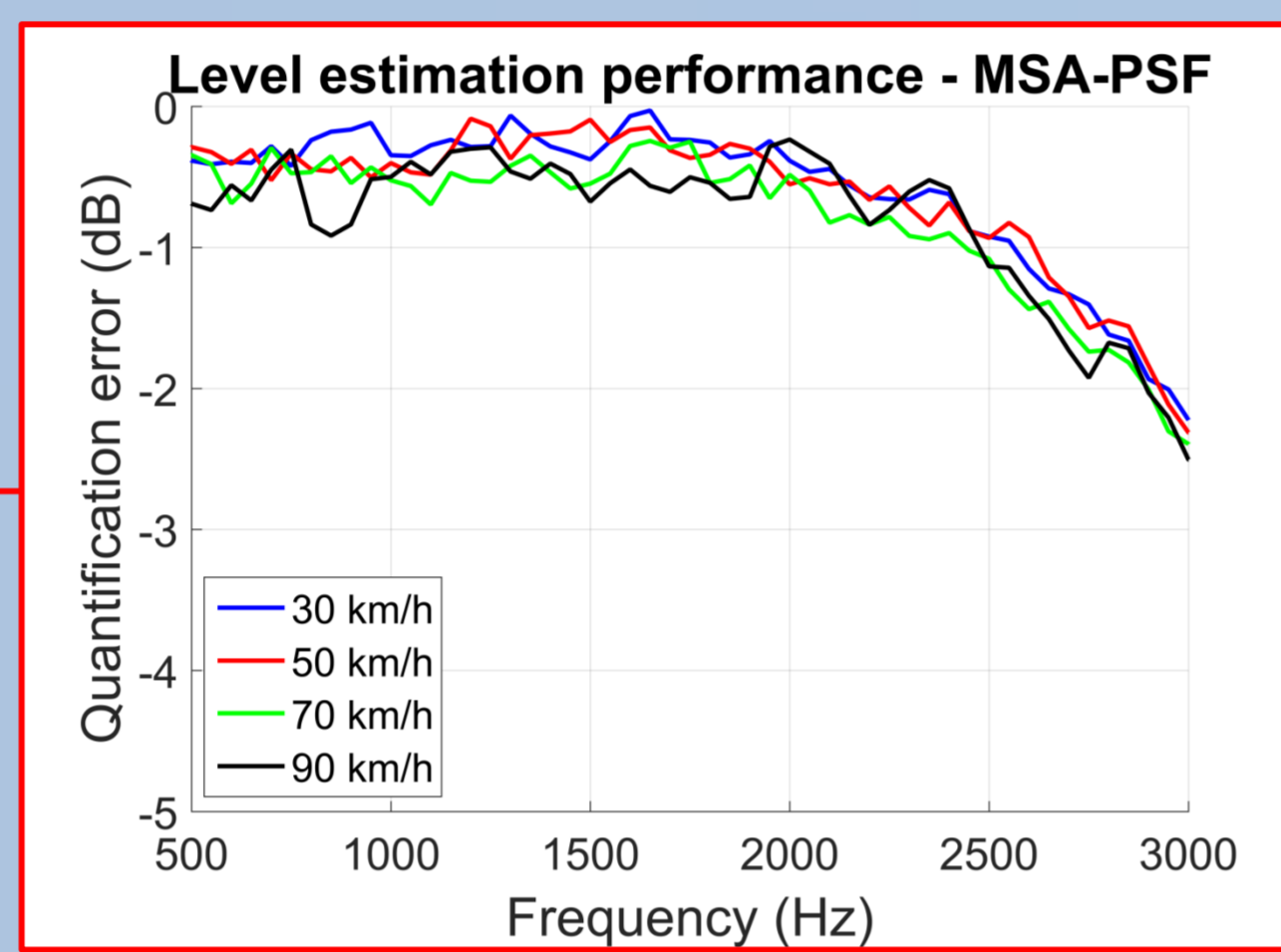
$$\Gamma_{i,m,n}^{(k)}(\omega_p) = \tilde{P}_m^{(k)} \left(\frac{\omega_p}{1 - M_{i,m}^{(k)}} \right) \tilde{P}_n^{(k)*} \left(\frac{\omega_p}{1 - M_{i,n}^{(k)}} \right)$$

NUMERICAL SIMULATIONS: PERFORMANCE ASSESSMENT

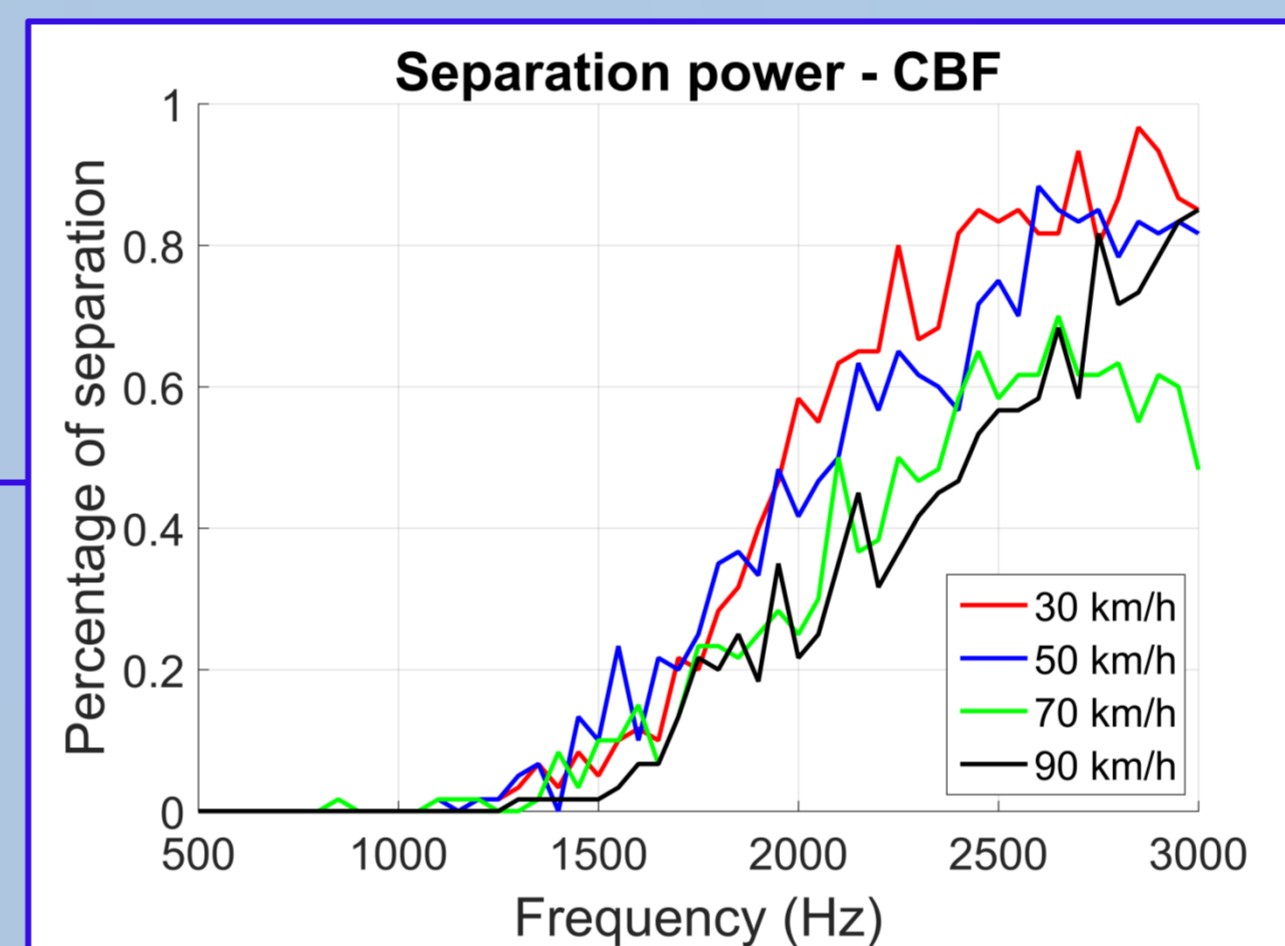
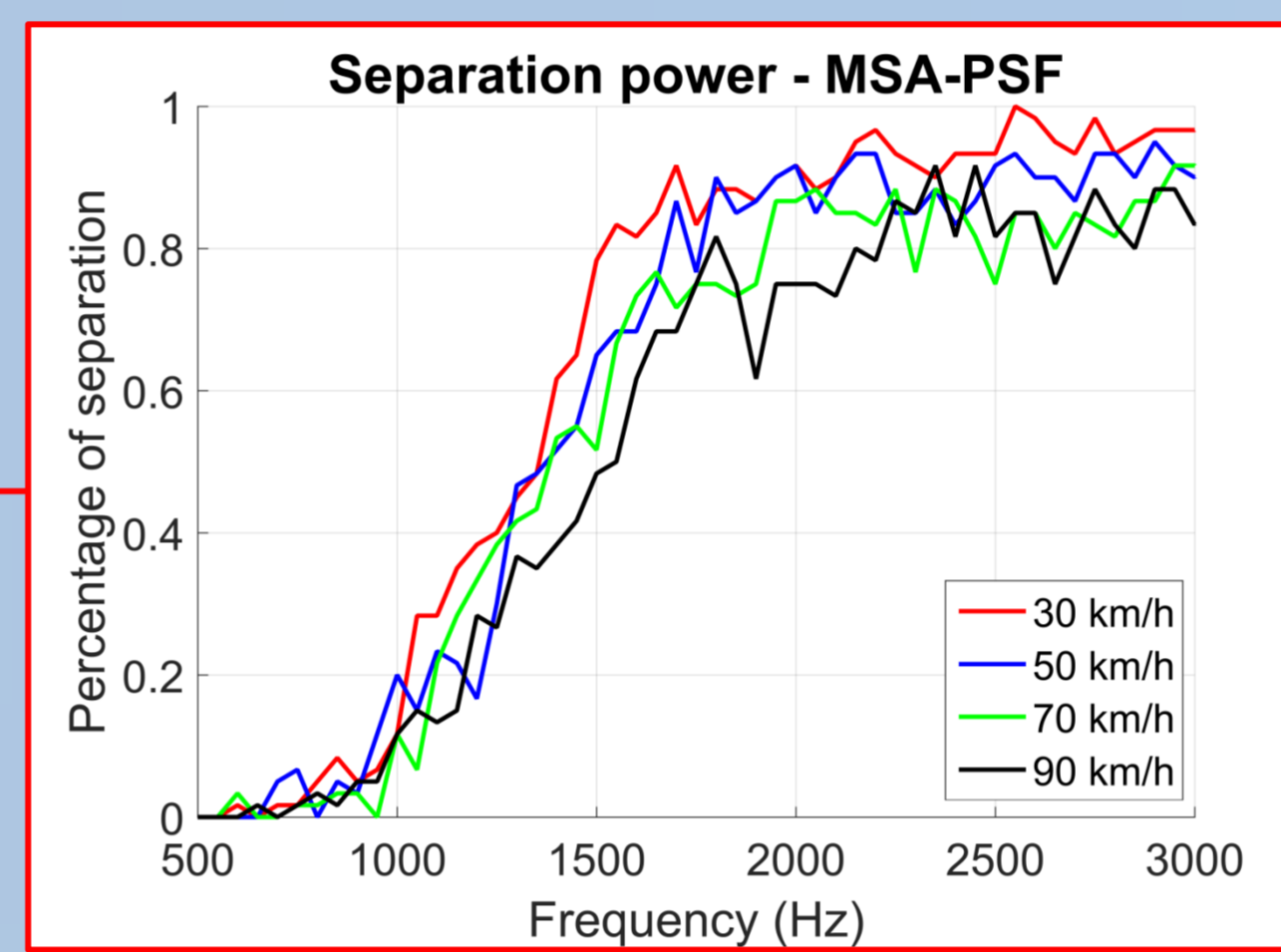
1. LOCALIZATION



2. QUANTIFICATION



3. SEPARATION POWER



SIMULATION PARAMETERS

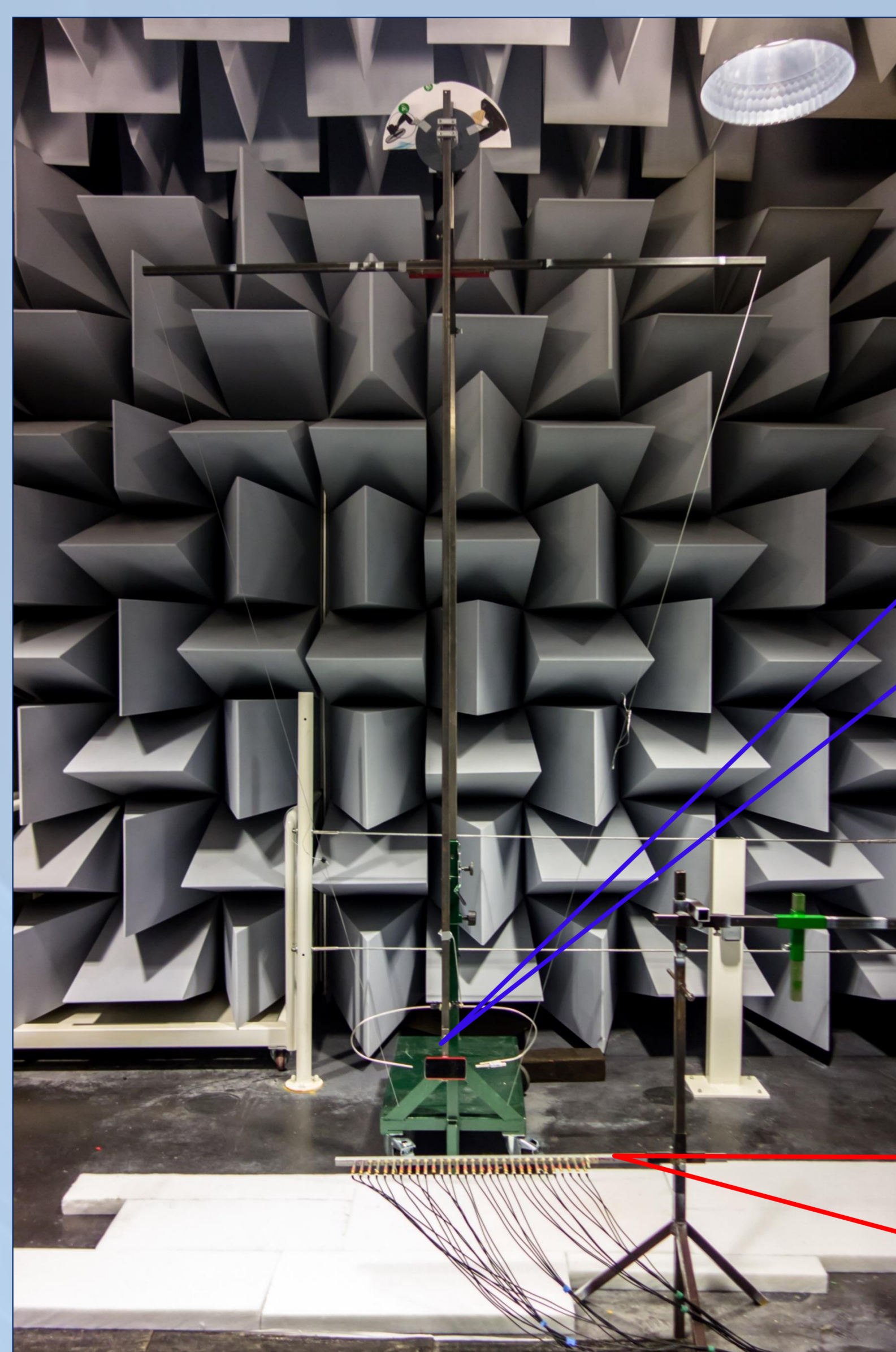
$F_s = 8000$ Hz	$X_{\text{source}} = 0$ m
$N_M = 32$ sensors	$X_{\text{sep}} = [-0.05; +0.05]$ m
$d = [0.05 - 0.29]$ m	$f_{\text{range}} = [500 - 3000]$ Hz
$L_{\text{array}} = 4$ m	$T = 0.02$ s
$D = 4$ m	$N_k = 29$
$T_{\text{signal}} = 2$ s	Overlap = 60%
$U = [30 - 90]$ km/h	$N_{\text{simus}} = 60$

MSA-PSF: Moving Source Adapted - Point Spread Function

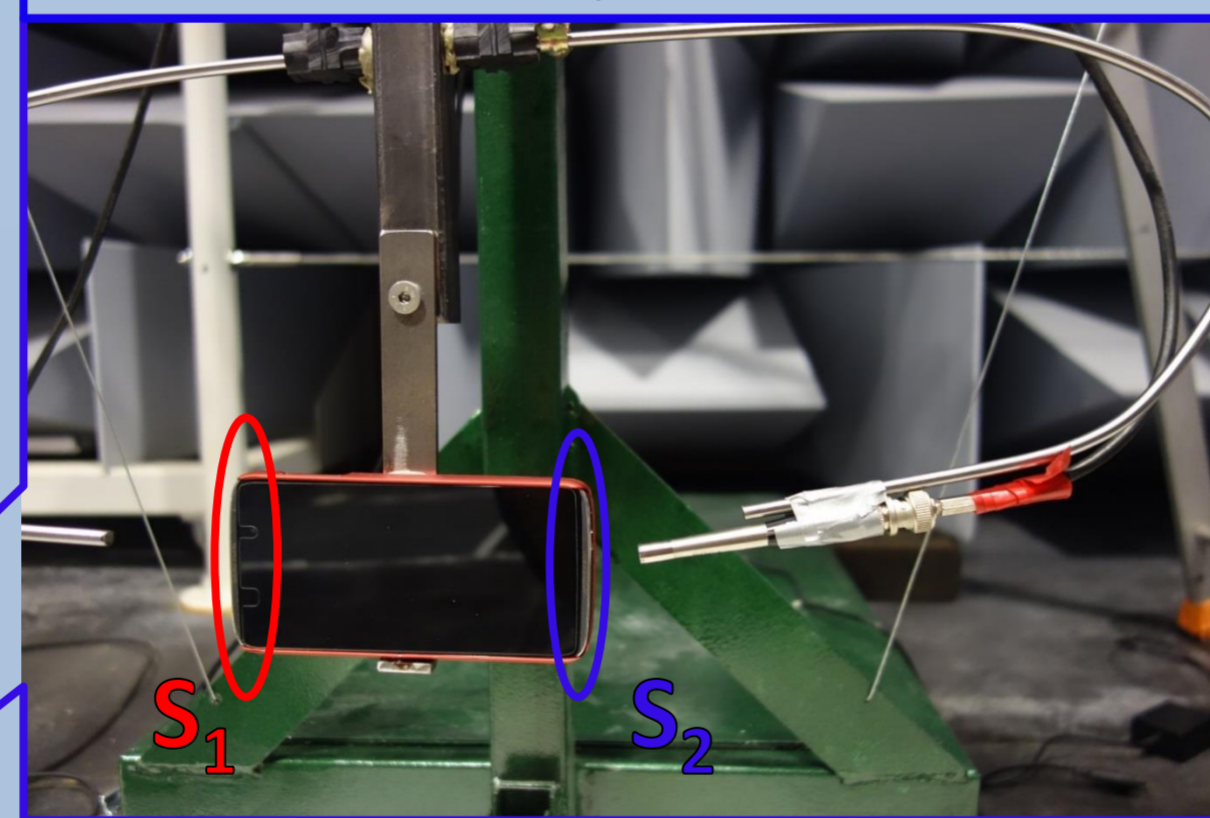
CBF: Conventional Beamforming (Sweeping focus time domain BF + Deconvolution with static PSF)

- Better localization of sources: more robust and less dispersive
- Better quantification: error < 1 dB until 2.5 kHz vs error > 1 dB in whole frequency range for CBF
- Better separation of close sources

ACADEMIC EXPERIMENT



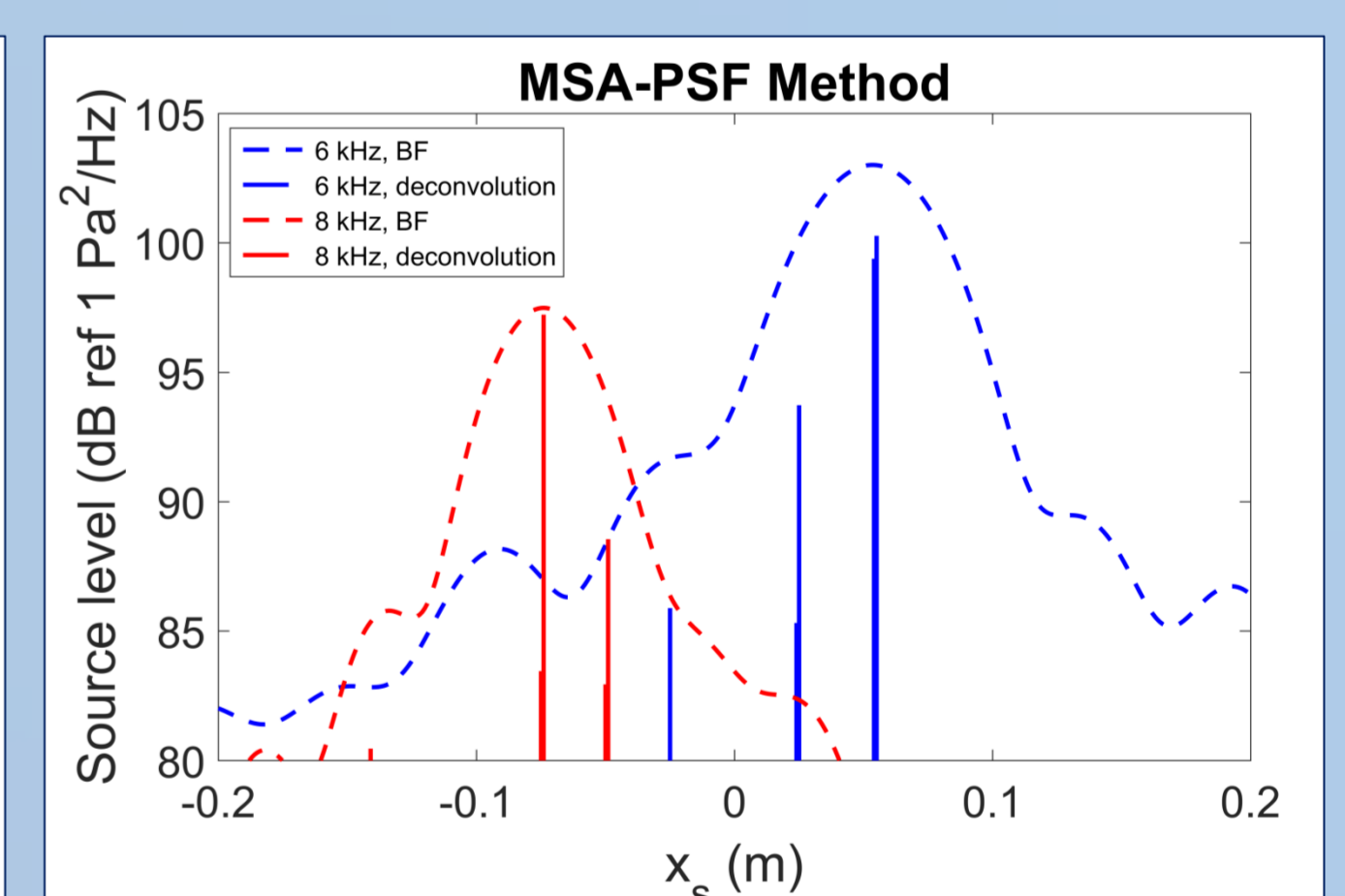
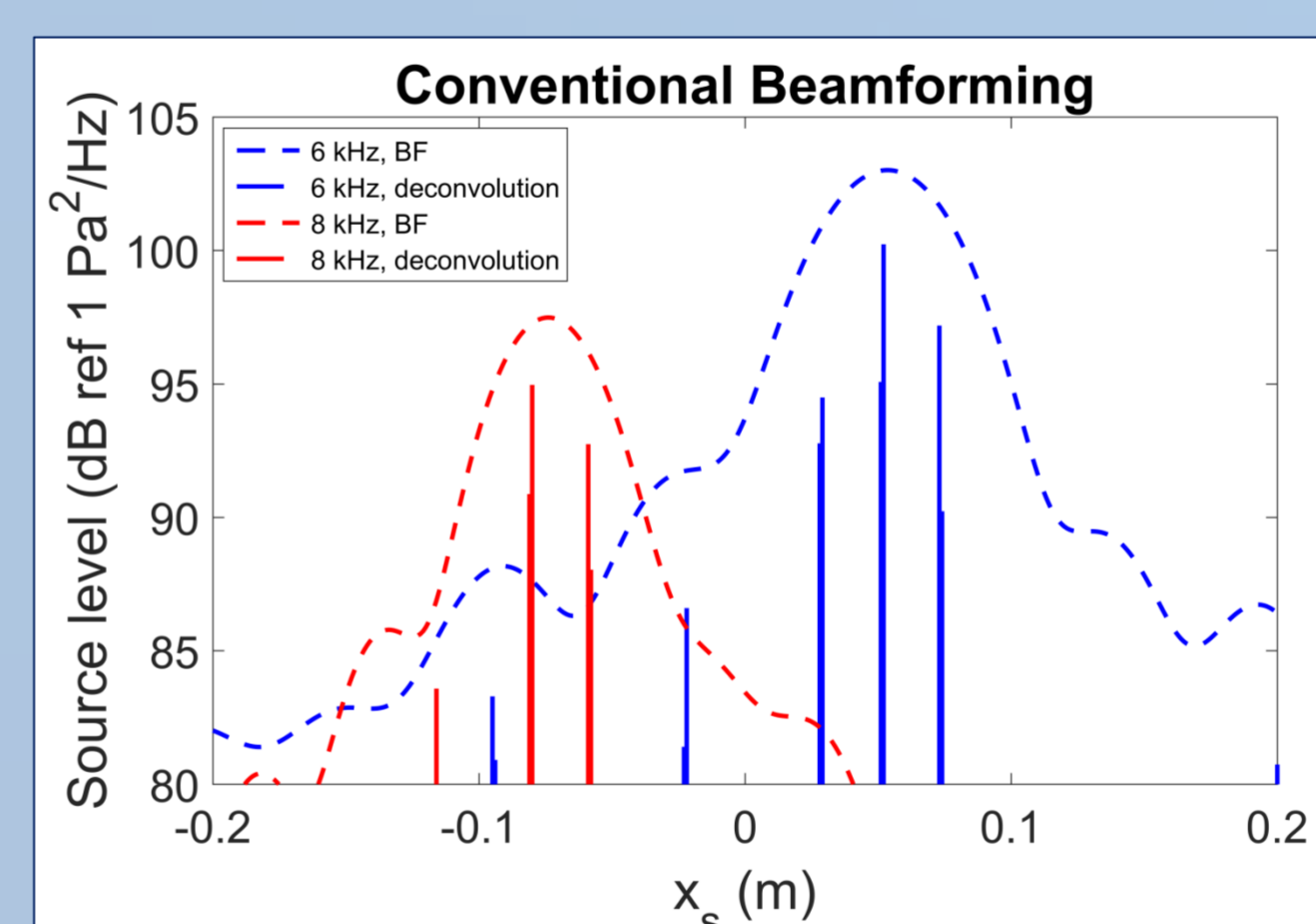
Moving sources: Smartphone with two independent loudspeakers



30 Microphones linear array microphones



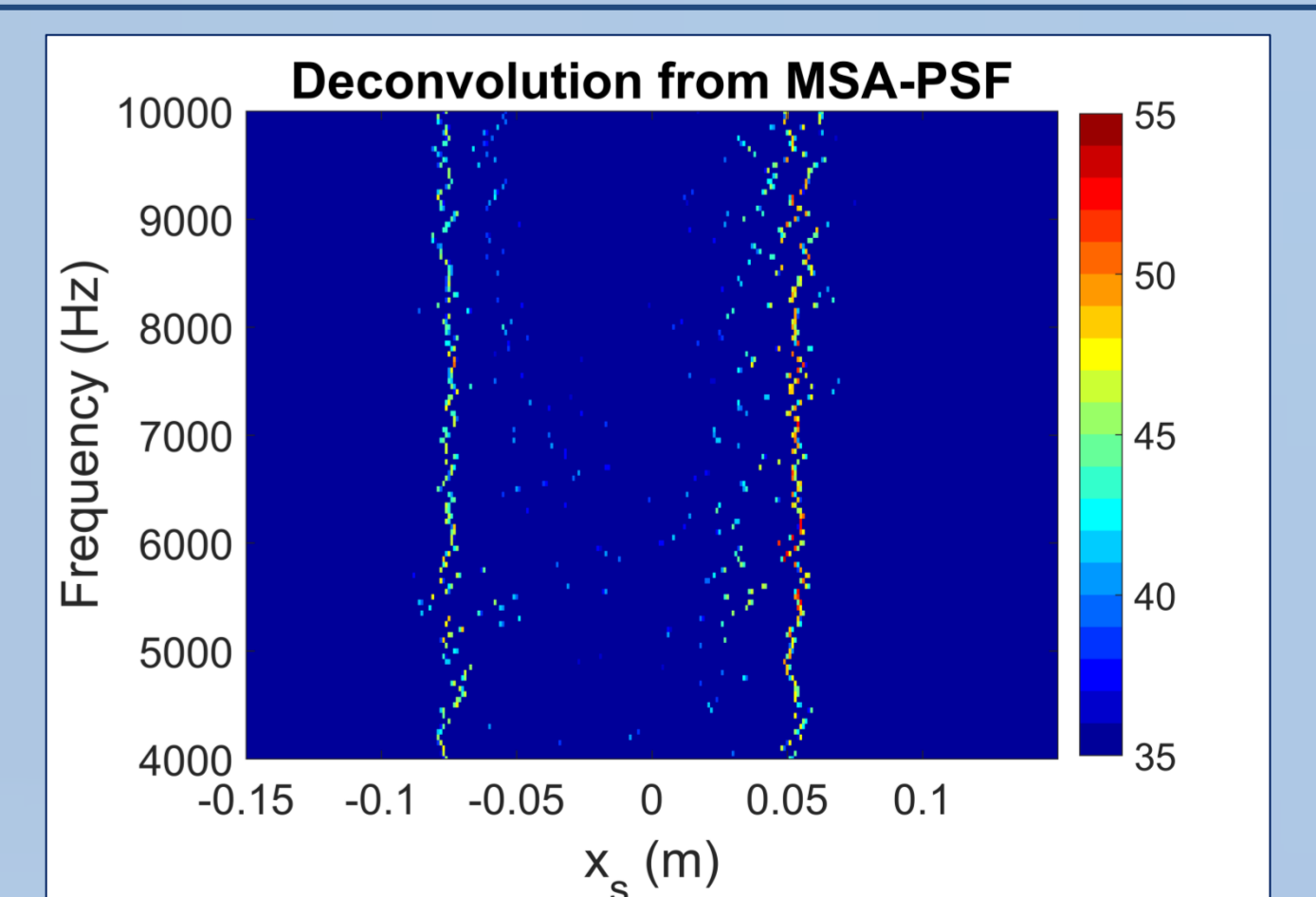
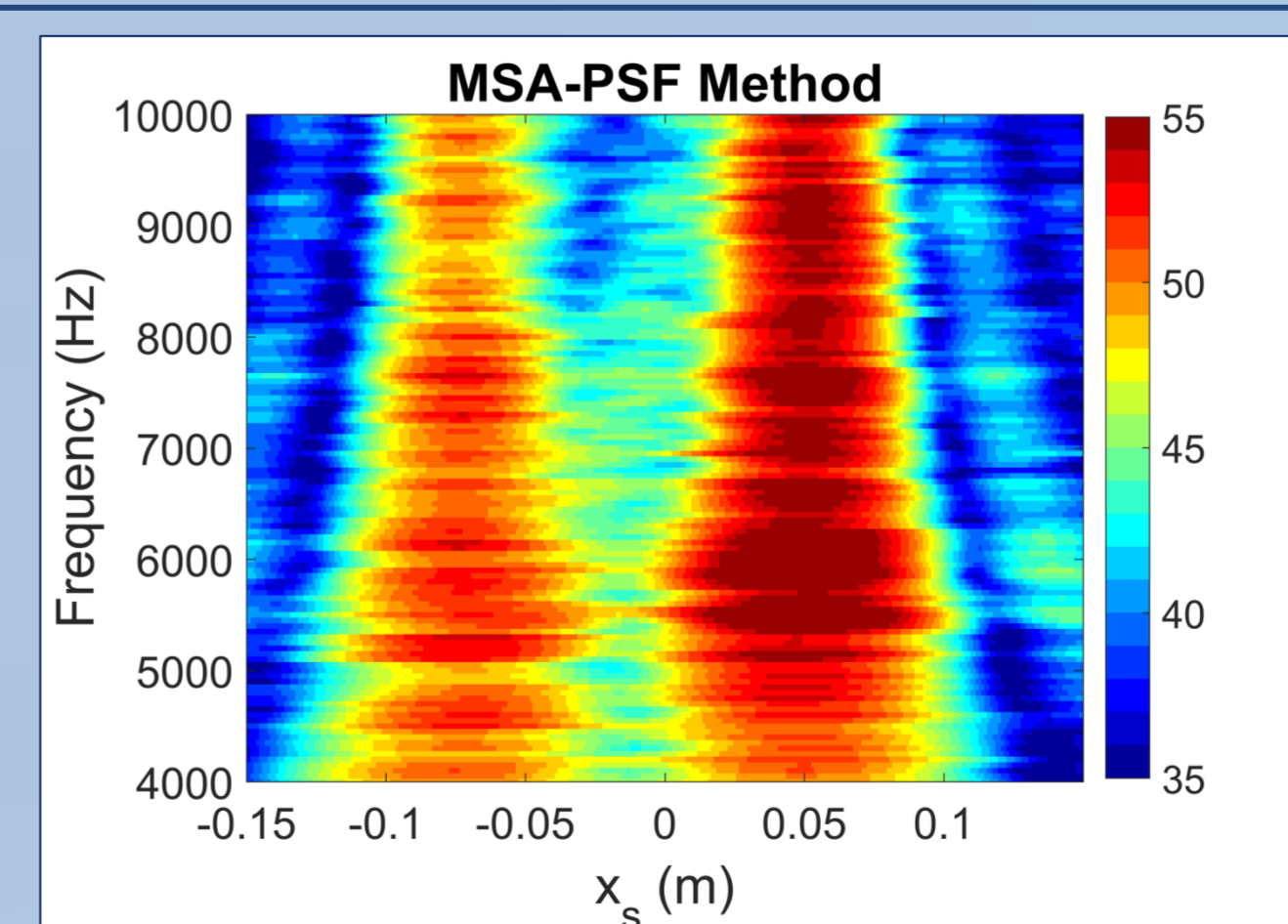
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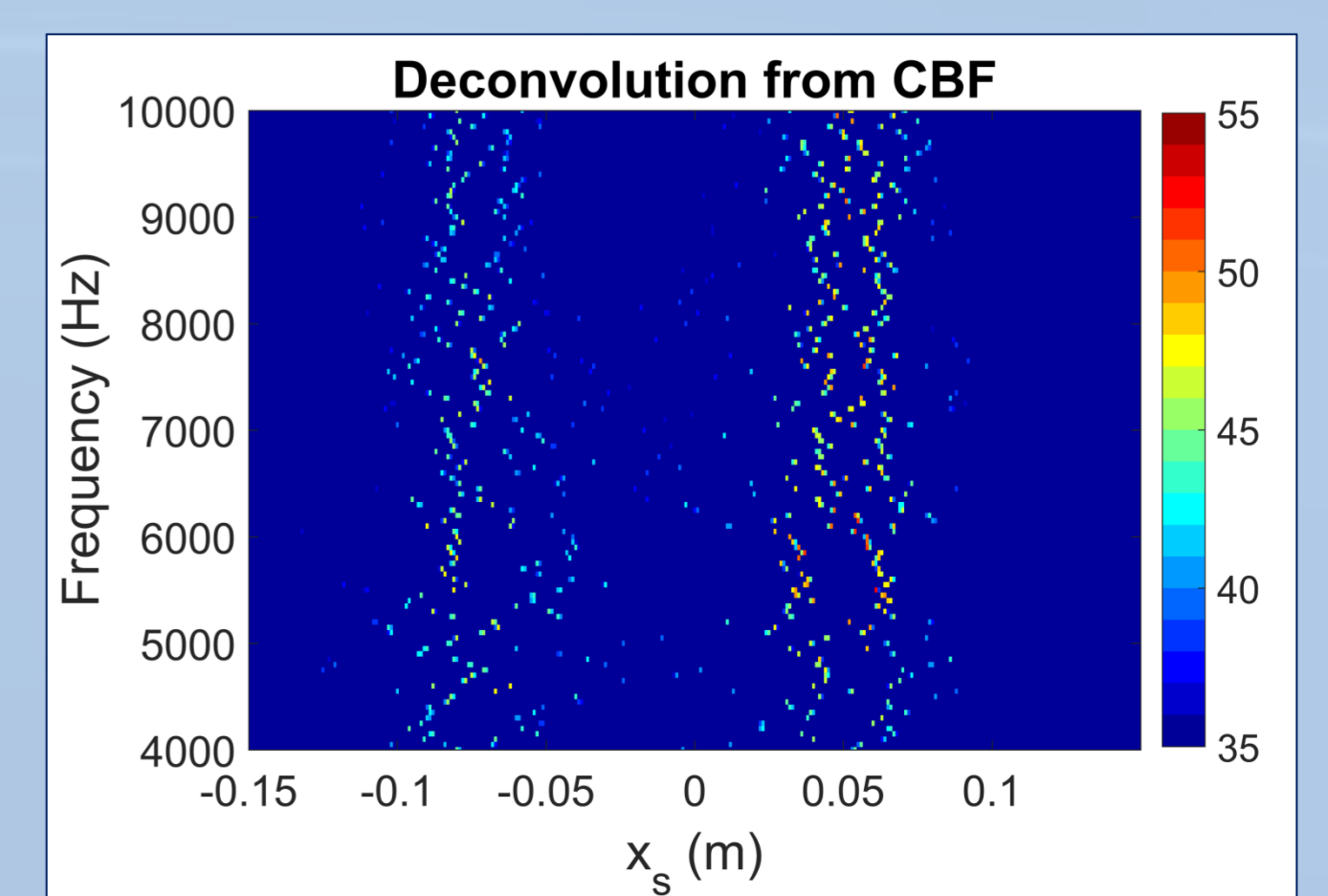
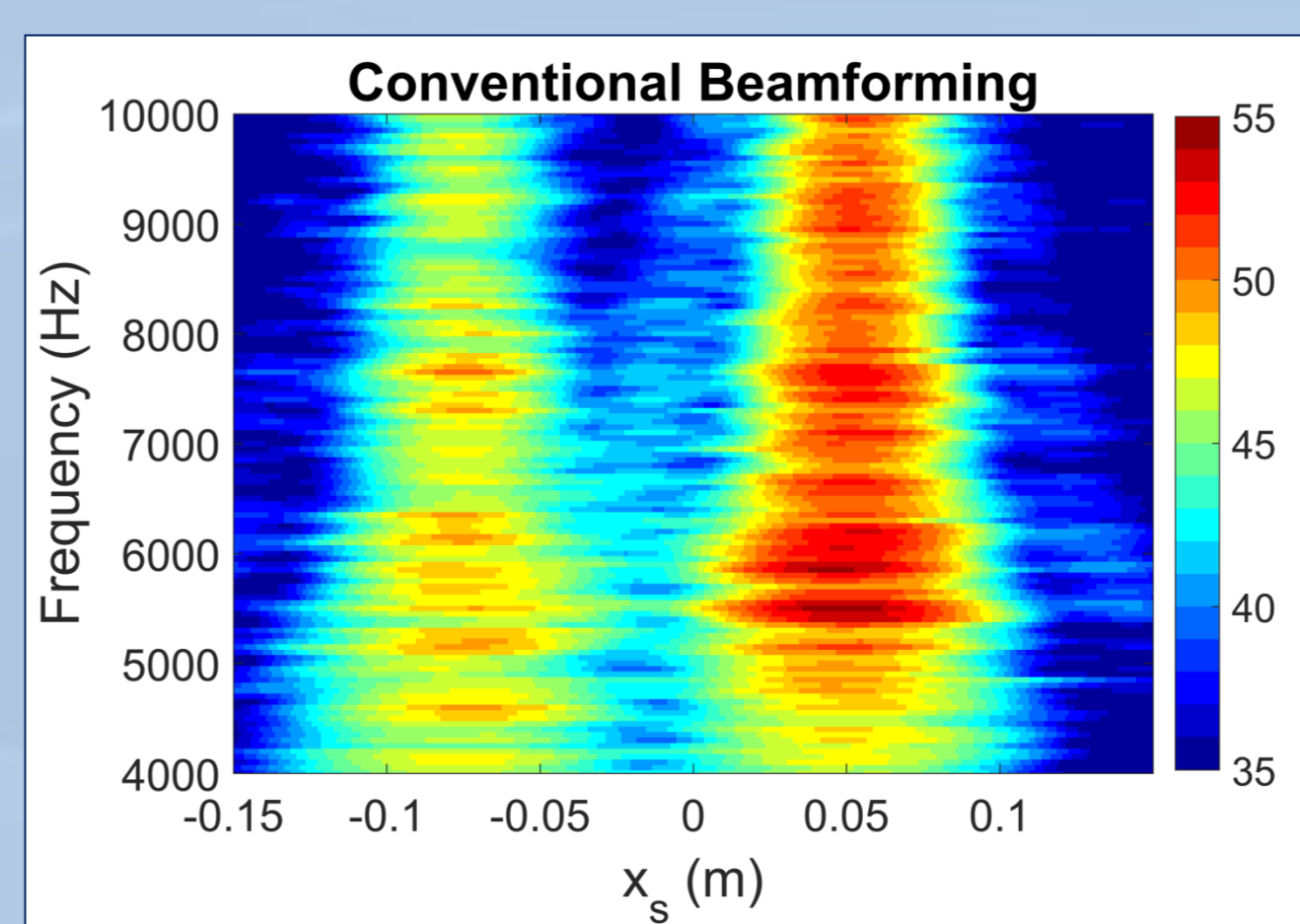
$F_s = 51200$ Hz
 $P = 30$ sensors
 $d = 0.02$ m
 $D = 0.5$ m
 $T_{\text{signal}} = 2$ s
 $U = 3.5$ m/s

$X_{\text{sources}} = [-0.06; +0.06]$ m
 $f_{S1} = 8$ kHz
 $f_{S2} = 6$ kHz
 $T = 0.02$ s
 $N_k = 21$
 Overlap = 60%

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REFERENCES

- [1] V. Fleury, J. Bulté, *Extension of deconvolution algorithms for the mapping of moving acoustic sources*, J. Acoust. Soc. Am., Vol. 129, 1417-1428 (2011)
- [2] B. Oudompheng, *Array processing for the localization and the contribution of acoustic sources of passing-by ship using a short antenna*, Univ. Grenoble Alpes (2015)
- [3] P.M. Morse, K.I. Ingard, *Theoretical Acoustics*, Princeton University Press, 717-726 (1992)

PERSPECTIVES

Real pass-by condition measurements

