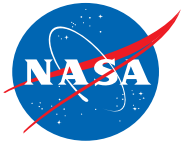


Background Acoustics Levels in the 9x15 Wind Tunnel and Linear Array Testing

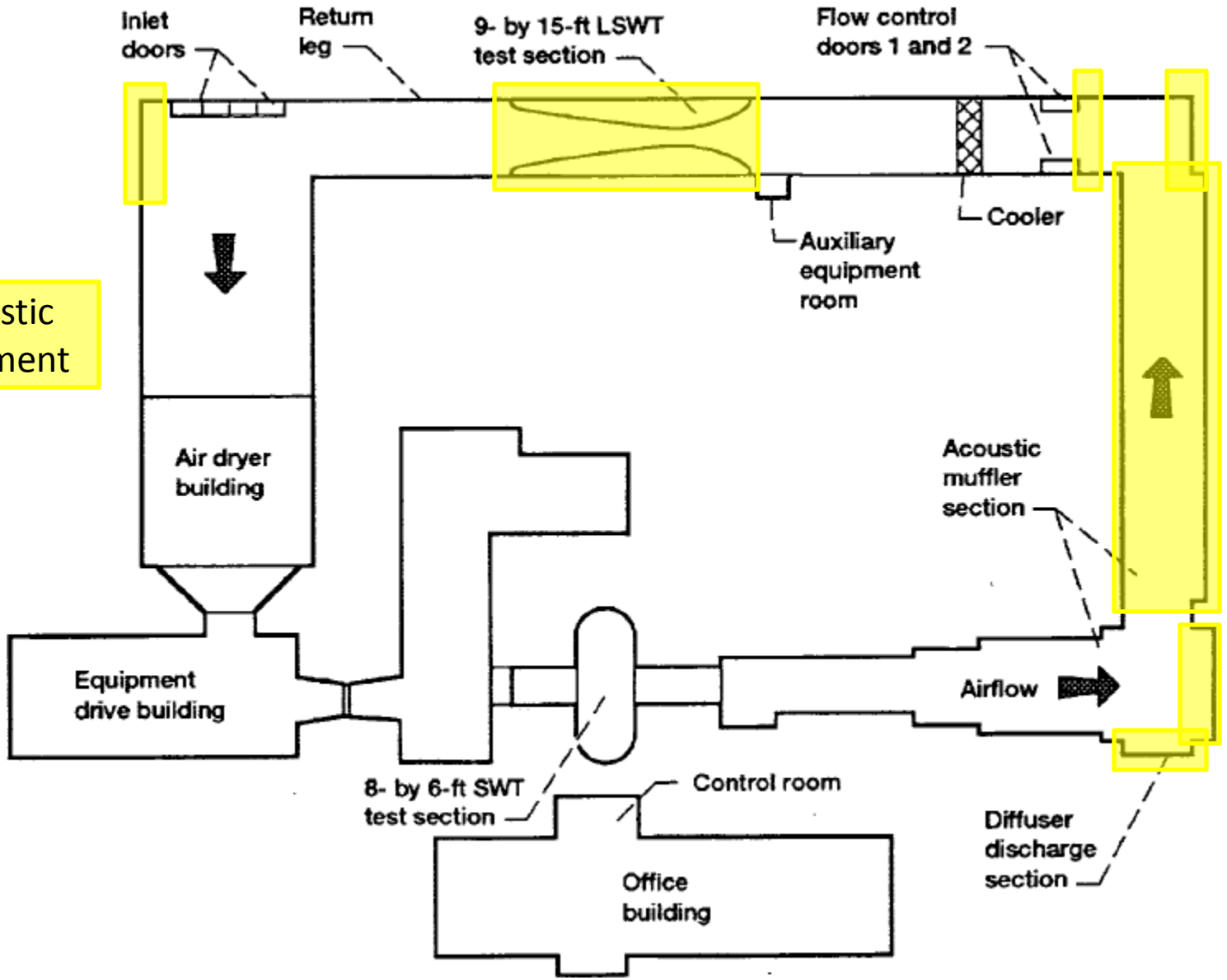
David Stephens

NASA Glenn Research Center

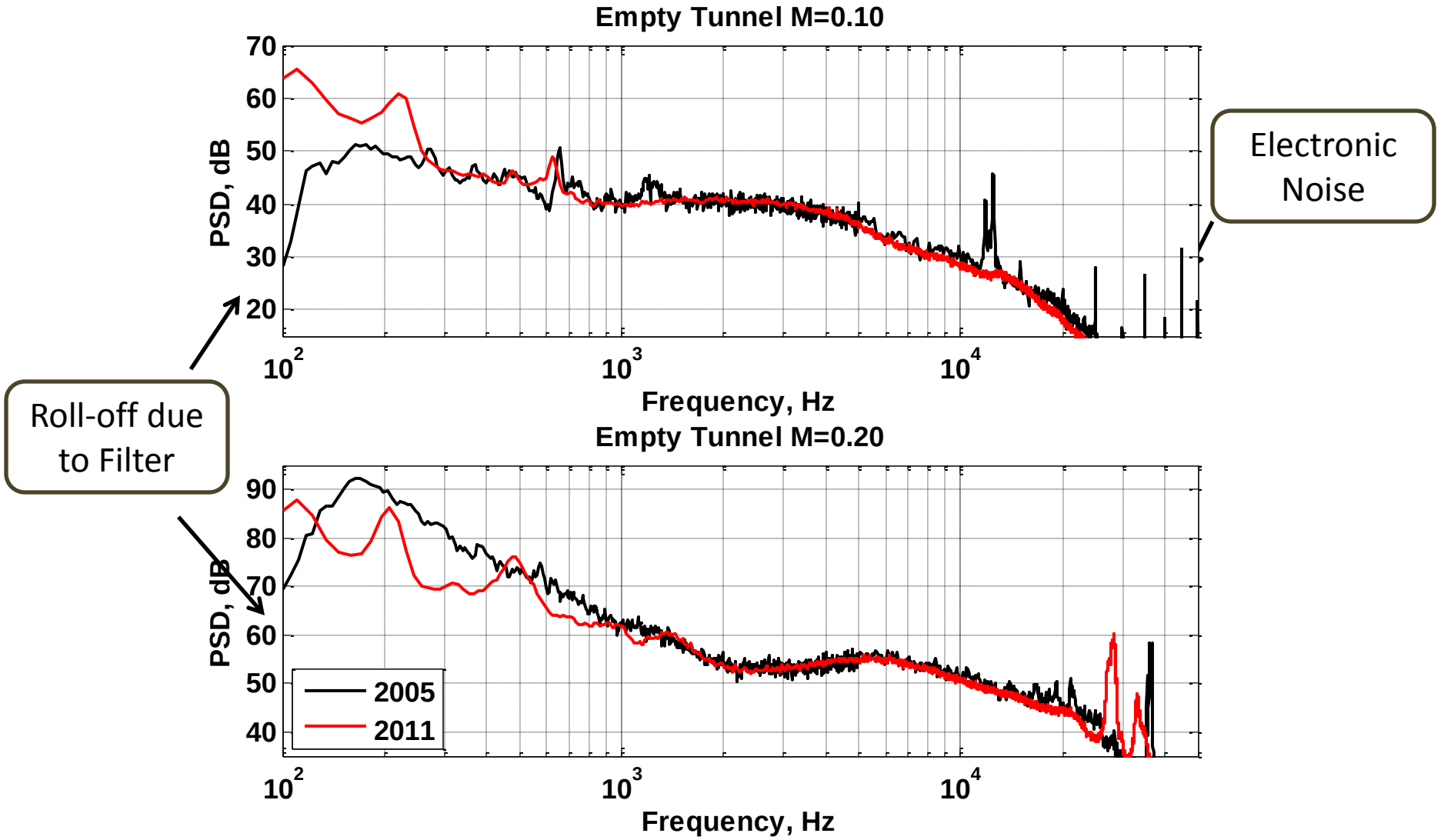
Funded by NASA projects:
Environmentally Responsible Aviation
and
Subsonic Fixed Wing

9x15 Tunnel Overview

Acoustic Treatment



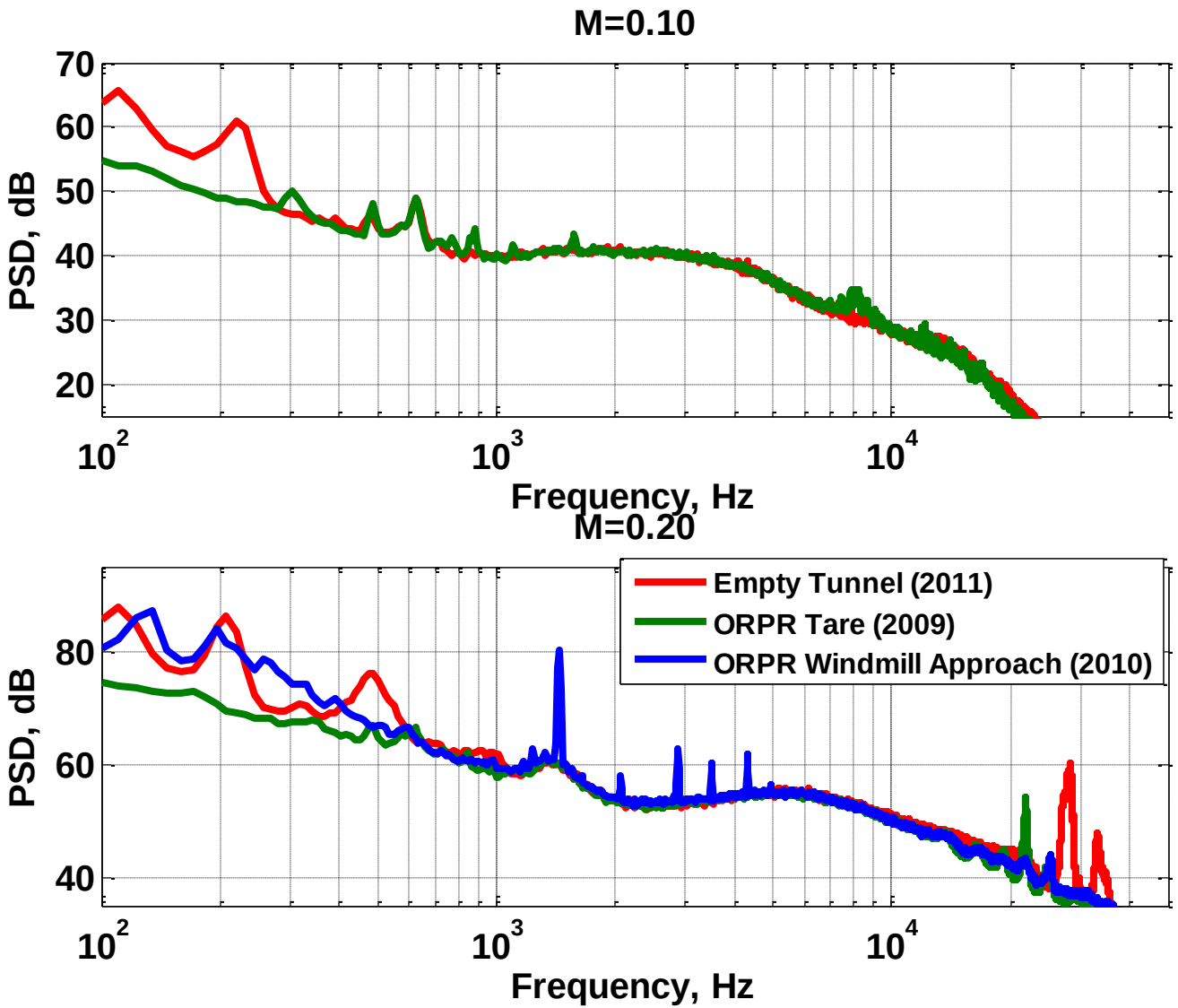
Comparison with 2005 Data



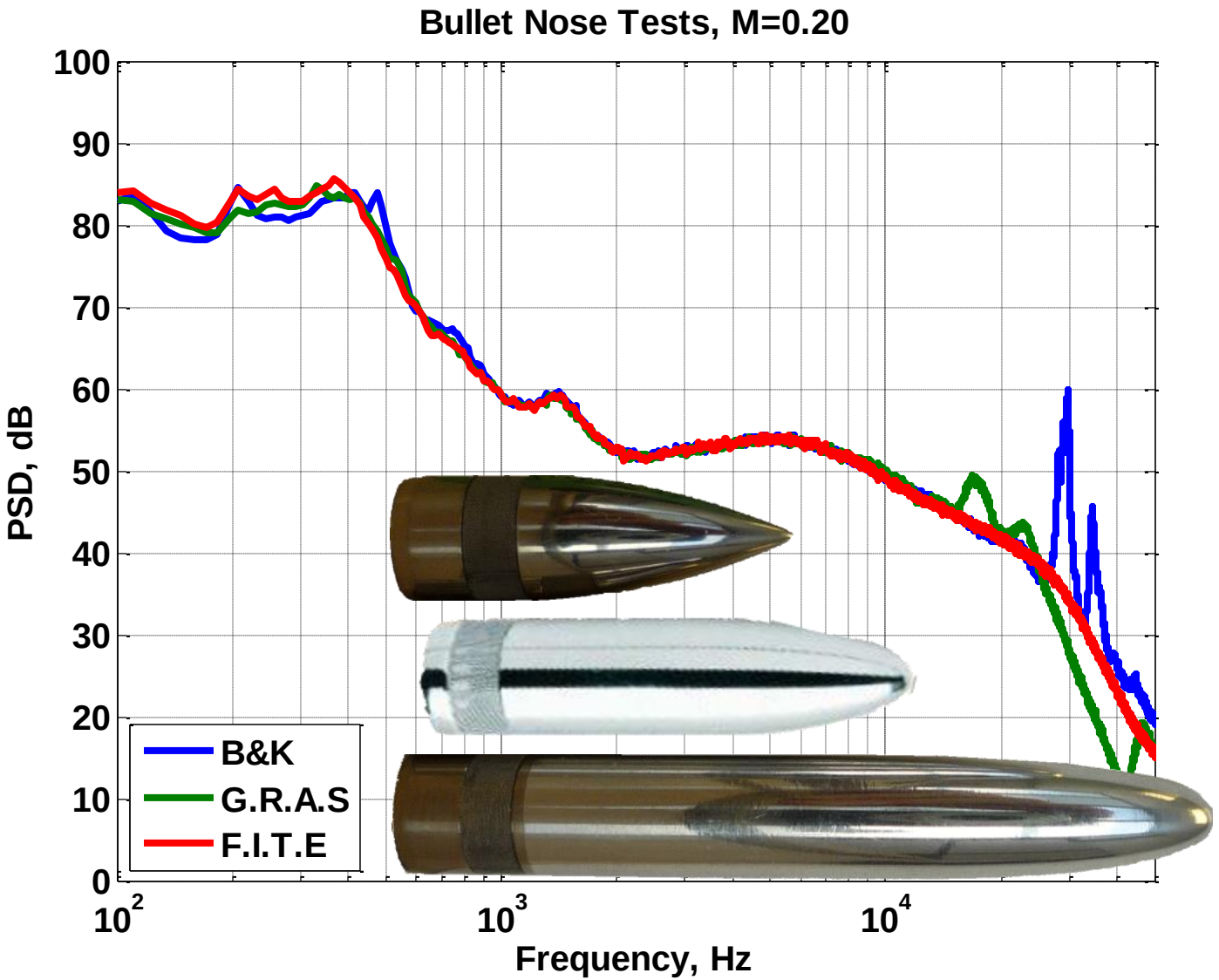
Electronic Noise

Roll-off due to Filter

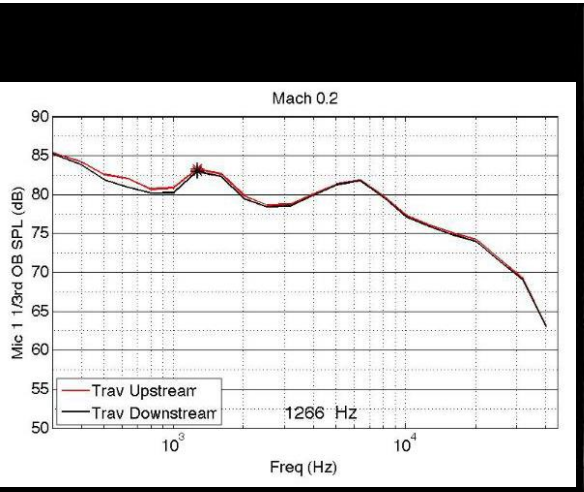
Comparison of Background Noise



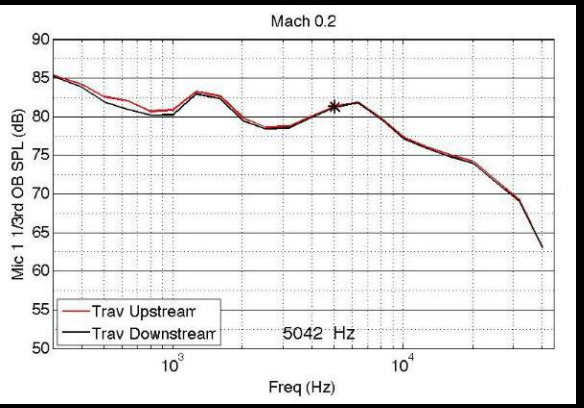
Aerodynamic Microphone Forebody



Phased Array Measurements: Noise from upstream of test section

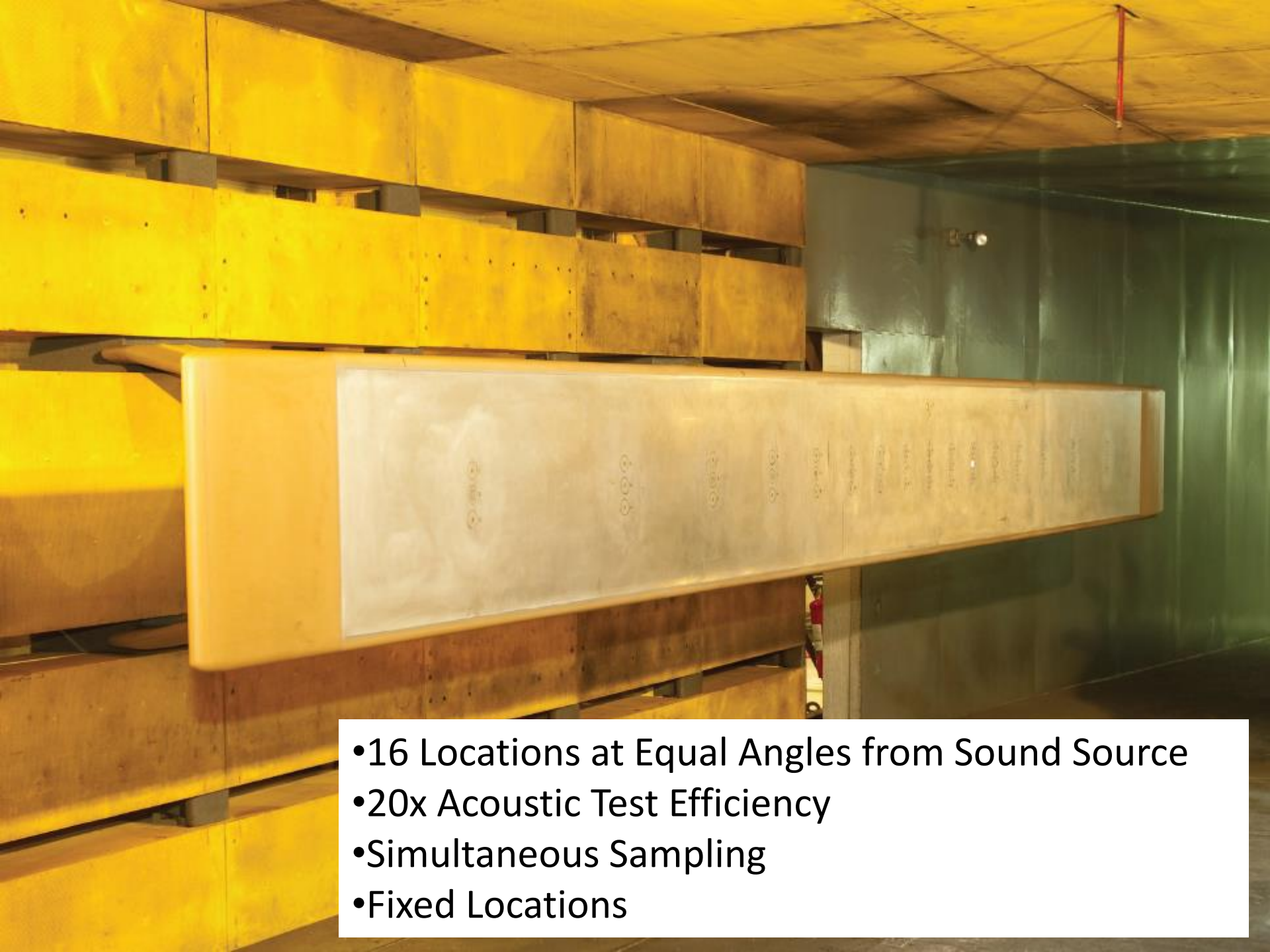


Flow



Conclusions on 9x15 Noise Level

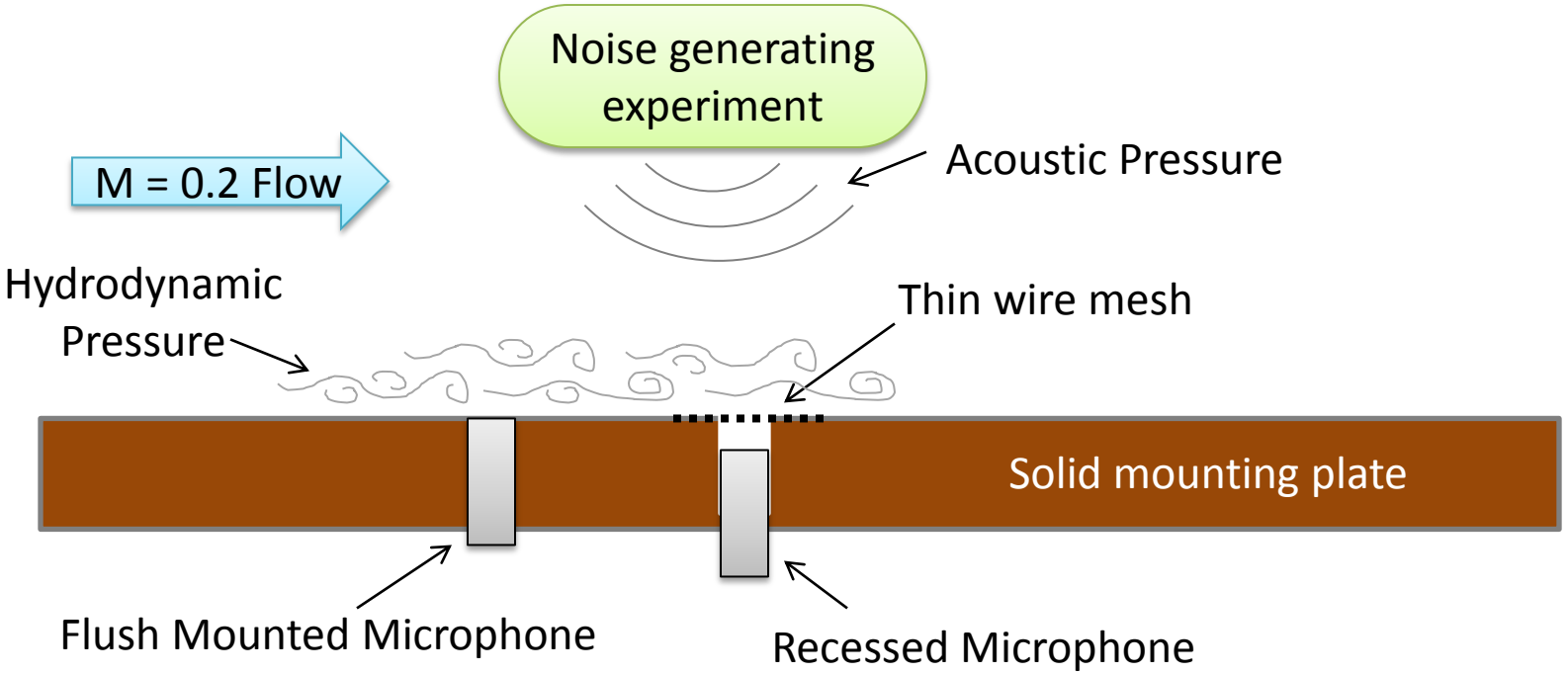
- Levels very similar to 1995
- M=0.20 about 15 dB higher than M=0.10
- High frequency tone due to AMF being investigated
- Phased array results suggest upstream noise sources



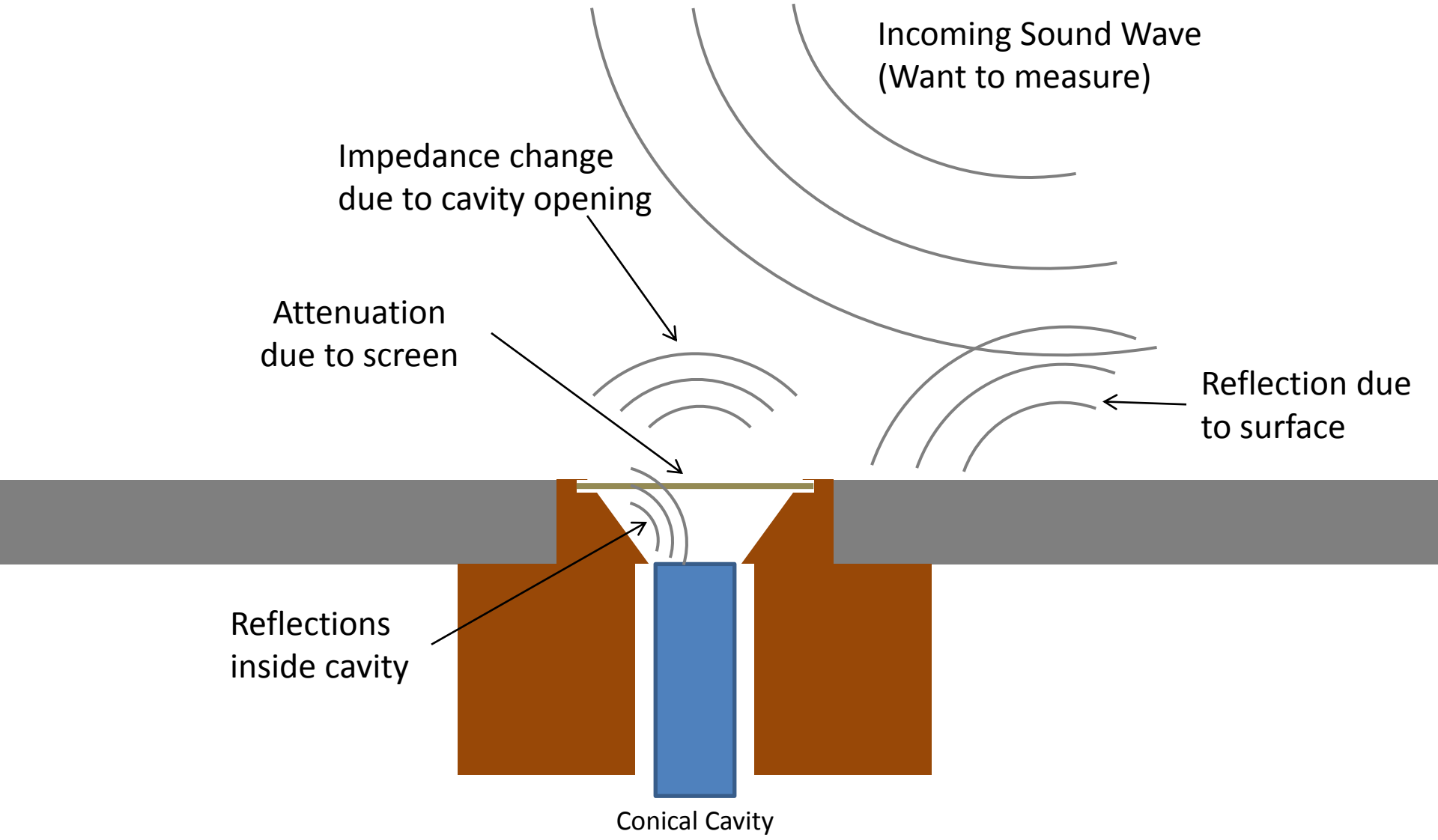
- 16 Locations at Equal Angles from Sound Source
- 20x Acoustic Test Efficiency
- Simultaneous Sampling
- Fixed Locations

Linear Array Modification

Problem: The flush mounted microphones are unable to distinguish between unsteady hydrodynamic pressures (casually referred to as “flow noise”) and the acoustic pressures of interest. The cross-correlation technique helps, but the signal to noise ratio in the current experiment is quite low at some frequencies.	Solution: Recess the microphone slightly and install a fine wire mesh over the sensing area to reduce the influence of the external flow while largely transmitting the acoustics.



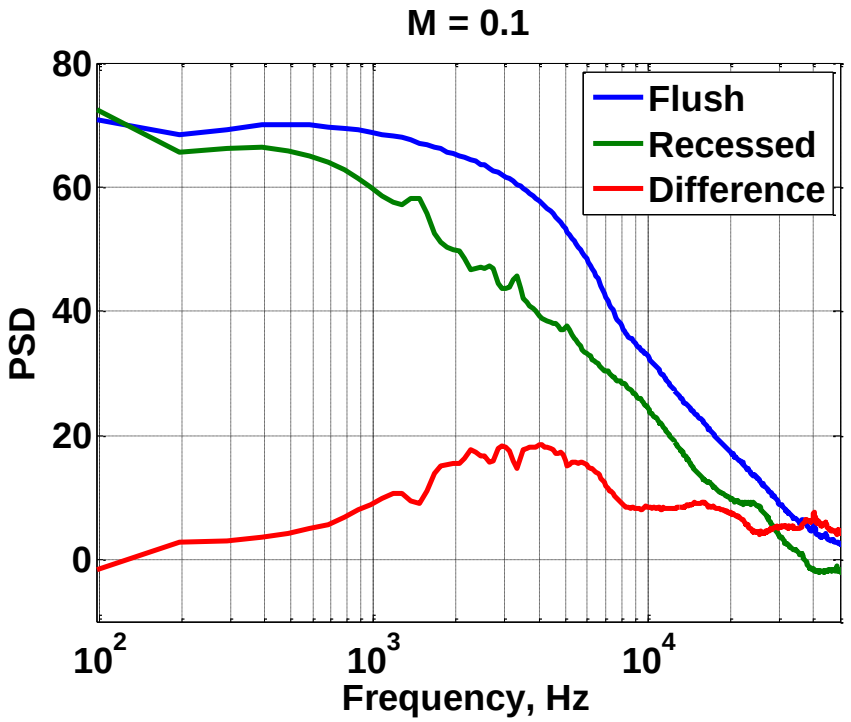
Additional Calibrations Required

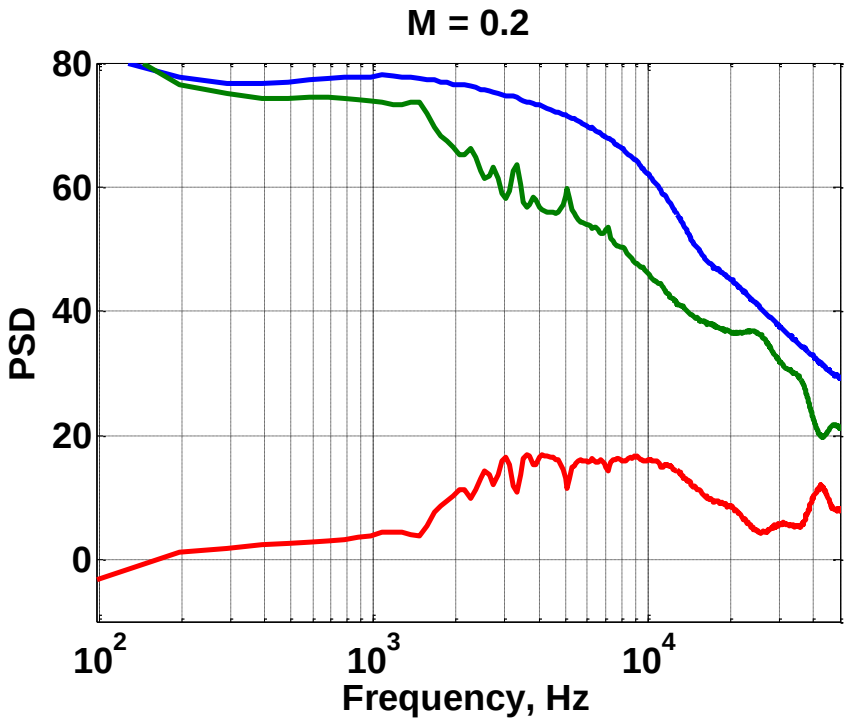


1
2
3
4
5
6

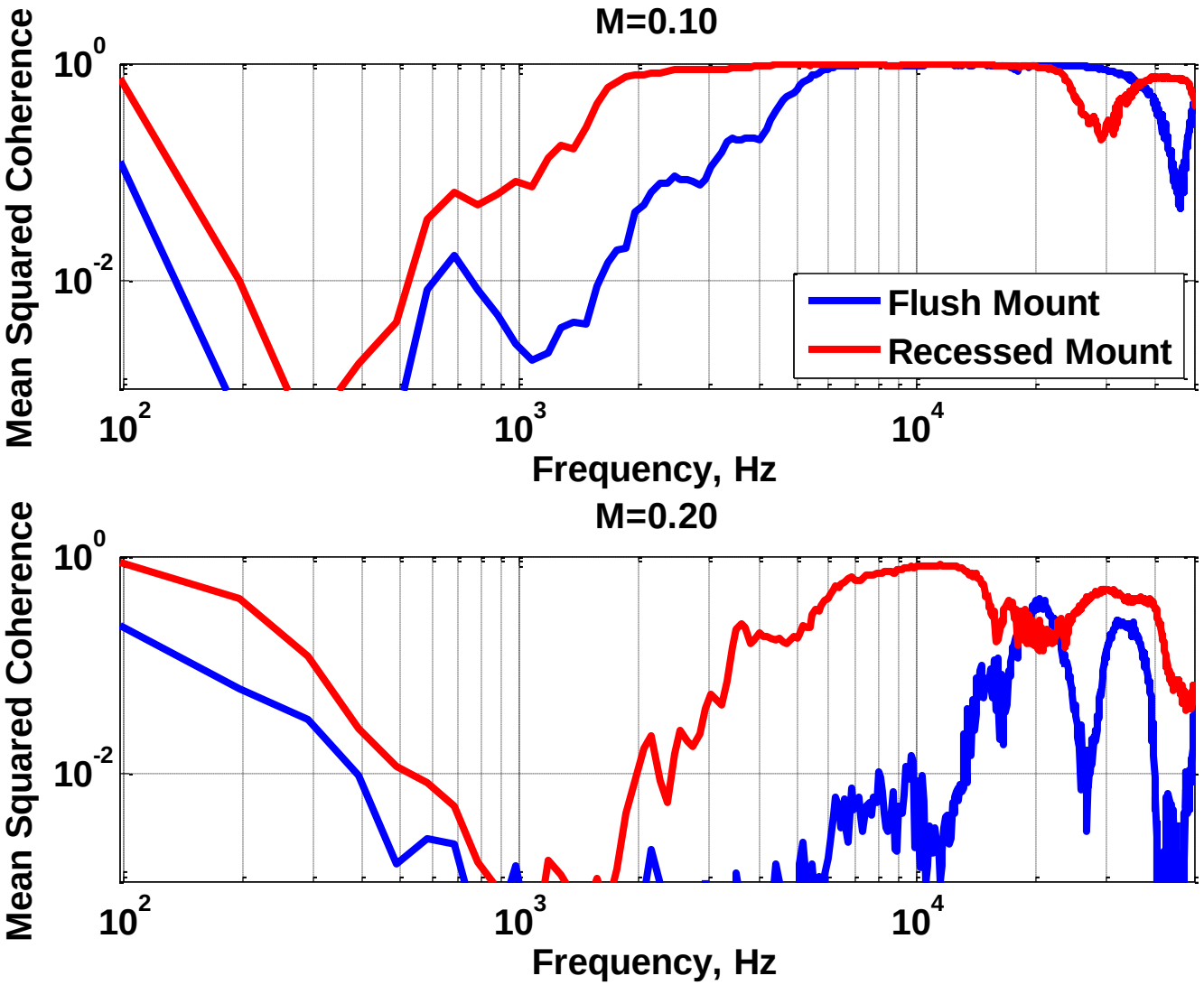
Tunnel On, Source Off

- Screen attenuates hydrodynamic pressure on microphone by 5-15 dB between 1k and 50k Hz





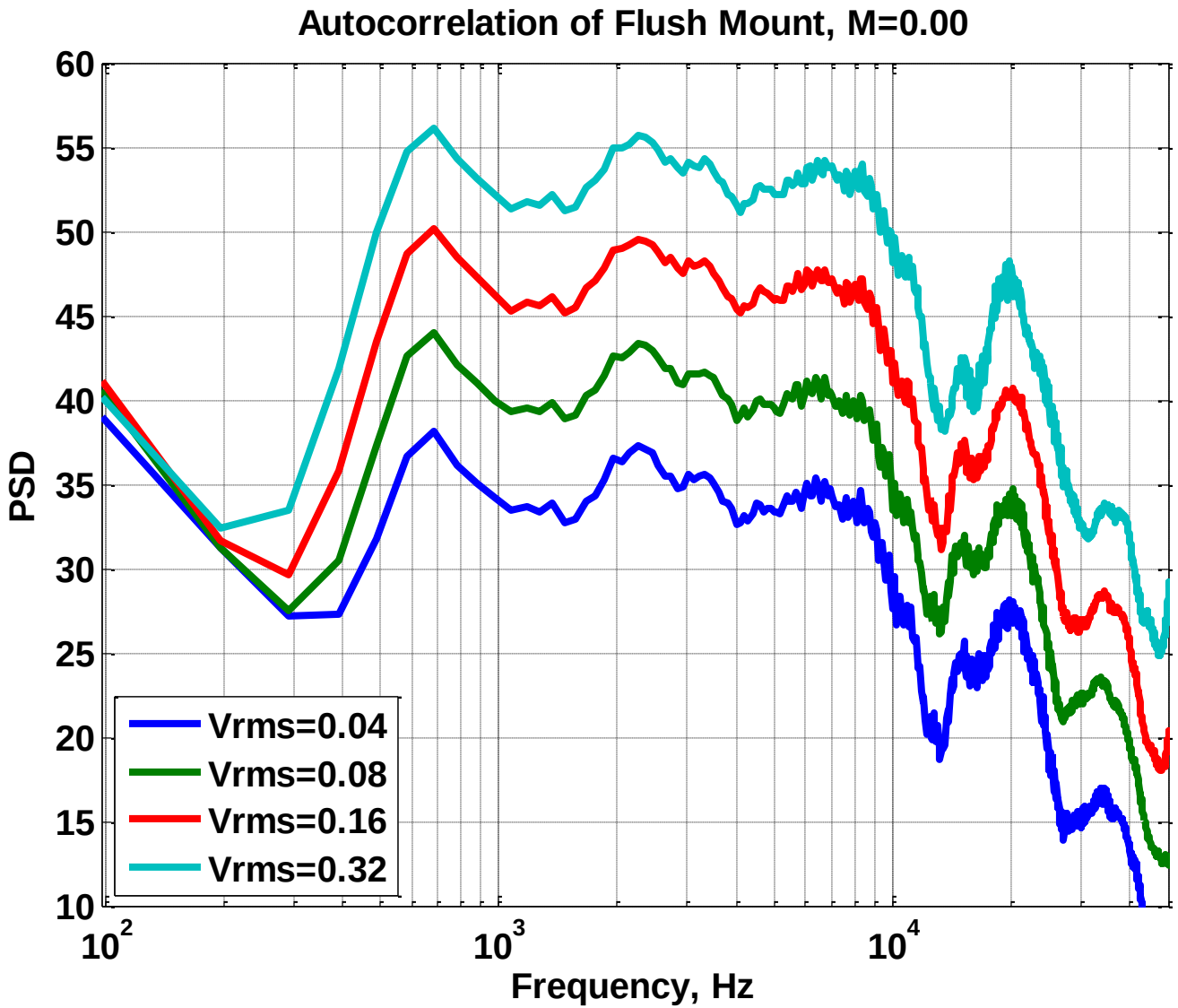
Improvement in Coherence Max Speaker Level



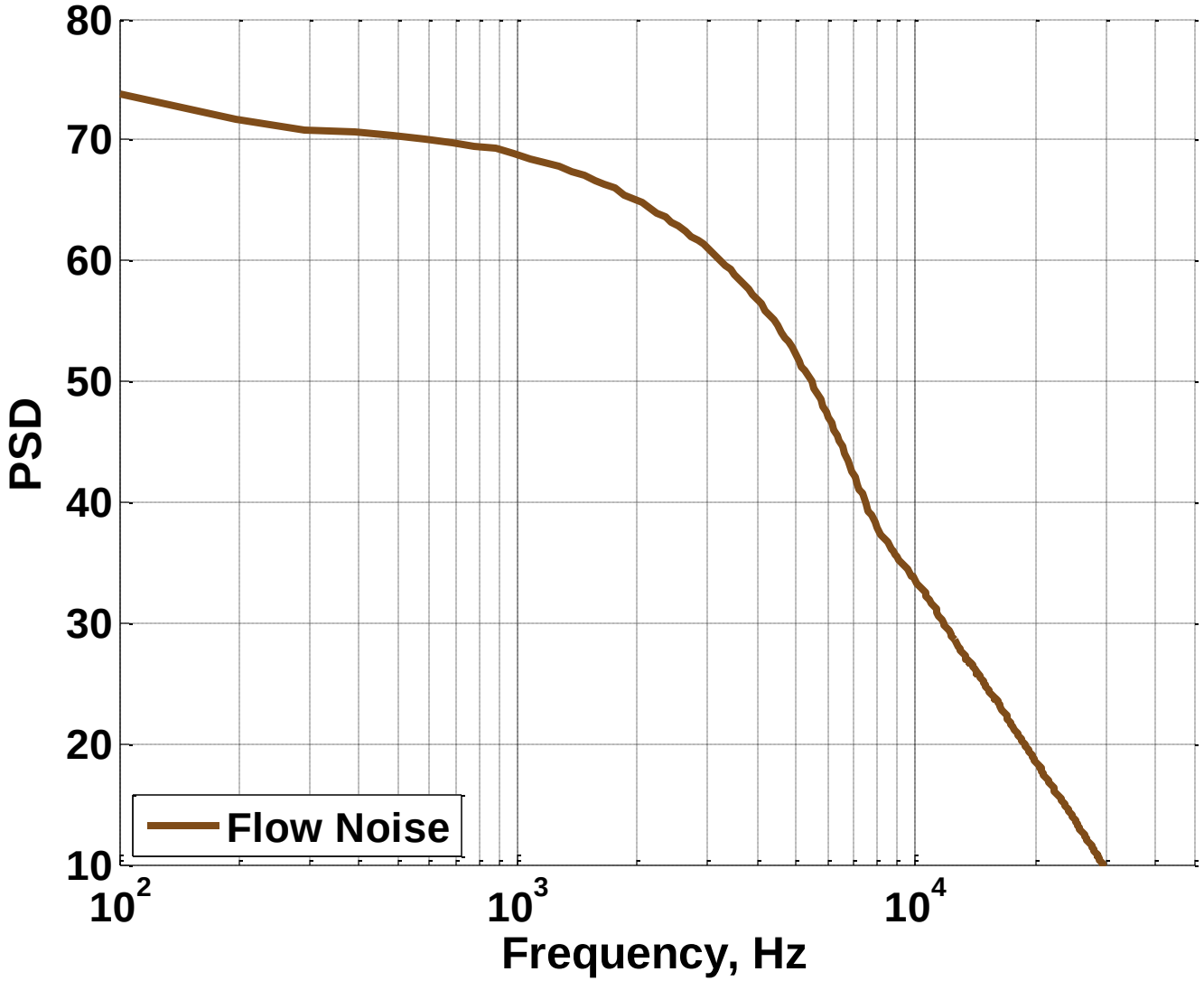
Signal Processing Methods

- To reject signal that is incoherent between microphones:
  - Coherent spectra technique $G_{11}\frac{\gamma_{12}\gamma_{13}}{\gamma_{23}}$
  - Auto-spectra of spatial average $G_{\langle 123 \rangle}$
  - Magnitude of Cross-Spectra $\frac{|G_{12}|+|G_{13}|+|G_{23}|}{3}$
- Speaker Noise was found to be dependent on Tunnel Speed

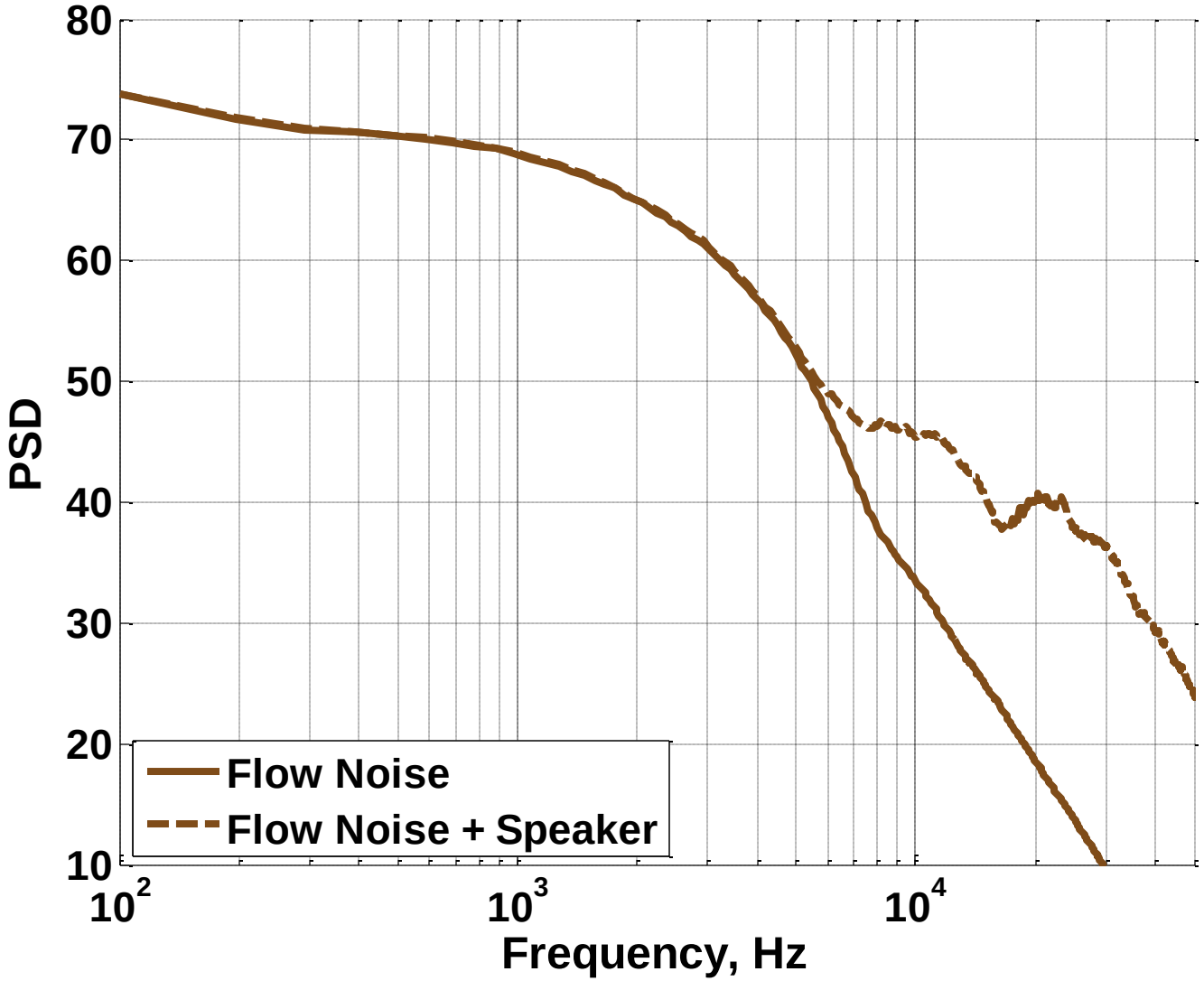
Result should scale as $Vrms^2$



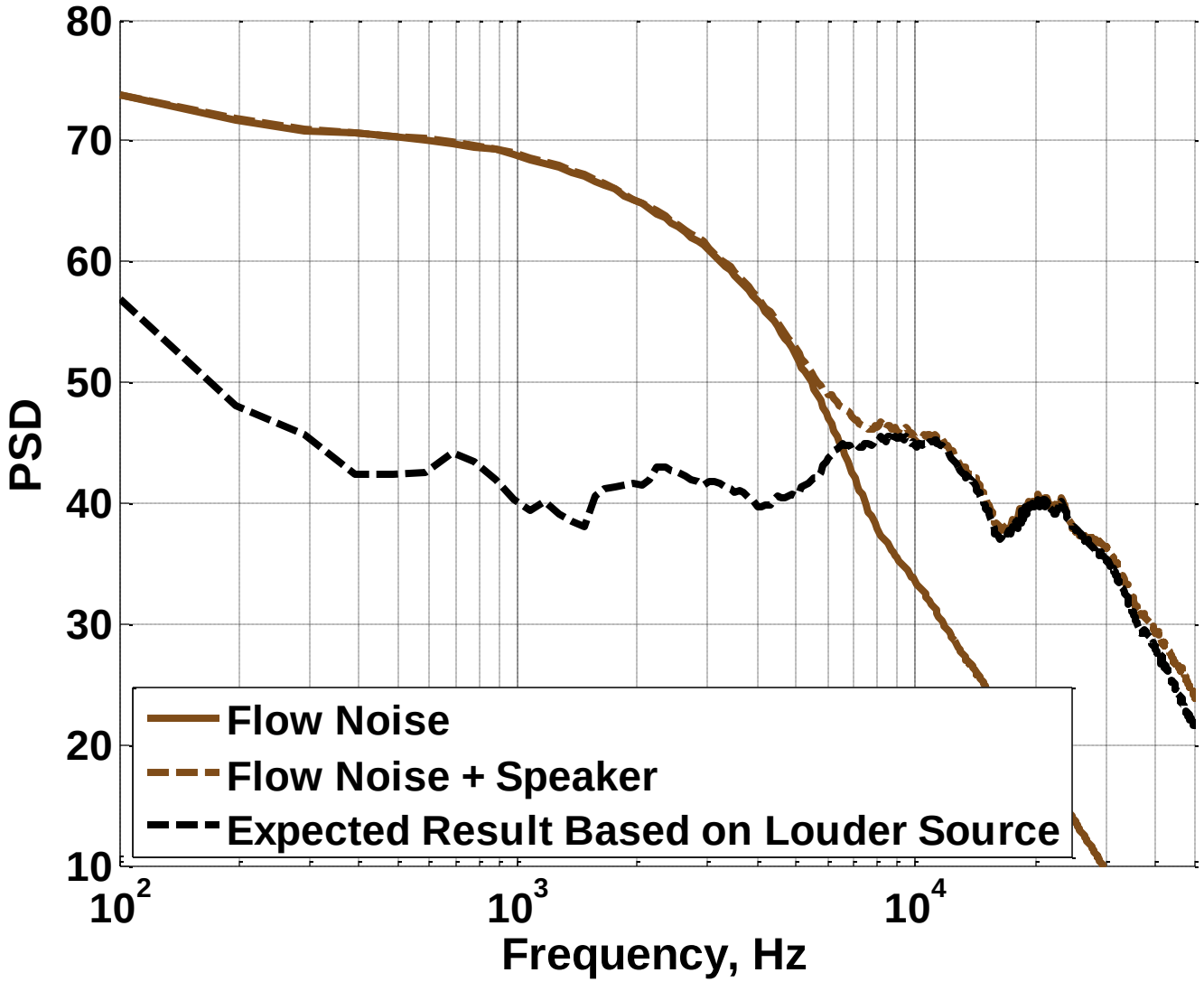
M=0.10, Flush Mount



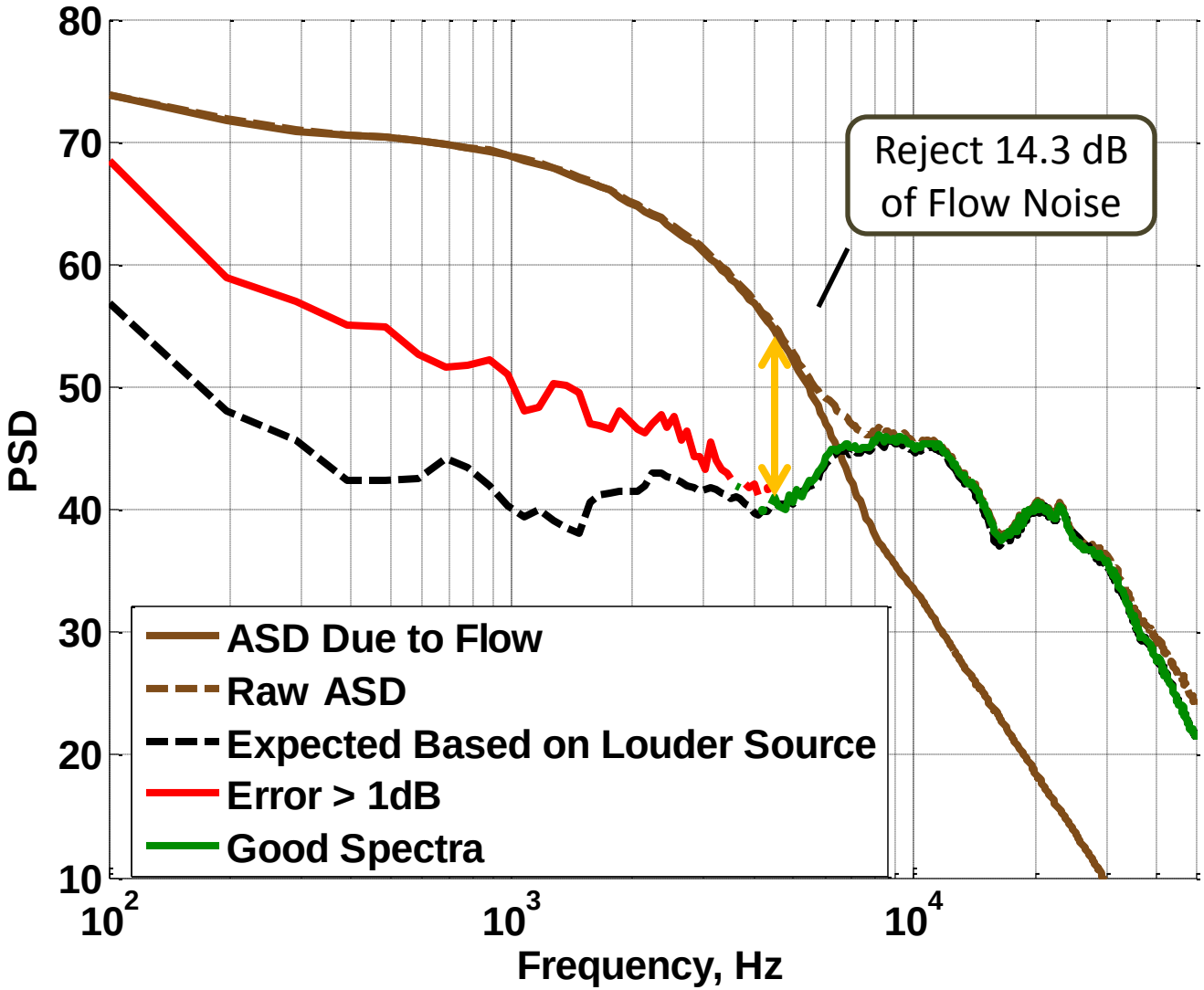
M=0.10, Flush Mount



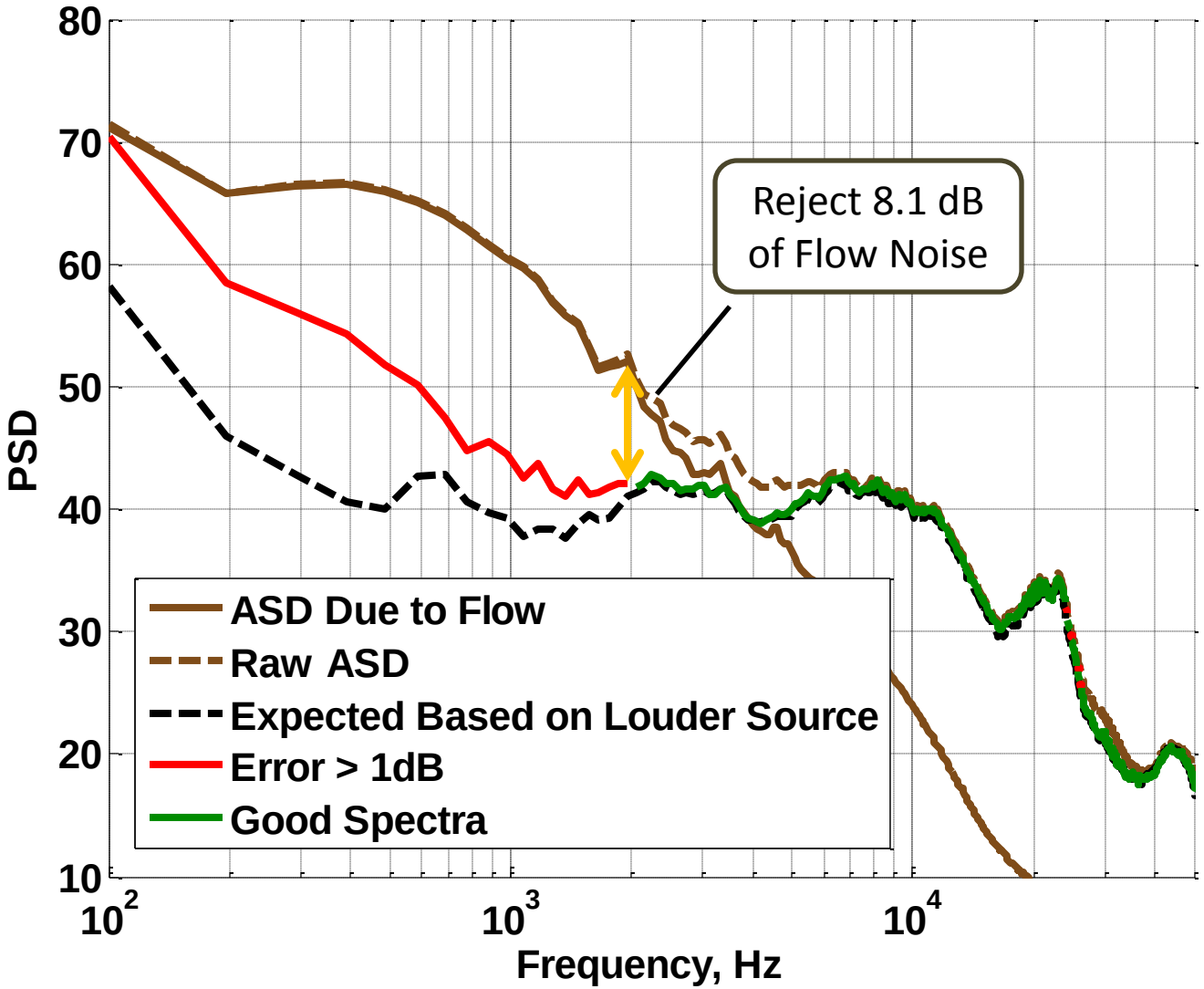
M=0.10, Flush Mount



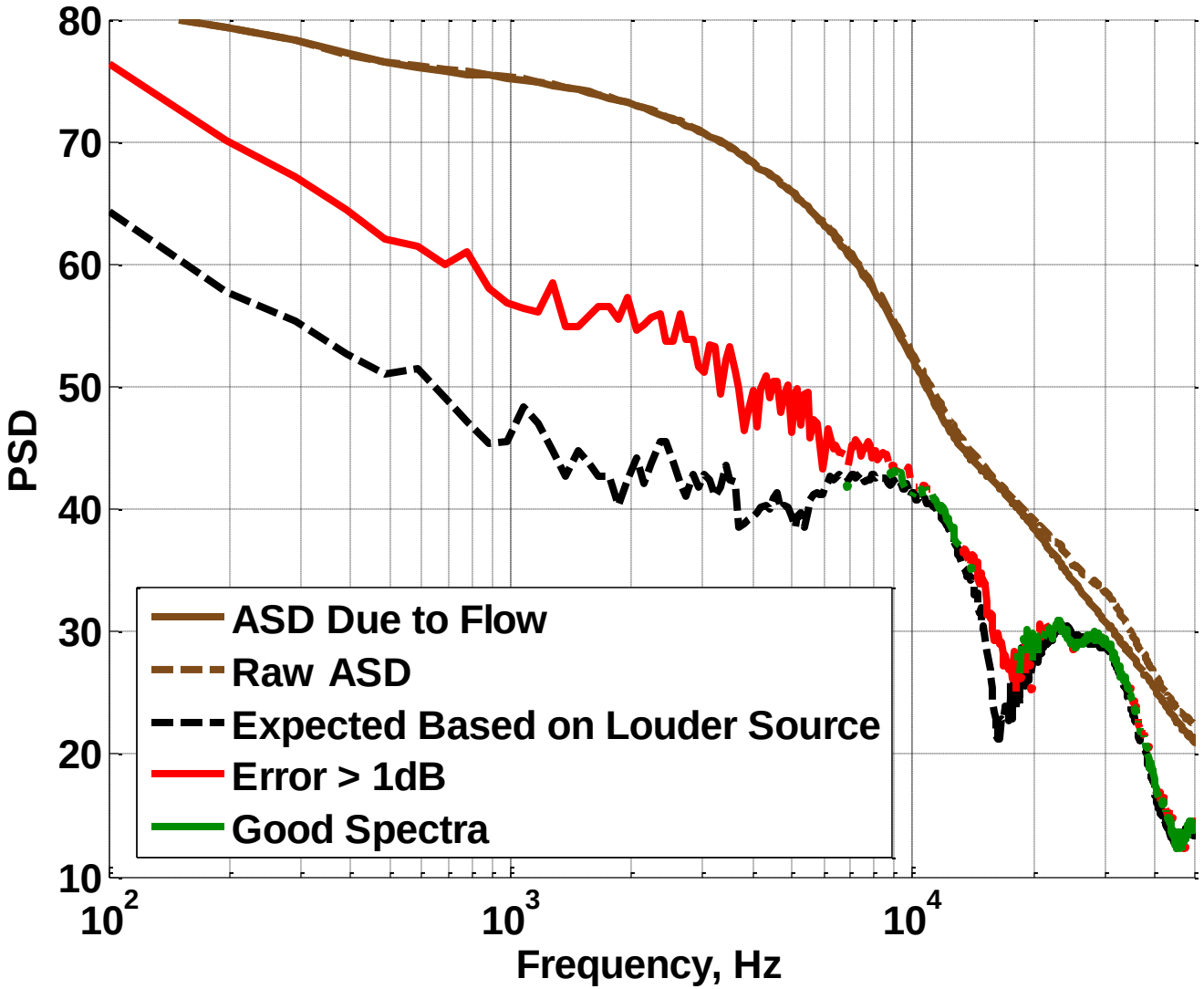
M=0.10, Flush, Signal Processing



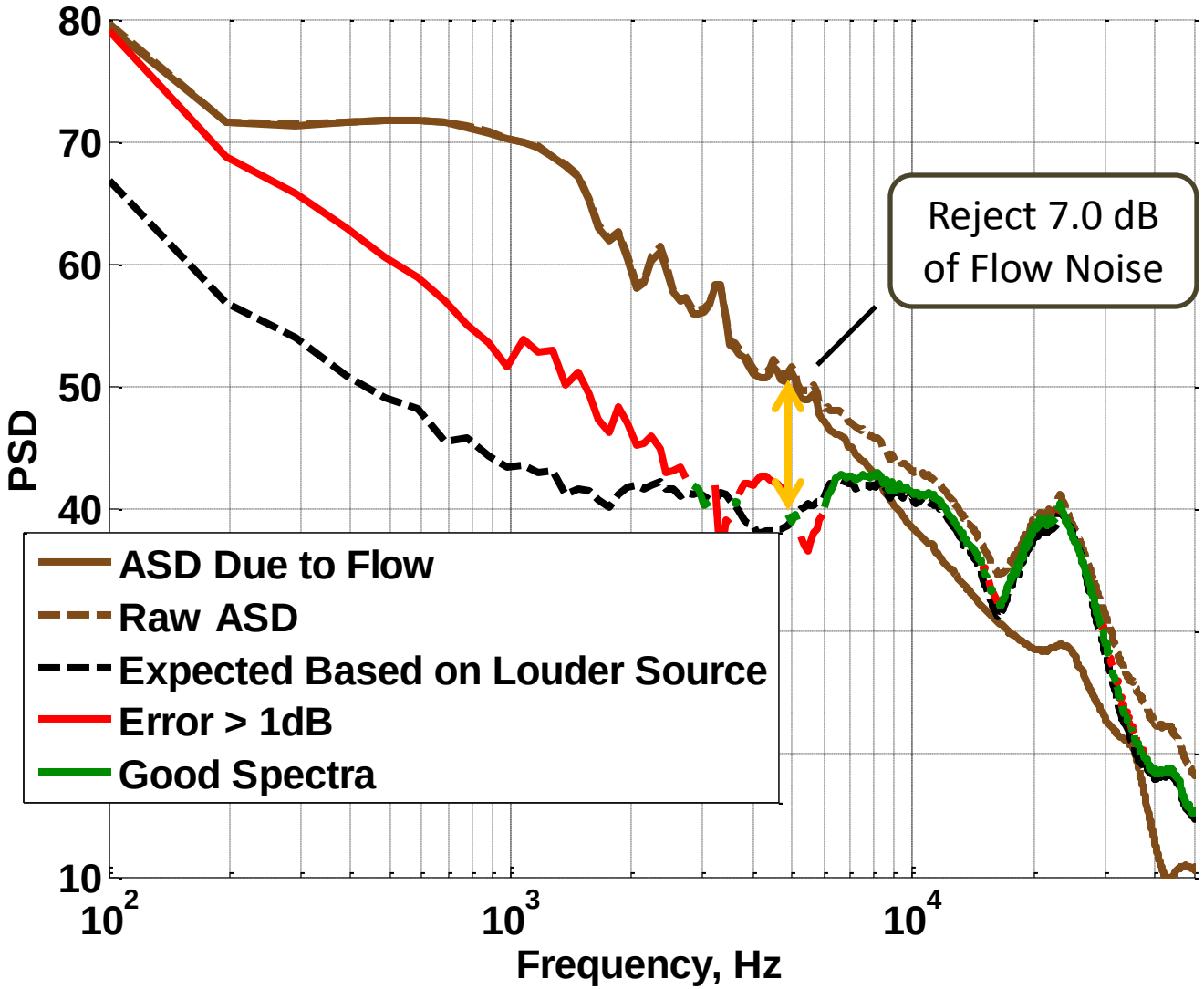
M=0.10, Recessed, Signal Processing



M=0.16, Flush, Signal Processing



M=0.16, Recessed, Signal Processing

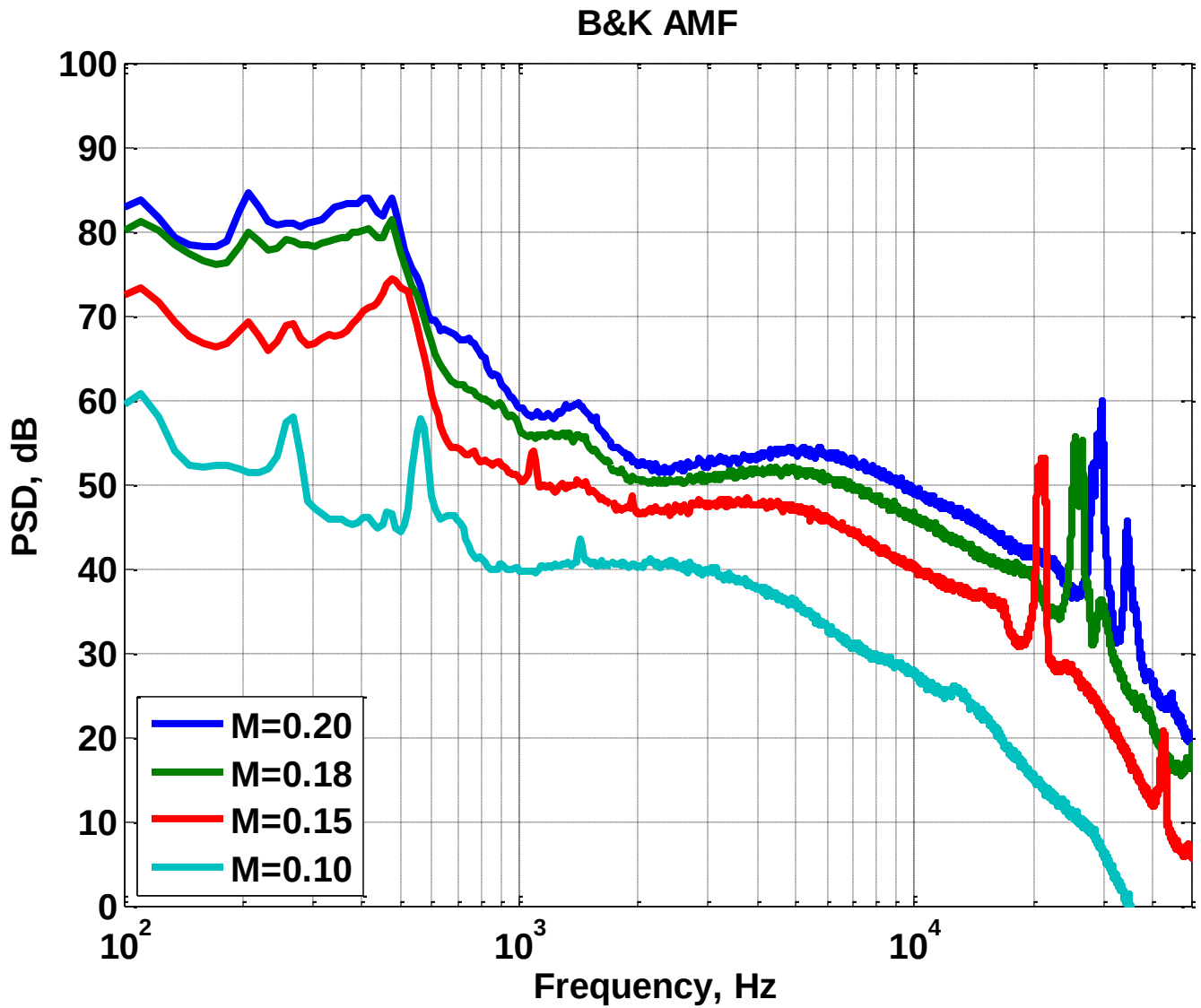


Conclusions on Linear Array Modifications

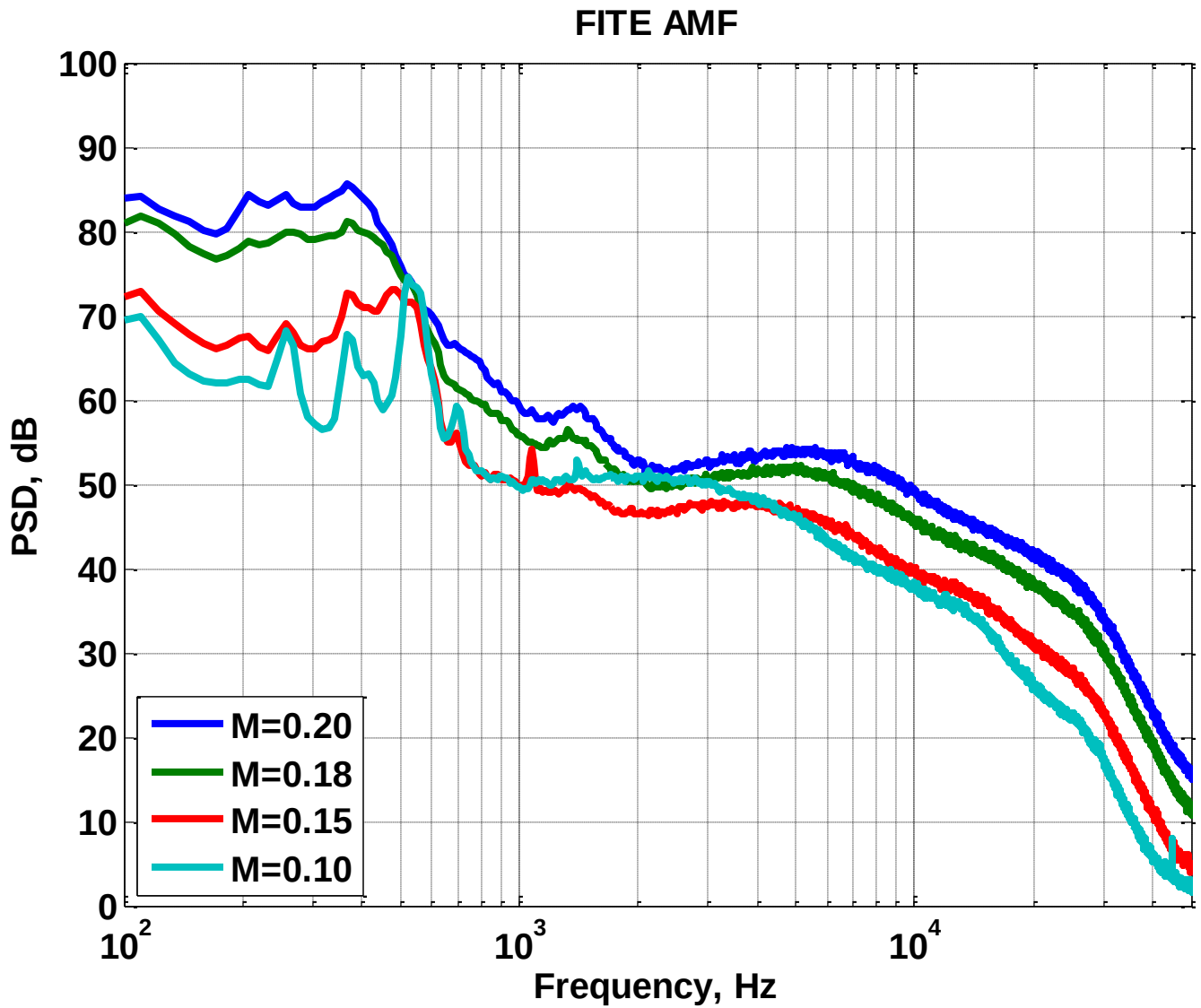
- Huge potential for test efficiency improvements
- Recessed mounting and screen reduces hydrodynamic pressures by 5-15 dB, but adds more calibration complexity
- Signal processing can reject perhaps 10 dB of hydrodynamic pressures

NASA

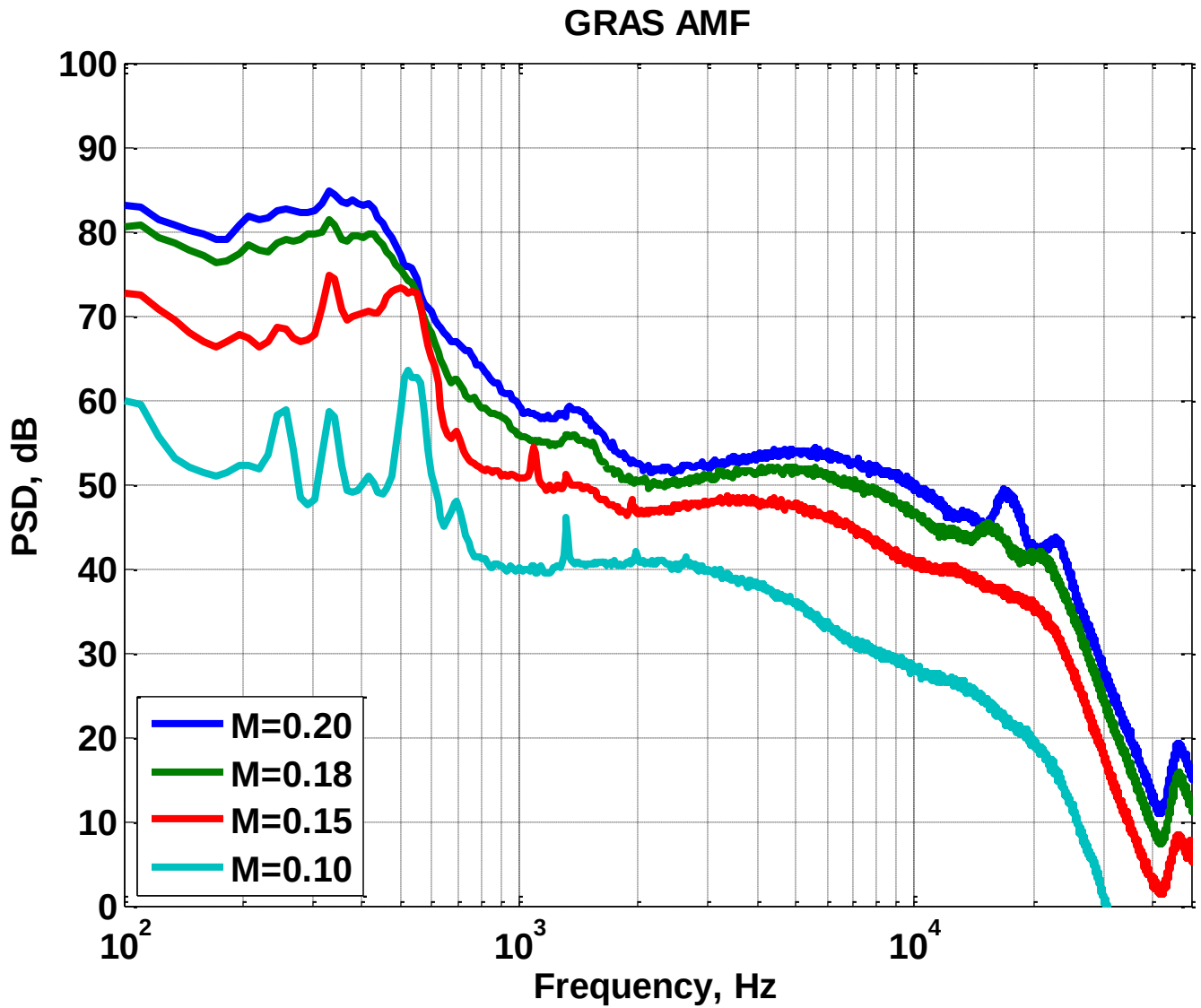
Traversing Microphone, B&K AMF



Traversing Microphone, FITE AMF



Traversing Microphone, GRAS AMF



Background Acoustics Levels in the 9x15 and Linear Array Testing

The background noise level in the 9x15 foot wind tunnel at NASA Glenn has been documented, and the results compare favorably with historical measurements. A study of recessed microphone mounting techniques was also conducted, and a recessed cavity with a micronic wire mesh screen reduces hydrodynamic noise by around 10 dB. A three-microphone signal processing technique can provide additional benefit, rejecting up to 15 dB of noise contamination at some frequencies. The screen and cavity system offers considerable benefit to test efficiency, although there are additional calibration requirements.