

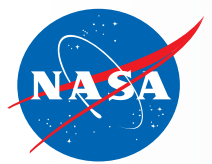


Time Domain Boundary Element Method Prediction of Noise Shielding by an NACA 0012 Airfoil

Douglas M. Nark
NASA Langley Research Center, Hampton, VA

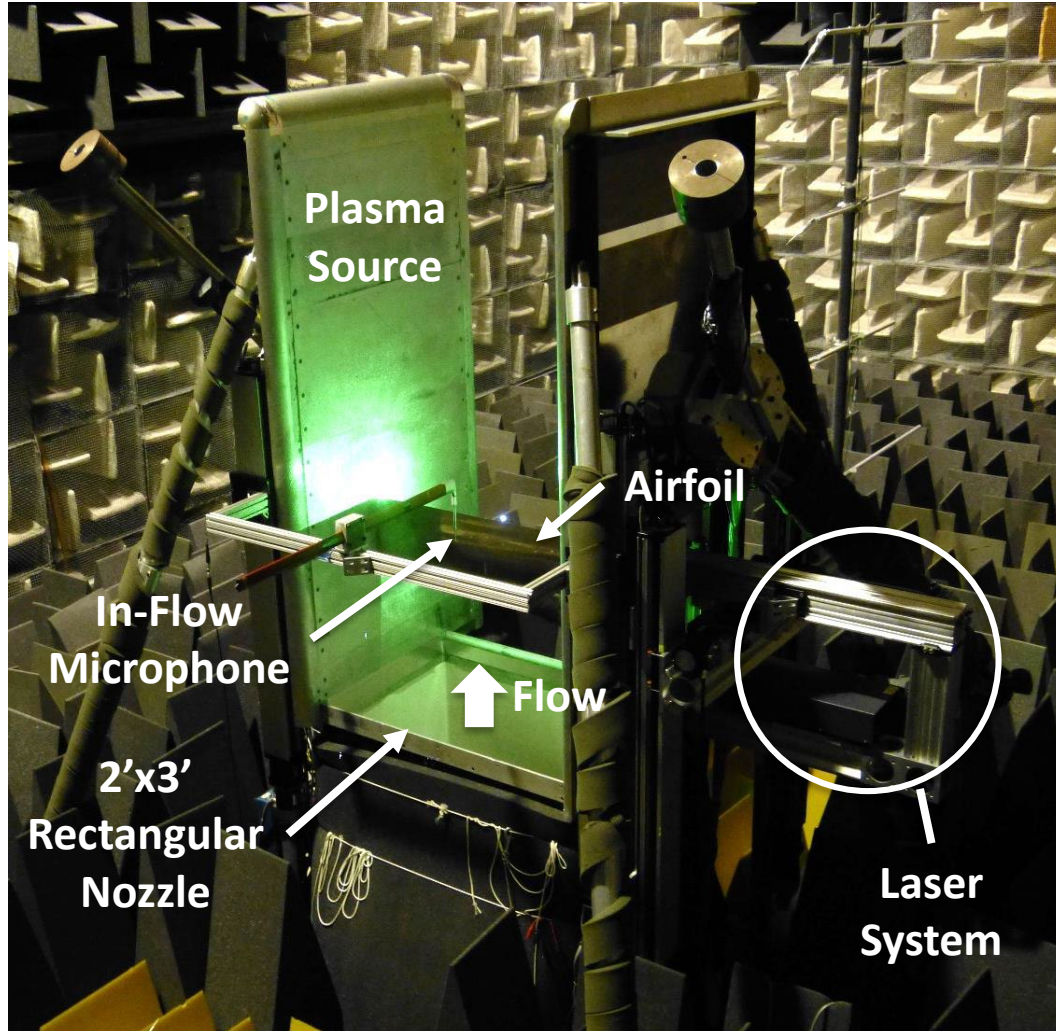
Fang Q. Hu
Old Dominion University, Norfolk, VA

AIAA Aviation Forum
AIAA/CEAS Aeroacoustics Conference
August 2-6, 2021



Quiet Flow Facility (QFF) Test

NASA Langley Quiet Flow Facility (QFF) Test Chamber

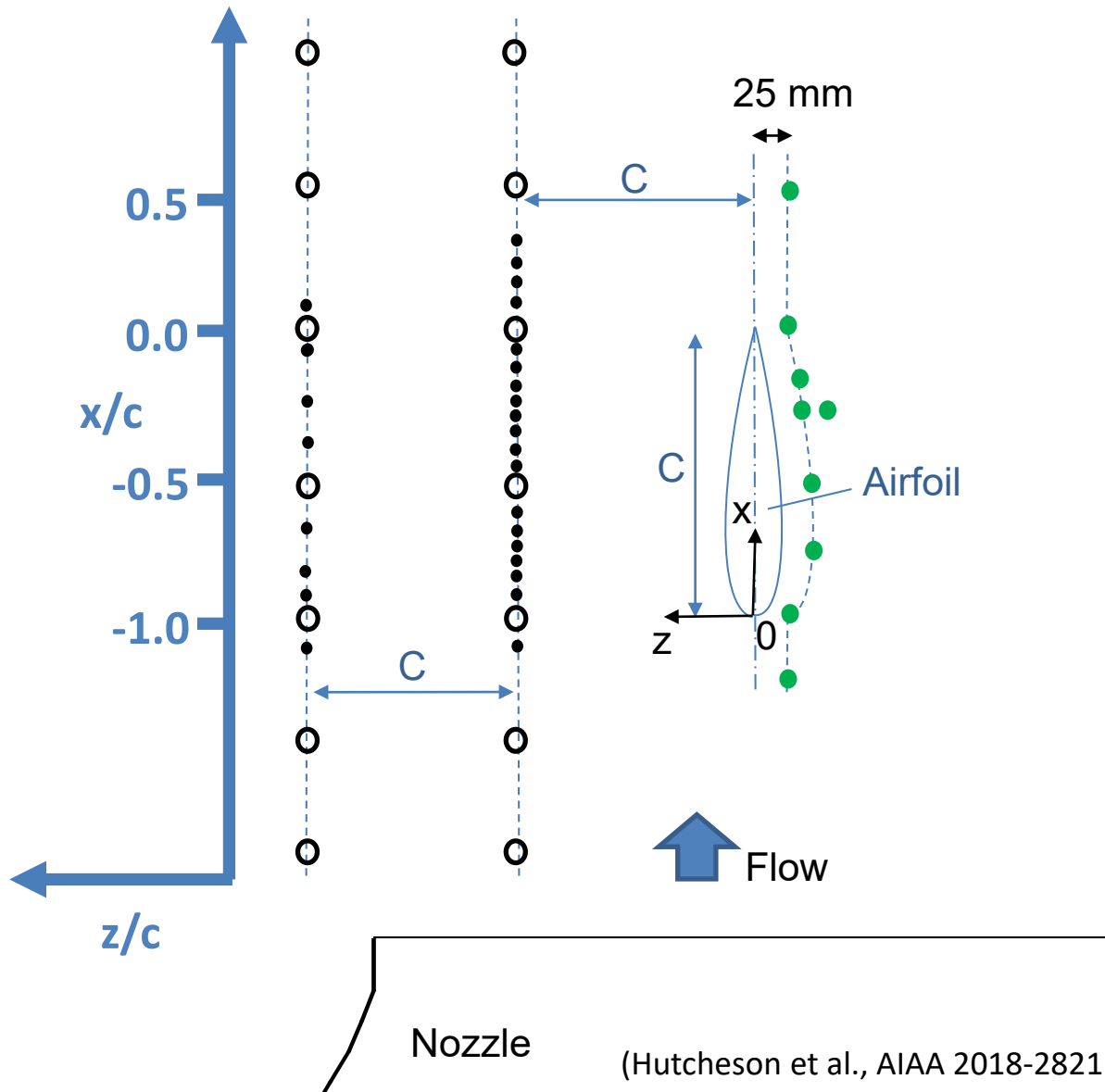


- Same experiment performed at DLR and ONERA (Rossignol et al. AIAA 2018-2820)
- Scattering surface: Wing with an NACA 0012 airfoil
 - (20 cm-chord)
- Sound Source: nonintrusive, laser-induced source
 - Solid green circles: LE, 0.70c, and 0.75c in paper
- 2 microphone survey stations (open circles)
 - In-flow microphone: 1/8" microphone with nose cone

(Hutcheson et al., AIAA 2018-2821)



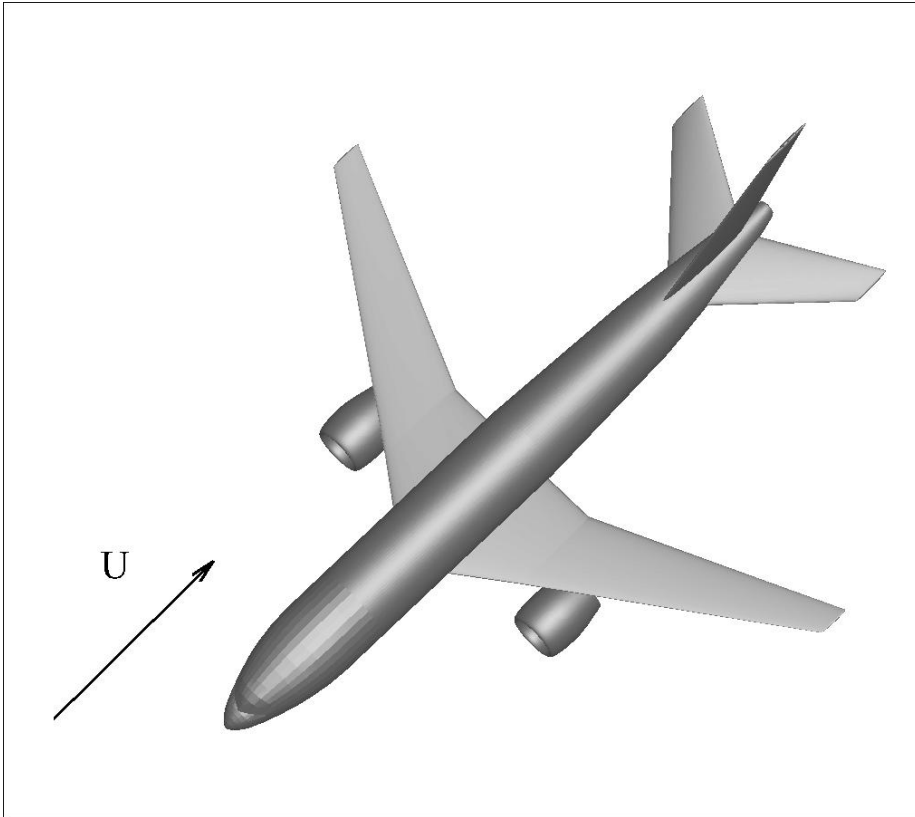
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TD-FAST: Time Domain Fast Acoustic Scattering Toolkit

- Time Domain Boundary Element Method

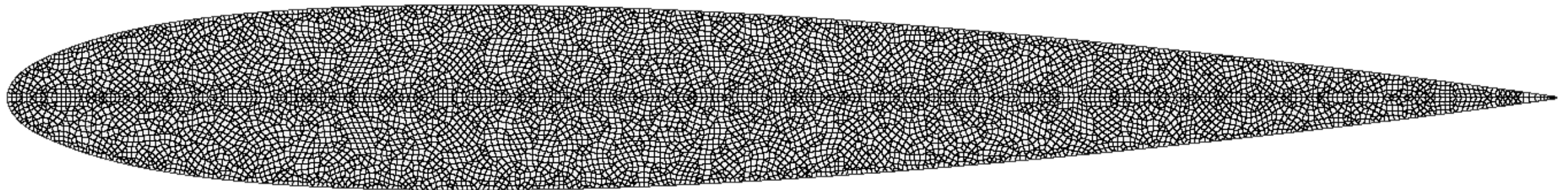
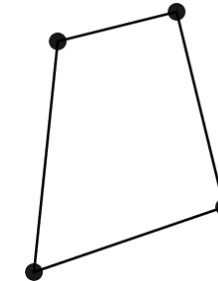
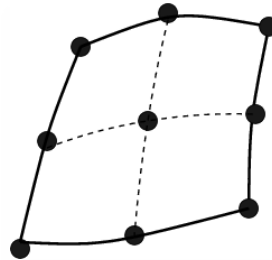
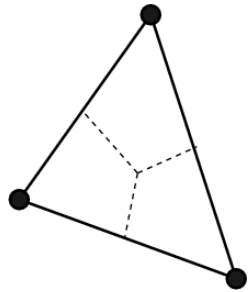


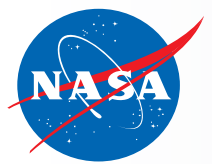
$$\left(\frac{\partial}{\partial t} + \mathbf{U} \cdot \nabla \right)^2 p(\mathbf{r}, t) - a^2 \nabla^2 p(\mathbf{r}, t) = s(\mathbf{r}, t)$$

- Uniform mean flow
- $s(\mathbf{r}, t)$: Spark source modeled using multiple analytical Gaussian functions with parameters based on QFF measurements

TD-FAST: Time Domain Fast Acoustic Scattering Toolkit

- Time Domain Boundary Element Method
- Surface Mesh: Unstructured triangular or quadrilateral elements

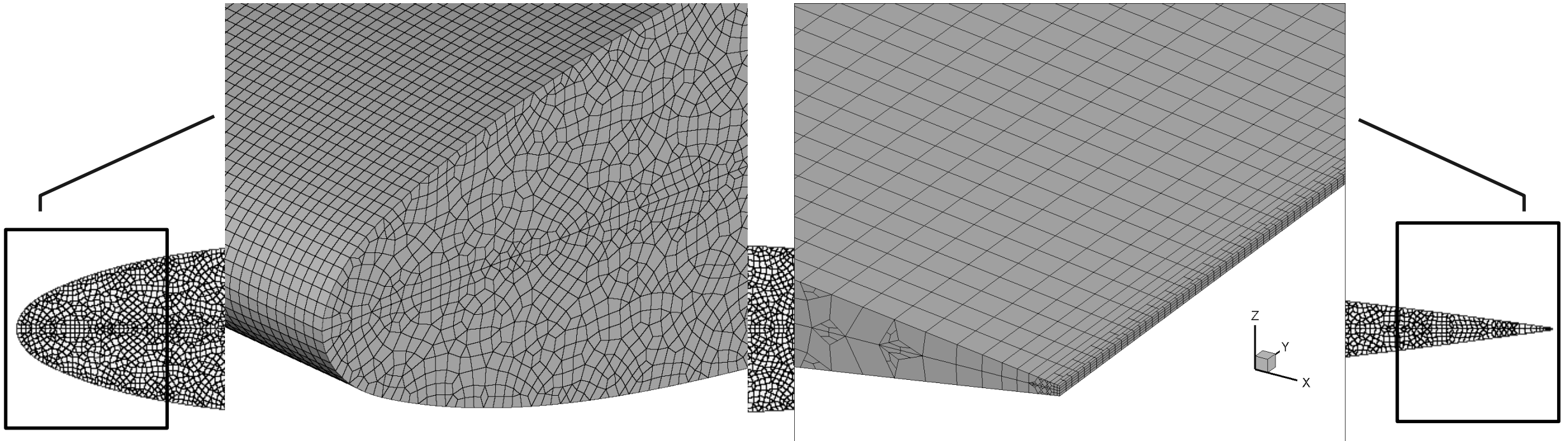




Computational Modeling

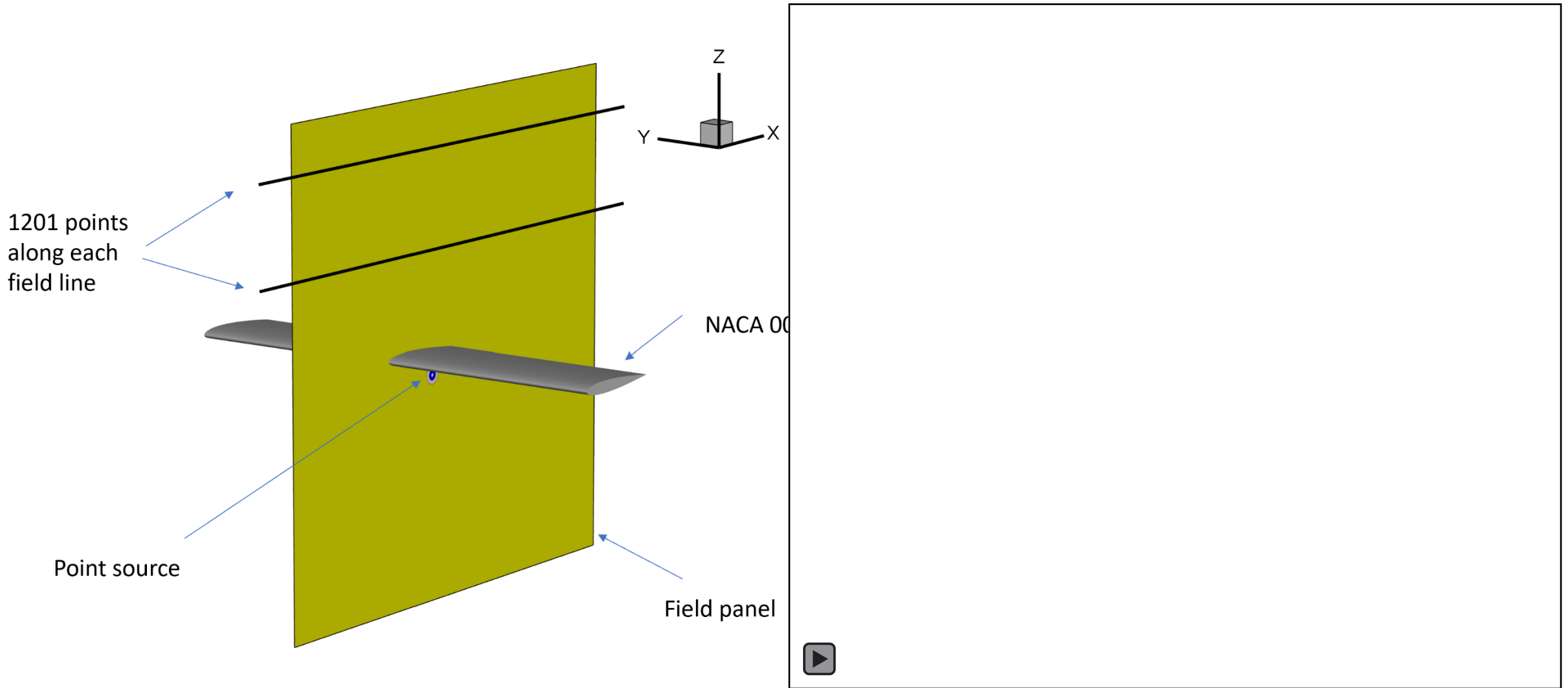
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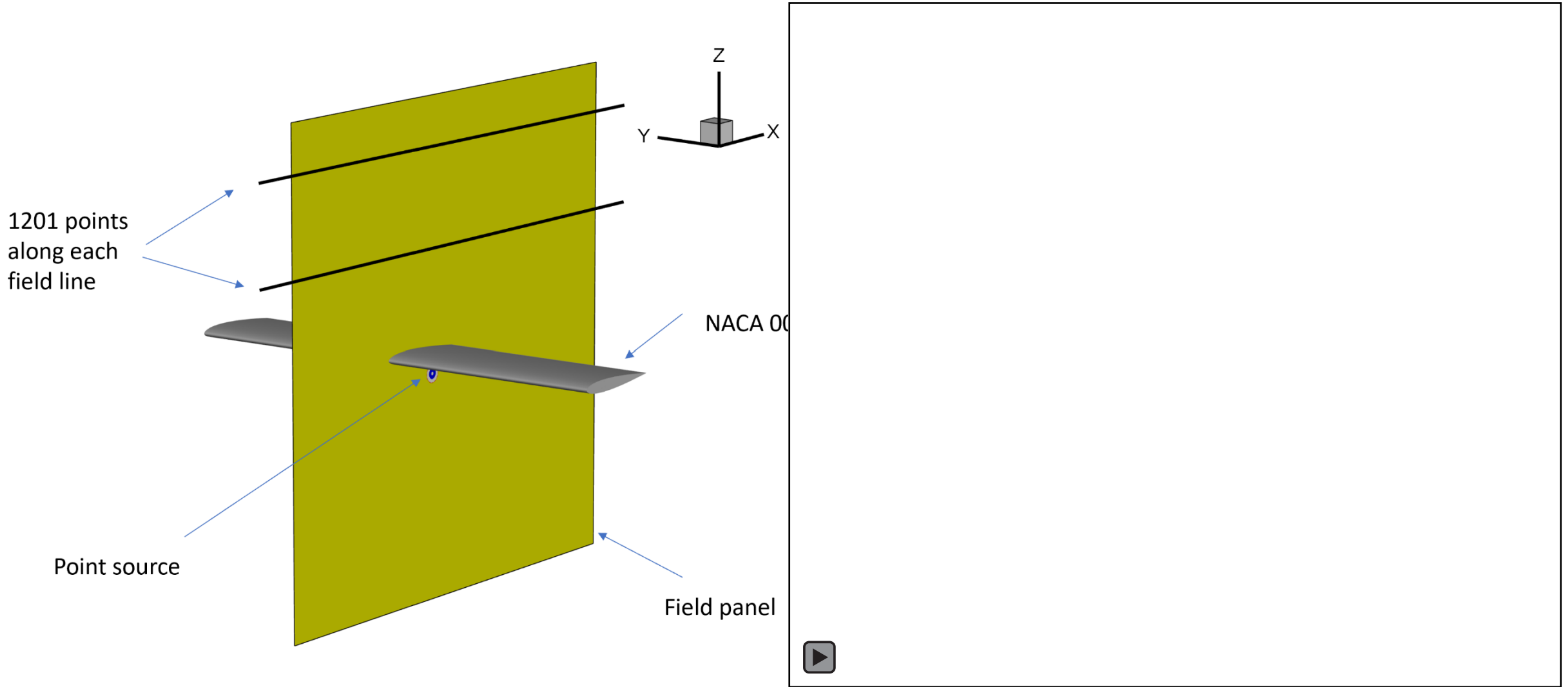


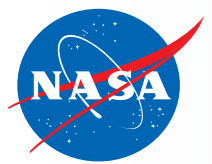
Computational Results (0.75c)



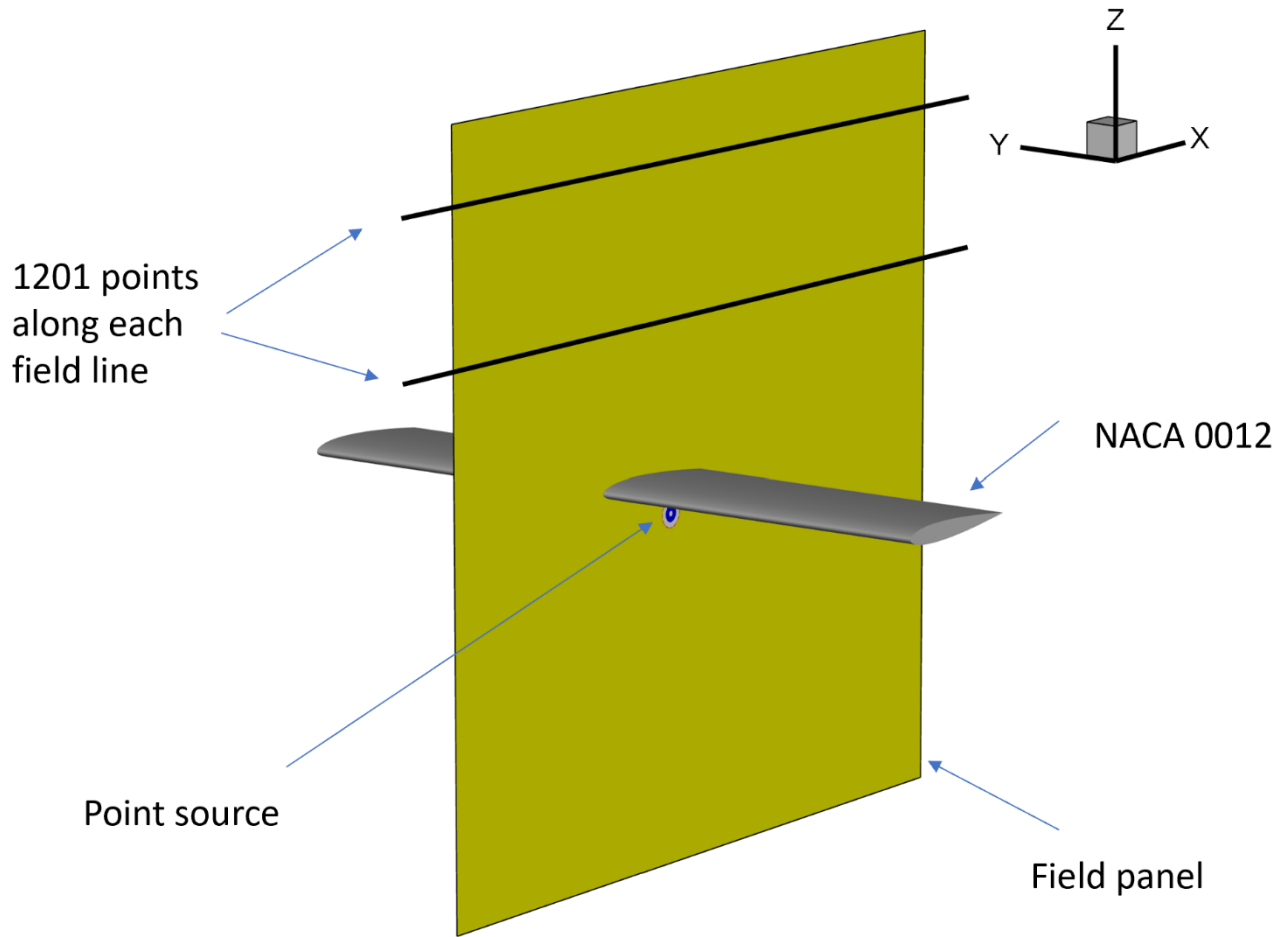


Computational Results (0.75c)

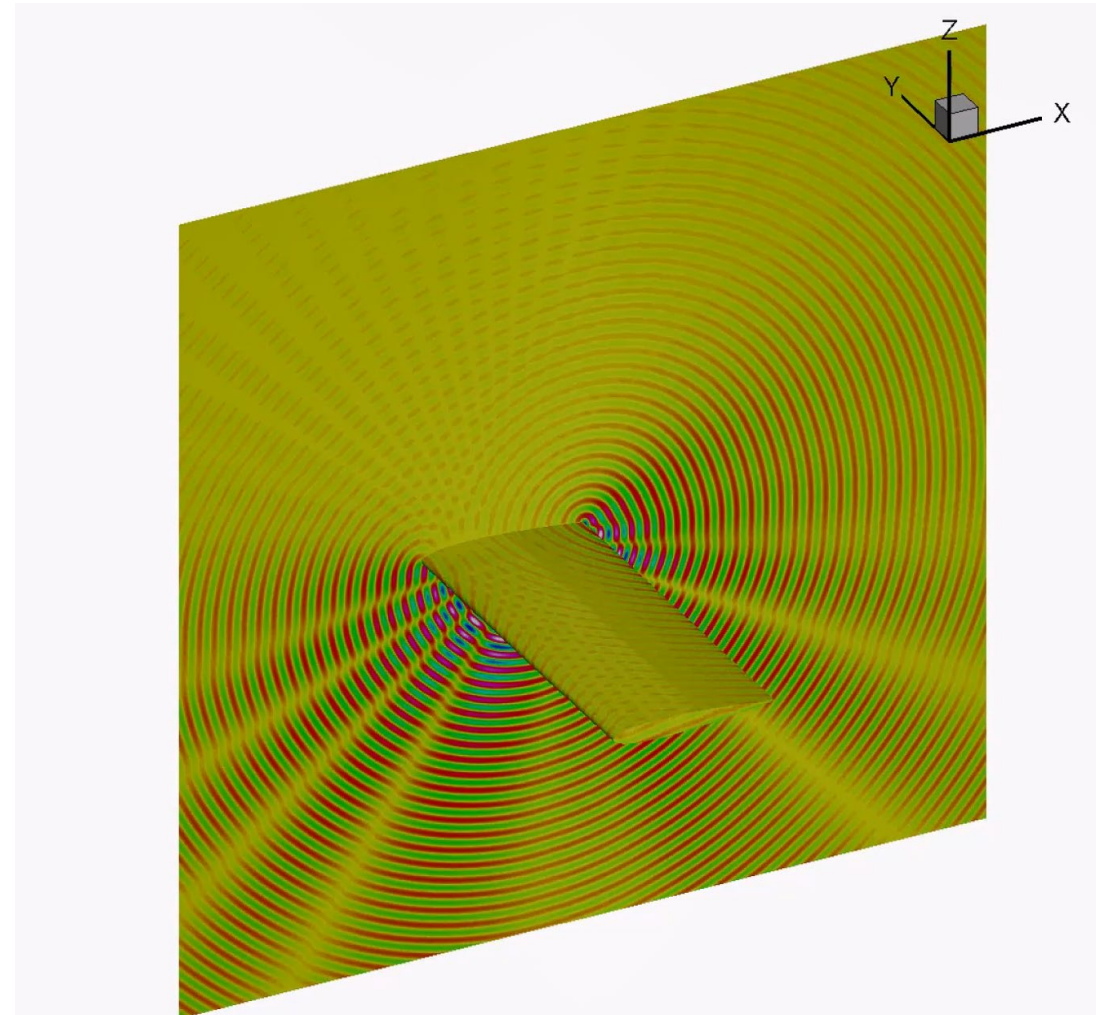




Computational Results (0.75c)

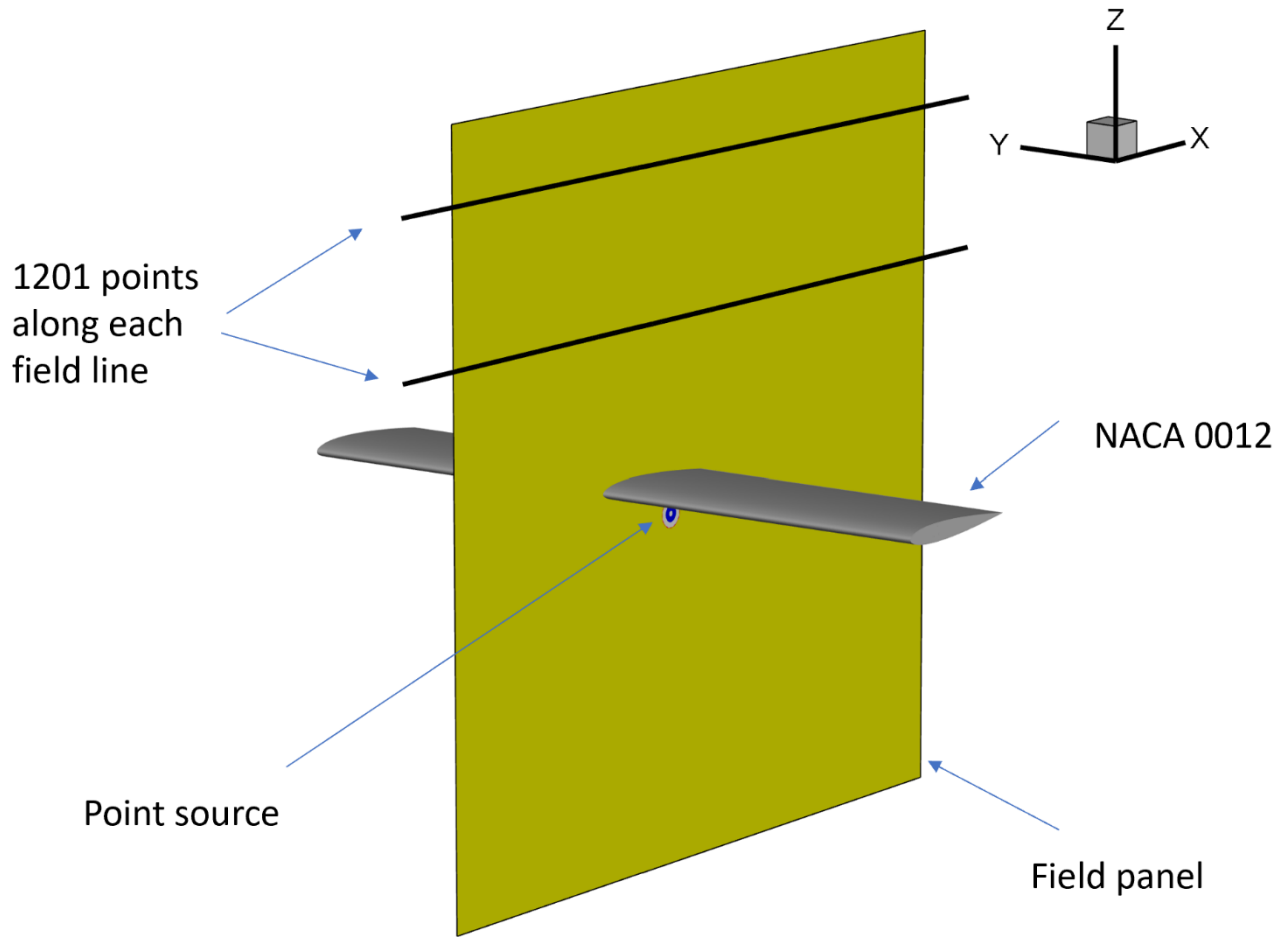


Frequency domain: 20 kHz

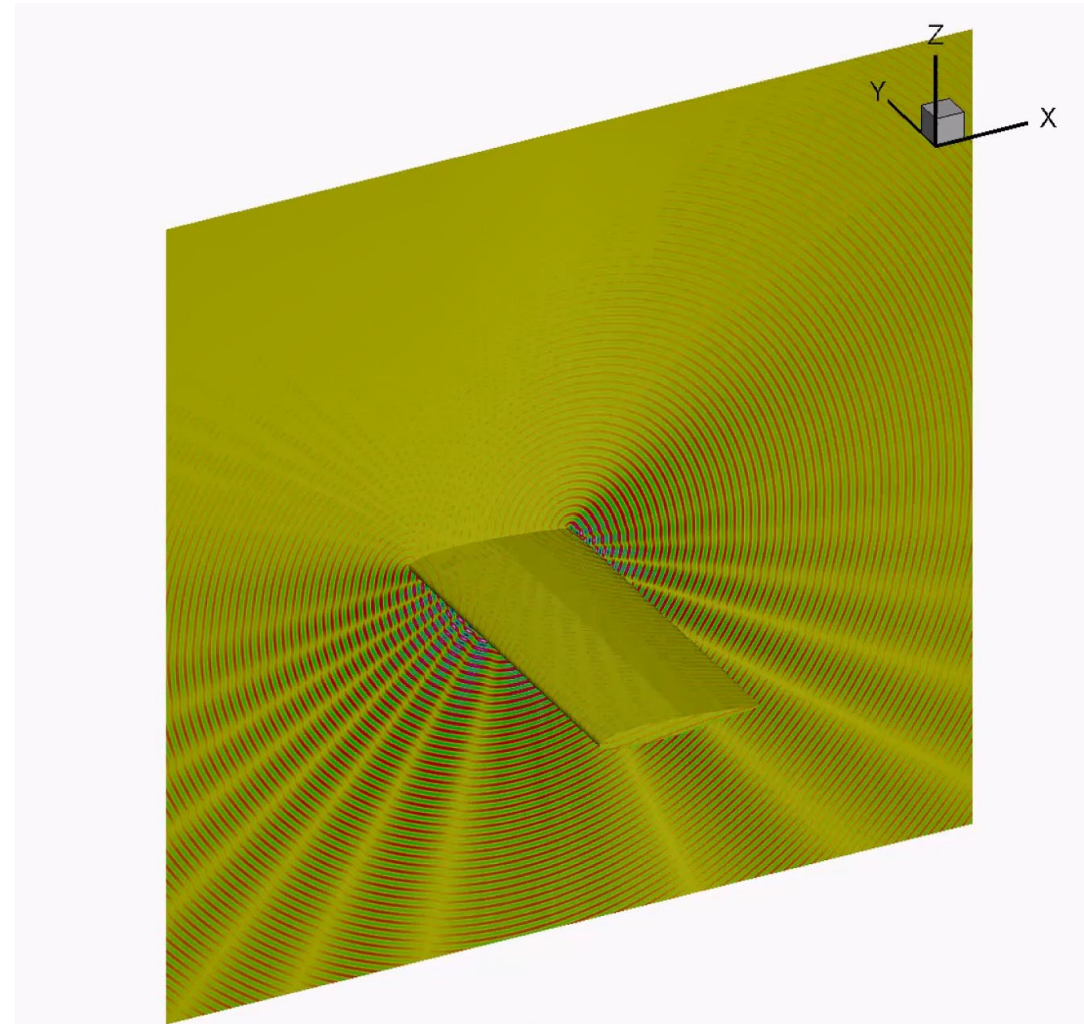




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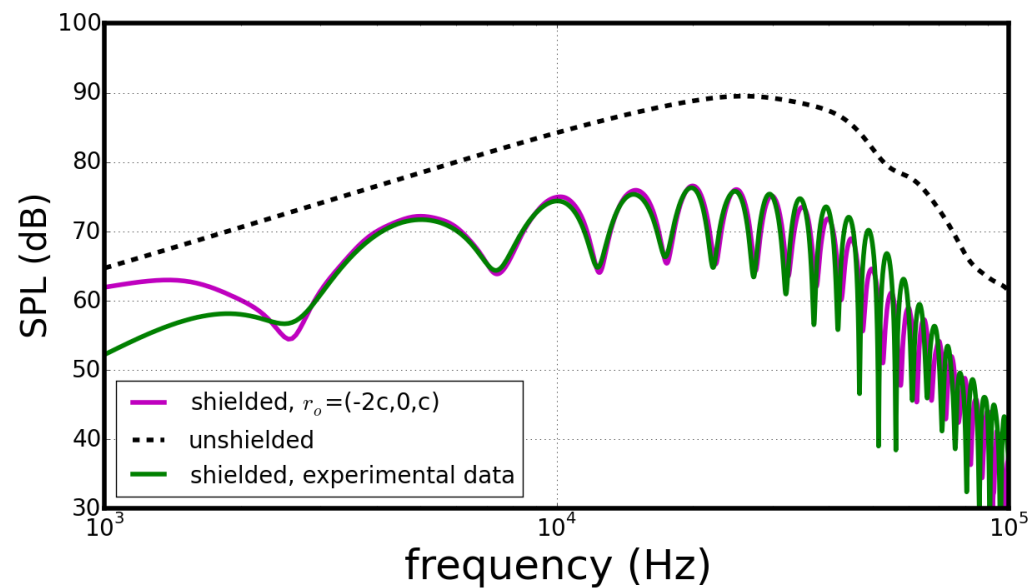
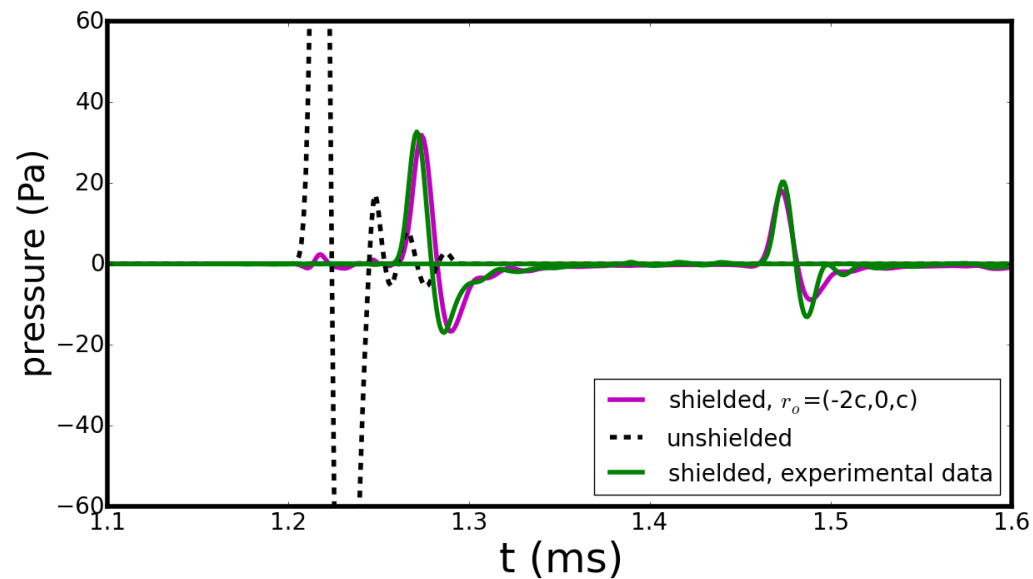
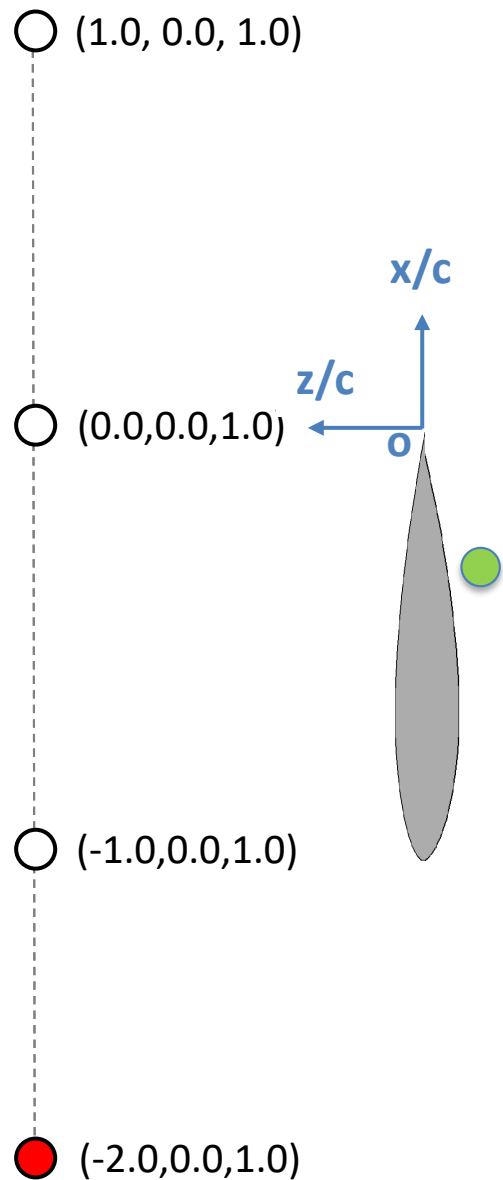


Frequency domain: 40 kHz



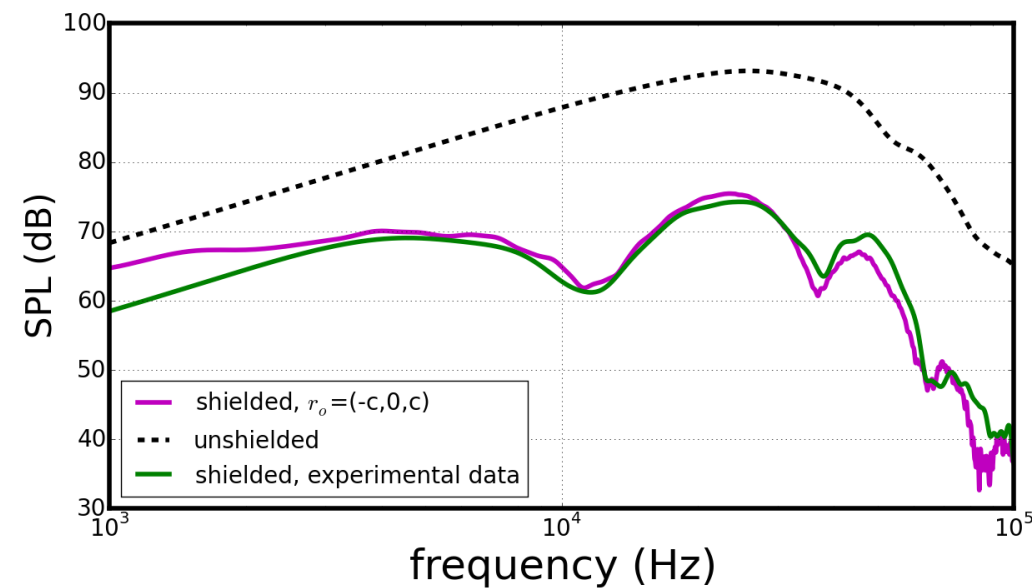
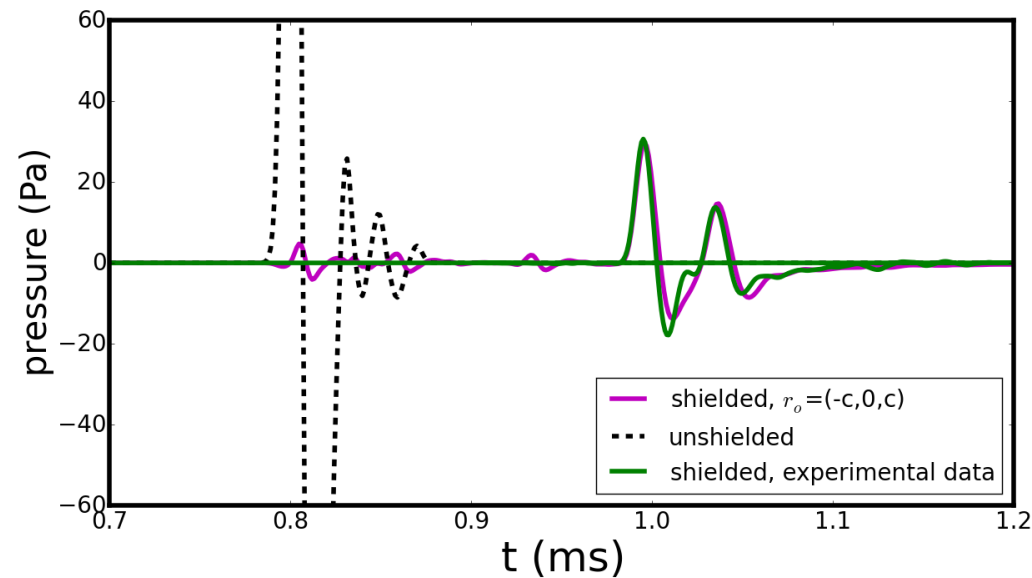
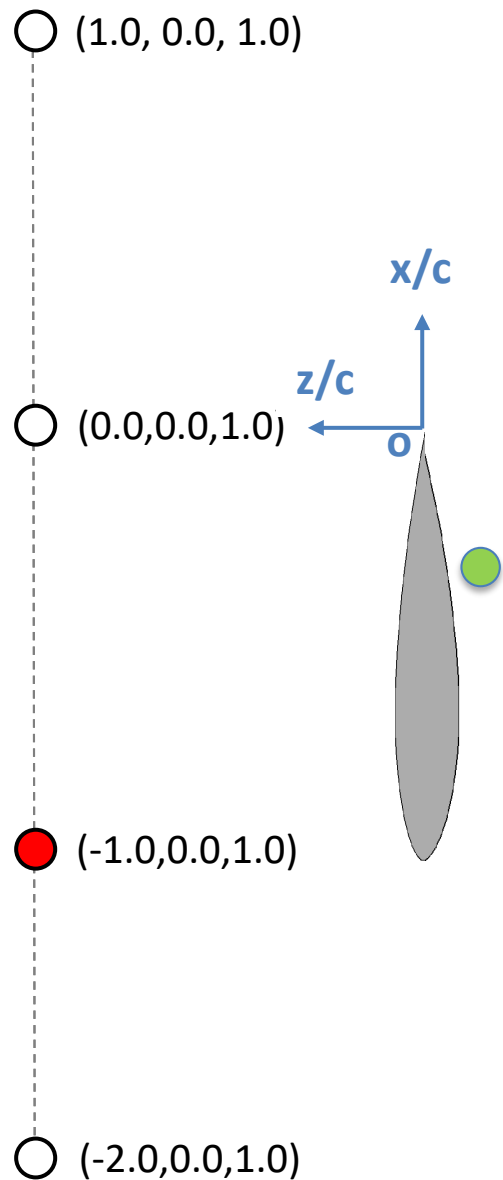


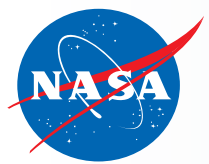
Computational Results (0.75c)



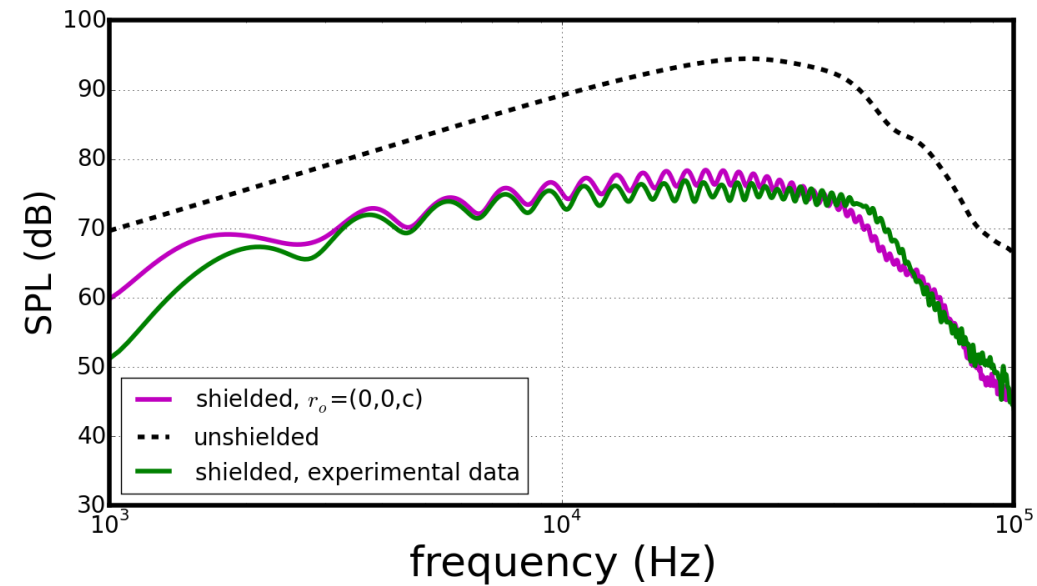
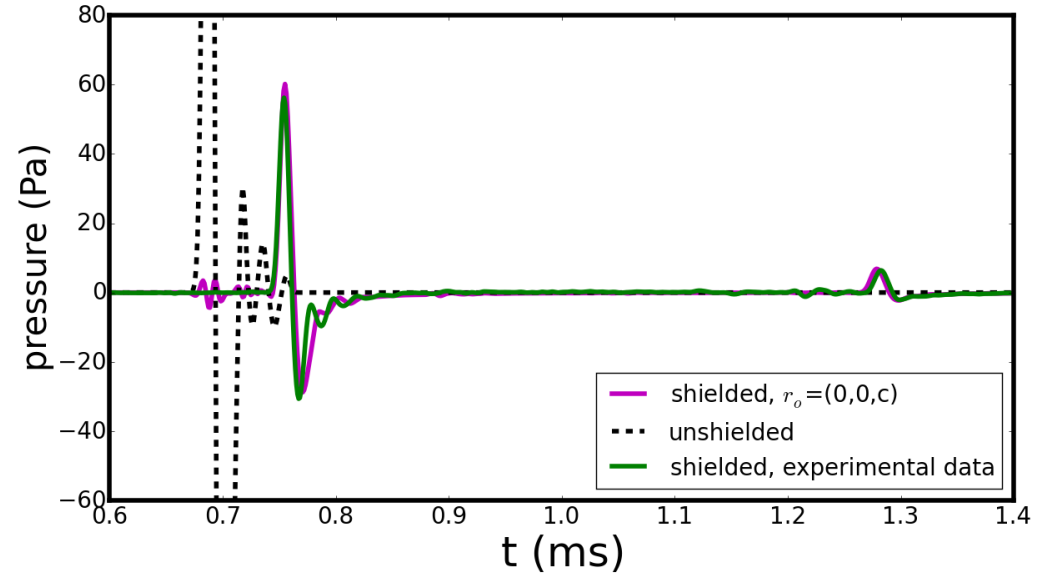
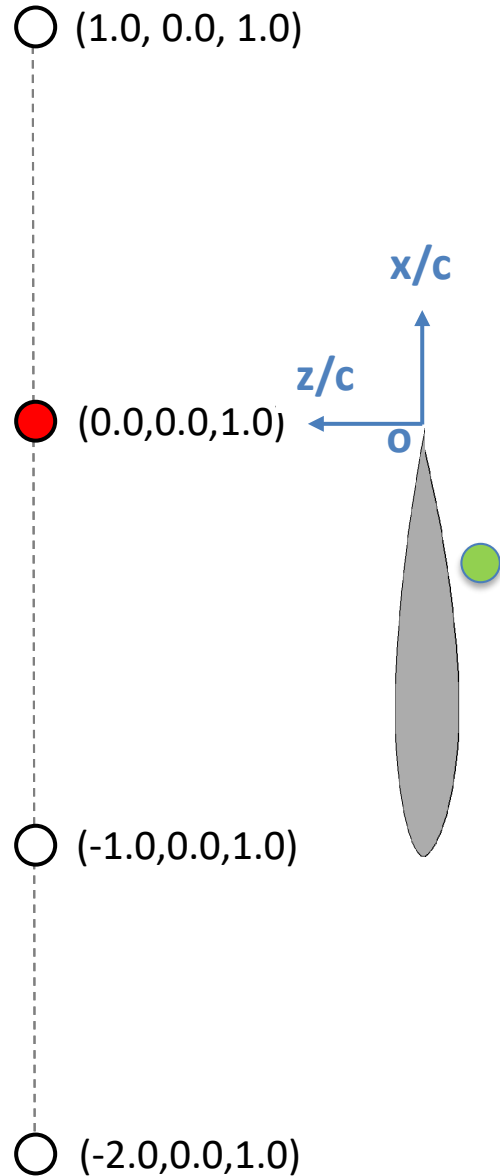


Computational Results (0.75c)



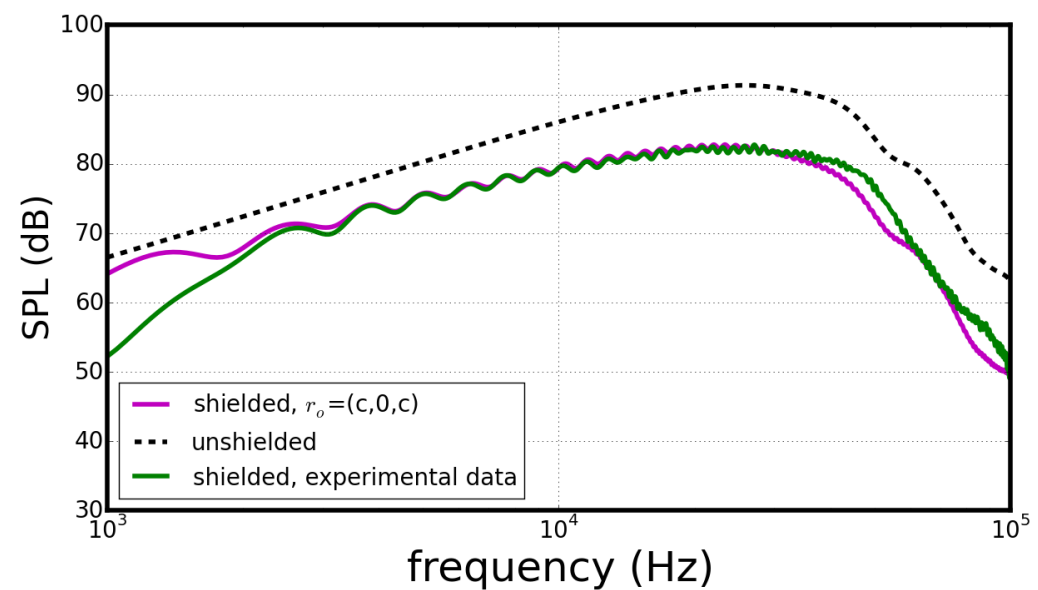
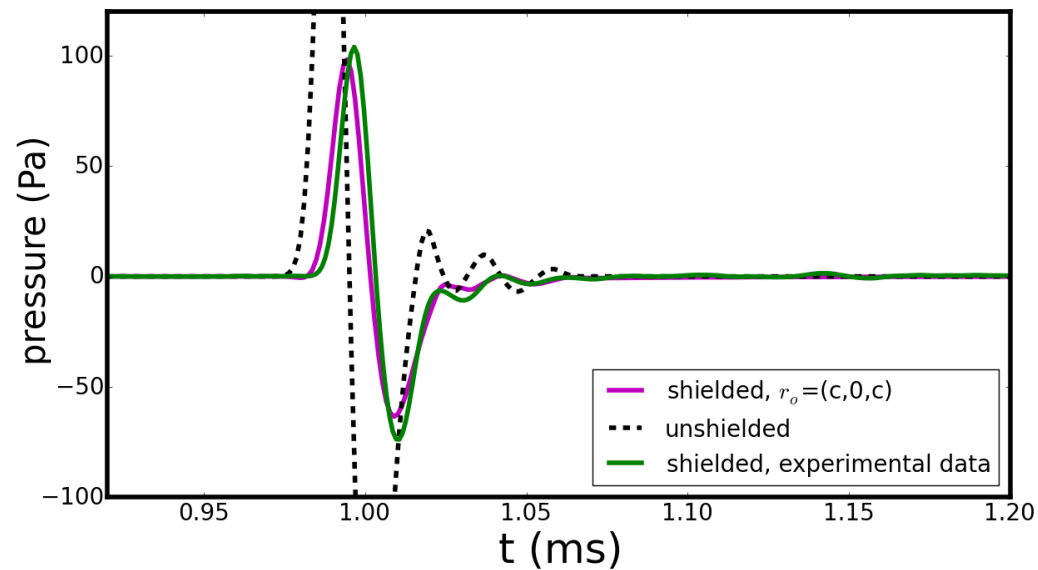
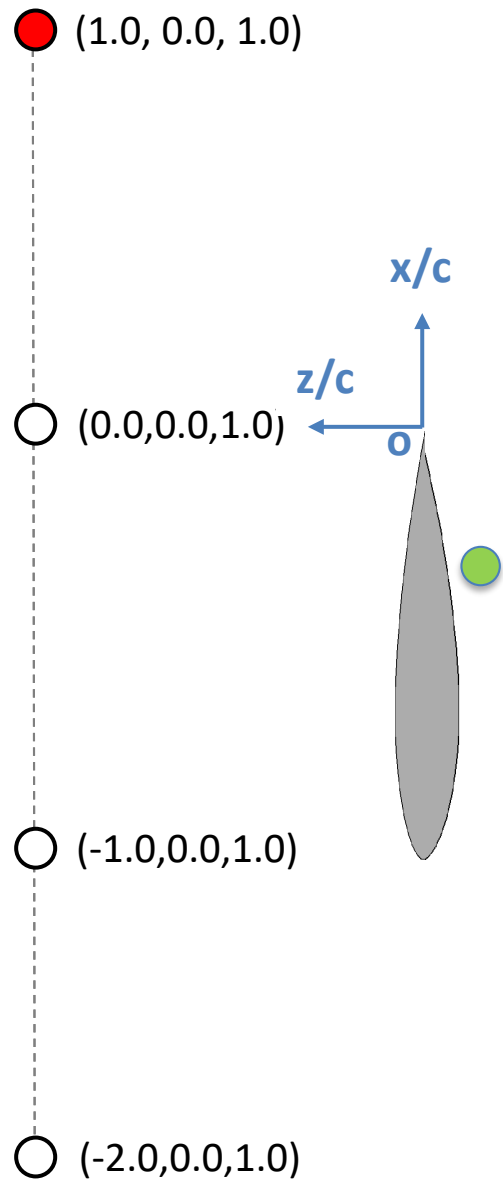


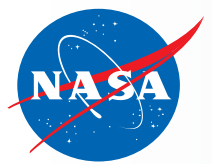
Computational Results (0.75c)





Computational Results (0.75c)





Computational Results (0.75c)

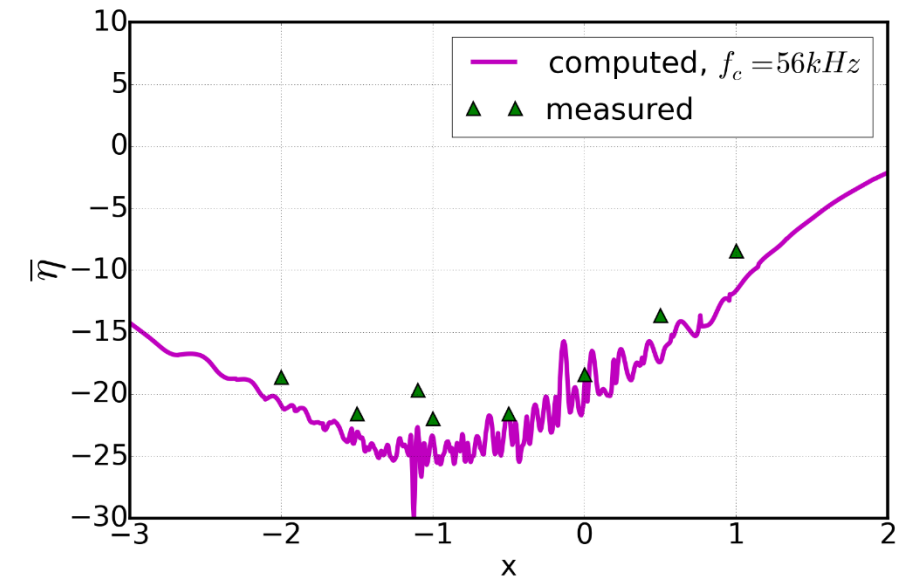
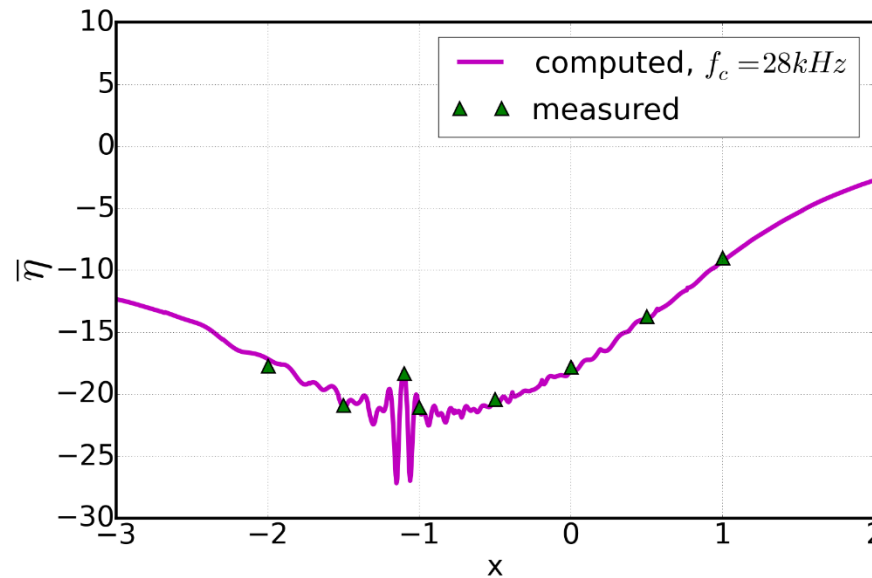
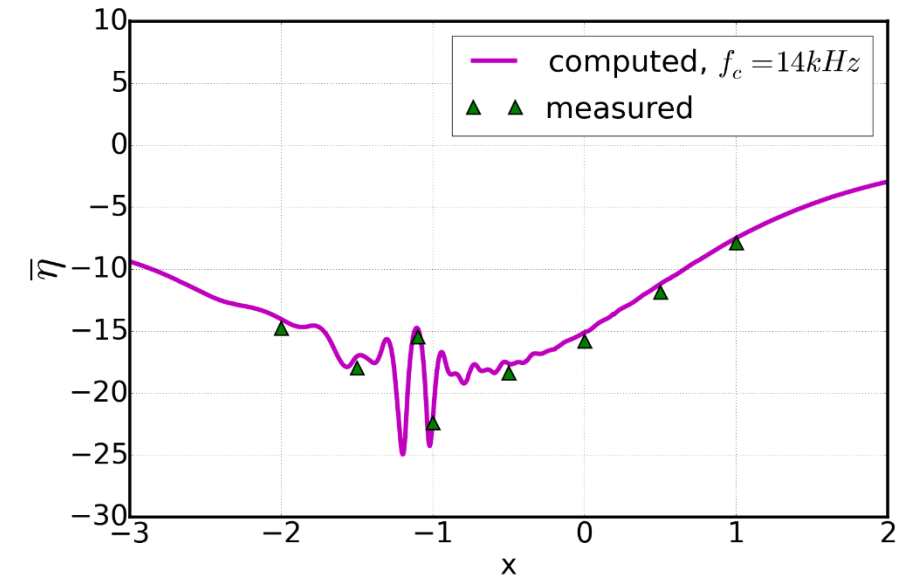
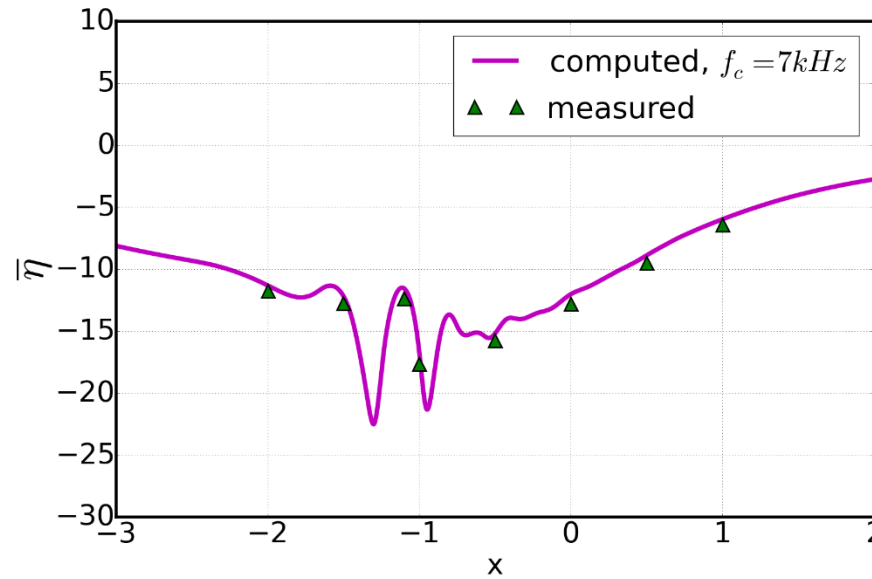
Shielding Factor

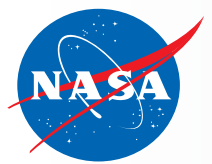
$$\eta(f) = \frac{|p_s(f)|}{|p_i(f)|}$$

$$\bar{\eta}(f_c) = \sqrt{\frac{\sqrt{2}}{f_c} \int_{f_c/\sqrt{2}}^{\sqrt{2}f_c} \eta^2(f) df}$$

p_s : Shielded

p_i : Unshielded





Concluding Remarks

- Manuscript includes
 - Comparisons at additional source locations
 - Effects of computational mesh refinement
 - Effects of source waveform modeling

Results demonstrate the capabilities of TD-FAST and provide further confidence in its continued development and application