Optimal Design of Bass Reflex Loudspeaker Ports

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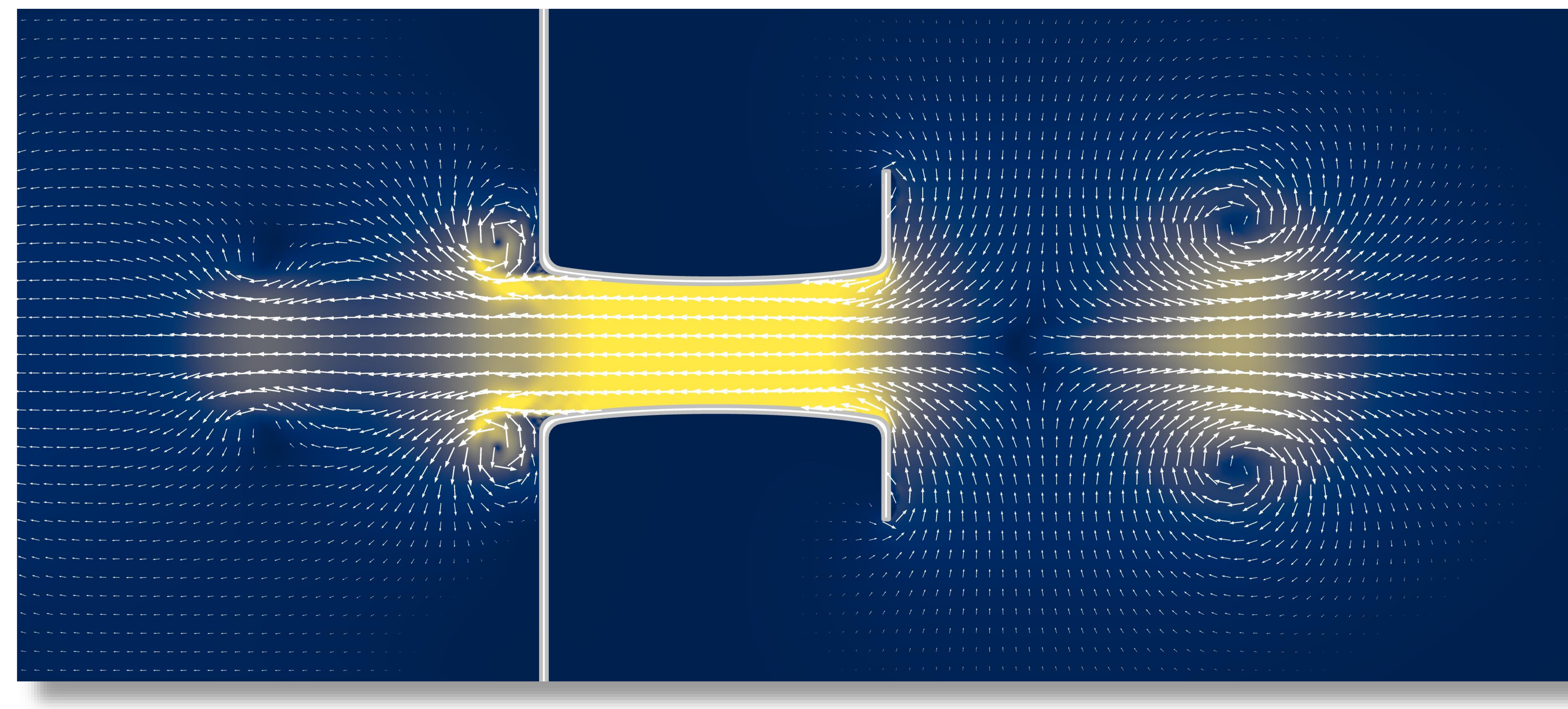
BACKGROUND

- Bass reflex ports enhance low frequency output of loudspeakers.
- Oscillating air can become turbulent and shed vortices
- Vortex shedding produces port noise
- Optimal flare rate of ports has never been established



COMPUTATIONAL METHODS

NAVIER STOKES EQUATIONS

- Describe turbulence and vortex shedding
- Too slow for optimization, even in 2D-axisymmetric models

ACOUSTIC HELMHOLTZ EQUATION

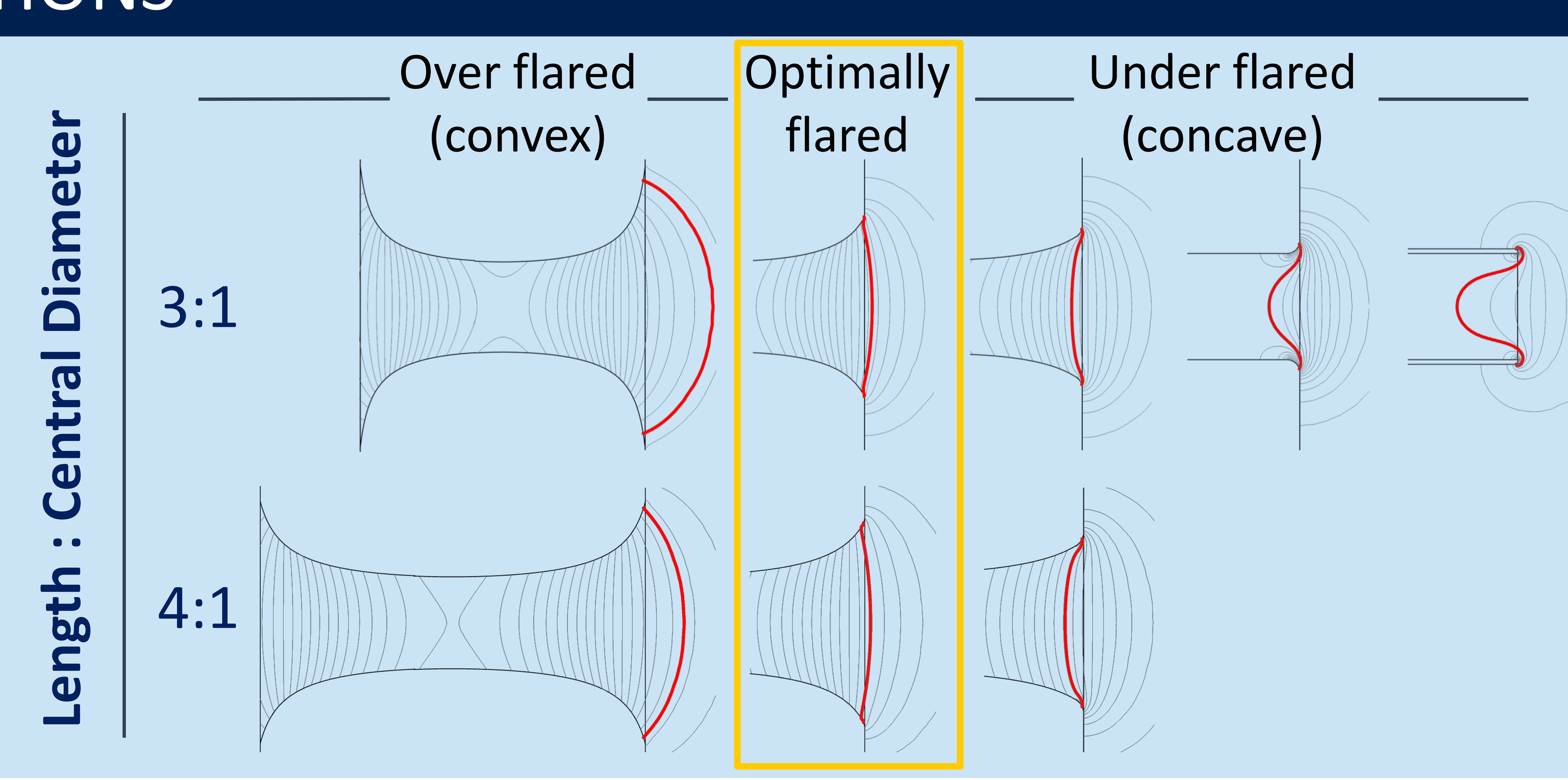
- Valid below level at which port becomes turbulent
- Well suited for optimization problems

Can Acoustic Helmholtz Equation be used to predict port shape with lowest propensity for vortex shedding?

SIMULATIONS

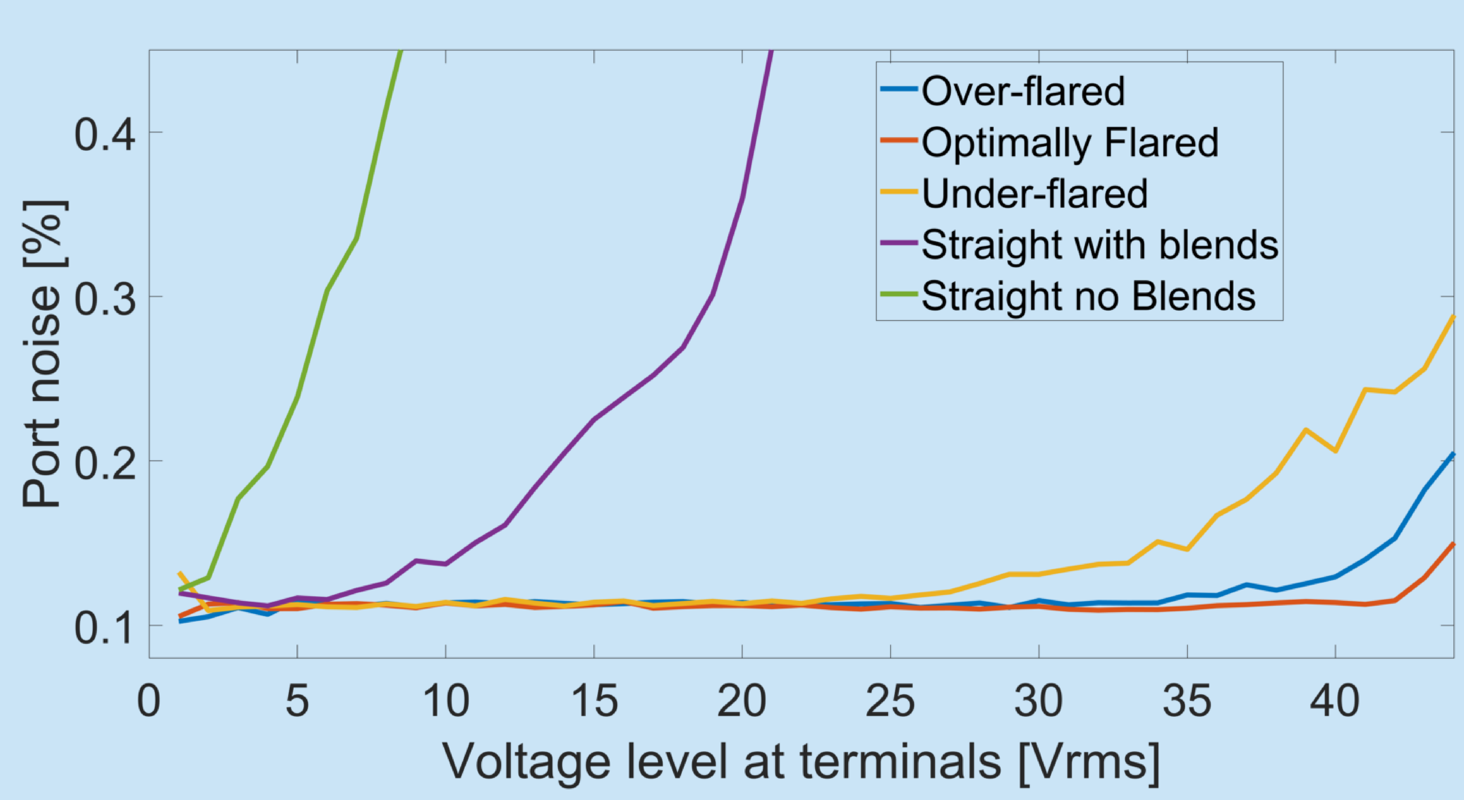
HYPOTHESIS:
Ports with lowest curvature of particle velocity contour at port exit are optimal

- Optimized port shape with different flare rates to tune at desired frequency
- Optimized and simulated ports with length-to-central-diameter aspect ratio of 3:1, and 4:1



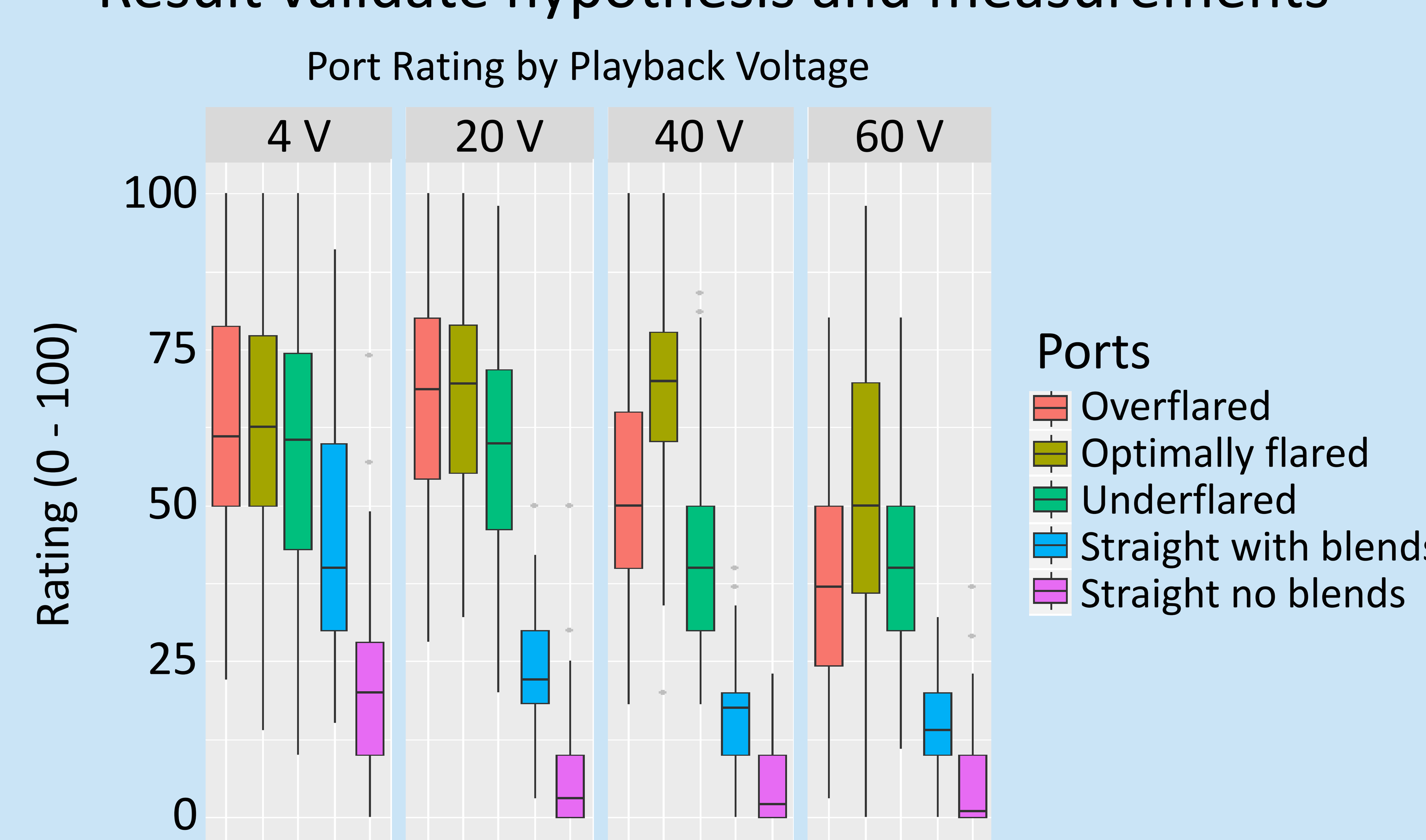
NOISE MEASUREMENTS

- Vortex shedding excites first port eigenmode f_p^1
- Measure ratio of spectral content around f_p^1 to total spectral content



DOUBLE-BLIND LISTENING TESTS

- 15 listeners participated in listening tests
- Result validate hypothesis and measurements



CONCLUSIONS

- Helmholtz equation can predict optimal port flare rate

Optimally flared ports can be played 0.8 to 3 dB louder than slightly under- or over-flared ports and 10 to 16 dB louder than straight ports

REFERENCES

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