AN IMPROVED LOW FREQUENCY RADIATION MODEL FOR FINITE SOUND REFLECTORS

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Acoustics ’08 Paris

June 30, 2008

UNIVERSITY OF Nebraska

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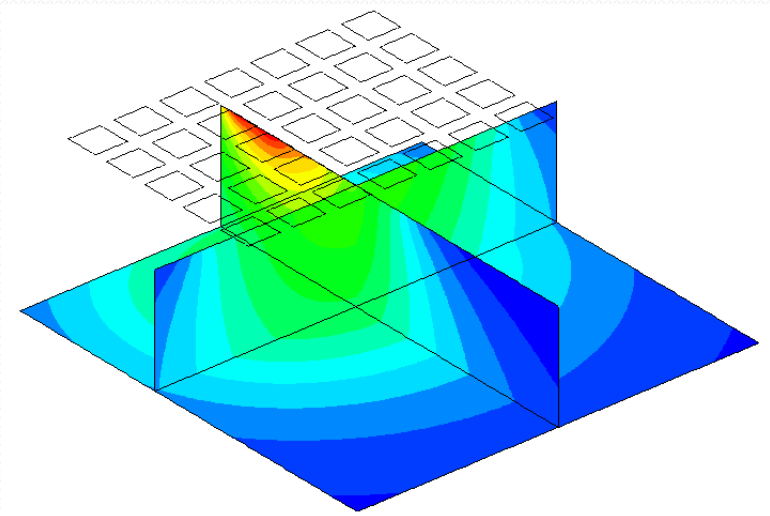
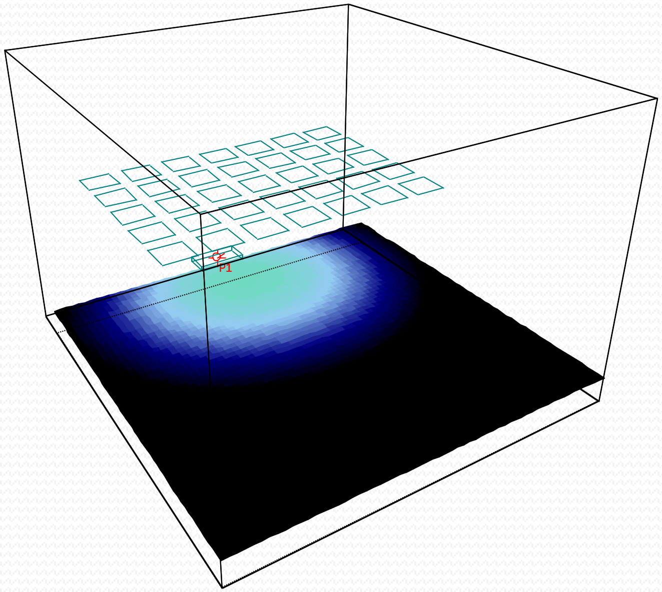
Reflector Panels/Canopies /Clouds

Simulation Methods





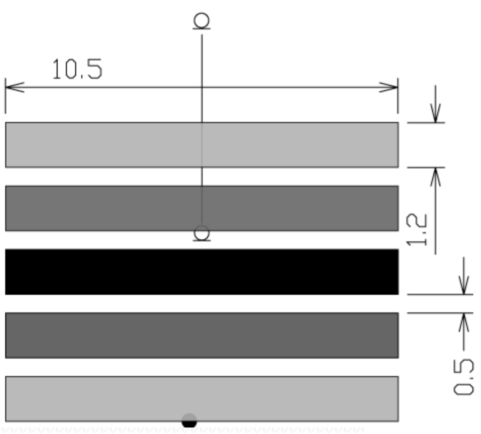
Boundary Element Method (BEM)

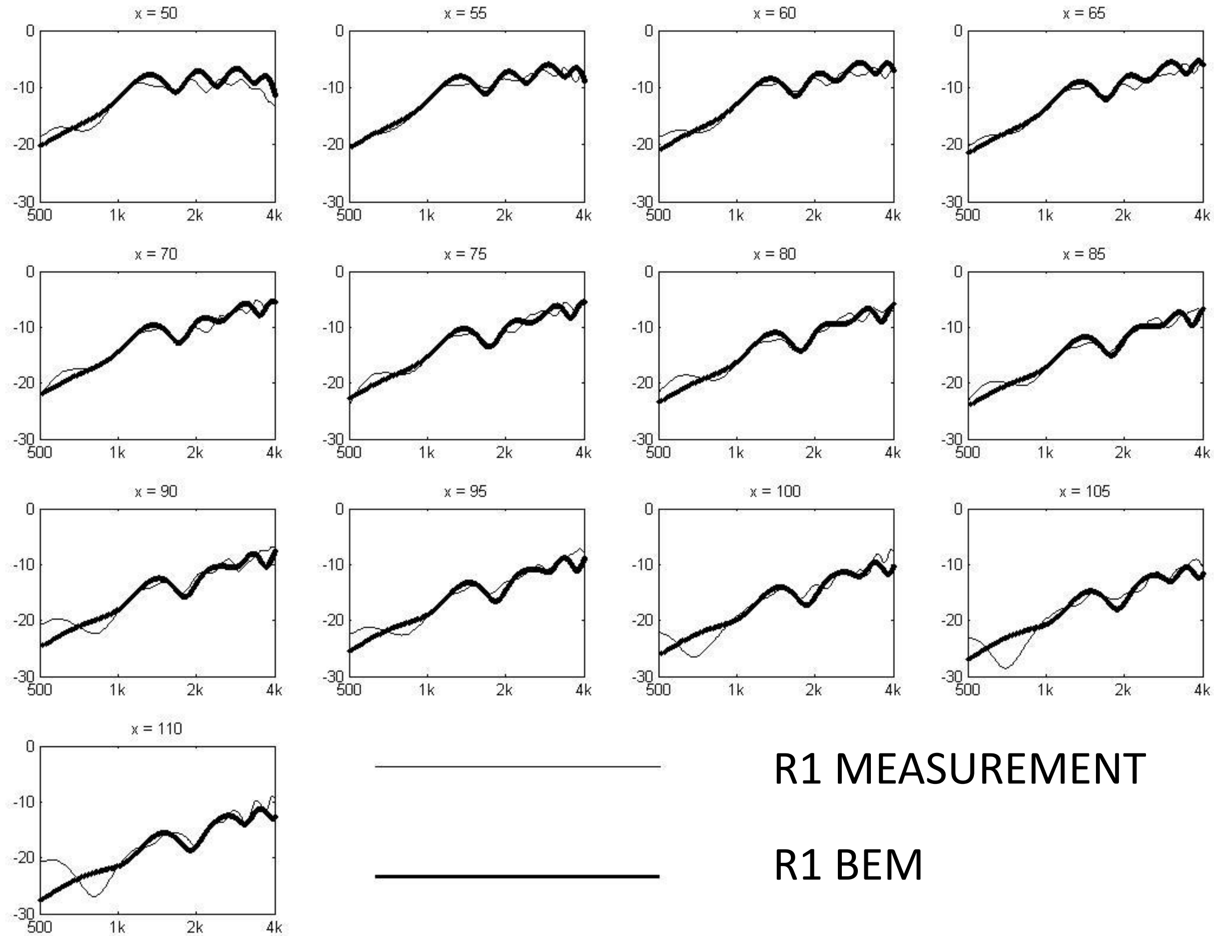
Sysnoise Rev 5.6

Geometric method

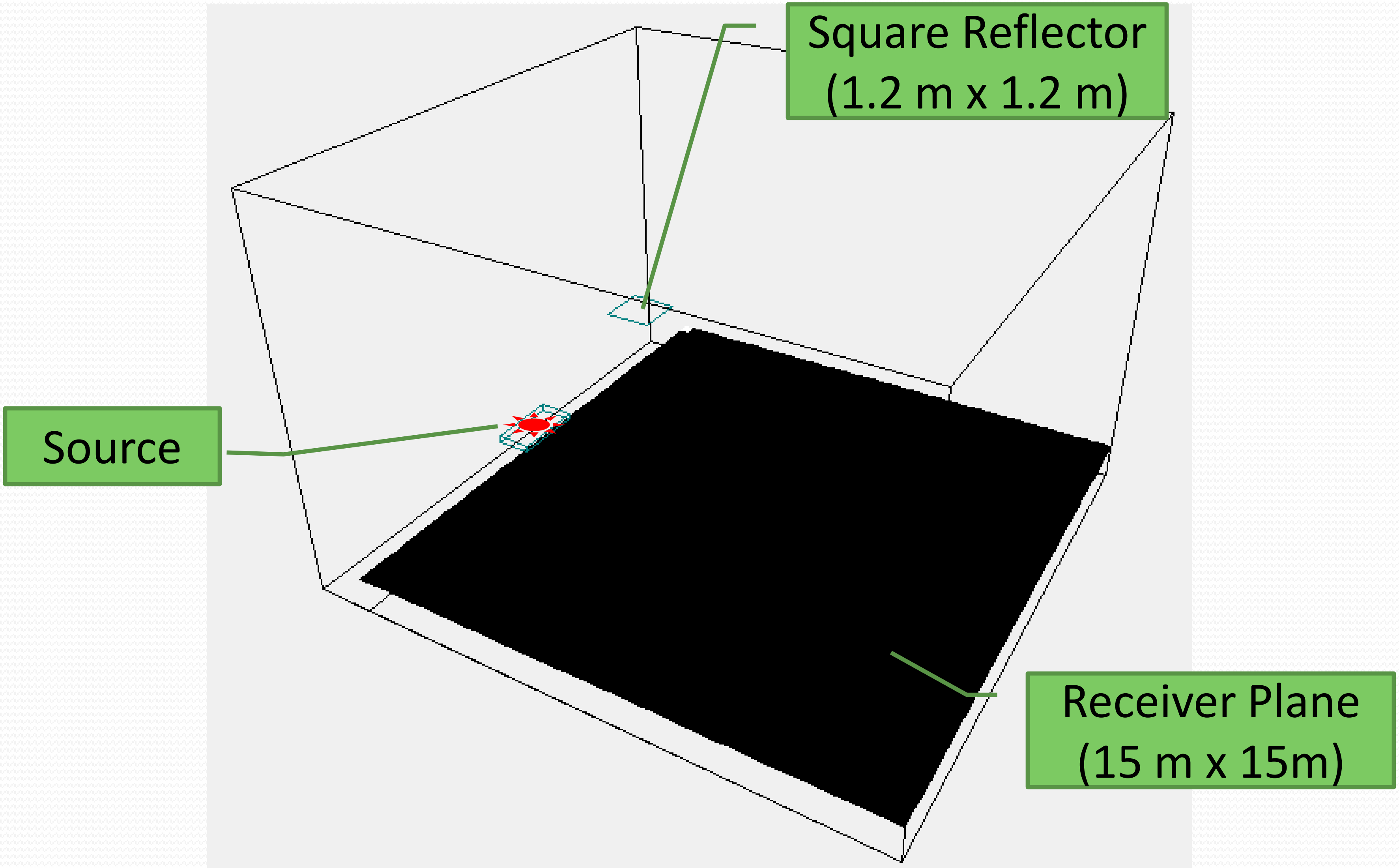
ODEON v9.0

BEM Validation

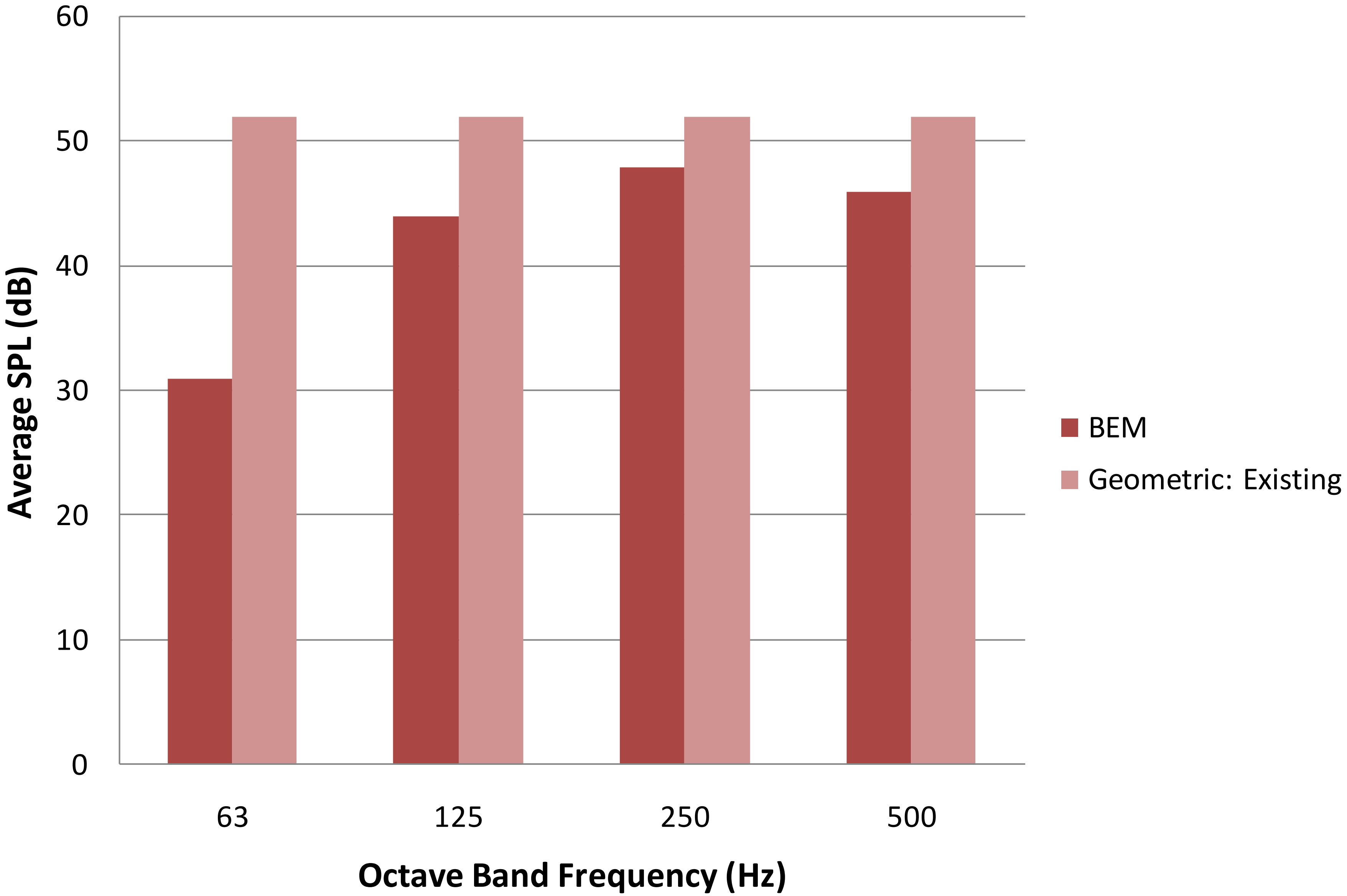




Simulation Geometry



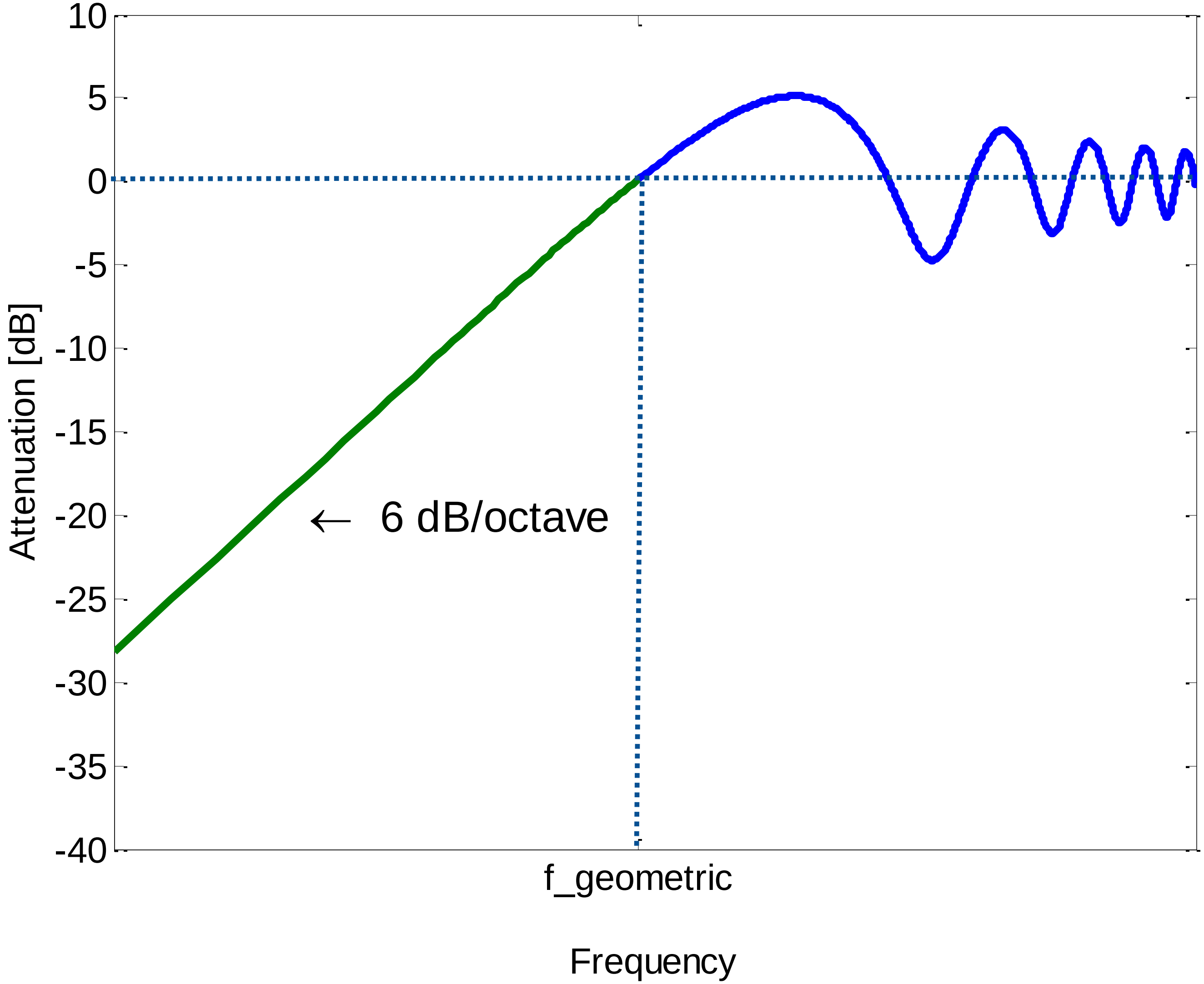
Low Frequency Scattering from Square Panel



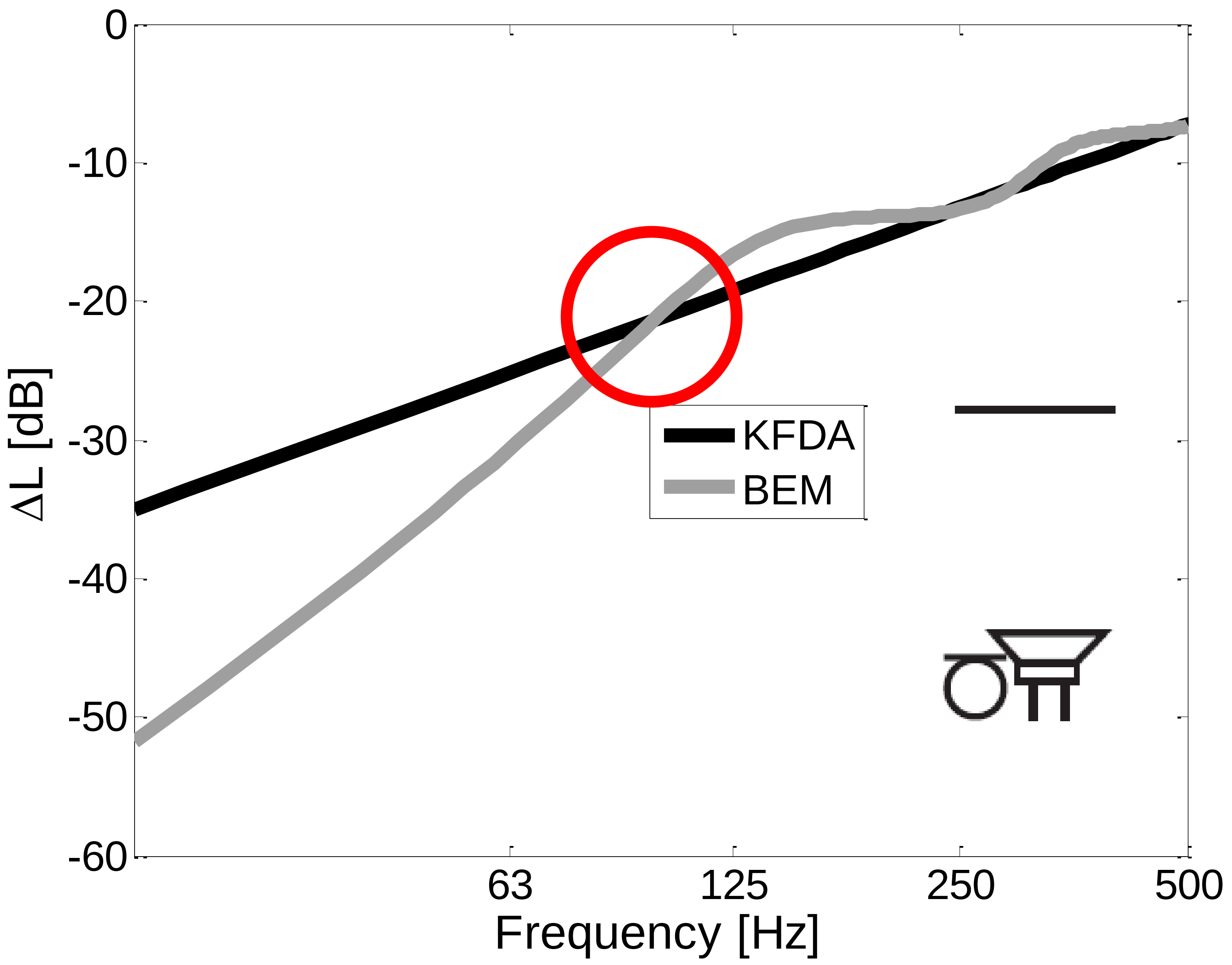
Research Questions

- What causes low frequency *discrepancy* between simulations?
- How can we modify geometric method to lessen this discrepancy?

Geometric Method Reflector Model (KFDA)



KFDA vs. BEM



Monopole/Dipole Radiation

- Monopoles : *energy* ~ f^2 → 6 dB / octave
- Dipole: *energy* ~ f^4 → 12 dB / octave
  - Occurs at low frequencies for baffled piston (Beranek 1993) and for baffled loudspeakers (Olson 1957) when $f < c/2l$

Dipole Limit Frequency, f_d

- We observe that *reflector* radiates as a dipole below the dipole limit frequency, $f_d = c/2l$
- Does f_d vary according to same parameters as the geometric limit frequency, f_g?

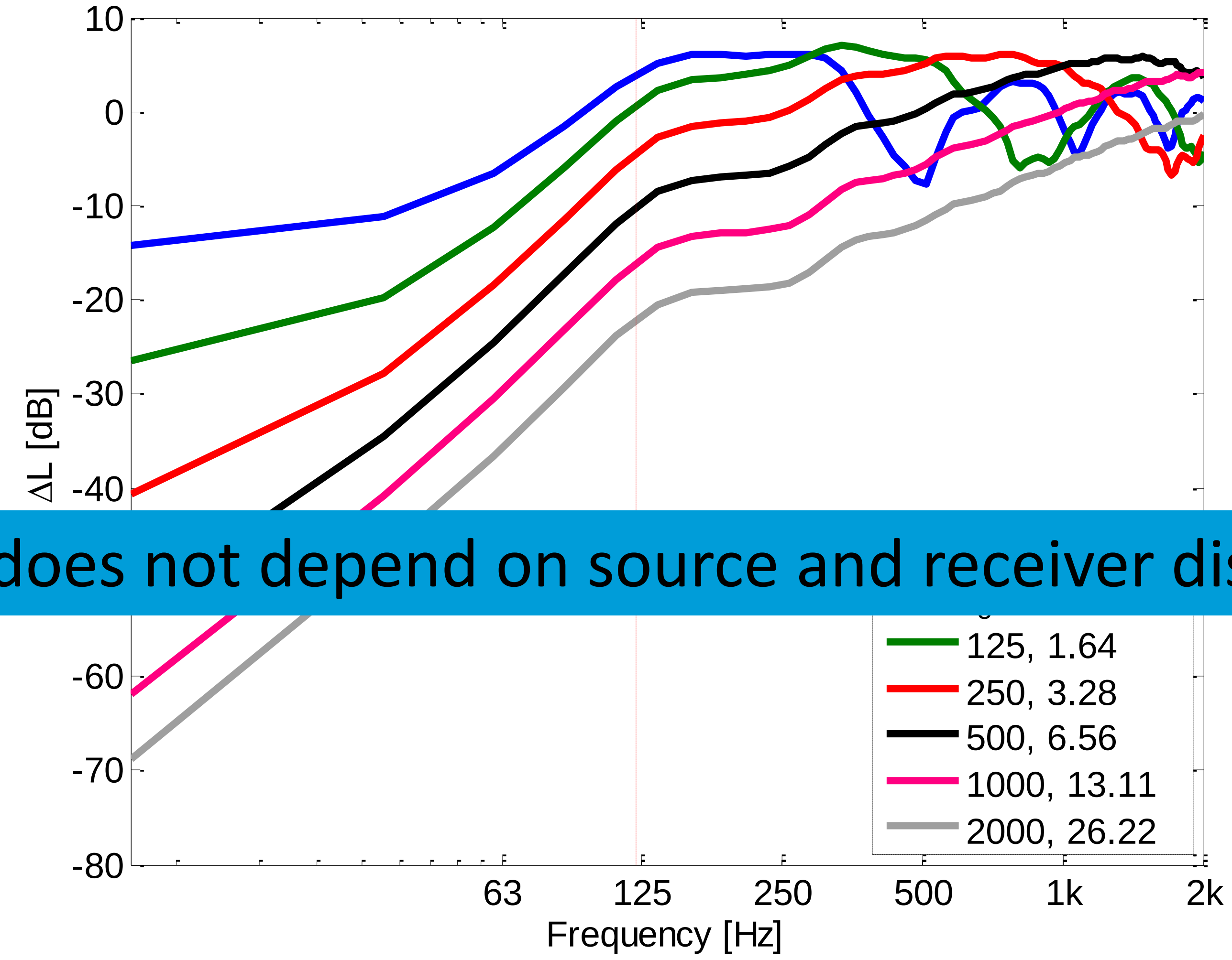
$$f_g = \frac{c\boxed{a^*}}{2\boxed{S}\cos\boxed{\theta}}$$

Source/Receiver Distance

Incidence Angle

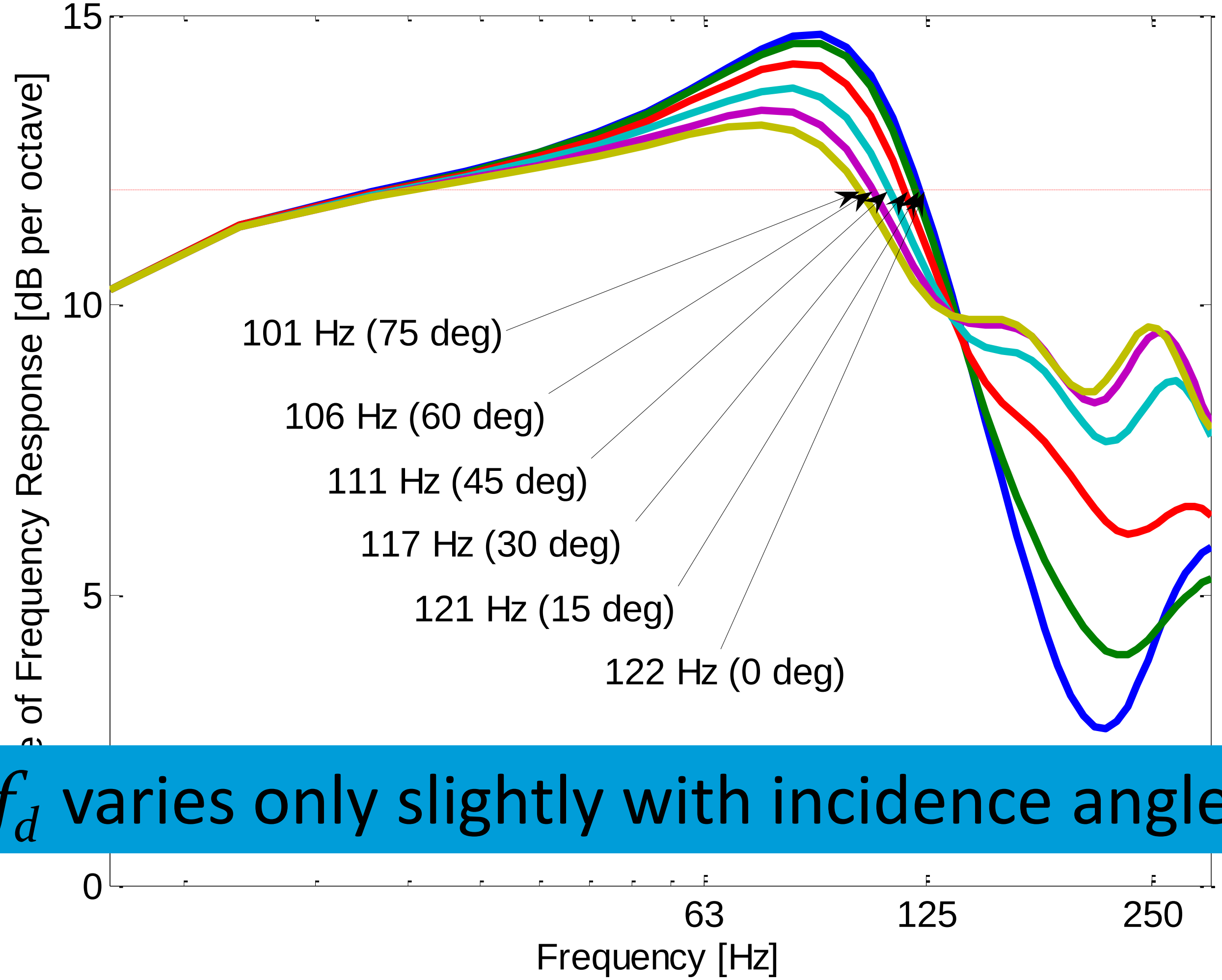
Reflector Area

f_d : Variance with S/R Distance



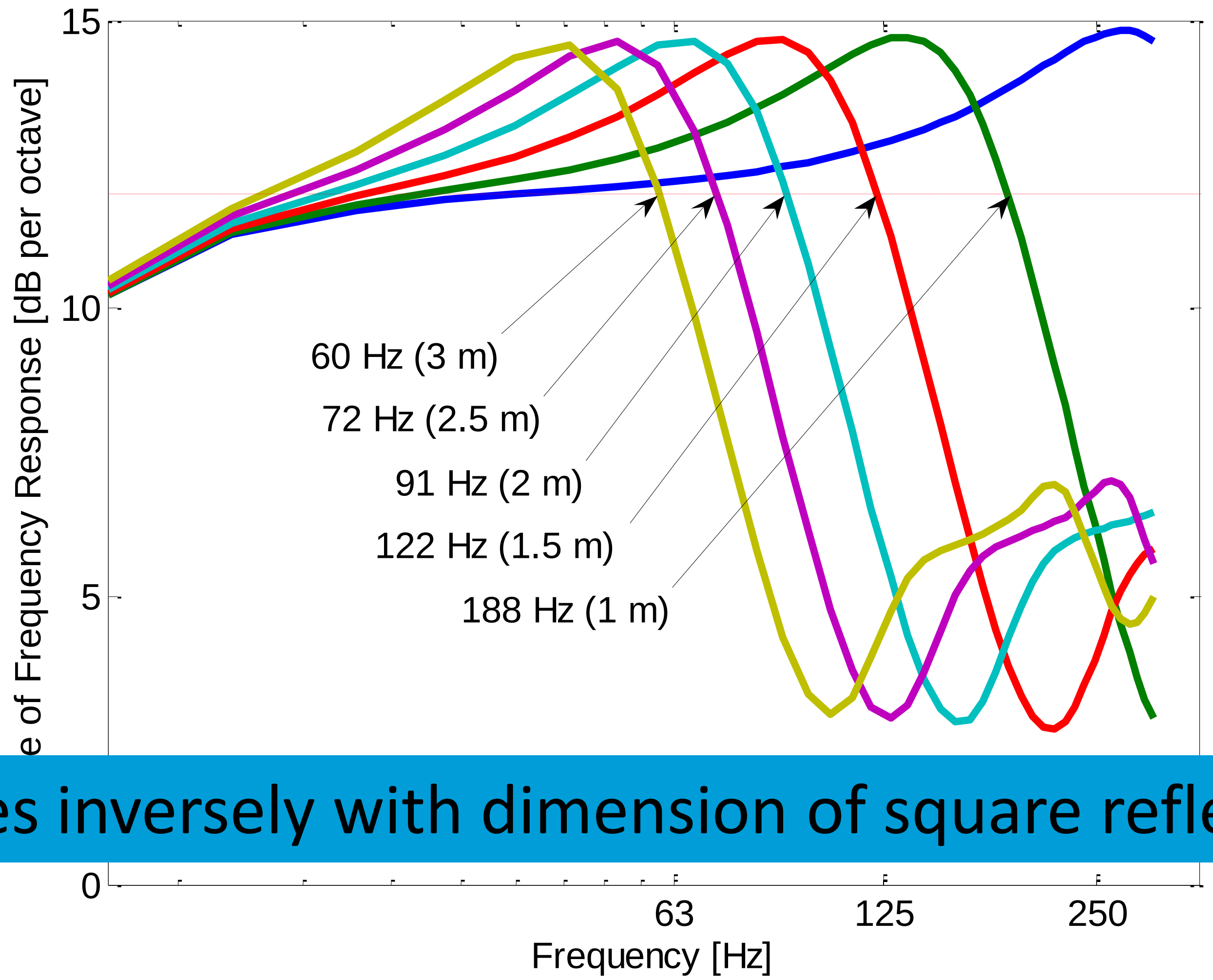
f_d does not depend on source and receiver distances.

f_d : Variance with Incidence Angle



f_d varies only slightly with incidence angle

f_d: Variance with Reflector Size



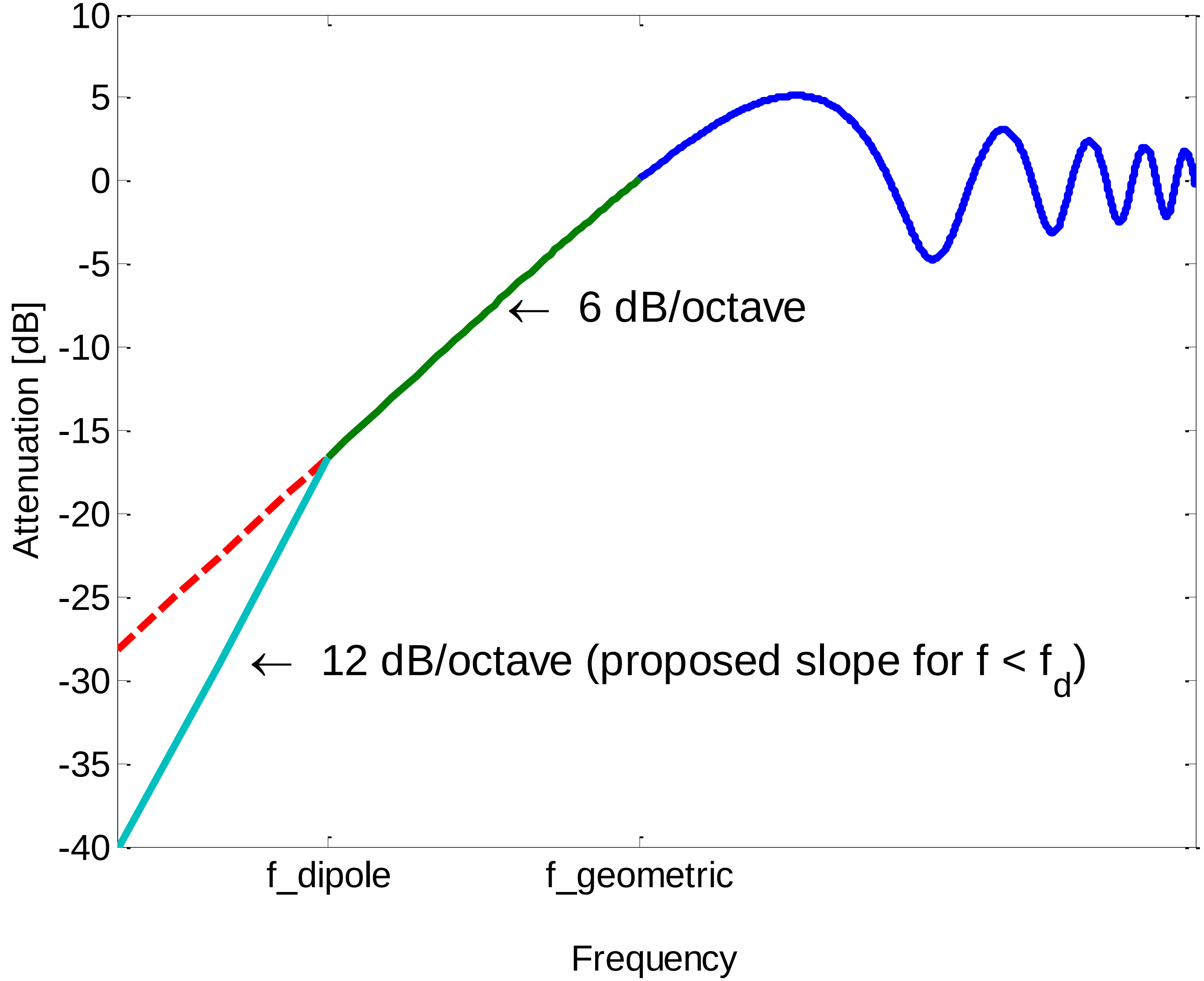
f_d varies inversely with dimension of square reflector

Dipole Limit Frequency

- Of the three parameters tested, f_d varies only with dimension of square reflector

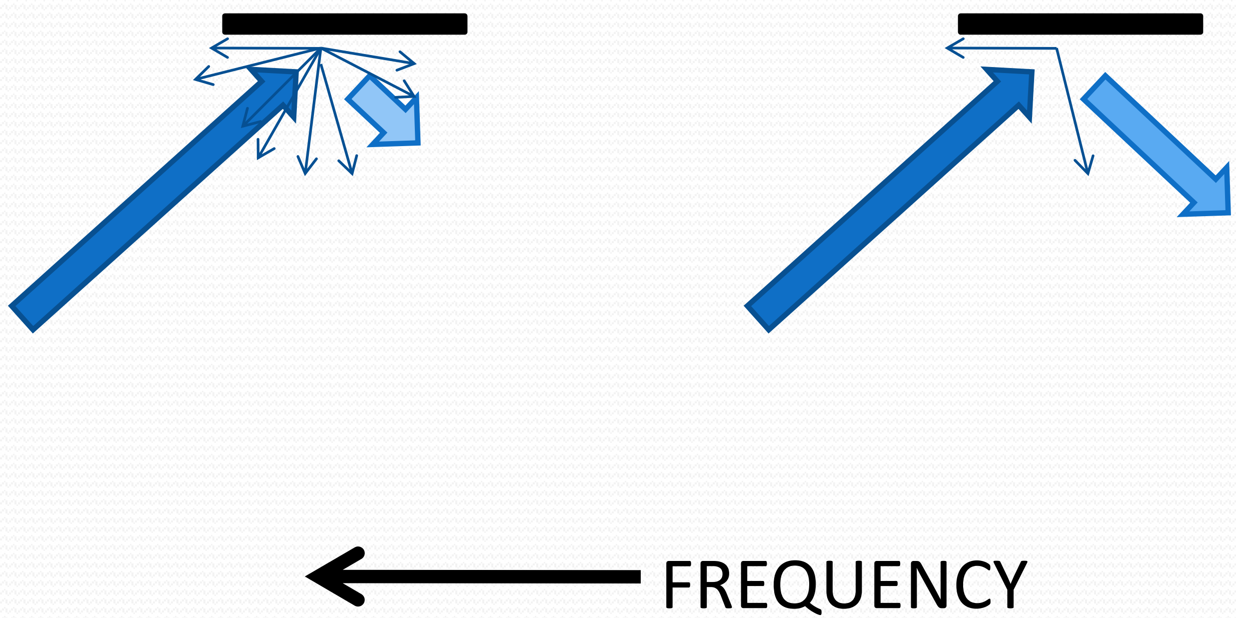
$$f_d = \frac{c}{2l}$$

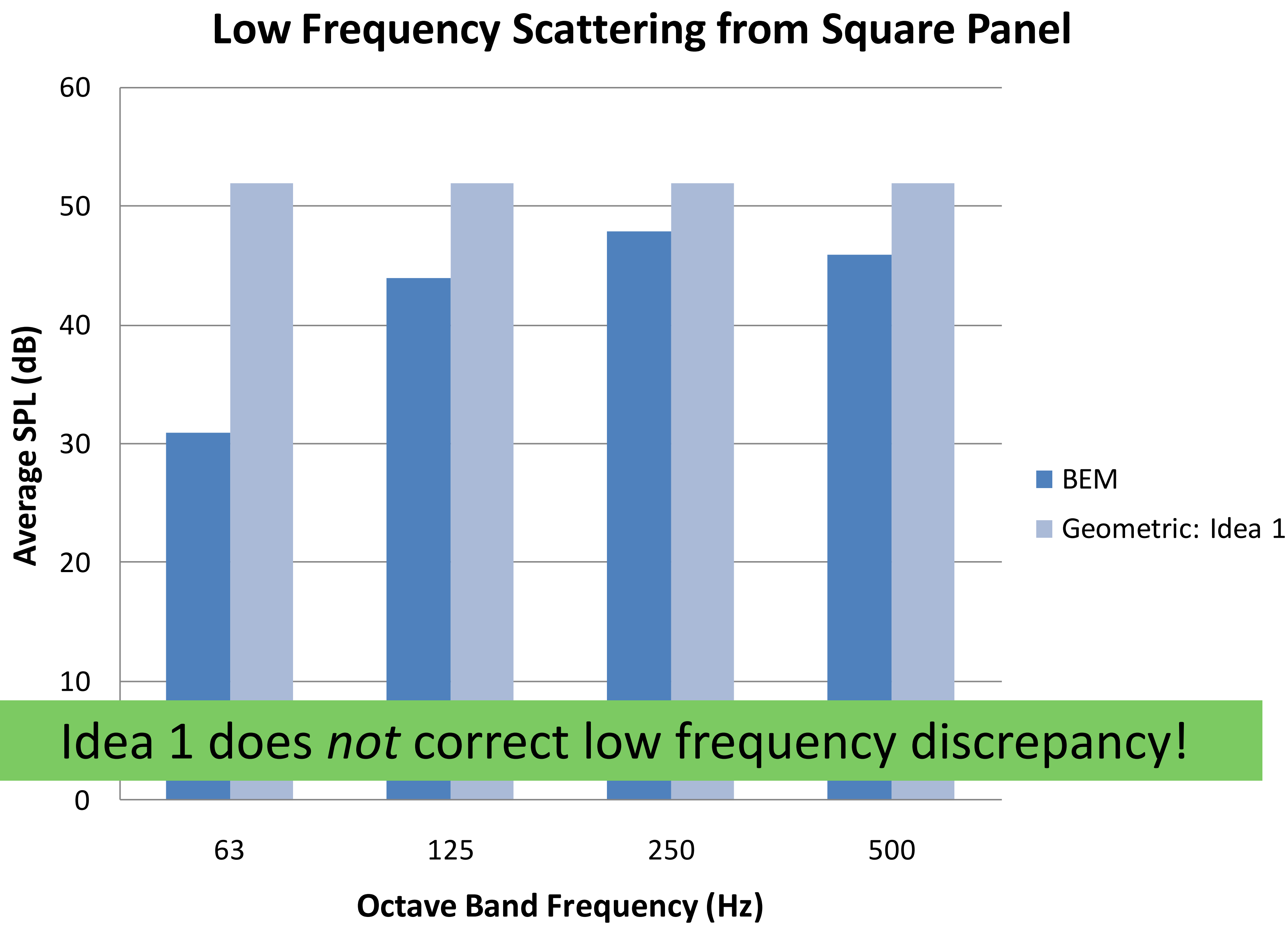
Updated Reflector Model



Applying Updated Reflector Model

- Idea 1: increase diffraction-based scattering coefficient in proportion with slope of radiation curve

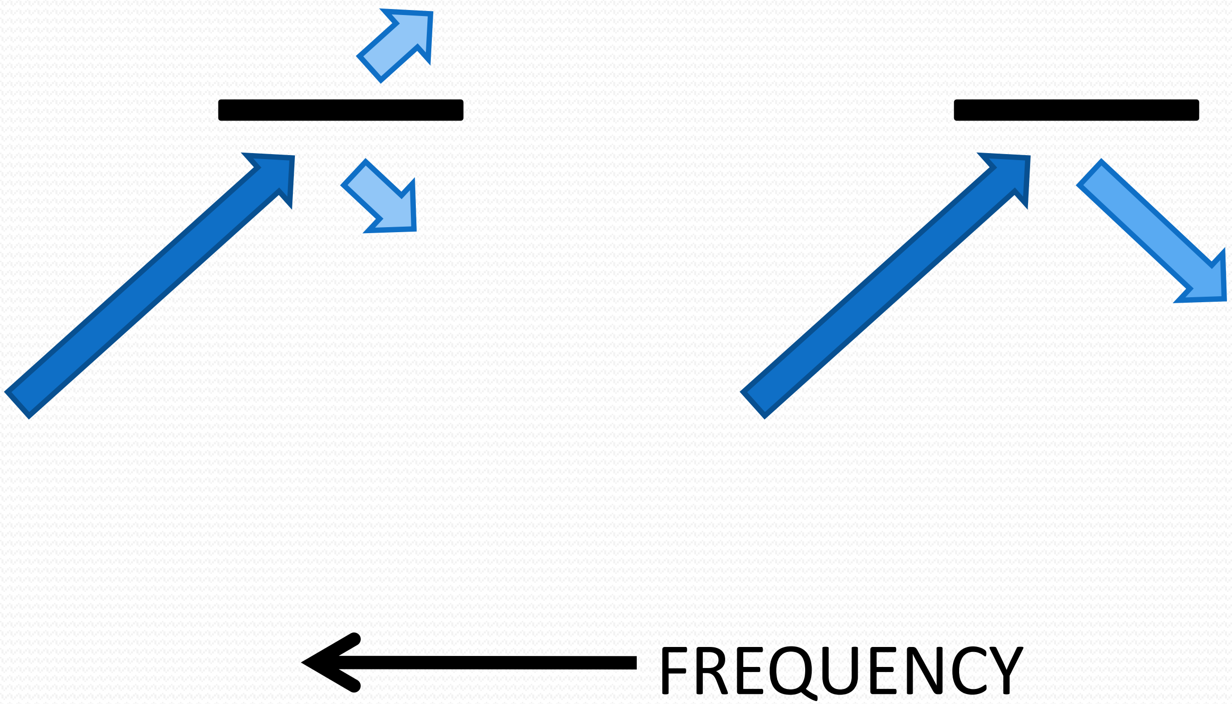


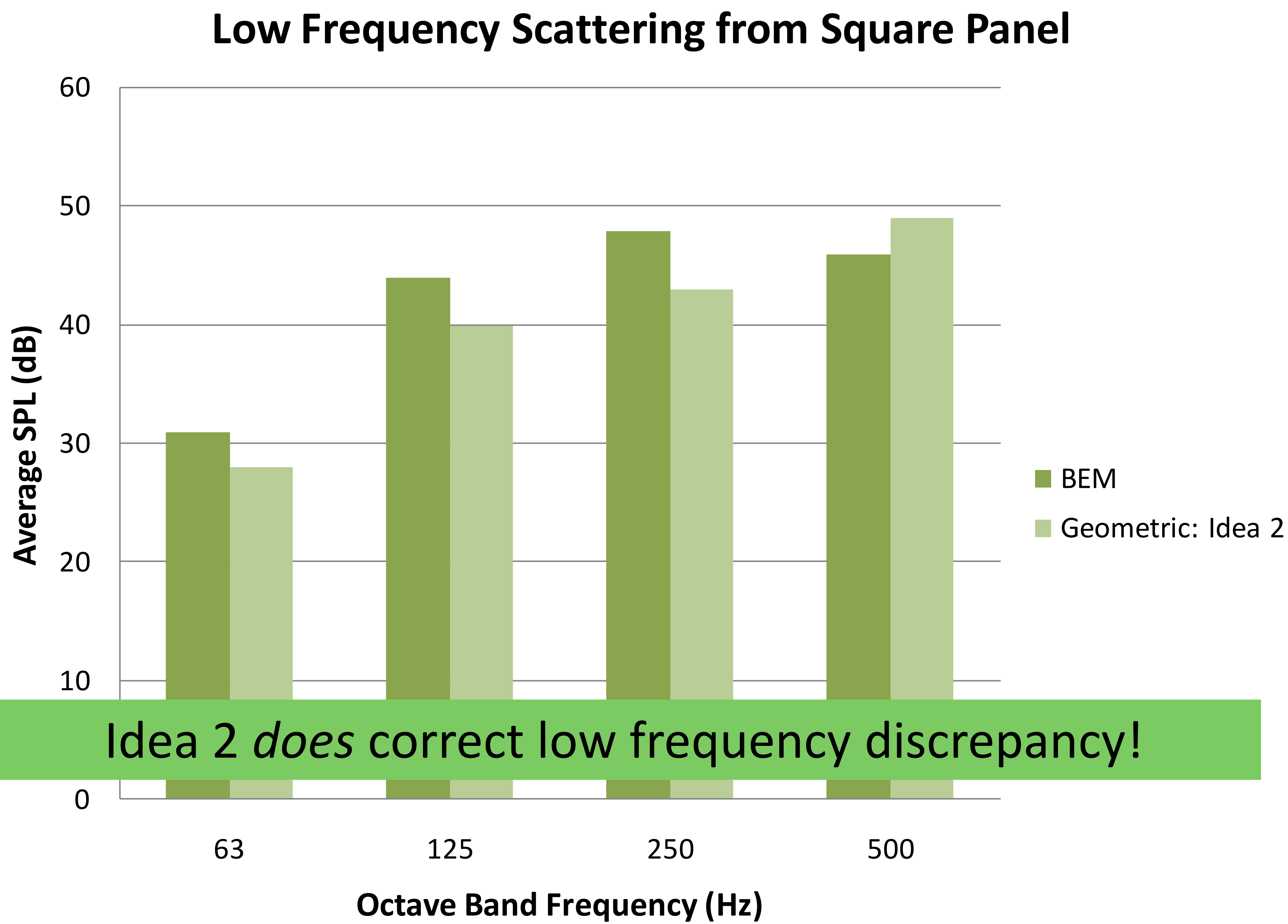


Idea 1 does *not* correct low frequency discrepancy!

Applying Updated Reflector Model

- Idea 2: increase transparency coefficient in proportion with slope of radiation curve





Idea 2 *does* correct low frequency discrepancy!

Conclusions

- What causes low frequency discrepancy between geometric prediction and BEM prediction?
  - Dipole Limit Frequency, f_d
  - Geometric handling of diffraction (including above f_d)

- Can geometric method be modified to correct low frequency predictions?
  - ~~Idea 1: Increase diffraction-based scattering~~
  - Idea 2: Increase transparency of finite panel

Further Work

- Classify behavior of f_d when panel is non-square
- Classify behavior of f_d for reflector arrays

Thank You

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•Work Supported by National Science Foundation

•Support for presentation of this paper has been provided through a grant from the Office of Naval Research (ONR)