Feed-forward/feed-backward mechanical amplification in the mouse cochlea

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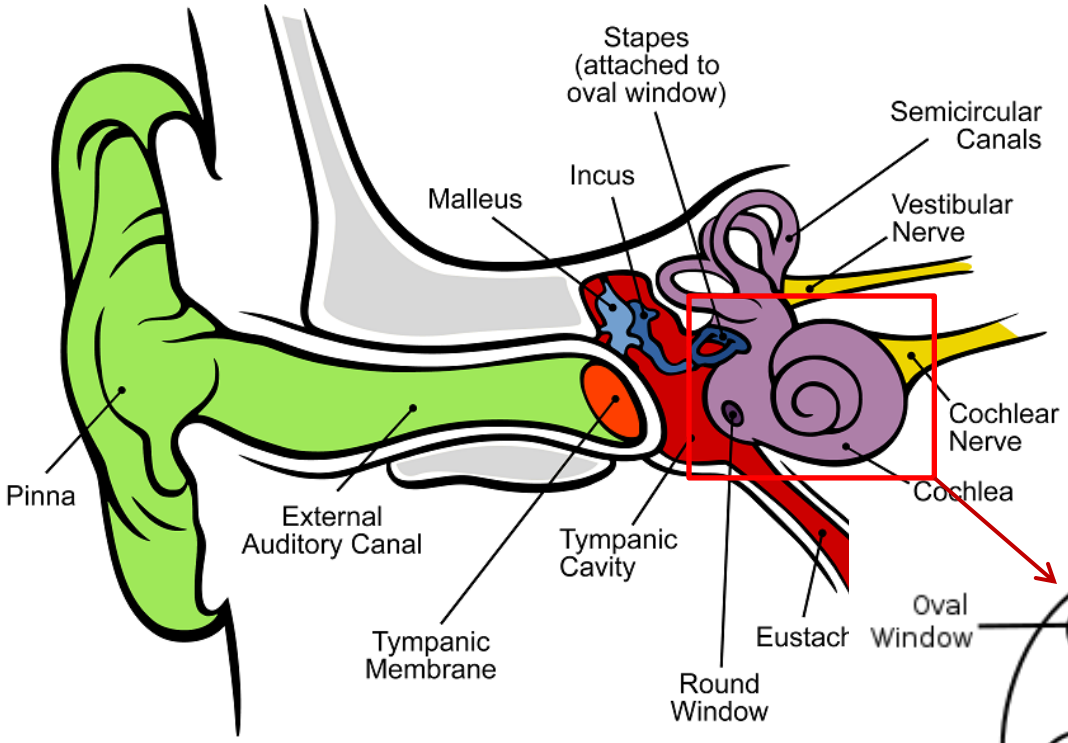
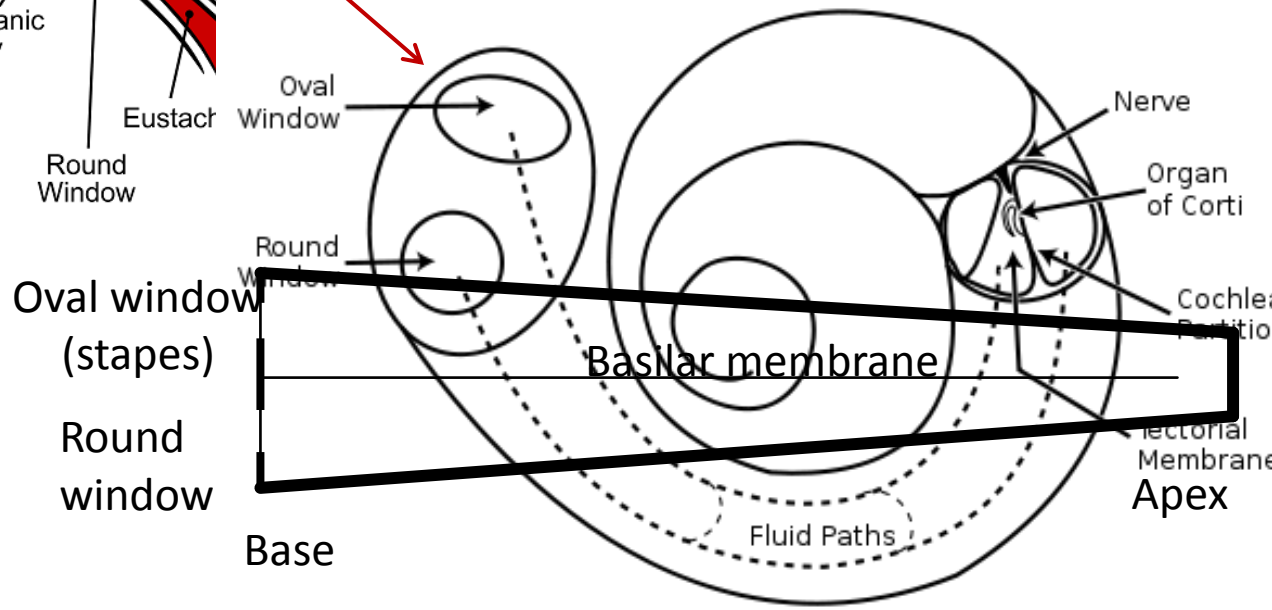
COMSOL CONFERENCE ROTTERDAM2013

University of Antwerp, Lab of biomedical physics

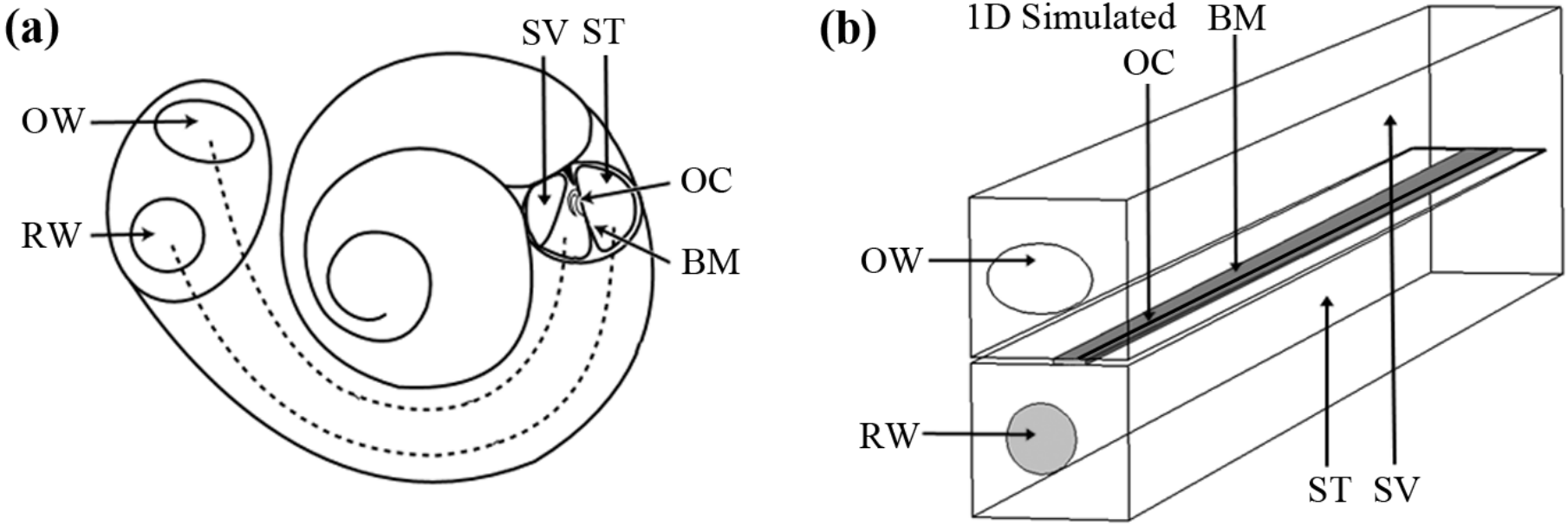
Stanford University, Mechanical Engineering

How do we hear?



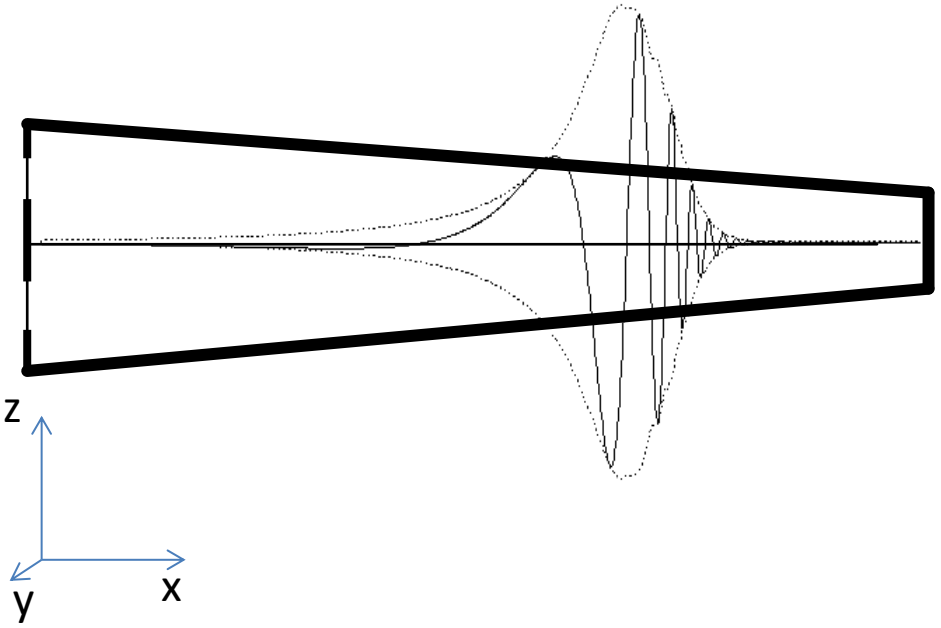


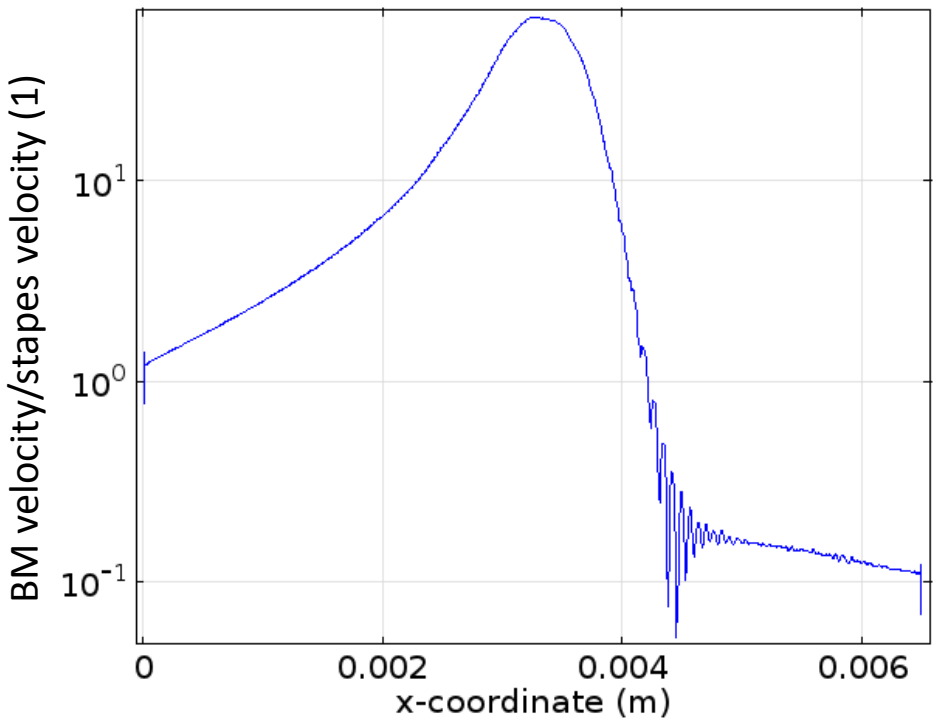
Comsol: Passive model

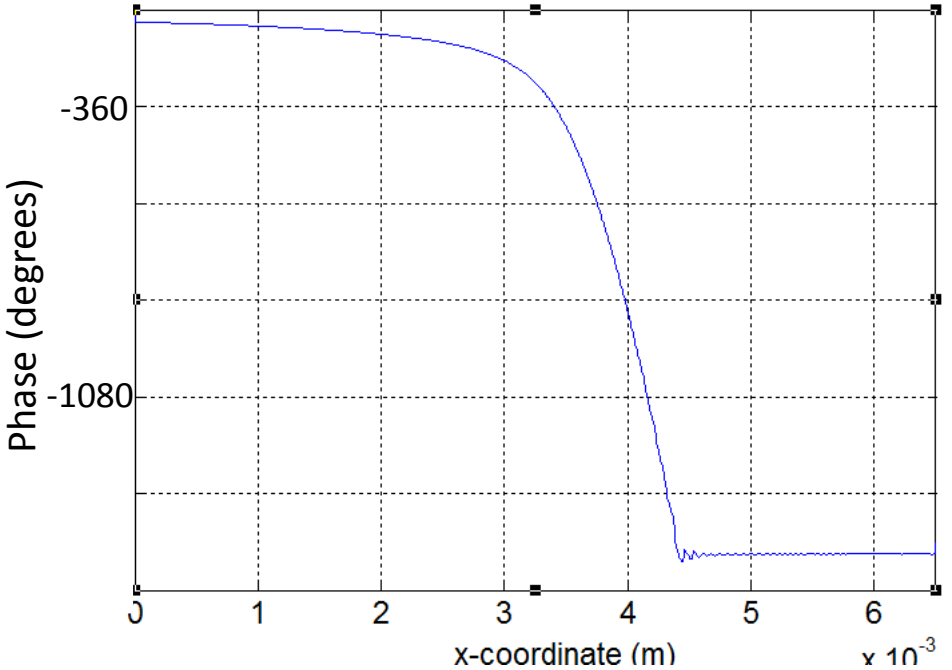


- frequency domain
- linearized Navier-stokes equations (ST,SV)
- structural orthotropic material (BM)

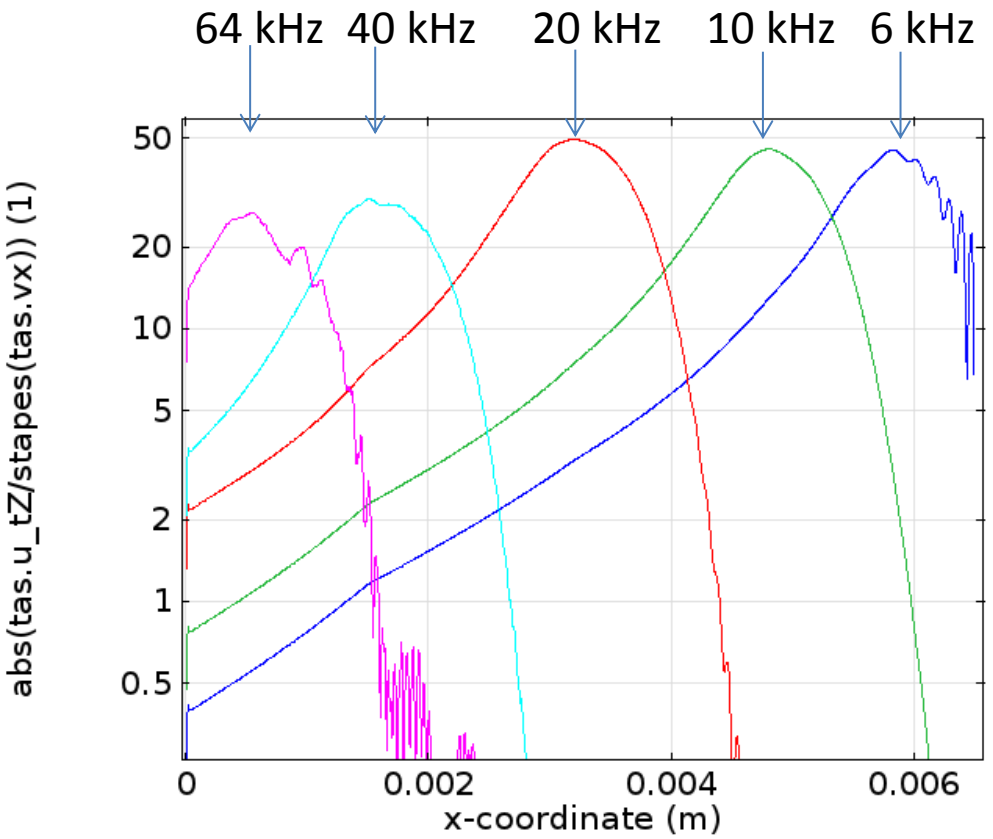
Passive results

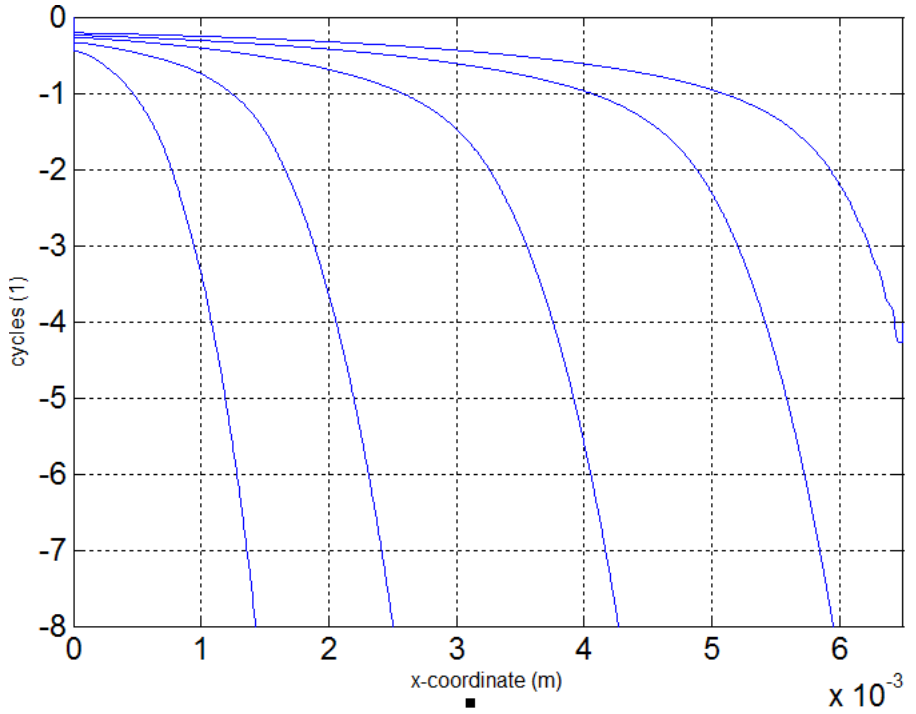




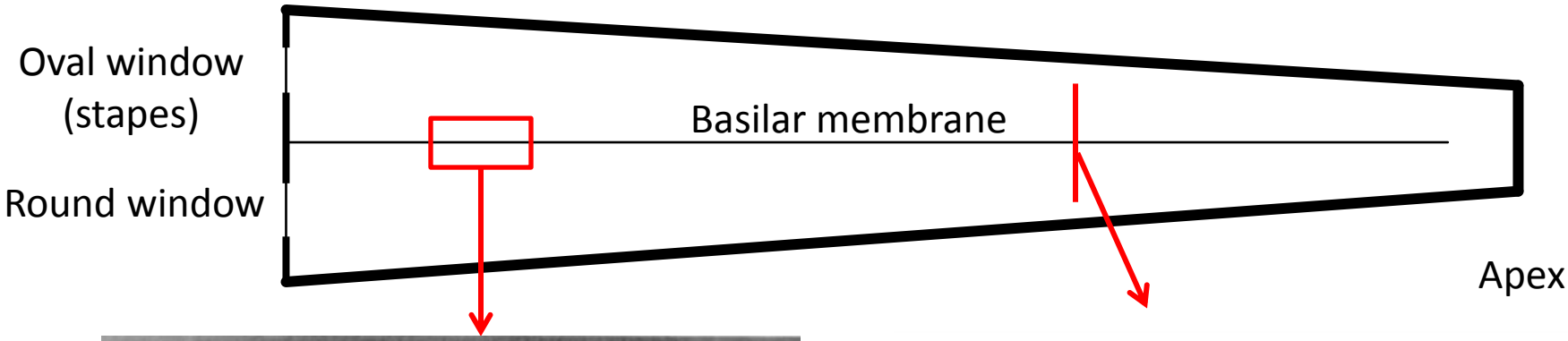


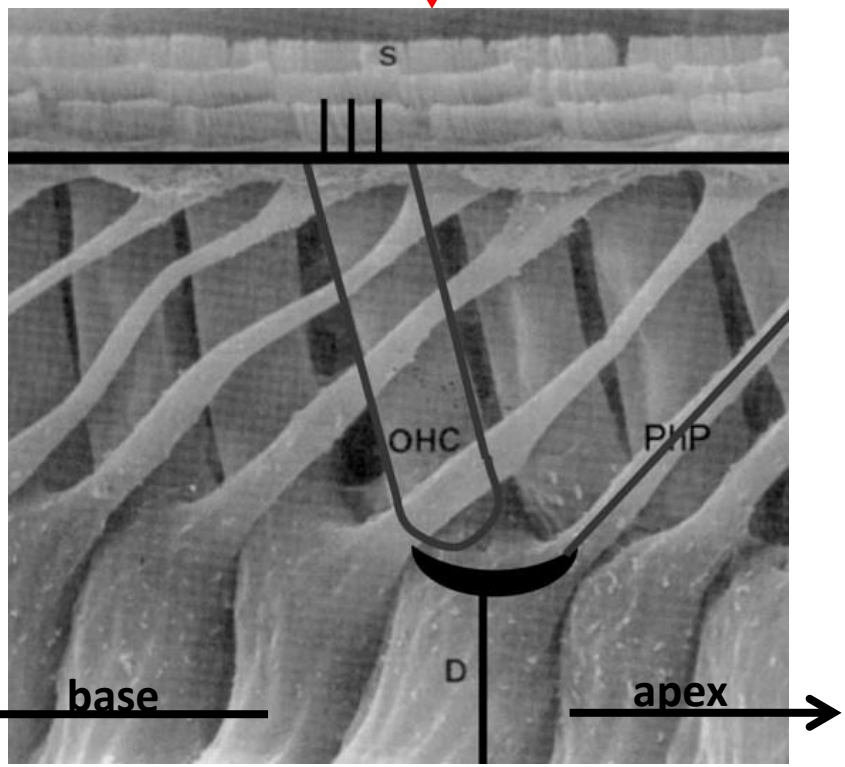
Different frequencies

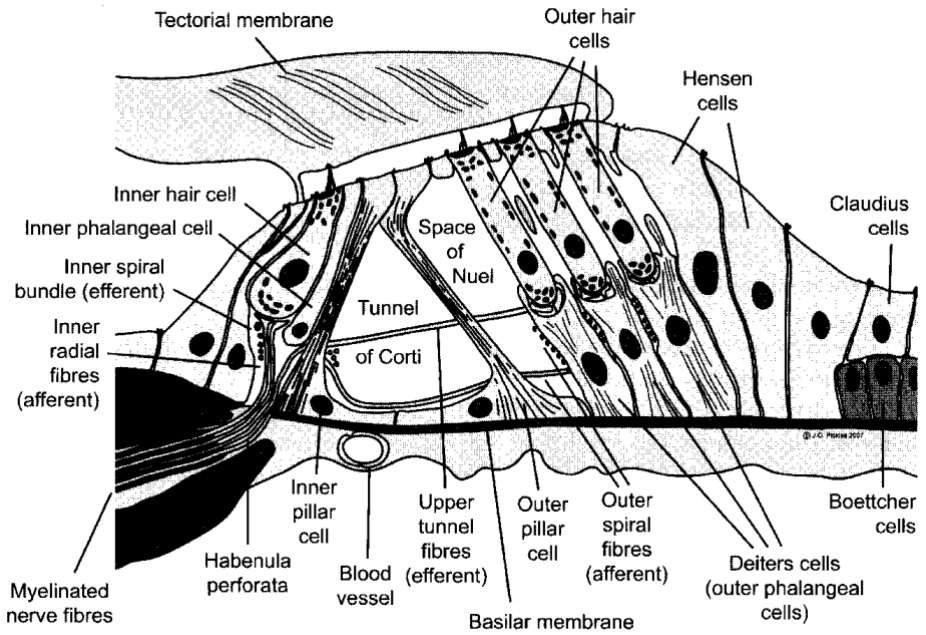




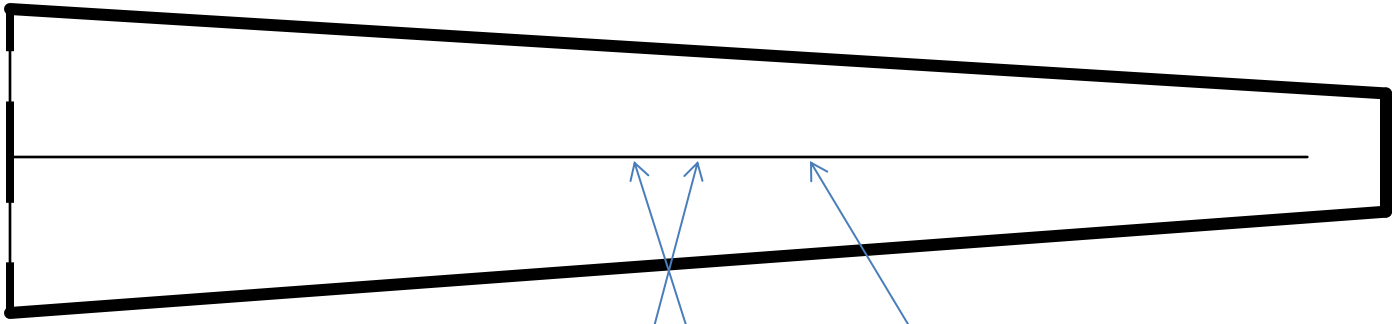
Active cochlea



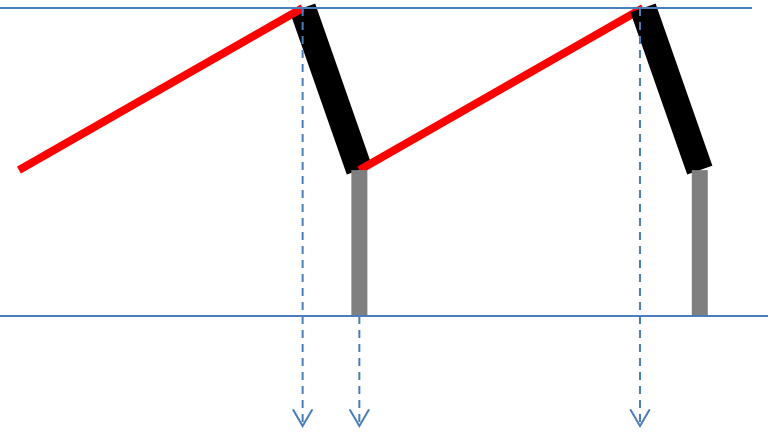




Active model: Feed-forward/feed-backward



$$F_{BM} = 2F^{f}_{BM} + F^{C}_{BM}.$$

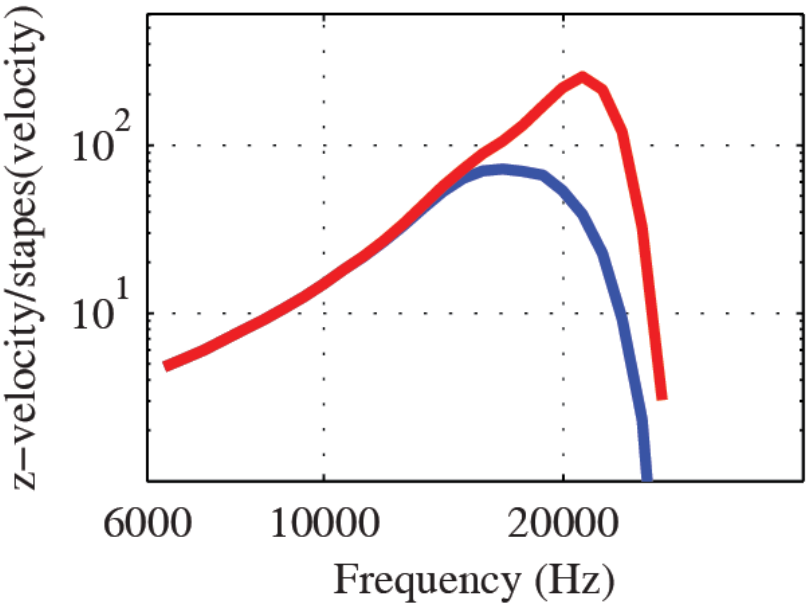


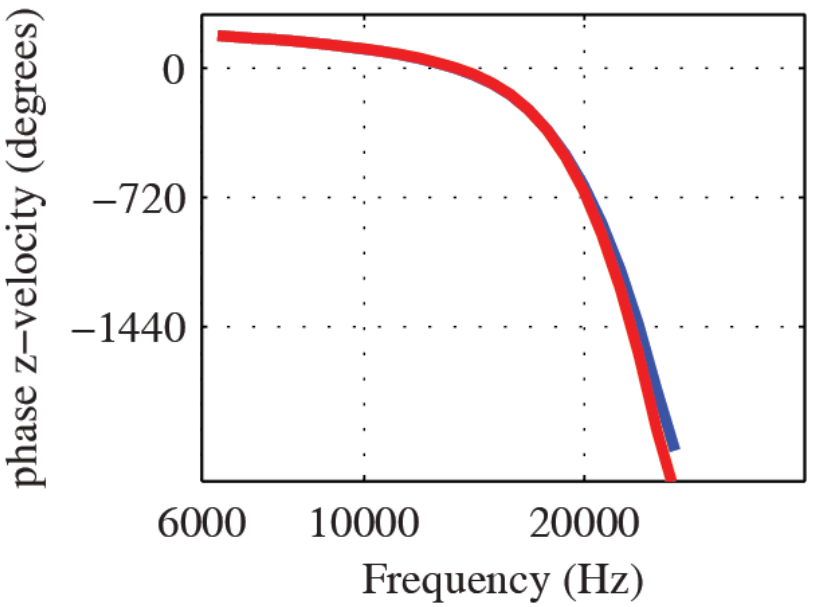
$$F^{C}_{BM}(x + \Delta x_1, t) = \alpha_1[F_{BM}(x,t)] - \alpha_2[F_{BM}(x + \Delta x_2, t)]$$

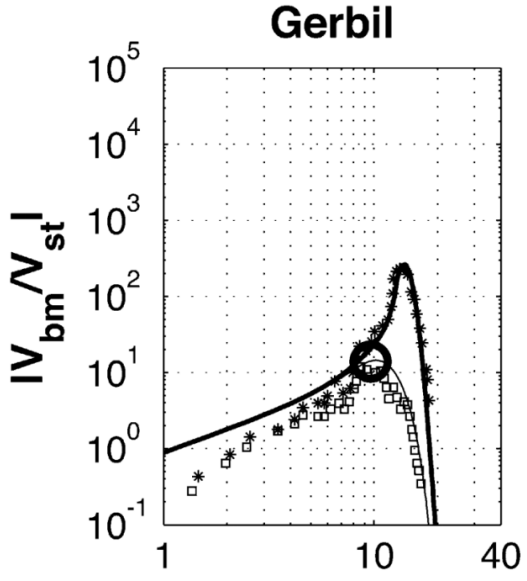
FF

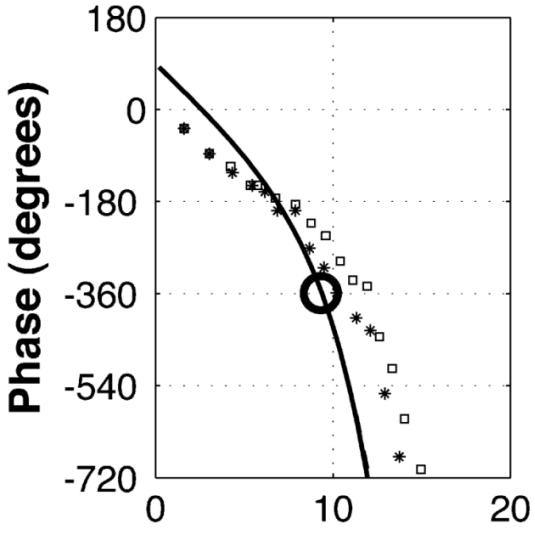
FB

Results: active cochlea

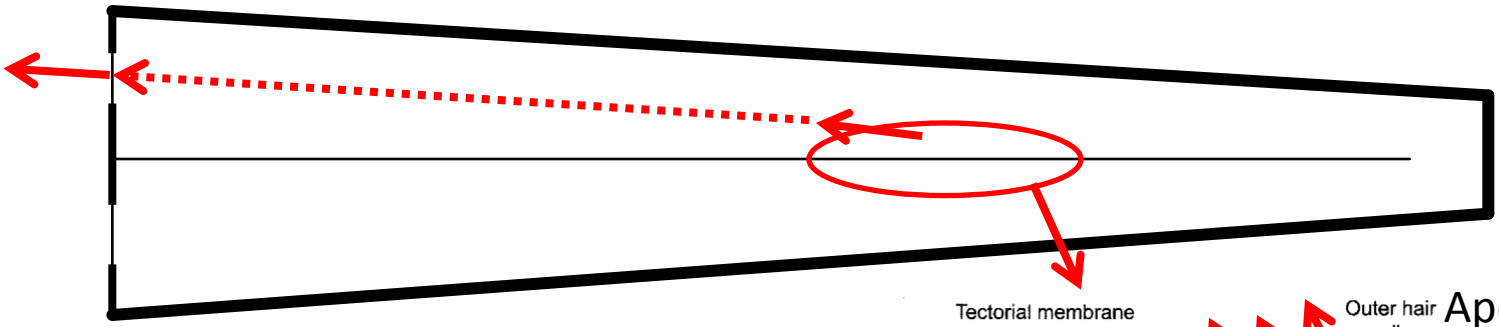




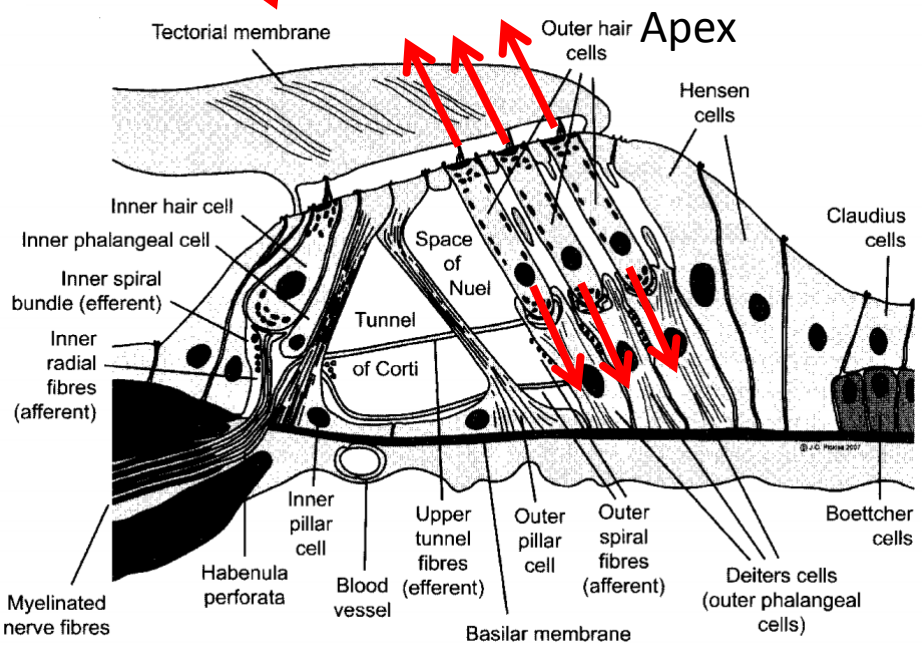




Oto-acoustic emisions

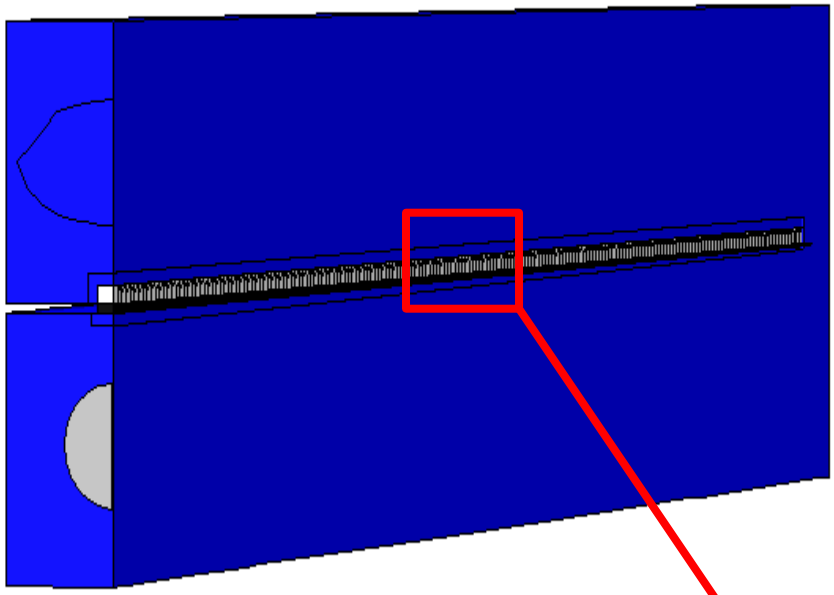


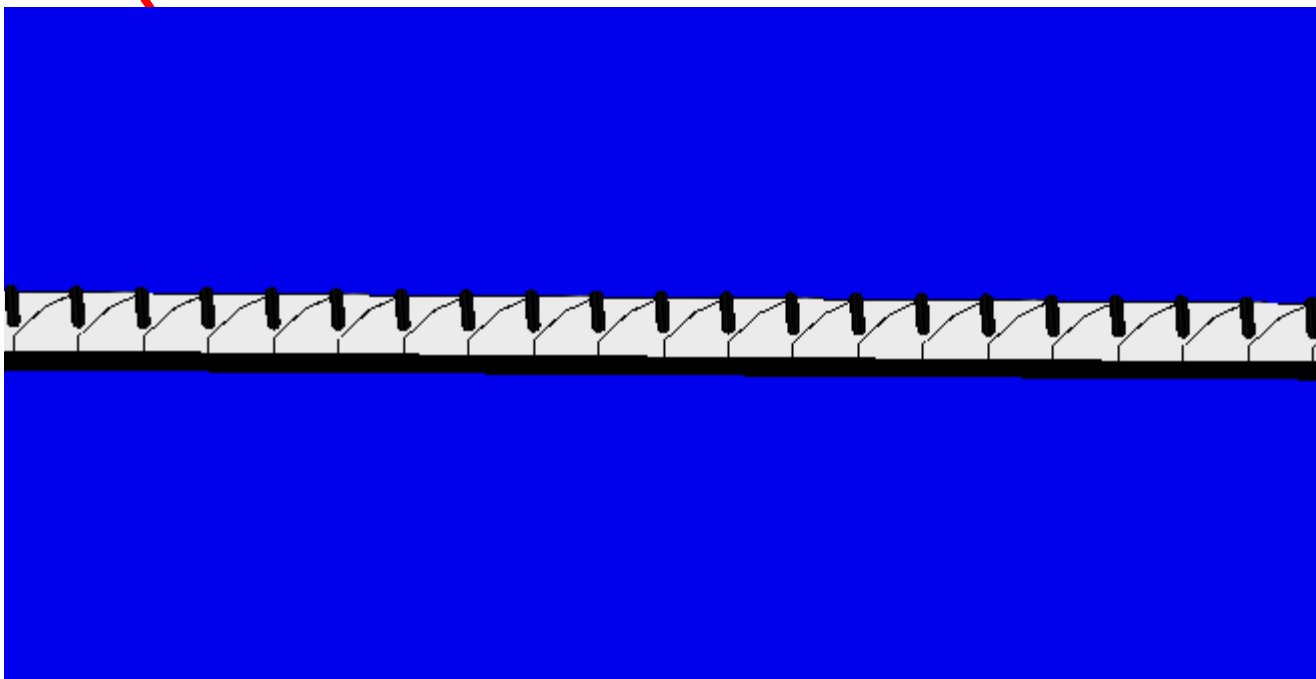
Base



Future Directions

1. Macroscopic ‘jelly’ Organ Corti
2. Microstructure: Beam elements (rods)

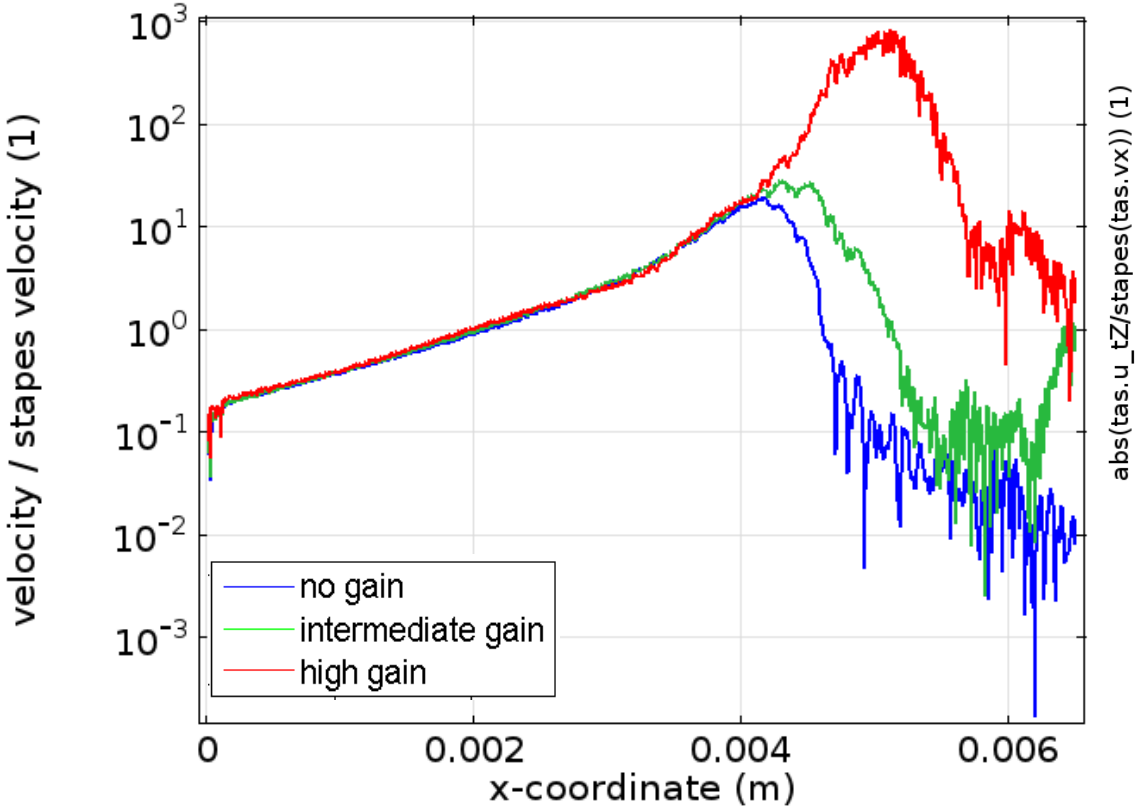




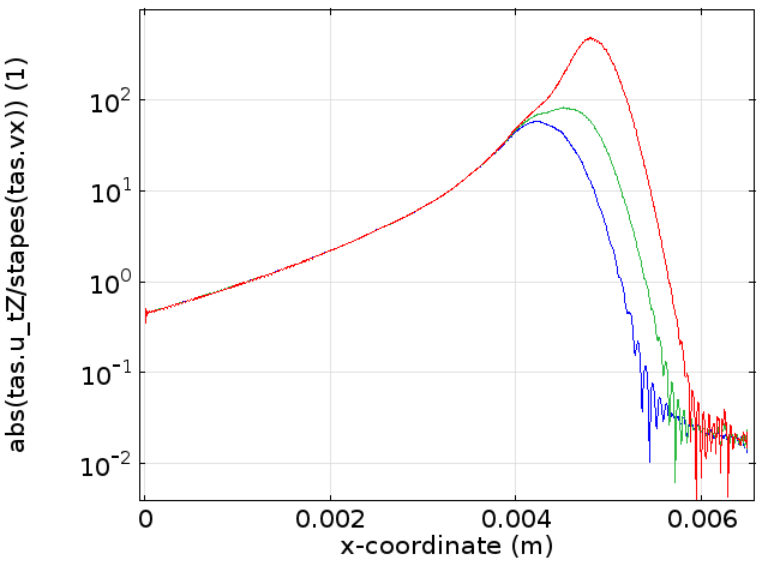
K_{OC}=2.2e9 Pa
G_{OC}=1e3 Pa

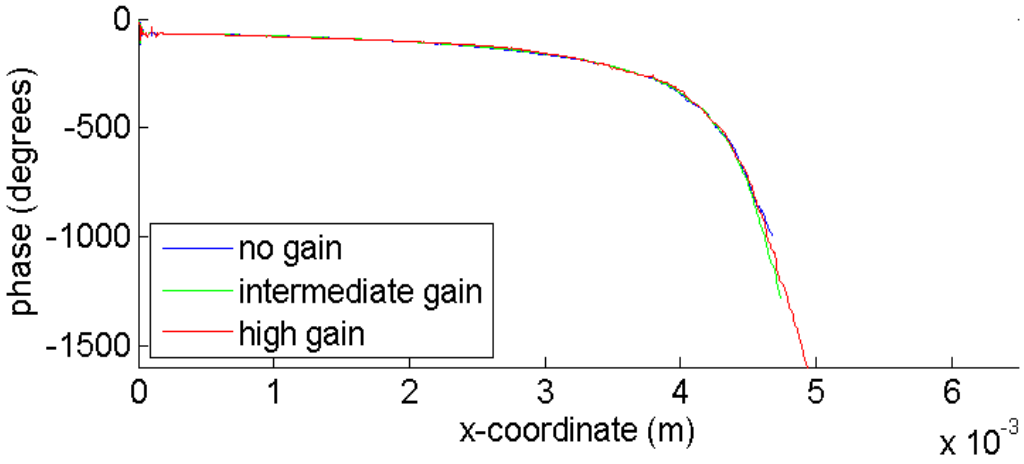
Density rods = 1000 kg/m^3
d_{HC}=7e-6m
d_{PP}=1e-6m
d_{DC}=1e-6m
E_{HC}=1e9 Pa
E_{PP}=E_{DC}=1e6 Pa

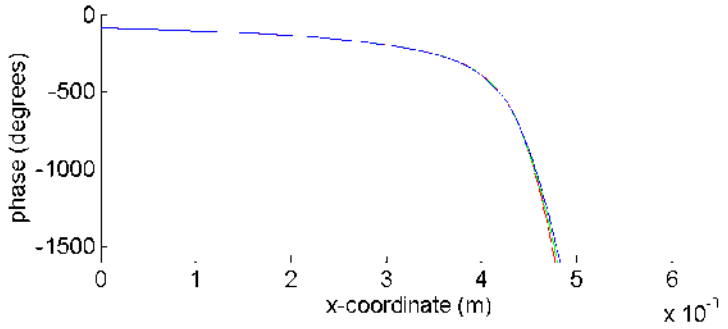
Full model



Algebraic

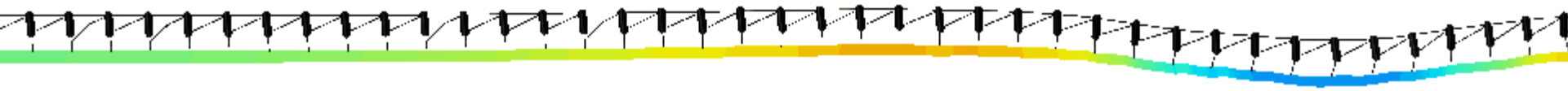






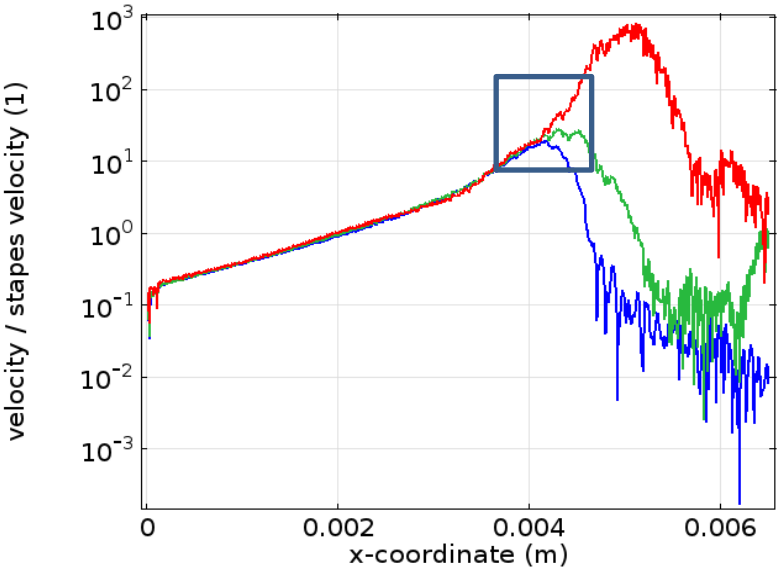

z-displacement (nm)
10
8
6
4
2
0
-2
-4
-6
-8
-10

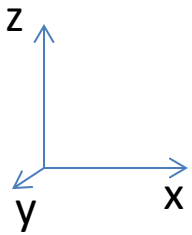
Passive



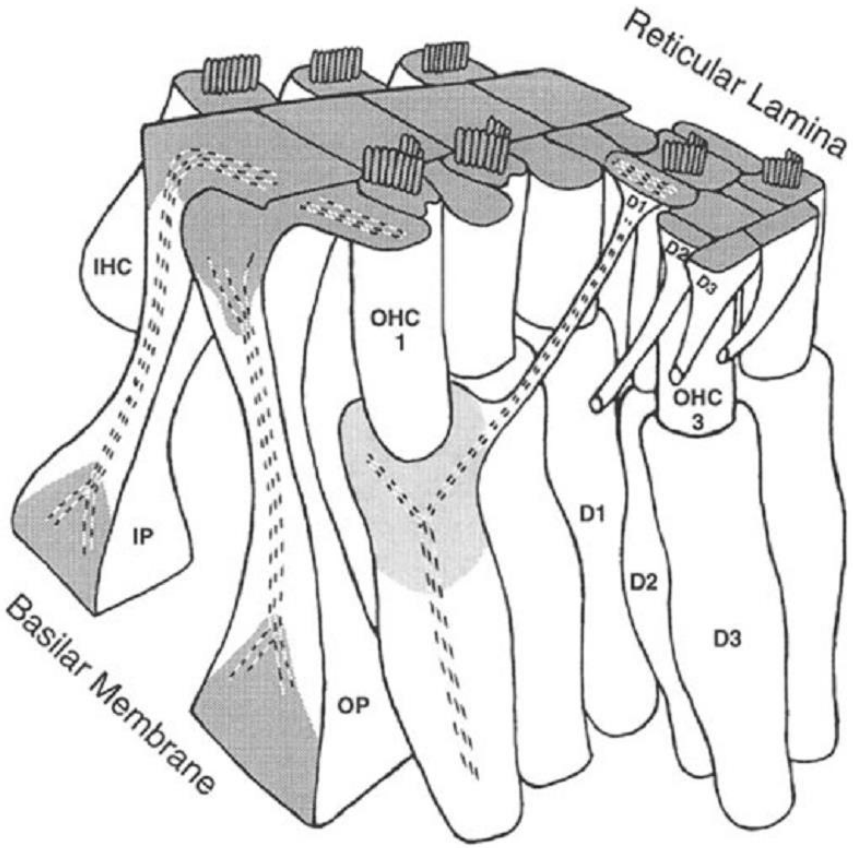

base

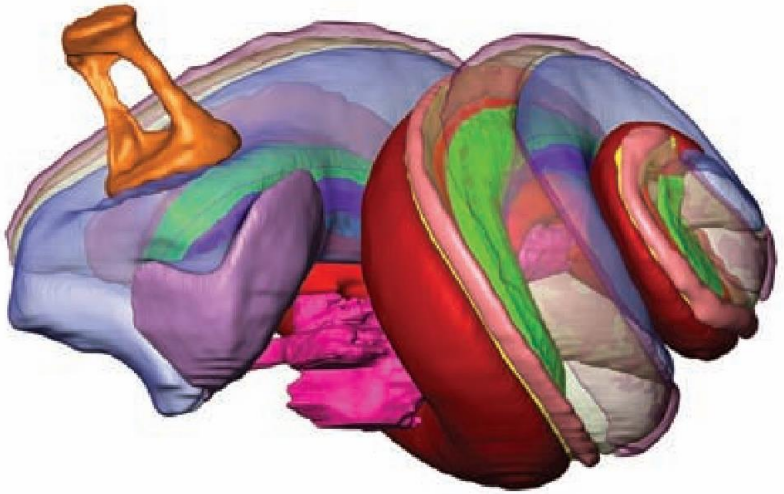

apex


velocity / stapes velocity (1)
10^3
10^2
10^1
10^0
10^{-1}
10^{-2}
10^{-3}
0
0.002
0.004
0.006
x-coordinate (m)


z
y
x

Towards full 3D





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