Exterior Acoustic Modeling for Gerbils

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Introduction

My main interest has been the computational modeling of aeroacoustic and acoustic phenomona.

Low-order when possible.

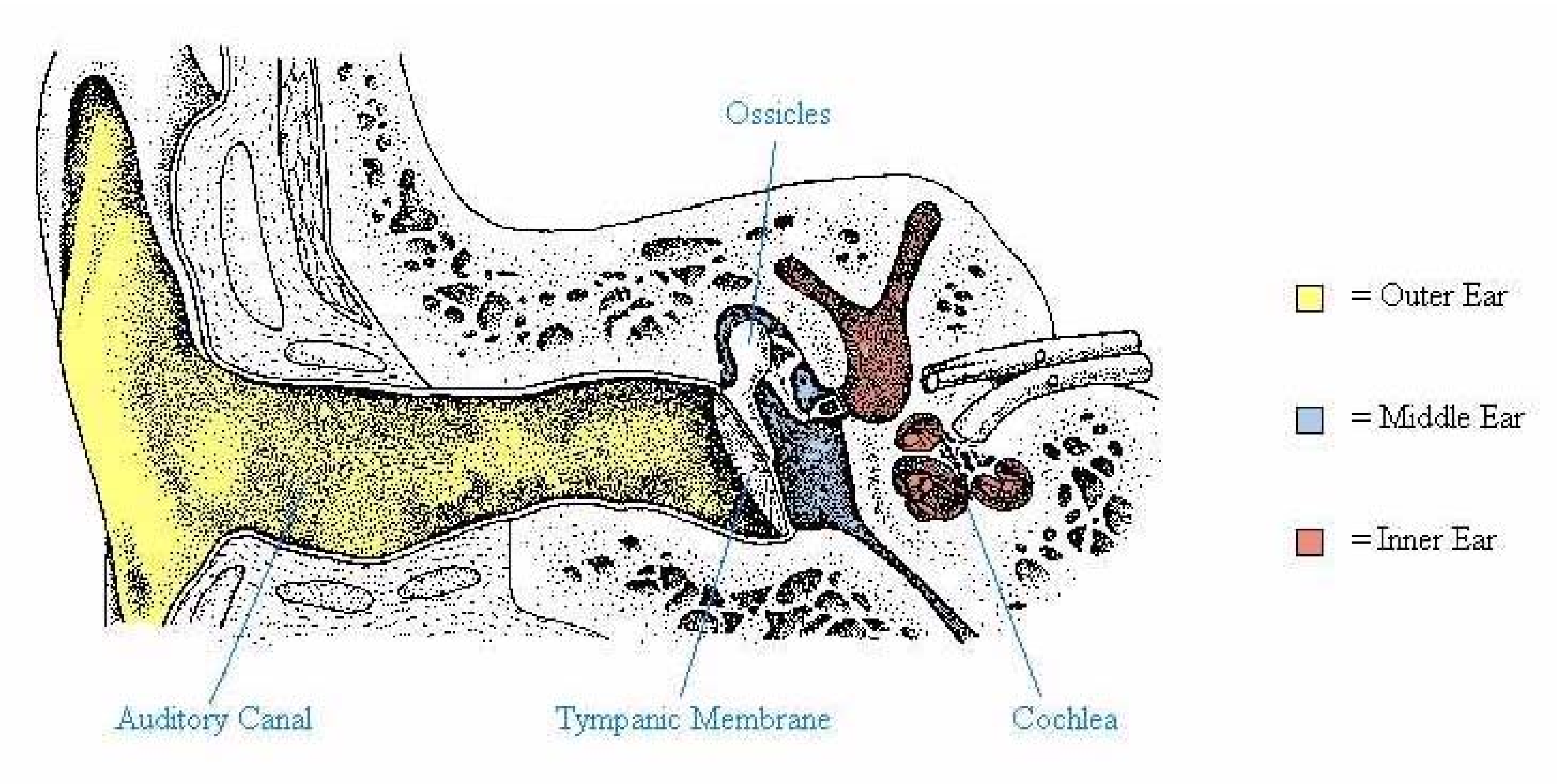
Found a fun new avenue for using some of the computational tools we built for other applications.

Change gears

www.princeton.edu/~jzana

Motivation

Bio-engineers at BU are trying to understand better the neurology associated with hearing



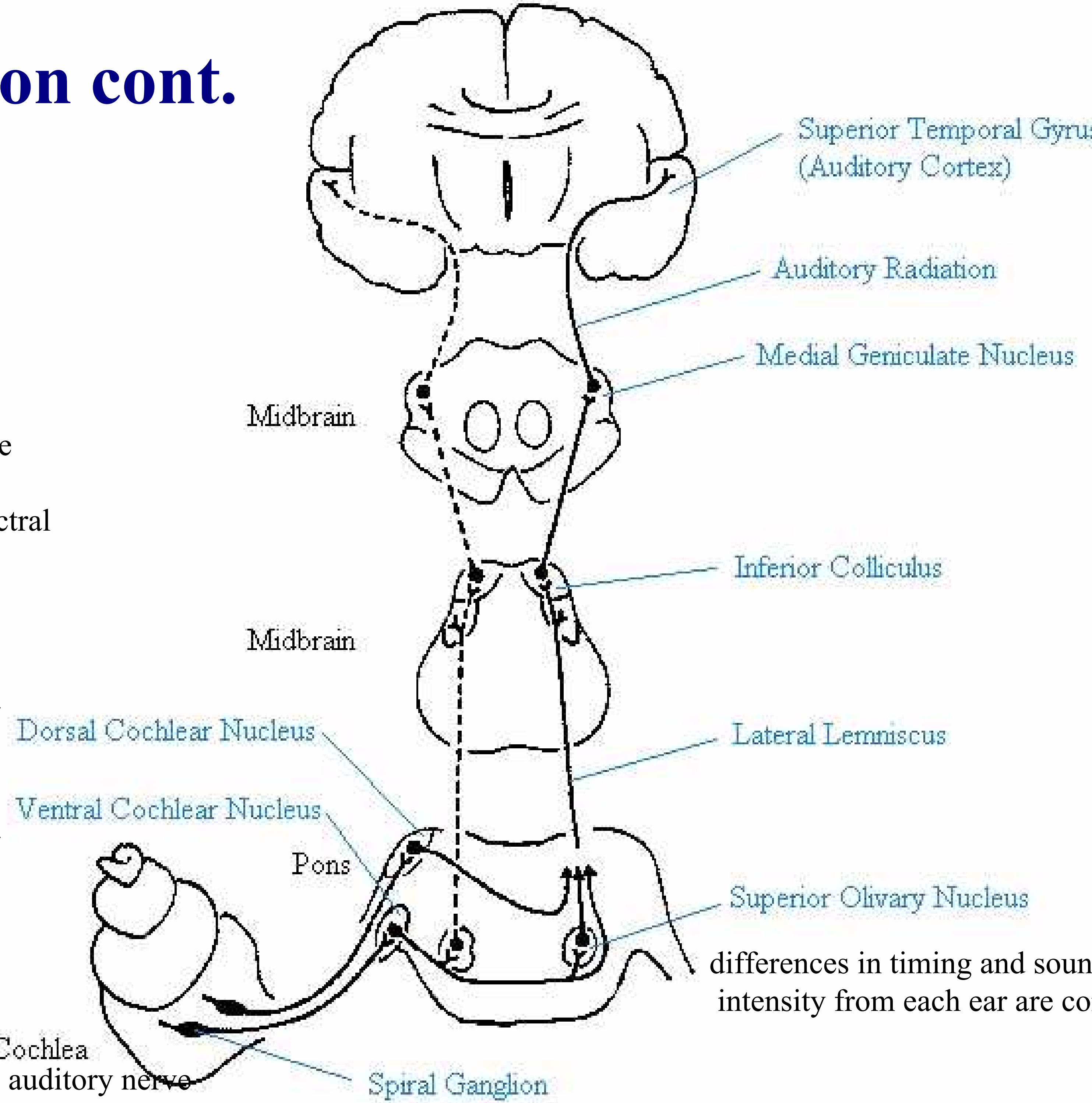
http://137.222.110.150/calnet/Aud/page2.htm, University of Bristol

Motivation cont.

VCN: fibers keep the timing of the signals

DCN: fibers interpret the quality of the sound;
--Fusiform cells are spectral notch detectors

synapses in either



differences in timing and sound intensity from each ear are compared

Auditory info leaves cochlea of the ear via the auditory nerve

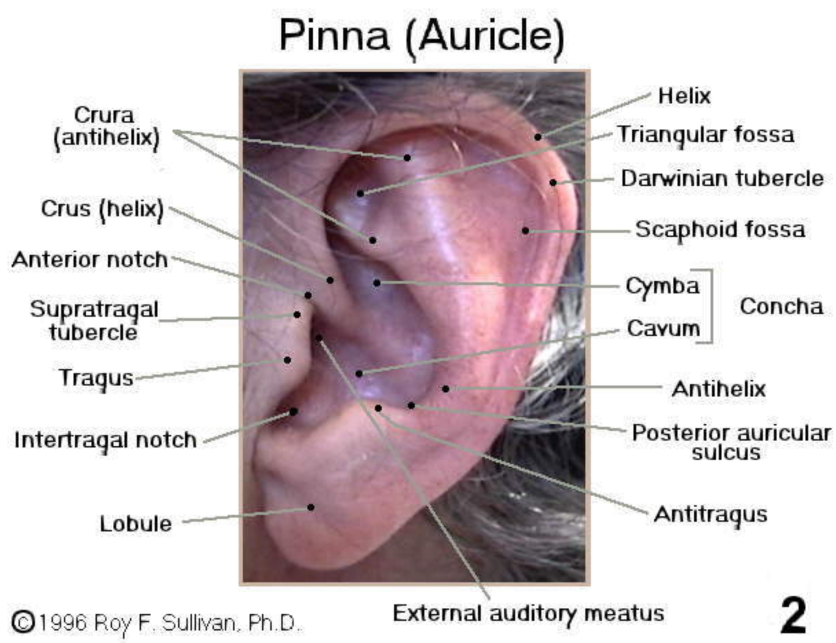
http://137.222.110.150/calnet/Aud/page2.htm, University of Bristol

Motivation cont.

In the median plane, no interaural time or intensity cues are available

Humans and other animals use pinna to help filter the sound and locate the source

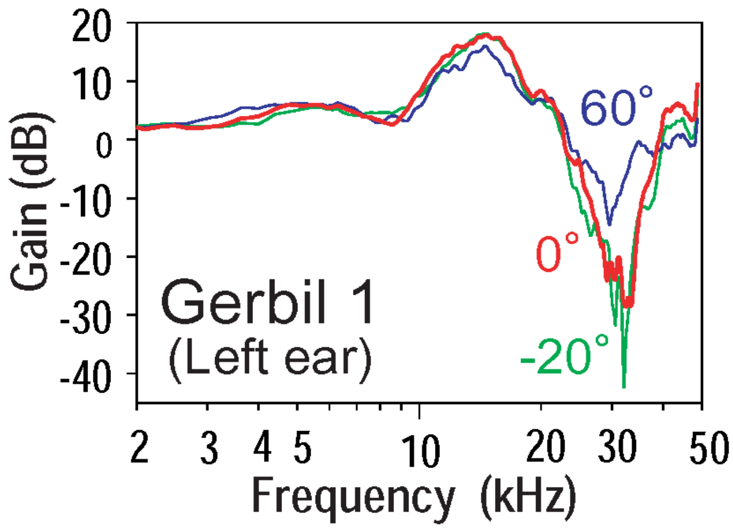
- pinna creates a spectral filter, notches (dependent on elevation)
- head related transfer function (HRTF)
- neurons in the dorsal cochlear nucleus (DCN) have been shown to act as spectral notch detectors



http://www.rcsullivan.com/www/pinna.htm

Gerbil HRTF

- Mongolian Gerbil's HRTF has a notch in the ultrasonic range (30kHz)

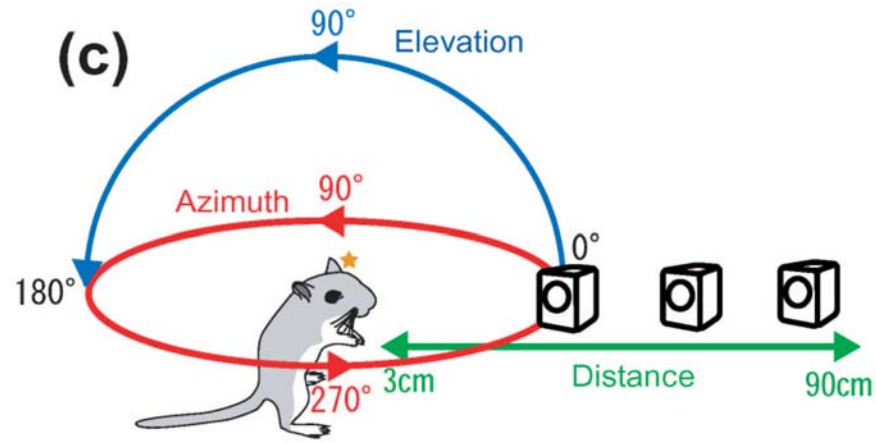


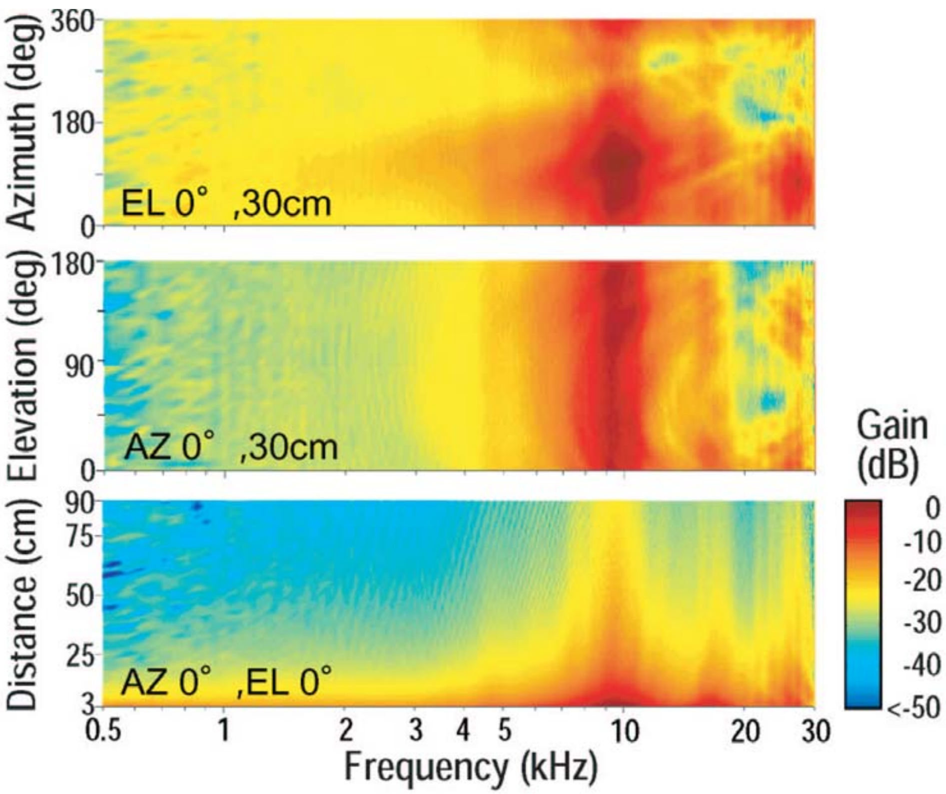
- Gerbil DCN units have been shown to have best frequency sensitivity at 5kHz though

What is going on?

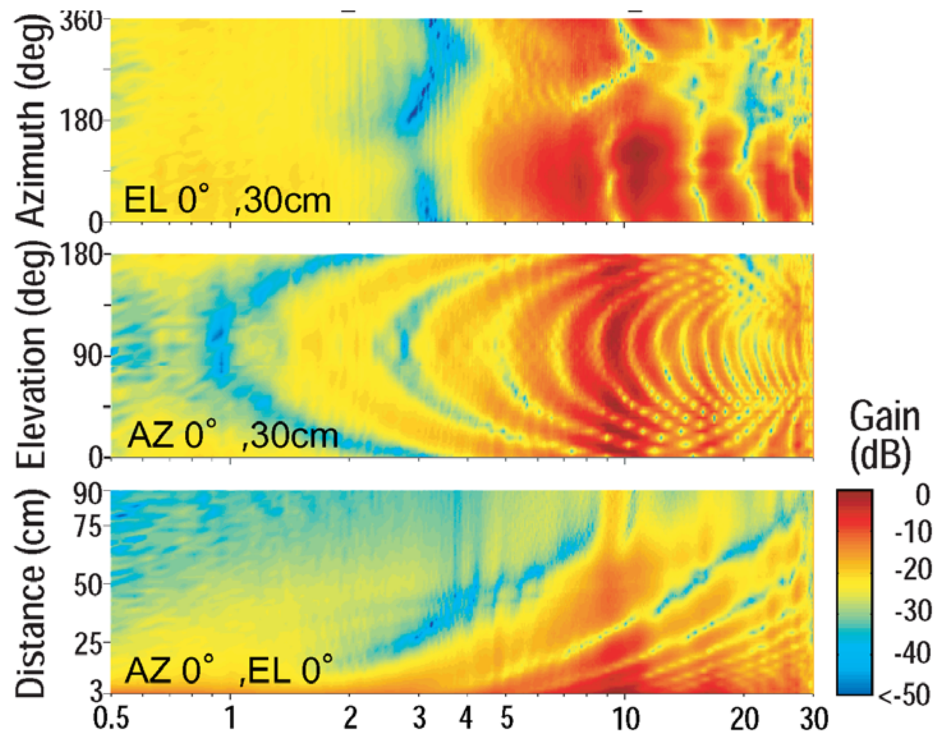
Measurement of Gerbil HRTF

Maki et. al. NTT Communication Science Lab,
Kanagawa, Japan





HRTF for Gerbil in free-space



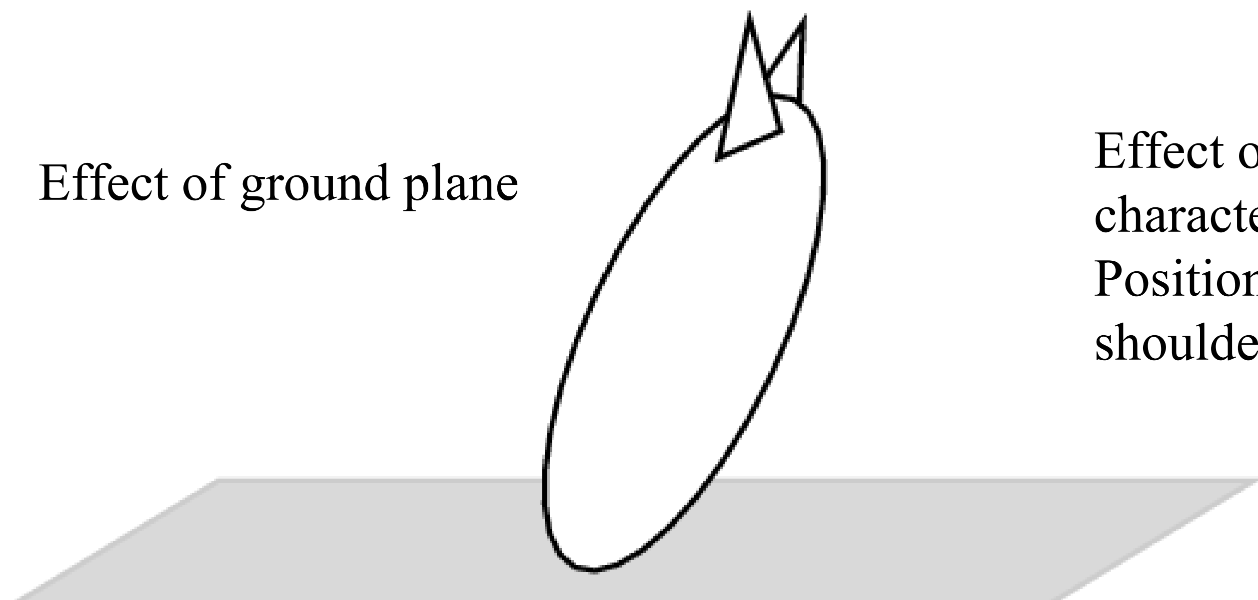
HRTF for Gerbil on floor

Our Approach

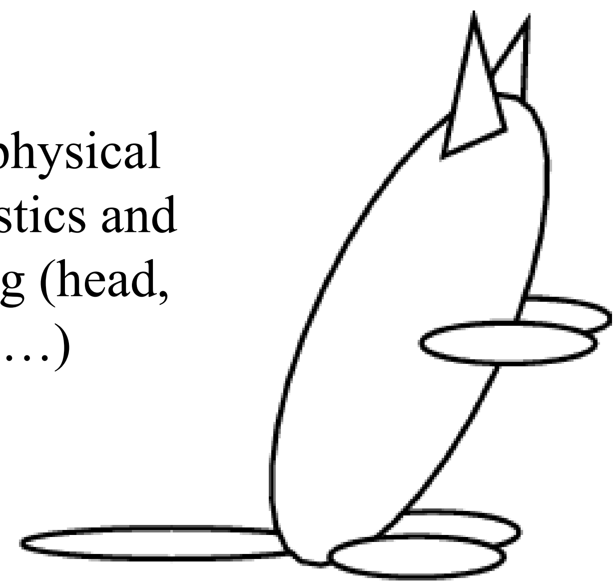
- Compute **HRTFs** for simplified Gerbil models in real environments

- Use BEM
  - quiescent field
  - simple acoustic scattering, analytic source
  - frequency domain (ka = 2,000 --> 30,000kHz)

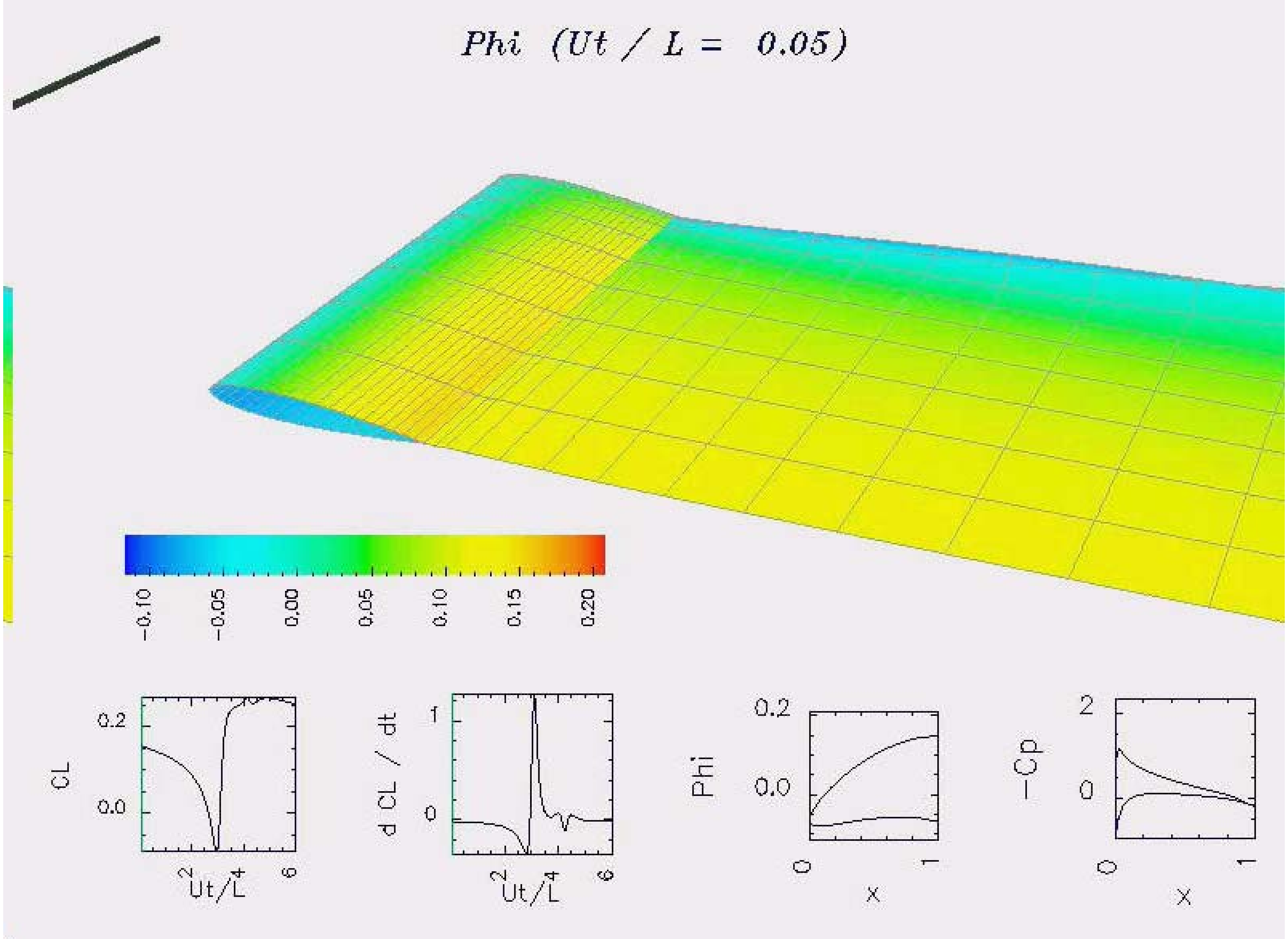
Effect of ground plane



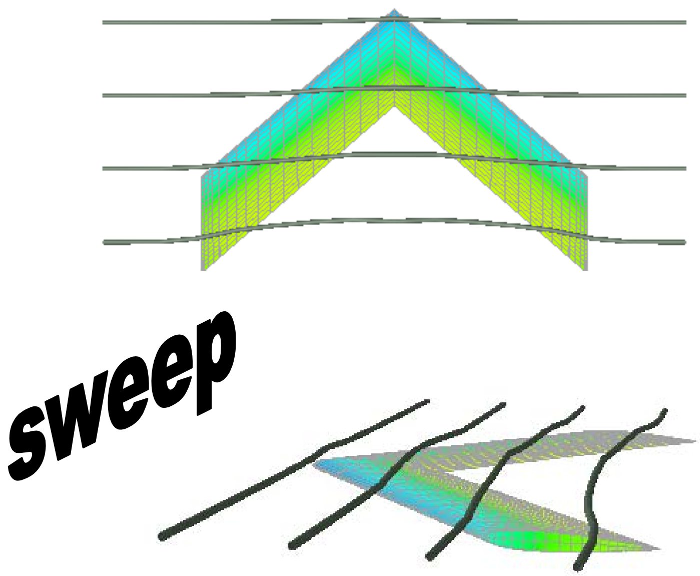
Effect of physical characteristics and Positioning (head, shoulders,…)



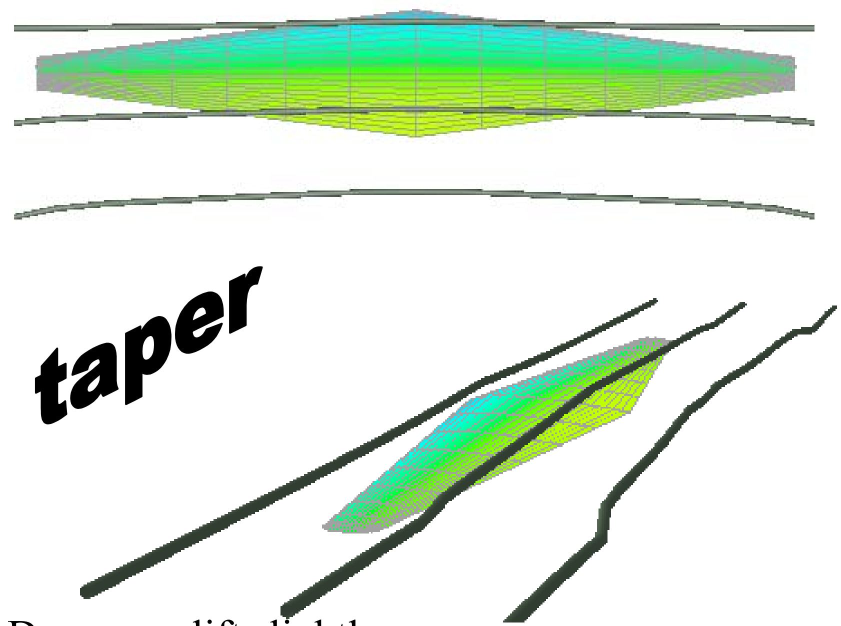
BVI simulation



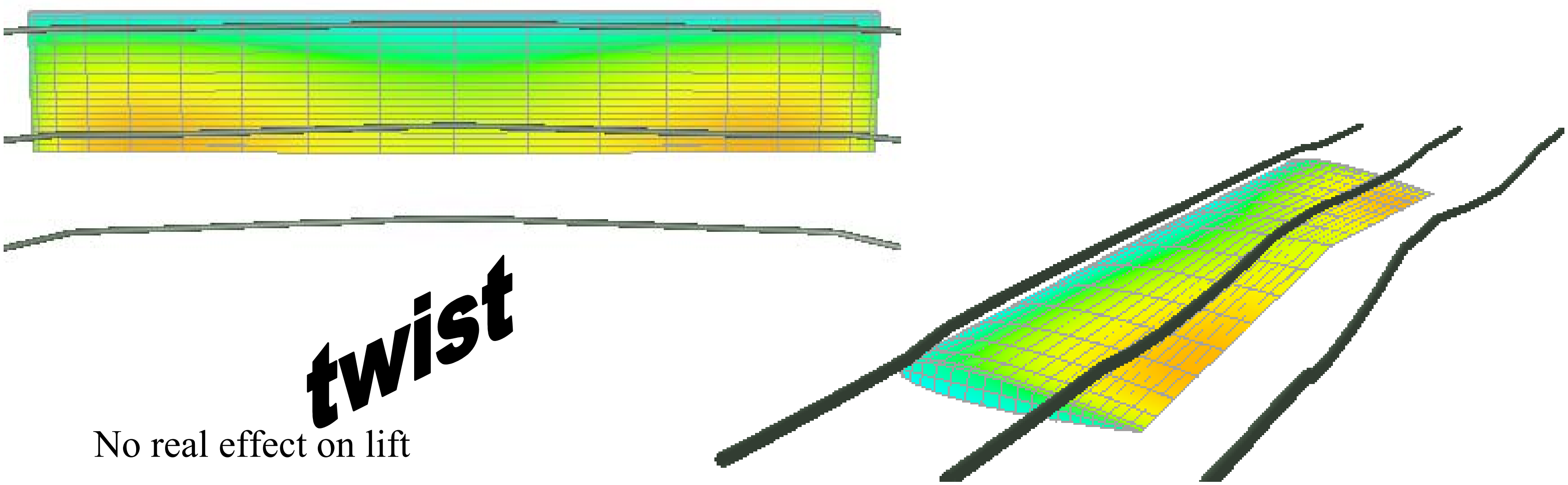
Fixed wing fun …



Decreases unsteady lift

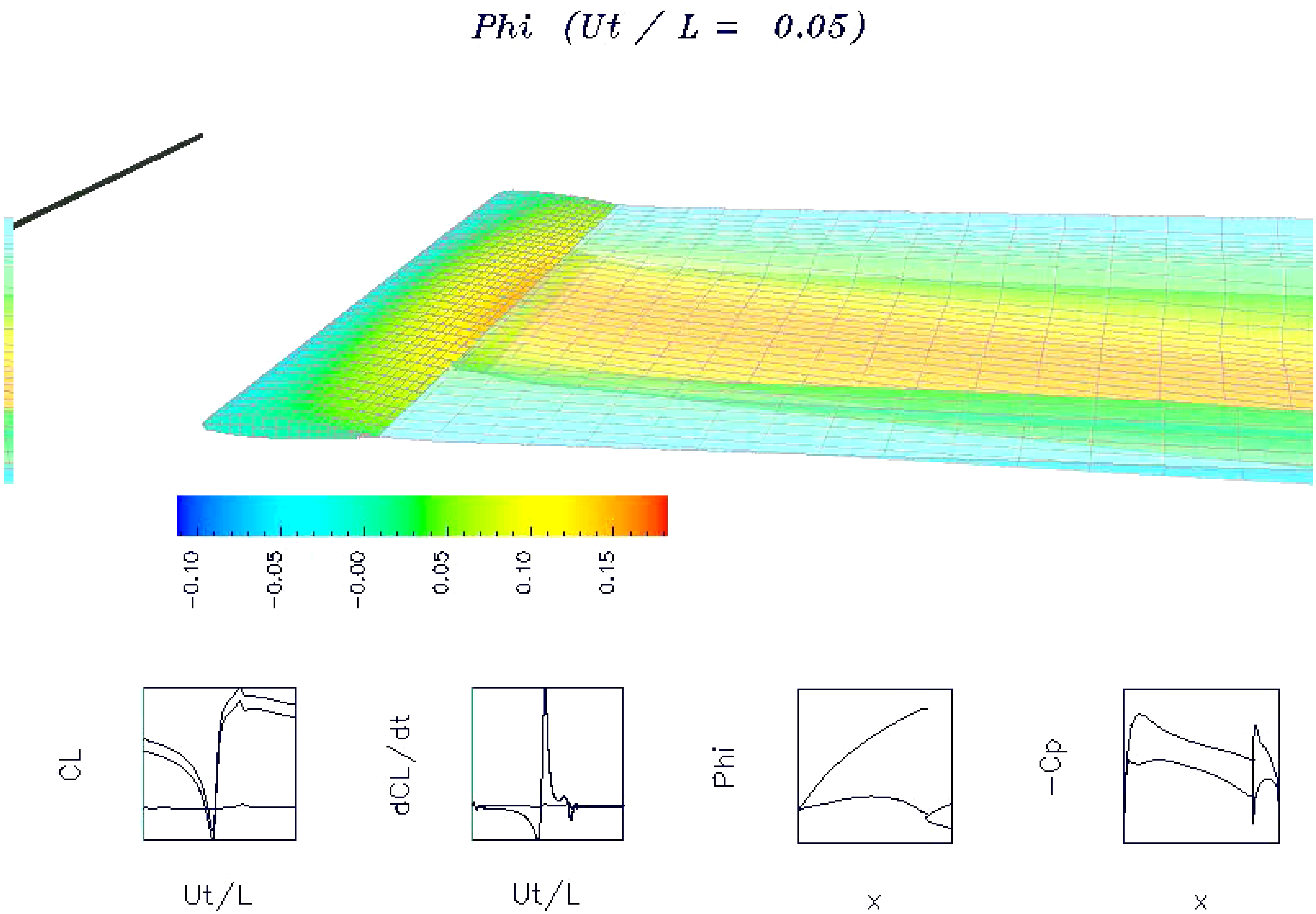


Decreases lift slightly



No real effect on lift

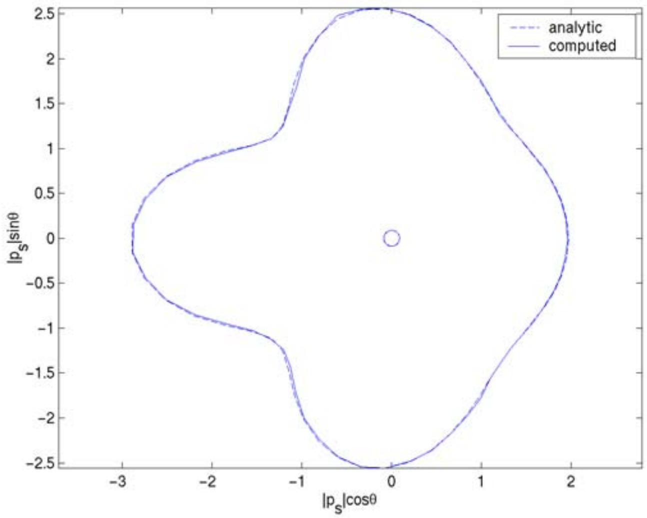
Multi-element wing BVI simulation



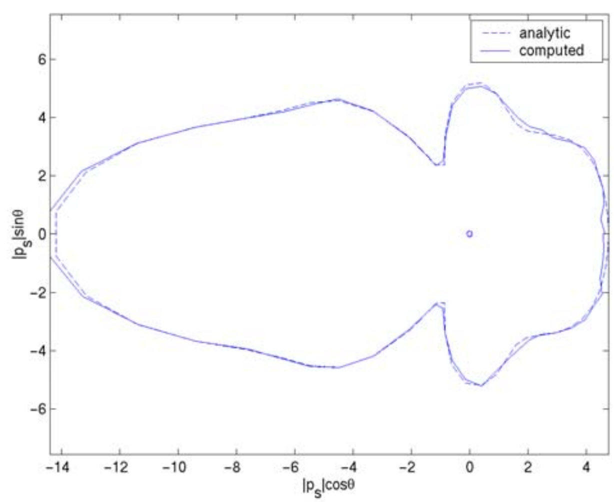
No flow in gerbil problem …

So far….

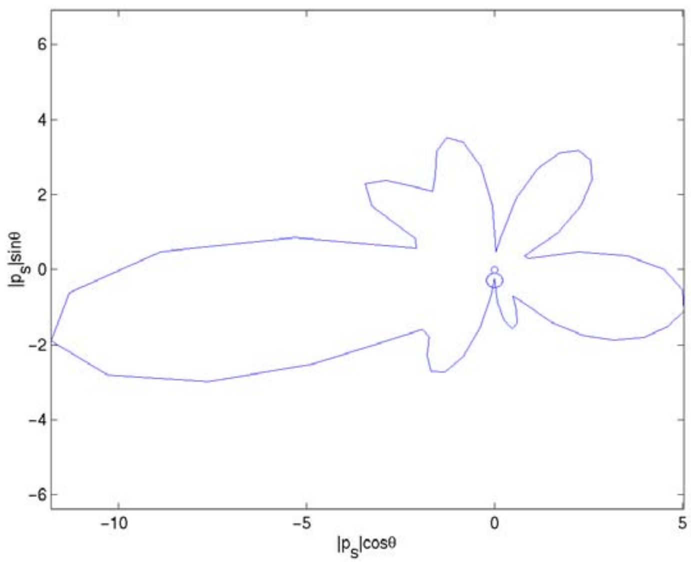
- Basic validations for sphere scattering against analytic results
- Comparison with some published results for scattering from the "snowperson"



Sphere:
ka = 2

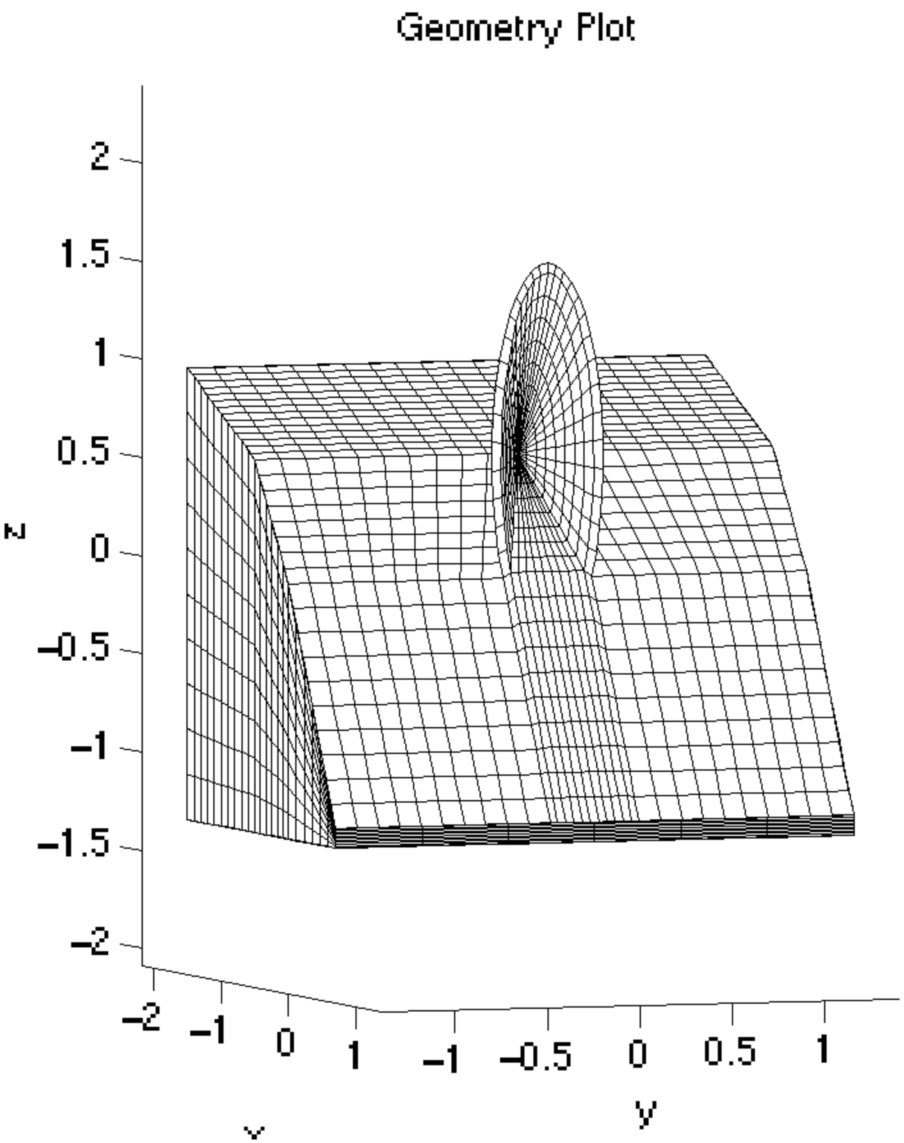


Sphere:
ka = 4

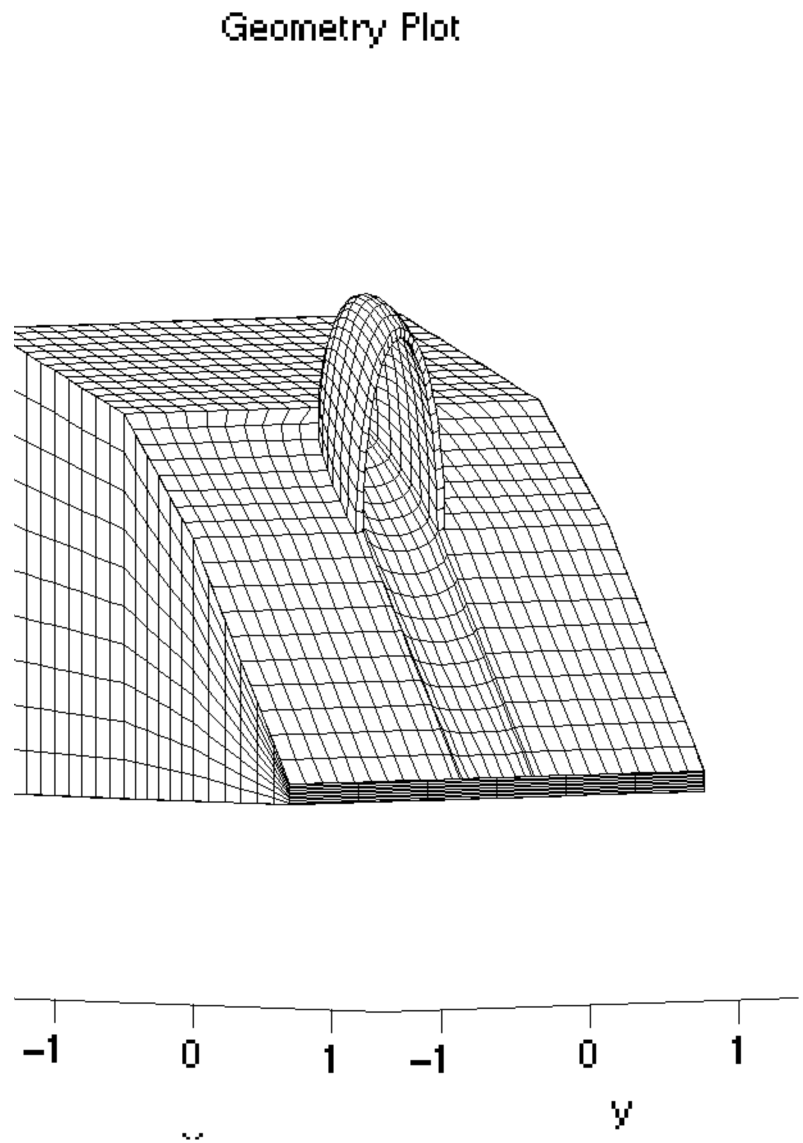


Snowperson: ka = 2

Ear models

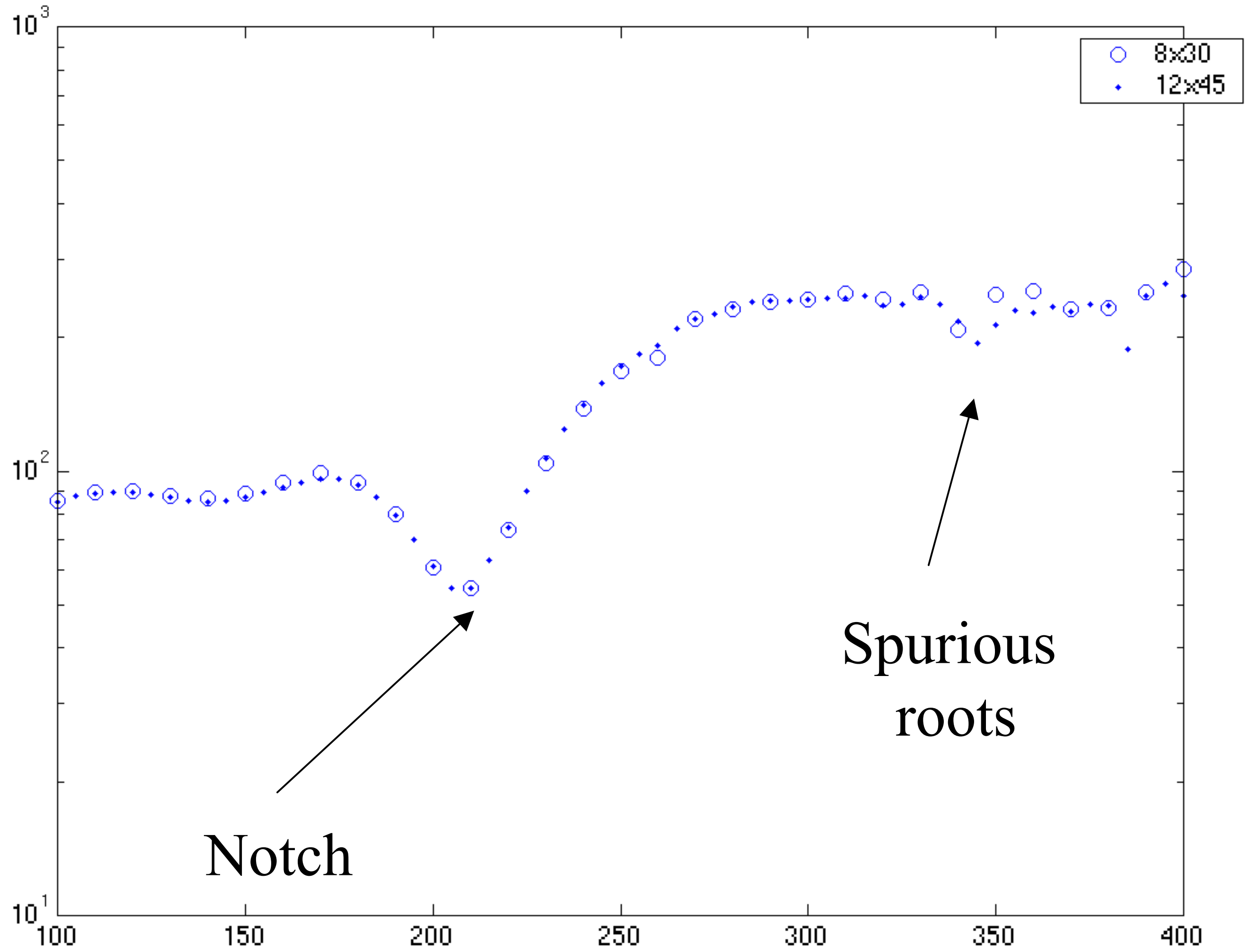


Conical

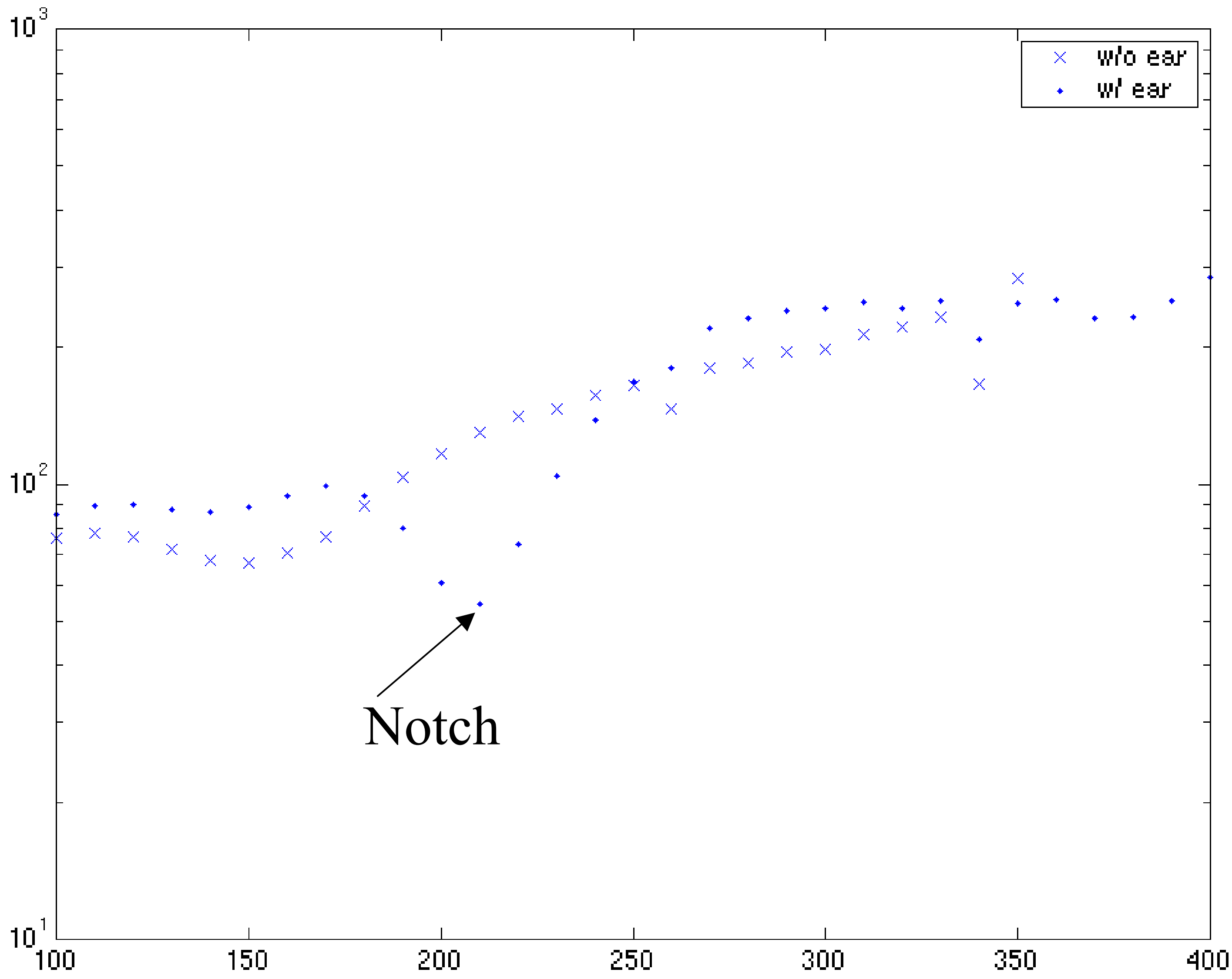


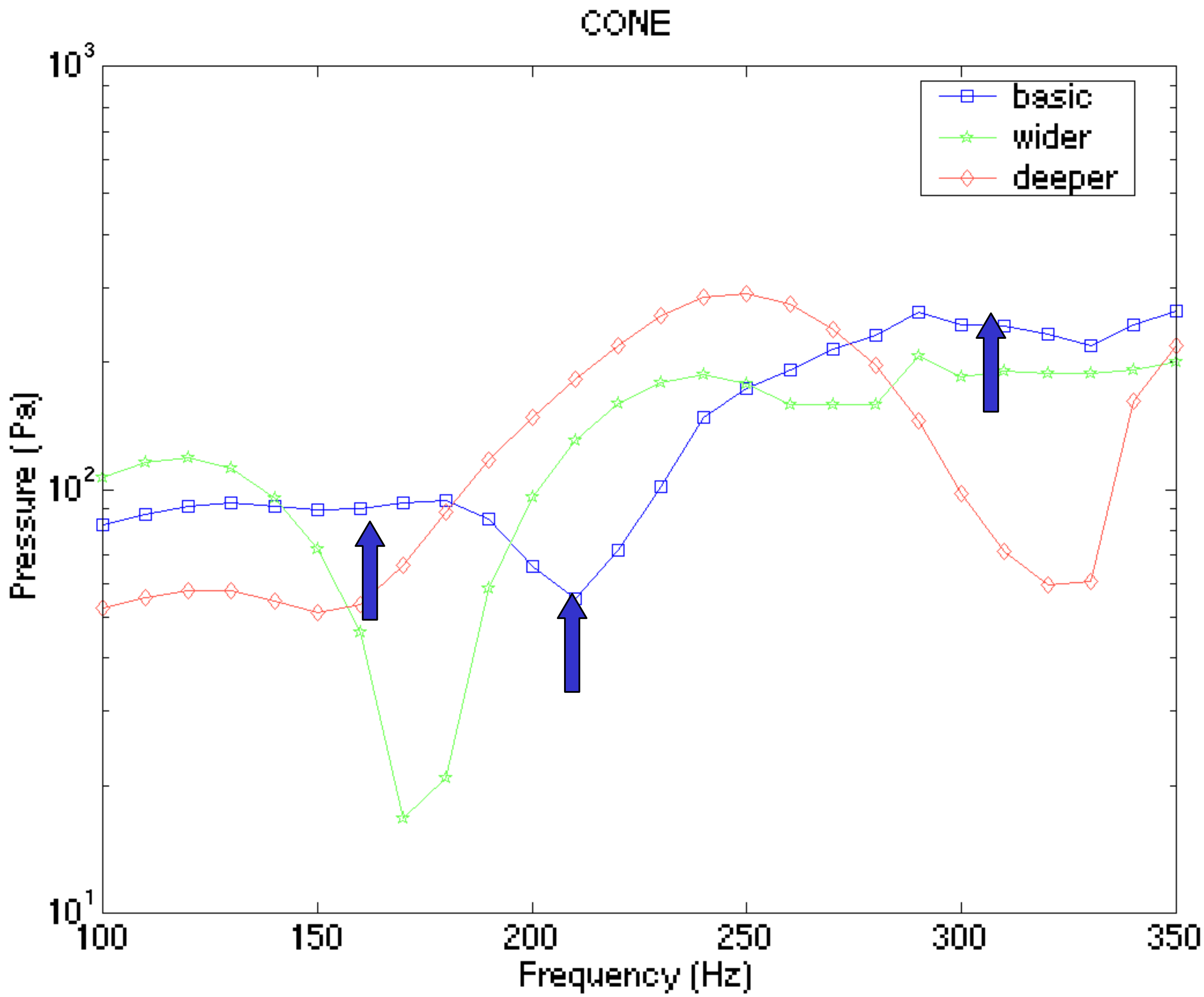
Elliptical

Cone shape on wedge

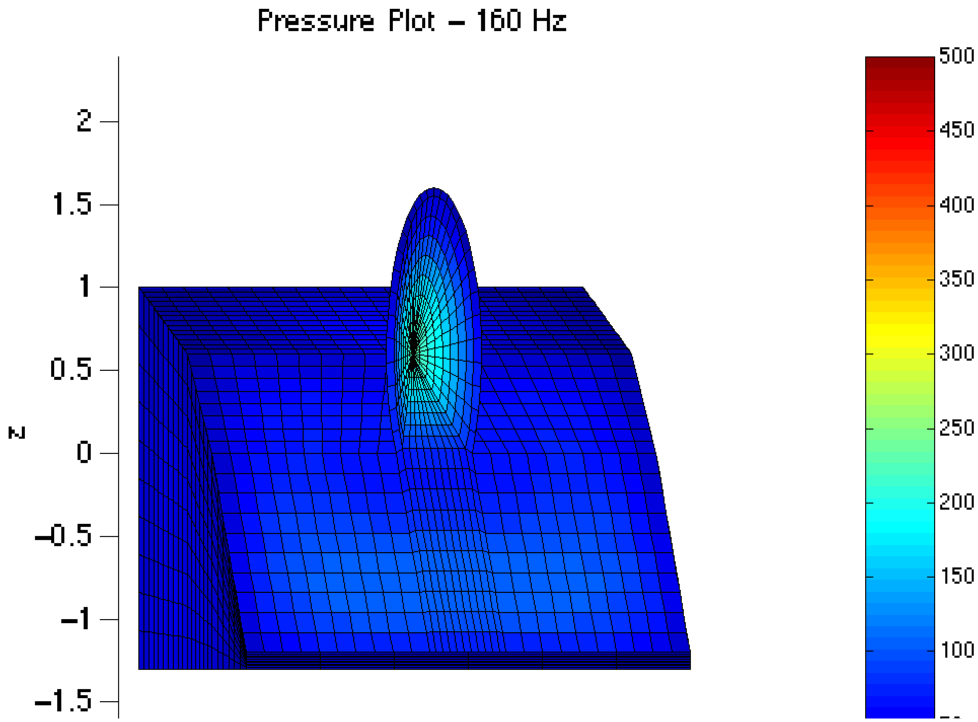


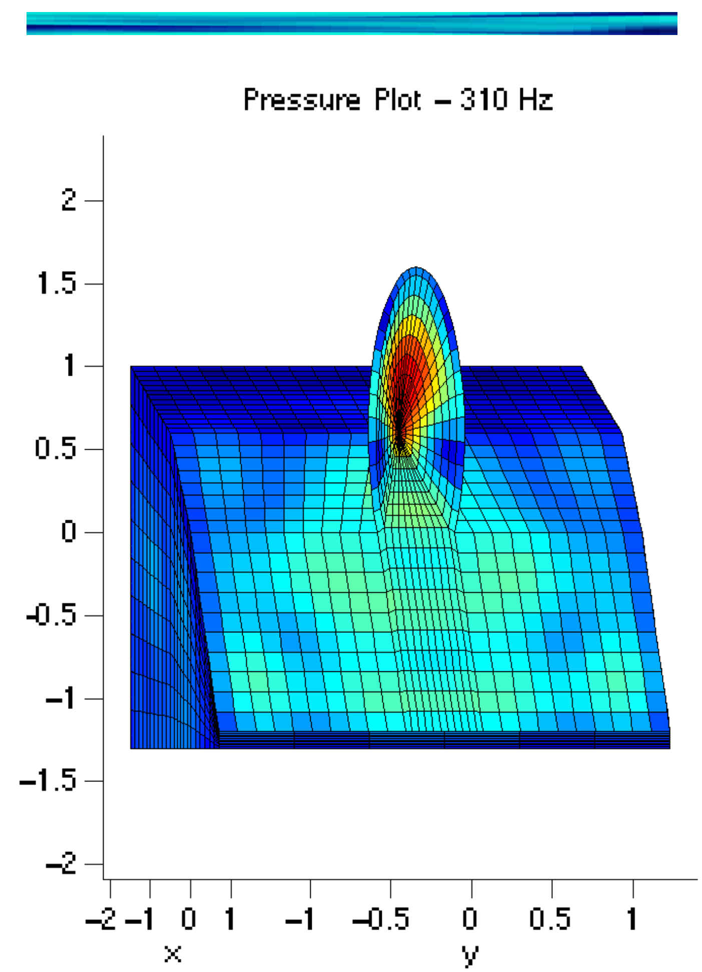
Notch is real

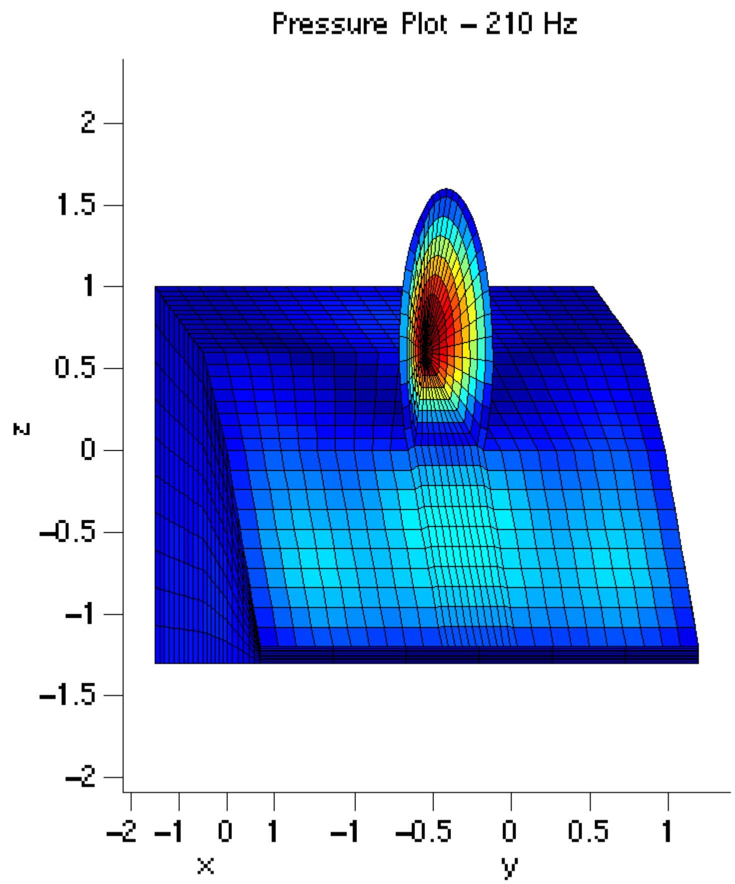




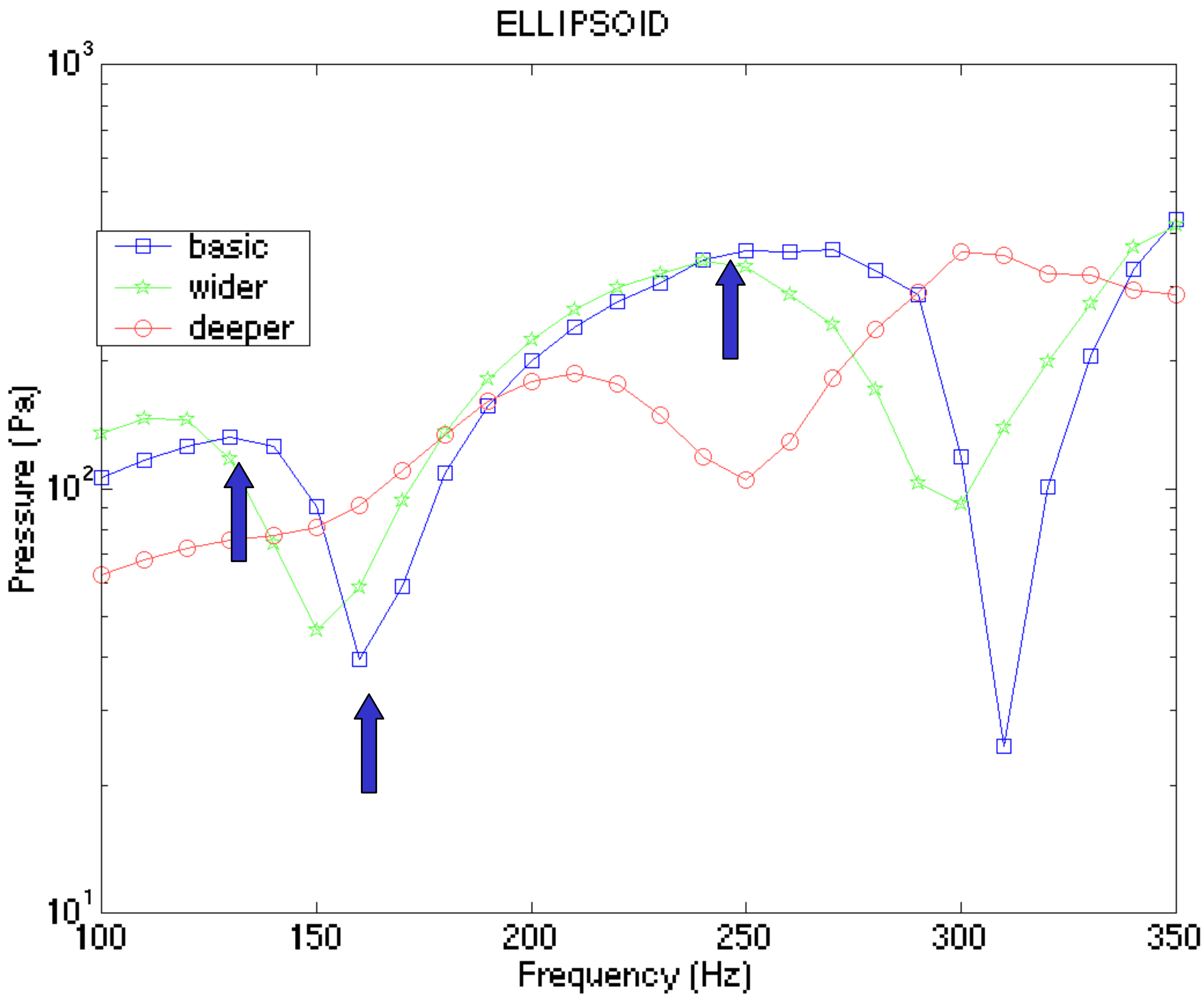
CONE
basic
wider
deeper
Pressure (Pa)
Frequency (Hz)
10^3
10^2
10^1
100
150
200
250
300
350



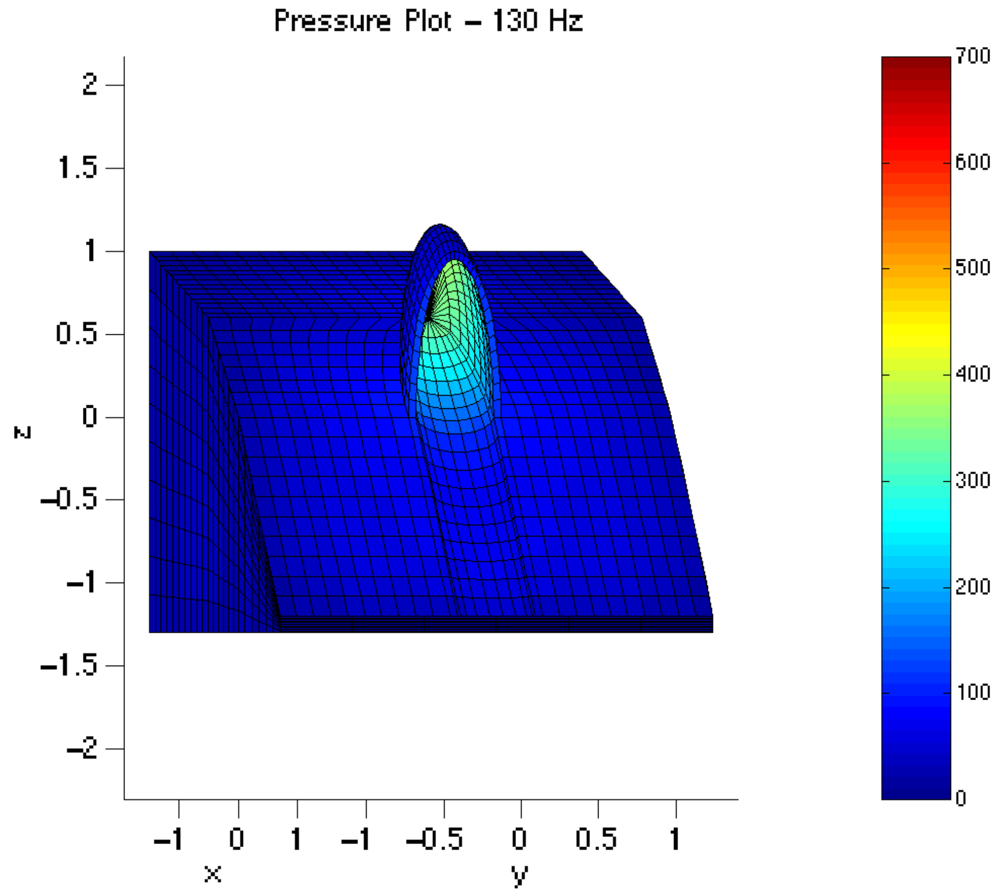


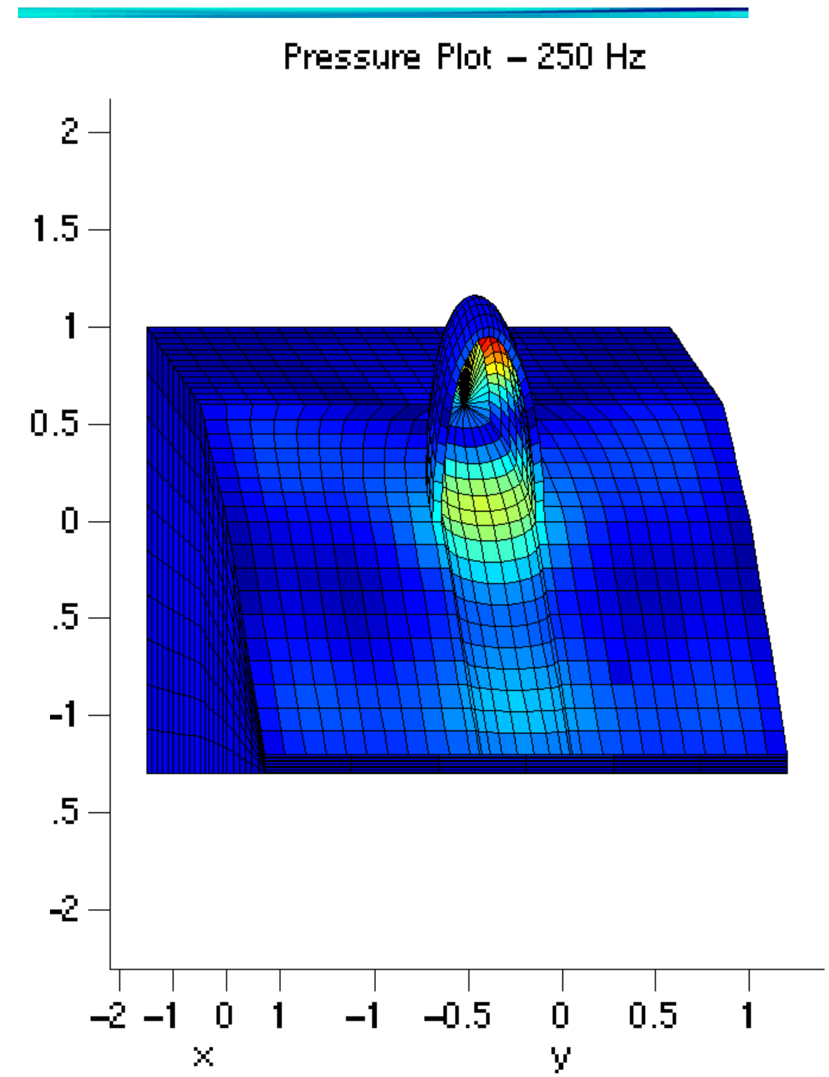


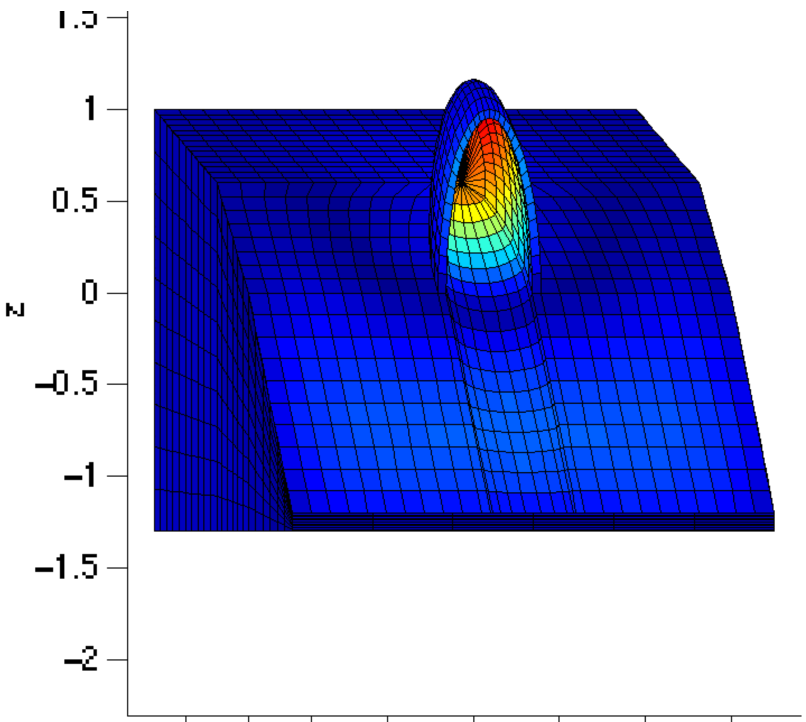
Notch frequency



ELLIPSOID
basic
wider
deeper
Pressure (Pa)
Frequency (Hz)
10^3
10^2
10^1
100
150
200
250
300
350







Notch frequency

The end

Thanks….

Questions….

Head, shoulders, knees, and toes….

Rob Stoker (Boeing), Richard Silcox (NASA Langley), Robert Putnam (BU)

www.animalnetwork.com/critters/profiles/gerbil/default.asp

www.princeton.edu/~jzana

Acoustical Cues for Sound Localization by Gerbils in an Ecologically Reaslistic Environment
Katuhiro maki, shigeto furukawa, and tatsuya hirahara   poster, 2003