# A Biophysical Computational Model:

## How the brain localizes sounds

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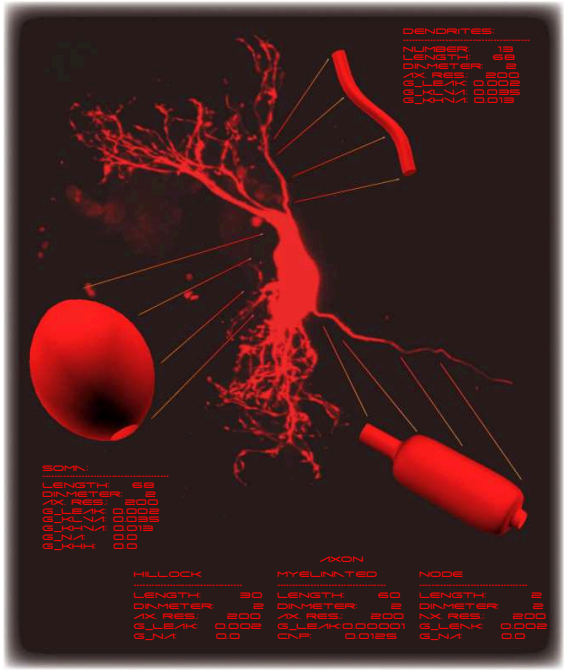
## Nucleus Laminaris

The azimuthal location of a sound source is determined in the brain by means of Interaural Time Differences (ITD). In the avian auditory pathway, Nucleus Laminaris (NL) determines ITD with coincidence detection of phase-locked stimuli coming from both ears.

Almost two orders of magnitude faster than neurons in the cortex, NL phase locks up to several kHz with help from the rapid dynamics of various $K^+$ channels. The contribution of each ion mechanism involved in the process is not yet fully understood.

## The Model

The aim of the model is to better understand the cells' behavior and role. Built using the NEURON environment, the model has a GUI for running the simulations and controlling all geometric, electrical, synaptic and channel parameters. Voltage dependent channels are specified by Hodgkin-Huxley-like equations. The required tradeoff between numeric accuracy and computational efficiency is attained through the high degree of customization implemented.



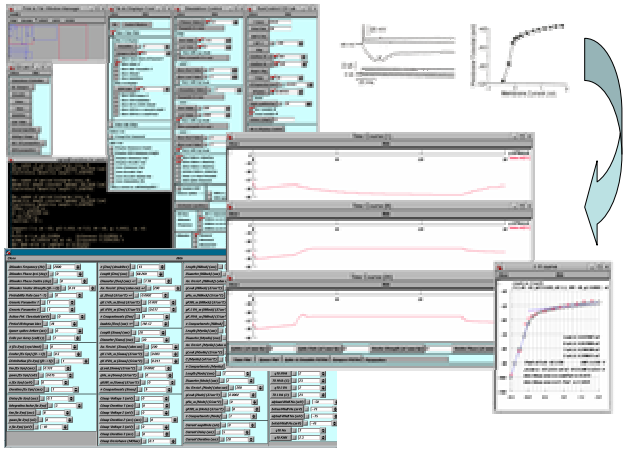

Note: Figures not to scale

## *n*-Dimensional Variable Space

Starting from the values given by the available literature, a valid parameter subspace is searched, exploring and selecting the values biophyisically consistent. *In vitro* recordings are replicated to enforce curve fitting to experimental results, while assessing the overall performance of the system according to psychophysical experiments. An ordered research plan (I-V curves, synaptic excitation, firing rates) ensures a reliable outcome of the model.

## Distributed Simulations

After finding a rough fit through manual tuning, its surrounding parameter space is explored using a brute force approach. Simulations are distributed over more than 30 Sun workstations in the Glue system, working in an asynchronously, fault tolerant and crash resistant mode for several days (AFS/Kerberos permissions maintained). Slightly less than a linear factor decrease in the overall running time is achieved through the distribution process (e.g. factor of 3.5 with 5 machines, independent of number of simultaneous simulations per machine). It cannot compensate for the exponential increase in the number of simulations (as a function of their quantity and depth), but it still provides a very powerful scanning tool.

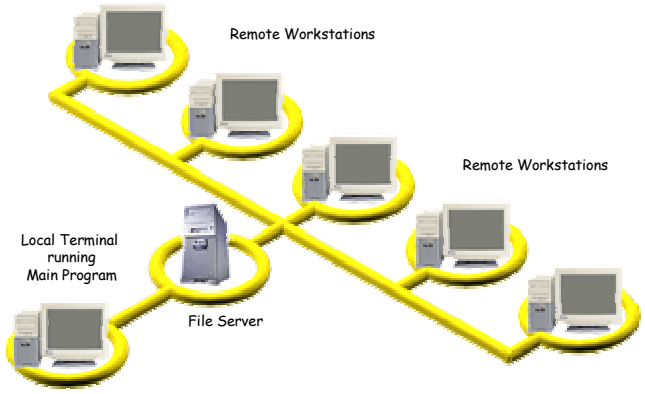


## Initial Results

Preliminary studies with this model have corroborated some key features of the coincidence detection mechanism cited in the literature, such as:

- intra-dendritic inputs sum sub-linearly.
- inter-dendritic interactions subtractively inhibit out-of-phase inputs.
- response to monaural activity does not require spontaneous activity from opposite side.

Current research focuses on analyzing the system performance, rating the amount of information conveyed in Rate-coded ITD tuning curves versus Vector-Strength-coded ones, or exploring the requirement of pre-synaptic cells (Nucleus Magnocellularis) to fire grouped in order to enhance phase locking.

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