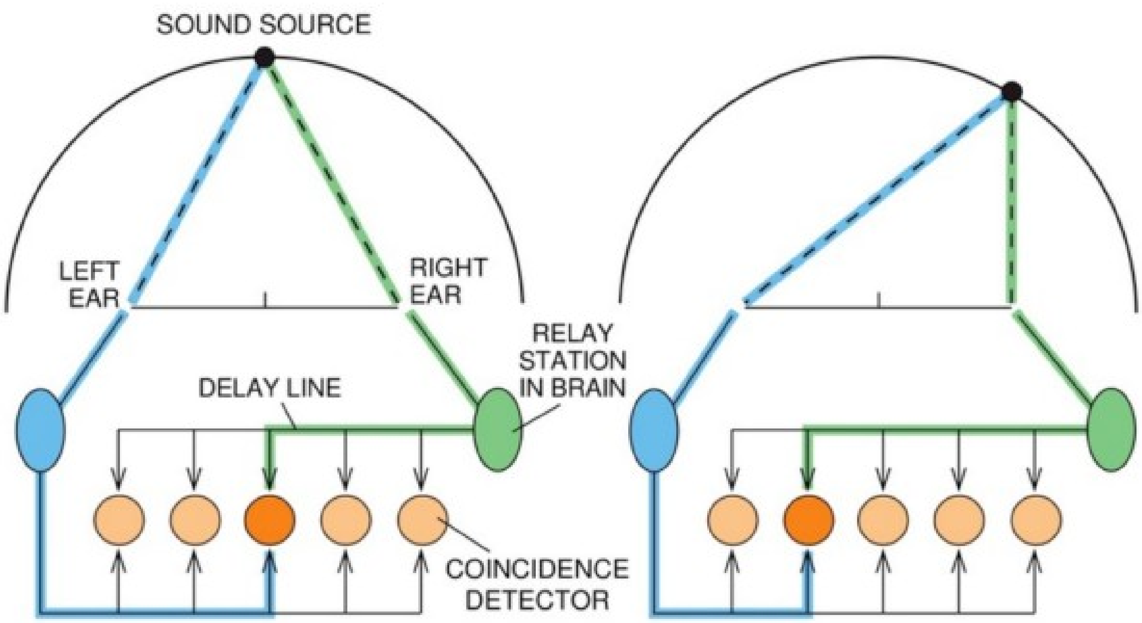
Exercise 2: Coincidence Detection (60 points)

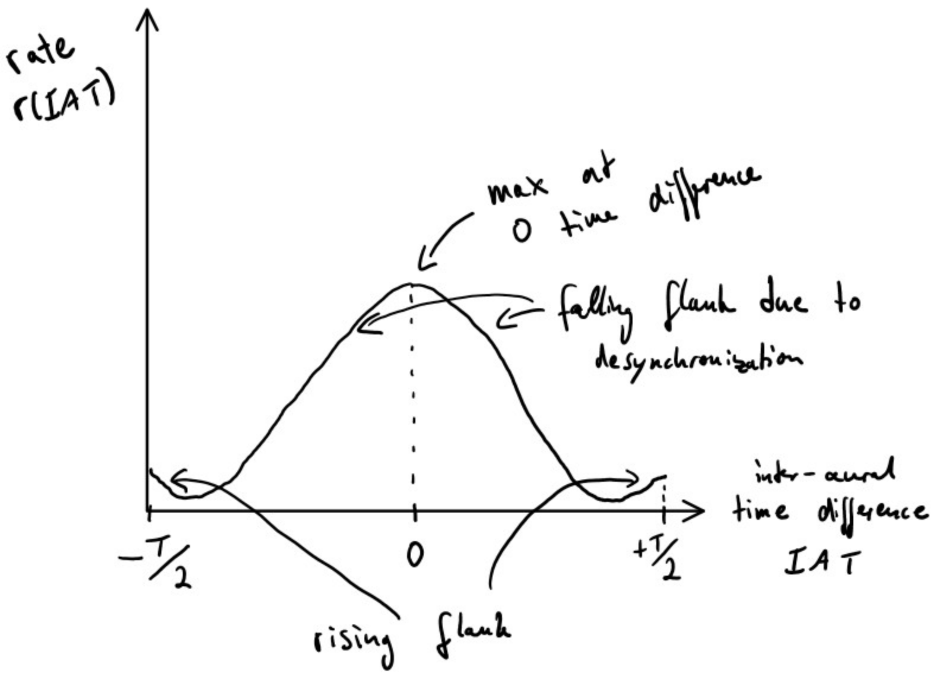


Schematic of the auditory pathway of barn owls. Neurons in the laminar nucleus detect coincidences between signals that arrive from both ears through fibres serving as delay lines (blue and green lines). The firing rate of the neuron at which the signals arrive simultaneously has the highest firing rate (colored darkly).
Consequently, each neuron codes for an azimuthal sector.

(a) (15 points) Describe the nature of the spike input from the left and right side in order to process inter-aural time differences. Is it a temporal or a rate code?

The auditory pathways of an organism decode incoming sounds. Our spike input is therefore in waveform (with the pitch encoded in the frequency). The coincidence detectors not only depend on a single input to process the inter-aural time differences. Because they need the exact timing of two distinct events (sound arrives at the left / right ear), the neural spike code needs to be temporal. (A rate coded detector would not be able to immediately react to those events).

(b) (15 points) The neurons serve as coincidence detectors and fire maximally when they receive the left and right sided input simultaneously. Sketch their tuning curves, i.e. their spike response rate, as function of the inter-aural time difference.



(c) Given that the speed of sound in the air is 350 m s −1 and the distance between the left and right ear is 15 cm (in humans). How big is the time delay between the left and right ear for a sound coming directly from the side? How does that relate to the typical duration of an action potential

$$t = \frac{d}{v} \simeq 0.429\,ms$$

The typical scale duration of an action potential is 1ms (source Dayan, Abbott – Theoretical Neuroscience), which is hence longer, but not too much.