In order to examine the performance of our common-input model in capturing the statistical dependencies in the population responses, we compared the pairwise cross-correlation function of retinal ganglion cells and simulated model spike trains (Figure 1). For nearby ON-ON and OFF-OFF pairs, the CCF exhibits a sharp peak at zero, indicating the prevalence of synchronous spikes, while for ON-OFF pairs, a trough at zero indicates an absence of synchrony.

The conditional intensity (spike rate) of each cell, \( \lambda(t) \) is:

\[
\lambda(t) = \exp \left( k \cdot x + h \cdot y + \left( \sum \lambda_i \cdot y_i \right) + \mu + Q(t) \right)
\]

Where \( x \) is the stimulus, \( y \) the cell’s own spike-train history, \( \mu \) is the cell’s baseline log-firing rate, \( y_i \) are the spike-train histories of other cells at time \( t \). Correspondingly, \( k \) is the stimulus filter, \( h \) is the post-spike filter accounting for past spikes dependancies, \( \lambda_i \) are direct coupling filters, which capture dependencies of the cell on the recent spiking of other cells. The term \( Q(t) \) is the instantaneous common input at time \( t \).

The prevalence of synchronous spikes, as seen in the CCF of the ON-ON and OFF-OFF cell pairs, can be explained by the relatively large amount of common input to the two cells compared to all other contributions (Top panel Figure 2).
Figure 2: Relative contribution of common, stimulus, direct coupling dependent, and self inputs to two ON cells. Top panel: Net linear common input, $Q(t)$. 2nd panel: The stimulus input, $k \cdot x$. 3rd panel: Direct coupling input from other cell, $\sum_i l_i \cdot y_i$. 4th panel: Refractory input from the cell, $h \cdot y$. 5th Panel: Spiking train of the cells. In panels 2 to 5 blue is cell 1 and green is cell 2. Note the large magnitude of the estimated common input term $Q(t)$, relative to the direct coupling contribution $\sum_i l_i \cdot y_i$. 