Evidence has been accumulating for significant departures from the Poisson model in a variety of brain regions, primarily motor-related like M1 and SMA and high-visual, like Area 5. Neurons in these areas display smaller coefficients of variation (CV) in their interspike interval (ISI) distributions.

Slice recordings with constant current injection typically show regular spike trains, but a degree of regularity is maintained even under in-vivo like stimulation with noisy inputs. The Poisson point process might be an appropriate useful simplification for a variety of brain areas but not in the rat Frontal Orienting Fields (FOF) where our lab has been conducting electrophysiological recordings. The FOF is a premotor area, but neurons also show persistent mnemonic activity.

They can be modeled with renewal point processes with ISI distributions above 3 ms. These distributions can be fit well with a gamma distribution as
\[ \text{Gamma}(k, \theta) = \frac{1}{\Gamma(k)\theta^k} x^{k-1} e^{-x/\theta} \]

for short AHP. For long AHP, a rate code is insufficient: our moving threshold method can be used for fitting parameters of (generalized) O-U processes in general, with one or two absorbing boundaries.

\[ \text{Estimate Regularity (Gamma Shape)} \]

\[ \begin{align*}
\int \text{d}R & \quad \Rightarrow \quad p(R) \\
\int \text{d}R & \quad \Rightarrow \quad p(R) \\
\int \text{d}R & \quad \Rightarrow \quad p(R) \\
\int \text{d}R & \quad \Rightarrow \quad p(R) \\
\int \text{d}R & \quad \Rightarrow \quad p(R) \\
\int \text{d}R & \quad \Rightarrow \quad p(R) \\
\end{align*} \]

\[ \begin{align*}
\text{Estimate Firing Rate} \\
\text{Integrated out after a spike} \\
\end{align*} \]

\[ \begin{align*}
\text{VERIFY ASSUMPTIONS} \\
\text{Data Results} \\
\end{align*} \]

\[ \begin{align*}
\text{Model Results} \\
\text{The 'peaking' profile does not.} \\
\text{The 'constant' profile requires long AHP currents.} \\
\end{align*} \]

\[ \begin{align*}
\text{Linear LIF model} \\
\text{We ask, for a given distribution p(ISI), what Th(t) would generate it?} \\
\text{We need the distribution of crossing times but O-U model with absorbing boundary is impossible to integrate in general.} \\
\text{Collect the deterministic part in a time-dependent threshold} \\
\text{An AHP spike is produced when} \\
\text{Eliminate absorbed particles, and choose randomly with replacement 10000 new particles from the ones left.} \\
\text{Propagate particles to the next time step.} \\
\end{align*} \]

\[ \begin{align*}
\text{The moving threshold fitting procedure} \\
\text{We use sequential Monte Carlo methods in discretized time (\Delta t = 1 ms).} \\
\text{Repeat the following procedure:} \\
\text{Choose Th(t) to match empirical and theoretical hazard rates} \\
\text{KL divergence between fitted LIF and gamma models shows necessity of (at least) one long time constant.} \\
\end{align*} \]

\[ \begin{align*}
\text{Moving Threshold Results} \\
\text{Fitted AHP-LIF models whose input is varied:} \\
\text{1) have a 'constant' profile, for long AHP.} \\
\text{2) have an 'increasing' profile, for short AHP.} \\
\end{align*} \]