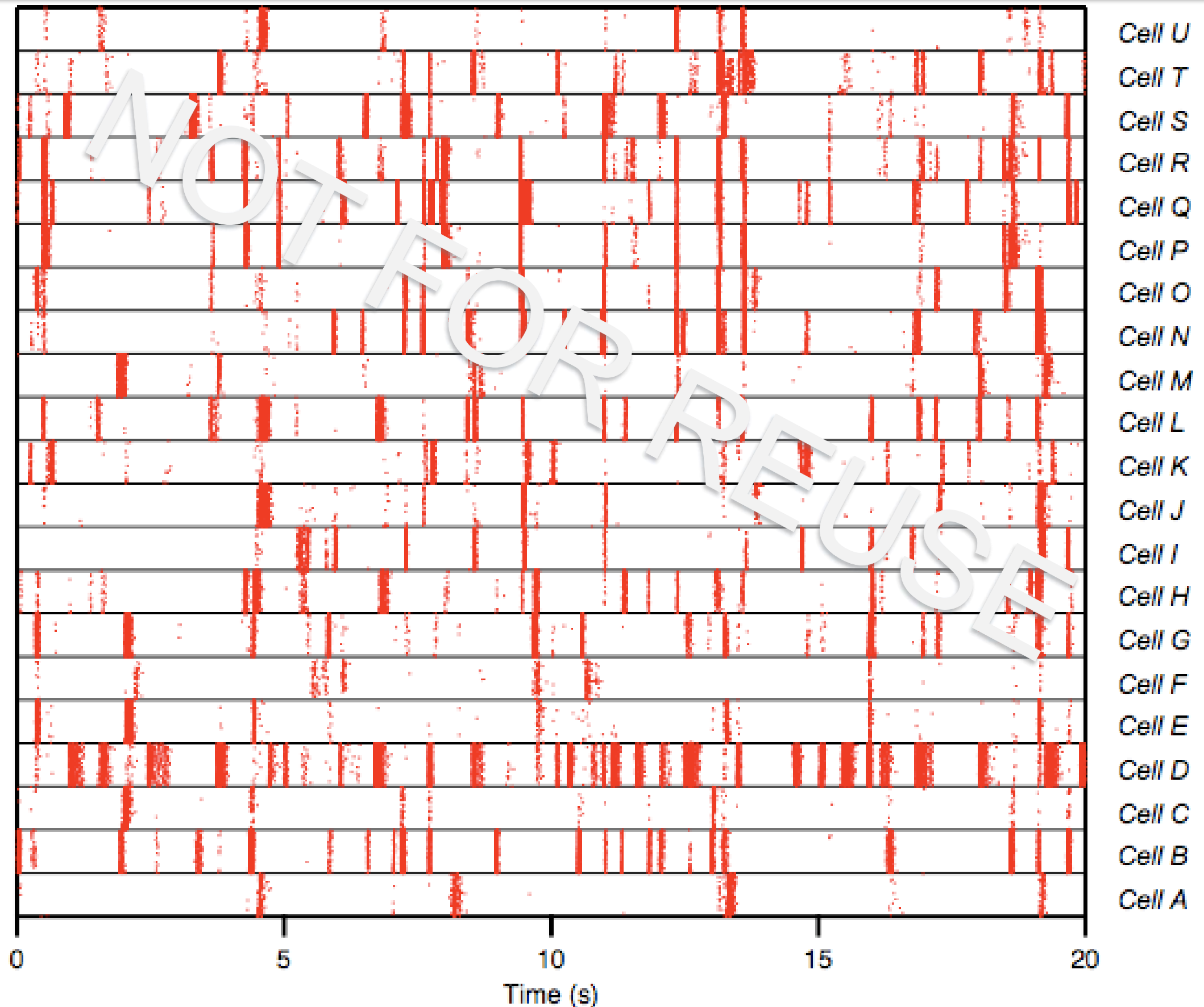
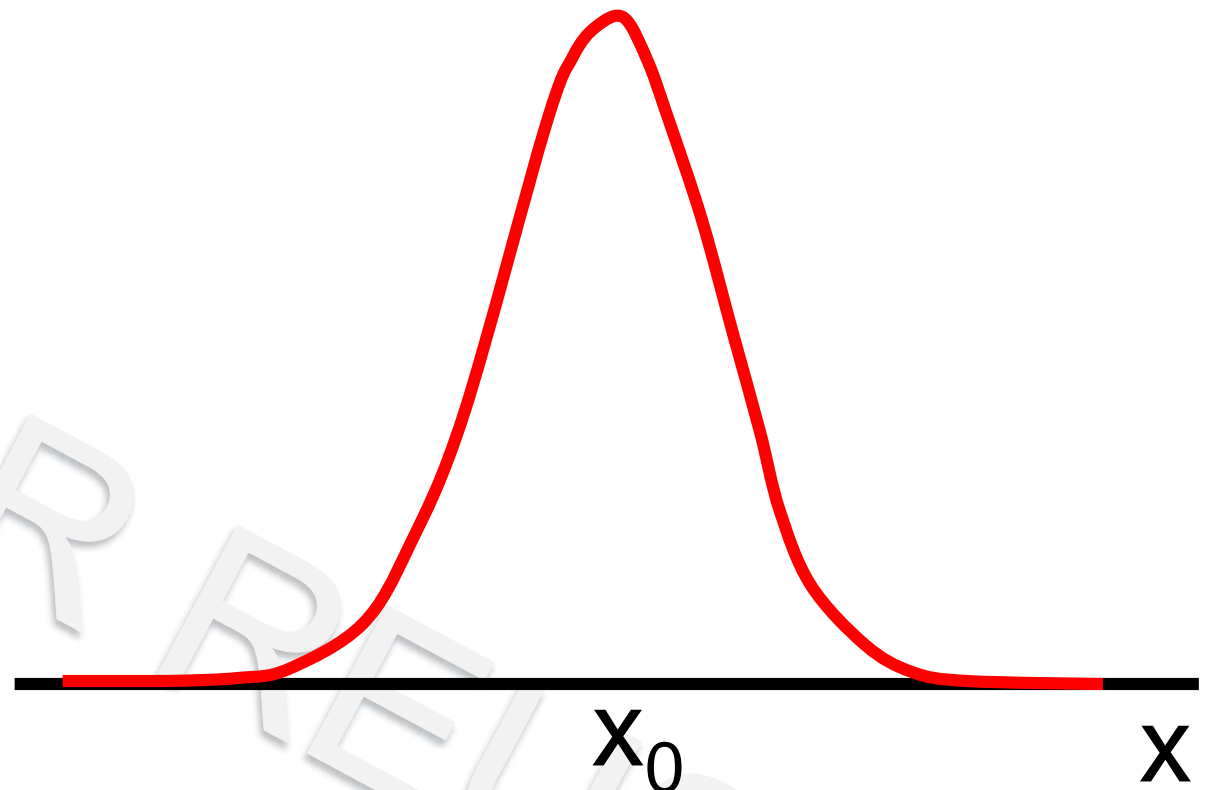


Better models



The magical Gaussian

$$P(x) = Ae^{-((x-x_0)^2/2\sigma^2)}$$



When have you found a good feature or features?

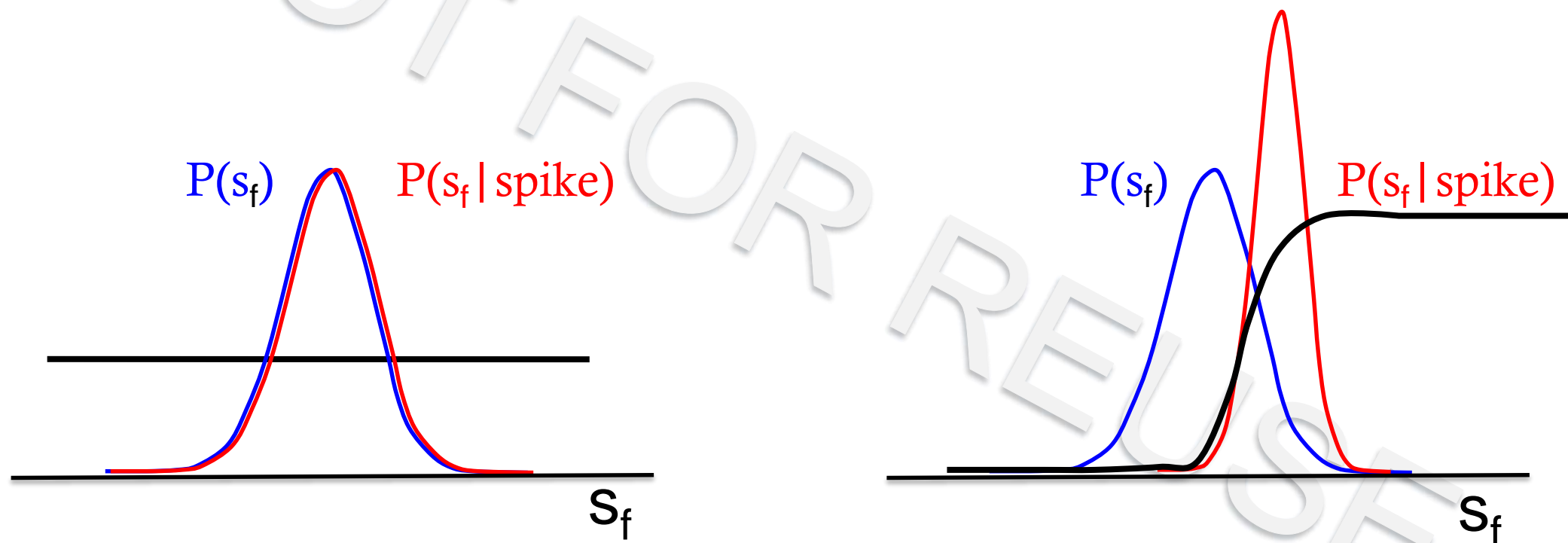
- When the input/output curve over your variable is *interesting*.
- How to quantify interesting?

When have you done a good job?

Tuning curve: $P(\text{spike}|s_f) = P(s_f|\text{spike}) P(\text{spike}) / P(s_f)$

Boring: spikes unrelated to stimulus

Interesting: spikes are selective



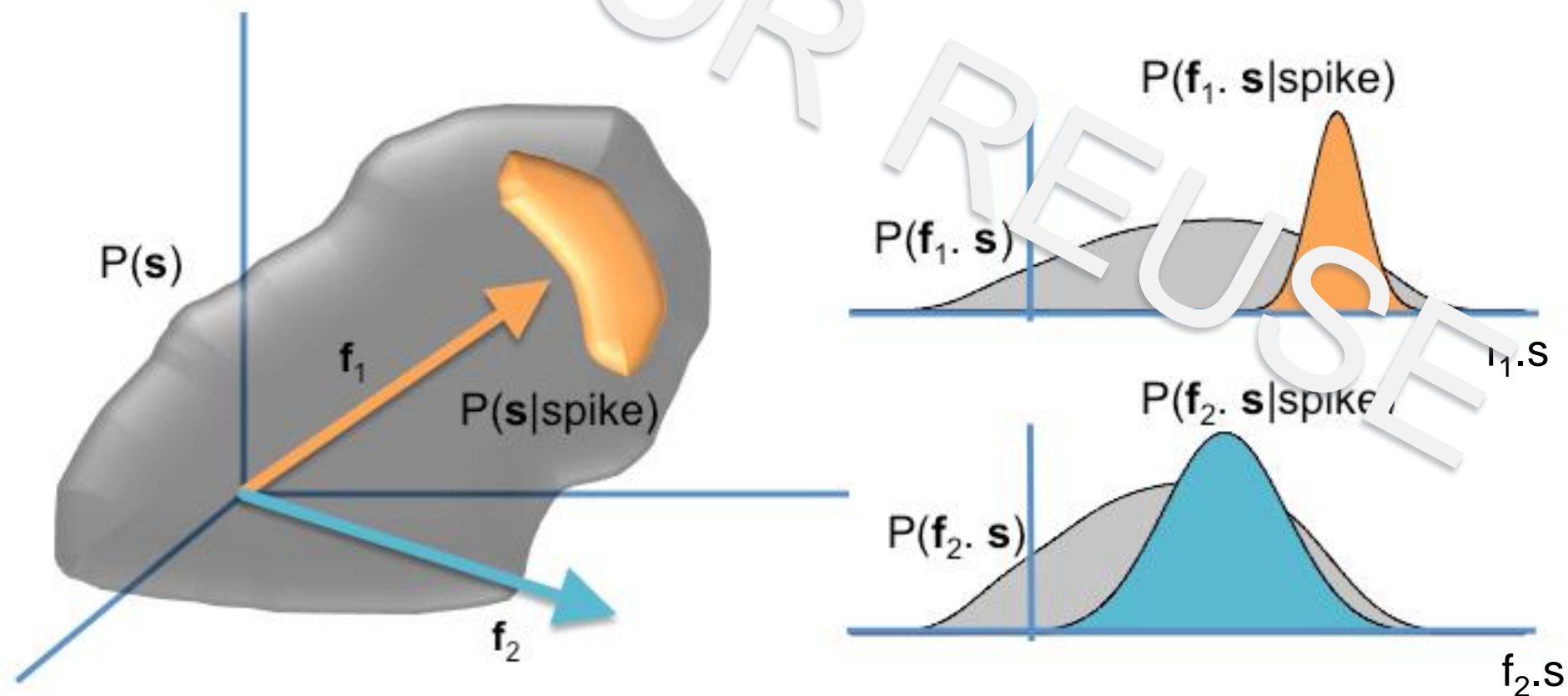
Introducing the Kullback-Leibler divergence

$$D_{\text{KL}}(P(s), Q(s)) = \int ds P(s) \log_2 P(s)/Q(s)$$

Goodness measure: $D_{\text{KL}}(P(s_f|\text{spike}), P(s_f))$

Maximally informative dimensions

Choose filter in order to maximize D_{KL} between spike-conditional and prior distributions



Sharpee, Rust and Bialek, Neural Computation (2004)

Image from Fairhall, Barreiro, Shea-Brown (2012)

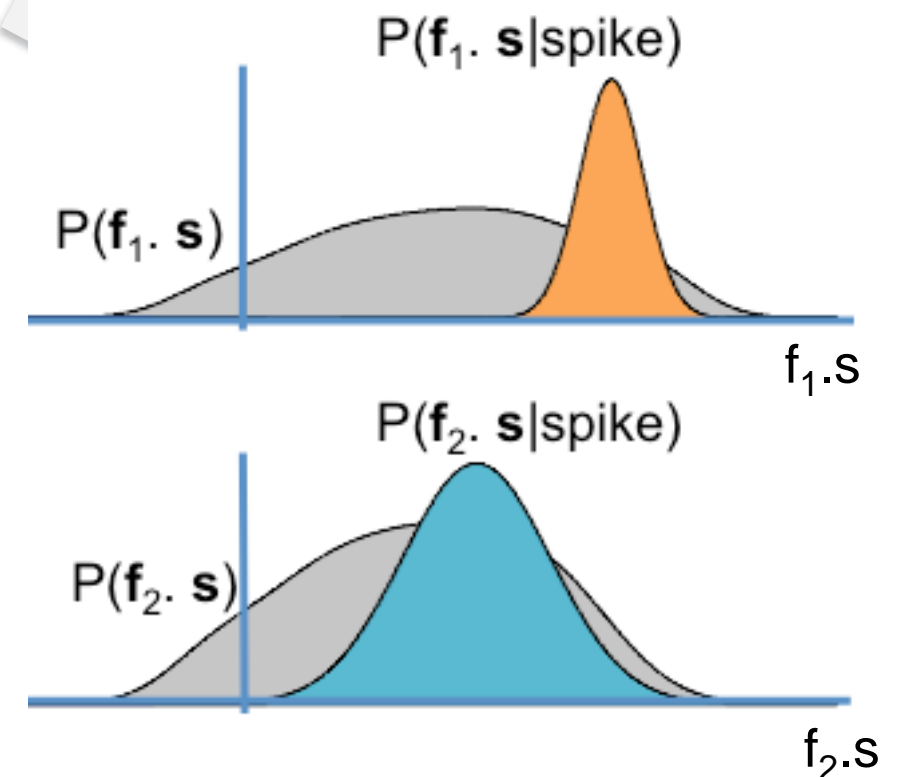
Maximally informative dimensions

Choose filter in order to maximize D_{KL} between spike-conditional and prior distributions

Equivalent to maximizing mutual information between stimulus and spike

Does not depend on white noise inputs

Can be used for deriving models from natural stimuli

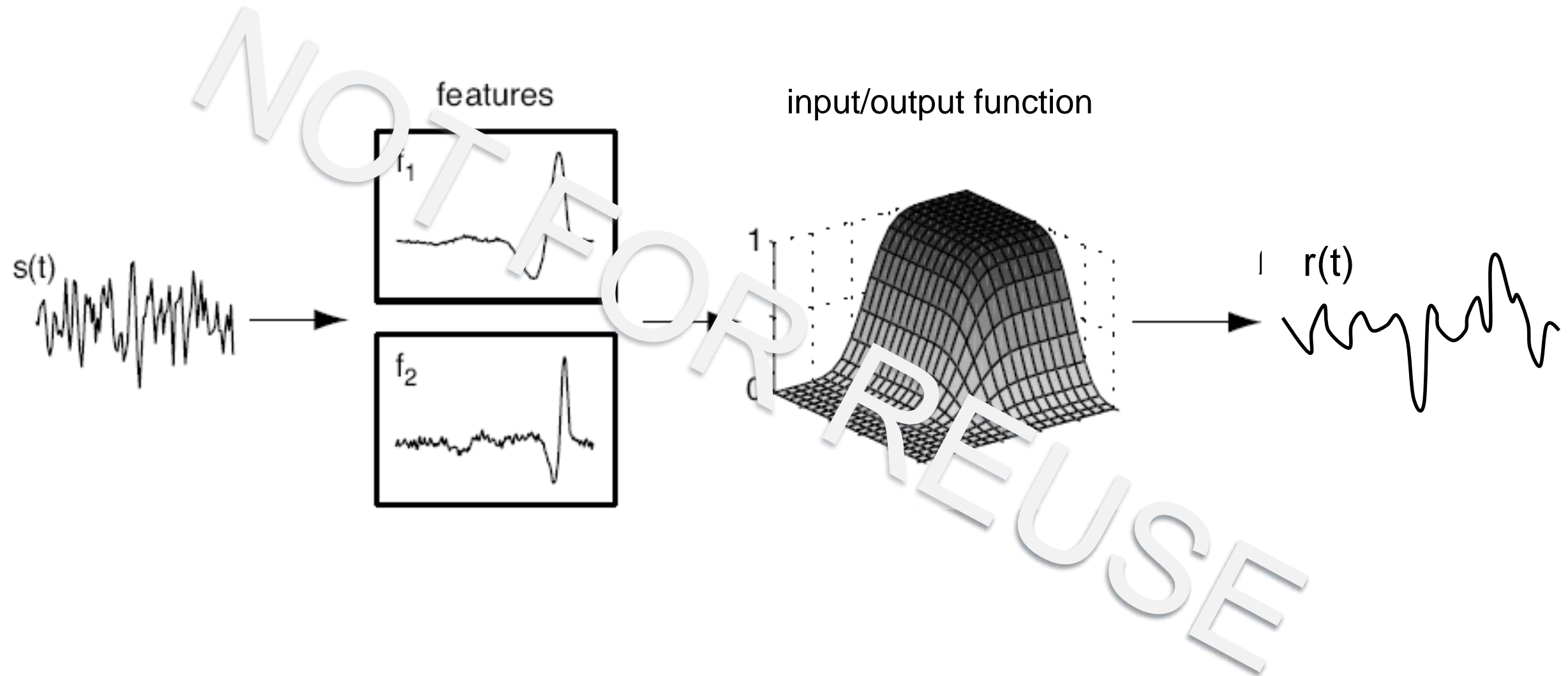


Finding relevant features

1. Single filter determined by the conditional average
2. A family of filters derived using PCA
3. Information theoretic methods use the whole distribution

Removes requirement for Gaussian stimuli

Modeling the noise



Bernoulli trials



Binomial spiking



Distribution:

$$P_n[k] = ?$$

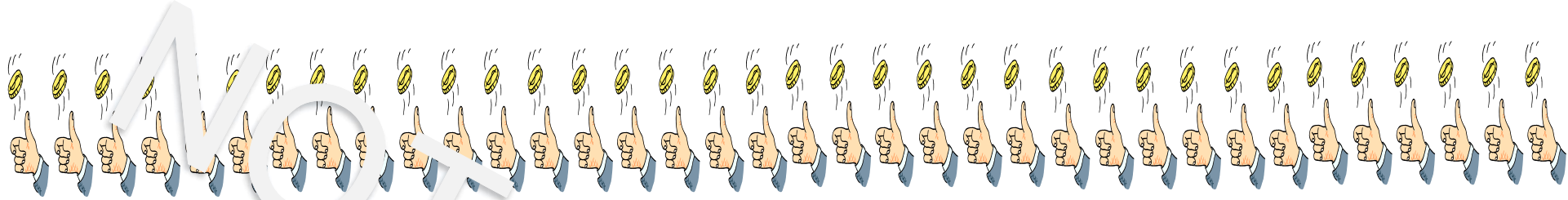
Mean:

$$\langle k \rangle = ?$$

Variance:

$$\text{Var}(k) = ?$$

Poisson spiking



Distribution: $P_T[k] = (rT)^k \exp(-rT)/k!$

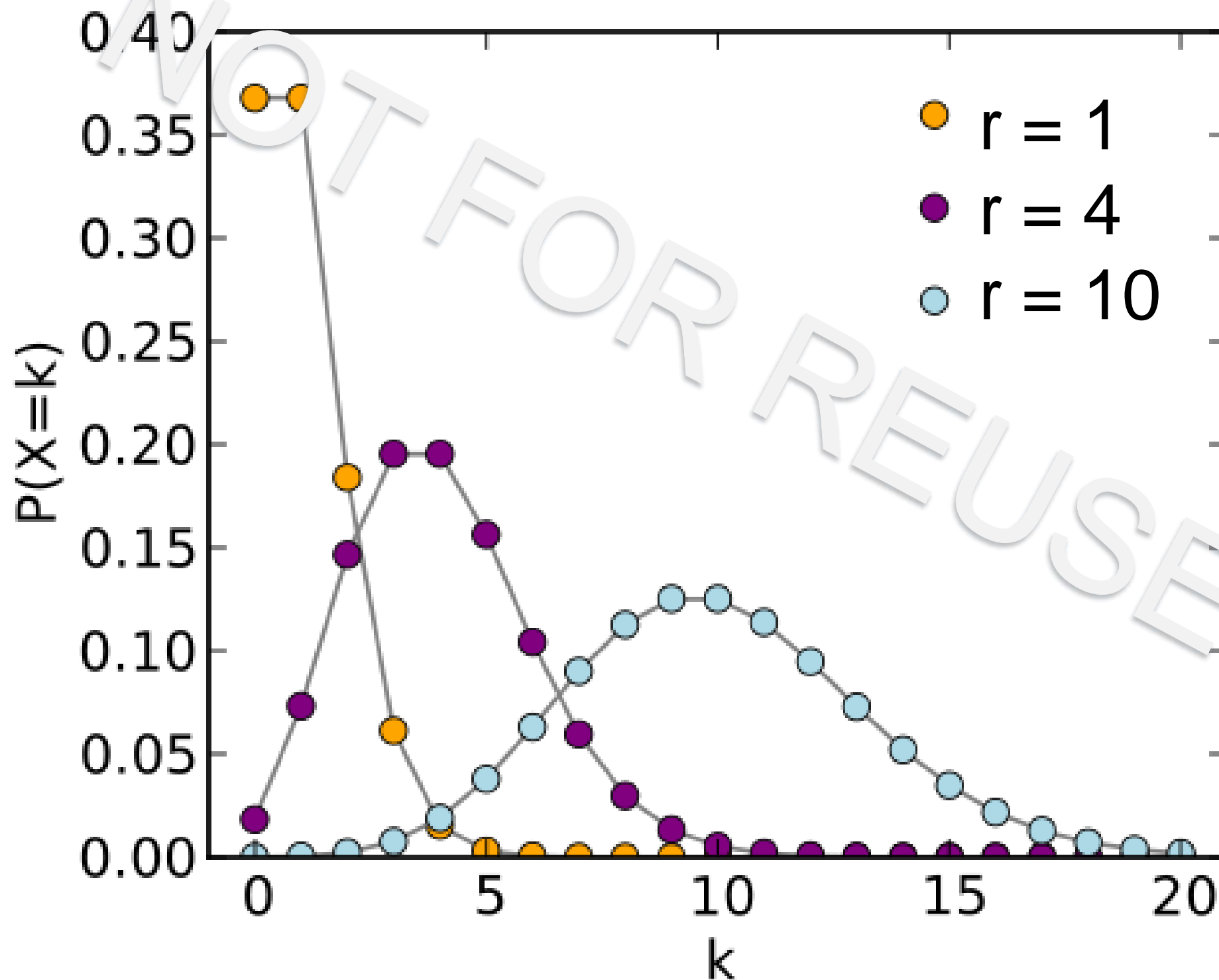
Mean: $\langle k \rangle = rT$

Variance: $\text{Var}(k) = rT$

Fano factor: $F = 1$

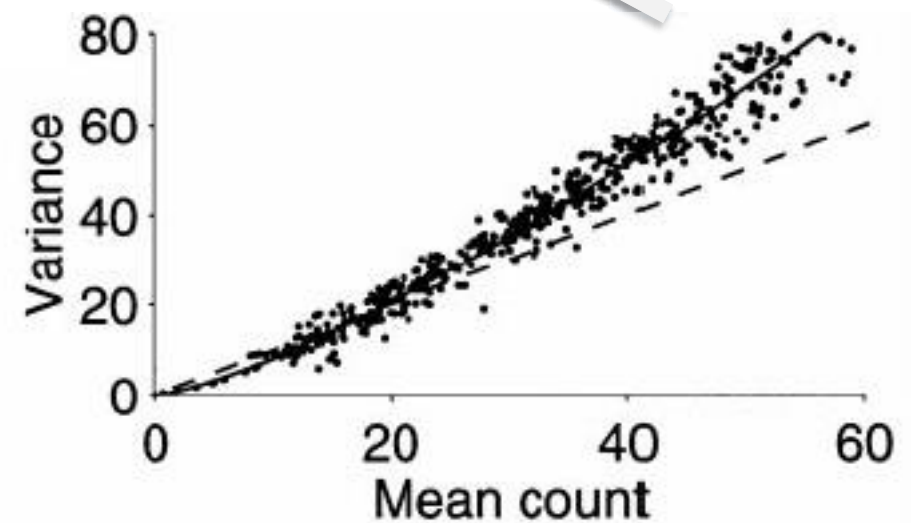
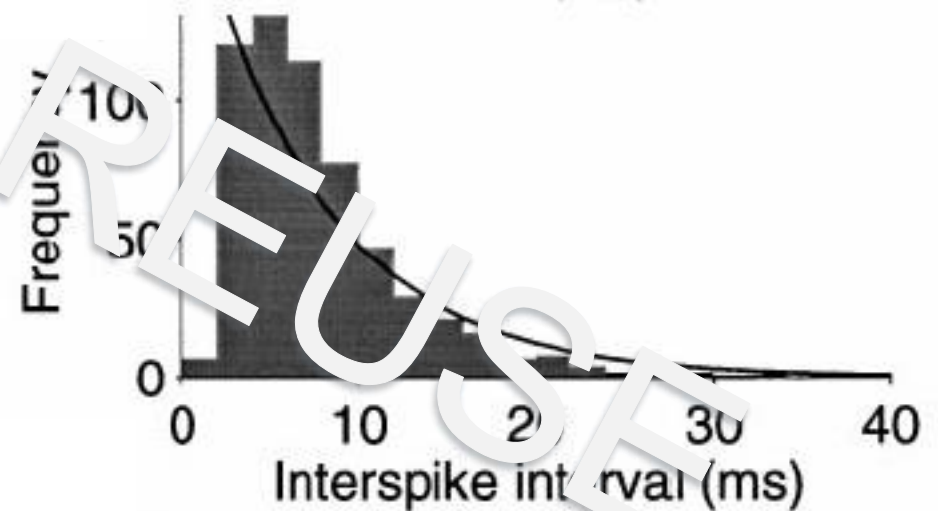
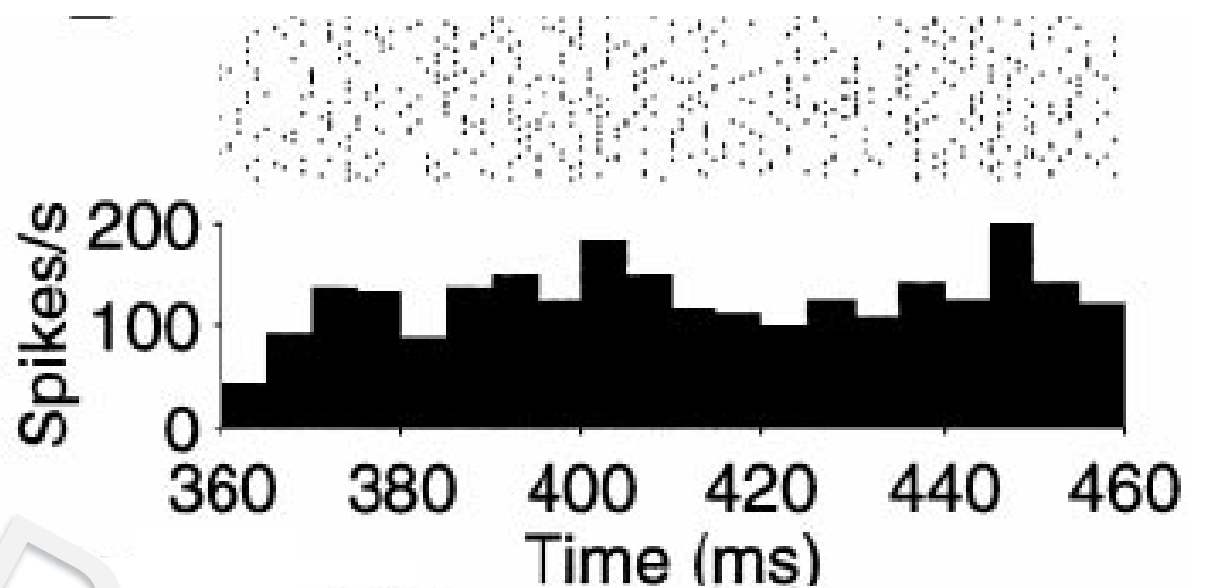
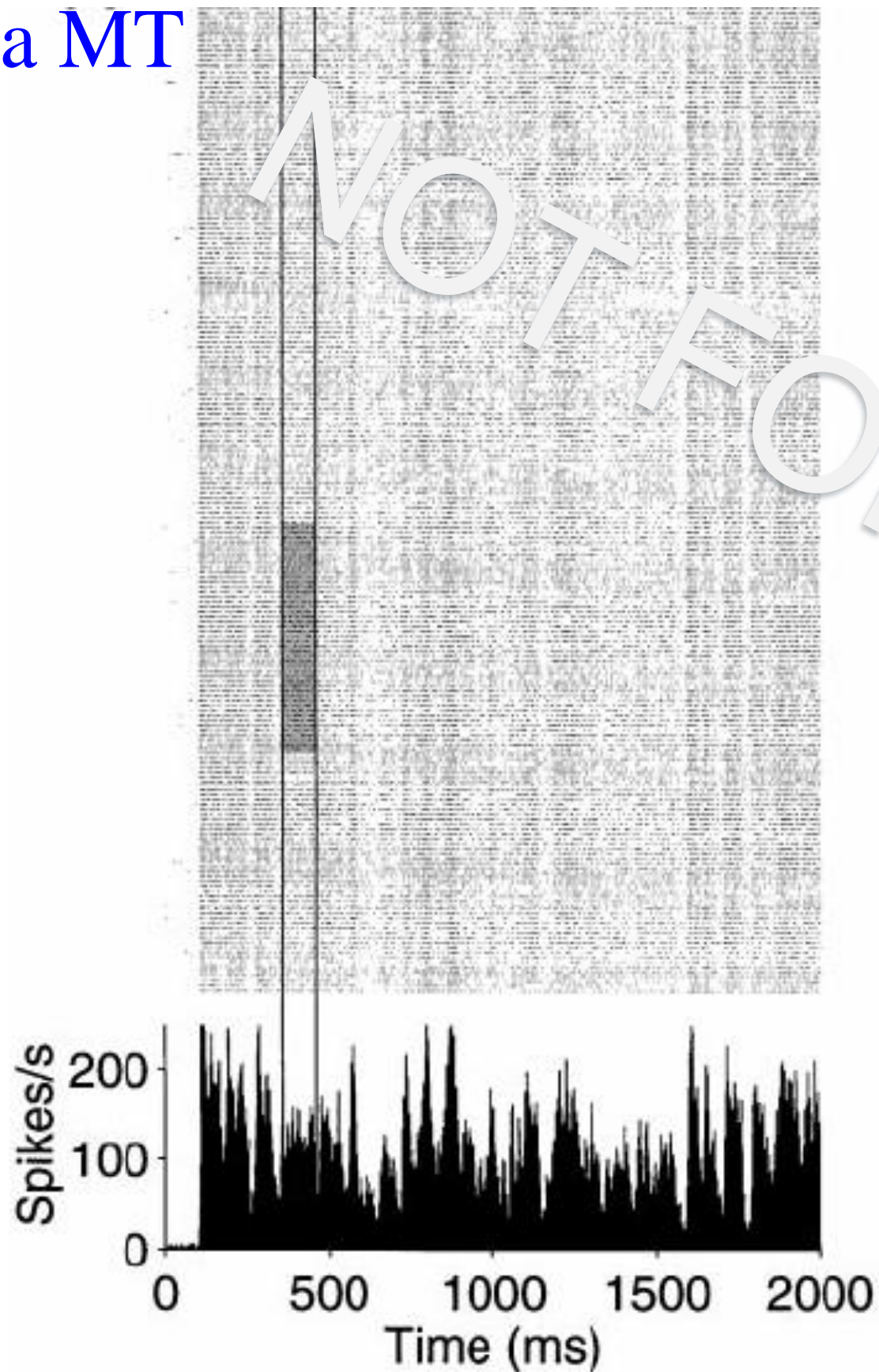
Interval distribution: $P(T) = r \exp(-rT)$

The Poisson distribution



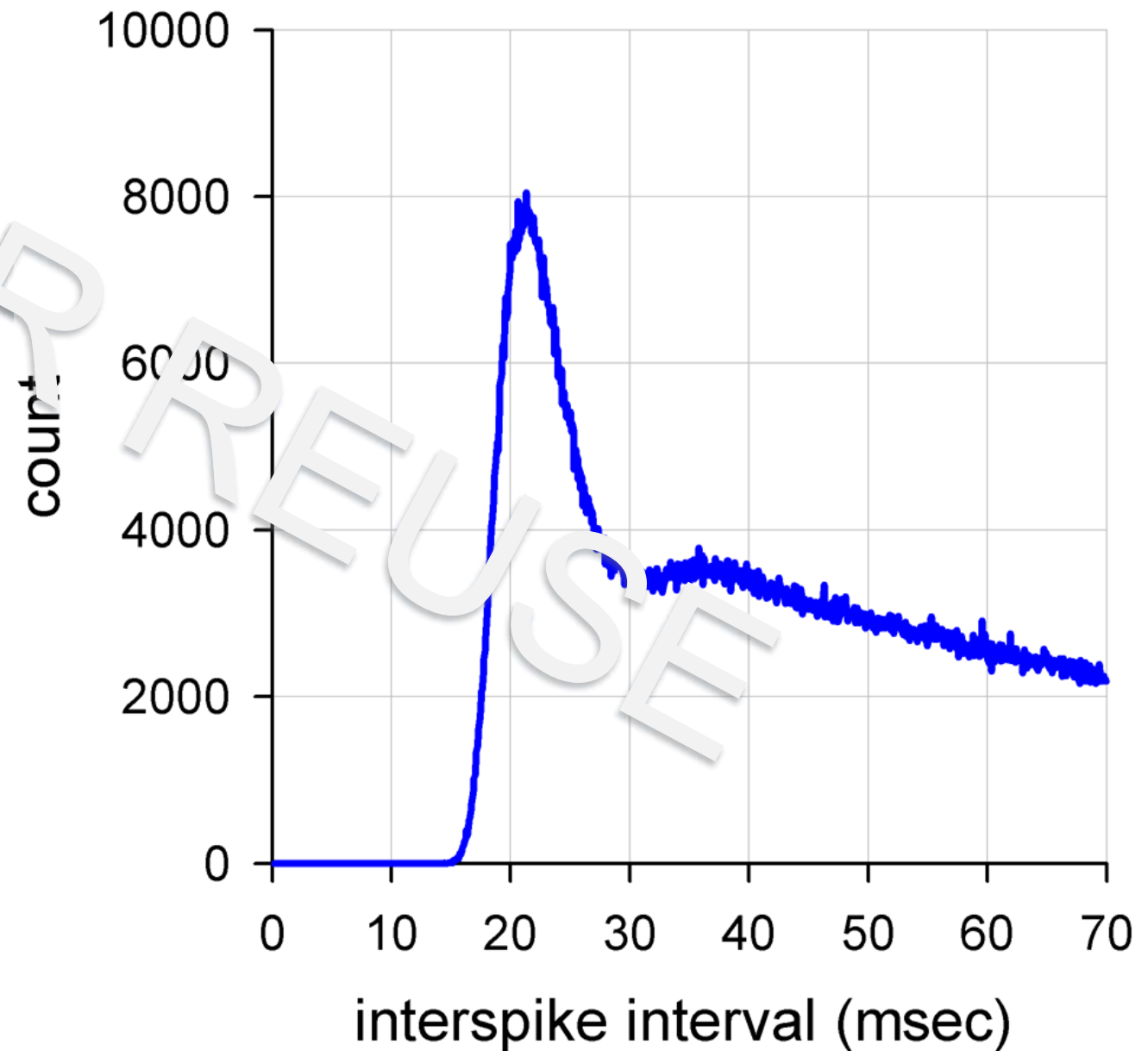
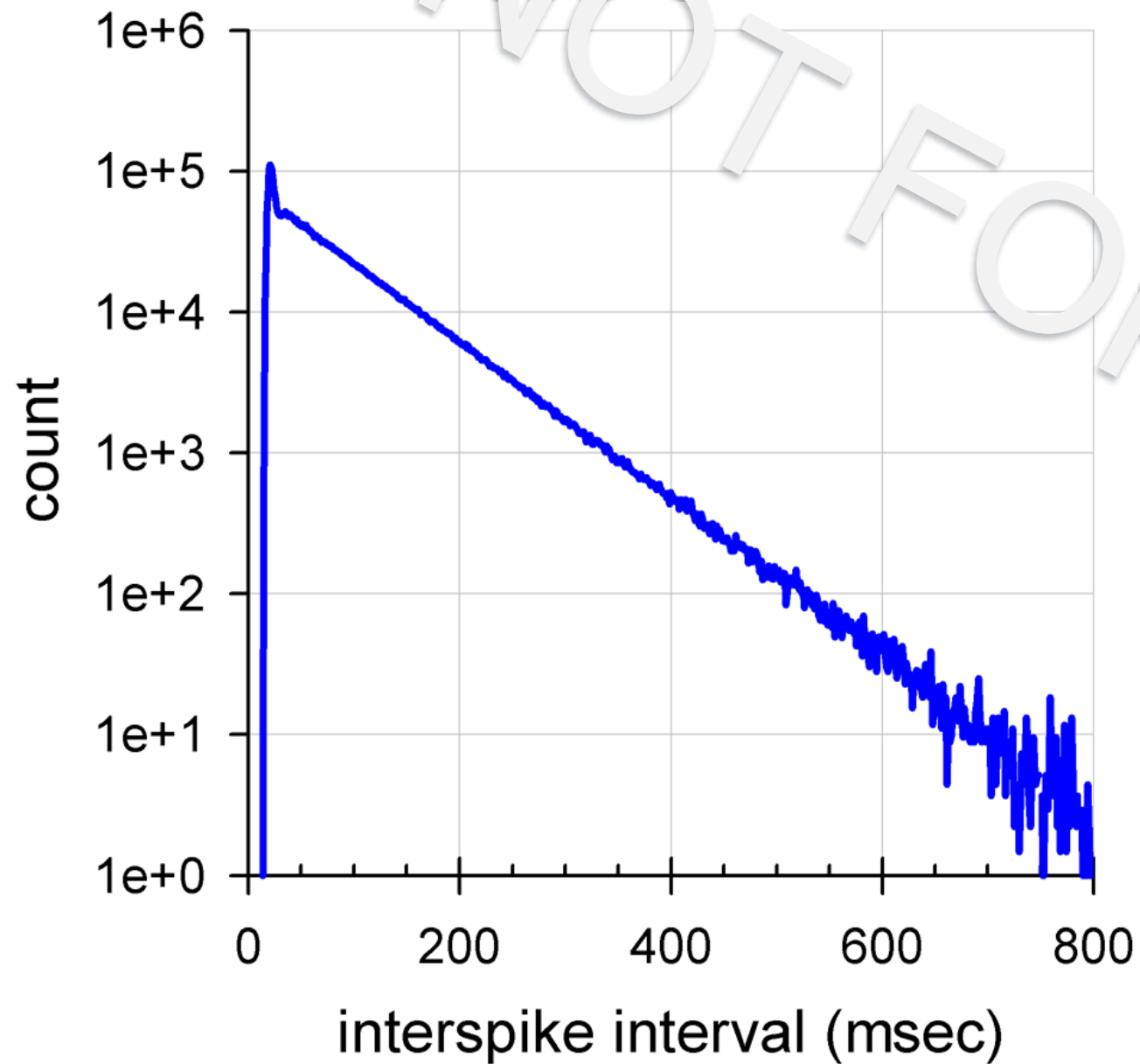
Poisson or not?

Area MT

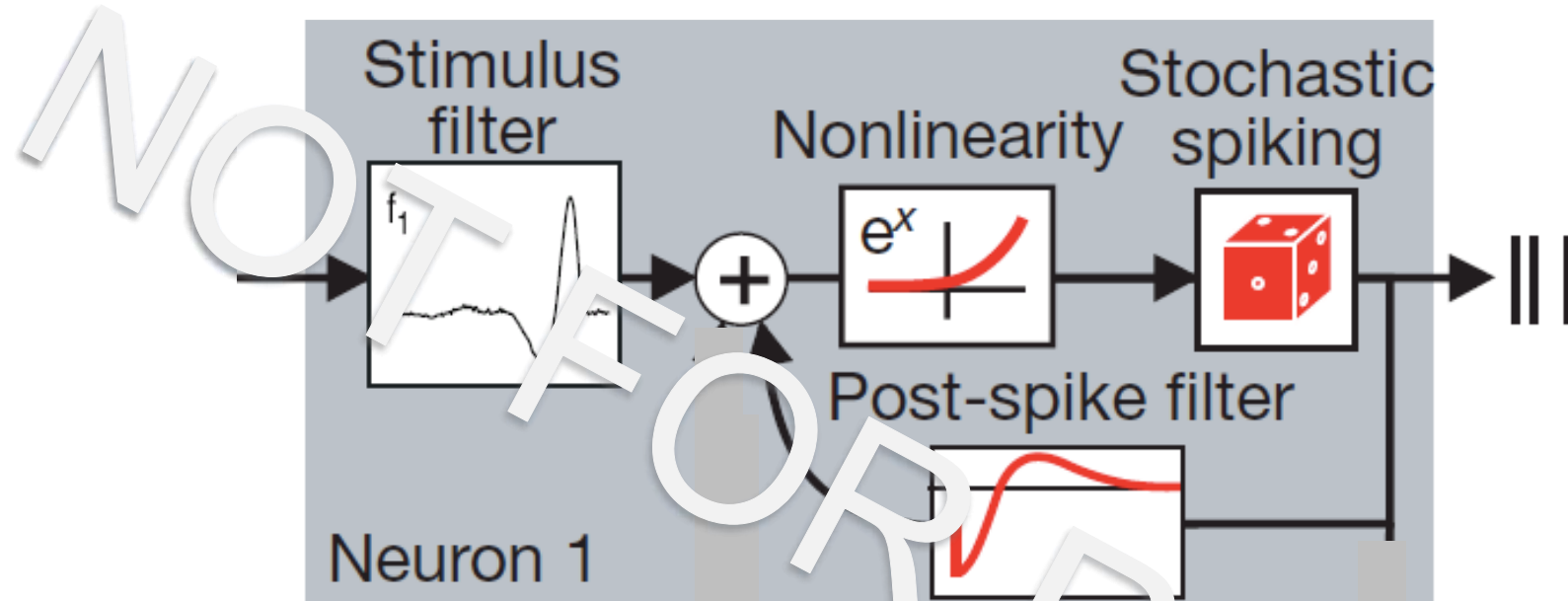


Shadlen and Newsome, 1998

Interspike interval distributions

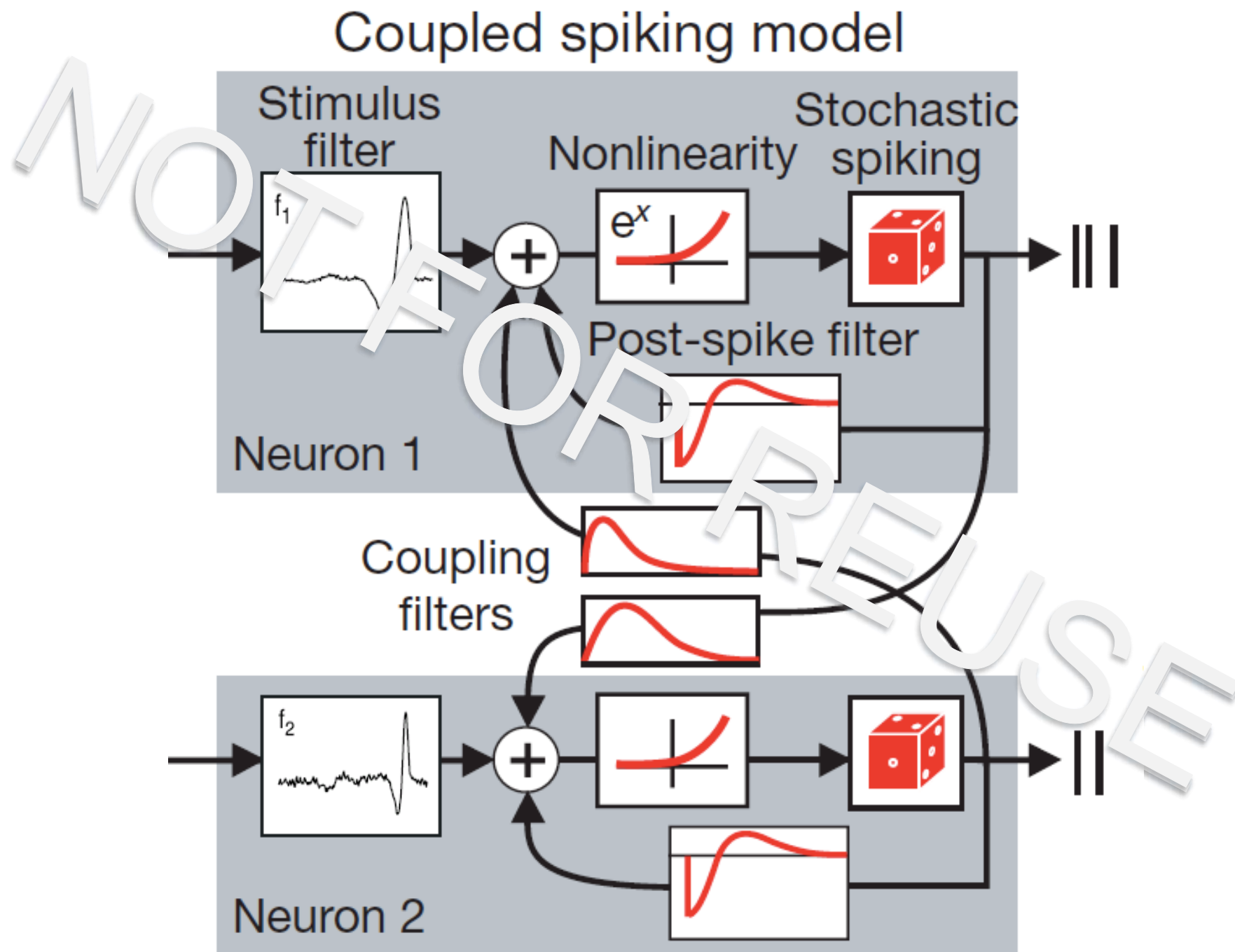


The generalized linear model



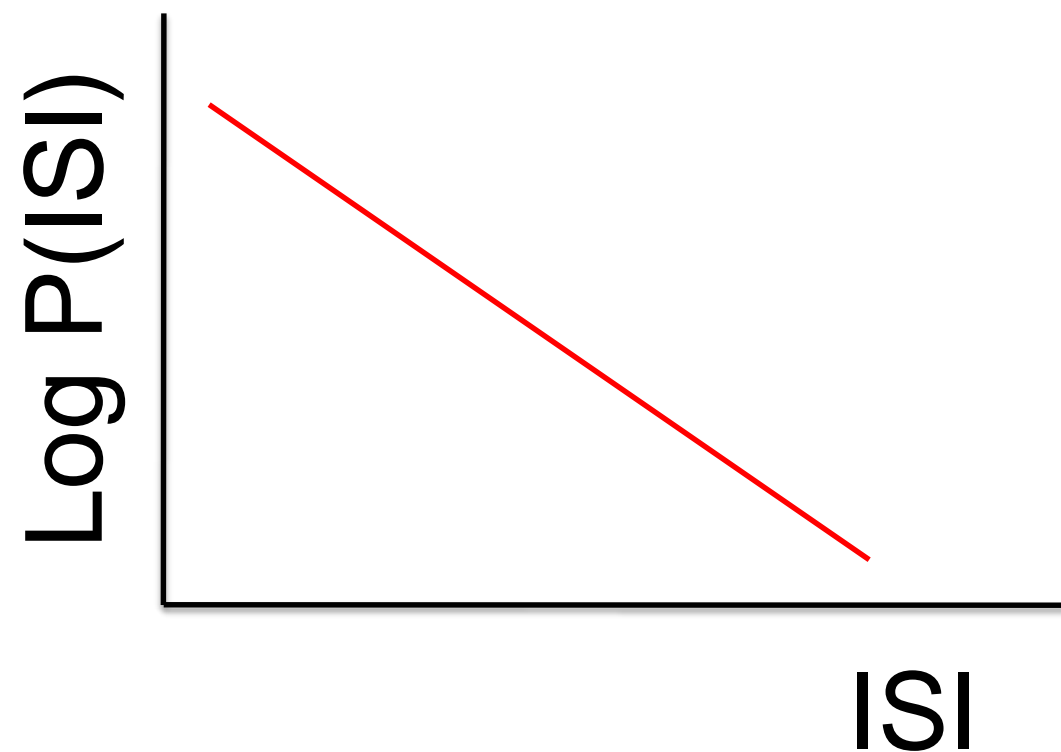
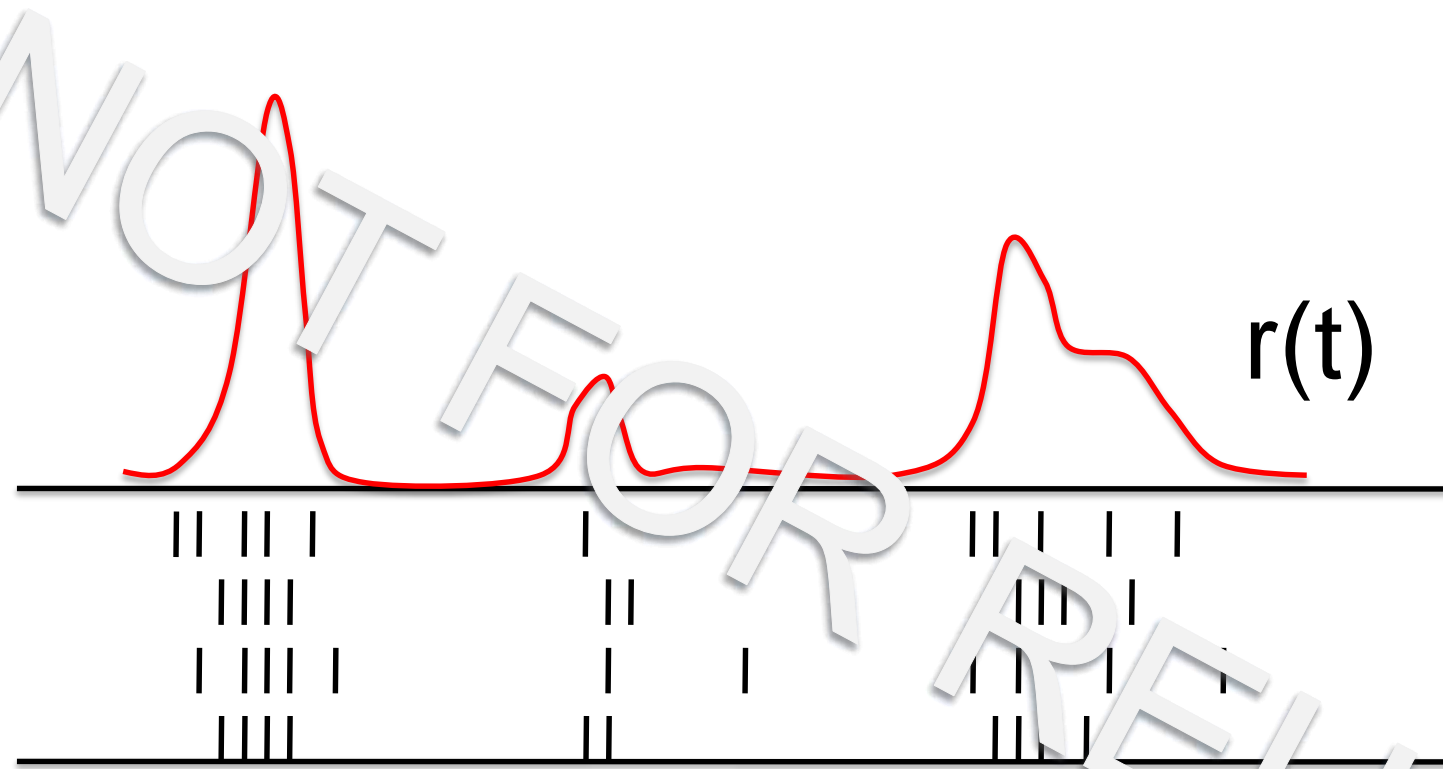
$$\text{GLM: } P(\text{spike at } t) \sim \exp(f_1 * s + h_1 * r)$$

But wait, there's more!



$$\text{GLM: } r(t) = g(f_1 * s + h_1 * r_1 + h_2 * r_2 + \dots)$$

Time-rescaling theorem



Exponential distribution
of *scaled* ISIs:
 $(t_{i-1} - t_i) r(t)$

That's it for encoding!

NOT FOR REUSE



That's it for encoding!

Next week...

- Reading minds!
- Decoding methods