Spatial extent of inputs to primate ganglion cells in natural viewing conditions

Nora Brackbill[1], Alexander Heitman[2], Eleanor Batty[3], Colleen Rhoades[4], Nishal Shah[5], Georges A. Goetz[6,7], Alexandra Tikidji-Hamburyan[6], Alexander Sher[8], Alan Litke[8], Liam Paninski[9], E.J. Chichilnisky[6]

1. Department of Physics, Stanford University, 2. Neurosciences Graduate Program, University of California, San Diego and Systems Neurobiology Laboratories, The Salk Institute for Biological Studies, 3. Department of Neurobiology and Behavior, Columbia University, 4. Department of Bioengineering, Stanford University, 5. Department of Electrical Engineering, Stanford University
6. Departments of Neurosurgery and Ophthalmology, and Hansen Experimental Physics Laboratory, Stanford University, 7. Stanford Neurosciences Institute, Stanford, CA, United States, 8. Santa Cruz Institute for Particle Physics, University of California, Santa Cruz, 9. Department of Statistics, Columbia University

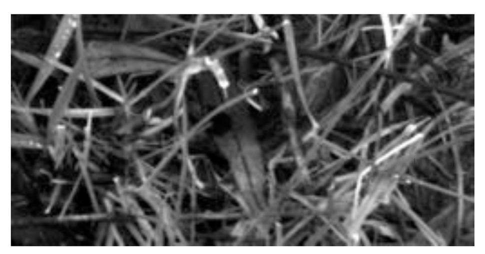
Stanford University

Further information: web.stanford.edu/~nbrack

Background

Pseudo-linear encoding models, where the first step is linear summation of the stimulus over space and time, have become the standard for predicting the responses of retinal ganglion cells (RGCs). They have been successful at predicting responses in some cases[1-5].

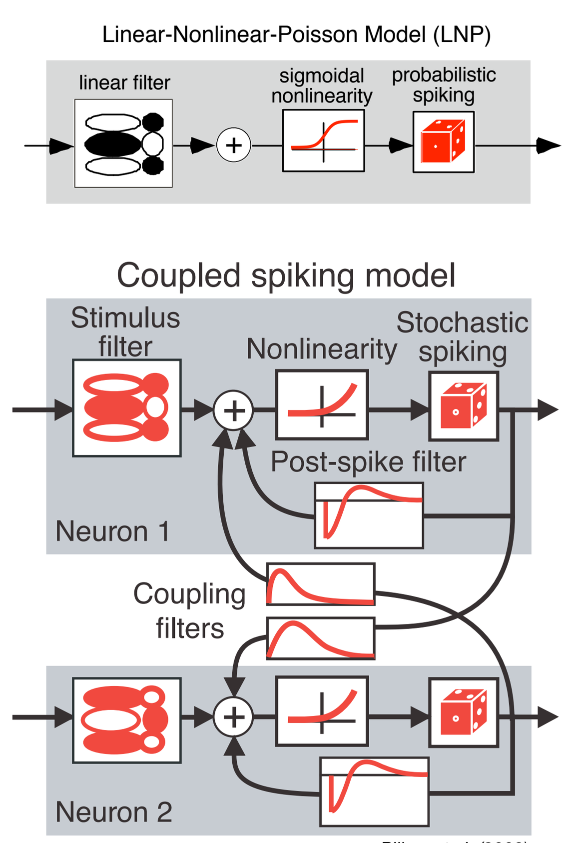
However, it is unclear how accurate this assumption of linearity is, given that there are many known nonlinear mechanisms that contribute to retinal light responses in specific stimulus conditions and cell types[6-9]. It is unknown whether primate RGCs sum visual inputs effectively linearly under the naturalistic conditions that it evolved to encode.



How accurate are pseudo-linear models in predicting primate ganglion cell responses to naturalistic stimuli?

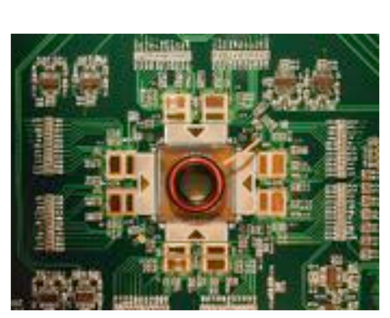
Modeling

The linear-nonlinear Poisson model (LNP) is one of the simplest and easiest to use models, and has been shown to work fairly well. However, it does not capture correlated firing or precise spike train structure, which can be captured by more accurate generalized linear models (GL). However, making these models flexible enough to work for natural scenes and still computationally tractable has proven difficult.

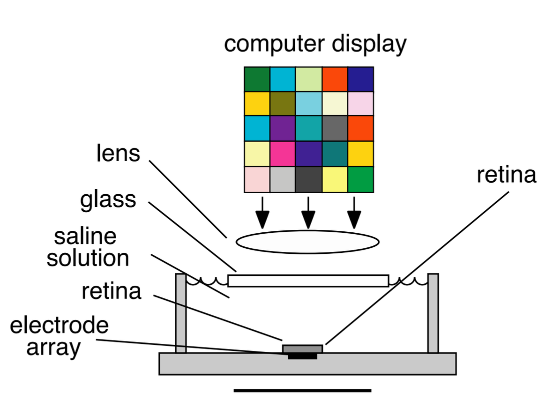


Methods

Large-scale multielectrode recordings were performed in peripheral macaque retina *ex vivo*.



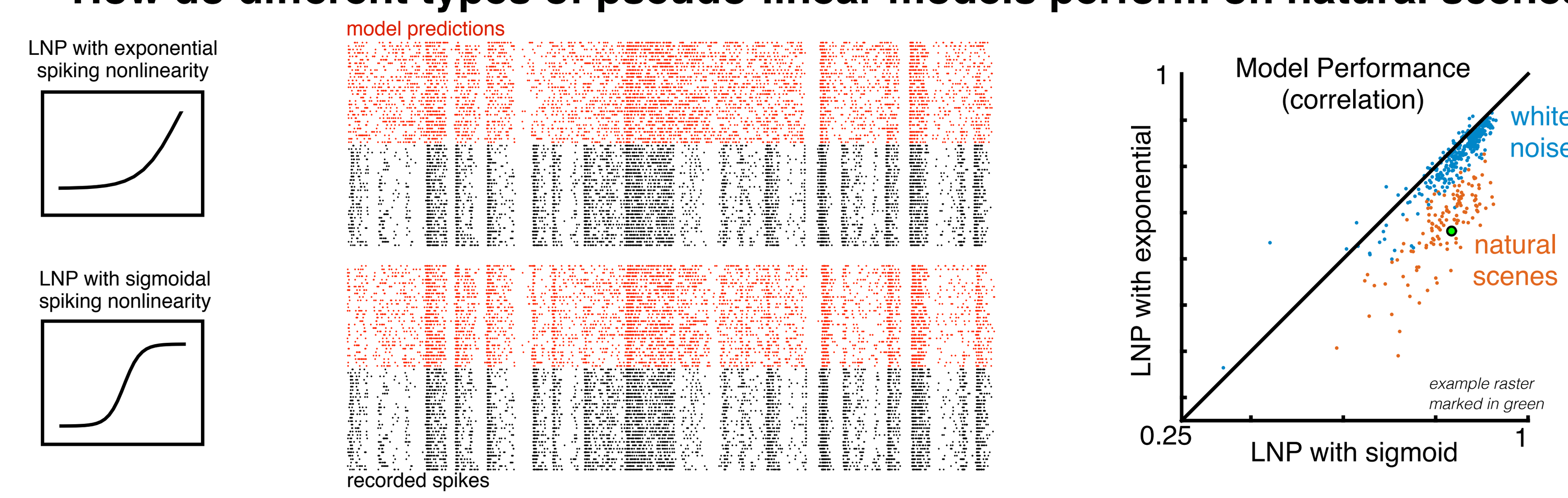
Litke et al. (2004), Frechette et al. (2005)



Natural scenes consisted of images from the van Hateren database[10] with fixational eye movements simulated by Brownian motion[11].

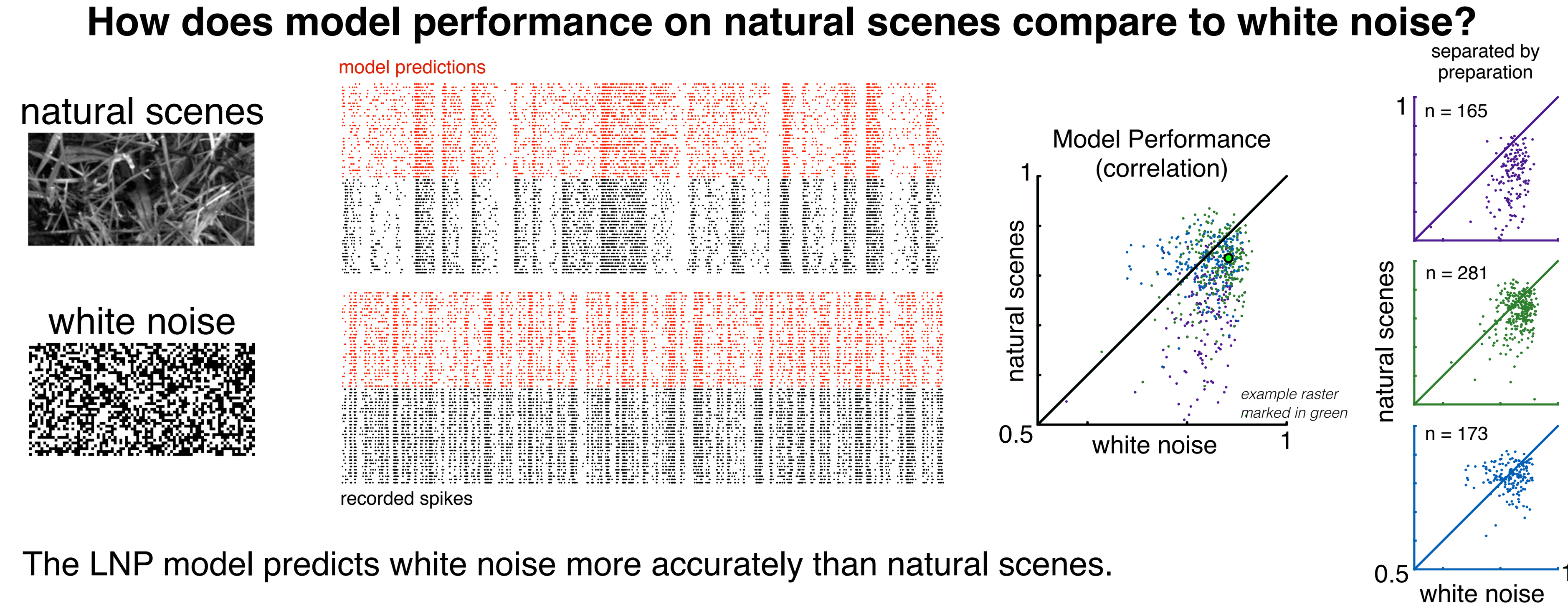
Modeling primate retinal ganglion cell responses to natural scenes using pseudo-linear models

How do different types of pseudo-linear models perform on natural scenes?



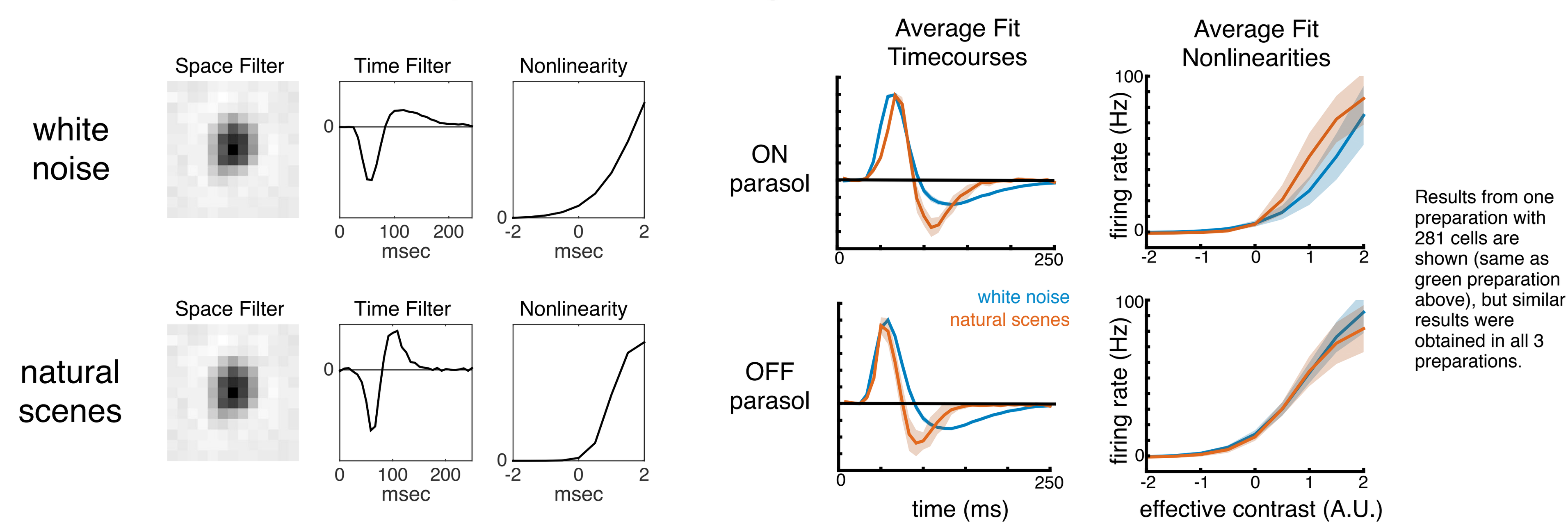
Performance on natural scenes is sensitive to the architecture of the model.

How does model performance on natural scenes compare to white noise?



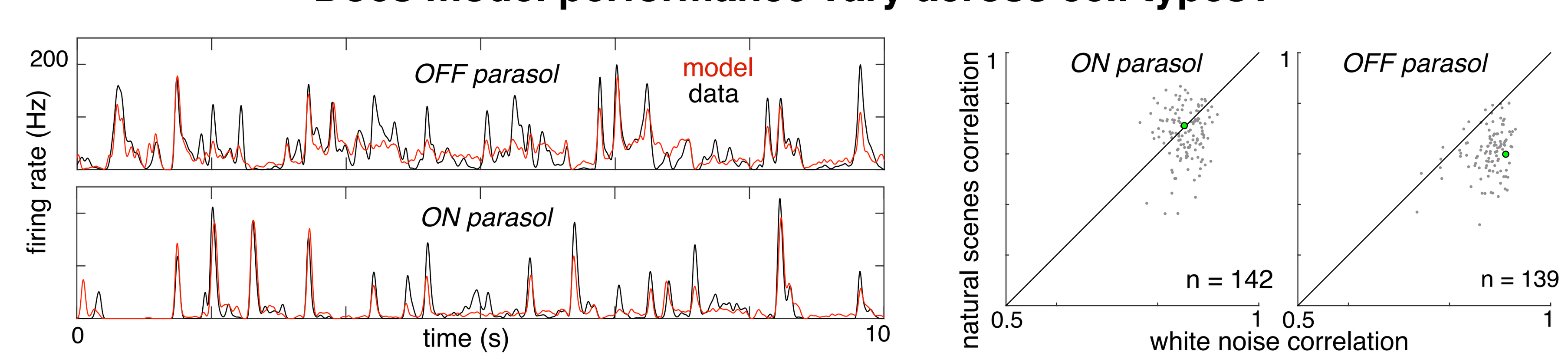
The LNP model predicts white noise more accurately than natural scenes.

How do the model parameters change from white noise to natural scenes?



The temporal filter is more biphasic and the spiking nonlinearity is more saturated for natural scenes.

Does model performance vary across cell types?

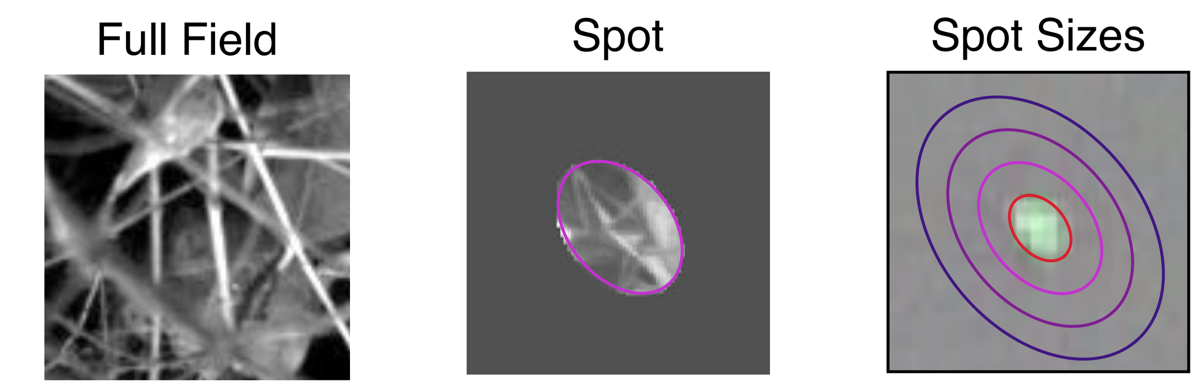


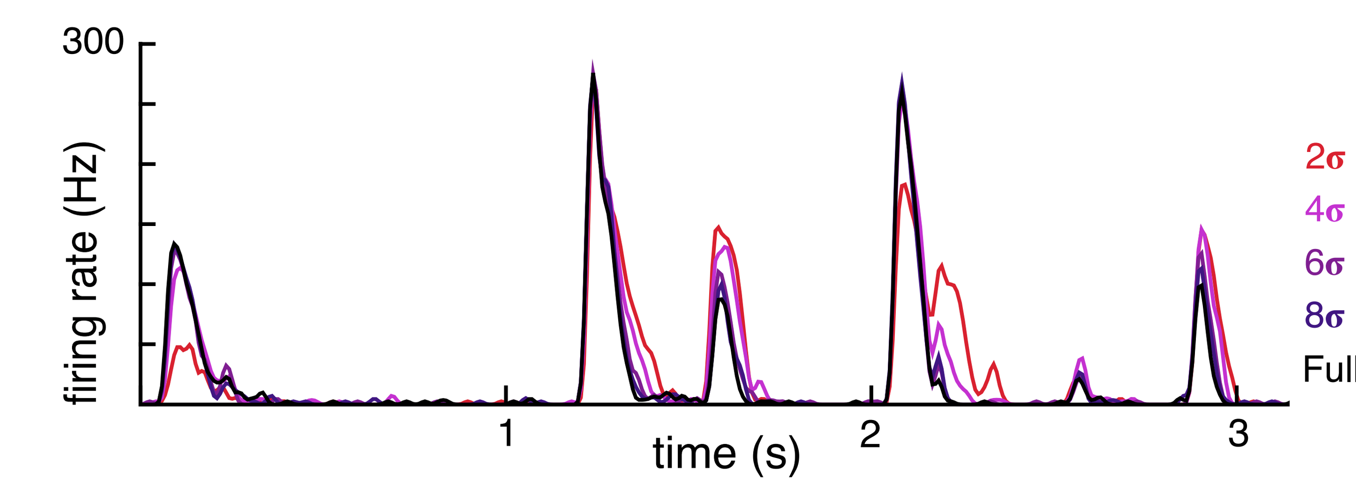
Previous work indicates that ON parasols integrate visual inputs more linearly than OFF[9,12]. A similar asymmetry was observed in 1/3 preparations tested using natural scenes (shown, same as green preparation above).

What effect does peripheral stimulation have on RGC responses under natural viewing conditions?

Extra-classical receptive field effects

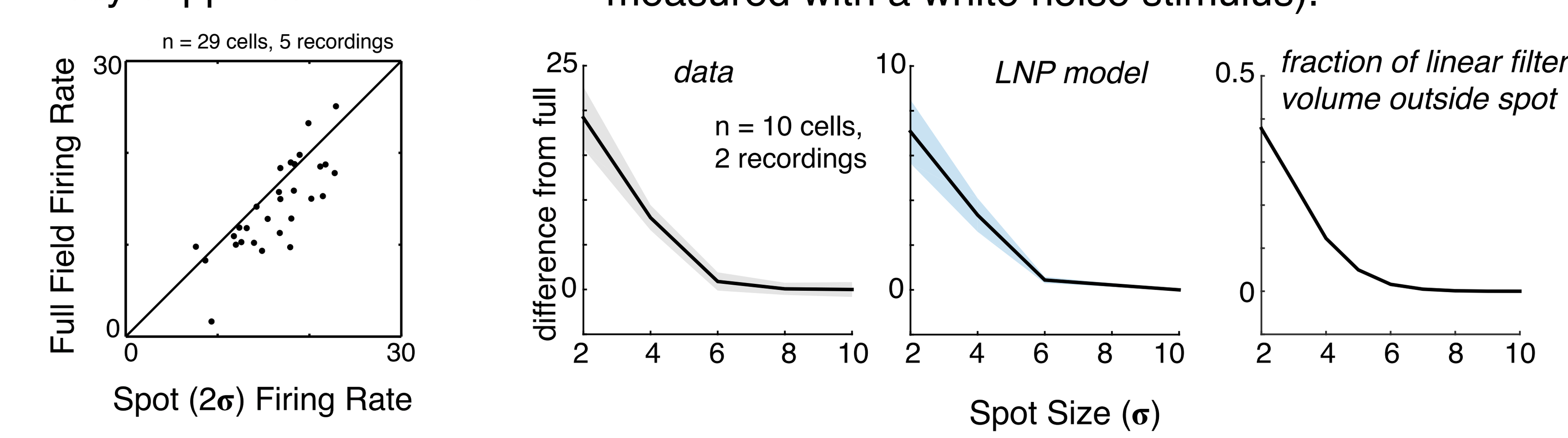
RGCs can receive peripheral input from outside their classical receptive fields[8], thought to be transmitted through wide field amacine cells. How do peripheral stimuli influence responses of primate RGCs in natural viewing conditions? Do we need to include peripheral input in our models?





Consistent with previous findings, the periphery had a mostly suppressive effect.

Surprisingly, this plateau at 6σ can be predicted by the spatial extent of the linear filter (as measured with a white noise stimulus).



The spatial extent of inputs to ON and OFF parasol RGCs can be predicted from the classical receptive field.

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