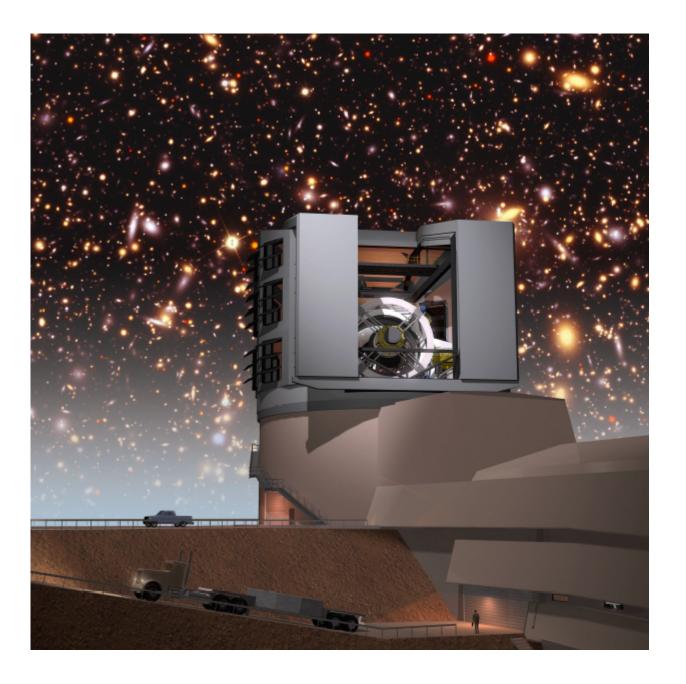
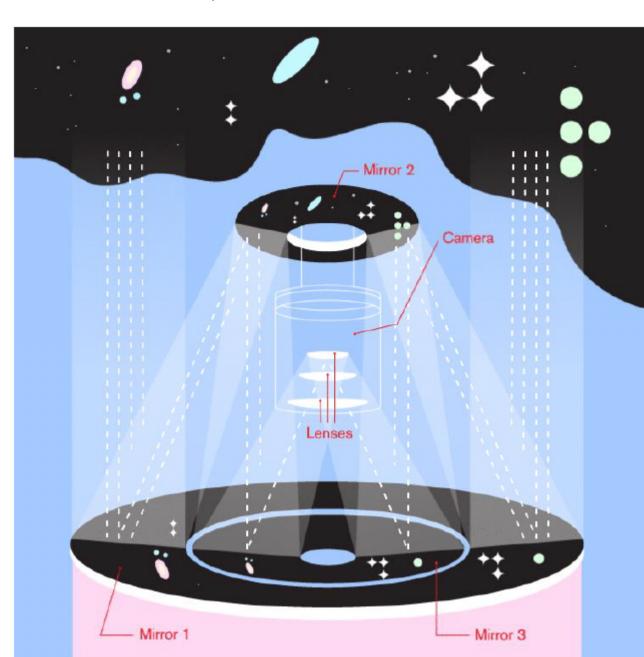
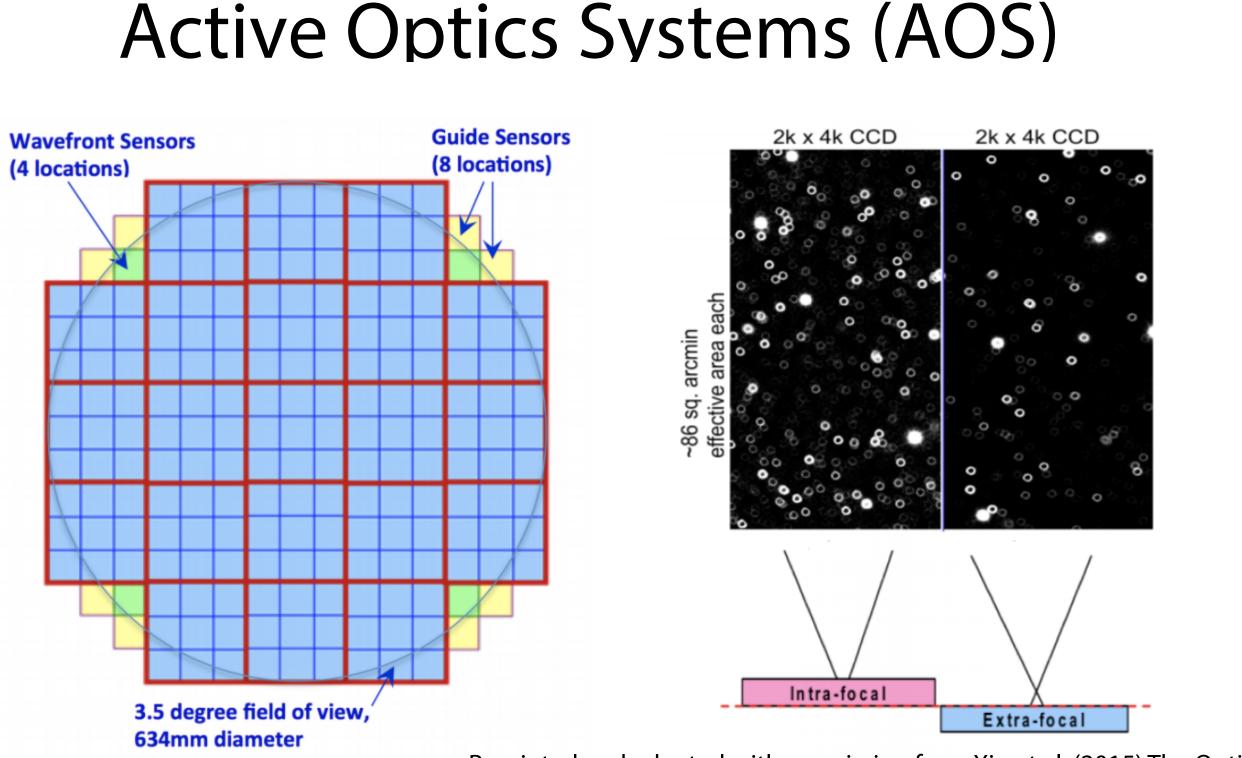


Vera C. Rubin Observatory (Rubin)



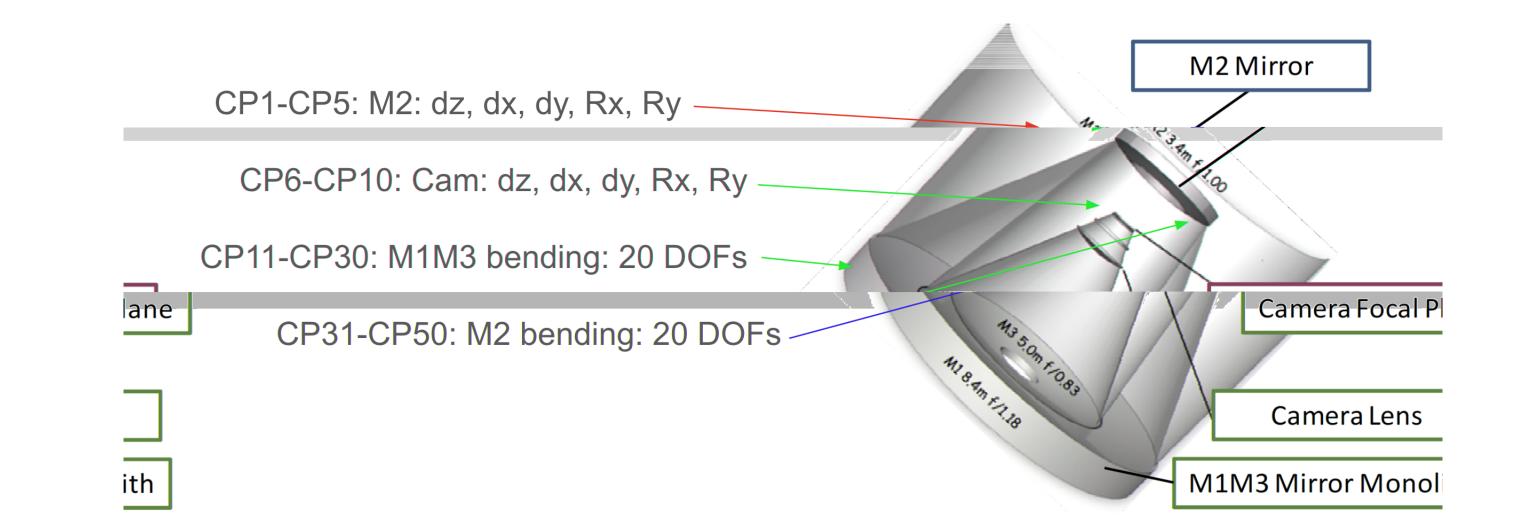


Optical design of Rubin



The Vera C. Rubin Observatory focal plane and the schematic operation of the split wavefront sensors

Control Parameters and Wavefront Generation



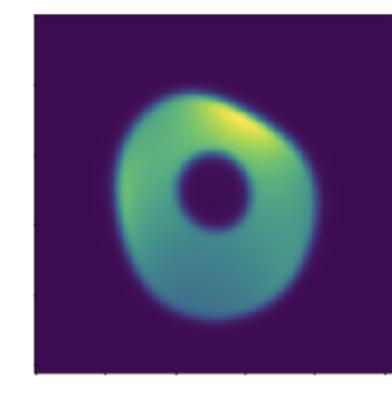
Active Optical Control with Machine Learning: A Proof of Concept for the Vera C. Rubin Observatory

Jun E. Yin, Daniel J. Eisenstein, Douglas P. Finkbeiner, Christopher W. Stubbs, Yue Wang

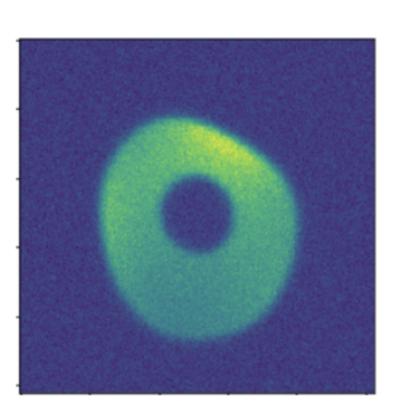
Reprinted and adapted with permission from Xin et al. (2015) The Optical Society.



Donut generation

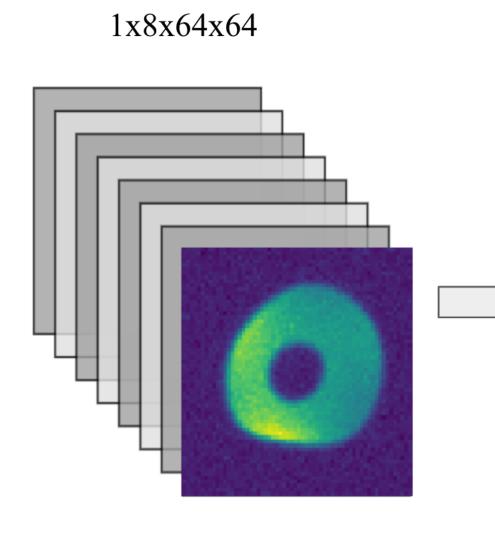


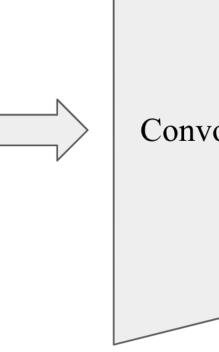
No noise and no shift



Donut images were produced using the *makedonut* code provided by A. Roodman.

Algorithm



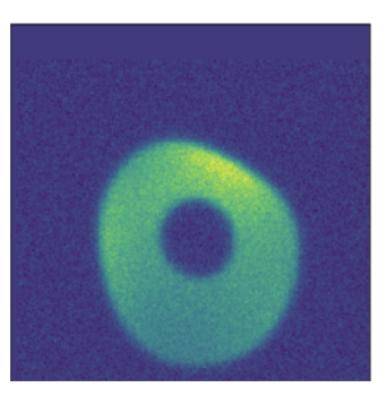


Input: 8 images from wavefront sensors

Loss function

 $L(\mathbf{y}, \mathbf{y}^*) = \sum \alpha_j L_2(y_j, y_j^*) + \beta f(\mathbf{y}^* - \mathbf{y})$

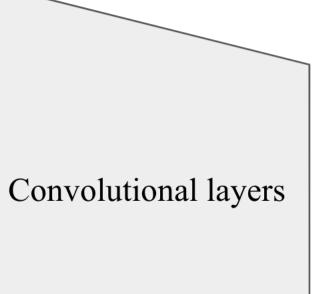
- scaled L2 loss;
- addition of a PSF term to the loss function;
- anti-aliasing pooling;
- self-attention



With noise but no shift

With noise and shift

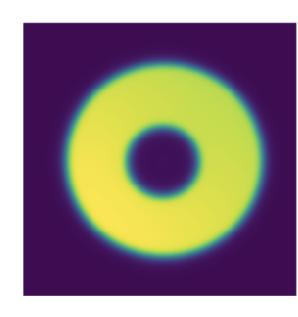
1x50





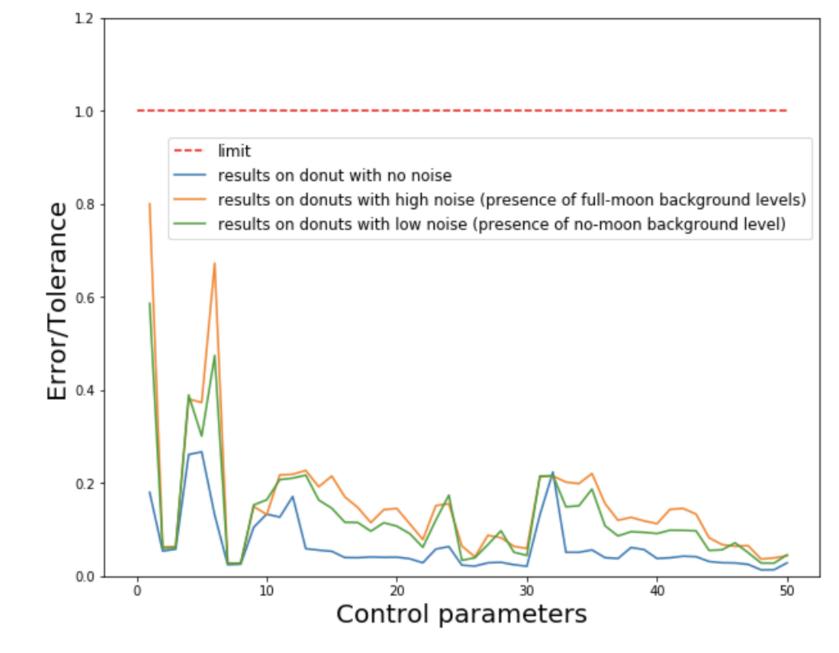
Network architectures

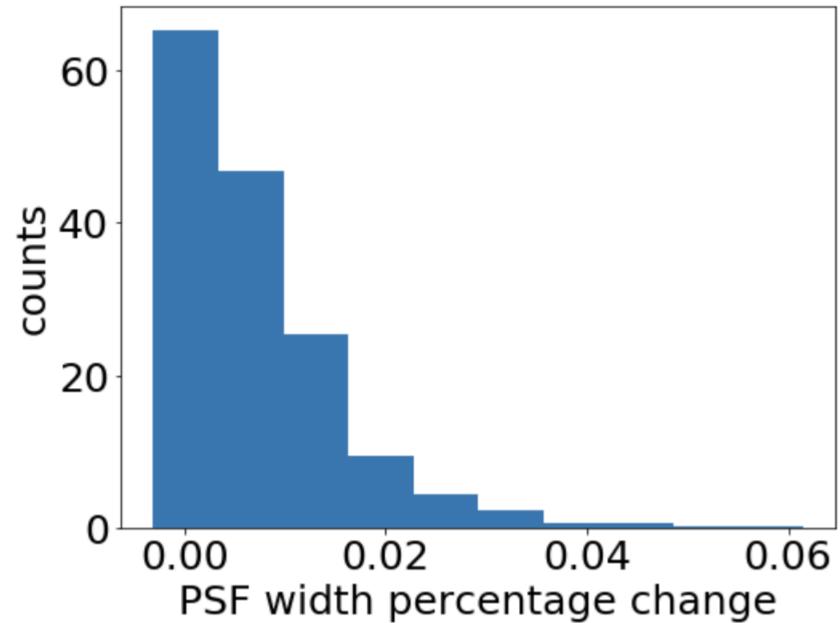
Output: prediction of 50 control parameters



Donut image with all perturbations corrected in the optical system

Results





Selecting the 10% worst cases based on PSF, we construct the PSF for typical seeing of ~0.65 arcsec, measure its FWHM, and find that the prediction error of the CPs makes only a small contribution to the FWHM.

Summary

modest changes in performance;



Prediction RMSE over error tolerance for the 50 con trol parameters. The RMSE of each CP output by the neural network is with in the tolerance.

• Using the scaled L2 loss and adding a PSF term to the loss function enhances performance substantially; Including anti-aliasing pooling, and augmenting the training data to include randomly shifted donuts, the resulting model performance is insensitive to image shift; Including self-attention modules in the CNN led to • Significant up-front computational expense is rewarded with fast and accurate evaluation