

2D point spread function characterization for Prime Focus Spectrograph

N. Caplar, J. Meyers, R. Lupton, J. Gunn, PFS collaboration



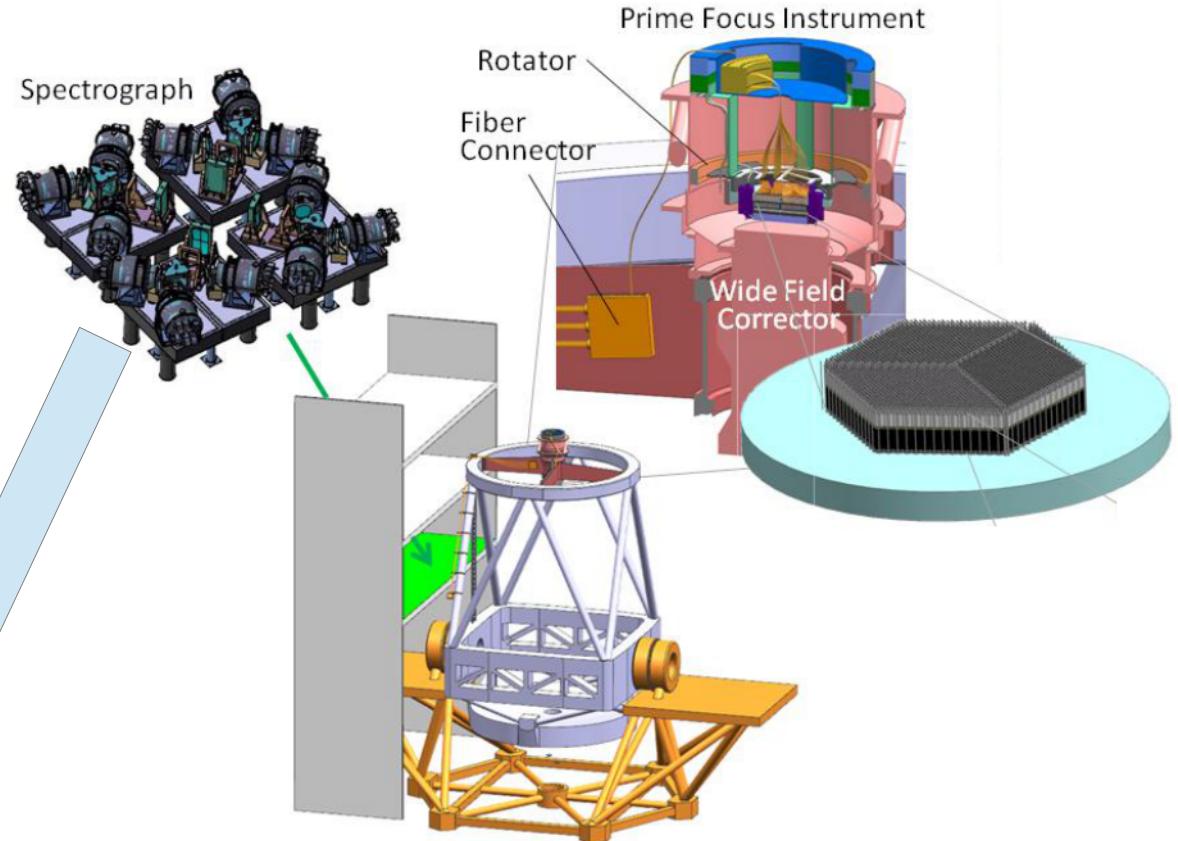
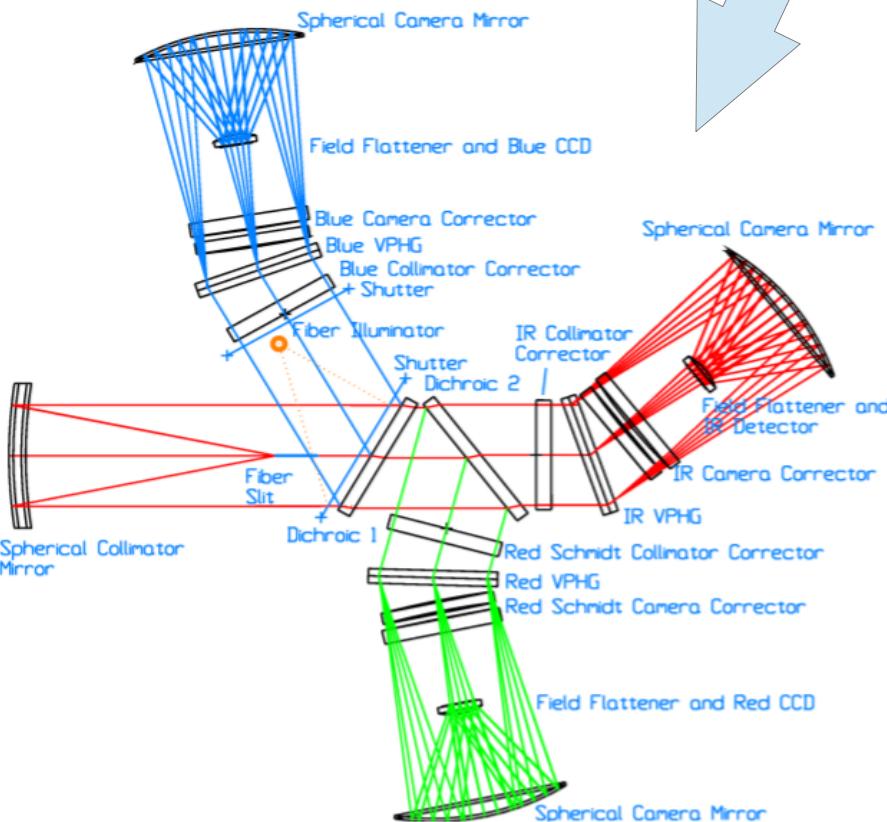
PRINCETON
UNIVERSITY



To be installed on Subaru telescope

Science drivers are:

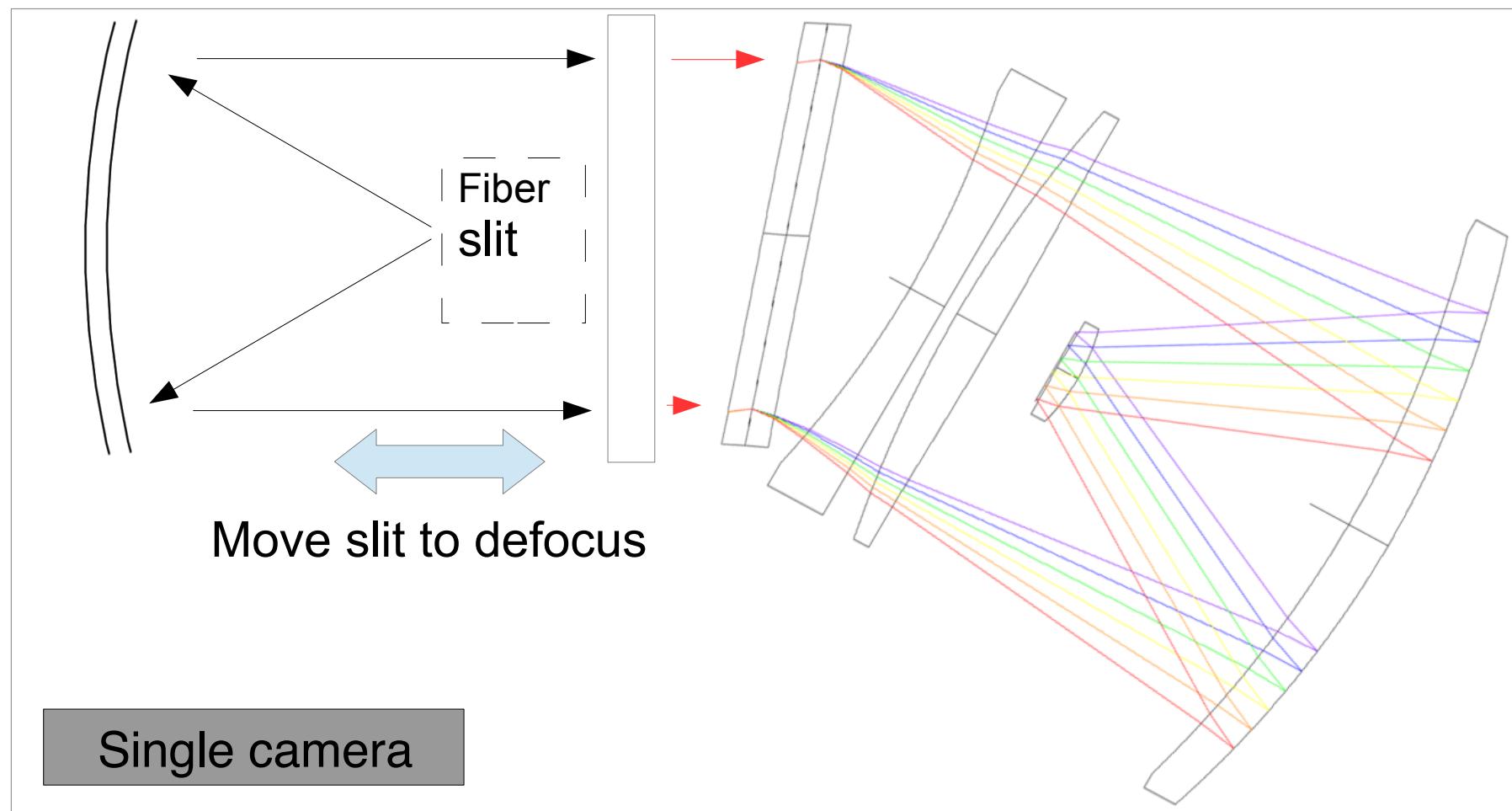
- cosmology
- galactic archeology
- galaxy/AGN evolution



- Commissioning start: 2019
- Fiber spectrograph (2400 fibers)
- Wavelength range: 0.38 to 1.28 μm

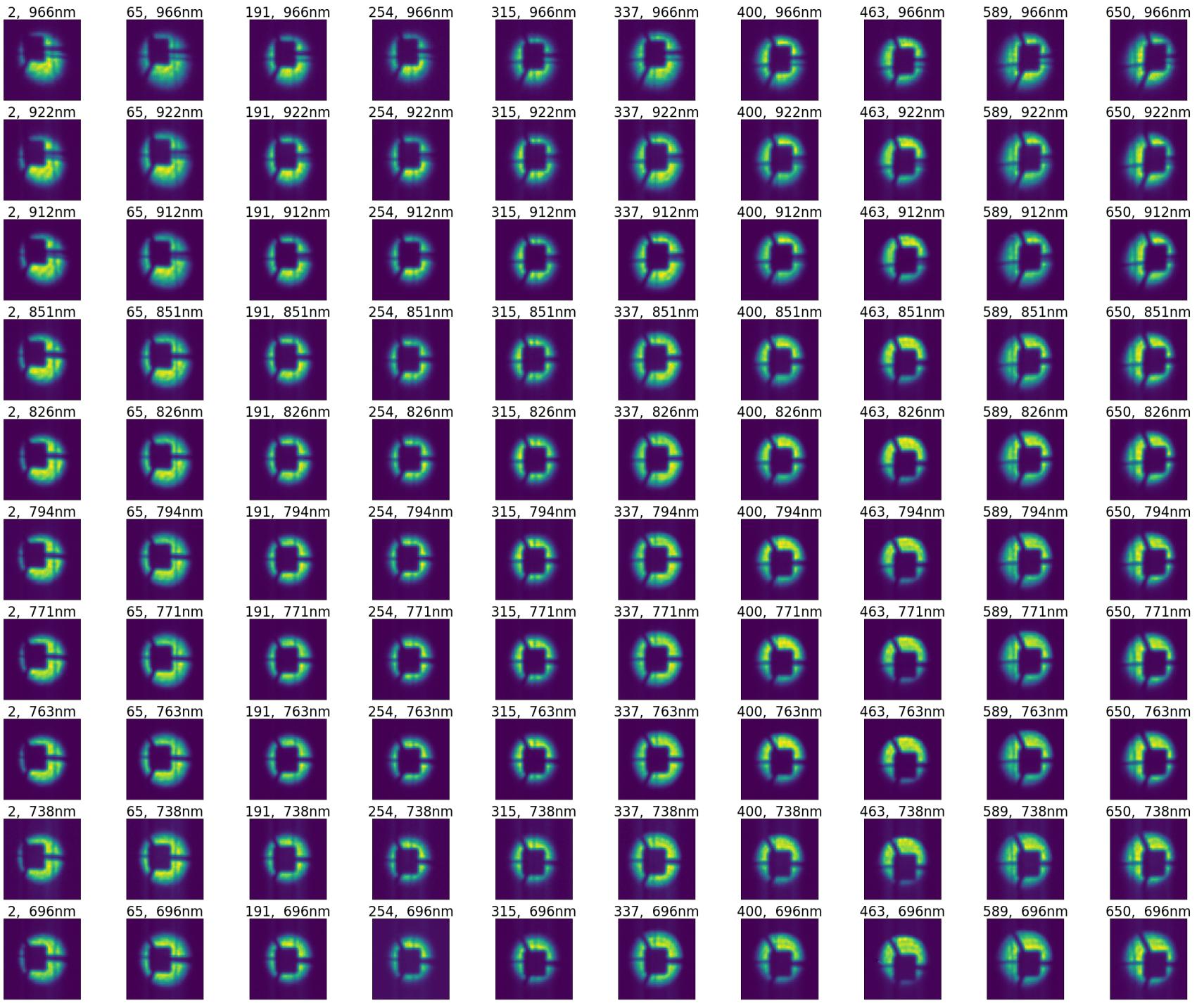
3 components to the PSF

- Telescope pupil illumination
- Focal ratio degradation in the fibres
- Spectrograph cameras



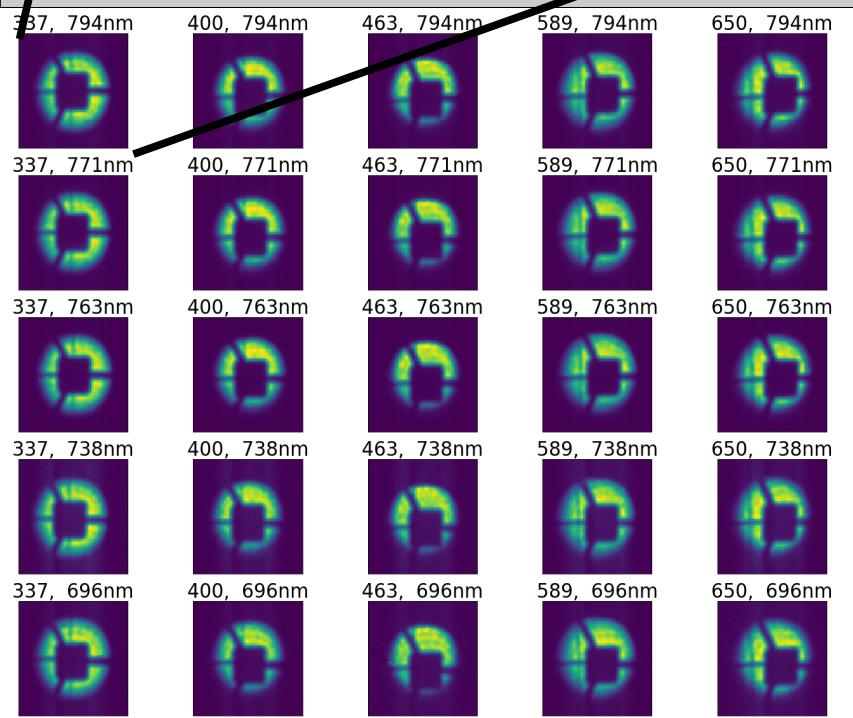
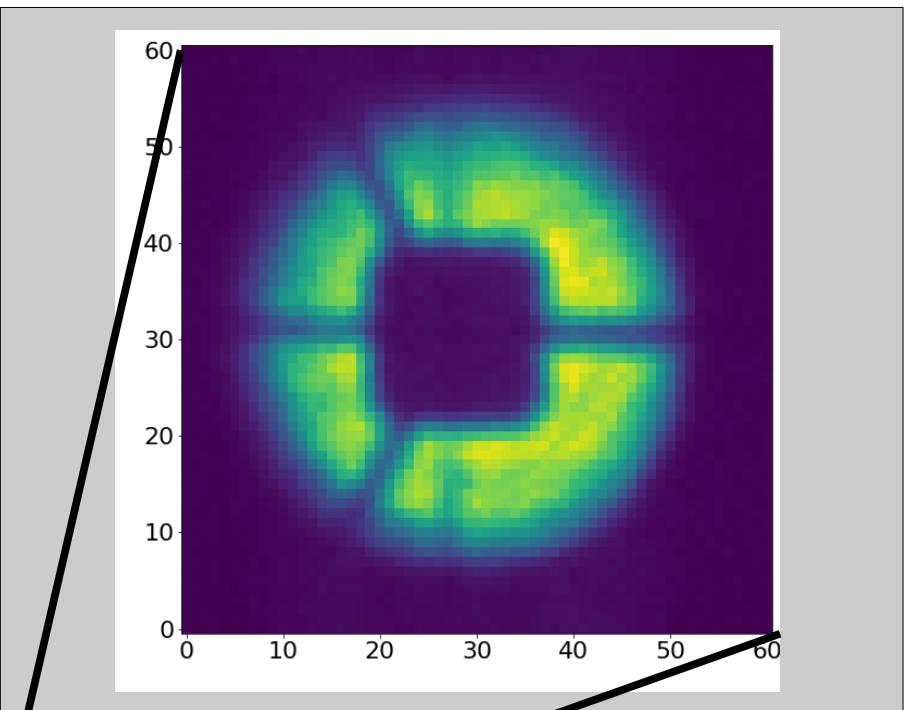
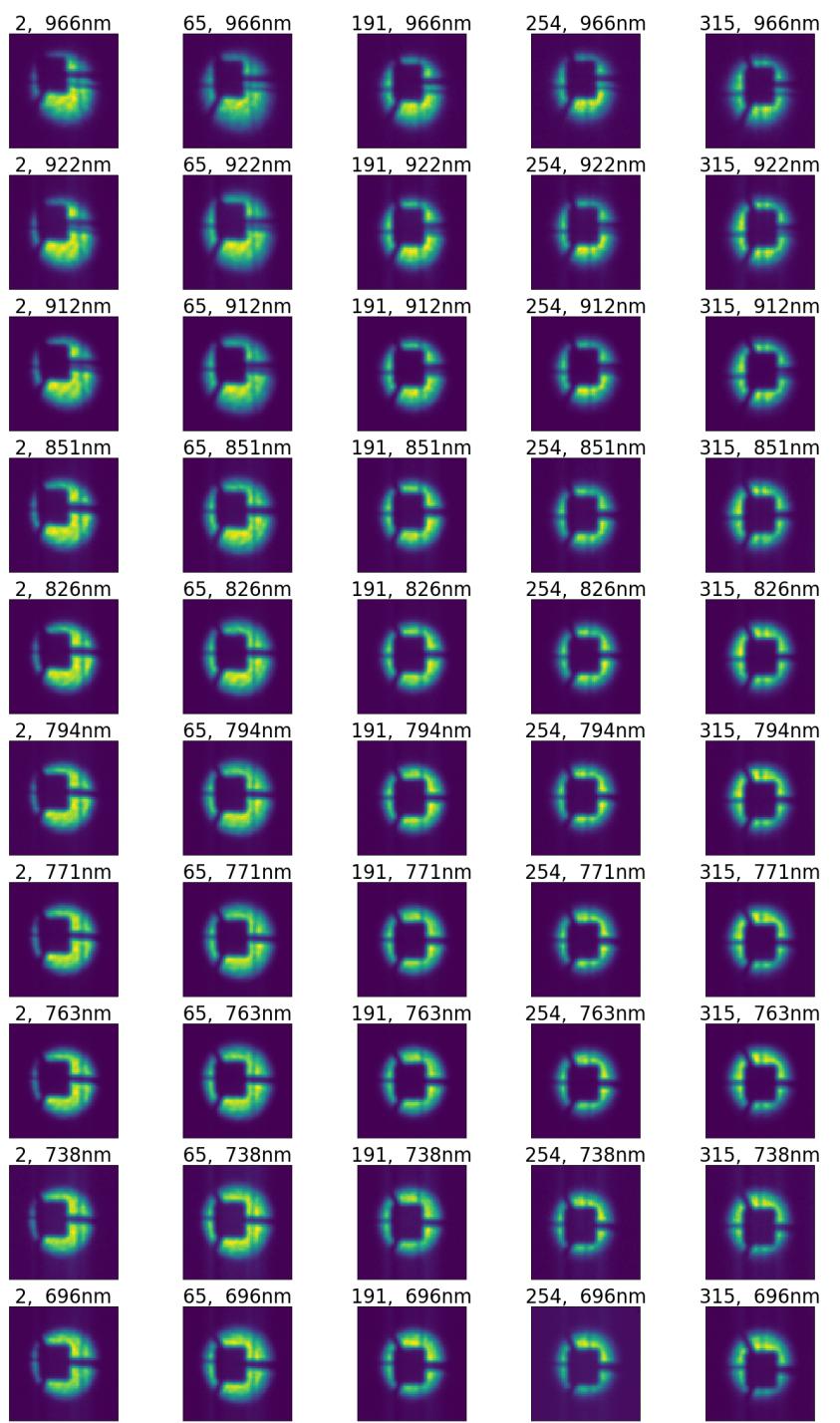
- Separate these 3 components (v, fibers & camera) causing aberrations in the PSF by working in wavefront space
- We aim to characterize contribution of camera imperfections to PSF by modelling optical performance using defocussed data
- Data taken from the first assembled camera at Laboratoire d'Astrophysique de Marseille
- Let's look at it!

wavelength

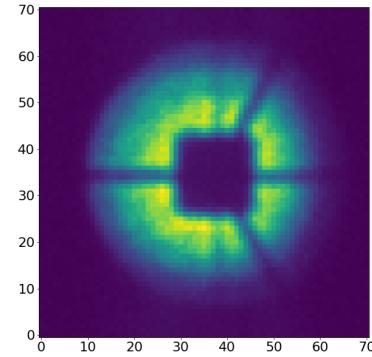


Different fibers

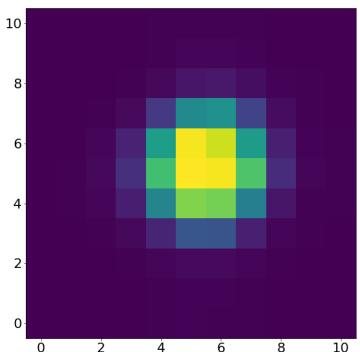
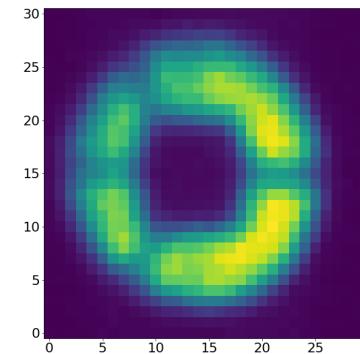
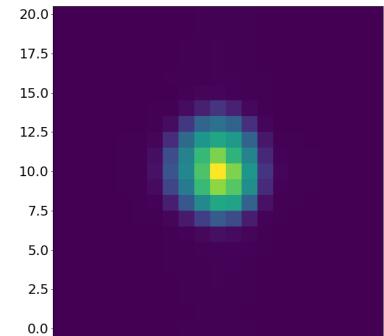
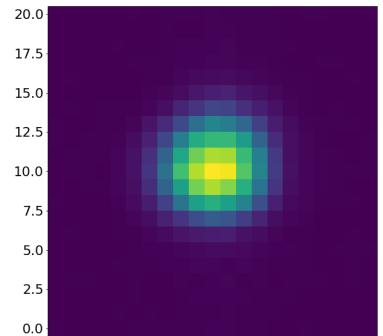
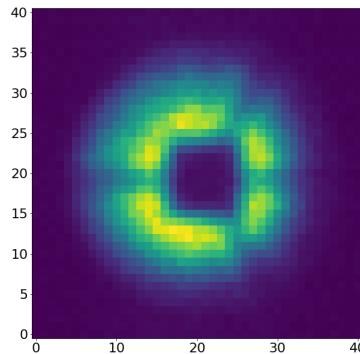
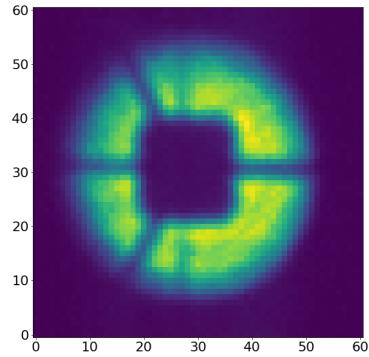
wavelength



Different fibers



We have even more information!
Images taken at different values of
defocus
Follow wavefront aberrations as a
function of defocus

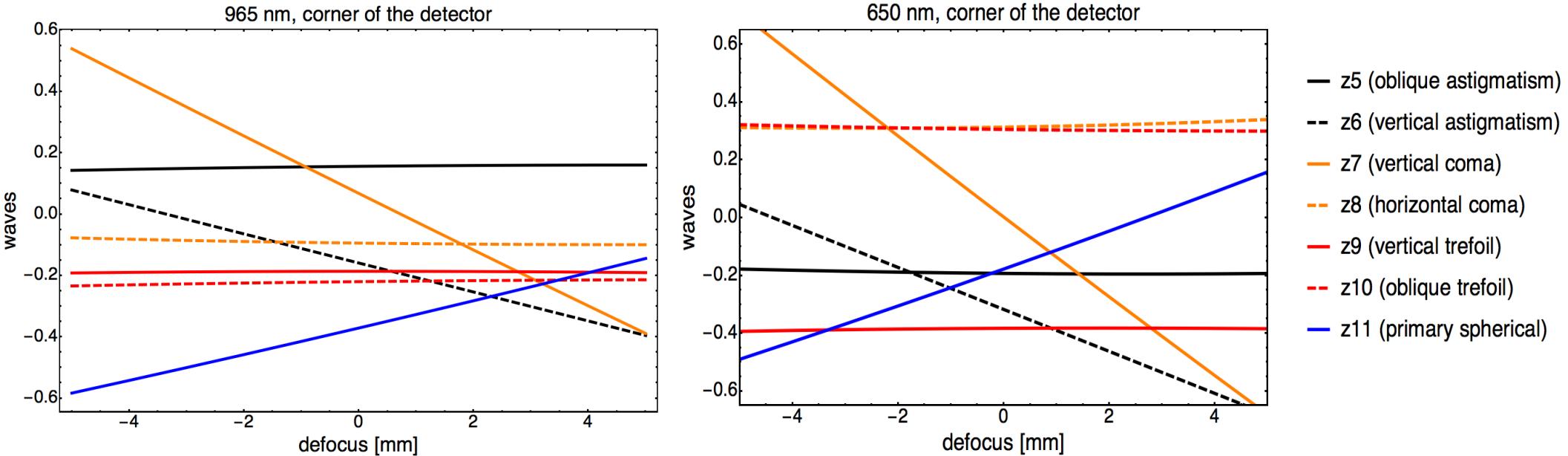


More defocused

In focus

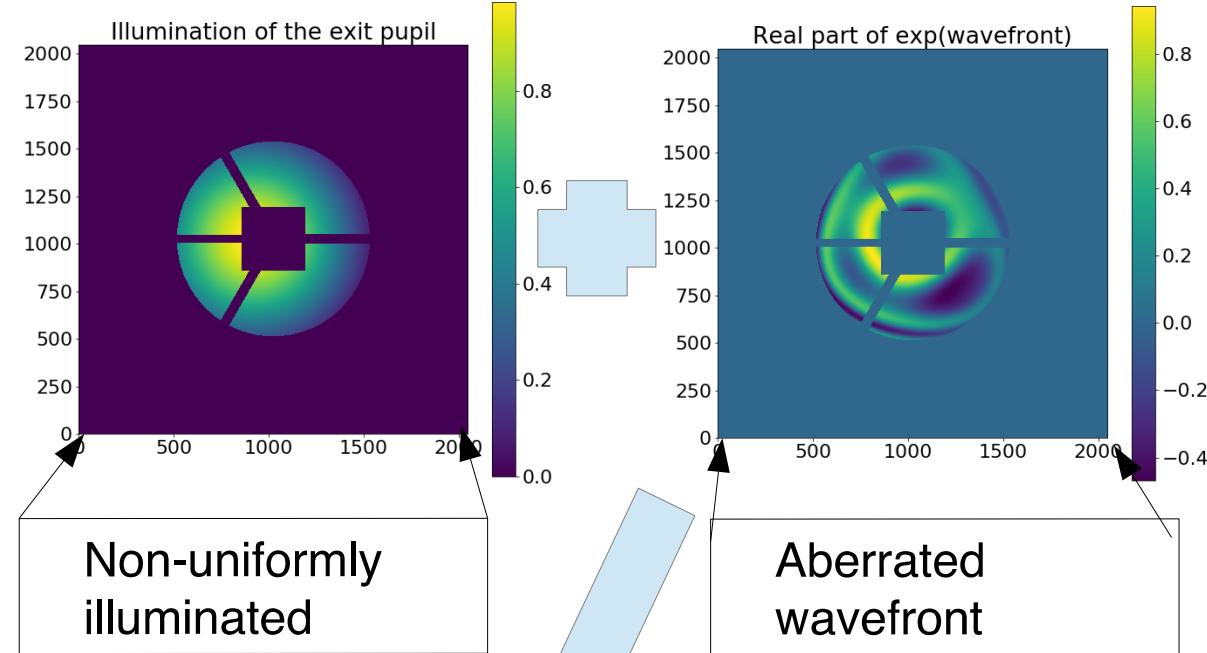
More defocused



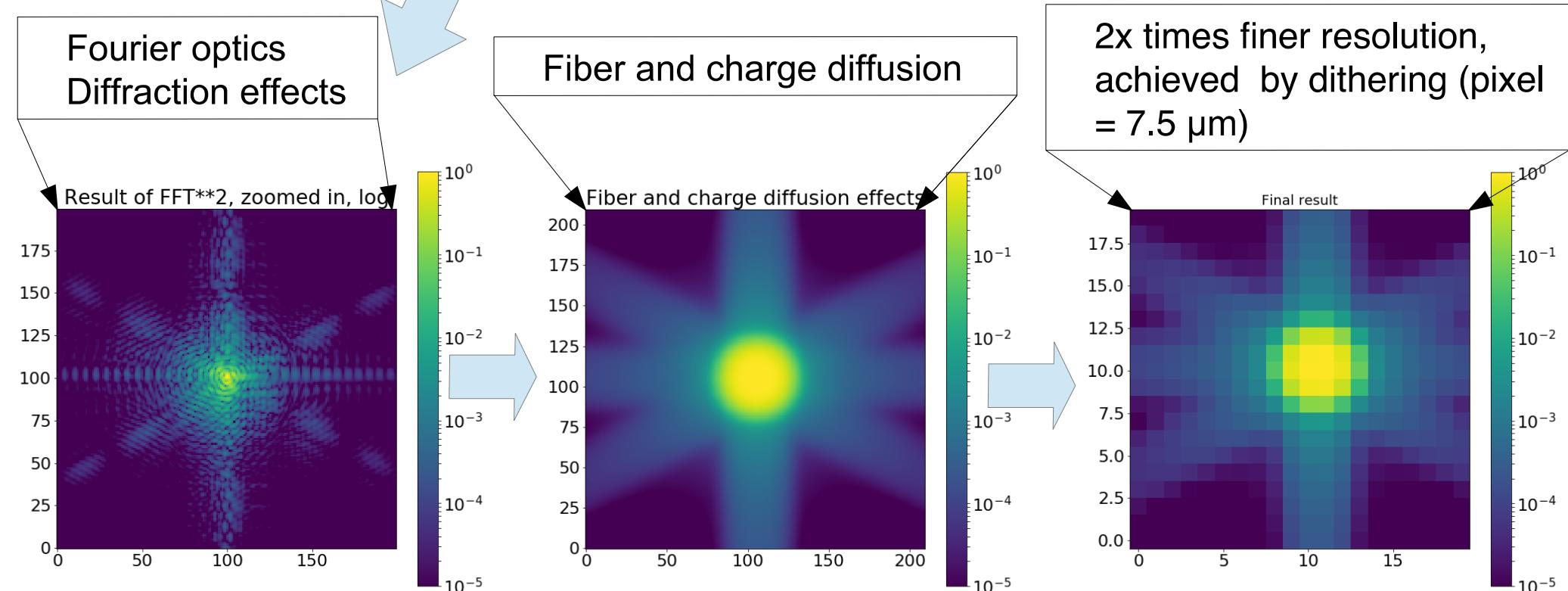


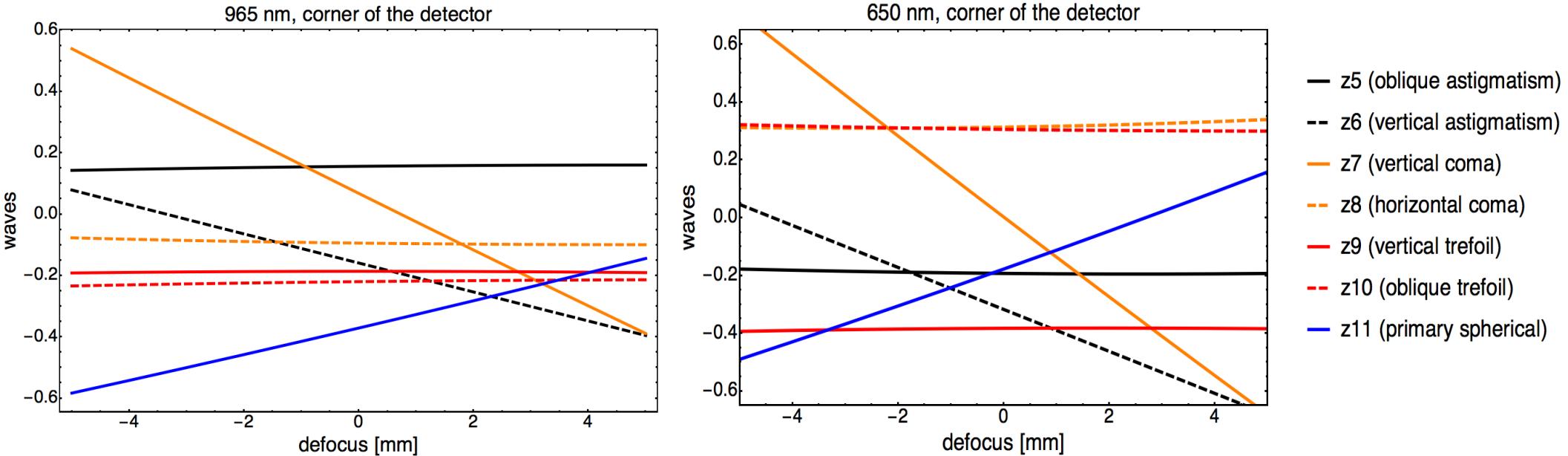
Example from Zemax modelling

We wish to deduce/reproduce these curves from the data
 Model wavefront aberrations at each position of the detector

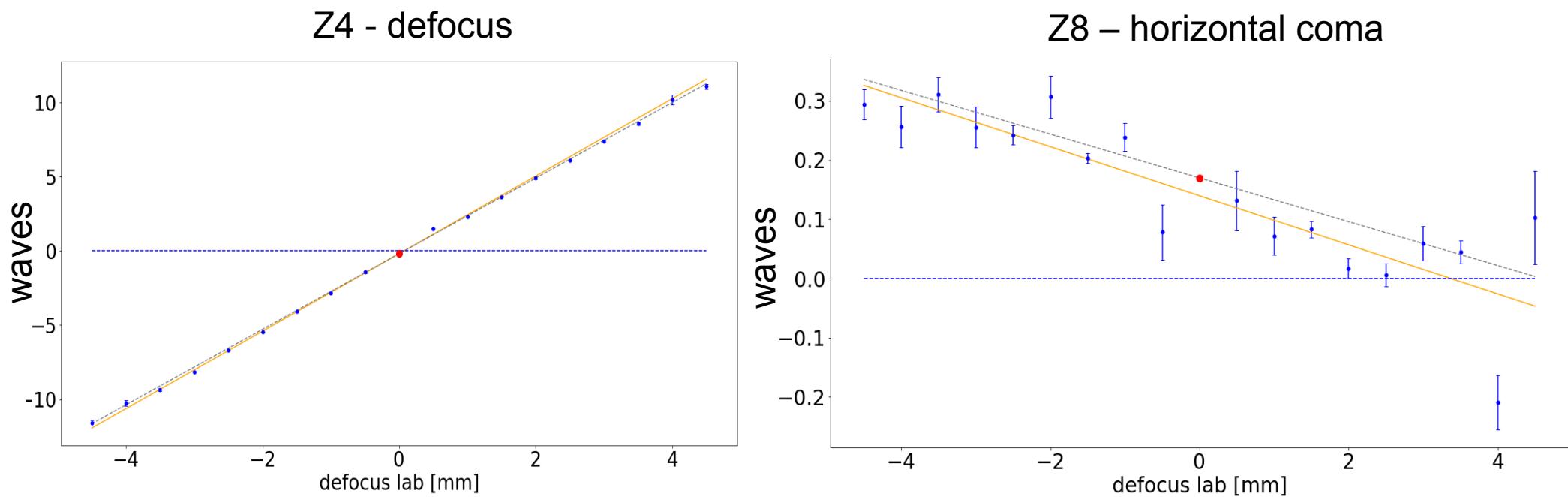


- We have been developing a model to simulate PSF based on our experience in HSC project
- Non-uniform illumination of the pupil
- Wavefront aberrations
- Fourier optics
- Finite size of fiber
- Charge diffusion

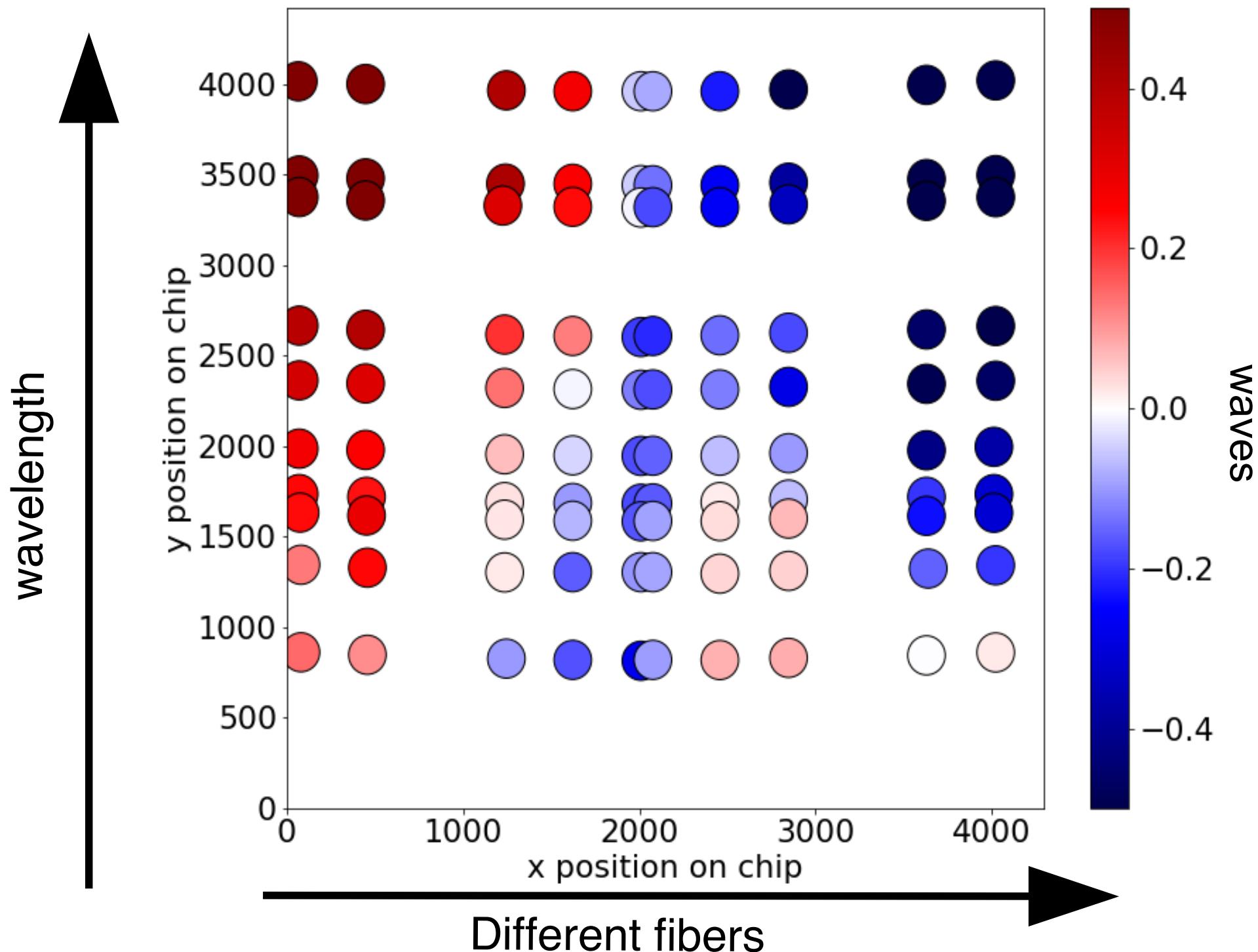


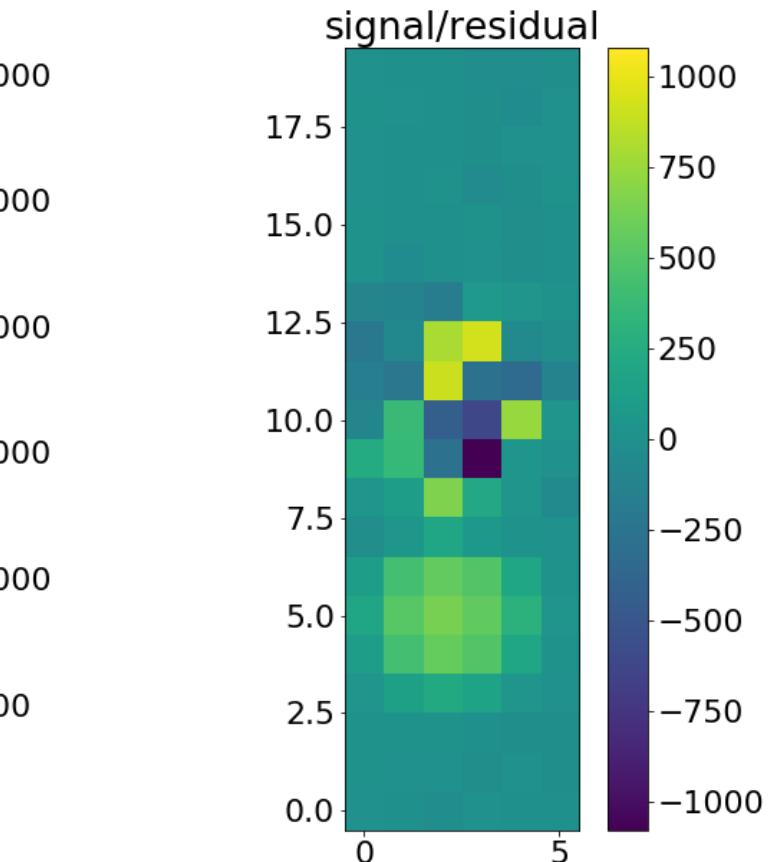
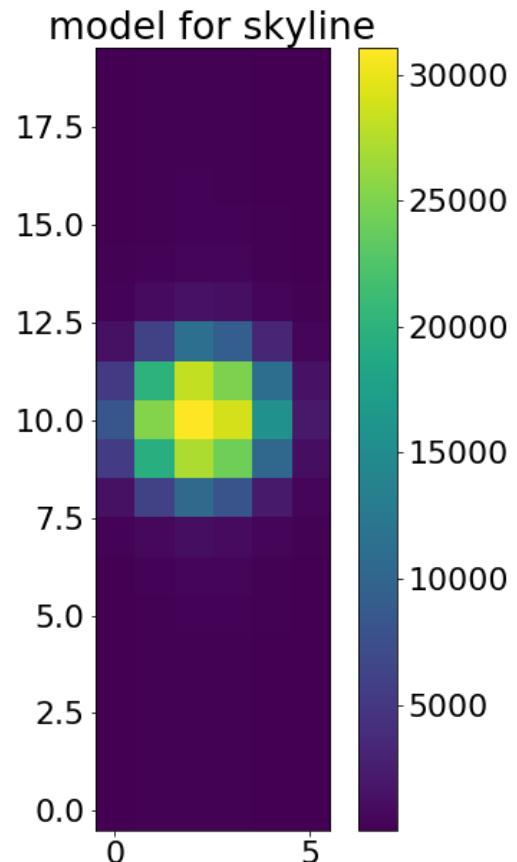
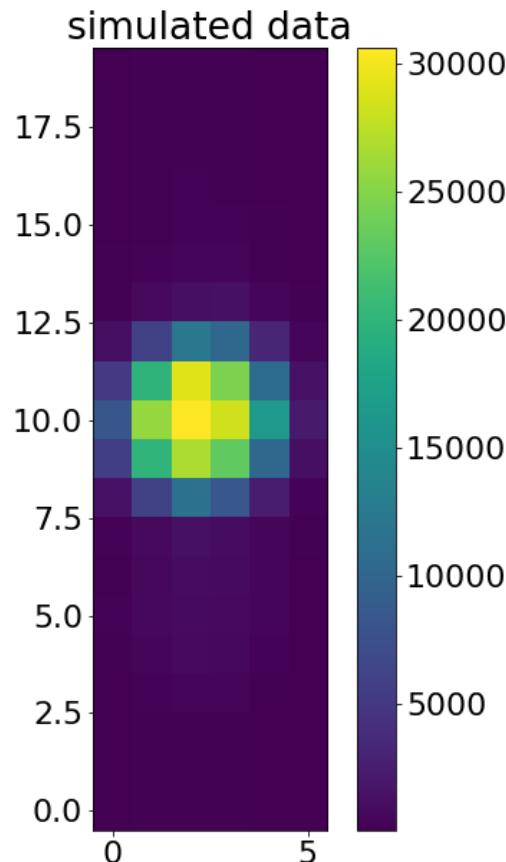


- Example from early modelling of the experimental data
(not the same spot and Zernike coefficients as above!)



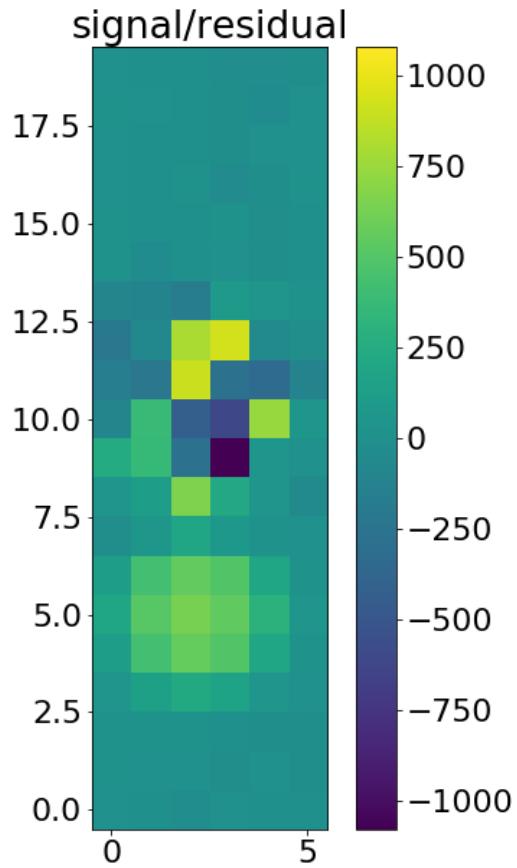
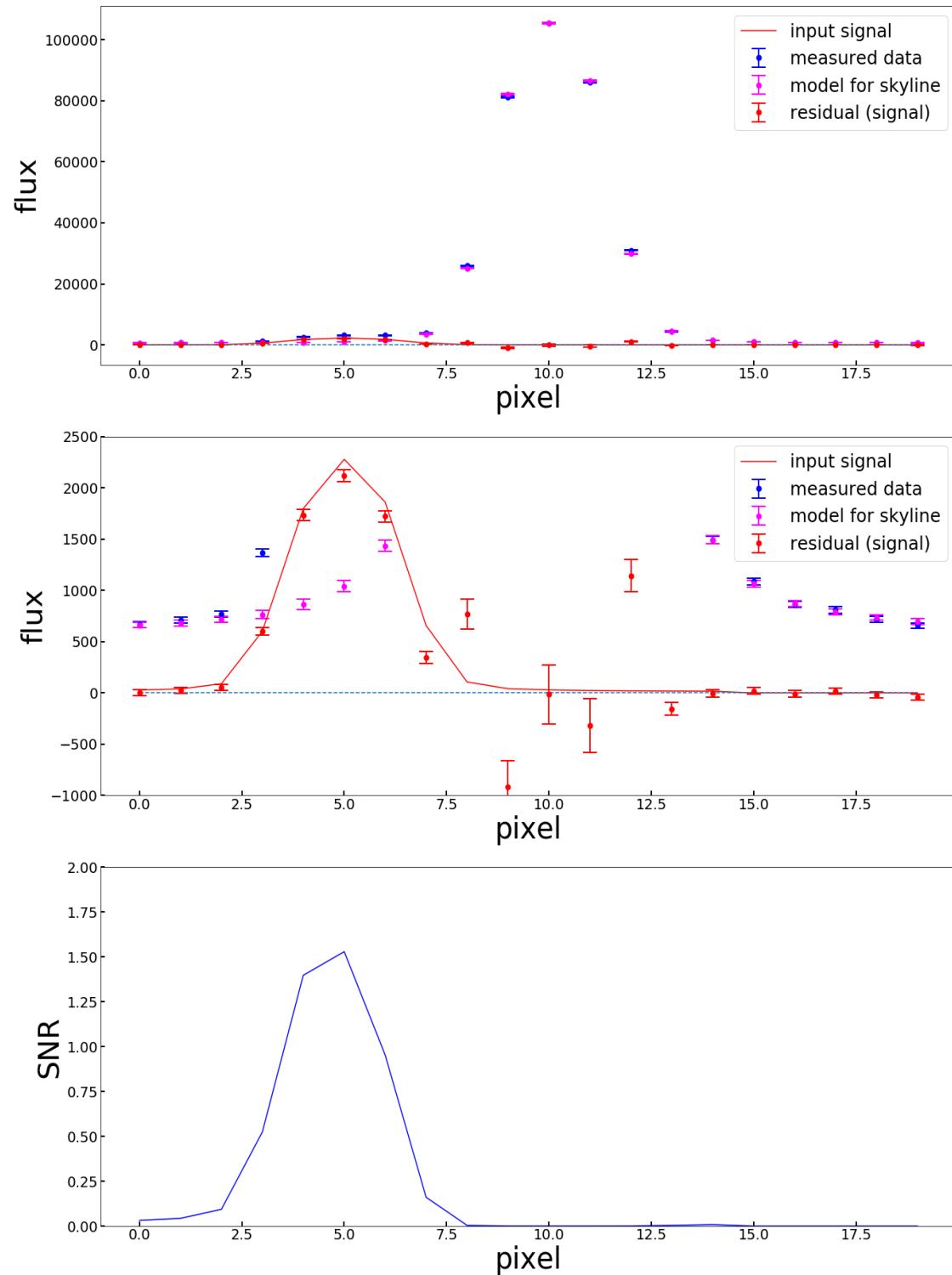
Example: Z5 – oblique astigmatism





Example of the desired behaviour:

- Modelled the skyline
- Subtract by the model
- Proceed with "optimal extraction" or similar 1D technique



Example of the desired behaviour:

- Modelled the skyline
- Subtract by the model
- Proceed with "optimal extraction" or similar 1d technique

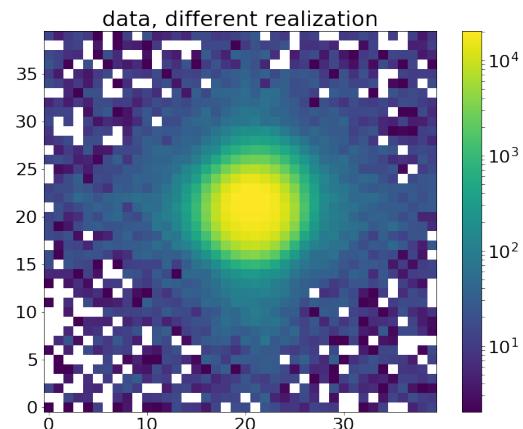
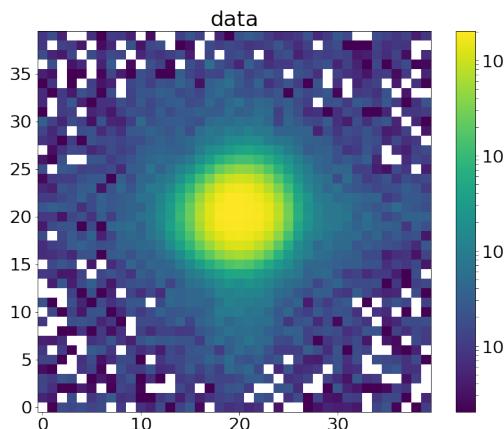
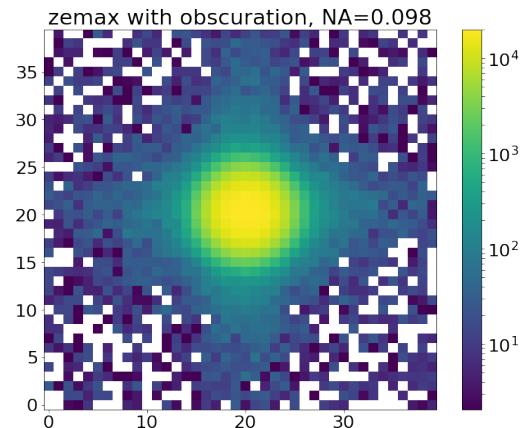
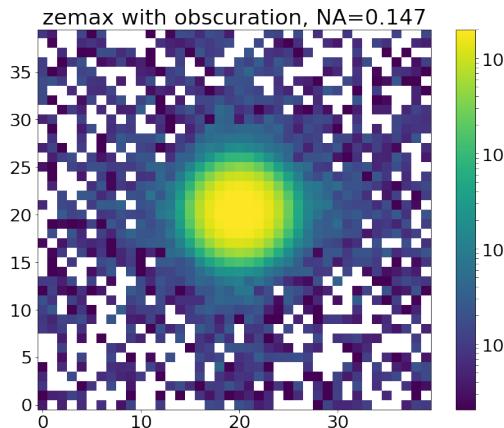
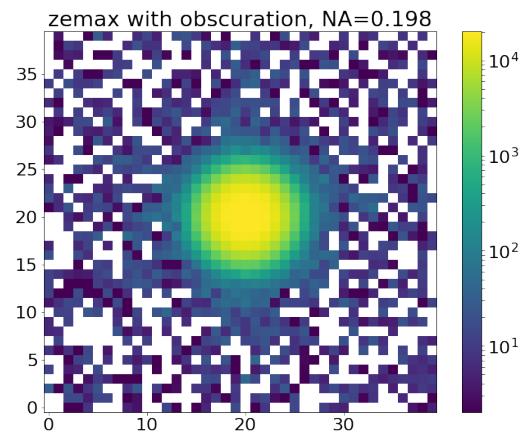
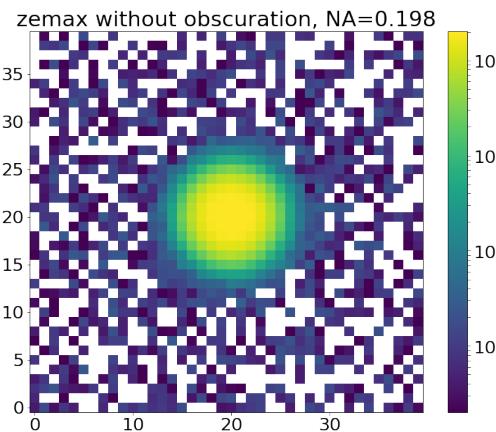
Where are we now; what am I thinking about

2 main issues at the moment:

- Stronger wings of the PSF than expected
- For some wavelengths, even stronger vertical component of the PSF

Diffraction effects are stronger than expected:

- Non-uniform illumination?
- Effective numerical aperture is smaller?



Where are we now; what am I thinking about

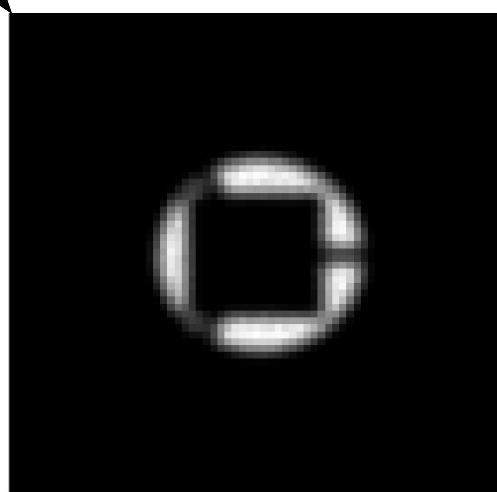
2 main issues at the moment:

- Stronger wings of the PSF than expected
- For some wavelengths, even stronger vertical component of the PSF

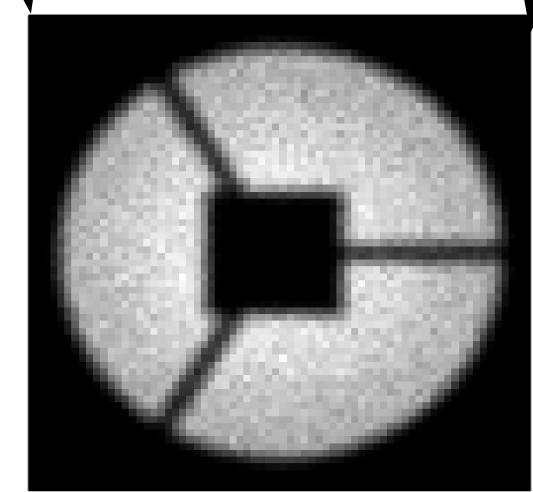
Diffraction effects are stronger than expected:

- Non-uniform illumination?
- Effective numerical aperture is smaller?
- Unlikely from defocused image analysis...

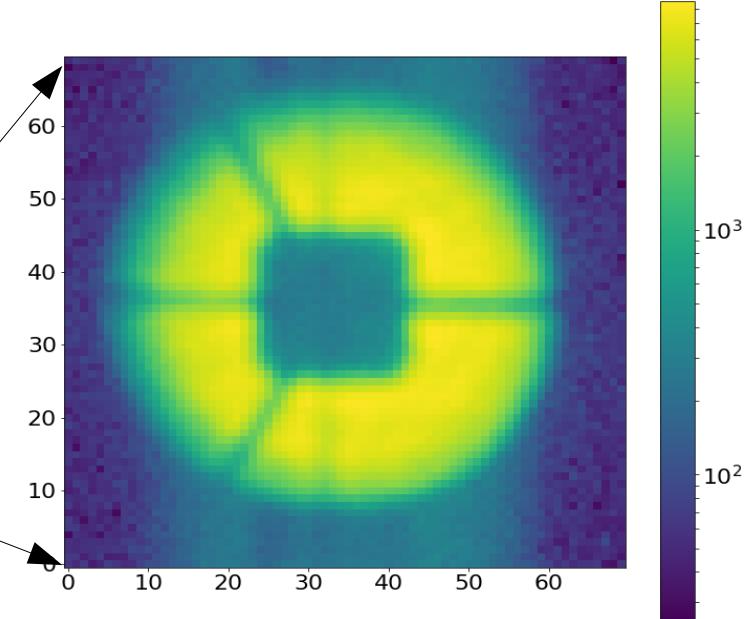
Defocused image that creates enough wings in focused data



Expected defocused image



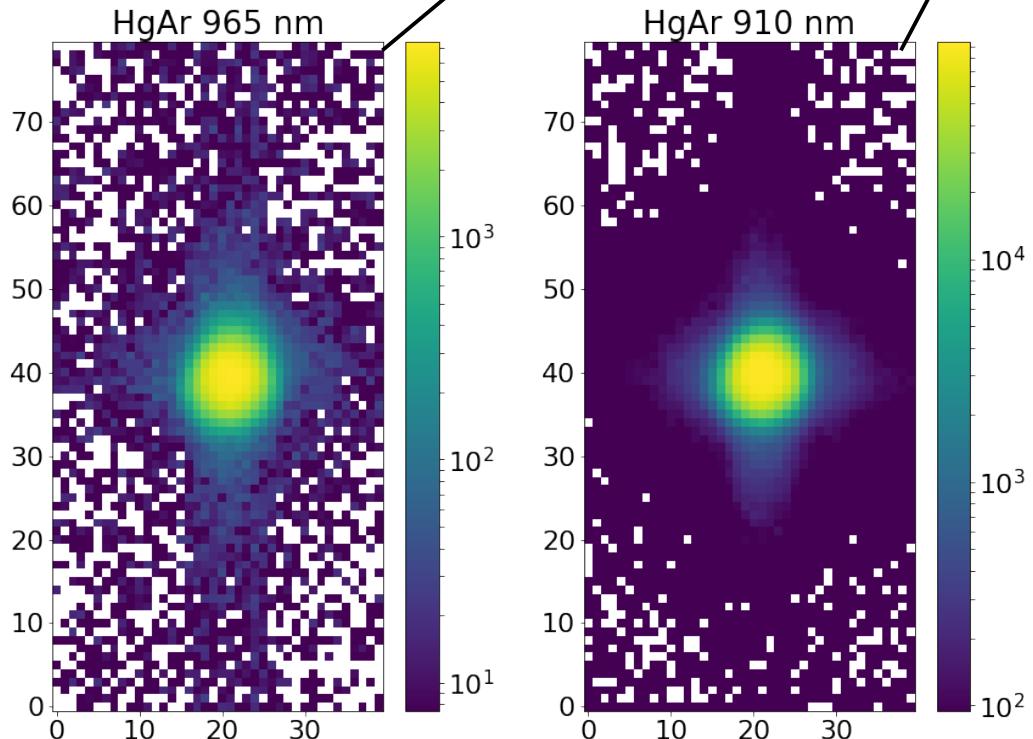
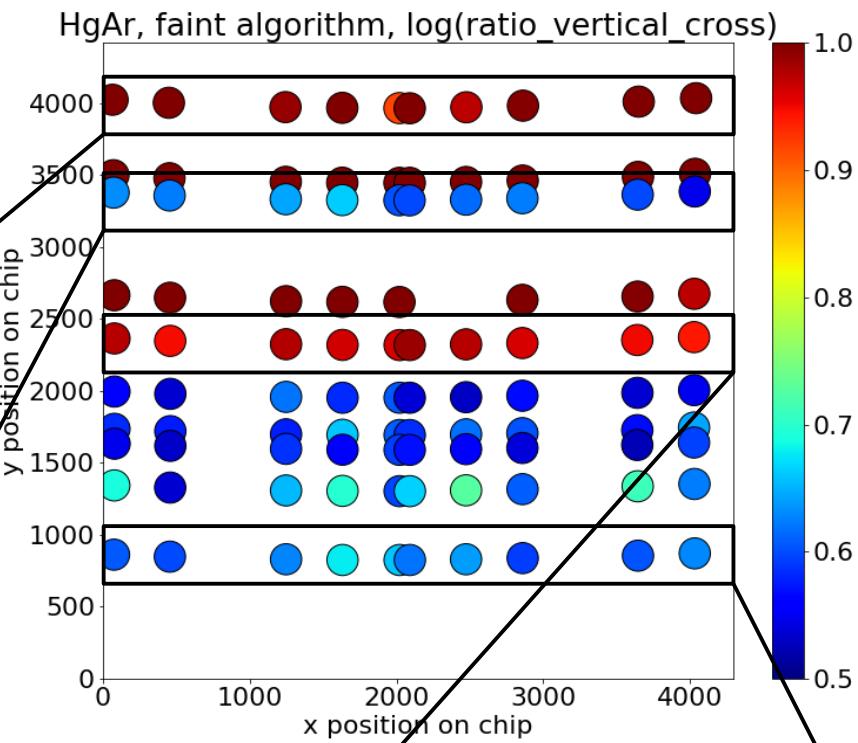
Actual data



Where are we now; what am I thinking about

2 main issues at the moment:

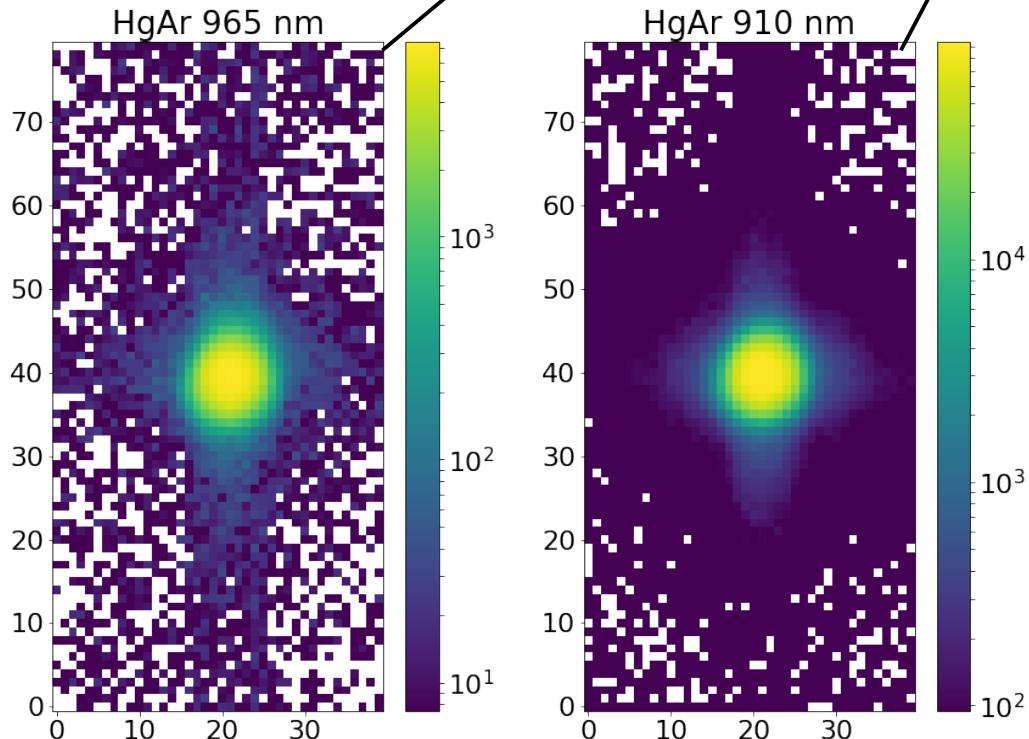
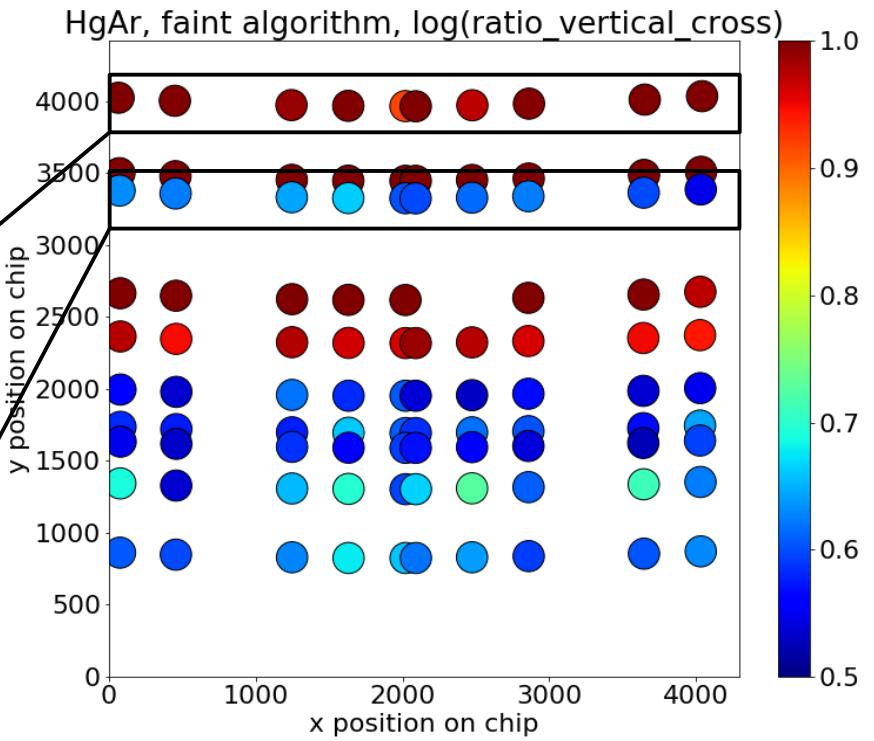
- Stronger wings of the PSF than expected
- For some wavelengths, even stronger vertical component of the PSF



Where are we now; what am I thinking about

2 main issues at the moment:

- Stronger wings of the PSF than expected
- For some wavelengths, even stronger vertical component of the PSF

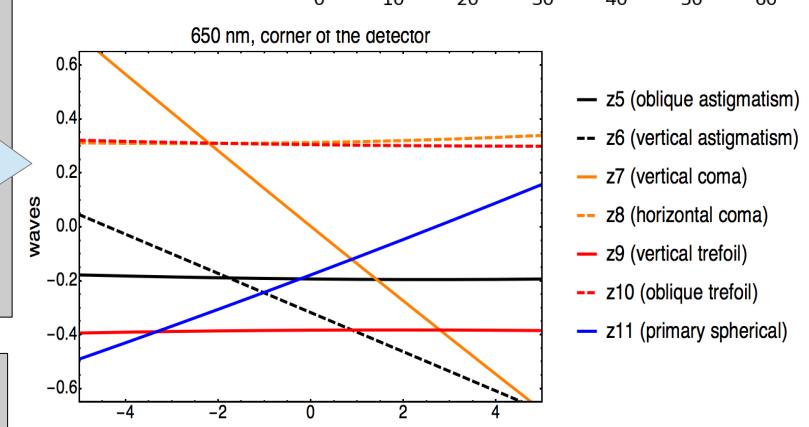
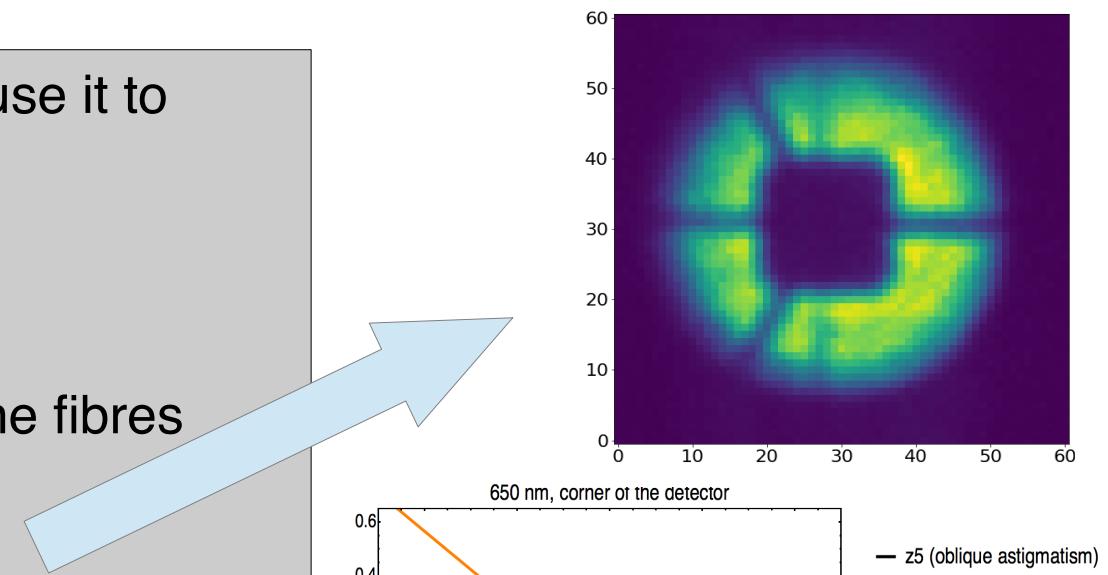


Most probable solutions for these issues:

- Incompetent Post-doc has wrongly modelled something and underestimated diffraction effects
- Extra power in the vertical wings due to grating

Summary

- We want to predict PSF and use it to subtract wings of the skylines
- 3 components to the PSF
 - Telescope pupil illumination
 - Focal ratio degradation in the fibres
 - Spectrograph cameras
- Characterize contribution of camera imperfections to PSF by modelling optical performance using defocussed data



- We are developing code to analyse and determine wavefront aberrations from the data taken at the optical bench
- Local problems
 - Possibly stronger wings than expected
 - Extra power in vertical direction at some wavelengths

