

2D point spread function characterization for Prime Focus Spectrograph

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

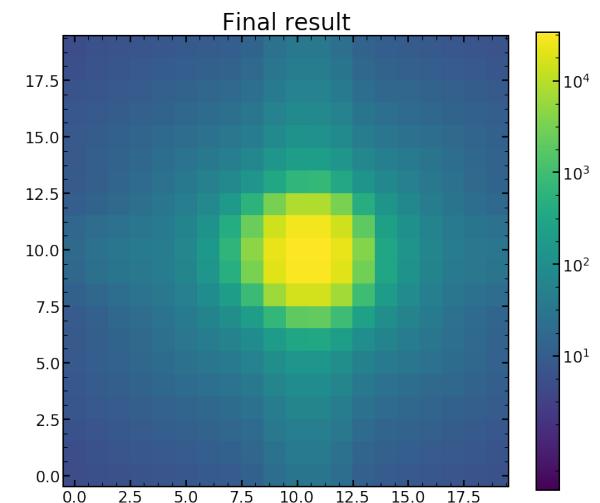
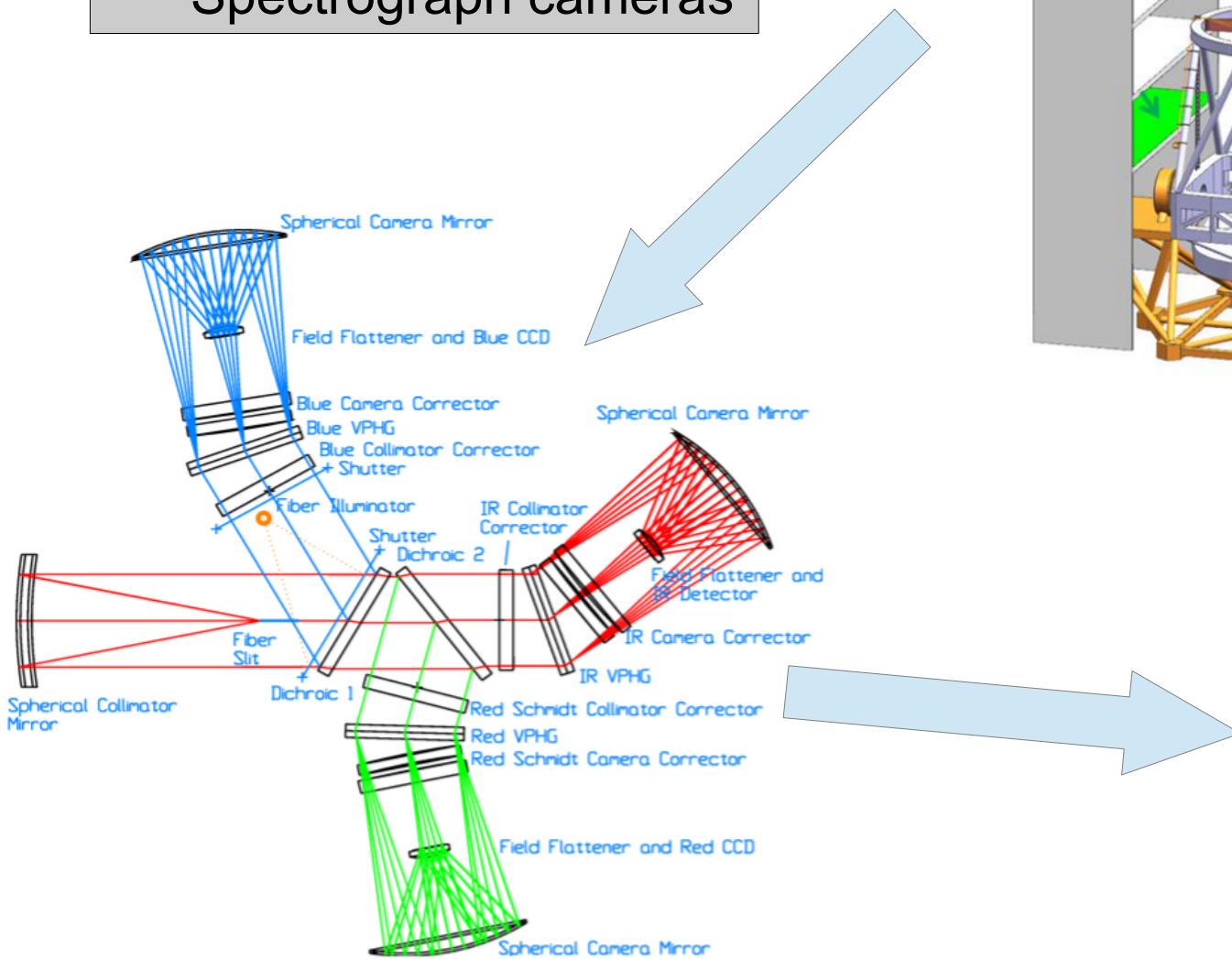
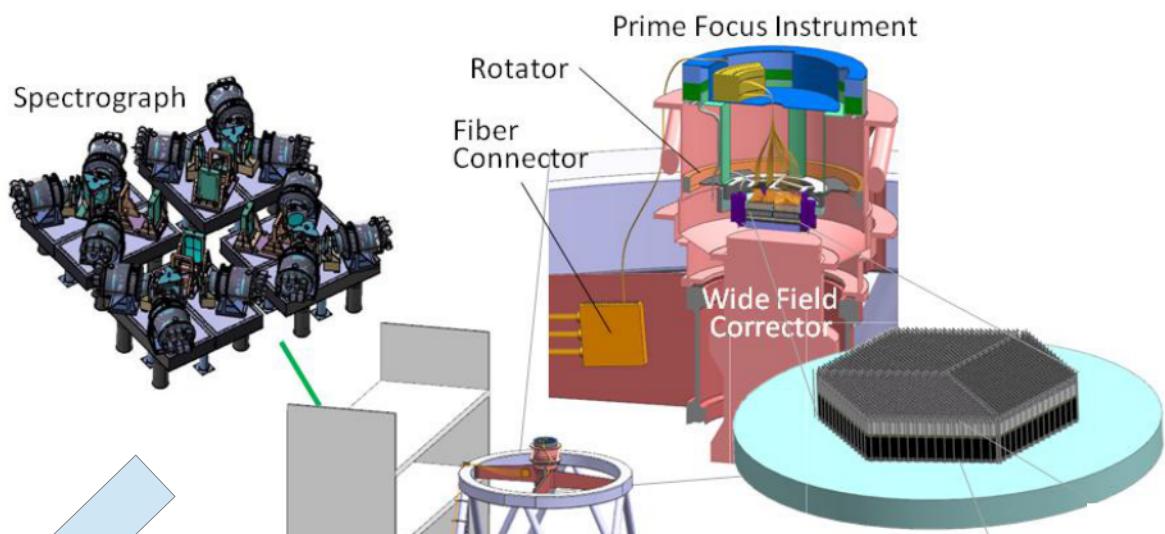


PRINCETON
UNIVERSITY



3 components to the PSF

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

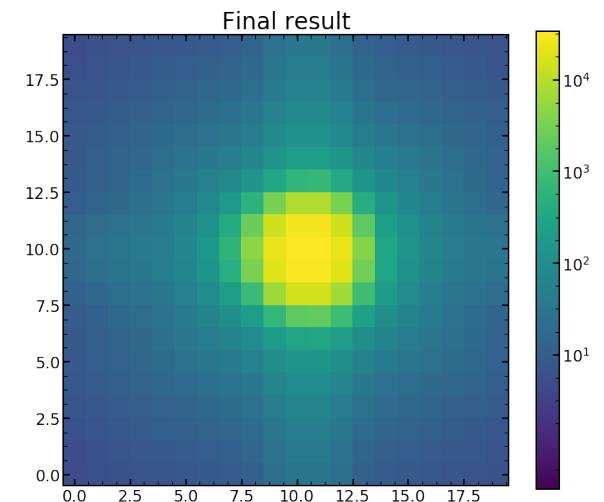
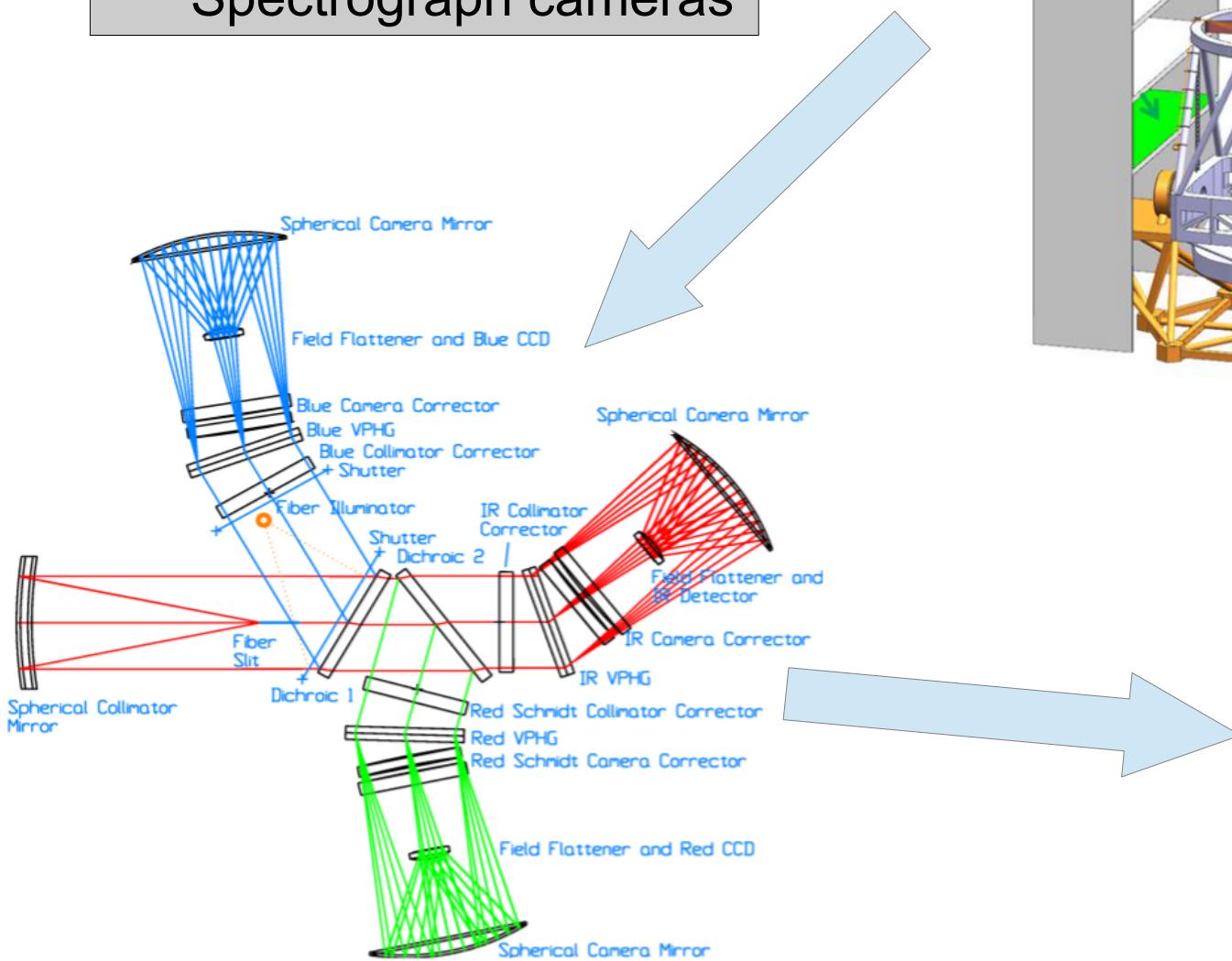
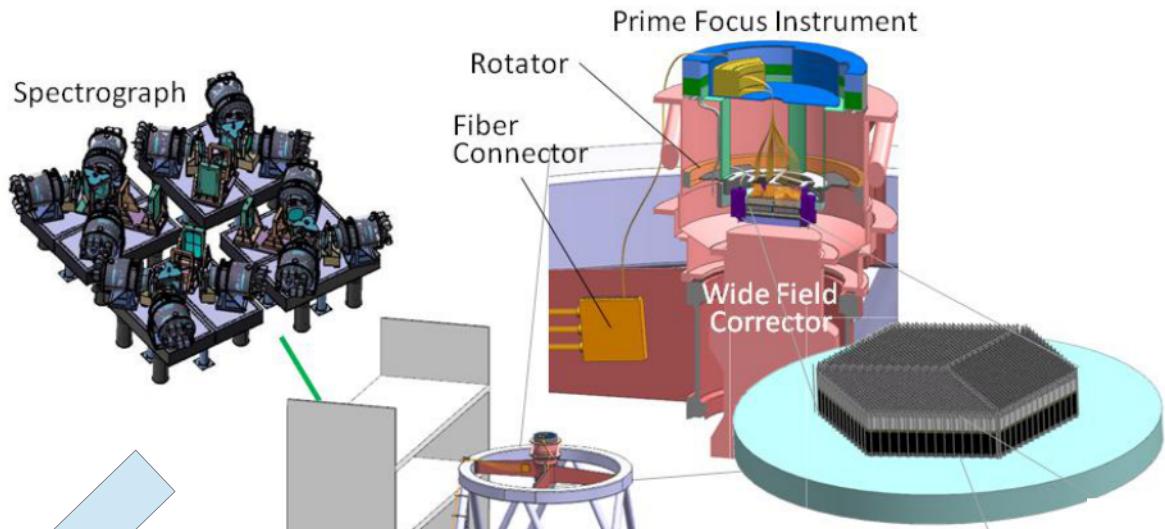


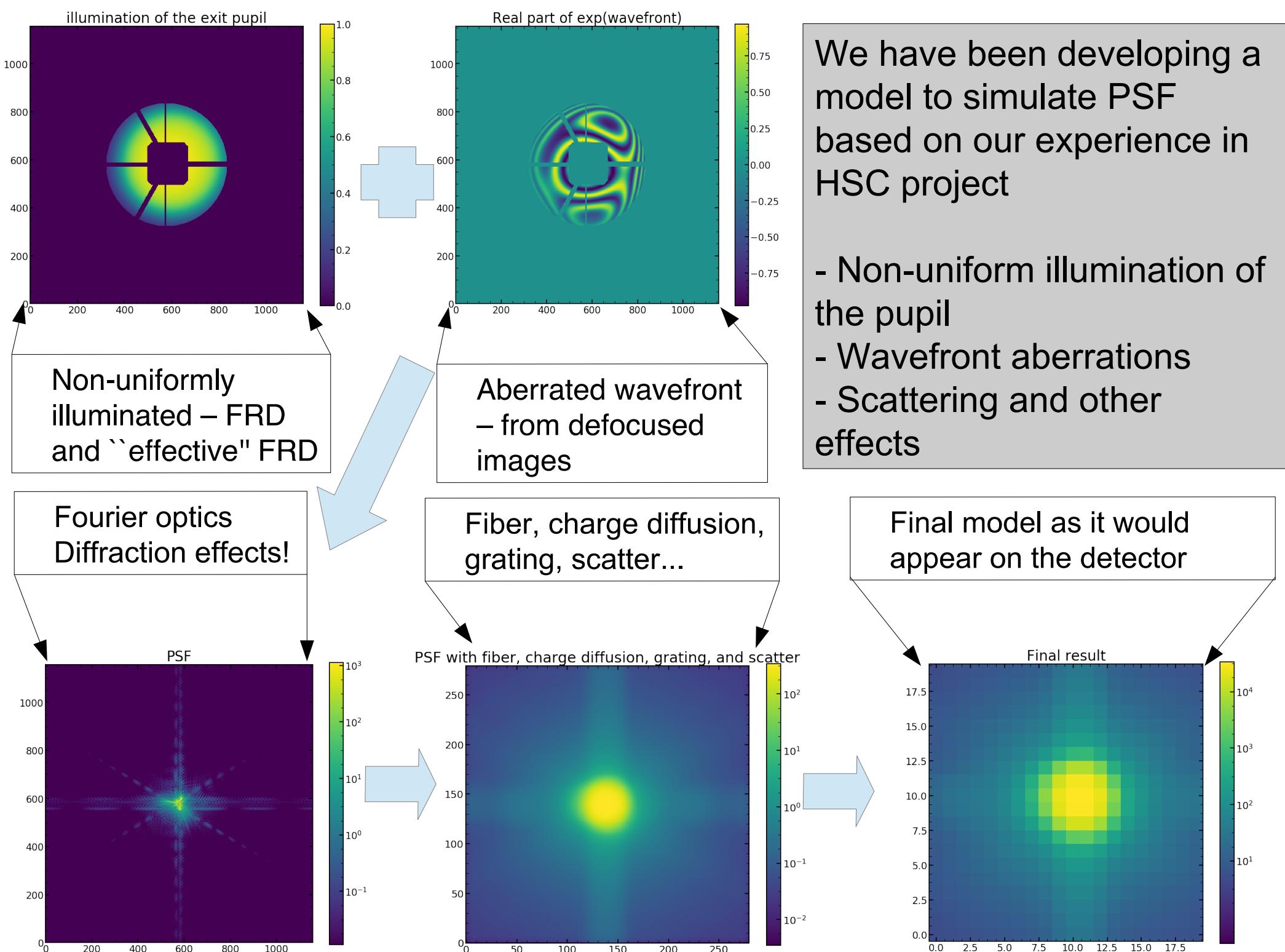
3 components to the PSF

Telescope pupil
illumination

Focal ratio degradation
in the fibres

Spectrograph cameras

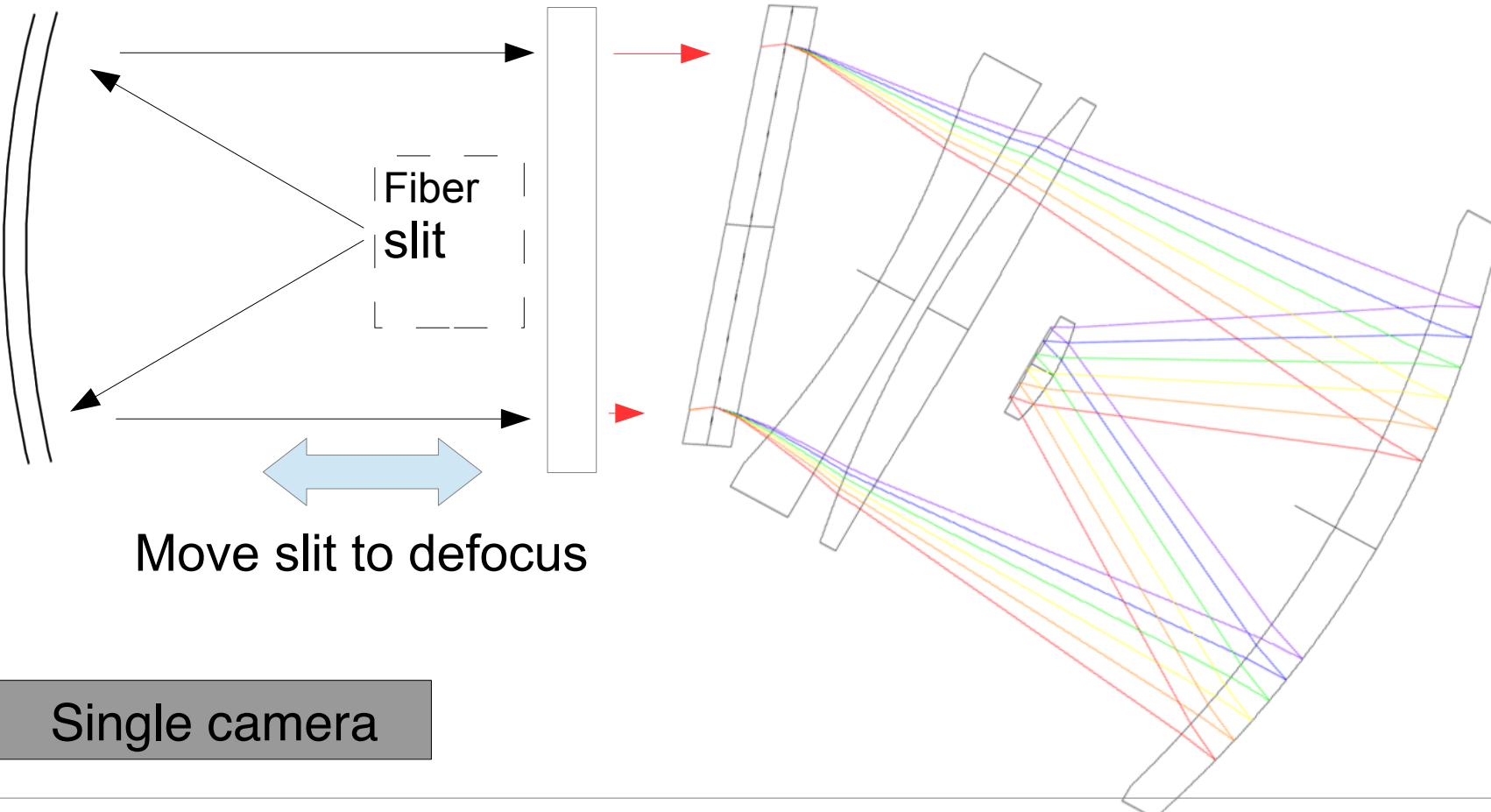




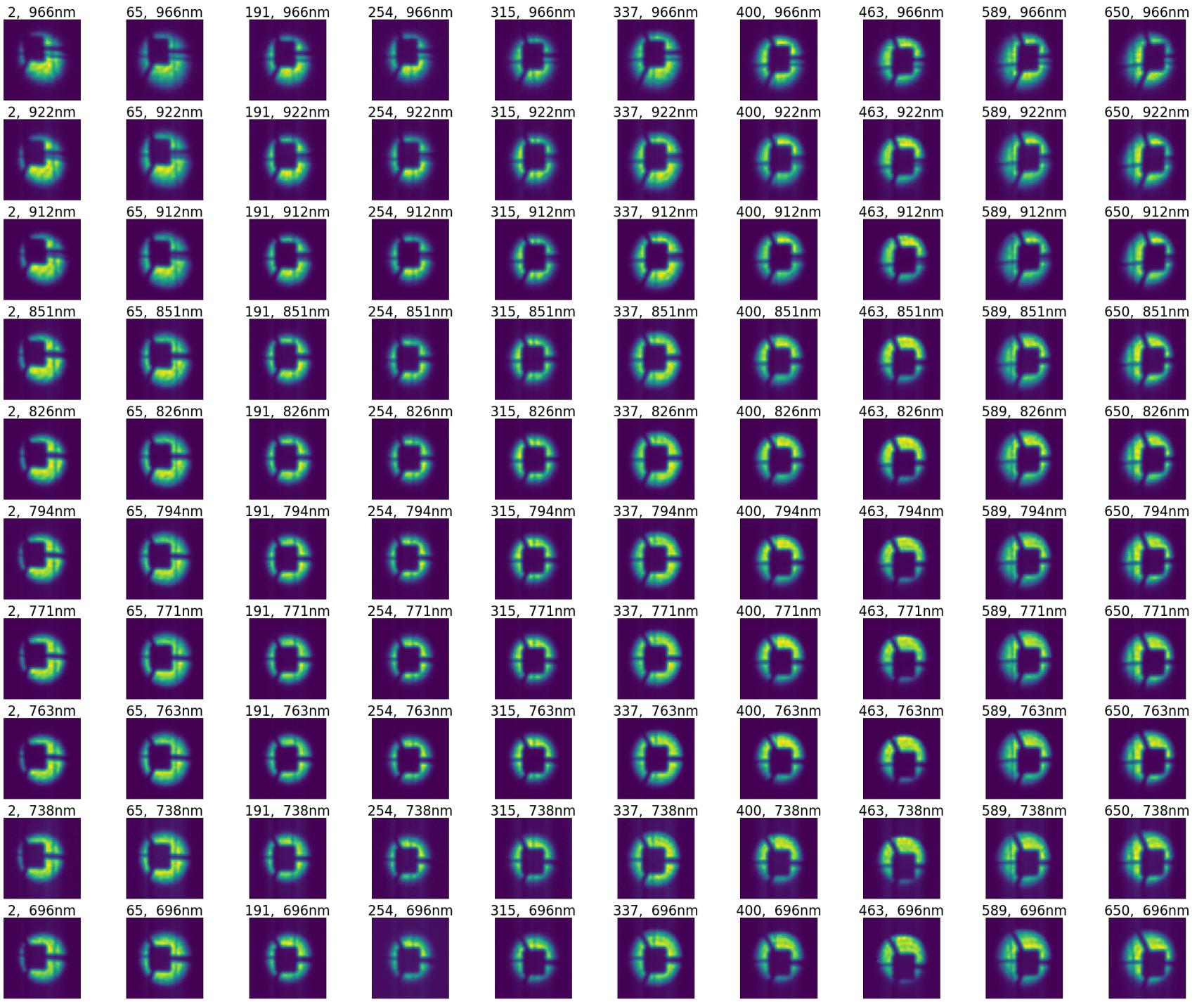
3 components to the PSF

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

- Separate these 3 components (vignetting, 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



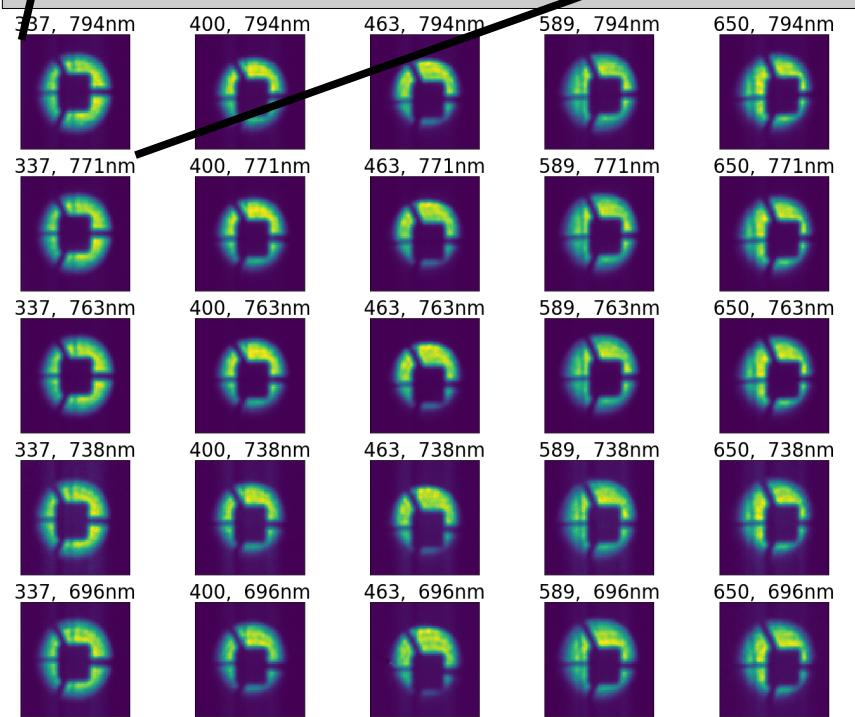
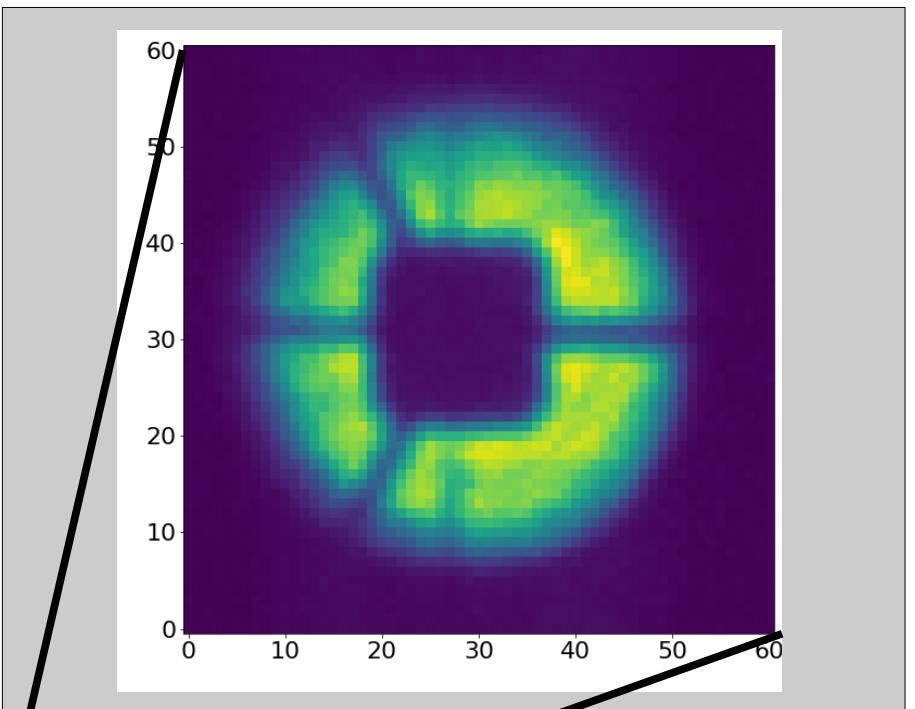
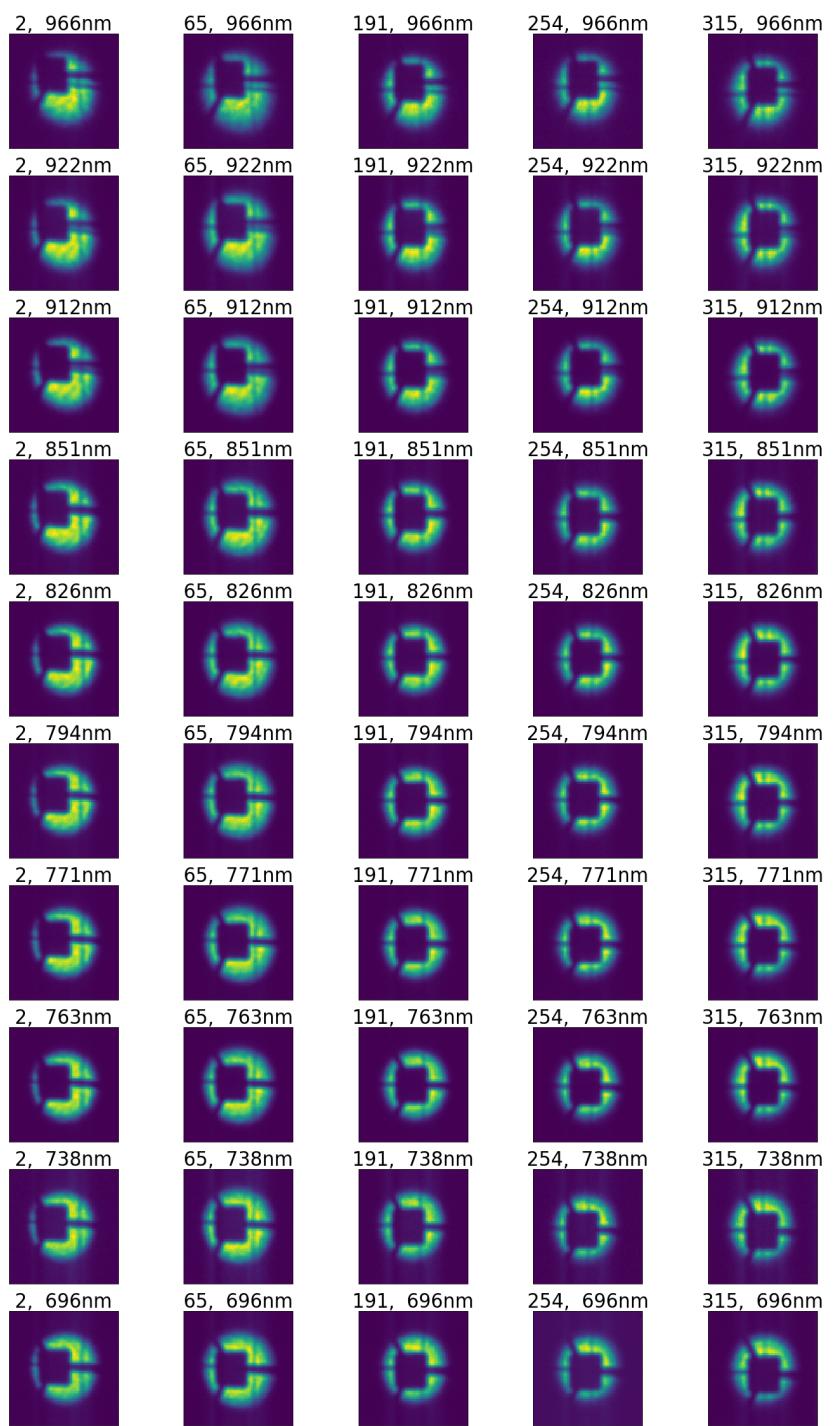
Wavelength



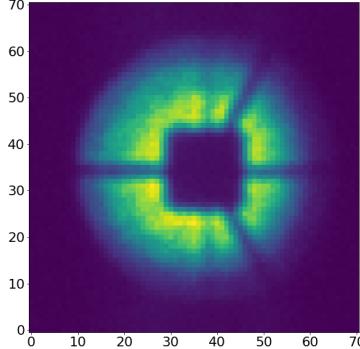
Different fibers

A large black arrow pointing horizontally to the right, positioned below the bottom row of heatmaps.

Wavelength

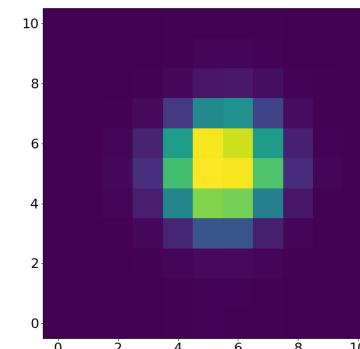
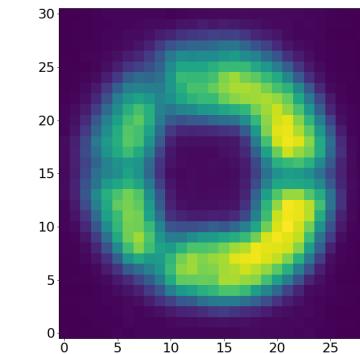
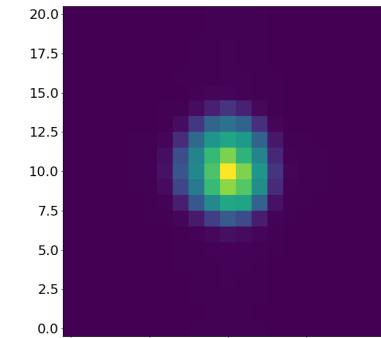
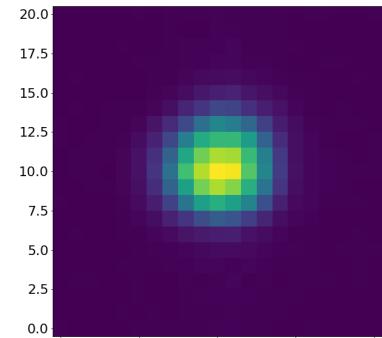
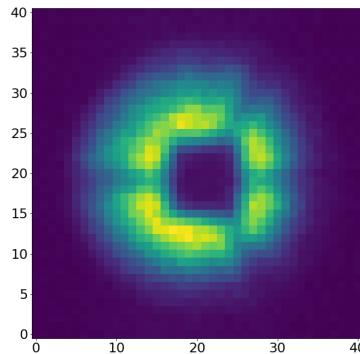
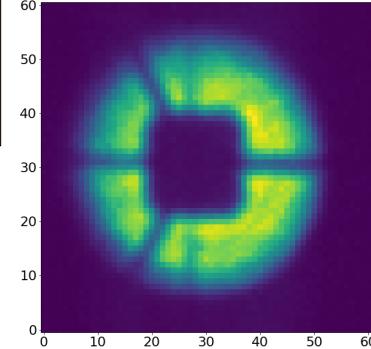


Different fibers



How to decouple the illumination and the wavefront aberrations?

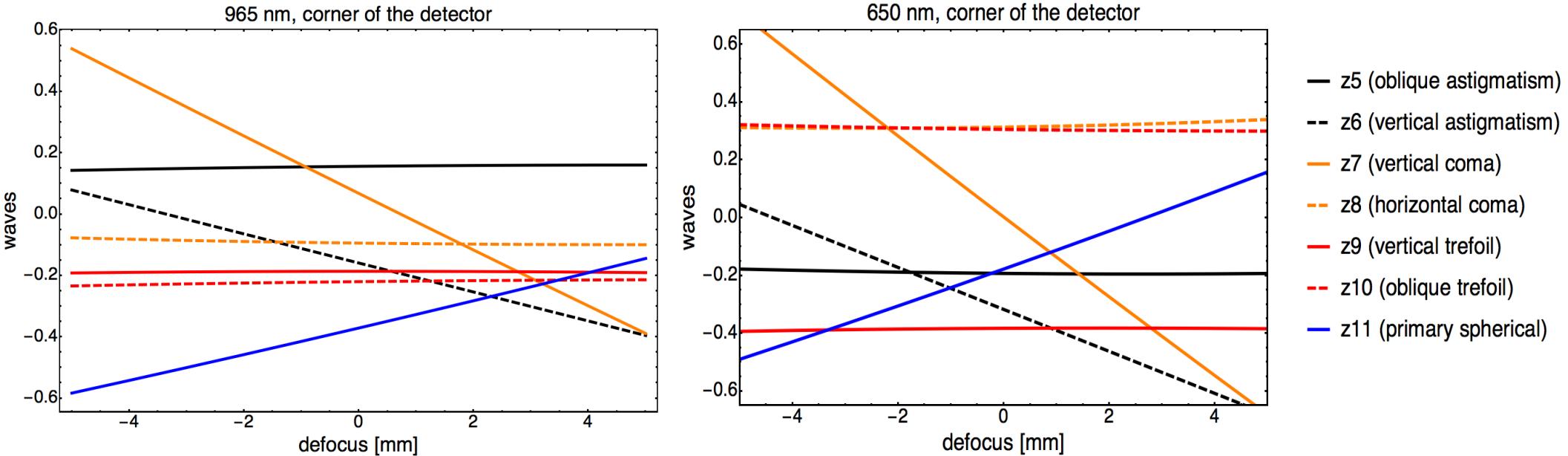
- Images at different value of defocus
- Follow wavefront aberrations as a function of defocus



More defocused

In focus

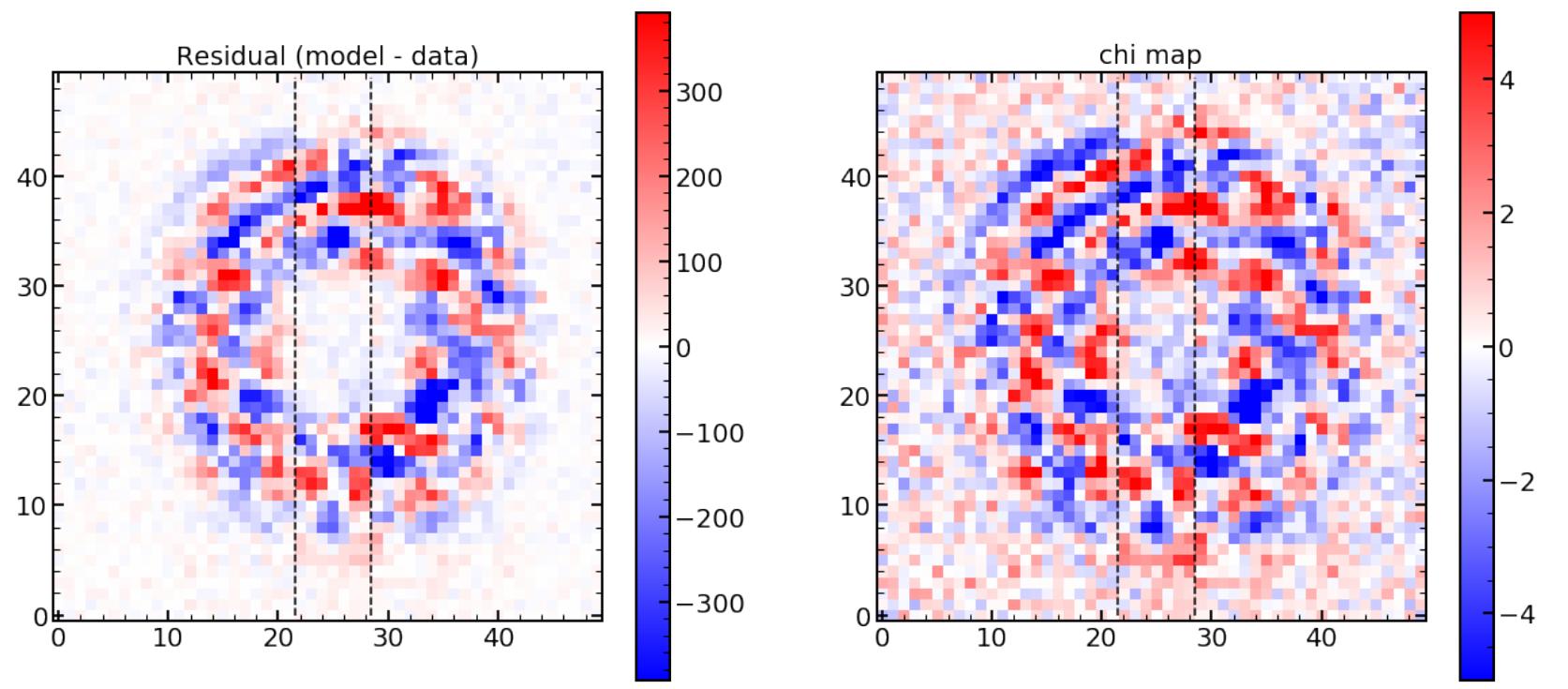
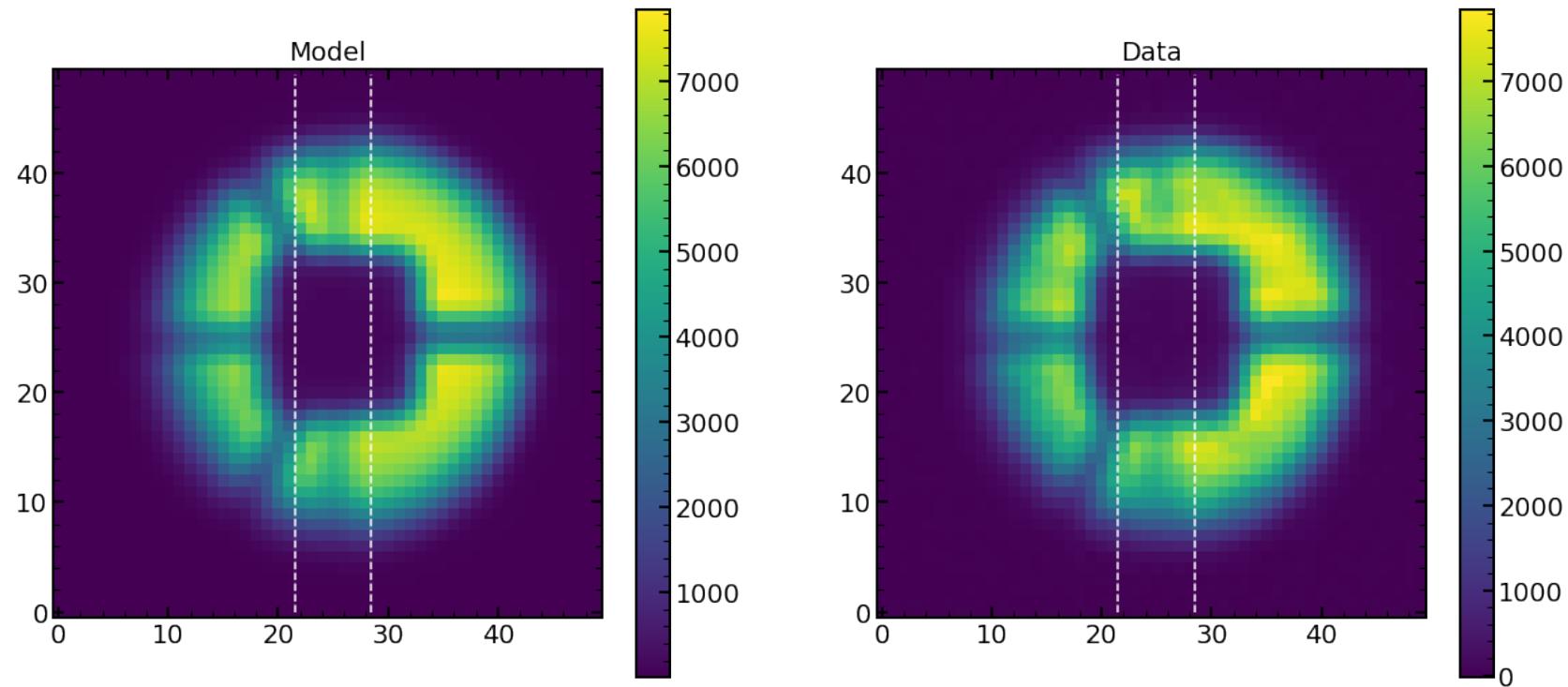
More defocused



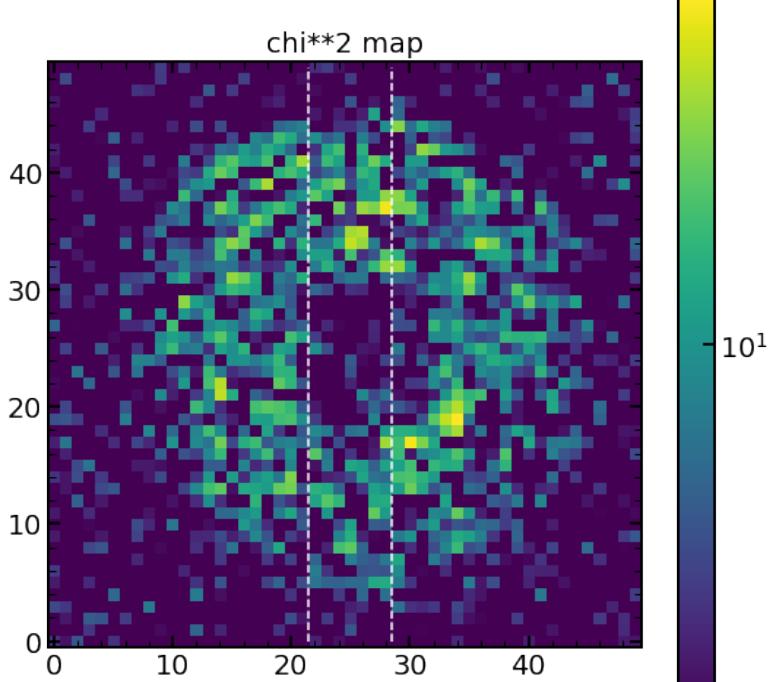
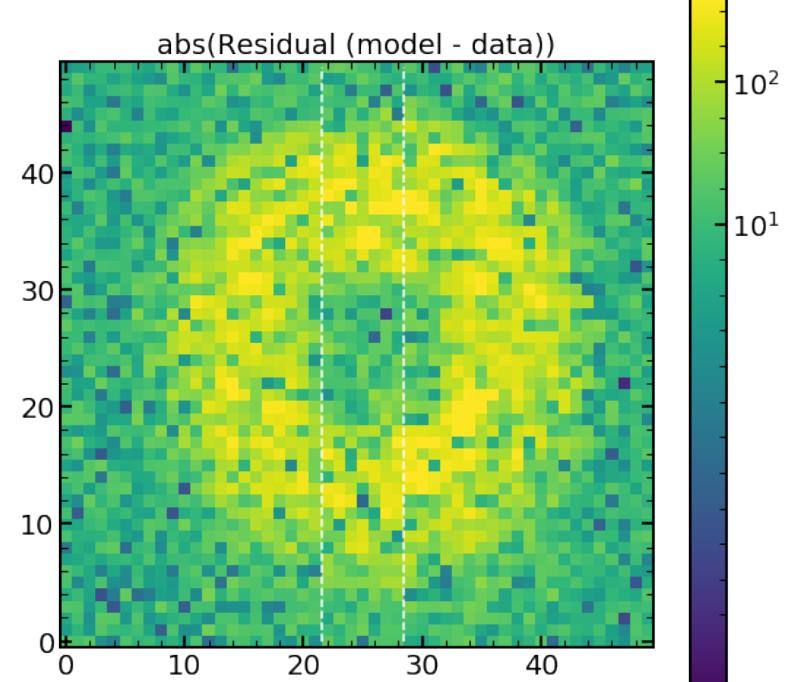
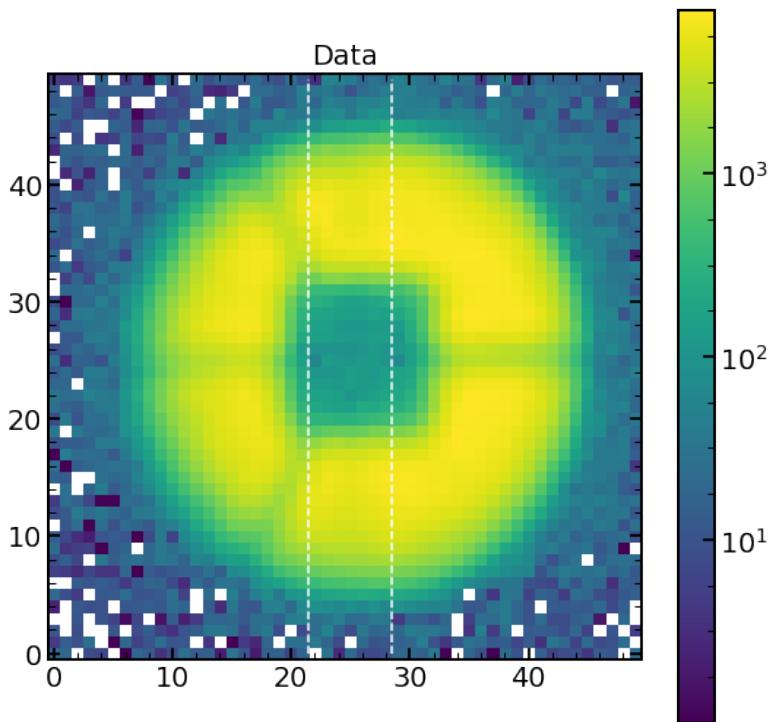
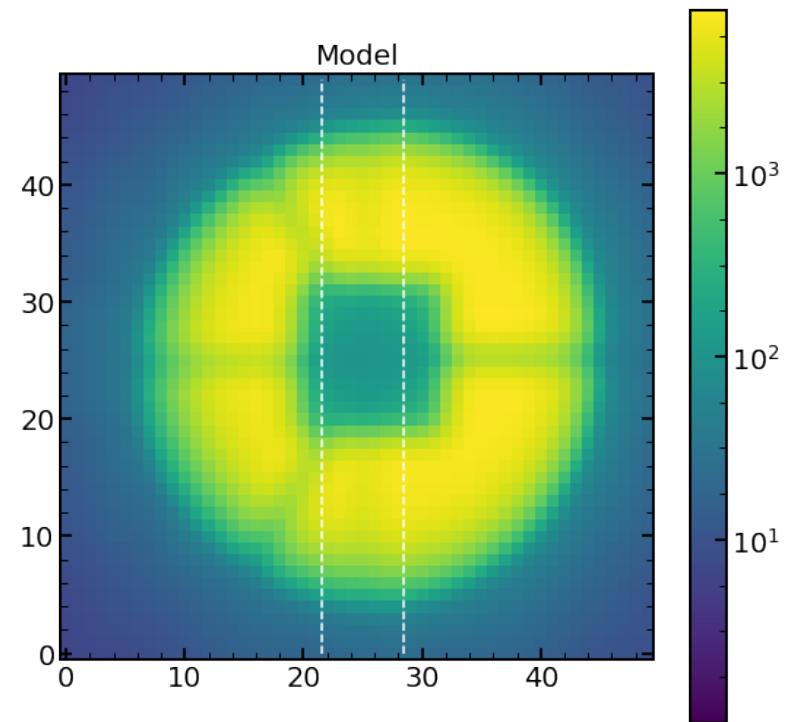
Wavefront aberrations as function of defocus (Zemax)

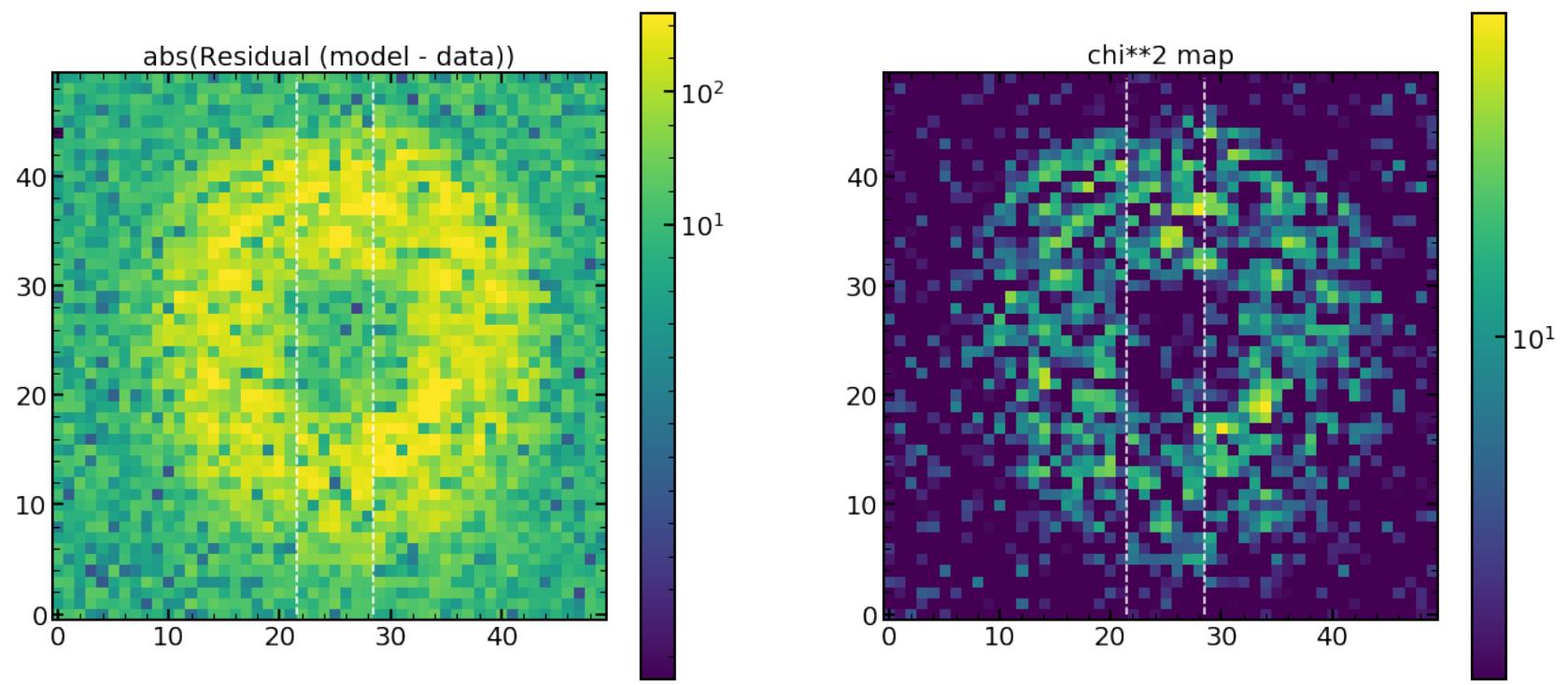
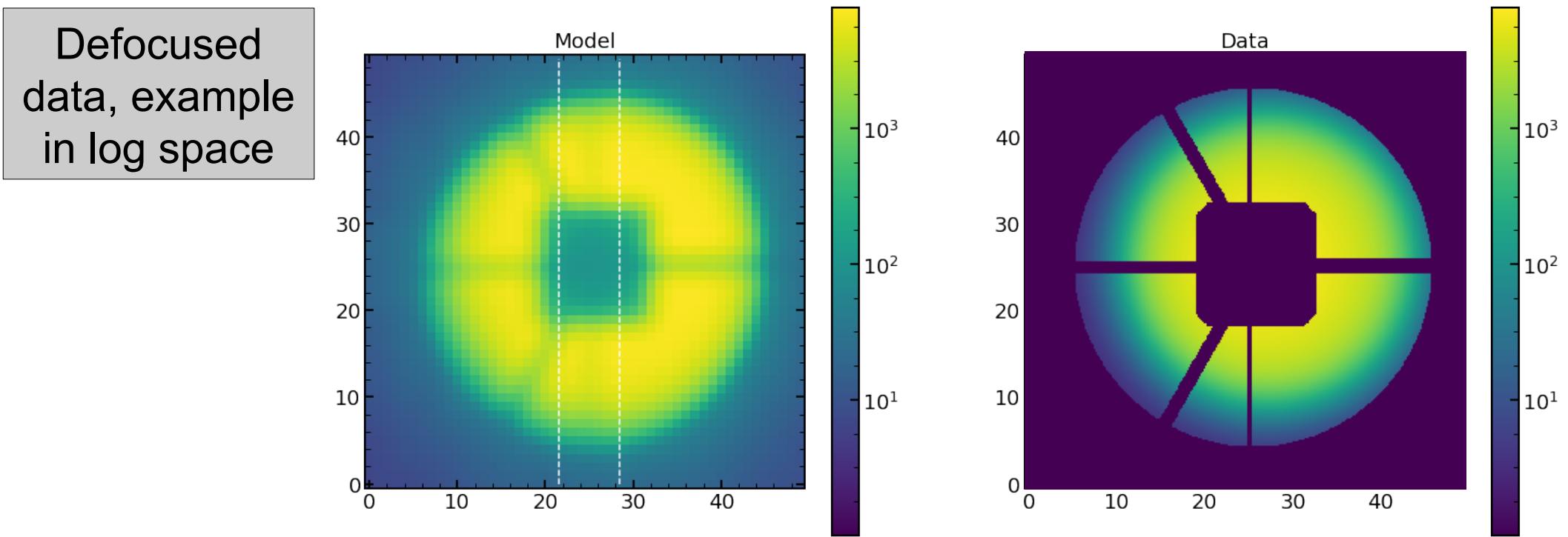
- We wish to deduce/reproduce these curves from the data
- Model wavefront aberrations at each position in the detector

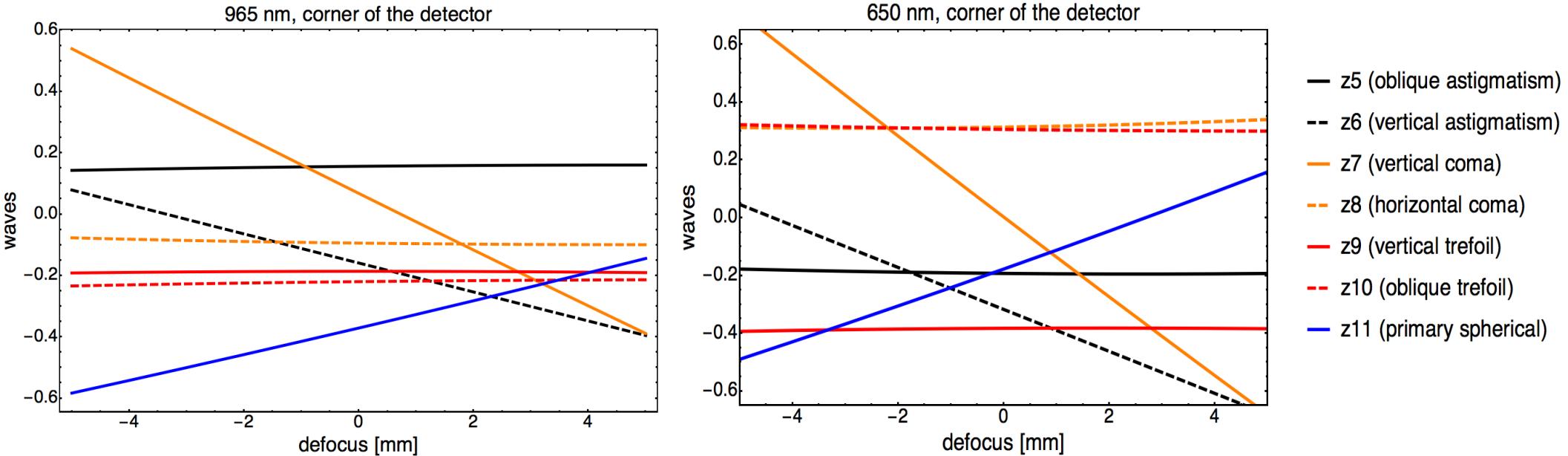
Defocused data, example in linear space



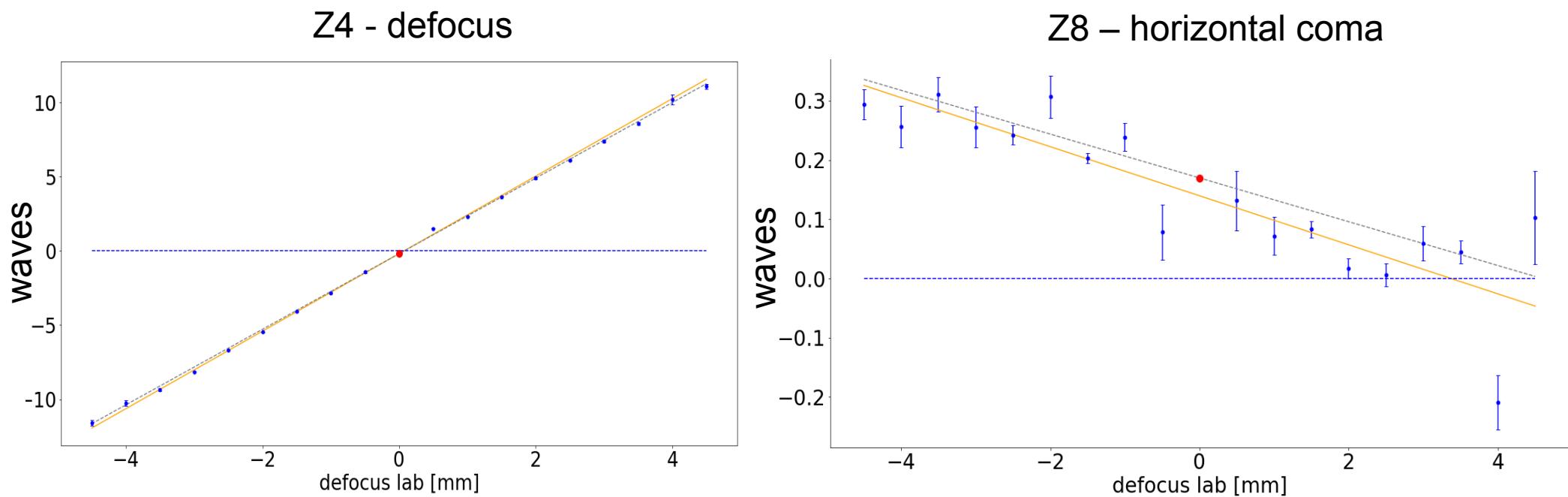
Defocused data, example in log space



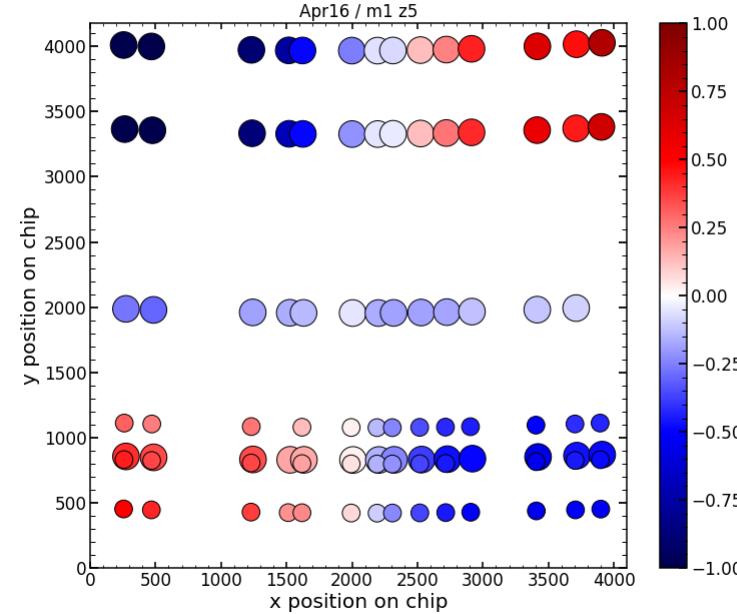
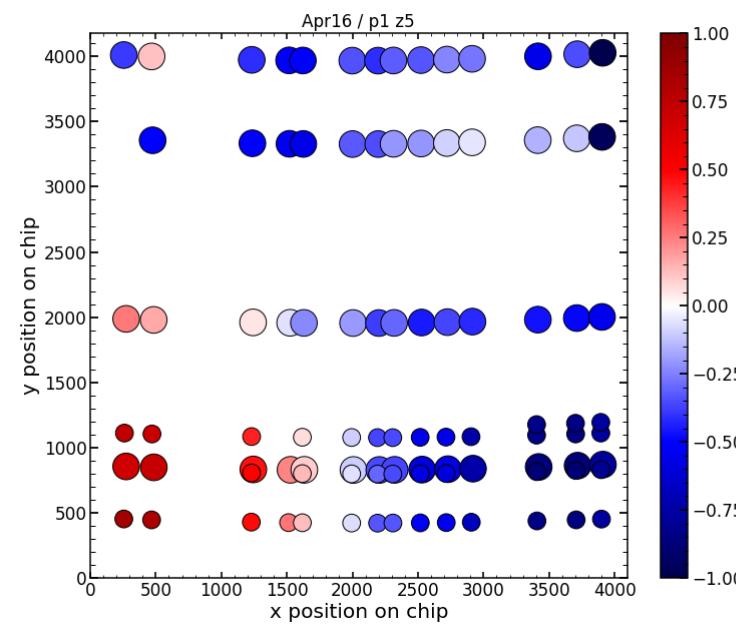
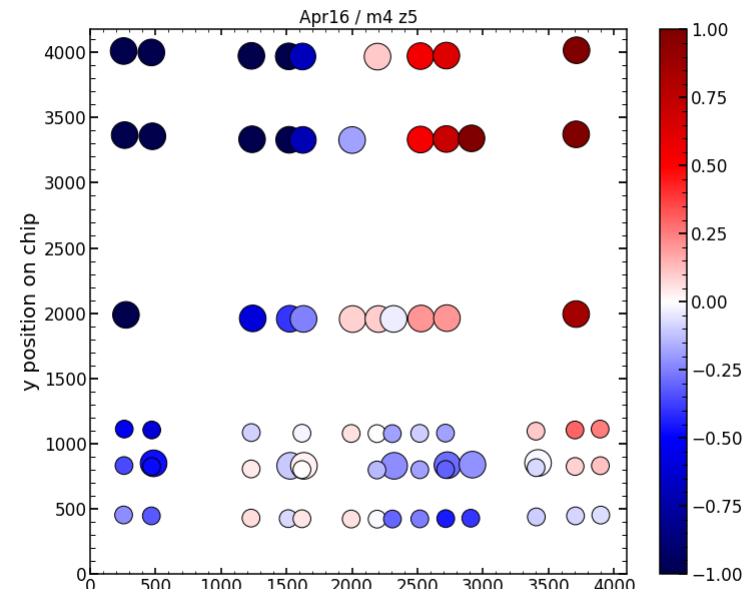
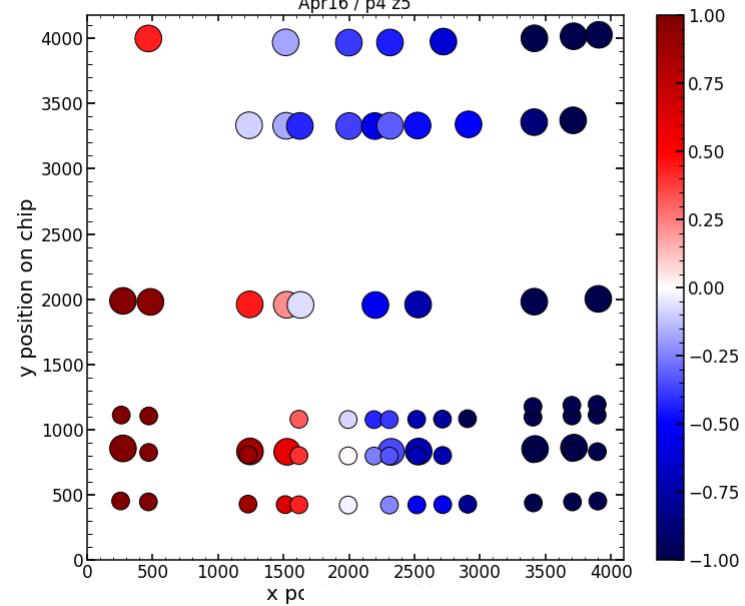




- Example from modelling of the experimental data below
(not the same spot as above!)

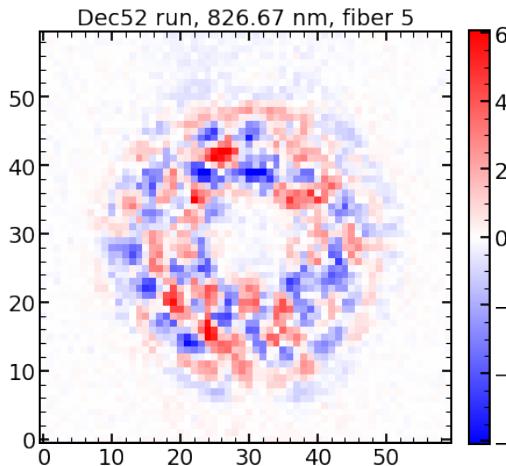


Change of single component – (vertical astigmatism)

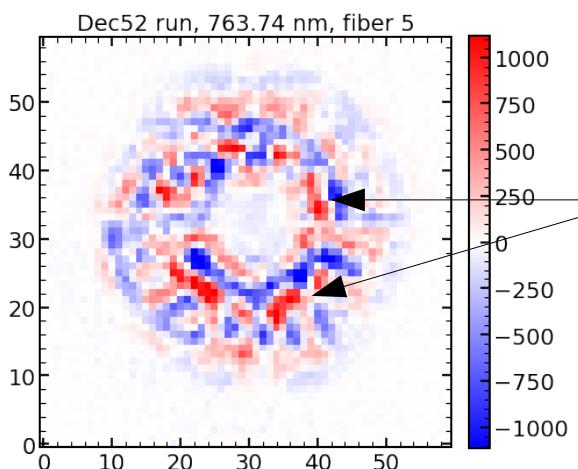
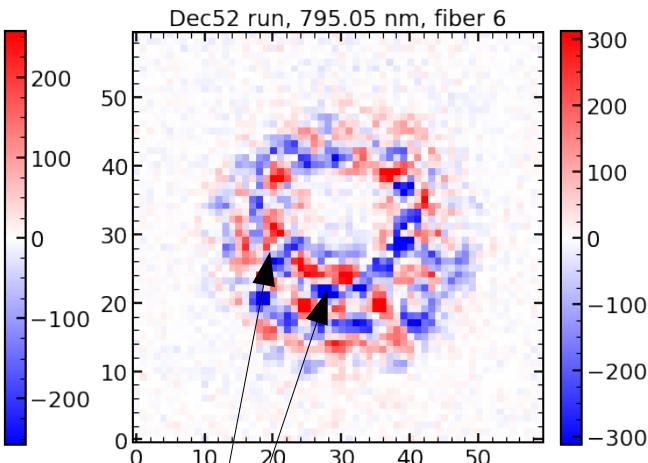
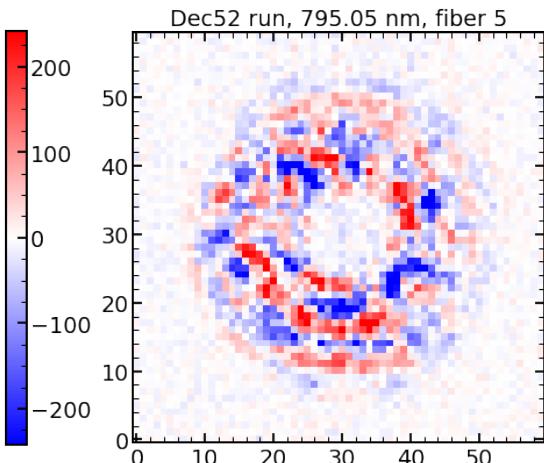
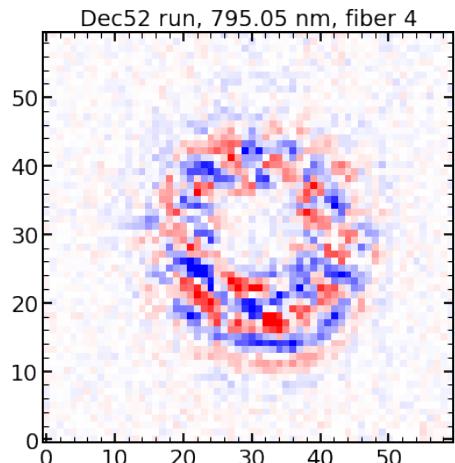


Changing defocus

Direct Fits

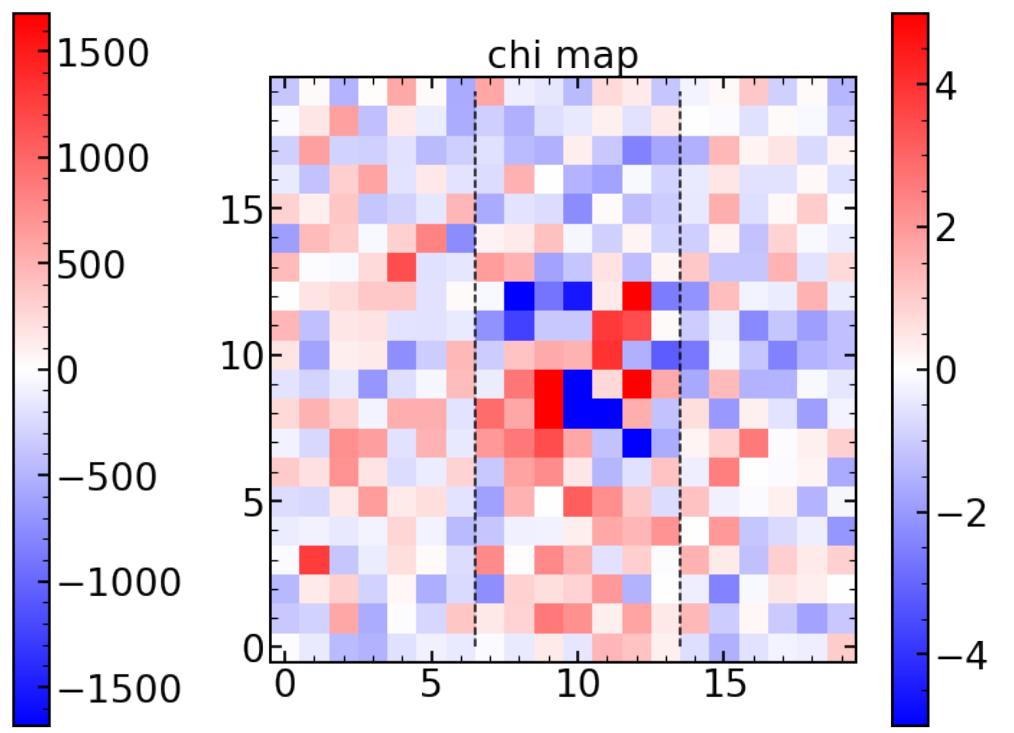
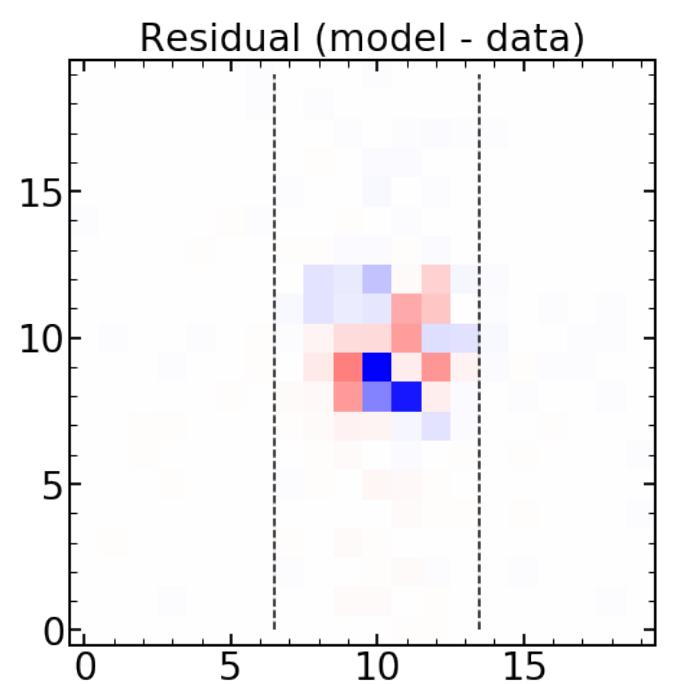
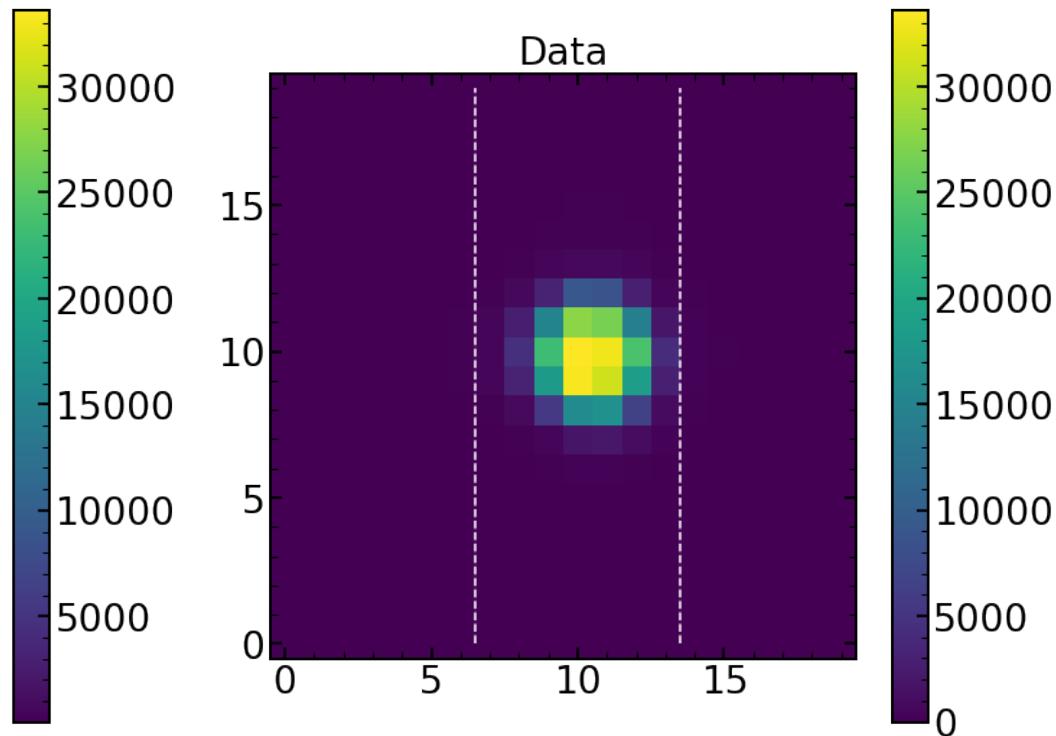
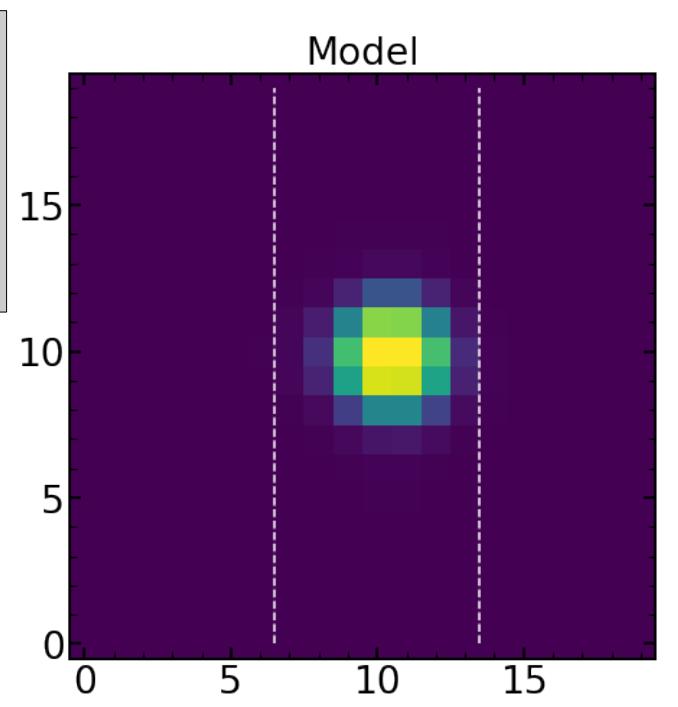


Residuals scaled to
5% of the maximal flux
in the data

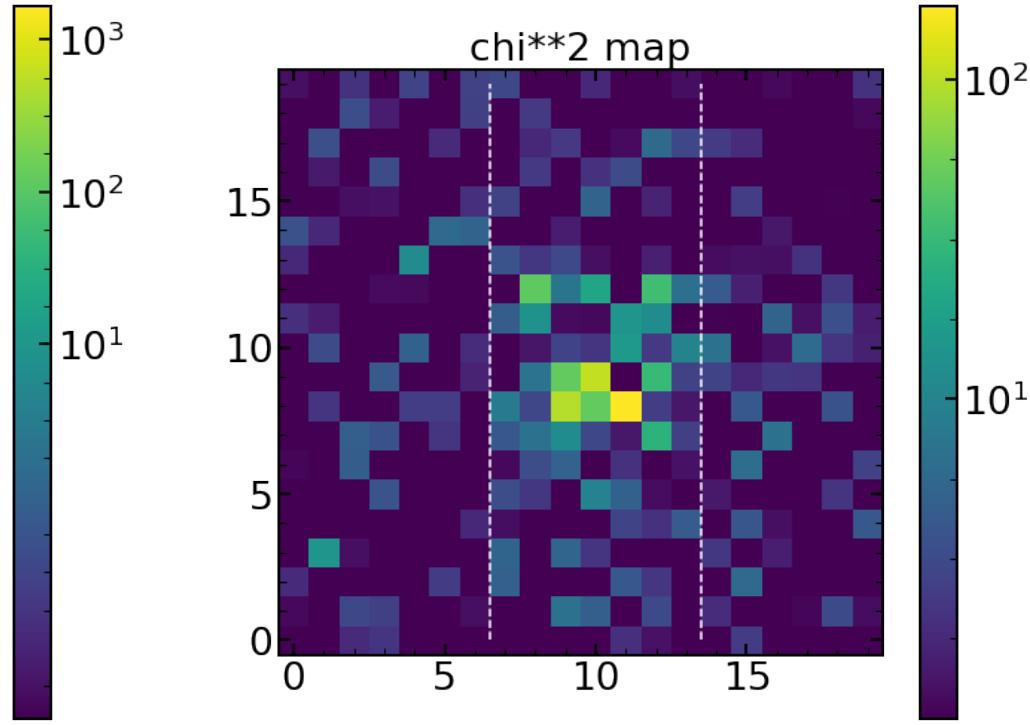
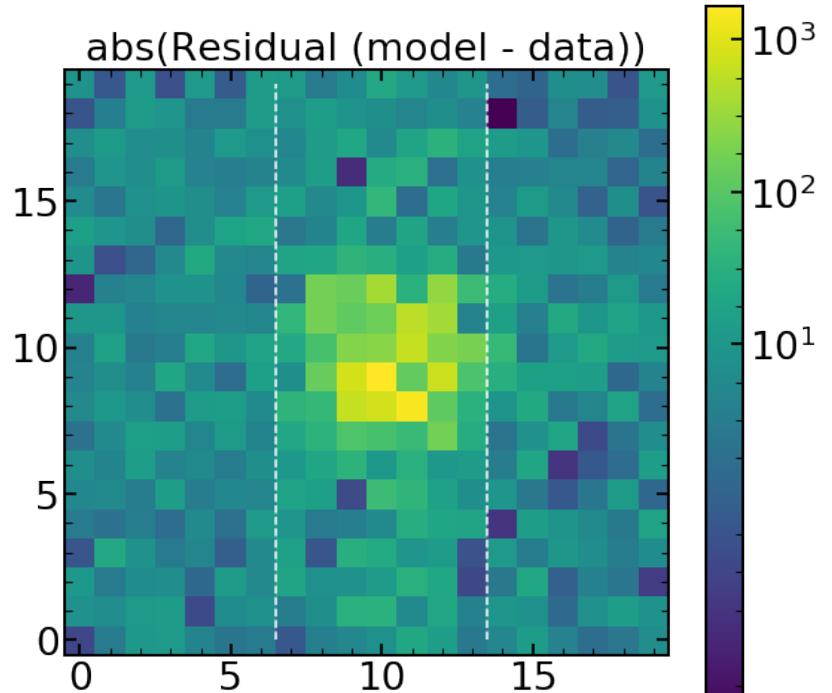
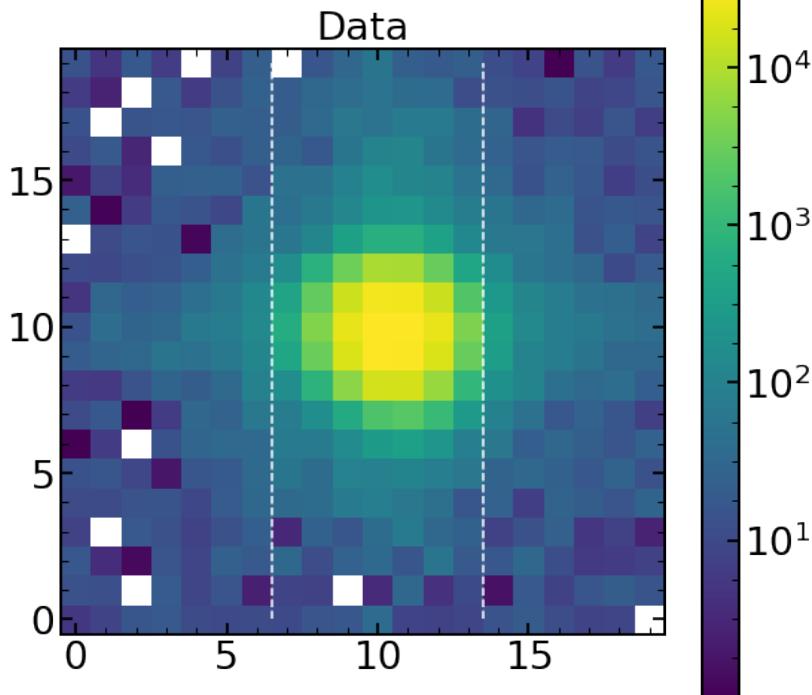
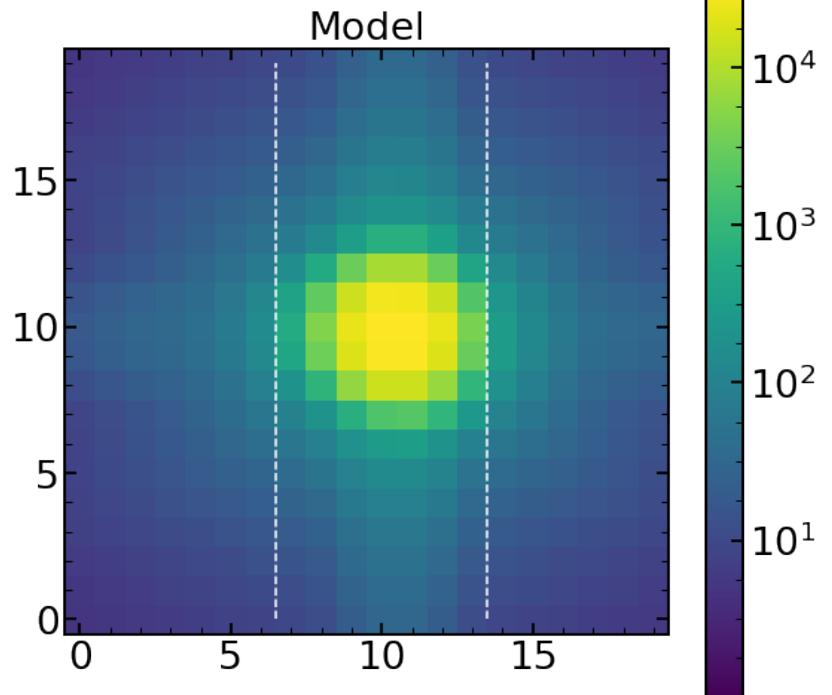


Speckles – can be
“removed” by fitting
higher order
wavefront
abberations

Focused
data,
example in
linear space

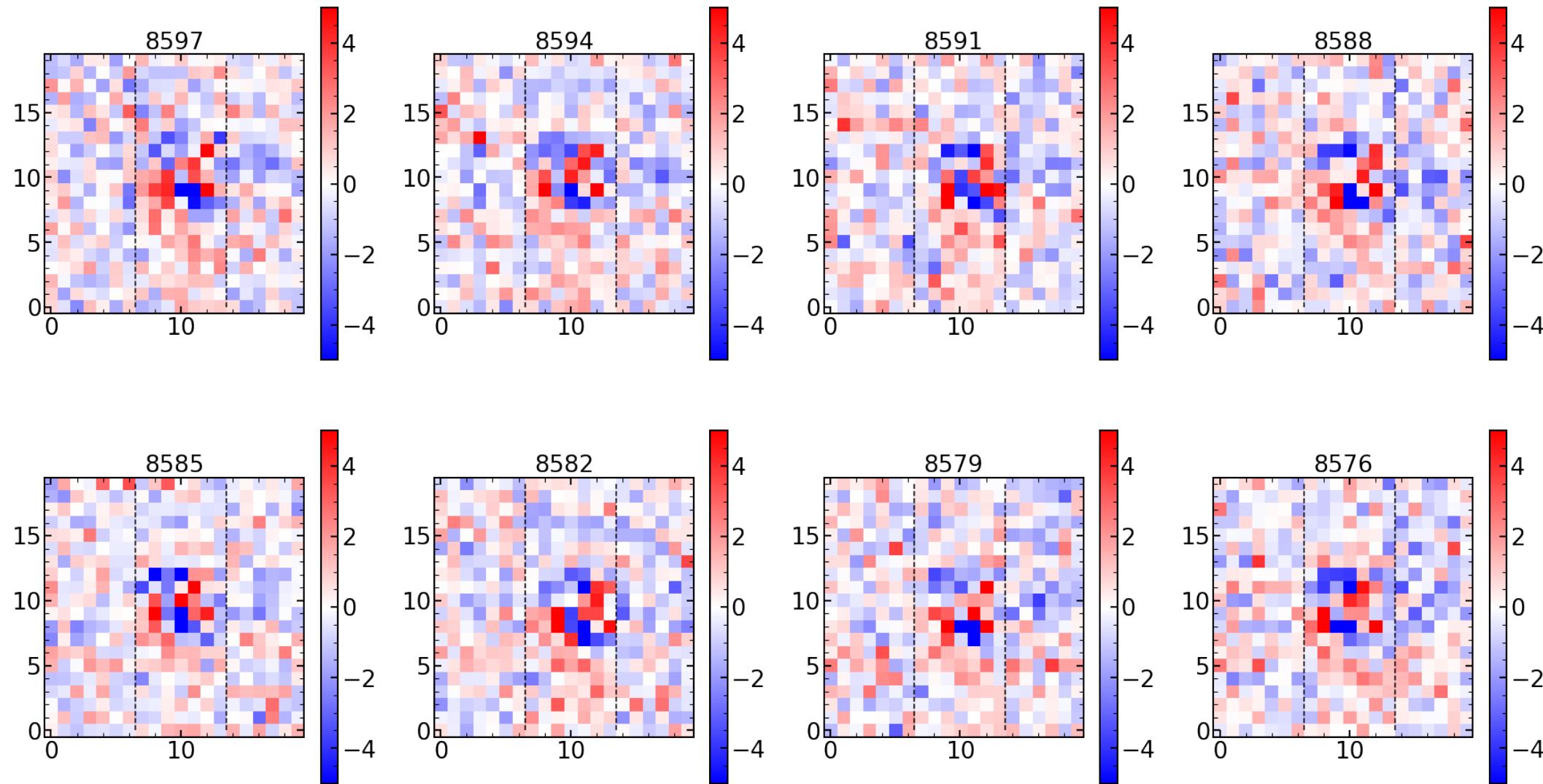


Focused
data,
example in
log space



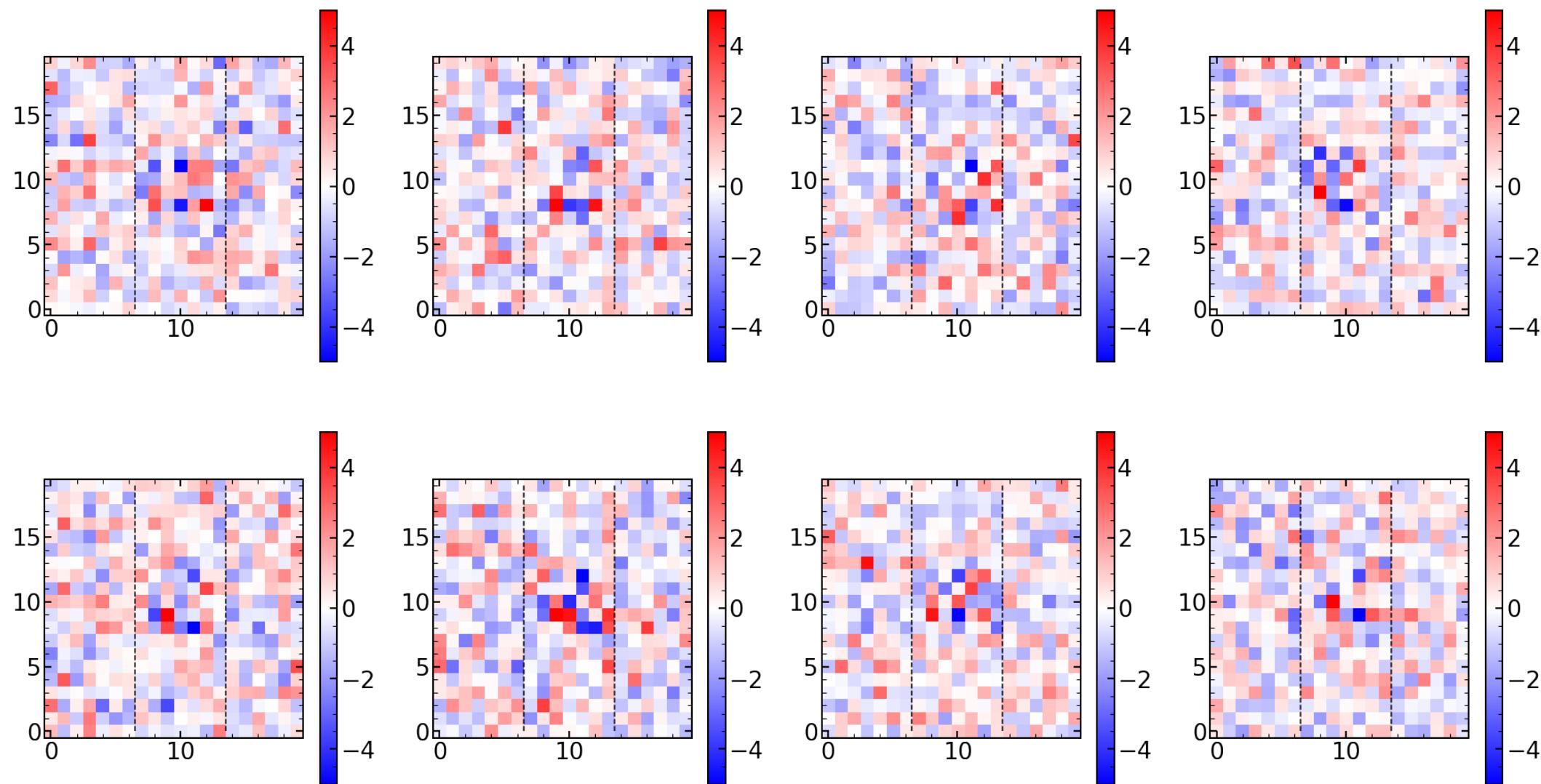
Residuals in the focused data, 8 different dithering positions

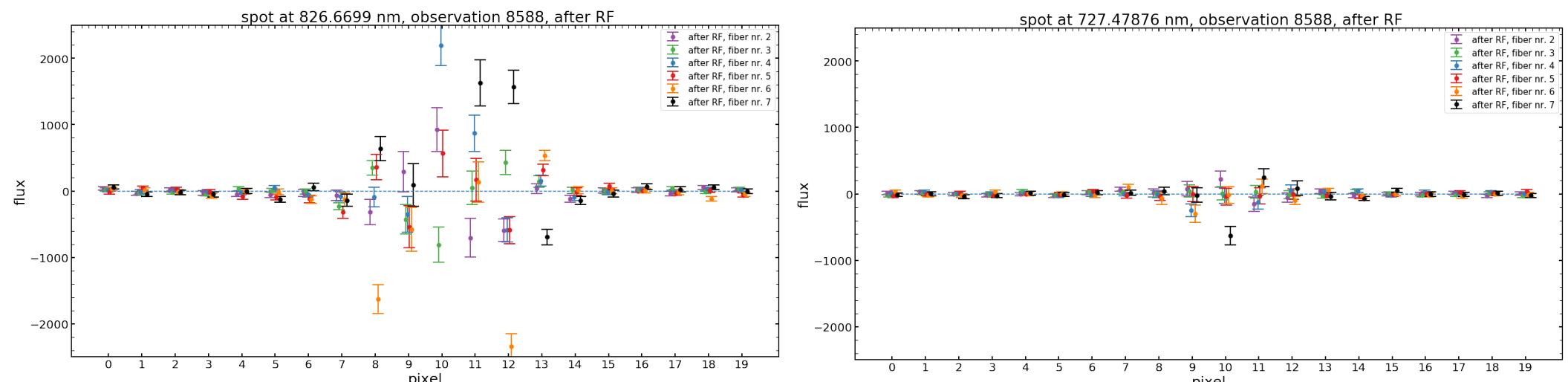
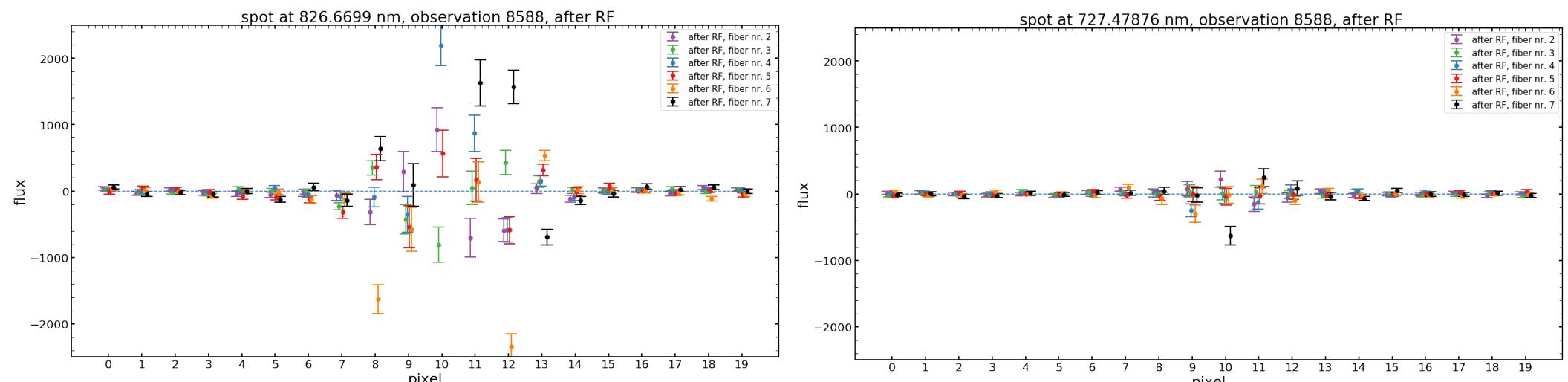
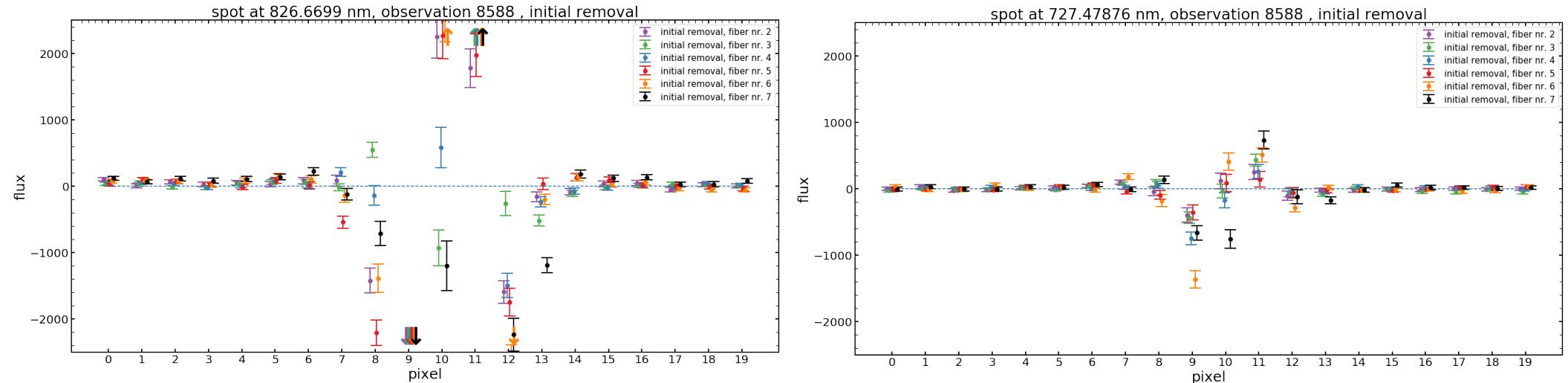
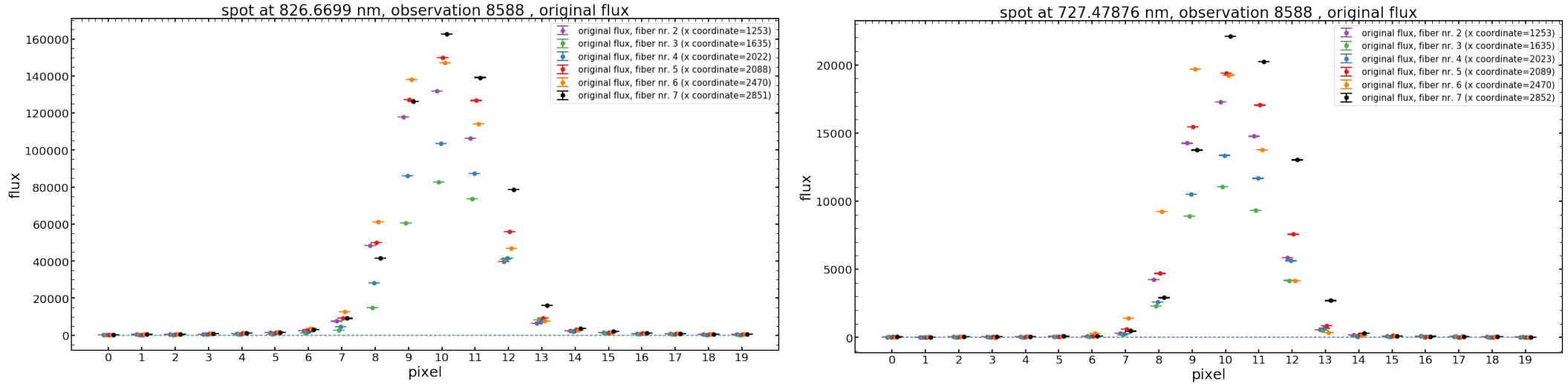
Residuals, up to Zernike 22 and Jan 15 modifications to centering'



Residuals in the focused data, 8 different dithering positions, after Random forest cleaning applied

up to Zernike 22, Jan 15 modifications to centering, and Random Forest postprocessing





Why do we keep asking for more data with different settings?

22 | 2 | 2D pipeline development and support Thursday, February 7th

 **Robert Lupton** 5:02 PM
I'm missing something. We need the `pfsConfig` file for the cable-B config
`expId`.

 **Craig Loomis** 5:02 PM
`pfsDesign`s will be fixed. I think we can probably freeze those to `pfsConfigs` with visit=lowNumber

 **Paul Price** 5:03 PM
A `PfsConfig` is an implementation of a `PfiDesign` for a particular exposure.

 **Craig Loomis** 5:03 PM
umm, a particular `visit0` (and up), right?
 1

 **Robert Lupton** 5:03 PM
Or add a fallback to the `PfiDesign` if the `PfsConfig` is unavailable.

 **Paul Price** 5:05 PM
That seems reasonable. We're not using the `pfiCenter` values from the `PfsConfig` yet...

 **Robert Lupton** 5:06 PM
Right.

 **Paul Price** 5:07 PM
Do we have a header keyword specifying the `pfiDesignId`, `@cloomis`?

 **Craig Loomis** 5:08 PM
yes, I think so. One sec.

 **Paul Price** 5:09 PM
My code is looking for `W_PFDGN`.

 **Craig Loomis** 5:09 PM
That sounds right.

 **Paul Price** 5:09 PM
Is it going to be set in data coming from LAM?

Every new dataset presents a new challenge

Why do we keep asking for more data with different settings?

★ | 8 22 | 2 2D pipeline development and support

Monday, April 29th

 **Fabrice Madec** 10:57 AM
yes that's for new data

I tried: ingestPfsImages.py /drp/fmadec/ --mode=link /drp/fmadec/pfiDesign-0x0000000000000000.fits -c clobber=True
register.ignore=True

 **Neven Caplar** 10:58 AM
nope!!!!

do not ingest pfiDesign
that will fail

you can ingest all *.fits as I did
pfiDesign will connect

10:59 AM so just ingest everything and do not worry about failures of ingesting pfiDesign files

 **Fabrice Madec** 10:59 AM
so we have to put the pfiDesign file in the raw directory

 **Neven Caplar** 10:59 AM
that is what I am doing ([@paulprice](#)?)

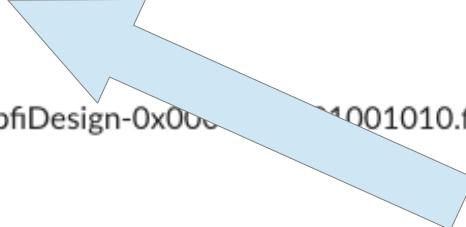
 **Paul Price** 10:59 AM
The ingest script looks in the raw directory for the pfsDesign files.
(The pfsDesign files should be alongside the raw images.)

 1

You don't need to refer to the pfsDesign files at all: they will be picked up automatically. It's the images that you want to ingest.

s/don't need to/shouldn't/

 **Fabrice Madec** 10:59 AM



Every new dataset
presents a new
challenge

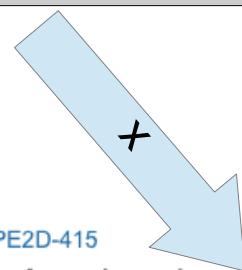
 DRP 2-D Pipeline / PIPE2D-414

reduceExposure.doSubtractContinuum=True does not remove continuum fro

[Edit](#) [Comment](#) [Assign](#) [More ▾](#) [In Progress](#) [In Review](#) [Workflow ▾](#)

Mercury - Argon

Krypton



DRP 2-D Pipeline / PIPE2D-415

Sometimes pfsArm has less elements than number of fibers in the image

[Edit](#) [Comment](#) [Assign](#) [More ▾](#) [In Progress](#) [In Review](#) [Workflow ▾](#)

Details

Type:	<input checked="" type="checkbox"/> Bug	Status:	OPEN (View Workflow)
Priority:	<input checked="" type="checkbox"/> Normal	Resolution:	Unresolved
Affects Version/s:	None	Fix Version/s:	None
Labels:	None		
Story Points:	4		
Sprint:	2DDRP-2019 E		

I. Different data (various arcs and fibers) are testing our pipeline

Description

Possibly closely connected with [PIPE2D-414](#).

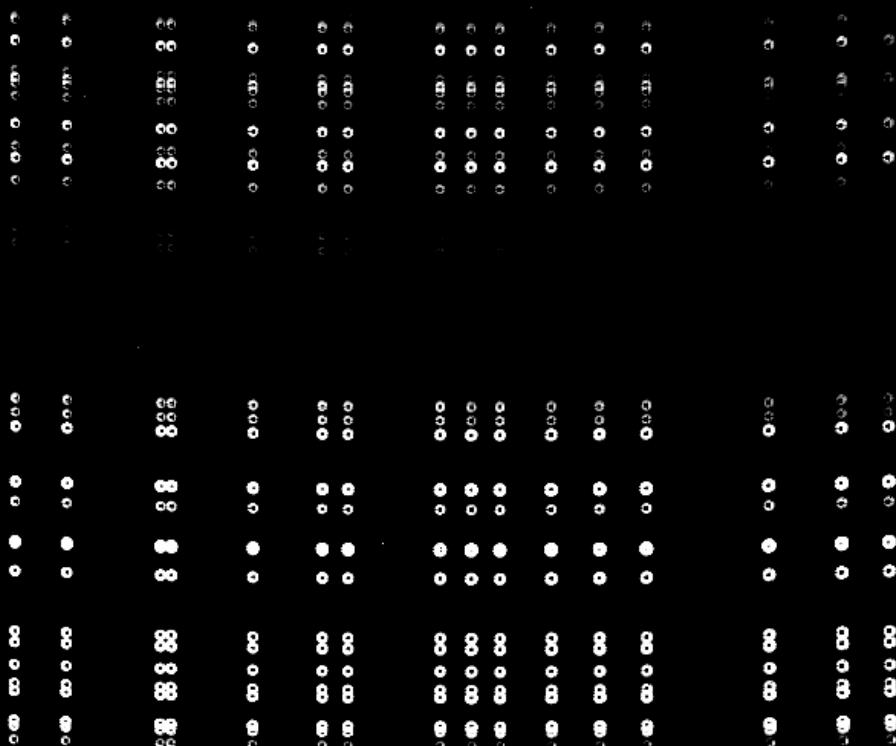
[naoki.yasuda](#) reports in [PIPE2D-339](#) that ``But for visit=14000 only a half of fibers will be identified (left hand side)``. This is probably the same problem as I report from Krypton data e.g., visit 13052, in [PIPE2D-411](#). There should be 16 fibers but

```
butler_KrFeb = Butler("/tigress/nkaplar/ReducedData/KrFeb_2019/rerun/Apr30_2019/arc")
arc = butler_KrFeb.get("pfsArm", visit=13052, arm="r", spectrograph=1)
arc.wavelength[14]
```

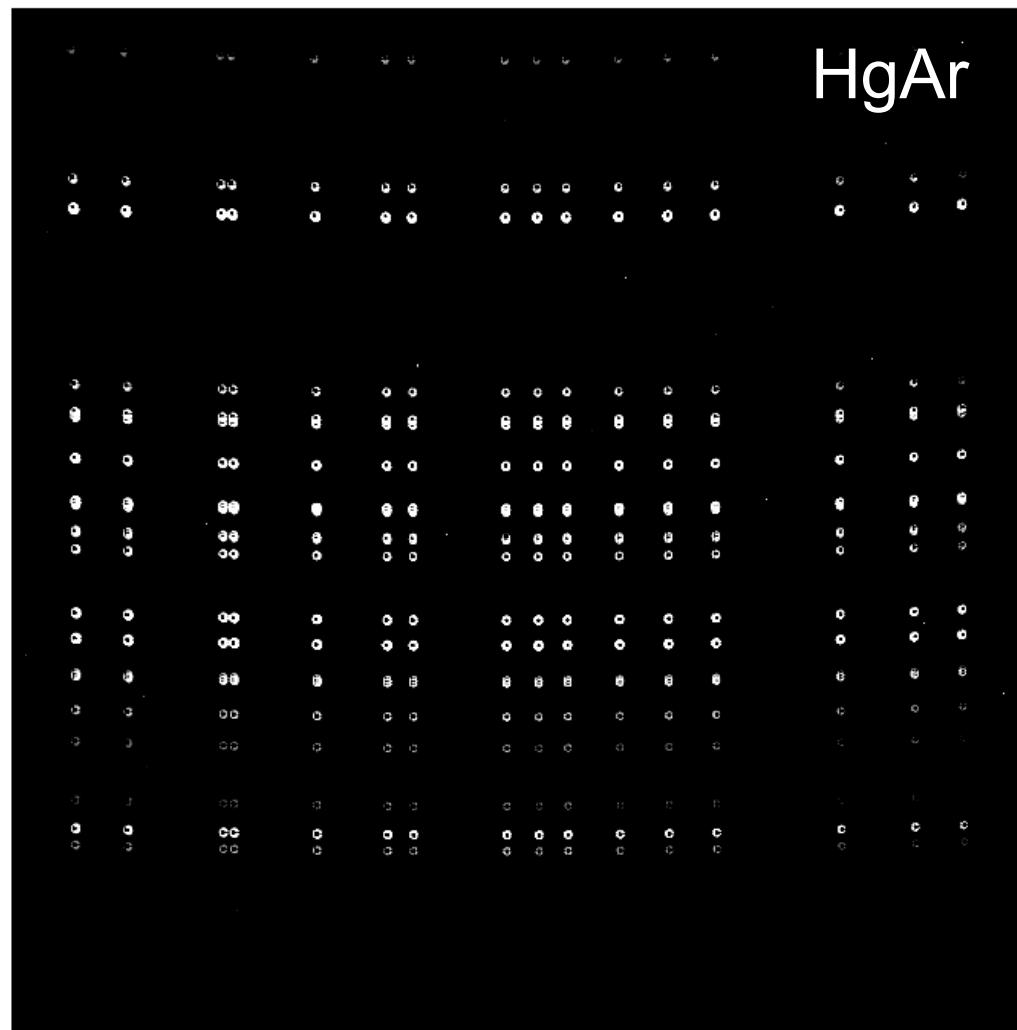
II. Why different arcs?

- a) To span the full focal plane
- b) To check consistency of the results

Neon



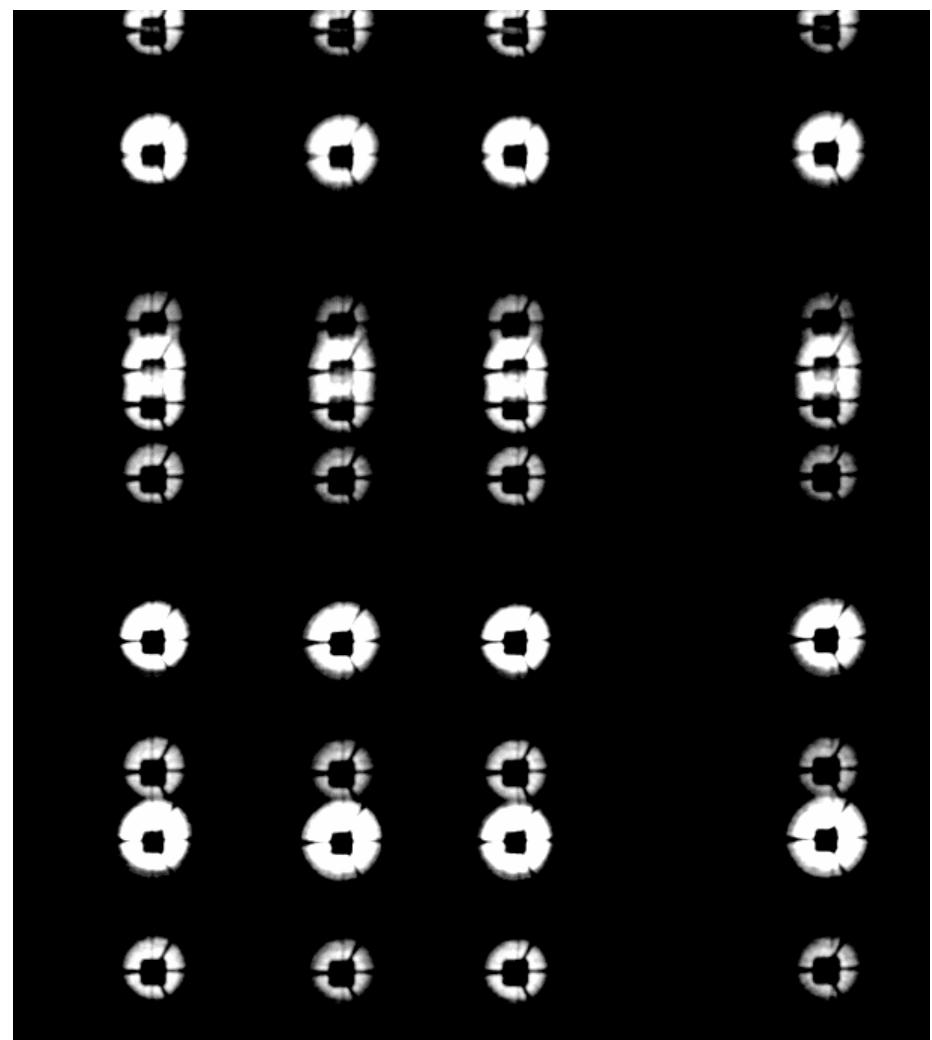
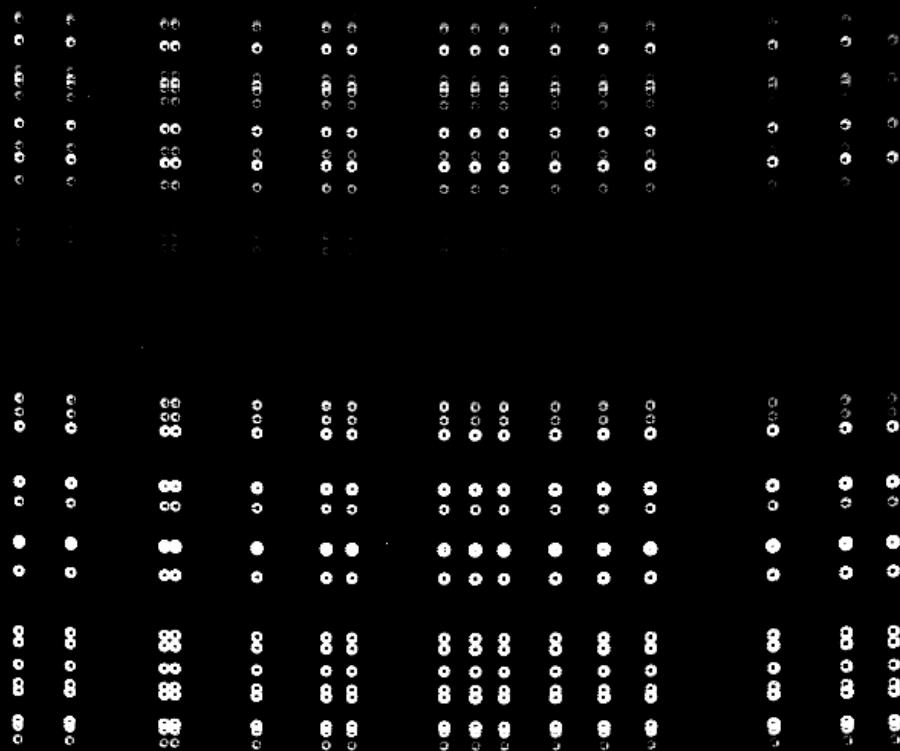
HgAr



II. Why different arcs?

- a) To span the full focal plane
- b) To check consistency of the results

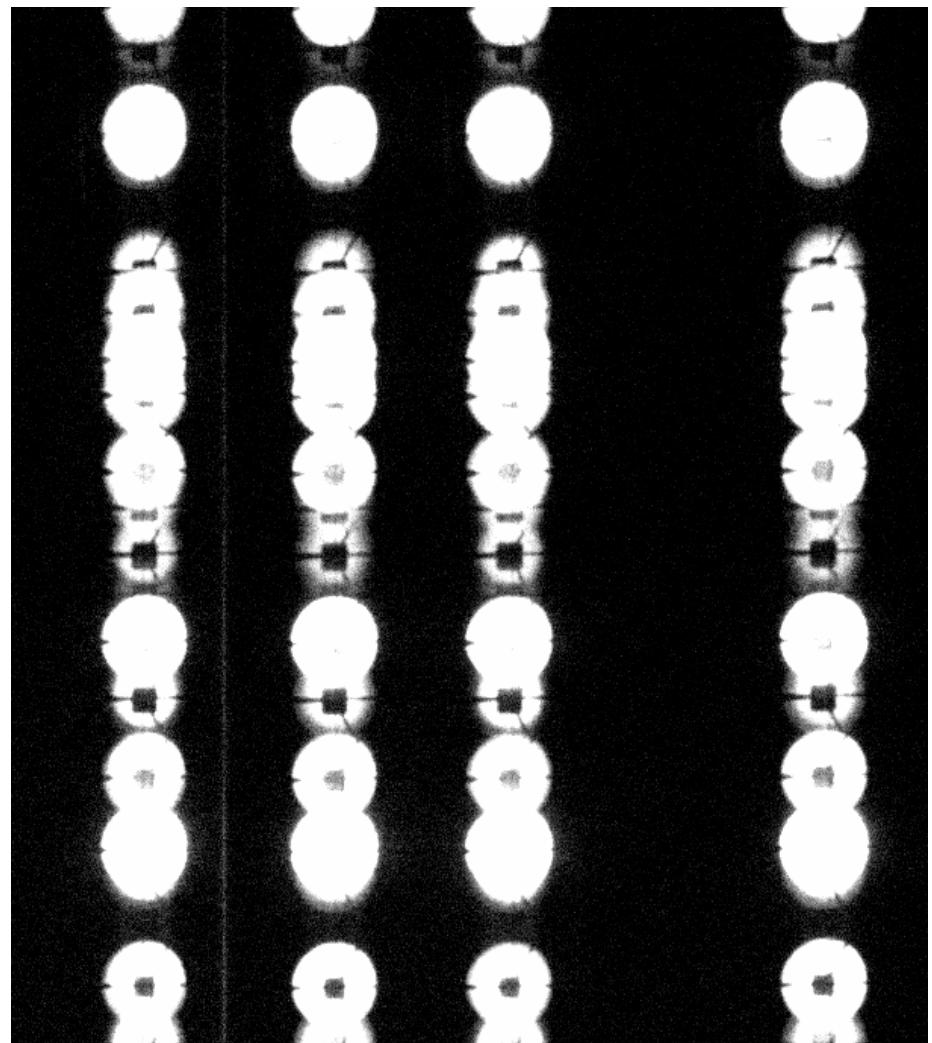
Neon



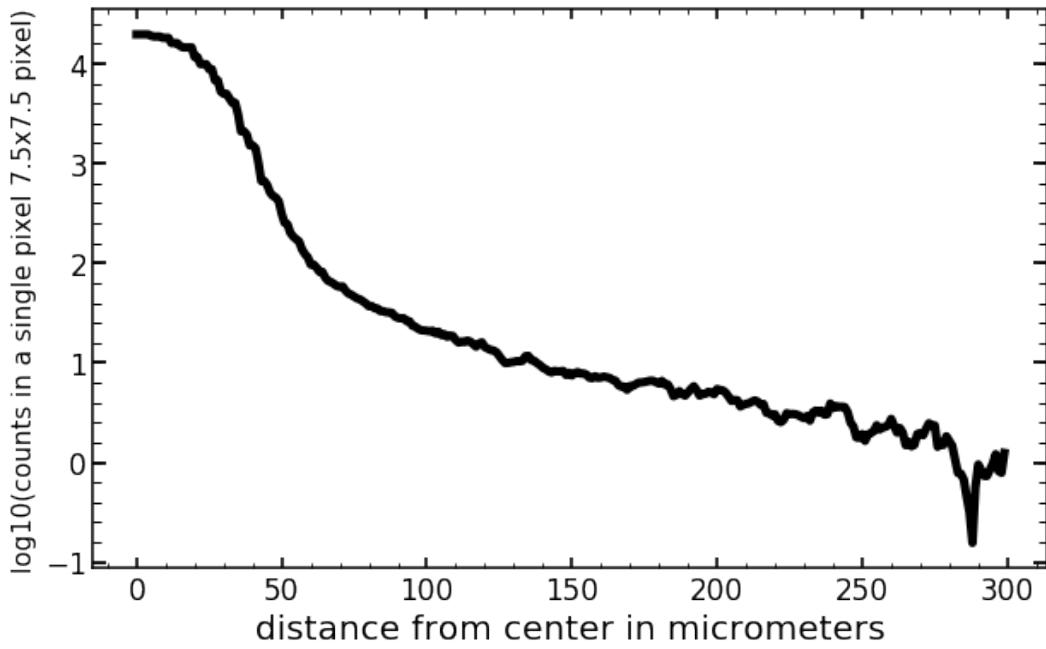
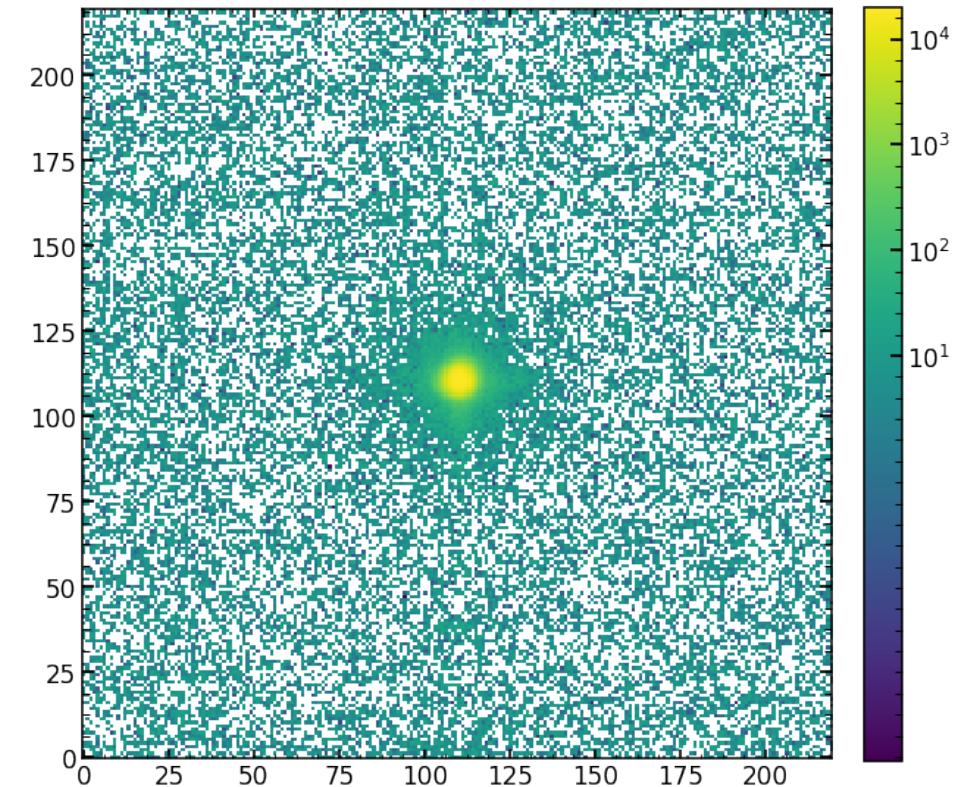
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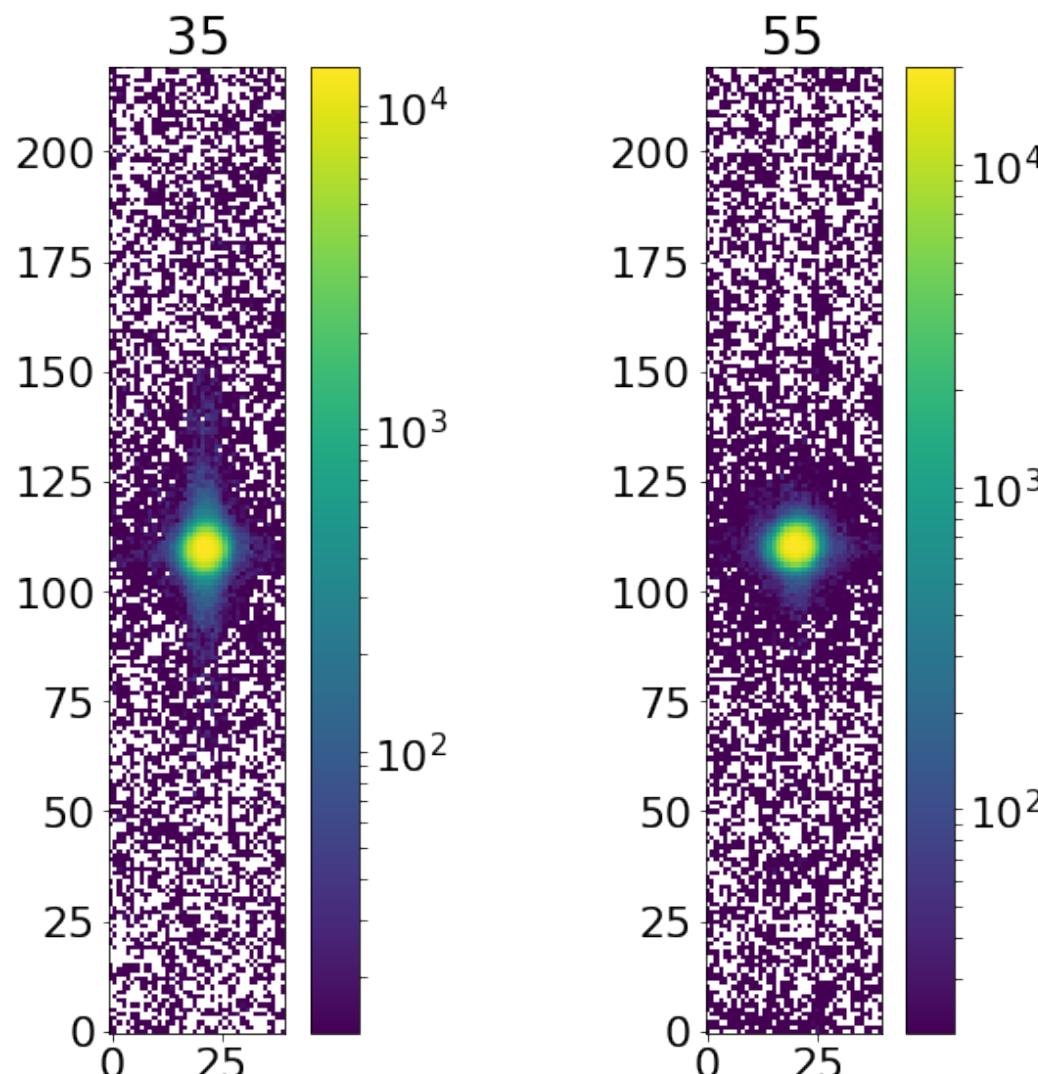
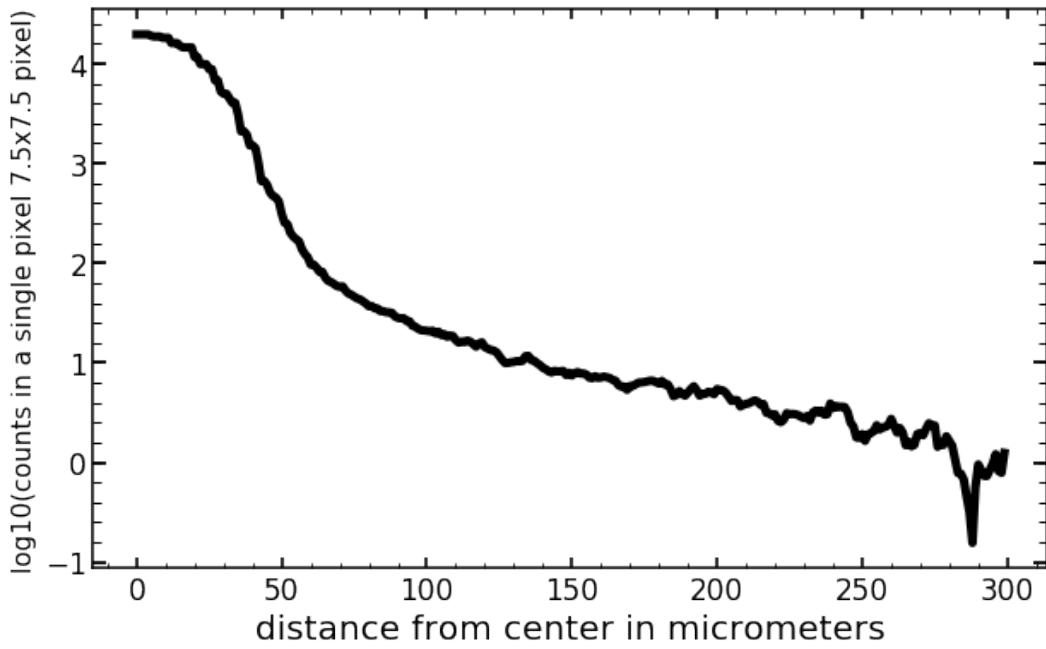
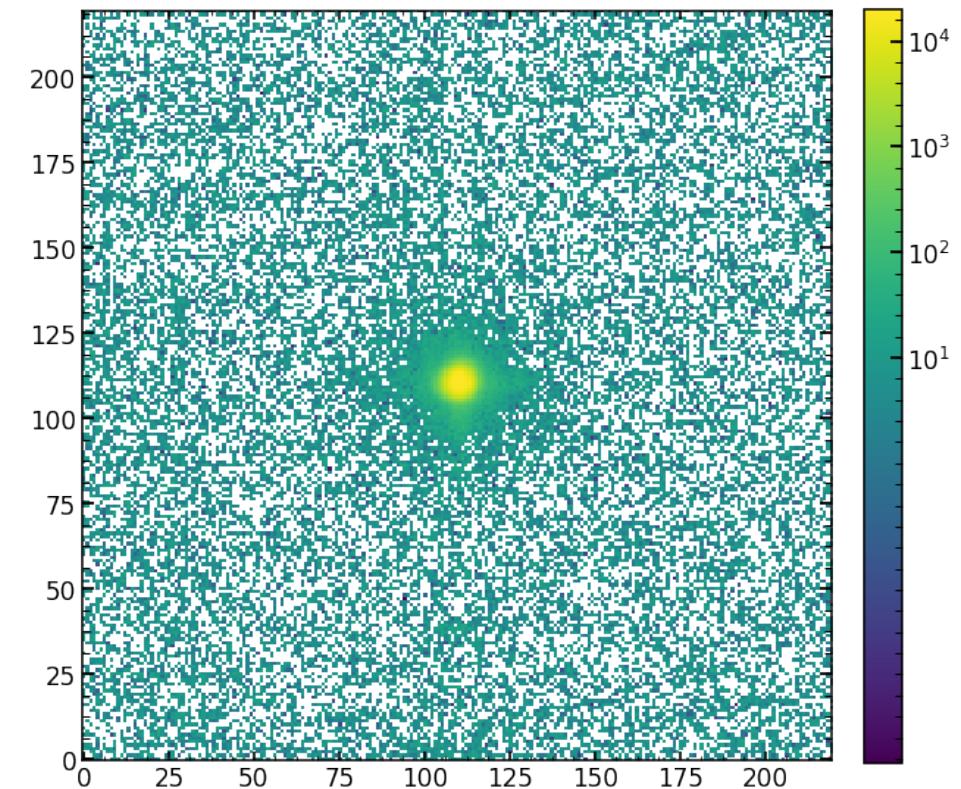


III. Why focused data?



a) Scattering, scattering...

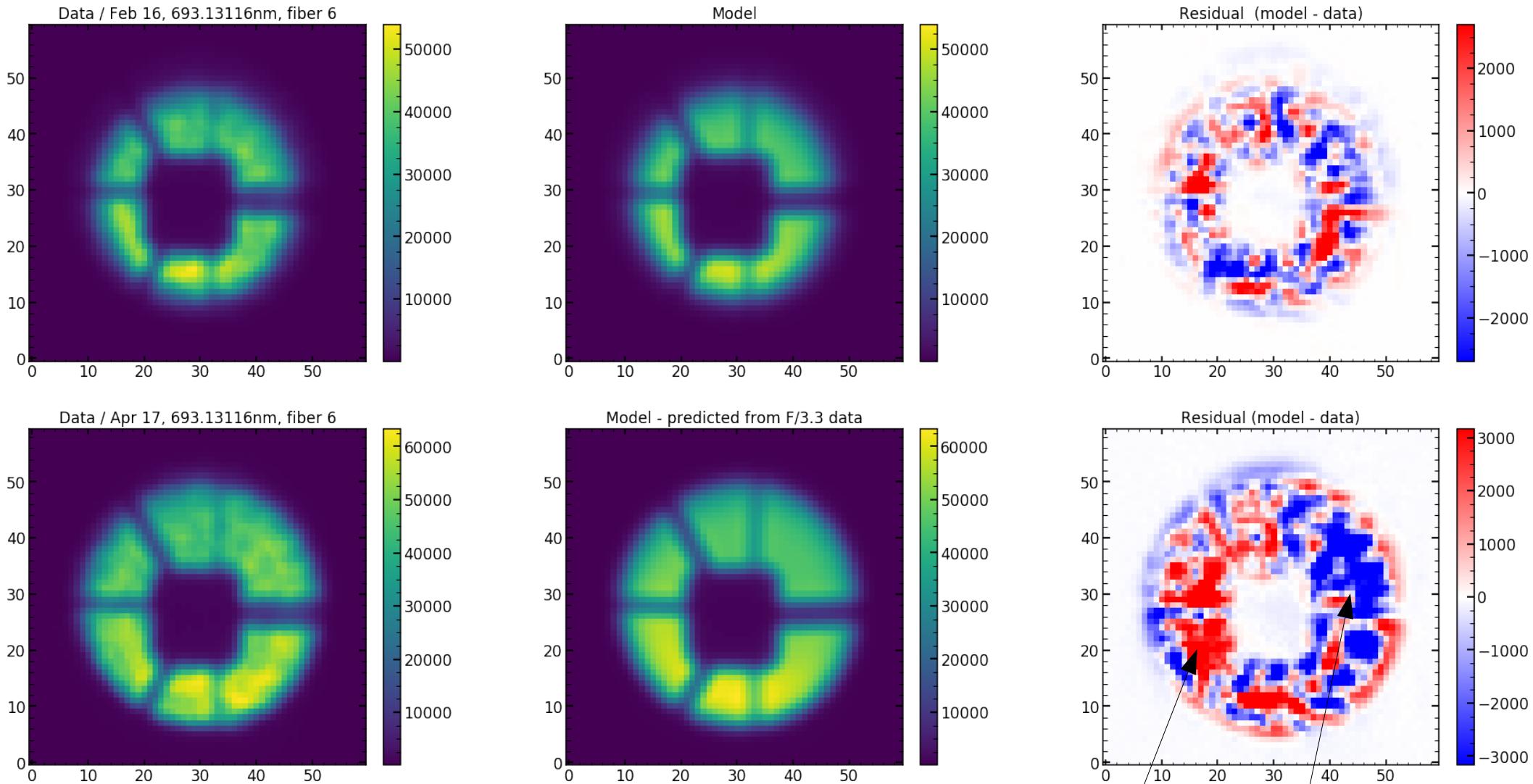
III. Why focused data?



a) Scattering, scattering...
b) Grating effects

IV. Why different stops?

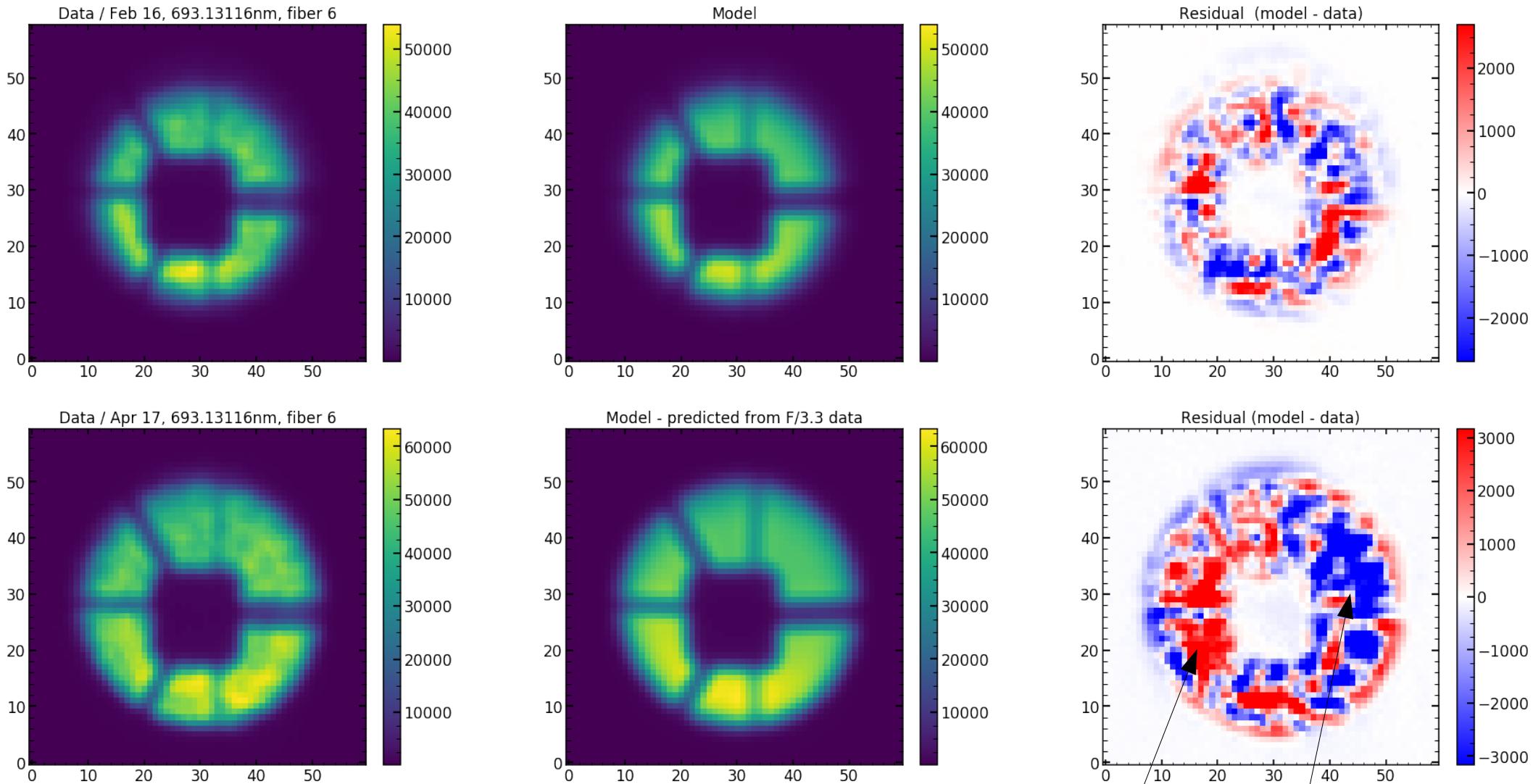
a) only illumination of the full pupil gives full information



Mistakes in the non-illuminated region!

IV. Why different stops?

a) only illumination of the full pupil gives full information



b) experiment for the quality of the approach

Mistakes in the non-illuminated region!

Summary

- 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
- Defocused image should allow to decouple the illumination and the wavefront abberations
- Why we need data
 - Testing the pipeline
 - Different arcs to fill up the plane
 - Defocused and focused data to test different properties
 - Different stops change the illumination of the pupil