2D point spread function characterization for Prime Focus Spectrograph

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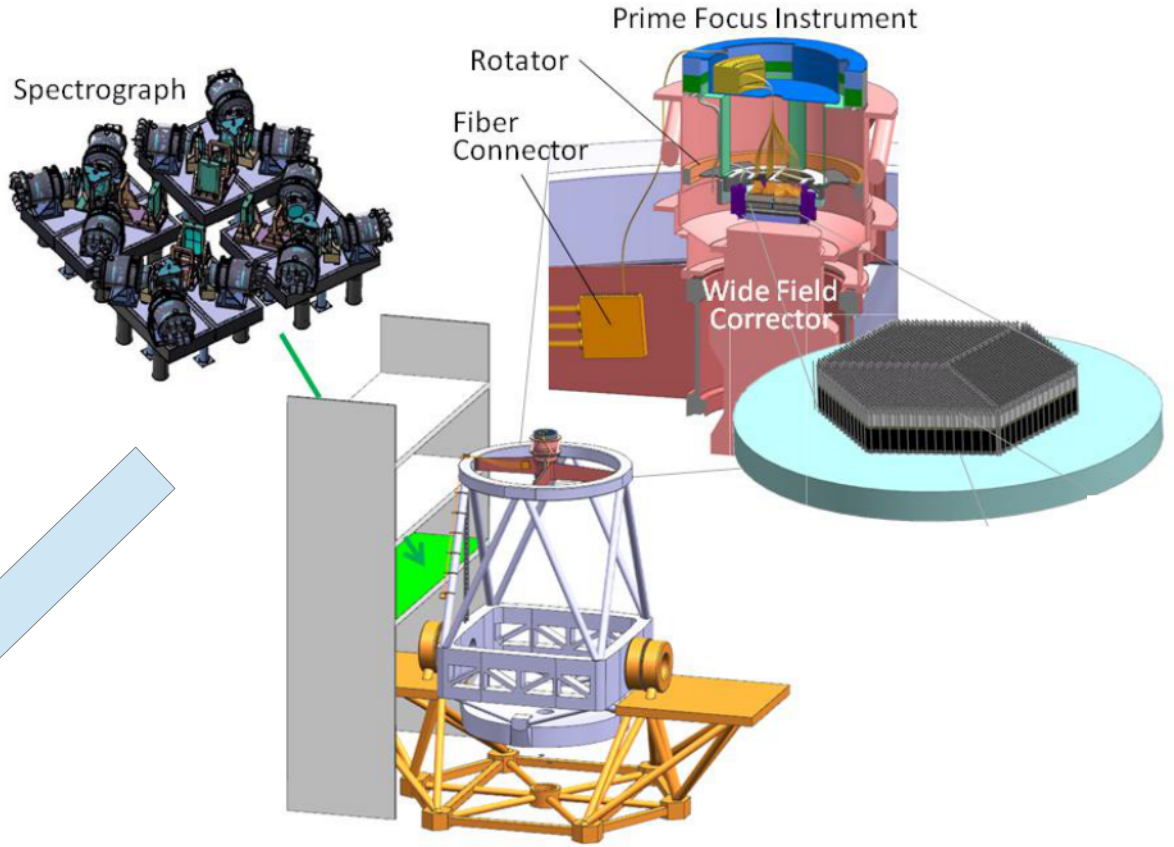
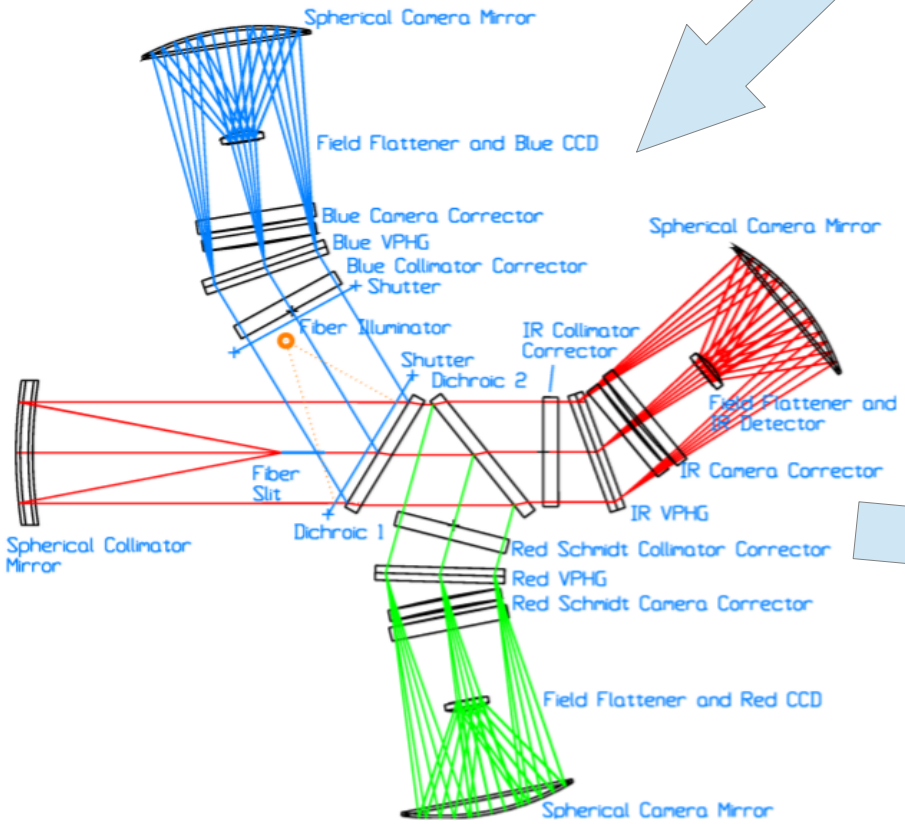
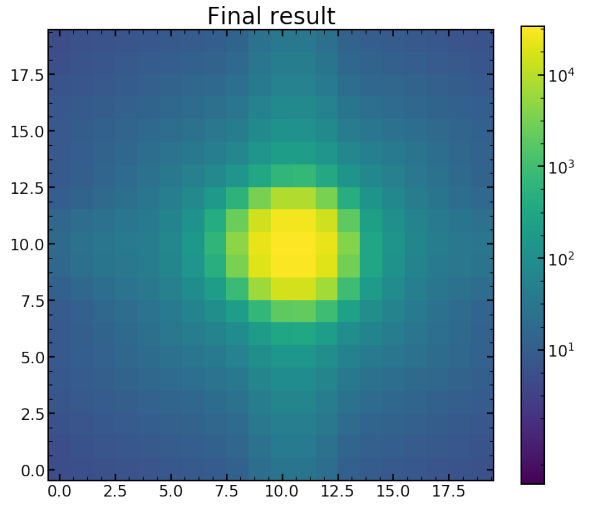
PRINCETON UNIVERSITY

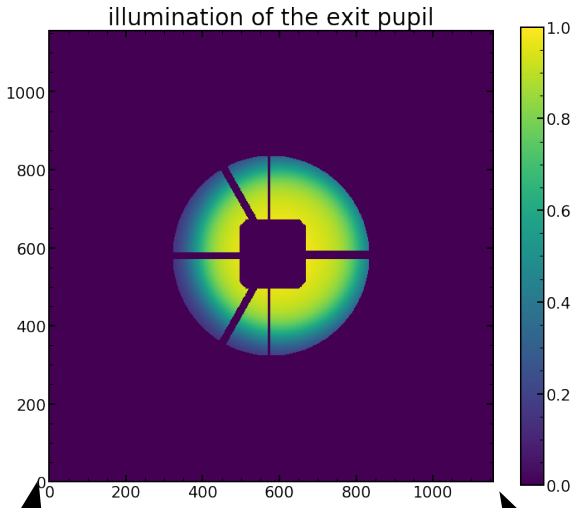
3 components to the PSF

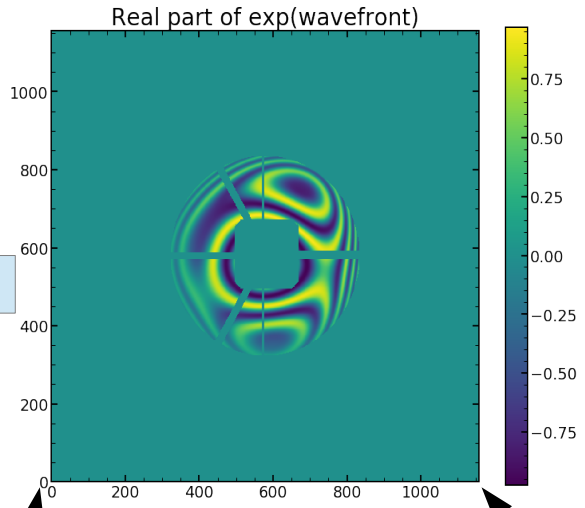
- Telescope pupil illumination
- Focal ratio degradation in the fibres
- Spectrograph cameras











Non-uniformly illuminated – FRD and ``effective'' FRD

Aberrated wavefront – from defocused images

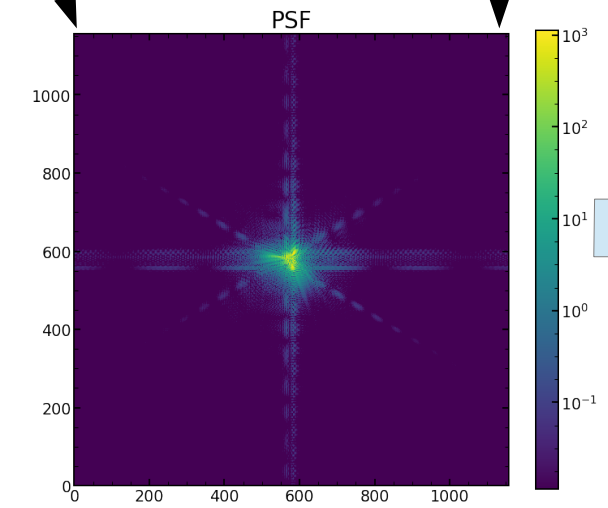
We have been developing a model to simulate PSF based on our experience in HSC project

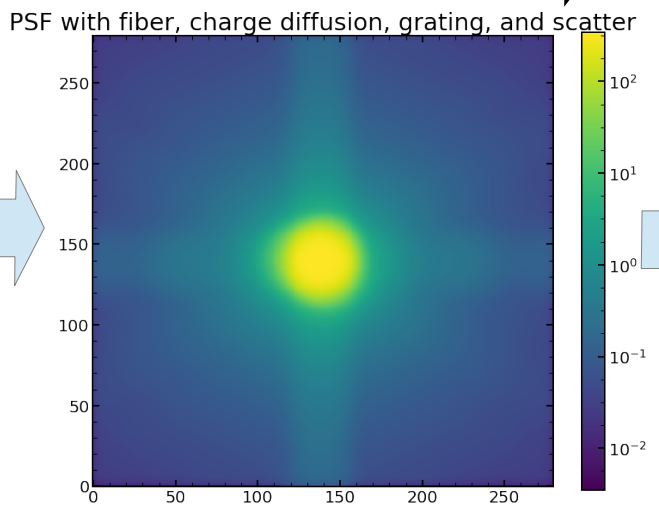
- Non-uniform illumination of the pupil
- Wavefront aberrations
- Scattering and other effects

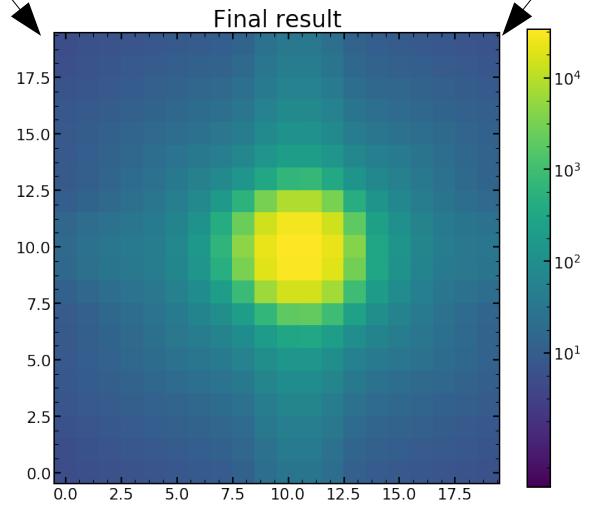
Fourier optics
Diffraction effects!

Fiber, charge diffusion, grating, scatter...

Final model as it would appear on the detector





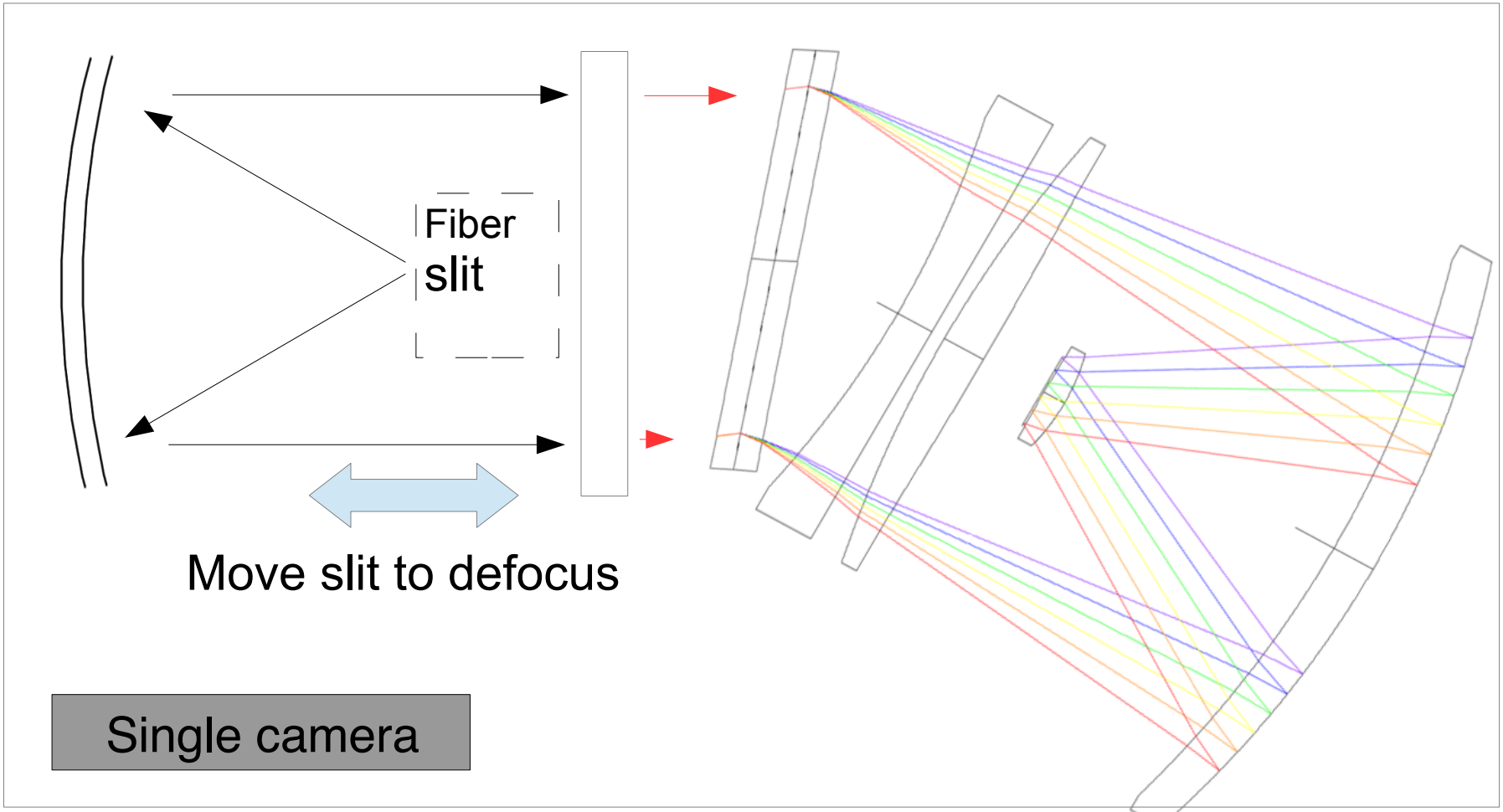


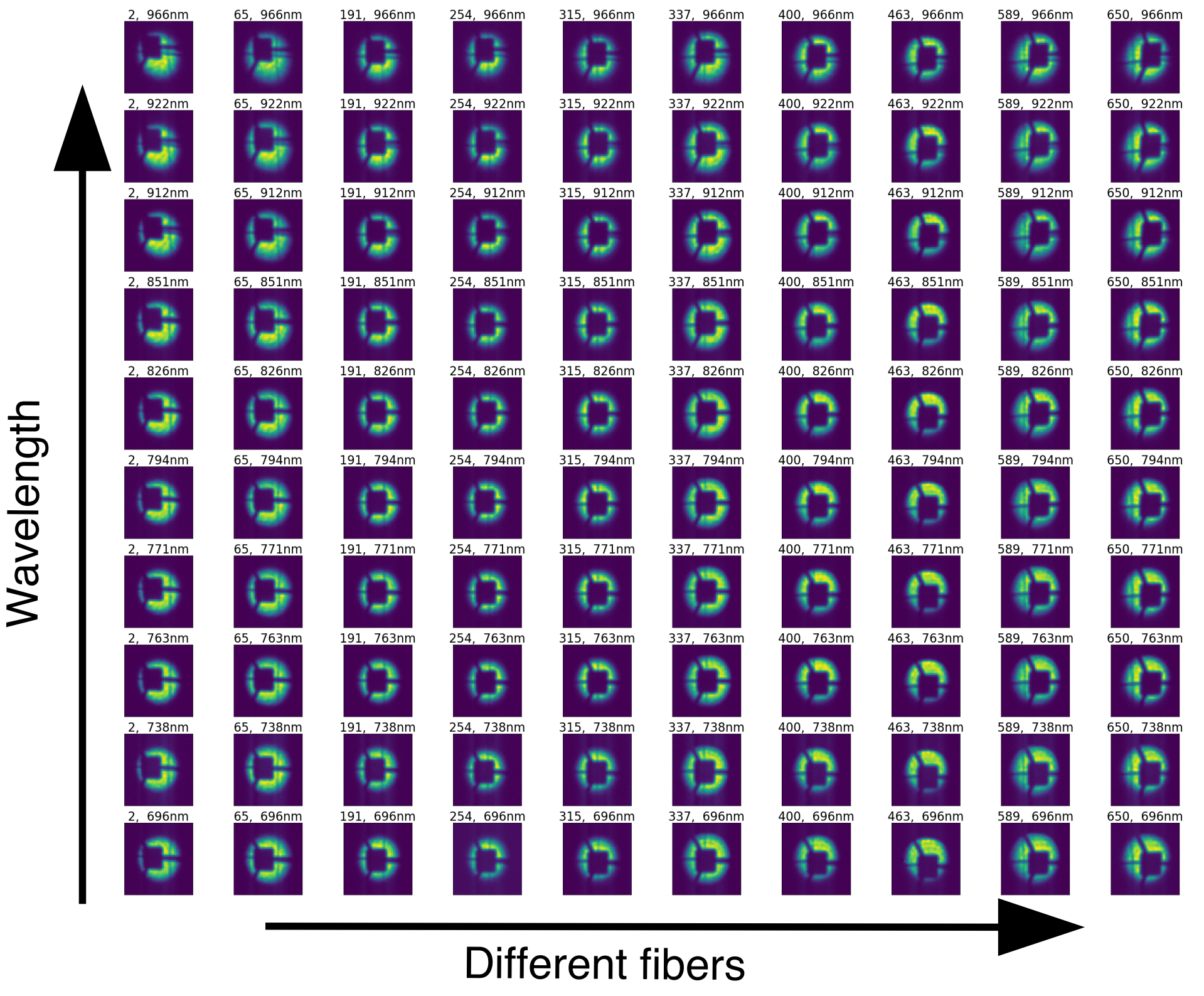
3 components to the PSF

- 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

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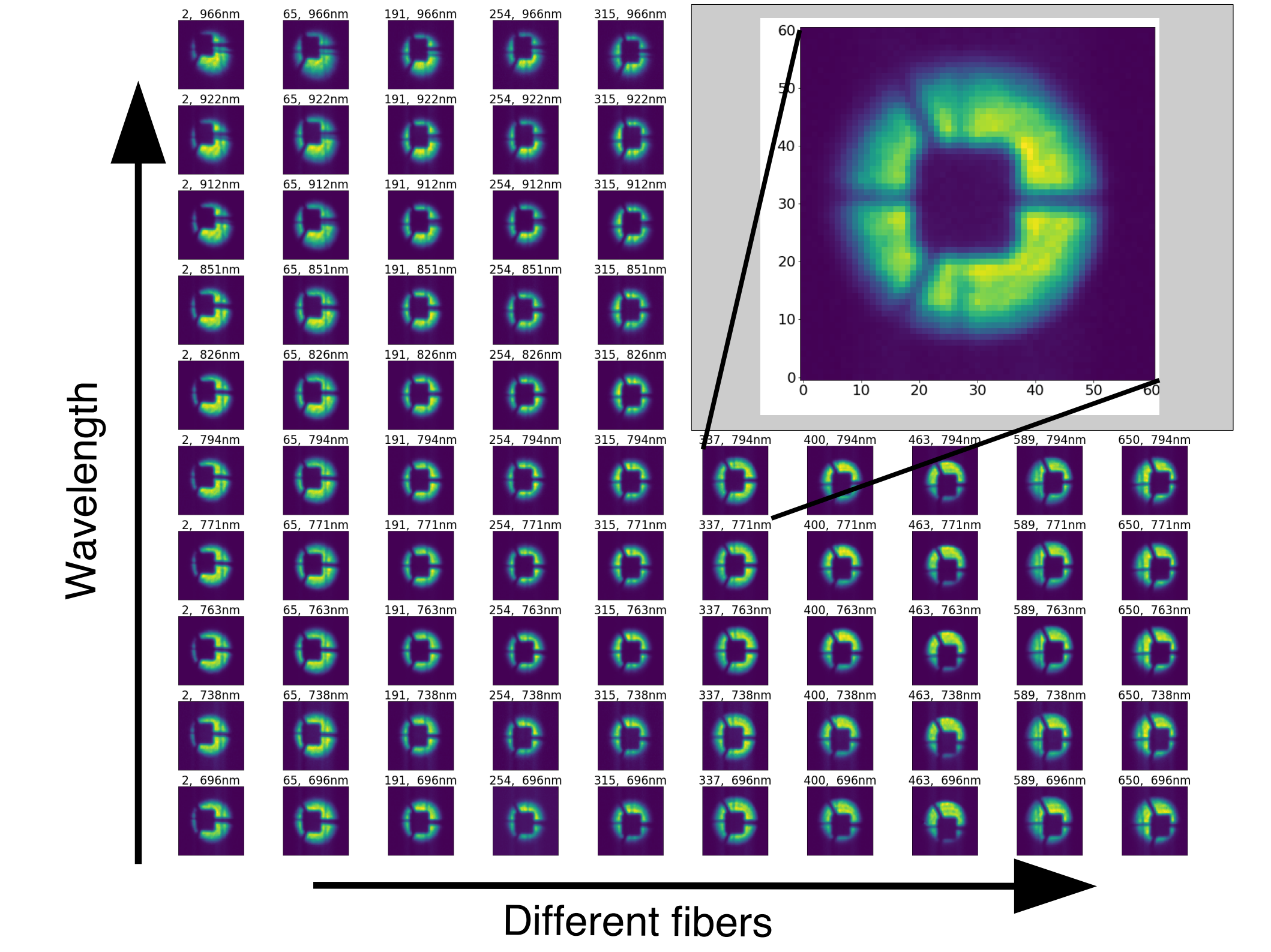
Wavelength
Different fibers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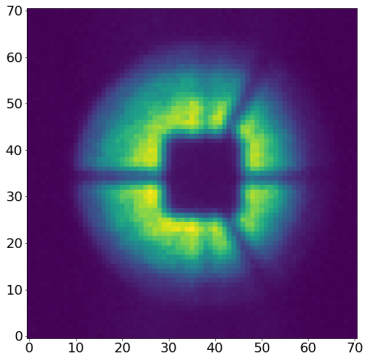
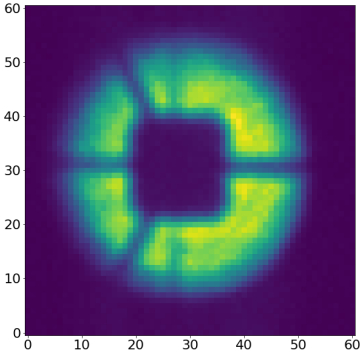
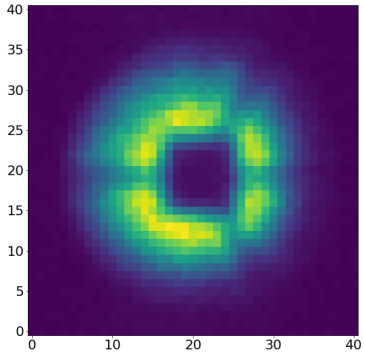
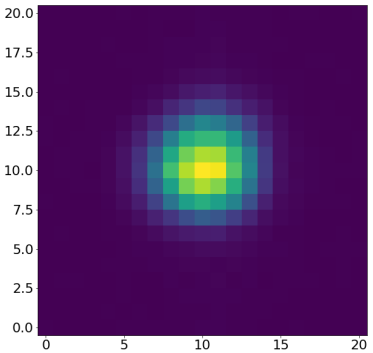
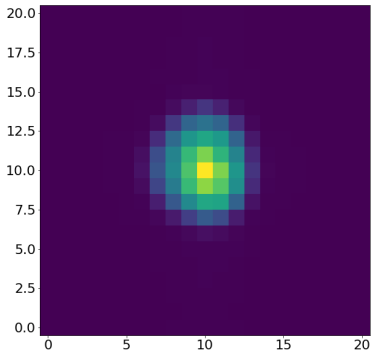
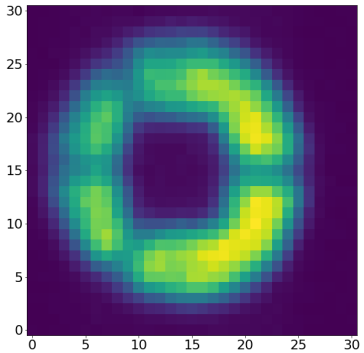
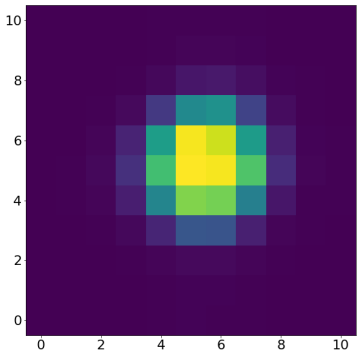
463, 696nm
589, 696nm
650, 696nm
0
10
20
30
40
50
60
Wavelength
Different fibers

How to decouple the illumination and the wavefront aberrations?

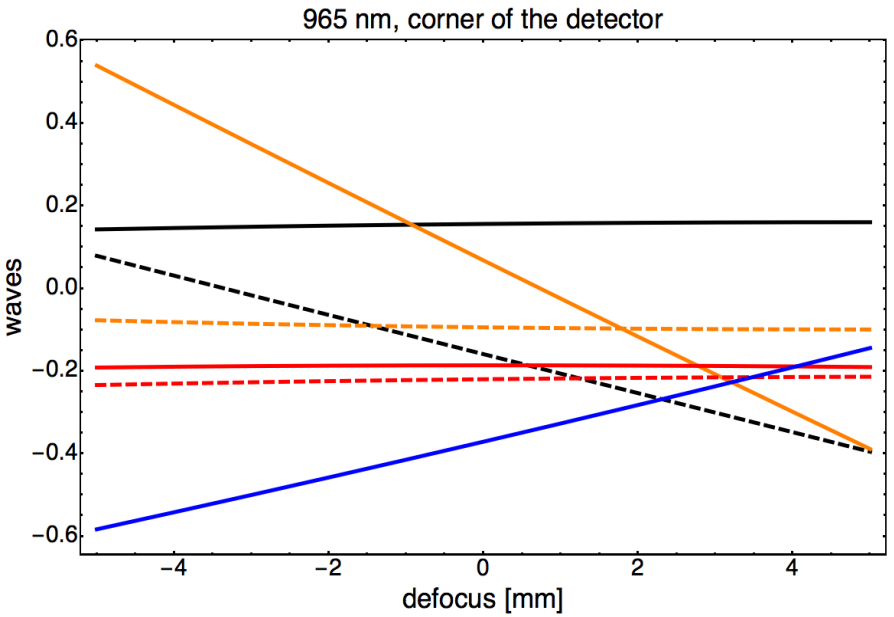
- Images at different value of defocus
- Follow wavefront aberrations as a function of defocus

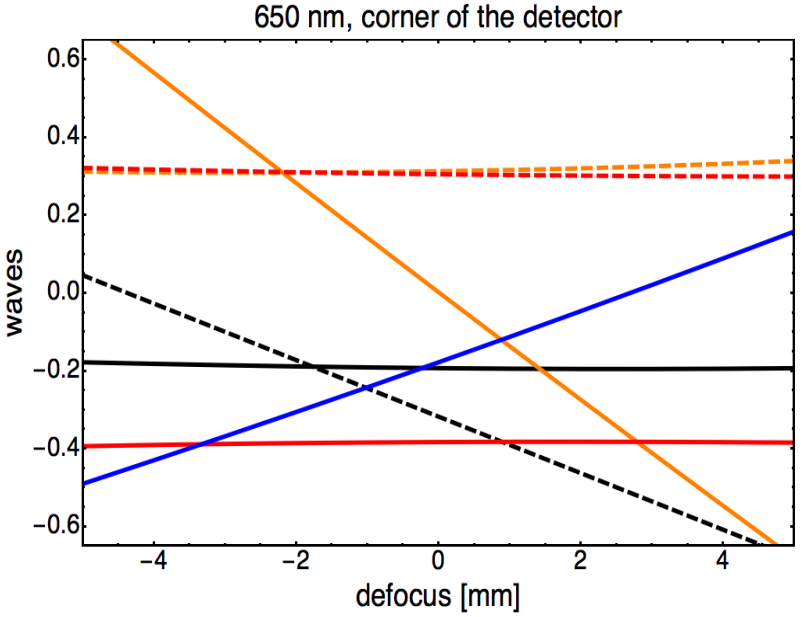








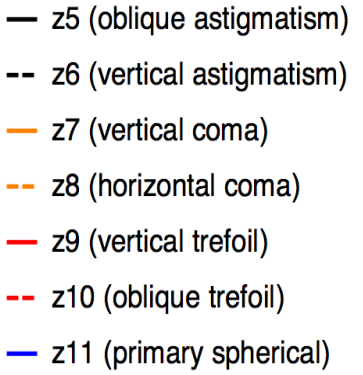
More defocused

In focus

More defocused



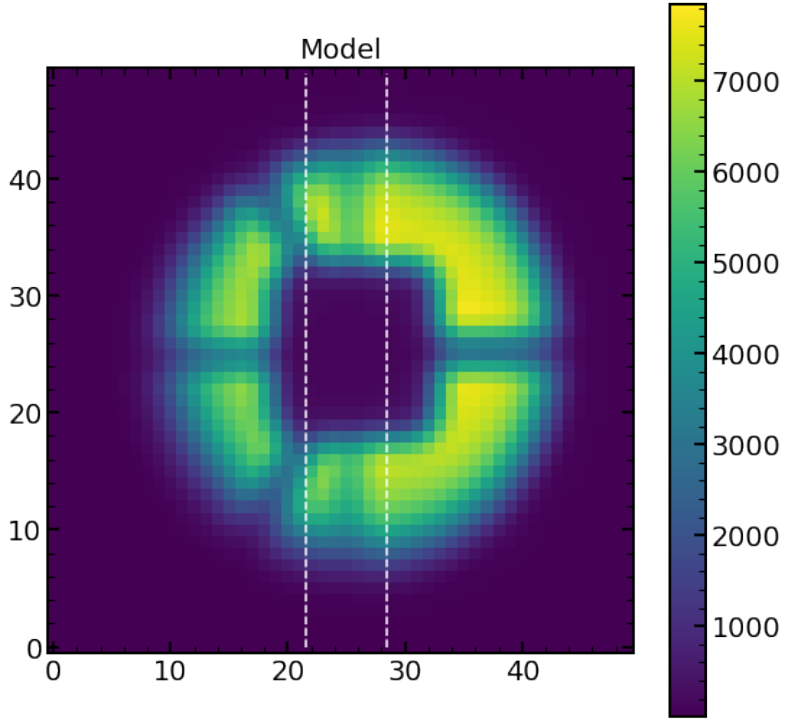


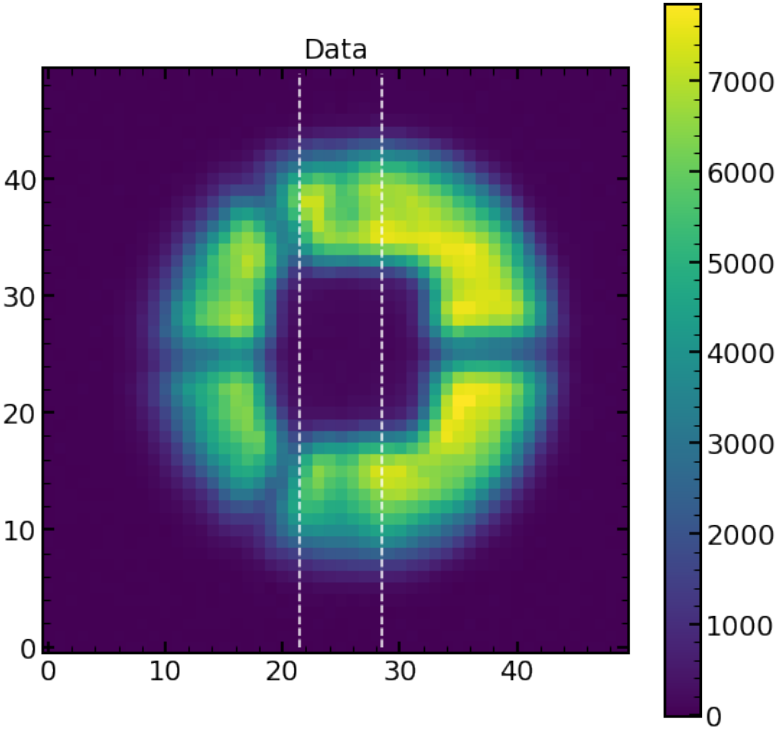


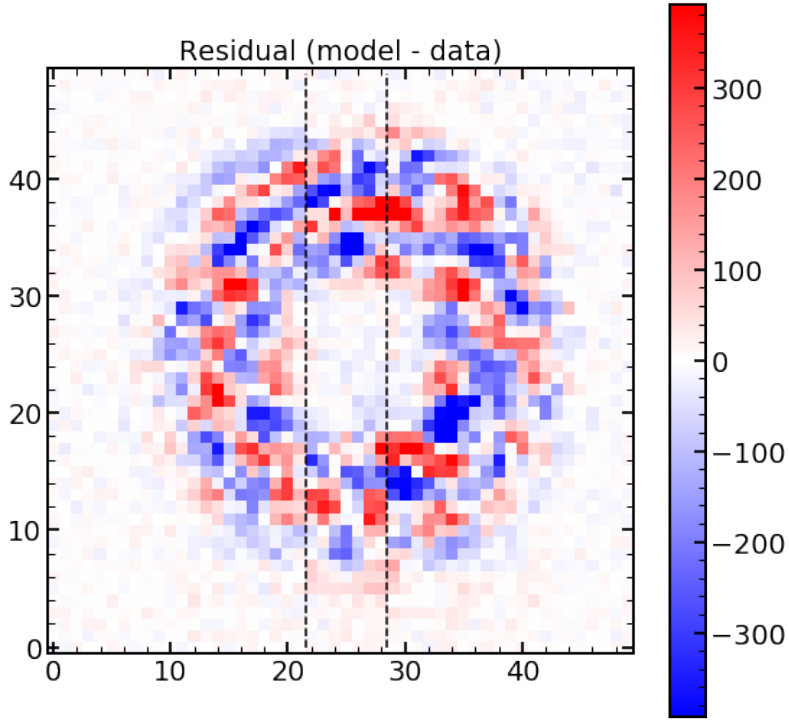
Wavefront aberrations as function of defocus (Zemax)

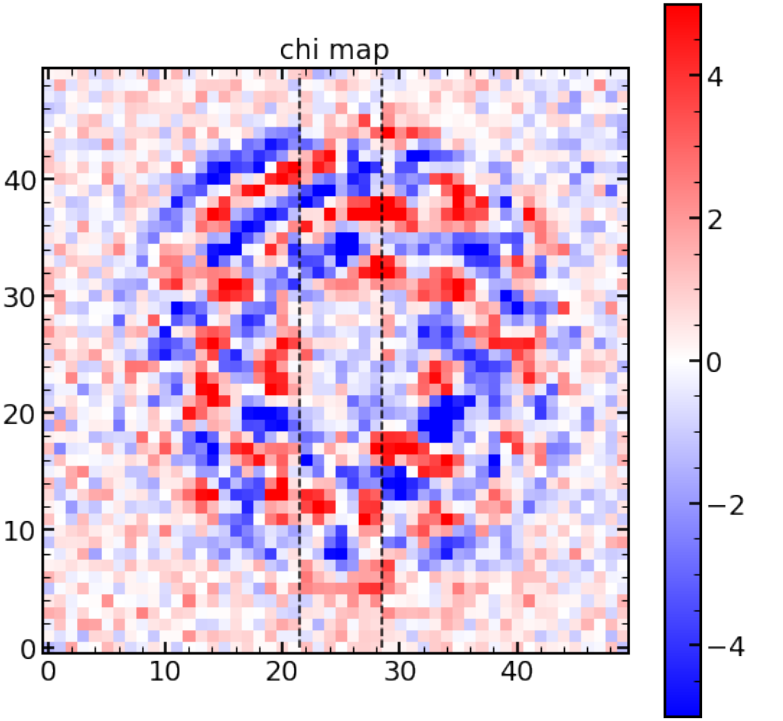
- We wish to deduce/reproduce these curves from the data
- Model wavefront aberrations at each position in the detector

Defocused data, example in linear space

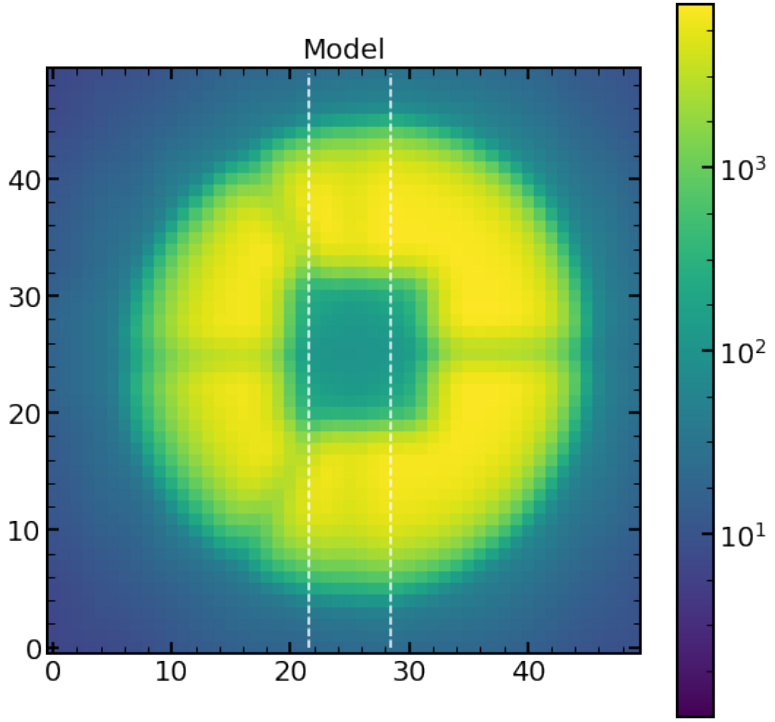


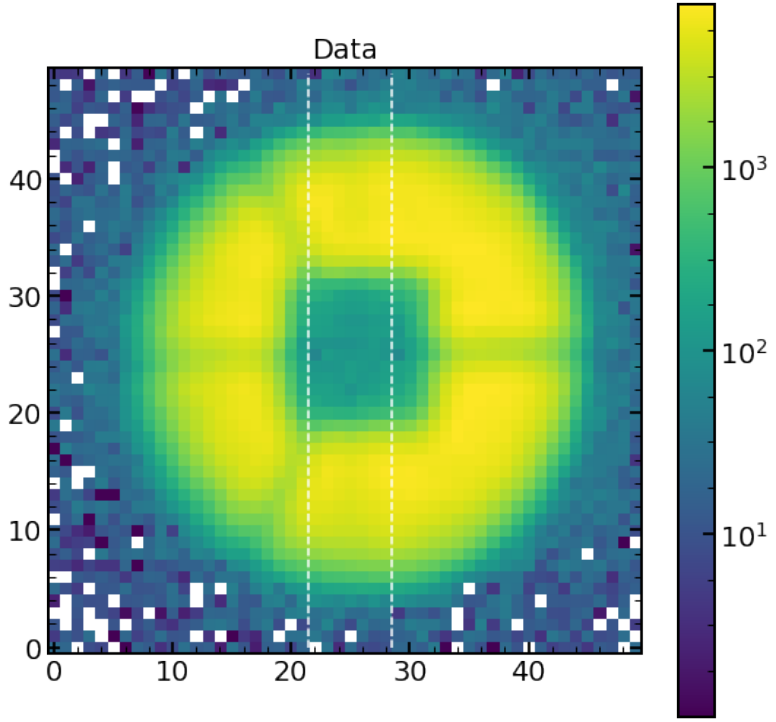


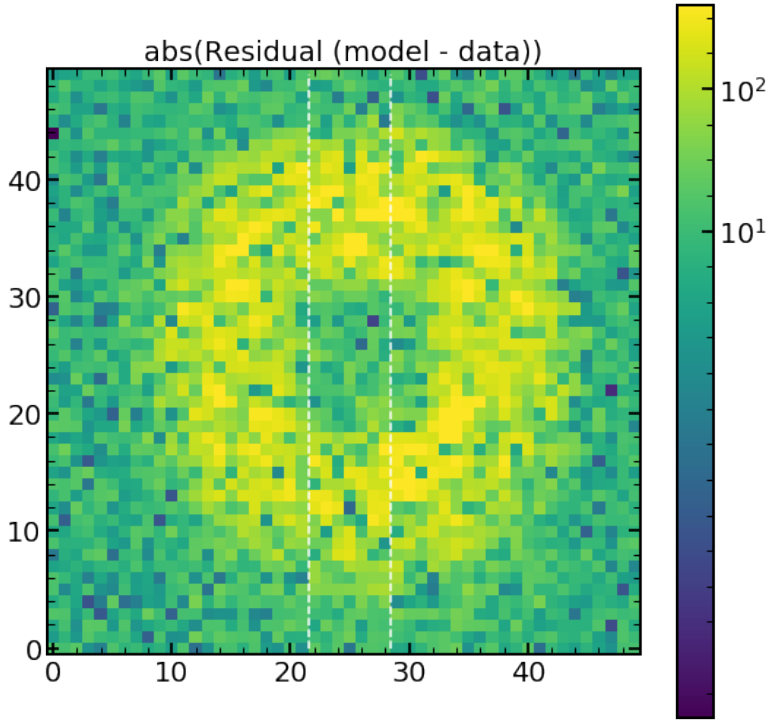


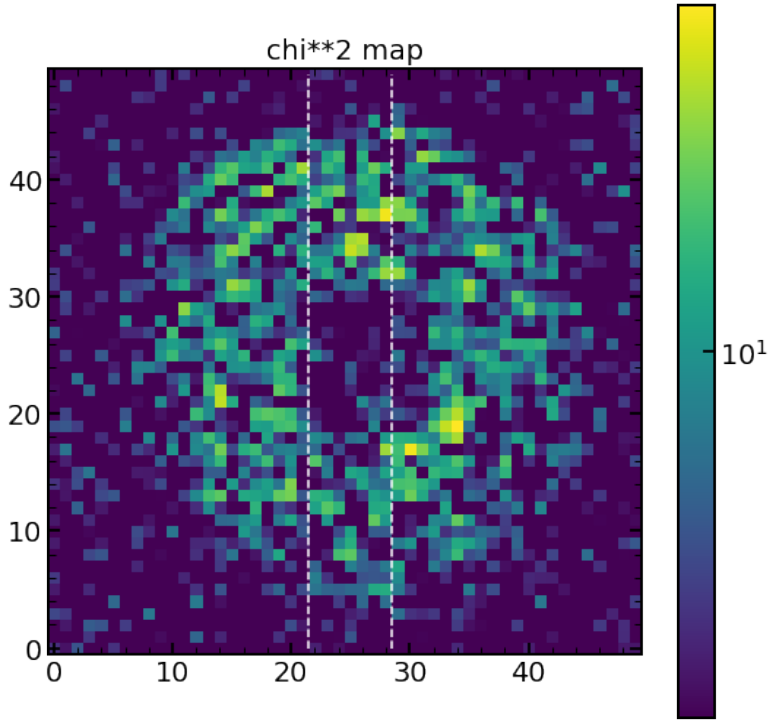


Defocused data, example in log space

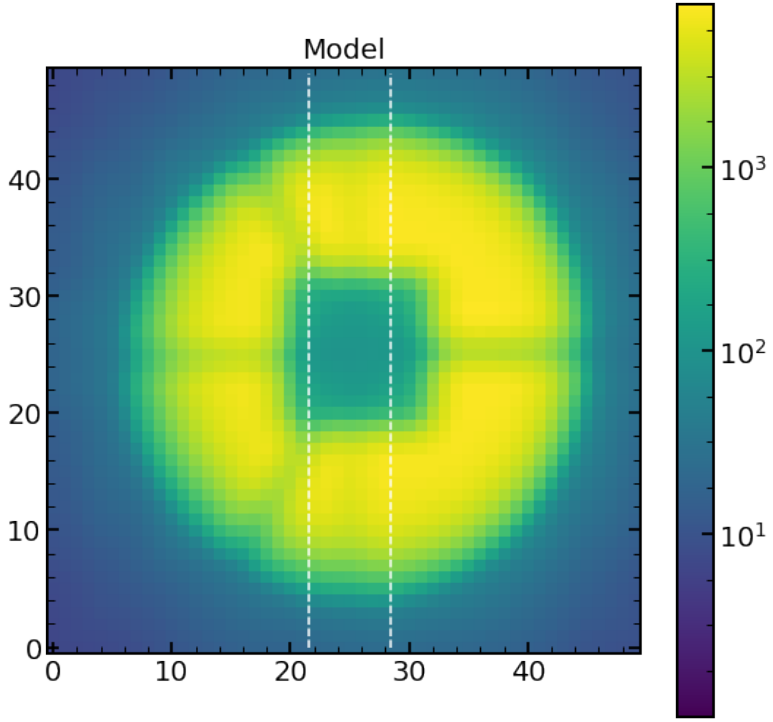


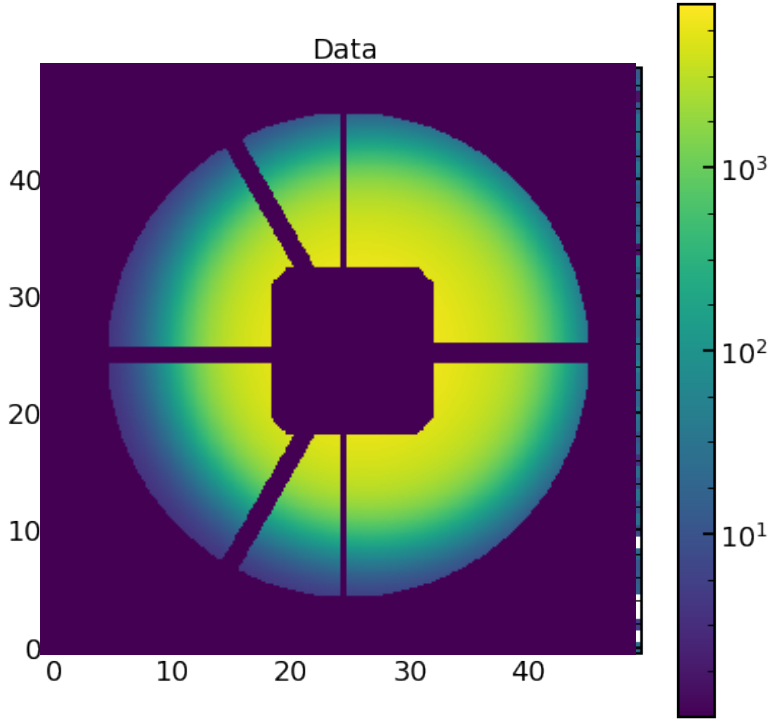


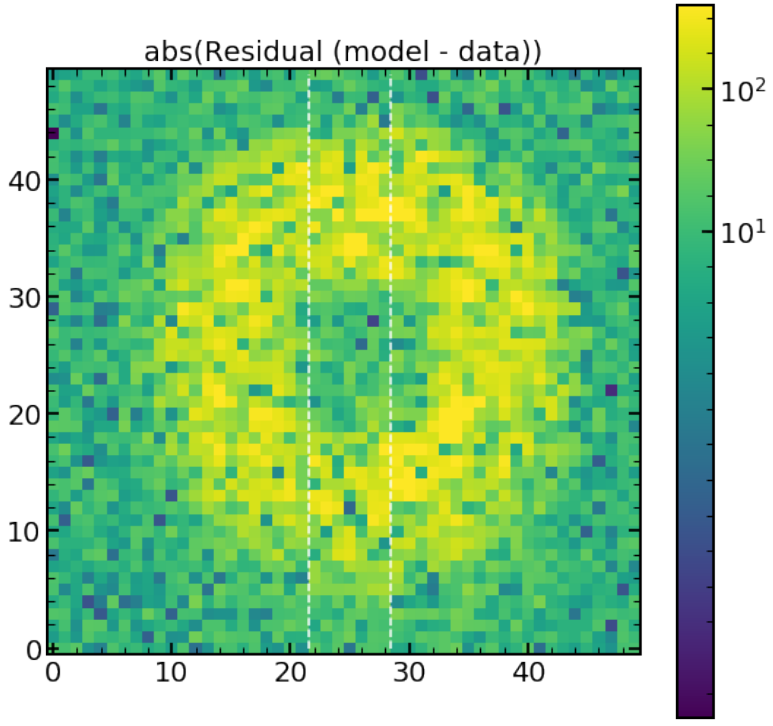


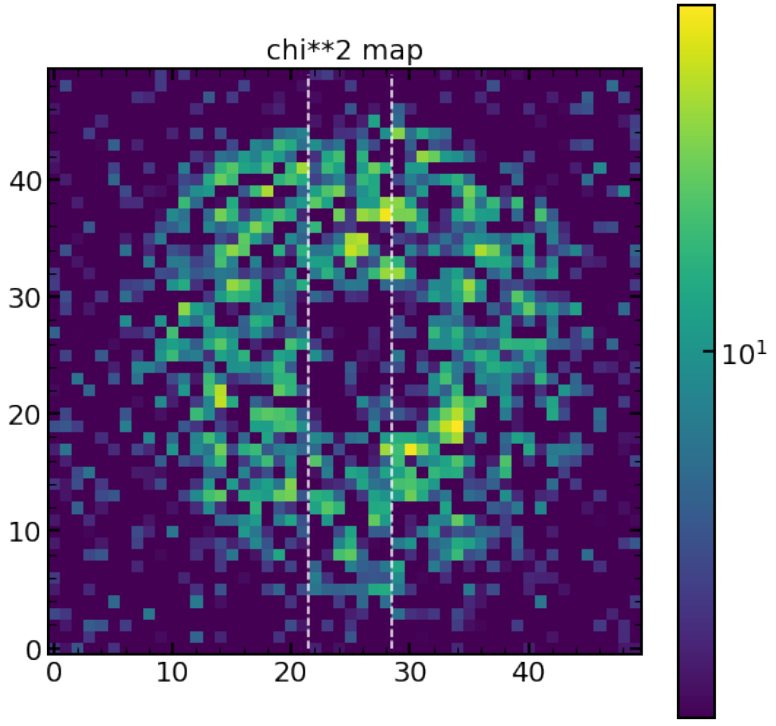


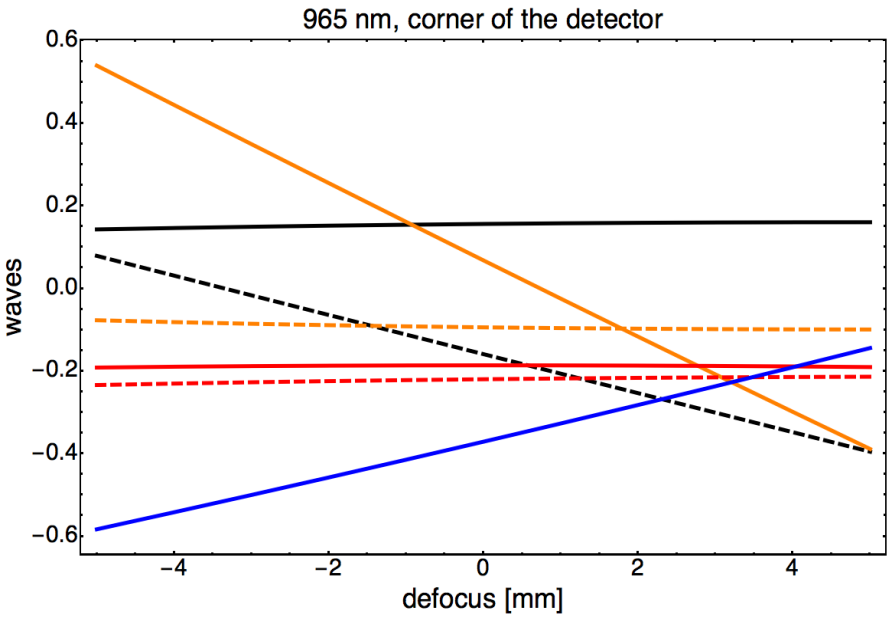
Defocused data, example in log space

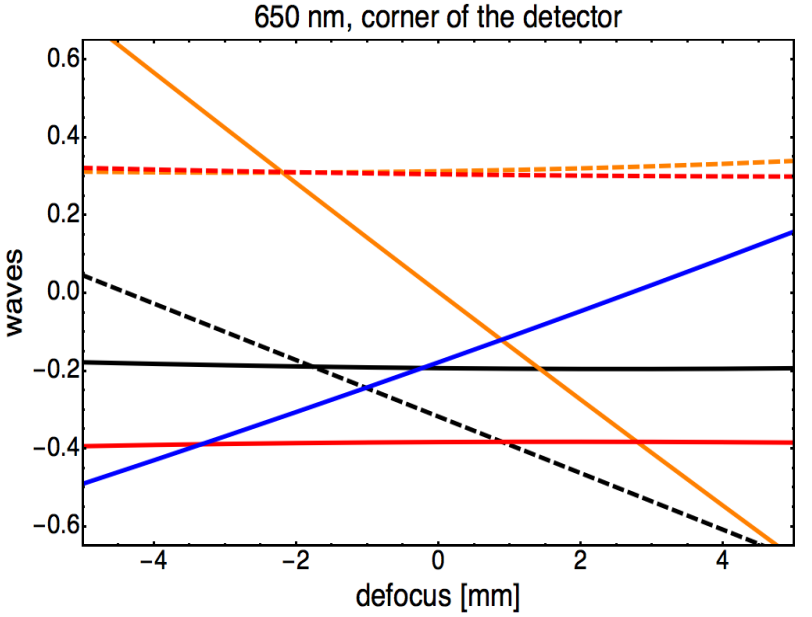


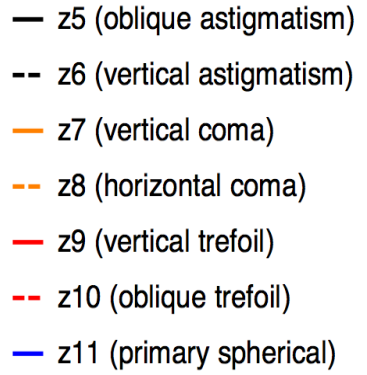






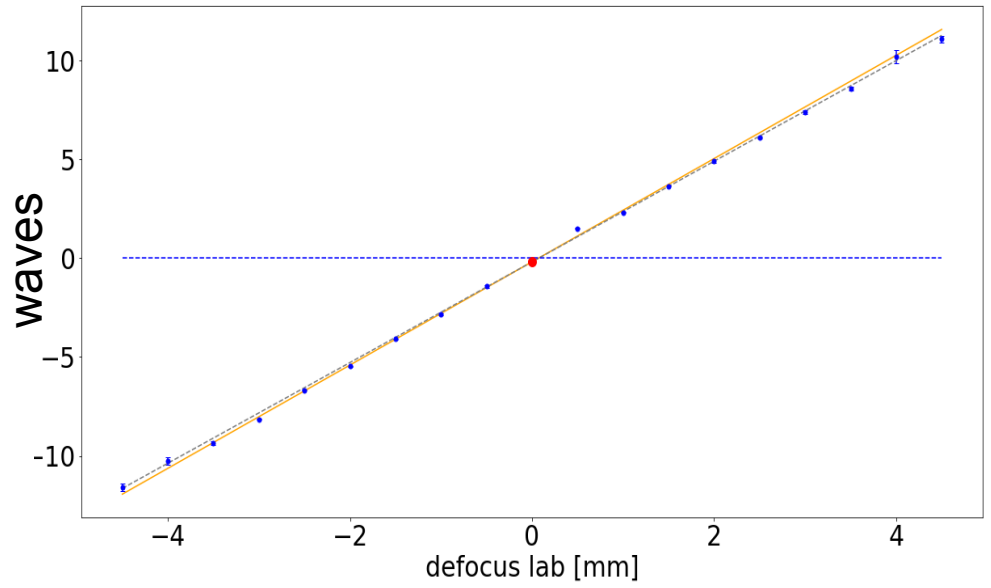




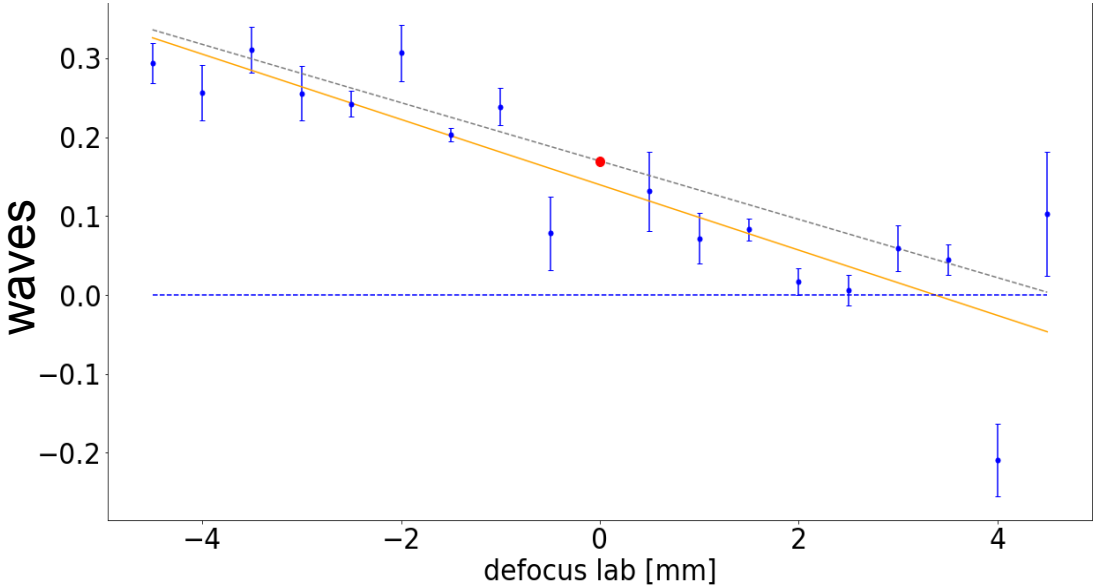


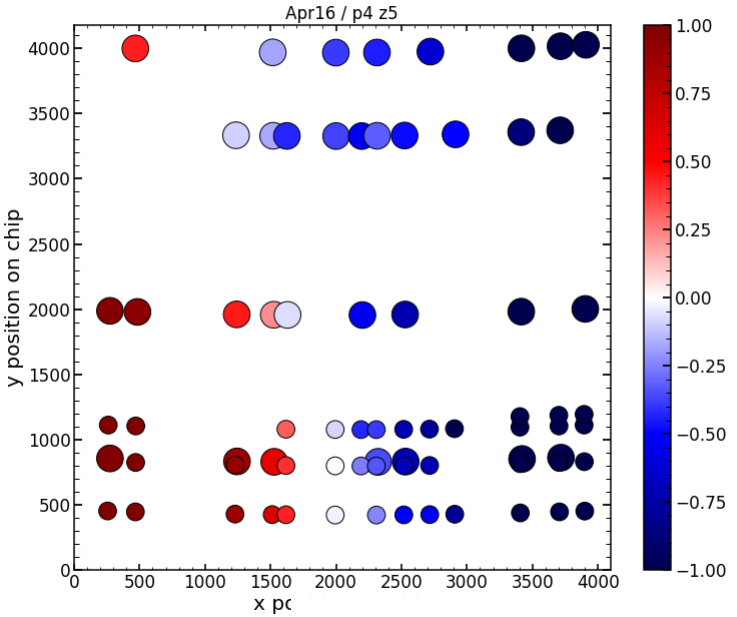
- Example from modelling of the experimental data below (not the same spot as above!)

Z4 - defocus

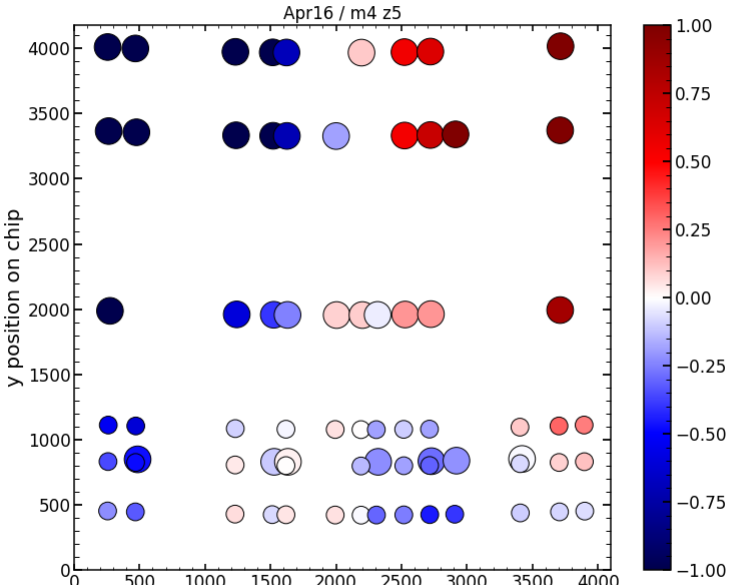


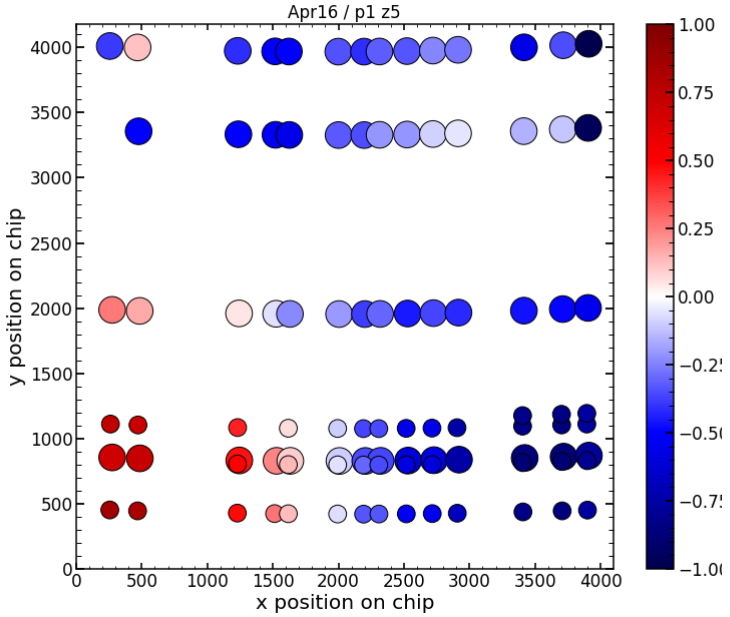
Z8 – horizontal coma

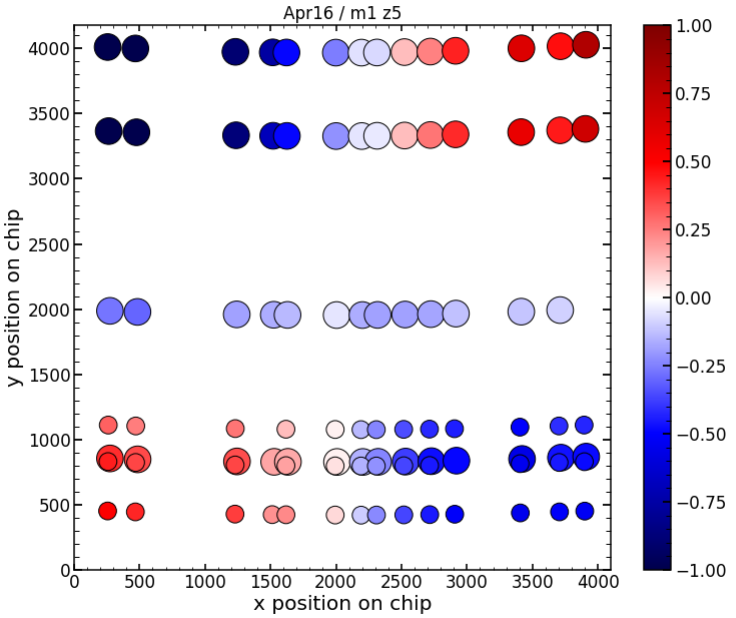




Change of single component – (vertical astigmatism)

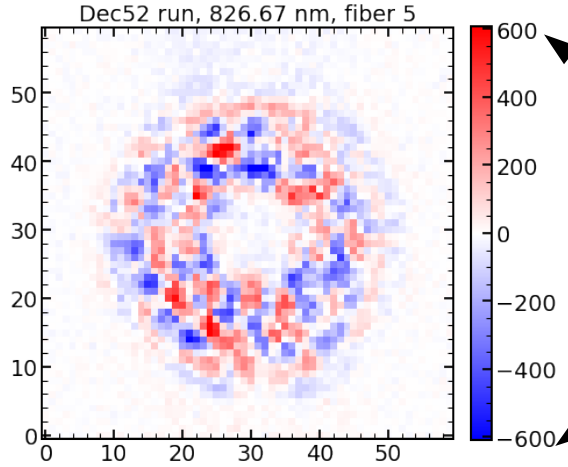




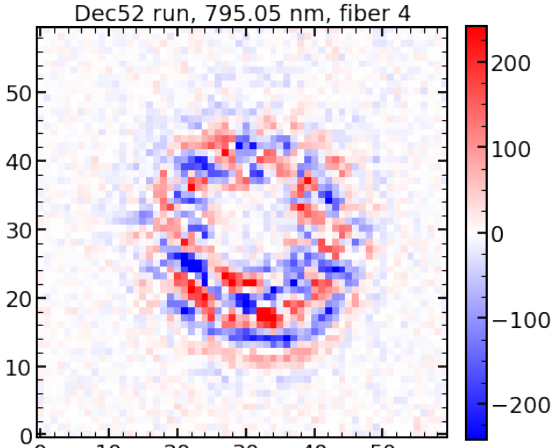


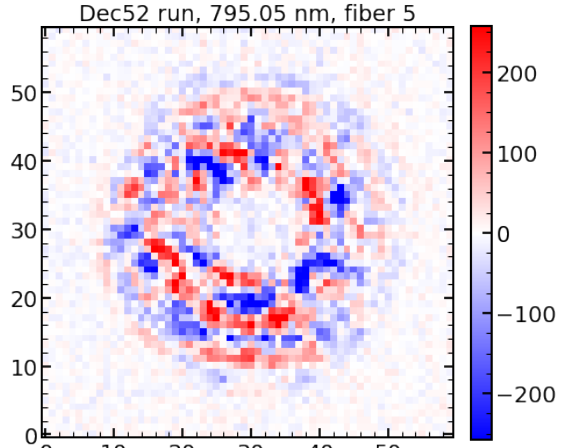
Changing defocus

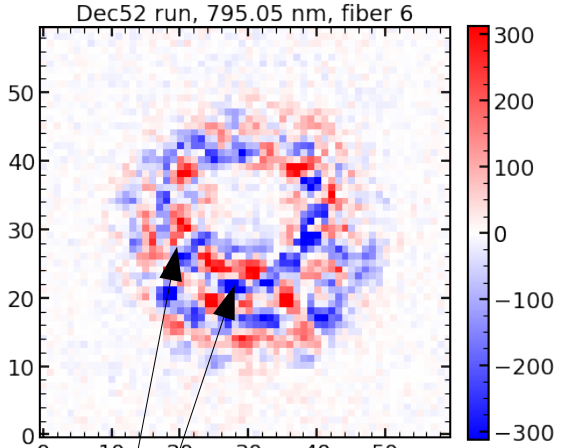
Direct Fits

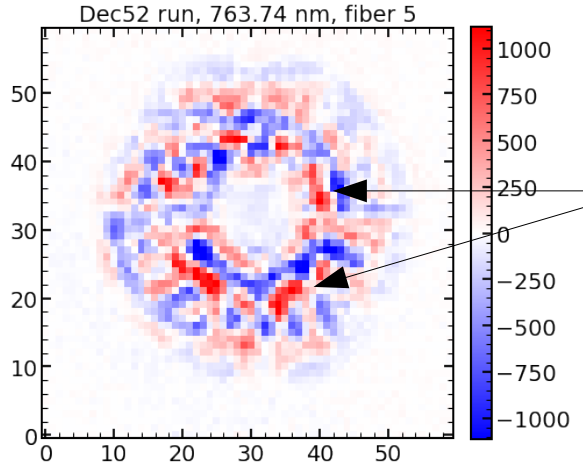


Residuals scaled to 5% of the maximal flux in the data







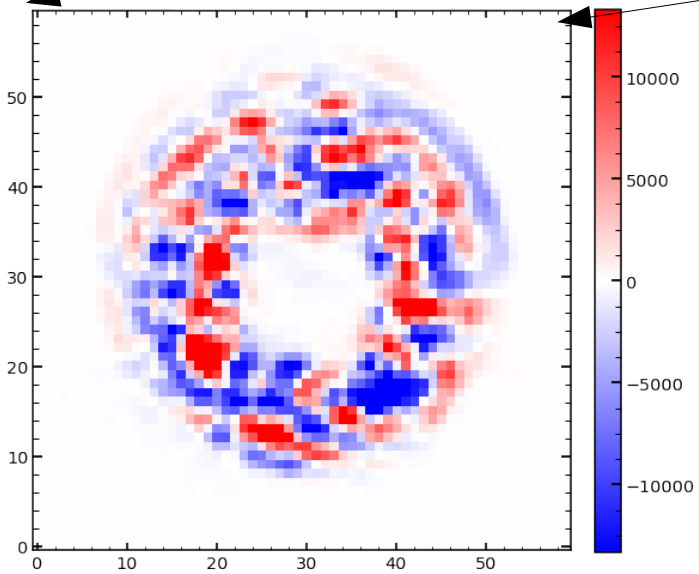


Speckles – can be ``removed'' by fitting higher order wavefront abberations

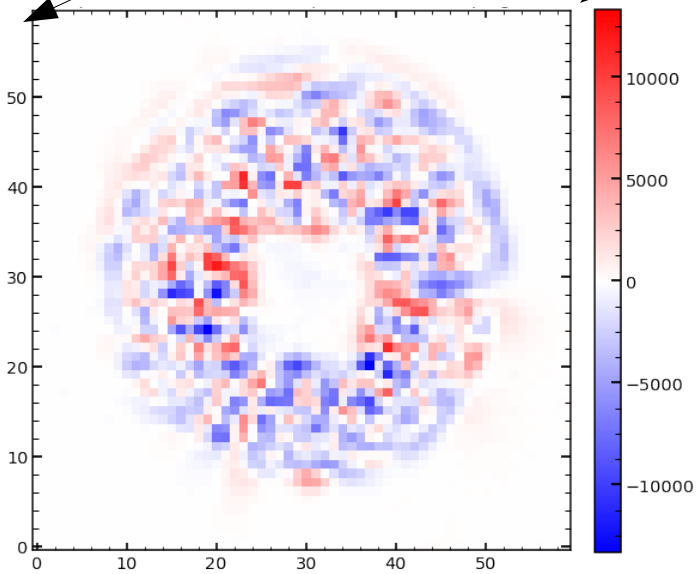
Direct Fits

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

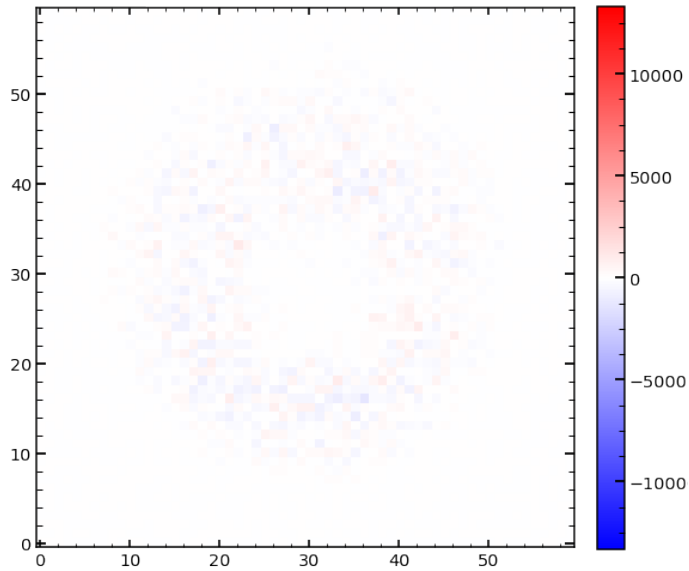
Up to z22



Up to z254



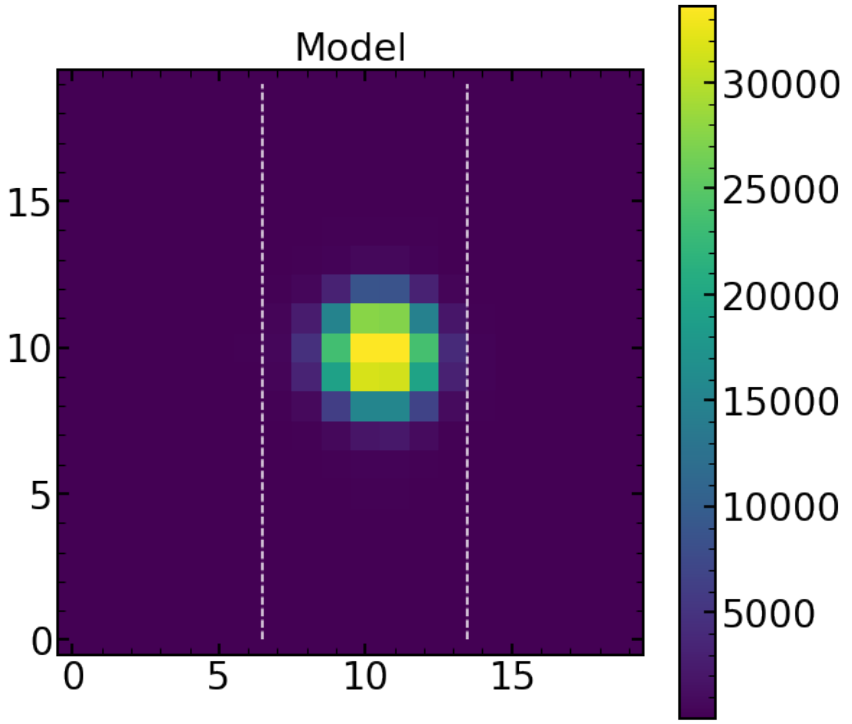
Perfection

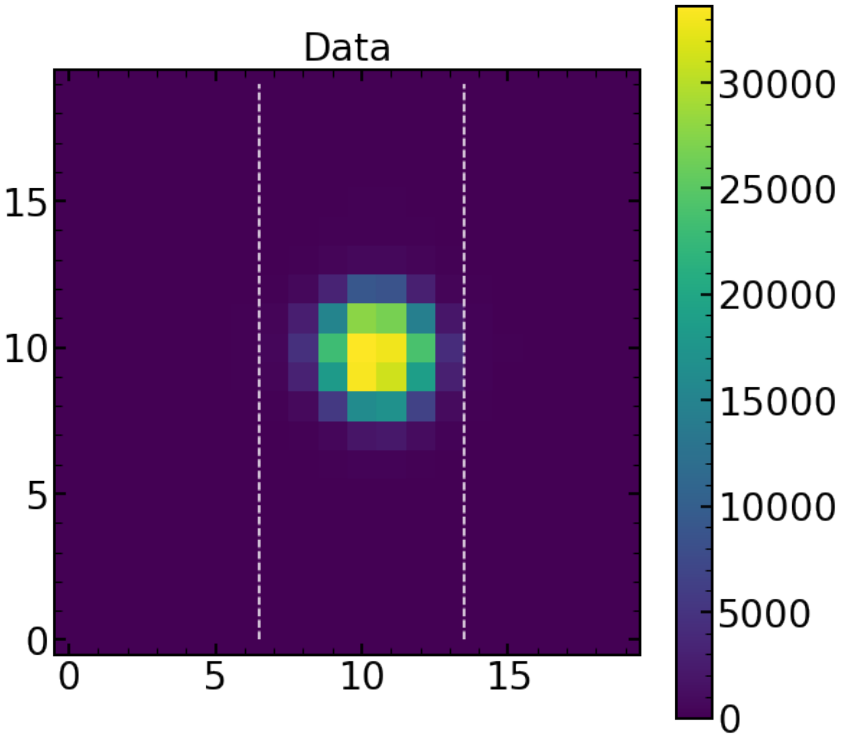


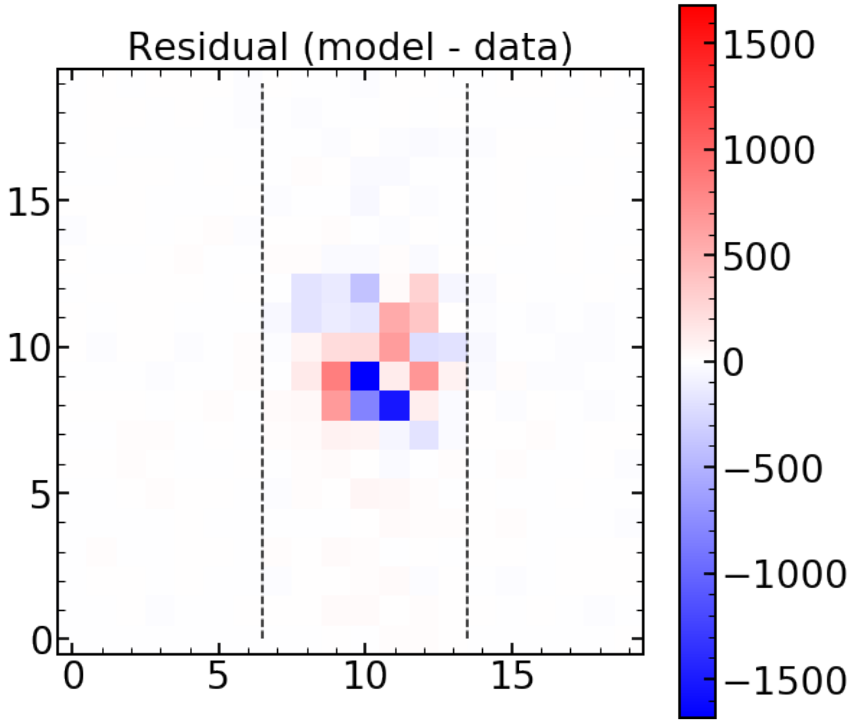
High order abberations do not vary as a position of the detector? (if they come from glass imperfections)

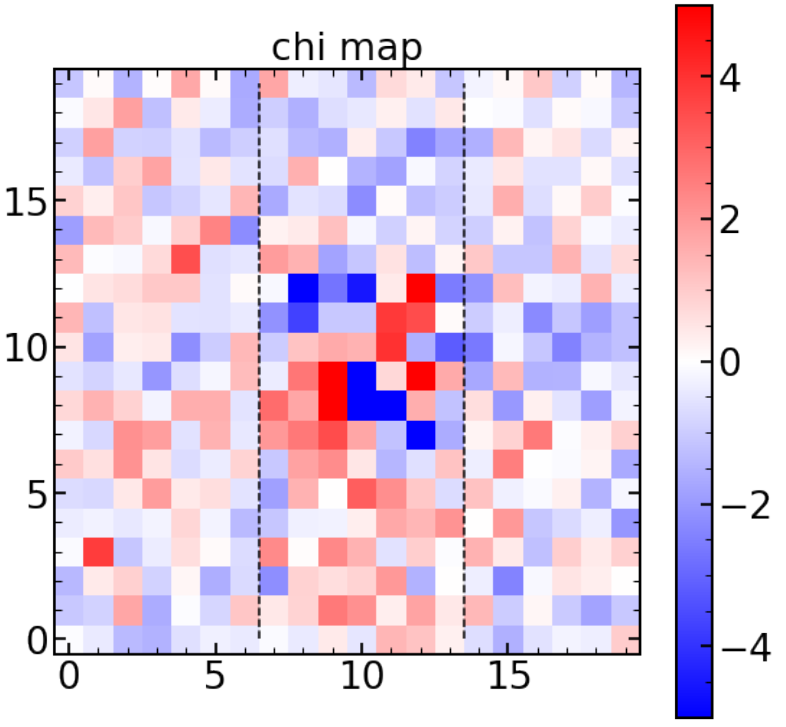
Speckles – can be ``removed'' by fitting higher order wavefront abberations

Focused data, example in linear space

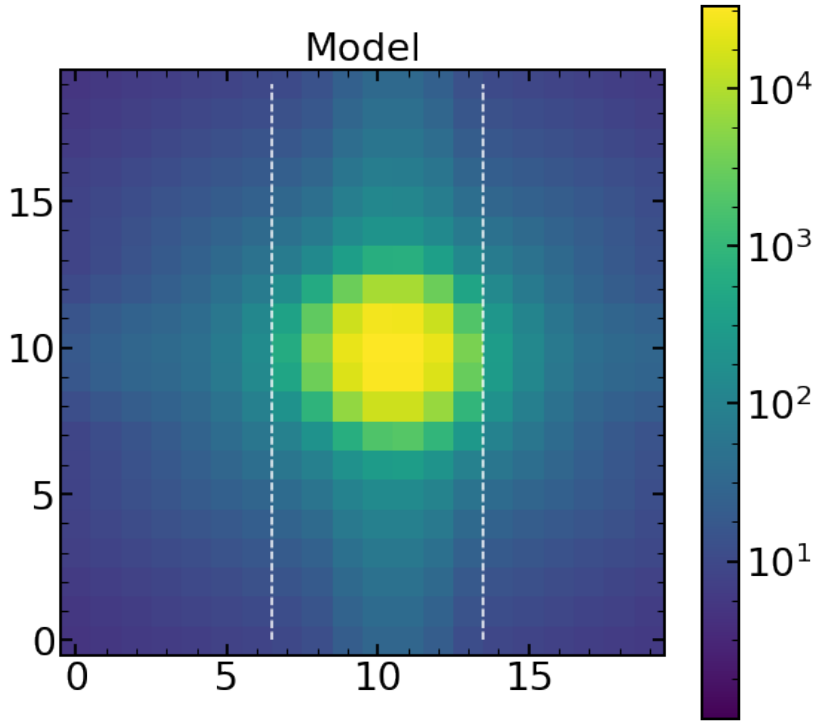


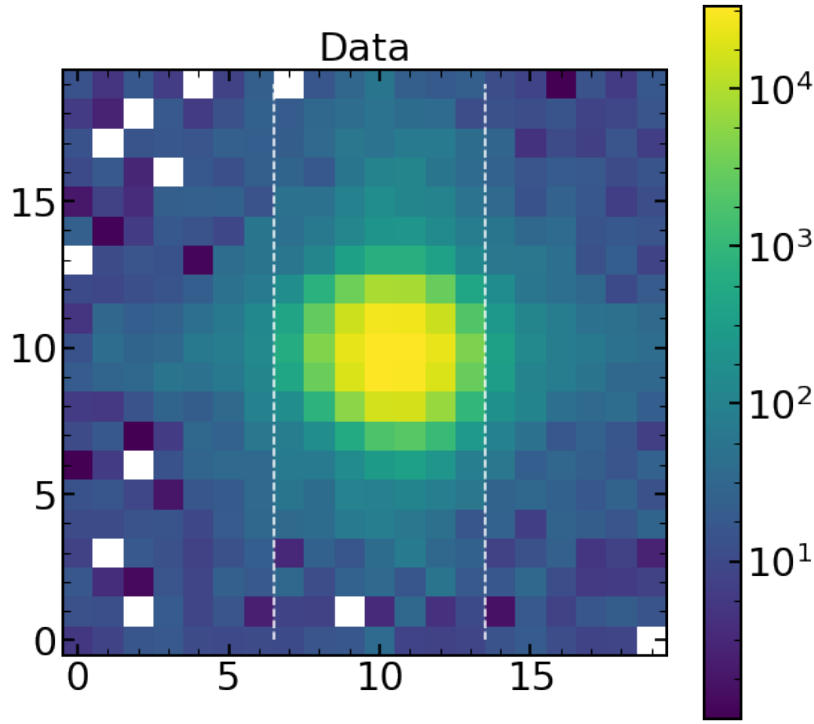


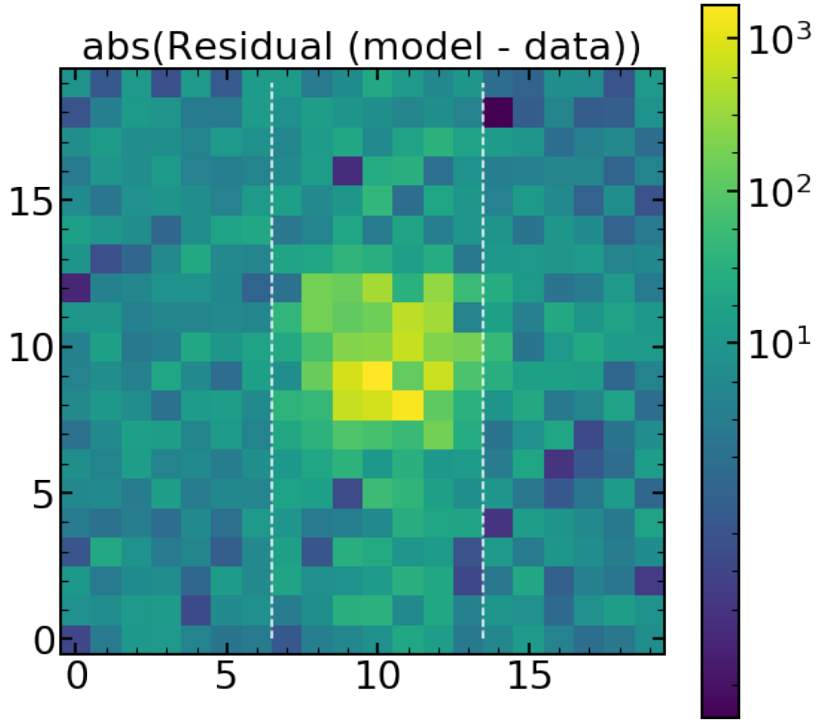


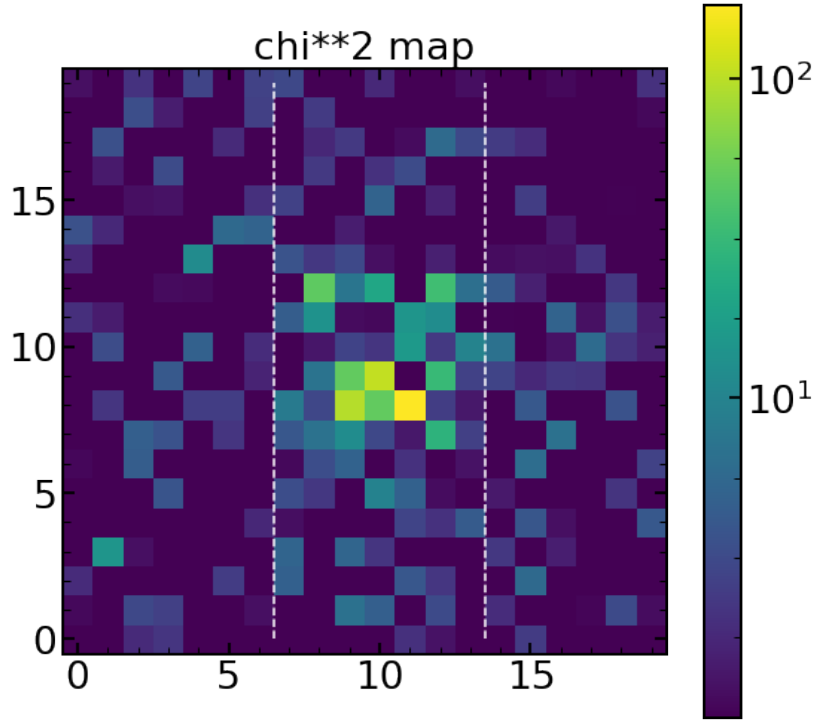


Focused data, example in log space

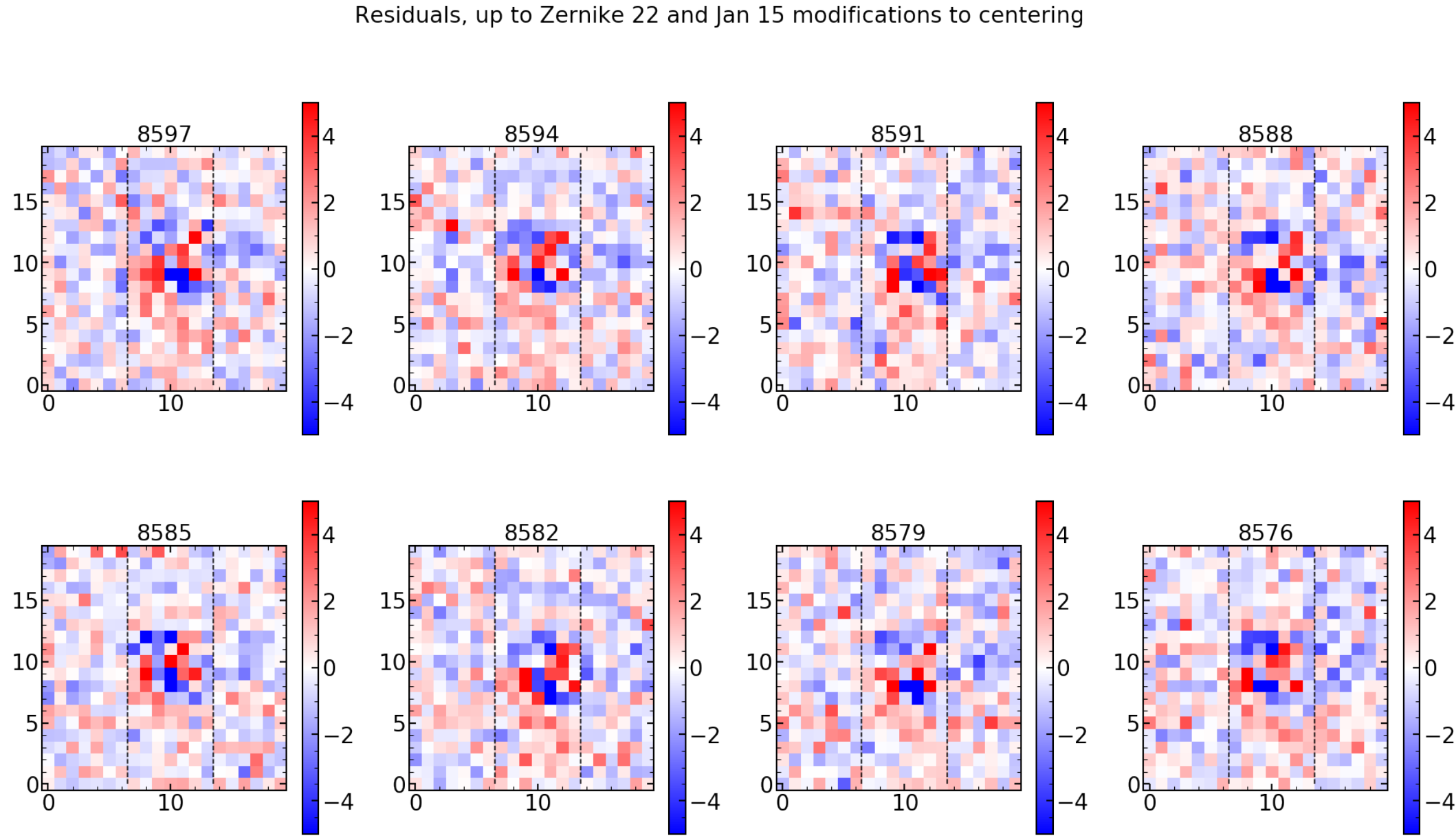






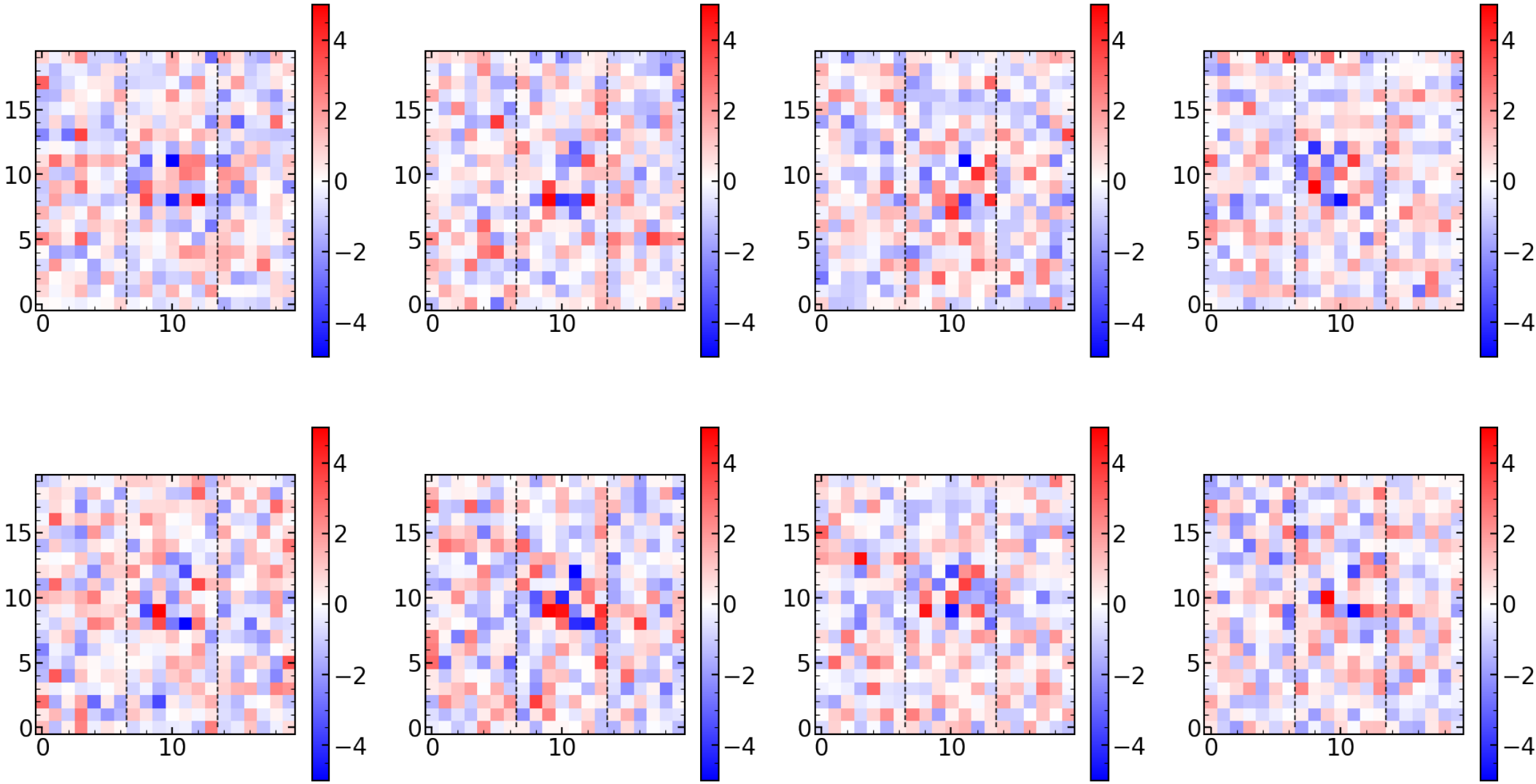


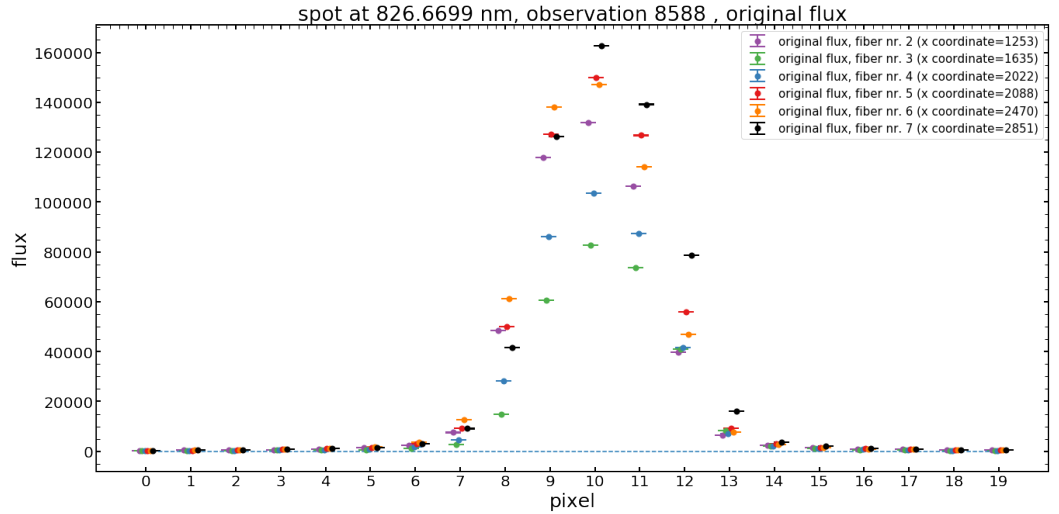
Residuals in the focused data, 8 different dithering positions

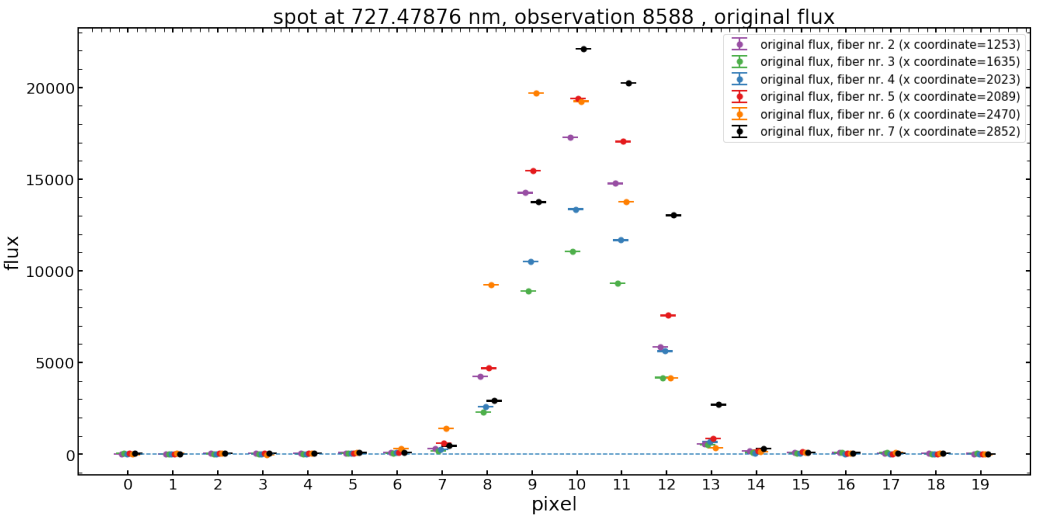


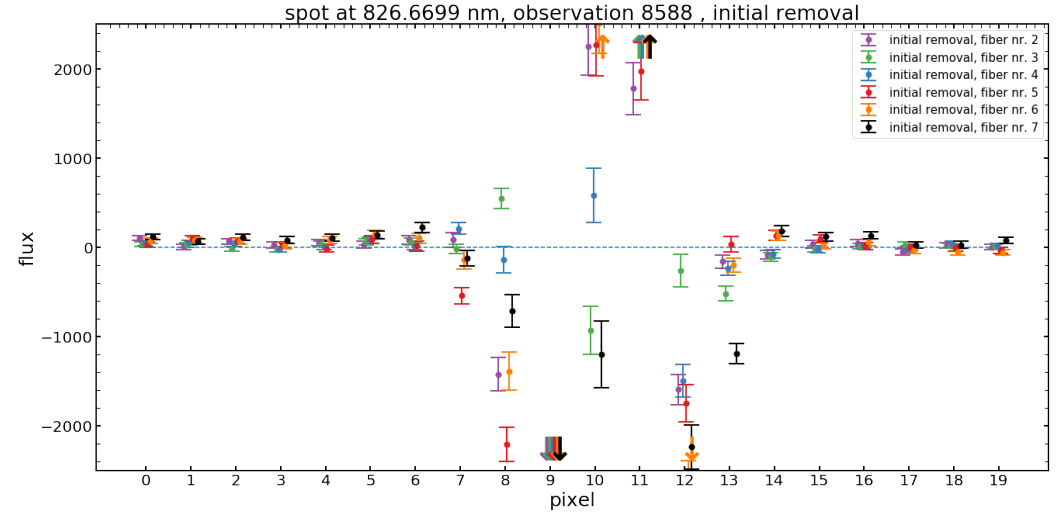
Residuals in the focused data, 8 different dithering positions, after Random forest cleaning applied

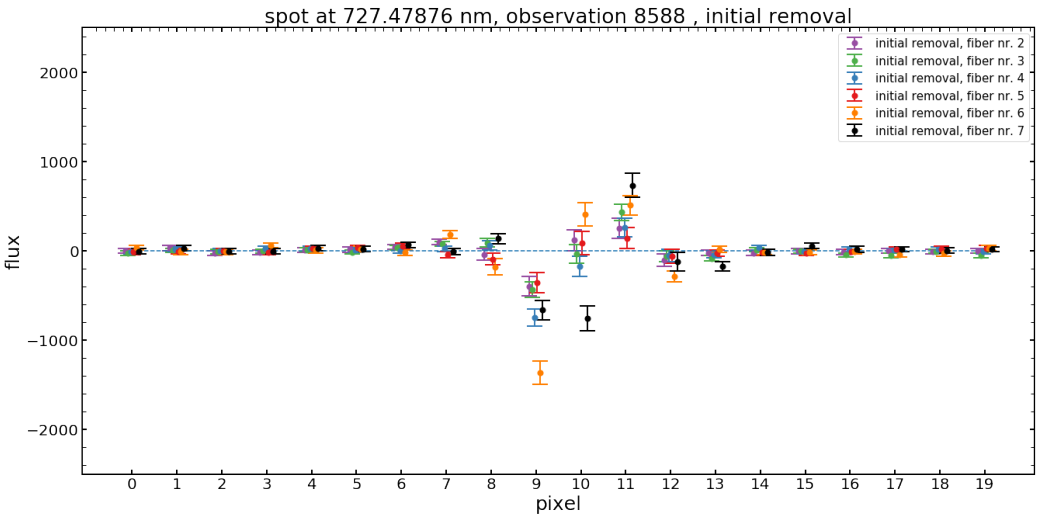
up to Zernike 22, Jan 15 modifications to centering, and Random Forest postprocessing

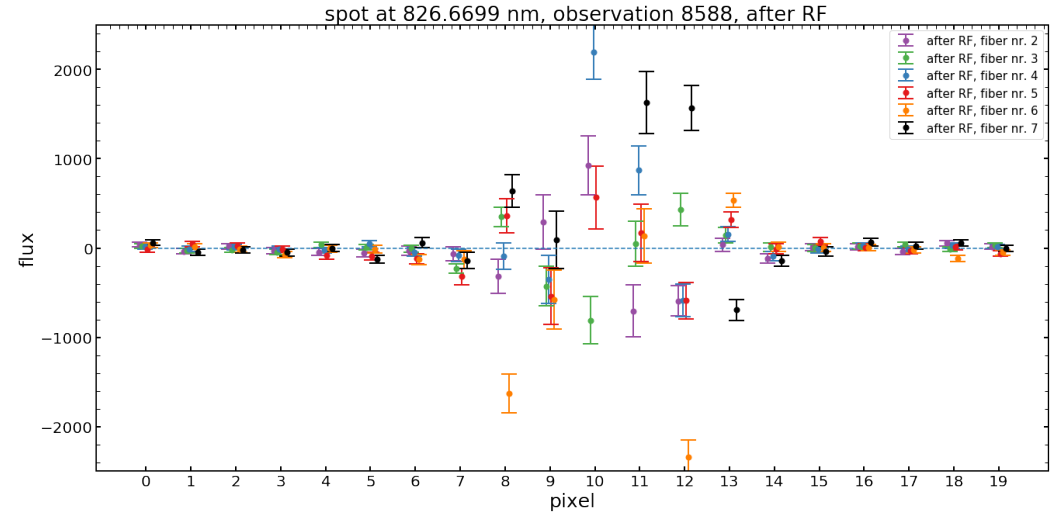


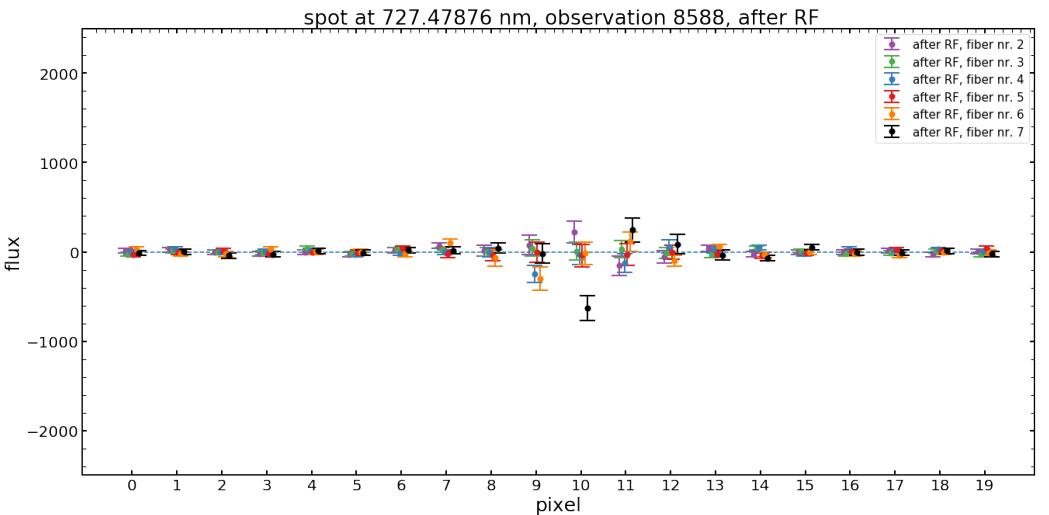

spot at 826.6699 nm, observation 8588 , original flux
original flux, fiber nr. 2 (x coordinate=1253)
original flux, fiber nr. 3 (x coordinate=1635)
original flux, fiber nr. 4 (x coordinate=2022)
original flux, fiber nr. 5 (x coordinate=2088)
original flux, fiber nr. 6 (x coordinate=2470)
original flux, fiber nr. 7 (x coordinate=2851)
flux
pixel


spot at 727.47876 nm, observation 8588 , original flux
original flux, fiber nr. 2 (x coordinate=1253)
original flux, fiber nr. 3 (x coordinate=1635)
original flux, fiber nr. 4 (x coordinate=2023)
original flux, fiber nr. 5 (x coordinate=2089)
original flux, fiber nr. 6 (x coordinate=2470)
original flux, fiber nr. 7 (x coordinate=2852)
flux
pixel


spot at 826.6699 nm, observation 8588 , initial removal
initial removal, fiber nr. 2
initial removal, fiber nr. 3
initial removal, fiber nr. 4
initial removal, fiber nr. 5
initial removal, fiber nr. 6
initial removal, fiber nr. 7
flux
pixel


spot at 727.47876 nm, observation 8588 , initial removal
initial removal, fiber nr. 2
initial removal, fiber nr. 3
initial removal, fiber nr. 4
initial removal, fiber nr. 5
initial removal, fiber nr. 6
initial removal, fiber nr. 7
flux
pixel


spot at 826.6699 nm, observation 8588, after RF
after RF, fiber nr. 2
after RF, fiber nr. 3
after RF, fiber nr. 4
after RF, fiber nr. 5
after RF, fiber nr. 6
after RF, fiber nr. 7
flux
pixel


spot at 727.47876 nm, observation 8588, after RF
after RF, fiber nr. 2
after RF, fiber nr. 3
after RF, fiber nr. 4
after RF, fiber nr. 5
after RF, fiber nr. 6
after RF, fiber nr. 7
flux
pixel

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 configu… …LAM is using, but not for every `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.

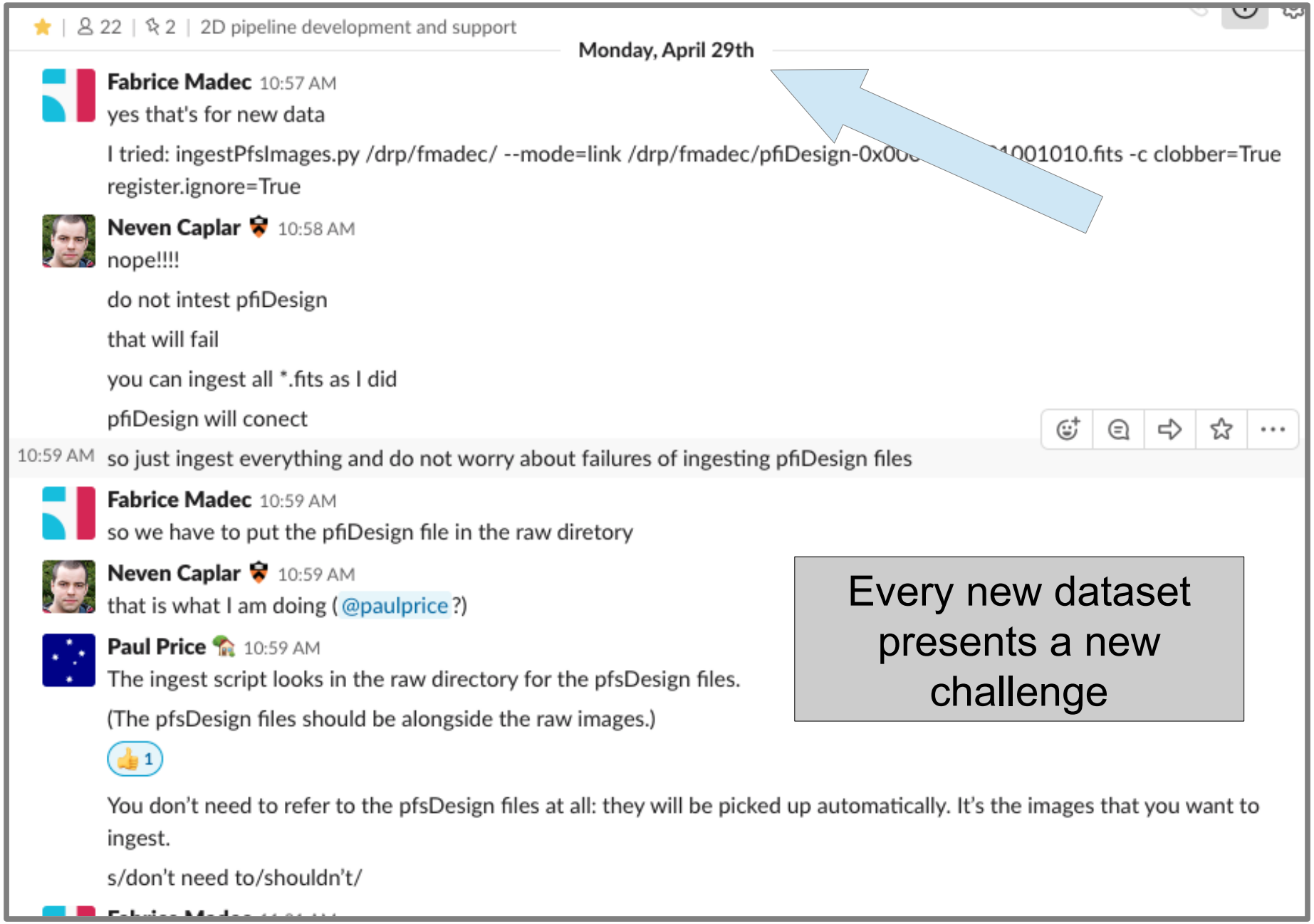
Paul Price 5:09 PM
My code is looking for `W_PFDSGN`.

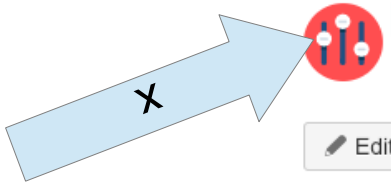
Craig Loomis 5:09 PM
That sounds right.

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

Every new dataset presents a new challenge

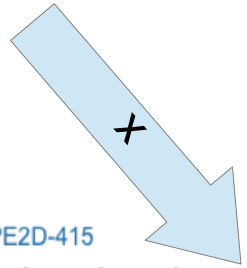
Why do we keep asking for more data with different settings?





Mercury - Argon

Krypton



DRP 2-D Pipeline / PIPE2D-414

reduceExposure.doSubtractContinuum=True does not remove continuum fro

Edit | Comment | Assign | More | In Progress | In Review | Workflow

Details

Type:	Bug	Status:	OPEN (View Workflow)
Priority:	Normal	Resolution:	Unresolved
Affects Version/s:	None	Fix Version/s:	None
Labels:	None		
Story Points:	4		
Sprint:	2DDRP-2019 E		

Description

As a concrete example, running the pipeline with `reduceExposure.doSubtractContinuum=True` for HgAr data taken in February, the continuum is removed from 11 out 16 fibers (see left hand side of the screenshot). This is even thought there are obviously 16 traces in the image (see right hand side of the screenshot) and psfArm has 16 inputs.

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:	Bug	Status:	OPEN (View Workflow)
Priority:	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

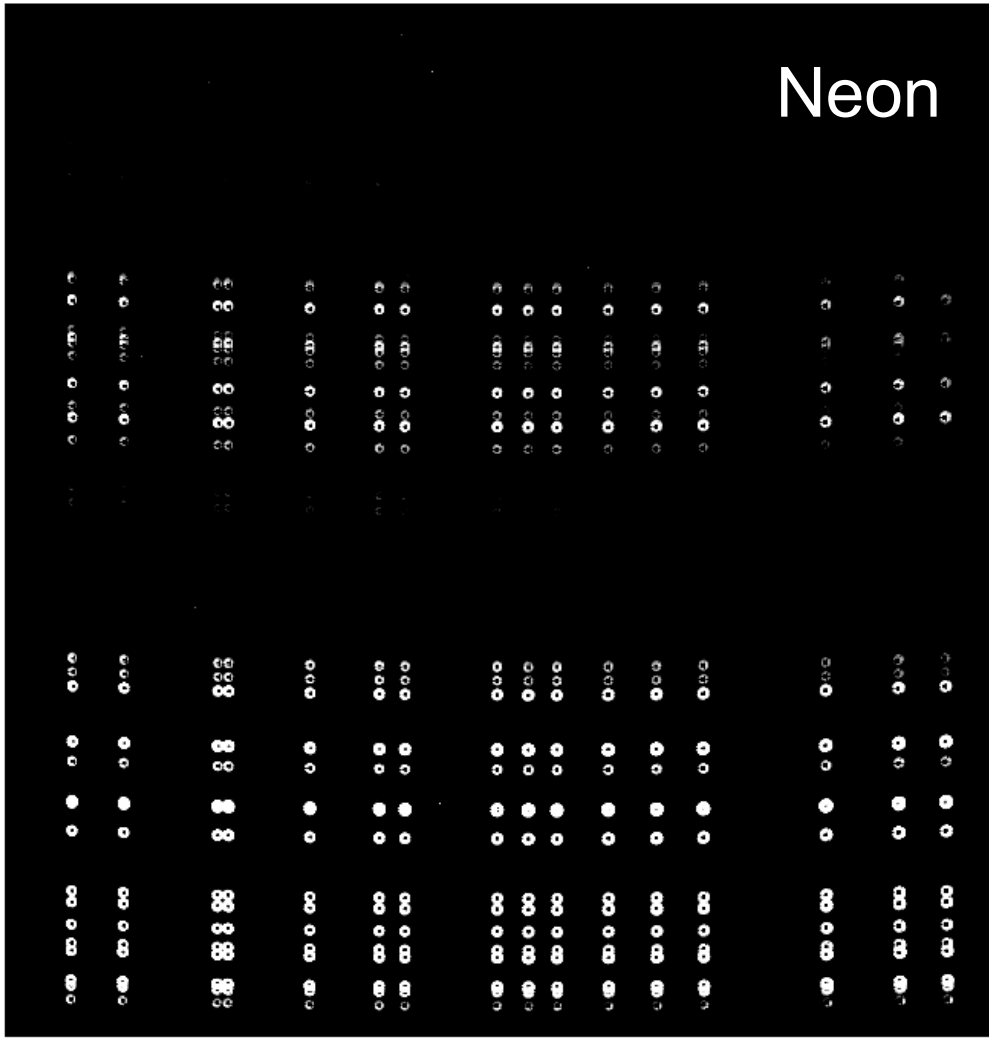
Possibly closely connected with PIPE2D-414.

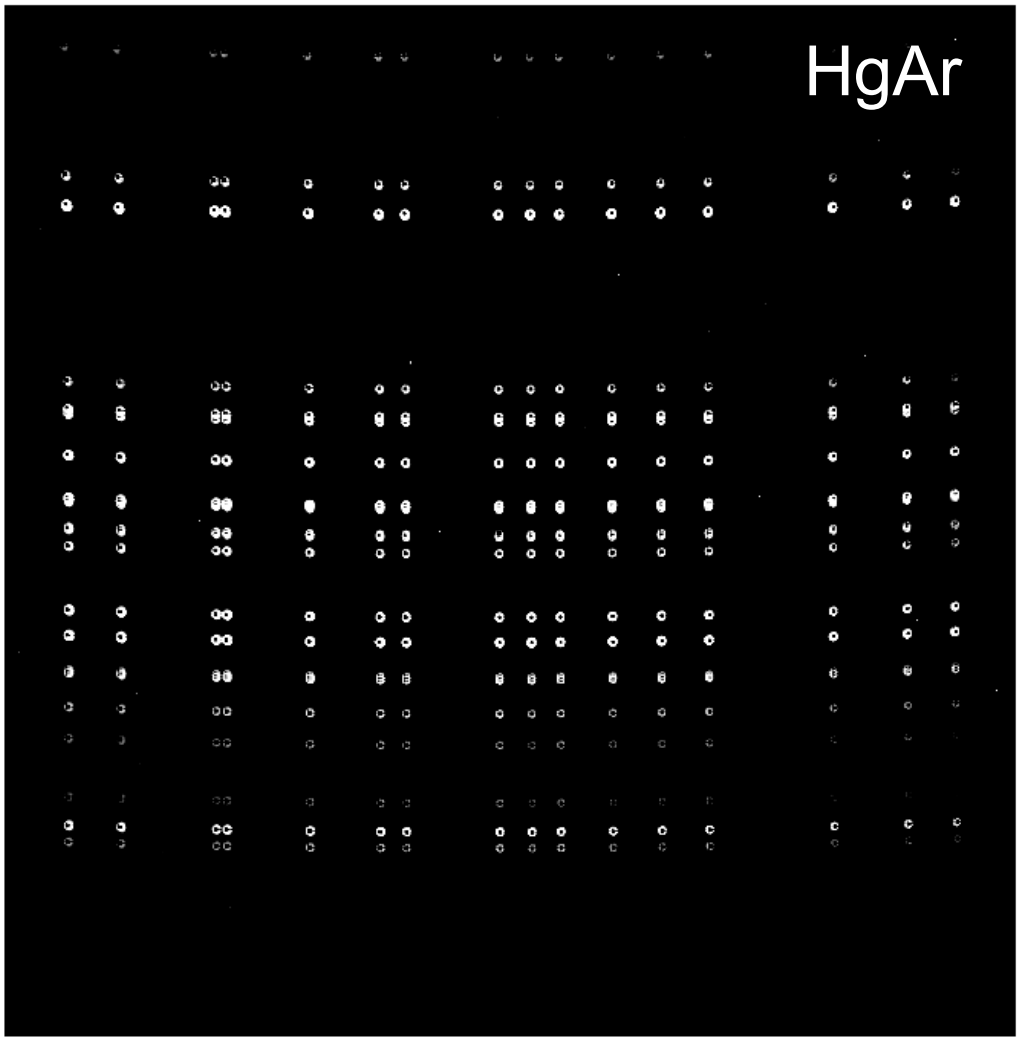
naoki.yasuda reports in PIPE2D-339 that ``But for visit=14000 only a half of fibers will be identified (left hand side)``. This is probably the same problem as I report from Krypton data e.g., visit 13052, in ~~PIPE2D-411~~. There should be 16 fibers but

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

II. Why different arcs?

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





II. Why different arcs?

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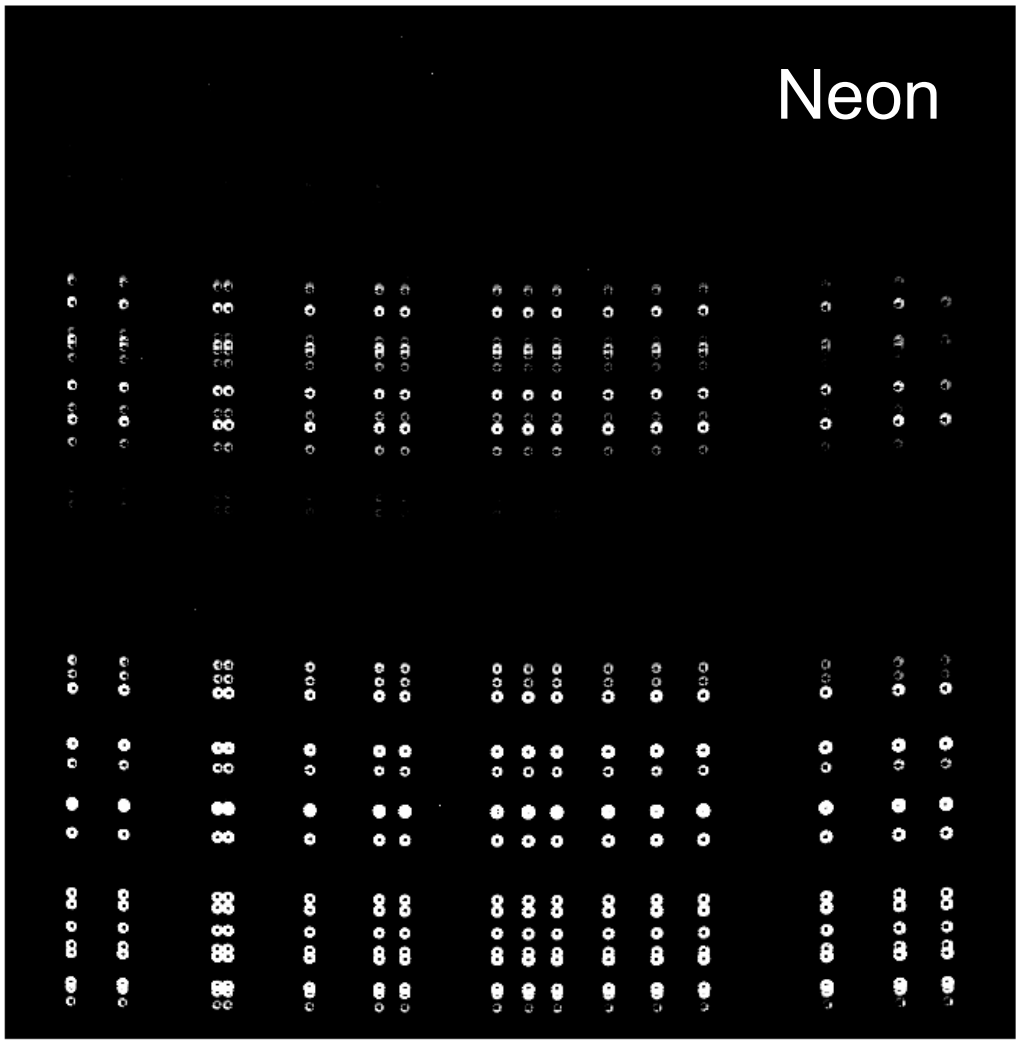

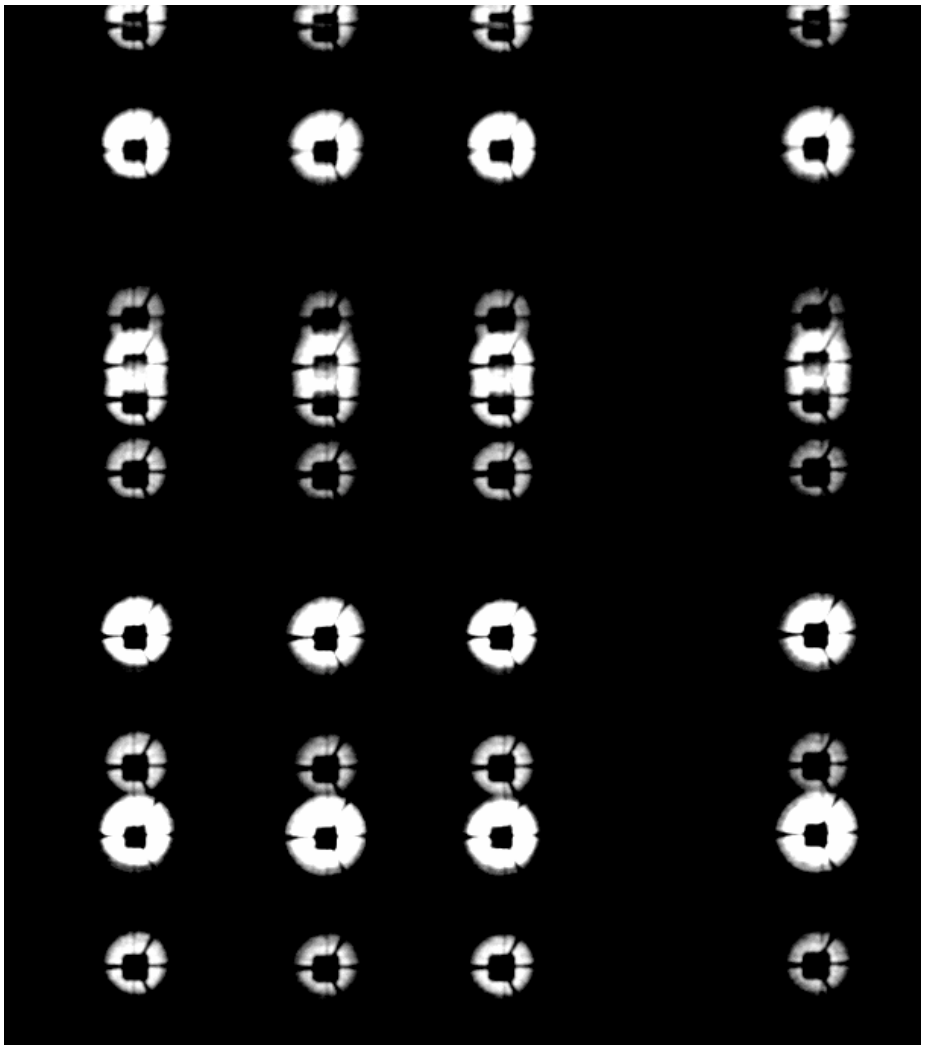

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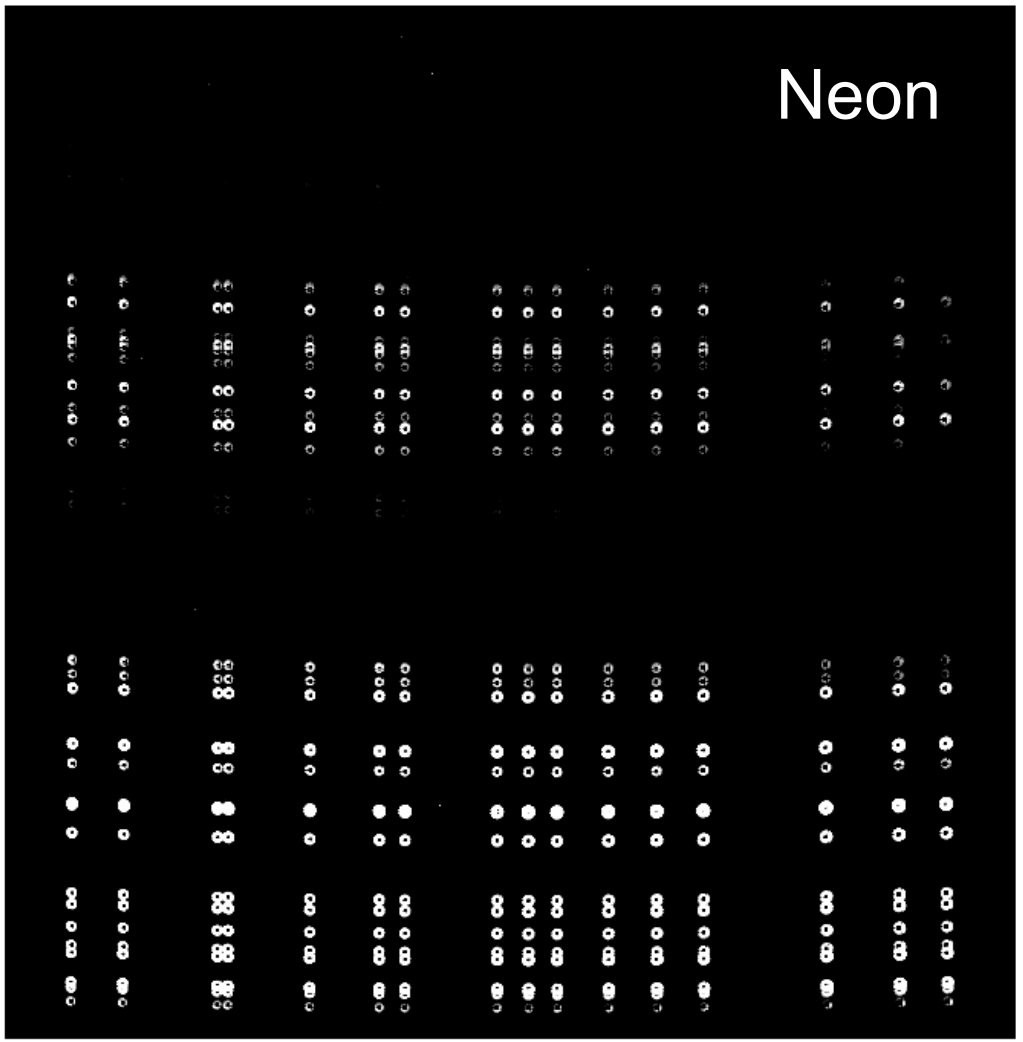
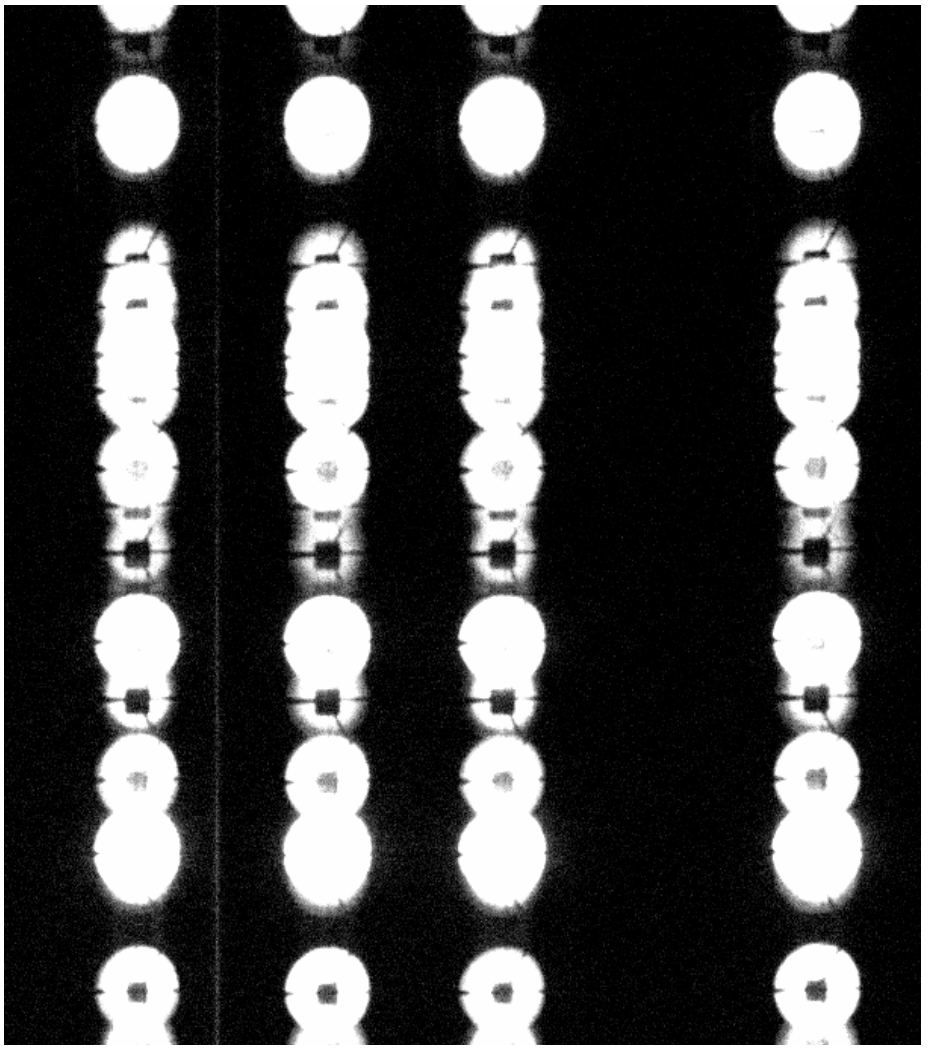
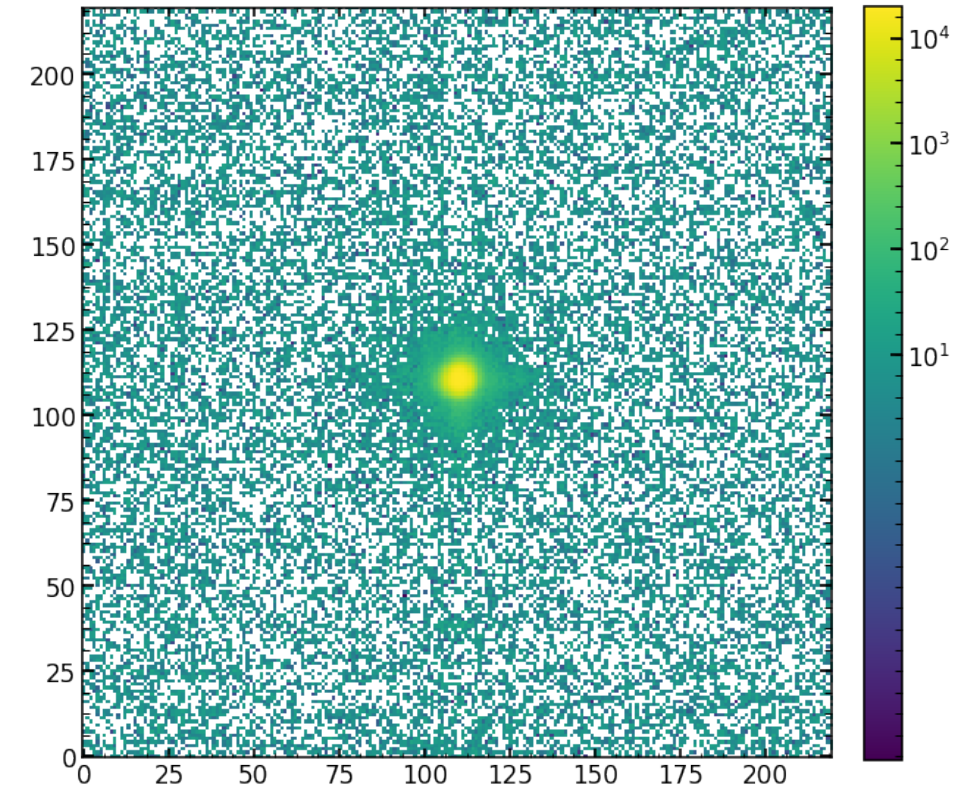
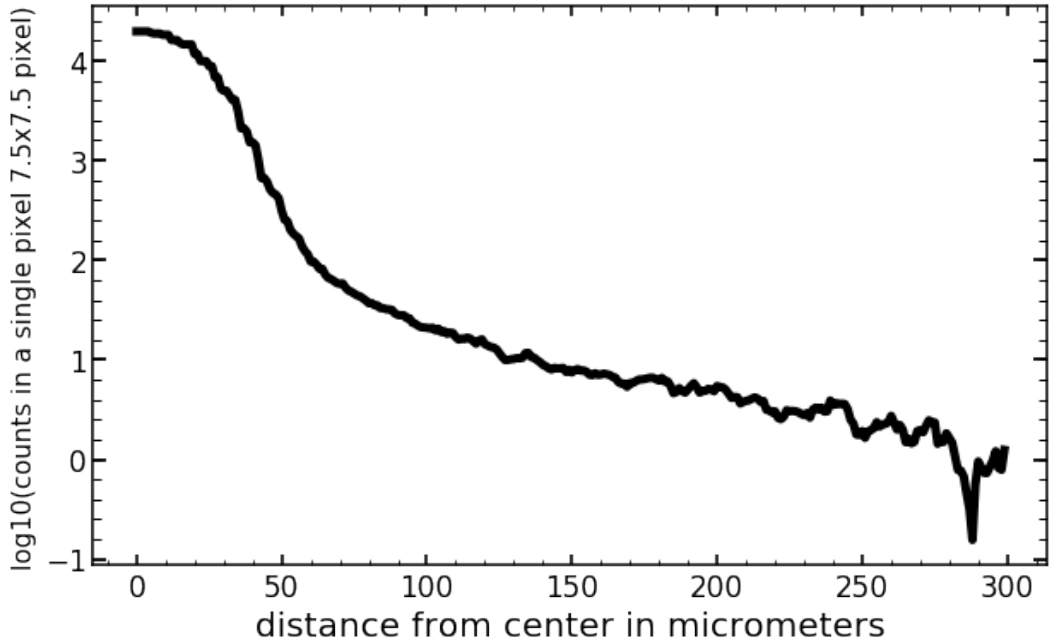




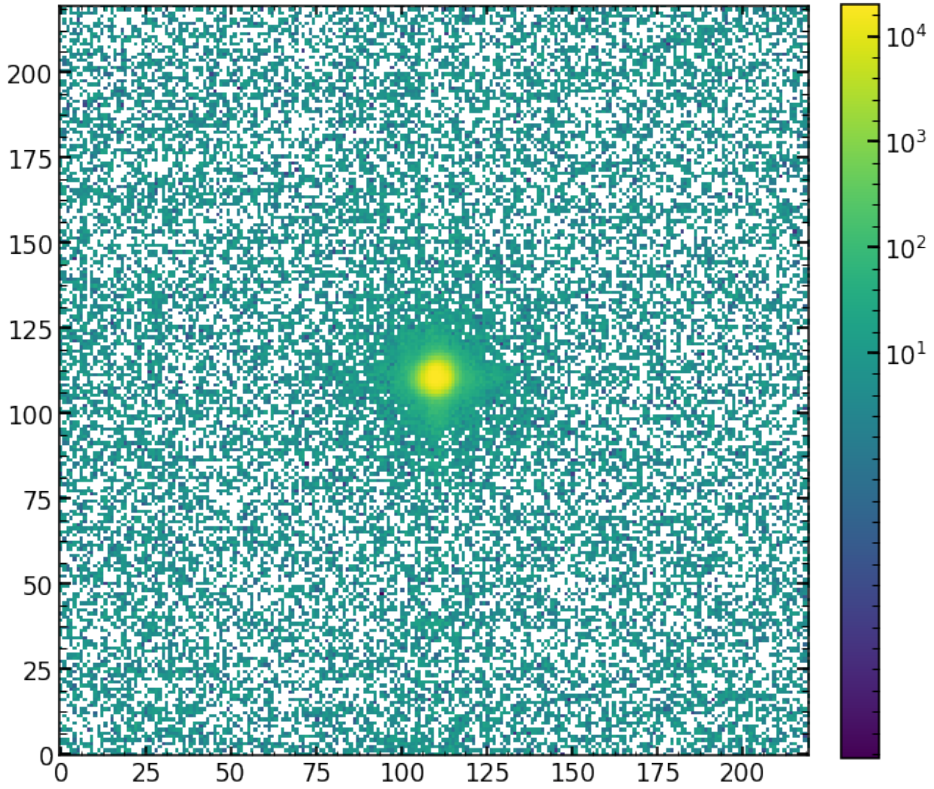
III. Why focused data?

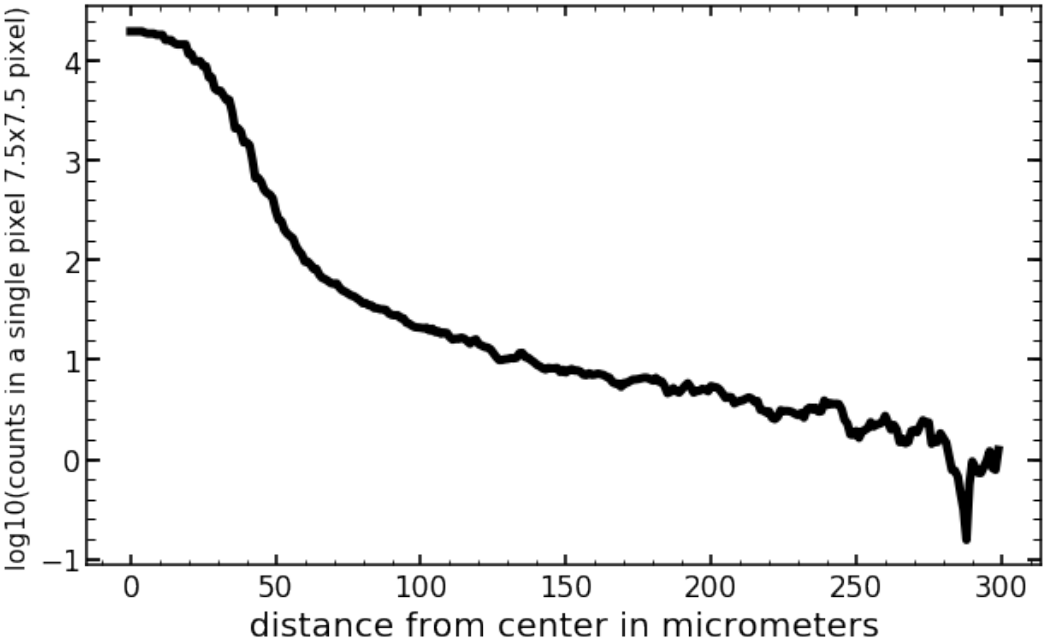




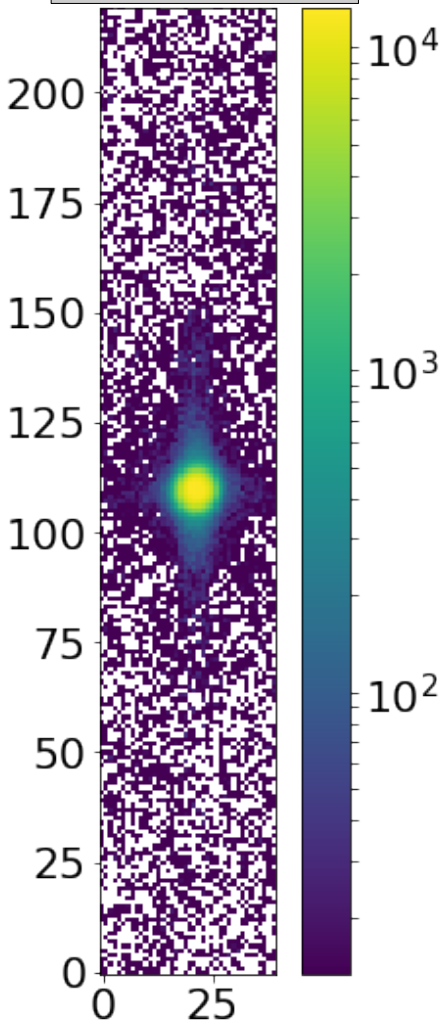
a) Scattering, scattering...

III. Why focused data?

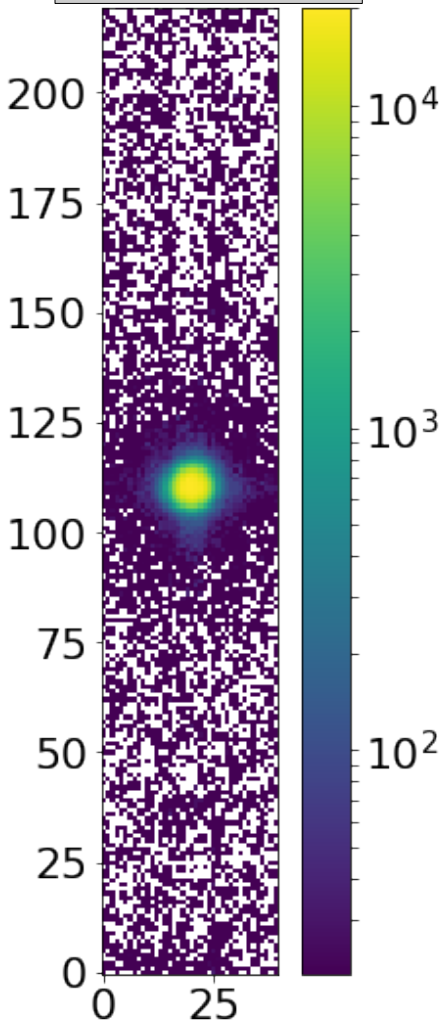




852.40 nm



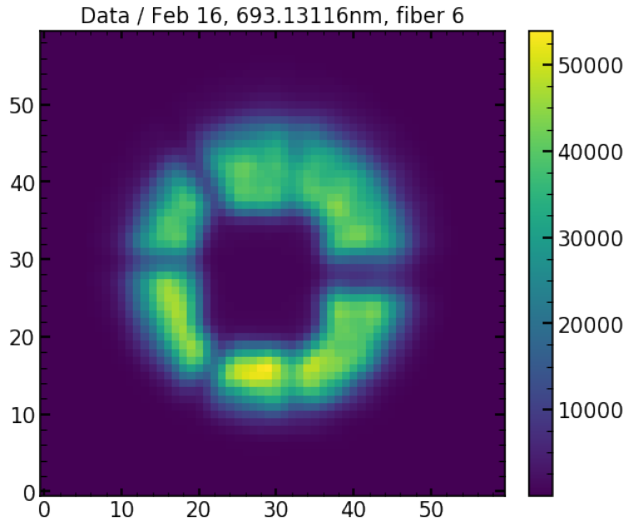
795.05 nm

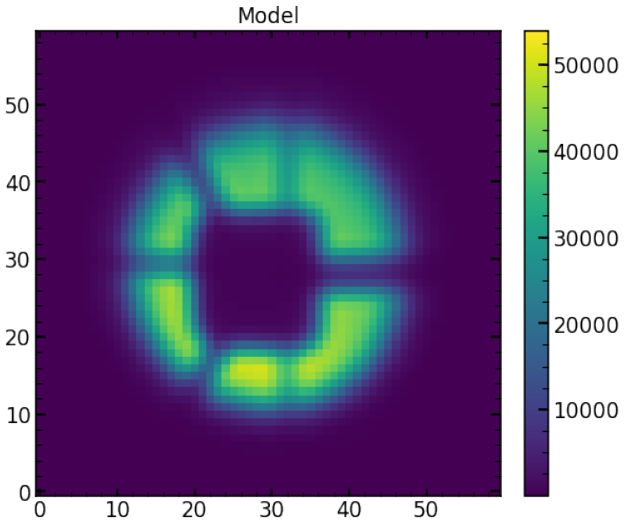


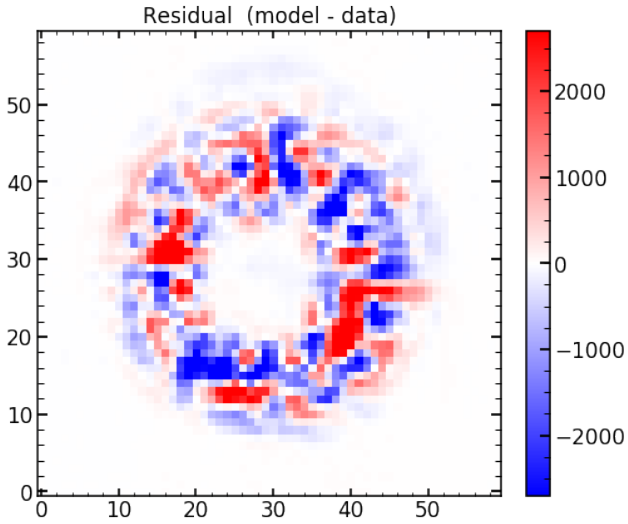
a) Scattering, scattering...
b) Grating effects

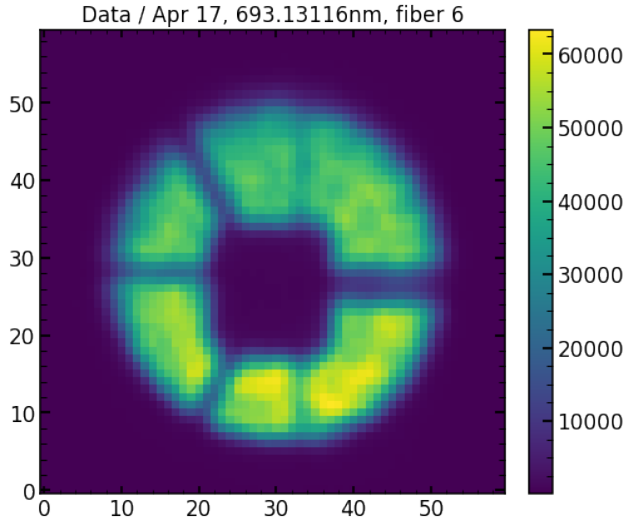
IV. Why different stops?

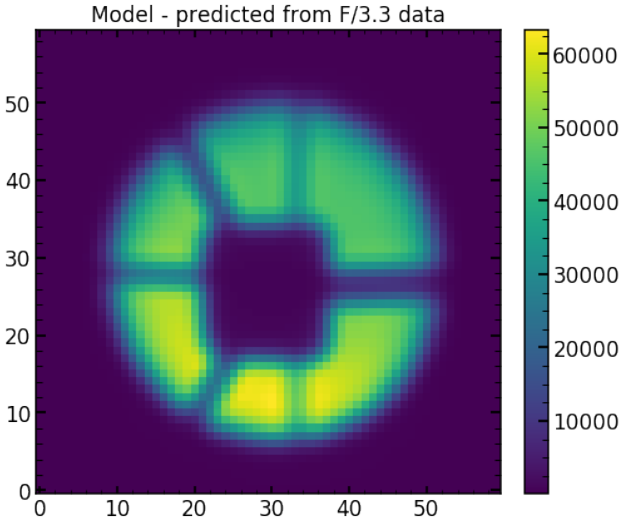
a) only illumination of the full pupil gives full information

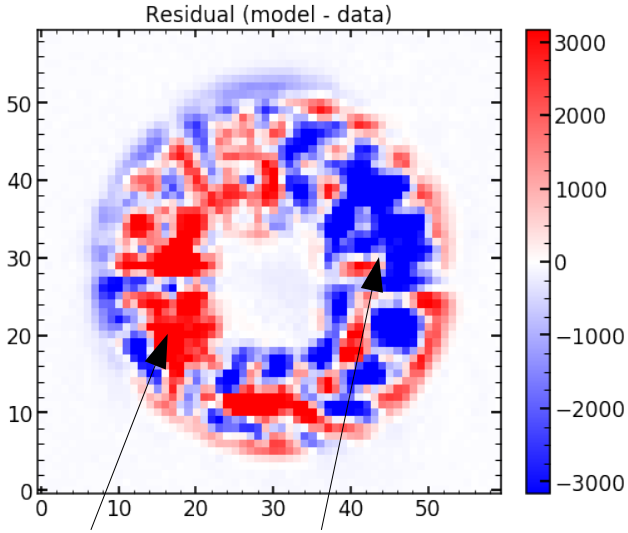








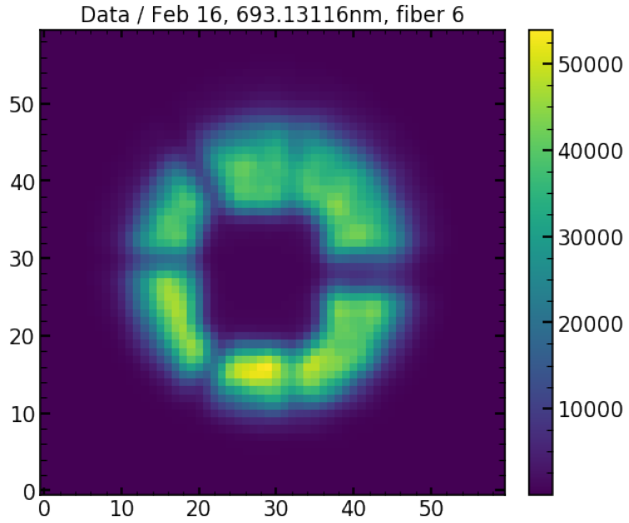


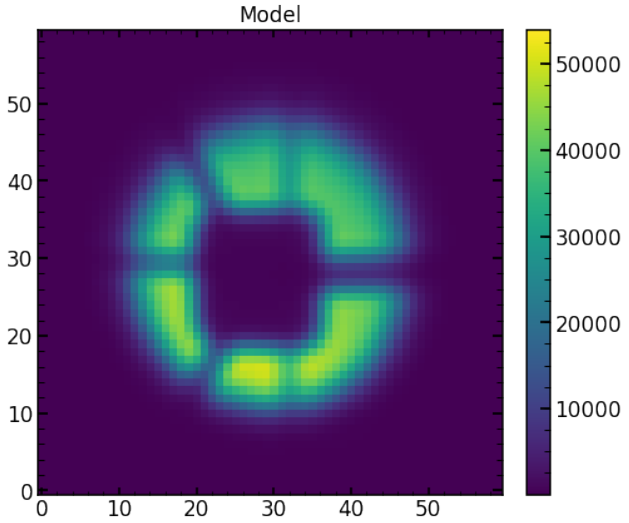


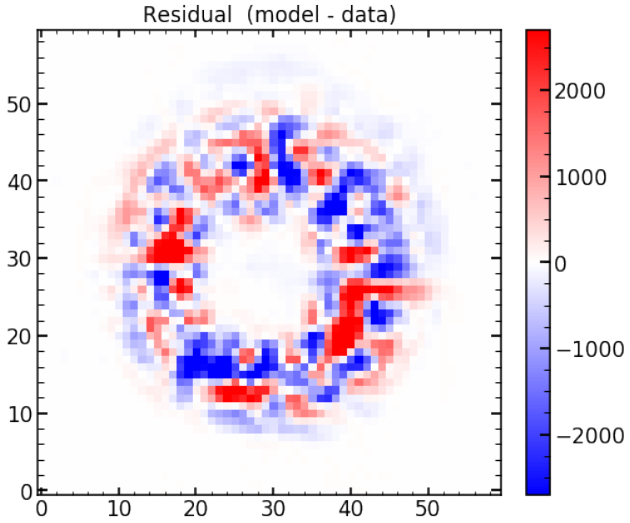
Mistakes in the non-illuminated region!

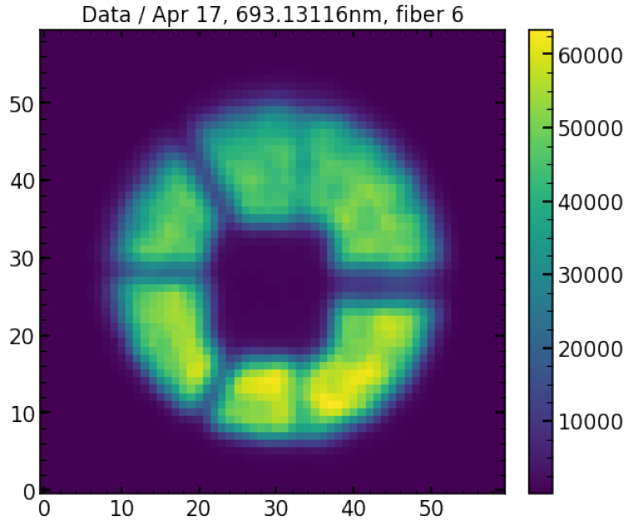
IV. Why different stops?

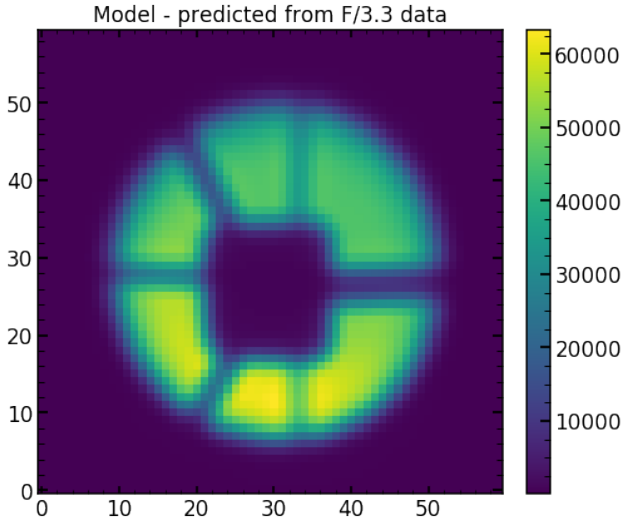
a) only illumination of the full pupil gives full information

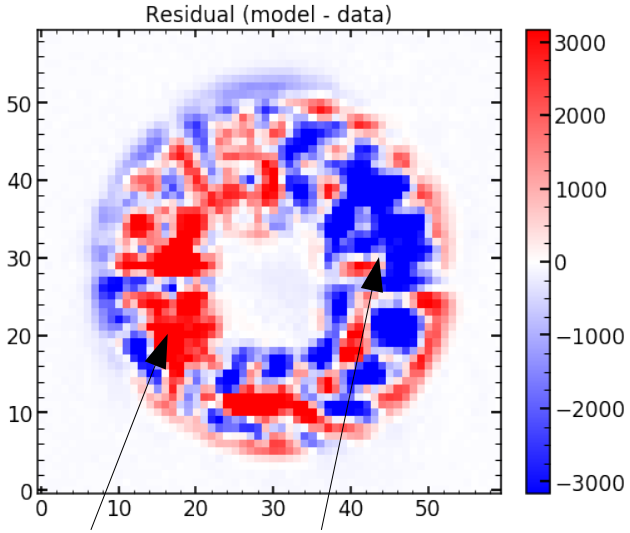












Mistakes in the non-illuminated region!

b) experiment for the quality of the approach

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 images on both sides of focus should allow to decouple the illumination and the wavefront abberations

- What do we use different data for
  - 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