Testing the Sensitivity Matrix of the LSST

Simulating Donuts with imSim

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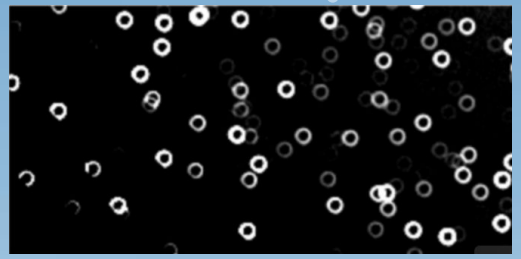
01
BACKGROUND

Determining Perturbations with Donuts

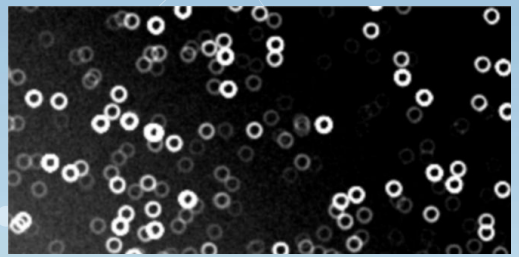
When the focal plane is taken slightly out of focus in either direction, formerly point-like sources become ‘donut’ shapes

- Donuts help us easily visualize and determine error in the alignment of the camera and mirror
- Zernike polynomials are more easily identifiable
- The Wavefront Sensors serve the purpose of providing an intra- and extrafocal image when the telescope is focused

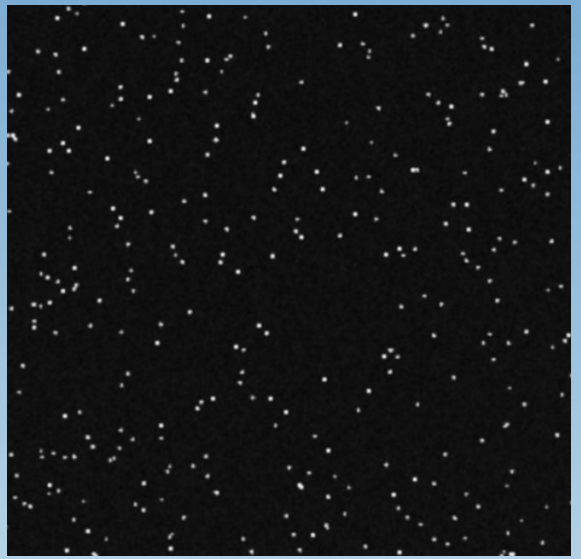
Wavefront Sensor 192



Wavefront Sensor 191

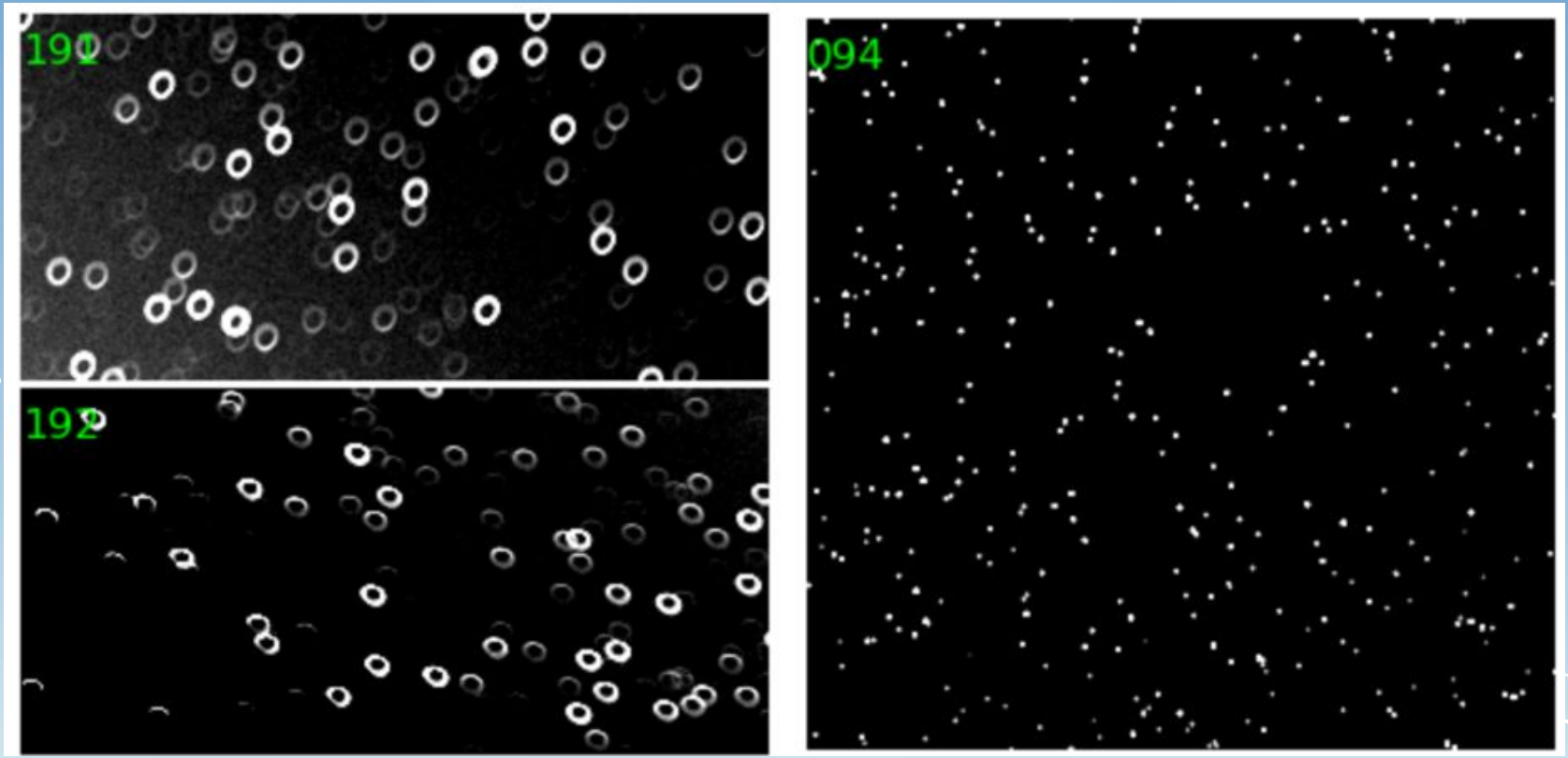


Science Sensor 94 (in focus)



Example:

6000 micron perturbation applied to the M2 mirror (dx)



Hexapod Degrees of Freedom

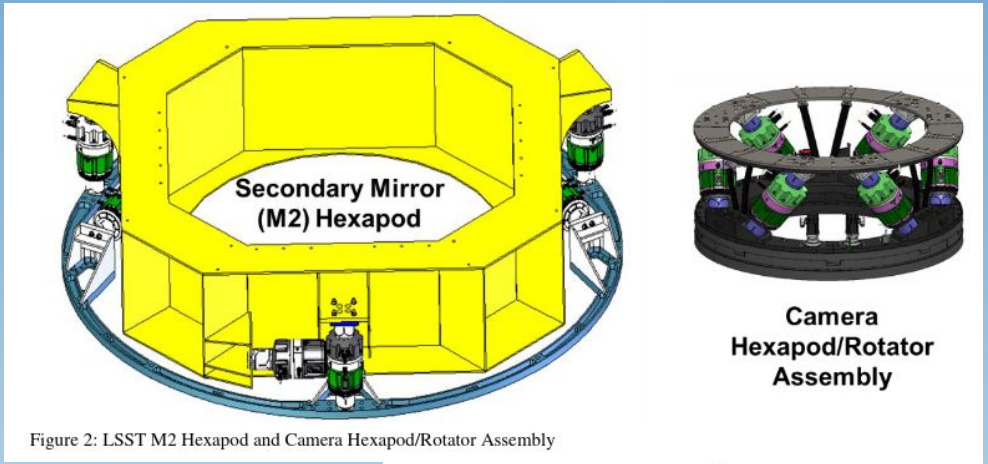


Figure 2: LSST M2 Hexapod and Camera Hexapod/Rotator Assembly

Sneed et al. 2016

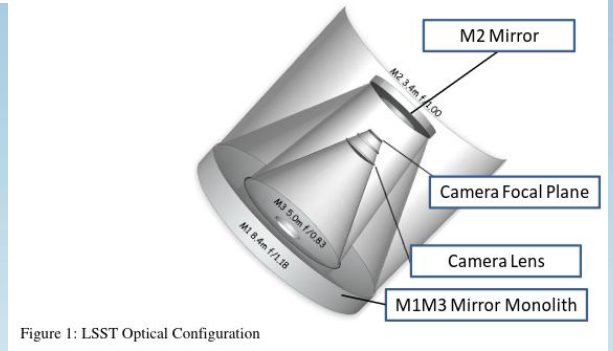


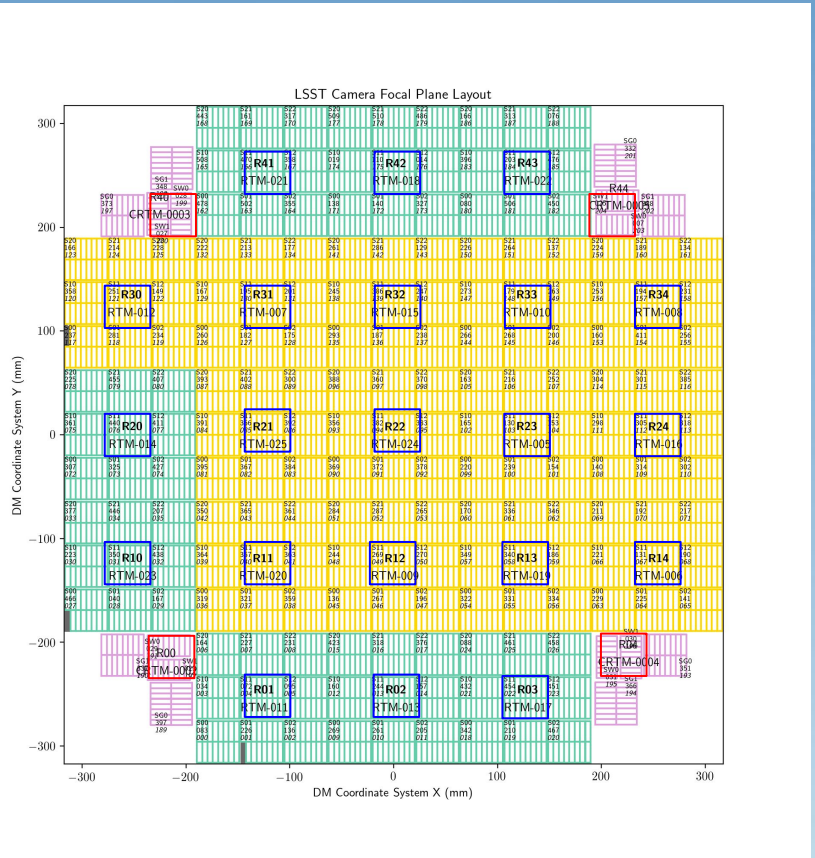
Figure 1: LSST Optical Configuration

Hexapod degrees of freedom:
0: M2 dz (microns)
1, 2: M2 dx, dy (microns)
3, 4: M2 rx, ry (arcsec)
5: Camera dz (microns)
6, 7: Camera dx, dy (microns)
8, 9: Camera rx, ry (arcsec)

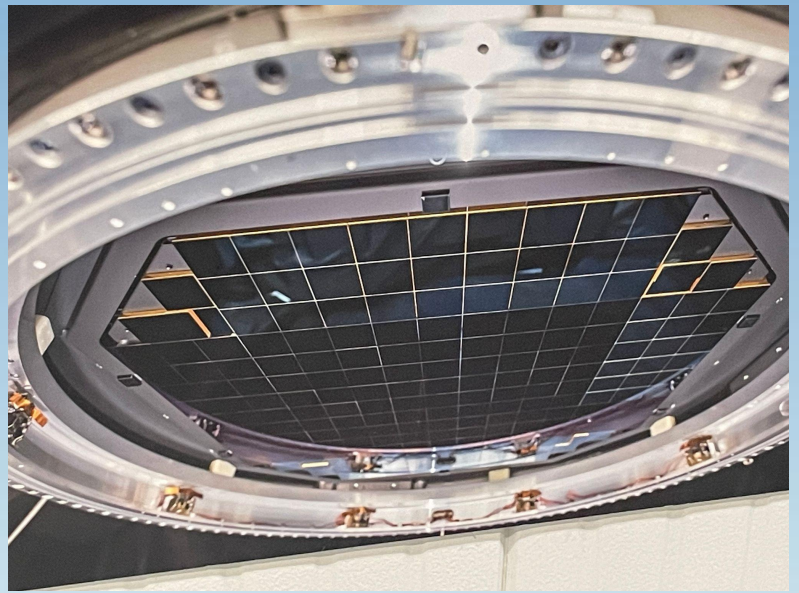
Out of the 50 degrees of freedom, 10-49 are bending modes of the M1M3 mirror and the M2 mirror

Science vs. Wavefront Sensors

The layout of the LSST camera



Credit: Seth Digel



The Loop

The ‘loop’ refers to a few different things:

- Open loop: Using a lookup table to correct for perturbations, does not require donuts
- Closed loop: Correcting for error by using the donuts of the wavefront sensors to determine the perturbations
- Nested loop: The testing of the sensitivity matrix during early active optics commissioning, what I am simulating images for right now

The Sensitivity Matrix

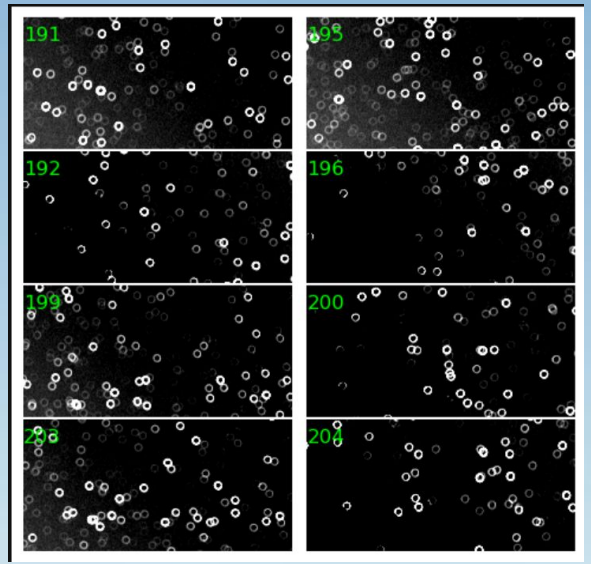
There are 10 degrees of freedom for the hexapods, 6 filters, 3 focuses (intra- extra- and in-focus), 5 or 7 variations per degree of freedom, so about 1260 images (some cancel out)

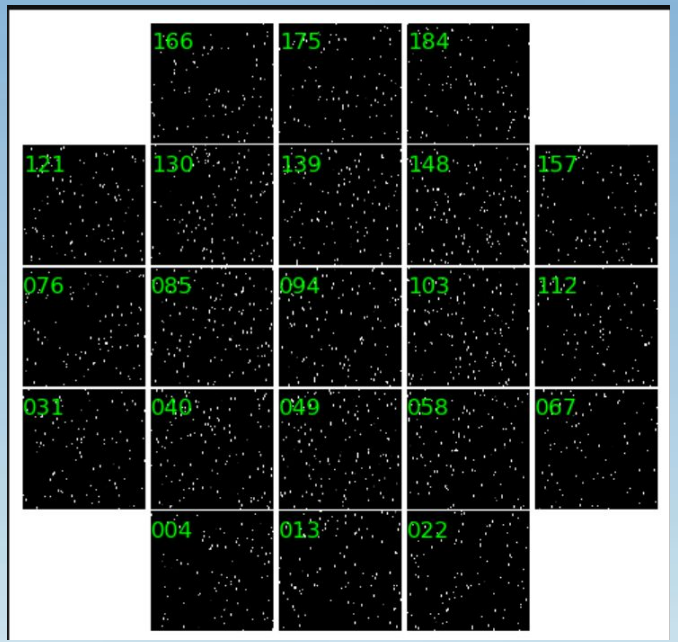
- The various combinations of all of these variables are how the sensitivity matrix is calculated, so I am simulating all of these images in preparation for the active optics commissioning on the telescope.

02
IMSIM

imSim and YAML

- imSim is now primarily written in YAML, pulling off the GalSim config dictionary
- Simulates images from LSST as-designed





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template: generating_perturbations

eval_variables:
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    iseqnum: 42
    fmjd: 60514.98
    frawSeeing: 0.5
    artp: 0.0 deg

image.random_seed: 42

input.telescope.fea.aos_dof:
  dof: [0.0, 0.0 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
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output.cosmic_ray_rate: 0.
output.type: LSST_CCD
output.nproc: 3
output.nfiles: 3
output.det_num: [94, 191, 192]
output.dir: /sdf/group/rubin/user/rp312

output.truth:
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        object_id: "@object_id"
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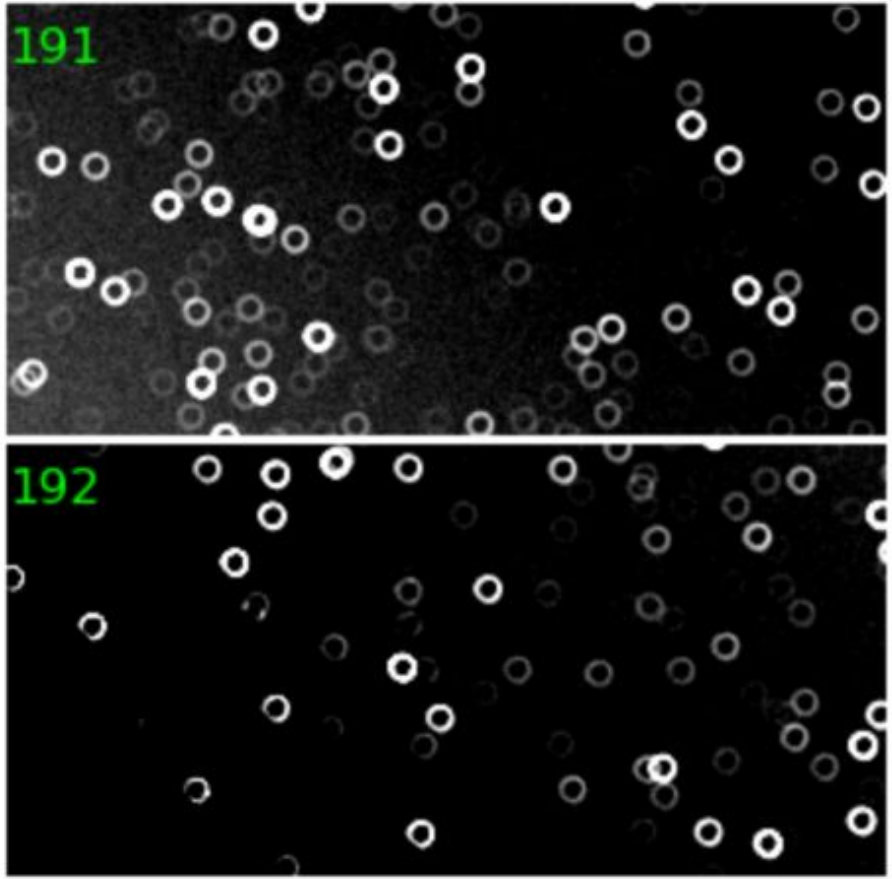
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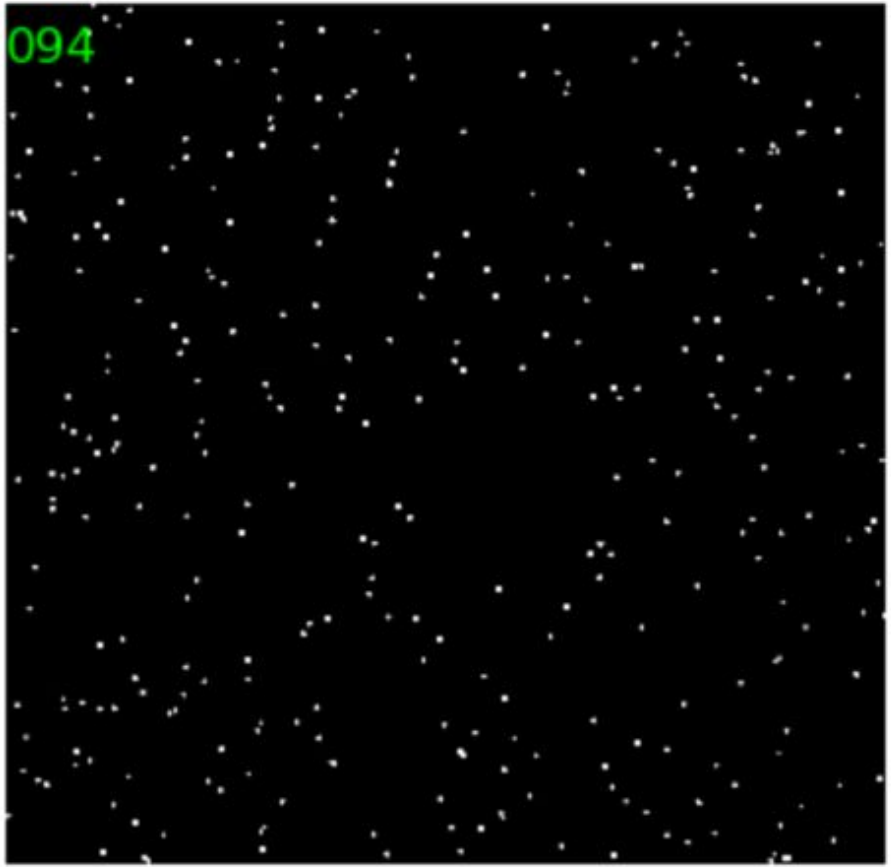
192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    fmjd: 60514.98
    frawSeeing: 0.5
    artp: 0.0 deg

image.random_seed: 42

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#dof: [M2dz, M2dx, M2dy, M2rx, M2ry, CAMdz, CAMdx, CAMdy, CAMrx, CAMry] microns or arcsec

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output.type: LSST_CCD
output.nproc: 1
output.nfiles: 3
output.det_num: [94, 191, 192]
output.dir: /sdf/group/rubin/user/rp312

output.truth:
    dir: /sdf/group/rubin/user/rp312/perturbations/dress_rehearsal
    file_name: centroid_fiducial_1_focus_det112.txt
    columns:
        object_id: "@object_id"
        ra: "$sky_pos.ra.deg"
        dec: "$sky_pos.dec.deg"
        x: "$image_pos.x"
        y: "$image_pos.y"
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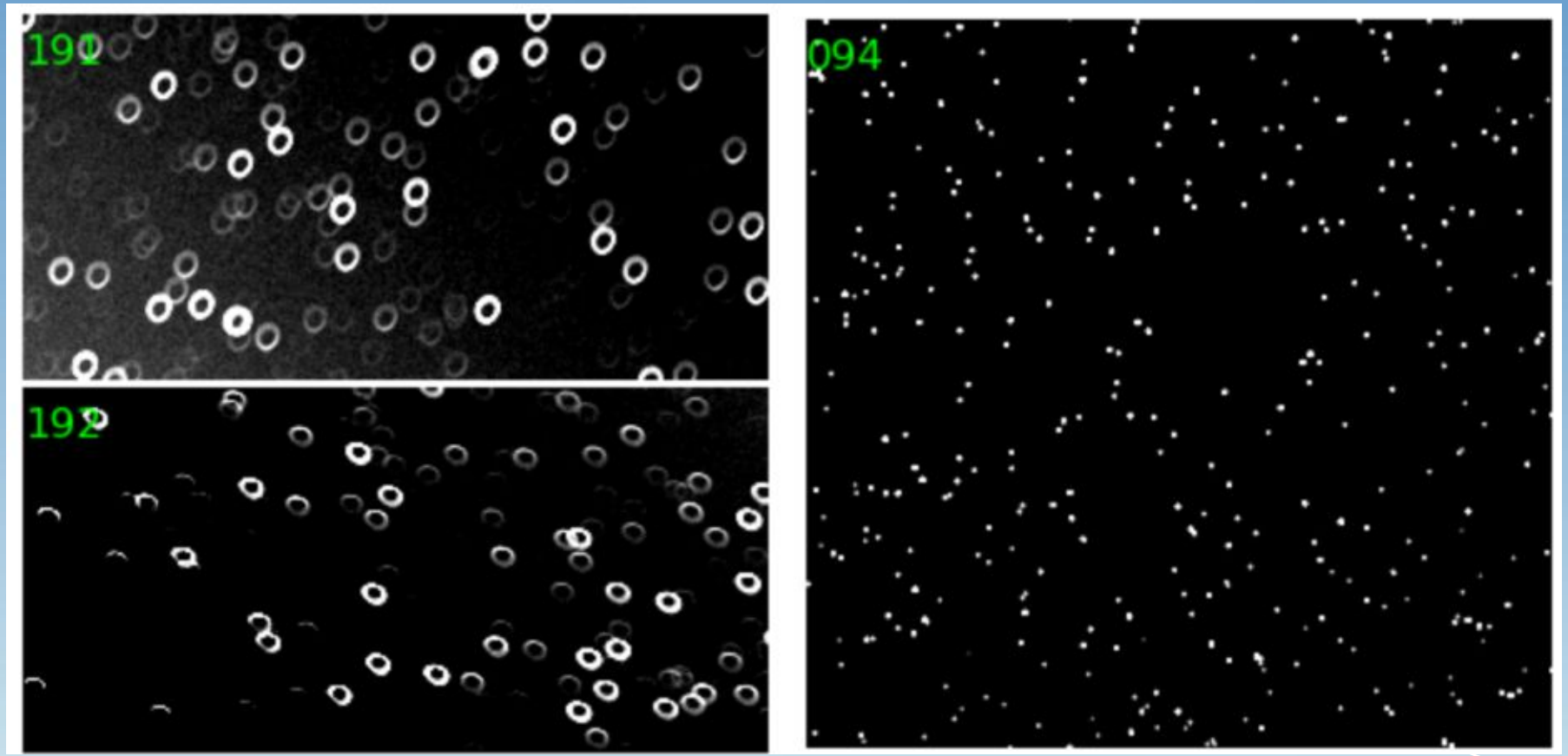
191
192
094

03
LOOKING FORWARD

Where Are We?

Confirming the Data

Is the Wavefront Estimation Pipeline able to figure out on its own what perturbations I applied to these images?

The Steps Ahead

Data Confirmed

WFE determines that the data makes sense

01

02

Simulate More of the Loop

Wider variety of combinations of degrees of freedom, filters

Move on to Batch Jobs

These images are computing intensive, move on to whole focal plane

03

04

Ingest into a Butler

To be used during early active optics commissioning

Thank you!

Credit: Slidesgo