GFA ETC Online Pipeline

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DESI OSU Workshop
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Dark Energy Spectroscopic Instrument
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Lawrence Berkeley National Laboratory

ETC Pipeline Overview

Delivers seeing, transparency and sky level to online ETC & observers.

Provides online image quality diagnostics.

Does not require any catalog or WCS.

Fast with minimal dependencies.

Documentation:
- DESI-5315
- notebooks in https://github.com/desihub/desicmx/tree/master/analysis/gfa

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ETC Pipeline Inputs: GFA Data

e2v CCD230-42: 2K x 1K sensor with 15um pixels (0.214" / 0.197")

Bias ~ 1150-1700 ADU: subtracted using overscan

Bias spatial variation ~ 15 ADU: calibrated

Readout noise ~ 5 ADU: calibrated

Gain ~ 3.7 elec/ADU: calibrated

Dark current ~ 30-55 elec/pix/s at 11C +23%/C: calibrated & subtracted

Dark current spatial variation ~30 elec/pix: calibrated
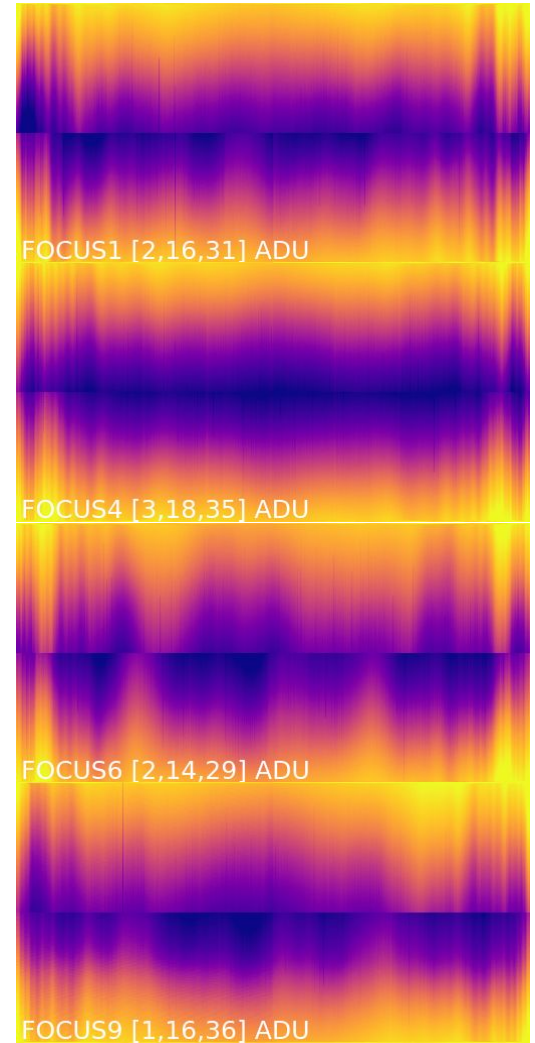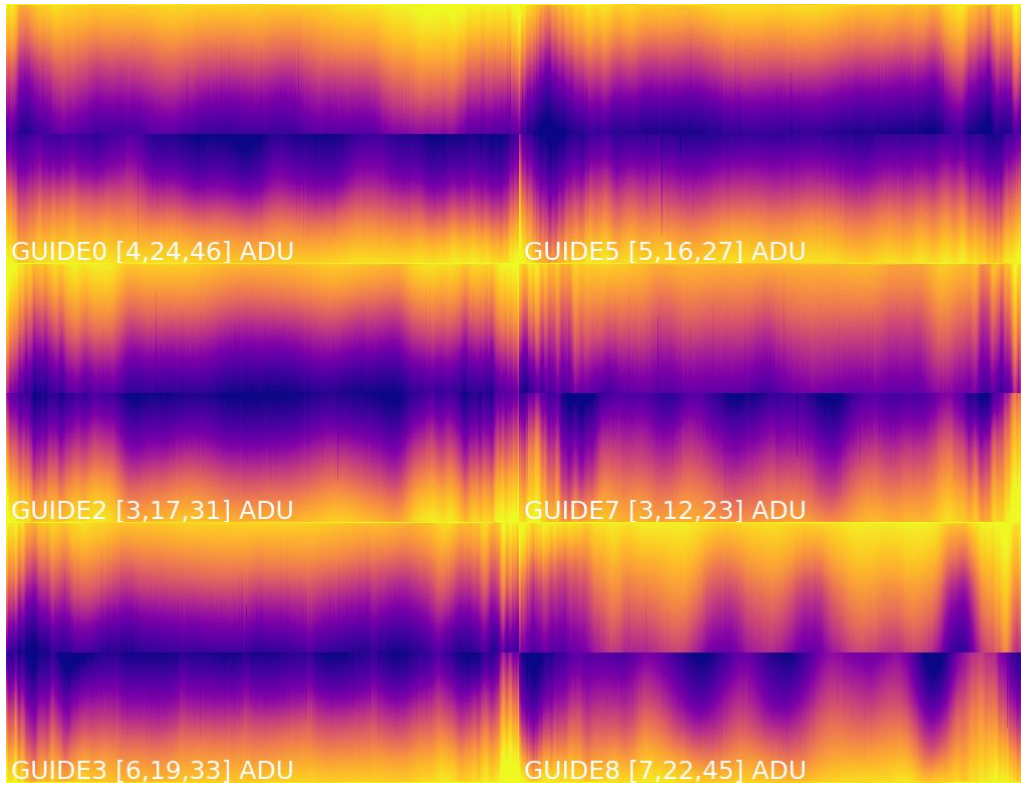
(GFA temperature measured to ~0.025C)

Dark sky level ~ 10 elec/pix/s

Bleed trails > 100K elec (full well ~190K elec, 32-bit max ~ 1.2M elec)
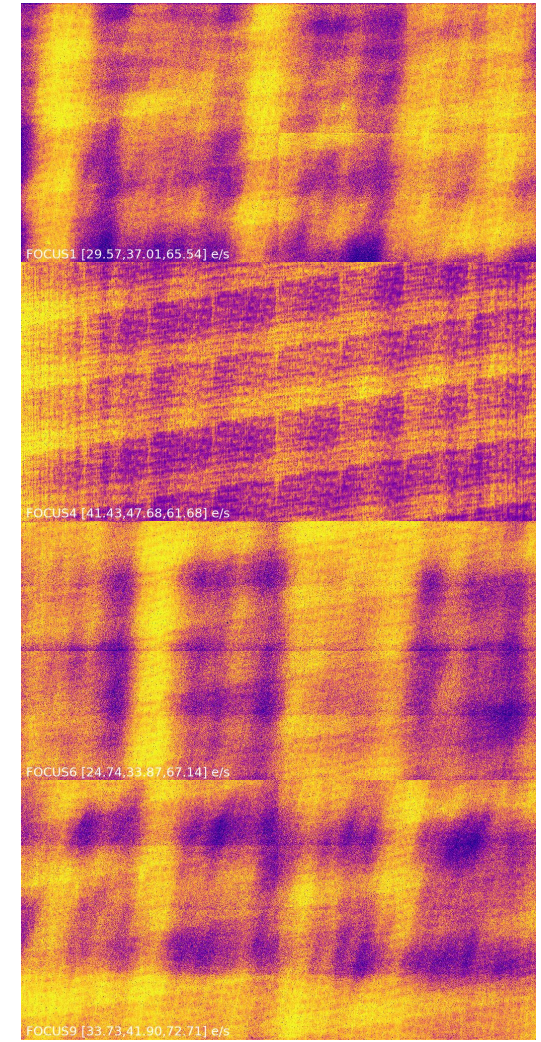
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Master bias images

Residuals after overscan subtraction are +0-40 ADU.

GUIDE0 [4,24,46] ADU
GUIDE5 [5,16,27] ADU
GUIDE2 [3,17,31] ADU
GUIDE7 [3,12,23] ADU
GUIDE3 [6,19,33] ADU
GUIDE8 [7,22,45] ADU

FOCUS1 [2,16,31] ADU
FOCUS4 [3,18,35] ADU
FOCUS6 [2,14,29] ADU
FOCUS9 [1,16,36] ADU

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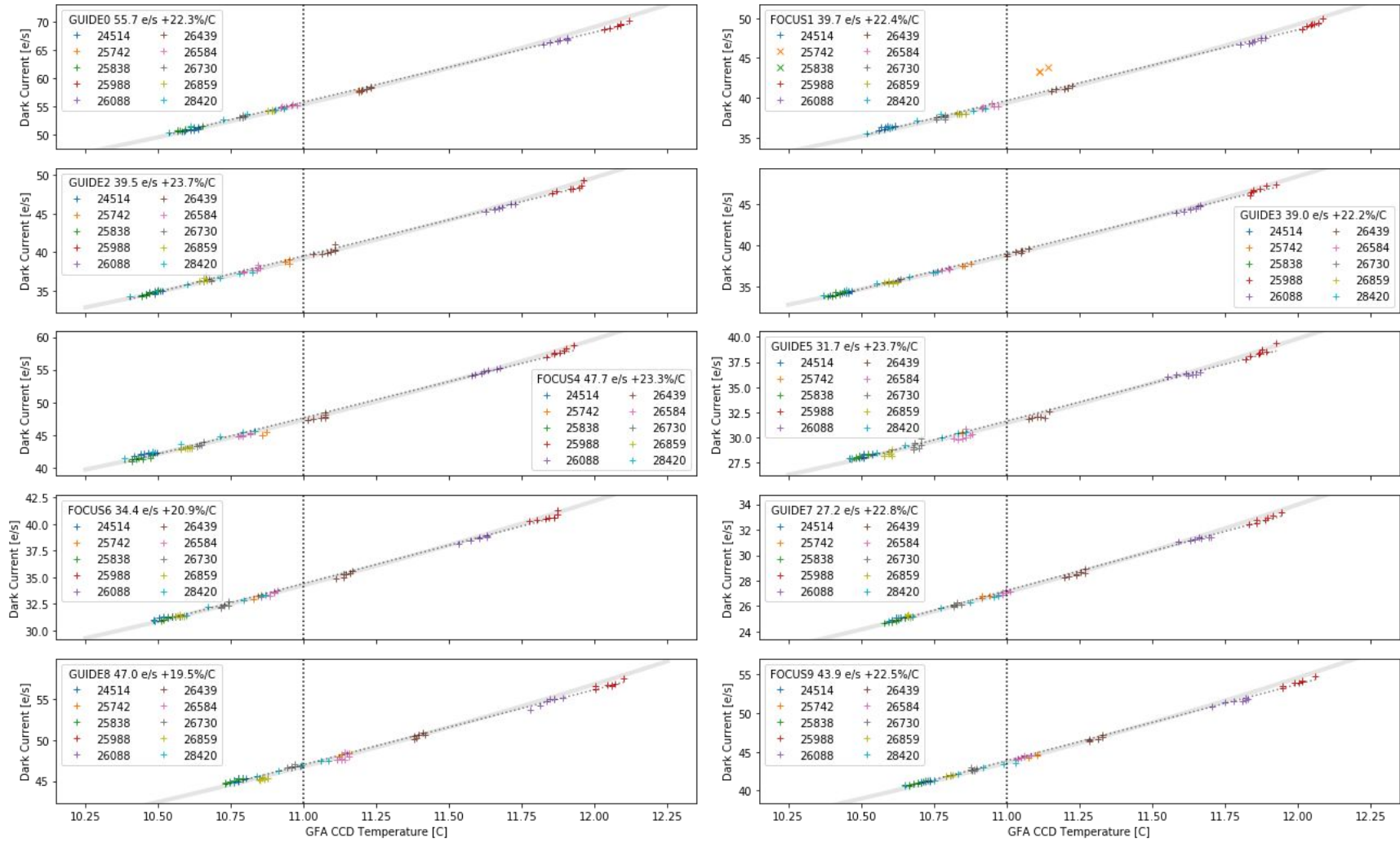# Master dark images

Dark currents are (30 - 55) elec/s at 11C.
Prominent geometric waffle structure due to
laser annealing of sensor.

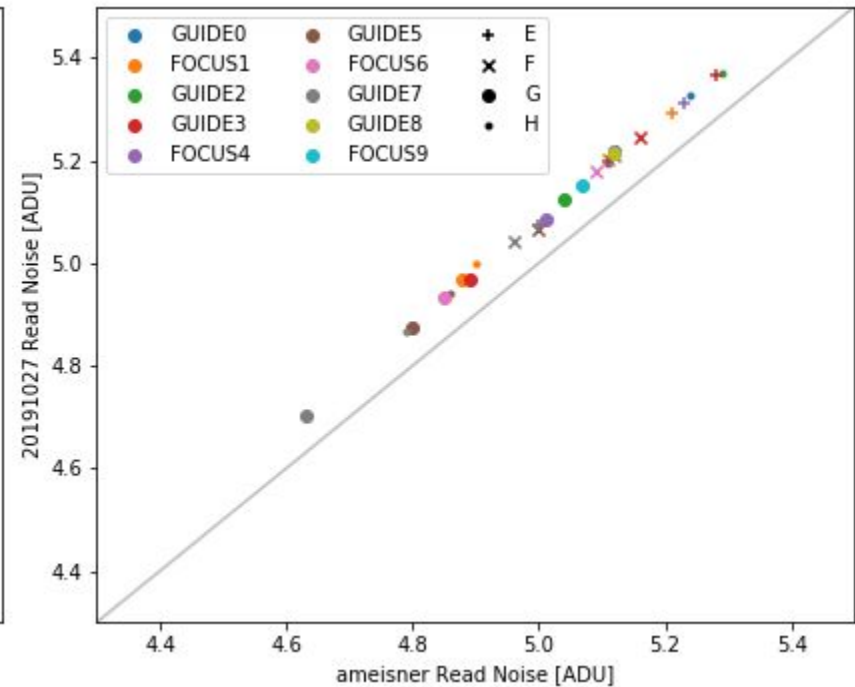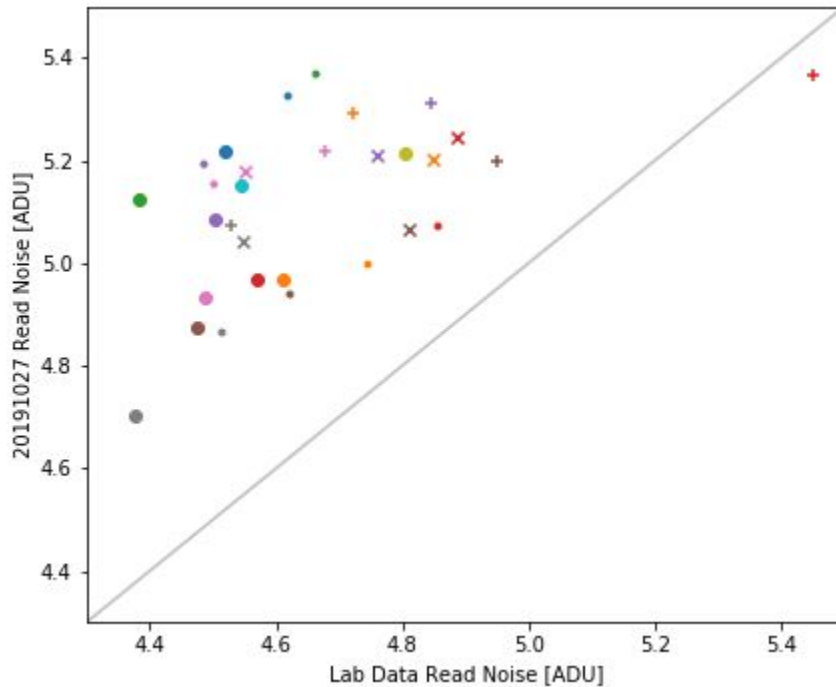**Dark Energy Spectroscopic Instrument**
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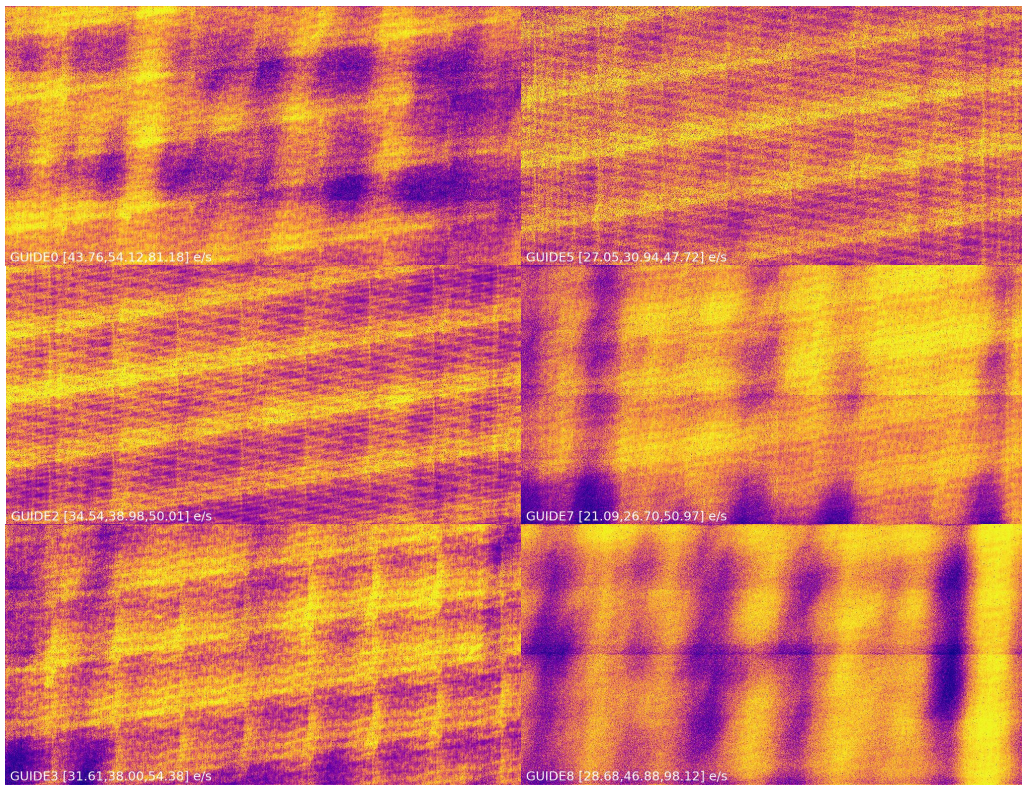
Temperature calibration

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Read noise comparisons

Aaron used a different method on the same data, obtaining consistent results (but with a shift of ~0.08 ADU).

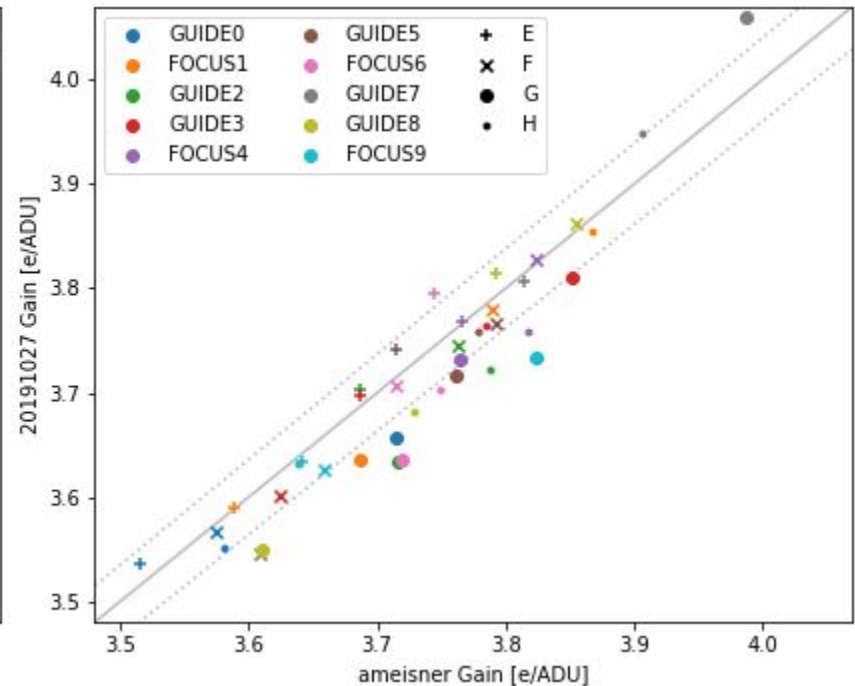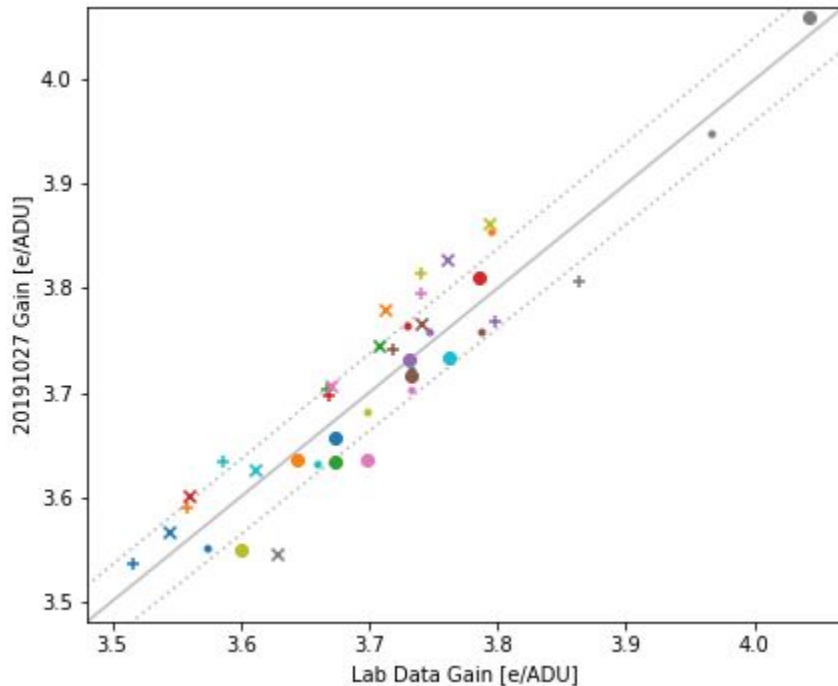Neither analysis of 20191027 data is consistent with lab data.

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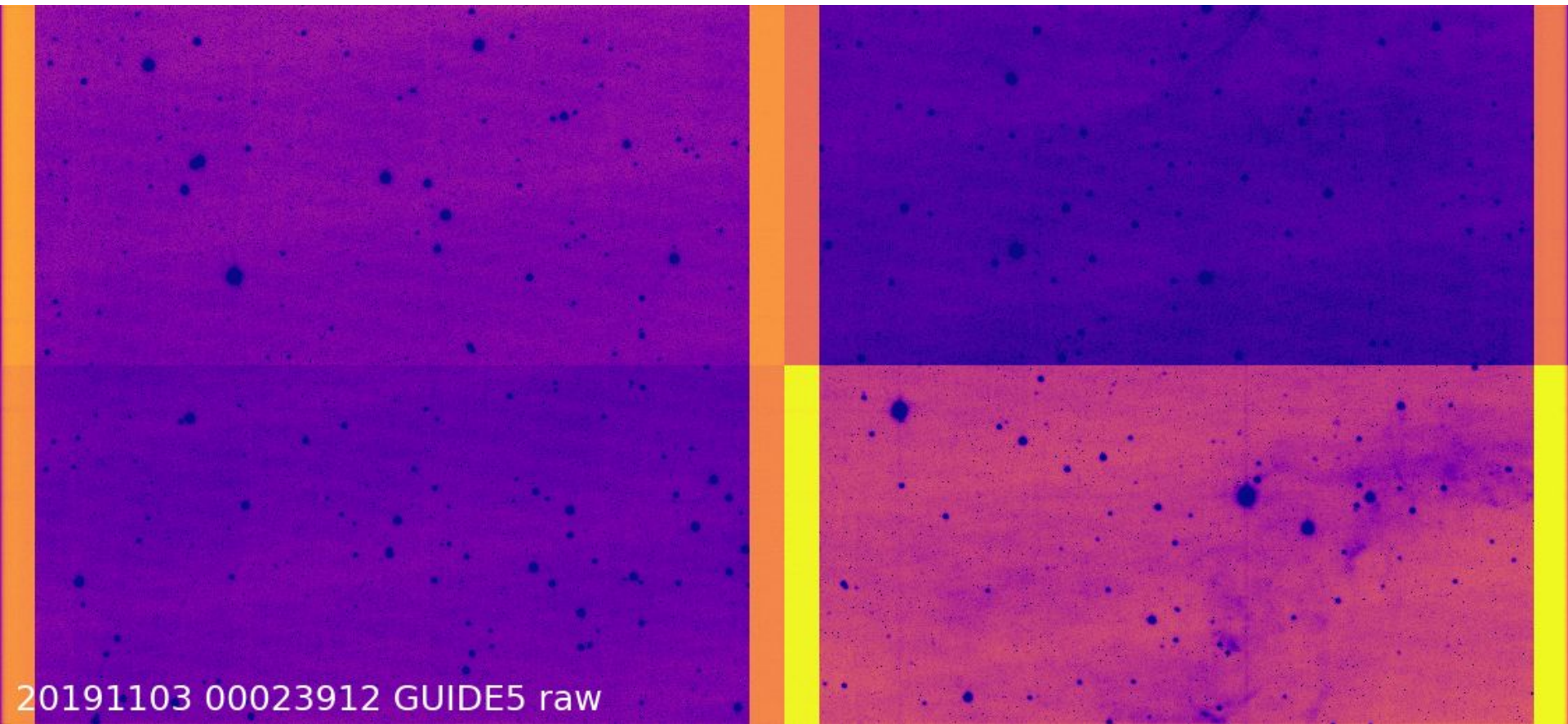
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Gain comparisons

Results agree with lab data at better than 1% level.

Aaron's gains are slightly lower on average (-0.02 e/ADU) likely due to extra variance in the "flat" images.

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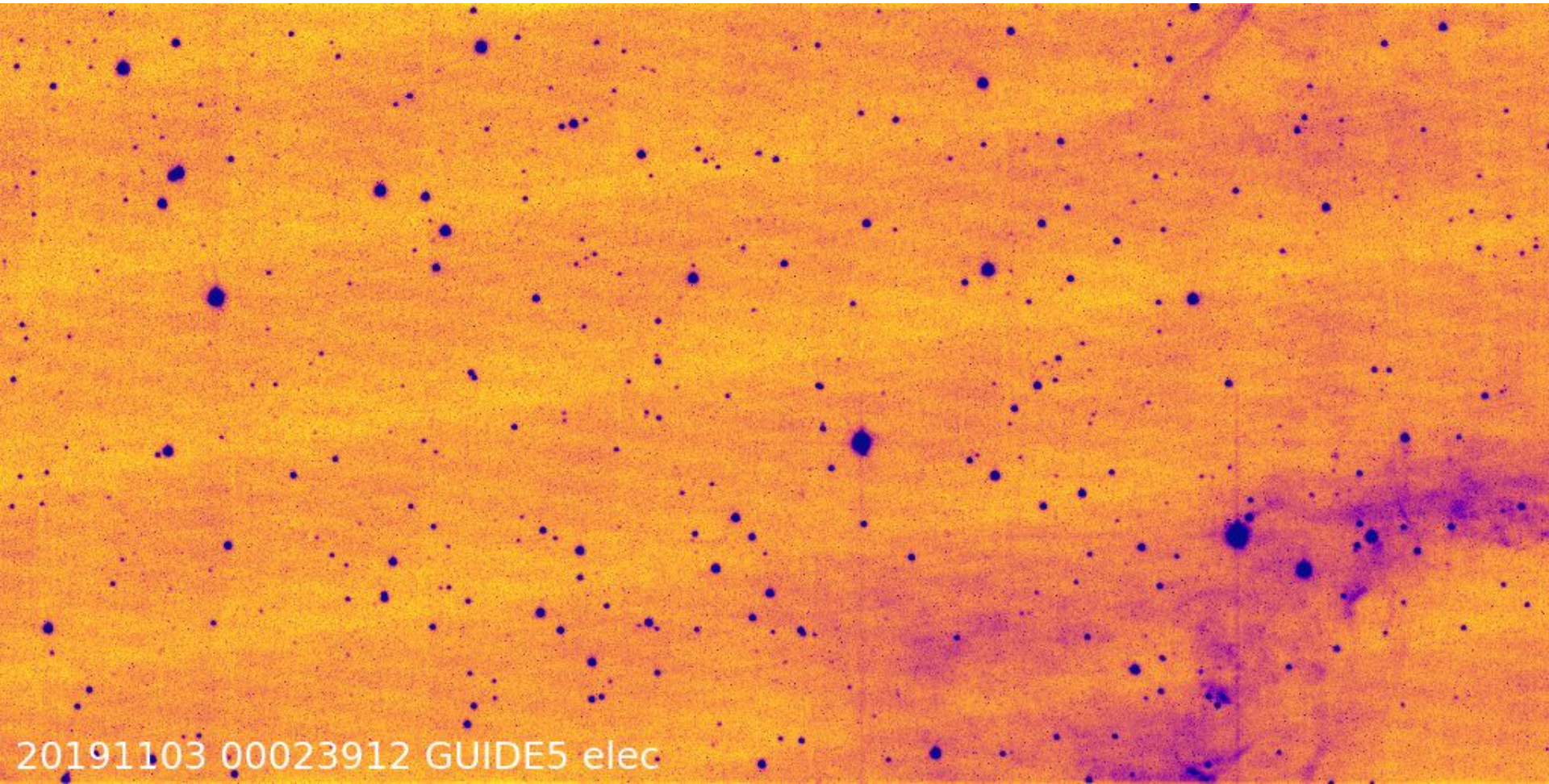
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Pipeline Steps: Raw Data
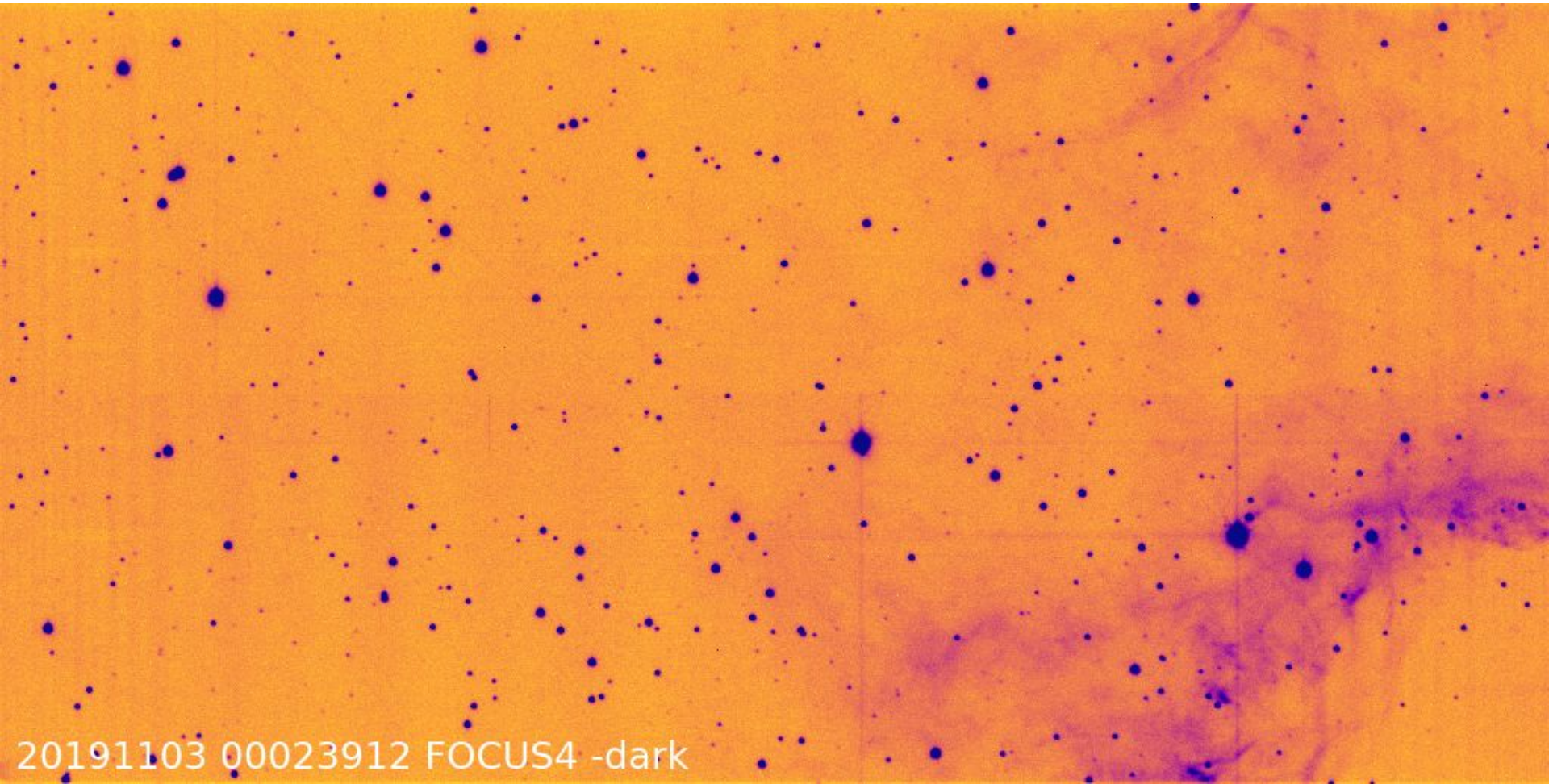

20191103 00023912 GUIDE5 raw

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Pipeline: Calibrated Data

20191103 00023912 GUIDE5 elec

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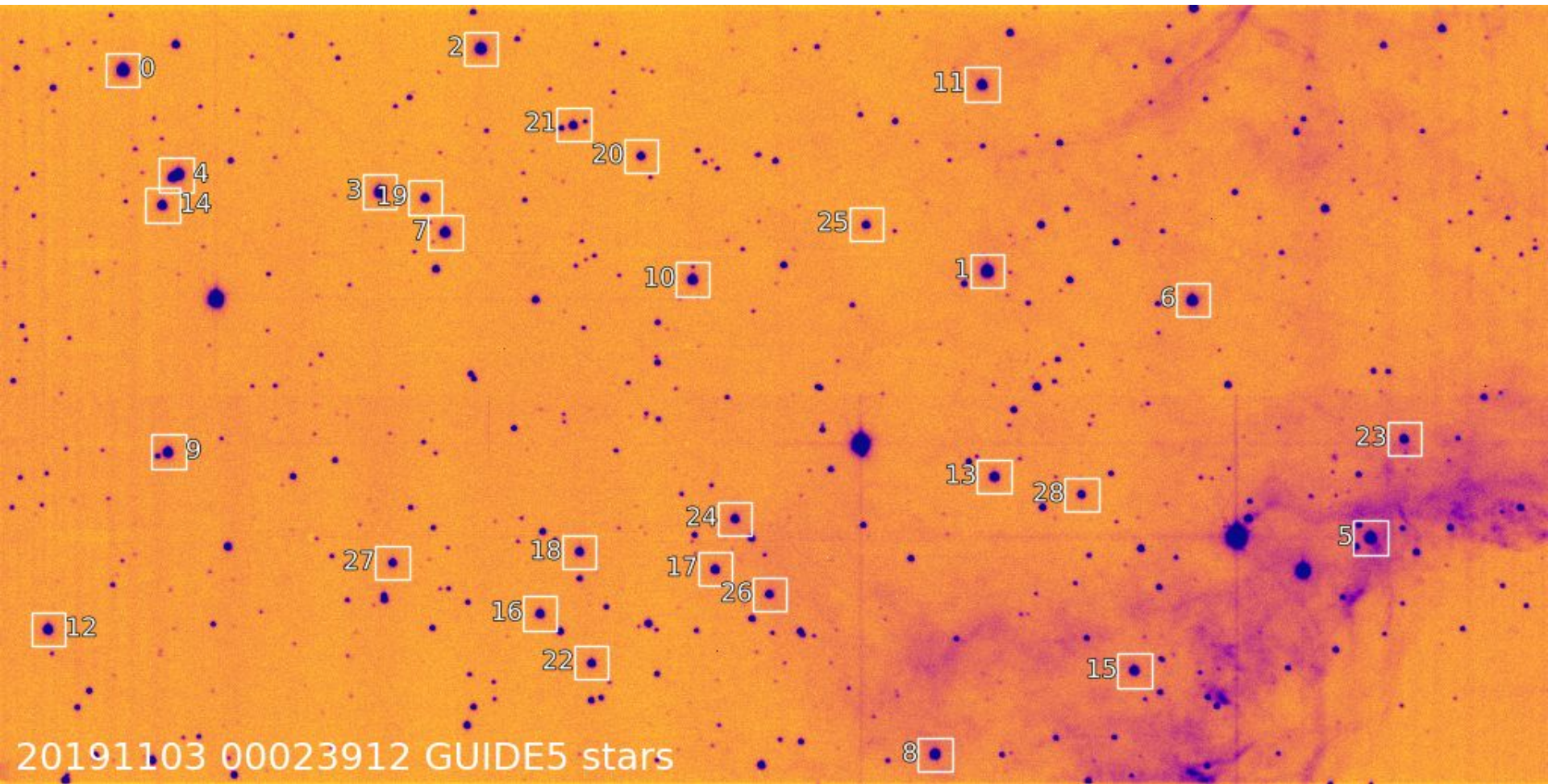
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# Pipeline: Dark Current Subtraction

20191103 00023912 FOCUS4 -dark

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Pipeline: Detected Stars

20191103 00023912 GUIDE5 stars

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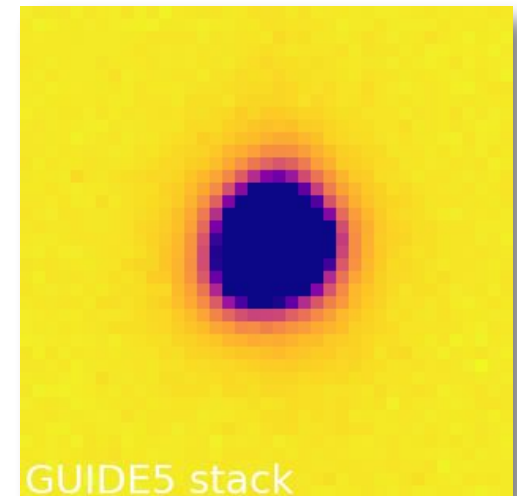
# Pipeline: Stacked PSF
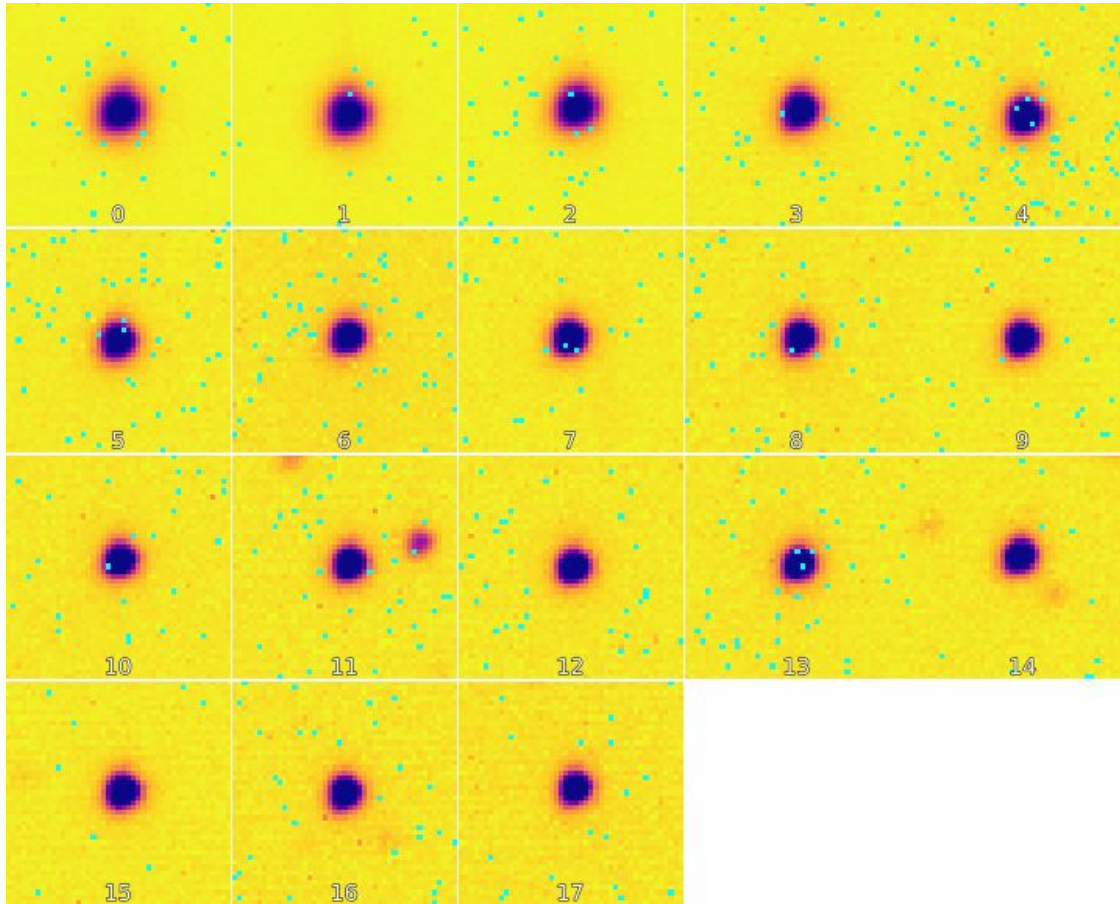
Ignore saturated stars and sensor edges.

Reject outliers (galaxies, blending, etc)

Center each PSF & calculate ivar-weighted stack.

Result is a high-SNR PSF with propagated ivars:

GUIDE5 stack

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Pipeline: Detected donuts

20191103 00023912 FOCUS4 donuts

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Online image quality diagnostics

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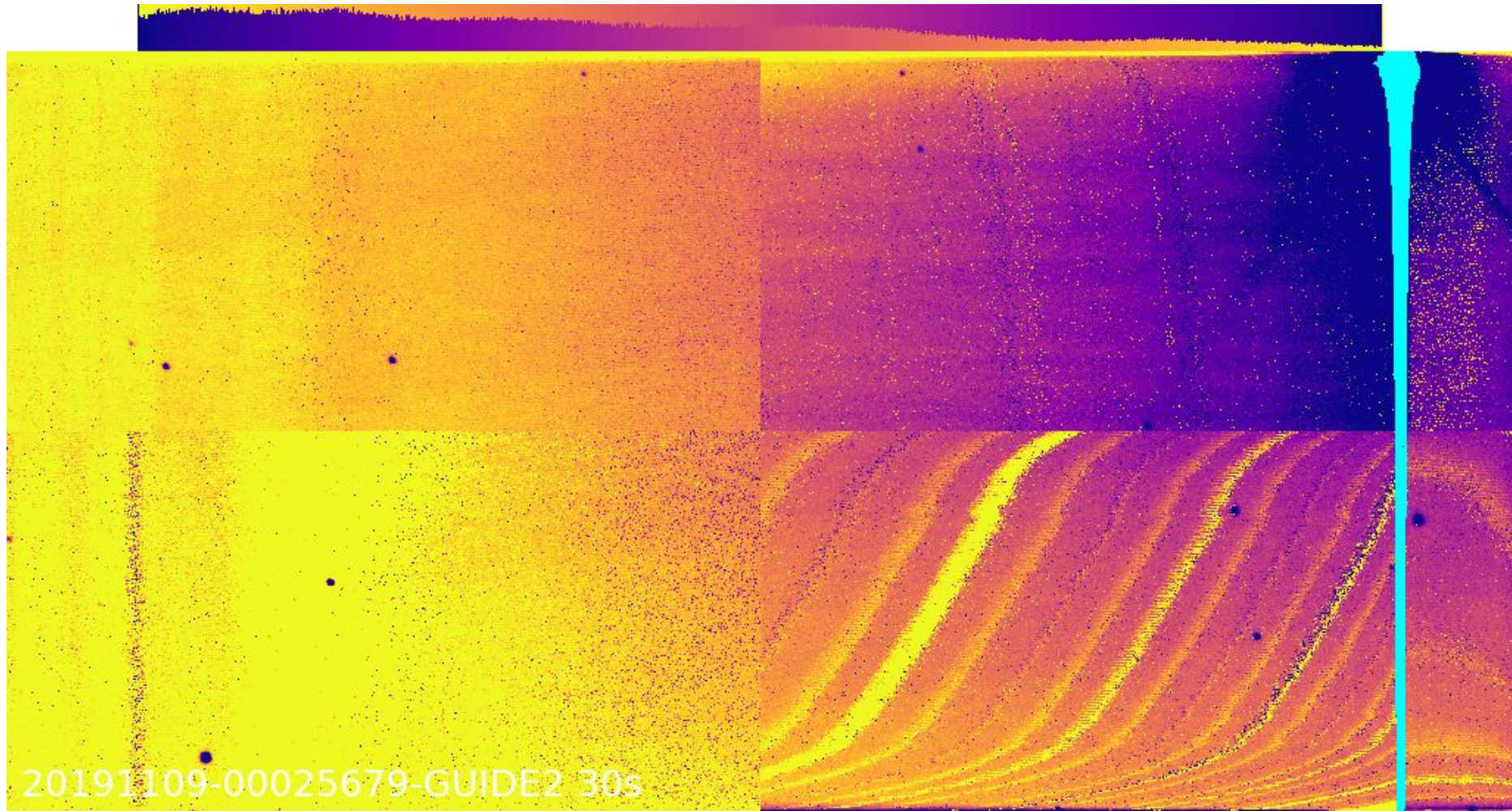.
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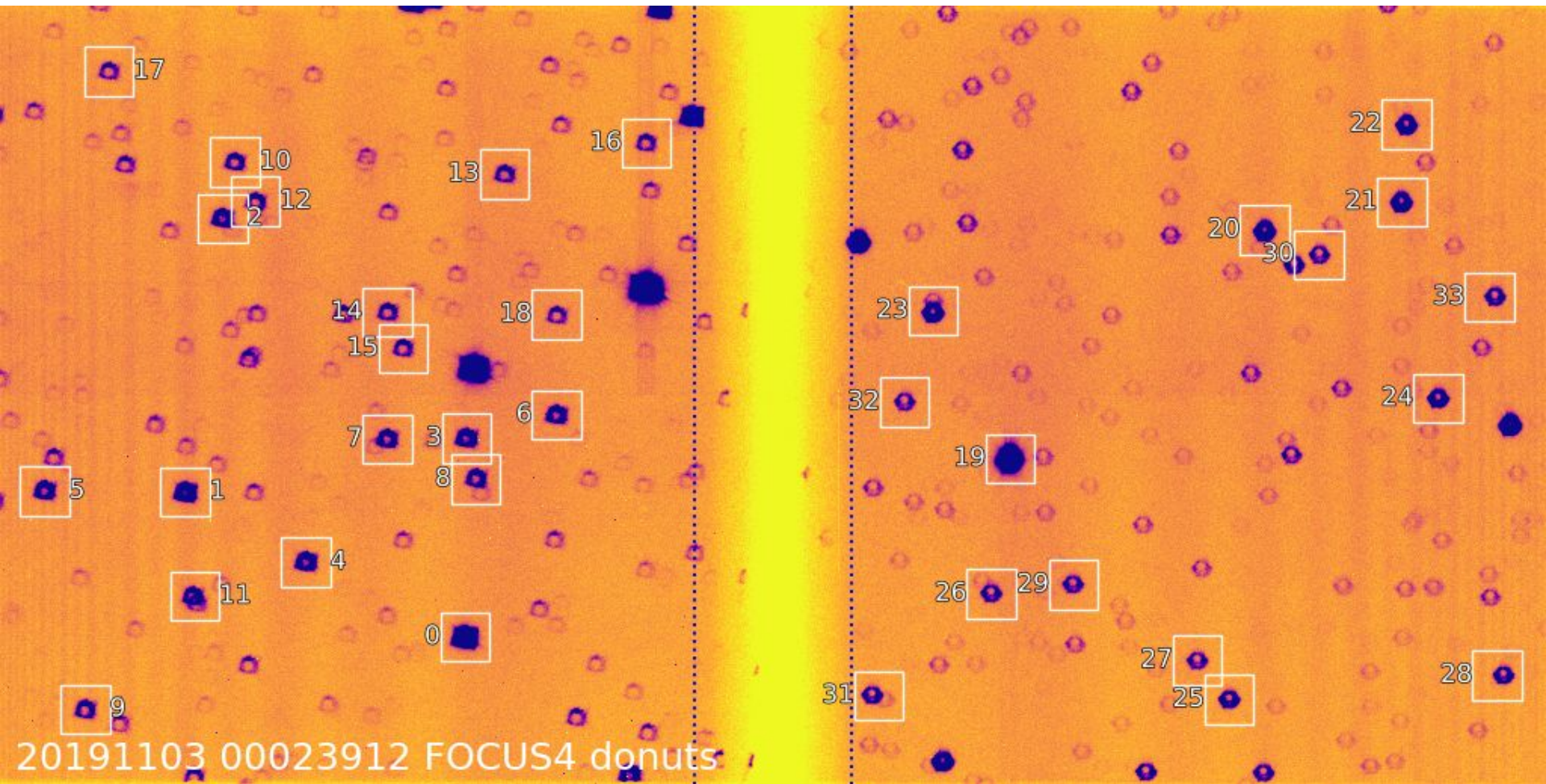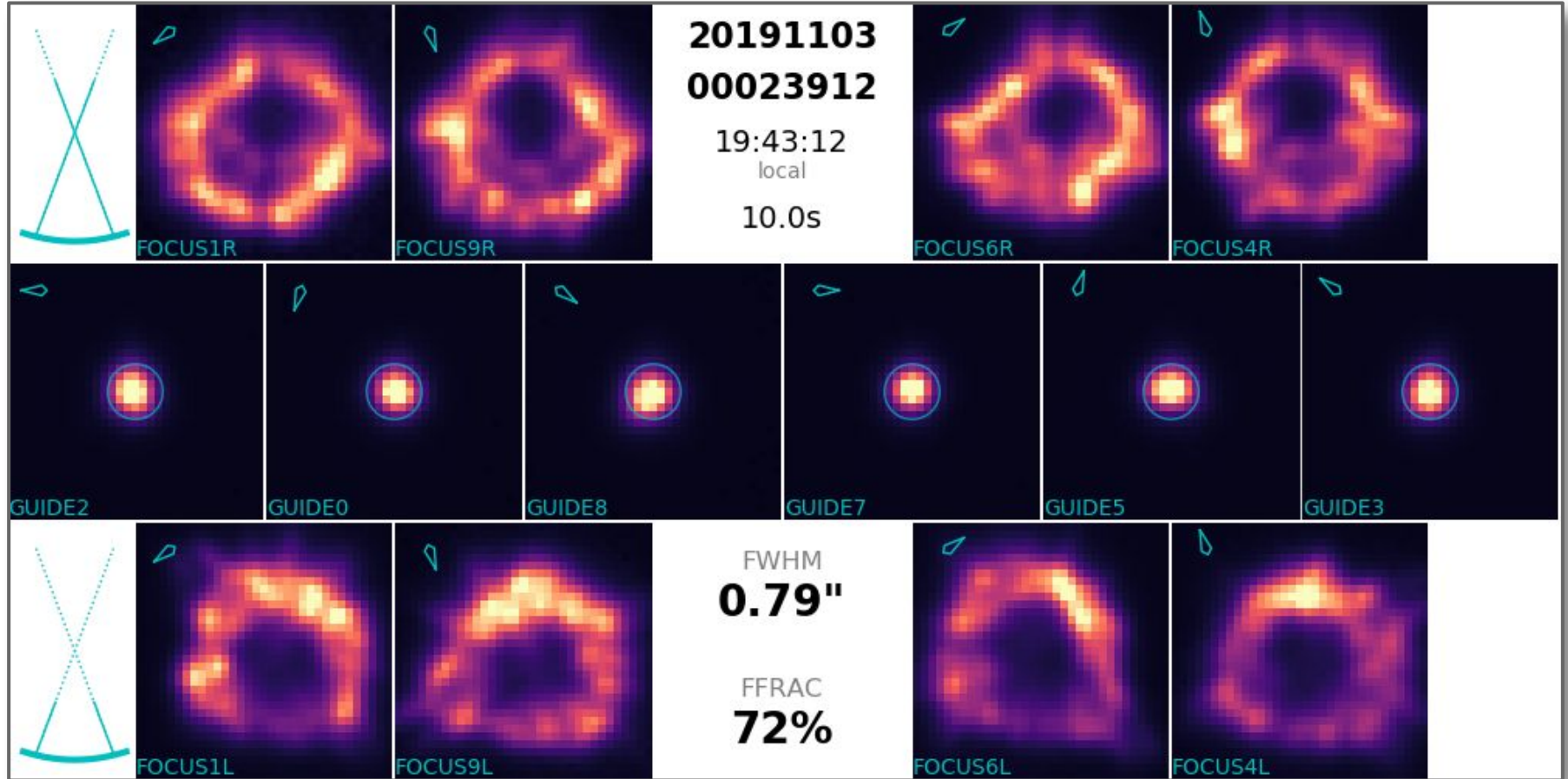
Open Issues: Overview

Sensor & readout:

- High-noise state (fixed by "denoising" process)
- Bad pixels
- Pattern noise
- Saturation horizontal streaks
- Gain variations
- Dark current versus exposure time

Telescope & optics:

- No shutter
- Dust pinhole images
- Vignetting at large radius
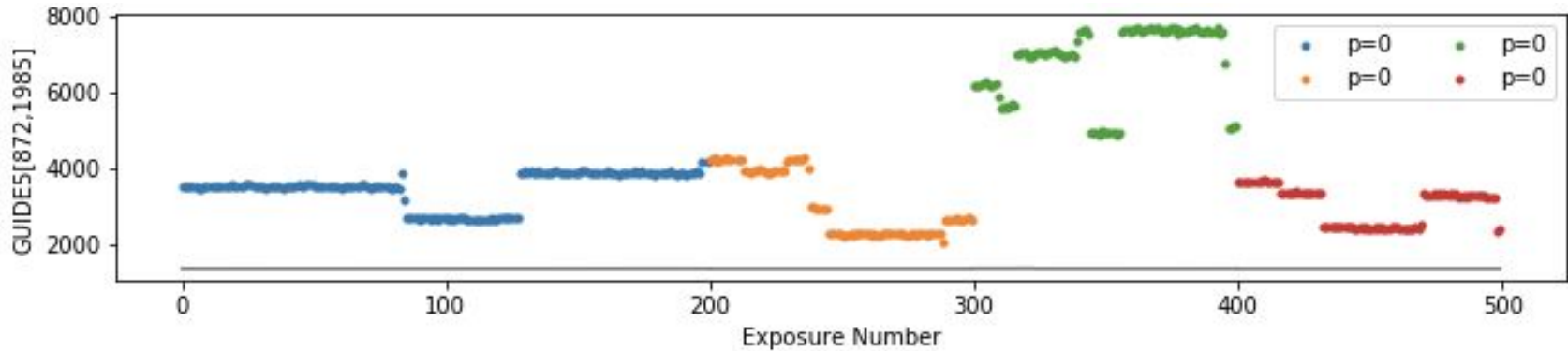- Asymmetric plate scales and optical PSF

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High-noise state

20191109-00025679-GUIDE2 30s

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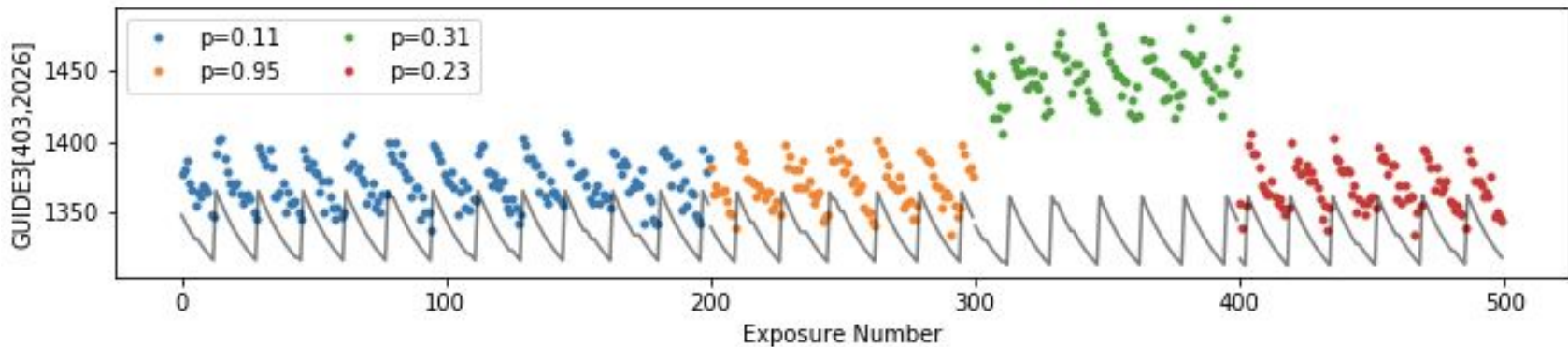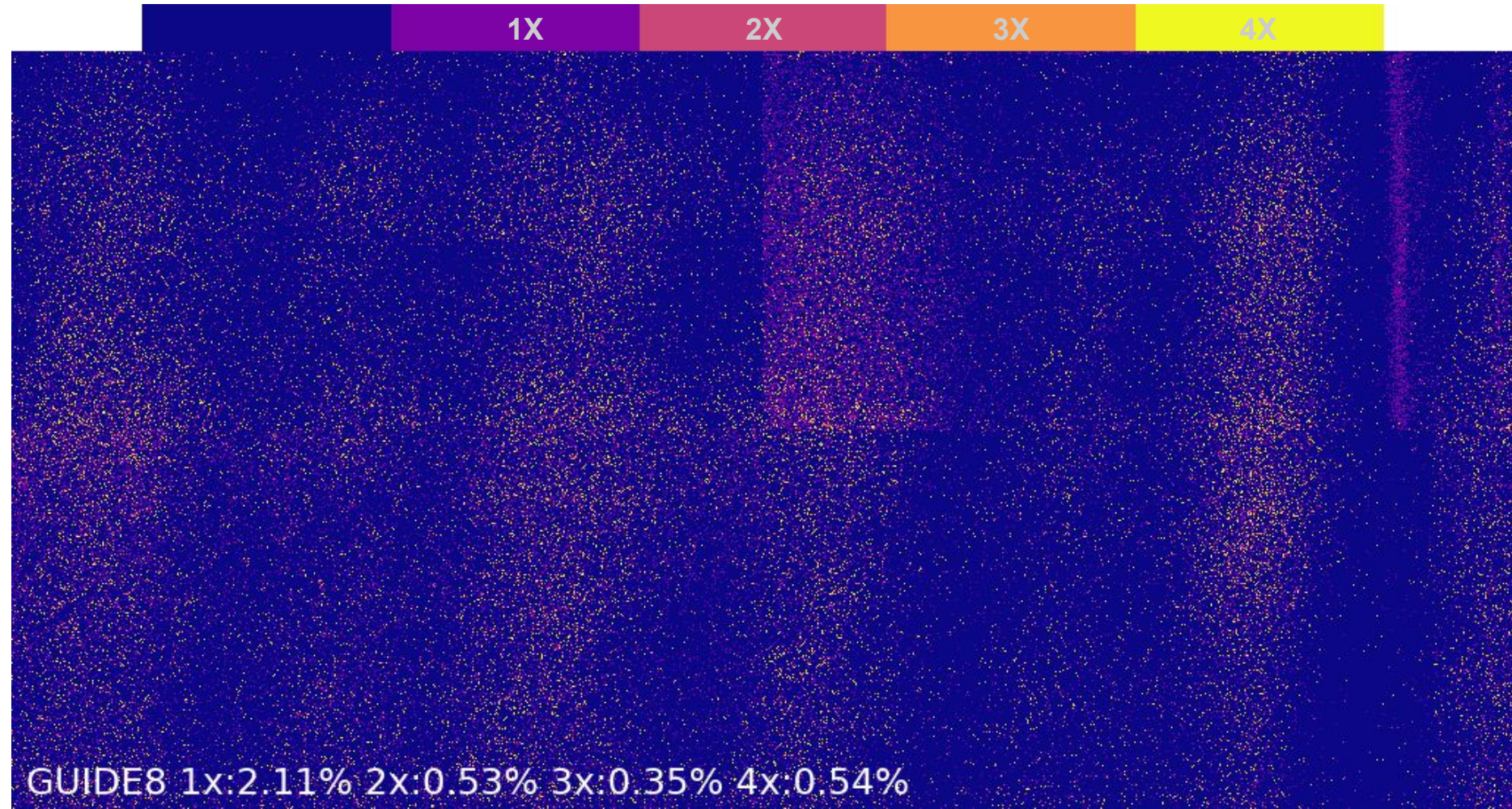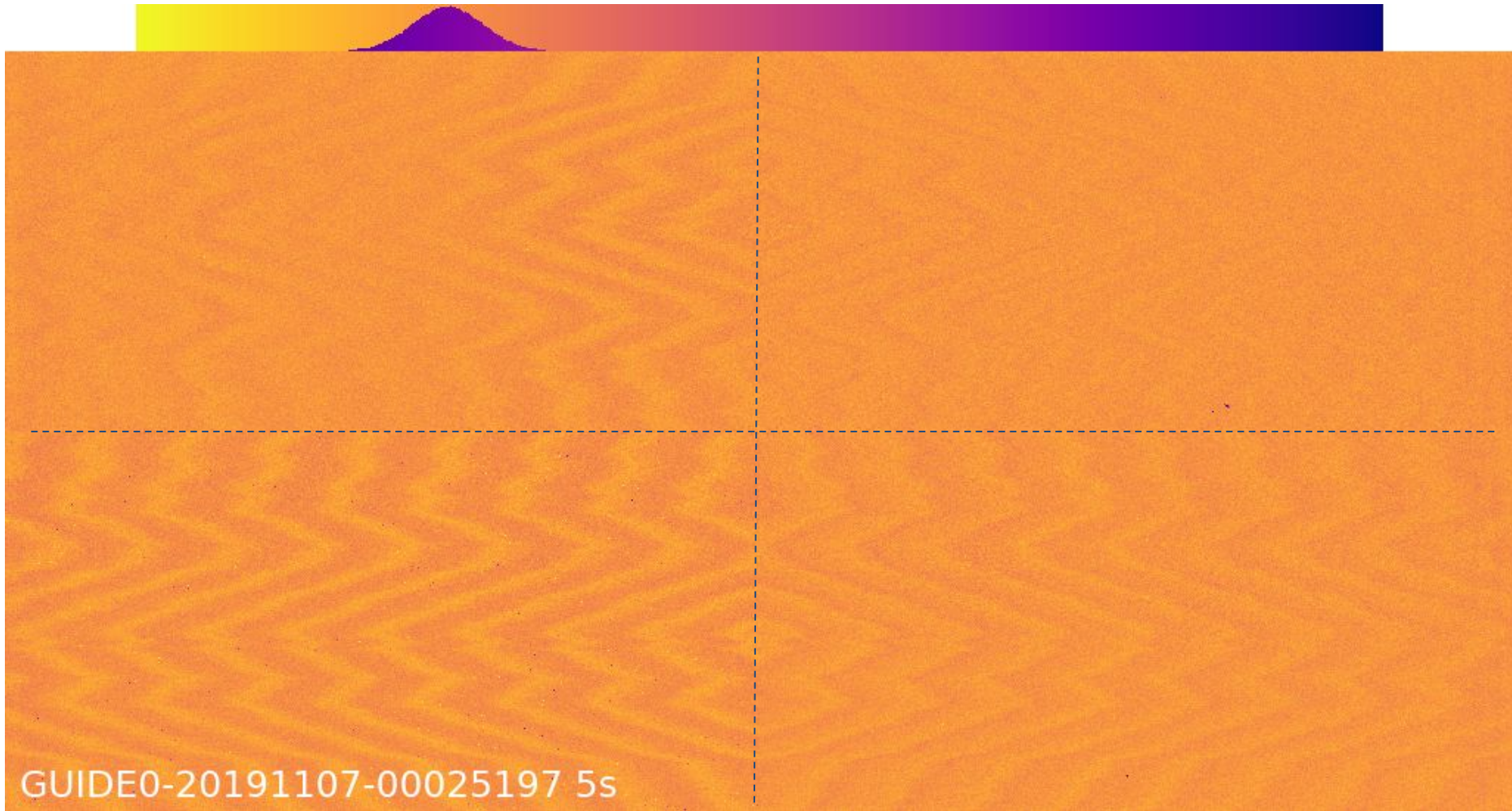# Bad pixels

ADC bit flips: https://desi.lbl.gov/trac/ticket/465

Bias sawtooth: https://desi.lbl.gov/trac/ticket/466

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Bad pixels

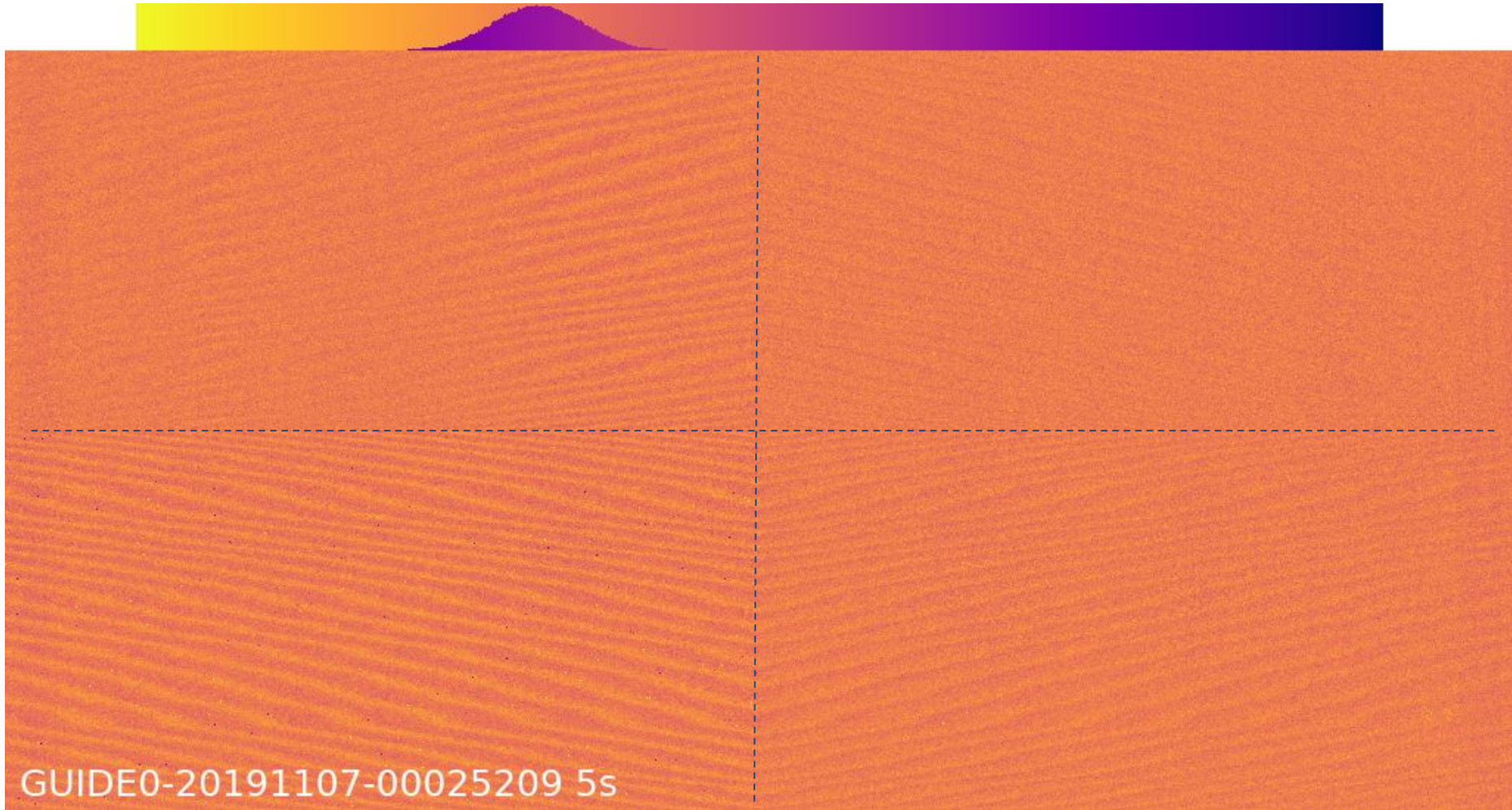GUIDE8 1x:2.11% 2x:0.53% 3x:0.35% 4x:0.54%

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Pattern noise

GUIDE0-20191107-00025197 5s

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Pattern noise

GUIDE0-20191107-00025209 5s

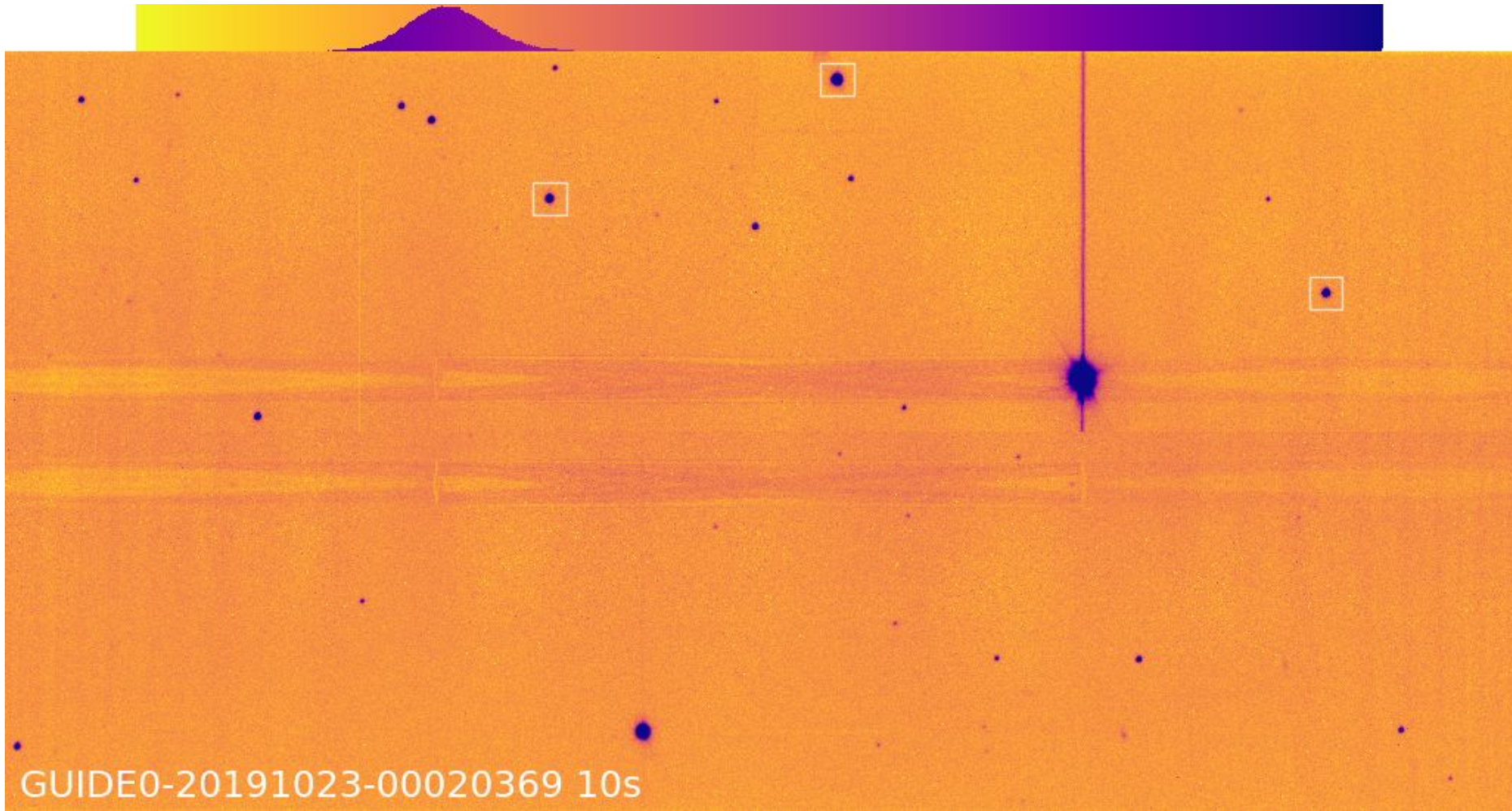**Dark Energy Spectroscopic Instrument**
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Horizontal streaks

GUIDE0-20191023-00020369 10s

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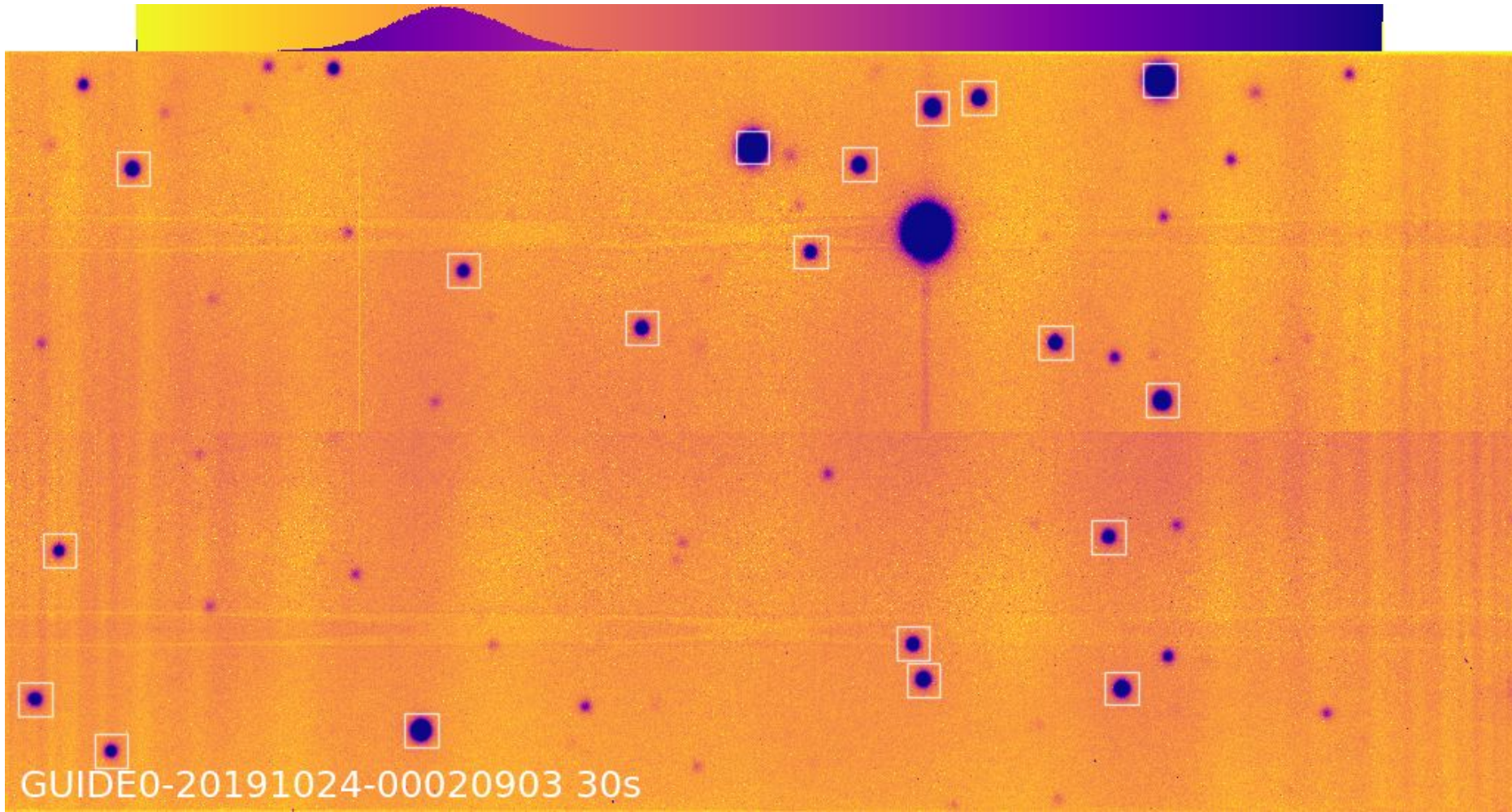
Horizontal streaks

GUIDE0-20191024-00020903 30s

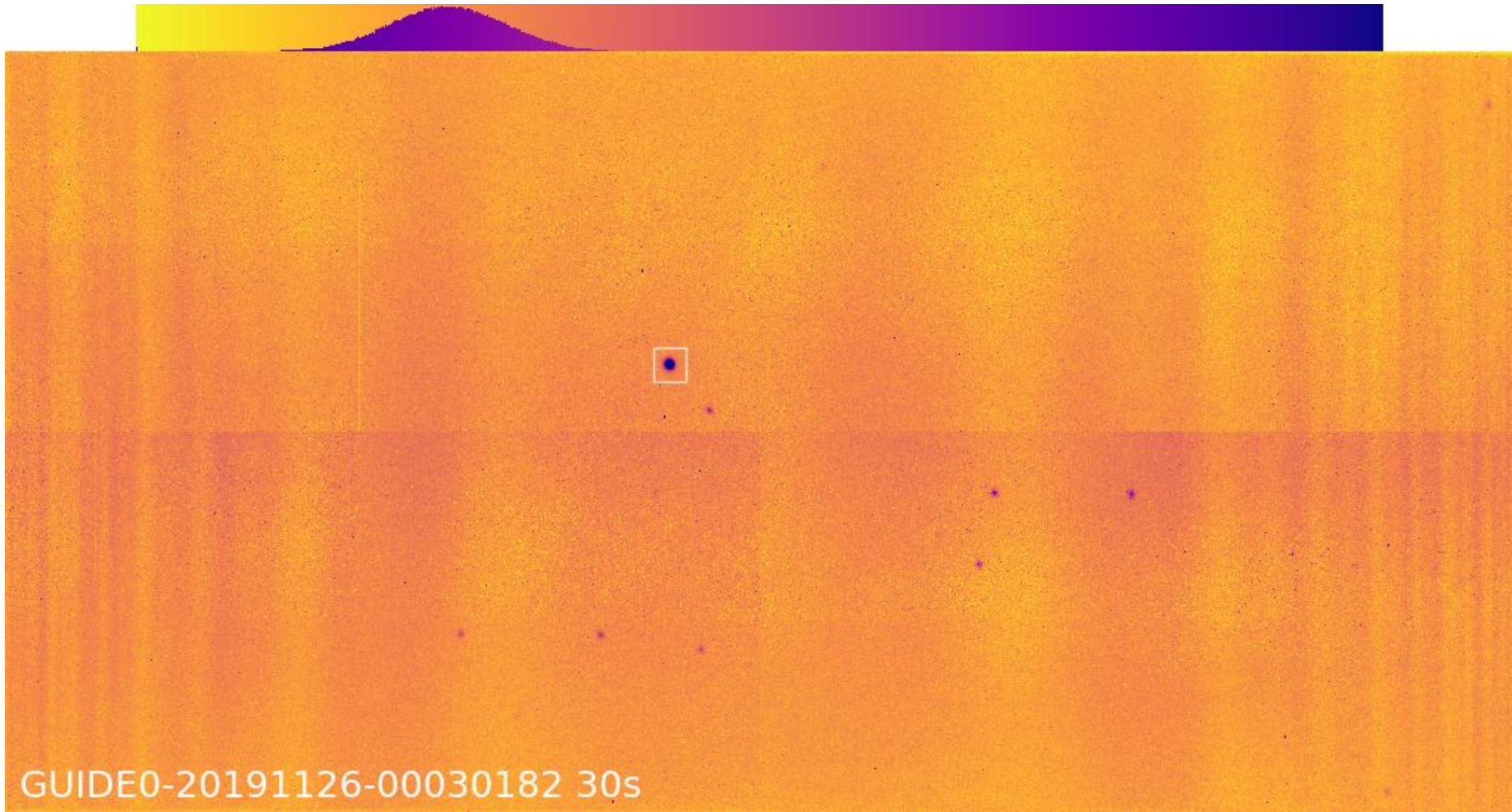David Kirkby

Gain variations

GUIDE0-20191126-00030182 30s

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Dust pinhole images

Out of focus dust in front of GFA acts a negative pinhole camera.
Introduces few % level variations in throughput:

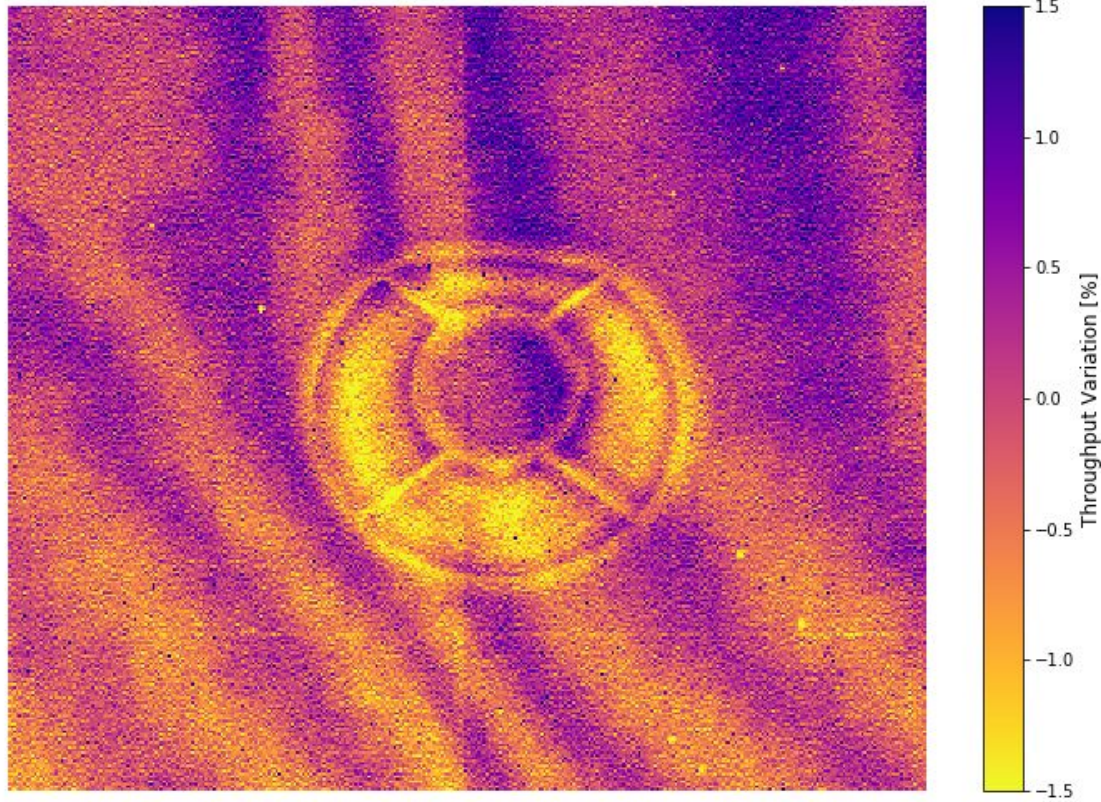**Dark Energy Spectroscopic Instrument**
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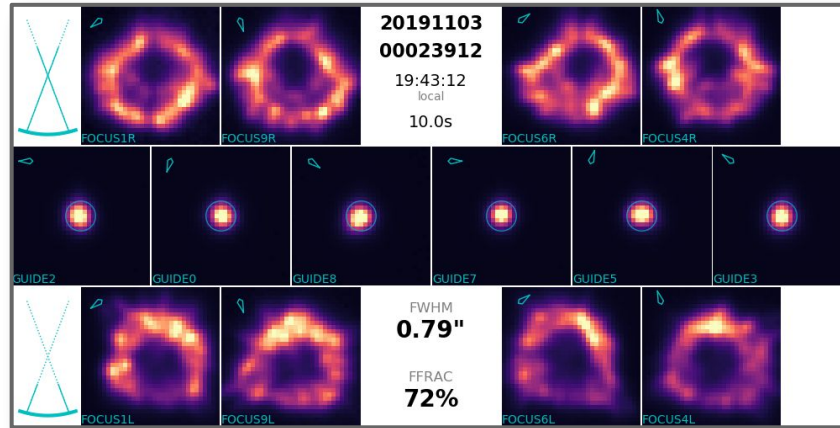# Next steps

Provide operator script to generate image quality diagnostic plot:

Run on all "GFA science" exposures to compile seeing statistics.

Add transparency and sky background estimates.

Adapt to guider cubes to track fiberloss fraction.

Plug into ICS ETC wrapper.

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