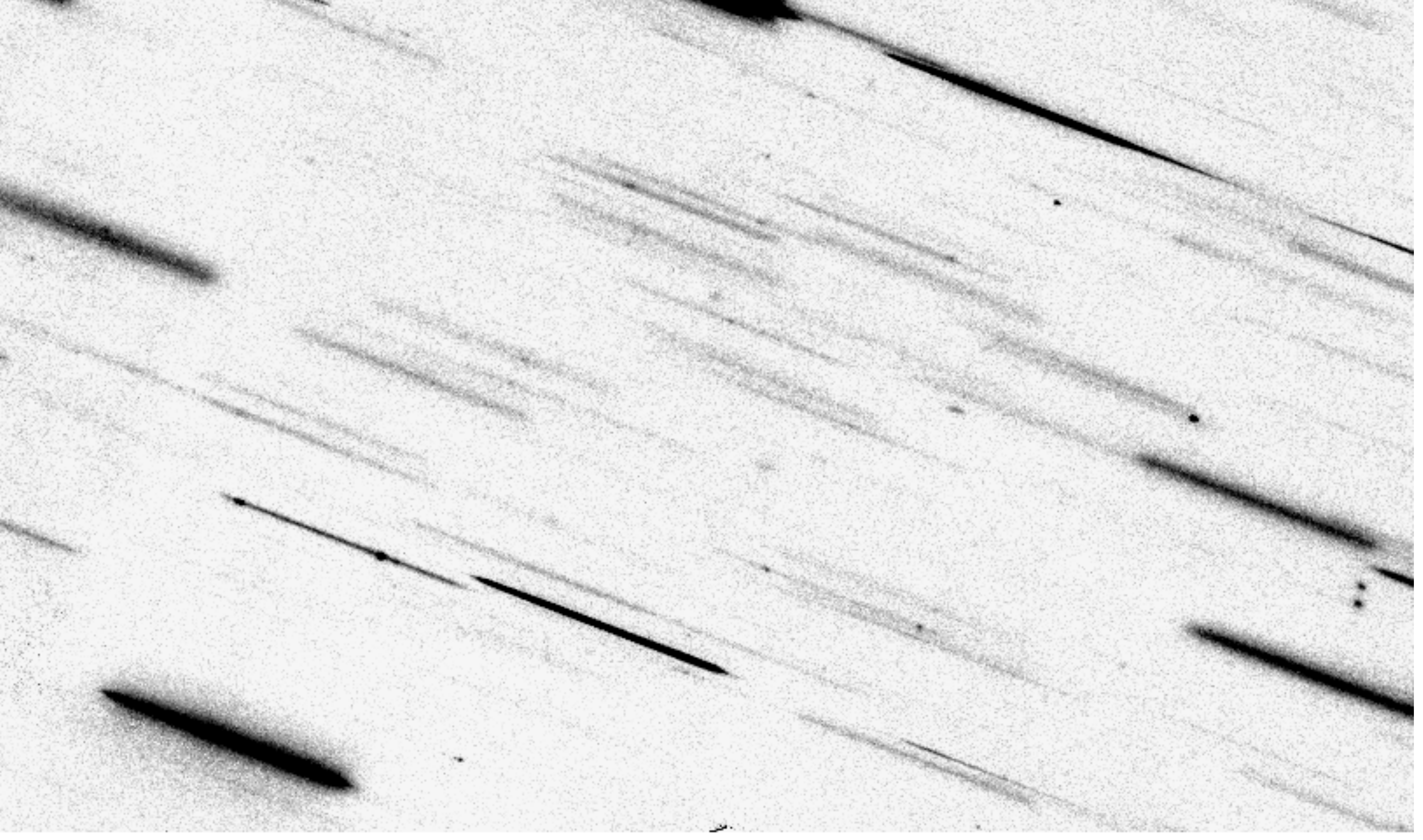
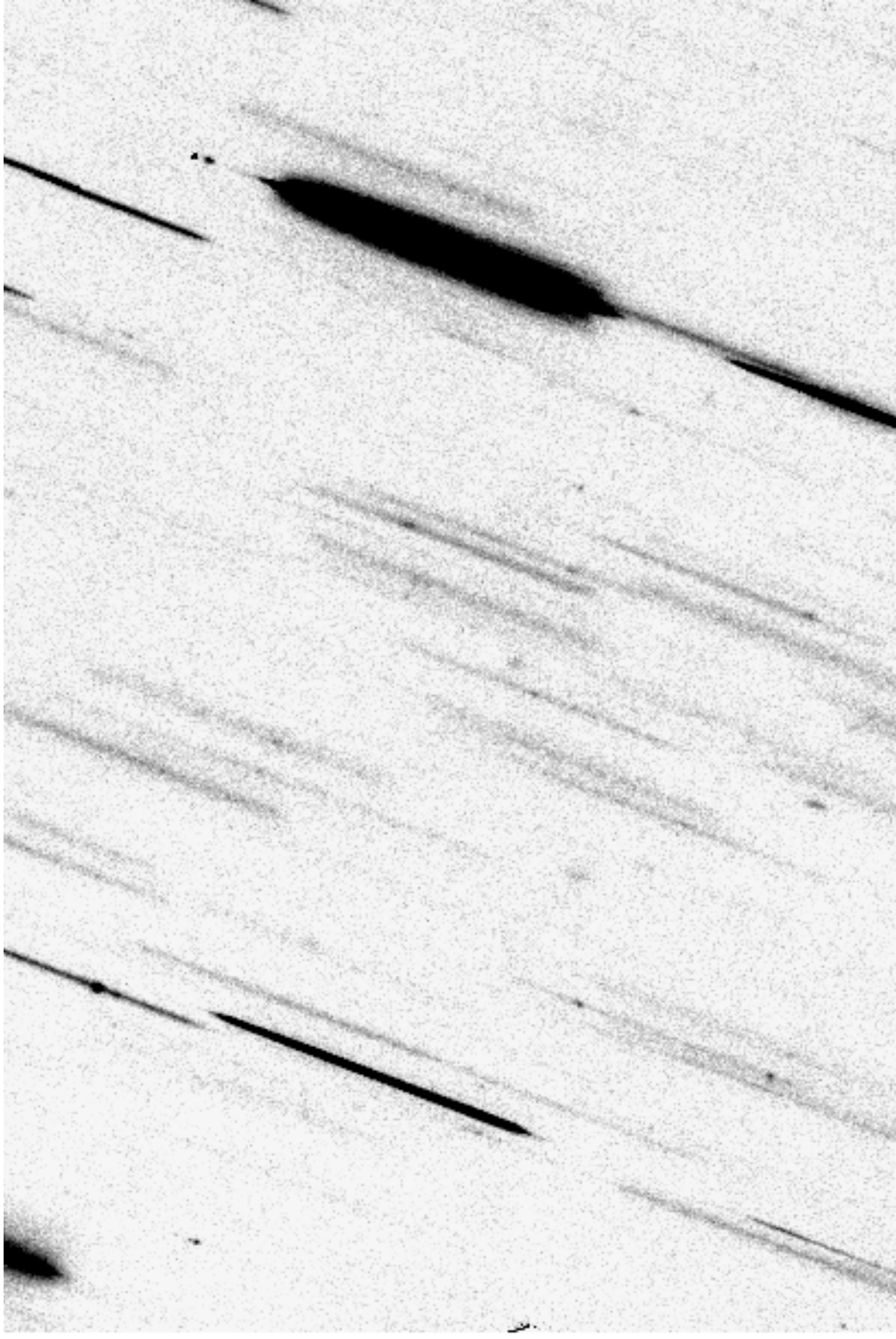


Grism Spectroscopy

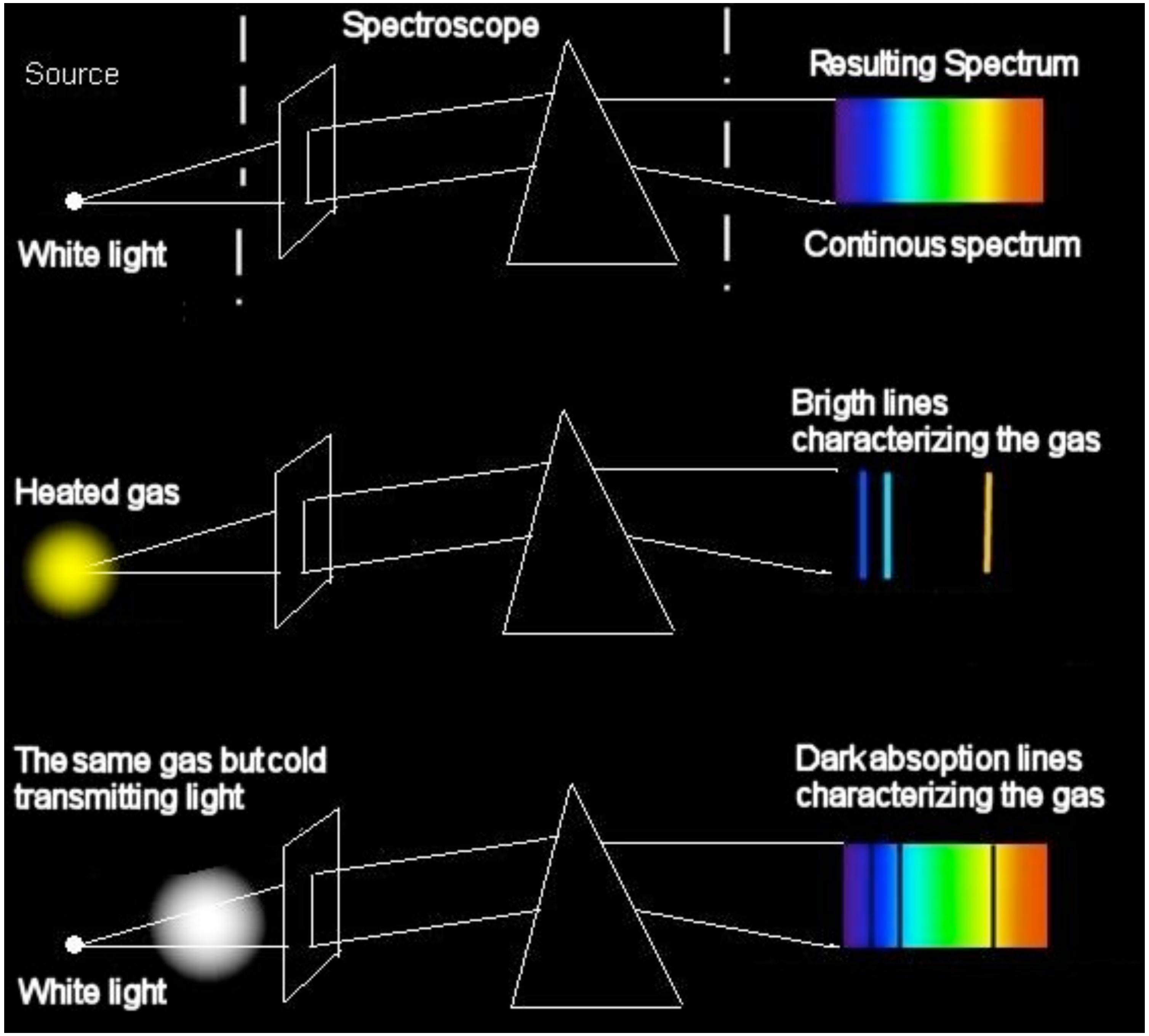
Iva Momcheva
Support Scientist, WFC3

Summary

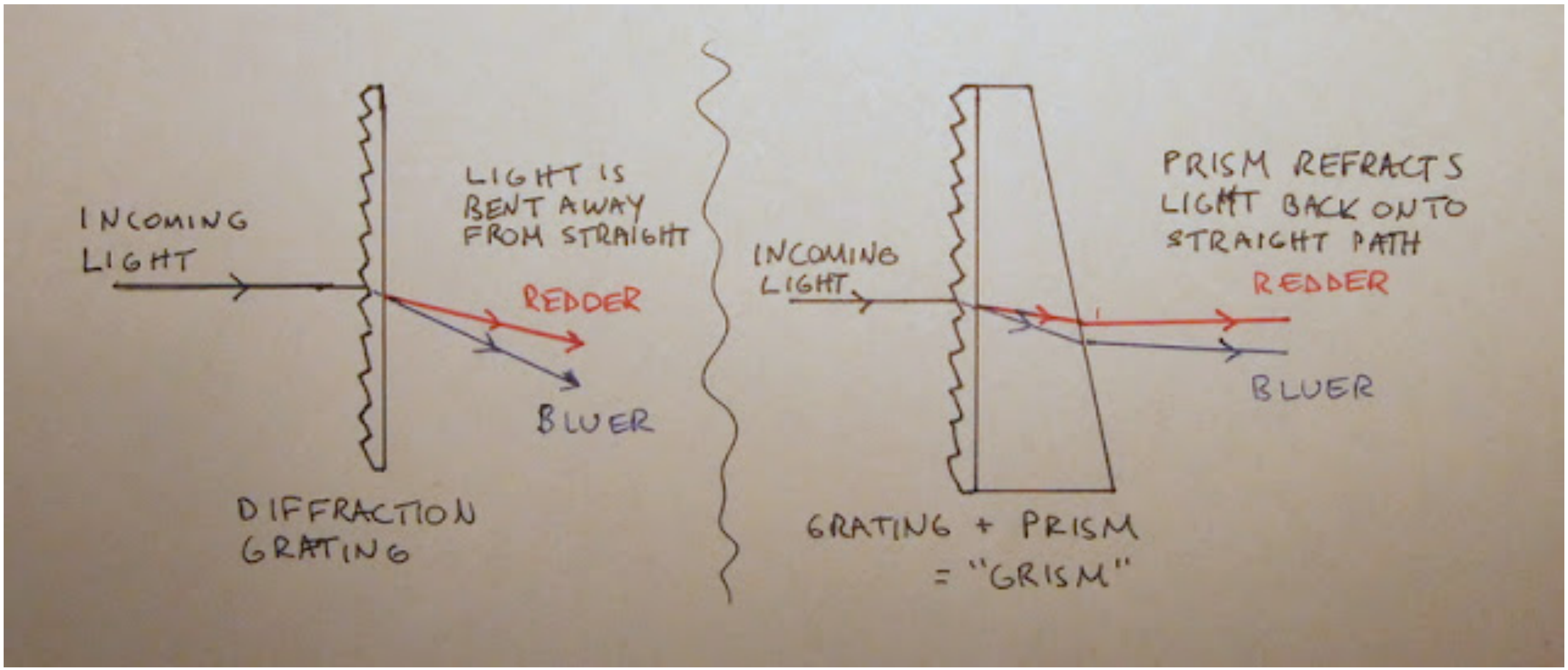
- What are grisms & how they work?
- HST & JWST capabilities
- Grism Tutorial



Basic Spectroscopy



How do grisms work?



- a combination of a prism and grating
- light at a chosen central wavelength passes straight through
- one and the same camera can be used both for imaging and spectroscopy
- grisms are inserted into a collimated beam

image courtesy of Benjamin Weiner

What is SLITLESS spectroscopy?

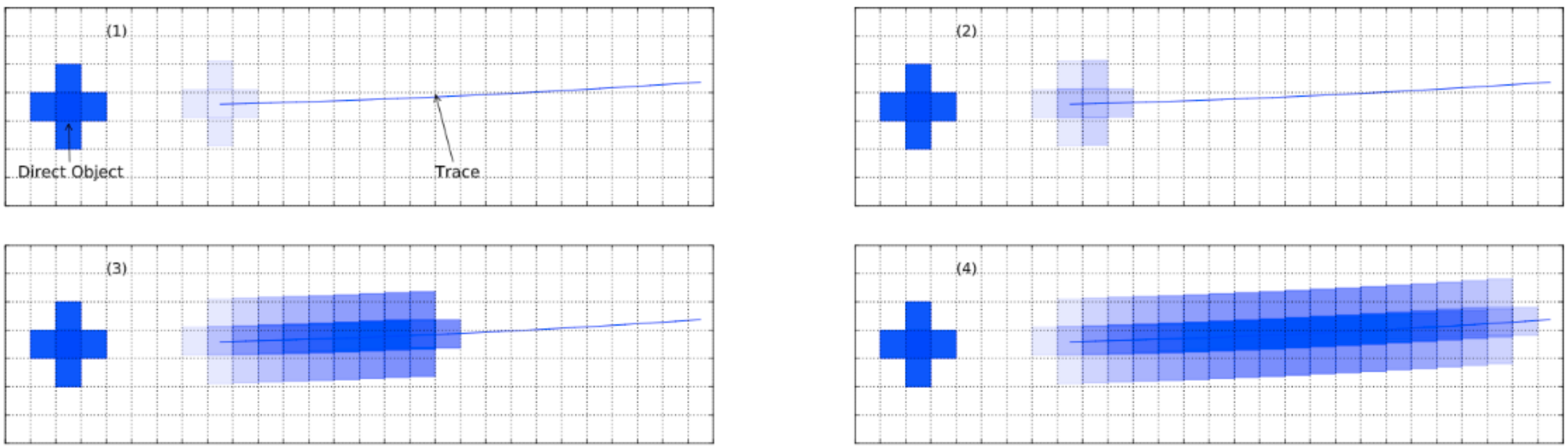


Fig. 3.— This example shows the process (Panels 1 through 4) of Object Based simulation, where the footprint of the object, shown on the left, is convolved with the spectral trace.

What is SLITLESS spectroscopy?

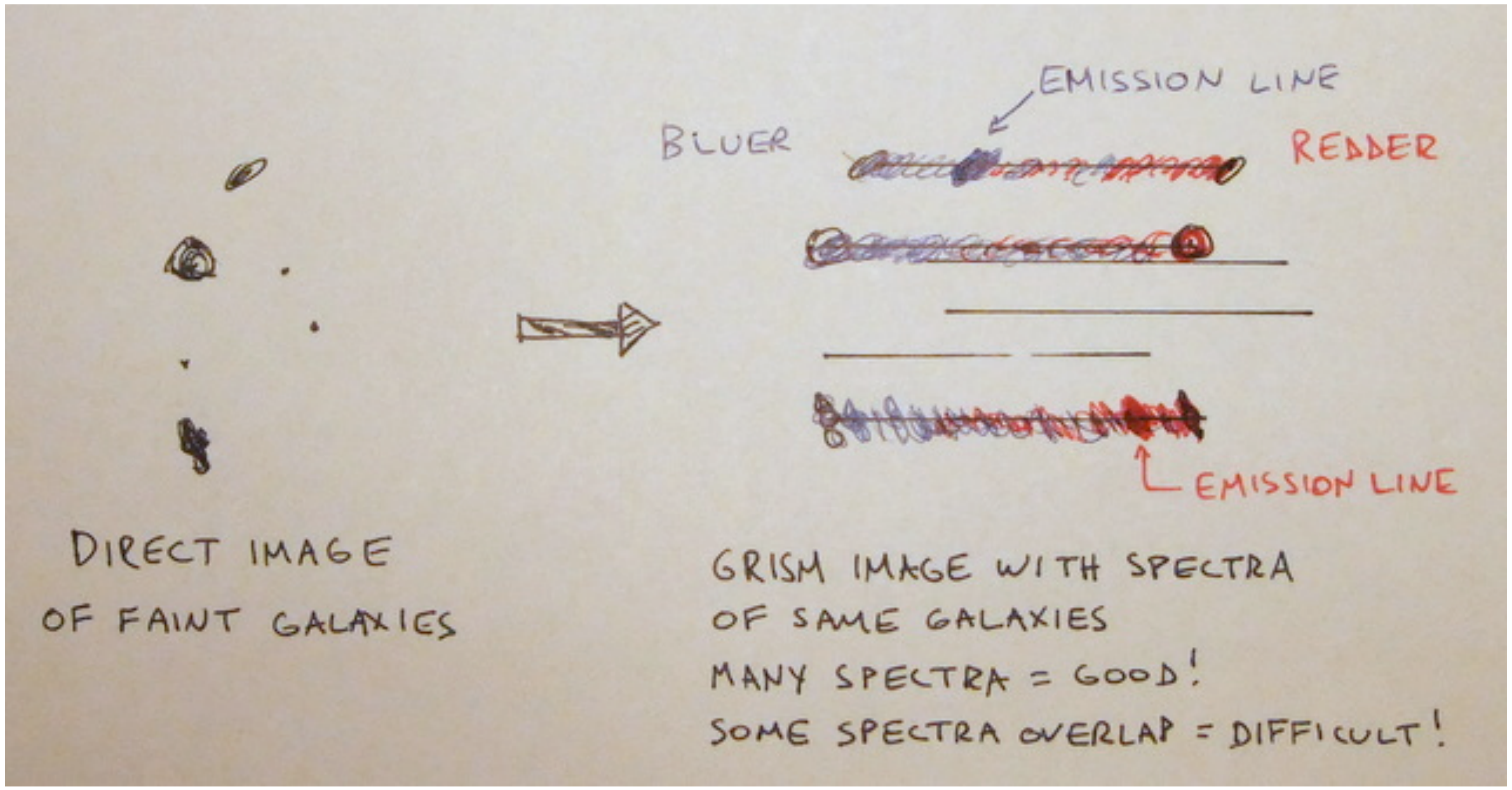
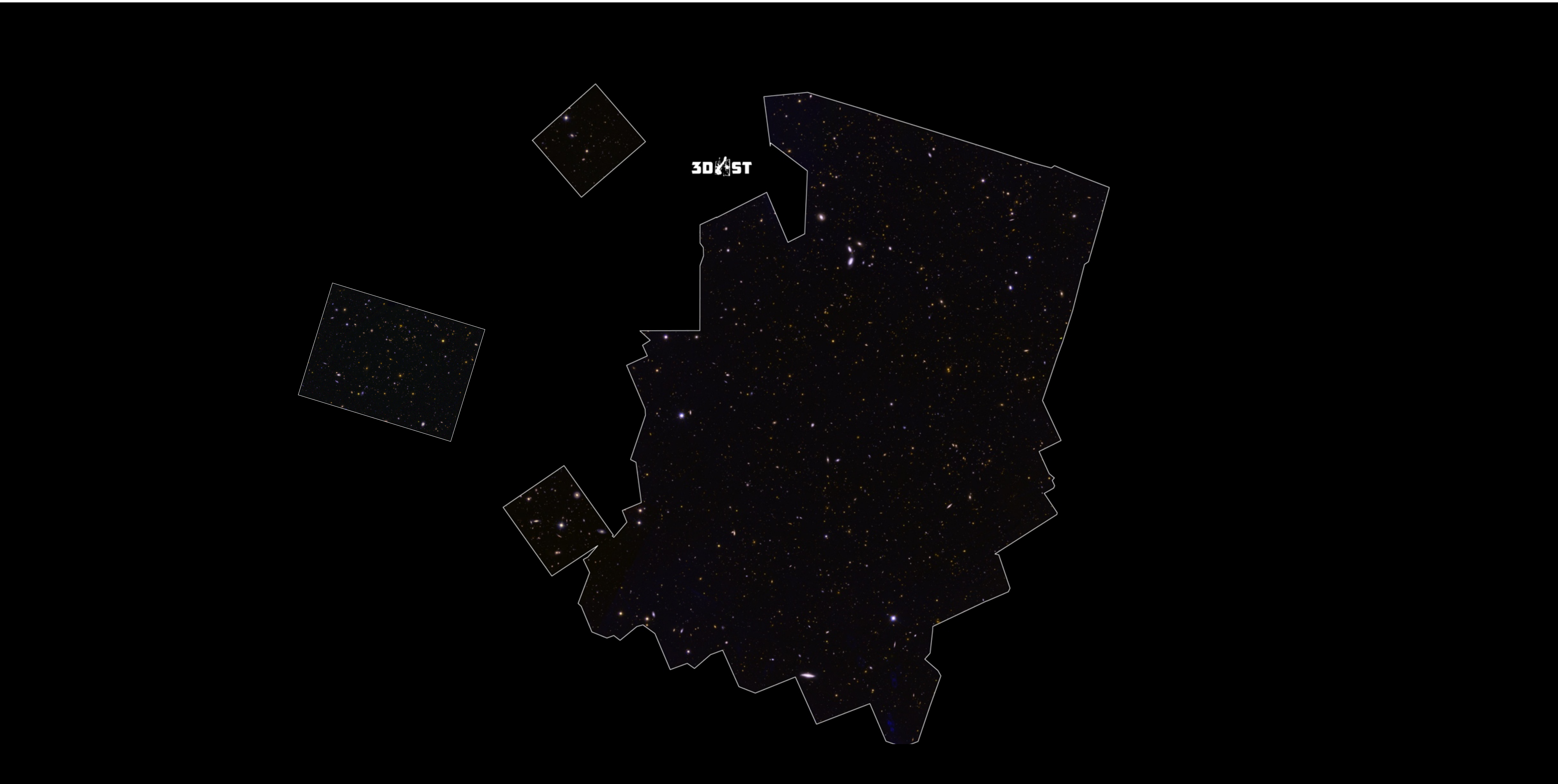
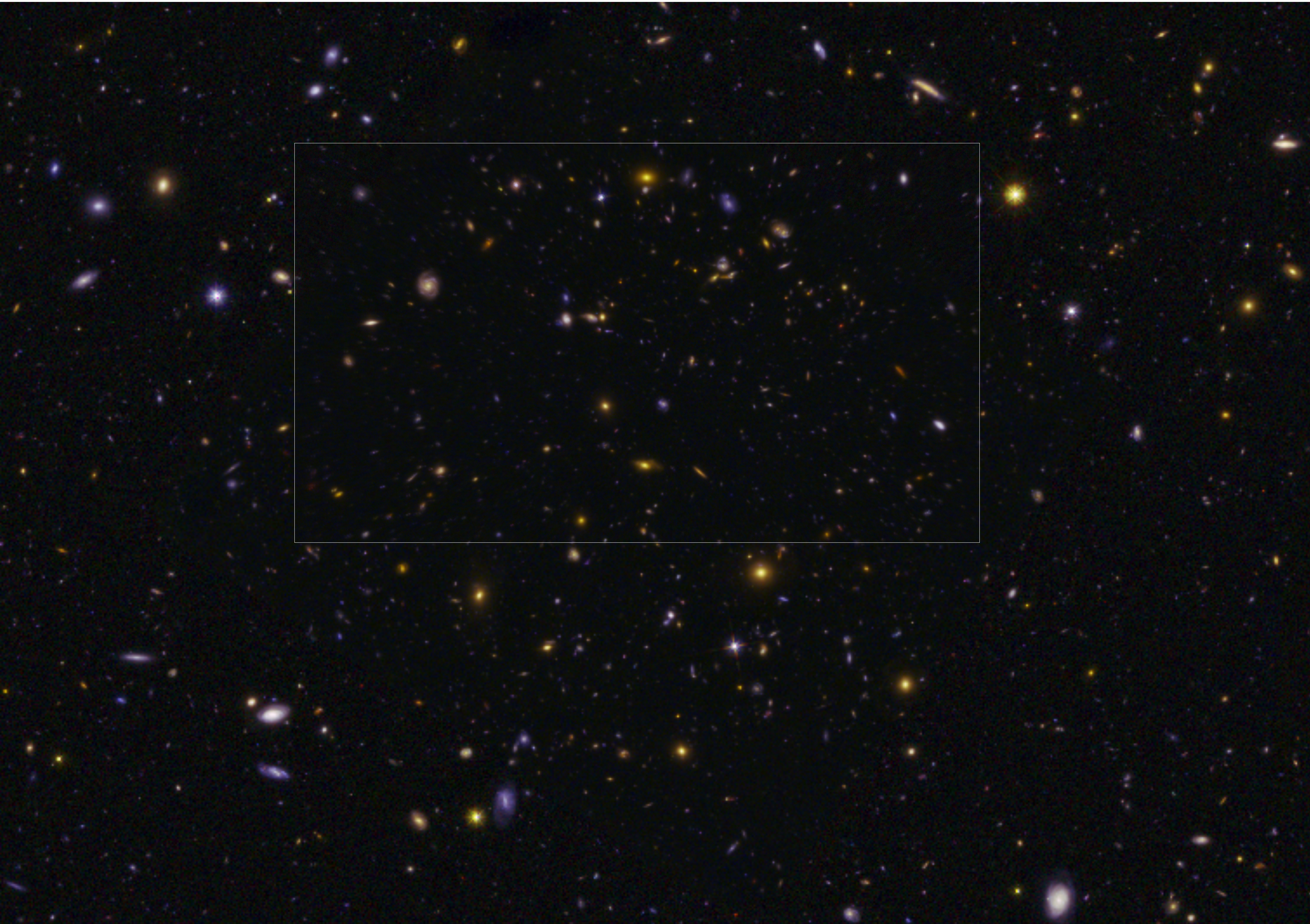


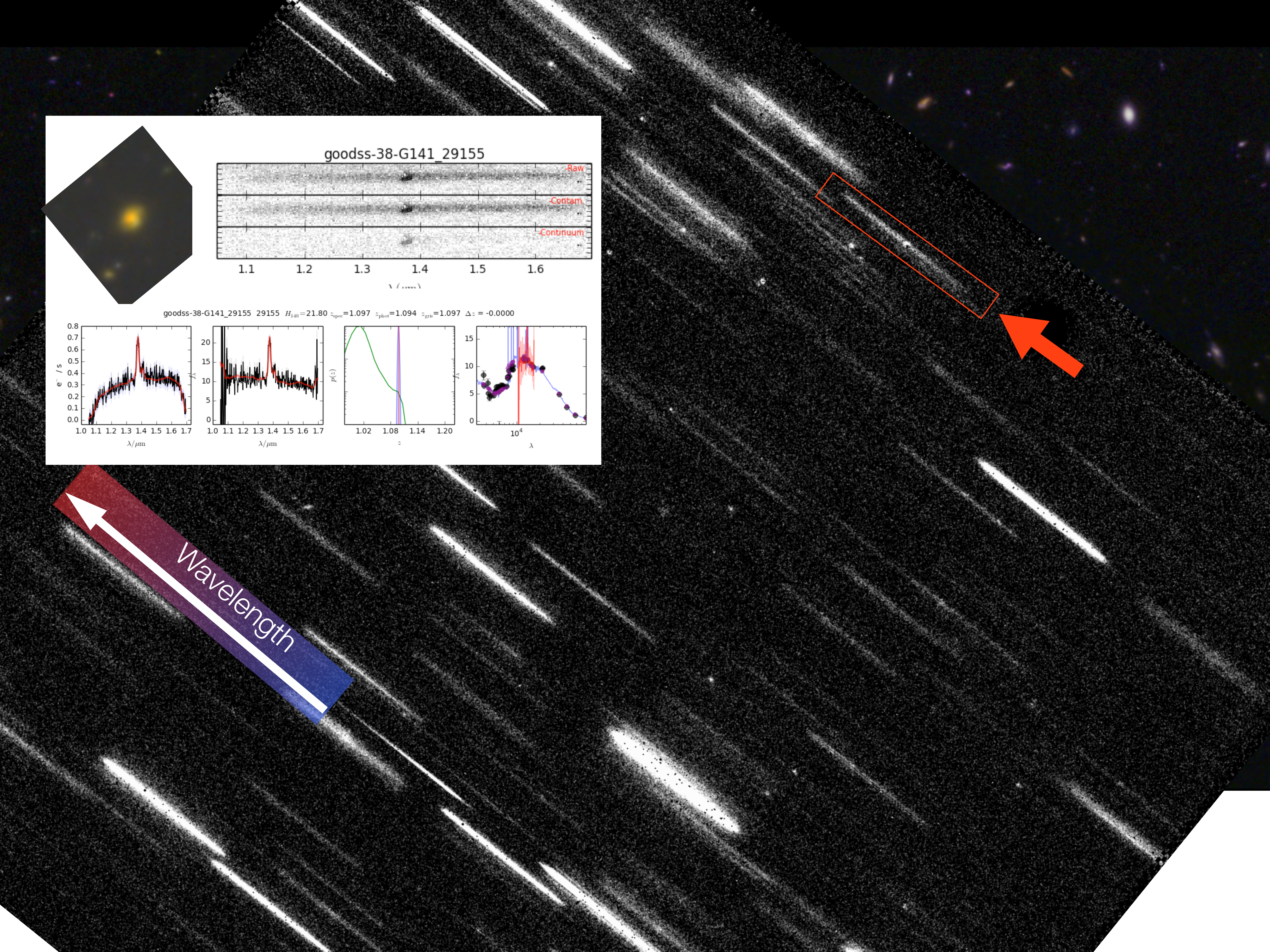
image courtesy of Benjamin Weiner



The 3D-HST Survey

Colors:
F814W(B)/F125W(G)/F160W(R)
3dhst.research.yale.edu





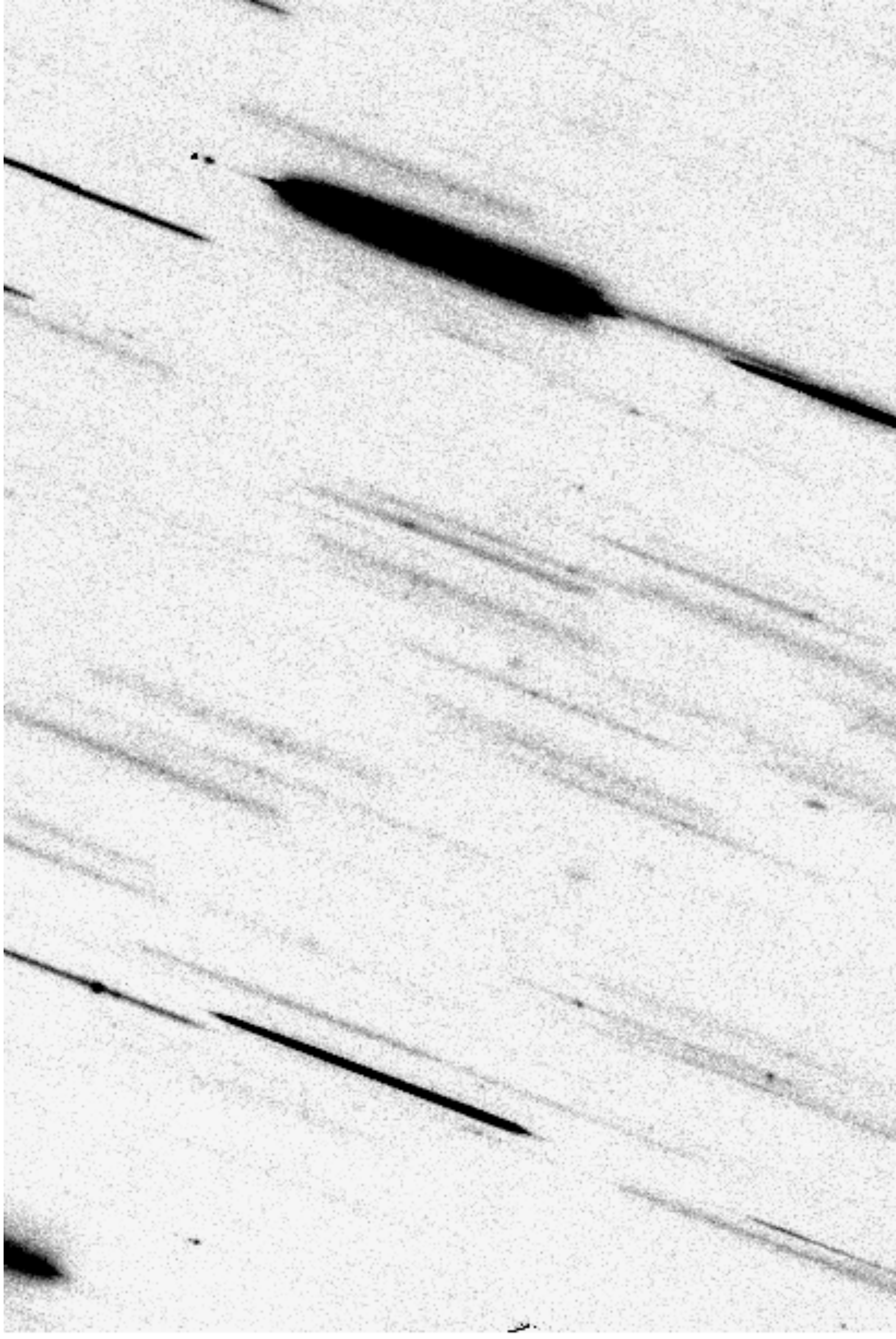
goodss-38-G141_29155
Raw
Contam
Continuum
1.1
1.2
1.3
1.4
1.5
1.6
goodss-38-G141_29155 29155 H_{140}=21.80 z_{spec}=1.097 z_{phot}=1.094 z_{gris}=1.097 Δz = -0.0000
$\lambda/\mu m$
$\lambda/\mu m$
$p(z)$
z
λ
10^4
Wavelength

Motivation: What are the grisms good for?

- Rest-frame optical @ $0.5 < z < 2.5$: high-z spectroscopic surveys
- Complete samples, high multiplexing : clusters of galaxies
- Spatially resolved emission lines: resolved emission line diagnostics
- Continuum sensitivity (low res): quiescent galaxies
- 10 x redshift accuracy over photometry: clustering, mergers
- Lots of great archival data (pst, 3D-HST just did a data dump: **http://3dhst.research.yale.edu**)
- Future grism capabilities: JWST/NIRISS, WFIRST, Euclid

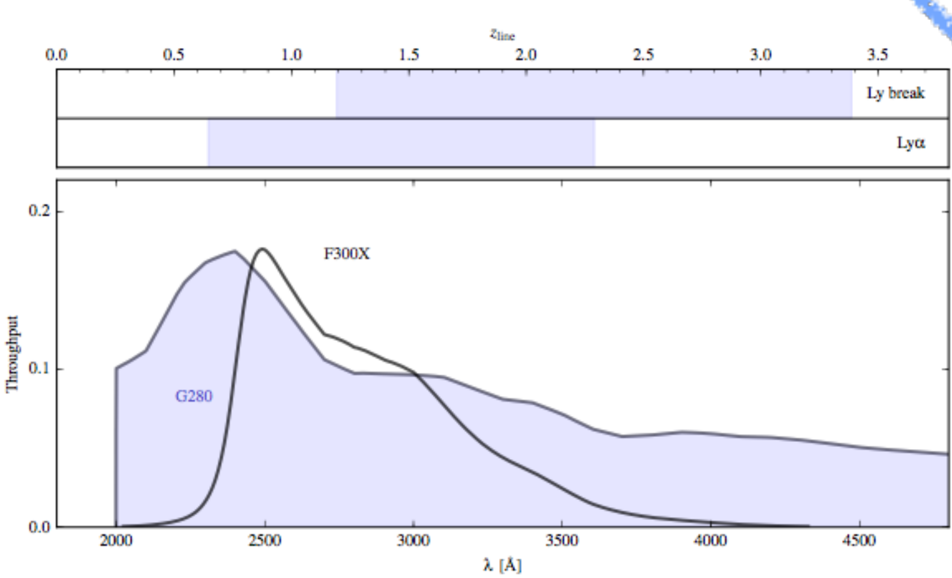
HST & JWST

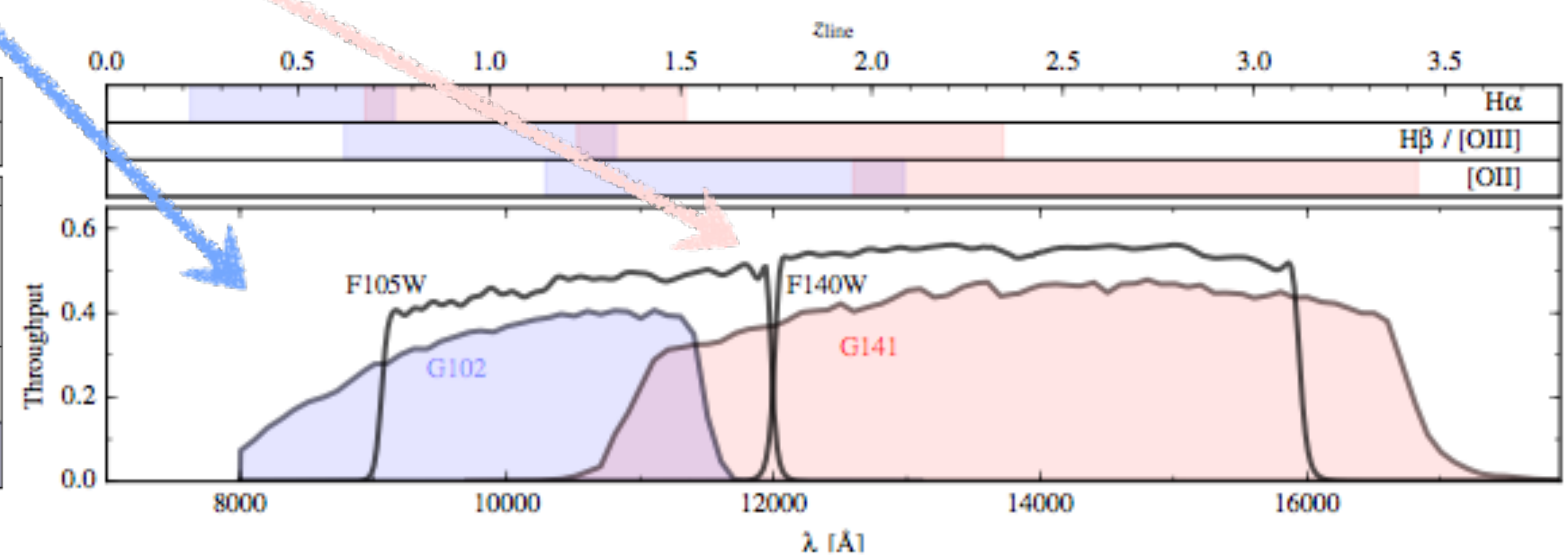
Capabilities



WFC3: Grism Spectroscopy

Grism	Channel	Wavelength range (nm)	Resolving power[1]	Dispersion (nm/pixel)	Tilt (deg)[2]
G280	UVIS	190–450	70 @ 300 nm	1.3	−3
G102	IR	800–1150	210 @ 1000 nm	2.45[3]	+0.7
G141	IR	1075–1700	130 @ 1400 nm	4.65[3]	+0.5





WFC3/IR - G102 & G141 Grism (zY, JH)

Grism	Channel	Wavelength range (nm)	Resolving power[1]	Dispersion (nm/pixel)	Tilt (deg)[2]
G280	UVIS	190–450	70 @ 300 nm	1.3	−3
G102	IR	800–1150	210 @ 1000 nm	2.45[3]	+0.7
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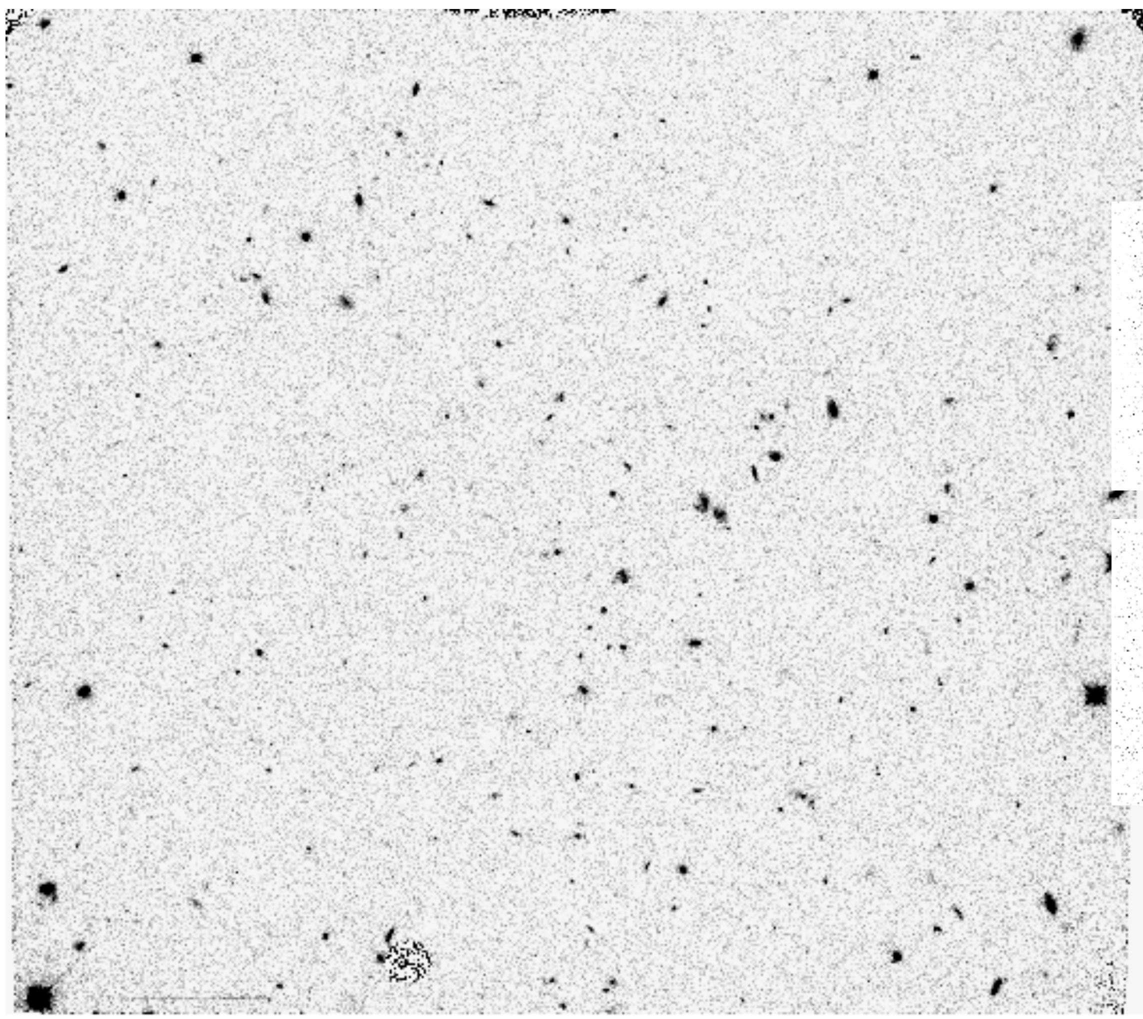
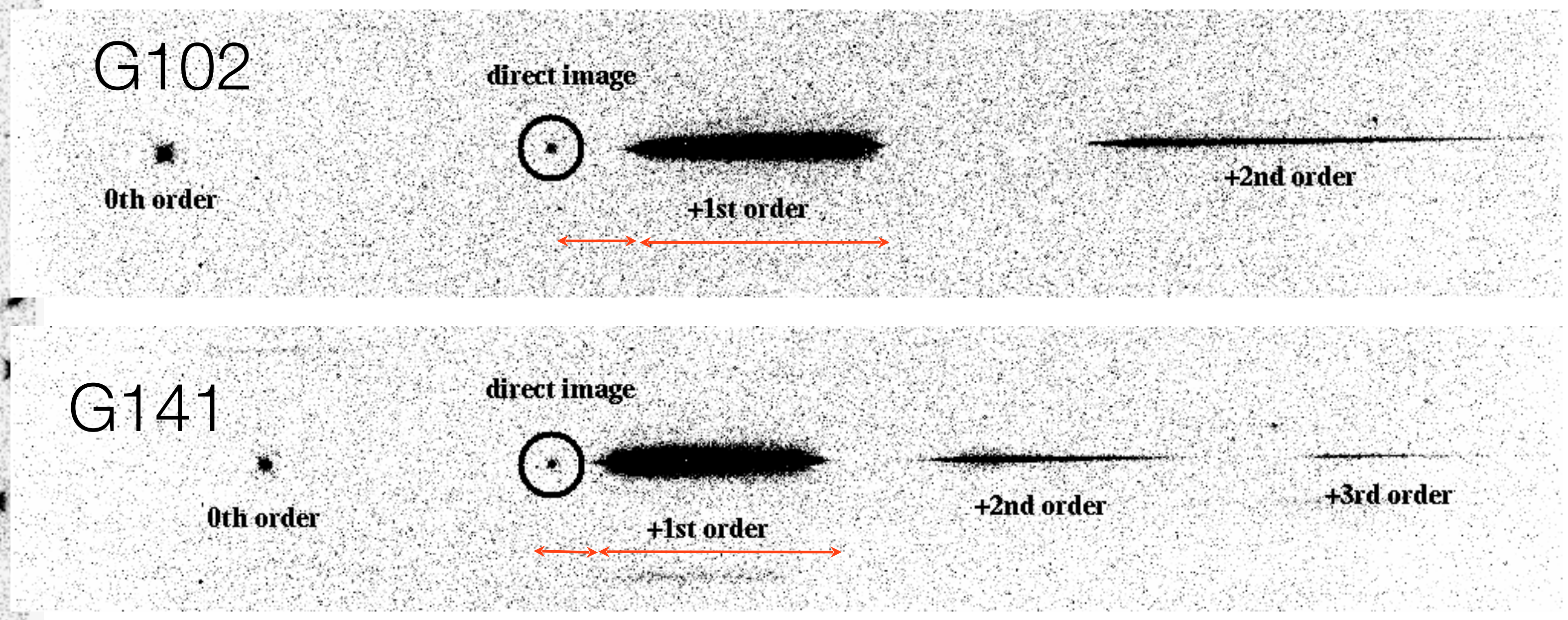
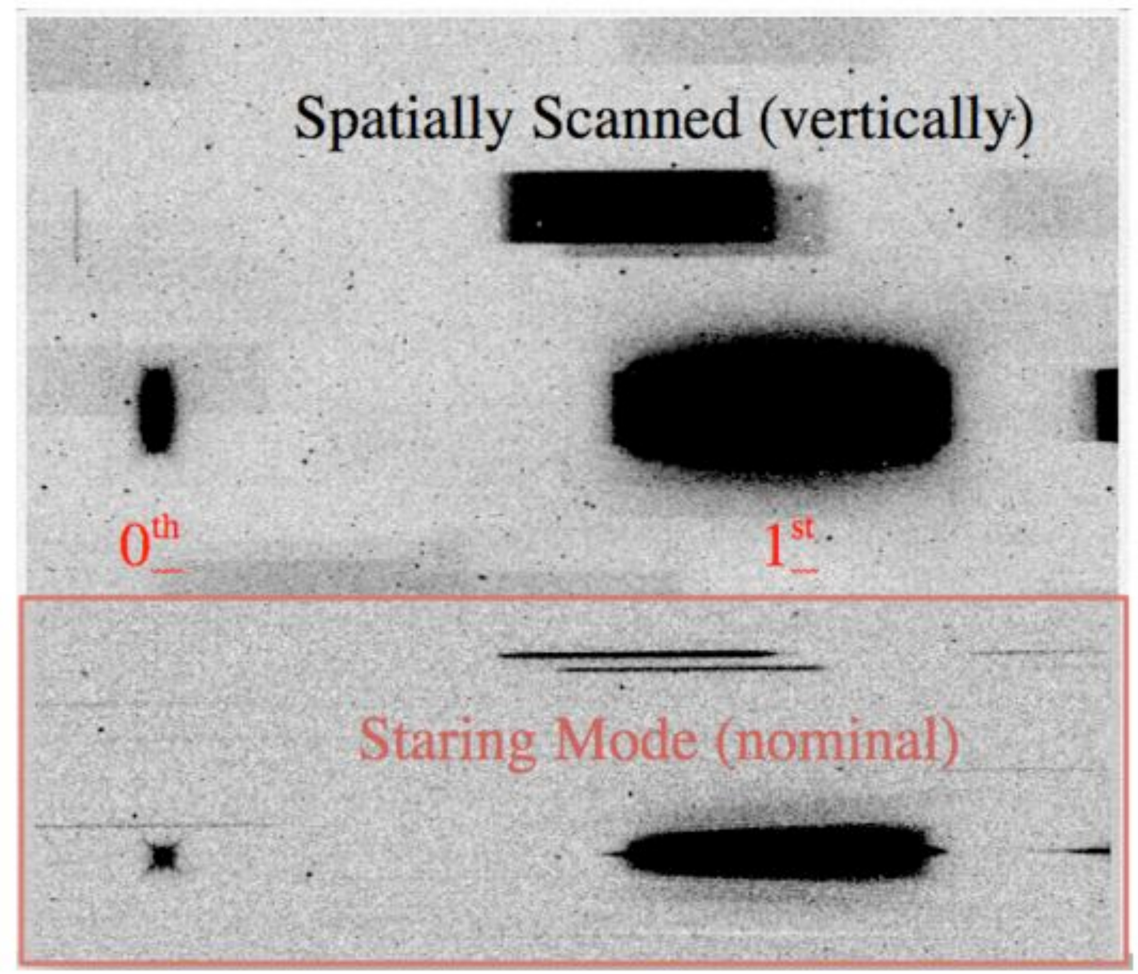




- Can use subarrays for fast readout
- Always dither!

WFC3/IR - Spatial Scanning Spectroscopy

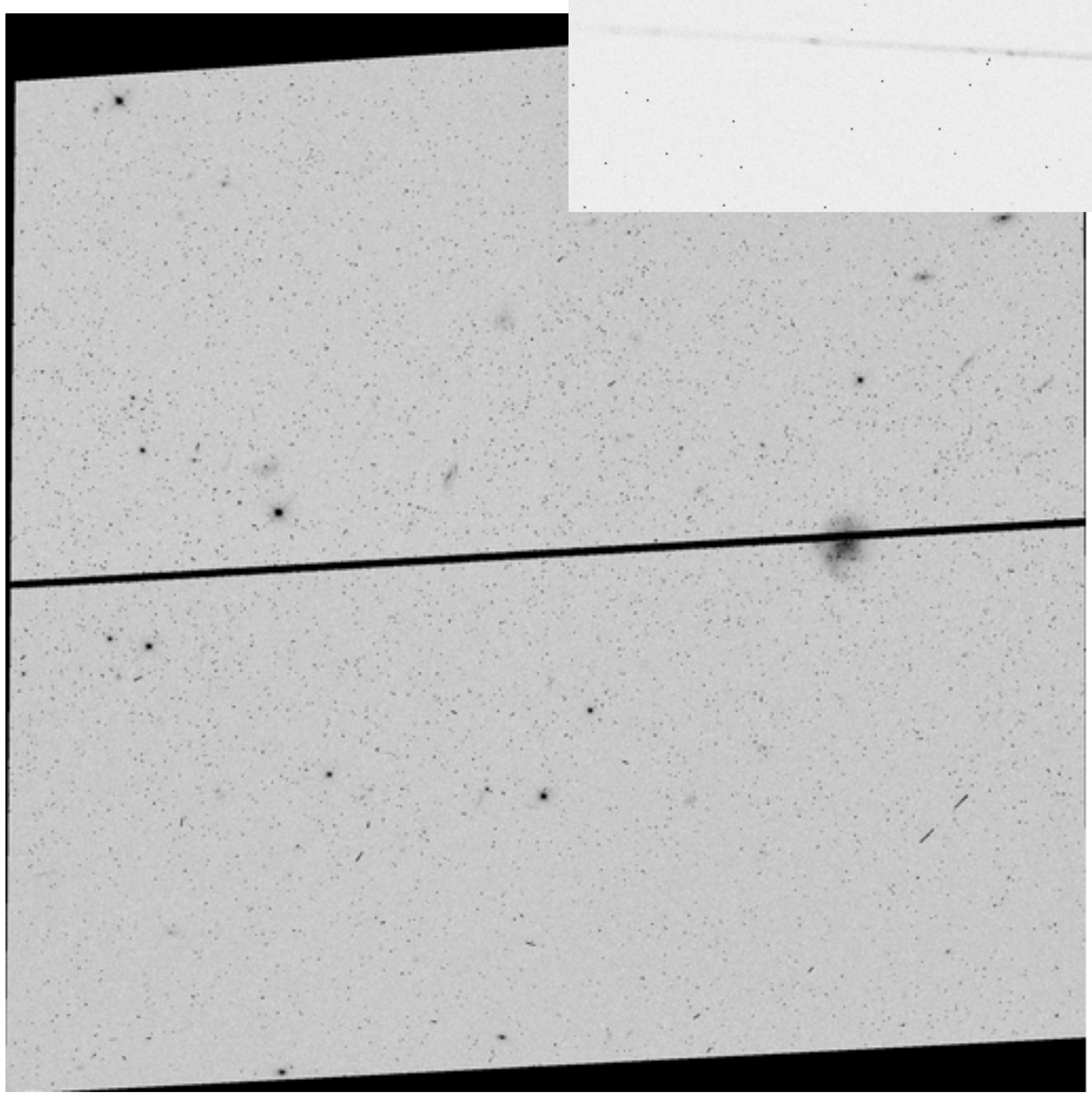
- Slew telescope during exposure to collect more photons without saturation
  - reduce overheads for time series with short exposures
  - can observe bright objects
  - better spectrophotometry (more photons)
- 0 to 4.8 arcsec per sec with FGS; up to 7.84 arcsec per sec in gyro mode (see WFC3 ISR 2012-08 for recommendations)
- Overlapping objects a greater issue

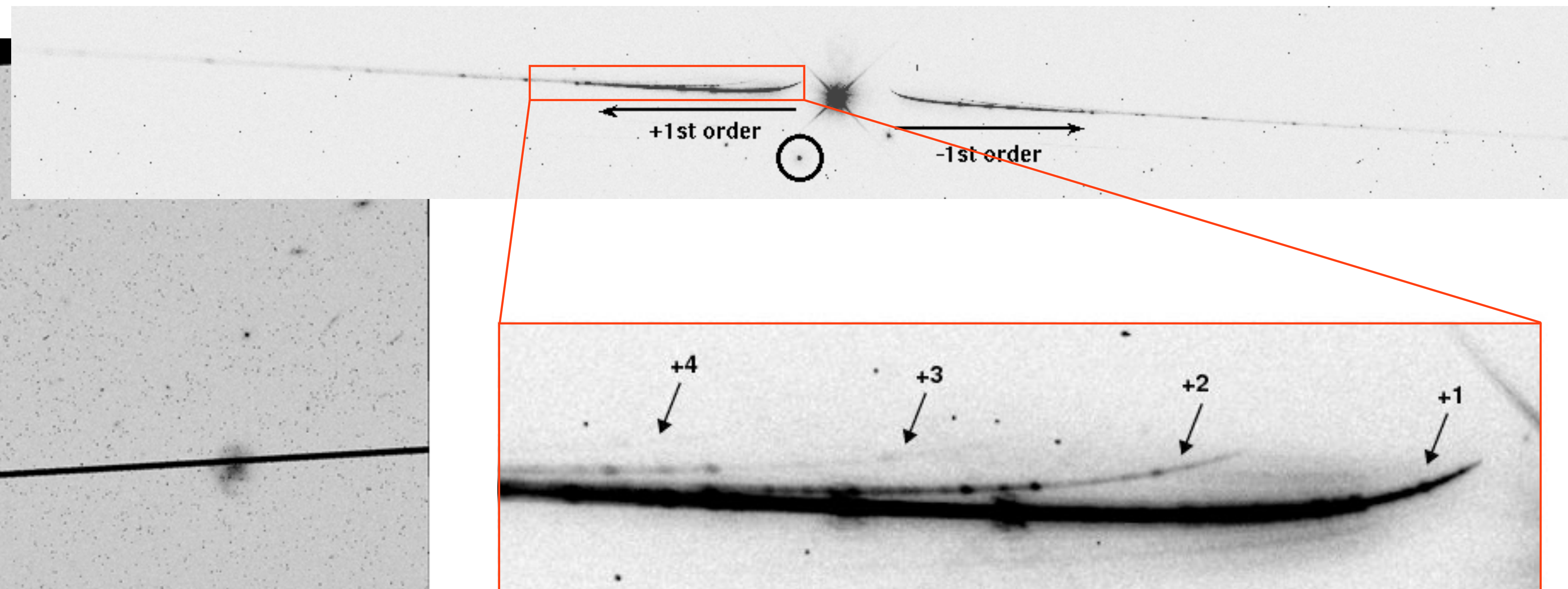


see Knutson et al. 2014,Kreidberg et al. 2014 and McCullough et al. 2014

WFC3/UV - G280 UV Grism

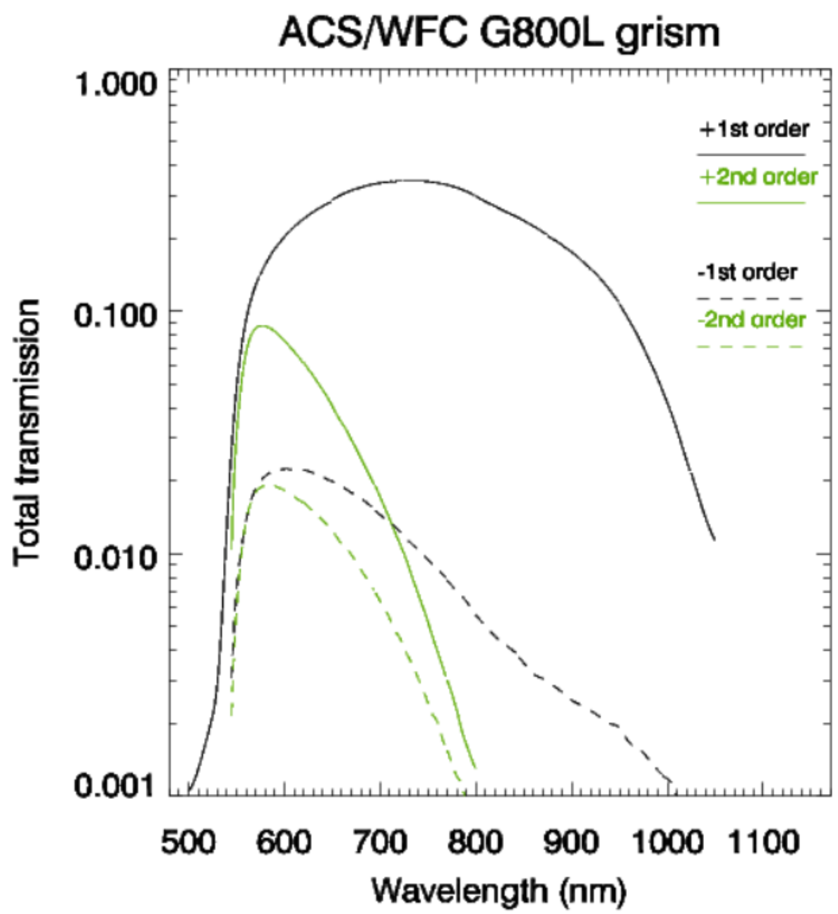
Grism	Channel	Wavelength range (nm)	Resolving power[1]	Dispersion (nm/pixel)	Tilt (deg)[2]
G280	UVIS	190–450	70 @ 300 nm	1.3	−3
G102	IR	800–1150	210 @ 1000 nm	2.45[3]	+0.7
G141	IR	1075–1700	130 @ 1400 nm	4.65[3]	+0.5



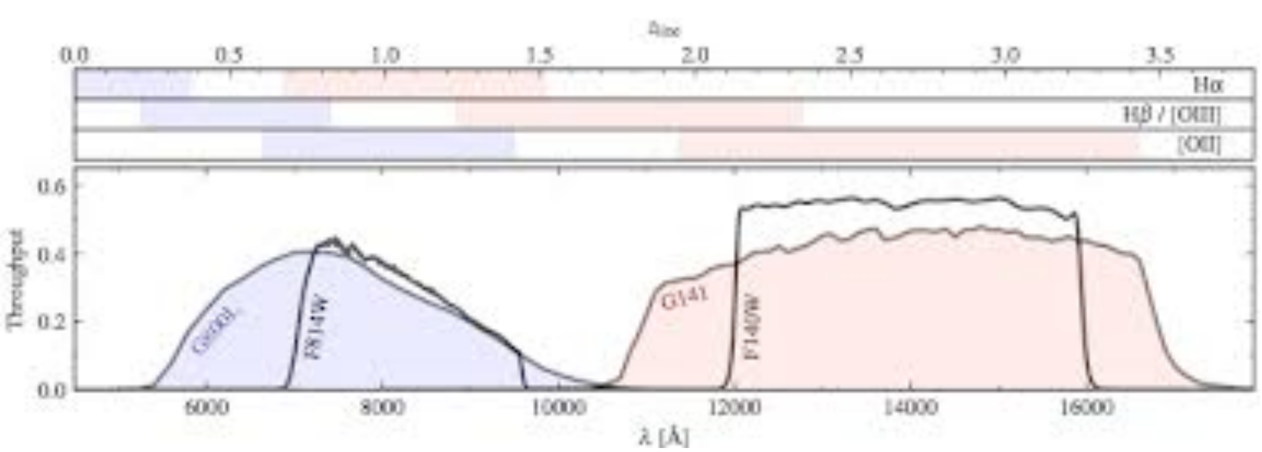


- Reference direct imaging: F300X or F200LP
- Dithering not recommended, use CR-SPLIT

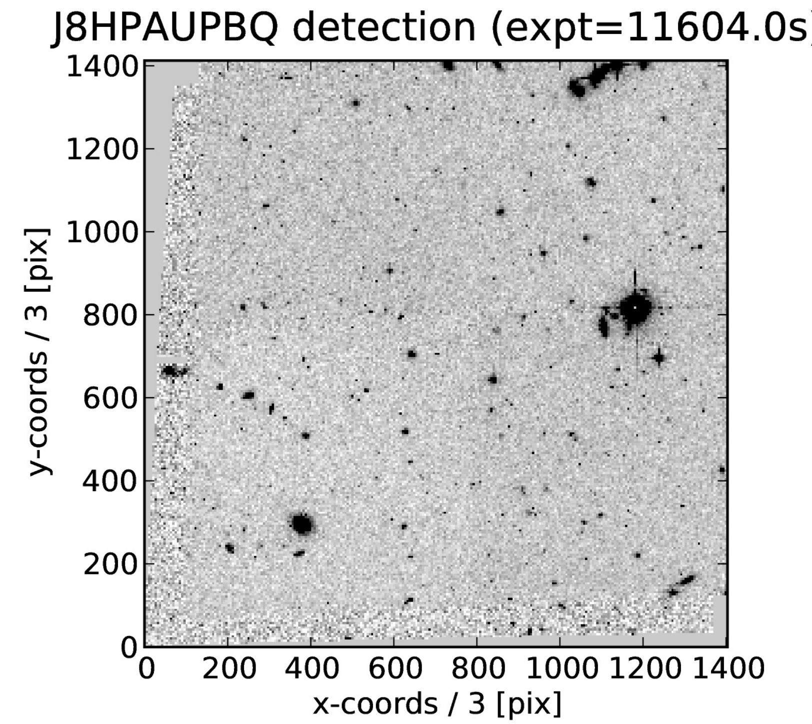
ACS - G800L



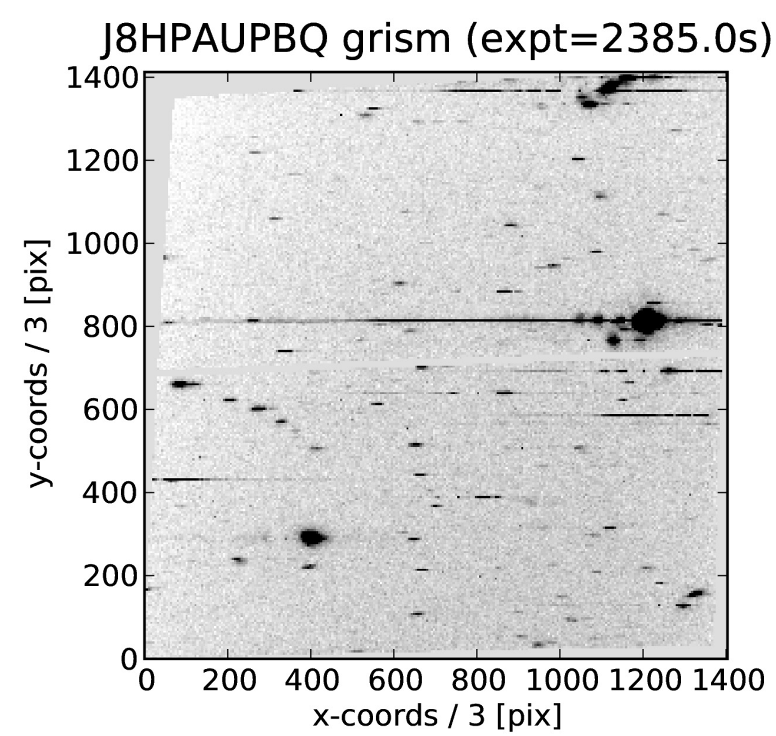
ACS/WFC G800L grism
+1st order
+2nd order
-1st order
-2nd order
Total transmission
1.000
0.100
0.010
0.001
500
600
700
800
900
1000
1100
Wavelength (nm)



Hα
Hβ / [OIII]
[OII]
Throughput
G800L
F814W
G141
F140W
6000
8000
10000
12000
14000
16000
λ [Å]

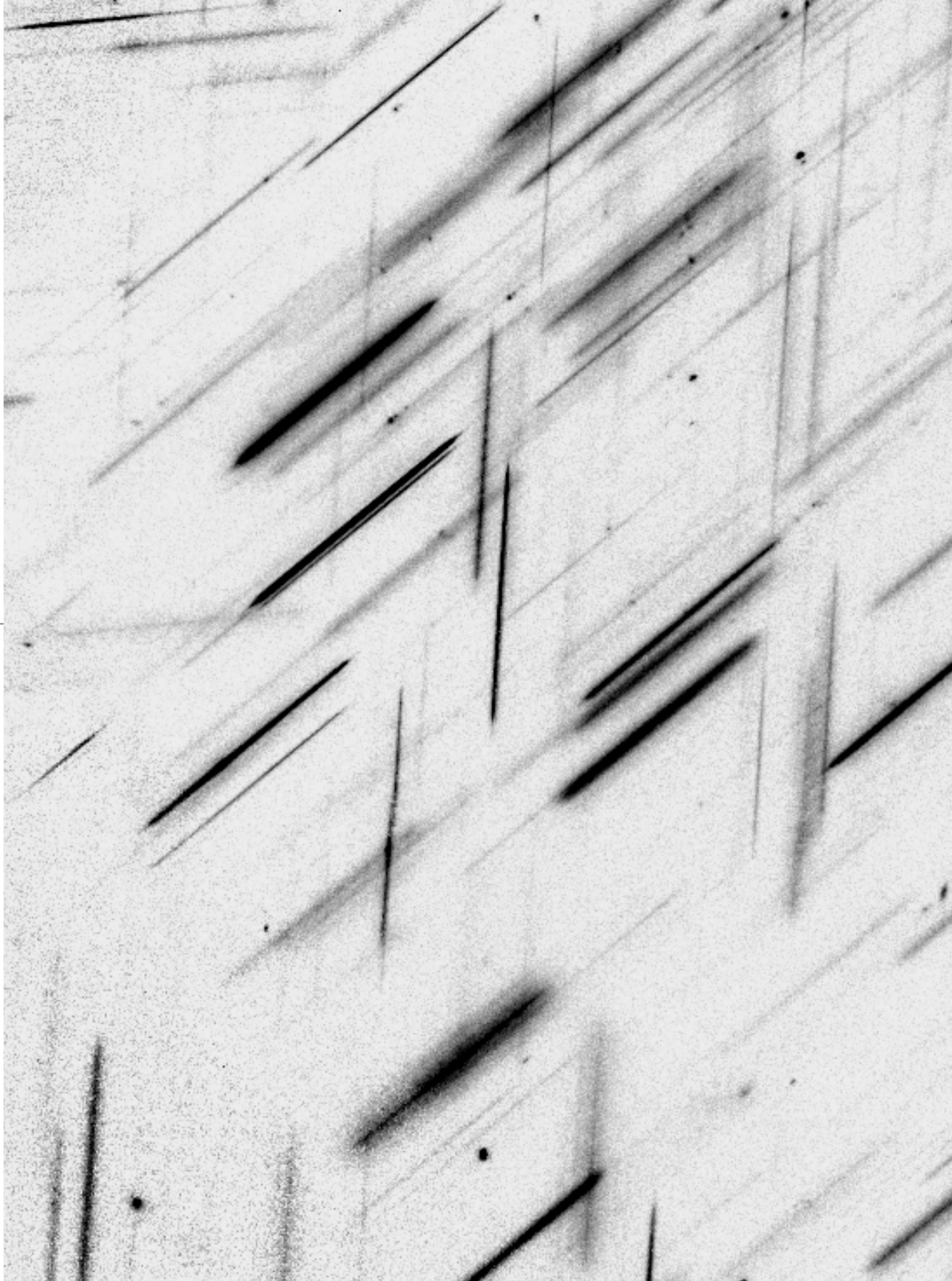


J8HPAUPBQ detection (expt=11604.0s)
y-coords / 3 [pix]
x-coords / 3 [pix]
0
200
400
600
800
1000
1200
1400

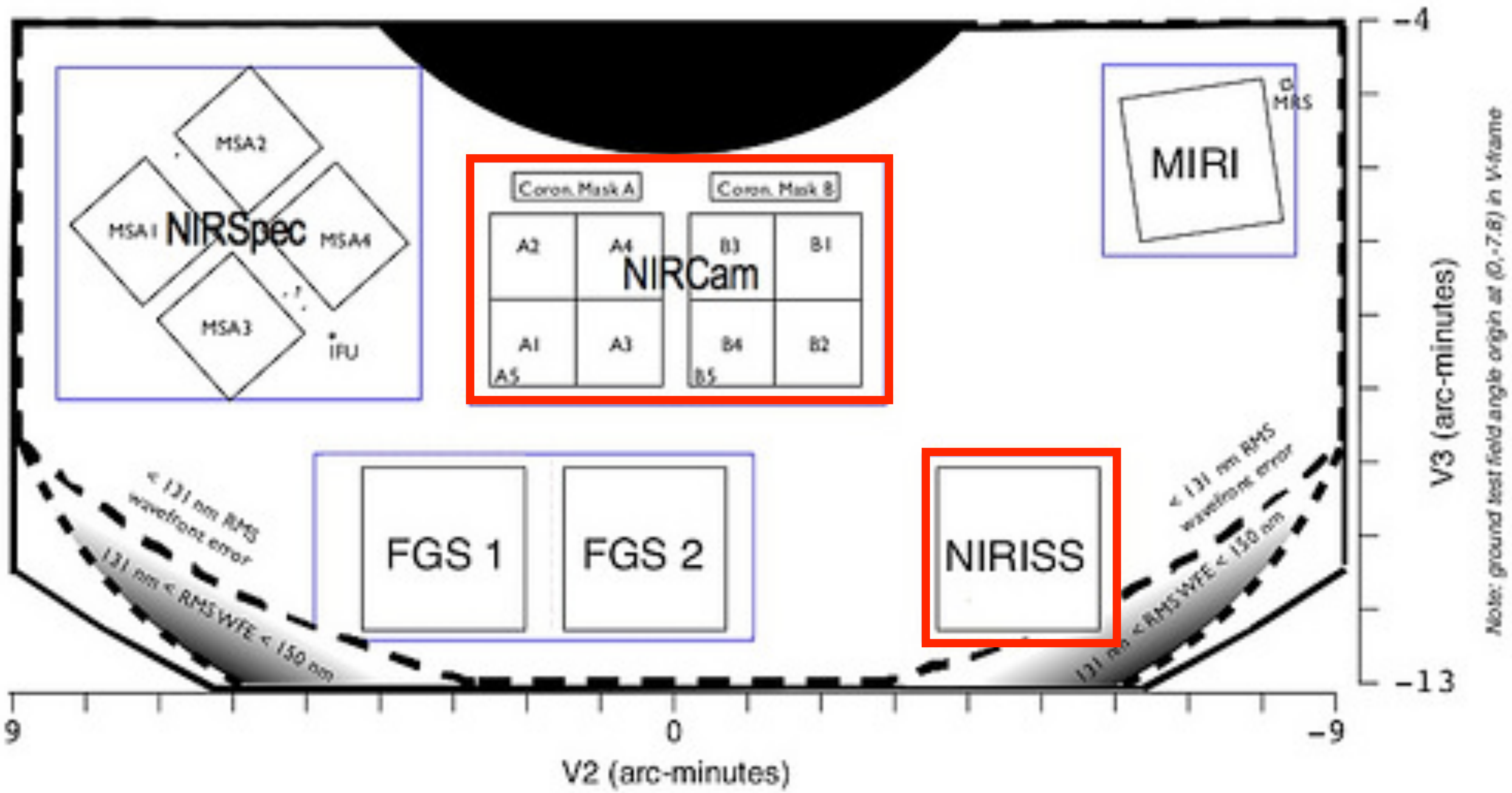


J8HPAUPBQ grism (expt=2385.0s)
y-coords / 3 [pix]
x-coords / 3 [pix]
0
200
400
600
800
1000
1200
1400

Future Prospects



New capabilities with slitless spectroscopy: JWST

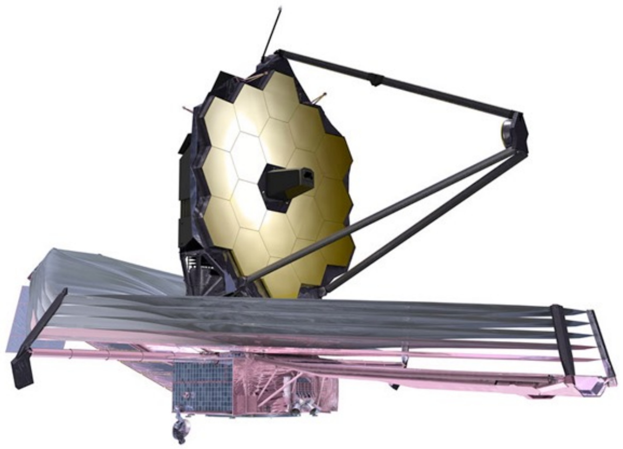


Capabilities science capabilities with dramatic improvements in:

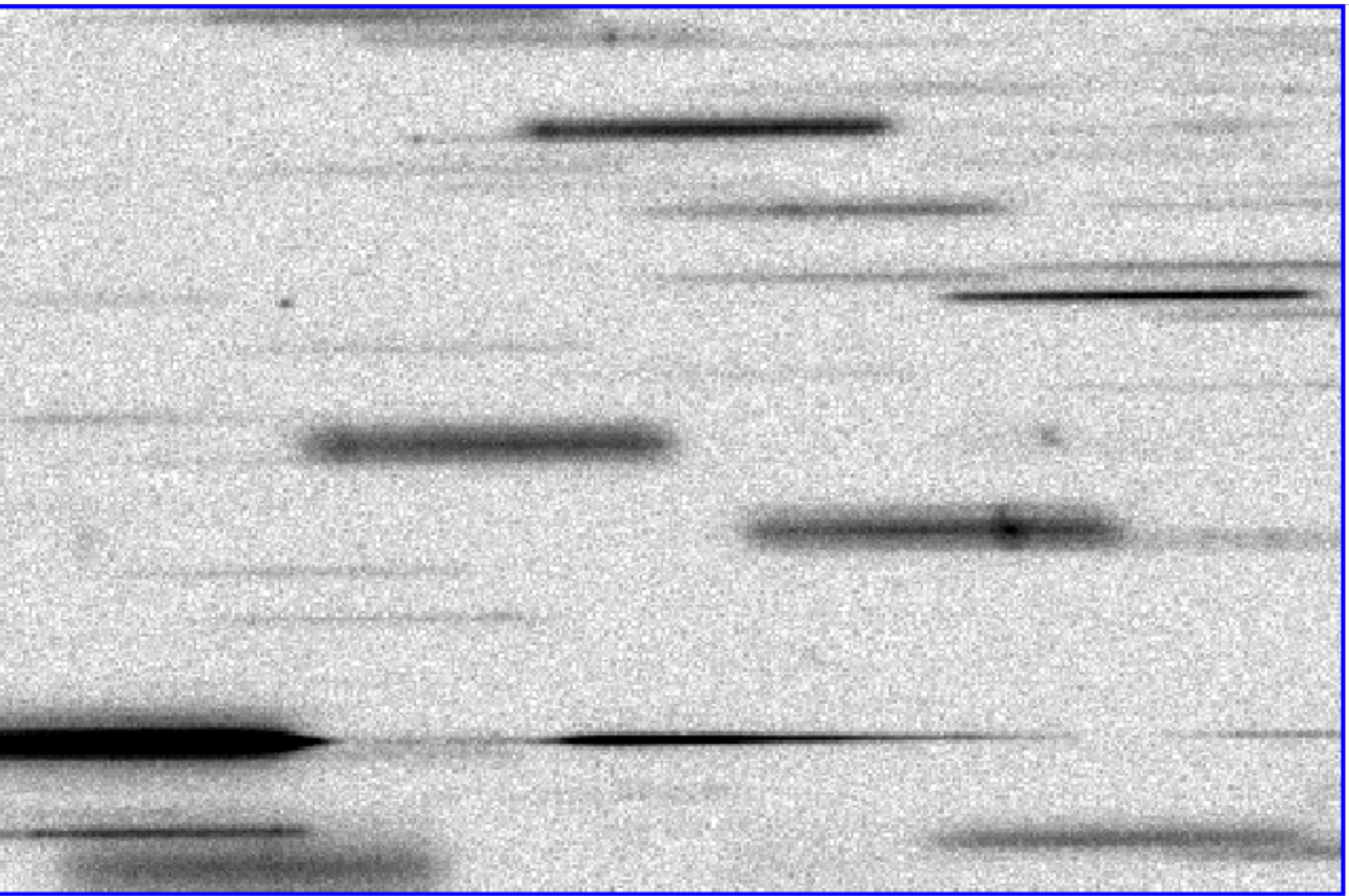
- Sensitivity
- Resolution
- Bandpass

New capabilities with slitless spectroscopy: JWST

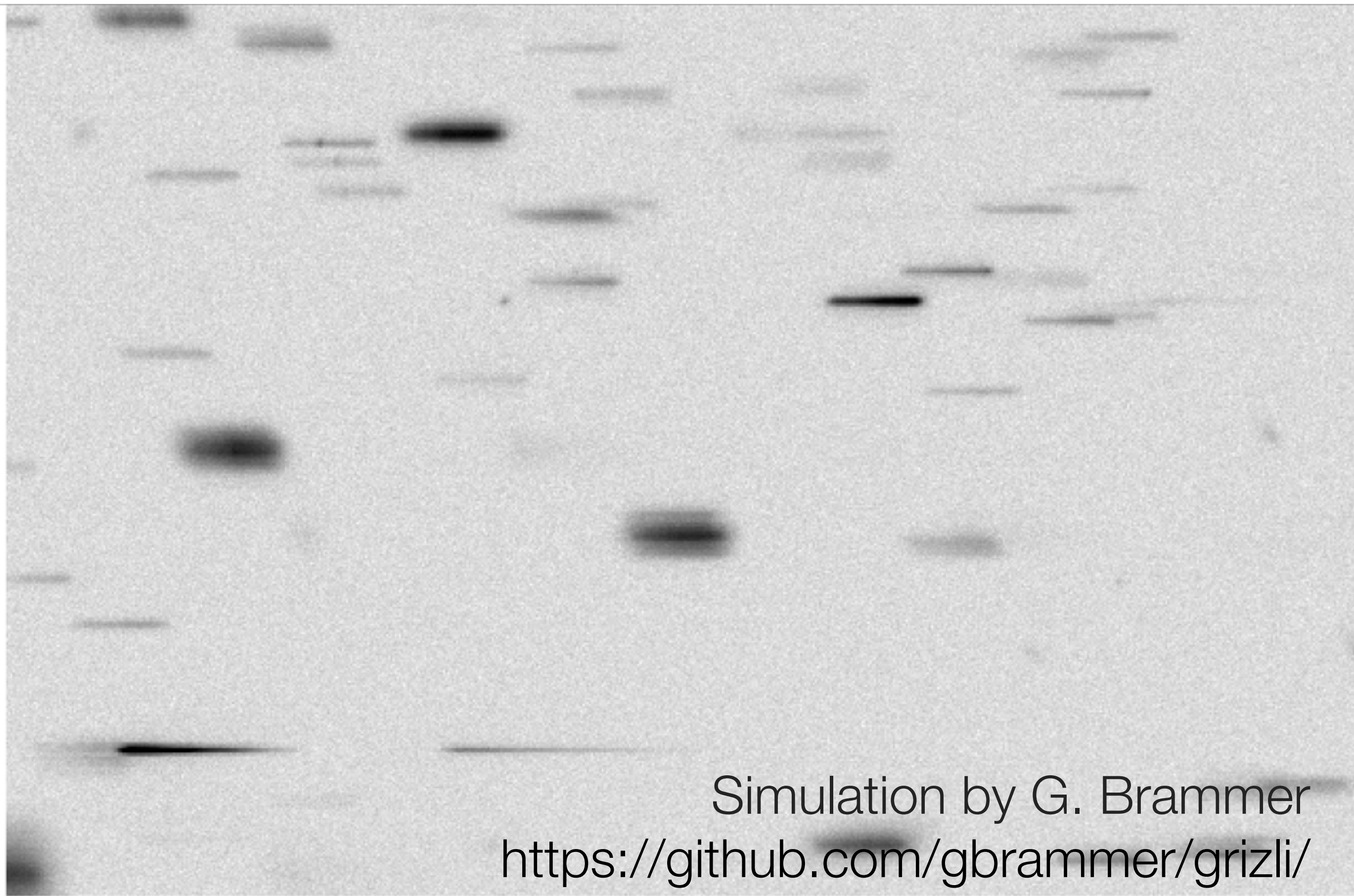
- **JWST NIRISS+FGS**
  - Big telescope! 0.065” pixels, ~WFC3/IR FOV
  - Two grisms rotated by 90°, R=150 (like WFC3/G141)
  - Bandpass limiting by crossed filters, **0.9 – 2.2 µm**



WFC3/G141



NIRISS, G150C + F115W



Simulation by G. Brammer
https://github.com/gbrammer/grizli/

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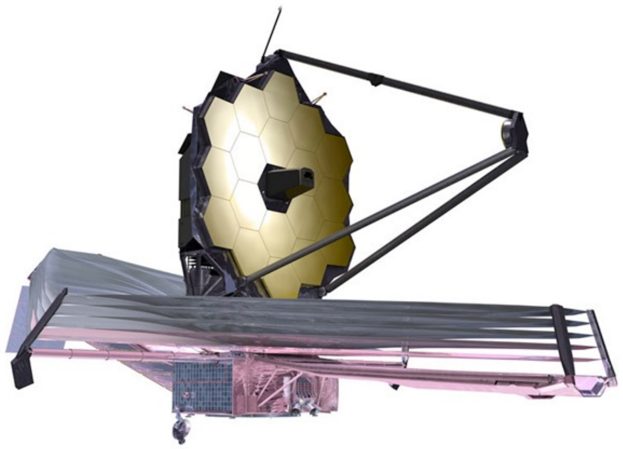
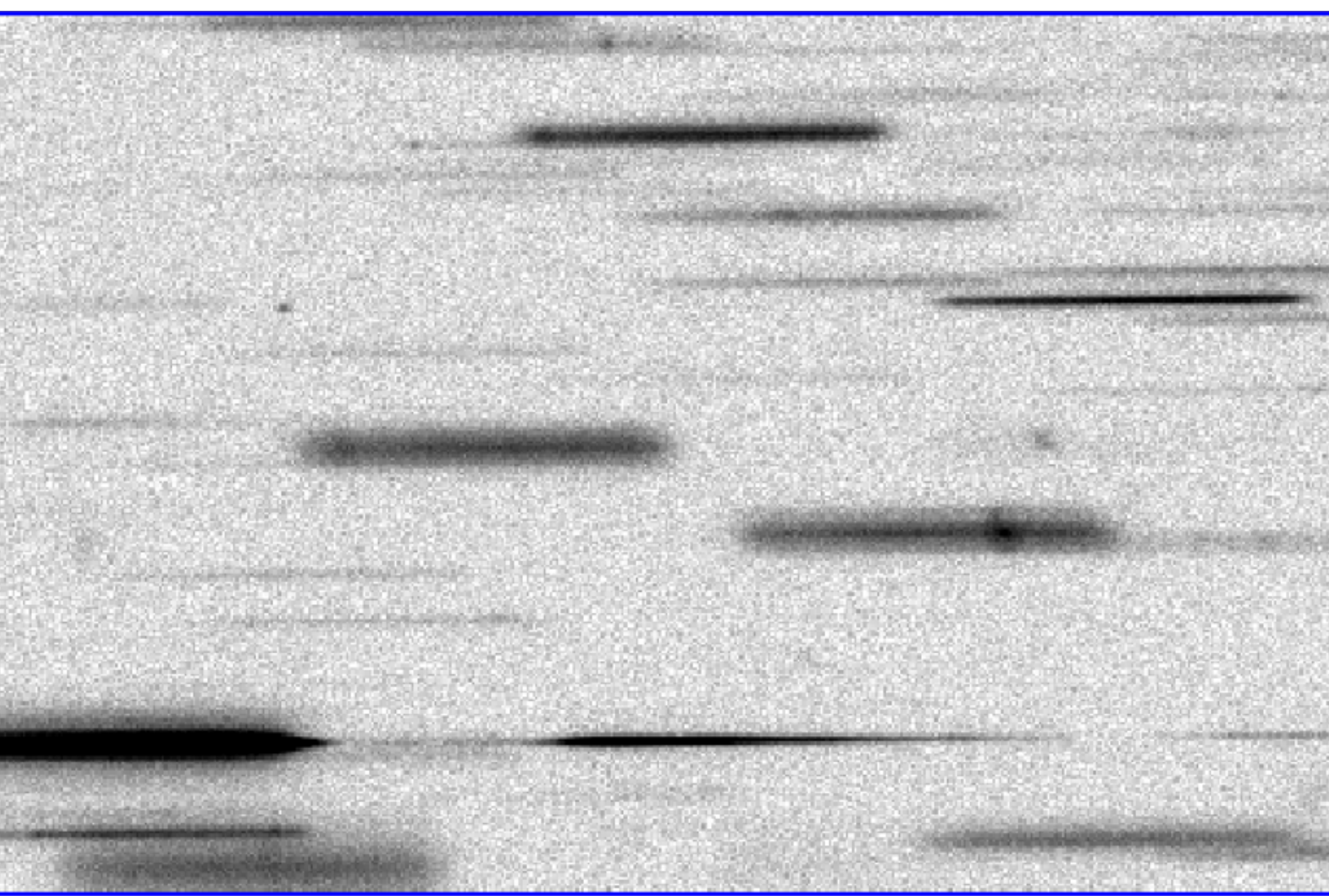
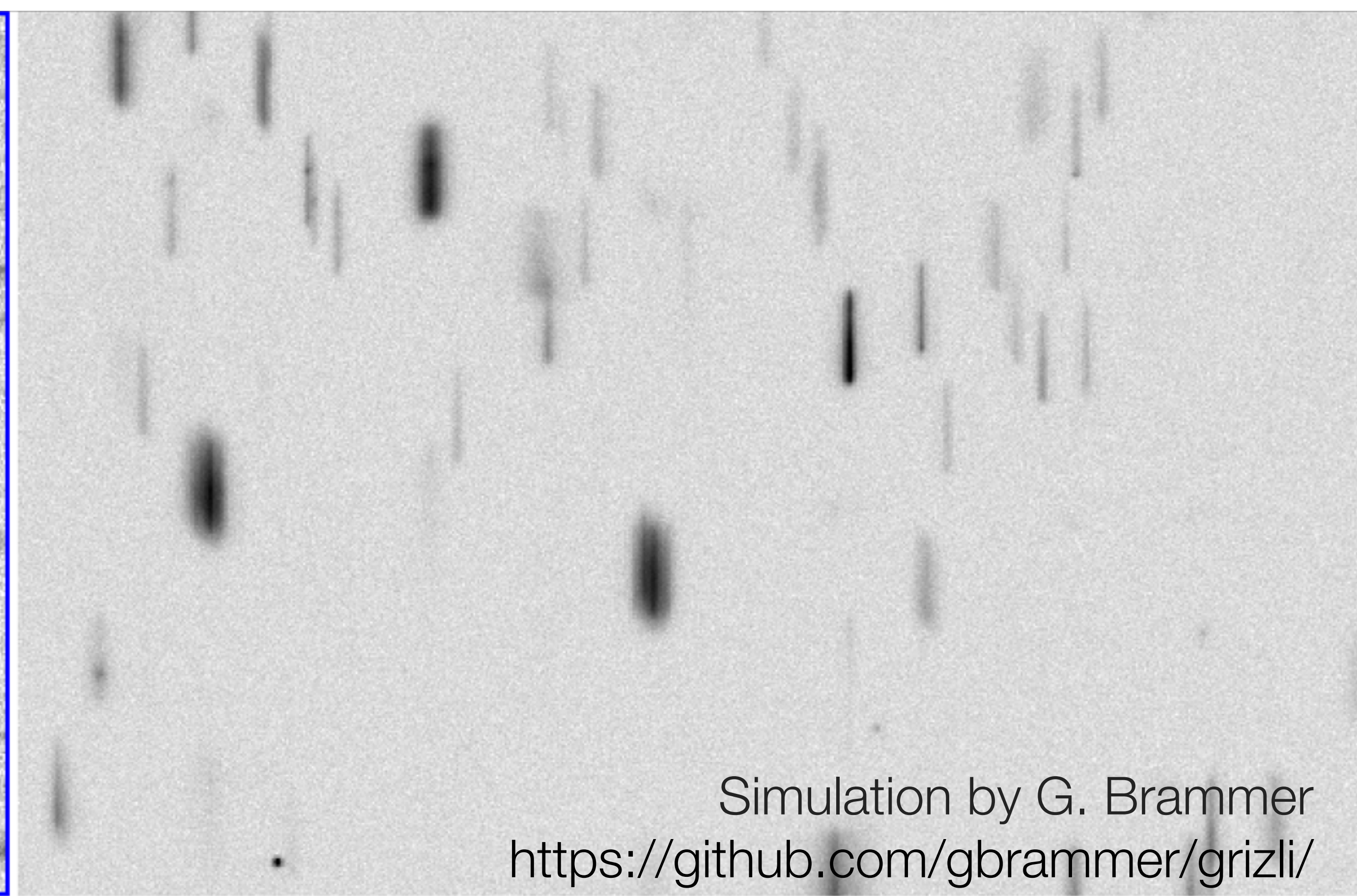


WFC3/G141



NIRISS, G150R + F115W



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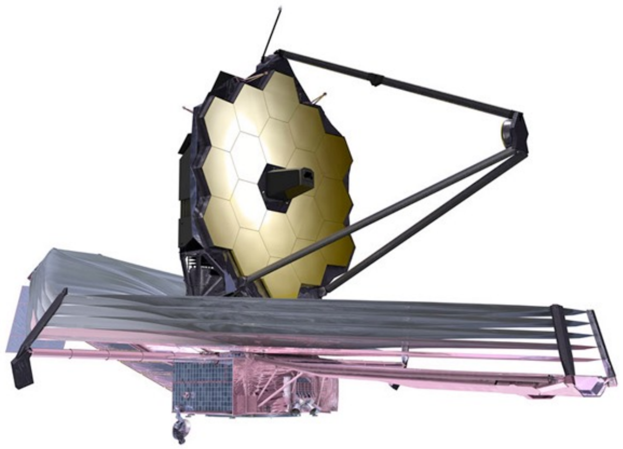
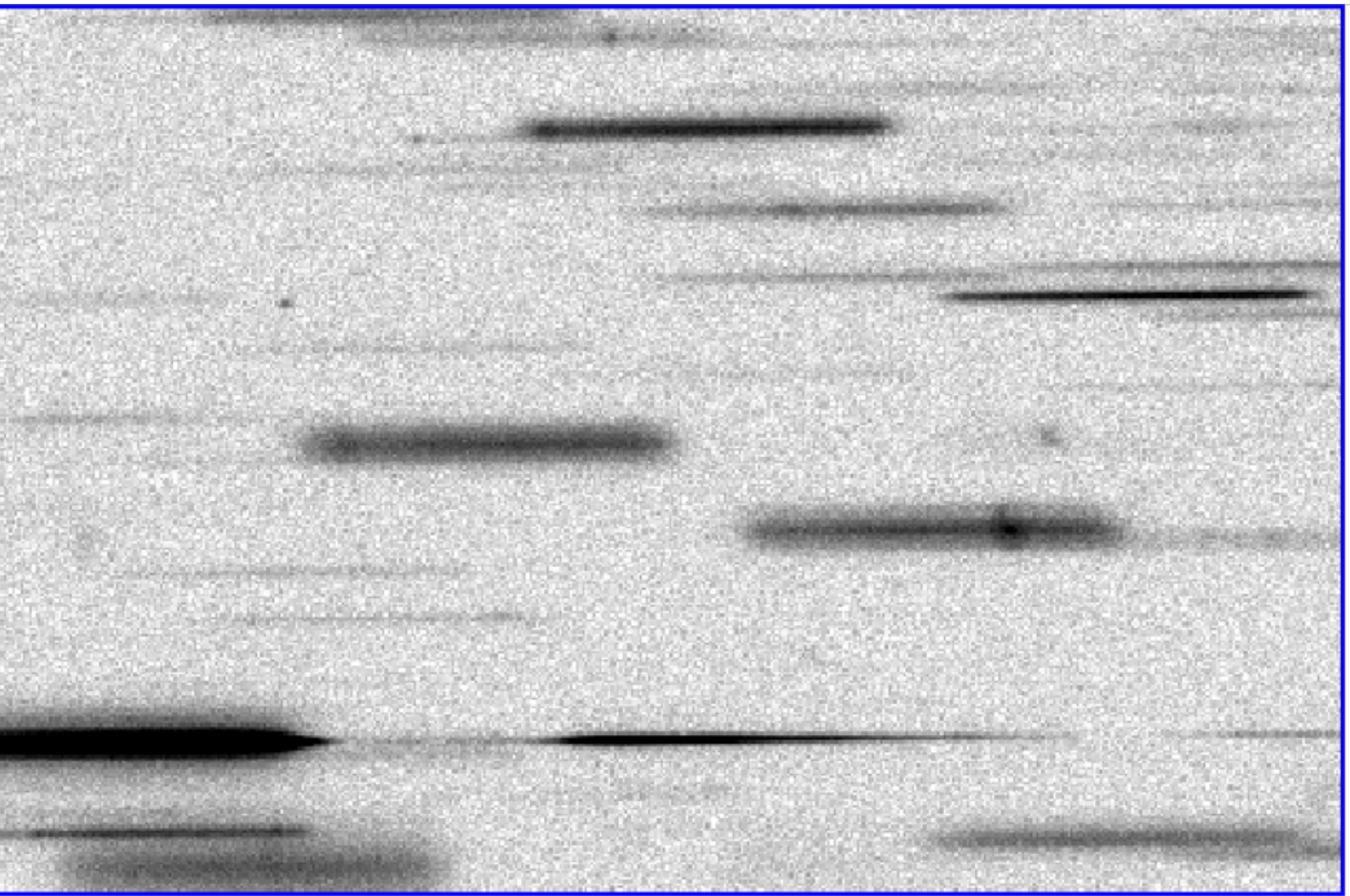
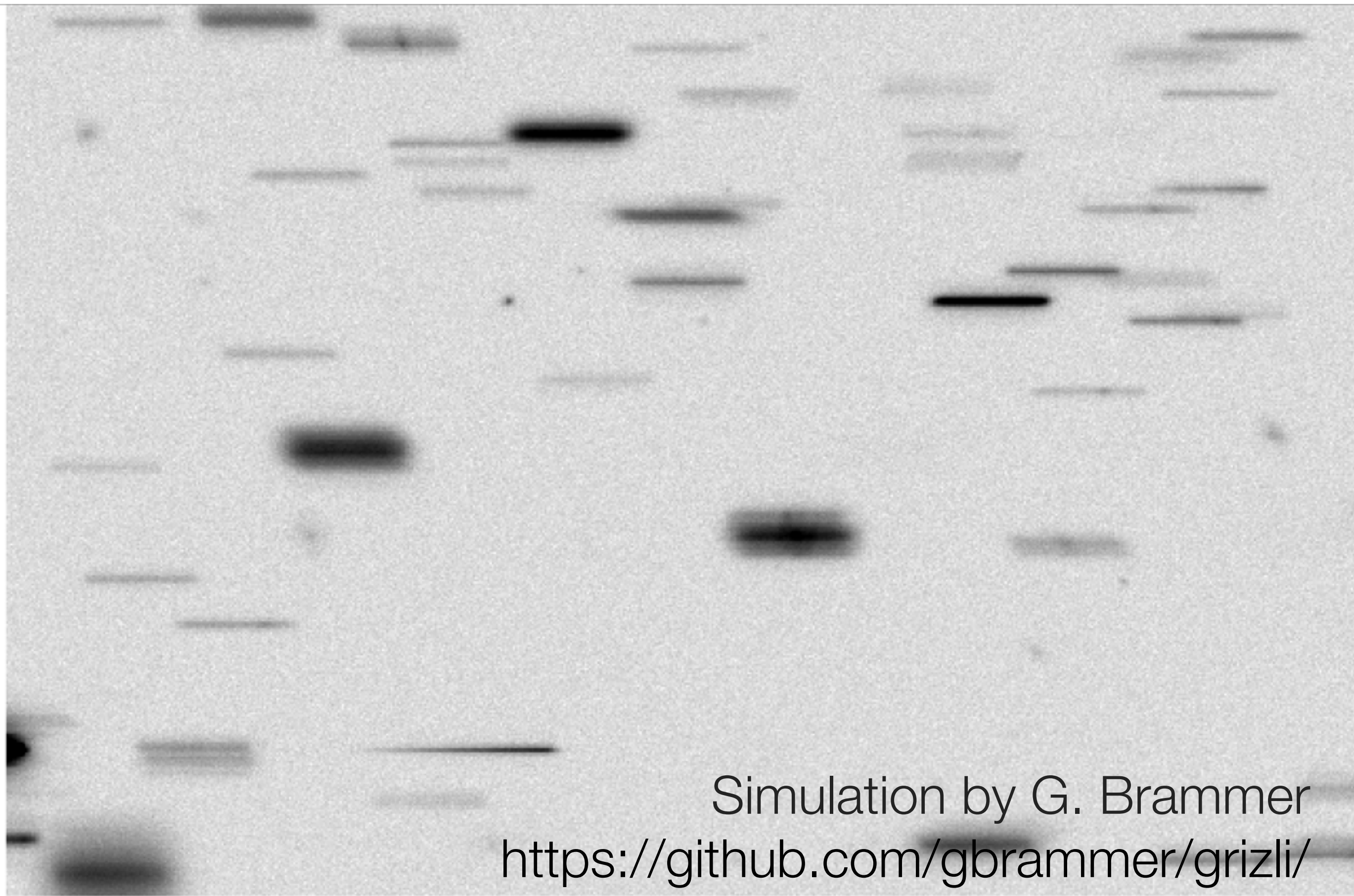


WFC3/G141



NIRISS, G150R + F150W



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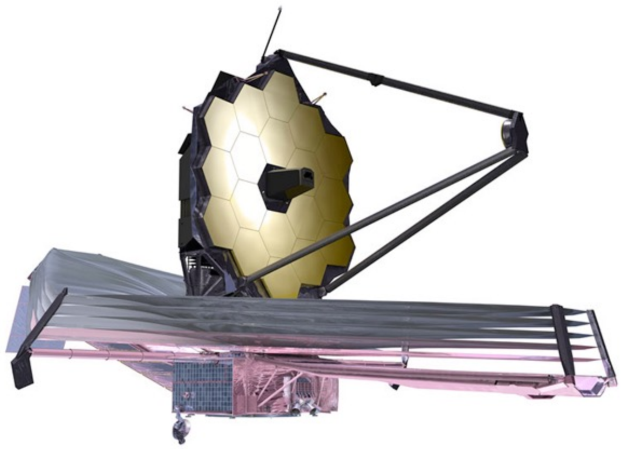
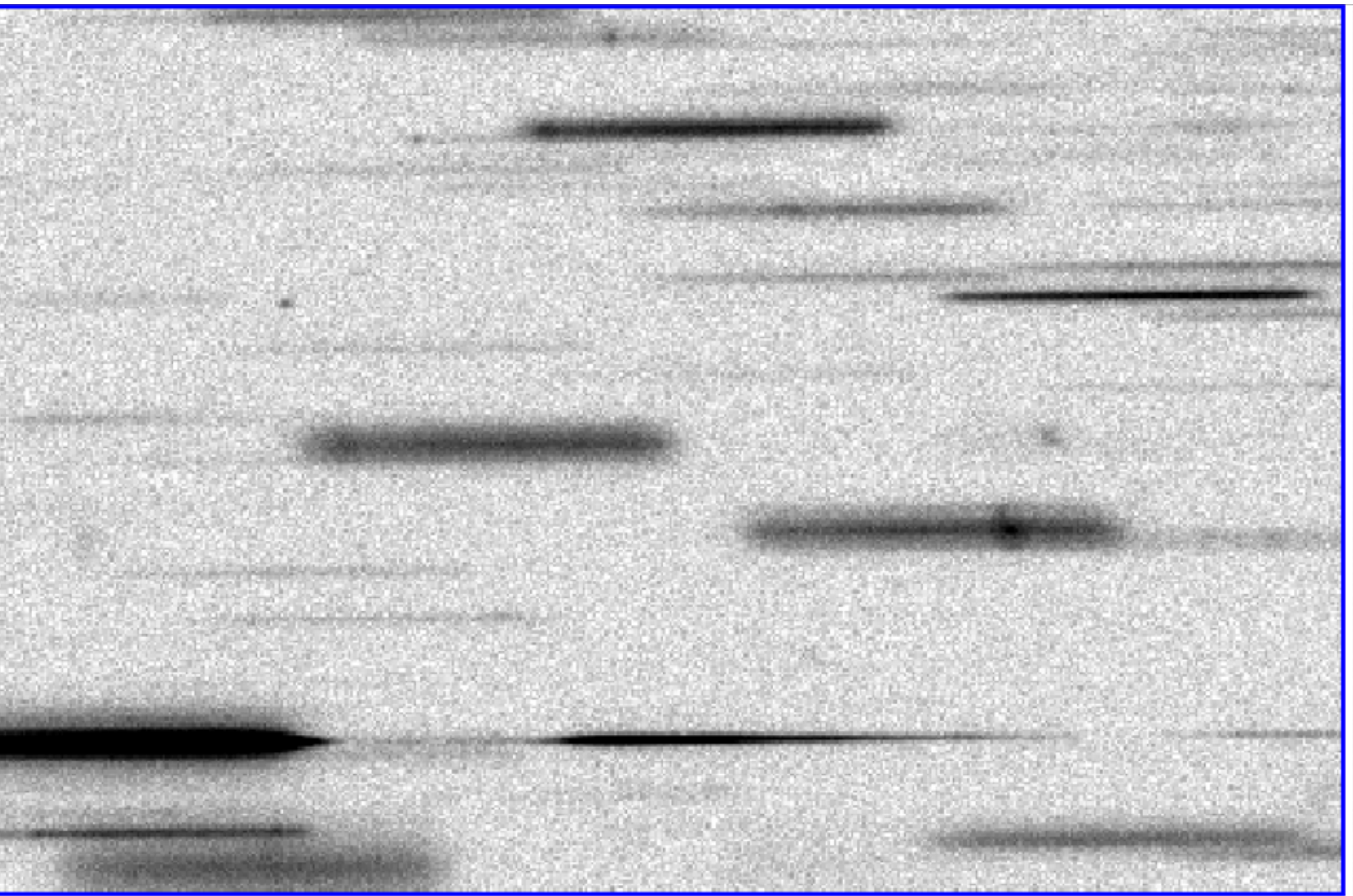
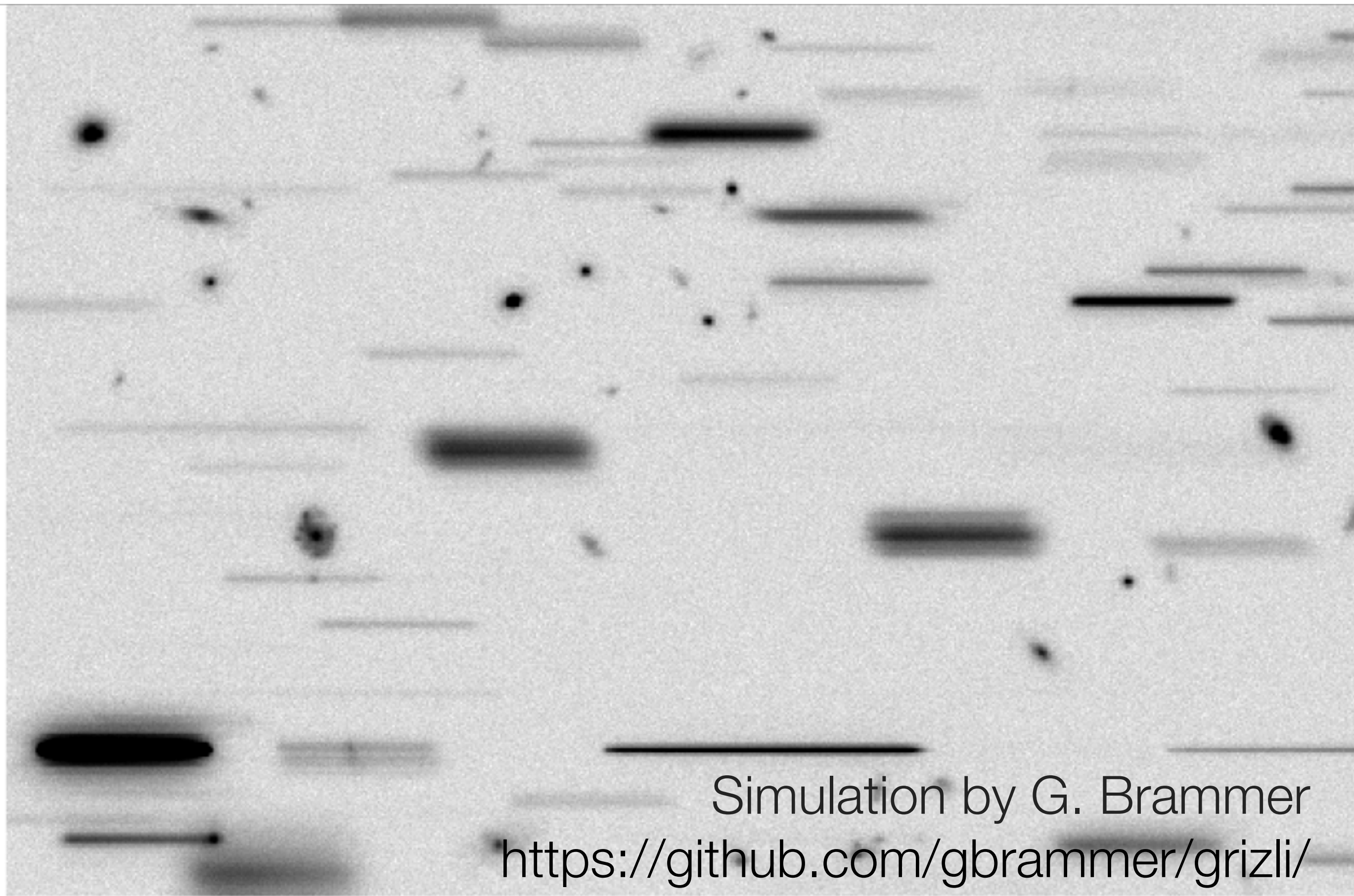


WFC3/G141



NIRISS, G150R + F200W



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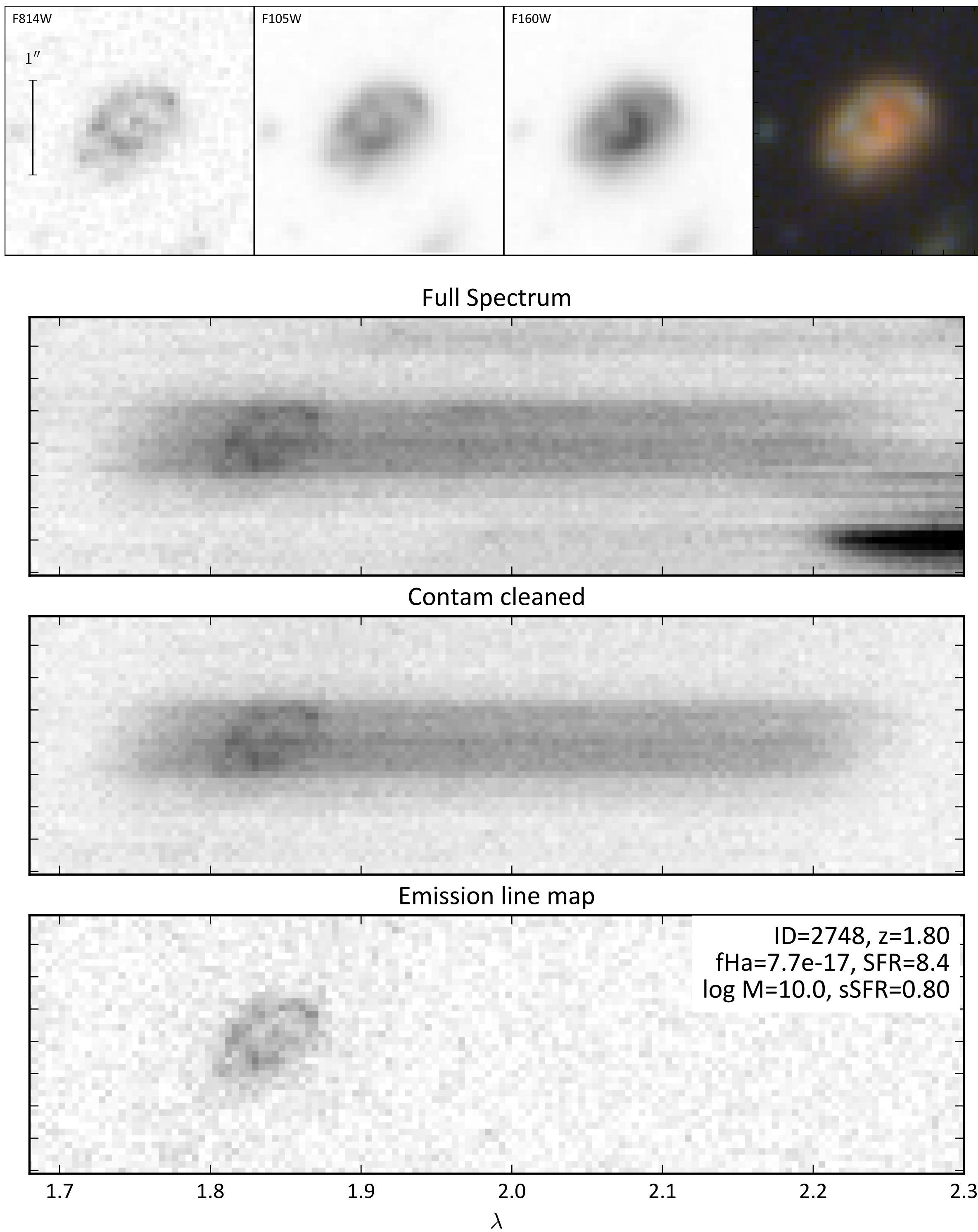

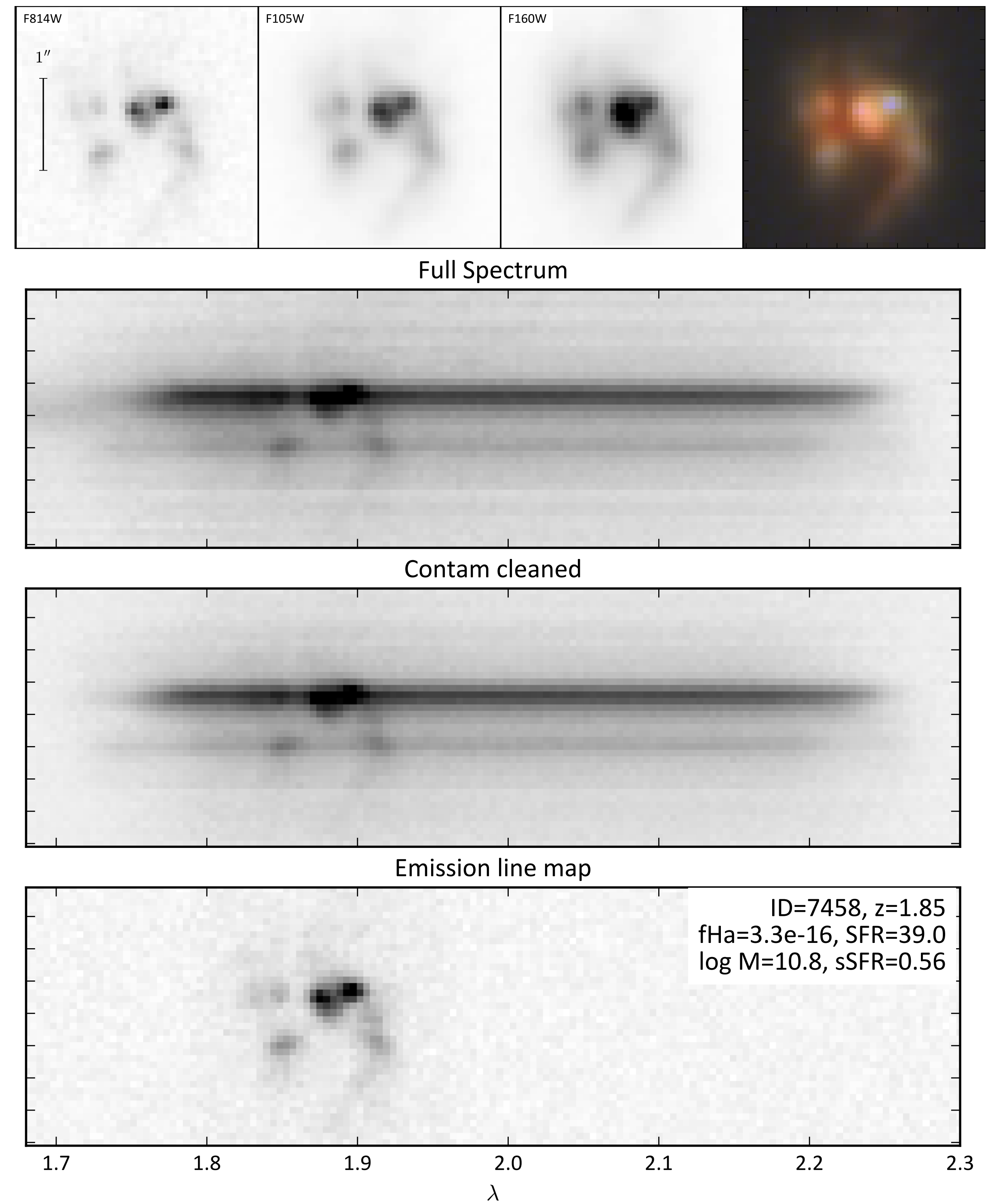

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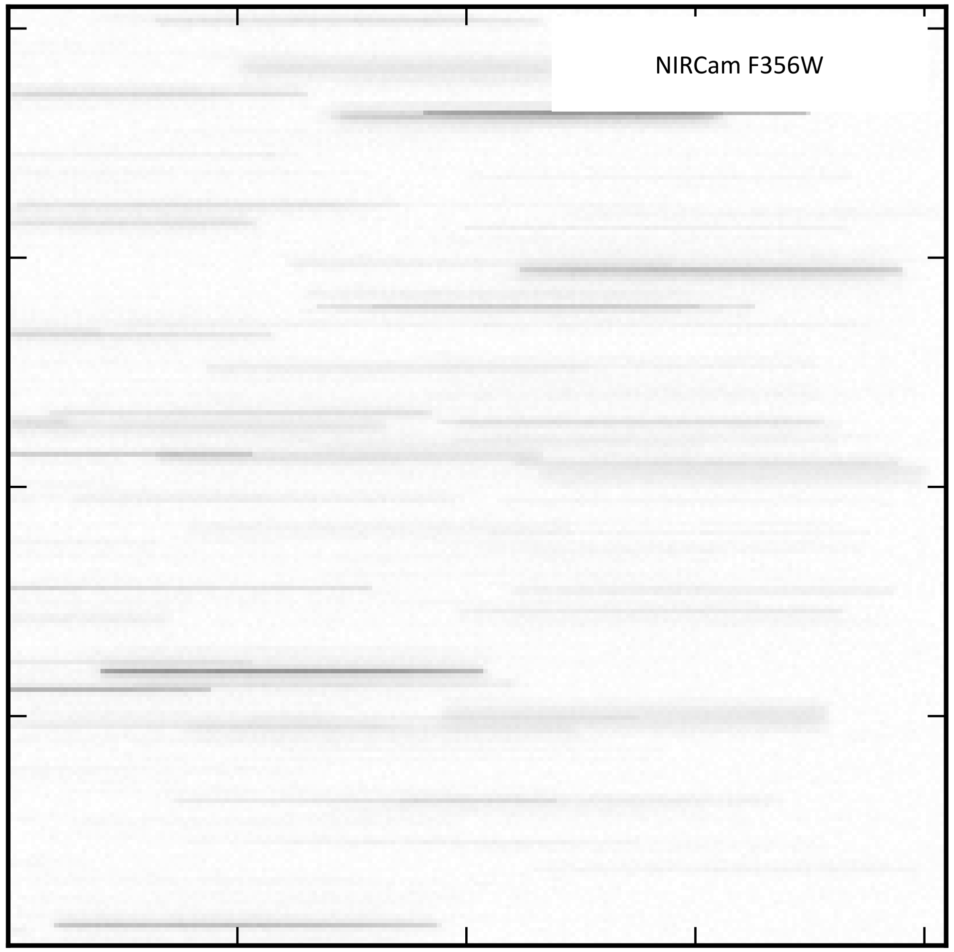
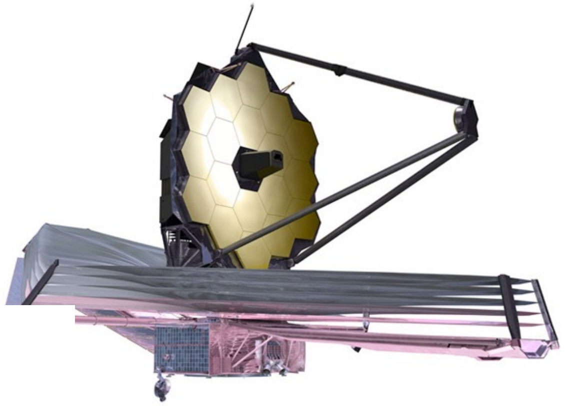
New capabilities with slitless spectroscopy: JWST

- **JWST NIRCAM Long Wave**
  - Big telescope! 0.065” pixels, 2 detectors, FOV~4.4’ x 2.2’
  - Two grisms rotated by 90°, ***R*=1500!**
  - Bandpass limiting by crossed filters, **2.4 - 5.0 μm**





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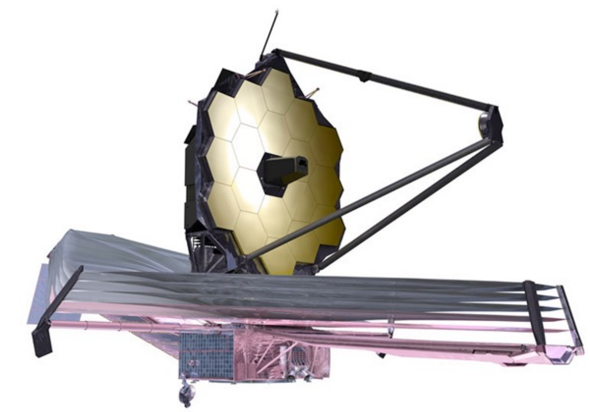
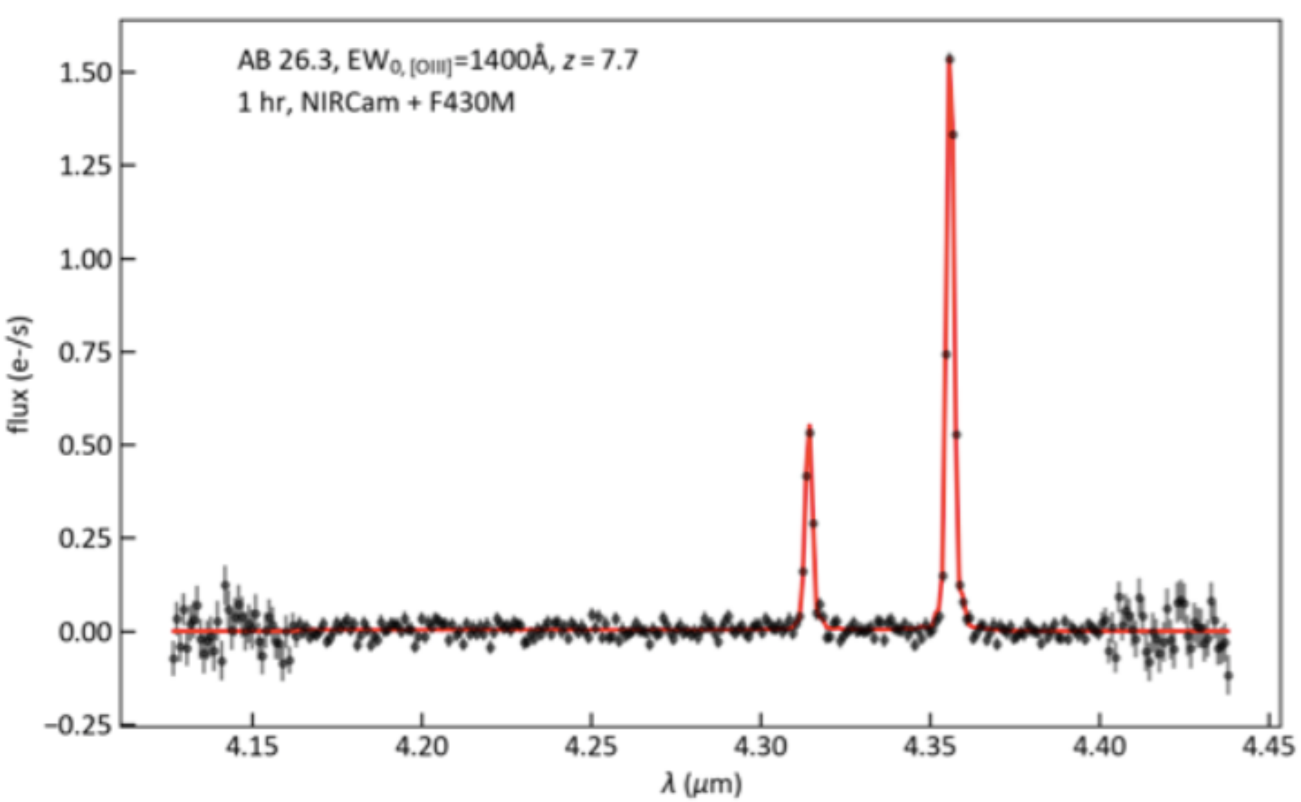
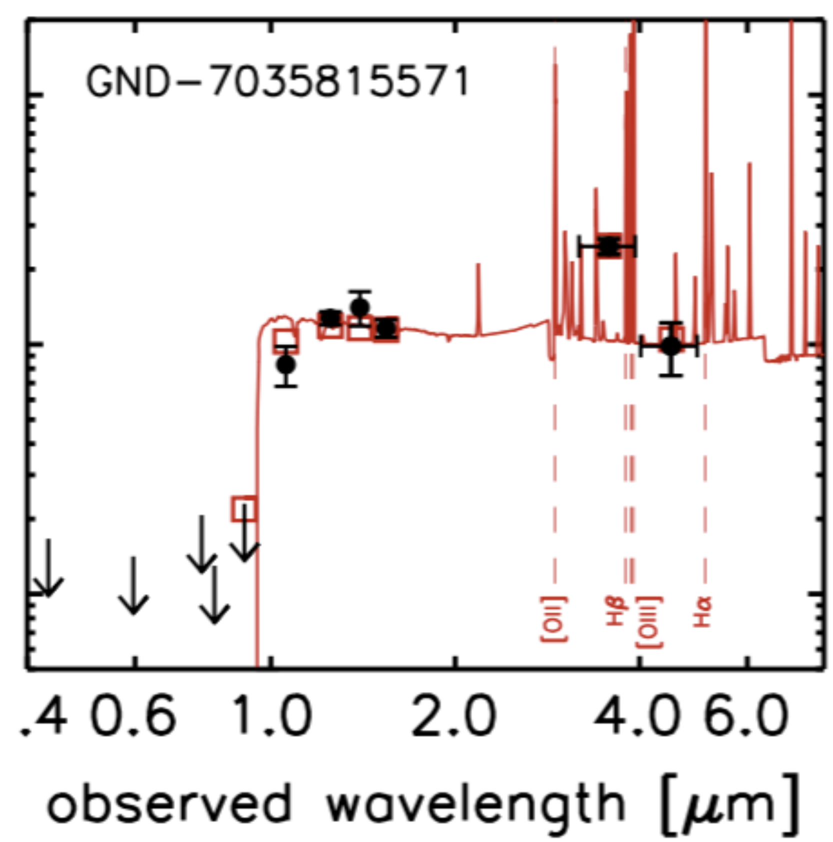


Smit+2015

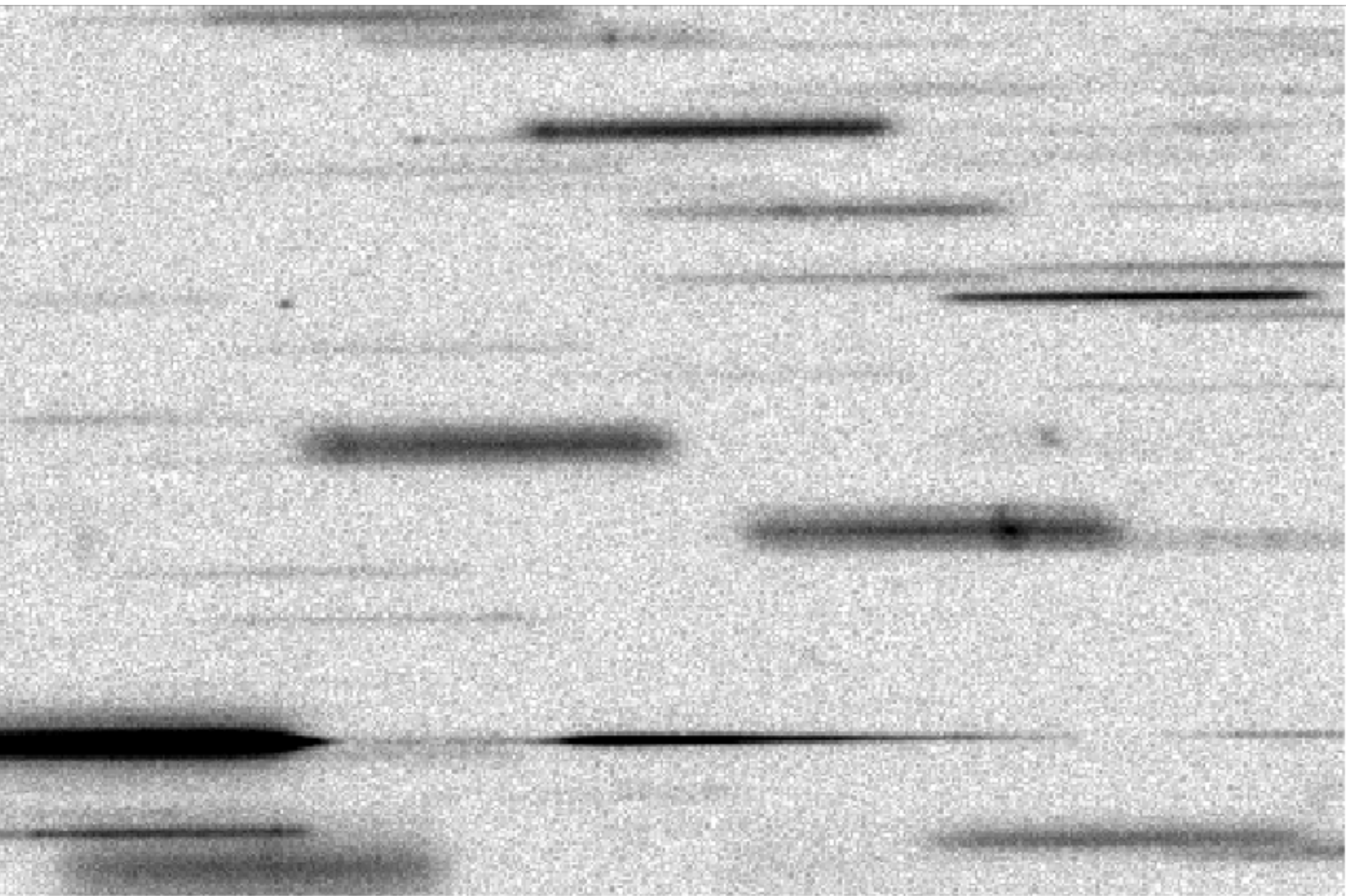




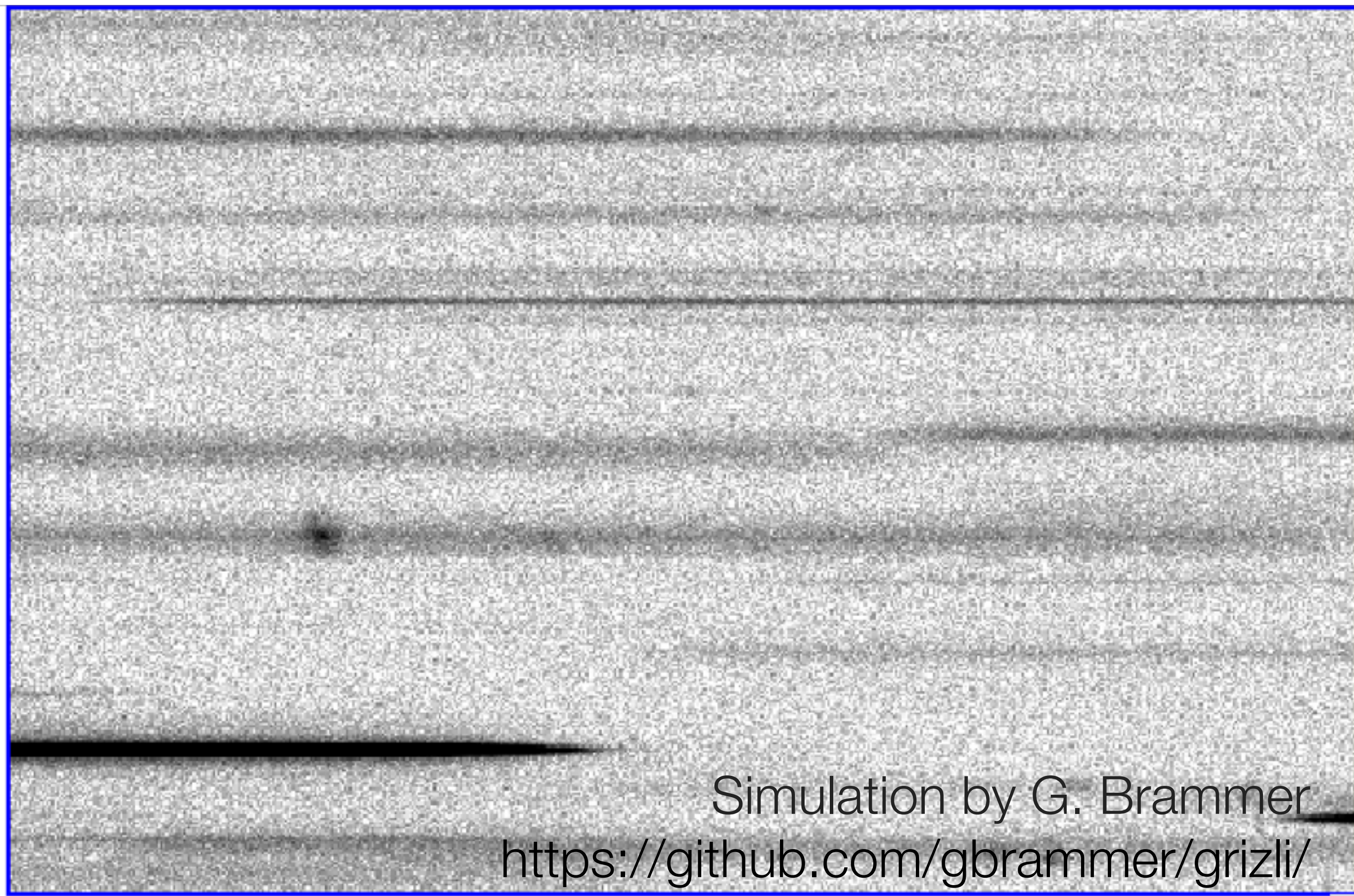
New capabilities with slitless spectroscopy: WFIRST

- **WFIRST GRS grism**
  - 0.28 deg^2 at a shot, 2400 deg^2 (!) High Latitude Survey (z for BAO, RSD, public survey)
  - 2.4m telescope (≈HST)
  - 1.3–1.9 μm, R = 4 x G141 (e.g., just resolves Hα, [NII])

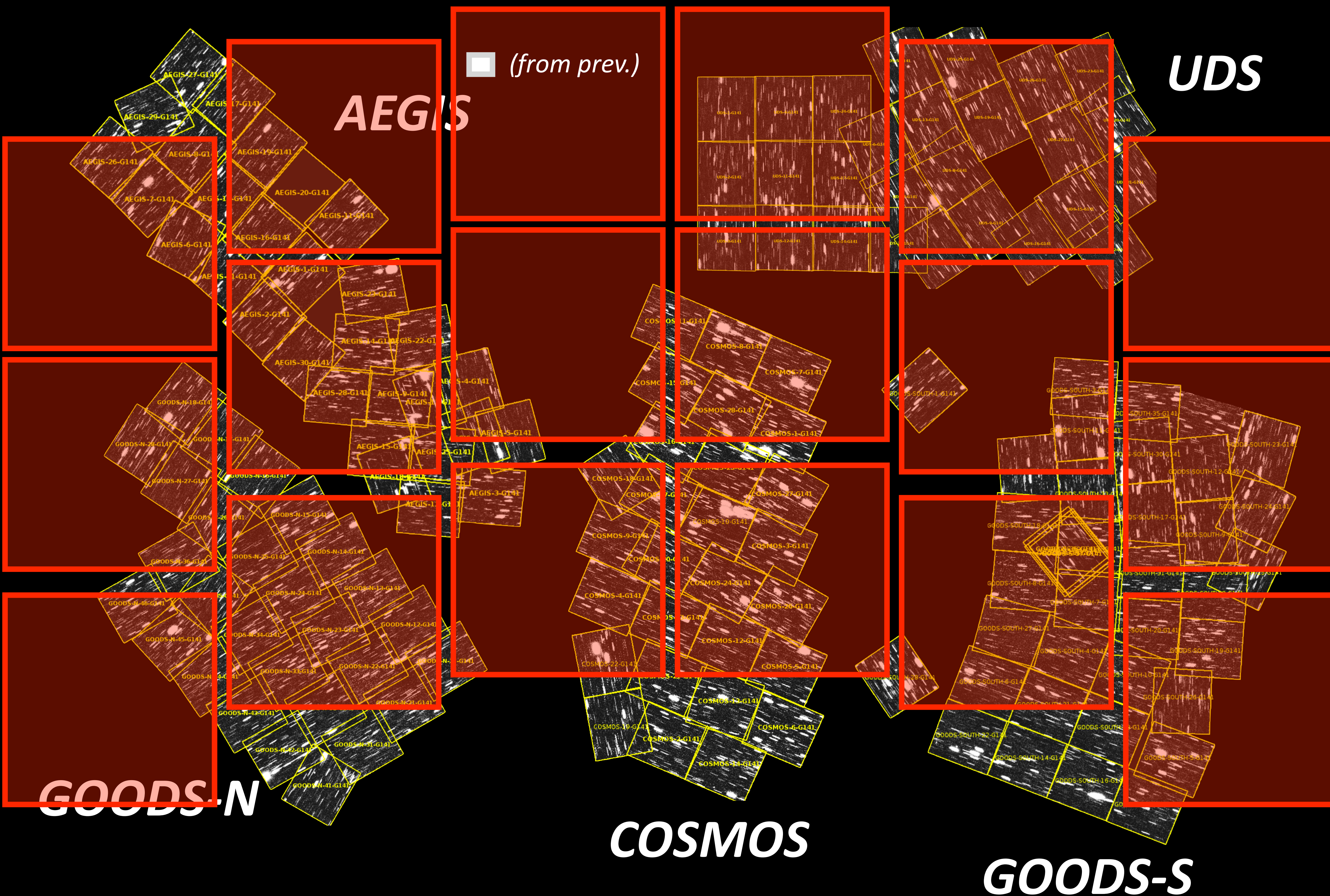
WFC3/G141



WFIRST GRS grism



WFIRST: 0.28 deg² / pointing, 2400 deg² total



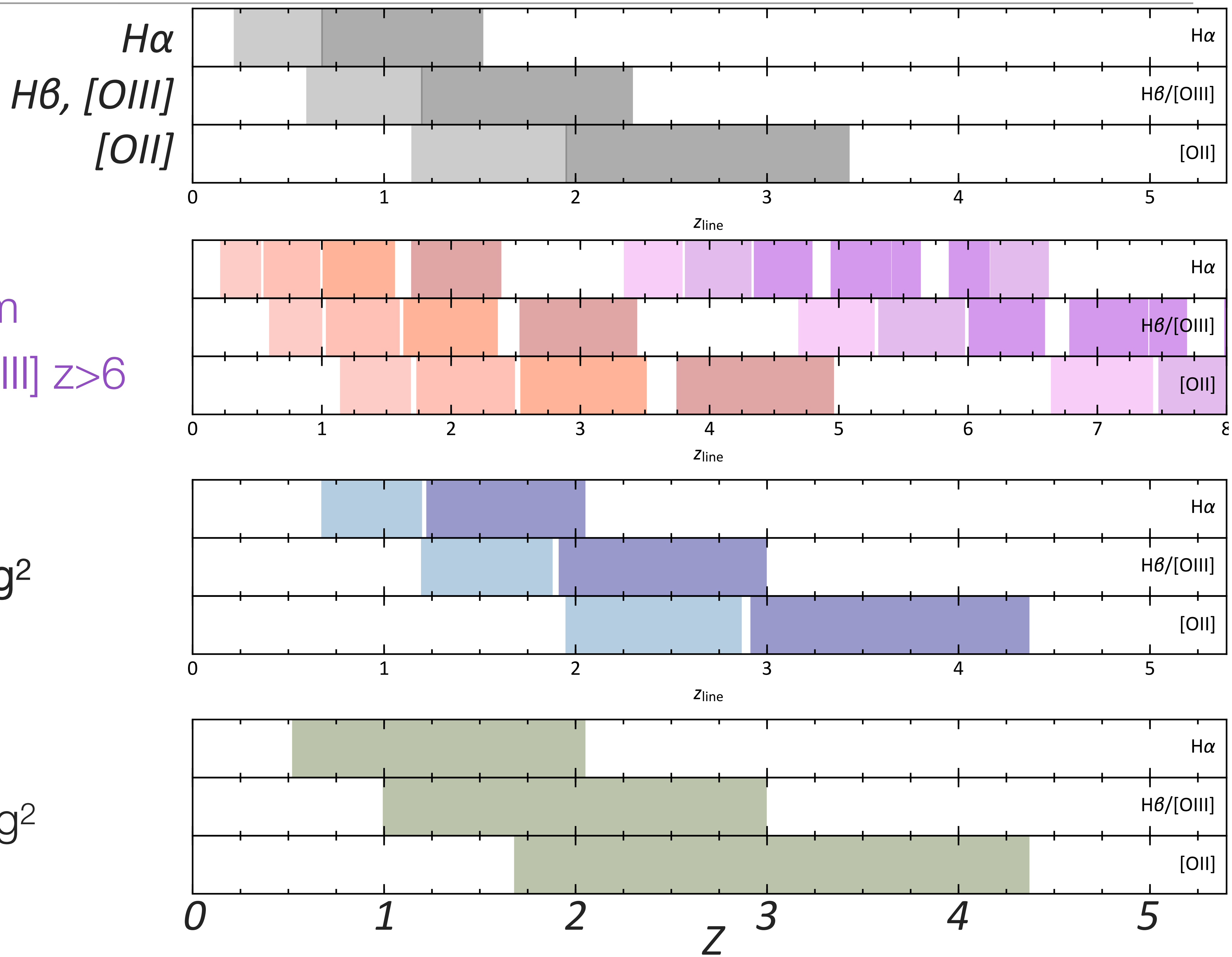
New capabilities with slitless spectroscopy

WFC3/IR

JWST
NIRISS, NIRCam
Deep, Hα z>5, [OIII] z>6

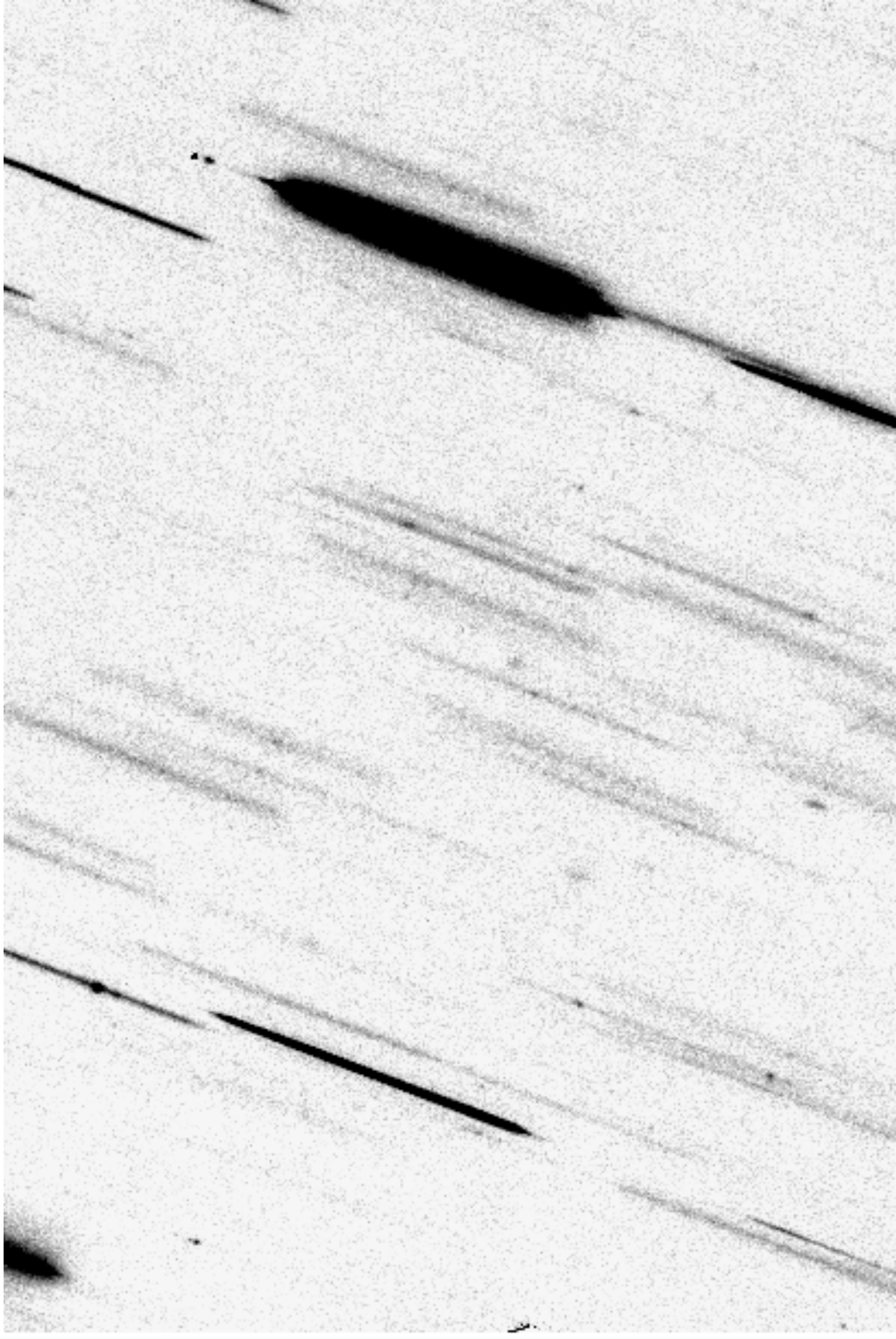
Euclid
Shallow, 10^4 deg^2

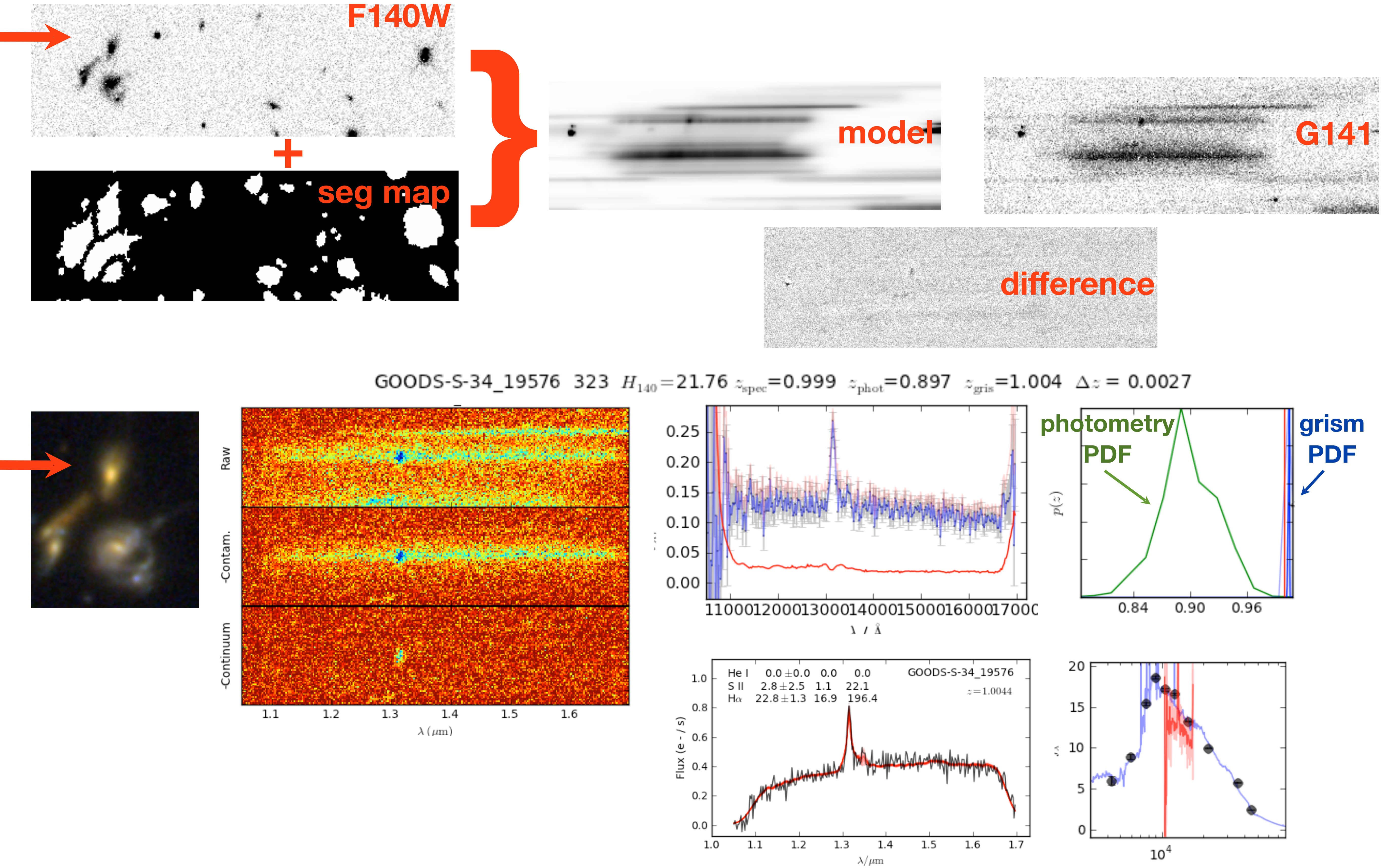
WFIRST
≈3D-HST, 2K deg^2



Grism Tutorial

Grizli





Grism Processing Example

https://github.com/gbrammer/grizli