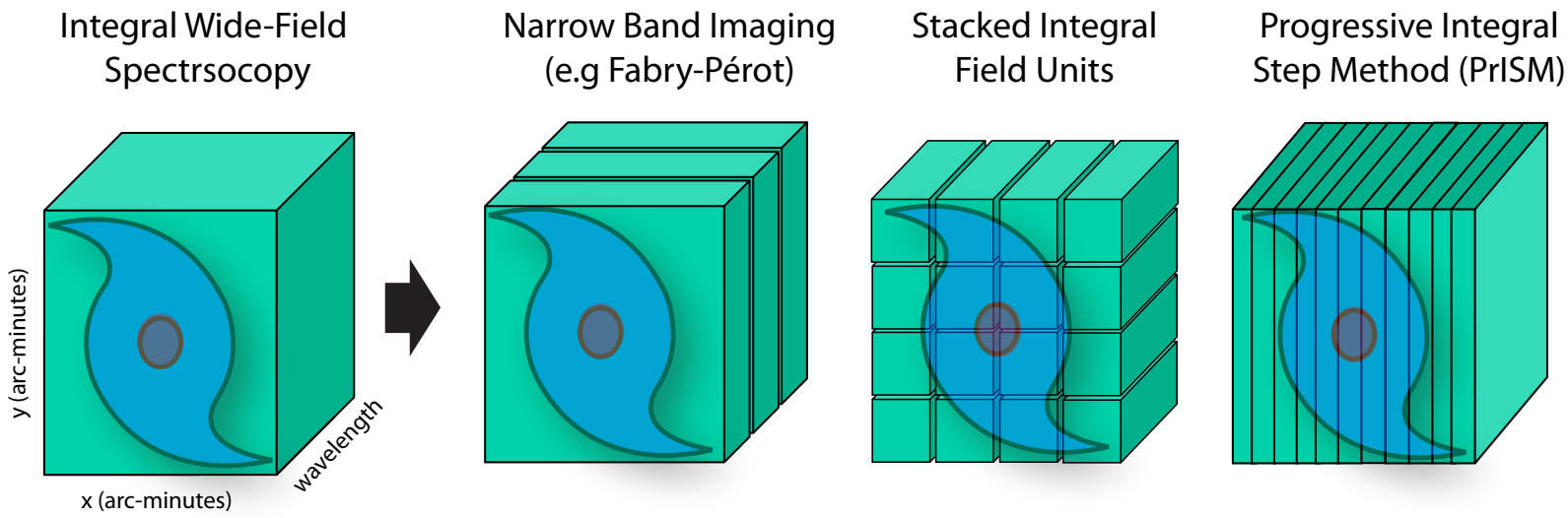
Wide Field Integral Spectroscopy with

Typhoon PrISM

Carnegie Institution for Science

Barry Madore, Jeff Rich, Mark Seibert



Spatially Resolved Galaxy IFS:
star formation
star formation histories
chemical evolution
separated by morphological components

Simple Execution:
modern telescope control systems
desktop computing power
cheap disk storage
~ $0

SLS/PrISM Concerns

INEFFICIENT

true for small objects

true for faint objects

use for large bright objects

SLS/PrISM Concerns

INEFFICIENT

true for small objects

true for faint objects

use for large bright objects

VARIABLE SKY

true always

ultra-long slit allows for simultaneous sky for each exposure if diameter < slit.

PrISM Specifications @LCO du Pont

Table 1. PrISM Specifications

Field of view (slit)	$18' \times 1.65''$ (0.5 arcminute^2)
Spectral resolution	R=800 (375 km s^{-1} FWHM)
Spaxel size	$1.65'' \times 0.484''$ (native) / $1.65'' \times 1.65''$ (binned)
Spatial resolution	2 – 177 pc (48 pc median)
Spectral range	3650 – 9000 Å
Flux limit (5000Å)[a]	4×10^{-17} erg s^{-1} cm^{-2} Å^{-1} per resolution element
	33.4 μJy per resolution element
	μ = 21.1 AB mag / arcsec^2
	S/N=3, 600 sec., 1.65^2 arcsec spaxel
Telescope	2.5m f/7.5 du Pont telescope, Las Campanas, Chile
Camera/Detector	Wide Field reimaging CCD (WFCCD)
	25 arcminute diameter field
	WF4K 4064 $\times$ 4064 CCD

Note. — (a) Spatial binning will provide high S/N measurements far below this limit.

PrISM 600sec

nucleus of UGC1382
distance=80 Mpc

22 steps
0.6' x 8.9'

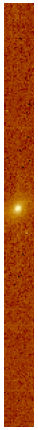
1.65"x0.48"
native pixel scale

PrISM 600sec
SDSS 2700sec

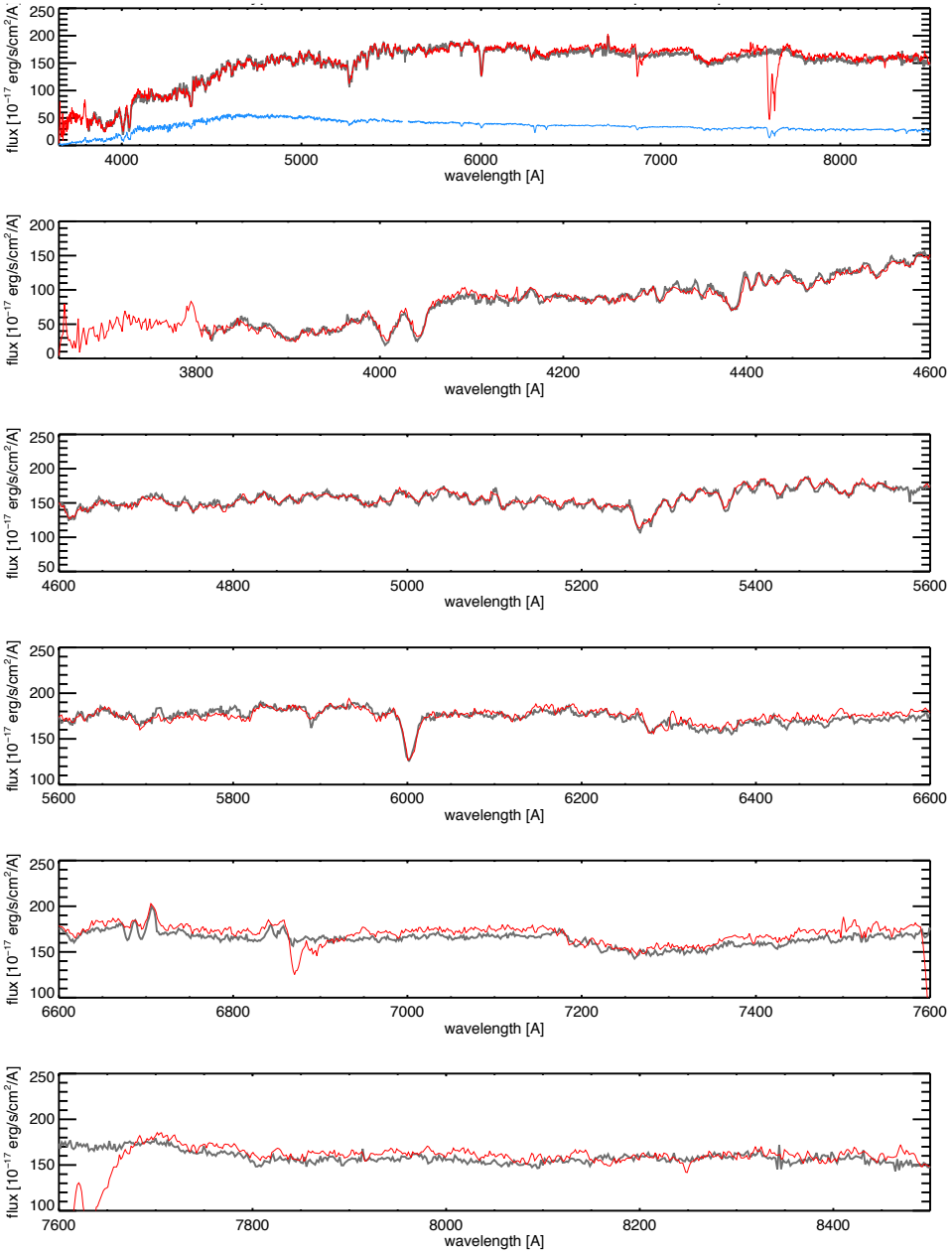
nucleus of UGC1382
distance=80 Mpc

22 steps
0.6’ x 8.9’

1.65”x1.65”
binned pixel scale



~7^2 arcsec aperture



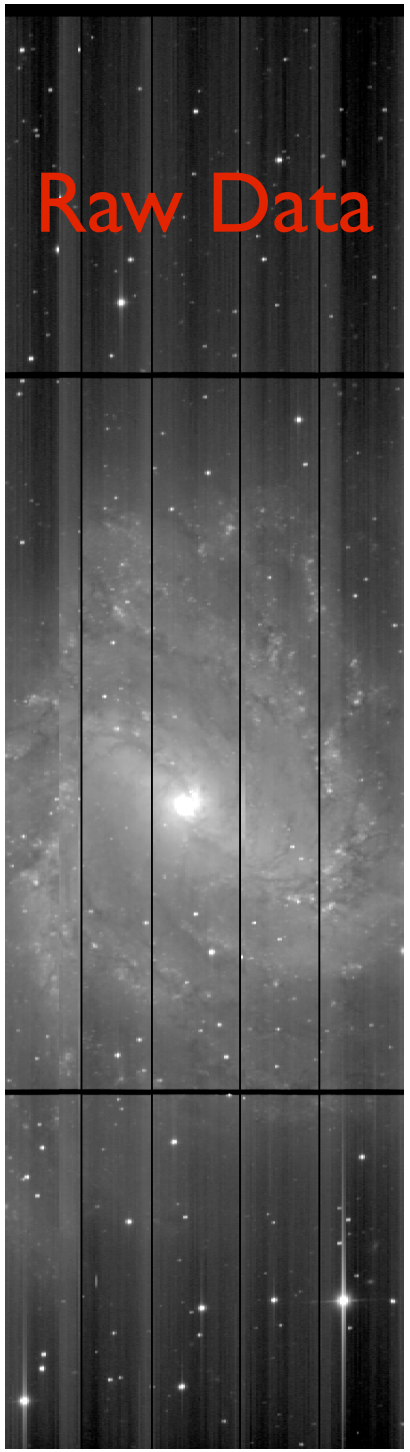
M83 / NGC5236

5 Nights

179 Spectra

5’ x 18’

Reduction is like long slit data
but with 2D distortion corrections
over entire FOV



M83 / NGC5236

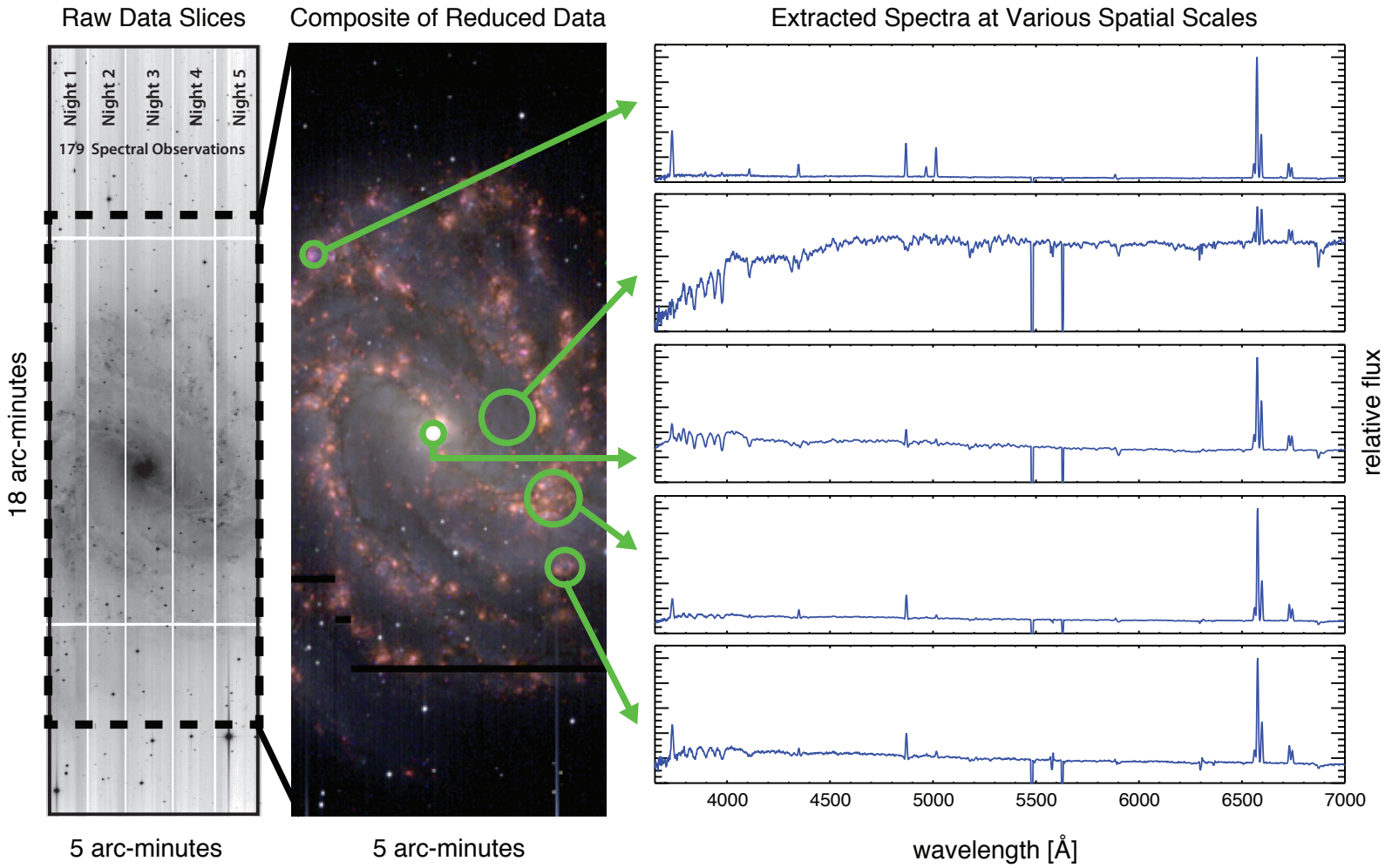
5 Nights

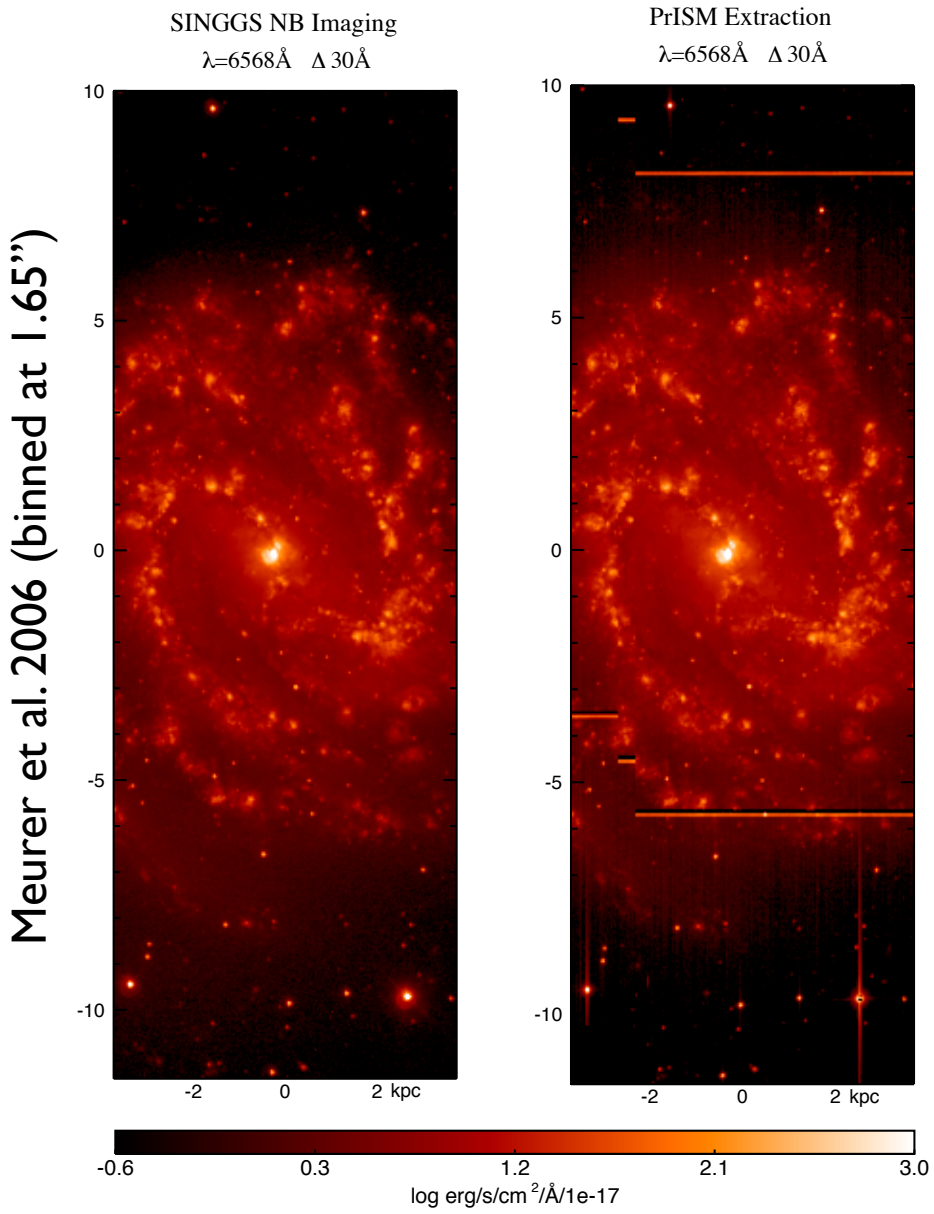
179 Spectra

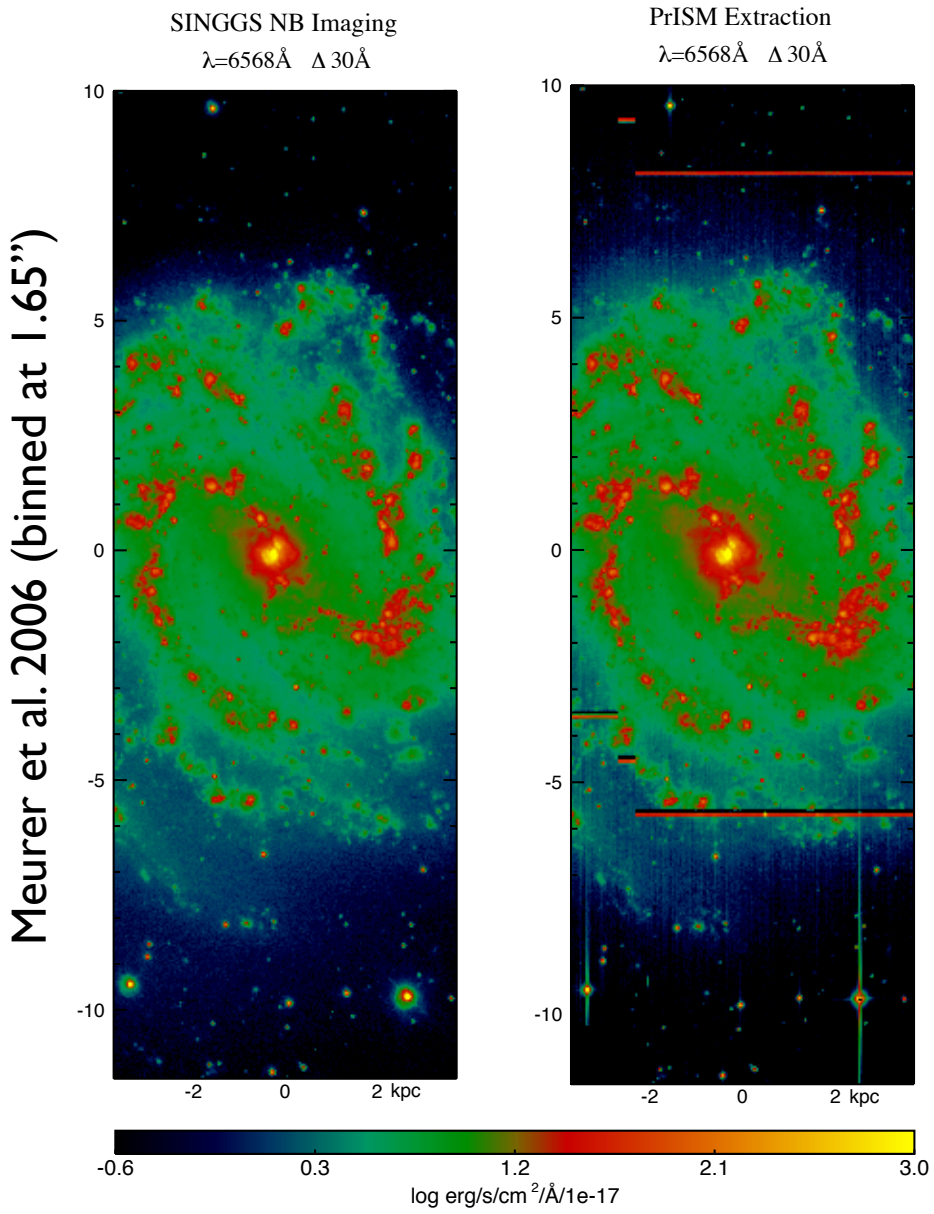
5’ x 18’

Reduction is like long slit data
but with 2D distortion corrections
over entire FOV

~9×10^8 voxels @native res.
~3×10^8 voxels @binned res.


Raw Data Slices
Composite of Reduced Data
Extracted Spectra at Various Spatial Scales
Night 1
Night 2
Night 3
Night 4
Night 5
179 Spectral Observations
18 arc-minutes
5 arc-minutes
5 arc-minutes
relative flux
4000
4500
5000
5500
6000
6500
7000
wavelength [Å]


SINGGS NB Imaging
λ=6568Å Δ 30Å
PrISM Extraction
λ=6568Å Δ 30Å
Meurer et al. 2006 (binned at 1.65")
10
5
0
-5
-10
-2
0
2 kpc
-0.6
0.3
1.2
2.1
3.0
log erg/s/cm 2/Å/1e-17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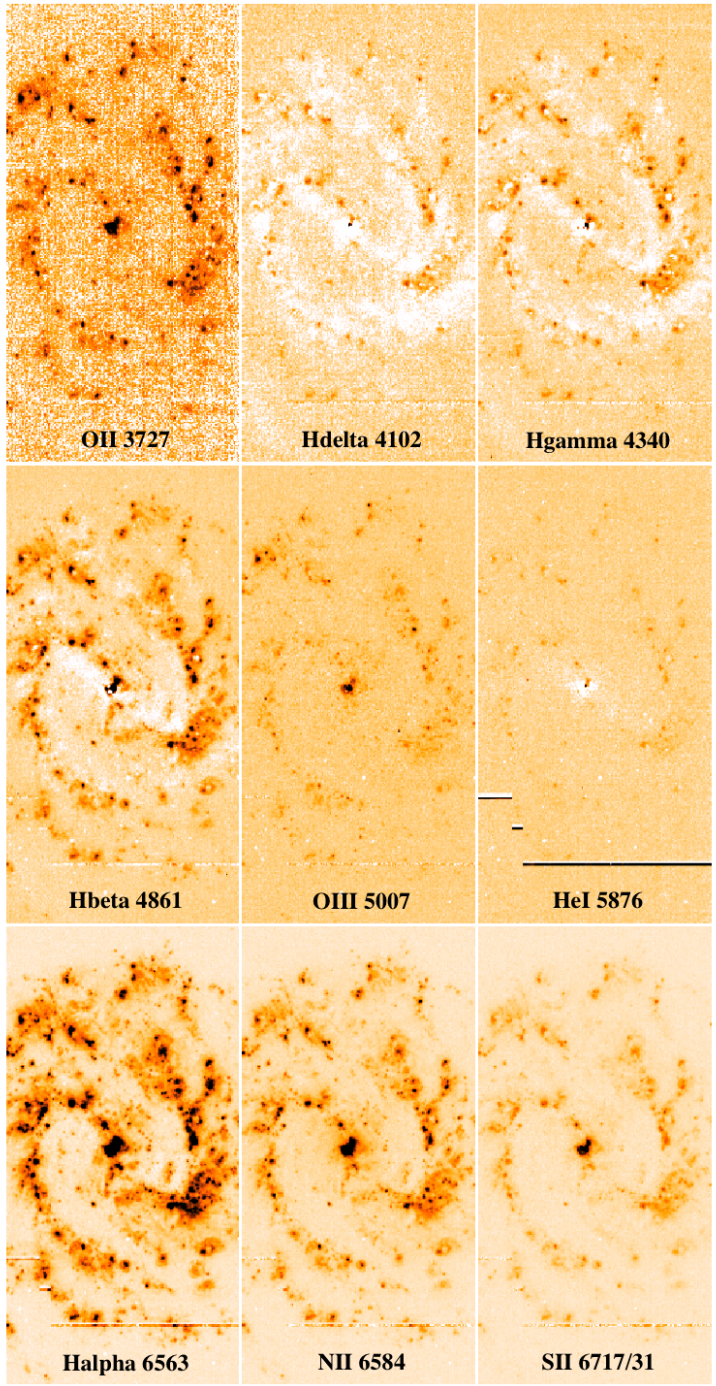
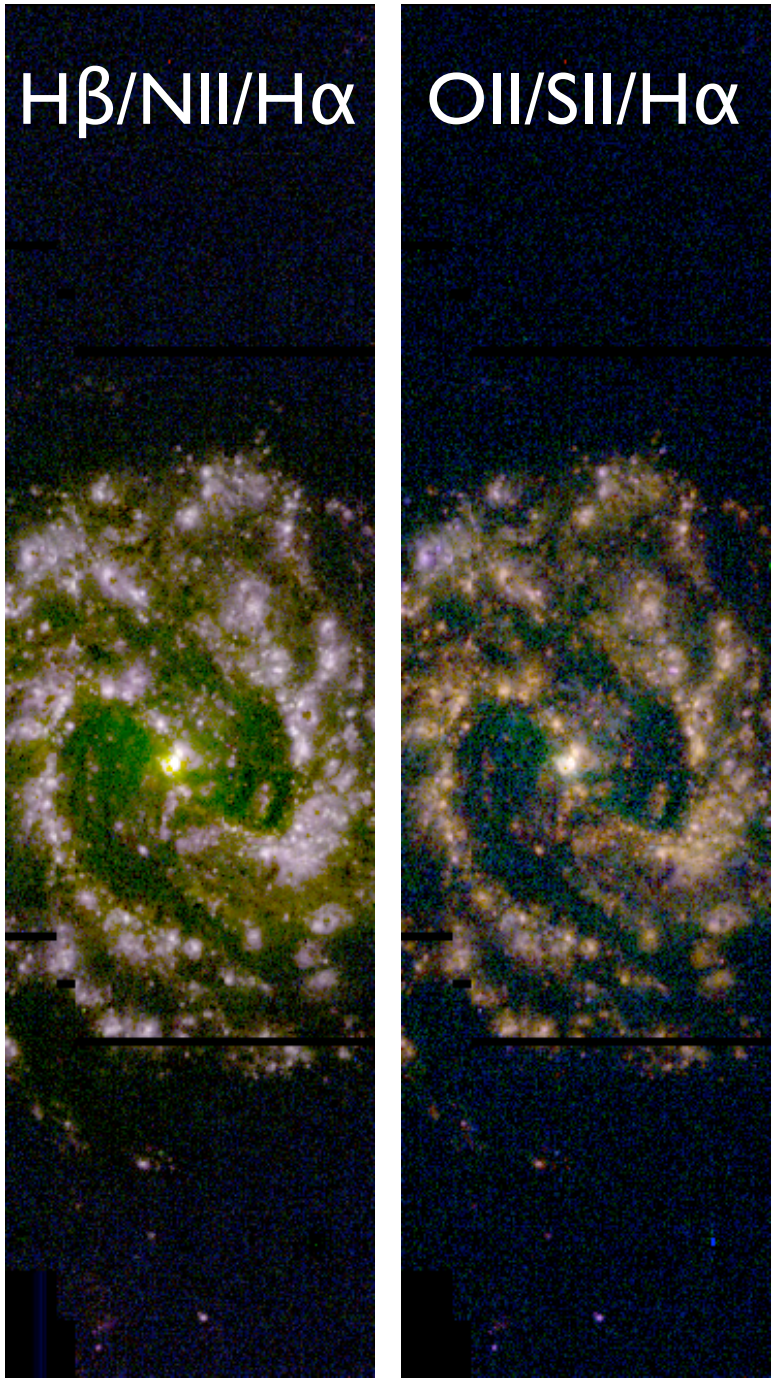
0
-5
-10
-2
0
2 kpc
-0.6
0.3
1.2
2.1
3.0
log erg/s/cm 2/Å/1e-17

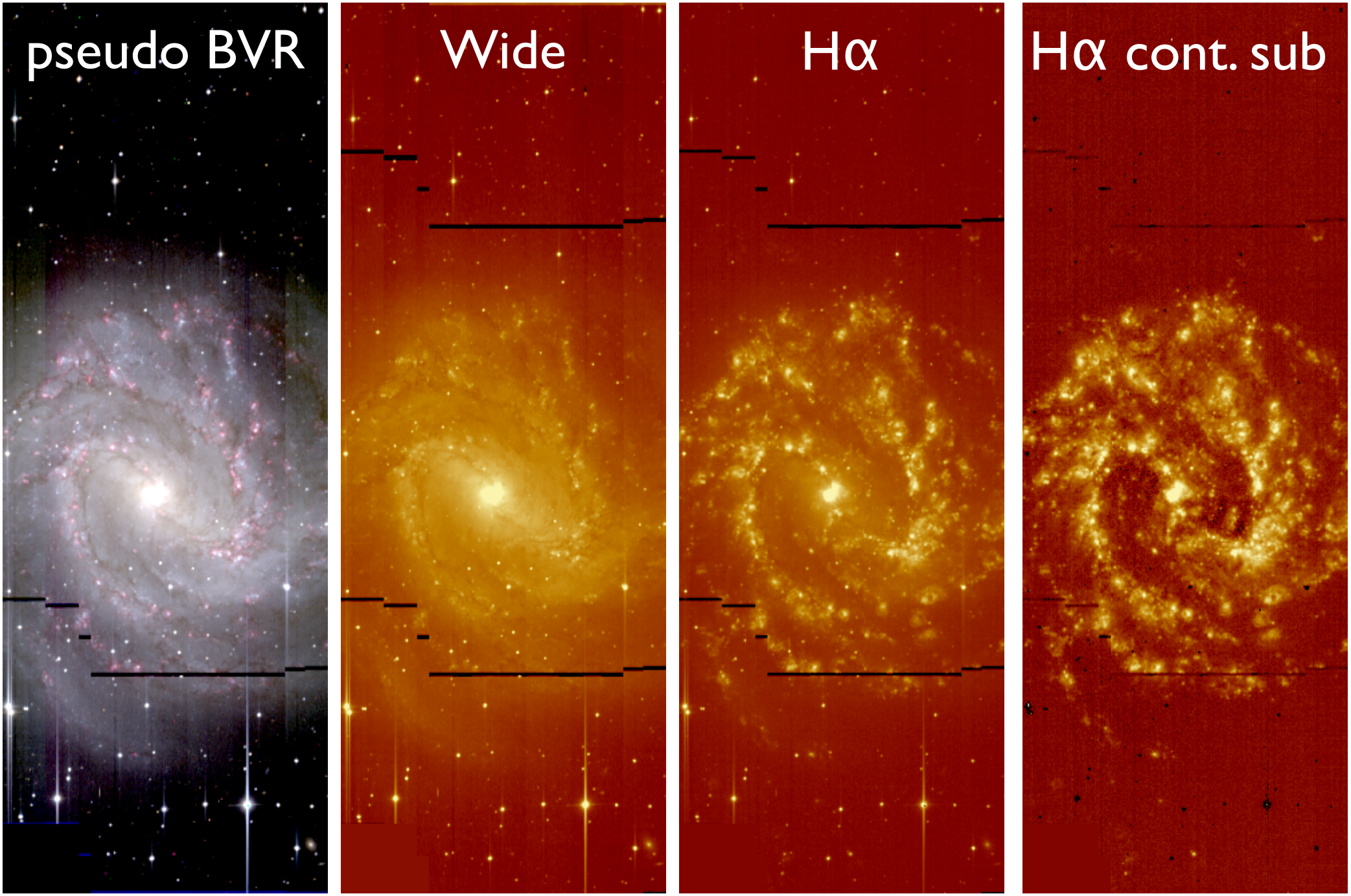
narrow-band
line maps

white ➠ absorption

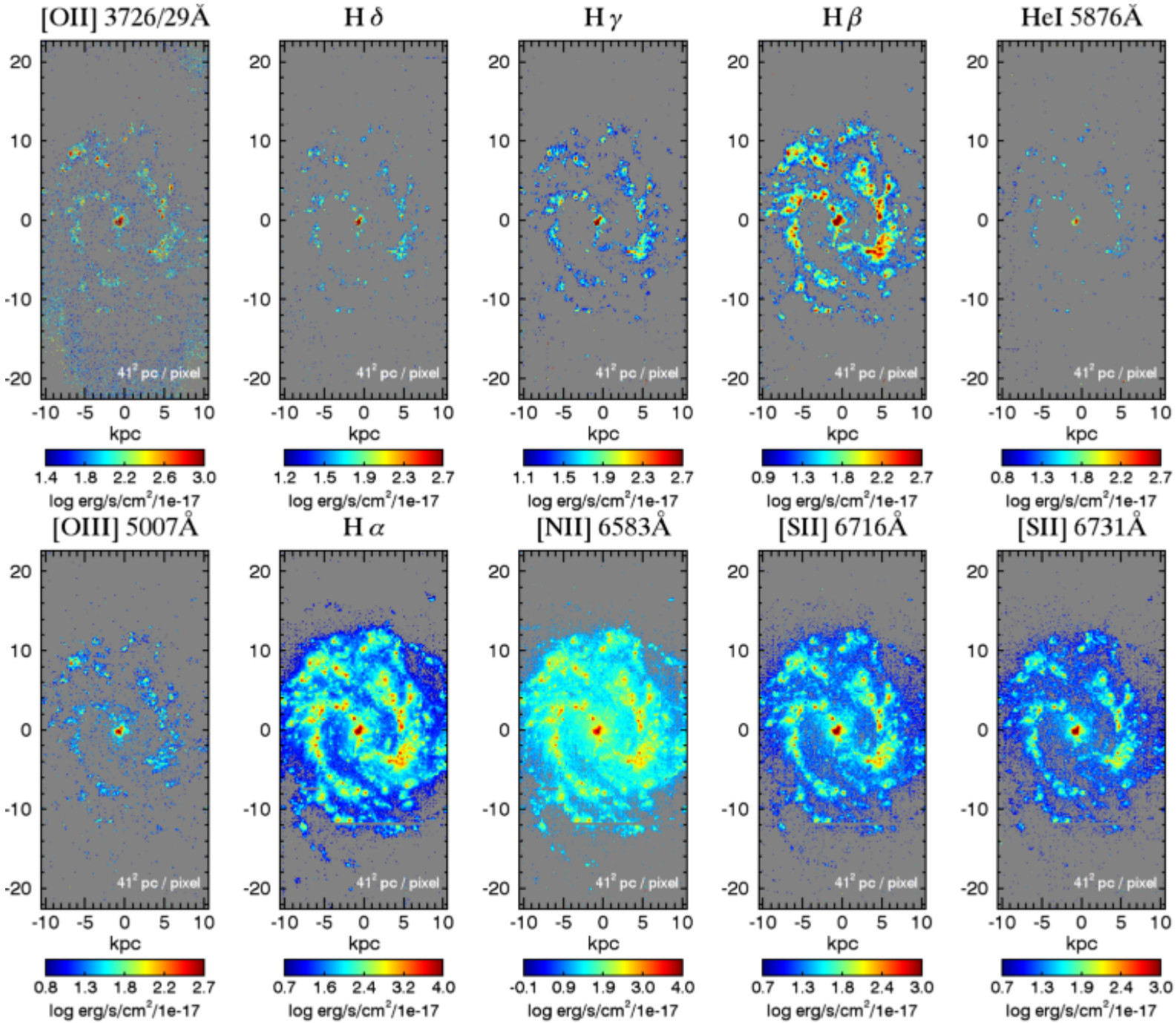



Hβ/NII/Hα
OII/SII/Hα

M83 Current State



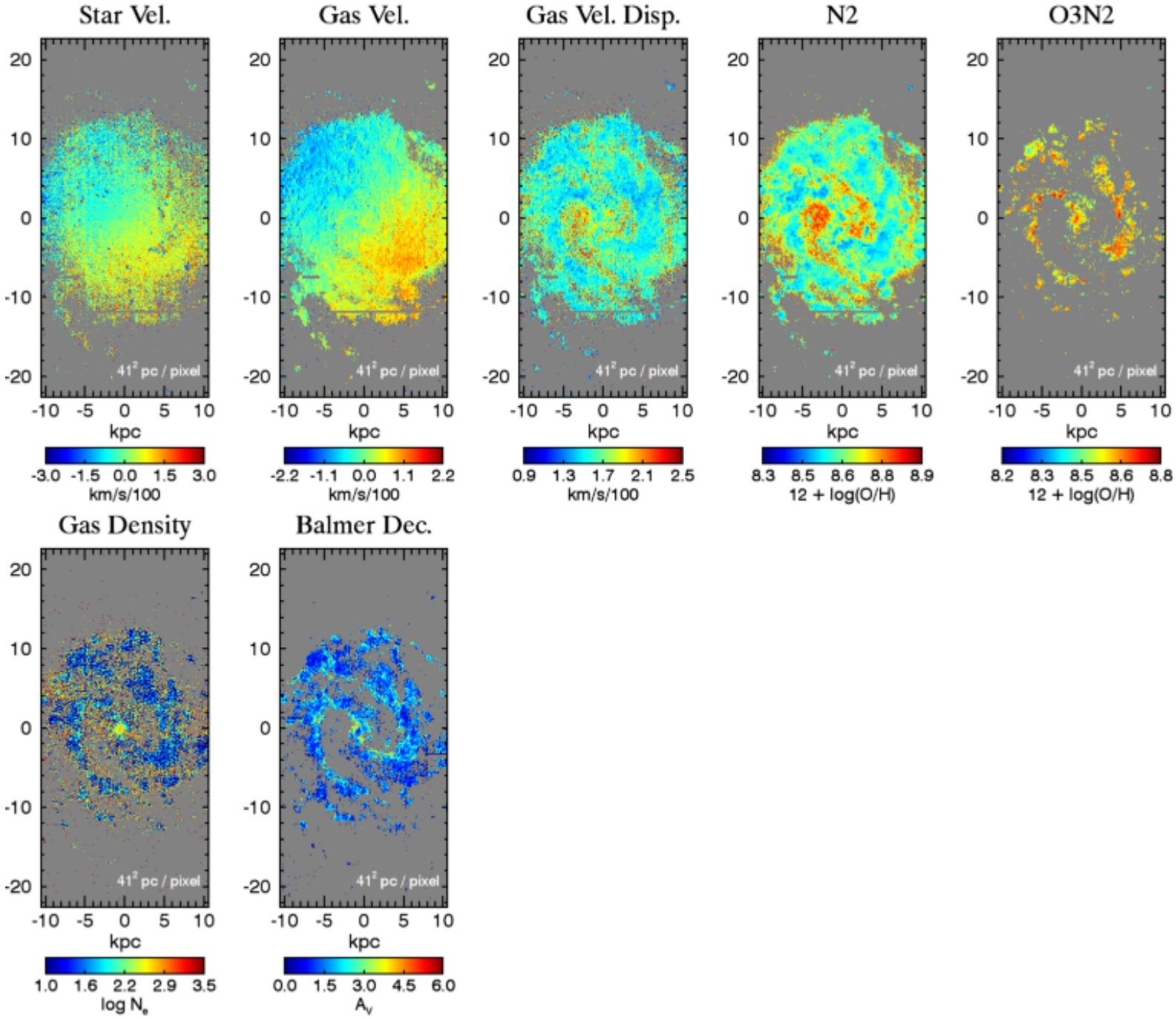
I-Ting Ho / LZIFU



61,000 spectra

41x41 pc resolution

I-Ting Ho / LZIFU



61,000 spectra

41x41 pc resolution

Science

just beginning

Kewley et al 2006

SDSS Sample:

- DR4
- S/N > 3 in H_beta, [OIII]5007, H_alpha, [NII]6584, [SII]6717
- Redshift between 0.04< z < 0.1

--> 85,224 galaxies!

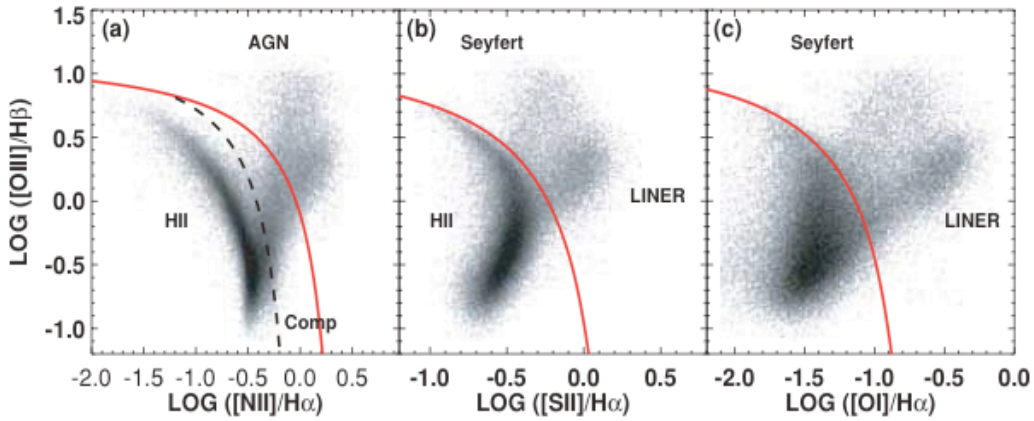


Figure 1. (a) The [N II]/Hα versus [O III]/Hβ diagnostic diagram for SDSS galaxies with S/N > 3. The Ke01 extreme starburst line and the Ka03 classification line are shown as the solid and dashed lines, respectively. (b) The [S II]/Hα versus [O III]/Hβ diagnostic diagram; (c) the [O I]/Hα versus [O III]/Hβ diagnostic diagram.

Blanc et al. 2009

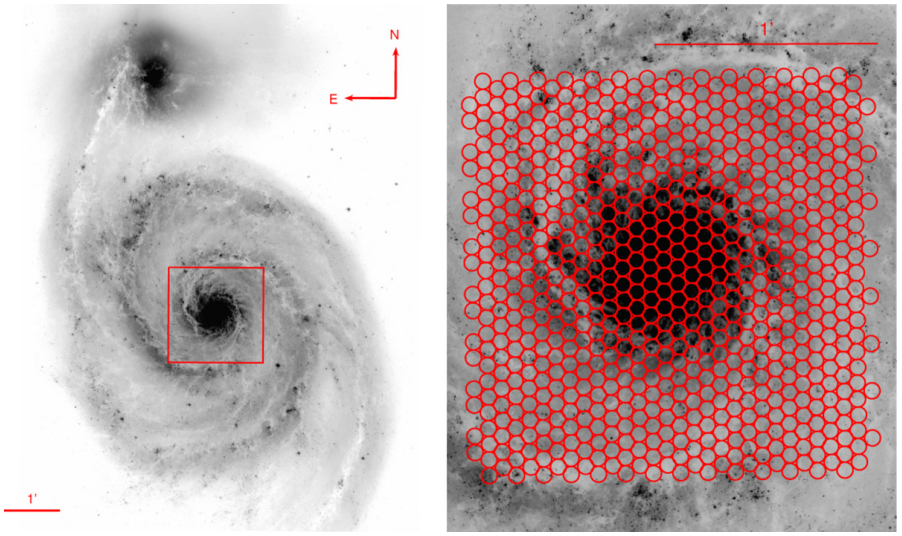


Figure 1. Left: *HST*+ACS *V*-band image of NGC5194 and its companion NGC 5195 (Mutchler et al. 2005). The central 4.1 × 4.1 kpc^2 region sampled by the 1.′7 × 1.′7 VIRUS-P field of view is marked in red. Right: map of the 738 regions sampled by VIRUS-P in the three dither positions. Each region has a diameter of 4.″3 corresponding to ∼170 pc at the distance of NGC5194.
(A color version of this figure is available in the online journal.)

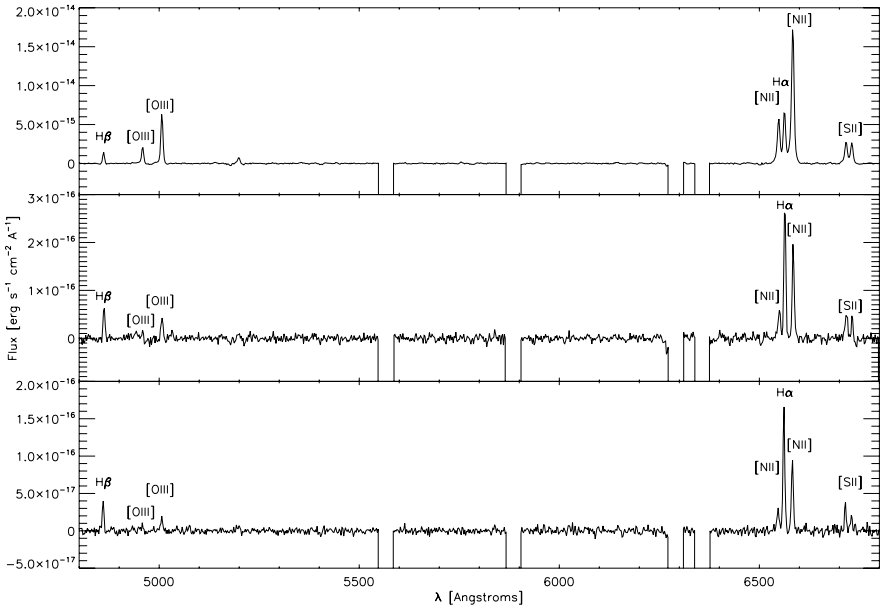


Figure 4. Nebular emission spectrum of the same regions shown in Figure 3, obtained by subtracting the best-fitted linear combination of stellar templates from the observed spectrum. Masked parts of the spectra correspond to the regions around strong night sky emission lines showing background subtraction residuals.

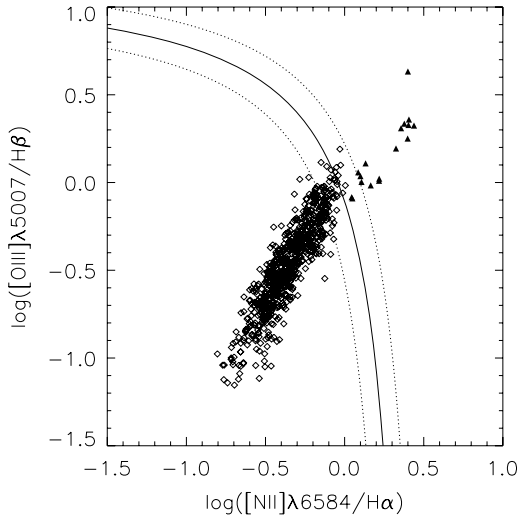
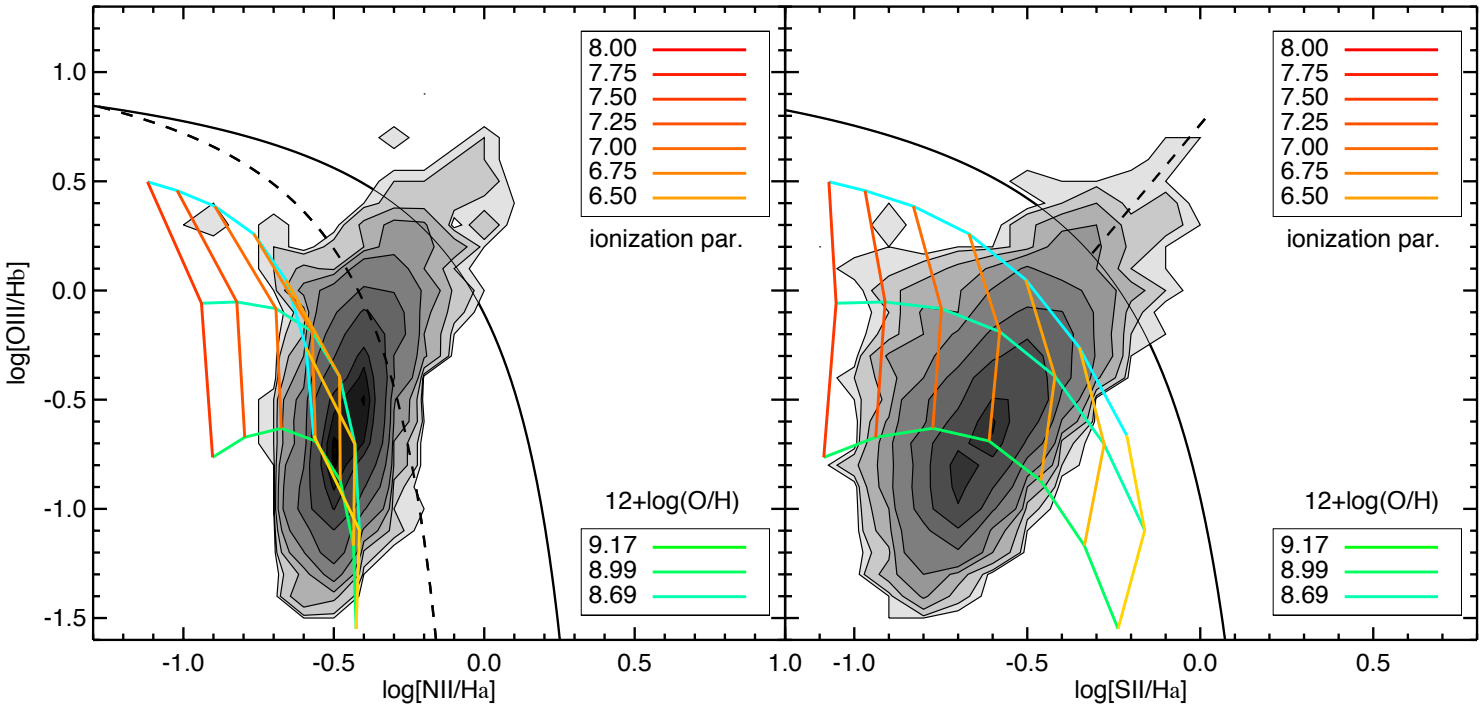


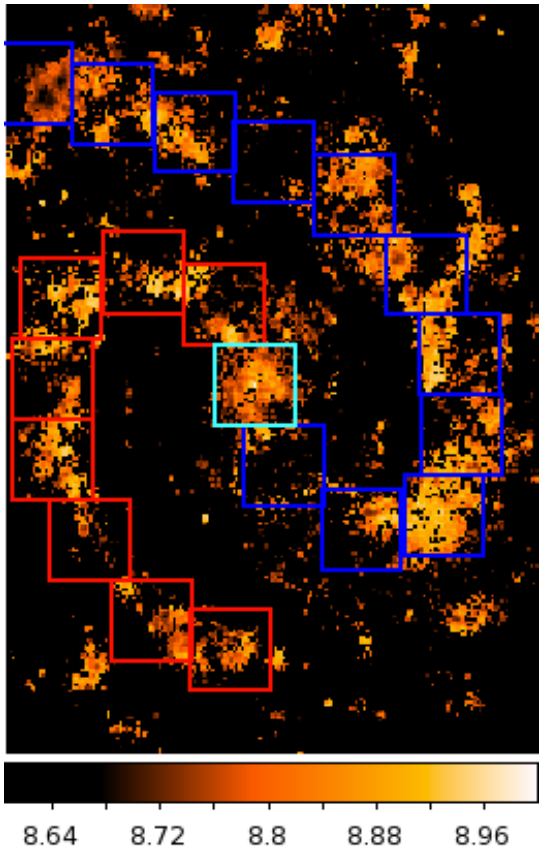
Figure 6. [N II]λ6584/Hα vs. [O III]λ5007/Hβ line ratio for the 735 regions. The solid line marks the theoretical threshold of Kewley et al. (2001) separating AGNs from star-forming galaxies. Dotted lines mark the ±0.1 dex uncertainty in the threshold modeling. The 17 regions above the threshold and having angular distances to the galaxy nucleus of <15″ are flagged as "AGN affected" and are shown as filled triangles. Open diamonds show the 718 regions unaffected by AGN contamination used to construct the SFL.

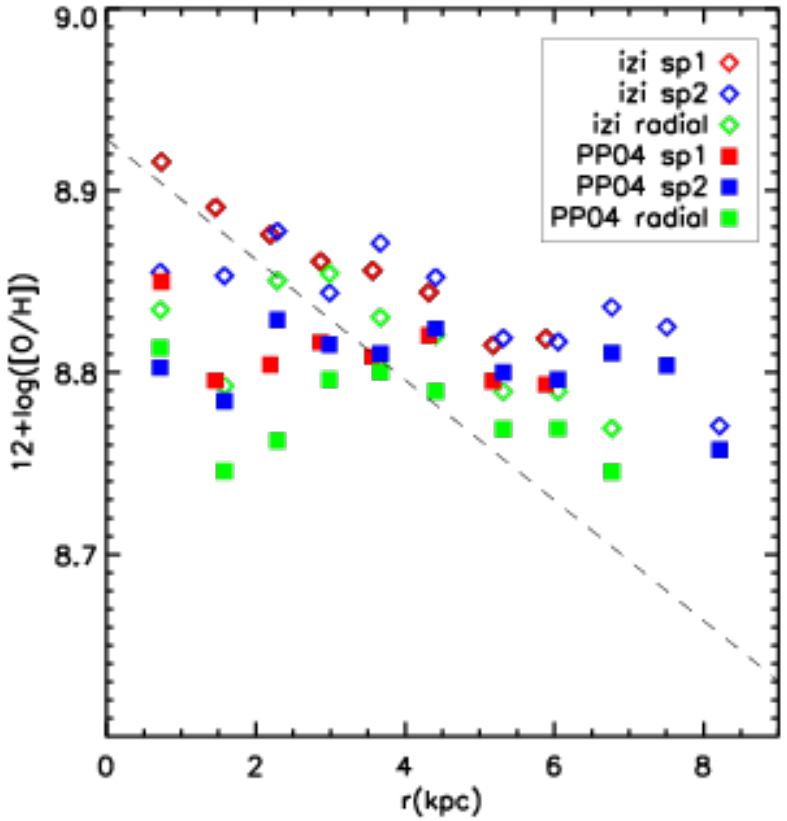
PrISM M83 Resolved BPT



J. Rich (in progress)

Metallicity w/IZI





J. Rich (in progress)

LCO Typhoon/PrISM Survey Sample Definition

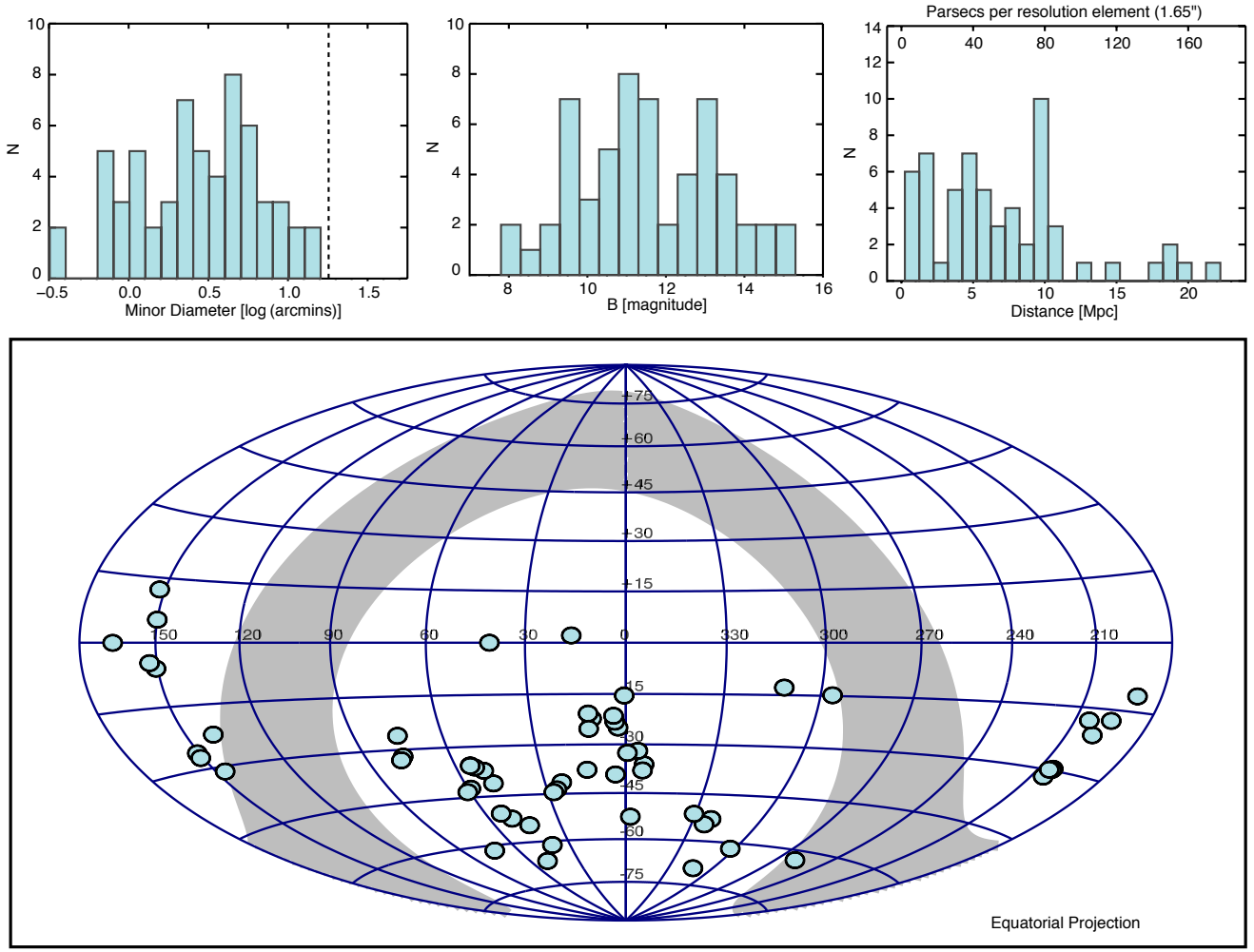


Table 2. Comparison of current integral field spectroscopy surveys

	PrISM	MaNGA	CALIFA	SAMI	ATLAS3D
Technique	LSS[a]	Fiber	Fiber	Fiber	Lenslets
Redshift range (z)	$\leq$0.005	$\sim$0.03	0.005 – 0.03	$\leq$ 0.05	$\leq$0.01
Field of view	18′ $\times$ 1.65″	12″ – 32″	74″ $\times$ 64″	14.9″ $\times$ 14.9″	33″ $\times$ 41″
Spaxel size	1.65″	2″	2.7″	1.6″	0.94″
Filling factor (%)	100	54	60	75	100
Spectral range (Å)	3650–9000	3600–10000	3700 – 5000[b]	3700 – 5800[b]	4810 – 5350
			4300 – 7000[c]	6300 – 7400[c]	
Spectral res. (R)	800	2000	1650[b]/850[c]	1750[b]/4500[c]	1300
Physical res. (pc spaxel^{-1})	$\sim$50	$\sim$1500	$\sim$400	$\sim$1000	$\sim$300

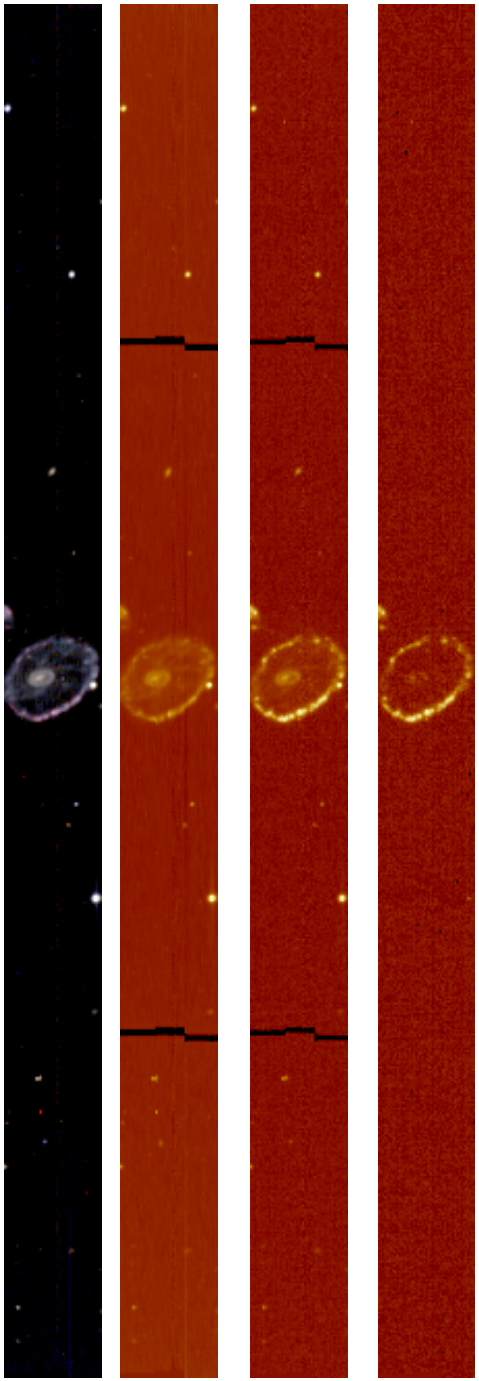
Note. — (a) LSS — Long Slit Stepping, (b) blue side, (c) red side.

Survey Targets

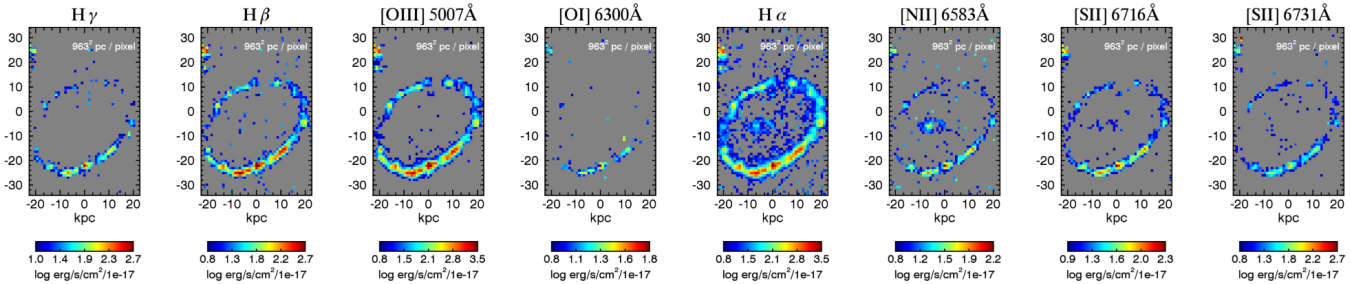
Target	Type	Major Axis arcmin	Minor Axis arcmin	B_{Total} mag	Distance Mpc	Resolution pc spaxel^{-1}	No. Steps	% Completed
WLM	IB	10.5	3.5	11.0	0.92	7.4	129	
NGC 24	Sc	6.2	2.4	12.1	8.13	64.9	87	
NGC 45	SABd	6.2	4.5	11.4	7.07	56.5	162	
NGC 55	SBm	30.2	3.1	8.5	2.17	17.3	112	
NGC 59	E-SO	2.4	1.3	13.1	5.30	42.3	45	
IC 1574	IB	1.8	0.7	14.5	4.92	39.3	25	
NGC 247	SABc	19.5	5.5	9.7	3.65	29.2	199	
NGC 253	SABc	26.9	4.6	7.9	3.94	31.5	166	38
NGC 300	Scd	19.5	12.9	8.8	2.00	16.0	468	100
IC 1613	I	12.9	12.0	10.1	0.65	5.2	437	
NGC 625	SBm	6.6	2.1	11.6	4.07	32.5	75	50
ESO 245-G005	IB	3.2	3.1	12.8	4.43	35.4	112	
M77	Sb	6.2	5.6	9.7	12.65	100.9	204	31
ESO154-G023	SBm	4.8	1.1	12.8	5.76	46.0	40	50
NGC 1291	S0-a	11.2	10.0	9.4	9.37	74.8	363	
NGC 1313	SBcd	11.0	9.1	9.6	4.15	33.2	331	12
NGC 1311	SBm	3.7	0.9	13.4	5.45	43.5	33	
NGC 1316	S0	13.5	7.8	9.4	20.17	160.5	282	24
NGC 1365	Sb	12.0	6.2	10.4	18.15	144.5	224	75
NGC 1399	E	8.5	7.8	10.4	18.28	145.6	282	25
NGC 1404	E	5.0	4.4	10.9	19.09	152.0	158	34
NGC 1487	Scd	2.7	2.1	12.3	9.08	72.5	75	
NGC 1512	Sa	8.5	4.1	11.1	9.64	76.9	148	1
NGC 1744	SBcd	5.2	2.0	11.7	7.65	61.1	72	100
NGC 1800	Sd	1.6	1.1	13.1	8.24	65.8	41	100
UGCA 106	SABm	3.1	2.8	13.1	9.77	78.0	102	20
NGC 2835	Sc	6.5	3.7	11.1	10.91	87.0	135	88
NGC 2997	SABc	10.2	6.2	10.0	11.23	89.6	224	100
Sextans B	IB	4.9	3.0	11.9	1.44	11.5	109	24
NGC 3109	SBm	15.8	2.7	10.4	1.34	10.7	97	100
Sextans A	IB	5.4	4.8	12.3	1.32	10.6	174	58
NGC 3521	SABb	8.3	4.5	9.9	8.03	64.1	162	100
M104	Sa	8.5	5.0	9.1	9.33	74.5	182	8
UGCA 320	IB	6.8	1.1	13.5	7.24	57.8	41	
NGC 5068	Sc	7.4	6.6	10.6	6.24	49.8	240	85
LEDA 166170	I	4.7	1.9	0.0	4.68	37.4	70	
M83	Sc	13.5	13.2	7.8	4.47	35.7	479	75
NGC 5247	SABb	5.4	4.3	10.8	22.20	176.6	155	78
NGC 5253	Pec	5.0	2.1	10.8	3.15	25.2	77	90
NGC 5264	IB	3.0	2.2	12.6	4.53	36.2	79	
NGC 6300	SBb	5.4	3.4	11.0	14.40	114.8	123	80
NGC 6822	IB	11.8	11.8	9.4	0.56	4.5	427	100
IC 4951	SBd	3.1	0.7	14.0	9.35	74.6	25	
Aquarius dIrr	IB	2.1	1.1	14.0	0.94	7.5	38	
IC 5052	SBcd	7.1	1.3	11.7	5.87	46.9	47	
NGC 7064	SBc	3.7	0.7	12.7	9.87	78.8	25	
NGC 7090	Sc	8.1	1.6	11.3	10.40	83.0	58	
IC 5152	IAB	5.1	3.7	10.4	2.10	16.8	135	
IC 5332	SABc	6.0	5.8	11.3	9.53	76.1	209	
NGC 7713	Scd	4.9	2.1	11.5	9.28	74.1	77	
ESO 149-G003	IB	1.3	0.4	15.1	6.40	51.1	13	
NGC 7793	SAd	10.5	6.0	9.7	3.91	31.2	219	65

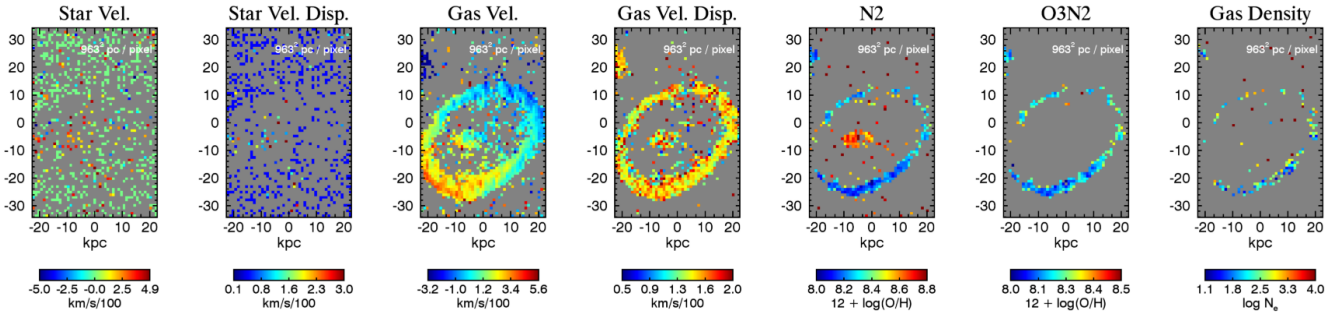
Status as of Nov. 2015

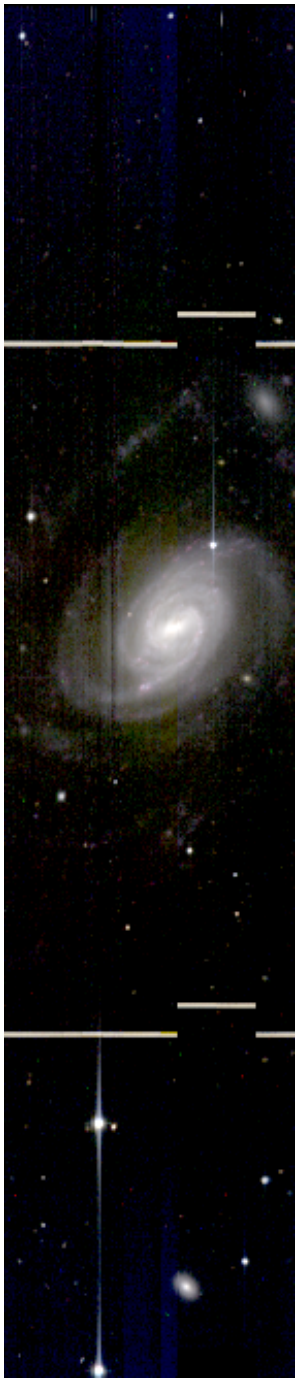
In Processes Data Examples

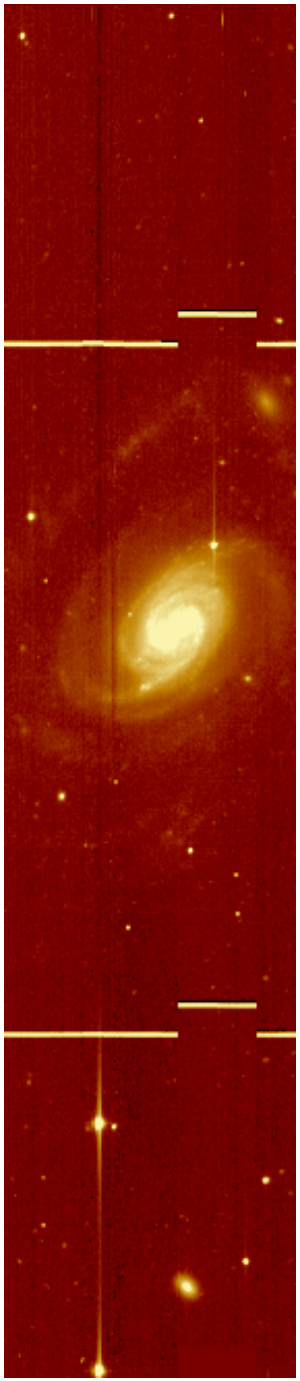


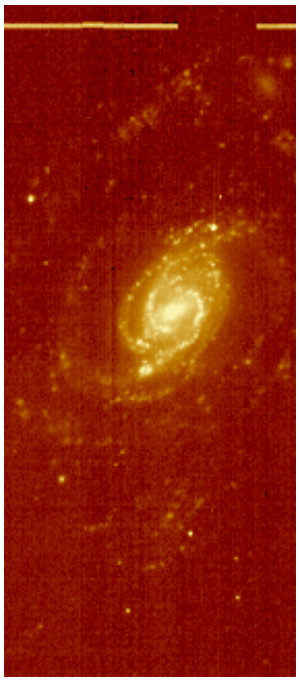
Cartwheel

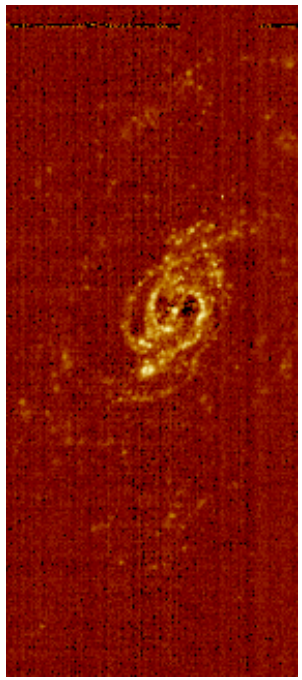

Hγ
Hβ
[OIII] 5007Å
[OI] 6300Å
Hα
[NII] 6583Å
[SII] 6716Å
[SII] 6731Å
963² pc / pixel
kpc
log erg/s/cm²/1e-17


Star Vel.
Star Vel. Disp.
Gas Vel.
Gas Vel. Disp.
N2
O3N2
Gas Density
963² pc / pixel
kpc
km/s/100
12 + log(O/H)
log N_e

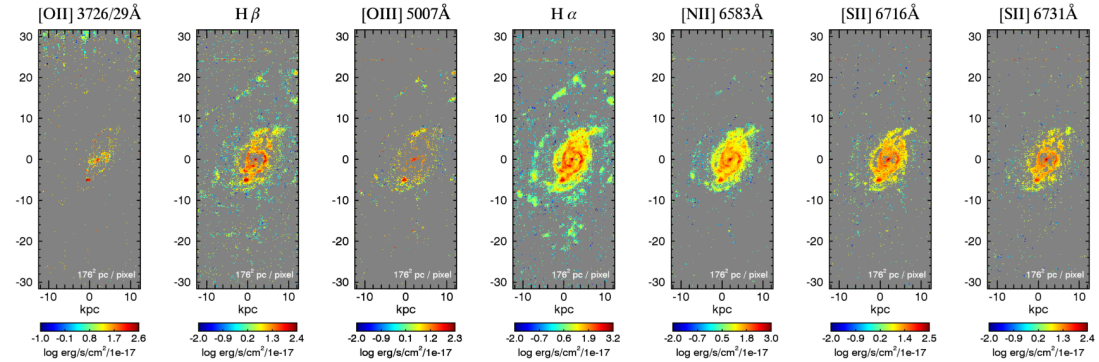








N289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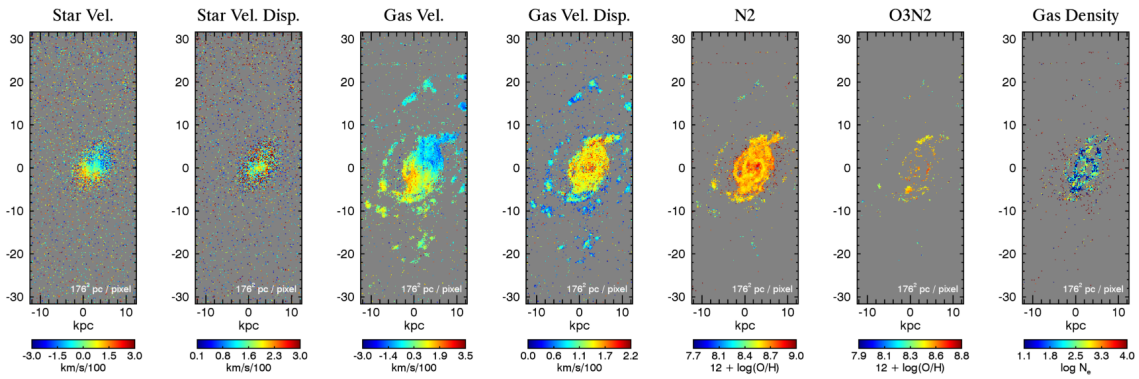
Star Vel.
Star Vel. Disp.
Gas Vel.
Gas Vel. Disp.
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O3N2
Gas Density
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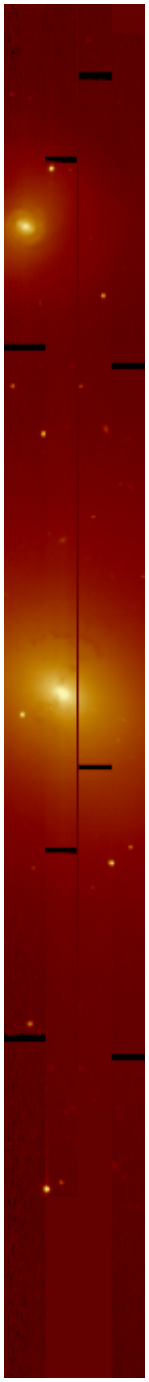
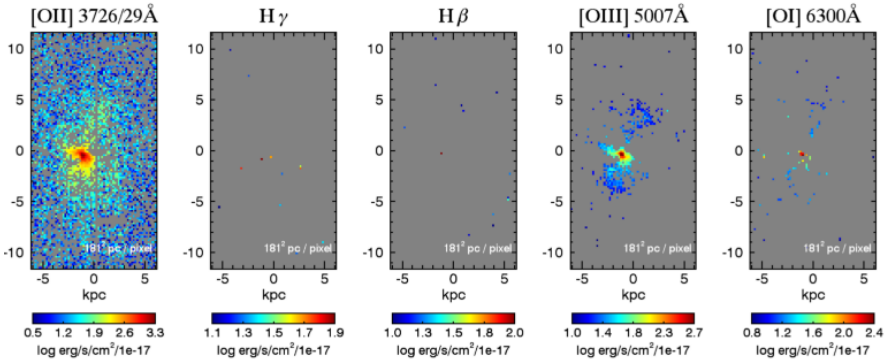
km/s/100
12 + log(O/H)
log N_e

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Hγ
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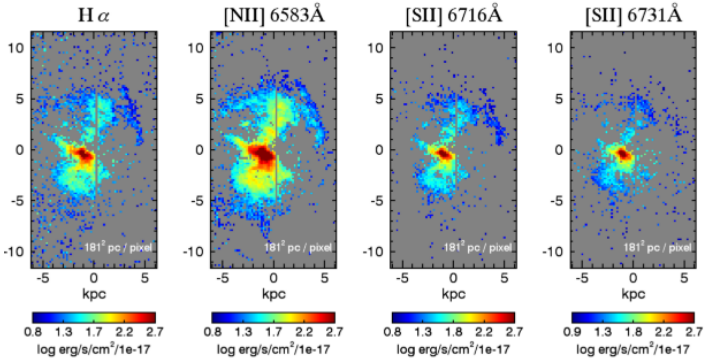
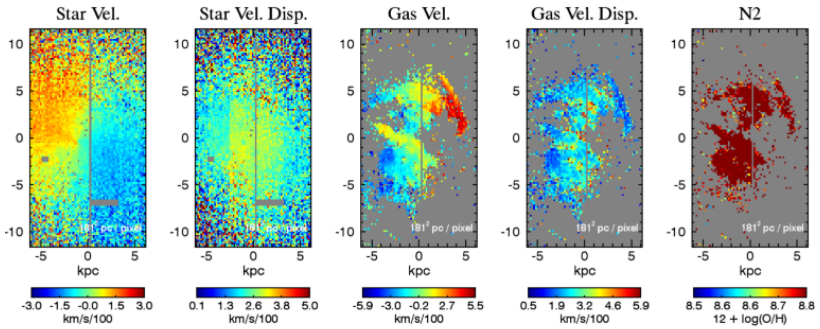
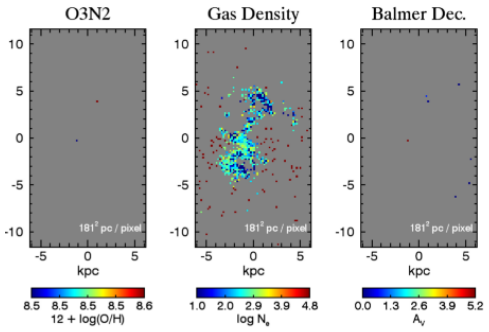
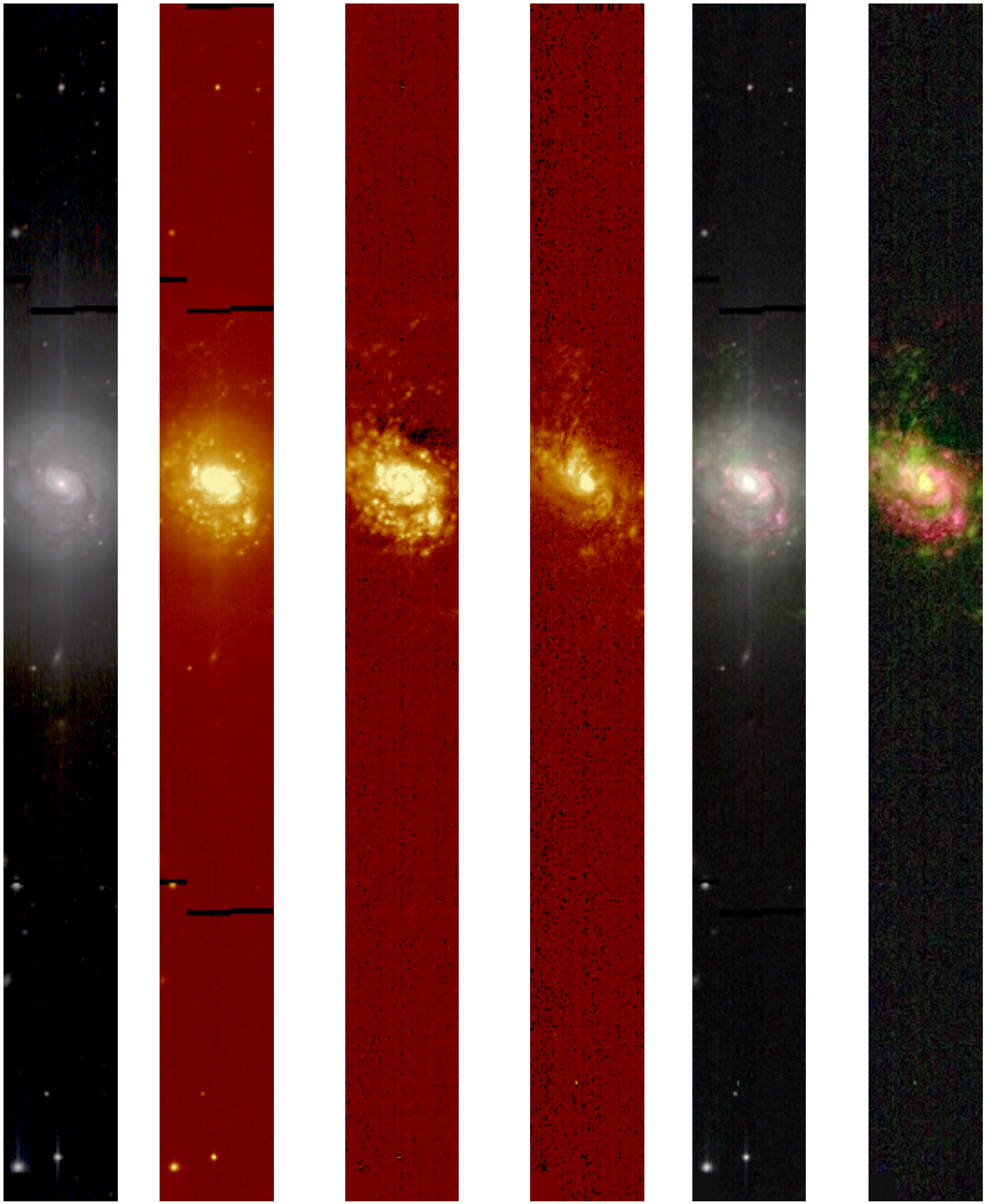
kpc
log erg/s/cm²/1e-17


Hα
[NII] 6583Å
[SII] 6716Å
[SII] 6731Å
kpc
log erg/s/cm²/1e-17

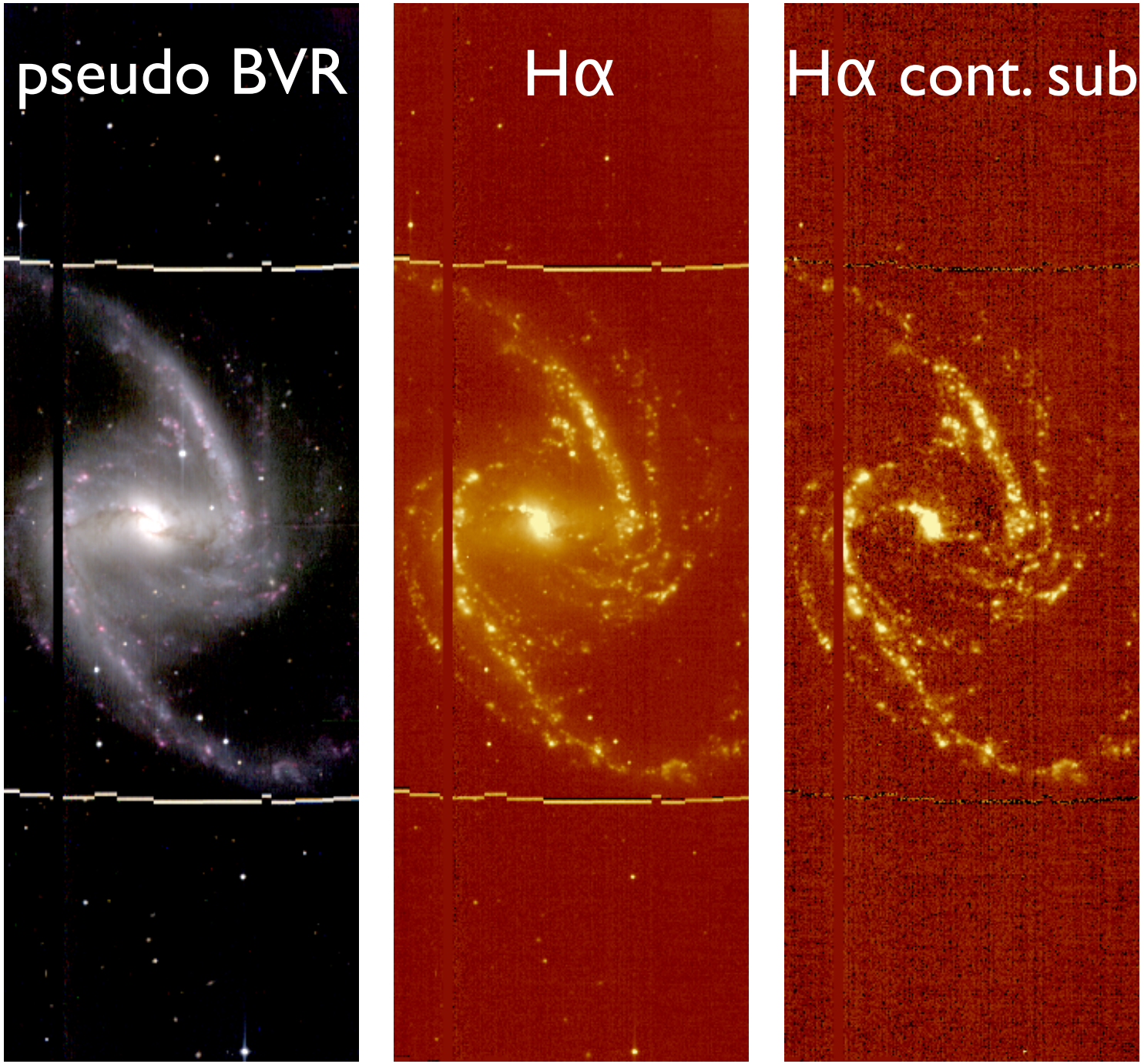
N1316/17


Star Vel.
Star Vel. Disp.
Gas Vel.
Gas Vel. Disp.
N2
kpc
km/s/100
12 + log(O/H)

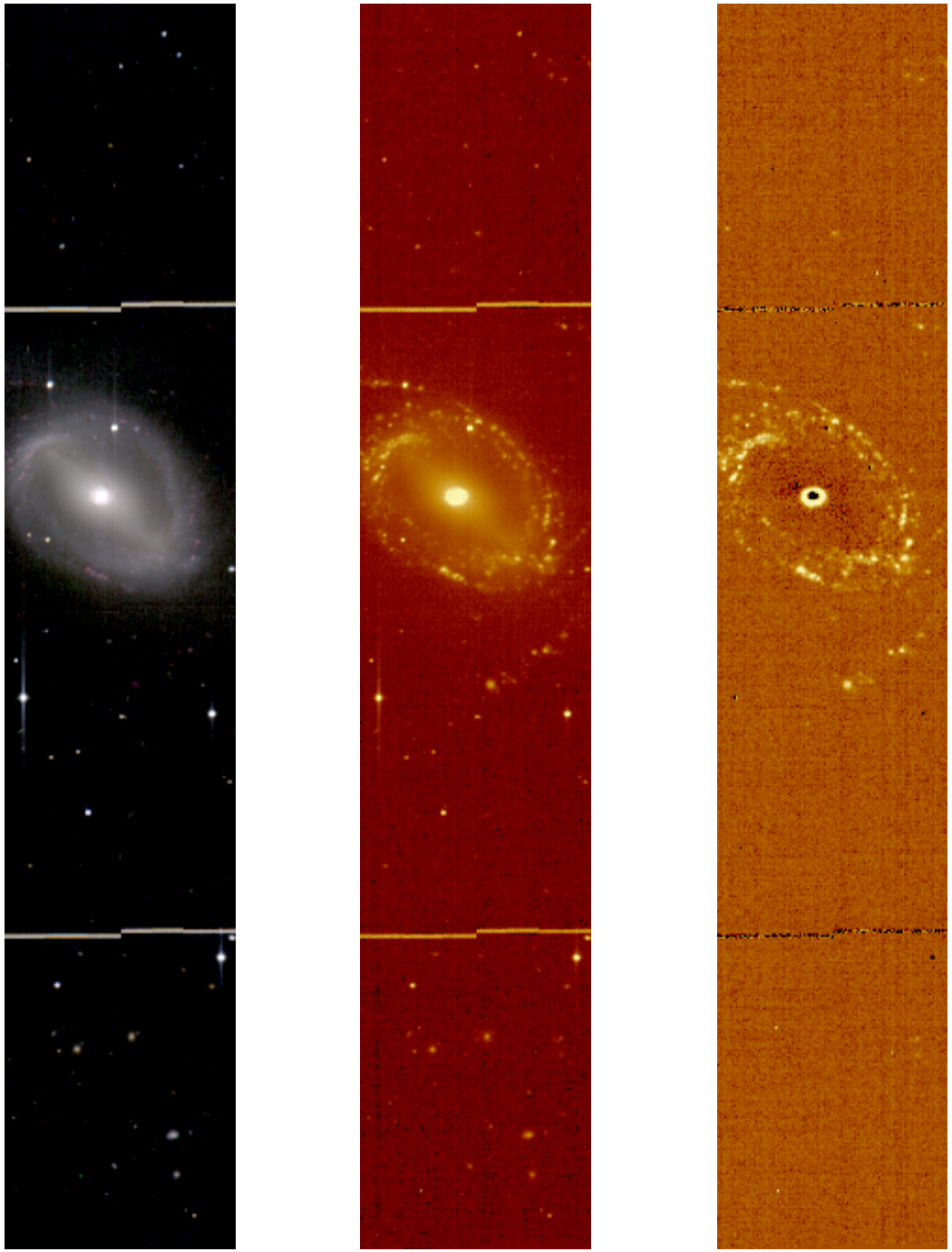

O3N2
Gas Density
Balmer Dec.
kpc
12 + log(O/H)
log N_e
A_V



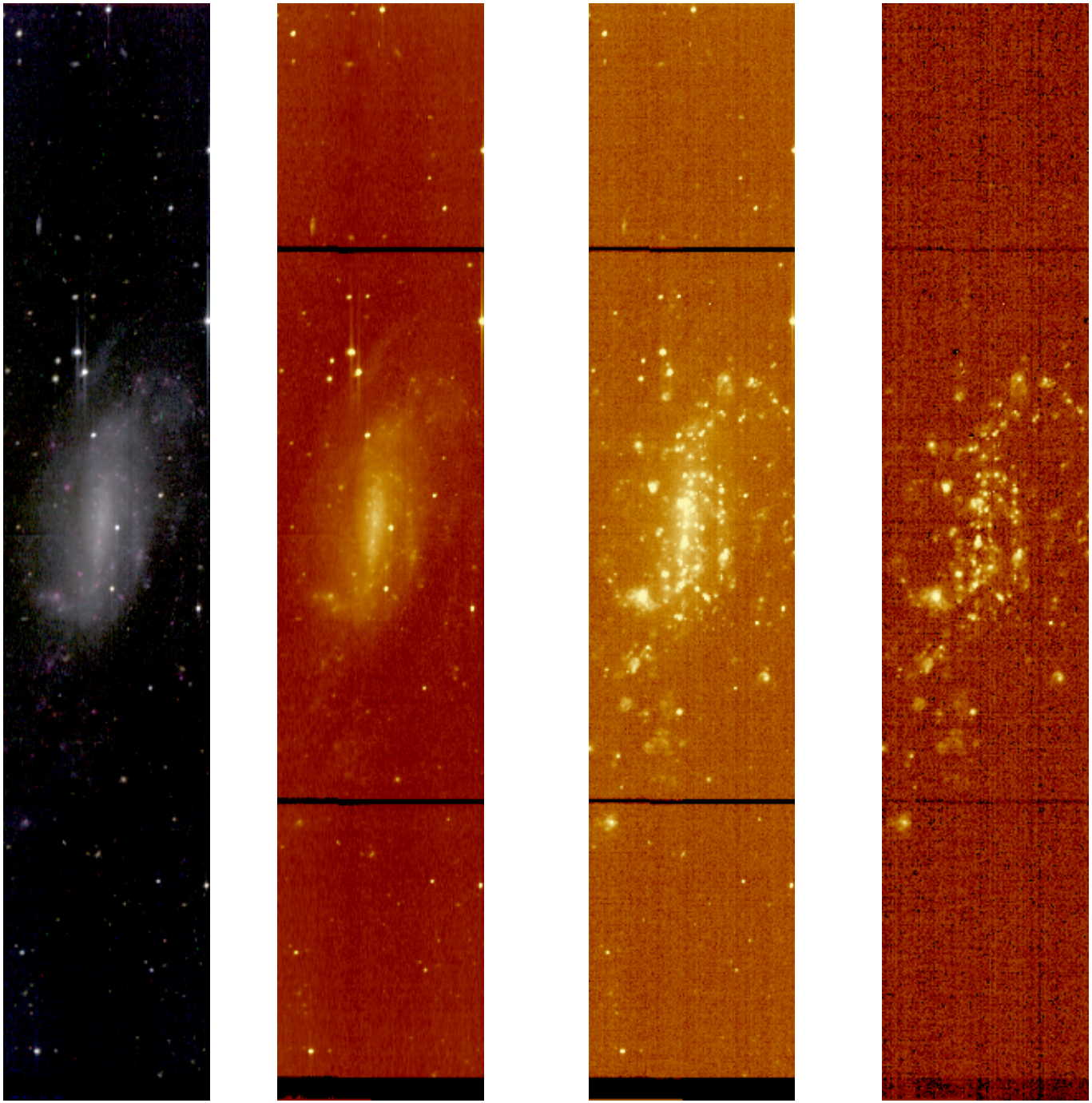
N1068



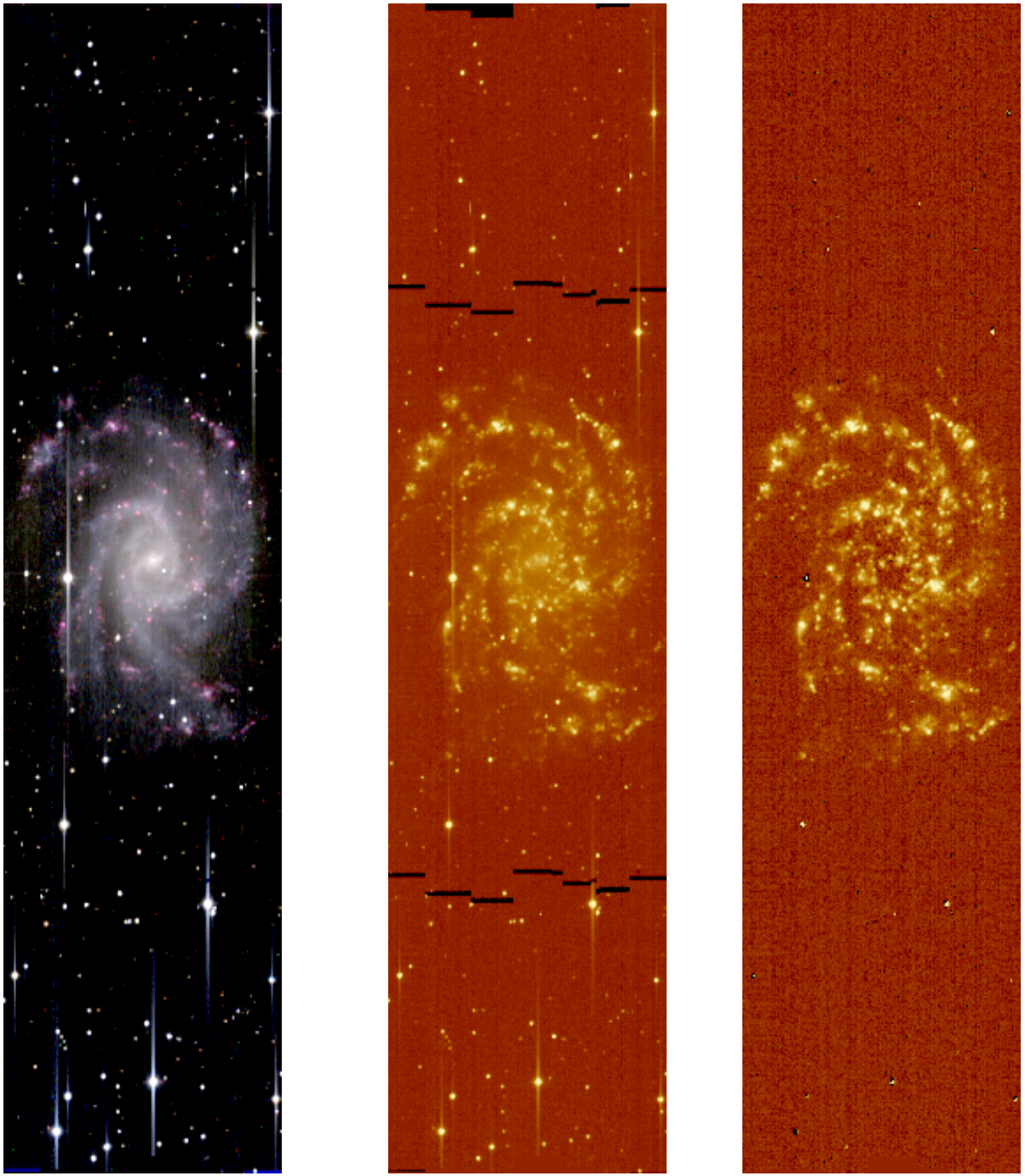
N1365



N1512

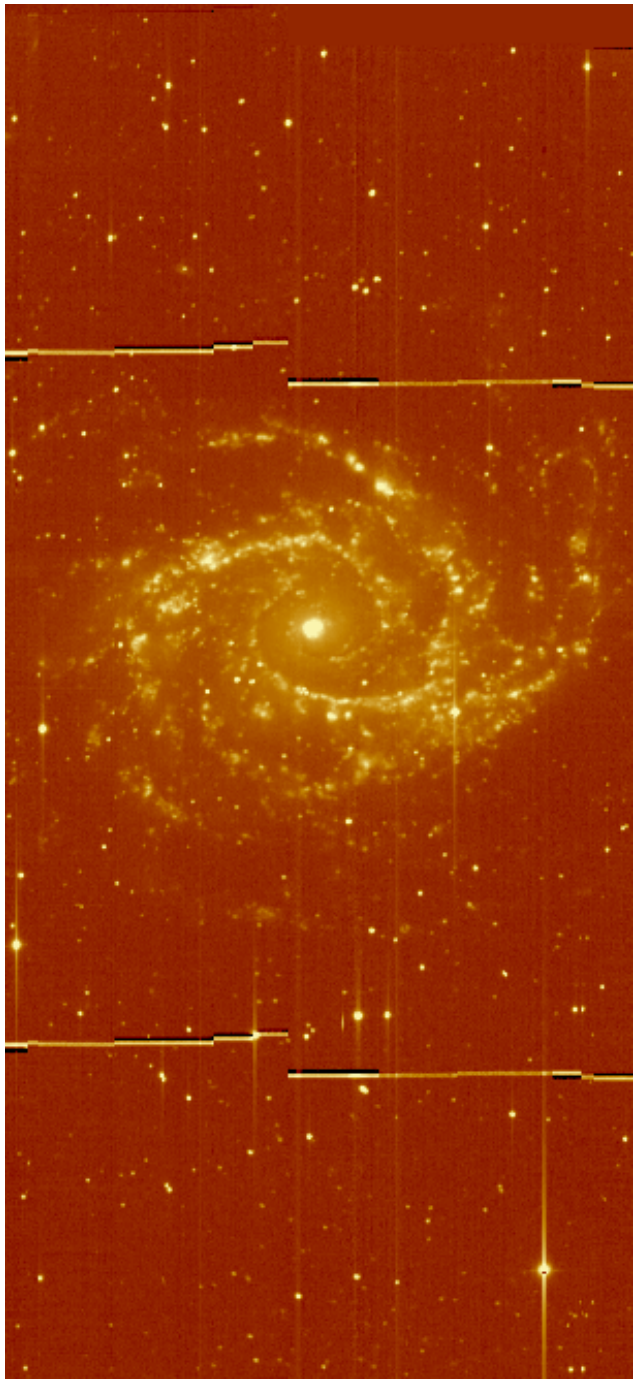


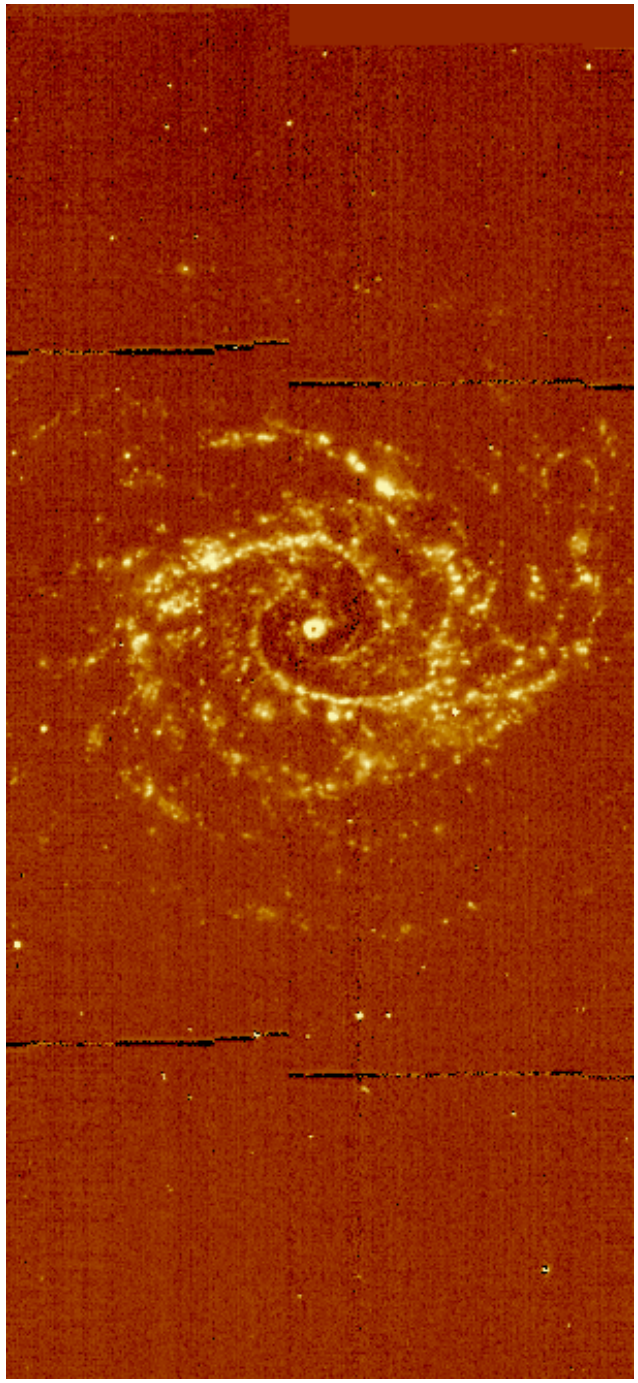
N1744



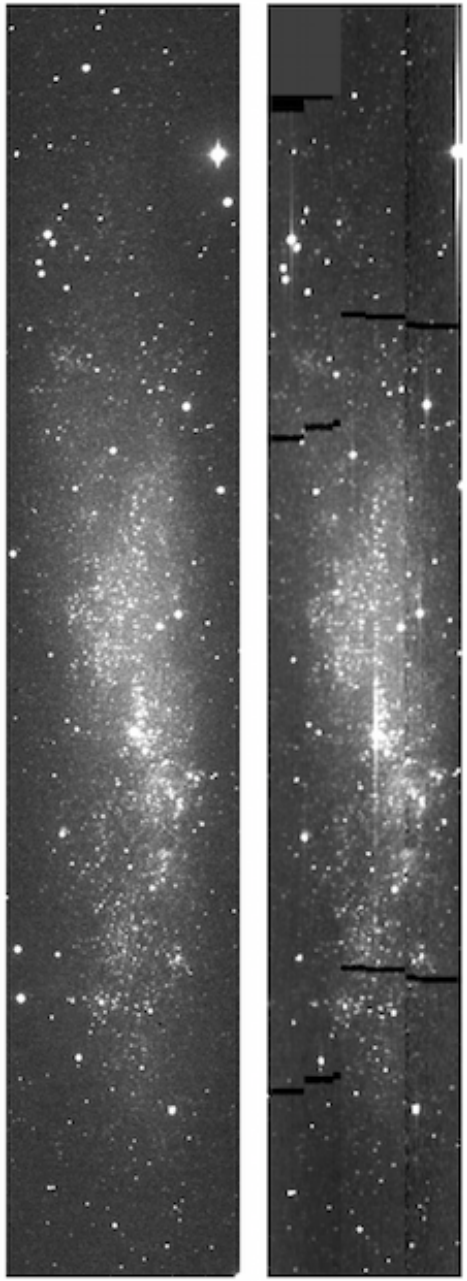
N2835

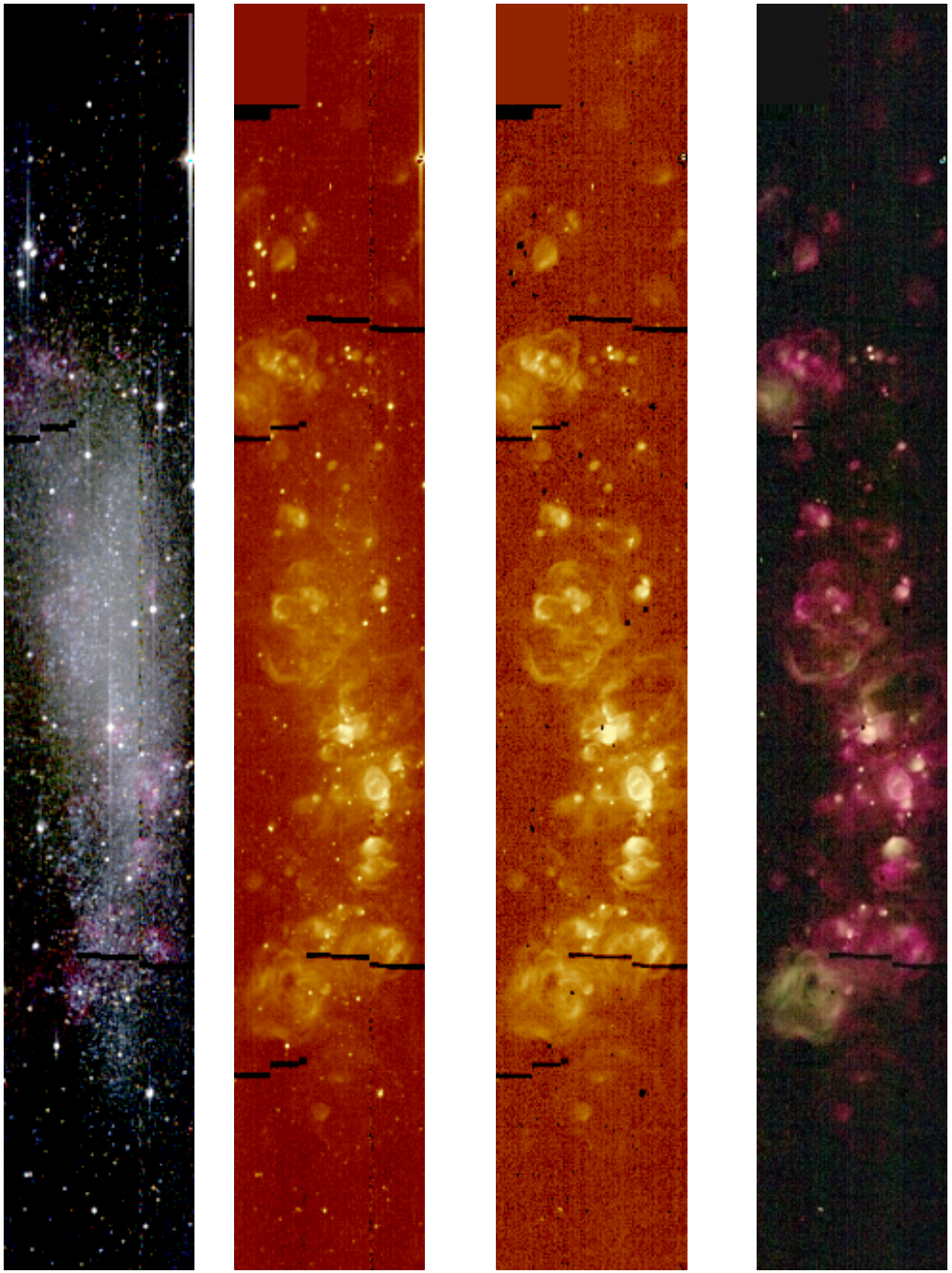
N2997



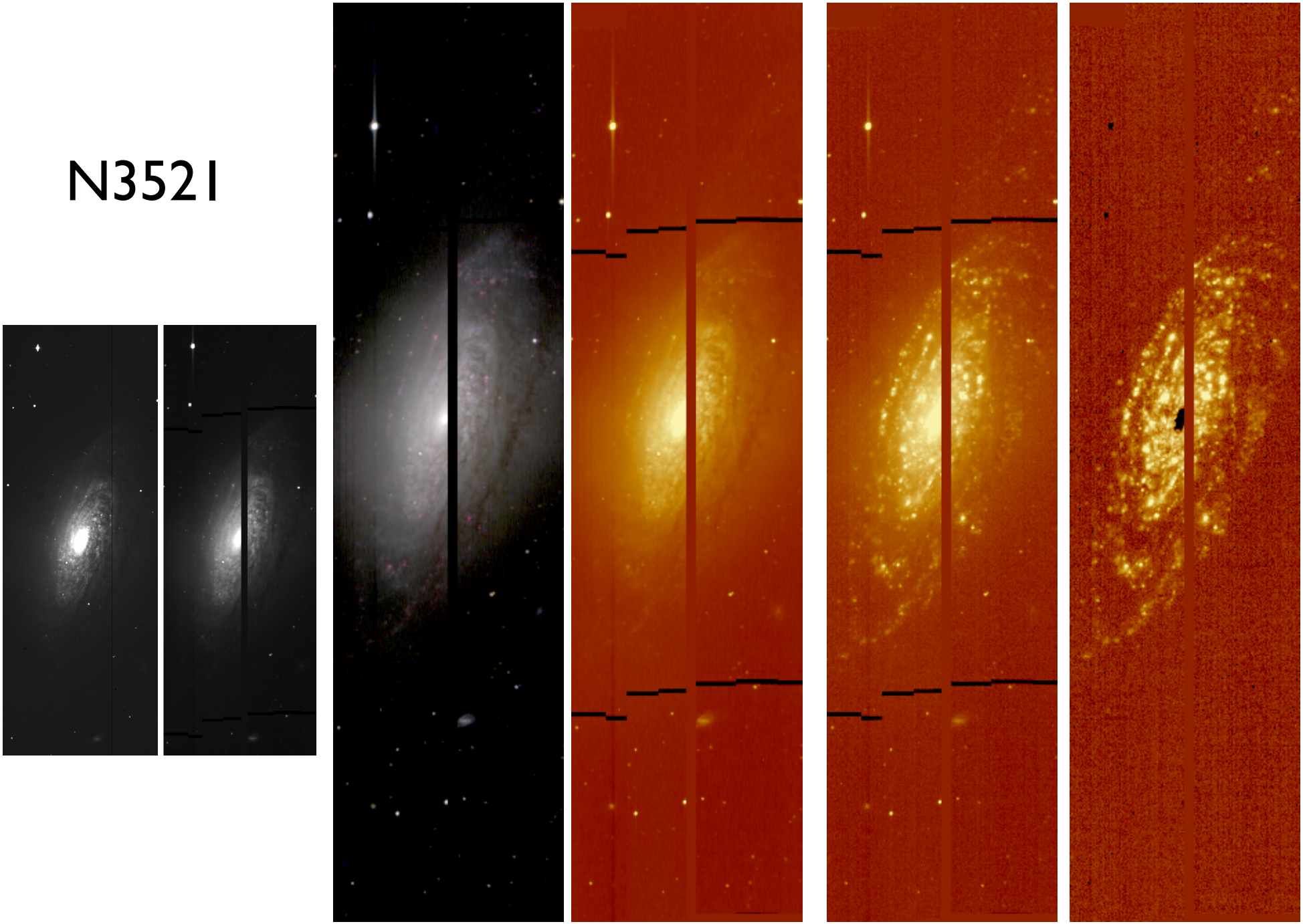


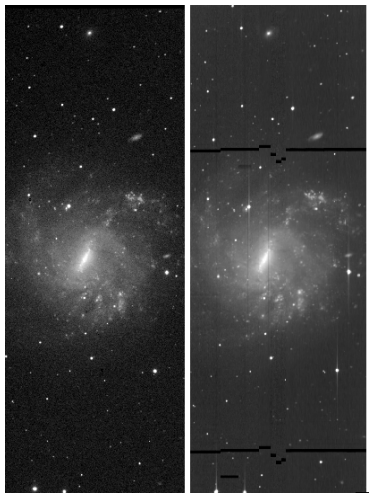
N3109



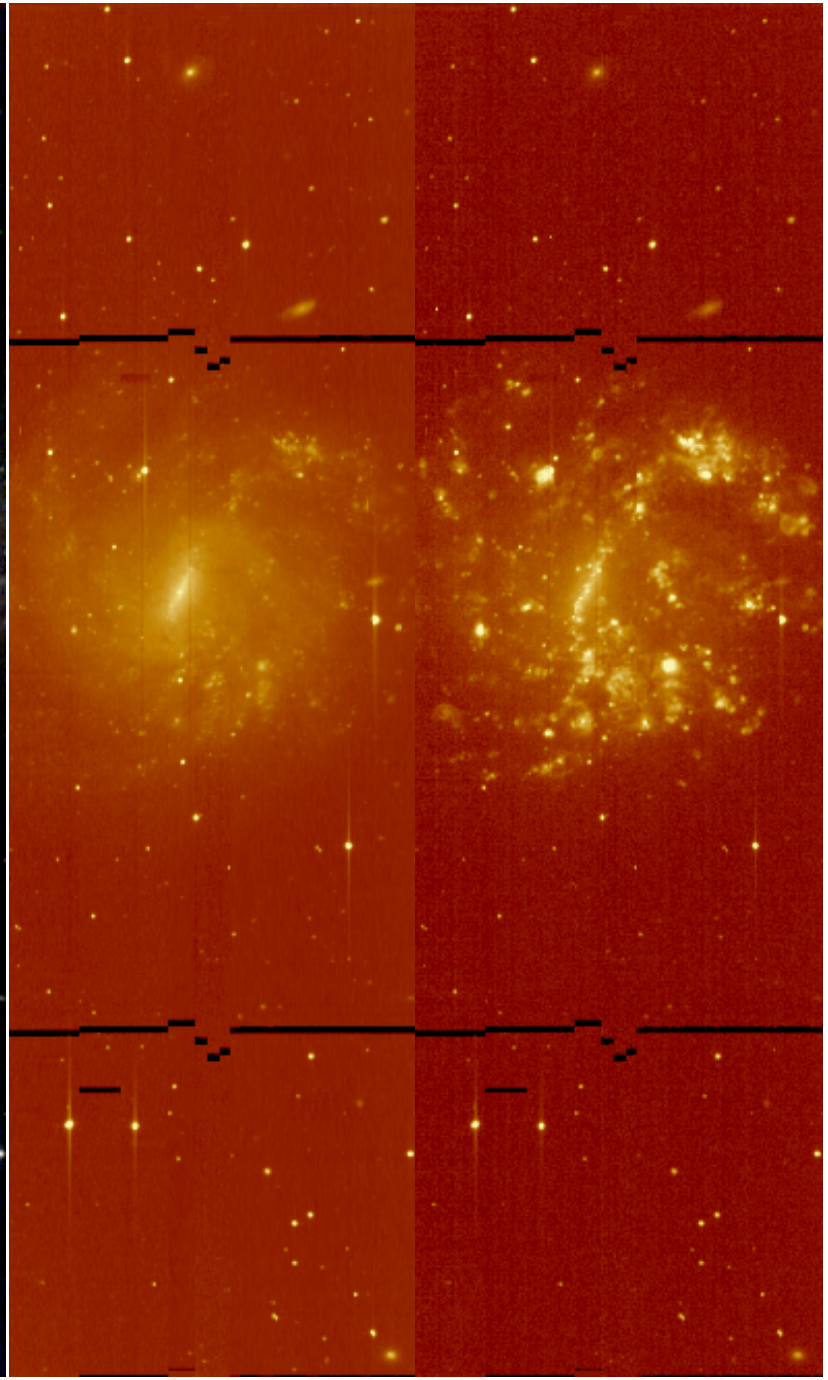


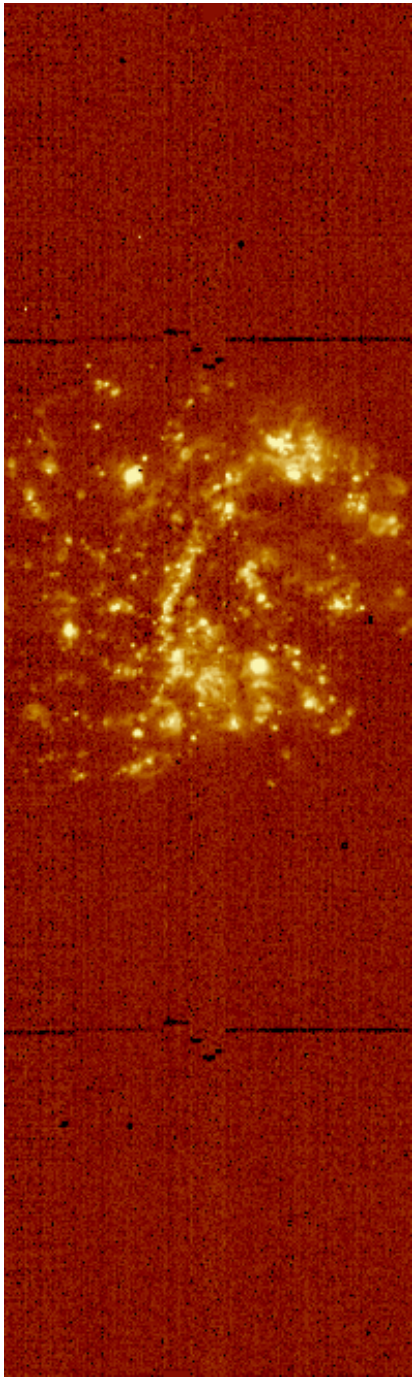
N3521



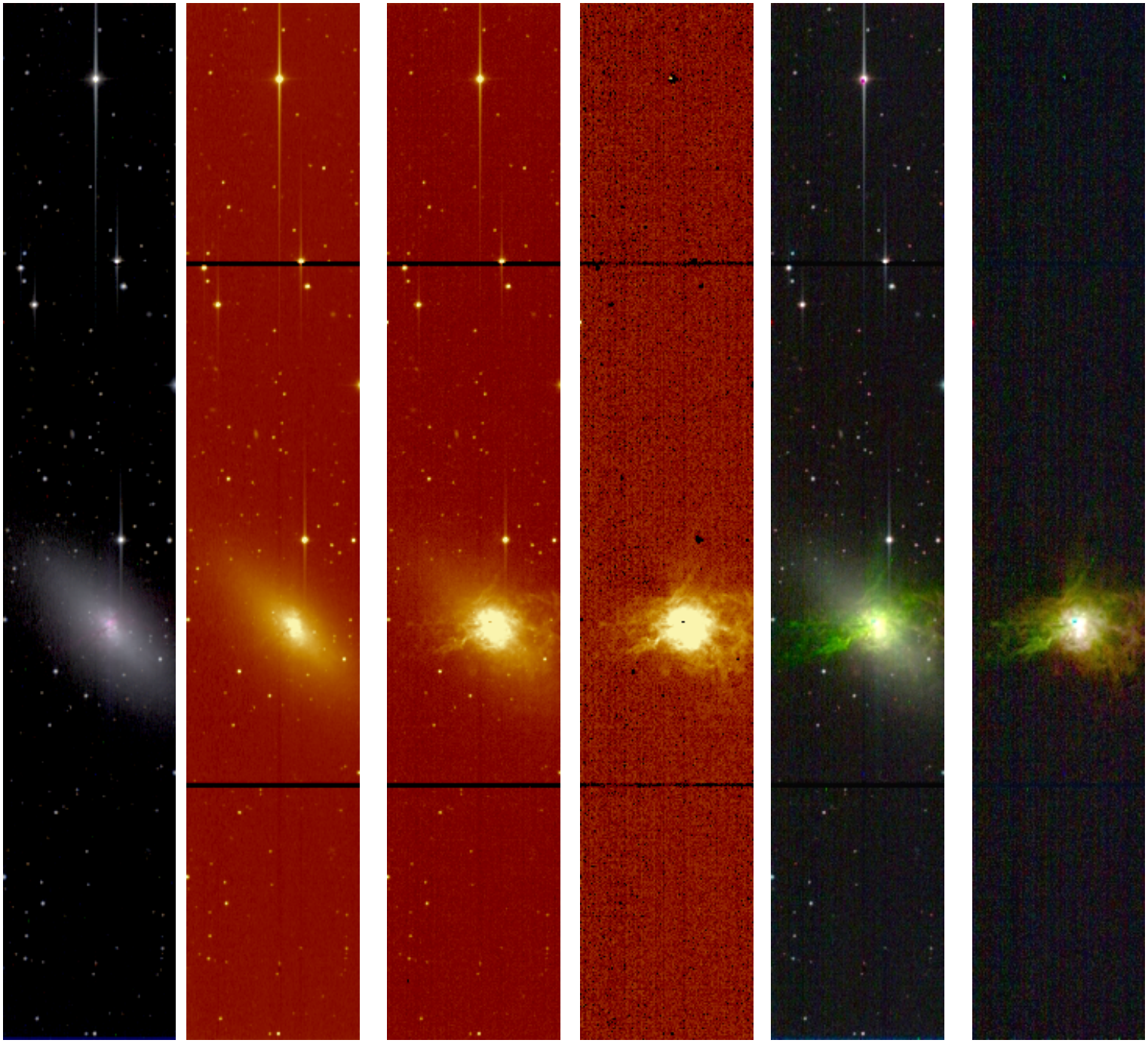


N5068

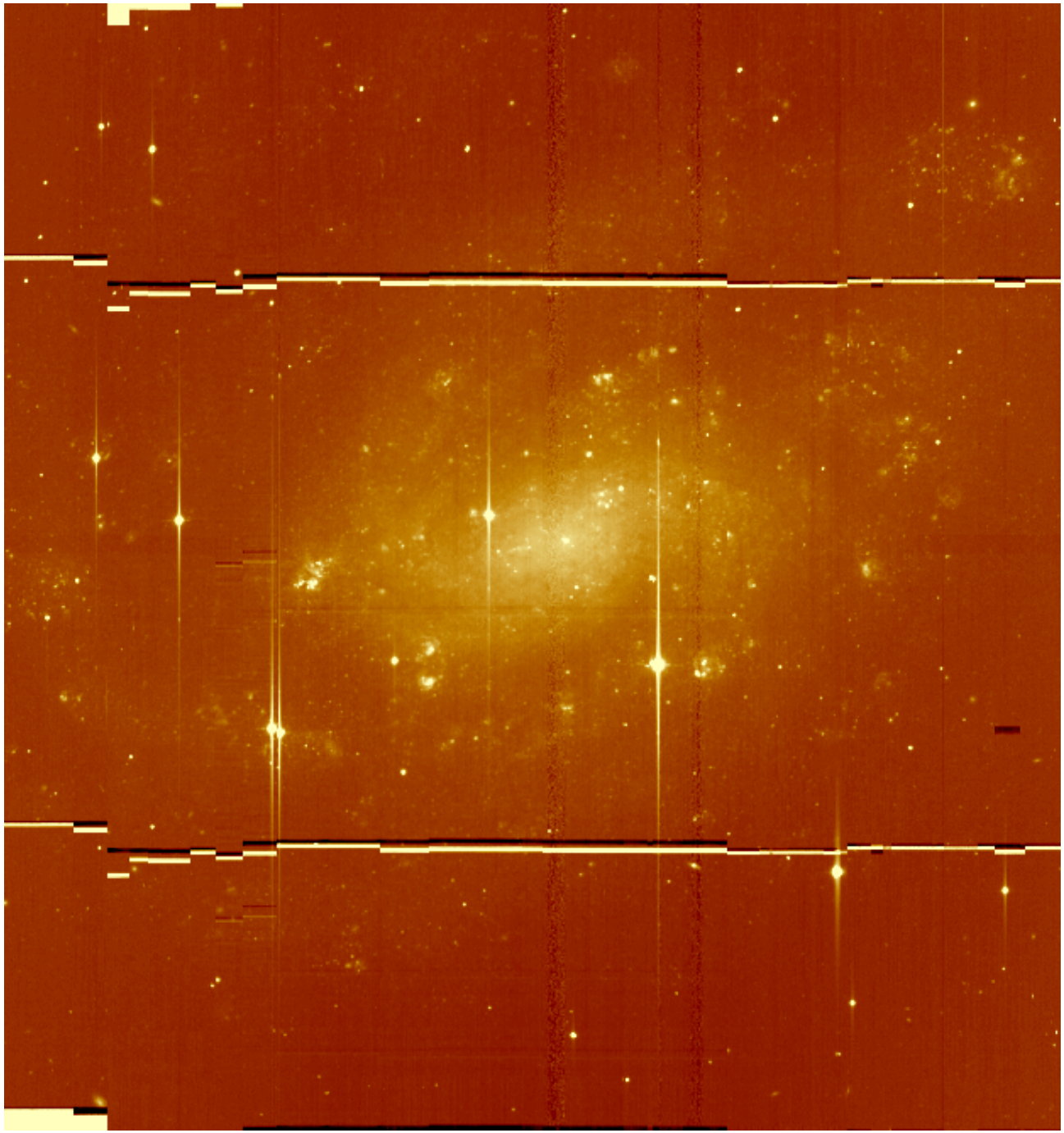




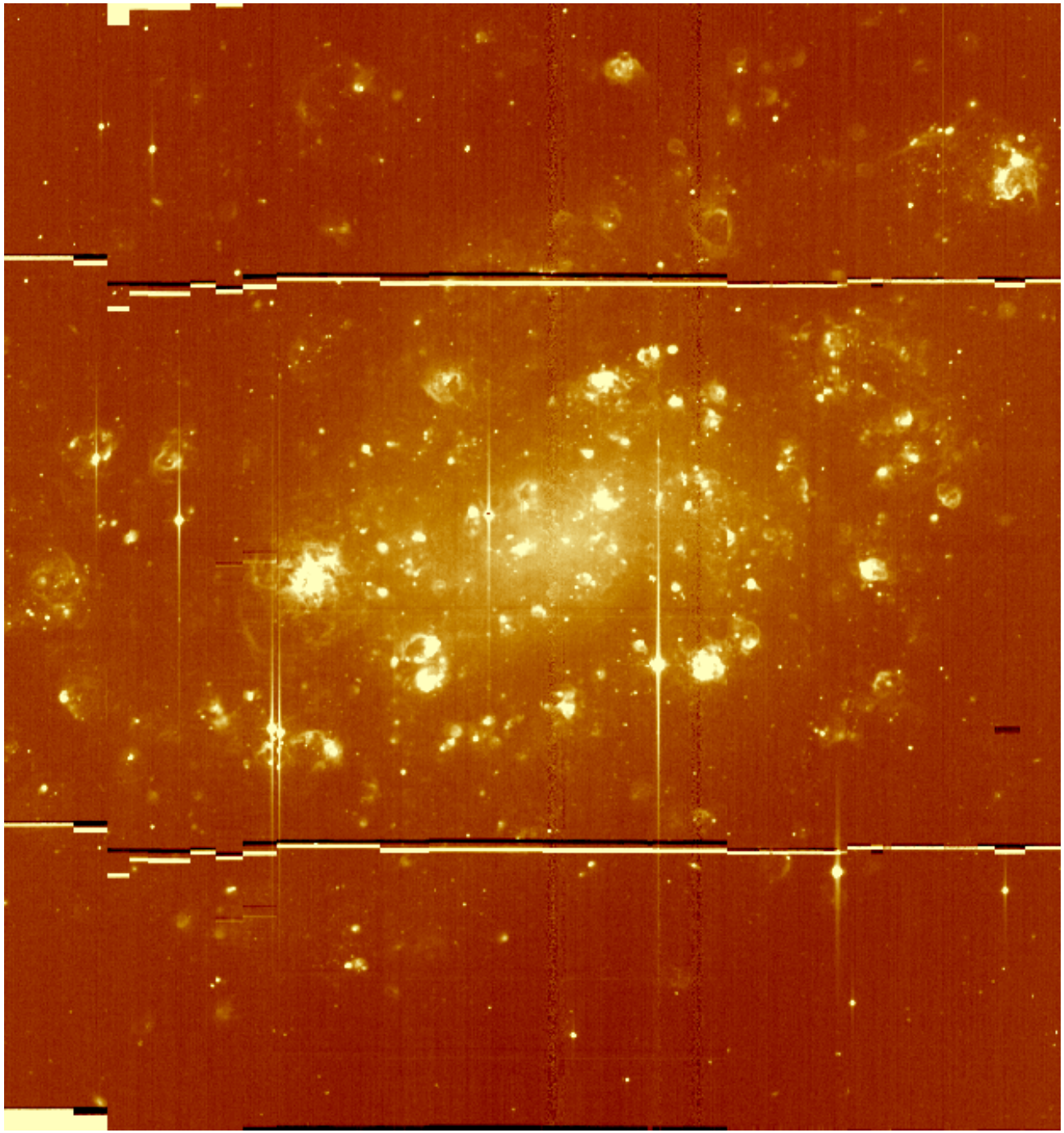
N5253



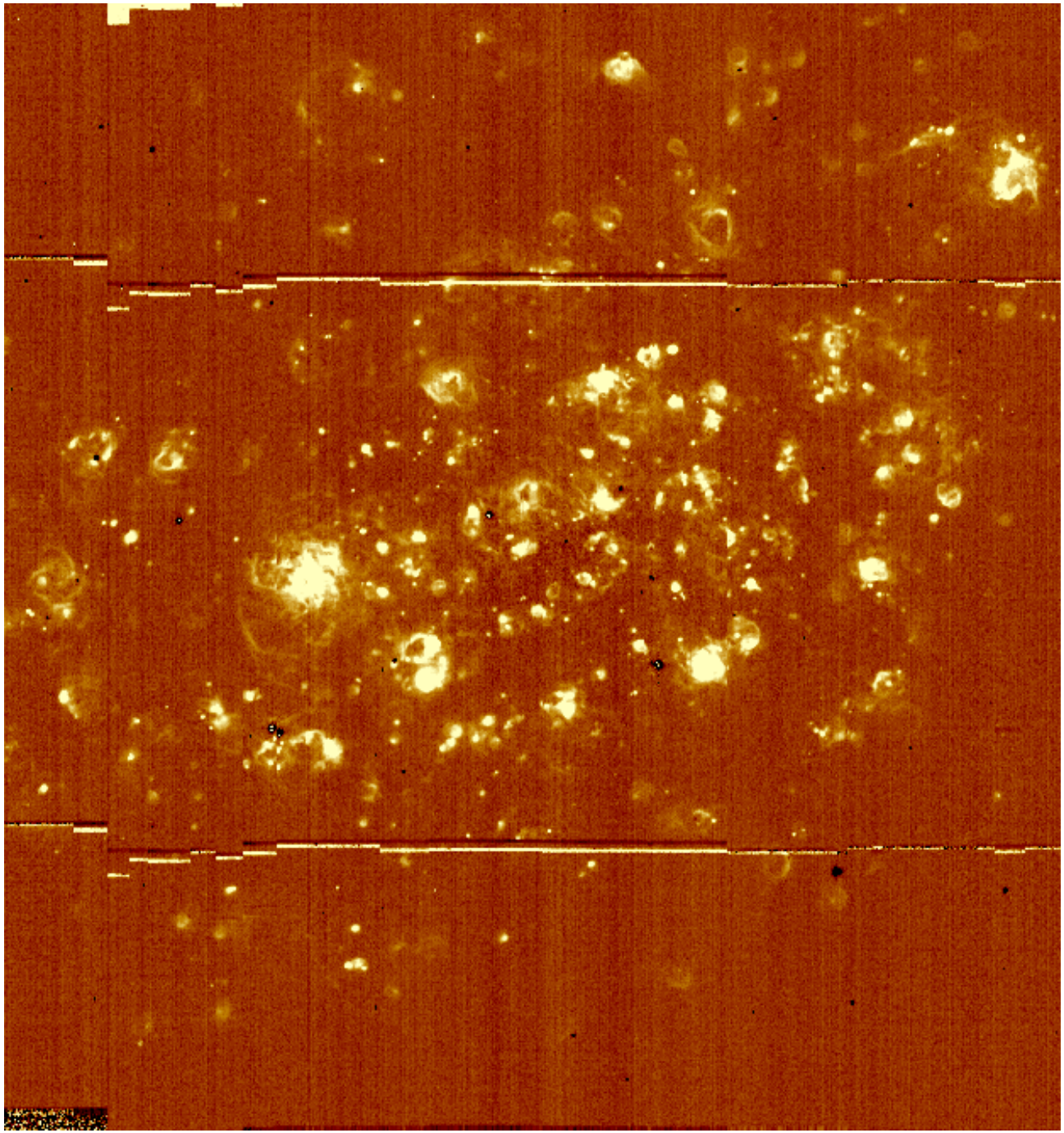
NGC300
Prelim



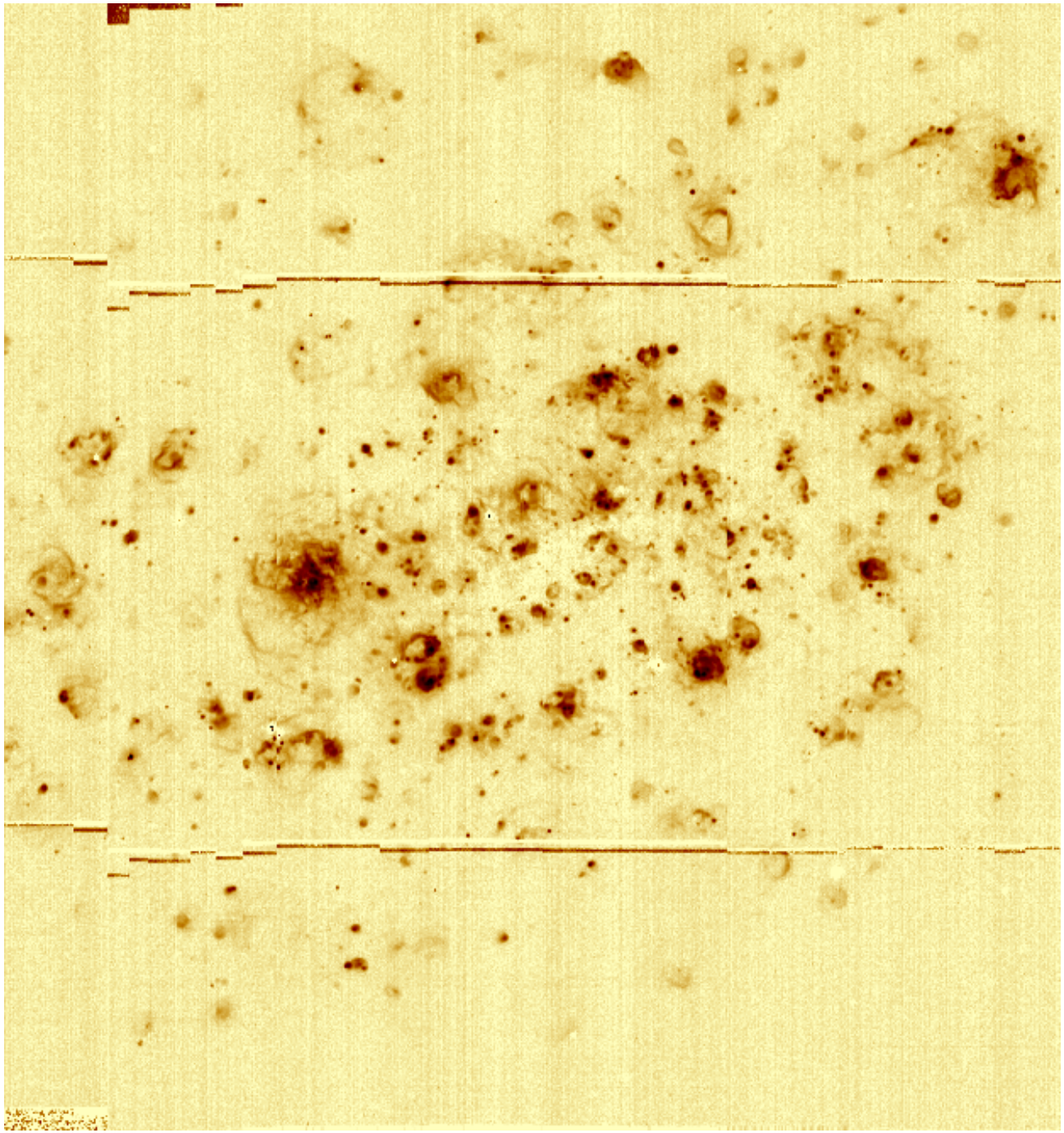
NGC300
Prelim



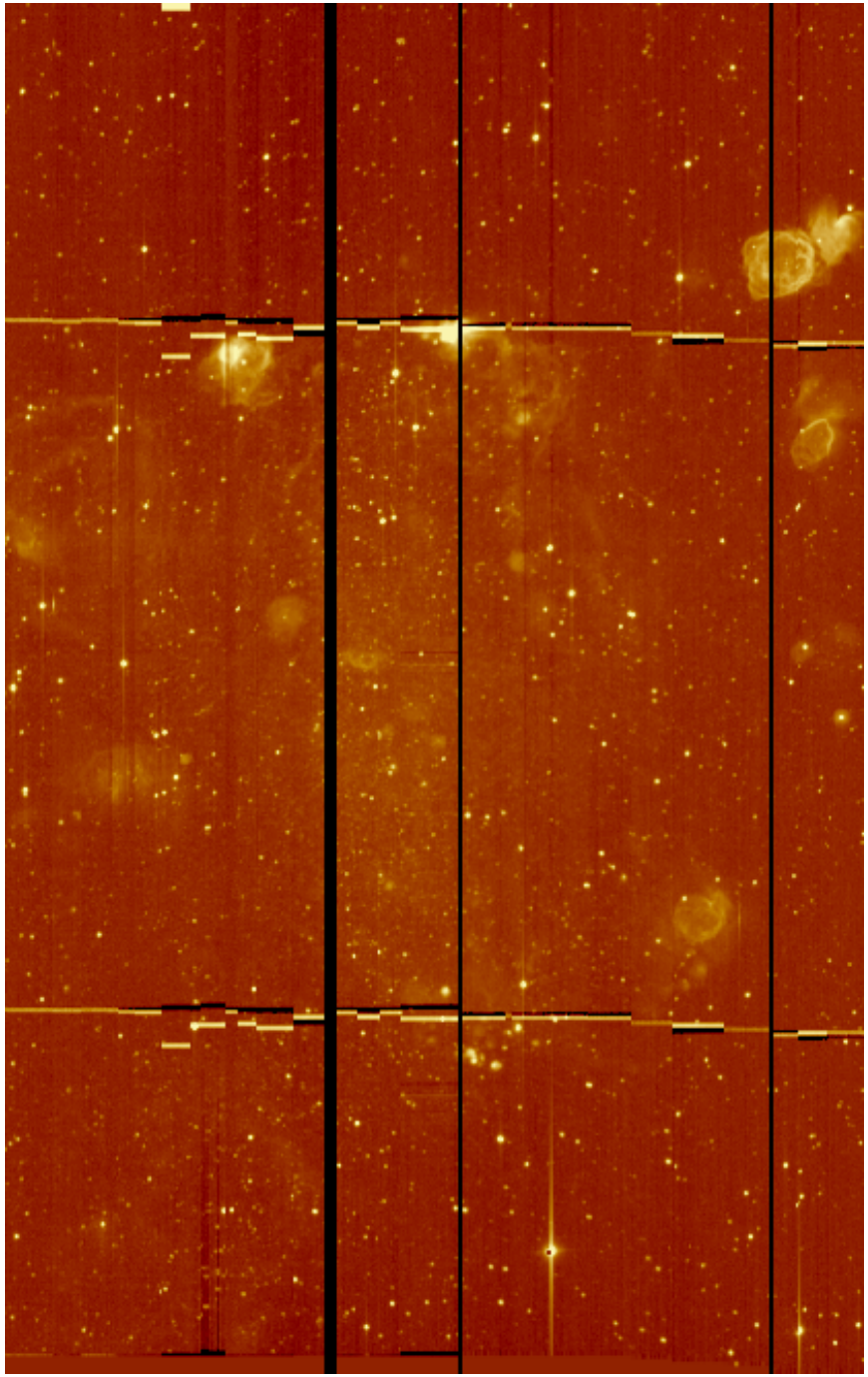
NGC300
prelim

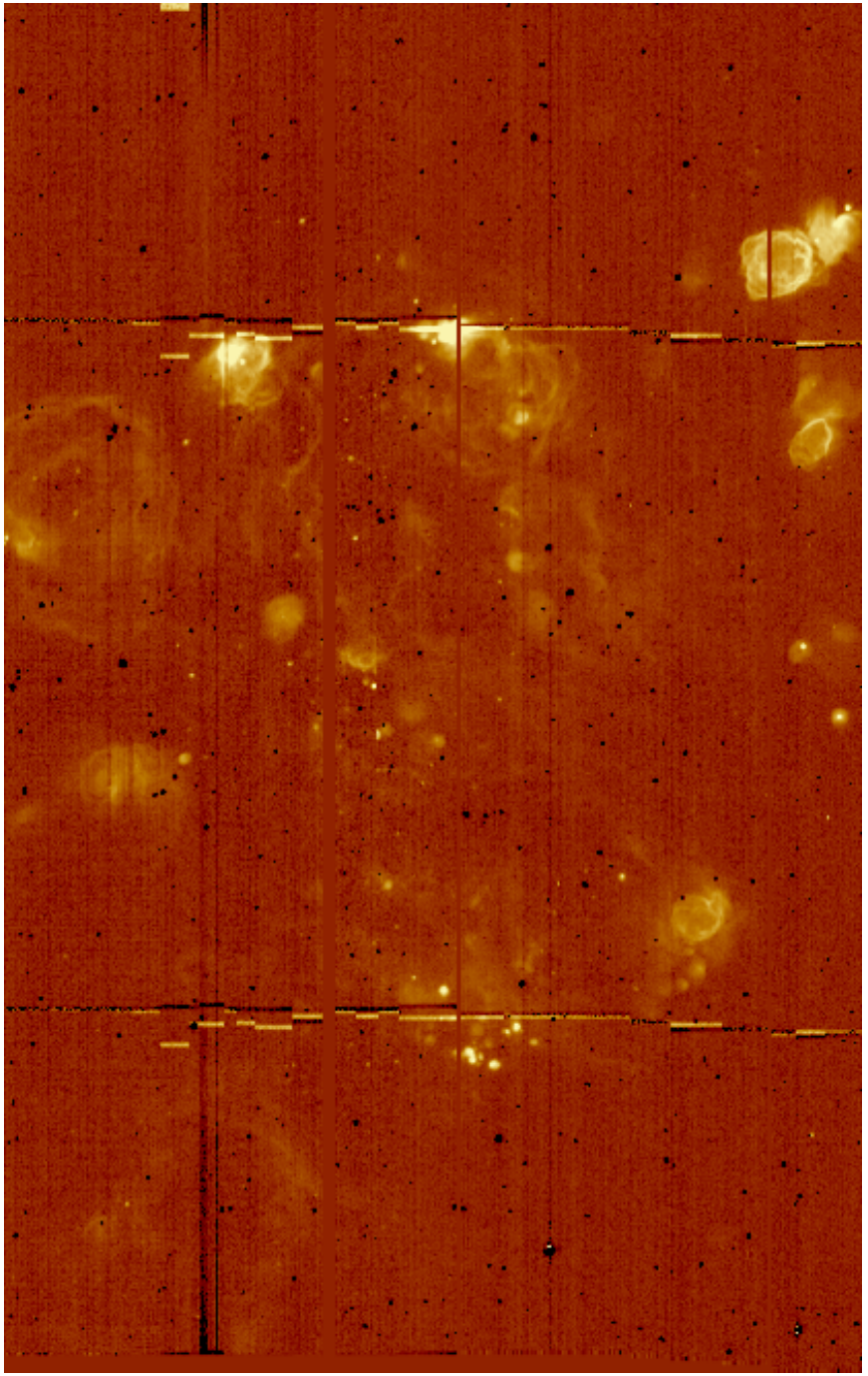


NGC300
prelim



NGC6822 prelim





End