SDSS-IV MaNGA early results — disks

Niv Drory (UT Austin)
for the MaNGA team

MaNGA Principles

- Unbiased sampling → flux limited
- Statistical power: allow binning by mass, color, morphology, environment, SFR, AGN, kinematics → large sample
- Rare objects: mergers, starbursts, blue spheroids, … → add ancillary programs
- Power of stacking: low SB features, outflows, winds, IMF → poisson-limited sky subtraction
- Legacy value → best possible calibration, new stellar library, 3600–10000 Å

MaNGA Key Science

- Open up the parameter space of internal galaxy properties
- Present-day growth of disks and spheroids
- minor and major merging, gas accretion
- Regulation and quenching of star formation
- environmental effects
- inflows, outflows
- Distribution of angular momentum
- Formation history of galactic sub-components

Bundy et al. 2015

MaNGA Sample

- I-band selected, otherwise unbiased
- 10k galaxies (10k stars) at *R*~2000, 1-2 kpc/fiber
- Uniform coverage to 1.5 Re (subsample to 2.5 Re)
    - requires large dynamic range in size
- S/N of 5 per Å in continuum @1.5 Re
- Outstanding spectrophotometric calibration

Yan et al. 2016,
Wake et al. 2016

Instrument & Survey

- The MaNGA survey and the MaNGA instrument share a name:

- Instrument and survey/sample designed together.

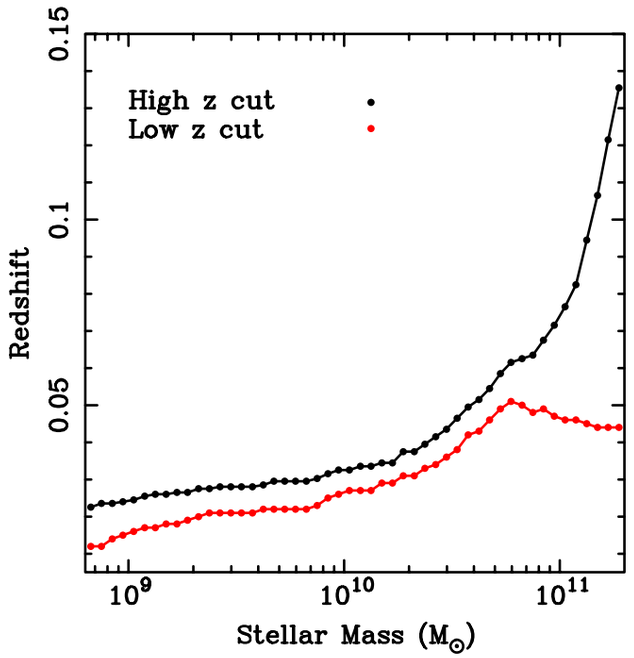
- Optimize throughput, efficiency, fiber usage, bundle utilization, spectrophotometry & image reconstruction.

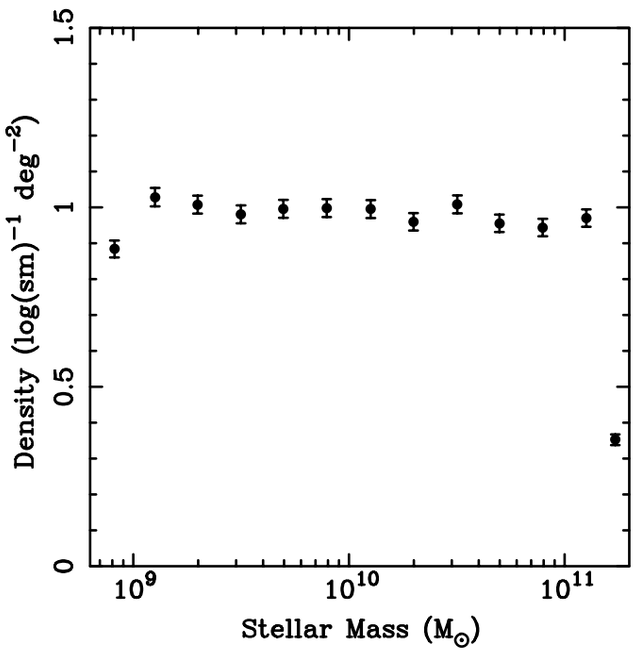
Drory et al. 2015

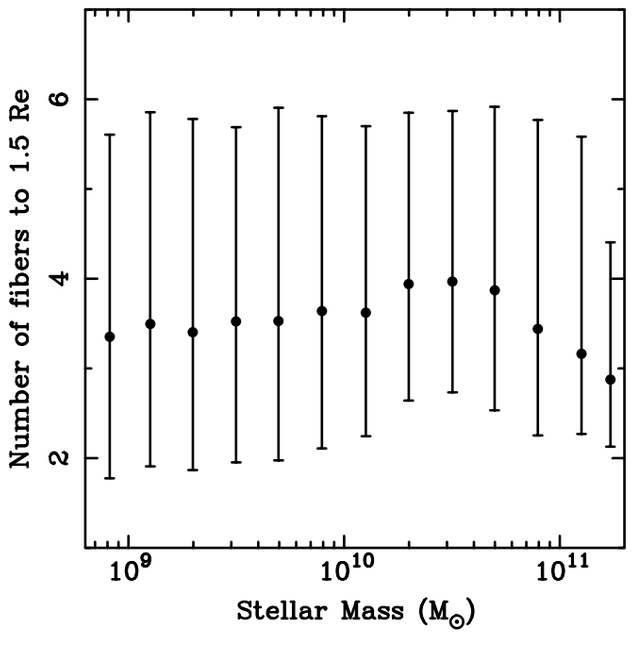
MaNGA Sample Design

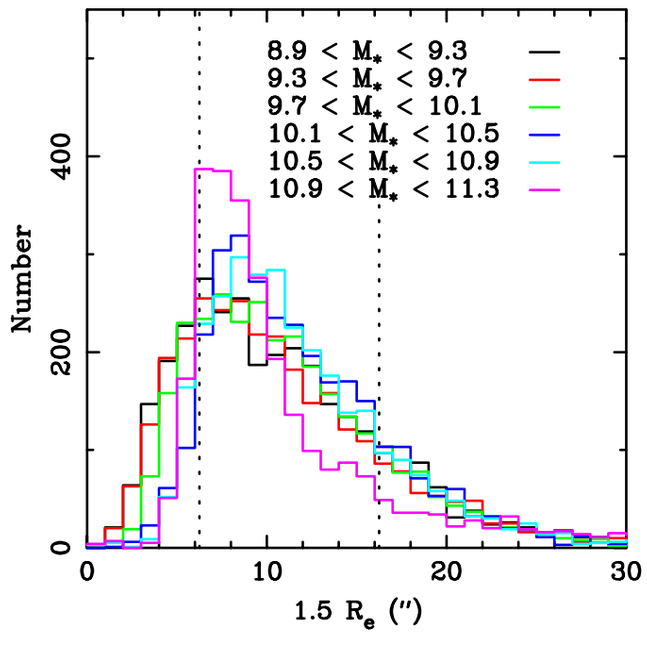
- flat stellar mass distribution
- variable redshift cuts to reduce dynamic range in size
- 5 bundle sizes: 19, 37, 61, 95, 127 fibers
- all masses sampled by all bundles sizes
- ~80% covered to 1.5 Re at all masses
- optimal 2, 4, 4, 2, 5 IFU size distribution
- 1247 IFU fibers
- ~100 sky fibers, 12 7 fiber mini-bundles for spectrophotometric calibration
- 3h exposures, 3x3 dithers

Wake et al. 2016, Law et al 2016

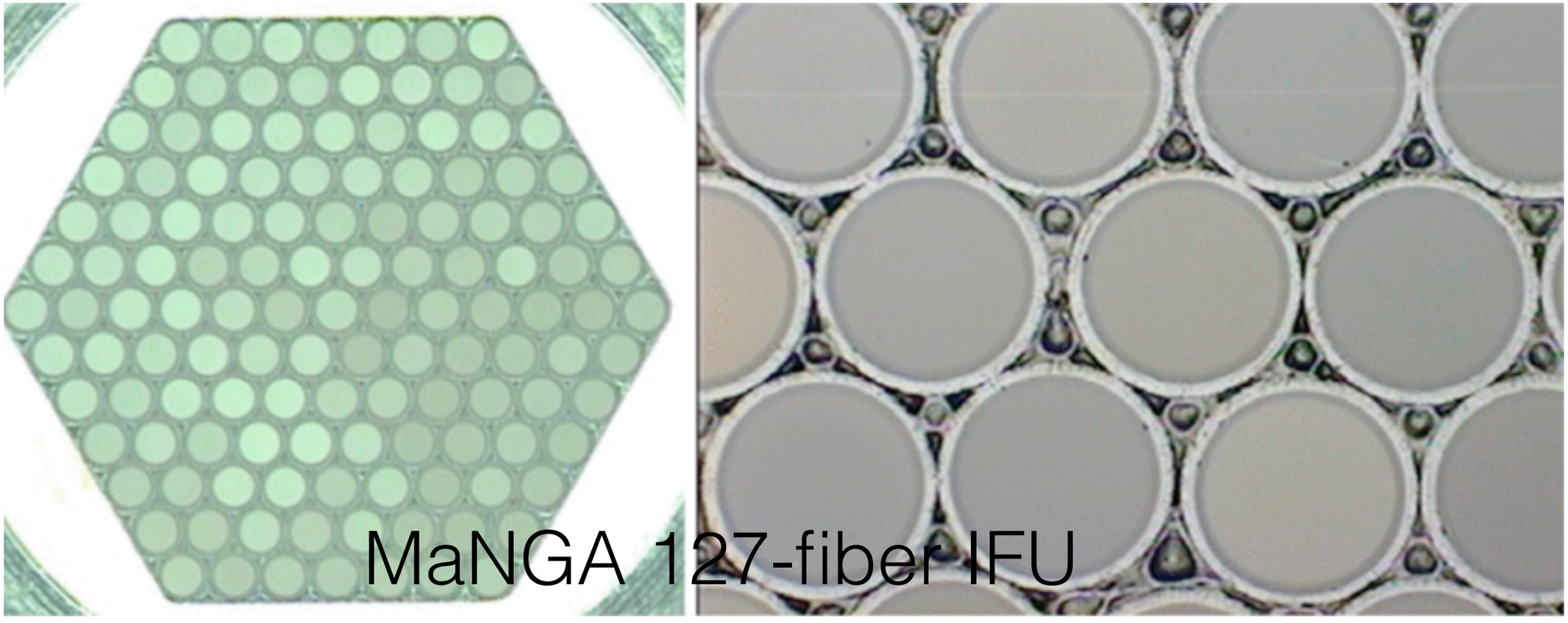


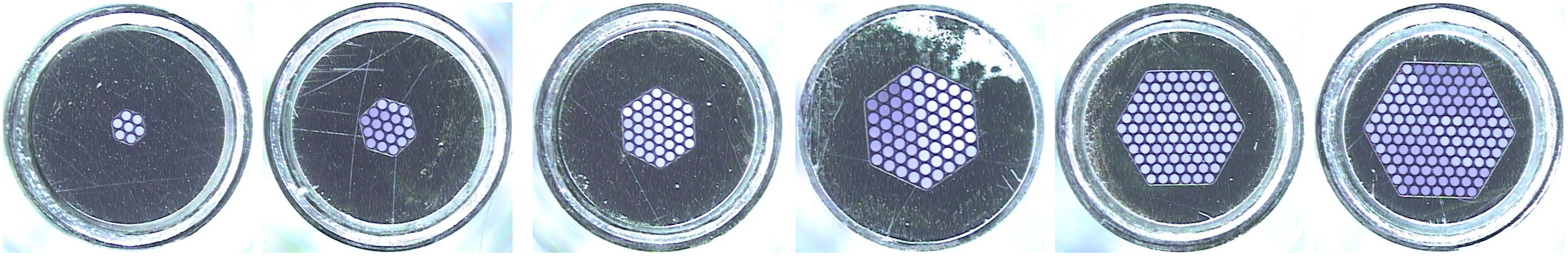




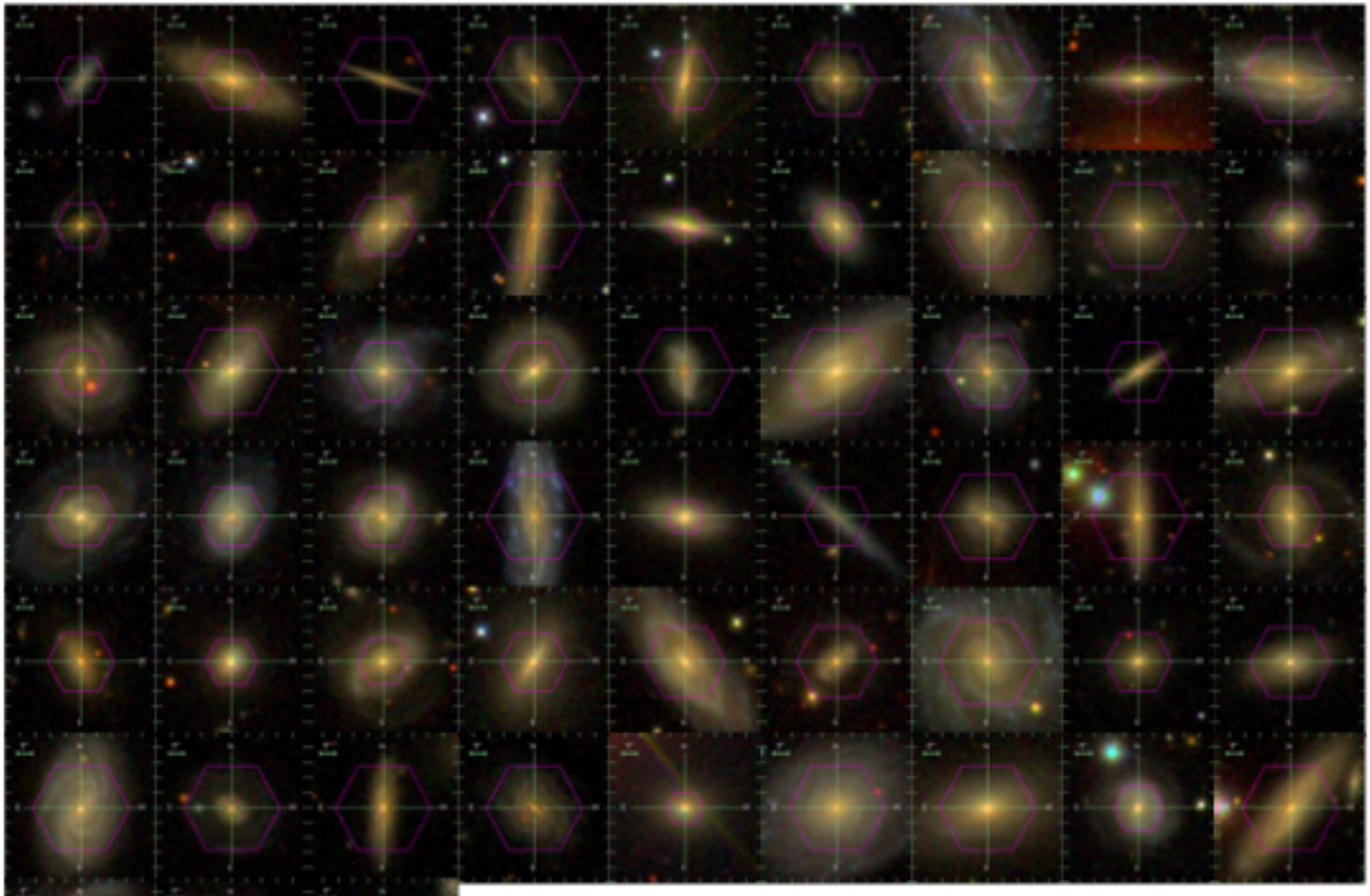


IFUs

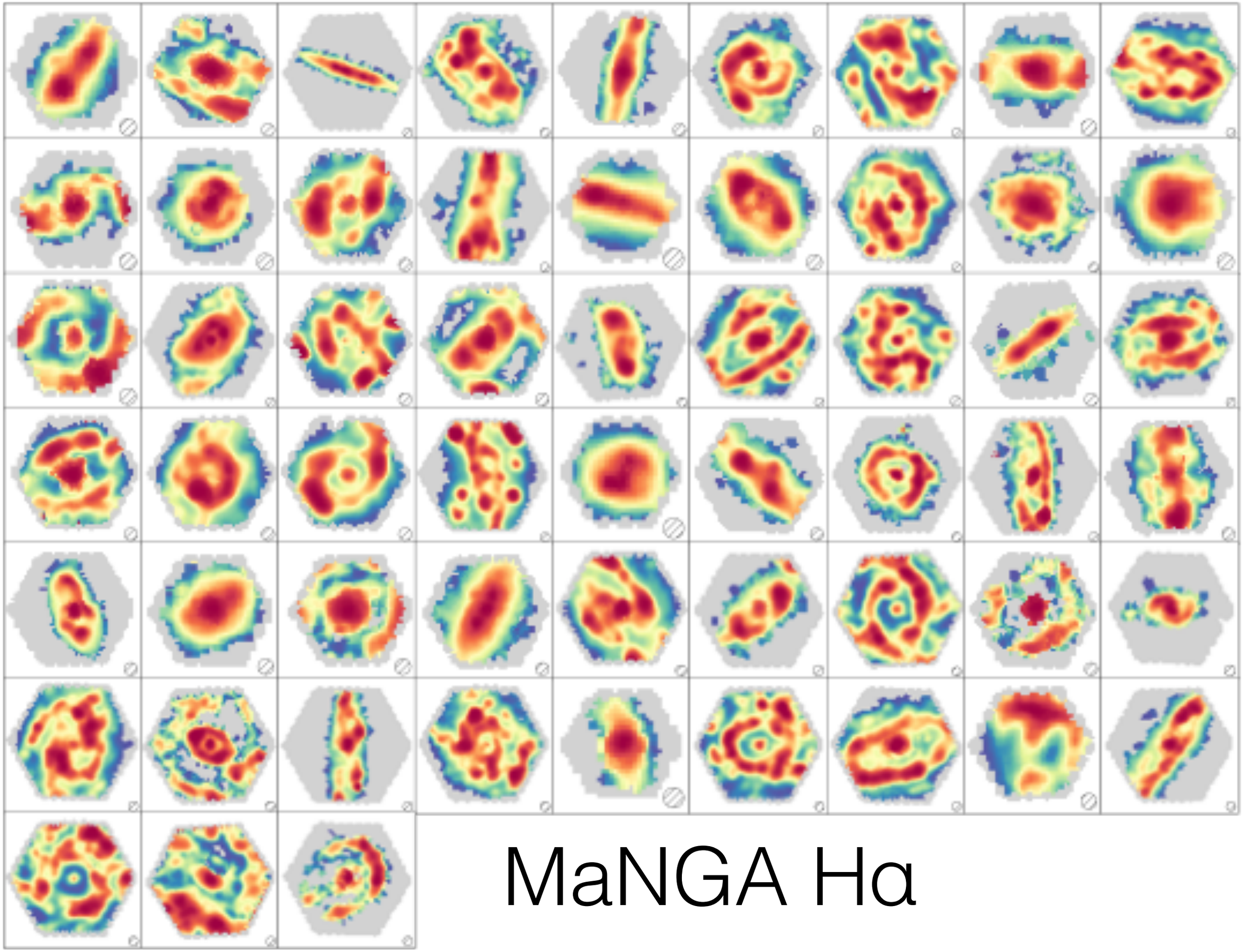




(Drory et al. 2015)



SDSS Imaging

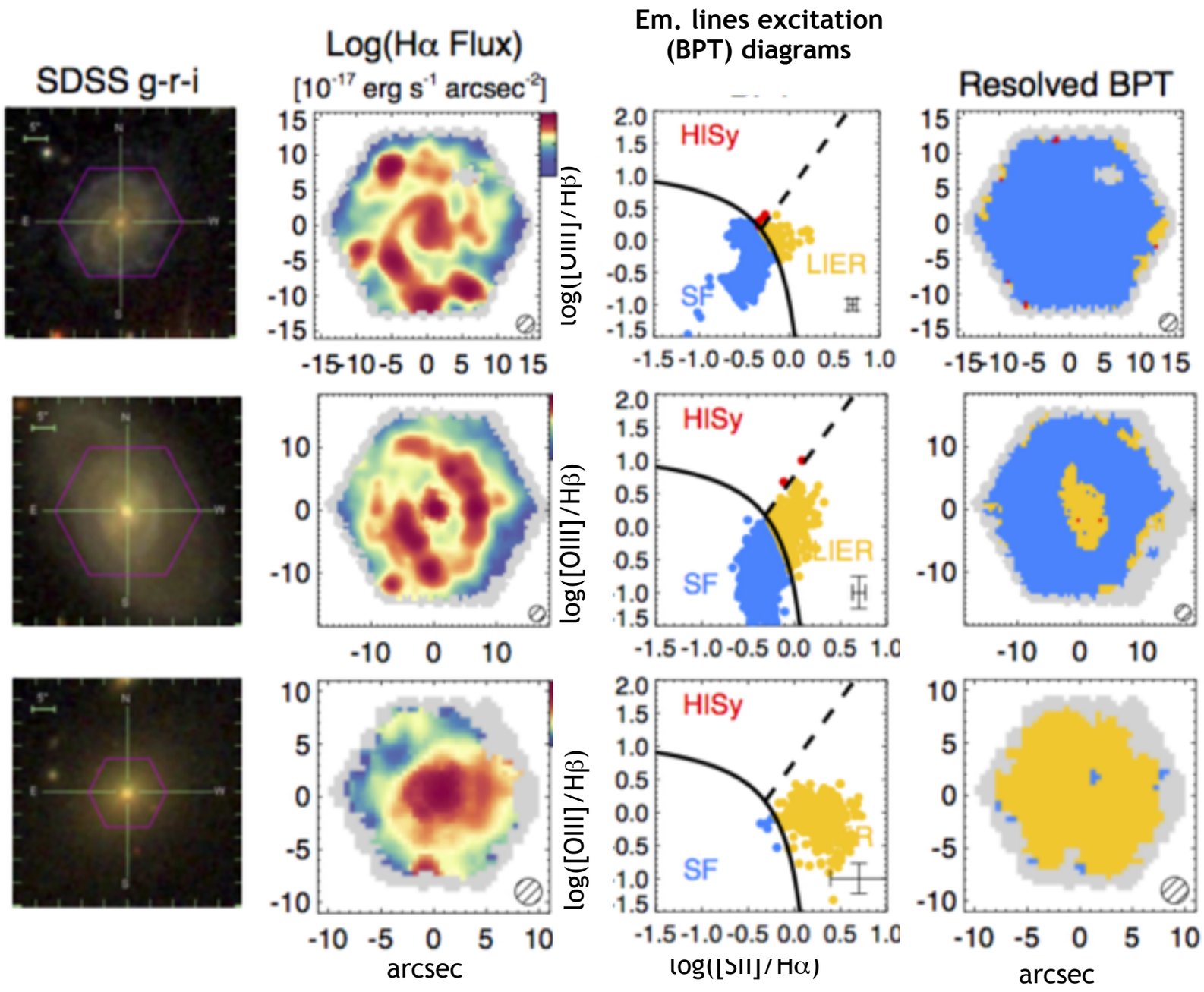


MaNGA Hα

MaNGA Progress

- 2800 galaxies observed so far
- 1400 (year 1) data to be released as part of SDSS DR13 (August 1 2016)
- Linear/Log data cubes, extracted RSS files, fully calibrated
- No higher-level science products released in DR13, scheduled for DR14 in 2017

Spatially Resolved Excitation



Star forming

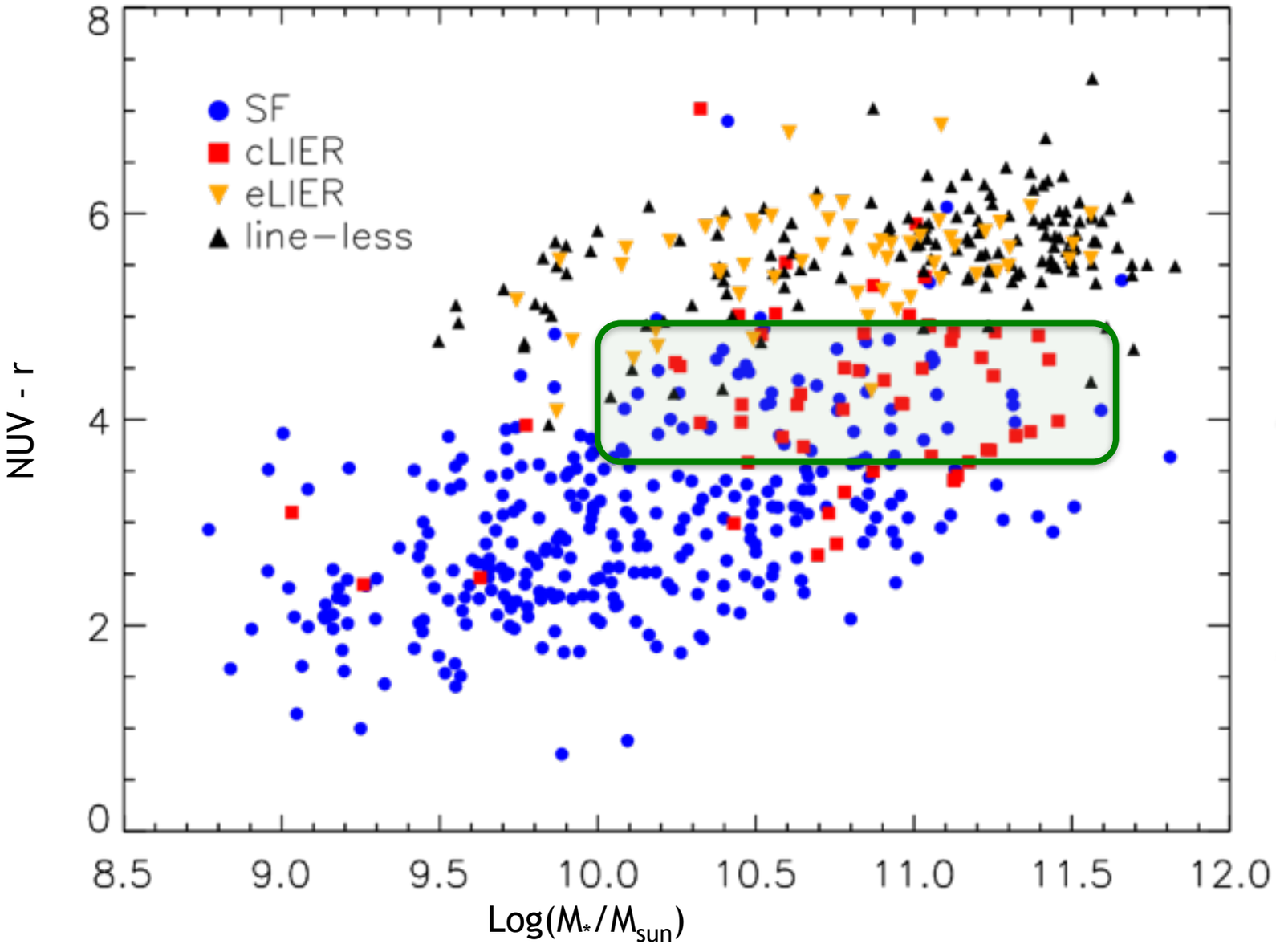
- Outer star forming
- Central quiescent:
  LI(N)ER-like emission

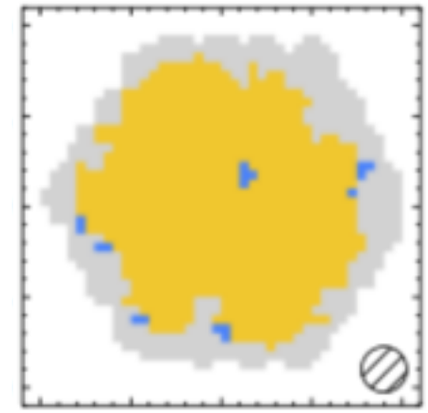
- Quiescent everywhere
  LI(N)ER-like emission
  or line-less

see Sarzi+2010, Singh+2013

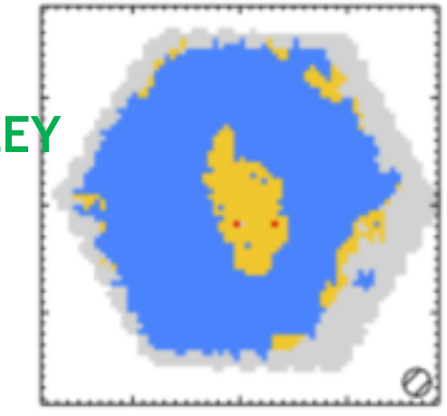
Belfiore et al. 2016

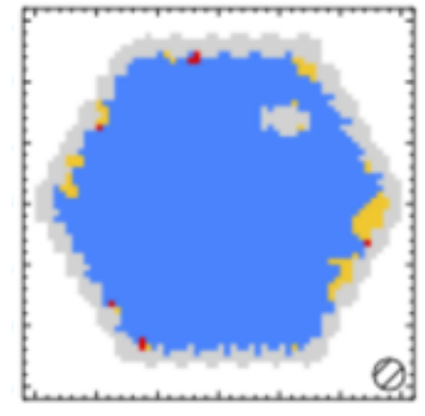
Inside-out Fading



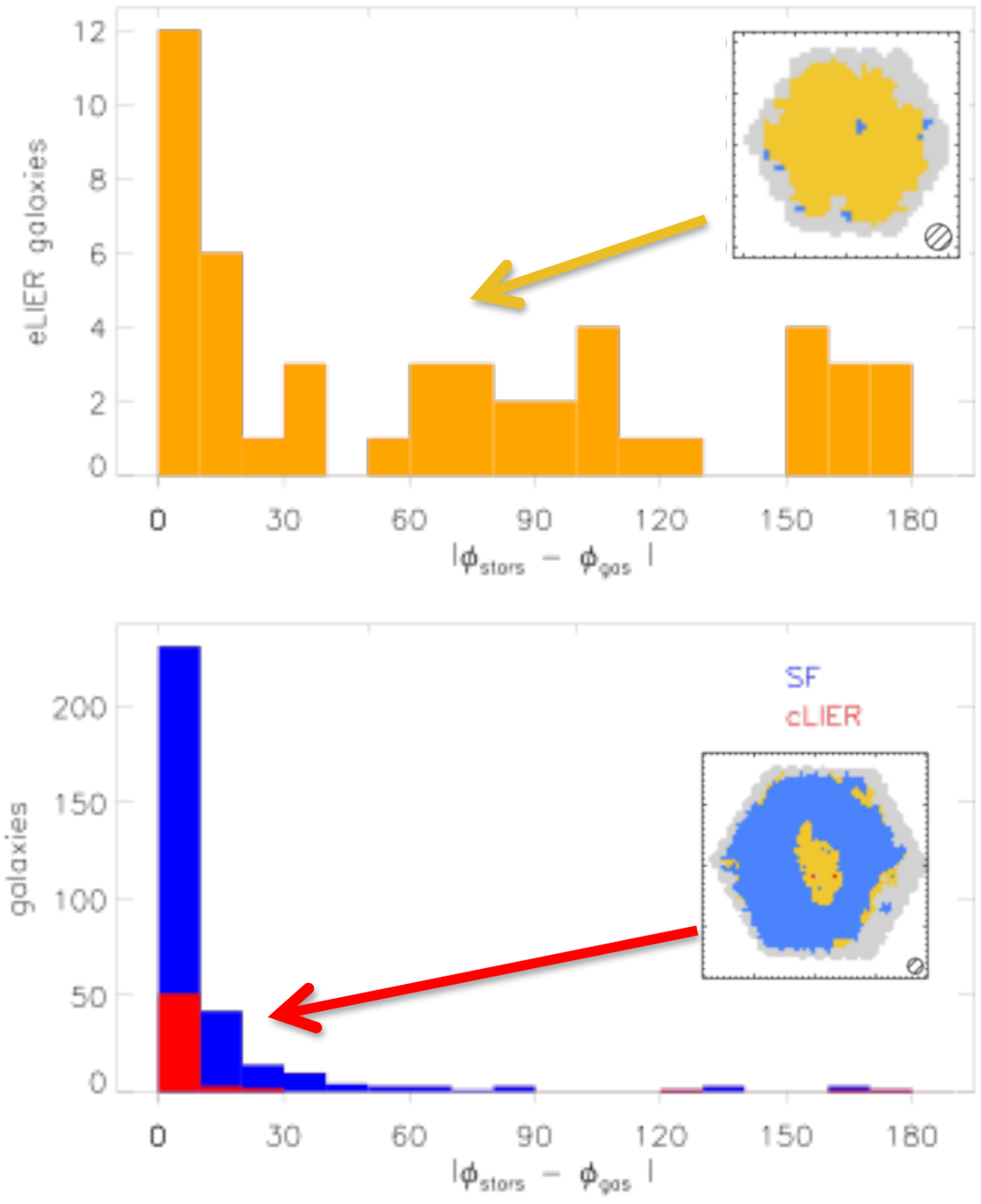


GREEN VALLEY





Internal & External Gas



|stars–gas| kinematic PA:

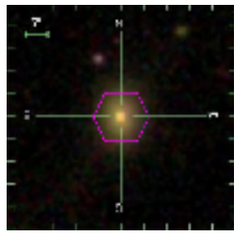
eLIERS: Both internal and external origin of gas

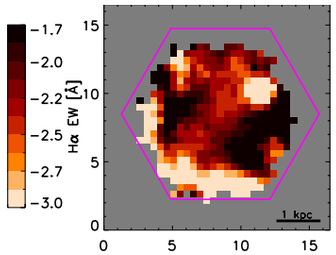
cLIERS: Only internal origin of gas

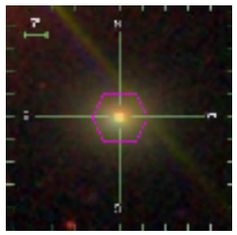
Red Geysers

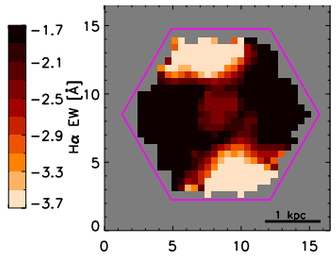
Ha EQW Morphology

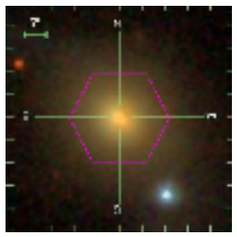
Cheung et al. 2016, Nature

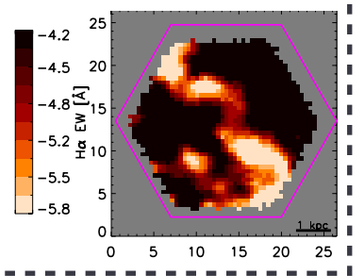


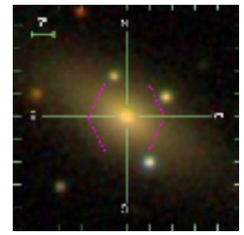


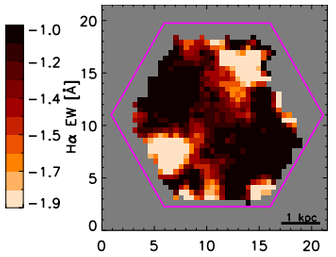


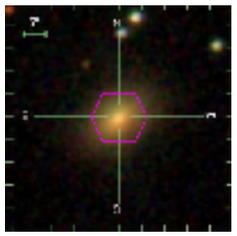


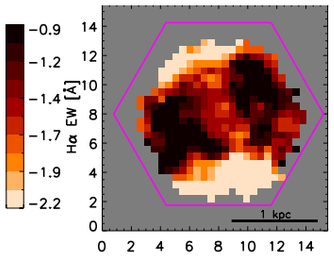


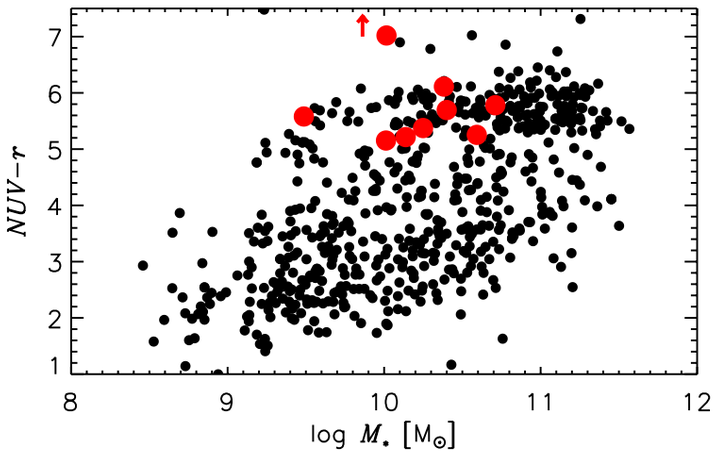


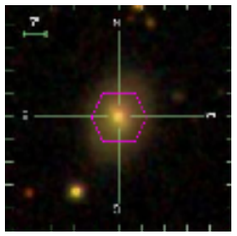


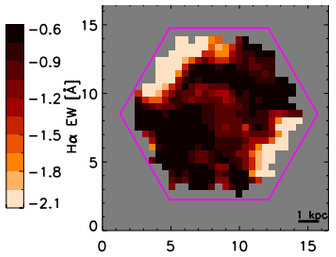


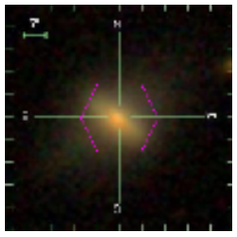


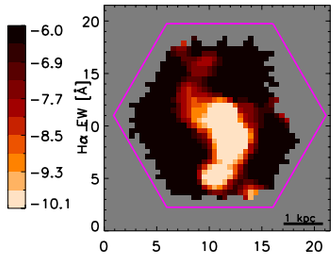


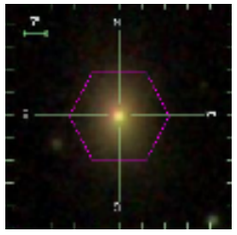


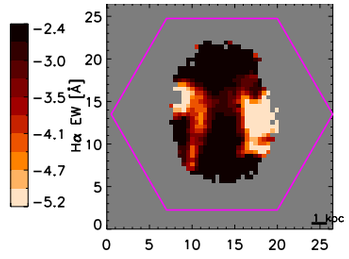


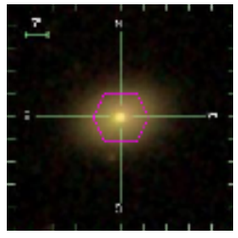


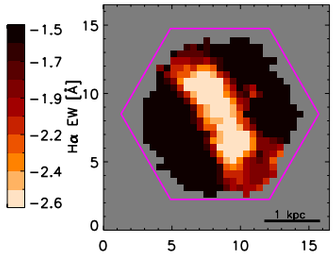


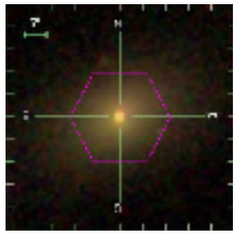


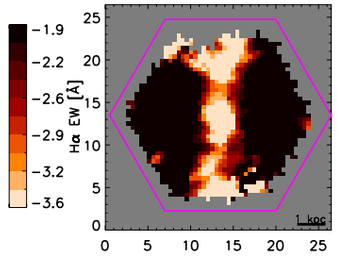




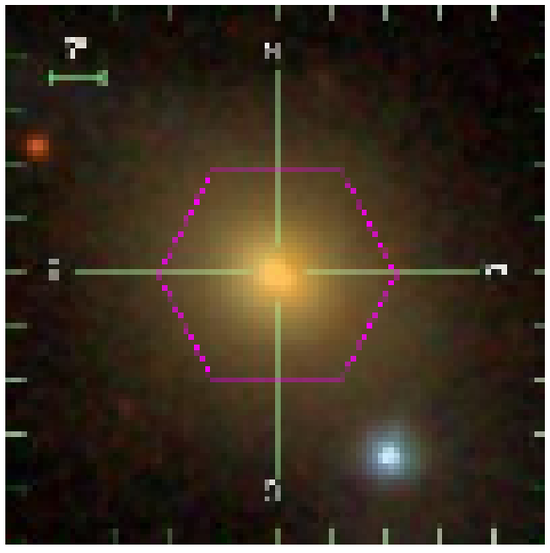


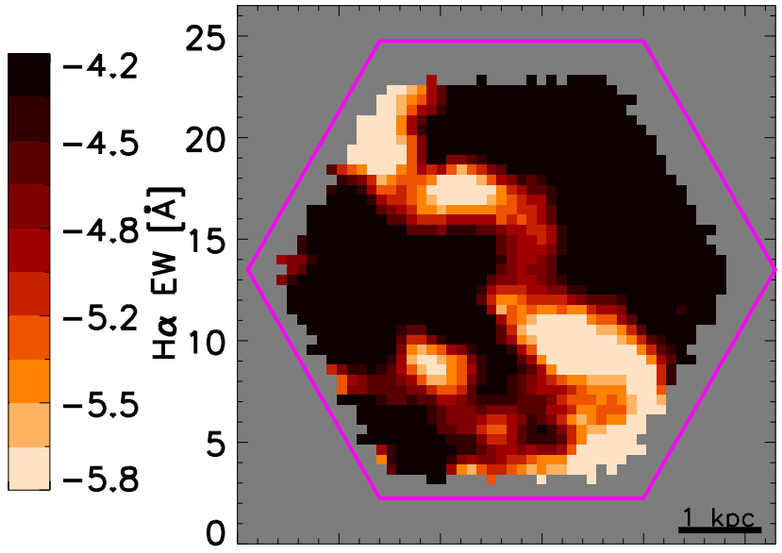




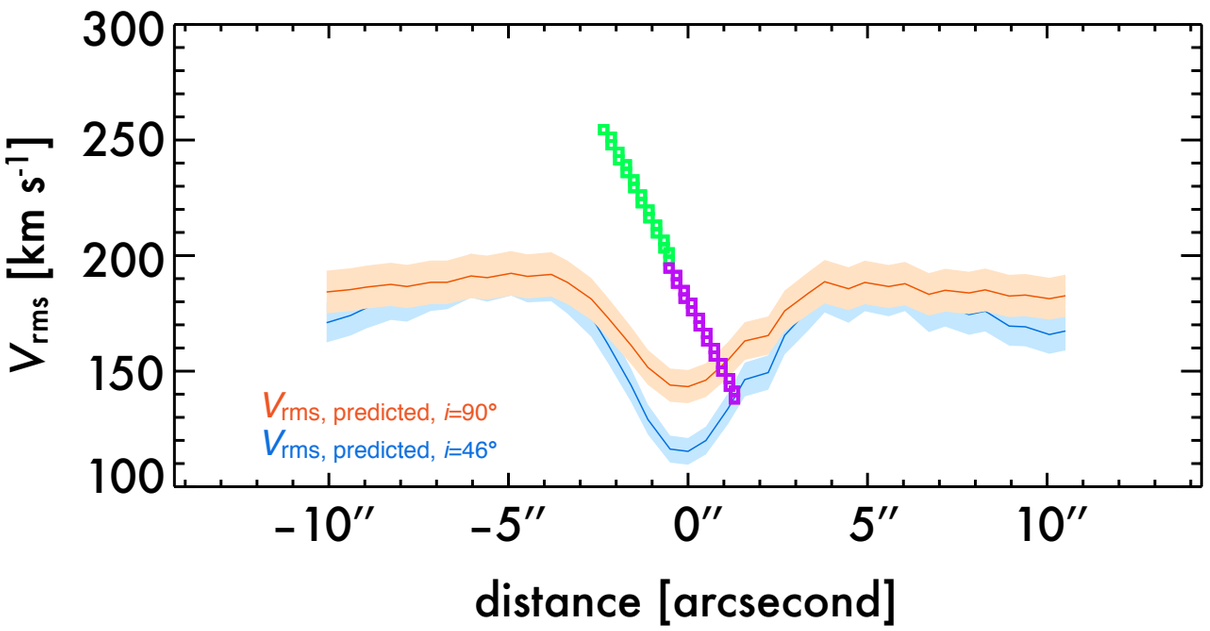


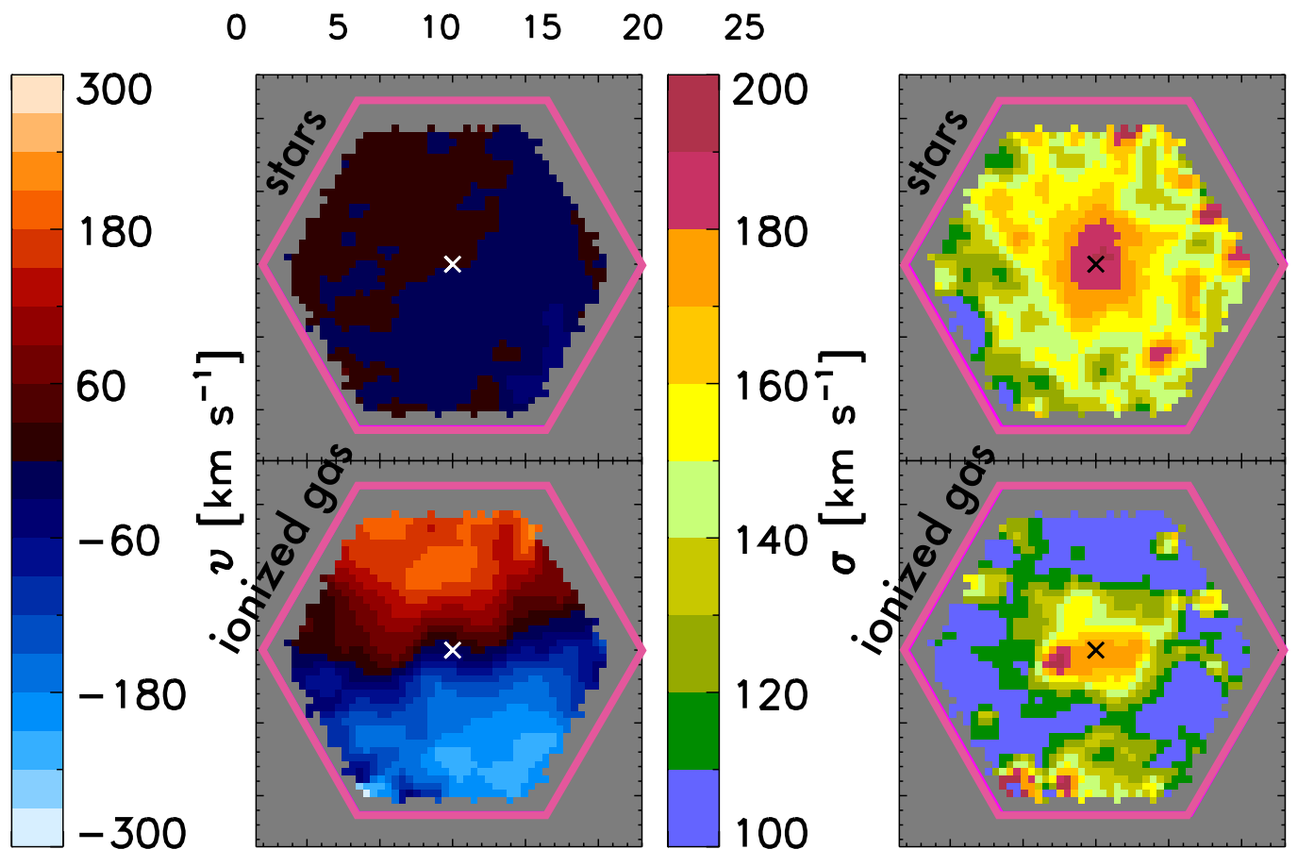
Suppressing SF with AGN-driven Winds



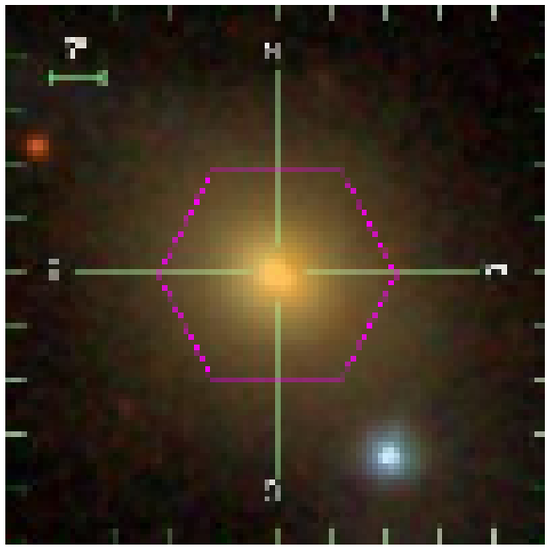


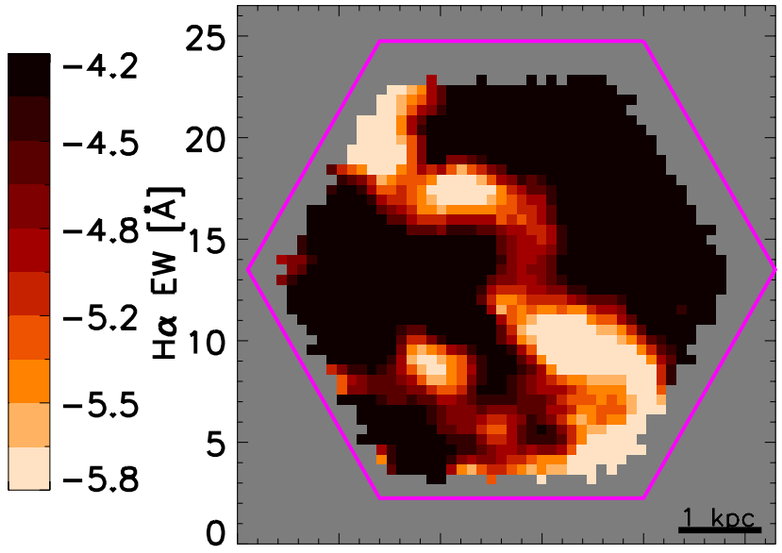
Cheung et al. 2016, Nature



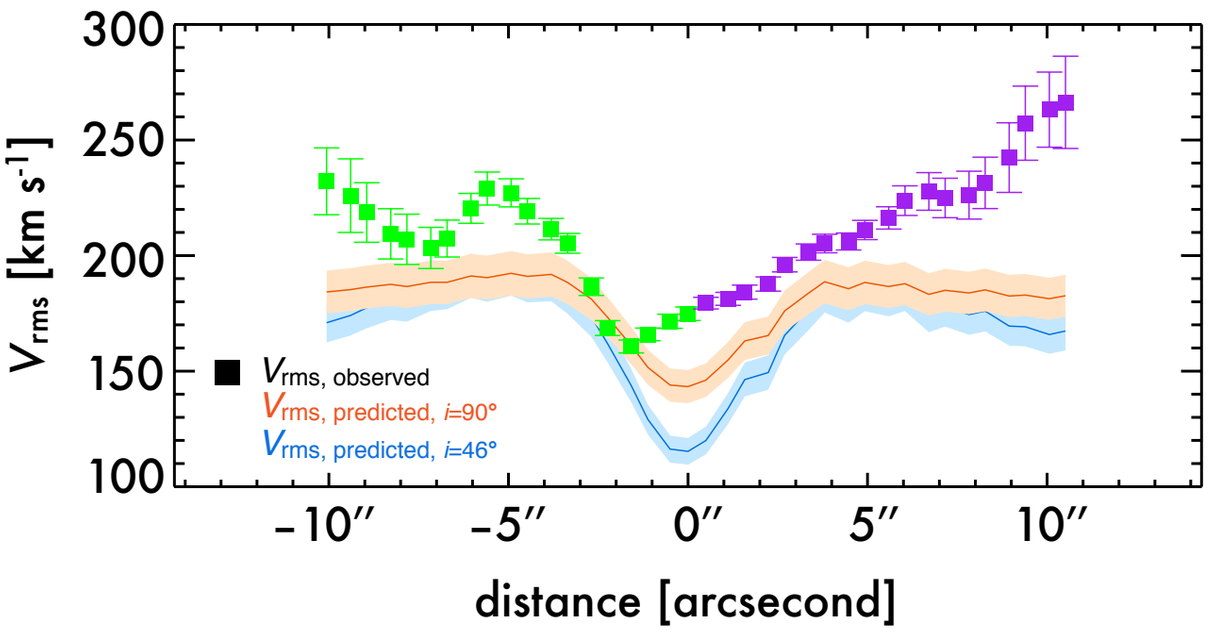


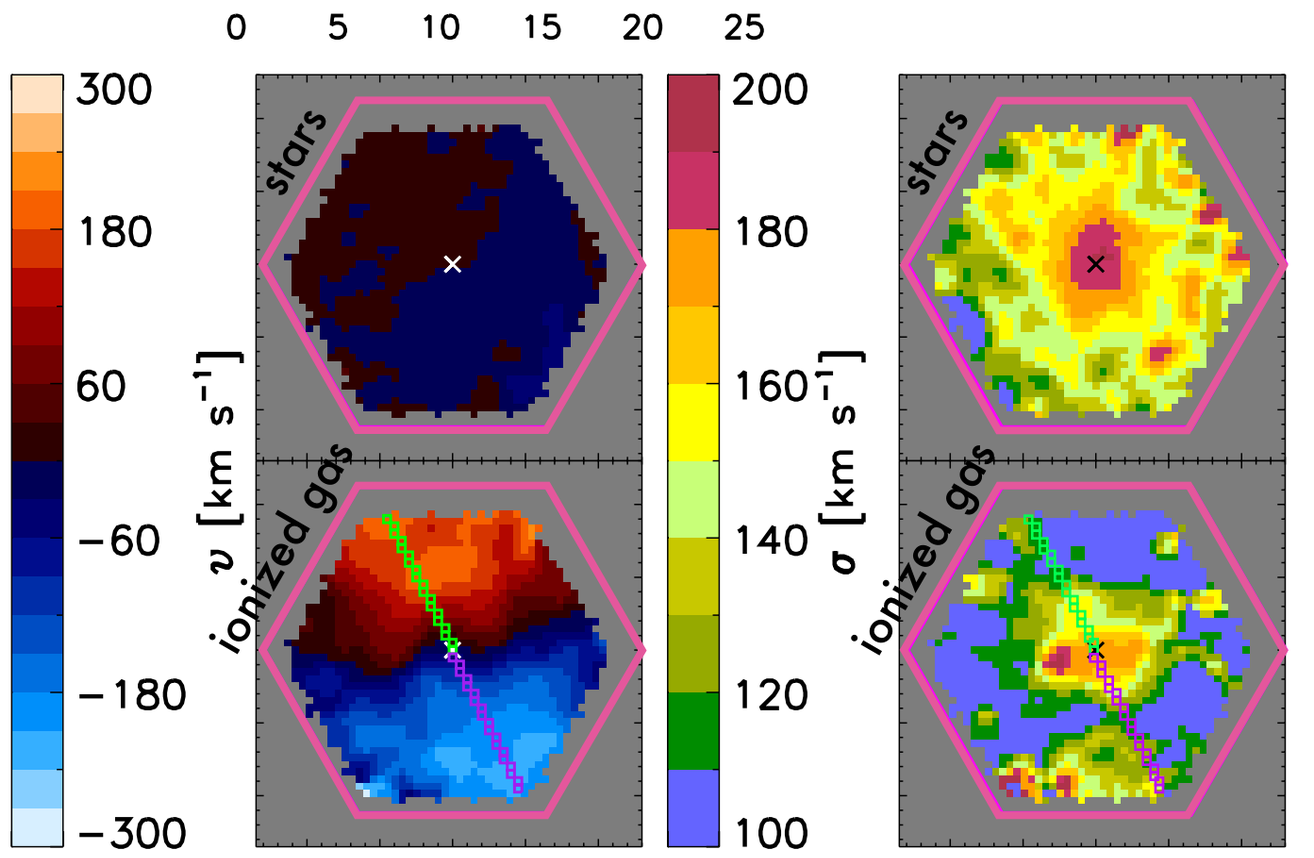
Suppressing SF with AGN-driven Winds





Cheung et al. 2016, Nature

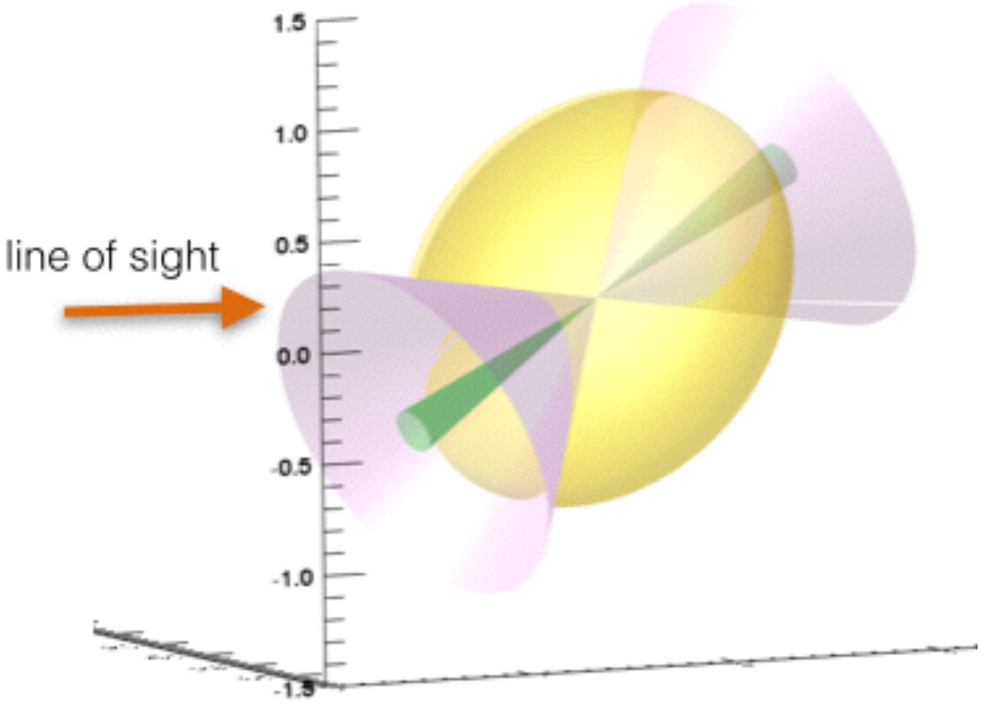


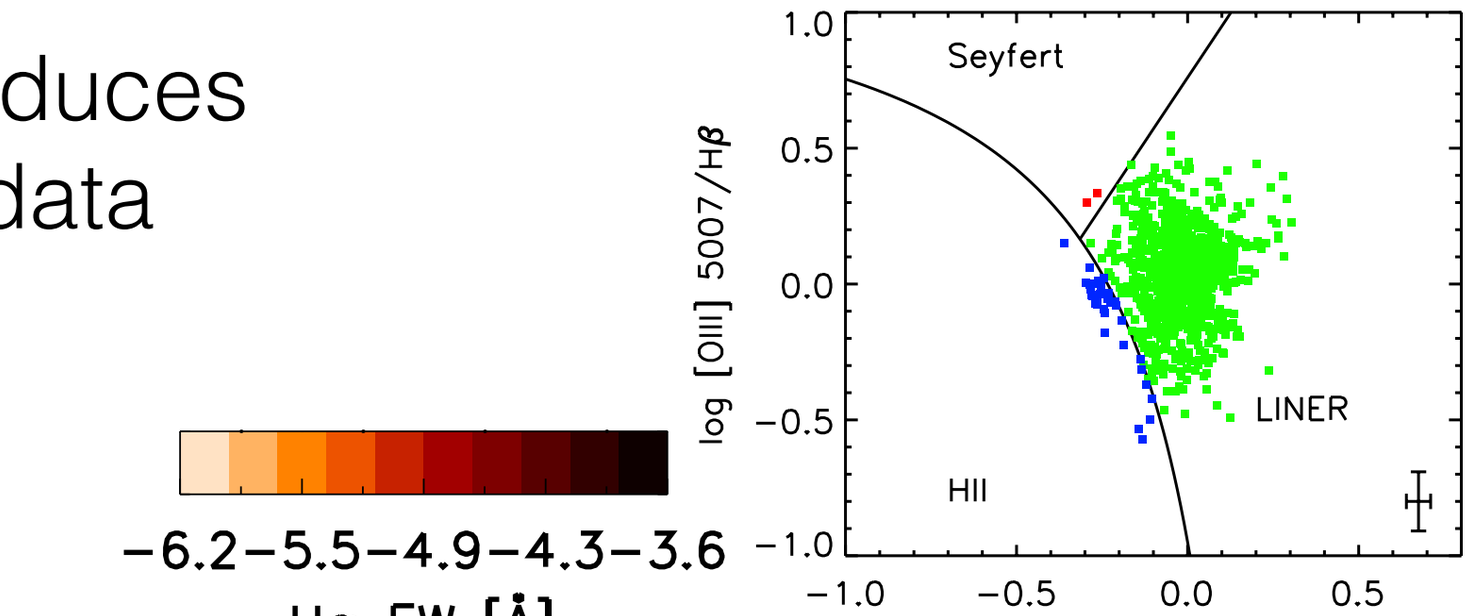


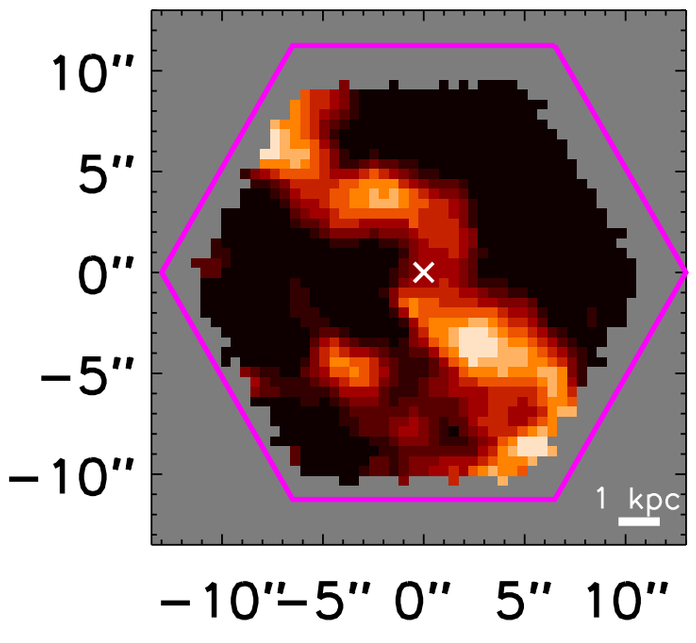
Suppressing SF with AGN-driven Winds

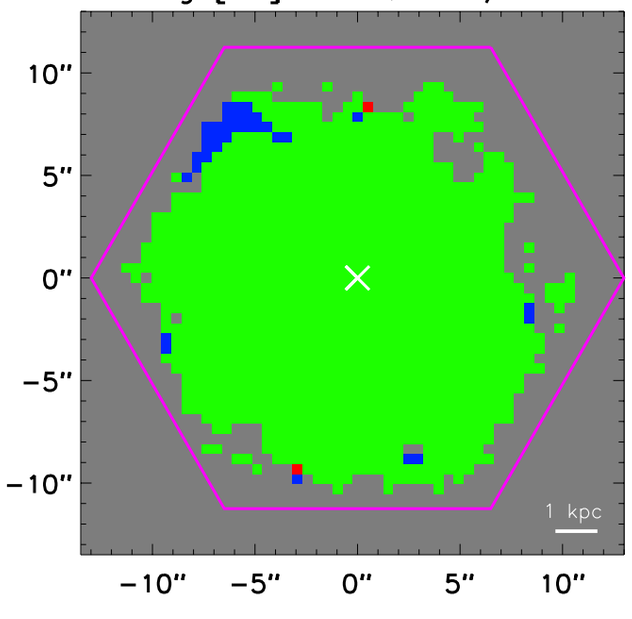
Wind model reproduces many features of data

Cheung et al. 2016, Nature



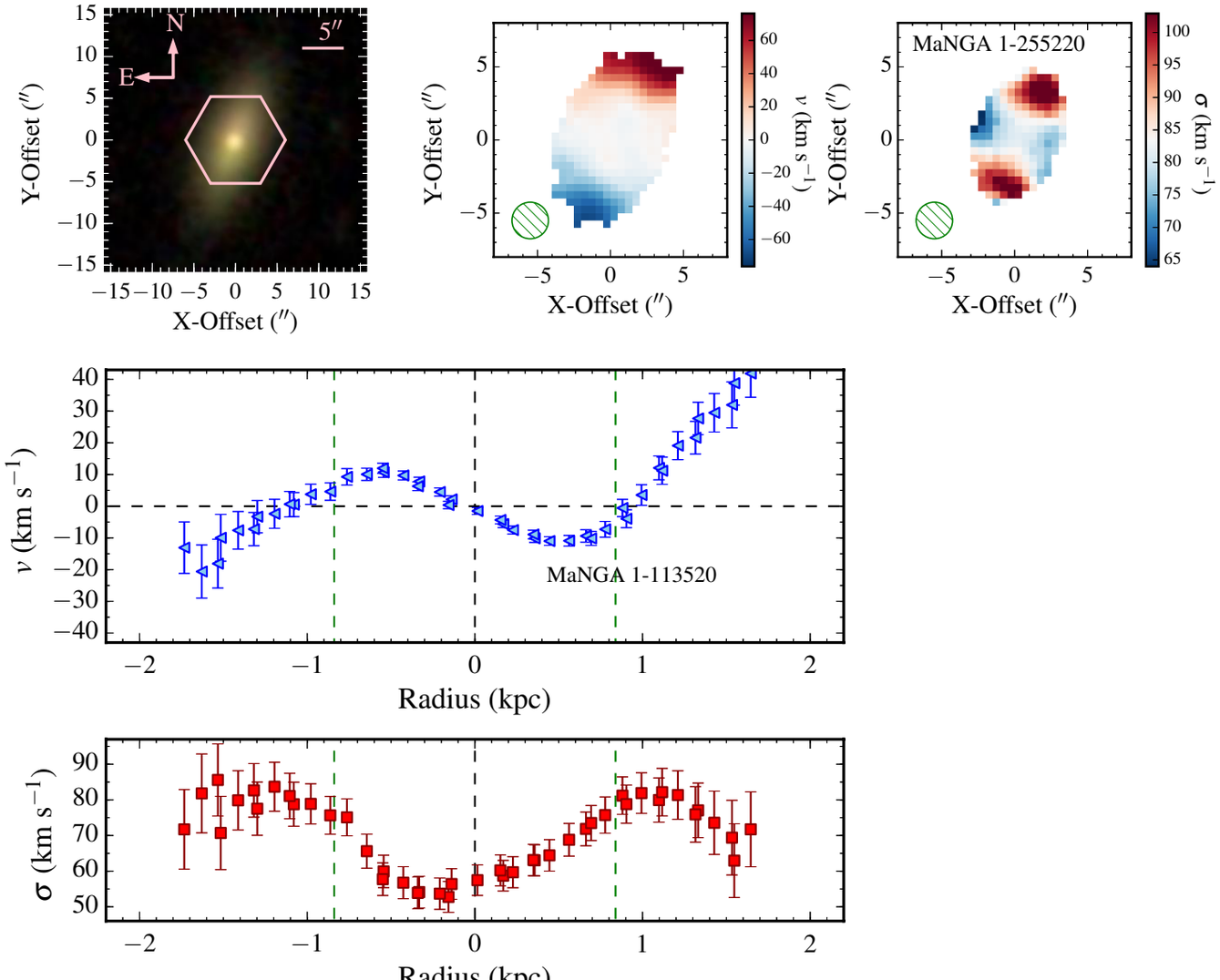




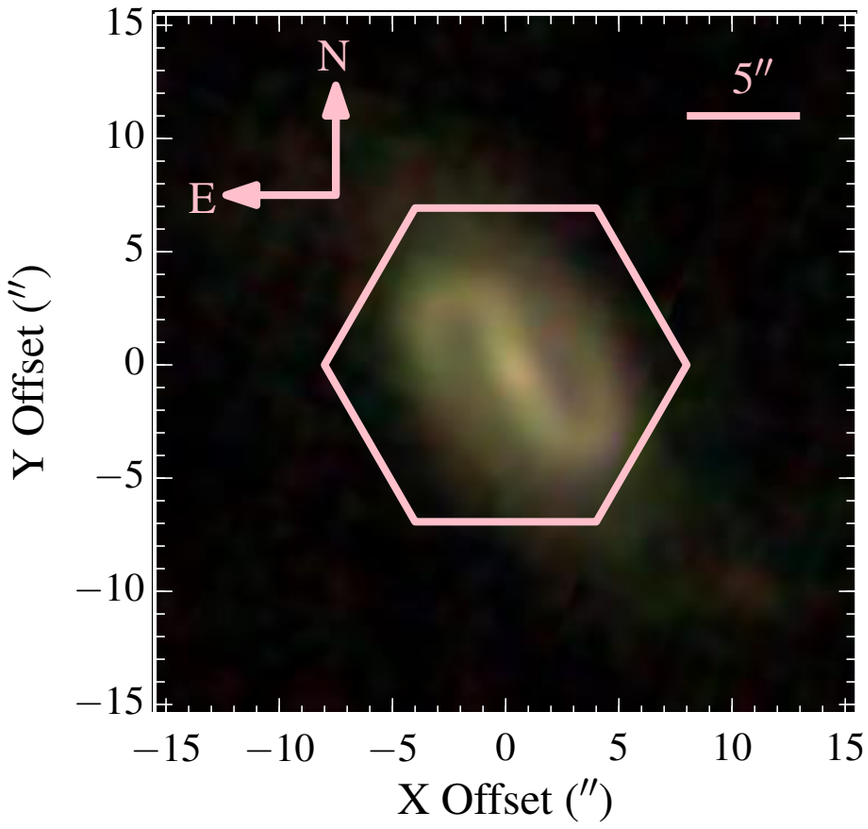


Low-M Quenched Galaxies

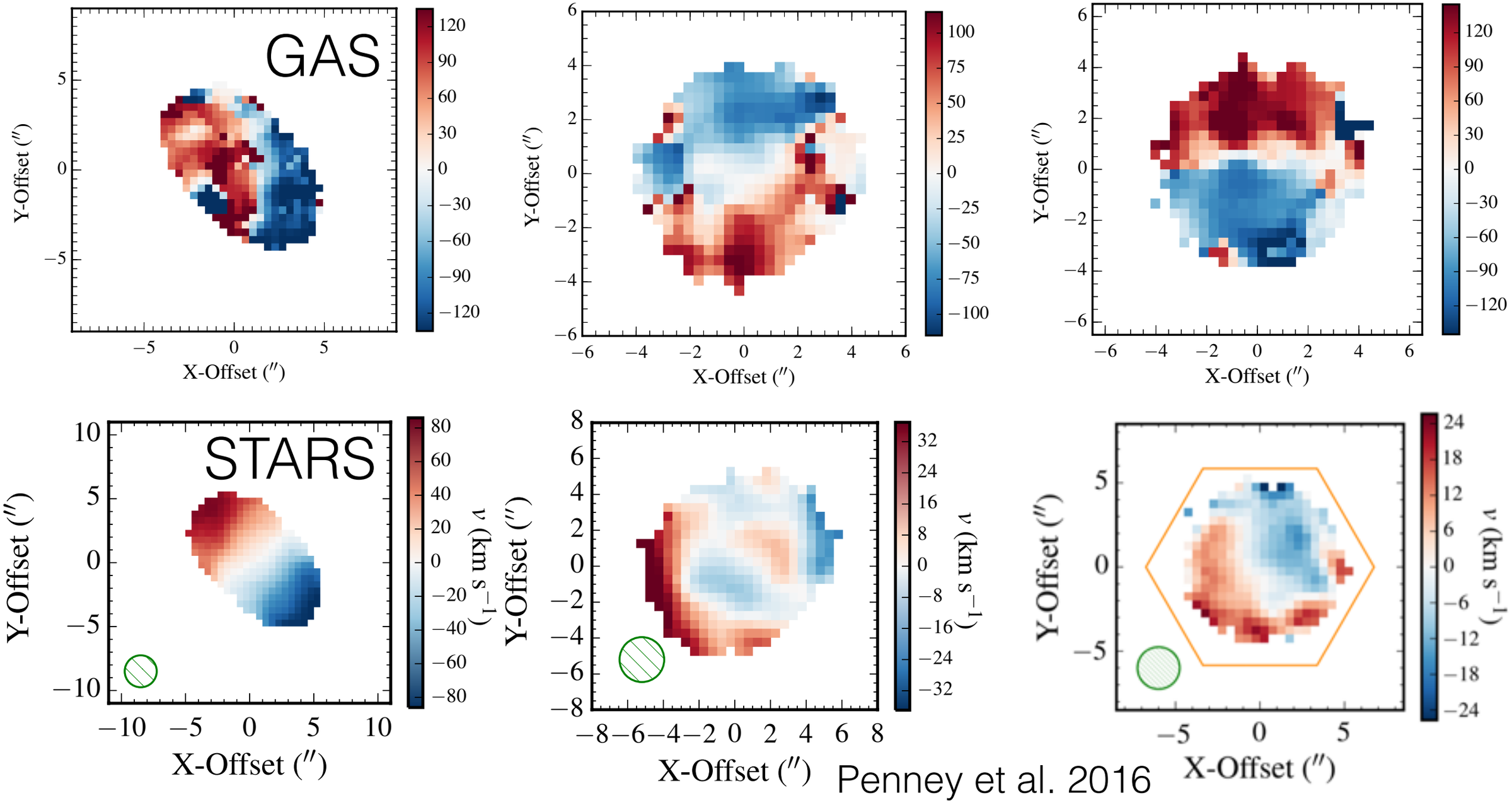
- Majority (>80%) dominated by rotation
- Some have kinematically decoupled structures
- Some show clearly disky structure such as spirals



Penney et al. 2016



Some still retain an ionised gas component- typically misaligned



Penney et al. 2016

Gas accretion but no star formation

MaStar Library

- Piggybacking on APOGEE-2 during bright time to construct a large, homogeneous, and comprehensive stellar library:

- Significantly improve stellar parameter coverage (including [α/M])

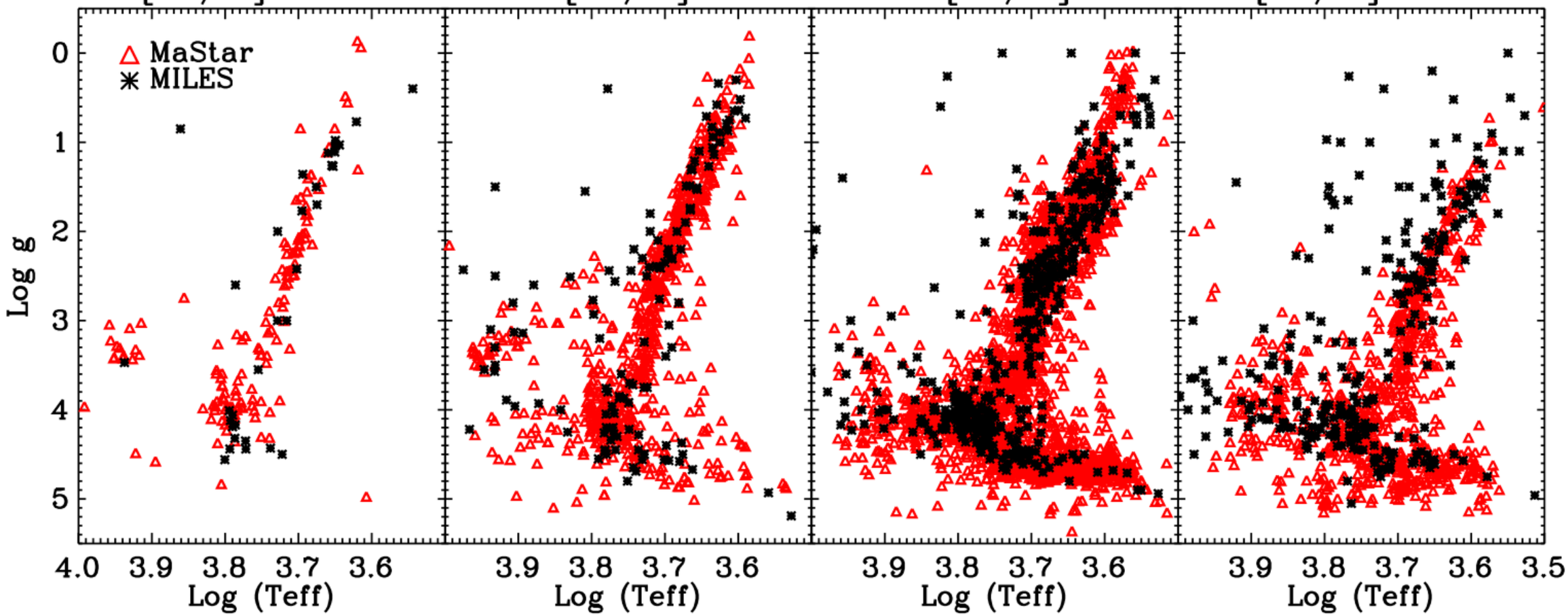
- Uniform flux calibration, wide wave coverage, and matching MaNGA's instrumental resolution.

- Large sample size (~10k stars) to ensure sufficient sampling in each bin.

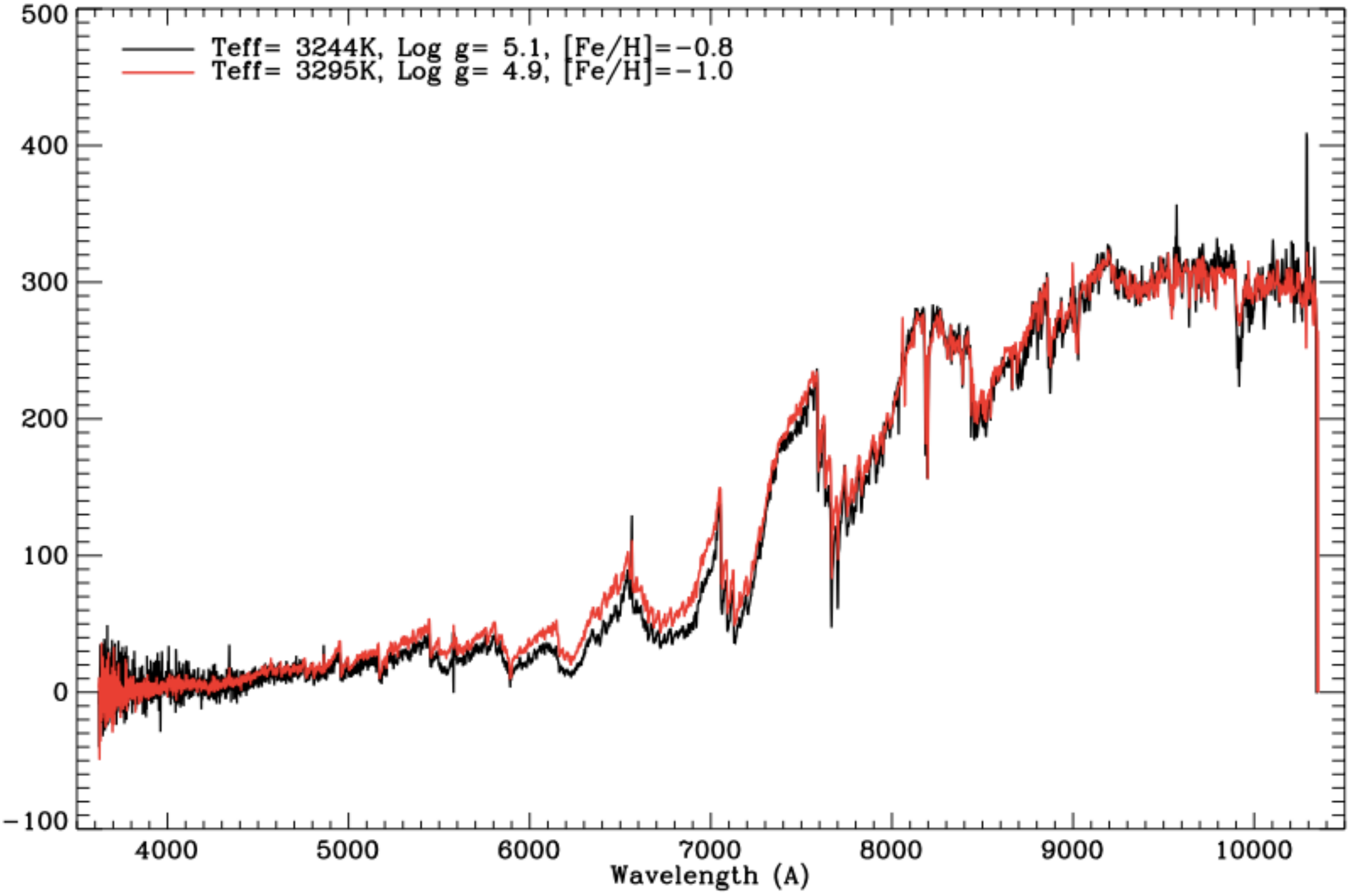
- Combined optical low res and IR high res studies.

Parameter Coverage

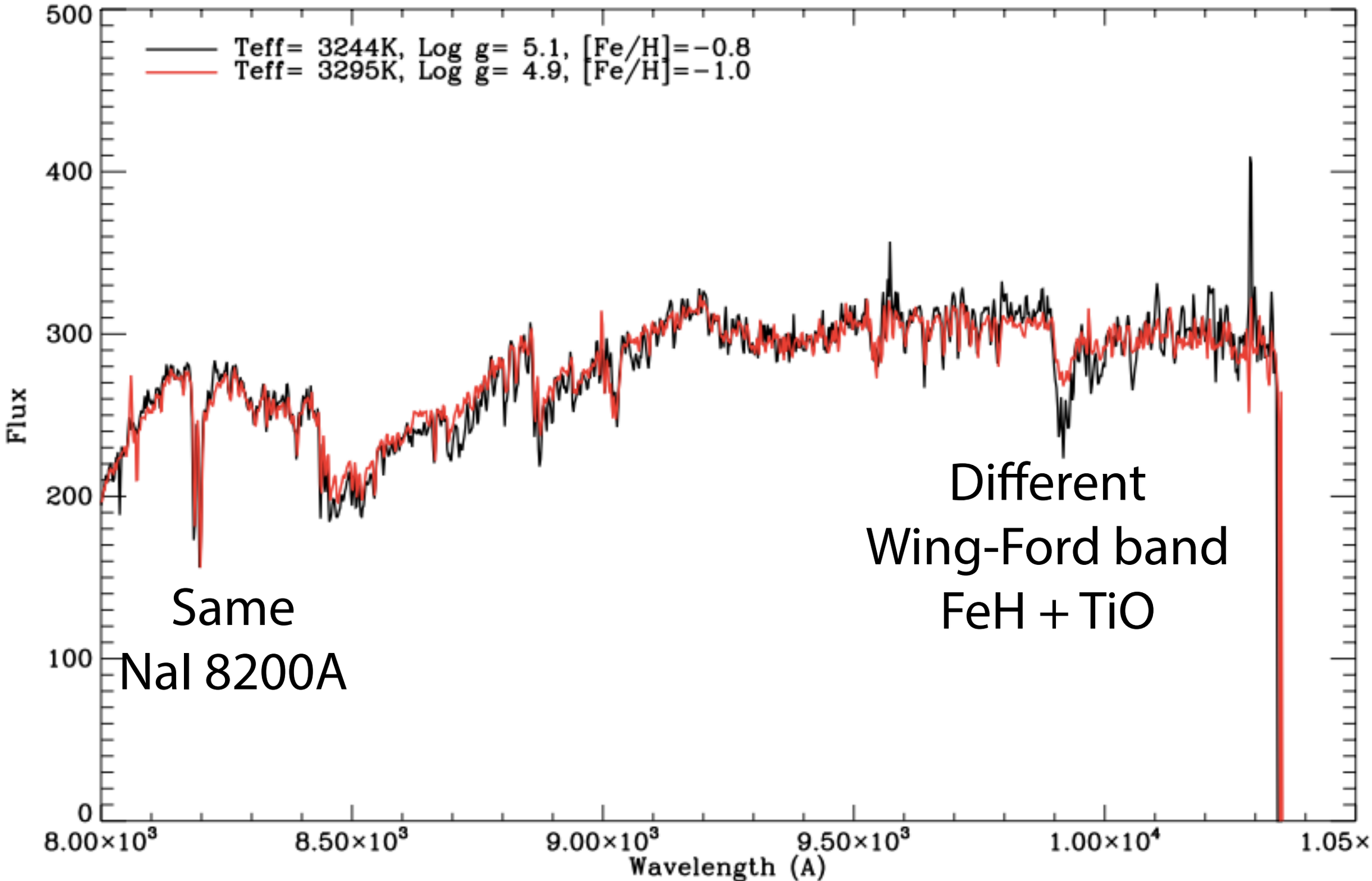
- ~3000 stars observed so far
- Wider parameter coverage, wavelength range
- Uniform calibration



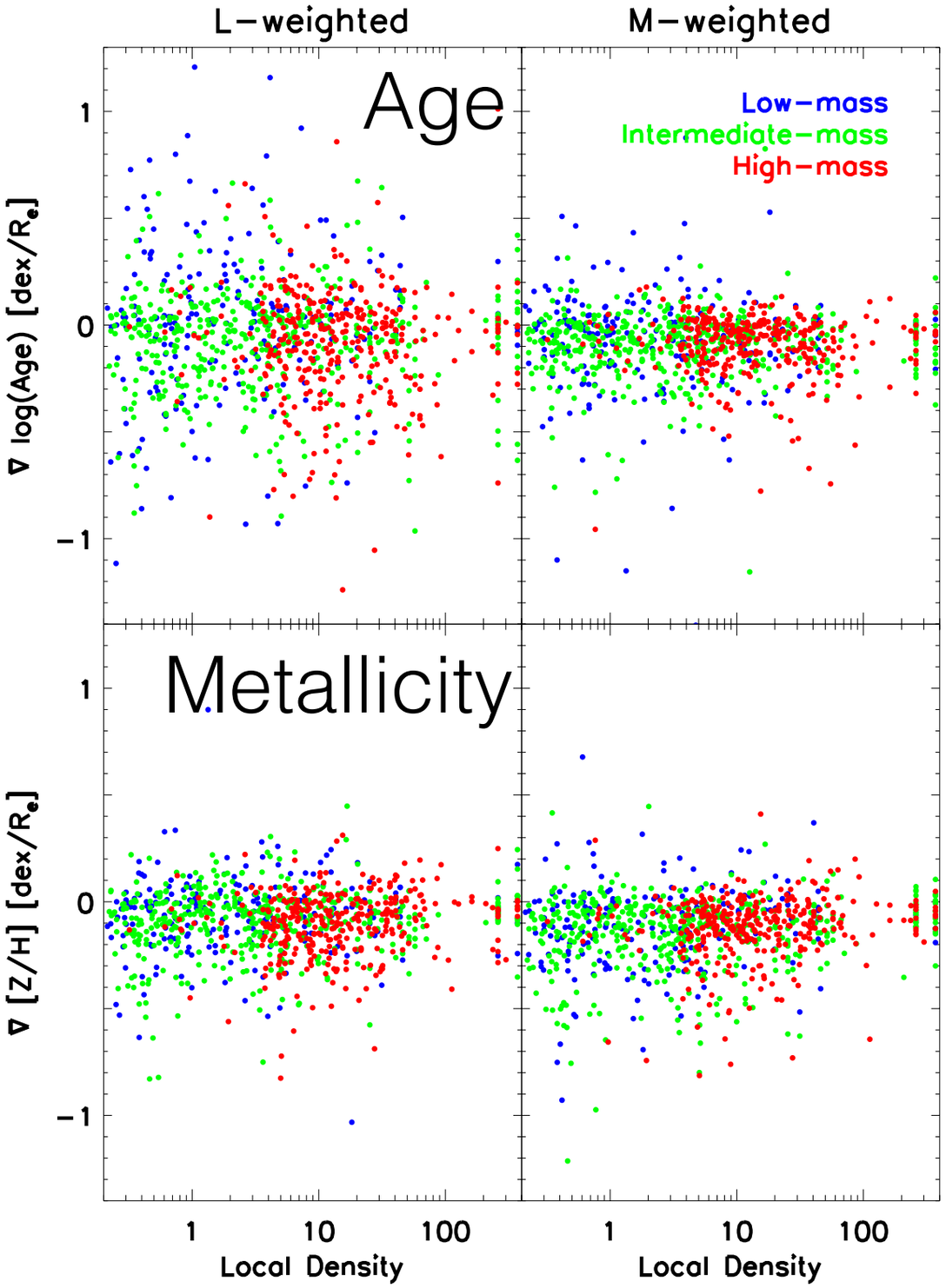
Example: IMF


Teff= 3244K, Log g= 5.1, [Fe/H]=−0.8
Teff= 3295K, Log g= 4.9, [Fe/H]=−1.0
Flux
Wavelength (A)
500
400
300
200
100
0
−100
4000
5000
6000
7000
8000
9000
10000

Example: IMF


Teff= 3244K, Log g= 5.1, [Fe/H]=−0.8
Teff= 3295K, Log g= 4.9, [Fe/H]=−1.0
Flux
Wavelength (A)
Same
NaI 8200A
Different
Wing-Ford band
FeH + TiO

Gradients vs. Environment



Gradients do not depend on Environment

Zheng et al. 2016

MaNGA Progress

- 2800 galaxies observed so far (3000 stars)
- 1400 galaxies (year 1) data to be released as part of SDSS DR13 (August 1 2016)
- Linear/Log data cubes, extracted RSS files, fully calibrated
- No higher-level science products released in DR13, scheduled for DR14 in 2017