MaNGA: how to run a successful survey

(and not die trying)

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Outline

(My) Science motivation

MaNGA overview

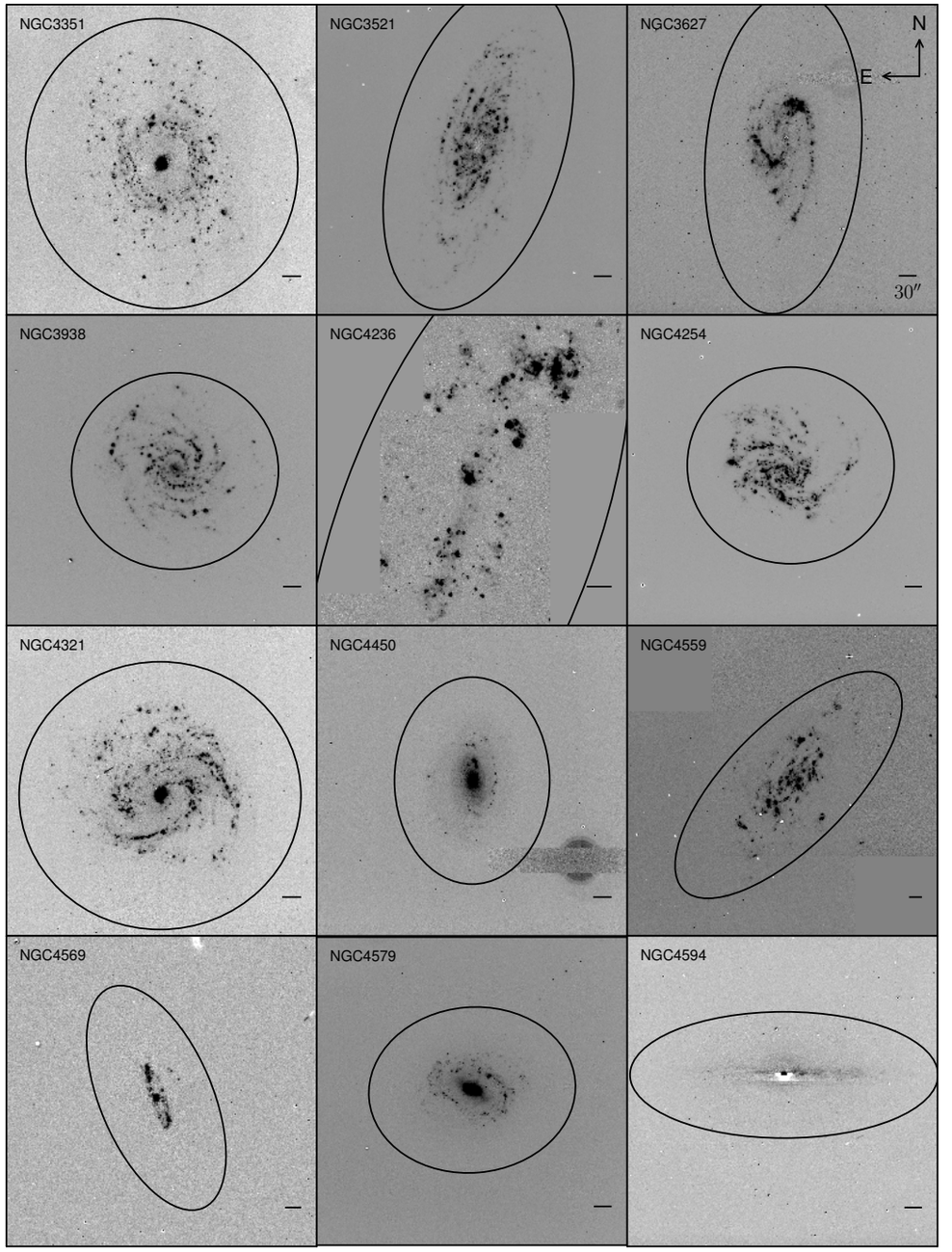
Observing strategy

A day in the life of MaNGA

Science motivation

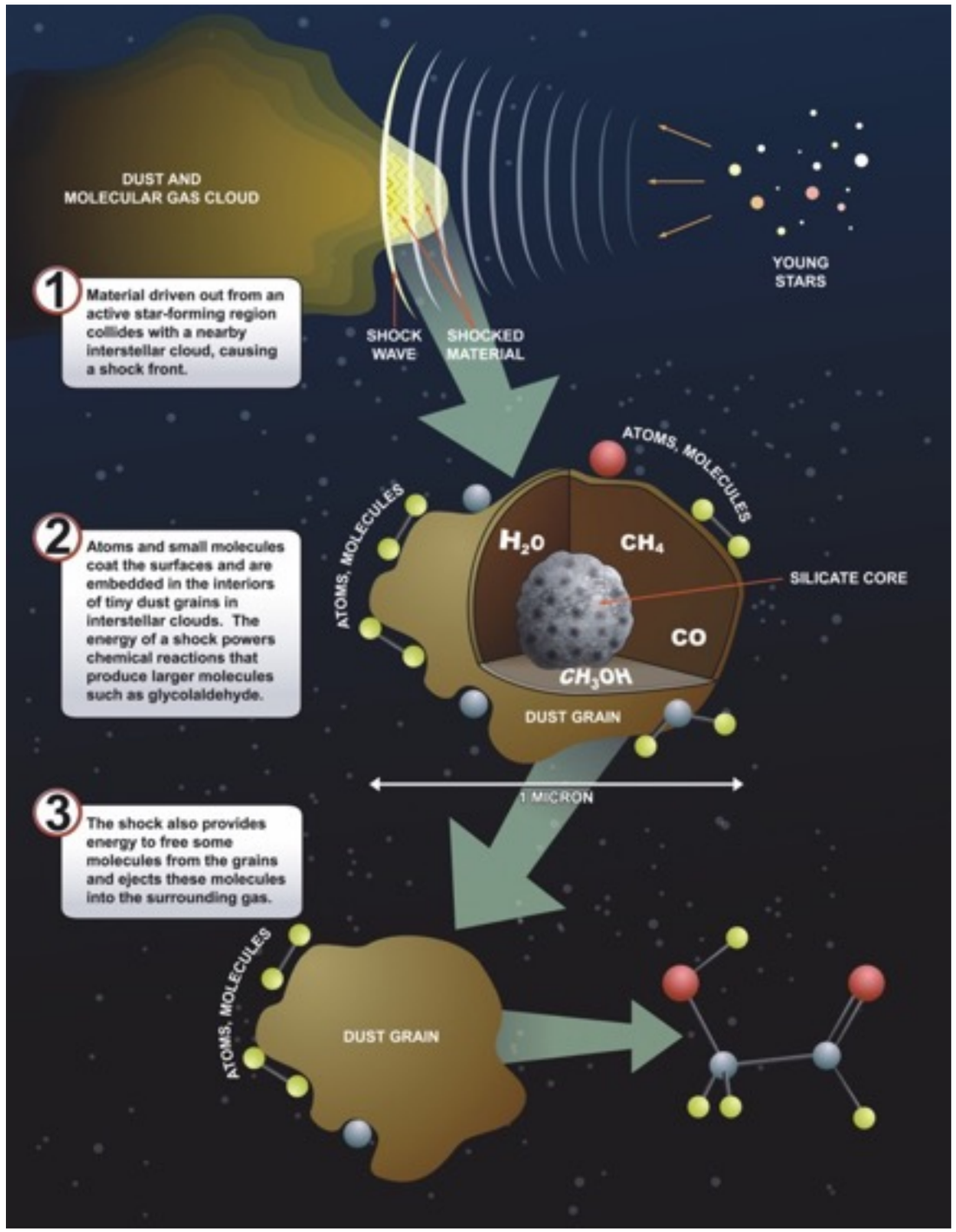
The JCMT Nearby Galaxies Legacy Survey

- 155 nearby galaxies (< 25 Mpc). Subsamples include field + Virgo + SINGS galaxies.
- Observed with JCMT in CO J=3–2 (HARP-B, completed) and dust continuum (SCUBA-2, ongoing).
- HI selected ⇒ morphologically complete.
- ^{12}CO J=3–2 using HARP-B:
  - Spatial resolution: 14.5 arcsec.
  - Spectral resolution: 0.43 km s^{-1}.
  - Noise level: T_A^* ~ 19 mK at 20 km s^{-1}.
- Halpha follow up (Sánchez-Gallego et al. 2012)



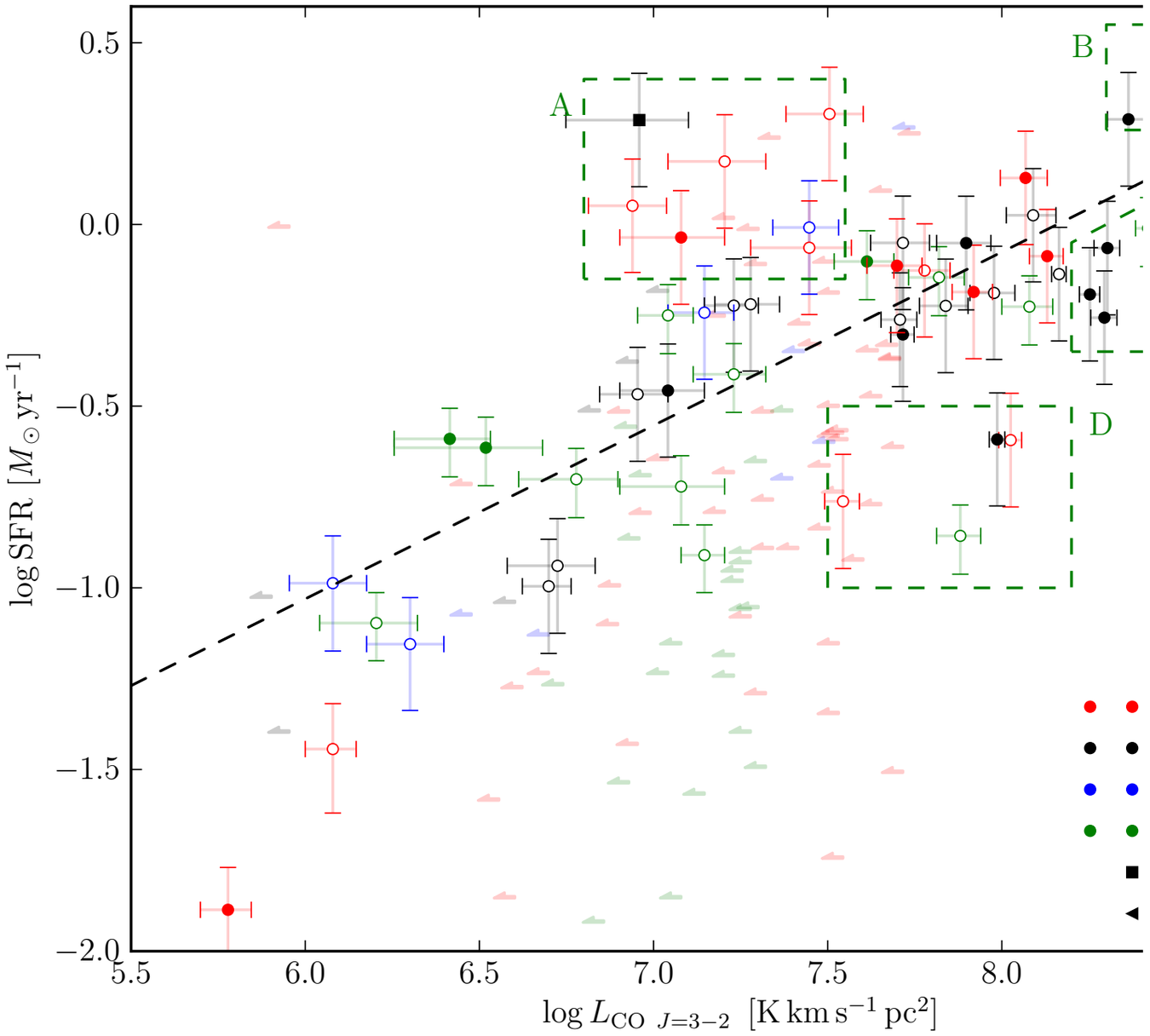
Science motivation

Molecular gas

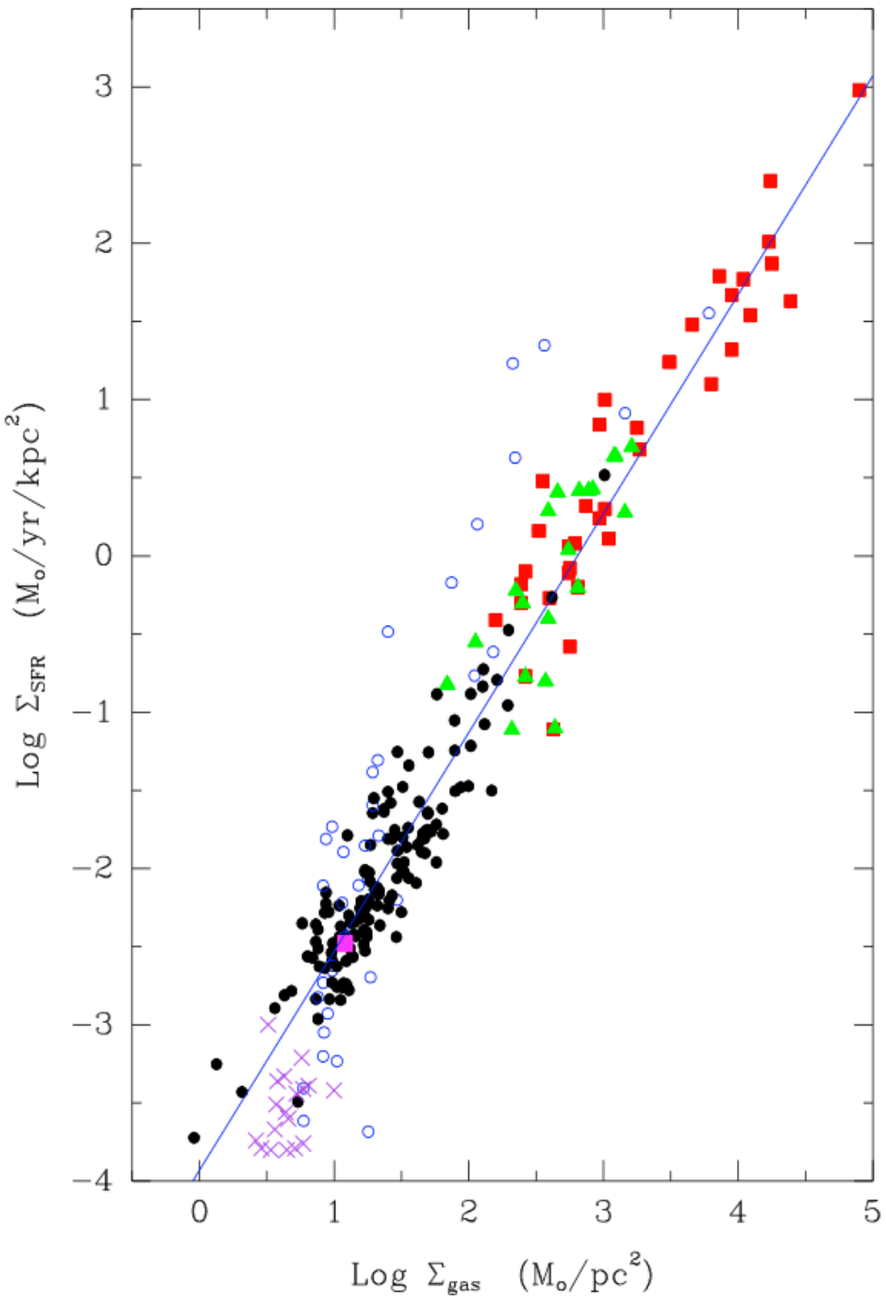


Science motivation

The JCMT Nearby Galaxies Legacy Survey



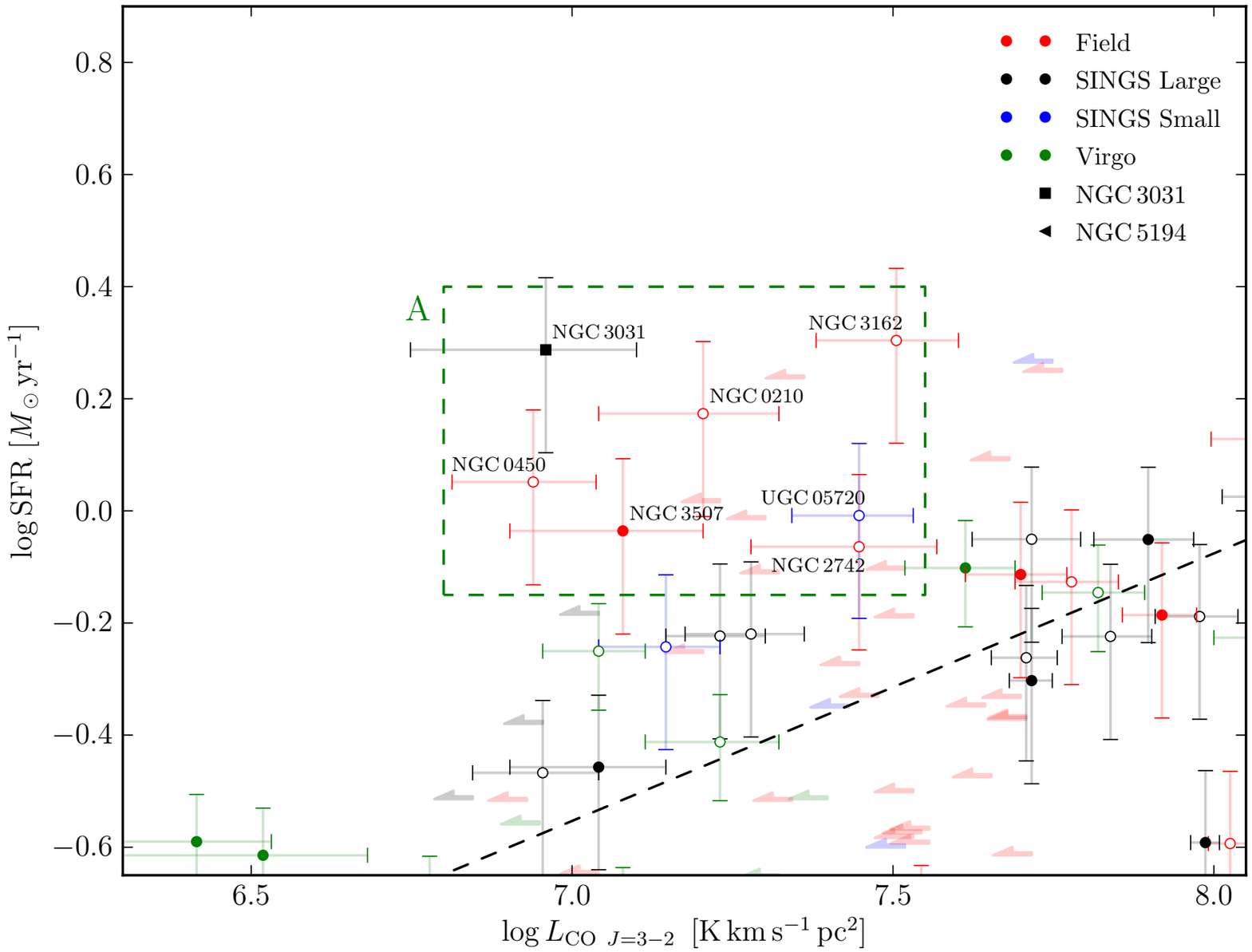
Sánchez-Gallego et al. (2012)



Kennicutt & Evans (2012)

Science motivation

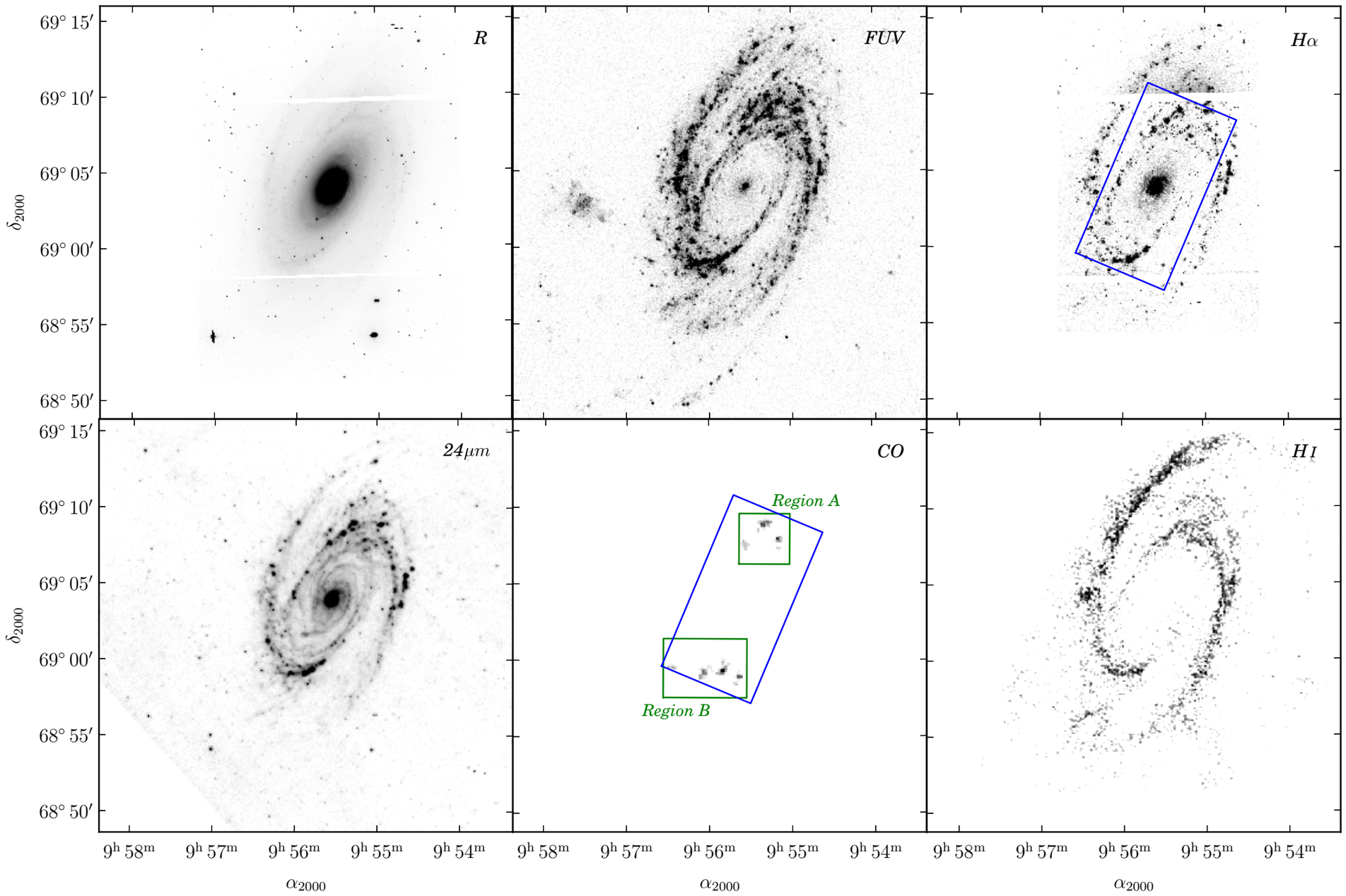
The JCMT Nearby Galaxies Legacy Survey



Sánchez-Gallego et al. (2012)

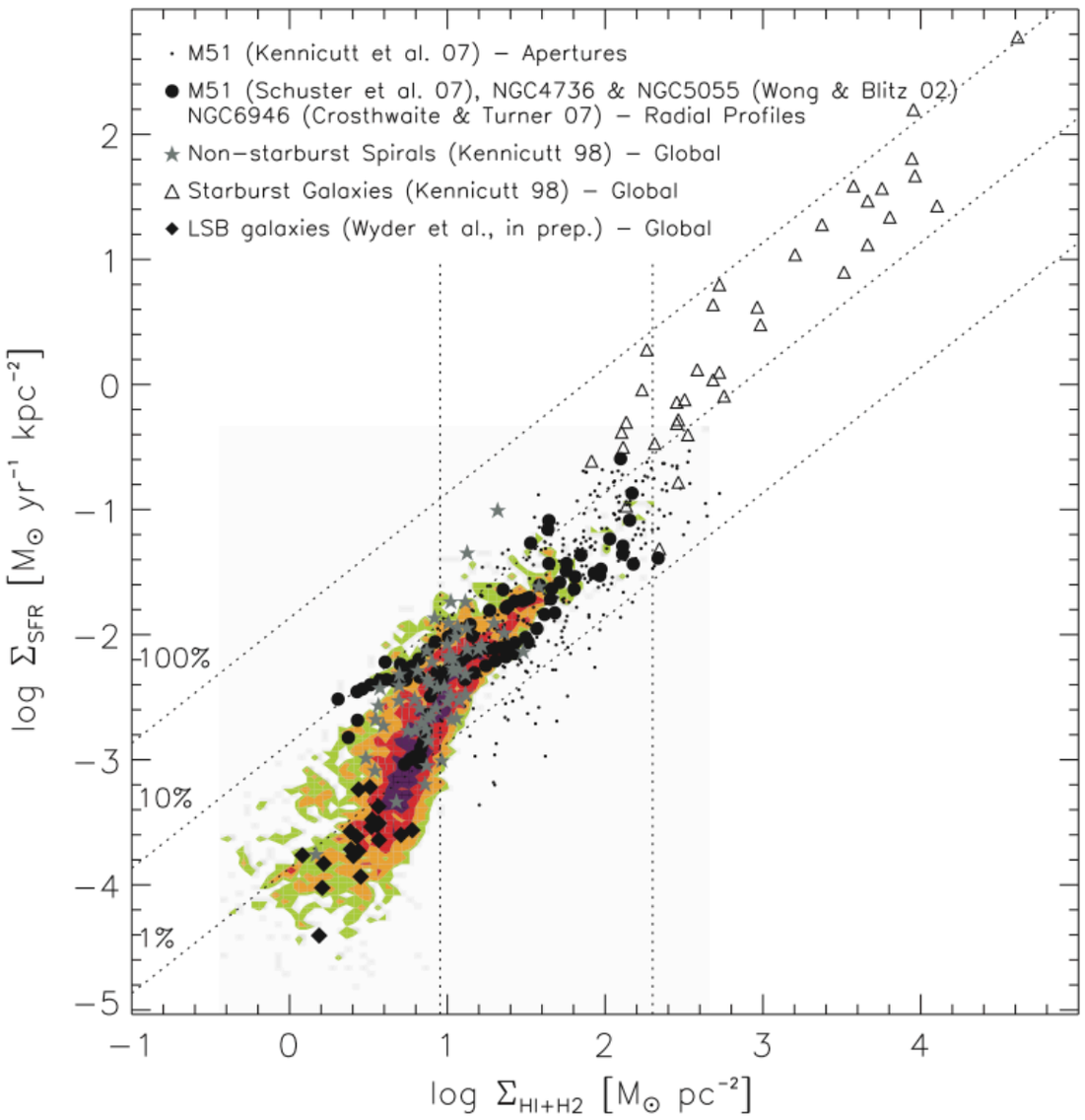
Science motivation

The JCMT Nearby Galaxies Legacy Survey

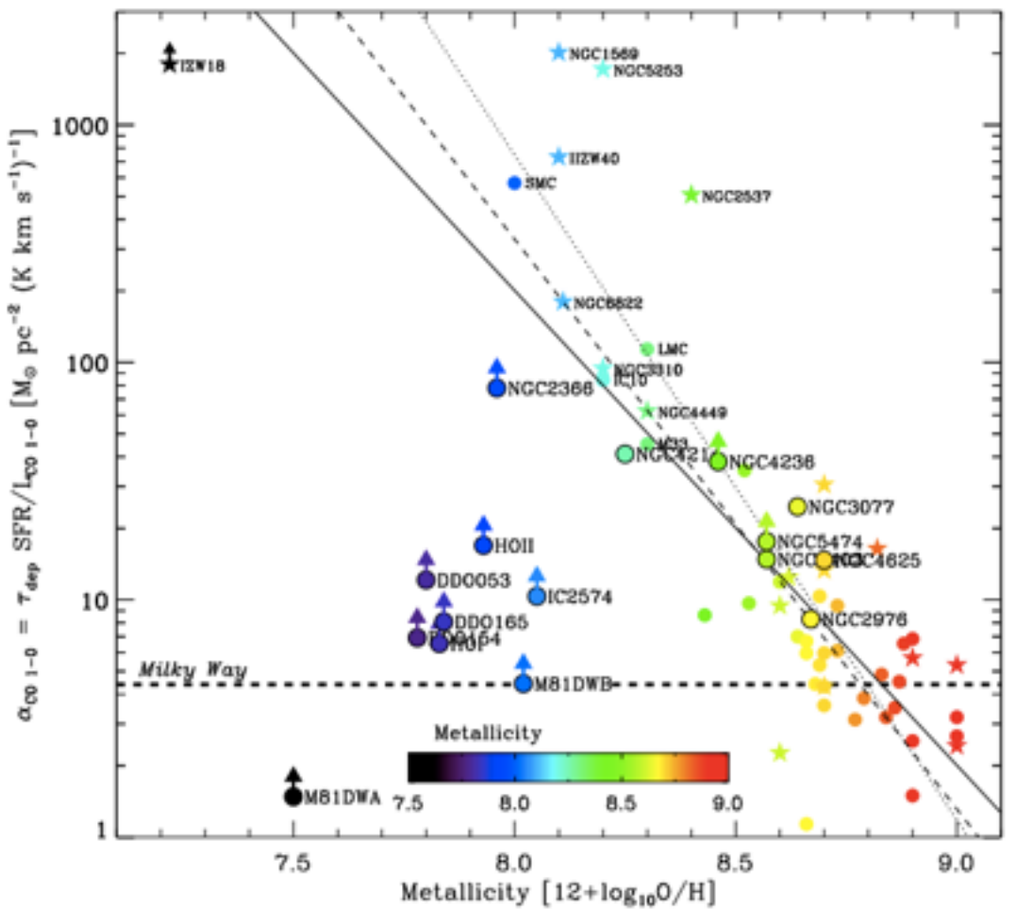


Sánchez-Gallego et al. (2011)

Science motivation



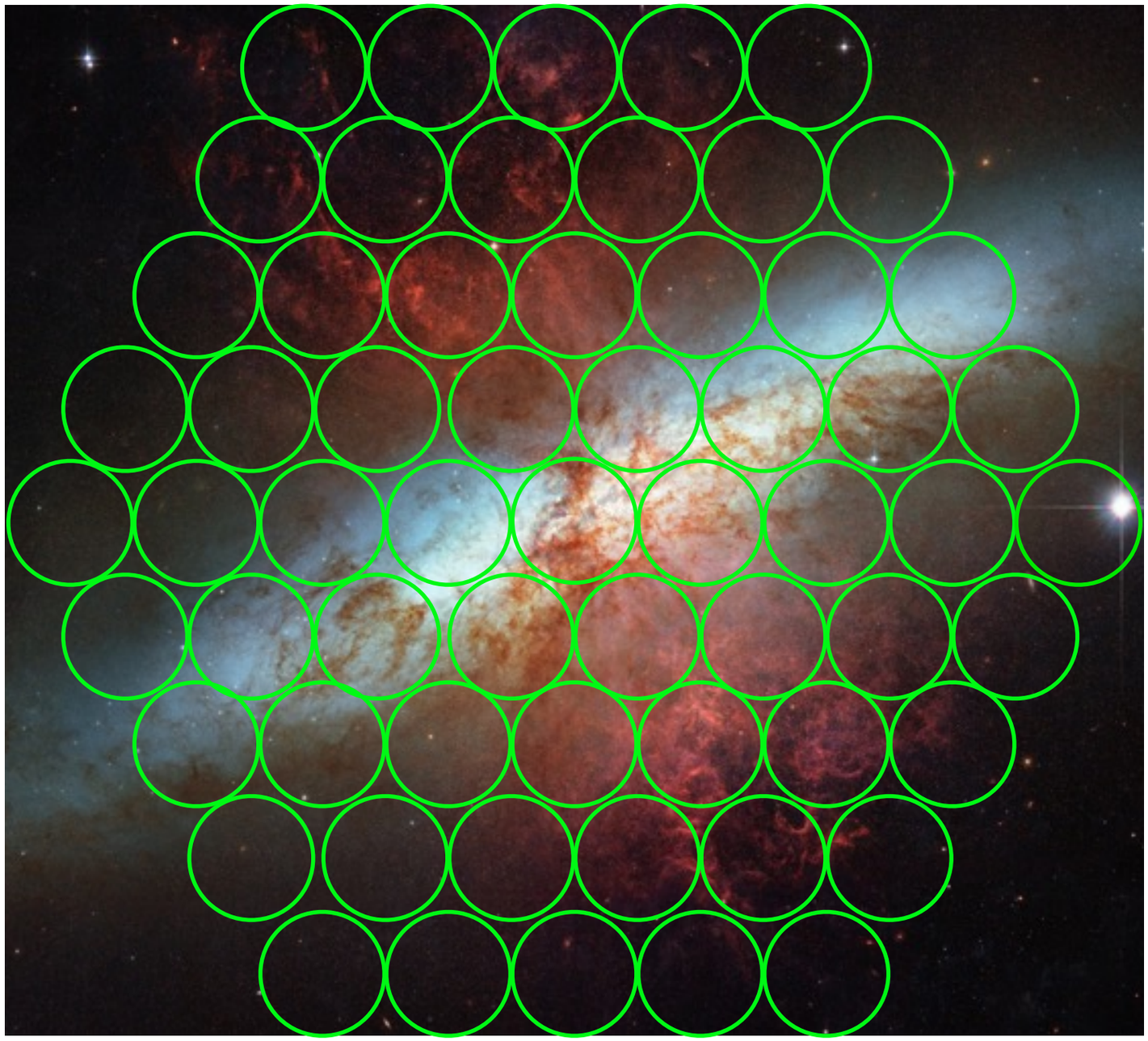
Bigiel et al. (2008)



Schruba et al. (2012)

Science motivation

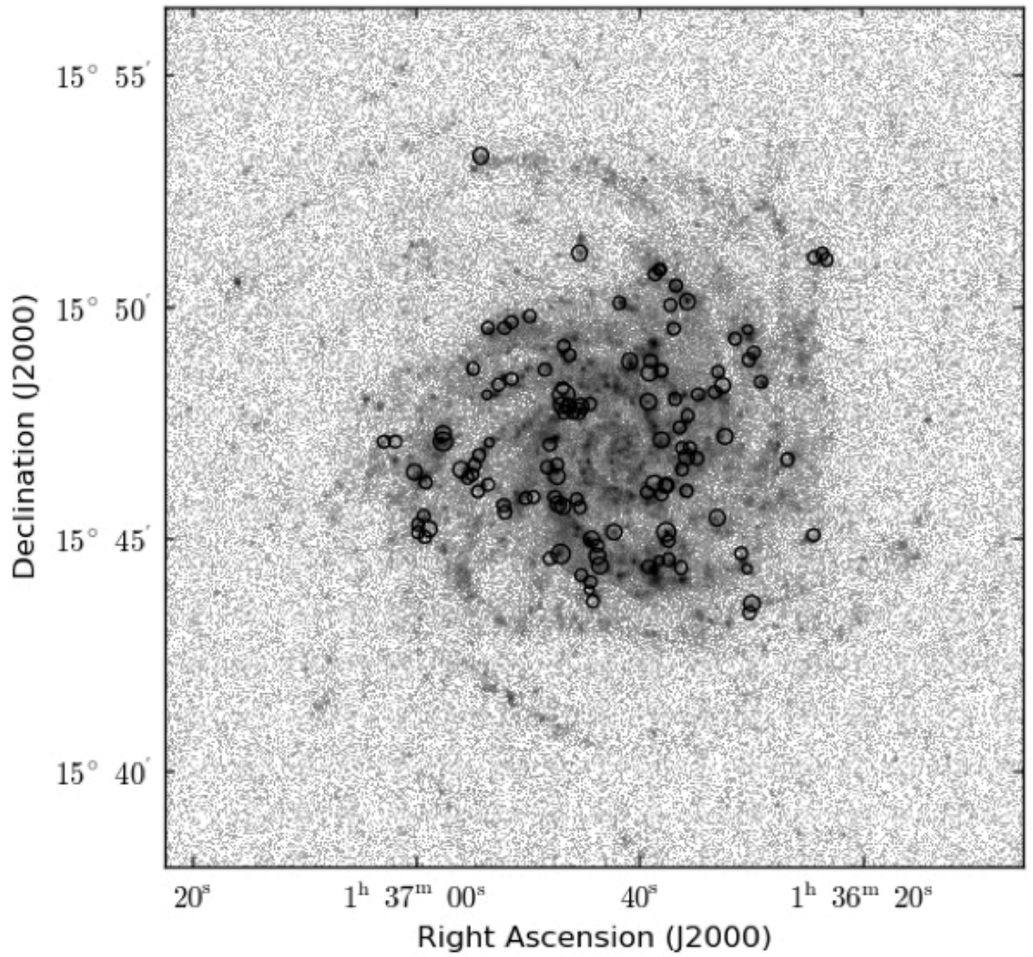
Science motivation

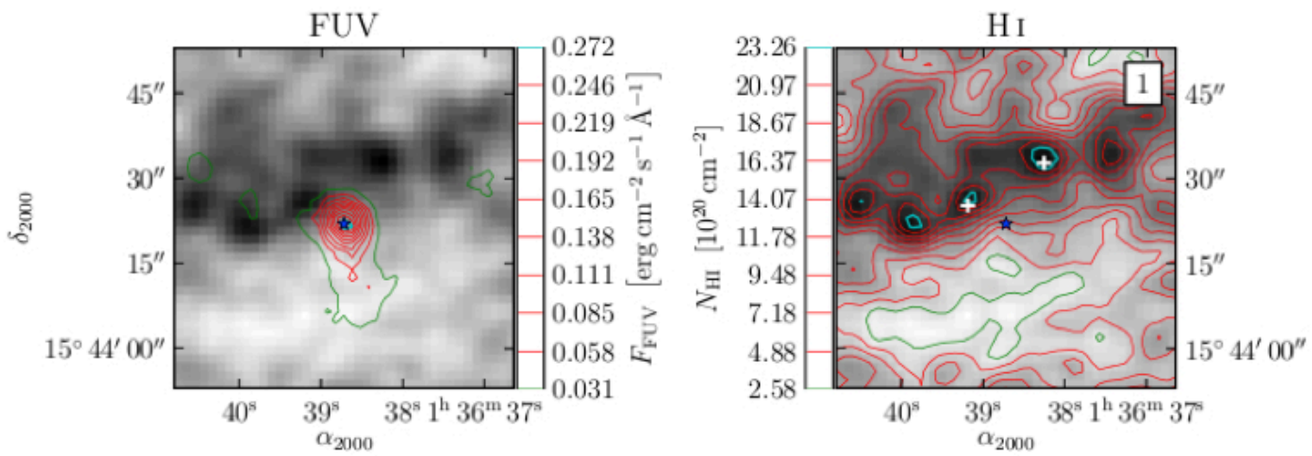


Science motivation

How can MaNGA improve our knowledge about gas and SF?

- The interplay between cold gas and star formation
- Molecular gas in massive early-type galaxies
- Spatially-resolved correlations
- The interaction between AGN activity and the ISM
- Kinematics of the different components of gas
- The impact of metallicity in the CO-to-H2 conversion ratio.
- Improve our photodissociation models





Heiner & Sánchez-Gallego (2013)

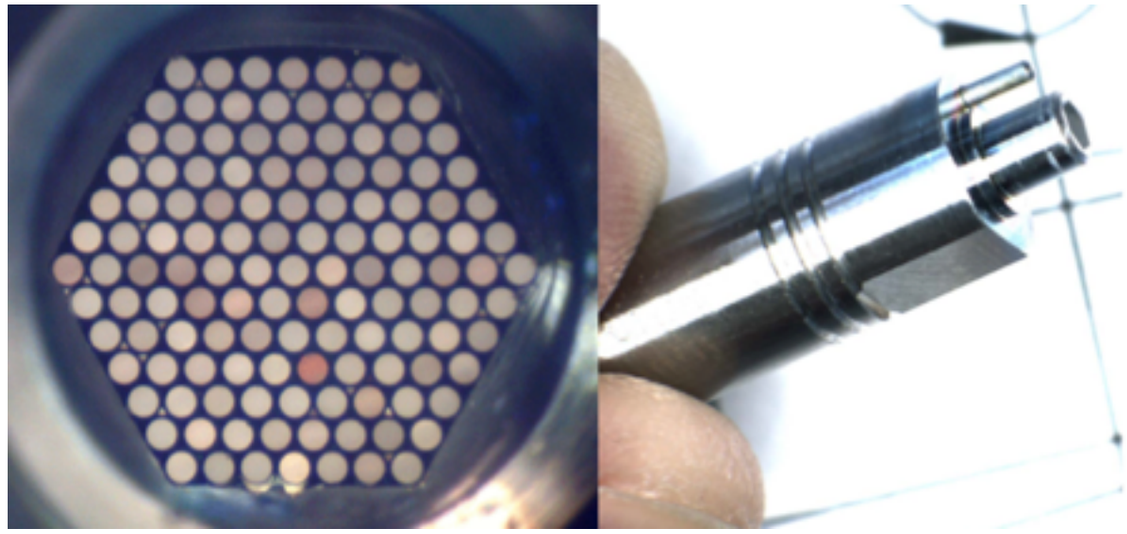
MaNGA overview

Overview on MaNGA

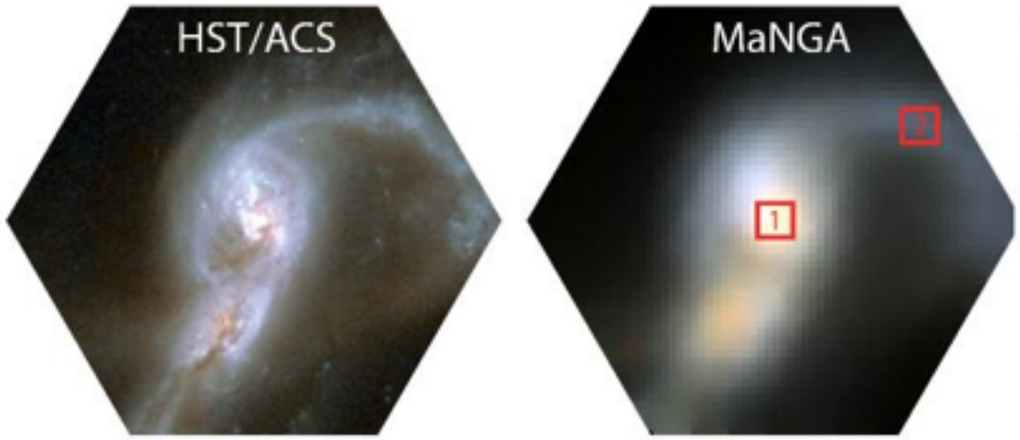
MaNGA overview

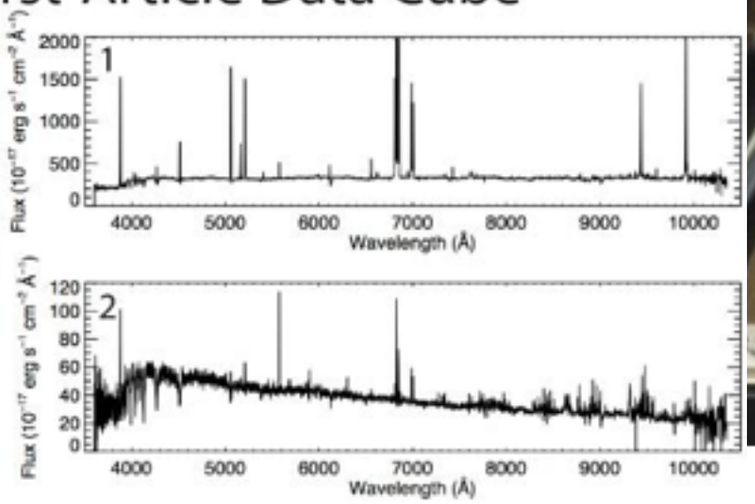
- MaNGA: Mapping Nearby Galaxies at APO
- PI: Kevin Bundy. Over 160 members in 50+ institutions.
- Part of SDSS-IV (2014-2020)

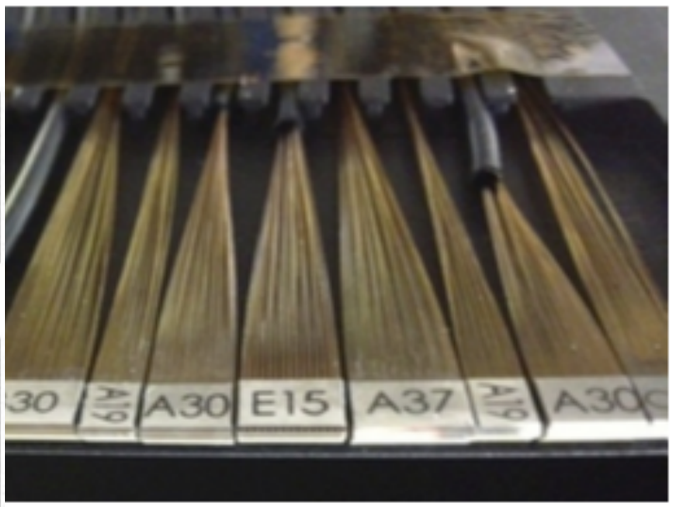
- IFU observations of 10,000 galaxies (1000 already observed!)
- $0.01 < z < 0.15$



Mrk 848: SDSS-IV/MaNGA First-Article Data Cube







MaNGA overview

Science goals

“

1. How are galaxy disks growing at the present day and what is the source of the gas supplying this growth?

2. What are the relative roles of stellar accretion, major mergers, and secular evolution processes in contributing to the present-day growth of galactic bulges and ellipticals?

3. How is the shutdown of star formation regulated by internal processes within galaxies and externally- driven processes that may depend on environment?

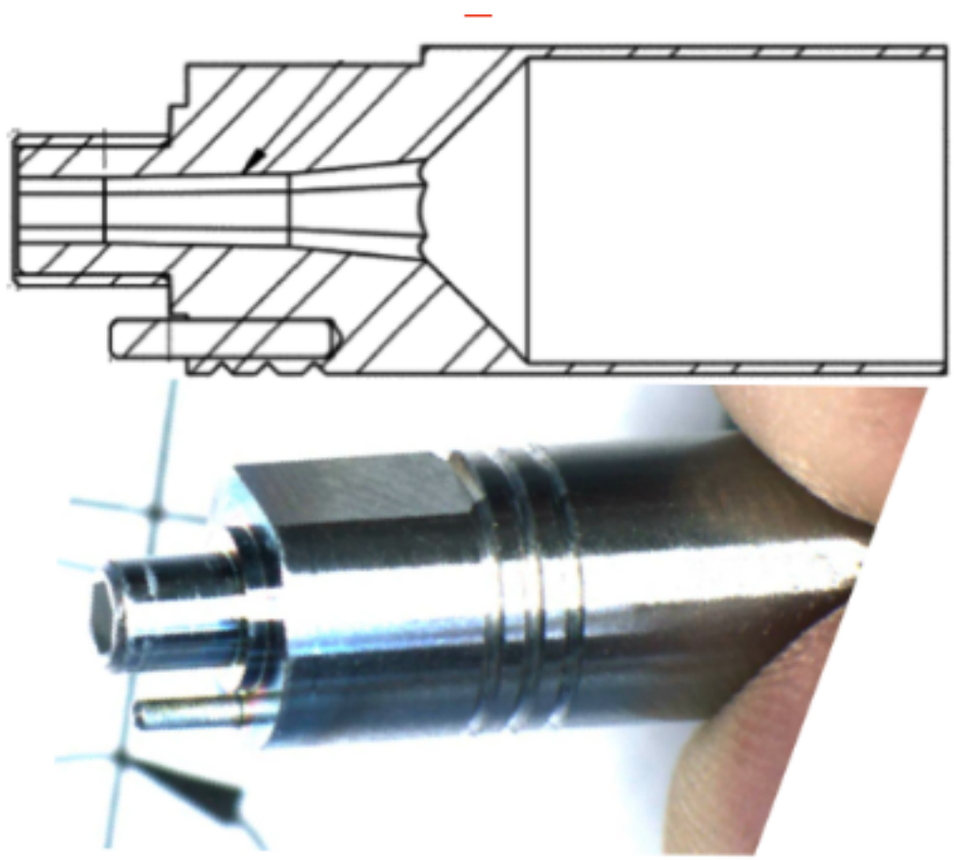
4. How is mass and angular momentum distributed among different components and how has their assembly affected the components through time?

”

Bundy et al. (2015)

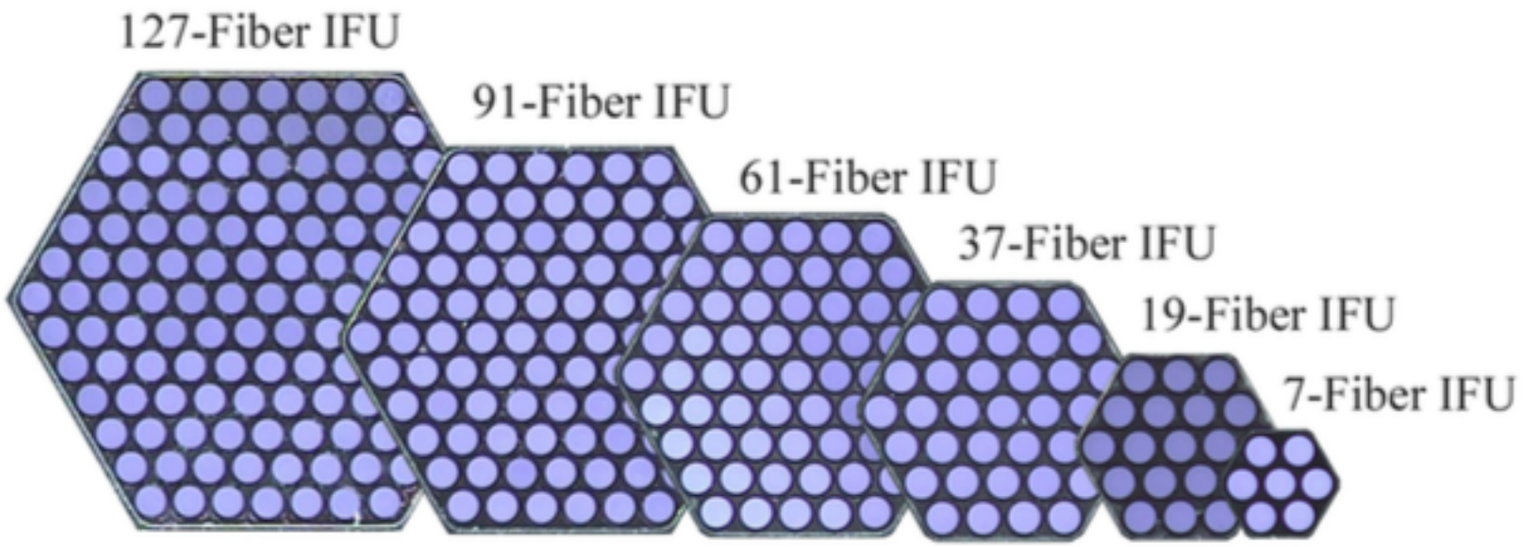
MaNGA overview

Hardware



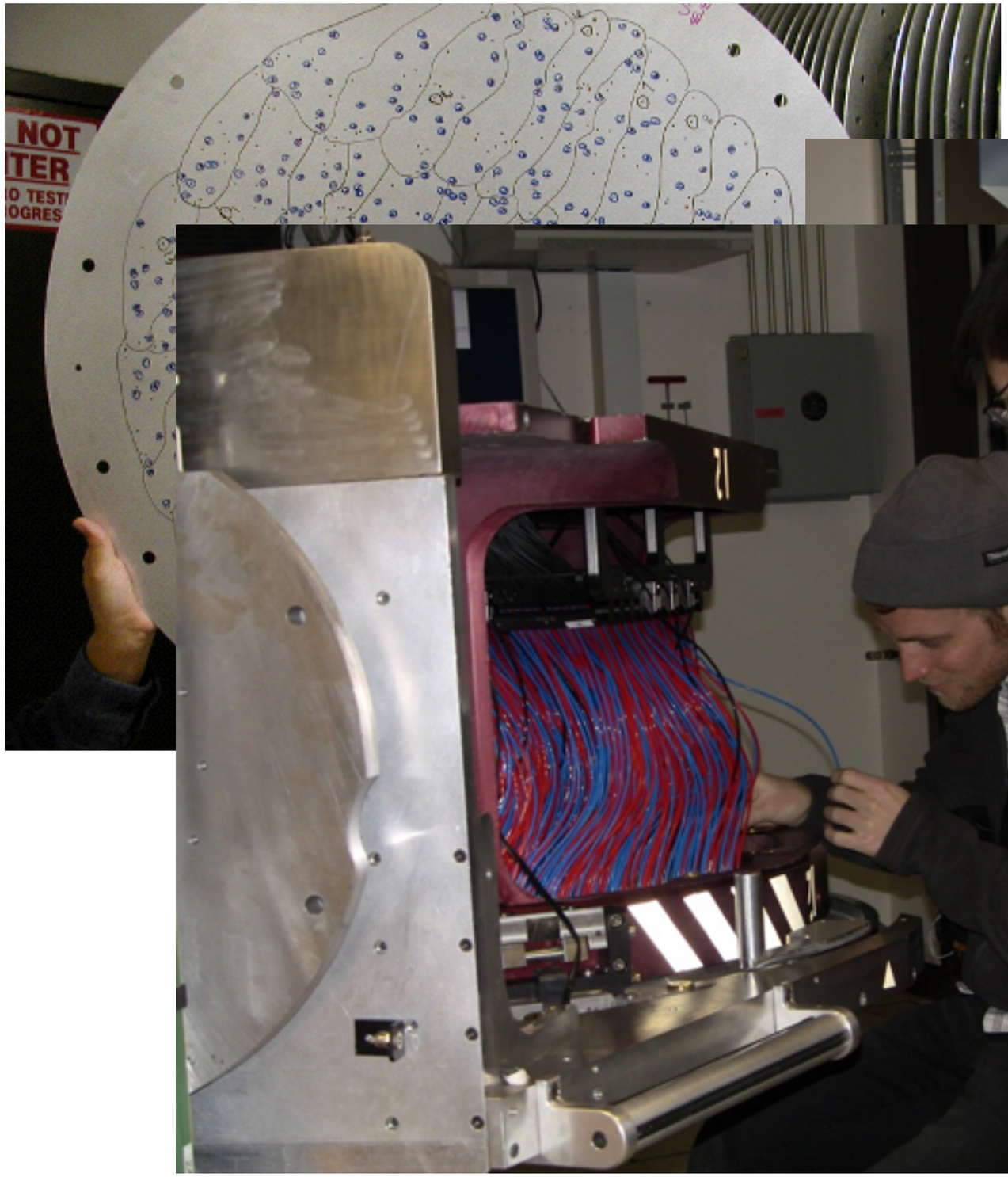
- 17 IFU bundles
- 5 bundle sizes ranging from 19 to 127 fibres in hexagonal pattern
- 12 x 7-fibre mini-bundles for spectrophotometric calibration
- 92 single fibres for sky subtraction

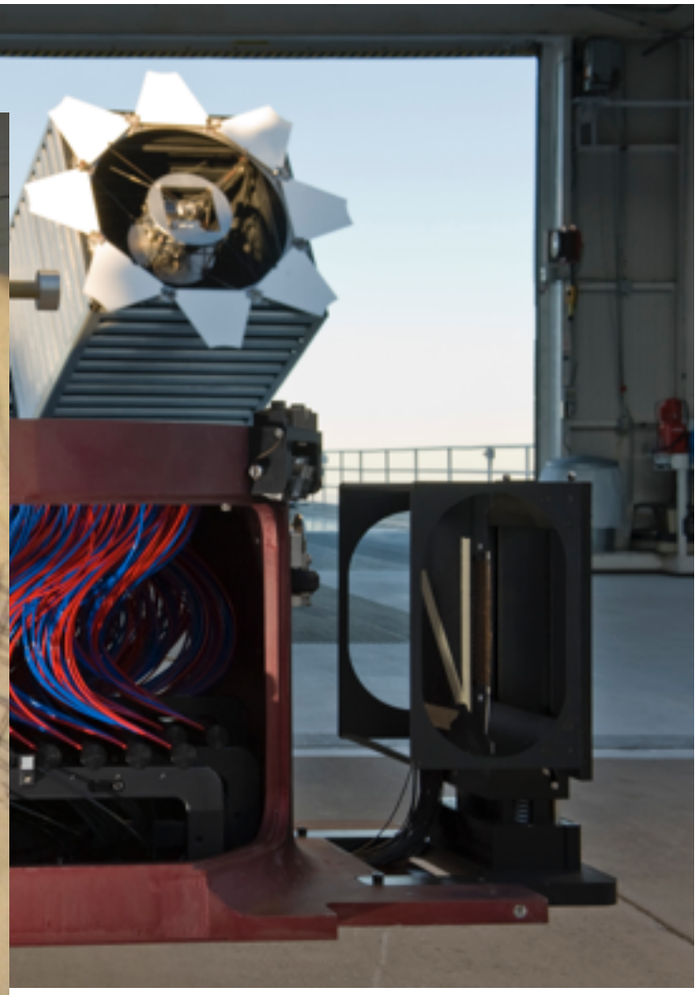
Drory et al. (2015)



MaNGA overview

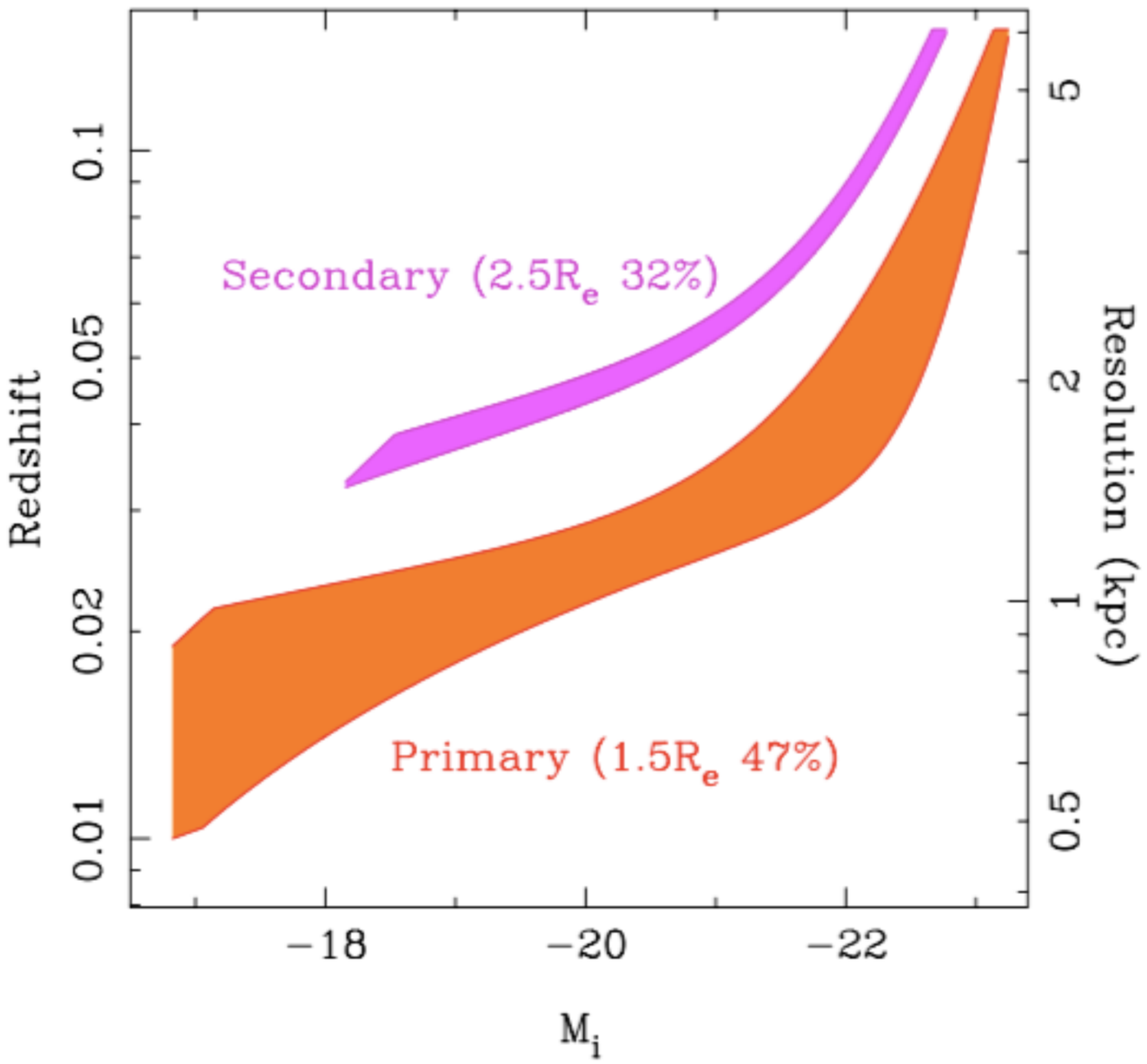
Hardware





MaNGA overview

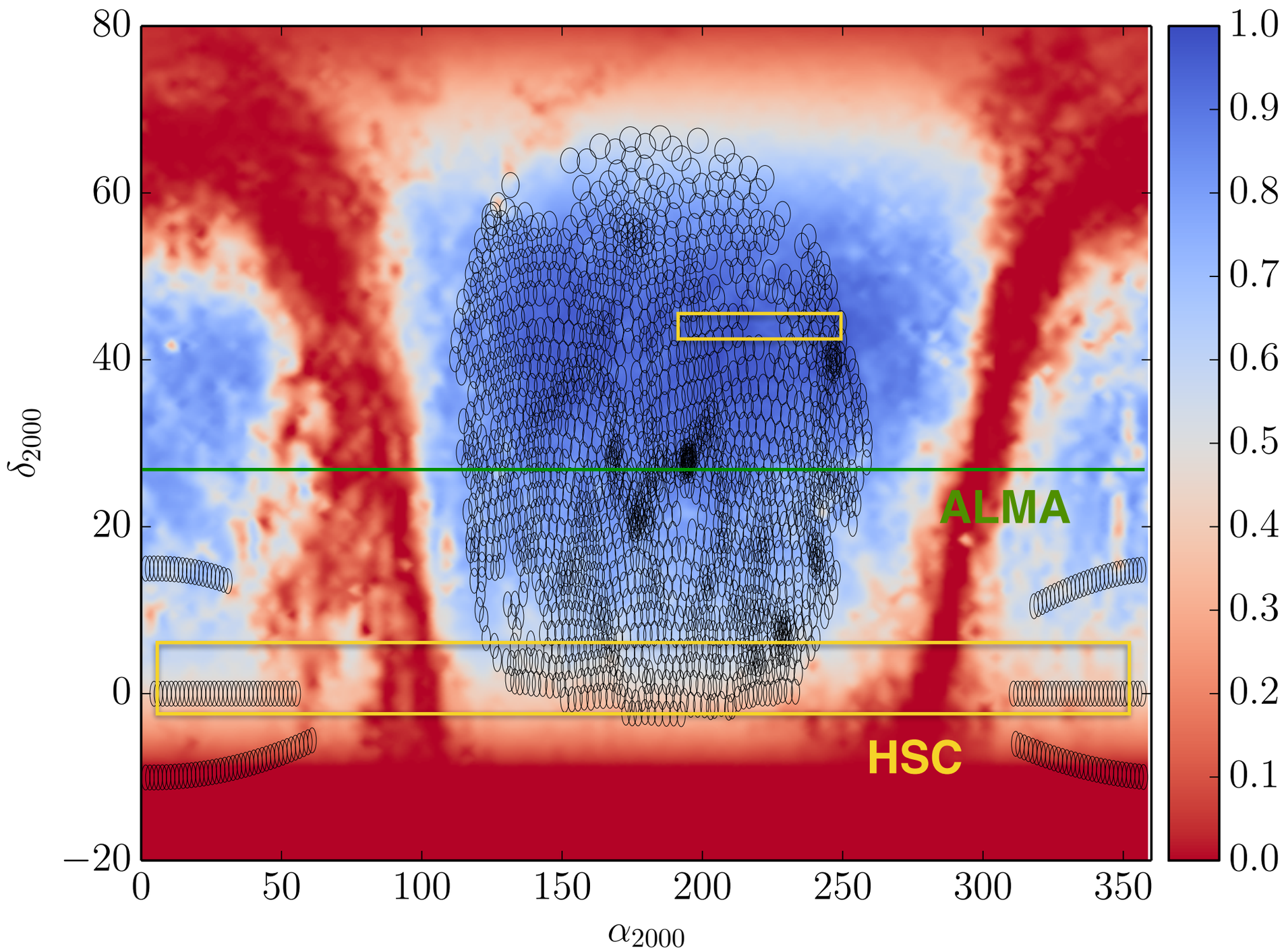
Sample design



- $M_* > 10^9 M_\odot$
- Two main subsamples at 1.5 and 2.5 Reff
- Flat distribution in M_*
- Based on NASA Sloan Atlas v1
- 5-10% bundles allocated to ancillary programs

MaNGA overview

Field selection

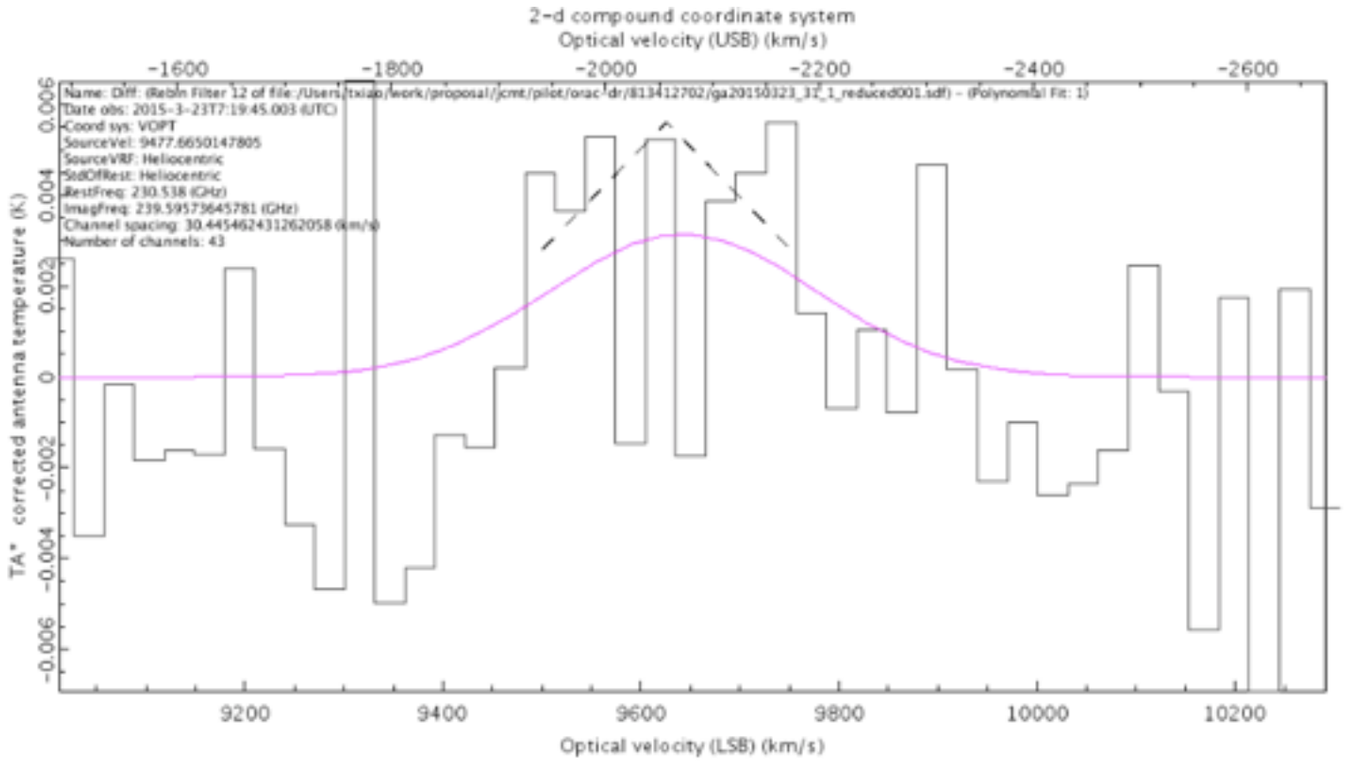


MaNGA overview

Field selection

MaNGA CO follow-up

- Overlap with COLDGASS (215 galaxies in MaNGA P+)
- New CO observations
  - CSO proposal (executed) (PI: Xiao)
  - 2xJCMT proposals (1 approved) (PIs: Xiao, Li)
  - ARO proposal (PI: Bothwell)
- ALMA!

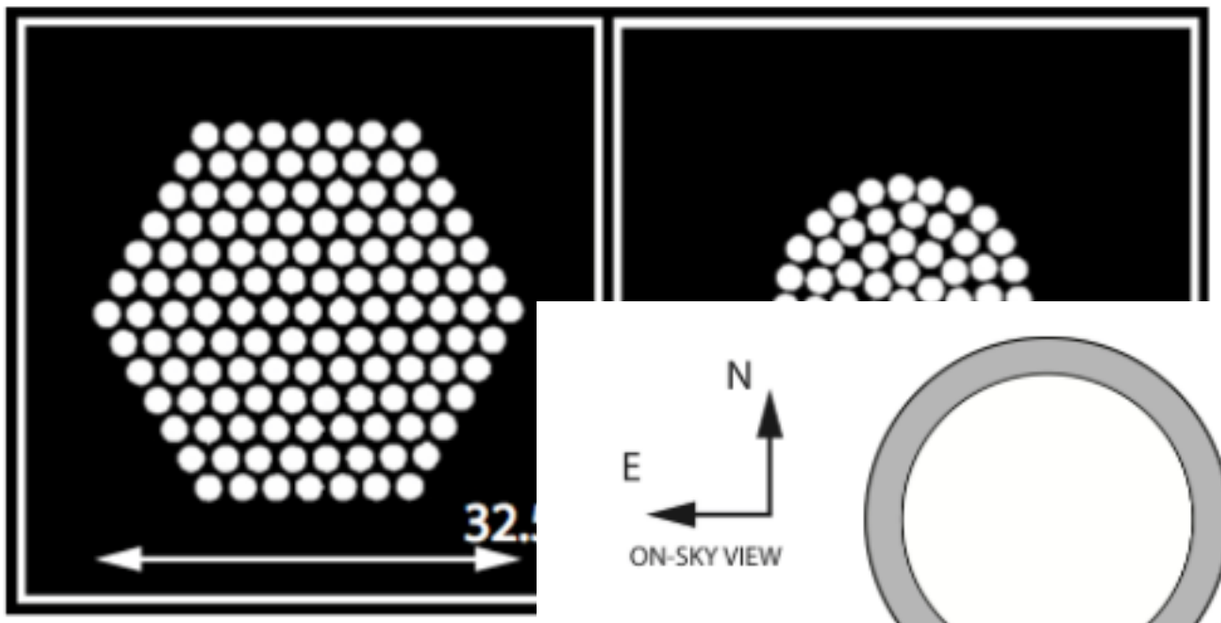


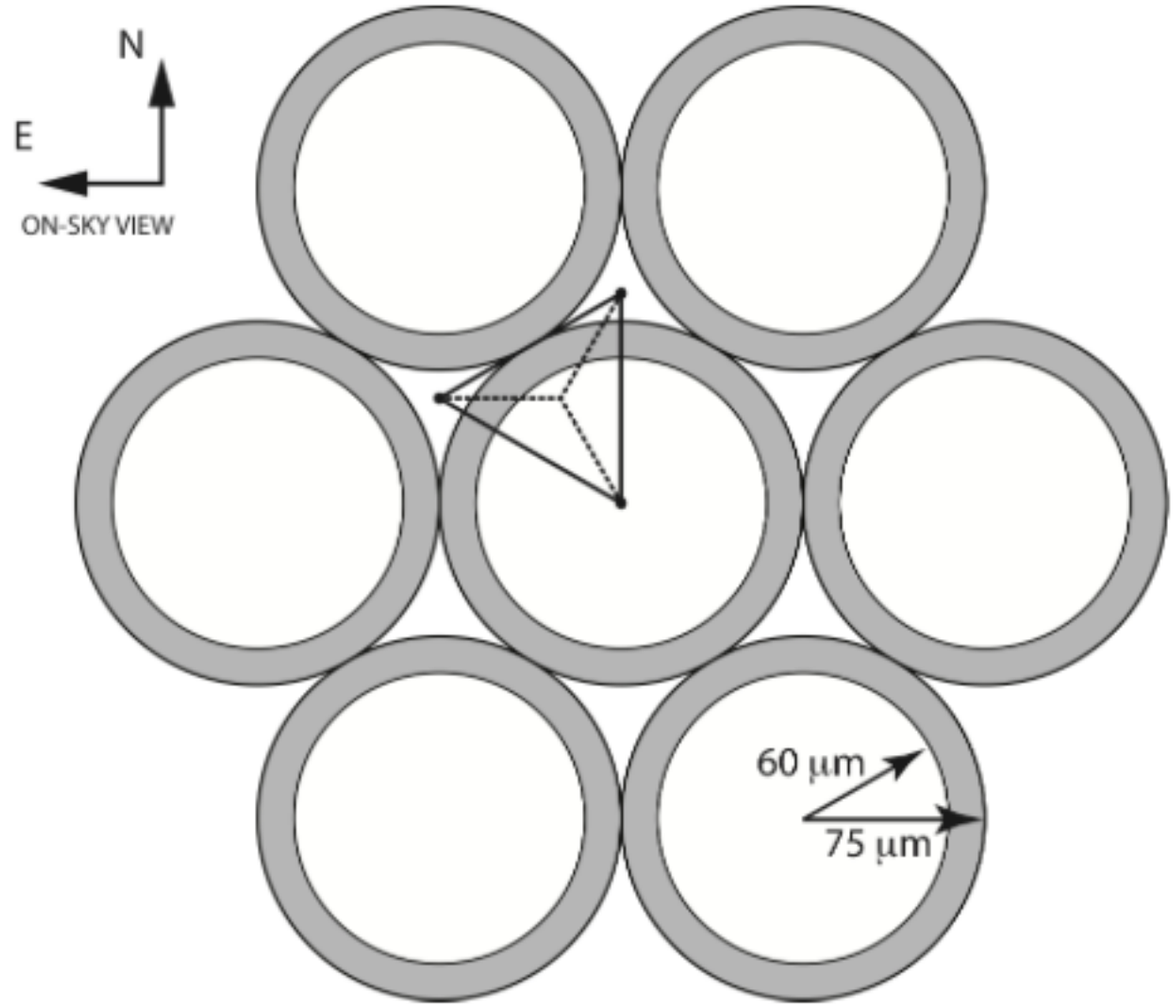
Observing strategy

Observing strategy

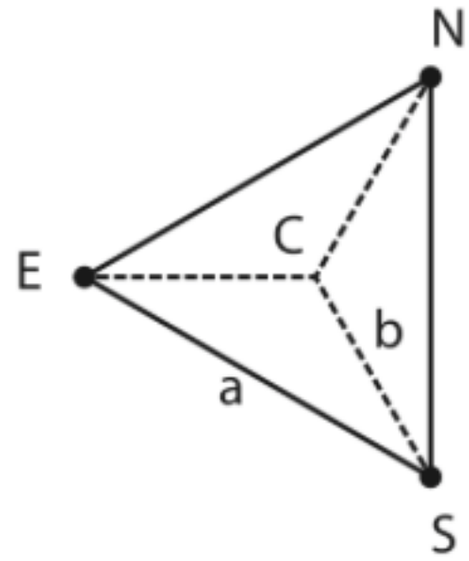
Observing strategy

Dithering





Set: combination of N+S+E exposures

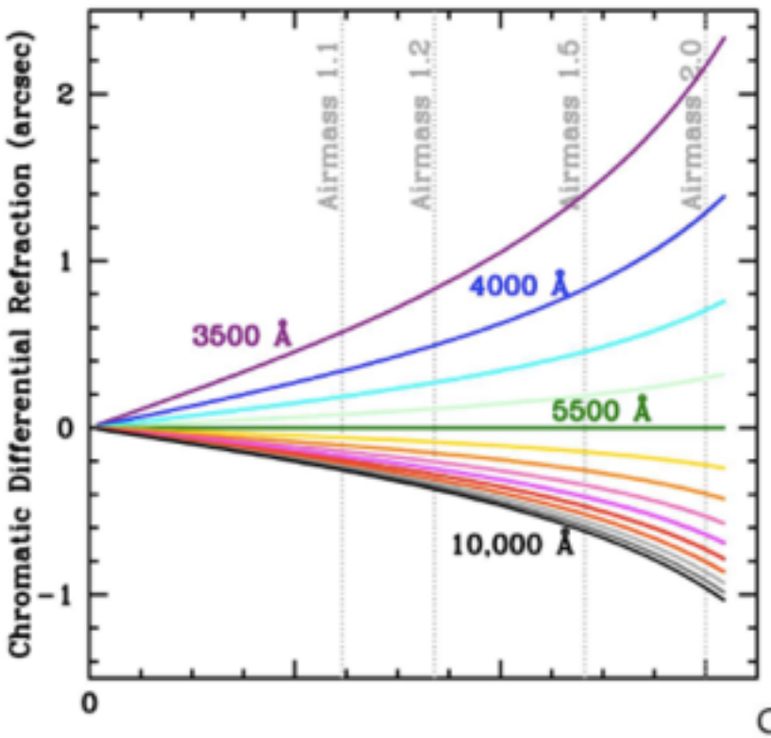


a = 86.6 μm = 1.44″
b = 50.0 μm = 0.83″

Law et al. (2015)

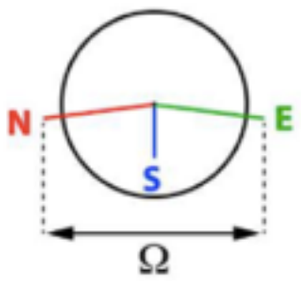
Observing strategy

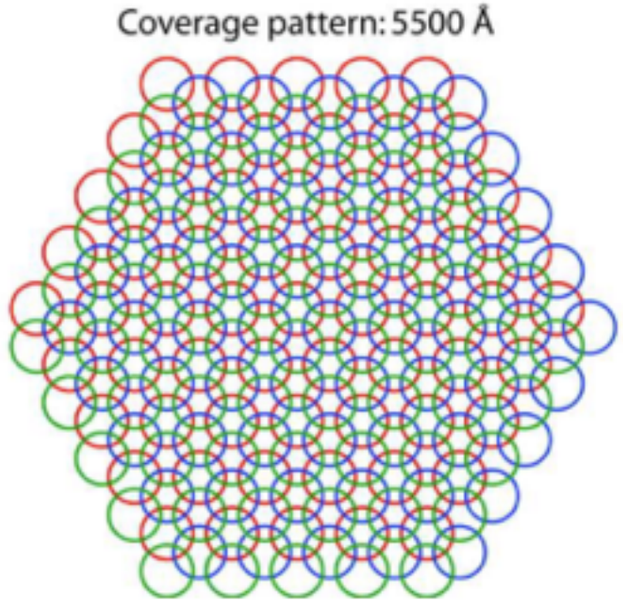
Chromatic differential refraction

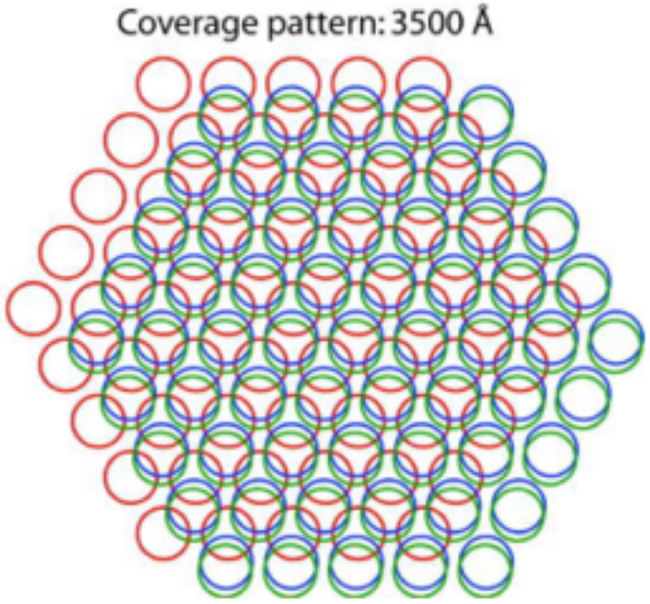


$$\tan\eta = \frac{\sin h \cos\phi \cos\delta}{\sin\phi - \sin\delta\cos z}$$

(Parallactic angle)





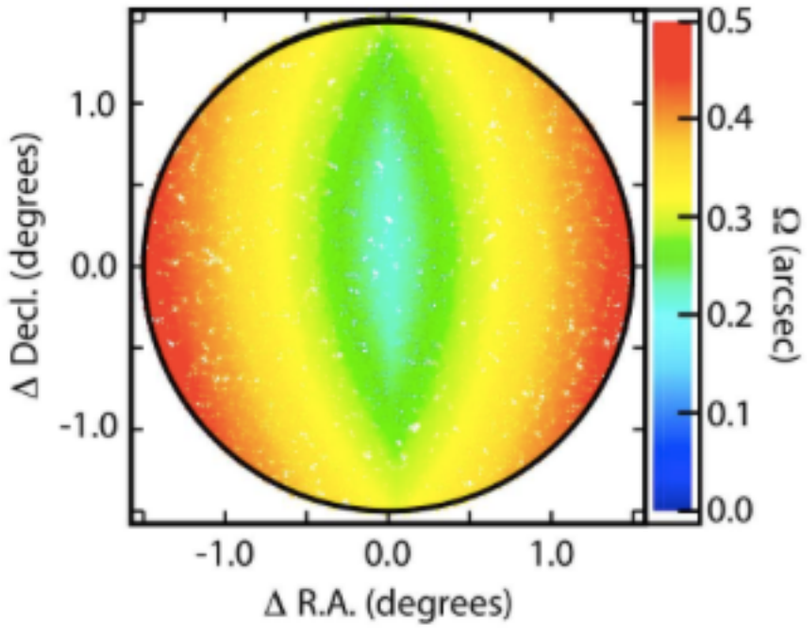


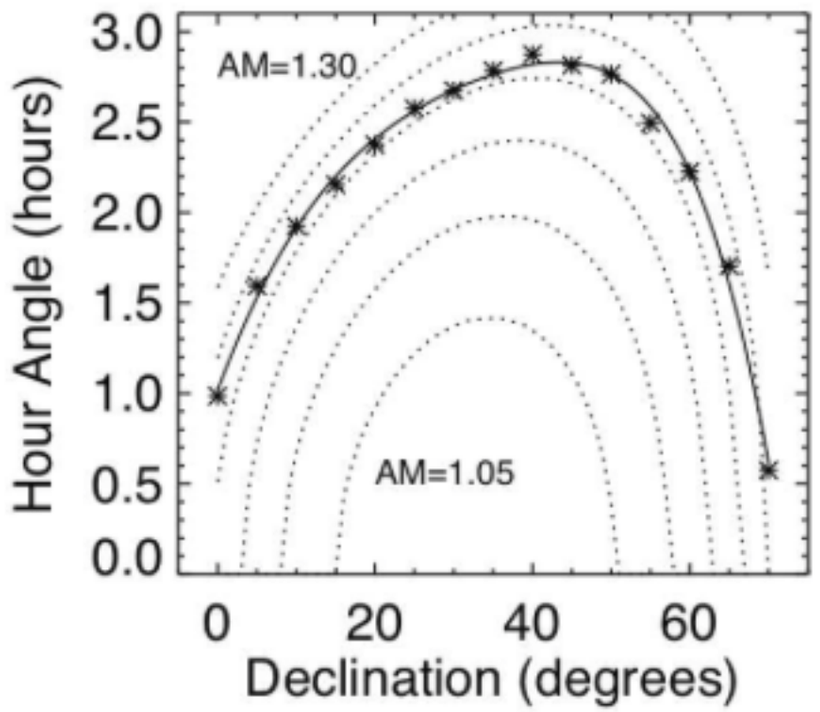
Law et al. (2015)

Observing strategy

MaNGA observing requirements

- Exposure time 15 minutes
- Sets of three dithered exposures
- Exposures in set must be taken within HA range of 1 hour
- Visibility window of plate for Ω < 0.4 arcsec @ λ 3600
- All exposures in a set should have seeing within 0.8 arcsec of each other.
- All exposures in a set should have $(S/N)^2$ values within a factor of two of each other.
- Each set of exposures should have median seeing 2 arcsec or below.





Law et al. (2015)

Observing strategy

MaNGA observing requirements

Totoro (Sánchez-Gallego et al., in prep.)

- Interface to access the DB information for MaNGA at APO.
- Runs after quick data reduction on the mountain and performs exposure-set allocation based on MaNGA constrains.
- Informs the observing staff of observability ranges in real time.
- Simulates observing conditions for the next nights and produces optimal schedule.
- Selects optimal fields to be observed.

Observing strategy

“Curiously enough, the only thing that went through the mind of the bowl of petunias as it fell was ‘Oh no, not again’ ”

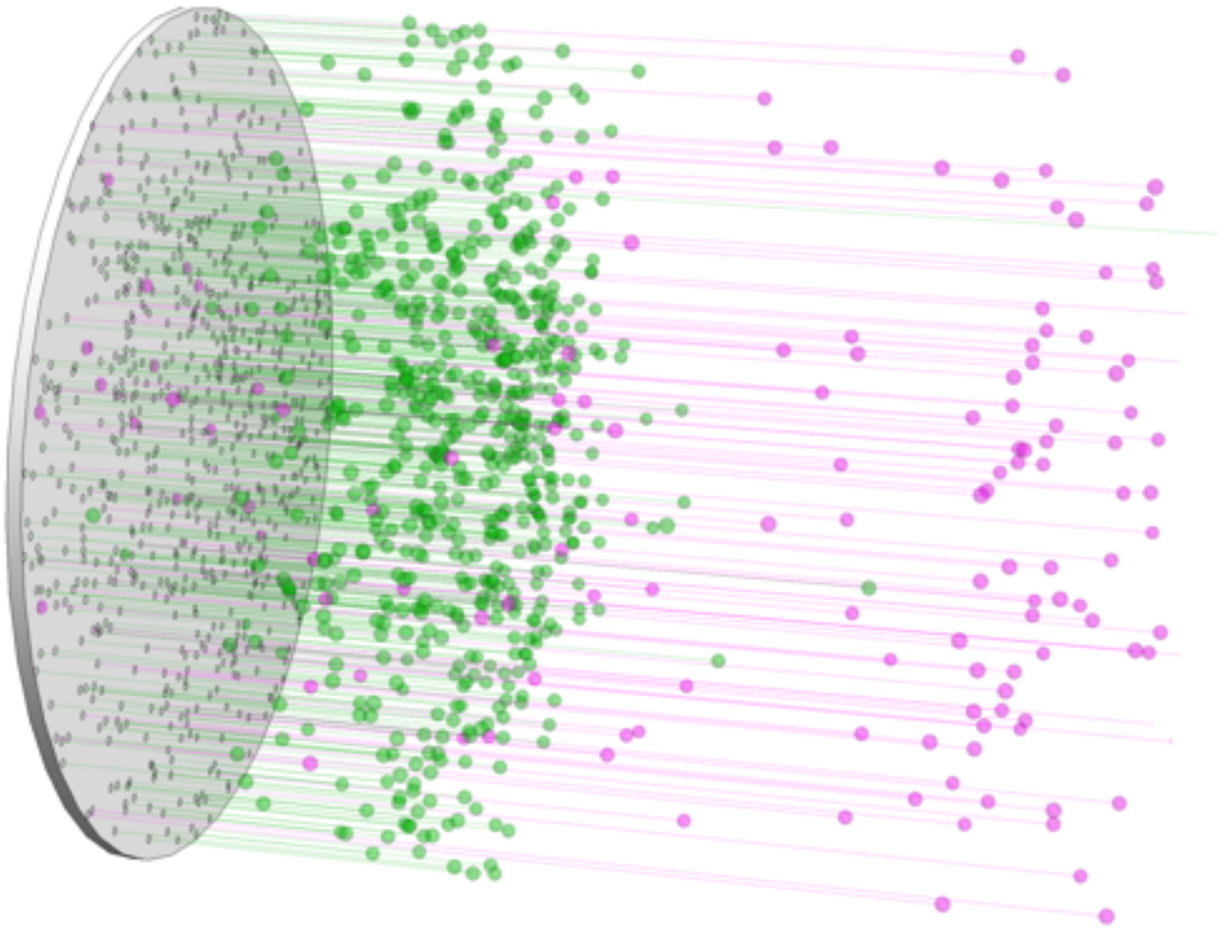
The Hitchhiker's Guide to the Galaxy

Operations

A day in the life of MaNGA

Operations

Plate Design

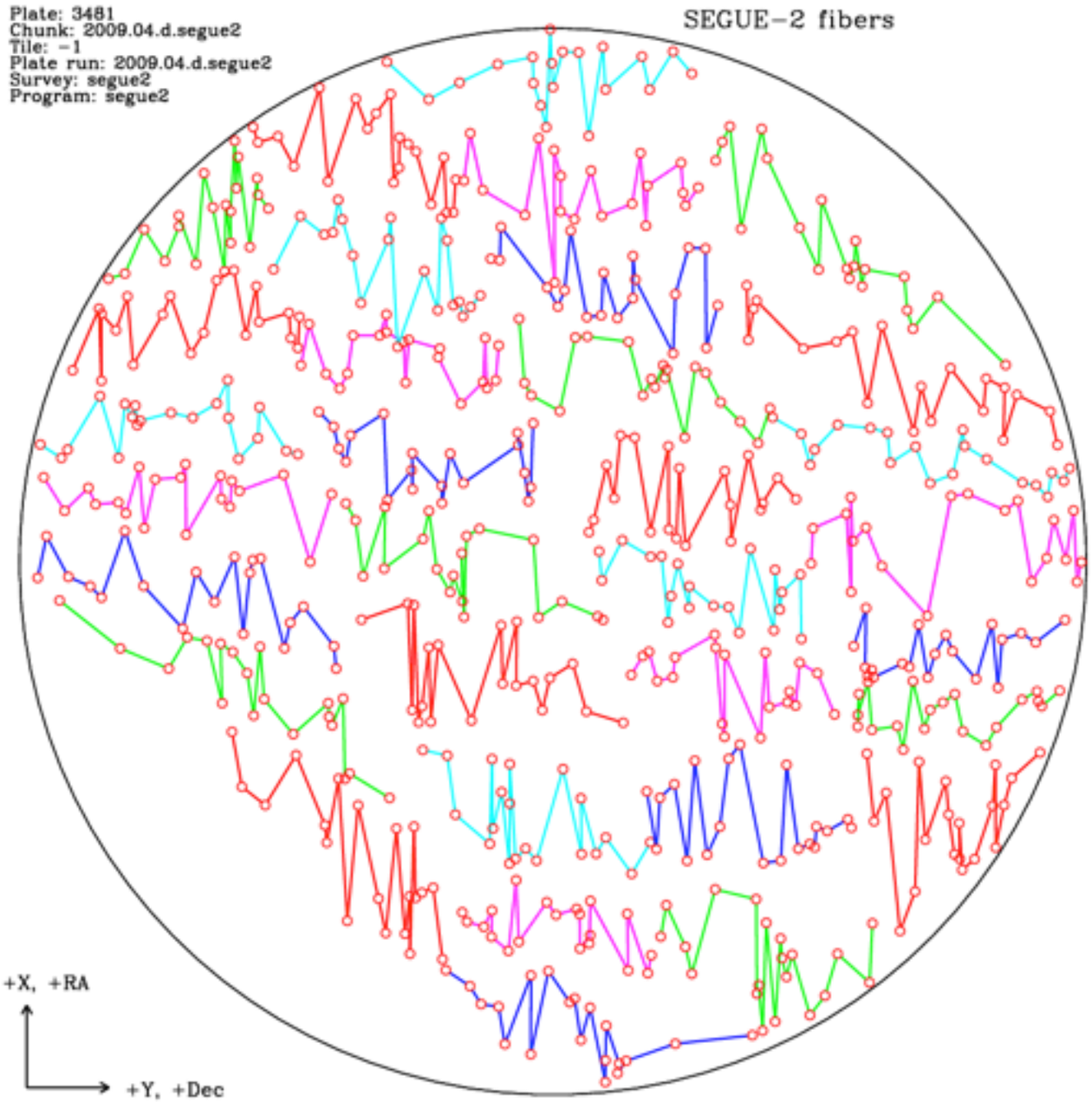


(α,δ) <—> (xfocal, yfocal)

- Field selection
- Target allocation
- Standards & skies selection
- Input files generation
- Drilling files and metadata genration
- Co-observing with APOGEE

Operations

Plate Design

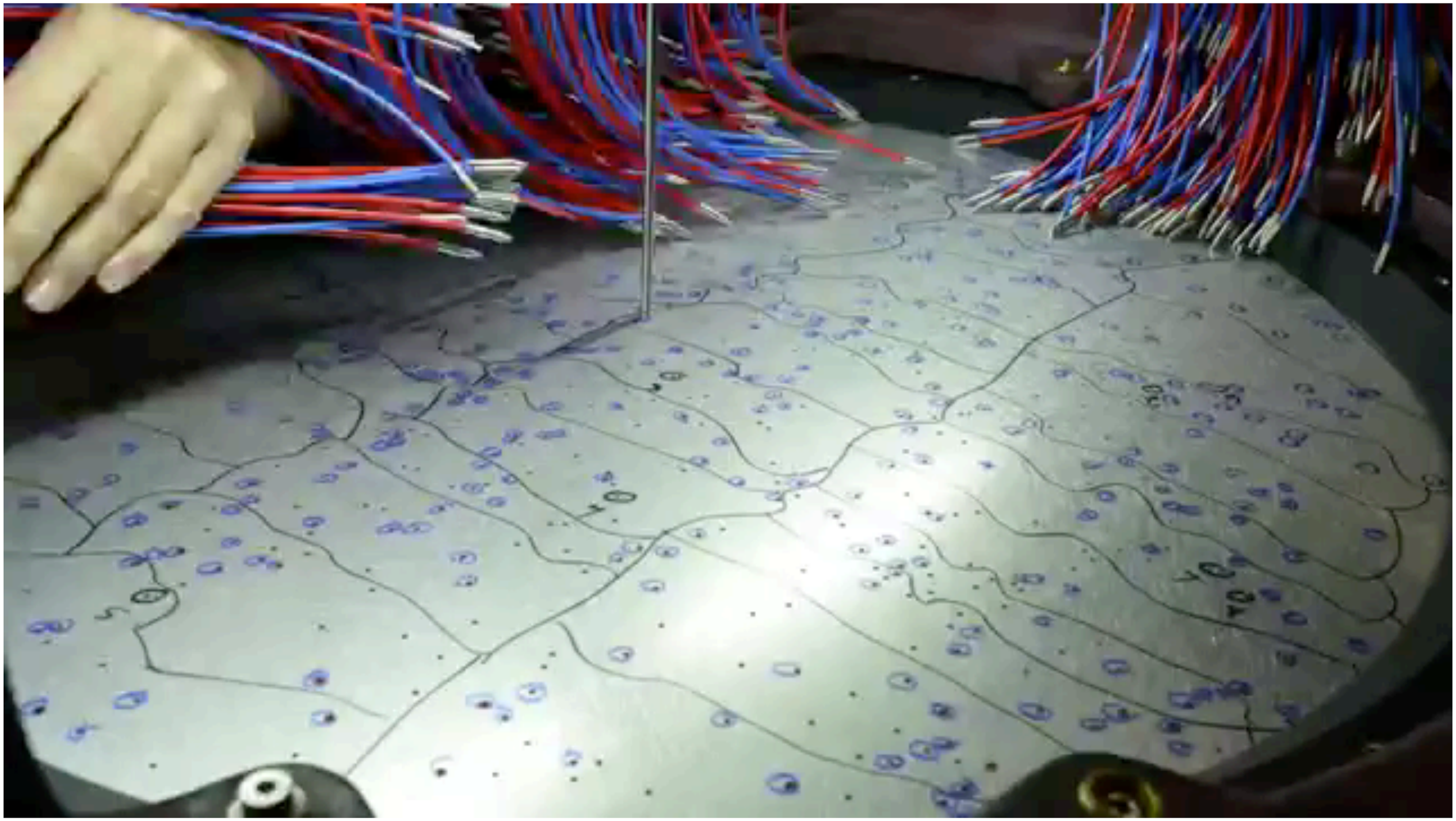


Operations

Plate Drilling

Operations

Plugging



Operations

Night operations

MaNGA

Extra slides

MaNGA overview

MaNGA vs the World

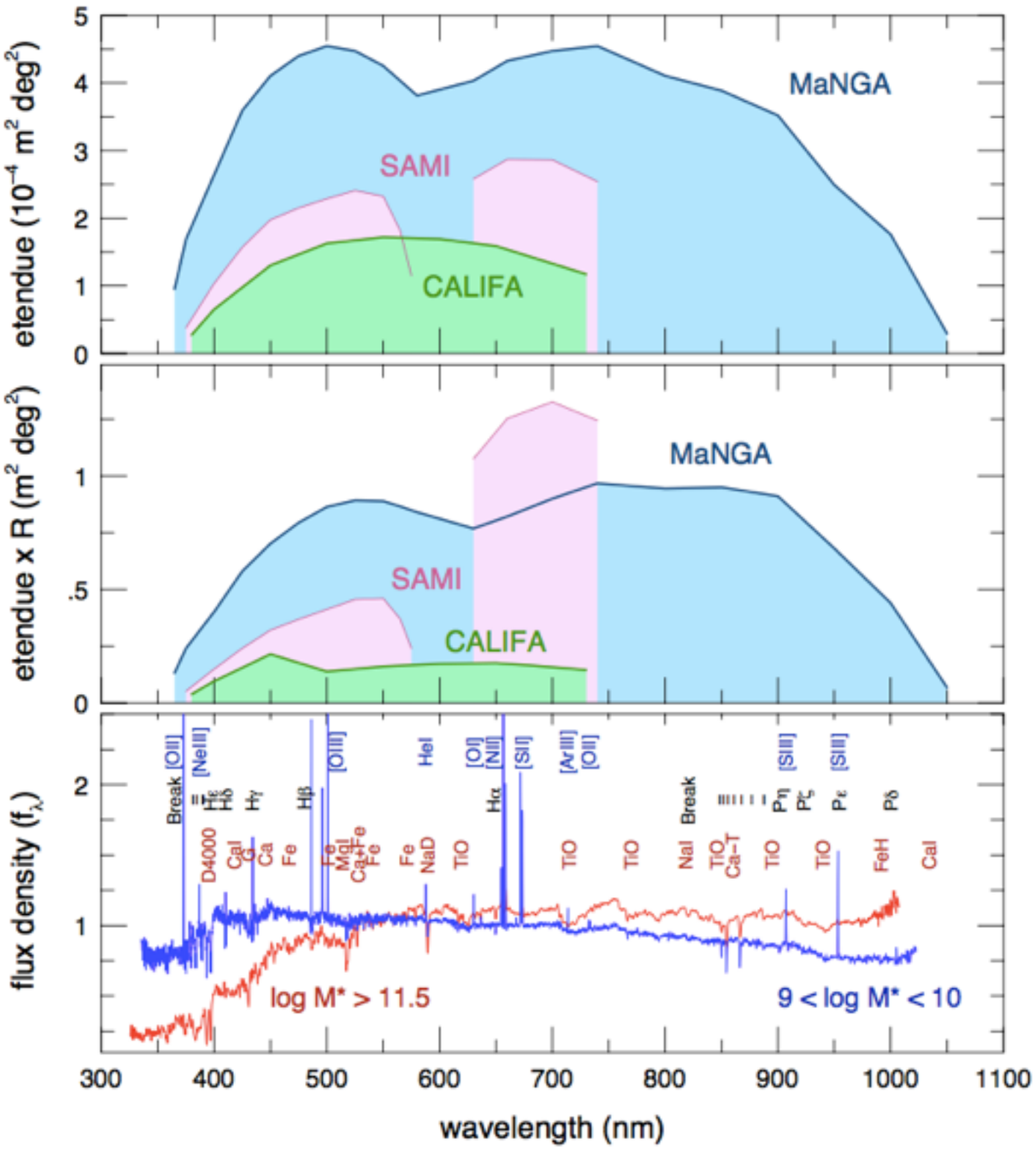
TABLE 3
COMPARISON OF IFU SURVEYS

Specification	MaNGA	SAMI	CALIFA	DiskMass (Hα)	DiskMass (stellar)	ATLAS^{3D}
Sample size	10,000	3,400	600	146	46	260
Selection	$M_* > 10^9 M_\odot$	$M_* > 10^{8.2} M_\odot$	$45'' < D_{25} < 80''$	S/SAab-cd, b/a>0.75 $10'' < h_R < 20''$		$M_* \gtrsim 10^{9.8} M_\odot$[e] E/S0
Redshift	0.01–0.15	0.004–0.095	0.005–0.03	0.001–0.047	0.003-0.042	$z \lesssim 0.01$
Radial coverage	1.5 R_e(P+) 2.5 R_e(S)	1.1–2.9 R_e	1.8–3.7 R_e	1.4–3 R_e	1.1–2.3 R_e	0.6–1.5 R_e
S/N[a] at 1R_e (per spatial sample)	14–35	12–28	10–50	6	9–16	15
λ range (nm)	360–1030	370–570 (580V) 625–735 (1000R)	375–750 (V500) 370–475 (V1200)	648–689	498–538	480–538
$\sigma_{\rm instrument}$ (km s^{-1})	50–80	75 28	85 150	13	16	98
Angular sampling[b] (diameter)	2″	1.″6	2.″7	4.″7	2.″7	0.″8
Angular FWHM (reconstructed)	2.″5	2.″1[c]	2.″5	6″	3.″5	1.″5
Spatial FWHM (physical)	1.3–4.5 kpc (P+) 2.2–5.1 kpc (S)	1.1–2.3 kpc	0.8–1.0 kpc	0.4–4.2 kpc	0.3–3.0 kpc	0.15 kpc
Spatial FWHM (in R_e)	0.2–0.6 (P+) 0.3–0.9 (S)	0.3–0.8	0.2	0.2–0.4	0.1–0.2	0.09
IFU fill factor	56%	73%	53%	25%	53%	100%
With gradients measurable[d] to						
1.0 R_e:	4070	720	580	128	39	112
1.5 R_e:	6050	790	521	122	20	47
2.0 R_e:	2570	680	462	80	5	26
2.5 R_e:	2340	460	340	26	0	13
3.0 R_e:	670	350	111	3	0	1

Bundy et al. (2015)

MaNGA overview

MaNGA vs the World



Bundy et al. (2015)

Science

And much more …

Modified gravity tests

- Use MaNGA sample to probe the interaction between baryonic and dark matter in screened vs unscreened systems to constrain MG models

Dwarf Galaxies As Cosmological Probes

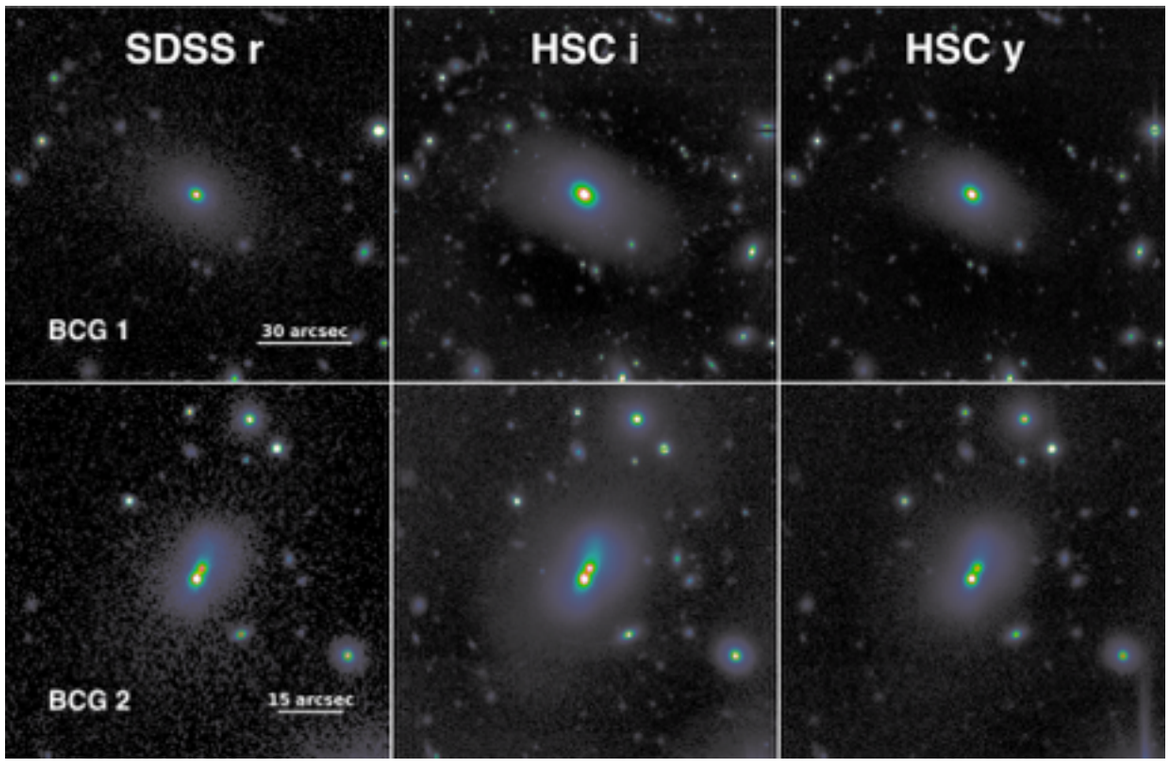
- Constrain ΛCDM by studying the stellar structure and assembly histories of satellite and isolated/central dwarfs
- Changes in global and spatially resolved properties in the isolated regime

Science

And much more …

BCGs and weak lensing (PI Lackner)

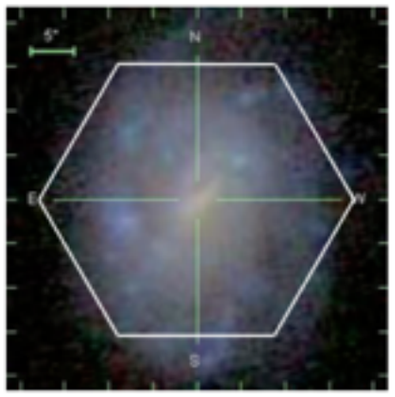
- Observe ~80 luminous BCGs in massive halos ($>10^{13.75}$ $h^{-1}M_{\odot}$)
- MaNGA to measure stellar population gradients to investigate merging history in BCGs
- Internal stellar kinematics
- HSC to mease halo mass using weak lensing.



Science

Early science results

p11-127A



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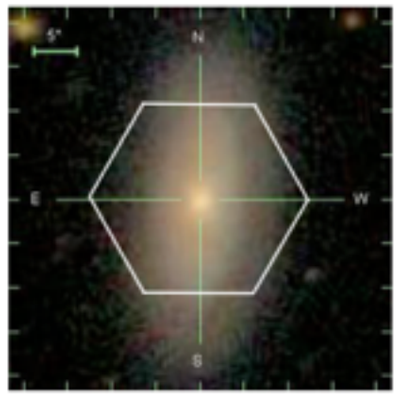

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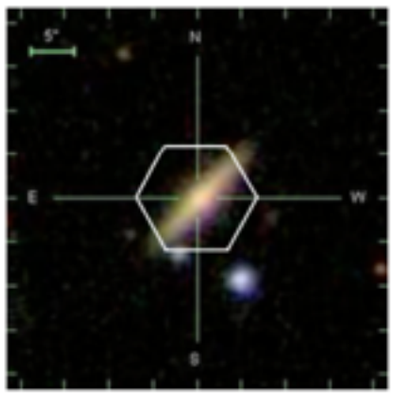
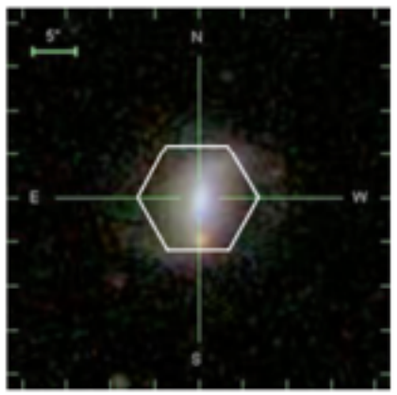
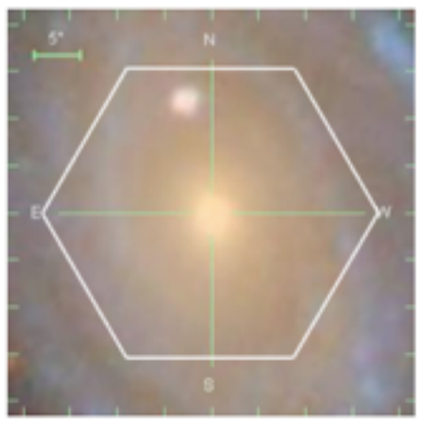


p11-19A



p11-19B



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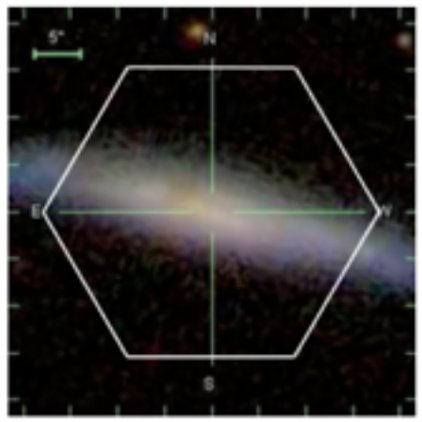
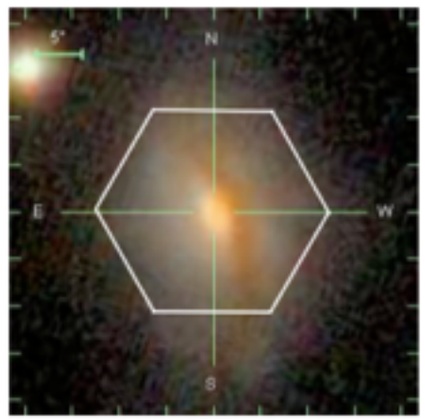
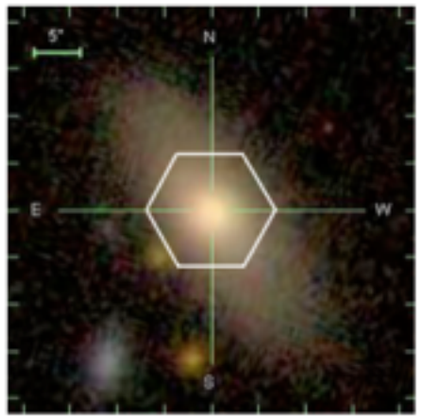


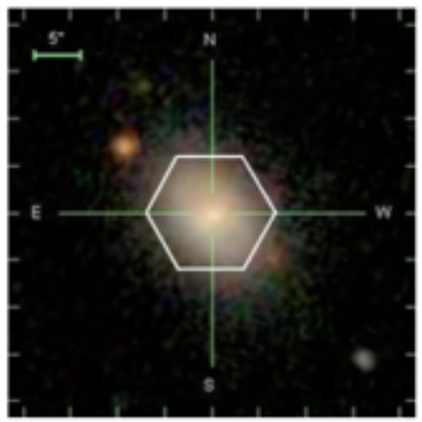
p9-127B



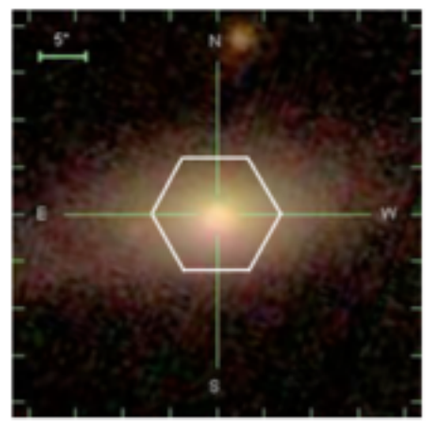
p9-61A



p9-19D



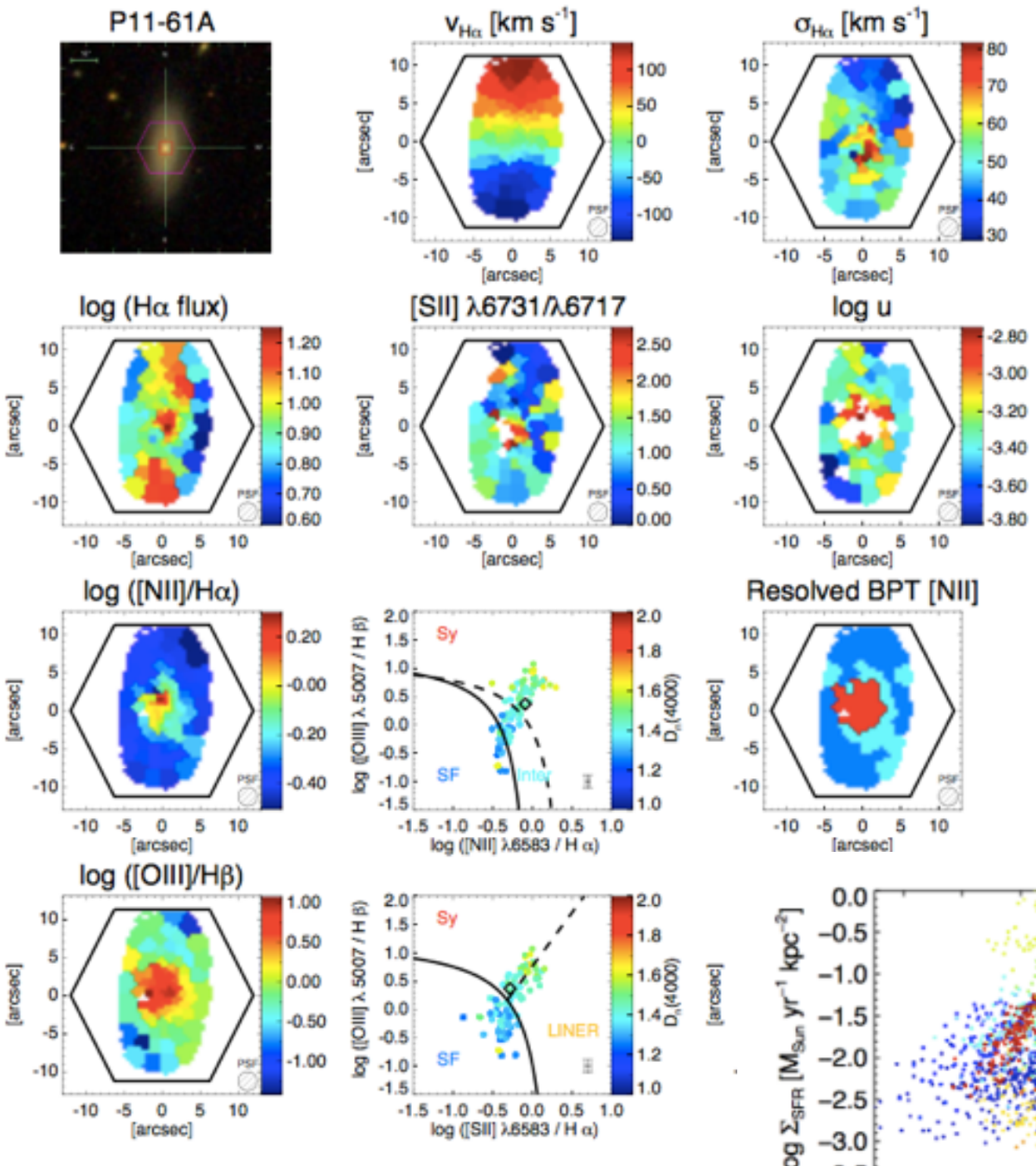
p9-19E



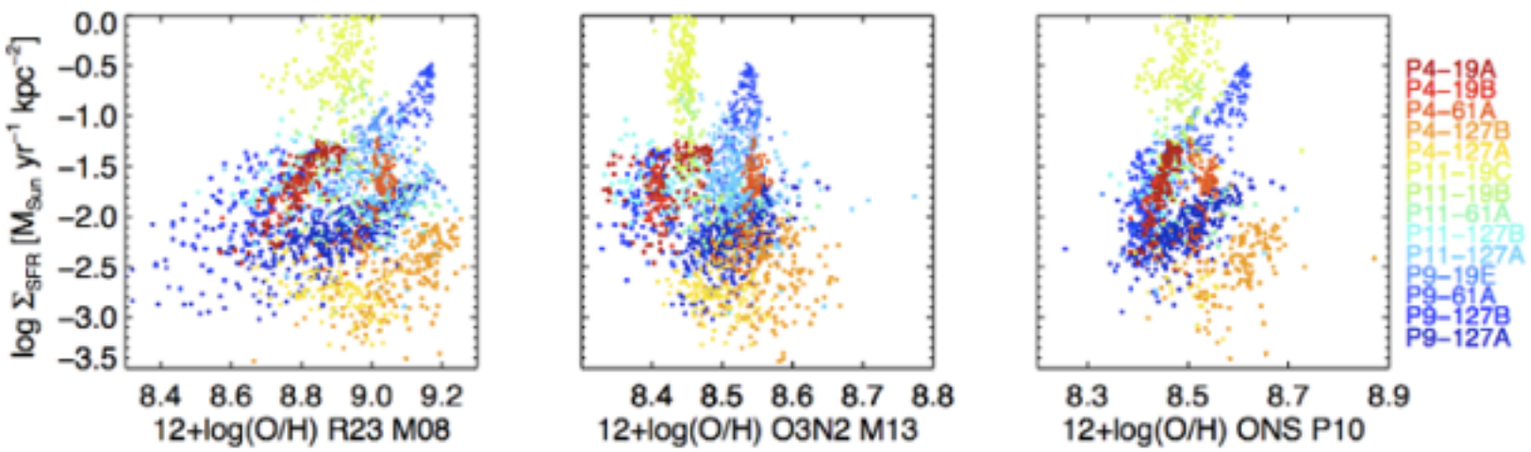
p9-19B

Science

Early science results: emission line diagnostics



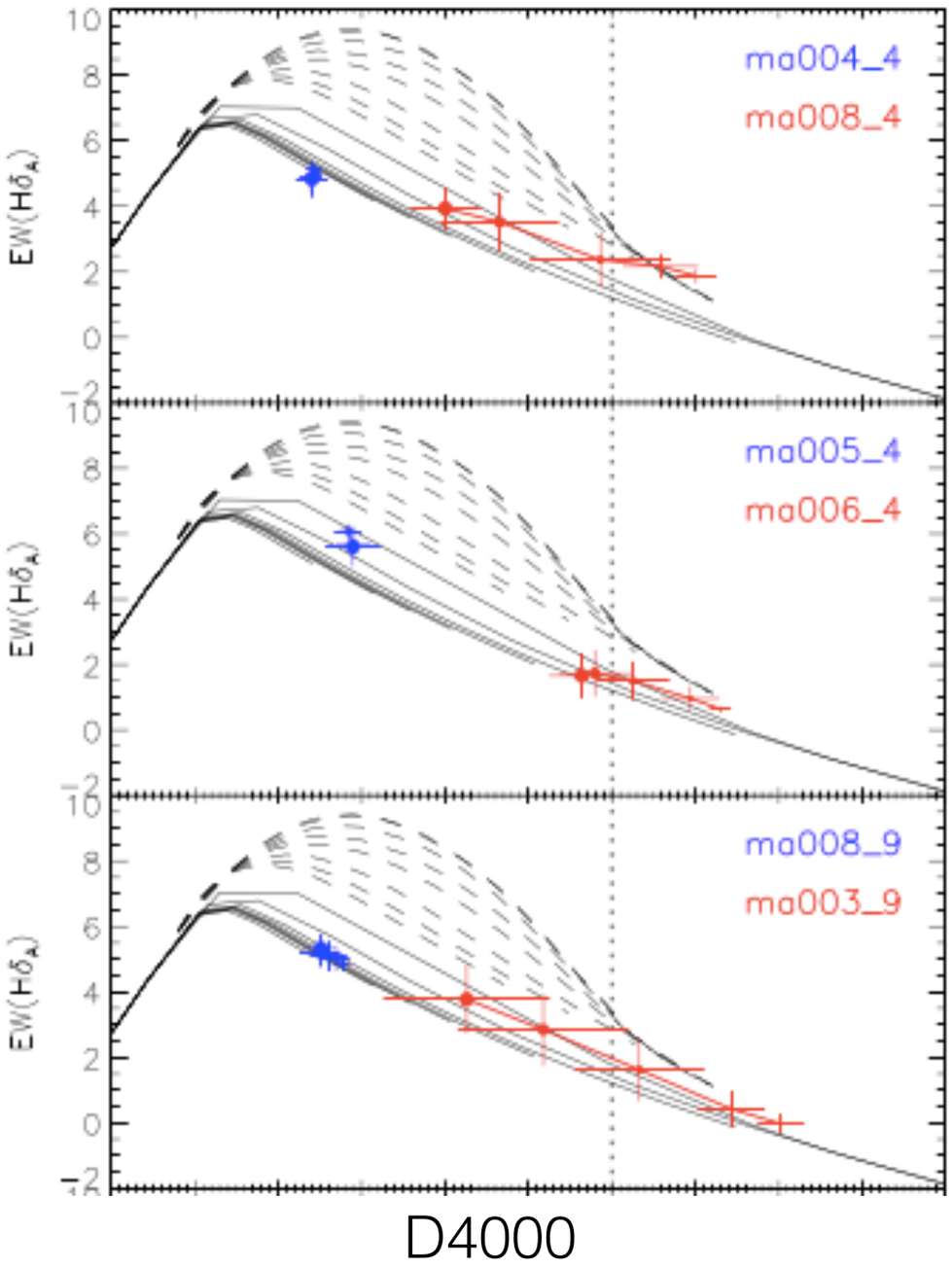
- Star formation in galaxies with central AGN-like emission
- SFR-metallicity correlation for low/intermediate-mass galaxies
- Inside-out growth picture



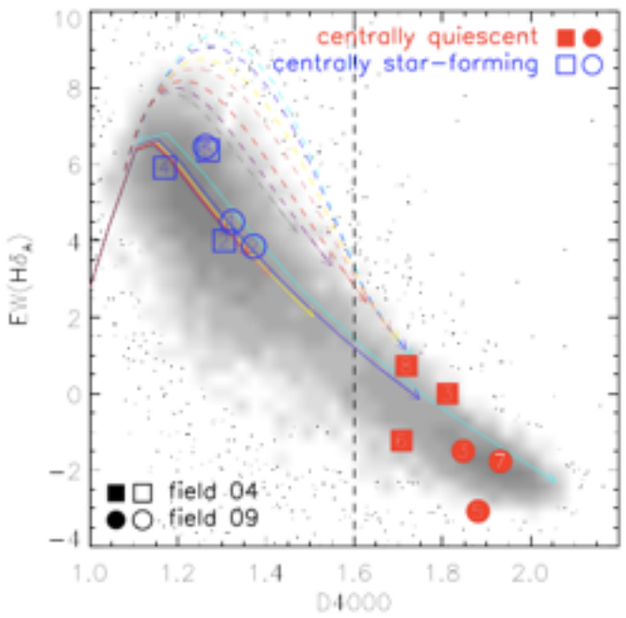
Belfiore et al. (2015)

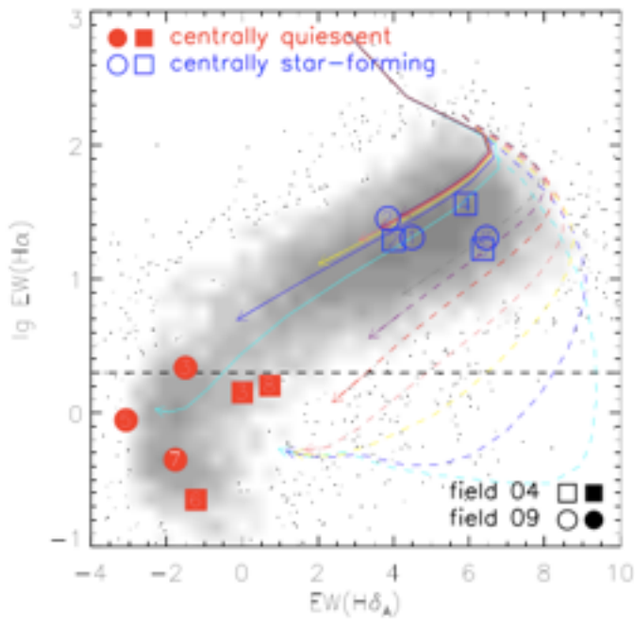
Science

Early science results: gradients of SF



- Quick star formation history
- Additional prove of inside-out growth picture

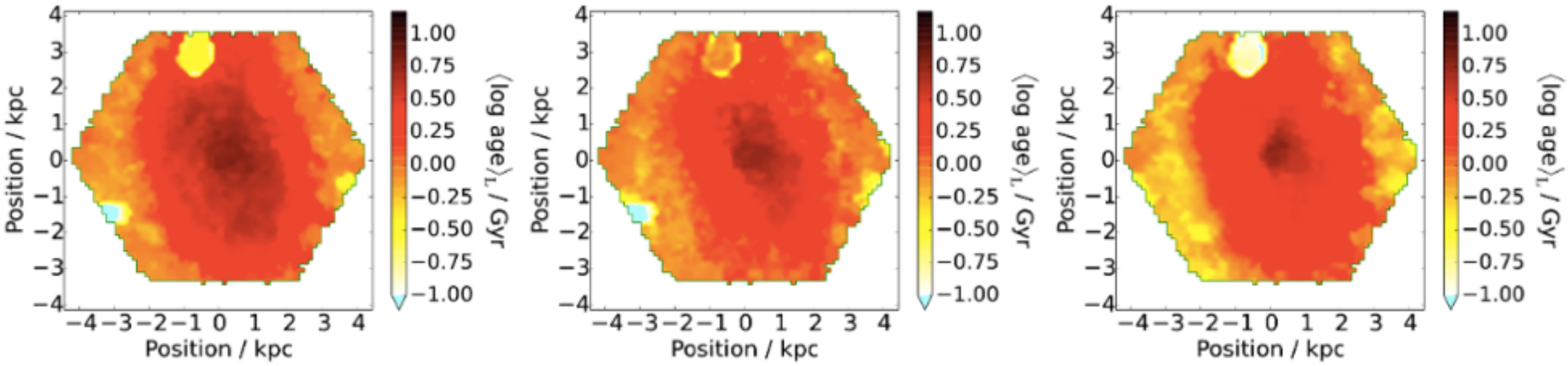




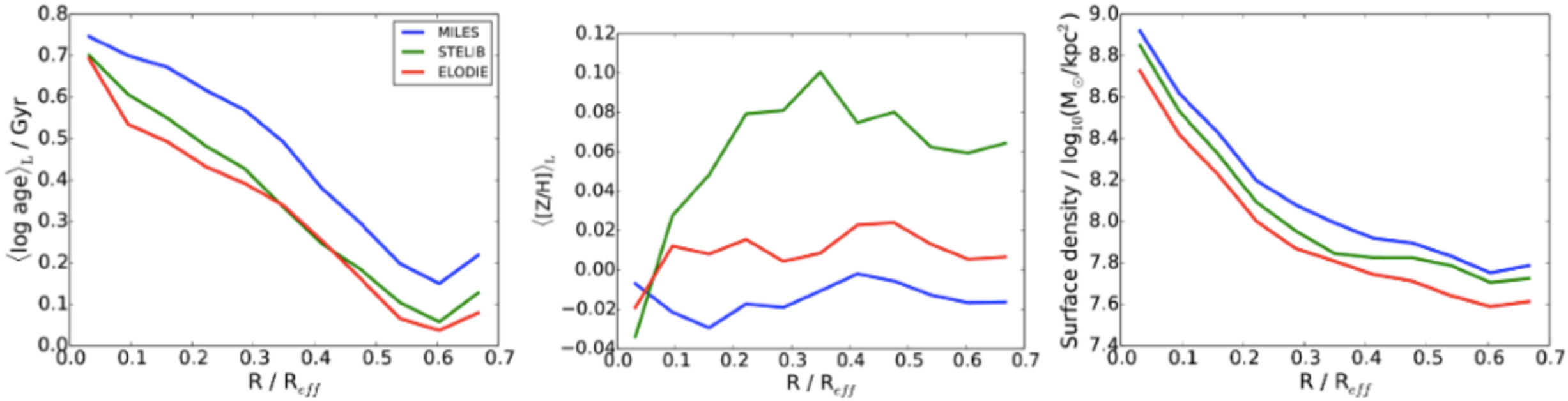
Li et al. (2015)

Science

Early science results: stellar population fitting



(a) Light-weighted age maps of p9-127A as a function of stellar library; MILES, STELIB, and ELODIE are shown in the left, middle, and right panels respectively.



Wilkinson et al. (2015)