The Calar Alto Legacy Integral Field Area (CALIFA) Survey
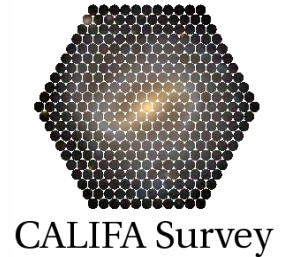
CALIFA collaboration

C. Jakob Walcher
Leibniz Institut für Astrophysik Potsdam (AIP)

State-of-astronomy

- ΛCDM is the paradigm for cosmology
- There is no full paradigm for galaxy evolution, because baryonic physics is a complicated, multi-parameter affair

➜ Age-old questions remain:

- Where and when do the stars in galaxies form?
- How is angular momentum lost and found?
- Where and when are the heavy elements made?
- How is the gas in galaxies processed?

Imaging Spectroscopy (IFS)
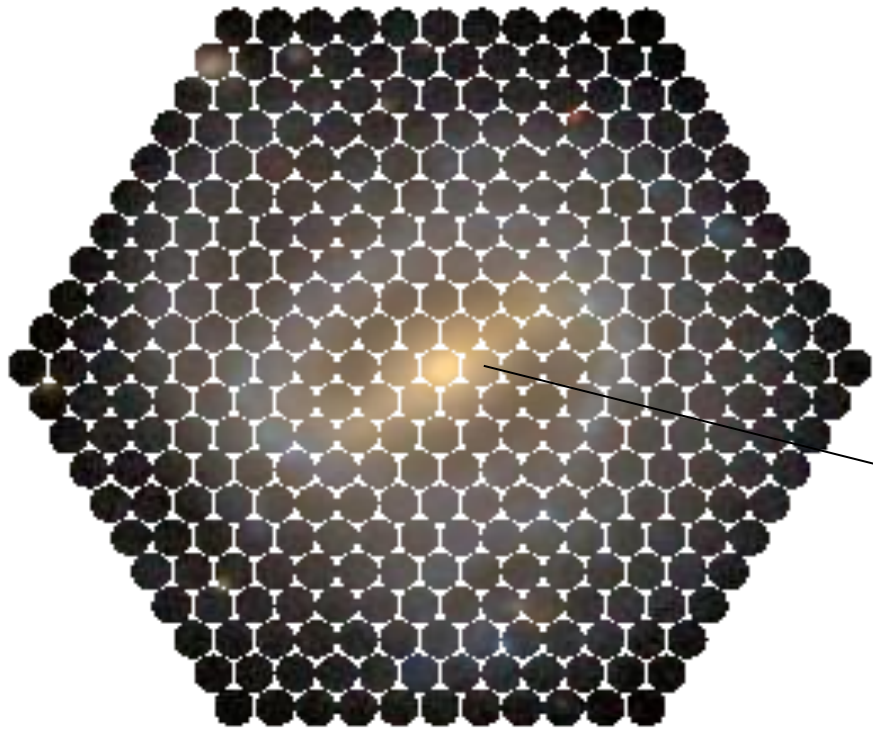
CALIFA Survey
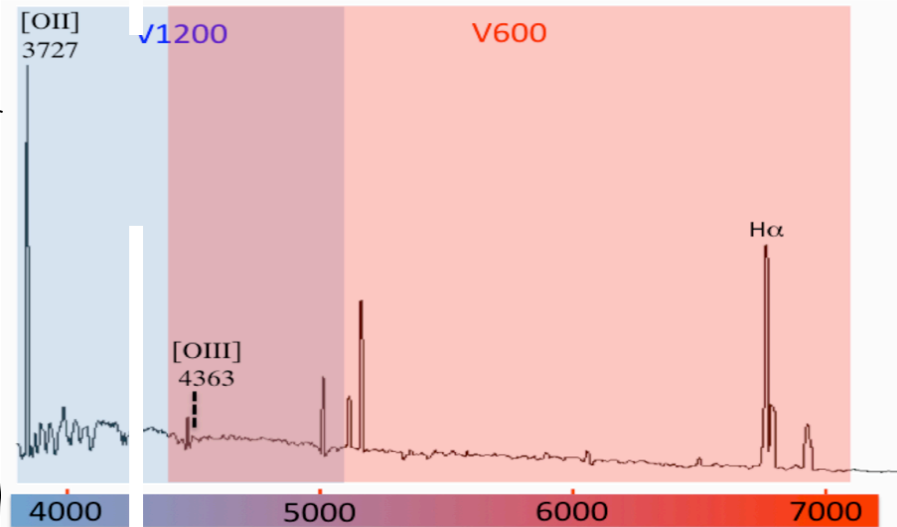
CALIFA Survey

Instrument used: PMAS (AIP) at CAHA3.5 (MPIA)

CALIFA: Design Drivers

- Be a legacy survey exploiting the power of IFS!
- Large sample of galaxies covering all types.
- Measure the following properties:
  - Stellar populations, ages and metallicities
  - Ionized gas: distribution, excitation mechanism and chemical abundances
  - Kinematics: both from stellar and ionized gas components
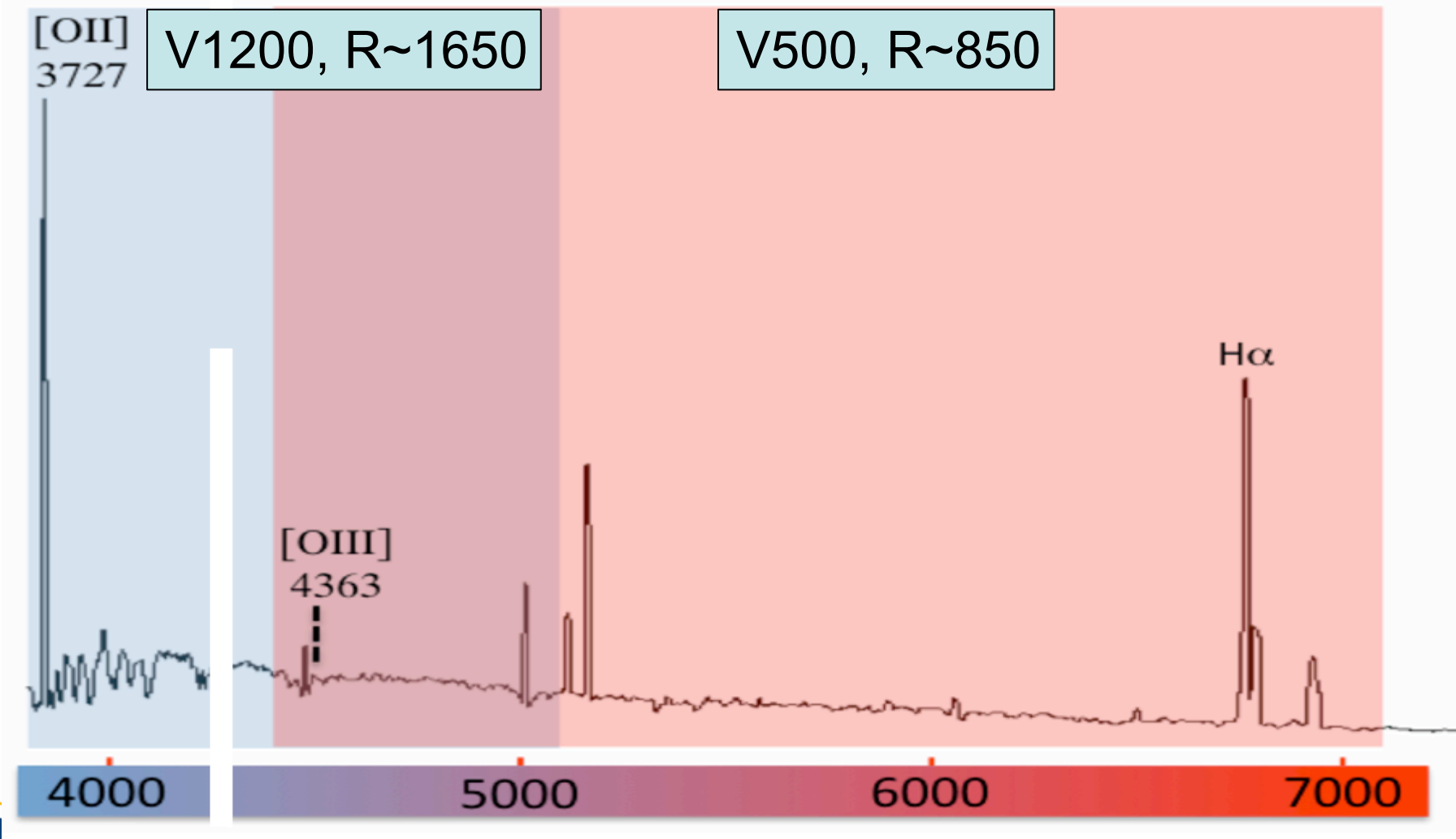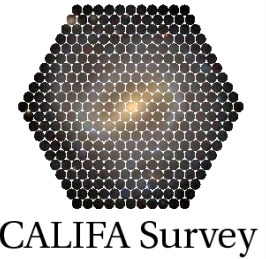- Probe targets over their whole optical extent

Spatial coverage
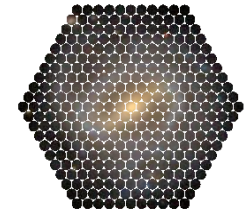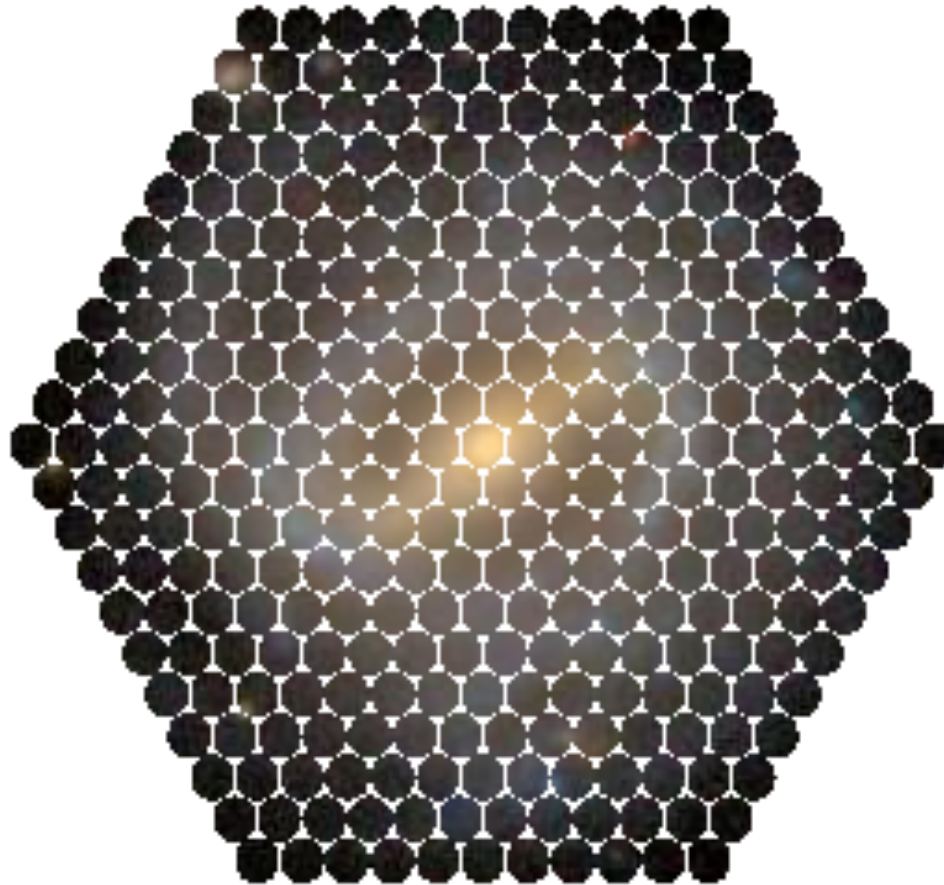
1 fiber ~ 0.5 kpc
1 FoV > 3*r_e

CALIFA Survey

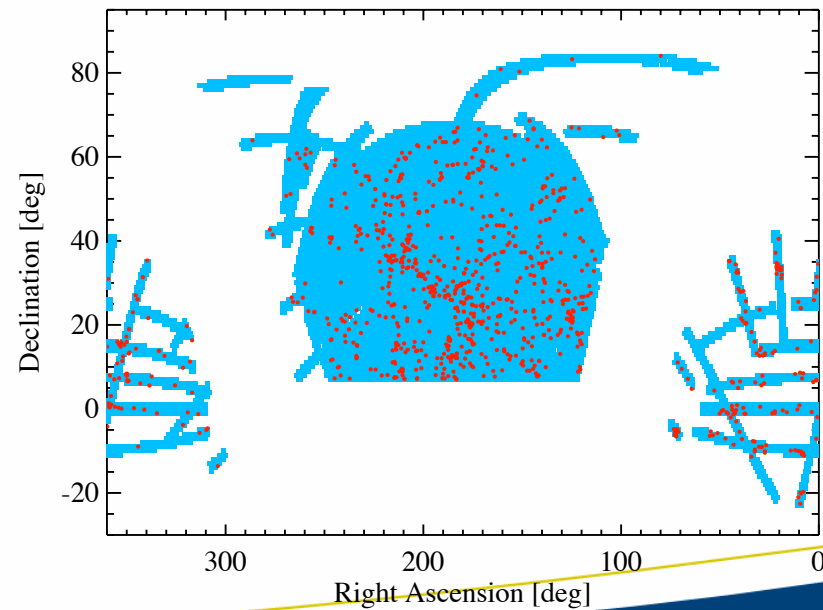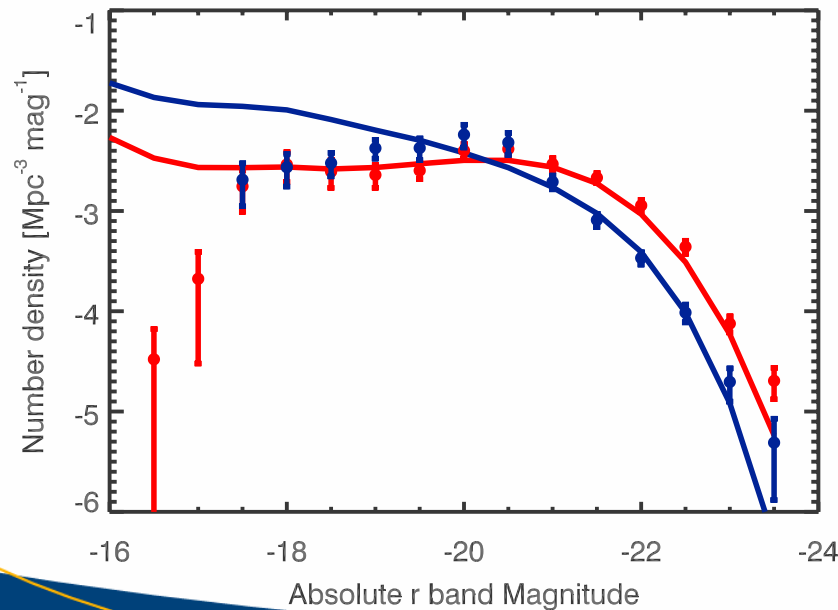# Wavelength coverage

V1200, R~1650

V500, R~850

Sample

- 600 galaxies will be observed out of a
- mothersample of 937 galaxies.
- 45" < D25 < 80"   isophotal radius at 25 mag/arcsec2
- 0.005 < z < 0.03   spatial sampling 2" ≈ 0.5-1 kpc
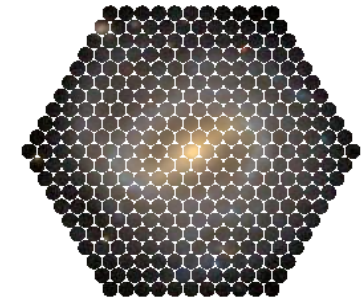
CALIFA Uniqueness

- **Large wavelength coverage**
  - full BPT, extended view on stelpops
- **Large FoV**
  - entire galaxies (>3 re)
  - good spatial resolution
- **Large, homogeneous sample**
  - statistics, classification
  - rare objects (e.g. 114 interacting)
  - comparison between different types
- **Regular data releases!**
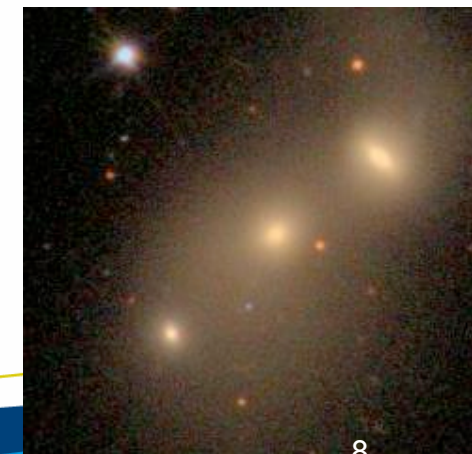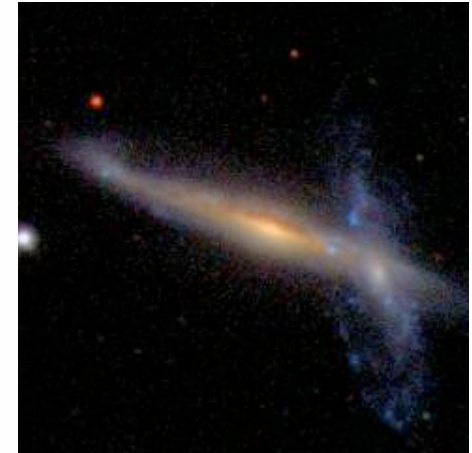
CALIFA status

- Granted 210 dark nights at CAHA over 3 years
- 80 scientists from 20 institutions in 7 countries
- PI: S. Sanchez, PS: C.J. Walcher
- >170 Objects observed in both setups (>250 V500)
- First articles being published
- Automatic data reduction pipeline working, vs 1.3

Data Release 1: November 1st 2012! 100 objects with good quality

http://califa.caha.es/

# DR1 tools

DR1 tools

Data Quality

- Characteristic performance:
  - Surface brightness 3σ: ~ 23.0 mag/arcsec^2 for V500
  - ~ 22.8 mag/arcsec^2 for V1200
  - Wavelength: ~ 5 km s^{-1} for V1200
  - ~ 10 km s^{-1} for V500
  - Sky subtraction residual ~ 6%
  - Flux calibration: ~ 3% relative (blue-to-red)
  - ~ 15% absolute (tied to SDSS)

- Primary products:
  - Resampled data cubes with 1sq arcsec spaxels
  - Meaningful noise cubes!

Husemann et al., submitted

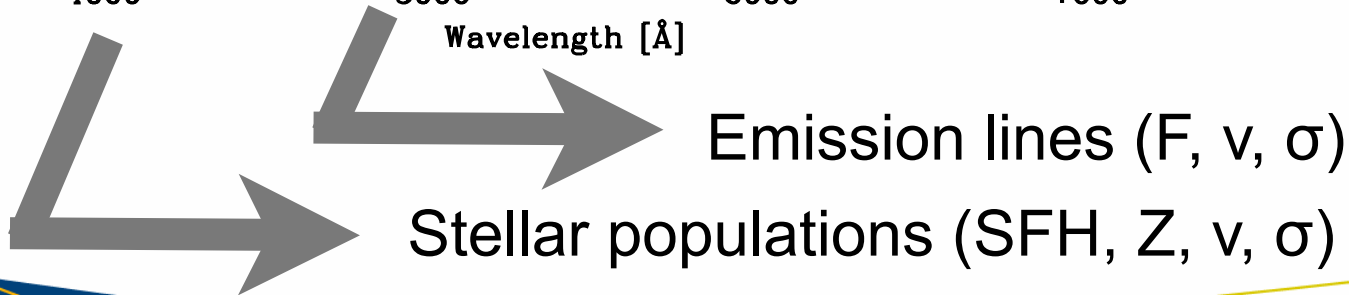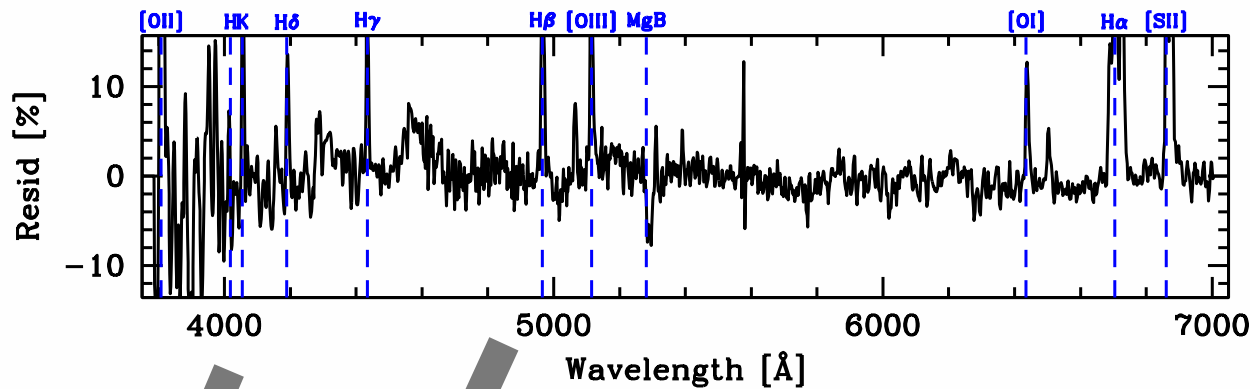# Data Analysis
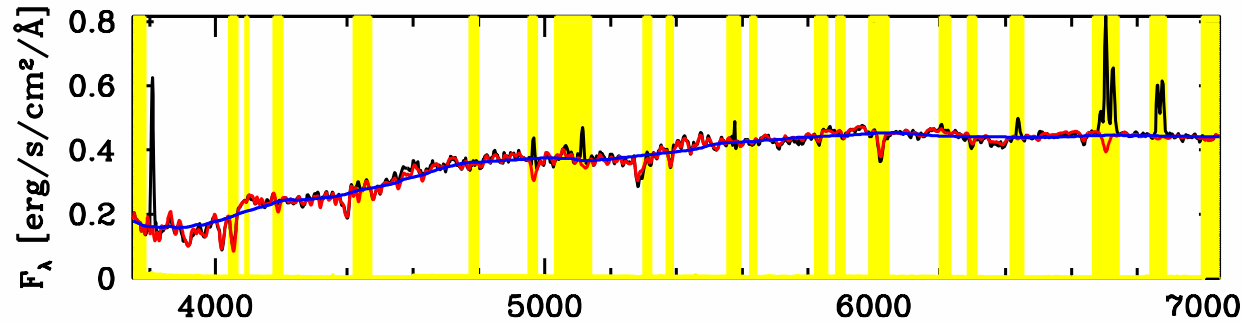
Spectral fitting is a key tool
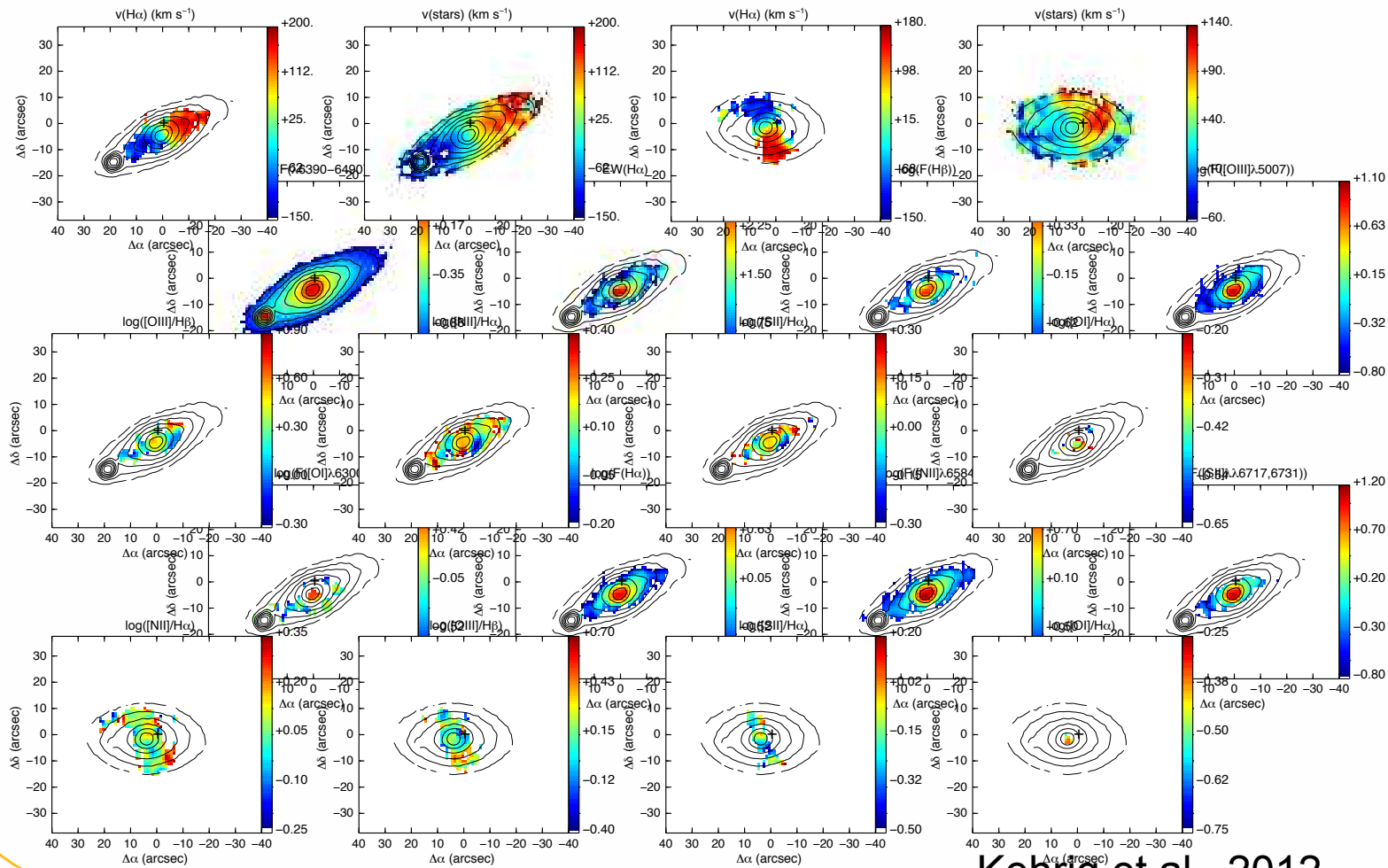
Challenges:
1 Million spectra
Data issues
Unusual physics
Data presentation
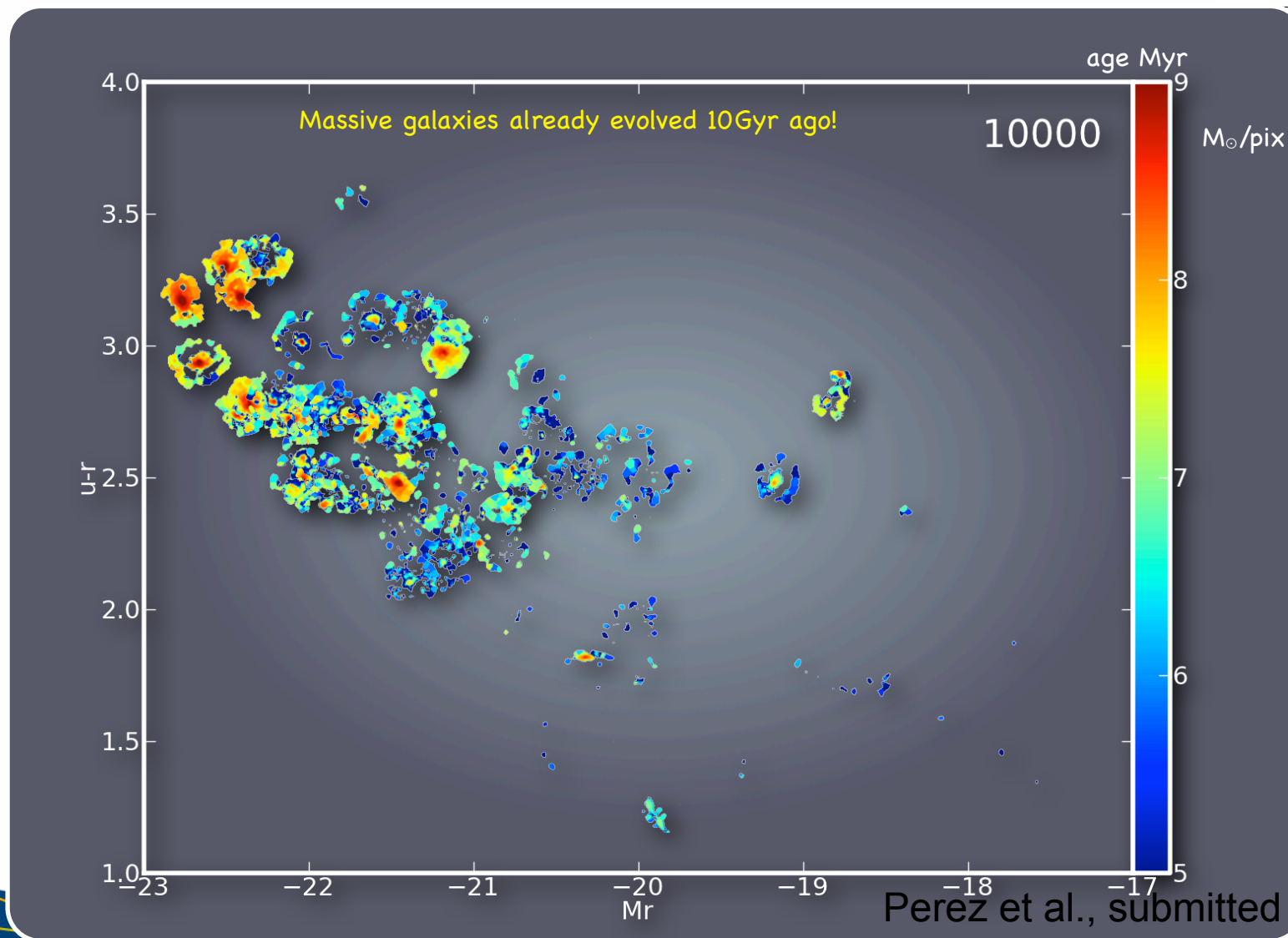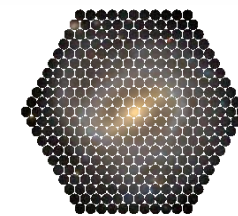
Emission lines (F, v, σ)

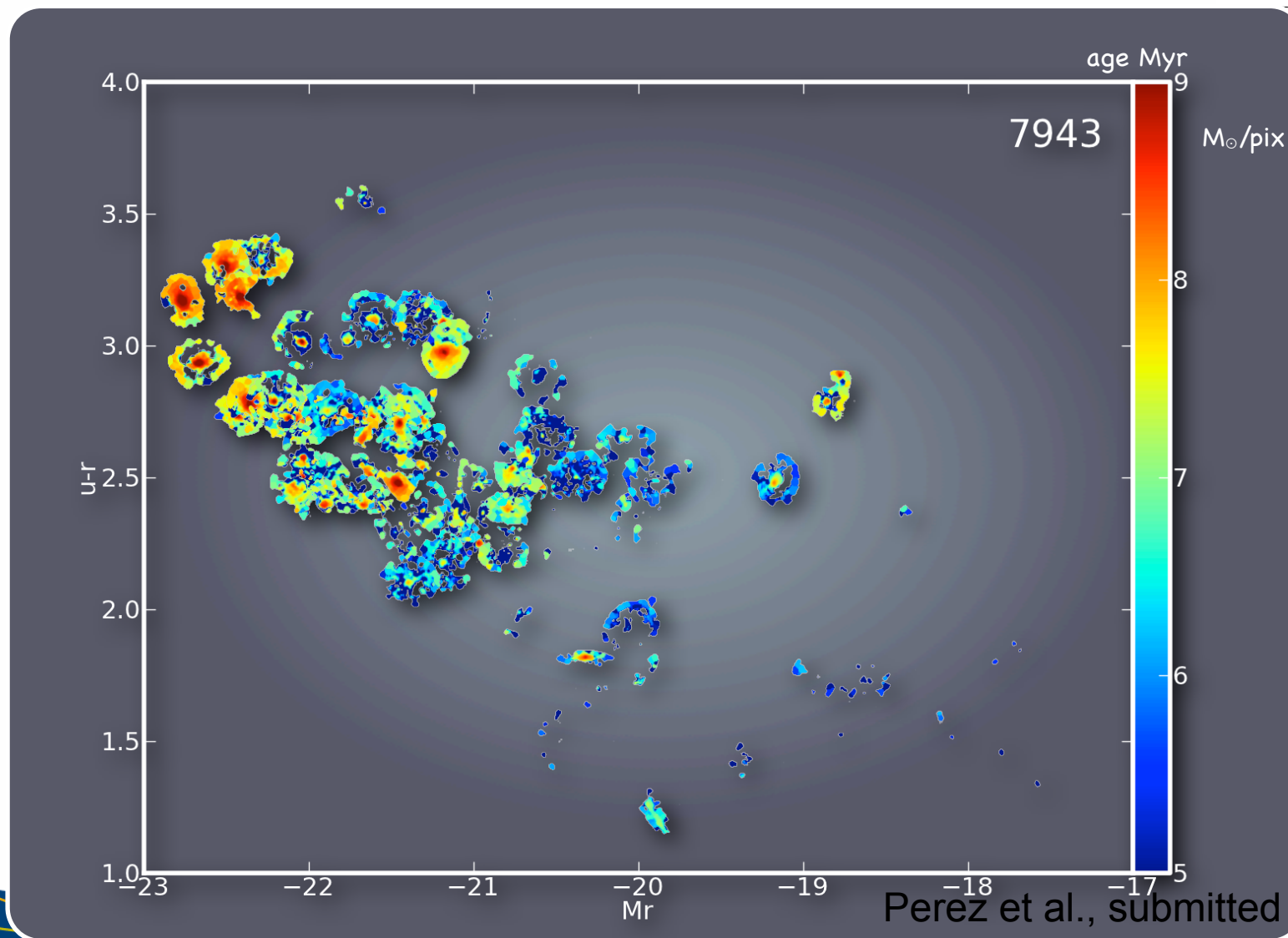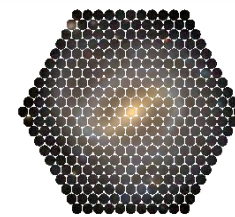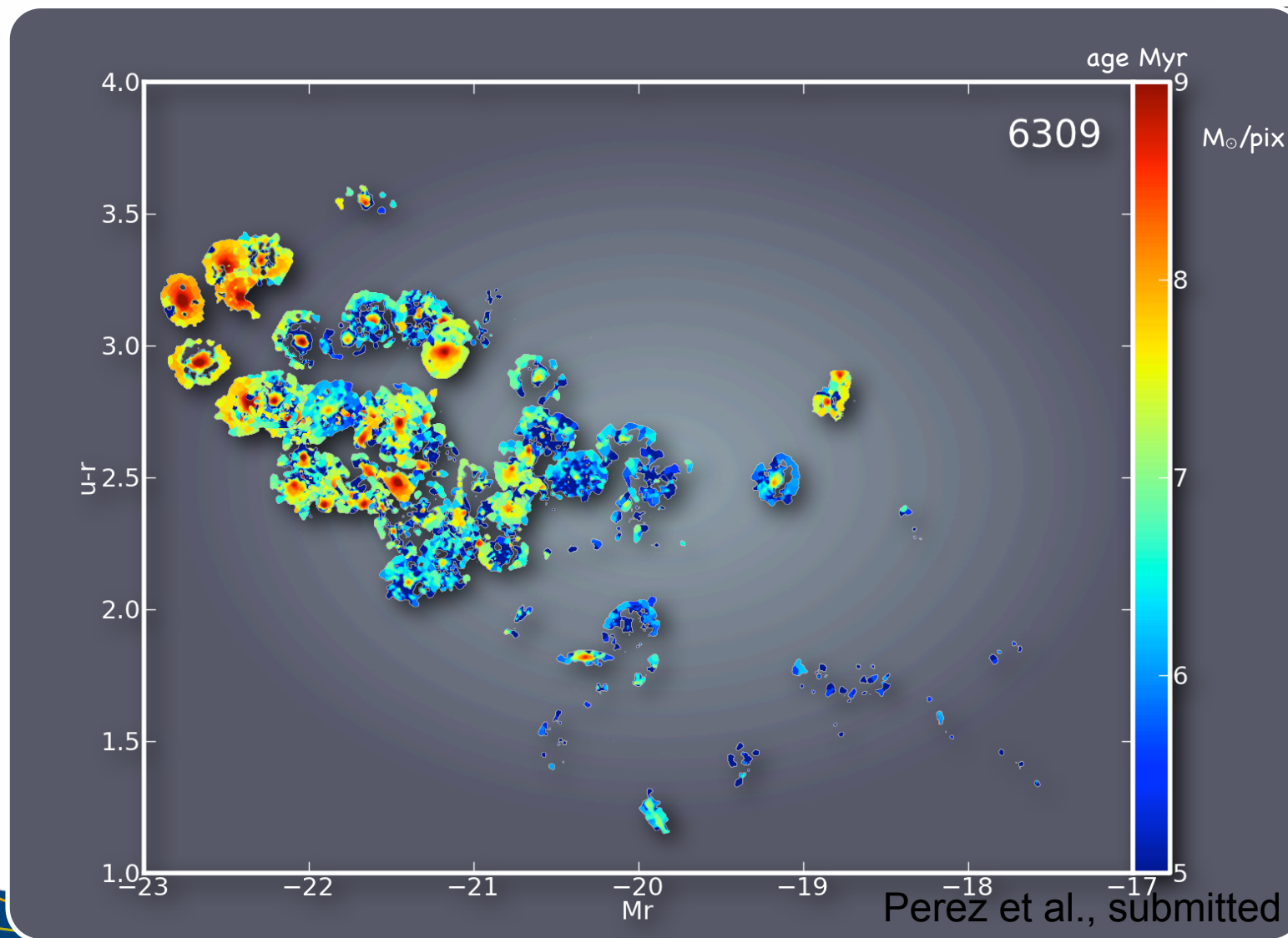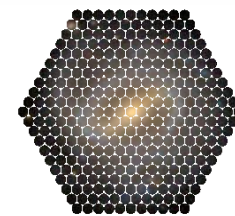Stellar populations (SFH, Z, v, σ)

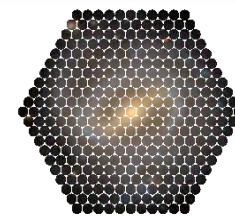# Data products: property maps

Kehrig et al., 2012

How stellar mass builds up

Massive galaxies already evolved 10Gyr ago!

10000

age Myr

M☉/pix

Perez et al., submitted

How stellar mass builds up

Perez et al., submitted

How stellar mass builds up

Perez et al., submitted

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Perez et al., submitted

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Perez et al., submitted
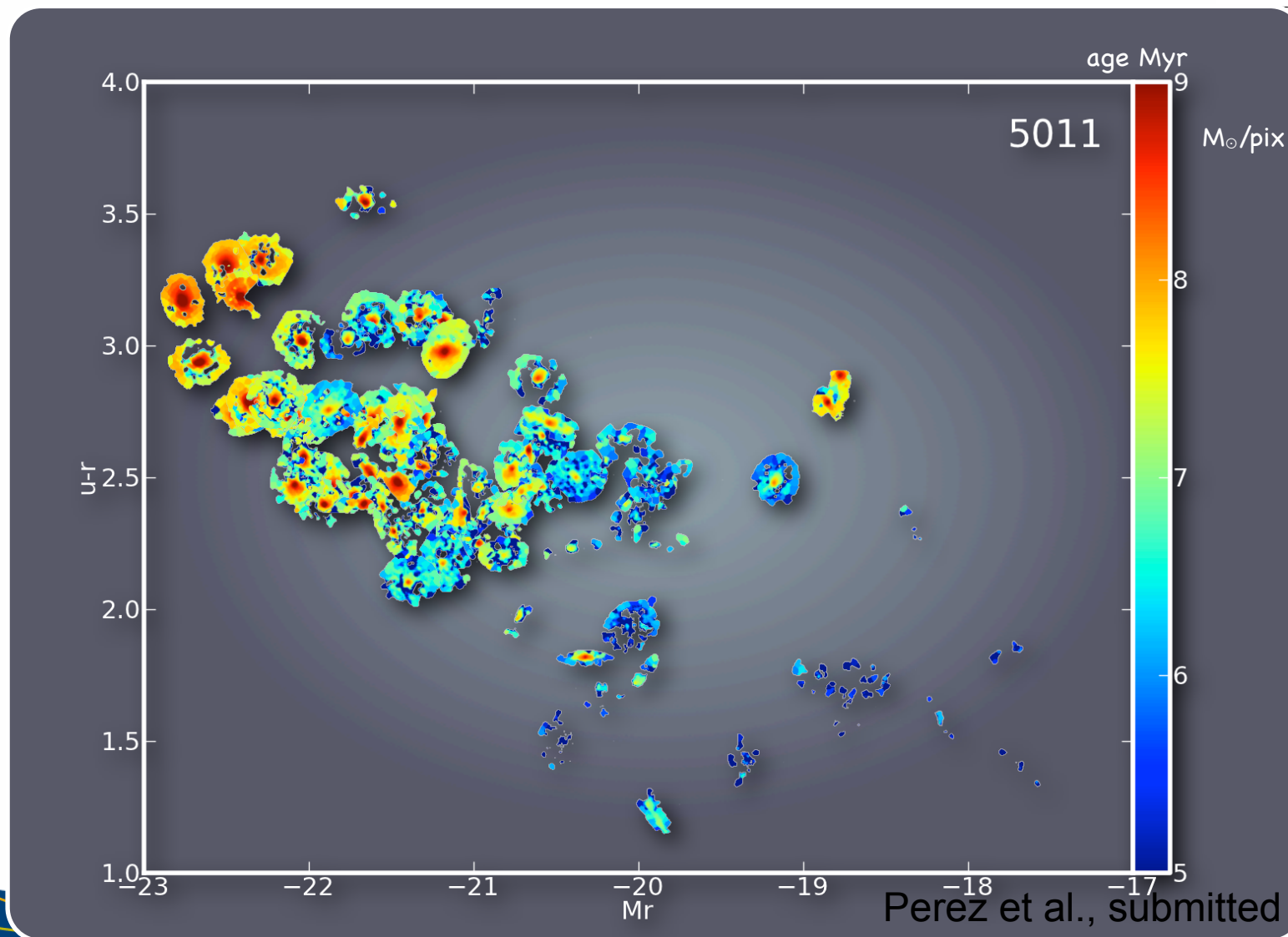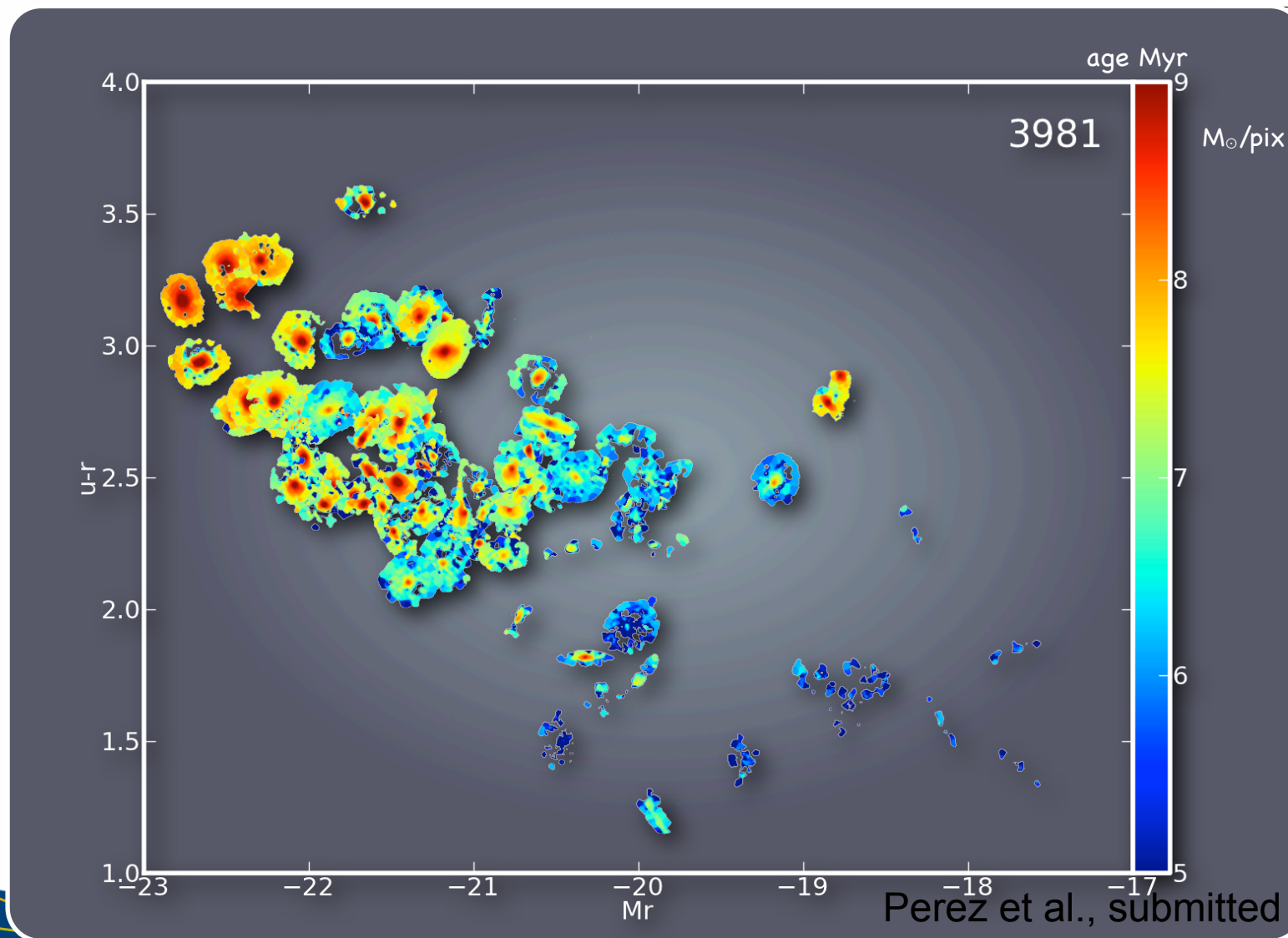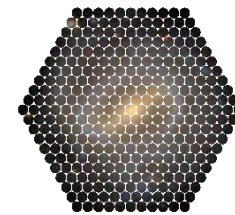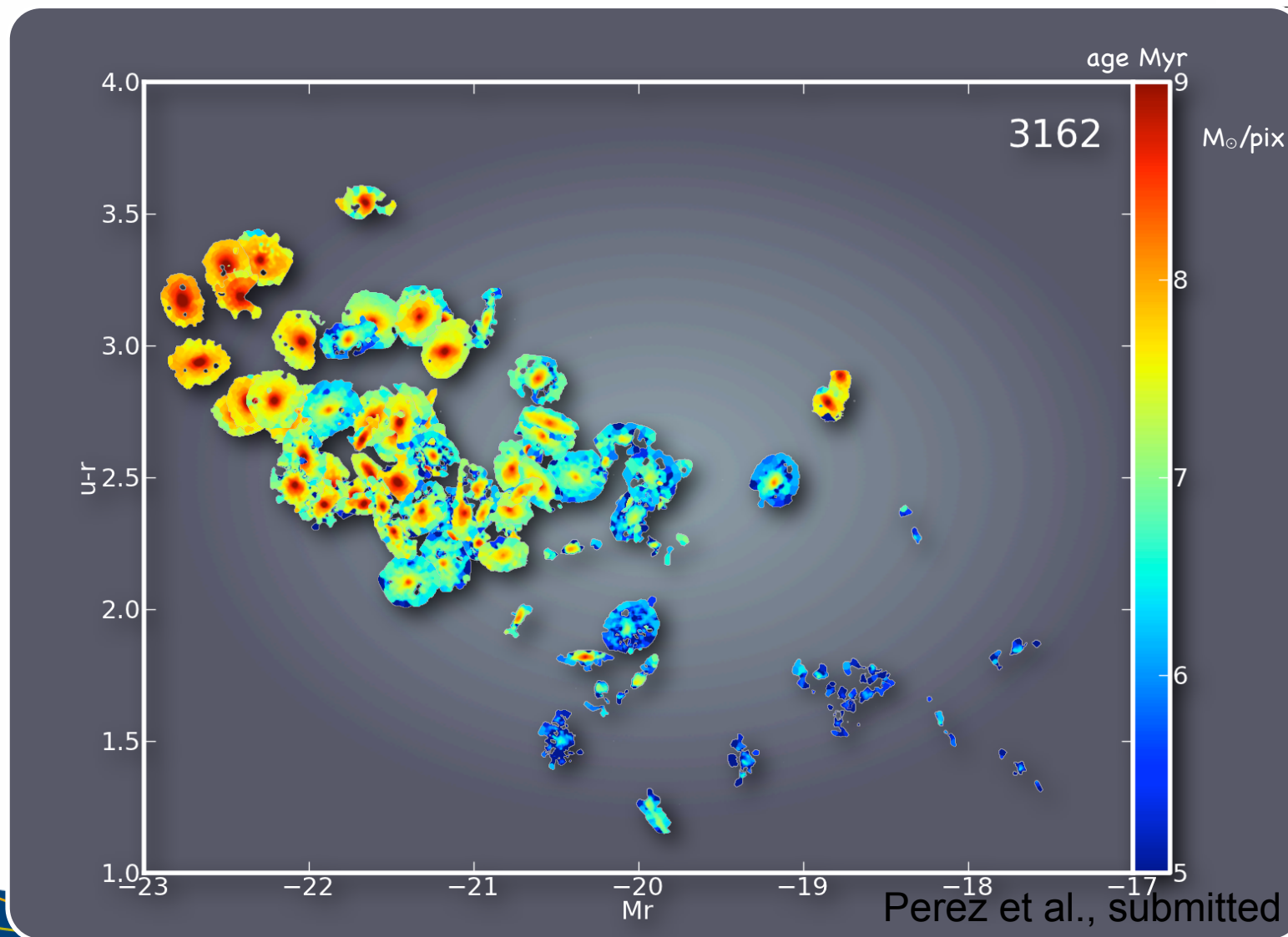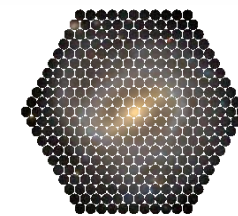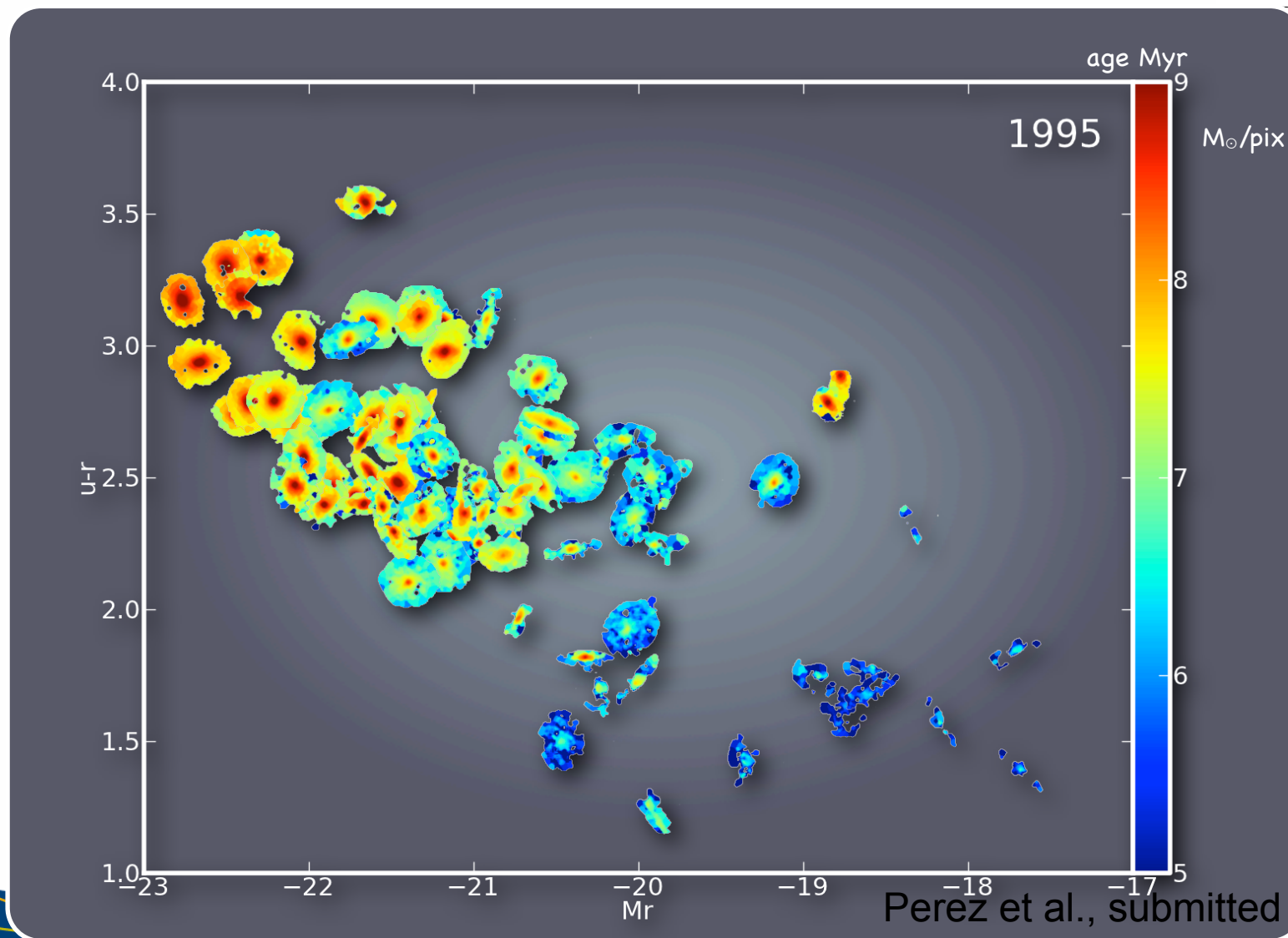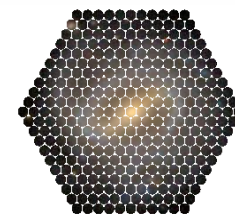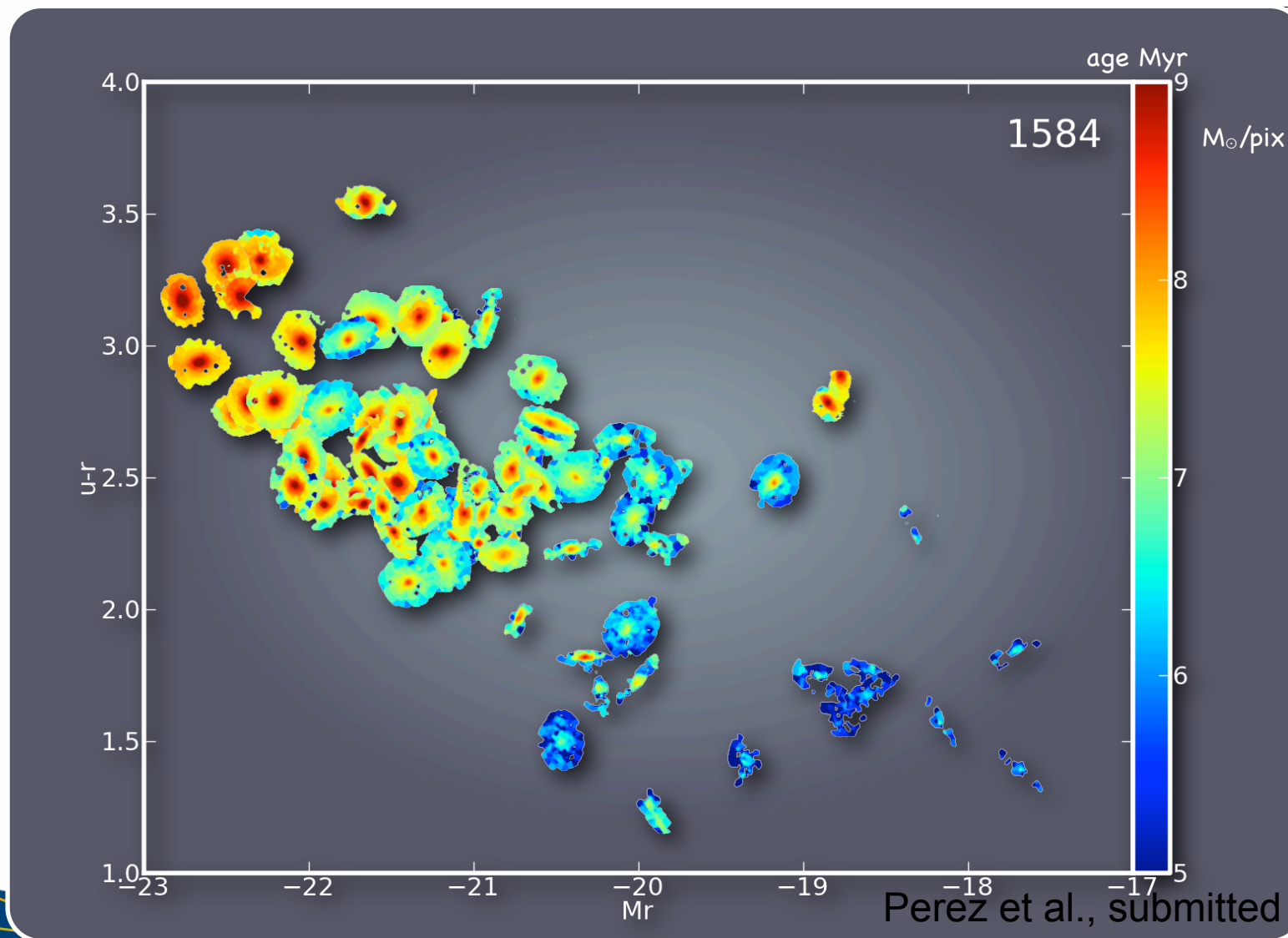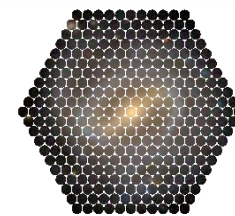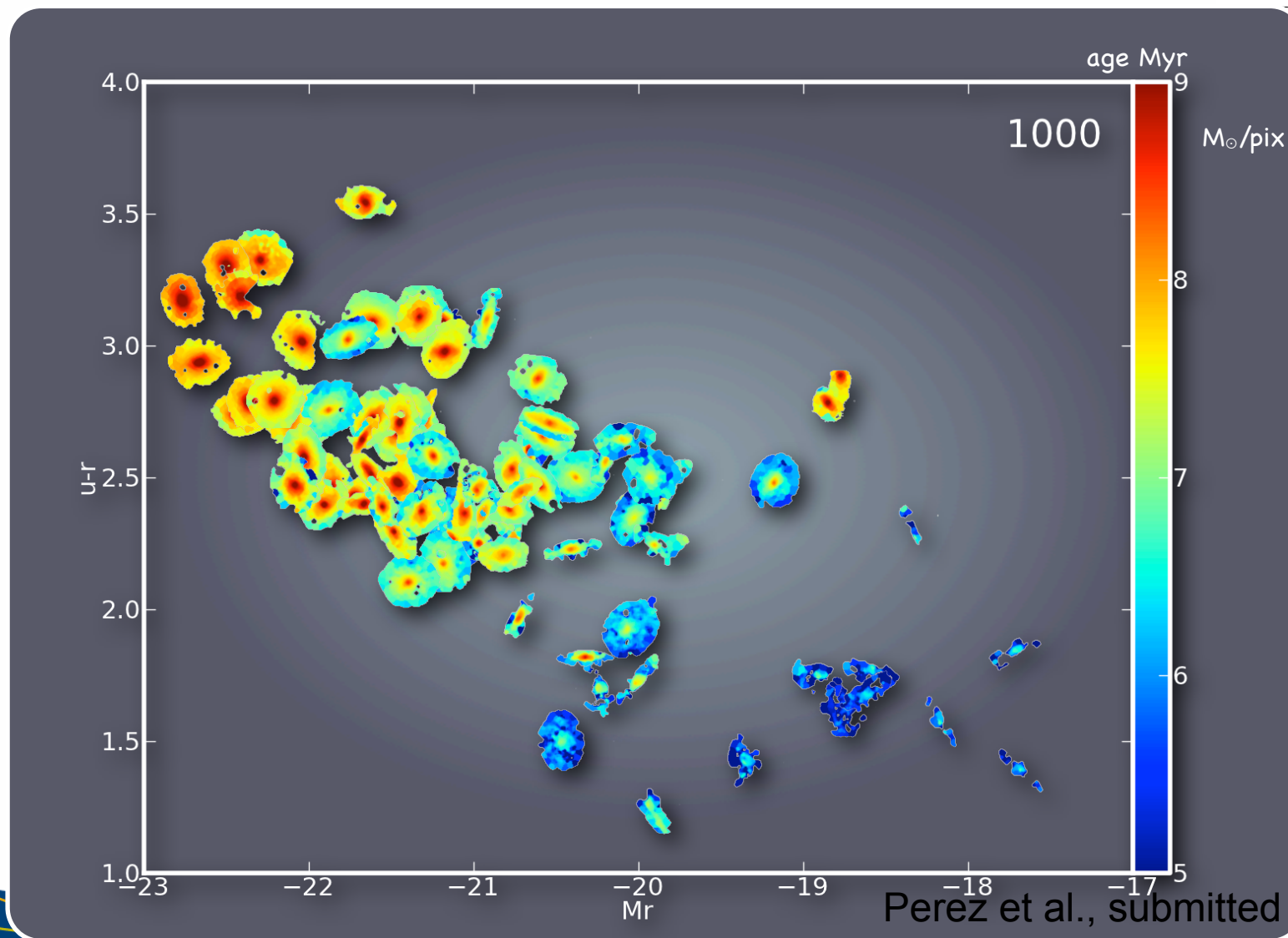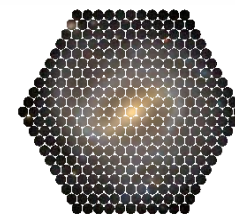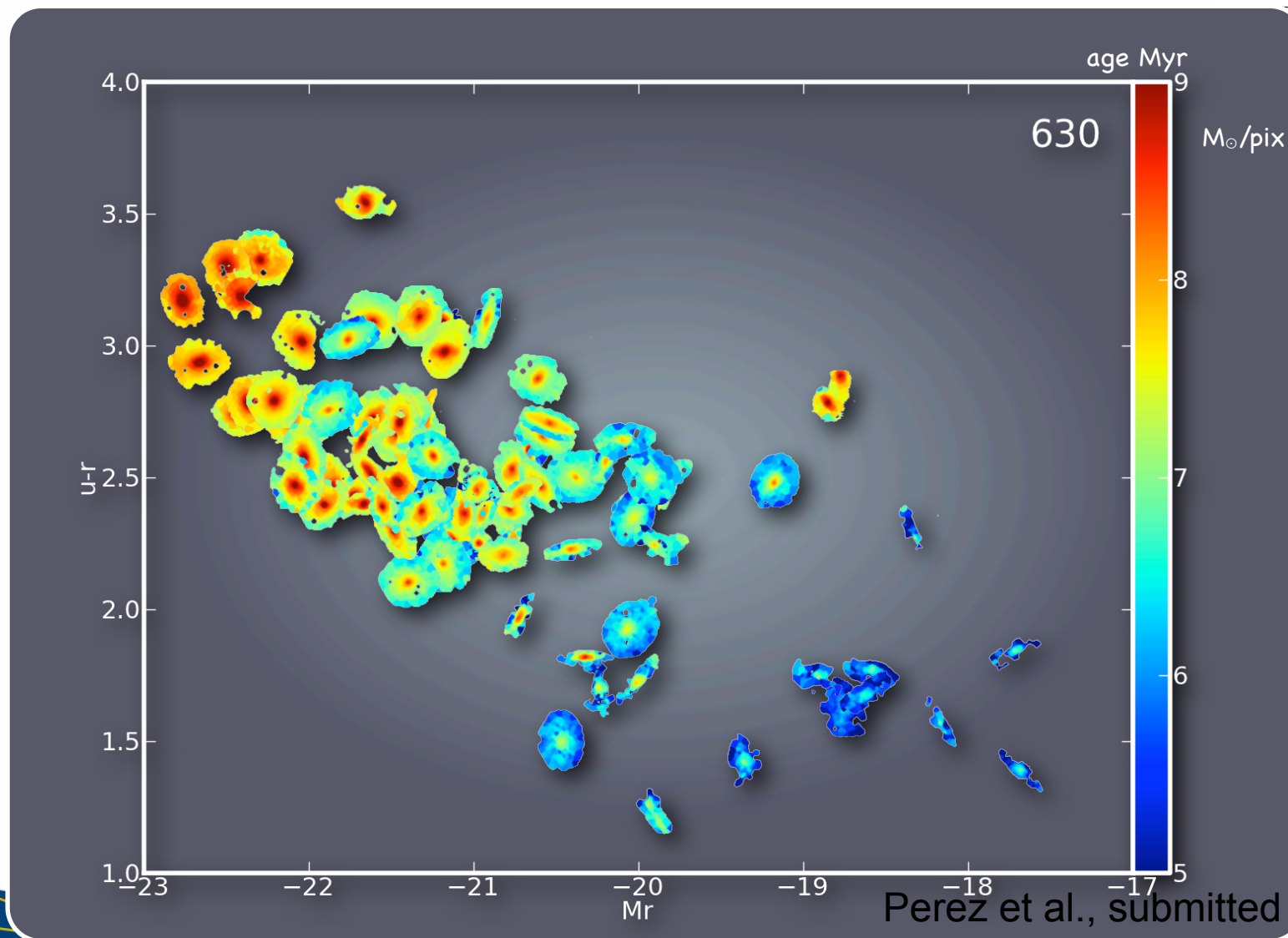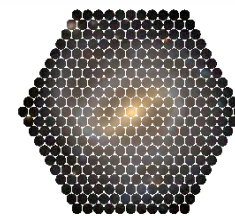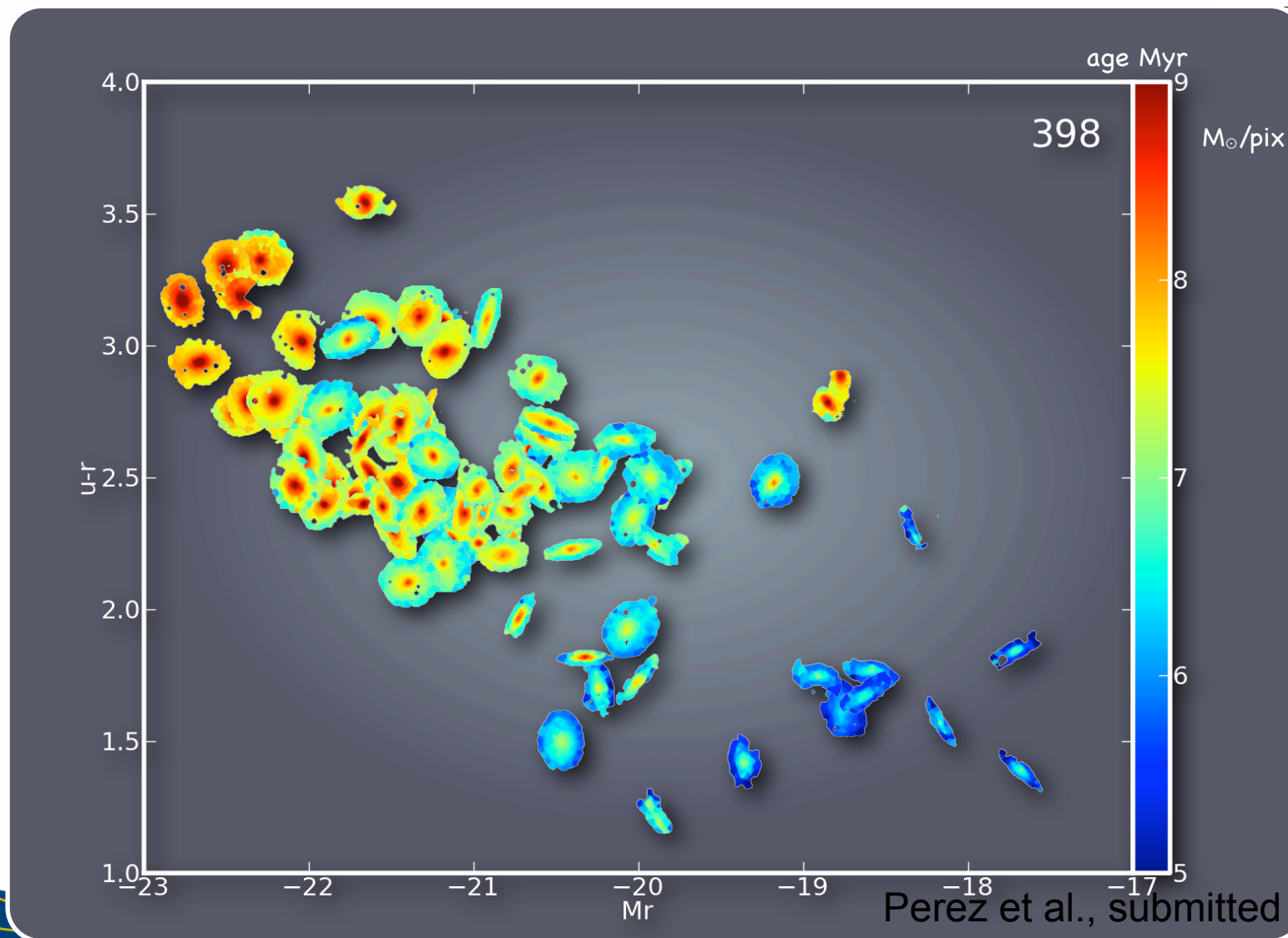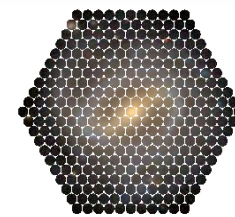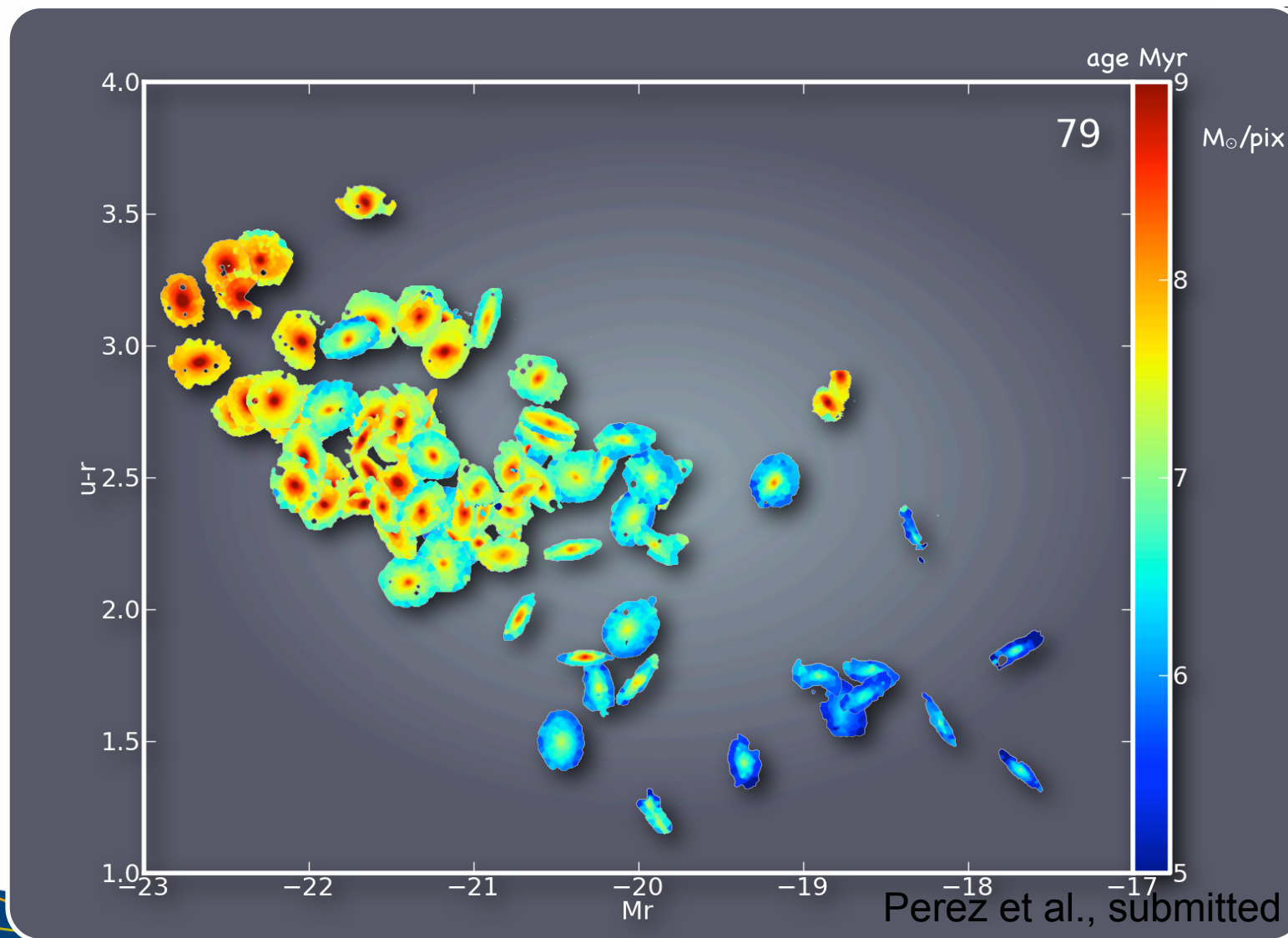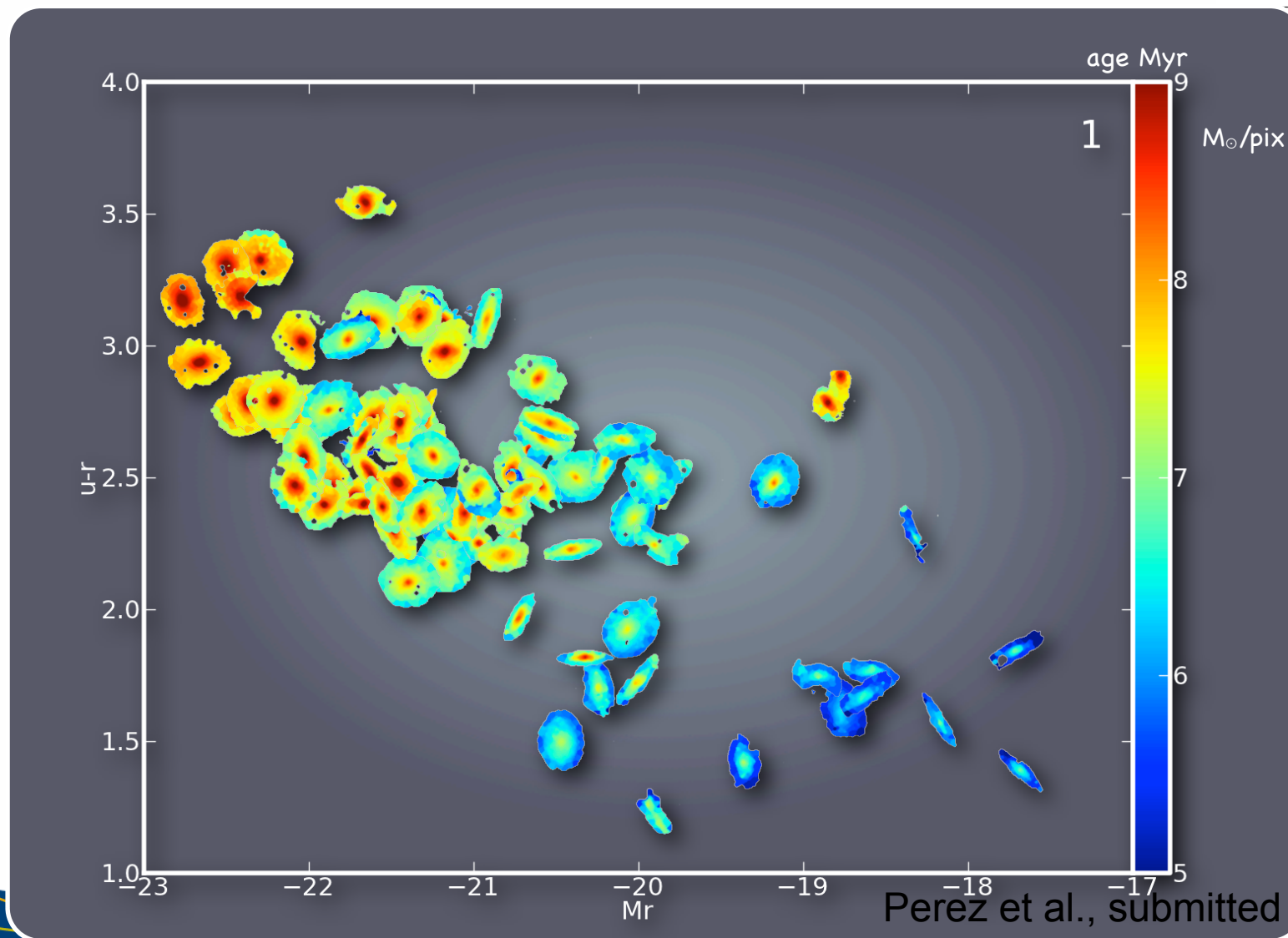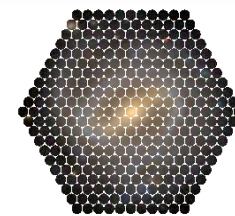
Stellar Kinematics
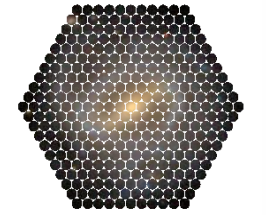
Slow Rotator (Low V, High σ) — NGC6125

Bulge+disk galaxy (High V, High σ) — NGC4210

Pure disk (High V, Low σ) — NGC1167
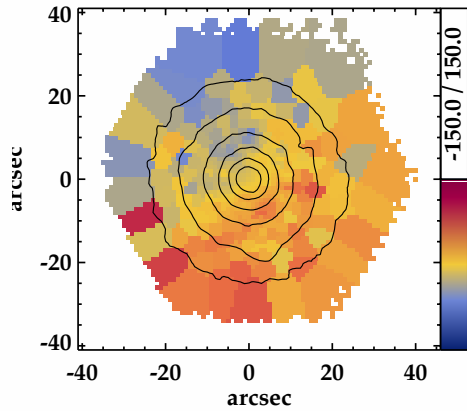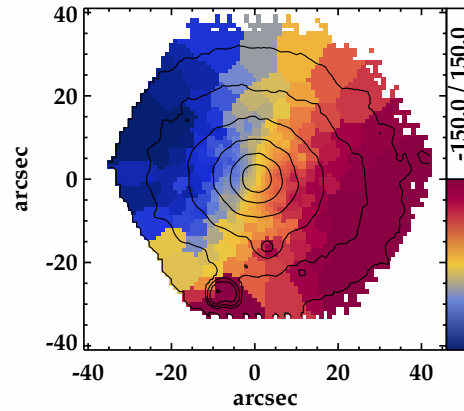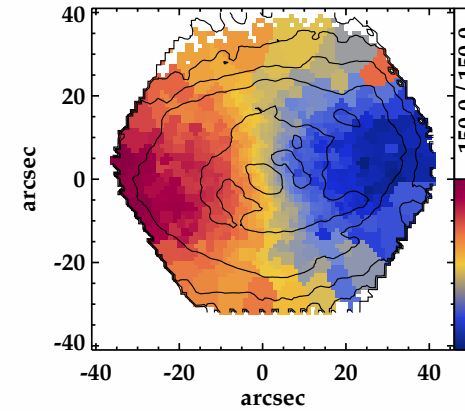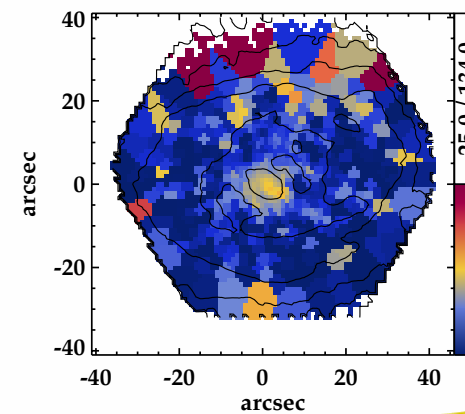
Falcon-Barroso et al., in prep.
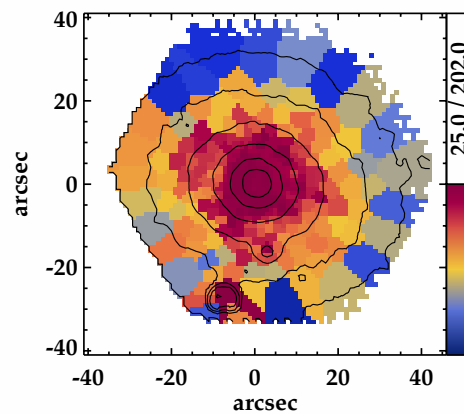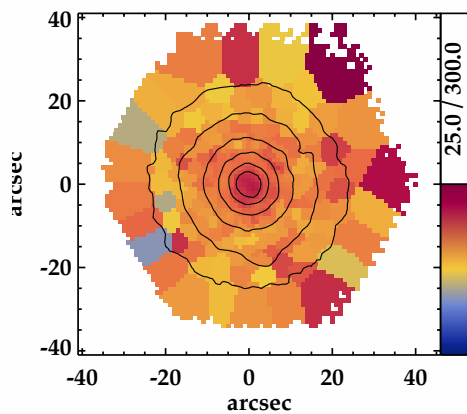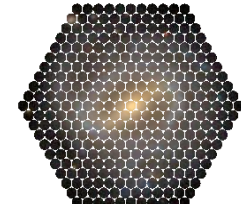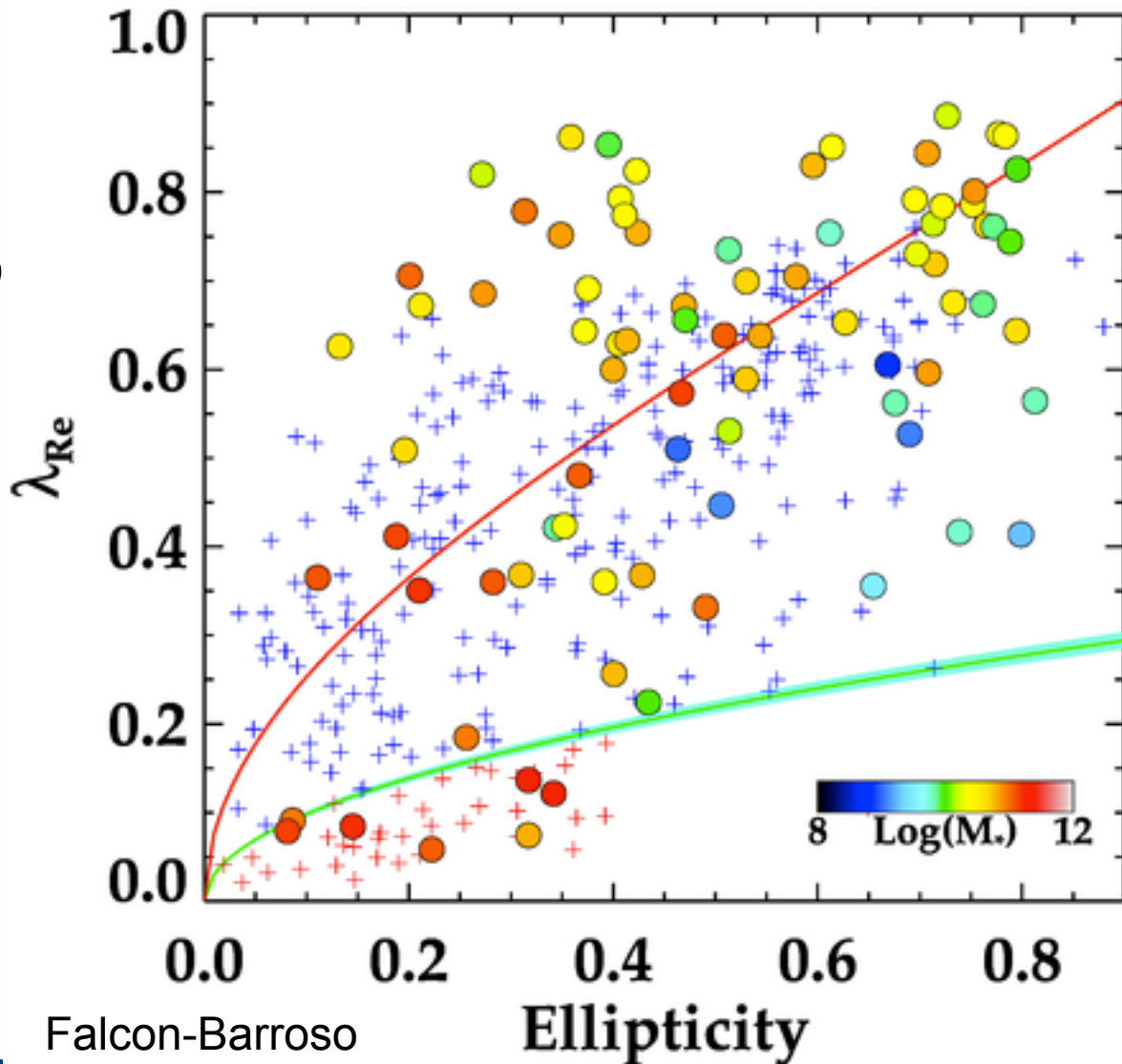
Kinematic classification

CALIFA: extension to

- Bulges
- Bars
- Disks!

Falcon-Barroso

ISM physics - excitation

Late types

log([OIII]/Hβ)

log([NII]/Hα)
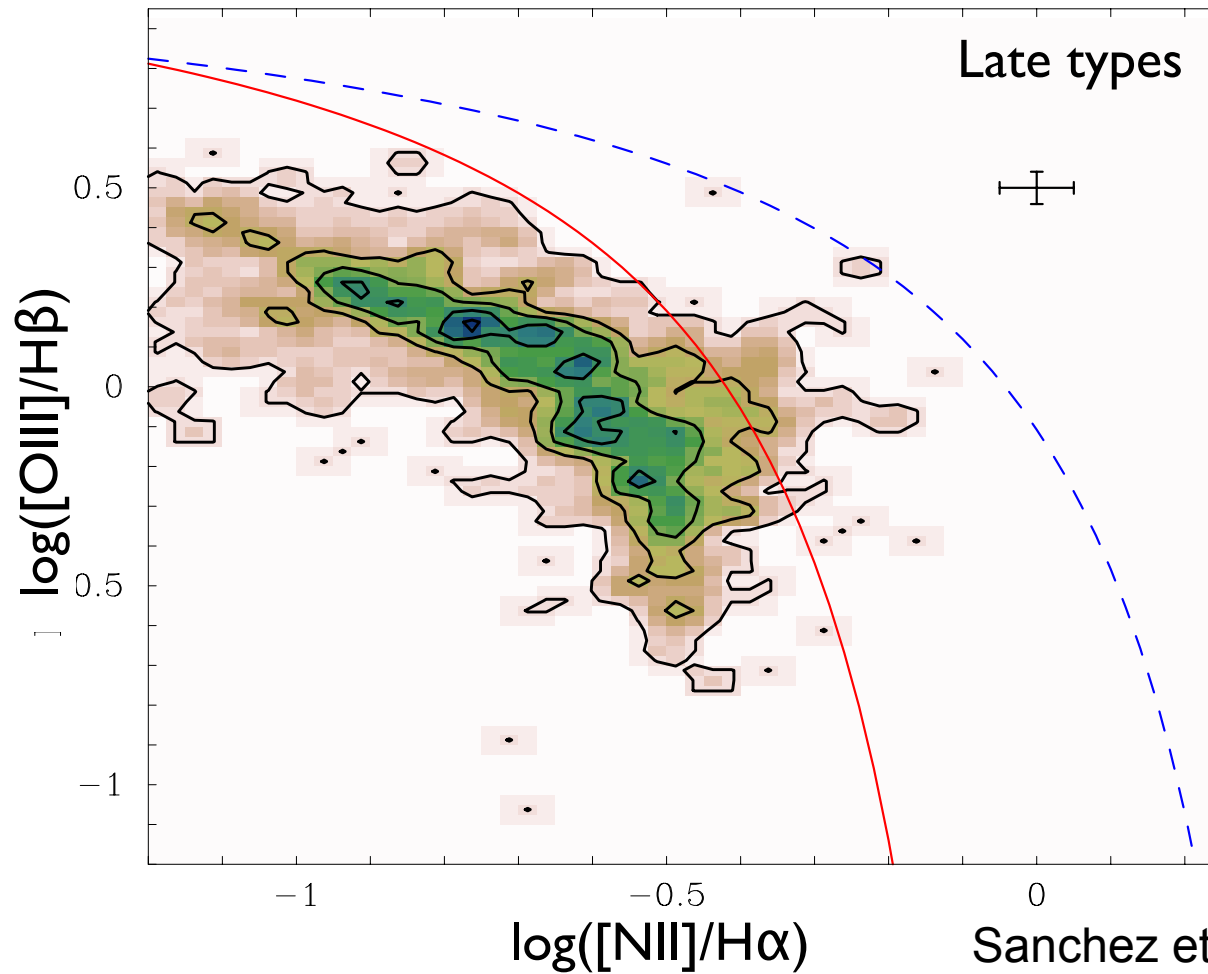
Plotting all the fibers

Sanchez et al., in prep.

Global M-Z ☐ local Σ-Z
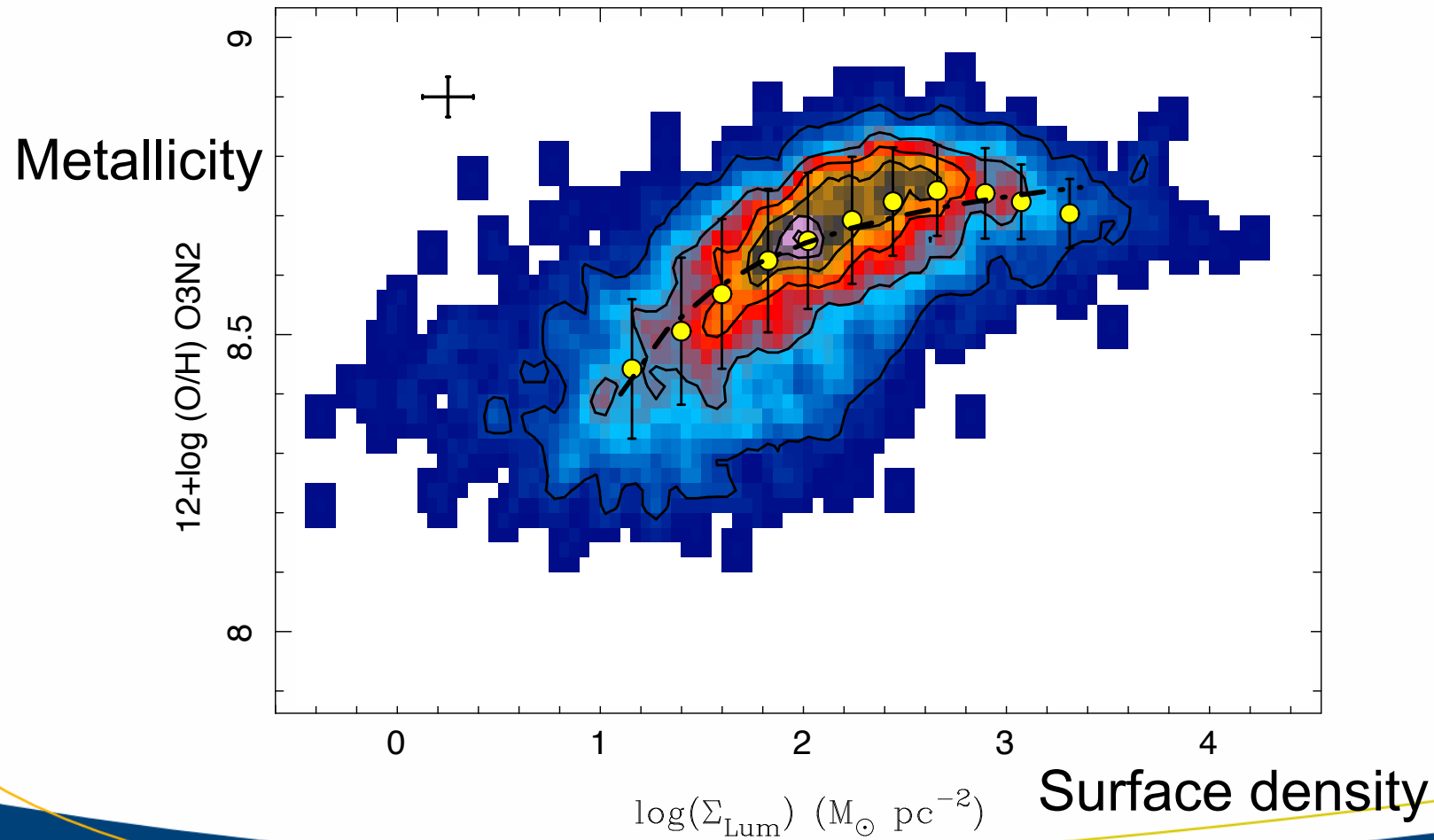
Future

THE next step after CALIFA is
a larger sample

- Science questions CALIFA only touches
  - Angular momentum in galaxies (clusters, sheets, voids)
  - Major and minor merger rates from internal kinematics
  - AGN fueling as function of mass and environment
  - Systematic variation of gradients as function of mass, environment, morphology
  - and more
- All of these need statistics (>10k galaxies)

CALIFA "follow-up"

SDSS   Need this!   CALIFA

$2 \cdot 10^6$ $10^4 - 10^5$ $6 \cdot 10^2$

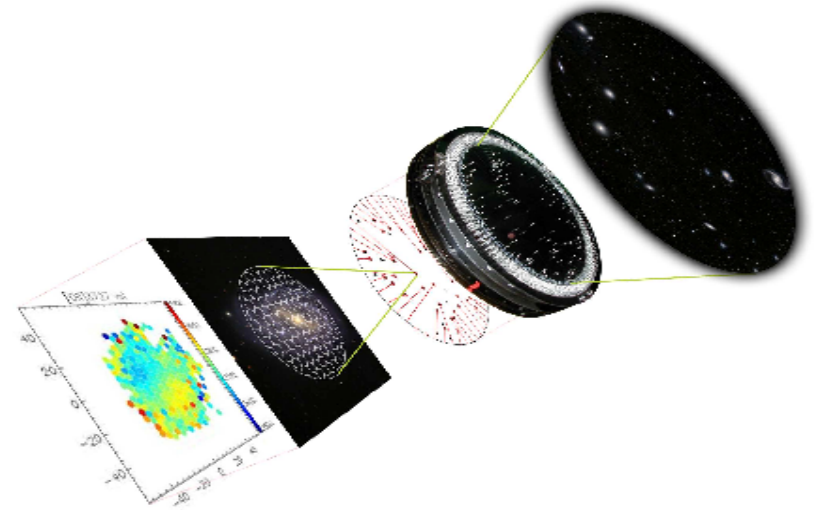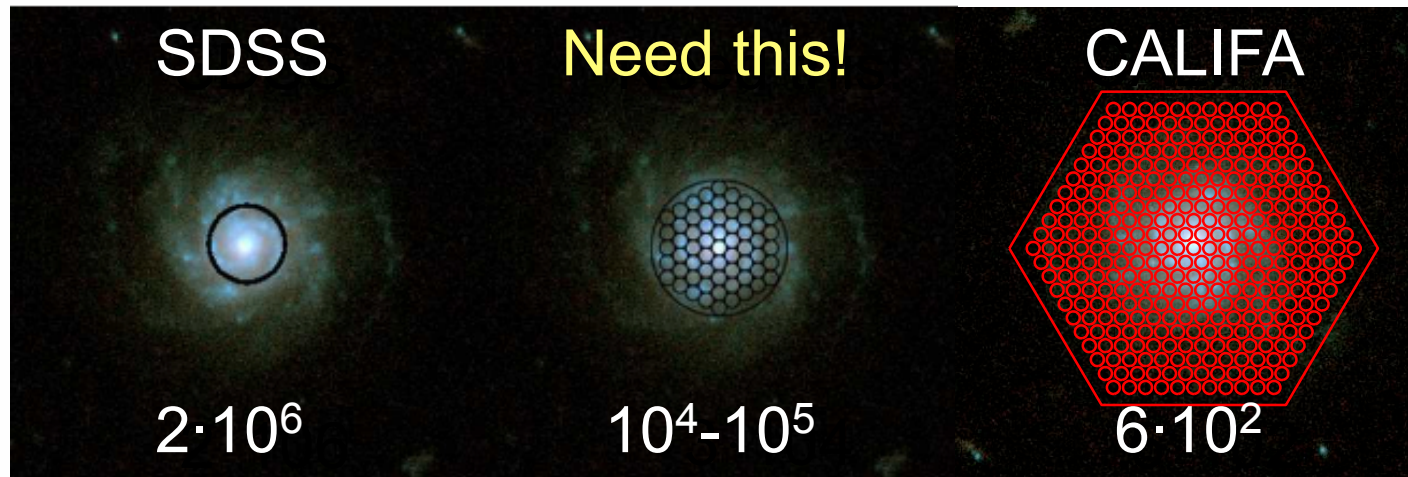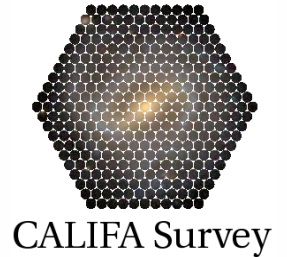- Fireball (FLAMES upgrade, currently held up, ~30k galaxies)

- Manga (SDSS extension in AS3, hardware developments underway, ~10k galaxies)

- SAMI (AAT, observations starting, ~10k galaxies)

Conclusions

- CALIFA is a unique opportunity to understand the baryonic physics of galaxies using integral field spectroscopy.

- CALIFA is a legacy survey, data are being collected, quality is excellent, and all will be public!

- CALIFA is producing first, exciting science results right now.

- Next generation IFS surveys will be complementary to CALIFA.

http://califa.caha.es/