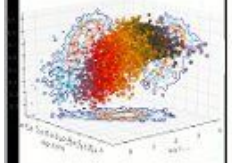
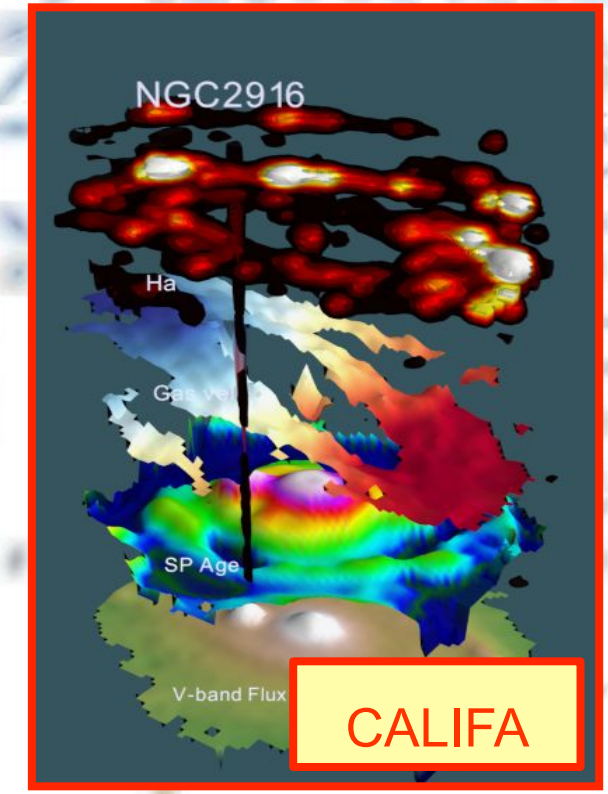
CALIFA Survey

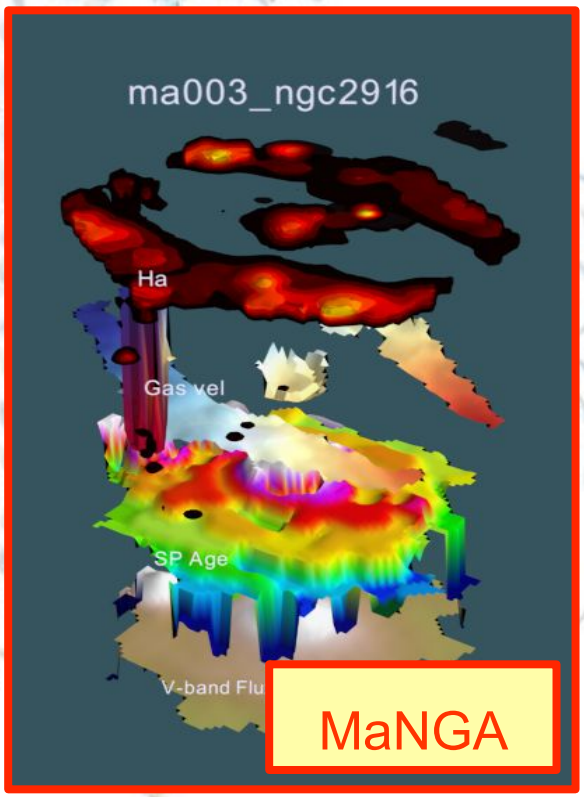
instituto de astronomía
unam



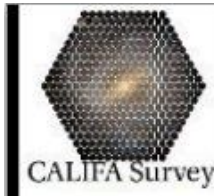
How to analyze IFS data: Pipe3D, an implementation

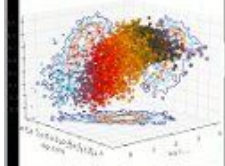
Sebastián F. Sánchez / IA-UNAM





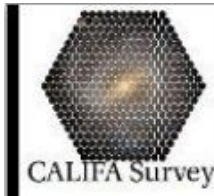
- GH2014, IFS School, INAOE -

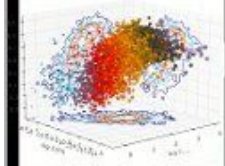




Pipe3D: Goals

- Derive a set of science quality data products:
  - Emission line intensity maps, velocities, and velocity dispersion.
  - Stellar population decomposition results: weights, age/met/dust maps, stellar kinematics.
  - Line indices maps.
  - Spatial decomposition analysis: HII/ ionized regions/diffuse.



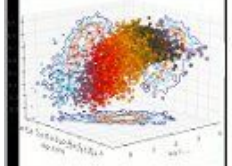


Pipe3D: Goals

- Run in an automatic way. When new data arrives, new dataproducts are produced.
- Fully connected with a DB, both to initiate the analysis and to provide with the results.
- Accessible to all the members of the collaboration.
- Useful for Science and verification.

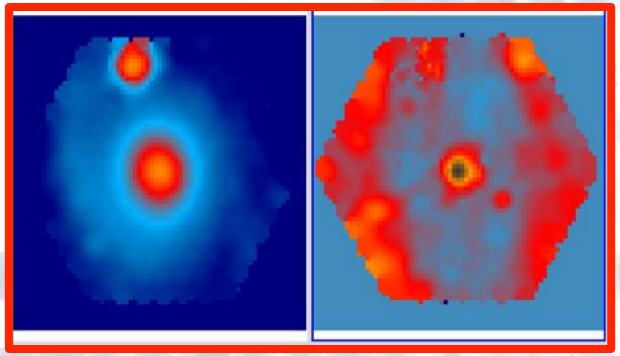
CALIFA Survey

instituto de astronomía
unam

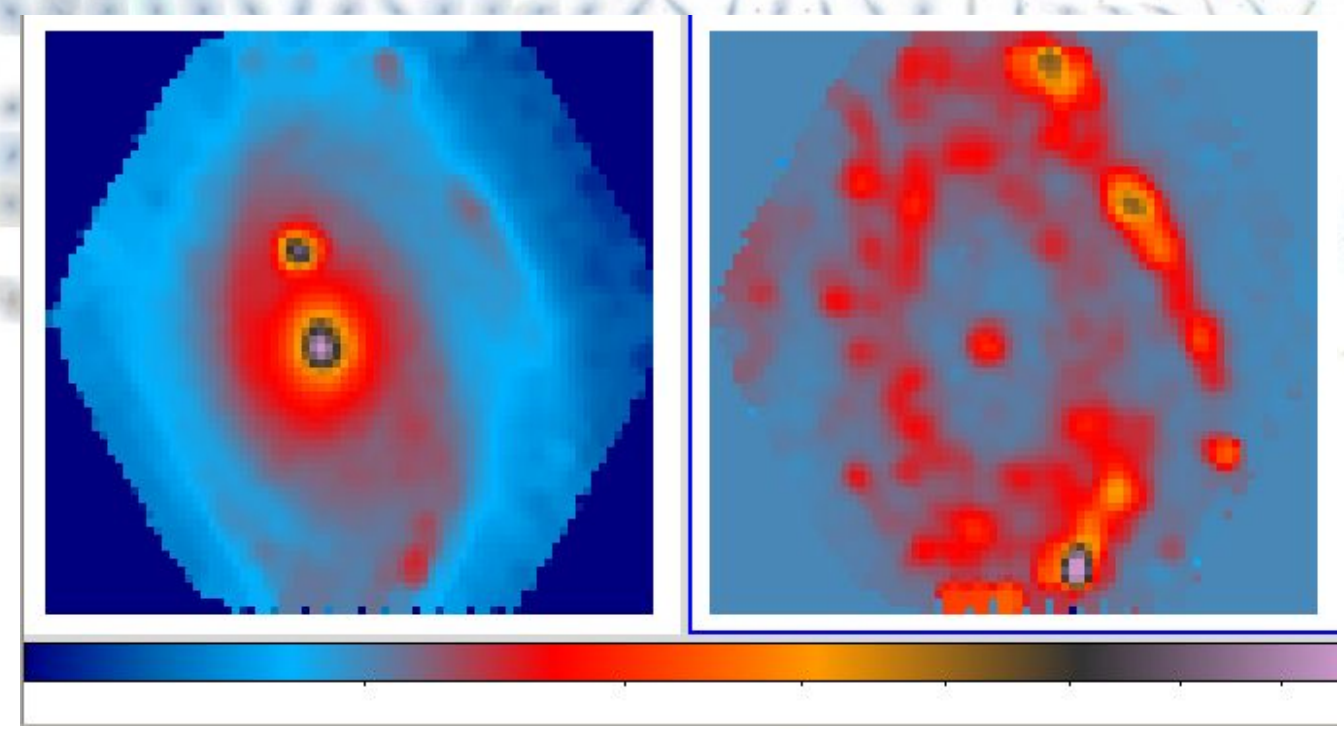


Pipe3D: Fundaments

Stellar continuum vs. Ionized gas.

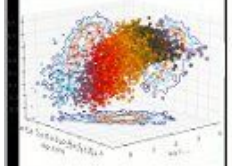


Different spatial distribution



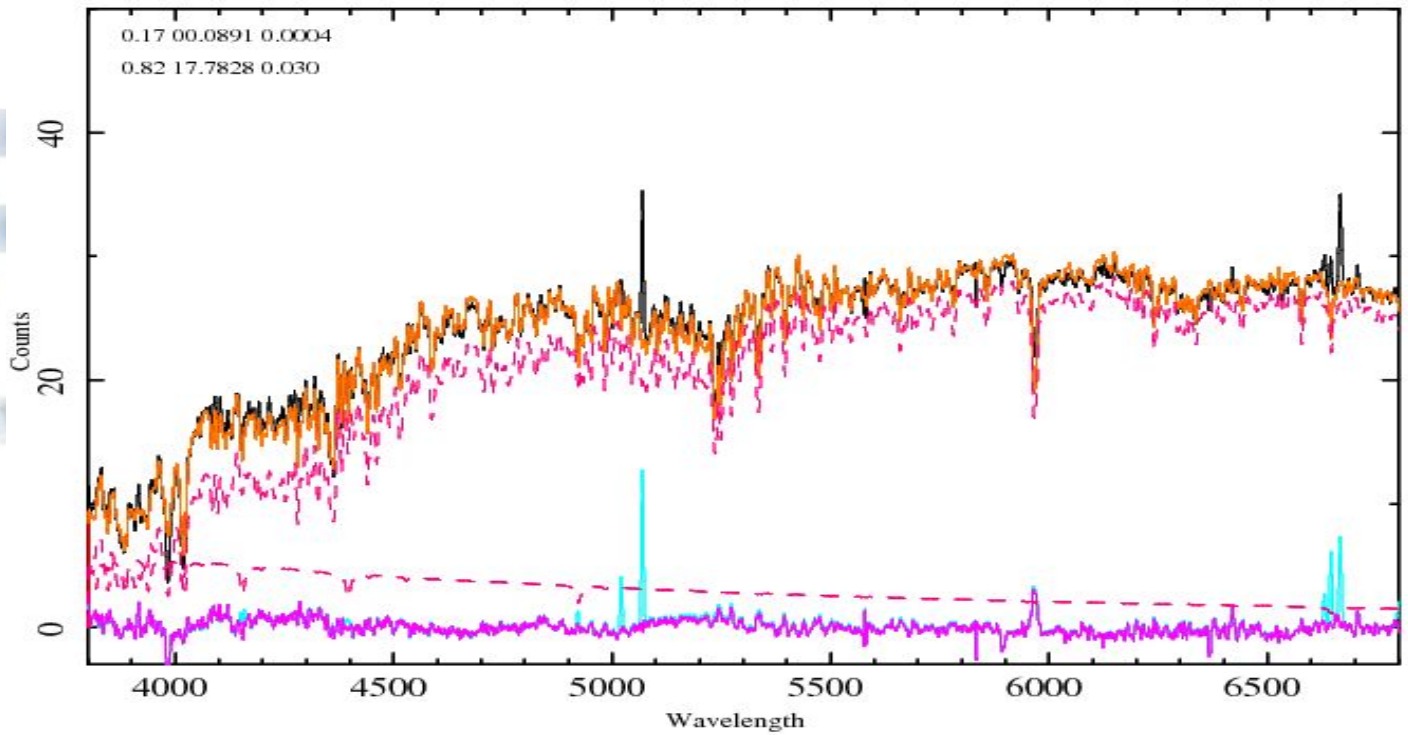
CALIFA Survey

instituto de astronomía
unam

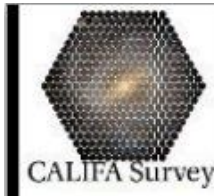


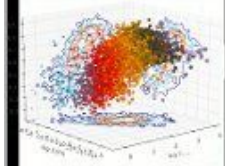
Pipe3D: Fundaments

Stellar continuum vs. Ionized gas.



Different Signal-to-noise ratio



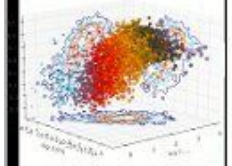


Pipe3D: Sequence (I)

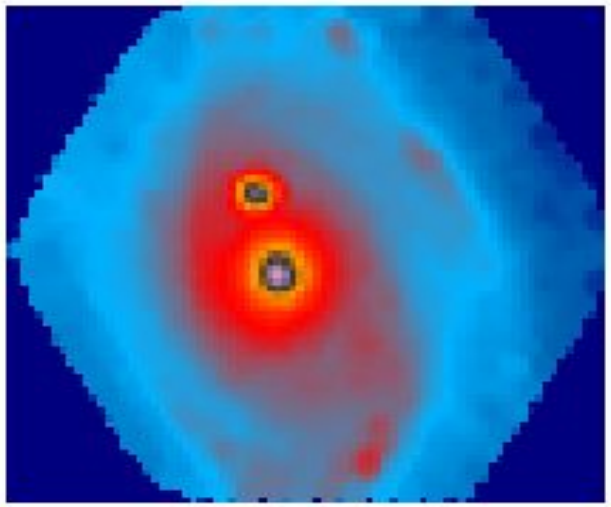
- IFS Cubes/RSS ⟹ Required format.
- Extract V-band image (centroid).
- Extract radial aperture spectra: SDSS-like spectra and redshift.
- Continuum segmentation (CS), based on flux intensity (not S/N).
- Multi-SSP and emission lines analysis of the CS-RSS.
- Analysis of the stellar indices on the gas-clean CS-RSS.
- Stellar-model and GAS pure cubes.

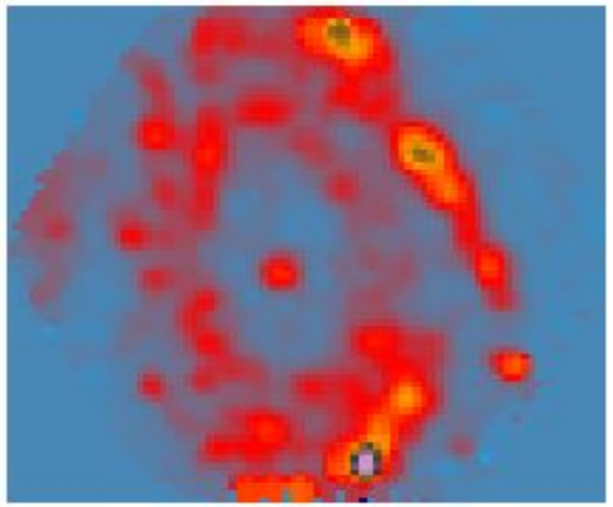
CALIFA Survey

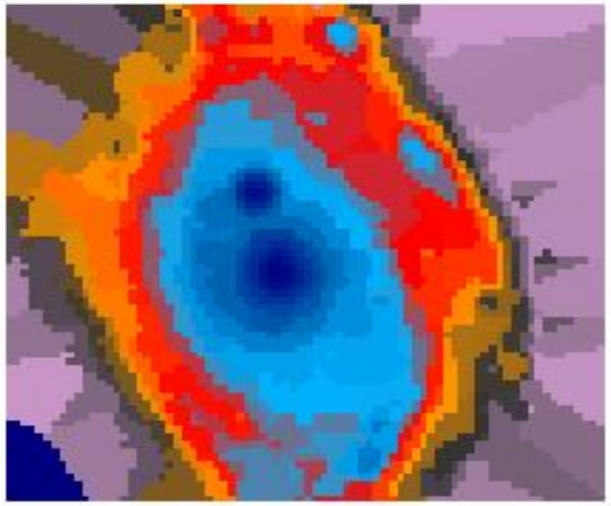
instituto de astronomía
unam

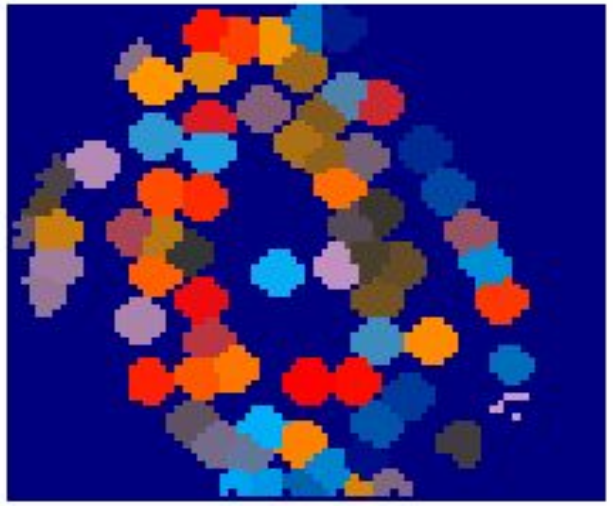


Pipe3D: Sequence (I)



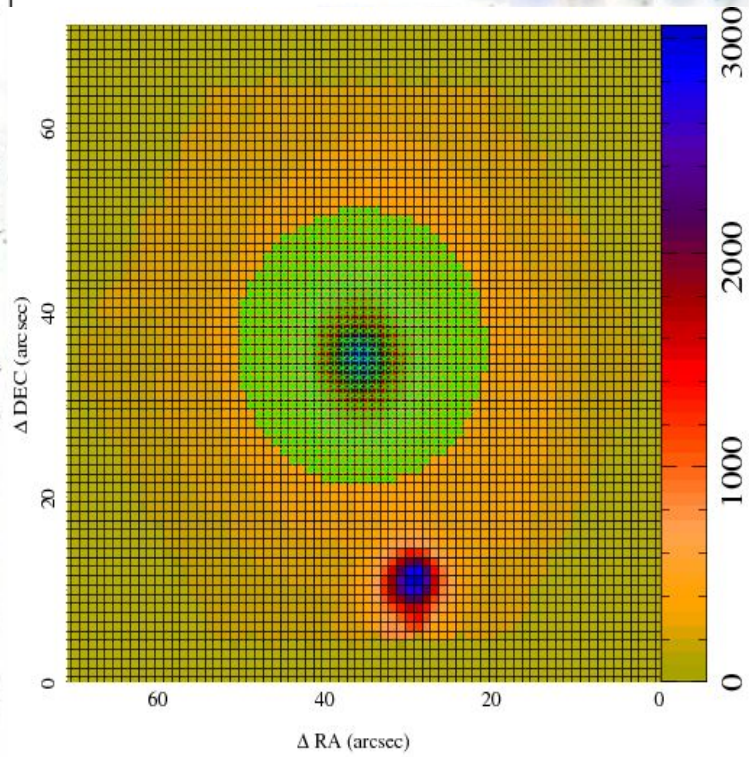


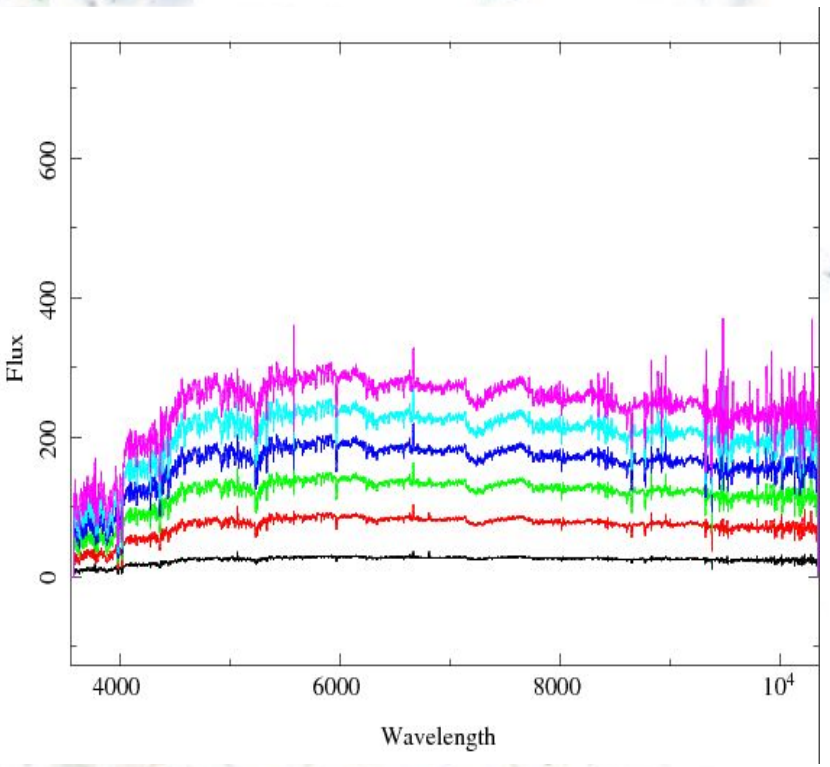


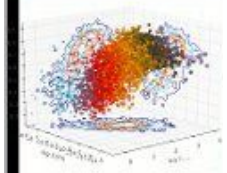


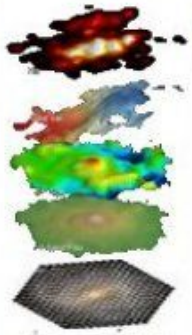
Different Binning schemes!

Pipe3D: Sequence (I)





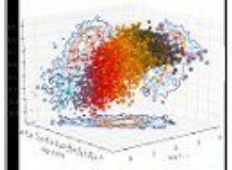




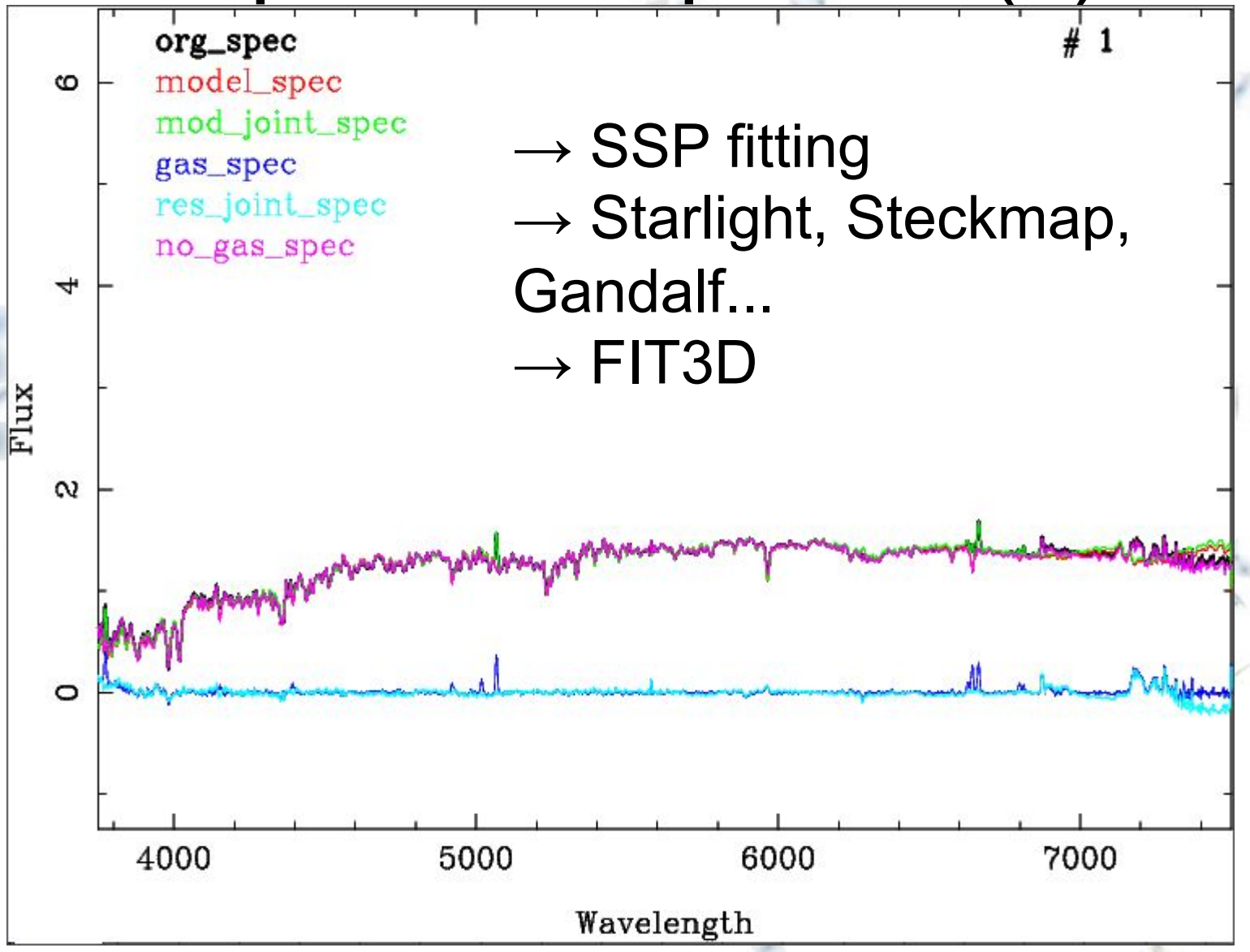
Different Binning schemes!

CALIFA Survey

instituto de astronomía
unam



Pipe3D: Sequence (II)

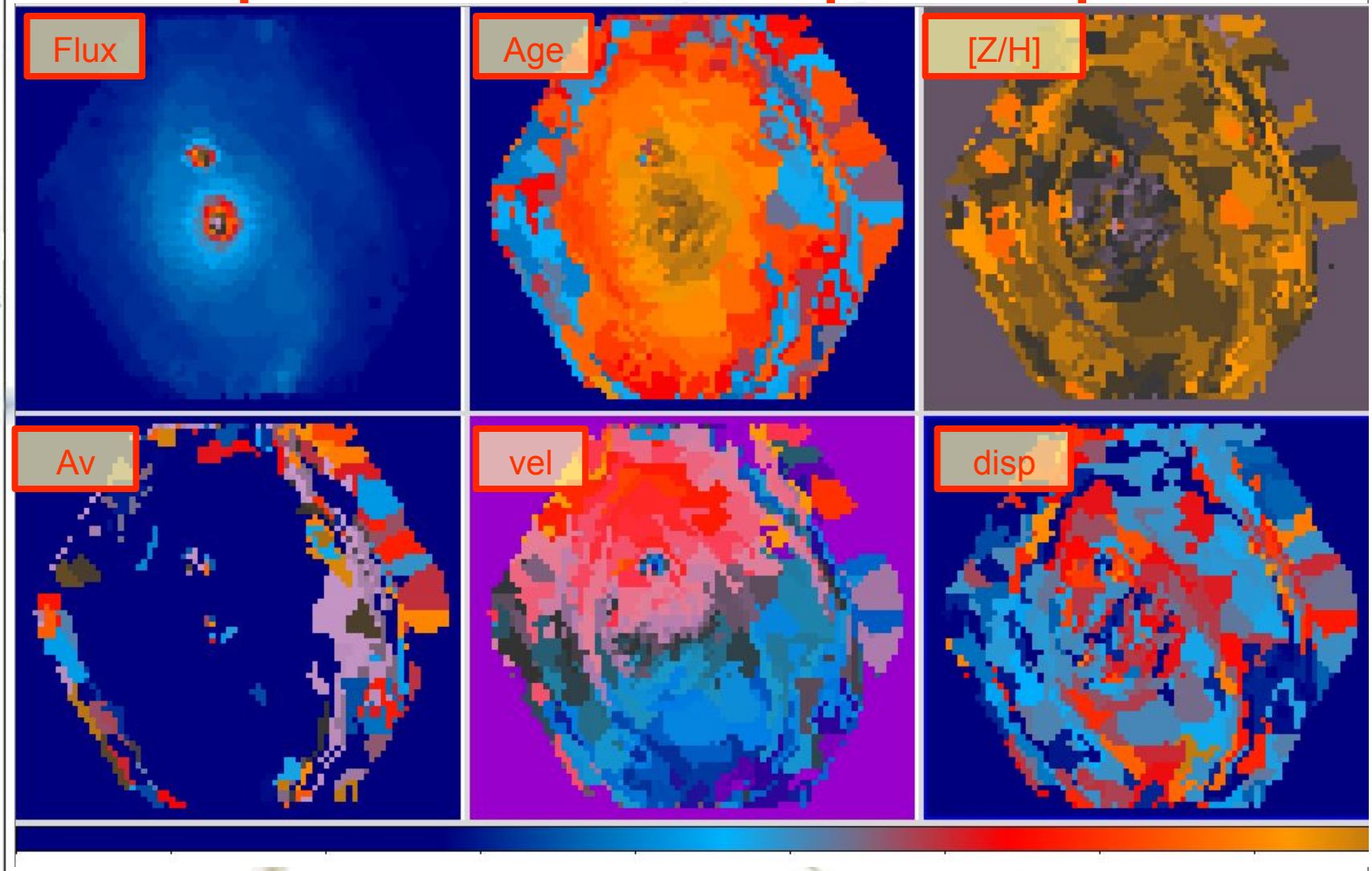


→ SSP fitting
→ Starlight, Steckmap, Gandalf...
→ FIT3D

CALIFA Survey

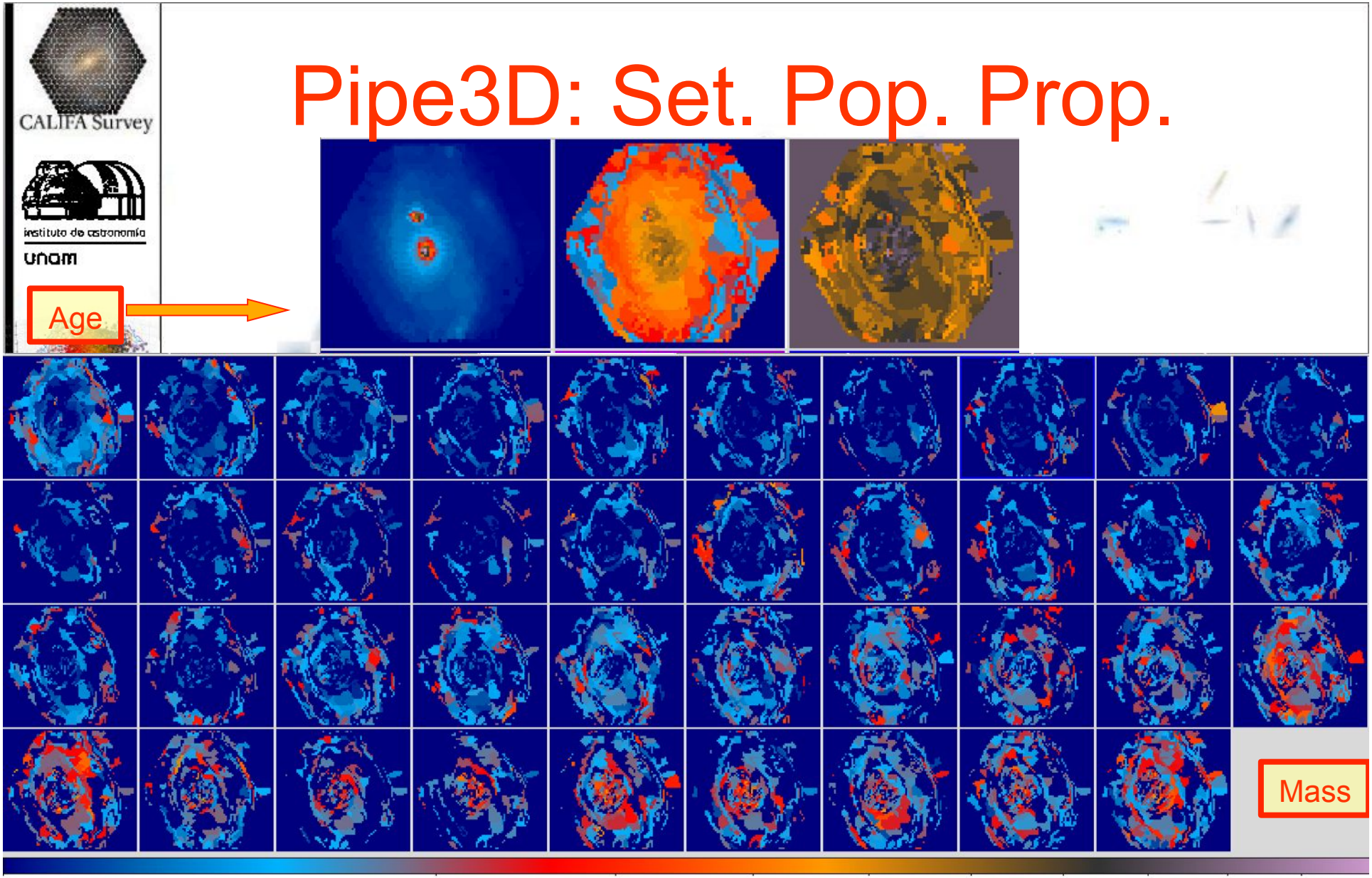
instituto de astronomía
unam

Pipe3D: Set. Pop. Prop.



Stellar Populations: Average Properties.

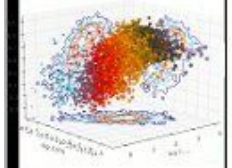
Pipe3D: Set. Pop. Prop.



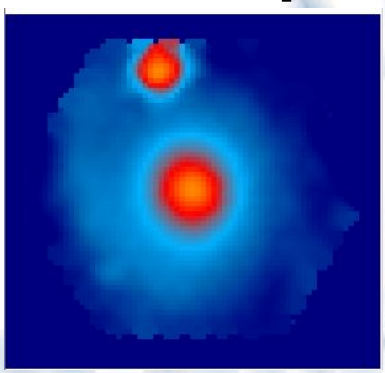
Stellar Populations: Mass Growth.

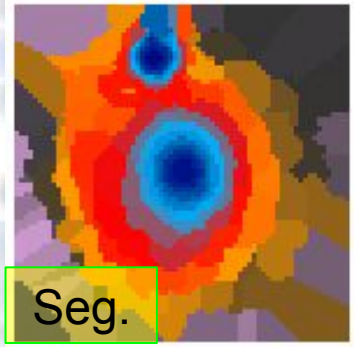
CALIFA Survey

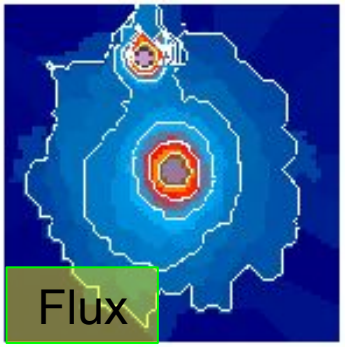
instituto de astronomía
unam

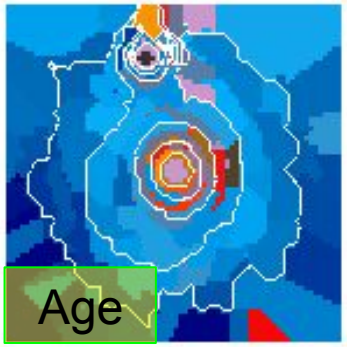


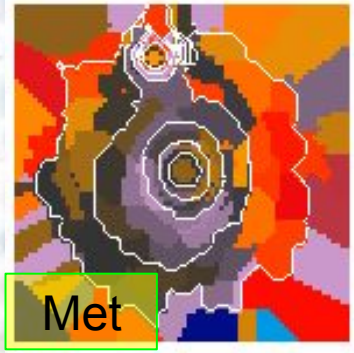
Pipe3D: SSP dataproducts

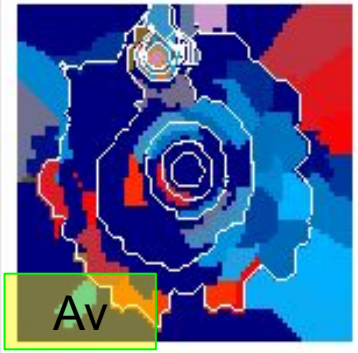


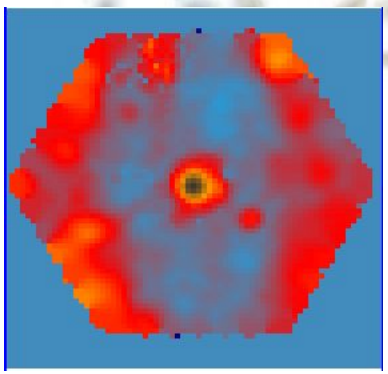


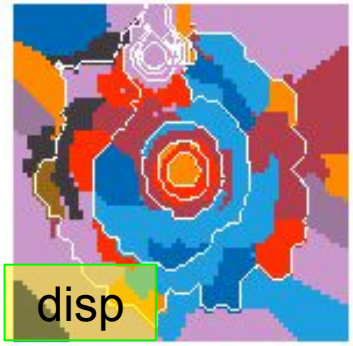


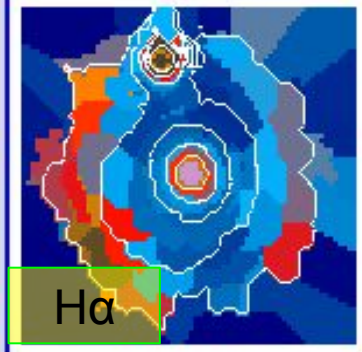








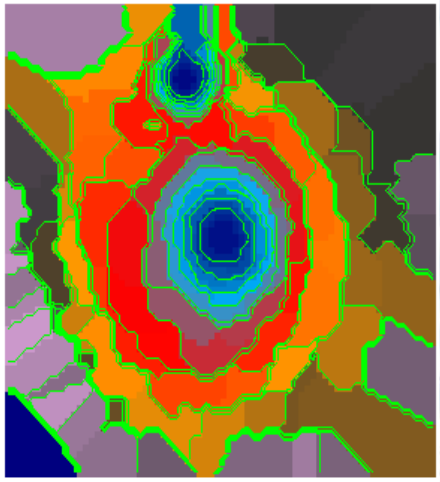


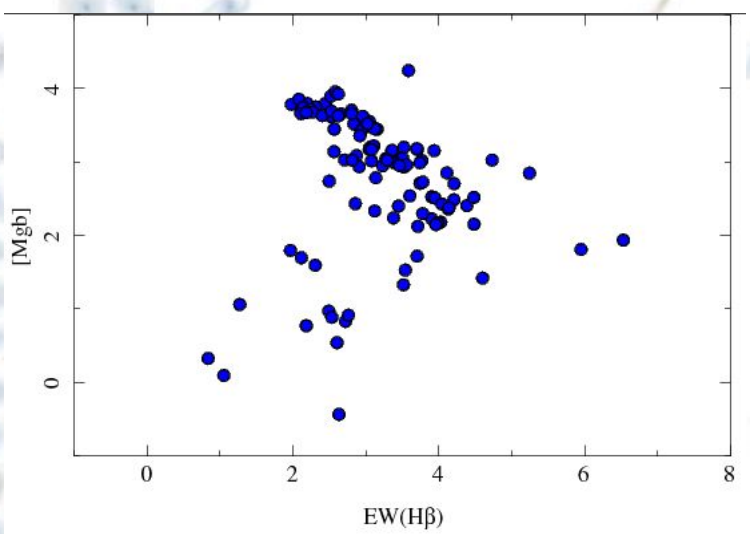


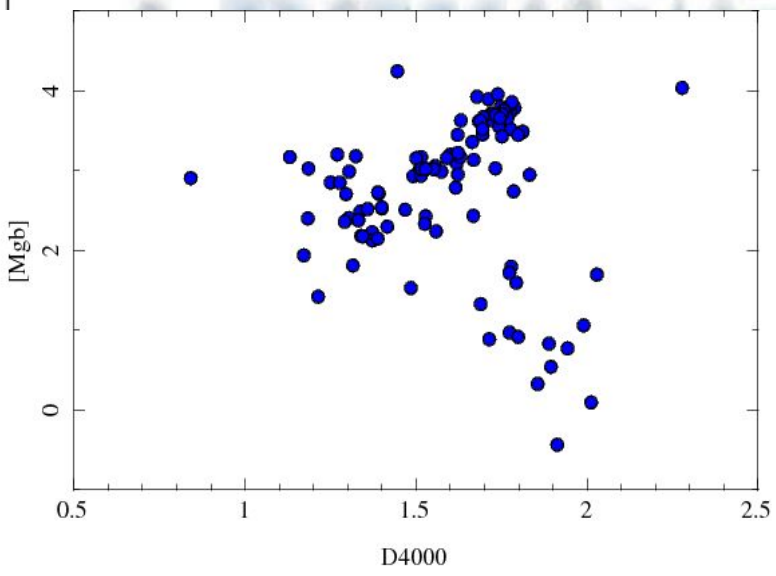
CALIFA Survey

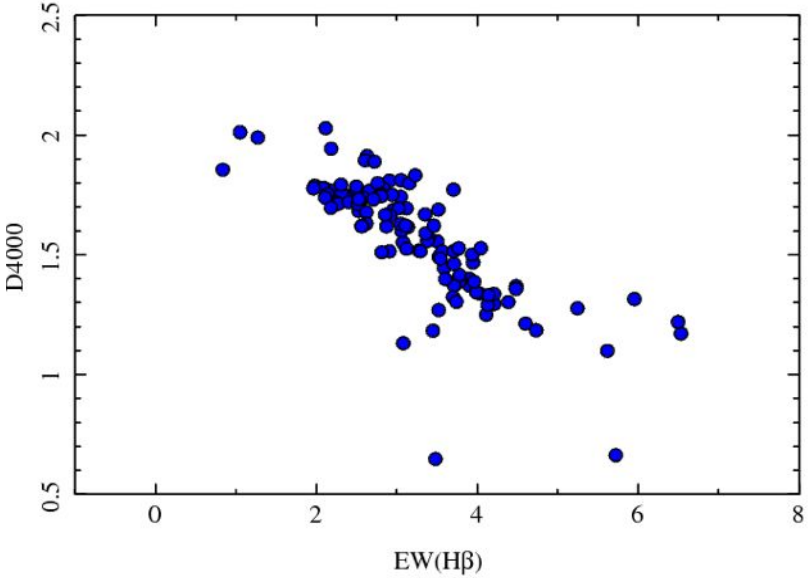
instituto de astronomía
unam

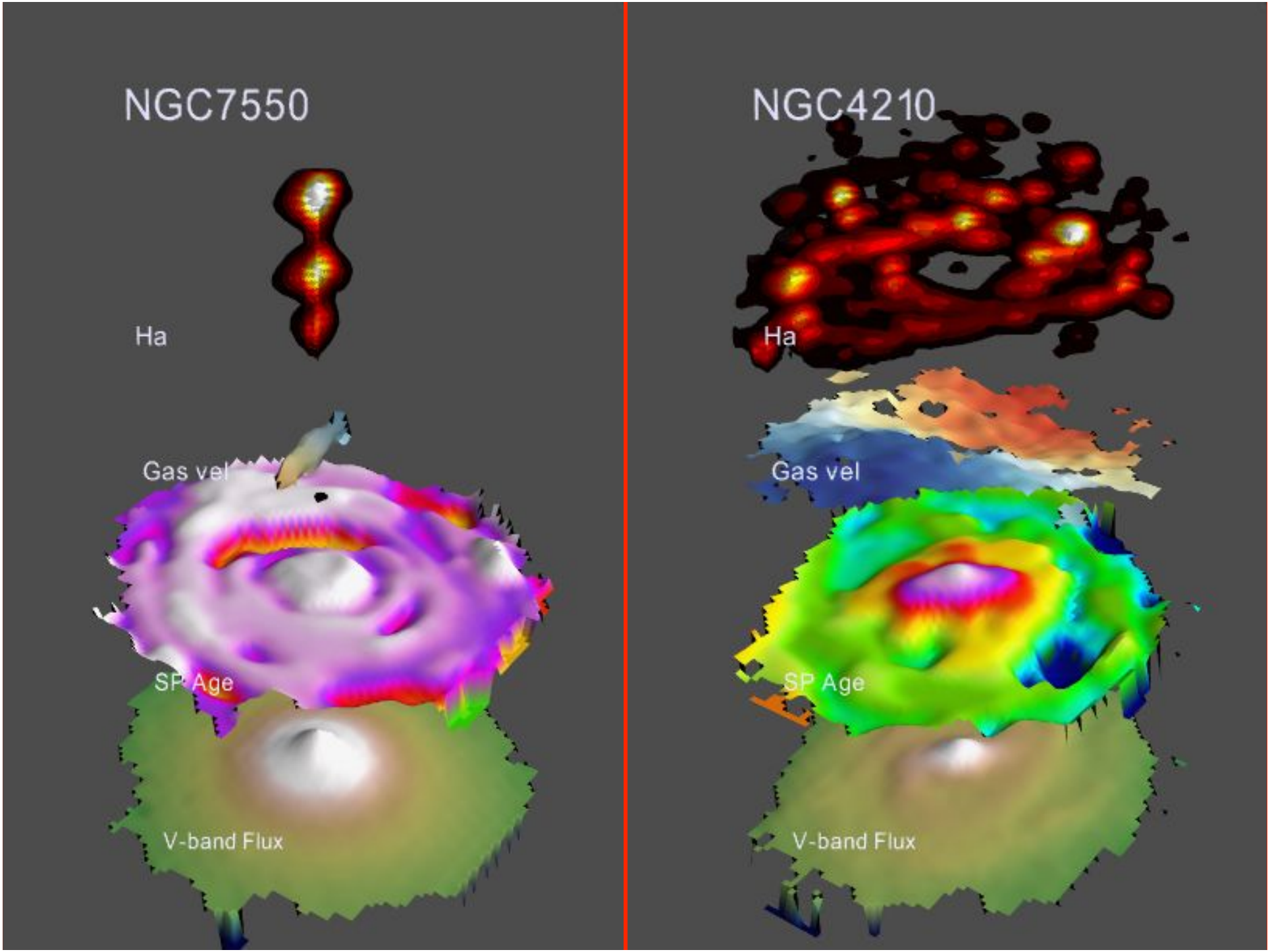
Pipe3D: Stellar Indices







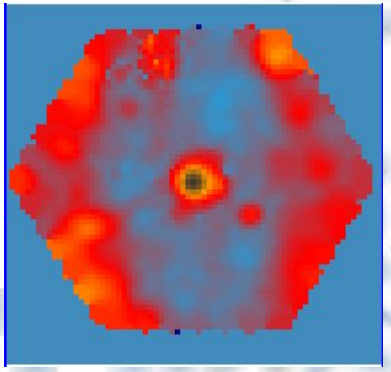


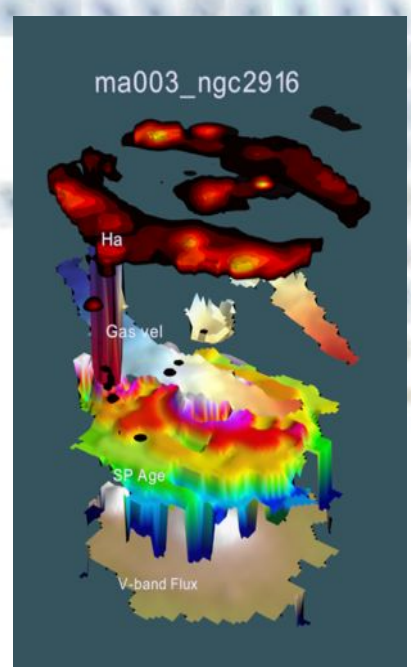

NGC7550
Ha
Gas vel
SP Age
V-band Flux
NGC4210
Ha
Gas vel
SP Age
V-band Flux

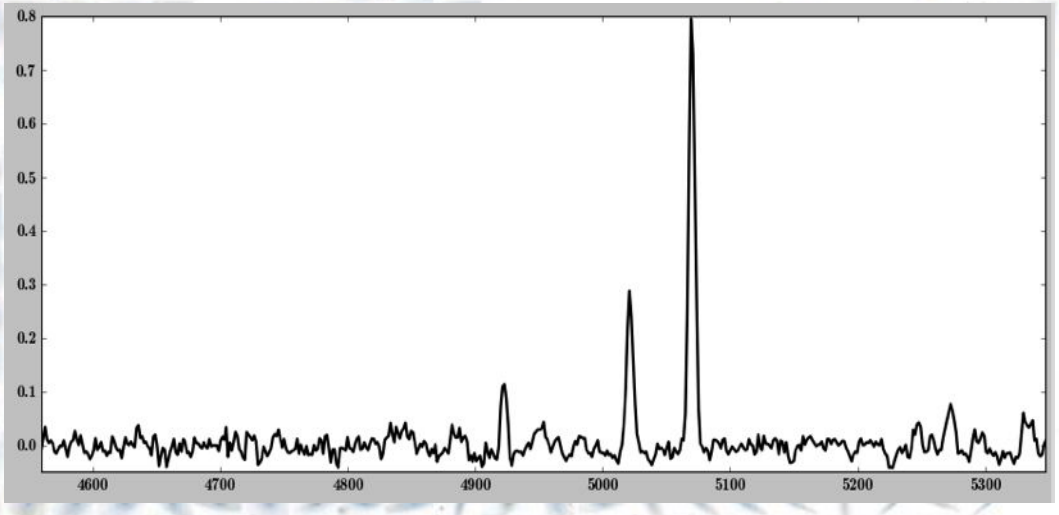
CALIFA Survey

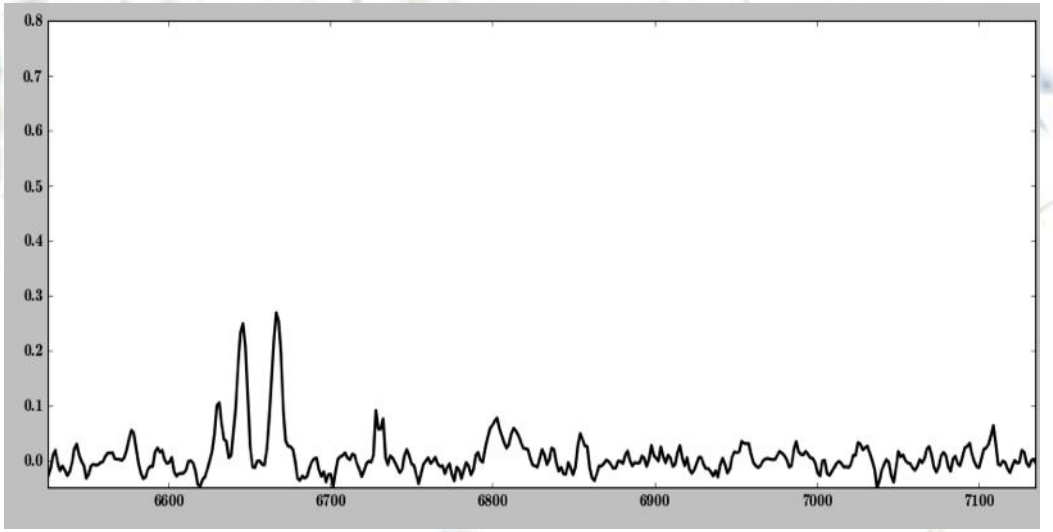
instituto de astronomía
unam

Pipe3D: Gas-pure Cube

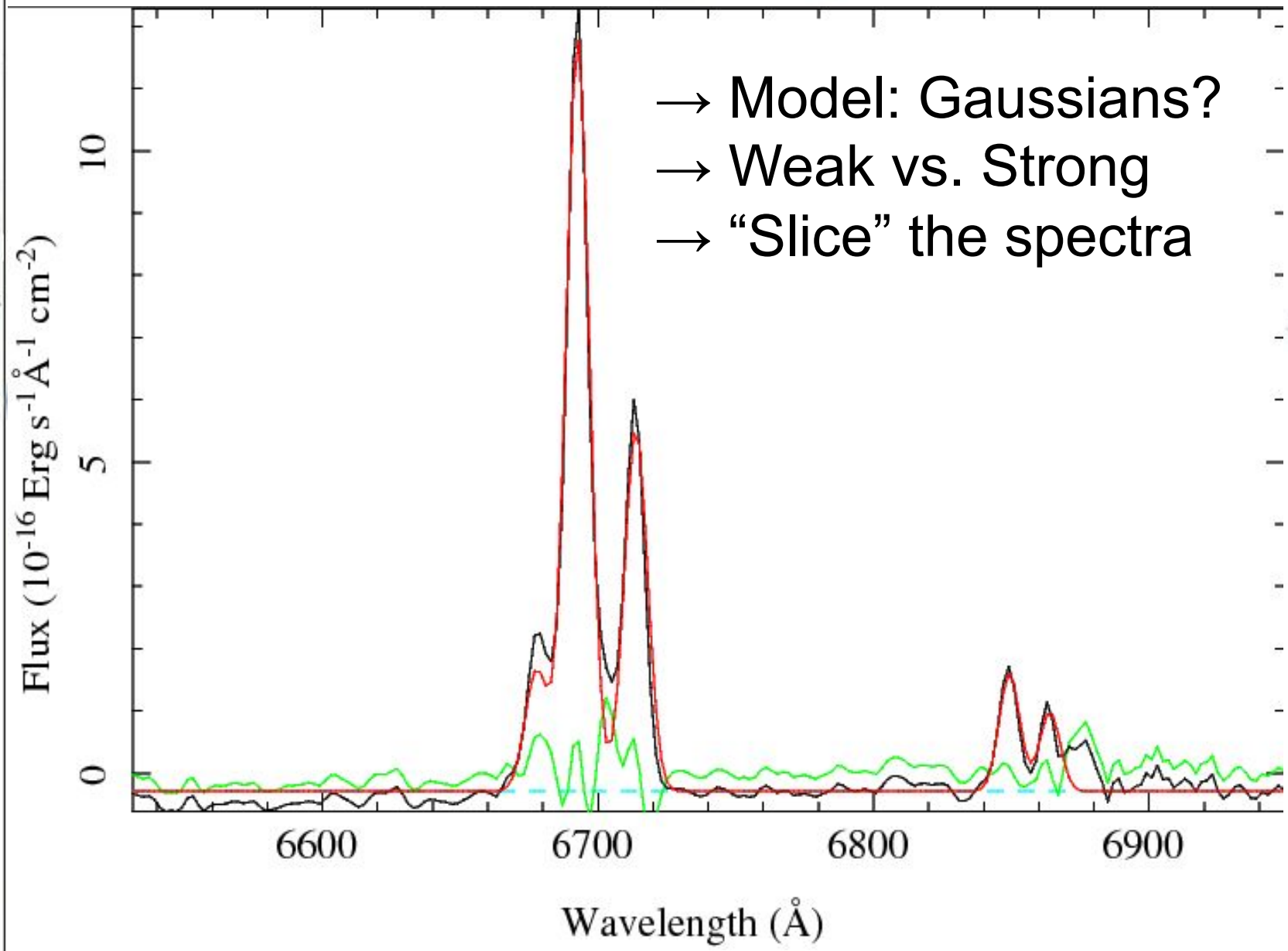






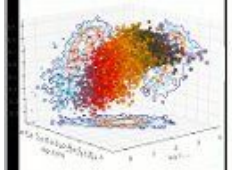


Pipe3D: fitting e-lines

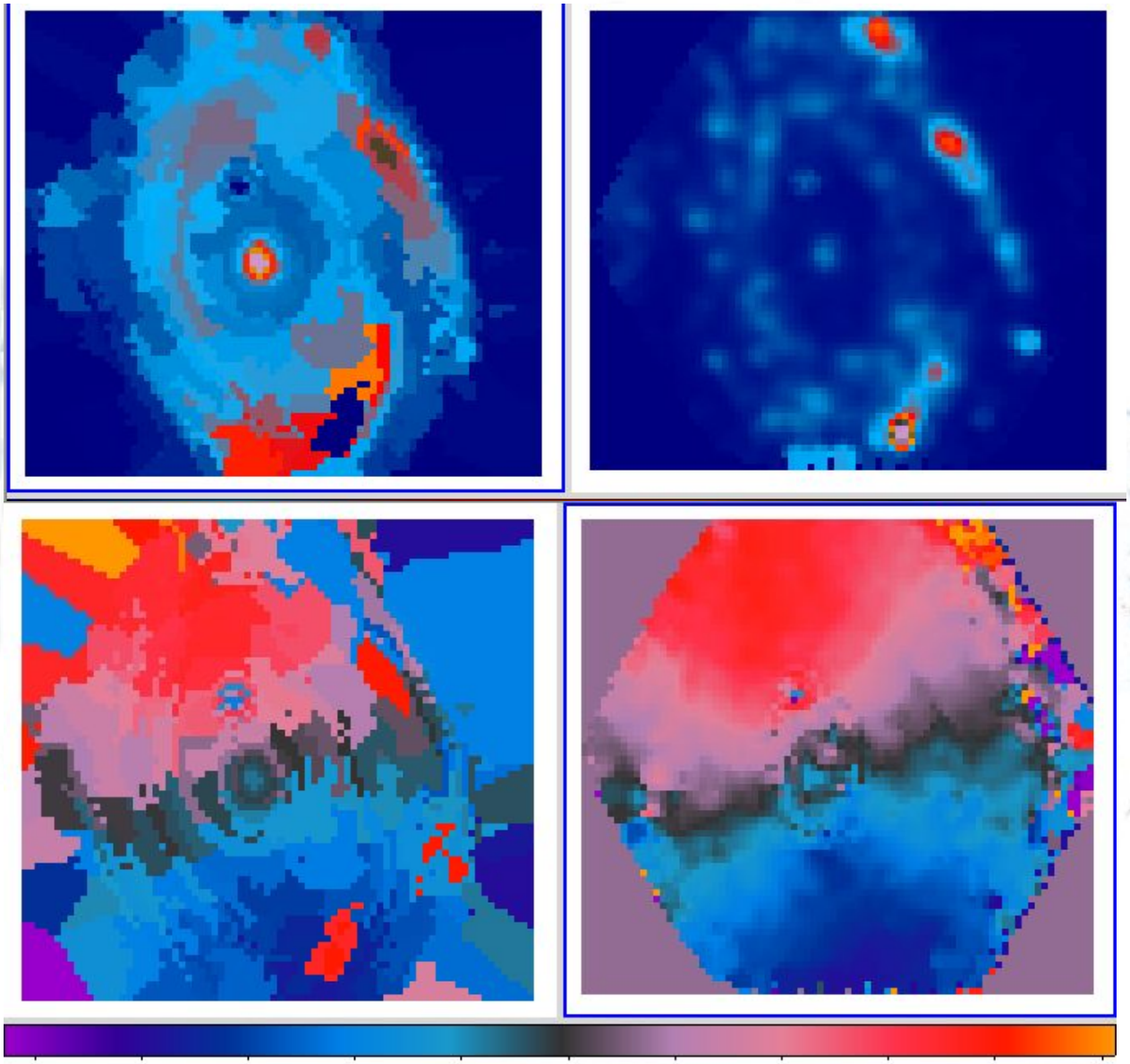


CALIFA Survey

instituto de astronomía
unam

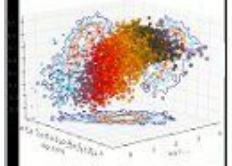


Emission lines: Binning effects

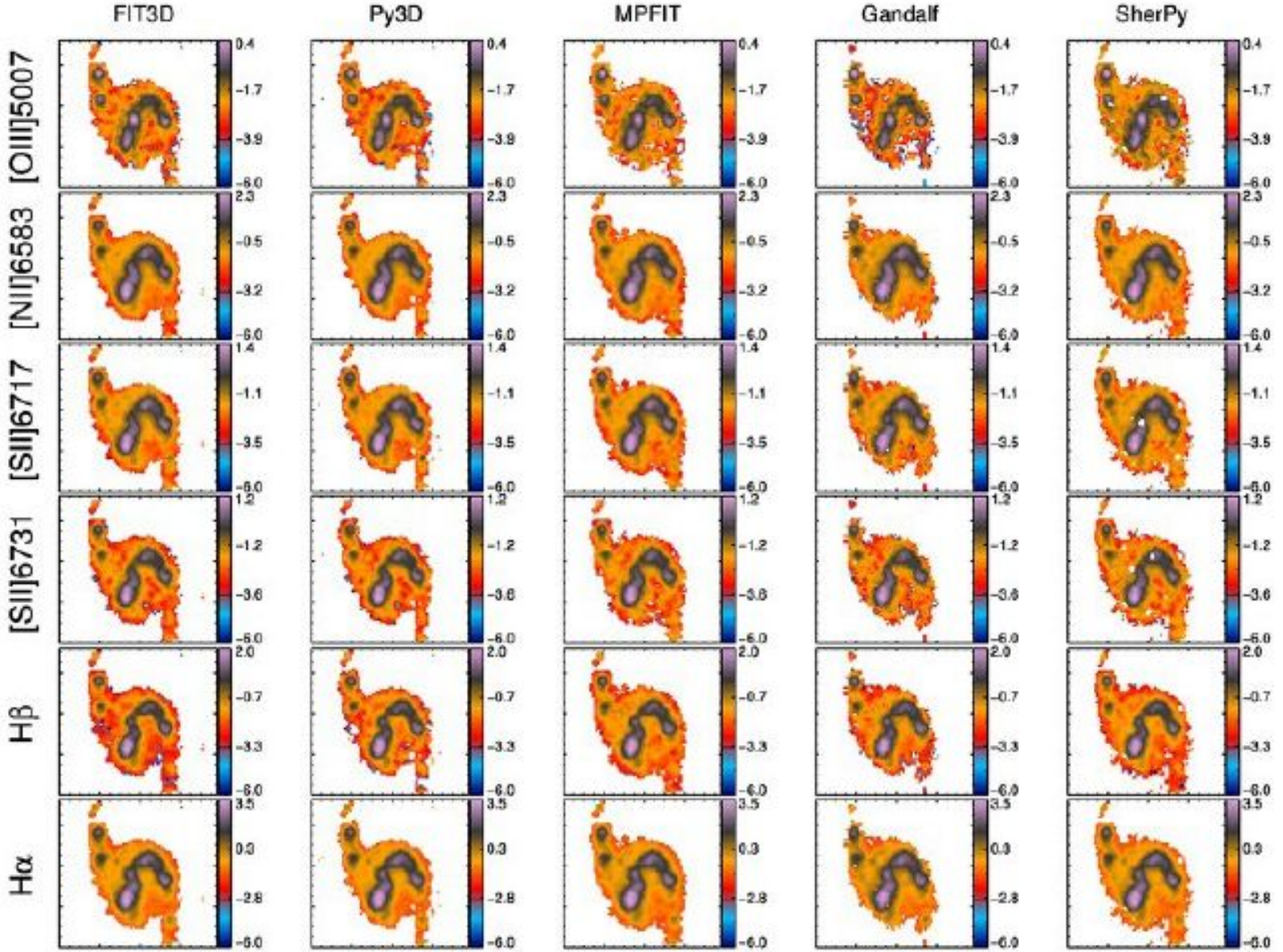


CALIFA Survey

instituto de astronomía
unam



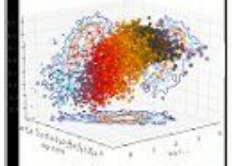
As many methods as possible!



Credits: J.Sebastian

CALIFA Survey

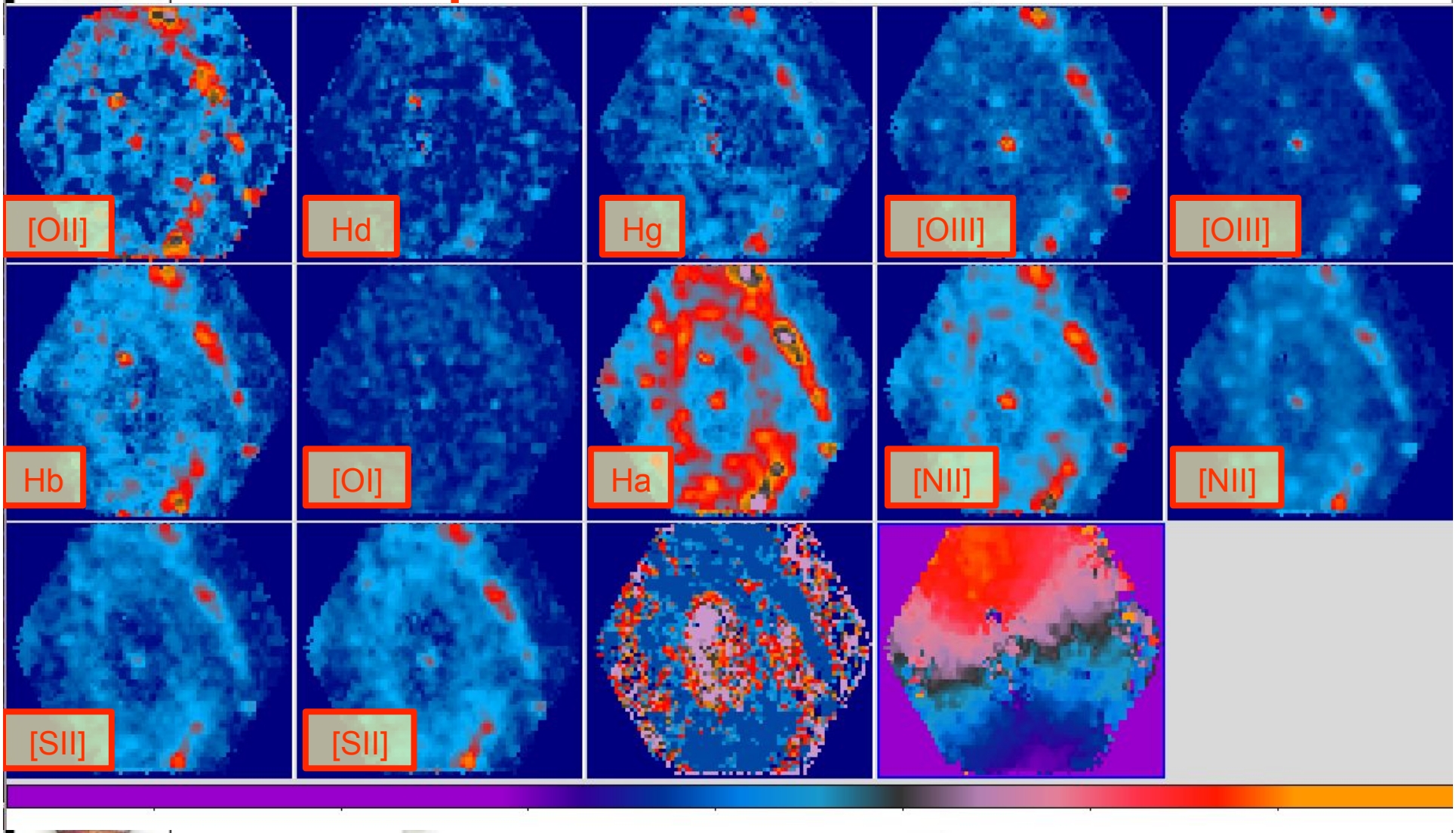
instituto de astronomía
unam



Pipe3D: Sequence (II)

- Halpha velocity map extracted from the GAS-pure datacube: Kin Proxy.
- Gaussian fitting for the required emission lines on the GAS-pure:
  - Emission line intensity maps.
  - Emission line velocity maps.
  - Emission line dispersion maps.
- HII-regions analysis.
  - Halpha-segmentation: HII-RSS.
  - Analysis of the HII-RSS: SFH, indices, emission line properties.

Pipe3D: Gas Results

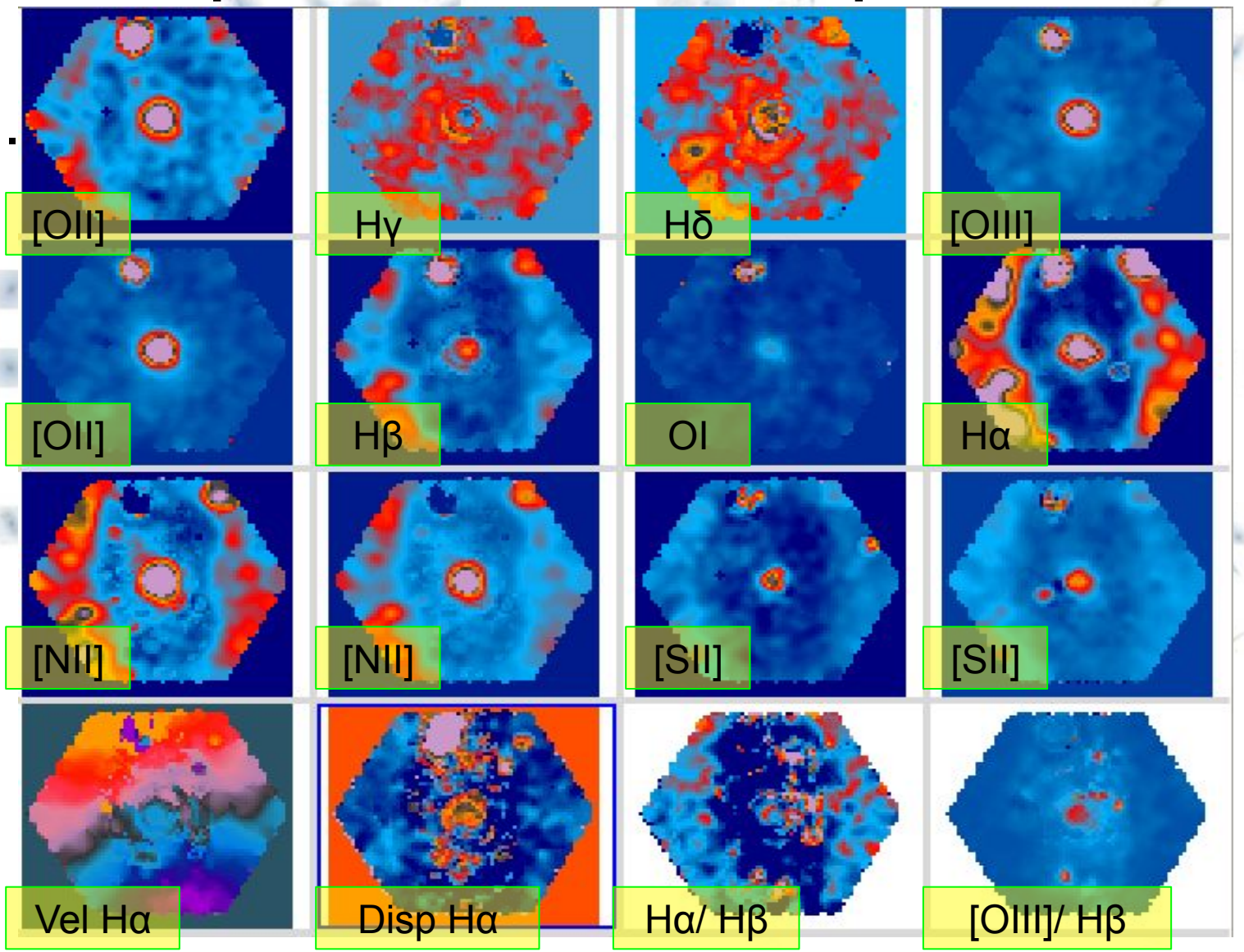


Ionized Gas: Multiple emission lines intensity maps, velocity and velocity dispersion.

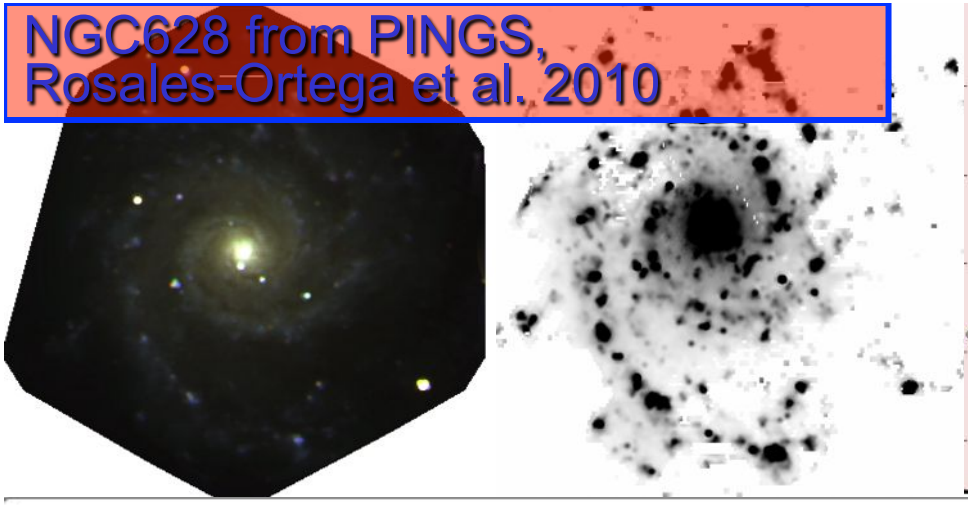
CALIFA Survey

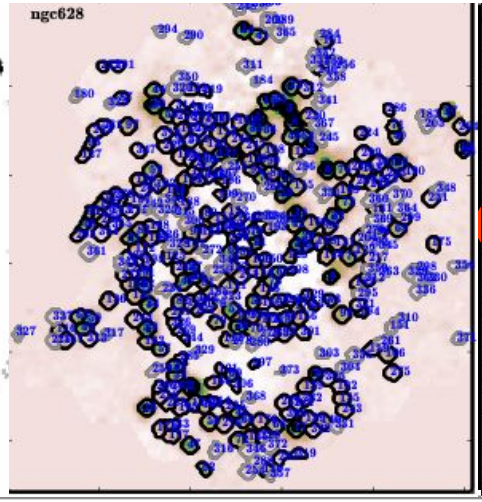
instituto de astronomía
unam

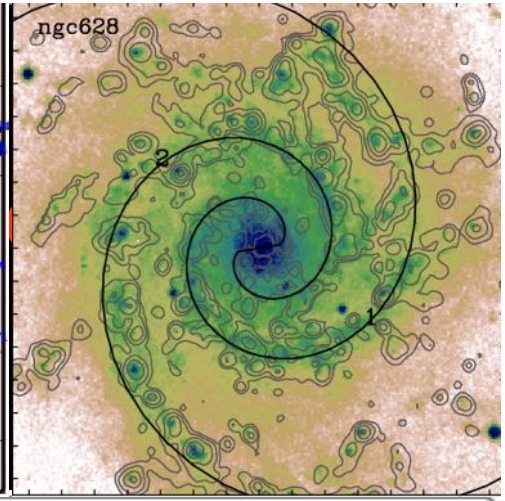
Pipe3D: Gas data-products

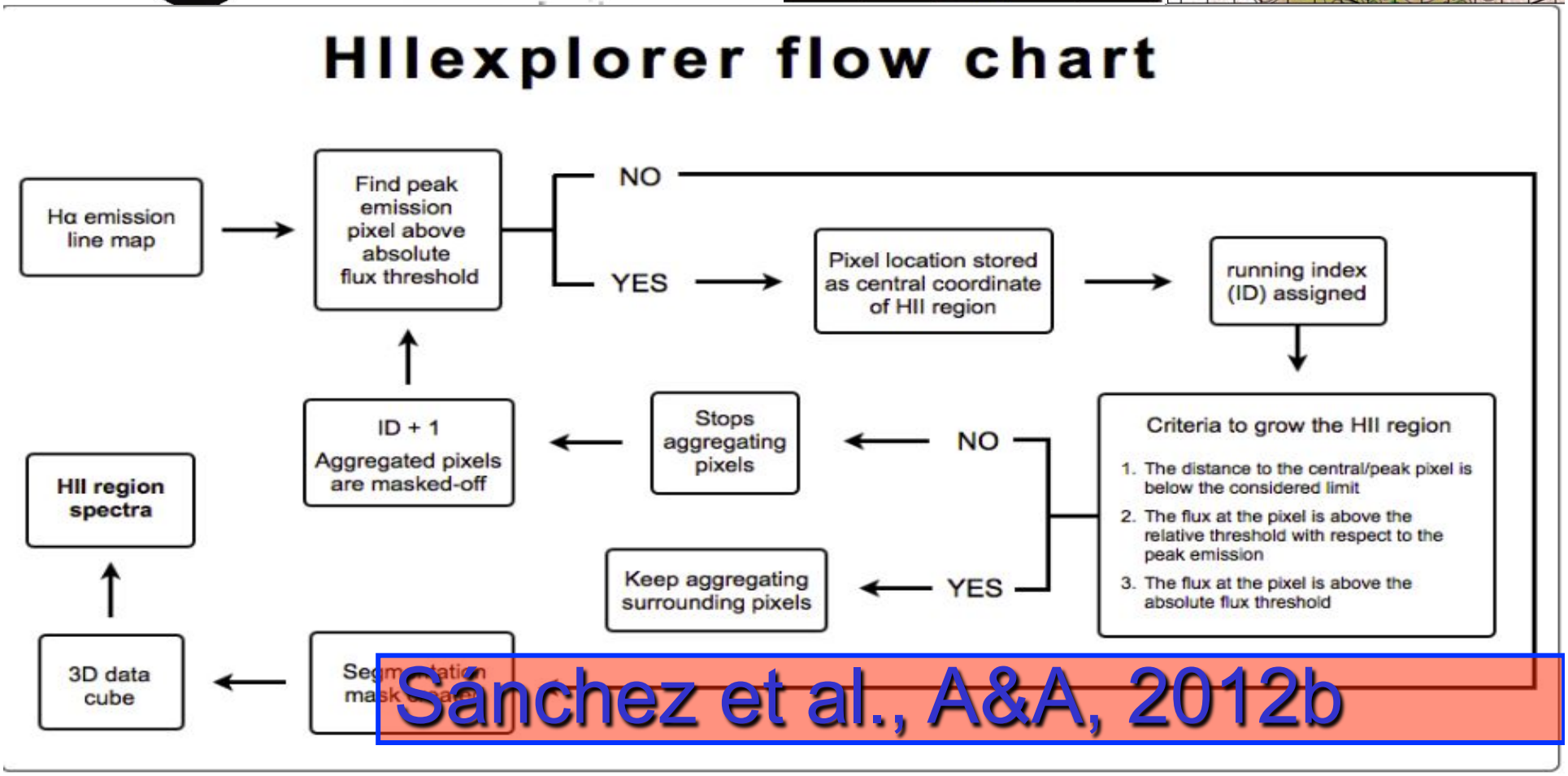


NGC628 from PINGS, Rosales-Ortega et al. 2010





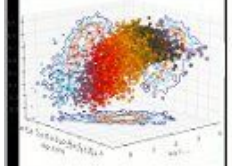




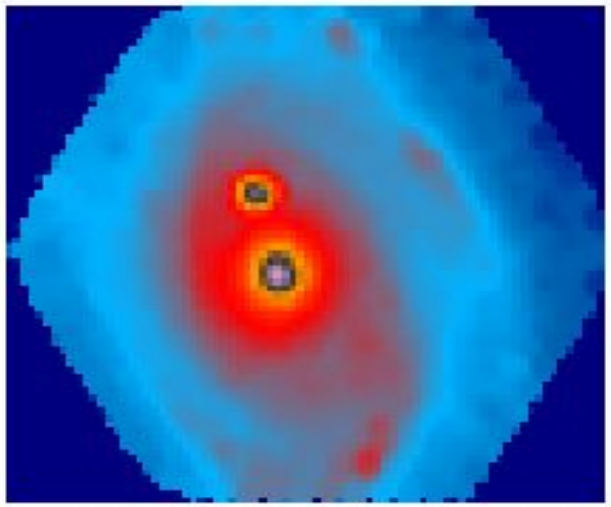
Sánchez et al., A&A, 2012b

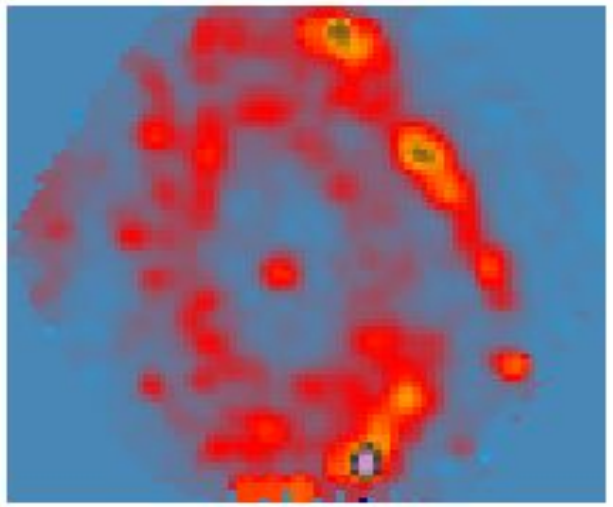
CALIFA Survey

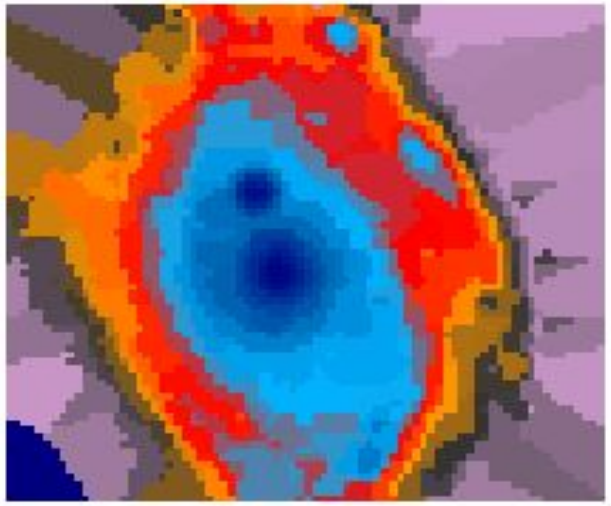
instituto de astronomía
unam

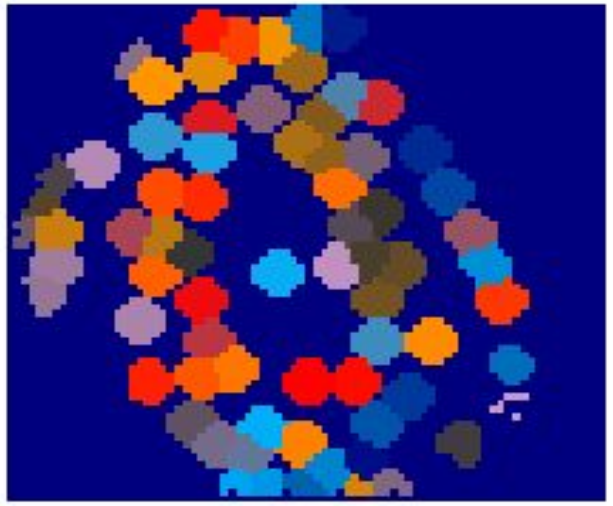


Pipe3D: Sequence (I)





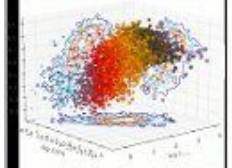




Different Binning schemes!

CALIFA Survey

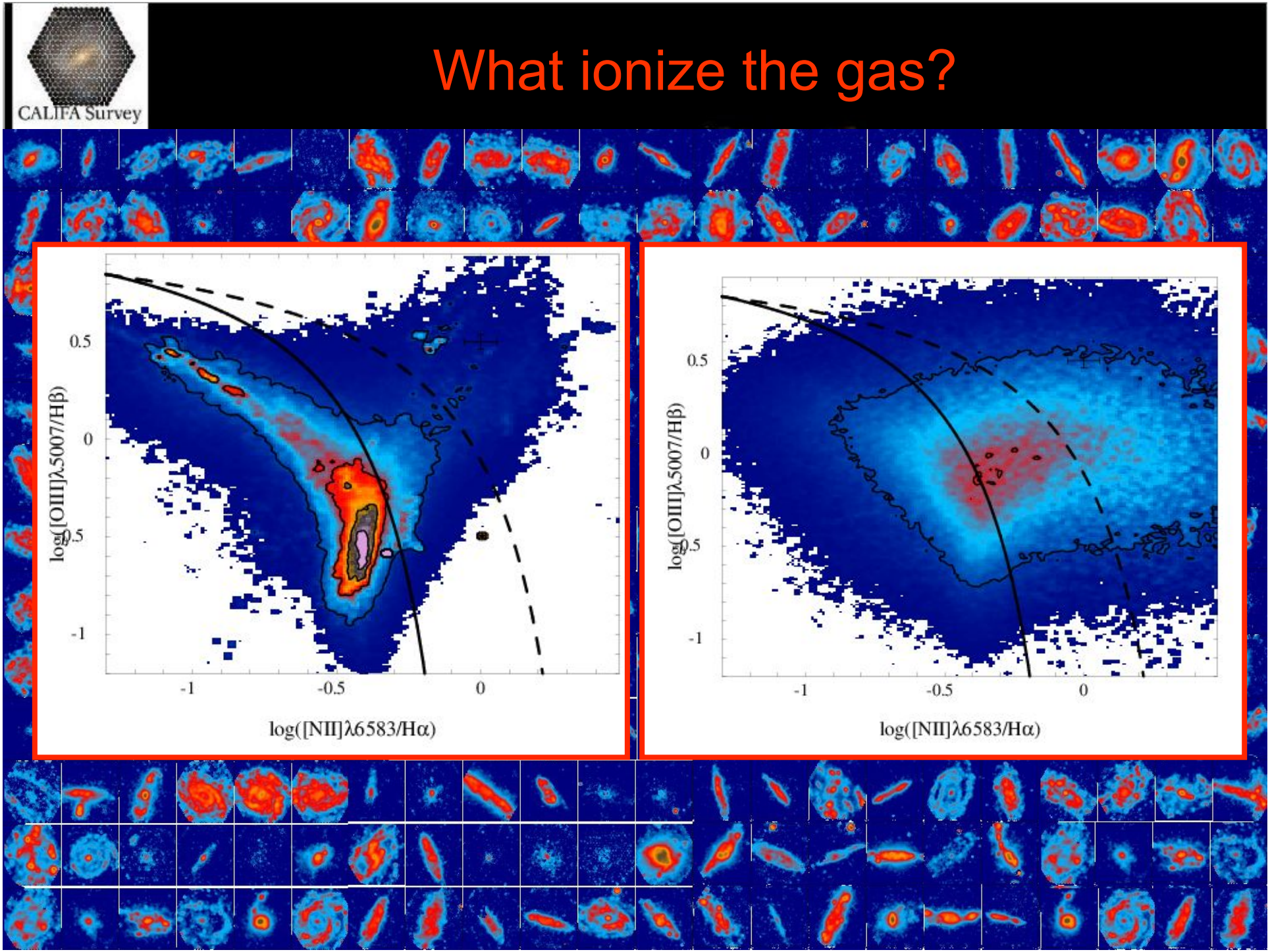
instituto de astronomía
unam



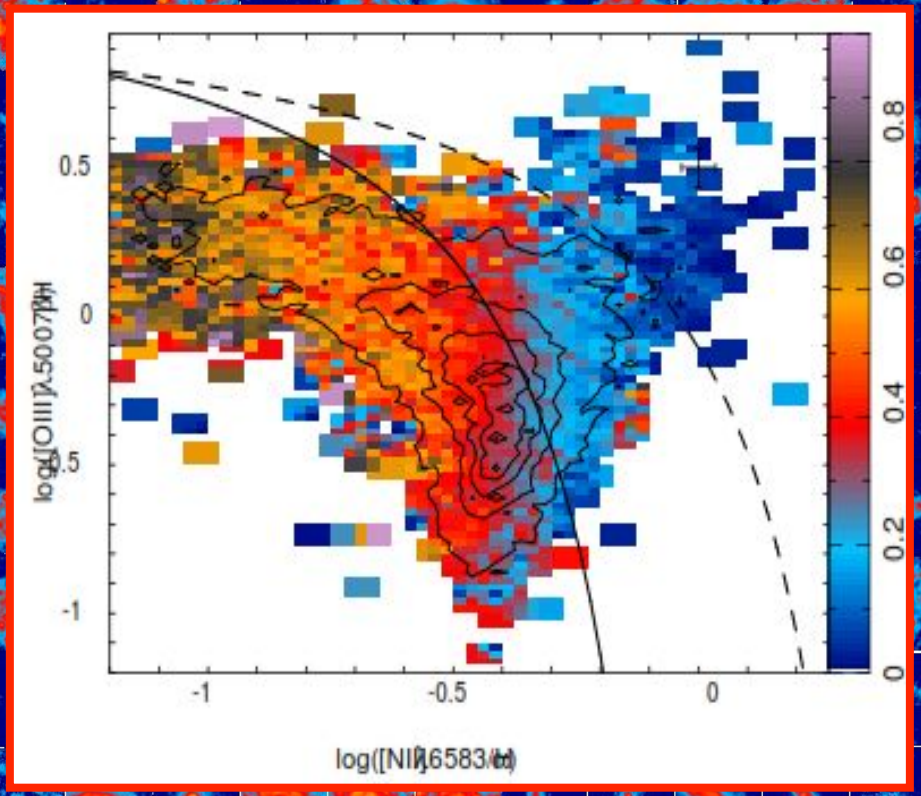
Interpreting the line ratios

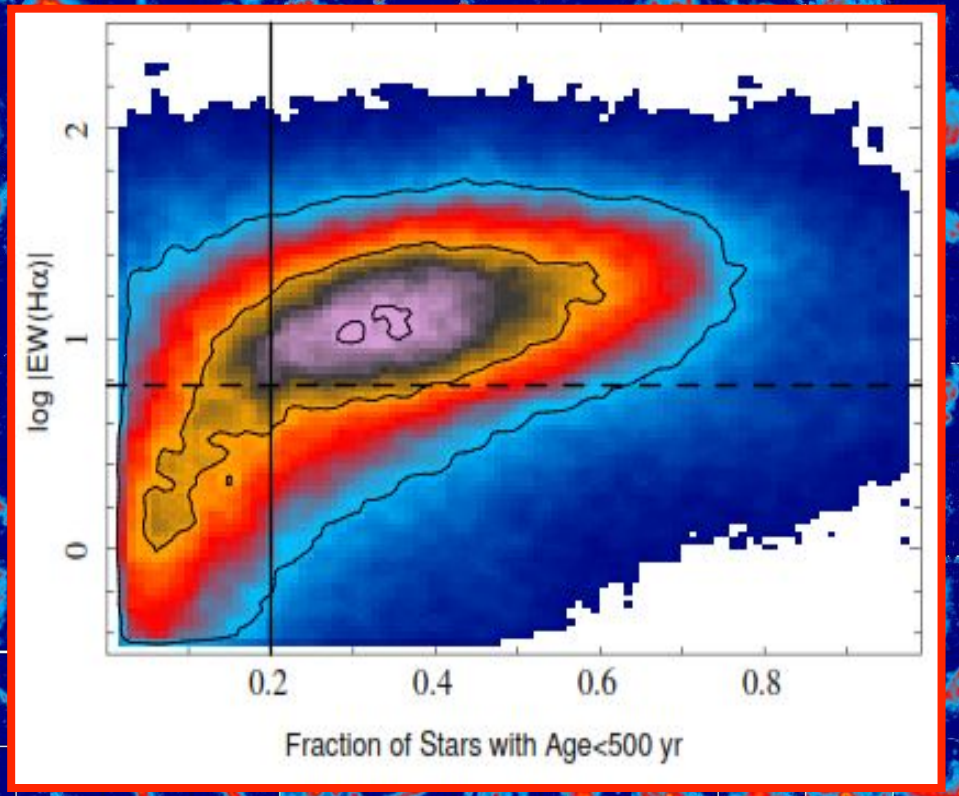
- Ha/Hb (Hb/Hd) → Dust attenuation.
- Correct by Dust attenuation.
- Diagnostic Diagrams to guess what ionize the gas.
- [SII] doublet line to get the electron density.
- Ha_corr → Spatial Resolved SFR
- O3N2, N2, R23, N2O2 → Metal abundances distributions (for SFR regions only!).
- Compare with velocity → Outflows.

What ionize the gas?



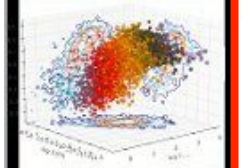
What ionize the gas?



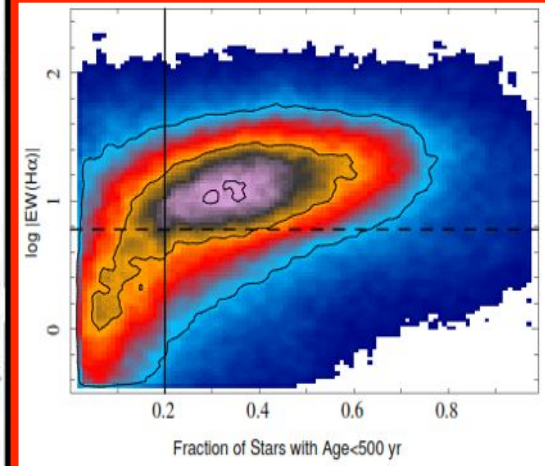


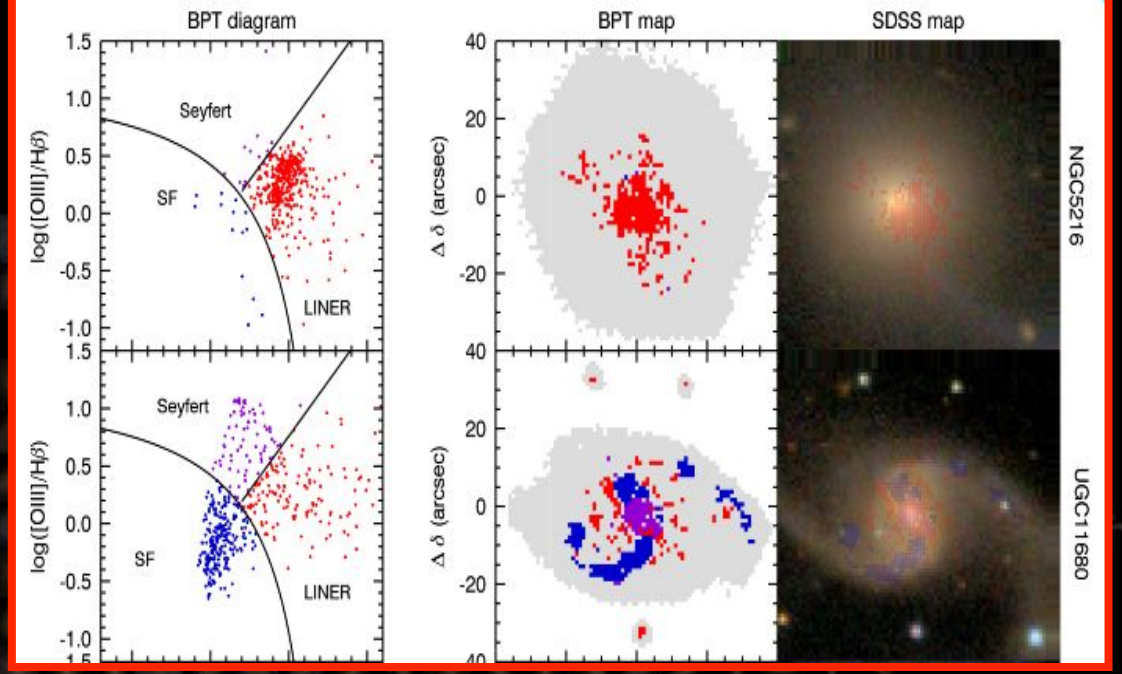
CALIFA Survey

instituto de astronomía
unam

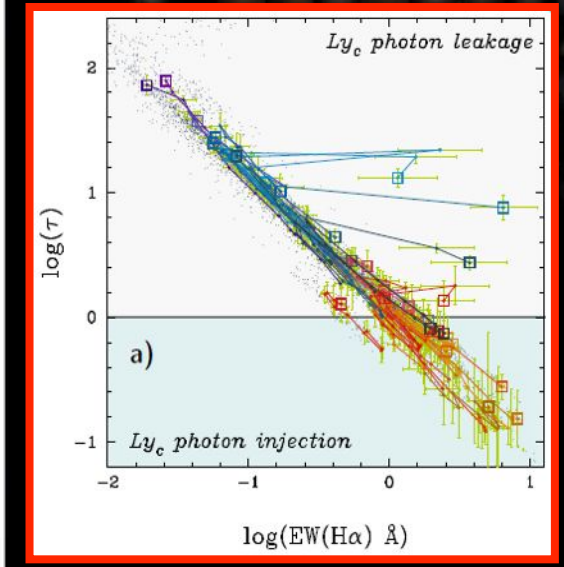


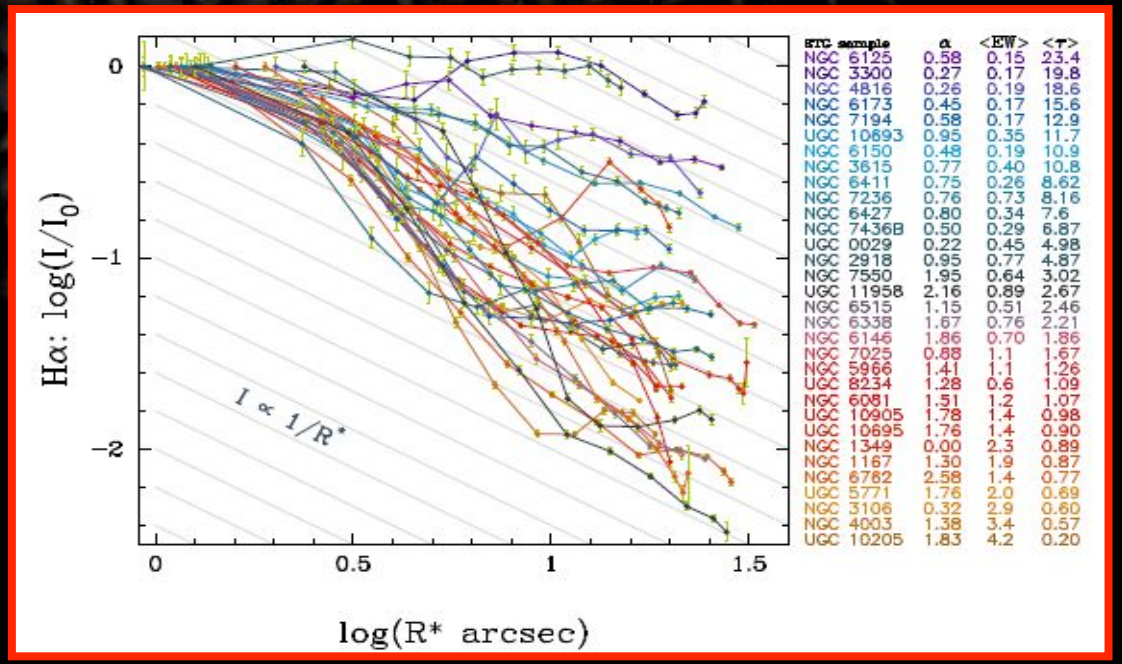
Singh et al., A&A, 2013



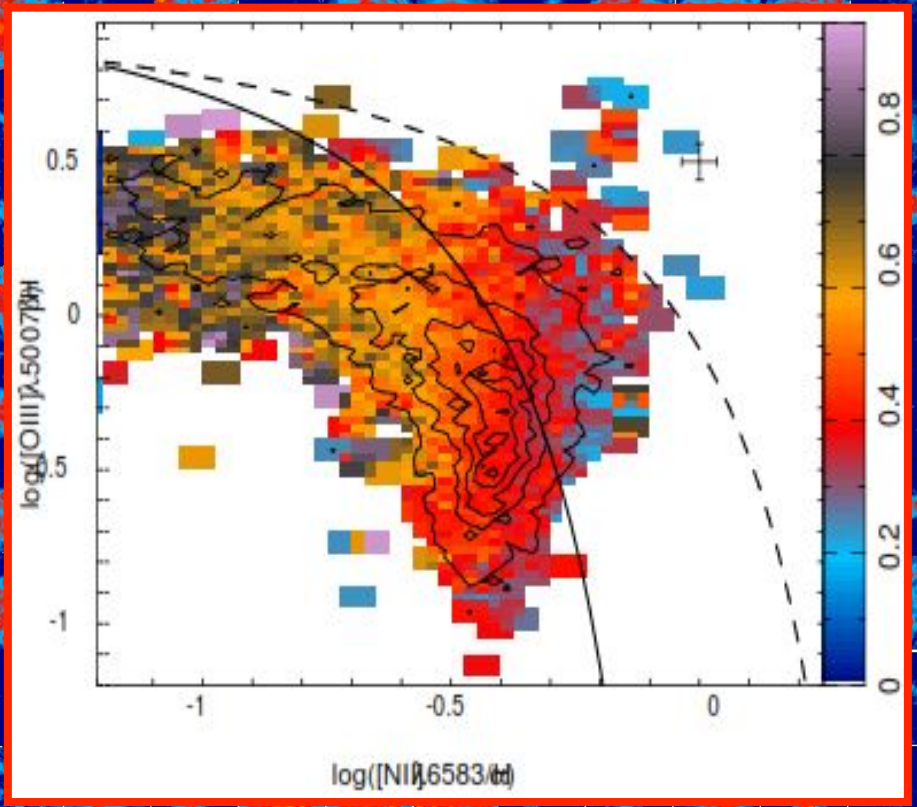


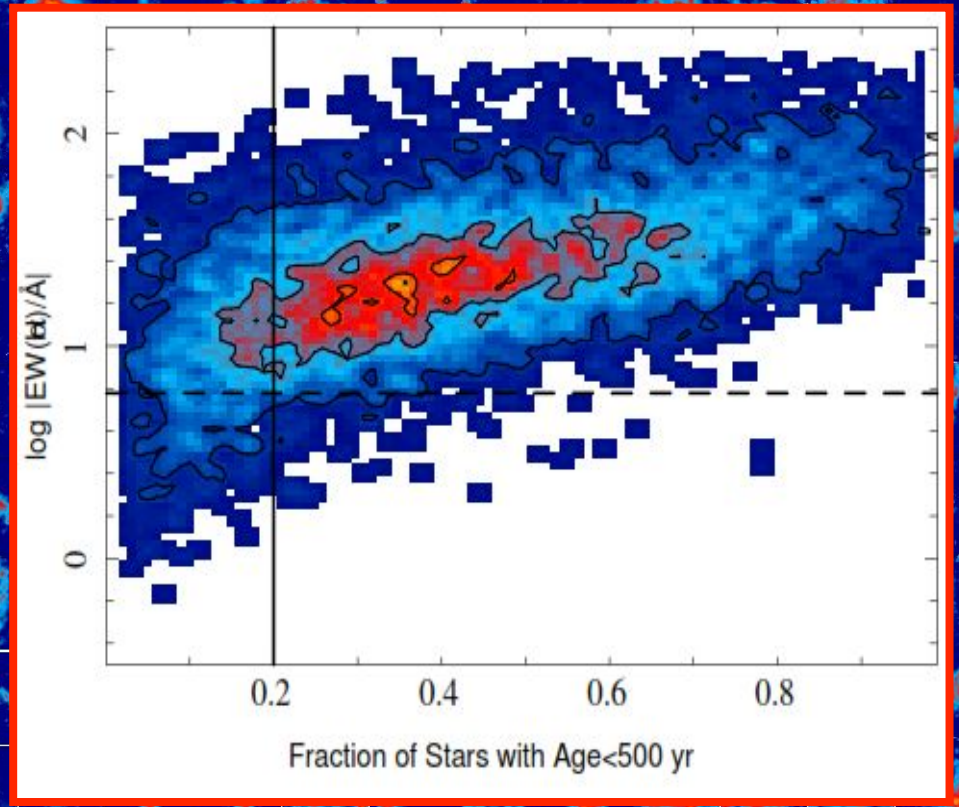
Paparedos et al, A&A, 2013



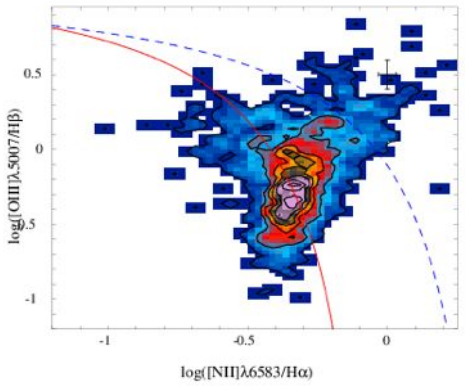


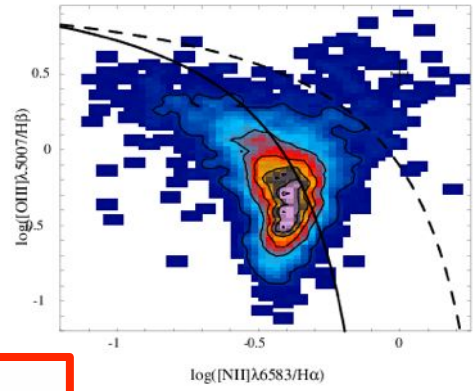
~6500 regions, with CALIFA

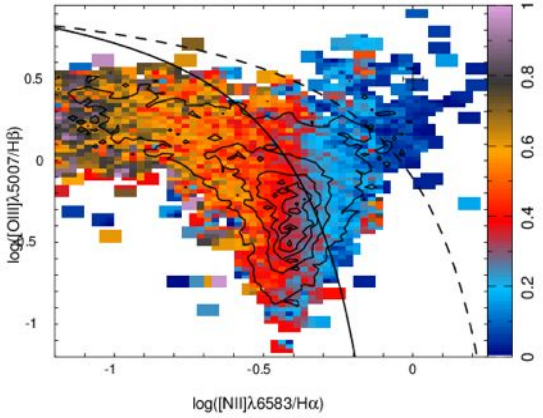


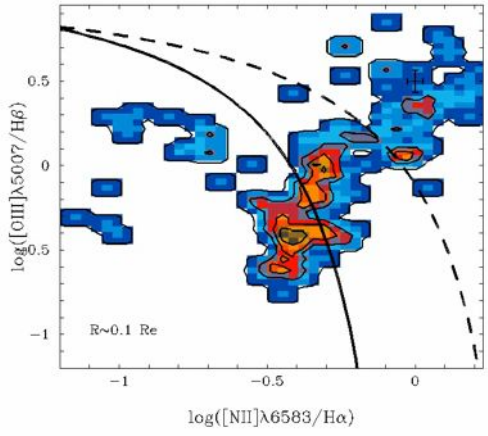


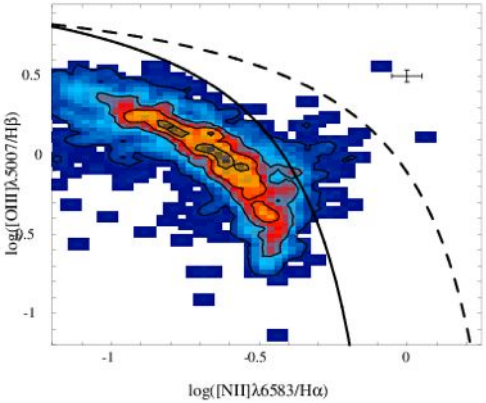
Do HII regions have memory of SFH?



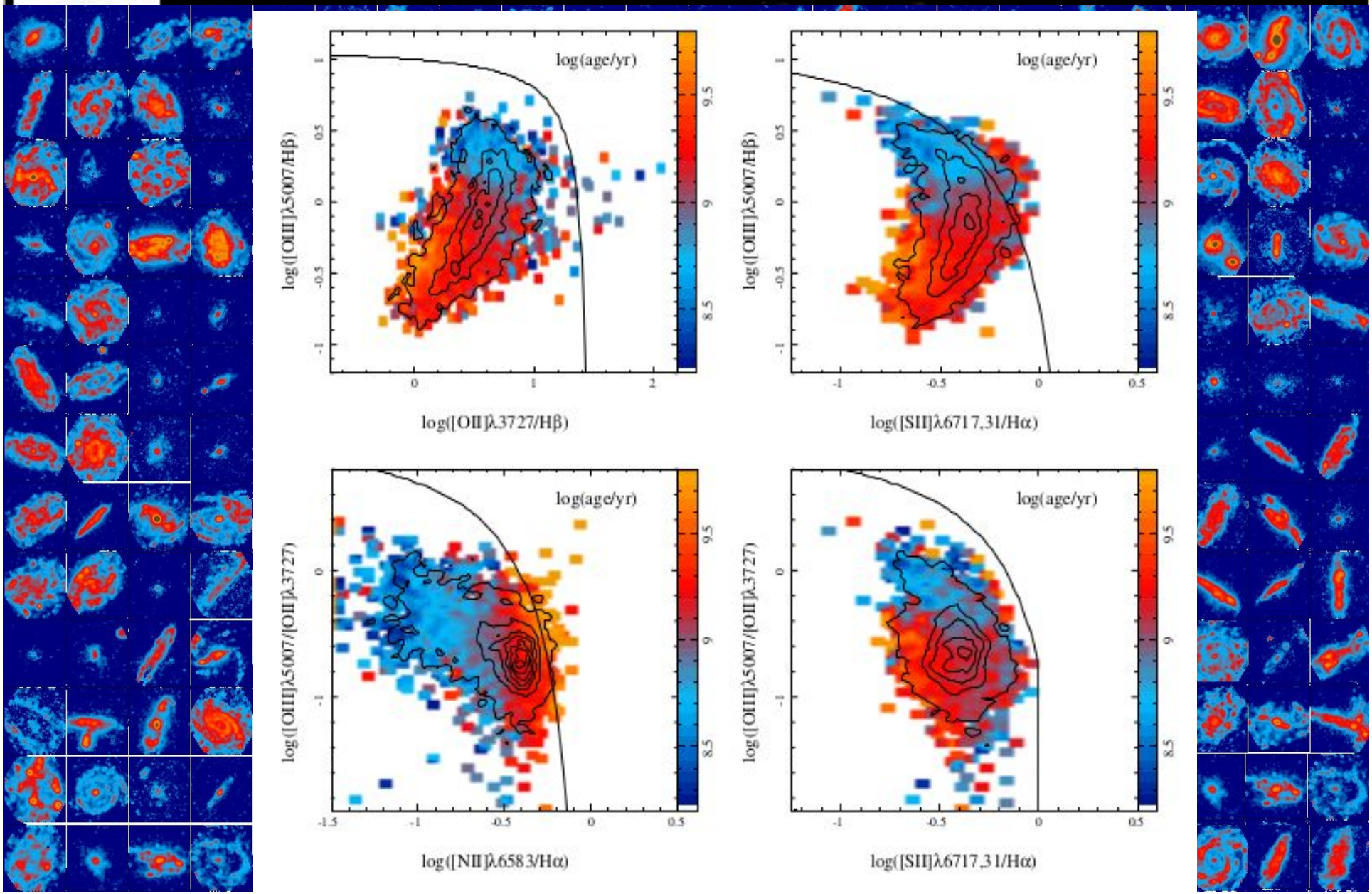




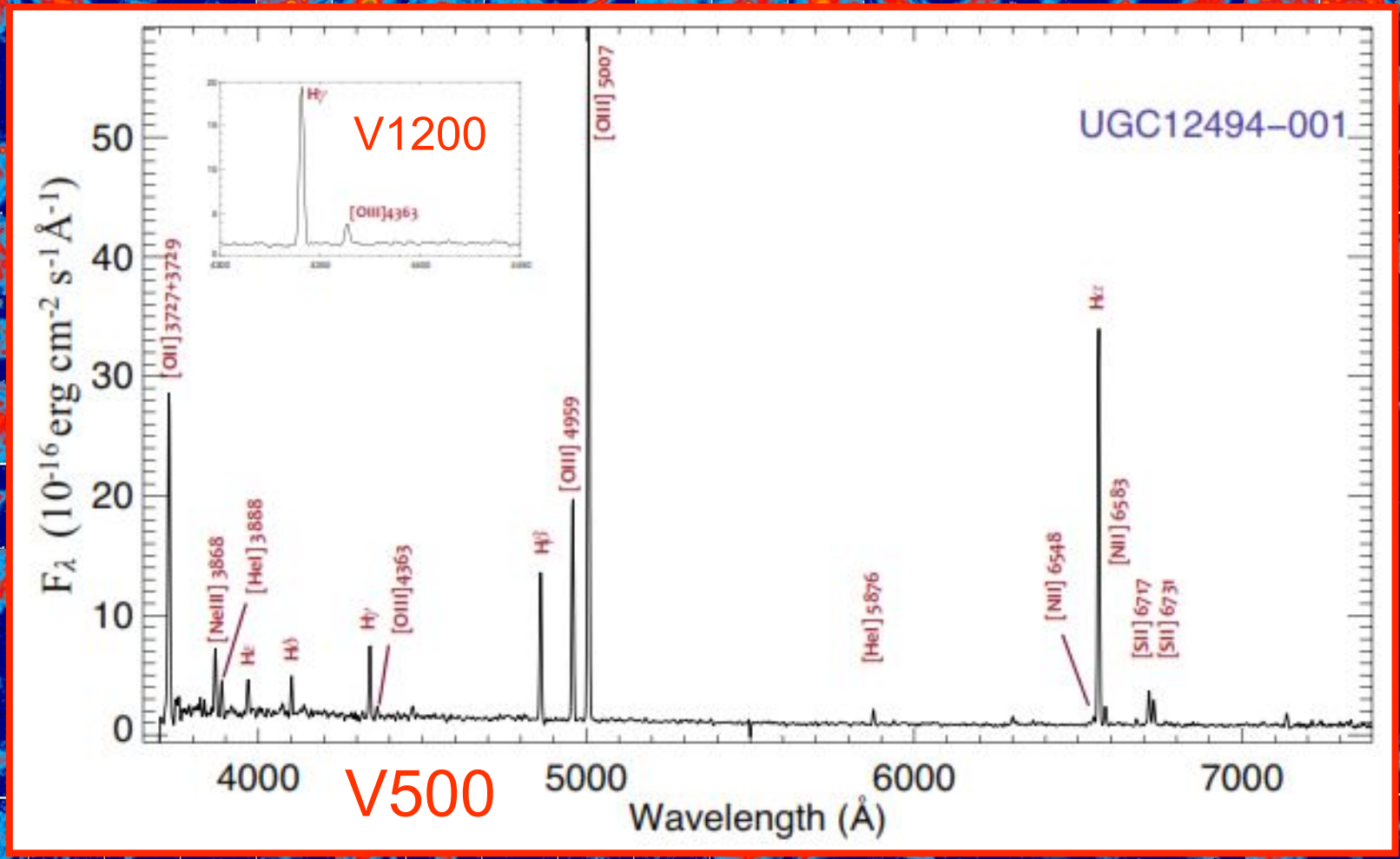




Other Diagnostic Diagrams

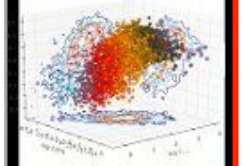


~6500 regions, with CALIFA

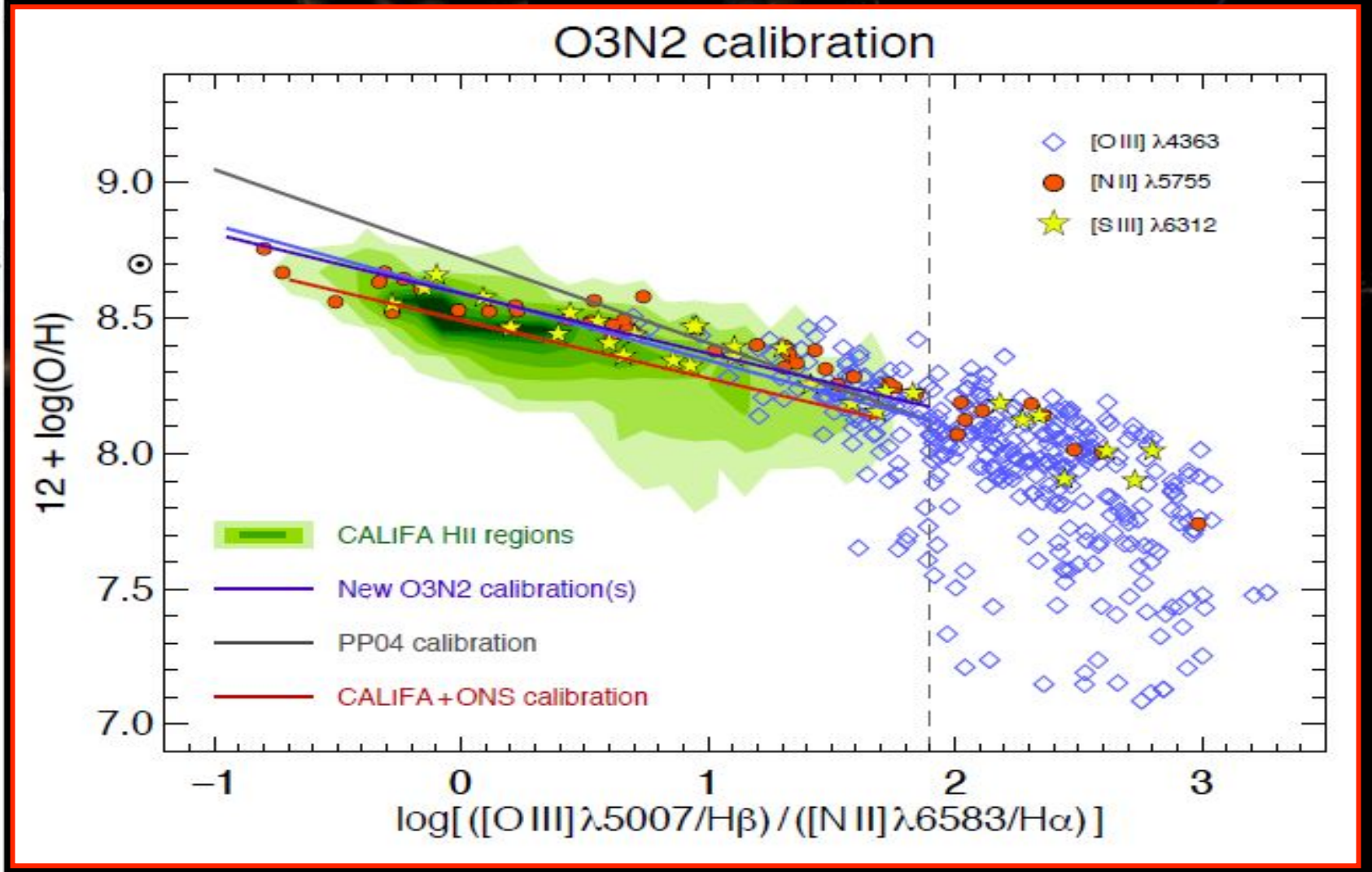


CALIFA Survey

instituto de astronomía
unam

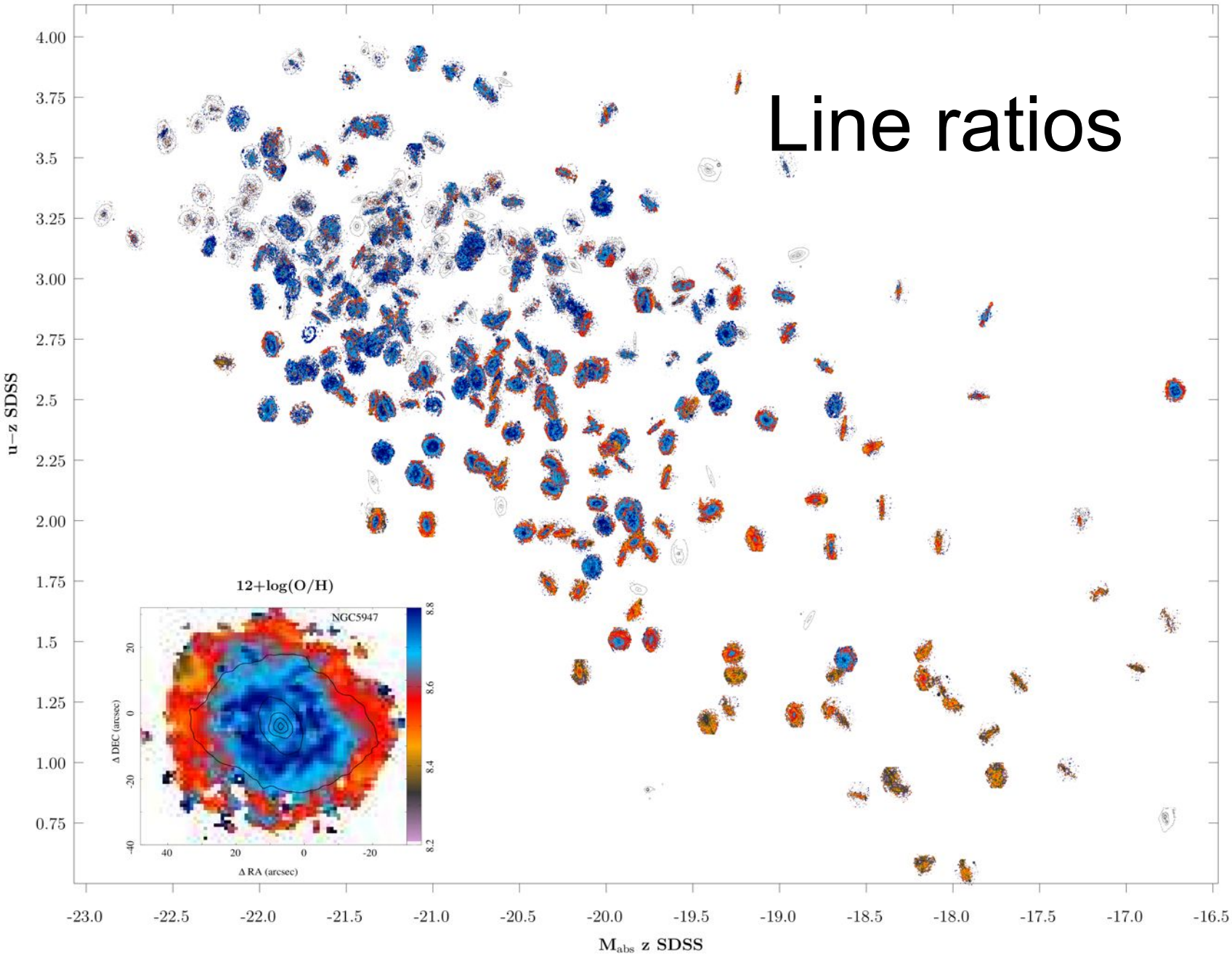


Improved O/H calibrators



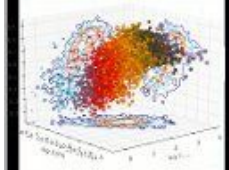
Marino et al., subm.

Line ratios

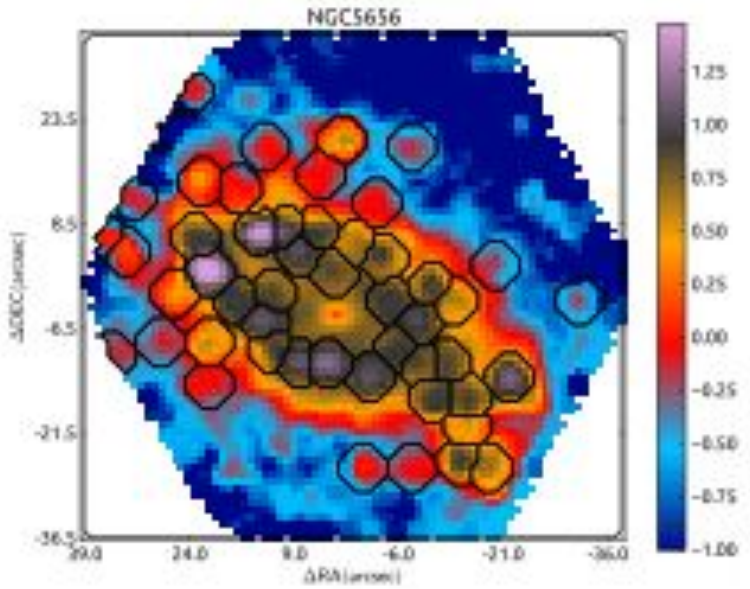

u−z SDSS
4.00
3.75
3.5
3.25
3.00
2.75
2.5
2.25
2.00
1.75
1.5
1.25
1.00
0.75
-23.0
-22.5
-22.0
-21.5
-21.0
-20.5
-20.0
-19.5
-19.0
-18.5
-18.0
-17.5
-17.0
-16.5
M_abs z SDSS
12+log(O/H)
NGC5947
Δ DEC (arcsec)
Δ RA (arcsec)
8.8
8.6
8.4
8.2

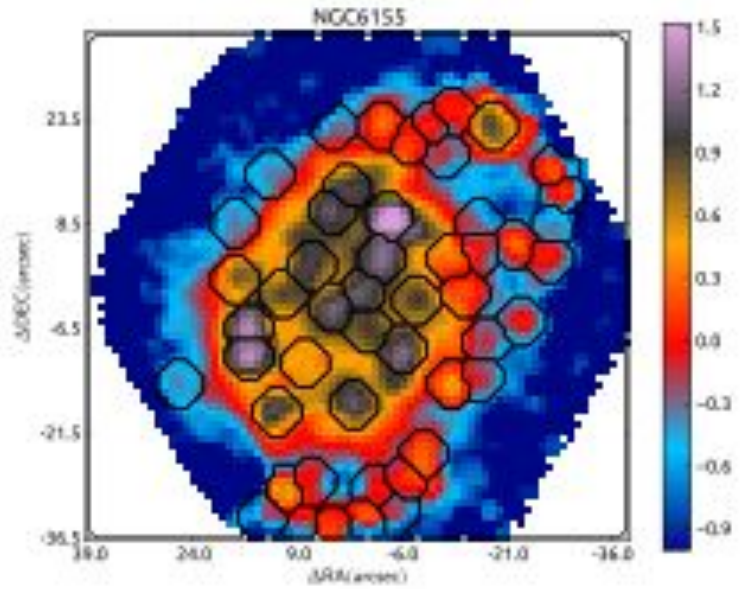
CALIFA Survey

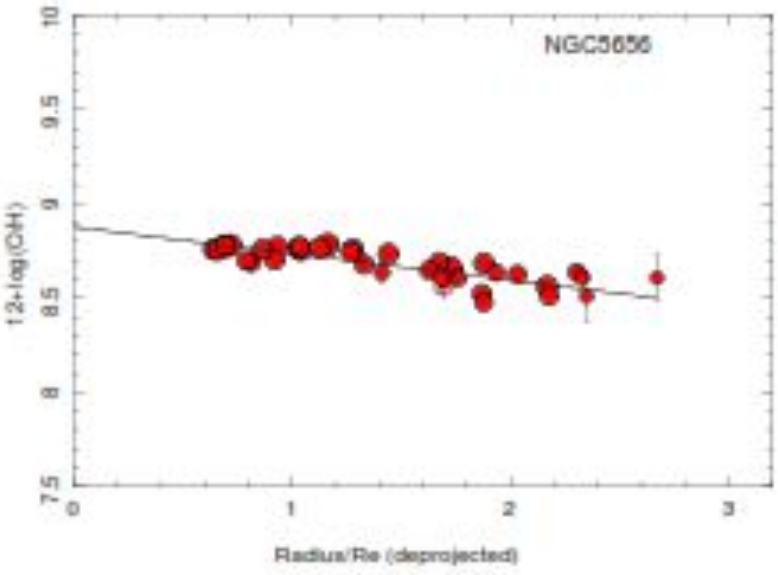
instituto de astronomía
unam

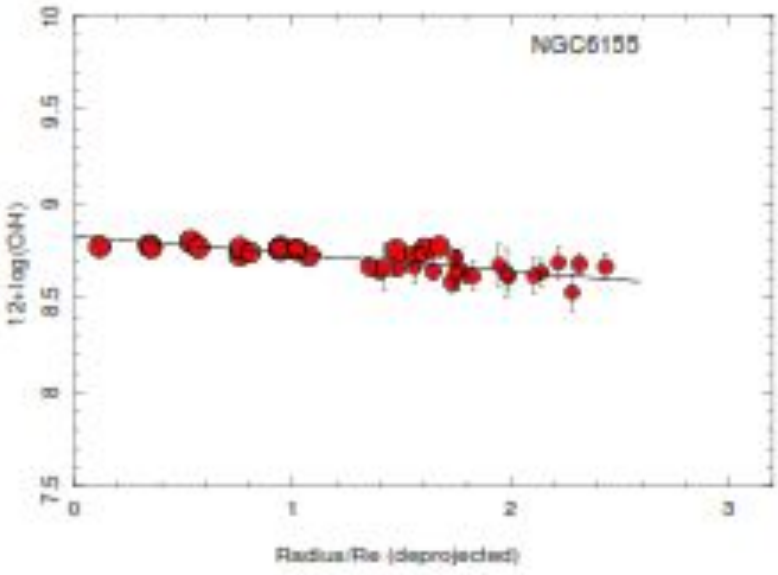


~6500 regions, with CALIFA







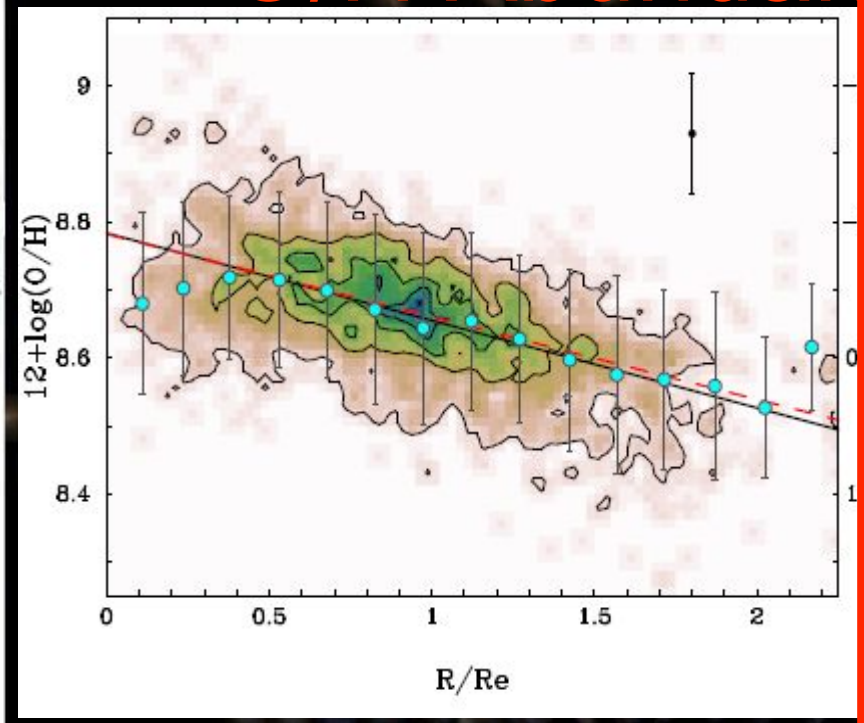


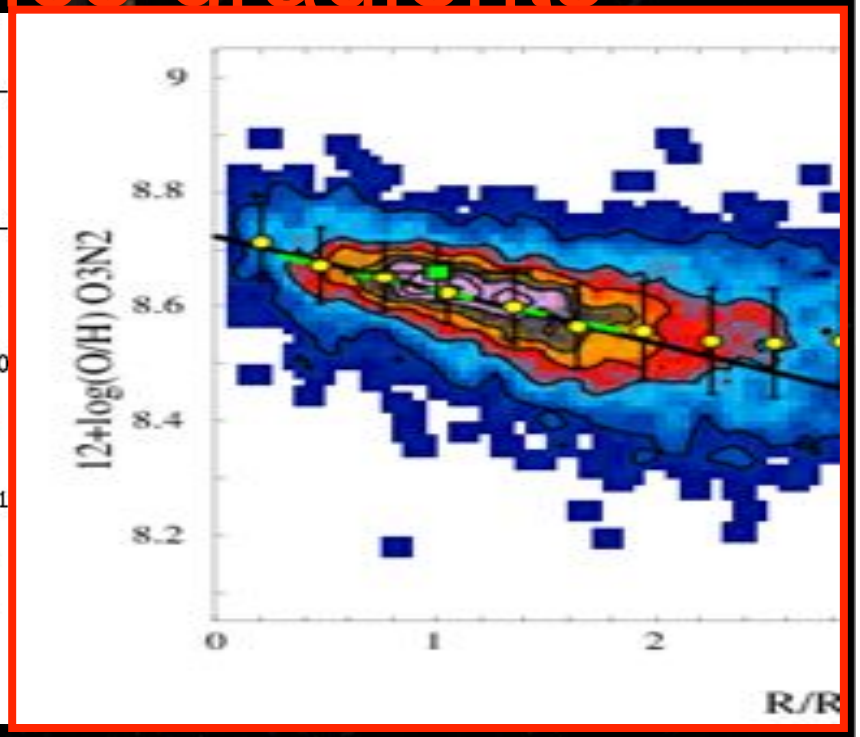
CALIFA Survey

instituto de astronomía
unam

Sánchez et al., A&A, 2012b

O/H Abundance gradients



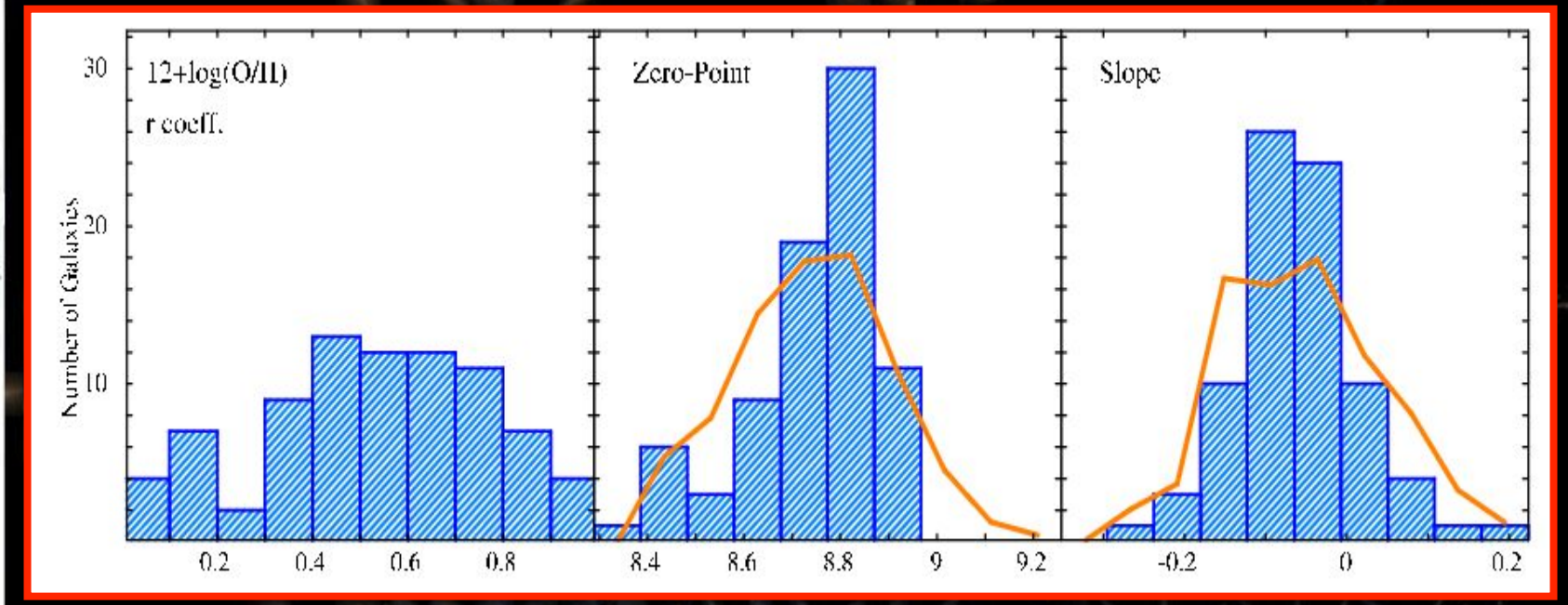


- All Abundance gradients are compatible with being a subsample of Gaussian distribution.
- Slope ~ -0.12+-0.10 dex/Reff.
- No significant difference found by galaxy types: Barred/unbarred, Grand-design/flocculent.

CALIFA Survey

instituto de astronomía
unam

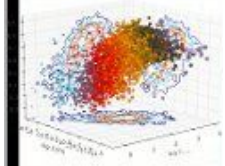
O/H Abundance gradients With CALIFA galaxies



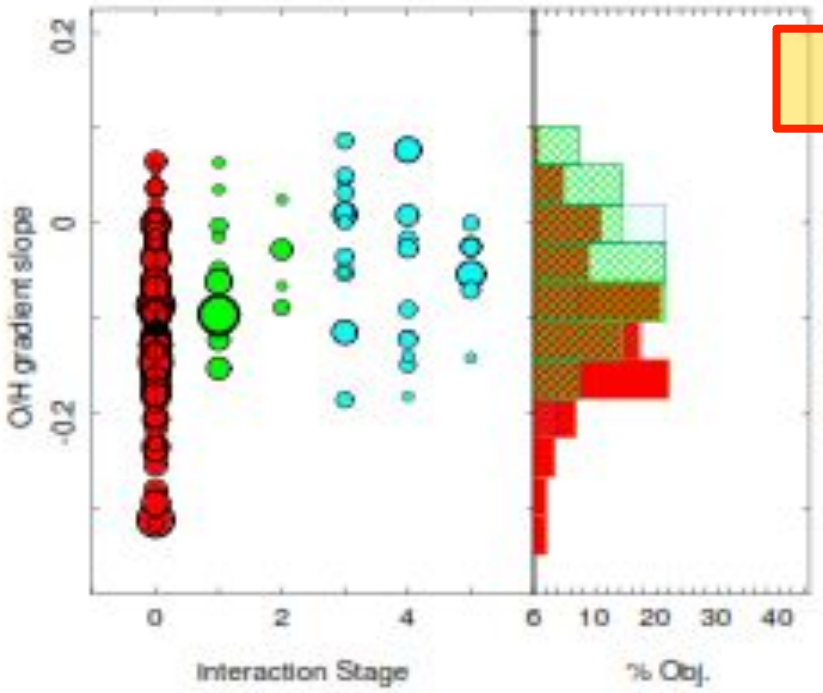
- Gradients determined at 0.3<R/Re<2.1.
- 207 galaxias, ~6500 regions.
- Gradients distribution compatibles with of single Gaussians.
- Slope ~ -0.11+-0.08 dex/Reff.

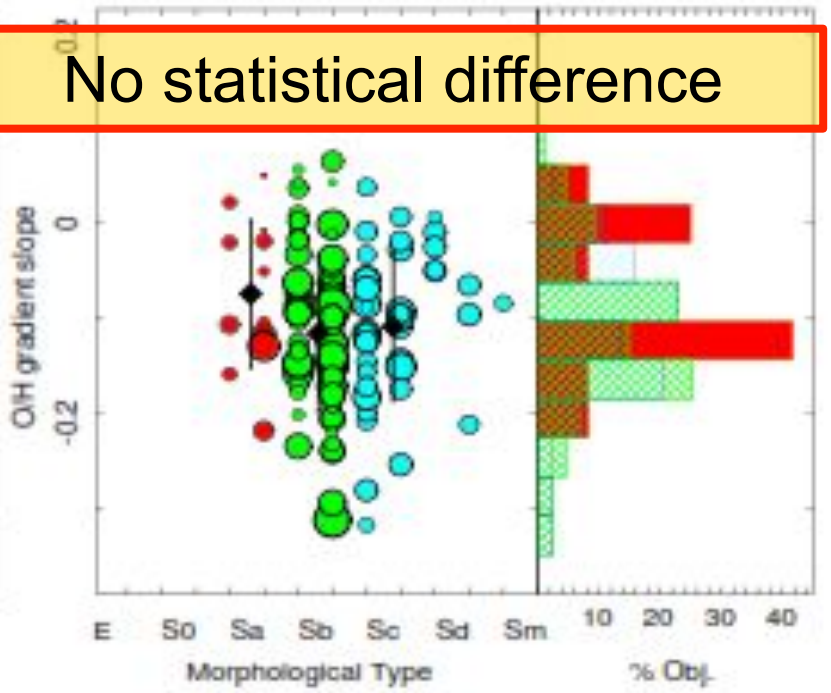
CALIFA Survey

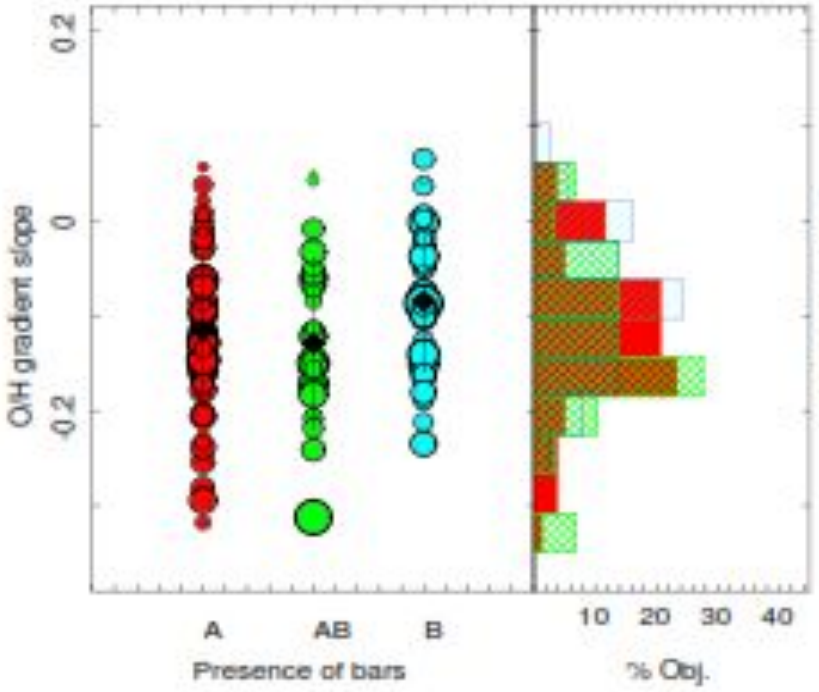
instituto de astronomía
unam

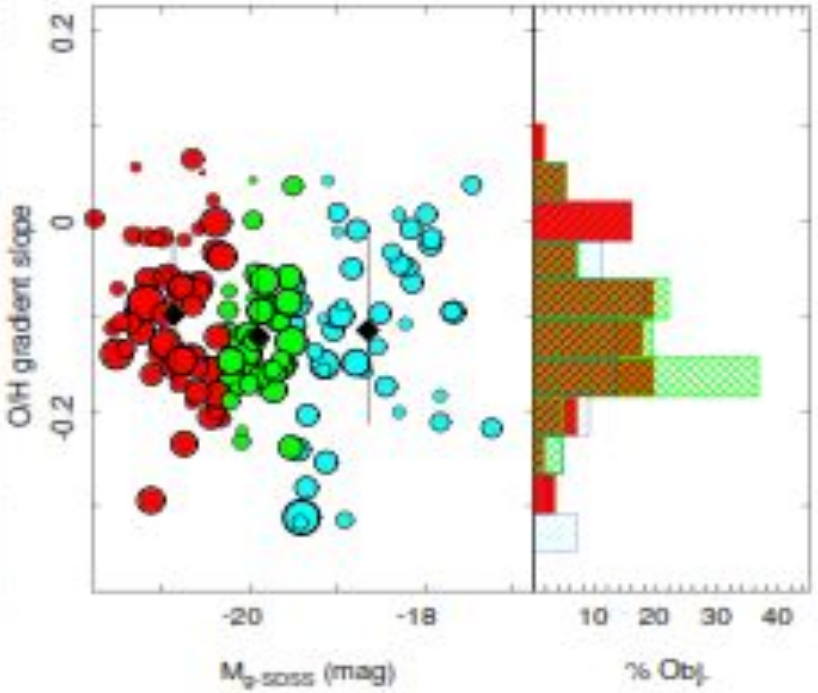


No statistical difference



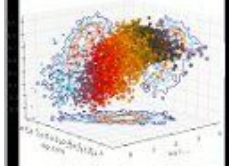




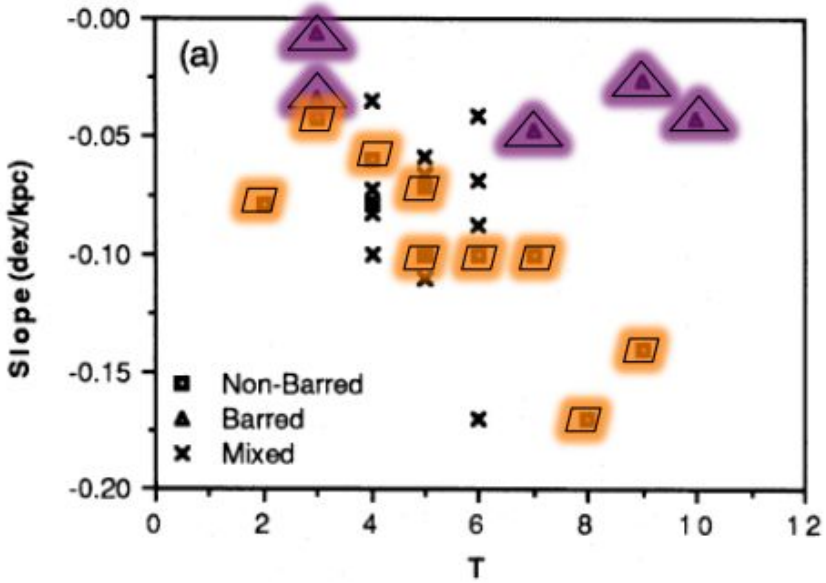


CALIFA Survey

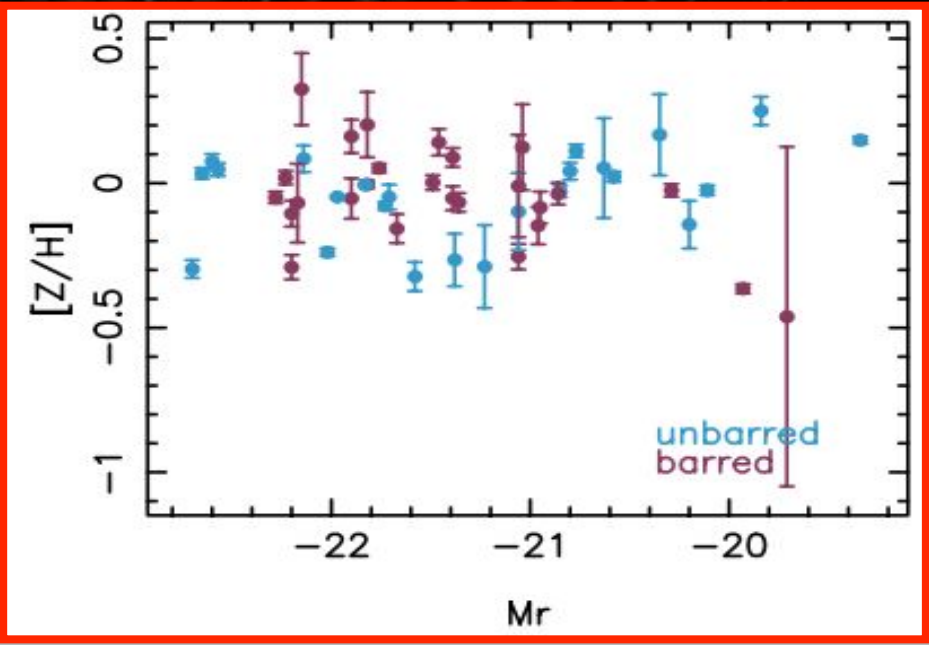
instituto de astronomía
unam



Zaritsky, Kennicutt & Huchra 1994

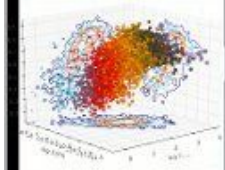


P. Sánchez-Blazquez et al., in prep.



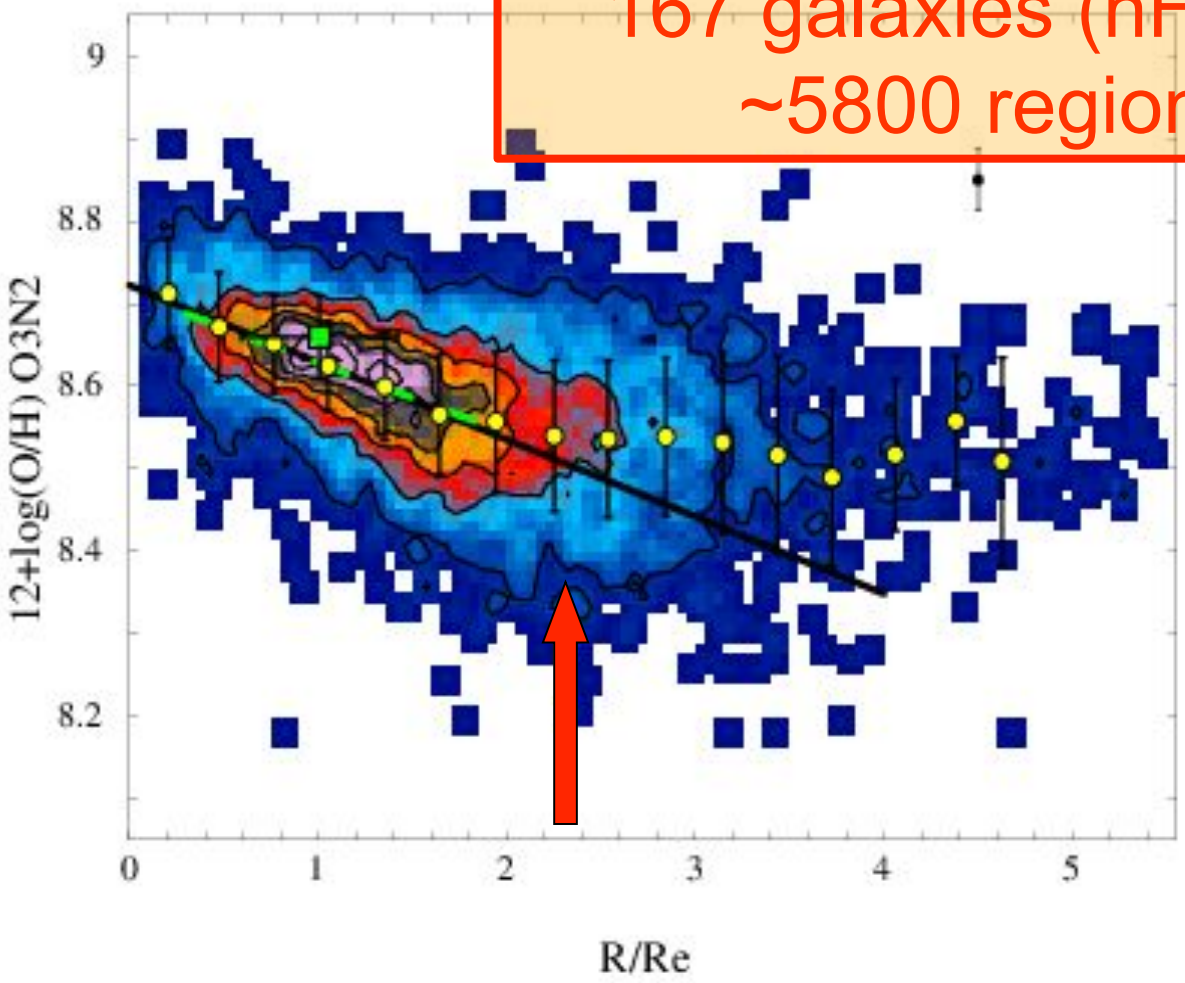
CALIFA Survey

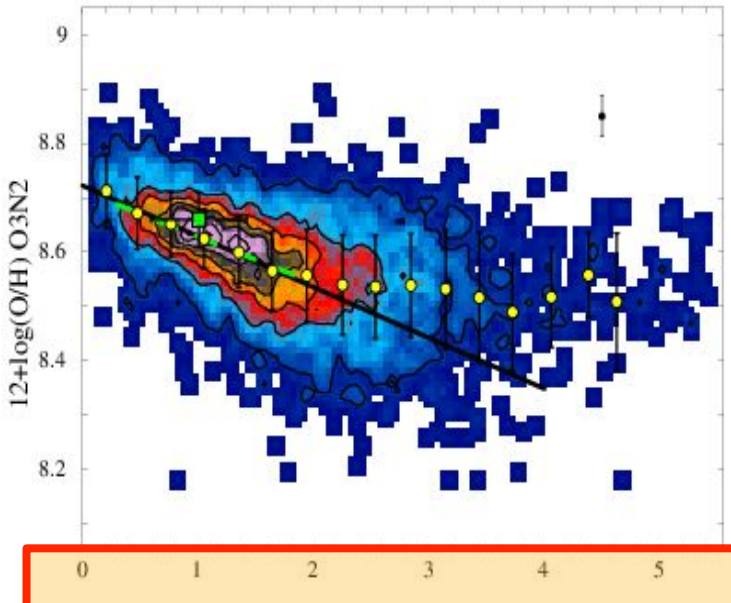
instituto de astronomía
unam

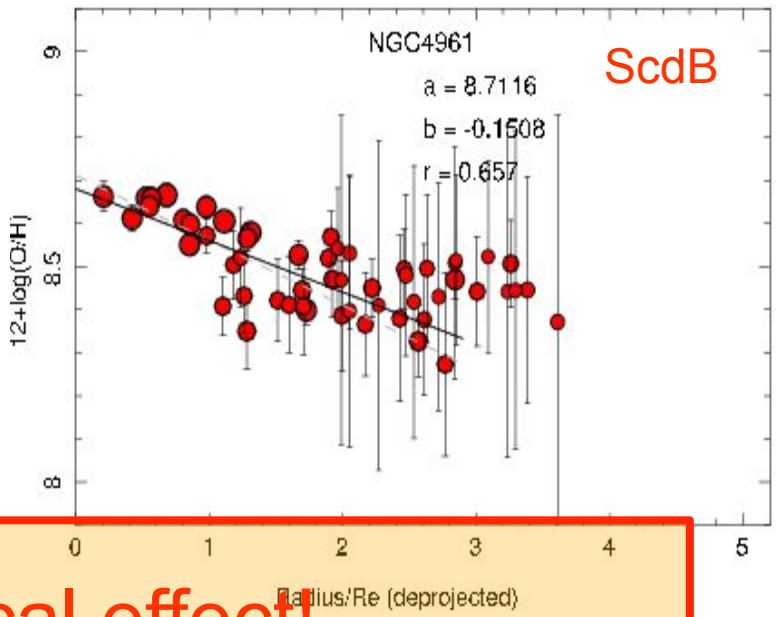


O/H Abundance gradients

167 galaxies (nHii>4)
~5800 regions

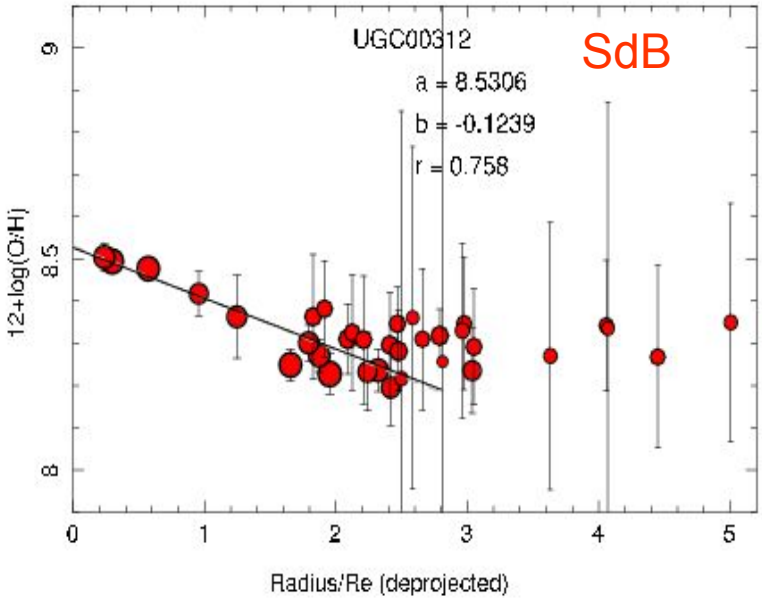




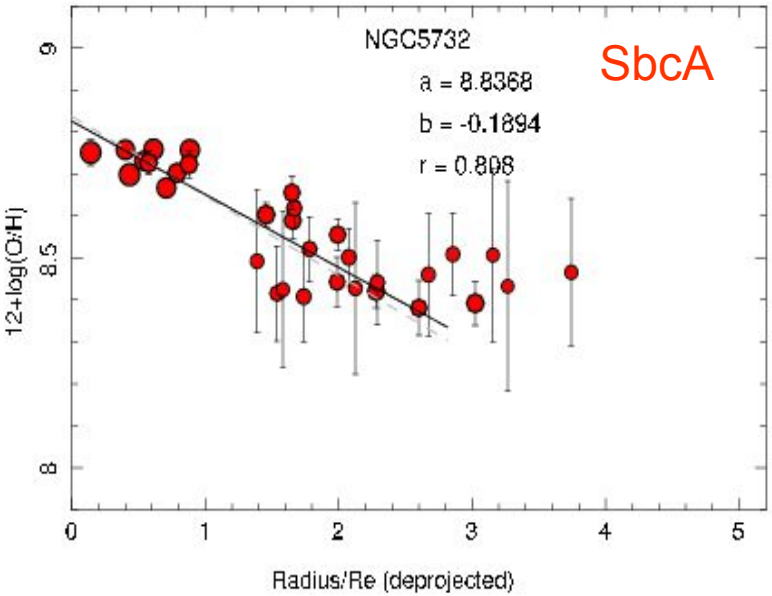


ScdB

Not an statistical effect!

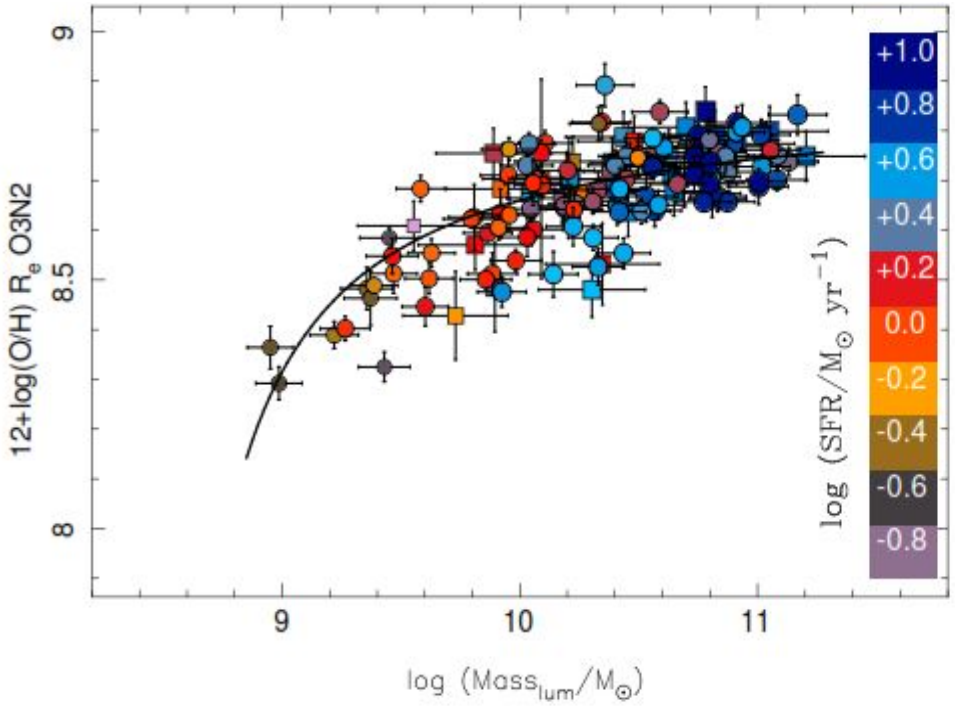


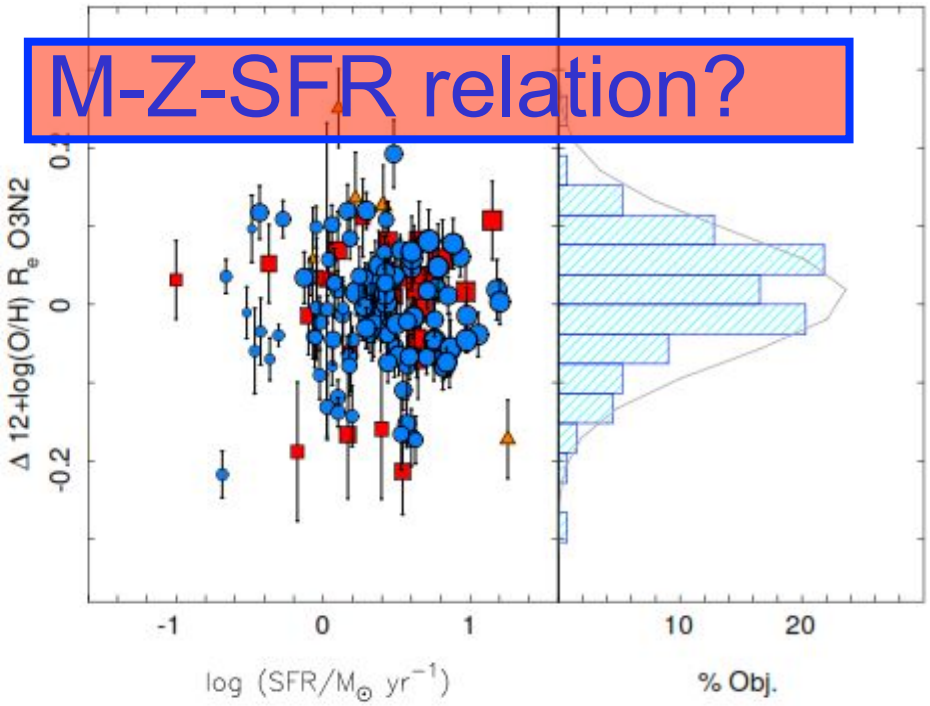
SdB

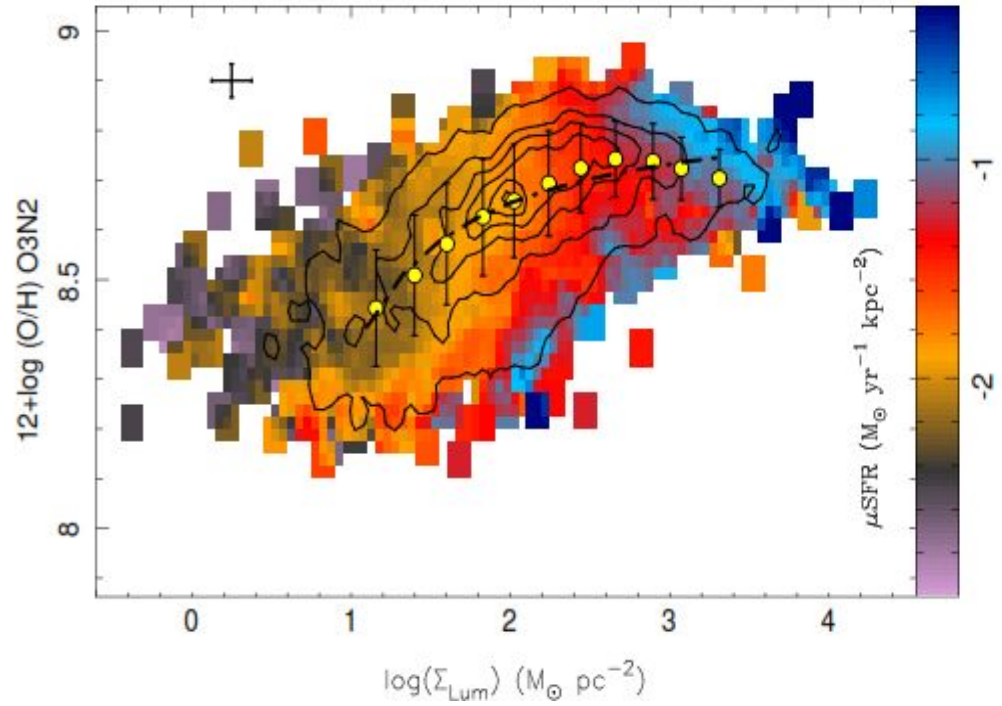


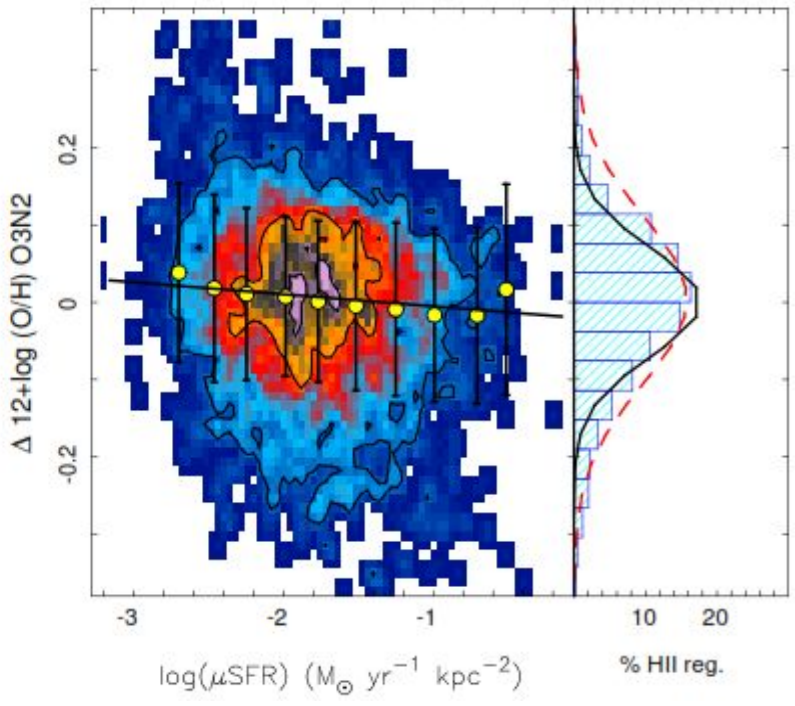
SbcA

M-Z-SFR relation?



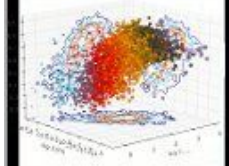






CALIFA Survey

instituto de astronomía
unam

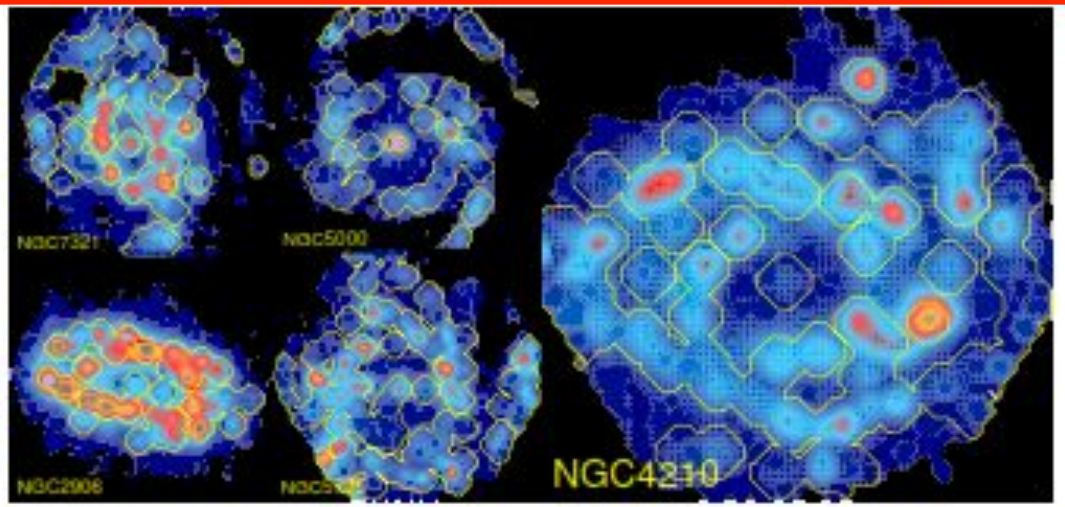


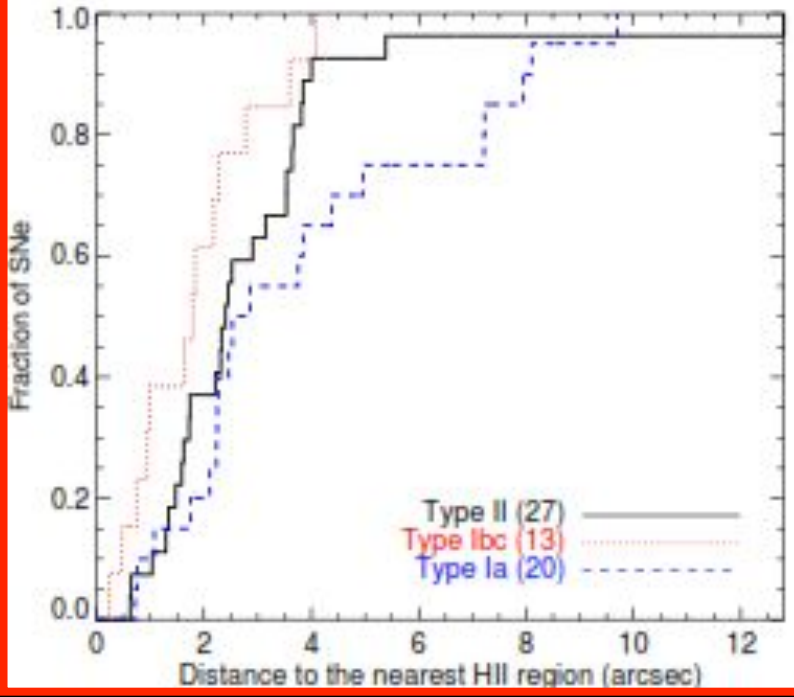
Which are the progenitors of SN?

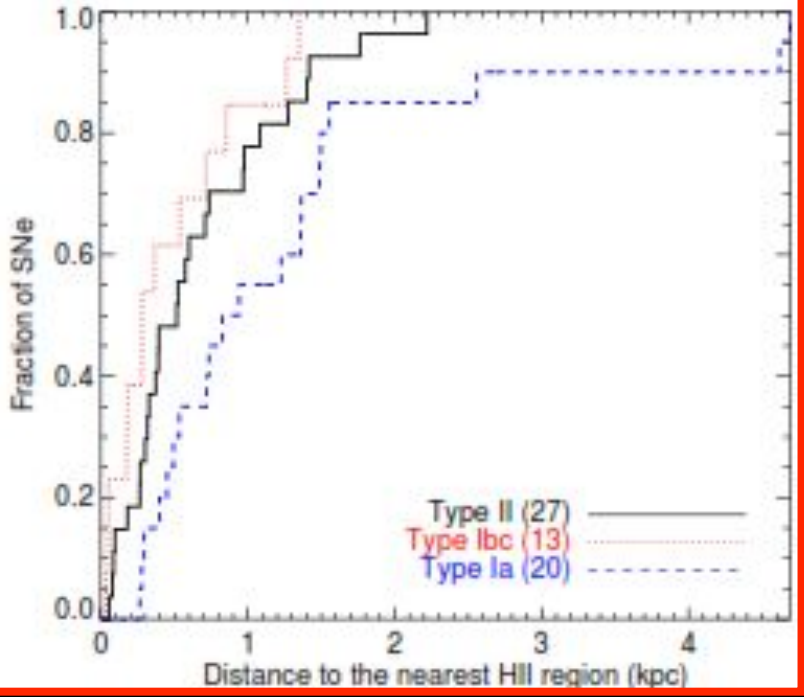
HII regions

60 Hosts Analyzed

HIIexplorer
Sánchez et al. 2012

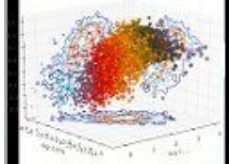






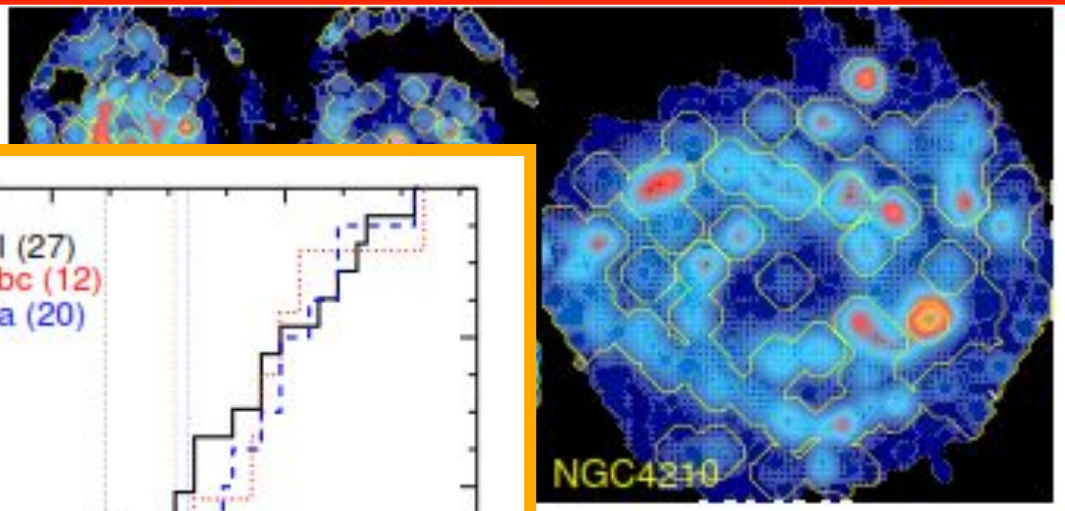
CALIFA Survey

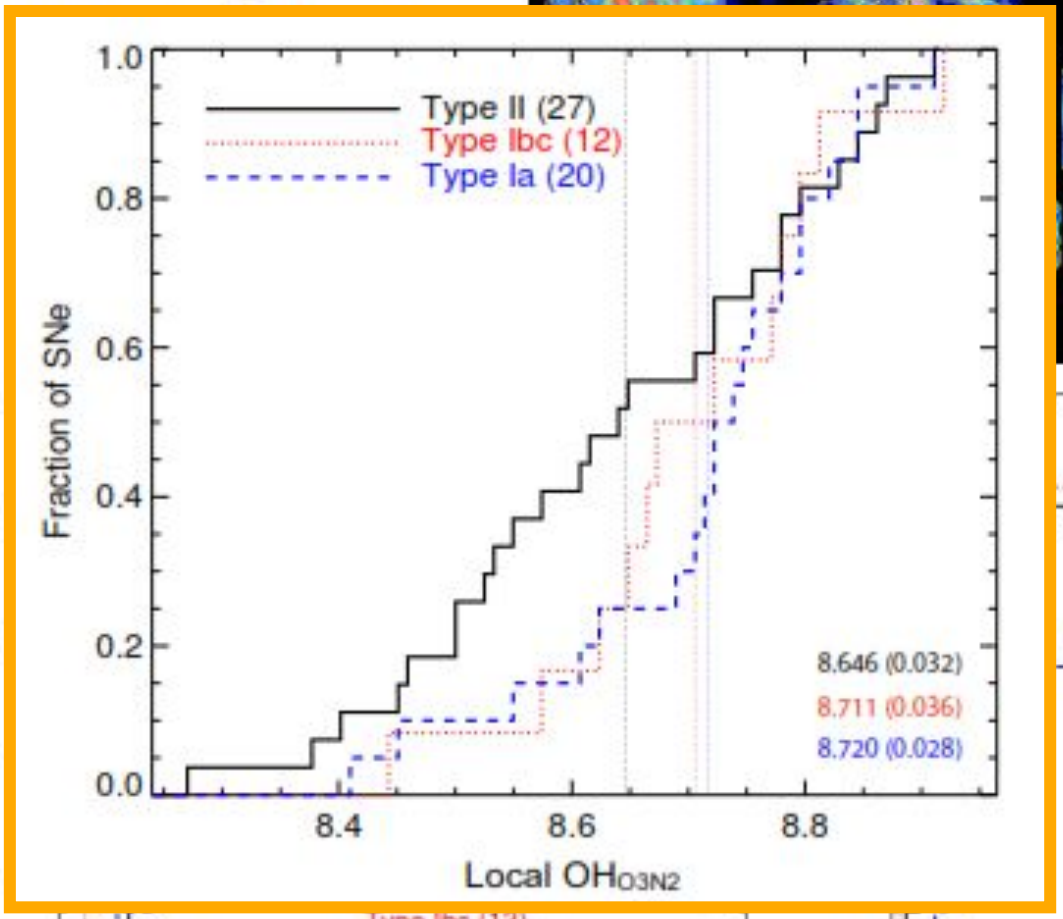
instituto de astronomía
unam

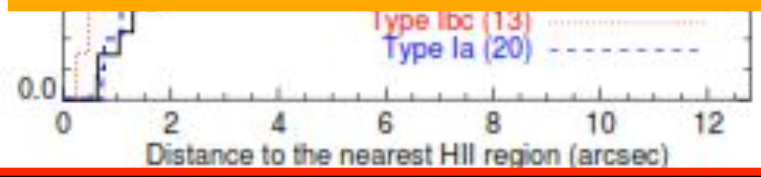


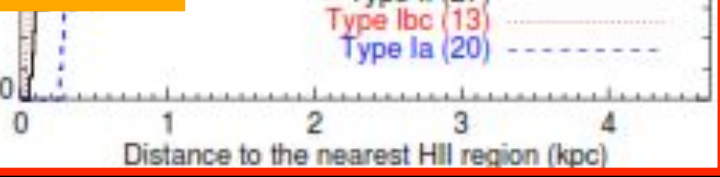
Which are the progenitors of SN?

HII regions



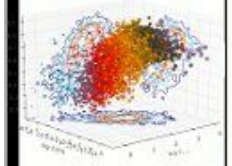




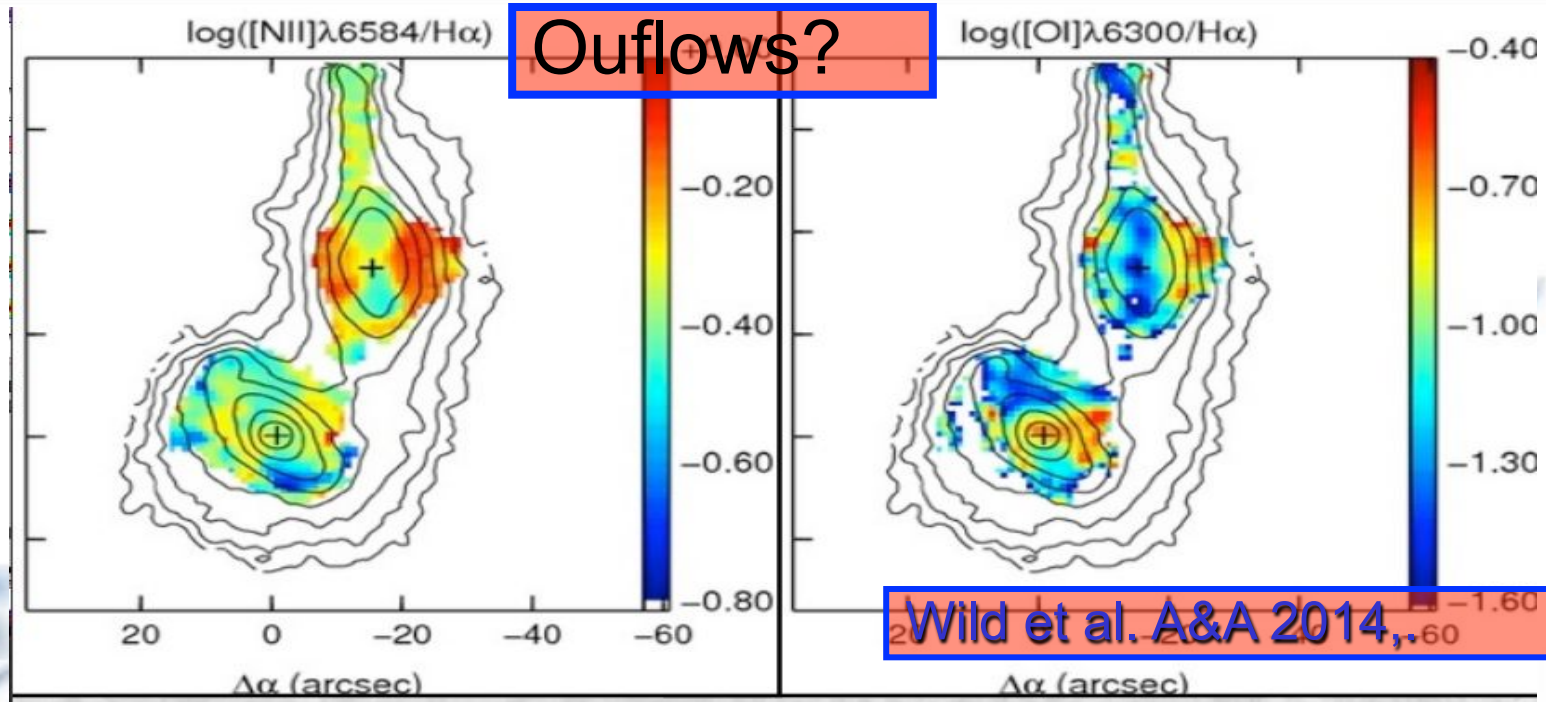


CALIFA Survey

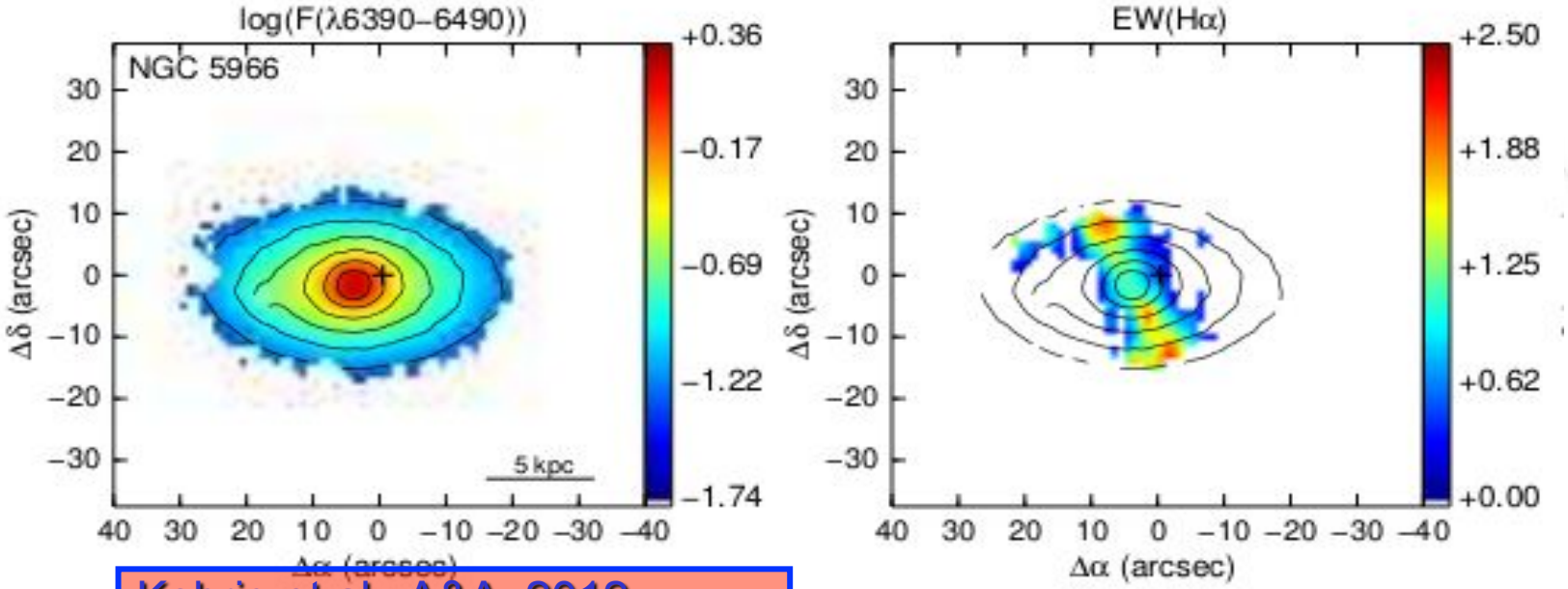
instituto de astronomía
unam



Ouflows?

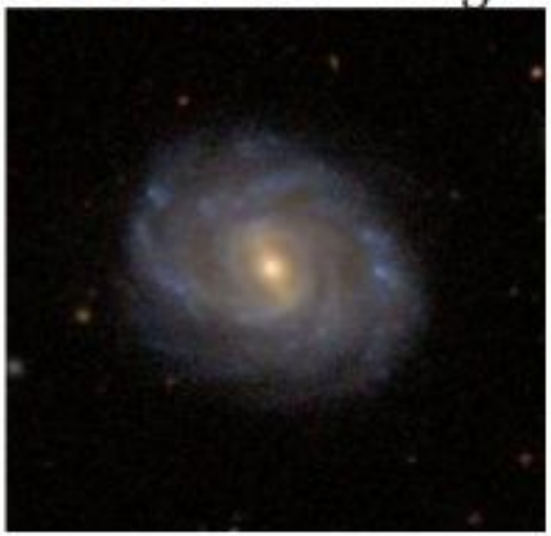


Wild et al. A&A 2014,.



Kehrig et al., A&A, 2012

SDSS 90”x90” image

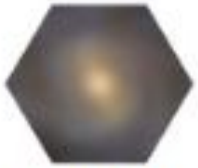


Atlas3D

Z~Z califa

Z~Z Atlas3D

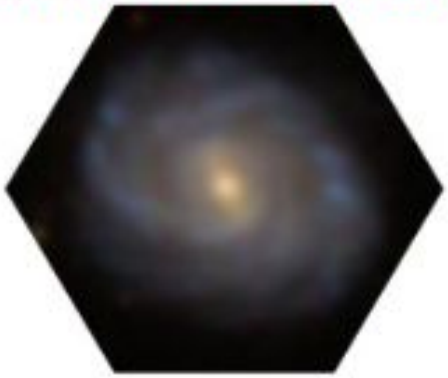
MaNGA largest FoV



FoV~1.5Re

~2.5Re

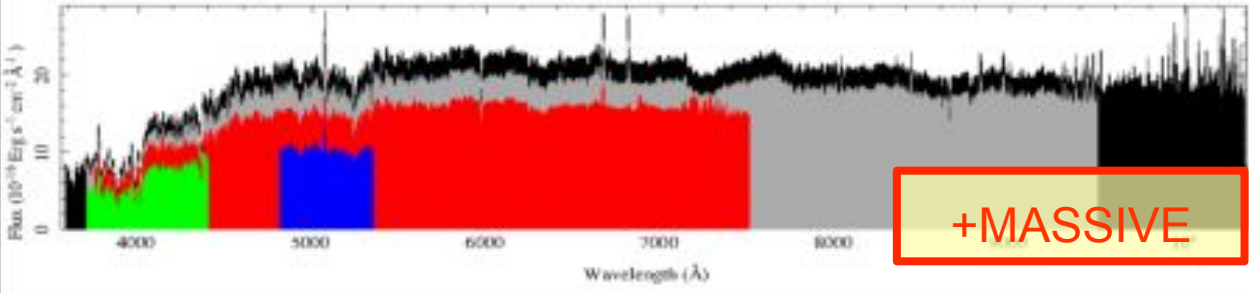
CALIFA (V500/V1200)



SAMI

Z~Z califa

Z~Z SAMI



+MASSIVE

CALIFA
2x3x331 spaxels; 2.7”/spaxel
600 galaxies of any type
~1.200.000 spec.; 3700-7500 Å

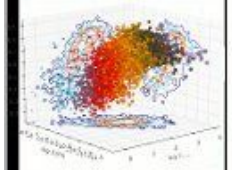
Atlas3D
1577 spaxels; 0.94”/spaxel
260 ETGs
~400.000 spectra; 4810-5350 Å

MaNGA
3x(19-127) spaxels; 2”/spaxel
7000 gal. of any type (~1.5Re)
2000 gal. of any type (~2.5Re)
1000 gal. of any type (any Re)
~800.000 spec.; 3550-10000 Å

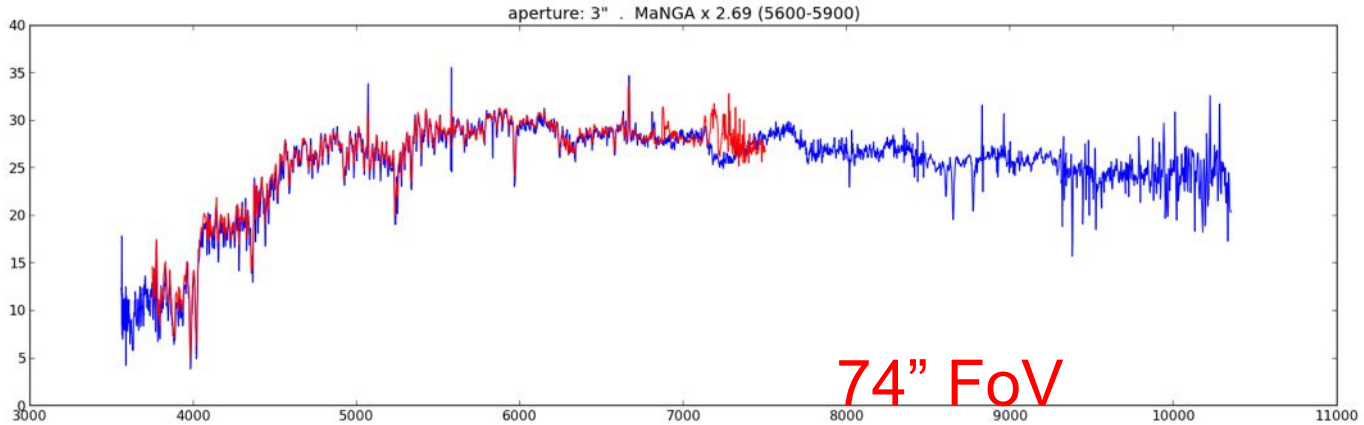
SAMI
9x61 spaxels; 1.6”/spaxel
3400 galaxies of any type
~1.900.000 spec.; 3700-9500 Å

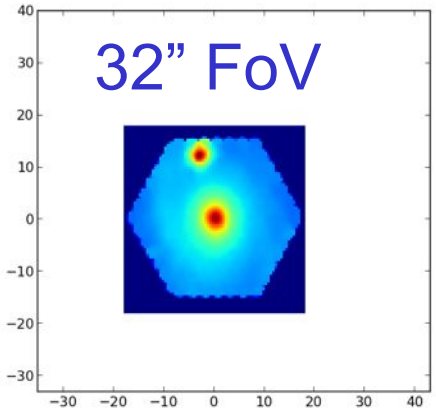
CALIFA Survey

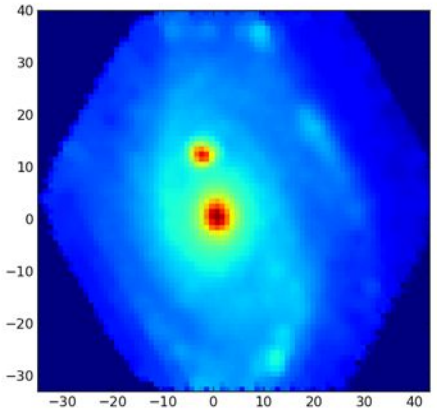
instituto de astronomía
unam



CALIFA compared with MaNGA



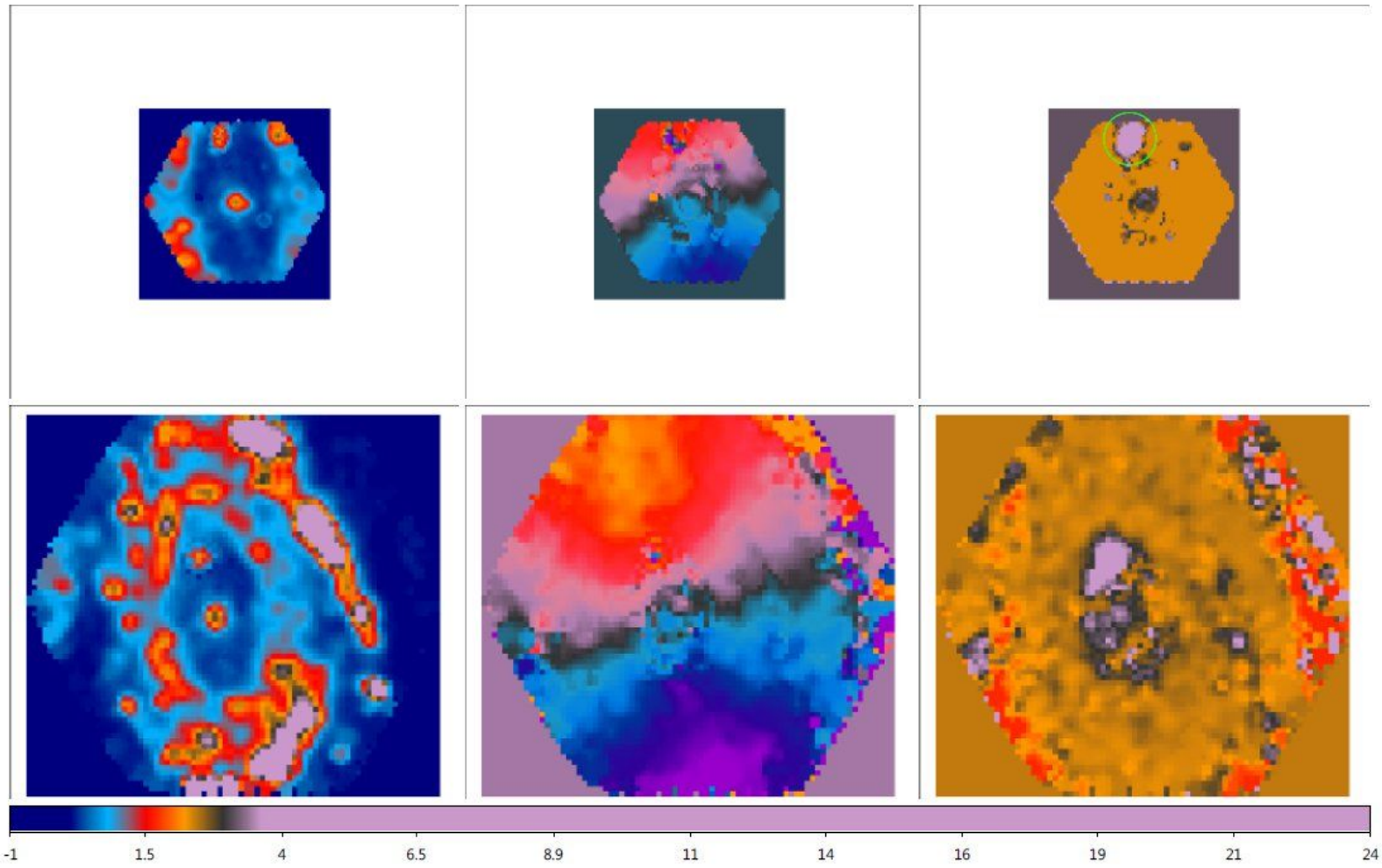




CALIFA Survey

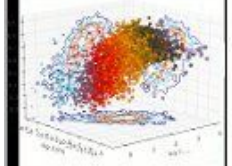
instituto de astronomía
unam

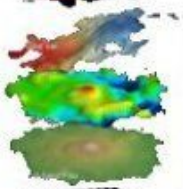
CALIFA compared with MaNGA



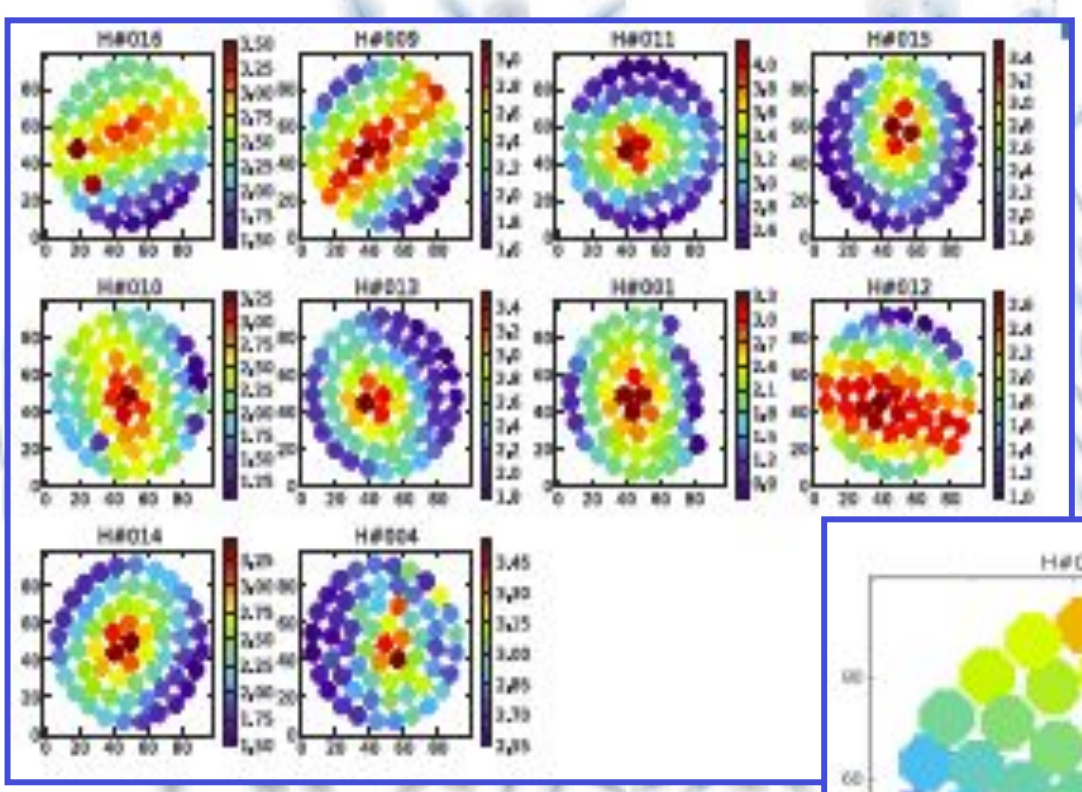
CALIFA Survey

instituto de astronomía
unam

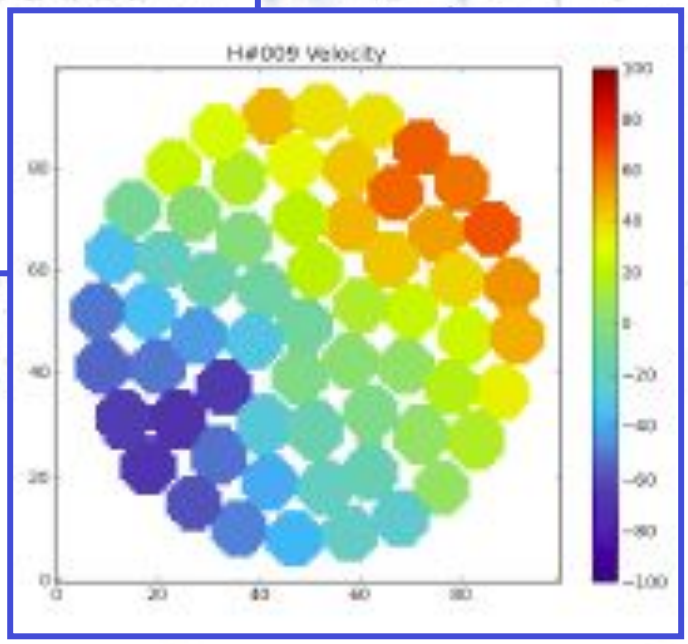


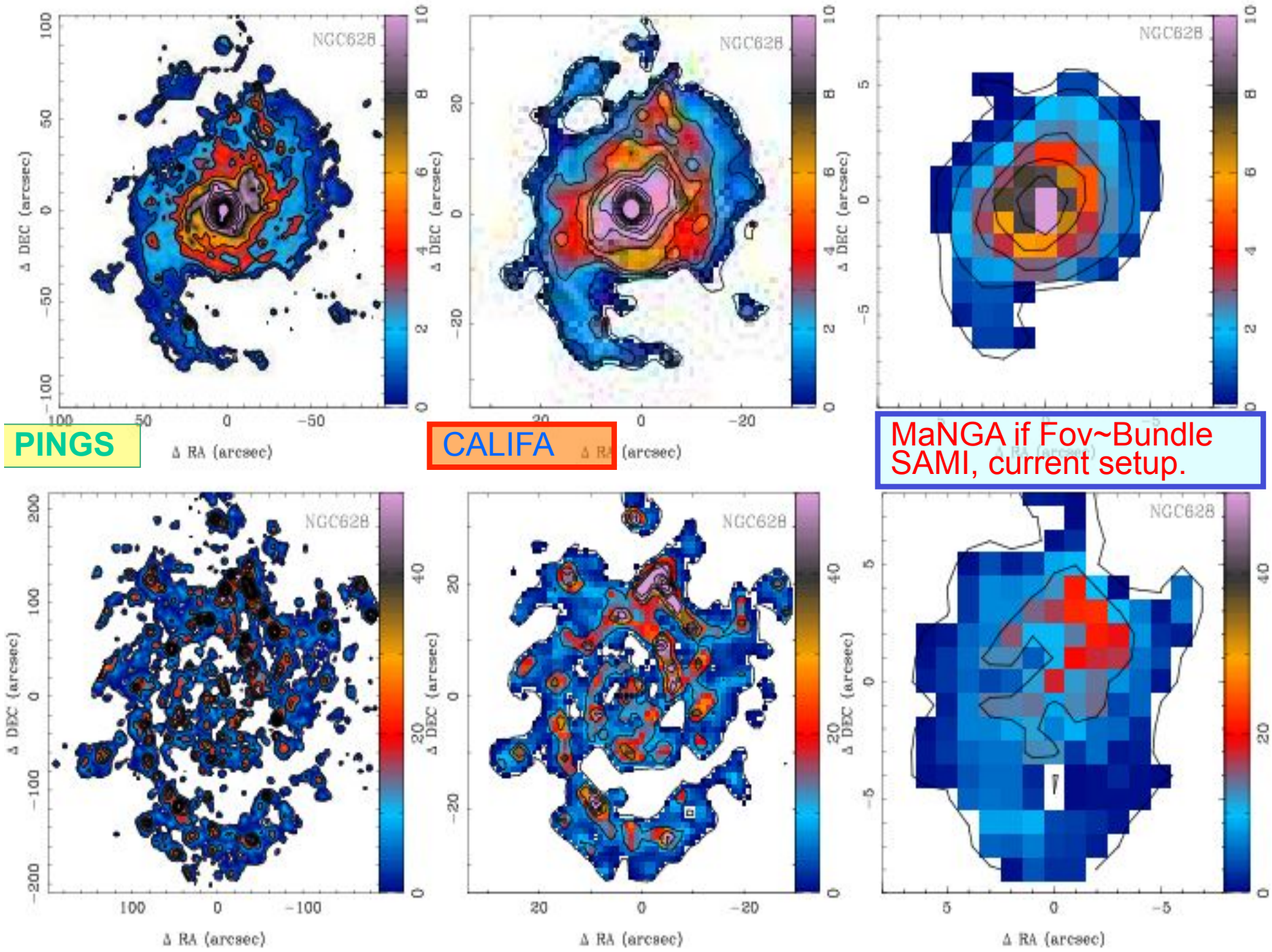


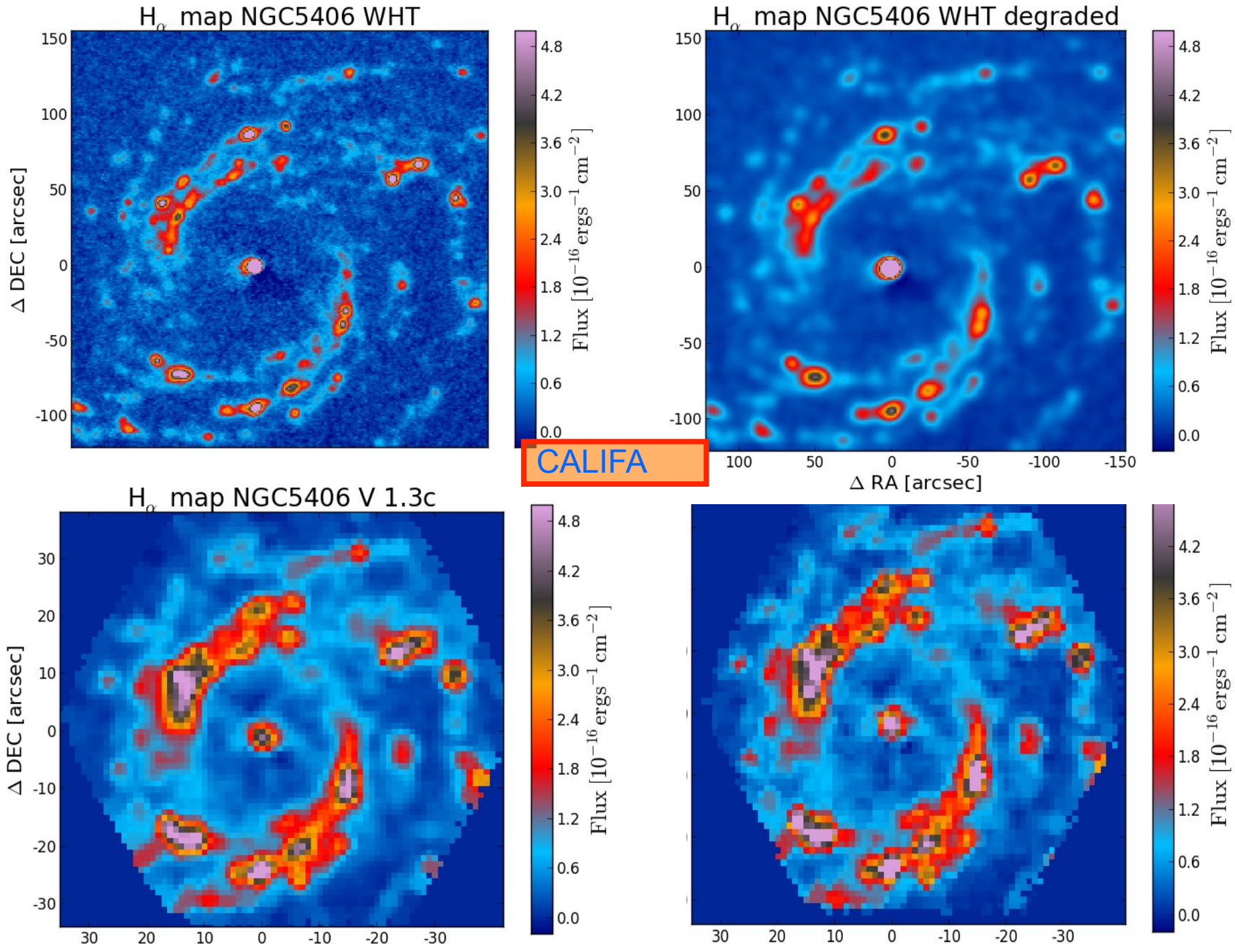
SAMI: The AAO Survey

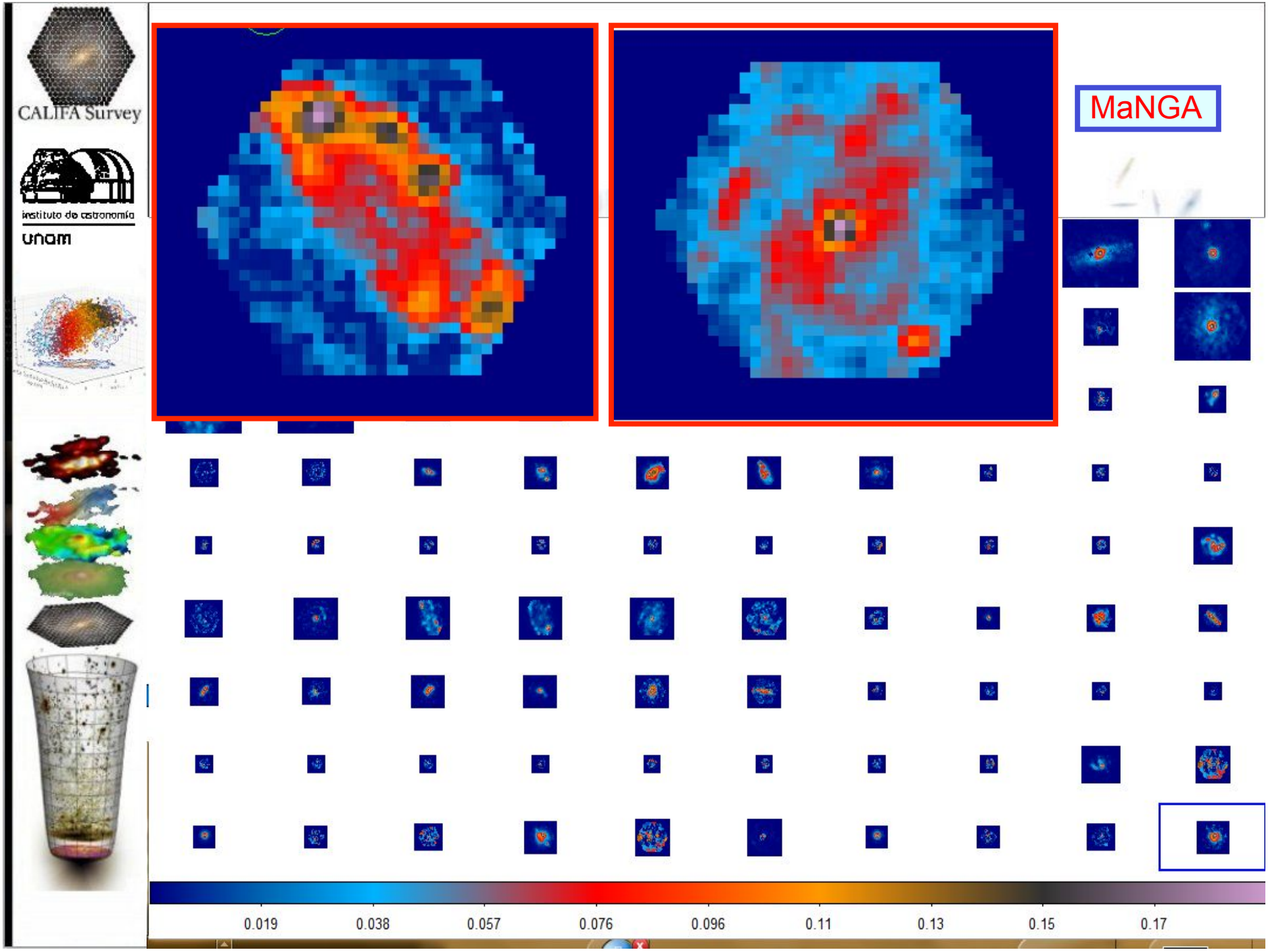


16” FoV



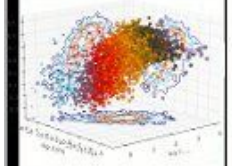

NGC628
Δ DEC (arcsec)
Δ RA (arcsec)
PINGS
CALIFA
MaNGA if Fov~Bundle
SAMI, current setup.


H$_\alpha$ map NGC5406 WHT
H$_\alpha$ map NGC5406 WHT degraded
H$_\alpha$ map NGC5406 V 1.3c
CALIFA
Δ DEC [arcsec]
Δ RA [arcsec]
Flux [10^{-16} ergs^{-1} cm^{-2}]


CALIFA Survey
instituto de astronomía
unam
MaNGA
0.019
0.038
0.057
0.076
0.096
0.11
0.13
0.15
0.17

CALIFA Survey

instituto de astronomía
unam



Now Hands On!!!