A systematic study of galactic outflows with IFS surveys

by

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Systematic study of outflows in the Local Universe using CALIFA: I. Sample selection and main properties.

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WORKSHOP ESTALLIDOS, Madrid 2018

CALIFA Survey

Outline

- Introduction
- Outflows in CALIFA:

  Criterion selection

  Global properties

  Dominant ionization

  The SFMS for outflows

  Radial distribution of the SFR density

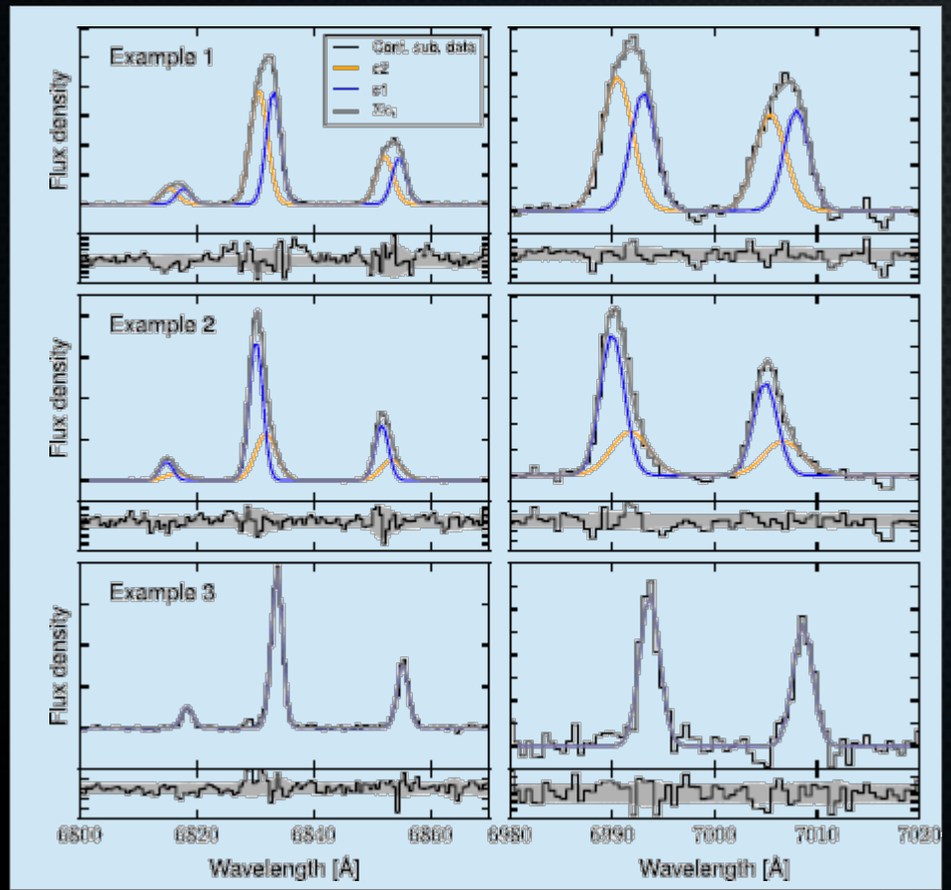
  The KS law for outflows, a real threshold?

  Clear outflows in other surveys
- Conclusions
- OUTFLOWS IN MUSE

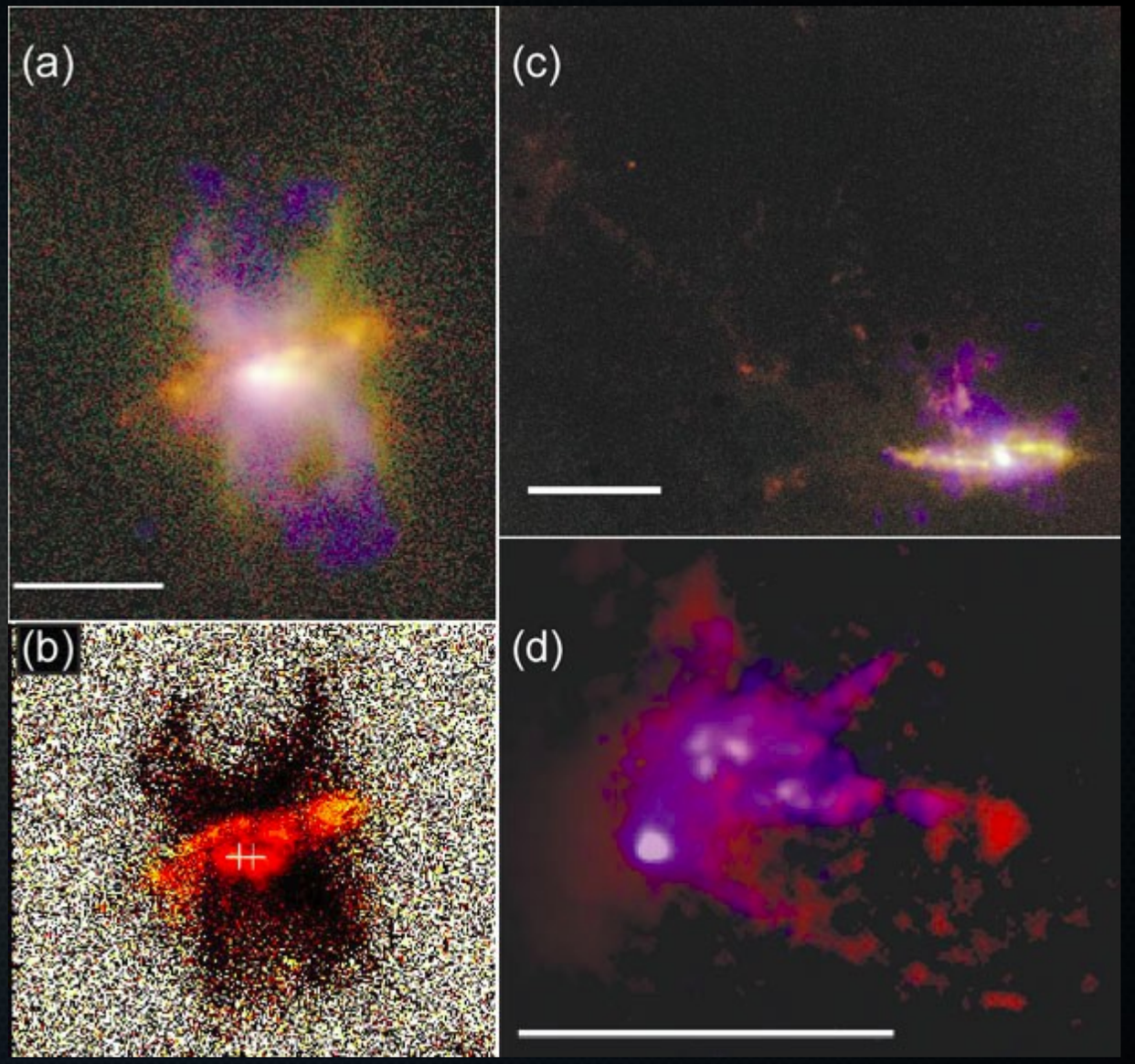
Introduction

Galactic Winds: Gas moving at high velocity (ionized/molecular) driven by SN explosions or AGN activity.

Complex kinematic: double picked → shocked layer

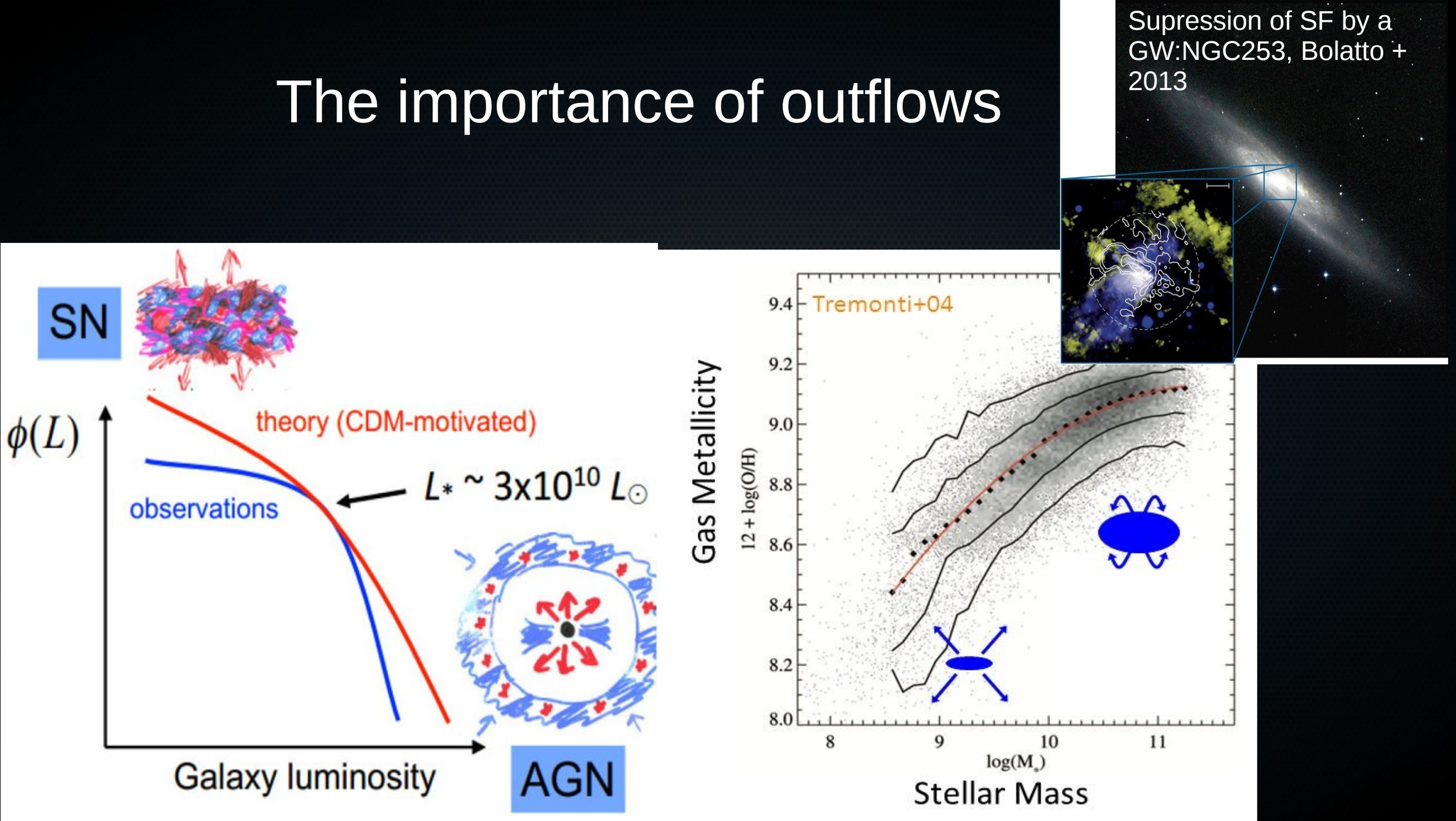


Ho + 2016

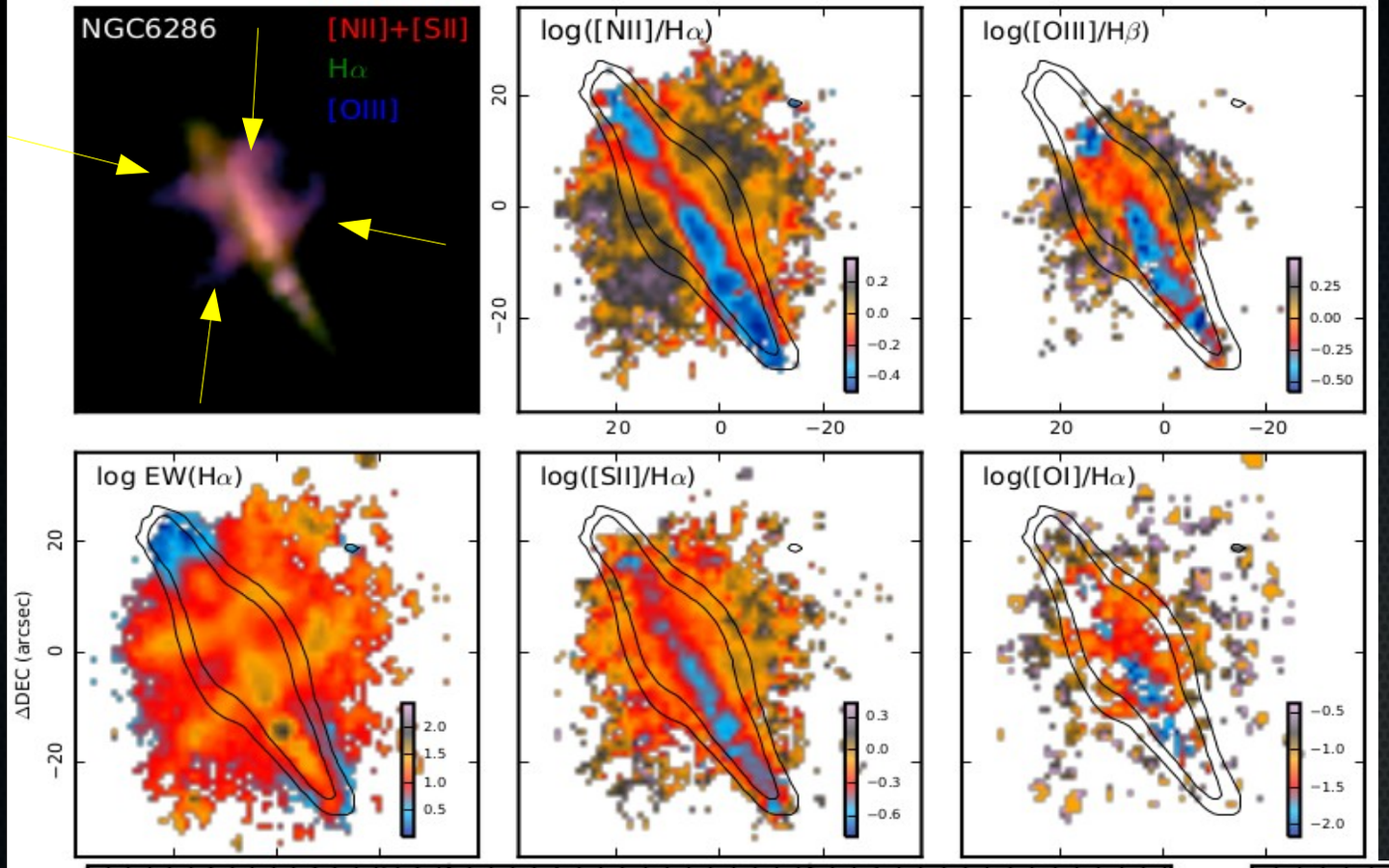


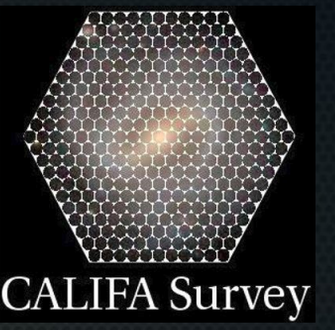
Veilleux + 2005

The importance of outflows

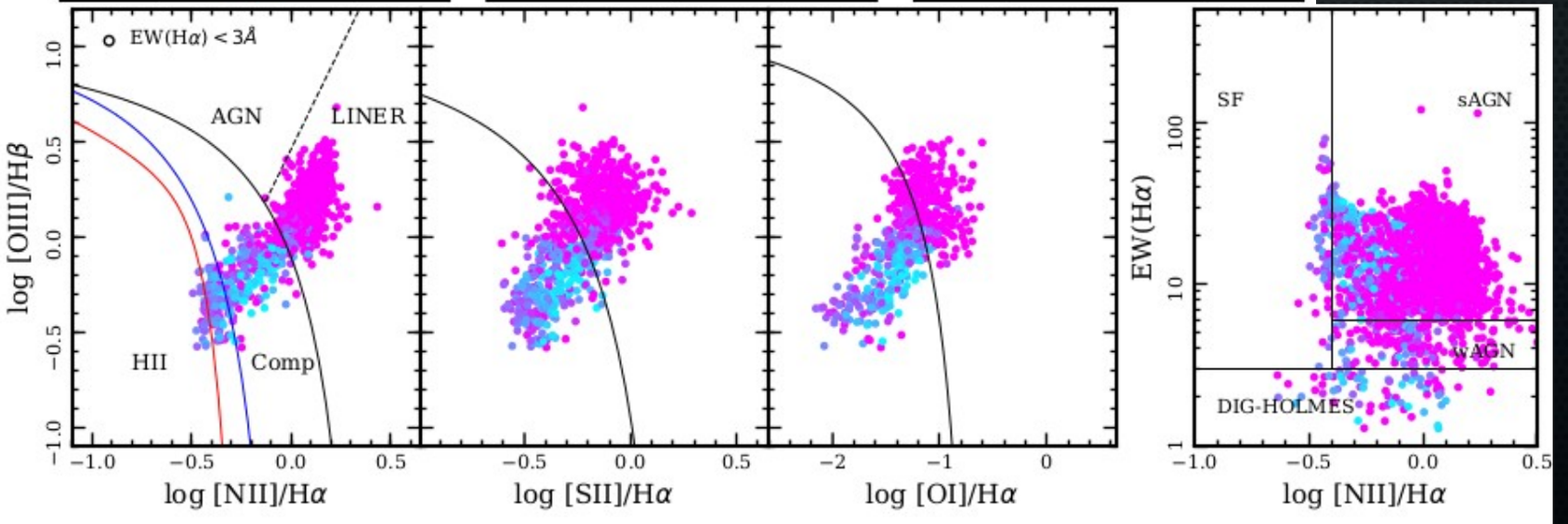


Systematic study of outflows in the Local Universe: CALIFA[1]





R ~ 850, FWHM = 2.5“, 835 galaxies (735 DR3+100)

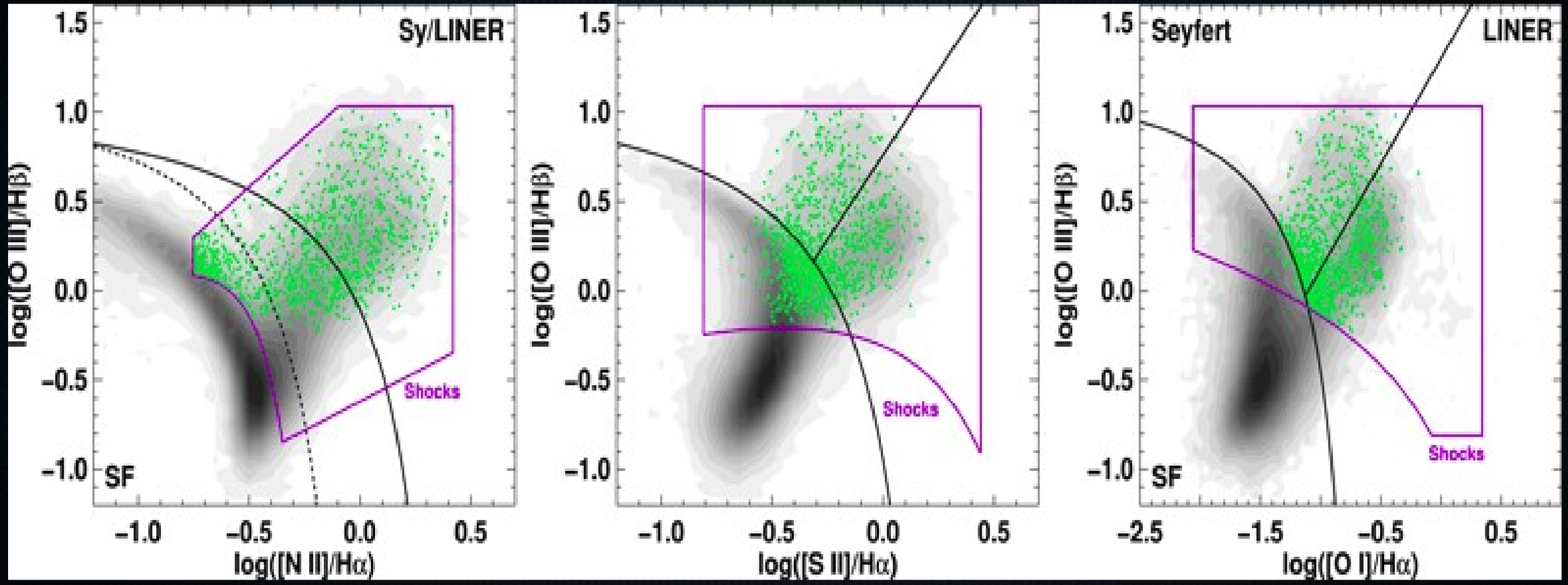


Archetype of an *outflow*: NGC 6286

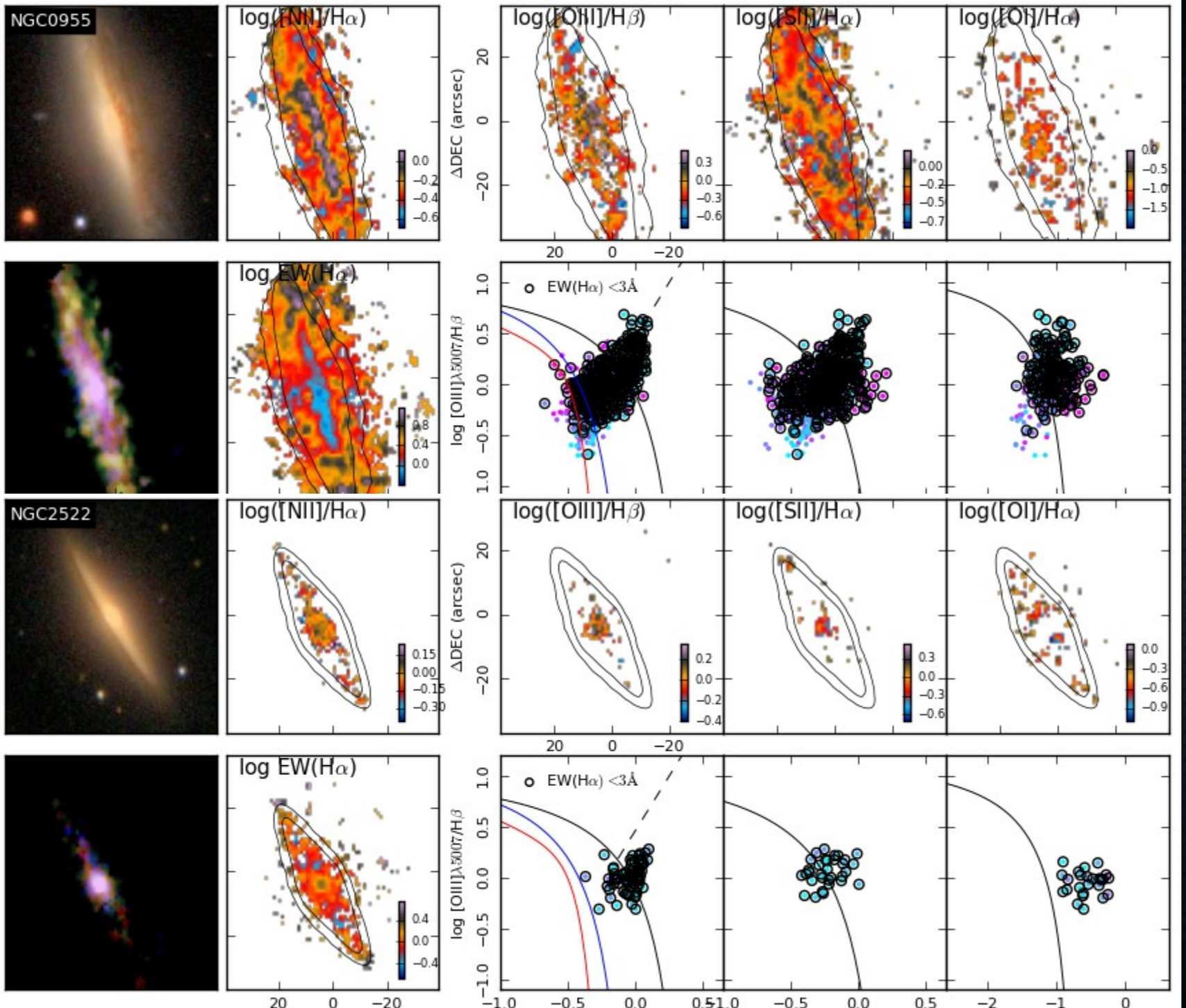
WHAN diagram, Cid Fernades+ 2010

[1] http://califa.caha.es/

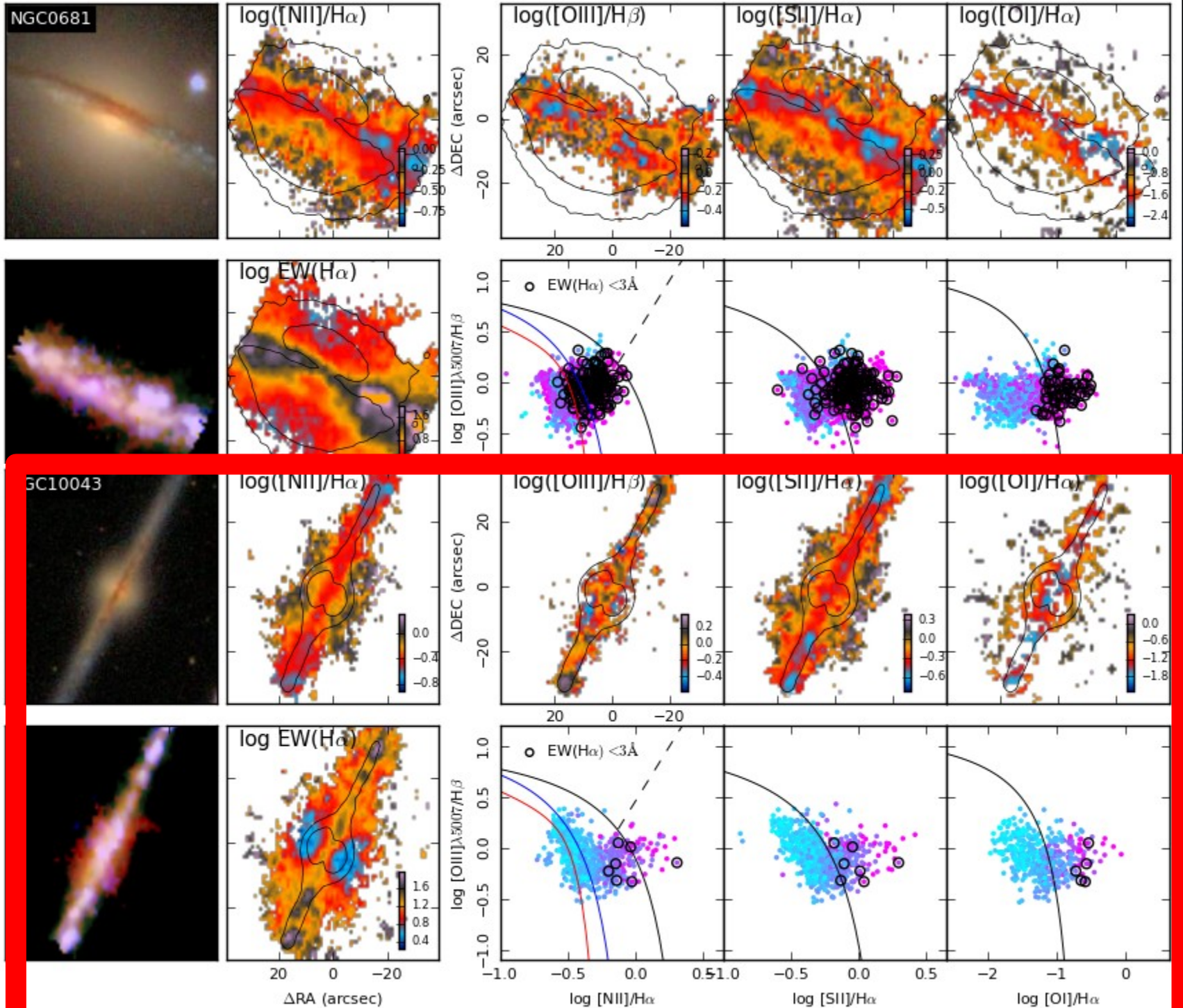
Shocks in the diagnostic diagrams



Alatalo +2016



Extraplanar gas is not always asociated to outflows



NOT OUTFLOW

OUTFLOW

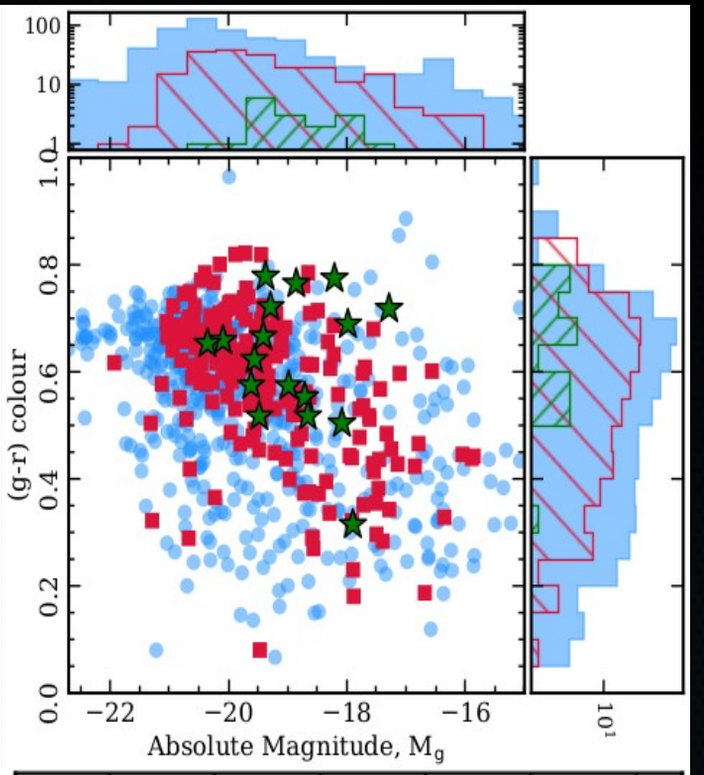
López-Cobá +17

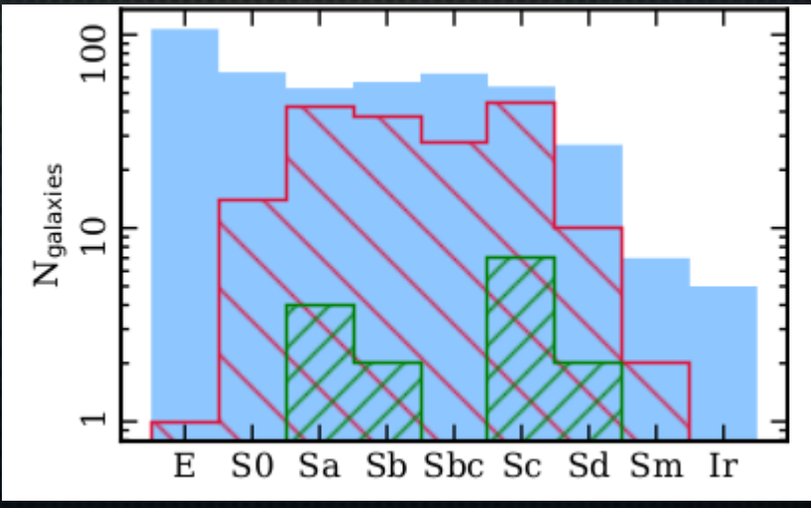
Global properties of the samples

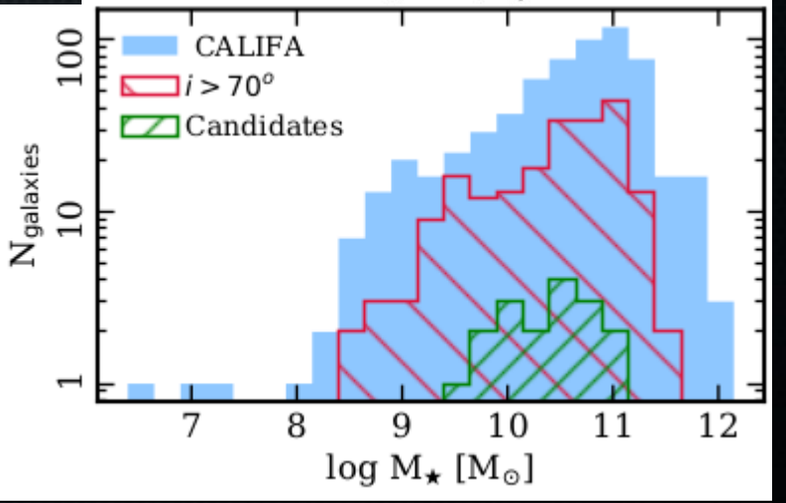
Criterion used to select outflows

(1) i>70º.
(2) Detection of extraplanar gas.
(3) Enhance in the line ratios.
(4) EW(Ha) > 3A.
(5) Biconical/Bipolar morhology in the extraplanar gas

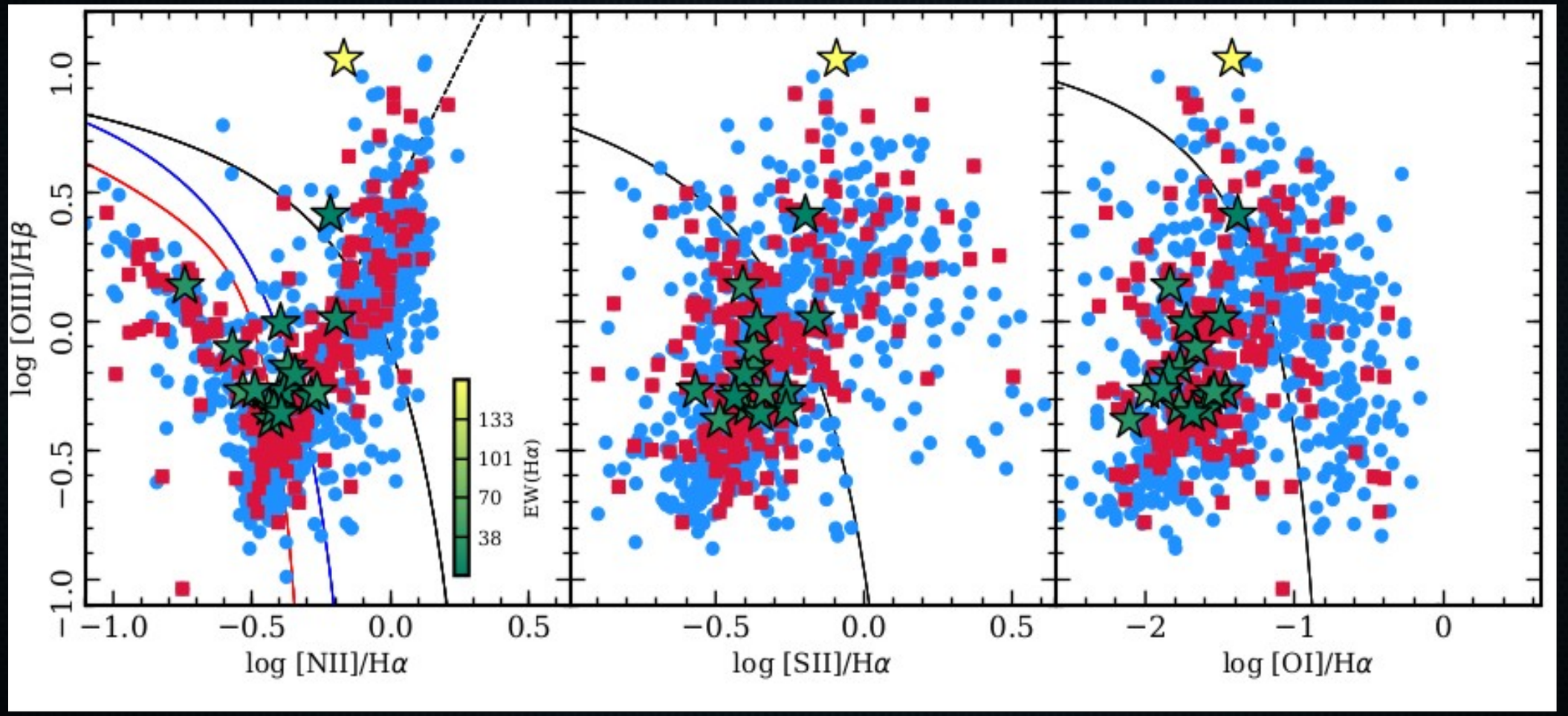
i< 70º (CALIFA subsample): 615 galaxies
i>70º : 203
Candidatos: 17/44 (2% of total)





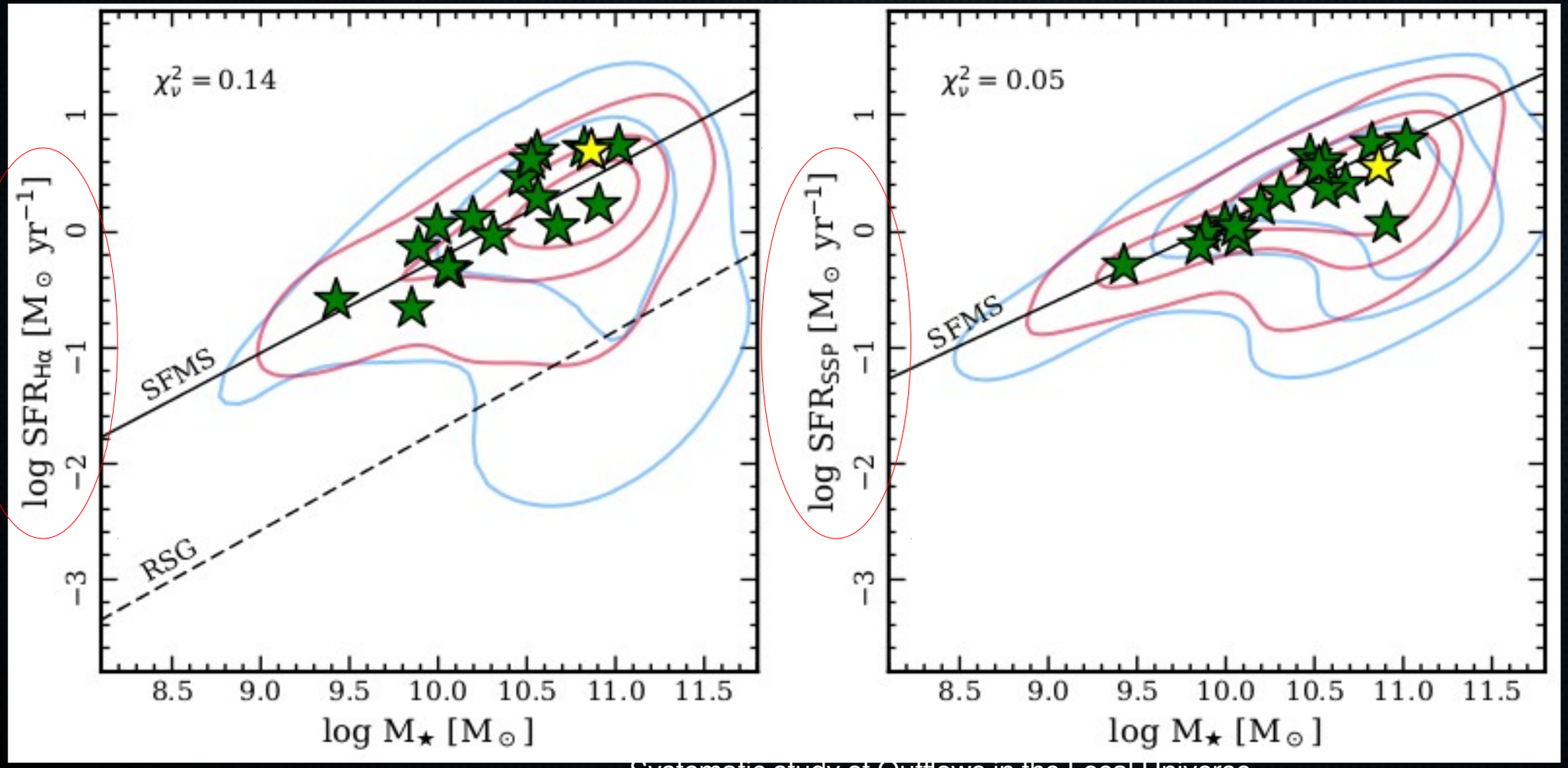


Dominant ionization in the nucleus of the samples

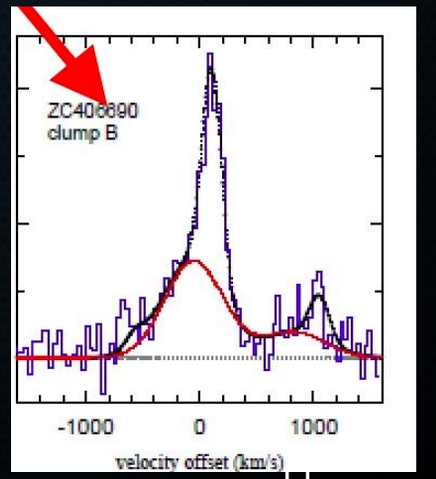


Do the galaxies hosting outflows present an increase in their SFR?

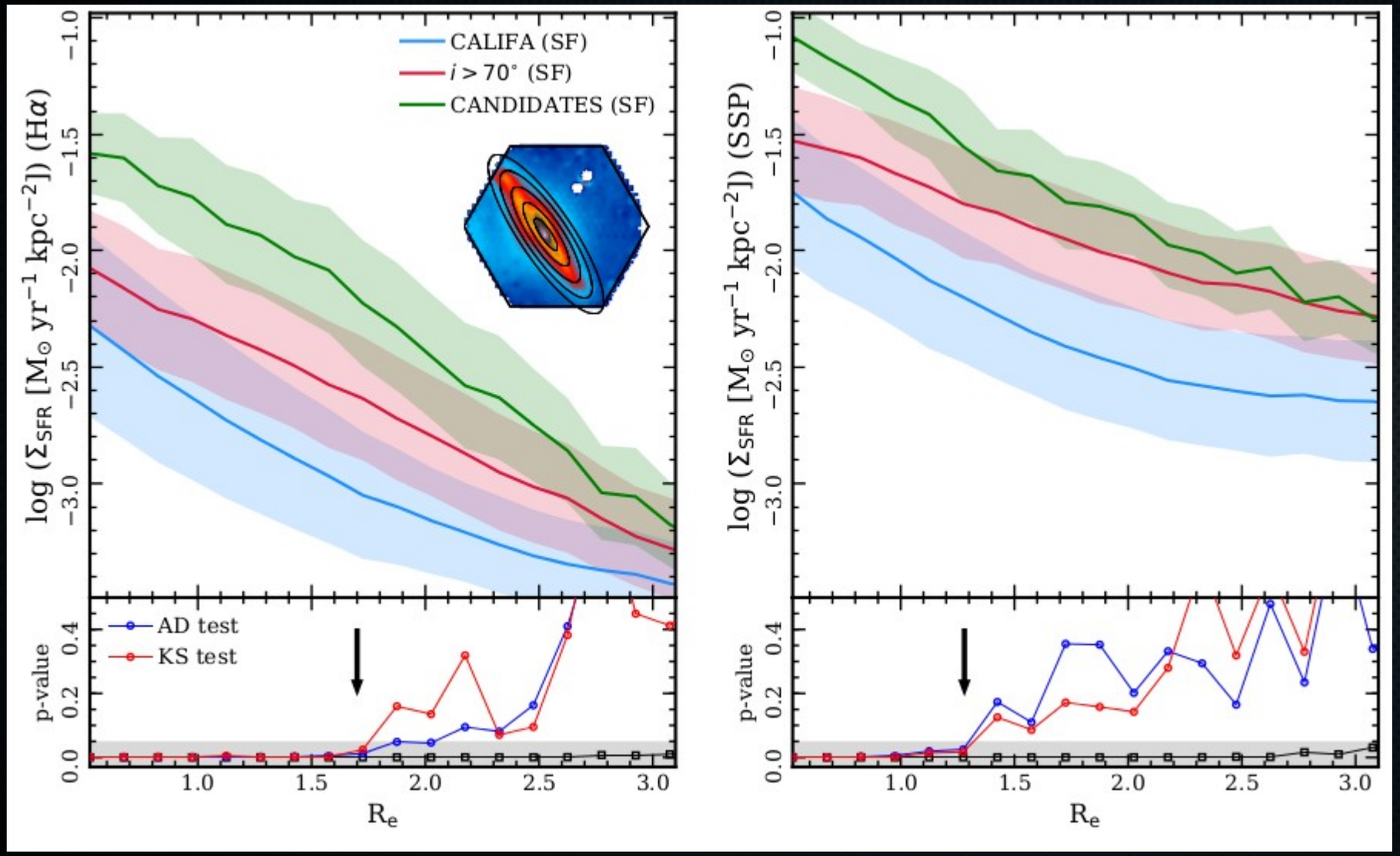
global SFR



Typical emission line profile of an outflow



Region of influence/production of *outflows*



Threshold en *outflows:* Heckman +2001, 2002 :

¨ *They are ubiquitous in galaxies in which the global SFR per unit area exceeds roughly* 10^{-1} *Msun* yr^{-1} kpc^{-2} *(a condition satisfied by local starburst and high redshift Lyman break galaxies)* ¨

None of the candidates surpasS the threshold

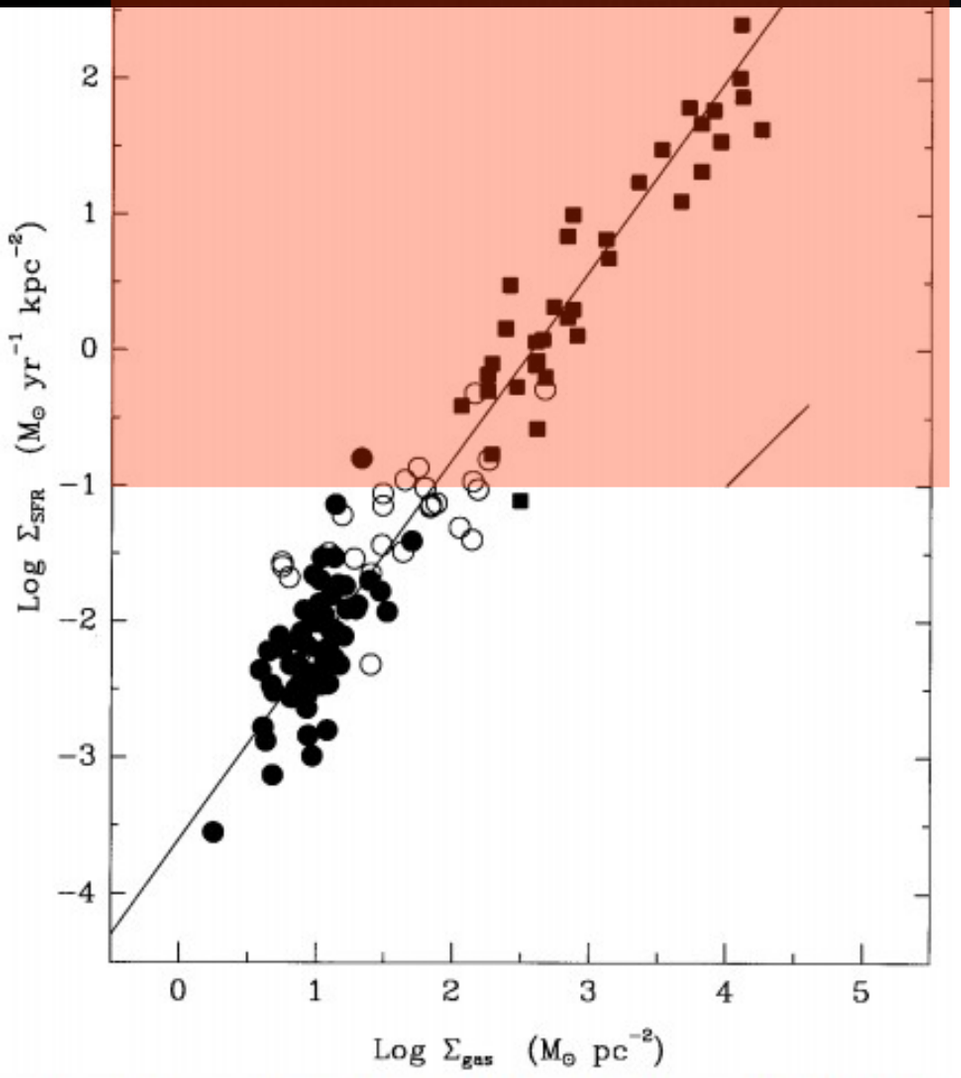


FIG. 6.—Composite star formation law for the normal disk (*filled circles*) and starburst (*squares*) samples. Open circles show the SFRs and gas densities for the centers of the normal disk galaxies. The line is a least-squares fit with index $N = 1.40$. The short, diagonal line shows the effect of changing the scaling radius by a factor of 2.

Threshold en *outflows:* Heckman +2001, 2002

¨ *They are ubiquitous in galaxies in which the global SFR per unit area exceeds roughly 10^{-1} Msun yr^{-1} kpc^{-2} (a condition satisfied by local starburst and high redshift Lyman break galaxies)* ¨

Kennicutt +1998

Heckman (2001, see also Heckman 2002) used Hα, NaD and X-ray observations to claim that efficient winds are launched provided the surface density of star formation, $\dot{\Sigma}_\star$, exceeds a threshold value of $\dot{\Sigma}_{\star,\rm crit} = 0.1\ M_\odot\ {\rm yr}^{-1}\ {\rm kpc}^{-2}$, a finding that is also

mass. The wind-dominated galaxies have SFRs as low as approximately $0.1\,M_\odot\ {\rm yr}^{-1}$, and SFR surface densities of approximately 10^{-3}–$10^{-1.5}\ M_\odot\ {\rm yr}^{-1}\ {\rm kpc}^{-2}$, much lower than the canonical threshold found in classical wind galaxies ($\Sigma > 0.1\,M_\odot\ {\rm yr}^{-1}\ {\rm kpc}^{-2}$; Heckman 2002).

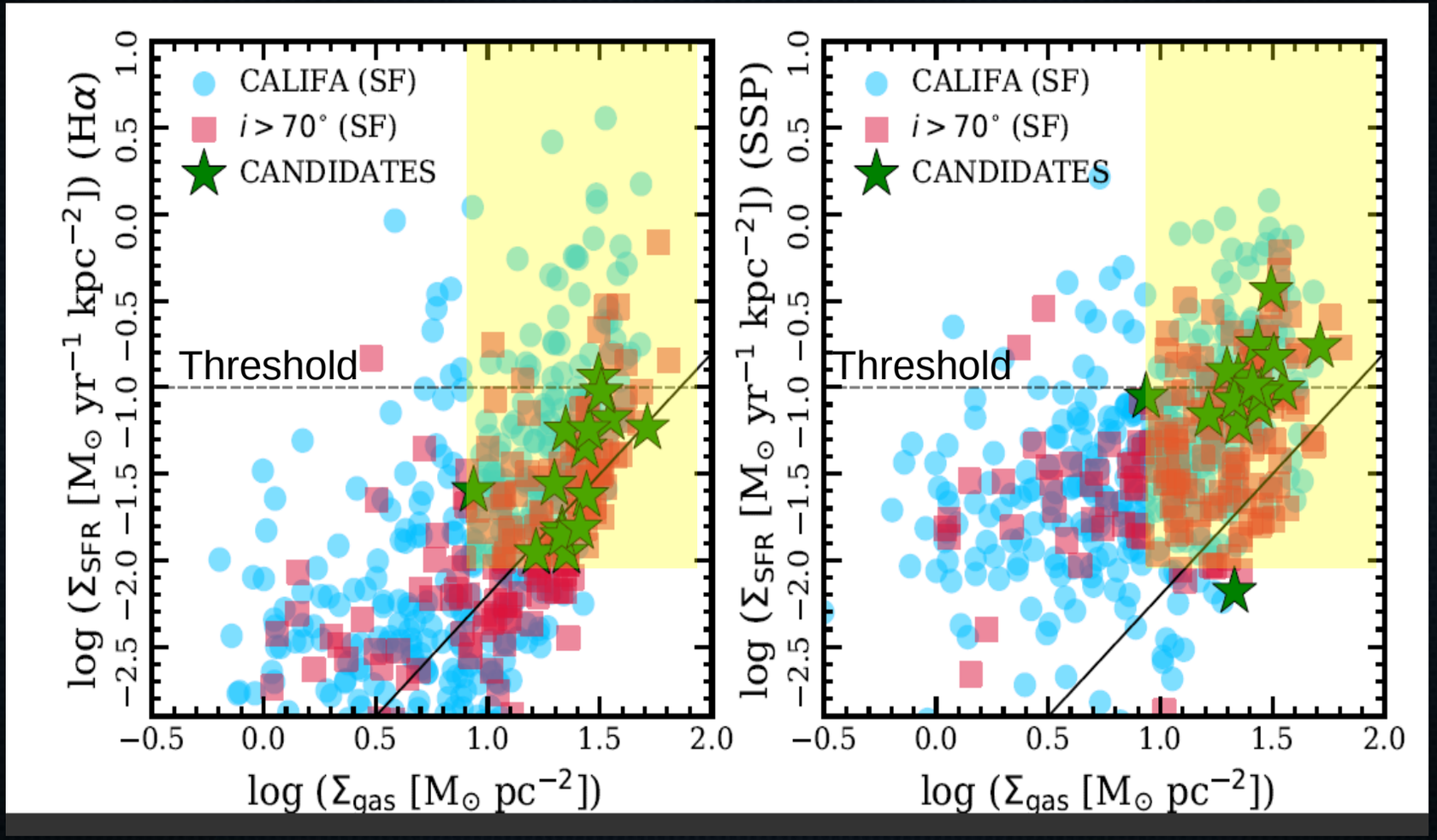
Observations show that cold outflows occur in galaxies with a high SFR per surface area, $\Sigma_{\rm SFR}$. Typically, outflows are observed if $\Sigma_{\rm SFR} > 0.1\ M_\odot\ {\rm yr}^{-1}\ {\rm kpc}^{-2}$ (Heckman 2002; Chen et al. 2010). This limit is supported by theoretical modelling (Murray et al. 2011; Scannapieco 2013). We calculated $\Sigma_{\rm SFR}$ using the area πR_{50}^2, in line with Rubin et al. (2010). Kornei et al. (2012) argue for a slightly different way of deriving the area $A = \pi R_{\rm P}^2/3.7$, where $R_{\rm P}$ is the Petrosian radius, which will result in slightly lower values of $\Sigma_{\rm SFR}$.

SFR surface density. Using these SFRs and estimates of the source size, we calculate an SFR surface density ($M_\odot$ kpc^{-2}) for both the 70 and 160 μm data (Figure 5). At least 30% and as many as 50% of the objects using 70 μm as the SFR indicator or between 20%–30% using 160 μm as the indicator have SFR densities larger than the empirical threshold of $0.1\ M_\odot\ {\rm yr}^{-1}\ {\rm kpc}^{-2}$ needed to drive a wind (Heckman 2001).

(we will explore the correlation in more detail in Section 5). According to Heckman (2002), starburst-driven winds are observed to be ubiquitous in galaxies with $\log(\Sigma_{\rm SFR}/[M_\odot\ {\rm yr}^{-1}\ {\rm kpc}^{-2}]) > -1$ (see also the results of Sharma et al. 2017). In our sample, $\log(\Sigma_{\rm SFR,max}/[M_\odot\ {\rm yr}^{-1}\ {\rm kpc}^{-2}]) = -1.95$, almost a dex lower.[12]

yr^{-1} for this galaxy we calculate an SFR surface density of $\Sigma_{\rm SFR} = 0.014 \pm 0.001\ M_\odot\ {\rm yr}^{-1}\ {\rm kpc}^{-2}$. Such a $\Sigma_{\rm SFR}$ is an order of magnitude smaller than the threshold of $\Sigma_{\rm SFR} \gtrsim 0.1\ M_\odot\ {\rm yr}^{-1}\ {\rm kpc}^{-2}$ (Heckman 2002; Bordoloi et al. 2014b) required for driving the large-scale galactic winds (see also Newman et al. 2012). In sum-

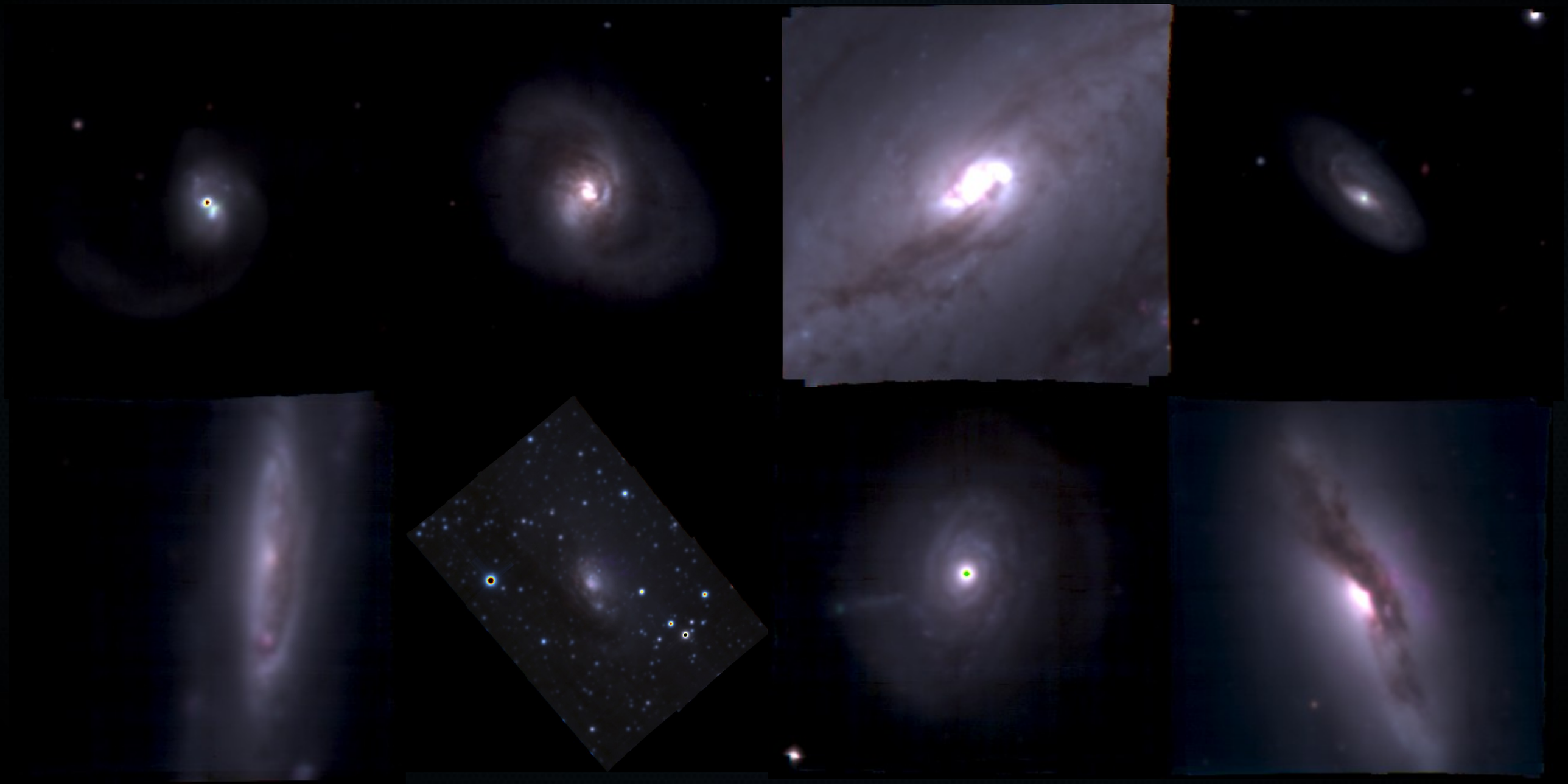
Gas molecular, another regulator of *outflows*?



Continuum images from AMUSING

muse
multi unit spectroscopic explorer

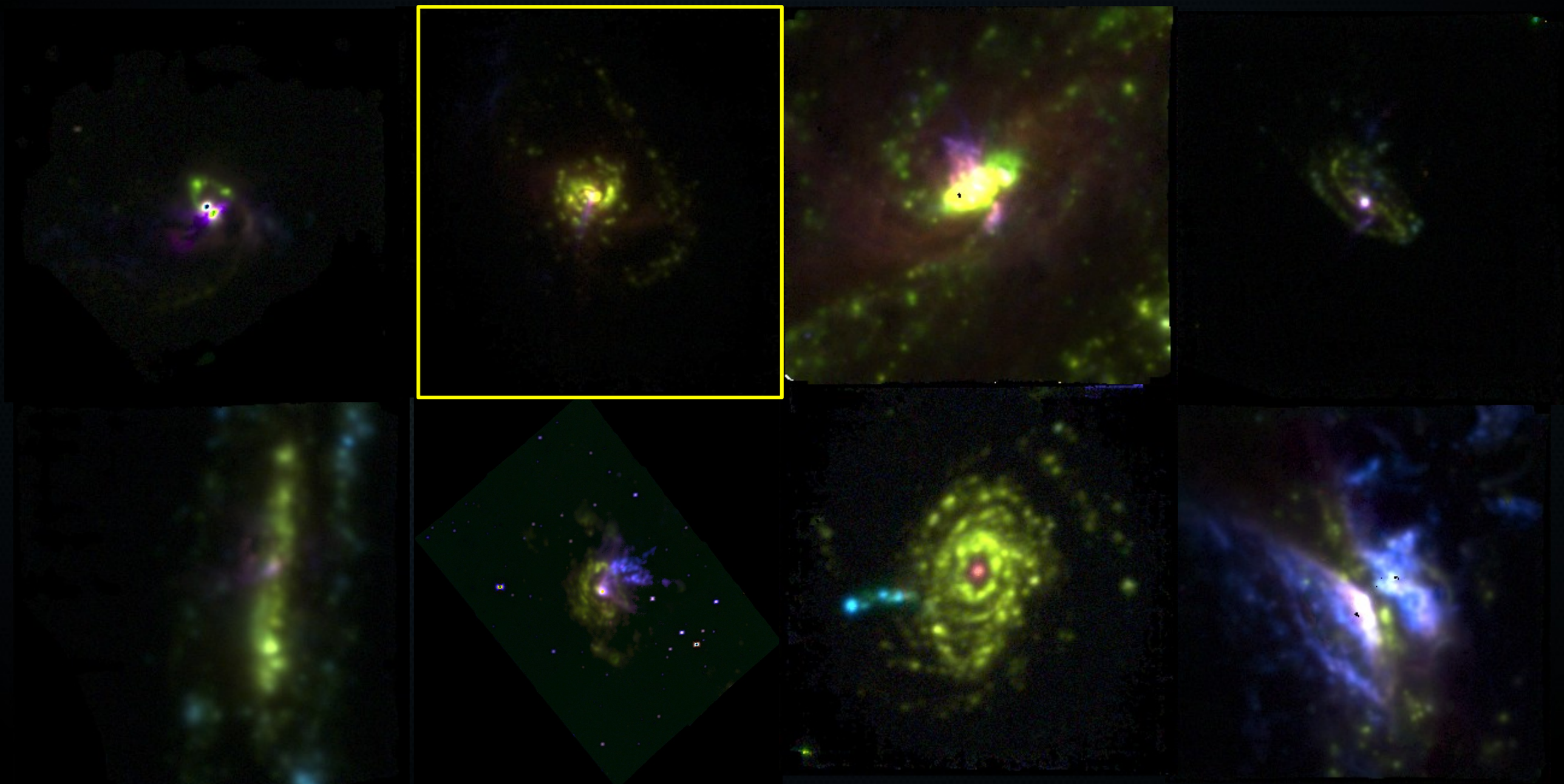
FoV 1' x 1', 0.2“/pix, R ~ 3000



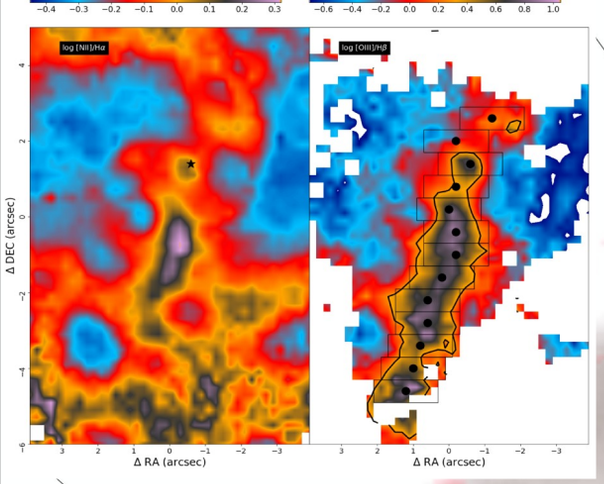
r: [NII], g: Ha, b: [OIII]

muse
multi unit spectroscopic explorer

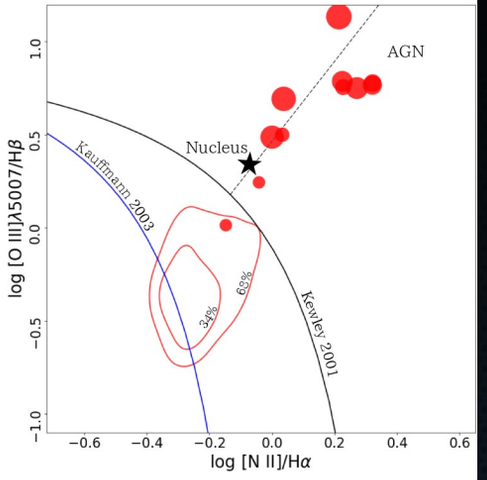
FoV 1' x 1', 0.2“/pix, R ~ 3000



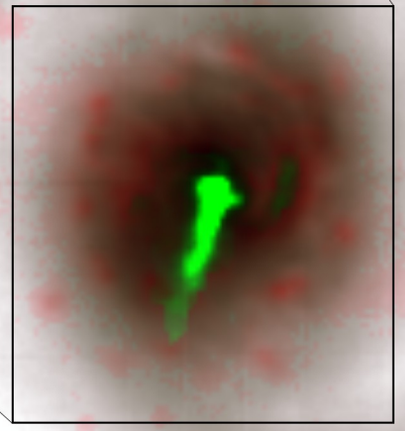
López-Cobá +17, ApjL

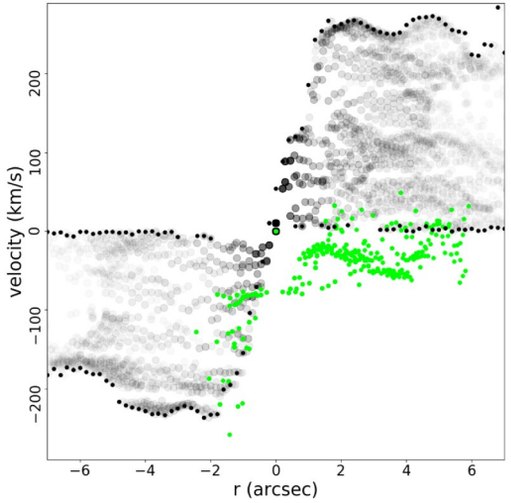


Spatially resolved maps of the log [O III]/Hβ and log [N II]/Hα line ratios zoomed around the jet-structure. Boxes of 1.8"x0.6", centered in the peak intensity of the [O III]/Hβ ratio, are drawn along the jet-structure. The black contour defines the jet-structure.



BPT diagram. The maximum red contour enclose the 68% of the total spaxels of the data cube lying outside the jet-structure. The red circles are the location of the boxes (in the log [O III]/Hβ map) along the jet-structure. The black star represent the box containing the nucleus.



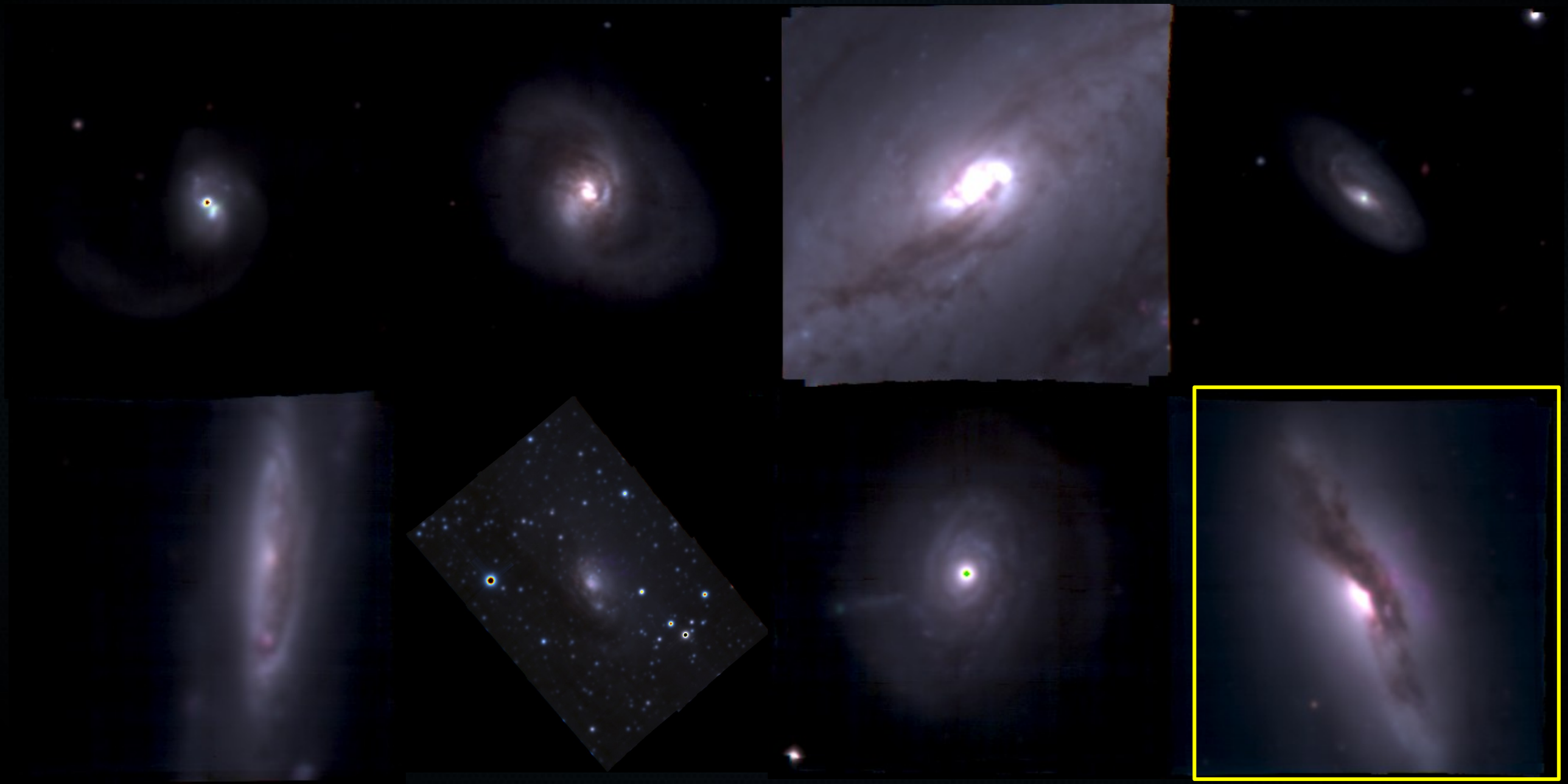


Rotation curve (Hα) for NGC 232. The green dots represent the rotation curve of the jet-structure ([OIII]λ5007), which is clearly decoupled from the disk kinematics.

+ proposal: VLA/18A-037

color-code
Red: Hα
Gray: *i*-band
Green: [O III]λ5007

Imagenes del conttinuo de galaxias de MUSE



Otra mas ..



Perfiles dobles por todos lados!!

Imagen compuesta r,i,Halpha,OIII

Conclusions

- We have performed an unbiased serch for outflows in the Local Universe (CALIFA)
- We have found that only 2 % of galaxies from CALIFA (total sample) present an outflow. This is in agreement with a similiar study in SAMI (Ho + 2016).
- There is a real increase in the SFR surface density in the inner regions of the ouflows galaxies (r<1.3 Re).
- Those ouflows galaxies seems to be NSFG.

Thank you !

Gracias !

Nib'oolal