“How often are the Outflows in the Local Universe: A systematic study using CALIFA”

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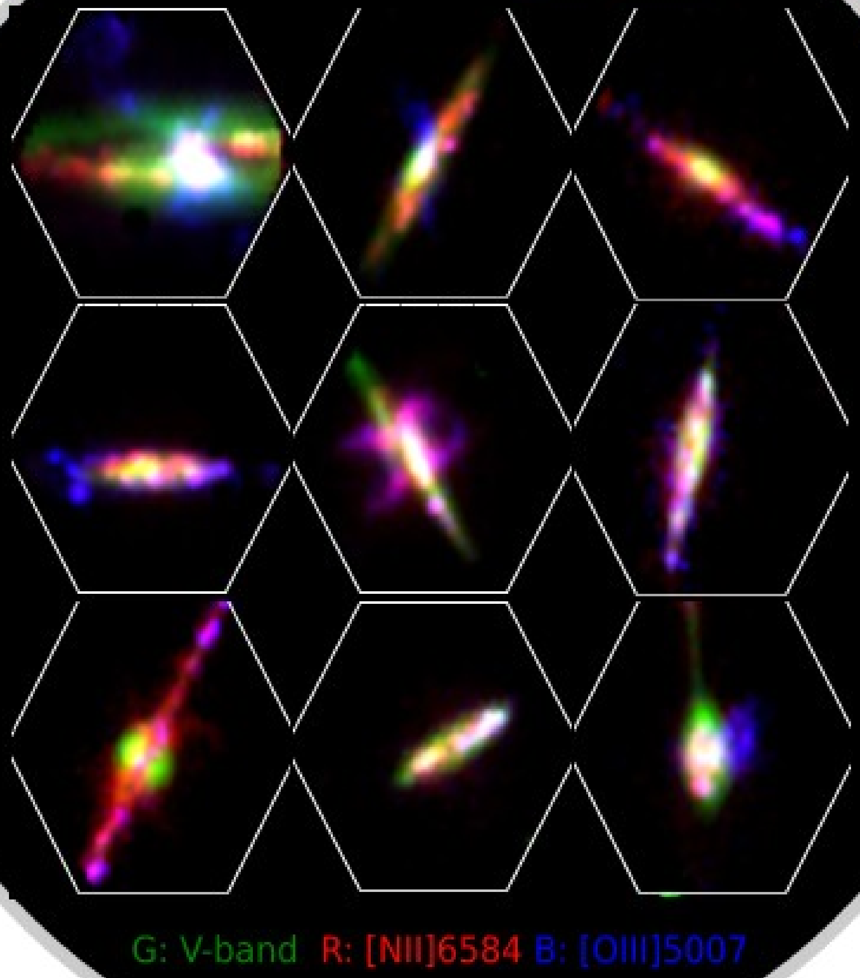
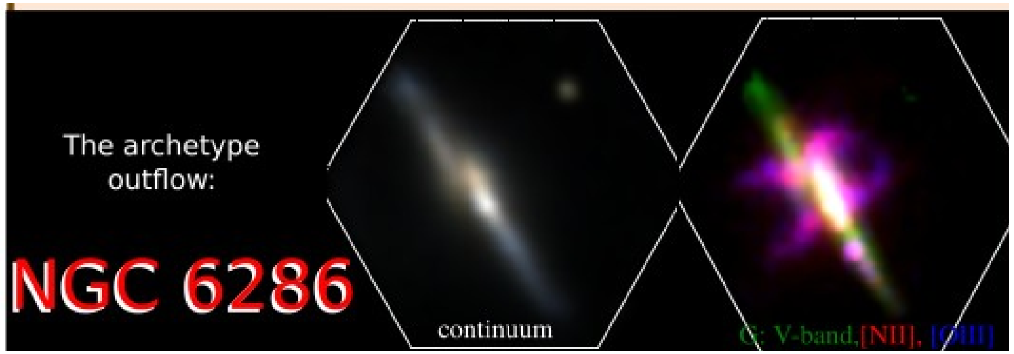




GUILLERMO HARO PROGRAM 2018

Tonantzintla, Puebla, Mexico

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

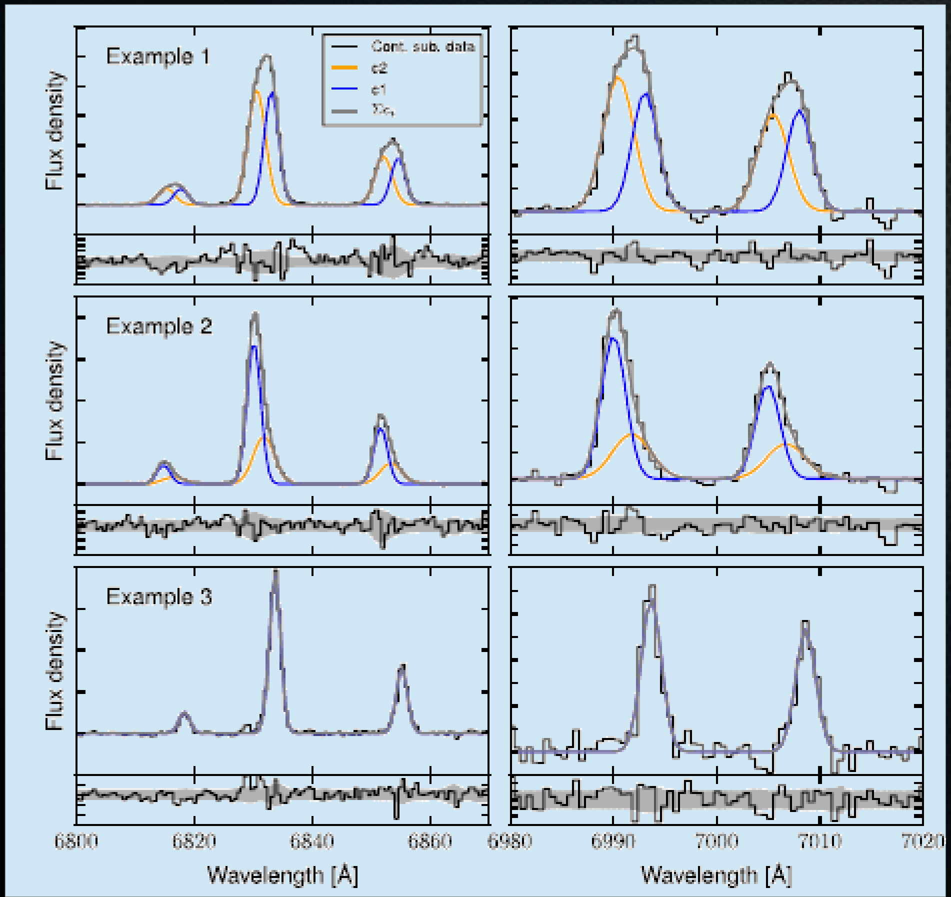
- Outflows in other IFS surveys: MUSE

- Conclusions

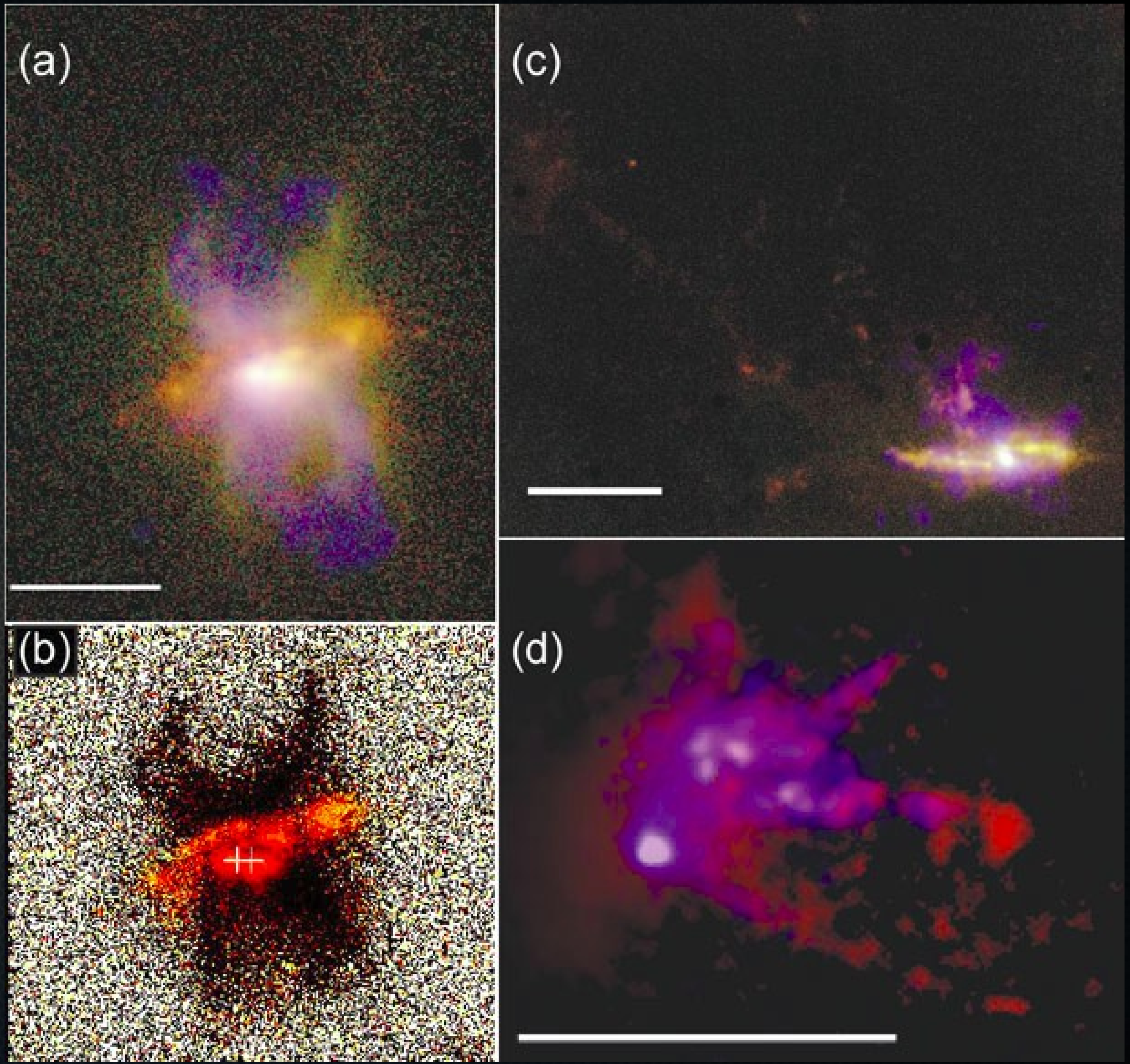
Introduction

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

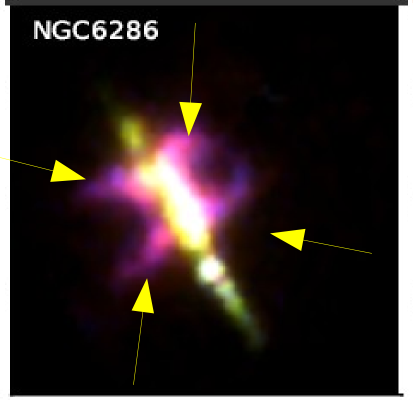
Complex kinematic: double picked → shocked layer

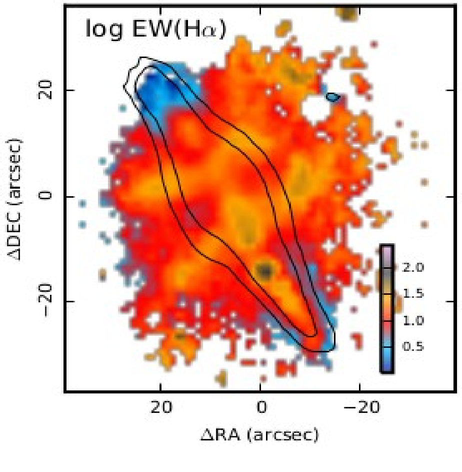


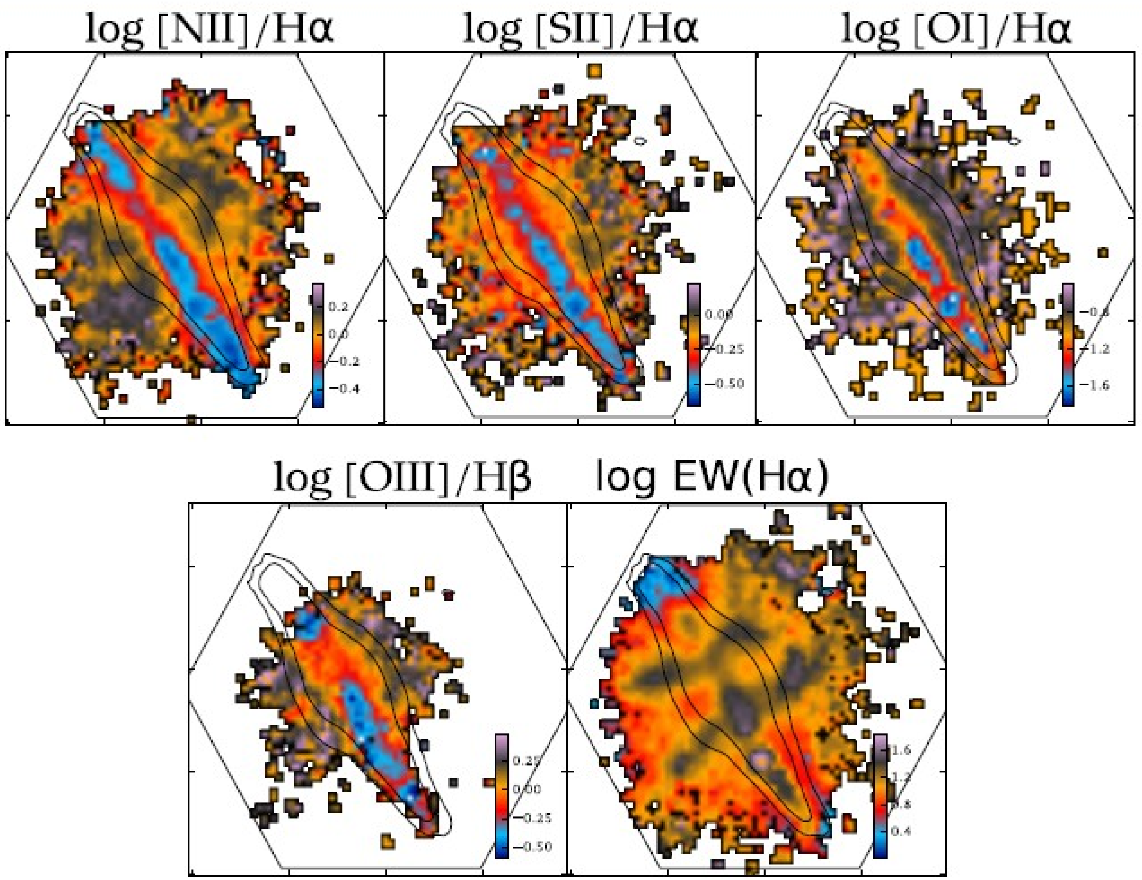
Ho + 2016



Veilleux + 2005



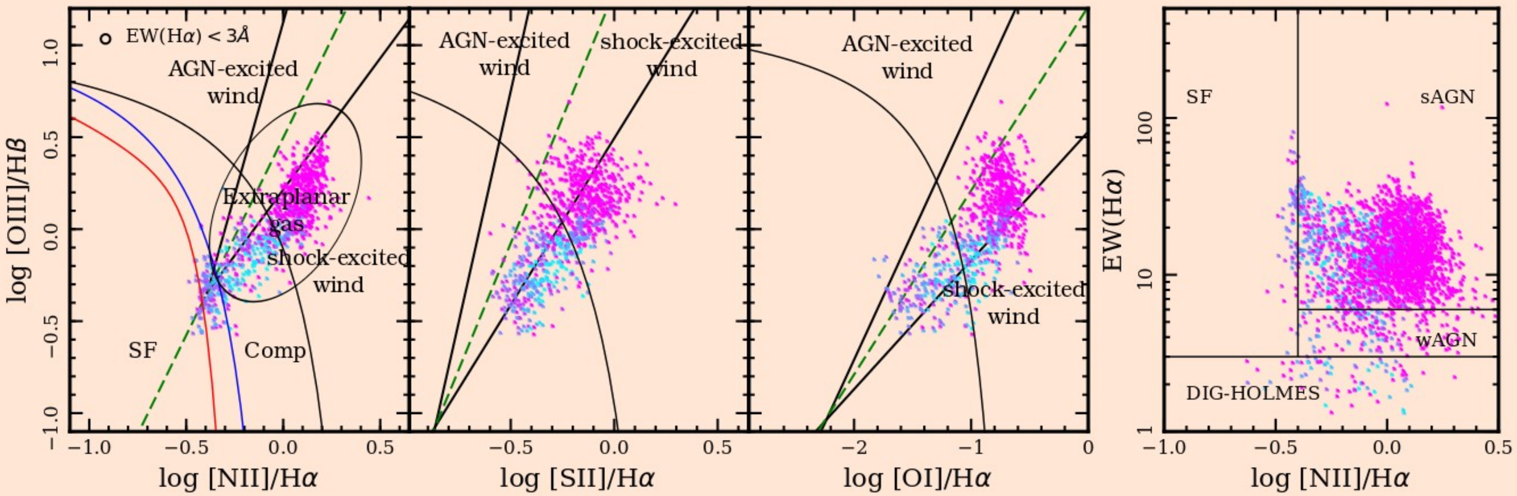




Systematic study of outflows in the Local Universe: CALIFA[1]

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

Archetype of an *outflow*: NGC 6286



- WHAN diagram, Cid Fernades+ 2010

- AGN-shock excited winds demarcations, Sharp & Bland-Hawthorn 2010

- fitting continuum and emission line analysis with Pipe3d & fit3d, Sanchez +2016ab

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

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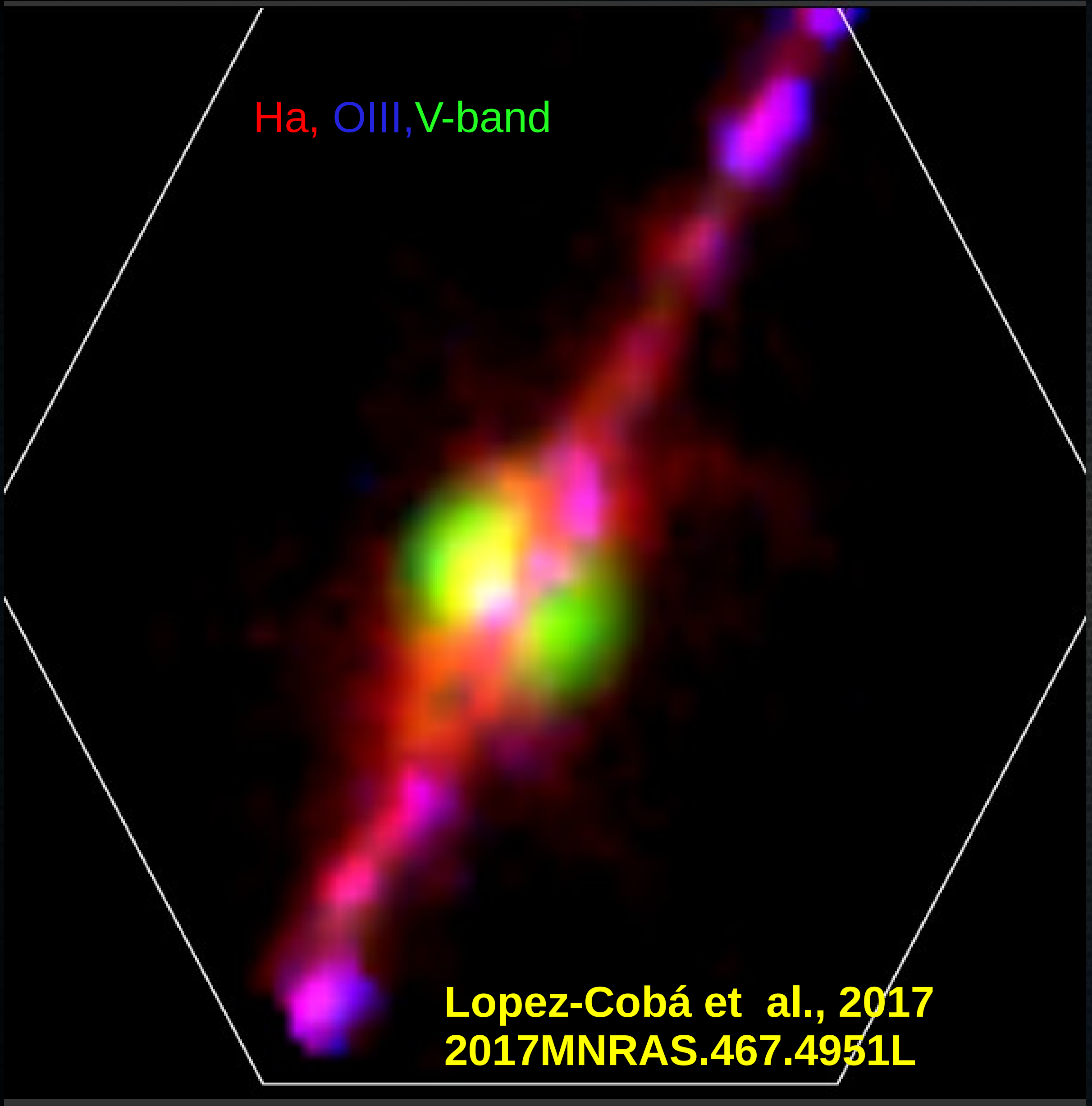
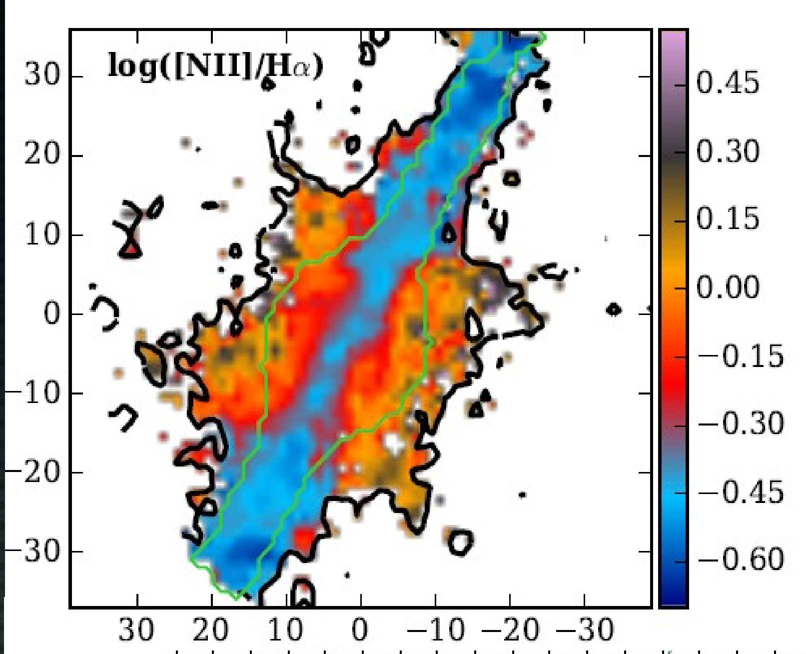
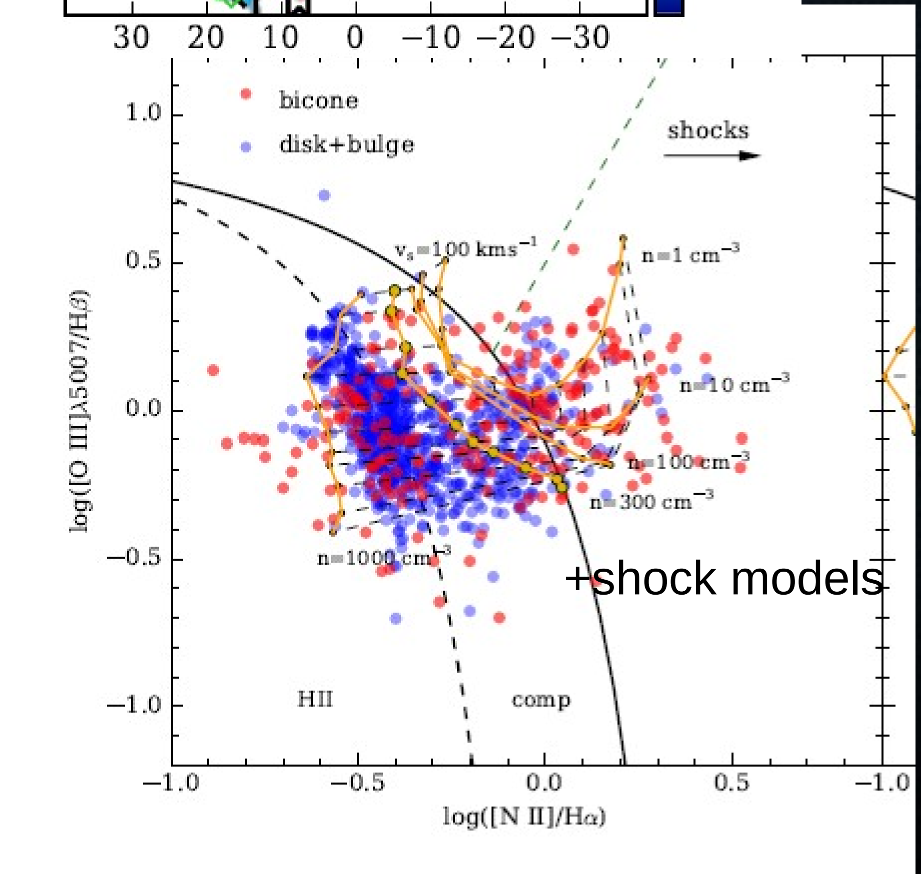
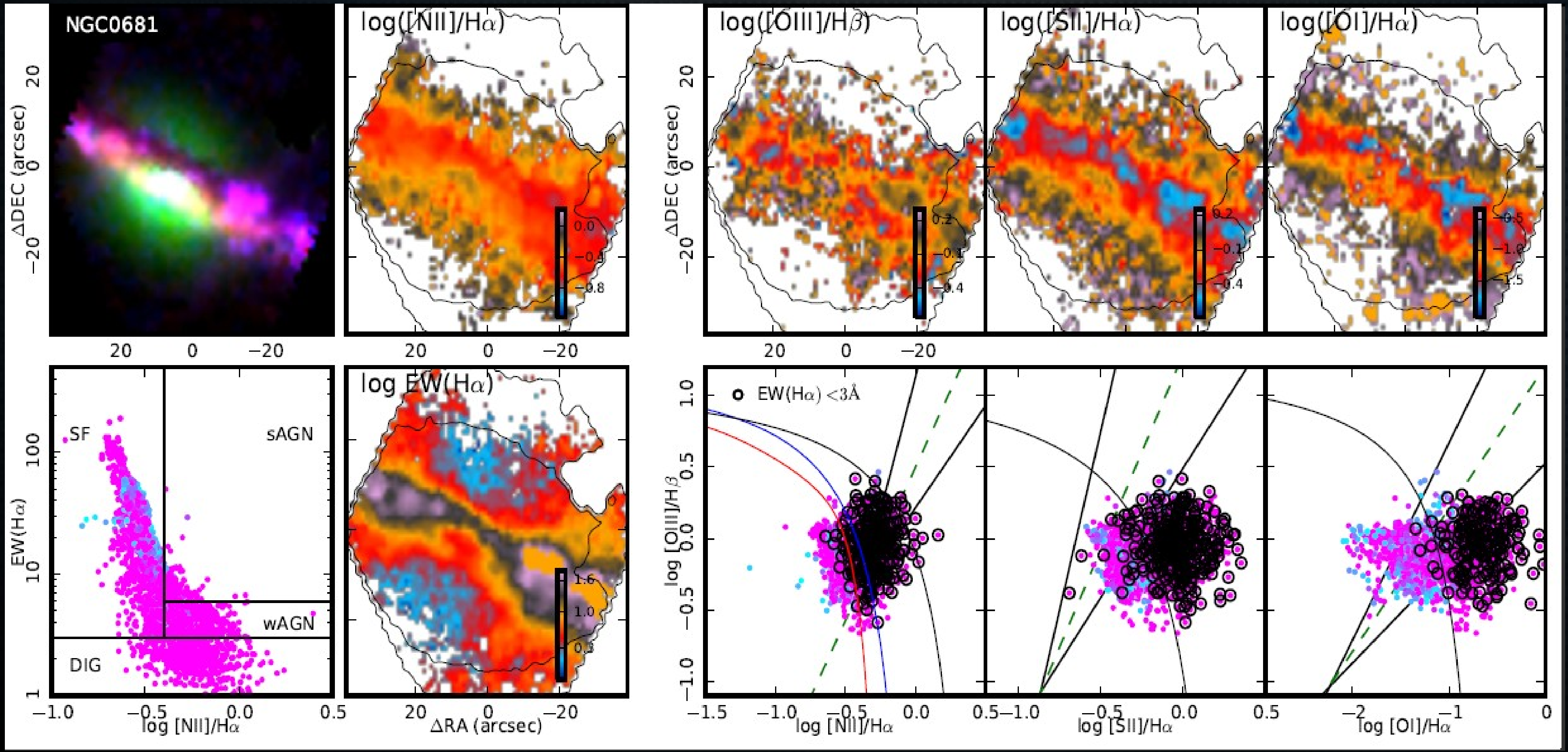

Ha, OIII,V-band
Lopez-Cobá et al., 2017
2017MNRAS.467.4951L

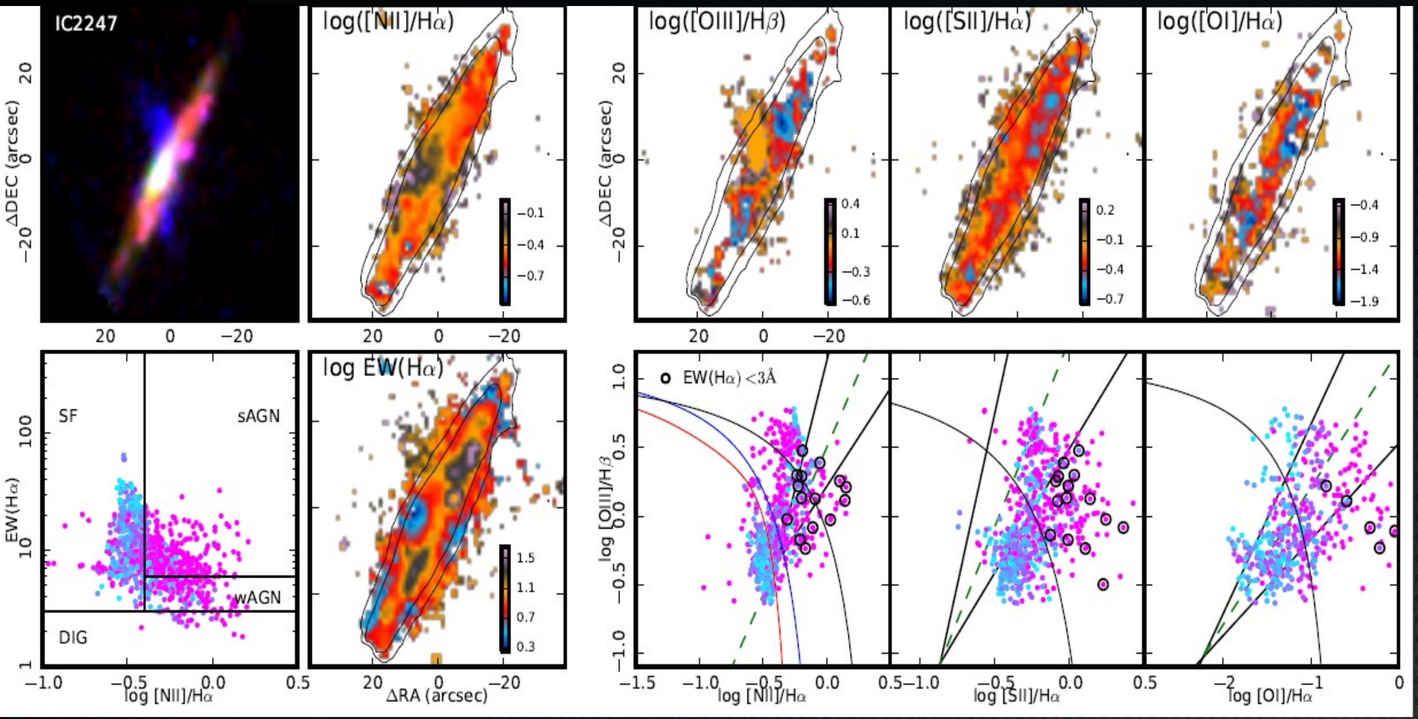

log([NII]/Hα)
0.45
0.30
0.15
0.00
−0.15
−0.30
−0.45
−0.60
30 20 10 0 −10 −20 −30


bicone
disk+bulge
shocks
v_s=100 kms^{-1}
n=1 cm^{-3}
n=10 cm^{-3}
n=100 cm^{-3}
n=300 cm^{-3}
n=1000 cm^{-3}
HII
comp
log([O III]λ5007/Hβ)
log([N II]/Hα)
+shock models

Not all the extraplanar gas is asociated with outflows

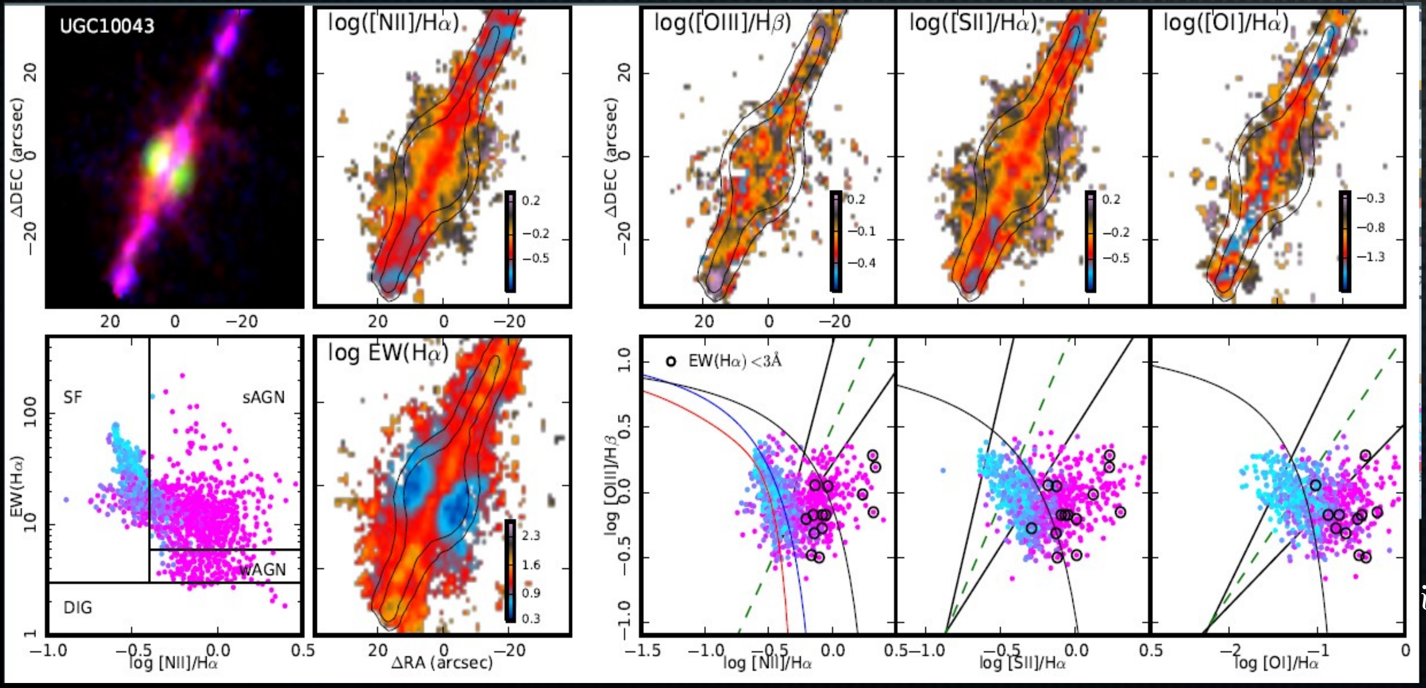
- Low EW(Ha) < 3A → HOLMES (Post AGB, white dwarfs)
  Binette+1994, Stasinska+2008,Flores+2011



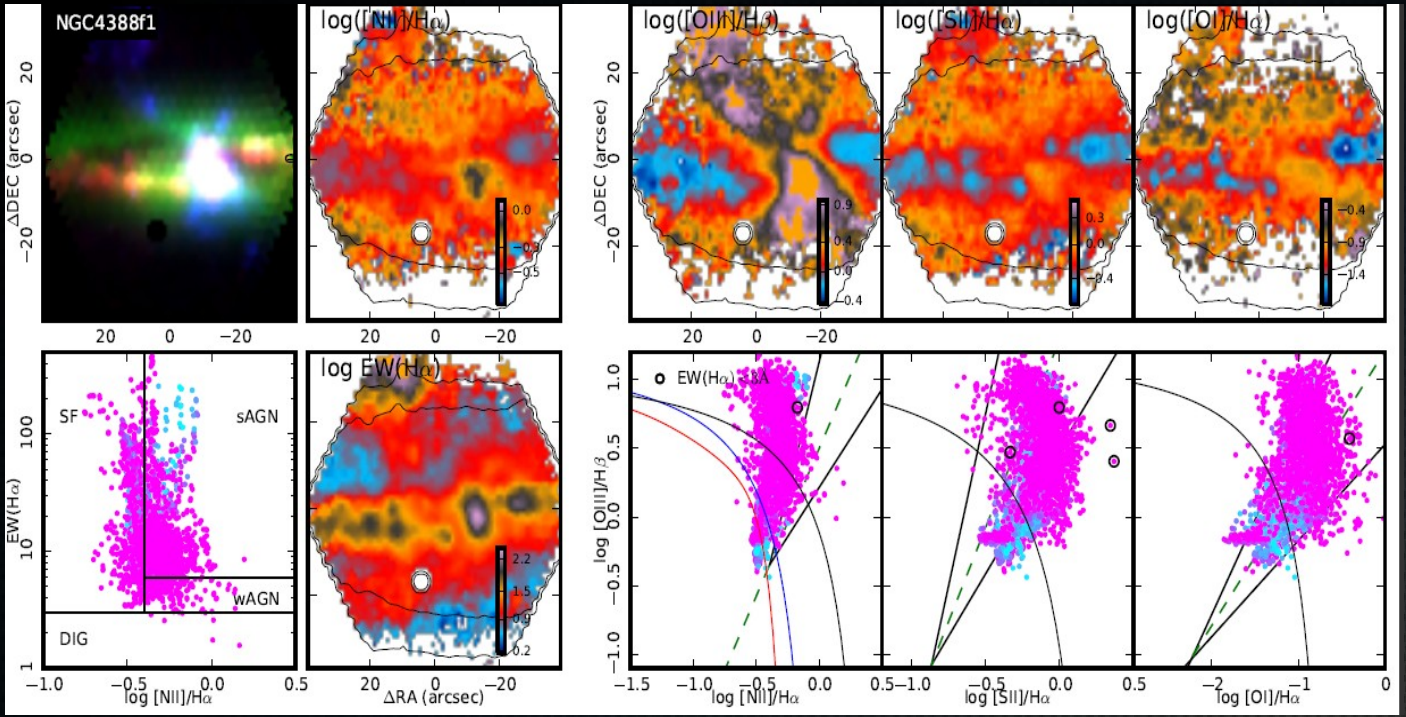


What dominates the ionization in the extraplanar gas ?
DIG, AGN-excited wind, shock-excited wind

AGN : 29% **SHOCK: 69 %** **DIG: 2 %**



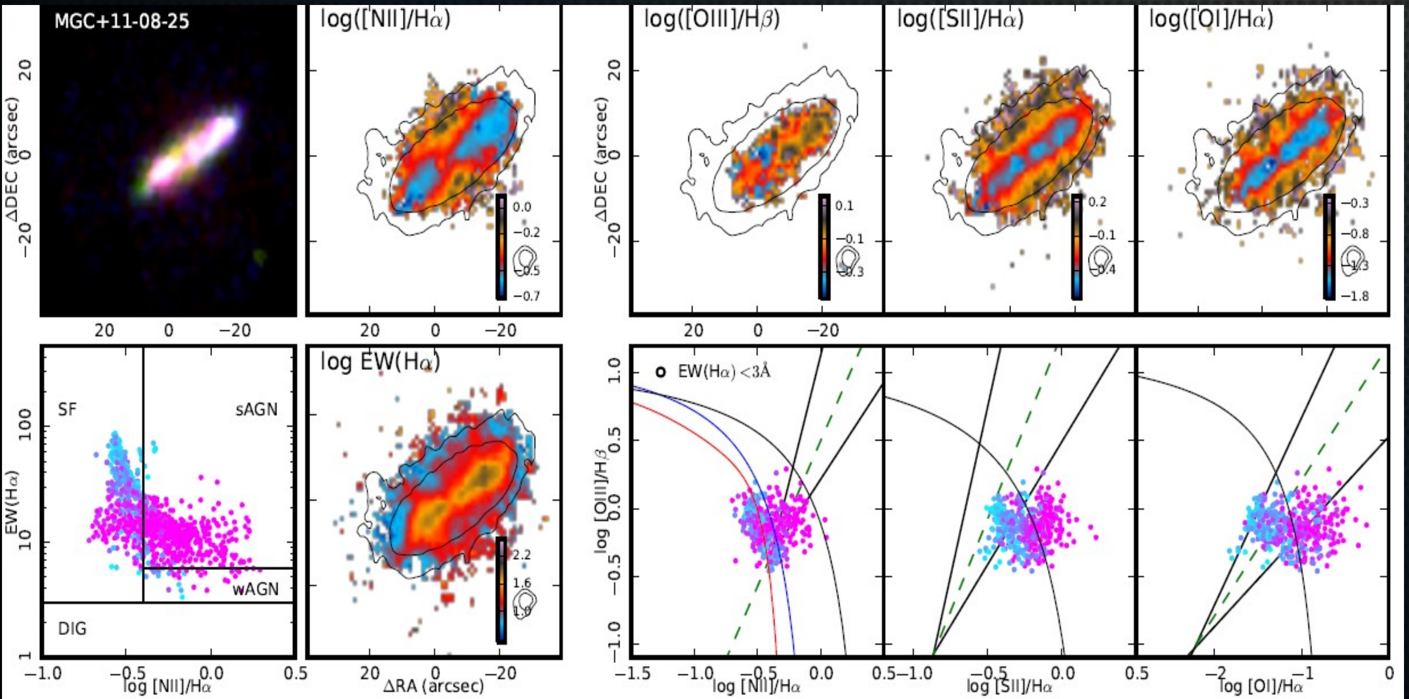
AGN : 1% **SHOCK: 94 %** **DIG 5 %**



AGN : 60%

SHOCK: 40 %

DIG 0 %



AGN : 0%

SHOCK: 100 %

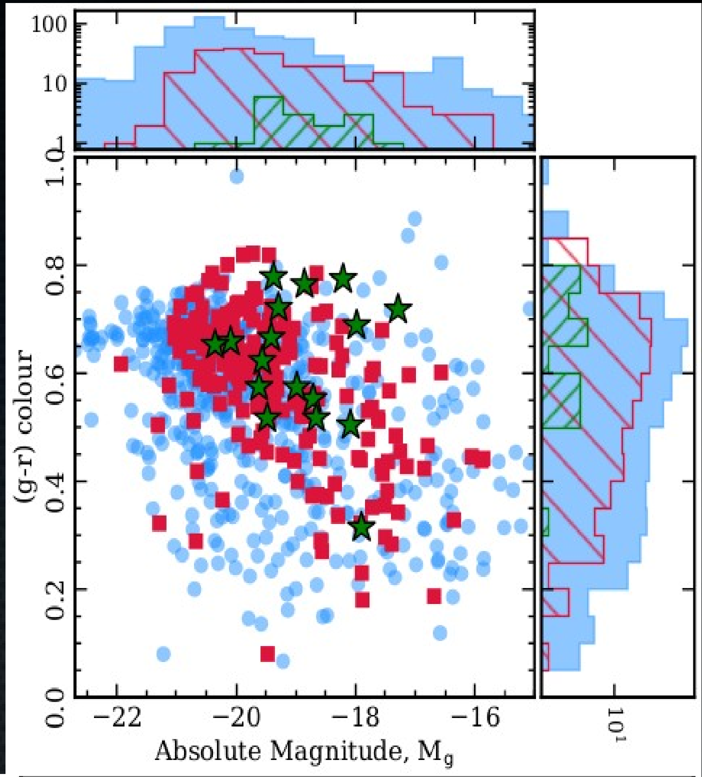
DIG 0 %

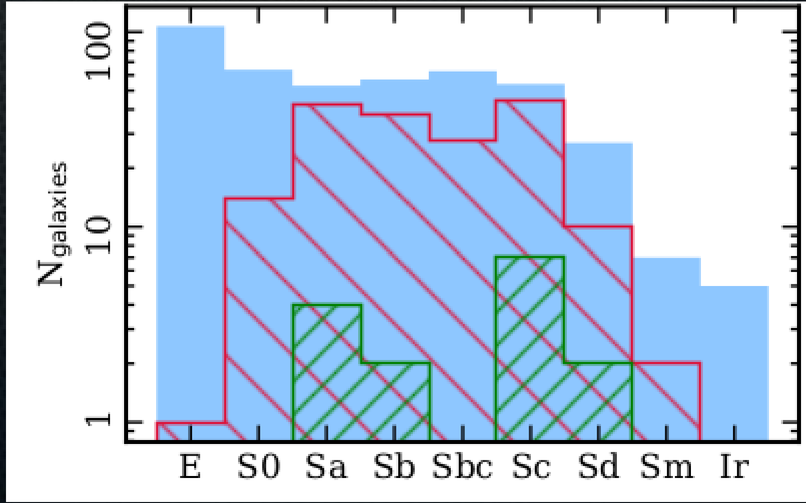
Global properties of the samples

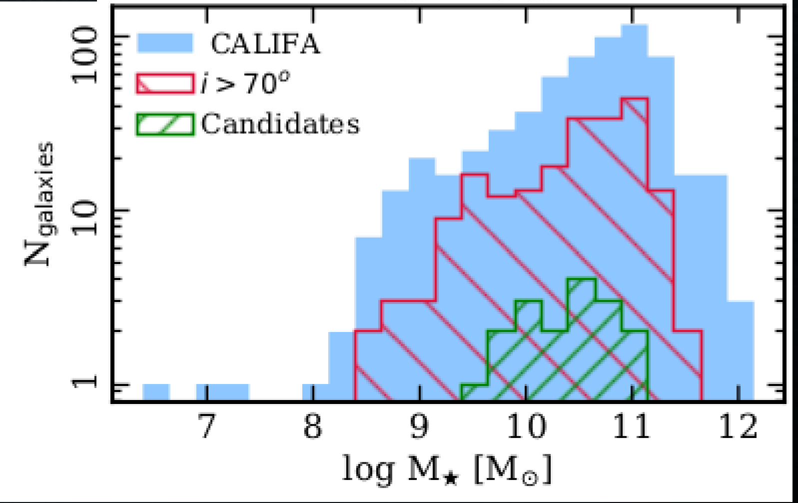
Criterion used to select outflows

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

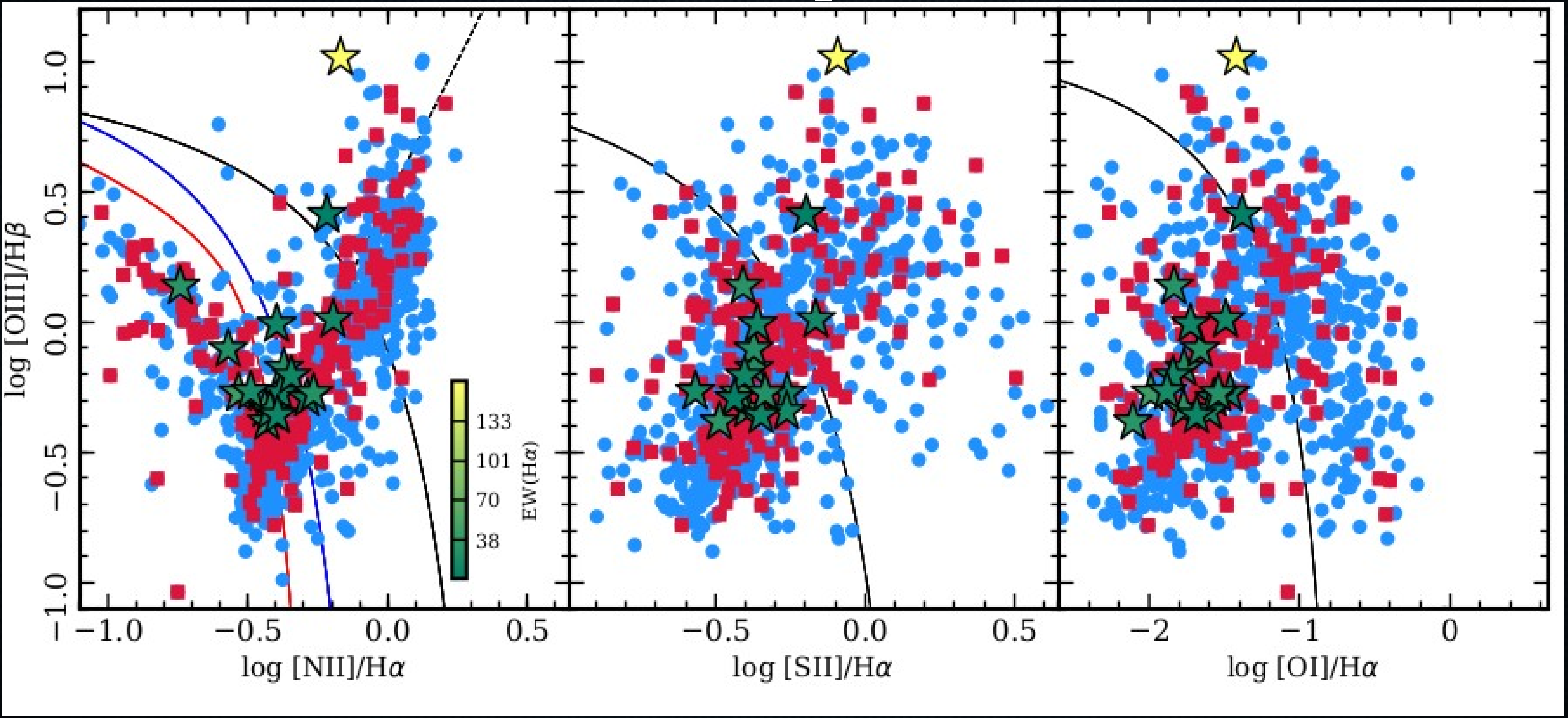
i< 70^o (CALIFA subsample): 615 galaxies
i>70^o : 203
Candidates: 17/44 (2% of total)





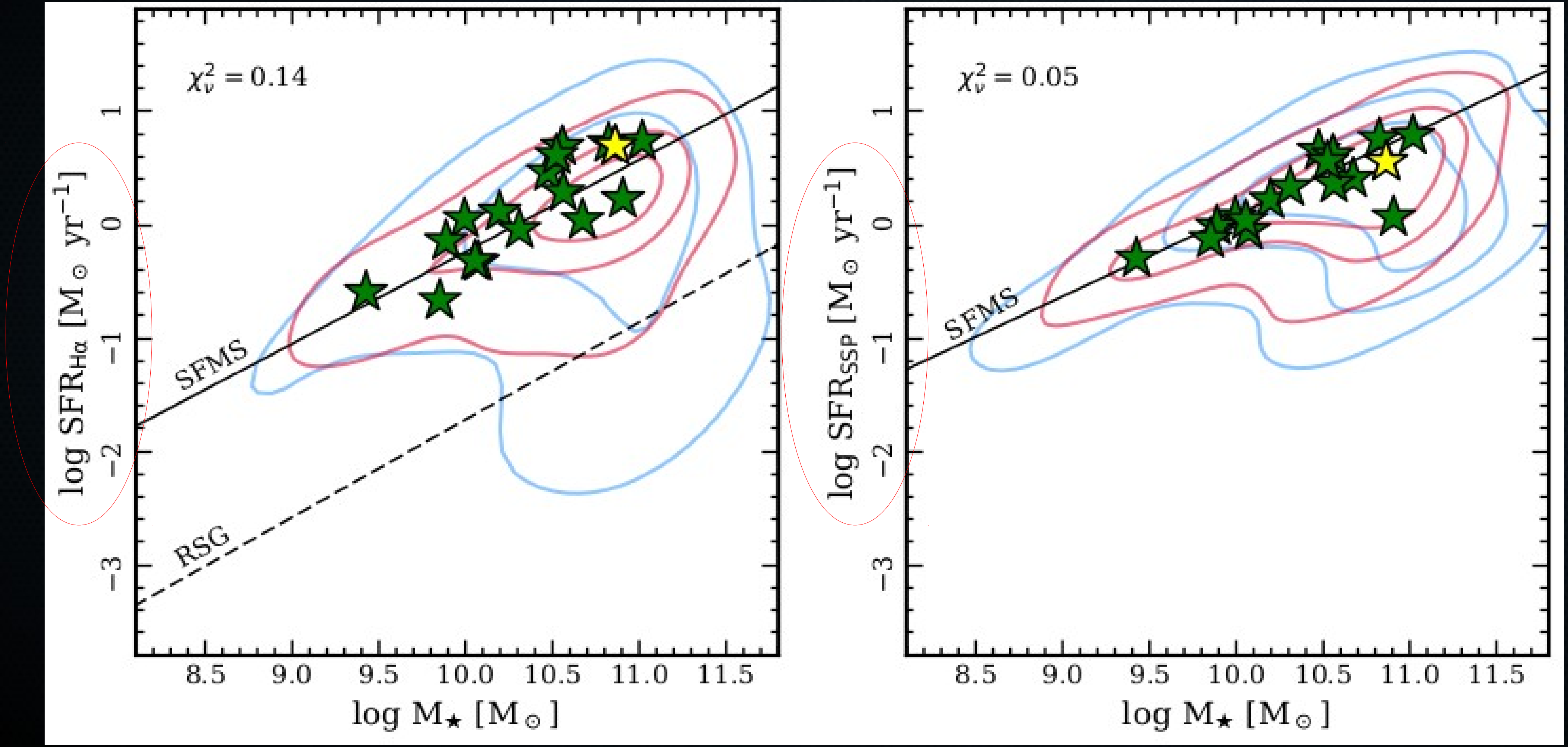


Dominant ionization in the nucleus of the samples

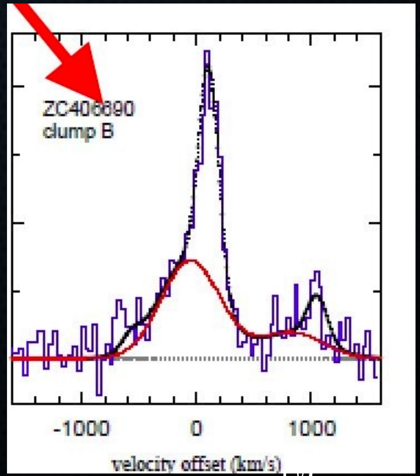


Do the galaxies hosting outflows present an increase in their SFR?

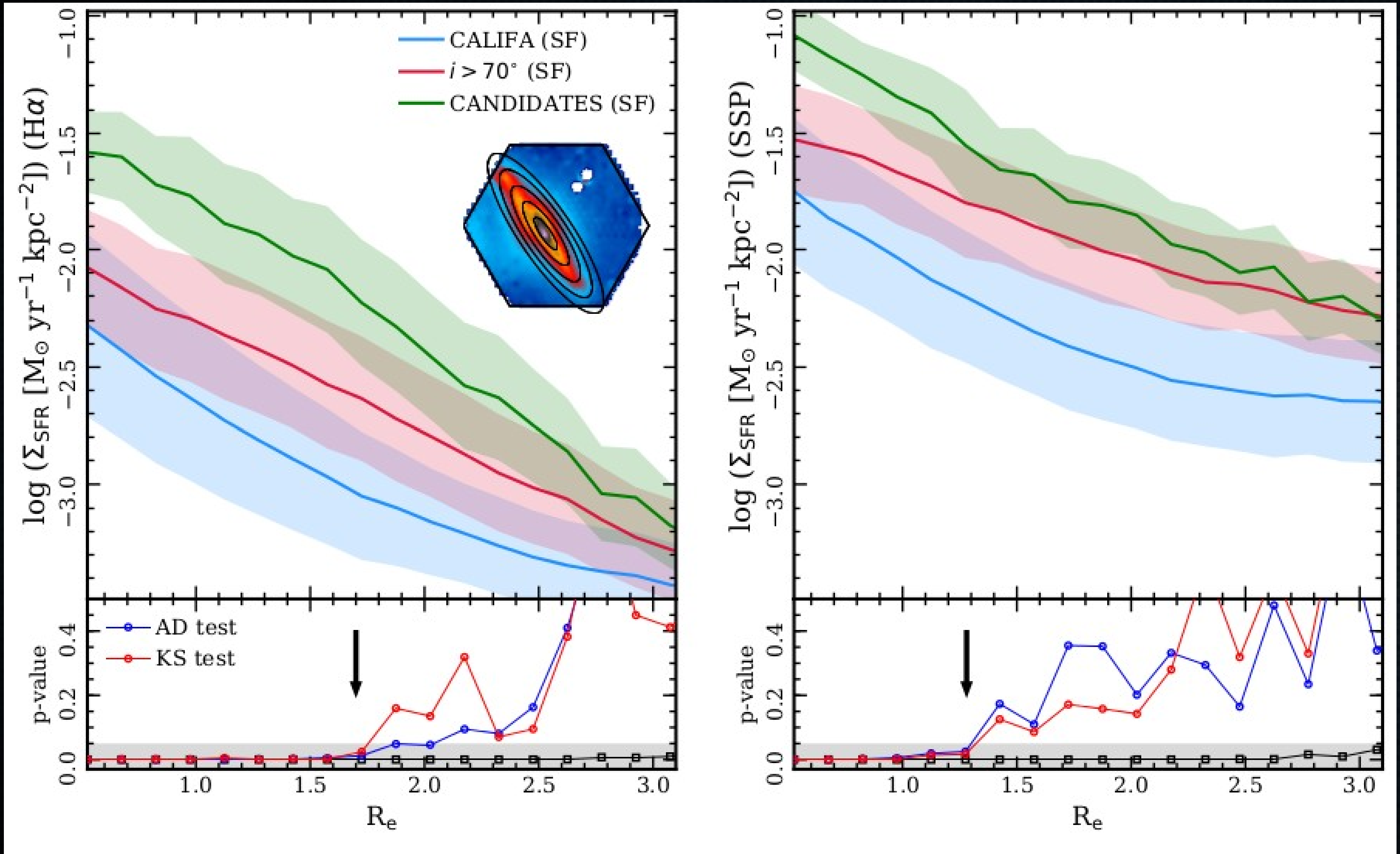
global SFR



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 surpas the threshold

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)* "

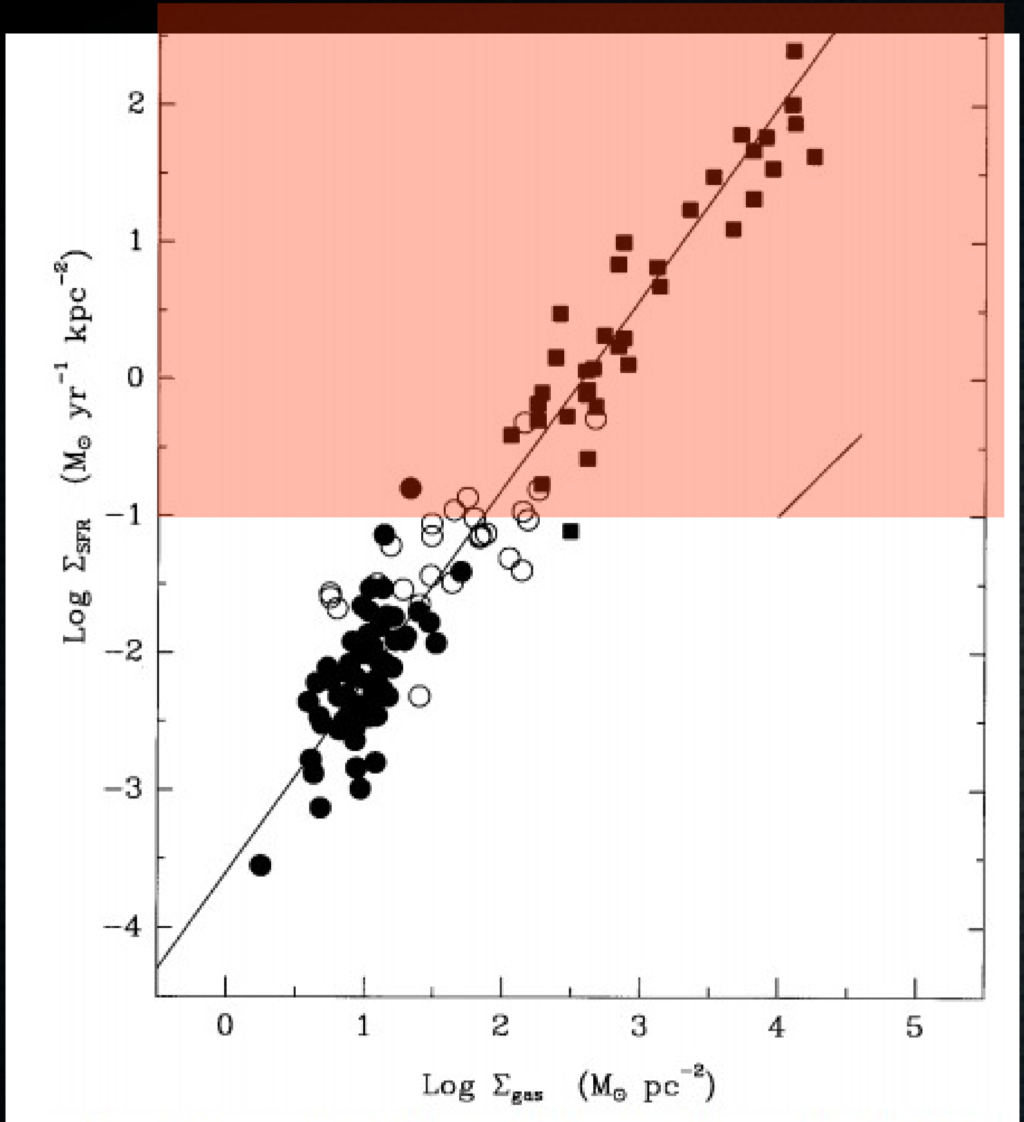


FIG. 6.—Composite star formation law for the normal disk (*filled circles*) and starburst (*squares*) samples. Open circles show the SFRs and gas densities for the centers of the normal disk galaxies. The line is a least-squares fit with index $N = 1.40$. The short, diagonal line shows the effect of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

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, $\dot{\Sigma}_*$, exceeds a threshold value of $\dot{\Sigma}_{*,crit} = 0.1$ $M_\odot$ yr^{-1} kpc^{-2}, a finding that is also

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

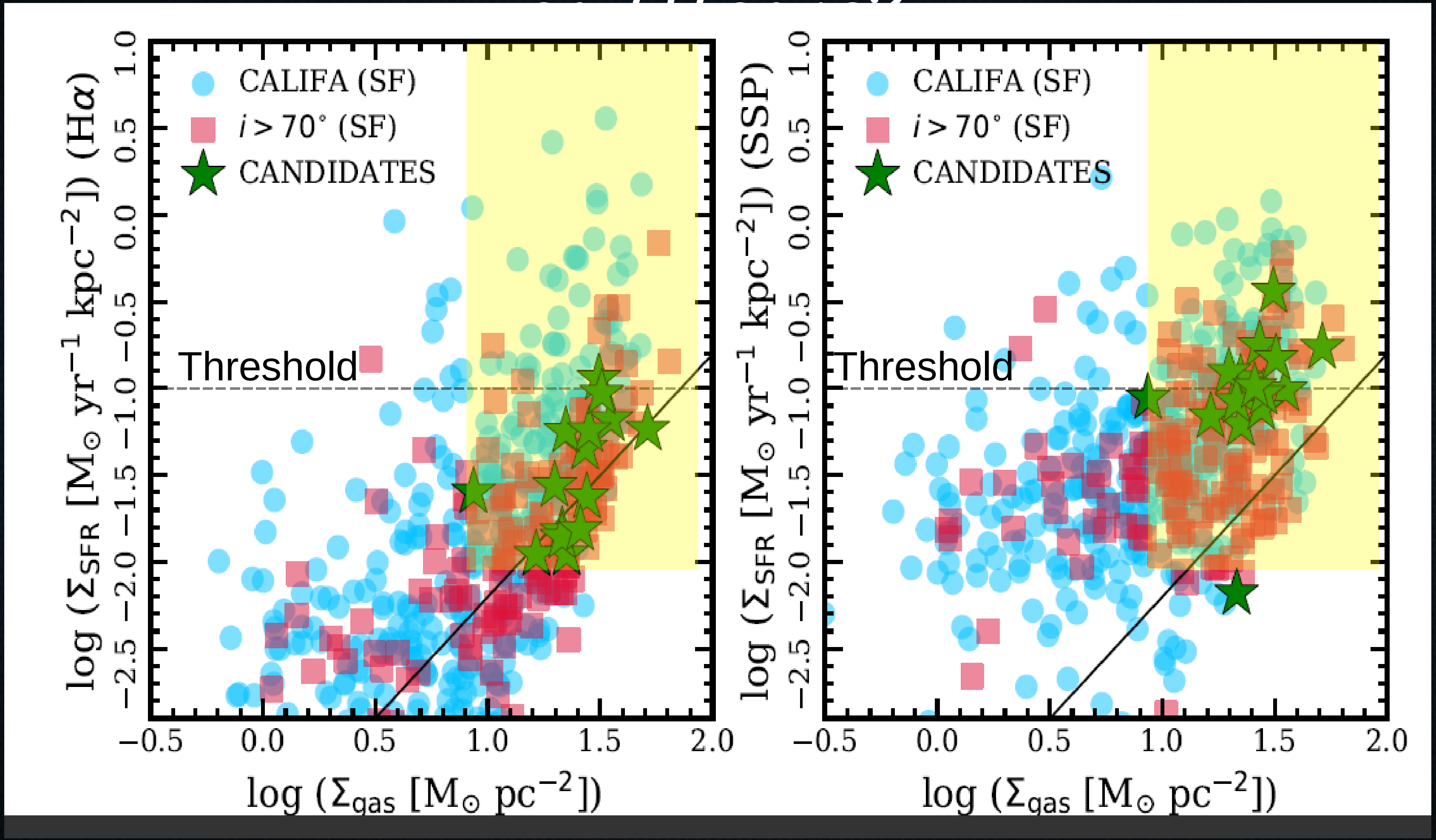
Observations show that cold outflows occur in galaxies with a high SFR per surface area, Σ_{SFR}. Typically, outflows are observed if $\Sigma_{SFR} > 0.1$ $\mathcal{M}_\odot$ yr^{-1} kpc^{-2} (Heckman 2002; Chen et al. 2010). This limit is supported by theoretical modelling (Murray et al. 2011; Scannapieco 2013). We calculated Σ_{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 $A = \pi R_P^2/3.7$, where R_P is the Petrosian radius, which will result in slightly lower values of Σ_{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 $M_\odot$ yr^{-1} 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 $(\Sigma_{SFR}/[M_\odot\ yr^{-1}\ kpc^{-2}]) > -1$ (see also the results of Sharma et al. 2017). In our sample, $\log(\Sigma_{SFR,max}/[M_\odot\ yr^{-1}\ kpc^{-2}]) = -1.95$, almost a dex lower.[12]

yr^{-1} for this galaxy we calculate an SFR surface density of $\Sigma_{SFR} = 0.014 \pm 0.001$ $M_\odot$ yr^{-1} kpc^{-2}. Such a Σ_{SFR} is an order of magnitude smaller than the threshold of $\Sigma_{SFR} \gtrsim 0.1$ $M_\odot$ yr^{-1} 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



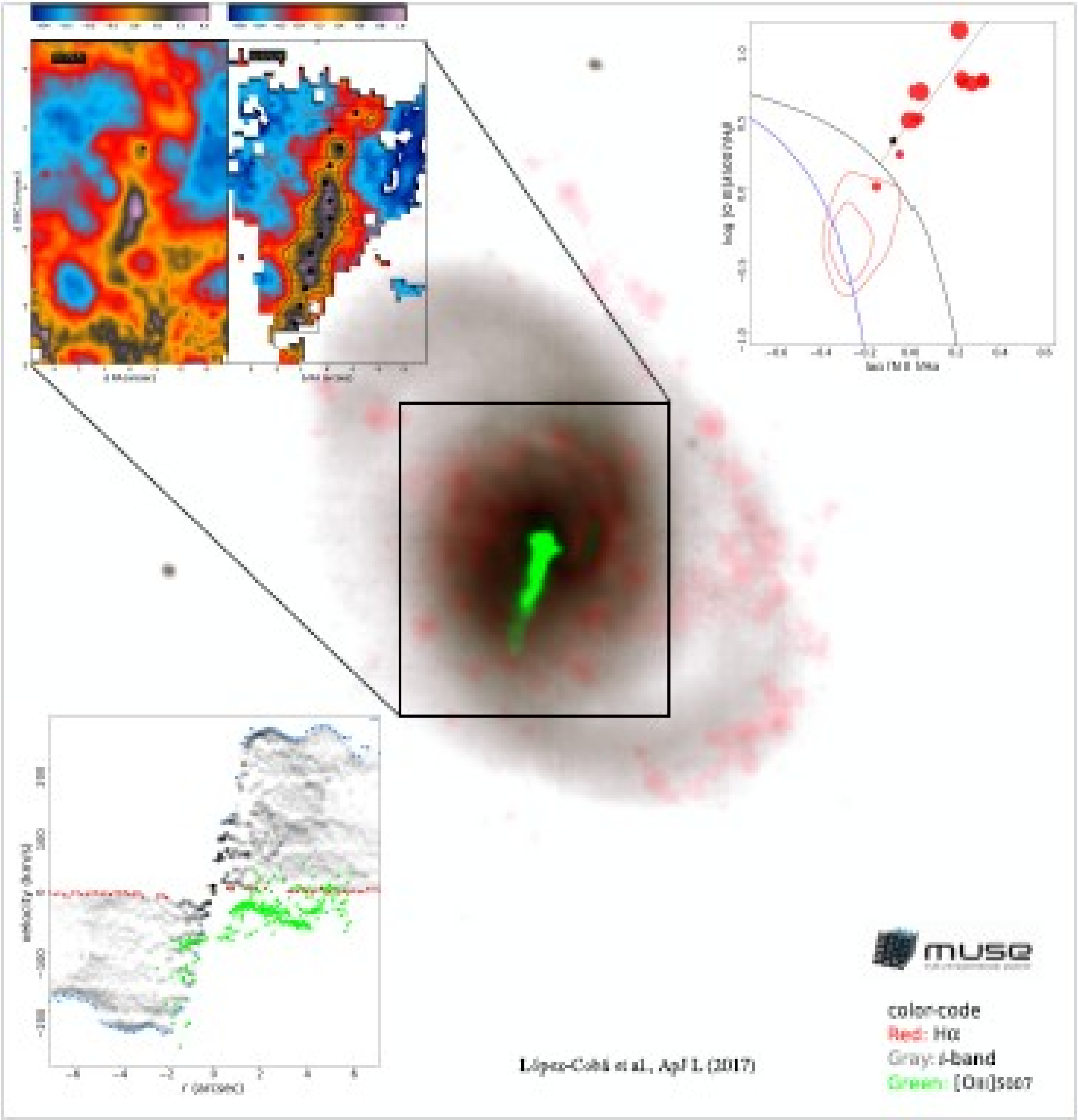
FoV 1' x 1', 0.2"/pix, R ~ 3000

Searching outflows in MUSE (in prep...)

muse
multi unit spectroscopic explorer

FoV 1' x 1', 0.2"/pix, R ~ 3000

Searching outflows in MUSE (in prep...)



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Serendipitous Discovery of an Optical Emission-line Jet in NGC 232

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2017ApJ...850L..17L

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