A census of ionising conditions in the local universe from CALIFA

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Outline

1. CALIFA as a volume-representative sample of galaxies;

   Estimating population properties from the CALIFA sample

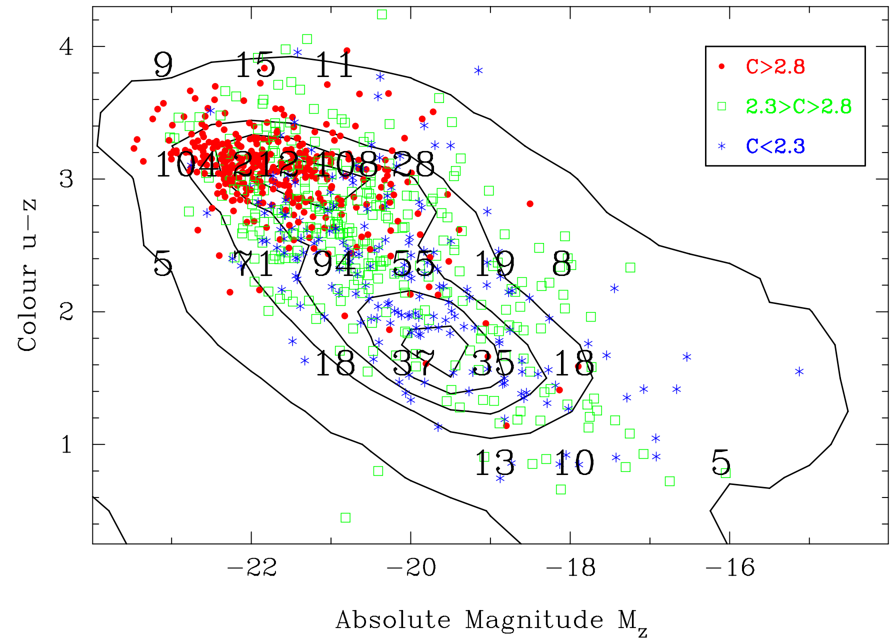
2. A volume-corrected BPT diagram;

   Boundaries of BPT domains

How representative for galaxies is the CALIFA sample?

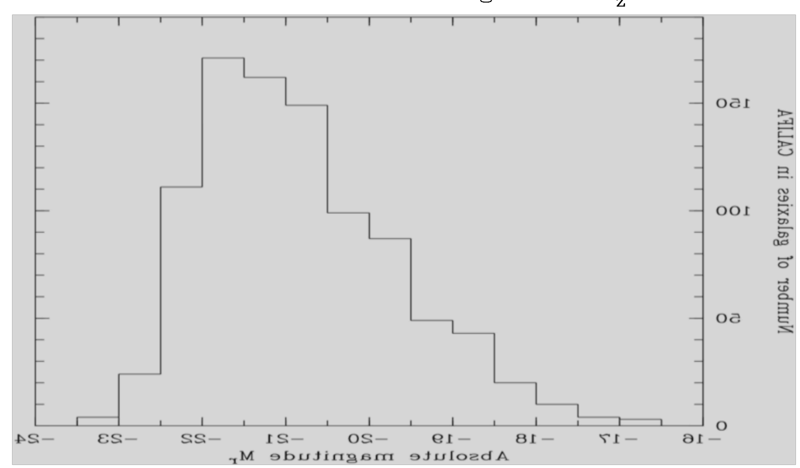
(and what do we mean by ``representativity´´?)

CALIFA objects cover the full range of galaxy locations in the colour-magnitude diagram:



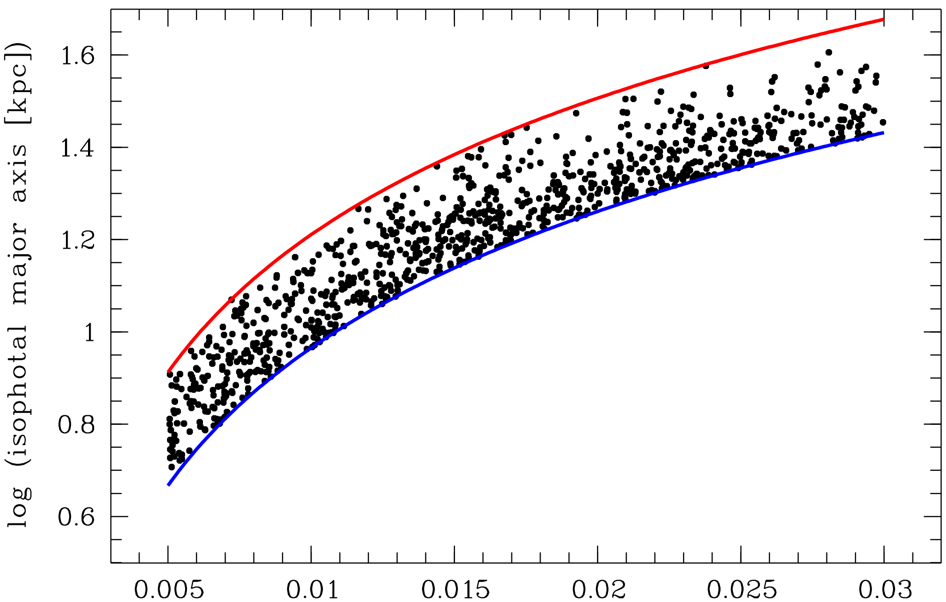
but the relative numbers reflect the sample selection criteria and not population properties!

(N.B.: the same is true for SDSS and any other survey!!!)



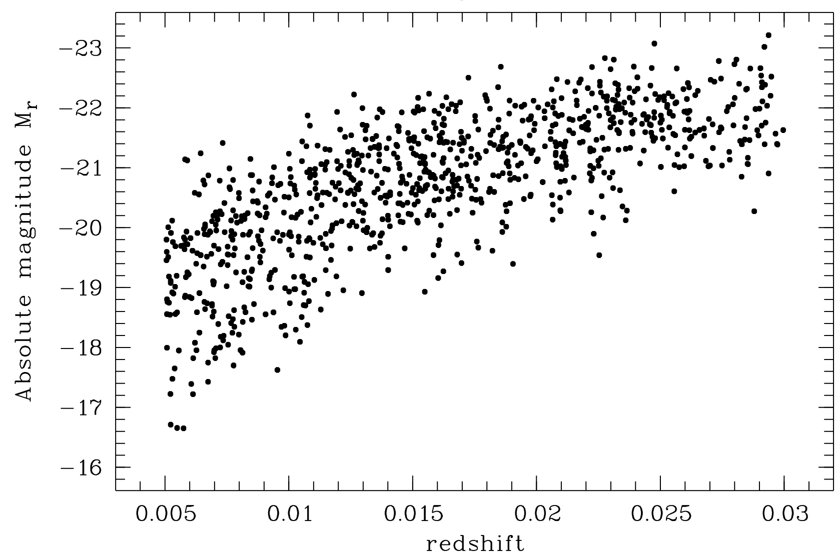
CALIFA selection criteria

- Footprint: inherited from SDSS DR7 photometric catalogue; Ω = 8700 deg2
- Redshift: $0.005 < z < 0.03$
- Angular isophotal major axis at 25 mag/arcsec2: $45'' < isoA_r < 79.2''$



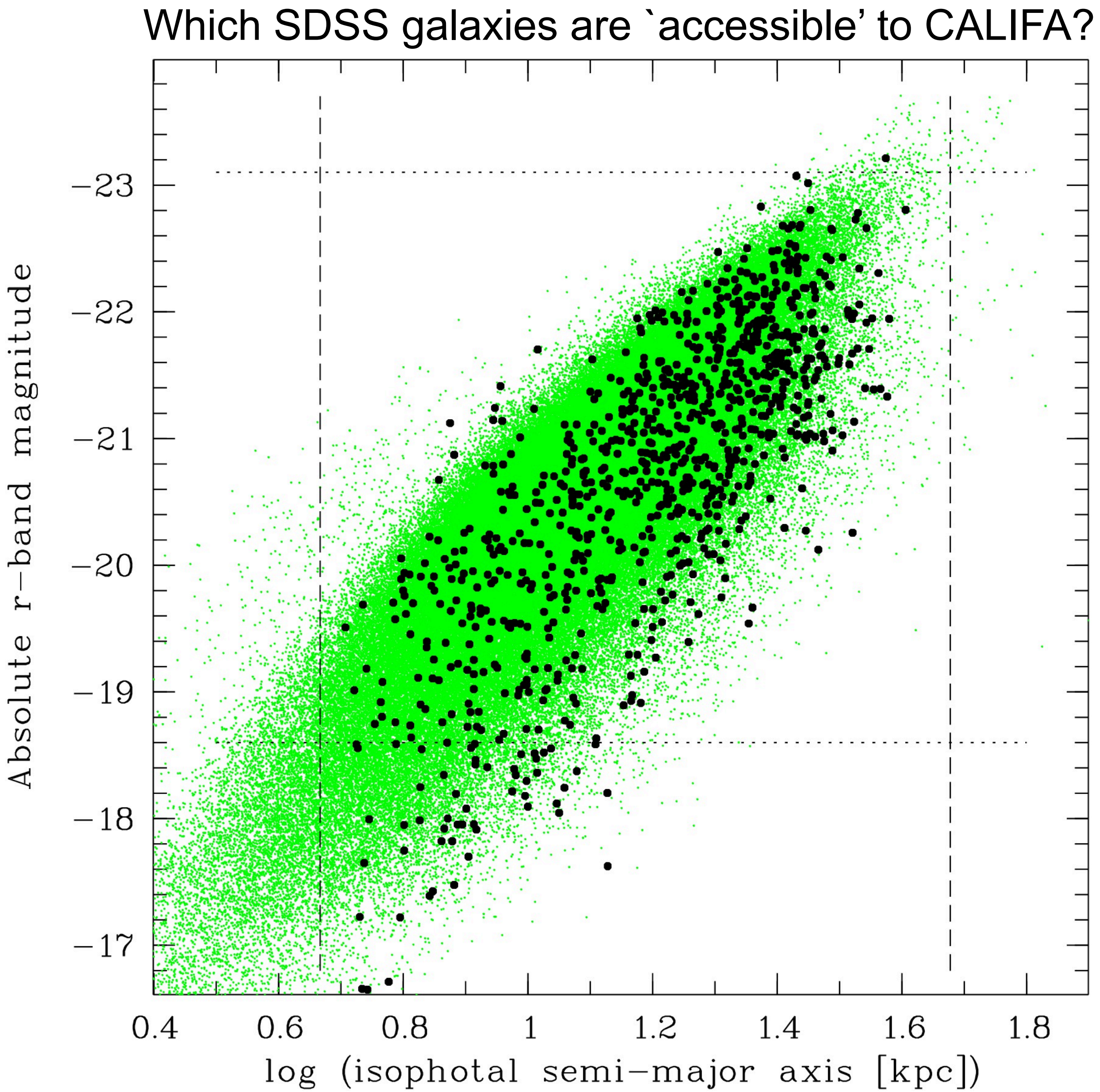
⇒ 937 galaxies within footprint.

in absolute magnitudes:



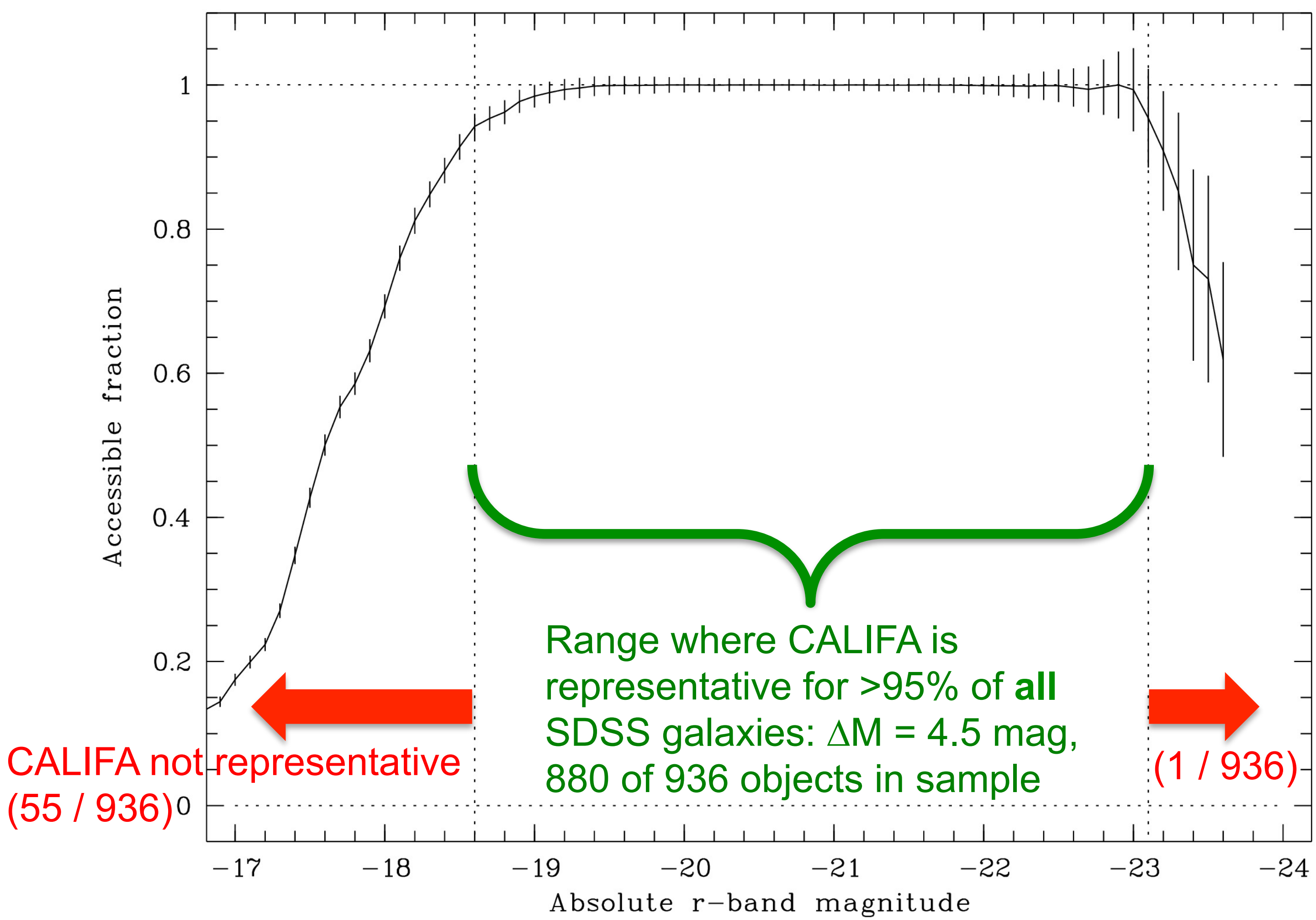
Plots on this and following pages will be published in CALIFA sample characterisation paper:
Walcher et al, to be submitted

Does CALIFA have a complicated selection function?



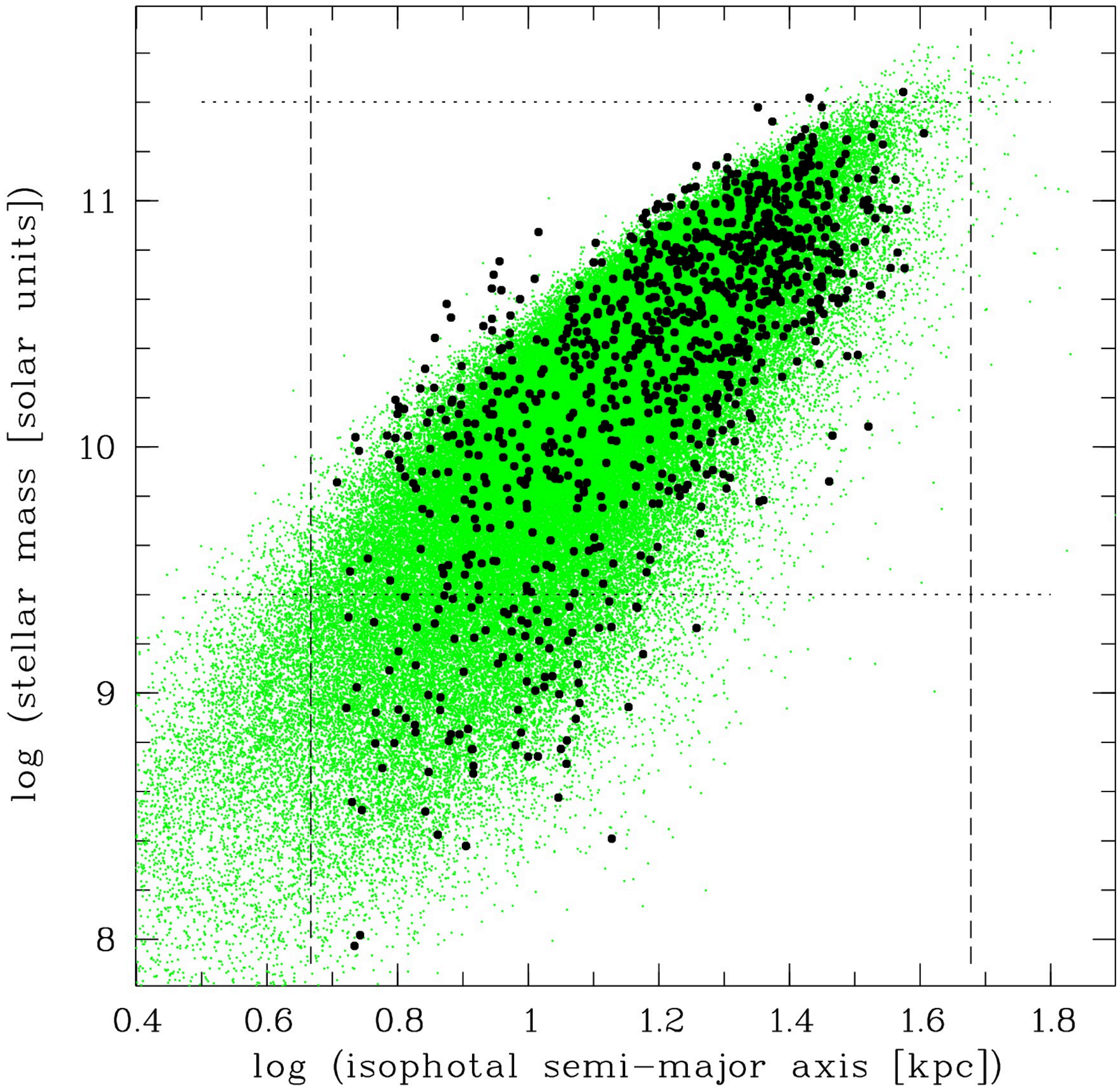
Does CALIFA have a complicated selection function?

Fraction of SDSS galaxies that **would be selected** by CALIFA if placed at suitable redshift, as function of absolute magnitude:



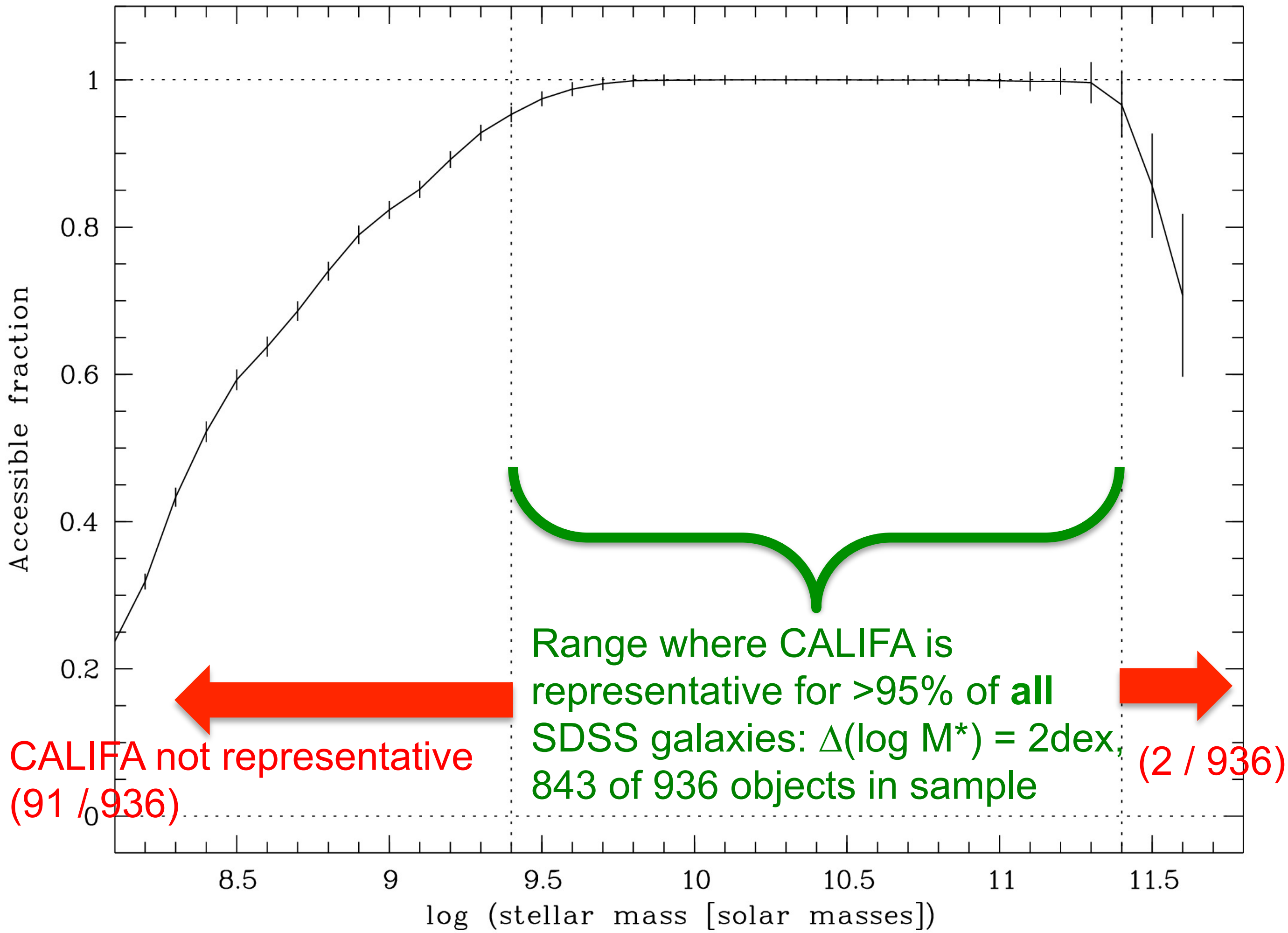
Does CALIFA have a complicated selection function?

Which SDSS galaxies are `accessible' to CALIFA? – now in stellar masses



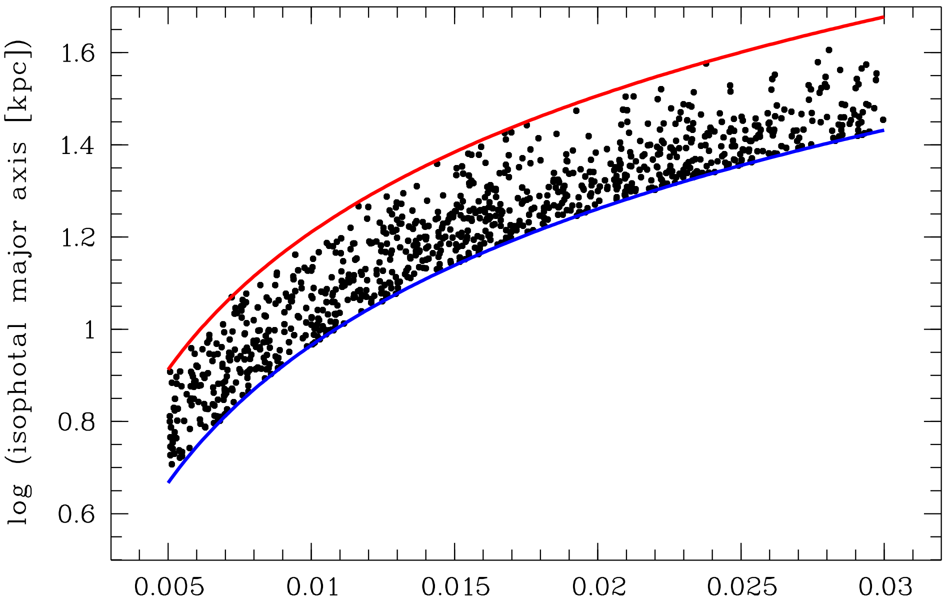
Does CALIFA have a complicated selection function?

Fraction of SDSS galaxies that **would be selected** by CALIFA if placed at suitable redshift, as function of stellar mass:



CALIFA survey volume

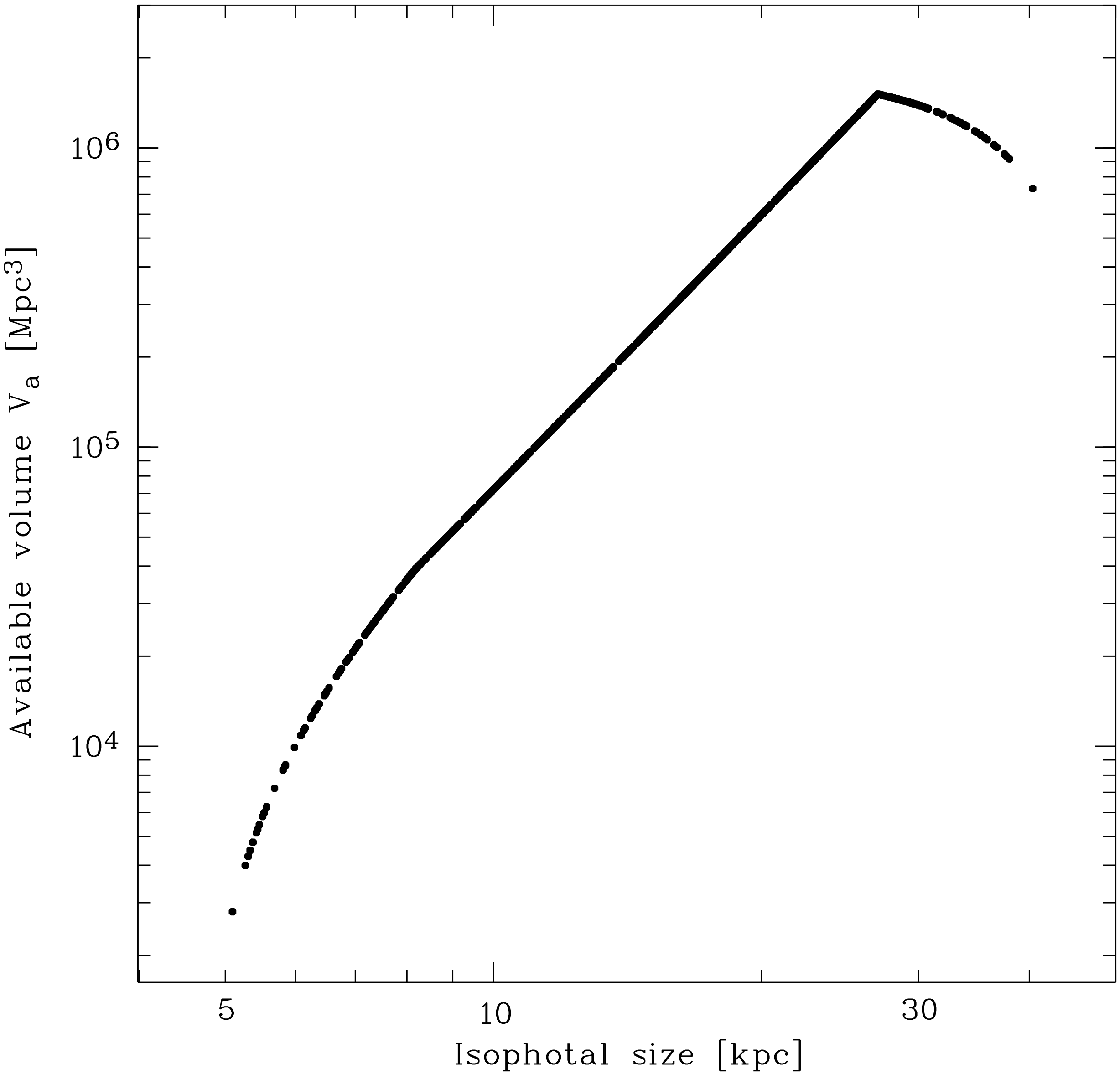
- Total volume between z=0.005 and z=0.03 over CALIFA footprint of 8700 deg^2: $V = 1.7 \times 10^6 \ Mpc^3$
- but each galaxy only "visible to CALIFA" within some redshift range:



- Actually available survey volume V_a is different from galaxy to galaxy.
- Value of V_a depends only on linear isophotal size D_{iso}.

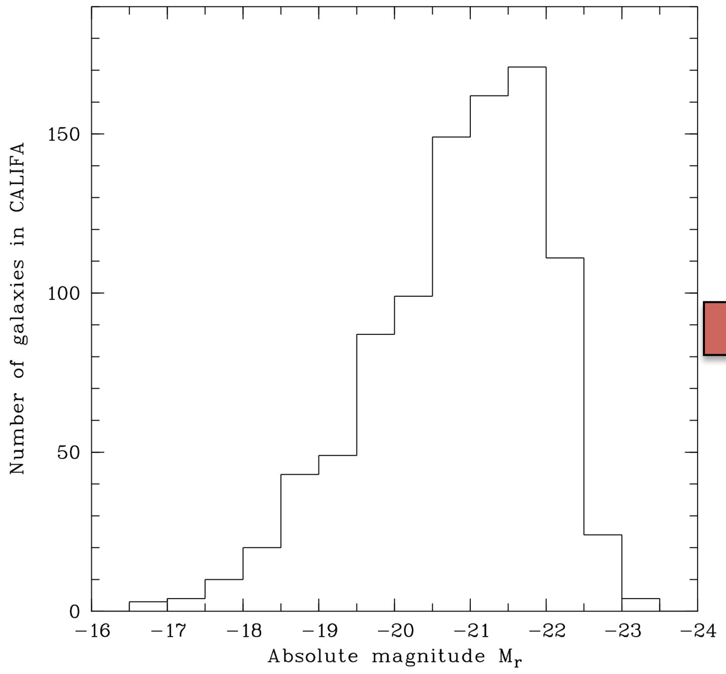
(completely analogous to V_{max} formalism in flux-limited surveys)

Object-specific CALIFA survey volume as function of D_{iso}

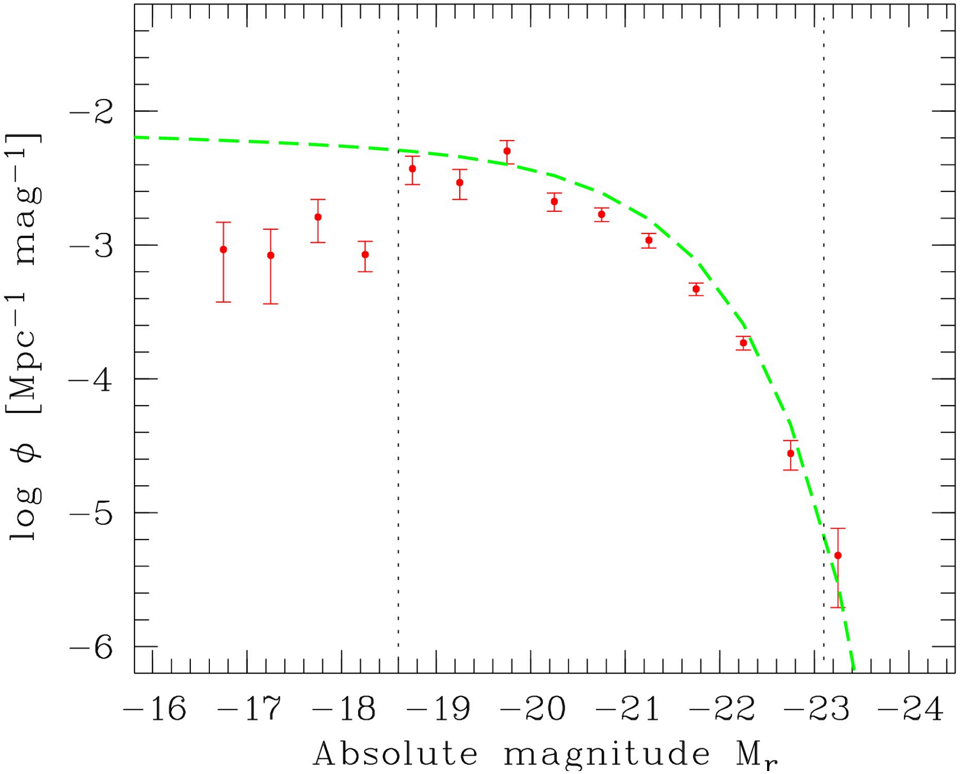


What can we do with volume correction?
From histograms to estimated population distribution functions

Absolute magnitudes

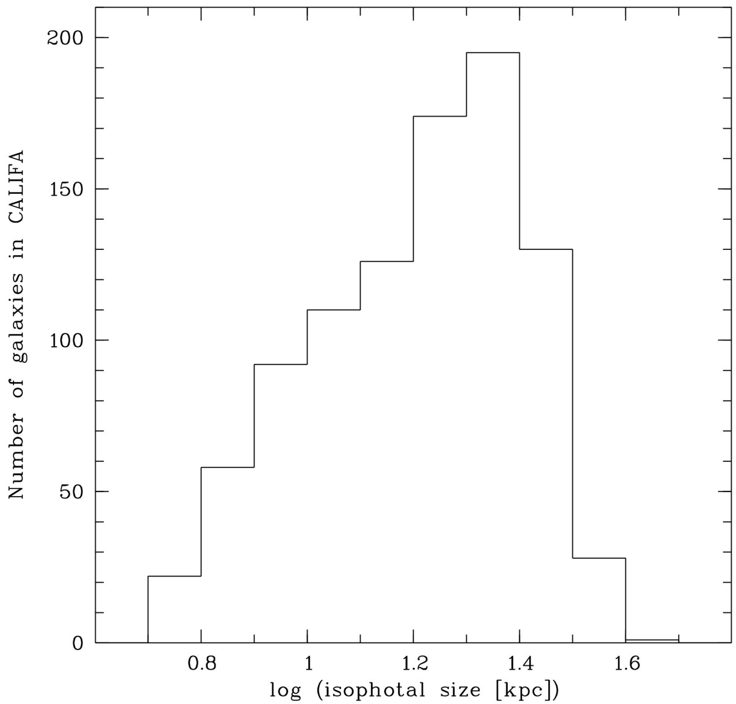


Luminosity function

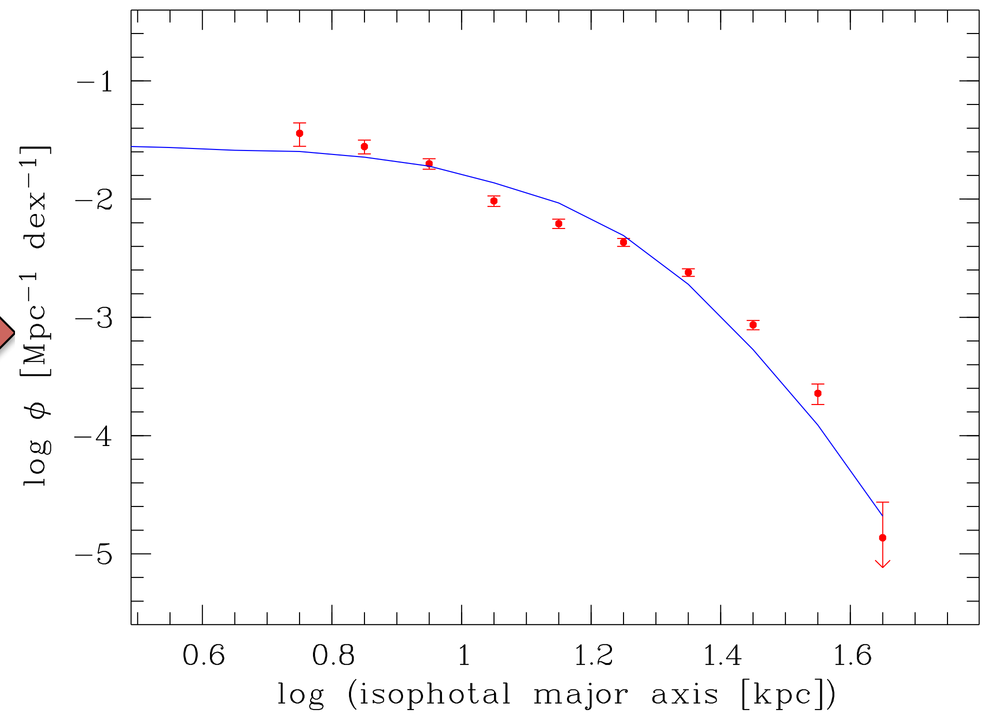


What can we do with volume correction?
From histograms to estimated population distribution functions

Linear isophotal sizes



Size distribution function



Estimating population distributions of spectroscopic properties from IFS samples

Just some possibilites:

- Stellar mass function from spectral modelling
- Total emission line luminosity function
  - SFR distribution function
- Beyond the Tully-Fisher relation:
  - circular velocity distribution function
  - bivariate distribution of velocities and stellar masses

...

Part 2: A census of ionising conditions from CALIFA

(work in progress, to be published as soon as possible)

BPT diagnostic emission line diagram(s)

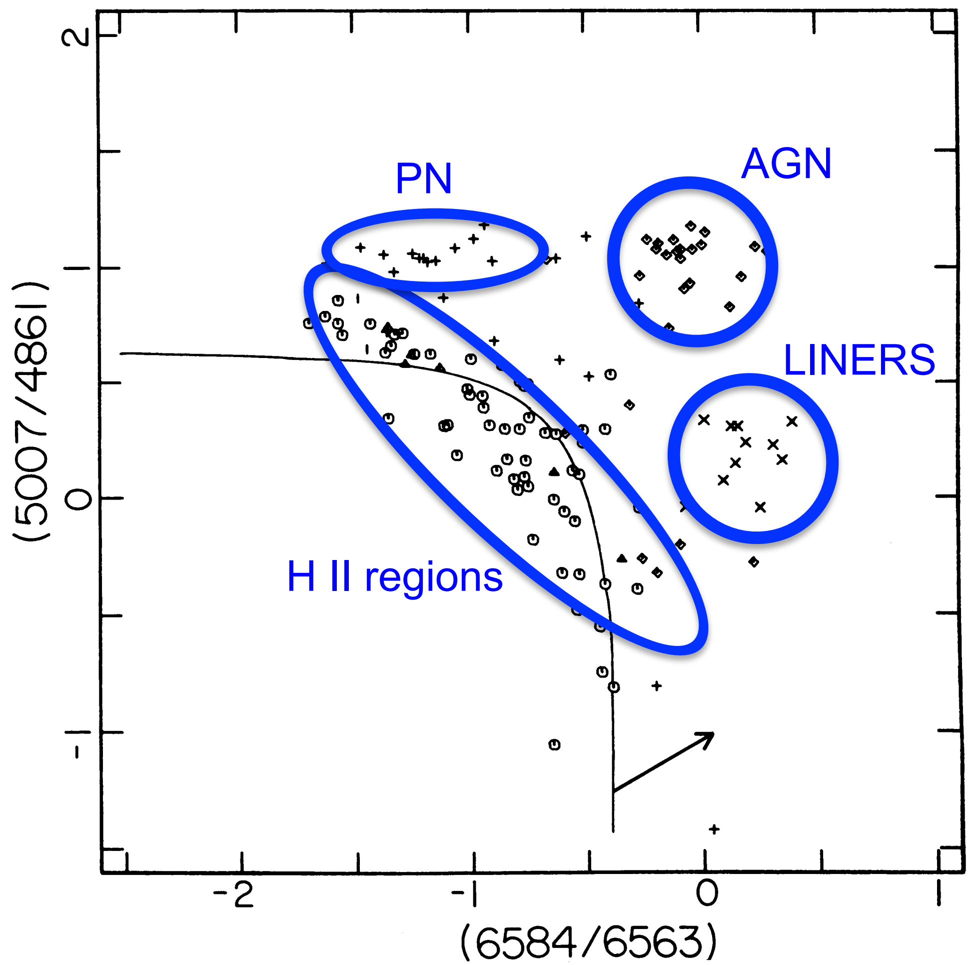
Emission line ratios can probe shape of ionising spectrum;

(also relevant: intensity of radiation field, gas density, abundances)

At least 2 line ratios required for classifying different types of excitation.

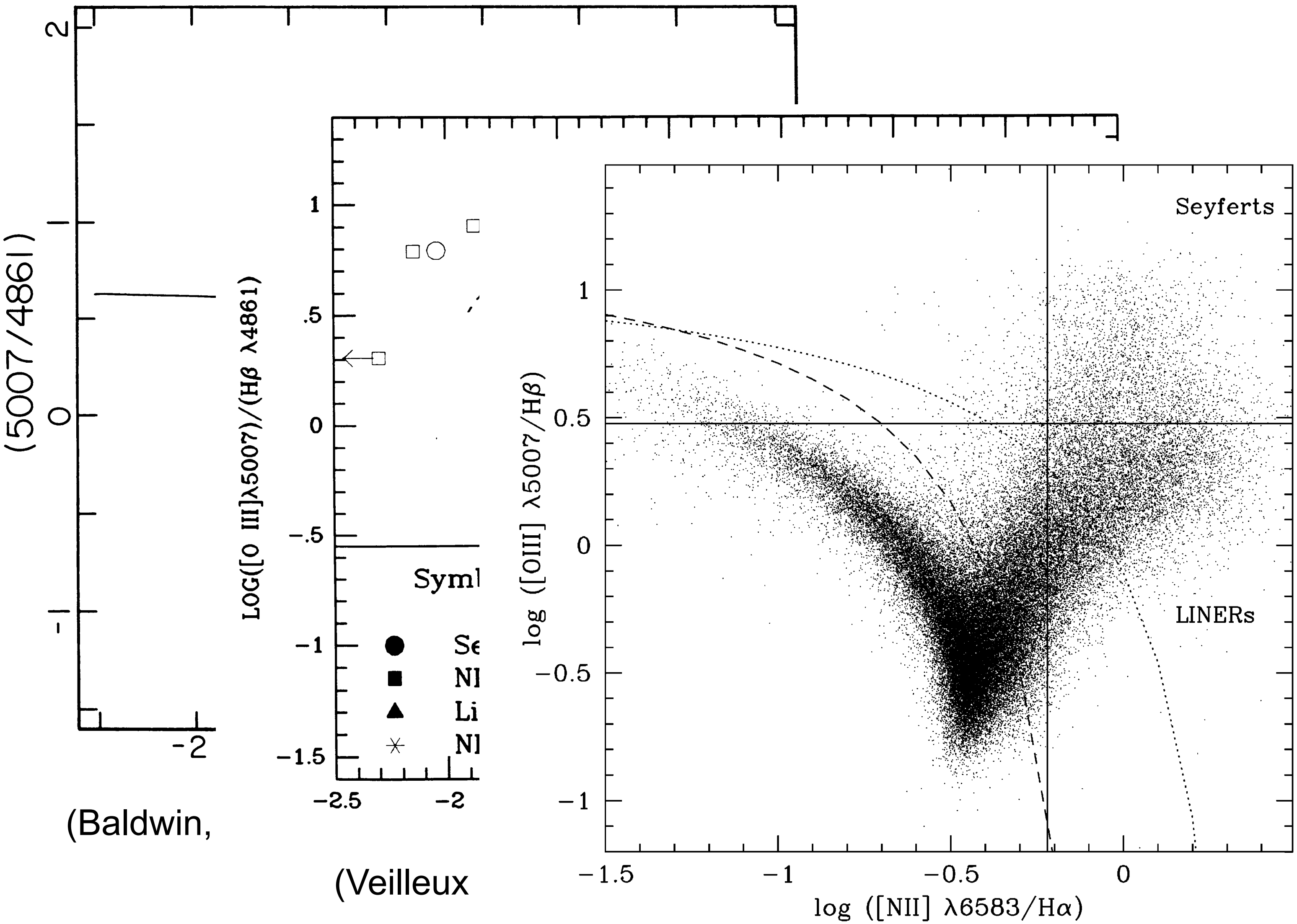
Most popular: [O III] λ5007 / Hβ vs. [N II] λ6584 / Hα

- lines are bright
- indepent of dust reddening
- low vs. high ionisation potential



(Baldwin, Phillips, Terlevich 1981)

Some steps in the evolution of the BPT diagram



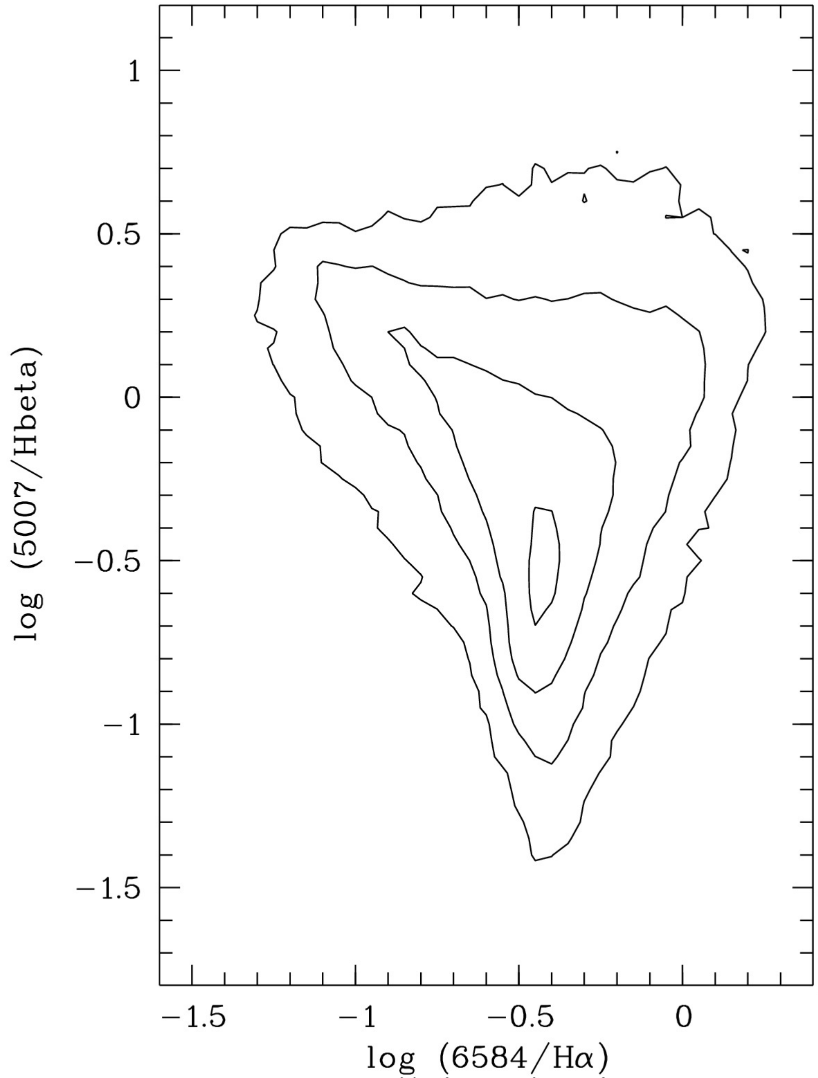
(Baldwin,

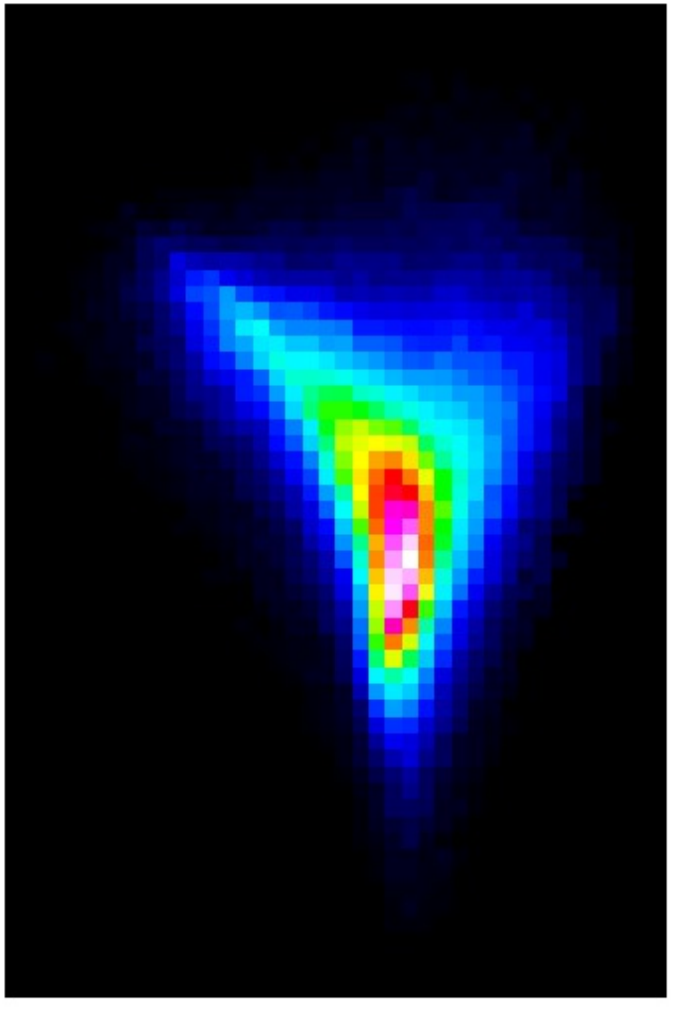
(Veilleux

(Kauffmann et al. 2003)

The CALIFA view on the BPT diagram

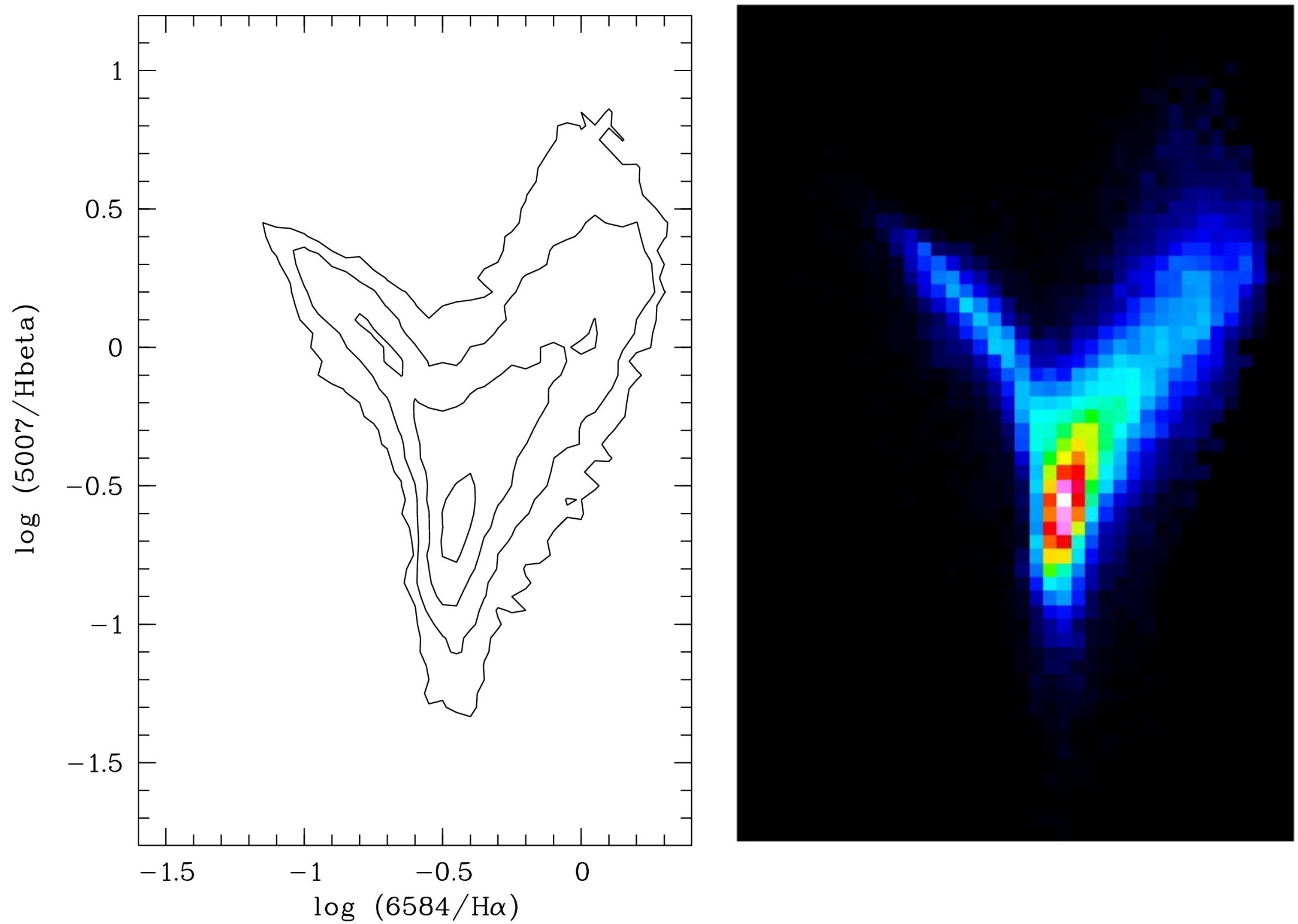
In 10^6 spectra from 300 galaxies: spaxel-by-spaxel evaluation of emission line ratios



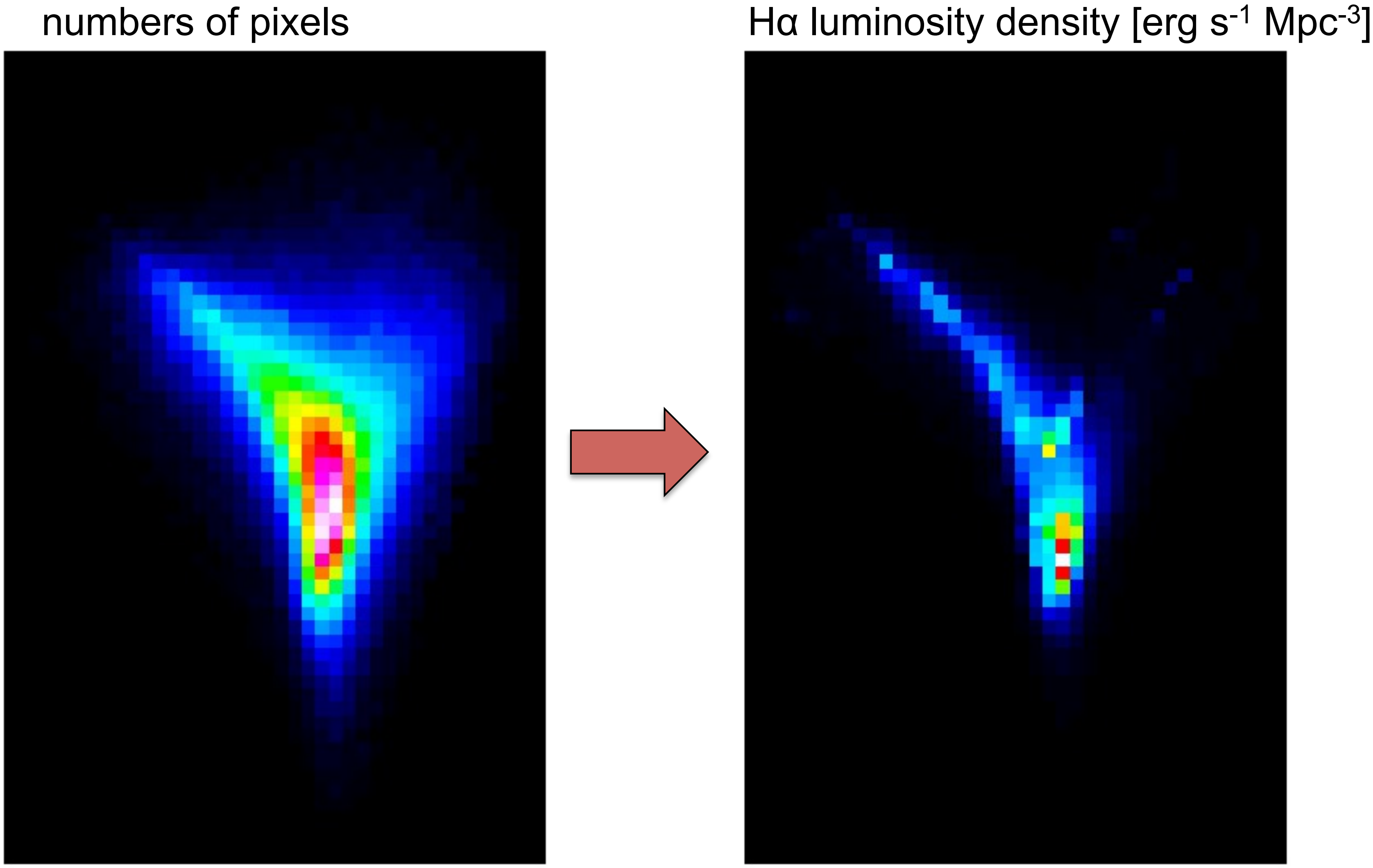


The CALIFA view on the BPT diagram

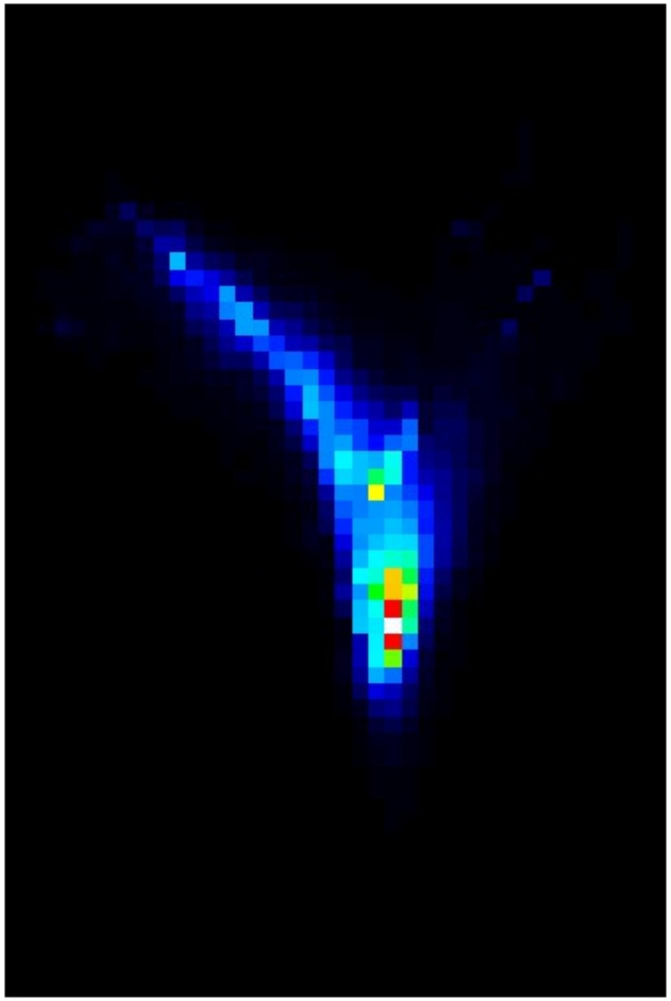
Same as before, but now only using spaxels with $r < 0.7\ r_{50}$ (≈ typical for SDSS)



Volume emissivity as function of excitation conditions



Volume emissivity as function of excitation conditions

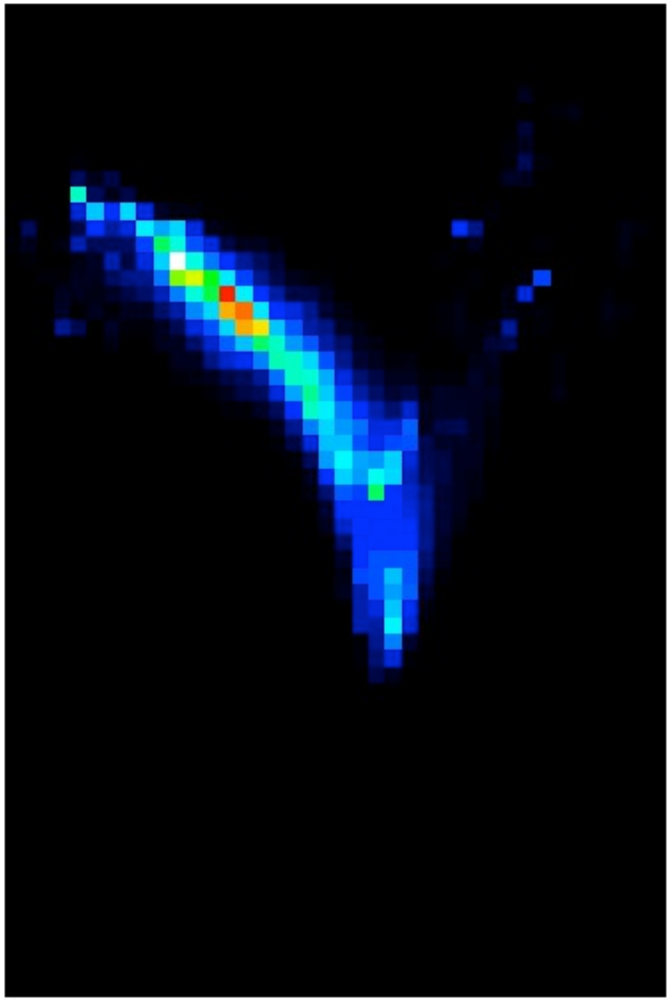


Implications:

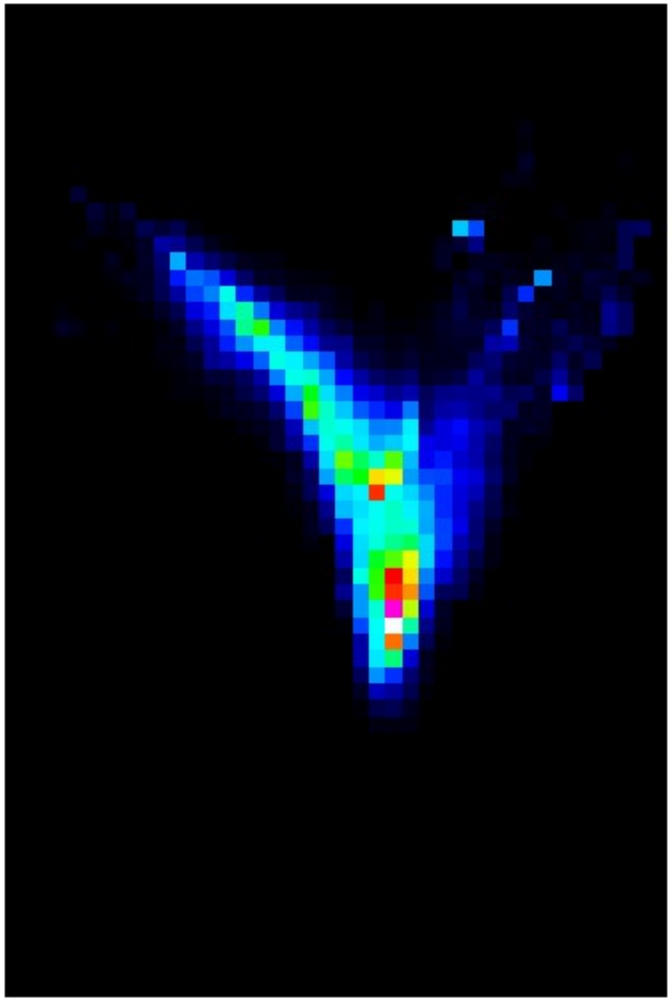
- H II regions provide > 90% of all Hα photons in the local universe
- forming a very narrow sequence
- Dominant contributors are low [OIII] (metal rich) regions.
- AGN / LI(N)ER contribution is <10% (but >50% of all spaxels)
- Sum over image gives total Hα luminosity density at z ≈ 0;

Luminosity densities of other lines

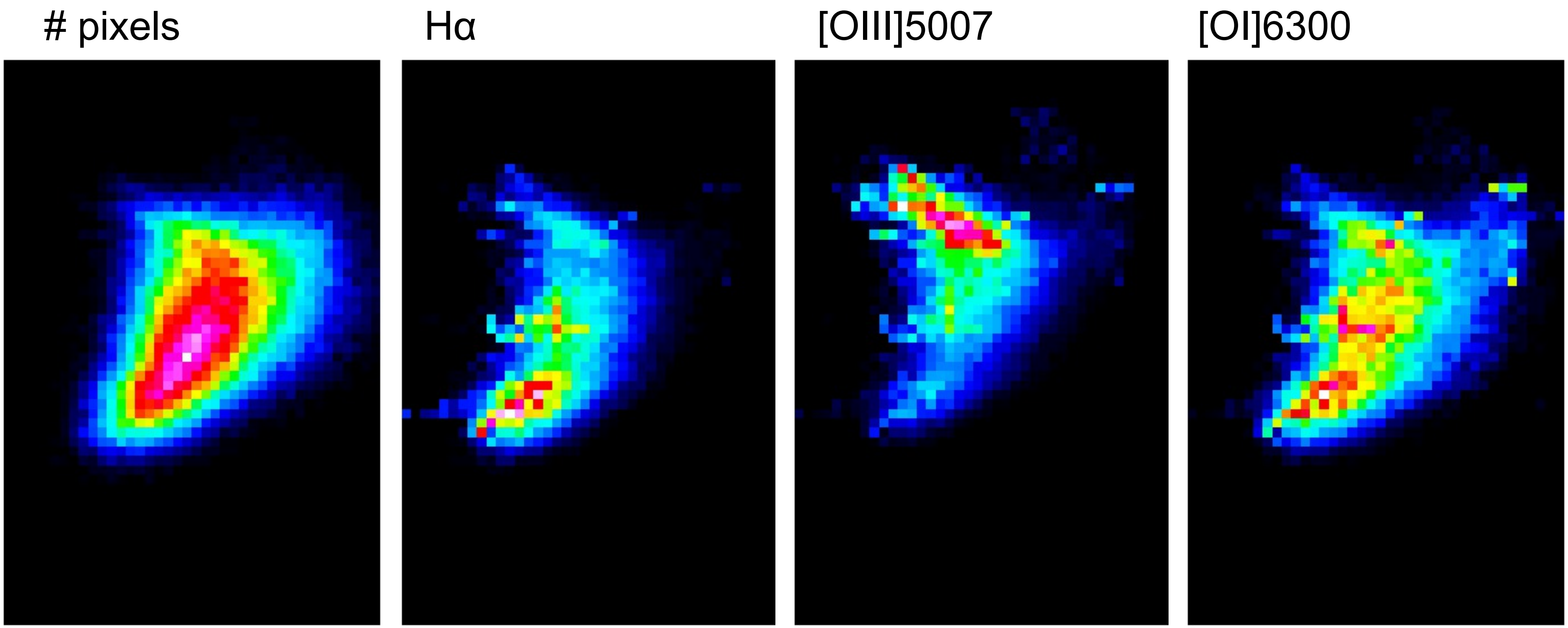
[O III] λ5007



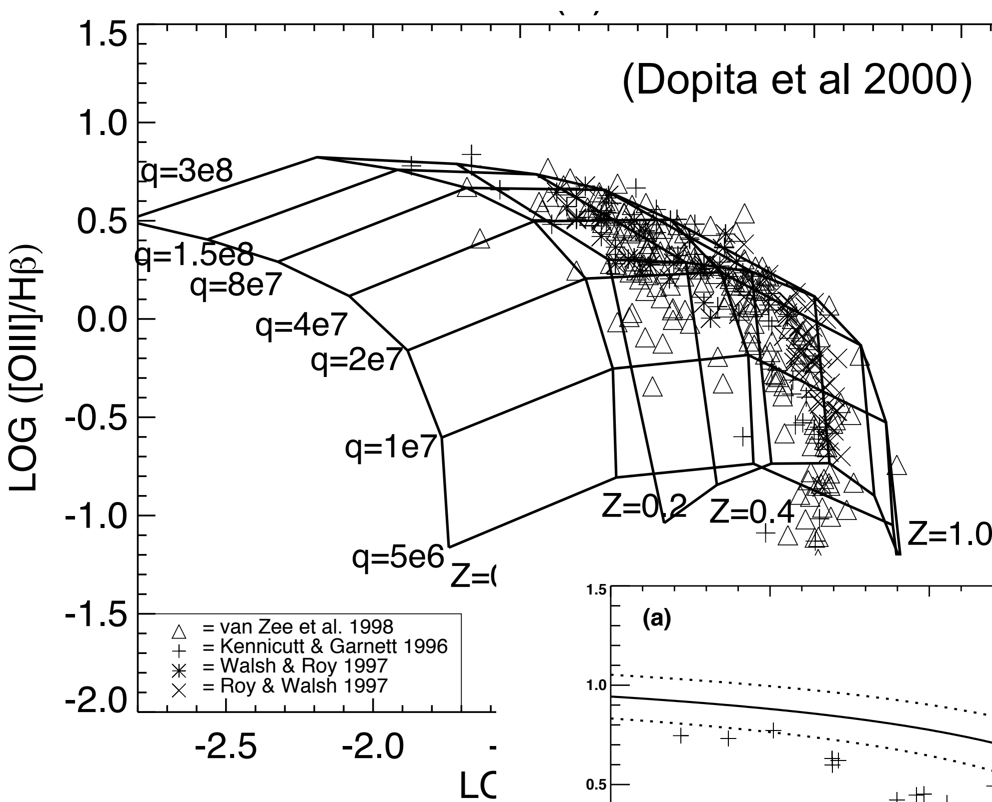
[O I] λ6300

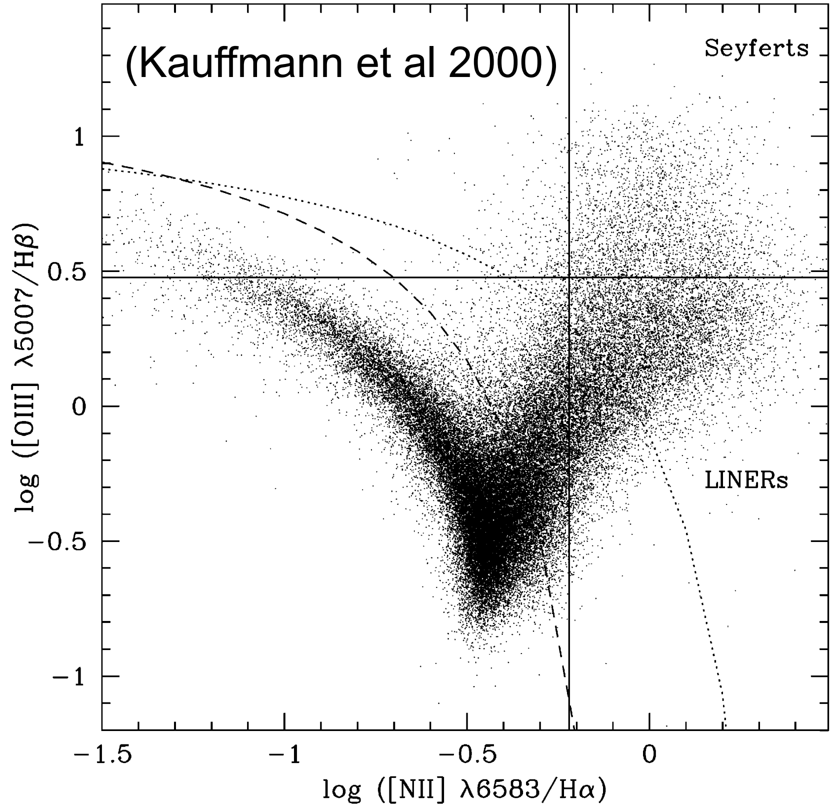


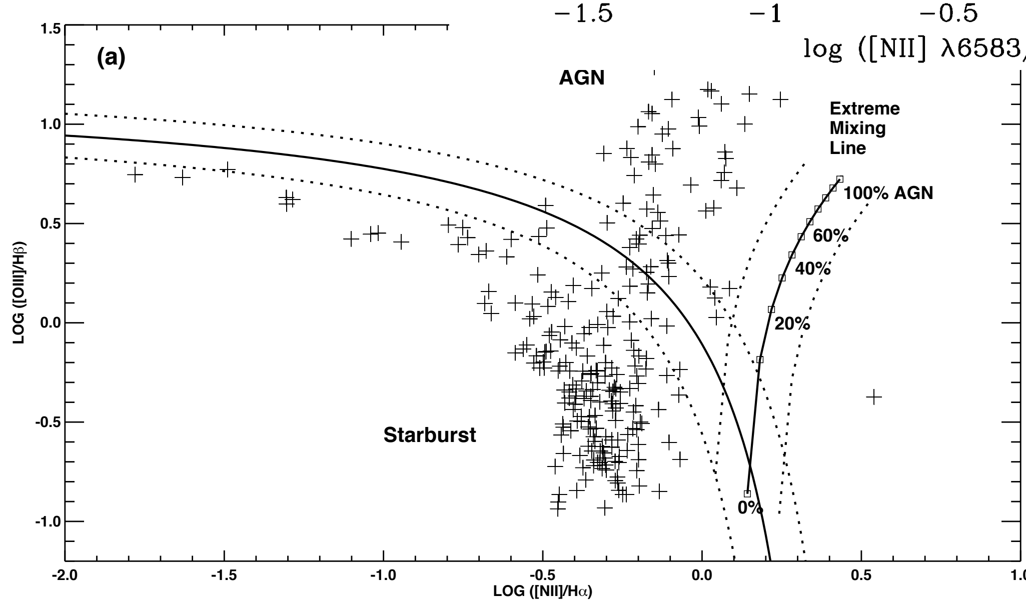
Luminosity densities in [OI]/Hα-[OIII]/Hβ diagram



Boundaries in the

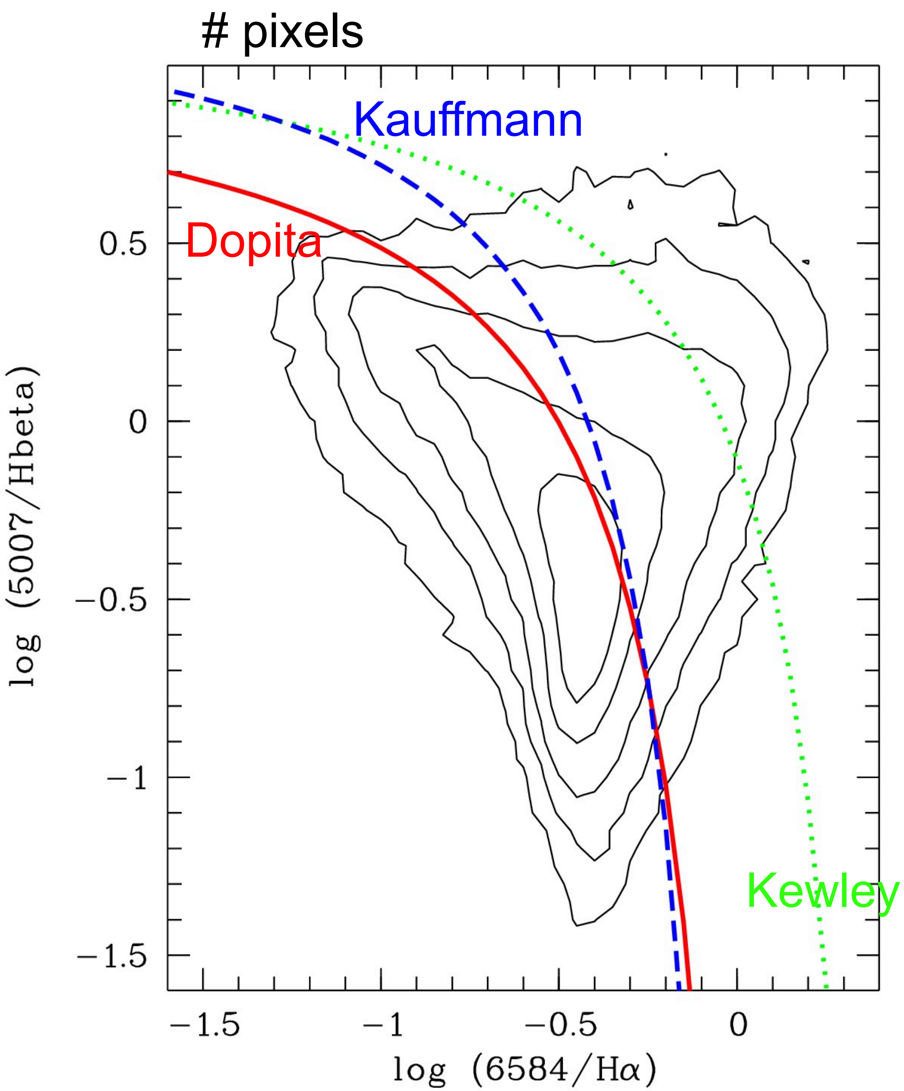


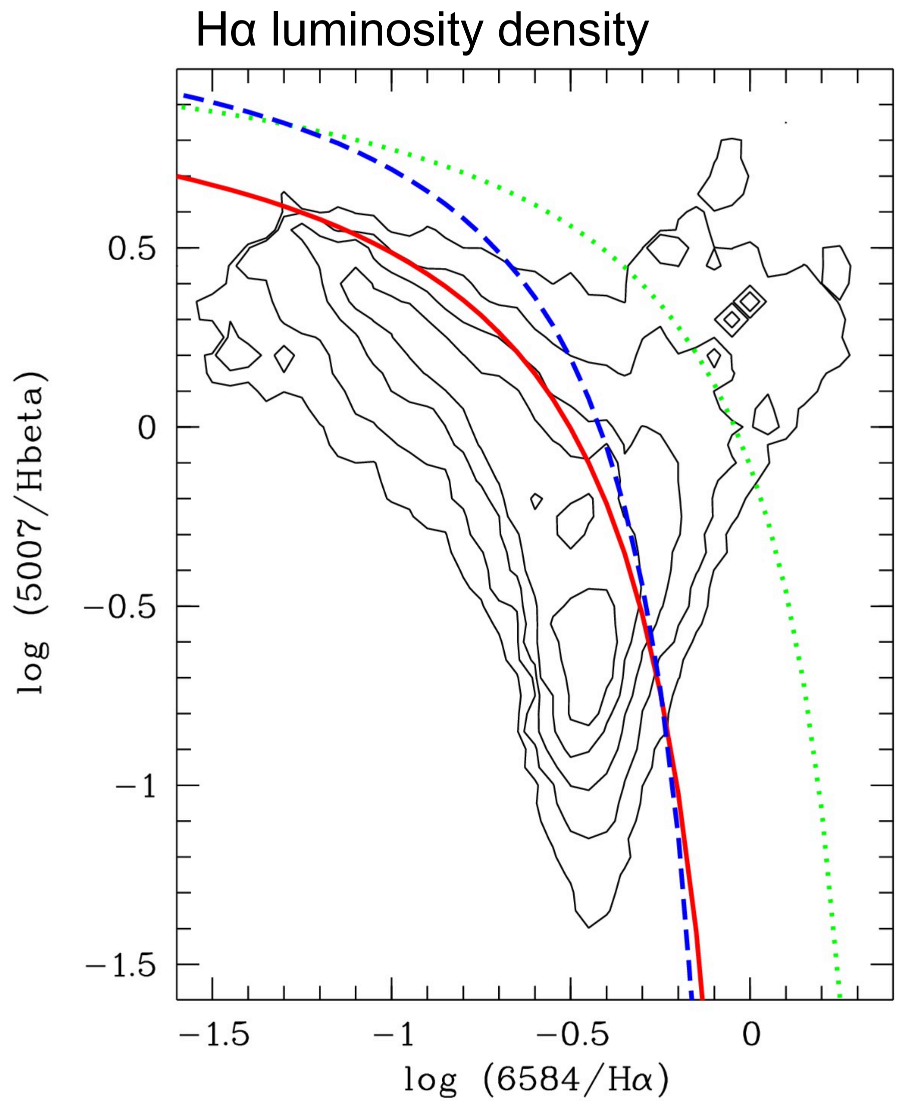




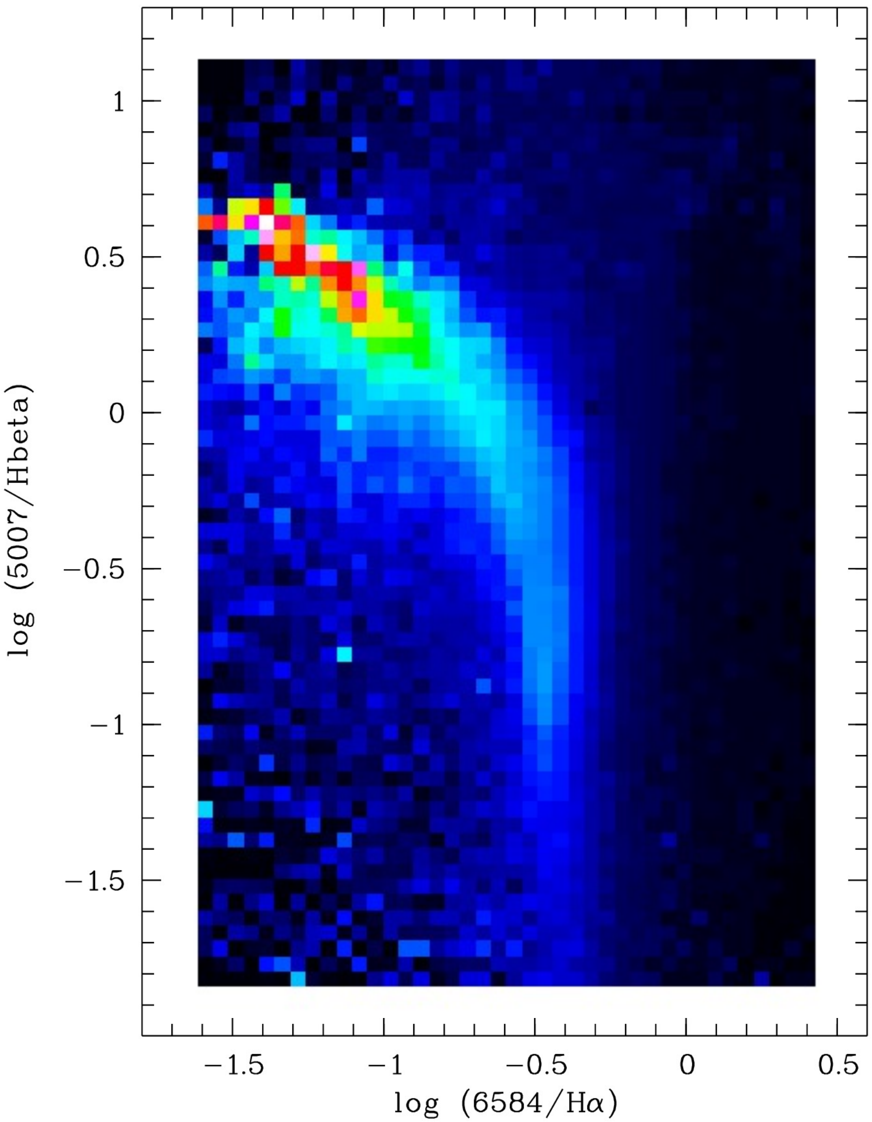
(Kewley et al 2001)

Boundaries in the BPT diagram





Distribution of mean Hα equivalent width in BPT diagram

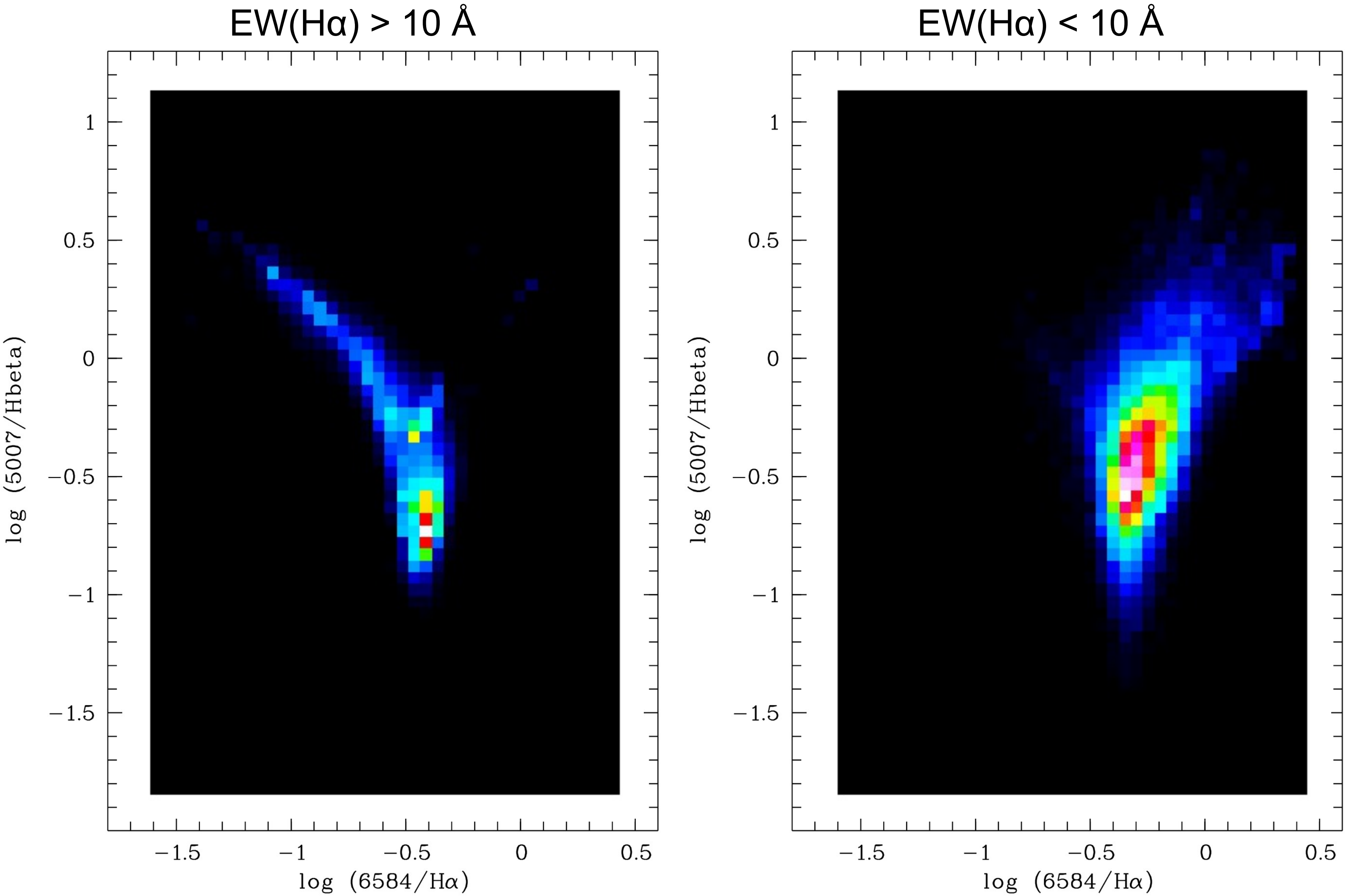


Notice:

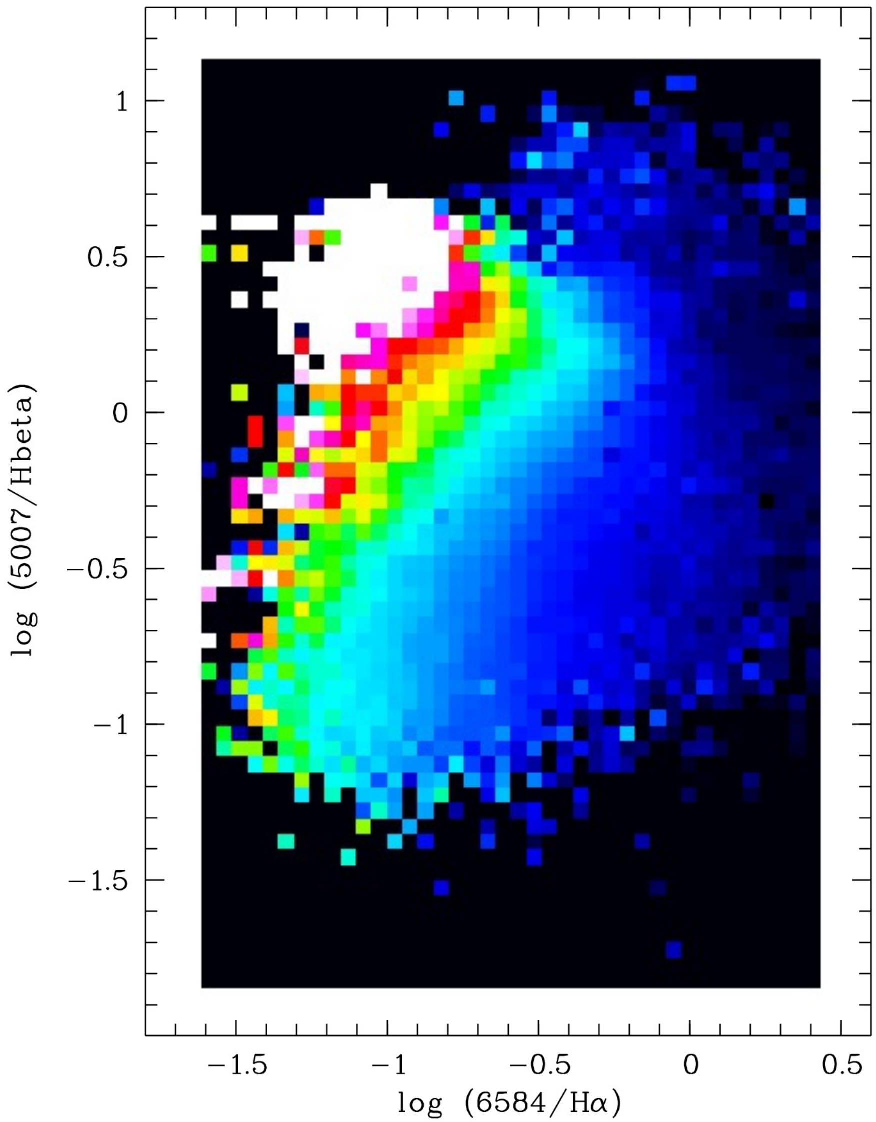
- Zone with W(Hα) > 10 Å identical with H II region sequence
  (cf. also Cid Fernandes et al 2011)
- Sharp cutoff towards AGN / LI(N)ER regime
- very few AGN in CALIFA
- in particular: no trace of "transition zone" from H II → LI(N)ER

⇒ a "natural boundary" between H II and other regions?
LI~~N~~ER regions = diffuse emission?

Hα luminosity densities for different equivalent widths



Hα equivalent widths in [OI] BPT diagram



- Sharp cutoff towards AGN / LI(N)ER regime remains
- Note: also low mean EW in "AGN zone" (there are only few AGN in CALIFA!)
- more evidence for LI~~N~~ER = DIG?

Conclusions

1. The angular diameter selection of the CALIFA sample ensures not only a broad coverage of galaxy properties; it also allows for straightforward volume correction.

2. It is thus possible to estimate population distributions from CALIFA measurements.

3. We present the first volume-corrected BPT diagram, showing how the Hα luminosity density in the local universe is distributed over different excitation conditions.

4. LI(N)ER-like regions are well separated from H II regions when using EW(Hα) as additional diagnostic.