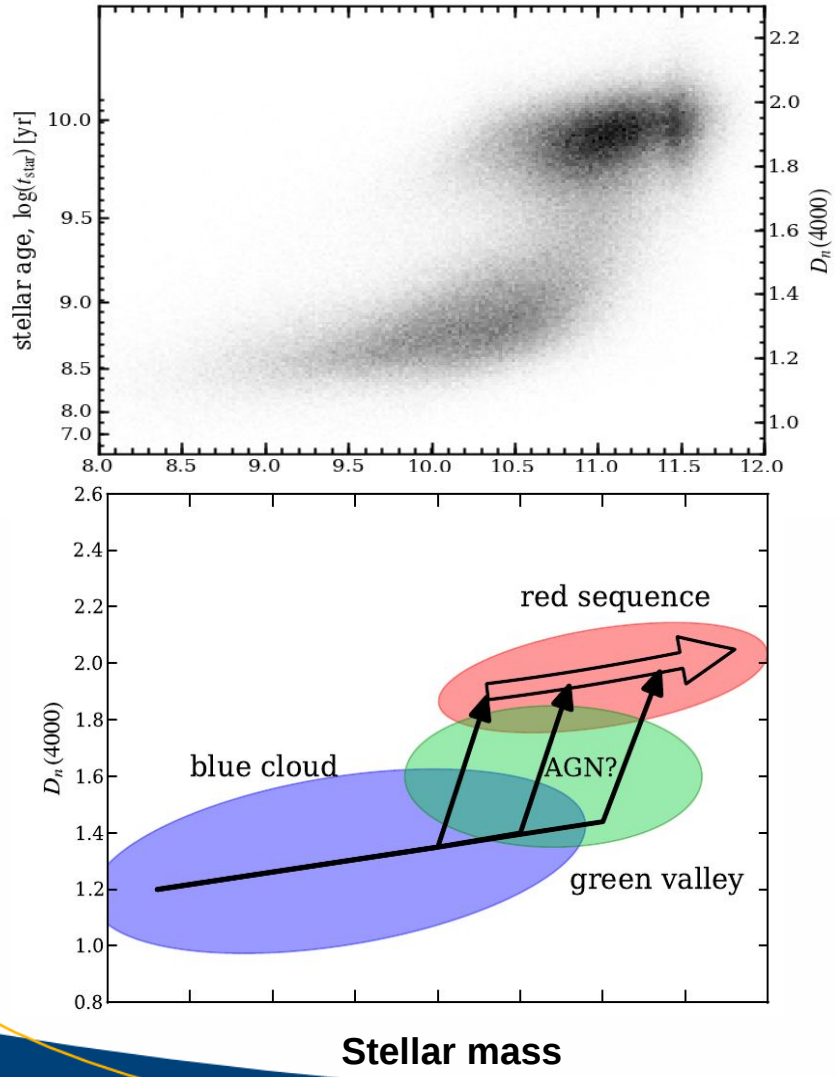
AGN host galaxies observed with integral field spectroscopy

Bernd Husemann (AIP)

L. Wisotzki, J. Walcher, J. Gerssen, D. Kupko (all AIP),
S. F. Sánchez (IAA), K. Jahnke (MPIA), V. Wild (St. Andrews)
and CALIFA collaboration

Why do we care about AGN hosts?



- clear galaxy bimodality
- build up of red galaxies
  - ➔ rapid quenching of star formation in the blue cloud

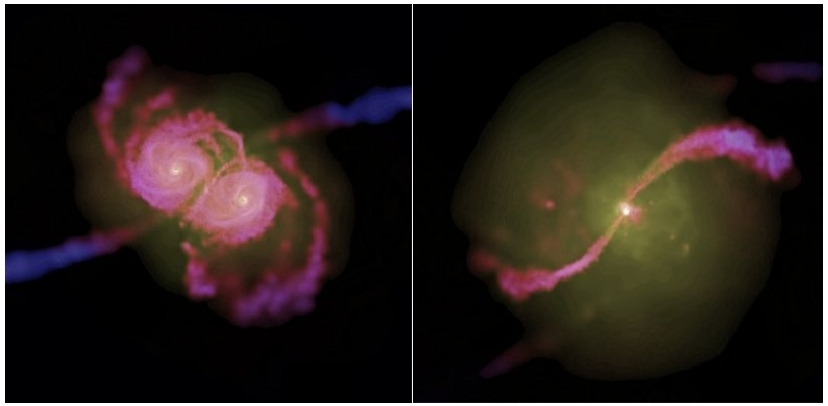
Caused by AGN feedback at high accretion rates?

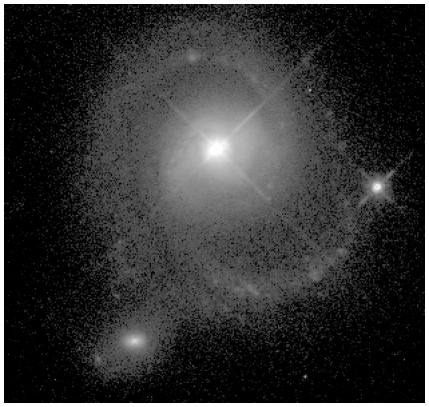
1. *AGN winds/outflows*
2. *AGN heating*
3. *other mechanisms?*

This mechanism is not understood at all!

What triggers AGN in galaxies?

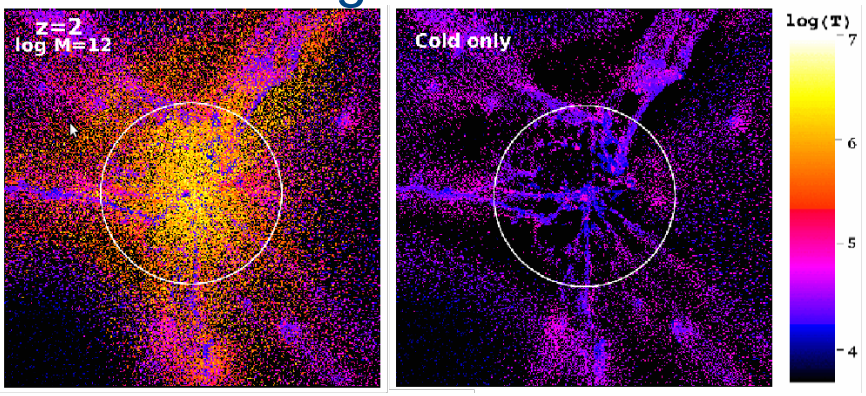
Major mergers

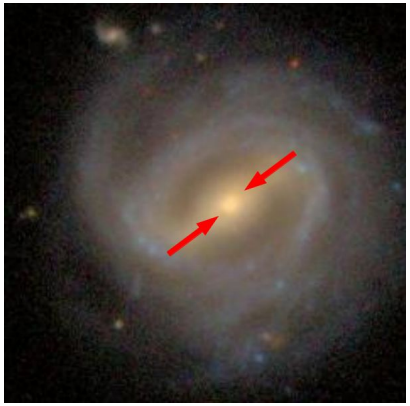




Minor mergers/
galaxy interactions

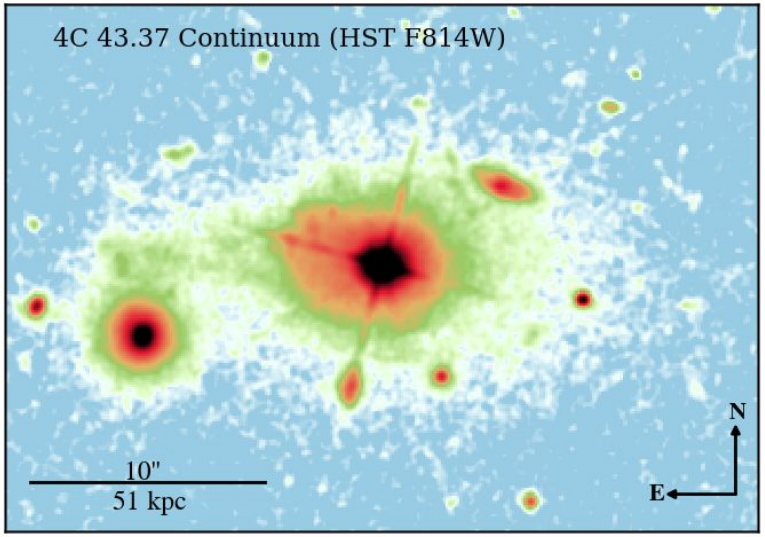
External gas accretion

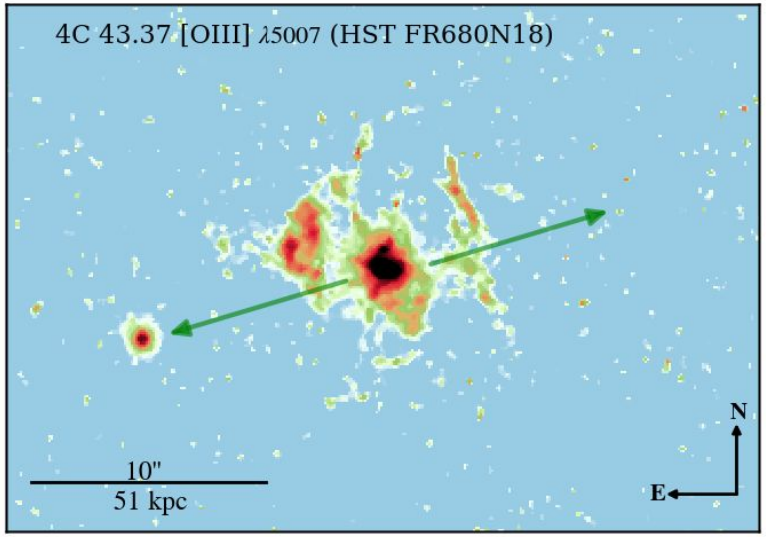




Internal processes
“Secular evolution”

Extended ionized gas in AGN hosts





Extended ionized gas found in the majority of luminous AGN

- May (partially) be powered by ongoing star formation
- Lock-up of metal enrichment history in the gas
- Could be remnants of large scale AGN outflows

Advantages of IFU spectroscopy

Several key aspects are obtained at the same time:

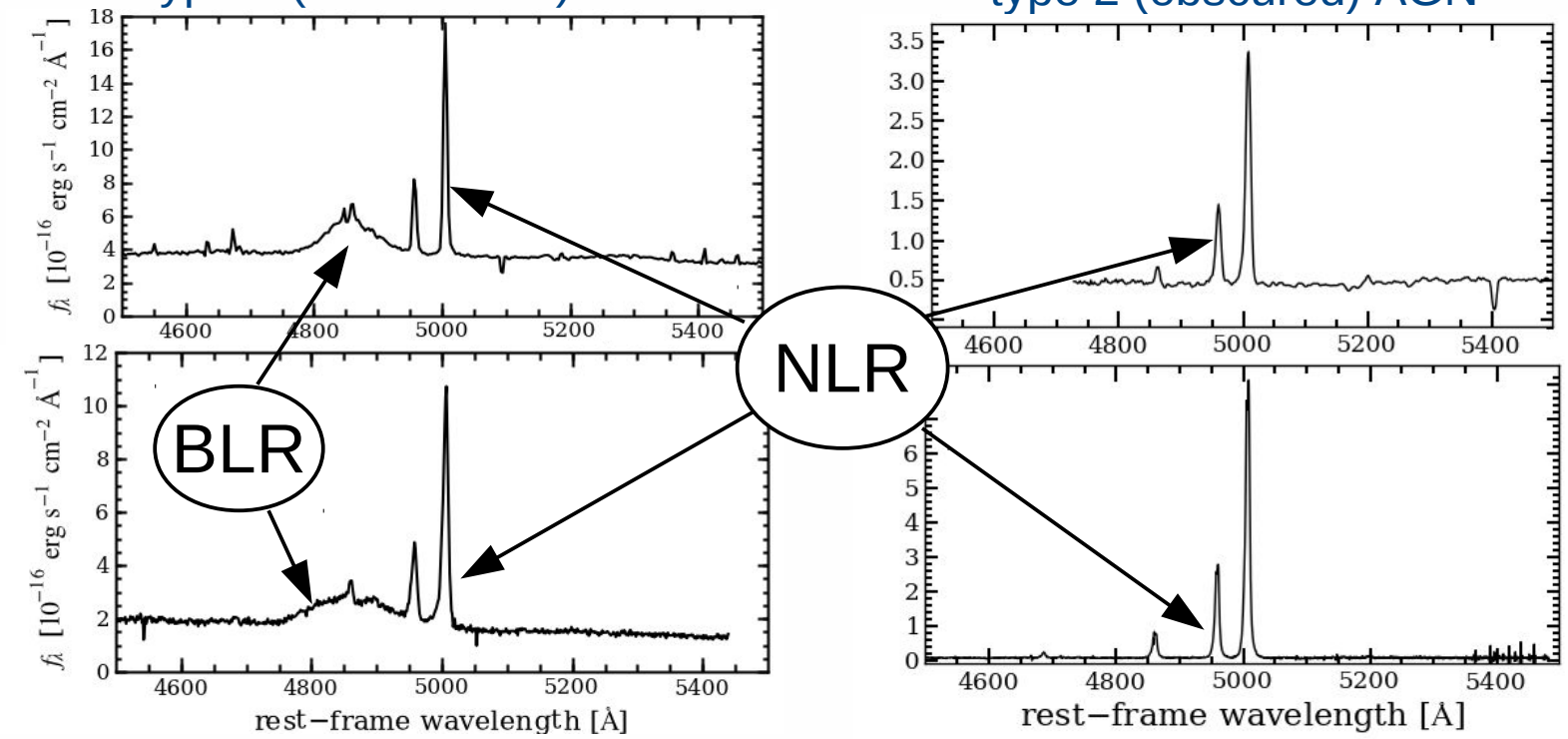
- **Kinematics of the gas and stars**
- **Physical conditions of the ionized gas**
- **Oxygen abundances (under certain conditions)**
- **Full coverage of galaxies (depending on redshift)**
- **Stellar population/star formation history (S/N issue)**

BUT usually practical compromise between FoV, sampling spectral resolution and spectral coverage

Targeting type 1 or type 2 AGN?

type 1 (unobscured) AGN

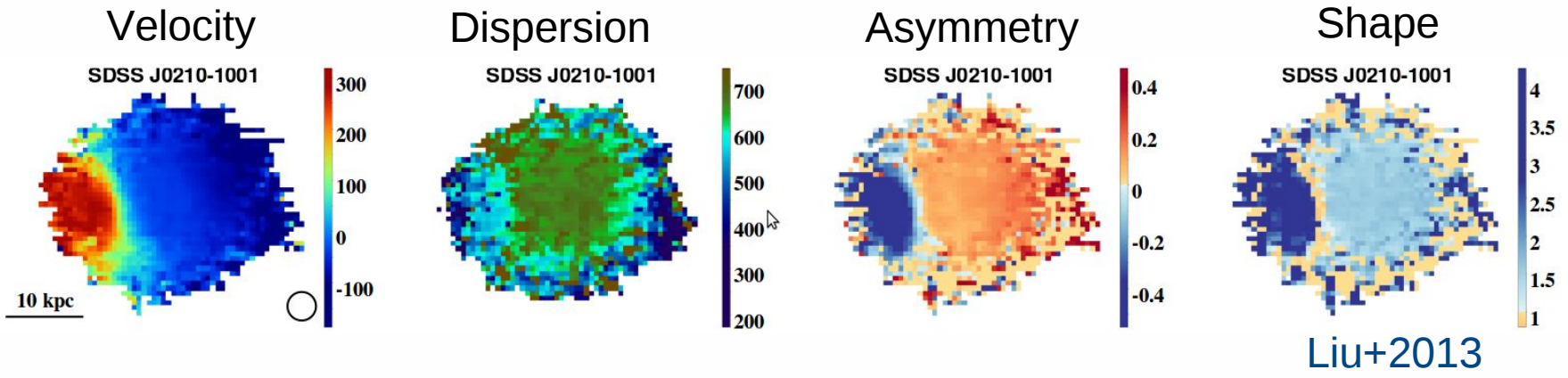
type 2 (obscured) AGN



- dominating AGN continuum
+ BH parameters can be obtained
+ PSF can be estimated from BLR

+ stellar continuum uncontaminated
- BH parameters only indirectly
- PSF unknown (except for stars)

Problematic type 2 AGN analysis



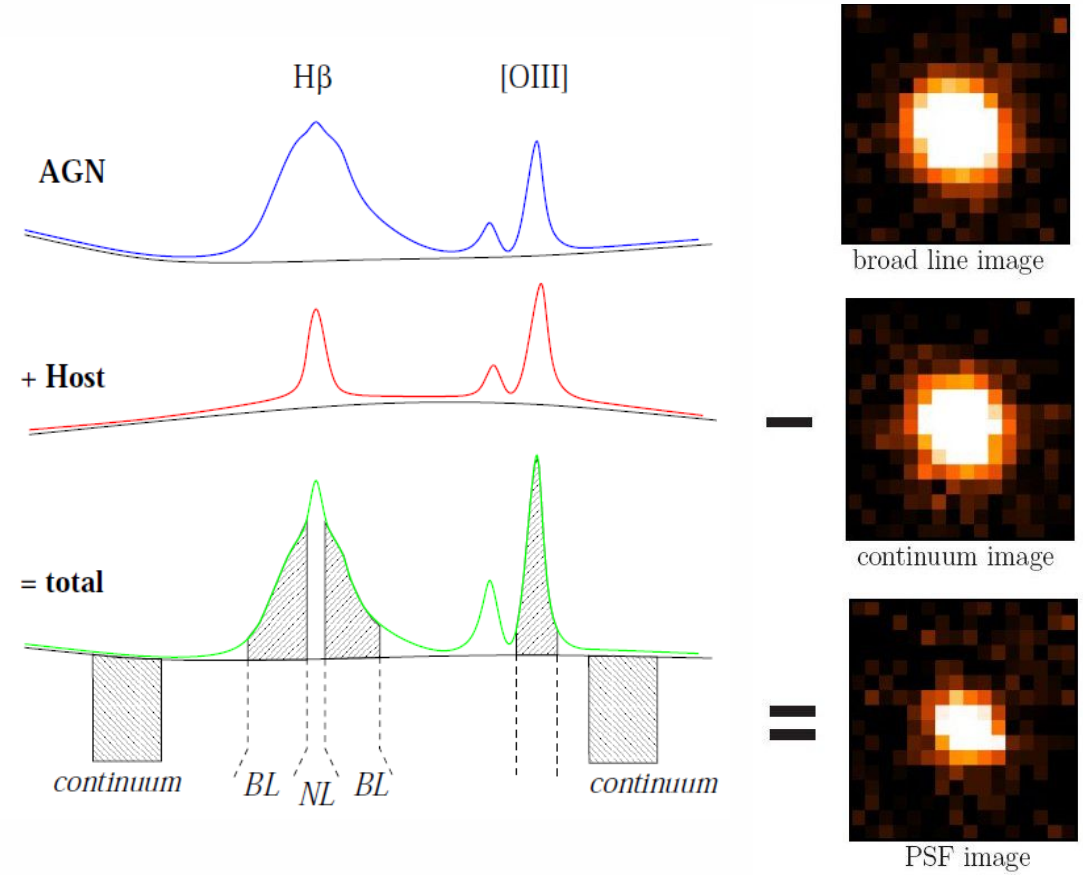
Liu+2013

- <1 kpc-scale NLR broaden by seeing
- FWHM of seeing is misleading because of contrast
- Very similar line parameters over a large area
- Large scale outflows or simply beam smearing?

➔AGN-host galaxy deblending difficult for type 2 AGN

PSF estimation for type 1 AGN

Jahnke+04



QSO-host deblending software QDeblend^{3D} developed for IFU data (Husemann+13)

A large IFU sample type 1 AGN

- PMAS@Calar Alto
- 0.5”x0.5” spaxels
- 8” x 8” FoV
- 0.1<z<0.3
- **30 objects**
- Often only Hβ and [OIII]
- Best for kinematics

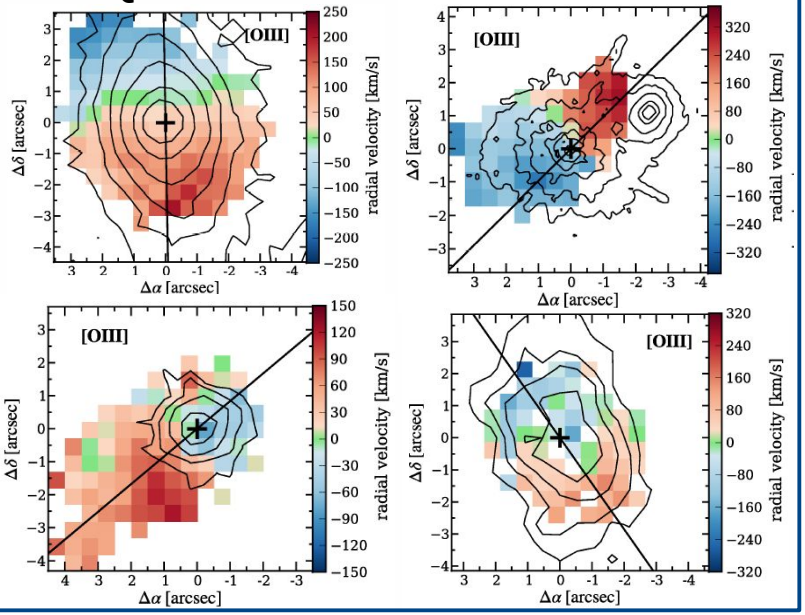
- VIMOS@ESO-VLT
- 0.66”x0.66” spaxels
- 27”x27” FoV
- 0.03<z<0.2
- **19 objects**
- All lines from Hβ to [NII]
- Full diagnostic power

➔ Largest sample of luminous AGN observed with IFU

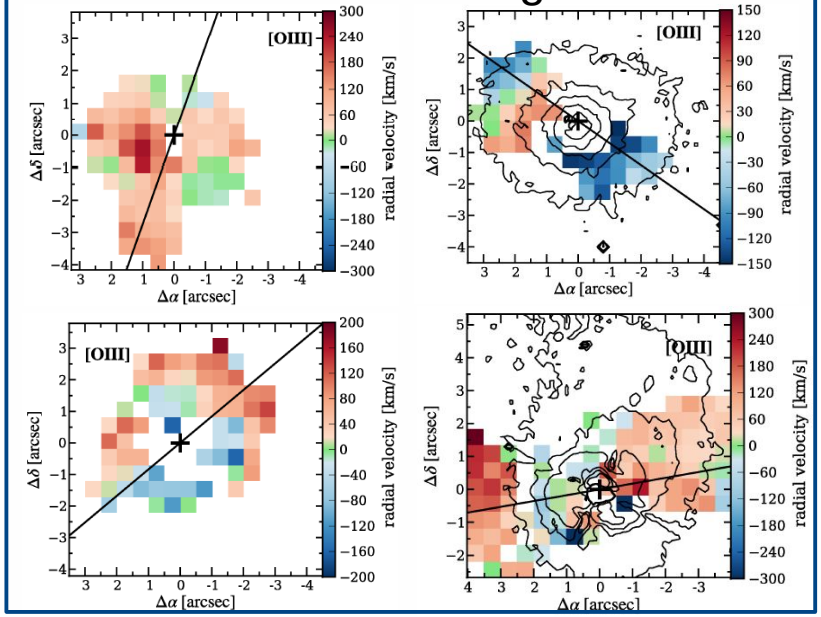
All AGN are the most luminous ones at their redshift!

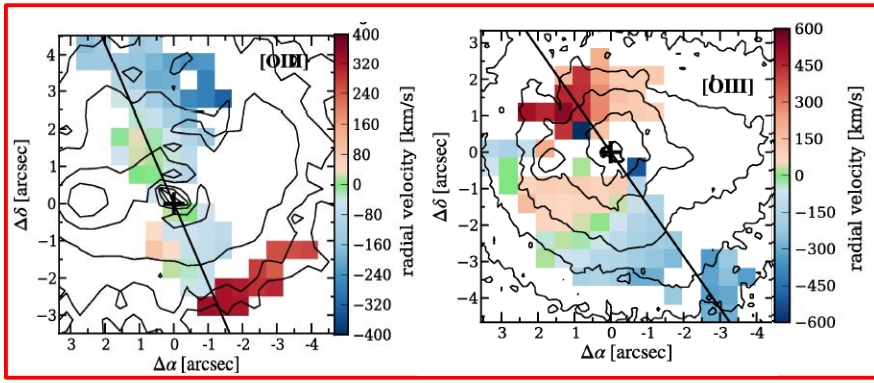
Velocity fields of the ionized gas - Lack of large scale powerful outflows

Quiescent/rotational motions



Peculiar with small gradients



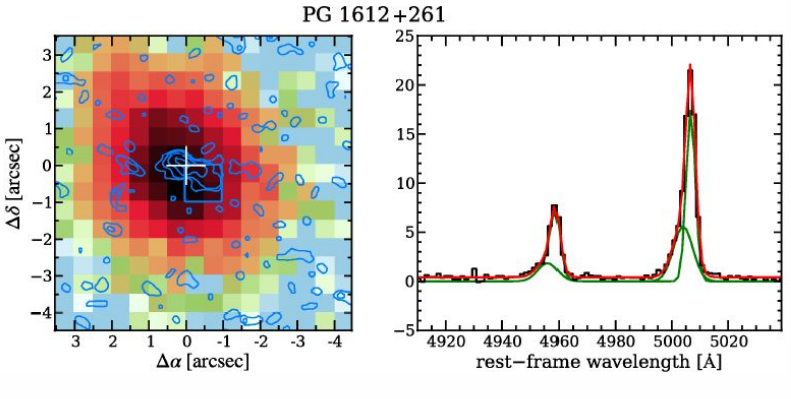


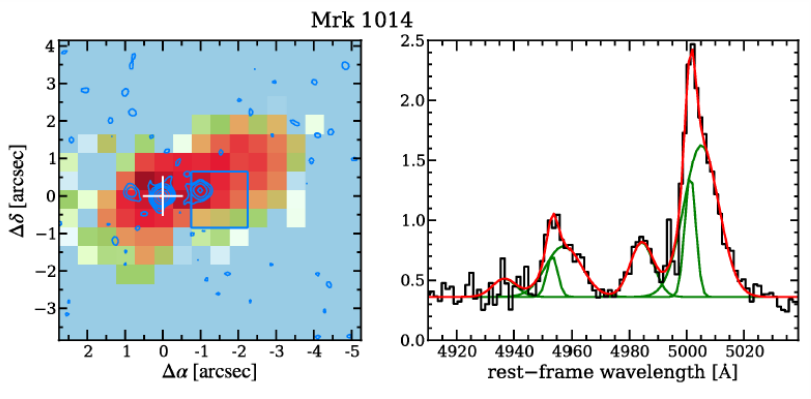
high-velocity gradients or outflows

>400 km/s

Husemann+13

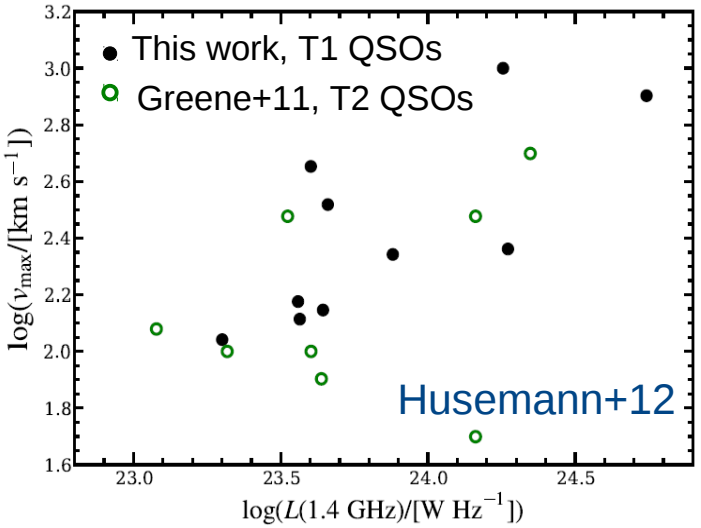
The kinematic impact of radio jets



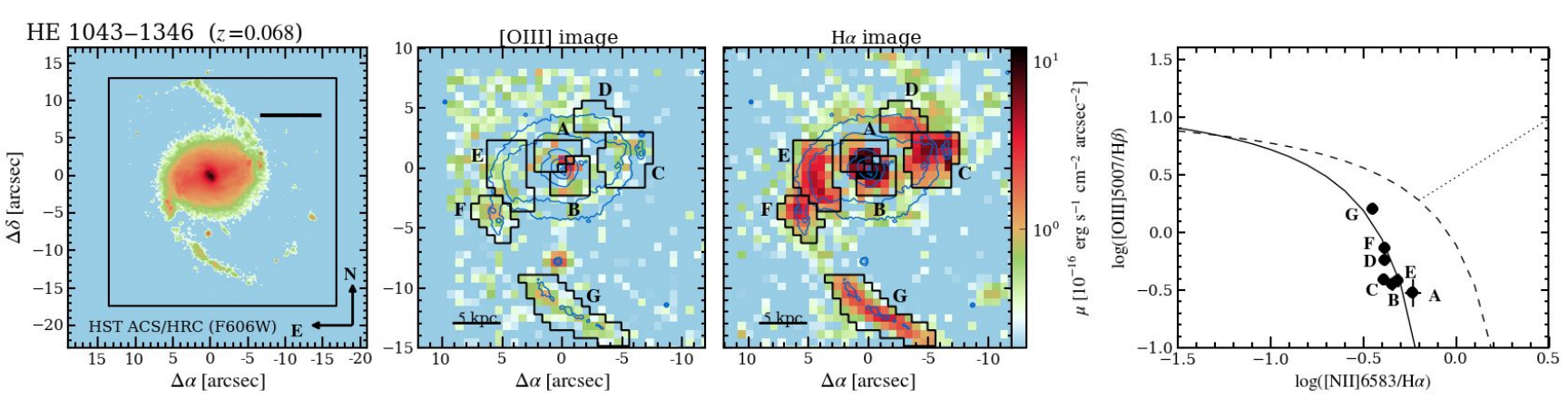


- Confirmed jet-cloud interactions in at least 2 of only 4 potential cases
- General link between **maximum velocity** and **radio luminosity**

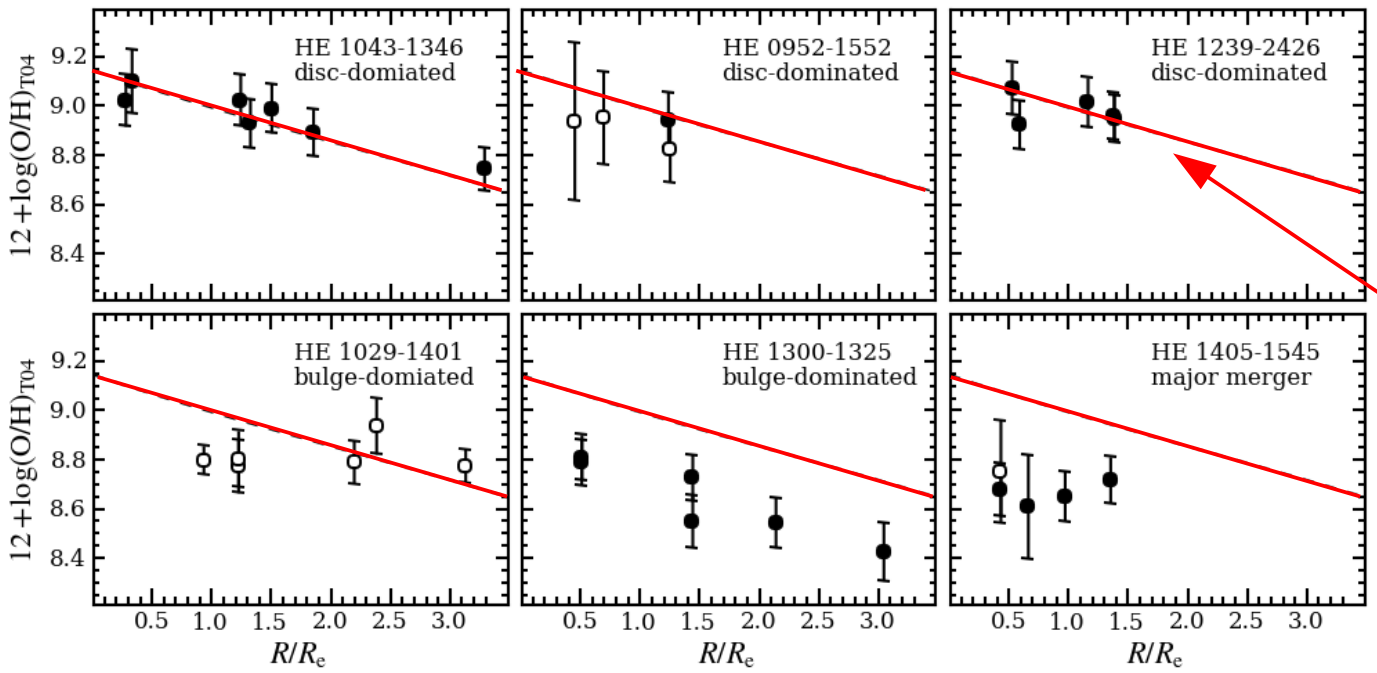
Radio jets may be import to
- directly drive outflows in the gas, or
- shape the conditions in the ISM



Radial metallicity gradients



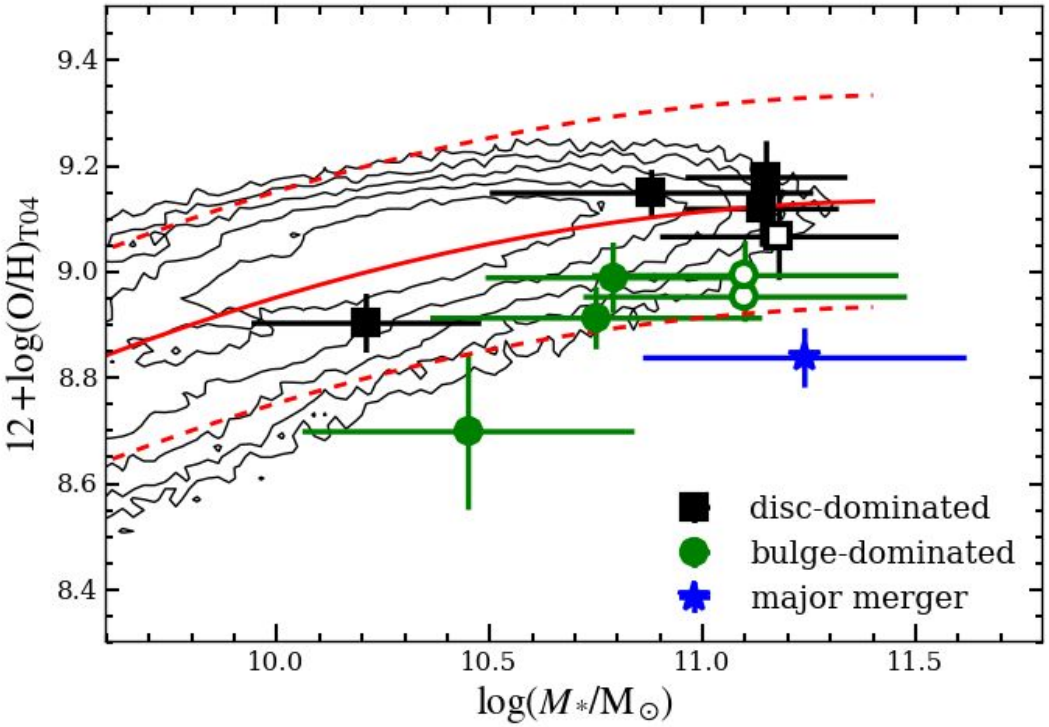
Radial metallicity gradients



Reference from CALIFA Sanchez+12

- Disc-dominated AGN host have gradients consistent with inactive galaxies
- Bulge-dominated and ongoing mergers seem to be significantly off from the normal relation

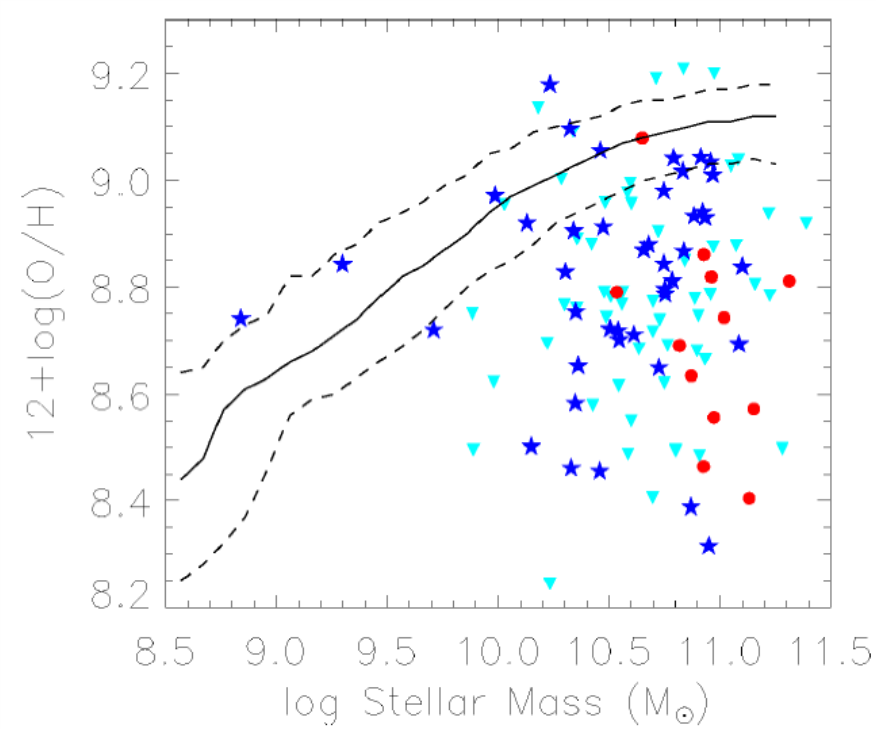
Different AGN triggering process in bulge- and disc-dominated hosts?



- Lower oxygen abundance in bulge-dominated AGN hosts
- Indication for radial gas inflow on galaxy-wide scales

  ➔ Interpret as minor mergers or major merger remnants

Different AGN triggering process in bulge- and disc-dominated hosts?



Montuori+12

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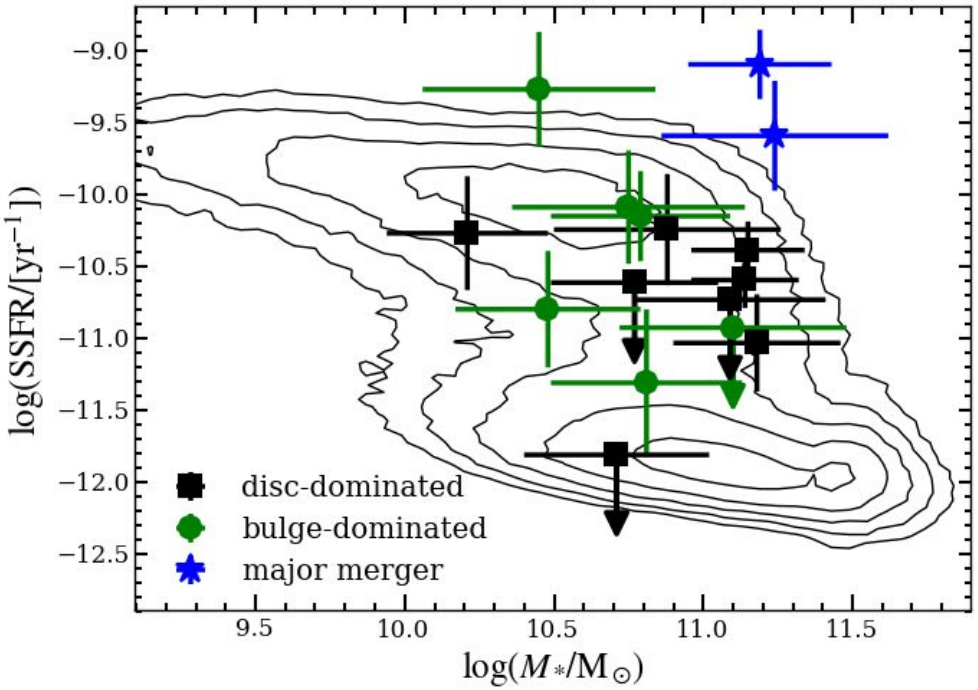
Enhanced, normal or suppressed star formation in AGN hosts?



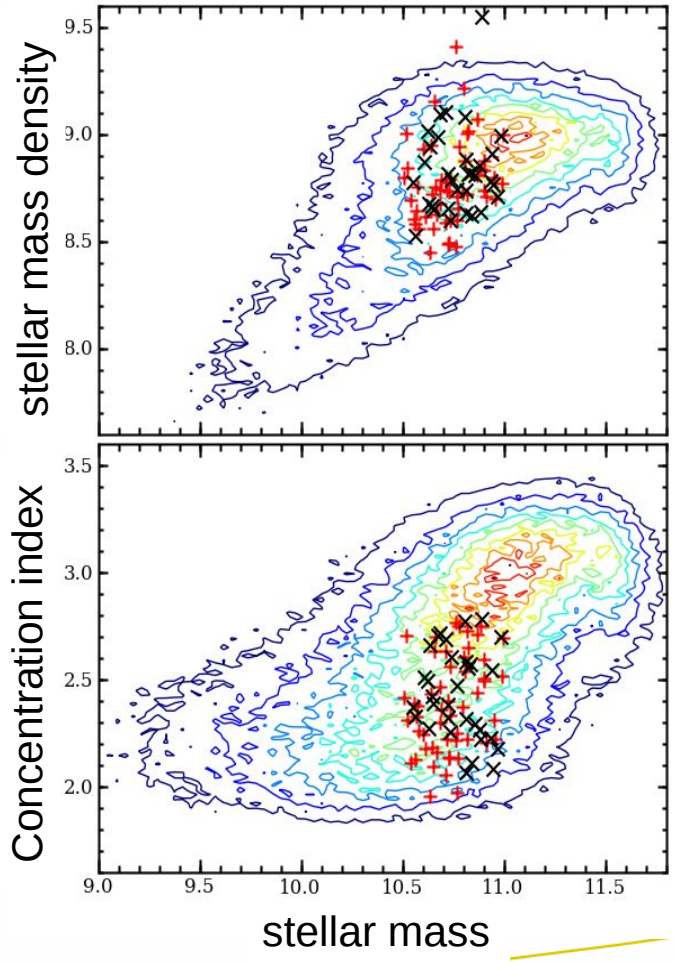
- AGN hosts display a variety of specific SFR
- Difficult to judge the impact of the AGN without comparison

  ➔ Matched control samples needed!

A AGN/non-AGN IFU mini-survey

- **20 AGN and 20 star forming galaxies**
- narrow stellar mass range
- late-type and face-on galaxies (*b/a*>0.6)
- redshift 0.03<*z*<0.05 and δ<10°
- mainly type 2 AGN

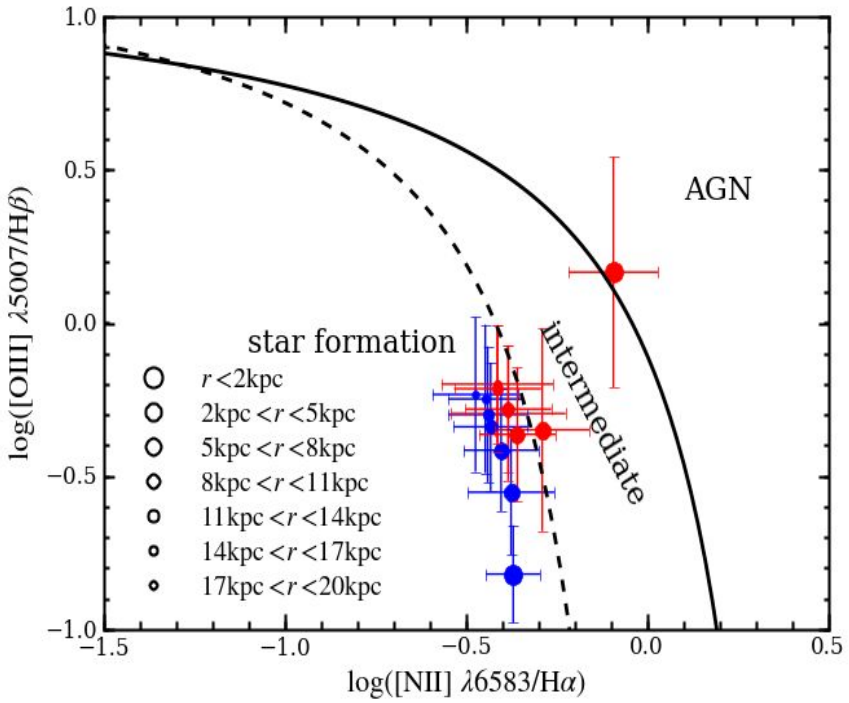
IFS with VIMOS to obtain the Hα distribution together with other BPT lines



Tracing star formation across galaxies

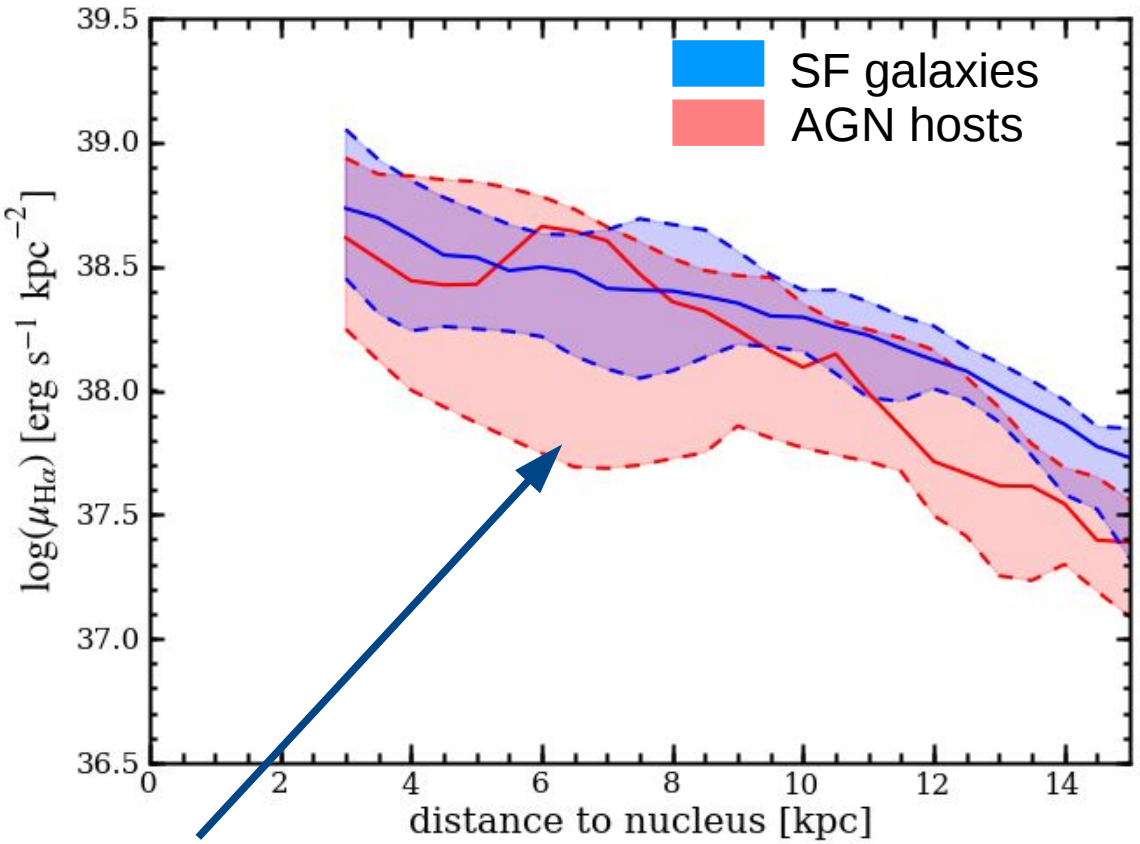
- HII line ratios follow sequence caused by radial metallicity gradients (e.g. Sánchez+12)
- AGN host galaxies show systematically shifted ratios:
  - *scattered light of nucleus?*
  - *higher fraction of shocks?*
  - *diffuse ionized gas?*
  - *other systematic effect?*

BPT diagnostic on radial bins



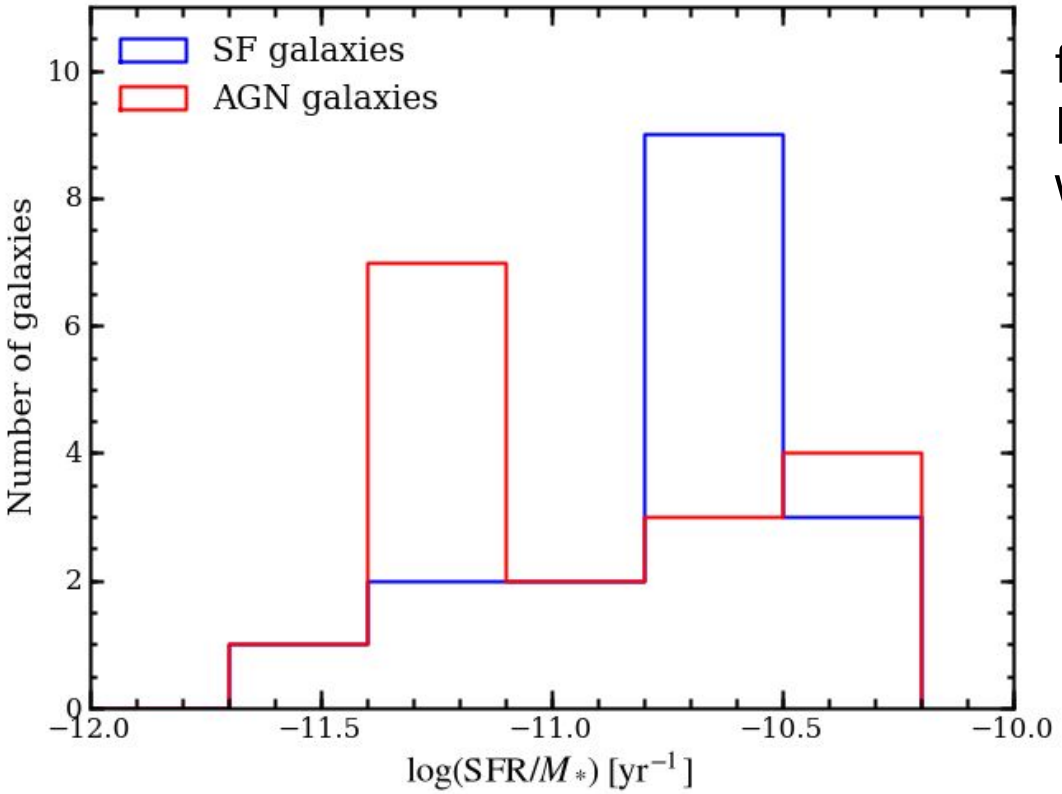
Conservative: Hα in the "intermediate" area considered as SF

Radial Hα surface luminosity



AGN hosts have **a larger range** in Hα surface luminosity at all radial distance

Comparison of specific SFRs



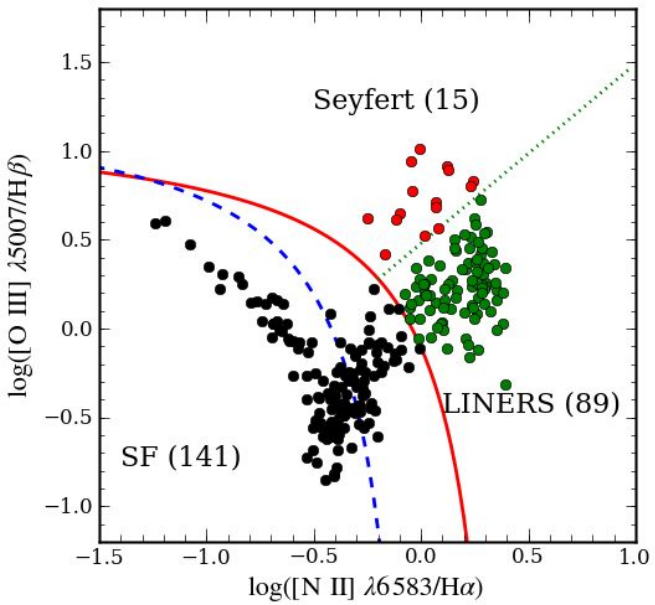
from integrated Hα emission within 2-10kpc

AGN distribution peaks at lower specific SFR

Extending samples with IFU surveys

CALIFA survey will provide data for **600 galaxies**:

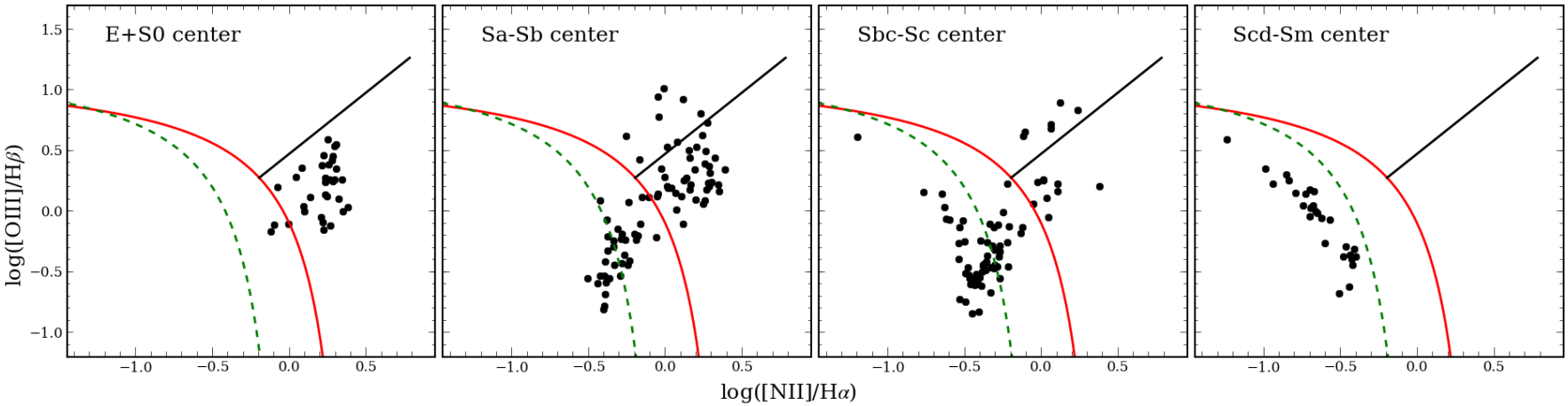
- variety of galaxy morphologies
- allows IFS comparison studies
- very nearby galaxies
- only few mainly type 2 AGN



SAMI and MANGA will provide data for **thousands of galaxies**:

- higher statistical power
- more flexibility in selecting (control) samples
- will contain more type 1 AGN
- smaller angular scale → **PSF bad for type 2 AGN**

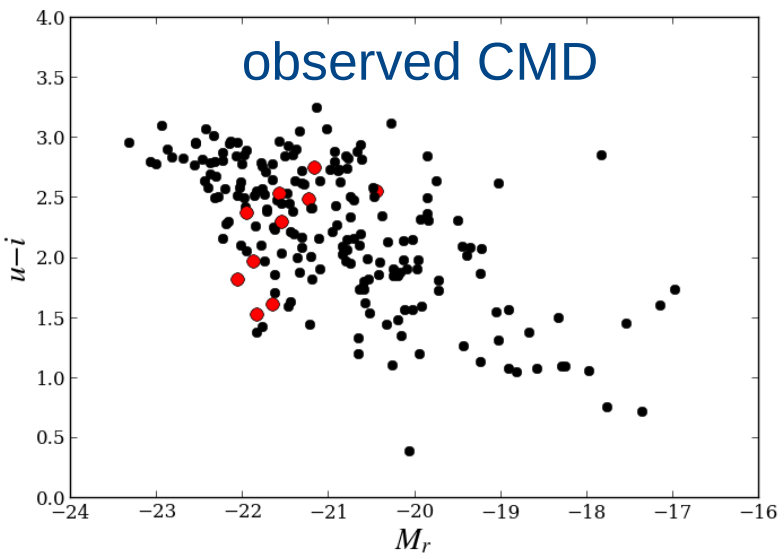
Control sample selection - The most critical point!

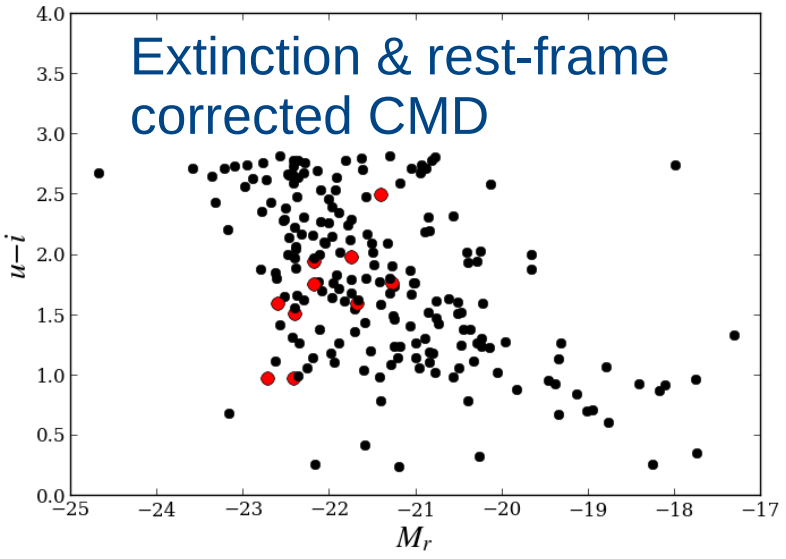


- majority of AGN reside in different galaxies than those with central star formation
- LINER emission powered by AGN?
  - ➔ Probably not (Kehrig+12,Papaderos+13,Singh+13)

➔ Understand ionization across the galaxy population

Control sample selection - What is the correct CMD?





- IFS allows to synthesis colors from SSP models
- Dust extinction can be measured per spaxel
  - ➔ “True” CMD can be re-constructed

CMD selection only on broad-band photometry is difficult

Conclusions

1. IFS has great potential to study the relation between AGN and there hosts in terms of
    - Kinematics signatures for outflows
    - Ongoing star formation to probe quenching
    - Metal content as a prove of past evolution
2. Analysis of type 2 AGN have important caveats
3. Large samples needed for sufficient statistics and construction of proper and consistent control samples

➔ Upcoming surveys such as CALIFA, SAMI and MaNGA offer unprecedented opportunities