Nearby AGN and QSO hosts

observed with near-infrared integral-field spectroscopy

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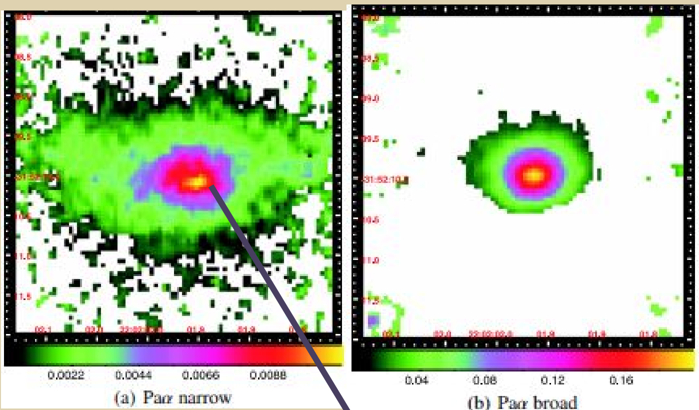
bcgs Bonn-Cologne Graduate School of Physics and Astronomy

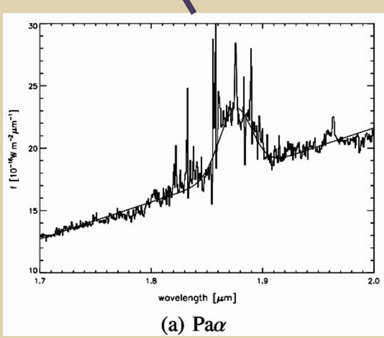
CLOSE AGN CARS REFERENCE SURVEY

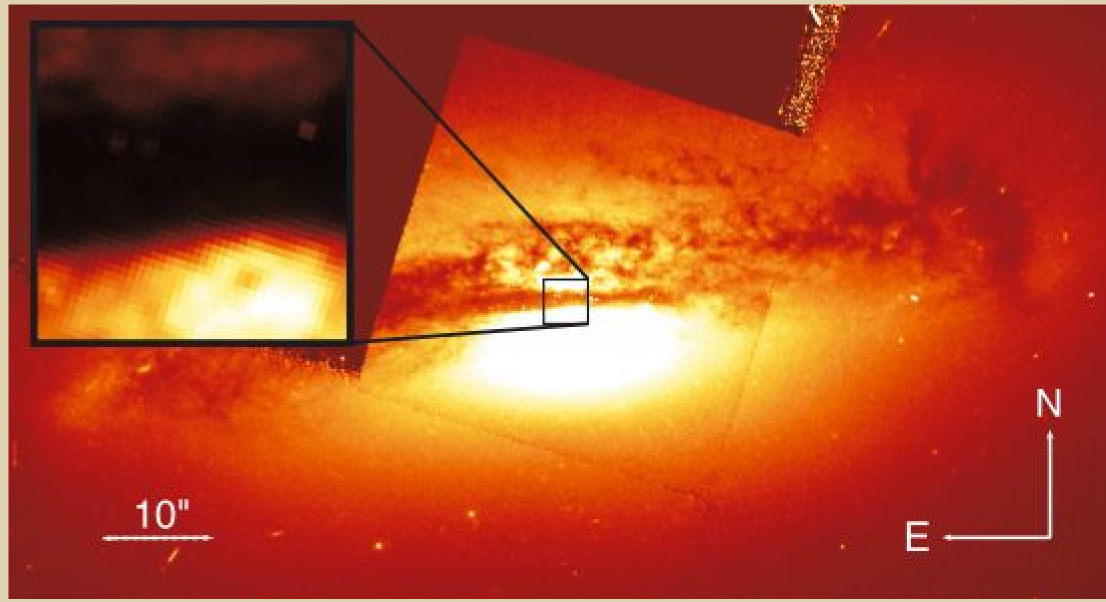
Great Lakes Quasar Symposium, 3rd May 2016

Near-infrared (NIR) integral-field spectroscopy (IFS) allows detailed studies of star formation and nuclear activity of dust-enshrouded galactic nuclei



Paα emission line maps (Smajić+12)





HST V-band image of NGC7172

The NIR IFS SINFONI provides a spectrum in every spatial pixel

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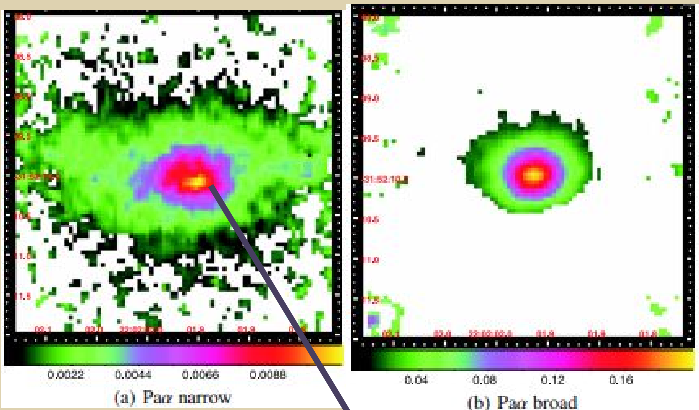

(a) Paα narrow (b) Paα broad

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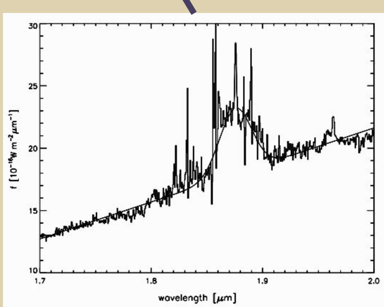
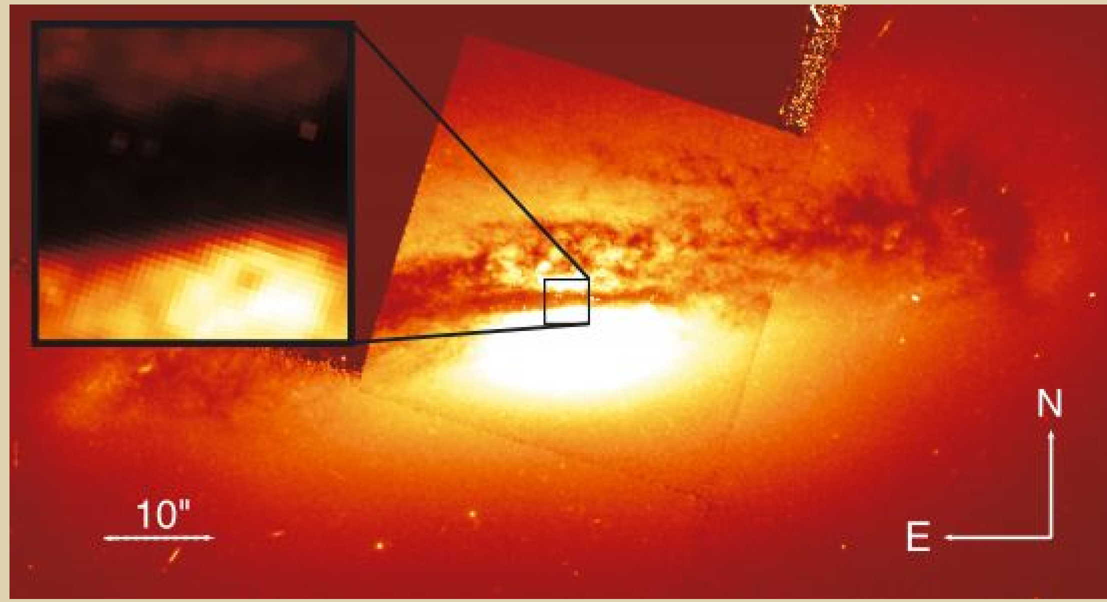


(a) Paα



HST V-band image of NGC7172

SINFONI

spectral resolution: ~100 km/s

spatial resolution: seeing limited (~0.8'')

adaptive optics (~ 100 mas)

typical integration time: 1 hour

The NIR IFS SINFONI provides a spectrum in every spatial pixel

Is there any relation between a SMBH and its host galaxy?

Why/how an AGN turns-on?

What are the main properties of AGN hosts?

Are QSO hosts similar to nearby galaxies?

multiwavelength survey CARS

CLOSE AGN CARS REFERENCE SURVEY

near-infrared integral-field spectroscopy of nearby galactic nuclei (NUGA project)

near-infrared studies of low-luminosity QSOs

wavelength λ

redshift z

Combination of sub-mm/CO and NIR data is ideal to study AGN hosts:

- distribution and kinematics of (cold & hot) molecular & ionised gas
- stellar potential/kinematics
- star formation history
- dust distribution

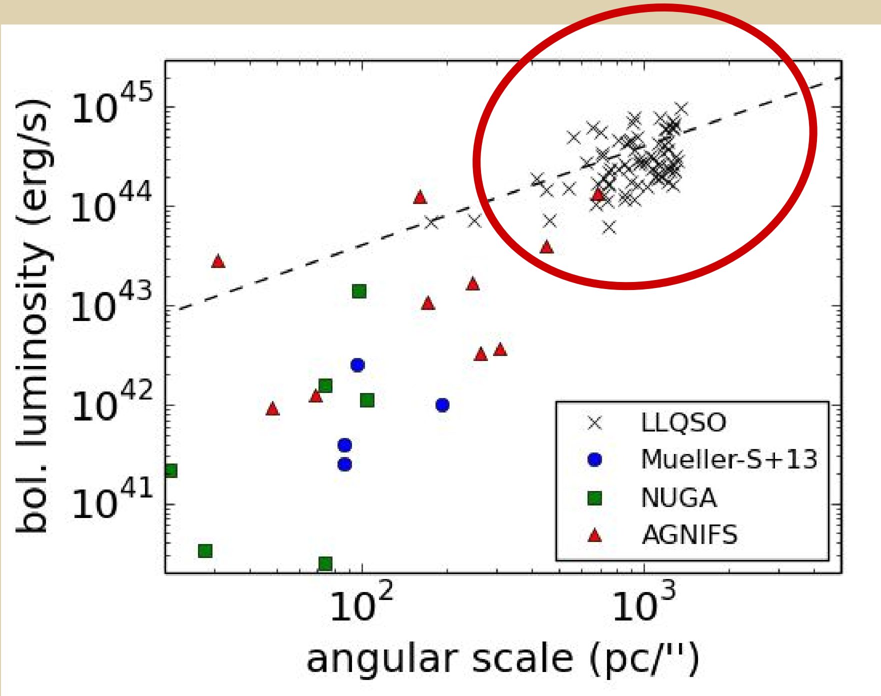
<u>NUclei of GAlaxies (NUGA)</u>
(García-Burillo, Combes, Tacconi, Eckart, Baker...)

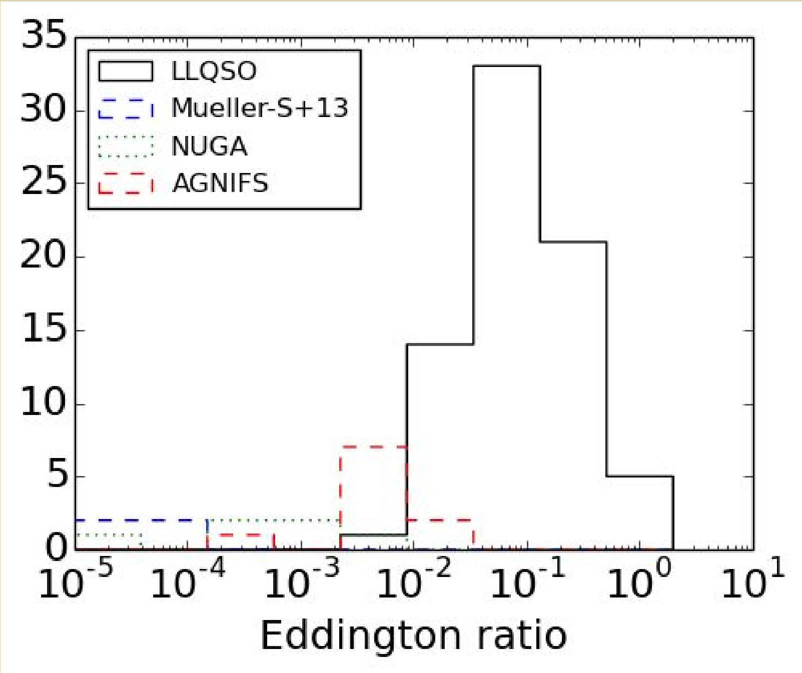
nearby AGN (Sy1, Sy2, LINERs)
Distance ~ 4-40 Mpc
linear scale ~30 pc
➡ detailed view on gas distribution, kinematics, excitation in inner pc.

<u>Low-luminosity type-1 QSO sample</u>
(e.g. Bertram+07,Krips+07, König+09, Busch+14,15, ...)

nearby quasars (only type-1)
$0.02<z<0.06$ (~ 90-270 Mpc)
linear scale ~100 pc (adaptive optics)
➡ fill the gap between nearby galaxies and high-z quasar samples

Moving on to more distant and more luminous/active objects





LLQSOs are more luminous than nearby Seyferts and have higher accretion rates.

Are still close enough to allow for detailed analysis of central kpc.

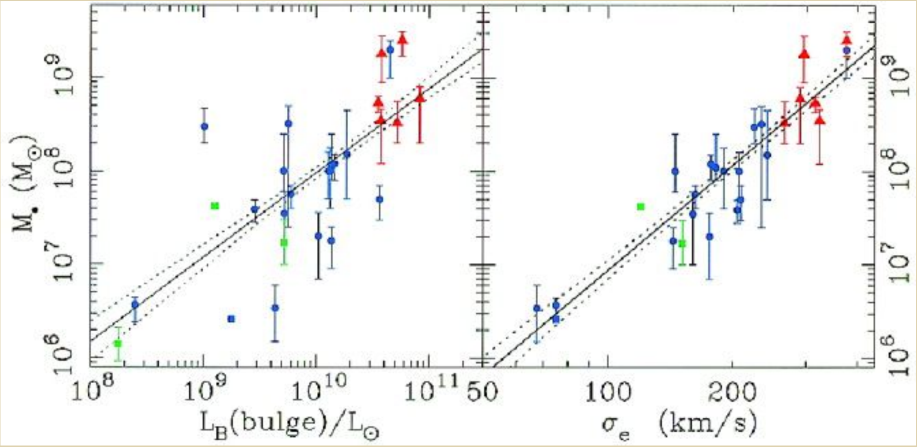
Unobscured AGN (type-1)

➜ M_{BH}, L_{bol}, Eddington ratio can be estimated

BH - host galaxy (bulge) relations

Relations between BH mass and bulge properties have been found in the last 15 years:

- stellar mass M_*
- velocity dispersion
- luminosity (optical, NIR)



(e.g. Magorrian+98, Ferrarese&Merritt 00, Gebhardt+ 00, Marconi&Hunt 03, Häring&Rix 04, Graham 07, Graham&Driver 07, Gültekin+ 09, Scott+ 13)

Gebhardt et al. 2000

But: M_{BH}/M_{bulge} ~ 0.1%

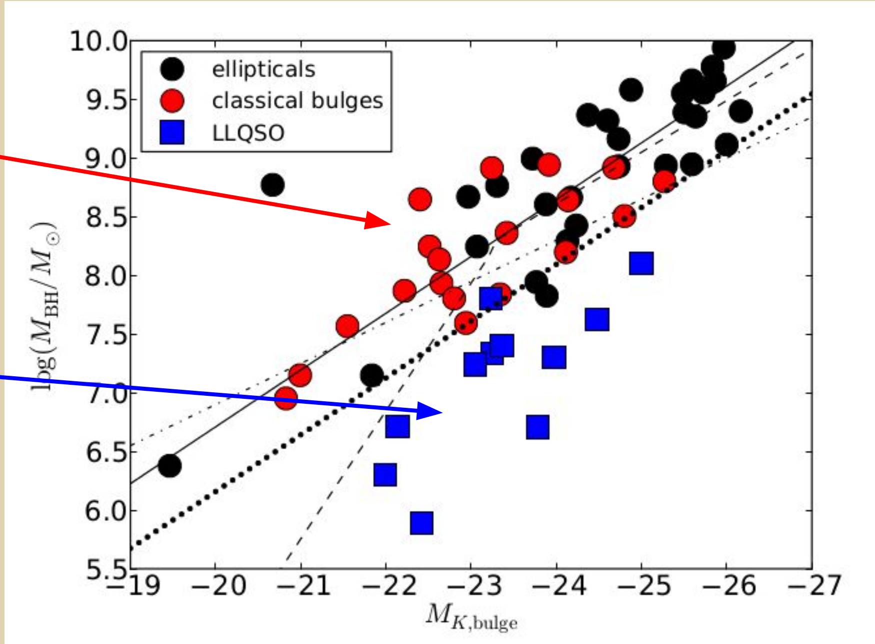
This relation has not been expected!

→ SMBH - host galaxy coevolution ?!

The M_{BH}-L_{bulge} relation of active galaxies

Inactive galaxies:
bulge magnitude and M_{BH} are correlated!

LLQSOs are under the relation!



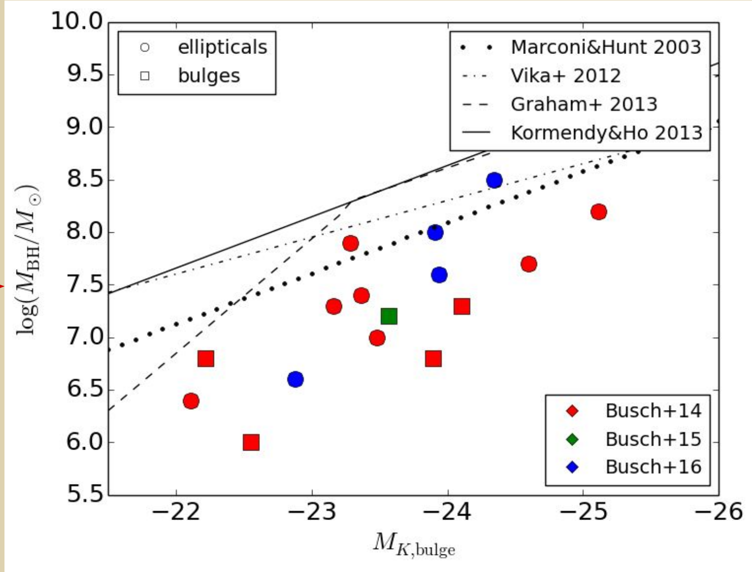
Busch et al. 2014, A&A 561, A140

In agreement with studies in the optical:
e.g. Nelson+04, Kim+08, Bennert+11

For first time observed in the near-infrared.

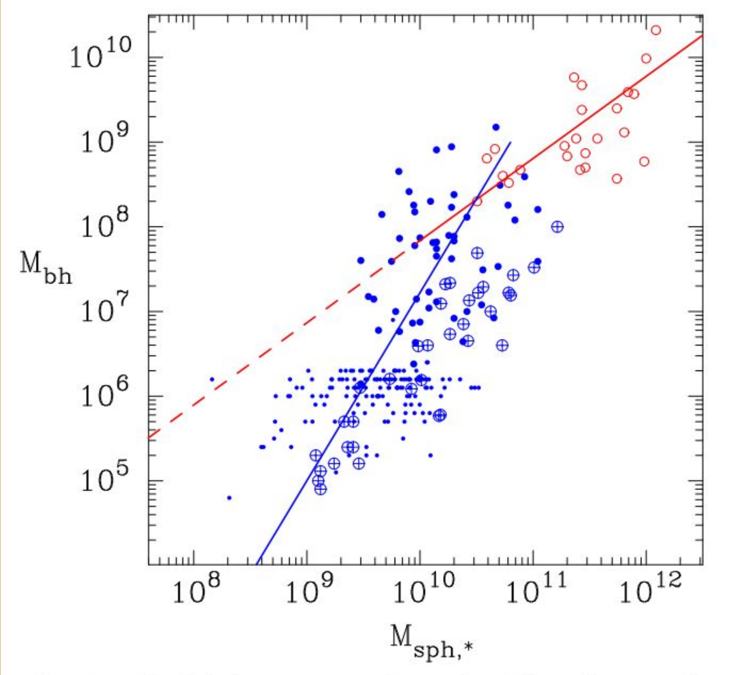
LLQSOs are under the relation!

including more sources

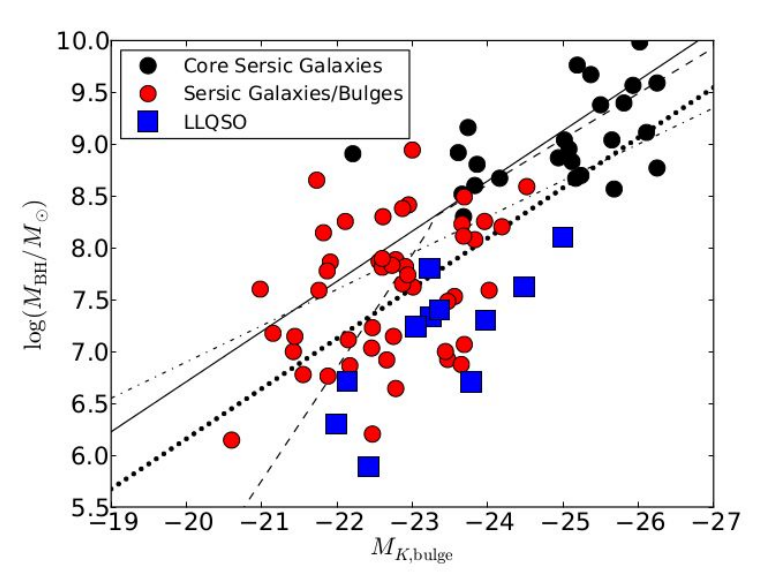


Busch +16

using a “broken power-law” relation:



Graham 2016



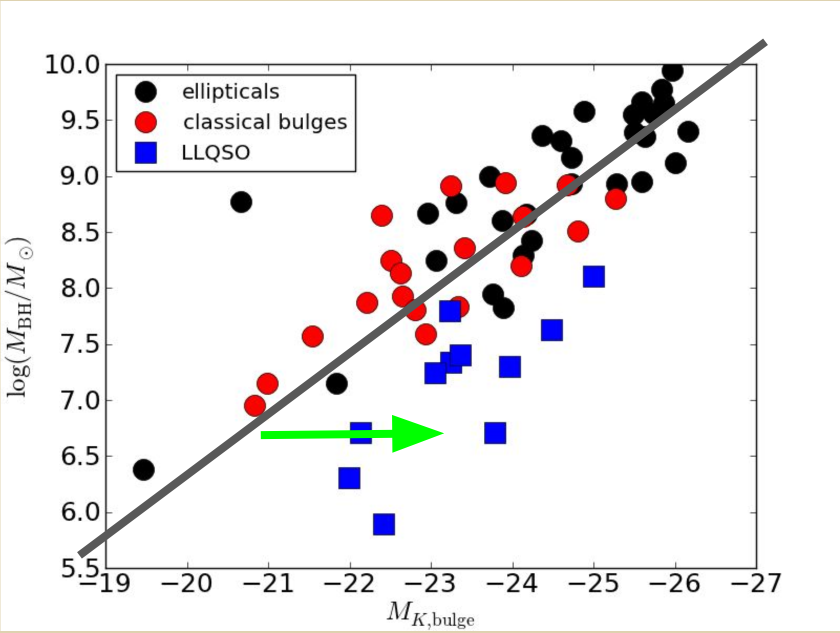
Busch +14

The M_{BH}-L_{bulge} relation of active galaxies

LLQSOs are under the relation!

Possible reasons:

- Overluminous bulges (through star formation?)



Busch+ 14

The M_{BH}-L_{bulge} relation of active galaxies

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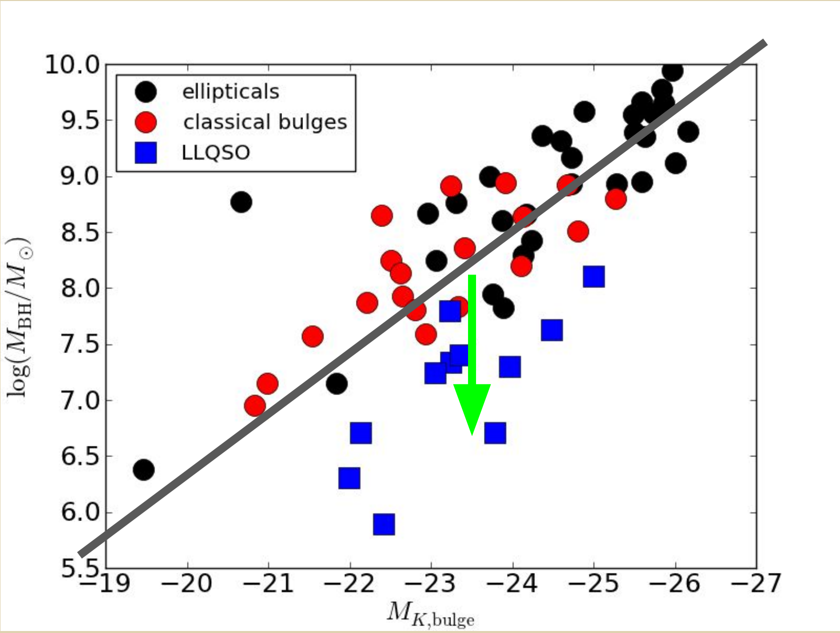
Possible reasons:

- Overluminous bulges (through star formation?)
- Undermassive black holes



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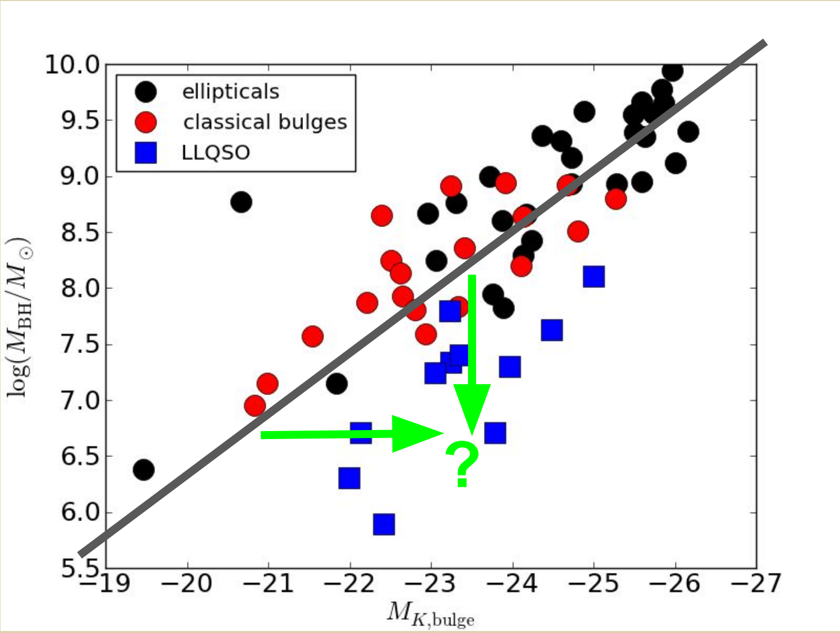


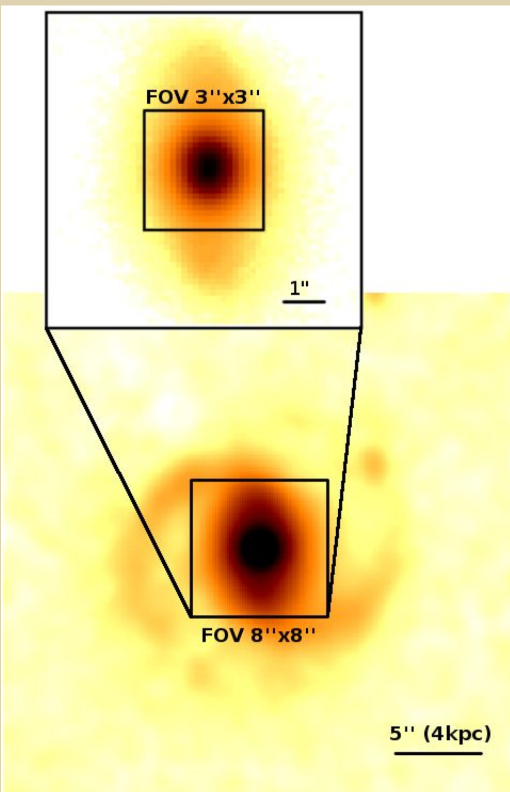
Busch+ 14

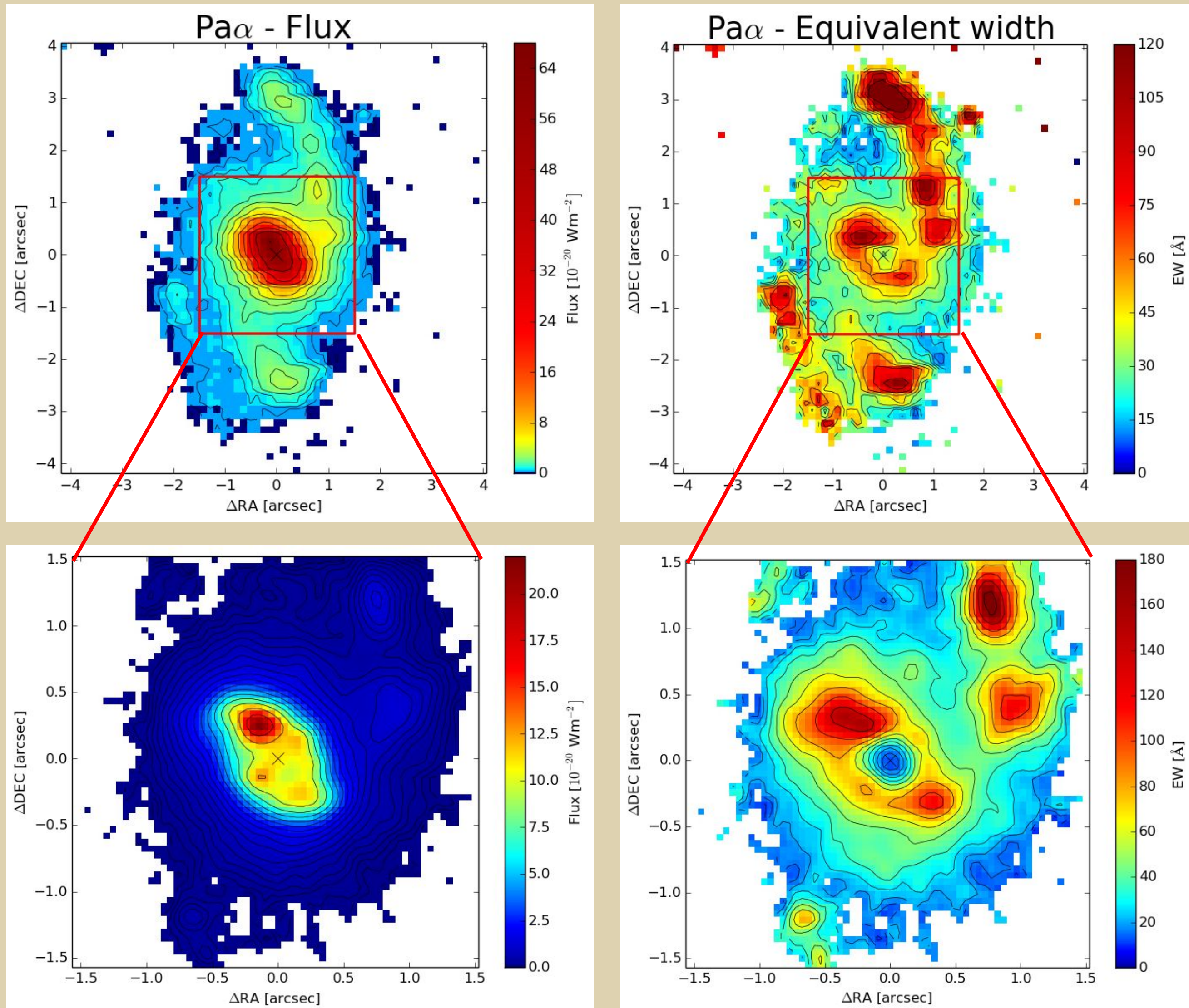
Implications for understanding of black hole - bulge coevolution!!

Pilot study:
Observing LLQSOs with NIR IFS (AO assisted)

SINFONI uncovers a circumnuclear star forming ring r~240 pc

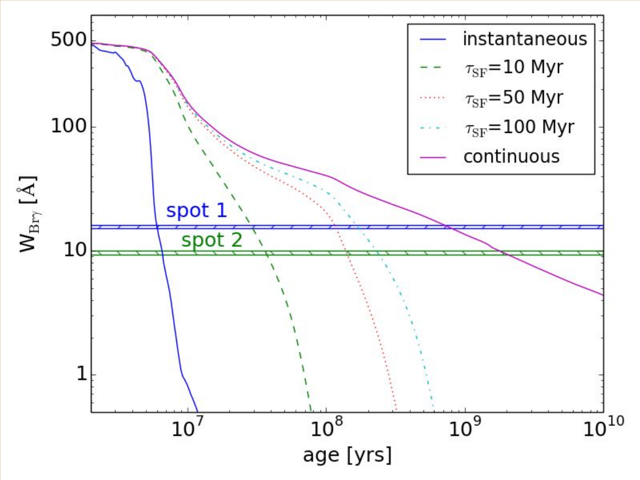
HE 1029-1831



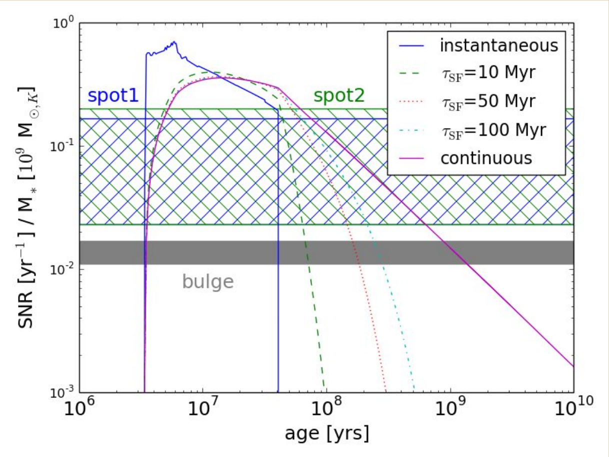


Busch et al. 2015, A&A 575, A128

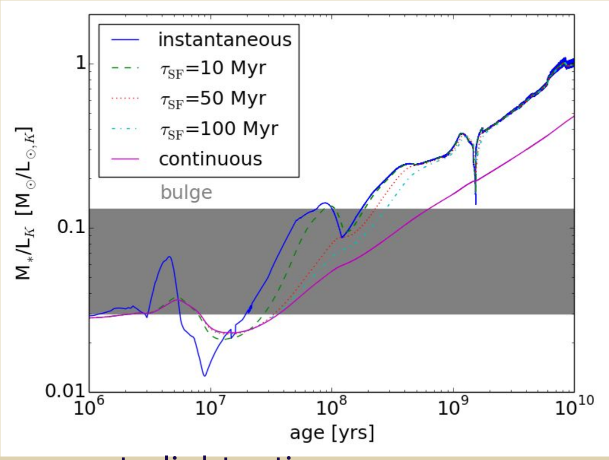
starburst99 diagnostics➜ star formation history



equivalent width of Brγ.
correction for AGN dilution by CO equiv. width



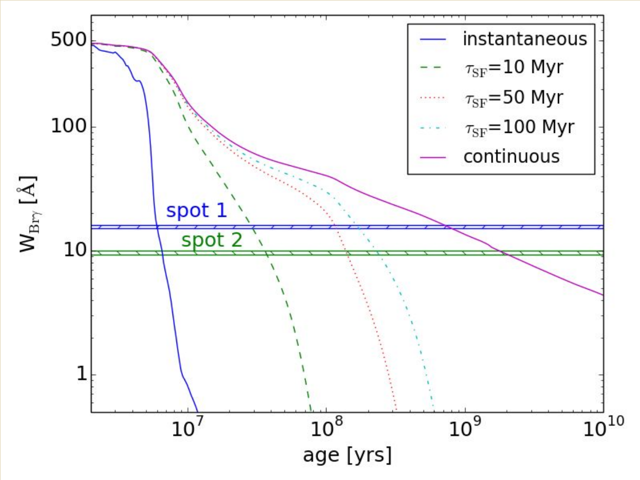
SN rate (normalized by stellar mass)
➜ SN rate from [FeII] emission
➜ stellar mass from dynamics (dyn. mass)



mass-to-light ratio
➜ stellar mass from dynamics
➜ luminosity from BUDDA fit

Favored model:
SB with time scale τ=50-100 Myr,
that began 100-200 Myr ago.
➜ intermediate-age stellar population dominates bulge luminosity

starburst99 diagnostics→ star formation history



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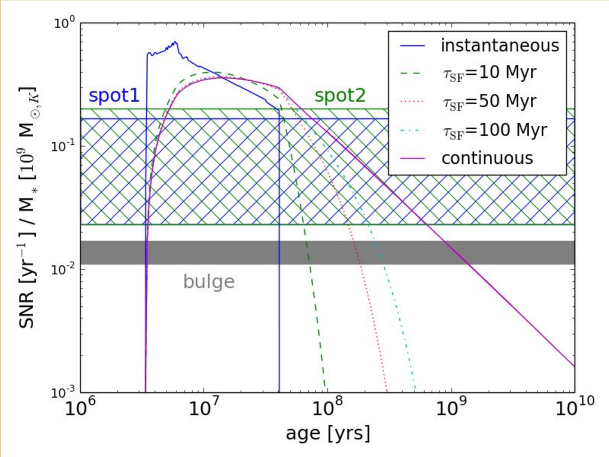

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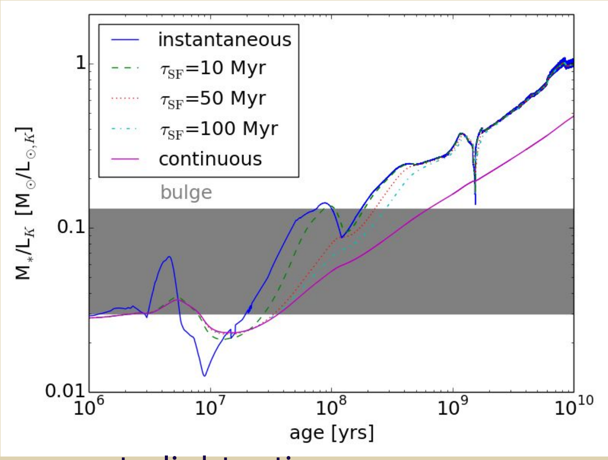
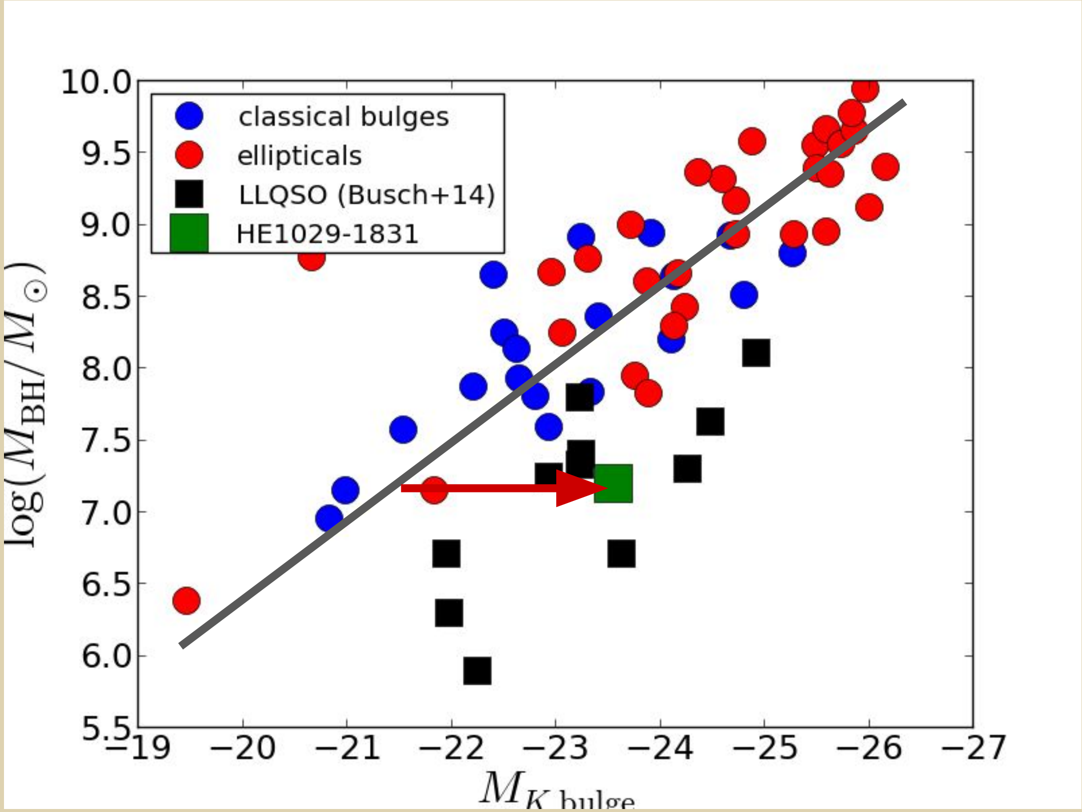


mass-to-light ratio
→ stellar mass from dynamics
→ luminosity from BUDDA fit

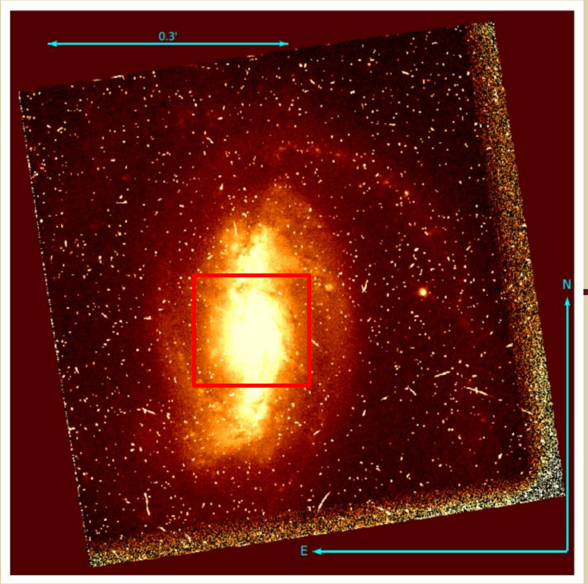
Since other M_{BH} estimates agree with each other
→ bulge is overluminous because of young stellar population

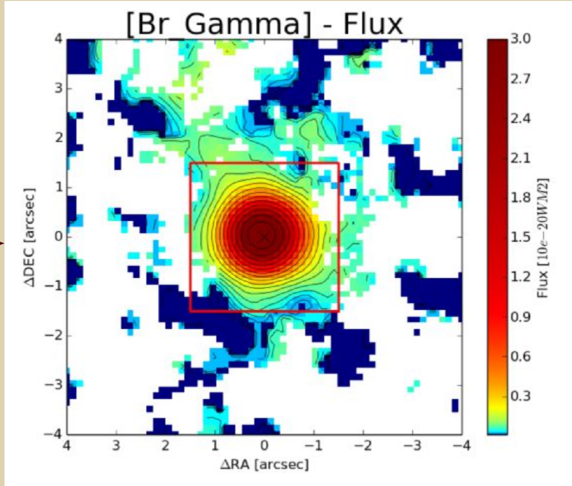


→ offset of HE 1029-1831 in M_{BH}-L_{bulge} relation due to young stellar populations in bulge

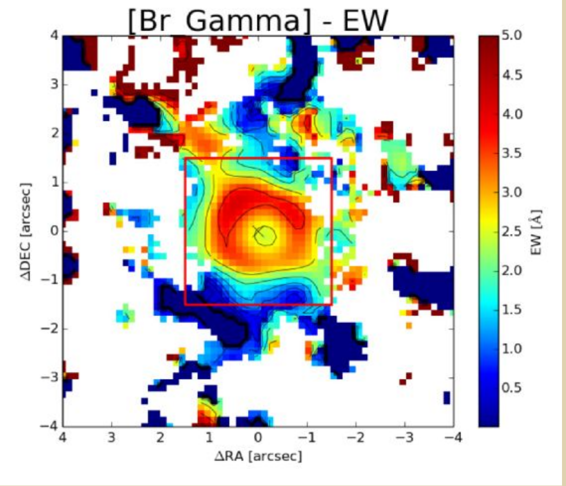
see Busch et al. 2015, A&A, 575, A128

Project is ongoing...





Bachelor-student: Nicolaus Preuss-Neudorf



More (NIFS-)data will come with the CARS-survey...

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near-infrared studies of low-luminosity QSOs

multiwavelength survey CARS

CLOSE AGN CARS REFERENCE SURVEY

wavelength λ

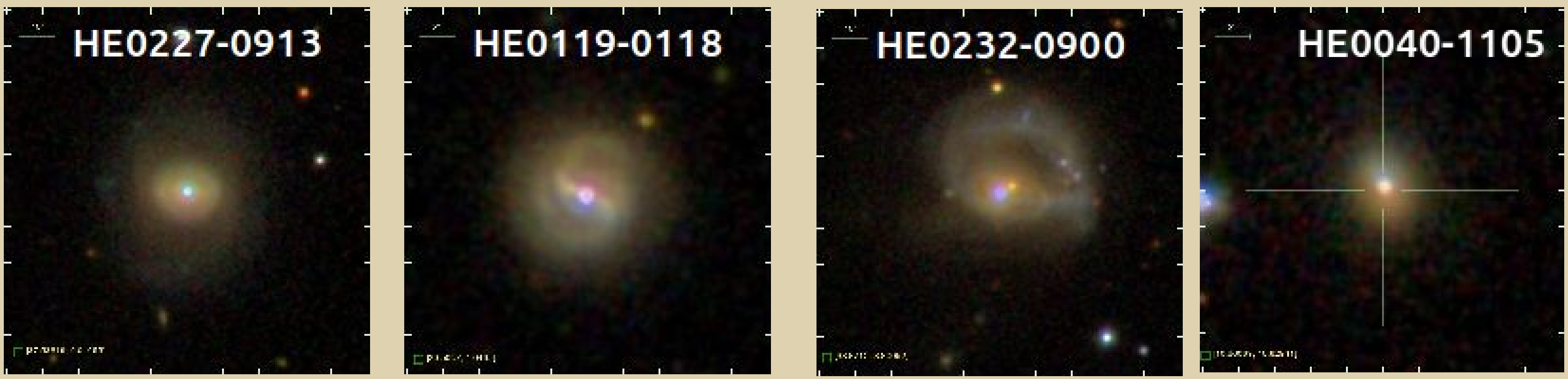
redshift z

The Close AGN Reference Survey (CARS)

Subsample of the LLQSO sample with single-dish CO(1-0) data (Bertram+07)

➔ 40 objects

http://www.cars-survey.org/



PI: B. Husemann (ESO)
SAB: F. Combes (Paris), S. Croom (Sydney), A. Eckart (Cologne)
G. Busch (Cologne), T. Davis (Cardiff), D. Gadotti (ESO), R. McElroy (Sydney), G. Tremblay & M. Powell (Yale), M. Perez-Torres (Granada), J. Scharwächter (Paris), T. Urrutia (Potsdam), et al.

What are the goals of CARS?

- Spatially-resolved multi-wavelength survey of AGN
  - ➜ Mapping various SFR tracers
  - ➜ Understanding the multi-phase ISM in AGN
  - ➜ Total gas mass budget
  - ➜ Statistics of outflows on host galaxy scales

- Unravel the intimate link between AGN and hosts

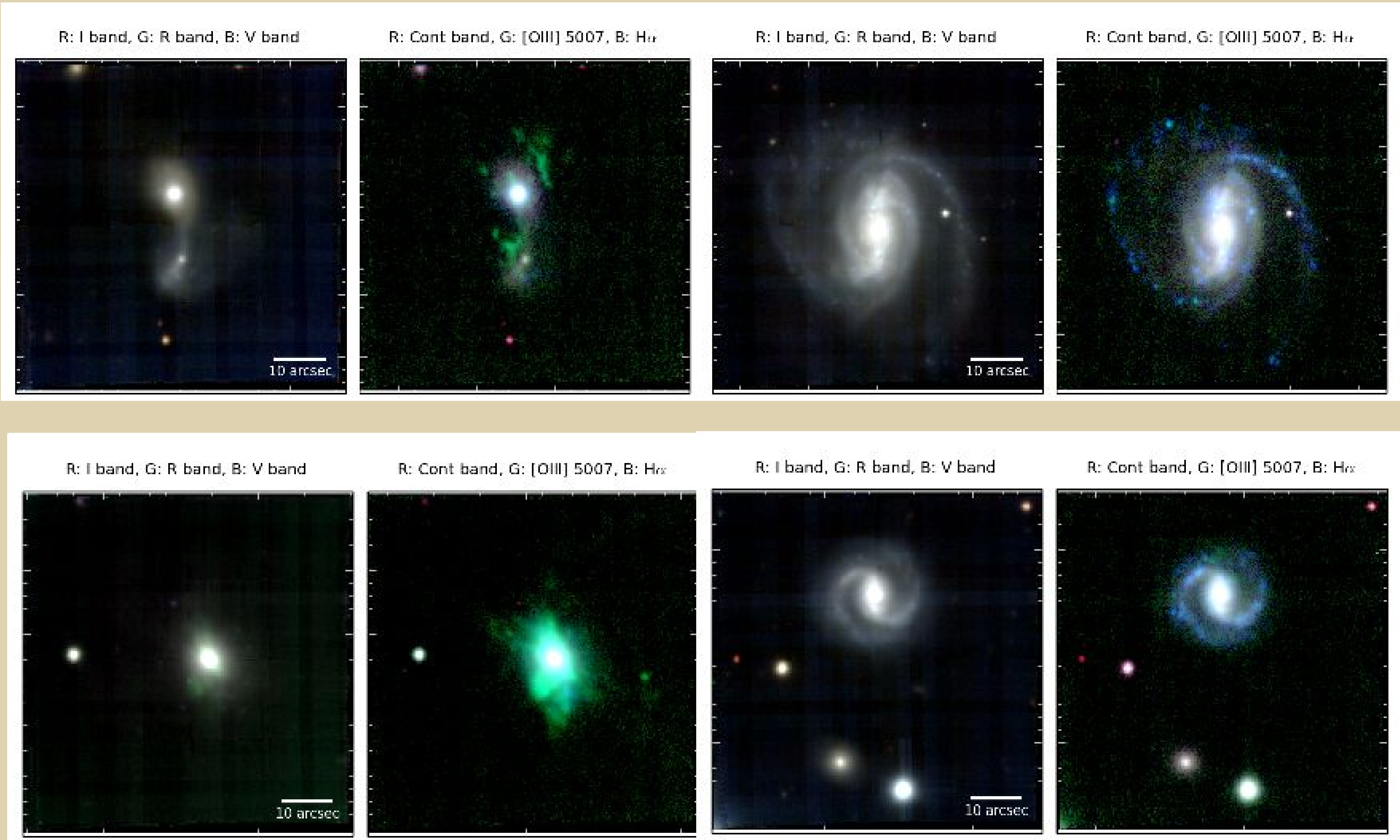
- Understand importance of AGN for galaxy evolution

- Set the local reference for studies at various z
  - ➜ Representative sample of luminous nearby AGN

Building-up a unique data set:

- optical 3D spectroscopy with MUSE
  - ➜ stellar/gas kinematics, line diagnostics, SFR

Optical IFS with VLT-MUSE: The game-changer



Building-up a unique data set:

- optical 3D spectroscopy with MUSE
  - ➜ stellar/gas kinematics, line diagnostics, SFR
- near-infrared 3D spectroscopy with SINFONI/NIFS
  - ➜ kinematics, diagnostics, SFR in the very center
- optical/near-infrared imaging
  - ➜ morphology, decomposition, stellar masses
- Chandra X-ray spectroscopy
  - ➜ mapping of hot gas
- JVLA/NOEMA radio data
  - ➜ mapping of neutral hydrogen (HI)
- SOFIA FIR observations
  - ➜ star formation tracer [CII]

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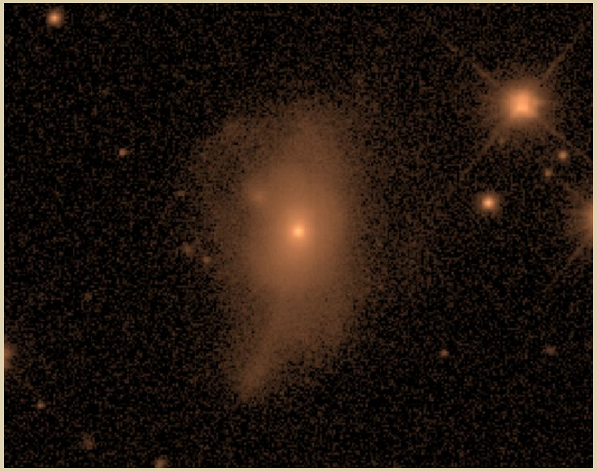
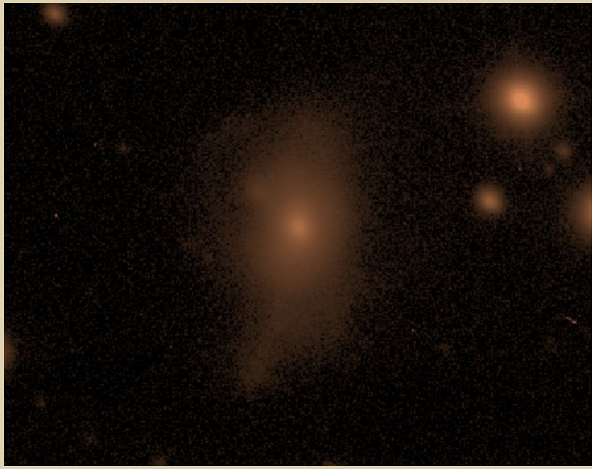
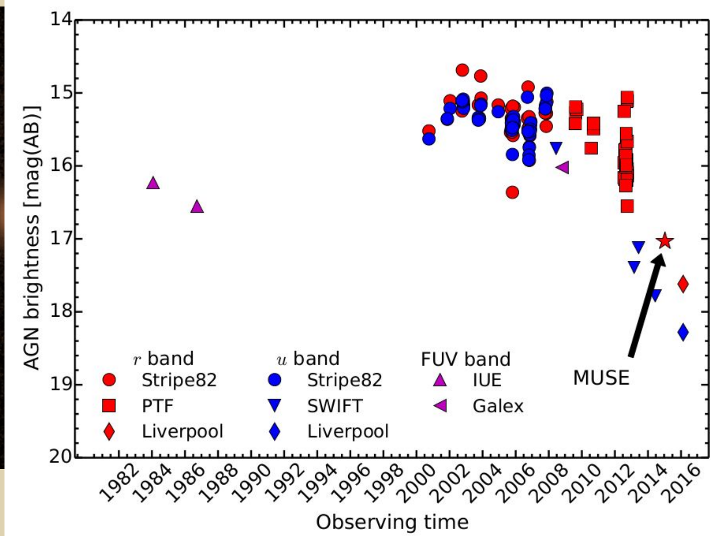
Exciting times ahead ...

SDSS (Nov 2003)



Liverpool Telescope (some weeks ago)





- source transitioned from Seyfert 1.9 to Seyfert 1 in 1980s
- has transitioned back to Seyfert 1.9 between 2013 and now (after ~30 years)
- Chandra and HST DDT proposals successful
- Letter will come out in the next weeks