Scaling relations of IMBH and their host-galaxies

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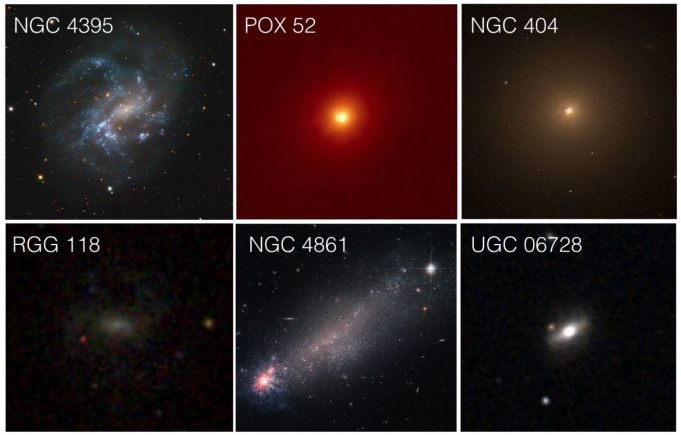
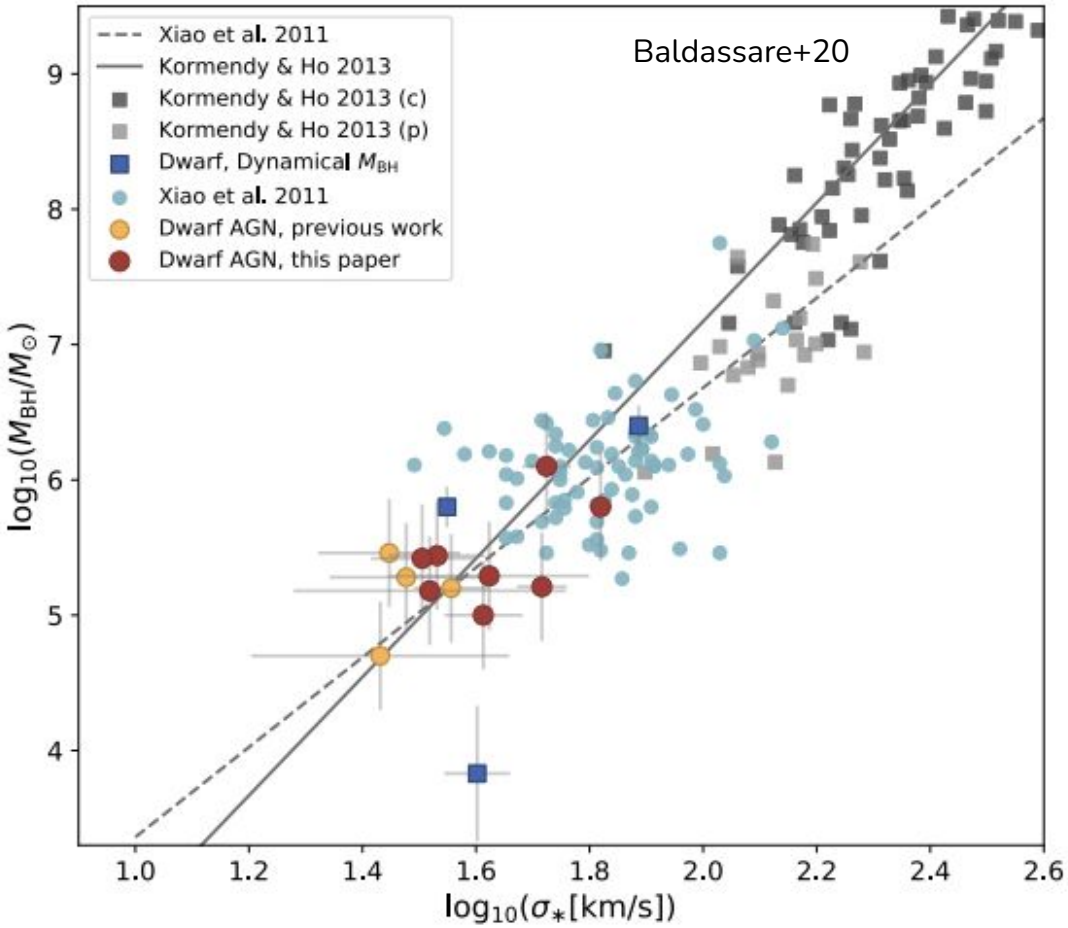
Growing Black Holes: Accretion and Mergers –
19/May/2022

Nuclear (I)MBH: what was known by 2017/20



NGC104 Kiziltan17



Optical follow-up spectroscopy of IMBH/LWSMBH

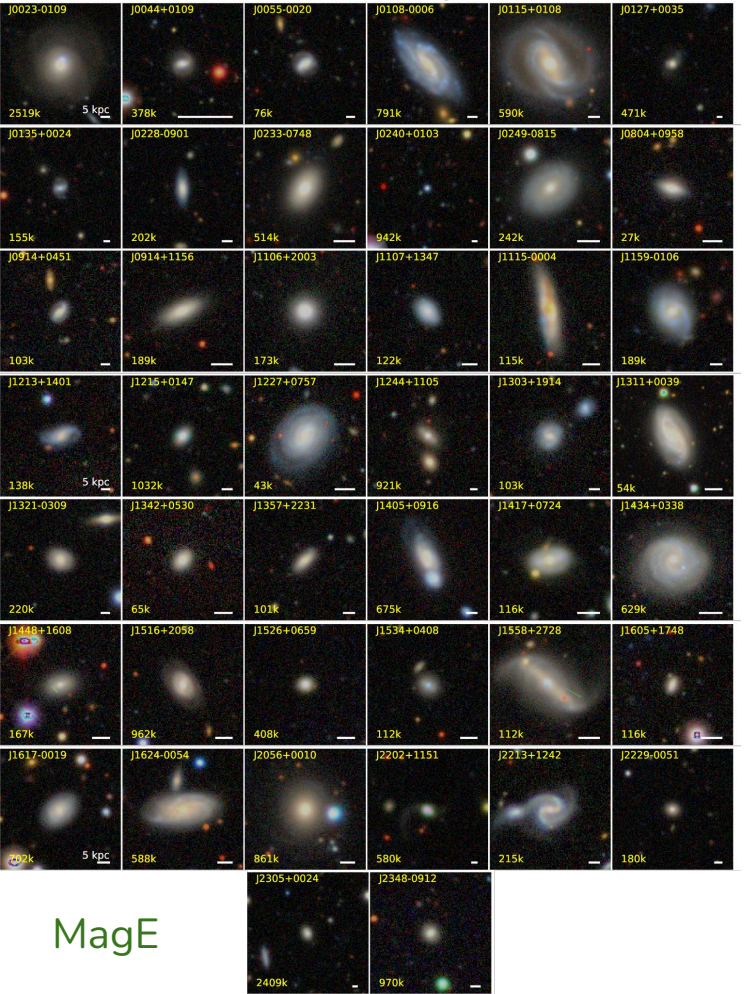
Optically selected AGN candidates (SDSS):

- IMBH: **305** galaxies (M_{BH}<200 000 M_{Sun})
- LWSMBH: **1623** galaxies ($2*10^5$<M_{BH} <10^6 M_{Sun})

Of the **141** X-ray confirmed IMBHs/LWSMBHs:

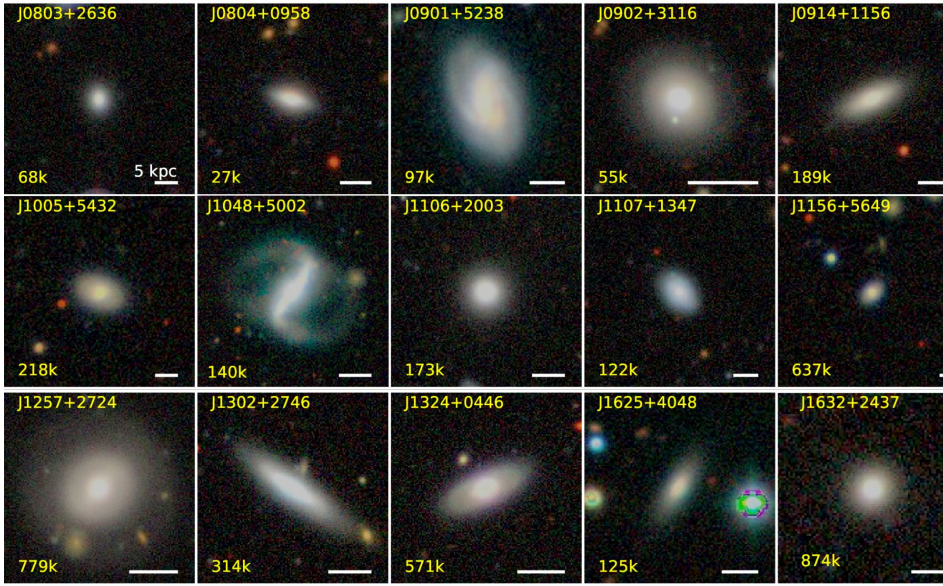
- ***44*** galaxies observed by our team with MagE (Magellan)
- ***15*** with ESI (Keck). +***11*** spectra were found in the Keck archive
- ***9*** with RSS (SALT). In total ***76*** unique objects.

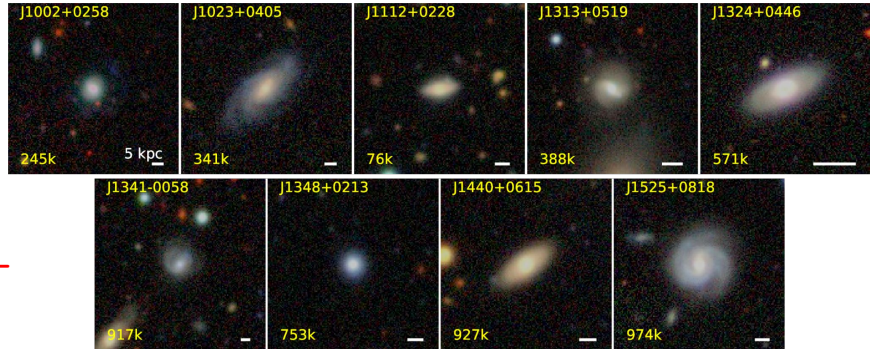
The targets of our optical follow-up campaign



MagE

ESI





SALT

Virial mass estimate

The virial mass of a black hole, according to Reines, A. E., Greene, J. E., & Geha, M. 2013, ApJ, 775, 116

$$M_{BH} = 3.72 \times 10^{6} \, (FWHM_{H\alpha} / 10^{3} \text{ km/s})^{2.06} \times (L_{H\alpha} / 10^{42} \text{ erg/s})^{0.47} \, M_{sun}$$

The upper limit of the IMBH mass is taken as 200 000 M_{Sun} (+1σ systematic uncertainty in the estimate of the virial mass of a black hole from BLR H_{alpha} , equal 100 000 M_{Sun})

Challenge: estimate the virial mass of central black holes

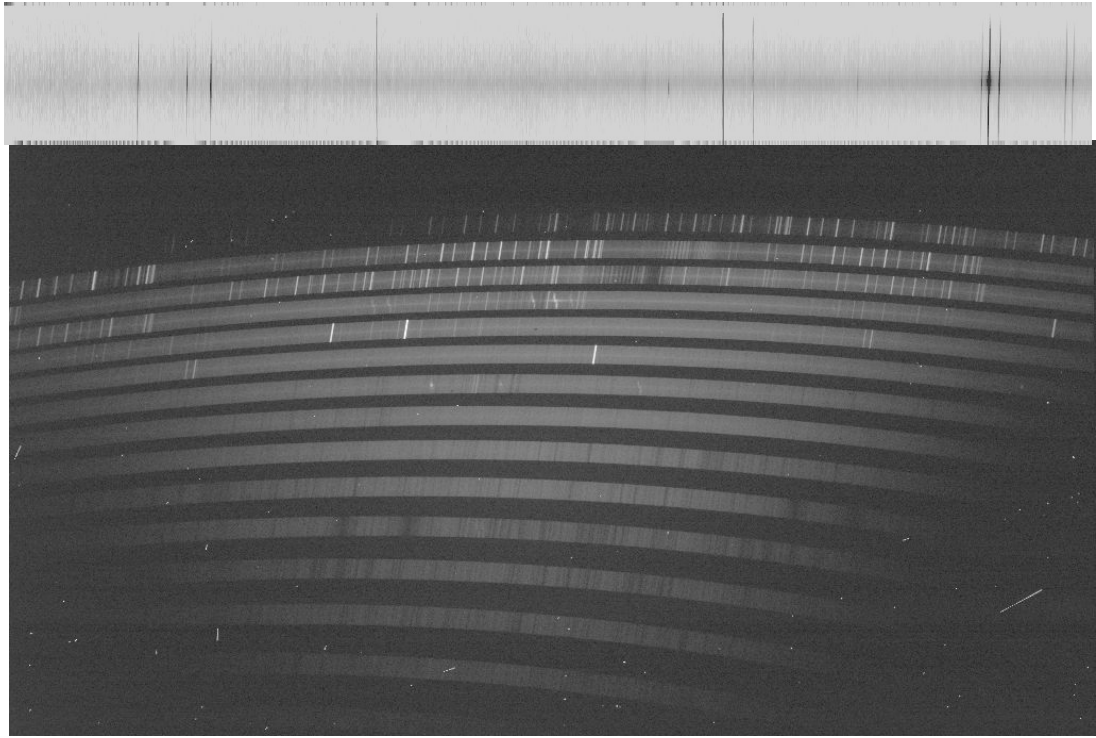
- sample of confirmed candidates for IMBH / LWSMBH (76).

Data reduction and post-processing of MagE and ESI data

MagE: a low-res echelle at the 6.5m Magellan

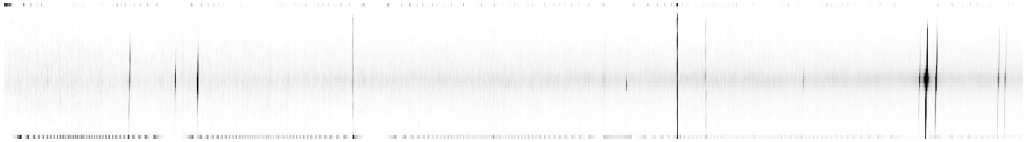
ESI: a low-res echelle at the 10m Keck

R_{MagE}= 6400 (σ_{inst} = 20 km/s)
R_{ESI} = 8700 (σ_{inst} = 15 km/s),
0.3< λ < 1.0 um



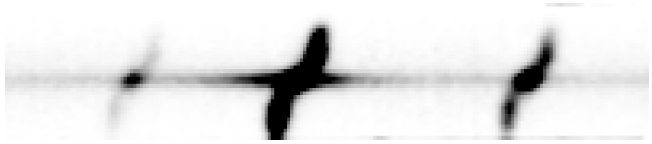
Analysis of the spectra of host galaxies with IMBH and LWSMBH

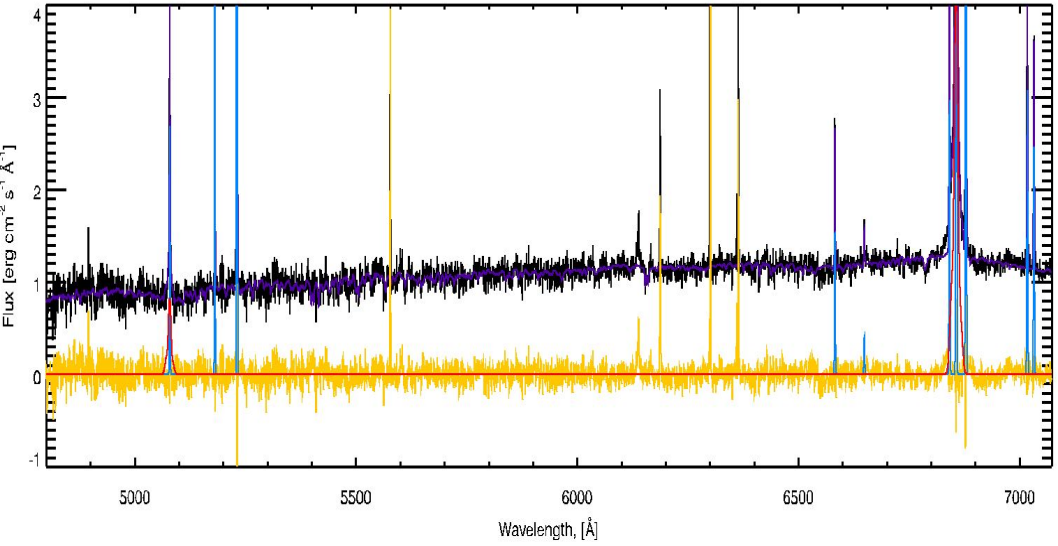
Three-component parametric 2d fit of the galactic center (NBURSTs):

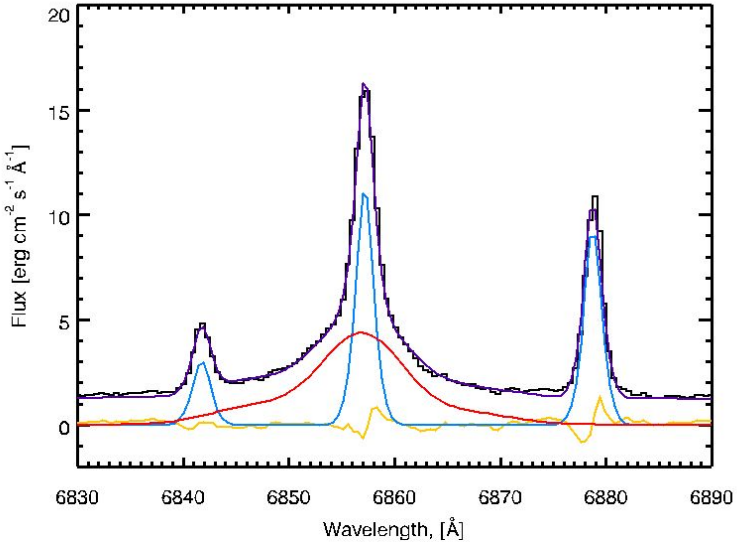


Galaxy SDSS J110731.23+134712.8

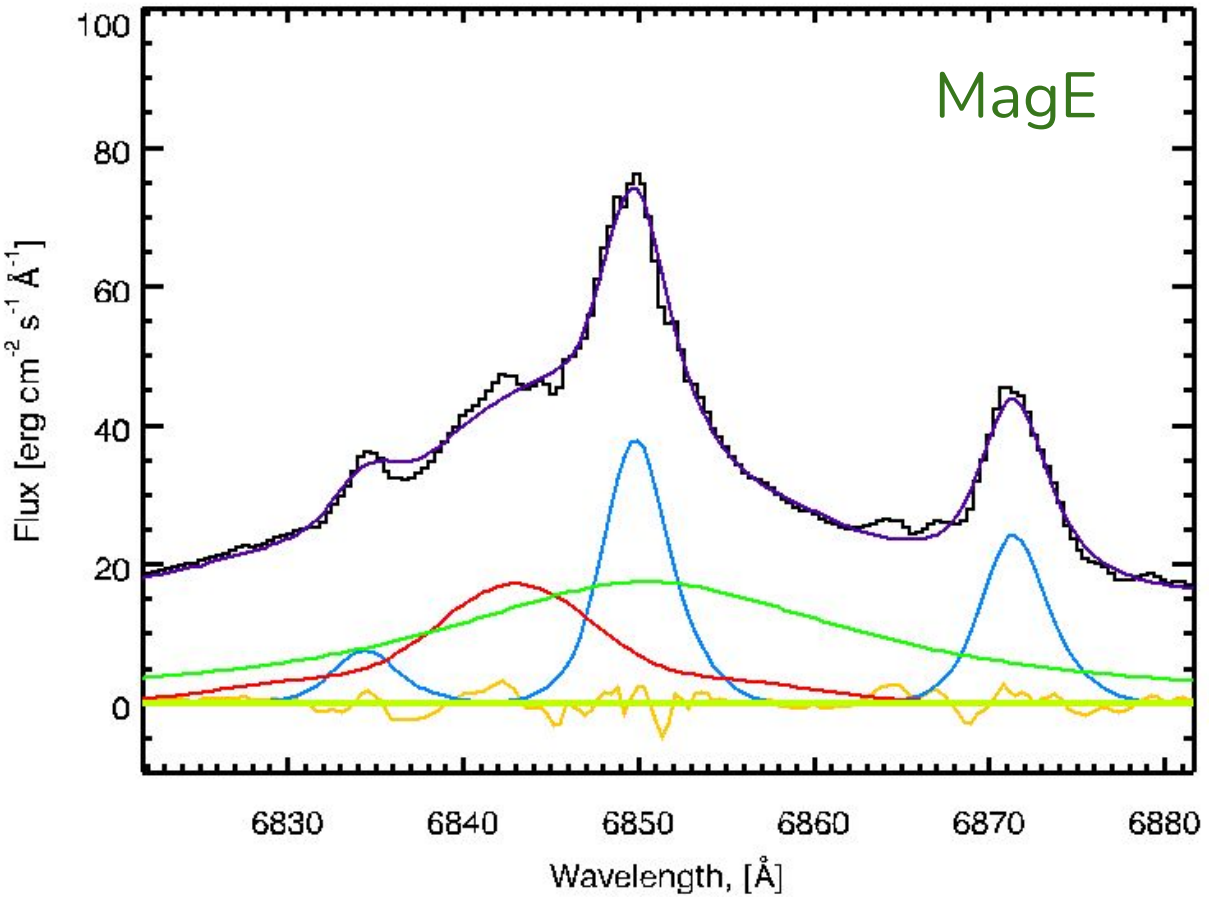
M_{BH} = 3.74e+04 M_{Sun}



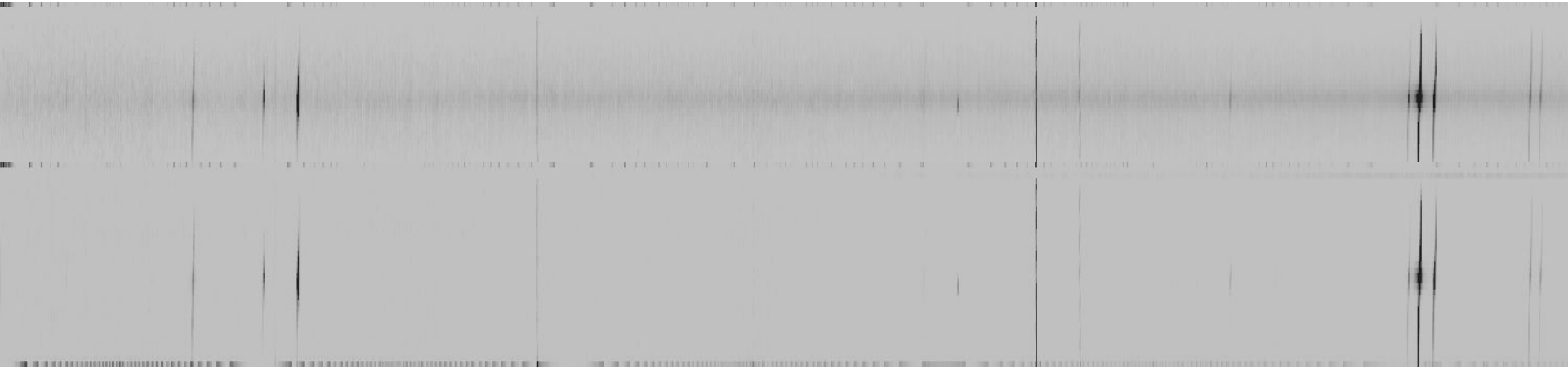




Also we find binary IMBH (MagE and ESI observations)



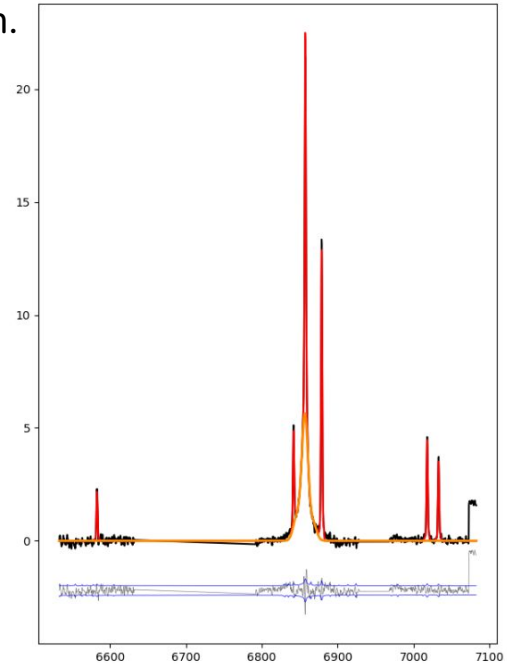
Subtraction of the stellar continuum

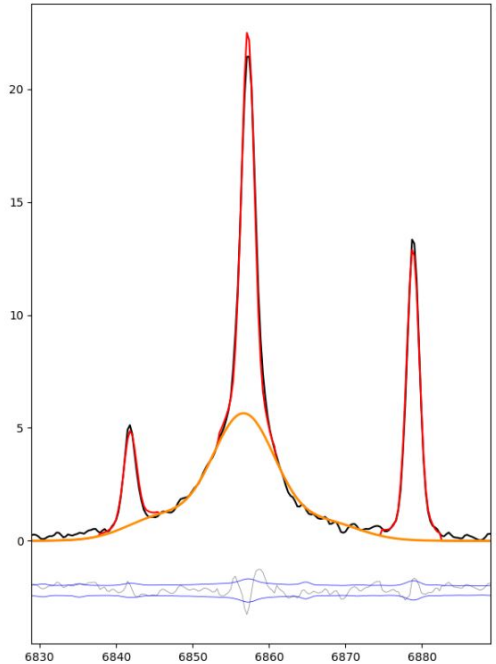


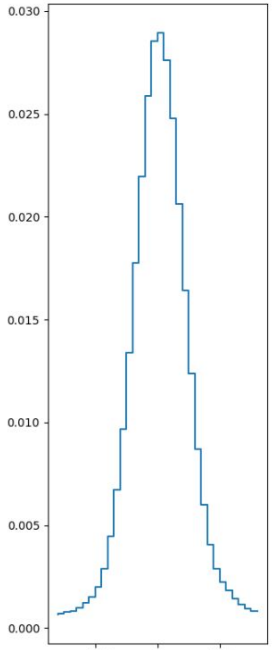
Top panel - original 2d spectrum. The lower panel is the spectrum with the subtracted stellar substrate (stellar population spectrum).

Non-parametric emission lines fitting

All other parameters are linearly fitted at each minimization function evaluation using an iterative procedure that includes the following two steps:
(i) the fluxes of all emission line components are determined by solving a linear problem with a non-negative constraint;
(ii) the shape of the NLR component is reconstructed in a nonparametric way by solving a linear convolution problem.

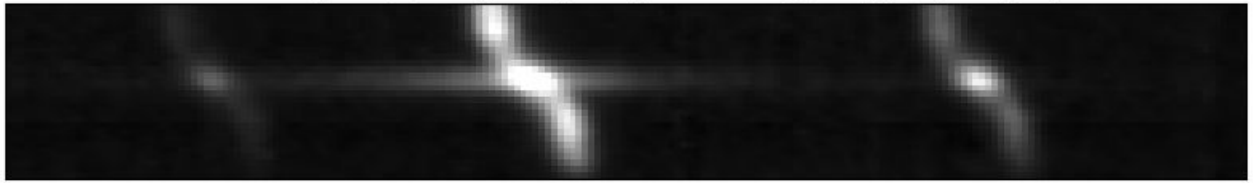






Non-parametric emission lines fitting in 2D

1107+13_0070_0072_0074_0076_24062018_spec_H_alpha+[NII]



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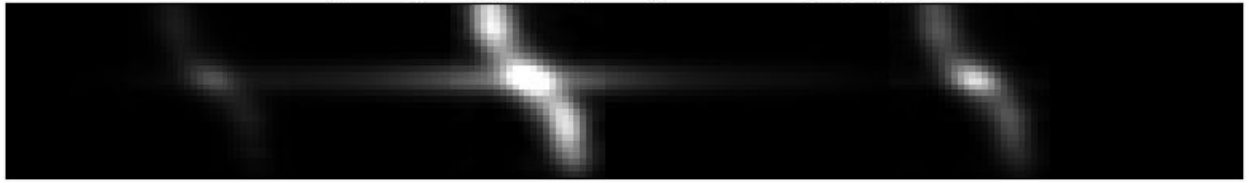
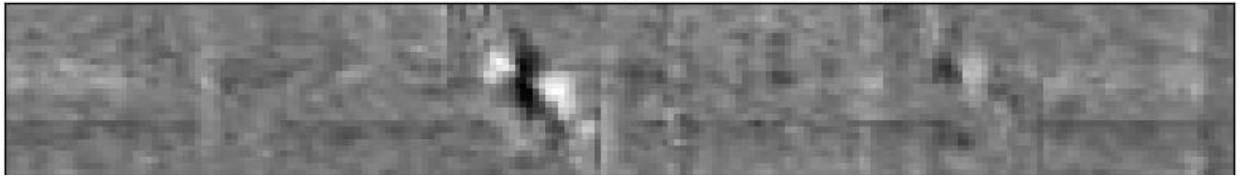
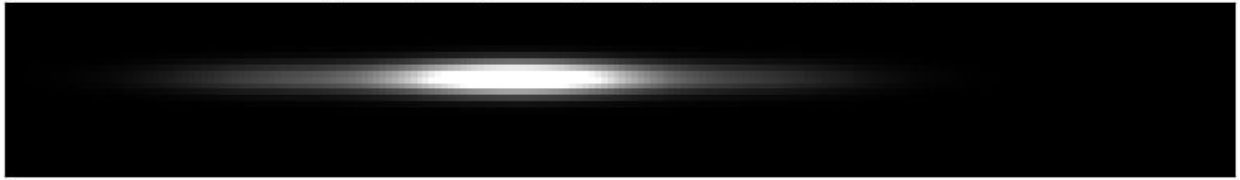


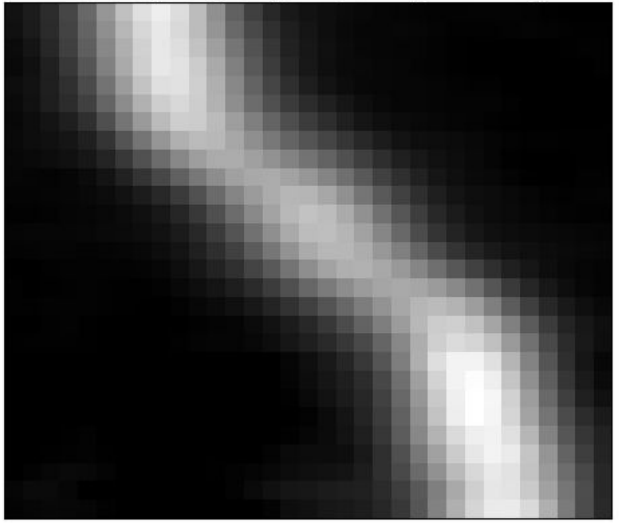
1107+13_0070_0072_0074_0076_24062018_resid_H_alpha+[NII]



1107+13_0070_0072_0074_0076_24062018_blr_H_alpha+[NII]

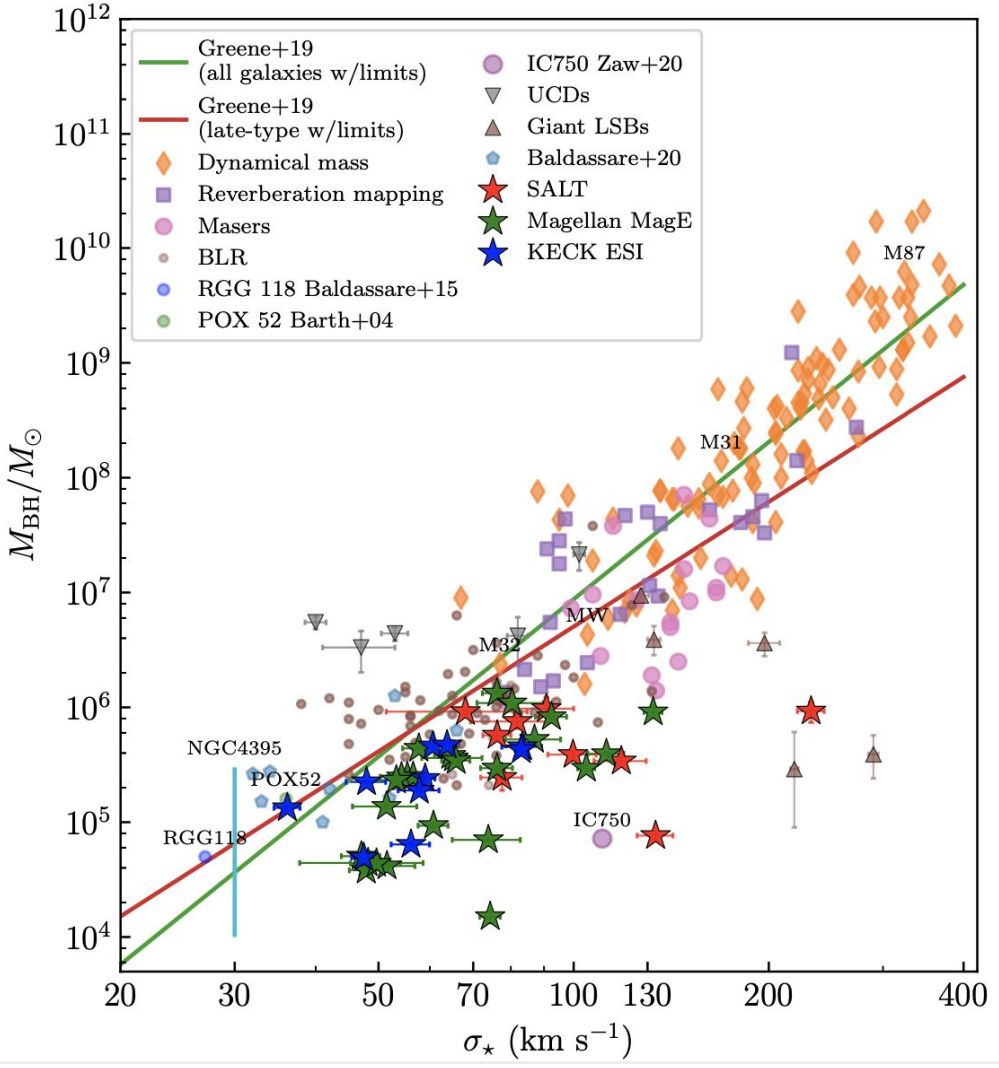


1107+13_0070_0072_0074_0076_24062018_nlr



The M_{BH}-σ_{bulge} relation

- estimates of virial masses of 44+11+8 (MagE+ESI+SALT) galaxies were obtained. The masses were refined for the slit losses and seeing effects.
- is there a correlation between the mass of a black hole and the velocity dispersion of bulge stars?
- it is too early to draw a conclusion about the coevolution of the bulge and low-mass black holes based on this correlation alone



Summary

- We have observed dozens of host galaxies of confirmed IMBH and LWSMBH candidates. The data were reduced and fitted, and the velocity dispersion of galaxy bulges was obtained.
- We have developed a method for two-dimensional nonparametric analysis of the emission spectrum of the host galaxy (I)MBH to refine the mass of the central black hole.
- We conclude that a population of IMBHs in AGN with $M_{BH} < 10^5\ M_{\odot}$ exists and this fact disfavors massive SMBH seeds
- IMBHs in the nearby Universe do not seem to co-evolve with their host galaxies: they grow by accretion, while their hosts grow secularly (even though the gas supplies may be connected)

Thank you