The BH/galaxy scaling relations in the local Universe: what is the role of type 2 AGN?

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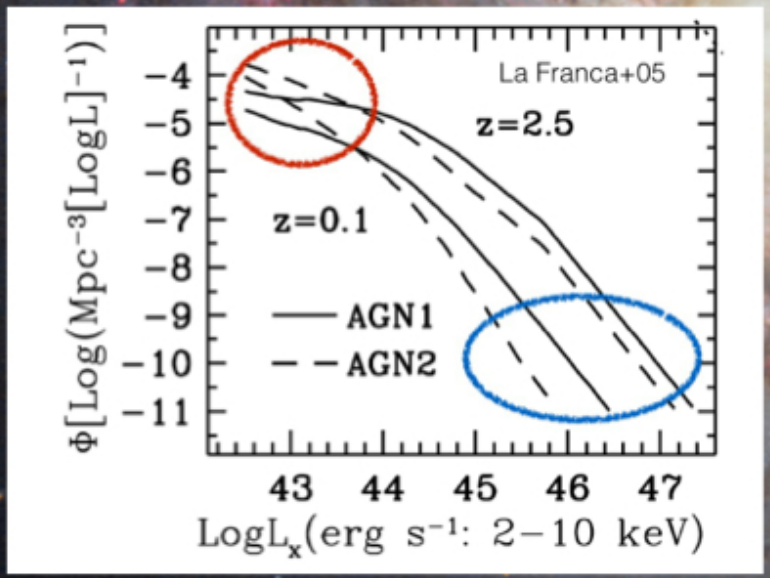
Type 1 and 2 AGN: not only orientation?

- **luminosities** (Lawrence&Elvis +82, La Franca+05, Ueda +03,+14)
- **clustering** (Hickox+11, Allevato+14, Lanzuisi+15, DiPompeo+16)
- **eddington ratios** (Lusso+12)
- **accretion rates** (Winter+10)



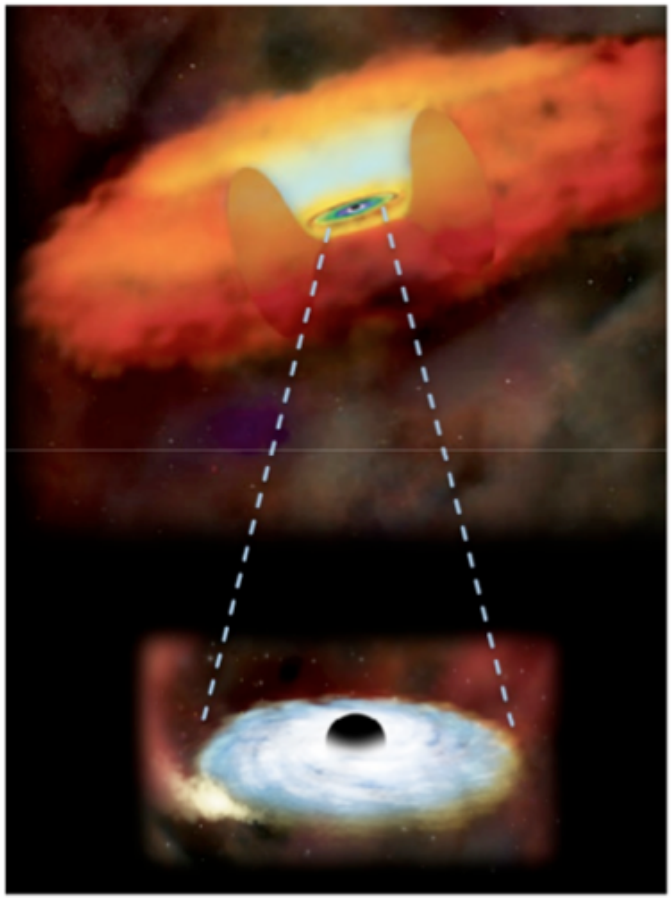
Direct measurement of the M_{BH} in AGN

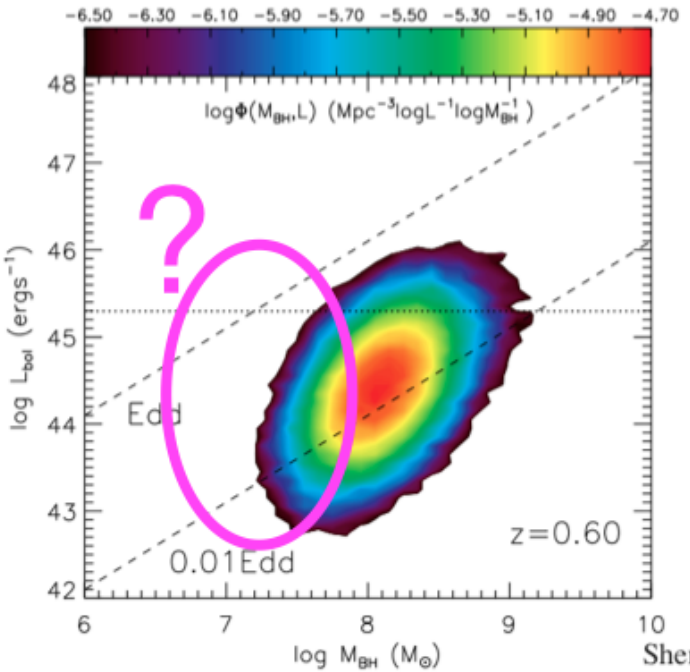
Are we missing someone?

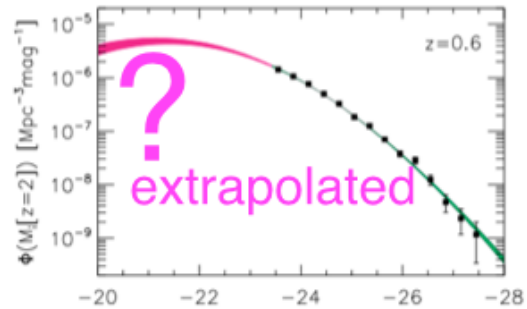
If BLR dynamics are virialized and dominated by the central mass

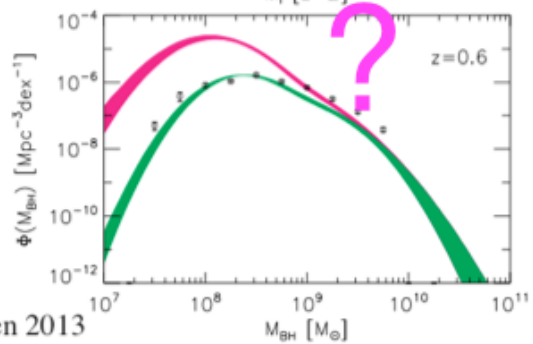
$$M_{\rm RM} = \frac{V_{\rm vir}^2 R}{G} = f\frac{W^2 R}{G}$$

$$\log\left(\frac{M_{\rm SE}}{M_\odot}\right) = a + b\log\left(\frac{\mathbf{L}}{10^{44}\,{\rm erg\,s^{-1}}}\right) + c\log\left(\frac{\mathbf{W}}{\rm km\,s^{-1}}\right)$$







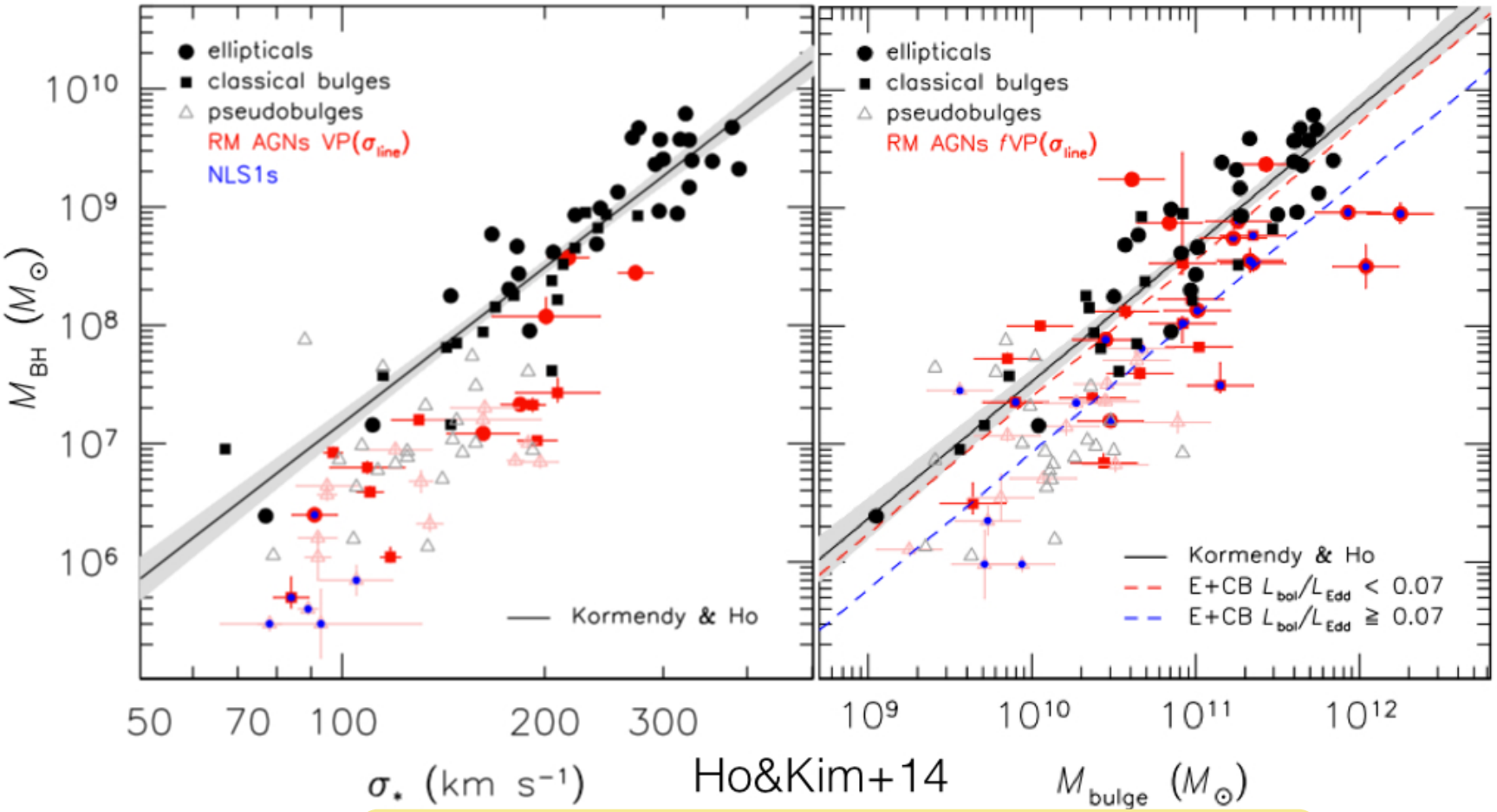


Shen 2013

We can't have a complete picture of the BHMF!

AGN-galaxy coevolution

AGN are thought to follow the same scaling relations observed in quiescent galaxies → RM AGN reproduce the scaling relation $M_{BH} - \sigma_\star$ once BH masses are scaled for the virial factor f (Kormendy&Richstone+95; Ferrarese&Merritt+00; Marconi&Hunt+03; Sani+11; Graham+11; Grier+13; Woo+15)

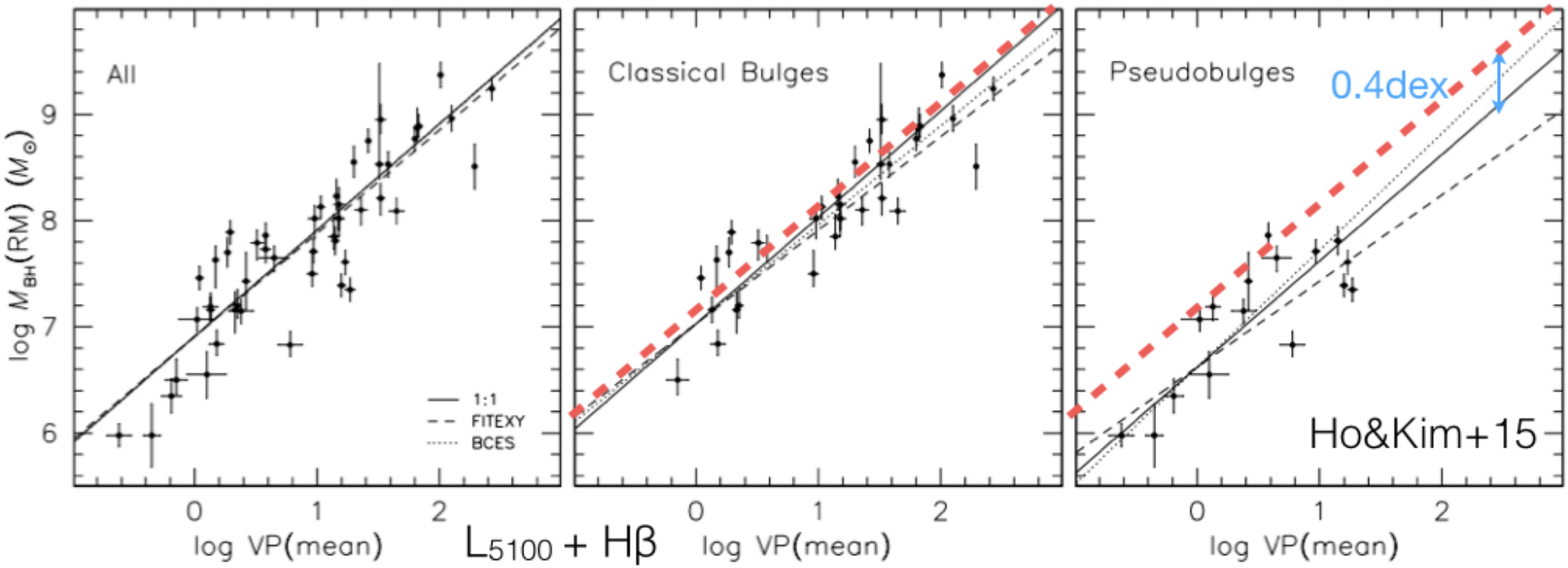


Are these relationships valid for AGN2 as well?
At least more than half of the AGN are AGN2!

Virial M_{BH} calibrations for AGN:

Bulge host morphology dependence?

If the scaling relation $M_{BH} - \sigma_\star$ changes according to the bulge host morphology, also the RM M_{BH} changes. Are the SE virial relations changing as well?



see also Kormendy&Ho+13, Ho&Kim+14

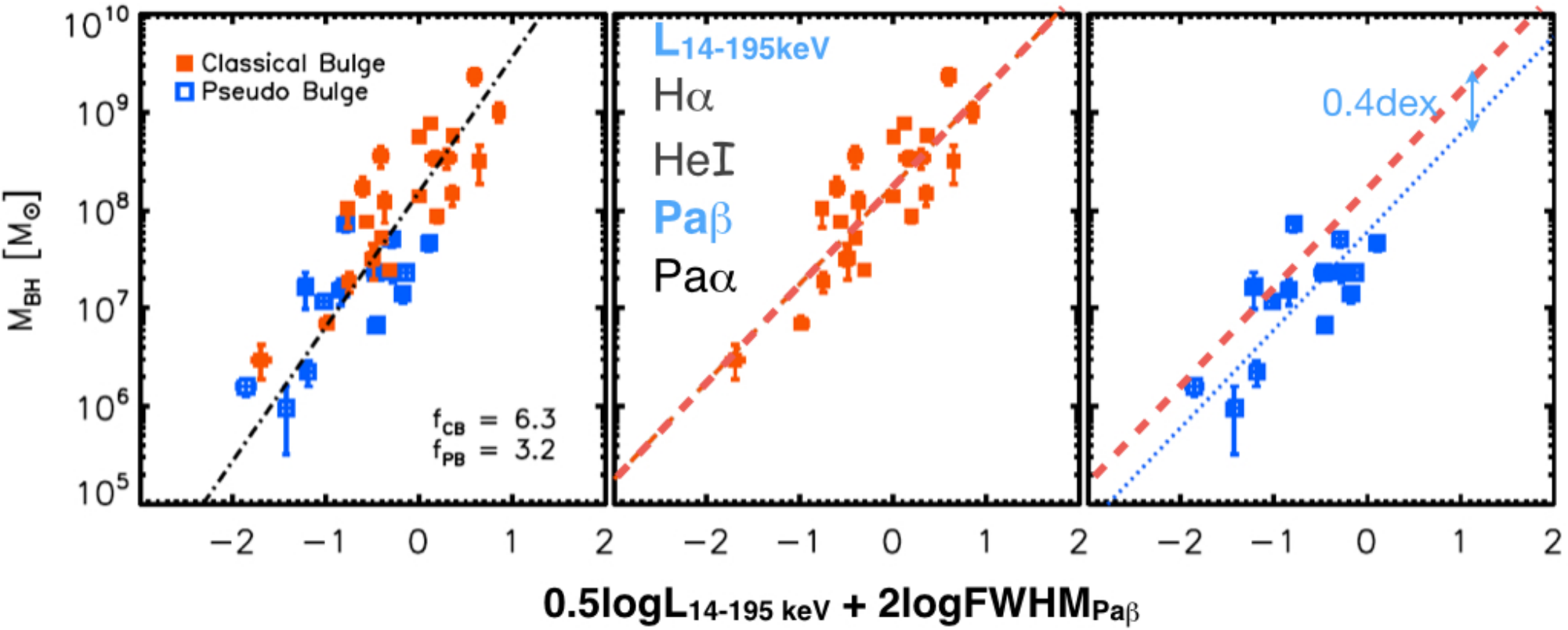
Virial M_{BH} calibrations for AGN:

Bulge host morphology dependence?

NIR virial relations based on the Paβ FWHM (but also Hα, Paα, HeI1.083μm) and the hard-X $L_{14-195\,keV}$, therefore potentially able to work with low-L AGN1 and AGN2

$\rightarrow$ Goal: see the BLR also in AGN2

F. Ricci, F. La Franca et al. 2017b, A&A

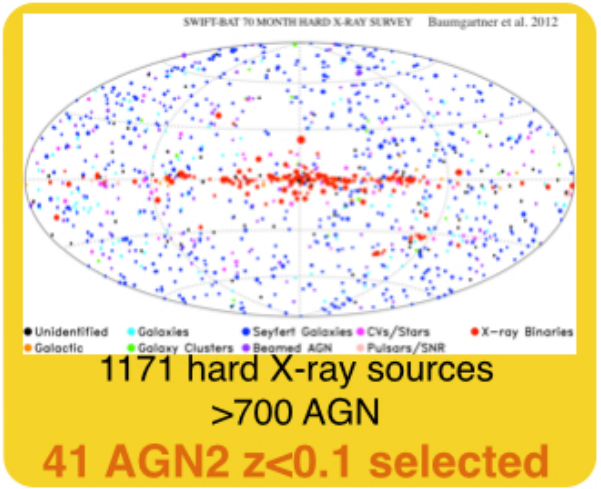


Project: measure BH masses of AGN2 in the SWIFT/BAT 70-month sample

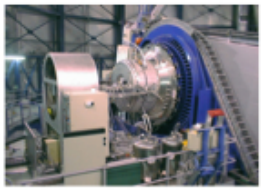
Selected in the 14-195 keV band

- no incompleteness in the Compton-thin AGN2 population
- no galaxy contamination in the hard-X L

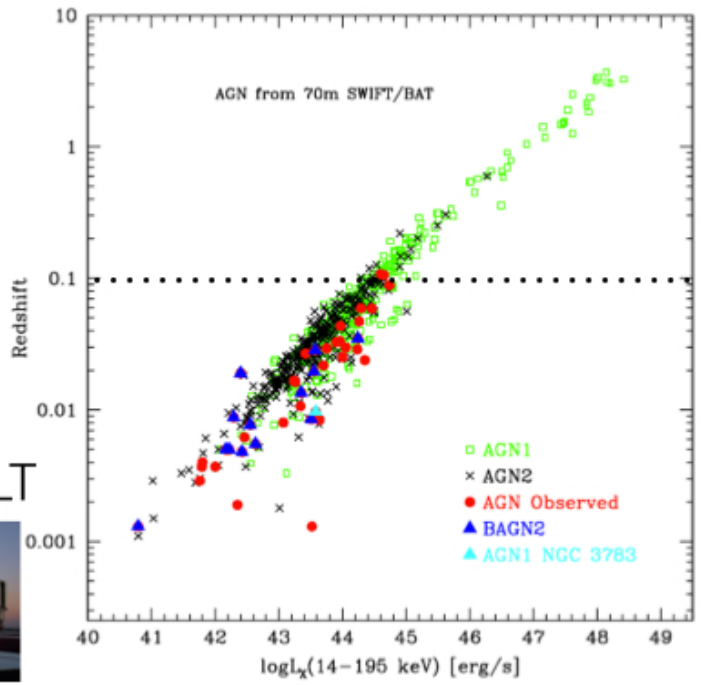
Additional 8 targets are being observed @LBT these semesters! (13.5 hours as PI)

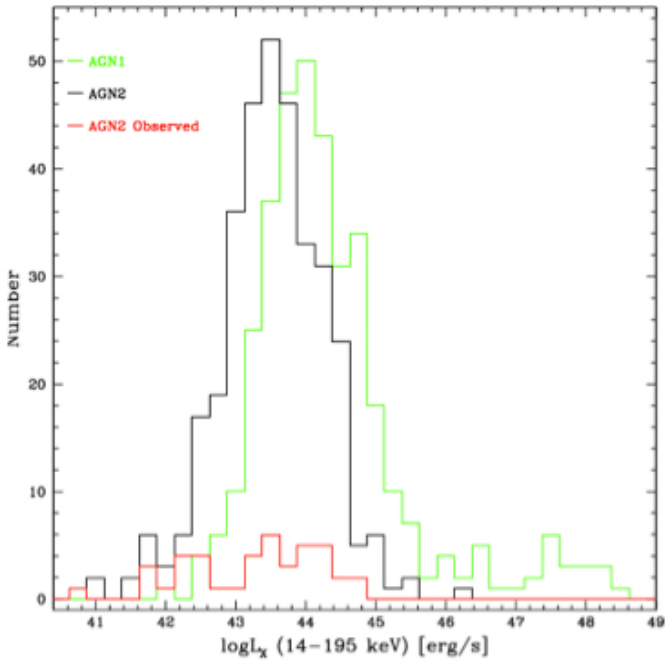


LUCI@LBT



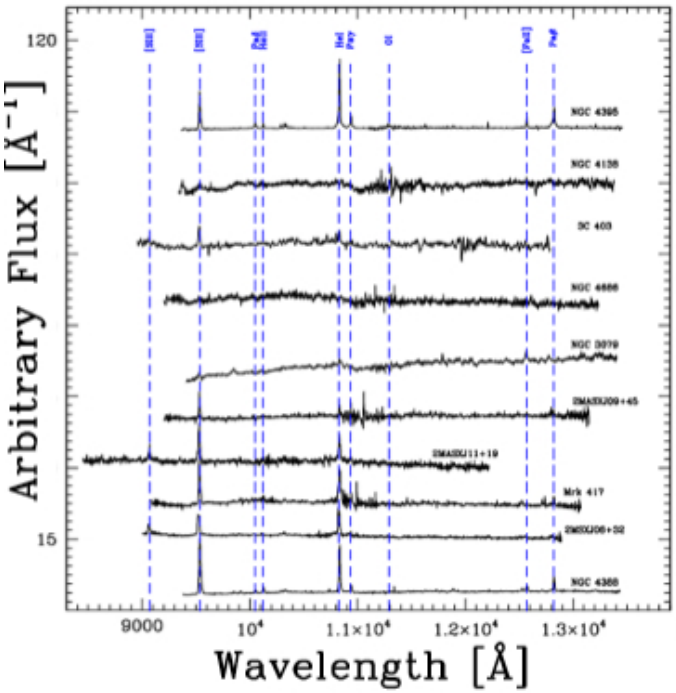
ISAAC/XSH@VLT





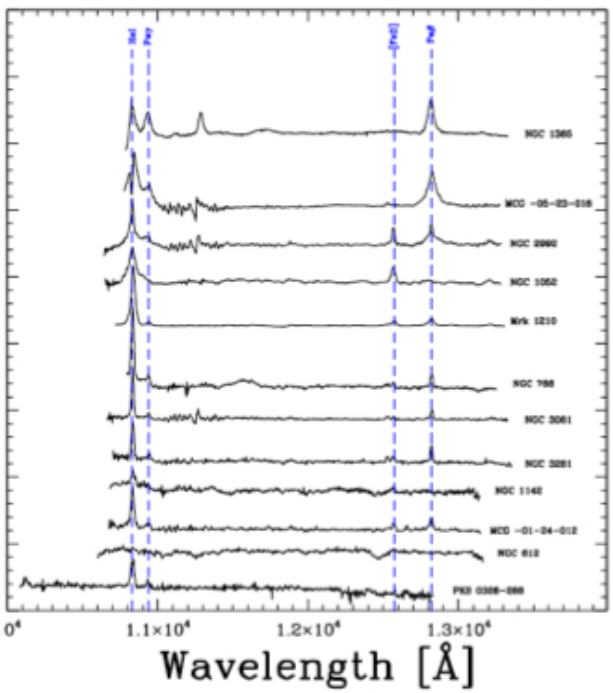
NIR Spectra

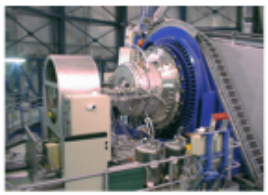
LUCI@LBT



10 AGN2
zJspec slit 1”
R=1360
ΔV≈220 km/s

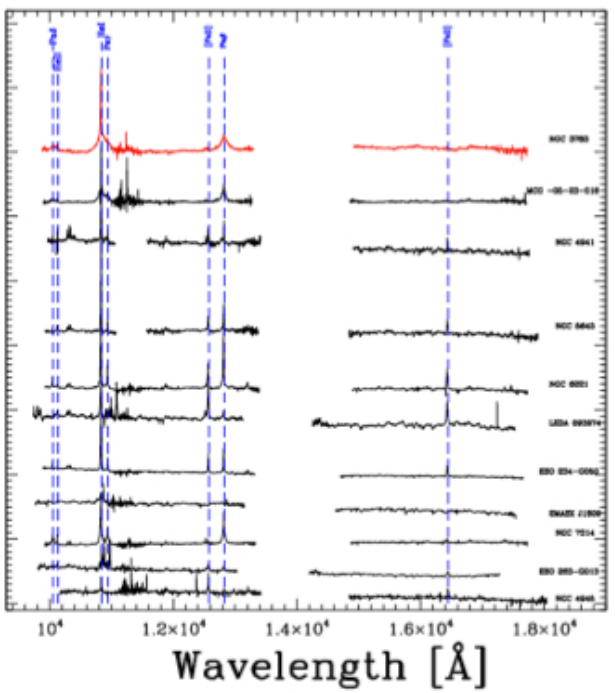
ISAAC@VLT





23 AGN2
J LR, MR, slit 0.8”
R=730 (LR)
R=4700 (MR)
ΔV≈ 60 km/s (MR)

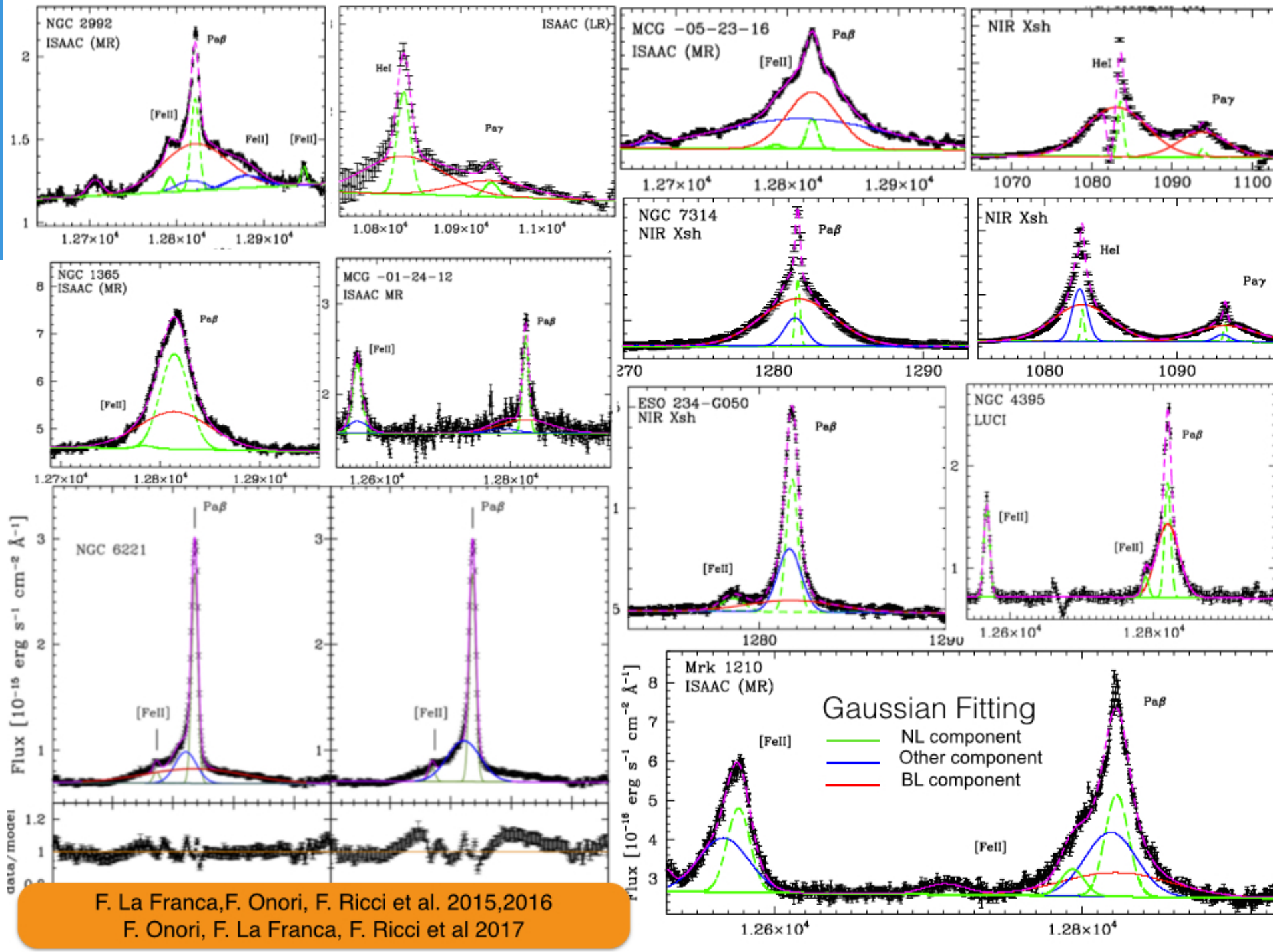
XSH@VLT



11 AGN2
slit 1”/0.9”/0.9”
R=4350/7450/5300
ΔV≈70/40/60 km/s
(UVB/VIS/NIR)

F. Onori, F. La Franca, F. Ricci et al. 2017a MNRAS

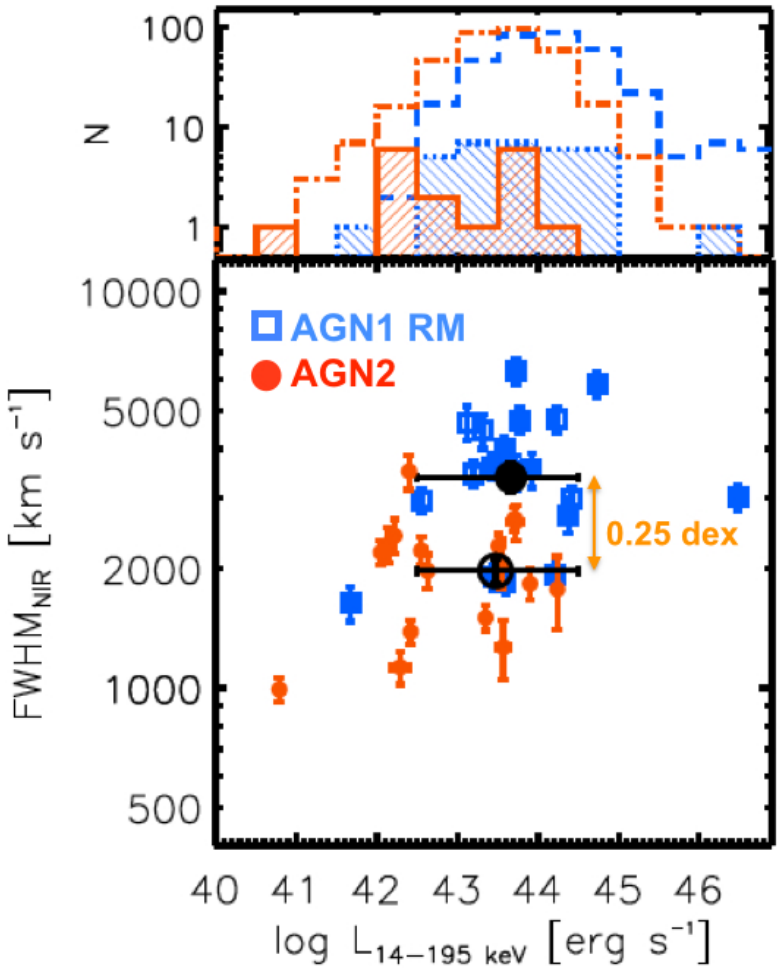
Broad emission line component (in Paβ, HeI1.083μm) found in 13 AGN2 $\rightarrow$ **spectral line fitting!**

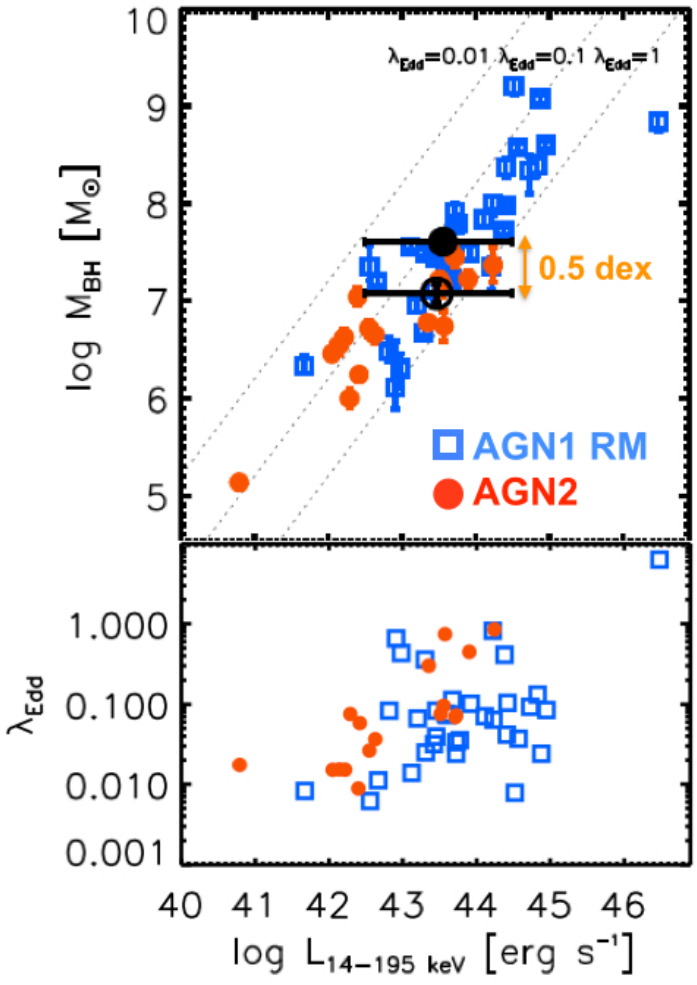


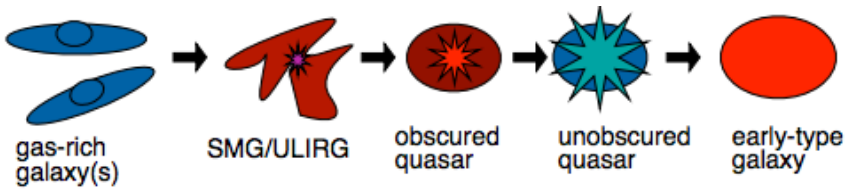
F. La Franca,F. Onori, F. Ricci et al. 2015,2016
F. Onori, F. La Franca, F. Ricci et al 2017

Results: M_{BH}, λ_{Edd} (F. Onori, F. Ricci et al. 2017b)

Assuming the average virial relation for all AGN2





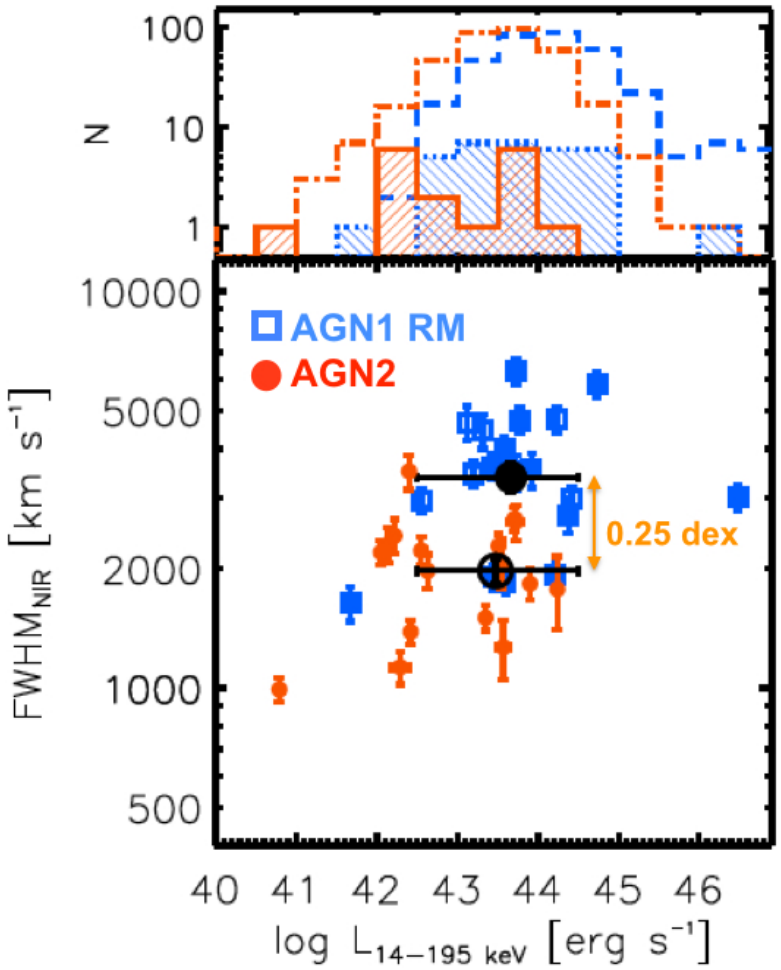


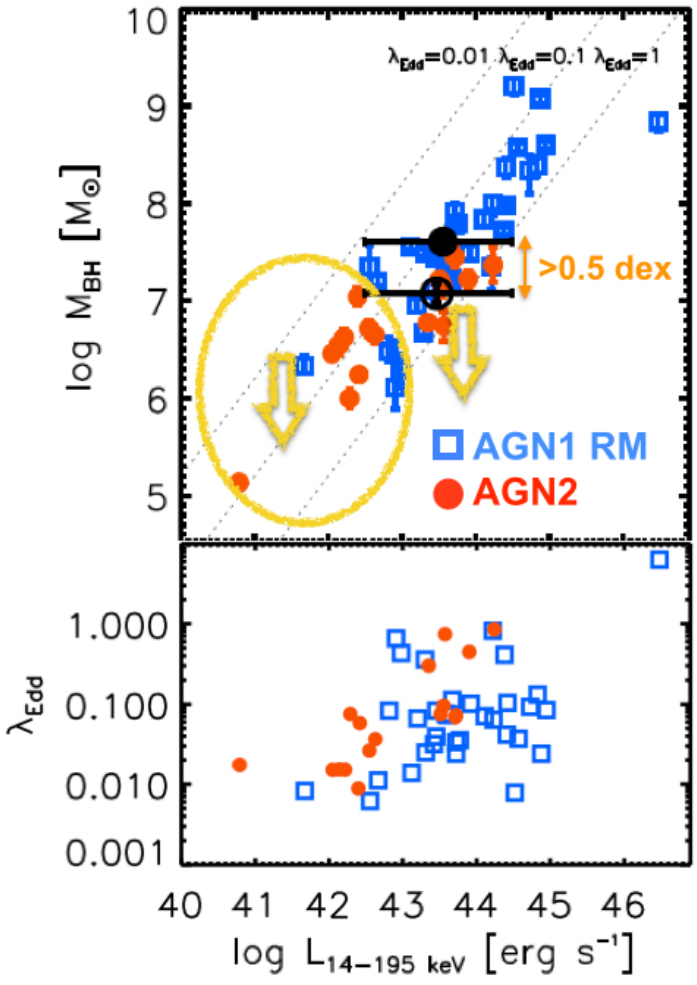
$M_{BH}(AGN1)$ - $M_{BH}(AGN2)$ $\sim$ 0.5 dex

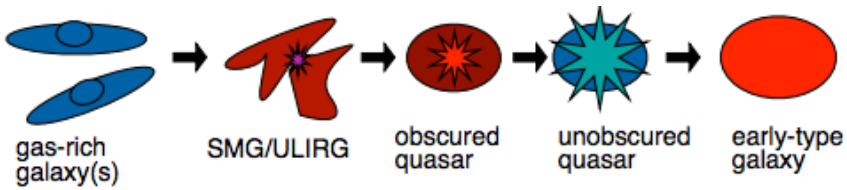
$\lambda(AGN2)$ -$\lambda(AGN1)$ $\sim$ 0.3 dex

Results: M_{BH}, λ_{Edd} (F. Onori, F. Ricci et al. 2017b)

Assuming the pseudo bulge virial relation for AGN2 with $\log L_X < 43$



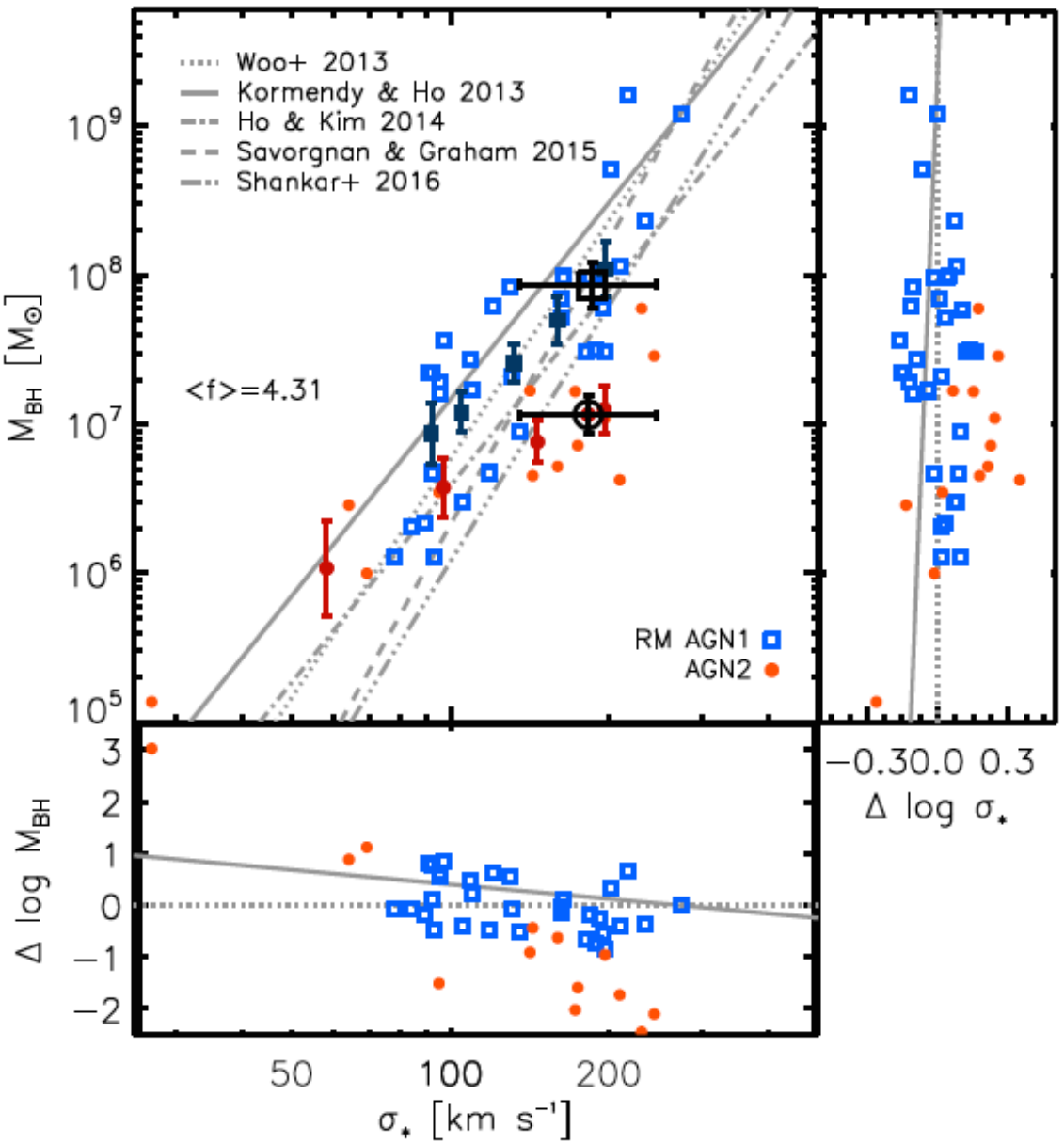




The bulge morphology of the host can have an impact on the measure of the M_{BH} → bulge/disk decomposition is crucial!

Results: the M_{BH}/galaxy coevolution in AGN2

1. $M_{BH} - \sigma_\star$ F. Ricci et al. 2017c

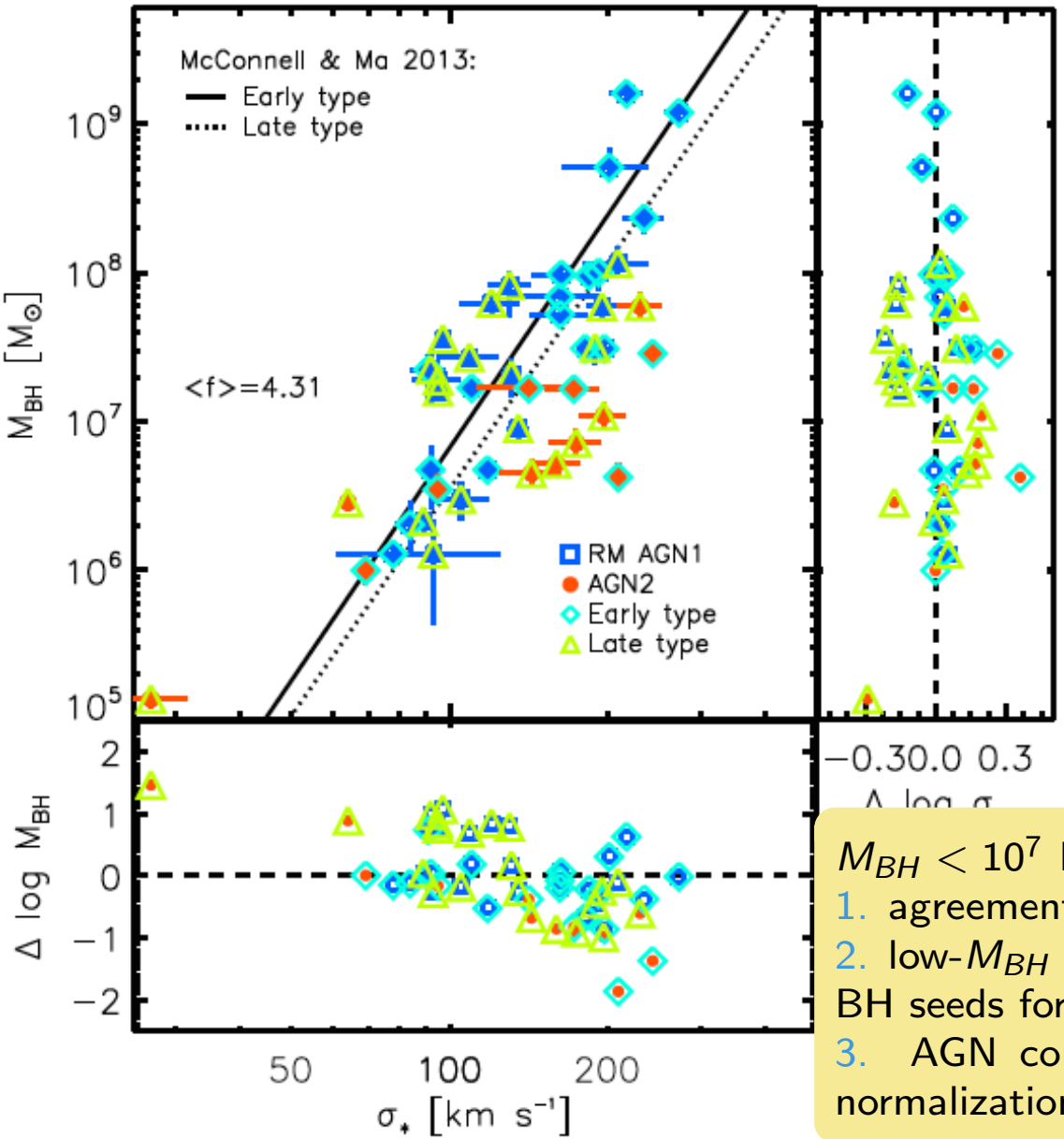


AGN2 have smaller M_{BH} than AGN1 or equivalently AGN2 hosts have higher $\sigma_\star$ than AGN1 hosts → rotational-disk contamination?

- $\langle f \rangle$ is the same for RM AGN1 and AGN2, but there are indications that for AGN2 could be even smaller (decrease with inclination, e.g. Risaliti+11, Pancoast+14, Bisogni+17)
- at $\sigma_\star \sim 185$ km s^{-1} $M_{BH}(AGN2) < M_{BH}(AGN1)$ of $\sim$0.9 dex
- at $M_{BH} \sim 10^7$ M$_\odot$ $\sigma_\star(AGN2) > \sigma_\star(AGN1)$ of $\sim$0.2 dex

Results: the M_{BH}/galaxy coevolution in AGN2

1. $M_{BH} - \sigma_\star$ F. Ricci et al. 2017c



AGN2 have smaller M_{BH} than AGN1 or equivalently AGN2 hosts have higher $\sigma_\star$ than AGN1 hosts → rotational-disk contamination? NO

In late-type galaxies with a rotating stellar disk, the line-of-sight velocity dispersion could be broadened due to the disk rotation → excluded rotational contamination since all AGN2 lie below the scaling relations, regardless the (early/late) host morphology.

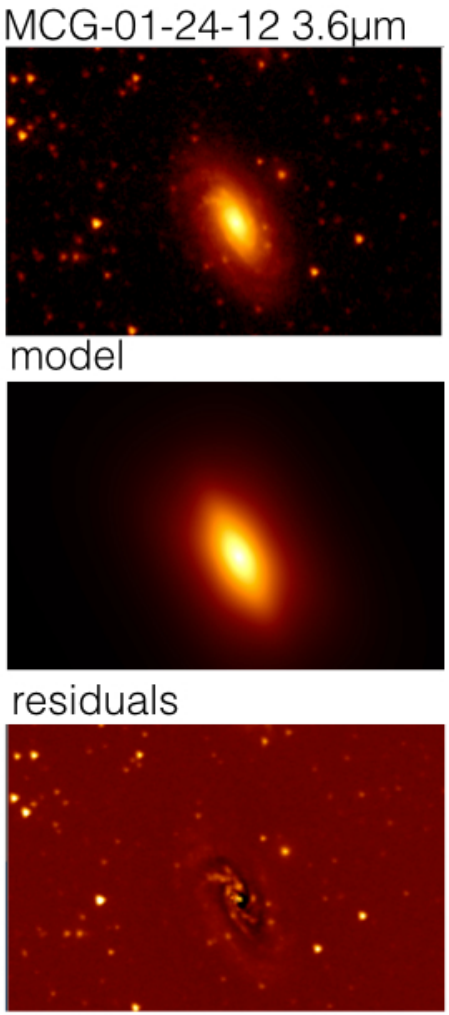
$M_{BH} < 10^7$ M⊙ → full distribution of M_{BH}!

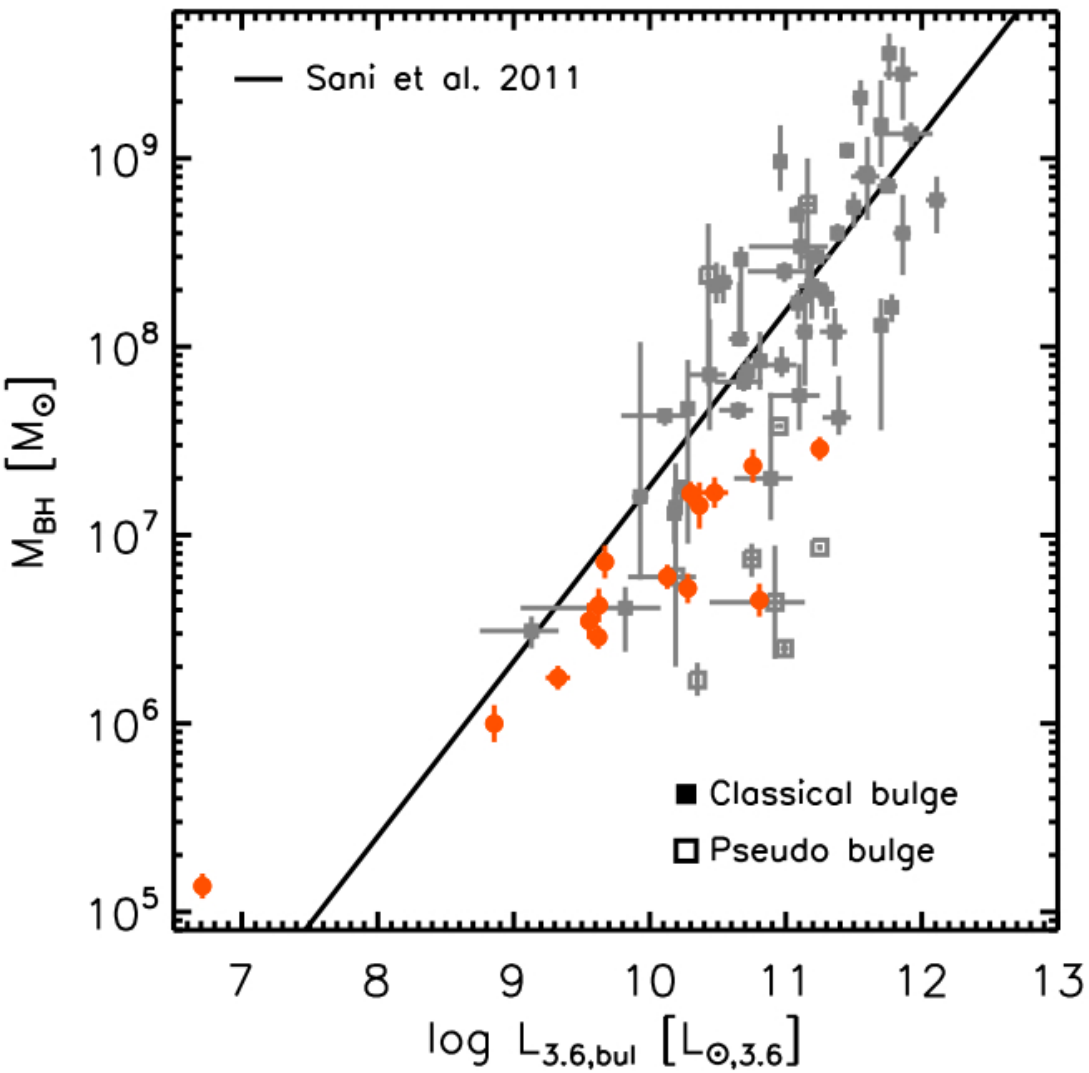
1. agreement with masers masses (Greene+10)
2. low-M_{BH} and low-$\sigma_\star$ sources help discern different BH seeds formation (Volonteri&Natarajan+09)
3. AGN could follow a scaling relation with lower normalization and broader scatter (Shankar+16)

Results: the M_{BH}/galaxy coevolution in AGN2

2. $M_{BH} - L_{3.6,bul}$ F. Ricci, E. Sani et al. in prep

AGN2 could play a peculiar role in the BH-galaxy co-evolution scenario: AGN2 tend to be below the $M_{BH} - L_{3.6,bul}$ relation





Take home message

- New virial estimators for M_{BH} in faint and obscured AGN (can also take into account the bulge type of the host)
- Broad emission lines detected in 13 type 2 and intermediate AGN $\rightarrow$ are narrower and fainter than in AGN1
- AGN2 harbour on average smaller BHs accreting at higher Eddington ratios than the AGN1 control population (with the same luminosity)
- At a given $\sigma_\star$, BHs are smaller in AGN2 than in AGN1 regardless the host morphology
- At a given $L_{3.6,bul}$, BHs are smaller in AGN2 than in AGN1. Pseudobulges could play a role $\rightarrow$ different evolutionary pattern?

AGN2 should be properly (separately from AGN1) taken into account to understand the AGN evolution


Thanks!