



Under-luminous active nuclei
of dwarf galaxies in the nearby
universe ($< \sim 100$ Mpc)

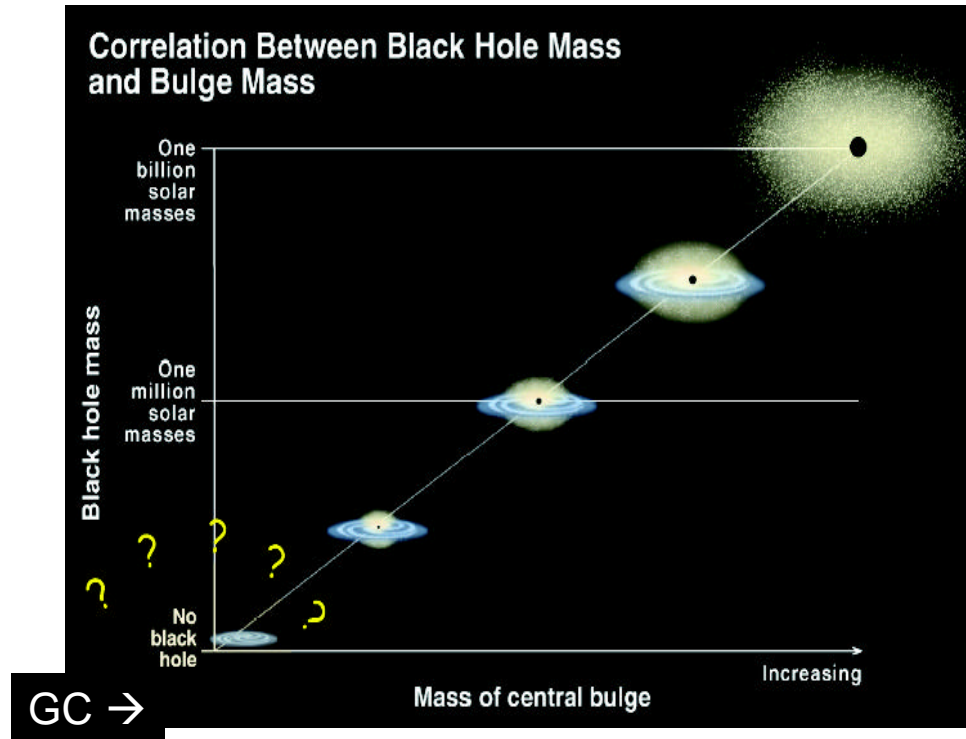
Weimin Yuan



X.B. Dong, H.Y. Zhou, T.G. Wang (USTC, @Hefei)



Where is the lower end of the galactic black hole mass function?



Credit L.C. Ho

→ almost every large galaxy harbors a SMBH.

Question: how about small galaxies (dwarf galaxies) ?

Intermediate mass black holes (IMBH)

Search for IMBH in AGN

$$M_{BH} = f \frac{v^2 R_{BLR}}{G} \\ v^2 L_{opt}^{0.5}$$

Virial mass



IMBH in AGN: three secured cases

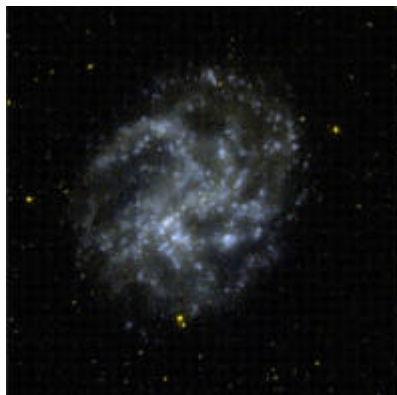
NGC4395

Host $M_B = -17.5$

BH mass = $3.6 \times 10^5 M_{\text{sun}}$

Filippenko & Ho (2003)

Peterson et al. (2005)

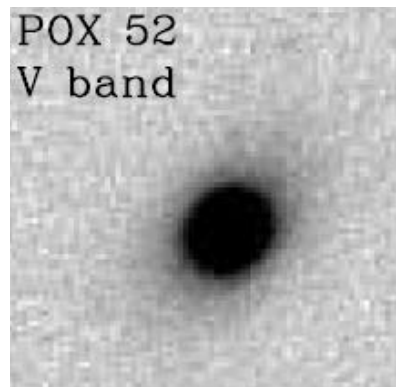


POX 52

Host $M_B = -16.8$

$1.6 \times 10^5 M_{\text{sun}}$

Barth et al. (2004)



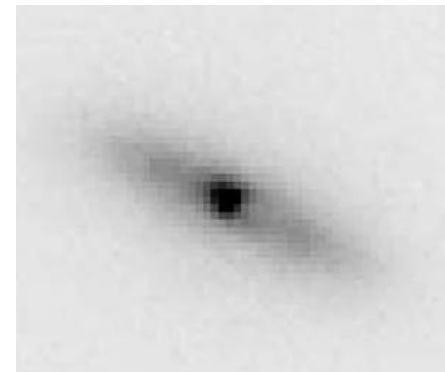
SDSSJ1605+1748

Host $M_B = -16.4$

$0.7 - 1.6 \times 10^5 M_{\text{sun}}$

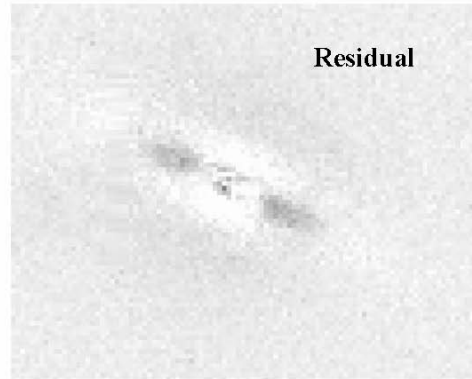
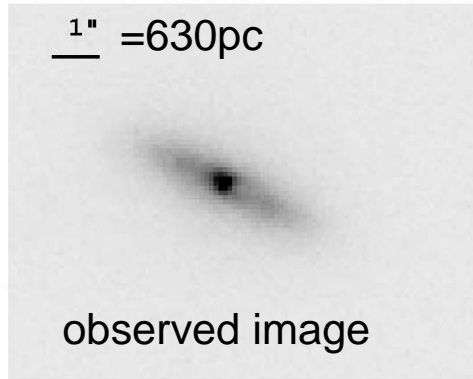
Dong, Wang, Yuan,

et al. (2007)



● ● ● | SDSSJ1605+1748

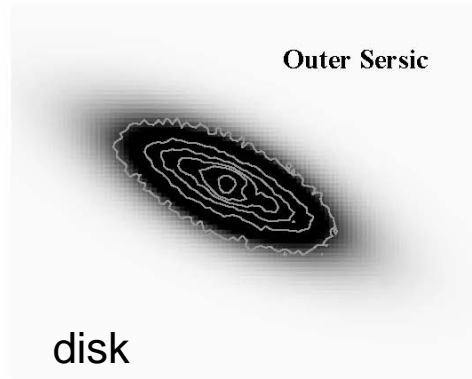
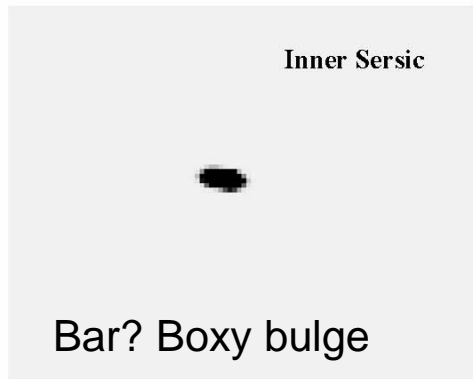
D=134.2 Mpc



HST image 2-D
decomposition

$M_B = -16.4$

Dwarf disk galaxy



Dong, Wang, Yuan,
et al. (2007)

roughly consistent with BH mass -- bulge relation

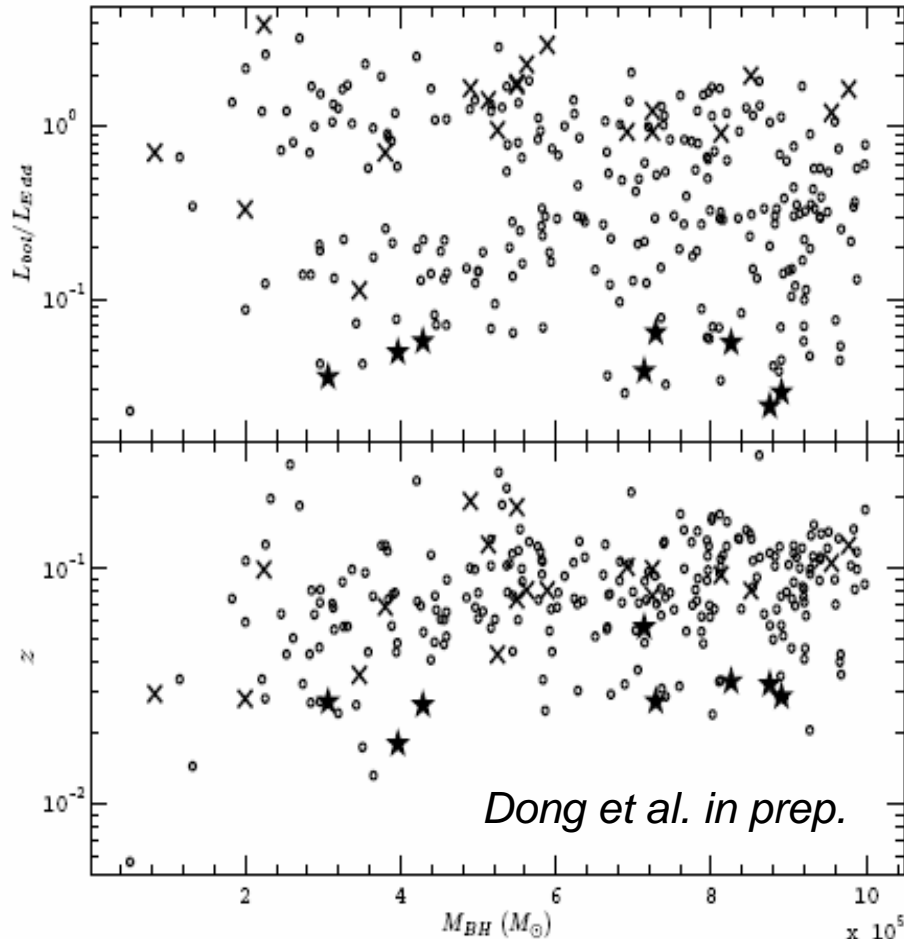


Finding IMBH AGN accreting at low Eddington rates

- Q: more IMBH in small galaxies?
- yes! SDSS DR1 (Green & Ho 2004) but rare.....while small/dwarf galaxies are numerous
- The original GH04 sample of IMBH AGN (19) all have high L/L_{Edd}
mass accretion rate represented by $Eddington\ ratio = L_{bol} / L_{Edd}$
- Question: Do IMBH AGN accreting at low rates exist?
- if YES, then a large population of under-luminous IMBH AGN are missing (too dim to be easily observed)
- prototype: NGC4395 $M_{BH}=3.6 \times 10^5 M_{sun}$, Eddington ratio 1.2×10^{-3} (Perterson et al. 2005)
- Is NGC4395 unique? More objects?



Under-luminous active nuclei of dwarf galaxies in nearby universe: sample



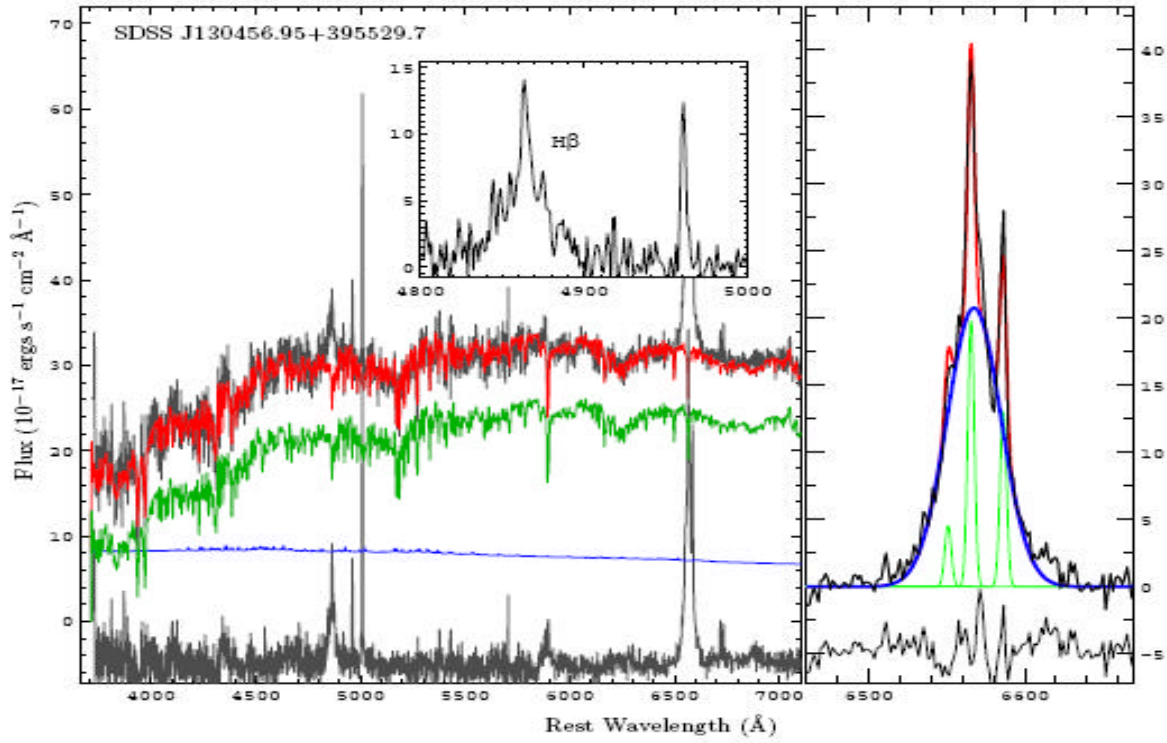
- A new sample of AGN with intermediate black hole
- some have low L/L_{Edd}

Confirmation needed in X-ray
→ 4 observed with Chandra

Some also found in the updated sample of Green & Ho (2007)



Example discovering SDSS spectrum



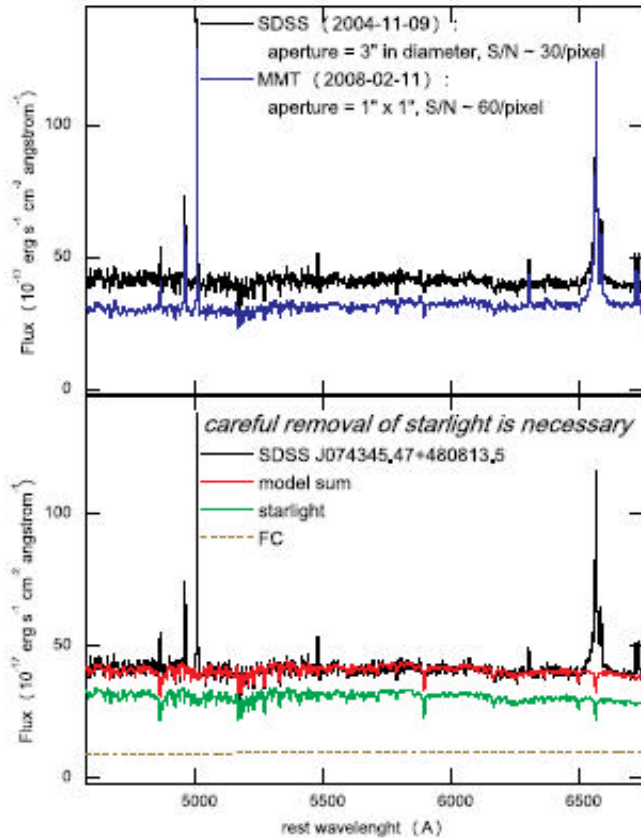
$$M_{BH} = f \quad v^2 R_{BLR} / G$$

$$v^2 L_{opt}^{0.5}$$

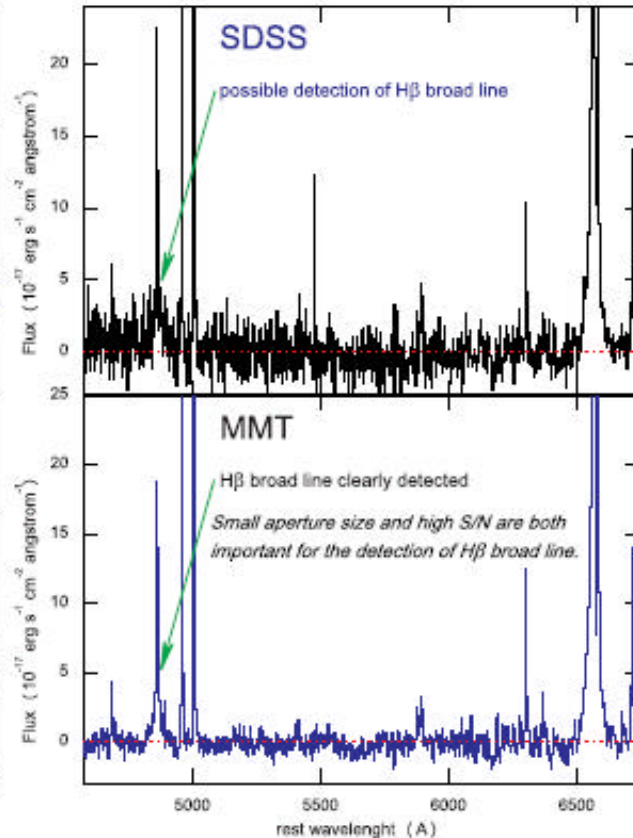
Proper subtraction of host galaxy starlight is crucial



1



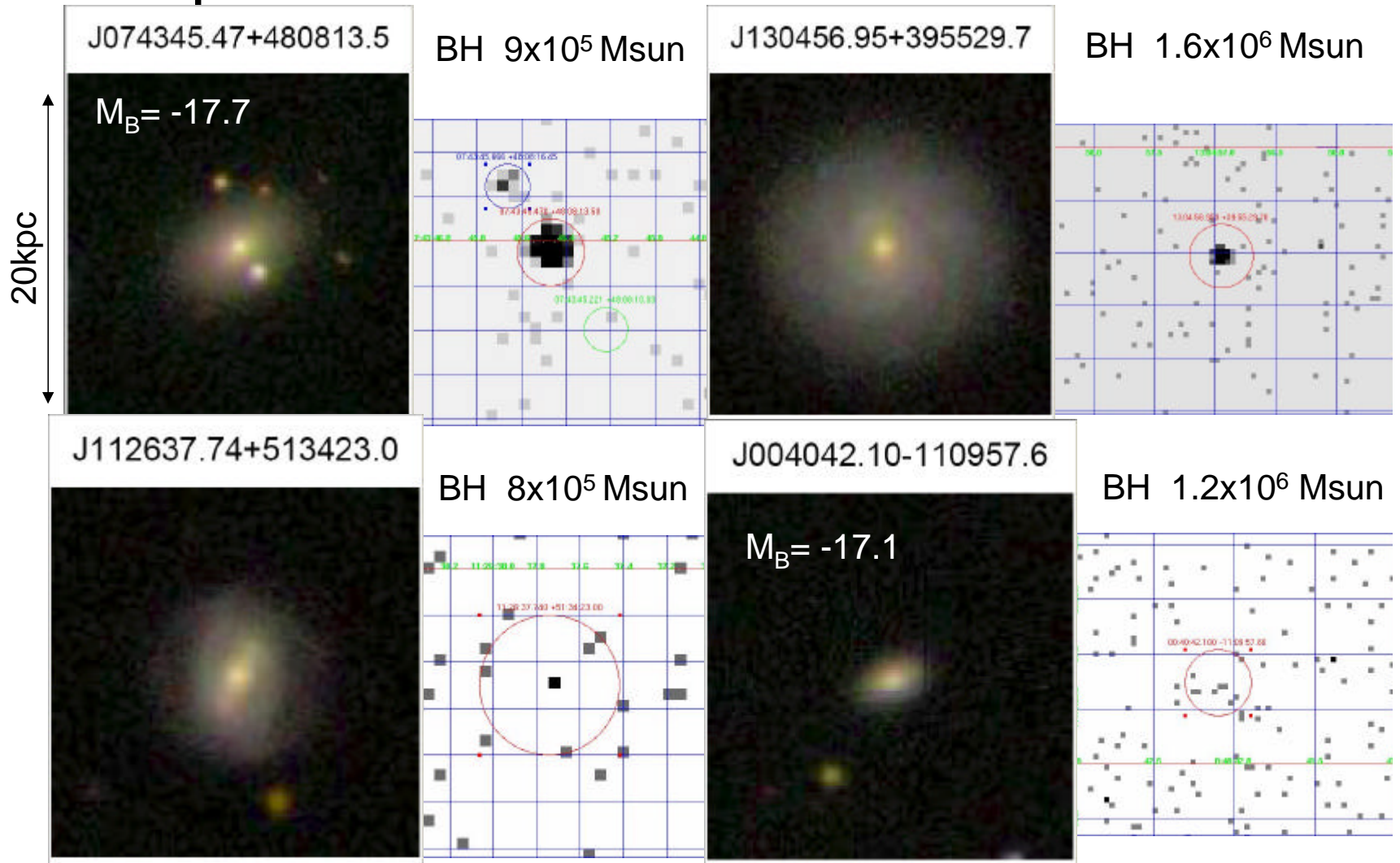
2



3

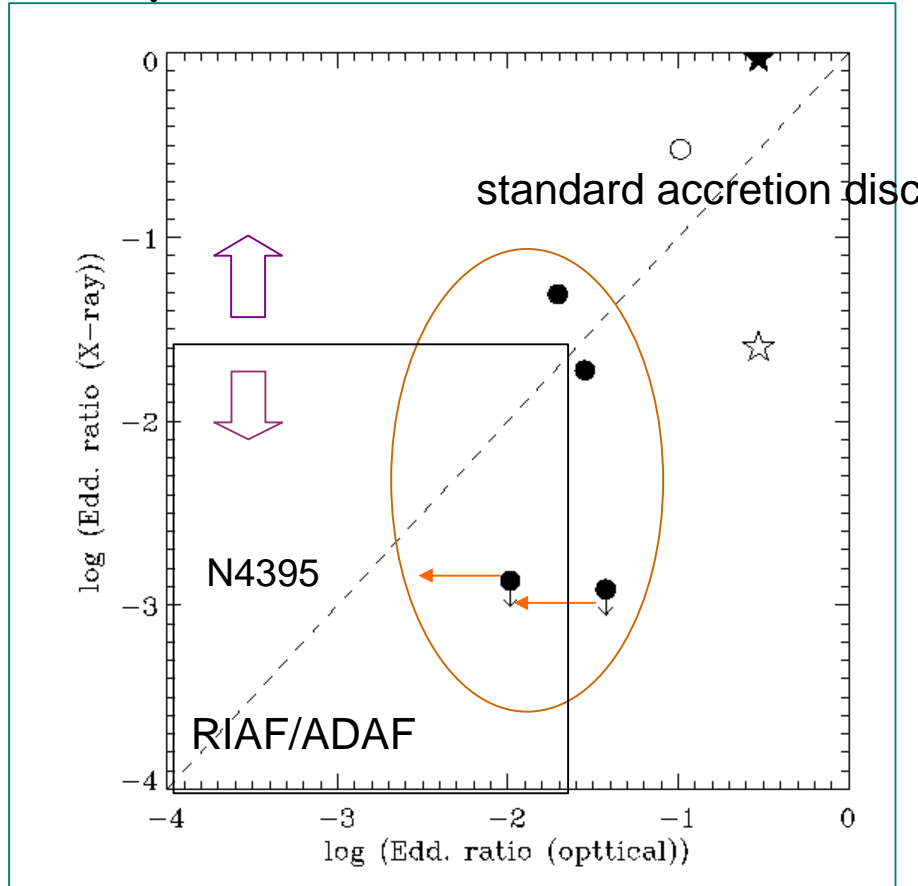
4

SDSS & Chandra images of low Eddington ratio IMBH AGN





Low Eddington ratios



Bolometric correction
assuming

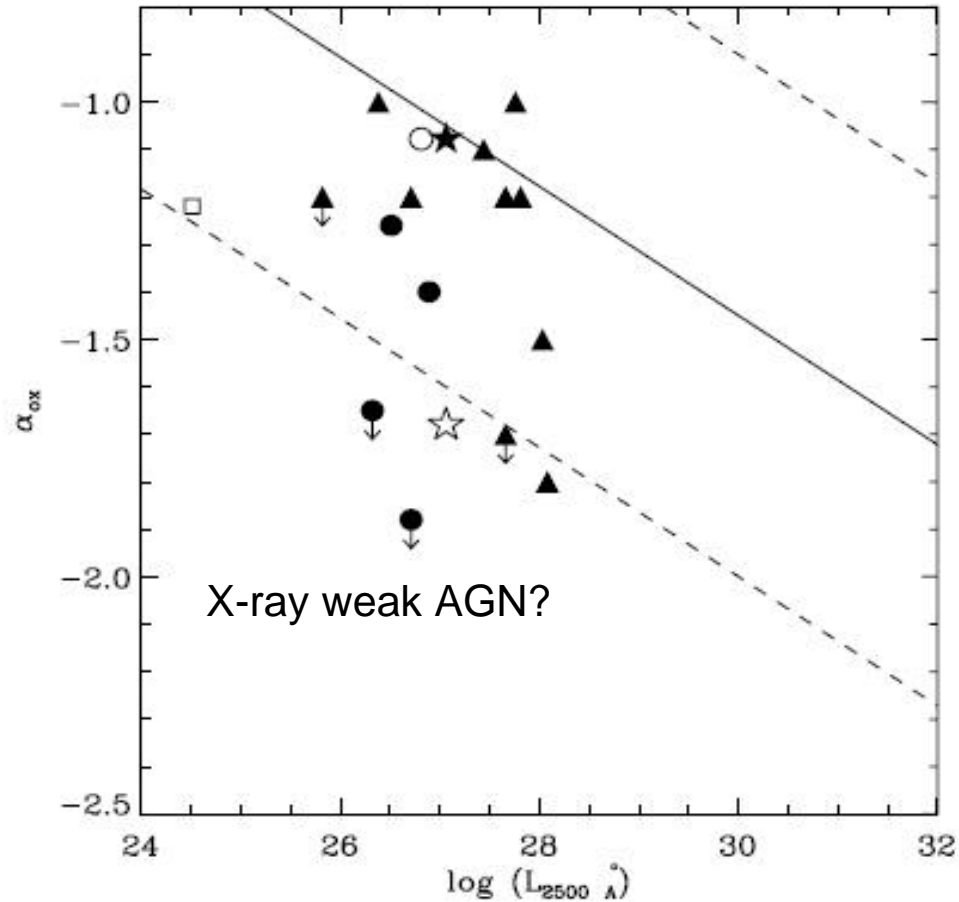
$$L_{\text{bol}} = 20 \times L_{\text{x}}(2-10\text{keV})$$

(Vasudevan & Fabian'07)

A few more IMBH AGN
accreting at low rates do
exist (in add. to NGC4395) !
There is a population of
under-luminous IMBH
AGN yet to be
discovered! And so are
IMBH

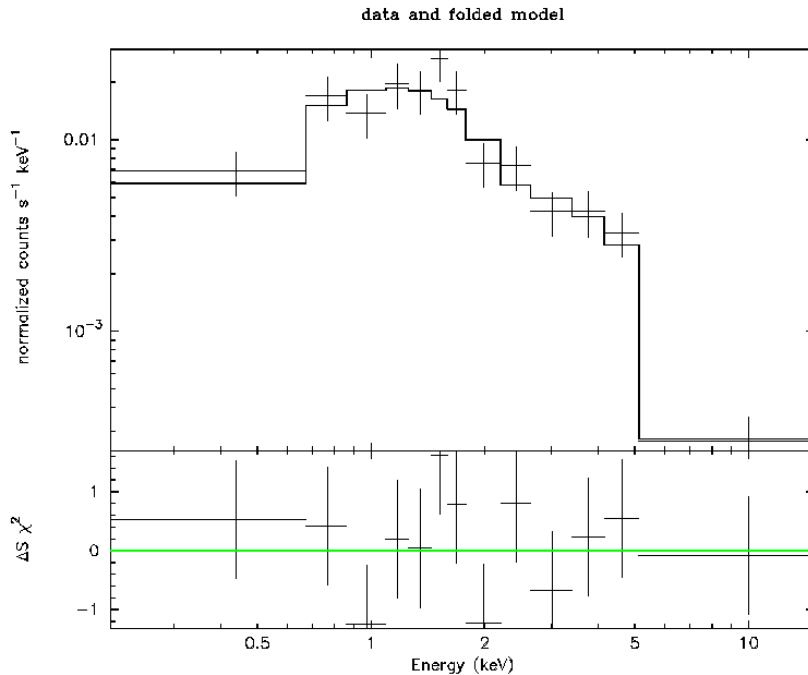


Optical -- X-ray SED



● ● ● | Chandra X-ray spectra

J1304+3955



An abnormally flat X-ray spectrum

$$=1.06(+/-0.2) ?$$



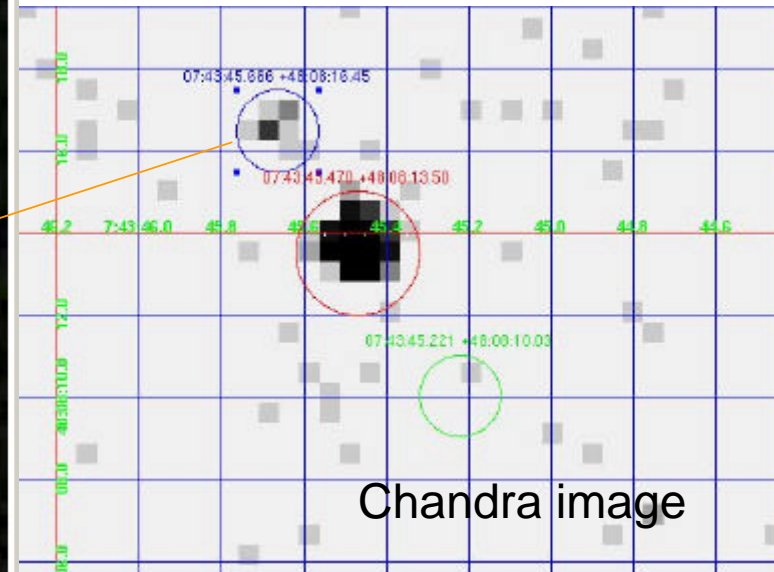
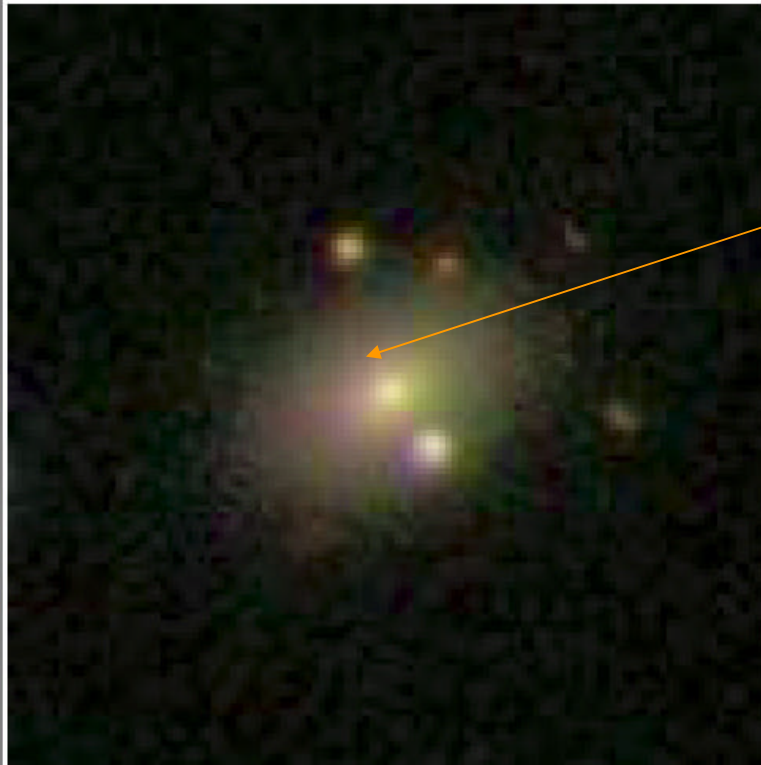
conclusion

- We found a few more intermediate-mass BH AGN with several times $10^5 M_{\text{sun}}$ BH masses accreting at low rates (around or lower than the critical rate) in dwarf galaxies
- They do exist. And we expect the existence of a population of dwarf galaxies harbouring IMBH in their centers, which are difficult to be detected due to their faintness of the

Yuan et al. in prep.

● ● ● | An ultra-luminous X-ray (ULX) source in a dwarf galaxy?

J074345.47+480813.5



$L_x(2-10\text{keV})=2.1E40\text{erg/s}$
~200 M_{sun} BH, if accreting at
Eddington rate?
(two IMBH merging?)