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

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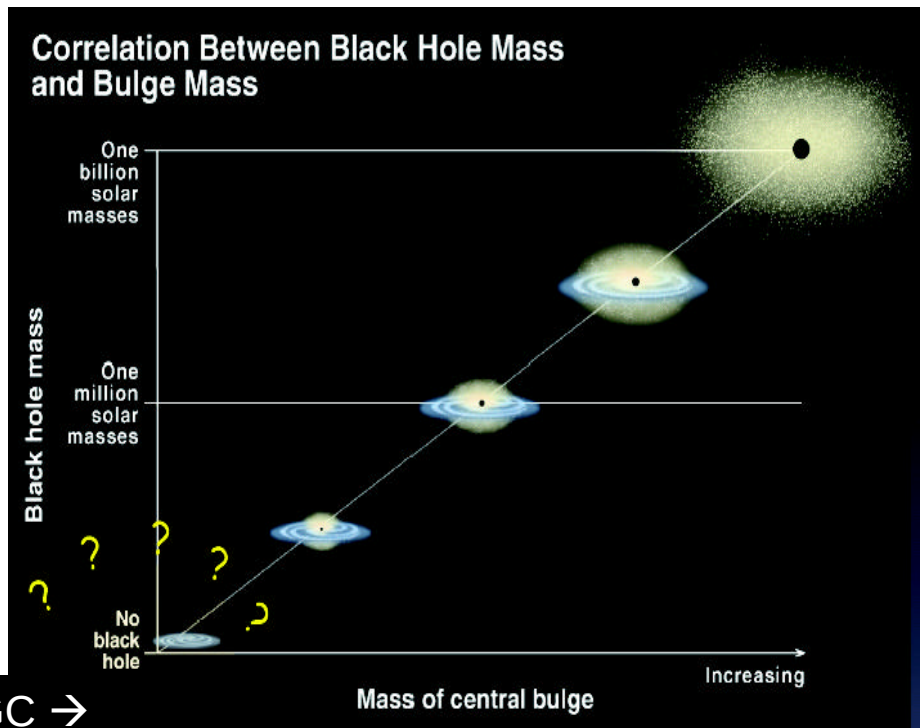
Where is the lower end of the galactic black hole mass function?



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

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

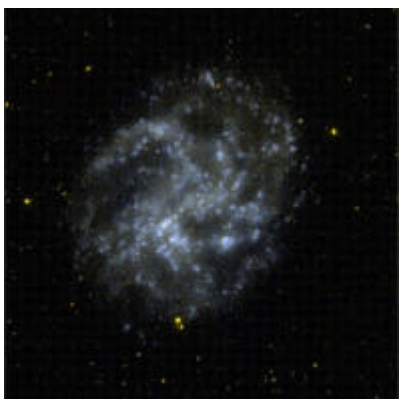
Virial mass

IMBH in AGN: three secured cases

NGC4395

Host M_B=-17.5
BH mass=3.6 x10^5 Msun

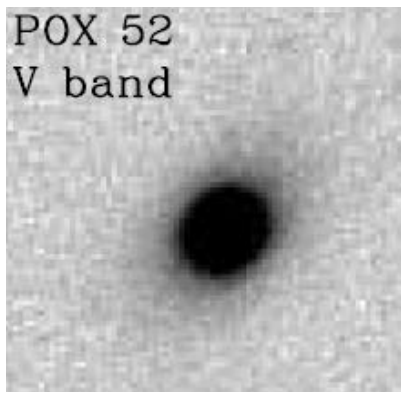
Filippenko & Ho (2003)
Peterson et al. (2005)



POX 52

Host M_B=-16.8
1.6 x10^5 Msun

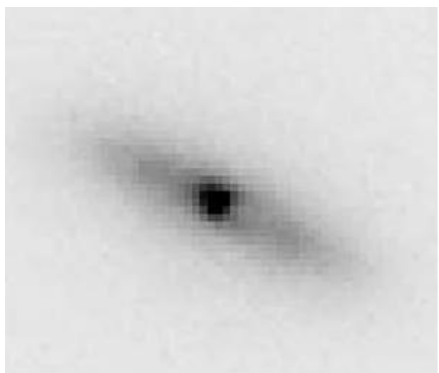
Barth et al. (2004)



SDSSJ1605+1748

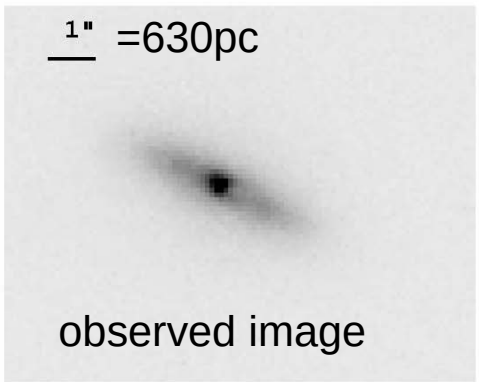
Host M_B=-16.4
0.7-1.6 x10^5 Msun

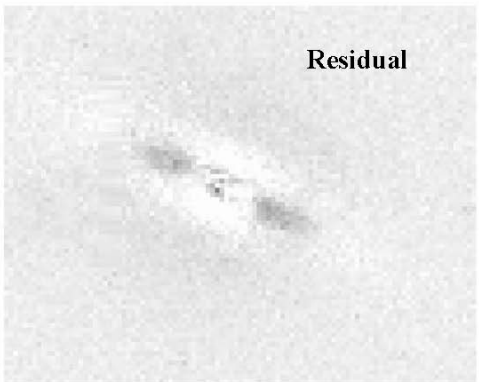
Dong, Wang, Yuan, et al. (2007)

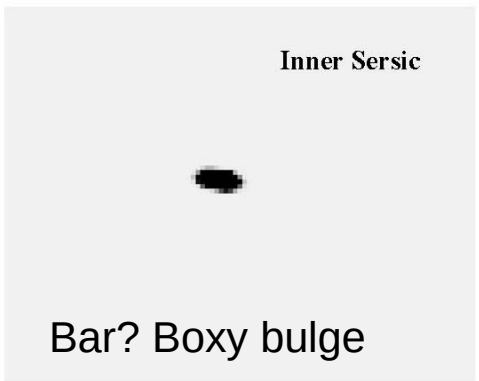


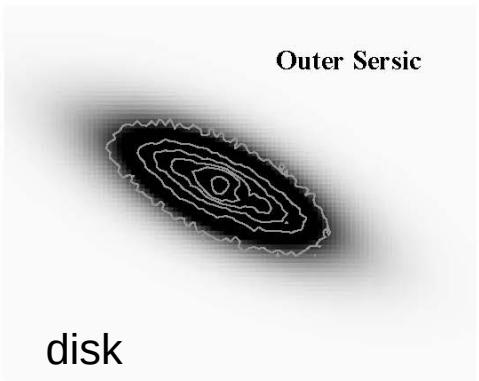
SDSSJ1605+1748

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

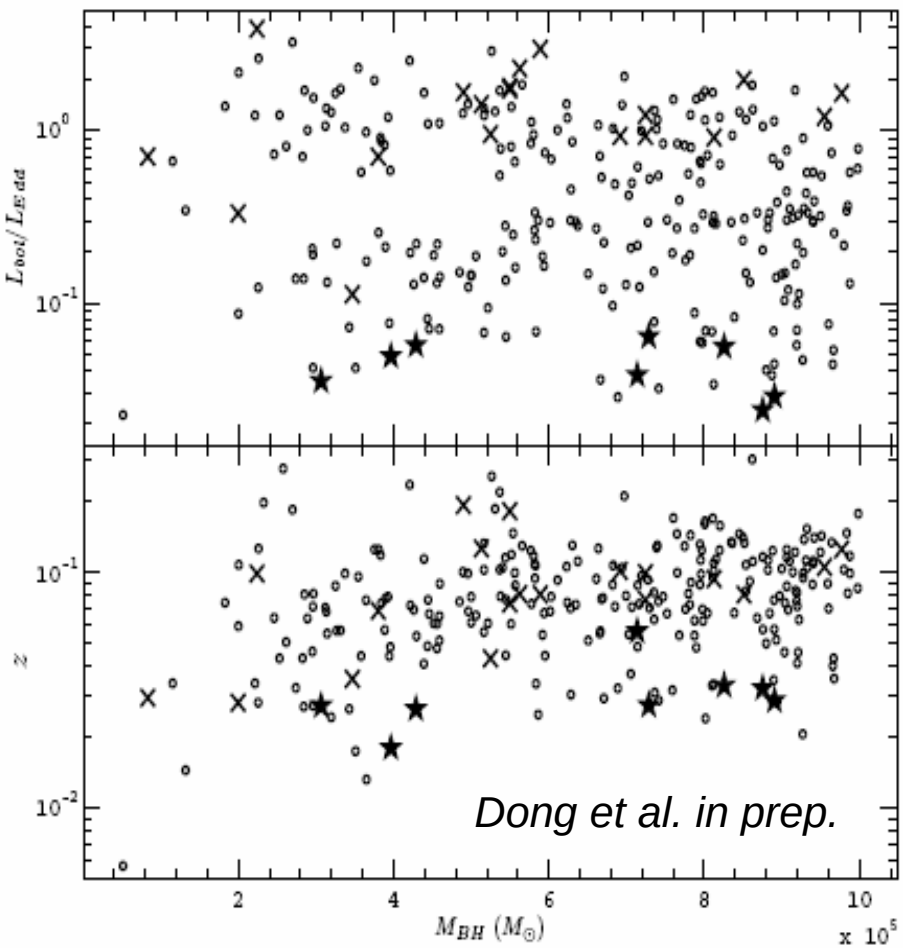
- Q: more IMBH in small galaxies?
- yes! SDSS DR1 (Green & Ho 2004) but rare……while small/dwarf galaxies are numerous
- The original GH04 sample of IMBH AGN (19) all have high L/Ledd

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 $M_{BH}=3.6x10^5$ Msun, Eddington ratio 1.2x10-3 (Perterson et al. 2005)
- Is NGC4395 unique? More objects?

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

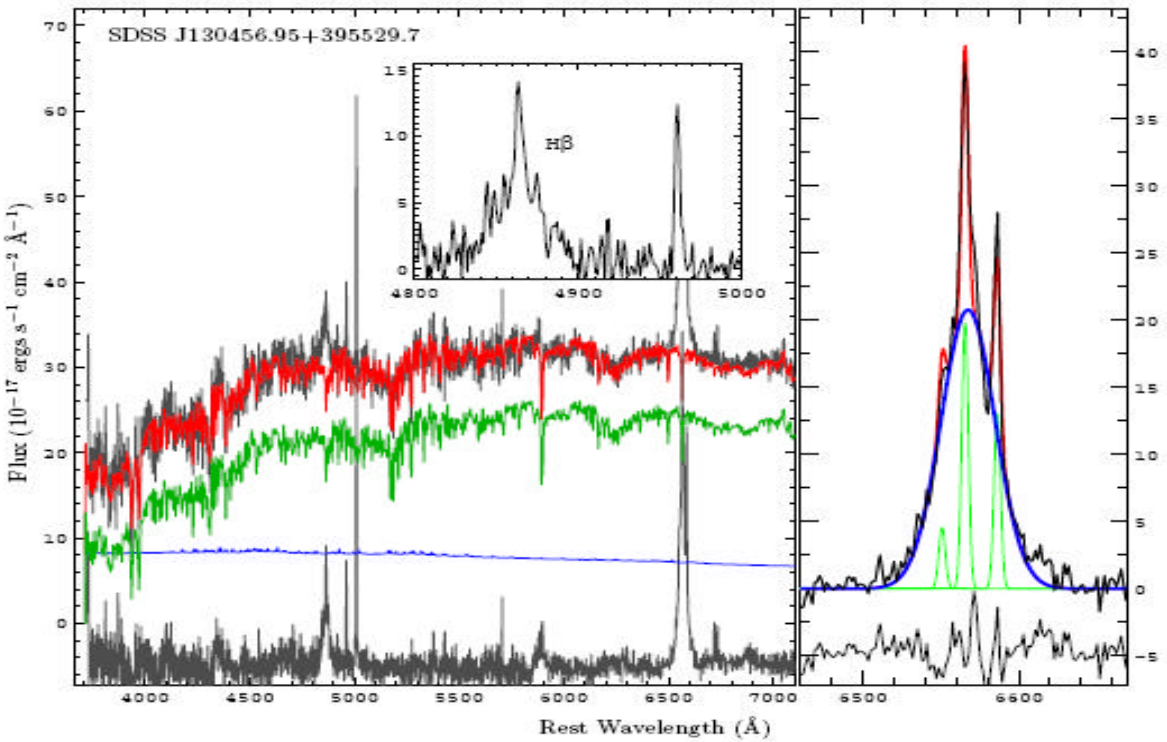


- A new sample of AGN with intermediate black hole
- some have low L/Ledd

Confirmation needed in X-ray
→ 4 observed with Chandra

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

Example discovering SDSS spectrum

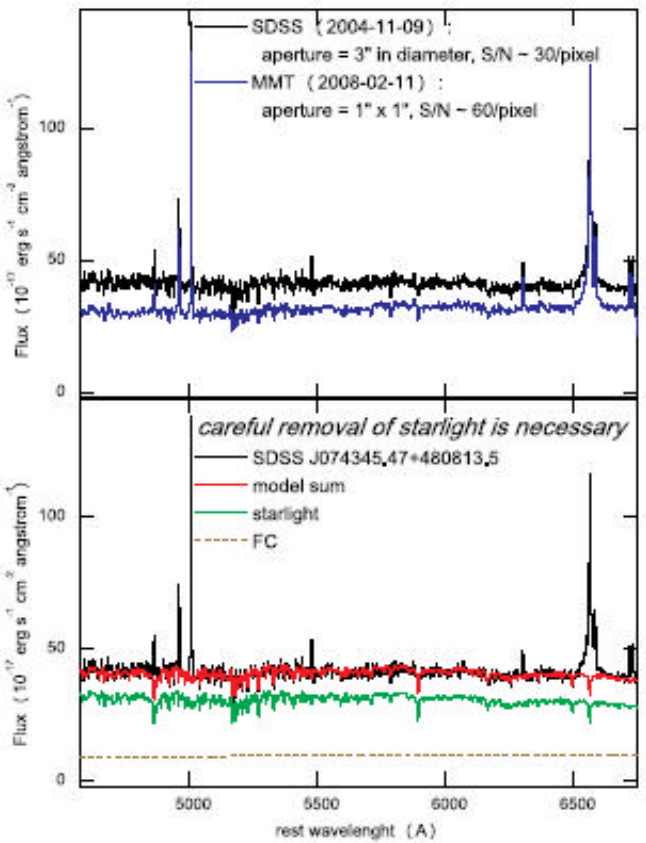


$$M_{BH} = f\,\triangle v^2\,R_{BLR}/G \propto \triangle v^2 L_{opt}^{0.5}$$

Proper subtraction of host galaxy starlight is crucial

1

2



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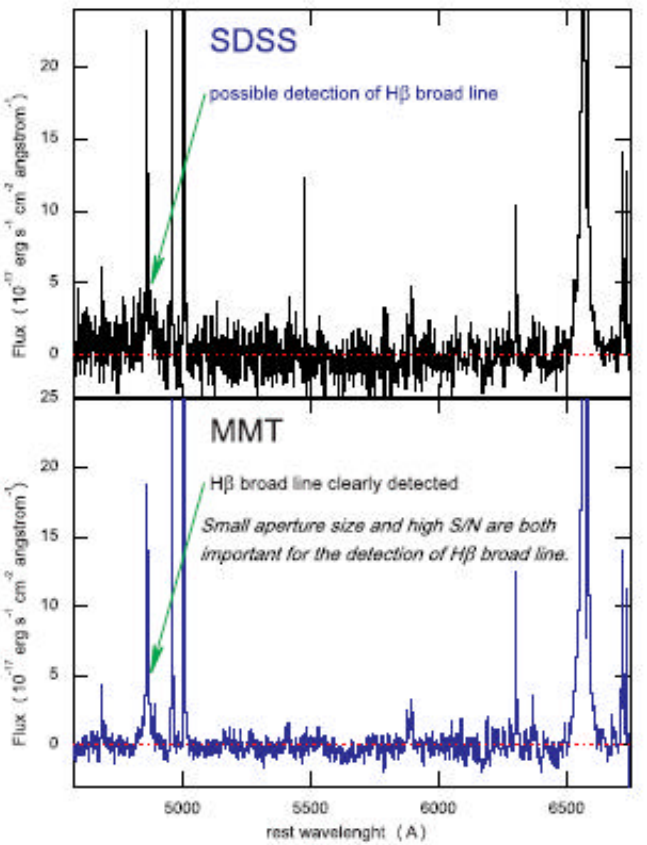
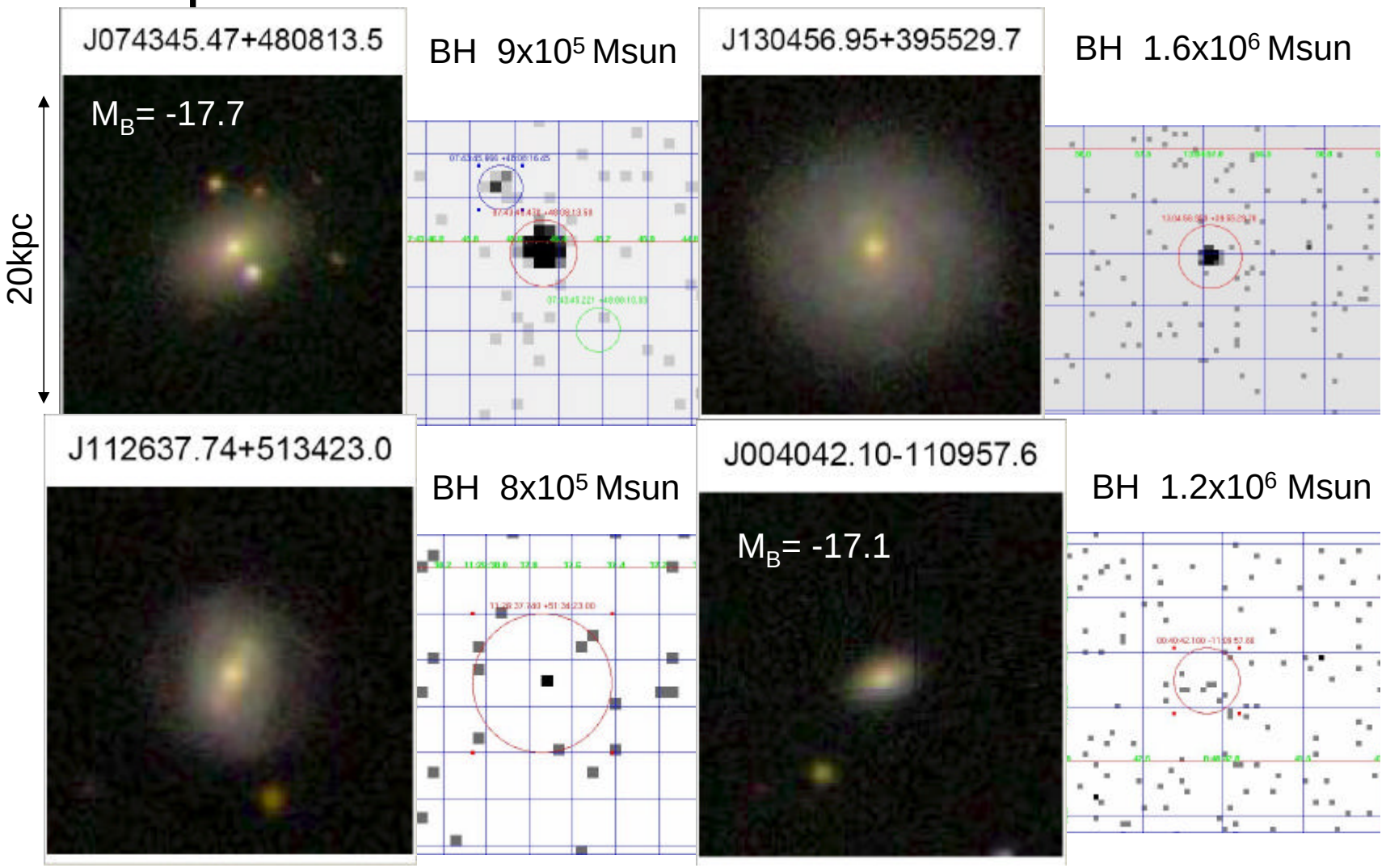
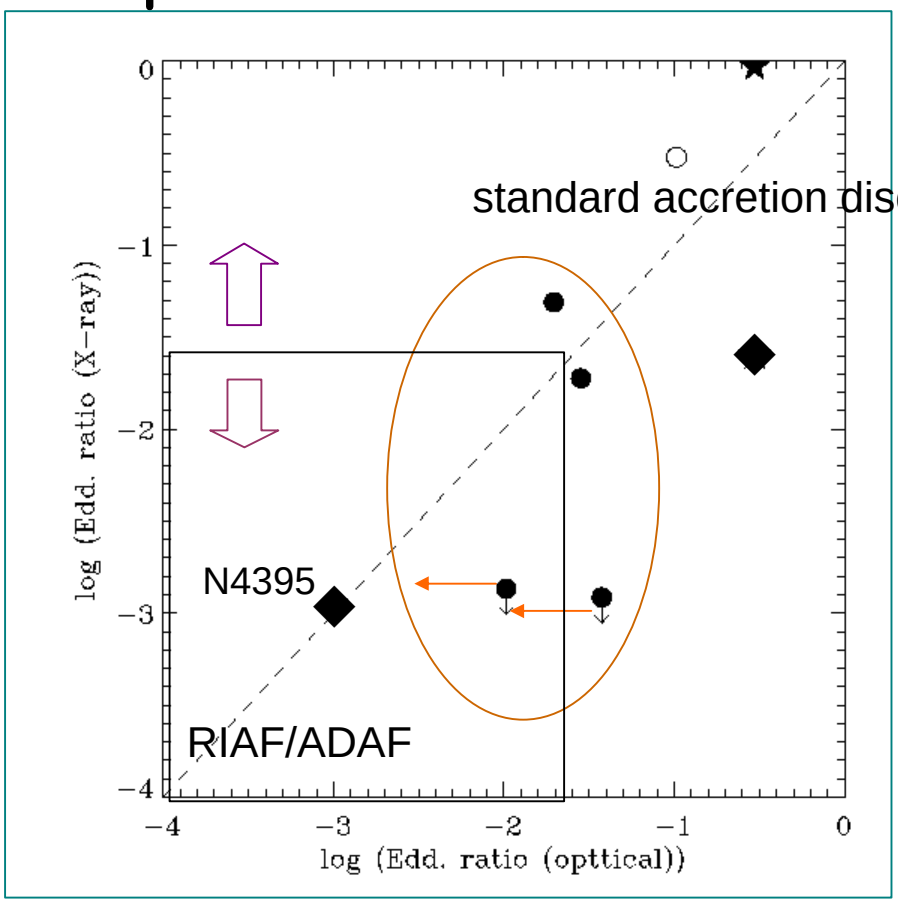


SDSS & Chandra images of low Eddington ratio IMBH AGN



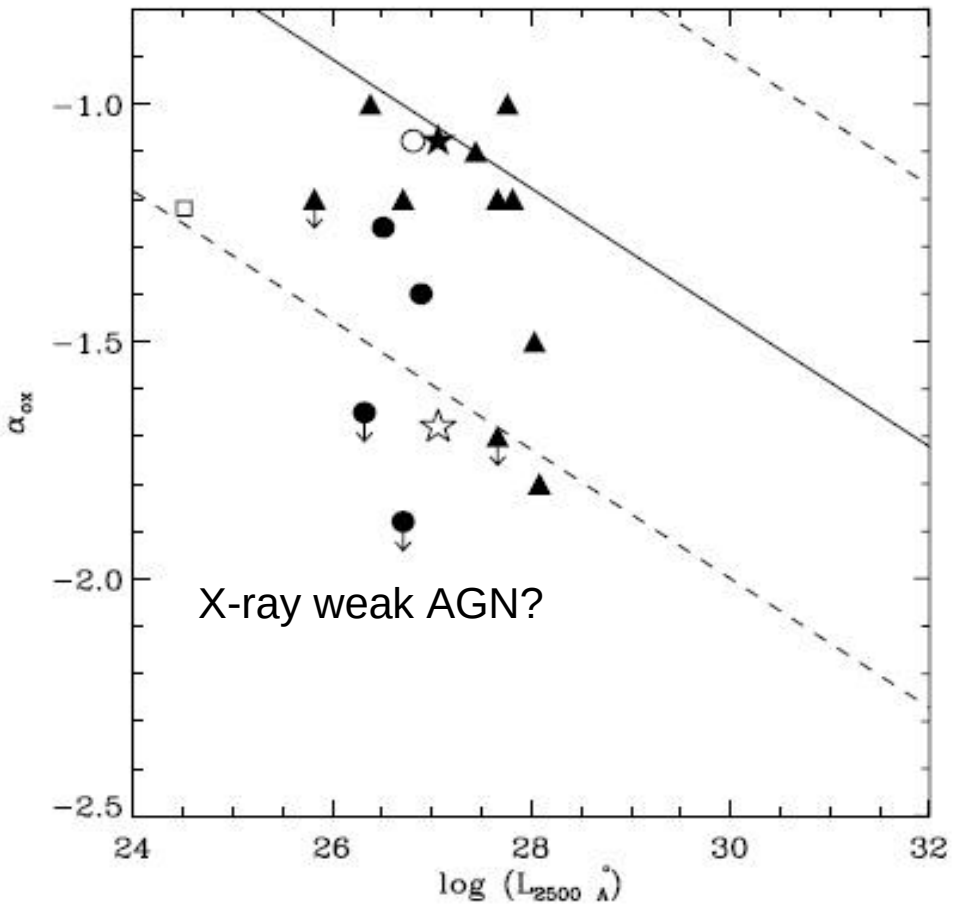
Low Eddington ratios



Bolometric correction assuming
L_{bol} = 20 x Lx(2-10keV)
(Vasudevan & Fabian'07)

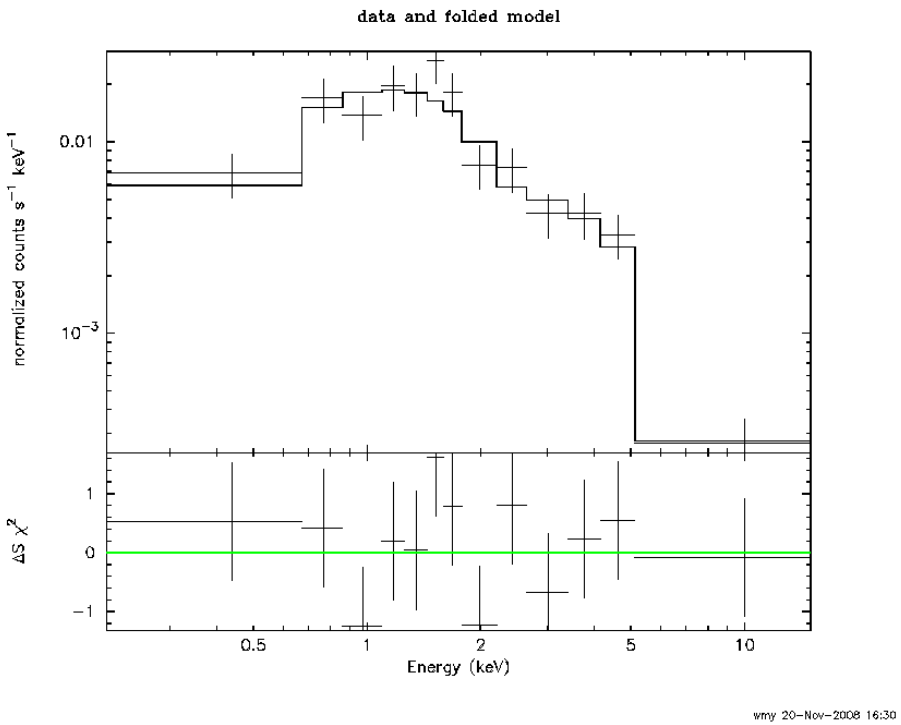
A few more IMBH AGN accreting at low rates do exist (in add. to NGC4395) ! There is a population of under-luminous IMBH AGN yet to be discovered! And so are IMBH

Optical -- X-ray SED



Chandra X-ray spectra

J1304+3955



An abnormally flat X-ray spectrum

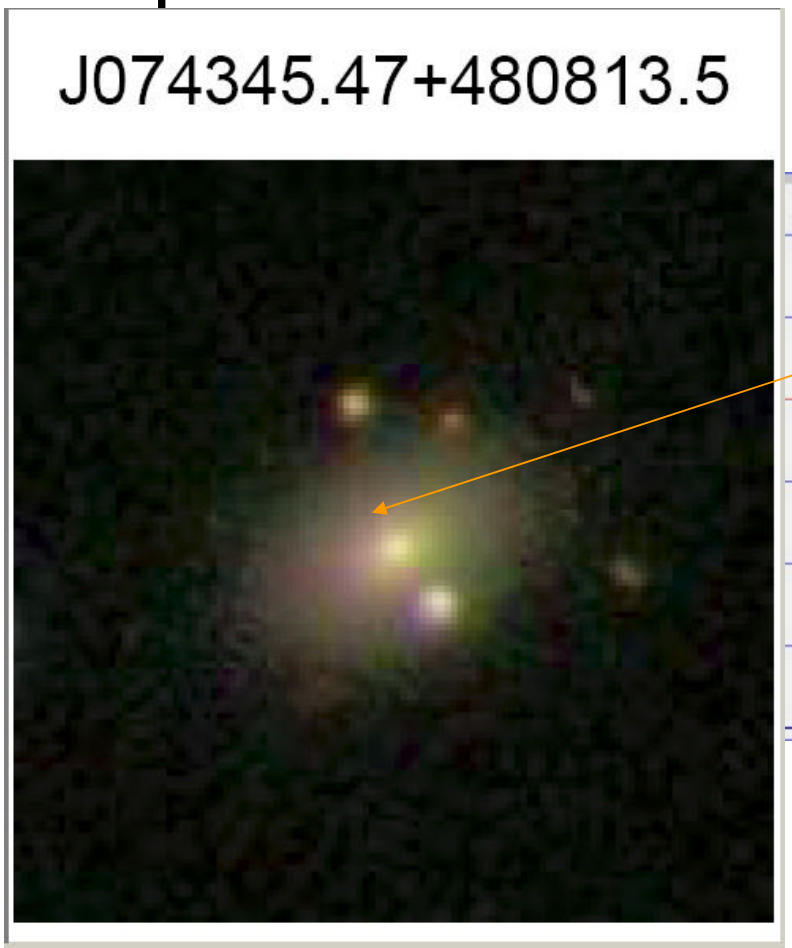
Γ =1.06(+/-0.2) ?

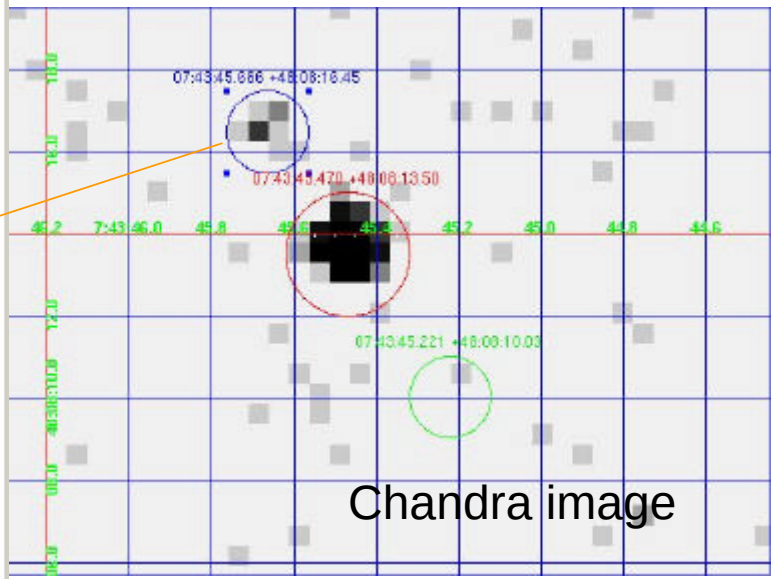
conclusion

- We found a few more intermediate-mass BH AGN with several times 10^5 Msun 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?





Lx(2-10keV)=2.1E40erg/s
~200Msun BH, if accreting at Eddington rate?
(two IMBH merging?)