AMUSE-Virgo

AGN

MUlti-wavelength

Survey

in Early type

galaxies

Black Hole Accretion in the Nearby Universe: Evidence for Down-Sizing

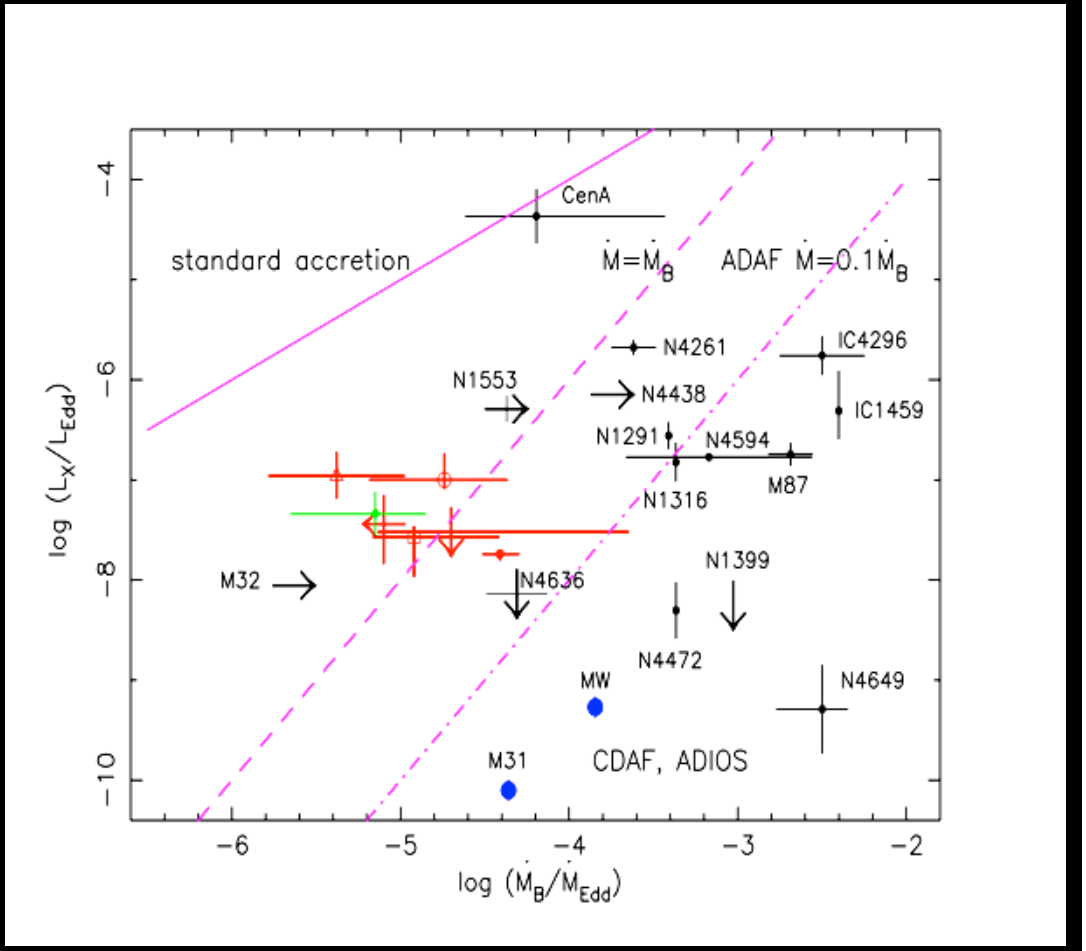
Elena Gallo | MIT Kavli Institute

X-rays: AGN vs. `inactive' galaxies

X-rays from inactive galaxies:

ROSAT effectively sensitive down to 1e40 erg/sec for nearby galaxies

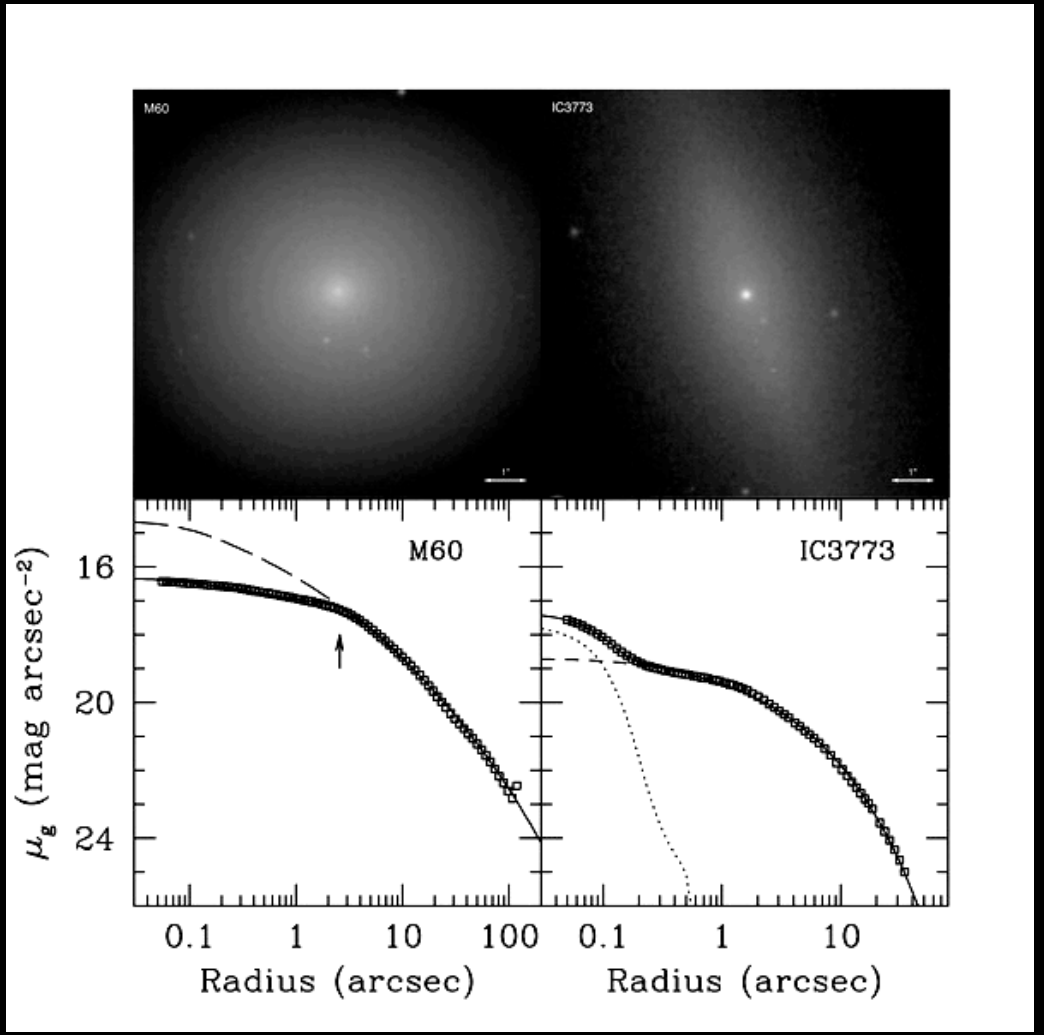
Chandra bridges the gap between active (>1E-2 L_Edd) and (formally) inactive galaxies



Pellegrini 2005; Soria et al 2006

Black hole vs nuclear star clusters

- ACS Virgo Cluster Sample (ACSVCS Cote' et al 04)
- Nuclear star clusters increasingly prominent moving down the mass function > might replace black holes
- X-ray perspective: enhanced contamination from X-ray binaries



Ferrarese et al. 2006 (also Wenher & Harris 2006, Kormendy et al 2009)

AMUSE-Virgo: the survey

- ✓ Targets 100 early type galaxies which compose the HST ACS Virgo Cluster Survey (ACSVCS, Cote' et al 04)

Chandra ACIS-S

Spitzer MIPS

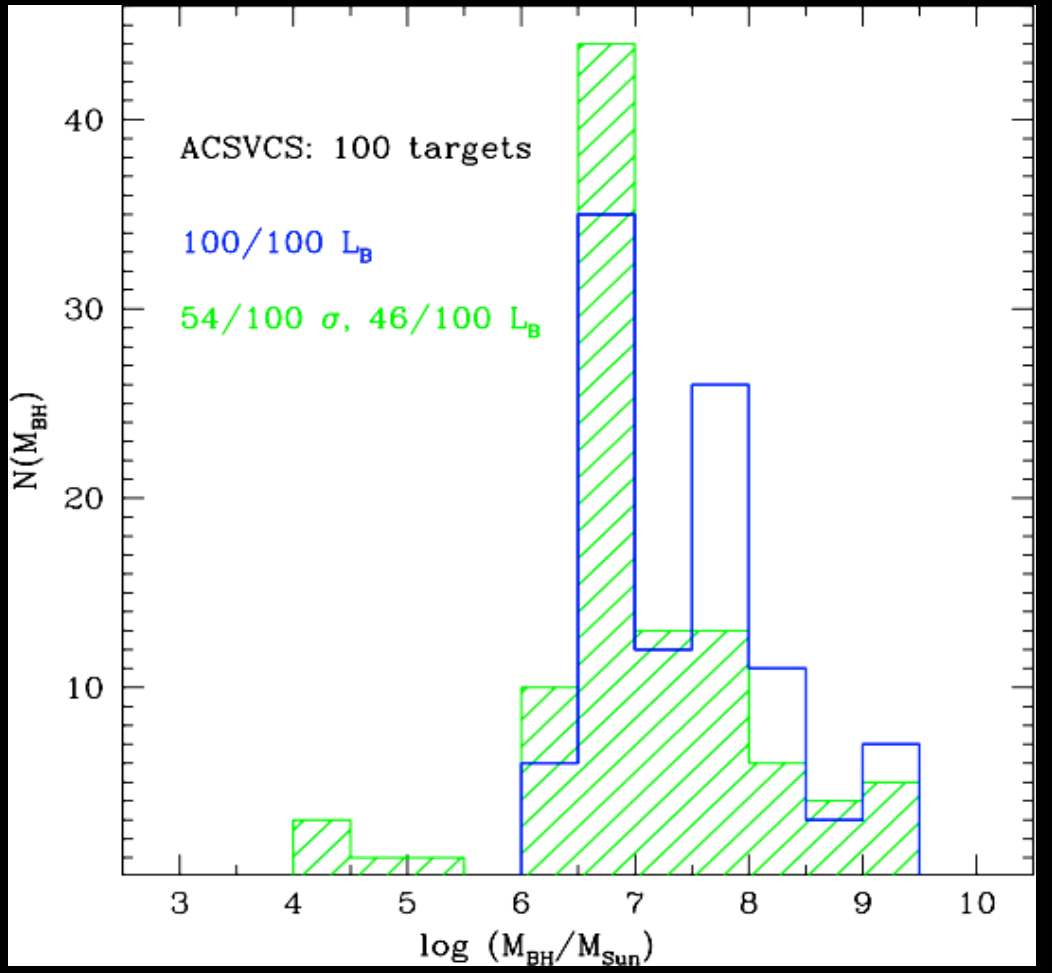
Hubble ACS

VLA

- ➢ Duty cycle of super-massive black hole (highly sub-Eddington) activity
- ➢ Local black hole occupation fraction

AMUSE-Virgo: the survey

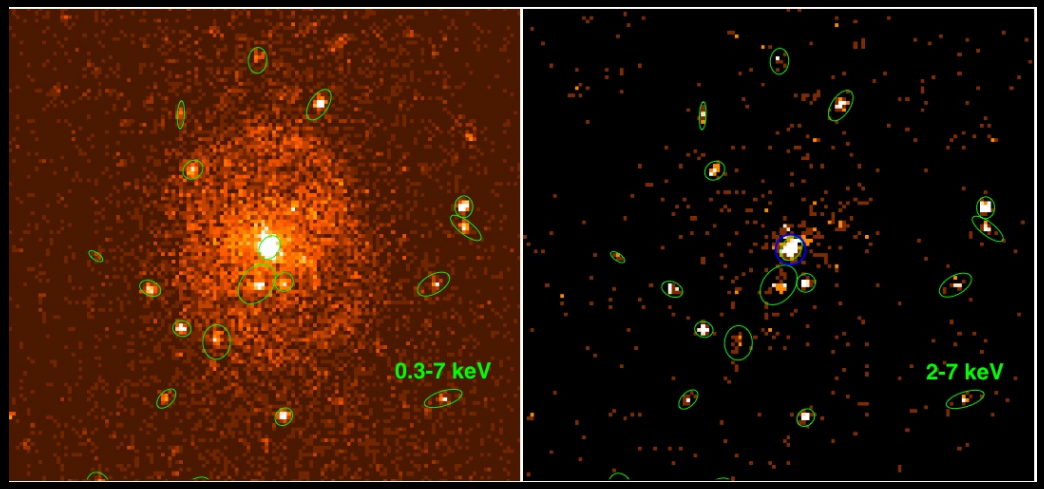
- 84 new targets with Chandra ACIS-S (454 ksec) + 16 archival (>1Msec) complete down to L_Edd for a 3 M_Sun object
- 57 new targets with Spitzer MIPS (9.5 hr) + 43 archival
- HST ACS g- & z-band archival images (ACSVCS)

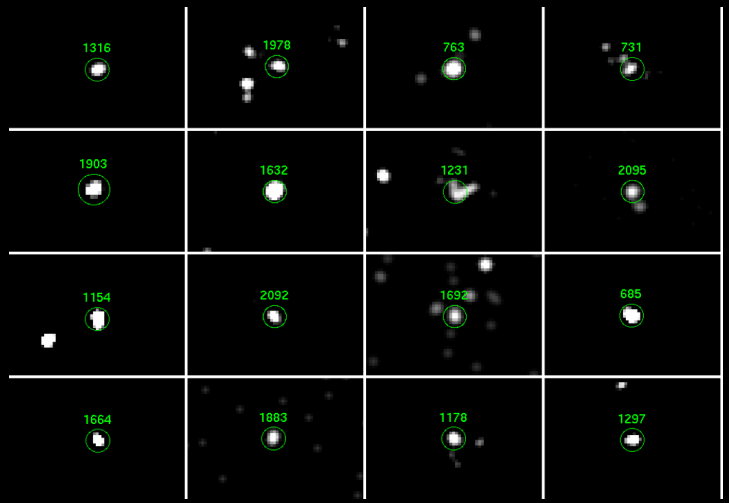


AMUSE: black holes, star clusters & LMXBs

Contamination from Low-Mass X-ray Binaries (LMXBs) addressed *quantitatively*: each nuclear X-ray source Lx is assigned a prob. (1-Px) to be an active black hole, where Px is the chance probability of having a LMXB ≥Lx within the ACIS PSF, based on X-ray luminosity function of LMXBs:

- in the FIELD (*Gilfanov 2004*) in the absence of nuclear star clusters
- in GLOBULAR CLUSTERS (*Sivakoff et al. 2007*) in the presence of a nuclear cluster



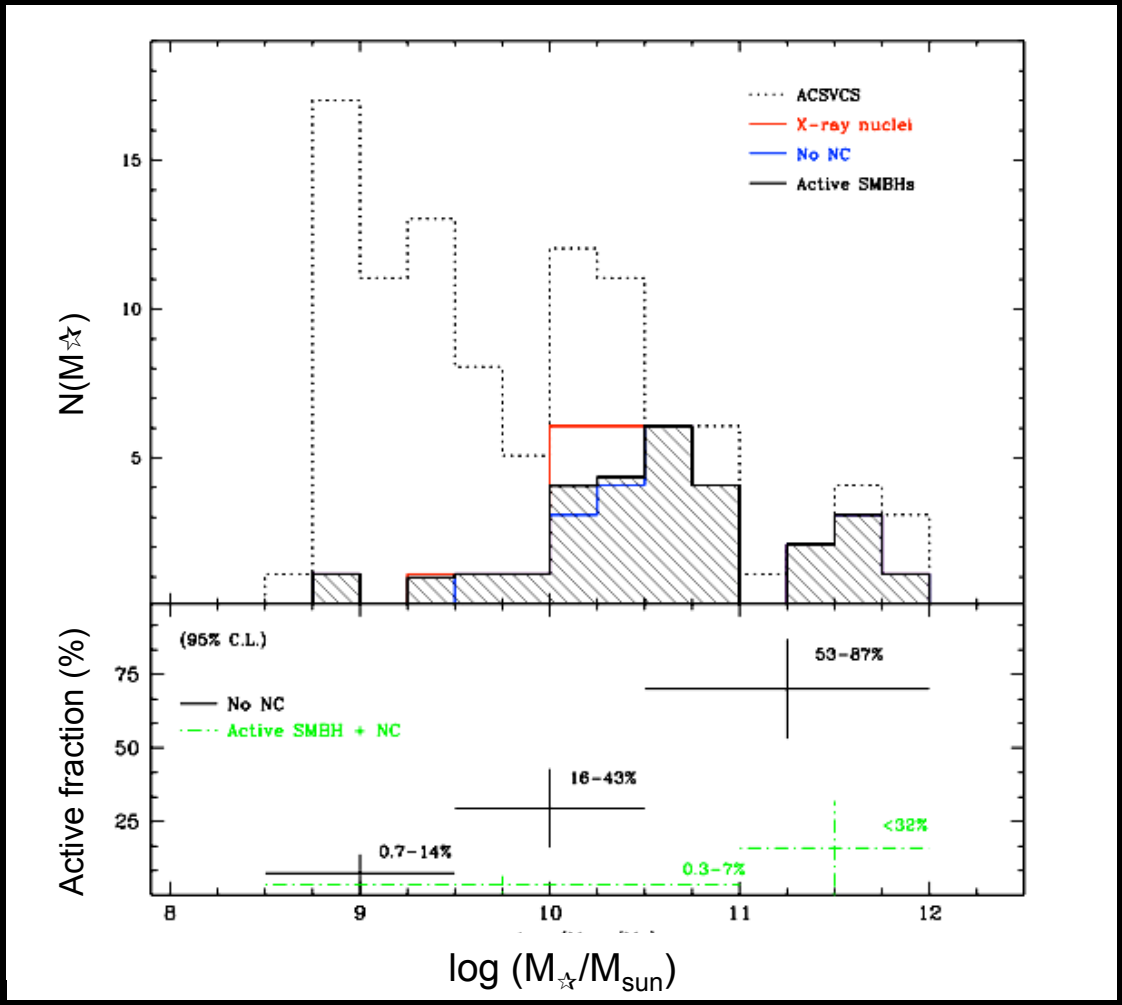


Gallo et al 2008, 2010

AMUSE-Virgo: Nuclear X-ray census

- 32/100 show a nuclear X-ray source
- 51/100 show a massive nuclear star cluster
- 6/100 show both a nuclear X-ray source and a star cluster
- 24-34% of the galaxies host an active super- massive black hole (95% C.L.)
- ACTIVE FRACTION as a function of M_*, M_{BH}

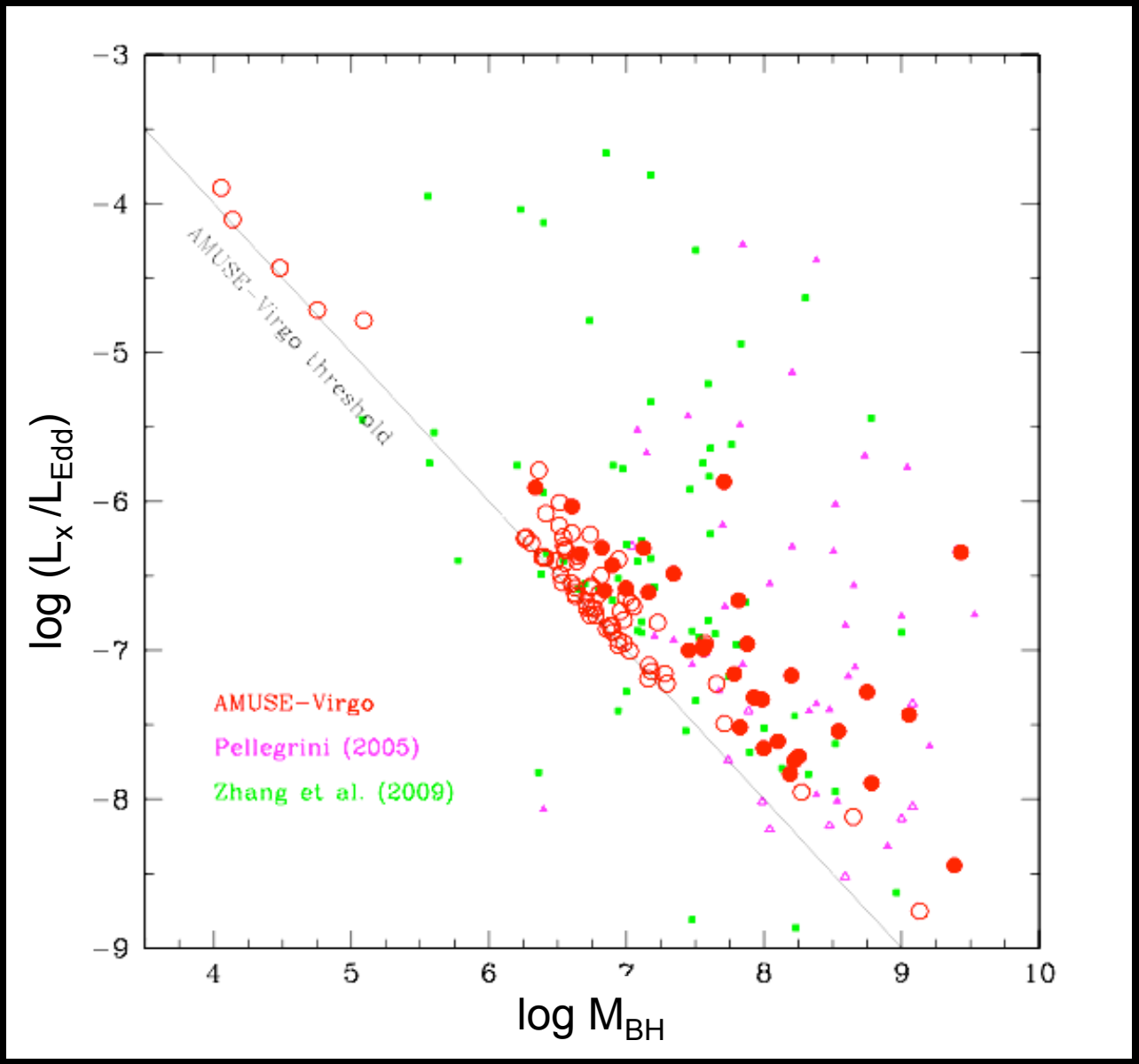
AMUSE-Virgo: Active black hole fraction



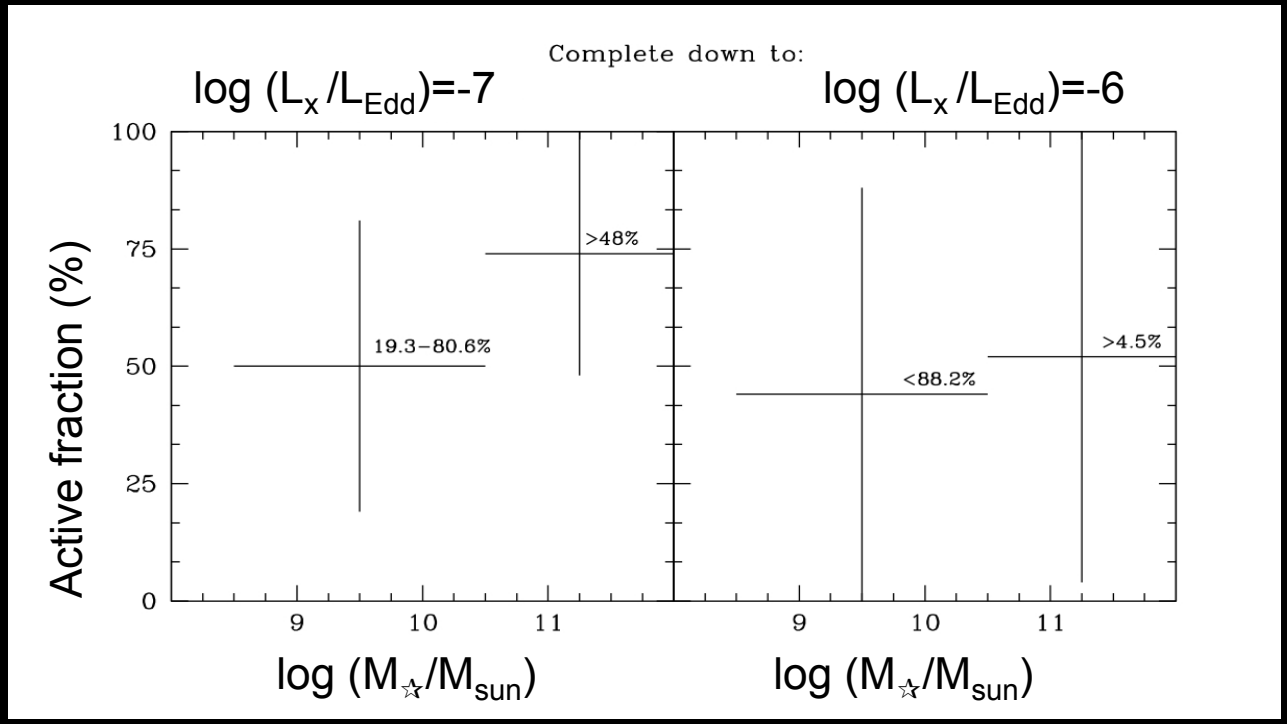
Active fraction raises with host stellar mass

(Gallo et al 2008, 2010; see Ho et al 1997 Kaufmann et al 2003, Decarli et al 2007, Seth et al 2008, 2010)

AMUSE-Virgo: Power vs. BH Mass



AMUSE-Virgo: L_x/L_{Edd} completeness



Active fraction raises with host stellar mass

HOWEVER

Dealing with `Eddington-limited' sub-samples results in no evidence that the fraction of active black holes depends on host mass

AMUSE-Virgo: Bayesian approach

Assume:

Log($\mathcal{L}_{X,38}$)=A + B log($\mathcal{M}_{BH,8}$)

Intrinsic scatter σ_0

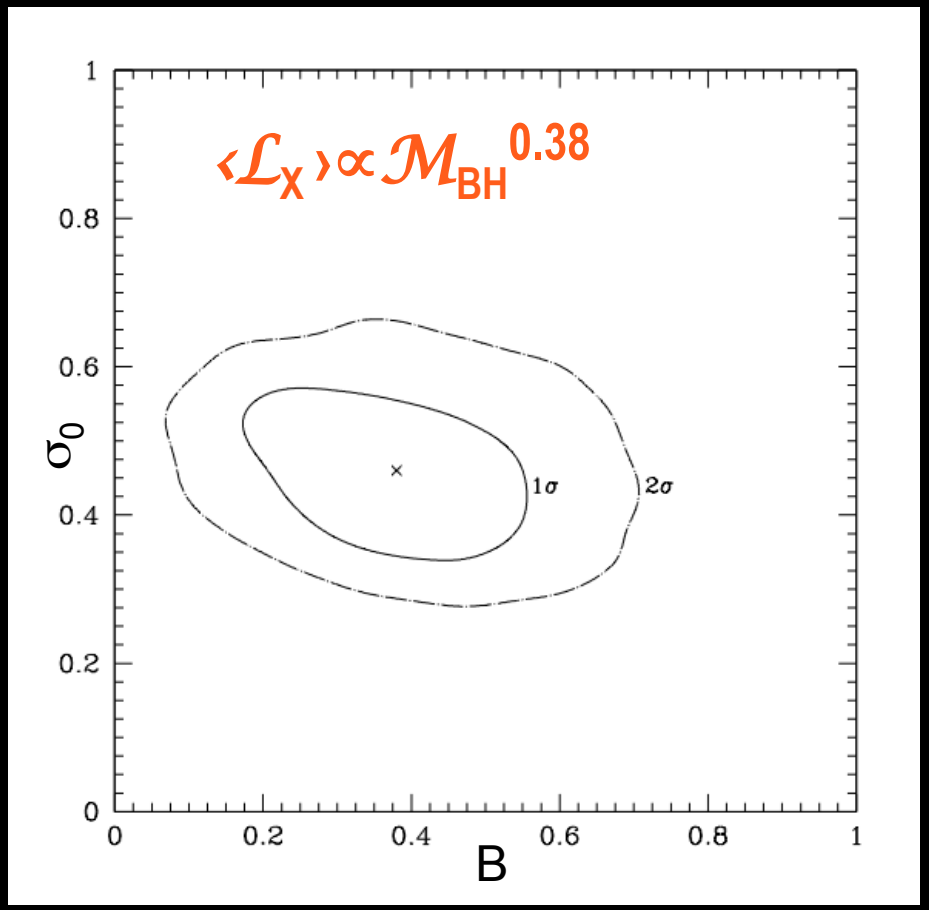
0.44 dex error on M_{BH}

Uniform prior on BH mass function

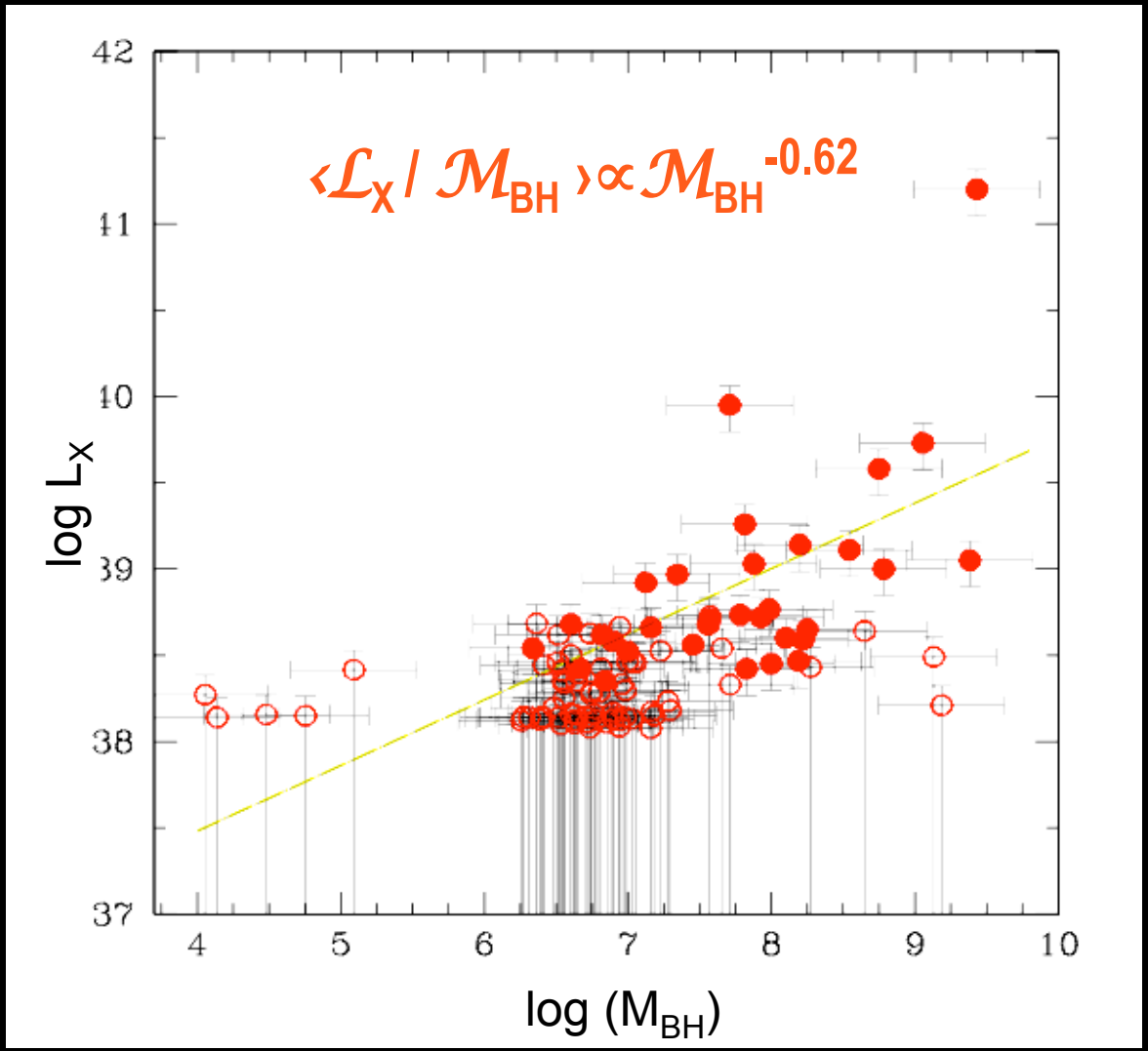
A=1.0±0.1

B=0.38±0.13

σ_0=0.46±0.08 dex



AMUSE-Virgo: Accretion Down-sizing



Gallo et al 2010 (ApJ, in press)

AMUSE-Virgo: Summary

- 32/100 nuclear X-ray sources ; 51/100 nuclear clusters ; 6/100 hybrids
- Bona fide active black holes (after LMXB contamination assessment): between 24-34% host an accreting black hole. Strong lower limit to occupation fraction in the local universe.
- AVERAGE L_X/L_{EDD} DESCREASES WITH INCREASING M_{BH}
- NEXT: results from Spizter MIPS: absorption, dust reprocessing etc. (*Leipski et al. in prep, Paper III)* + AMUSE-Field approved Large Program (Cycle 11, PI Gallo) on 100 *field* spheroidals, to investigate environmental effects.