AMUSE-Virgo

AGN

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wavelength

Survey

n Early type

galaxies

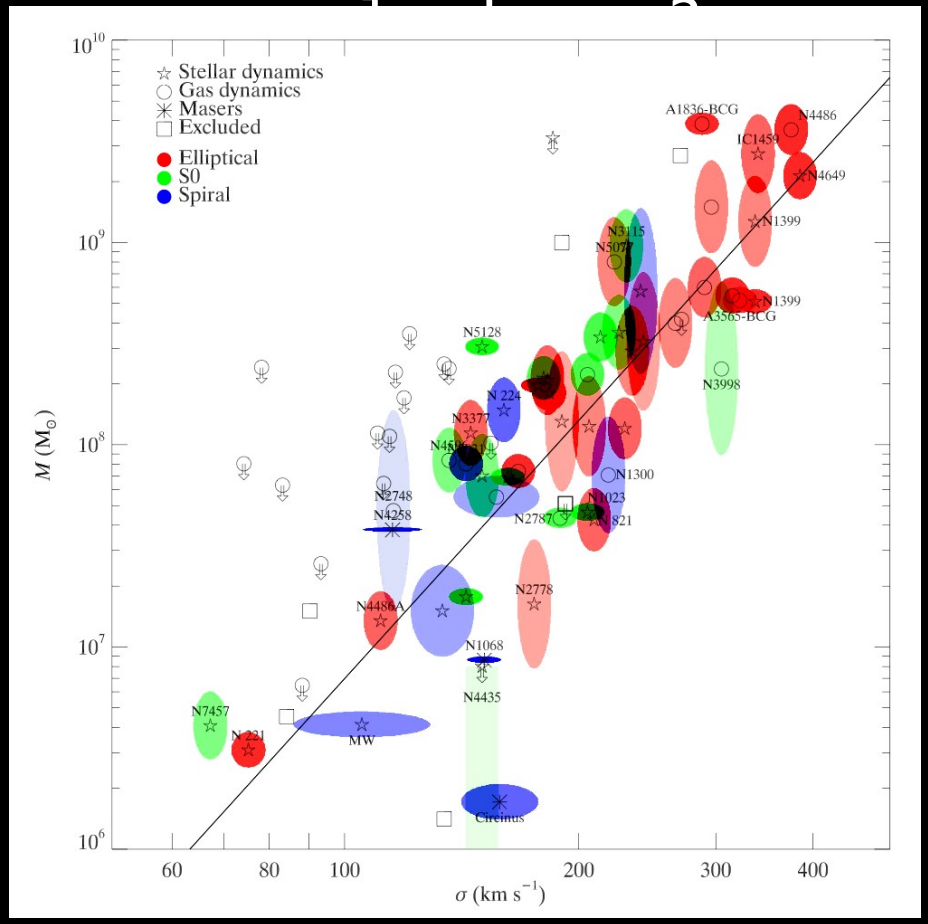
AMUSE-Virgo

Super-massive black holes vs. nuclear star clusters: the X-ray view

Elena Gallo | MIT Kavli Institute

Scaling relations in faint/low-mass spheroids

Do massive black holes *exist* in faint / low-mass

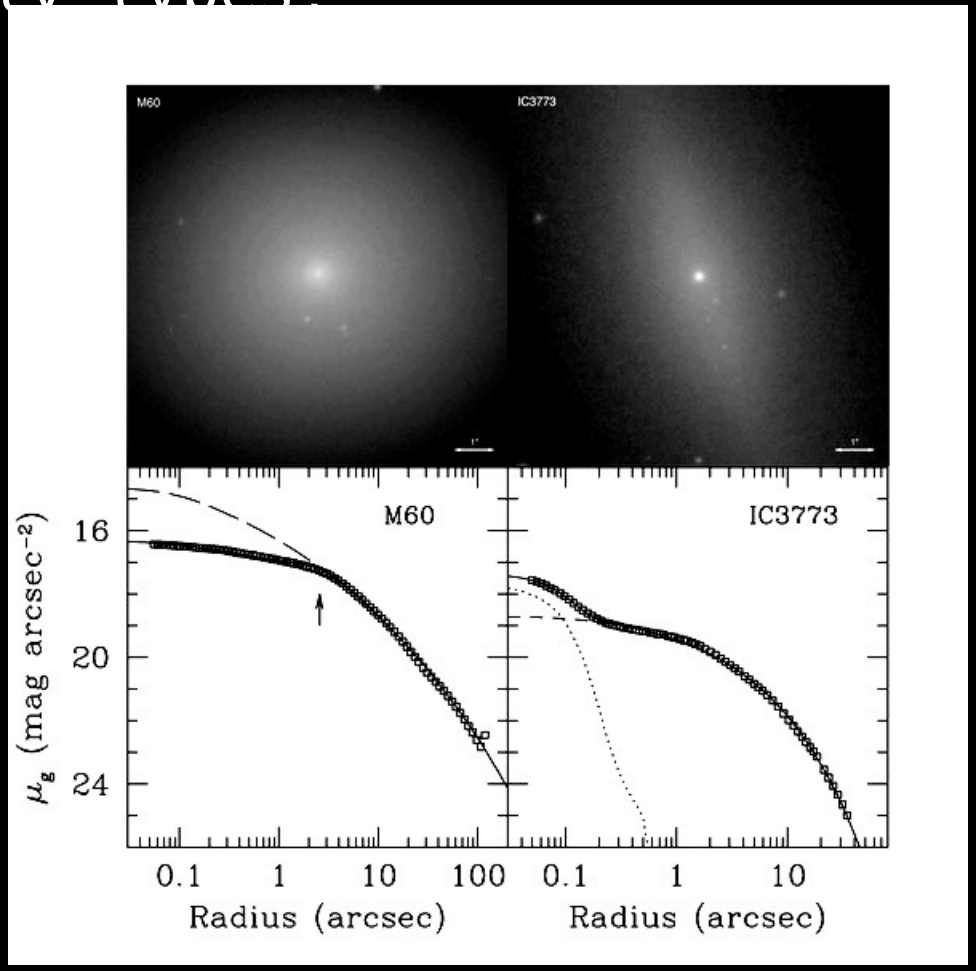


Gultekin et al. 2009

Black hole vs nuclear star clusters

Do massive black holes *exist* in faint / low-mass early types?

- ACS Virgo Cluster Sample (ACSVCS Cote' et al 04)
- Nuclear star clusters increasingly prominent moving down the mass function (present in 80% of the galaxies with stellar masses <1E



Ferrarese et al 2006 Wehner & Harris 2006 Kormendy et al

AMUSE-Virgo: science goals

- Census of super-massive black hole activity in the local universe (Chandra+Spitzer +Hubble)
- Black hole occupation fraction (Chandra +Spitzer+Hubble)
- X-ray luminosity function of globular clusters + Ultra-luminous X-ray sources in early type galaxies (Chandra+Hubble)
- Testing super-massive black hole mass scaling relations at the low mass end

AMUSE-Virgo: the survey

Targets 100 early type galaxies which compose the HST ACS Virgo Cluster Survey (ACSVCS, *Cote' et al 2004*)

Stellar mass range: 1E+8.5-1E+12

Nuclear black hole mass range: 1E+5-1E+9

- 84 new targets with Chandra ACIS-S (454 ksec) + 16 archival (>1Msec)

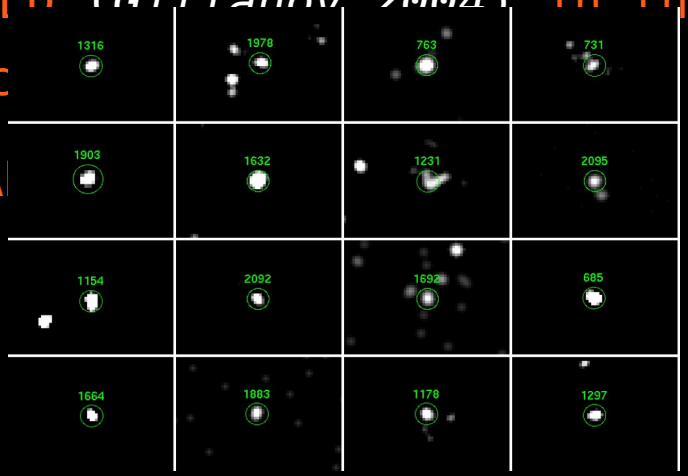
  complete down to L_Edd for a 3 M_Sun object
- 57 new targets with Spitzer MIPS (9.5 hr) + 43 archival
- HST ACS g- & z-band archival images (100 orbits)
- VLA 5 GHz, in progress

AMUSE, the team: E. Gallo (MIT), T. Treu, R. Antonucci

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:

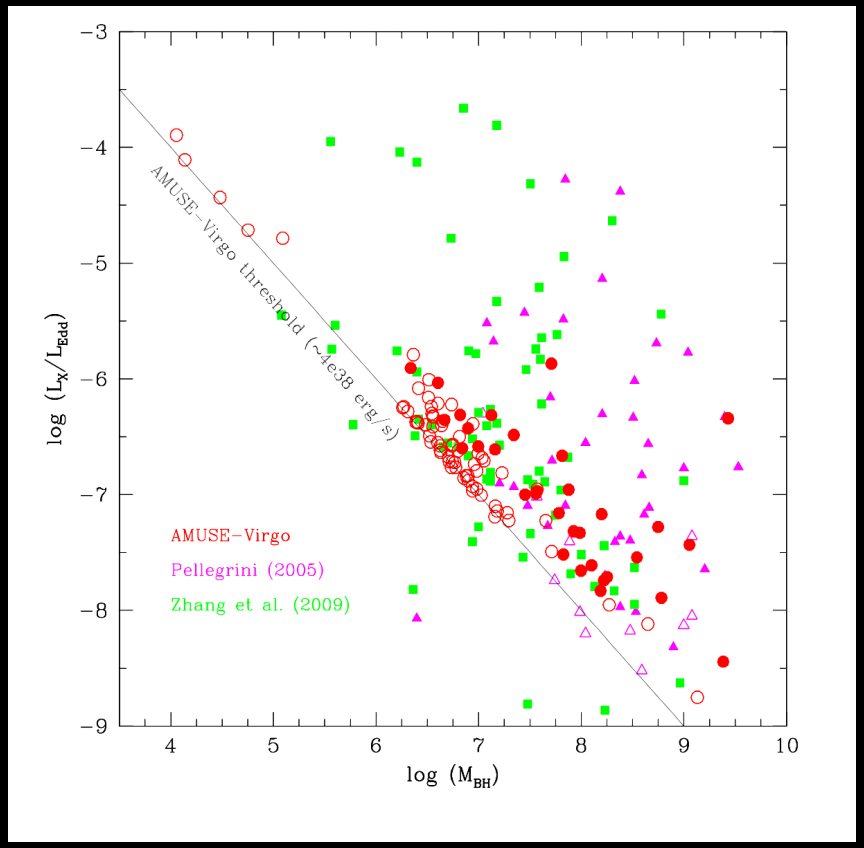
- in the FIEL[illegible] (*Gilfanov 2004*) in the absence of nuclear star c[illegible]
- in GLOBULA[illegible] *al. 2007*) in the presence of a



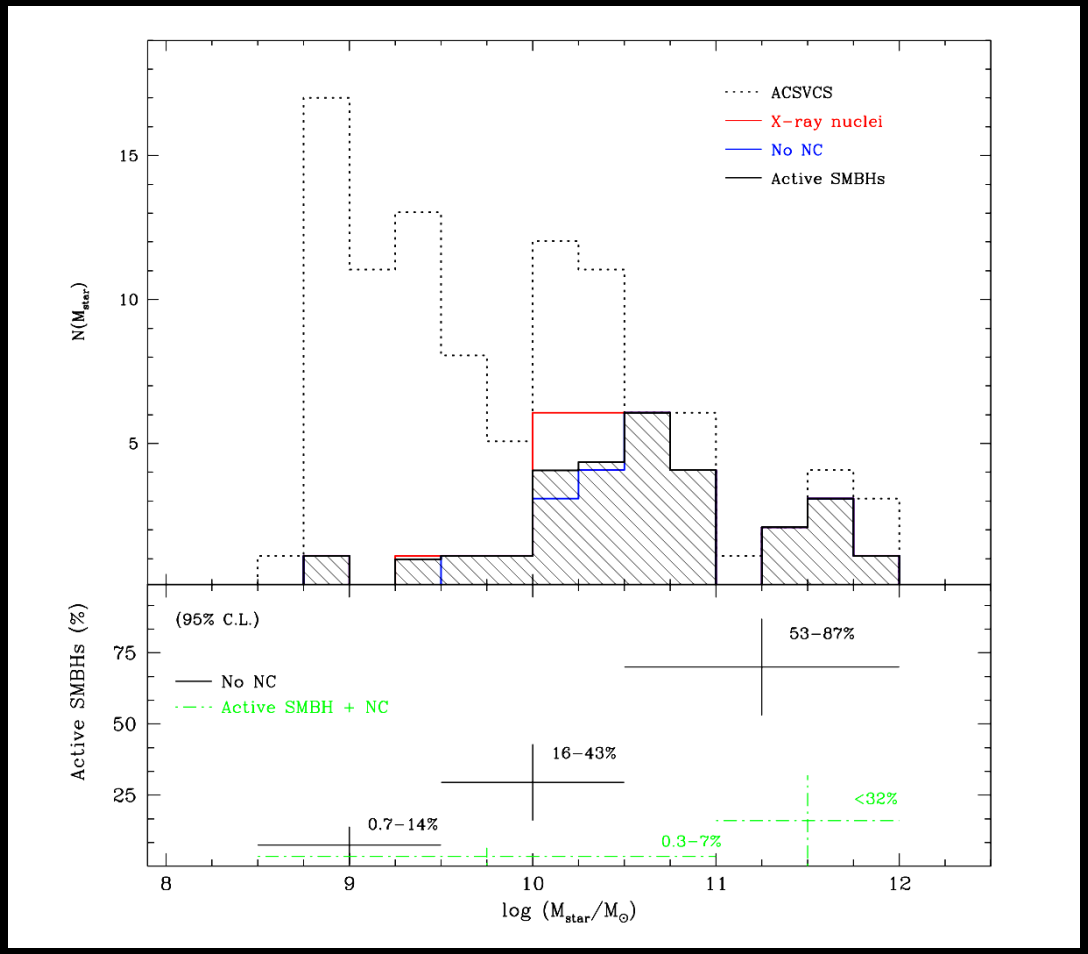
Gallo et al. 2008 (Paper I.), Gallo et al. 2009, to be submitted (Paper II.)

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.)
- Measured X-ray luminosities range between 1E-8.5 and 1E-6 L_Edd

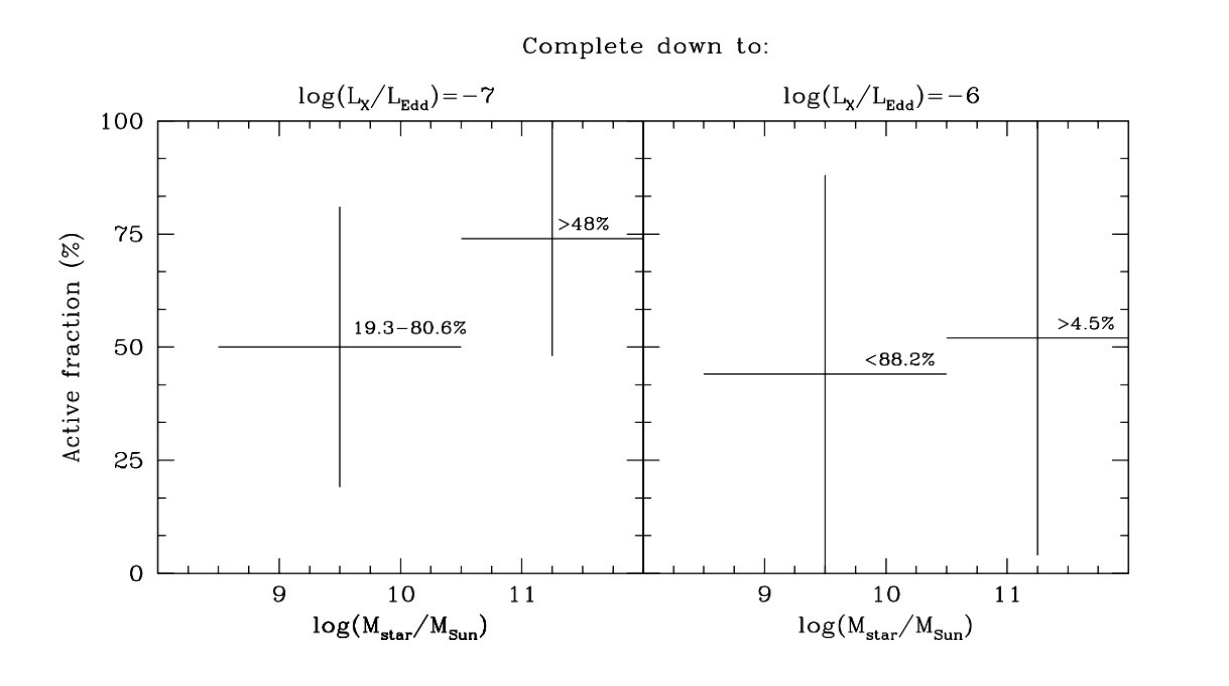


AMUSE-Virgo: Active black hole fraction



Active fraction raises with host stellar mass (Paper I.; agrees with e.g. *Kauffmann et al., 2003, Decarli et al., 2007, Seth*

AMUSE-Virgo: L_X/L_{Edd} completeness

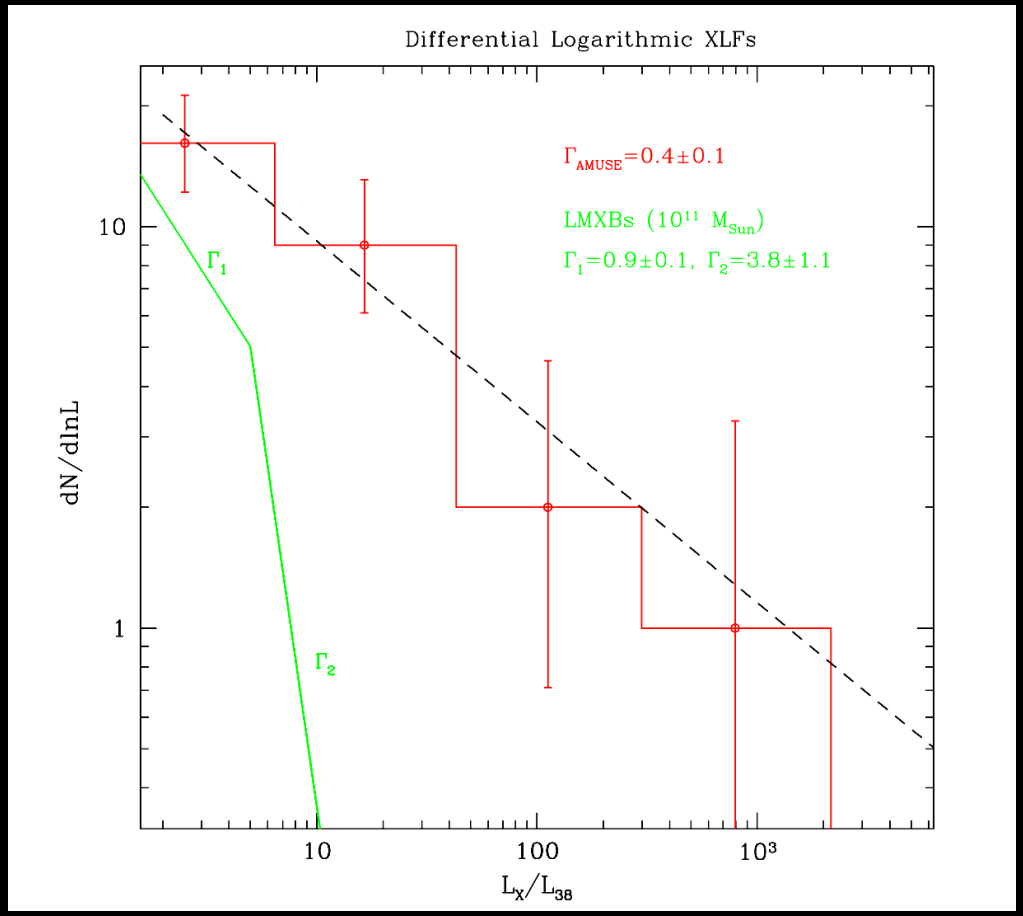


Active fraction raises with host stellar mass

HOWEVER

Dealing with `Eddington-limited' sub-samples results in no evidence that the fraction of active black

AMUSE-Virgo: Differential XLF



Substantially different from XLF of LMXBs (*Gilfanov 2004*)
Slope agrees with *Zhang et al. 2009* (187 galaxies < 15 Mpc)

AMUSE-Virgo: Summary

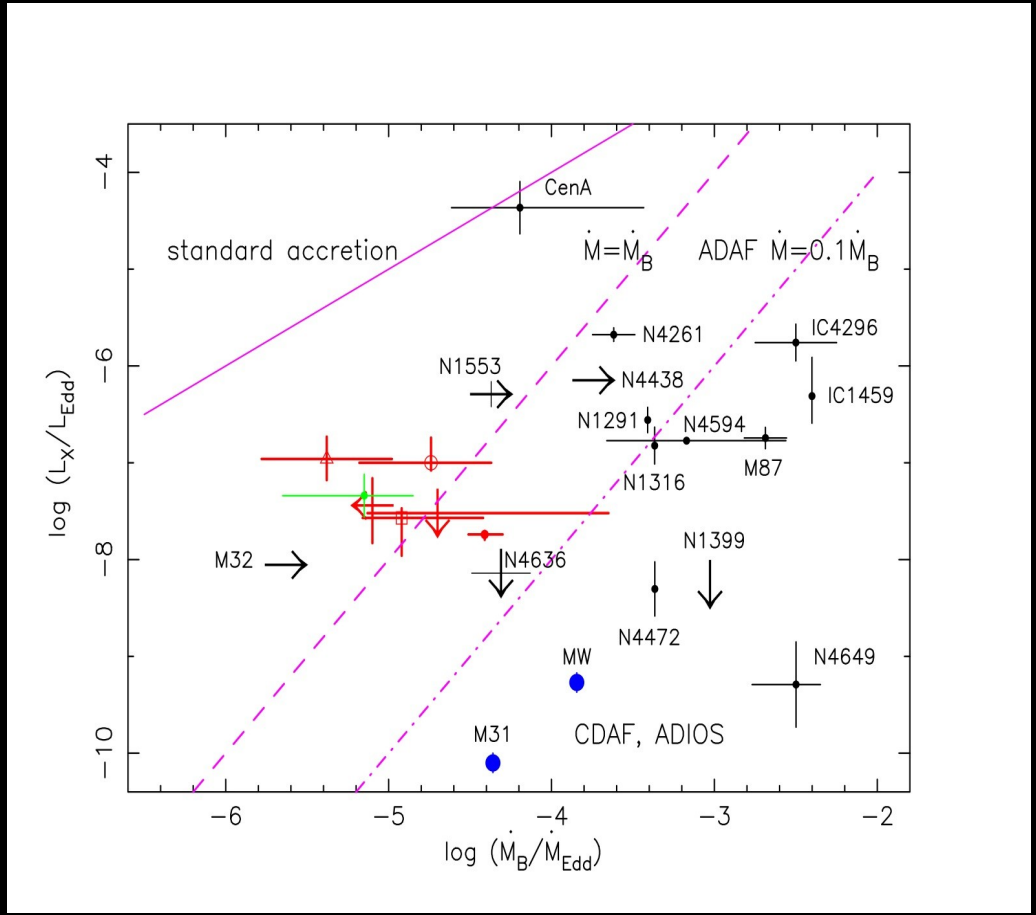
- 32/100 nuclear X-ray sources ; 51/100 nuclear clusters ; 6/100 hybrids
- *Bona fide* active black holes (after LMXB contamination assessment): between 24-34% host an accreting black hole. Strong lower limit to occupation fraction in the local universe.
- No evidence for increase in the active fraction of X-ray active with host stellar mass when Eddington-limited samples are considered.
- Measured X-ray luminosities between 1E-8.5 and 1E-6 times Eddington lum.

X-rays: AGN vs. `inactive' galaxies

X-rays from inactive galaxies:

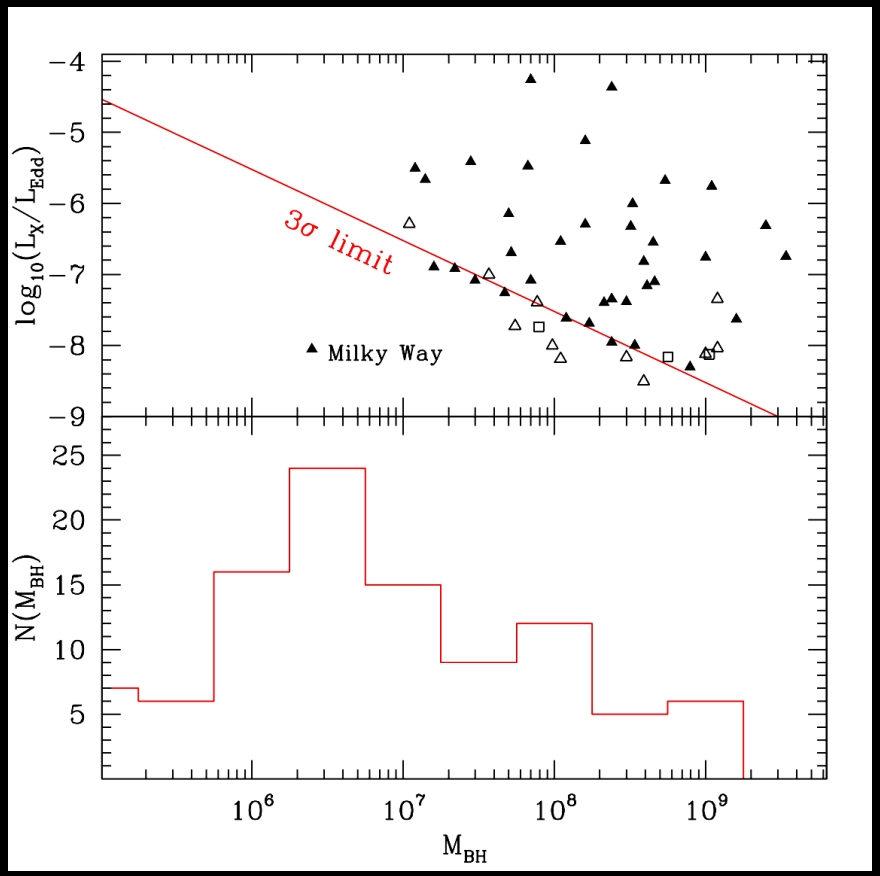
ROSAT effectively sensitive down to 1e40 erg/sec for nearby galaxies

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

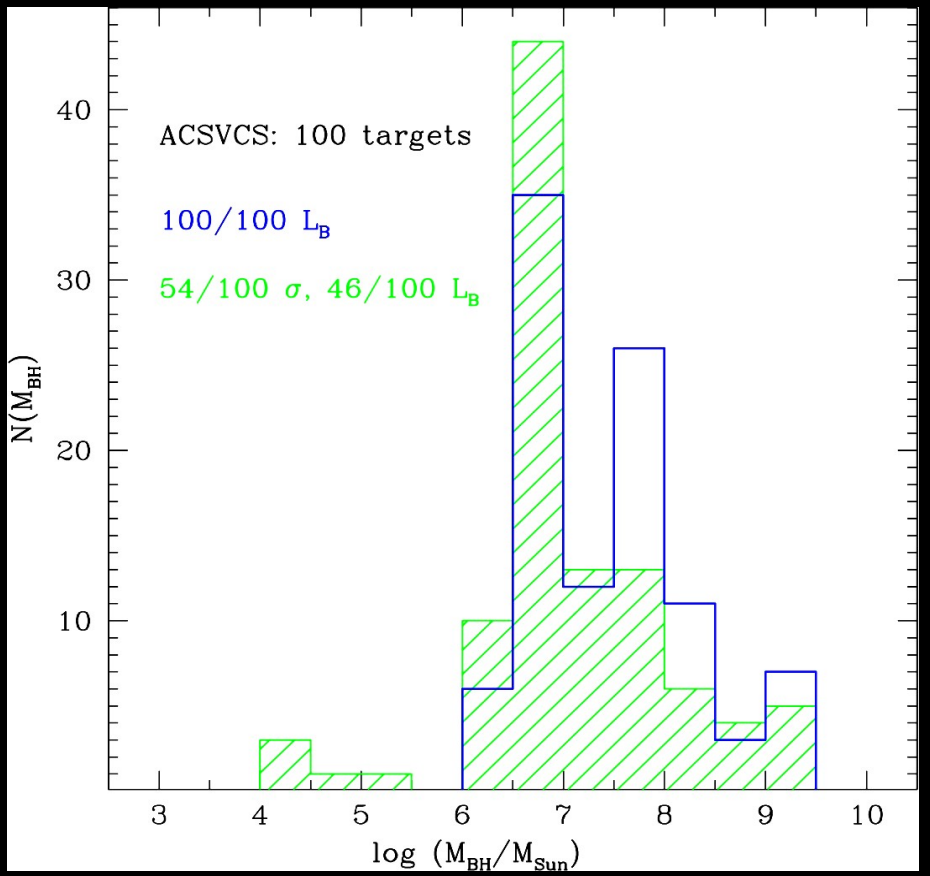


Pellegrini 2005, Soria

AMUSE-Virgo: parameter space



Host stellar mass distribution



Nuclear black hole mass distribution