AMUSE-Virgo

AGN

Multi-wavelength

Survey

in Early type

galaxies

On the survival of super-massive
black holes in faint spheroids

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AMUSE: science goals

- ✓ Census of super-massive black hole (SMBH) activity in the local universe (Chandra+Spitzer+Hubble+VLA)

- ✓ SMBH occupation fraction/mechanical heating (Chandra+Spitzer+Hubble+VLA)

- ✓ Ultra-luminous X-ray sources in low-mass early type galaxies (Chandra+Hubble)

- ✓ Testing SMBH mass scaling relations at the low mass end (Hubble+Keck)

AMUSE: the survey

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

    - 84 new targets with Chandra ACIS-S (454 ksec; PI: Treu) + 16 archival

    - 57 new targets with Spitzer MIPS (9.5 hr) + 43 archival

    - HST ACS archival data (100 orbits)

    - VLA, in progress (with D. Axon)

✓ AMUSE, the team: E. Gallo, T. Treu, J.-H. Woo, J. Jacob, R. Antonucci, P. Marshall, L. Bildsten, C. Liepski (UCSB)

  http://tartufo.physics.ucsb.edu/~amuse/

Science background

The quest for SMBHs:

- ✓ prolonged periods of low-level SMBH activity *needed* in order to reproduce the galaxies' colors (`radio mode', Croton et al. 06).

Do SMBH *exist* in faint early types?

- ✓ SMBH/active stellar nuclei competition at B mag fainter than –20 (Ferrarese et al. 06)
- ✓ Low BH occupation fraction (Volonteri et al. 07)

Scaling relations: SMBH in faint spheroids

✓ SMBHs replaced by `compact stellar nuclei' moving down the mass function.

✓ SMBHS:

   - Dominate B mag < –20

   - Disappear B mag > –18

   - Coexist in between
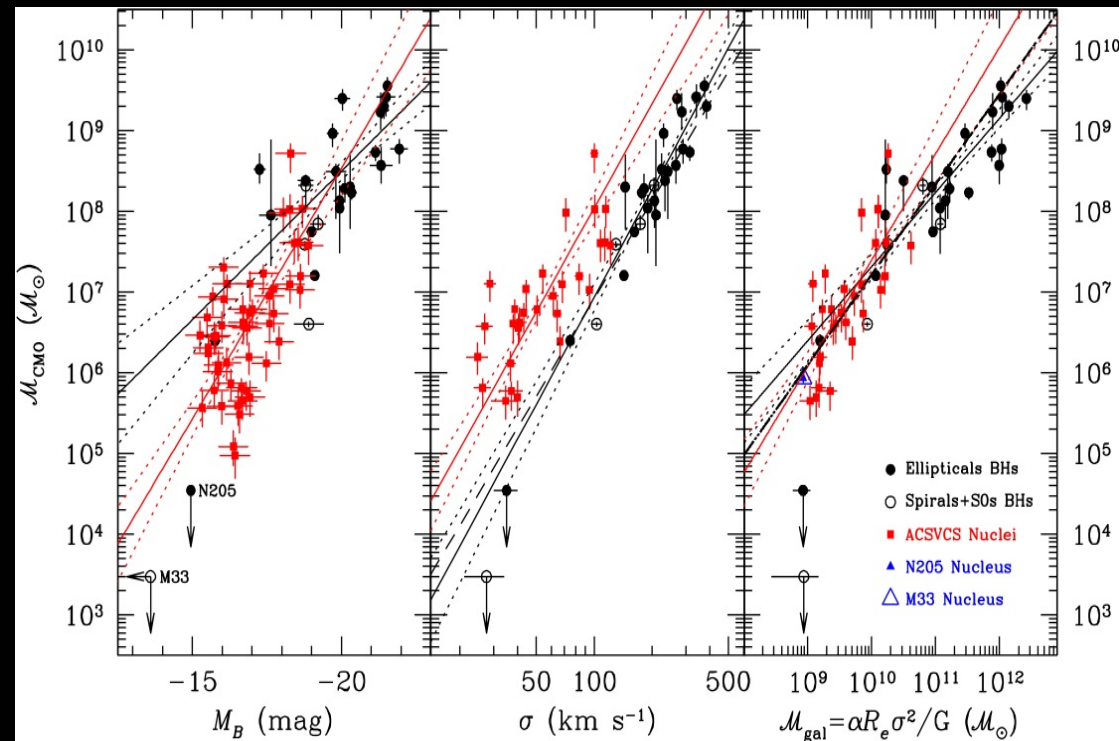
Ferrarese et al. 2006

AMUSE: first Chandra results I.

✓ Search for accretion-powered activity from SMBH:

- improve astrometry (match to SDSS-DR5)

- separate hot gas from low mass X-ray binaries (LMXBs)

- search for point like nuclear X-ray source

✓ Contamination:

- CXB: negligible (<1e-7 sources, Chandra DF South, Rosati et al 02)

- LMXBs in the field: Gilfanov 04

- LMXBs in star clusters: Sivakoff et al 07

AMUSE: first Chandra results II.

✓ 32 galaxies: 16 archival (>500 ksec), 16 new (5.4 ksec each: sensitive to L_Edd for a 3 M_Sun object)

✓ Point-like nuclear X-ray source detected in 16 objects:

- 4/16 belong to the new 5.4 ksec obs. Of the remaining 12 (archival data):

- 9/12 already reported in the literature

Nuclear SMBHs

Chandra ACIS-S
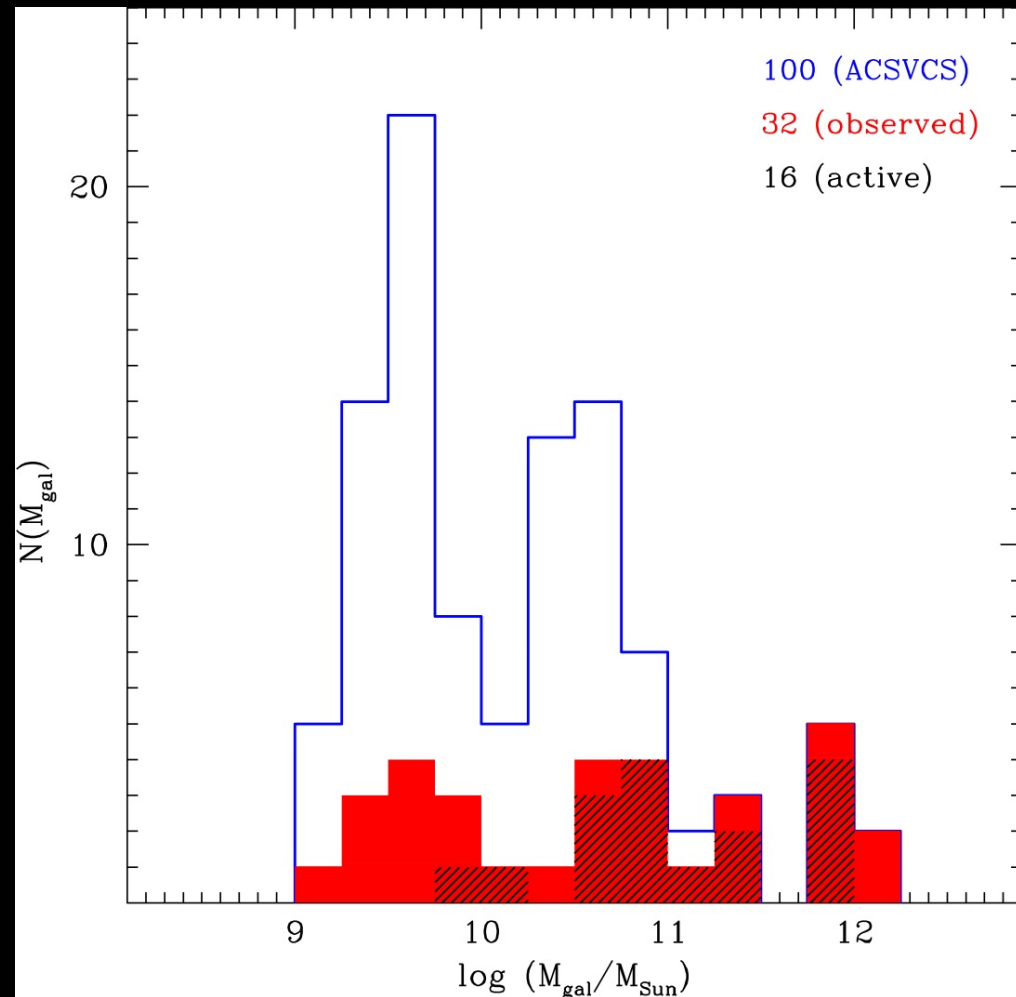
AMUSE: SMBH survival

✓ In the absence of nuclear star clusters, LMXB contamination is negligible (n_X<1e-2 within Chandra PSF; Gilfanov 04)

✓ Nuclear X-ray sources due to weakly accreting SMBH

AMUSE: SMBH vs compact stellar nuclei

✓ 2 of the detected nuclei in galaxies with B mag > -18

vcc1178 may host a nuclear stellar cluster, just resolvable with HST

✓ Star cluster mass < 3e7 M_Sun implies n_X<0.12 (Sivakoff et al. 07)

HST ACS - g′ band
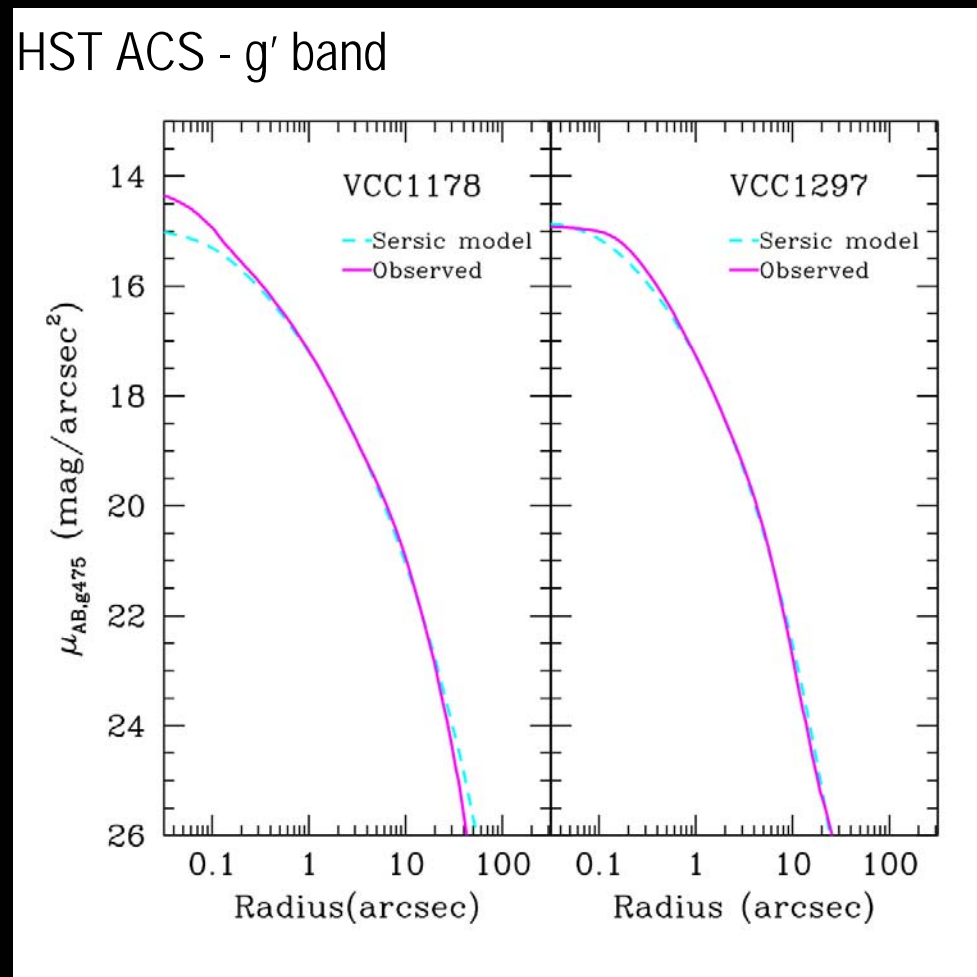
Eddington ratio distribution

✓ **For the 16 detected nuclei**
   – 8.4< log(L_X/L_Edd)< – 5.8

✓ **Bolometric correction**
   f_bol =8-60 (Marconi et al. 04)

✓ **Mechanical SMBH feedback:**
   – 4.6< log(L_kin / L_Edd)< –3.3
   (applying Merloni & Heinz 07)
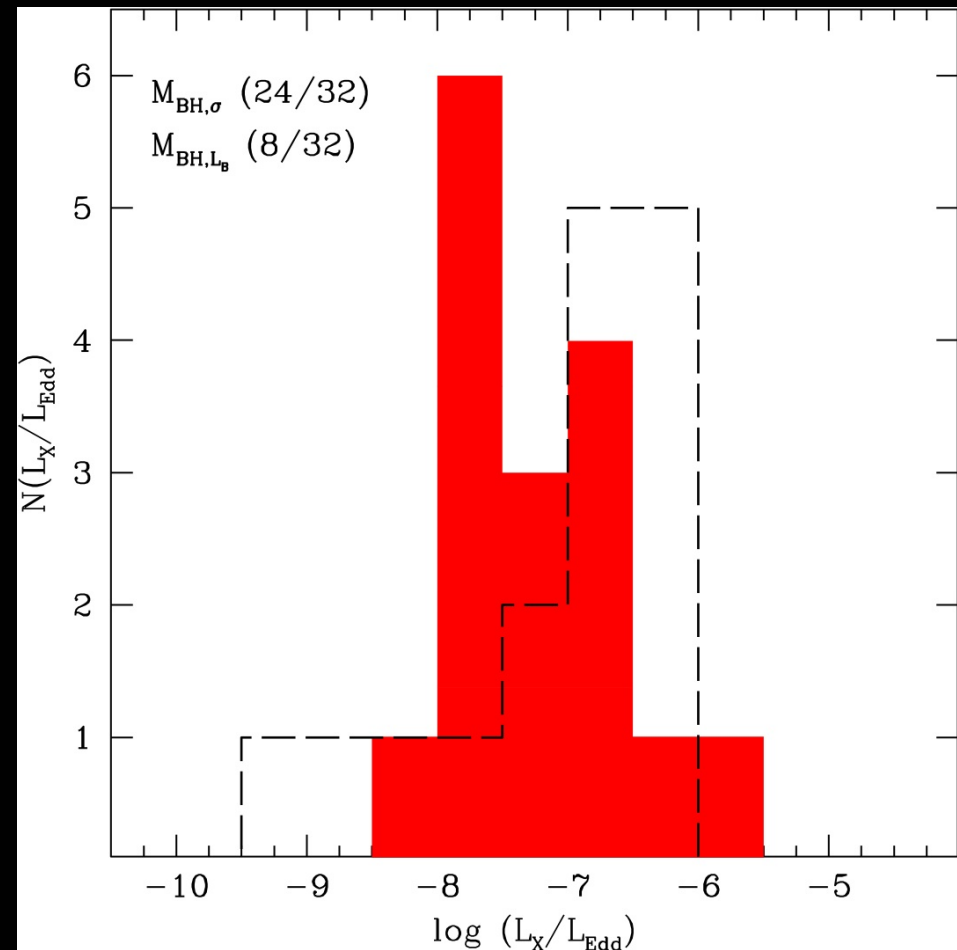
AMUSE-Virgo: first Chandra results

- ✓ Nuclear SMBH in 16/32 galaxies: $-8.4 < \log(L_X/L_{Edd}) < -5.8$

- ✓ Low level SMBH feedback (AGN `radio mode') may play a role in low mass spheroids as well as massive ellipticals

- ✓ Two of the detected nuclei hosted in galaxies with B mag > –18. SMBH and compact stellar nuclei are not mutually exclusive.

Gallo et al., in prep.

see: http://tartufo.physics.ucsb.edu/~amuse