AMUSE-Virgo

AGN

Multi-wavelength

Survey

in Early type

galaxies

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

Elena Gallo | UCSB

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)
- ✓ X-ray luminosity function of globular clusters + Ultra-luminous X-ray sources in 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:

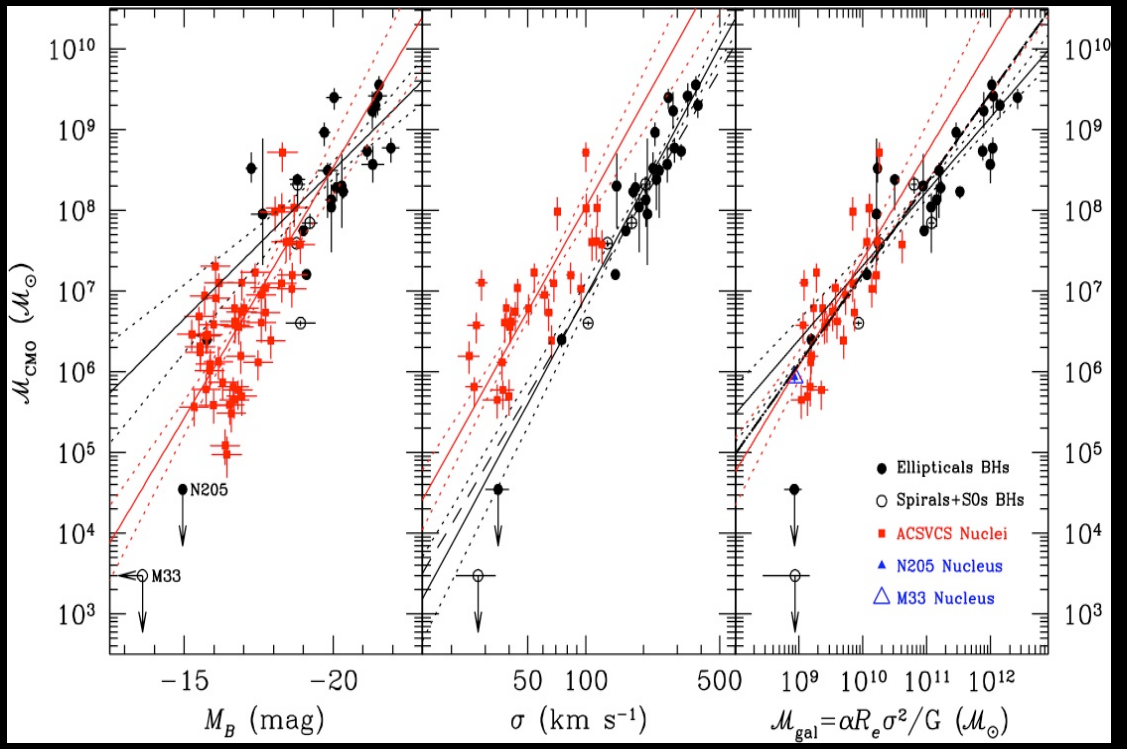
- ✓ prolonged periods of low-level SMBH activity *needed* in order to reproduce the galaxies' colors (`radio mode', Croton et al. 06).

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 (<1e-2 sources within the Chandra PSF, luminosity function, Gilfanov 03)

AMUSE: first Chandra results II.

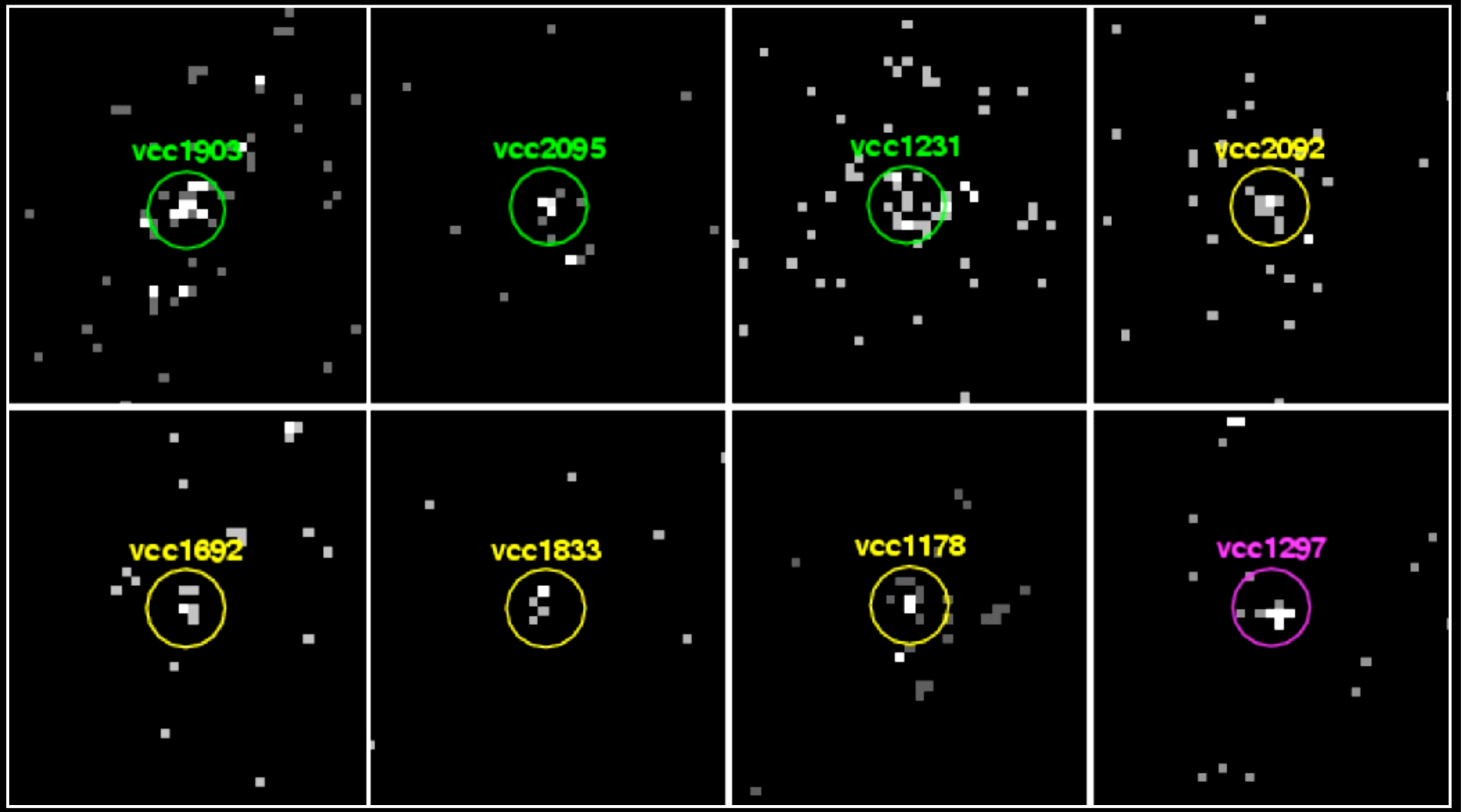
- ✓ 32 galaxies: 16 archival (>500 ksec), 16 new (5.4 ksec each: sensitive to L_Edd for a 3 M_Sun object)

- ✓ 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

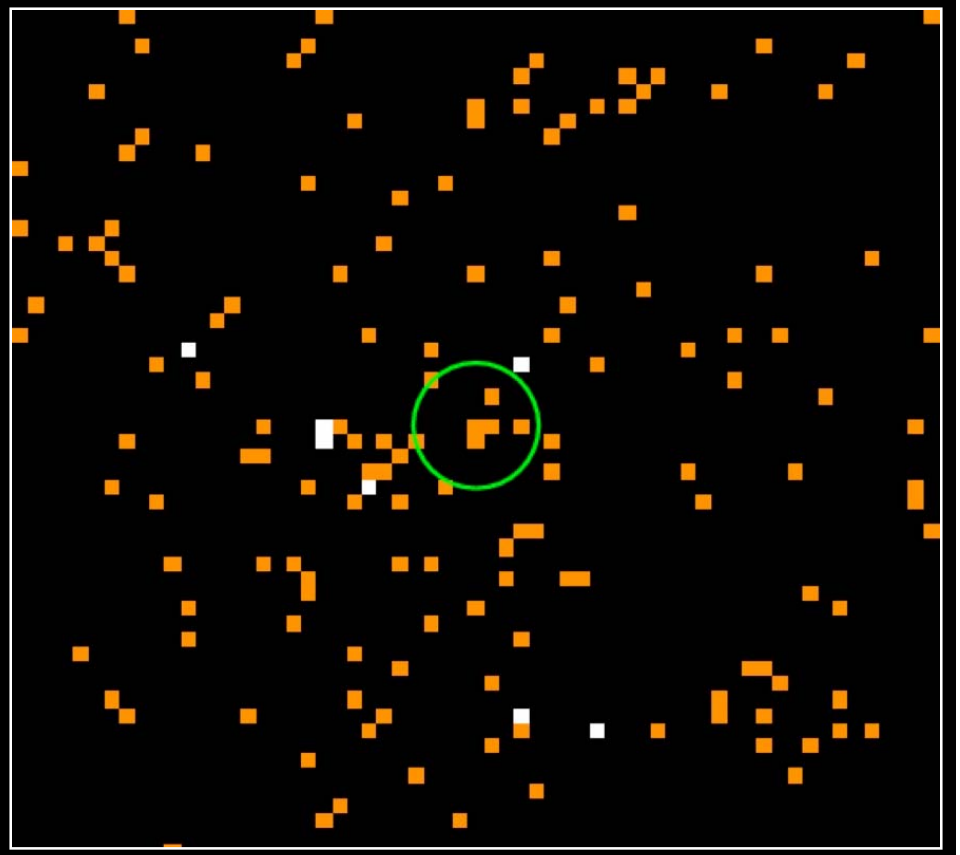
Nuclear SMBHs



Chandra ACIS-S

Non detections: stacking

- ✓ 12 snapshot observations, 62.3 ksec net exposure
- ✓ L_X<3.8e37 erg/sec (average distance 16.5 Mpc)
- ✓ L_X/L_Edd < 3e-8 (average M_BH=9.3e6 M_Sun)



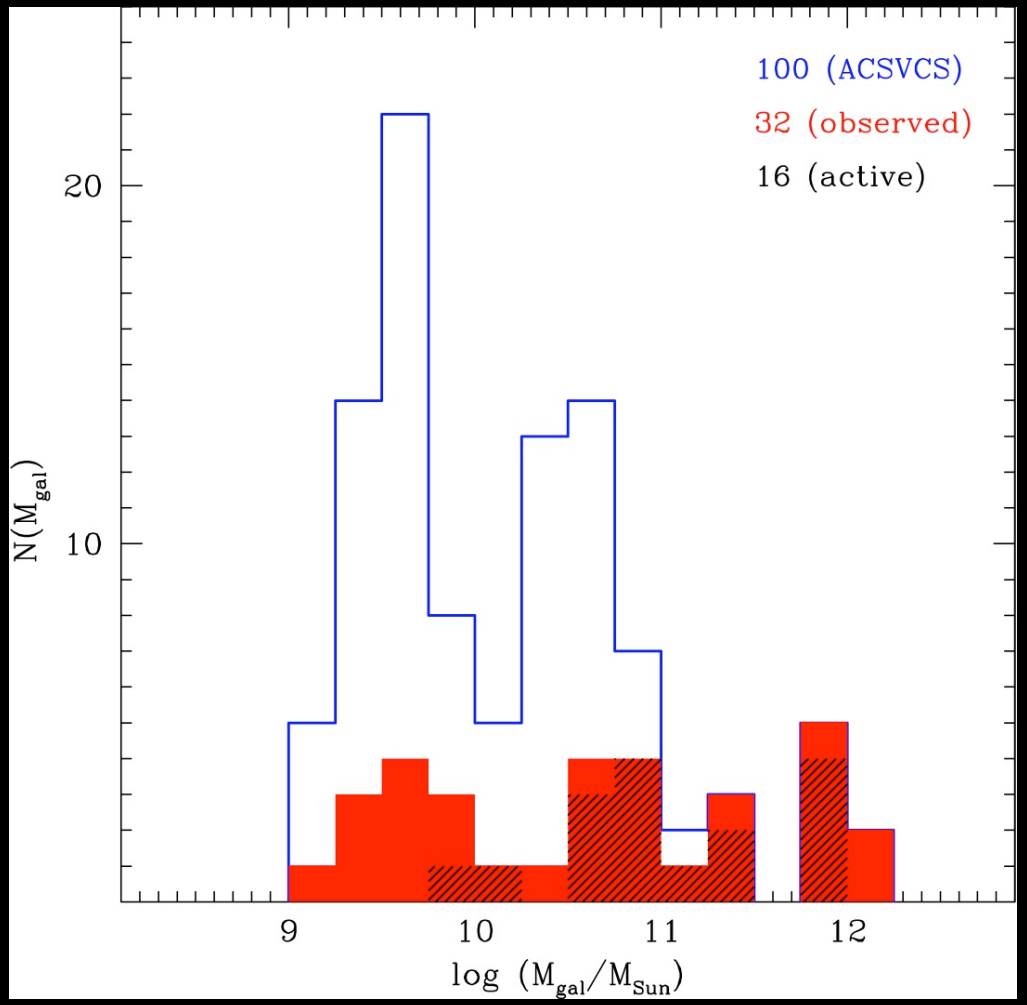
AMUSE: SMBH survival

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

  vcc1178: M*=1.4e10 M_Sun

  vcc1297: M*=6.7e9 M_Sun

- ✓ 15% of the targets with log (M*/M_Sun) < 10.5 harbor *active* SMBHs



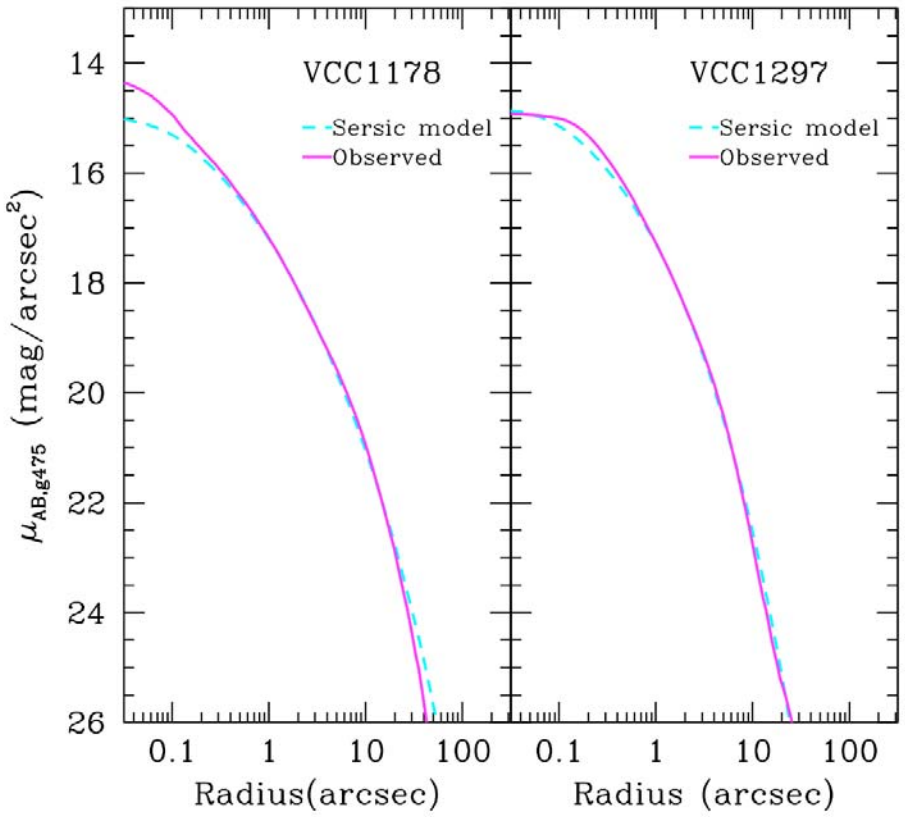
AMUSE: SMBH vs compact stellar nuclei

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

  vcc1178 also hosts a compact stellar nucleus

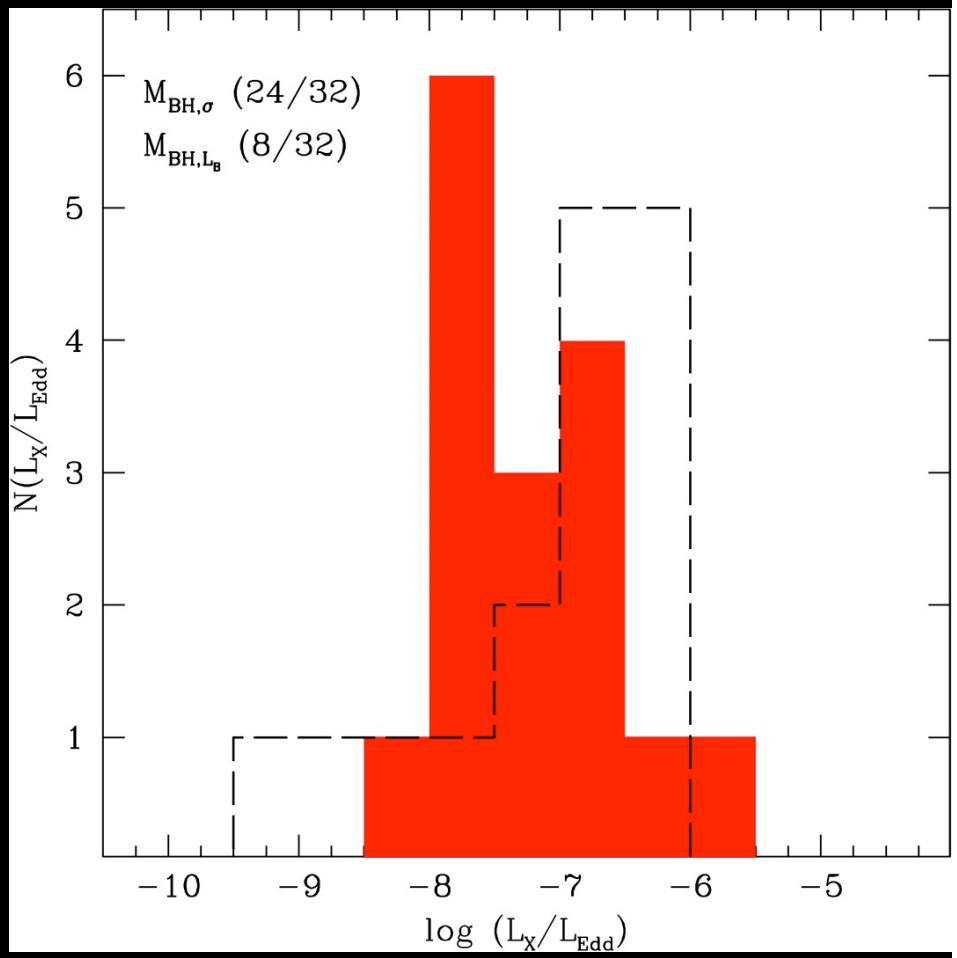
- ✓ 15% of the targets with log (M*/M_Sun) < 10.5 harbor *active* SMBHs

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
- ✓ L_kin in agreement with models for cosmic structure formation (AGN `radio mode')
- ✓ Two of the detected nuclei hosted in galaxies with B mag > –18. SMBH and compact stellar nuclei are NOT mutually exclusive.
- ✓ SMBH occupation fraction f >15% below M*=10^10.5 M_Sun

Gallo et al., in prep.

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