IAC SUMMER FELLOWSHIP IN ASTRONOMICAL RESEARCH 2022

On the origin of M87's globular clusters

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INTRODUCTION

HYPOTHESIS AND OBJECTIVES

DATA

- M87 images
- M87 globular clusters sample

METHODOLOGY

- Extraction of the surface brightness profile
- Extrapolation of the surface brightness profile
- Computation of the globular clusters subpopulations and radial distributions

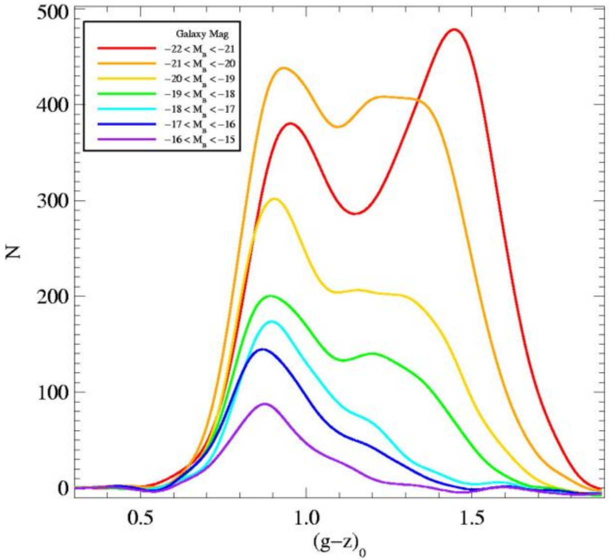
RESULTS AND DISCUSSION

CONCLUSIONS

M87

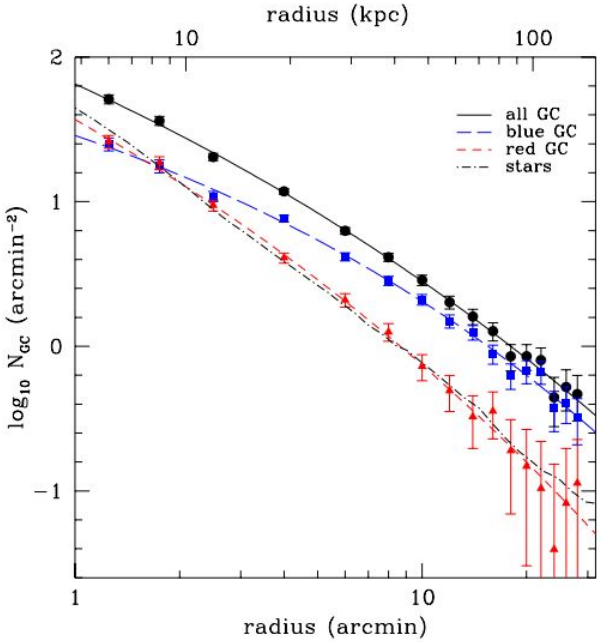
- Giant elliptical galaxy at the center of Virgo
- Brightest cluster galaxy (BCG)
  - Dualistic star formation histories (De Lucía & Blaizot, 2007)
  - Globular clusters (GCs) with bimodal color distributions (Kundu et al. 1999, Peng et al. 2006)
    - Blue GCs subpopulation
      - Metal-poor
      - Low-mass dark matter haloes
      - Accreted from the surrounding galaxies
    - Red GCs subpopulation
      - Metal-rich
      - Stellar body of the parent BCGs

Peng et al. 2006



M87

- Rich GCs system
- Spatial distribution of the GCs subpopulation (Lauer & Kormendy 1986, Strader et al. 2011)
  - 750 GCs in 1’-30’ (Strader et al. 2011)
    - Blue GCs more extended at larger radii
    - Red GCs more centrally concentrated
      - Red GCs profile ≃ M87 surface brightness p



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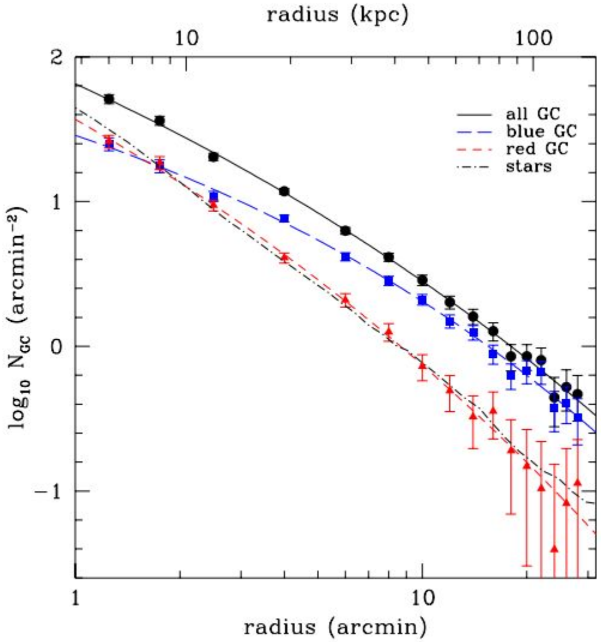


Common formation scenario
for red GCs and the host galaxy

Hypothesis and objectives

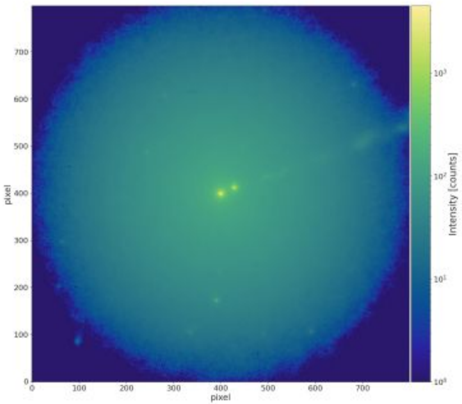
High spatial resolution AO images

- M87 stellar surface brightness profile till the galactic centre
- Detection and classification of M87 GCs in the central kpcs
    - Radial numerical distribution of each subpopulation
- Comparison between M87 light profile and GCs systems radial distribution

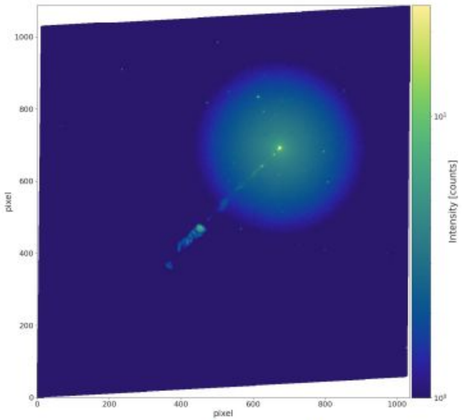
Infer about the behaviour and origin of each GCs subpopulation within the central kpcs

Infrared high-spatial resolution images

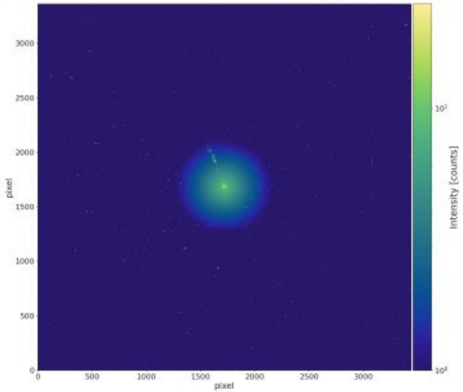
- NaCO-VLT (Cerro Paranal, Chile)
  - K-band filter, centered at 2.2 μm
  - *scale = 0.0271”/pixel,* *FOV = 22” x 22”*
  - *θ (FWHM) = 0.16”*
- HST-WFC3-UVIS
  - F814W filter, centered at 0.814 μm (≃ I-band)
  - *scale = 0.04”/pixel,* *FOV = 43” x 41”*
  - *θ (FWHM) = 0.12”*
- HST-ACS-WFC
  - F850LP filter, centered at 0.850 μm (≃ Z-band)
  - *scale = 0.05”/pixel,* *FOV = 3.5’ x 3.5’*
  - *θ (FWHM) = 0.15”*



(a) NaCO-VLT K-band



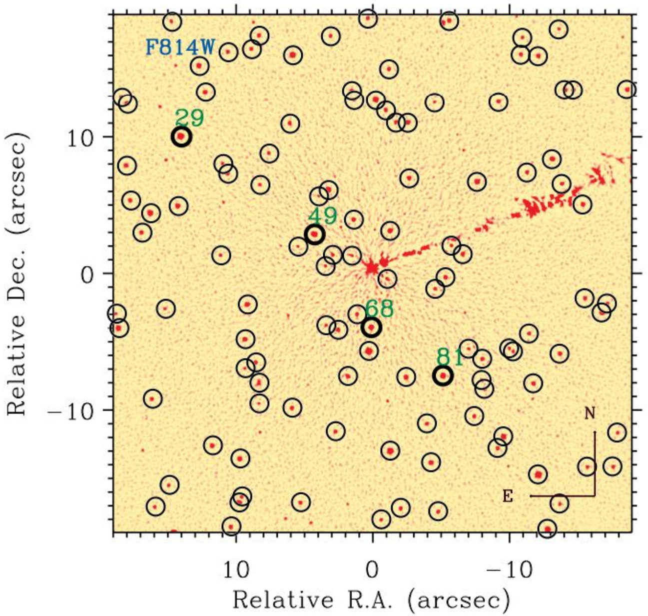
(b) HST-WFC3 F814W



(c) HST-ACS F850LP

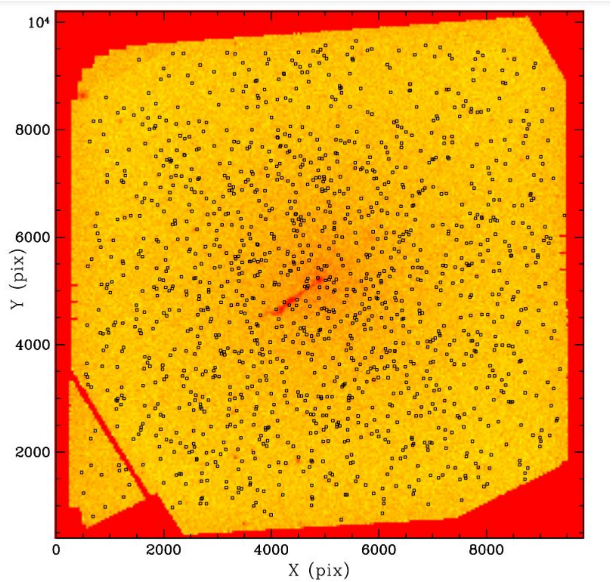
Globular clusters

Montes, 2013



- 115 GCs in the central 38.4'' x 38.4'' (3x3 kpc^2)
- Detected in J and K-band NaCO-VLT
- V and I magnitudes

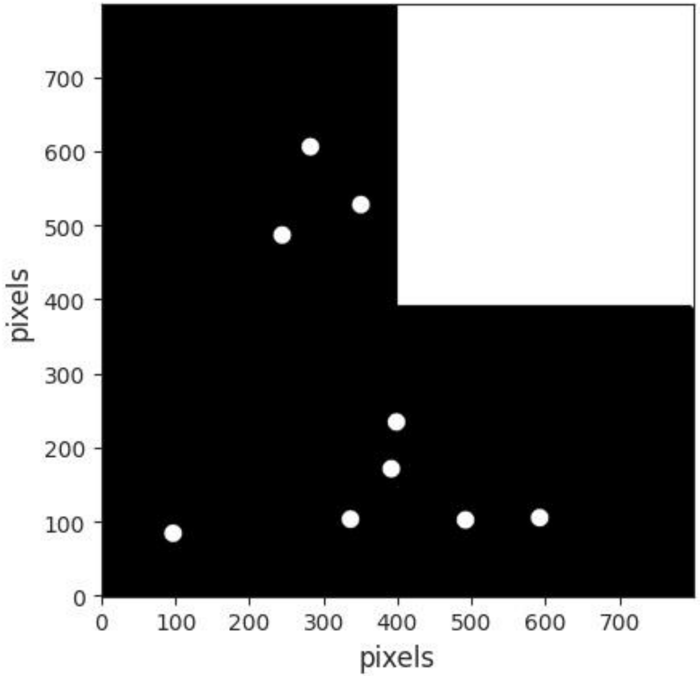
Bellini et al. 2015

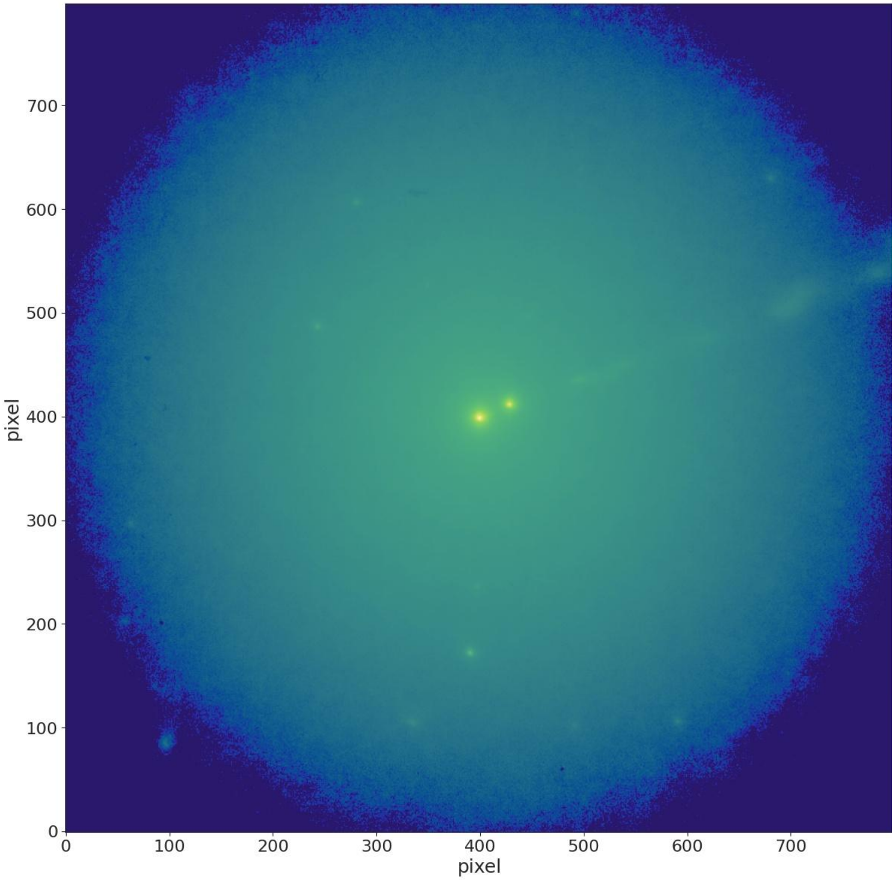


- 1460 GCs in the central 2.7' x 2.7' (12.6x12.6 kpc^2)
- Detected in HST-WFC3-UVIS
- F606W and F814W magnitudes

Extraction of M87 surface brightness profile

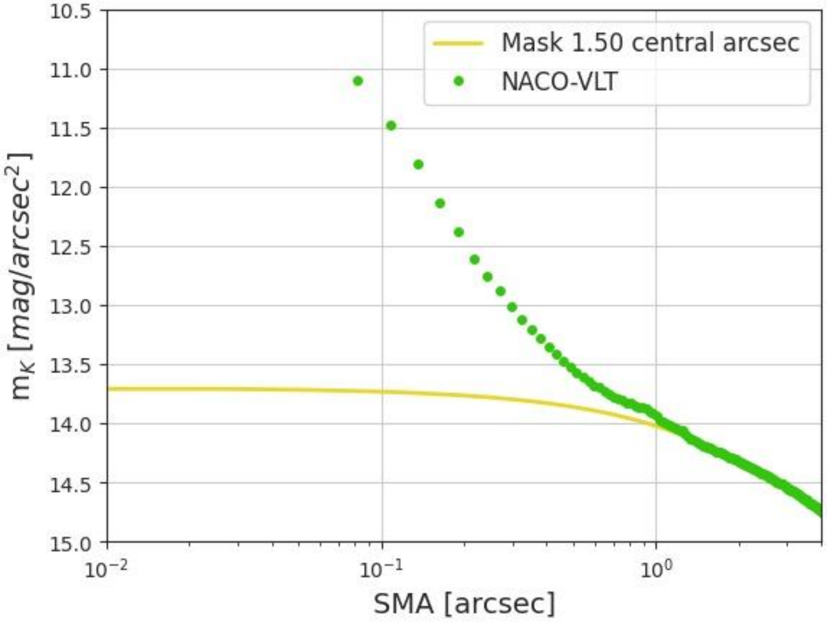
- IRAF *ellipse* task
  - Masking the quadrant affected by the jet





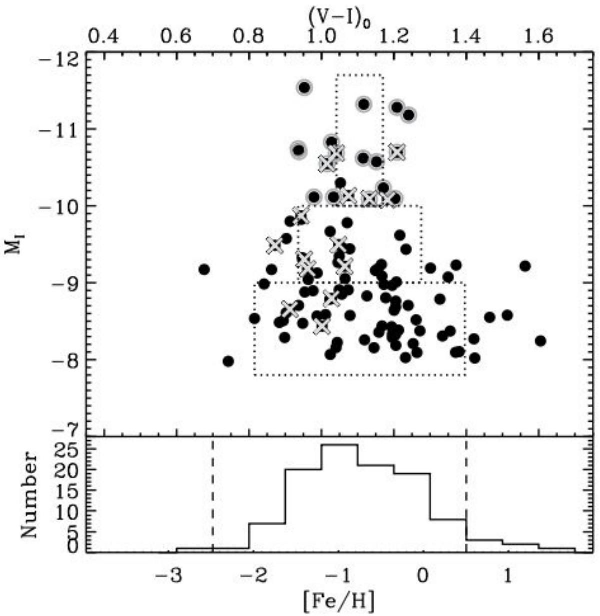
Extrapolation of M87 surface brightness profiles

- Need for subtracting the nuclear contribution
  - PSF distribution weighted by the luminosity → observable PSF secondary lobes
- Extrapolation from 1.5'' (120 pc) to the inner region

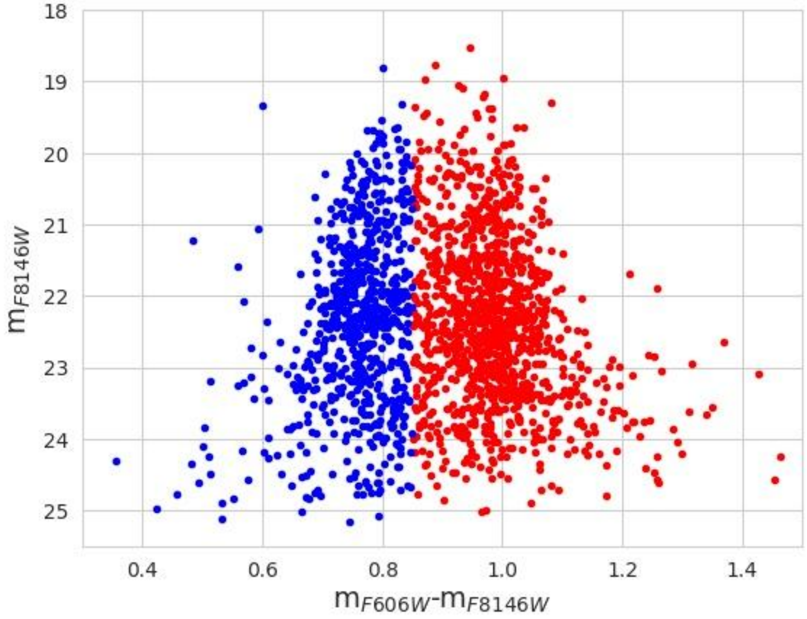


Globular clusters

Montes, 2013



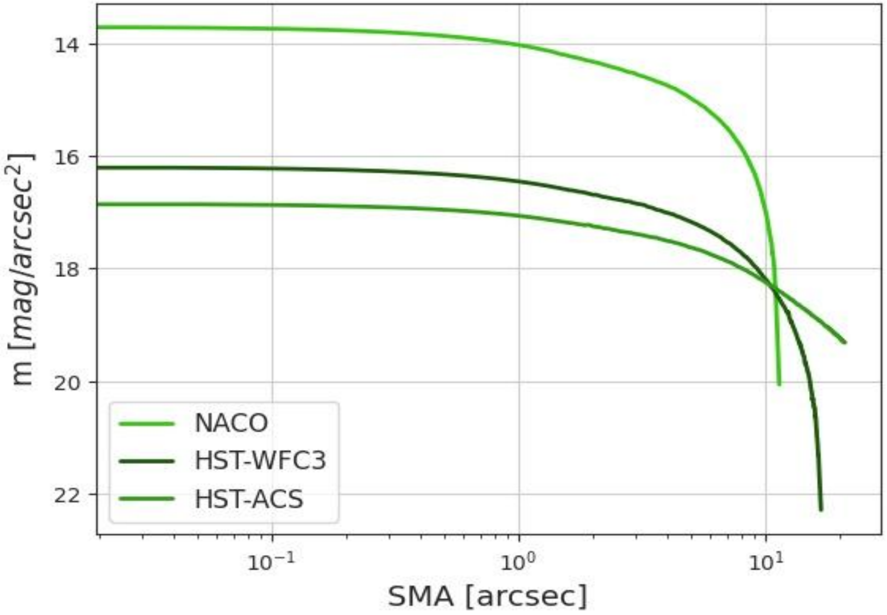
Bellini et al. 2015

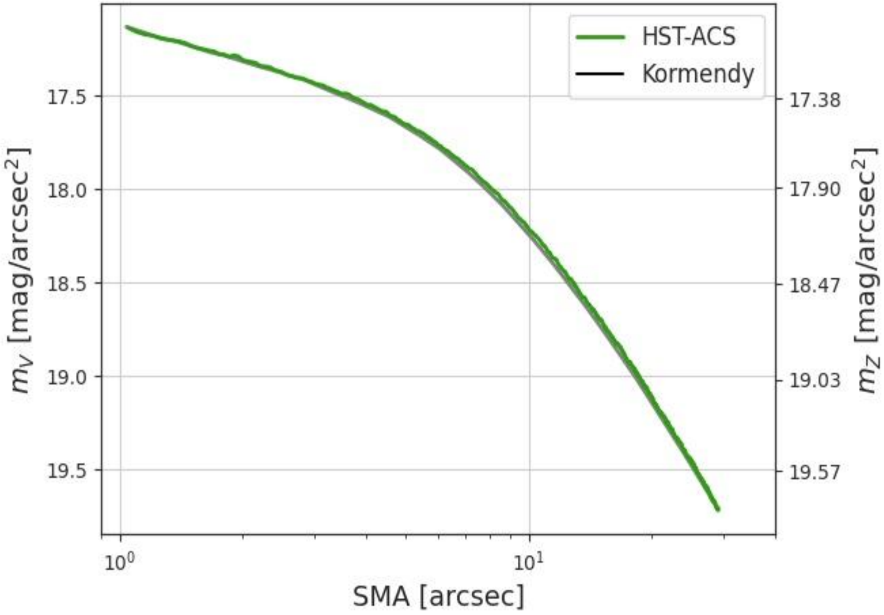


- Red subpopulation: V - I = 1.1 mag (Kundu et al. 1999)
- Equally radii bins from 0 to 19.2''

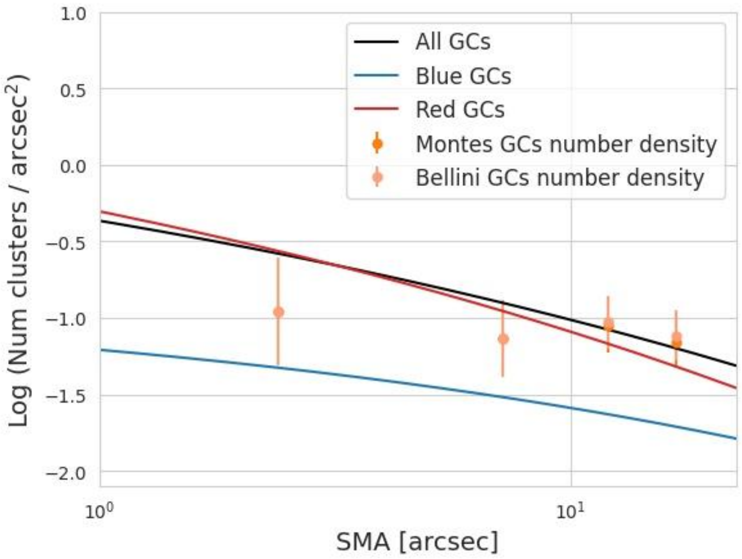
- 1147 red GCs: m_{F606W} - m_{F814W} = 0.985
- 735 blue GCs: m_{F606W} - m_{F814W} = 0.754
- Bins of 5'' from 0'' to 80'' (1.33').

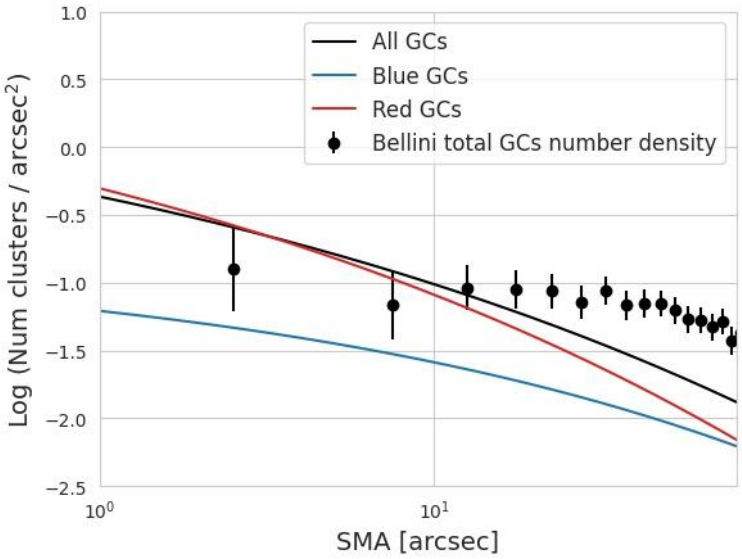
M87 surface brightness profiles





GCs radial distribution

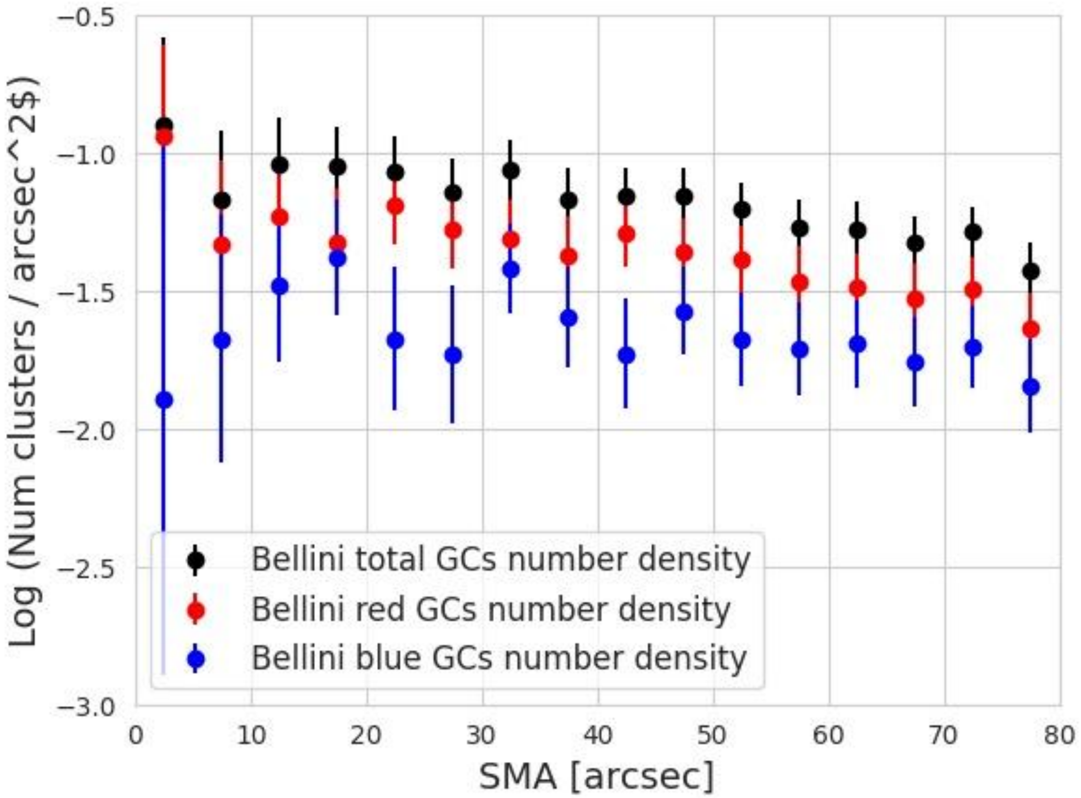




- Agreement between the IR Montes (2013) detections and Bellini et al (2015) optical detections
  - No dust extinction

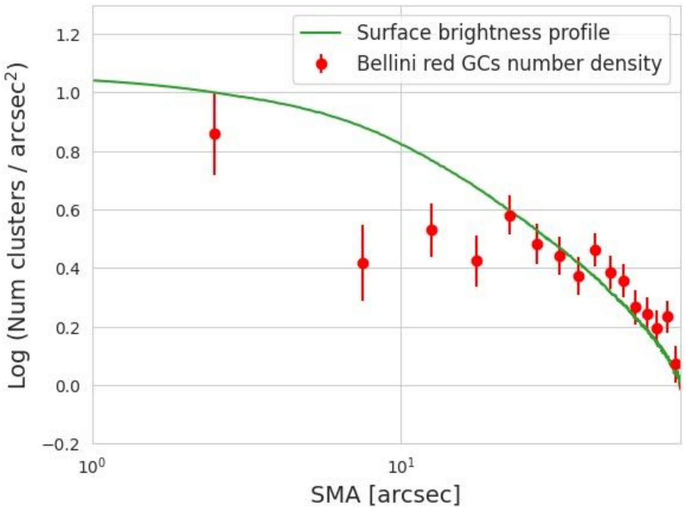
- Higher surface densities than Strader et al. (2011)
- Flatter GCs radial distribution than the modeled by Strader et al. (2011)

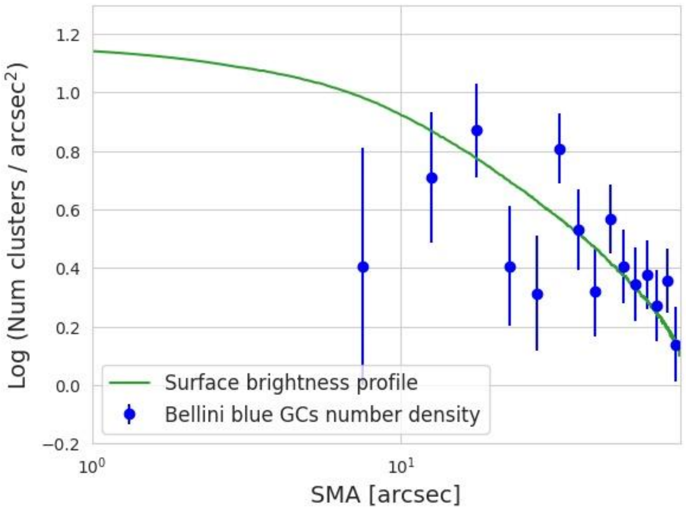
GCs radial distribution



- Red GCs are the main contribution
- Blue GCs less abundant in the inner 80’’, specially under 20’’

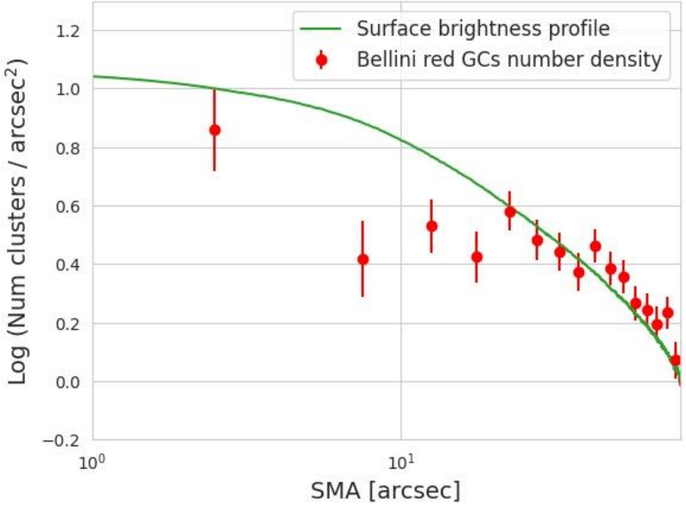
M87 surface brightness profiles and GCs radial distribution

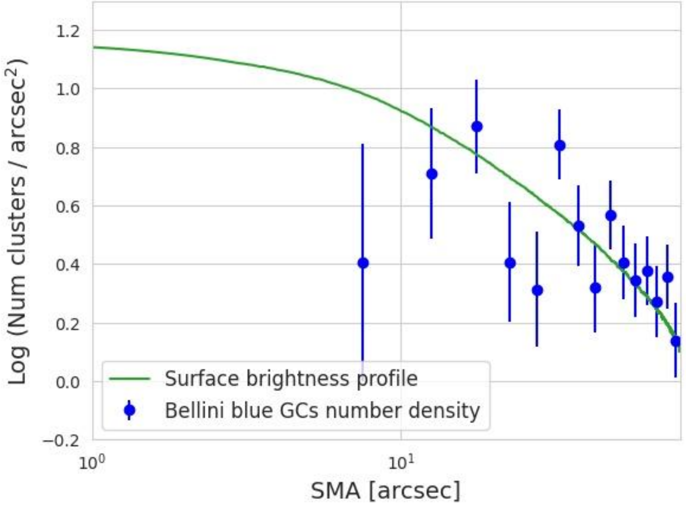




- Similar behaviour as M87 light profile for both subpopulations over 35'' away from the nucleus (2.7 kpc)
- Red GCs present the same trend till the inner 20'' (1.5 kpc), then it becomes flatter than M87 light profile

M87 surface brightness profiles and GCs radial distribution





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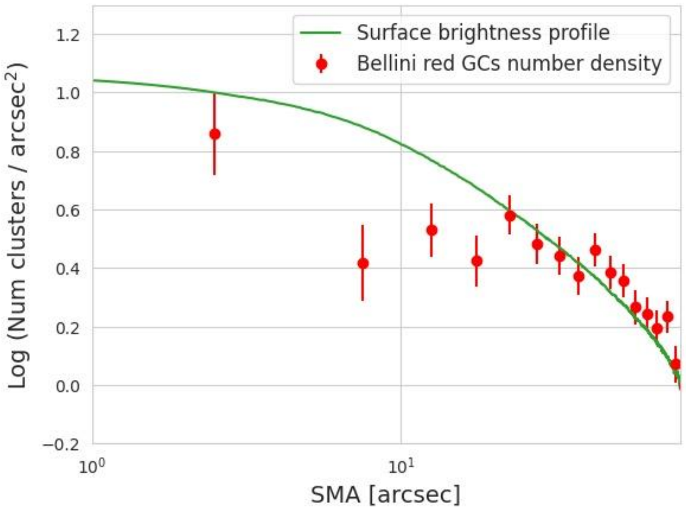
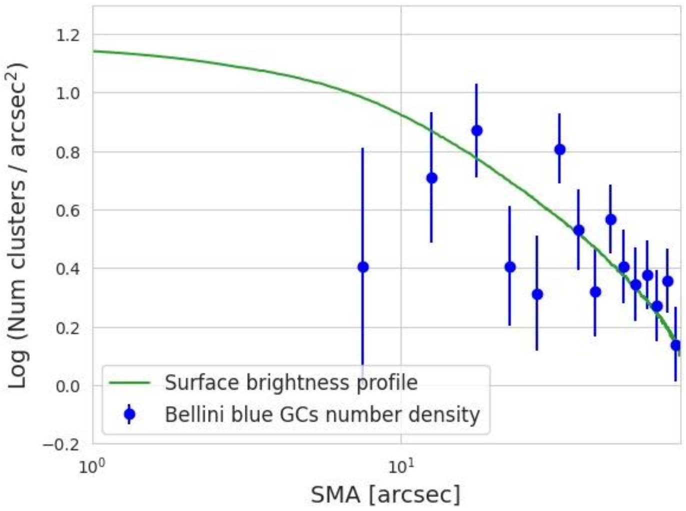
(Capuzzo-D & Mastrobuono-B 2009) GCs erosion by the central BH

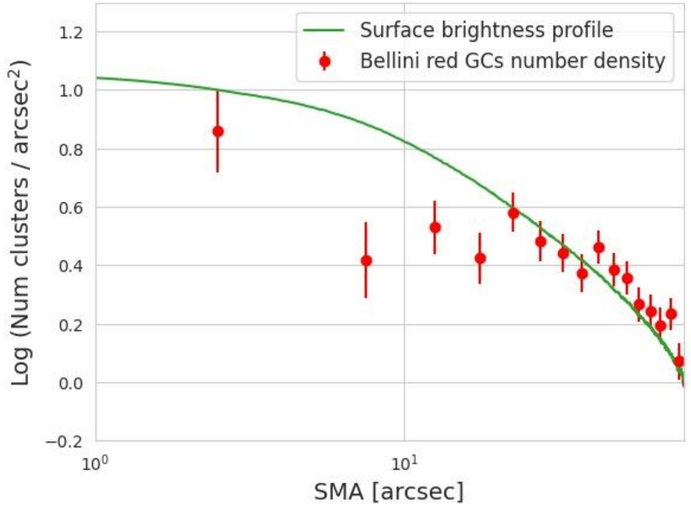
M87 surface brightness profiles and GCs radial distribution

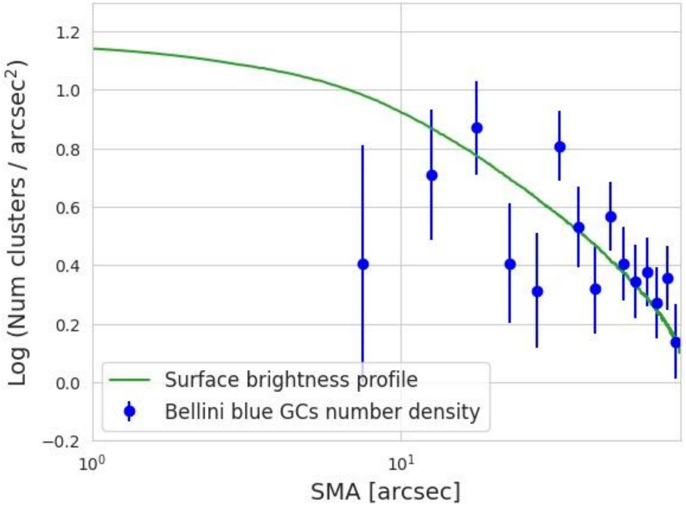




- **Red GCs: higher but flatter surface density profile in the centre,** colour match with M87 field stars, metal-rich

M87 surface brightness profiles and GCs radial distribution





- **Red GCs: higher but flatter surface density in the centre,** colour match with M87 field stars, metal-rich

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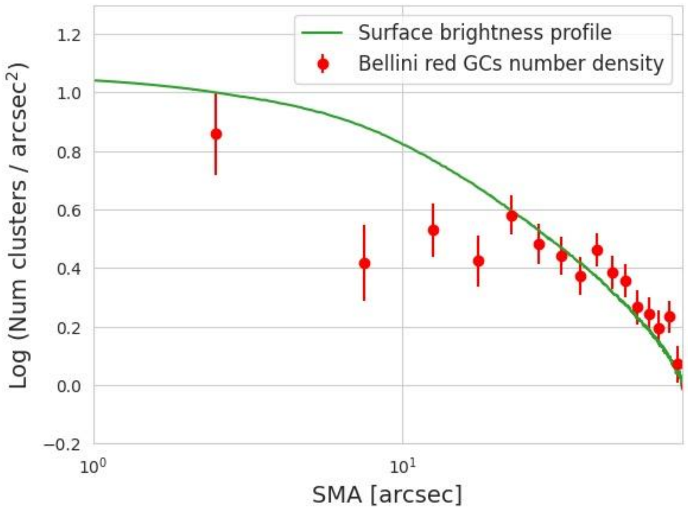
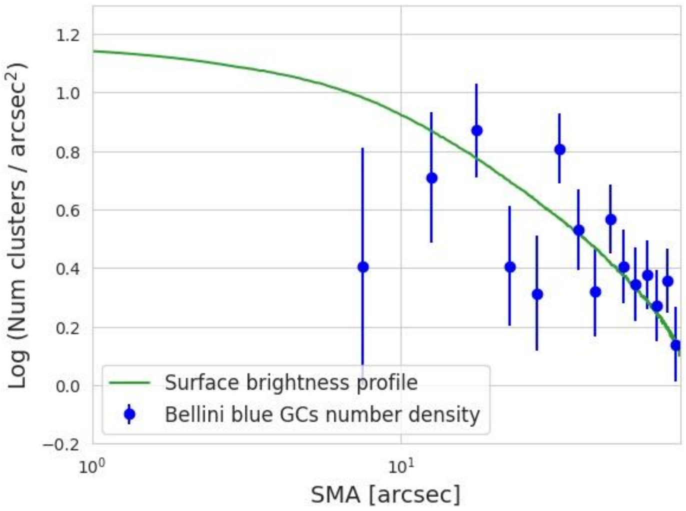
Tentatively: red GCs share a common formation scenario with M87 and were affected by GCs erosion by the BH

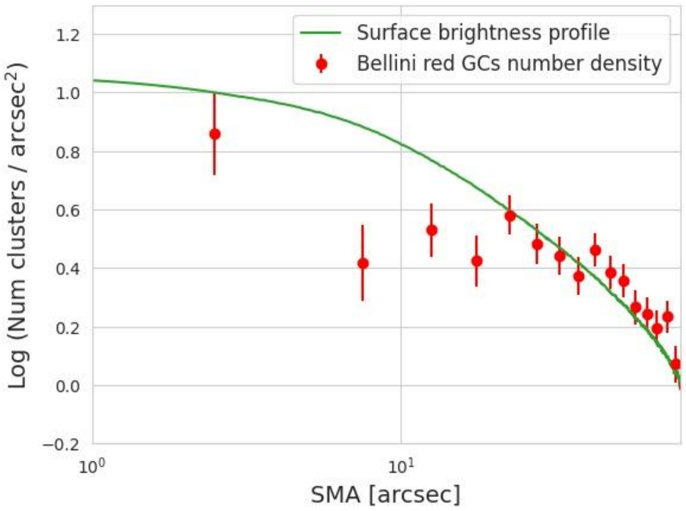
M87 surface brightness profiles and GCs radial distribution

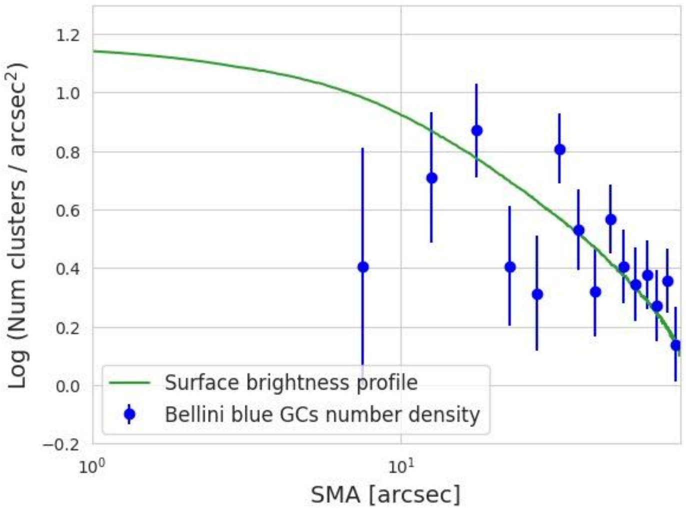




- **Blue GCs: fade towards the centre,** extended distribution at larger radii, metal-poor

M87 surface brightness profiles and GCs radial distribution





- **Blue GCs: fade towards the centre,** extended distribution at larger radii, metal-poor

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Tentatively: blue GCs accreted by M87 from canibalised galaxies

We have benefited from previous AO M87 images of high spatial resolution in the NIR and the IR, taken with NaCO at VLT and with the HST. This has permitted us to derive the M87 brightness profile in different bands, with an unprecedent spatial resolution. We have also benefited from samples of GCs, detected by other authors in the IR and the optical range.

- We have computed the surface density profiles for the two M87 GCs subpopulations in the IR range for the innermost region of 20’’. Its agreement with the profiles derived from optical observations, till 80’’, expose no dust extinction affecting the GCs detection.

- Red GCs dominate the GCs surface density profile in the inner region of 80’’. This result matches previous results obtained in wider distances, over 1’.

- From 35’’ (2.7 kpc) on, both red and blue GCs follow the same decreasing distribution as the M87 surface brightness profile. Red GCs keep following the M87 light profile trend till 20’’ (1.5 kpc) and then become more flatter than the M87 light profile.

- These results, along with other authors' results could tentatively support the scenario where red GCs share a common formation scenario with M87, and some of the GCs within a few kpc of the galactic centre would have been dragged into the central black hole.

Further work of interest would be to calculate the globular clusters mass percentage that could have been accreted by the central black hole.

Thank you for your attention!