When a Black Hole Fails to do its Job

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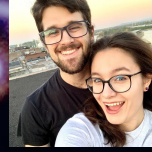
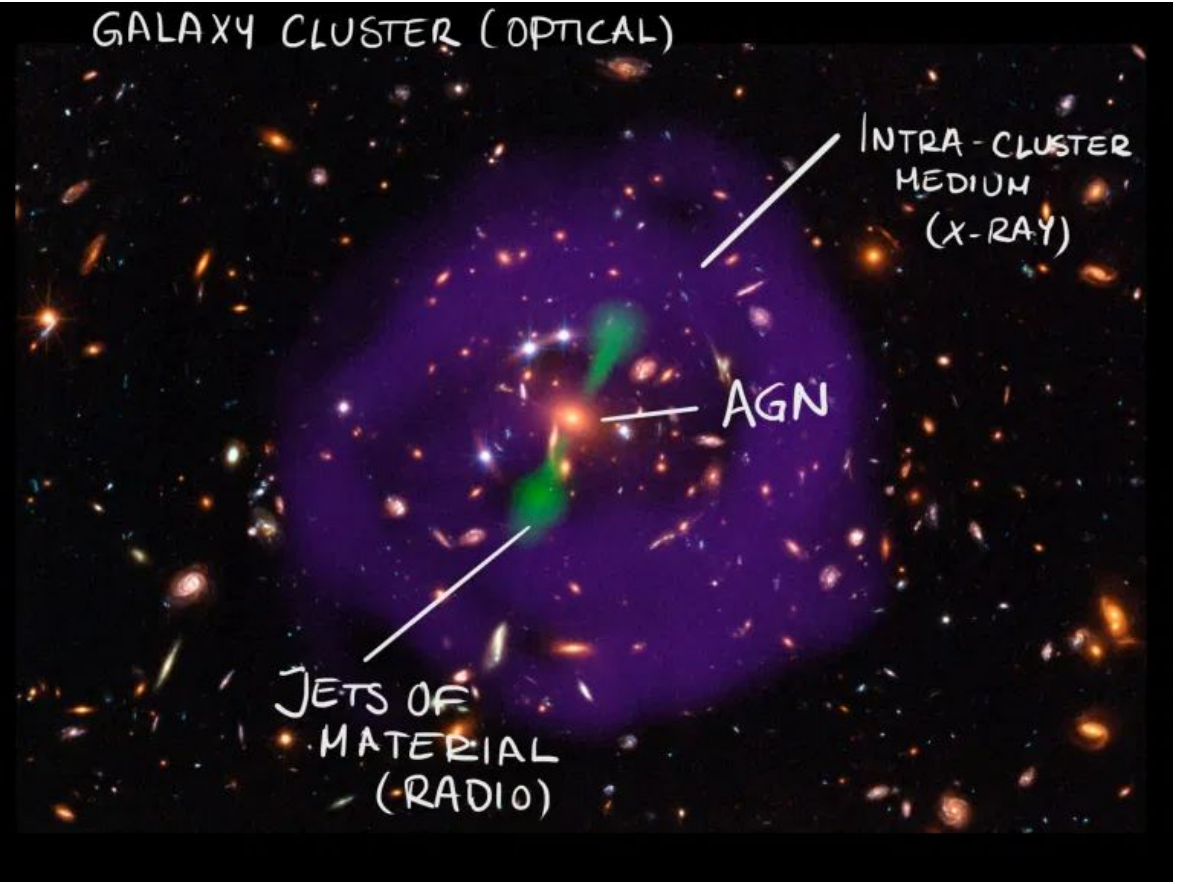
Evidence of Runaway Gas Cooling in the Absence of Supermassive Black Hole Feedback at the Epoch of Cluster Formation
The Astrophysical Journal Letters, Volume 898, Issue 2, id.L50
Arxiv: 2007.15660

Press Release:
https://chandra.harvard.edu/press/20_releases/press_080320.html
Blog:
https://chandra.harvard.edu/blog/node/766

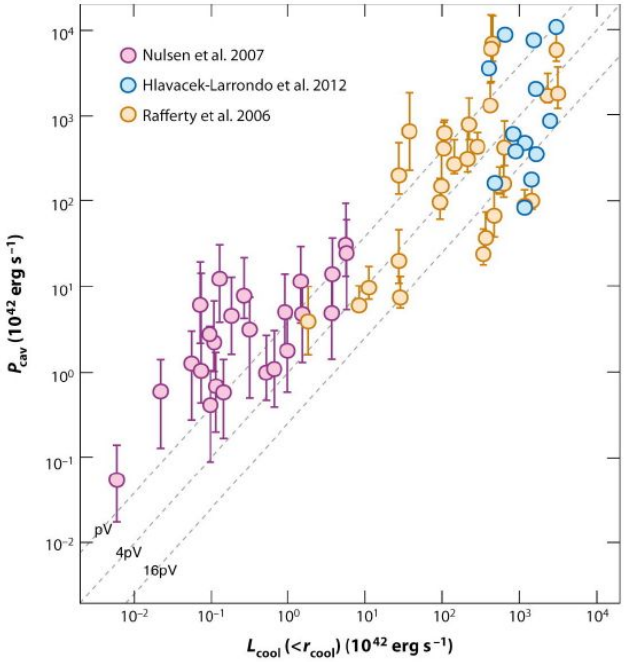


X-ray: NASA/CXO/Univ. of Montreal/J. Hlavacek-Larrondo et al; Optical/IR: NASA/STScI

Galaxy Clusters & AGN Feedback

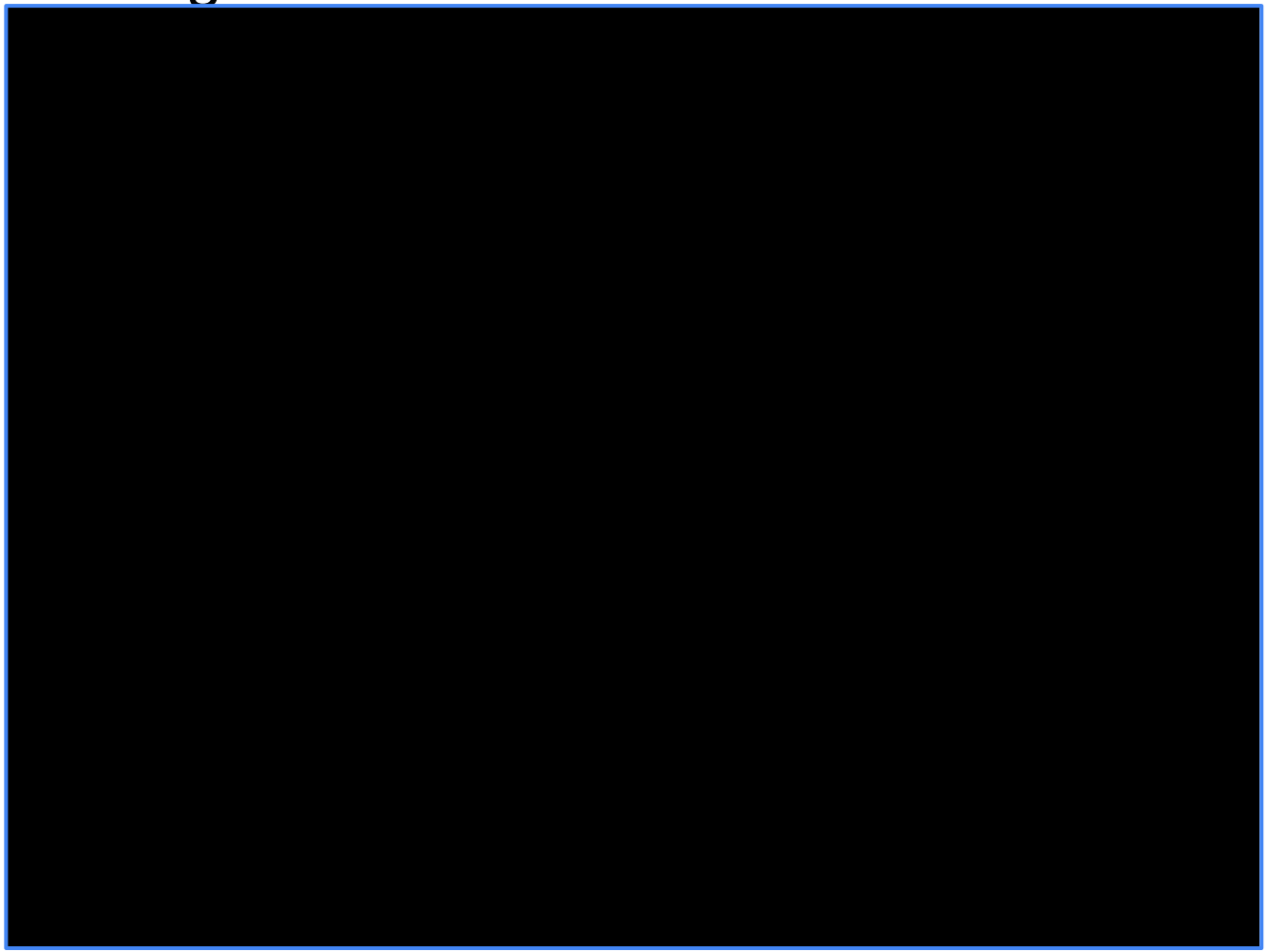


Background image: Galaxy cluster SDSS J1004+4112. Real optical image. Credit: NASA/STScI/ESA



Fabian+2012 (1204.4114)
Hlavacek-Larrondo+2013 (1306.0907)

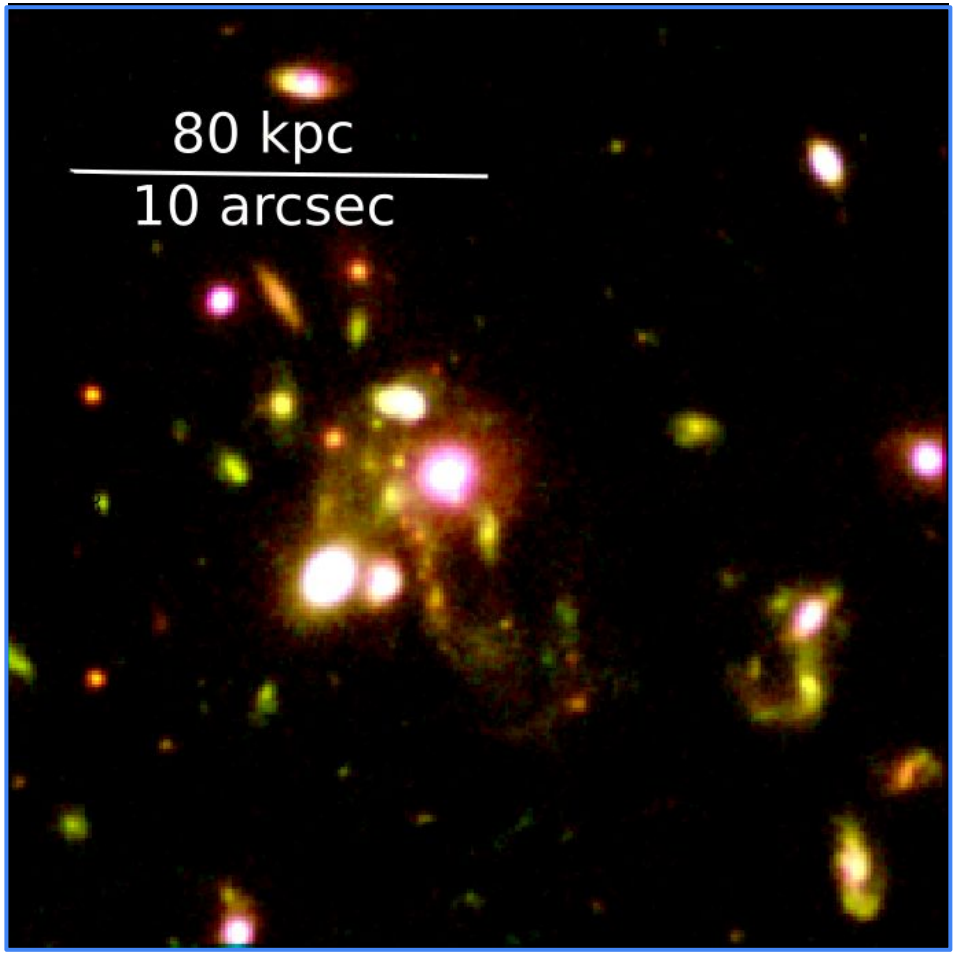
Cooling Flow Problem



1. We start with a centrally peaked ICM emitting photons
2. Loss of energy via radiation causes gravitational collapse of central ICM
3. **Cooling Flow** commences
4. Increased Star Formation Expect 100-1000 $M_{\odot}$/yr
5. However, we see 1-10 $M_{\odot}$/yr

NASA/CXC/A. Hobart

SpARCS1049: A View from the Optical/Infrared



- Hubble Space Telescope:
  - F160W ~ 9000s
  - F105W ~ 8500s

z = 1.709[1,2]
M ~ 3x10[14] $M_\odot$[3]
SFR ~ 900 $M_\odot$/yr[1]

1 - Webb+15 (1508:04982)
2 - Finner+20 (2002.01956)

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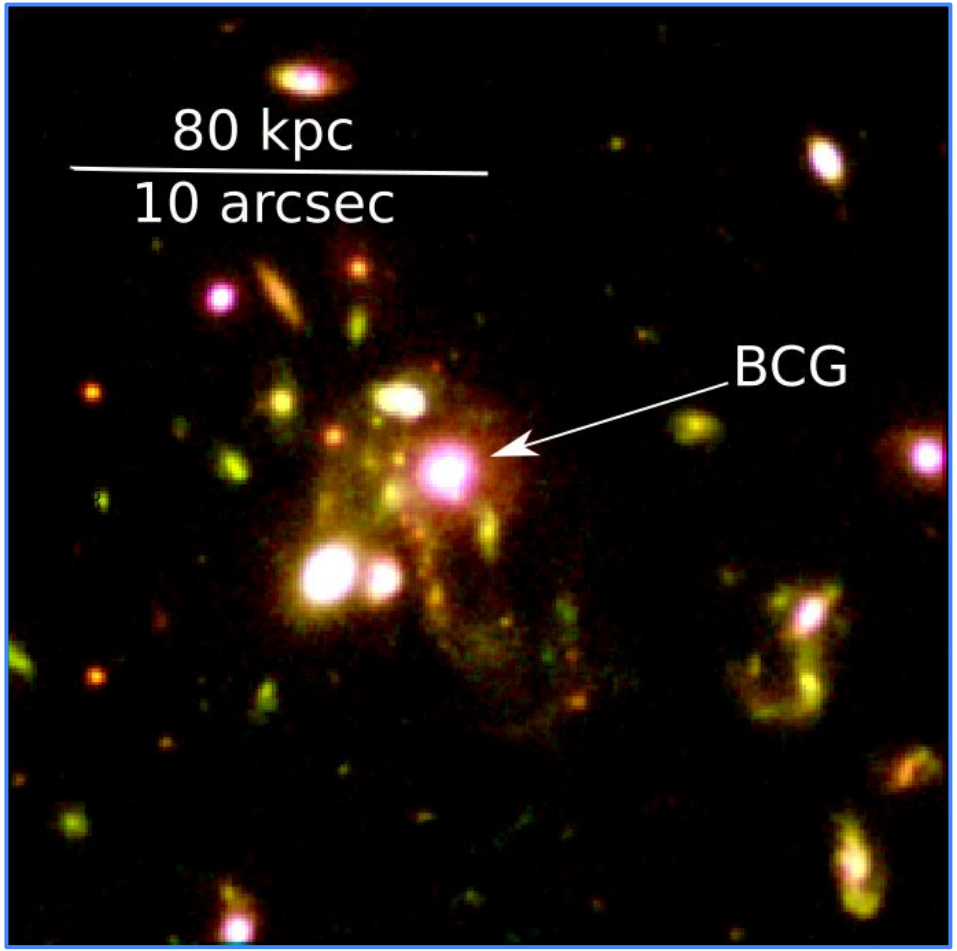

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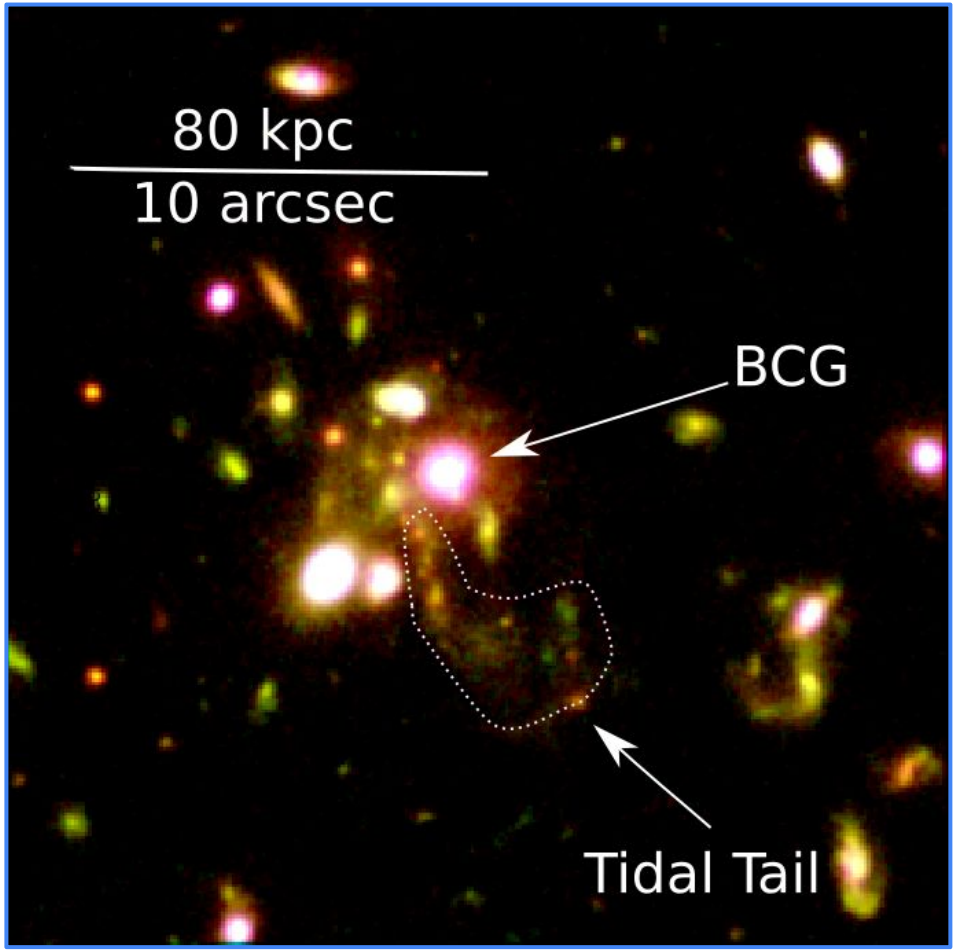

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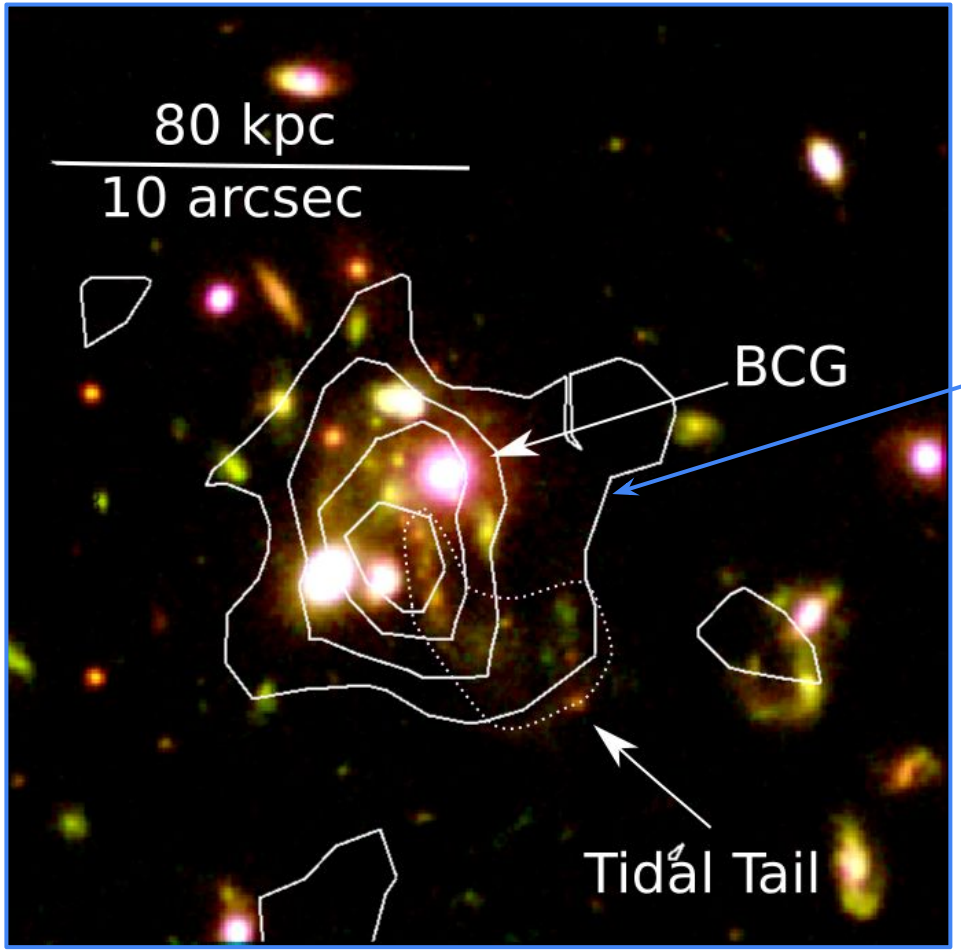

- Hubble Space Telescope:
  - F160W ~ 9000s
  - F105W ~ 8500s
- Spitzer Space Telescope:
  - 24 micron

$z = 1.709$[1,2]
$M \sim 3 \times 10^{14}\ M_{\odot}$[2]
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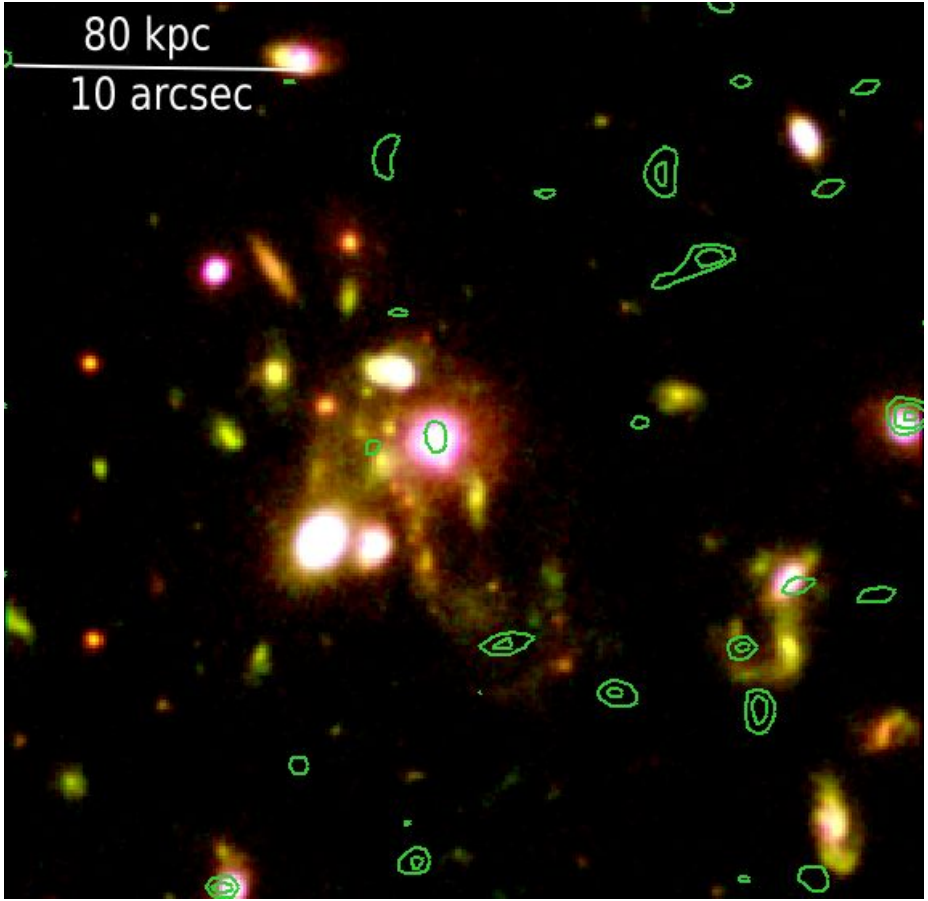
Evidence Against a Wet Merger (Radio & Molecular Gas)



- P.I. Julie Hlavacek-Larrondo
- Relatively Modest AGN Activity [1]
- Radio Emission centered on AGN -> No Jets
- Disfavors wet merger scenario
- $M_{H2} = 10^{12} M_{\odot}$ [2]

1 - Trudeau+19 (1905.05875)
2 - Webb+17 (1706.01366)

HST F160W + F105W & JVLA L-Band (1.5GHz)[1]

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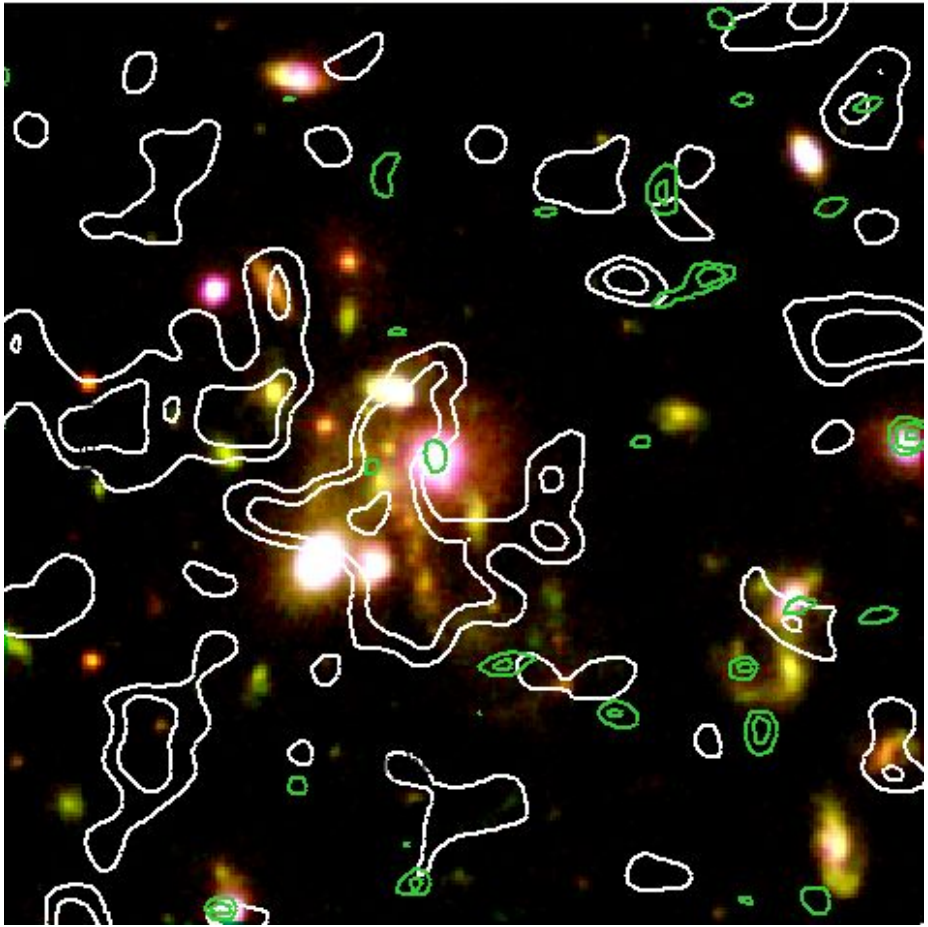

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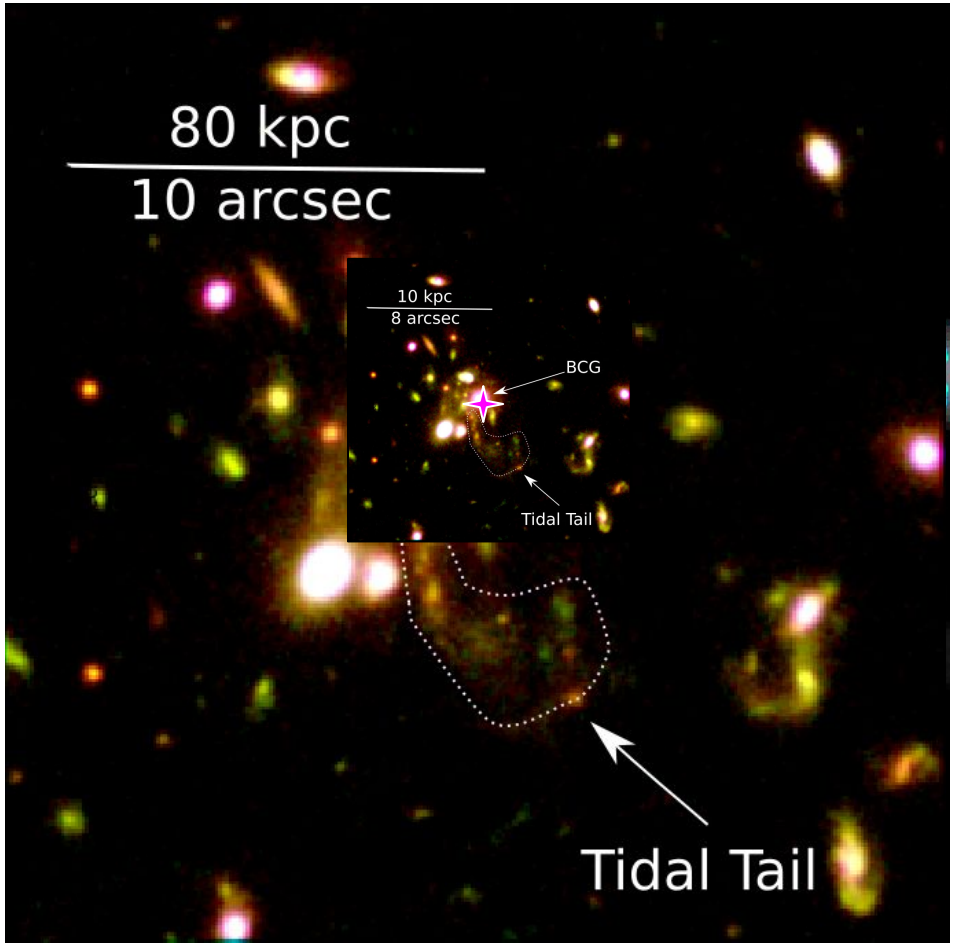
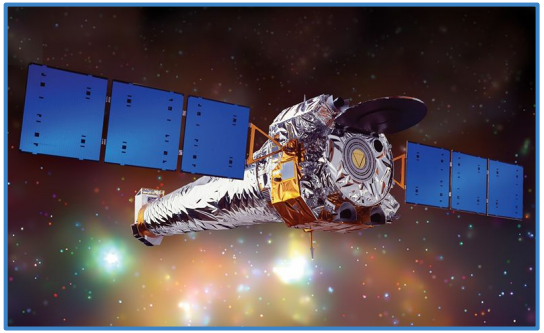
1 - Trudeau+19 (1905.05875)
2 - Webb+17 (1706.01366)
3 - Valin+21 (in prep)

HST F160W + F105W & JVLA L-Band (1.5GHz)[1] & VLA CO(1-0)[3]

X-rays with Chandra



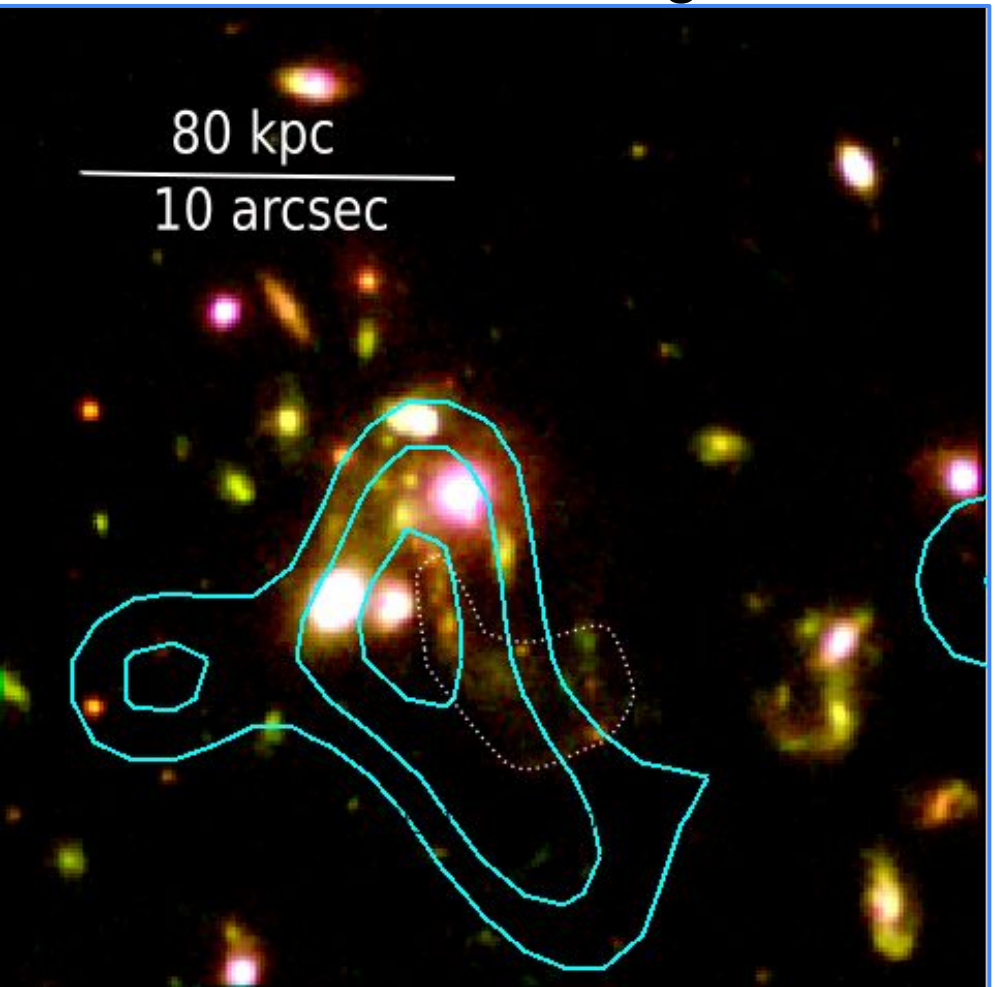
- 170 ks of Chandra Observations (50 hrs)
- P.I. Julie Hlavacek-Larrondo
- Compact Morphology
- Coefficient of Surface Brightness indicates strong Cool Core (~0.19)



Chandra X-ray Observatory

Hlavacek-Larrondo & Rhea+2020 (2007.15660)

An Uninhibited Cooling Flow

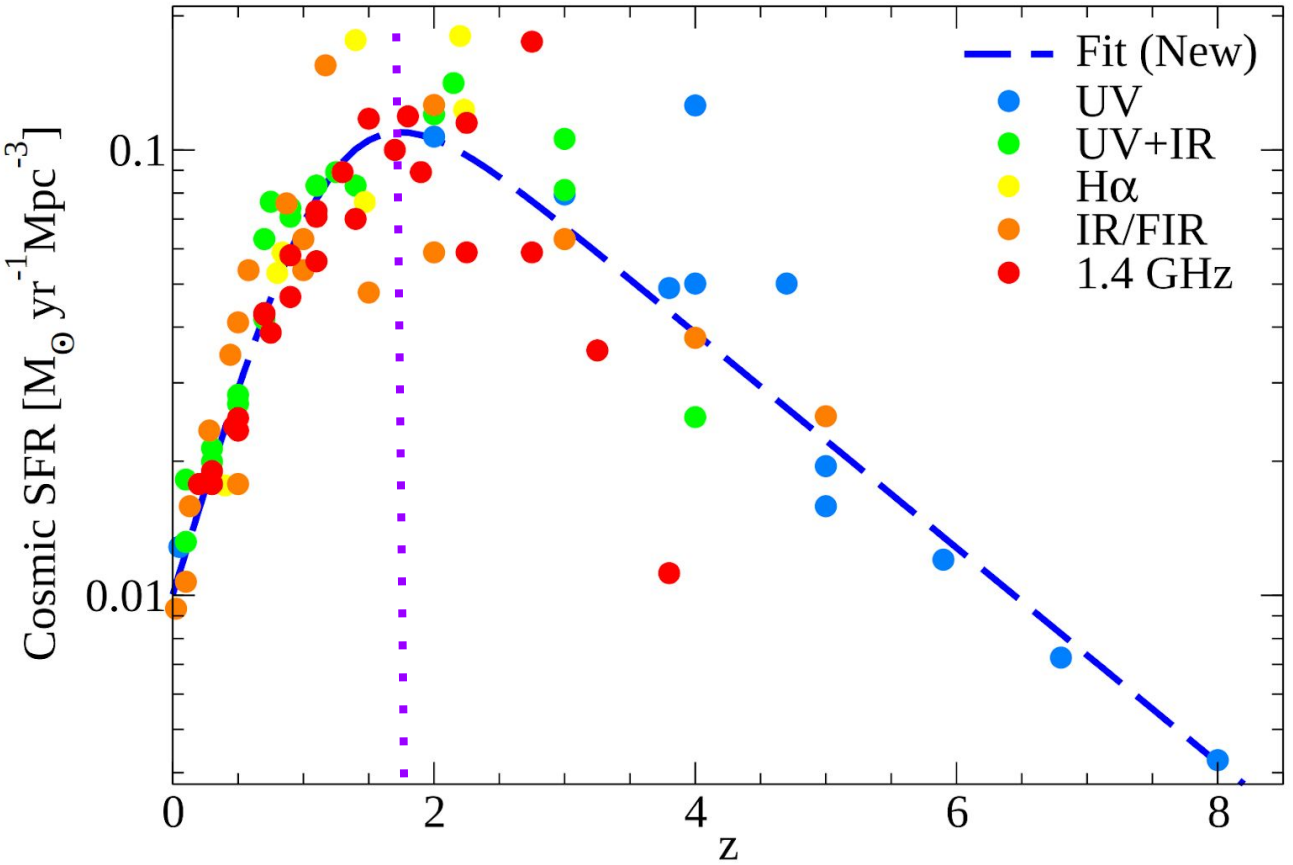


HST F160W + F105W & Soft X-rays (0.7-1.0 keV)

~40 kpc offset between BCG and X-ray Core
Soft X-ray Emission Follows Optical Tidal Tail

Hlavacek-Larrondo & Rhea+2020 (2007.15660)

Star Formation Mechanisms



Behroozi, P.S., Wechsler, R.H., Conroy, C. 2013. Ap. J. 770:57

Conclusions

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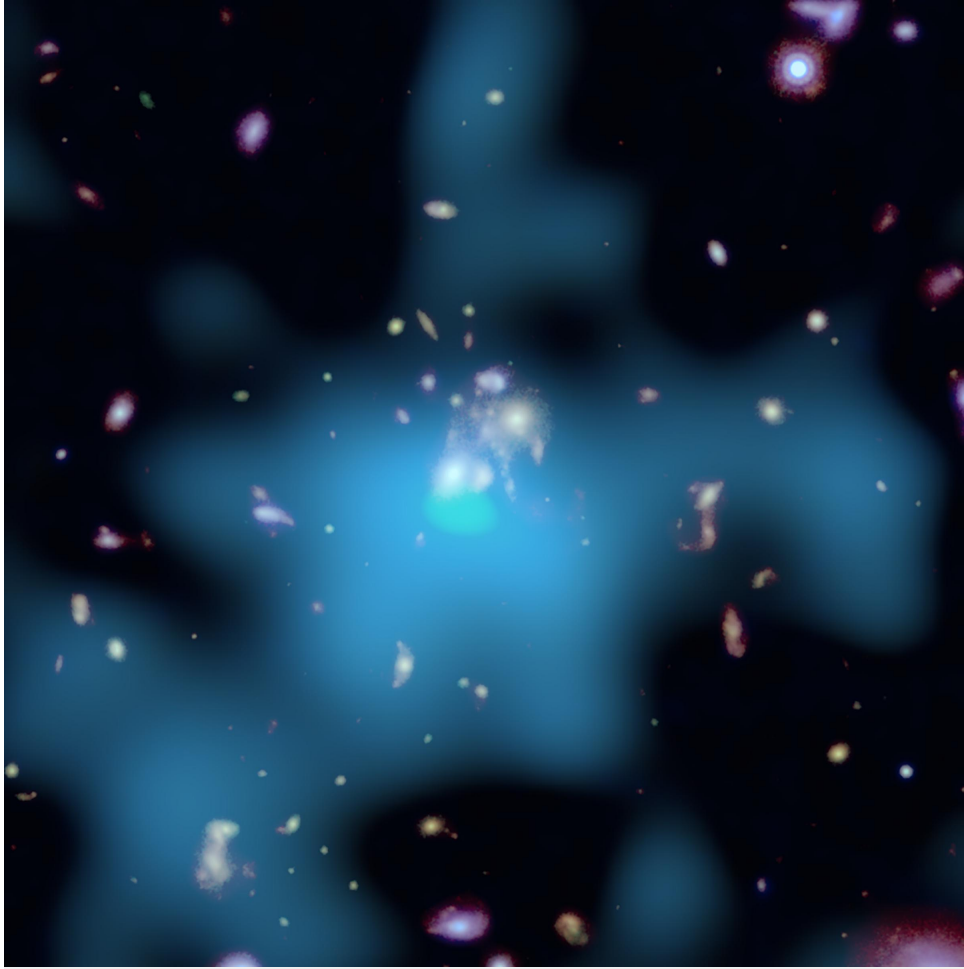
Arxiv: 2007.15660

First Author Papers:
Machine Learning Approach to Integral Field Unit Spectroscopy Observations: I. HII Region Kinematics
Arxiv: 2008.08093

A Novel Machine Learning Approach to Disentangle Multi-Temperature Regions in Galaxy Clusters
Arxiv: 2009.00643

A Machine Learning Approach to Integral Field Unit Spectroscopy Observations: II. HII Region LineRatios
Arxiv: 2102.06230



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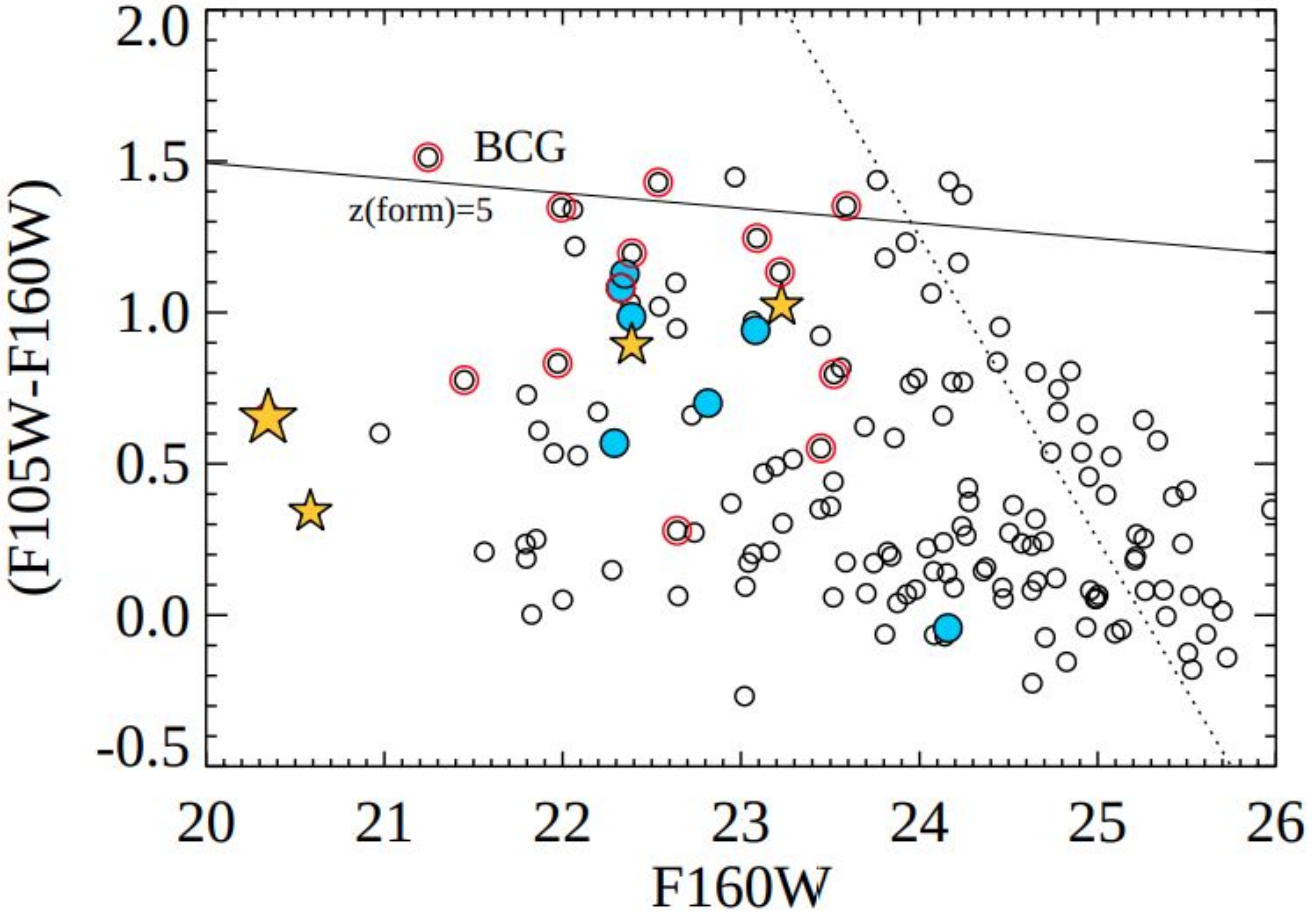
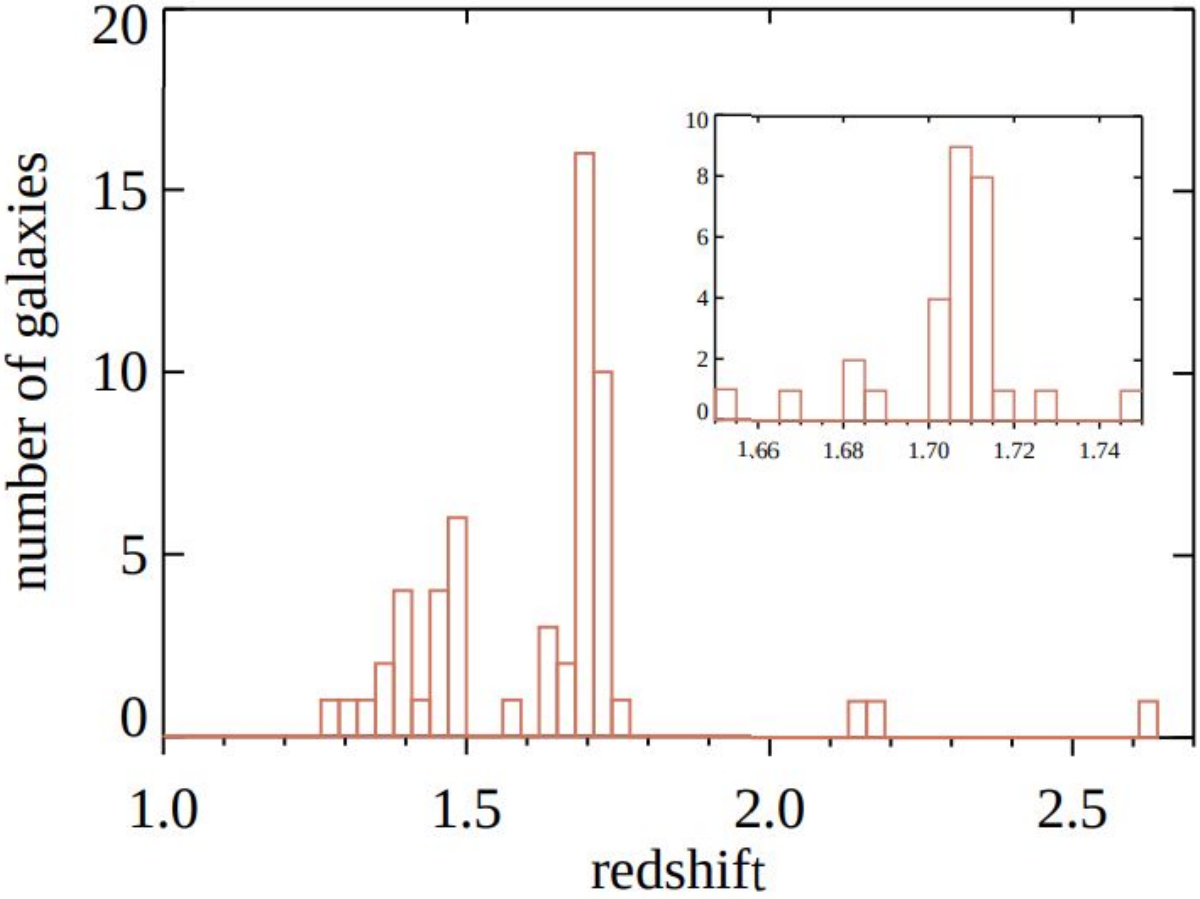
Selection of BCG



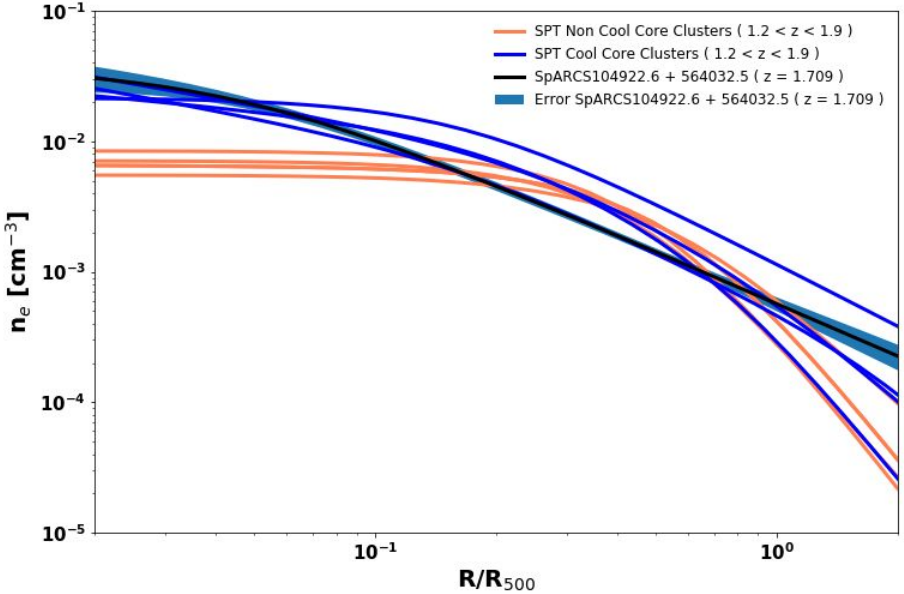
Webb+15
(1508:04982)

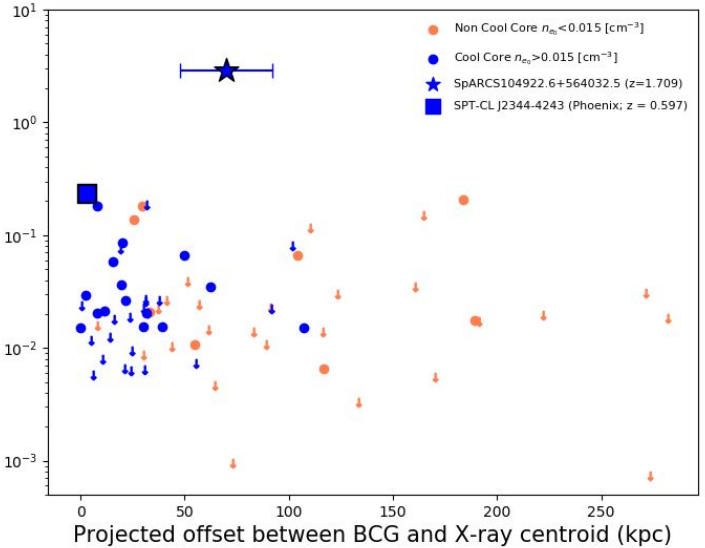
Redshift Space



Webb+15
(1508:04982)

Cool Core


SPT Non Cool Core Clusters (1.2 < z < 1.9)
SPT Cool Core Clusters (1.2 < z < 1.9)
SpARCS104922.6 + 564032.5 (z = 1.709)
Error SpARCS104922.6 + 564032.5 (z = 1.709)
n_e [cm^{-3}]
R/R$_{500}$


Non Cool Core n_{e_0}<0.015 [cm^{-3}]
Cool Core n_{e_0}>0.015 [cm^{-3}]
SpARCS104922.6+564032.5 (z=1.709)
SPT-CL J2344-4243 (Phoenix; z = 0.597)
Projected offset between BCG and X-ray centroid (kpc)