Triggering nuclear and galaxy activity in the Bullet cluster

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Introduction: Disentangling between galaxy interactions, internal galaxy dynamics, and chaotic cold accretion as the main trigger mechanism of AGN that are not very luminous is extremely difficult. A promising possibility is to study AGN demography in dense environments, such as groups and clusters of galaxies. To this purpose, we present a detailed analysis of the point-like X-ray sources in the Bullet cluster field. Thanks to ~ 600 ks *Chandra* observations, we produced a catalog of 381 X-ray point sources up to a distance of ~1.5 virial radius and with flux limits ~ 1×10^{-16} and ~ 8×10^{-16} erg cm^{-2} s^{-1} in the 0.5-2 keV and 2-10 keV bands, respectively. We identified optical and infrared (Spitzer/IRAC) counterparts for ~84% and ~48% of the X-ray sources, respectively. We obtained new spectroscopic VIMOS redshifts for 106 X-ray sources. Spectroscopic and photometric redshifts of optical and infrared sources have been also collected, and these sources were used as ancillary samples.

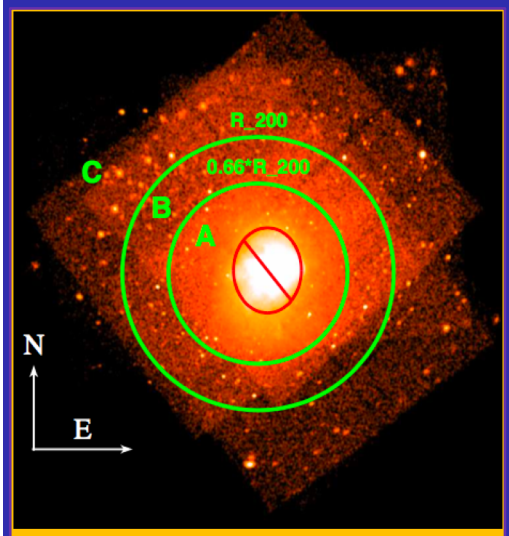
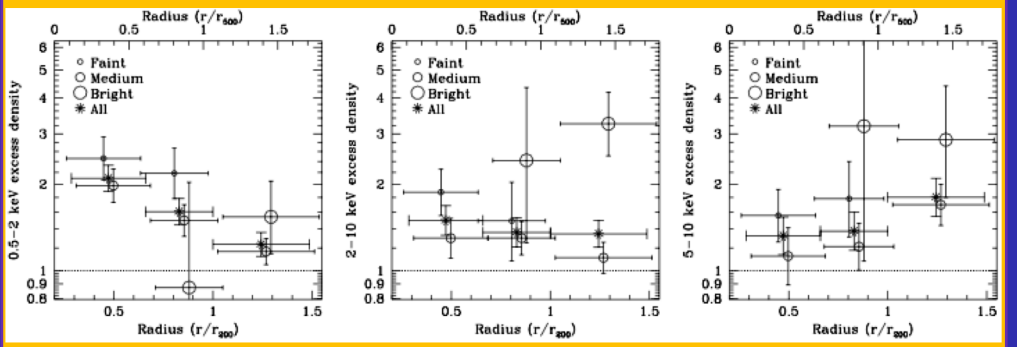


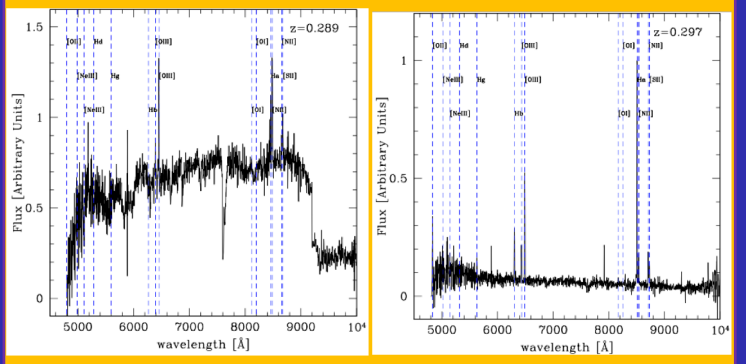
Image of the mosaic of the ten *Chandra* observations of the Bullet cluster field in the 0.5–7 keV energy range. The green circles are centred on the main cluster and have radii of 0.66 and $1\times R_{200}$. The observations cover up to ~ $2\times R_{200}$.

Excess–density of X-ray sources with respect to the field as a function of the distance from the cluster centre in units of R_{200} ,in the three energy bands 0.5–2 keV (*left panel*), 2–10 keV (*central panel*) and 5–10 keV (*right panel*).

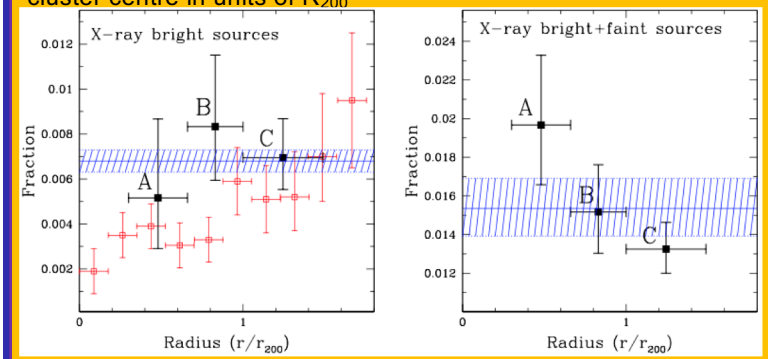


Faint flux sources = small open circles; medium flux sources = medium open circles; bright flux sources = large open circles; all sources = stars. Note that the excess densities could include some contribution from cosmic variance (< 1.25, < 1.20 and < 1.10 in the A, B and C regions).

Vimos spectra of two Bullet sources



Fraction of X-ray active galaxies (i.e. cluster members + foreground sources) as a function of the distance from the cluster centre in units of R_{200}



Left panel: black solid squares=Bullet cluster X-ray sources with 0.5–8 keV flux > 1×10^{-14} erg cm^{-2} s^{-1}; red open squares=the cluster sample by Ehlert et al. (2014). *Right panel*: black squares= Bullet cluster sources with 0.5–2 keV keV flux ≥ 3×10^{-16} erg cm^{-2} s^{-1} .The average field AGN fraction is marked by the blue solid line, with 1σ uncertainties identified by the dashed region.

The fraction of the Bullet cluster galaxies hosting an X-ray detected AGN is 1.0±0.4%, nearly constant with the radius, a fraction similar to that reported in other clusters of galaxies at similar redshift. The fraction of X-ray bright AGN ($L_{2-10keV}>10^{43}$ ergs s^{-1}) in the region $0.3R_{200} < R < R_{200}$ is $0.5^{+0.6}_{-0.2}$ %, higher than that in other clusters at similar redshift and more similar to the AGN fraction in the field.

RESULTS: we found a strong and significant over–density in the full region studied. The over-density in the region $0.3R_{200} < R < R_{200}$ is likely due to X-ray AGN (mostly obscured) and star-forming galaxies both associated to the cluster, while in the more external region it is likely mostly due to background AGN. Cluster of galaxies are over-dense regions of the Universe, thus it is not surprising that excess X-ray sources with respect to the field are found, nevertheless we found evidence that the X-ray bright AGN fraction is consistent with the fraction found in the field and thus slightly higher than the average fraction found in clusters. Finally, the spatial distributions of AGN and star–forming galaxies, selected also thanks to their infrared emission, appear similar, thus suggesting that both are triggered by the same mechanism.