AGN duty cycle and relic emission in the low frequency sky

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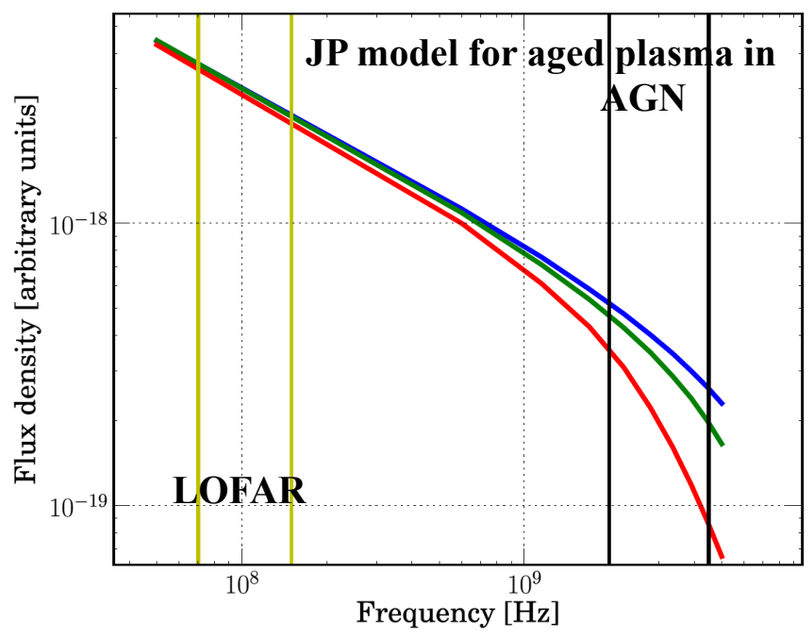
Radio loud AGNs are amongst the most bright sources in the radio sky that deposit large amount of energy in the interstellar and intergalactic medium (ISM, IGM) via their jets. As the AGN activity shuts down, the ejected plasma in jets ages and loses energy through synchrotron radiation as well as inverse compton (IC) scattering of electrons off cosmic microwave background (CMB) photons. This aged plasma gives rise to *'relics'* that are fossil radio plasma from an earlier episode of AGN activity. They are classified into 2 broad categories i.e. fading and restarted. These *'relics'* show very steep spectral index (alpha > -1.5) and emit predominantly at lower frequencies

==> ***justification for low frequency radio survey***



Object of the poster: **B2 0924+30**

1-B2 0924+30 is a relic radio source hosted by the galaxy, IC2476 that resides into a group of 8 galaxies (Jamrozy et al. 2004). The host galaxy is located at the redshift of z = 0.0261 with no emission line indicative of a passive elliptical galaxy.

The radio morphology suggests that B2 0924+30 is a FRII radio relic but shows no radio jet or core features. Shuleveski et al. 2015 measured with LOFAR a spectral index of alpha = -1 for the lobes, down to alpha = -1.8 for the inner regions of the lobe in this source and confirmed that it is a radio relic of a shutdown FRII. There is no sign of restarted AGN activity suggesting that the relic emission is due to the fading of aged plasma.

Low frequency GMRT-TGSS 150 MHz (Intema et al. 2016) and LOFAR-MSSS (Heald et al. 2015) survey detected the radio relic of 440 kpc in B2 0924+30

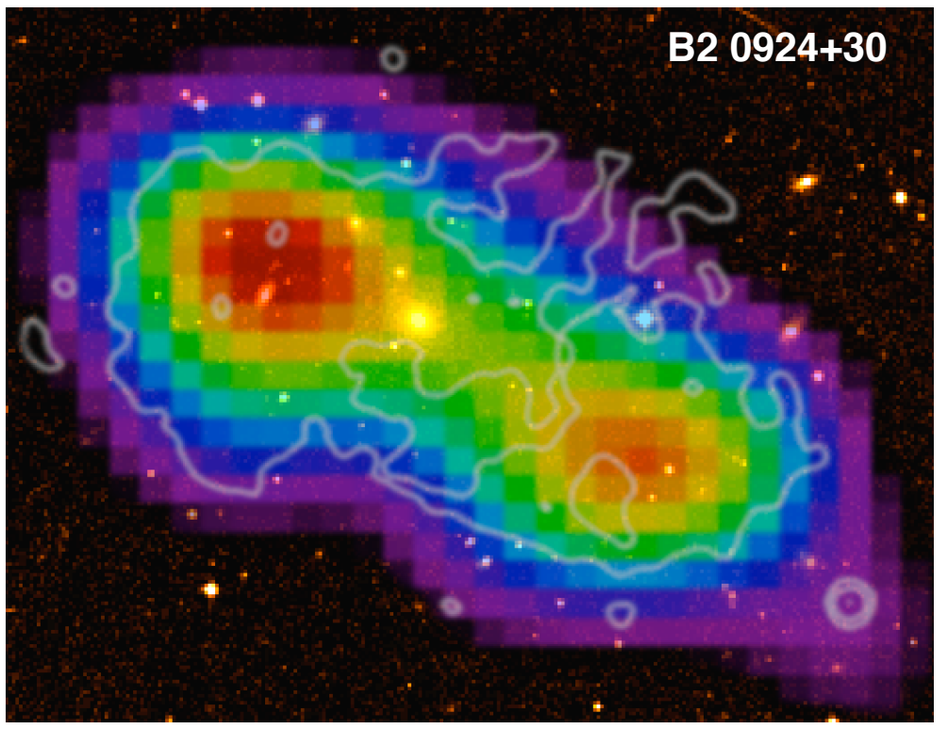


Figure 1. GMRT 150 MHz (contours) overlaid on LOFAR MSSS colour scale image at 110 MHz for B2 0924+30

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2- 4C 35.06

4C 35.06 resides in the core of a cD galaxy UGC 2489 that lies in the centre of Abell 407 cluster of galaxies. The galaxy lies at a redshift of z = 0.046726 and shows no emission line in the optical spectra suggesting that the host is a passive elliptical galaxy. The SDSS optical image of UGC 2489 shows multi-component (9 galaxies) core structure with a stellar halo around the core of roughly 40 kpc in extent.

High resolution VLA (Liuzzo et al. 2010), GMRT (Biju et al 2014) and LOFAR (Shulevski et al. 2015) images shows a twisted helic jet structure extending upto 210 kpc with no clear hotspots suggesting a FRI radio galaxy. The jet pattern suggest that the AGN has been active recently and has produced helical jet structure due to merger or interaction with the other AGNs in the core region.

The low resolution observations with the GMRT down to 150 MHz with the TGSS survey suggests a jet structure extending upto 435 kpc with a presence of underlying diffuse emission with a steep spectral index (alpha = -2), indicative of a relic of old plasma. The relic emission has been also measured with the LOFAR by Shulevski et al. 2015.

MSSS LOFAR survey confirms the presence of relic emission in 4C 35.06 and the extended jet structure of 435 kpc.

The radio morphology and spectral index suggest that the AGN is intermittently active as it moves in the dense cluster environment.

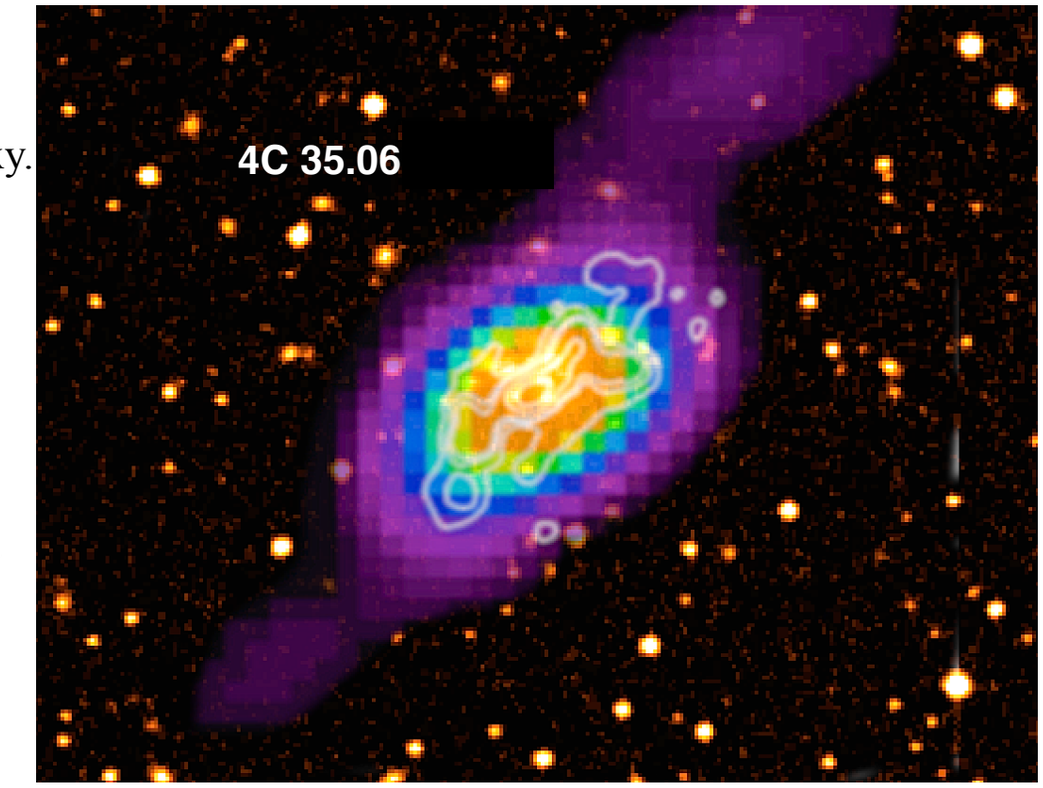

Figure 2 GMRT 150 MHz (contours) overlaid on LOFAR MSSS colour scale image at 110 MHz for 4C 35.06

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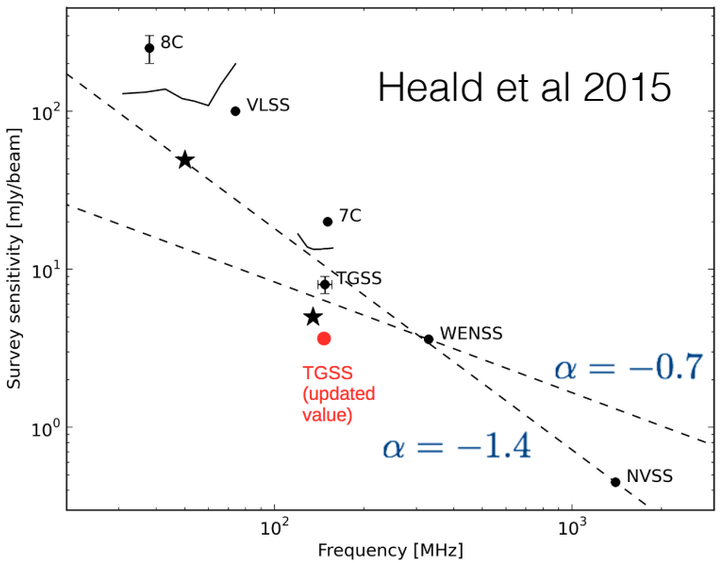
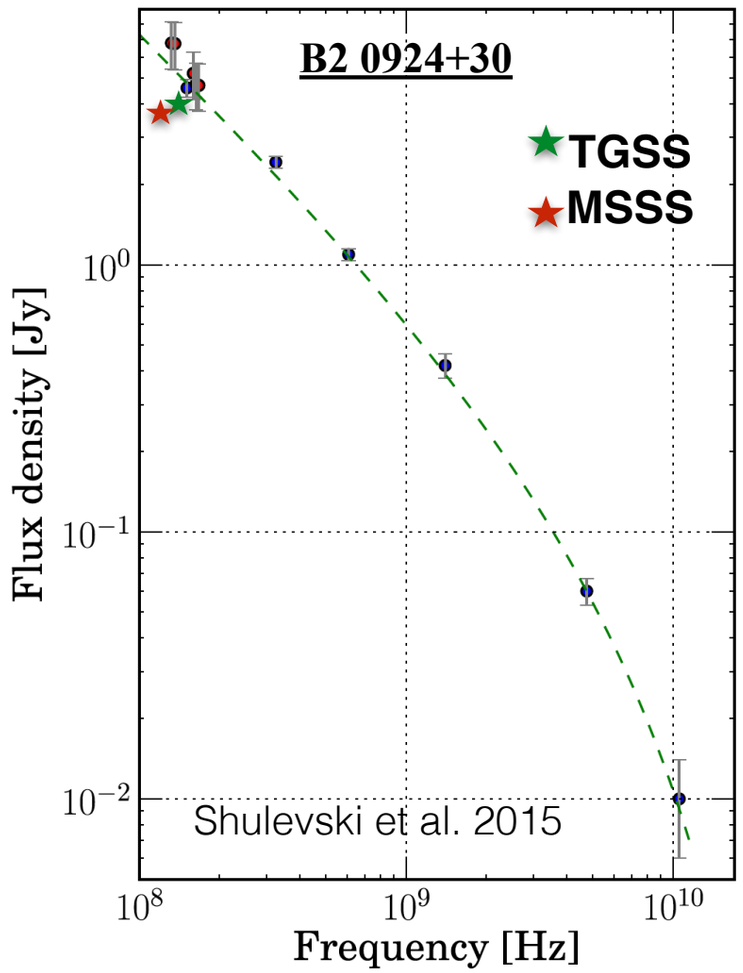
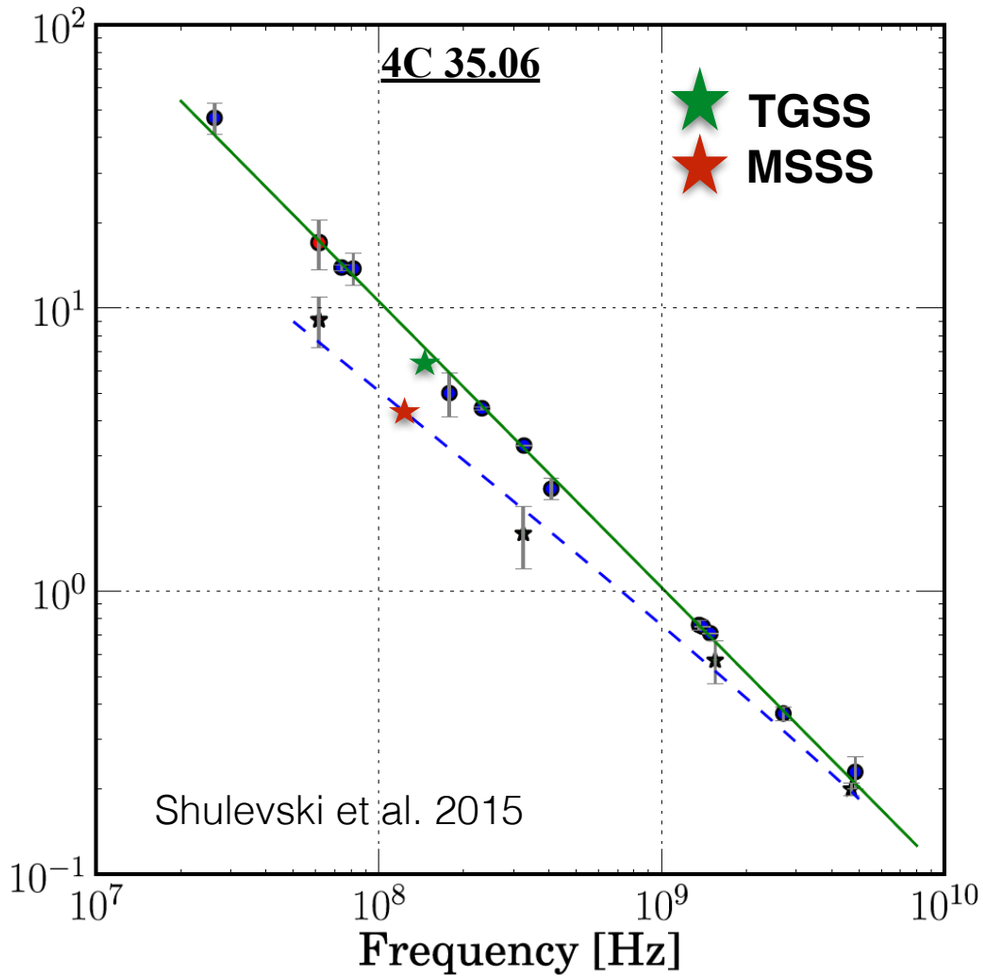
Figure 3 **Integrated flux density of AGNs**







Discussion:

-Raditaive ageing model (Jaffe & Perola 1973) suggests that AGN activity in B2 0924+30 has ceased around 100 Myrs ago, with inner younger regions in the lobe of 20 Myr.

-2 different phase (shutdown and restart) of AGN activity in 4C 35.06 were proposed based on the spectral properties, suggesting a delay between the 2 phase of 35 Myr (Shulevski et al. 2015)

-LOFAR and SKA offer improved resolution and sensitivity at low frequencies and enable us to compute the age of the radio emitting plasma across the source, which allows us to investigate the AGN activity history and their duty cycle

-LOFAR MSSS survey is efficient in detecting low surface brightness regions likes radio lobes, relics etc. however, the flux density measurements still needs to be fixed

-TGSS survey has better resolution and point source sensitivity than MSSS, but less surface brightness sensitivity and is equally efficient in detecting diffuse emission in AGNs

Reference:

1-Biju, K. , M. Pandey-Pommier, et al. 2014, Astro-ph, 1411.7261 2-Heald, G. R. Pizzo, ….M. Pandey-Pommier, et al. 2015, A&A 3- Intema et al. 2016, astro-ph arXiv:1603.04368 4-Jamrozy, M. , Klein …et al. 2004, A&A, 427
5-Jaffe & Perol 1973, A&A, 26 6-Liuzzo et al. 2010, A&A, 516 7-Shulevski, A, Morganti, R., ….M. Pandey-Pommier… et al. 2015, A&A, 2015 8-Shulevski et al. 2015, PhD thesis