Radio galaxies at low frequencies with the SKA and pathfinders

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Radio galaxies are among the most dynamical sources in the low frequency radio sky. They grow via accretion and mergers with galaxies present in their neighbourhood, giving rise to central supermassive blackholes and radio jets. These jets may extend from a few kpc up to Mpc in size and terminate into radio lobes or relics of fossil plasma. Low frequency observations are best suited to discover jets and relic regions around radio galaxies and provides a detailed insight on the distribution of relativistic electrons and magnetic field in such objects thereby providing useful information on their formation and evolution. In this poster, I will summarize in general the results (with LOFAR and GMRT) of low frequency observations on different types of radio galaxies and synergy with multi wavelength (Optical/X-ray) studies. I will finally discuss the capabilities of SKA and its path finders (NenuFAR) to study such dynamical objects in the Universe.

1- Discovery of Giant Radio Galaxies with LOFAR (SKA-Pathfinder)

Giant radio galaxies (GRG) are the largest single objects in the Universe with lobes having a total projected linear size of more than 1 Mpc. GRG are *rare* objects, with at least 100 of them know as of now. They tend to grown in low density environments and are expected to be at the end stage of their life cycle (e.g., Clarke et al. 2017). Finding samples of GRG is particularly important for statistically classifying the properties of the evolution of radio sources and test the dynamical models of radio galaxy evolution.

Thanks to the high sensitivity and resolution of LOFAR survey at MHz -range, it is now possible to discover many new Giant Radio galaxies. Fig. 1 shows the example of a recently discovered Giant Radio Galaxy UGC 9555 of 2.56 Mpc in size down to 120 MHz (ref fig. 1, Clarke et al. 2017) in the LOFAR MSSS survey.

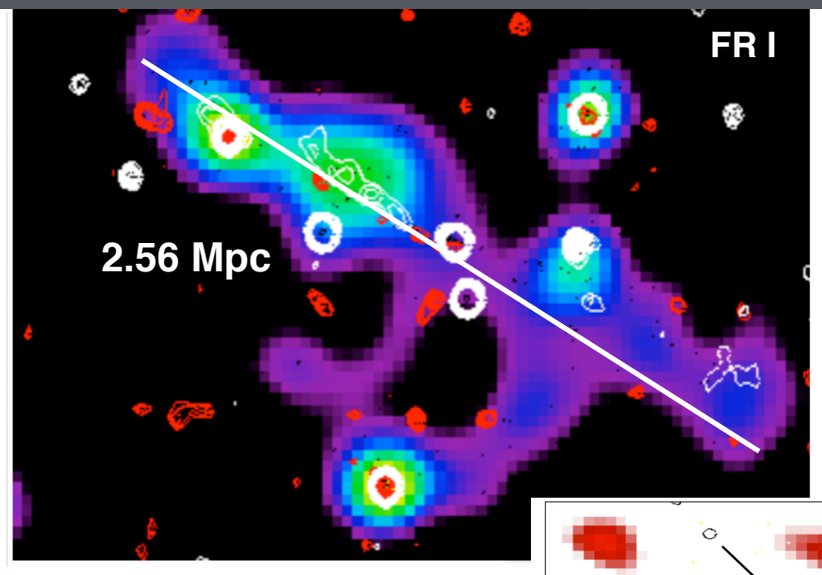
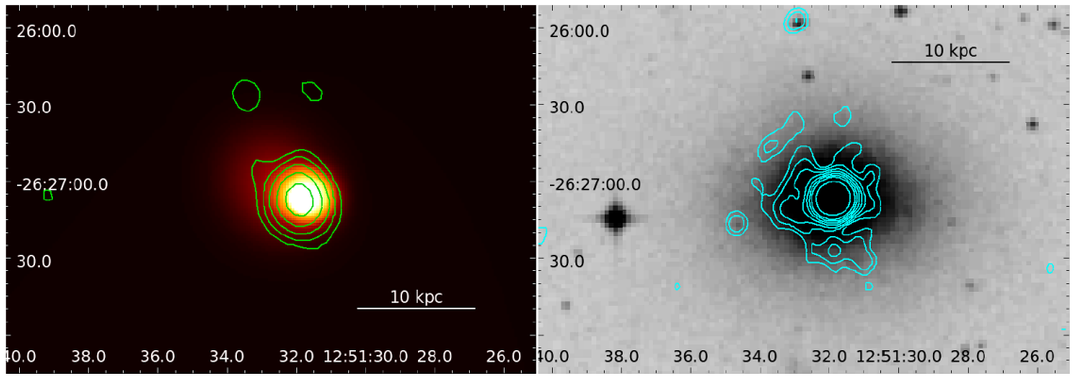


Figure 1. LOFAR 110 MHz image (panel 1 & 2) of newly discovered GRGs with overlaid contours from VLA (Clarke et al. 2017, Pandey-Pommier et al.)

2-Radio Galaxies in galaxy groups and clusters- GMRT (SKA-Pathfinder)

Galaxy groups are building blocks of galaxy clusters. The evolution of galaxies takes place in the group environment that also plays an important role in the large scale structure formation and galaxy evolution. Dominant Bright Group Early-type elliptical (BGEs) present in galaxy groups are prominent targets for the study of galaxy evolution in groups. They host radio emission of a few pc to kpc scale with a wide range of luminosities from 10^20 to 10^24 W/Hz and X-ray cavities suggesting AGN interaction and feedback mechanism in the Intra Group Medium (IGM).



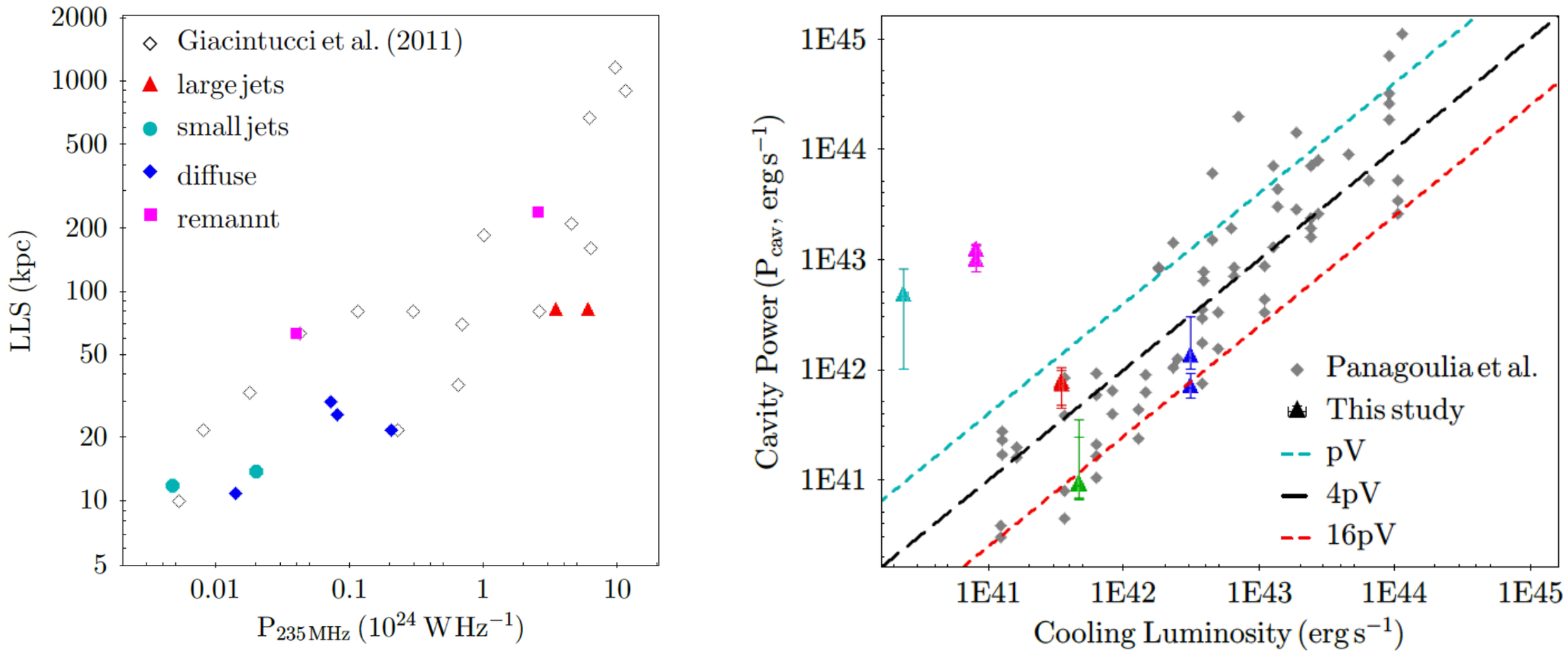
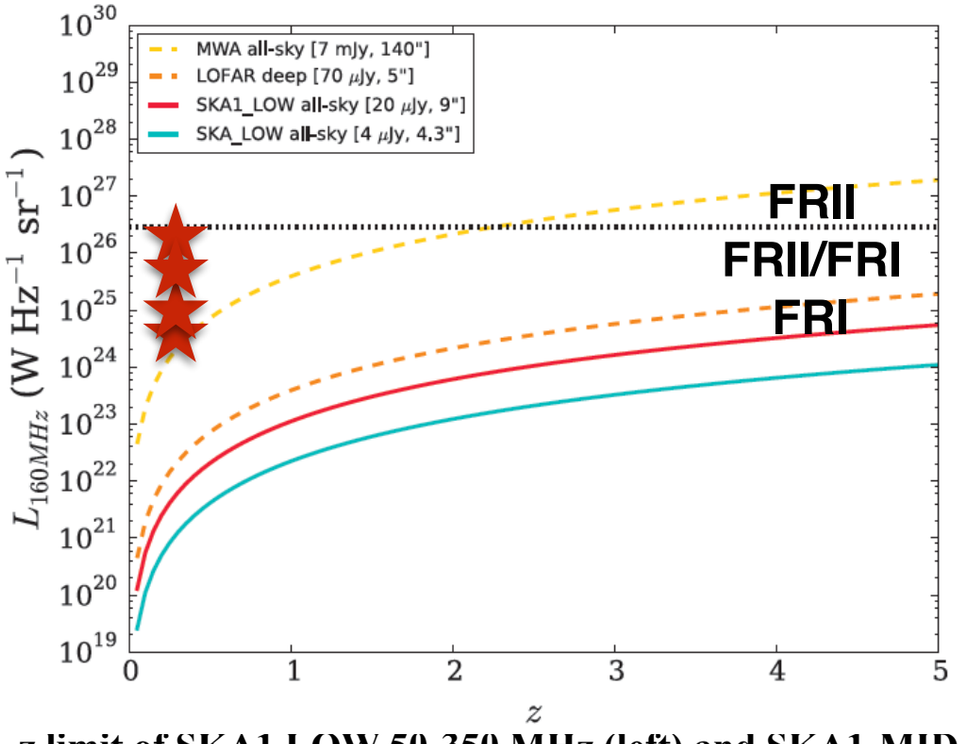
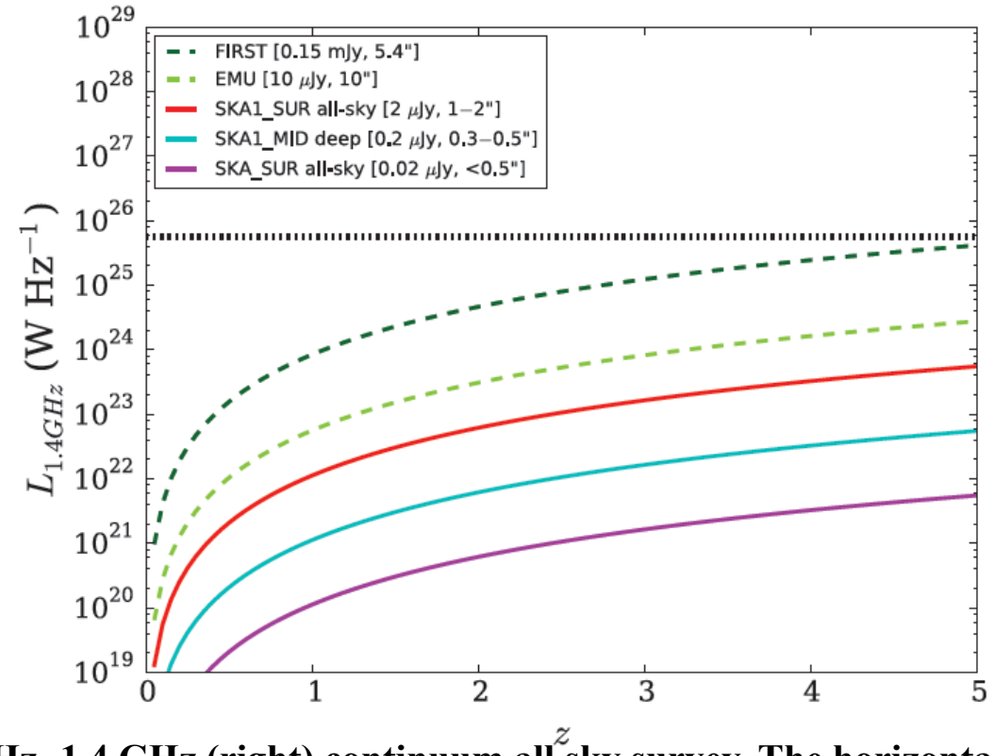


Fig.2 Top- GMRT 235 MHz (left) overlaid on Chandra X-ray and 610 MHz contours (right) overlaid on SDSS image at for LGG 310 Galaxy group Bottom- (left) Radio Power at 235 MHz vs Size of radio source for central elliptical galaxy and (right) Cavity Power vs Cooling Luminosity for CLoGS sample (extracted from Kolokythas et al. 2018)

3-Radio galaxy population with SKA and NenuFAR (SKA-Pathfinder)





NenuFAR

Fig.3 L-z limit of SKA1 LOW 50-350 MHz (left) and SKA1-MID 350 MHz- 1.4 GHz (right) continuum all sky survey. The horizontal line marks the traditional FRI/FRII divide (extracted from Kapinska et al. 2014)

Discussion:

-Radio galaxies will be the dominant population of bright sources discovered by the SKA and its pathfinders NenuFAR **(Zarka et al.)**.

-The SKA Pathfinder Nenufar will play a significant role in the discovery of such bright radio galaxies (GRGs, radio galaxies in cluster environment and galaxy groups) thanks to its high sensitivity to low surface brightness sources.

-NenuFAR offers improved sensitivity (19x LOFAR international LBA station at 10-80 MHz range, 31-9 mJy) and resolution (5-40 arcmin) at low frequencies. It will detect radio galaxies with linear size of a a few kpc - Mpc scale and with lower limit in the luminosity up to 10^24 to 10^26 W/Hz/sr.

-This will 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, discover new Giant radio galaxies and jets in erstwhile ‘extended’ core type galaxies **(Pandey-Pommier et al. 2016)**.