Restarting activity in hard X-ray selected giant radio galaxies

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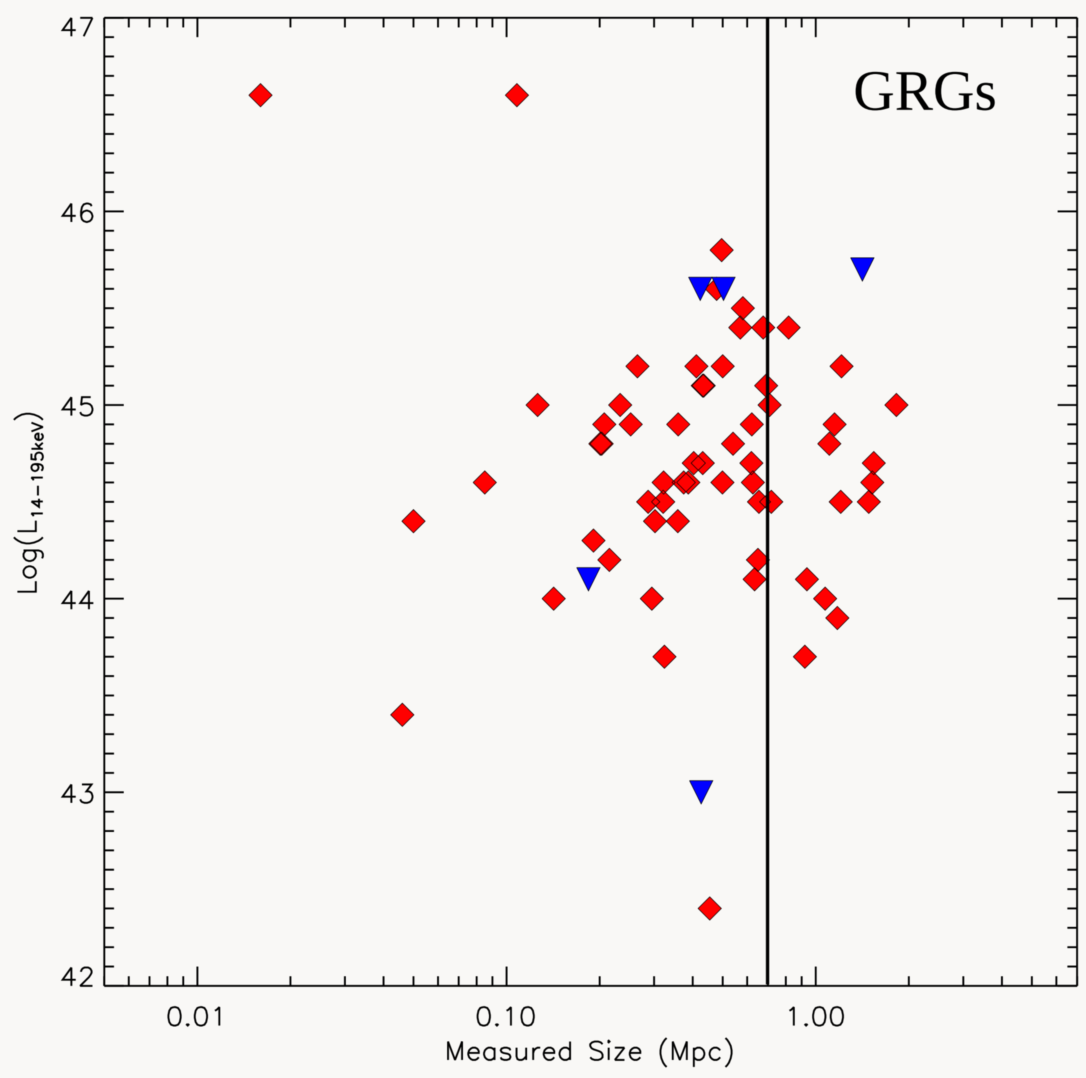
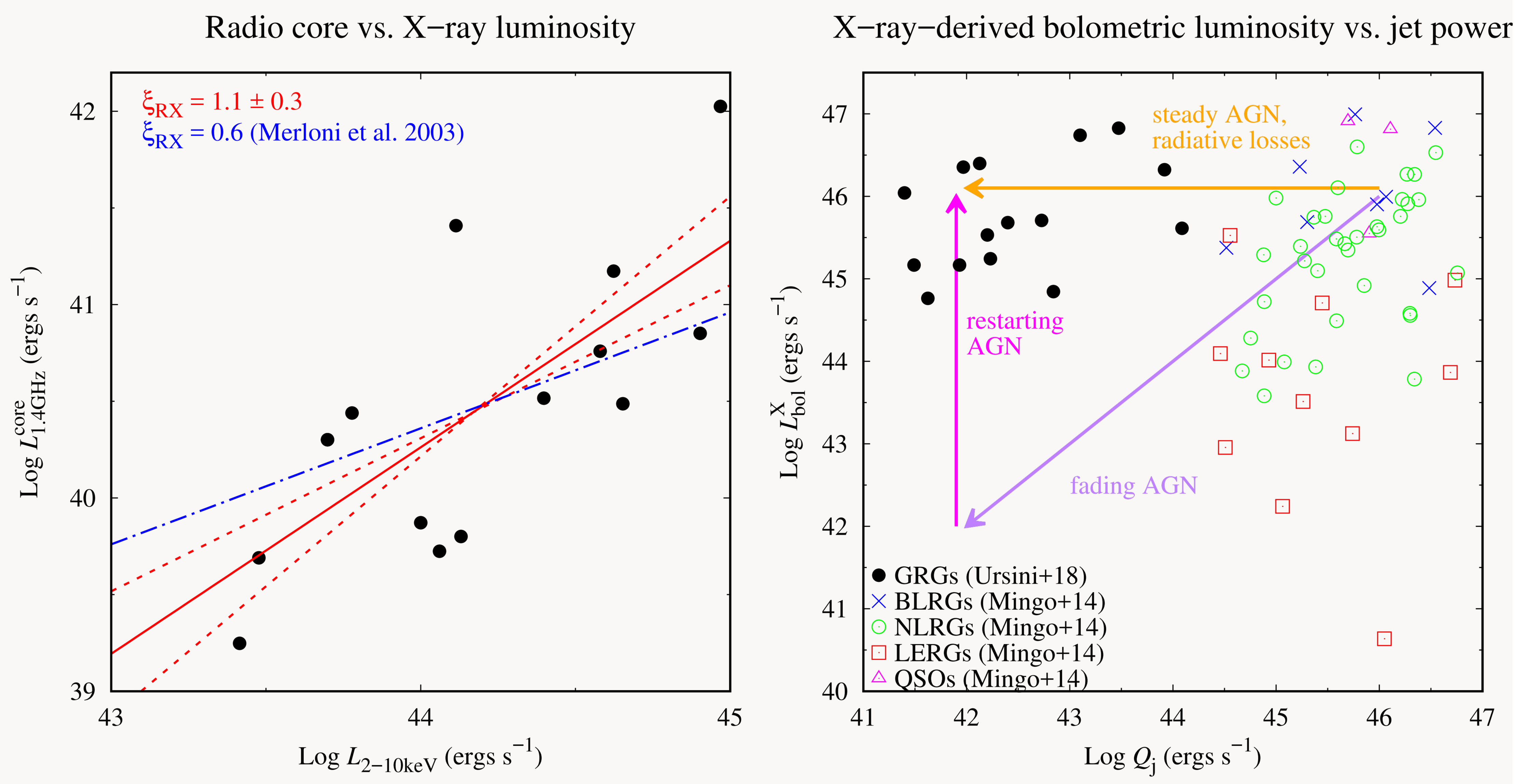
Hard X-ray selection favours giant size discovery (Bassani et al. 2016)



We study a sample of 64 AGNs with extended radio morphology, selected from the hard X-ray catalogues of *INTEGRAL*/IBIS and *Swift*/BAT [1]. 14 sources are giant radio galaxies (GRGs), i.e. with a linear size >0.7 Mpc. The fraction of GRGs is thus 22%, significantly larger than what is generally found in radio surveys (1–6%). Given their huge size, GRGs represent an extreme class among radio-loud AGNs, as they should be very old and/or residing in a very low-density environment compared with regular radio galaxies. The origin and growth of GRGs is still an open issue, and could be related to the restarting of their central engines during multiple activity phases.

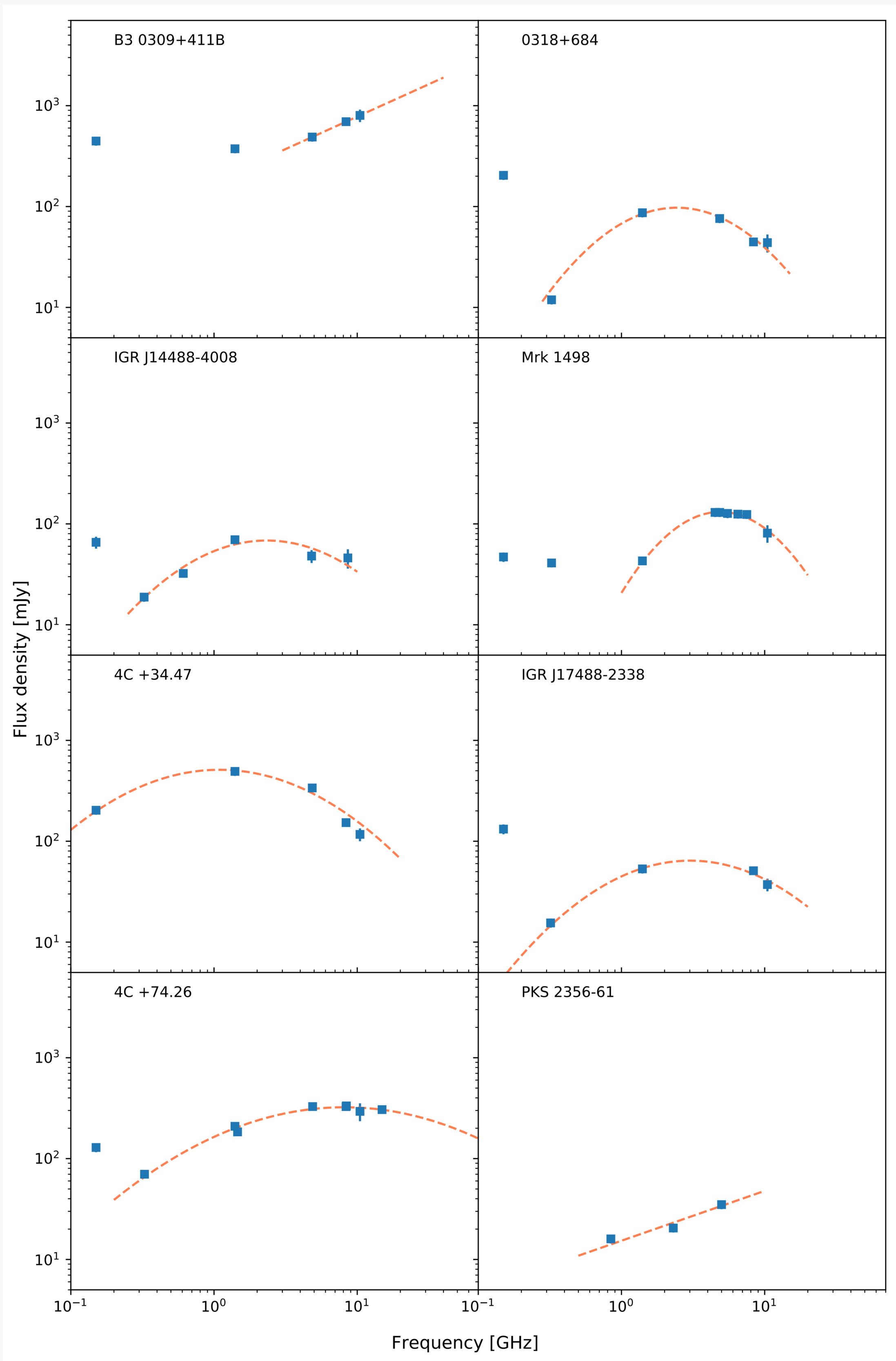
X-ray properties and radio connection (Ursini et al. 2018)



The bulk of the X-ray emission of GRGs in our sample is consistent with originating from a Comptonizing corona coupled to a radiatively efficient accretion flow (Eddington ratio > 0.02) [8], like in normal-size FR II radio galaxies. We also study the relation between the X-ray emission and the radio emission, separating the contribution from the core and from the lobes:

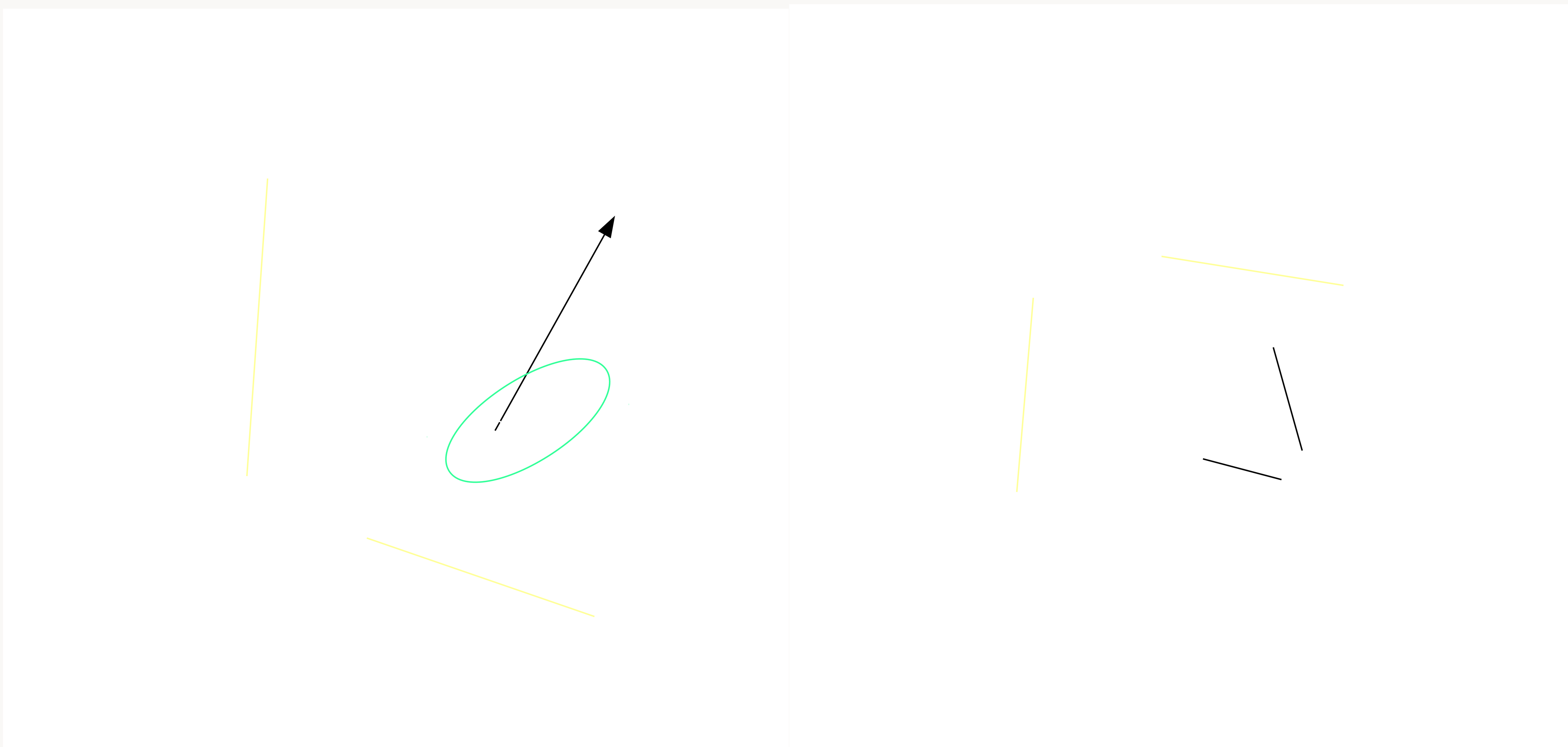
- The X-ray luminosity $L_{2\text{–}10\mathrm{keV}}$ correlates with the radio core luminosity $L^{\mathrm{core}}_{1.4\mathrm{GHz}}$, as expected from the so-called fundamental plane of black hole activity [6]. The slope of the correlation is consistent with the ‘radiatively efficient’ branch of the fundamental plane rather than the ‘standard/inefficient’ branch [4].
- In most sources, the luminosity of the radio lobes and the estimated kinetic power of the jet (Q_j) are much smaller than the bolometric luminosity inferred from the X-ray luminosity (L^X_{bol}). This discrepancy is clear when comparing the values of Q_j and L^X_{bol} with the most radio luminous galaxies [7]. This can be explained by restarting activity (i.e. the sources are currently highly accreting and in a high-luminosity state following a new accretion episode) or by steady activity accompanied by significant expansion losses. The radio morphological/spectral properties show signatures of restarting activity in all sources, favouring this scenario [2].

Young radio cores (Bruni et al. 2019)



Surprisingly, 60% of hard X-ray GRGs host a GigaHertz peaked spectrum (GPS) radio core [2]. GPS sources are considered to be the young precursors of FR I and FR II radio galaxies. This means that the cores of hard X-ray GRGs are mostly young (kyr), despite being hosted by much older (Myr) and extended structures.

Restarting radio morphology (Bruni et al., in prep.)



The radio morphology of most sources shows signatures of multiple activity phases, such as two sets of lobes (double-double), an X-shaped morphology or an extended radio cocoon [3]. This, together with the high fraction of young radio cores, indicates that all the hard X-ray GRGs underwent at least one episode of restarting activity. J0318+684 and PKS 0707-35 are two clear examples. The former shows three distinct radio phases: a young GPS radio core, a pair of extended lobes (> 1:5 Mpc) and an older ’bulge’ that could be a remnant of a former jet. The latter has a double-double and X-shaped morphology, the outer pair of lobes being brighter and more recently fueled.

Future perspectives

LOFAR will likely discover 10^4 new GRGs [5], boosting the study of sub-mJy remnants and restarted radio sources. The combination with X-ray data (like the eROSITA all-sky survey) will be key to constrain the AGN/jet duty cycle tracing the different activity phases.

References

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