X-ray radio galaxies

giant fraction and obscuration

Francesca Panessa

Hernandez-Garcia, Bassani, Venturi, Molina, Dallacasa, Ubertini, Bazzano, Malizia, La Franca, Landi
Starting Point: the INTEGRAL AGN (Malizia et al. 2012) and SWIFT/BAT AGN from 70 month catalogue by Baumgartner et al. (2013)

**Radio Morphology**

search for a double lobe morphology
64 Radio Galaxies (+ 3 candidates):
→ 27 from the INTEGRAL survey
→ 63 from the Swift survey
→ 22 have detection in both

<table>
<thead>
<tr>
<th>Opt class</th>
<th>Morph type</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 type 1</td>
<td>51 FR II&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>12 type 1.2–1.5</td>
<td>6 FR I&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>9 type 1.8–1.9</td>
<td>6 FR I/FR II</td>
</tr>
<tr>
<td>19 type 2</td>
<td>1 C</td>
</tr>
<tr>
<td>2 unknown</td>
<td>3 unknown</td>
</tr>
</tbody>
</table>

Mostly HERG
Log $L_{\text{bol}}/L_{\text{edd}}>0.01$

Sensitivity limit $9\times10^{-12}$ cm$^{-2}$ s$^{-1}$ (14-195 keV)

7-10% of all hard X-ray AGN are radio galaxies
hard X-ray radio galaxies

Estimate of the fraction of GIANT RADIO GALAXIES

Bassani et al. 2016

Estimate of the fraction of absorbed radio galaxies

Panessa et al. 2016
Sources with size > 0.7 Mpc
> 20% of soft gamma-ray selected RG

Typical percentage in radio selected sample are:

- 6% in 3CR catalogue (Ishwara-Chandra & Saika 1999)
- 1% for z<0.2 ~3500 NVSS, SUMSS & WENSs images (Andernach et al. 2014)
- 5.6% among 672 FRII with known z (Nilsson 1998)
- 5.5% among 401 FR II in the SDSS sample (Kozile-Wierzbowska & Stasinska 2011)
- 2% among 46 HEG in the sample (Buttiglione et al. 2010)

1-6% in radio versus 20% in soft gamma
Bassani et al. 2016

**giant radio galaxies**

Largest radio Angular Size (in arcsec) versus 14-195 KeV Luminosity → no correlation

- 60% → LAS > 0.4 Mpc
- 22% → LAS > 0.7 Mpc

Measured Size (Mpc)

Log \( L \) (14 - 195 keV)
GIANT RADIO GALAXIES: Largest and most energetics single entities in the universe

Main reasons for the production of such large scale structures still unclear

- play a role in the formation of large-scale structures -- used to probe the Warm-Hot Intergalactic Medium (Malarecki et al 2013)

- unique laboratories where to study particle acceleration processes and understand cosmic magnetism (Kronberg et al. 2004)

- ideal targets to study the duty cycle of radio activity → episode of restarting activity
THE REACTIVATING NUCLEUS OF PBC J2333.9-2343 from giant radio galaxy to blazar!

Hernandez-Garcia et al. 2017

Live at 18:30 (Caudini room)!!
hard X-ray radio galaxies

Estimate of the fraction of absorbed radio galaxies

Panessa et al. 2016
the unified model in radio galaxies

- Does the presence of a jet influence the surrounding medium?
- Is the unified model still valid when a jet is present?

(are we still stucked at the Urry&Padovani scheme?)

In the local Universe, only a handful of CT radio galaxies are found (e.g., Hardcastle, Evans & Croston 2006, Eguchi et al. 2009, Guainazzi et al. 2006, Guainazzi et al. 2004)
the column density distribution

estimate of the column density via high quality broad-band spectra

Panessa et al. 2016

No missing Compton thick

✓ Fraction of obscured objects: 40% (75% among type 2 AGN)
✓ Fraction of Compton thick objects: 2-3% (4% among type 2 AGN)
comparison with a radio quiet sample

total INTEGRAL AGN sample in Malizia et al. (2012):

→ 22 out of 271 AGN are radio galaxies

fraction of absorbed AGN

→ 49 (+6,-7) % in RQ
→ 36 (+21,-16) % in RG

fraction of Compton thick AGN

→ 6 (+3,-3) % in RQ
→ < 1.3 % in RG
comparison with a radio quiet sample

the null hypothesis can be rejected at 1% level

the null hypothesis cannot be rejected at 1% level

Low fraction of Compton thick objects $\rightarrow$ both samples affected by selection biases?

However, no confirmed Cthick among radio galaxies in the local Universe (Ursini et al. in preparation)
Radio core dominance:

\[ R_{\text{core}} = \frac{S_{\text{core}}}{S_{\text{tot}} - S_{\text{core}}} \]

Core and the total flux densities at 5 GHz

The null hypothesis probability of correlation of 0.00027

\[ \rightarrow \text{anti-correlation} \]

Confirmation of a previous result

(Grandi et al. 2006)
Thank you!