Probing the viability of CMB quenching for high-z jetted AGN

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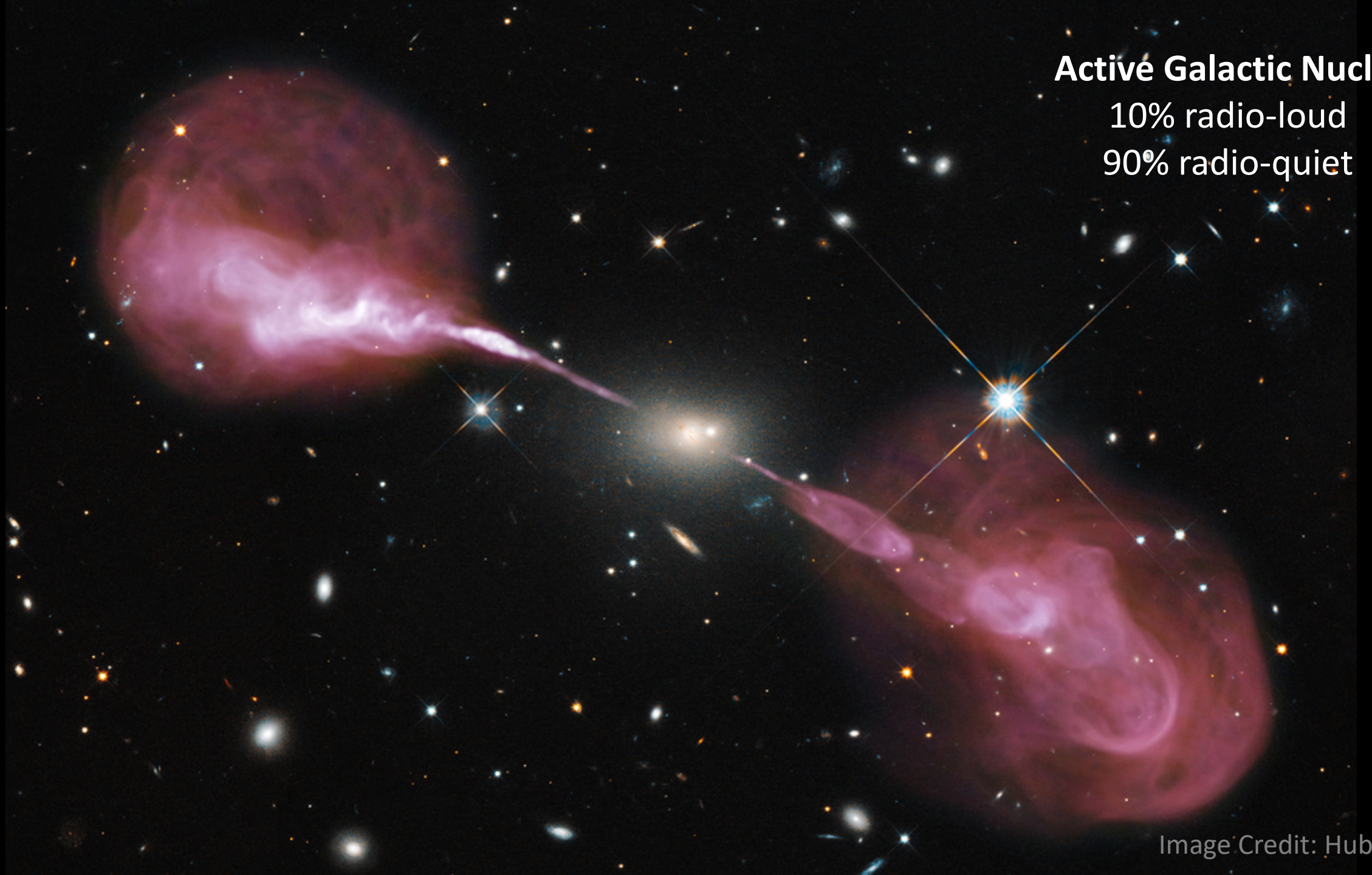
Active Galactic Nuclei
10% radio-loud
90% radio-quiet
Image Credit: Hubblesite

$$\Gamma = \frac{1}{\sqrt{1 - \left(\frac{v}{c}\right)^2}}$$

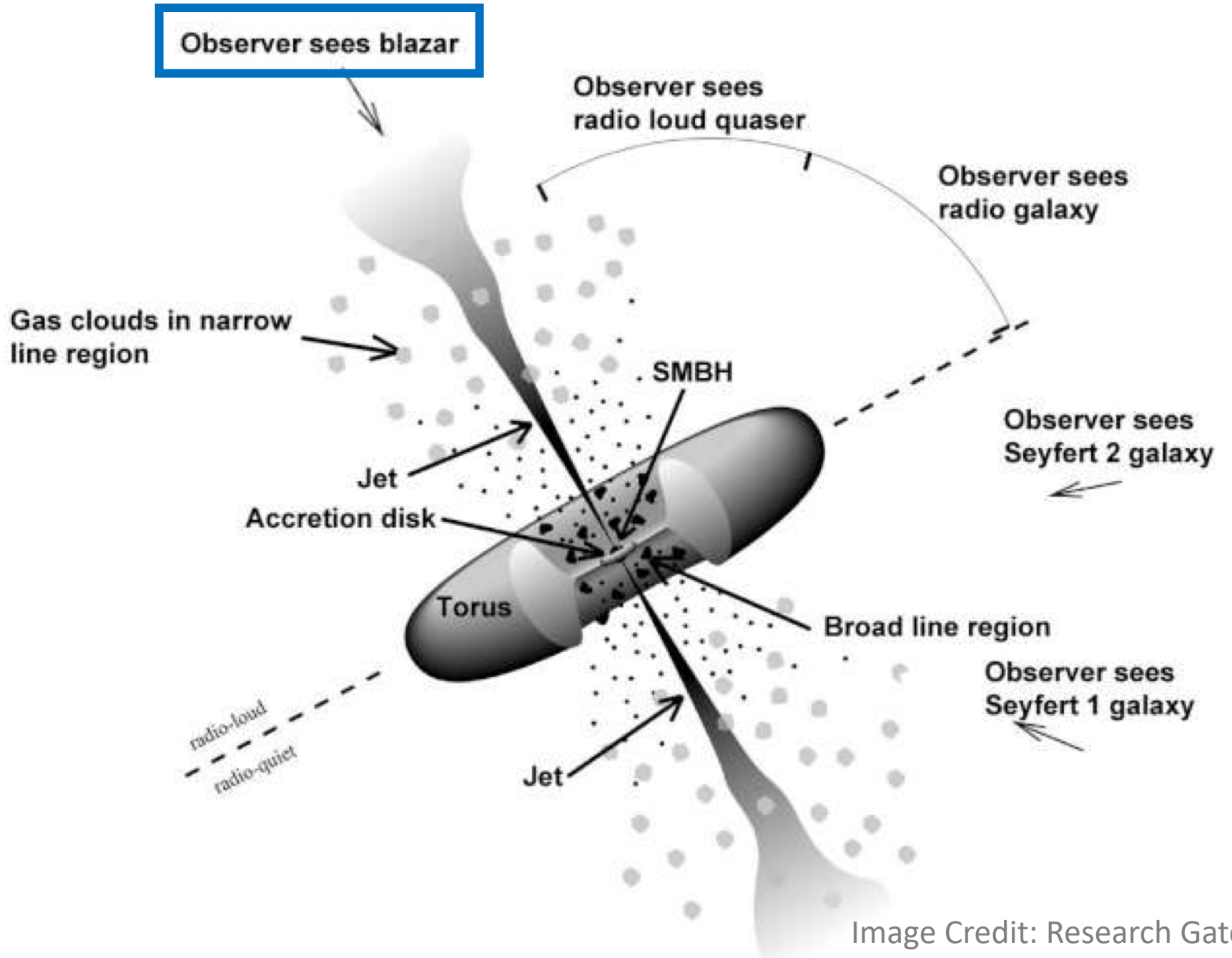

Image Credit: Research Gate

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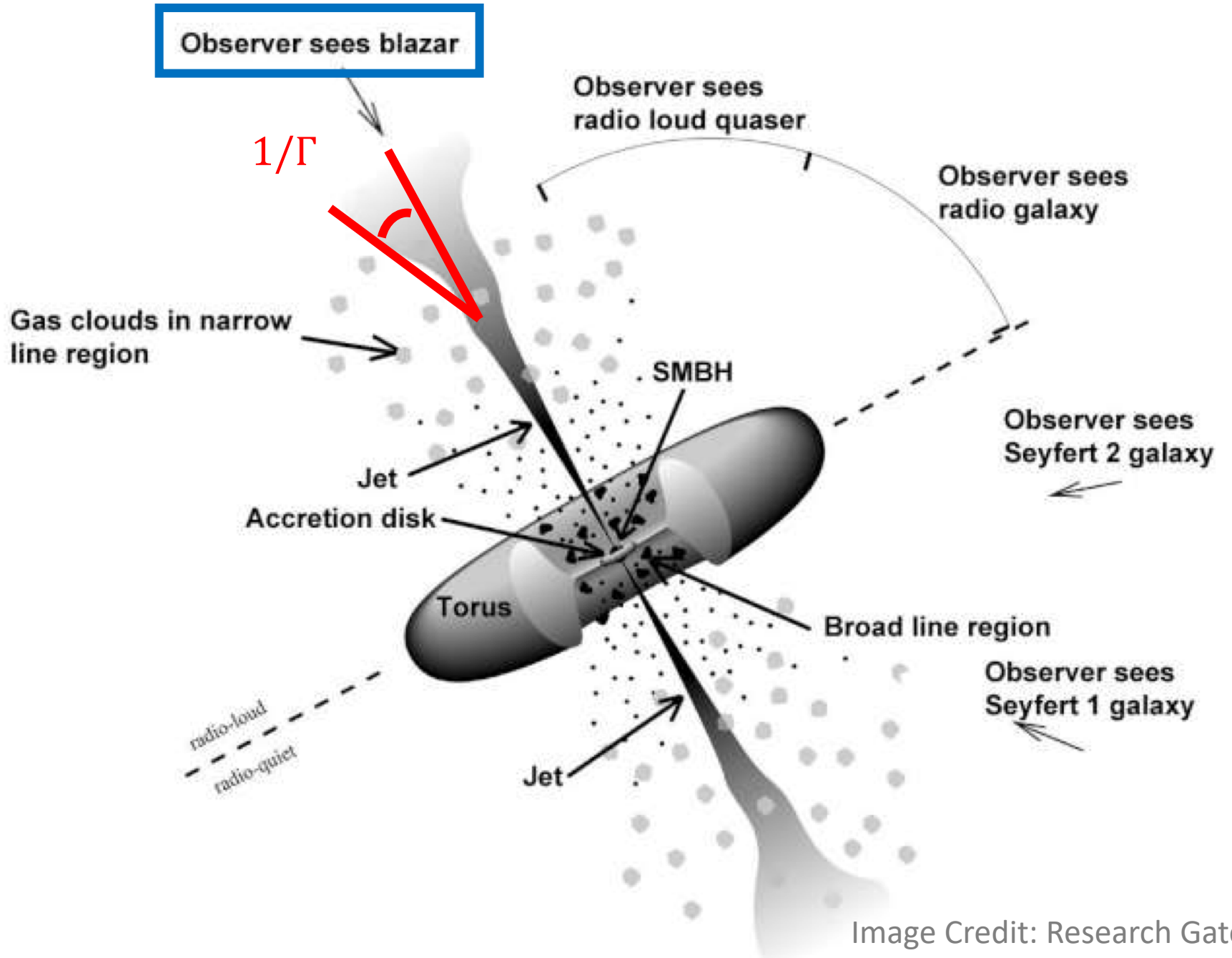


Image Credit: Research Gate

$2\Gamma^2$ misaligned sources

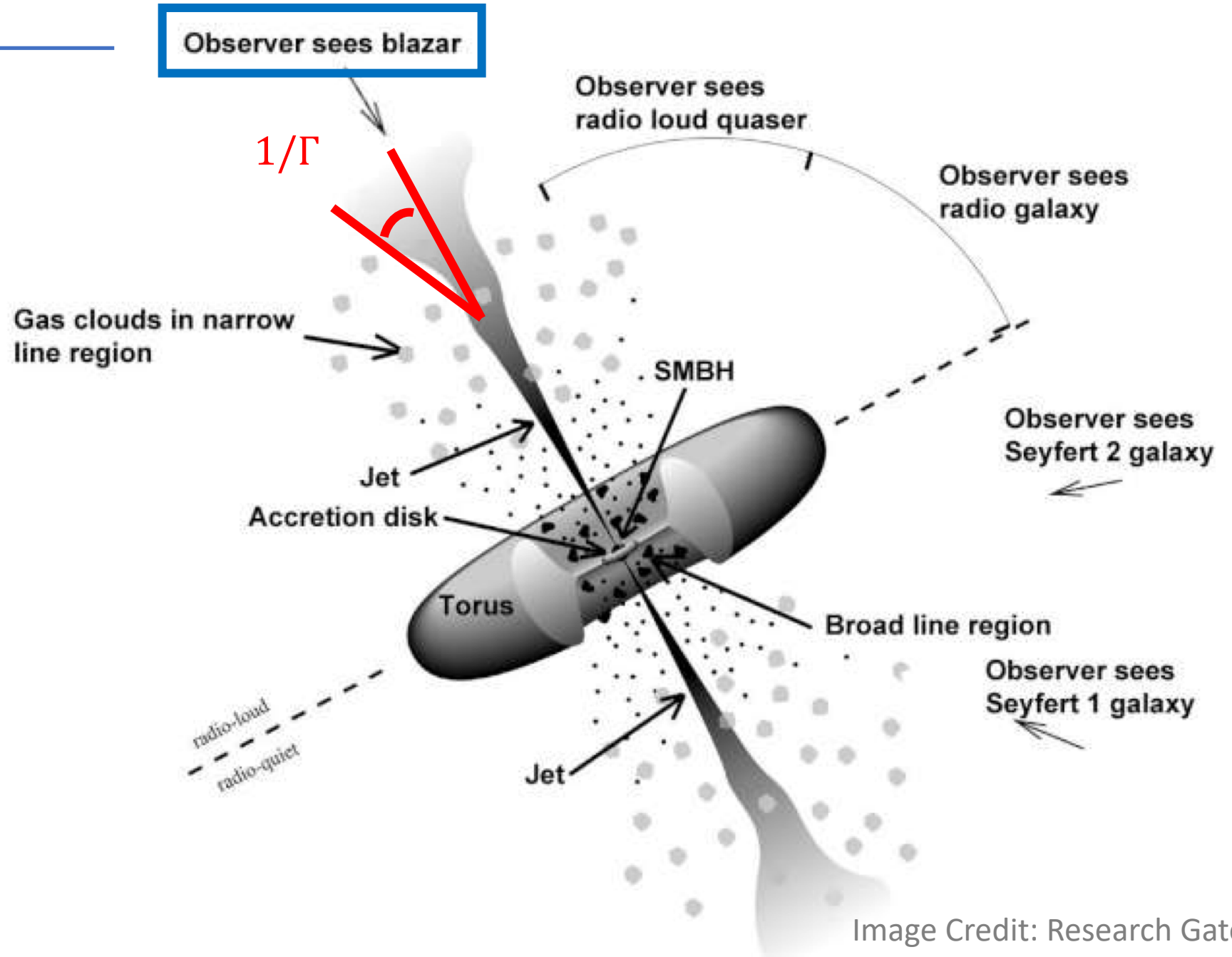


Image Credit: Research Gate

$$\Gamma = \frac{1}{\sqrt{1-\left(\frac{v}{c}\right)^2}}$$

Problem: Abrupt drop-off in number of observed radio-loud AGN at $z \gtrsim 3$

- Up to $z \sim 3$, observed number of radio-loud AGN matches expected number

  (Ajello et al. 2009 & Ghisellini et al. 2011)

- The observed number falls short of the expected number, despite the expected flux of these systems being within the sensitivity thresholds of our radio instruments.

  (Volonteri et al. 2011)

  - By a factor of 3 in z = 3-4
  - By a factor of >10 z = 4-5

Proposed solutions

- Selection bias

  Volonteri et al. 2011

  E.g. Heavy optical obscuration by dust

- Intrinsic differences in the physical properties of jets at high z

  Volonteri et al. 2011

  E.g. Lower average Γ factor

- Substantial dimming of the radio lobes at $z \gtrsim 3$

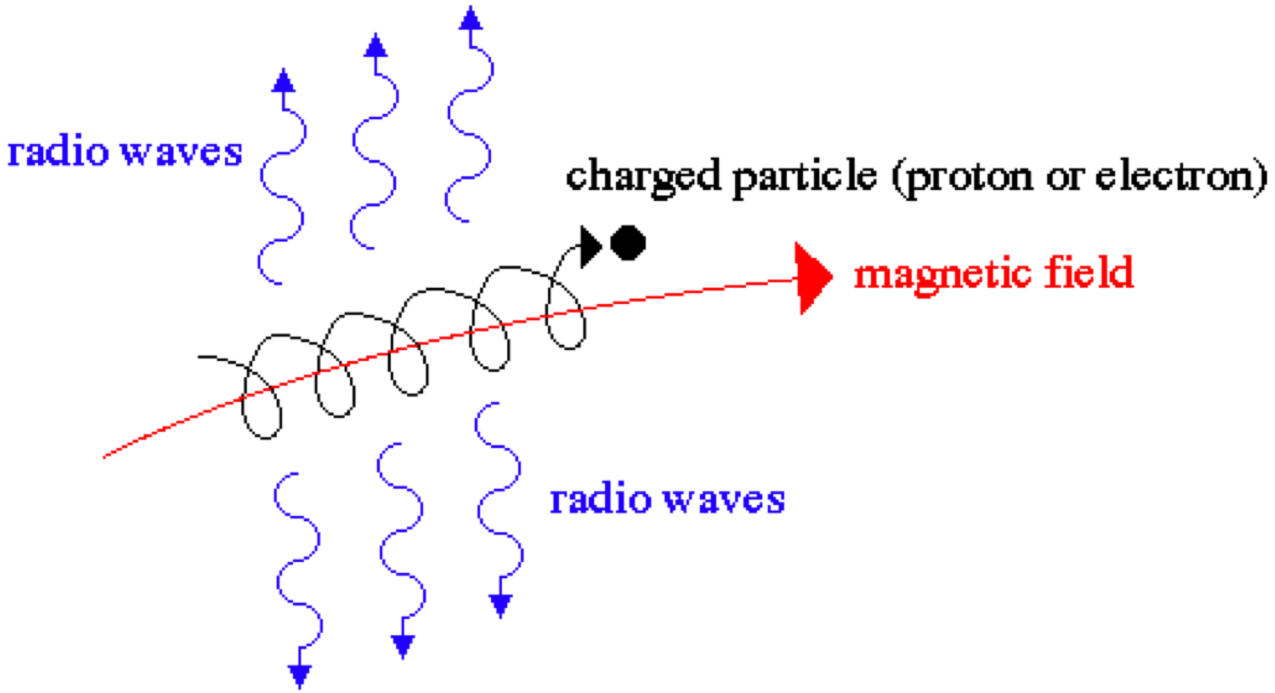
  Ghisellini et al. 2014

  E.g. CMB-induced quenching

Cooling Processes

Synchrotron Emission

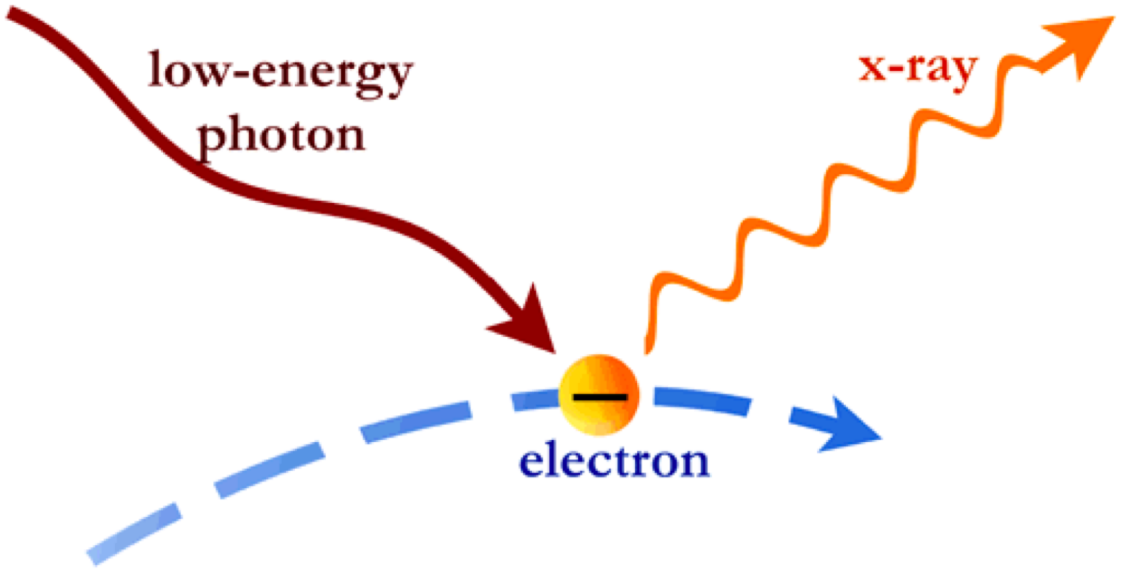
Radio



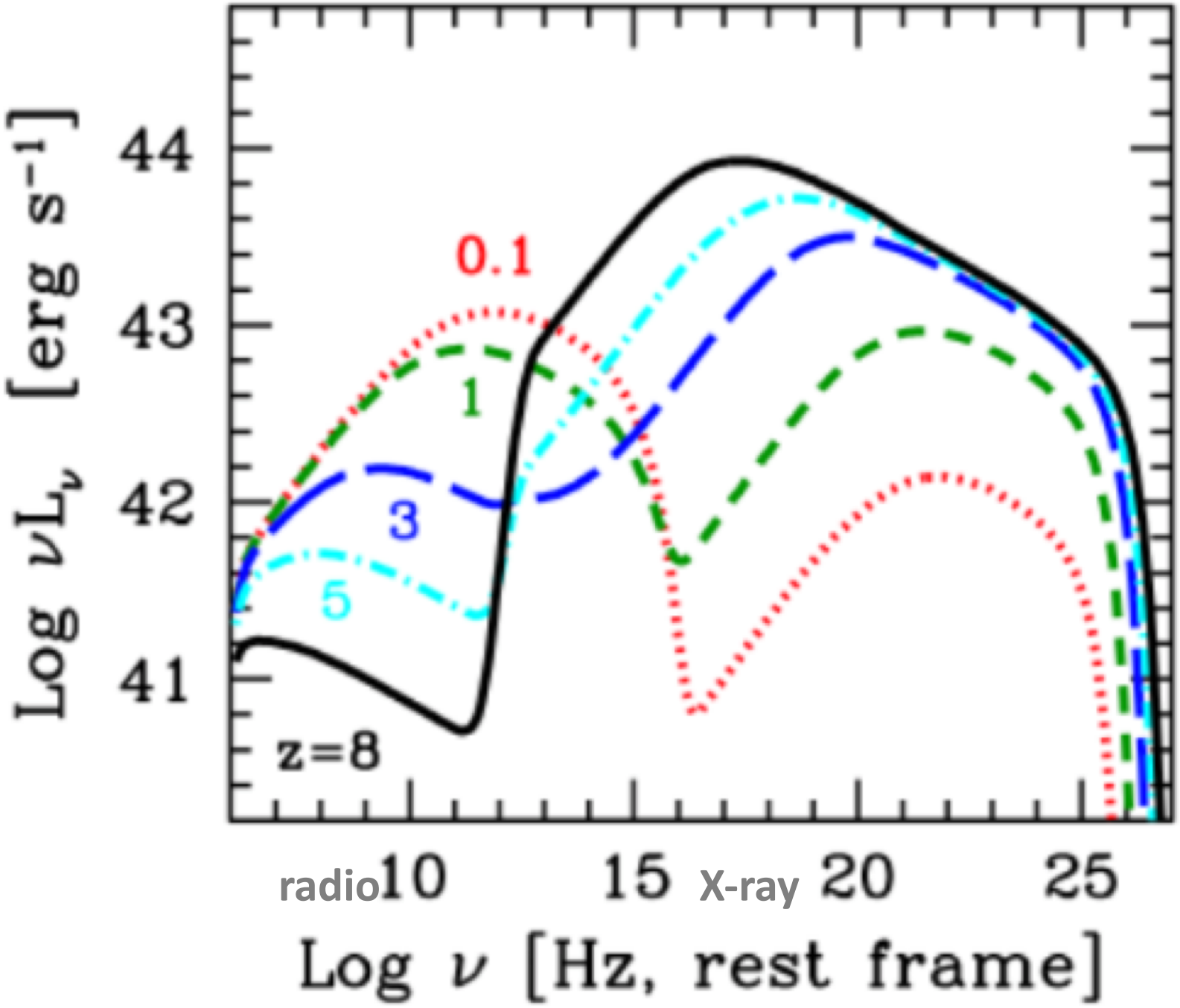
$$P_{sync} \propto U_B$$

Inverse Compton Scattering

X-ray



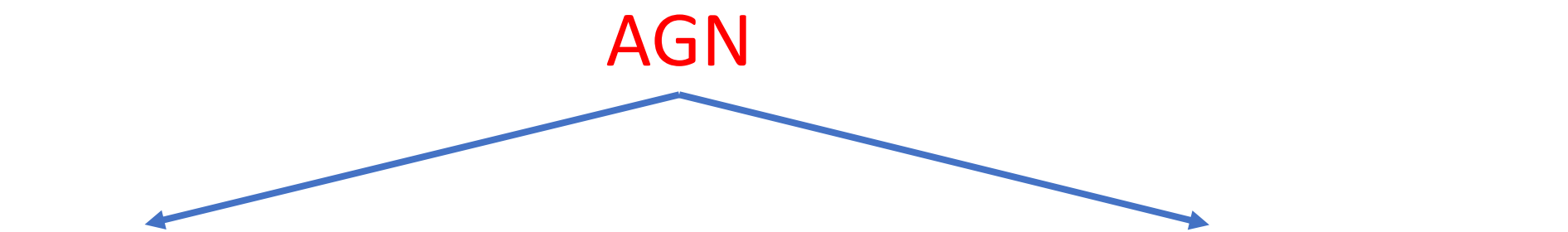
$$P_{IC} \propto U_{CMB} \propto (1+z)^4$$



Ghisellini et al. 2014

Target: 4C +63.20

a very rare radio galaxy at z > 4

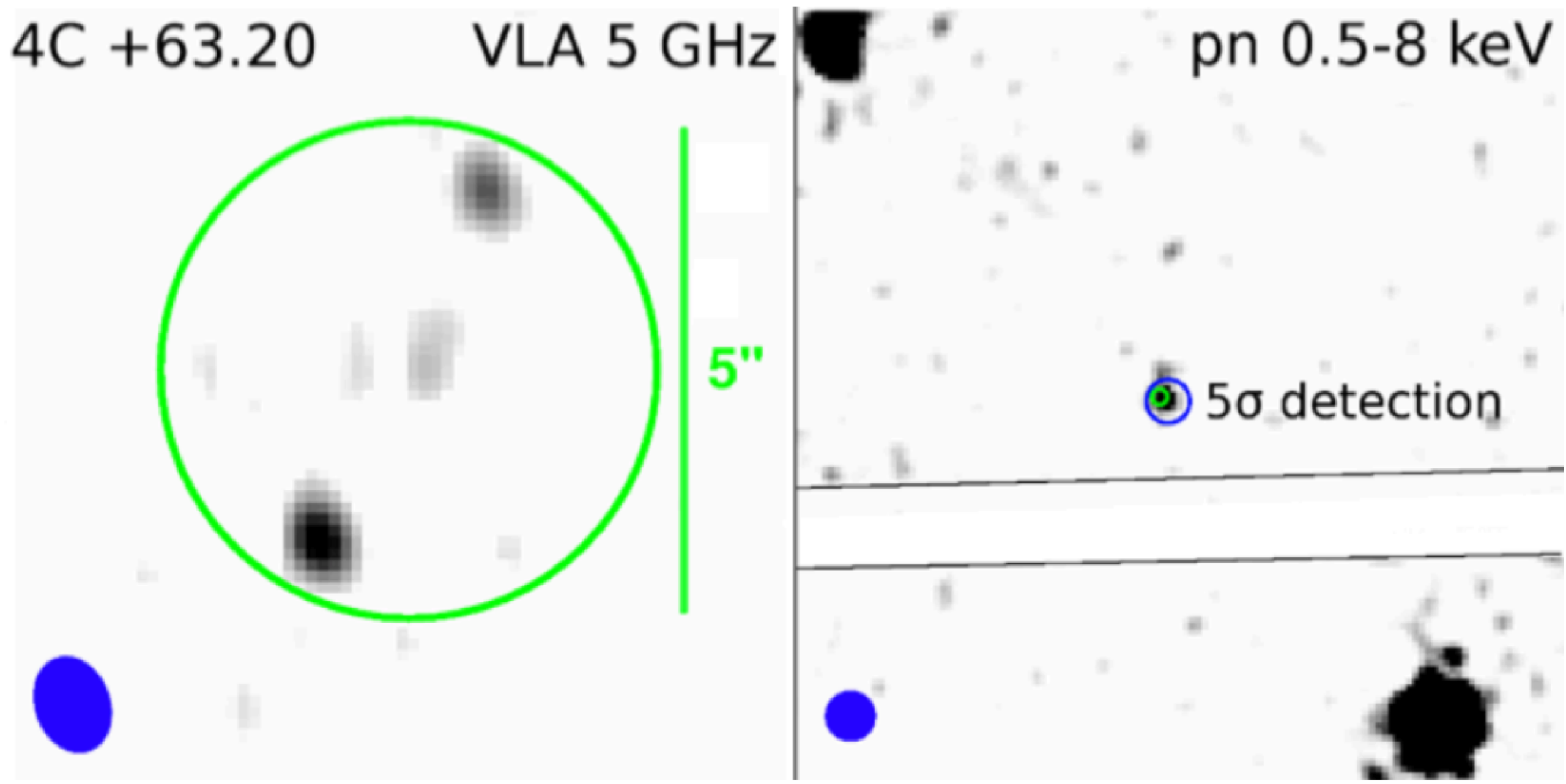


10% jetted

90% non-jetted
Intrinsically non-jetted
Misclassified as non-jetted

Model Predictions

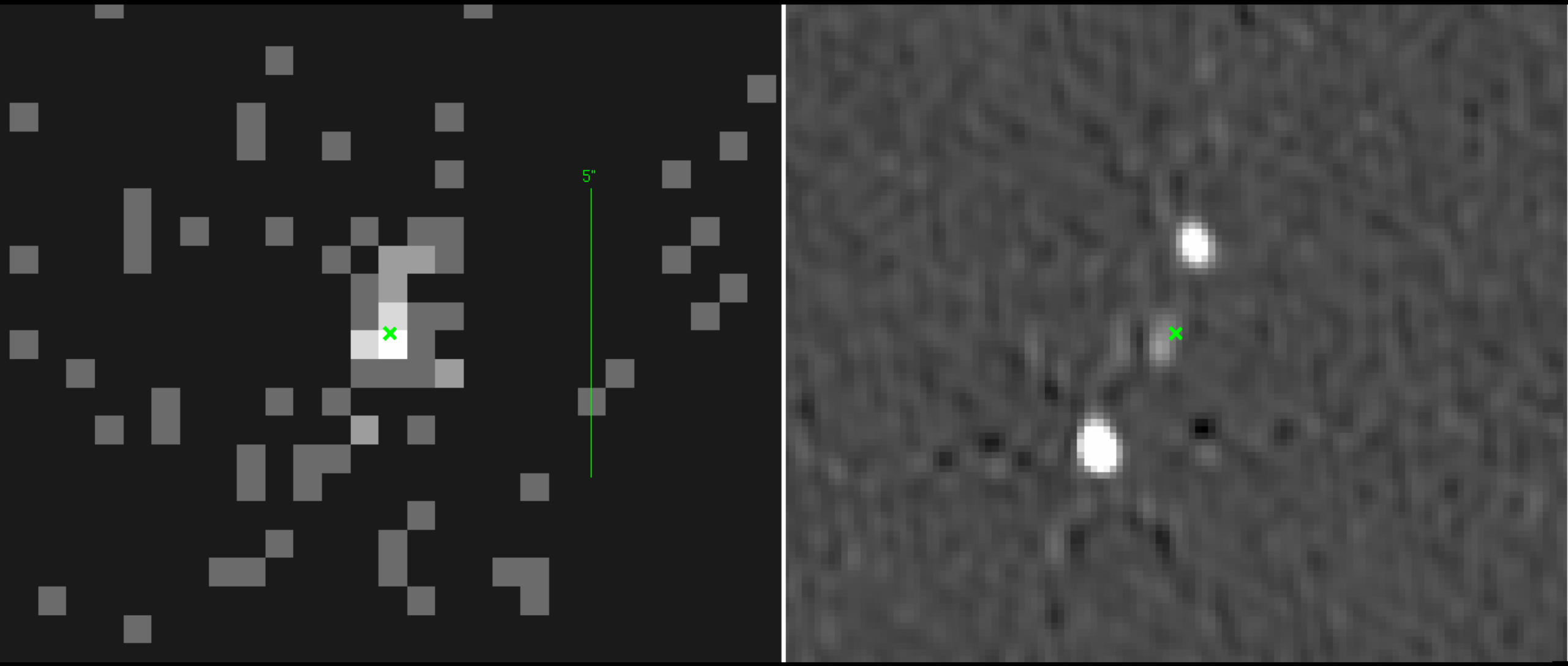
- The high-z, jetted AGN should become X-ray lobed sources at $\sim z > 3$
- The X-ray lobes must be more luminous than for its low-z counterpart



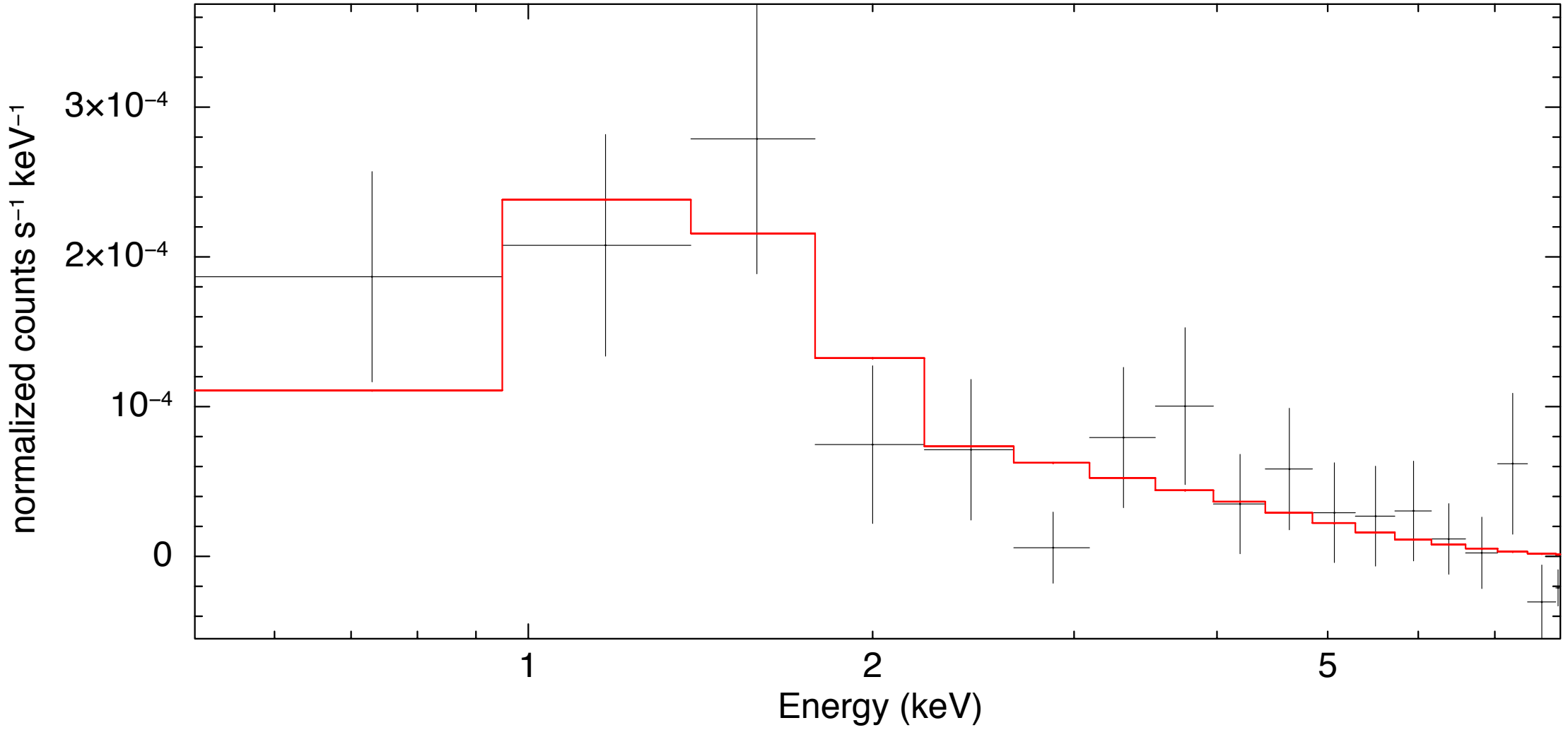
$Chandra\ PSF(<\ 0.5") < angular\ size\ of\ galaxy\ radio\ lobes\ (4.5") < XMM-pn\ PSF\ (5")$

X-ray

Radio



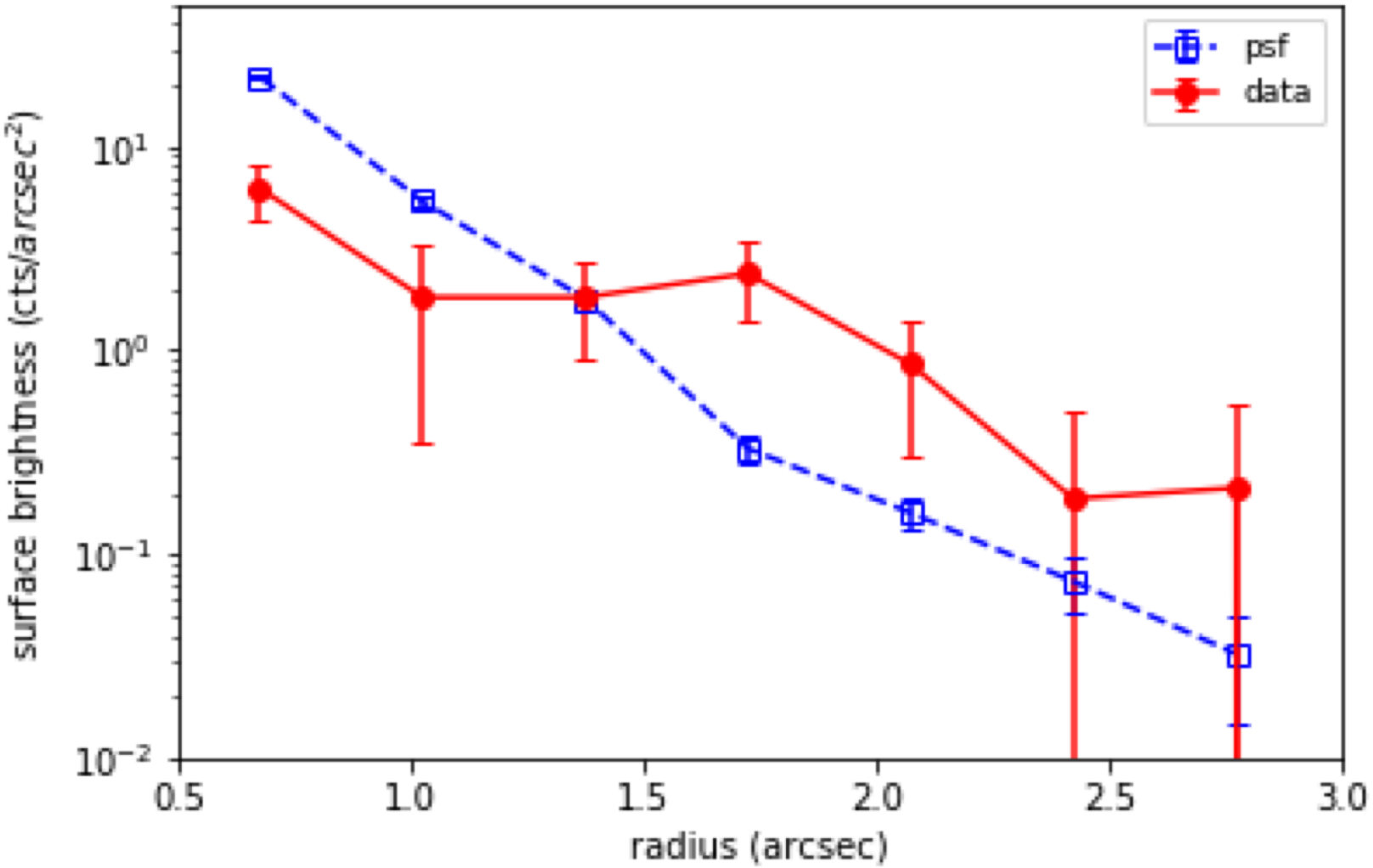
X (RA,Dec): 14:36:37.1880, +63:19:14.184



Total measured X-ray flux: 5.68 x 10^{-15} erg cm^{-2} s^{-1}

Does 4C +63.20 have extended X-ray emission?

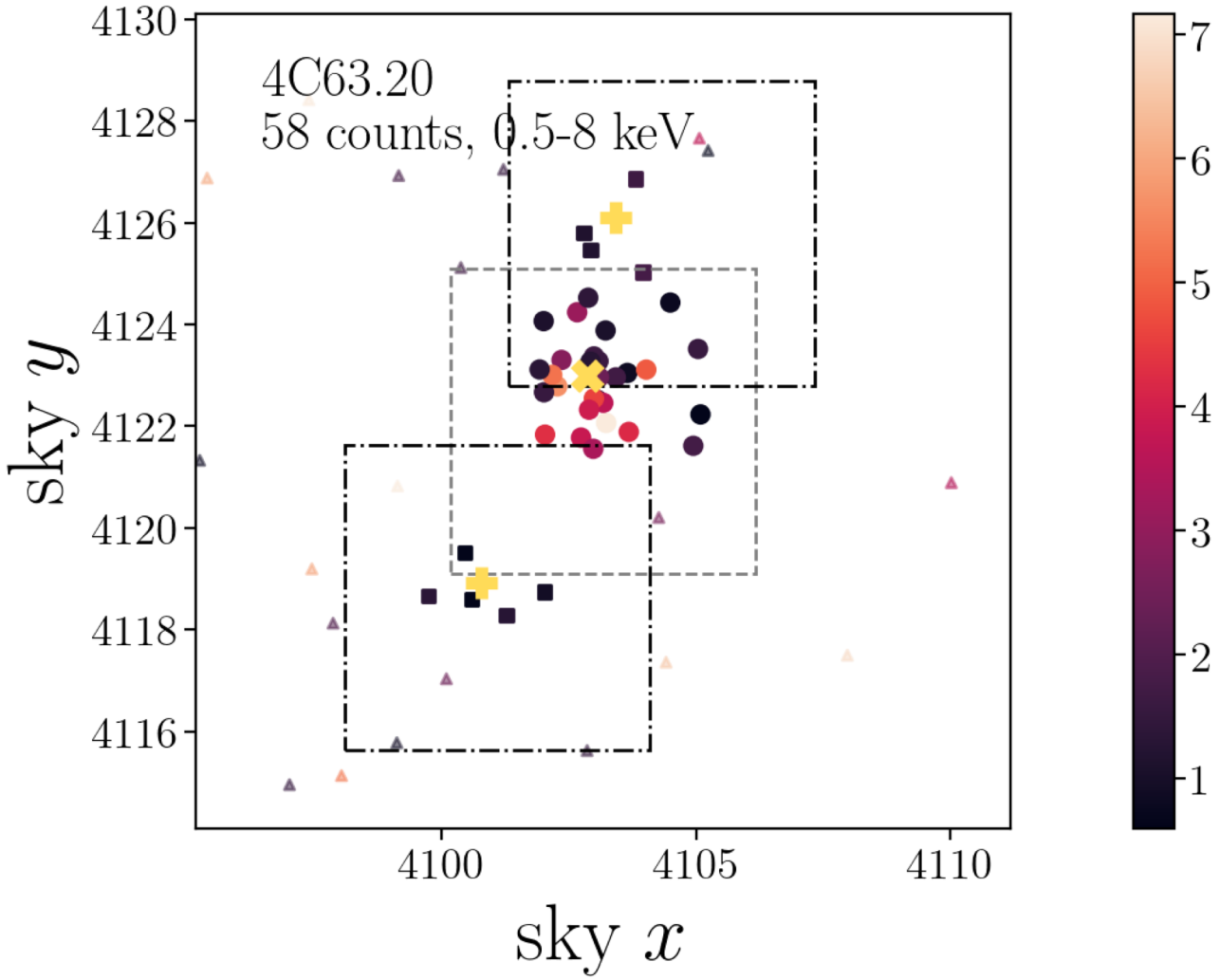
Method 1: radial surface brightness profiles



Does 4C +63.20 have extended X-ray emission?

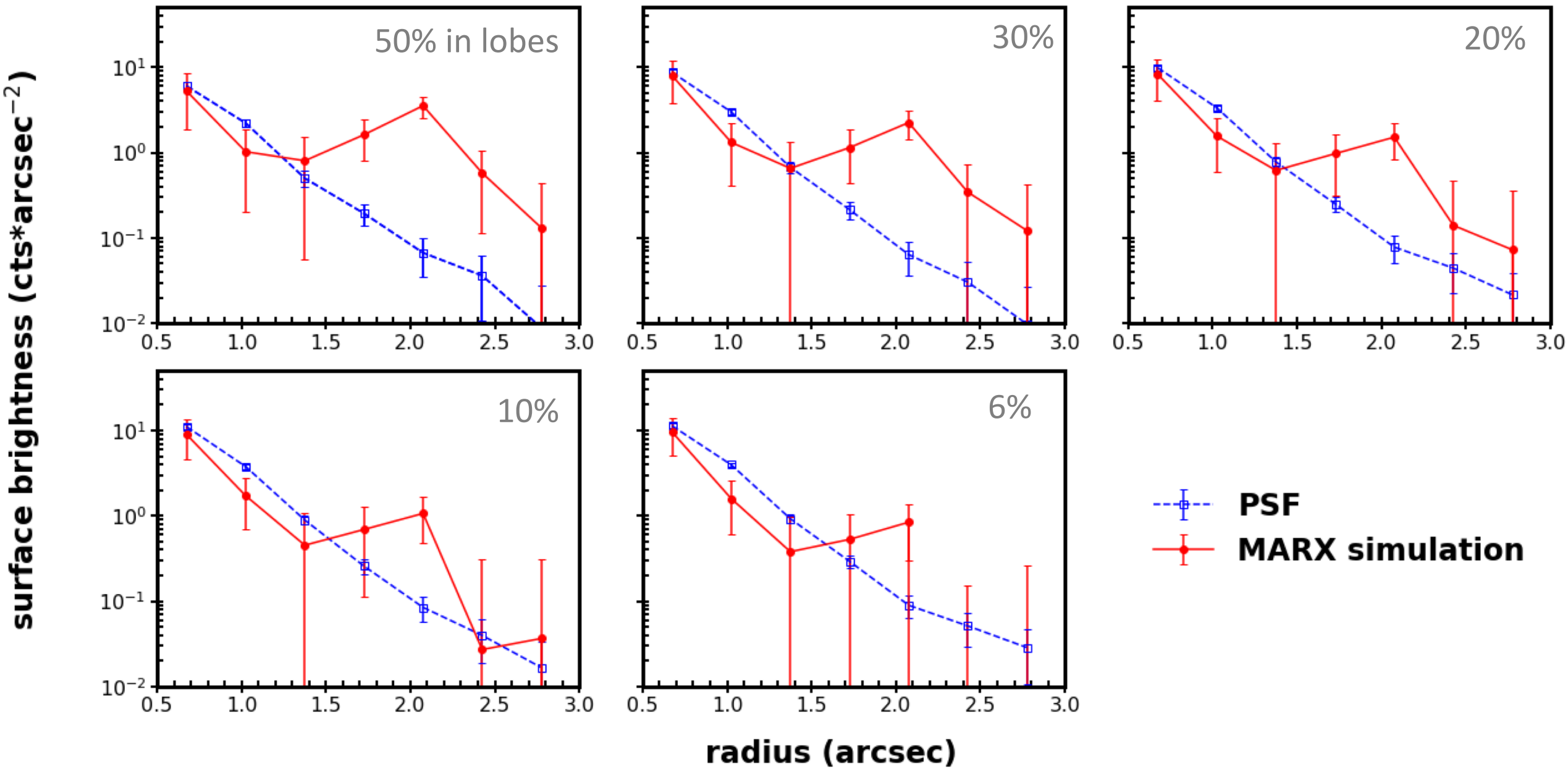
Method 2: BAYMAX (Foord et al. 2019)

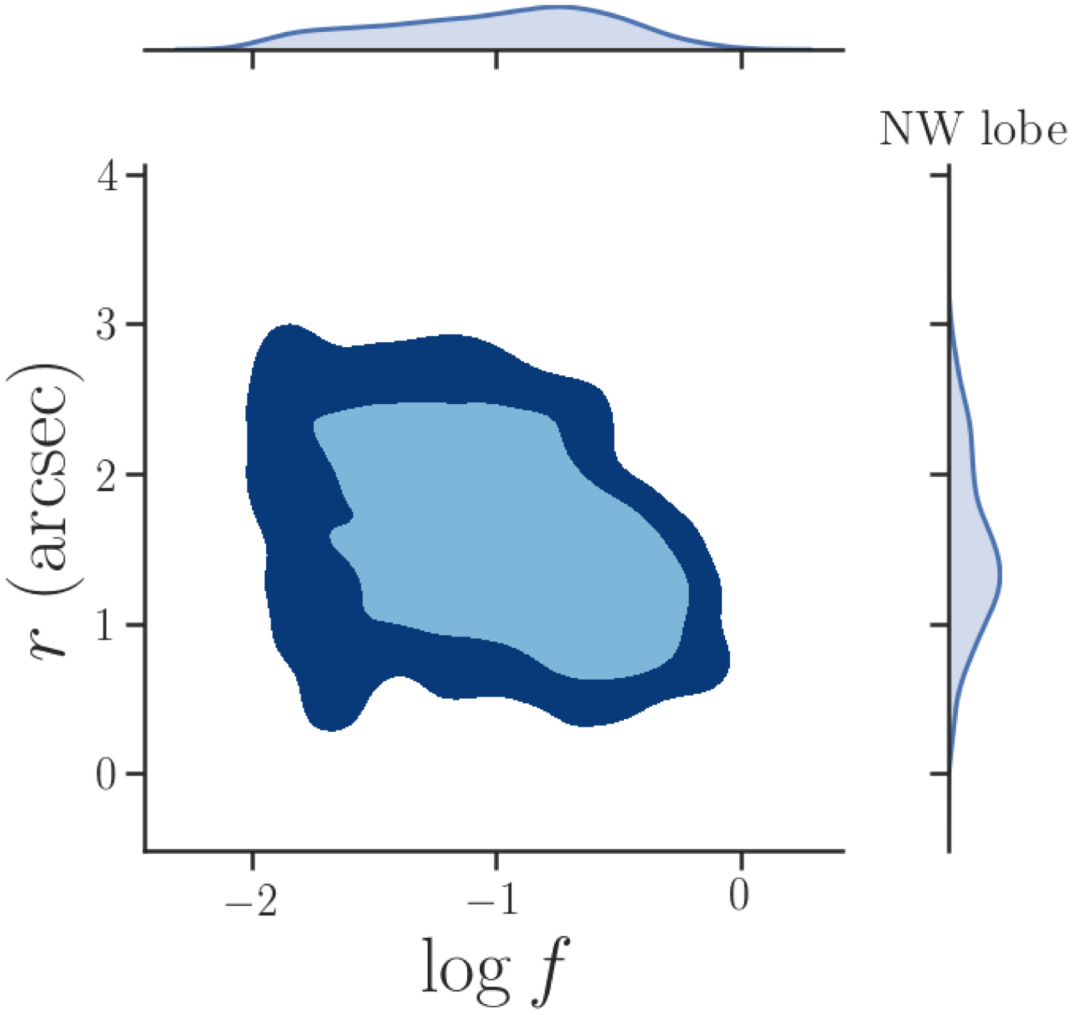
- Is 4C +63.20 consistent with single or multiple point sources?
- Favored triple point system with Bayes factor ~ 234
- False-positive test to determine strength of BF
  - Simulate 100 single point sources
  - 0/100 times did BAYMAX favor a triple point-source with a BF > 2

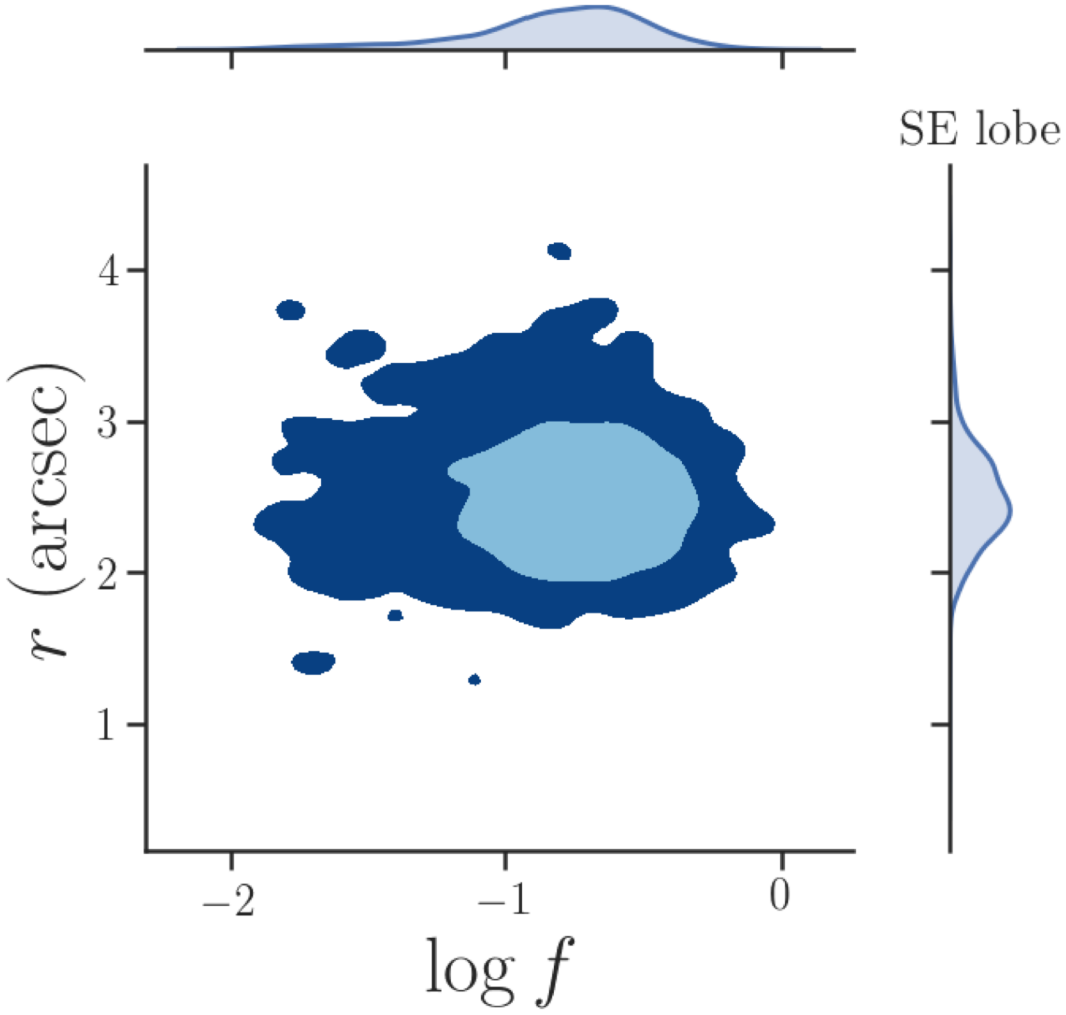


We have confirmed the presence of **extended X-ray emission** co-spatial with the radio lobes.

How much do the lobes contribute to the total measured X-ray flux?


50% in lobes
30%
20%
10%
6%
surface brightness (cts*arcsec^{-2})
radius (arcsec)
PSF
MARX simulation

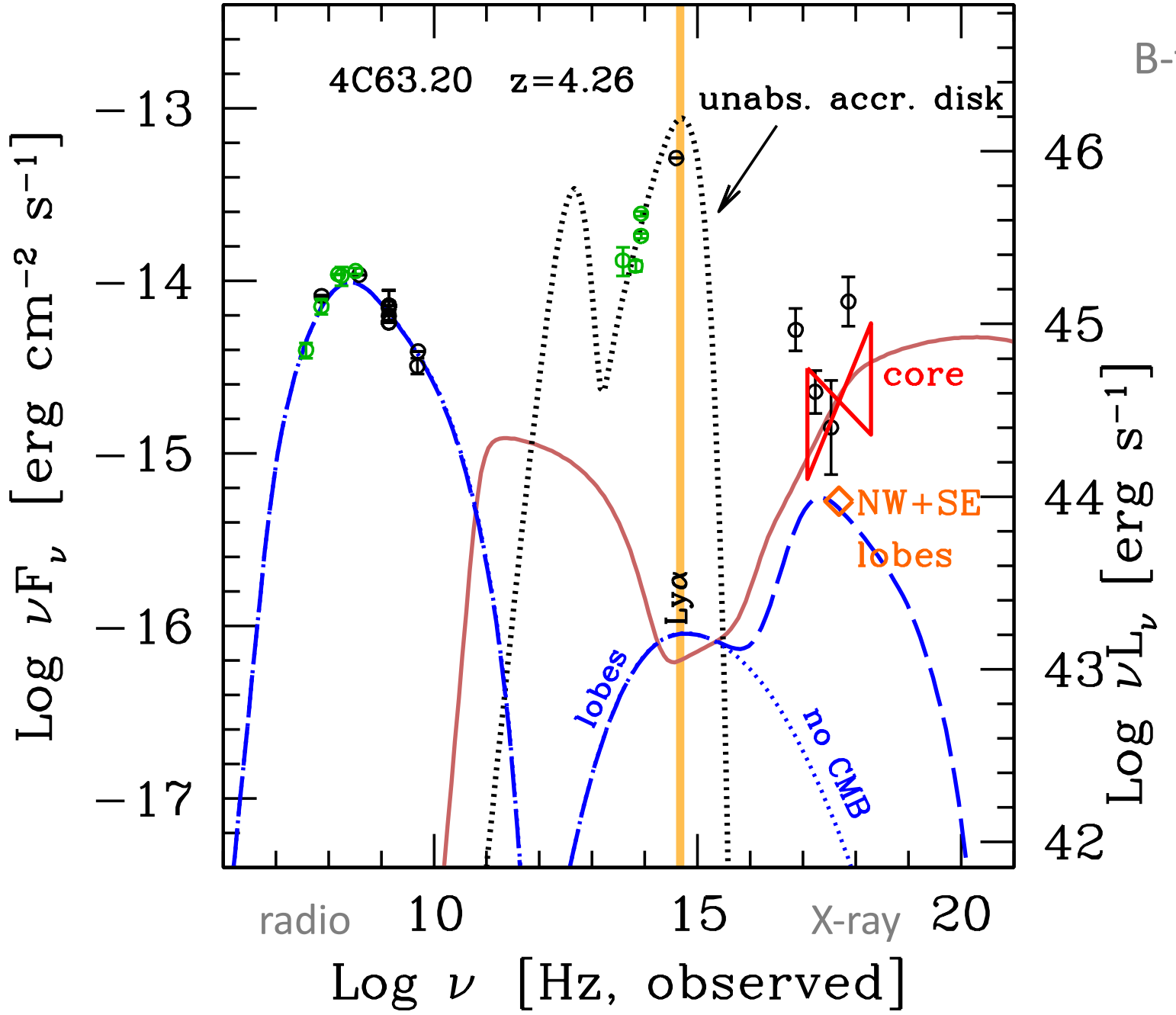




Northwest lobe: ~11%

Southeast lobe: 17%

B-field: 3.5 x 10^{-4} Gauss



Conclusions

- As expected from IC/CMB model, 4C +63.20 is extended
- At some level, expect this process to work because the CMB is present
- We are in the process of framing our result in the larger body of literature