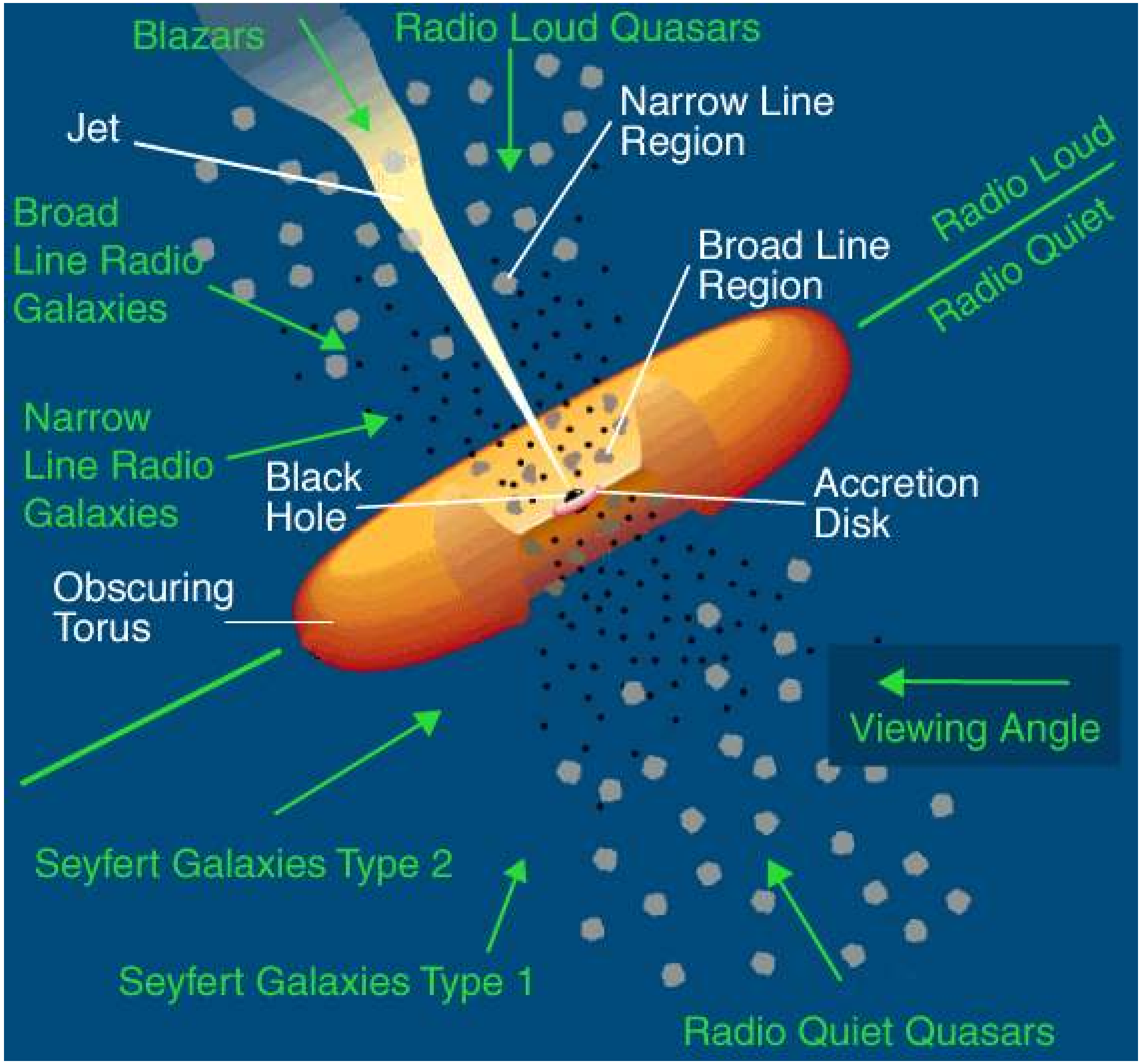
What can we do with radio galaxies from surveys?

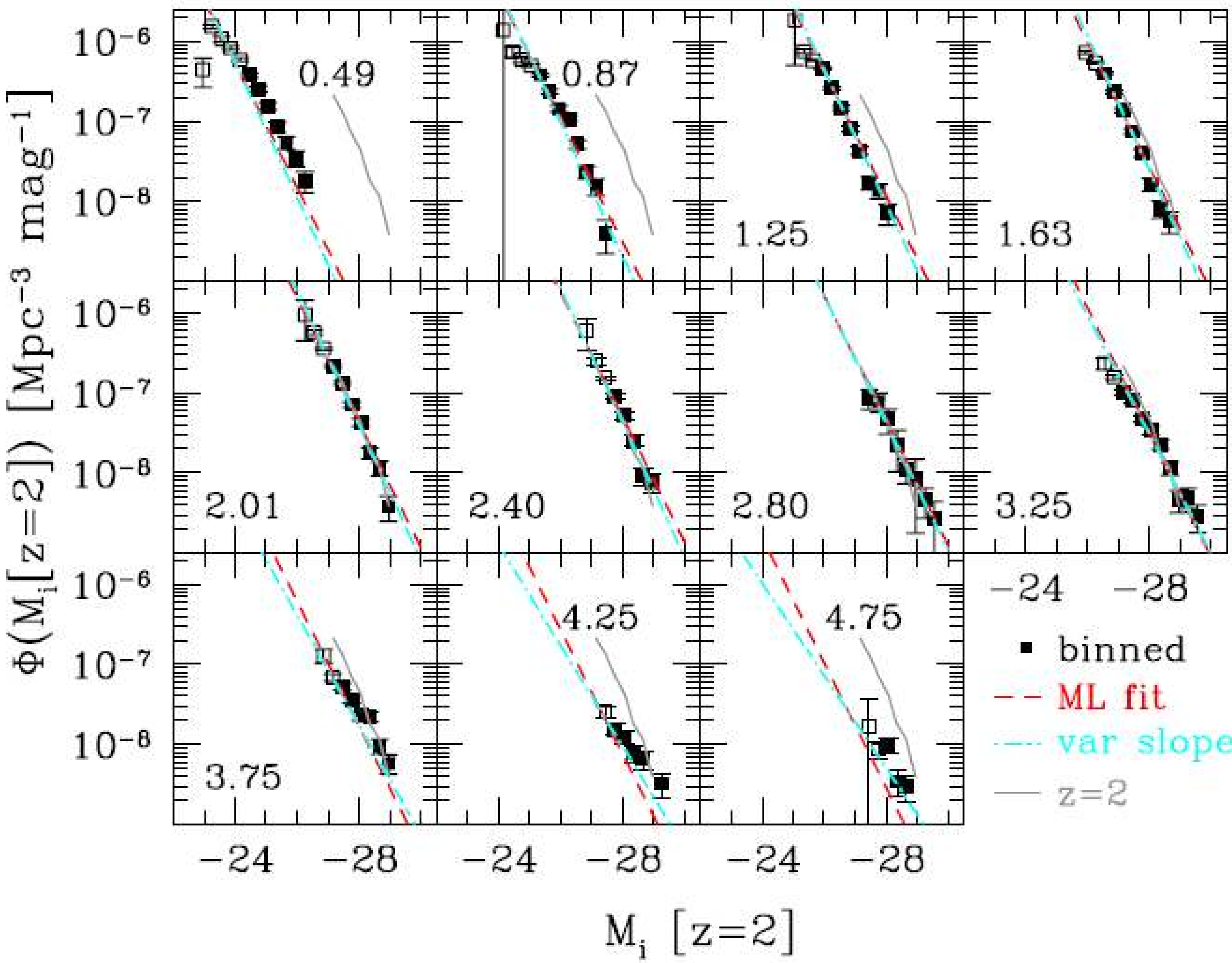
Martin Hardcastle

NAM, July 2015

RLAGN + RQAGN are different!



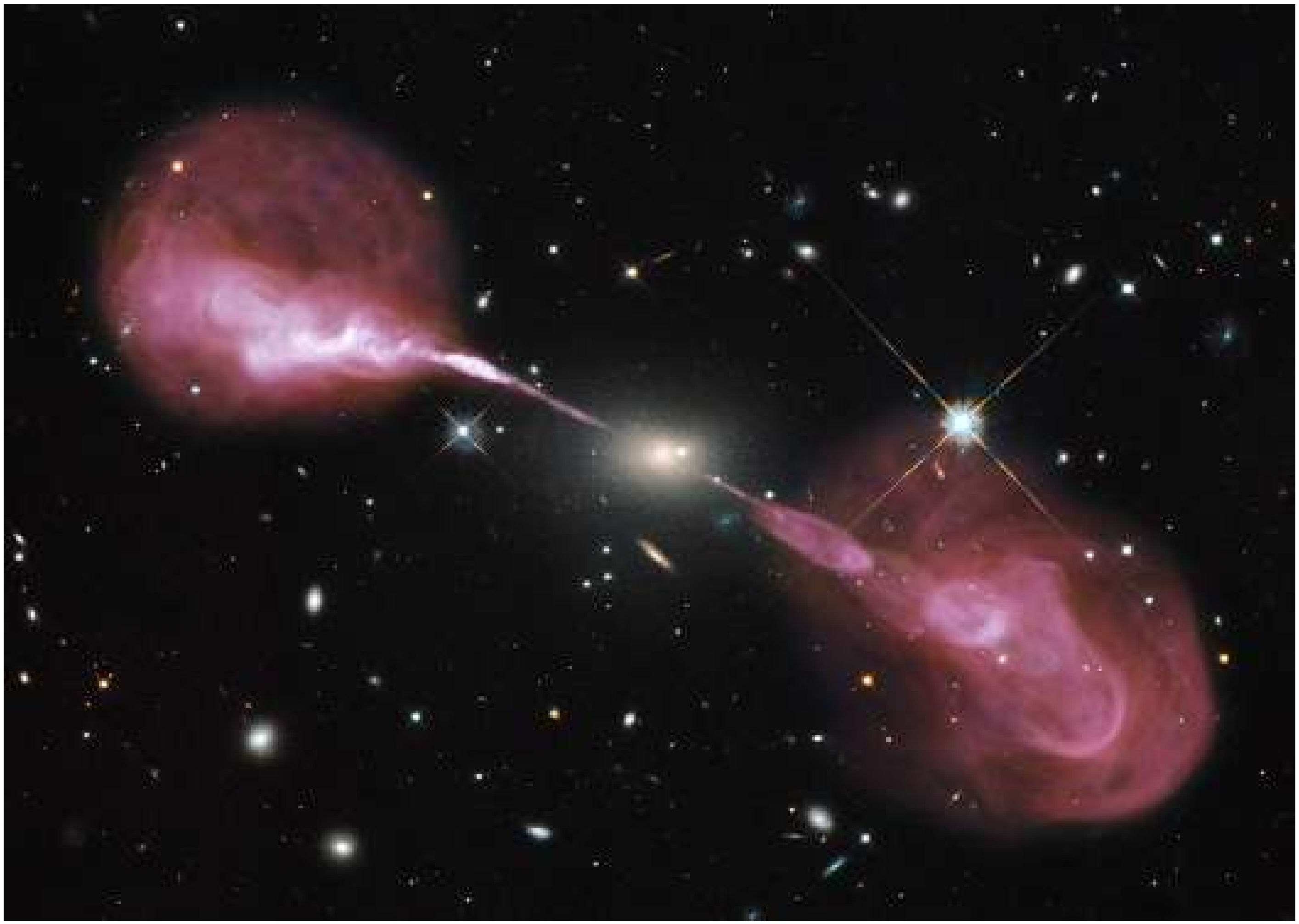
Constructing LFs makes sense for quasars



Optical quasar luminosity function (Richards +06)

(luminosity is the product of a RQAGN: one parameter, average over stochasticity)

RLAGN have life cycles!

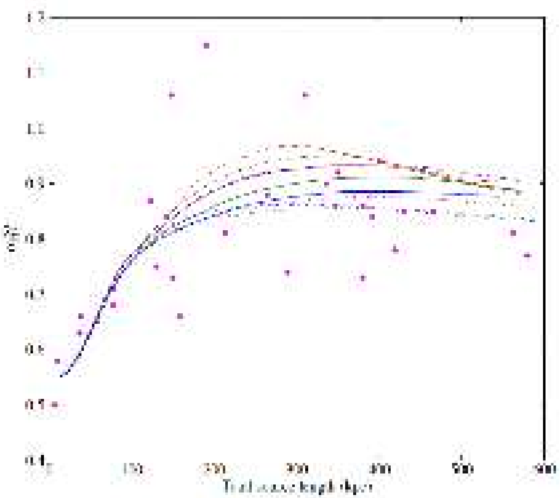


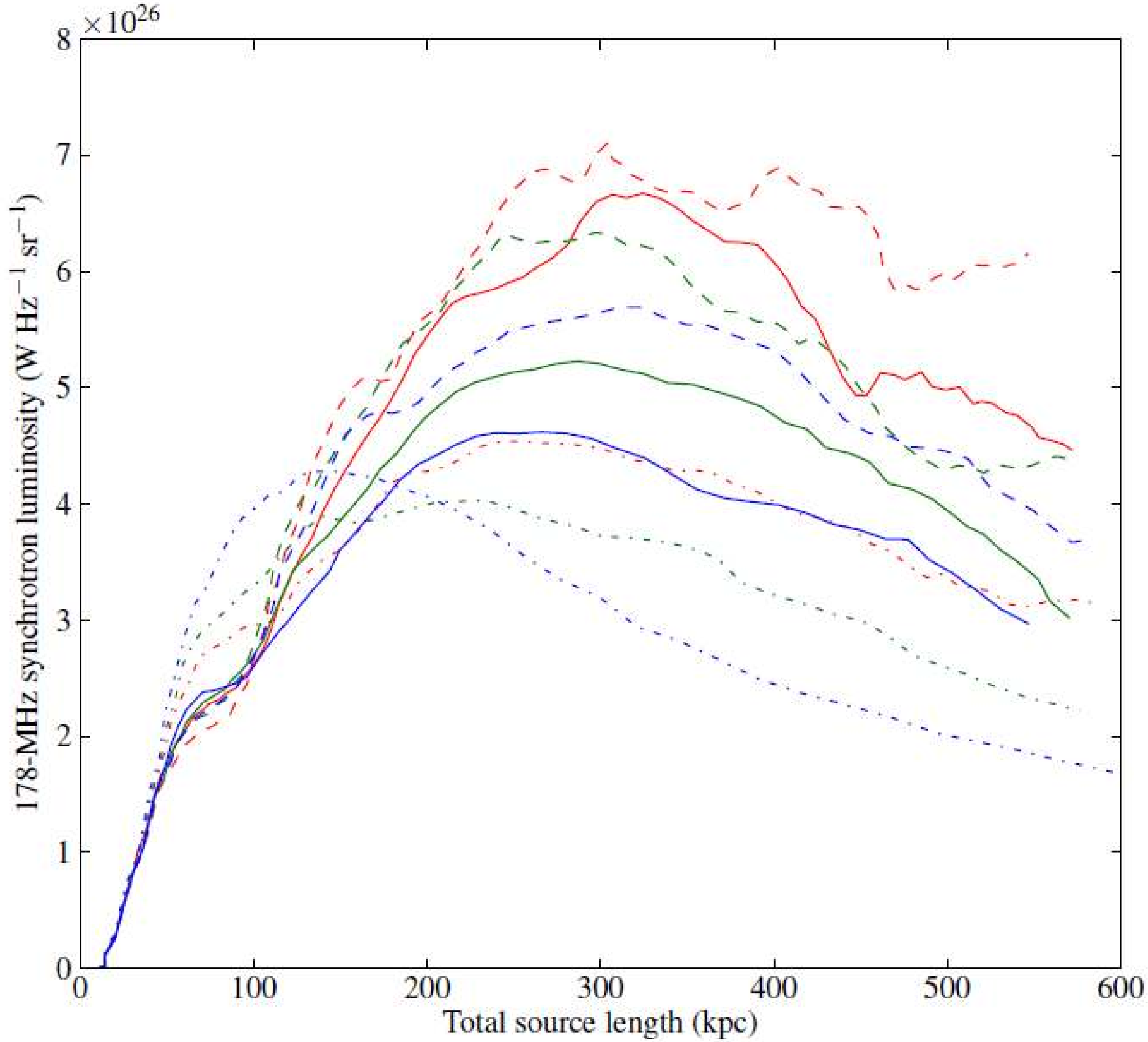
For one night only…

Radio power doesn't trace jet power

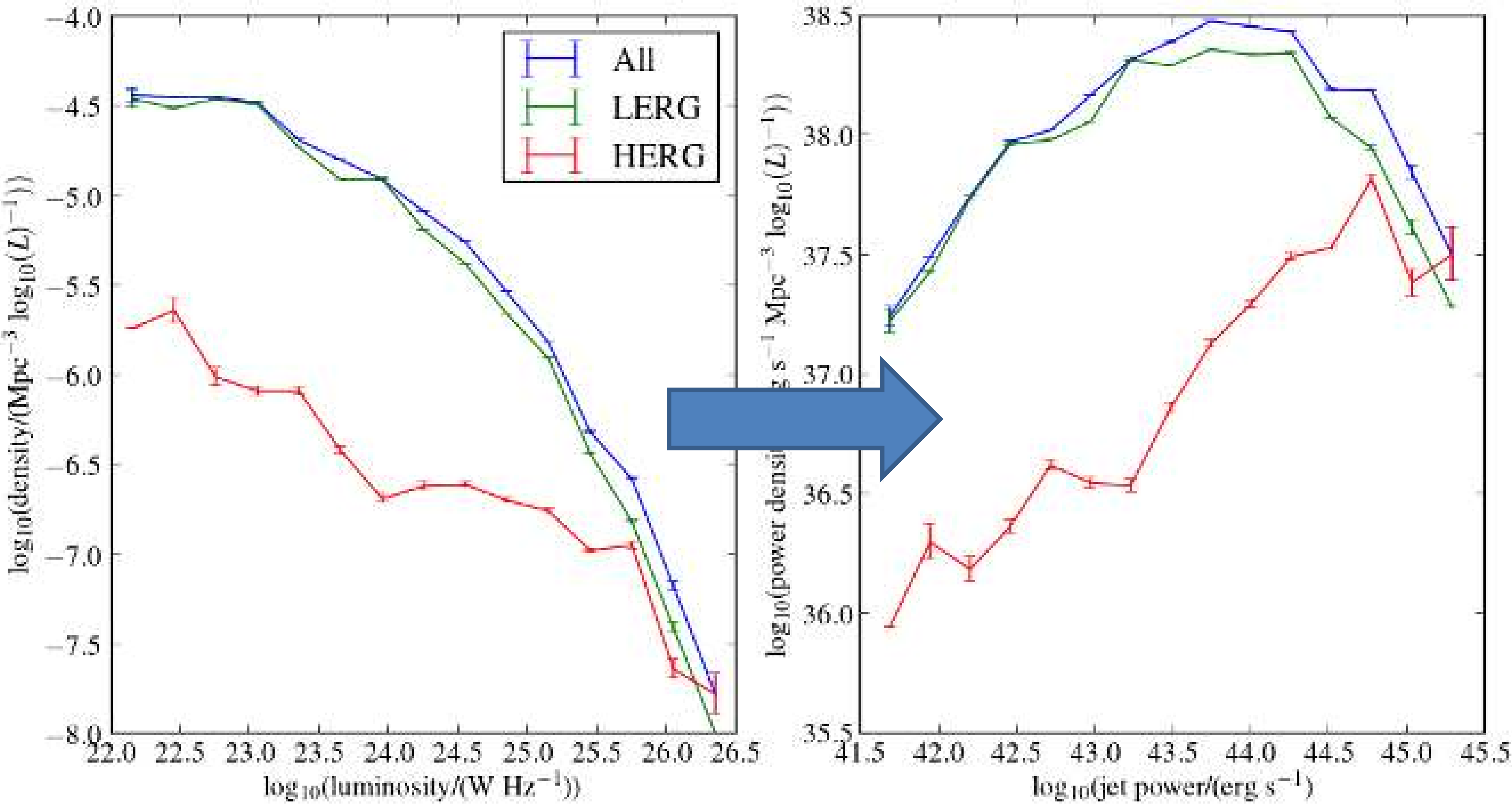
Simulated tracks in the P-D diagram for sources with Q = 10^{45} erg/s in a range of environments (red = rich, green = medium, blue = poor).

Radiative losses are taken into account. Adapted from H+K 14





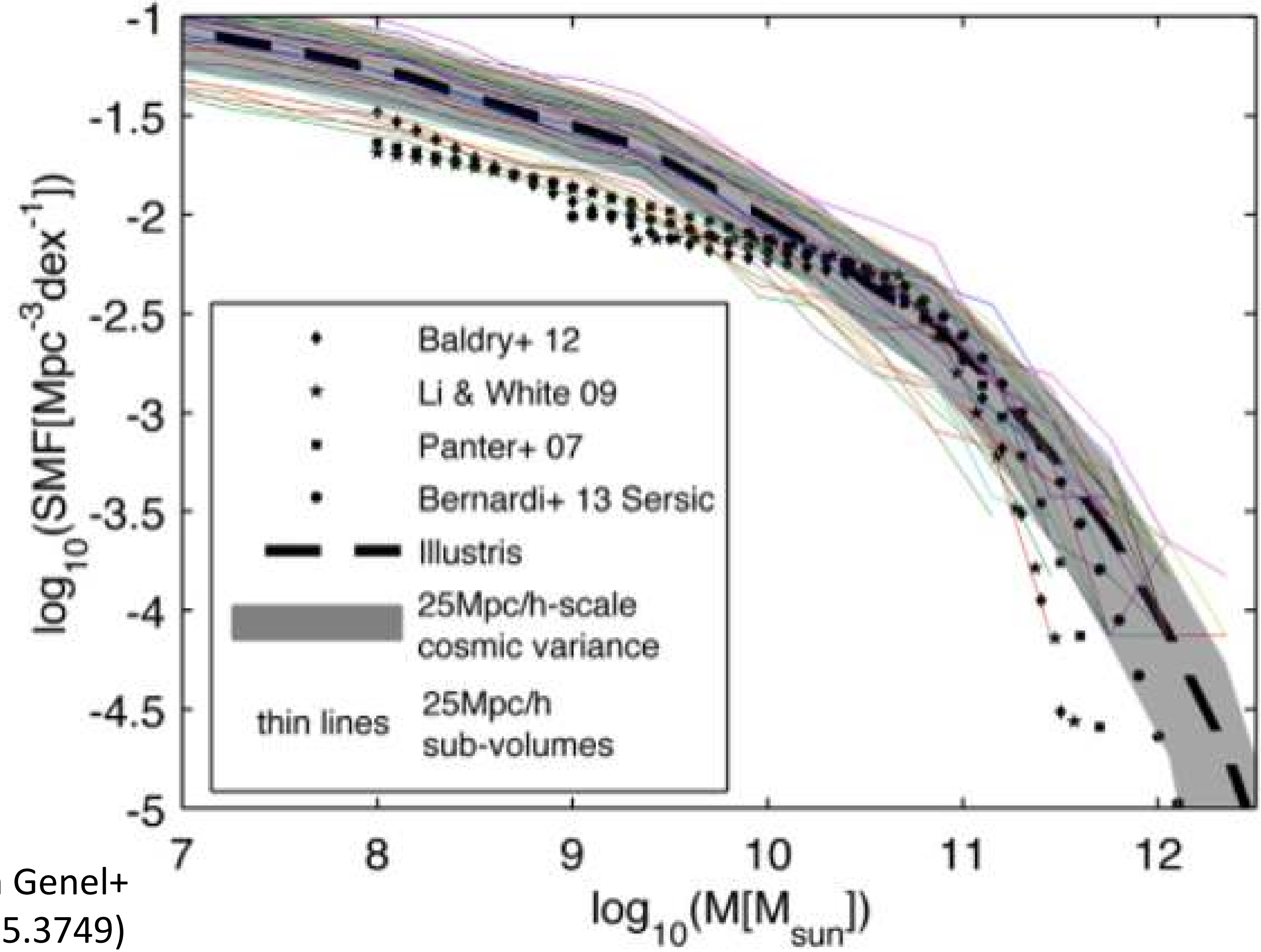
So you can’t do this:



Best + Heckman 12

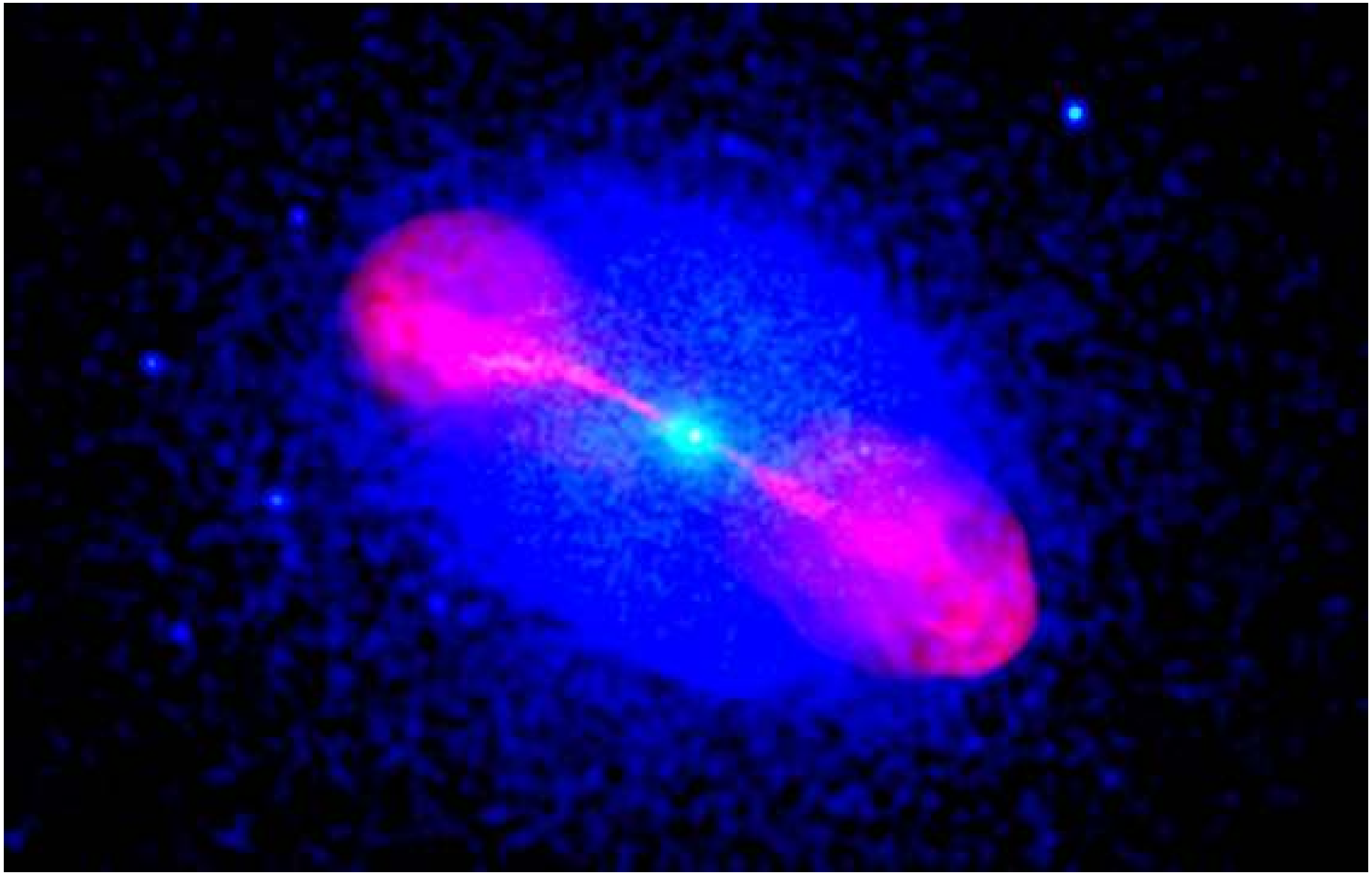
… power function, with ‘bolometric correction’ using Willott+ 99

Feedback, or, why we care



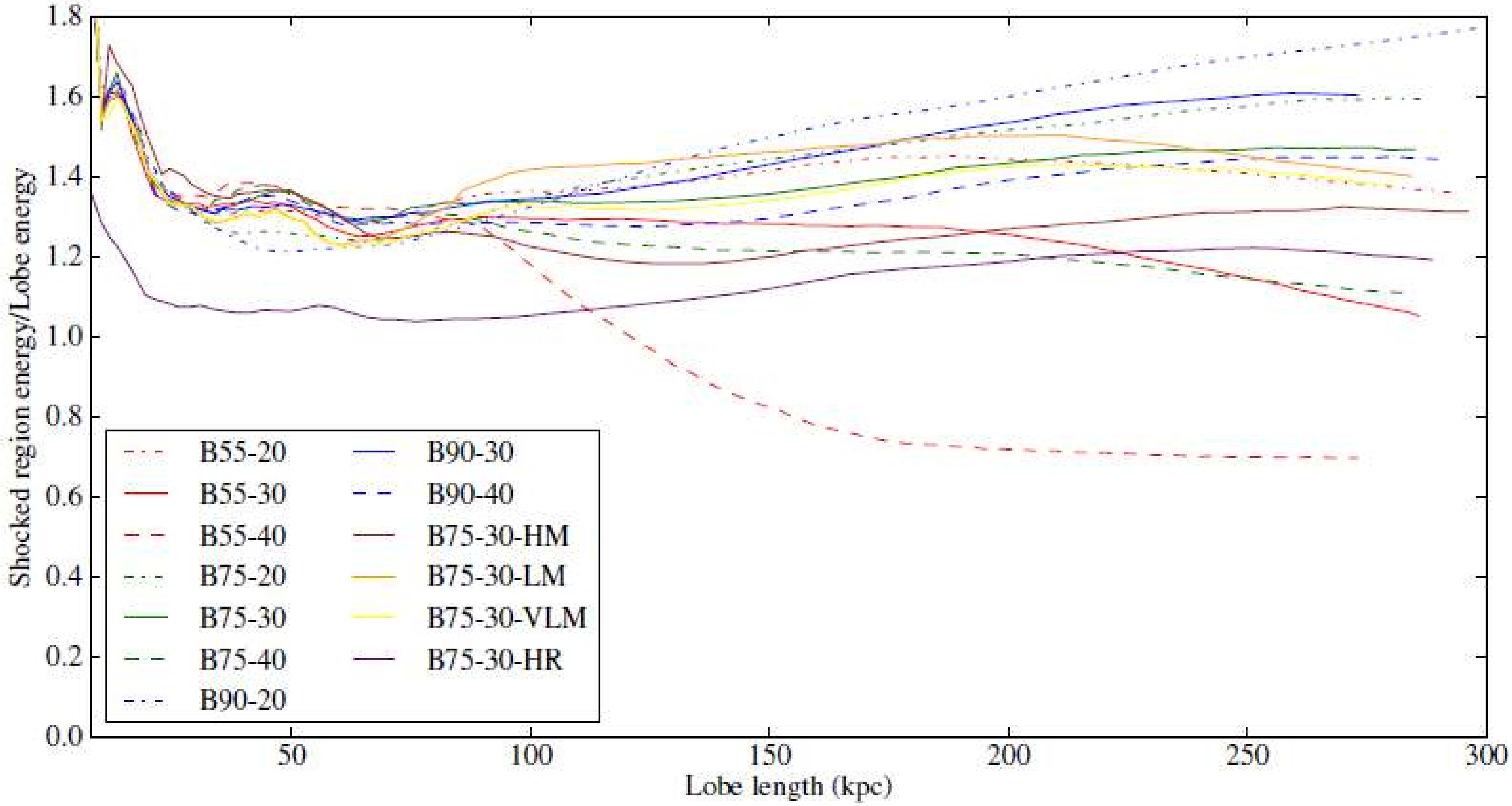
(Figure from Genel+ 14 arxiv:1405.3749)

Radio-loud AGN feedback



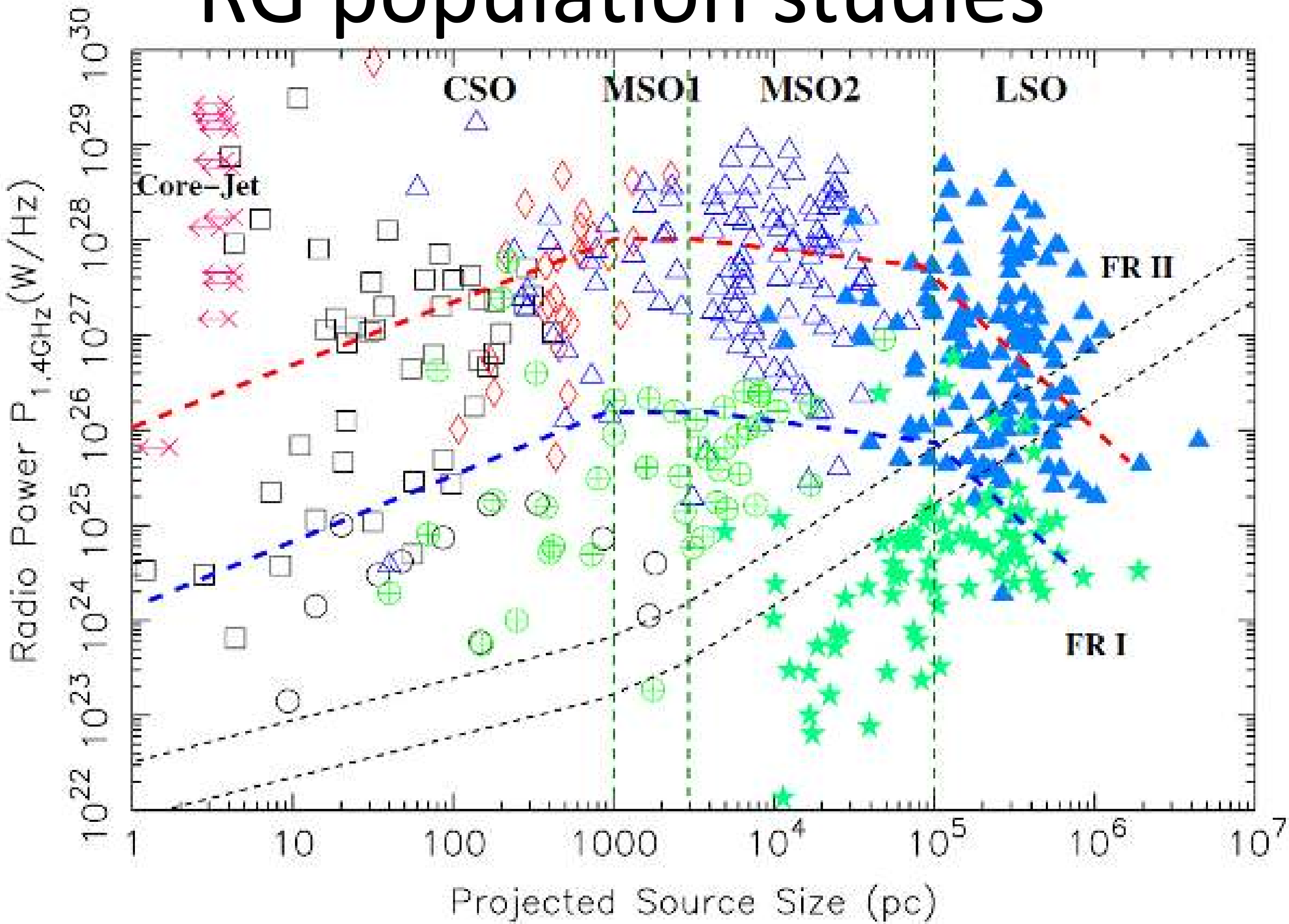
Nulsen+ 05; Hardcastle & Croston 10

RL AGN: energy input understood



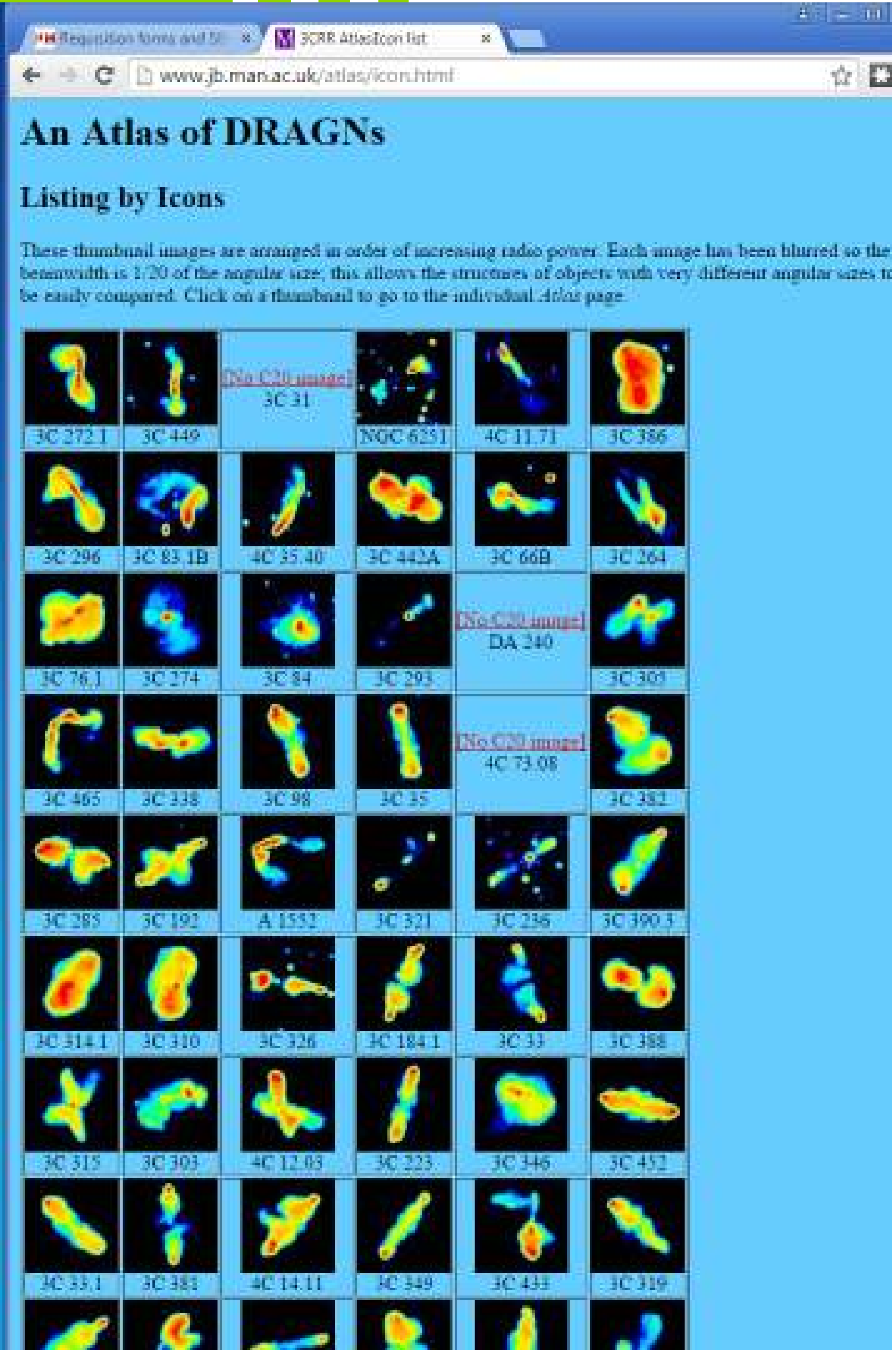
(Hardcastle + Krause 13, 14)… but RL AGN populations aren't.
(For RQAGN it is arguably the other way round.)

RG population studies



An + Baan 12

Note *really* small sample sizes!

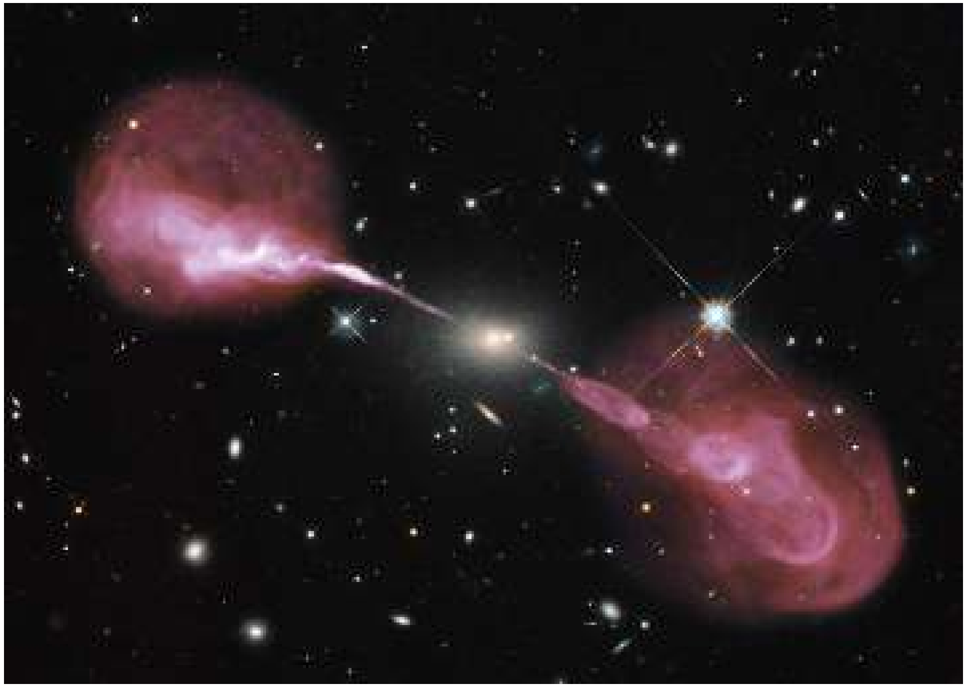


Small samples

- Really hard to get well-imaged, identified, complete samples of RLAGN!
- (Those that exist have whole websites dedicated to them)

Benefits of new surveys

1) Sensitivity – obvious
2) Fidelity – needs some explaining?



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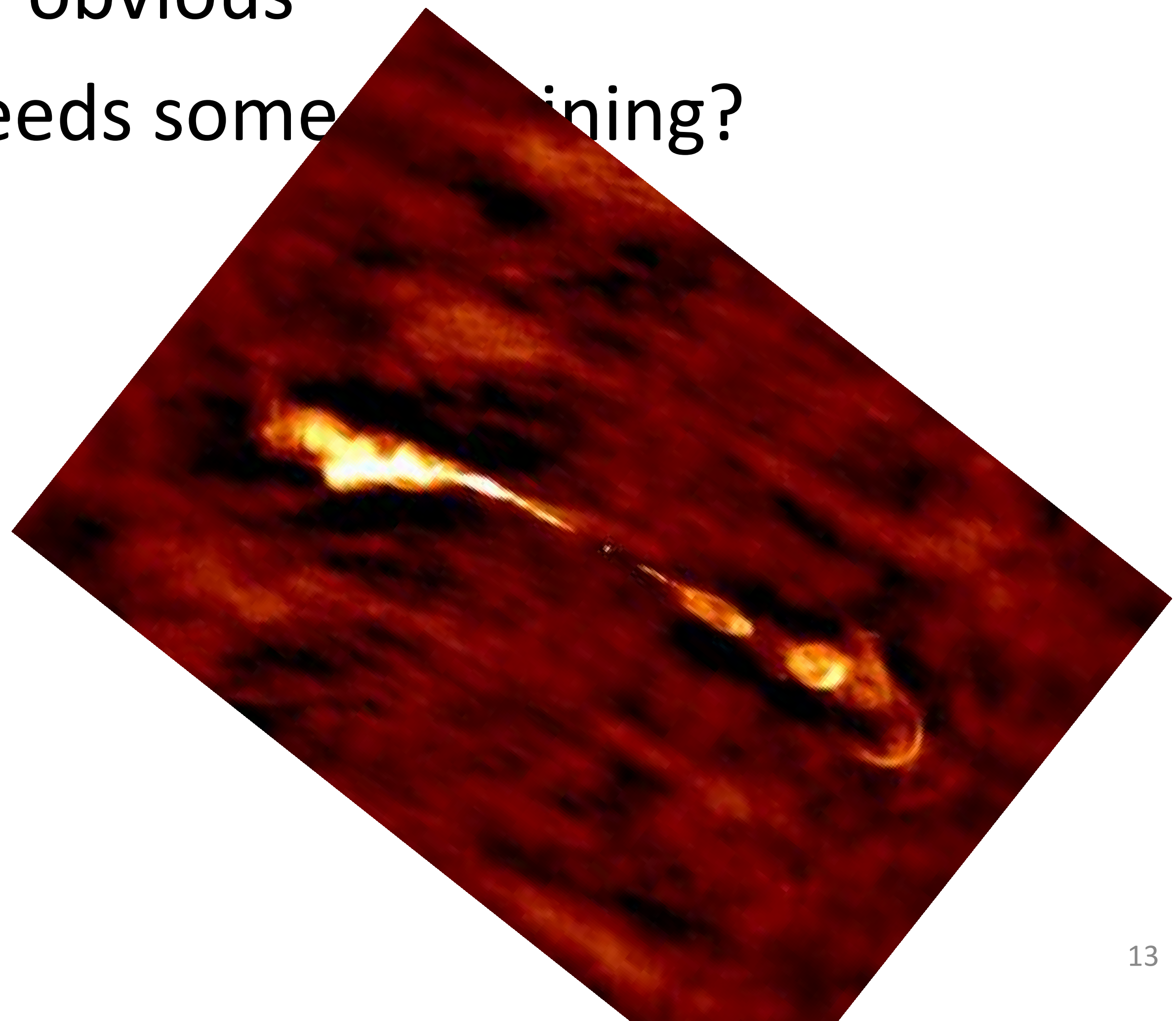
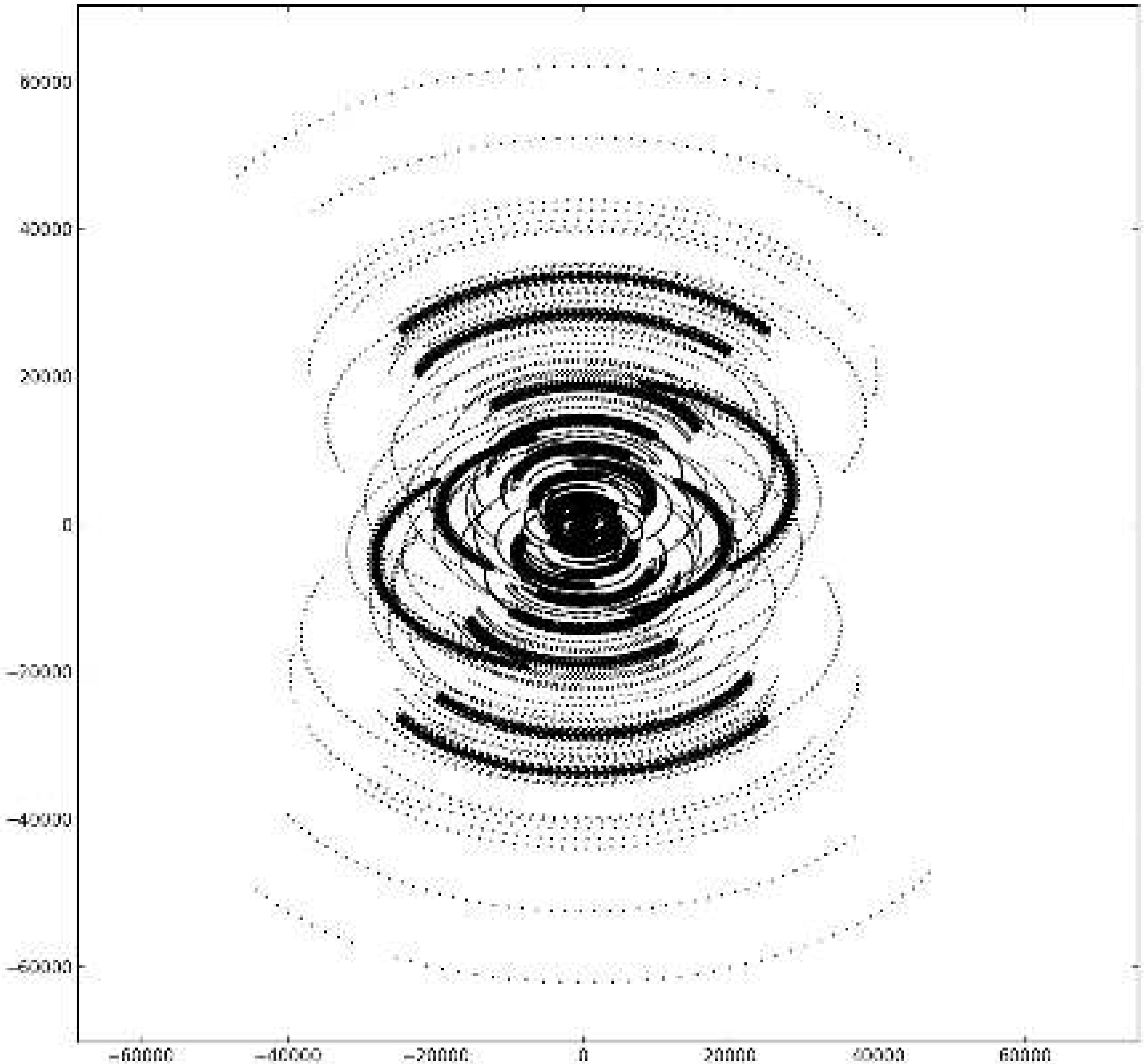


Benefits of new surveys

u,v (lambda)



Benefits of new surveys

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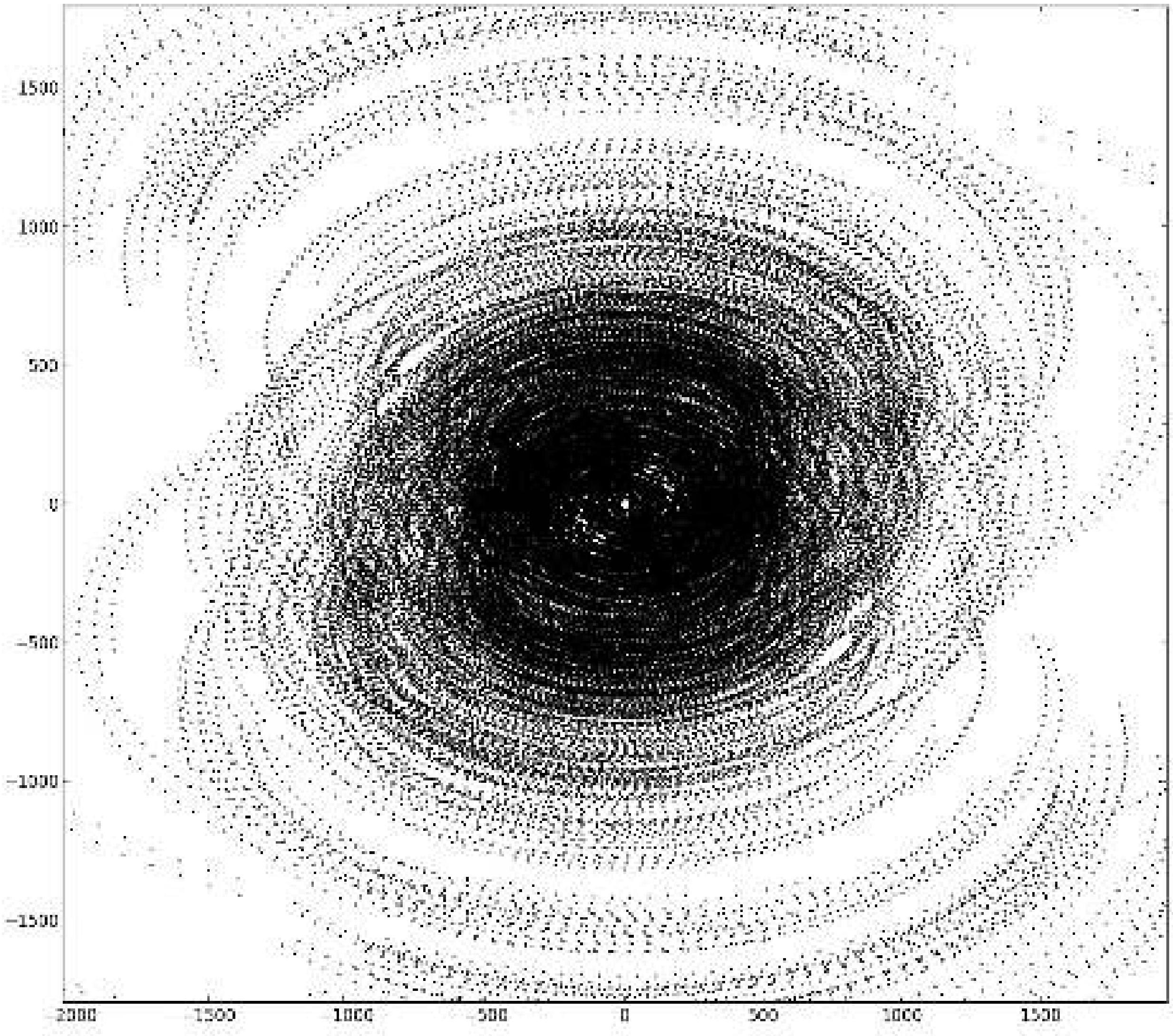
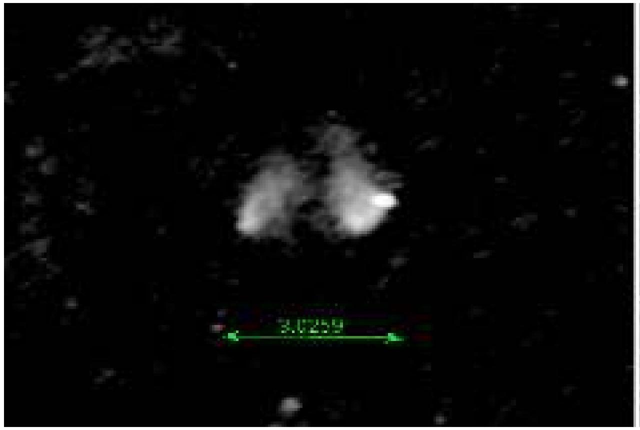
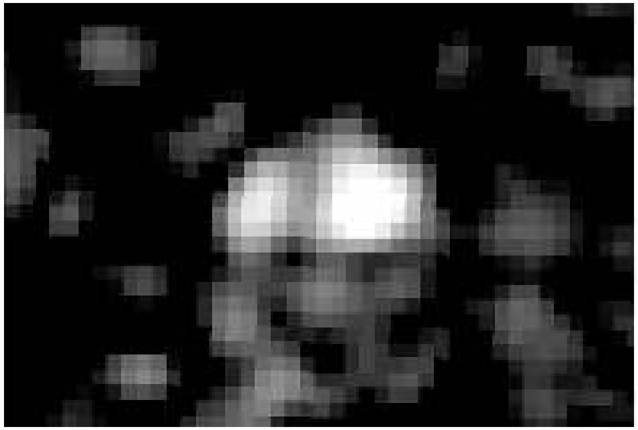


Fidelity in practice



LOFAR

FIRST (VLA B)

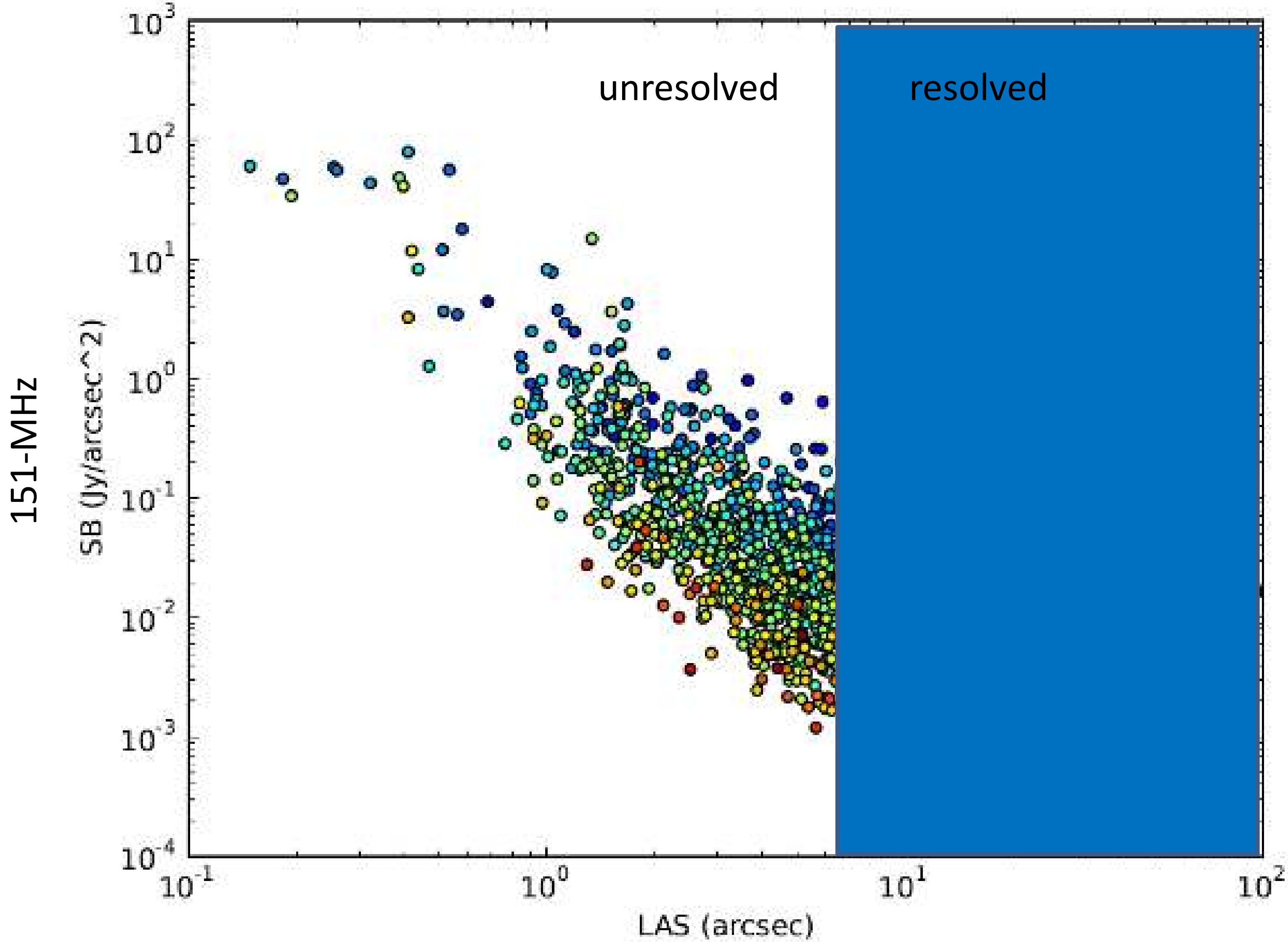


NVSS (VLA D)

Fidelity

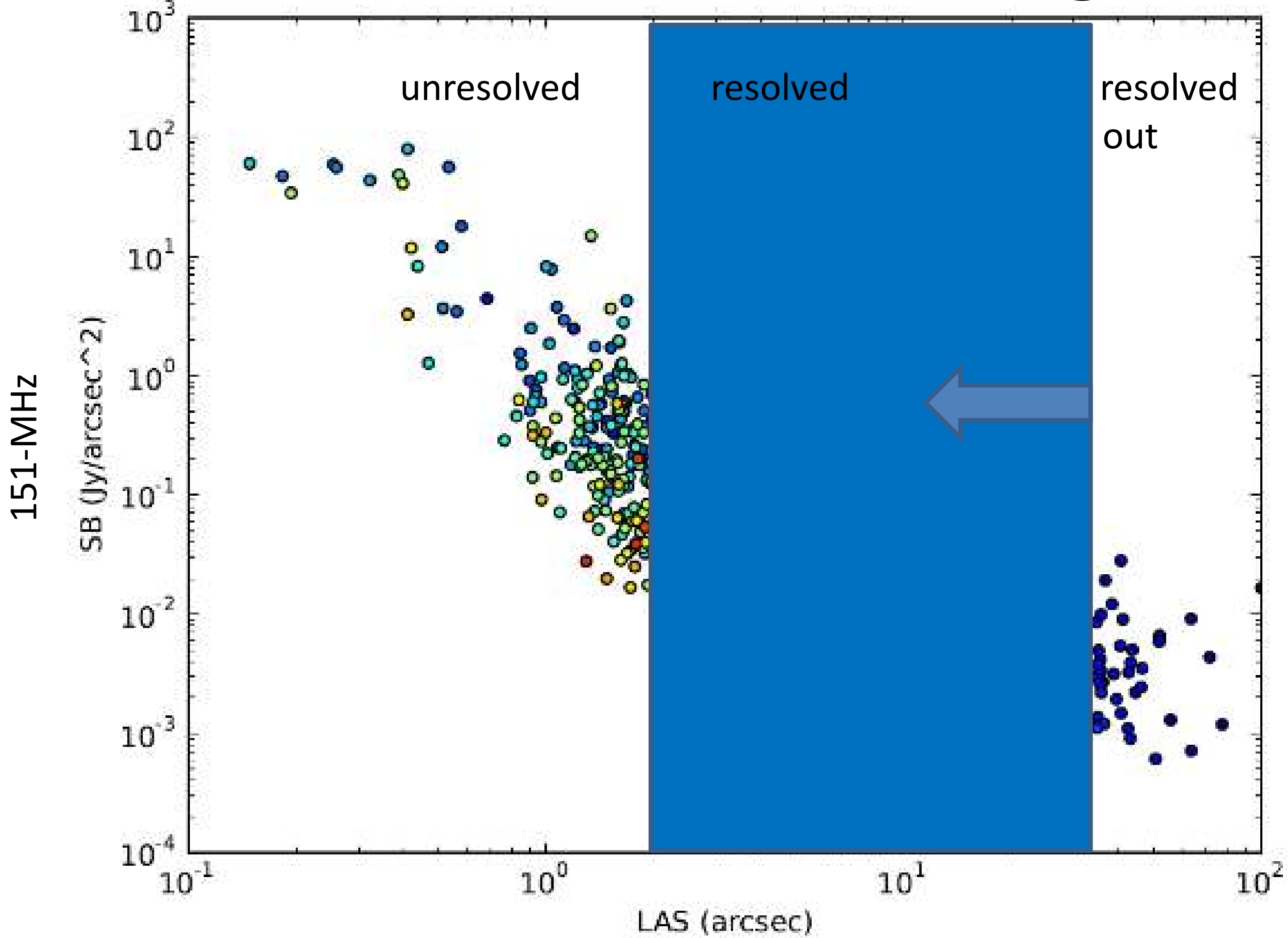
- LOFAR, MeerKAT and SKA-1 will all have this ability to map all structures in one shot
- GMRT has it to a lesser extent
- VLA does not have it at all
  - VLASS limited in value for extended sources – though still important for high resolution / compact objects

LOFAR



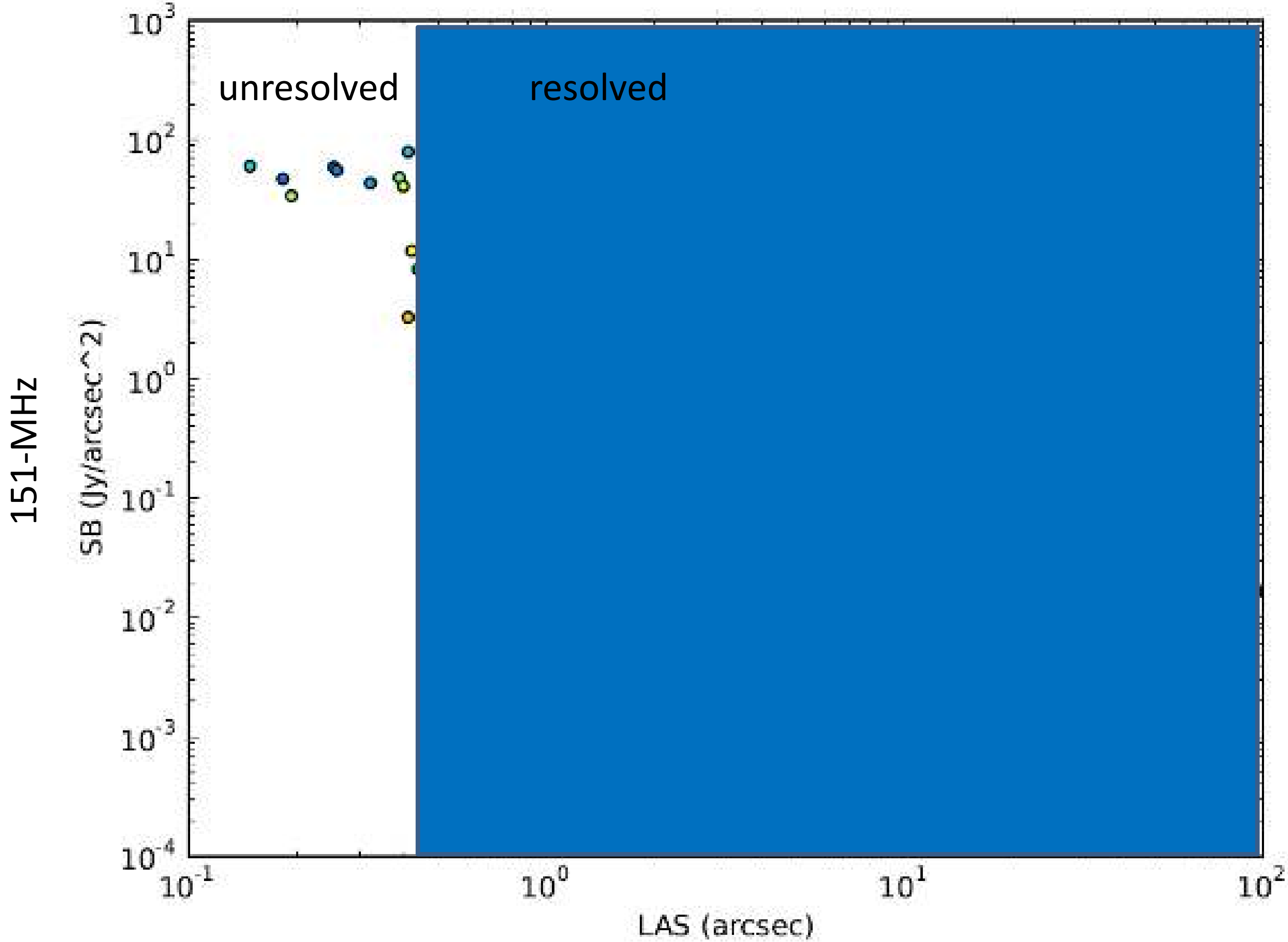
FRII sources from SKADS simulations (colour = z, dark blue = 0, red = 6)

VLASS (S-band B-config)



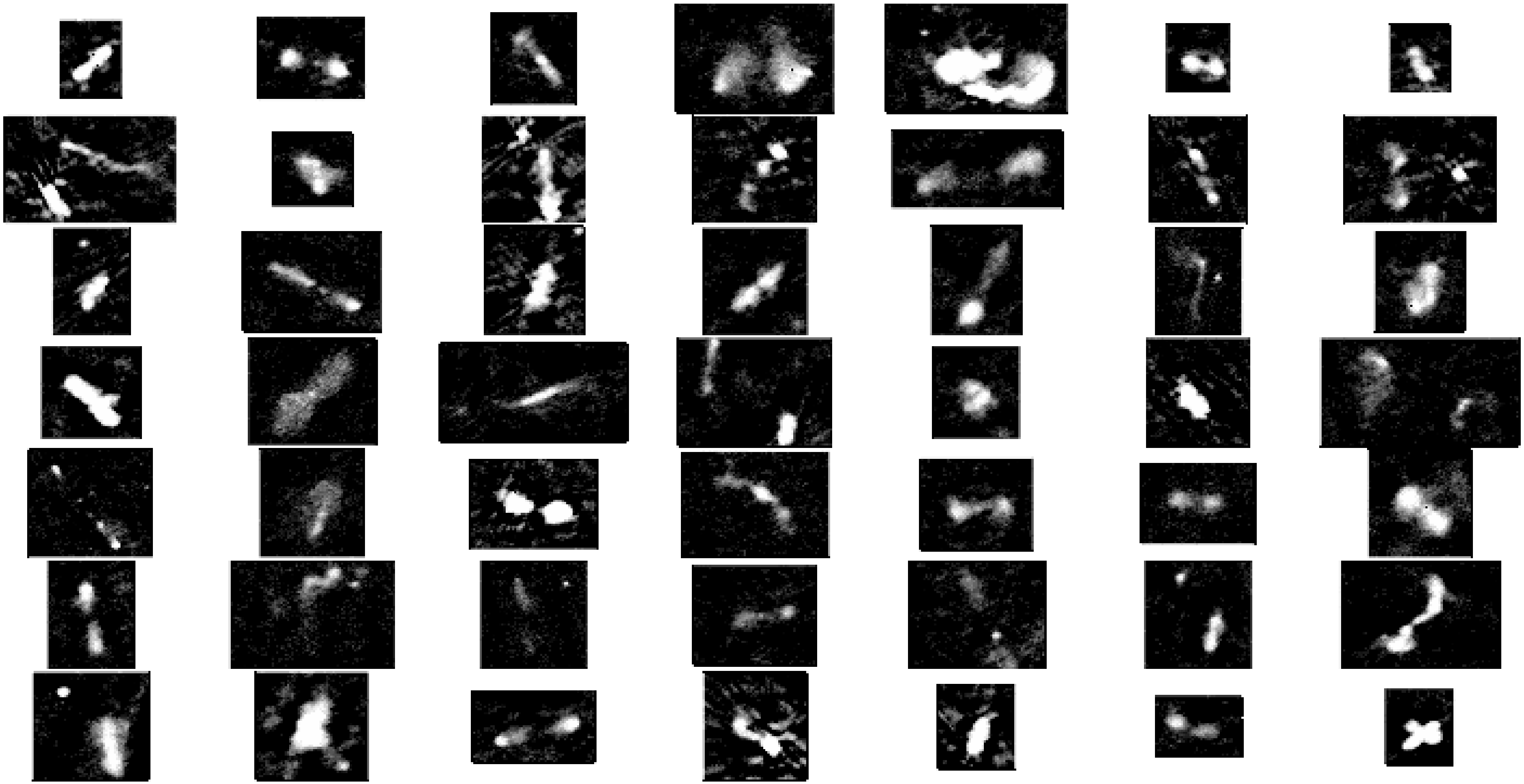
FRII sources from SKADS simulations (colour = z, dark blue = 0, red = 6)

SKA-1-mid



FRII sources from SKADS simulations (colour = z, dark blue = 0, red = 6)

LOFAR results



(Some) well-resolved bright sources in H-ATLAS NGP NW – 8h observation

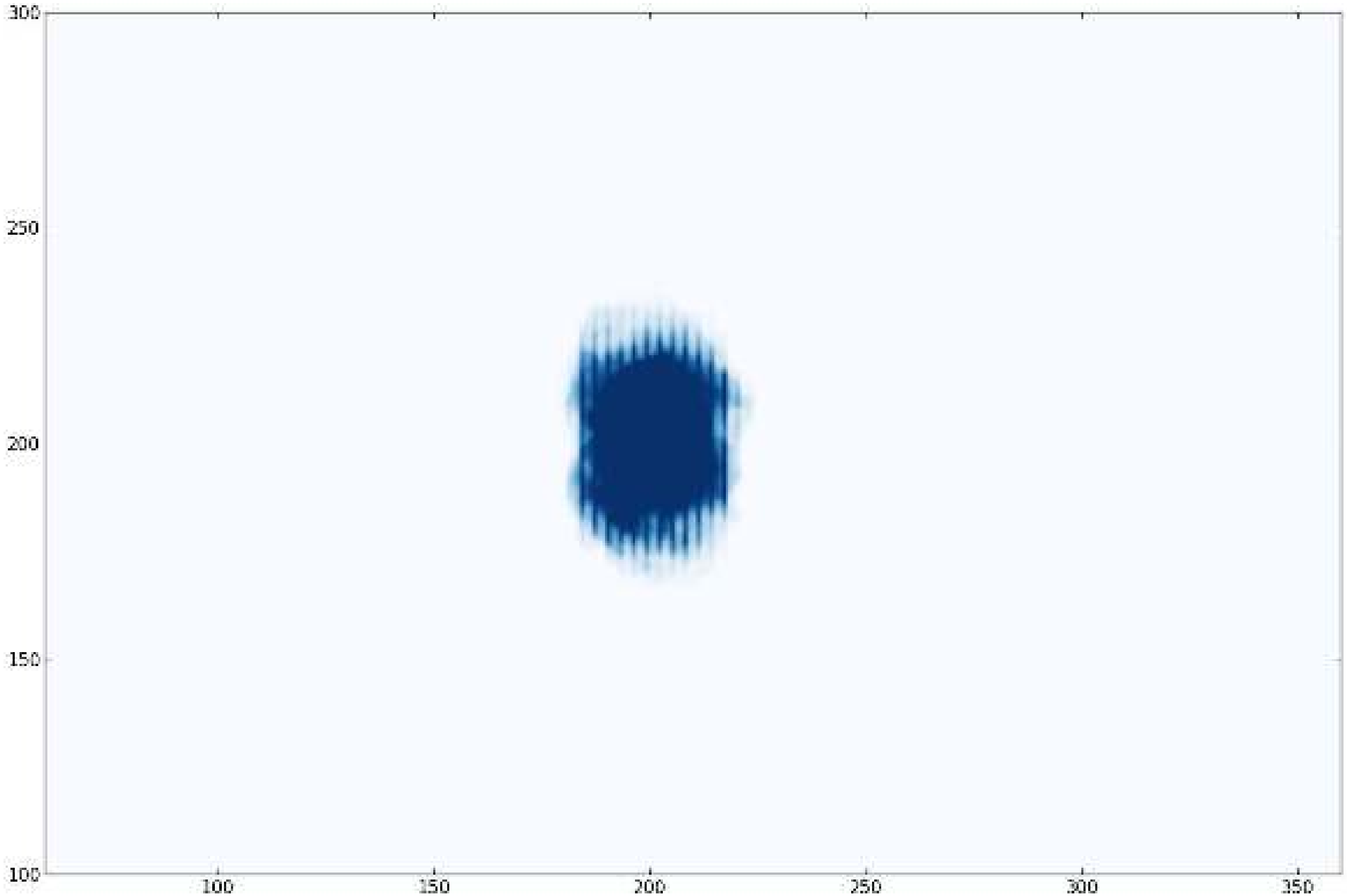
To get from here to physics:

- Need:
  - IDs and redshifts!
  - Physical sizes, shapes
  - Spectra – resolved and unresolved
  - Polarization
- Then *in principle* can solve for
  - projection angle!
  - jet power
  - age
  - environment…

Methods

- Numerical modelling taking into account:
  - realistic environments ✓
  - realistic jet and lobe densities ✓
  - magnetic field evolution ✓
  - relativity ~✓
  - cosmic ray transport and loss ✗…
- (see Hardcastle & Krause 2013, 2014; English+ 201?)

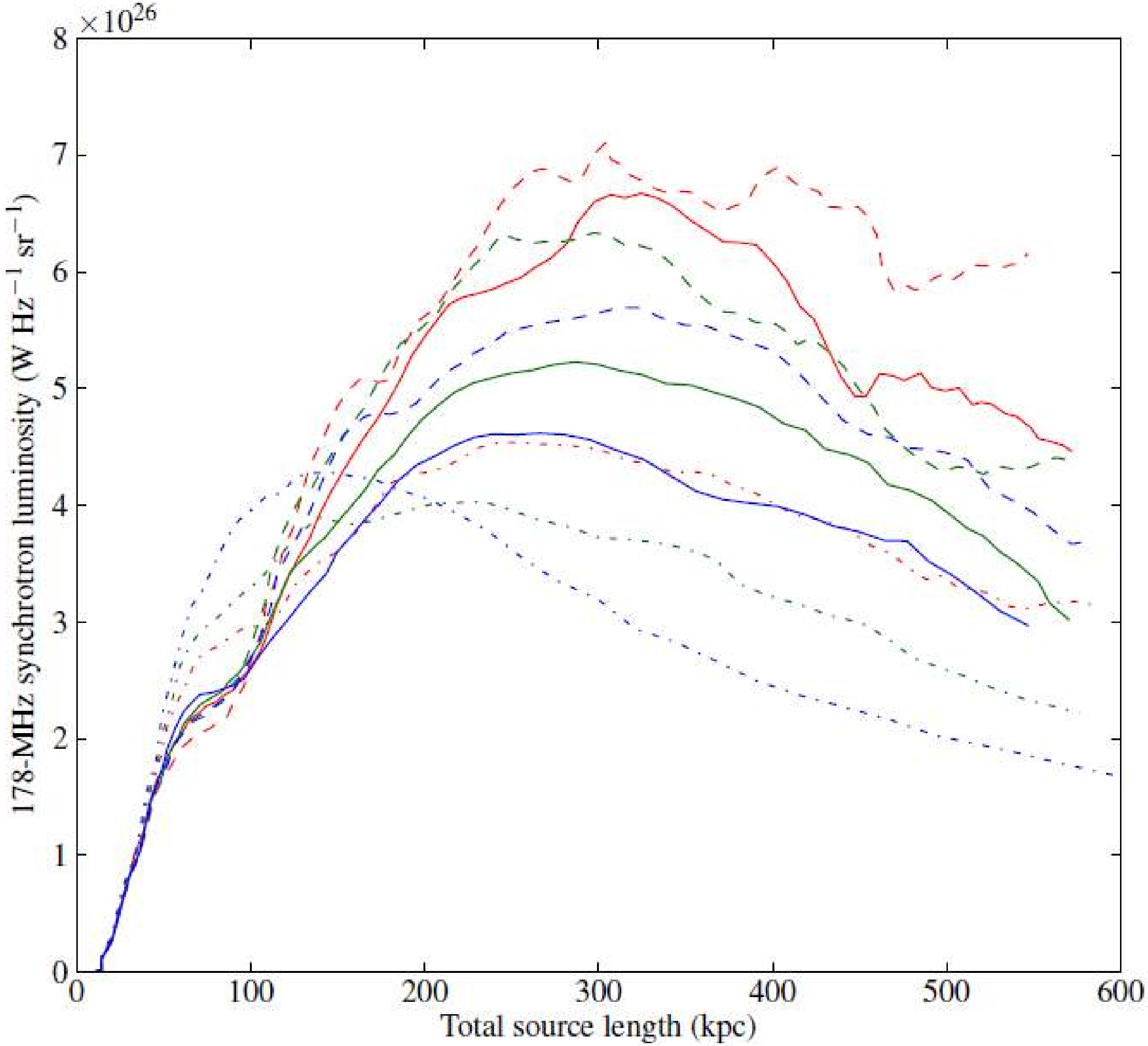
Numerical modelling


300
250
200
150
100
100
150
200
250
300
350

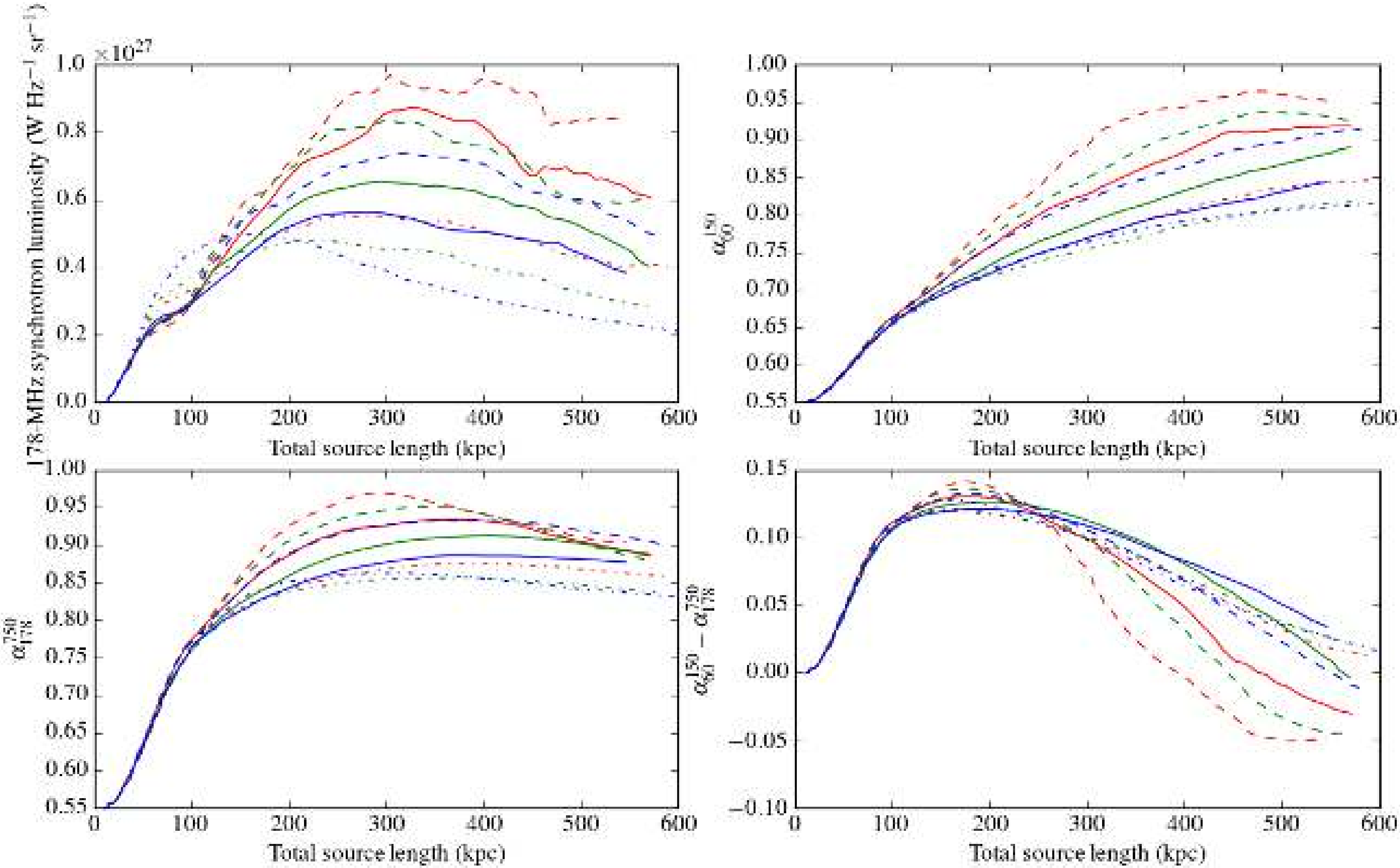
Evolution of radio power

Simulated tracks in the P-D diagram for sources with Q = 10^{45} erg/s in a range of environments (red = rich, green = medium, blue = poor).

Radiative losses are taken into account. Adapted from H+K 14

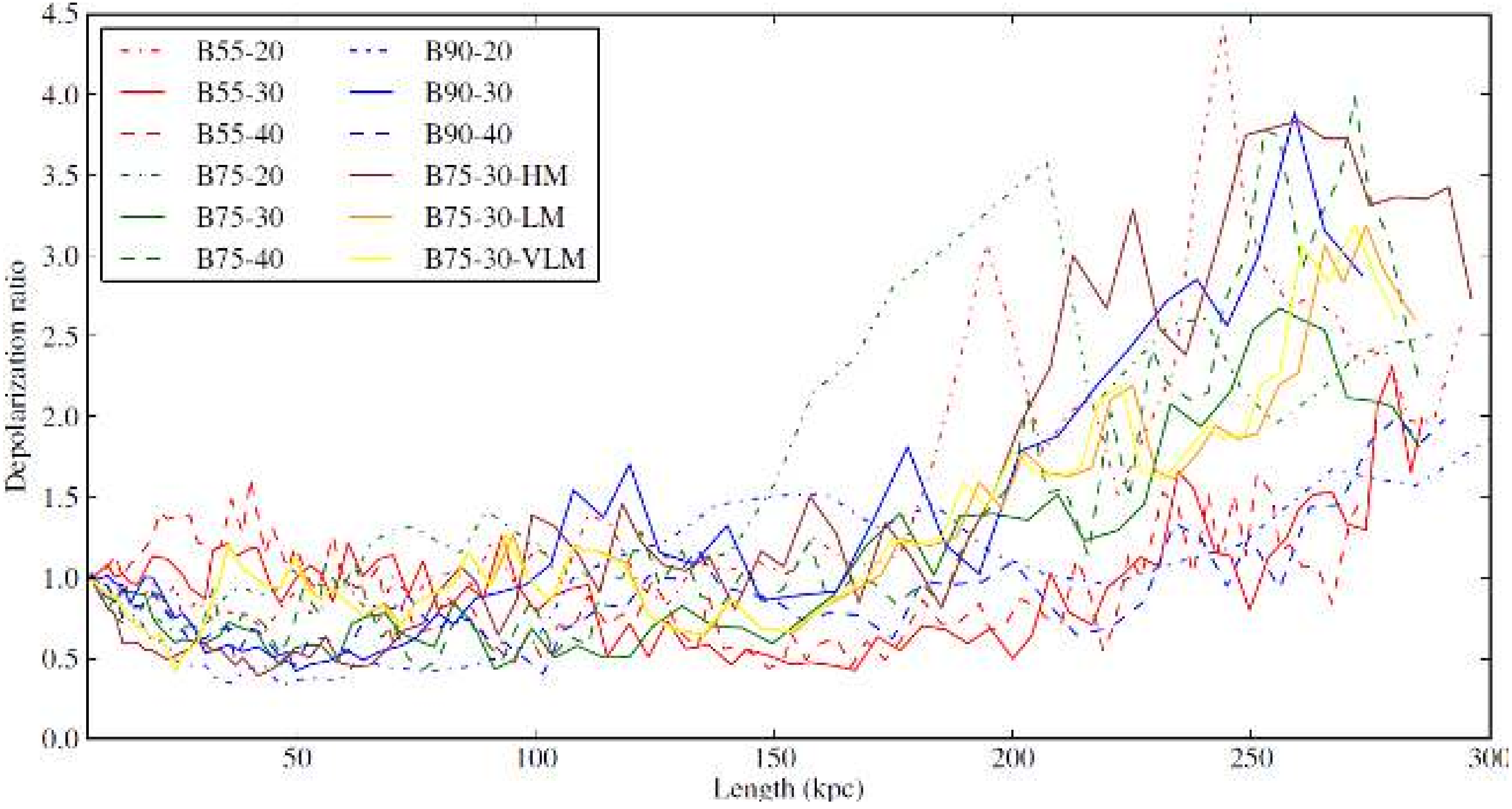


Broad-band spectra: ageing

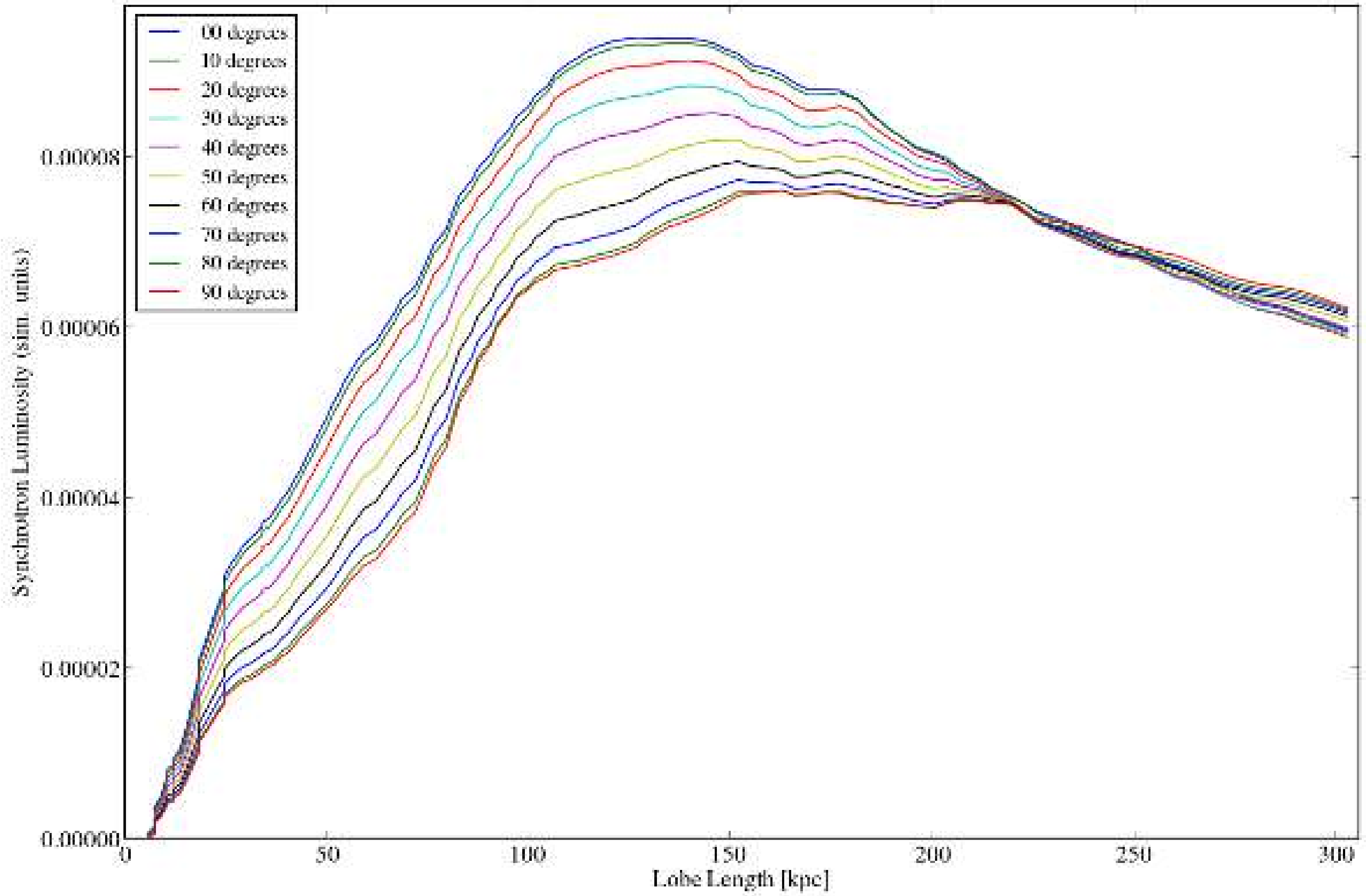


Lines denote different simulation runs w/ same jet power: red, green, blue different slopes of cluster density profile (red flat, blue steep): dashed, solid, dotted different core radii (dashed large, dotted small)

Depolarization



Beaming and projection angle



Where from here?

- Observations:
  - need large samples of *identified* RLAGN w/ high-fidelity imaging
  - spectral indices (maps for resolved sources)
  - polarization? (Not yet for LOFAR)
- Modelling:
  - cosmic ray transport – crucial for spectra
  - calibration: compare with deep multi-waveband images of individual objects

Where from here?

- Then:
  - grids of numerical models
  - grids of simulated images
  - extract key parameters
  - compare with images
  - marginalize over nuisance parameters (angle etc)
  - Bayesian estimate of interesting parameters (jet power etc)
  - jet kinetic luminosity function!