Science with high-resolution surveys

Martin Hardcastle

High-resolution surveys meeting, Leiden, March 2018

Why do a high-resolution radio survey?

The competition

- FIRST – 1.4 GHz, 4 arcsec, low sensitivity, partial sky, no short baselines

- VLASS – 2.5 arcsec, intermediate sensitivity, all sky, even fewer short baselines

- SKA1-MID – 0.5 arcsec, high sensitivity, ~ 10000 deg^2?, doesn't exist yet

- (LoTSS – 140 MHz, all sky eventually, 6 arcsec, high sensitivity, sky coverage not yet achieved.)

Take-home message #1

- Nobody has ever done a wide-area radio survey with resolution comparable to ground-based optical

- A wide-area high-resolution survey with LOFAR would be competitive NOW with what SKA1-MID will achieve at some (unknown) point in the future

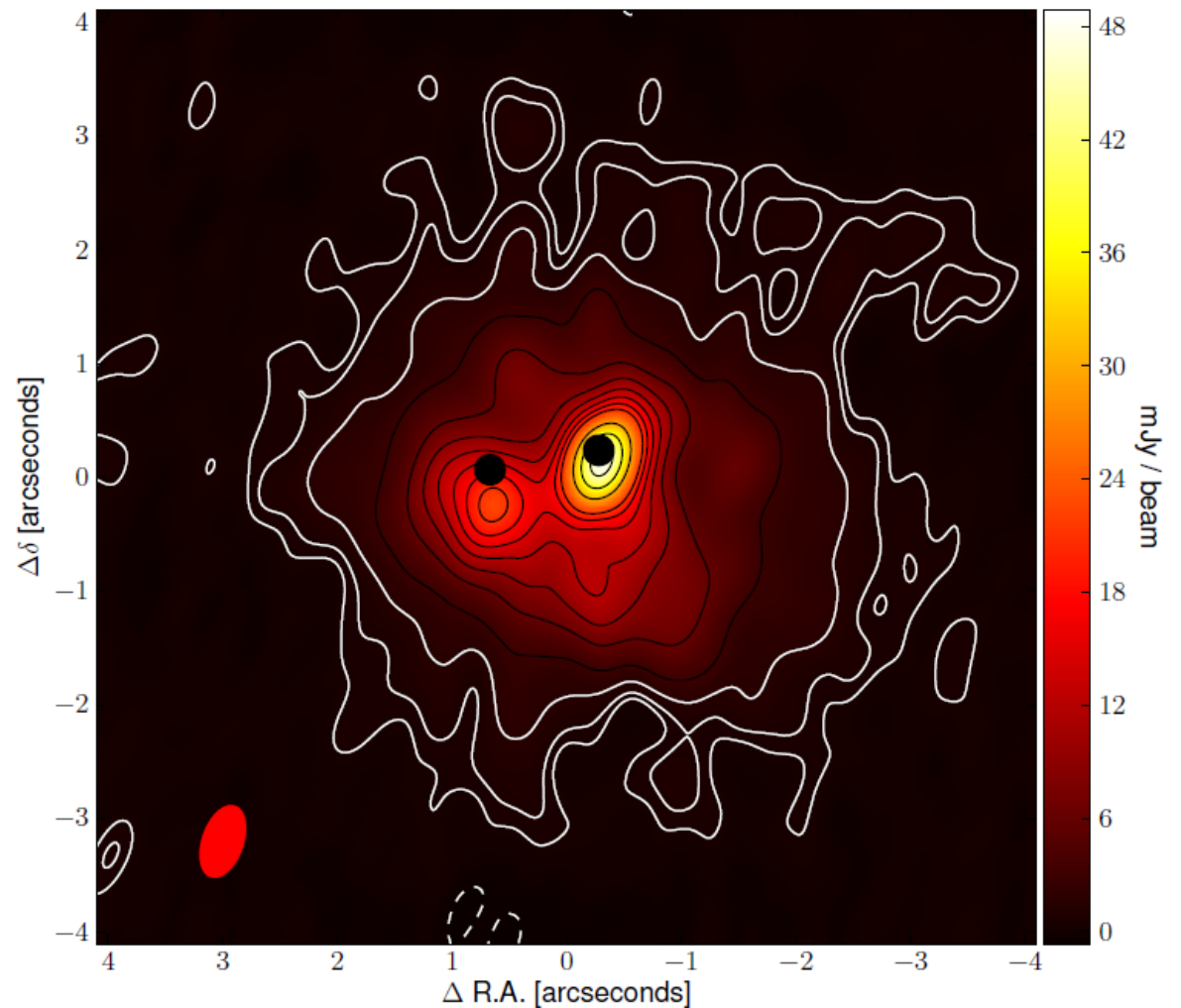- (Assuming 0.5 arcsec, 100 microJy/beam @140 MHz for LOFAR and 0.4 arcsec, 10 microJy/beam @1.5 GHz for SKA.)

General value of surveys

- Completeness – include but not limited to rare objects

- Statistics!
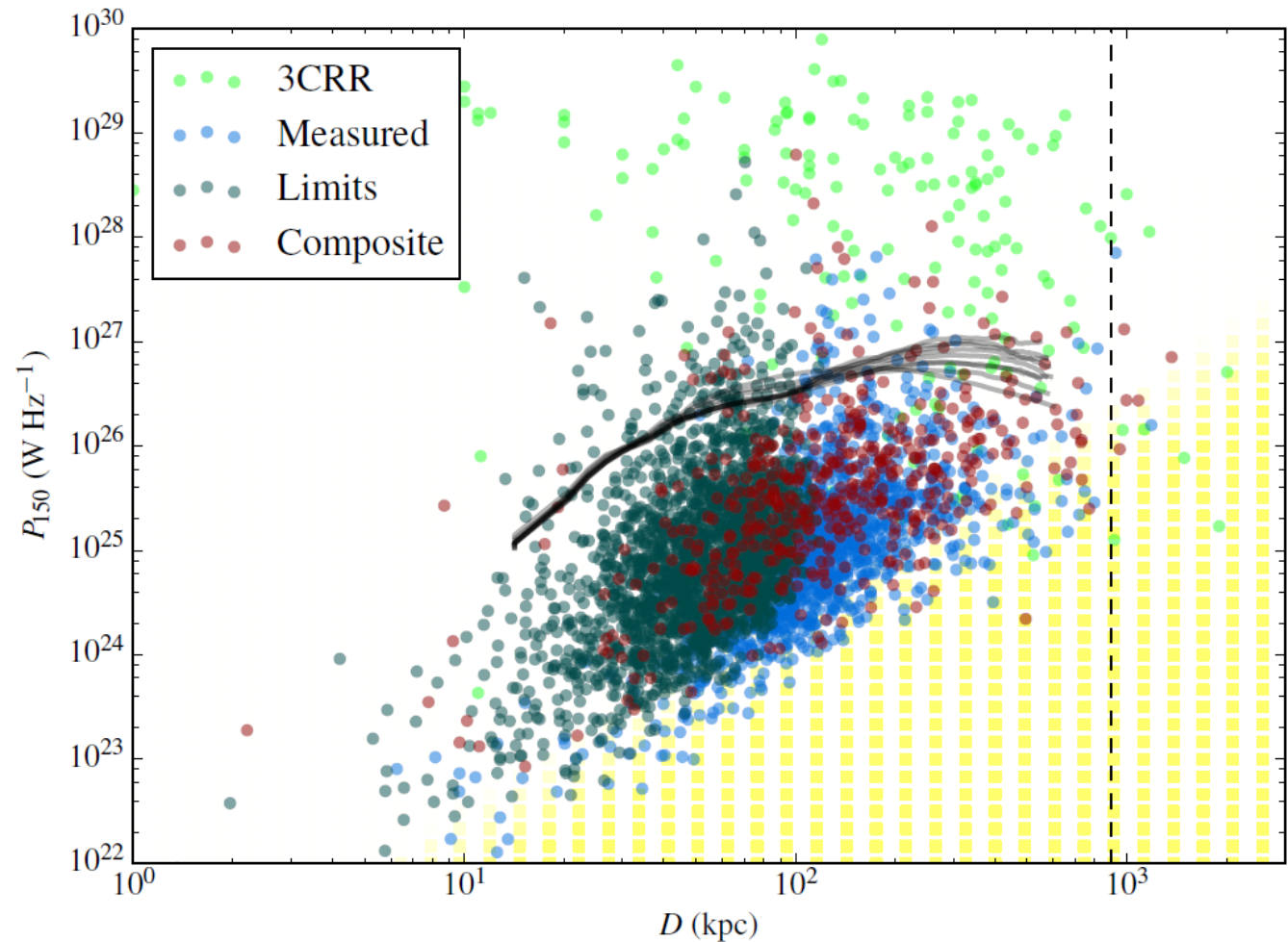
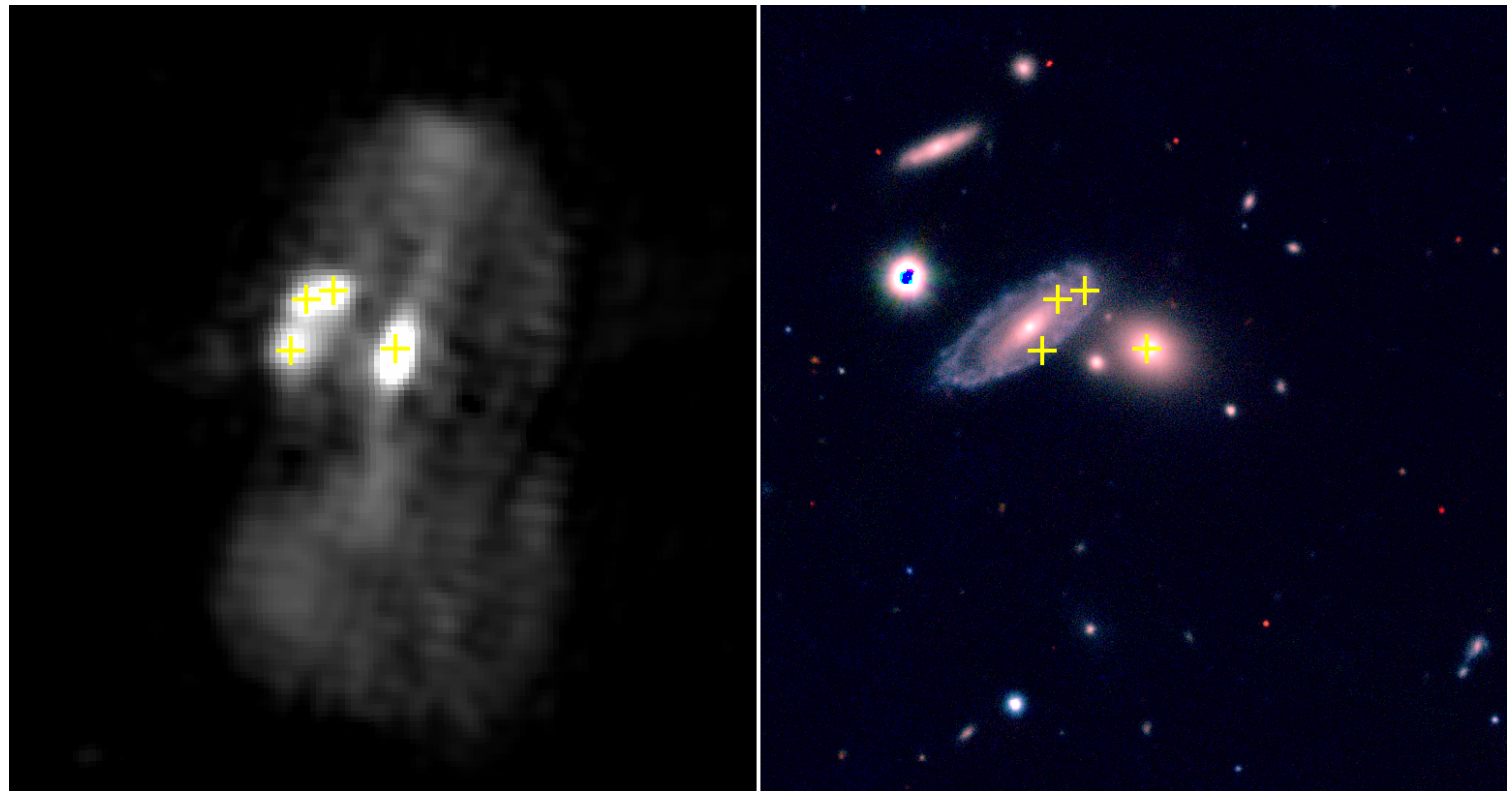# General value of a high-resolution survey

1) Detailed images of everyone's favourite objects...


Arp 220, Varienius et al 2016

General value of a high-resolution survey

2) Optical identifications get much better when optical and radio resolutions match – affects all science areas

3) Improved sensitivity to compact sources embedded in diffuse structure – improves interpretation of images...

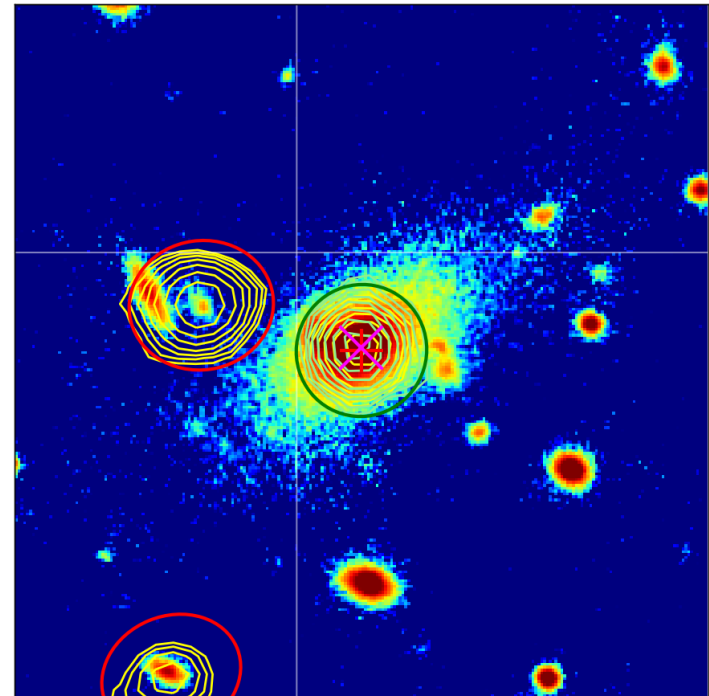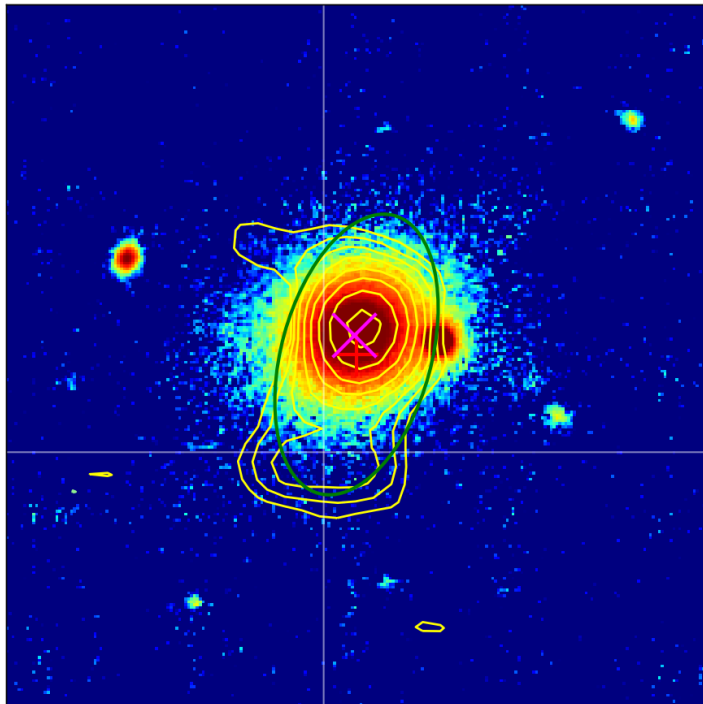# General value of a <u>high-resolution</u> survey

- Morphological classification of compact objects becomes much easier
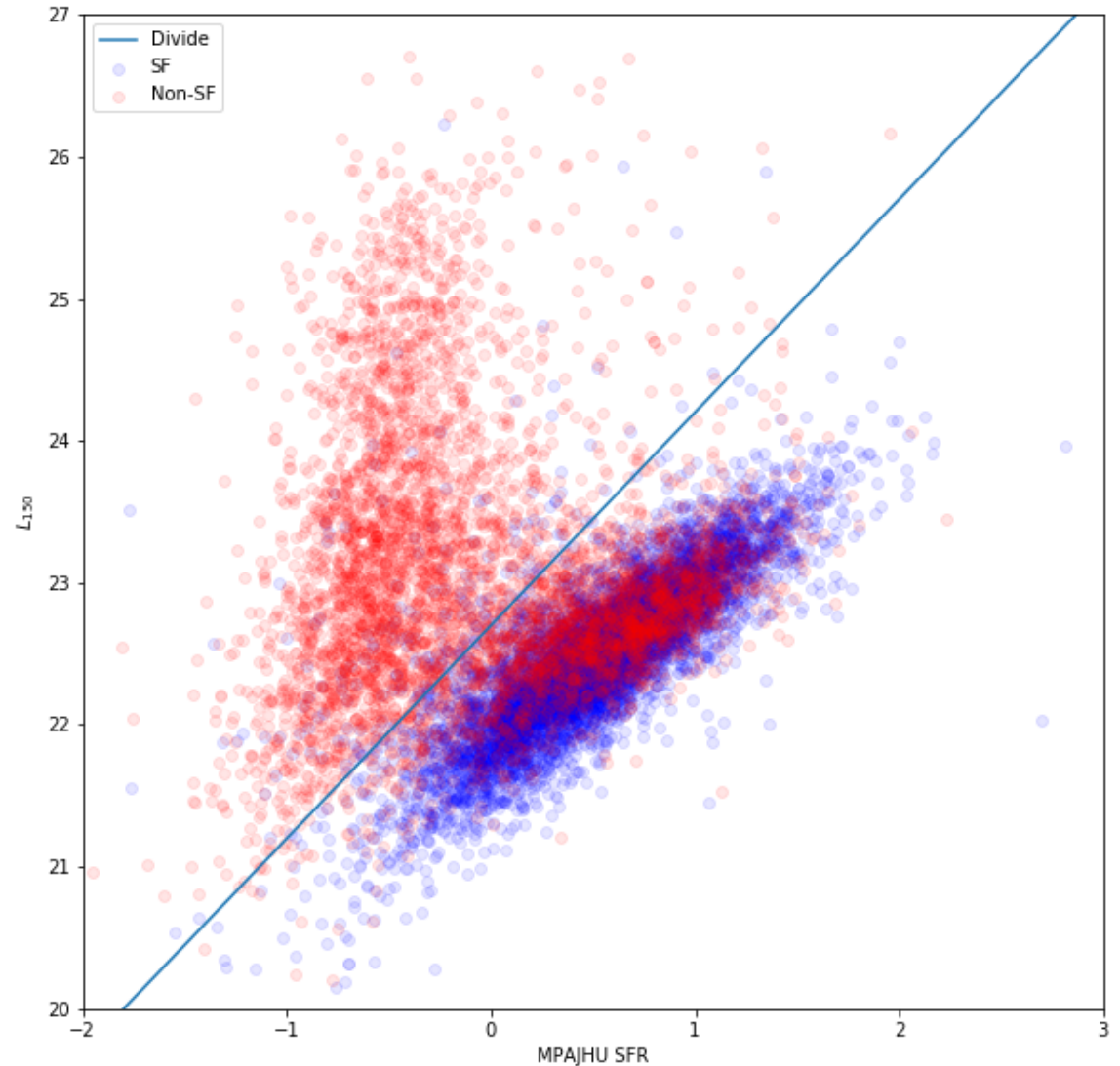
- (e.g. AGN vs SF?)

Selection of low-luminosity AGN in
HETDEX where SFR is known
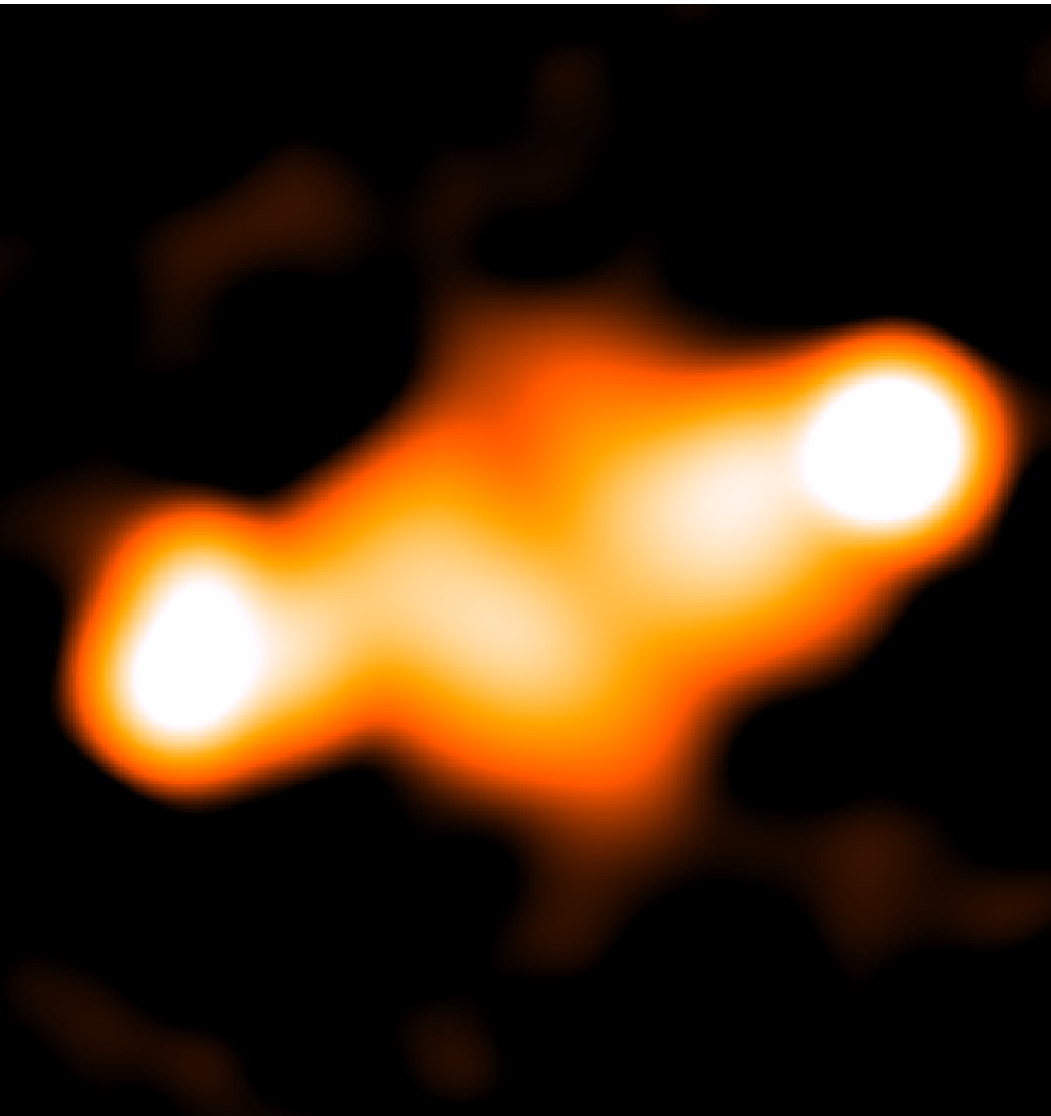(MJH+ in prep)

General value of a <u>high-resolution</u> survey

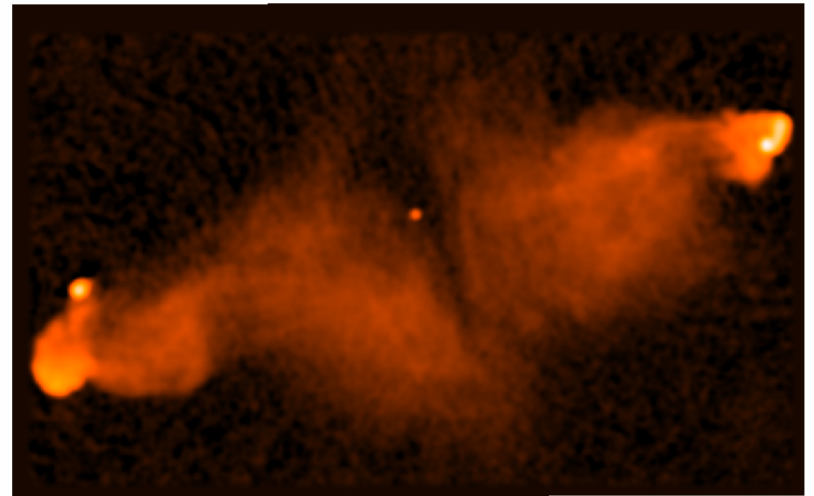- Morphological classification becomes much easier

- (e.g. AGN vs SF?)

Example radio-excess sources from HETDEX – 6-arcsec LOFAR contours + PanSTARRS r
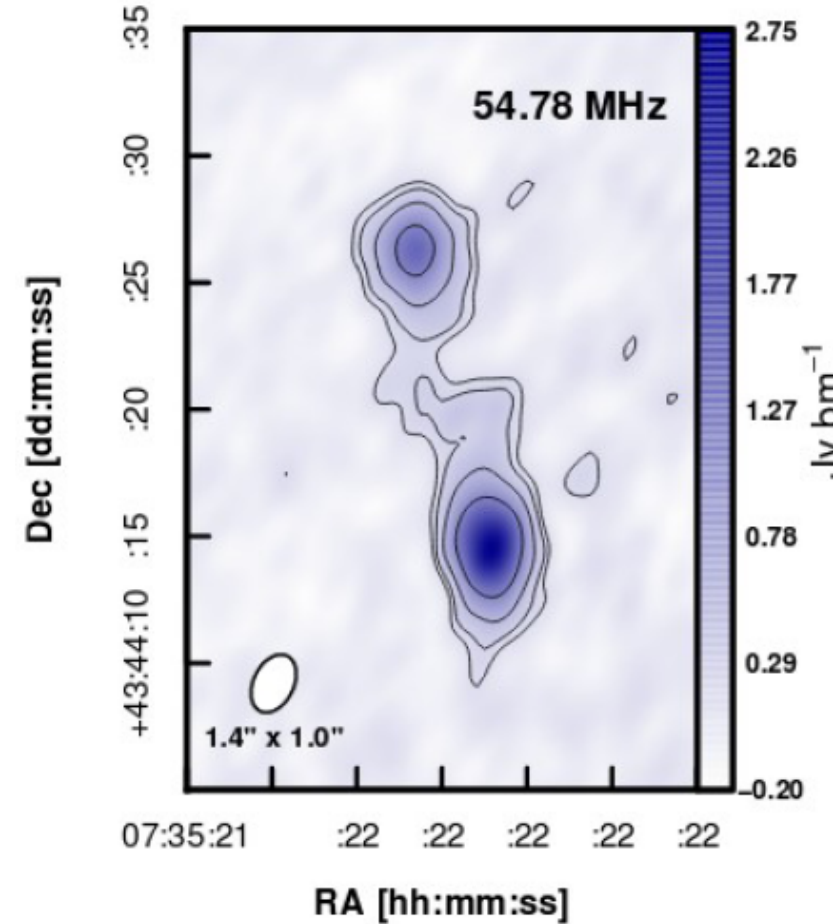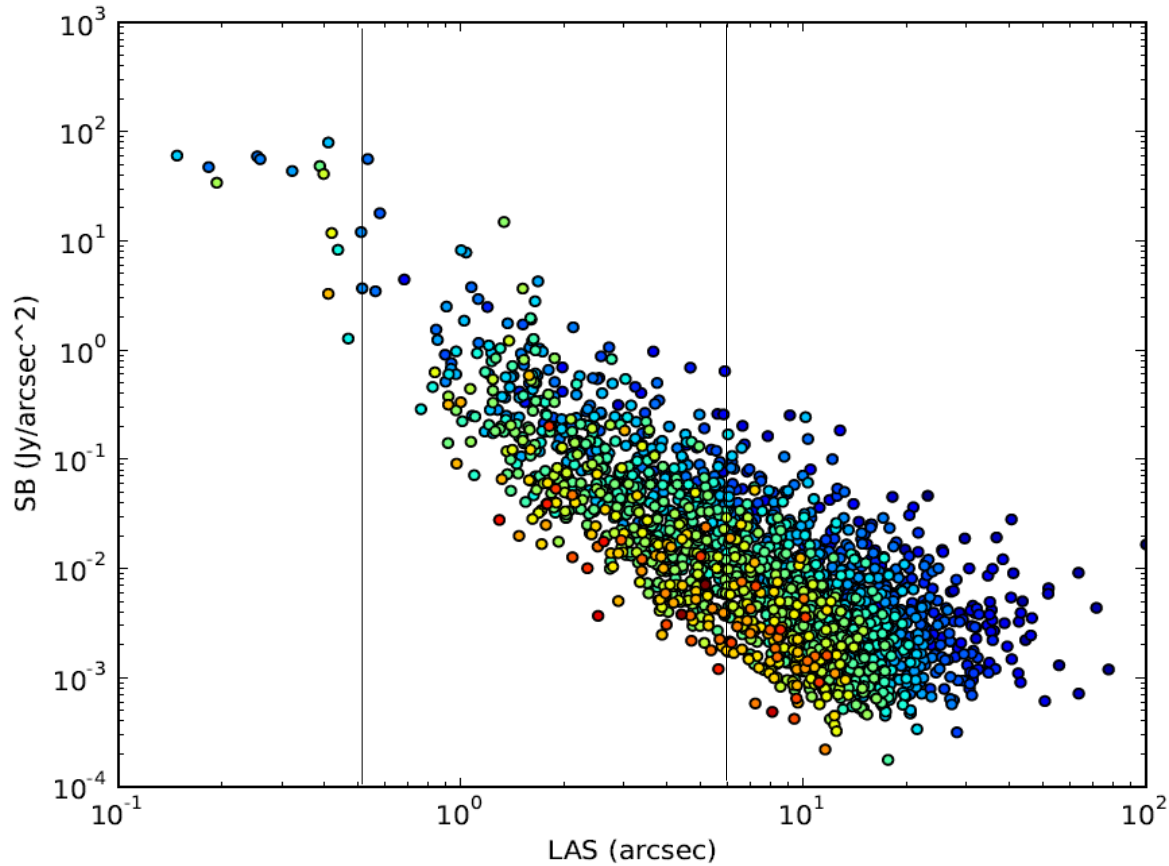
AGN science: (1) structure at all scales

3C20 at 6 arcsec   and at 0.5 arcsec   (MJH+ 97)

AGN science: (2) size matters

Left: FRII sources from SKADS simulations (colour = z, dark blue = 0, red = 6) Right: LBA long baselines resolve 4C 43.15, Morabito+ 16
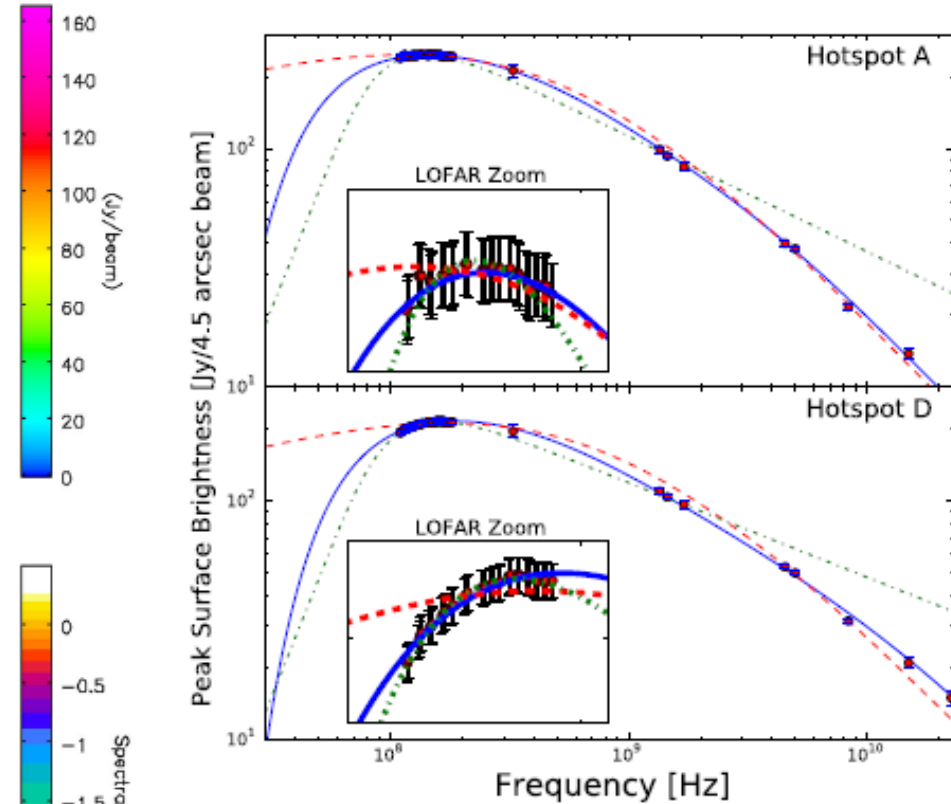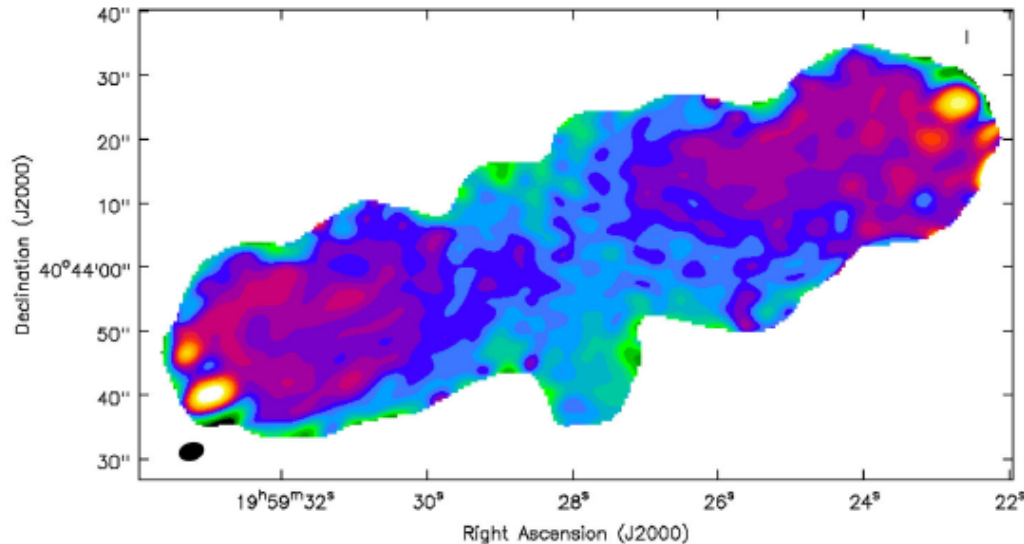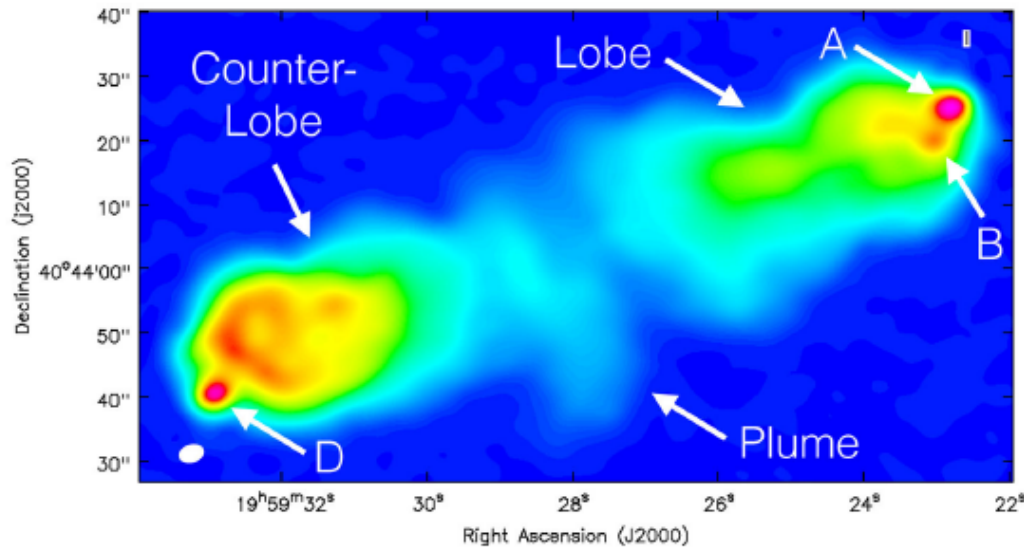
AGN science: (2) size matters

Physical size distributions can tell us about the lifetime distribution of radio galaxies, on some assumptions about environments: low end is key!

(simulations of LOFAR-selected sources from MJH 18: sample (i) has uniform lifetime distribution, sample (ii) has power law with more short-lived sources.)
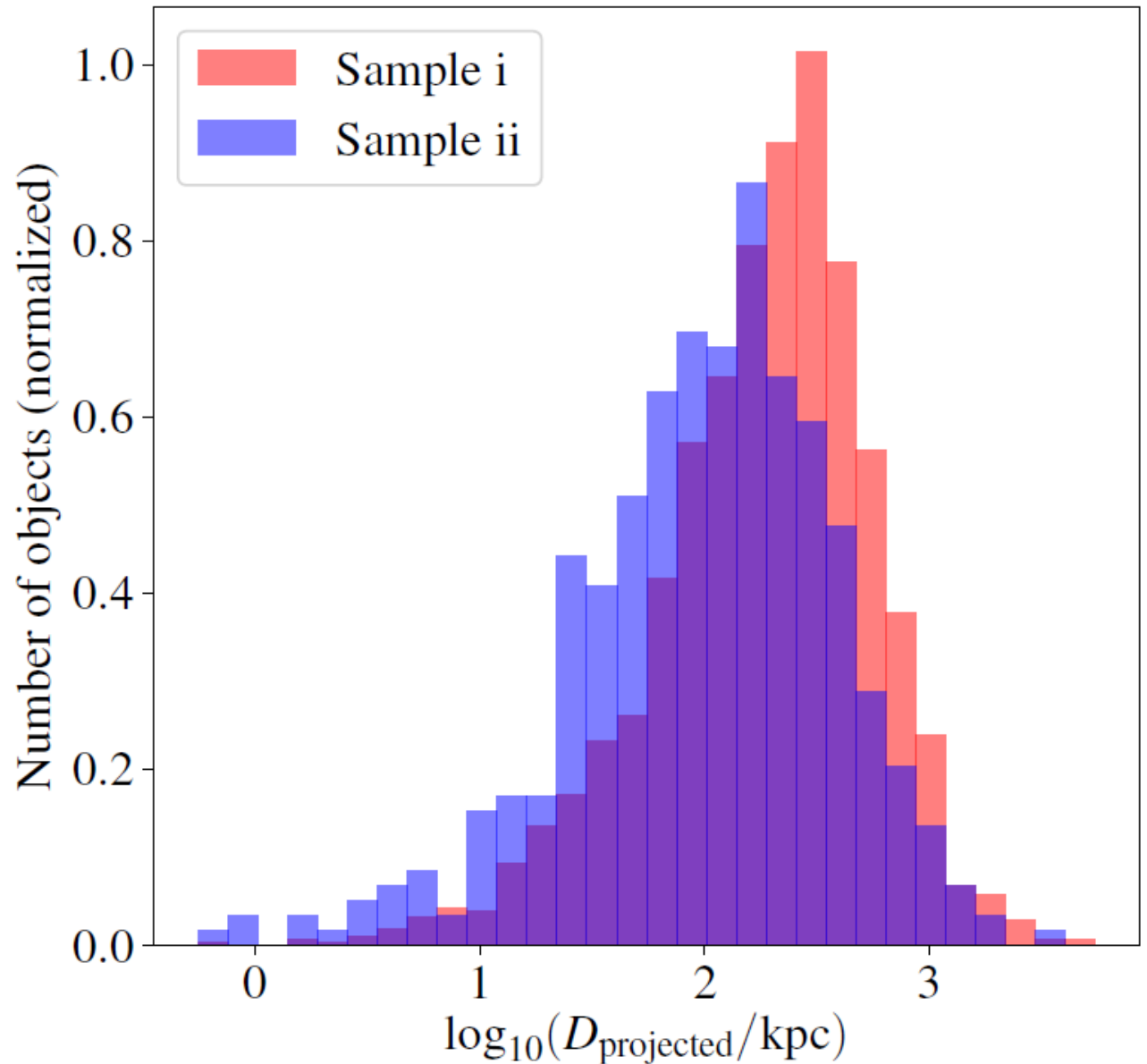
AGN science: (3) spectral studies

McKean+16

Physics we don't understand is emerging at low frequencies
Large populations of sources need to be well resolved to study this

SFG science

- Resolved cosmic ray structure and spectra
- Direct comparison between optical and radio structure on industrial scales
- Free-free absorption
- Relate to structures on optical scales
- SNRs vs HII regions
- Out to high z in deep fields

NGC 4157 with 6-arcsec LoTSS contours
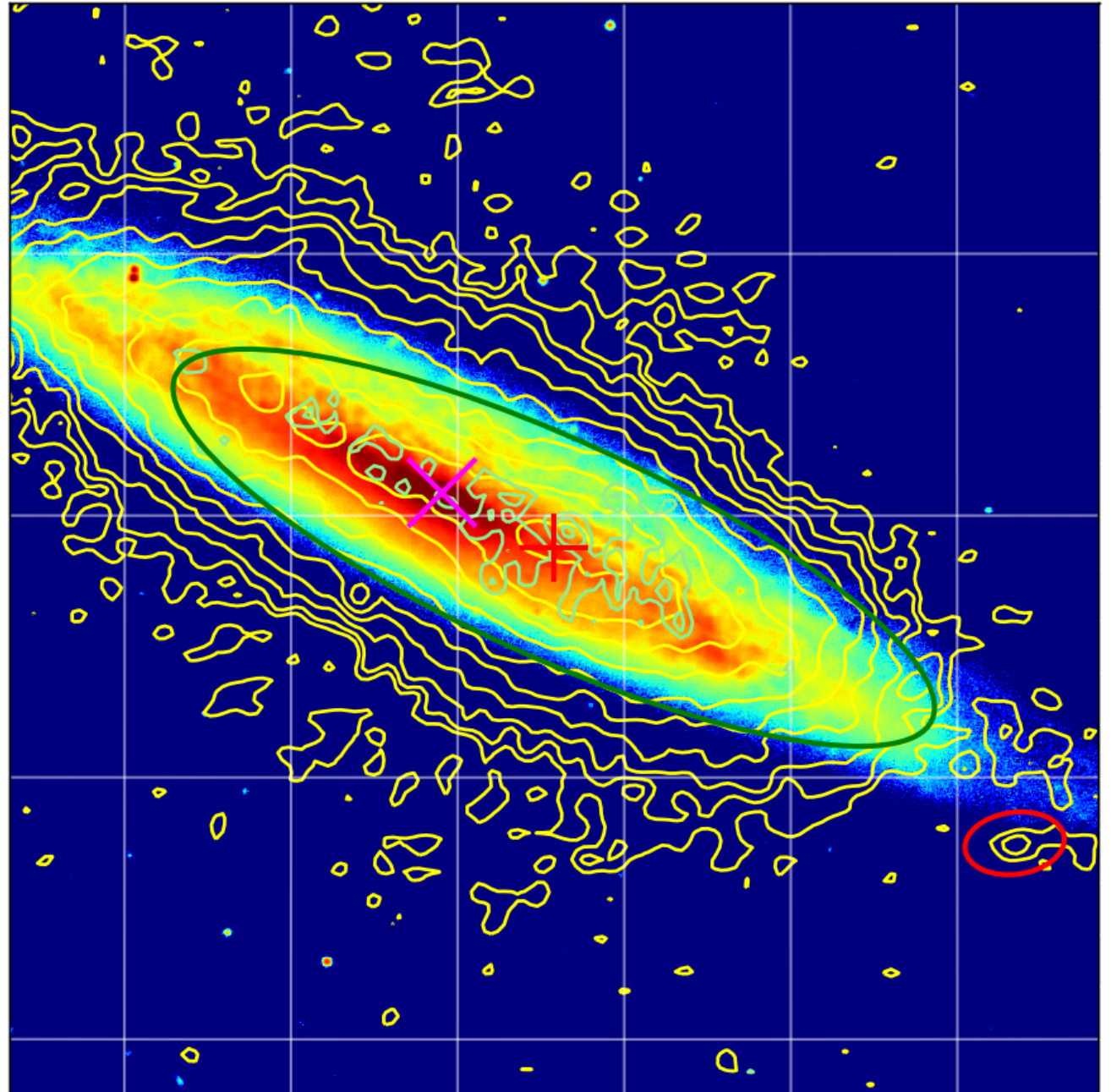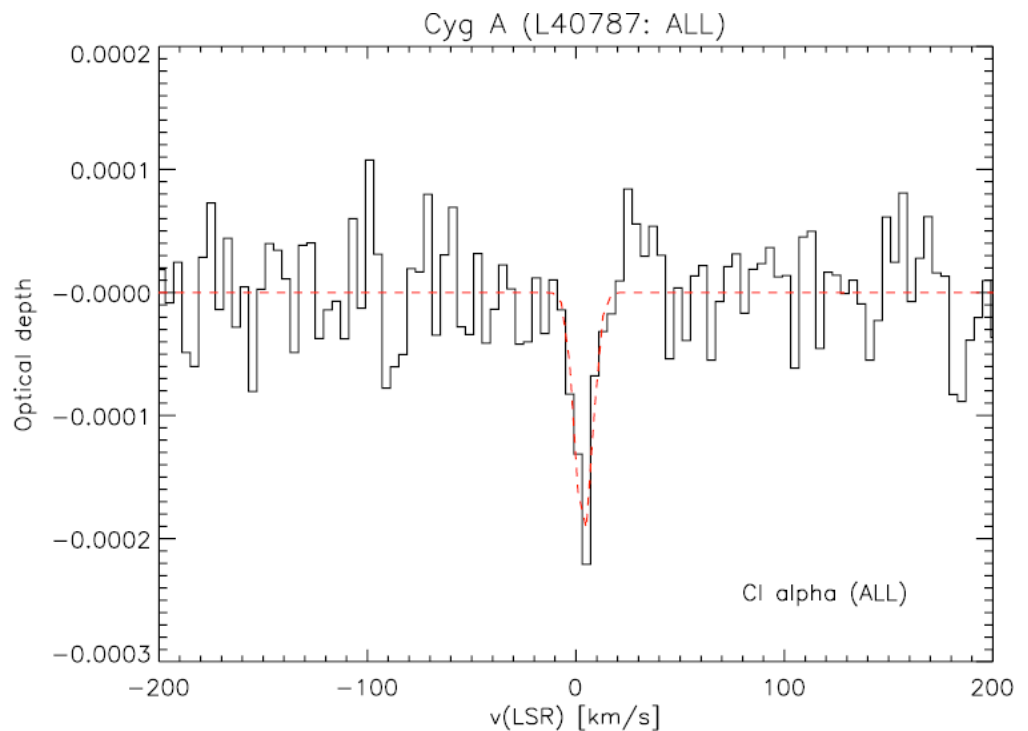
Strong lensing science

- Sub-arcsec resolution critical
- Survey for + image lenses => followup
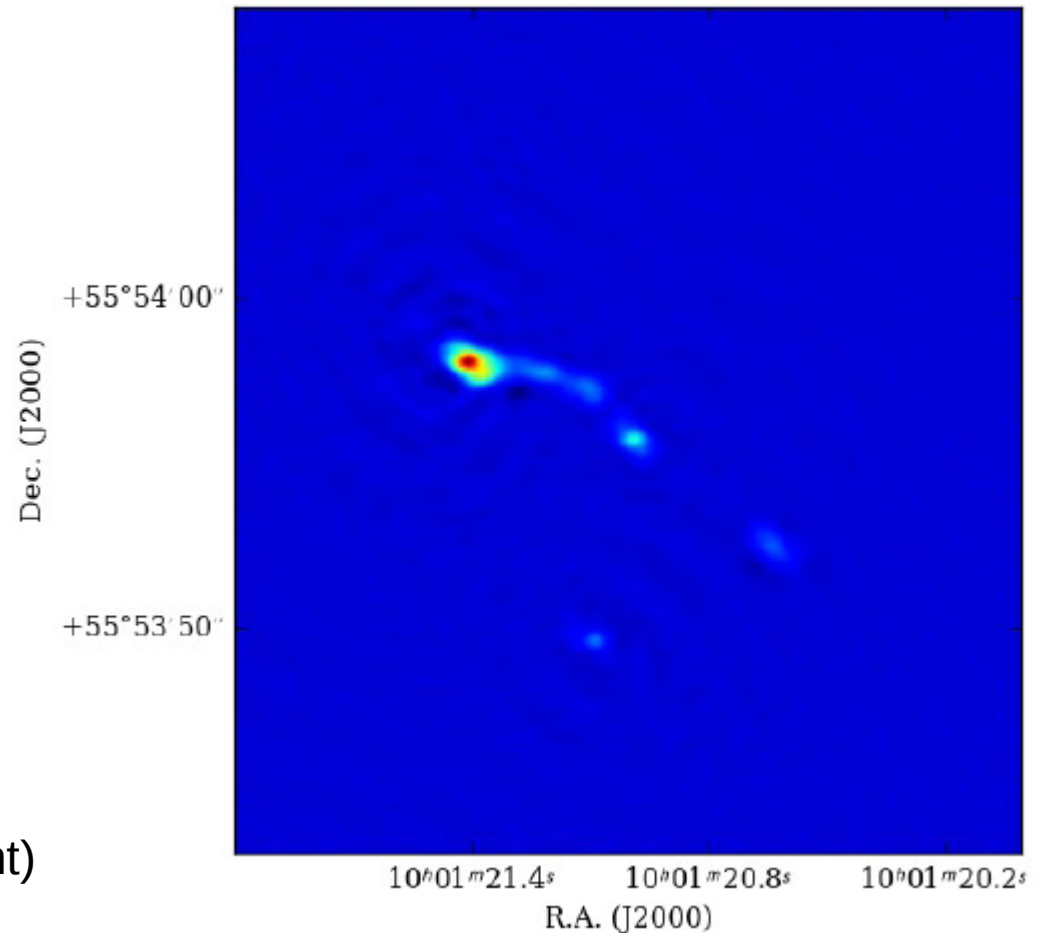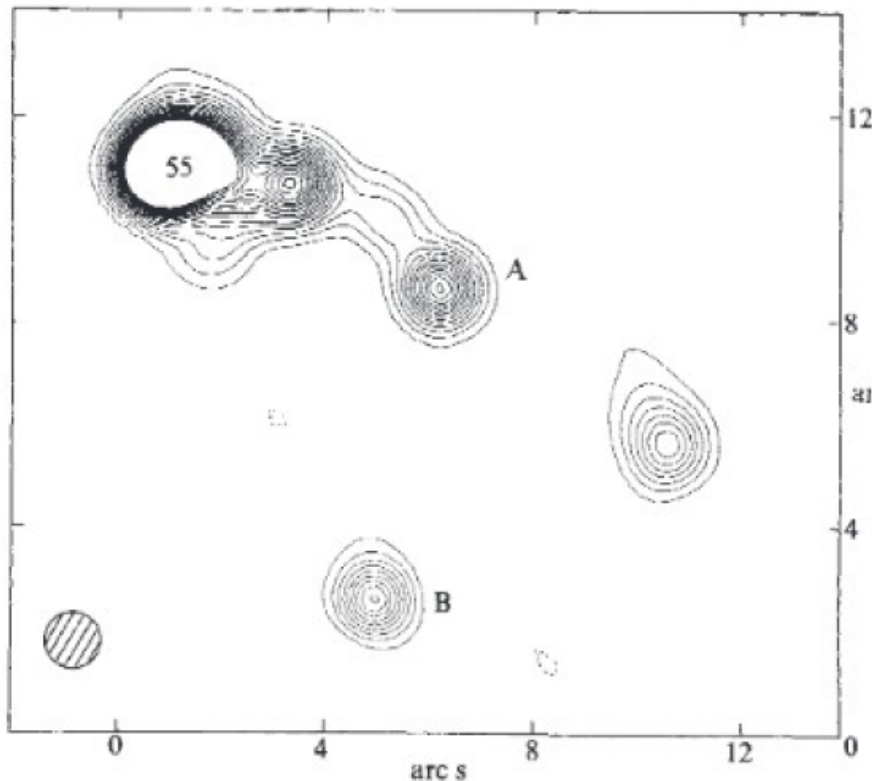
Q0957+561 old (above) and LOFAR LB (right)
(ask Neal for more info!)

Other science

- Other rare objects, e.g. YSOs (see later talk)
- Resolved RRL studies towards bright objects
- Weak lensing? (deep fields)
- ….

- Big expansion of potential discovery space

RRLs towards Cyg A, Oonk+ 14

Take-home message #2

- Lots of science value in a high-resolution LOFAR survey

- A lot of it persists even if done at a higher flux limit than 6-arcsec LOTSS

- Some is vital to the full exploitation of the LOFAR surveys, so let's get on and do it!