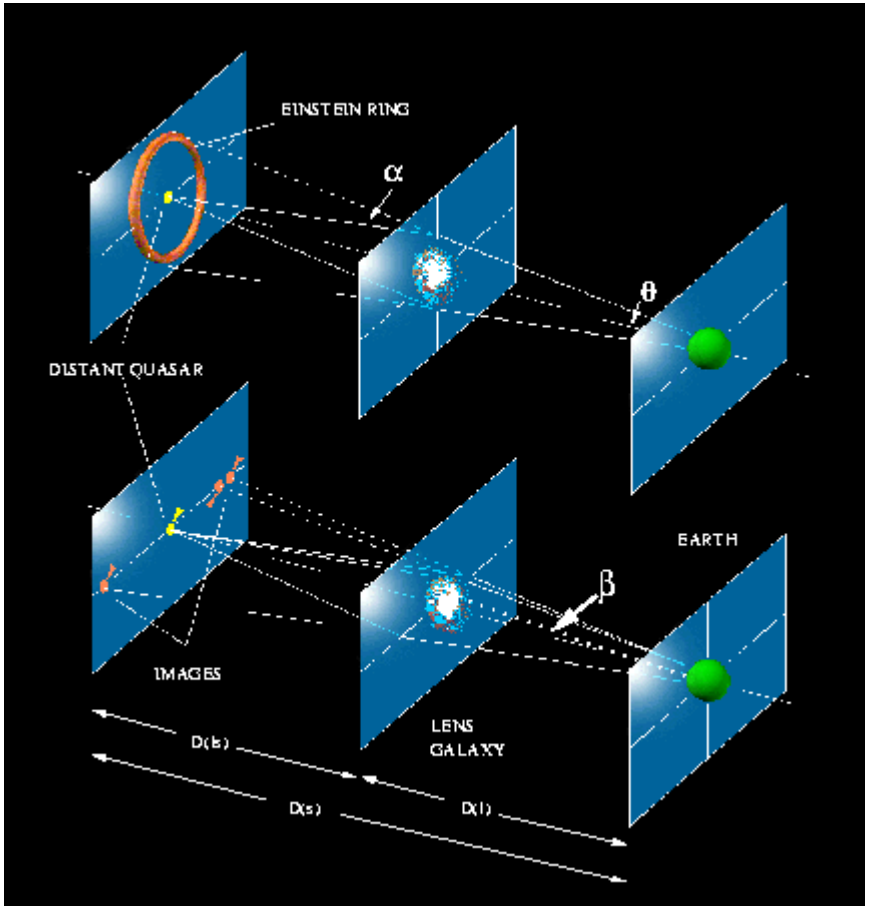
The University of Manchester
Jodrell Bank
Observatory

MANCHESTER 1824



E-Merlin and strong lensing

Outline

- why look at lenses at all?

- the e-MERLIN legacy programme: core images and submm lenses (more on core images: talk by Jonathan Quinn)

- radio imaging of radio-quiet objects (JVLA, and soon e-MERLIN, programme

- and the future

Why study lenses?

- Evidence of things not seen: dark matter in lenses

Moore et al. 1999

Why study lenses?

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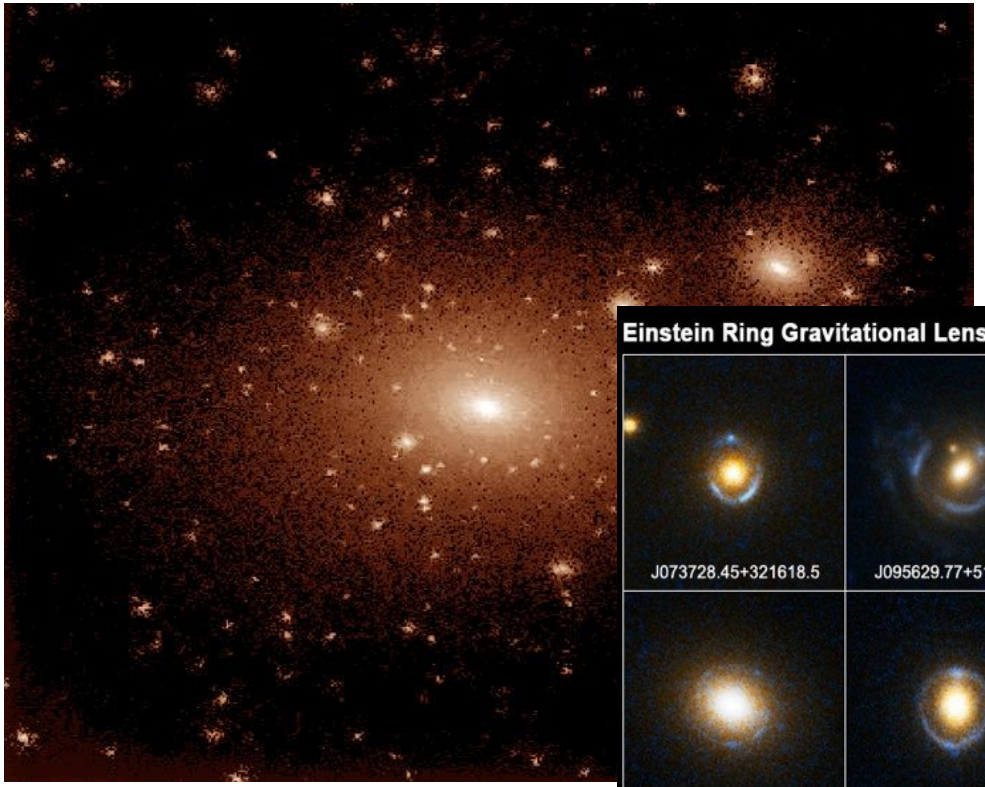
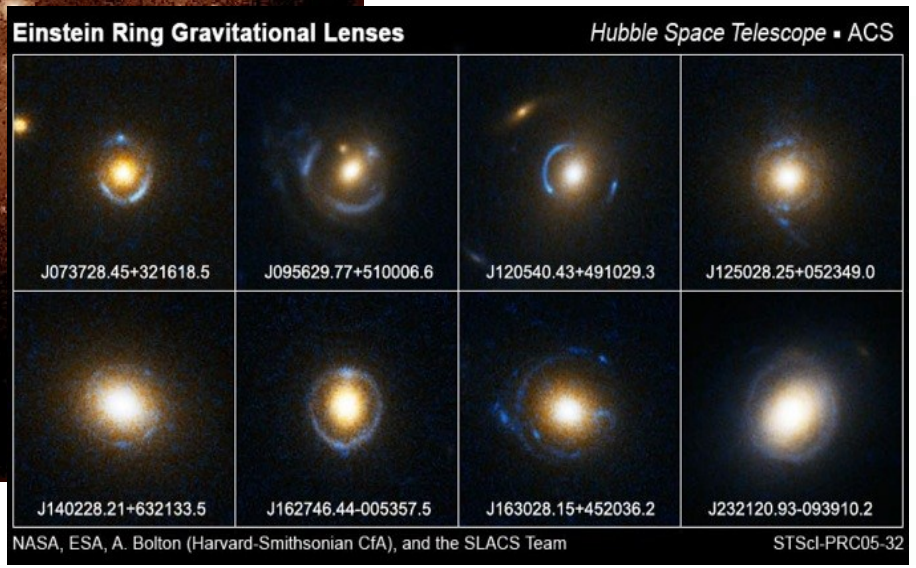
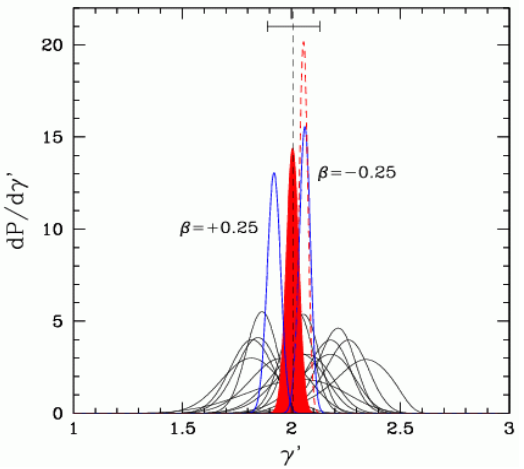


Moore et al. 1999



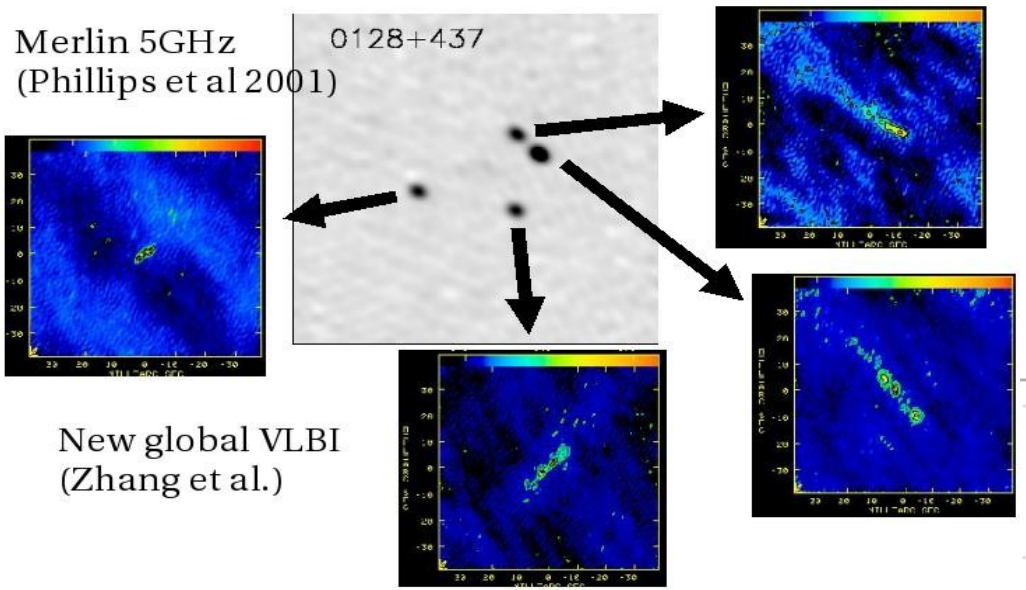
Overall shape of dark matter halo?
Dark matter subhalos?

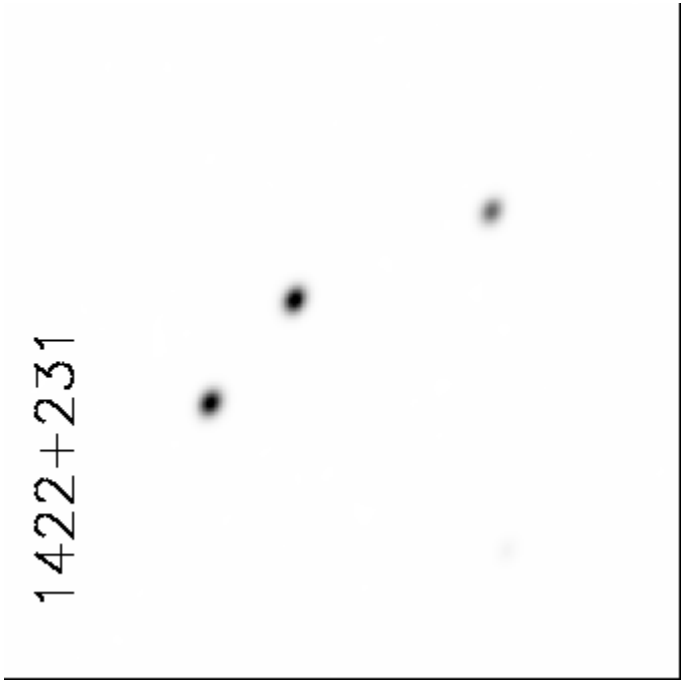


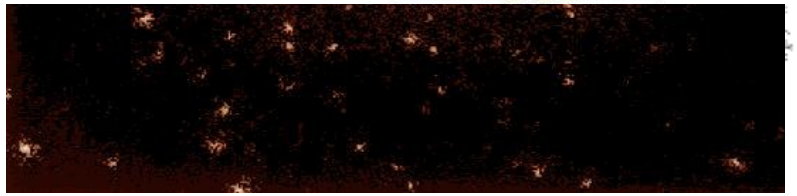
SLACS survey: mass slope (Bolton et al. 2006, Koopmans et al. 2006): “isothermal conspiracy”

Why study lenses?

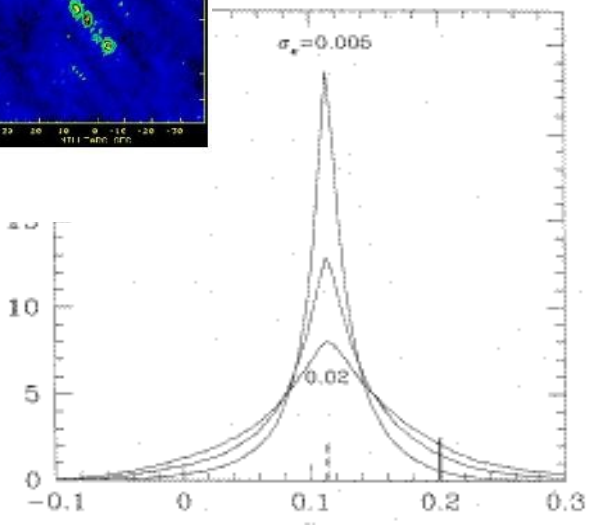
- Evidence of things not seen: dark matter in lenses

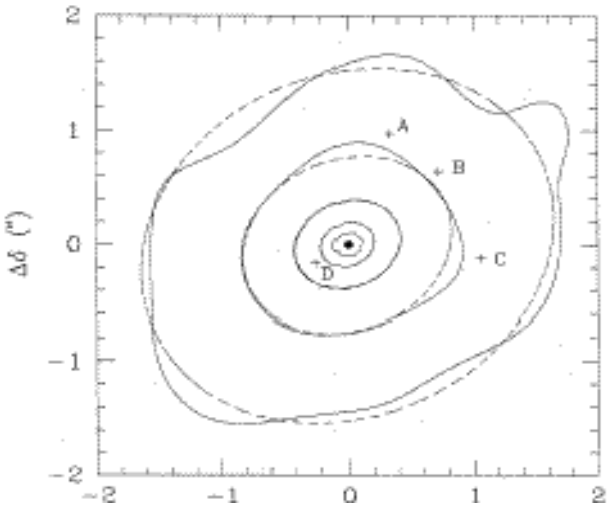






Moore et al. 1999

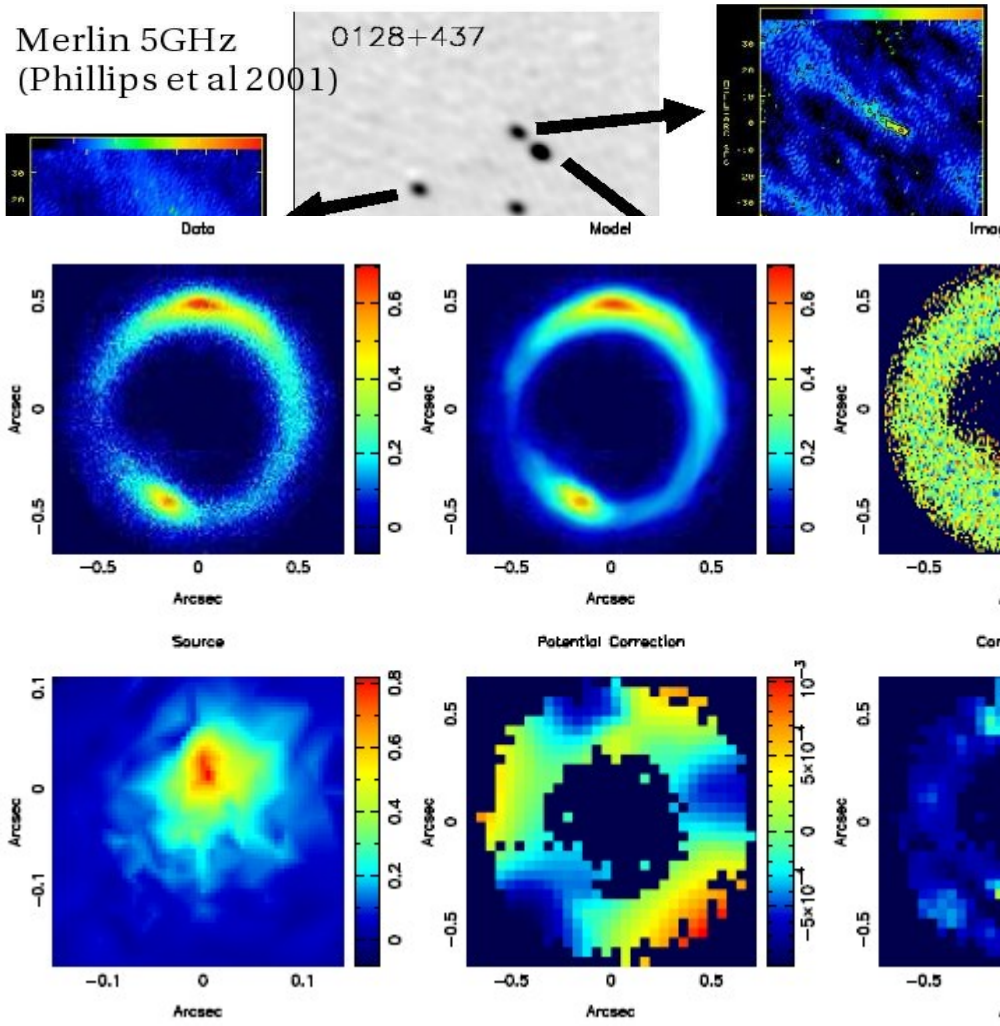


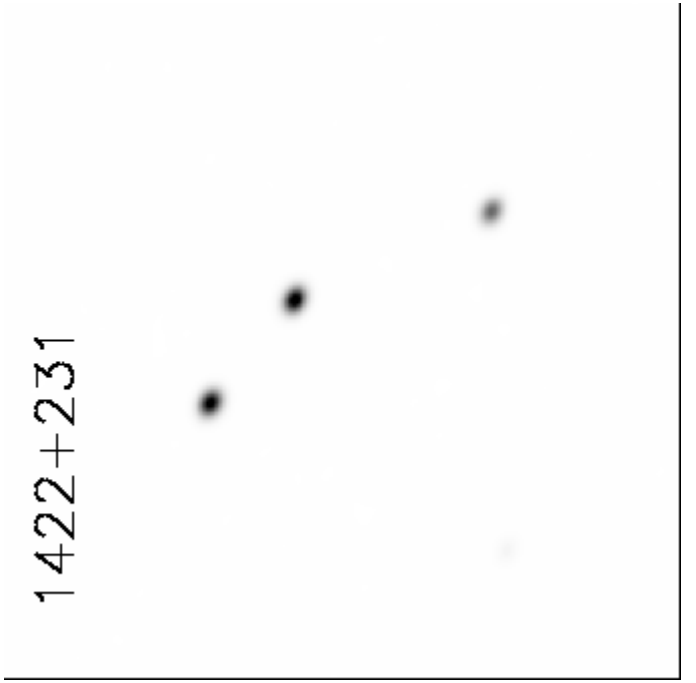


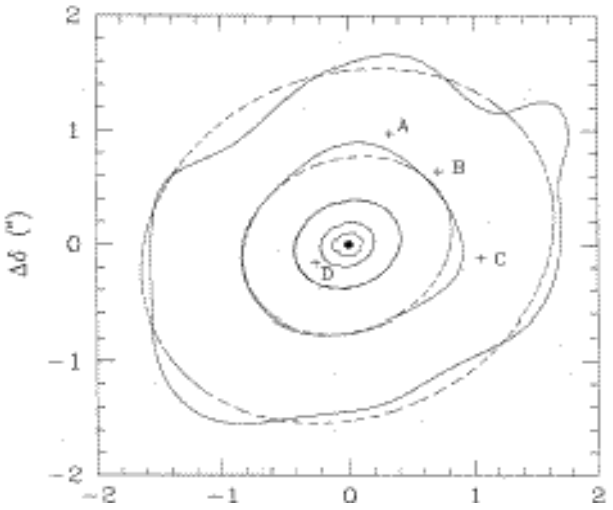
Mao et al. 1998 (CLASS radio survey lens B0128+437)

Why study lenses?

- Evidence of things not seen: dark matter in lenses





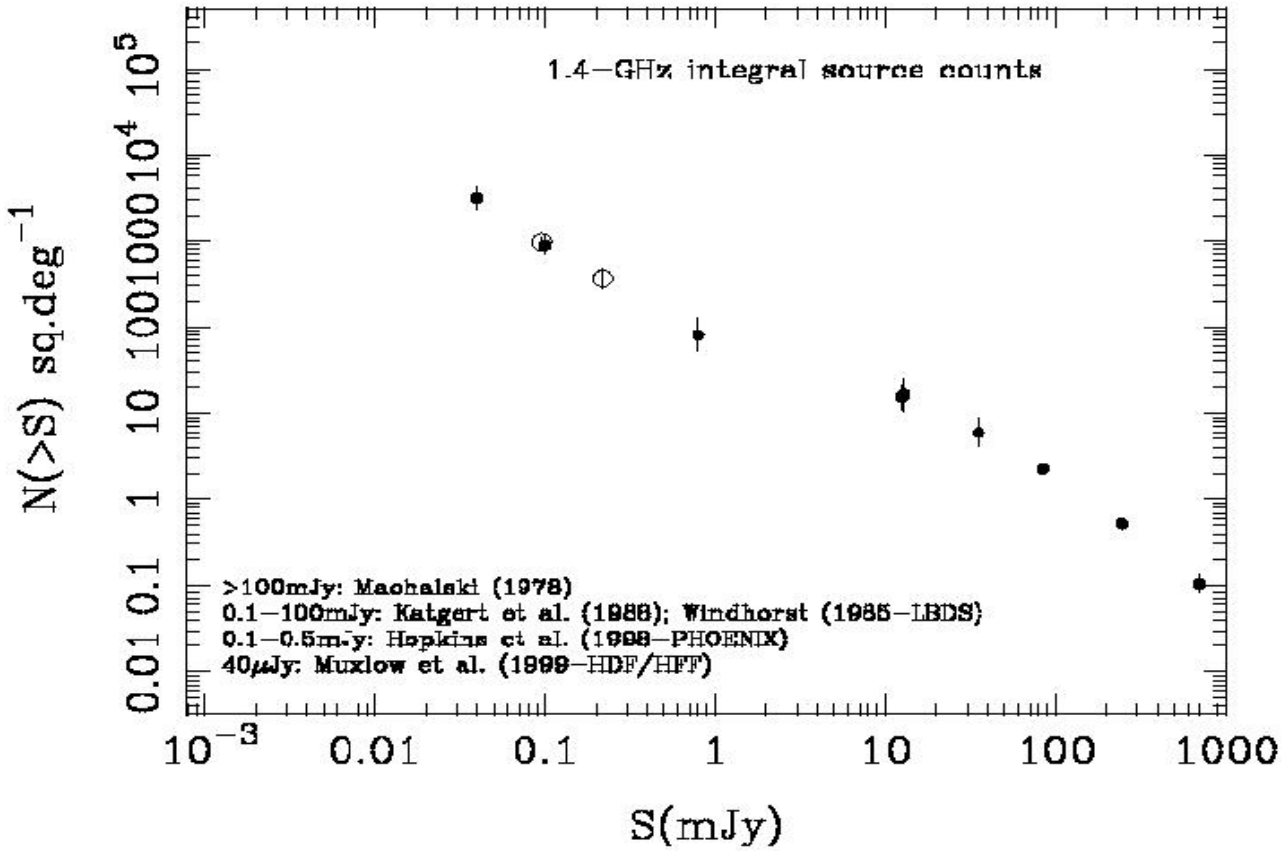


LASS radio survey lens B0128+437)

Vegetti et al. 2012: modelling of extended optical lens

Why study lenses?

- Magnification of background sources

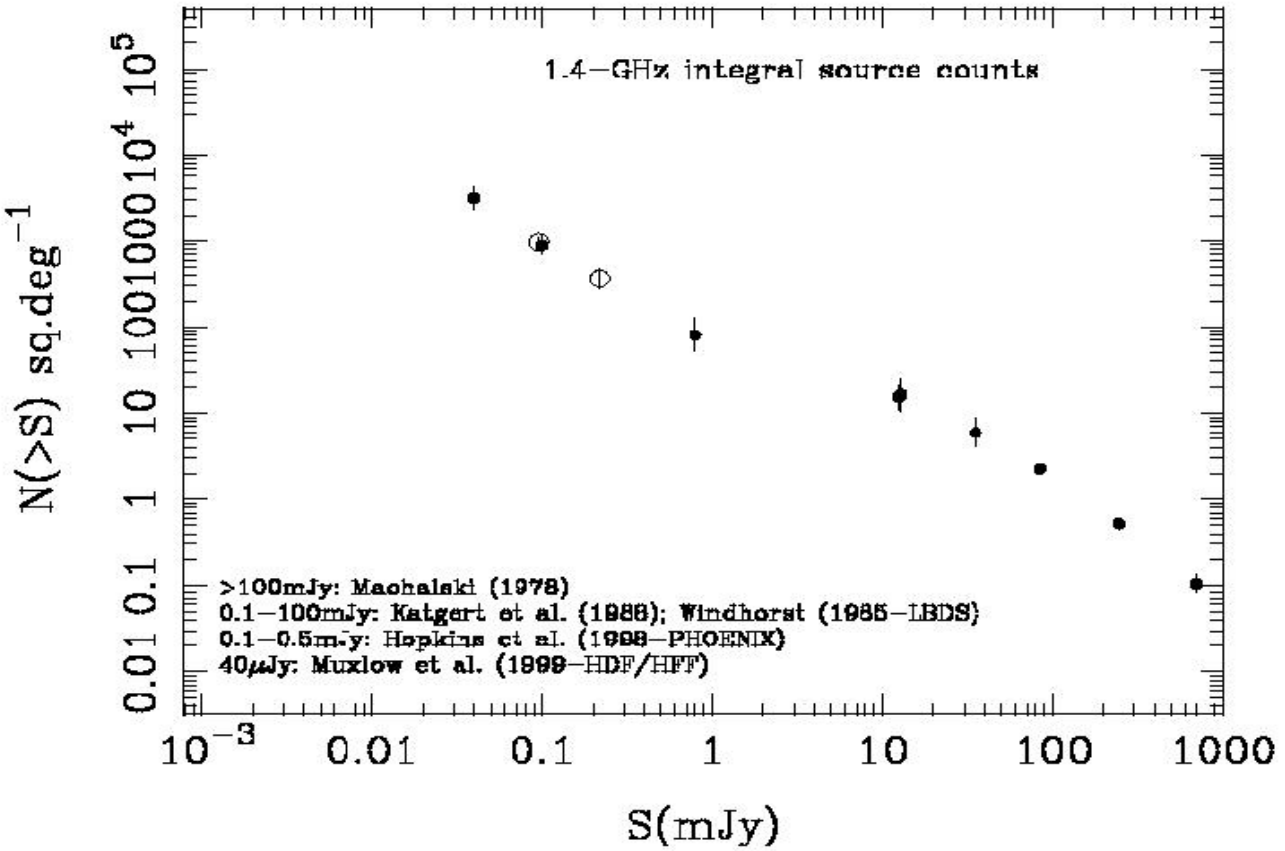


Typical magnifications of 5-10 save the expense of a factor 5-10 bigger interferometer

Allows investigation of 1-2 microJy radio sources already with e-MERLIN and JVLA

Why study lenses?

- Magnification of background sources



Typical magnifications of 5-10 save the expense of a factor 5-10 bigger interferometer

Allows investigation of 1-2 microJy radio sources already with e-MERLIN and JVLA

SKA will catch up in 2020! (then can look at fainter lenses of course)

The e-MERLIN Lensing Legacy Programme

(PIs N. Jackson (Manchester), S. Serjeant (OU))

Co-I:David Bacon, Andrew Biggs, Andrew Blain, Mark Birkinshaw, Ian Browne, Nieves Castro-Rodriguez, Scott Chapman, David Clements, Kirsten Coppin, Simon Dye, Steve Eales, Ian Heywood, Rosalind Hopwood, David Hughes, John Mckean, Angela Mortier Mattia Negrello, Chris Pearson, Ismael Perez-Fournon, Douglas Scott, Mark Thompson, Mattia Vaccari, Ludovic van Waerbeke, Steve Warren, Glenn White, Olaf Wucknitz, Ming Zhang, Gianfranco de Zotti

- Use of high sensitivity to detect core images (204h)
- Followup of H-ATLAS submm detections (24h)

- Programme started (first results e-MERLIN/JVLA)
- Awaits 2-GHz C-band for full programme

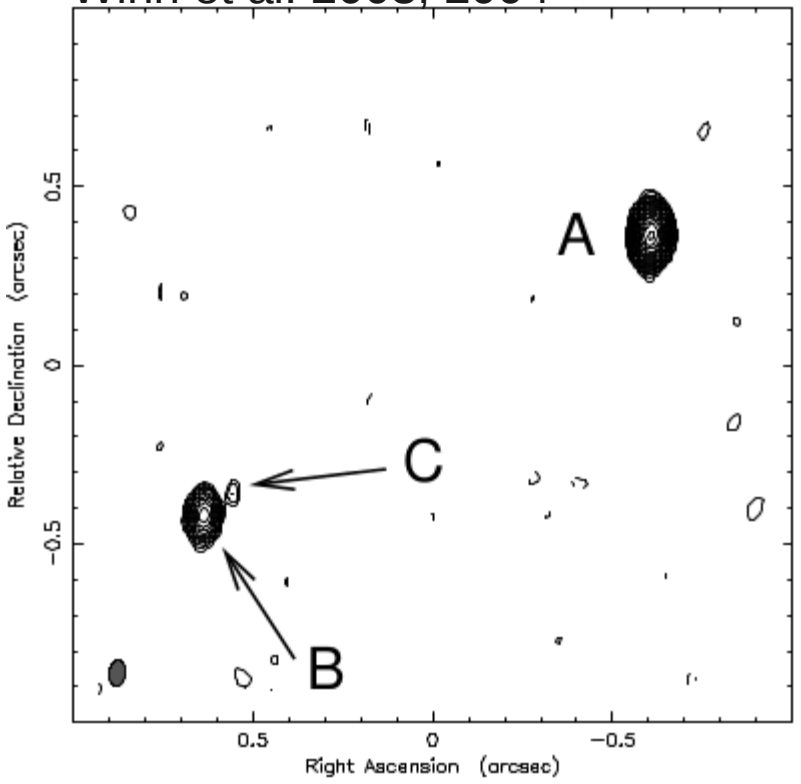
JVLA/e-MERLIN

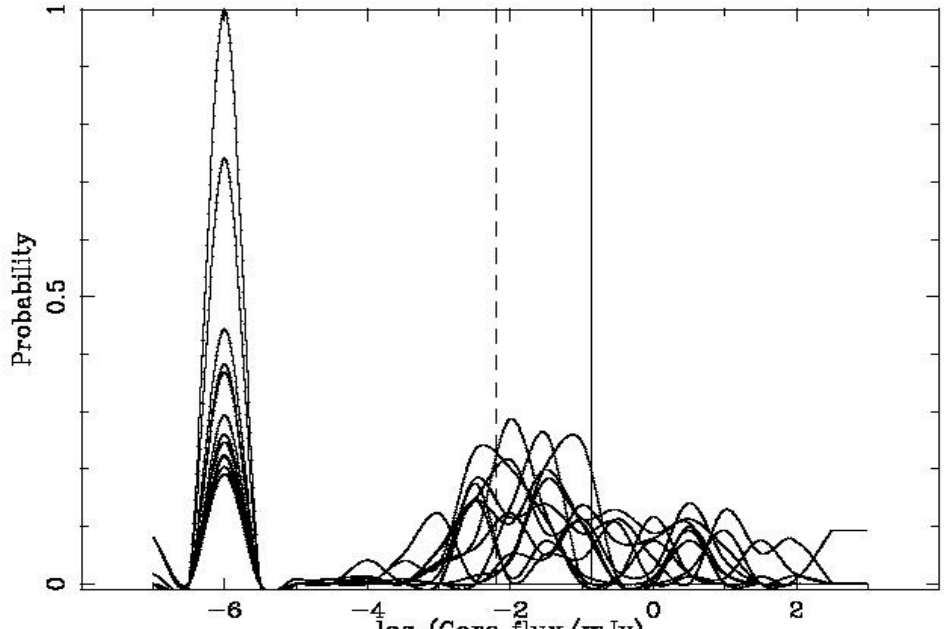
- Observations of radio-quiet objects (first JVLA observations, E-MERLIN to follow)
- Spacewarps lens

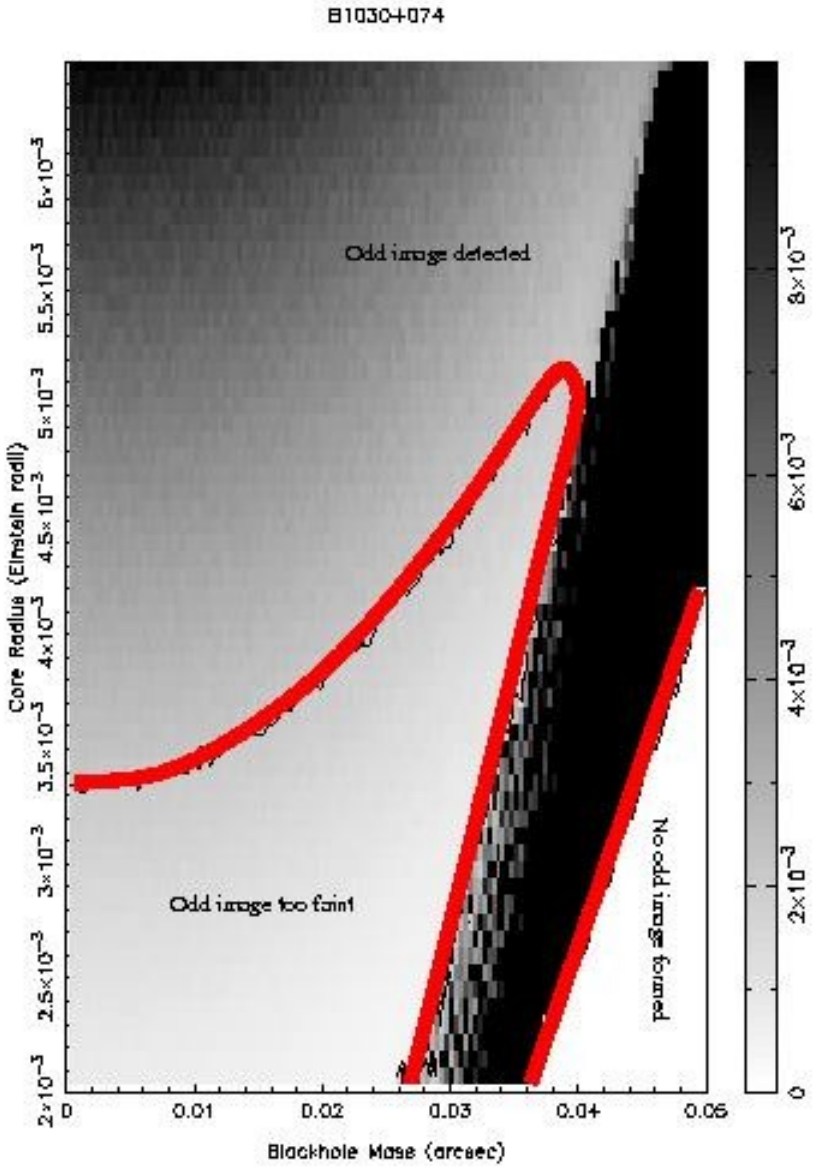
SKA

- Next-generation discovery programmes

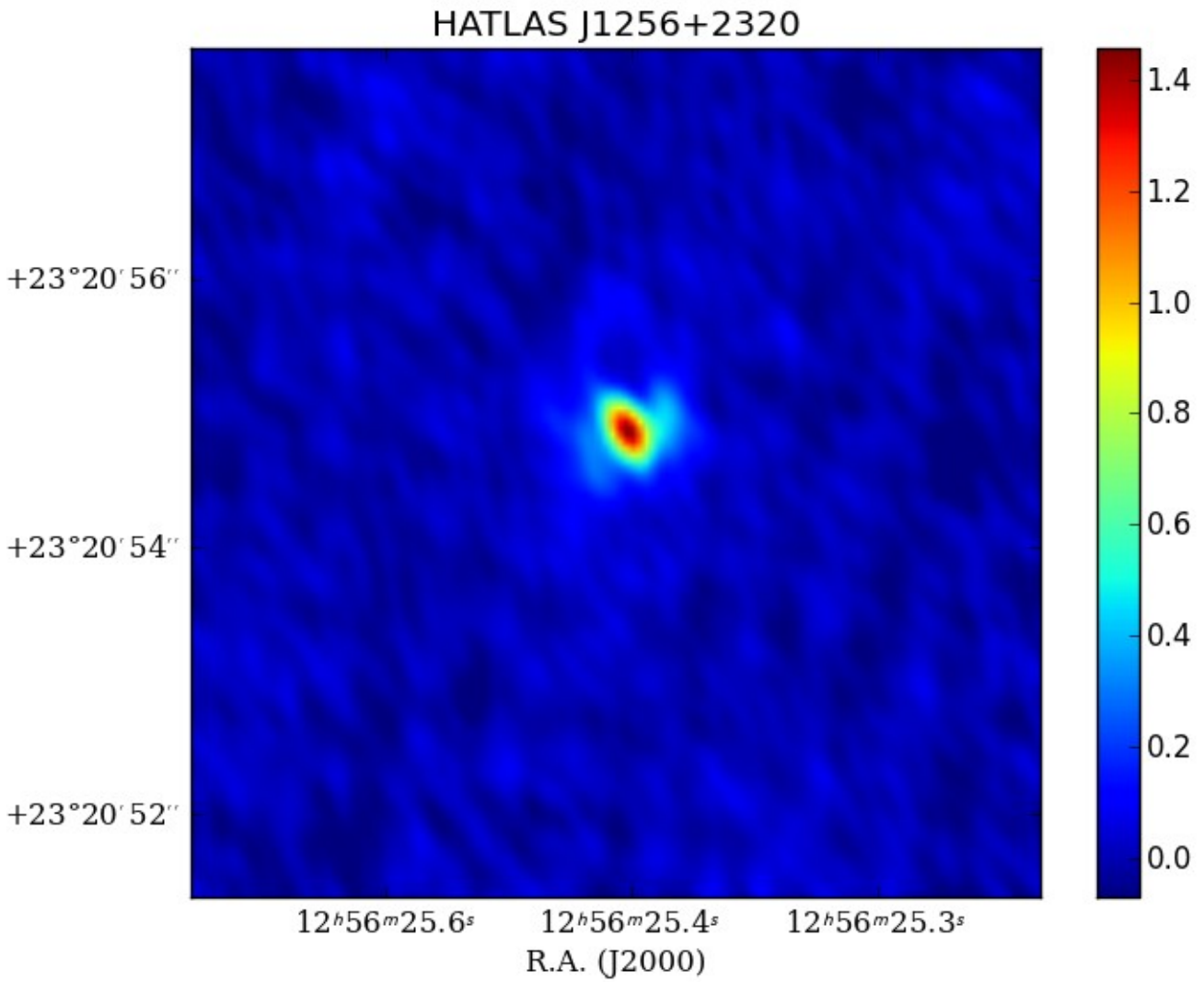
Winn et al. 2003, 2004



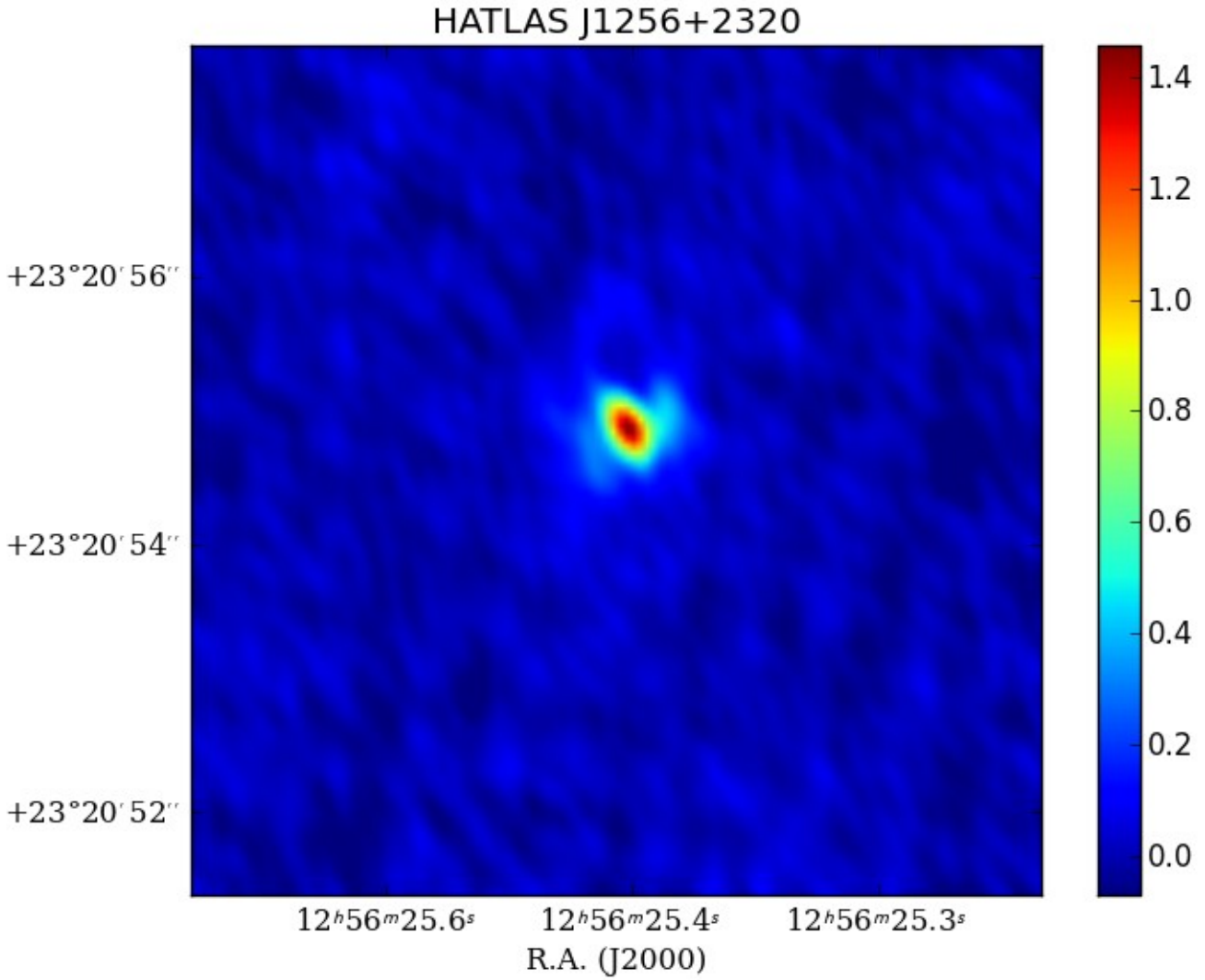




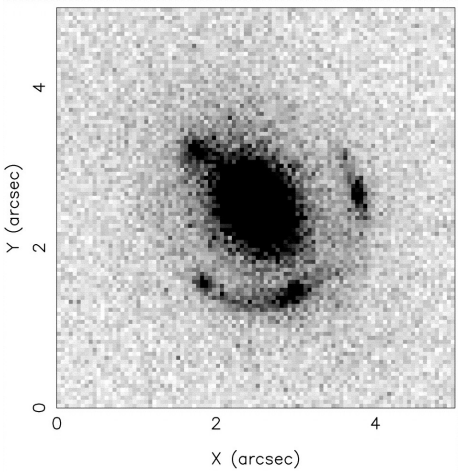
Norbury 2005

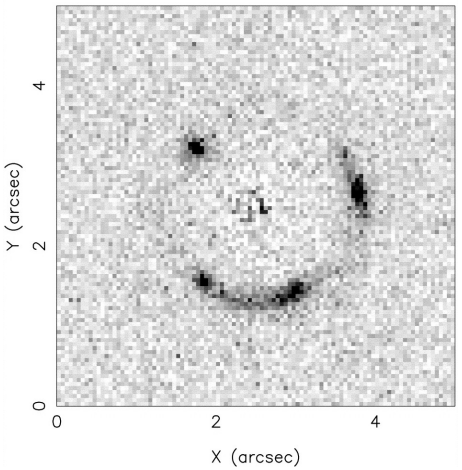


e-MERLIN 1.4GHz track (Mk2,Pi,De,Da,Kn,Cm)



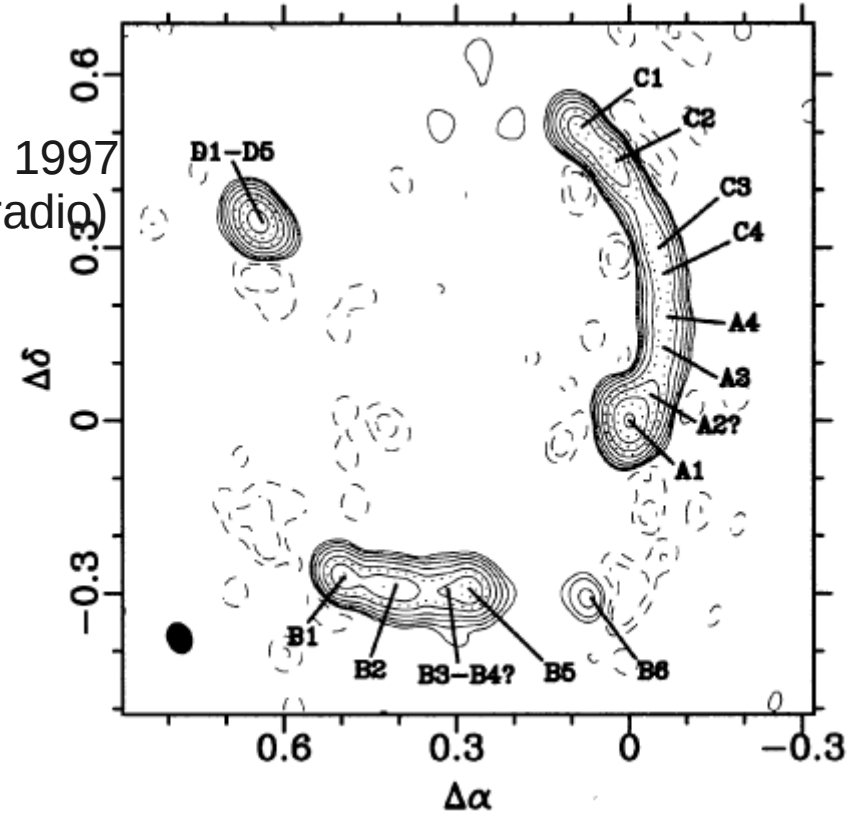
Expect ~50% lens discovery efficiency, hence next one will be a lens



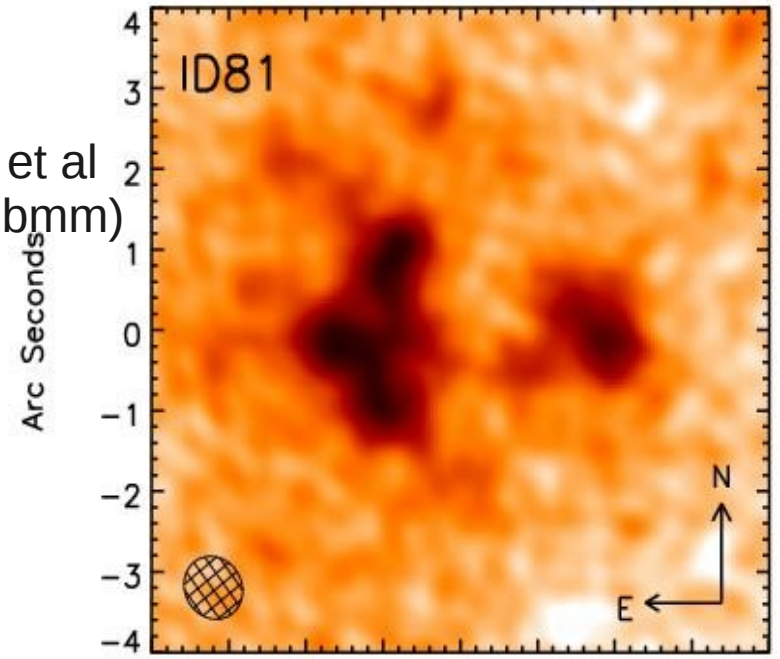


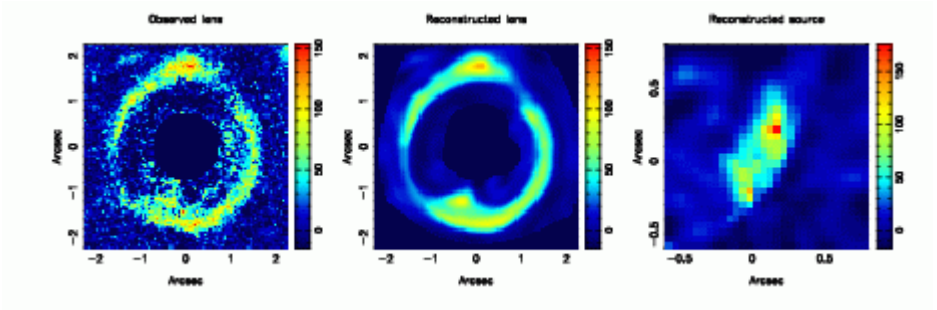
Dye & Warren 2005 (optical)

Lehar et al 1997
MG0751 (radio)

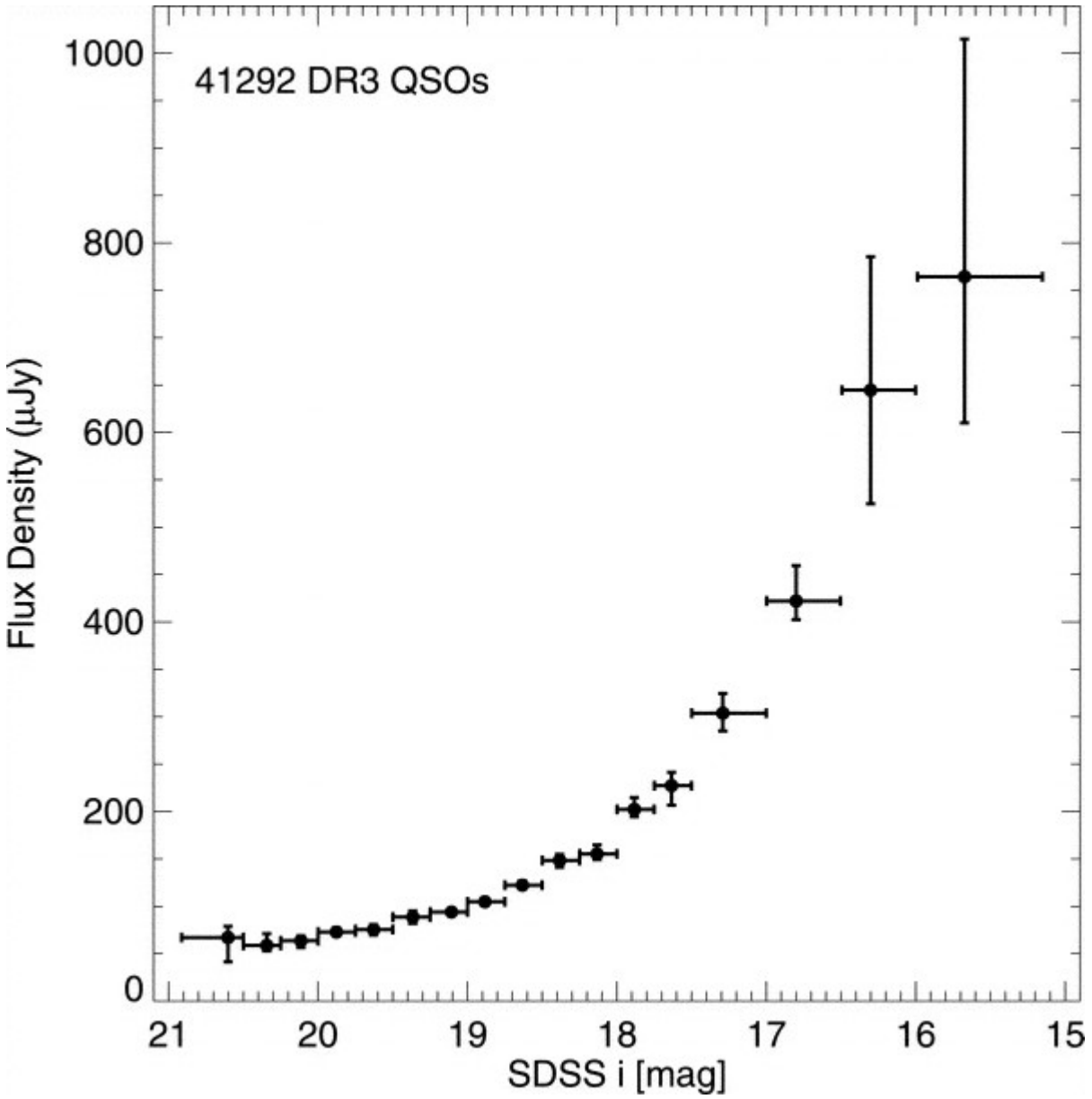


Negrello et al 2009 (submm)





Vegetti et al. 2012, Barnabe et al. 2009



White et al. 2007 (“Signals from the Noise…”) stacking of the FIRST survey

THE FAINTEST RADIO SOURCE YET: EVLA OBSERVATIONS OF THE GRAVITATIONAL LENS SDSS J1004+4112

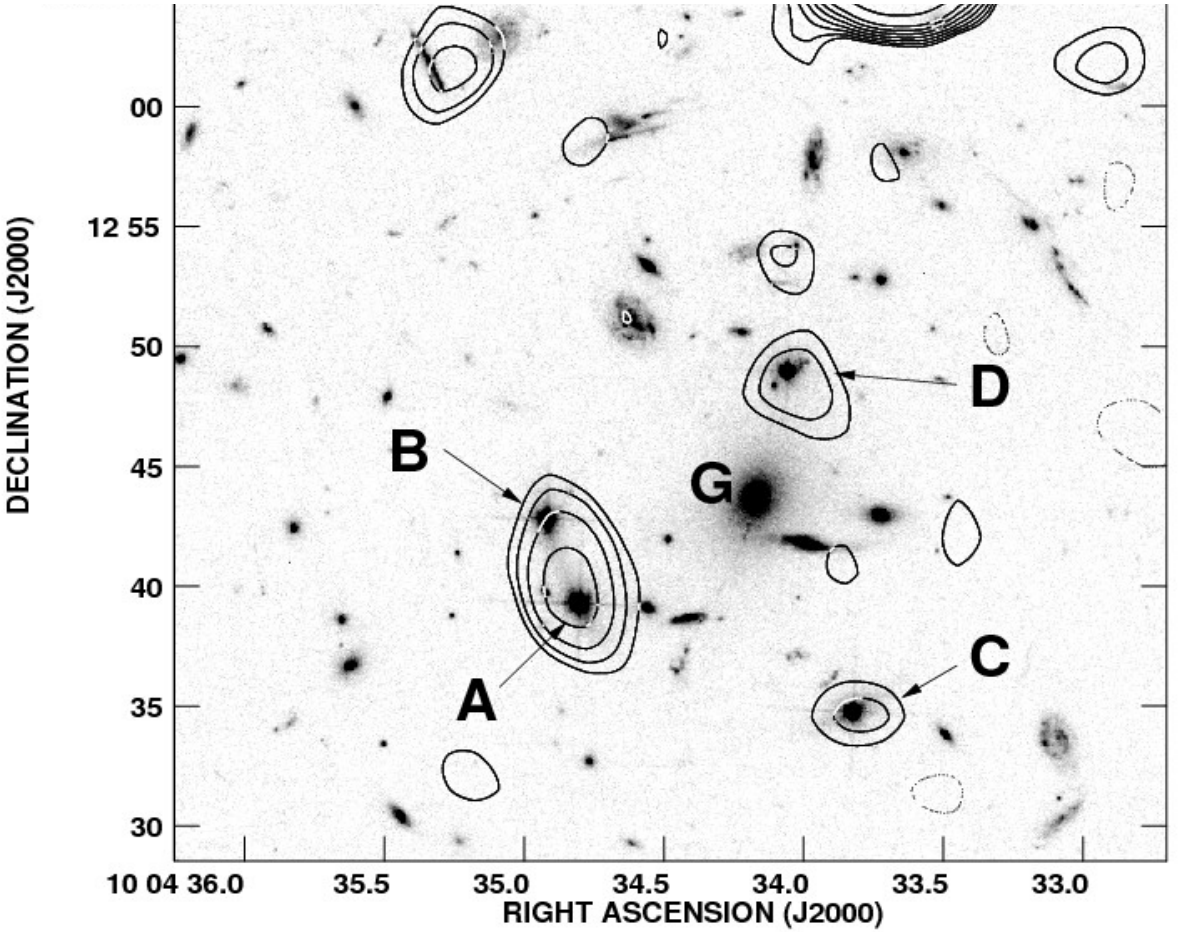
N. Jackson
Jodrell Bank Centre for Astrophysics, School of Physics & Astronomy, University of Manchester, Alan Turing Building, Oxford Road, Manchester M13 9PL, UK

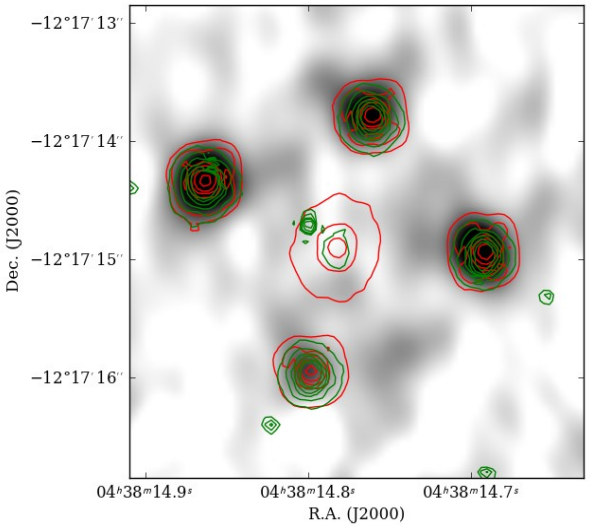
Draft version June 14, 2011

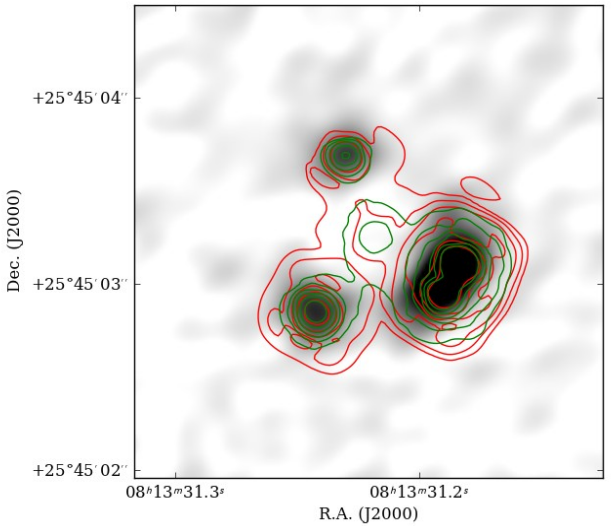
ABSTRACT

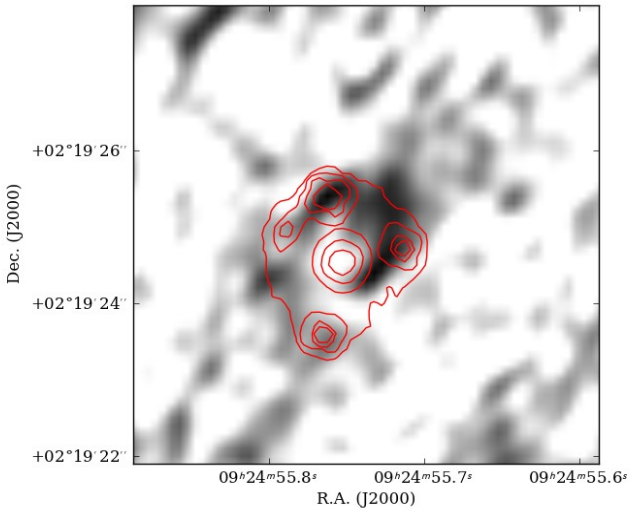
We present new radio observations of the large-separation gravitationally-lensed quasar SDSS J1004+4112, taken in a total of 6 hours of observations with the Extended Very Large Array (EVLA). The maps reach a thermal noise level of approximately 4μJy. We detect four of the five lensed images at the 15-35μJy level, representing a source of intrinsic flux density, after allowing for lensing magnification, of about 1μJy, intrinsically probably the faintest radio source yet detected. This reinforces the utility of gravitational lensing in potentially allowing us to study nanoJy-level sources before the advent of the SKA. In an optical observation taken three months after the radio observation, image C is the brightest image, whereas the radio map shows flux density ratios consistent with previous optical observations. Future observations separated by a time delay will give the intrinsic flux ratios of the images in this source.

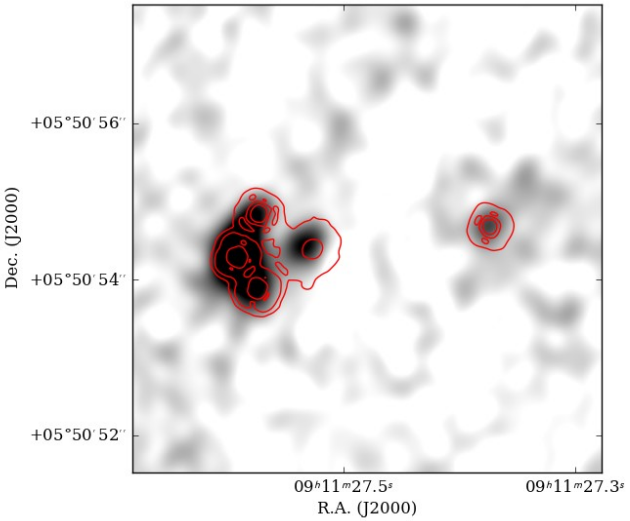
Subject headings: gravitational lensing:strong — quasars:individual(SDSS J1004+4112) — radio continuum:galaxies





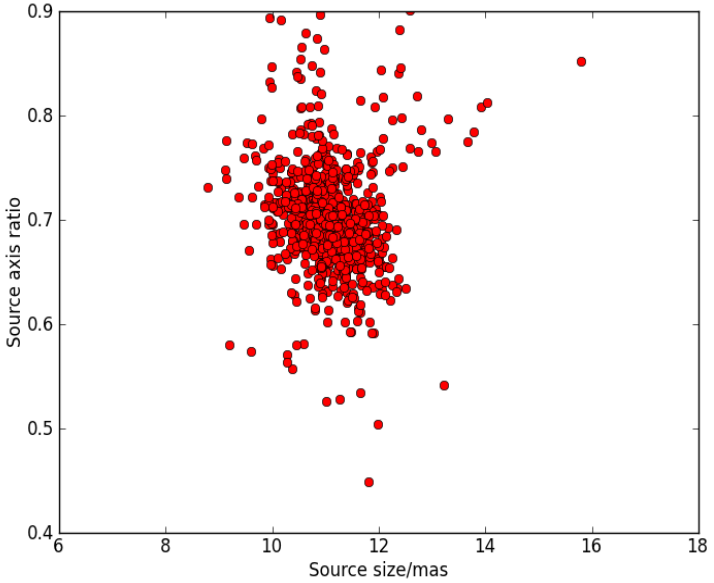


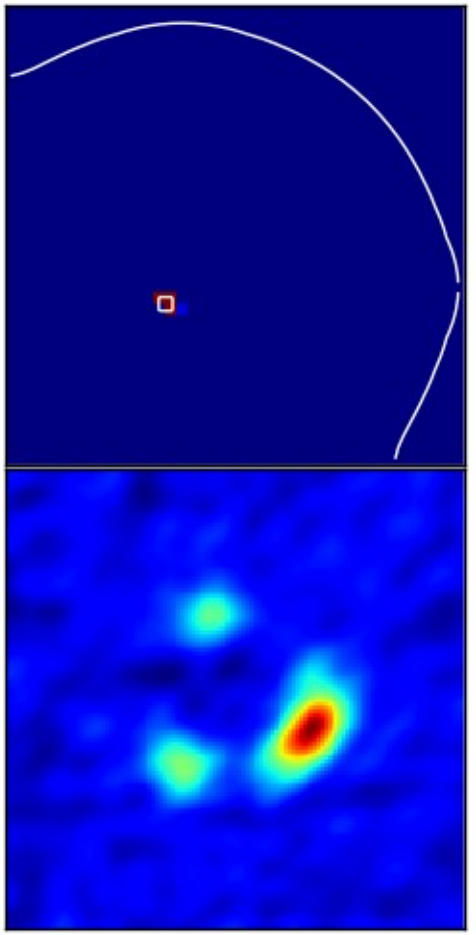


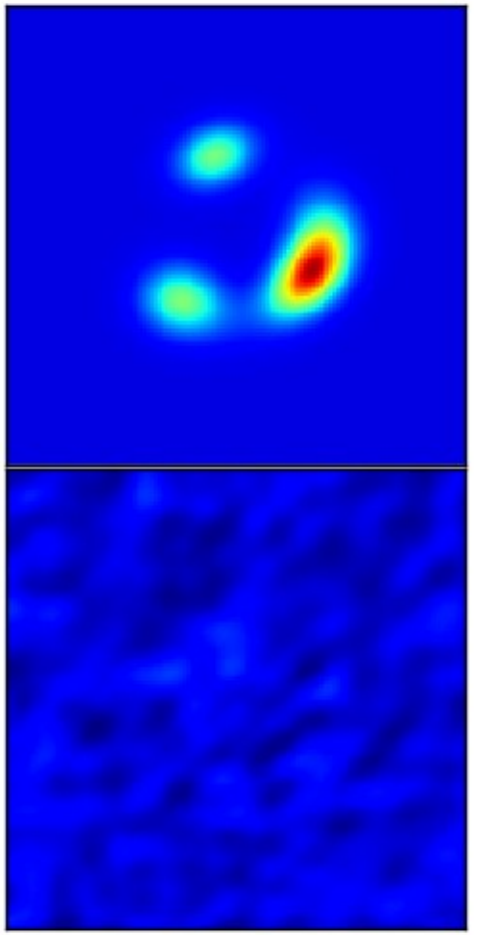


JVLA imaging of four of the targets; all microJy radio sources intrinsically

Modelling of 0810 with SIE: good fit with simple model, source is extended and ~11mas



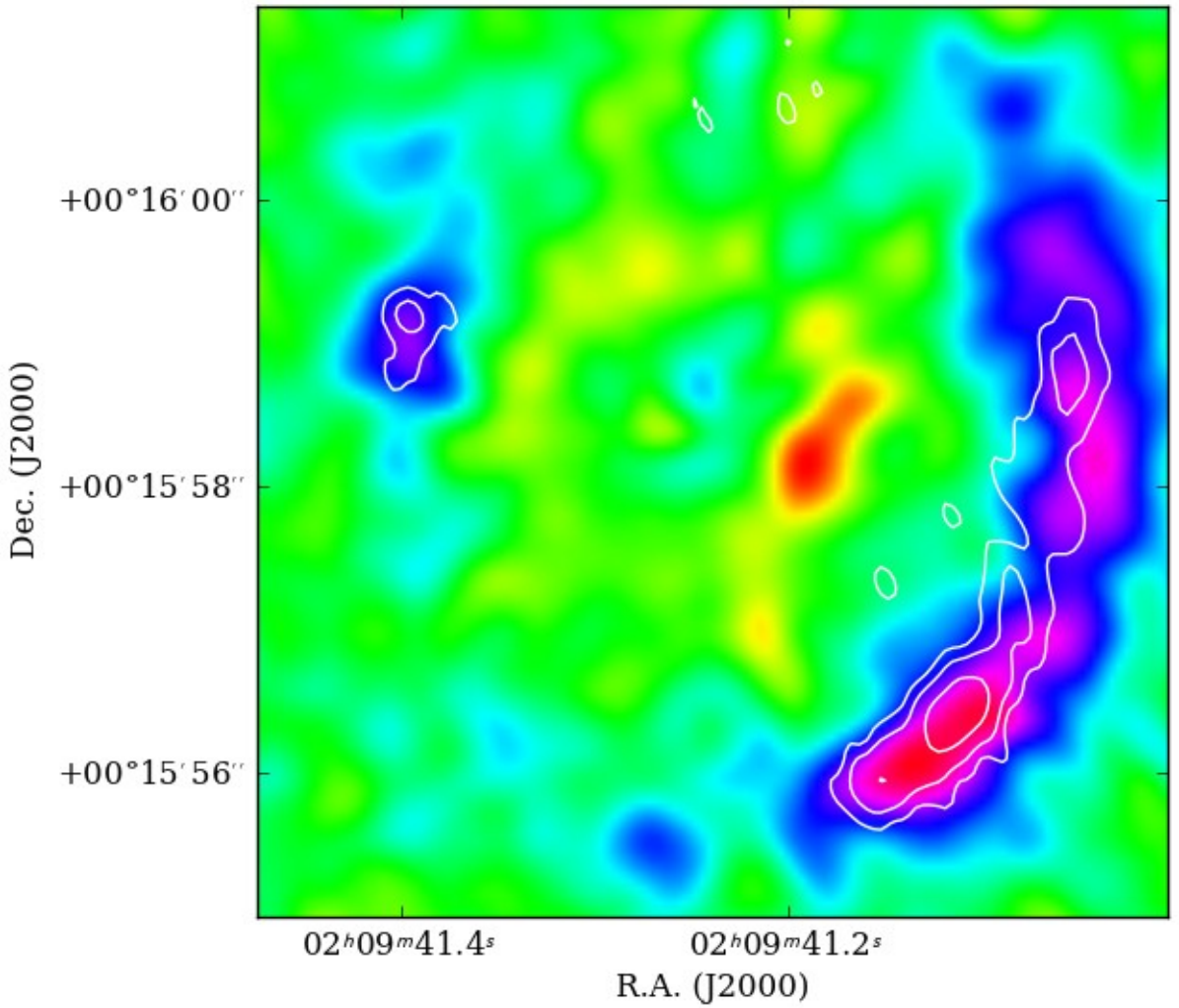




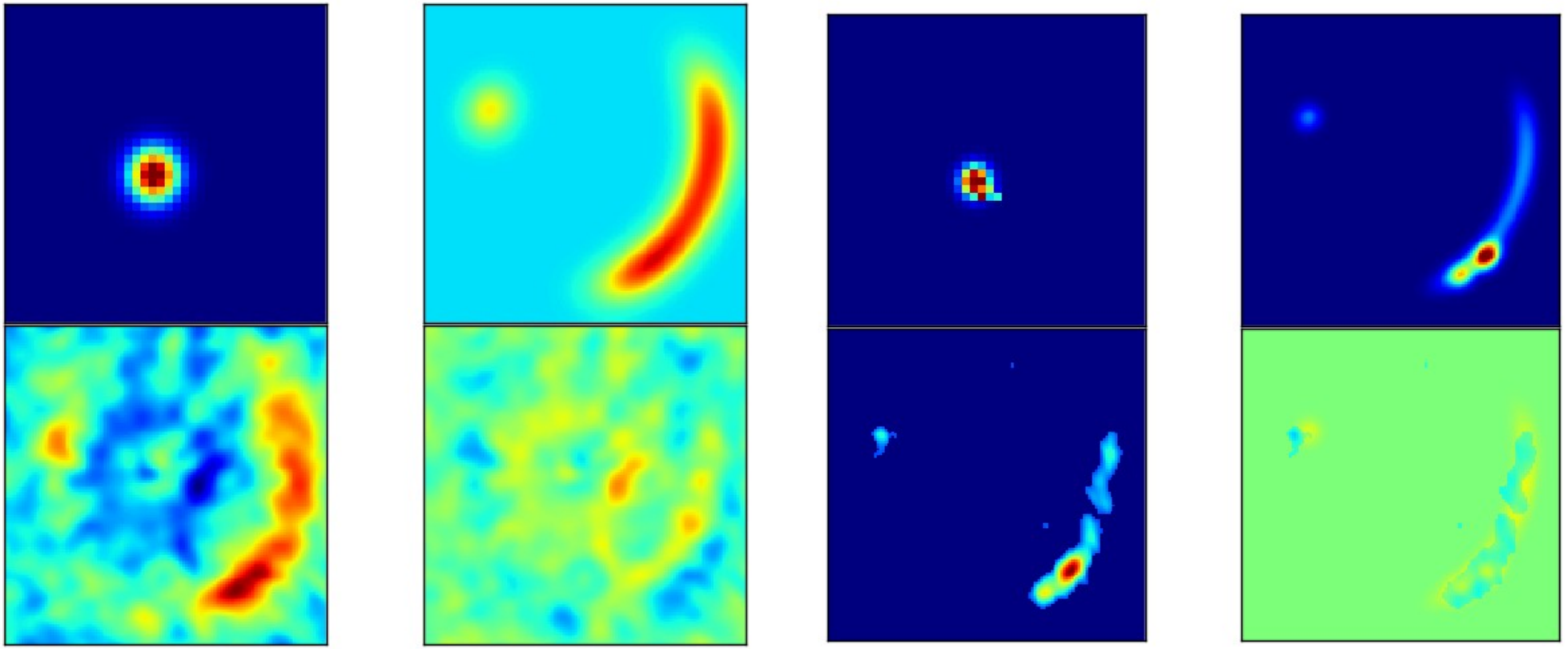
Need to combine with higher-resolution image (e-MERLIN will help a lot!)

SPACEWARPS citizen science project lens (Stargazing Live)

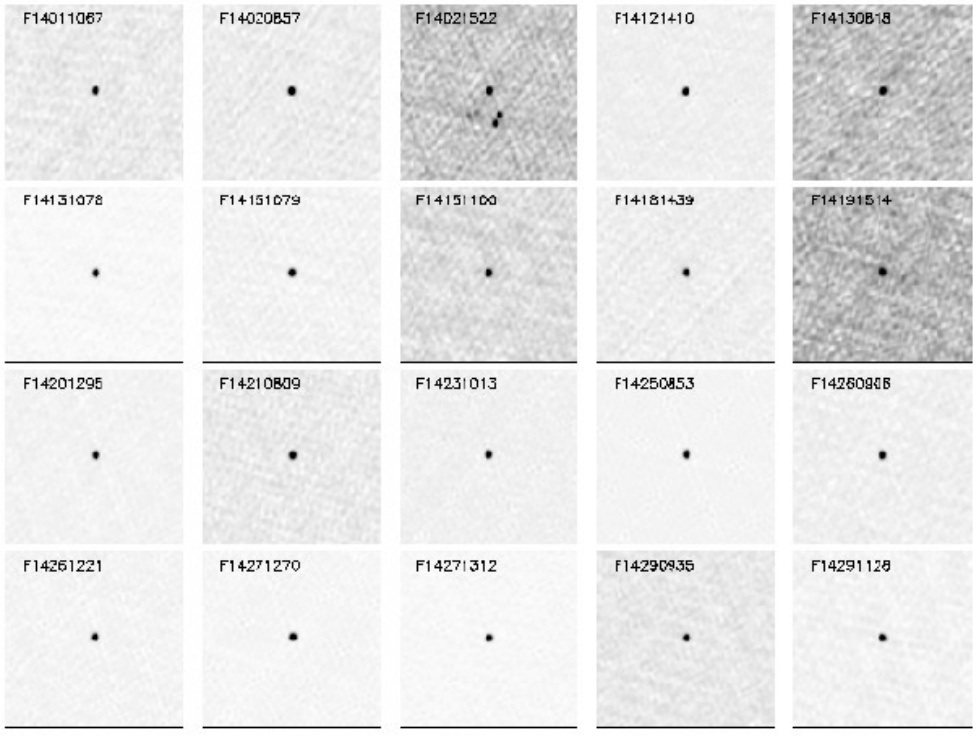
PIs: A. More (IPMU), A. Verma (Oxford), P. Marshall (KIPAC):
http://spacewarps.org



Contours: radio e-MERLIN 1.4GHz (map by Tom Muxlow)
IR image: J.Geach and the VICS82 team/TERAPIX/CNRS/INSU/CASU



Left: model of IR image (source, model, image, residual)
Right: model of radio image (source, model, image, residual)


F14011067
F14020857
F14021522
F14121410
F14130818
F14131078
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F14151100
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F14191514
F14201295
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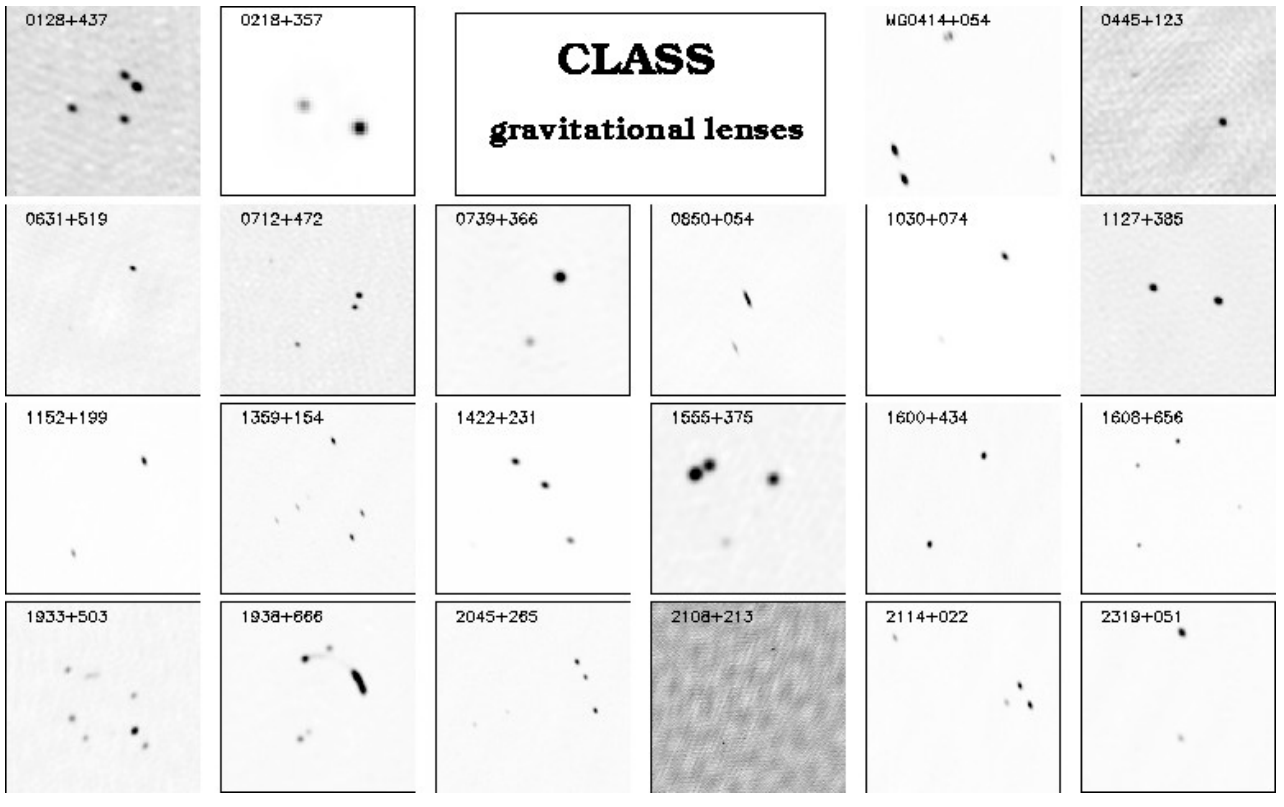
F14291128


0128+437
0218+357
CLASS
gravitational lenses
MG0414+054
0445+123
0631+519
0712+472
0739+366
0850+054
1030+074
1127+385
1152+199
1359+154
1422+231
1555+375
1600+434
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1933+503
1938+666
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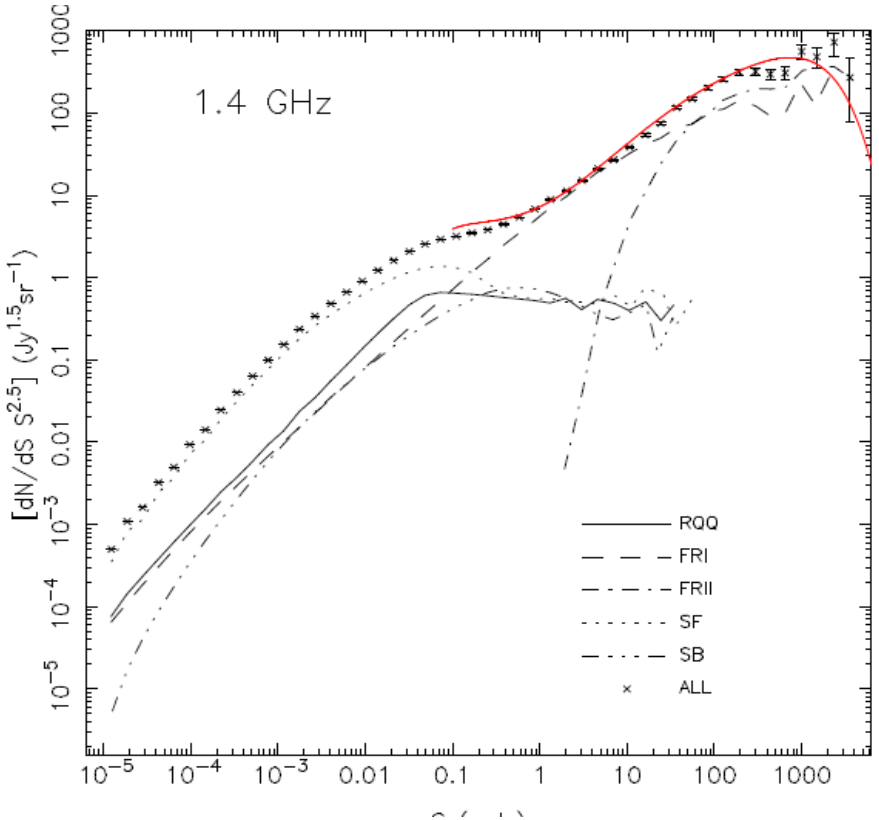
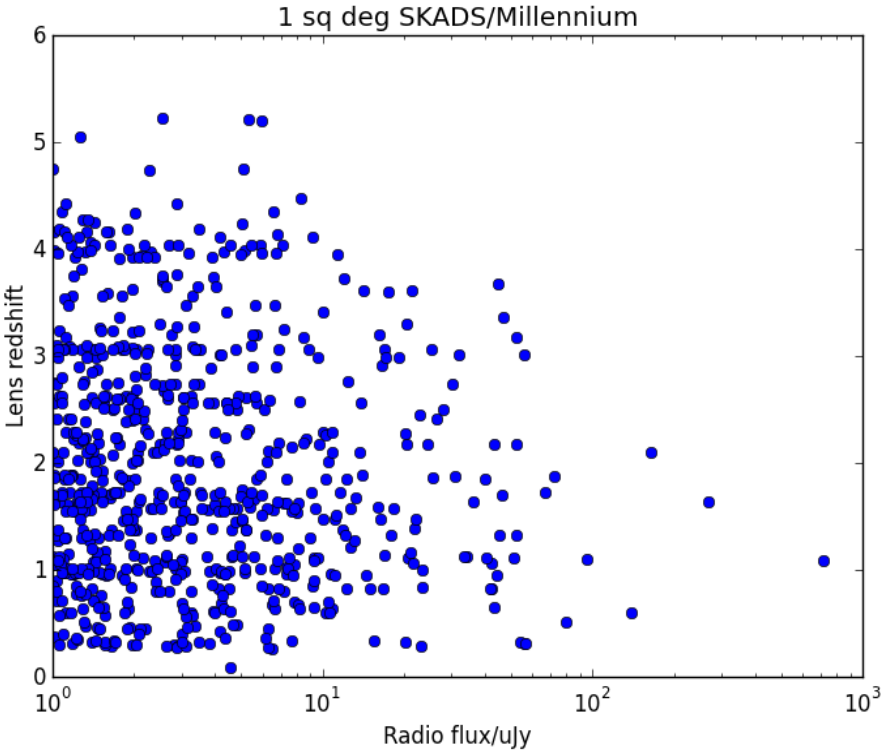
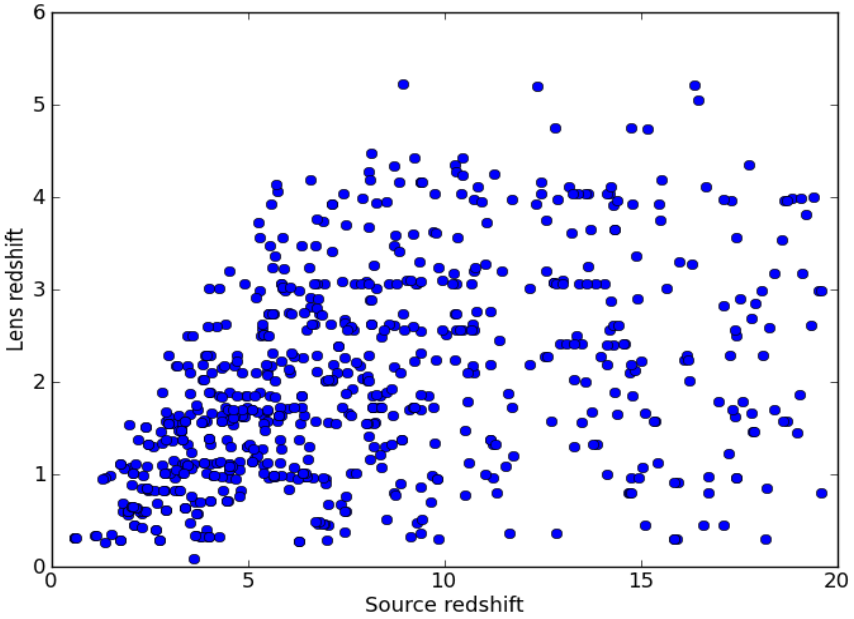
2108+213
2114+022
2319+051

class



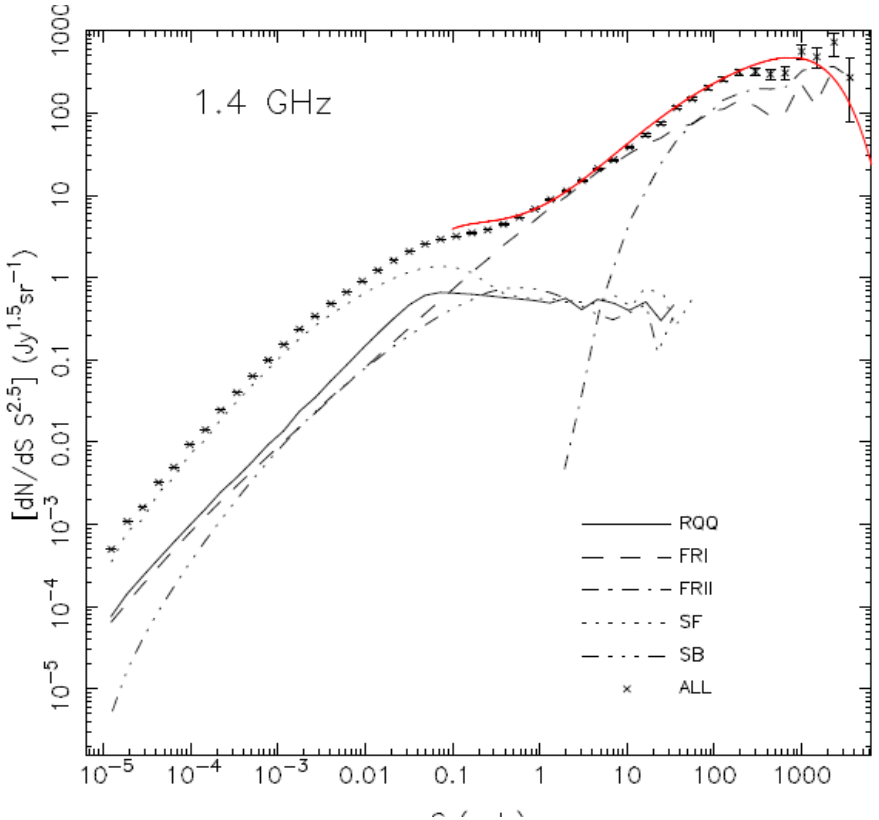
Source counts/model: Wilman et al. 2007





Simple simulation gives nature and number of SKA lenses: agrees roughly with CLASS sample at high fluxes

SKA-1: few lensed SF sources/sq deg
Full SKA: huge number of high-redshift lenses (or at any rate great probe of high-z universe)



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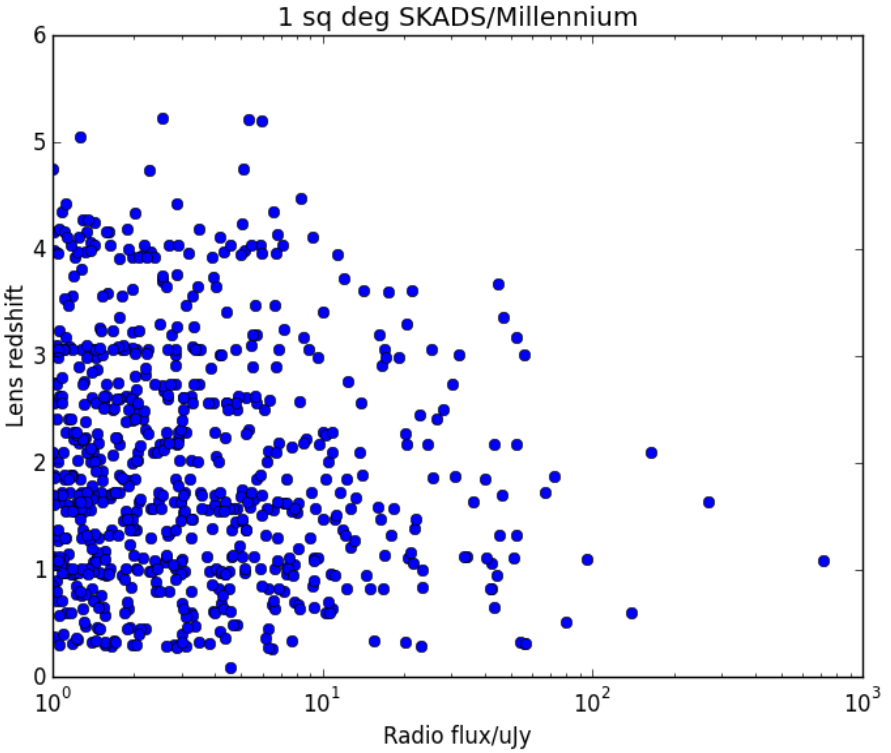

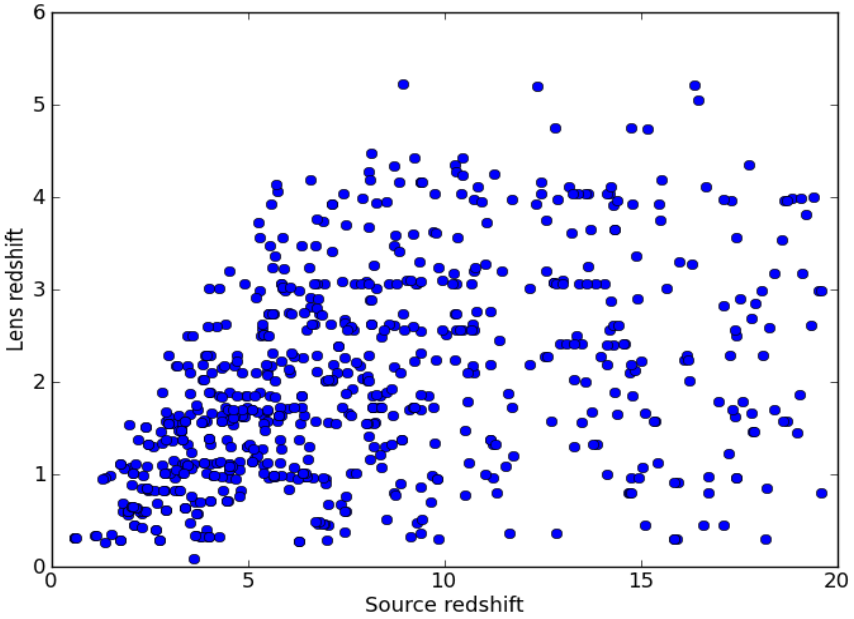

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SKA-1: few lensed SF sources/sq deg
Full SKA: huge number of high-redshift lenses (or at any rate great probe of high-z universe)
SKA book chapter (McKean, Jackson et al; Co-authors welcome)