MANCHESTER 1824
The University of Manchester

Introduction to e-MERLIN

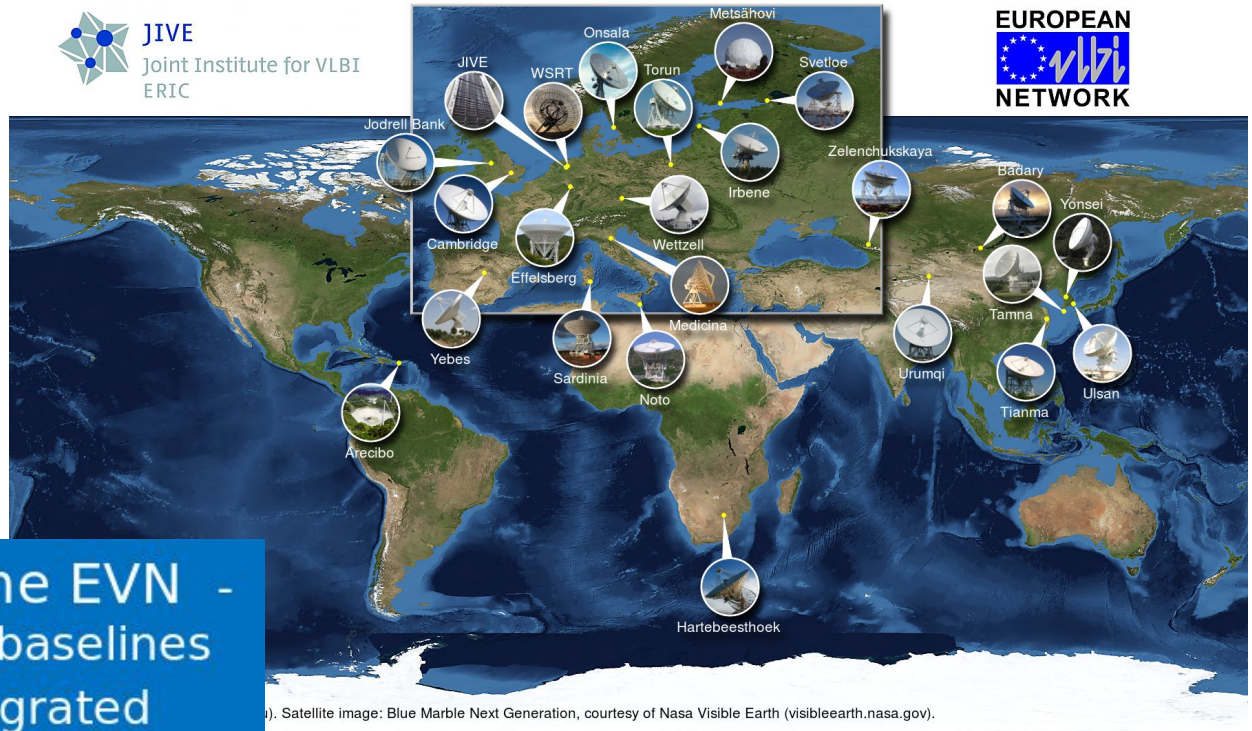
Javier Moldon

This presentation/publication has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730562 [RadioNet].

e-MERLIN summary

- array of 7 antennas
- operating at cm-λ
- with μJy sensitivity
- ~10-220 km baselines
- elements connected with optical fibre
- SKA-pathfinder

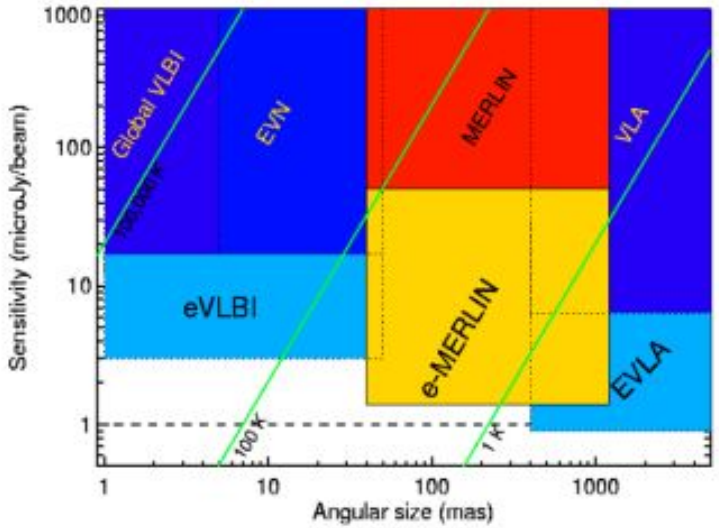
e-MERLIN as part of the EVN

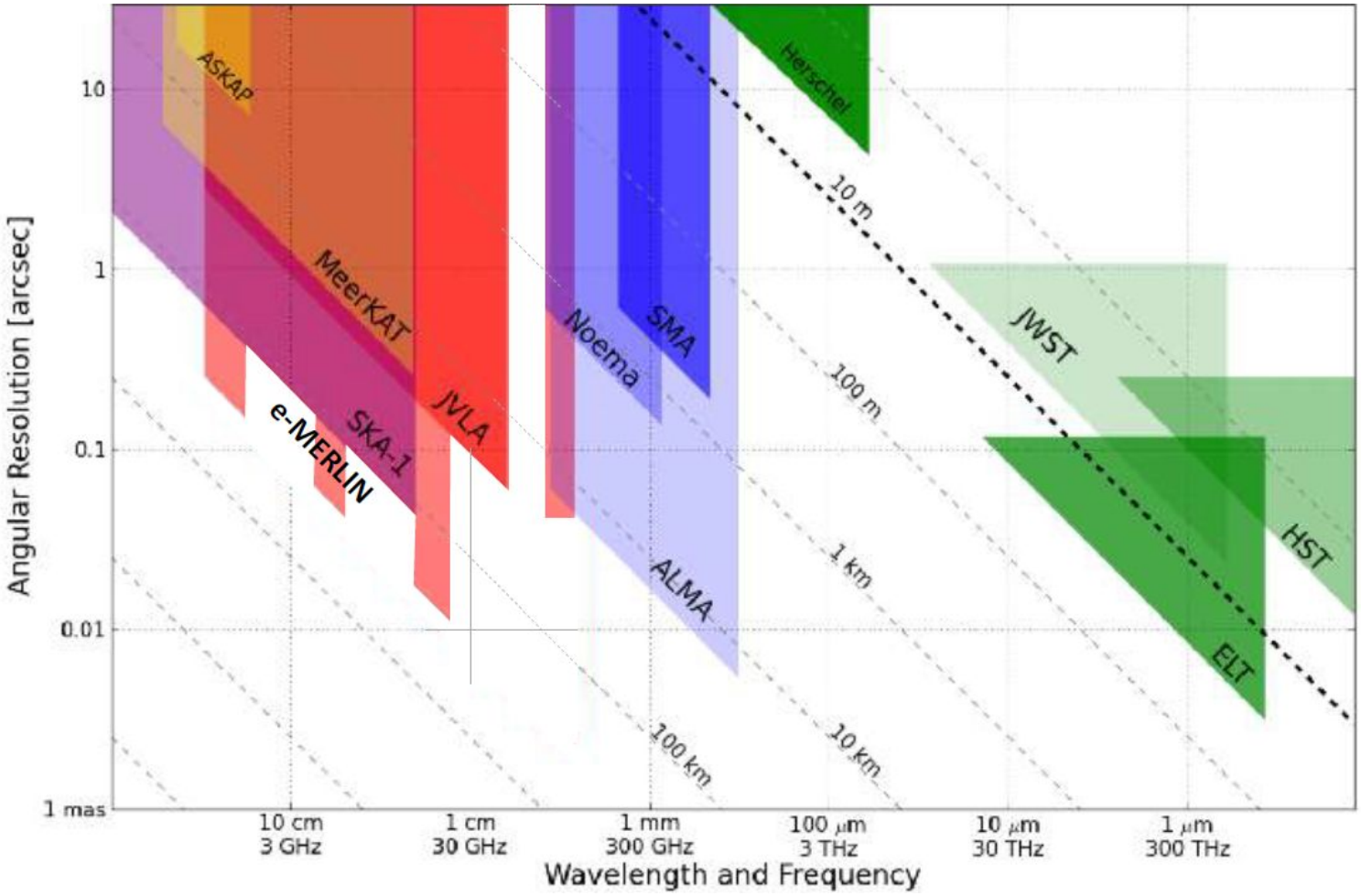


Key/integral part of the EVN - providing 'short' spacing baselines
- Now becoming fully integrated

Basic capabilities

- L band (1.4 GHz), C band (5 GHz), K band (22 GHz)
- ~10-20 uJy sensitivity in typical runs
- 150, 40, 10 mas resolution
- Filters scales bigger than 1-5 arcsec
- Mix line and continuum
- Order of mag better than MERLIN performance
- Much improved aperture coverage (frequency)
- Spectral mapping 1.3-1.7; 4.5-7.5 GHz
- Polarization (L, R IQUV)
- Astrometry goal is < 1 mas wrt ICRF




ASKAP
MeerKAT
e-MERLIN
SKA-1
JVLA
Noema
SMA
ALMA
Herschel
JWST
HST
ELT
10 m
100 m
1 km
10 km
100 km
10
1
0.1
0.01
1 mas
Angular Resolution [arcsec]
10 cm
3 GHz
1 cm
30 GHz
1 mm
300 GHz
100 μm
3 THz
10 μm
30 THz
1 μm
300 THz
Wavelength and Frequency

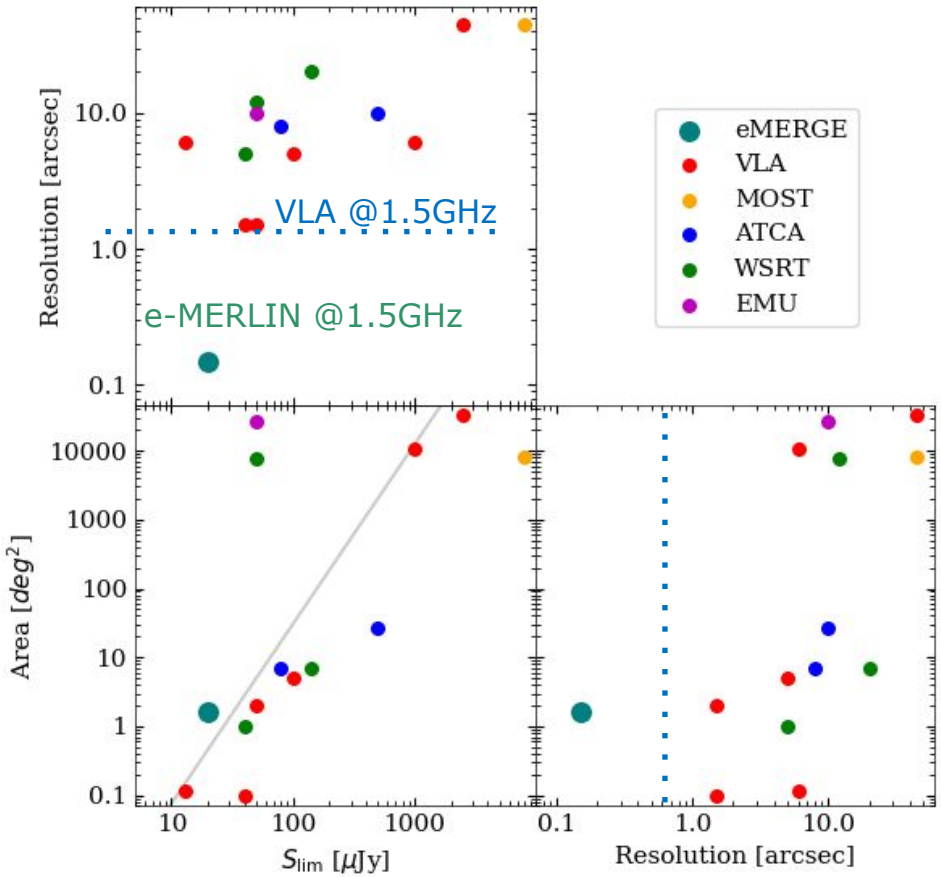
Survey power

Legacy surveys now targeting:

- moderate areas (~deg^2)
- with high resolution (120 mas)

For example:

eMERGE, AGATE, SuperCLASS & CoBRAS



Detailed capabilities

	1.5GHz (L-band)	5GHz (C-band)	22GHz (K-band)	Notes
Resolution (milliarcseconds)	150	40	12	Uniform weight at central frequency
Field of View (FoV) (arcmin)	30	7	2	FWHM of 25m dishes; reduced when the Lovell Telescope is included
Frequency range (GHz)	1.25-1.75	4-8	21-24	Tuneable frequency range
Bandwidth (GHz)	0.5	2	2	Max bandwidth per polarisation; at C or K-band, 4GHz is possible using a single polarisation.
Sensitivity (μJy/bm) in a full imaging run	6-7	4	15	Performance depends on usable bandwidth and observing conditions. Figures are for e-MERLIN with the Lovell telescope at L and C-band.
Surface brightness sensitivity (K)	190	~70	~530	
ICRF astrometric performance (mas)	2	~1	~2	With respect to the ICRF (assuming a typical 3^{o} target-calibrator separation)
Astrometric repeatability (mas)	~0.5	~0.2	~1	Day-to-day repeatability using surveyed or in-beam sources, and assuming a full imaging run
Amplitude calibration (%)	2	1	10	Targets for day-to-day repeatability

Legacy and PATT proposals

PATT proposals (aka PI-led proposals of all sizes)

- 6 monthly call cycle (spring/Autumn) – fully open
- Proposals accepted via Northstar proposals system
- Online Simulator tools and exposure calculators available from e-MERLIN website

See www.e-merlin.man.ac.uk/observe/
Any use questions : e-merlin@jb.man.ac.uk

Typical oversubscription rates are

- 4-3:1 (all proposals)
- 8-5:1 (proposals requesting Lovell telescope inclusion)

Existing Large Legacy projects

- Account for ~50% of available observing time
- Competitively allocated programme of 12 large projects
- Cover all science areas – planets to cosmology
- Long-term observing status – allowing large international teams to build resources and sustain projects.

Opportunities for new projects will be available… soon!...

e-MERLIN/VLBI Legacy Science

- Pulsars, Gravity & Gravitational waves
- Time-domain & Transient astrophysics
- Planet & star-formation
- Galaxy formation & evolution
- Cosmic shear & Gravitational lensing

Current e-MERLIN Legacy Programme

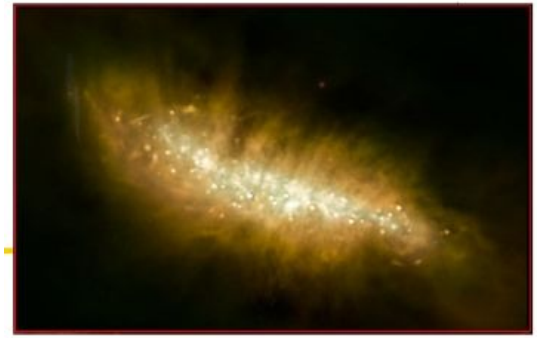
Galactic Science:

- e∏ - Pulsar astrometry	Vlemmings/Stappers et al.	160hrs
- PEEBLES – planet formation	Greaves et al.	402hrs
- Feedback processes in Massive SF	Hoare/Vlemmings et al.	450hrs
- Thermal jets from low mass stars	Rodriguez et al	180hrs
- COBRaS – wide-field deep galactic survey	Prinja et al.	294hrs

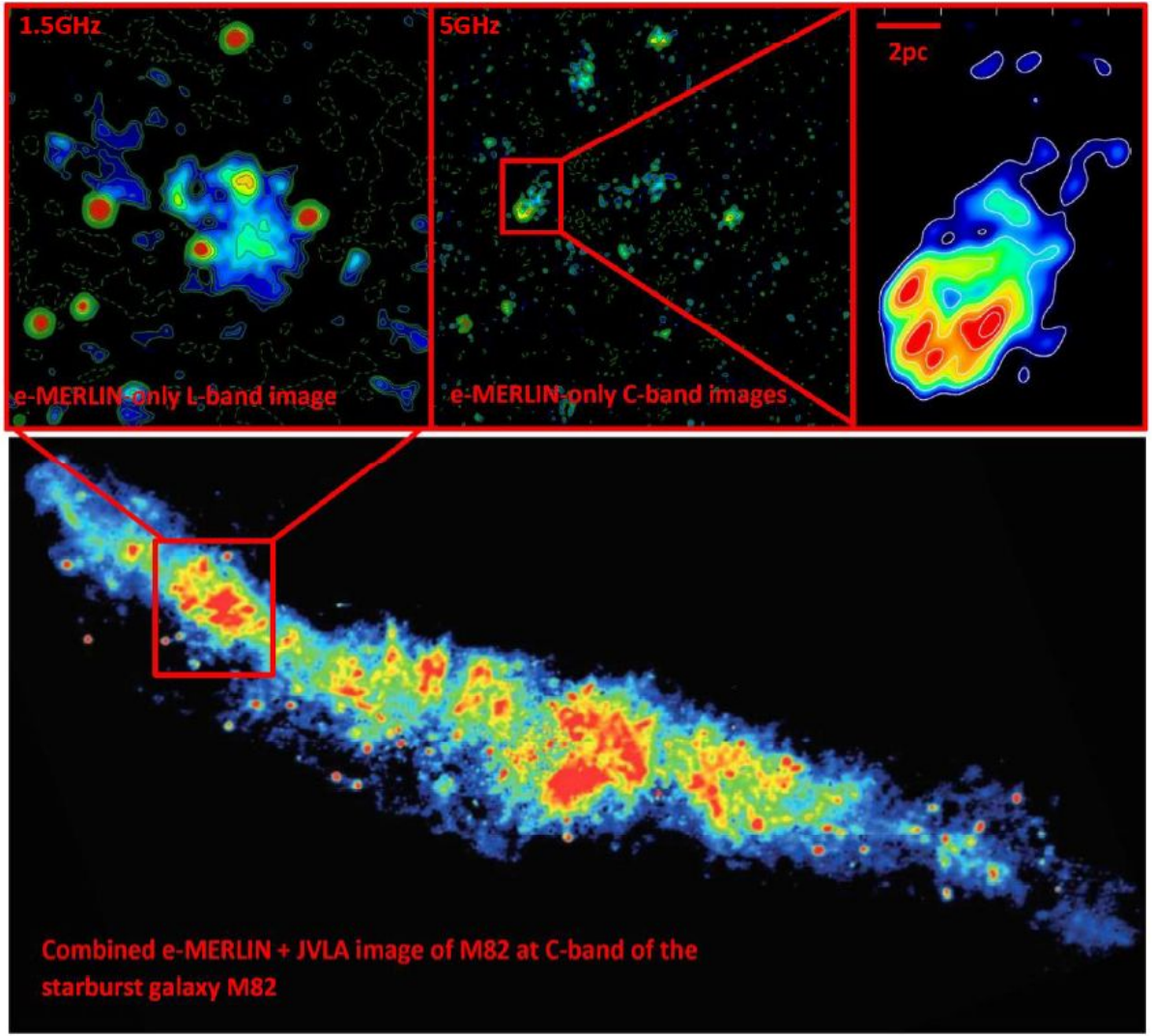
Extragalactic and cosmology:

- LEMMINGS – 300 nearby gals	Beswick/McHardy et al.	810hrs
- LIRGI – LIRGs/ULIRGs	Conway/Perez-Torres et al.	353hrs
- Extragalactic Jets	Laing/Hardcastle et al	375hrs
- AGATE – cluster fields	Simpson/Smail et al	330hrs
- e-MERGE – deep field	Muxlow/Smail/McHardy et al	918hrs
- Gravitational lenses	Jackson/Serjeant et al	228hrs
- SuperCLASS – 1+deg2 supercluster field	Battye et al	832hrs

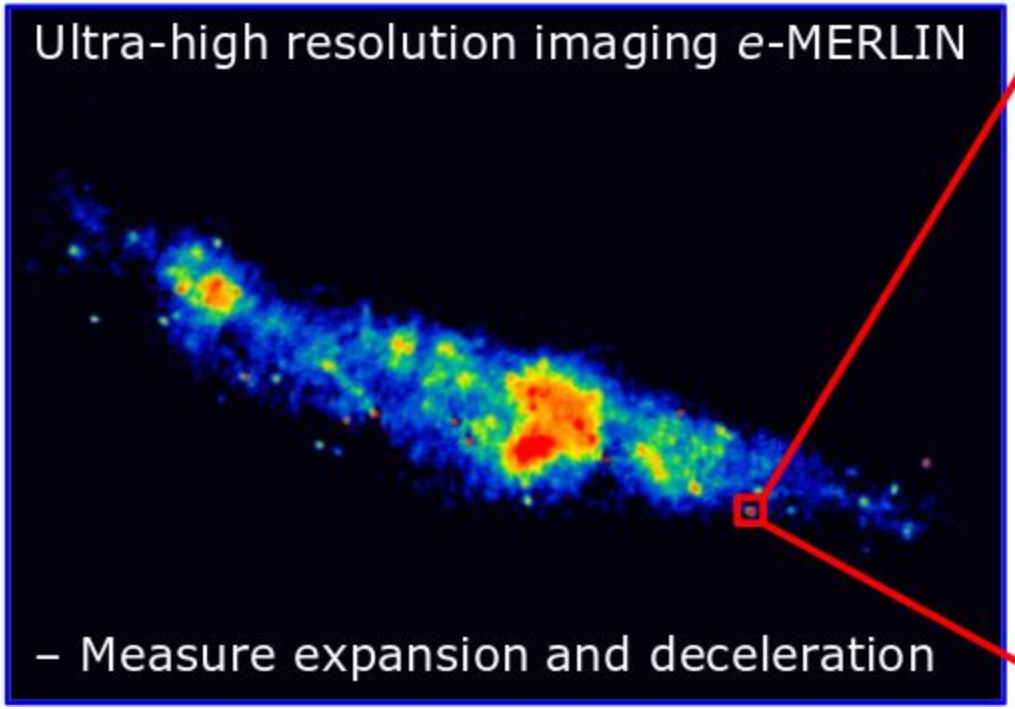
Example: M82

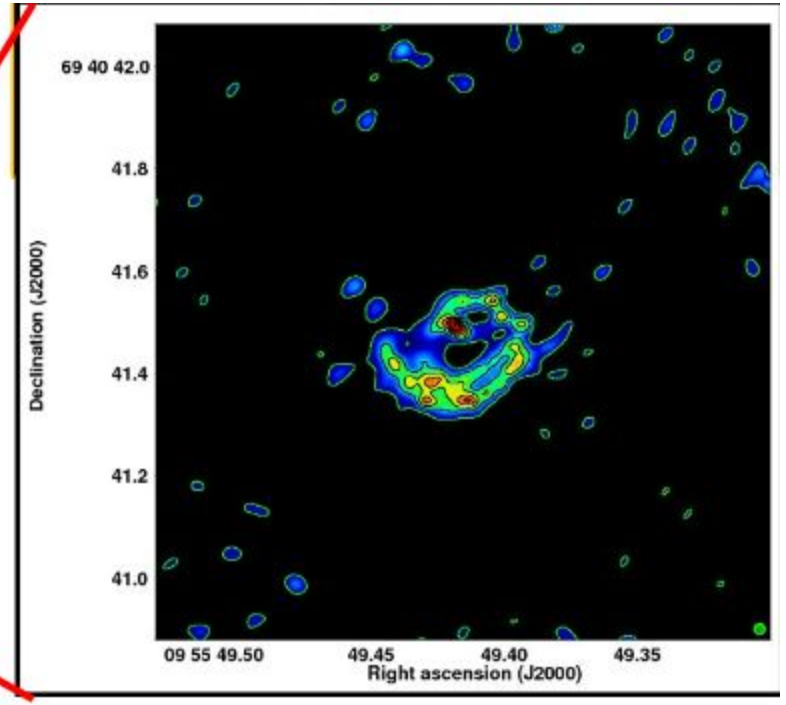


M82 with the VLA

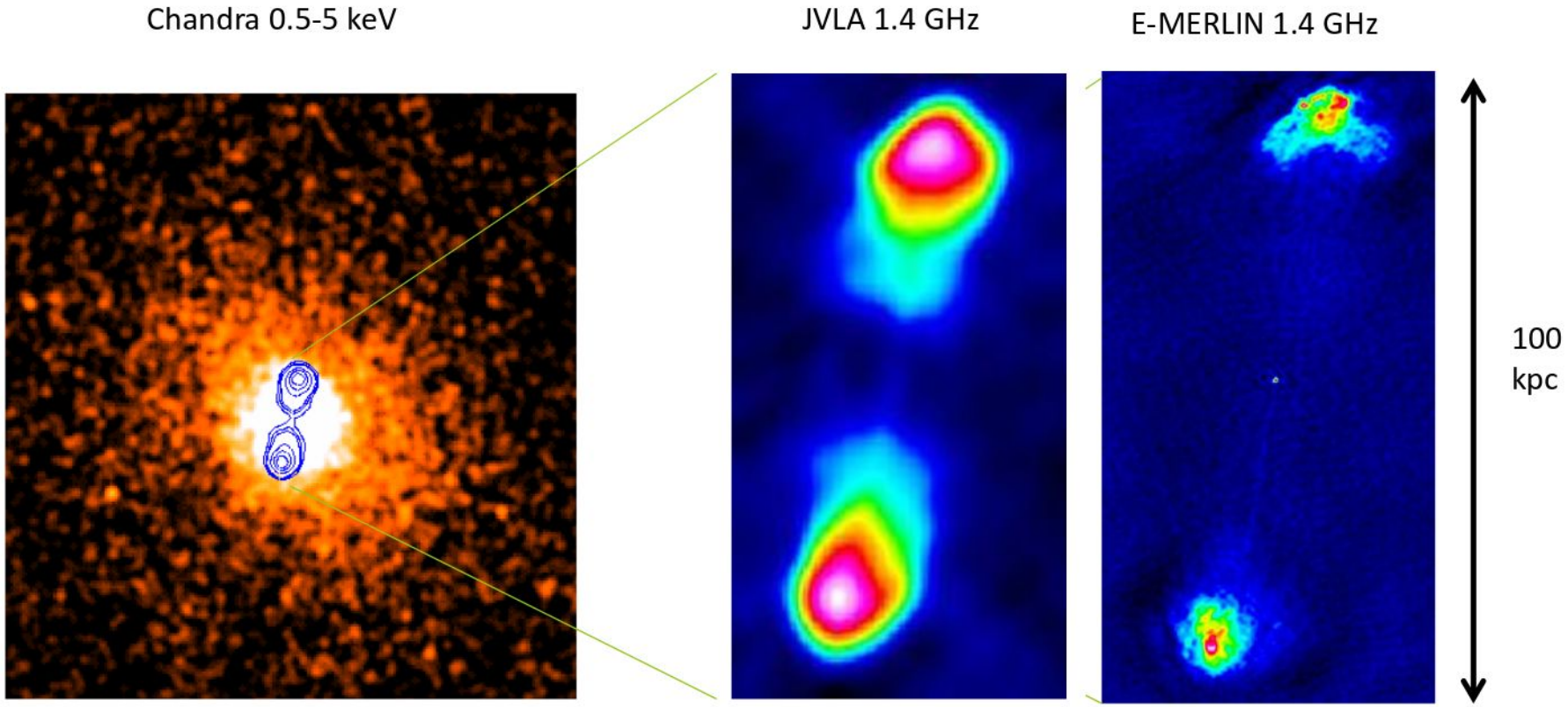


Example: M82


Ultra-high resolution imaging e-MERLIN
– Measure expansion and deceleration

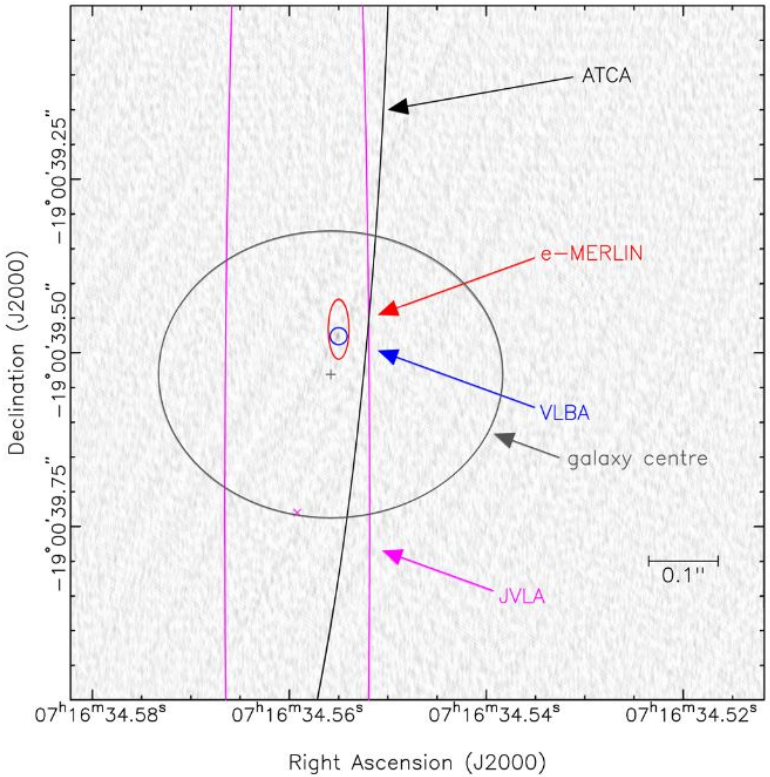

69 40 42.0
41.8
41.6
41.4
41.2
41.0
Declination (J2000)
09 55 49.50
49.45
49.40
49.35
Right ascension (J2000)

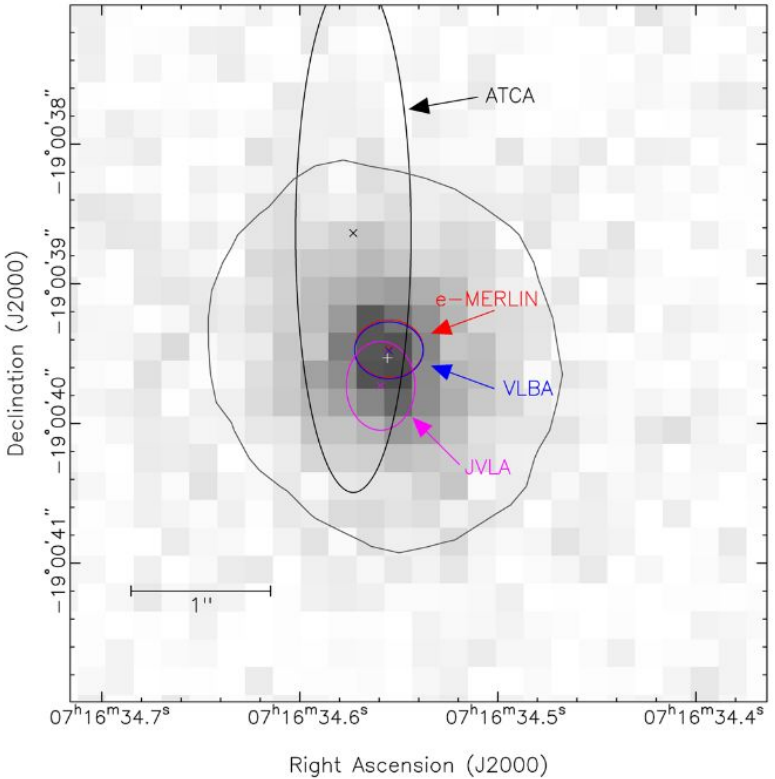
Dynamics & Energetics of Radio-loud AGN



Vijay et al. 2018

Astrometry of the galaxy associated with FRB 150418





Bassa et al. (2016)

Probably the weak radio active galactic nucleus of the host galaxy.

Future prospects

- Increase bandwidth to 2 GHz (C-band)
- Include Lovell Telescope at C-band
- Phasing up of array – superb PSR/transient instruments ~equivalent to 110m dish
- EVN recording/transmission for multiple telescopes
- Inclusion of new dishes – Goonhilly + other? – More resolution, more coverage

Future prospects

- Increase bandwidth to 2 GHz (C-band)
- Include Lovell Telescope at C-band
- Phasing up of array – superb PSR/transient instruments ~equivalent to 110m dish
- EVN recording/transmission for multiple telescopes
- Inclusion of new dishes – Goonhilly + other? – More resolution, more coverage

- New telescope optics, feeds, receivers, IF, samplers
- New correlator: wide field imaging; simultaneous line & continuum observations
- Digital transmission system: 30 Gb/s from each telescope
- Dedicated optical fibre network
- 100 km installed; 600km leased (total ~700km)
- H-maser freq (1 part in 1014)std over optical fibre network

SKA pathfinder

SKA SDP for e-MERLIN

- New Software investment
- Take development of SKA pipelines via the SDP consortia
- Absorb these into a new e-MERLIN SDP packages.
- Complete ‘look, feel’ behave like SKA
- Advantage of ability to store data and re-run SDP pipeline ‘understand, learn, develop’
- Repeatability available (not for SKA)

Re-call e-MERLIN has many SKA1-Mid similarities:
- Similar frequency coverage 1-22GHz
- Similar baseline ranges 10 -217km (actually a bit more than SKA1-mid)
- But larger D, smaller N.
- Ideal for prototyping SKA1-mid science and SDP processing