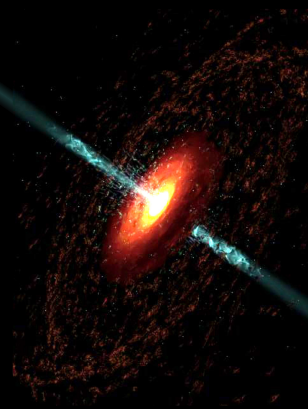


Big Radio Telescopes and Big Radio Galaxies

Matthew Alger



Australian
National
University



Radio arrays

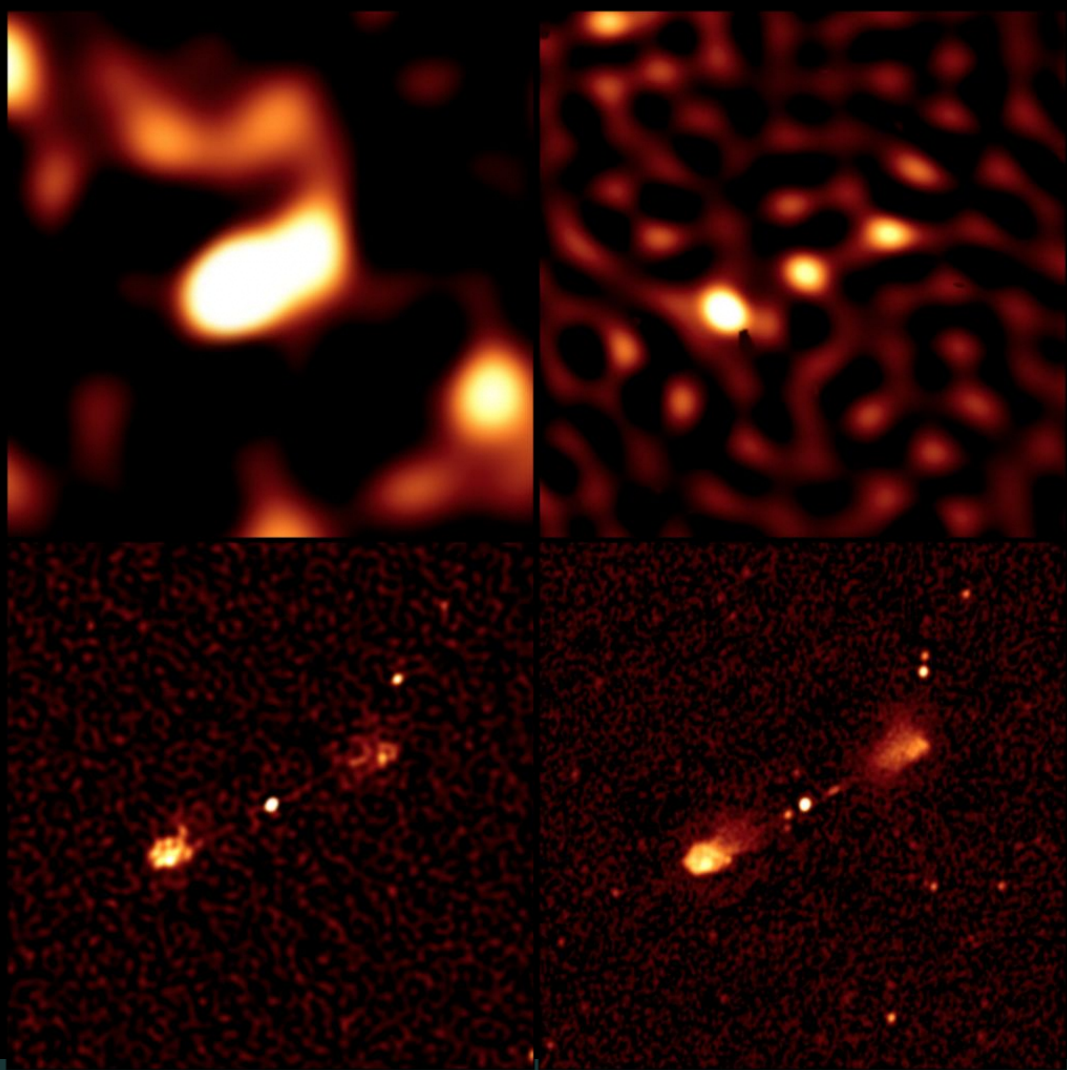
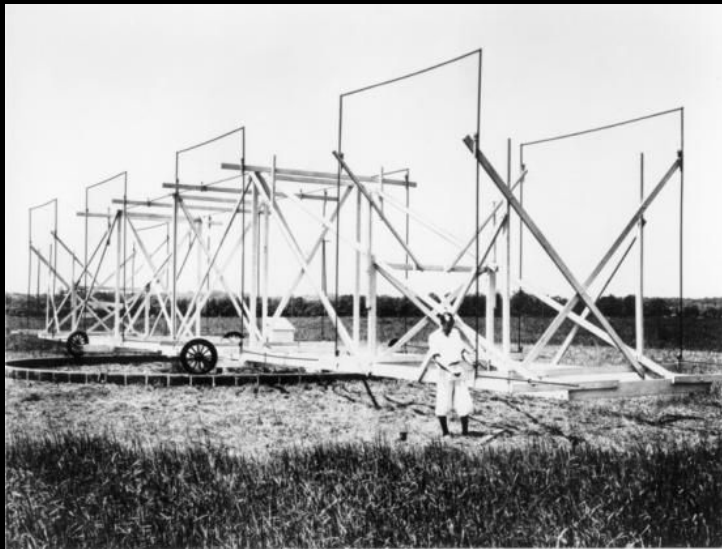


Image: SKA/Meerkat (Radio); NRAO (Optical)

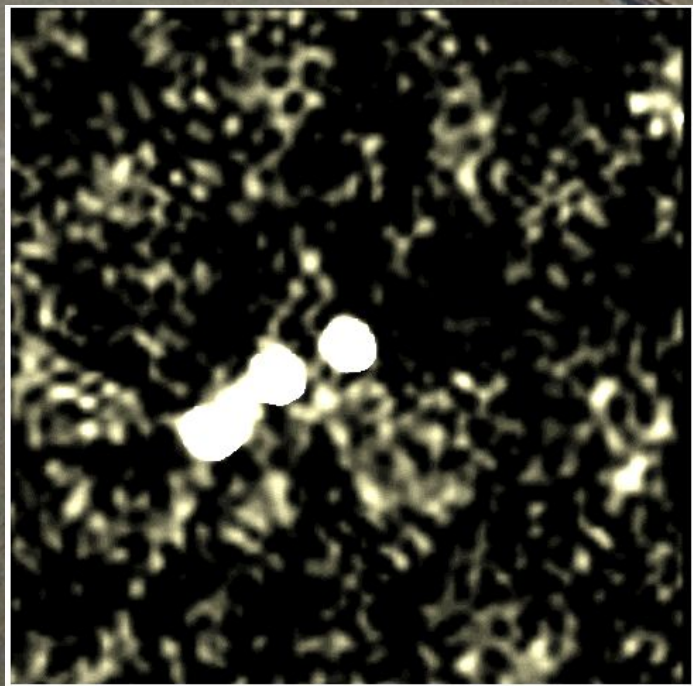


Image: NRAO (Optical); Radio Galaxy Zoo/FIRST (Radio)

ASKAP (Western Australia)



Image: CSIRO

Title slide image: Cosmovision (led by Dr. Wolfgang Steffen of the Instituto de Astronomía, UNAM, Ensenada, Mexico) for A. Marscher; NRAO/AUI/NSF

ASKAP (Western Australia)

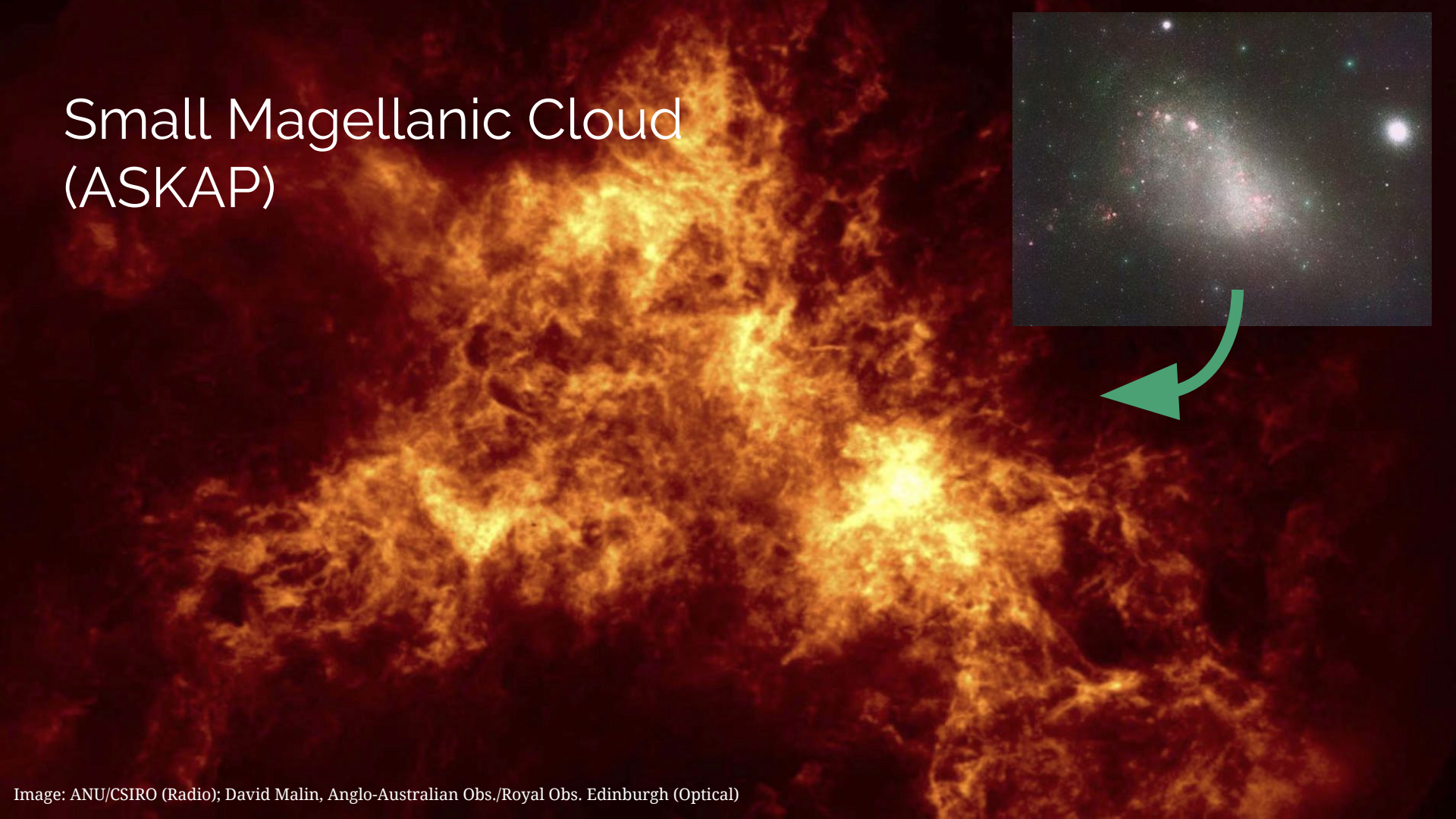
- Huge 30 deg² field of view
- Fast!
- 32 antennae
- 15500 km of optical fibre
- 1.9 Tb/s
- 4000 m² collecting area
- 2 PB of science data so far



Image: CSIRO

Title slide image: Cosmvision (led by Dr. Wolfgang Steffen, Institut für Astronomie, UNAM, Ensenada, Mexico) for A. Marscher; NRAO/AUI/NSF

Small Magellanic Cloud (ASKAP)



MeerKAT (South Africa)

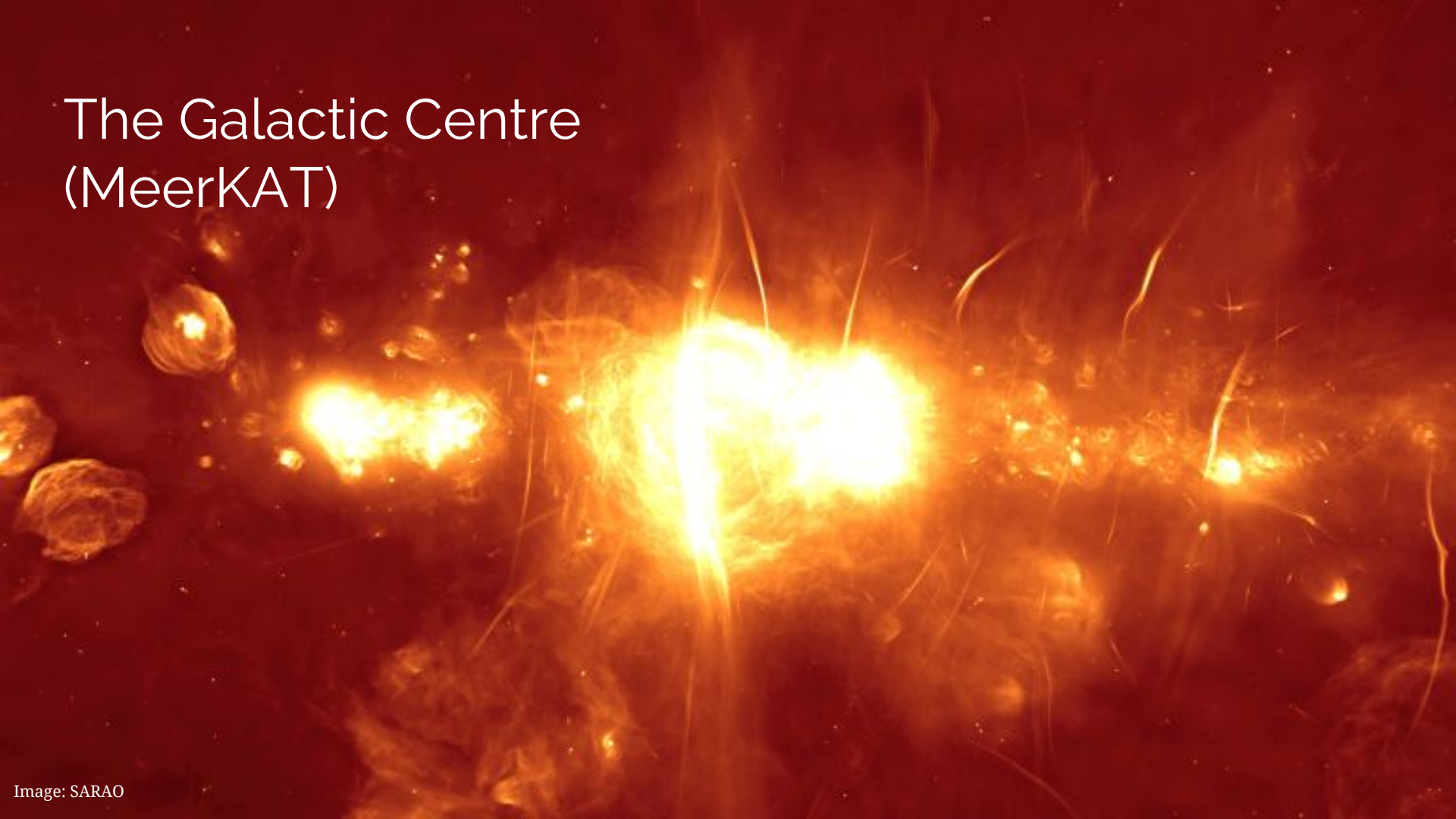


MeerKAT (South Africa)

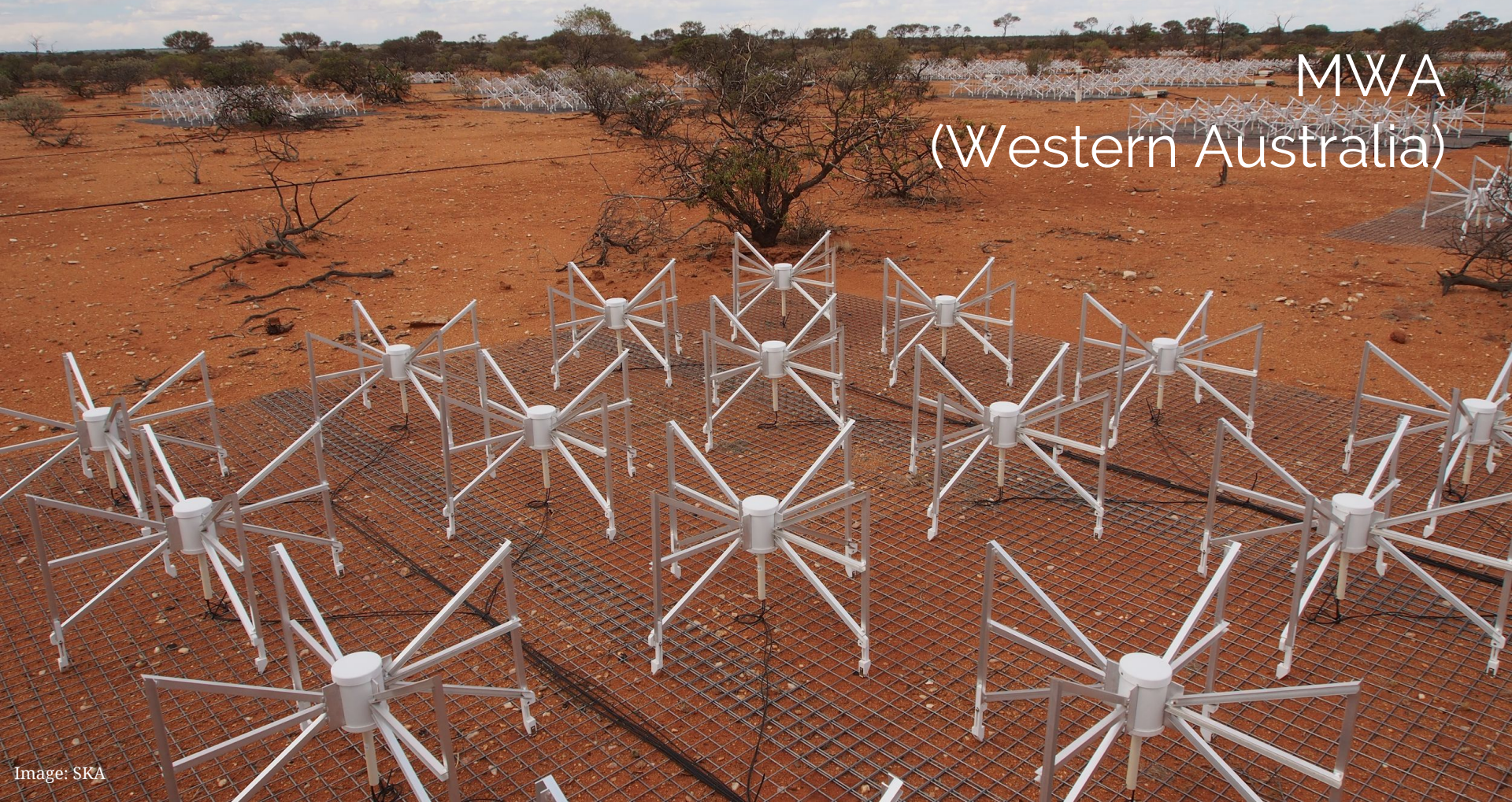
- 64 antennae
- ~1 Tb/s
- 9000 m² collecting area
- 2" resolution



The Galactic Centre (MeerKAT)



MWA (Western Australia)



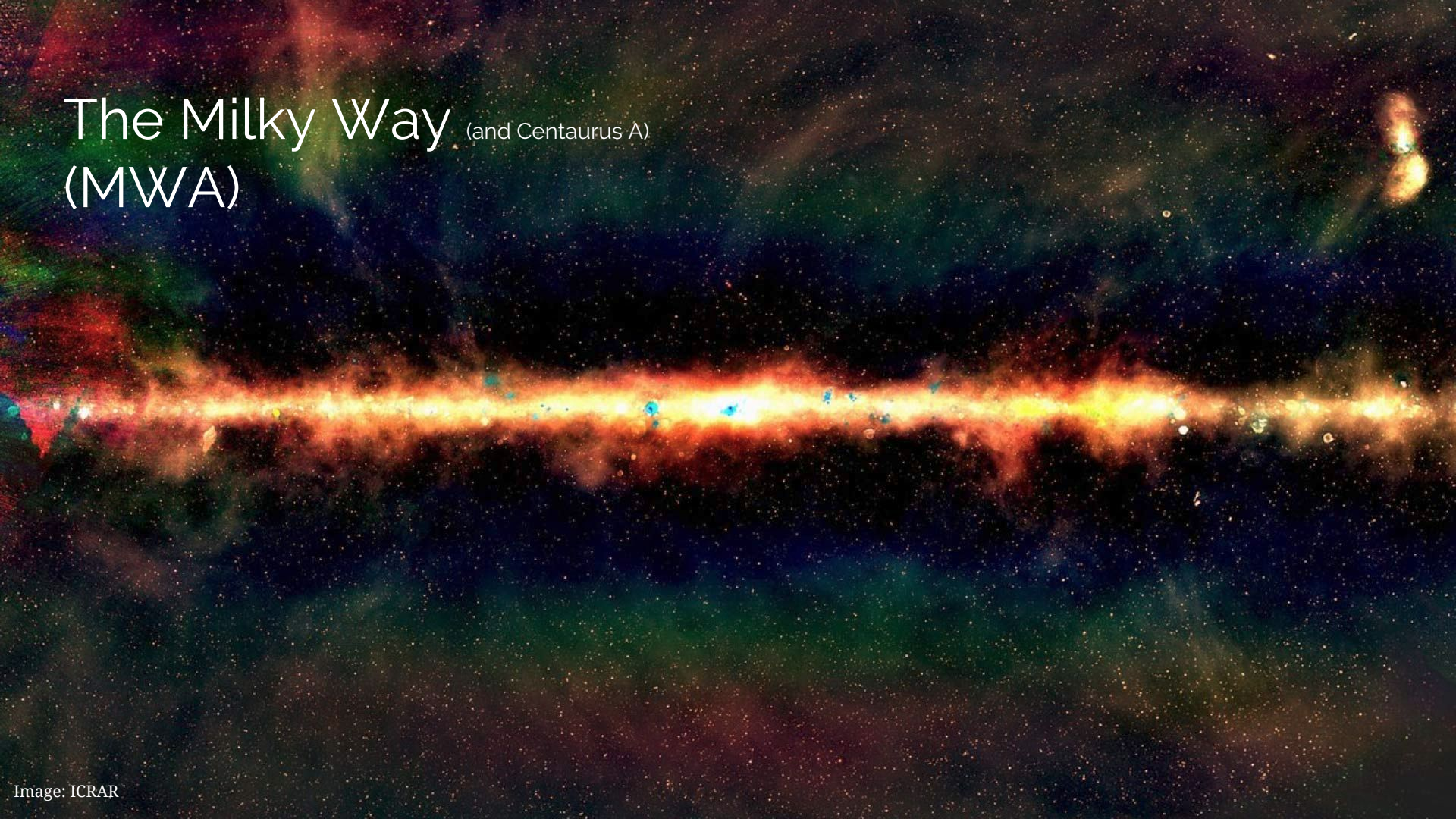
MWA (Western Australia)

- 2048 antennae in 128 tiles
- Low frequency
- *Huge* 2500 deg² field of view
- Very fast!
- 2000 m² collecting area



The Milky Way (and Centaurus A)

(MW/A)



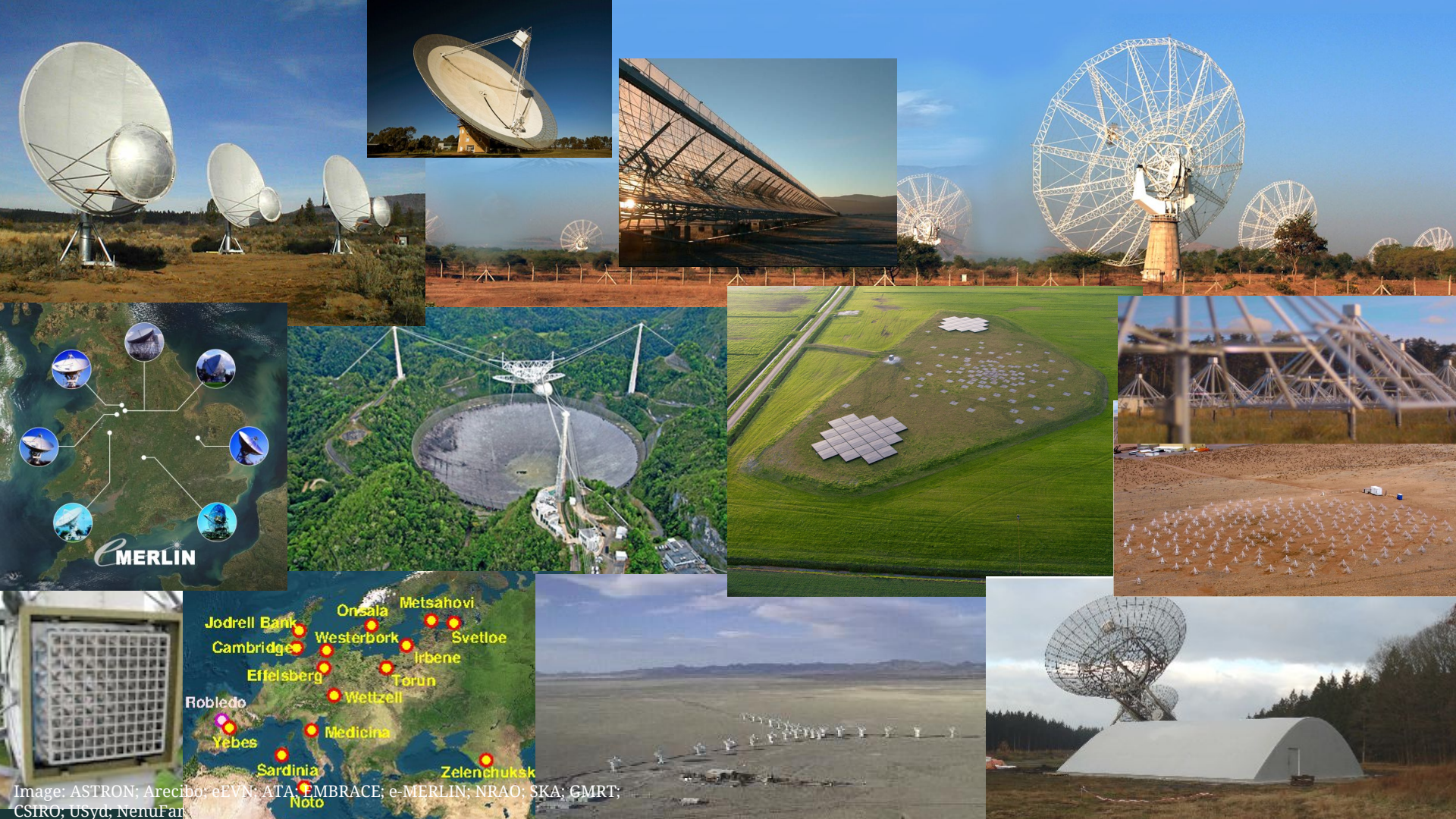


Image: ASTRON; Arecibo; e-EVN; ATA; EMBRACE; e-MERLIN; NRAO; SKA; GMRT; CSIRO; USyd; NenuFar

An aerial photograph showing a vast array of white, parabolic radio telescope dishes scattered across a dry, red-brown desert landscape. The dishes are densely packed in the distance and become more sparse towards the foreground. In the far background, a range of low, flat-topped mountains is visible under a clear sky. The text 'SKA (South Africa + Western Australia)' is overlaid in white on the right side of the image.

SKA (South Africa + Western Australia)

What does the SKA want to investigate?

- Galaxy evolution
- Cosmology
- Dark energy
- Pulsar/black hole tests of general relativity
- Giant magnetic fields
- Cosmic dawn
- First star/black hole formation
- SETI
- Astrobiology
- Unknown unknowns



What does the SKA want to investigate?

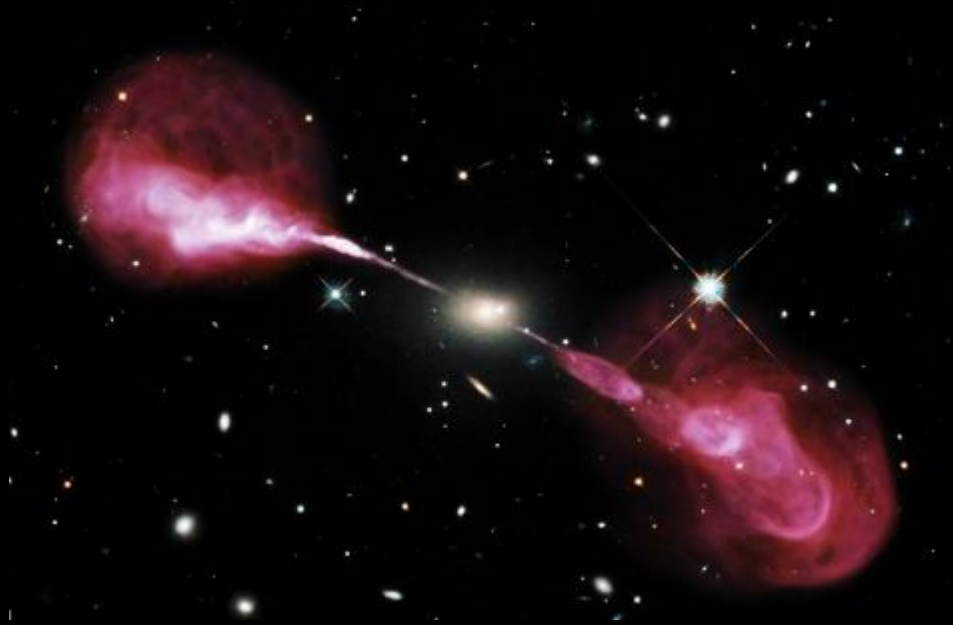
- **Galaxy evolution**
- Cosmology
- Dark energy
- Pulsar/black hole tests of general relativity
- **Giant magnetic fields**
- Cosmic dawn
- First star/black hole formation
- SETI
- Astrobiology
- Unknown unknowns



Galaxy evolution

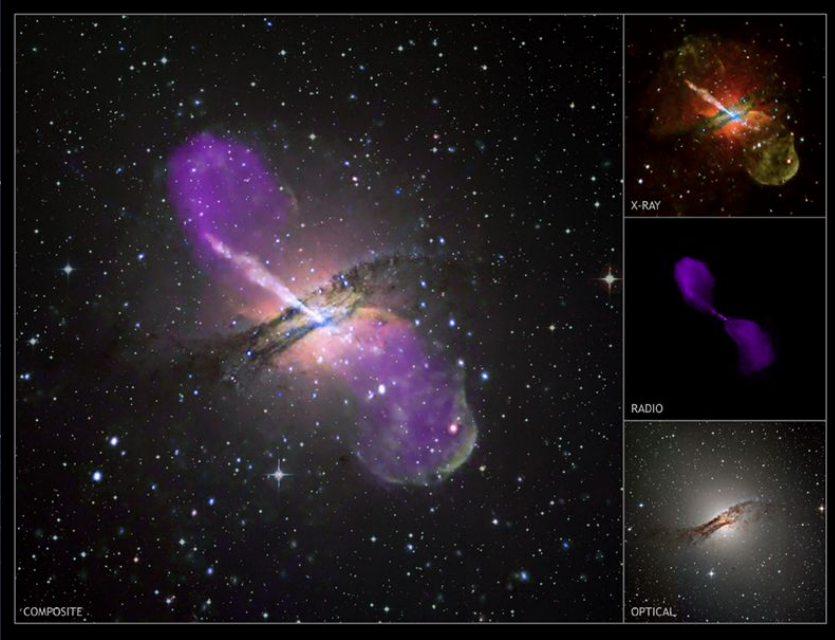


How do radio jets affect galaxy evolution?



How do radio jets affect galaxy evolution?



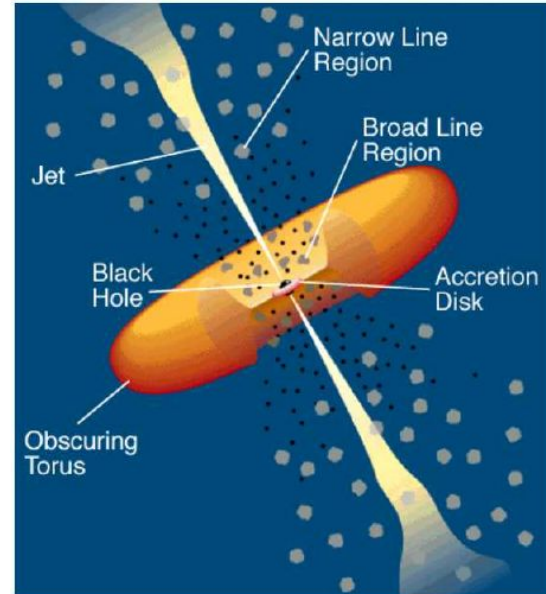
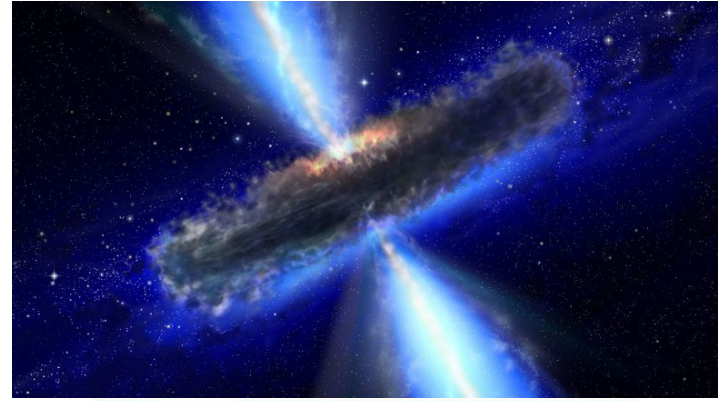


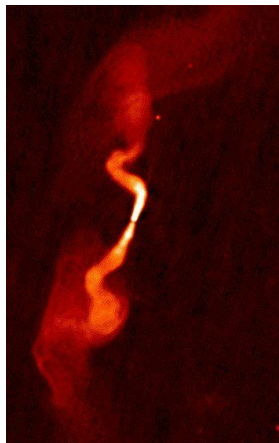
Centaurus A, a radio galaxy 13 million light years away.

Top: NASA/CXC/R.Kraft (CfA), et al.; NSF/VLA/M.Hardcastle (U Hertfordshire) et al.; ESO/M.Rejkuba (ESO-Garching) et al.
 Left: Ilana Feain, Tim Cornwell & Ron Ekers (CSIRO/ATNF); R. Morganti (ASTRON); N. Junkes (MPIfR); Shaun Amy, CSIRO

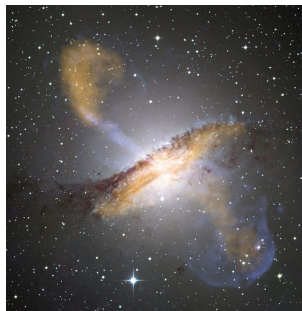
Active Galactic Nuclei

- $\sim 10^{21} - 10^{28}$ W/Hz
- $\sim 10^6 - 10^8 M_{\odot}$
- Pretty big
- Fun and exciting jets

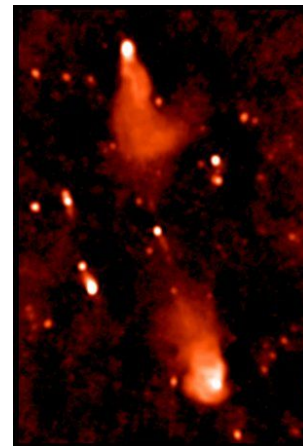
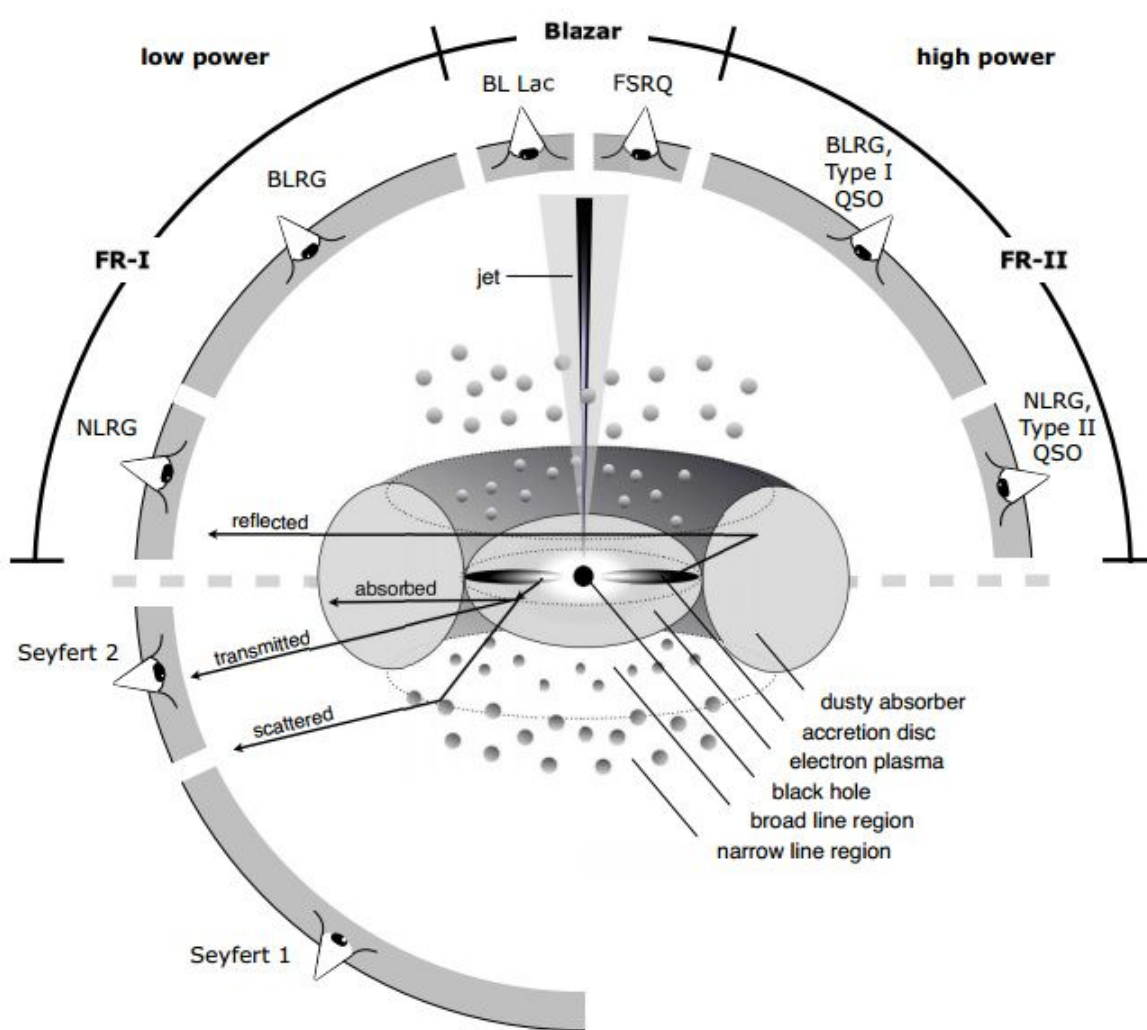




radio-loud (RL) AGN



radio-quiet (RQ) AGN



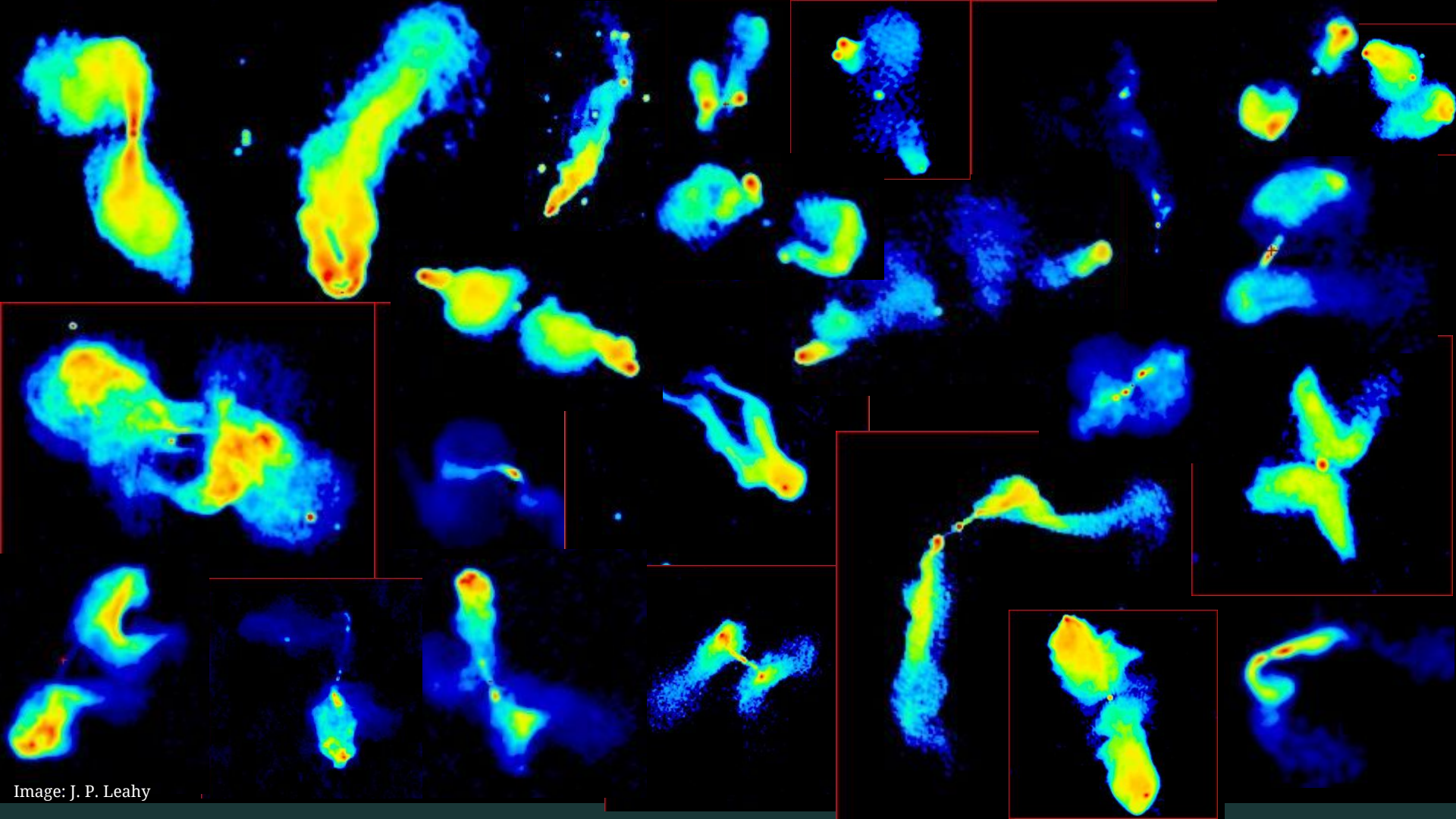


Image: J. P. Leahy

Radio galaxies are pretty big





UGC 10014 - "The Tadpole"
Disturbed spiral galaxy with a very long tail
Distance: ~620,000,000 LY
Total length: 380,000 LY

NGC 1316 - "Fornax"
Dusty elliptical galaxy
Distance: 62,000,000 LY
Diameter: 220,000 LY

NGC 508

Scattering galaxy with
disturbed spiral arms
Distance: 65,000,000 LY
Diameter: 75,000 LY

Hercules A
Clart of spiral galaxy with powerful radio jets
(shown in pink) powered by a supermassive
black hole at the galaxy's center
Distance: 2,100,000,000 LY
Diameter: 1,500,000 LY (jets)



Hercules Object
Elliptical galaxy surrounded by a ring of blue stars
Distance: 150,000 LY
Diameter: 120,000 LY (if over 100)



M100
Spiral galaxy in the Virgo Cluster
Distance: 56,000,000 LY
Diameter: 116,000 LY



NGC 670
Two interacting galaxies seen edge-on
Distance: ~600,000,000 LY
Diameter: 120,000 LY



M33 - "Trinity"
Smaller spiral galaxy
Distance: 2,700,000 LY
Diameter: 50,000 LY



M104 - "Sombrero"
Spiral galaxy with a prominent
bulge and dust ring
Distance: 28,000,000 LY
Diameter: 50,000 LY



ESO 350-IG05 - "Cocoon"
Every part has a ring galaxy
(well, probably)
Distance: 560,000,000 LY
Diameter: 150,000 LY



Centaurus A
Elliptical galaxy with a prominent dust lane
It also possesses radio jets (not shown) of a
similar size to those of Hercules A
Distance: 11,300,000 LY
Diameter: 97,000 LY

R

Radio galaxies are pretty big

Radio Galaxy Zoo: discovery of a poor cluster through a giant wide-angle tail radio galaxy

J. K. Banfield ✉, H. Andernach ✉, A. D. Kapińska, L. Rudnick, M. J. Hardcastle, G. Cotter, S. Vaughan, T. W. Jones, I. Heywood, J. D. Wing, ... [Show more](#)

Monthly Notices of the Royal Astronomical Society, Volume 460, Issue 3, 11 August 2016, Pages 2376–2384, <https://doi.org/10.1093/mnras/stw1067>

Published: 05 May 2016 **Article history** ▼



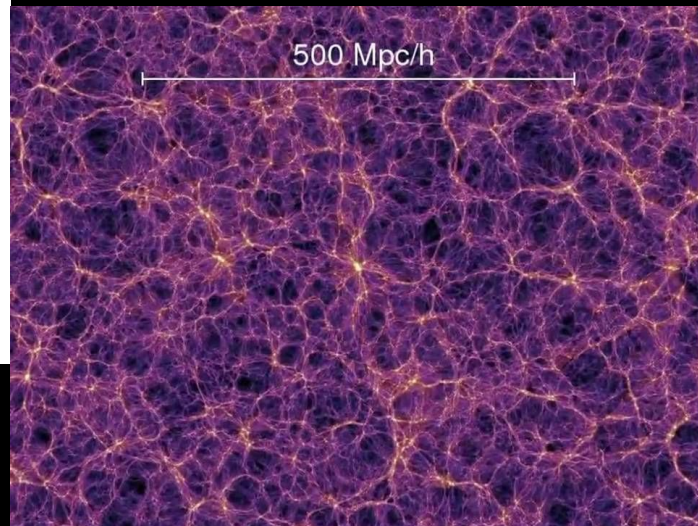
Cosmological alignment?

Radio Galaxy Zoo: cosmological alignment of radio sources FREE

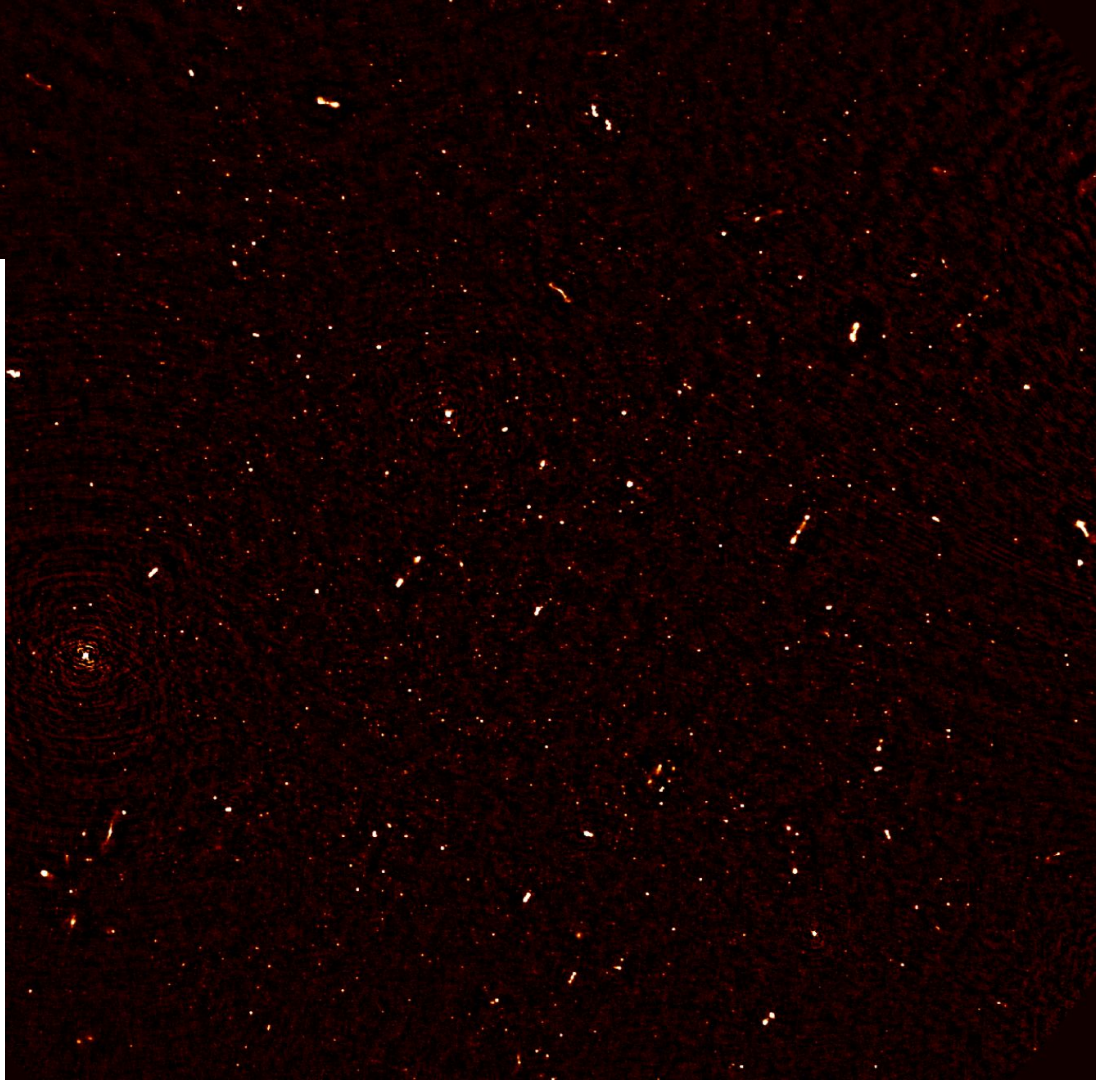
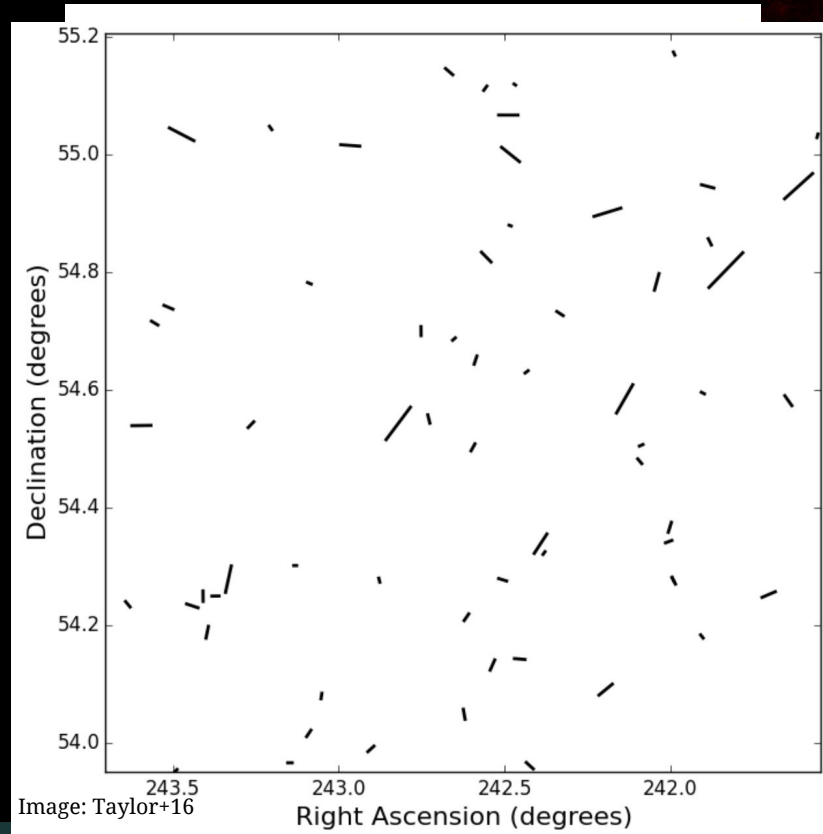
O. Contigiani ✉, F. de Gasperin, G. K. Miley, L. Rudnick, H. Andernach,
J. K. Banfield, A. D. Kapińska, S. S. Shabala, O. I. Wong

Monthly Notices of the Royal Astronomical Society, Volume 472, Issue 1, 21
November 2017, Pages 636–646, <https://doi.org/10.1093/mnras/stx1977>

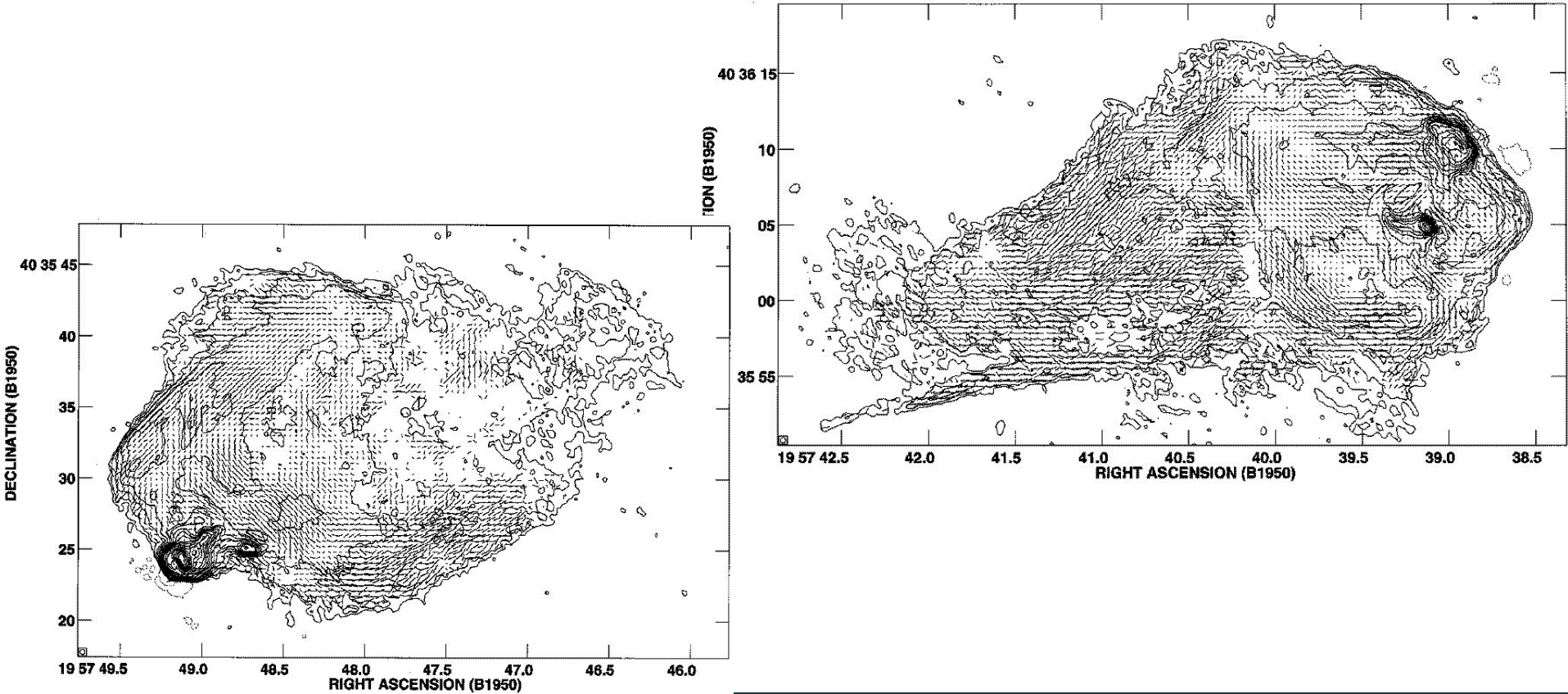
Published: 02 August 2017 **Article history** ▼



Cosmological alignment



But what about the magnetic fields?



The SKA and Radio Galaxies



How will SKA1 be better than today's best radio telescopes?



Astronomers assess a telescope's performance by looking at three factors - **resolution**, **sensitivity**, and **survey speed**. With its sheer size and large number of antennas, the SKA will provide a giant leap in all three compared to existing radio telescopes, enabling it to revolutionise our understanding of the Universe.

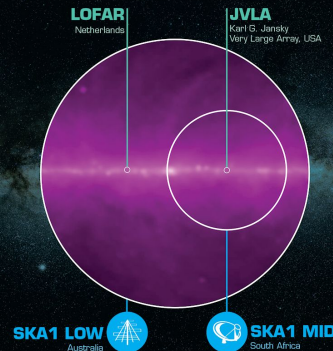


SKA1 LOW x1.2 LOFAR NL

SKA1 MID x4 JVLA

RESOLUTION

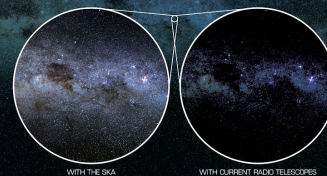
Thanks to its size, the SKA will see smaller details, making radio images less blurry, like reading glasses help distinguish smaller letters.



SURVEY SPEED

Thanks to its sensitivity and ability to see a larger area of the sky at once, the SKA will be able to observe more of the sky in a given time and so map the sky faster.

The **Square Kilometre Array (SKA)** will be the world's largest radio telescope. It will be built in two phases - SKA1 and SKA2 - starting in 2018, with SKA1 representing a fraction of the full SKA. SKA1 will include two instruments - **SKA1 MID** and **SKA1 LOW** - observing the Universe at different frequencies.



SKA1 LOW x8 LOFAR NL

SKA1 MID x5 JVLA

SENSITIVITY

Thanks to its many antennas, the SKA will see fainter details, like a long-exposure photograph at night reveals details the eye can't see.