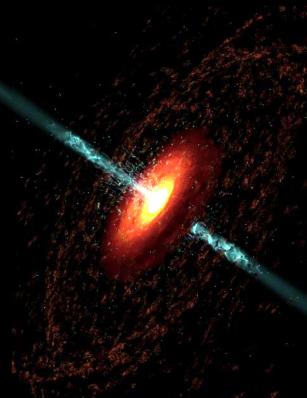


Big Radio Telescopes and Big Radio Galaxies

Matthew Alger



Australian
National
University



Radio arrays

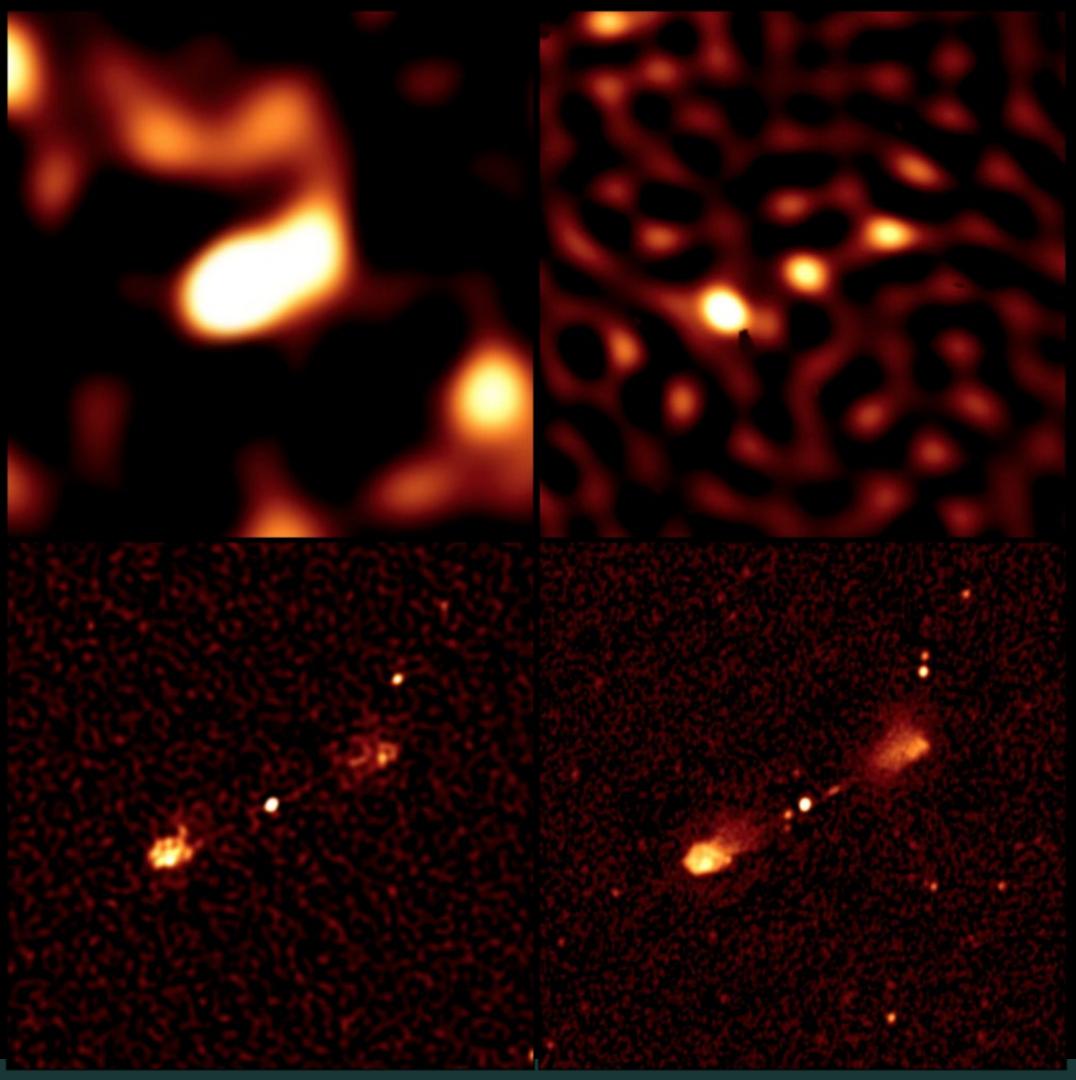
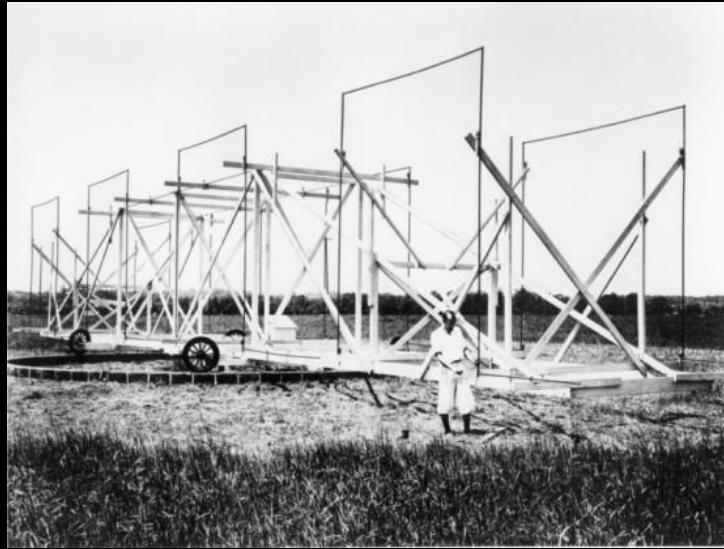


Image: SKA/Meerkat (Radio); NRAO (Optical)

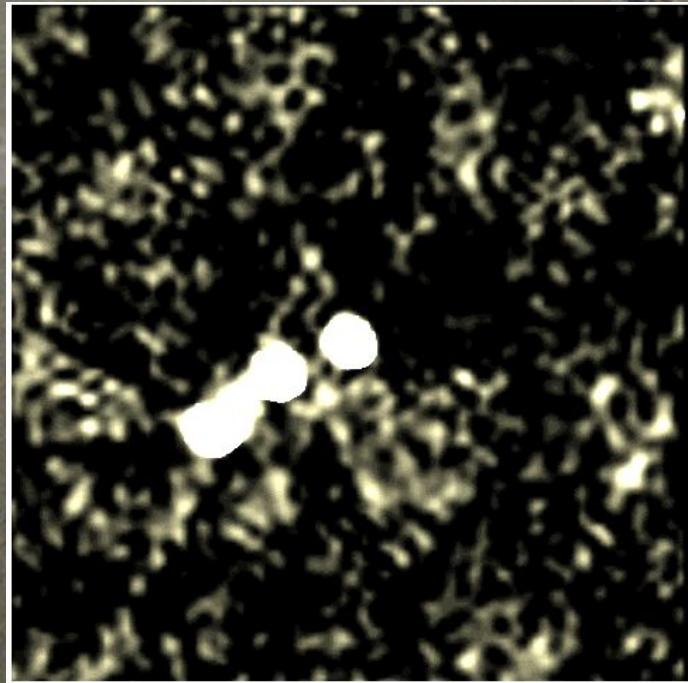


Image: NRAO (Optical); Radio Galaxy Zoo/FIRST (Radio)

ASKAP (Western Australia)



Image: CSIRO

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

ASKAP (Western Australia)

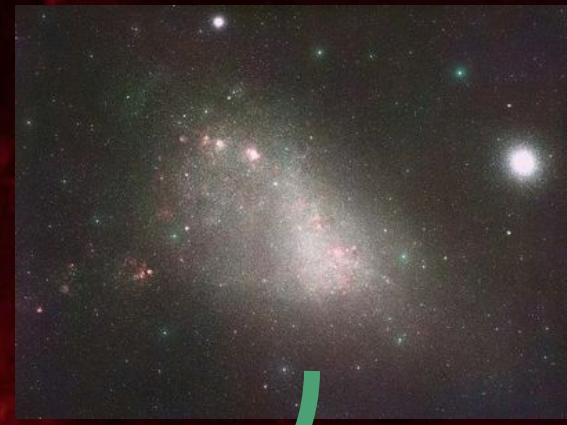
- Huge 30 deg² field of view
- Fast!
- 32 antennae
- 15500 km of optical fibre
- 1.9 Tb/s
- 4000 m² collecting area
- 2 PB of science data so far



Image: CSIRO

Title slide image: Cosmovision (led by Dr. Wolfgang Steff
Astronomia, UNAM, Ensenada, Mexico) for A. Marscher; NRAO/AUI/NSF

Small Magellanic Cloud (ASKAP)



MeerKAT (South Africa)

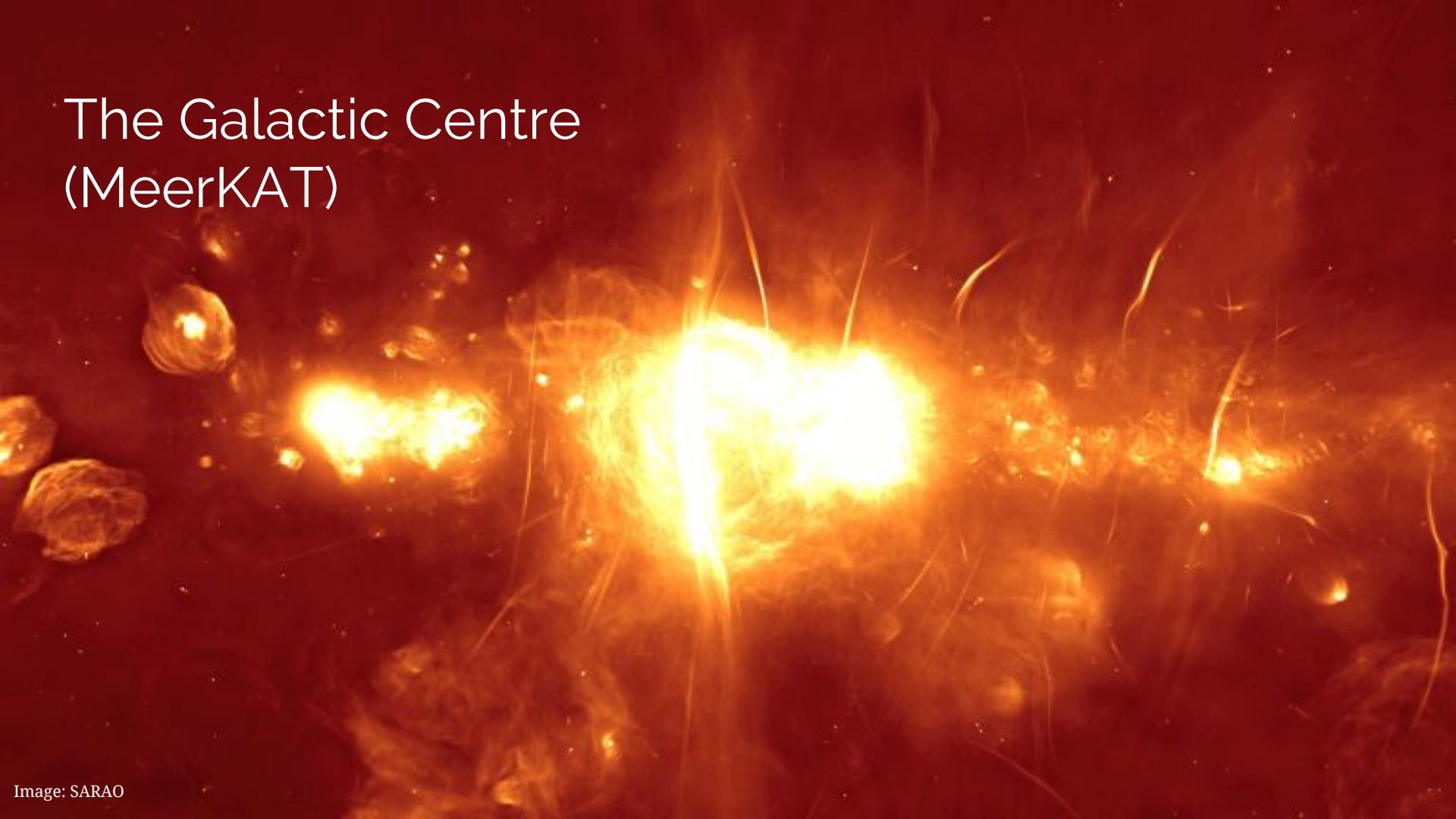


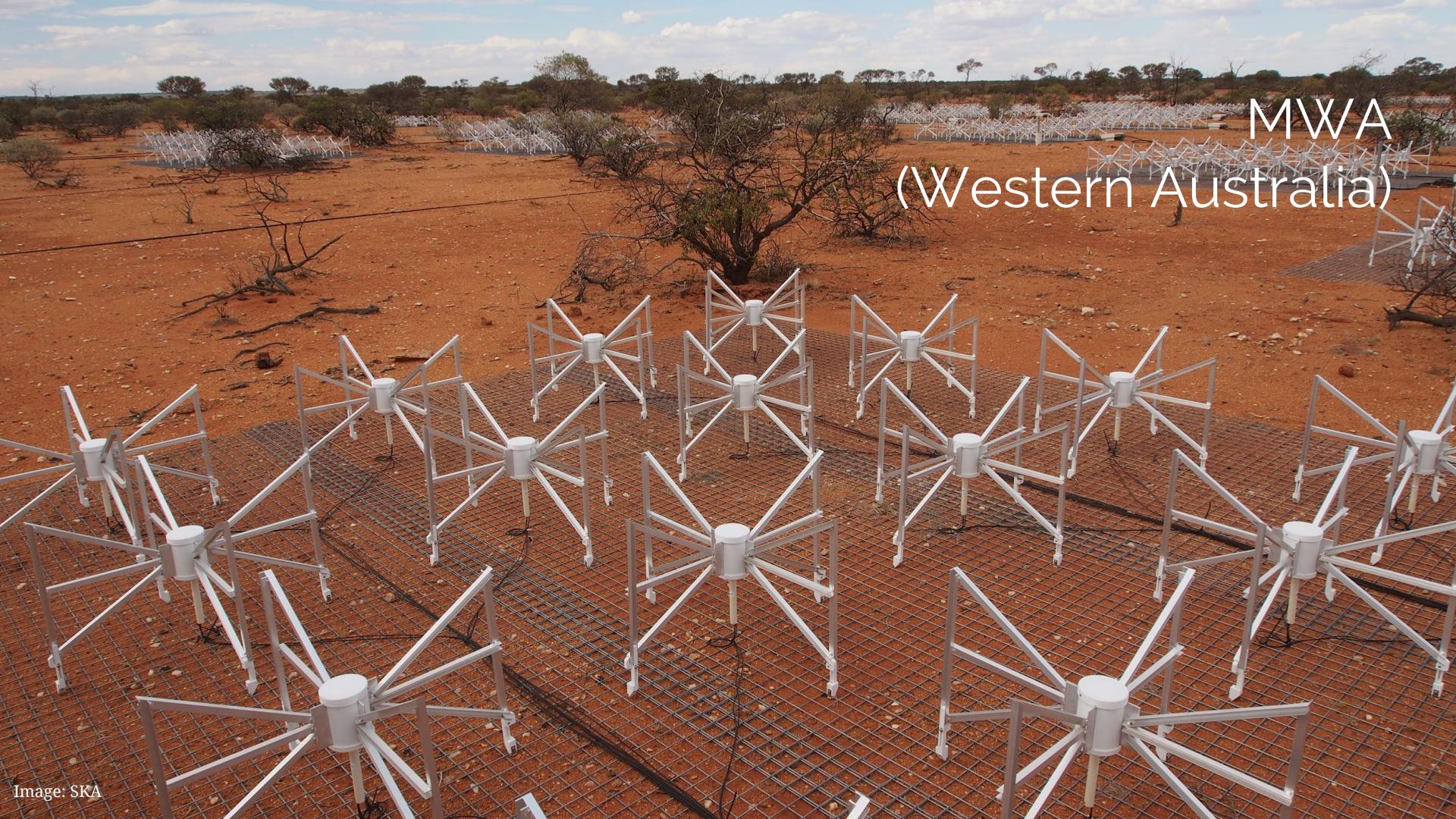
MeerKAT (South Africa)

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



The Galactic Centre (MeerKAT)



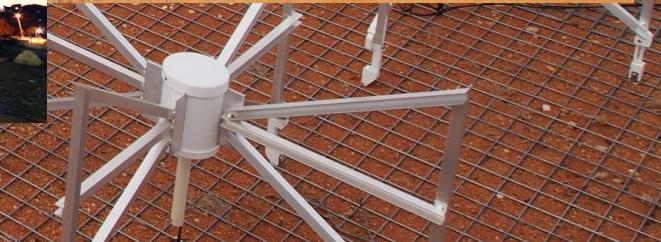


MWA
(Western Australia)

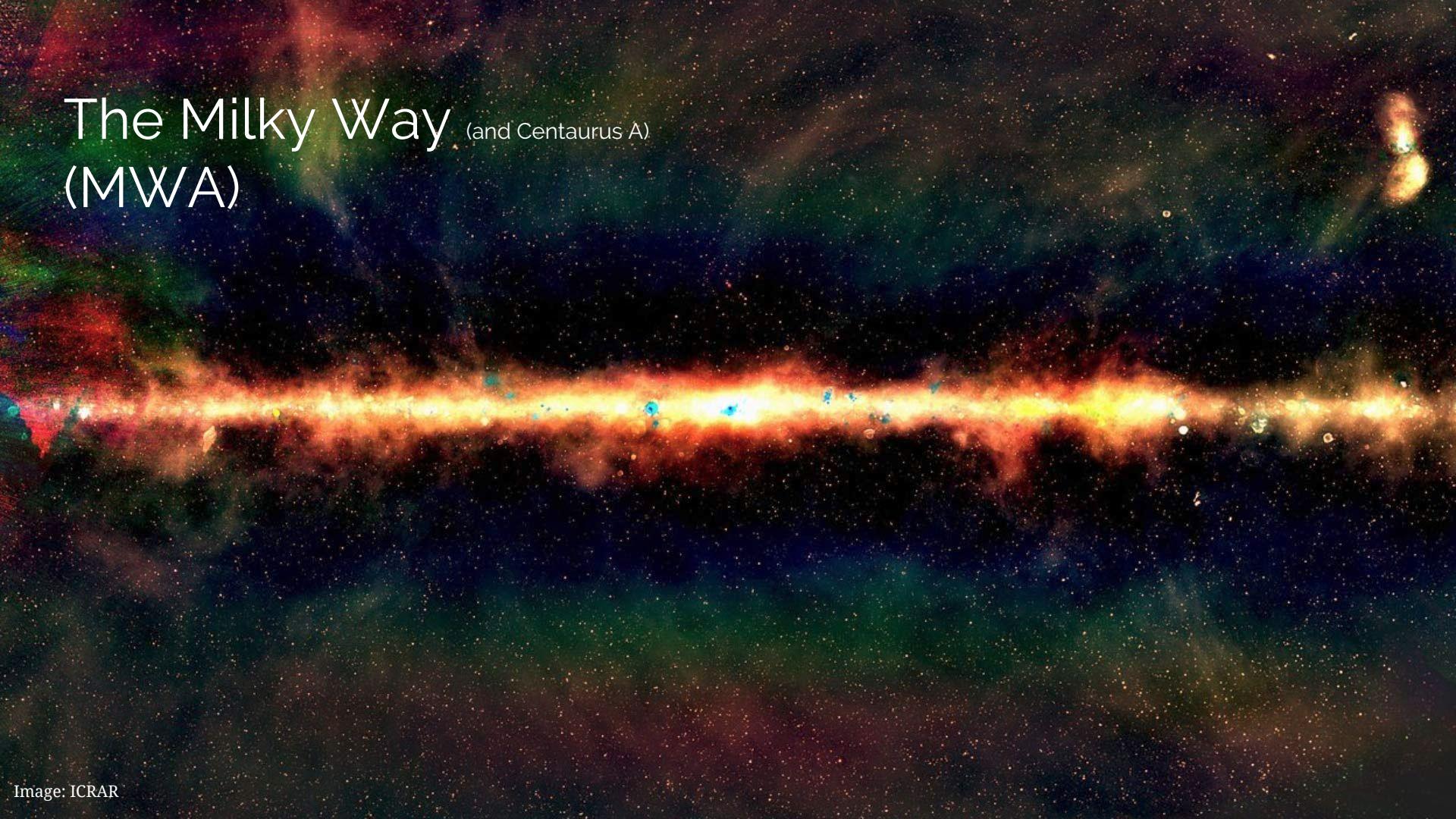
MWA

(Western Australia)

- 2048 antennae in 128 tiles
- Low frequency
- Huge 2500 deg^2 field of view
- Very fast!
- 2000 m^2 collecting area



The Milky Way (and Centaurus A) (MWA)



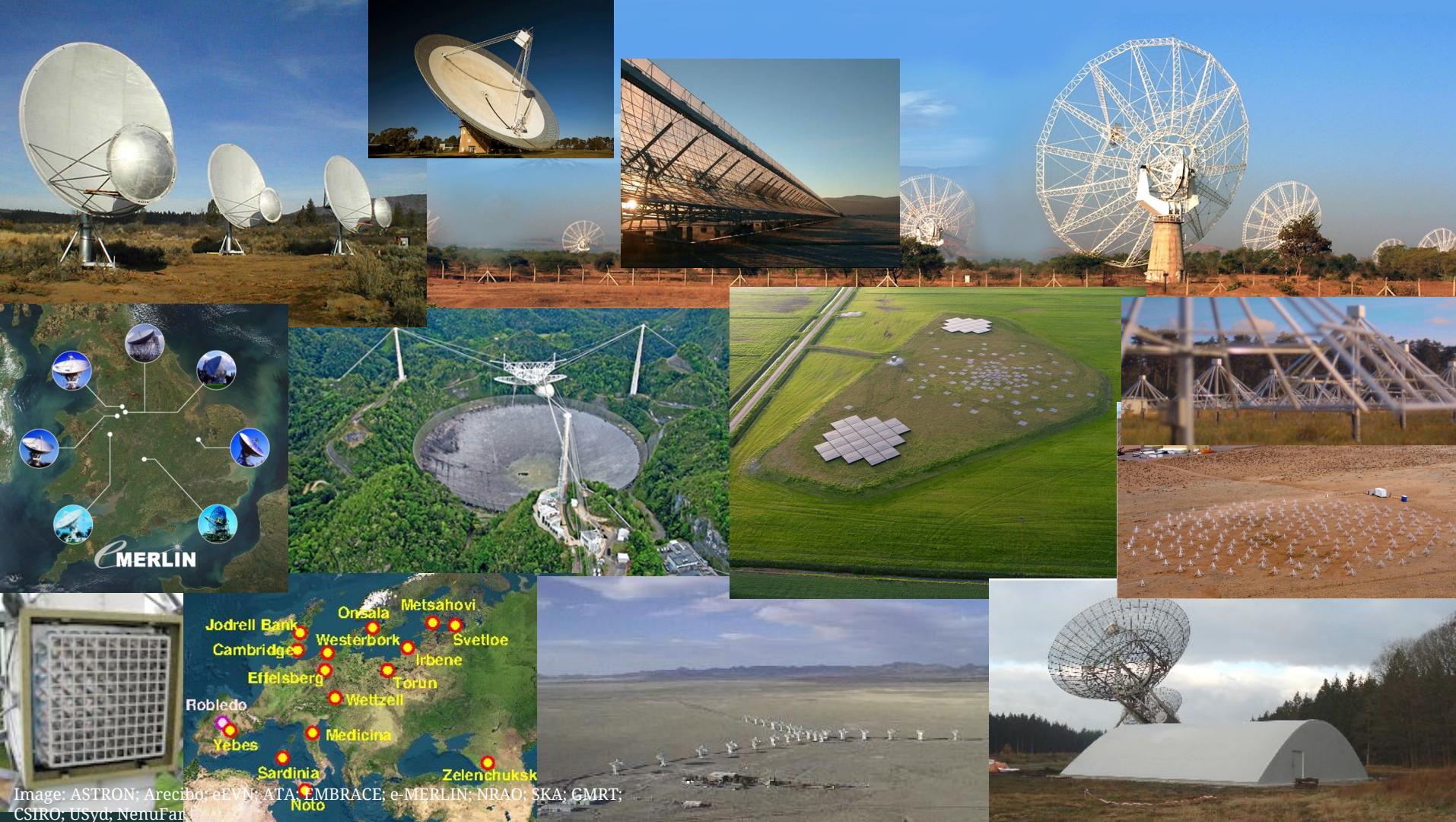


Image: ASTRON; Arecibo; eEVN; ATA; EMBRACE; e-MERLIN; NRAO; SKA; GMRT; CSIRO; USyd; NenuFaro

An aerial perspective of the Square Kilometer Array (SKA) radio telescope. The array consists of numerous white dish antennas scattered across a vast, arid landscape with sparse green vegetation. The antennas are arranged in several large, roughly parallel bands that curve slightly across the frame. In the background, a range of mountains is visible under a clear blue sky.

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

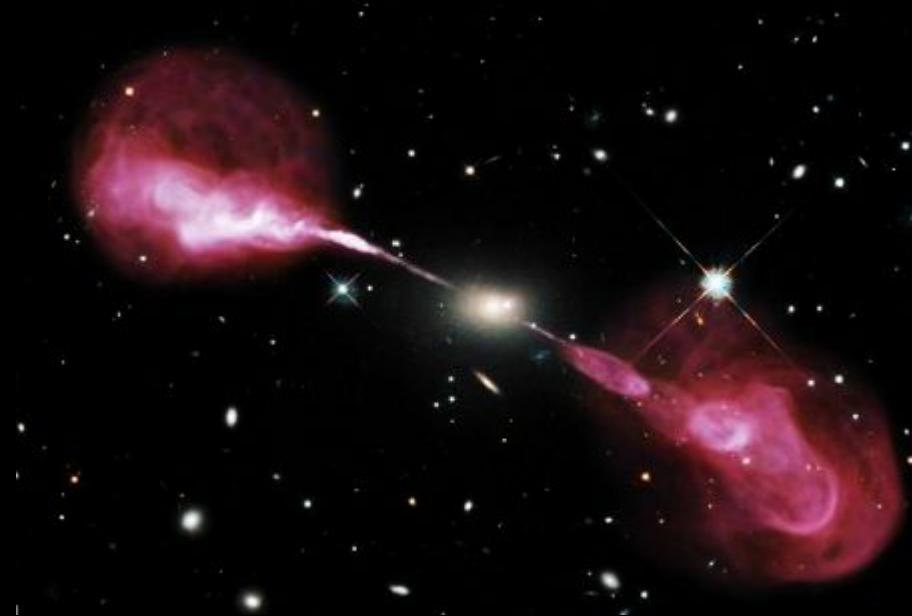
What does the SKA want to investigate?

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- Pulsar/black hole tests of general relativity
- **Giant magnetic fields**
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- First star/black hole formation
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- Unknown unknowns

Galaxy evolution

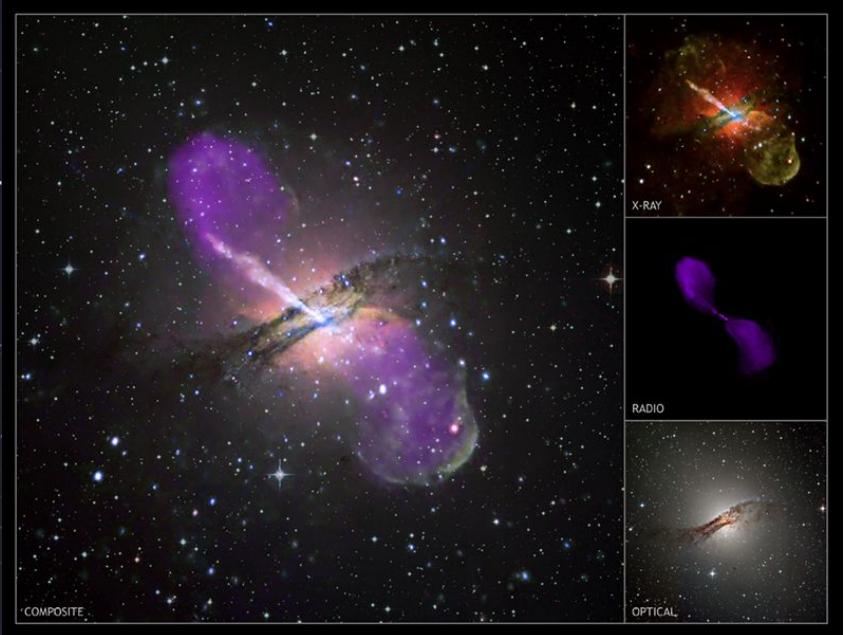


How do radio jets affect galaxy evolution?



How do radio jets affect galaxy evolution?



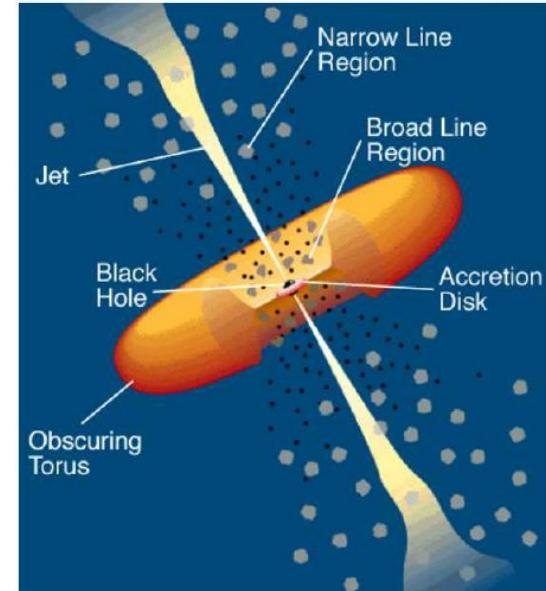
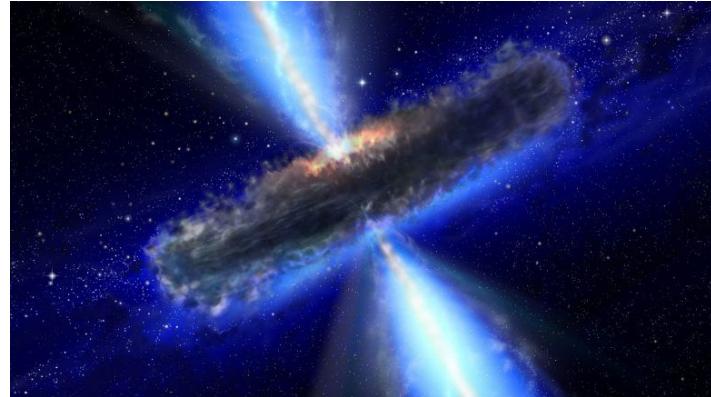


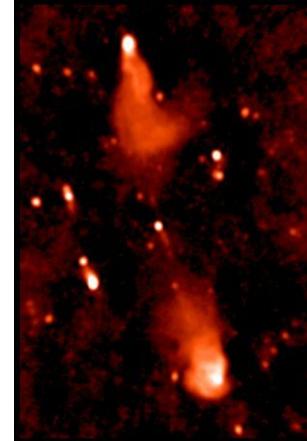
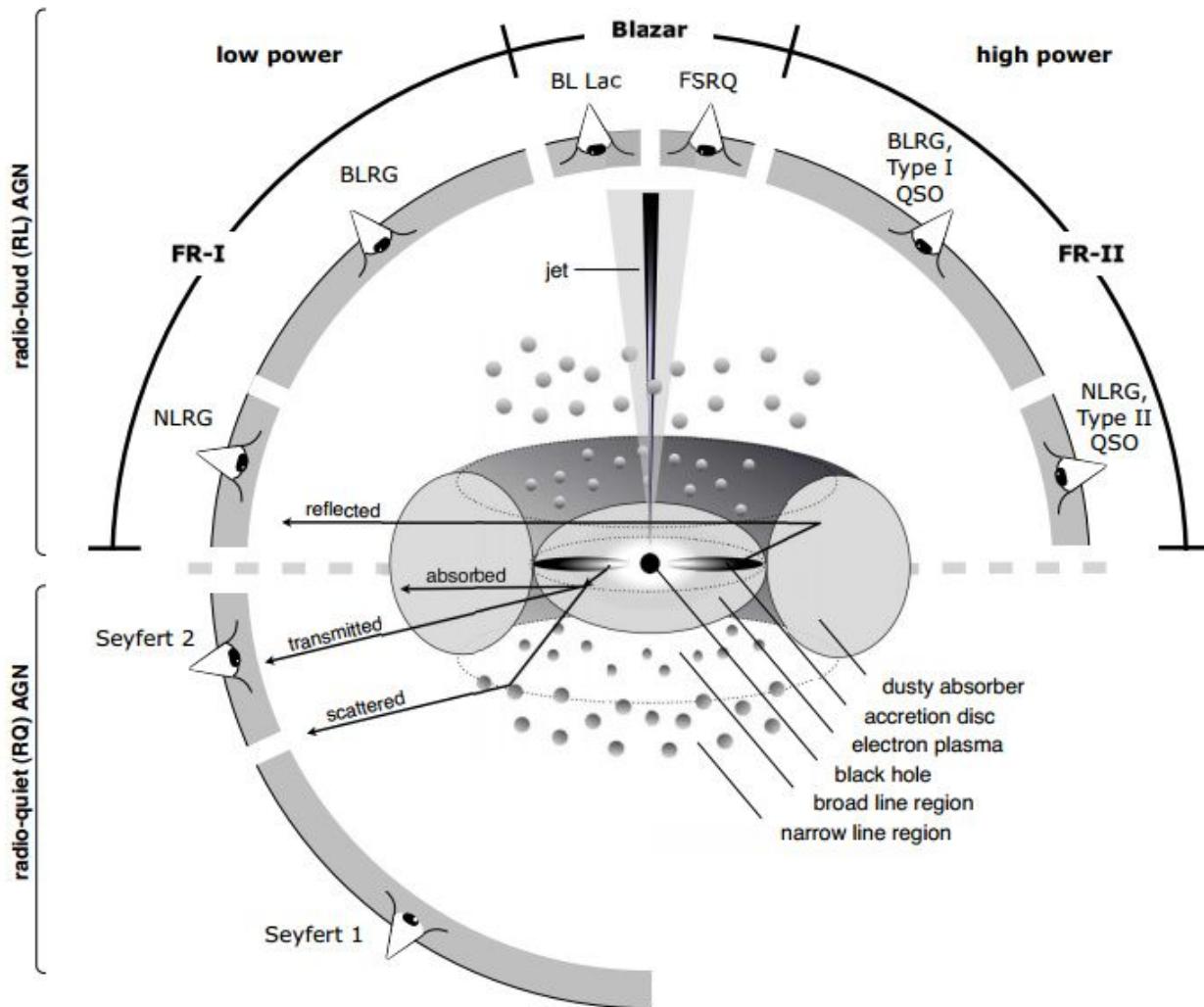
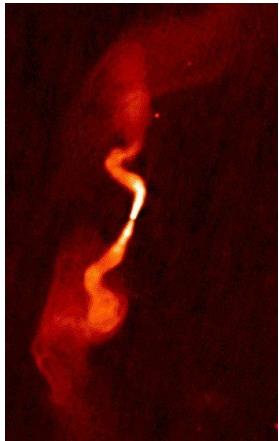
Centaurus A, a radio galaxy 13 million light years away.

*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

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





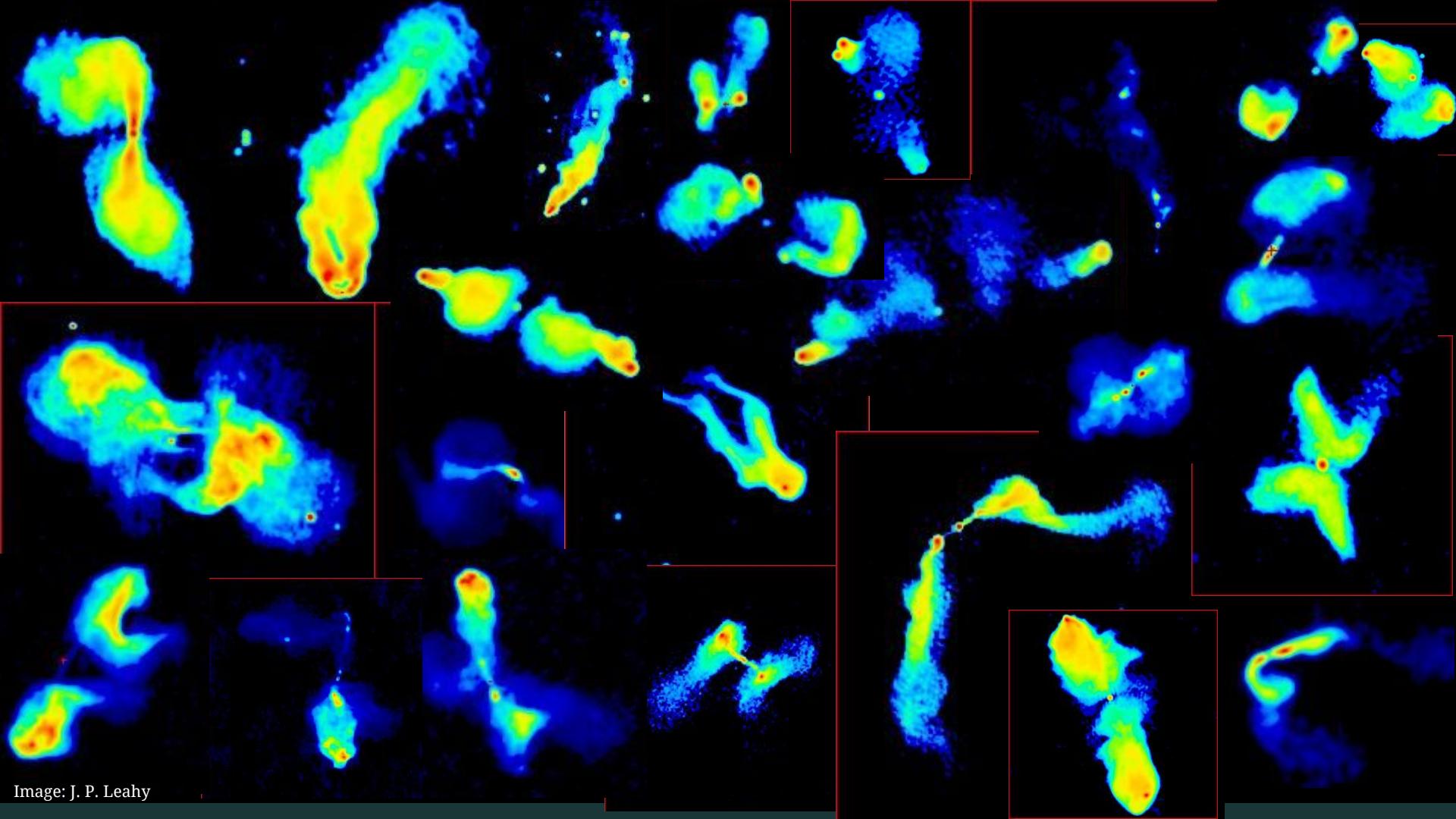
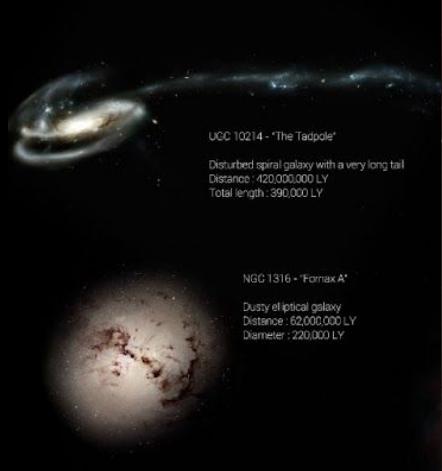


Image: J. P. Leahy

Radio galaxies are pretty big



UGC 10214 - 'The Tadpole'

Disturbed spiral galaxy with a very long tail
Distance : 420,000,000 LY
Total length : 390,000 LY

NGC 1316 - 'Fornax A'

Dusty elliptical galaxy
Distance : 62,000,000 LY
Diameter : 220,000 LY



At its center,
black hole is
Distance : 53
Diameter : 96

NGC 4921

A spiral galaxy in the Coma Cluster, it has lost much
of its gas and can longer form many new, blue stars,
giving it an unusually pale appearance.
Distance : 320,000,000 LY
Diameter = 230,000 LY

M31 - 'Andromeda'

Nearby spiral in our Local Group.
About as massive as the Milky Way.
It's headed straight for us! Collision in about 4 billion years.
Distance : 2,500,000 LY
The main stellar disc is about the same size as the Milky Way
but an extended, fainter disc spans about 220,000 LY

2013



Arp 81

Two merging galaxies
Distance : 280,000,000 LY
Diameter : 200,000 LY

The Milky Way

It's us!
Diameter about 100,000 LY
Artist's impression (Nick Risinger)

M33 - 'Triangulum'

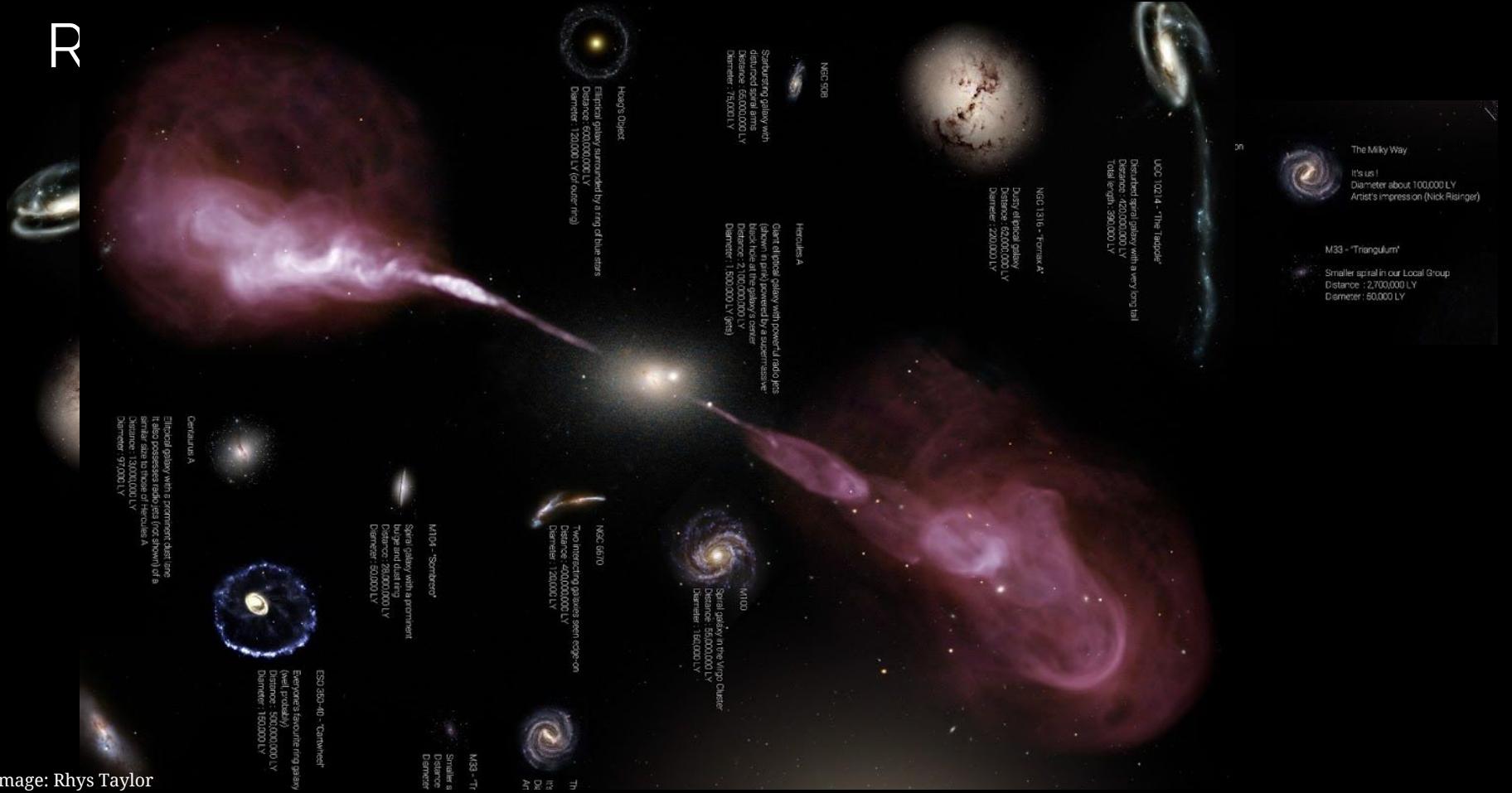
Smaller spiral in our Local Group
Distance : 2,700,000 LY
Diameter : 50,000 LY



NGC 1866

Barred spiral galaxy in the Fornax Cluster
Distance : 61,000,000 LY
Diameter : 200,000 LY

R



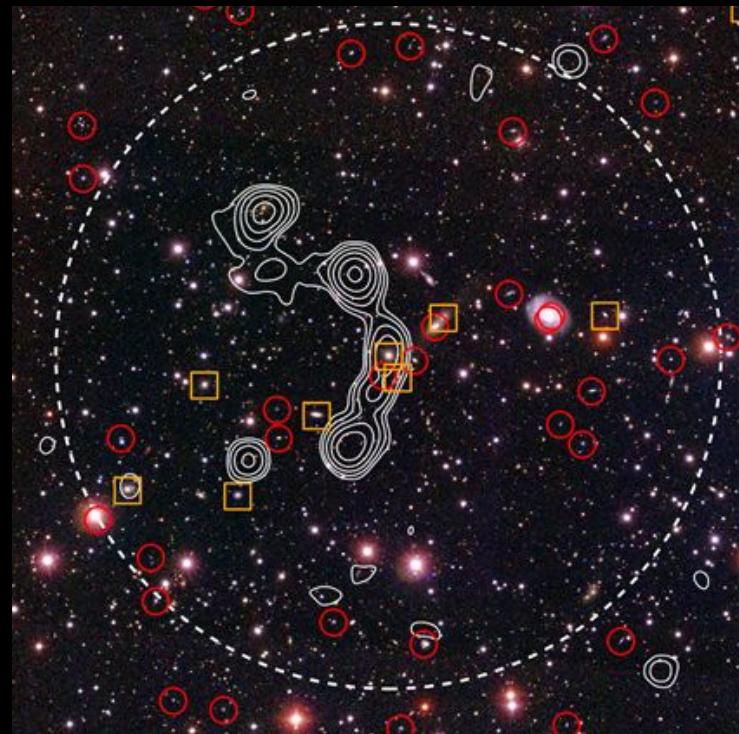
Radio galaxies are pretty big

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 ▾



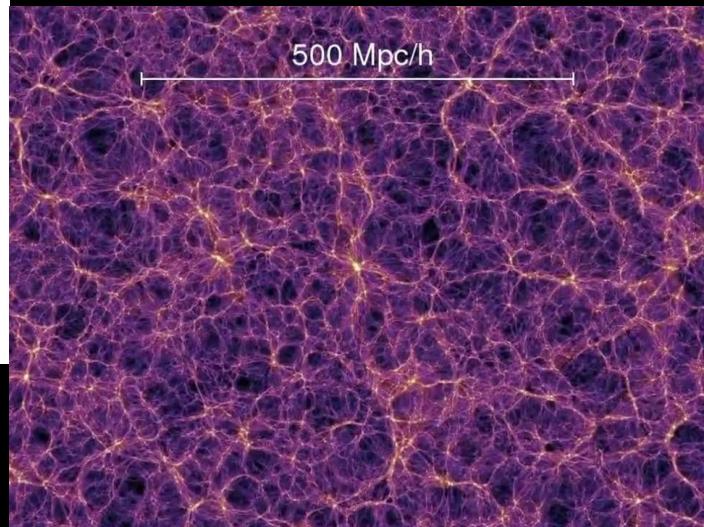
Cosmological alignment?

Radio Galaxy Zoo: cosmological alignment of radio sources FREE

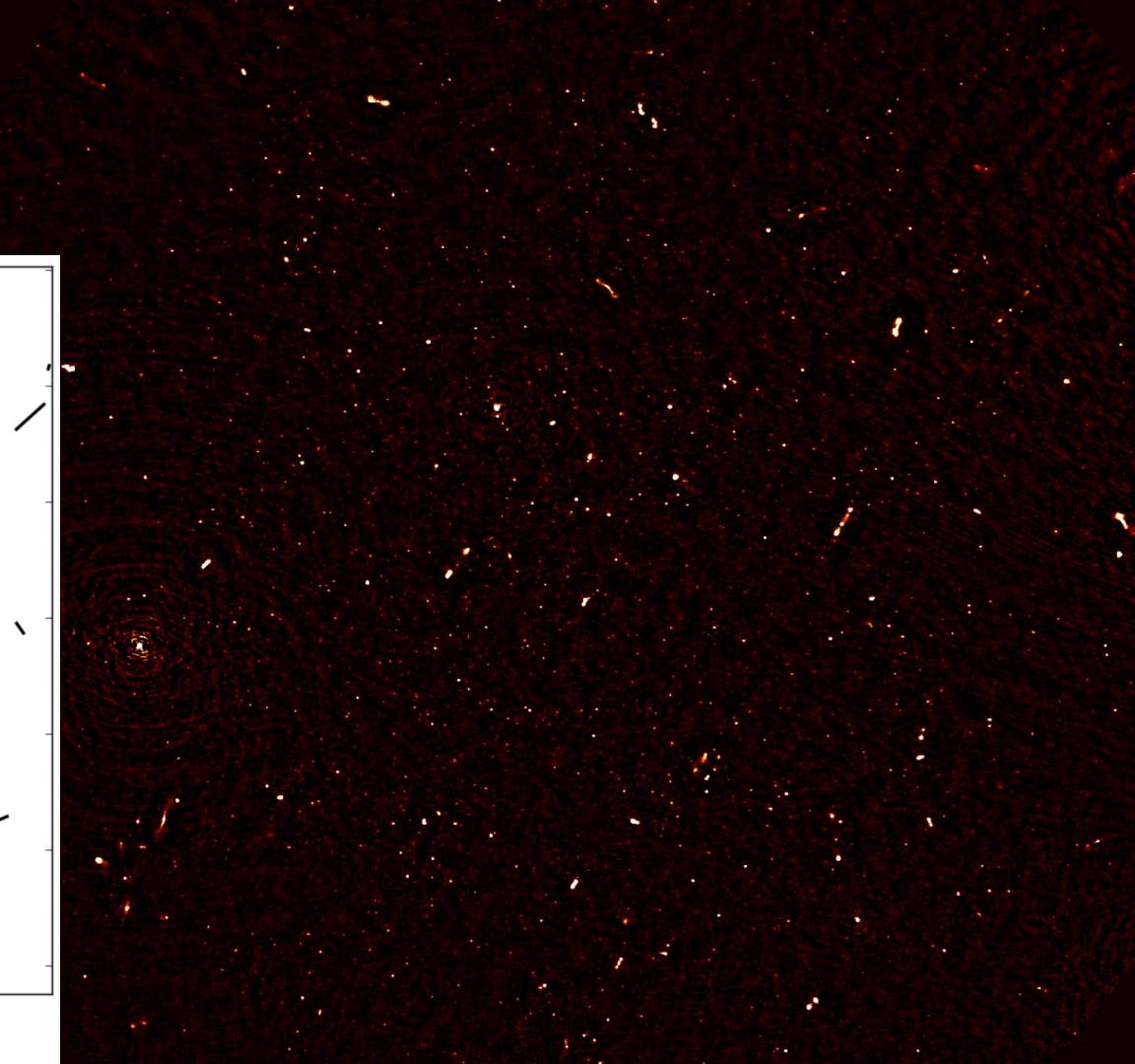
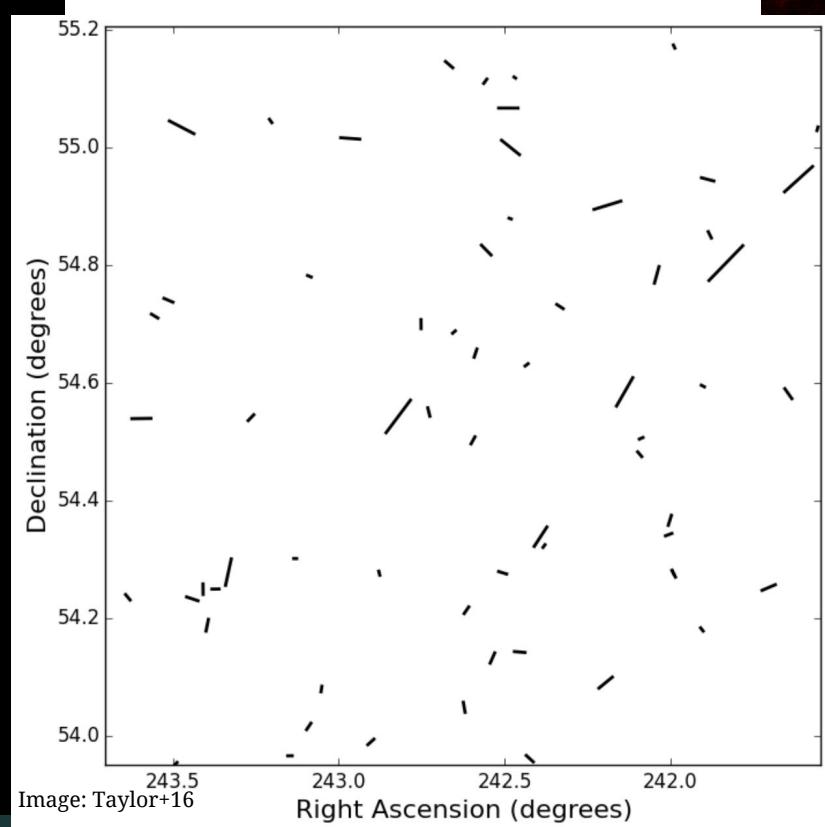
O. Contigiani ✉, F. de Gasperin, G. K. Miley, L. Rudnick, H. Andernach,
J. K. Banfield, A. D. Kapińska, S. S. Shabala, O. I. Wong

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

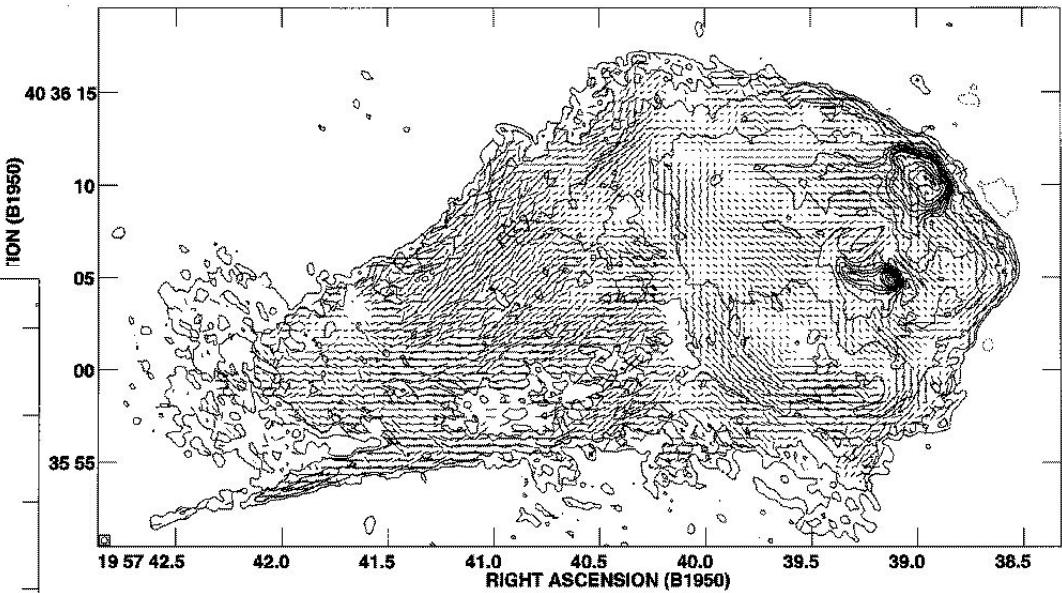
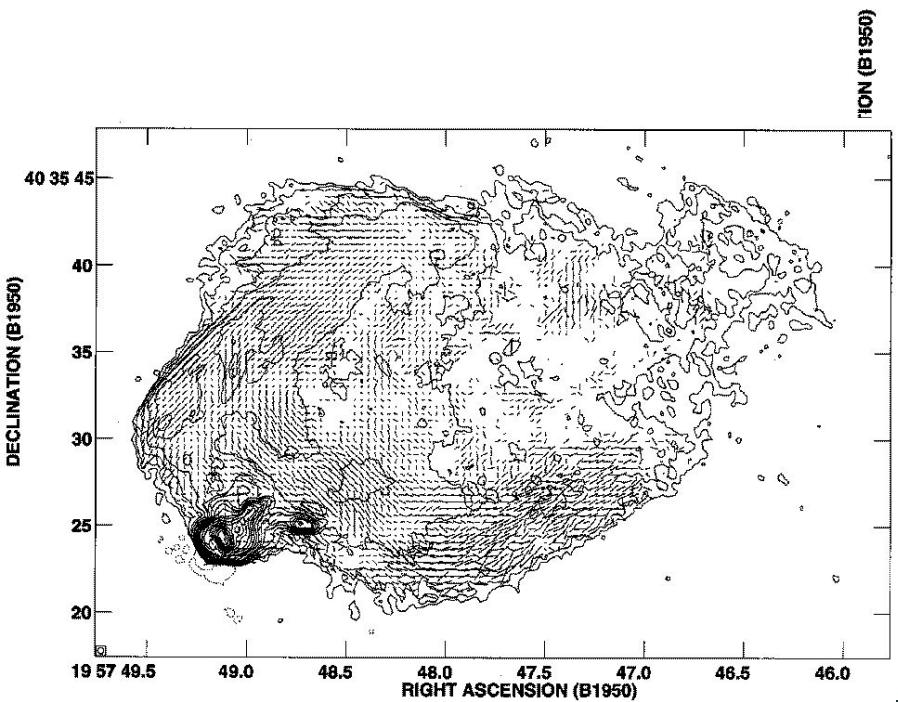
Published: 02 August 2017 **Article history ▾**



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.

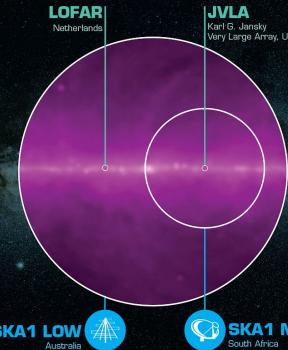


SKA1 LOW x1.2 LOFAR NL

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.



SKA1 LOW x135 LOFAR NL

SKA1 MID x60 JVLA

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.