The Square Kilometer Array……

- How did it all start?

Professor Peter Wilkinson
University of Manchester

Wilmslow Guild 1 December 2014

Within the theme of 21st Century Astrophysics

In 20th Century: We discovered our place in the Universe

In 21st Century: We seek to understand the Universe we inhabit….

Fundamental "Stuff"

- Gravity
- Magnetism
- Nuclear forces (LHC at CERN)
- Dark Matter
- Dark Energy

Origins of Structures

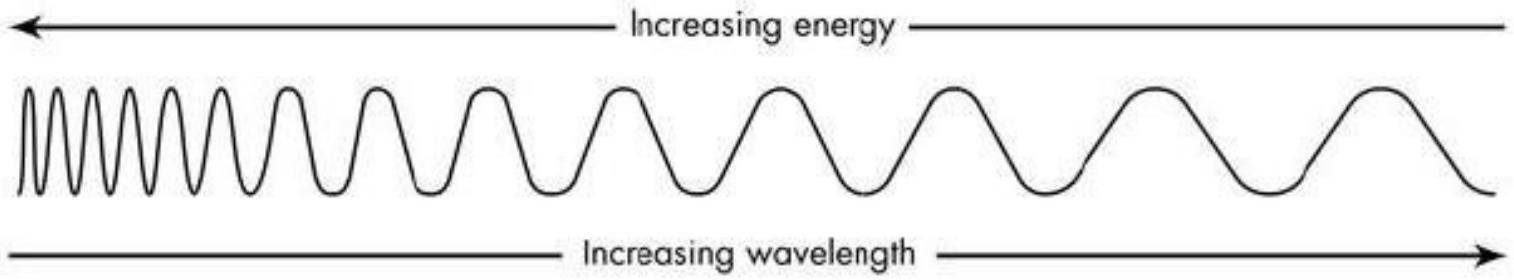
- The Universe
- Galaxies
- Stars, Planets, and Life

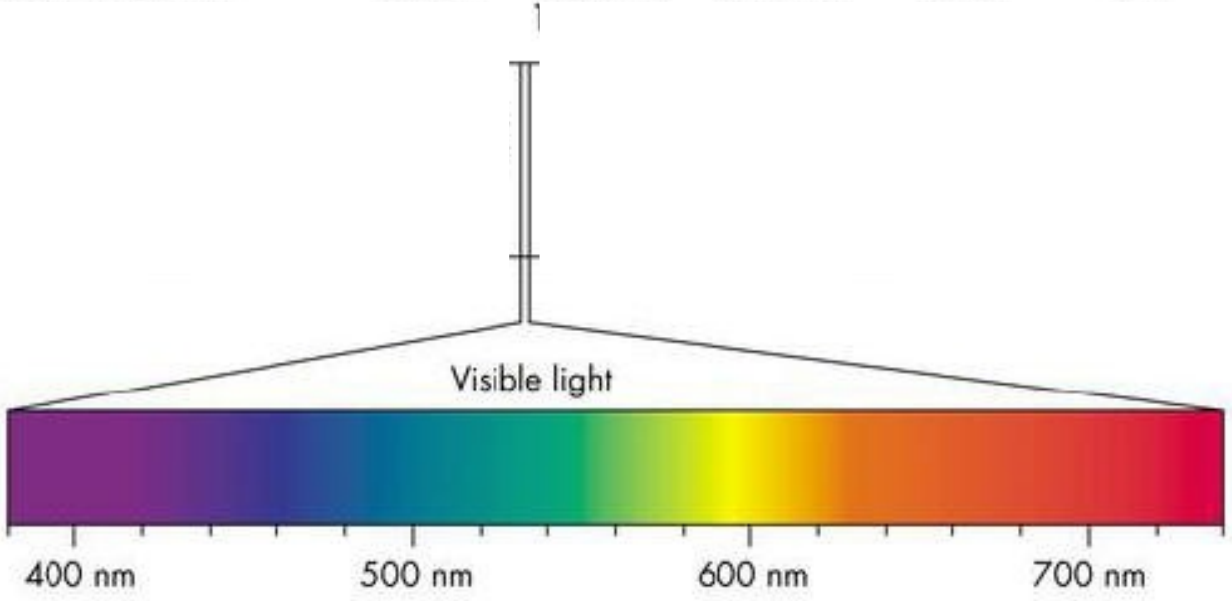
Studies of electromagnetic waves will play the major role

- Different Wavelengths
- Time variations
- Polarization
- Greater Sensitivity
- Larger Field of View
- Higher Angular Resolution

Electromagnetic spectrum

- For 400 years our view of the Universe was limited to a tiny fraction of the spectrum:



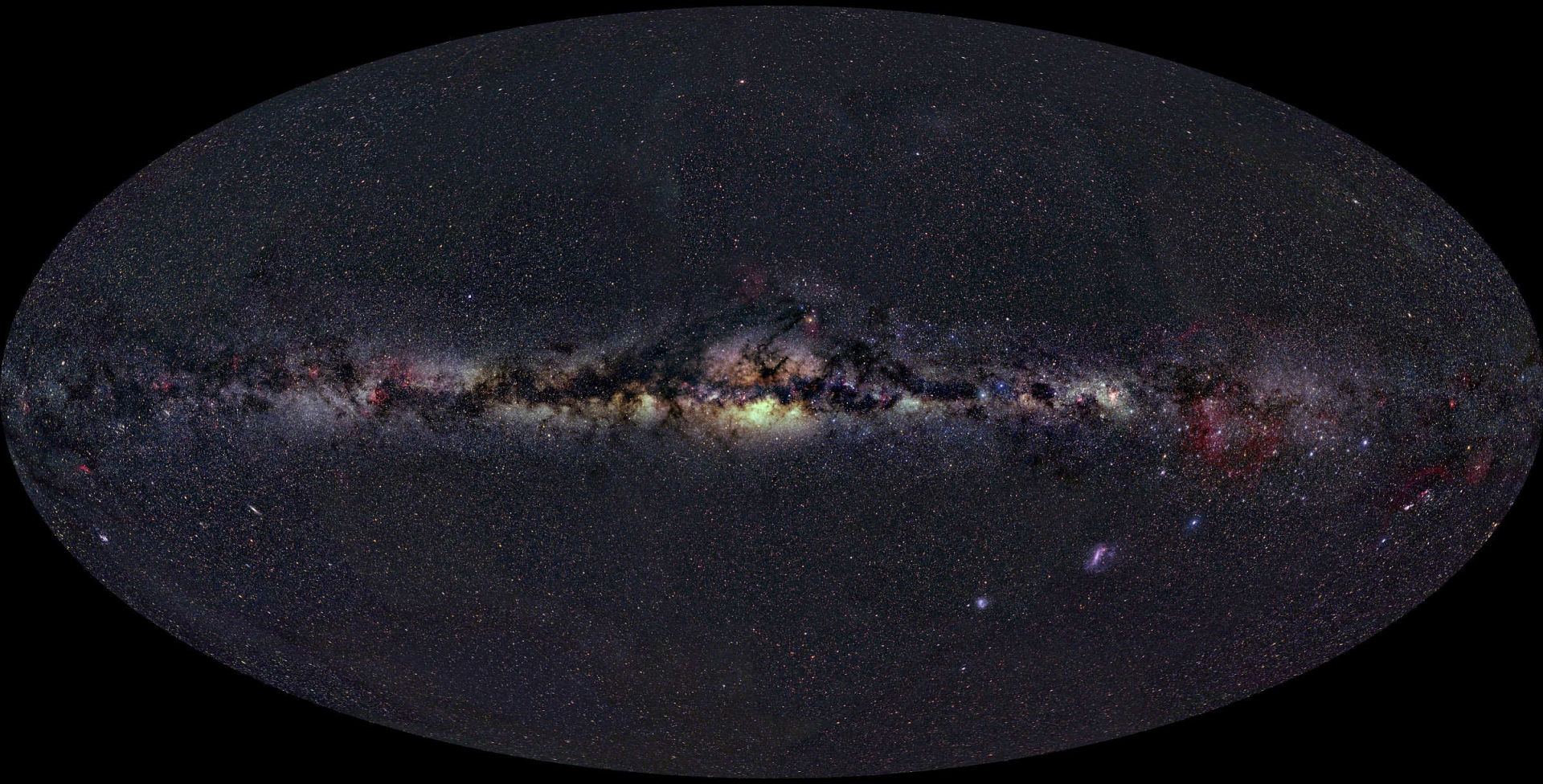


escope

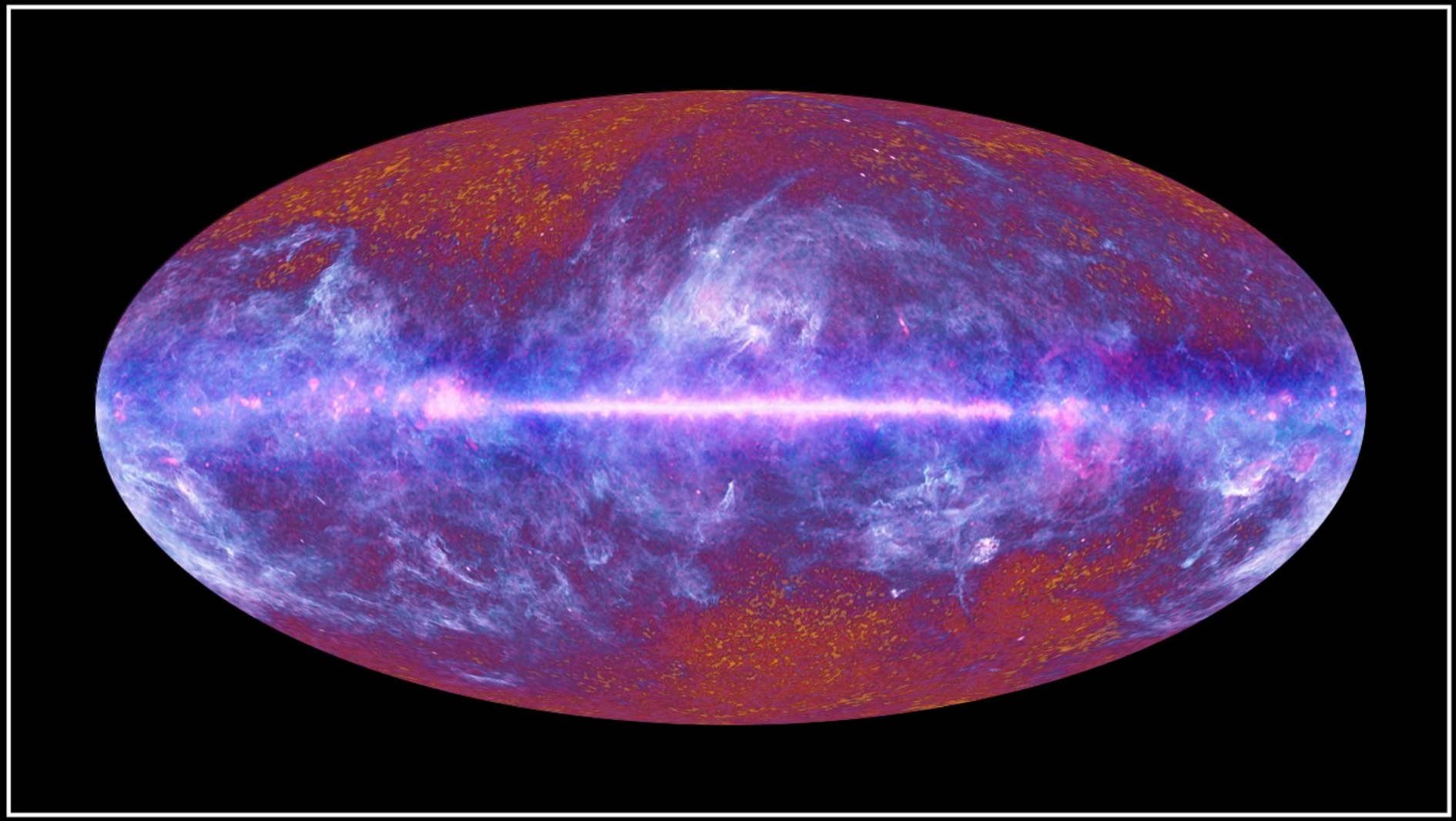
Then came radio telescopes….

Why is astronomy in the radio band important?

A Universe of stars and dust



A Universe of gas, dust and radio radiation



The Planck one-year all-sky survey

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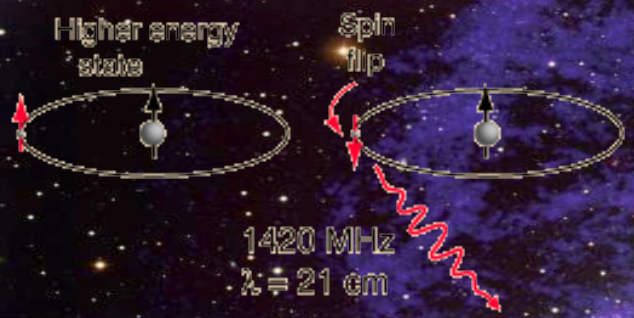
But why a square kilometre?

Exploring the Universe with the world's largest radio telescope



1420 MHz radio emission from atomic hydrogen – the commonest element in the universe

Visible starlight

Radio emission

A different view of the universe -- but the hydrogen signal is weak → need MUCH larger collecting area than today's giant telescopes to study in the distant universe

"A volume of the 'Encyclopaedia of the Universe' is written in 21 cm typescript. Unfortunately the printing is rather faint and we need a large 'lens' to read the text! Wilkinson 1991:

Radio Interferometry: Theory, Techniques and Applications
I AU Coll. 131, ASP Conference Series, Vol. 19, 1991
T.J. Cornwell and R.A. Perley (eds.)

THE HYDROGEN ARRAY

P. N. WILKINSON
University of Manchester, Nuffield Radio Astronomy Laboratories, Jodrell Bank, Macclesfield, Cheshire SK11 9DL, United Kingdom

ABSTRACT The time is ripe for planning an array with a collecting area of 1 km^2 (14 times larger than Arecibo and 75 times larger than the VLA). In view of its major astronomical target I have dubbed this concept 'The Hydrogen Array', although 1μJy continuum sources will also be reliably detected. I present some initial thoughts about the issues involved.

Cosmic radio signals are weak…

- Energy emitted by a galaxy can be enormous (10^{38} MegaWatts)

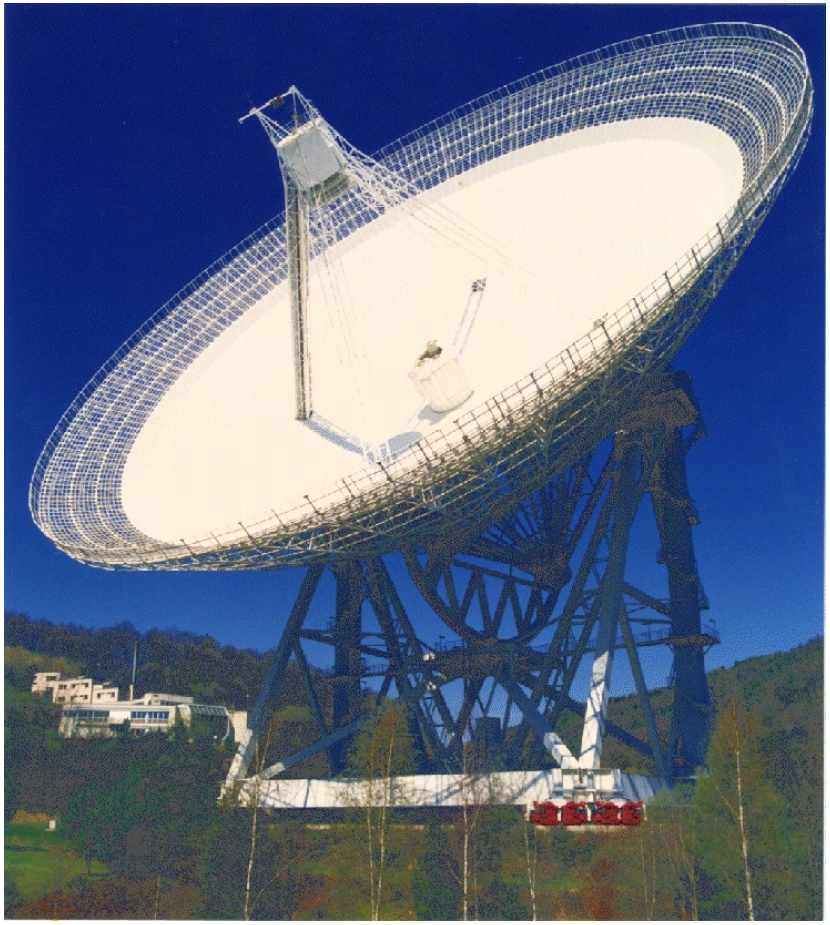
  100,000,000,000,000,000,000,000,000,000,000,000,000,000 W

- But the distances are enormous, so the energy received is tiny.

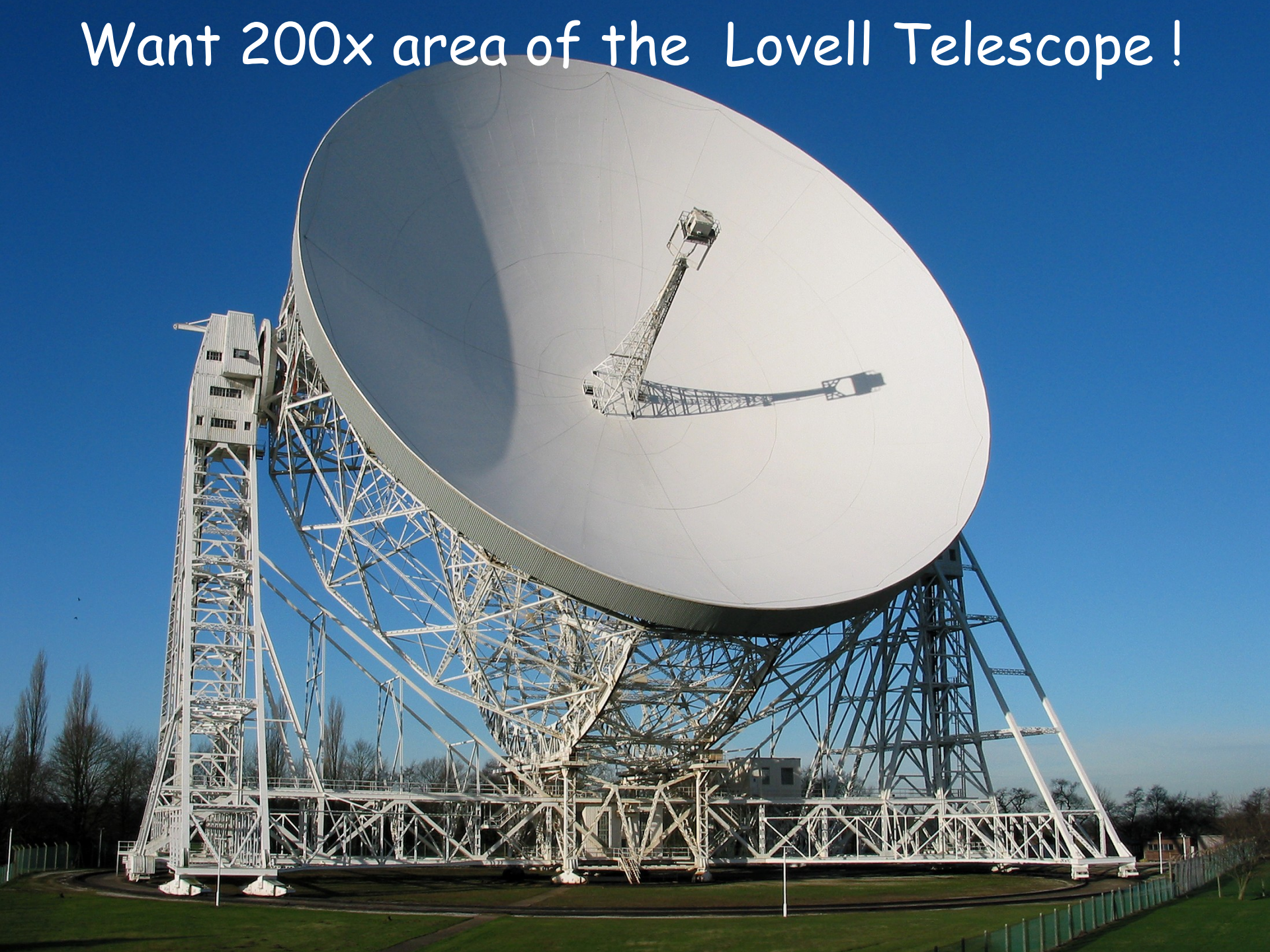
- The bigger the telescope, the more distant objects can be detected

- BUT… wind and gravity are enemies requiring more massive structures as the diameter grows…

- Too expensive beyond 100m diameter



Effelsberg 100m radio telescope


Want 200x area of the Lovell Telescope !

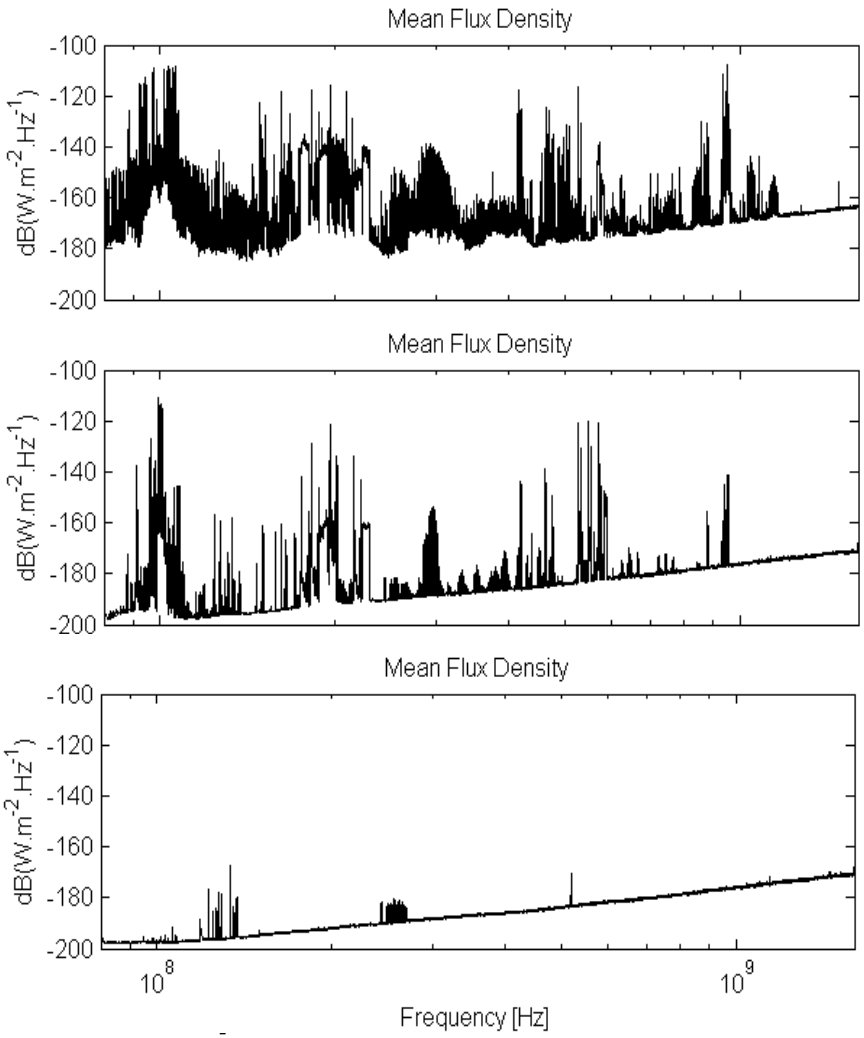
Cosmic radio signals are weak & man made signals are strong !

- If one could add together ALL the radio energy collected by ALL the world's radio telescopes over the past 50 years it would be less than switching on a torch for a thousandth for a second !

- A mobile phone radiating 1km from a radio telescope contributes a power, in its band, millions of times greater than the most powerful cosmic radio source

- A open microwave oven on the Moon…… 10x greater than the most powerful cosmic radio source !

Avoid man-made interference !

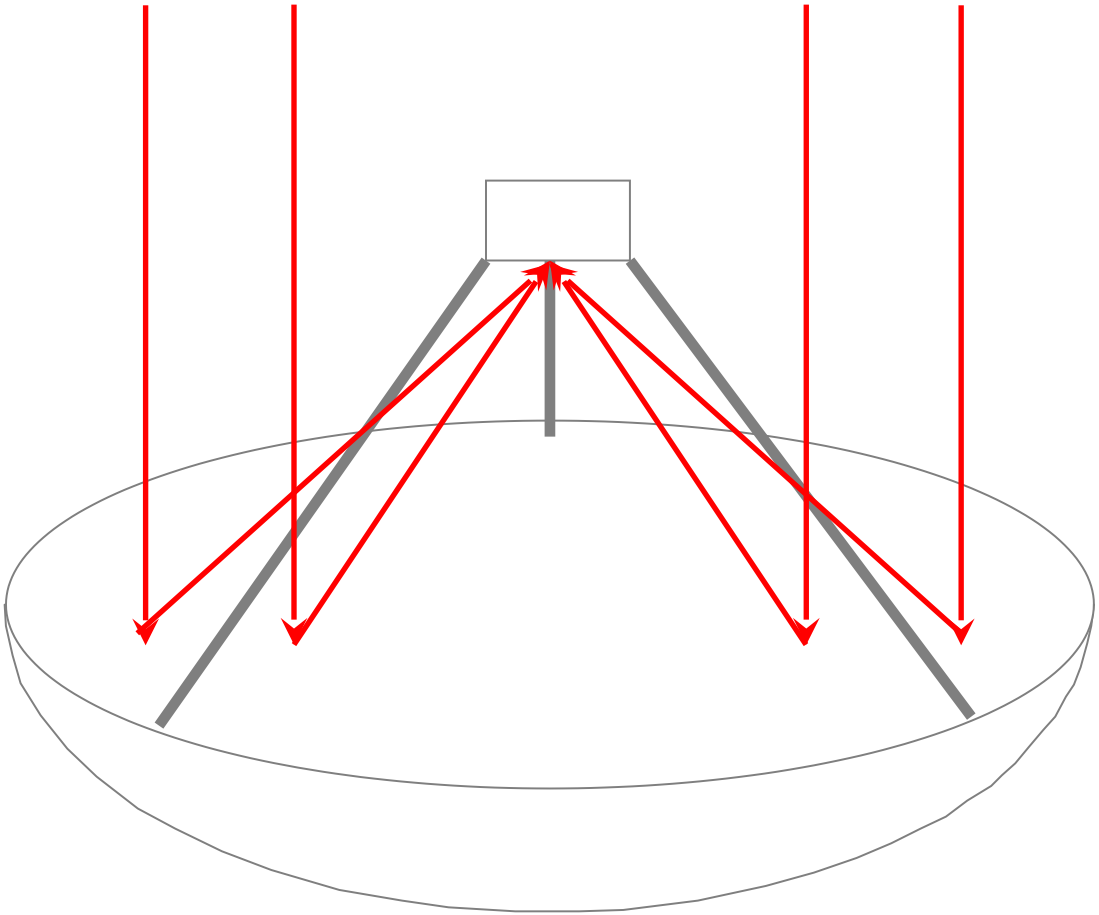


Large city
population: several million

Small town
population: several thousand

Candidate SKA site

Building Bigger Radio Telescopes

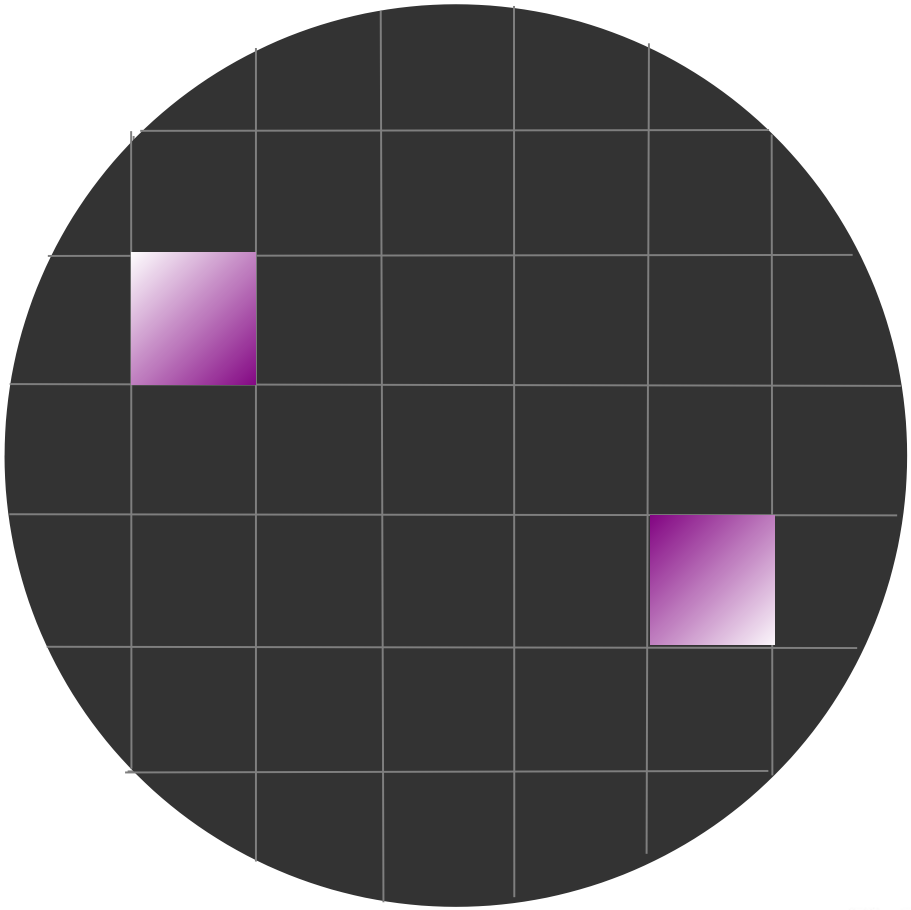


Conventional radio telescopes reflect the signals from distant objects from a parabolic surface to a focus

Shape of parabola ensures all parts of the incoming wave arrive at the focus at the same time

from Malcolm Longair

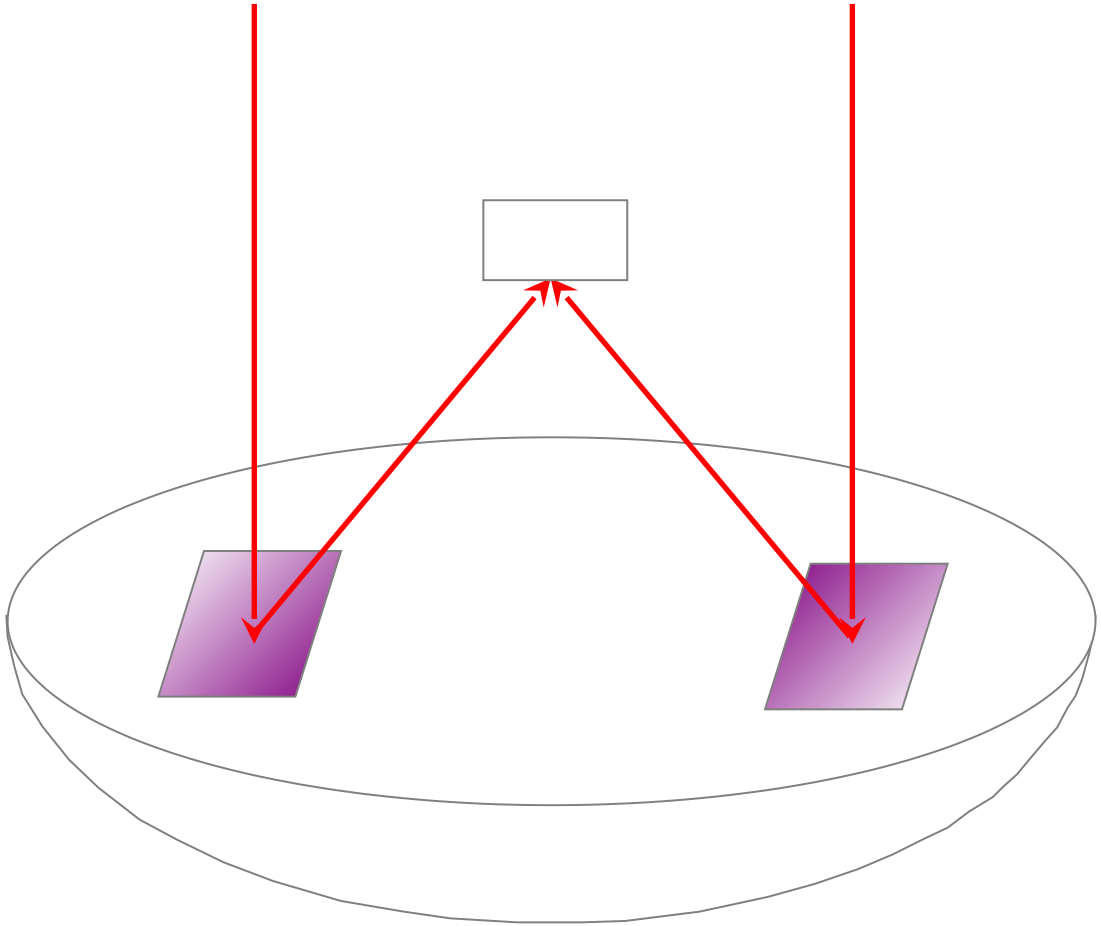
A Partially Filled Telescope



But the reflecting surfaces do not need to be part of the same surface.

Suppose we cover up most of the surface of the mirror.

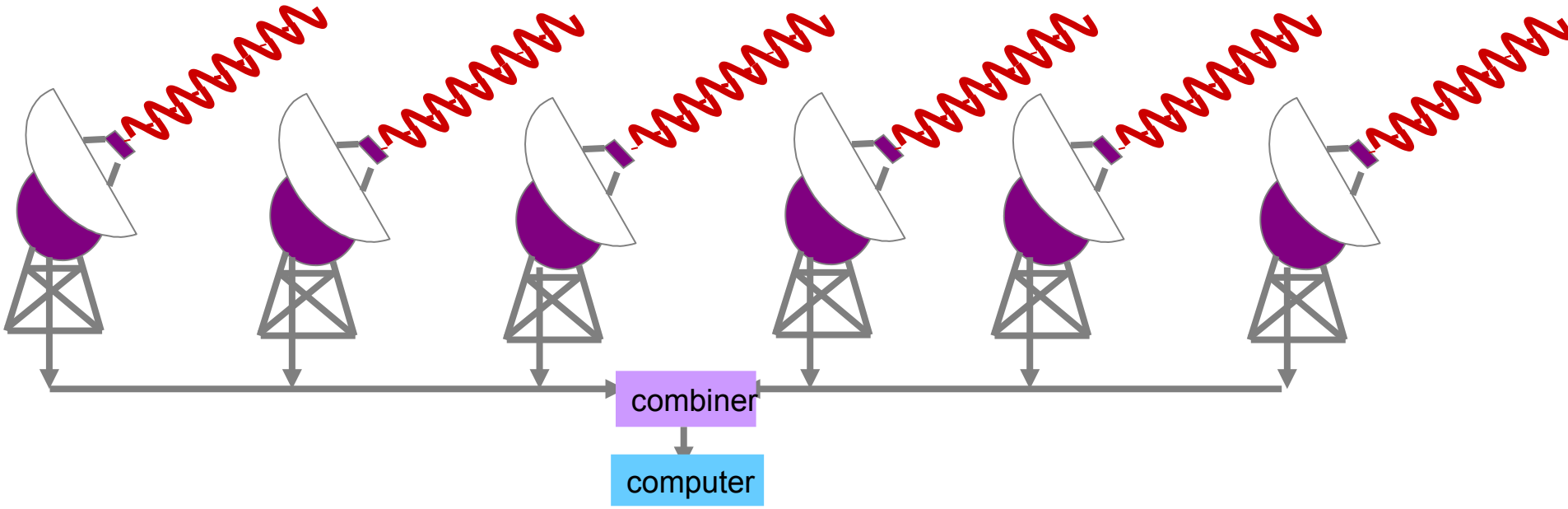
Building Bigger Radio Telescopes



We can still combine the radiation from the uncovered sections to create an image of the distant object, if we arrange the path lengths to the focus to be the same.

Building Bigger Radio Telescopes

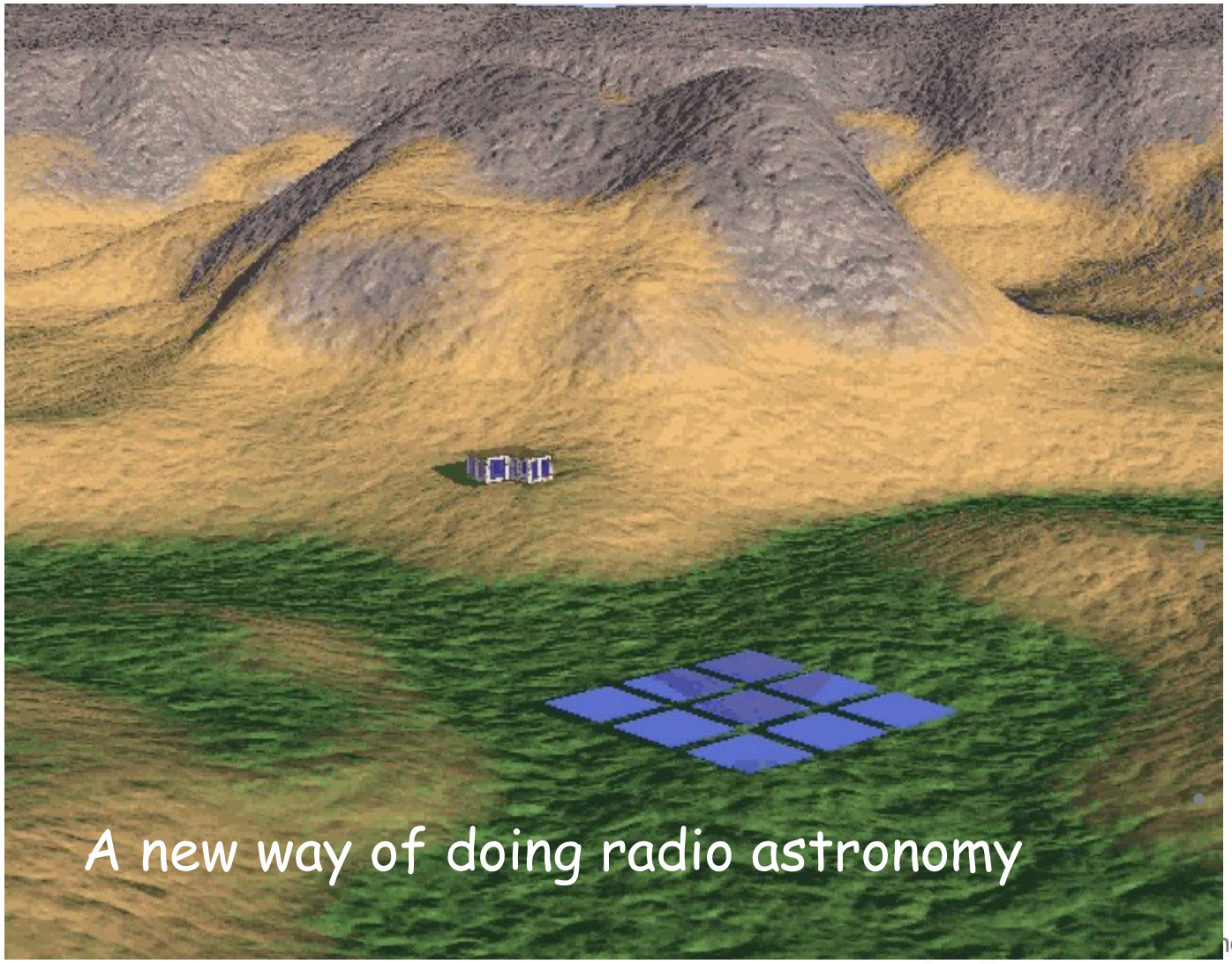
As electronics and fibre costs fall it becomes cheaper to build up large collecting areas from smaller elements !



- Each *pair* of antennas is called a baseline
- More different baselines N(N-1)/2 → more details in the astronomical image.

Looking to construct the radio equivalent of this… !!

Potential of multiple fields-of-view



Science survey advantage:

- projects needing lots of time
- rapid sky scanning for transient events

Community advantage:

- many groups can access the whole aperture at same time
- room for high risk projects

SKA was conceived in Manchester

.....has European DN

.....was "born global

.....is now being nurtured in the UK....

No radio astronomy project has ever been conceived on this scale

- Everything is required "en masse"
- Remote environment
- Very challenging performance goals
- Very low cost per unit area
- Major ICT Project

Exploration of the Unknown

"The SKA will address many currently topical problems in astronomy and astrophysics. But, these are today's problems—will they still be the outstanding problems that will challenge astronomers in the period 2025 to 2050 and beyond, when the SKA will be in its most productive years?

Wilkinson, Kellermann, Cordes, Ekers, Lazio (2004)

"There are more things in heaven and earth, Horatio, than are dreamt of in your philosophy."

- *Hamlet*, Act 1, Scene V

The Unknown……

As we know,
There are known knowns.
There are things we know we know.

read literature

We also know
There are known unknowns.
That is to say
We know there are some things
We do not know.

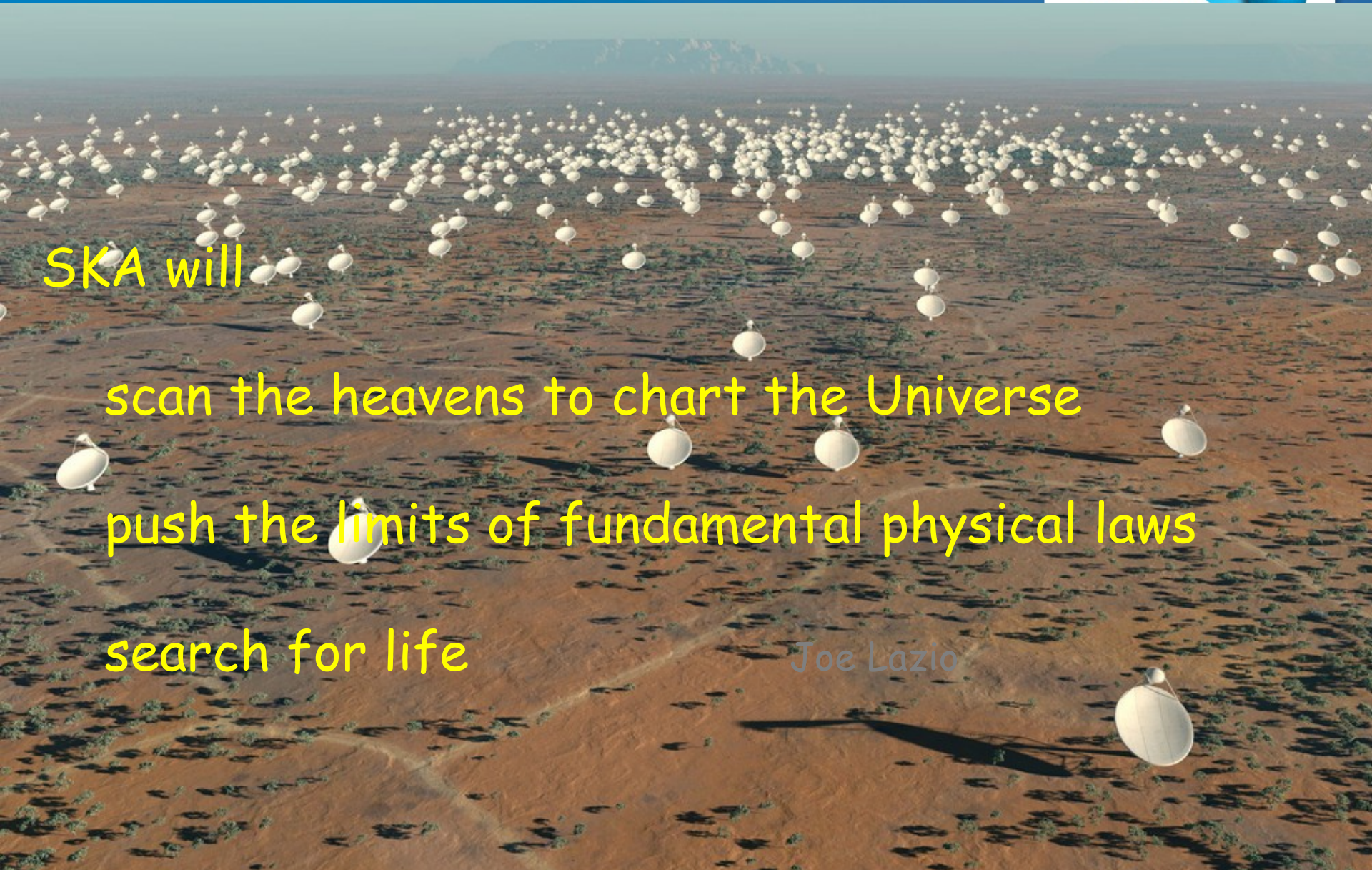
write a proposal

But there are also unknown unknowns,
The ones we don't know
We don't know.

realise a vision!

Donald Rumsfeld 2002

One of the world's Great Observatories for the coming decades



Visionary projects take a long time..

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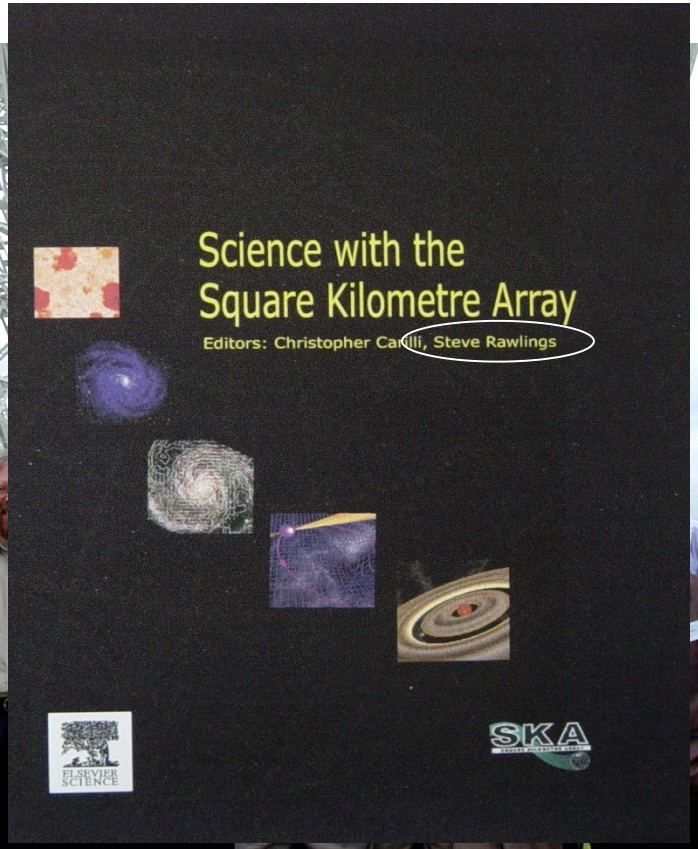

SKA MoU signed IAU Manchester 2000

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KADS

Exploring the Universe with the world's largest radio telescope

Present Timeline

- 2005-2009 Technology research
- 2006 Short listing of sites(Australia OR South Africa)
- 2008-2012 Technology development
- 2011 Site selection (South Africa AND Australia)
- 2013 – 2016: Pre-construction, detailed design
- 2014 – 2016: Partners seek SKA1 funding UK
- 2016-2017: Construction approved
- 2017: Issue construction contracts
- 2018 – 2022: Construction of SKA1
- 2019/20: Early science begins
- 2018-2021: Design of SKA
- 2022 – 2025: Construction of SKA
- SKA operational for 50 years.....

Fun facts about the SKA

Did you know?

The SKA will be so sensitive that it will be able to detect an airport radar on a planet 50 light years away.