The Square Kilometre Array Observatory
Big Data and Transformational Science

Dr Chris Pearson : RAL Space

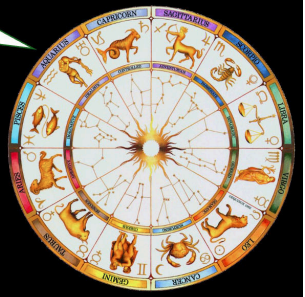
credit-SKAO-Max Alexander

The Square Kilometre Array Observatory (SKAO) : an international effort to build
The world’s largest radio telescope
The largest scientific facility in the history of humankind

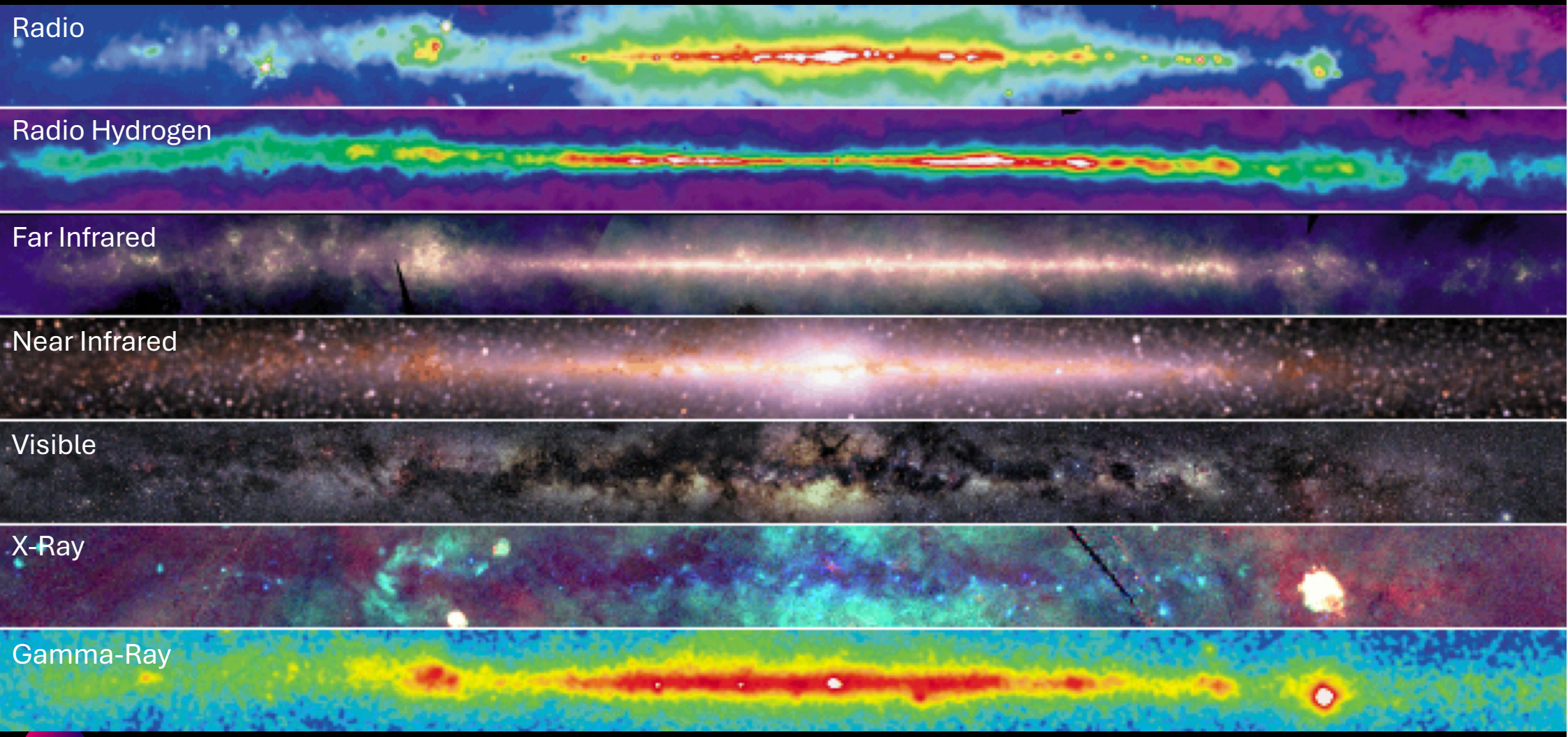
Radio Astronomy ?

Observing our Universe at radio wavelengths

NOT predicting horoscopes over the radio



The Milky Way



Why Radio Astronomy ?

1. Access the invisible Universe.

2. Observe from the ground without launching expensive rockets into space.

3. High sensitivity (collecting lots of light)

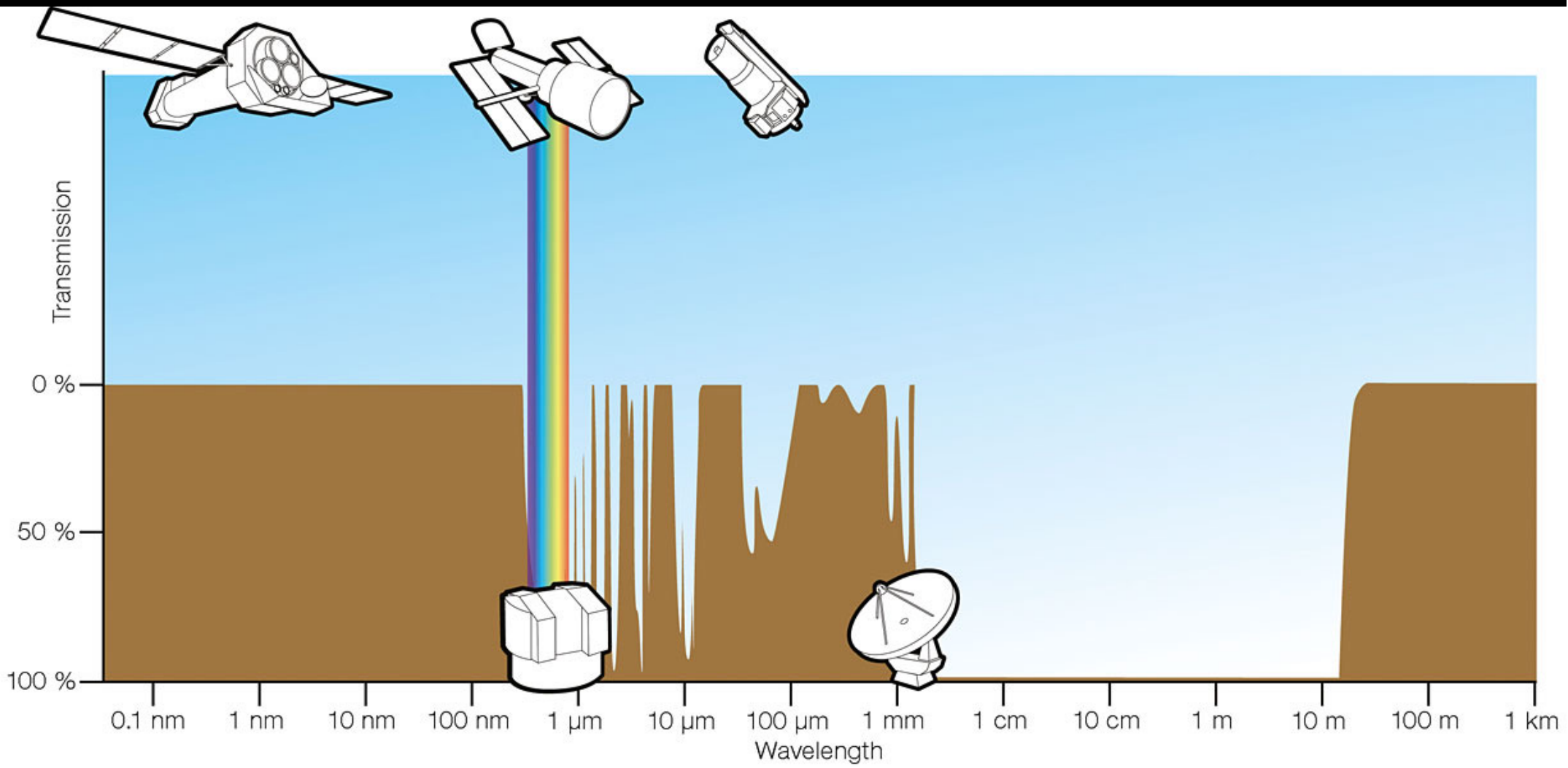
4. Observe objects in extremely high resolution (detail).

Why Radio Astronomy ?

1. Access the invisible Universe.

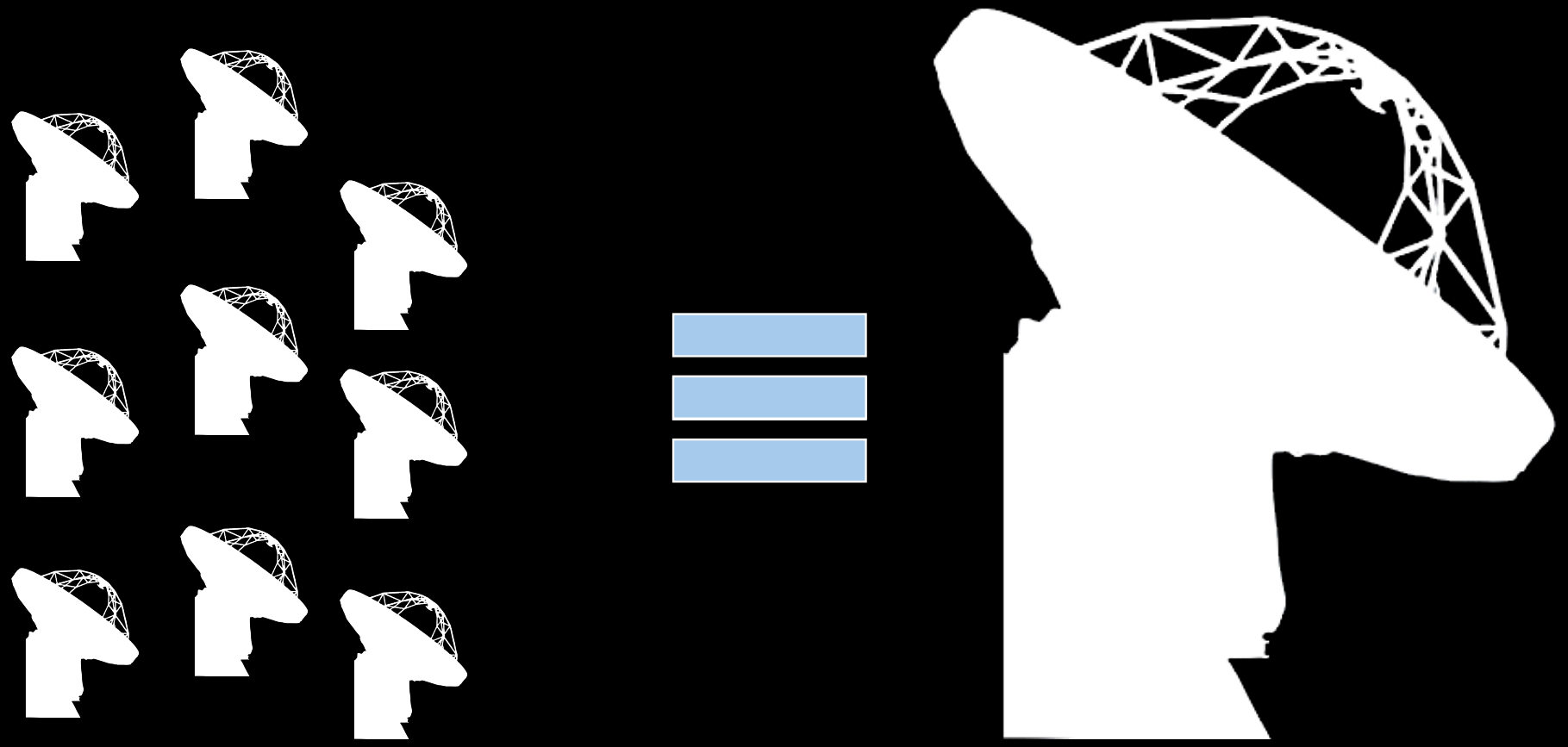
Why Radio Astronomy ?

2. Observe from ground without launching expensive rockets into space.



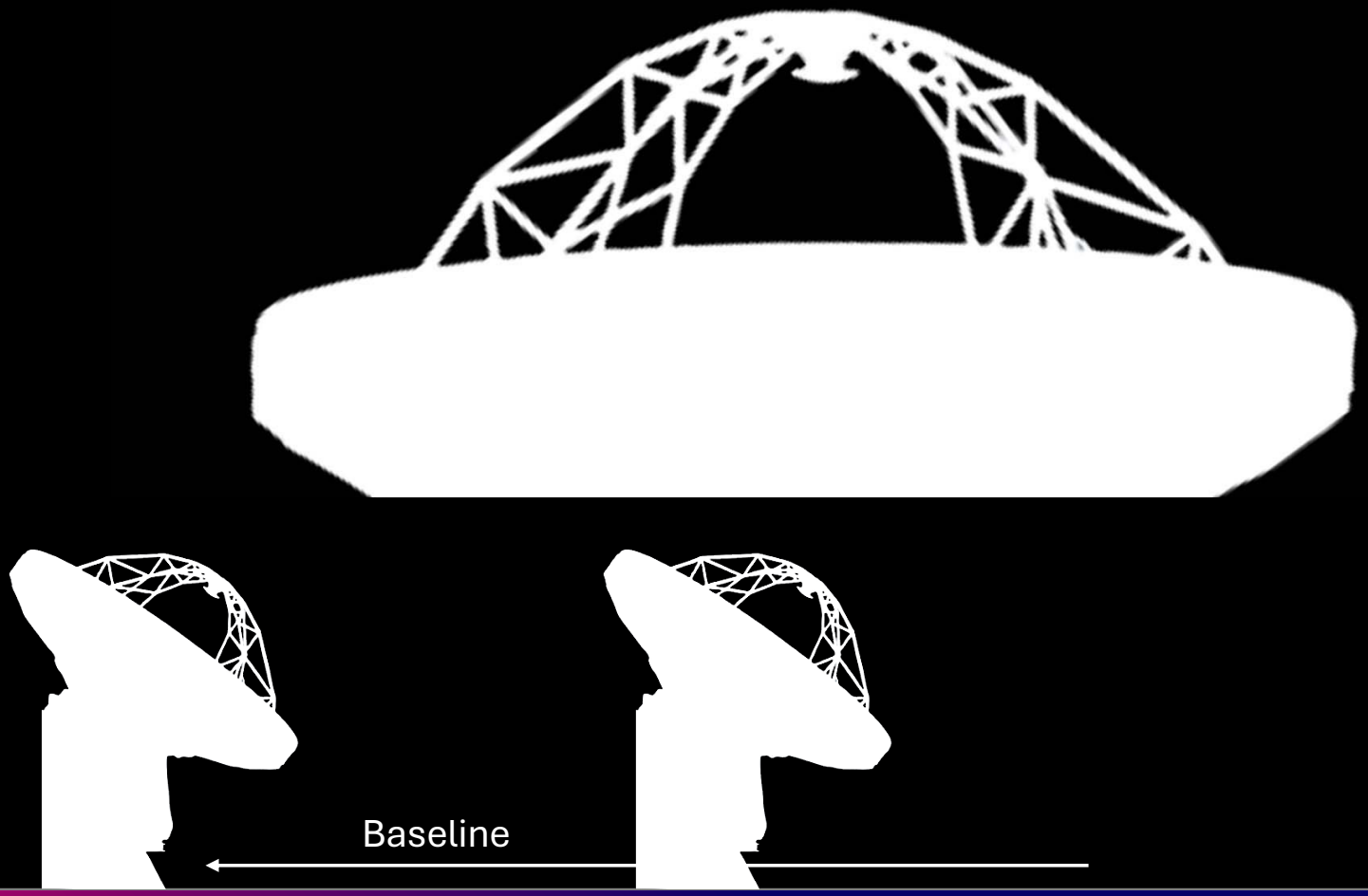
Why Radio Astronomy ?

3. High sensitivity (collecting lots of light)



Why Radio Astronomy ?

4. Observe objects in extremely high resolution / detail.



The Square Kilometre Array Observatory

- **Location:** Needs an isolated and wide-area location.
- **Sensitivity:** Needs to have many radio dishes / radio arrays.
- **Resolution:** Dishes need to be separated by big distances.
- **Timing:** Needs computer software to synchronise telescopes.
- **Data Storage:** Big Science needs Big Storage

Challenge:

Make all these single telescopes work together like one giant single telescope!

The Square Kilometre Array Observatory

South Africa : SKA MID

The Karoo 800 km north of Cape Town

Frequency range 350 MHz – 15.4GHz

197 Dishes

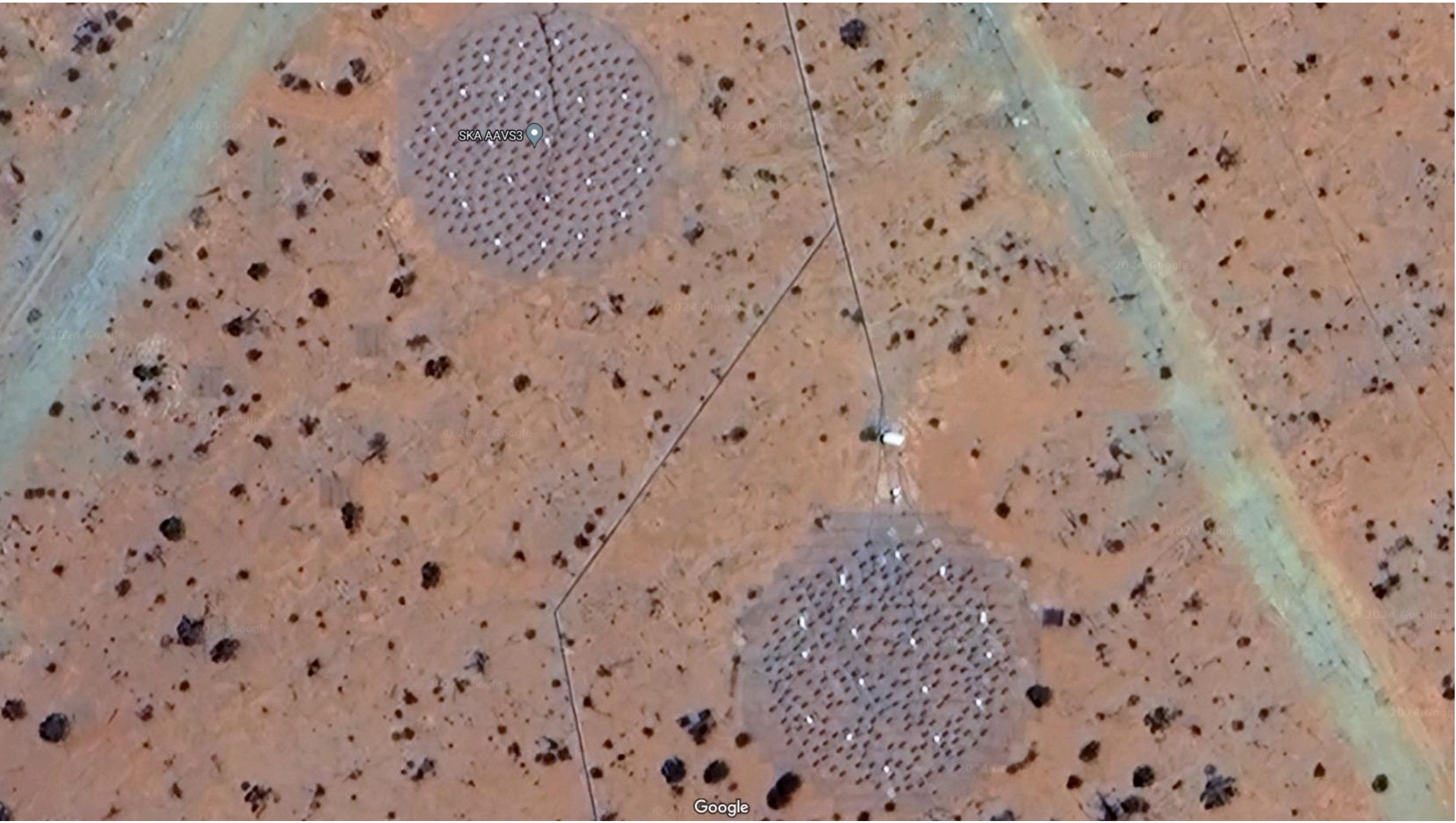
The Square Kilometre Array Observatory

Australia : SKA LOW

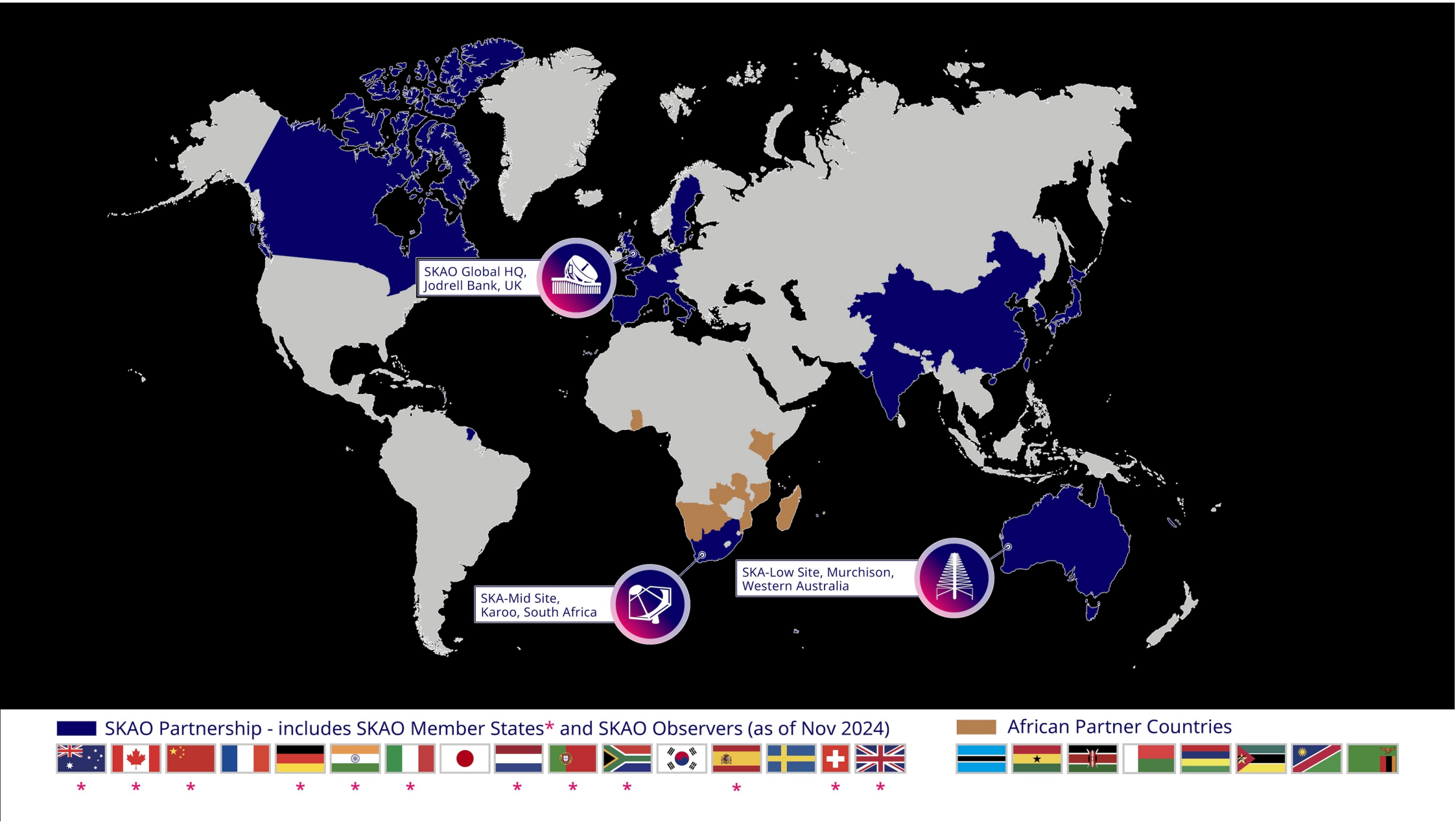
Murchison Region 800km north of Perth

Frequency range 50 MHz – 350 MHz

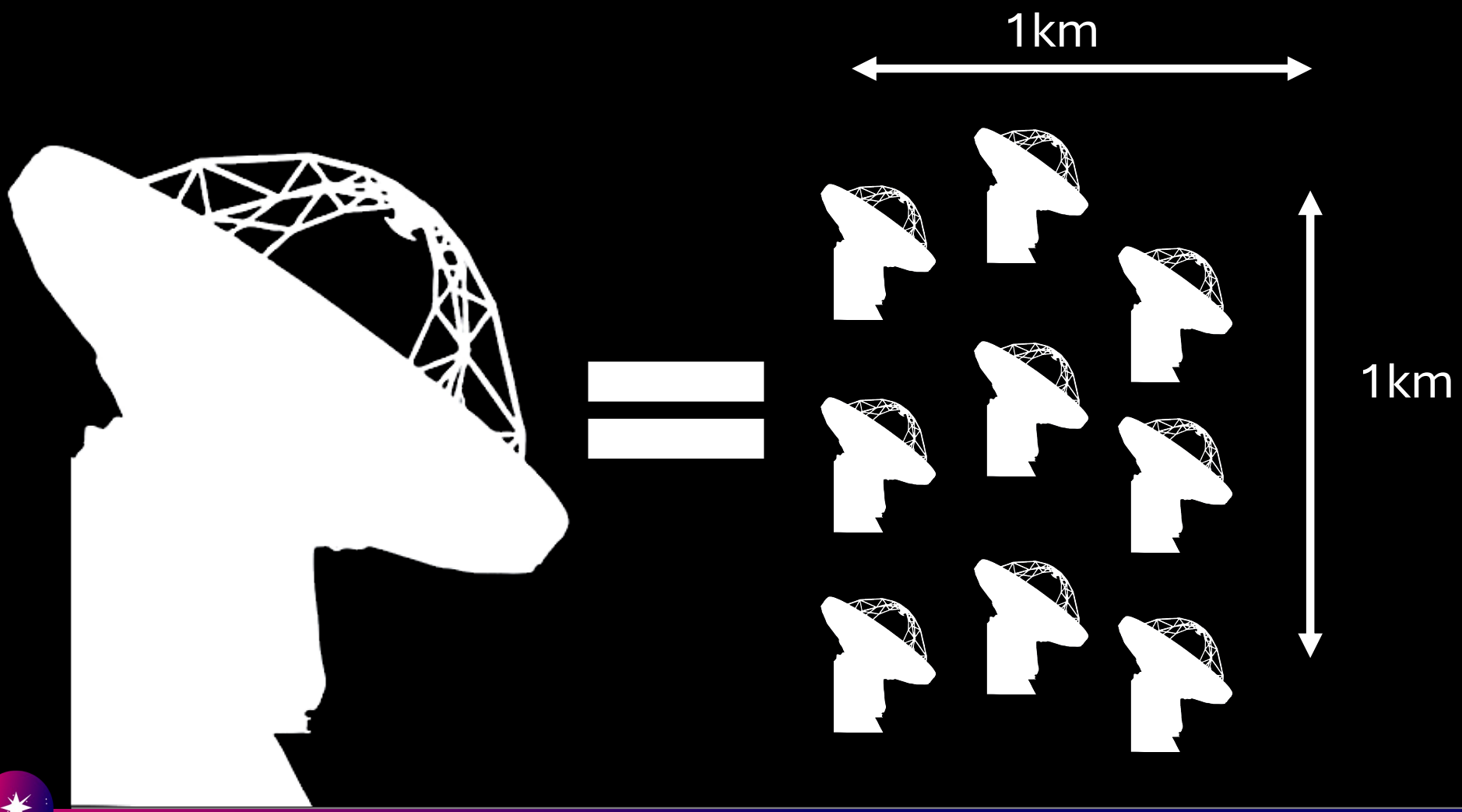
131,072 Antennas


SKA AAVS3
Google


CSIRO
Australian Government
You are now entering a Radio Quiet Zone for radio astronomy
Please
• Place all devices in flight mode
• Switch off satellite phones
• Minimise use of CB radio
• Emergency use is permitted
Your co-operation is appreciated


SKAO Global HQ,
Jodrell Bank, UK
SKA-Mid Site,
Karoo, South Africa
SKA-Low Site, Murchison,
Western Australia
SKAO Partnership - includes SKAO Member States* and SKAO Observers (as of Nov 2024)
African Partner Countries

The Square Kilometre Array Observatory



The Square Kilometre Array Observatory

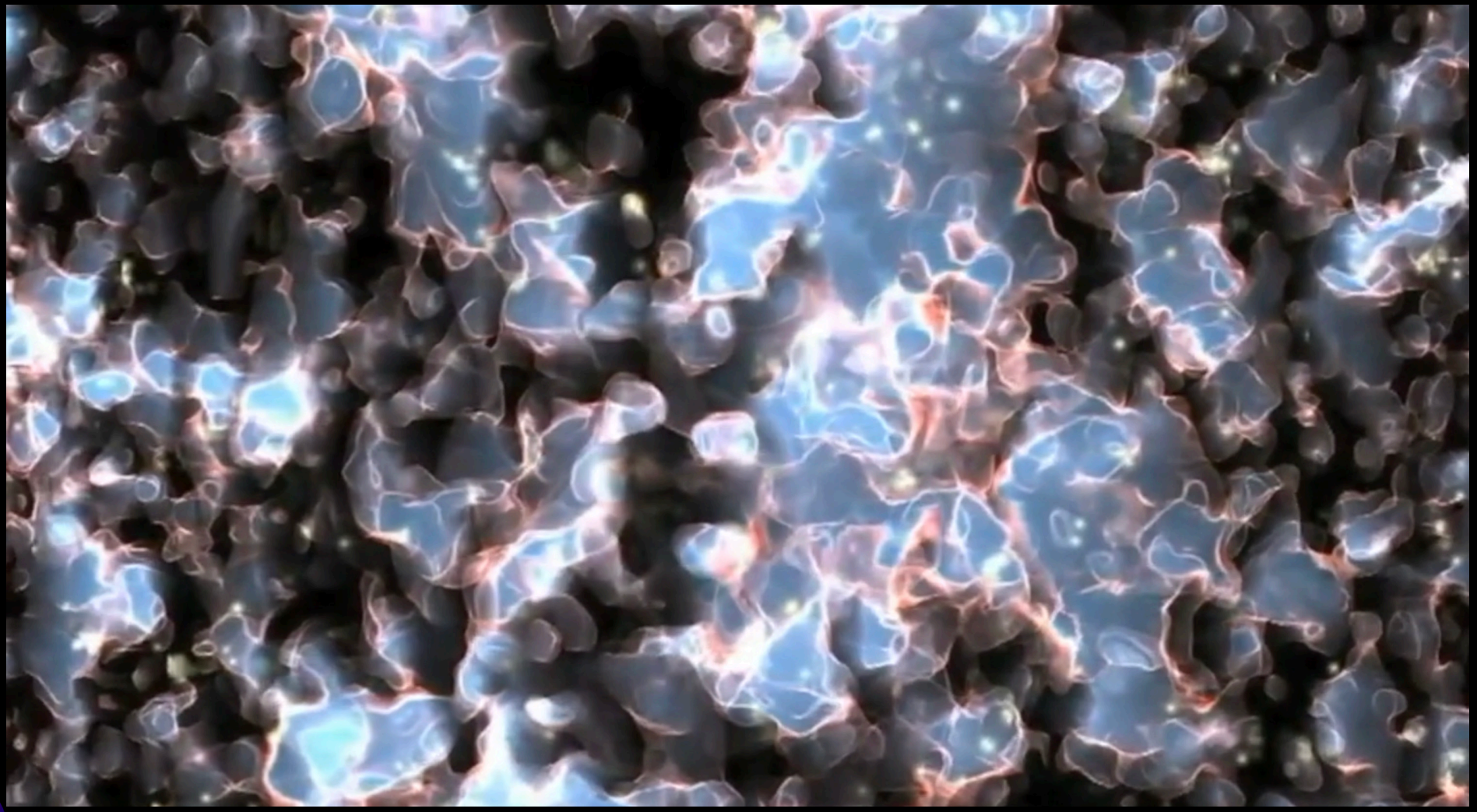
Adding up all the dishes and arrays, the total collecting area of the SKA will be towards 1 Square km.

Hubble Space Telescope ~ 4.2 square metres ……

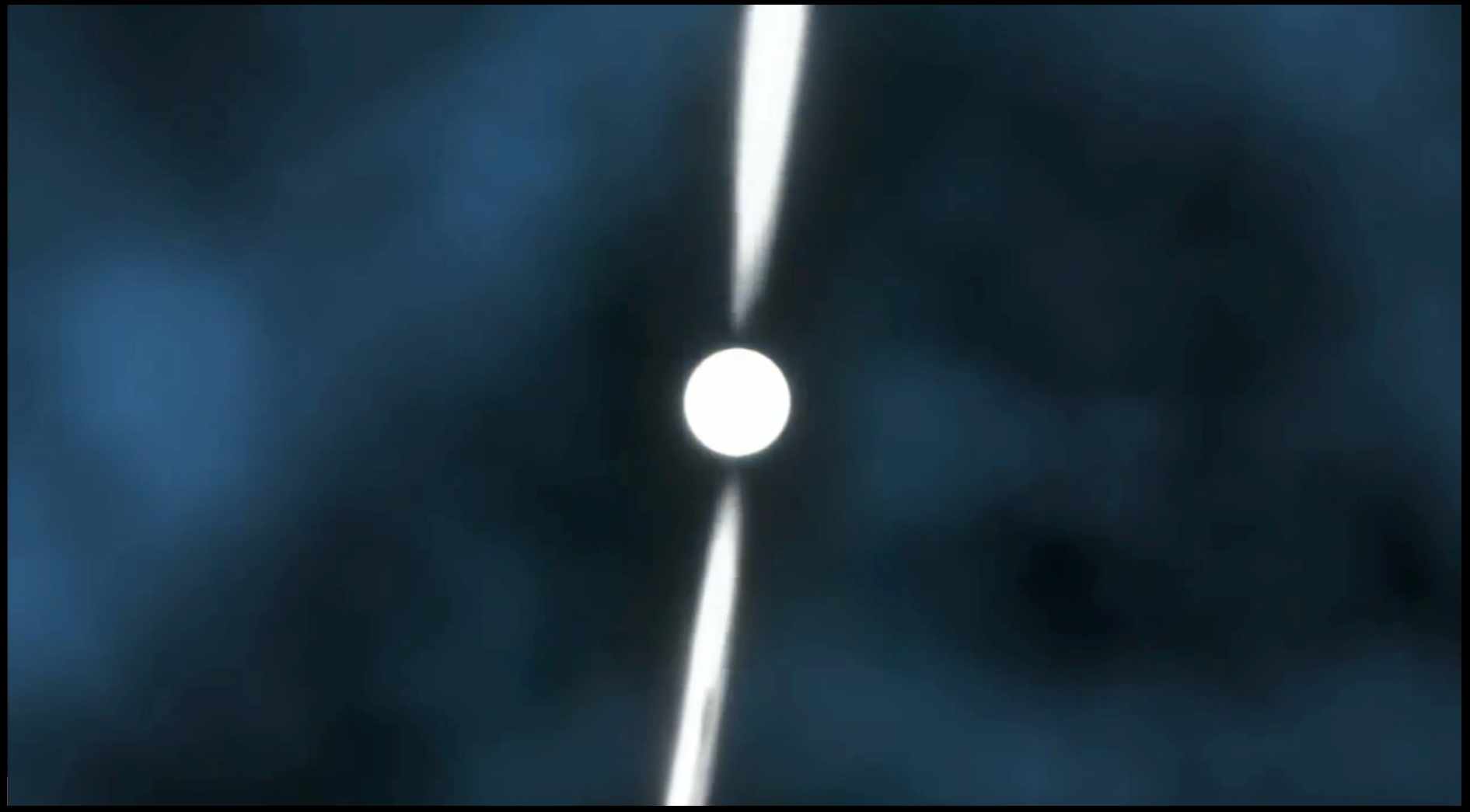
The SKA will be so sensitive that it will be able to detect an airport radar on an alien planet tens of light years away.

(that’s at least 60,000,000,000,000 miles away).

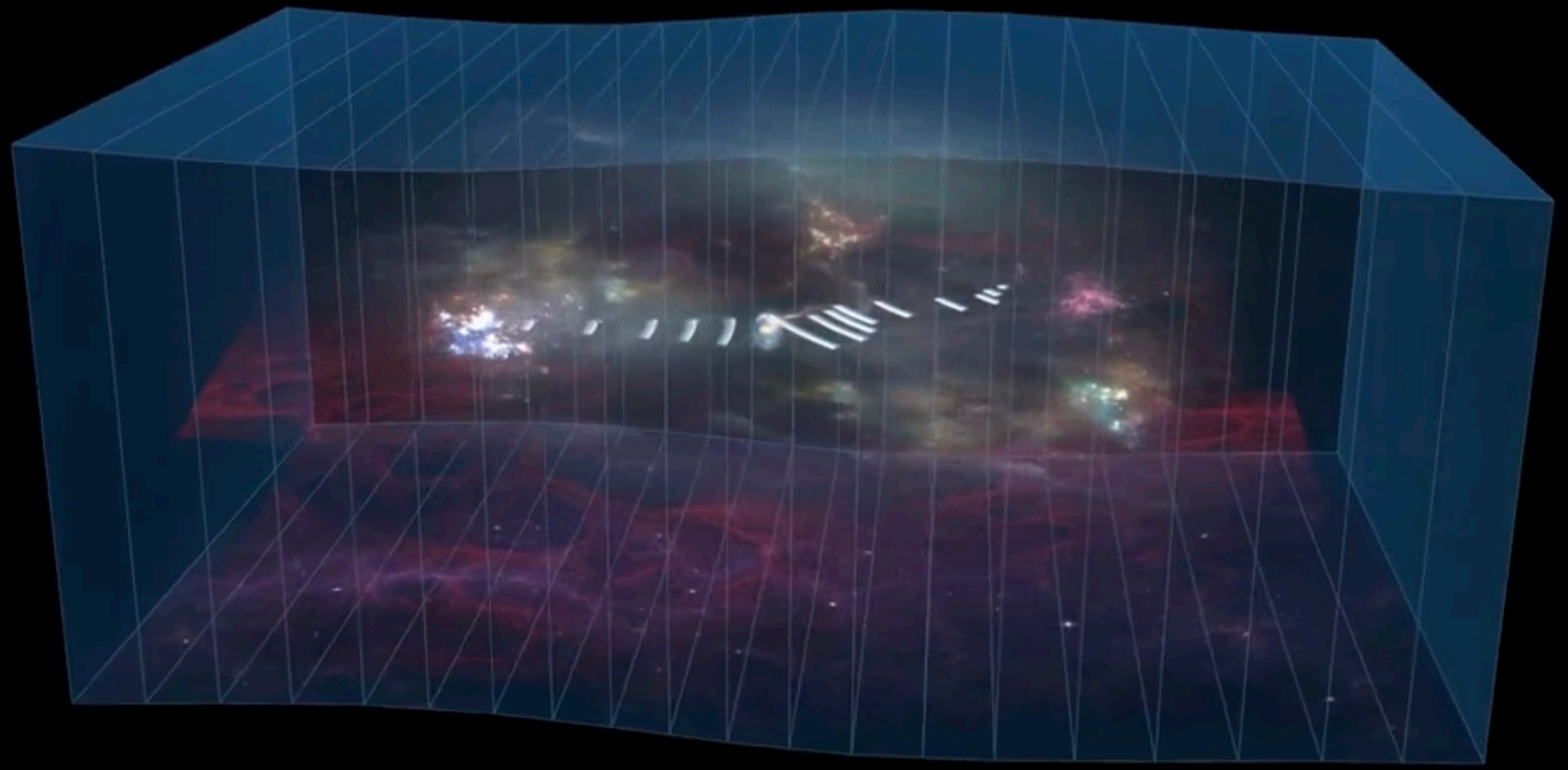
The Square Kilometre Array: Science



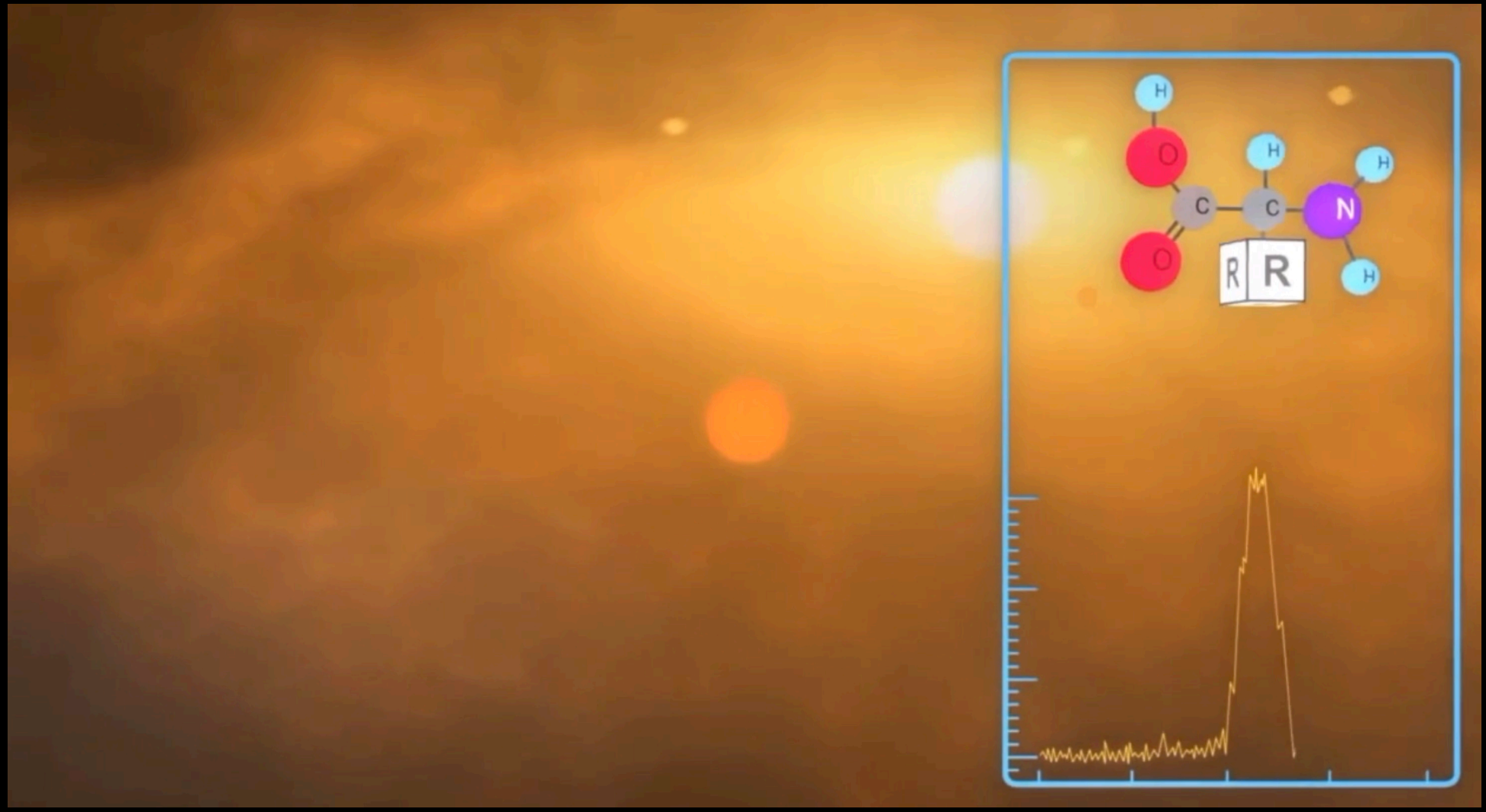
The Square Kilometre Array: Science



The Square Kilometre Array: Science

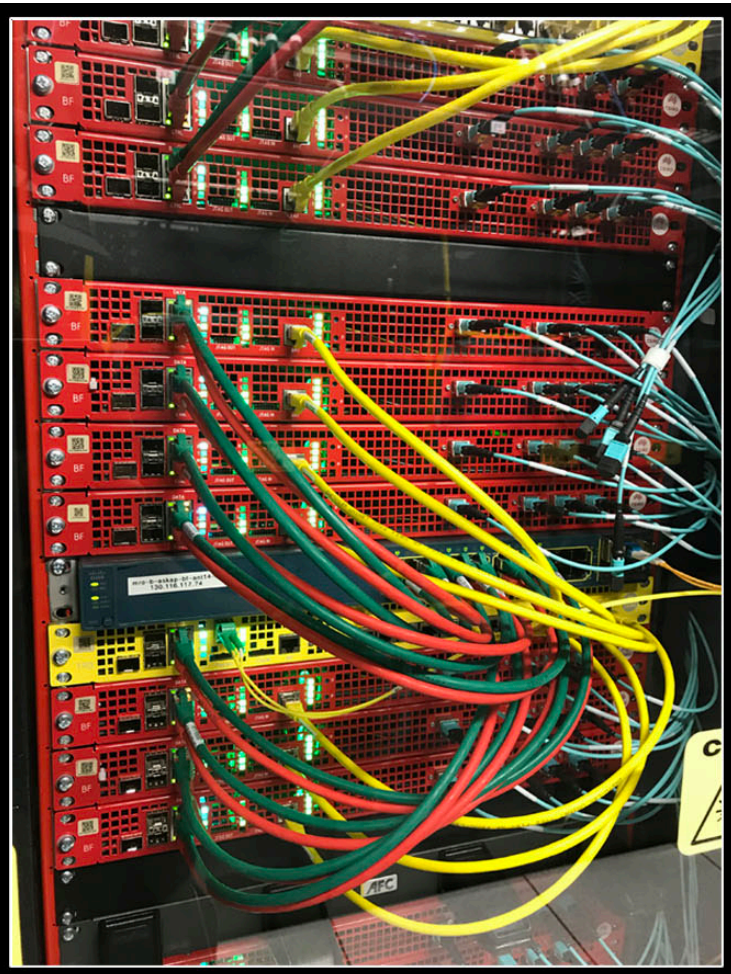


The Square Kilometre Array: Science



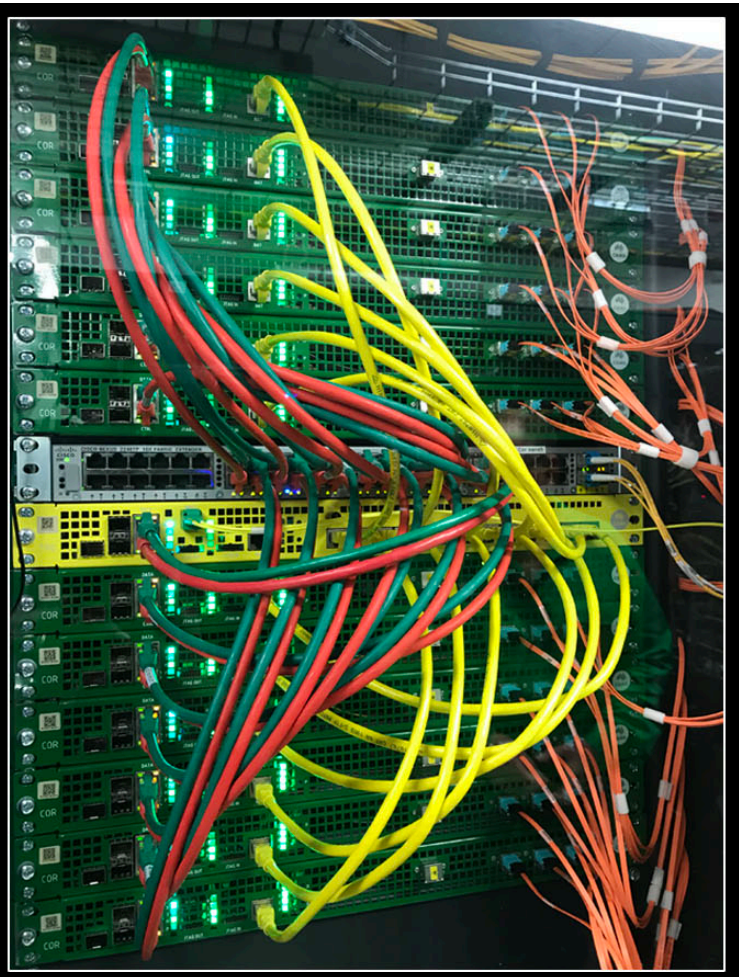

CAUTION


CAUTION



Beamforming

Digitization

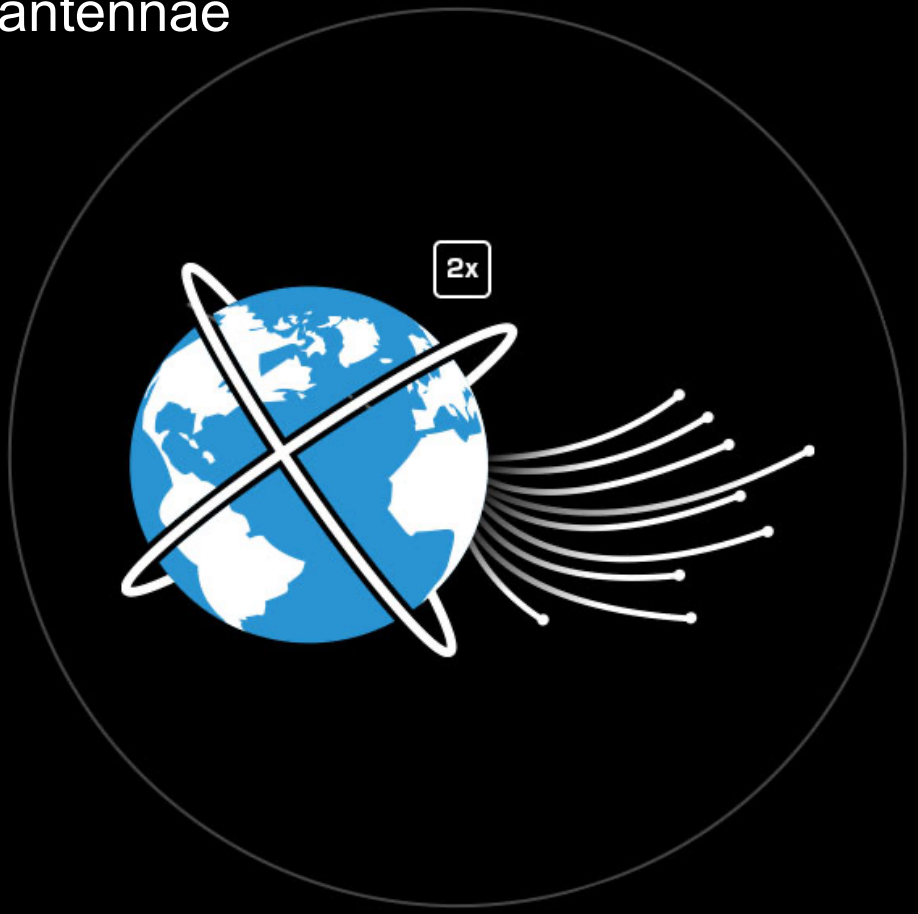


Correlation

Data Challenges: Timing

- Need to synchronise
  - 100’s radio dishes and more than 100,000 antennae
  - over 3000-5000km

- Needs a lot of optical fibre

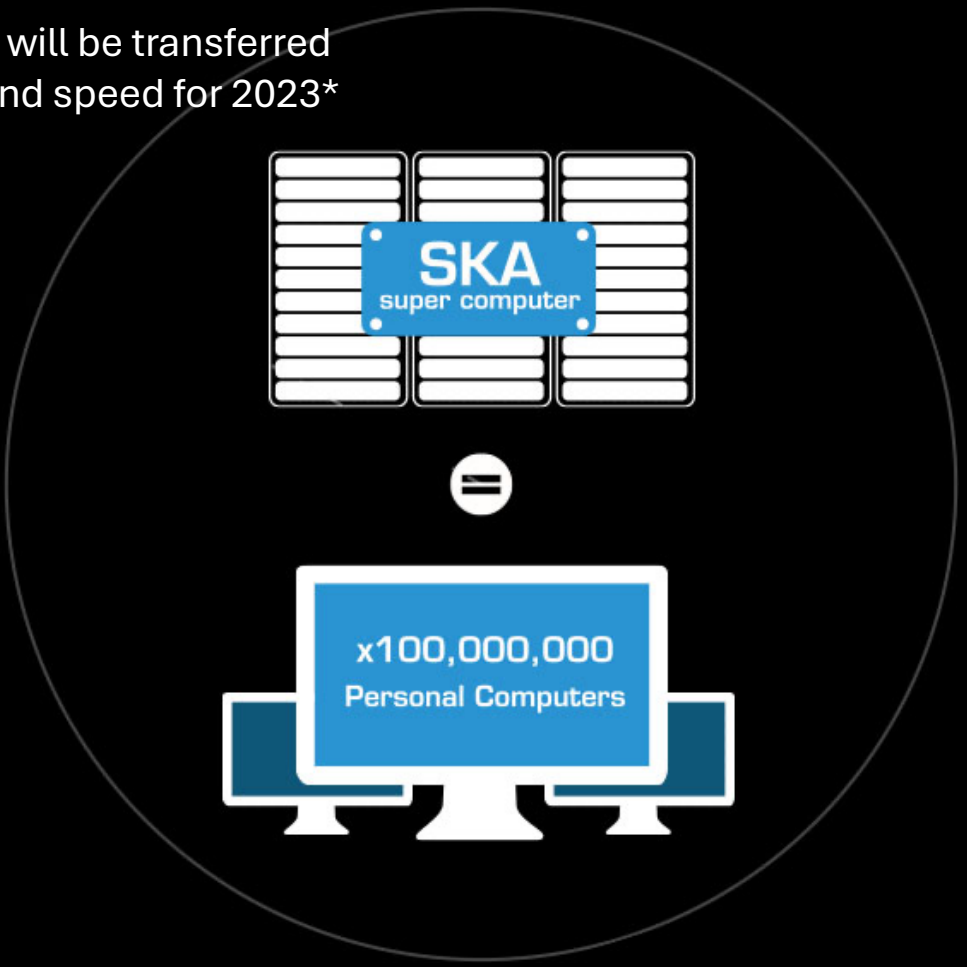


The SKA will use enough optical fibre to wrap twice around the Earth!
(that’s at least 80,000 km).

Data Challenges: Timing

- Need to move a lot of data
- Data flowing from the antennas to the on-site signal processor will be transferred 65,000 times faster than the projected global average broadband speed for 2023*
  -

- Needs a lot of computing power

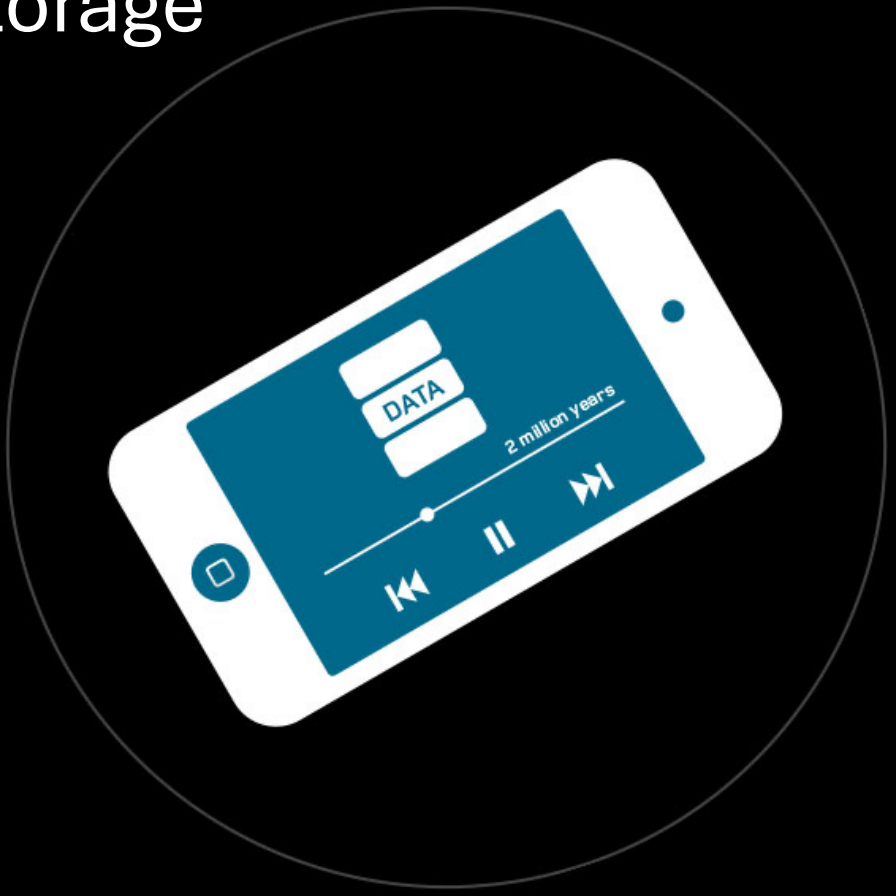


Processing 10 petabytes of data every hour
(10 million Gigabytes)

Data Challenges: Data Storage

Big Science needs ALOT of Data Storage

The data stored by the SKA telescopes in a single year would take nearly two million years to playback on your iPhone.

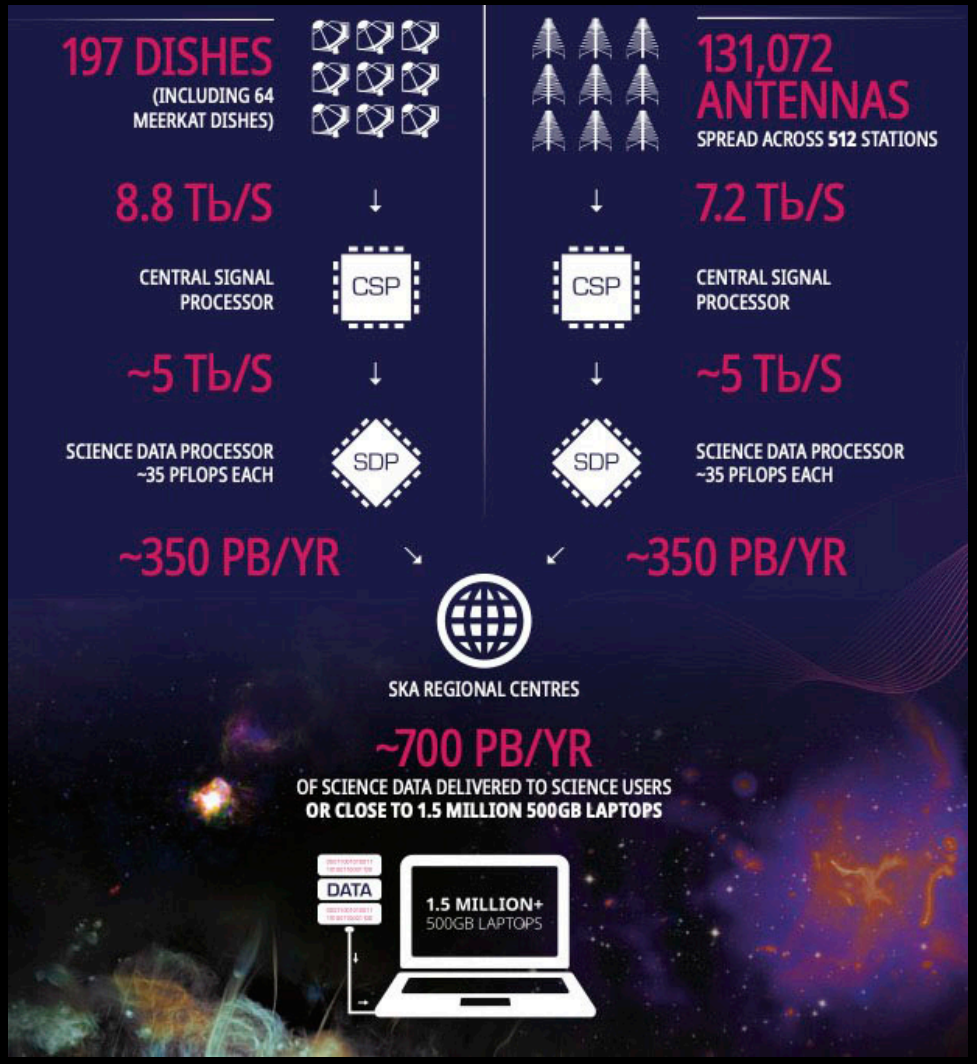


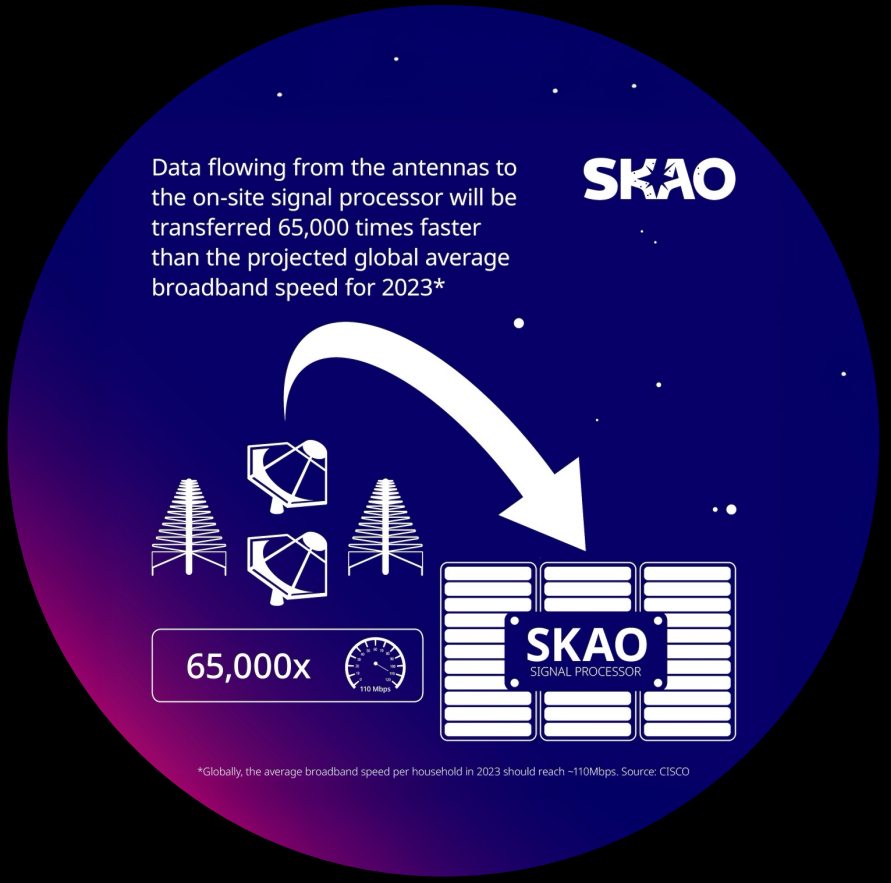
The raw data produced by the SKA telescopes in a single year .....

Data Challenges: Data Storage

170 million years

Data Challenges: Processing Scaling

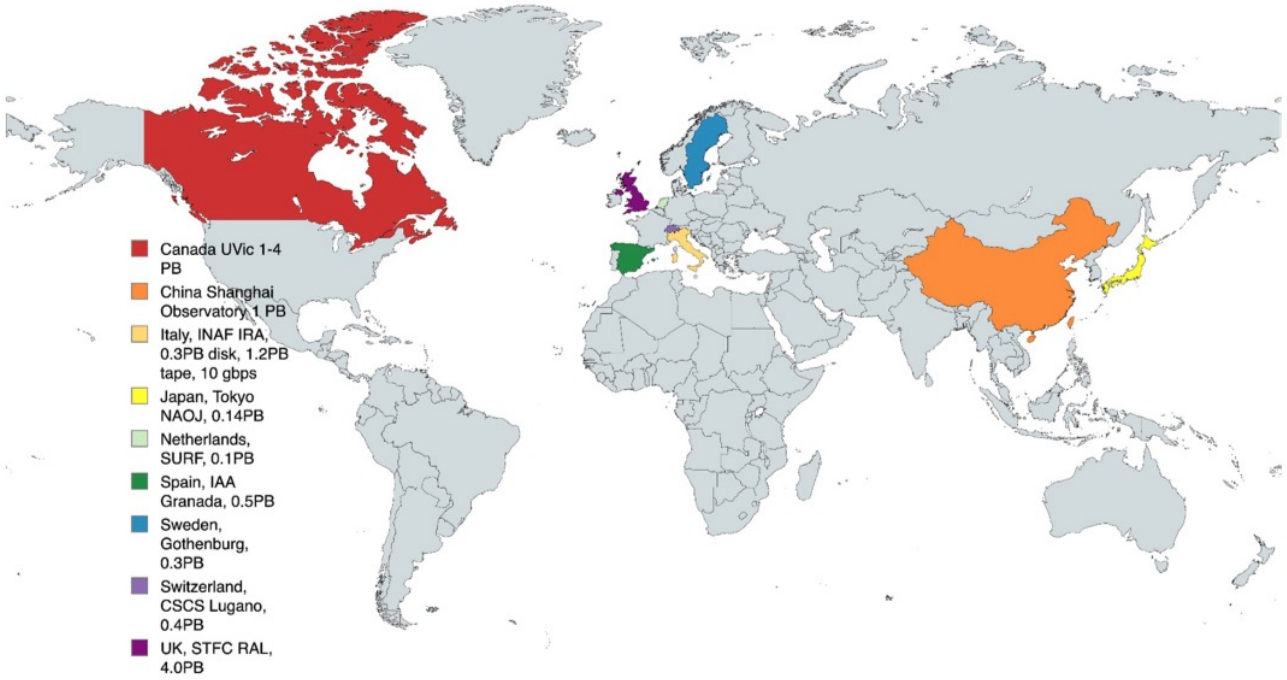


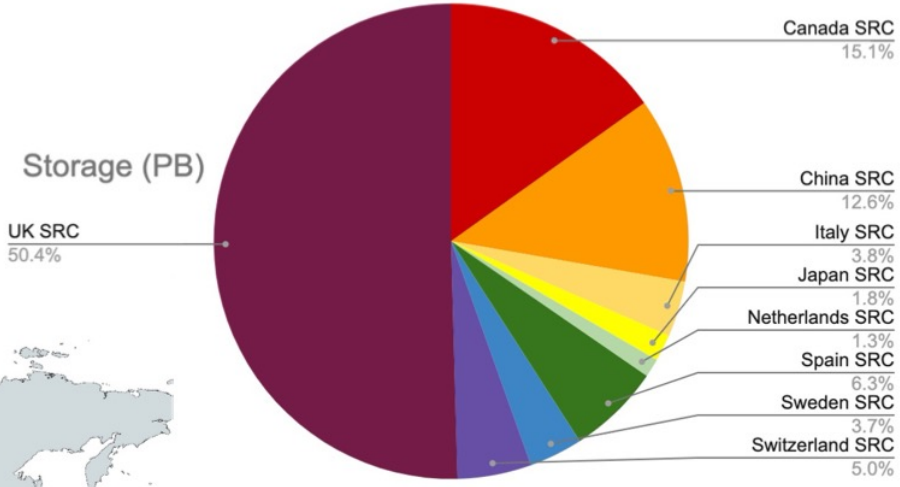


Need to compress, reduce the data.
Extract what we need and throw away the rest.

SKAO Data Storage

Science Regional Centre Network





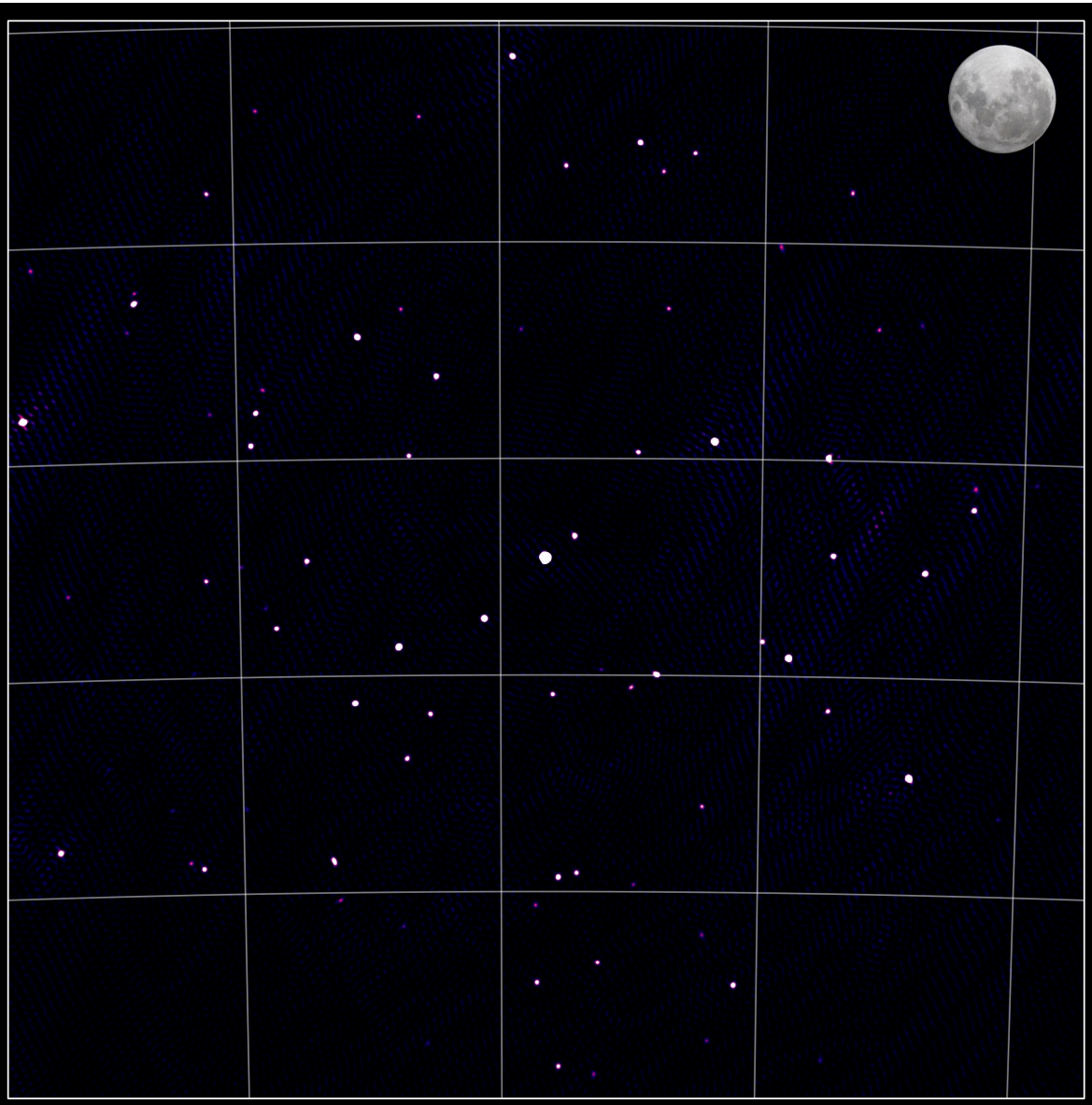
SRCNet0.1
8 PB Data Storage
(Goal 20 PB)


SKA-LOW
First Antenna
March 2024

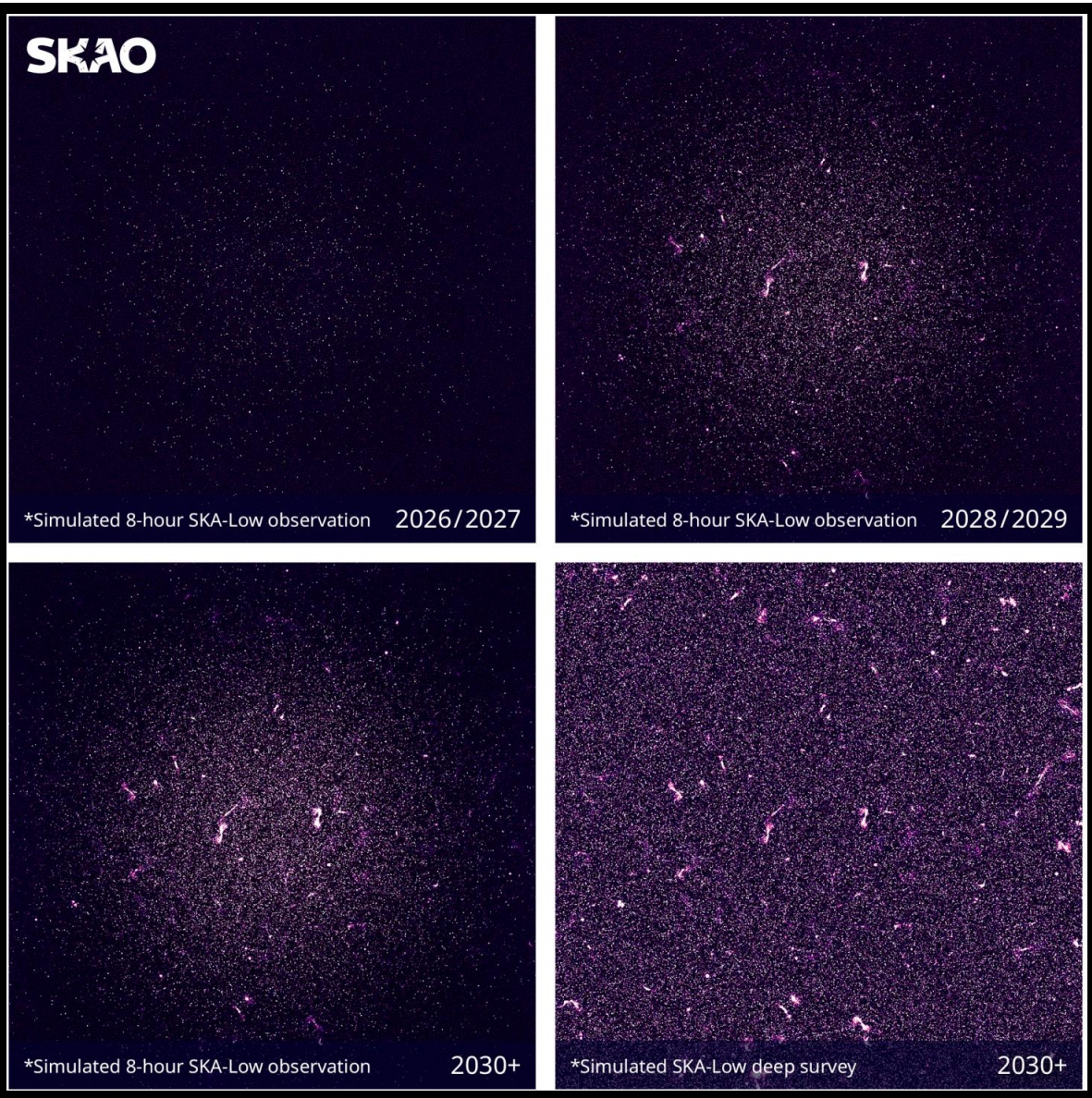
SKA-MID
First Dish

July 2024

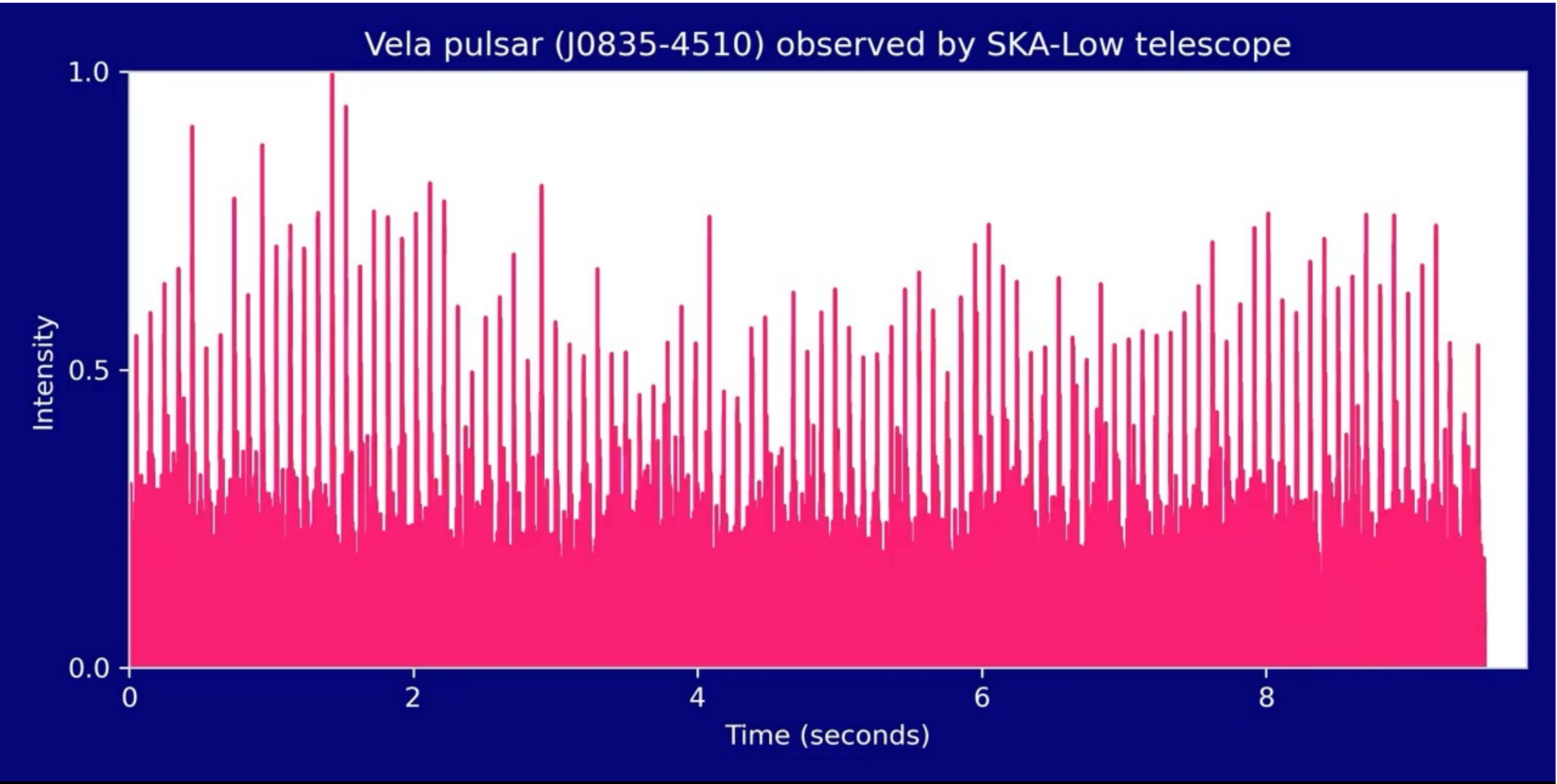
SKAO – First Image



SKAO – First Image

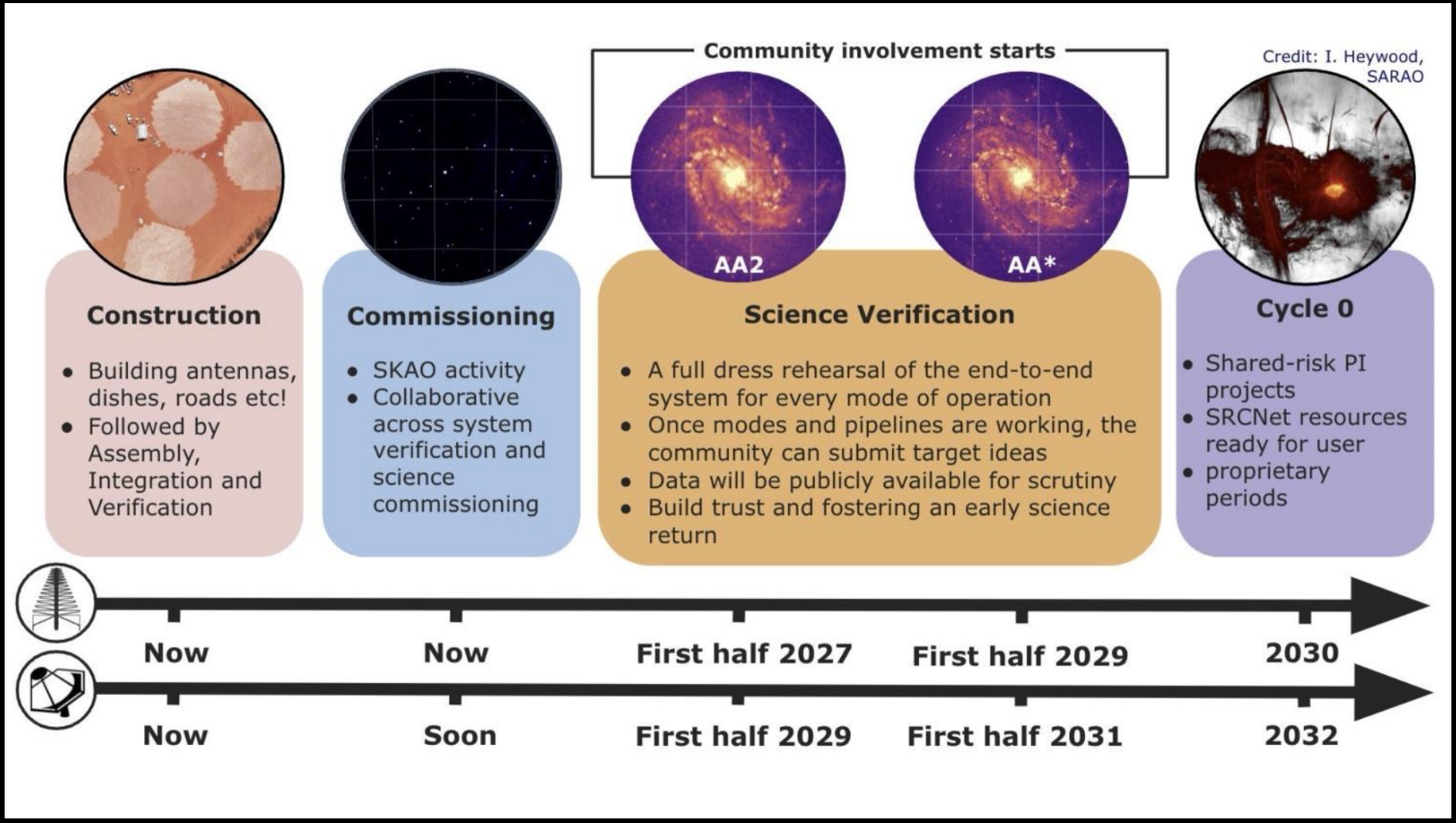


‘Cosmic Clocks’ preparing SKAO for early science


Vela pulsar (J0835-4510) observed by SKA-Low telescope
1.0
0.5
0.0
Intensity
0
2
4
6
8
Time (seconds)

SELECTED FOR THE ROYAL SOCIETY SUMMER SCIENCE EXHIBITION 2025

The Square Kilometre Array



The Square Kilometre Array

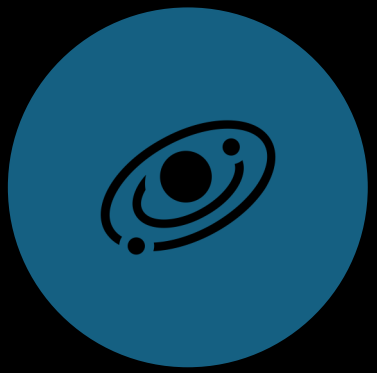
- The SKA will produce a leap forward in
  - Advanced engineering
  - high-performance computing
  - Big data structures
  - New manufacturing and construction techniques.

- Many of our everyday products come from inventions pioneered by BIG science research, including;
  - Wi-Fi technology
  - Digital cameras
  - Medical imagery devices.
  - The World Wide Web
  - HTML
  - GPS (Satnavs), would not work without Einstein's Theory of Relativity.

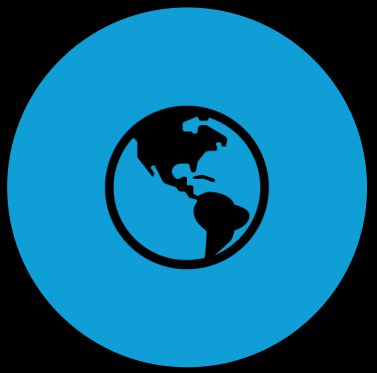
- The creation of new knowledge, young scientists and engineers with skills and expertise in a wide range of innovative fields in a large number of countries around the world.

The Square Kilometre Array

ONE OBSERVATORY



TWO TELESCOPES



THREE CONTINENTS

We recognise and acknowledge the Indigenous peoples and cultures that have traditionally lived on the lands on which our facilities are located