The SKA Project and Collaboration

Simon Berry: SKA Observatory

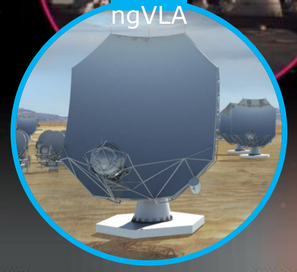
12th July 2023

21st Century Astronomy

SKA Mid & Low

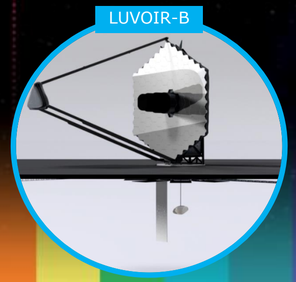
ALMA

ngVLA



ROMAN

LUVOIR-B



LUT

XRISM

CTA

RADIO | MICROWAVE | INFRARED | VISIBLE | ULTRAVIOLET | X-RAY | GAMMA RAY

SKA PRECURSORS & PATHFINDERS

JWST

ELTs

ASTROSAT-1 & -2

ATHENA

GRAVITATIONAL WAVES DETECTORS

LISA

LIGO

VIRGO

KAGRA

One Observatory, Two Telescopes, Three Sites

SKAO-HQ: Jodrell Bank, UK

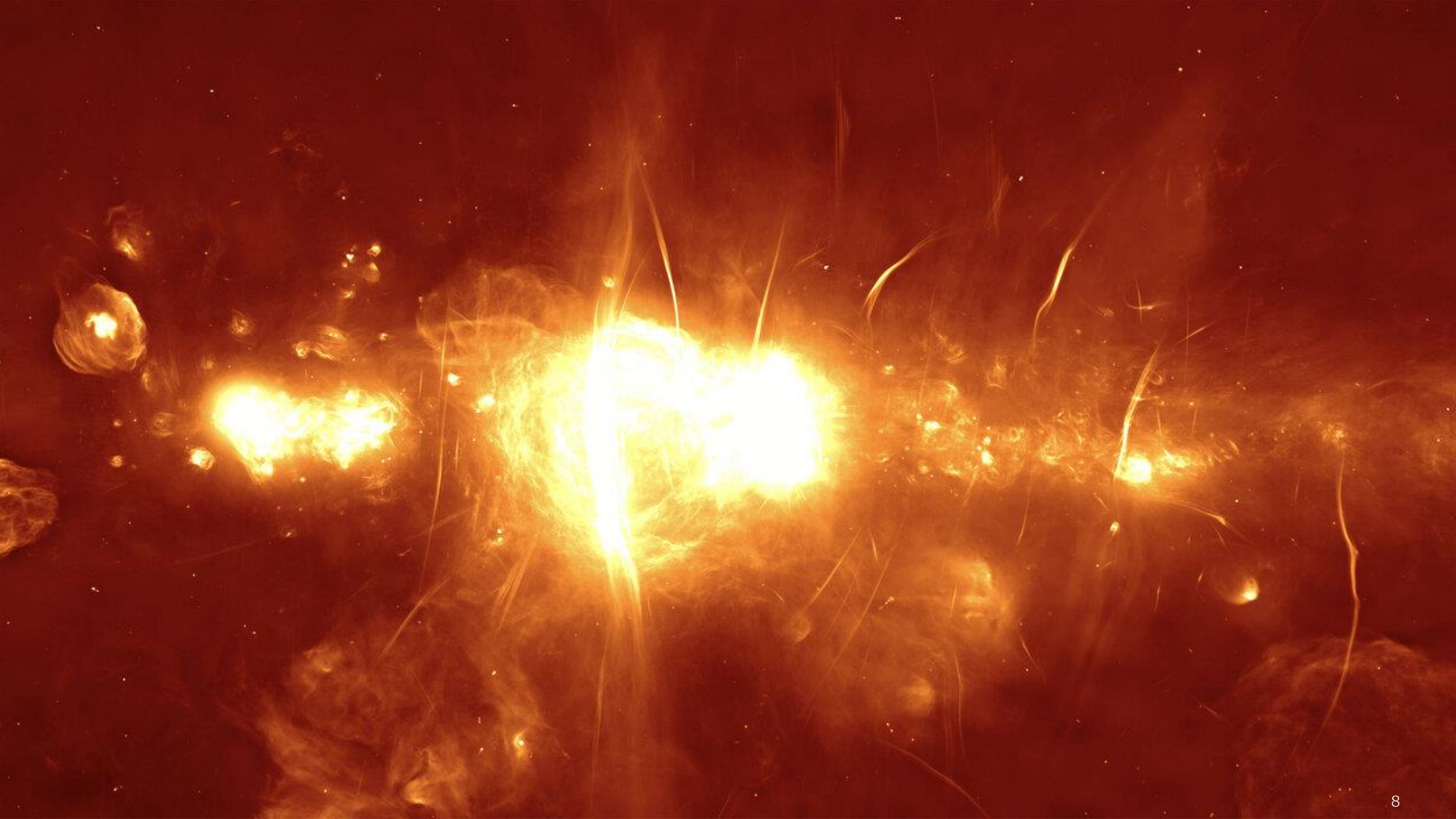
- SKAO total project cost: ~€2.1B
- Early science 2026/27;
- Operational in 2029/2030
- SKA Phase 2, ~10 times larger

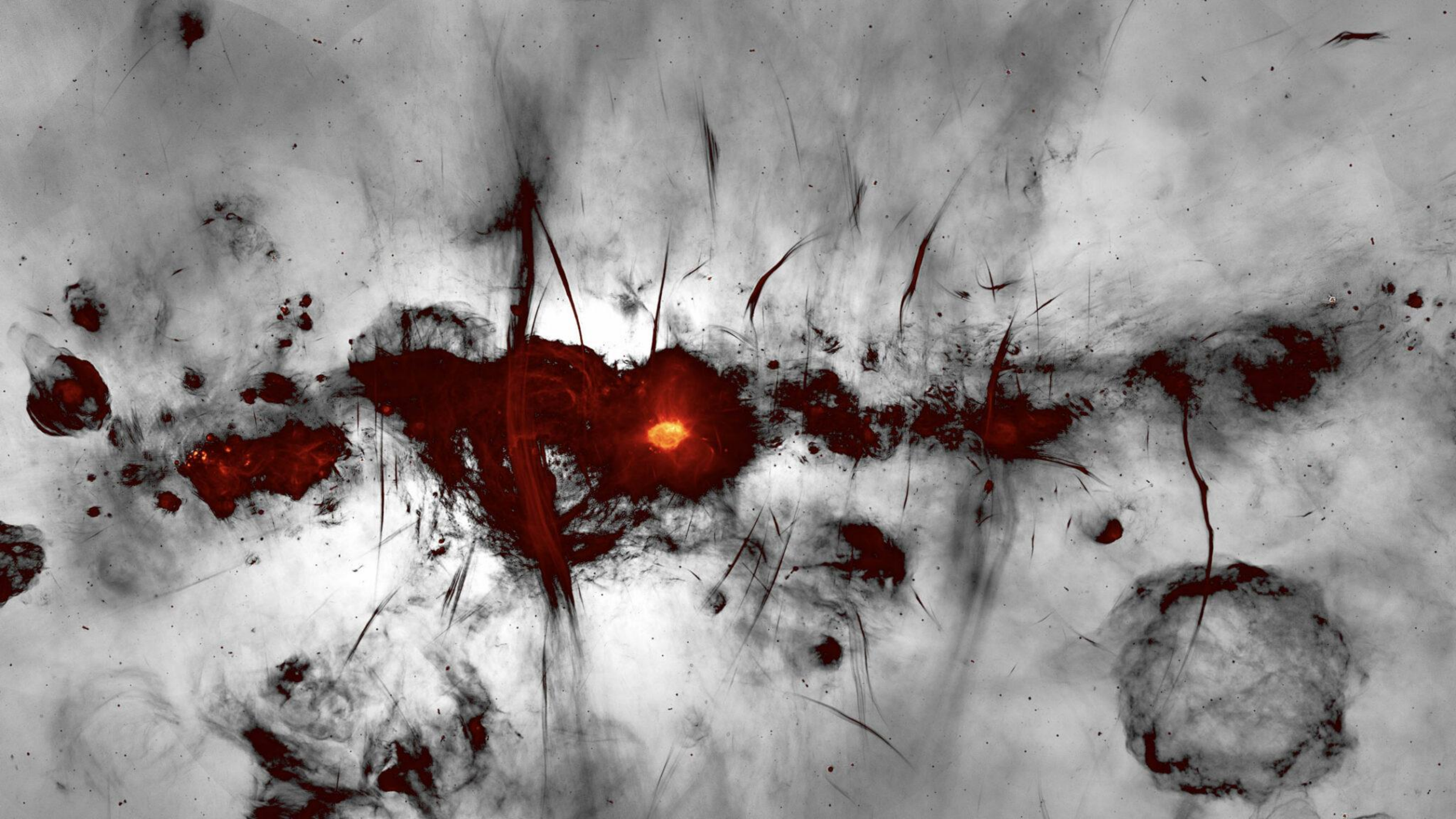
SKA Low: Australia

131,072 low-frequency antennas
(512 stations each with 256 dipoles)
50 – 350 MHz
65 km baselines (11” @ 110 MHz)

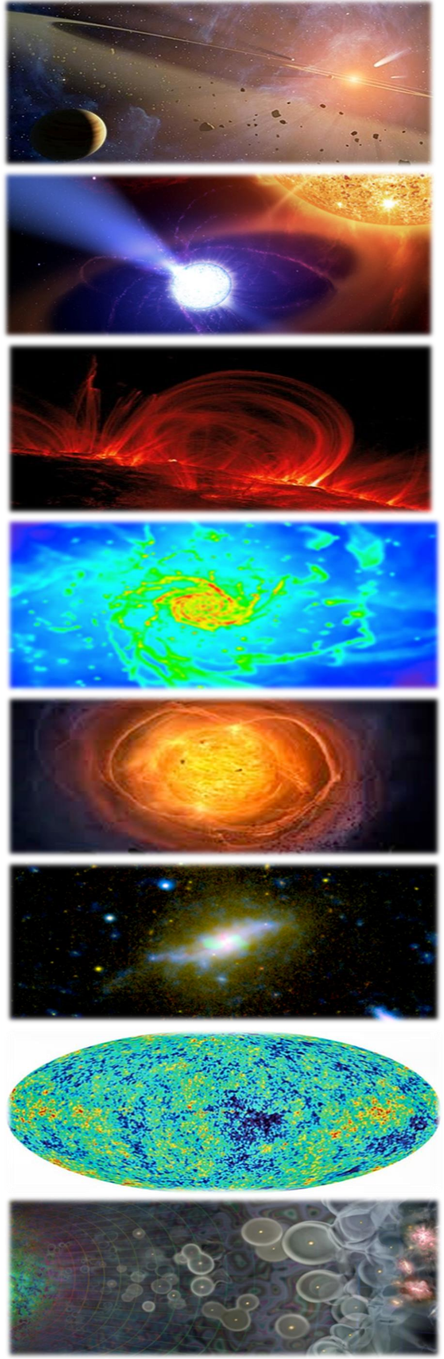
SKA Mid: South Africa

197 dishes (133 x 15m + 64 x 13.5m dishes)
0.35 – 15.4 GHz
150 km baselines (0.22” @ 1.7 GHz; 34 mas @ 15 GHz)

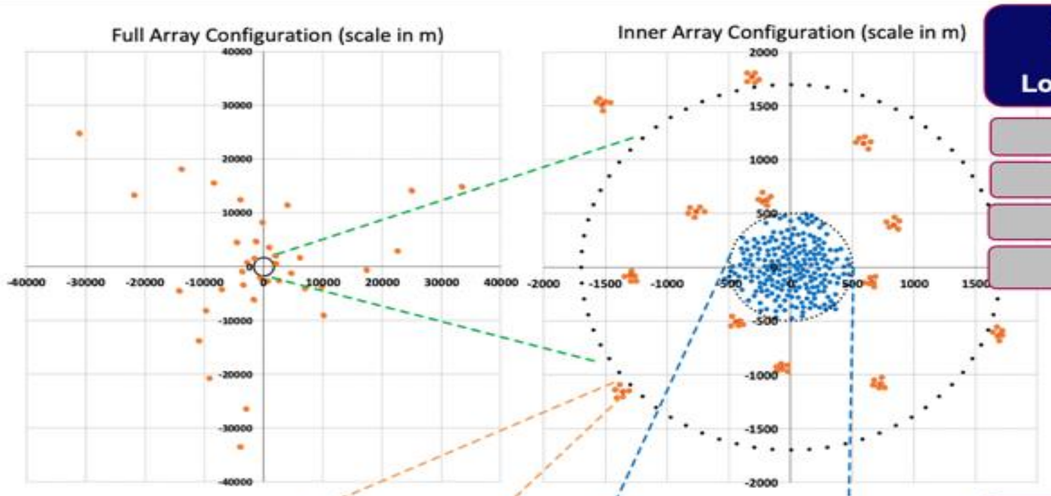




- **The Cradle of Life & Astrobiology**
  - *How do planets form? Are we alone?*
- **Strong-field Tests of Gravity with Pulsars and Black Holes**
  - *Was Einstein right with General Relativity?*
- **The Origin and Evolution of Cosmic Magnetism**
  - *What is the role of magnetism in galaxy evolution and the structure of the cosmic web?*
- **Galaxy Evolution probed by Neutral Hydrogen**
  - *How do normal galaxies form and grow?*
- **The Transient Radio Sky**
  - *What are Fast Radio Bursts and how can we best utilise them? What haven't we discovered?*
- **Galaxy Evolution probed in the Radio Continuum**
  - *What is the star-formation history of normal galaxies?*
- **Cosmology & Dark Energy**
  - *What is dark matter? What is the large-scale structure of the Universe?*
- **Cosmic Dawn and the Epoch of Reionization**
  - *How and when did the first stars and galaxies form?*



The Telescopes in one slide...



Cluster:
6 Stations

Optical Analogue
RF signals

256 antenna-
elements

Core:
224 Stations

Optical Analogue
RF signals

Digital Fibre

Central Processing
Facility

Core-Station
Beamformers

On-site

Correlator – Beamformer
(512 Stations)

Pulsar Processing

Long-haul Fibres

Science Data Processing and VLBI

Off-site

Global Distribution to Regional Science Centres

Low Infra PSC
Low Infra 1
Low Infra Materials

Low Infra 5

Low Infra 6

Low Infra 7

Low Infra 8

Low Antenna Assembly

Low Field Node Dep

Low Station M&I

Low FEM
Low PaSD
Low SPS
Low SAT
Low Freq Dis'n

Low Networks

Low Infra 3

Low CPF

Low CSP

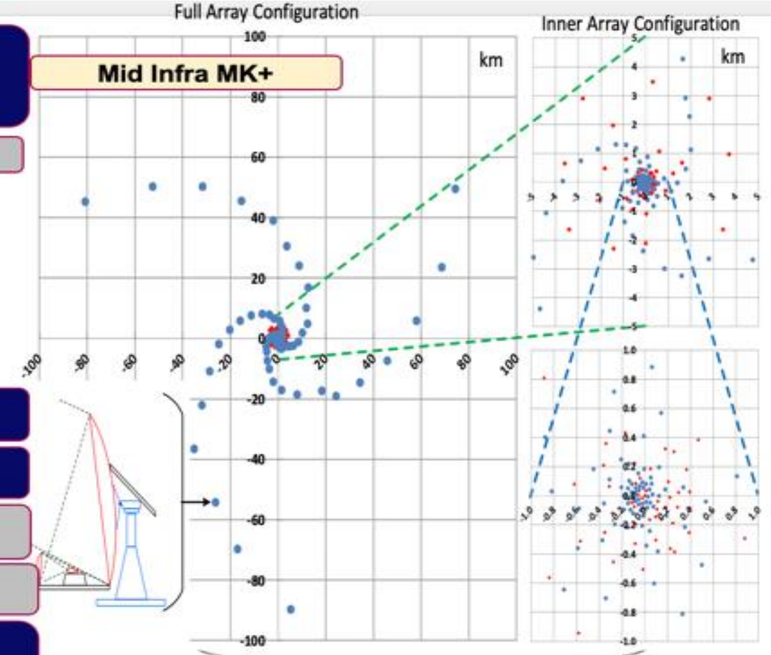
SDP
PSS, PST

Low SPC

AIV

Mid Infra PSC
Mid Infra 1
Mid Infra 4

Mid Infra 2



Mid Infra MK+

Mid Dish Structure

Mid Dish Indexer

Mid Band 1
Mid SPF Services

Mid Band 2
Mid SPF Rx123

Mid Band 5
Downcoverter

Mid Dish Element

Mid SAT

Mid Networks

Mid CPF

Mid CSP

SDP
PSS, PST

Mid SPC

Mid Band 2 (MK+)

Mid MK Integration

Optical Fibre:
Digitised RF Data

On-site

Correlator – Beamformer
(197 Dishes)

Pulsar Processing

Karoo Array Processing Building (KAPB)

Long-haul Fibres

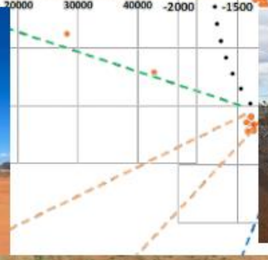
Science Data Processing and VLBI

Off-site

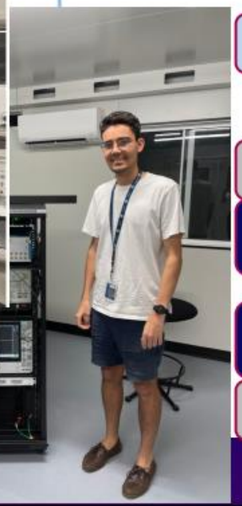
Global Distribution to Regional Science Centres





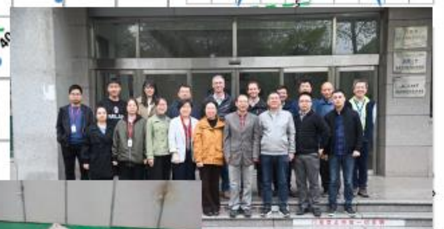




RF signals
Low Infra PSC
Low Infra 1
Low Infra Materials
Low Infra 3
Low Infra 5
Low Infra 6
Low Infra 7
Low Infra 8
Low Antenna Assembly
Low Field Node Dep
Low Station M&I
Low FEM
Low SPS
Low SAT
Low Freq Dis'n
Low PaSD
Low Networks
Low CPF
Low CBF, CSP
SDP
PSS, PST
Low SPC
AIV
Mid Infra PSC
Mid Infra 1
Mid Infra 4
Mid Infra 2
Mid Dish Structure
Mid Dish Indexer
Mid Band 1
Mid SPF Rx123
Mid Band 2
Mid SPF Services
Mid Band 5
Mid Cryo
Mid SPF Rx45
Downconverter
Mid SAT
Mid Dish Element
Mid Networks
Mid CPF
Mid CBF, CSP
SDP
PSS, PST
Mid SPC



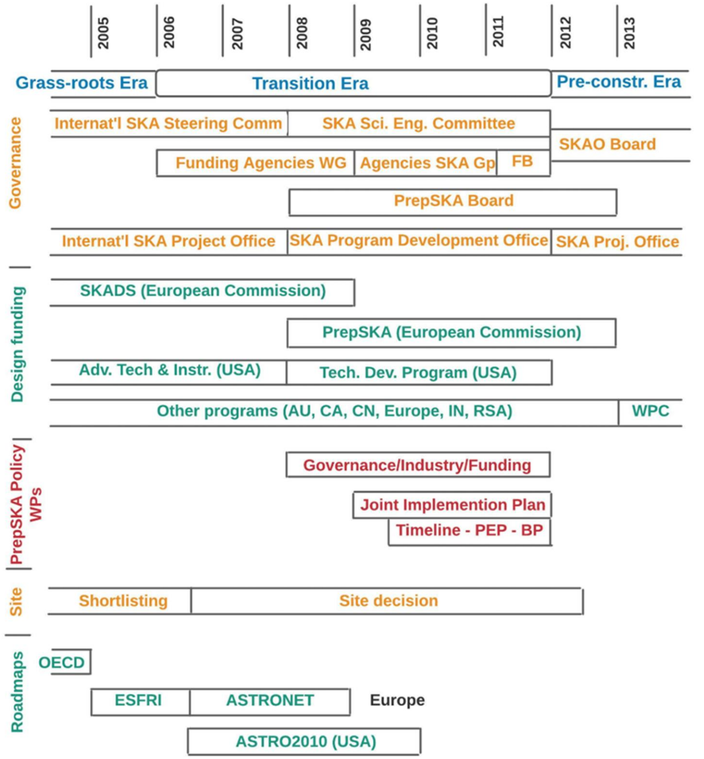

Mid MK Integration
Telescope Timesc
clocks)
Karoo Array Processing
Long-h

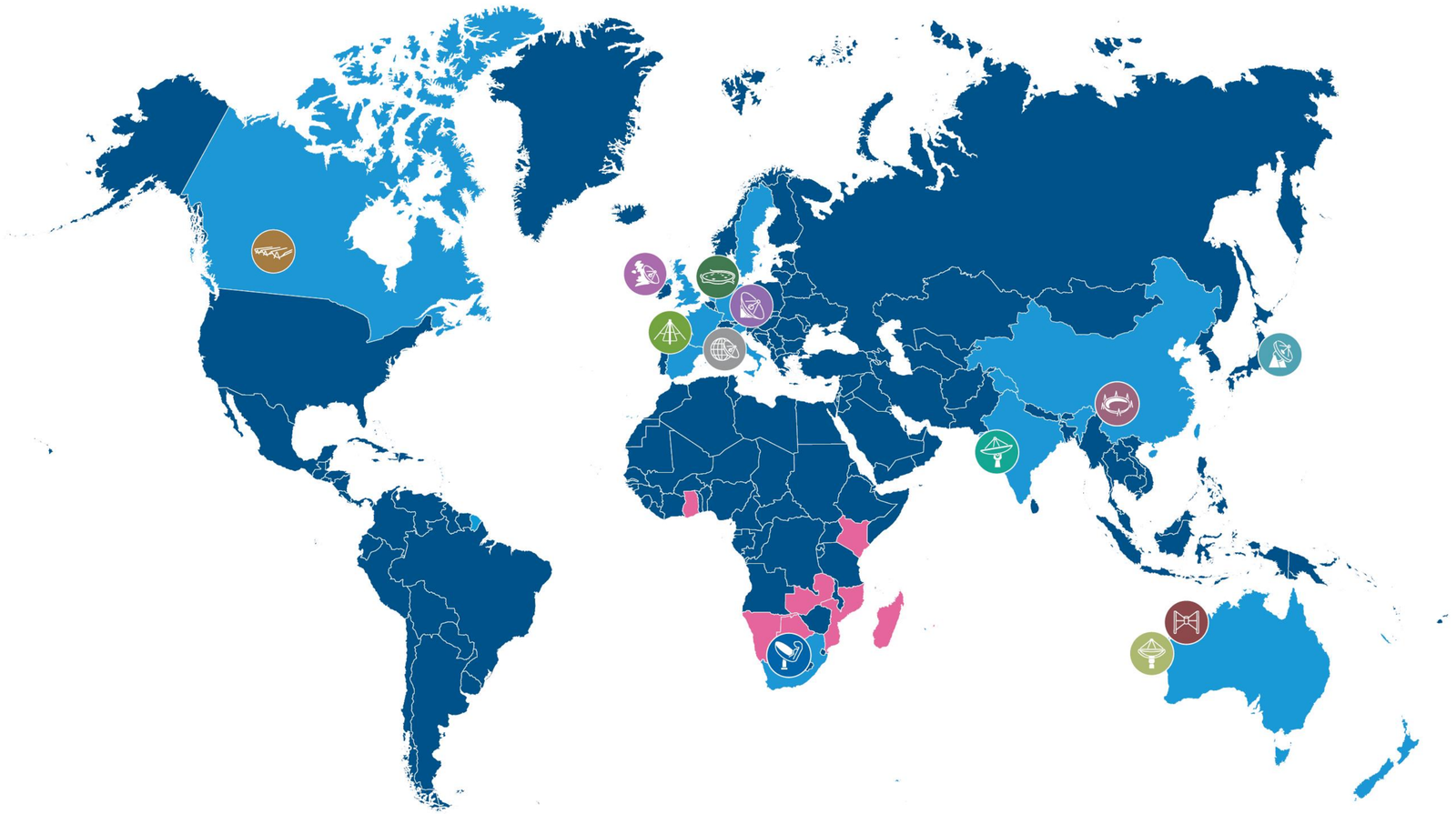




Building the SKA Observatory as an IGO

- SKA a 25-year journey… concept to construction
- Several distinct eras:
  - Community-led: early 90s-early 2000s
  - Agencies and governments get involved: mid 2000s
  - Agencies start to control – form first legal entity: late 2000s
  - Decision to establish a global organisation as IGO: 2015+
  - IGO in operation 2021+
- Several big decisions: Site selection… HQ site selection… Several rescoping exercises
  - Construction approval by SKAO Council in June 2021
- SKAO first science IGO since ITER (2015) – commitment of hosting countries as champions, critical





Canadian Hydrogen Intensity Mapping Experiment (CHIME) - Canada

NenuFAR - France

Low Frequency Array (LOFAR) - the Netherlands

Five-hundred-meter Aperture Spherical Telescope (FAST) - China

Giant Metrewave Radio Telescope (GMRT) - India

VLBI Exploration of Radio Astrometry (VERA) - Japan

European VLBI Network (EVN) - Europe

enhanced Multi Element Remotely Linked Interferometer Network (e-MERLIN) - United Kingdom

MeerKAT Radio Telescope - South Africa

Australian SKA Pathfinder (ASKAP) - Australia

Murchison Widefield Array (MWA) - Australia

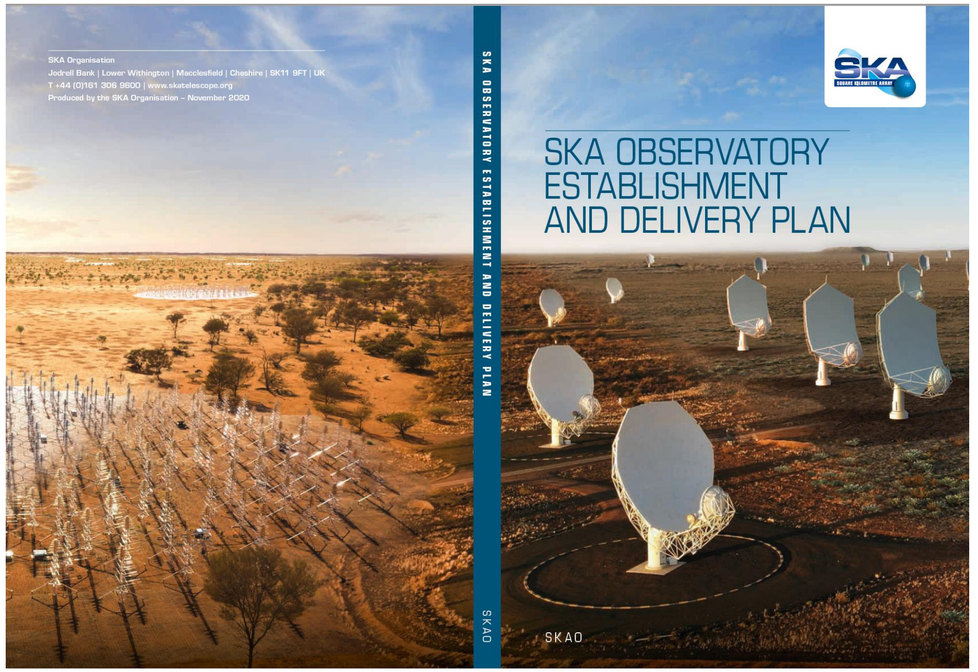
Effelsberg 100m Radio Telescope - Germany

Members of the SKA Organisation
Host Countries: Australia, South Africa, United Kingdom

African Partner Countries

Maintaining a sustainable Business Case for investment

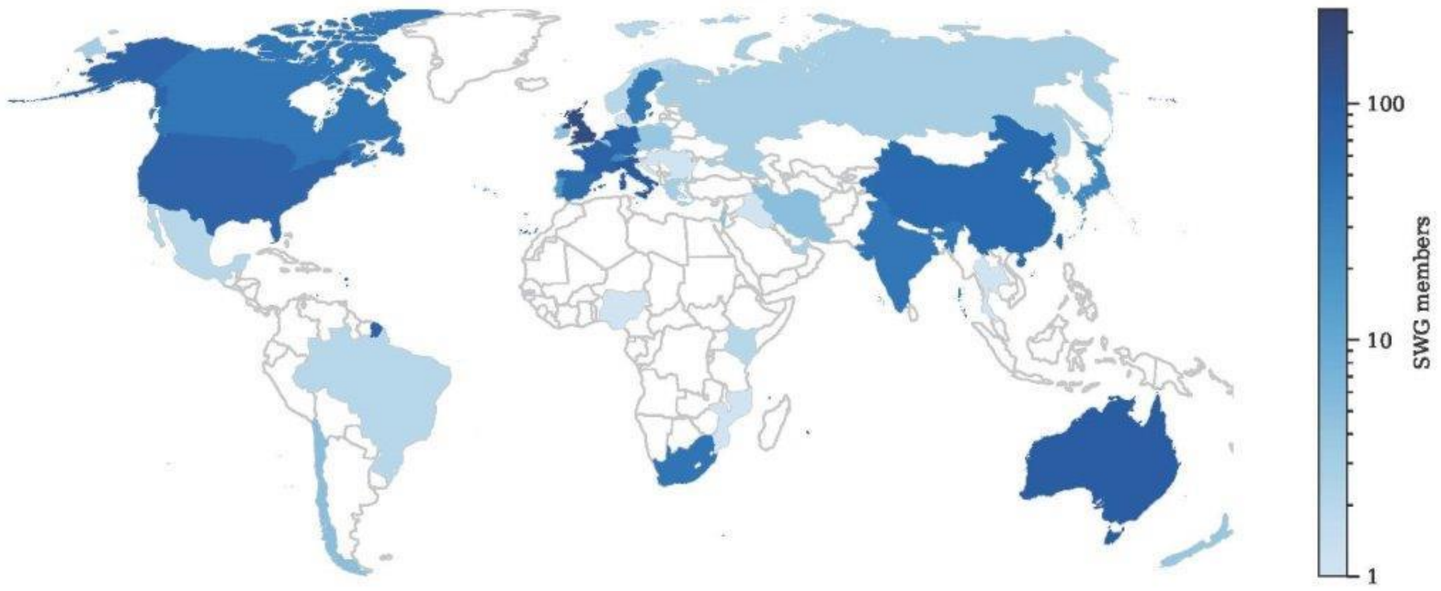
- Underpinning case: Science excellence
- Direct and indirect return on investment
- Innovation and technology transfer
- Human capital development and direct societal impacts
- Inclusion and a sustainable approach to hosting communities
- Broader global impact through open science
- International influence and science diplomacy



Industrial participation

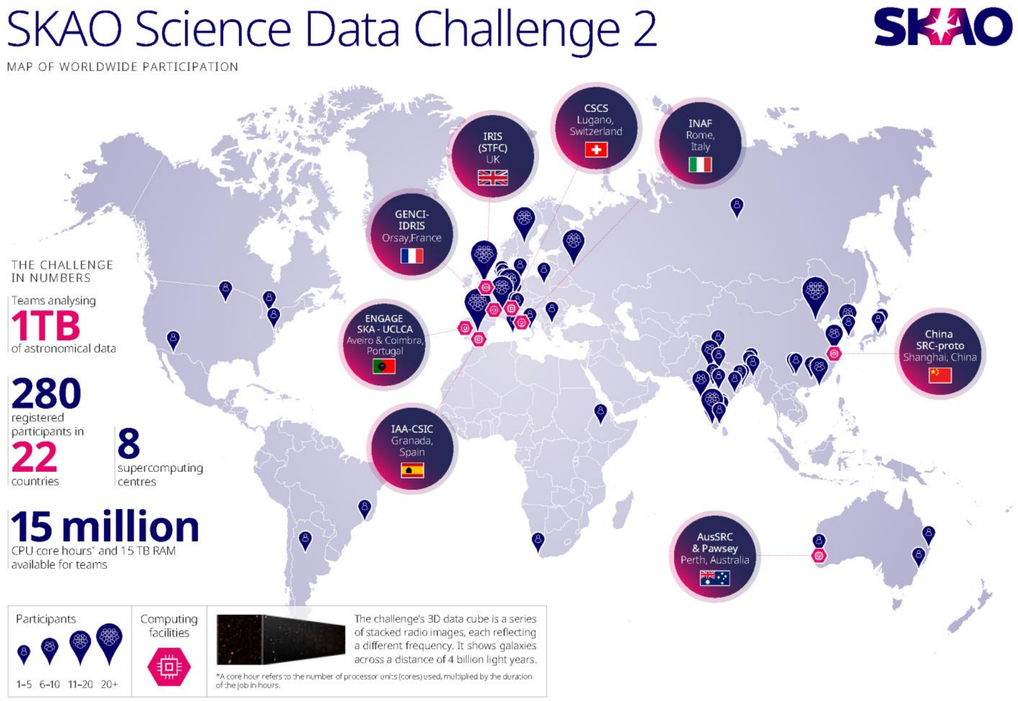
- SKAO's policies based on 'Fair Work Return'
  - Guarantees minimum % return on contribution through industrial participation
  - Enabled through cash procurements and in-kind contributions by Members – competition as far as possible
  - Early 'allocation' process to set starting guarantees for Members
    - Time will tell us whether our policies were right….
  - Some additional considerations for hosts – recognising special status
- IPR policy
  - Protection for background IPR made available to SKAO, general access to all Members for foreground IPR generated in SKAO

Building the science user community globally

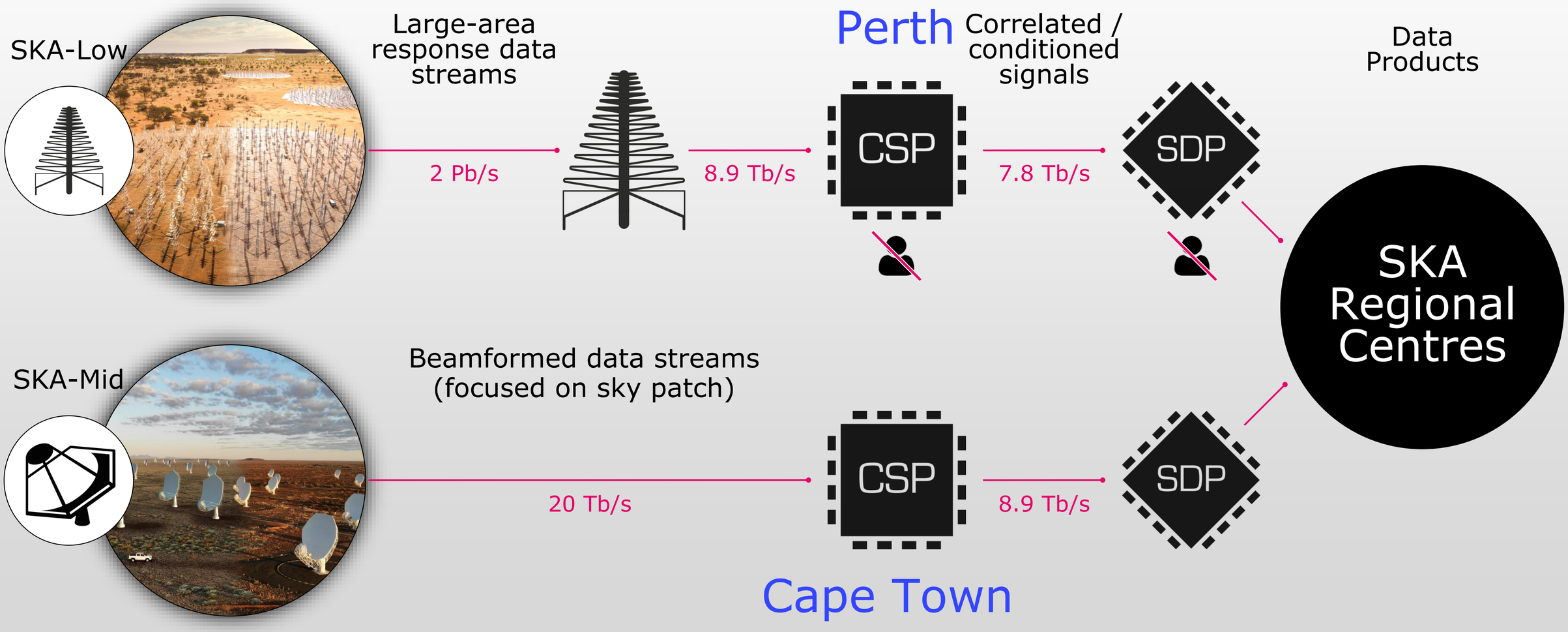


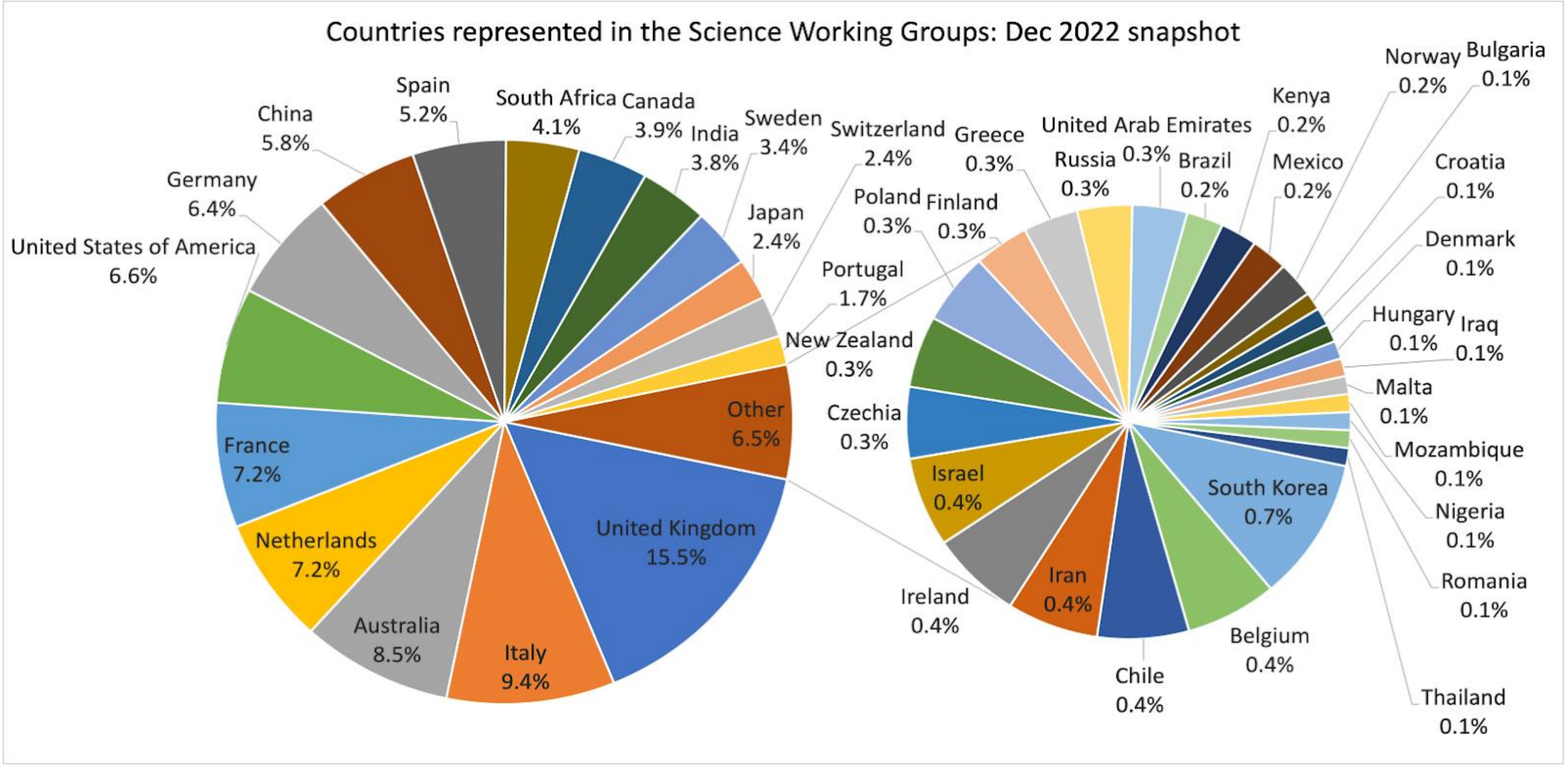
- Global SKA Science Working Group community
  - SKAO Members and beyond
  - Organised around science themes

- Preparing for the specific SKAO Big Data challenge
  - Global collaborations in computing and software
  - Training for SKA science and developing capability for SKA science



SKA Regional Centres: SKAO data processing stages





- Looking at opportunities to expand the SKAO Membership
- Examining the global radio astronomy community – where the potential is… SWG's a useful proxy for community

Sustainability and power

- Sustainability audit underway – examining all areas
  - Main drivers: telescope operations, computing facilities (facilities and regional centres) travel and astronomer activity
  - Pressure from several directions – design of SKA was set to strict power budgets from outset
- SKAO's sites have unique challenges:
  - AUS: Remoteness; SA: Infrastructure reliability
- Plans now:
  - Australia: PV power
  - South Africa: PV/diesel/battery
- In Australia, the Murchison Radio-astronomy Observatory already hosts a hybrid 2 MW solar power station
  - Supplemented by a 2.5 MWh battery system, which supplies around 60% of the Australian SKA Pathfinder telescope's power needs.

Challenges and lessons (being) learned

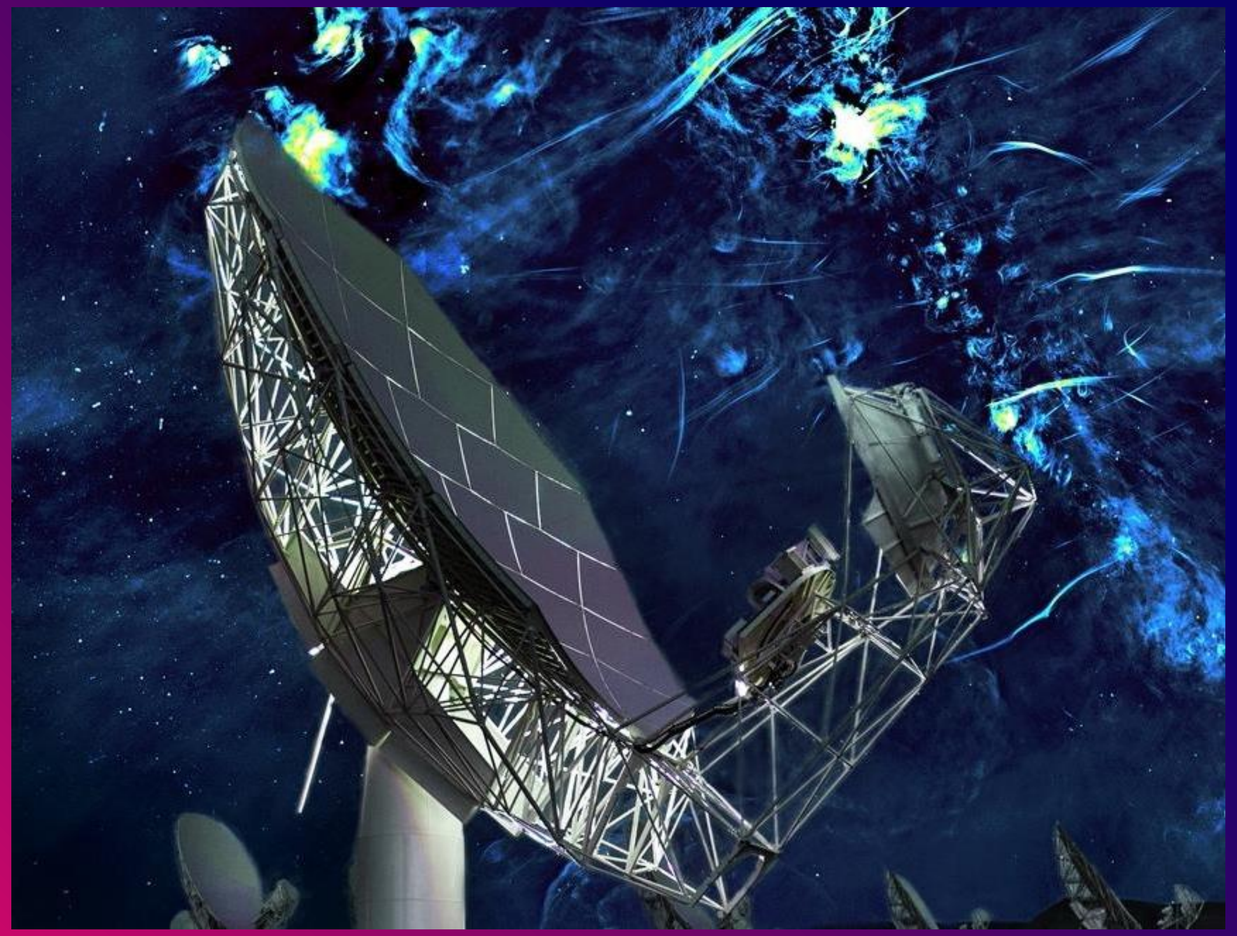
- Establishing an IGO was a deliberate decision reflecting the global nature of SKA – but don’t underestimate how difficult it is
  - Making the IGO operational and functional across the globe is as difficult as setting it up….
- Once done, being an IGO (even a small one) is different: political support, convening power, perhaps more opportunities for organisational sustainability
- Huge financial challenges now from global situation – but offering a scalable project makes it more palatable for funders
  - SKA’s science underpins everything – we preserve it at all costs in our project choices
  - But now need a coherent data and regional science network – challenging already…
- Diversity and inclusivity (in the organisation) is an advantage but hard to get right – needs constant effort; we are determined to ensure benefit for the Members and society, and demonstrate why our infrastructure matters
  - Host country relationships critical: local participation and engagement

Up to **150** **high-income** qualified staff from **around the world**

SKA HQ staff are expected to contribute an estimated **£6.2million per year** to the local economy

Around **£500,000** **per year** is currently spent on local businesses

SKA HQ staff are expected to invest an estimated **£6m** in the local property market



SKAO

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

www.skao.int