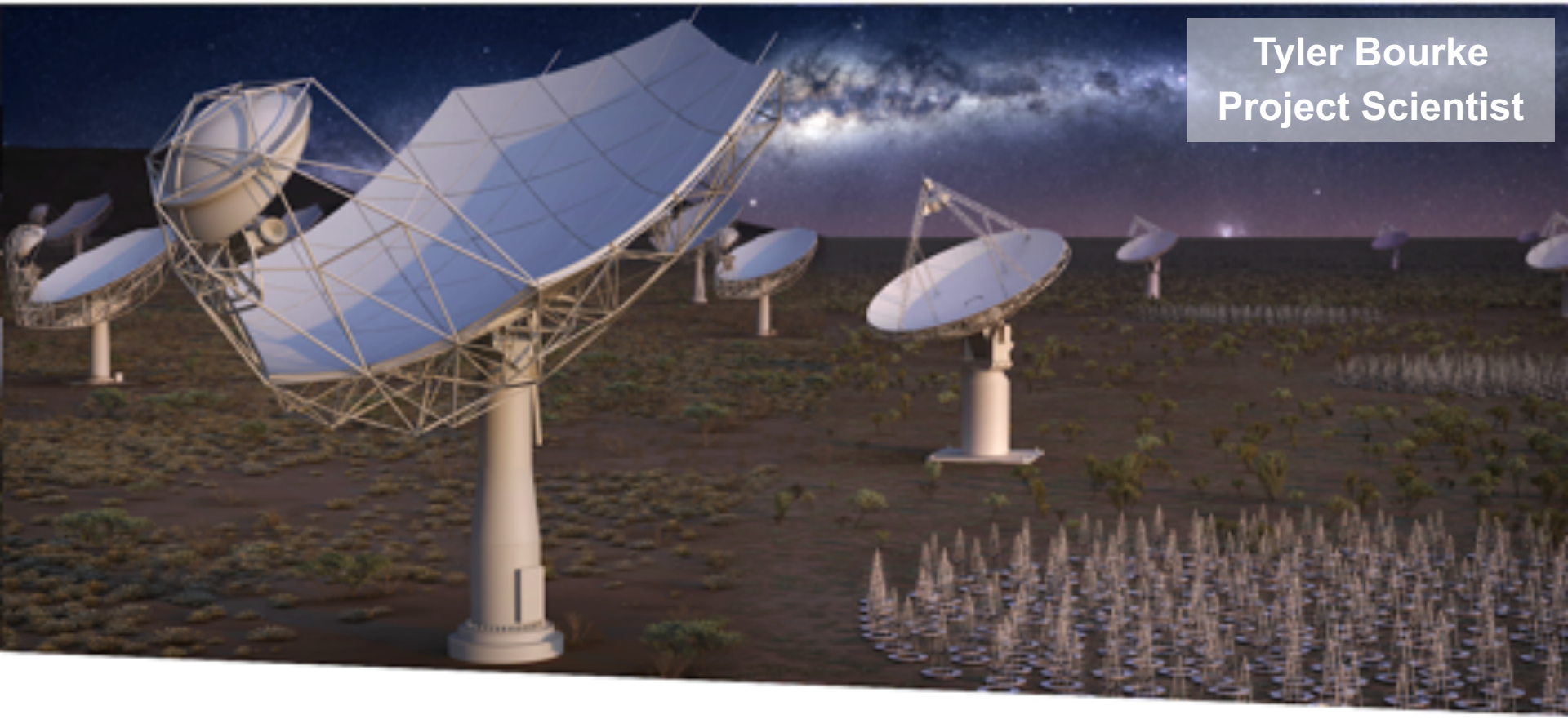
SKA Science Planning

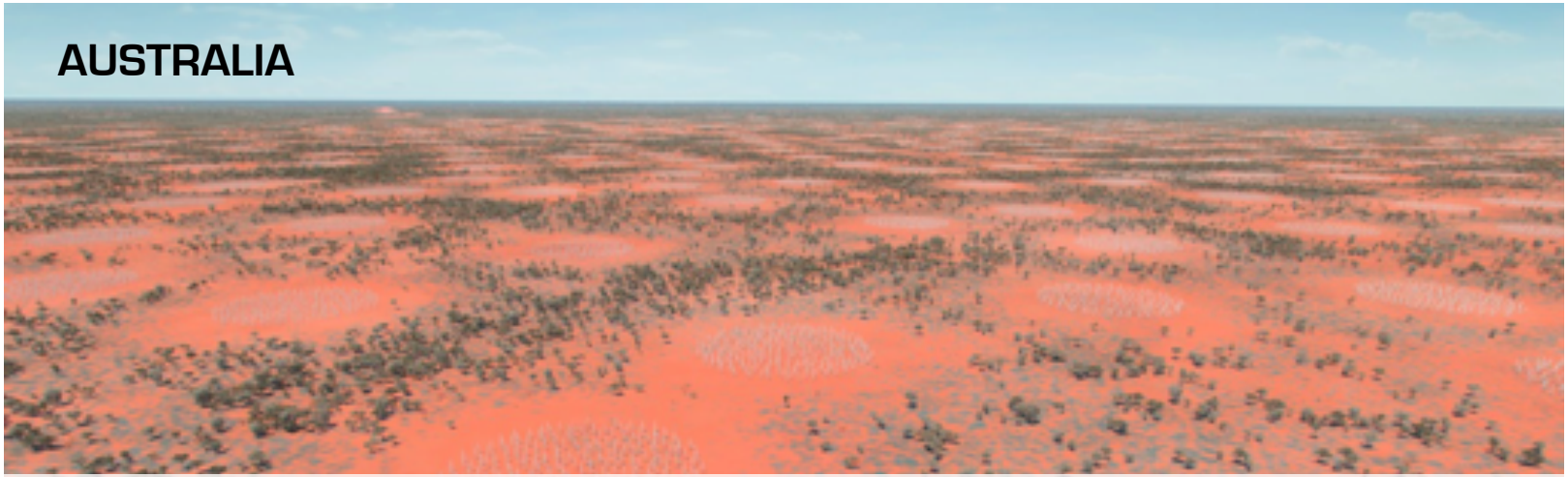


Tyler Bourke
Project Scientist

SQUARE KILOMETRE ARRAY

Exploring the Universe with the world's largest radio telescope

Swiss SKA Days
19 June 2019



International effort to build the World's largest radio telescope

Prime Motivation: Study the history of the Universe in Hydrogen

Will enable transformational science in many other areas

SKA– Key Science Drivers: The history of the Universe

Cosmic Dawn
(First Stars and Galaxies)

Testing General Relativity
(Strong Regime, Gravitational Waves)

Galaxy Evolution
(Normal Galaxies z~2-3)

Cradle of Life
(Planets, Molecules, SETI)

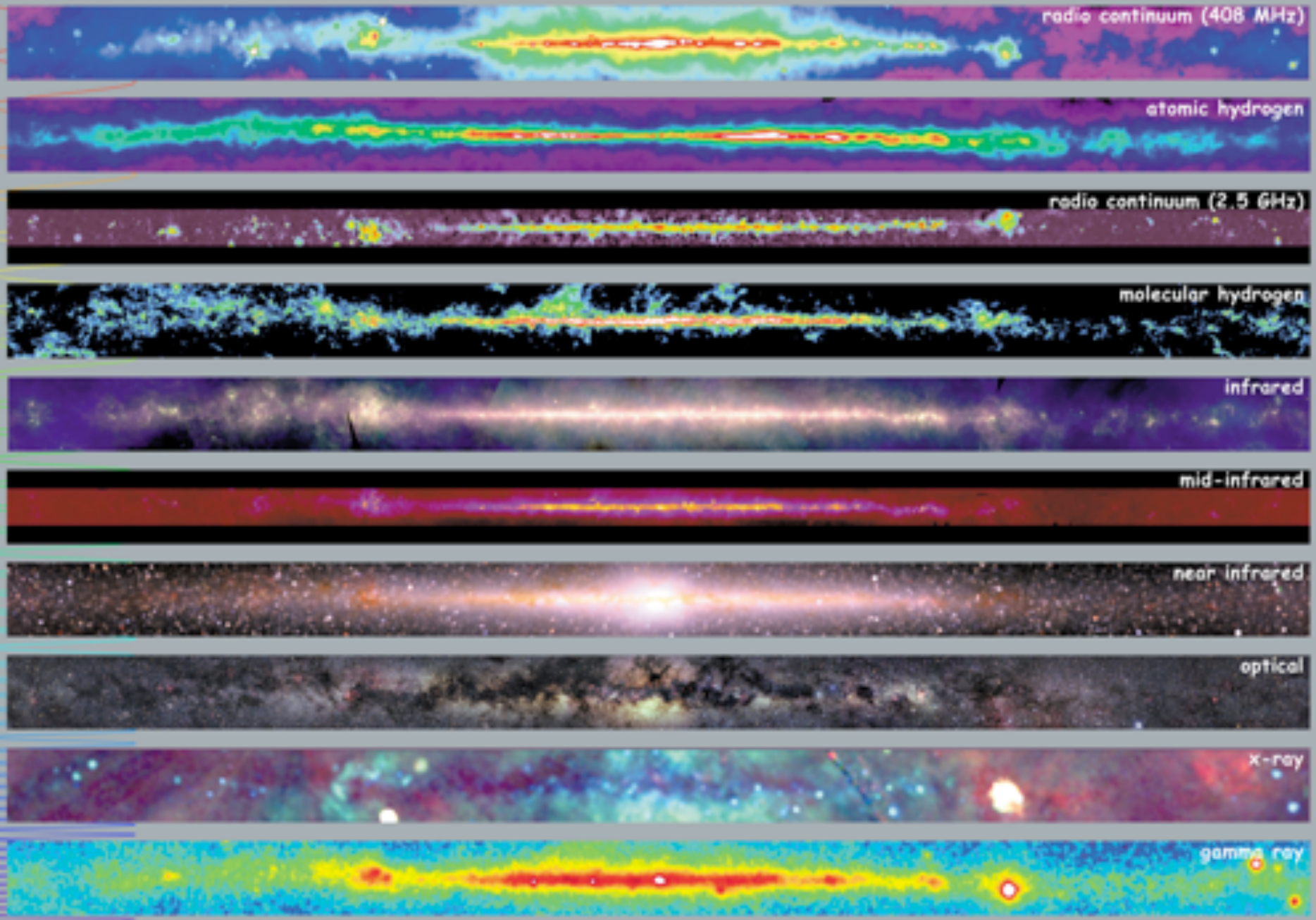
Cosmic Magnetism
(Origin, Evolution)

Cosmology
(Dark Matter, Large Scale Structure)

Our Galaxy
(Matter, Stars, Structure)

Exploration of the Unknown
(Transients, ...)

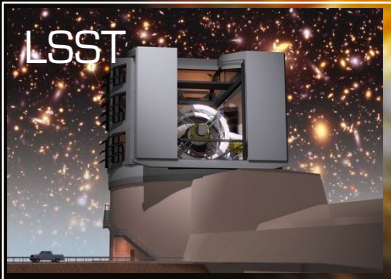
Broadest range of science of any facility, worldwide

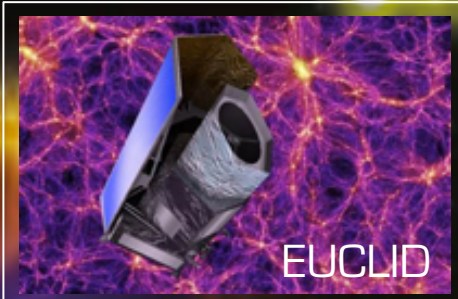


Multiwavelength Milky Way

The Astronomical Future

ngVLA?





SPICA?

SKA Phase 1

3 sites (AUS, RSA, UK-HQ) **2 telescopes (LOW, MID)** **one Observatory (SKAO)**

Construction Cost-cap: €691M (2017)

Construction: 2021-2028 (Science commissioning 2023+)

SKA1-Low: 512 x 256 low-freq dipoles,
50 – 350 MHz
65 km baselines (11" @ 110 MHz)
Murchison, Western Australia

SKA1-Mid: 133 x 15m + 64 x 13.9m dishes,
0.35 – 15 GHz (++)
120 km baselines
(0.22" @ 1.7 GHz; 34 mas @ 15 GHz)
Karoo, South Africa

SKA Phase 2

Start ~2030

AUSTRALIA

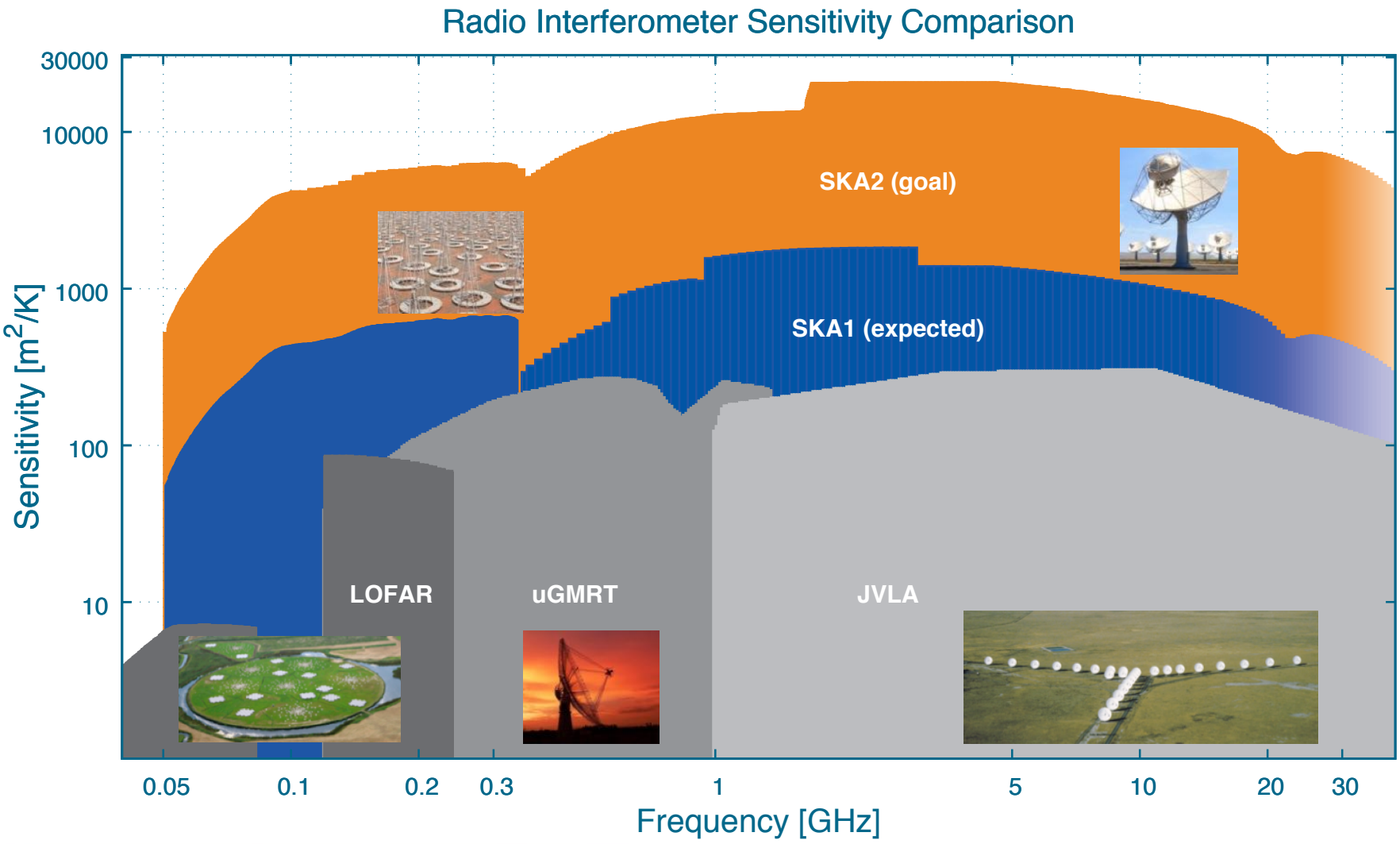
SKA-Low: ~500,000 low-freq dipoles,
200 km baselines
Murchison, Western Australia

SOUTH AFRICA

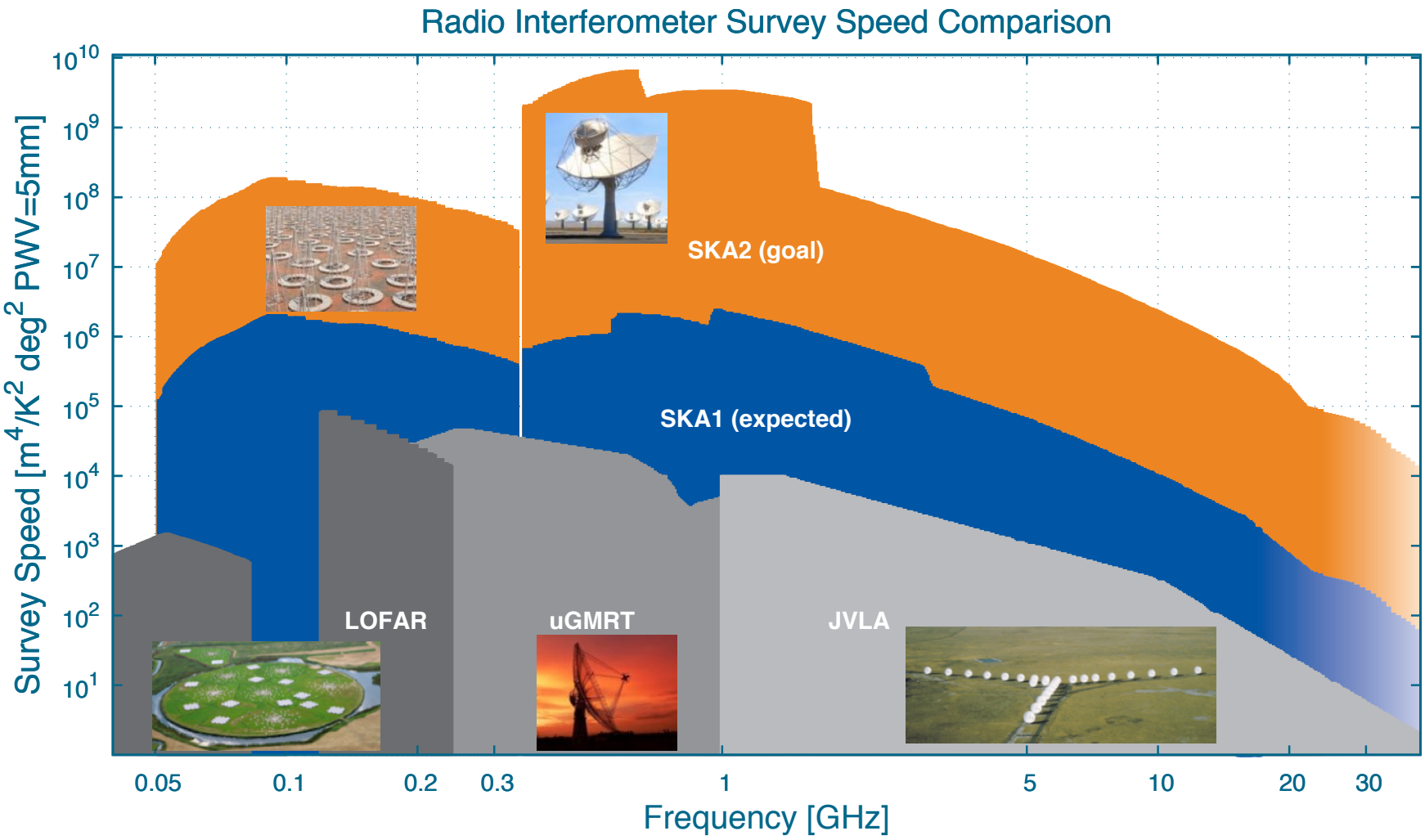
SKA-Mid: ~2000 x 15m dishes
3500 km baselines
Karoo, South Africa

+ Mid-Frequency Aperture Array?
+ Phased-Array Feeds?

Sensitivity Comparison



Survey Speed Comparison



Sensitivity Estimates

Frequency [GHz]	Line Sensitivity[a] [μJy per beam]	Continuum Sensitivity[b] [μJy per beam]	Min. Beam Size[c] [arcsec]	Max. Beam Size[c] [arcsec]
0.11	1850	26.0	12.00	600
0.30	800	14.0	6.00	300
0.77	300	4.4	1.00	145
1.40	140	2.0	0.60	78
6.70	90	1.3	0.13	17
12.50	85	1.2	0.07	9

One hour integrations

Table Notes:

[a] Line sensitivity assumes fractional bandwidth per channel of $\Delta\nu/\nu = 10^{-4}$ ($>10^{-6}$ will be possible)

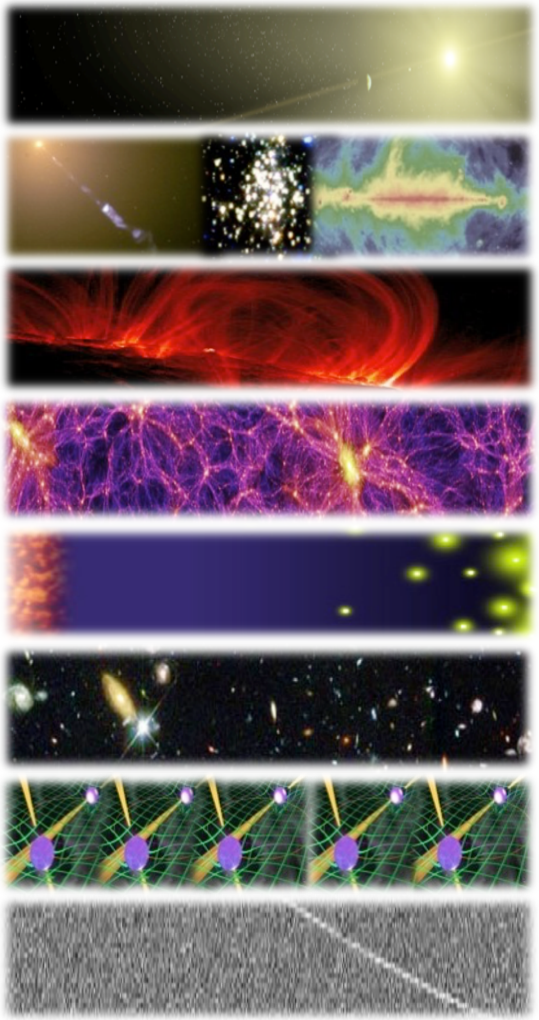
[b] Continuum sensitivity assumes fractional bandwidth per channel of $\Delta\nu/\nu = 0.3$

[c] The sensitivity numbers apply to the range of beam sizes given by Min. and Max. beam sizes

Anticipated SKA1 Science Performance: https://astronomers.skatelescope.org/documents/

SKA Big Questions

- **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? 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?*



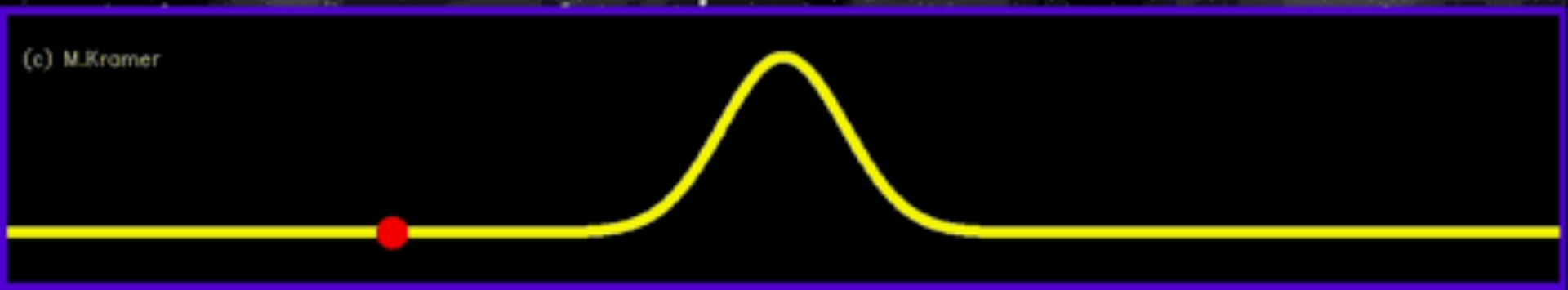
SKA Science Case

http://astronomers.skatelescope.org/meetings-2/aaska14/

www.skatelescope.org/books

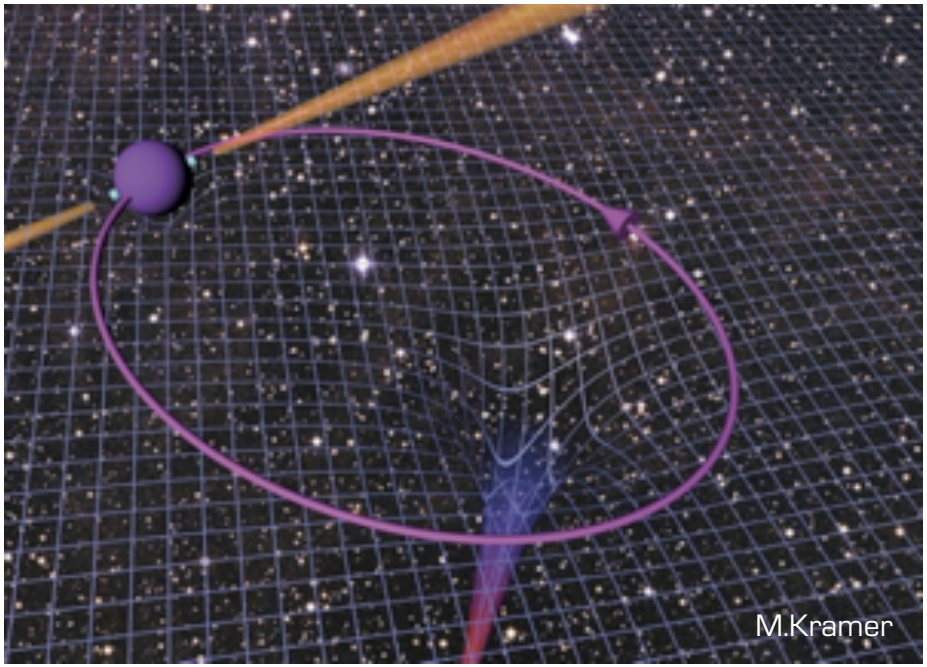
Pulsars
Testing General Relativity
in extreme environments

- 5.75745192436213 7(2) ms (Verbiest et al. 2008) = 2 atto (10^{-18}) seconds uncertainty!



Testing GR in strong field regime

Tests of GR in strong field regime via:
Neutron Star – White Dwarf binaries
Neutron Star – Neutron Star binaries
Pulsars around Galactic Centre
Neutron Star – Black Hole binaries



No Hair Theorem

Black Holes can be described by 3 classical parameters:

- Mass
- Electric Charge
- Angular Momentum (Spin)

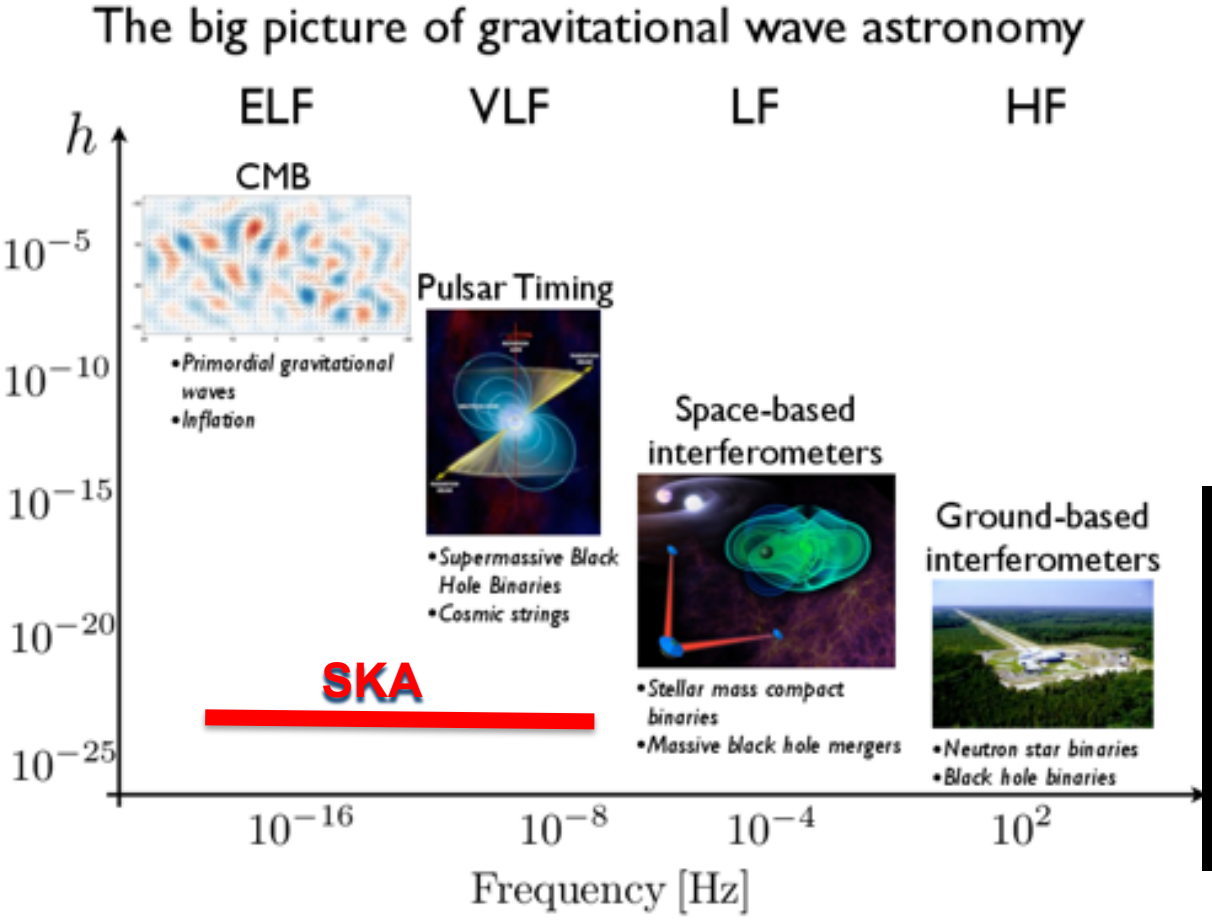
Cosmic Censorship

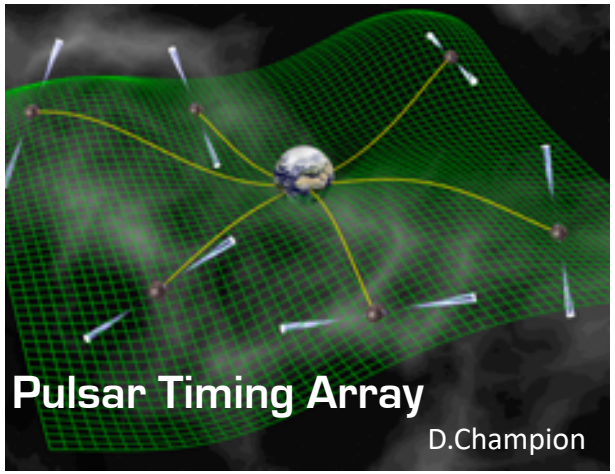
BHs have an event horizon which hides the singularity, i.e.., there are **no naked singularities**

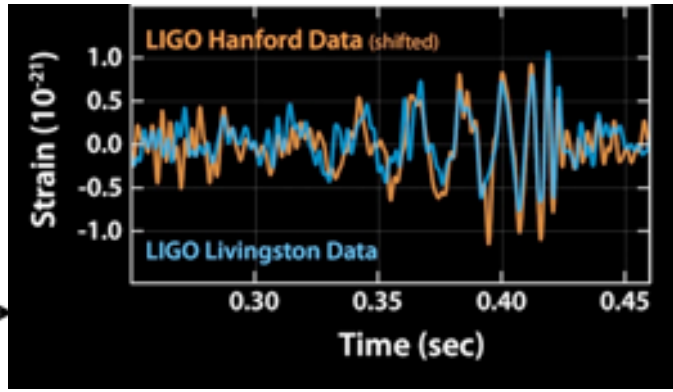
Order of Magnitude Improvement

Kramer & Stappers 2015

Gravitational Waves with Pulsars







Discoveries with SKA1 (SMBH mergers, Primordial GWs)

"GW astronomy" with SKA2 (discrete sources)

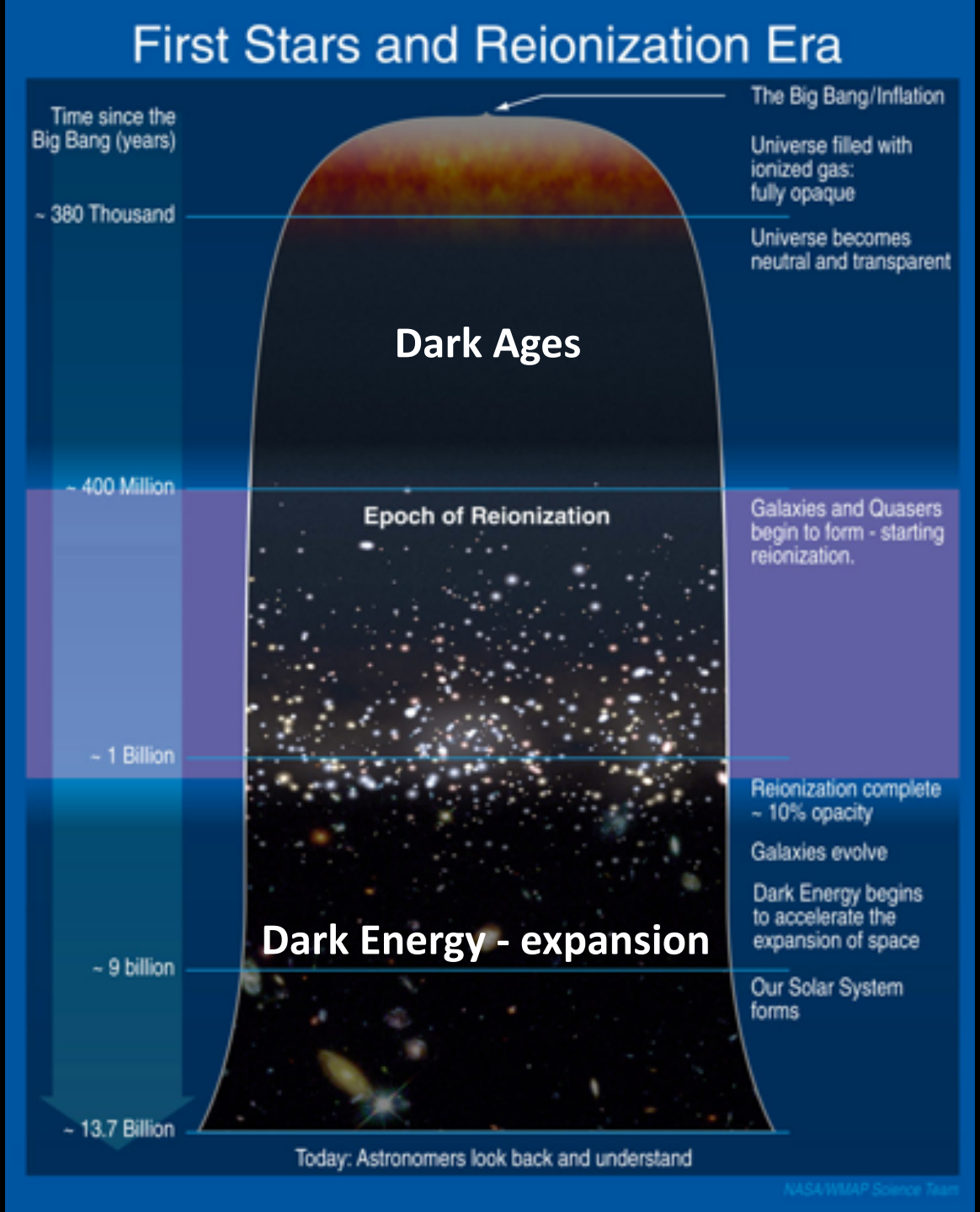
380,000 yrs

400 million yrs

1 Billion yrs

9 Billion yrs

13.7 Billion yrs



CMB

Stars form

Galaxies evolve

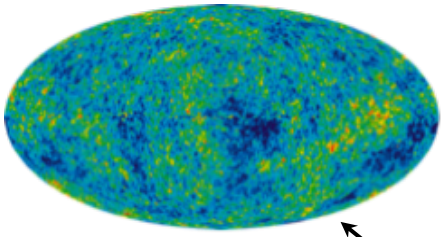
Solar System forms

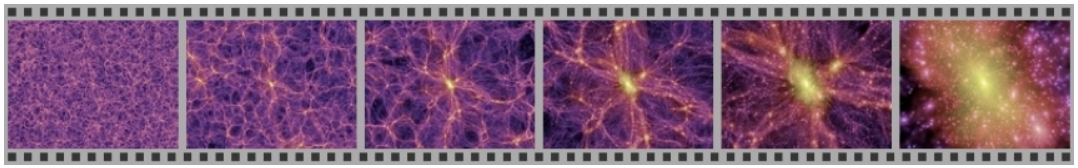
Humans

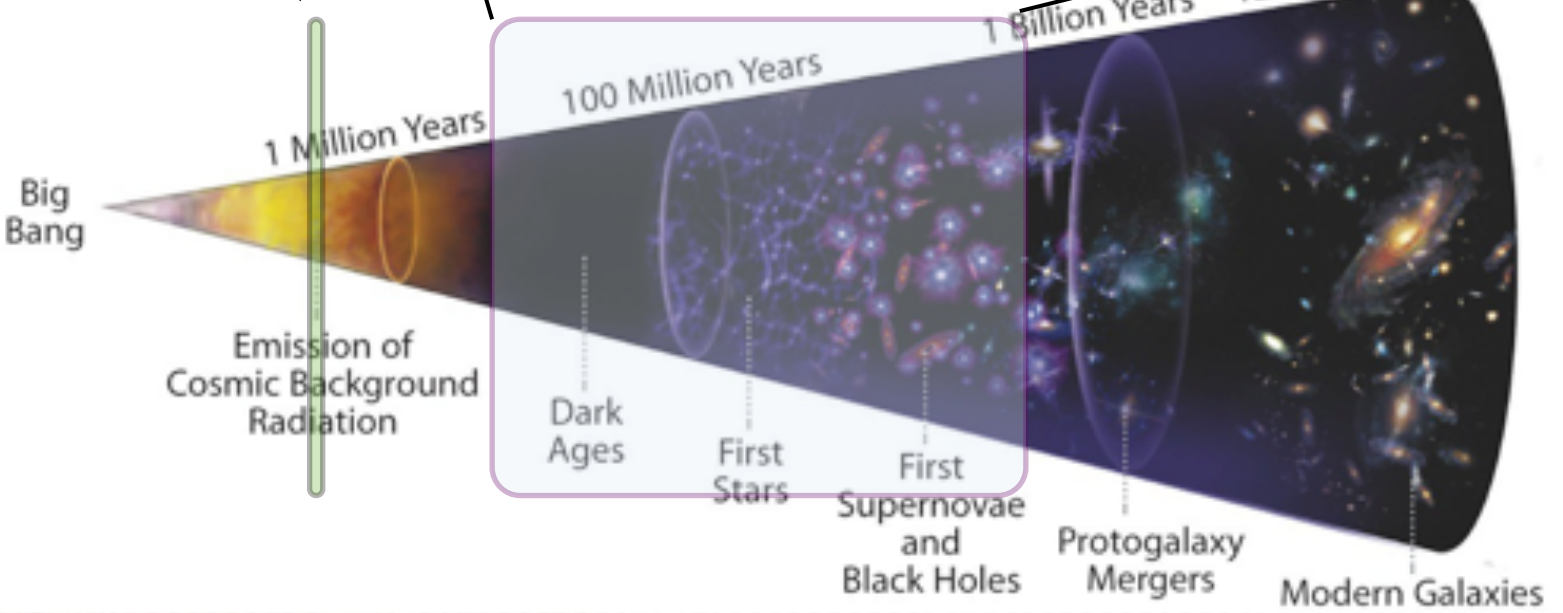
A Cosmic Movie

CMB displays a single moment of the Universe. Its initial conditions at ~400,000 yrs

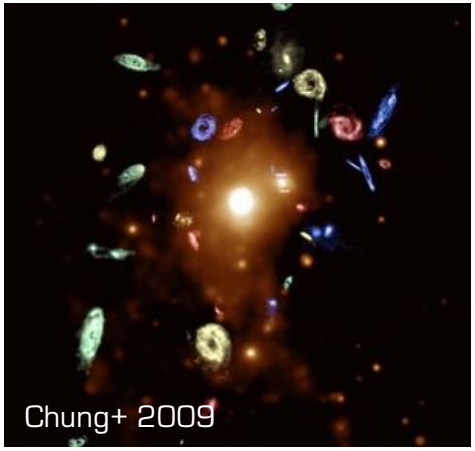
HI emission from the Dark Ages, Cosmic Dawn & EoR traces an evolving "movie" of baryonic and DM structure formation at $t_{univ}<10^9$ years.





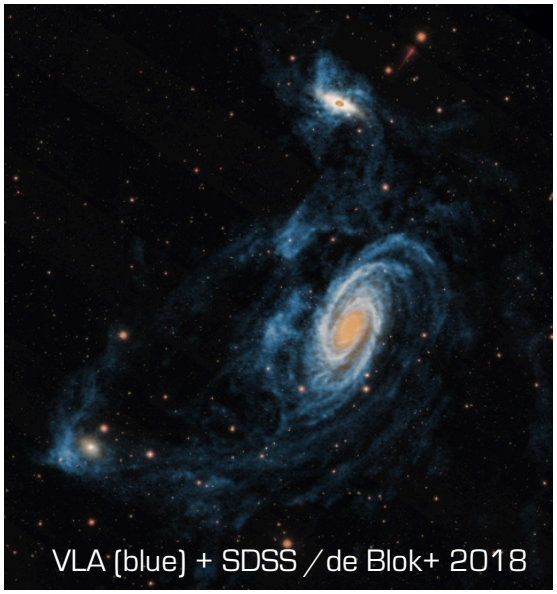


Evolution of Normal Galaxies



Resolved HI kinematics and morphology of 10^{10} $M_{\odot}$ mass galaxies out to z~0.8

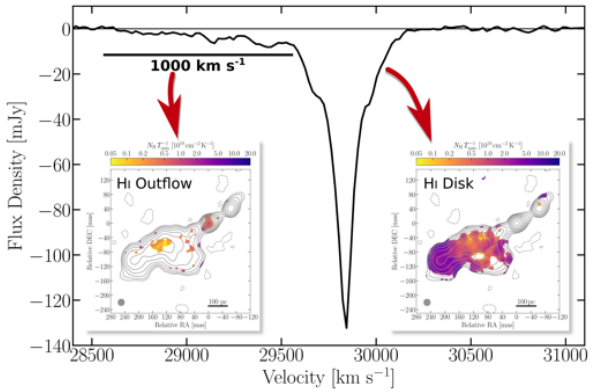
High spatial resolution (50 pc) studies of the ISM in nearby galaxies



Gaseous interface and accretion physics between galaxies and the cosmic web

Cosmological evolution of cold HI (absorption) out to z=6

Schulz+ 2018



SKAO Science Team

Robert Braun (CA/NL)
Science Director
HI in nearby galaxies

At present:
3 PhD students through
STFC Industry Placements (6 mo)

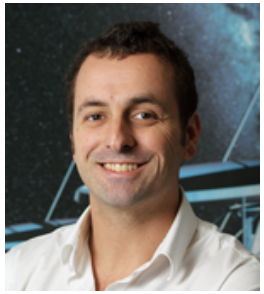
Near Future:
First SKA Post-Doc, more to come

Project Scientists

Anna Bonaldi (IT)
Cosmology
Large Data

Evan Keane (IRE)
Pulsars
Radio Transients

Tyler Bourke (AUS/USA)
Star Formation
Magnetic Fields

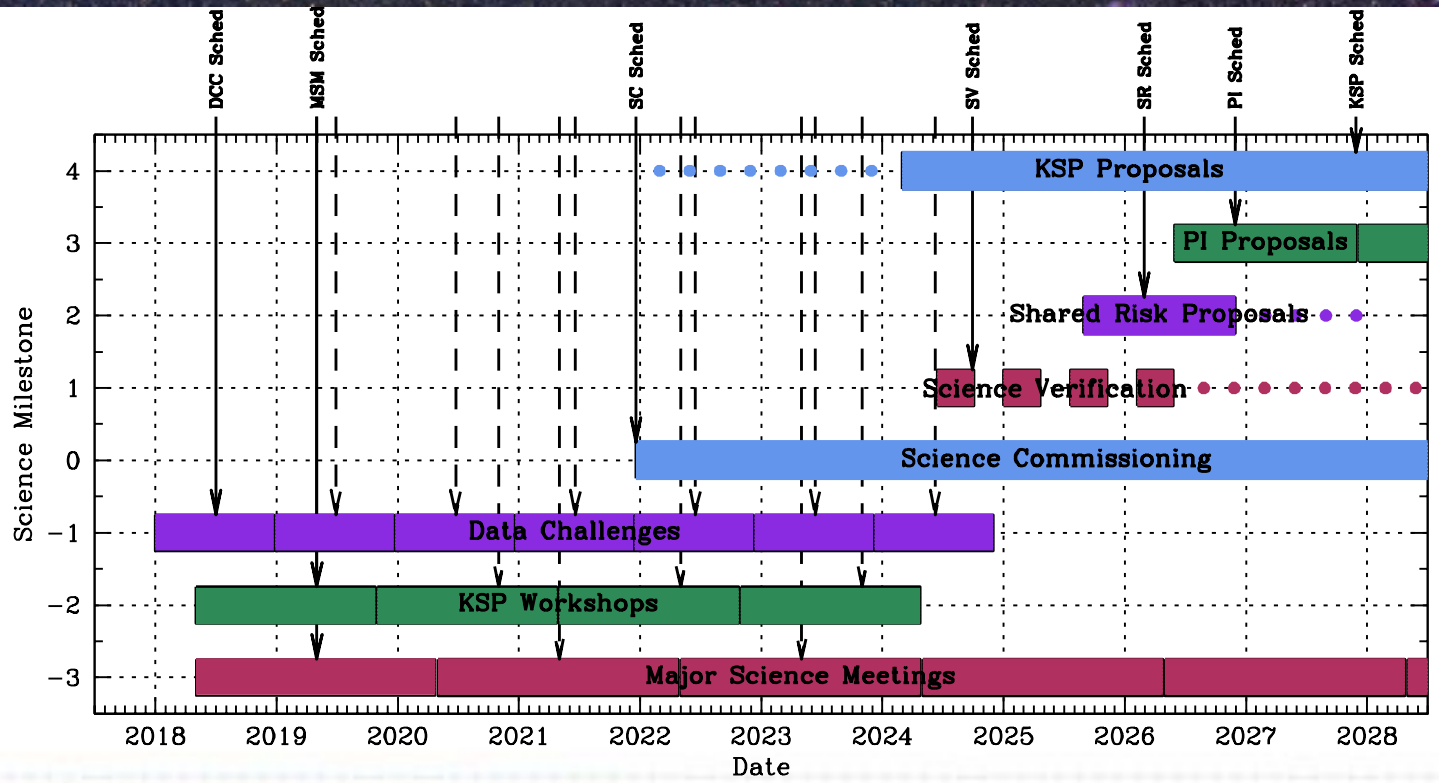


Jeff Wagg (CA)
Cosmology
High-Z spectral line

Timeline

Major dates

- **2020** Construction & Operations proposal submitted to SKAO Council
- **2021** Start of construction activities
- **2023** Start of science commissioning
- **2025-28** Key Science Project (KSP) planning & proposals
- **2028** Commencement of PI-led programmes
- **2029** Commencement of KSPs



Science Working Groups

Plus ...

- (Gravitational Waves – currently forming)
- VLBI

https://astronomers.skatelescope.org/science-working-groups/

Sci ing Groups

YOU CAN JOIN THESE GROUPS!

Membership to SWGs is

- open to any actively publishing researcher with a science interest in SKA and willingness to contribute an appropriate level of effort toward SKA science needs as described below.
- open to researchers affiliated with both SKA-member and non-member nations.

Researchers can nominate themselves for membership by contacting the relevant SWG Chair or office project scientist. Each Science Working Group consists of two tiers of membership: Core members and Associate members.

Plus ...

- **(Gravitational V**
- **VLBI**

https://astronomers.skatelescope.org/science-working-groups/

SKA1 Observing Time (Indicative)

KEY SCIENCE PROJECTS (KSPs)

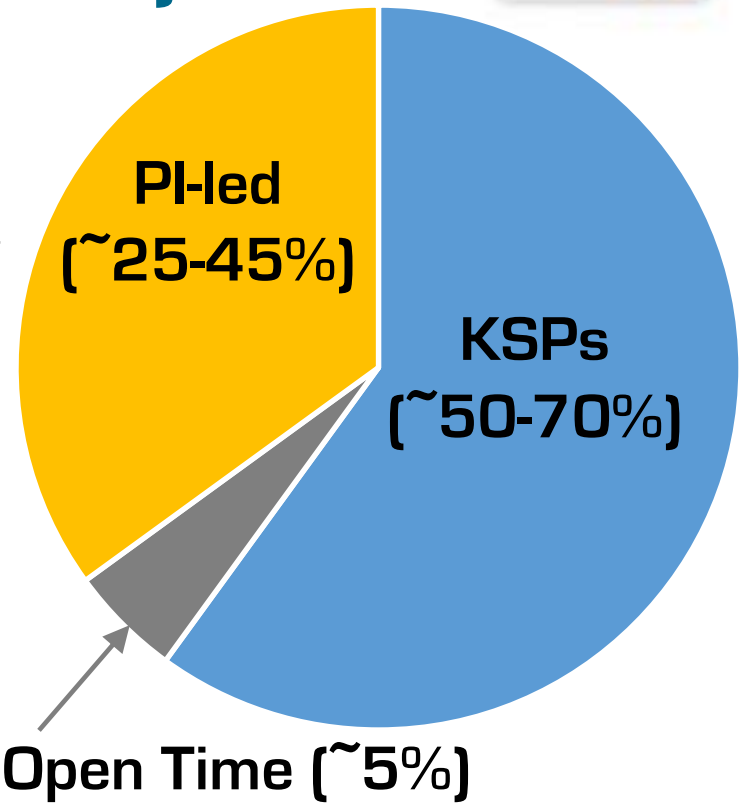
- Large programs (>1000 h) performed over multiple semesters (nominally 1 year)
- PI & management team from SKA-member countries; co-Is from any country
- Expected to provide added-value data products and tools back to SKAO

PRINCIPAL INVESTIGATOR (PI) PROJECTS

- Small programs (<1000 h) performed within a single semester
- PI and majority of co-Is from SKA-member countries

OPEN TIME (~5% of available time)

- Small programs led by PI from any country, performed with a single semester

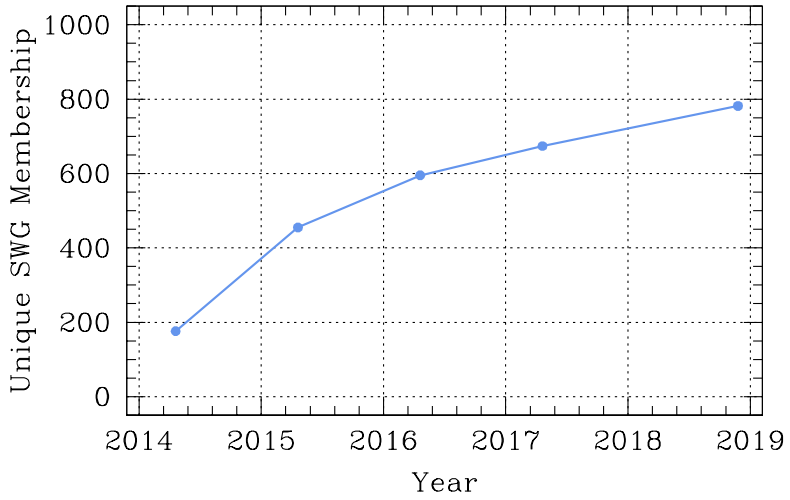


Limited Open Skies – most time will go to astronomers from member countries

“Notional” SKA1 KSPs

- Science community developed **“High Priority Science Objectives (HPSOs)”** in 2015.
- Strongly endorsed by advisory bodies (SRP, SEAC)
- Converted into “Notional” KSPs
- **Representative** package of high-impact science within first 5 years of SKA1
- Actual list of potential high-impact projects much broader (e.g. SKA Science Books)
- SWGs increased from 8 to 13
- SWG membership increased fourfold from 2014 to 2019

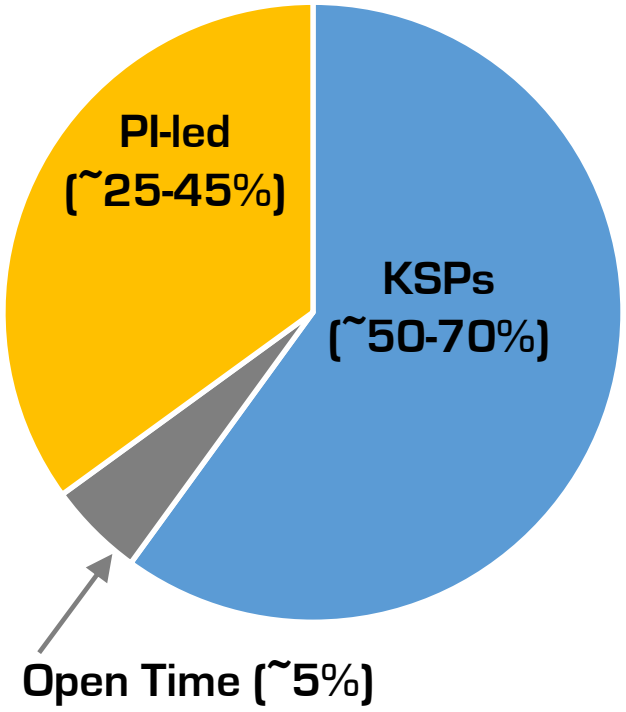
SWG	Objective
CD/EoR	Physics of the early universe IGM - I. Imaging
CD/EoR	Physics of the early universe IGM - II. Power spectrum
Pulsars	Reveal pulsar population and MSPs for gravity tests and Gravitational Wave detection
Pulsars	High precision timing for testing gravity and GW detection
HI	Resolved HI kinematics and morphology of ~10^10 M_sol mass galaxies out to z~0.8
HI	High spatial resolution studies of the ISM in the nearby Universe.
HI	Multi-resolution mapping studies of the ISM in our Galaxy
Transients	Solve missing baryon problem at z~2 and determine the Dark Energy Equation of State
Cradle of Life	Map dust grain growth in the terrestrial planet forming zones at a distance of 100 pc
Magnetism	The resolved all-Sky characterisation of the interstellar and intergalactic magnetic fields
Cosmology	Constraints on primordial non-Gaussianity and tests of gravity on super-horizon scales.
Cosmology	Angular correlation functions to probe non-Gaussianity and the matter dipole
Continuum	Star formation history of the Universe (SFHU) – I+II. Non-thermal + Thermal processes



KSP Planning

Indicative Key Science Project policy (actual policy will be determined by SKAO Council)

- Only scientists from SKA member countries may lead a KSP
- KSP Leadership is guaranteed to be distributed amongst SKA members in proportion to their financial contribution
- KSP participation (at the non-Leader level) is guaranteed to be distributed amongst SKA members in proportion to their financial contribution
- KSP participation (at the non-Leader level) of SKA non-members is capped at the value defined in the Access Policy



HPSOs are NOT KSPs
SWGs are NOT proto-KSPs
There are NO guaranteed KSPs
NO time has been allocated for ANY projects

KSP Planning

- **Further develop KSP concepts**
  - Regular workshops to provide a forum for open discussion of KSP concepts
- **Support development of potential KSP collaborations**
  - There will ultimately be a competitive process of KSP proposal submission, evaluation and allocation
  - Regular workshops to provide a forum for the key areas of interest of particular communities to be presented, leadership aspirations to begin to be identified and resourcing strategies to begin development
- **Maximizing commensality**
  - It is likely that the same data stream will serve multiple KSP or PI-led groups, each with limited data rights to address specific scientific objectives
  - Regular workshops to provide a forum for early discussion of support for such commensal programs, including the development of efficient survey strategies

Data Flow & Challenges (SKA1)

SKA-LOW

~2 Pb/s

SKA SQUARE KILOMETRE ARRAY — LOW-FREQUENCY APERTURE ARRAY

7.2 Tb/s

SKA-MID

8.8 Tb/s

SKA SQUARE KILOMETRE ARRAY — SIGNAL AND DATA TRANSPORT

Global Traffic in 2020 ~500 Tb/s

Conservative Analysis

SKA SQUARE KILOMETRE ARRAY — CSP — CENTRAL SIGNAL PROCESSOR

~50 PFlops

~5 Tb/s (over 600 km)

SKA SQUARE KILOMETRE ARRAY — SDP — SCIENCE DATA PROCESSOR

@Perth

~130 PFlops/SPD

@Cape Town

Data Archive ~600 PB/yr

SKA Regional Centres

Uploads to Google 100PB

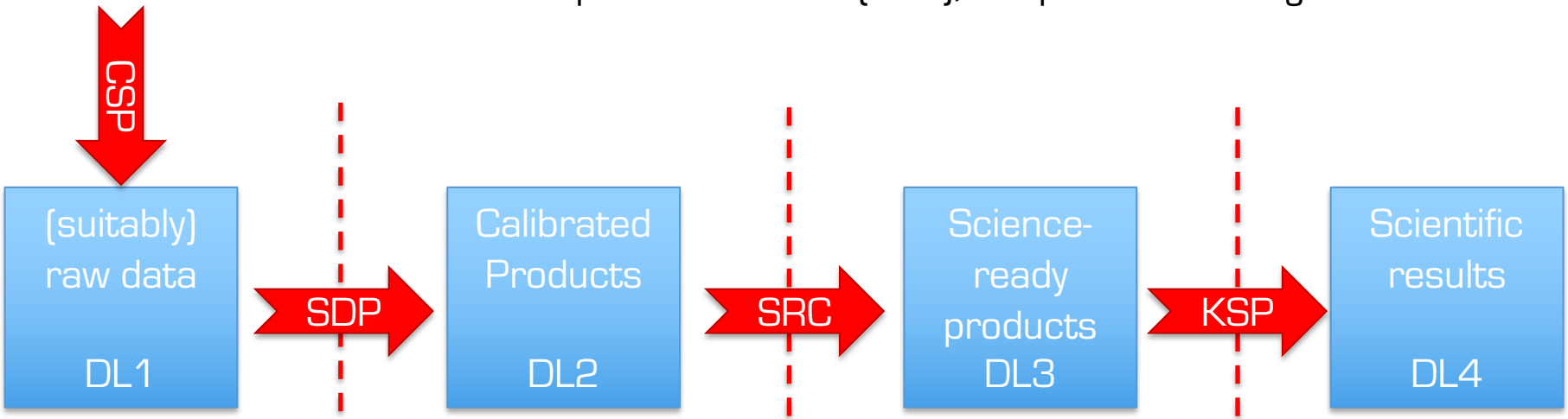
Uploads to Facebook 180PB

Tera 10^{12}

Peta 10^{15}

SKA data challenges: Data Layers (DL)

DL0 = raw data from telescope to correlator (CSP), not part of challenge

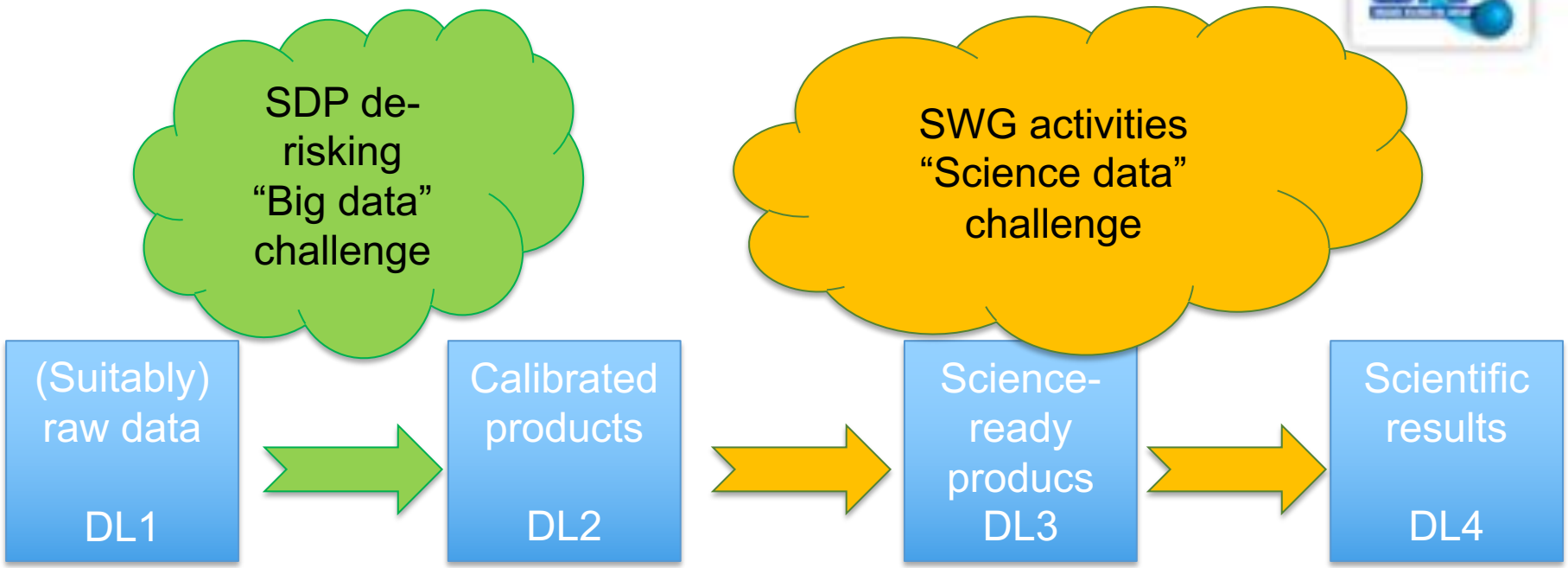


- per observation (integration time hours)
- Suitably averaged and compressed
- Uncalibrated
- unflagged
- ...

- per observation (integration time hours)
- Standard output product
- Calibrated
- Flagged
- ...

- Different observations integrated together
- total telescope time 100-1000 h
- Standard output product
- Flagged and Calibrated

- Additional analysis done



- Focus on efficiency/scalability
- Calibration strategy and implementation
- Data size 10-100 TBs

- Focus on algorithm development
- Data co-addition between observing epochs
- Proposal-Specific processing
- Data size few TBs

Data Challenges - Details

1. Science Data Processor Challenges
   - Algorithms for Calibration and Imaging, particularly where there are competing approaches (hence suitable for challenge)
   - Example: DD Calibration: A-Projection versus DD-Faceting
   - Computational efficiency of pipelines running on the SDP platform, working in conjunction first with Bridging activities in this area, followed by construction.
   - Algorithm development community/SDP engagement
2. SKA Regional Centre Challenges
   - Data movement
   - Data formats
   - Protocols
   - Security/data federation
   - Databases
3. Science/Key Science Project Challenges
   - Engagement with the scientific community by demonstrating SKA capabilities
   - Preparing the scientific community for SKA data formats and sizes
   - Converting standard SDP products
   - Defining useful added value data products
   - Algorithm development for SRCs and other centres
   - Feedback on specific issues e.g. transient buffers, SDP and SRC design

SKA Science Data Challenge

The first SKA Science Data Challenge (SDC1) consists of nine large images each being

- ~32,000 pixels on each side
- 4GB in size
- Science Ready (output from SRC)

Images consist of

- 3 frequencies (560 MHz, 1.4 GHz and 9.2 GHz)
- 3 depths: 8 hours, 100 hours and 1000 hours of observing time

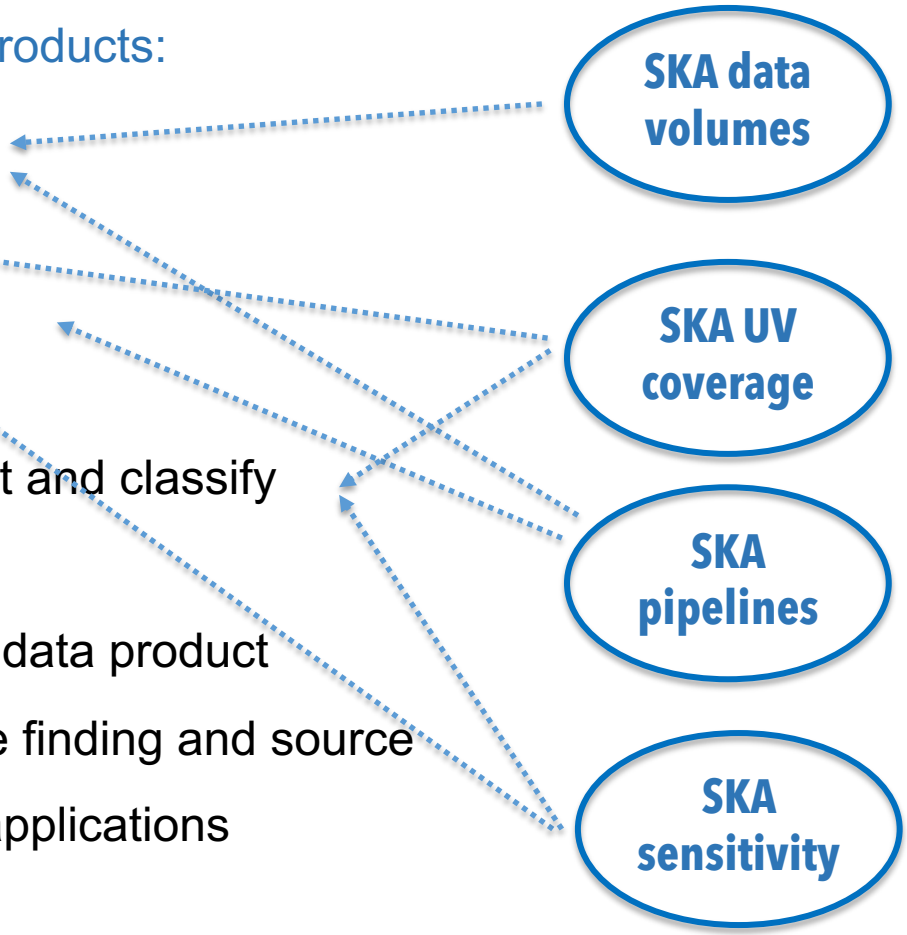
Images contain

- ~10 millions sources, taken from
  - TRECS (Bonaldi+ 2018)
  - Atlas of DRAGNs (Univ. Manchester)

https://astronomers.skatelescope.org/ska-science-data-challenge-1/

SKA Data Challenge

- SKA unique features map into the data products:
  - ✓ In the image plane, not visibilities
  - ✓ "Benign" dirty beam
  - ✓ Deconvolved down to 8h exposures
  - ✓ Very deep -> confusion limited
  - ✓ Very big number of sources to detect and classify
- **SDC1 goals:**
  - ✓ Get the community familiar with this data product
  - ✓ Develop efficient methods for source finding and source characterization -> SWG and SRC applications



https://astronomers.skatelescope.org/ska-science-data-challenge-1/

SKA Data Challenge

Square Kilometre Array Science Data Challenge 1

ANNA BONALDI & ROBERT BRAUN, FOR THE SKAO SCIENCE TEAM *

SKA Organization, Jodrell Bank, Lower Withington, Macclesfield, Cheshire, SK11 9DL, United Kingdom

November 27, 2018

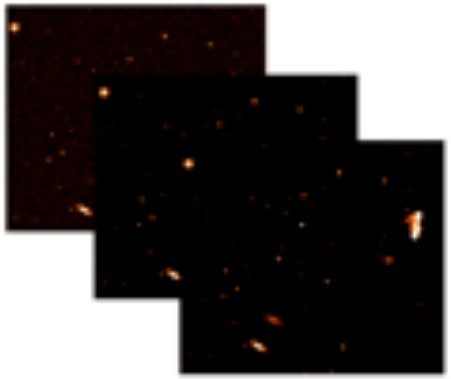
Abstract

The Square Kilometre Array (SKA, https://skatelescope.org) will be the world's largest radio telescope. SKA Science Data Challenges will be regularly issued to the community as part of the science preparatory activities. The purpose of these challenges is to inform the development of the data reduction workflows, to allow the science community to get familiar with the standard products the SKA will deliver, and optimise their analyses to extract science from them. These challenges may consist of real data from currently operating radio facilities or of simulated SKA data. The purpose of this document is to provide information on how the SKA Science data challenge #1 (SDC1) has been produced and to set the challenge for the community. For more information on how to take part in the challenge and to download the data see https://astronomers.skatelescope.org/ska-science-data-challenge-1/

arXiv:1811.10454

Includes a small training set with the answers provided

SKA Science Data Challenge #1



Zoom-in of the 1.4 GHz maps, showing the same region of the sky with different telescope integration: 8, 100, 1000 h left to right.

The SKA Science Data Challenge #1 (SDC1) release consists of 9 files, with the format of FITS images. Each file is a simulated SKA continuum image in total intensity of the same field at 3 frequencies (560 MHz, representative of SKA Mid Band 1, 1.4 GHz, representative of SKA Mid Band 2 and 9.2 GHz, representative of SKA Mid Band 5) and 3 telescope integrations (8, 100, 1000 h as representative of a single, medium-depth and deep integration, respectively).

Ancillary data consist of primary beams and synthesized beams for each frequency. An explanatory supplement describes the data and the challenge that is set for the community. A training set is also released, which consists in truth catalogues listing the objects in the simulated 1000 h data and their properties for a 5% of the field-of-view.

Challenge Description

The challenge set for the community is to undertake:

- source finding (RA, Dec) to locate the centroids and/or core positions,
- source property characterization (integrated flux density, possible core fraction, major and minor axis size, major axis position angle)
- source population identification (one of SFG, AGN-steep, AGN-flat)

The full description of the data and of the challenge set is here:
SKA Data Challenge #1 description DOWNLOAD

Take up the challenge!

Submission of results are accepted from either individuals or teams. If you would like to participate, please let us know by registering your interest, as detailed on Sec. 8 of the Challenge Description file, so that we can you keep you in the loop of challenge progress updates and other communications. Details on how to format and submit your results are also given in the document. The challenge starting day is 26/11/2018 and the deadline for submitting results is 15/3/2019, after which results will be graded.

Have a taste of what SKA data will be!

You are welcome to use the data for your own research, and to perform analyses and tests beyond the set challenge. Please acknowledge the use of these data as "SKAO data challenges, science data challenge #1". Details on how the dataset has been made and further references, including scientific papers, can be found in the Challenge Description file.

560 MHz, 8 hours	4 Gb	DOWNLOAD
560 MHz, 100 hours	4 Gb	DOWNLOAD
560 MHz, 1000 hours	4 Gb	DOWNLOAD

https://astronomers.skatelescope.org/ska-science-data-challenge-1/

Future Data Challenges

Intensity Mapping simulation may be next (TBD)

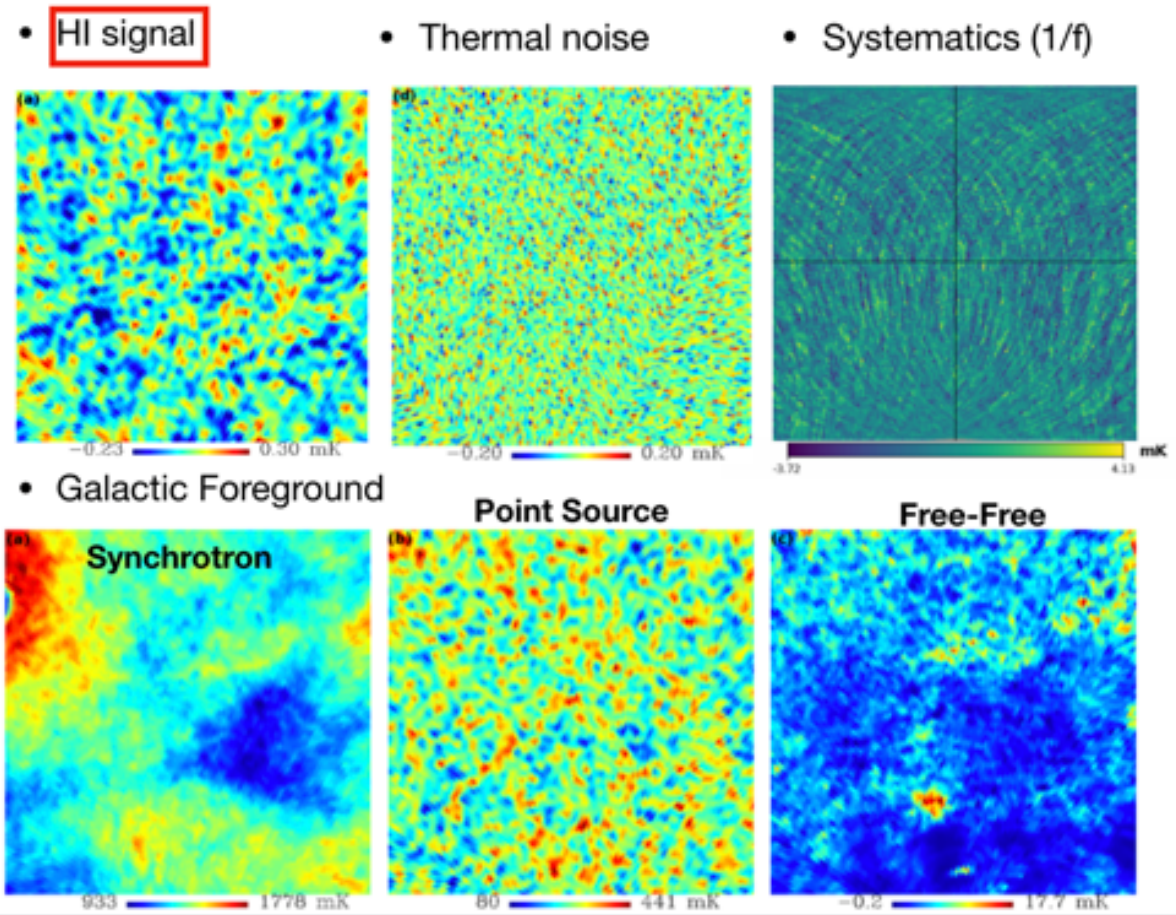
- Wide area, including diffuse Galactic emission
- Total power, "single dish" measurement
- Investigate scan strategy
- Investigate foreground removal methods
- Investigate systematics

Increasing realism, e.g.:

- Time variability
- Polarization
- Instrumental systematics

- **Long-term goal: combine with the SDP and SRC challenges to "end to end" simulations**

Stay tuned!
Ideas and Assistance Welcomed



SKA Regional Centres (SRC)

Motivation

1. The science data products that emerge from the SKA observatory are not always in the **final state** required for science analysis and publication
2. The data **volumes are so large** that direct delivery to end users is unfeasible
3. The community of scientists working on SKA science data will be **geographically distributed**

The SRCs will collaborate to form a global network that will provide the SKA community with:

- access to **support** using the SKA and its data products
- a platform for **collaborative science**
- transparent and **location agnostic** interface for users
- access to **project data** for all SKA users
- a place for **development** of software tools: analysis, modelling, visualisation

SKA Regional Centres (SRC)

1. The science data products that emerge from the SKA observatory are not always in the final state required for science analysis and publication

Generation of advanced data products not in scope of project

SDP must maintain throughput matched to input data rate combination & further analysis of data products outside of observatory boundaries

2. The data volumes are so large that direct delivery to end users is unfeasible
3. The community of scientists working on SKA science data will be geographically distributed

SKA Regional Centres (SRC)

1. The science data products that emerge from the SKA observatory are not always in the final state required for science analysis and publication
2. The data volumes are so large that direct delivery to end users is unfeasible

Also, does not account for possible future "discovery" archive
Final data volume for each project will exceed that delivered by the observatory
Downloading data to local machines/cluster expensive and unfeasible in long term "take processing to the data"

3. The community of scientists working on SKA science data will be geographically distributed

SKA Regional Centres (SRC)

1. The science data products that emerge from the SKA observatory are not always in the final state required for science analysis and publication
2. The data volumes are so large that direct delivery to end users is unfeasible
3. The community of scientists working on SKA science data will be geographically distributed

KSPs with 1000s of hrs of observing time will dominate the science programme
Large international teams drawn from across the membership
Need new methods, algorithms and techniques
Driven by the community so they need a platform on which to do this

SKAO Data Products

1. Image Cubes
   - continuum, residual, clean components, line cube, residual line, psf
2. (u,v) Grids
   - gridded calibrated visibilities (FFT of dirty image)
3. Calibrated Visibilities
   - EoR, with direction dependent calibrations and time/freq. averaging
4. Local Sky Model (LSM) Catalogue
5. Transient Source Catalogue
6. Pulsar Timing Solutions
7. Transient Buffer Data
   - Voltage data
8. Sieved Pulsar and Transient Candidates
9. Science Alerts Catalogue
10. Science Product Catalogue

Data processed at SDP centres in Perth and Cape Town

Data delivered from SDP centres to SKA Regional Centres (SRCs)

Users obtain data via SRCs; Further Processing and Analysis performed at SRCs

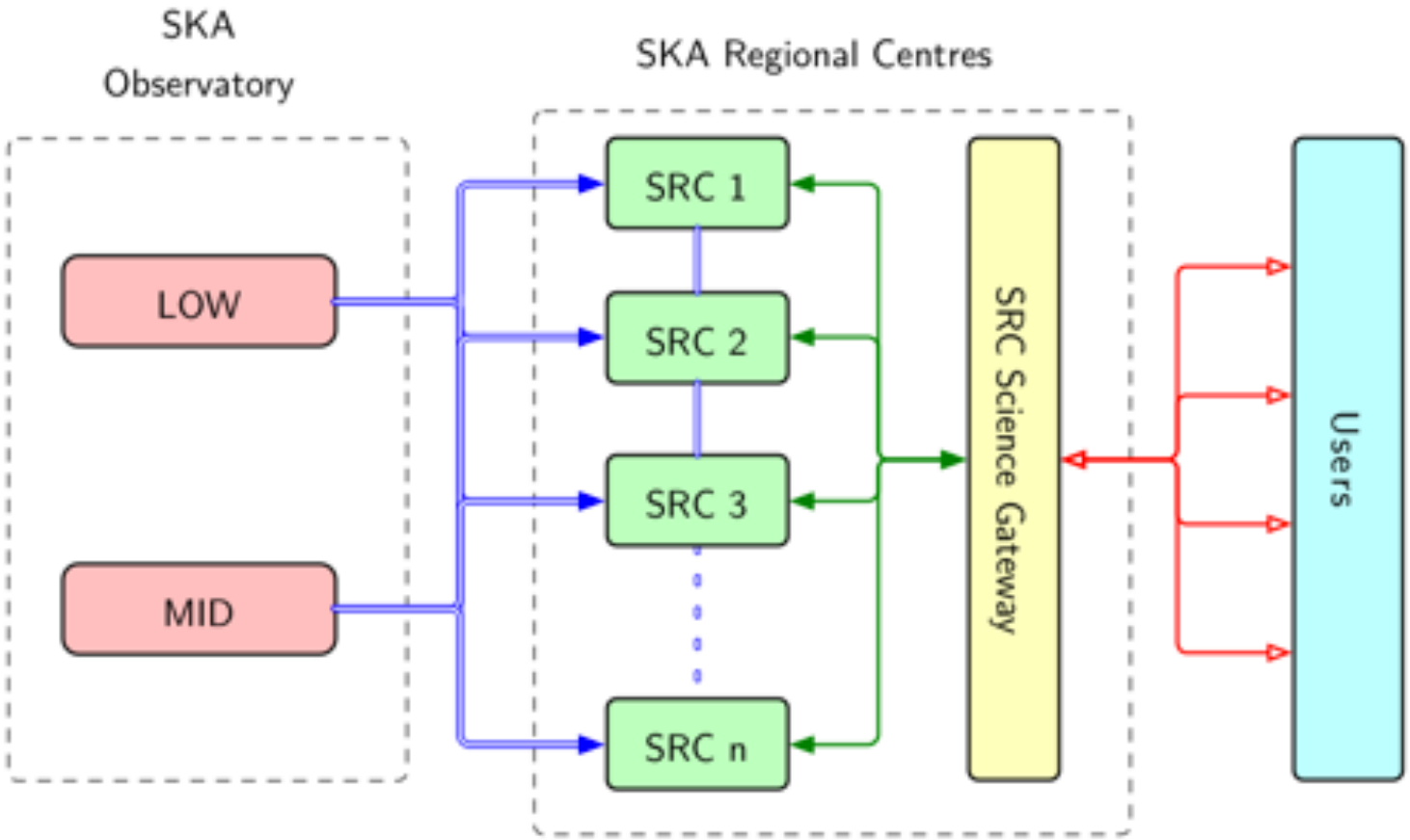
SKAO Data Products

Image Products 1: Image Cubes

1. Imaging data for Continuum, as cleaned restored Taylor term images (n.b. no image products for Slow Transients detection have been specified – maps are made, searched and discarded)
2. Residual image (i.e. residuals after applying CLEAN) in continuum
3. Clean component image (or a table, which could be smaller).
4. Spectral line cube after continuum subtracted
5. Residual spectral line image (i.e. residuals after clean applied)
6. Representative Point Spread Function for observations (cutout, small in size compared to the field of view (FOV))

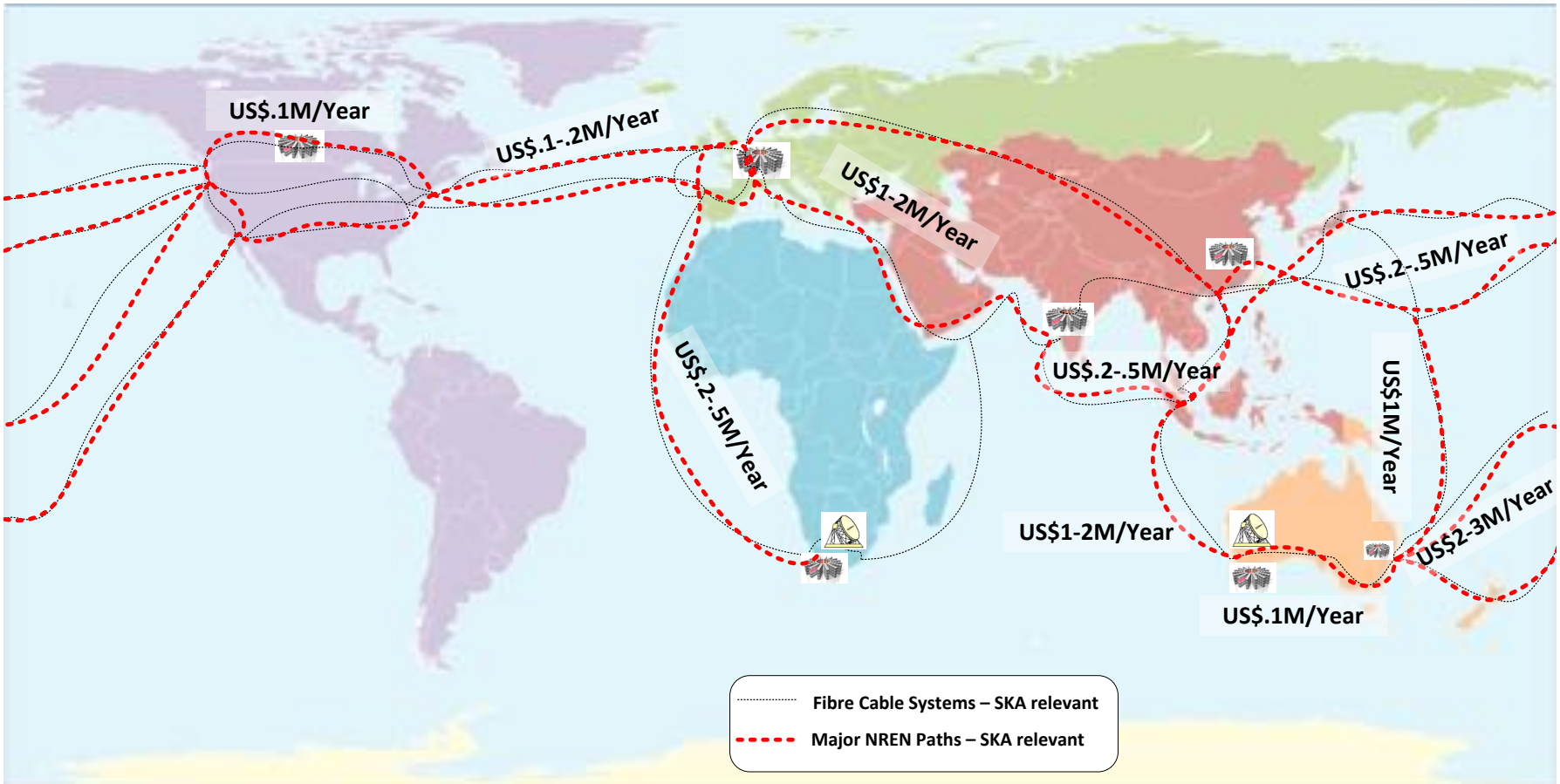
Data processed at SDP centres in Perth and Cape Town
Data delivered from SDP centres to SKA Regional Centres (SRCs)
Users obtain data via SRCs; Further Processing and Analysis performed at SRCs

SKA Regional Centres



Each SRC will present itself to the SKA and to the SKA users in a standardised way, observing the requirements on technical interfaces and provided access via the user-facing science gateway.

SKA Regional Centres



Estimates are based on 100Gbit/s links connecting the sites and regional centres (full duplex). Based on current technology and cost trends we are confident that the provision of this network will be affordable and achievable – assuming that we purchase 10-15 year IRUs on dedicated fibres within larger cables.

SKA Regional Centres

https://astronomers.skatelescope.org/the-ska-regional-centres/

https://projectescape.eu/

https://www.aeneas2020.eu/project/regional-centres/

https://www.idia.ac.za/

Exascale Research Infrastructure For Data In Asia-Pacific Astronomy Using The SKA

https://eridanus.net.au/

http://cirada.org/Main/ProjectDescription

Observation Management and Controls Software Architect

This role would be ideal for an experienced software architect with a background in management and control systems.

Area / Department: Software Data Management and IT
Contract Type: Permanent
Ref No: 10047

Read More

Project Manager, SKA-MID Digitisation

Ideal for a Project Manager with radio astronomy/ digitisation/ signal processing/ correlator/ time & frequency/ telecomms/ space/ defence expe...

Area / Department: Engineering and Project Management
Contract Type: Permanent
Ref No: 10055

Read More

Facilities Support

Ideal for a diligent, customer-orientated individual able to provide hands-on general facility upkeep whilst ensuring a clean and tidy environment.

Area / Department: Business Support function
Contract Type: Fixed Term Contract
Ref No: 10054

Read More

Executive Assistant to the Director-General

This is an ideal role for a talented Executive Assistant able to lead others and drive professional administration standards in an international setting.

Area / Department: Business Support function
Contract Type: Permanent
Ref No: 10053

Read More

SKA Operations Scientist/SAFe® Product Manager

This role is ideal for candidates with software development experience within a radio astronomy environment.

Area / Department: Telescope Operations
Contract Type: Permanent
Ref No: 10049

Read More

Time & Frequency Specialist Engineer

This is a role for a skilled engineer with "hands on" experience in timing (e.g. clocks) and time and frequency distribution.

Area / Department: Engineering and Project Management
Contract Type: Permanent
Ref No: 10050

Read More

Junior Engineer

This is an ideal role for an engineer with an interest in radio astronomy.

Area / Department: Engineering and Project Management
Contract Type: Permanent
Ref No: 10051

Read More

Science Data Processing Software Architect

This role would be ideal for an experienced software architect with a background in high performance data analysis systems.

Area / Department: Software Data Management and IT
Contract Type: Permanent
Ref No: 10048

Software Development Lead/SAFe® Product Manager

This role would suit an experienced agile software developer with an understanding and interest in astronomy.

Area / Department: Software Data Management and IT
Contract Type: Permanent
Ref No: 10046

SQUARE KILOMETRE ARRAY

Exploring the Universe with the world's largest radio telescope

http://astronomers.skatelescope.org/

June 2019 EWASS Special Session 29:
The role of European-led surveys in guiding future SKA1 science

Useful updates:

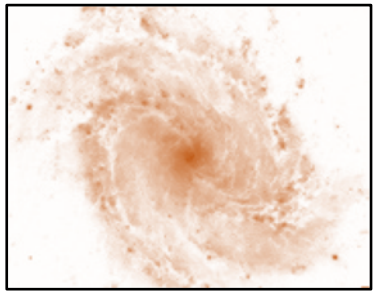
1. Minutes/Slides from Monthly SWG Chairs telecons
astronomers.skatelescope.org/swg-chairs-meeting-minutes/

2. SKA e-newsletter
newsletter.skatelescope.org

3. SKAO Bulletin (for the SKA community)
www.skatelescope.org/skao-bulletin/

Imaging Performance (Mid)*

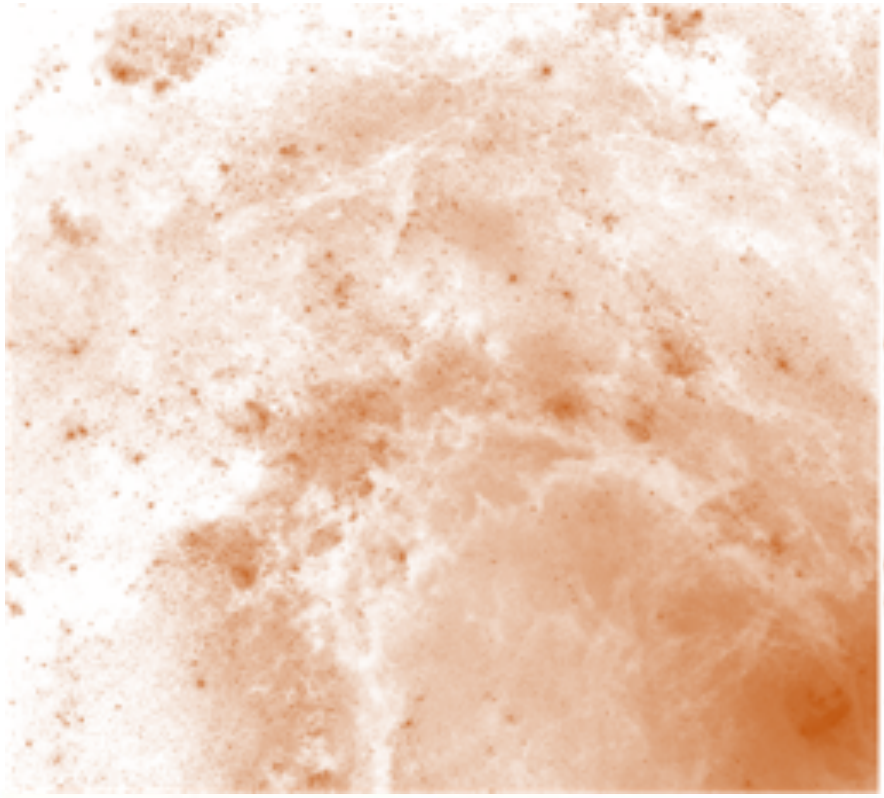
*Noiseless

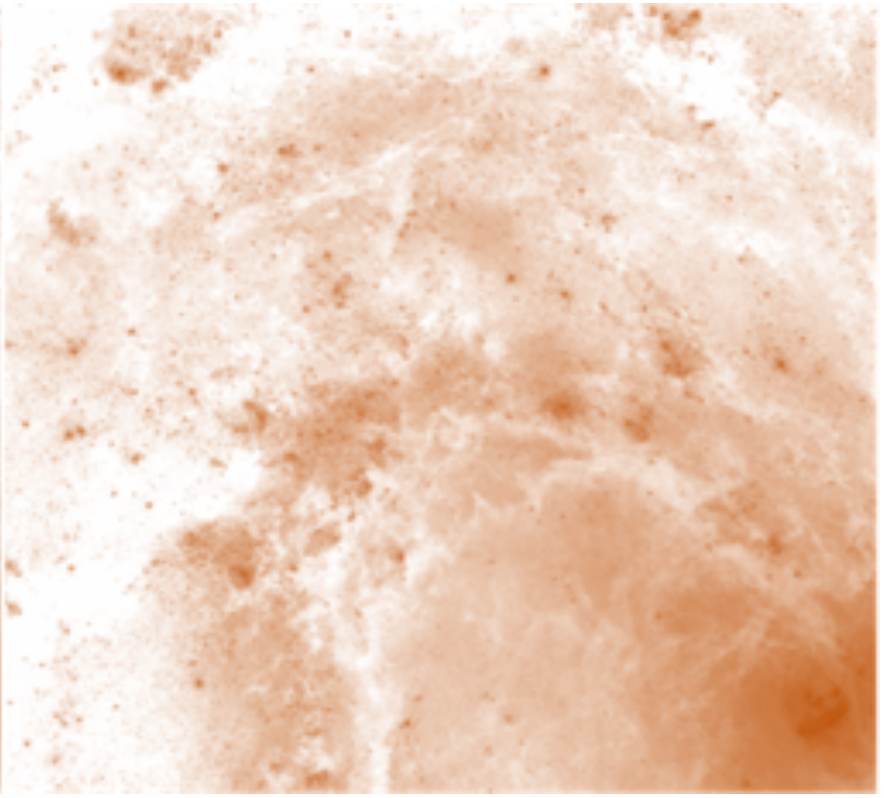


~1" @ 1.4 GHz
Images resampled to
SKA resolution

Input Model Image

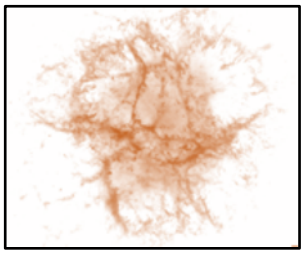
SKA1-Mid, 8h track





Imaging Performance (Low)*

*Noiseless



~10” @ 140 MHz
Images resampled to
SKA resolution

Input Model Image

SKA1-Low, 4h track