

Status of the SKA project and the SKA Regional Centre Network

Credits: SKA Organisation

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Lourdes Verdes-Montenegro, Susana Sánchez and Julio Gallardo, the Spanish coordination team



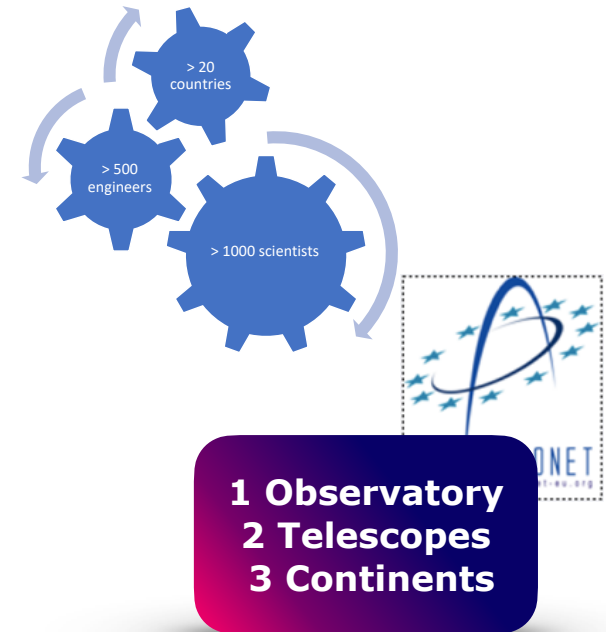
XV Reunion científica - Sociedad Española de Astronomía, 7/09/2022

Instituto de Astrofísica de Andalucía, IAA-CSIC



The SKA project

Open key questions in Astrophysics,
Astrobiology and Fundamental Physics



SKA1-Mid

the SKA's mid-frequency telescope



Location: South Africa



Frequency range:
350 MHz
to
15.4 GHz
with a goal of 24 GHz



197 dishes
(including 64 MeerKAT dishes)



Maximum baseline:
150km

SKA1-Low

the SKA's low-frequency telescope



Location: Australia



Frequency range:
50 MHz
to
350 MHz



131,072
antennas spread between
512 stations

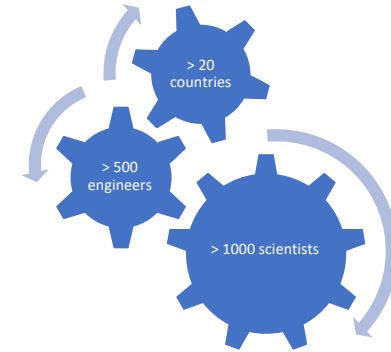


Maximum baseline:
~65km



The SKA Observatory journey

- 2008-2013 Preparatory Phase: system design and costing
- 2013-2020 Detailed design & pre-construction, Bridging



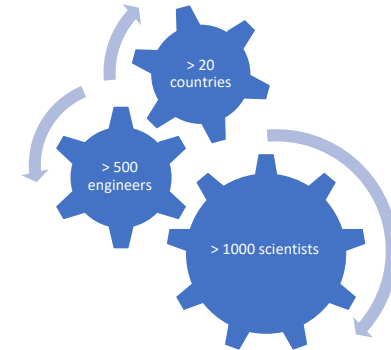
**1 Observatory
2 Telescopes
3 Continents**

Pre-construction dates

2013 DESIGN CONSORTIA FORMED	2015-2016 ELEMENT PRELIMINARY DESIGN REVIEWS	2016 SYSTEM PRELIMINARY DESIGN REVIEW	2018-2019 ELEMENT CRITICAL DESIGN REVIEWS	DECEMBER 2019 SYSTEM CRITICAL DESIGN REVIEW	EARLY 2020 INDEPENDENT COST REVIEW	MID 2020 OPERATIONS REVIEWS
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The SKA Observatory journey

- 2008-2013 Preparatory Phase: system design and costing
- 2013-2020 Detailed design & pre-construction, Bridging
- 2018: Spain joins the SKA Organisation
- Jan-2021: SKA Observatory establishment as IGO at first Council
 - Current membership:
 - 8 full members (AU, CN, IT, NL, PT, ZA, CH, UK)
 - 8 prospective members (CA, FR, DE, IN, JP, KR, ES, SE)

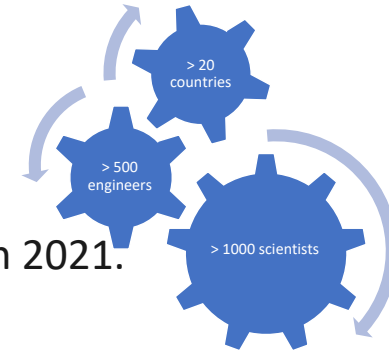


**1 Observatory
2 Telescopes
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The SKA Observatory journey

- 2008-2013 Preparatory Phase: system design and costing
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- Jan-2021: SKA Observatory establishment as IGO at first Council
- Jul-2021: Spain's membership to the SKA Observatory approved in 2021.

Accession process ongoing



**1 Observatory
2 Telescopes
3 Continents**



'El compromiso de España para la construcción del Observatorio es de 41,4 millones de euros durante los próximos diez años.'

Feb-2021



May-2022

Key Project Milestones

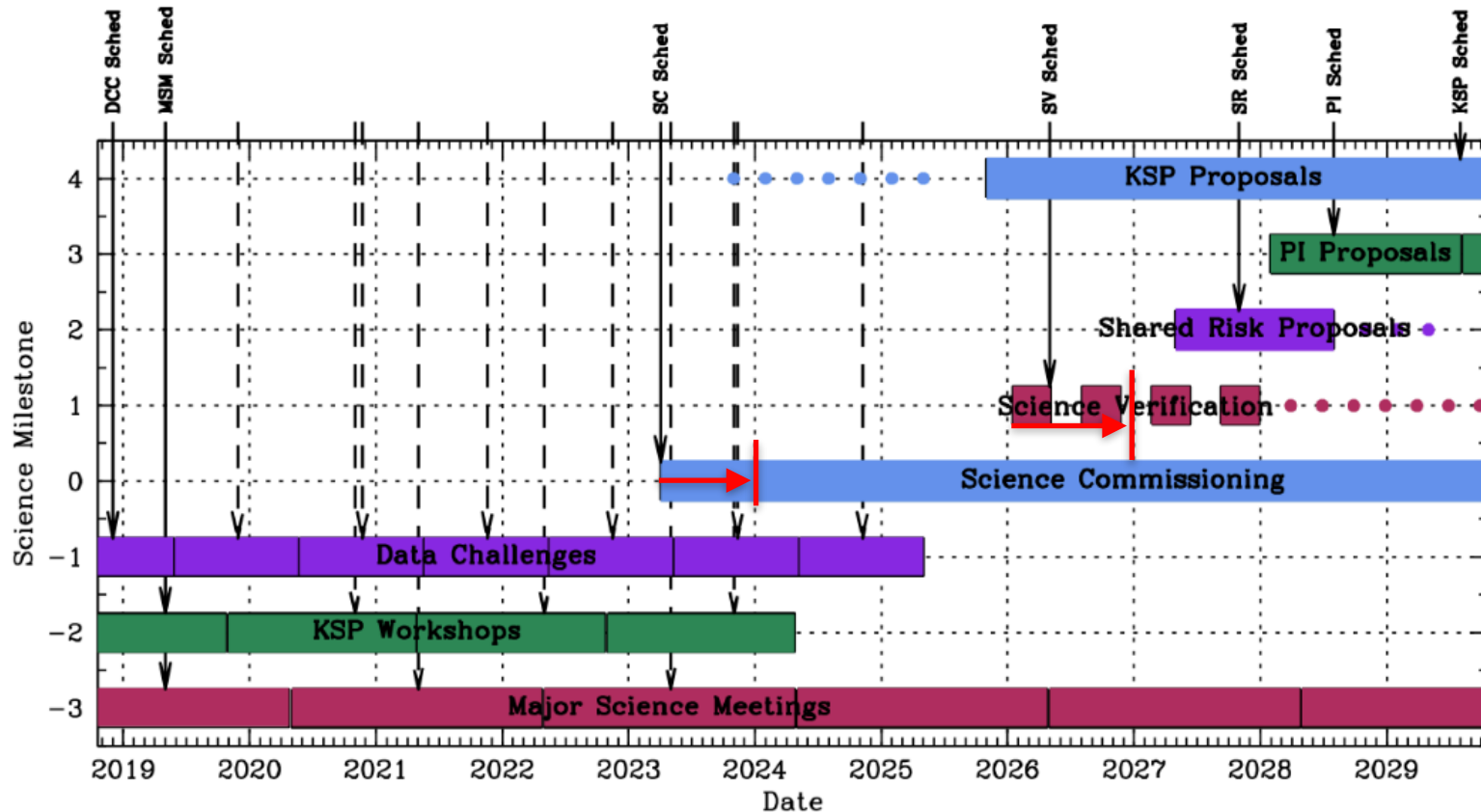
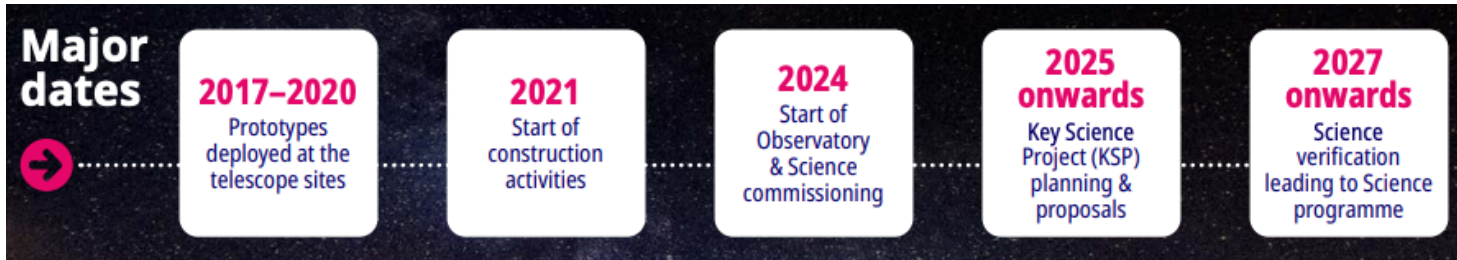
Key project milestones		
	SKA-Low	SKA-Mid
Start of construction (T0)	1ST JULY 2021	1ST JULY 2021
Earliest start of major contracts (C0)	AUGUST 2021	AUGUST 2021
Array Assembly 0.5 finish (AA0.5) SKA-Low = 6-station array SKA-Mid = 4-dish array	FEBRUARY 2024	MARCH 2024
Array Assembly 1 finish (AA1) SKA-Low = 18-station array SKA-Mid = 8-dish array	FEBRUARY 2025	FEBRUARY 2025
Array Assembly 2 finish (AA2) SKA-Low = 64-station array SKA-Mid = 64-dish array, baselines mostly <20km	FEBRUARY 2026	DECEMBER 2025
Array Assembly 3 finish (AA3) SKA-Low = 256-station array, including long baselines SKA-Mid = 133-dish array, including long baselines	JANUARY 2027	SEPTEMBER 2026
Array Assembly 4 finish (AA4) SKA-Low = full Low array SKA-Mid = full Mid array, including MeerKAT dishes	NOVEMBER 2027	JUNE 2027
Operations Readiness Review (ORR)	JANUARY 2028	DECEMBER 2027
End of construction	JULY 2029	JULY 2029

SKAO is preparing a staged procurement process, to reflect the arrival time of funds



Credit: Nasief Manie/SARAO

Scientific SKA timeline



High-level SKA Documents

- SKA Phase 1 Executive Summary

- <https://skao.canto.global/b/HU8H0>



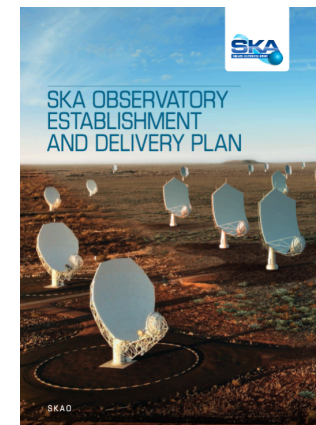
- SKA Phase 1 Construction Proposal

- <https://skao.canto.global/b/R3L6J>



- SKA Observatory Establishment and Delivery Plan

- <https://skao.canto.global/b/H75SN>



Scientific preparatory work: precursors and pathfinders

Northern hemisphere

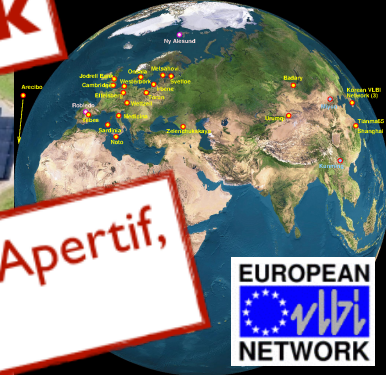
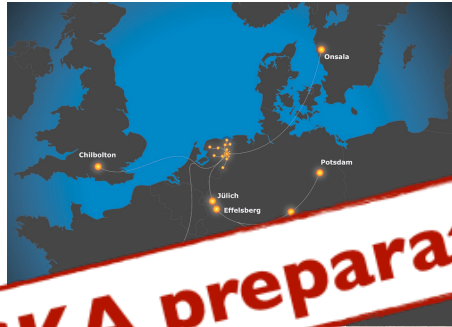
Jansky Very Large Array (JVLA, USA)



27 x 25m
(36km)

Low Frequency Array (LOFAR, Europe)

30 - 80, 120 - 240 MHz
100m - 15000 km



Crucial for SKA preparatory work

Not a complete list

Southern hemisphere

MeerKAT (South Africa)

64 x 13.5m
(8km)

GMRT (India)



GASKAP, WALLABY, MHONGOOSE, MIGHTEE, WEAVE-Apertif, LeMMINGs, POLAMI, LADUMA, LoTSS ...

Scientific preparatory work for SKA

- Participation in Science Working Groups
- Use of pathfinder/precursor telescopes
- Preparation for commissioning
- Exploitation of multiλ/multimessenger synergies



ASKAP (Australia)

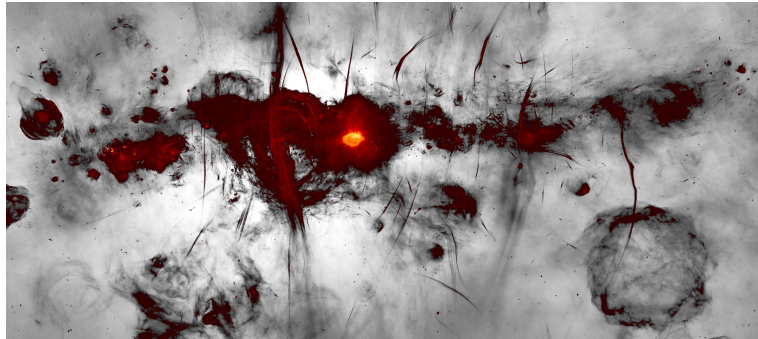
36 x 12m
(6km)

MWA (Australia) 80 - 300 MHz. 1.5 - 3 km



SKA precursors recent science 2022

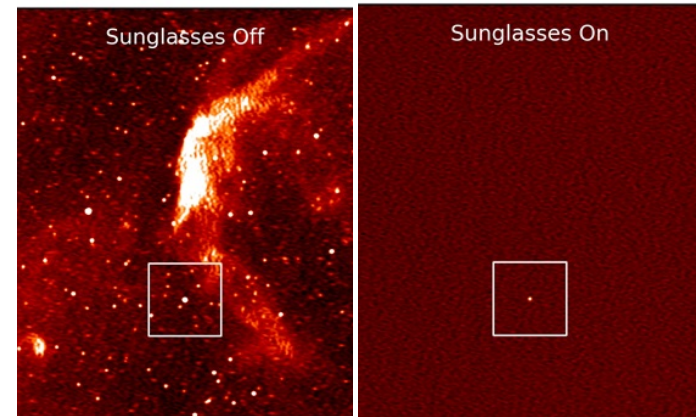
MeerKAT



01/2022: Deepest, most resolved image of Milky Way centre, public data release:

“The new MeerKAT image of the Galactic centre region is shown with the Galactic plane running horizontally across the image. Many new and previously-known radio features are evident, including supernova remnants, compact star-forming regions, and the large population of mysterious radio filaments. The broad feature running vertically through the image is the inner part of the radio bubbles, spanning 1400 light-years across the centre of the Galaxy. Colours indicate bright radio emission, while fainter emission is shown in greyscale.” Credit: I. Heywood et al. 2022, SARA0.

ASKAP



05/2022: Brightest ever pulsar found in Large Magellanic Cloud, using new systematic technique, looking for polarised light (instead of pulsar-flickering). Before, this was thought to be a distant galaxy, but now shown to be a rapidly rotating pulsar. Credit: Wang et al. 2022

Science: participation in SKA Science Groups



Cosmology

Cradle of Life

Epoch of Reionisation

Extragalactic Continuum

Extragalactic Spectral Line

Gravitational Waves

HI Galaxy Science

Magnetism

Our Galaxy

Pulsars

Solar, Heliospheric & Ionospheric Physics

Transients

VLBI

High Energy Cosmic Particles



More than 1000 researchers from around the world

CAB-INTA (CSIC)

CIEMAT

ESA-Madrid

IFCA-CSIC

IAA-CSIC

IAC

ICC-U. Barcelona

ICE IIEEC-CSIC

IFIC-CSIC/UV

IFT, UAM-CSIC

IRAM

OAN (IGN)

UAM

UGR

U. Politécnica de Cartagena

U. Salamanca

U. Santiago de Compostela

U. Valencia

Membership in SKA Science Groups:

	Members	SWGs	Co-Chairs	Centres
Spain	58	13*	3**	18

*out of 14

** aggregated value (2018-2022)

+14 new members since last SEA meeting (Jul 2020)



COORDINATION of the SPANISH PARTICIPATION in SKA

- Support to academic groups, industry & Ministry
- Dissemination & organisation of SKA activities
- Industry capacity map

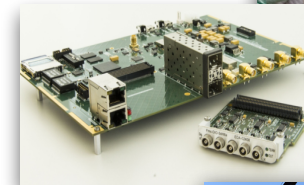
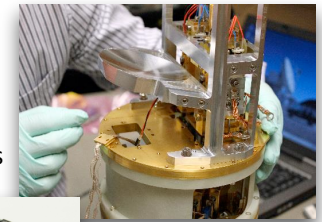
2020/22: Thematic network **RED-SKA:**

IAA-CSIC (PI), BSC, CAB INTA-CSIC, CEFCA, IAC, ICE IEEC-CSIC, IFCA-CSIC, IFIC-CSIC, OAN-IGN, UGR, UMA, UPM, USAL, USC, UV

Negotiation of construction contracts + CDTI + MCIN



Receivers



Distribution of time



Dish manufacturing

Spanish pre-allocated contracts	Tender starting date	Contract Award
LOW TIMING: UTC Distribution	03/10/2022	01/03/2023
MID TIMING: UTC Distribution	03/10/2022	01/03/2023
Band 5 Feed and OMTs	19/05/2023	22/09/2023
Band 1FPC Electronics	10/10/2022	16/01/2022
Dish sub-reflectors	24/08/2022	13/12/2022

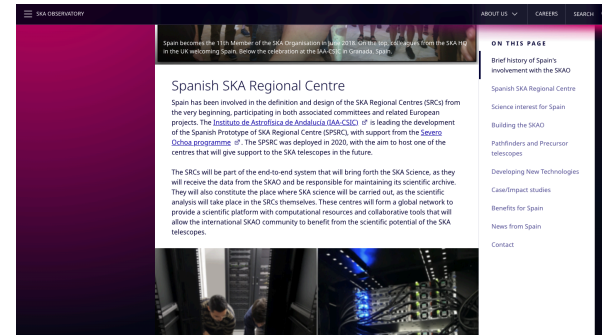
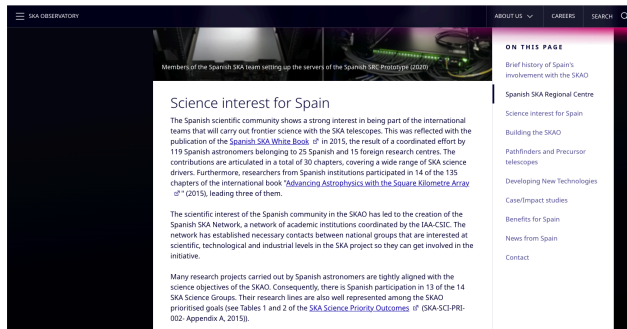
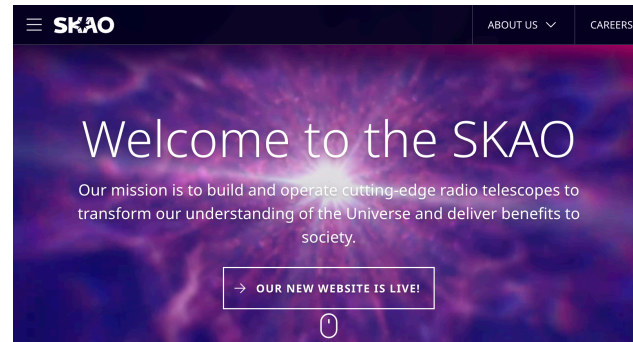
Outreach and communication

SKAO Communication Strategy document (for approval at next Council)

- The strategy covers the whole of construction (2022-2029)

New SKA Observatory website with a Spanish section on it:

- <https://www.skao.int/en/partners/prospective-members/398/spain>

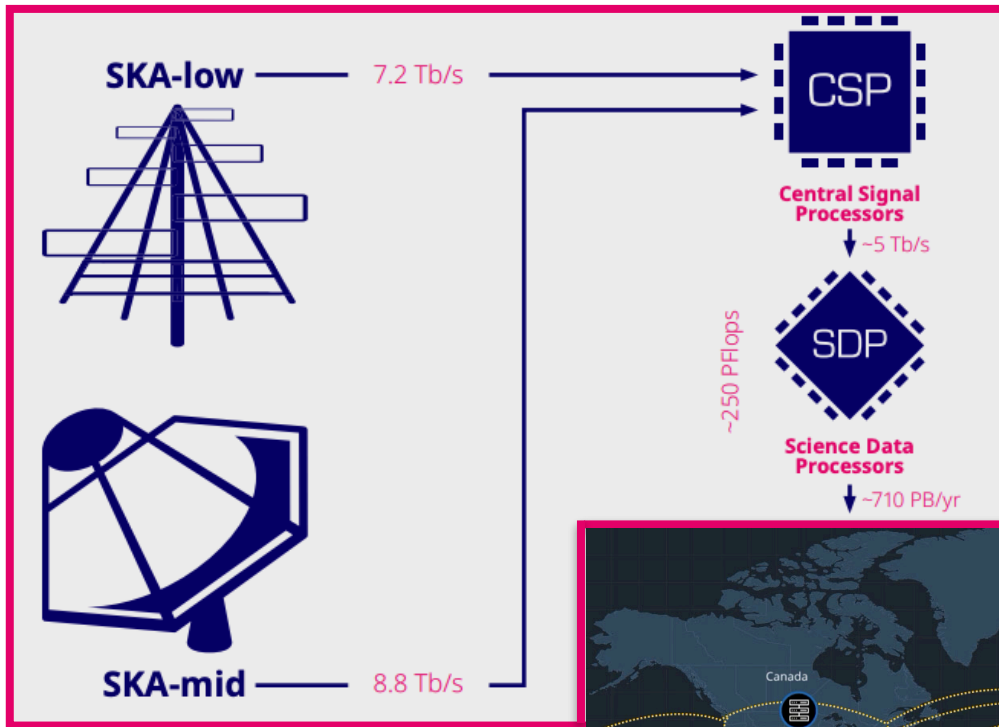


Collaboration with 'Aldeas Infantiles' NGO

- First activity to be held in November at Childhood's week
- Intention to keep the collaboration growing



The CHALLENGE: EXTRACTION of SCIENTIFIC KNOWLEDGE

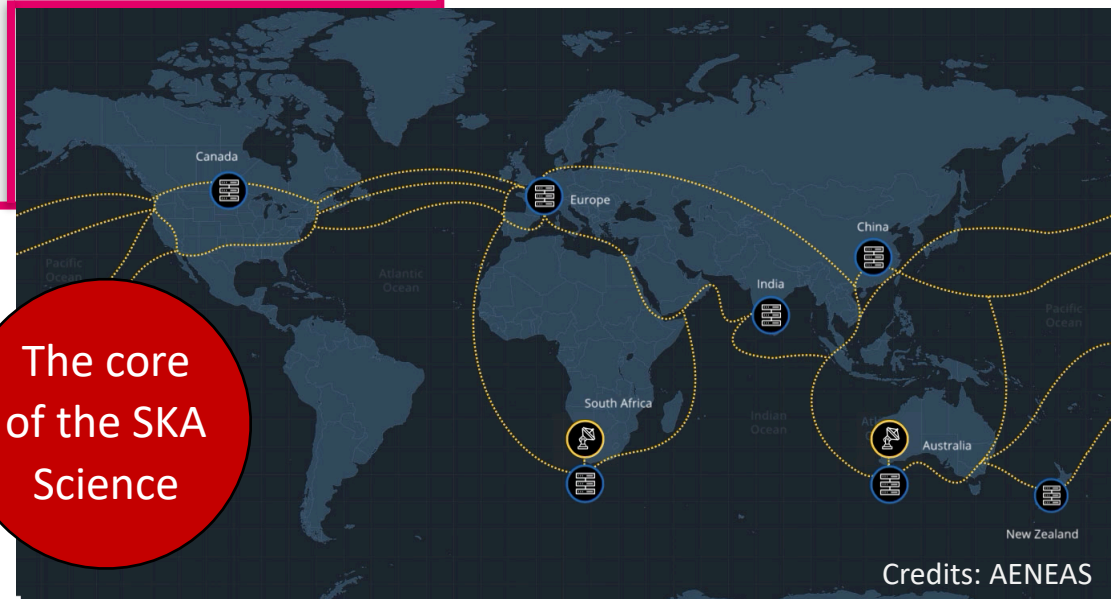


Credits: SKA Organisation

Credits: SKA Fact sheets. Aug 2018
skatelescope.org

SKA Regional
Centres

The core
of the SKA
Science



Credits: AENEAS

Technological challenges: Big-data, e-Science, Data management, Remote Scientific Data visualisation, Scientific Data Analysis Algorithms, AI, End-to-End reproducibility, Green computing, etc



SRC activities

- **SRCSC, SRC Steering Committee (March 2019-)**
 - Define and create a long-term operational partnership between the SKA Observatory and an ensemble of independently-resourced SKA Regional Centres.
 - **Formation of the 1st global network of SRC**
 - Formed by SKA country representatives
- Activities within the SRCSC Working Groups (2020-2022) focused on producing a **detailed view of the functionalities and requirements** for the SRC Network and design a high-level SRC Network architecture

SRCSC Working Groups → 12 members from 7 Spanish institutions in all of the groups

- WG0 - Architecture
- WG1 - Data Logistics
- WG2 - Operations
- WG3 - Software Processing/Work Flow
- WG4 - Science Archive/VO/FAIR
- WG5 - Compute
- WG6 - Science user engagement

Main outputs: SRC Network requirement gathering (206) and high-level architecture

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SRCSC Working Groups

WG6 - Science user engagement

- Engage the science community in tuning the requirements for the SRC network
- Guide the scientific community towards the new end-to-end procedures
- Currently arranged in three Task Packages:
 - TP1: identify and update a complete set of requirements using feedback from the User community
 - TP2: facilitate interaction between software developers and science users AND coordinate scientific validation of prototyping deliverables
 - TP3: coordinate set up of SRC capability challenges in conjunction with SKAO science data challenges

Third stage of the SRCSC activities started: SRCSC prototypes

- 5 prototypes have been defined that will be built by the members of the different protoSRC projects involved in the WGs.

- 1) **Data management.**
- 2) **Federated Authentication and Authorization.**
- 3) **Data processing Notebooks.**
- 4) **Visualisation.**
- 5) **Distribution of software, tools and services.**

SAFe
methodology
followed

- 9 agile international teams have been defined since April 2022:

5 teams focused on different components of the SRC Network

- Cyan team: data management
- Tangerine team: science data platform
- Orange team: visualisation technologies
- Olive team: HPC platforms
- Purple team: authentication and authorisation

2 teams that have not yet started their activity:

- Evergreen team: Hardware and network
- Blue Navy team: operations

2 teams in charge of building testbed to provide feedback and a formal assessment of the technologies

- Blue-Lavender team: testbed to provide feedback
- Coral team (led by SPSRC): testbed to provide feedback

AN SKA REGIONAL CENTRE PROTOTYPE AT THE IAA

Beyond a computing cluster

Hardware

A cloud-computing service
Storage

Software

VO Archive
Collaborative analysis tools

Services

User support

Training: radioastronomy,
software, Open Science

← Interoperable →



More details in the SRC's session

Support **preparatory scientific activities** for SKA Key Science Projects with precursors/pathfinders

Following best practices:
Open Science and **FAIR** principles

Transversal, wavelength agnostic



Coordinator: Lourdes Verdes-M (LVM), Technical lead: Susana Sánchez (SS)

Instituto de Astrofísica de Andalucía, IAA-CSIC

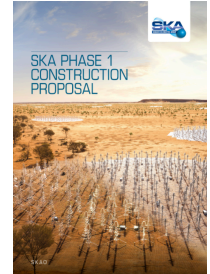


Open Science at SKA Observatory

- SKA Phase 1 Construction Proposal

“Open Science, based on the precept of making scientific research collaborative, transparent and accessible to all, is rooted in SKA’s foundational principles. So is the related concept of scientific reproducibility, a fundamental aspect of the modern Scientific Method since the 17th century allowing independent teams to have access to methodology and tools to be able to confirm experiments and validate results.”

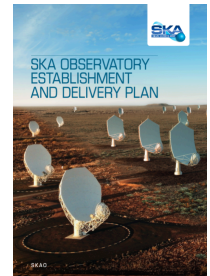
Adoption of Open Science values



- SKA Observatory Establishment and Delivery Plan:

“reproducibility of SKA science data products. This metric will measure how complete the workflow description is that is linked to each SKA data product. ... completeness of the provenance information for each data product and accessibility of the software used. This is related to how well SKA science data products adhere to the FAIR principles .”

Reproducibility as a metric of success



- Talk at the United Nations 75th General Assembly



- Open Science for sustainability and inclusiveness: the SKA role model

- First SKA Open Science school (late 2022)

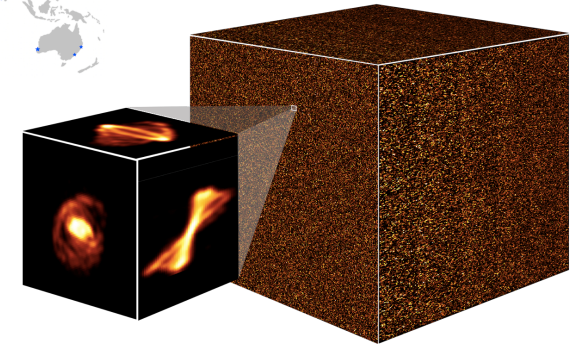


SRC Activities: SKA Data Challenge 2

Source finding and source characterisation data challenge on a simulated SKA HI data product (1TB size) across a sky area of 20 square degrees.

40 teams registering to take part.
In total, 276 participants representing 80 institutes and 23 countries

Credits: SKA Observatory



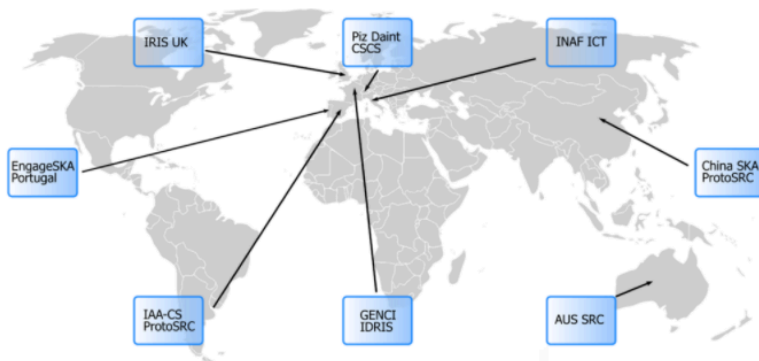
Winner: MINERVA team (France).
Spanish team: 5th place

Reproducibility award classification:

Gold: [HI-FRIENDS](#)

Silver: [Team SoFiA](#); [FORSKA-Sweden](#)

Bronze: [EPFL](#); [NAOC-Tianlai](#); [SHAO](#)



Above: Map of high-performance computing centres involved in SDC2. Eight facilities are involved, including two prototype SRCs.

Credit: SKAO/Philippa Hartley

8 nodes giving services to the SDC2,
2 of them (Australian and Spanish)
being SRC prototypes

SRC Activities: SKA Data Challenge 3

SDC3 will consist of two tiers:

SKA Data Challenge 3: epoch of re-ionisation - Foregrounds EoR foreground subtraction and 21cm Power Spectrum Extraction.

Input data:

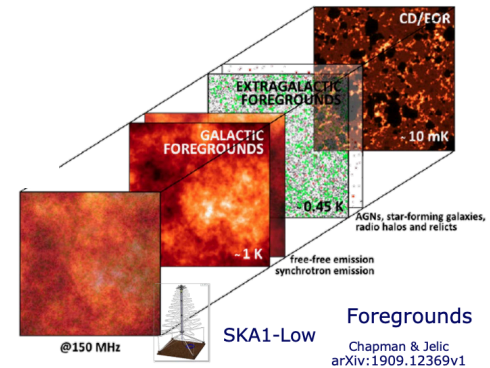
- Calibrated visibilities and high fidelity images.

Goals:

- Remove the point source + diffuse foregrounds
- Extract the spherical and cylindrical power spectrum

Dates:

- Autumn 2022, 6 months duration



SKA Data Challenge 3: epoch of re-ionisation - Interference Extraction of re-ionization parameters

Input data:

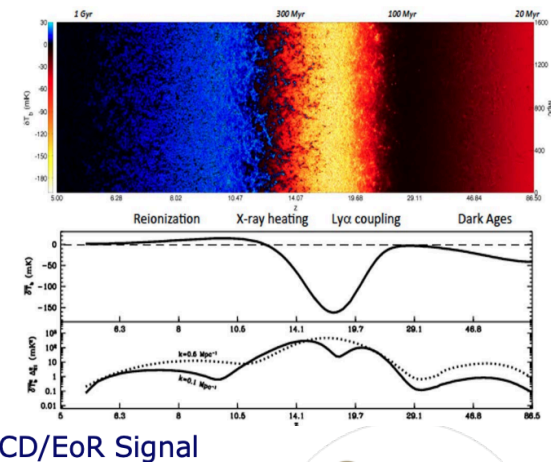
- EoR PS + noise and residual foreground contamination

Goals:

- Extract the IGM and source properties

Dates:

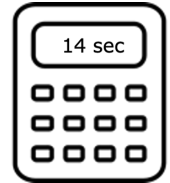
- During 2023, 6 months duration



The user experience

Up to the point of data delivery:

- Users will request observations AND data products at the proposal stage
- Users will have access to all of the information and planning tools to accurately determine their requirements (e.g. Mid sensitivity calculator is being now developed)

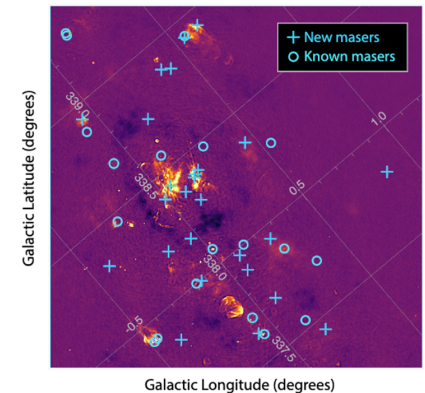


Data delivery and beyond:

- Data will be queued from SDP (up to 2 weeks), to be sent to the SRC network
- Once passed Q&A, raw and intermediate data will be deleted
- Data Products will be made public after proprietary period

When users get to the SRC Network:

- Visualise huge data sets, create advanced data products, conduct other analysis
- Both of these activities will include astronomers bringing their own scripts and workflows to the Network
- Compare with other SKA data products or those from other facilities
- Archive users



Credit: Based on Shari Breen's presentation (SKAO, 2022)

Questions?

- Slides: <https://doi.org/10.5281/zenodo.7042854>
- jgarrido@iaa.es

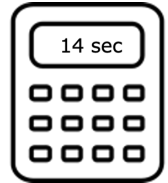


Questions?



SKAO Data products

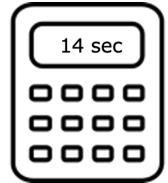
- Observatory Data Products (ODPs):
 - Observation-level data products (OLDPs) are calibrated data products generated by SDP workflows and are based on data obtained from a single execution of a scheduling block (SB).
 - Project-level data products (PLDPs) are calibrated data products generated by combining several, related, observation-level data products, delivering the requirements of the PI as outlined in their original proposal
- Advanced Data Products (ADPs): These are the user-generated products, produced through the detailed and rigorous analysis and modelling of Observatory data products (either at the observation or project level). The generation of ADPs will usually require some level of interactive visualisation and examination of data, as well as comparison to data from other SKA observations or other facilities.



Reference: https://astronomers.skatelescope.org/wp-content/uploads/2021/06/SKA-TEL-SKO-0001818-01_DataProdSummary-signed.pdf

SKAO Data products

- Observation-level data products (OLDPs) are calibrated data products generated by SDP workflows and are based on data obtained from a single execution of a scheduling block (SB).
 - Image Products (Image Cubes, uv grids)
 - Calibrated visibilities
 - Local Sky Model catalogue.
 - Imaging Transient Source Catalogue
 - Pulsar Timing Solutions
 - Transient Buffer Data
 - Sieved Pulsar and Transient Candidates
 - Science Alerts Catalogue
 - Science Product Catalogue



Reference: https://astronomers.skatelescope.org/wp-content/uploads/2021/06/SKA-TEL-SKO-0001818-01_DataProdSummary-signed.pdf