The SKA Observatory

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Outline of the talk

- The SKA Observatory
- Overview of the SKA science
- Some SKA technical challenges

SKAO at a glance

- A new Intergovernmental Organisation for astronomy and fundamental physics with 50+ year lifetime
- SKAO is now:
 - $\circ~$ February 3-4, 2021: first SKA Observatory Council
 - $\,\circ\,$ July 1st, 2021: construction activity began
 - $\circ~$ December 5, 2022: SKAO Construction Commencement Ceremonies





- A mega-science facility of the 21st century to provide capabilities to transform our understanding of the Universe
 - A very wide variety of science cases and associated science data products
 - $\circ~$ Diverse and complex workflows to run on Big Data





SKA Phase 1

- <u>SKA-LOW</u> (50-350 MHz) : **131072 log periodic antennas, spread across** 512 stations Maximum distance between stations: 74 km
- <u>SKA-MID</u> (350 MHz 15.4 GHz) : 197 fully steerable dishes, including the existing 64 MeerKAT dishes Maximum distance between dishes: 150 km
- <u>SKA-HQ</u> : SKAO headquarters located on the UNESCO World Heritage Site of Jodrell Bank
- <u>SRC-Net</u> (SKA Regional Center Network) : a world wide network of data/computing centers





Image/Video courtesy: SKAO, H2020 AENEAS project

Construction strategy

- Target: build the SKA Baseline Design (AA4)
- Not all funding yet secured, therefore following Staged Delivery Plan (AA*)
- Develop the earliest possible working demonstration of the architecture and supply chain (AA0.5)
- Then maintain a continuously working and expanding facility that demonstrates the full performance capabilities of the SKA Design
- At the end of 2026, SKAO becomes the most powerful radio observatory on Earth



Milestone Event (earliest)		SKA-Mid (date)	SKA-Low (date)
AA0.5	4 dishes 6 stations	2025 Nov	2024 Jul
AA1	8 dishes 18 stations	2027 Jan	2026 Jan
AA2	64 dishes 64 stations	2027 Dec	2026 Nov
AA*	144 dishes 307 stations	2028 Sep	2028 May
Operations Readiness Review		2029 Jan	2028 Jul
End of Staged Delivery Programme		2029 Mar	2029 Mar
AA4	197 dishes 512 stations	TBD	TBD





The magnetised Cosmos

- Radio astronomy: uniquely suited to study cosmic magnetism
 - Synchrotron emission
 - <u>Faraday rotation</u>
 - Faraday tomography
 - Zeeman splitting
- Why we care about a proper knowledge of cosmic magnetic fields?
 - <u>Astrophysics</u>: huge impact on a variety of physical processes in galaxies and large-scale structures
 - <u>Cosmology</u>: relevant for modelling of polarised Galactic foregrounds in the search for B-mode polarisation patterns associated to gravitational waves from inflation









Galaxy formation and evolution

Courtesy: Mark Sargent (co-chair Extragalactic Continuum SWG)



SFH - non-thermal processes & AGN/galaxy co-evolution

band 2/1, ≤0.5" resolution duration: ~2 years





SFH - thermal processes & AGN/galaxy co-evolution

band 5 (~10 GHz), ~0.1" resolution duration: ~6 months









Fernàndez et al. 2013; Staveley-Smith & Oosterloo 2015; Oosterloo (HI Science Working Group)

The emergence of galaxies



Image credit: M. Bianco Slide courtesy: SKAO

Pulsar Timing Array (PTA)



Searching for the unknown



SKAO data processing stages



SKA project milestones & Dependencies for the SRC Net development



SRCNet essential functions

- To give SKA users access to SKA data, in compliance with the SKA data access policy
- To provide the computational and data management resources for the archiving of SKA data
- To provide SKA users with processing infrastructure to enable the scientific analysis of SKA data
- To form a federated environment which allows transparent data access across the SRC network, giving access to data products across the global science archive to all member of the SKA community
- To provide users with local user support
- Some regions may wish to provide additional, non-essential functions through their local SRC (e.g., regional point of contact; outreach and publicity; development activities). Such additional functions are optional and at the discretion of the regions



Towards the **fr** SRC



MINISTÈRE DE L'ENSEIGNEMENT SUPÉRIEUR ET DE LA RECHERCHE

Liberté Égalité Fraternité

> Service de la Stratégie de la Recherche et de l'Innovation

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Le Chef de Service

à

Chiara FERRARI Directrice SKA-France

Objet : constitution du nœud français du SKA Regional Center européen du Square Kilometer Array Observatory

Madame la Directrice,

La France a décidé le 15 décembre 2020 de devenir membre du Square Kilometer Array Observatory. Cette infrastructure de recherche est en cours de construction. Sa modularité en permet le déploiement progressif d'ici à 2027. Ainsi, de premiers jeux de données sont attendus pour 2024 avec un embryon d'observatoire opérationnel doté d'un petit nombre d'antennes sur les sites sud-africain et australien. SKA requiert de façon parallèle un déploiement progressif des SKA Regional Centers dont la constitution ne figure pas au budget de SKAO. Il relève de la responsabilité des pays membres d'apporter les moyens nécessaires, en coordination avec SKAO et, au minimum, à proportion de leur part dans le budget de SKAO.

Les partenaires de SKA-France disposent de ressources, humaines et matérielles, susceptibles de répondre partiellement ou intégralement à la contribution attendue de la France en stockage, calcul et mise à disposition des données de SKA. Le SSRI, pour le MESR, confie à SKA-France et ses membres le soin de mener une étude dont l'objectif est d'exprimer les besoins nécessaires à cette contribution française. Vous pourrez commencer par faire un état des lieux des contributions possibles dés 2024, puis préciserez les ressources manquantes, en prenant en compte les infrastructures numériques disponibles ou auxquelles vous pourriez avoir accès d'ici à 2028. Cette étude précisera quelle coordination est envisagée avec les autres pays européens participant à SKAO et à ce proiet de SRC européen.

Dans l'attente des résultats de cette étude, je vous prie de croire, Madame la Directrice, à mes meilleurs sentiments.

Cyril MO Chef du Service de la stratégie de la recherche et de l'innovation

Direction générale de la recherche et de l'innovation

Objectives of the FR-SRC

- Contribute to the SRC Net at an appropriate level within the SKAO IGO
- Enable French scientists to lead/contribute to future SKA projects (KSP and PI)
- Meet the needs of the French (radio) astronomical community
- Provide to the French community the necessary access and support to SKA and pathfinders/precursors data



FR-SRC in the national landscape

- Synergies with:
- SKA Precursors/Pathfinders + Multi-messenger projects
- Unique services provided to the international community by CDS
- Federated, distributed resources building upon:
- Regional sites (OSUs, regional data centres, ...)
- National infrastructures & GENCI
- Dedicated communication network (RENATER)
- Human capital critically needed as well as collaborations with digital research and engineering communities, e.g.
- NumPEX (Le Numérique pour Exascale)
- ECLAT (Extreme Computing Lab for Astronomical Telescopes)









Aladin Lite in the prototype SRCNet Science Gateway





Vision, strategy and initiatives at European level



S Consortium Overview

- Coordinator
- EGI Foundation
- Research Infrastructure representatives
- · LHC: CERN, INFN
- SKA: CRNS/OCA
- LOFAR: NWO-I through ASTRON
- e-Infrastructure representatives
- FZJ (HPC Exascale and quantum computing)
- CINECA (HPC & Quantum)
- SURF (HTC, HPC, Cloud)
- (also EGI Foundation, INFN)



S Key Data

Duration: 30 months

Start date: 1 Jan 2024 - End date: 30 June 2026

Partners: 9 partners + 1 affiliated

Budget: 2,449,542.50€

Funding Source: Horizon Europe - Call HORIZON-INFRA-2023-DEV-01-05

• Preparation of common strategies for future development of RI technologies and services within broad RI communities

S Project Vision and Overall Objective

VISION

Data-intensive scientific collaborations have access to a European exabyte-scale research data federation and compute continuum

PROJECT OVERALL OBJECTIVE

Deliver a **Strategic Research, Innovation and Deployment Agenda (SRIDA)** which defines the vision, overall goals, main technical and non-technical priorities, investment areas and a research, innovation and deployment roadmap for data-intensive science and infrastructures

14/12/2023 | SPECTRUM PreKOM (online)

Spectrum management & low-earth orbit mega-constellations



Satellites Behind Pinnacles Image Credit & Copyright: <u>Joshua Rozells</u>





Conclusions of the talk

• The SKA Observatory

- A new Inter-Governmental Organisation for ground-based astronomy
- o Construction started in July 2021 and proceeding at pace
- At the end of 2026, SKAO will become the most powerful radio observatory on Earth

Overview of the SKA science

- After a 30-year journey since first conceptual ideas were floated, SKAO science is now clearly on the horizon
- o Important preparatory activities of pathfinder and precursor telescopes
- o SKAO will produce unique science

• Some SKA technical challenges

- o A mega-science facility of the 21st century with diverse and complex workflows (HDA, HPC, AI)
- Need of an end-to-end partnership for SRCs
- o Spectrum management issues related to constellations of satellites



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