



Big Science for National and Regional Unity

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First Pan-African Astro-Particle and Collider Physics Workshop

21 to 23 March 2022

<https://indico.tlabs.ac.za/event/109/>



Presentation outline

- National Values and Principles of Governance - Kenya
- Big Science
- Examples of big science projects
- Specific example – CERN
- Current big science in Africa – The SKA project
- Way forward for Africa



National Values and Principles of Governance

The national values and principles of governance include:

- (a) patriotism, **national unity**, sharing and devolution of power, the rule of law, democracy and participation of the people;
- (b) human dignity, equity, social justice, inclusiveness, equality, human rights, non-discrimination and protection of the marginalized;
- (c) good governance, integrity, transparency and accountability; and
- (d) sustainable development.



National Values and Principles of Governance

The national values in Kenya:

2. National Unity

National unity is the deliberate decision to appreciate and work with others in pursuit of common goals.



Big Science

- Large scale instruments and facilities
- Huge funding by governments and international agencies
- Wide collaborations of scientists, engineers and technicians
- Some examples of big science
 - **Astronomy and Astrophysics** – Auger Observatory, Hubble Space Telescope, LIGO, **SKA**
 - Biological sciences - Human Genome Project
 - **High-energy physics** – **CERN** – **LEP, LHC**
 - Space science - Apollo program



European Organization for Nuclear Research - CERN

- **1949** – European Cultural Festival, Lausanne: L. de Broglie proposed the creation of a European science laboratory
- **1950** – 5th General Conference of UNESCO, Florence: Proposal by Isidore Rabbi unanimously adopted, authorising the Director General of UNESCO, "to assist and encourage the formation and organization of regional centres and laboratories in order to increase and make more fruitful the international collaboration of scientists ..."



European Organization for Nuclear Research - CERN

- **1952:**
 - 11 European governments sign an agreement setting up a provisional "Conseil européen pour la Recherche nucléaire" (CERN)
 - a site near Geneva is selected for the planned laboratory
- **1954:** The European Organization for Nuclear Research is formally created
- **1955:** Twelve founding Member States ratify the Convention: Federal Republic of Germany, Belgium, Denmark, France, Greece, Italy, Norway, The Netherlands, United Kingdom, Sweden, Switzerland and Yugoslavia



European Organization for Nuclear Research - CERN



1954: First excavation at Meyrin site



1955: First CERN council meeting



European Organization for Nuclear Research - CERN

- **1959**: Operation of the 28 GeV Proton Synchrotron (PS) – the world's highest energy particle accelerator (then)
- **1960**: PS inaugurated
- **1965**: CERN site extended over French Border
- **1976**: Super Proton Synchrotron (SPS) starts



N. Bohr



M. Willems, W. Hesienberg



European Organization for Nuclear Research - CERN

- **1981:**
 - Conversion of SPS into proton-antiproton collider 2 x 270 GeV
 - Start-up of the new Antiproton Accumulator ring (AA)
 - Member States authorise construction of the Large Electron-Positron collider (LEP) for an initial operating energy of 50 GeV per beam
- **1983:**
 - Discovery of the W- and the Z-bosons the carriers of the weak nuclear force - thus confirming the theory of electro-weak interactions and unifying the weak and electromagnetic forces
 - ground-breaking ceremony for LEP. Attended by the French and Swiss Presidents, Mr. François Mitterrand and Mr. Pierre Aubert.
 - LEP - largest scientific instrument ever constructed, with a circumference of 27 kilometers
- **1989:**
 - Inauguration of LEP
 - Discovery of the Z⁰ particle
 - Invention of the world wide web by T. B. Lee



European Organization for Nuclear Research - CERN



ALEPH – Apparatus for LEP Physics



L3



LEP – Large Electron Positron Collider at CERN



OPAL – Omni Purpose Apparatus for LEP



DELPHI - DEtector with Lepton, Photon and Hadron Identification



European Organization for Nuclear Research - CERN

- **1994**: CERN Council gave the go-ahead for the construction of the Large Hadron Collider (LHC) project
- **1999**: Number of member states of CERN reach 20
- **2000**: End of LEP operations to make way for the Large Hadron Collider (LHC)

The Twenty Member States of CERN

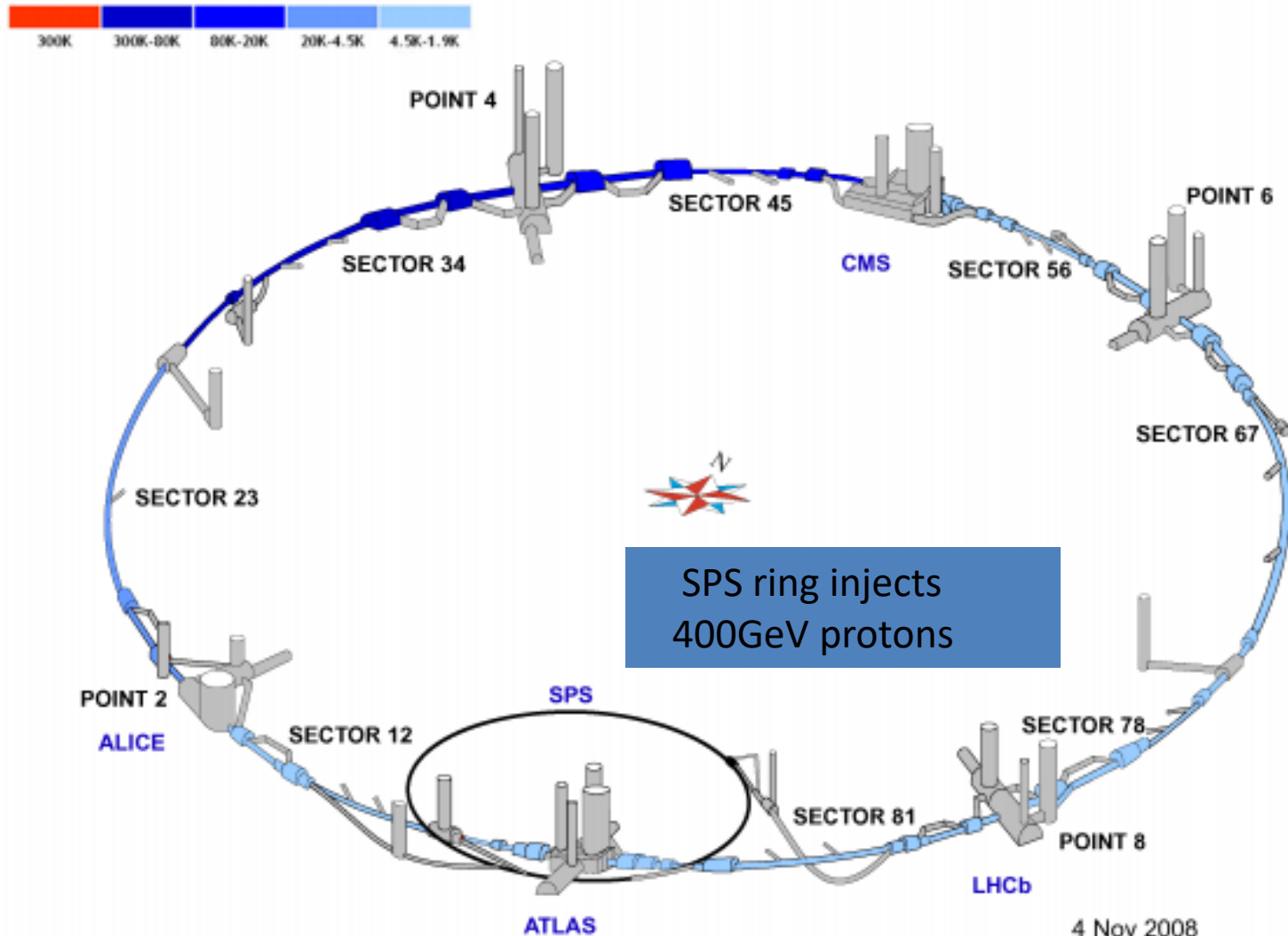


Member States (Dates of Accession)

AUSTRIA (1959)	DENMARK (1953)	GREECE (1953)	NORWAY (1953)	SPAIN (1/1961-12/1968-1/1983)
BELGIUM (1953)	FINLAND (1991)	HUNGARY (1992)	POLAND (1991)	SWEDEN (1953)
BULGARIA (1999)	FRANCE (1953)	ITALY (1953)	PORTUGAL (1986)	SWITZERLAND (1953)
CZECH FR (1993)	GERMANY (1953)	NETHERLANDS (1953)	SLOVAK FR (1993)	UNITED KINGDOM (1953)



European Organization for Nuclear Research - CERN



The Large Hadron Collider (LHC)

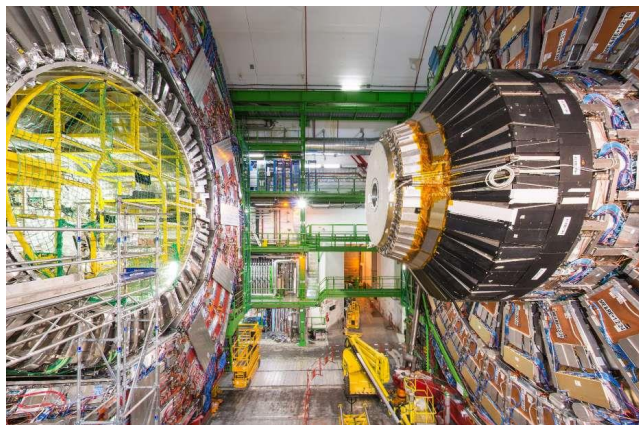
- Experiments:
 - ALICE
 - ATLAS
 - LHCb
 - CMS
- Collision of protons at 14 TeV
- Experimental evidence of the Higgs Boson in 2012



European Organization for Nuclear Research - CERN

Science goals of the LHC

- ✓ Higgs boson
- ✓ Beyond standard model – supersymmetry
- ✓ Grand unification, extra dimensions, dark matter



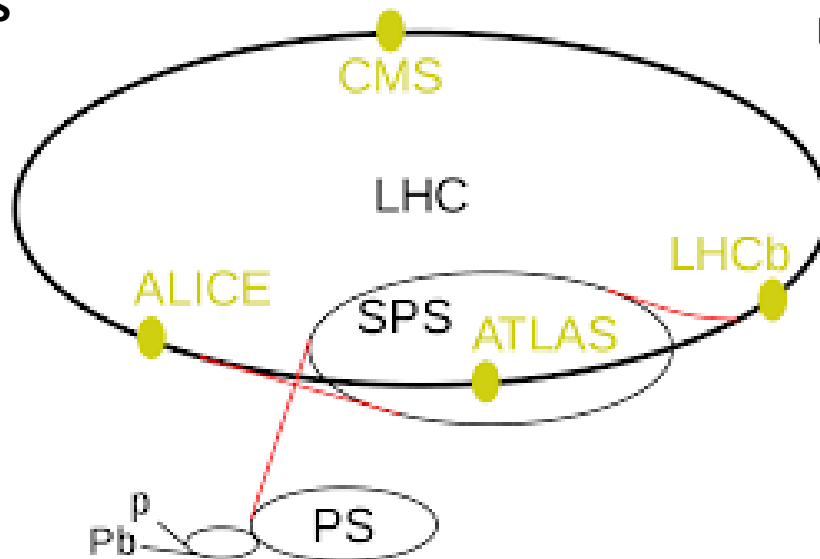
CMS



LHCb



ALICE



ATLAS



Physics with the ATLAS at the LHC



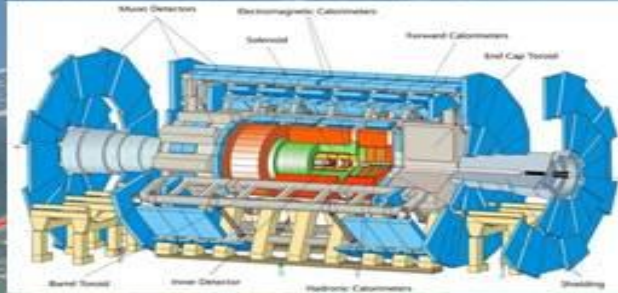
www.ku.ac.ke

Seminar by Dr. Simon K. Nderitu

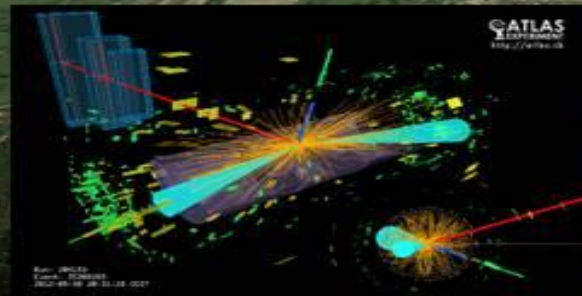
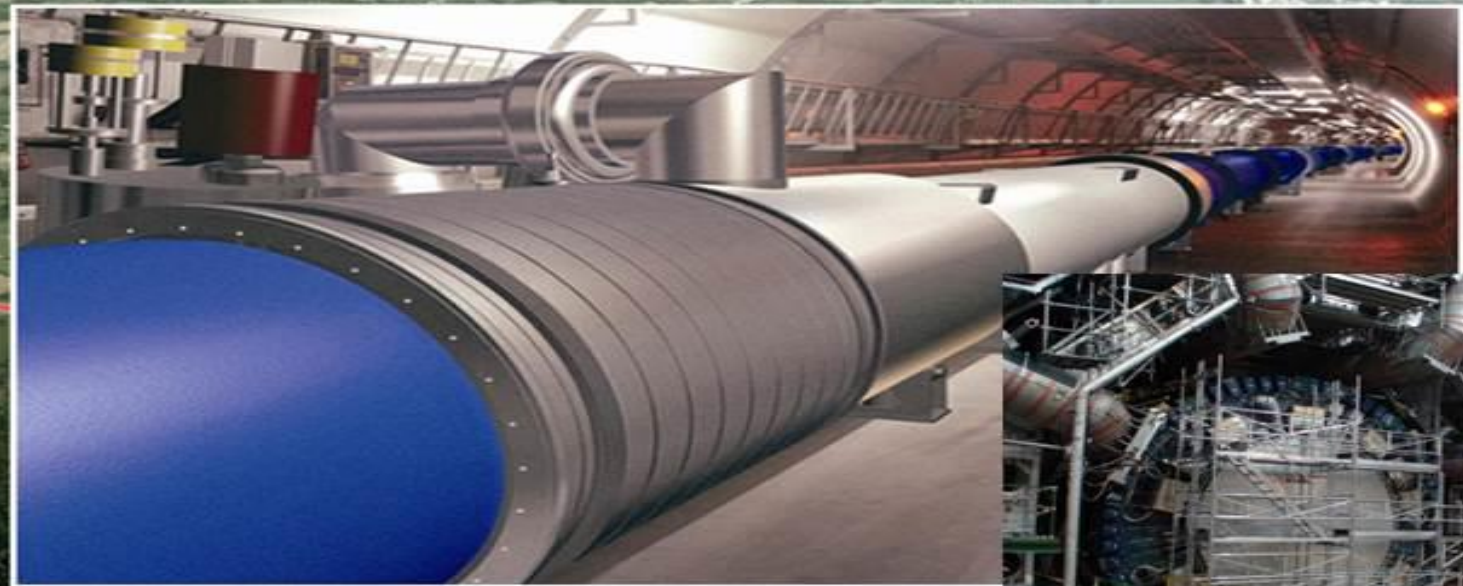
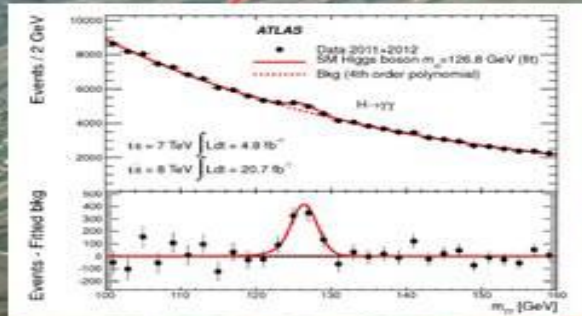
McGill HPC Centre,
McGill University, Canada

simon.nderitu@mcgill.ca

Wednesday 14th February 2018, 11am
Physics Department, Kenyatta University



<https://atlas.cern/>

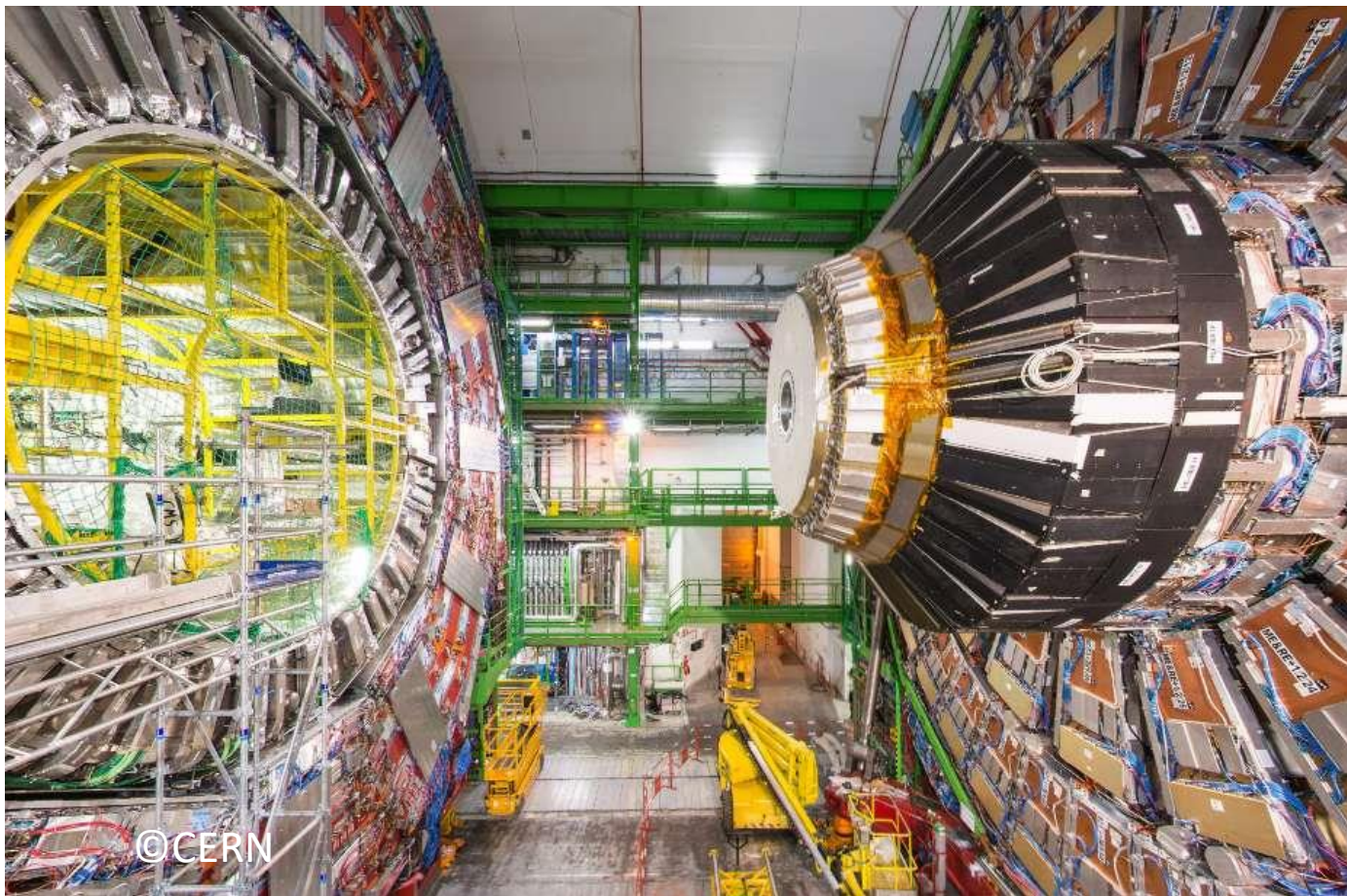


<http://home.cern/>



European Organization for Nuclear Research - CERN

CMS – Compact Muon Solenoid experiment



Sir Tejinder Virdee

- Born in Kenya
- Family migrated to UK
- Leader of the CMS experiment



European Organization for Nuclear Research - CERN

Physics Nobel Prizes for work done at CERN

- **1952: Felix Bloch and Edward Mills Purcell** "for their development of new methods for nuclear magnetic precision measurements and discoveries in connection therewith."
- **1976: Burton Richter and Samuel Chao Chung Ting** "for their pioneering work in the discovery of a heavy elementary particle of a new kind."
- **1984: Carlo Rubbia and Simon van der Meer** "for their decisive contributions to the large project, which led to the discovery of the field particles W and Z, communicators of weak interaction."
- **1988: Leon M. Lederman, Melvin Schwartz, Jack-Steinberger** "for the neutrino beam method and the demonstration of the doublet structure of the leptons through the discovery of the muon neutrino."
- **1992: Georges Charpak** "for his invention and development of particle detectors, in particular the multi-wire proportional chamber."
- **2013: François Englert and Peter W. Higgs** "for the theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles, and which recently was confirmed through the discovery of the predicted fundamental particle, by the ATLAS and CMS experiments at CERN's Large Hadron Collider."



SESAME - **Synchrotron-light for Experimental Science and Applications in the Middle East**

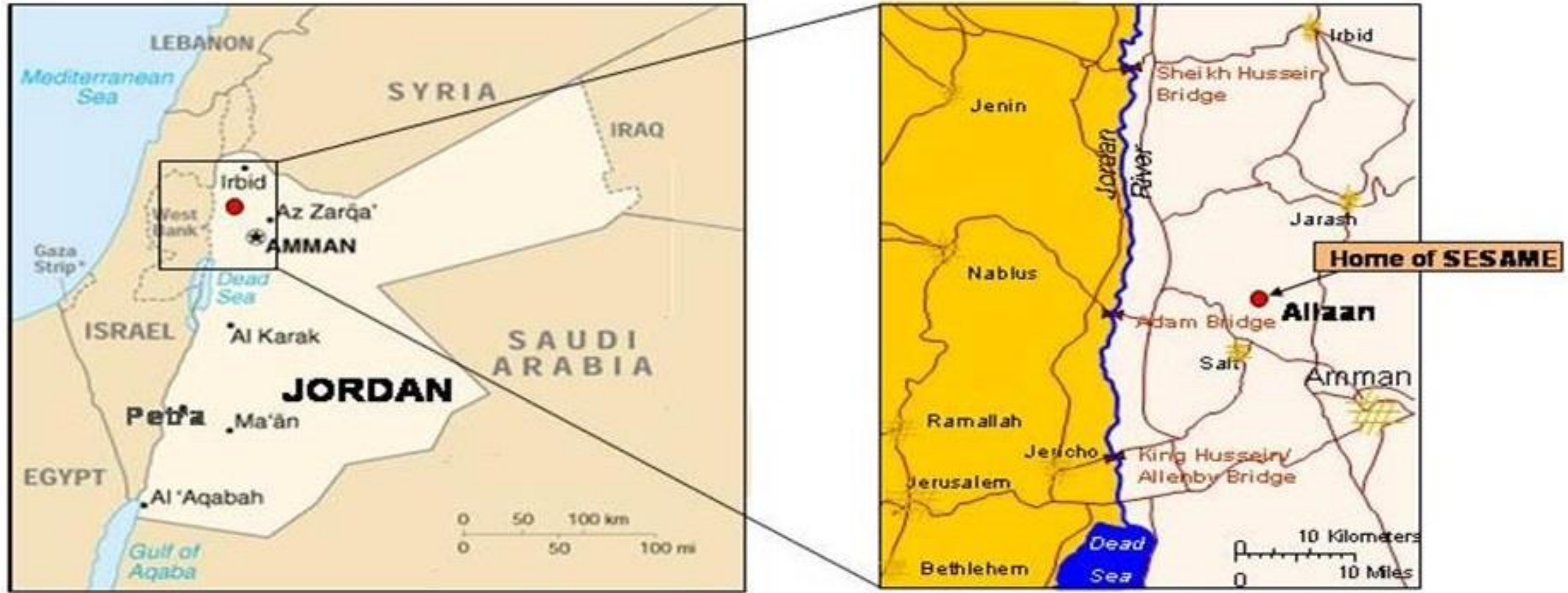
Conceived in the 1990s to:

- Enable construction of a facility beyond means of individual members
- Foster cooperation between peoples recently in conflict

Members: Bahrain, Cyprus, Egypt, Iran, Israel, Jordan, Pakistan, Palestinian Authority, Turkey



SESAME - Synchrotron-light for Experimental Science and Applications in the Middle East





SESAME - **Synchrotron-light for Experimental Science and Applications in the Middle East**



2003: Ground
breaking ceremony



SESAME - Synchrotron-light for Experimental Science and Applications in the Middle East



2008:

- 45 Nobel Laureates visit SESAME
- SESAME endorsed ***“as a beacon, demonstrating how shared scientific initiatives can help light the way towards peace”***



Big Science in Africa – The UHURU Satellite



- ❑ Also known as X-ray Explorer Satellite SAS A
- ❑ Launched on 12.12.1970 at the San Marco Platform in Malindi, Kenya
- ❑ First satellite dedicated to X-ray Astrophysics
- ❑ Discovery and detailed study of binary X-ray sources – Cen X-3, Vela X-1, Her X-1, Cygnus X-1



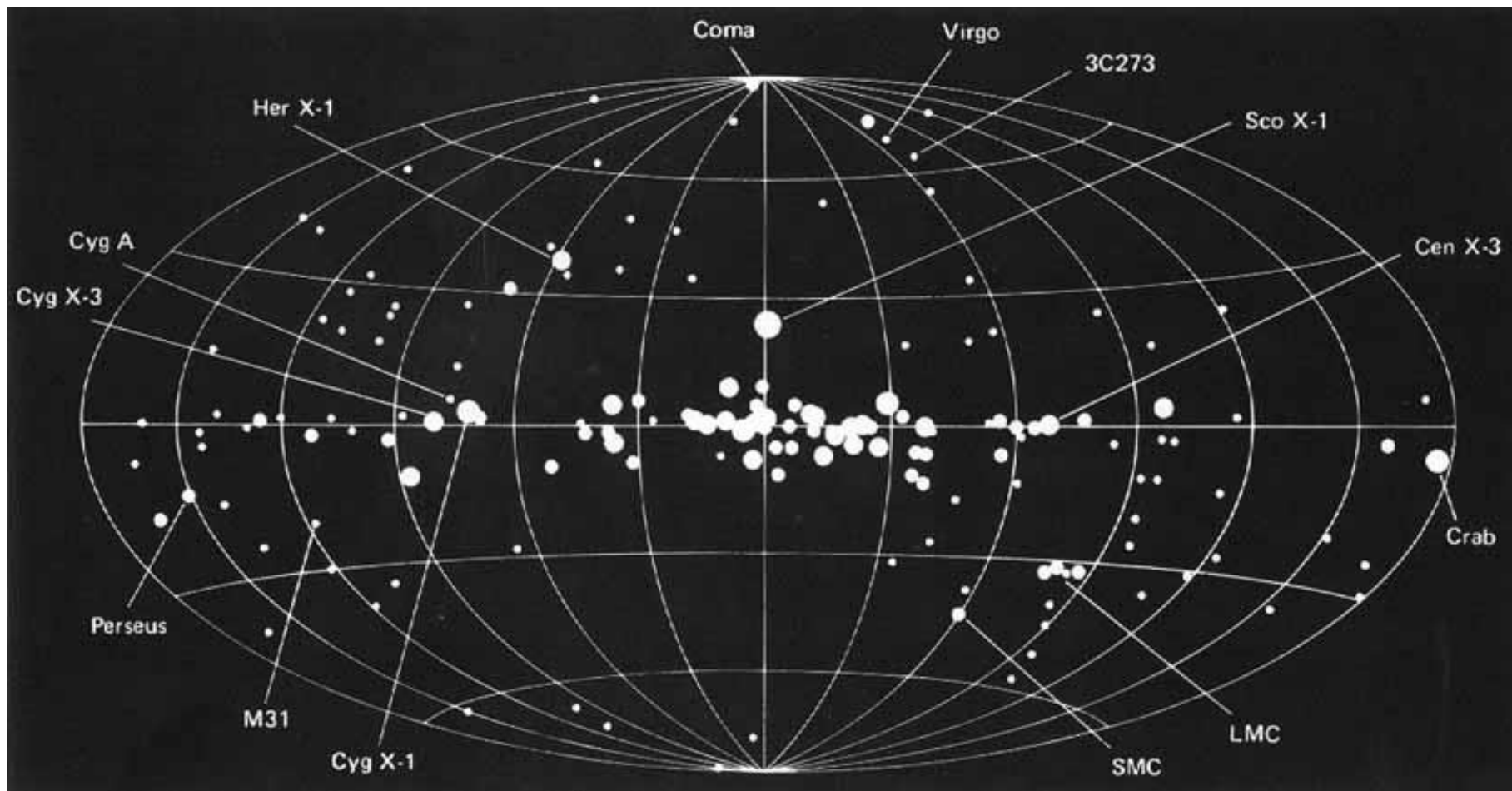
Big Science in Africa – The UHURU Satellite



The San Marco Launch
Platform in Malindi, Kenya



Big Science in Africa – The UHURU Satellite



The UHURU catalogue of X-ray sources

Physics Nobel Prize 2002



Raymond Davis Jr. and Masatoshi Koshiya "for pioneering contributions to astrophysics, in particular for the detection of cosmic neutrinos" and **Riccardo Giacconi** "for pioneering contributions to astrophysics, which have led to the discovery of cosmic X-ray sources."



Big Science in Africa – The UHURU Satellite



The UHURU catalogue of
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Big Science in Africa - The Square Kilometer Array (SKA)

- The world's largest array of radio telescopes to be operated in Africa and Australia
- 3000 dishes each about 15 m wide will be deployed to cover frequency range of 70 MHz to 10 GHz (4 m to 3cm wavelength)
- Collaboration of institutions in US, Europe, Africa, Asia and Australia-New Zealand
- Unprecedented performance in sensitivity and survey speed



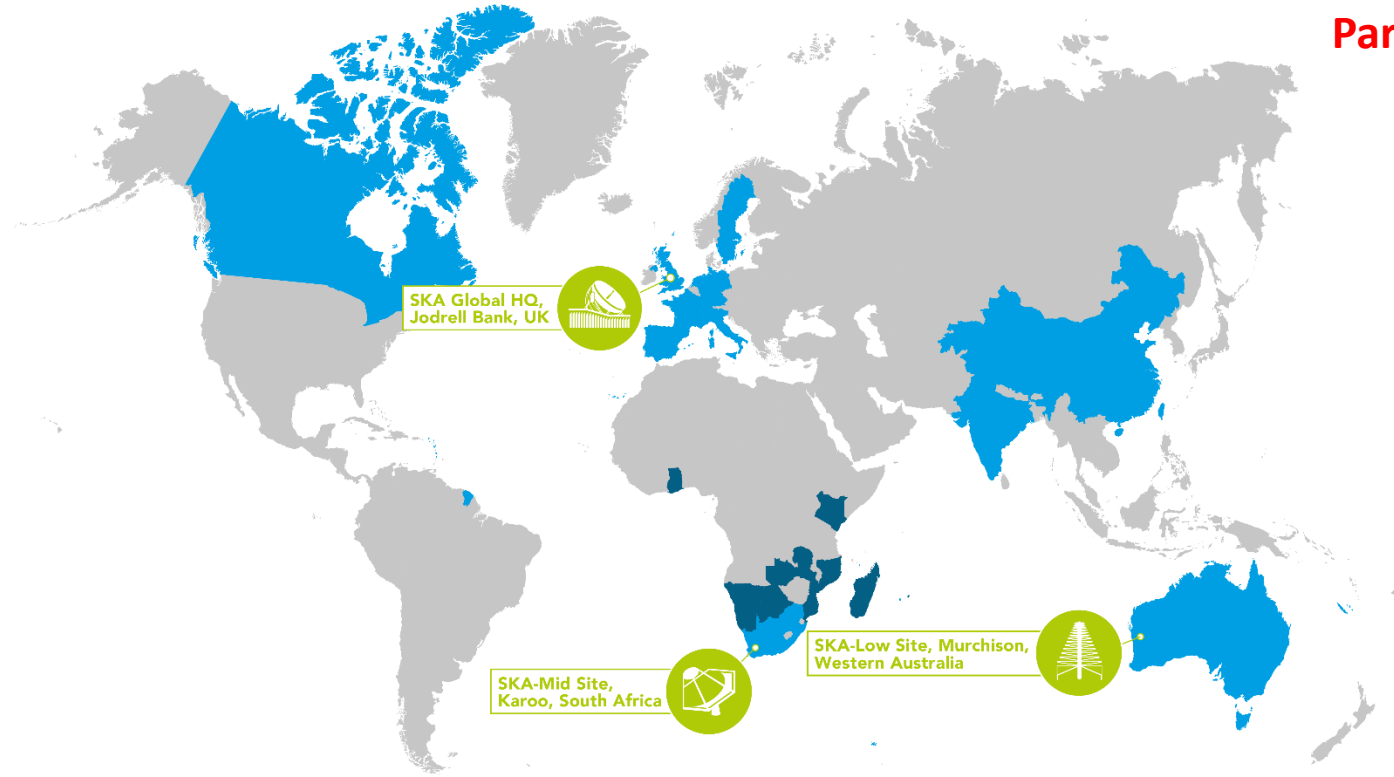
Member and Partner Countries of the SKA

SKA Partners

Australia
Canada
China
France
Germany
India
Italy
The Netherlands
Portugal
South Africa
South Korea
Spain
Sweden
The United Kingdom

Partner Countries in Africa

Botswana
Ghana
Kenya
Madagascar
Mauritius
Mozambique
Namibia
Zambia



SKA Partners – includes Members of the SKA Organisation, precursor to the SKAO –, current SKAO Member States*, and SKAO Observers (as of January 2022)



African Partner Countries



See updated list:

<https://www.skatelescope.org/participating-countries/>



Key Science Goals of the SKA

- ✓ Challenging Einstein
- ✓ Galaxy evolution, cosmology and dark energy
- ✓ Cosmic magnetism
- ✓ Probing the cosmic dawn
- ✓ the cradle of life / astrobiology
- ✓ Continuum surveys
- ✓ Radio transients
- ✓ Solar and heliospheric physics

More Information:

<https://www.skatelescope.org/science/>



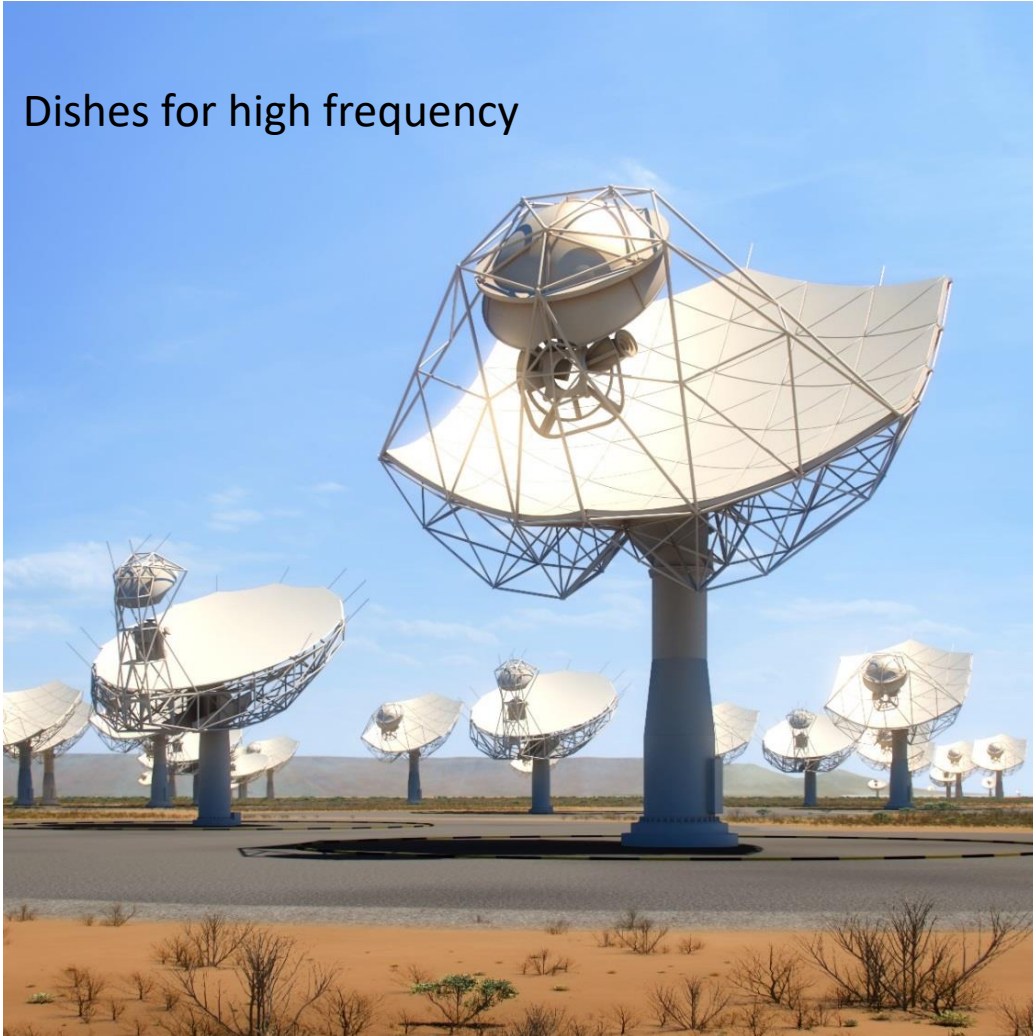
Current Long Baseline Networks

- ✓ **African Very Long Baseline Network (AVN)**
 - will modify existing but redundant large (30m) telecommunications dishes for astronomy
- ✓ **Joint Institute for VLBI in Europe (JIVE)**
 - a SKA Pathfinder founded in 1993
- ✓ **LOFAR telescope**
 - built by ASTRON in the Netherlands
 - a pathfinder for the SKA
 - currently the largest connected radio telescope currently in existence
- ✓ **Very Long Baseline Array (VLBA)**
 - uses ten dedicated, 25-meter telescopes
 - spanning 5351 miles across the United States
 - the largest radio telescope array
 - operates all year round as an astronomical instrument
- ✓ **European VLBI Network (EVN)**
- ✓ **East Asia VLBI Network (EAVN)**

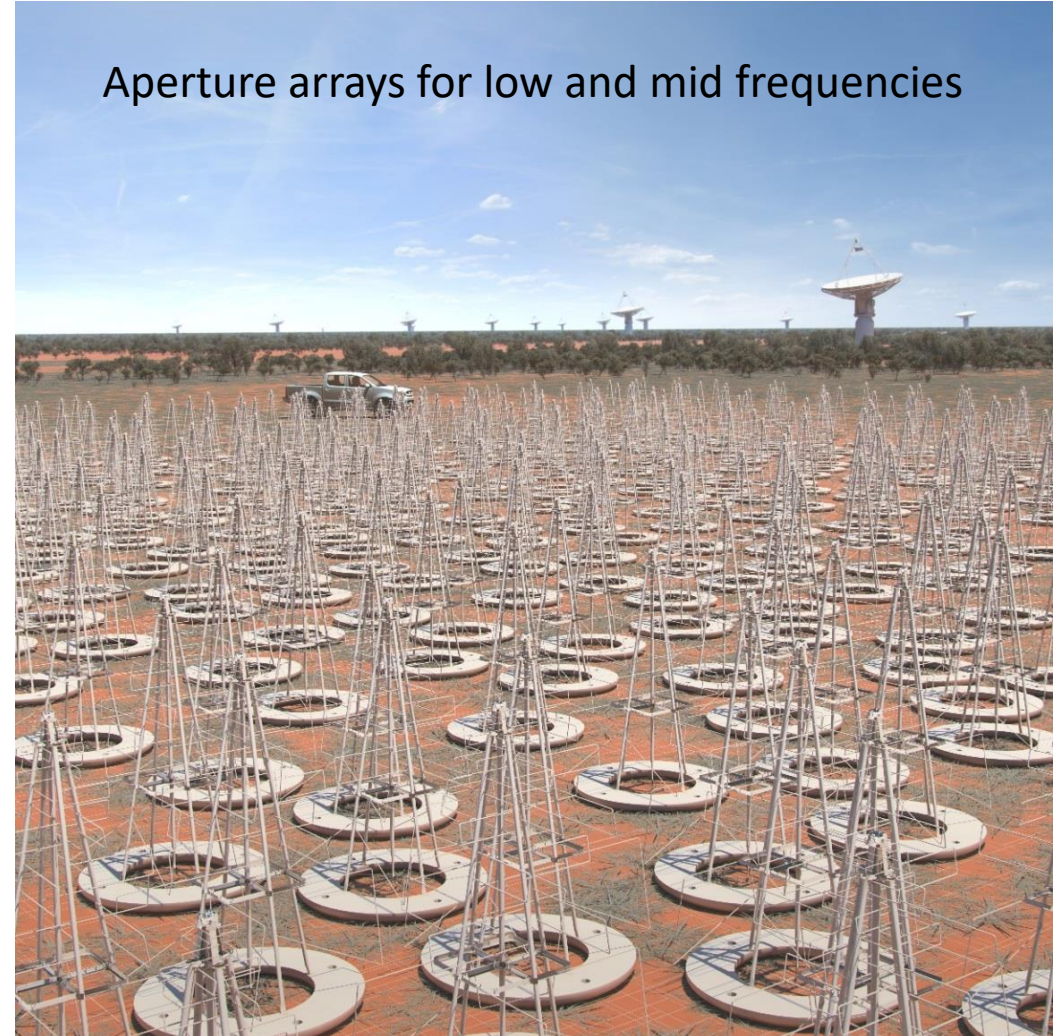


The Dishes and Aperture Arrays of the SKA

Dishes for high frequency

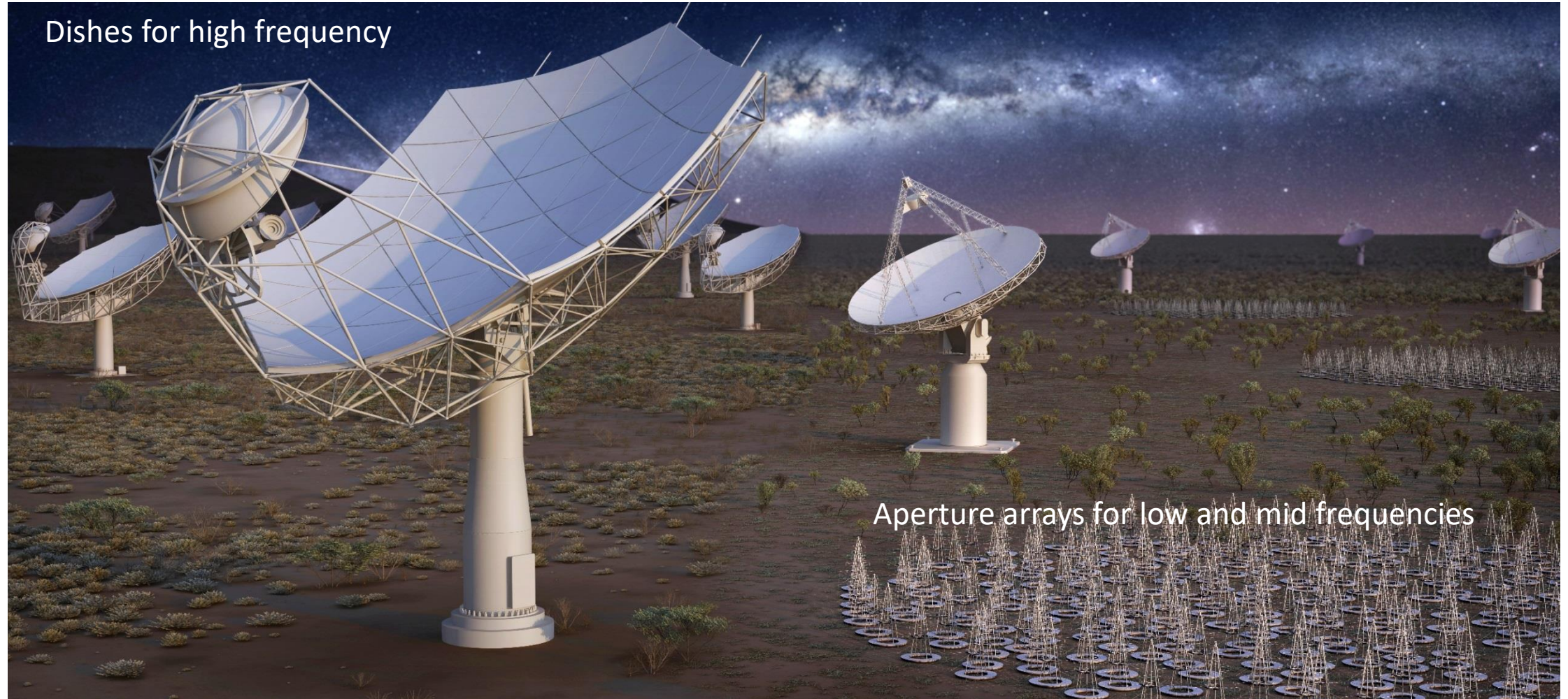


Aperture arrays for low and mid frequencies





The Dishes and Aperture Arrays of the SKA





The MeerKAT – a precursor of the SKA in South Africa



- An array of 64 dishes located at the SKA site - about 90 km from Carnarvon in South Africa
- Launched on 13th July 2018
- First clear image of the centre of the Milky Way

Photo credit: SKA South Africa



The MeerKAT – a precursor of the SKA in South Africa



- Radio bubbles observed at the centre of the Milky Way
- Powerful event happened at the centre of the galaxy
 - Interstellar gas falling into the black hole
 - Burst of star formation
 - Galaxy-scale outflow of matter

See publication

Inflation of 430-parsec bipolar radio bubbles in the Galactic Centre by an energetic event, by I. Heywood et al., published in the 12 September 2019 issue of Nature.

<https://nature.com/articles/s41586-019-1532-5>



Arrangement of the SKA Antennae across a continent





African Very Long Baseline Interferometry Network (AVN)

❑ a network of VLBI capable radio telescopes in Africa

❑ towards building the SKA in Africa

❑ African ministers meeting resolutions

- ✓ To make provision for operational, maintenance and upgrade costs associated with the respective AVN observatories.
- ✓ To make available the land and associated infrastructure needed for the AVN project.
- ✓ To intensify Human Capital Development programmes.
- ✓ To develop a governance framework for radio astronomy initiatives on the continent, in particular for SKA and AVN
- ✓ To work towards a formal multilateral agreement, to be signed during 2016.



SKA / AVN in Kenya: The Earth Station at Longonot



- 32 m dish that was used for analog signal transmission
- Now redundant
- Identified for conversion to a radio telescope
- Part of the AVN/SKA array
- Ideal research and training facility



Building Capacity in Big Science - Kenya

First Cohort of DARA/Newton Fund Students
– October 2015

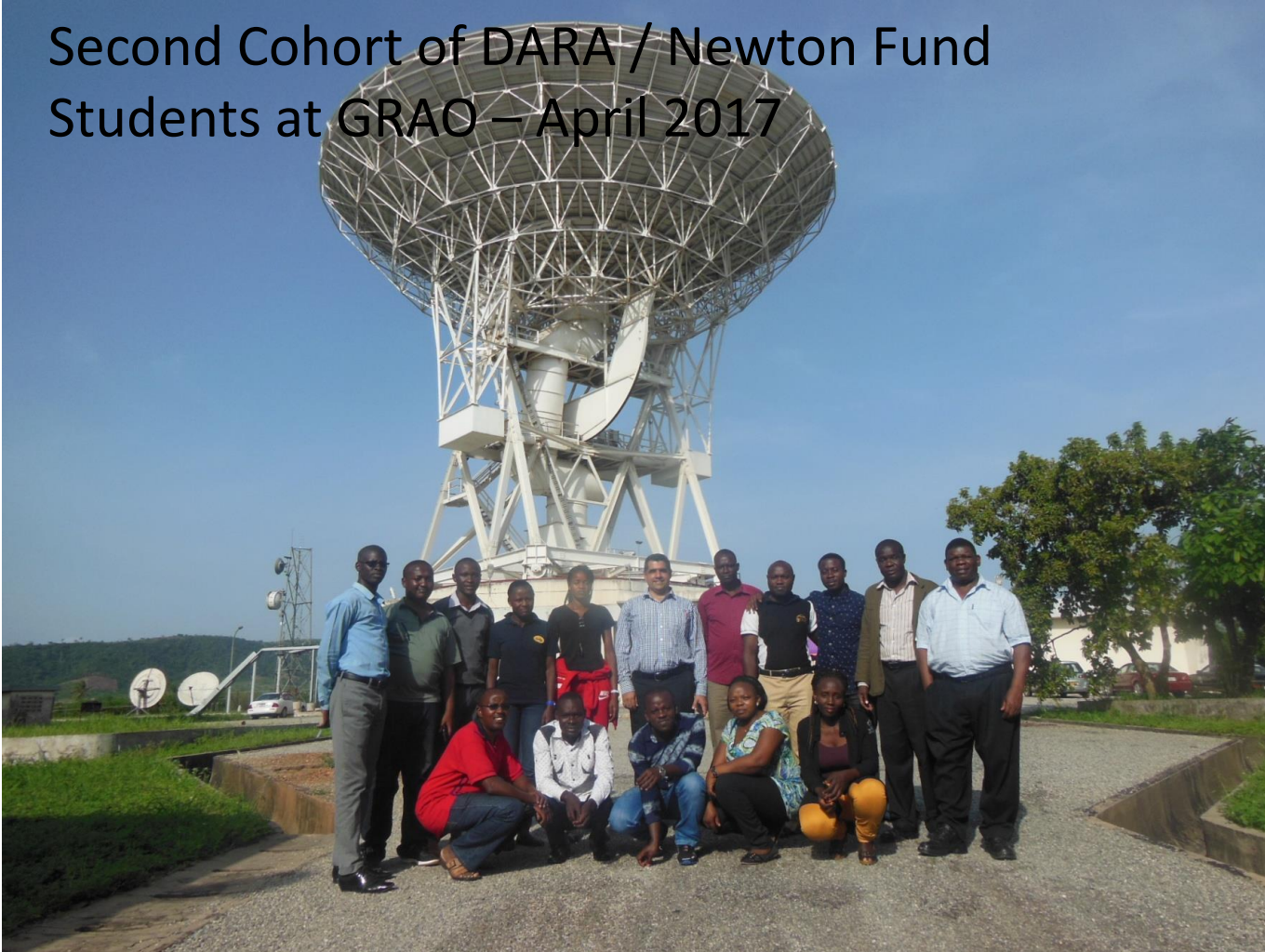


- 32 m dish that was used for analog signal transmission
- Now redundant
- Identified for conversion to a radio telescope
- Part of the AVN/SKA array
- Ideal research and training facility



The Ghana Radio Astronomy Observatory

Second Cohort of DARA / Newton Fund
Students at GRAO – April 2017



- 32 m dish that was used for analog signal transmission
- converted to a radio telescope
- Part of the AVN/SKA array
- Ideal research and training facility

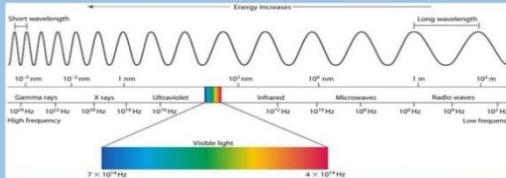


SKA – inspiring the young generation

Students' project



Introduction to the electromagnetic spectrum



Sources of radio waves

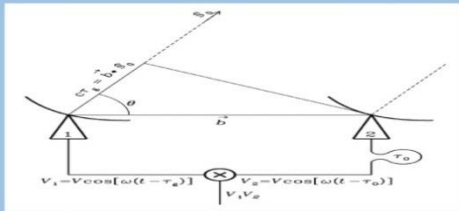
- ✓ Natural sources – galactic and extra galactic (stars, lightning)
- ✓ Artificial sources – radio transmitters (radio and TV stations, GSM, domestic appliances)

Applications in science

- Understanding the universe – galaxy formation, structure and evolution

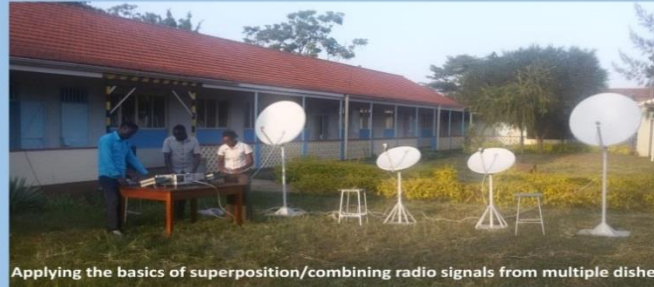
Aim of this project

- Learn the basics of radio wave interferometry



Preparations for Big Science in Africa

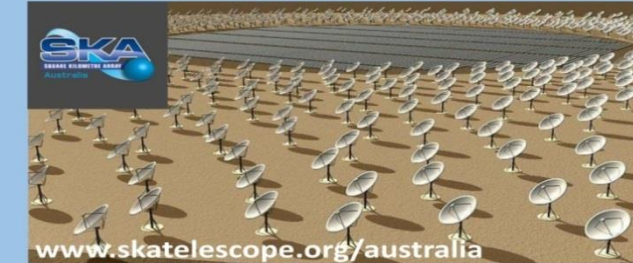
Radio astronomy with satellite dishes



The Square Kilometer Array Project

- ✓ The world's largest array of radio telescopes to be hosted in Africa and Australia
- ✓ Kenya is one of the partner countries of the SKA in Africa
- ✓ Great opportunity for careers in STEAM

www.skatelescope.org





Way Forward for Africa

- ❖ Embrace Big Science
- ❖ Develop human capacity in STEM, ICT
- ❖ Collaborate in science within the SKA/AVN and other big science projects
- ❖ Enhance national and regional unity



Big Science for National and Regional Unity



© KOTI

Excellent opportunity for building unity
through science



Short Bio of the Presenter



Nadir Hashim is a senior lecturer and immediate former chairman, Department of Physics at Kenyatta University. He earned his Ph.D. at Siegen University in Germany. His Ph.D. work was on the measurement of cosmic ray muons using the ALEPH facility at CERN. Over the years Dr. Hashim has trained postgraduate students and published widely in the fields of cosmic ray physics, astronomy and astrophysics, nuclear science and technology. He has served as the Chair of the National Technical Steering Committee of the Square Kilometer Array (SKA) in Kenya at the National Commission of Science, Technology and Innovation (NACOSTI). He is a founder member of the African Network for Education in Nuclear Science and Technology (AFRA-NEST) – a regional network supported by the International Atomic Energy Agency (IAEA).

<http://spas.ku.ac.ke/index.php/departments/departments-of-physics/89-faculty/11-dr-nadir-omar-hashim>

<https://africanscientists.africa/business-directory/hashim/>