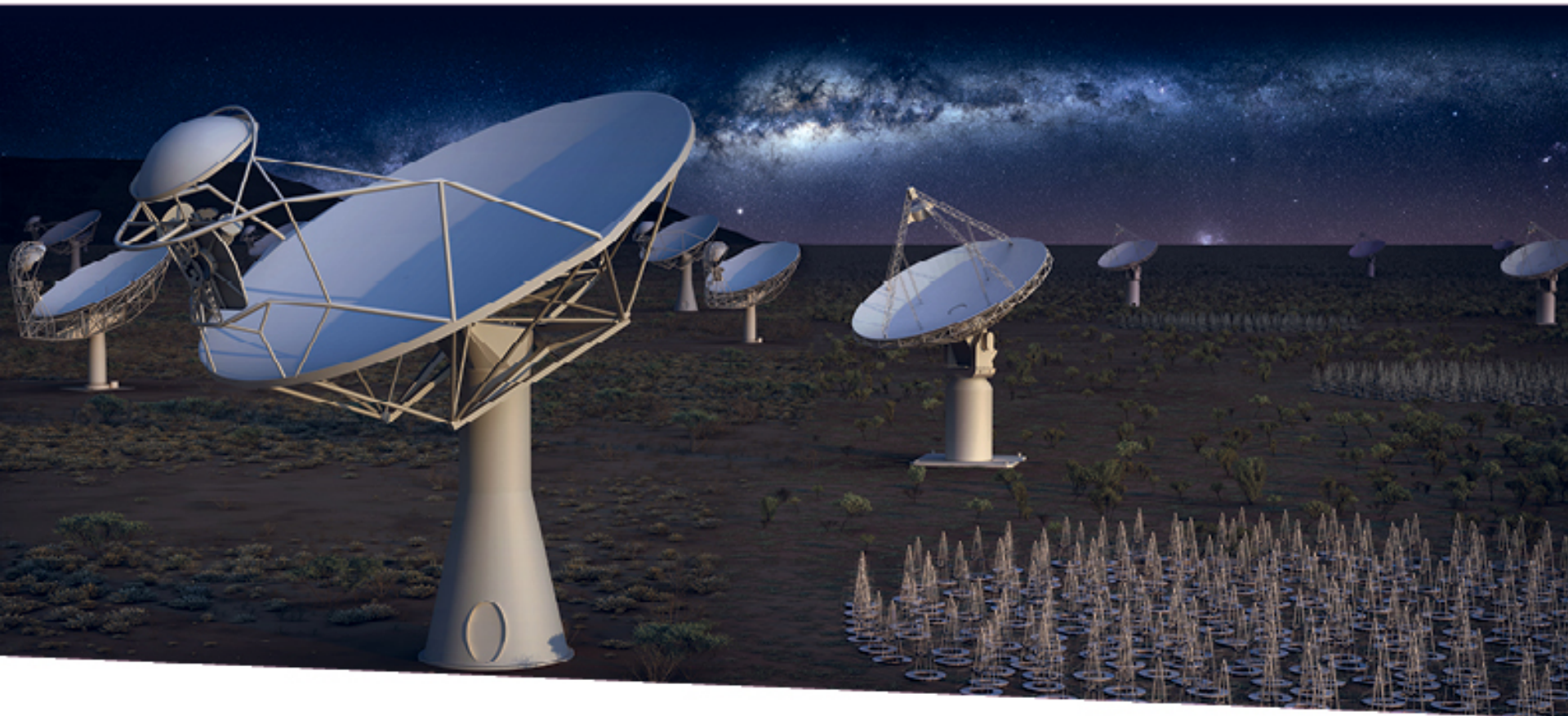


The SKA Project



SQUARE KILOMETRE ARRAY

Exploring the Universe with the world's largest radio telescope

Philip Diamond, Director General

EPFL 18th May 2016

Objectives

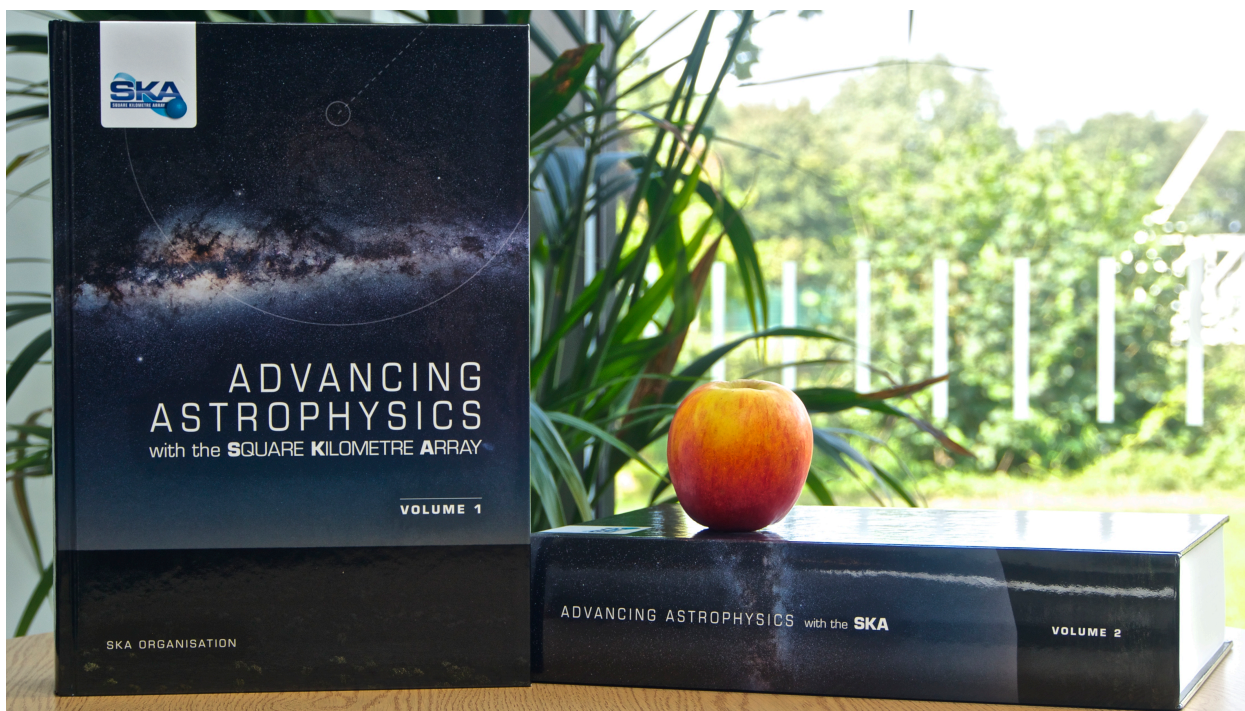
Science Vision

SKA Science

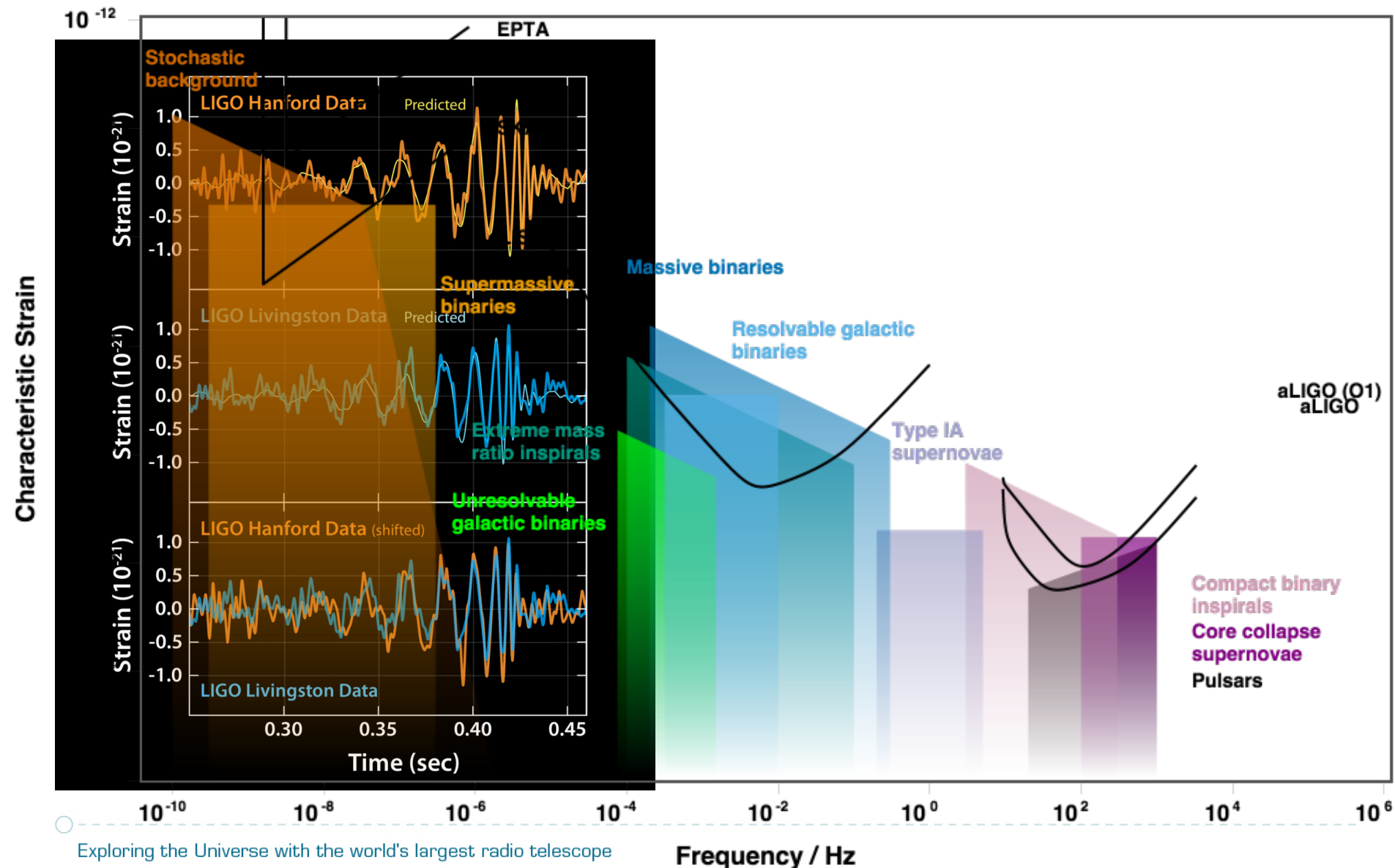
- SKA: will be one of the great physics machines of 21st Century and, when complete, one of the world's engineering marvels.
- Science goals:
 - Fundamental physics: Gravity, Dark Energy, Cosmic Magnetism
 - Astrophysics: Cosmic Dawn, First galaxies, galaxy assembly and evolution; proto-planetary discs, biomolecules, SETI + much more
 - The unknown: transients; +...????
- Broader science range than any other science facility on Earth.

SKA Science Book:

- 135 self-contained chapters; > 1200 authors from 31 countries
- Published electronically in Proceedings of Science, May 2015
- Hardcopy: 2 volumes, total weight 9kg!



Gravitational Waves



21st Century Observatories

JWST: 2018



ALMA: operational



ATHENA: 2028



SKA: 2023



E-ELT/TMT/GMT: ~2024



CTA: 2024



Radio waves

Microwaves

Infrared

Ultraviolet

X-rays

Gamma



SKA Phase 1



3 sites; 2 telescopes + HQ
1 Observatory

Phase 1

Construction: 2018 – 2023

Construction cost: €650M

Operations cost: ~€100M/yr, TBD

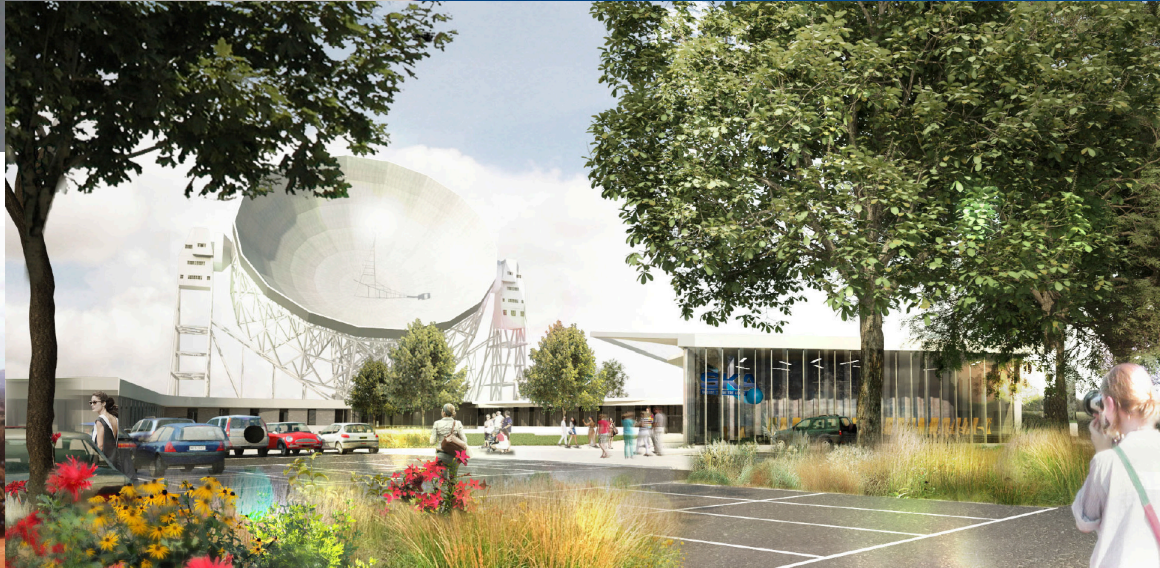
Phase 2

2023 - 2033

Multi-billion Euro project



SKA HQ: Jodrell Bank, UK





SKA1-LOW: Australia

Phase 1: ~130,000 antennas

Phase 2: ~ 500,000 antennas

500 stations over 80 km

Raw data output: Tb/sec, ZB/yr

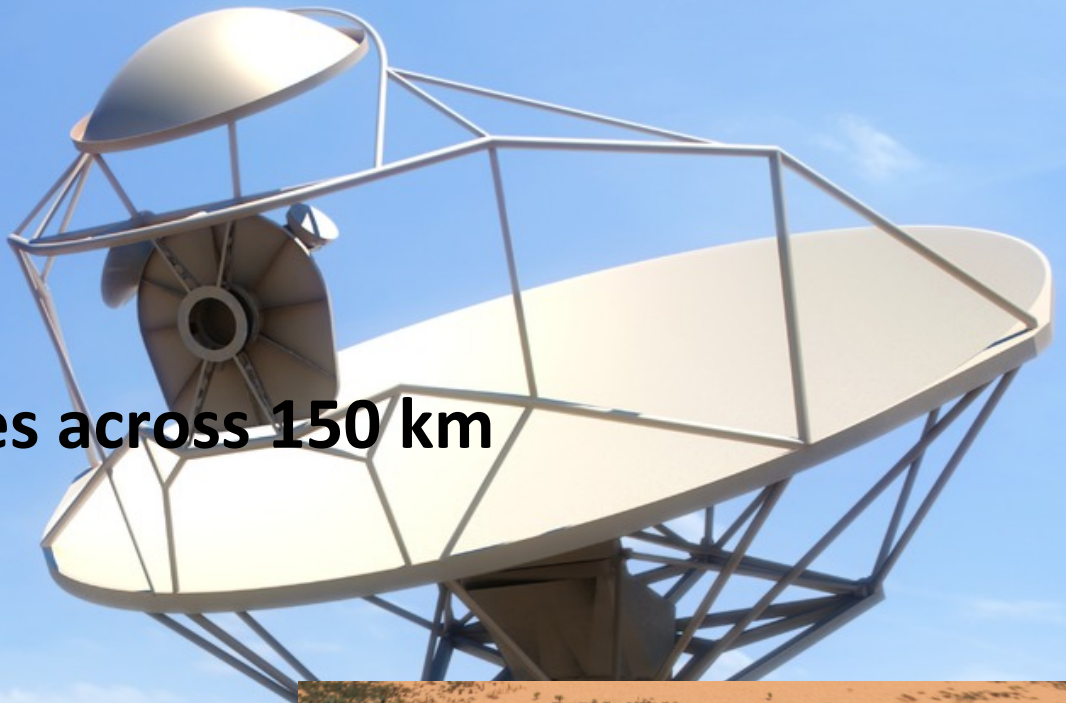
Huge engineering, computational and science challenge



SKA1-MID: Africa

Phase 1: 200 15-m dishes across 150 km

**Phase 2: ~2,000 dishes,
across southern Africa**



**Massive increase in capability over current
facilities**

Huge data rates and infrastructure challenge





22 antennas in place: aiming for fringes on 16 by 30th June. Completed in 2017

Precursor progress: ASKAP



Murchison Widefield Array

The Core

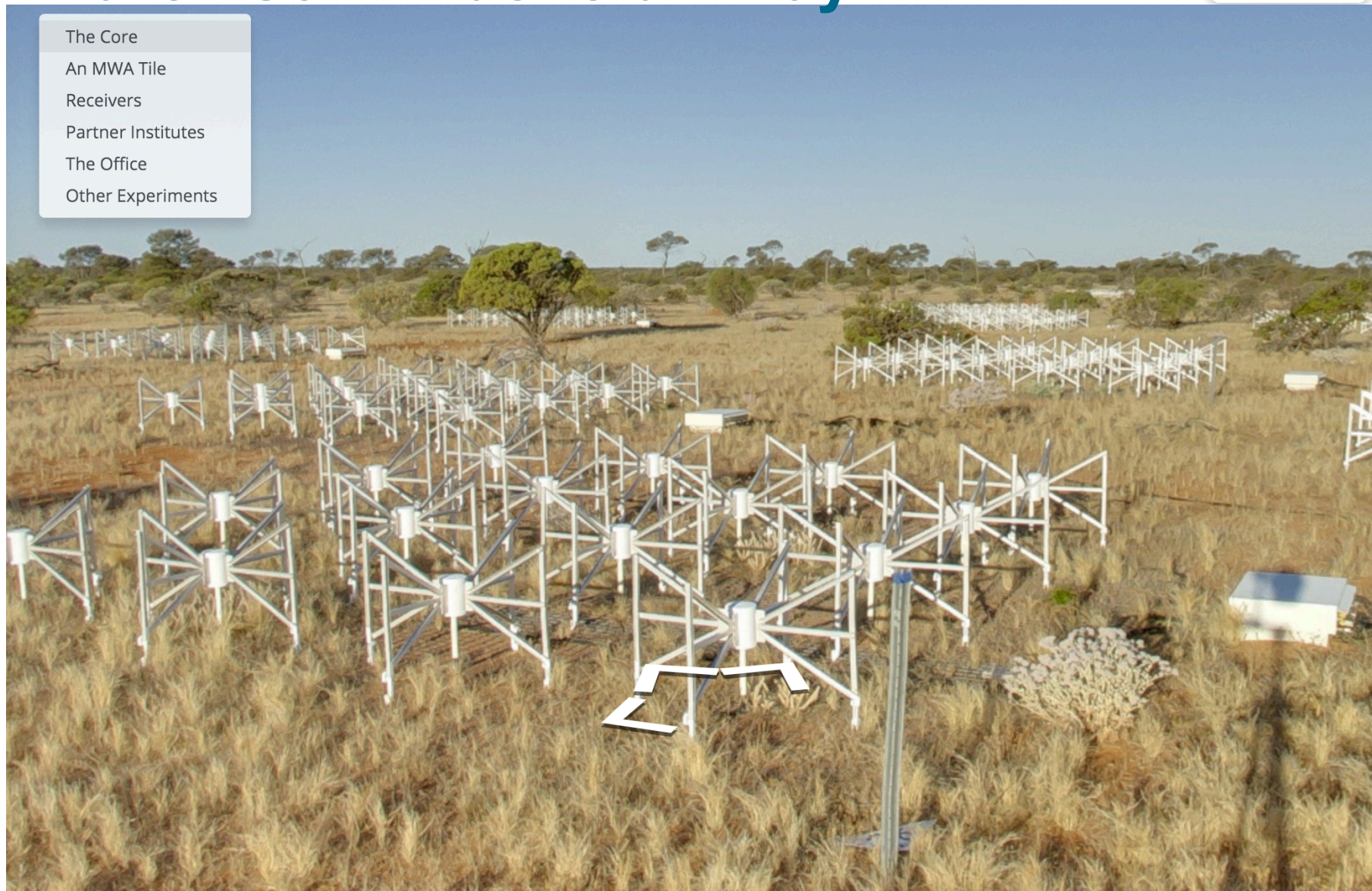
An MWA Tile

Receivers

Partner Institutes

The Office

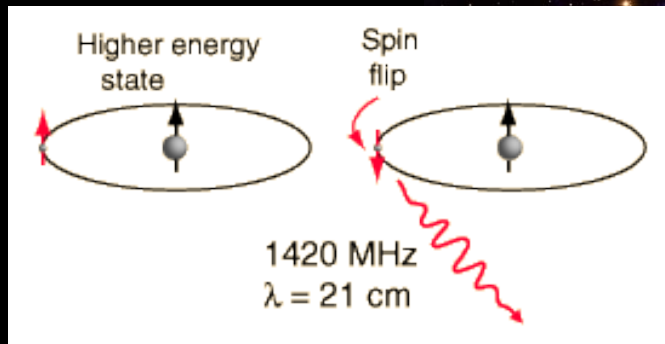
Other Experiments



Exploring the Universe with the world's largest radio telescope

How did we select the sites?

Consider the expanding Universe.....



Mobile Phone

Aircraft

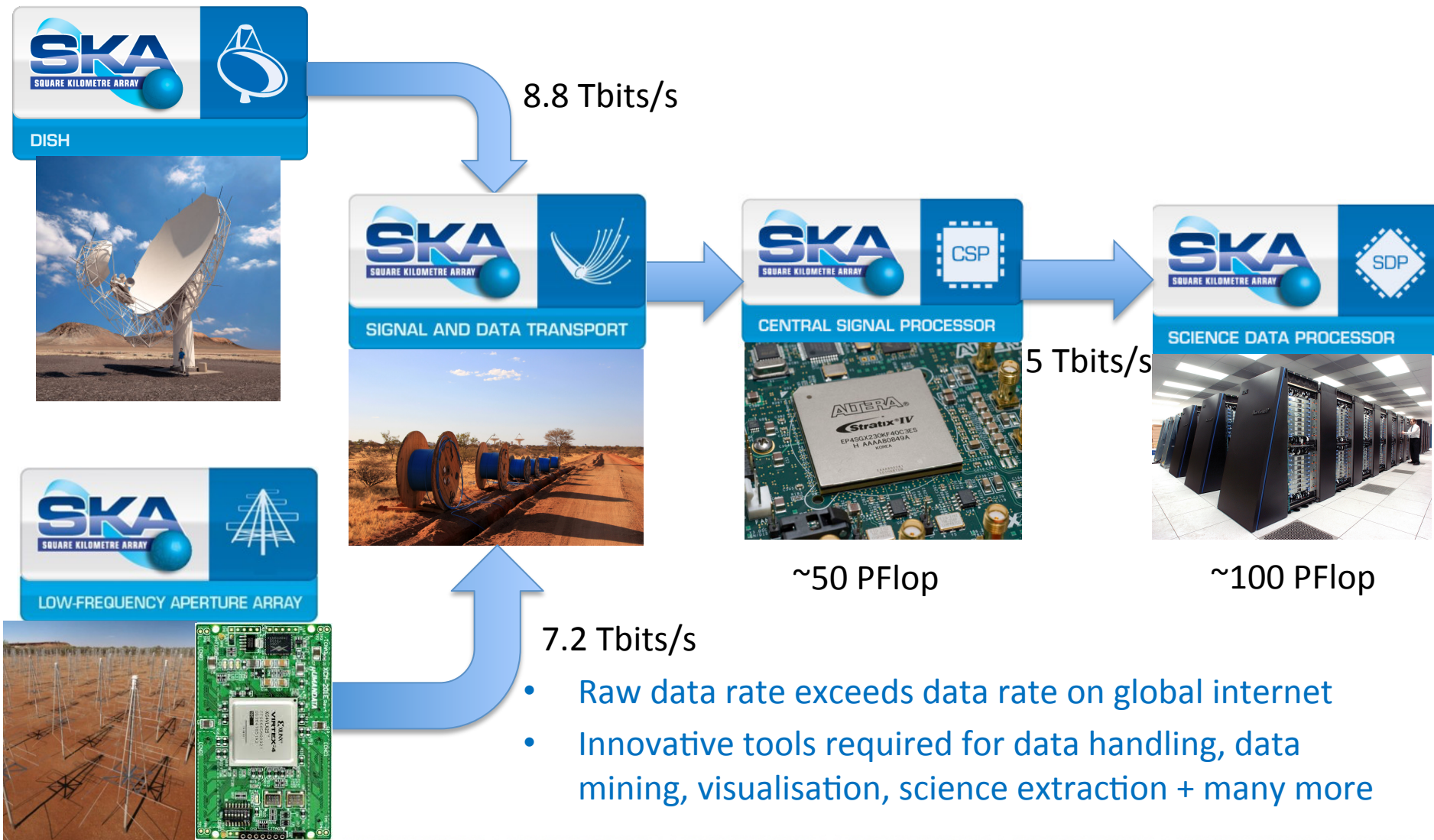
Digital TV

FM

An ICT-driven Science Facility



Scale of the SKA data challenge



ICT-driven facility



Tianhe-2: world's fastest supercomputer

天河

天河

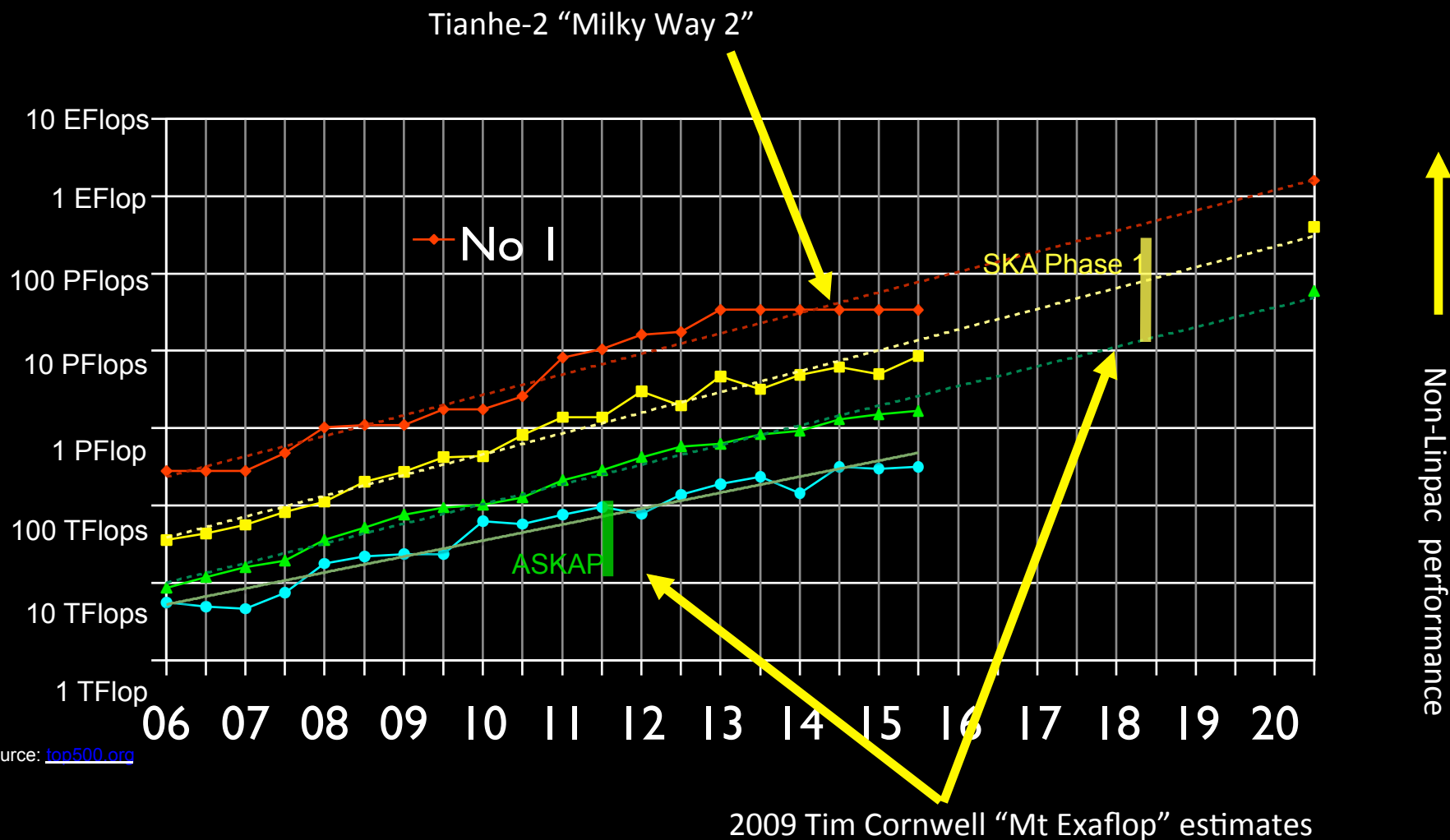
Over 10s to 1000s kms

HPC Processing
2020: 300 PFlop
2028: 30 EFlop

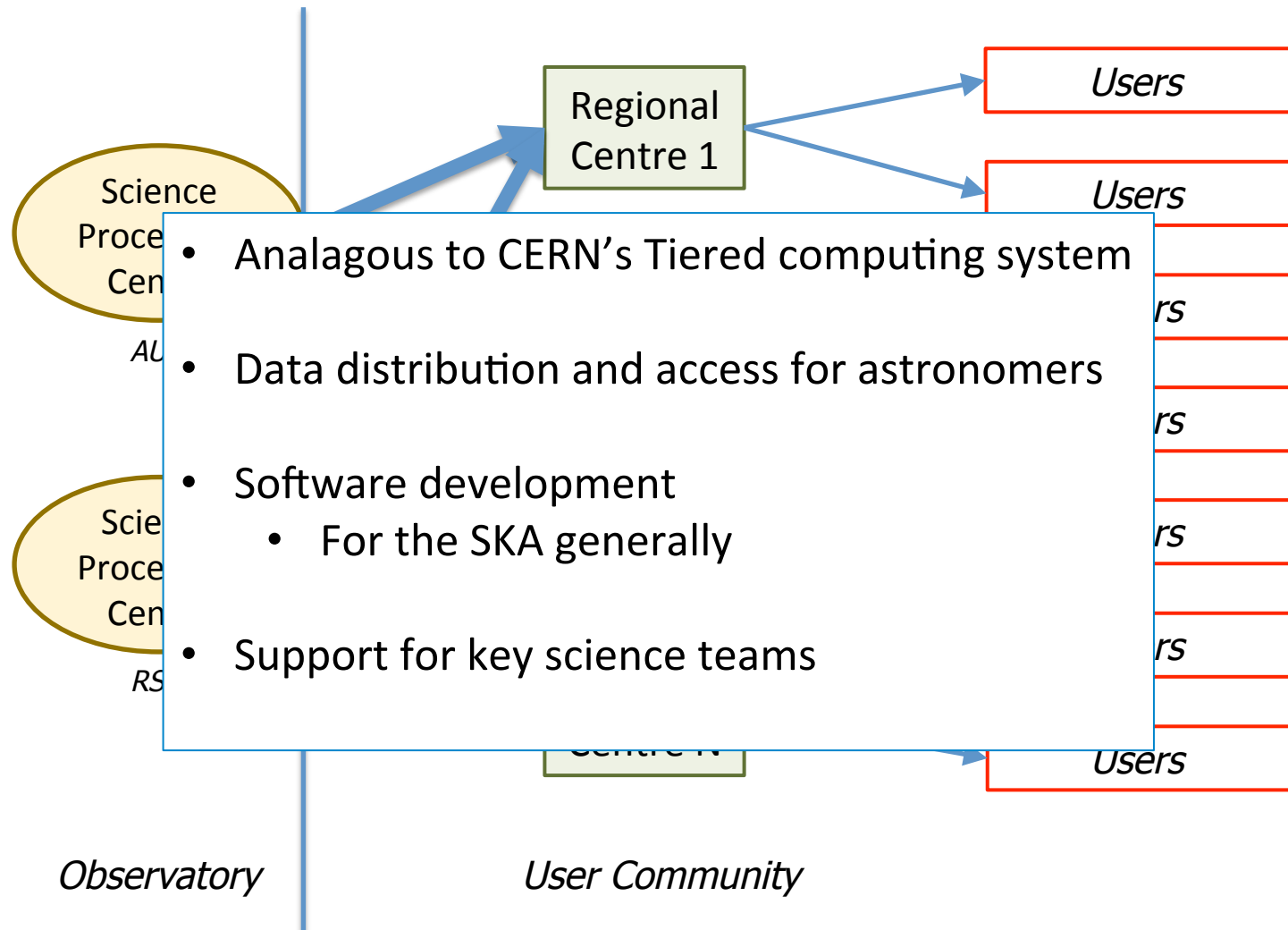
High Performance Computing
Facility (HPC)



Projected Performance



SKA Regional Centres:



Current Status



Project Milestones

- Early 1990s: first ideas that became SKA concept
- Late 90s/early 00s: first coherent technology developments (NL, Europe, USA, CA, Aus)
- 2000: Int'l SKA Steering Committee formed
- ~2005: ASKAP, MeerKAT projects began
- 2006: SKA site shortlisting; Funding Agency group formed
- 2011: SKAO company formed
- May 2012: SKA site decision; D-G appointed
- March 2013: Baseline Design of SKA1
- July 2013: Cost-cap set
- Nov 2013: Design consortia formed & detailed design began

Project Milestones in 2015

- Prioritisation of the SKA Science goals
- Re-baselining of the SKA project, to fit within the Board's €650M cost-cap
- Selection of Jodrell Bank as the long-term HQ for the SKA
- The UK's commitment of £200M (~€270M)
- 8 of the 9 core design consortia completing PDR; some system-level reviews; sub-system down-selects.
- Stockholm science meeting on future SKA Key Science Projects
- Publication of SKA Science Book
- Department of Atomic Energy take over India's membership of SKAO.
- Start of negotiations to establish the SKA as an InterGovernmental Organisation governed by a Convention
- Approval of SKAO budget for 2016 and 2017
- All-hands engineering meeting in Penticton, Canada
- Begin design of the new SKA HQ building at Jodrell Bank
- Announcement of AUS\$293.7M funding for SKA by Australian PM
- Award of €4.95M grant EC H2020 programme funds for infrastructure design

SKA: Driving development

- Dishes, feeds, receivers ($N=200 \rightarrow 2000$)
- Low and mid aperture arrays ($n=130k \rightarrow 500k$)
- Signal transport ($\sim 20 \text{ Tb/s} \rightarrow \text{Pb/s}$)
- Signal processing (exa-MACs)
- Software engineering and algorithm development
- High performance computing (exa-flop capability)
- Data storage (exa-byte capacity)
- (Distributed) power requirements ($10 \rightarrow 50\text{MW}$)

Design Consortia



WIDE BAND SINGLE PIXEL FEEDS



TELESCOPE MANAGER



CENTRAL SIGNAL PROCESSOR



SIGNAL AND DATA TRANSPORT

Preliminary Design Reviews now complete



SCIENCE DATA PROCESSOR



DISH



MID-FREQUENCY APERTURE ARRAY



LOW-FREQUENCY APERTURE ARRAY



ASSEMBLY, INTEGRATION & VERIFICATION



INFRASTRUCTURE AUSTRALIA

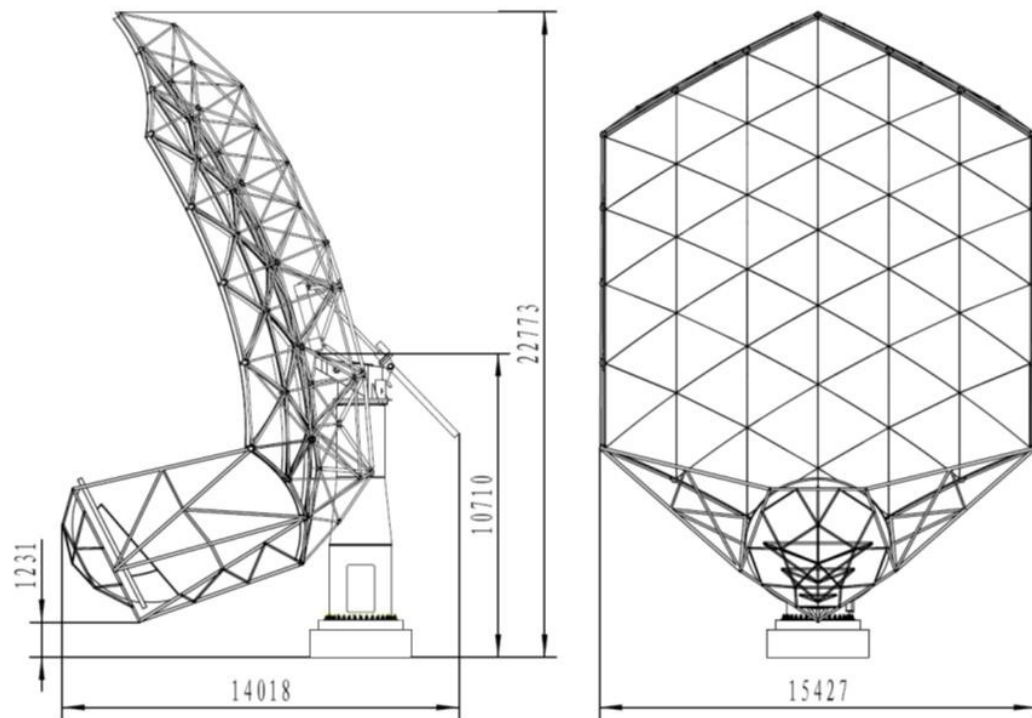


INFRASTRUCTURE SOUTH AFRICA



One example: Dish structure

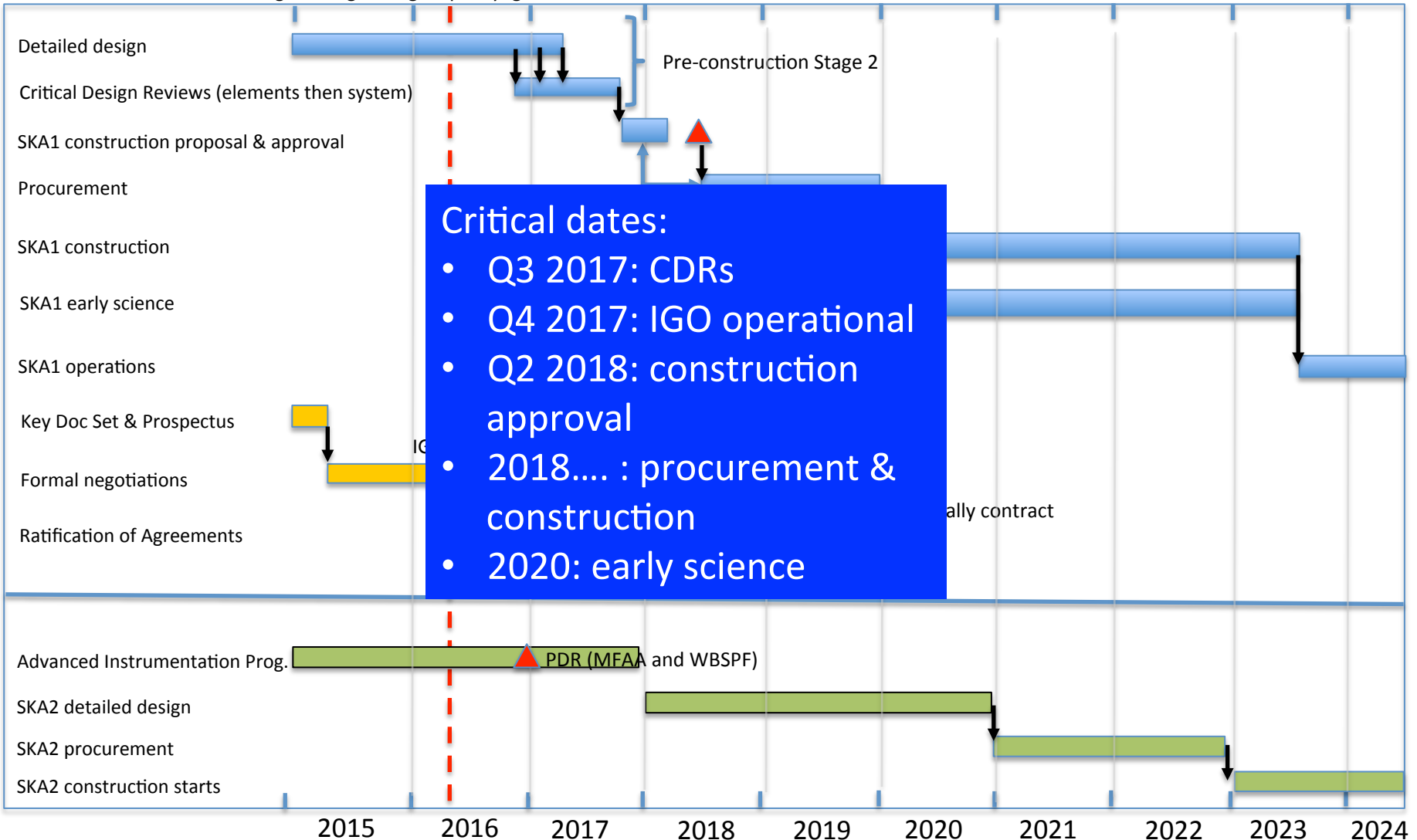
- Dish structure down-select, completed November 2015.
CETC54/MTM panellised aluminium surface design



High-level SKA Schedule



KEY: Blue = SKA1 science & engineering; orange = policy; green = SKA2



SKA structure Governance



SKA Organisation: 10 countries, more to join

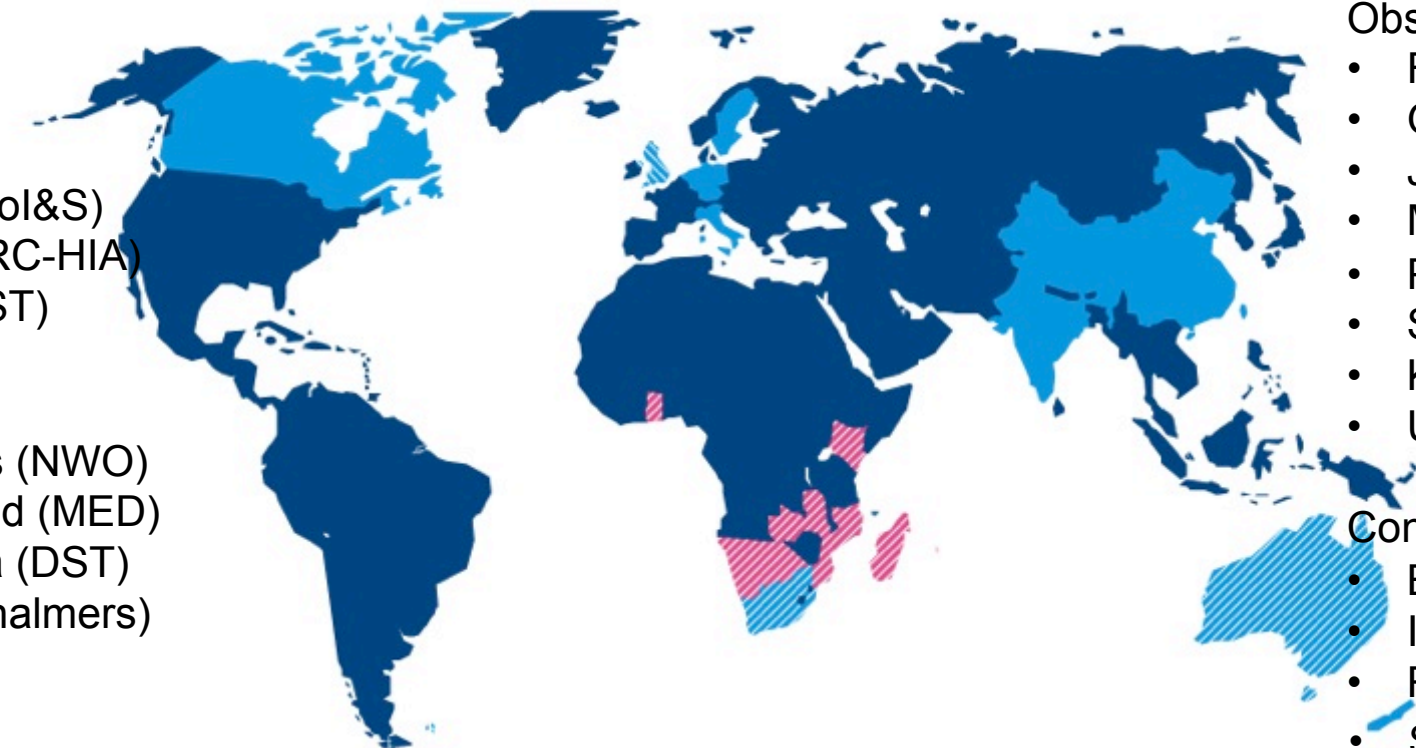
Australia (DoI&S)
 Canada (NRC-HIA)
 China (MOST)
 India (DAE)
 Italy (INAF)
 Netherlands (NWO)
 New Zealand (MED)
 South Africa (DST)
 Sweden (Chalmers)
 UK (STFC)
 Switzerland

Observers:

- France
- Germany
- Japan
- Malta
- Portugal
- Spain
- Korea
- USA

Contacts:

- Brazil
- Ireland
- Russia
- Switzerland



- Full members
- ▨ SKA Headquarters host country
- ▨ SKA Phase 1 and Phase 2 host countries

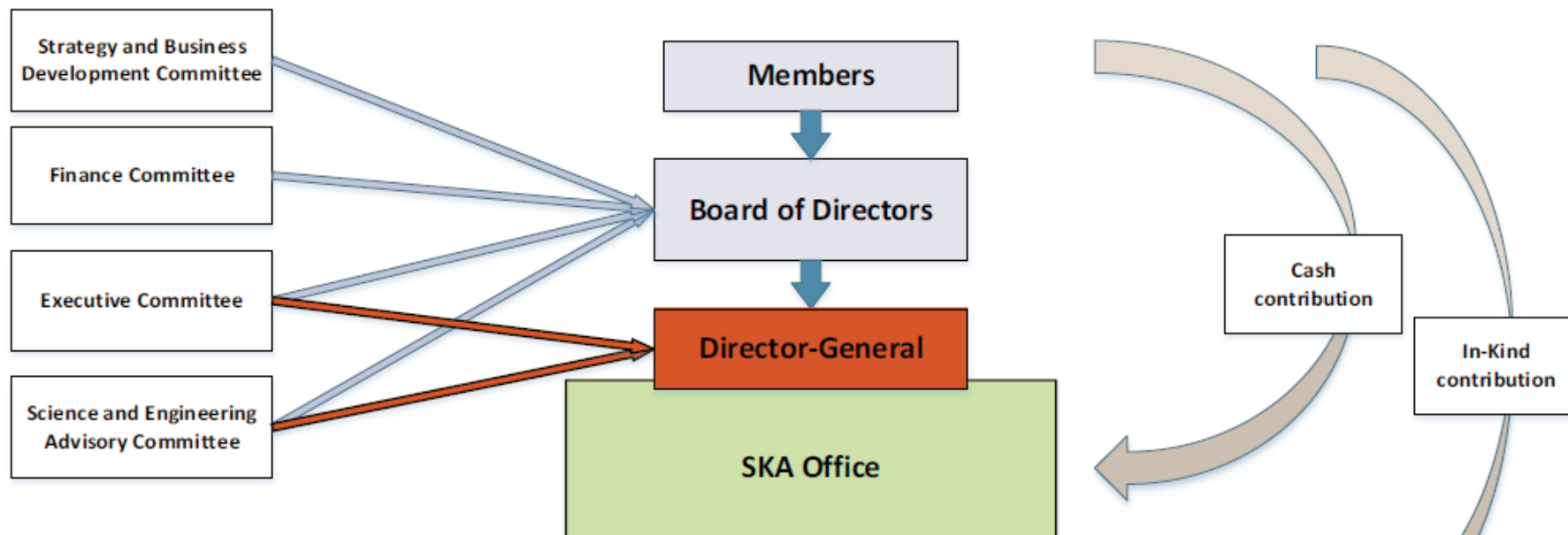


- ▨ African partner countries
(non-member SKA Phase 2 host countries)

This map is intended for reference only and is not meant to represent legal borders

SKA Ltd structure

Will evolve to Inter-Governmental Organisation



~ €170M
committed to
design phase





Negotiations to establish an IGO

- Governments currently negotiating to set up an Inter-Governmental Organisation similar to CERN/ESA/ITER etc
- Rationale:
 - Government commitment: Long-term political stability, funding stability
 - Availability of Privileges and Immunities from members
 - 'Freedom to operate', specifically through procurement process
- 3rd negotiation meeting in Rome 19-21 April
- Next, possibly final meeting, Sept 27-29.
- Agreement by end of year (?), ratification by December 2017

Summary

- Project momentum excellent:
 - Preliminary Design Reviews completed
 - Critical Design reviews in Q3/Q4 2017
 - IGO formal negotiations in progress
 - Procurement plan in advanced stage
 - Progressing to construction approval in 2018
- Challenges are large but not insurmountable
- SKA construction is on the horizon.

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www.skatelescope.org