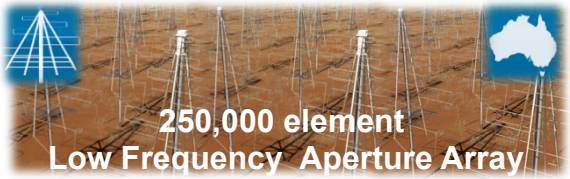
SKA1 Capabilities for HI Surveys

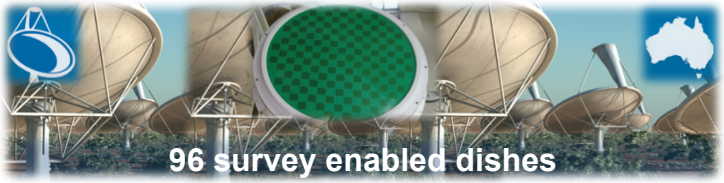
Robert Braun
SKA Science Director
18th March 2014

Exploring the Universe with the world's largest radio telescope

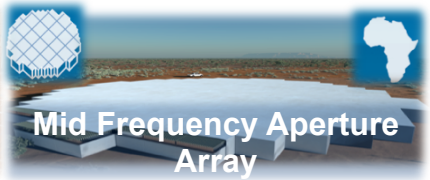
SKA
SQUARE KILOMETRE ARRAY

Phase I : 2020

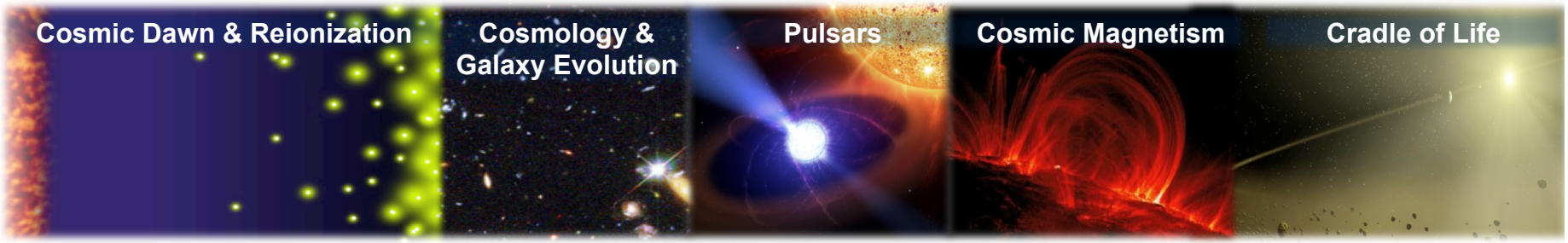




Phase II : 2024



Science



50 MHz 100 MHz 1 GHz 10 GHz

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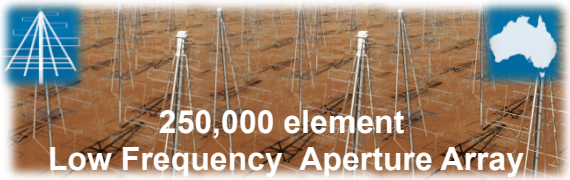
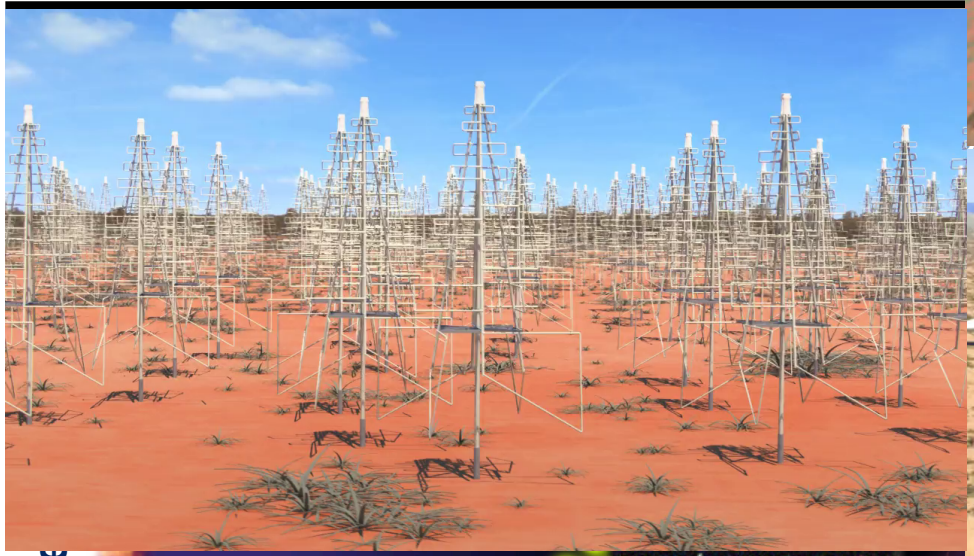
SKA
SQUARE KILOMETRE ARRAY

Phase I : 2020





Scie

50 MHz 100 MHz 1 GHz 10 GHz

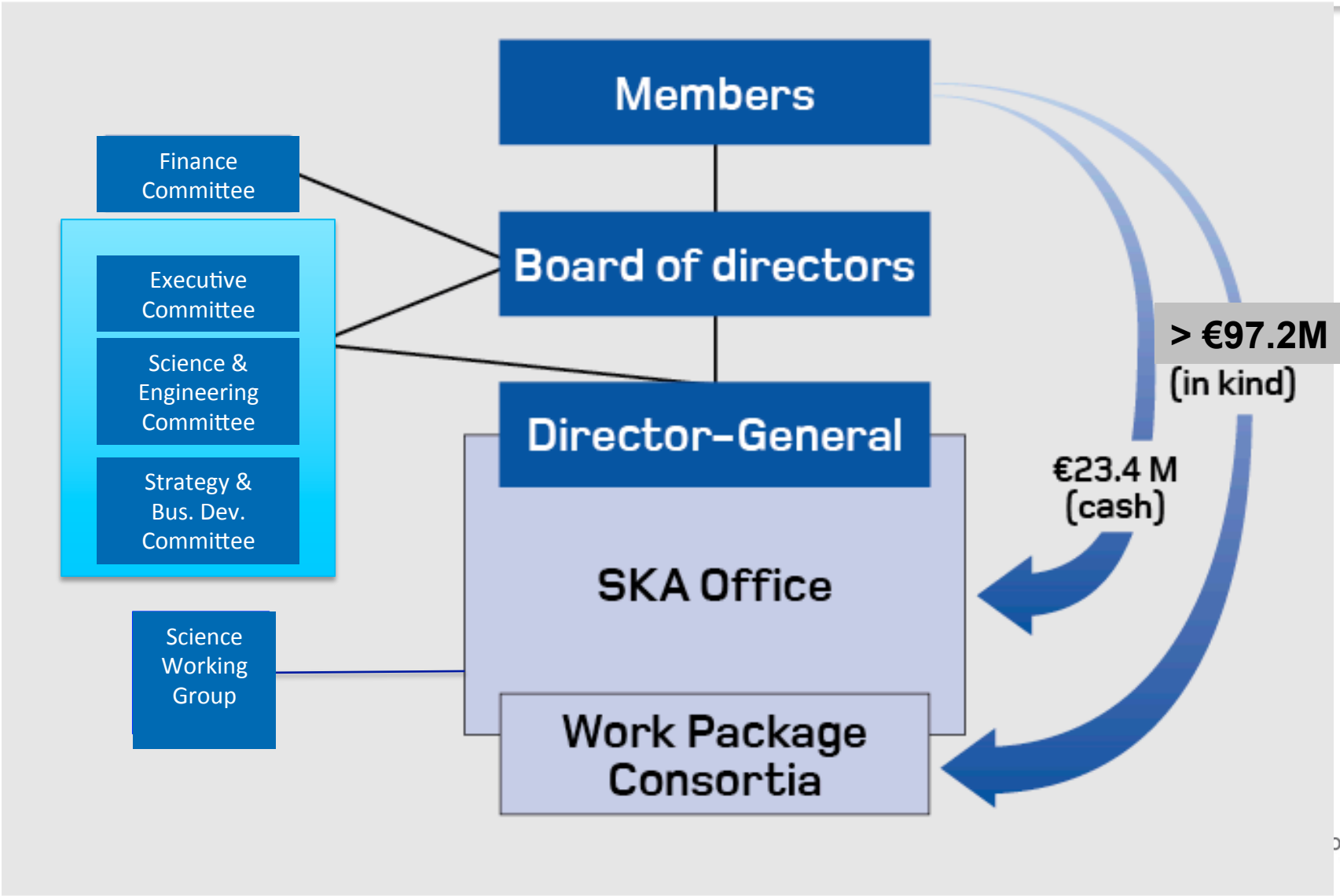
SKA Members and Governance

Australia (DIISRTE)
China (MOST)
Italy (INAF)
New Zealand (MED)
Sweden (Chalmers)
India (Tata/DAE)

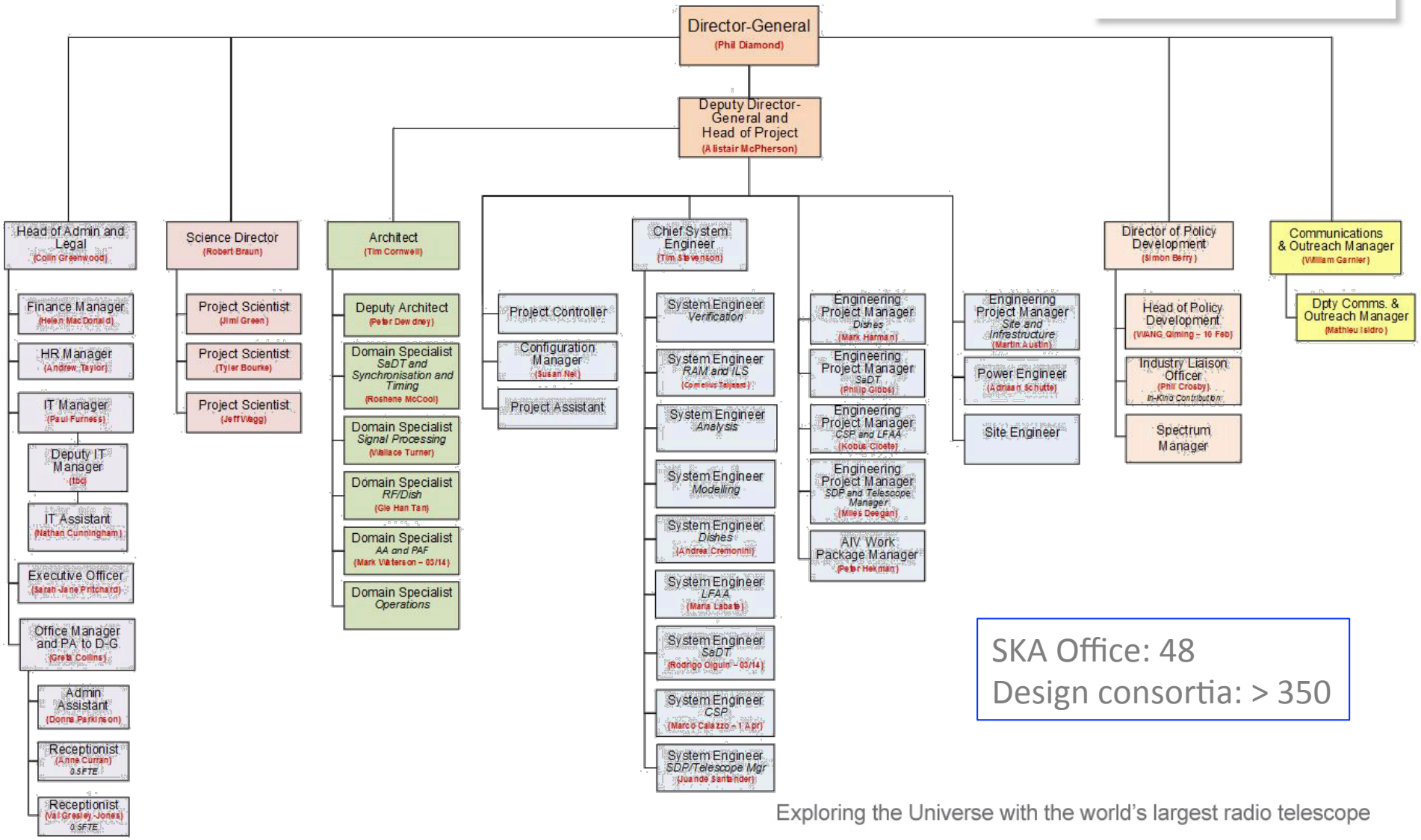
Canada (NRC-Herzberg)
Germany (BMBF)
Netherlands (NWO)
South Africa (DST)
UK (STFC)

- UK Company Limited by Guarantee
- (Expedient solution to enable SKA project to proceed; long-term governance structure under review)

SKA Members and Governance



SKA Office Organisational Chart



SKA Office: 48
Design consortia: > 350

The Work Package Consortia

Project Scientist: Jimi Green

Project Scientists: Jeff Wagg & Tyler Bourke

Project Scientist: Tyler Bourke

Project Scientist: Jeff Wagg

Project Scientists: Jimi Green & Tyler Bourke

Project Scientist: Jimi Green

Project Scientist: Jimi Green

Project Scientist: Tyler Bourke

Project Scientist: Tyler Bourke

Project Scientist: Tyler Bourke

Project Scientists: Jeff Wagg & Tyler Bourke

SKA Recent Milestones

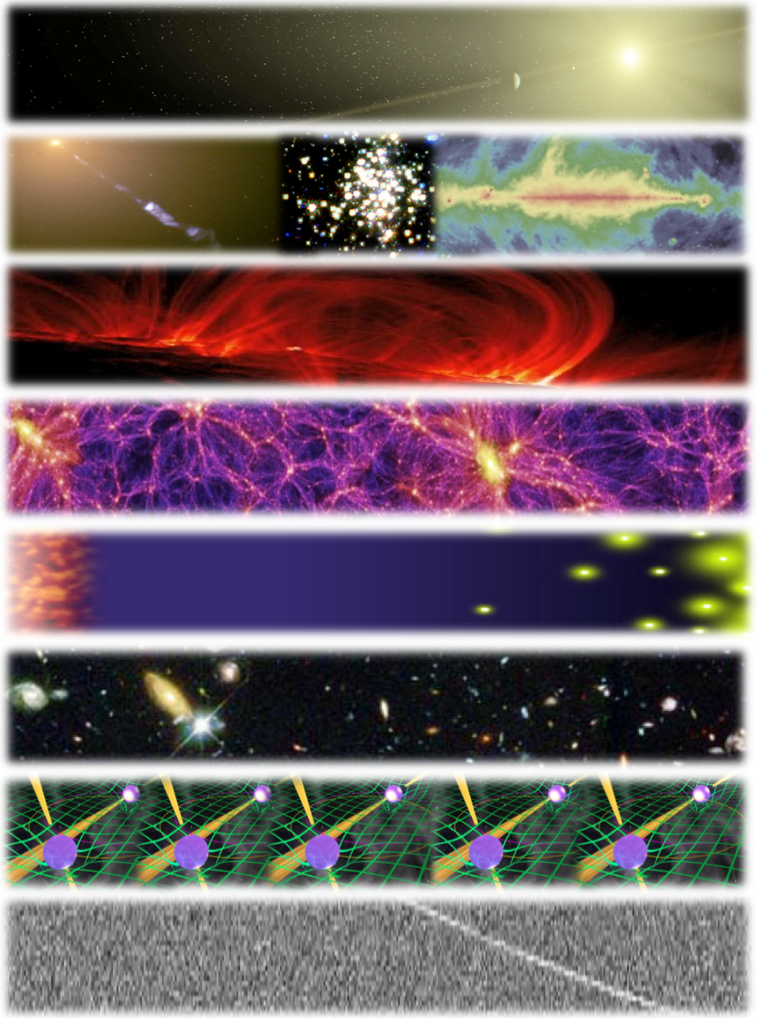
- Board sets cost-cap of €650M capital for construction of SKA Phase 1
  - Imposes discipline on design process
  - Design consortia will be given target unit costs (where appropriate)
  - Evolution of design guided by scientific and engineering assessments
  - Provides solid basis on which to raise construction funding.
- Top-level principles of Concept of Operations approved
- Design Consortium Agreements signed

SKA Recent Milestones

- **11 March Announcement by UK Science Minister:**
  £100M toward construction and early operations

The Science Working Groups

- **Astrobiology ("The Cradle of Life")**
  - *Project Scientist:* Tyler Bourke
  - *Working Group Chair:* Melvin Hoare
- **Galaxy Evolution – Continuum**
  - *Project Scientist*: Jeff Wagg
  - *Working Group Chairs:* Nick Seymour & Isabella Prandoni
- **Cosmic Magnetism**
  - *Project Scientist:* Jimi Green
  - *Working Group Chairs:* Melanie Johnston-Hollitt & Federica Govoni
- **Cosmology**
  - *Project Scientist:* Jeff Wagg
  - *Working Group Chair:* Roy Maartens
- **Epoch of Reionisation & the Cosmic Dawn**
  - *Project Scientist:* Jeff Wagg
  - *Working Group Chair:* Leon Koopmans
- **Galaxy Evolution – HI**
  - *Project Scientist:* Jimi Green
  - *Working Group Chairs:* Lister Staveley-Smith & Tom Osterloo
- **Pulsars ("Strong field tests of gravity")**
  - *Project Scientist:* Jimi Green
  - *Working Group Chairs:* Ben Stappers & Michael Kramer
- **Transients**
  - *Project Scientist:* Tyler Bourke
  - *Working Group Chair:* Rob Fender



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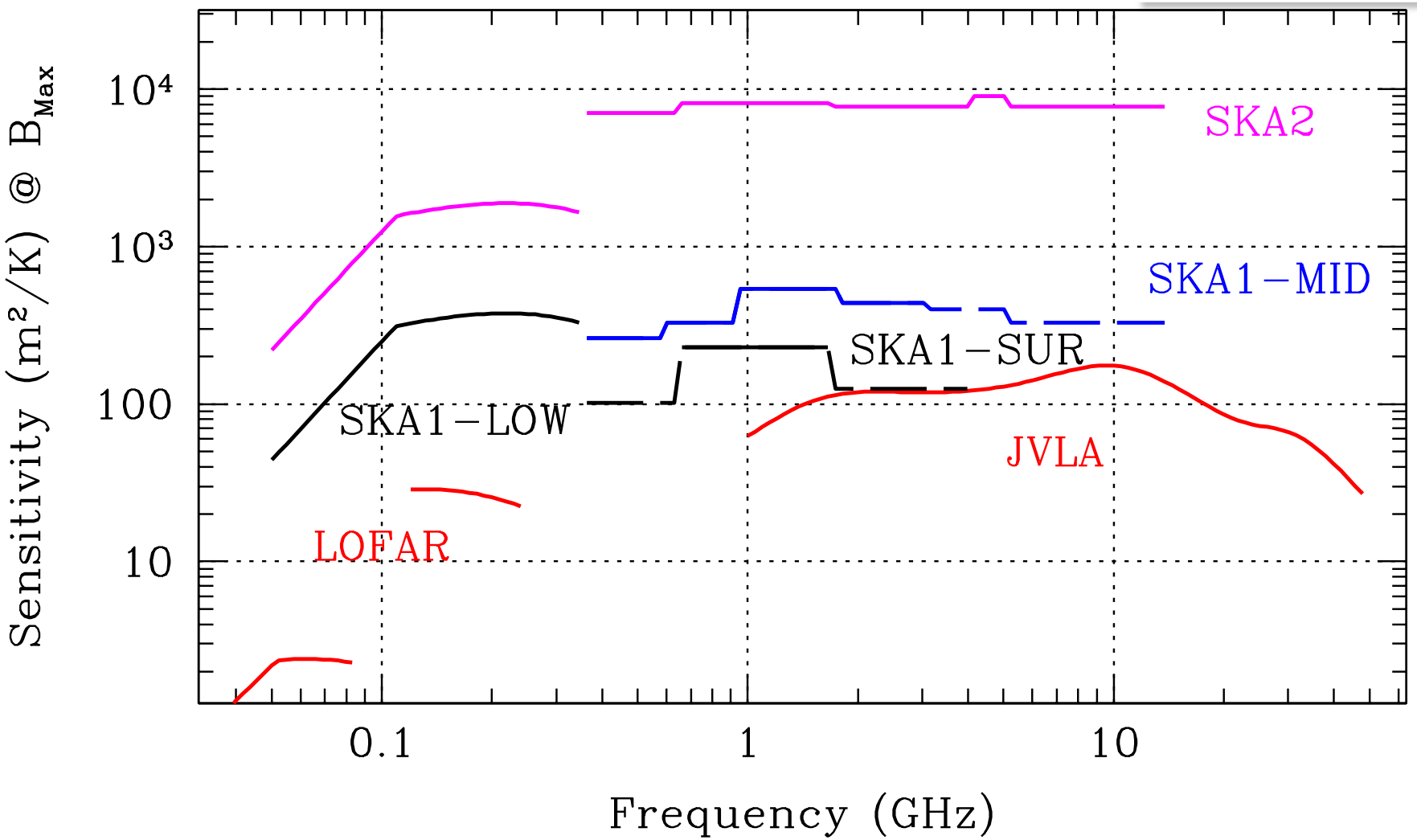
How does SKA1 baseline redefine state-of-art?

		JVLA	MeerKAT	SKA1-mid	ASKAP	SKA1-survey	LOFAR-NL	SKA1-low
Aeff/Tsys	m^2/K	265	321	1630	65	391	61	1000
Survey FoV	deg^2	0.14	0.48	0.39	30	18	6	6
Survey Speed FoM	$deg^2\ m^4\ K^{-2}$	0.98×10^4	5.0×10^4	1.0×10^6	1.3×10^5	2.8×10^6	2.2×10^4	6.0×10^6
Resolution	arcsec	1.4	11	0.22	7	0.9	5	11

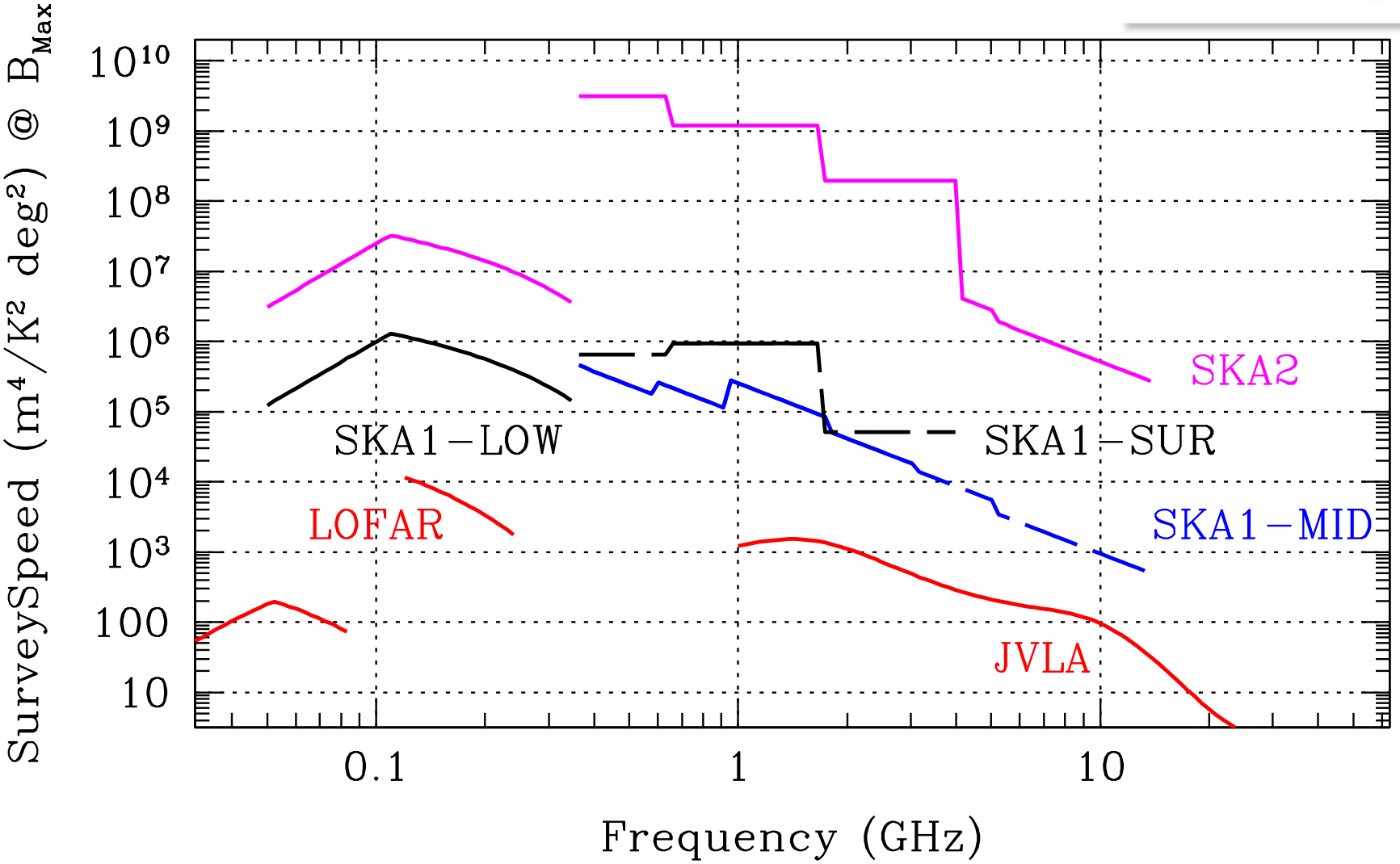
A_{eff}/T_{sys}: 6xJVLA 6xASKAP 16xLOFAR

Survey Speed: 100x 22xASKAP 270x 280xJVLA

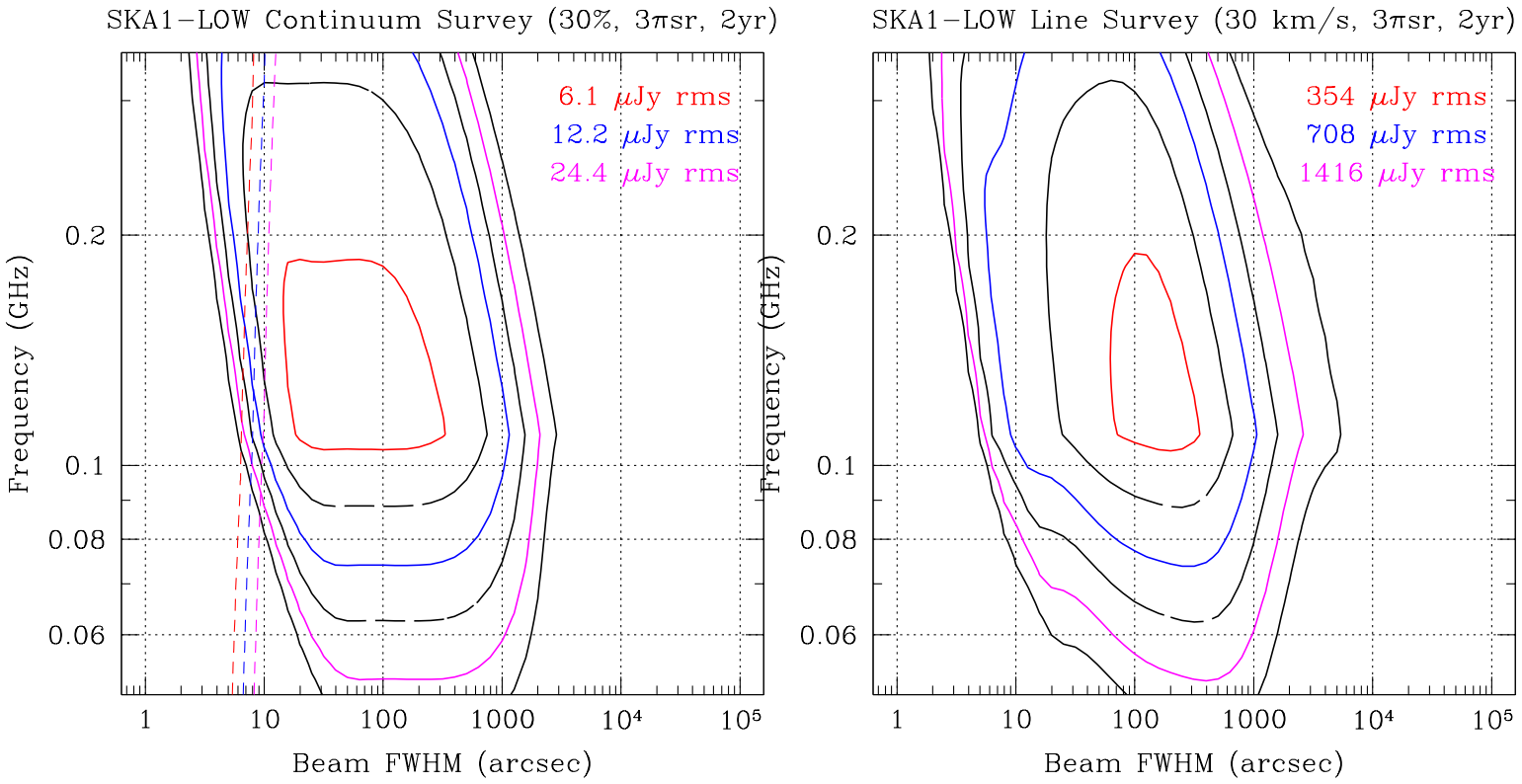
Sensitivity comparison



Survey speed comparison

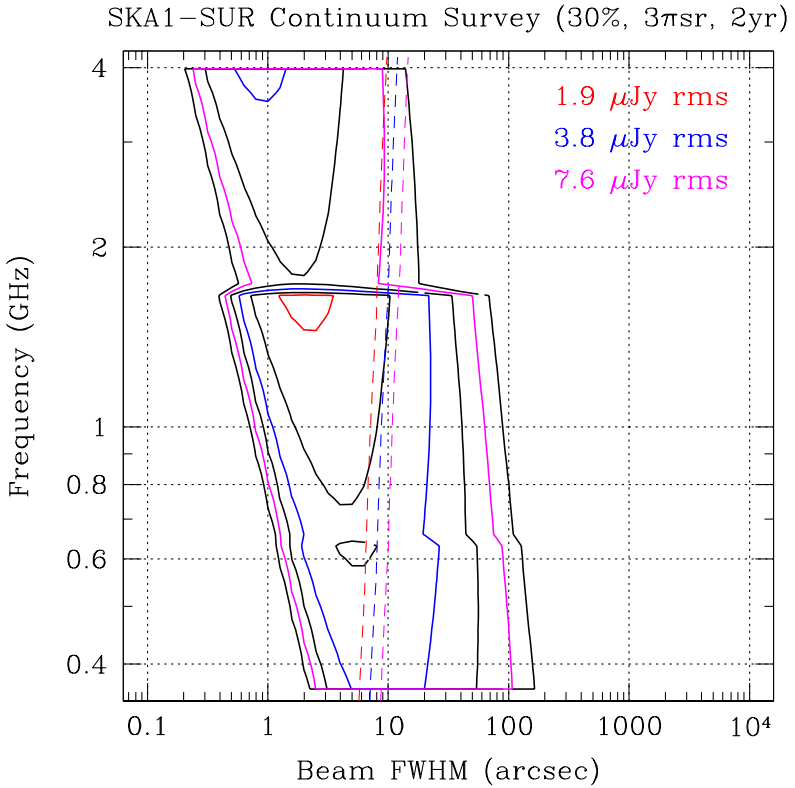


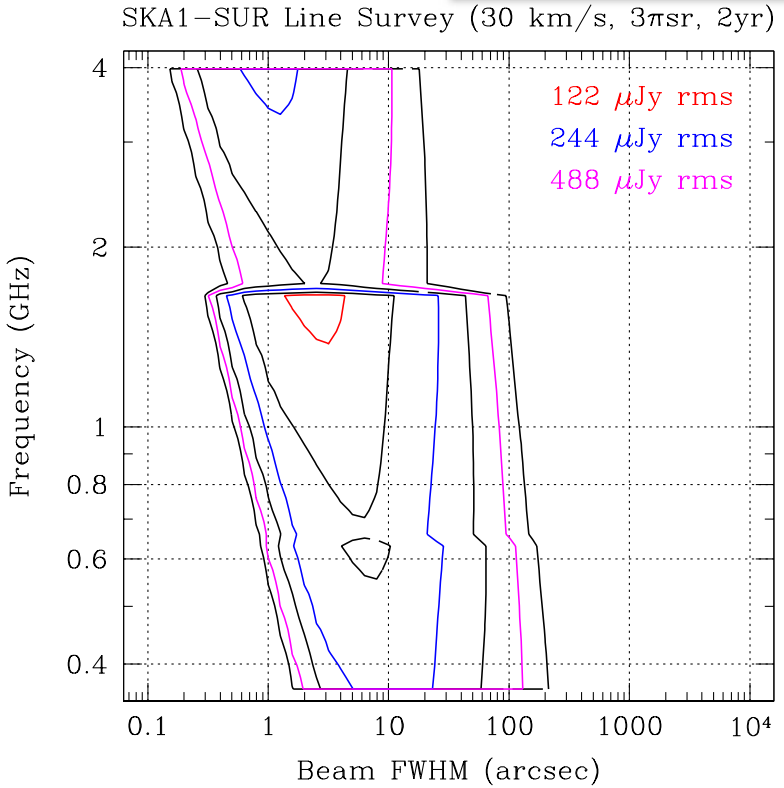
SKA1 HI Capabilities



- **Wide-field** continuum imaging and HI absorption cubes with with SKA1-LOW

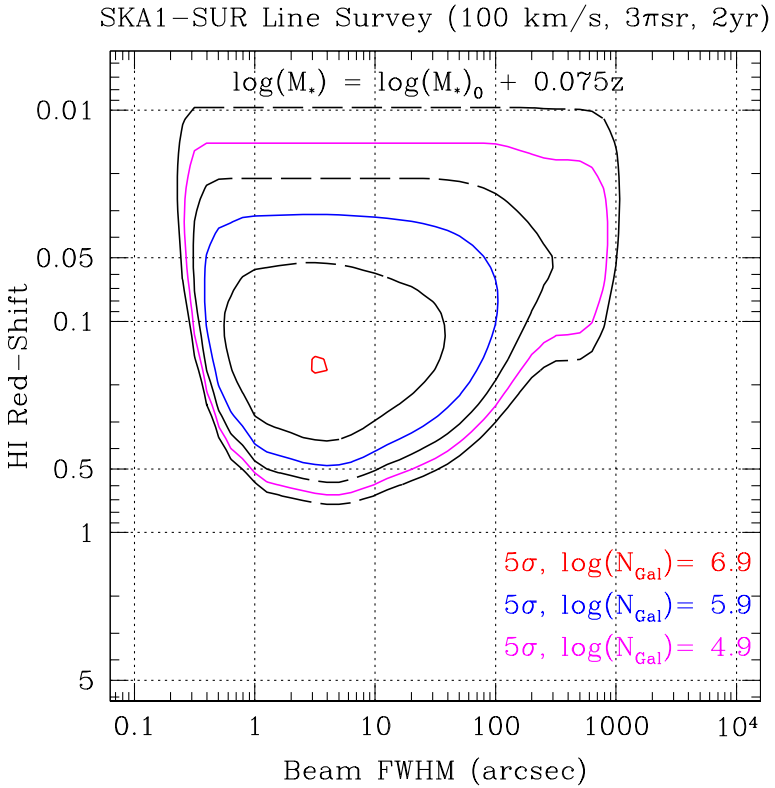
SKA1 HI Capabilities

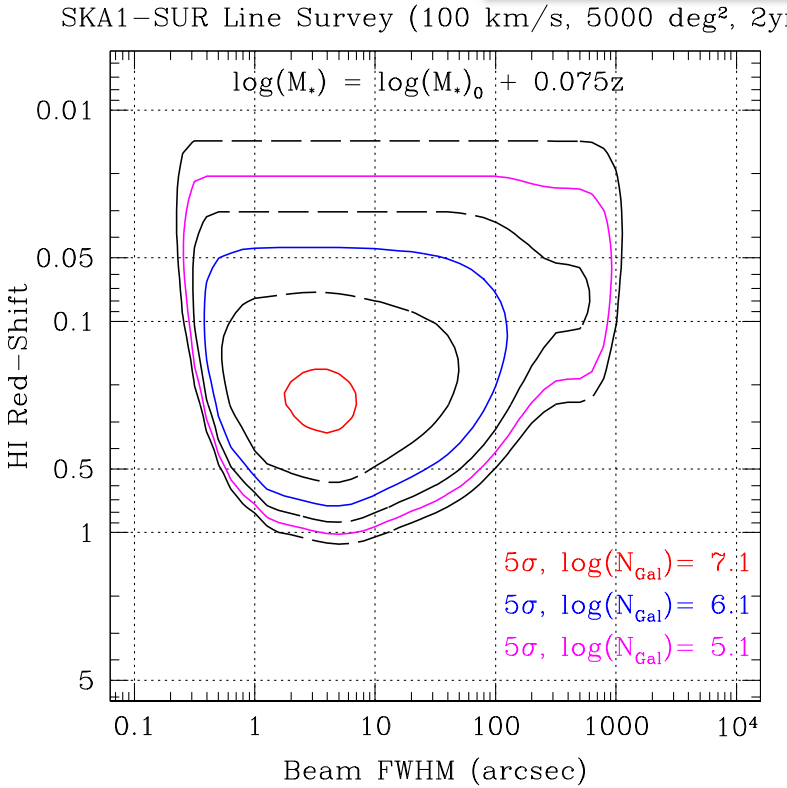




- **Wide-field** continuum and HI line cubes using SKA1-SUR

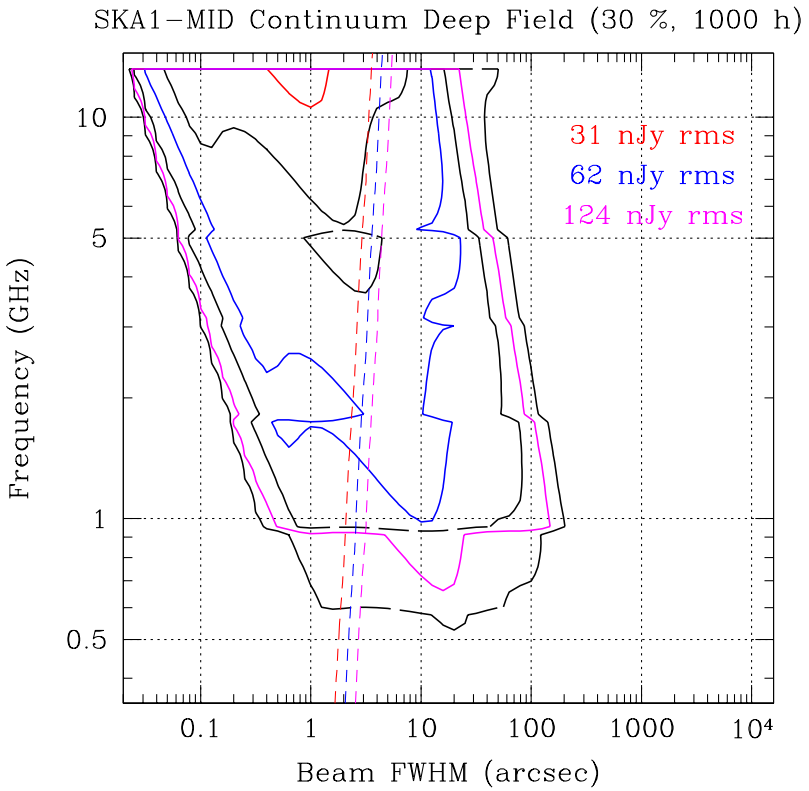
SKA1 3-D Capabilities

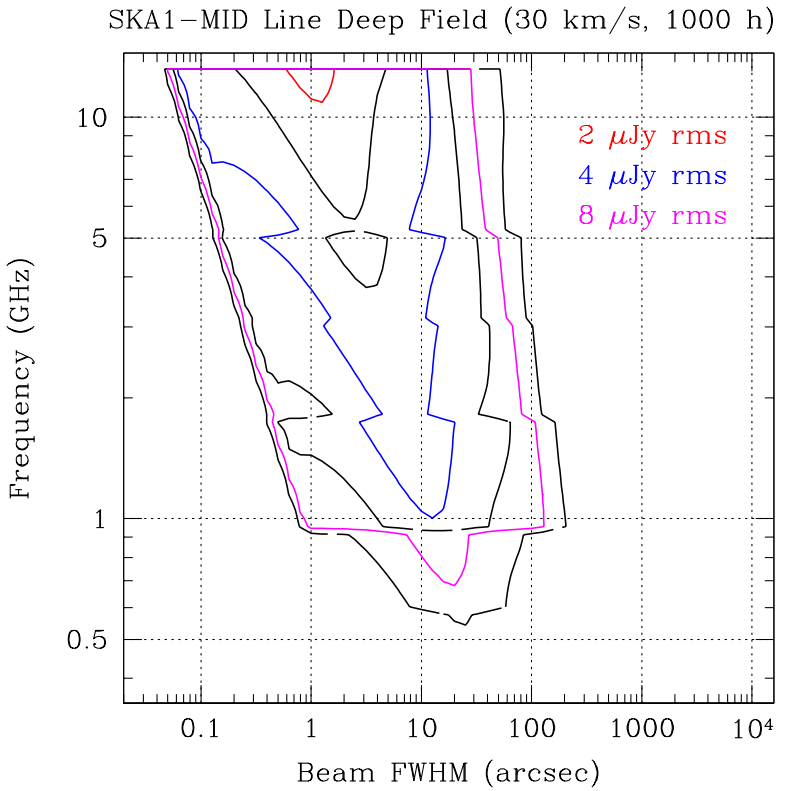




- **All-sky versus wide-field** HI surveys using SKA1-SUR
  - **Contours of detected galaxy density per 0.3 dex of z as function of z and beam**

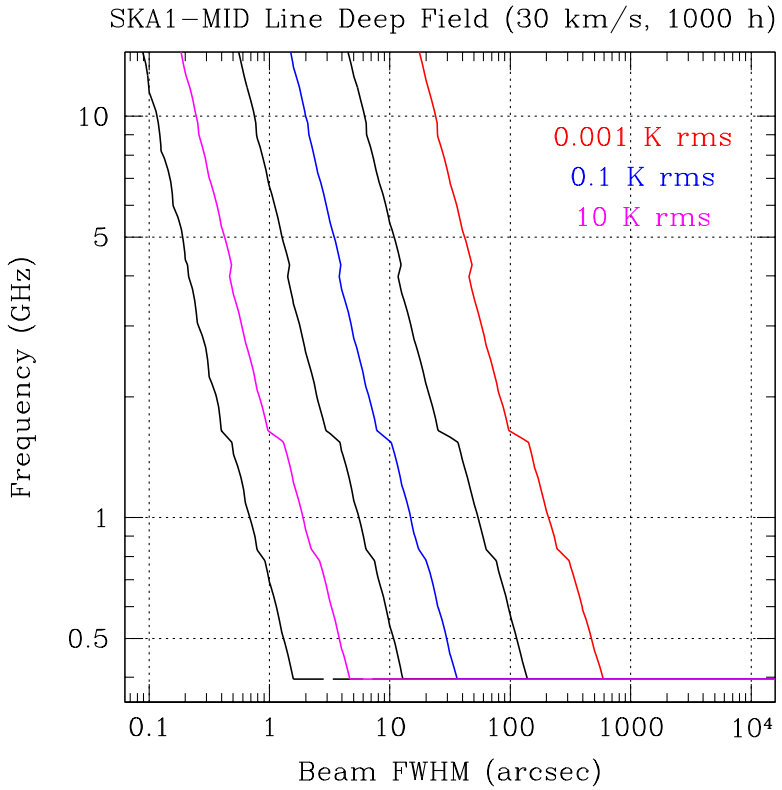
SKA1 HI Capabilities





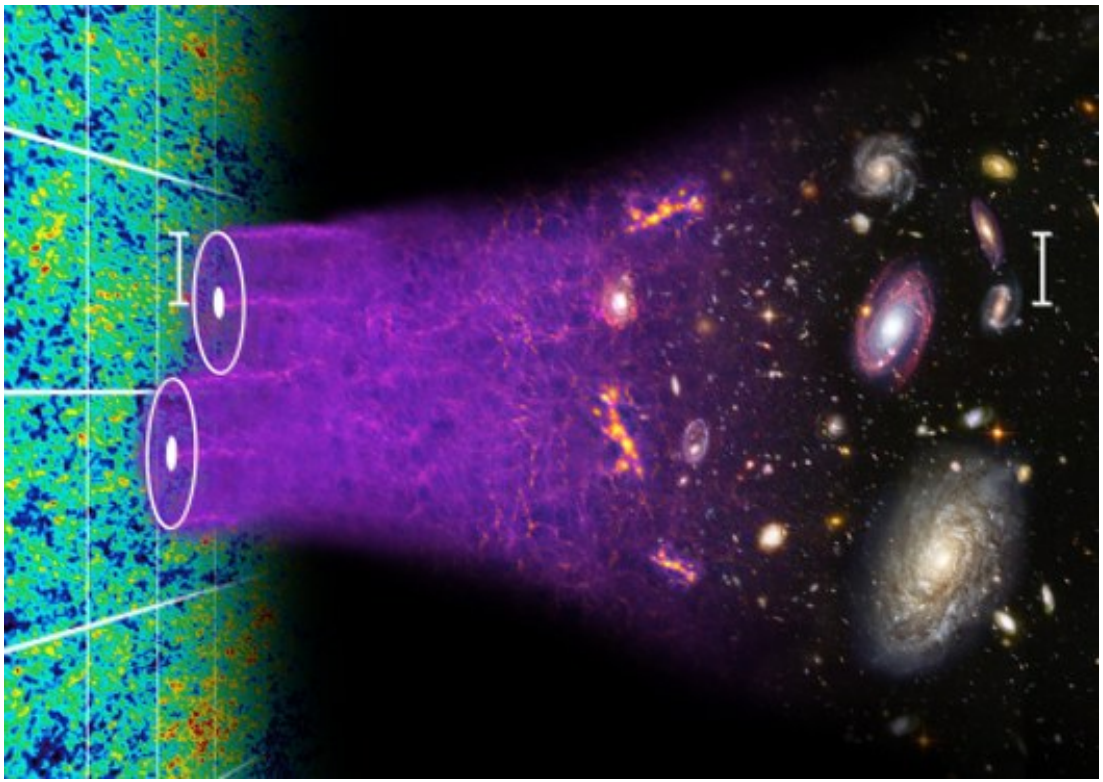
- **Deep** continuum imaging and HI line cubes using SKA1-MID with sub-arcsecond resolution

SKA1 3-D Capabilities



- **Deep** line cubes using SKA1-MID with Kelvin sensitivity at ~arcsecond resolution

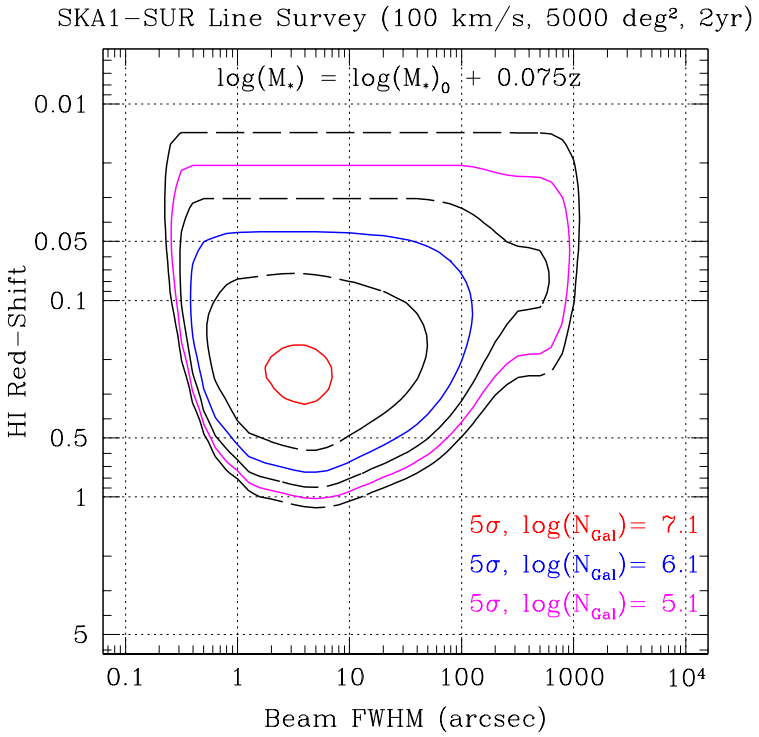
Cosmology with SKA1: Baryon Acoustic Oscillations

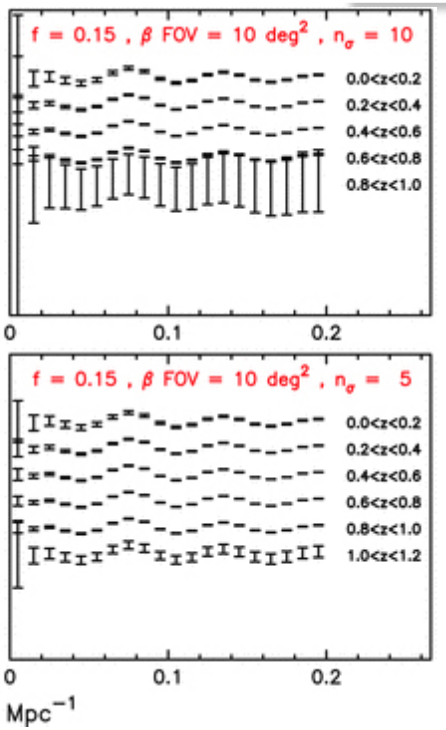


(Blake & Moorfield)

- Constraining Dark Energy models with redshift-resolved BAO measurements

A wide-field HI emission survey for BAO and $\Omega_{HI}(z)$

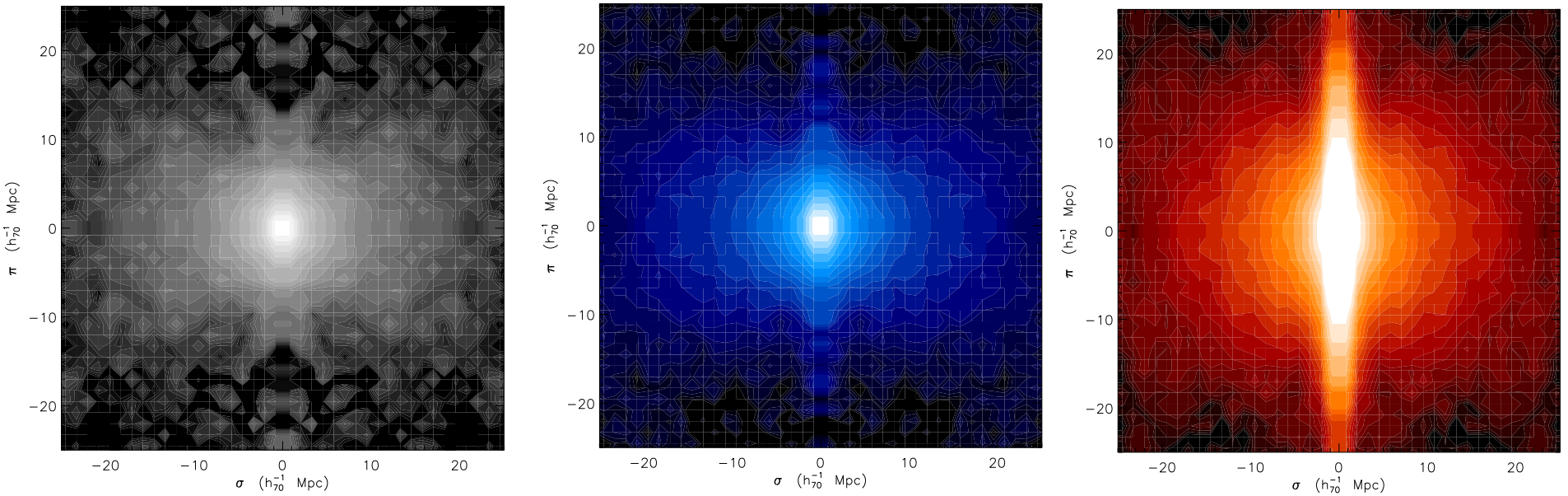




(Abdalla et al 2010)

- Detect $10^{7.1}$ galaxies <z> ≈ 0.3, $10^{5.1}$ galaxies <z> ≈ 1
- Density ≈ 2500 galaxies deg^{-2} , 1 arcmin^{-2}
- Compare SDSS: $10^{6.2}$ galaxies with <z> ≈ 0.1 over 15,000 deg^2
- Compare WigglesZ $10^{5.2}$ galaxies with <z> ≈ 0.6
- **Major contribution to BAO science, complementary systematics versus Opt/IR**

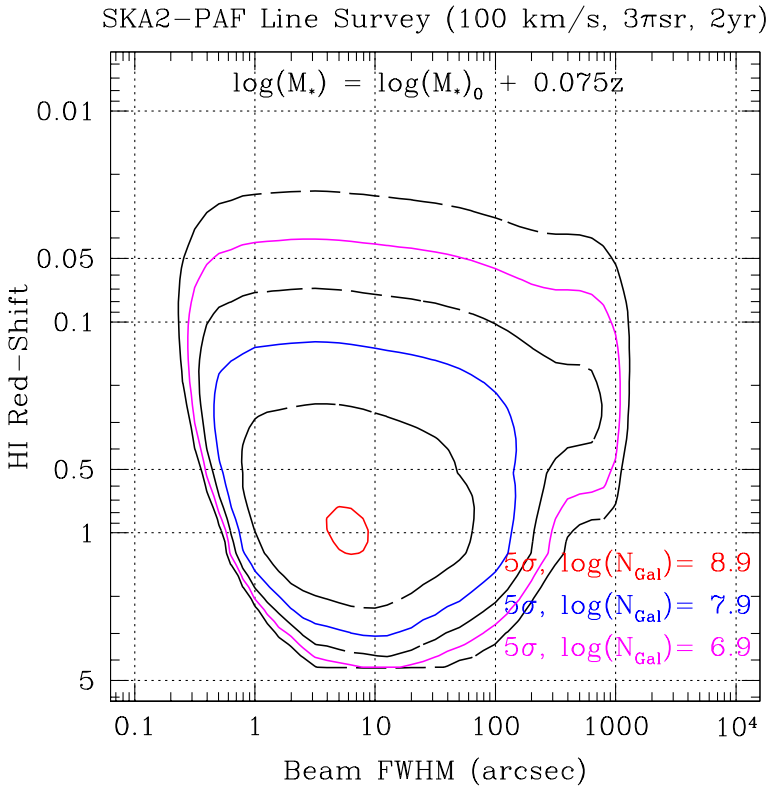
Cosmology with SKA1: complementarity with optical



(Papasterigis et al. 2013) ALFALFA HI versus SDSS blue and red samples

- Correlation functions of HI detections demonstrate much lower bias and excellent prospects for Redshift-space distortion measurements once interesting sample sizes are achieved with SKA1

An SKA2 HI emission survey for precision Cosmology



- Detect $10^{8.9}$ galaxies with <z> ≈ 1, $10^{7.9}$ with <z> ≈ 2
- Compare Euclid (2020+5?) target of 10^{8} spectra with <z> ≈ 1
- **SKA2 will provide an unrivaled capability for precision cosmology!**

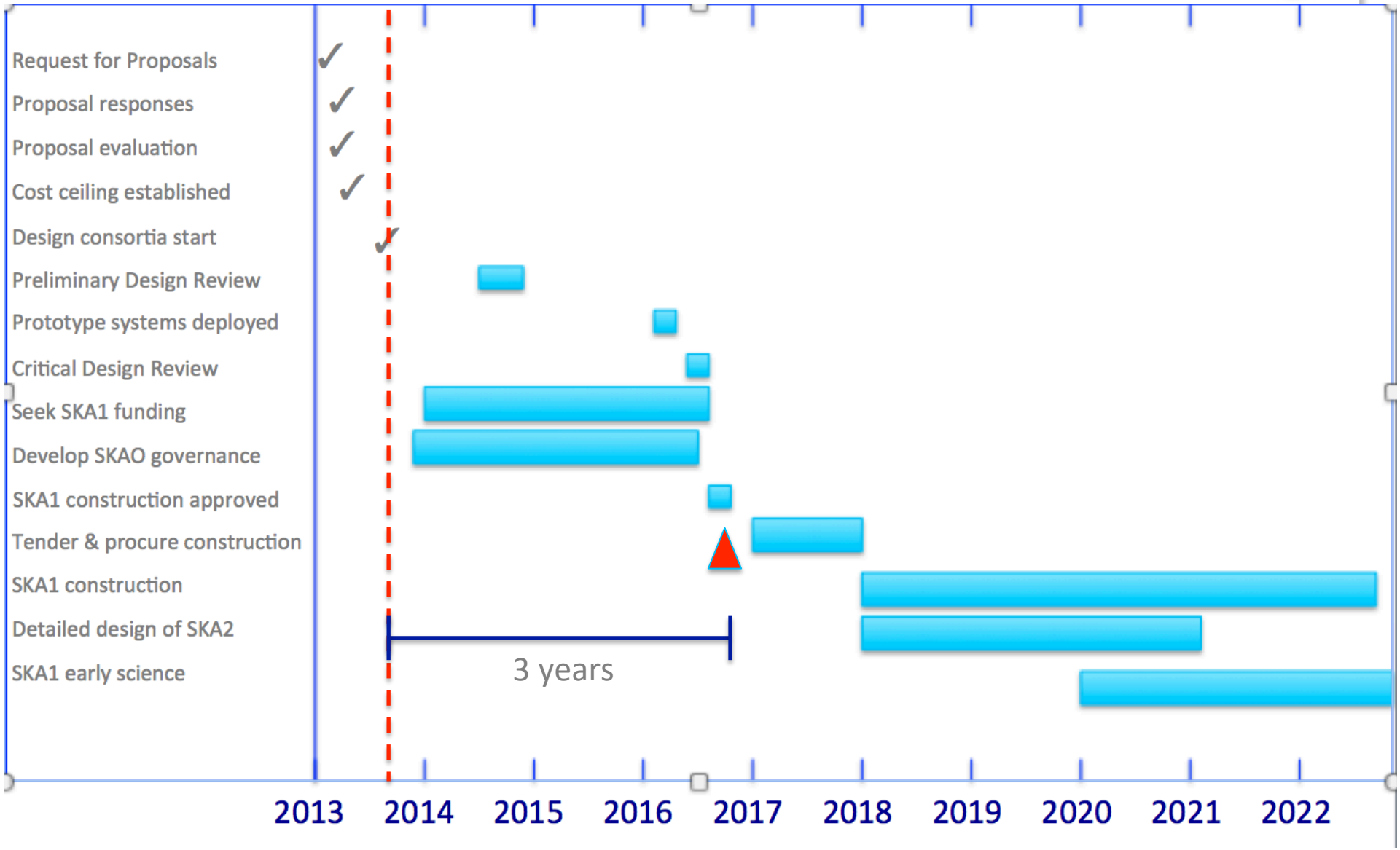
SKA Key Science

- Strong-field Tests of Gravity with Pulsars and Black Holes
  - **Unique GR constraints, major contributions in Phase 1 and Phase 2**
- Galaxy Evolution, Cosmology, & Dark Energy
  - **Cutting edge contributions in non-Gaussianity and Dark Energy**
  - **Complementarity to Euclid, LSST in Phase 1 (reduced systematics)**
  - **Unmatched performance in Phase 2 (Billion Galaxy Surveys)**
- Emerging from the Dark Ages and the Epoch of Reionization
  - **Unique EoR imaging capability in Phase 1**
  - **Reaching to Cosmic Dawn in Phase 2**
- The Cradle of Life & Astrobiology
- The Origin and Evolution of Cosmic Magnetism

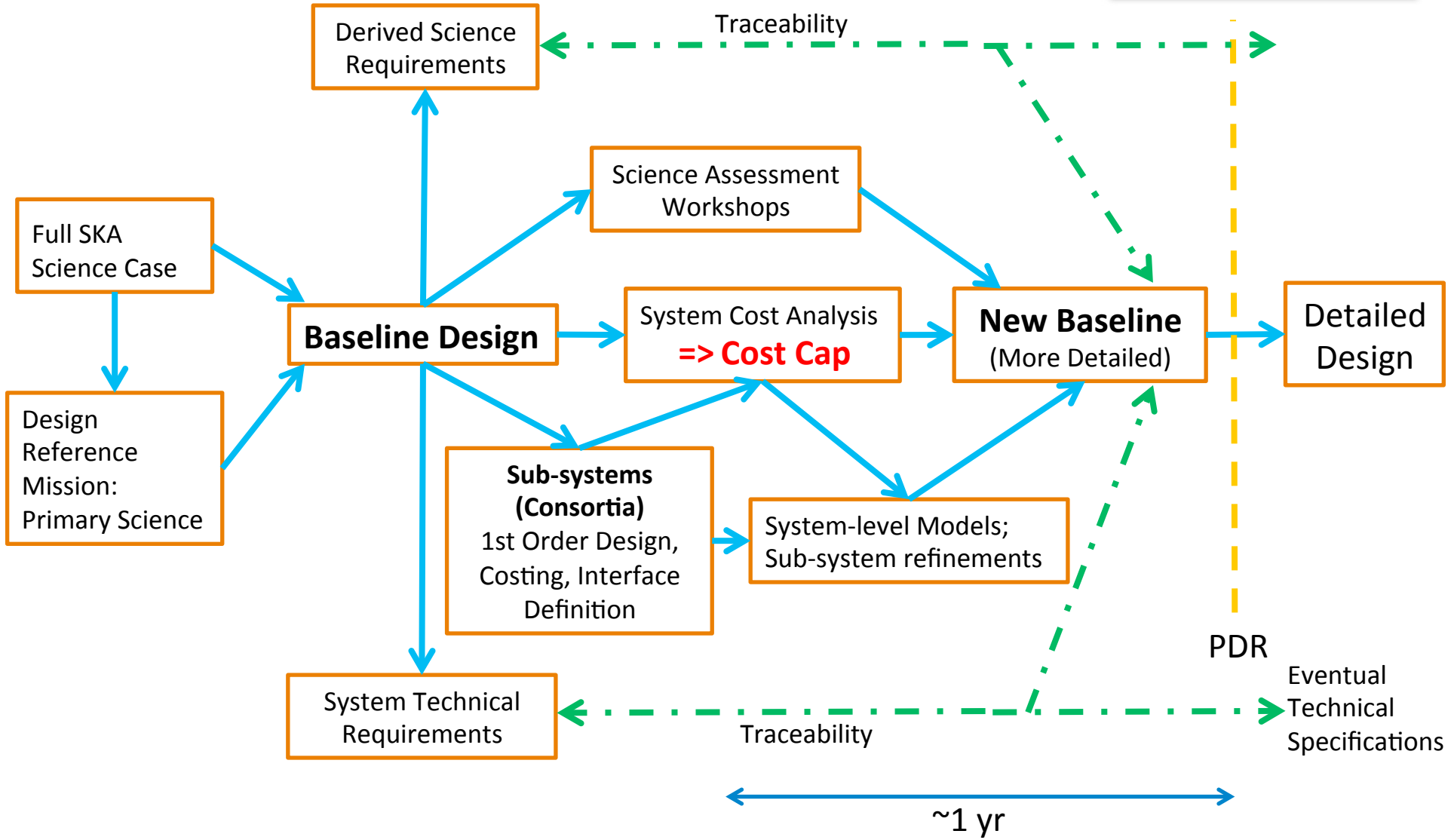
With design philosophy of *Exploration of the Unknown*

Unmatched prospects (complement to LSST) in Phase 1 and Phase 2

Timeline


Request for Proposals
Proposal responses
Proposal evaluation
Cost ceiling established
Design consortia start
Preliminary Design Review
Prototype systems deployed
Critical Design Review
Seek SKA1 funding
Develop SKAO governance
SKA1 construction approved
Tender & procure construction
SKA1 construction
Detailed design of SKA2
SKA1 early science
3 years
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022

Approx. Design Process up to PDR



SKA1 Change Process

3 Engineering Change Proposal (ECP)

3.1 What is an ECP?

An ECP expresses the need for a permanent change of one or more Configuration Items. The rationale for a change could be one or more of the following:

- Functional/Performance improvement or correction
- Change of interfaces
- New requirements
- A change in schedule and/or costs above a certain threshold (TBD)

The ECP process is the formal way to evaluate and to assess possible impacts that a proposed change will have on:

- Schedule,
- Performance,
- Full lifecycle cost,
- Interfaces to other Elements or the external world.

According to their impact, ECPs are classified as either Minor, Major or System Level, based on an evaluation by the SKA Chief System Engineer, SKA Architect & SKA Project Manager and following guidelines provided by the SKA Configuration Control Board (see below).

SKA1 Change Process

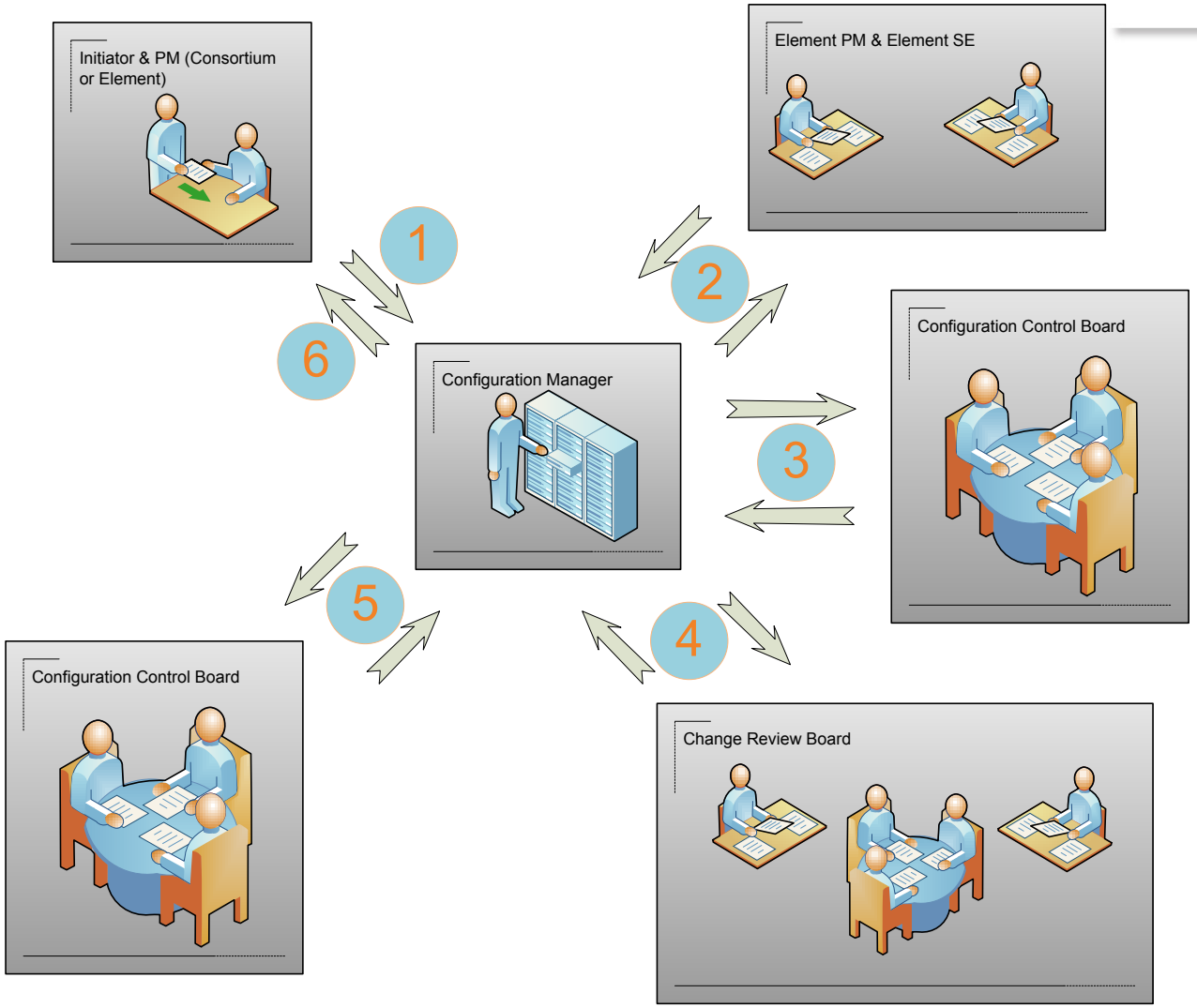


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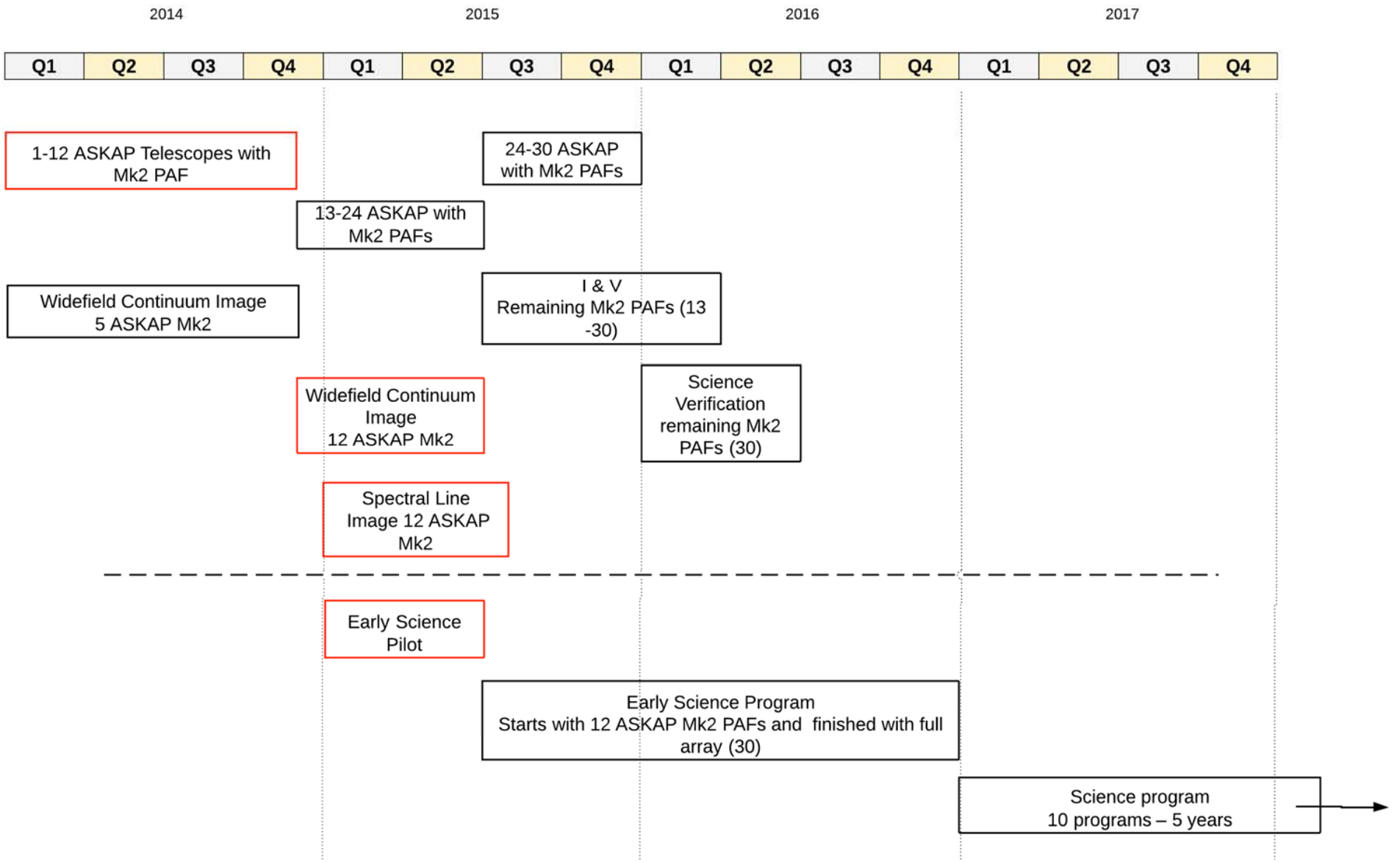
Figure 1: The normal ECP work flow.

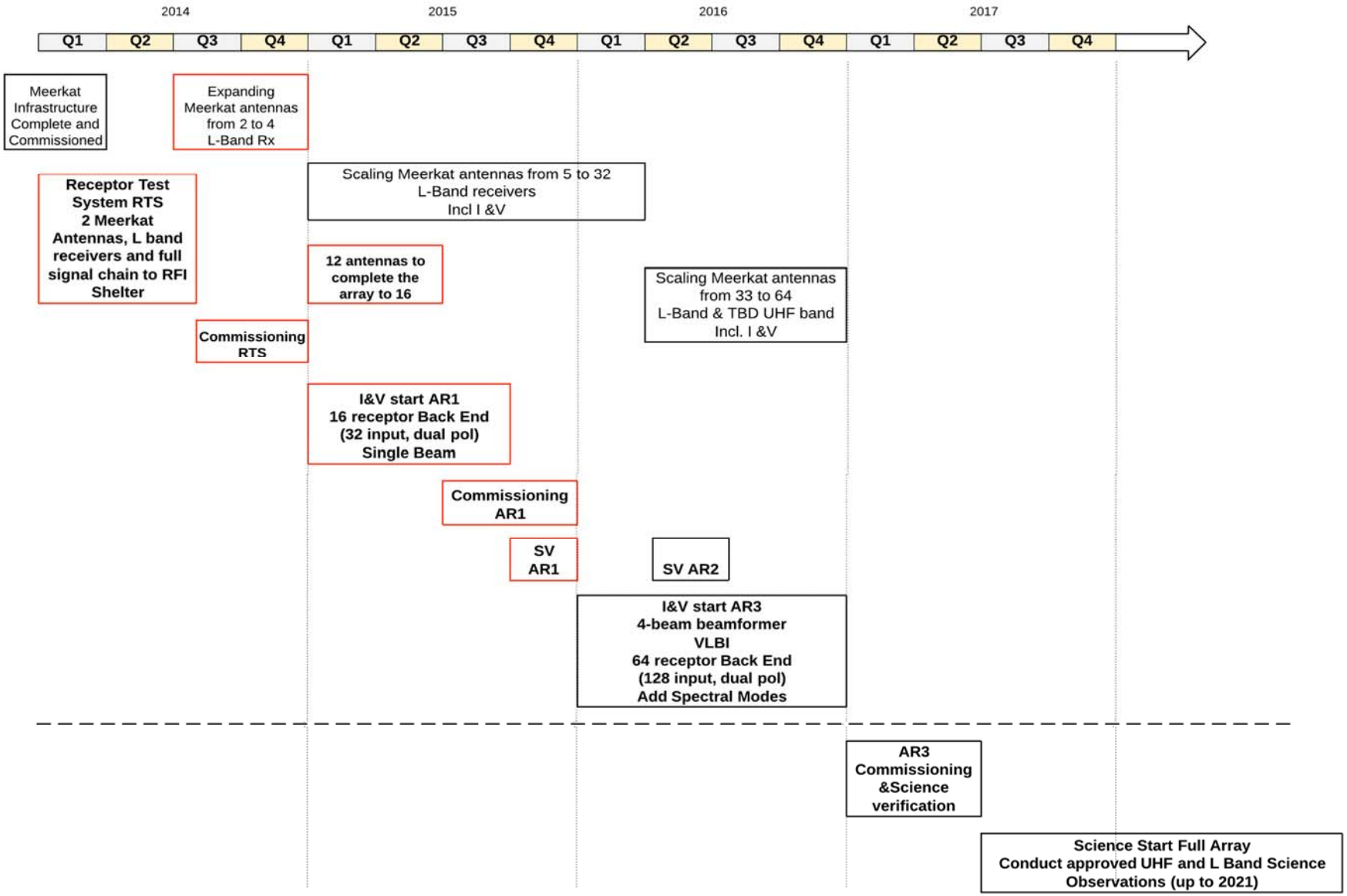
ASKAP Timeline



ASKAP HI Survey Science

- **WALLABY:** Widefield ASKAP L-Band Legacy All-Sky Blind Survey
- **FLASH:** The First Large Absorption Survey in HI
- **GASKAP:** The Galactic ASKAP Spectral Line Survey
- **DINGO:** Deep Investigations of Neutral Gas Origins

MeerKAT Timeline



MeerKAT HI Survey Science

- **LADUMA** (Looking at the Distant Universe with the MeerKAT Array)
- **MeerKAT Absorption Line Survey MHONGOOSE** (MeerKAT HI Observations of Nearby Galactic Objects: Observing Southern Emitters)
- **A MeerKAT HI Survey of the Fornax Cluster**

Advancing Astrophysics

with the Square Kilometre Array

9-13 June 2014, Giardini Naxos, Italy

#skascicon14

2014 marks 10 years since the publication of the comprehensive **'Science with the Square Kilometre Array'** book and 15 years since the first such volume appeared in 1999. In that time numerous and unexpected advances have been made in the fields of astronomy and physics relevant to the capabilities of the Square Kilometre Array (SKA). This meeting will facilitate the publication of a new, updated science book, which will be relevant to the current astrophysical context.

Scientific Organising Committee

Robert Braun (SKAO) – co-Chair
Grazia Umana (INAF-OACt) – co-Chair
Tyler Bourke (SKAO)
Rob Fender (Oxford)
Federica Govoni (INAF–OA Cagliari)
Jimi Green (SKAO)
Melvin Hoare (Leeds)
Melanie Johnston-Hollitt (Victoria Univ. Wellington)
Leon Koopmans (Kapteyn Astronomical Institute)
Michael Kramer (MPIfR)
Roy Maartens (Univ. Western Cape)
Tom Oosterloo (ASTRON)
Isabella Prandoni (INAF–IRA)
Nicholas Seymour (CASS)
Ben Stappers (Manchester)
Lister Staveley-Smith (ICRAR)
Wen Wu Tian (NAOC)
Jeff Wagg (SKAO)

Enquiries: ska-june14@skatelescope.org
or visit: indico.skatelescope.org/event/AdvancingAstrophysics2014

Thank you

www.skatelescope.org

SKA HI Science Questions

- Basic access model
  - "Common skies" with N% "international" time
  - How much international time?
- Time for large surveys versus PI projects
  - 50:50 ? or 75:25 or 25:75 ???
- Key projects
  - Based on proposals?
  - Predefined?
  - Counting of team members
    - Restriction to member countries ?
    - Right of member countries to nominate several team members/ leaders?