ASTRON

Netherlands Institute for Radio Astronomy

Opportunities for torus observations with new radio facilities and the Square Kilometre Array (SKA)

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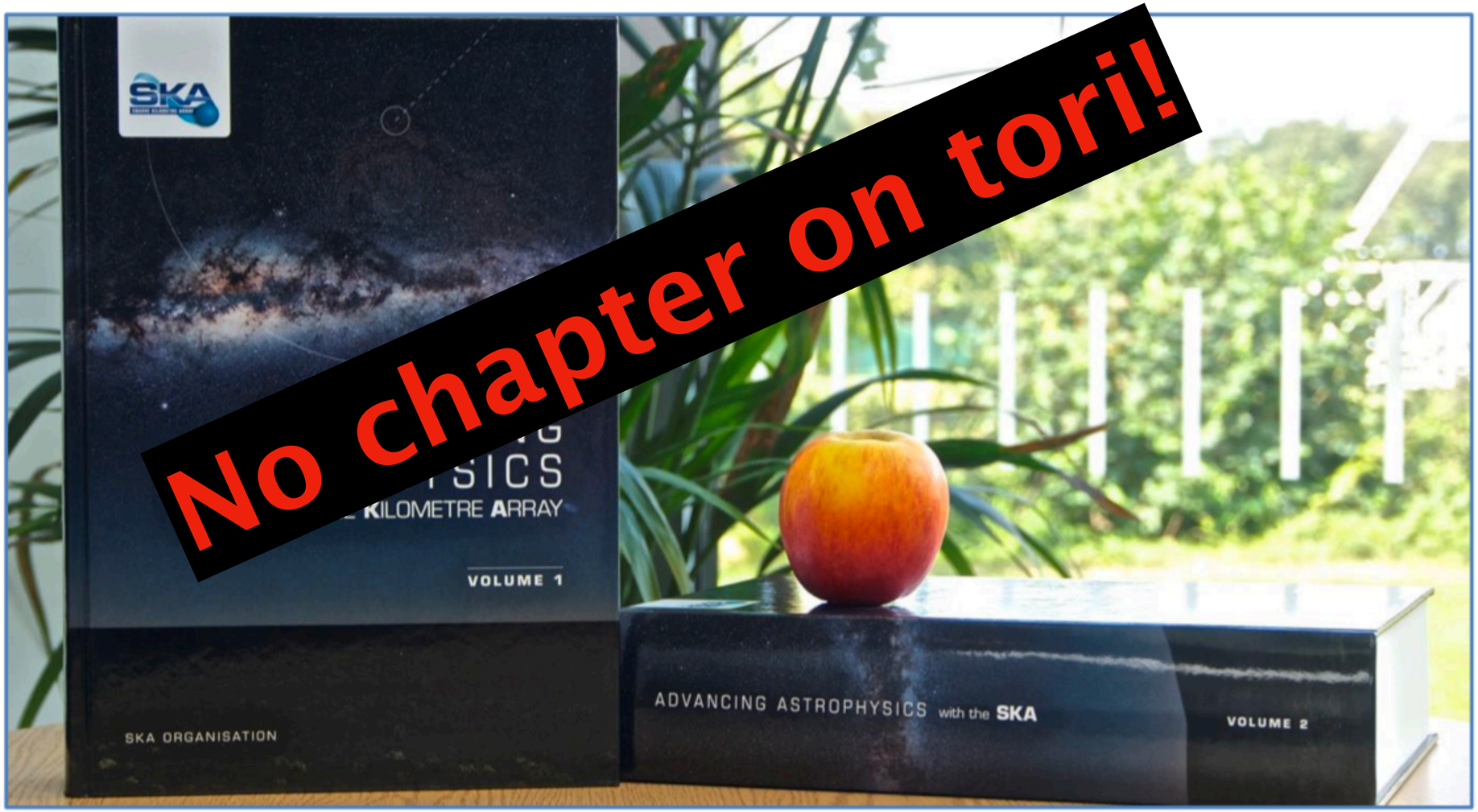
SKA science case – 2015

- 135 Chapters
- more than 1200 authors
- 31 countries
- 9-kg of science



SKA science case - 2004

New Astronomy Reviews
Volume 48, Issues 11–12, December 2004, Pages 1195-1209

Disks, tori, and cocoons: emission and absorption diagnostics of AGN environments

R. Morganti [a], L.J. Greenhill [b, 1], A.B. Peck [c], D.L. Jones [d], C. Henkel [e]

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Abstract

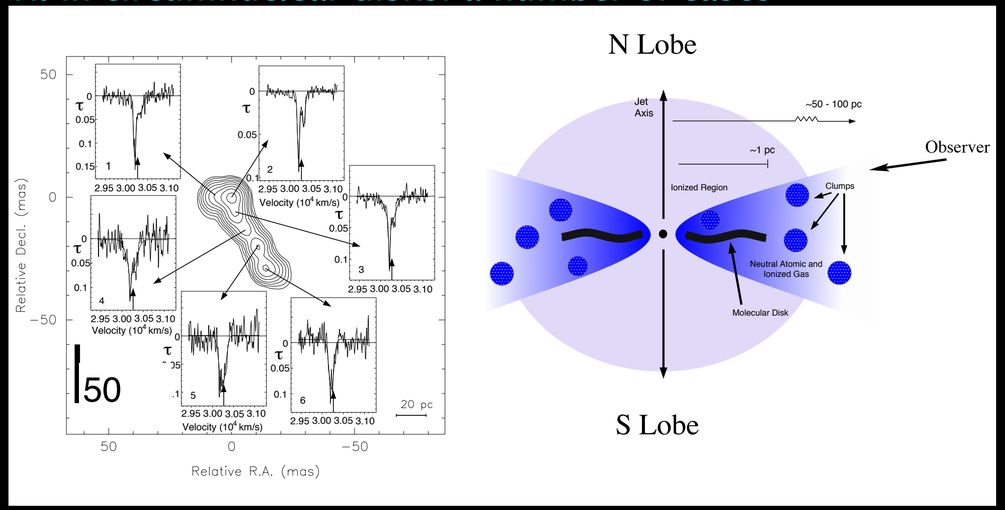
One of the most important problems in the study of active galaxies is understanding the detailed geometry, physics, and evolution of the central engines and their environments. The leading models involve an accretion disk and torus structure around a central dense object, thought to be a supermassive black hole. Gas found in the environment of active galactic nuclei (AGN) is associated with different structures: molecular accretion disks, larger scale atomic tori, ionized and neutral "cocoons" in which the nuclear regions can be embedded. All of them can be studied at radio wavelengths by various means. Here, we summarize the work that has been done to date in the radio band to characterize these structures. Much has been learned about the central few parsecs of AGN in the last few decades with contemporary instruments but the picture remains incomplete. In order to be able to define a more accurate model

Topics:

- Masers
- Tori/circumnuclear disks in absorption:
  HI and free-free
- HI outflows

…

HI in circumnuclear disks: a number of cases



Peck and Taylor (2001)

ngVLA – next generation VLA

From the web page (http://ngvla.nrao.edu/page/) “Depending on the recommendation for the Astro2020 Decadal Survey, we expect to enter the design phase in late 2021 and have a final design completed by late 2023. Procurement and construction would then commence in 2024 and should be completed by 2034. “

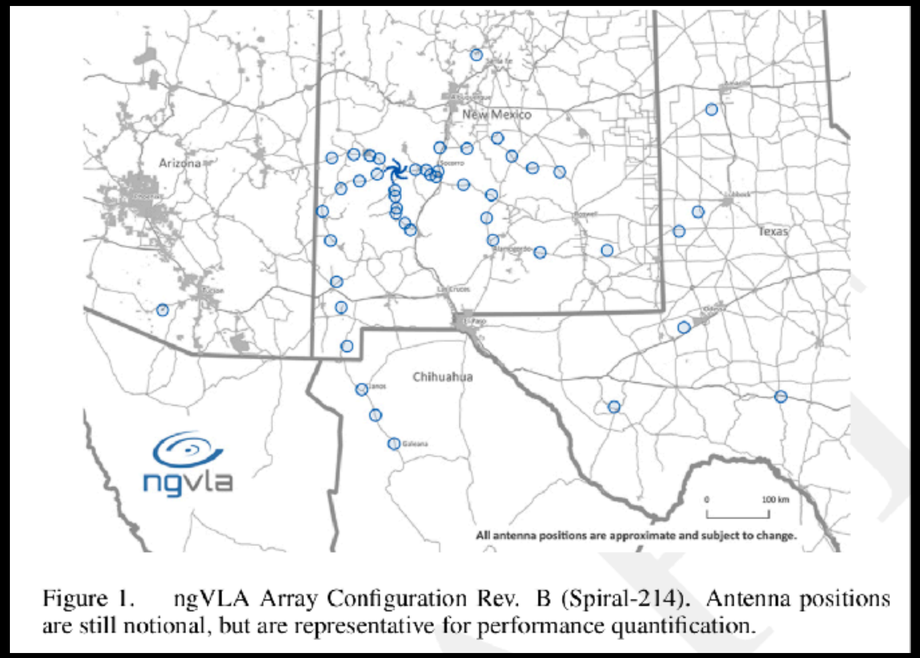


Figure 1. ngVLA Array Configuration Rev. B (Spiral-214). Antenna positions are still notional, but are representative for performance quantification.

Science with a Next-Generation Very Large Array
ASP Conference Series, Monograph 7
Eric J. Murphy, ed.

DRAFT EDITION

The ngVLA Science Case and Associated Science Requirements

Eric J. Murphy,[1] Alberto Bolatto,[2] Shami Chatterjee,[3] Caitlin M. Casey,[4] Laura Chomiuk,[5] Daniel Dale,[6] Imke de Pater,[7] Mark Dickinson,[8] James Di Francesco,[9,10] Gregg Hallinan,[11] Andrea Isella,[12] Kotaro Kohno,[13] S. R. Kulkarni,[11] Cornelia Lang,[14] T. Joseph W. Lazio,[15] Adam K. Leroy,[16] Laurent Loinard,[17,18] Thomas J. Maccarone,[19] Brenda C. Matthews,[9,10] Rachel A. Osten,[20] Mark J. Reid,[21] Dominik Riechers,[3] Nami Sakai,[22] Fabian Walter,[23] & David Wilner[21]

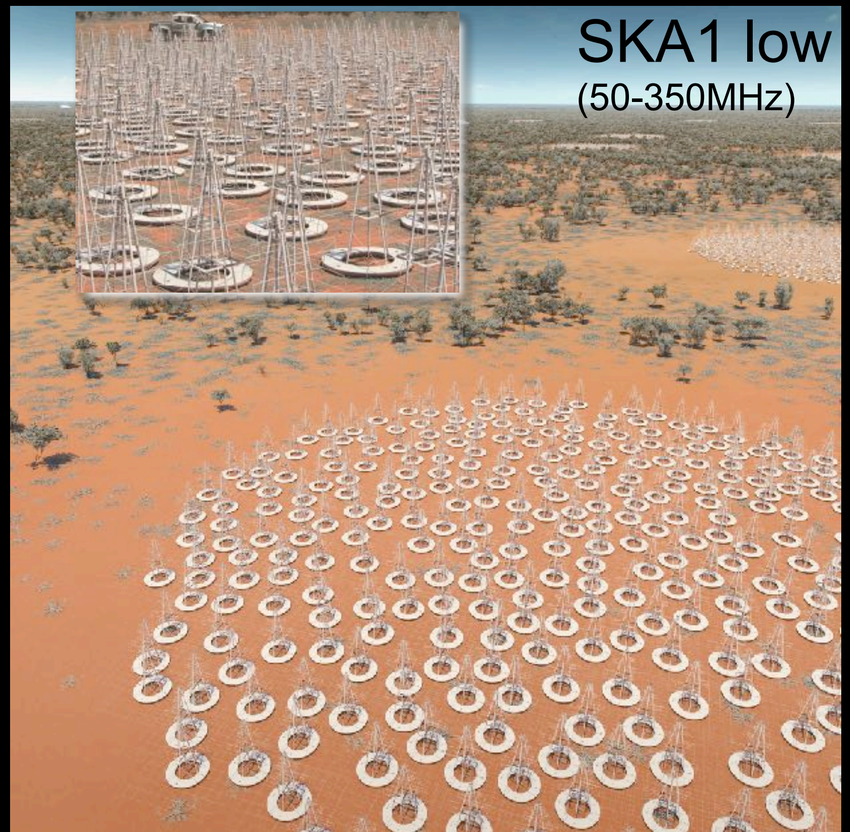
Abstract. The science case and associated science requirements for a next-generation Very Large Array (ngVLA) are described, highlighting the five key science goals developed out of a community-driven vision of the highest scientific priorities in the next decade. Building on the superb cm observing conditions and existing infrastructure of the VLA site in the U.S. Southwest, the ngVLA is envisaged to be an interferometric array with more than 10 times the sensitivity and spatial resolution of the current VLA and the ALMA, operating at frequencies spanning ~ 1.2–116 GHz. The ngVLA will be optimized for observations at wavelengths between the exquisite performance of ALMA at submm wavelengths, and the future SKA-1 at decimeter to meter wavelengths, thus lending itself to be highly complementary with these facilities. The ngVLA will be the only facility in the world that can tackle a broad range of outstanding scientific questions in modern astronomy by simultaneously delivering the capability to: unveil the formation of Solar System analogues; probe the initial conditions for planetary systems and life with astrochemistry; characterize the assembly, structure, and evolution of galaxies from the first billion years to the present; use pulsars in the Galactic center as fundamental tests of gravity; and understand the formation and evolution of stellar and supermassive blackholes in the era of multi-messenger astronomy.

But also here no chapter on tori!

The Square Kilometre Array project – SKA1

South Africa's Karoo region

Western Australia's Murchison Shire



Participating Countries

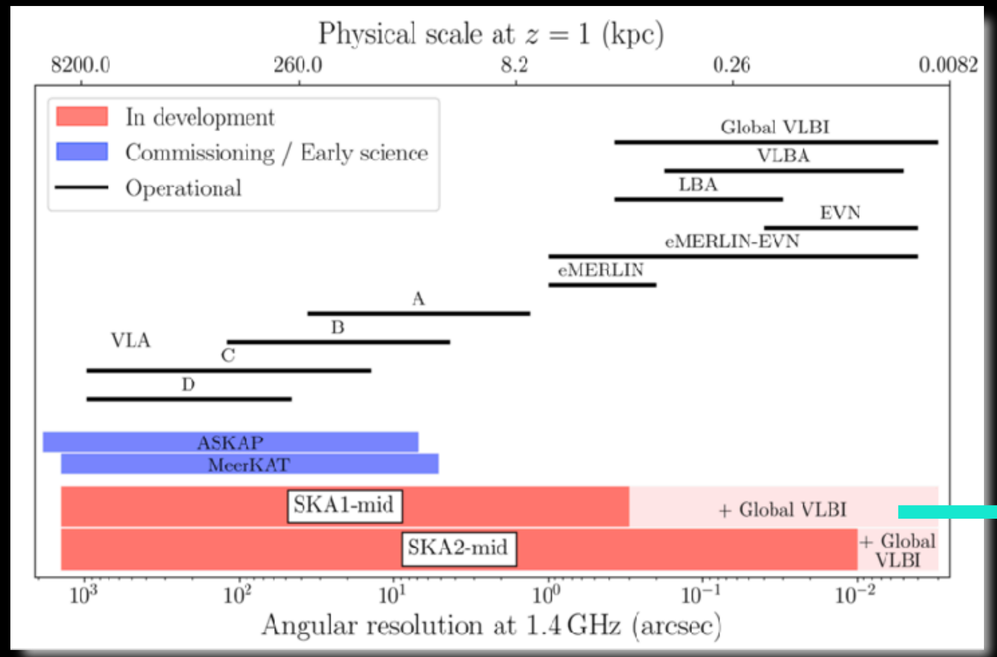
Observers: Japan, Portugal, Malta, USA (Germany)

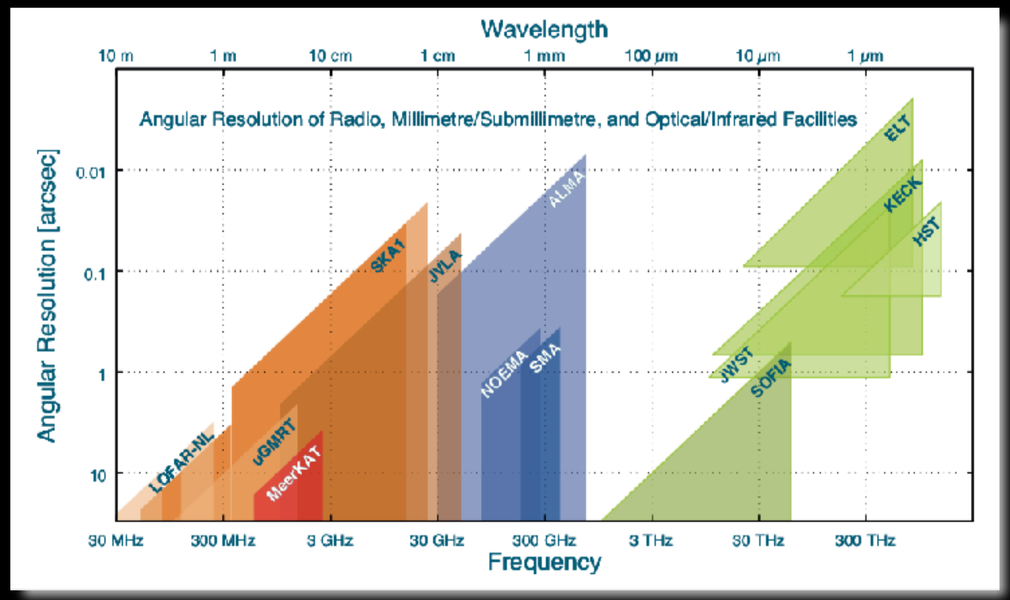
Expected Performance

SKA1 Telescope Expected Performance – Imaging

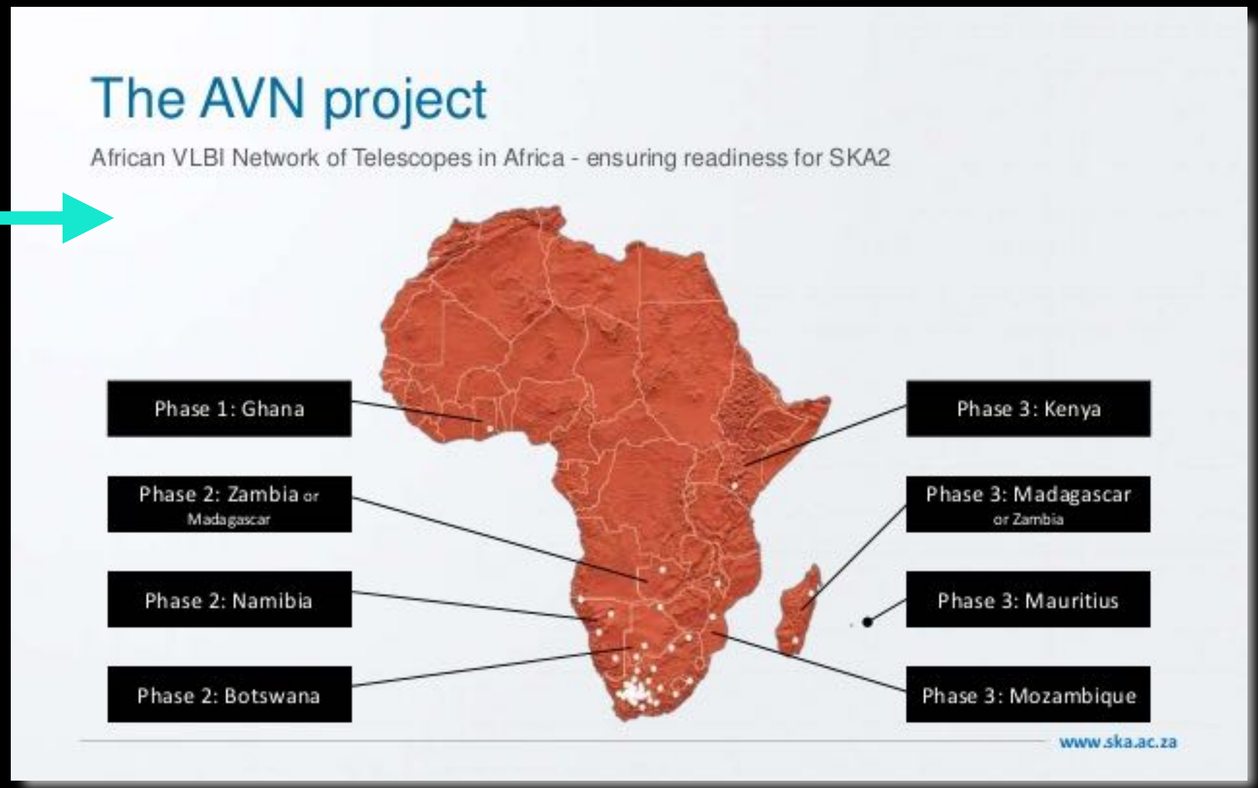
Nominal Frequency	110 MHz	300 MHz	770 MHz	1.4 GHz	6.7 GHz	12.5 GHz
Range [GHz]	0.05-0.35	0.05-0.35	0.35-1.05	0.95-1.76	4.6-8.5	8.3-15.3
Telescope	Low	Low	Mid	Mid	Mid	Mid
FoV [arcmin]	327	120	109	60	12.5	6.7
Max. Resolution [arcsec]	11	4	0.7	0.4	0.08	0.04
Max. Bandwdith [GHz]	0.3	0.3	1	1	4	5
Cont. rms, 1 hr [μJy/beam][a]	26	14	4.4	2	1.3	1.2
Line rms, 1 hr [μJy/beam][b]	1850	800	300	140	90	85
Resolution Range for Cont. and Line rms [arcsec][c]	12–600	6–300	1–145	0.6–78	0.13–17	0.07–9
Channel width (uniform resolution across max. bandwidth) [kHz]	5.4	5.4	15.2	15.2	61.0	79.3
Spectral zoom windows X narrowest bandwidth [MHz]	4 X 4.0	4 X 4.0	4 X 3.125	4 X 3.125	4 X 3.125	4 X 3.125
Finest zoom channel width [Hz]	244	244	190	190	190	190

Resolution @ 1.4 GHz and planned VLBI network





African VLBI Network



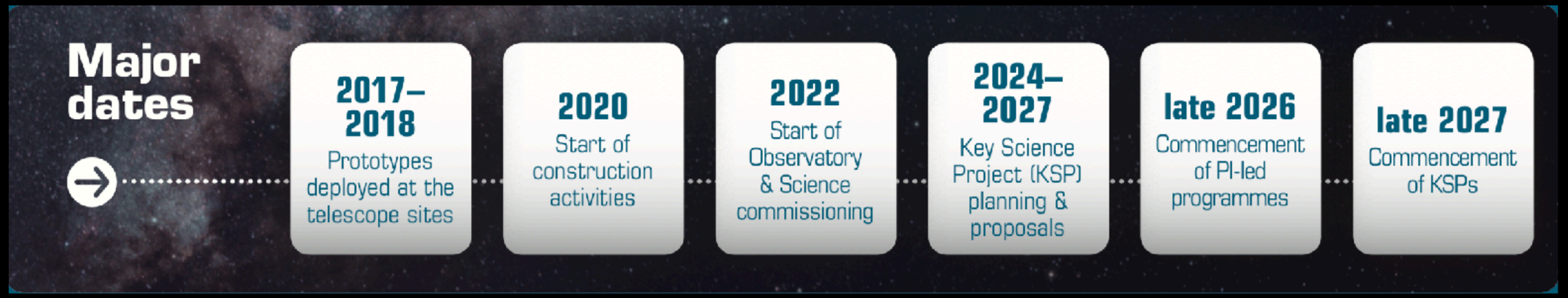
VLBI network to expand SKA

Timeline and access

On-going negotiations for an intergovernmental agreement to establish the SKA Observatory

Access Principles

- Common time allocation process based on **scientific merit** and **technical feasibility**
- Access **proportional to national share** in the project
- **Up to 5%** Open Time available
- **Key Science Projects to take up 50-75% of observing time**, with conventional PI-led projects taking up the remainder
- **All data** to be made **openly available** following a proprietary period



New generation radio telescopes

Major new capabilities of radio telescopes:

★ **large field of view** → Many sq deg in one pointing! with high spatial resolution

★ **broad instantaneous band** → HI over large redshift, spectral properties, magnetism

★ **fast response** → Transient events

Commensality of the observations ➜ allow a variety of different science using one pointing

New possibilities for the science ➜ but huge datasets and need for pipelines

Availability of ancillary data very important!

Coordination with other facilities/telescopes essential for success

SKA pathfinders/precursors

		Frequencies	Surveys?	Status	Open Time
LOFAR	North	40 - 200 MHz	Yes	Surveys in progress First release HETEX field (Shimwell et al. 2018)	Yes
Apertif-WSRT	North	1.4GHz	Yes	Start surveys Jan 2019	No, but open to collaboration
MWA	South	74 - 230 MHz	Yes	Surveys published	Some
ASKAP	South	1.4GHz	Yes	Close to completion Commissioning	No
MeerKAT	South	1.4GHz	Large areas, famous fields	Close to completion	Maybe

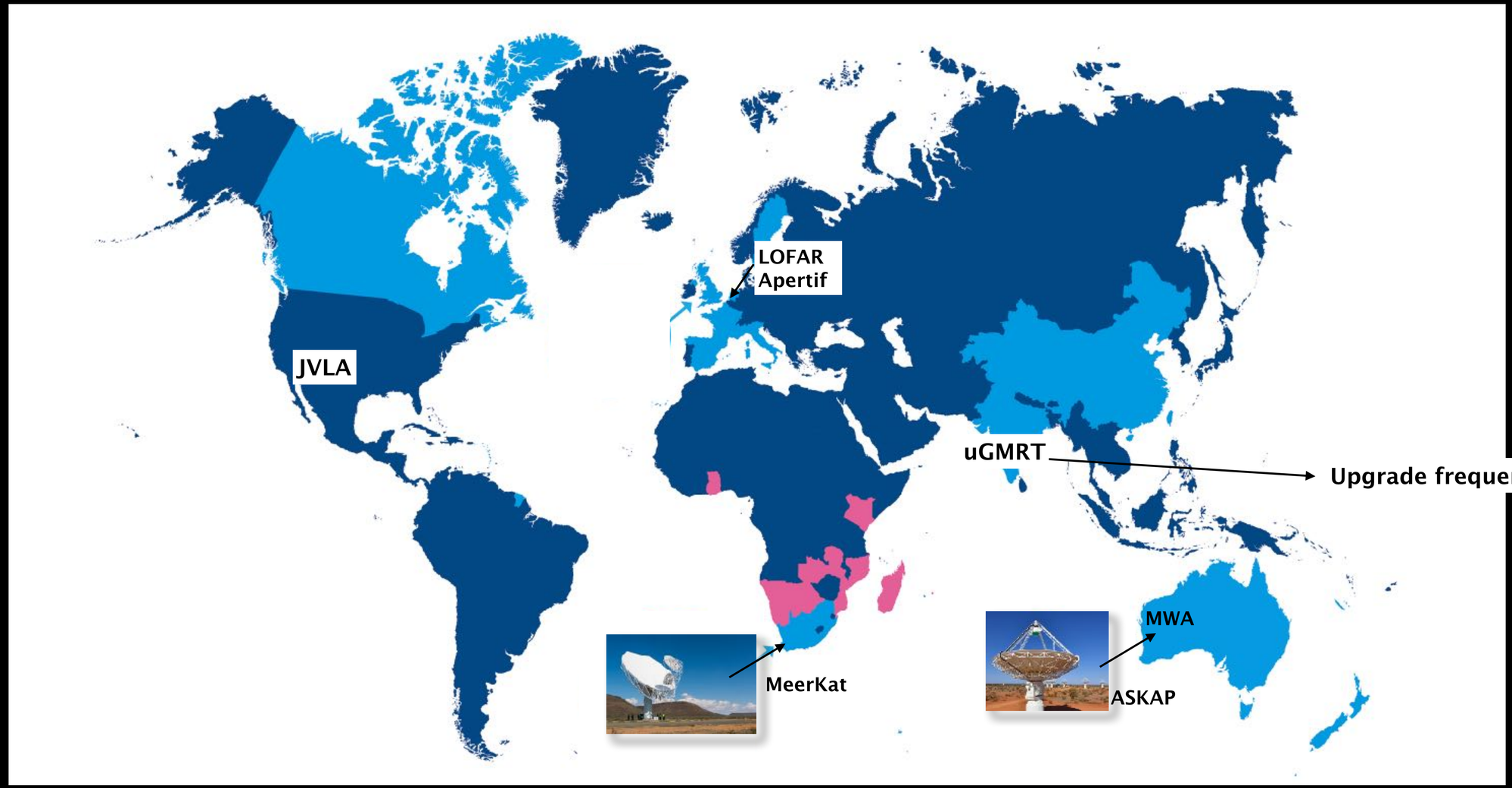
← HI low z

← HI to high z

← HI to high z

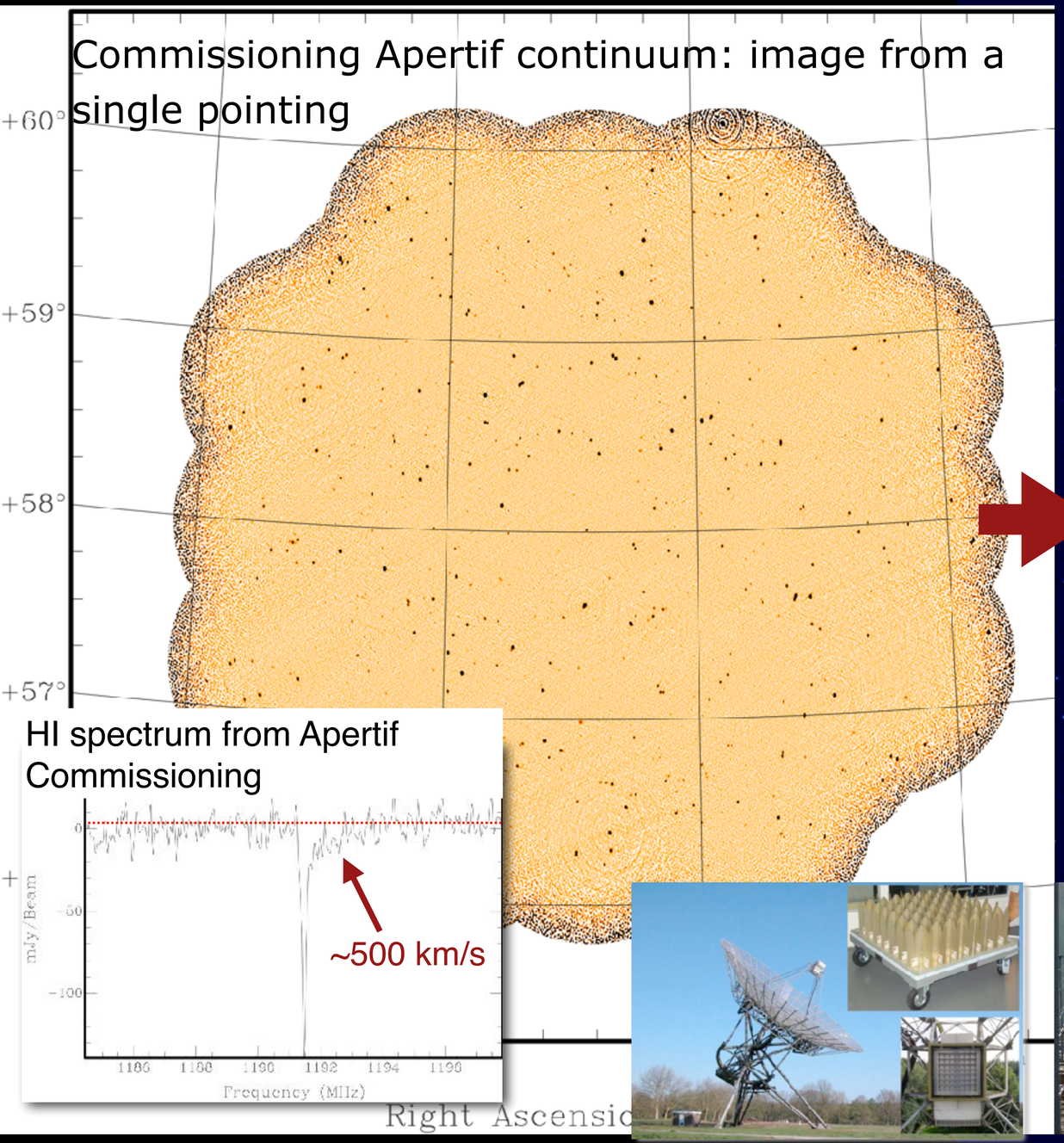
Square Kilometre Array - SKA

Pathfinders



Examples of large field of view

Commissioning Apertif continuum: image from a single pointing



HI spectrum from Apertif Commissioning

LOFAR one pointing
Mahony et al. 2016

ASKAP - Example of redshift coverage for HI abs

Allison et al. (2016)

- SKA is slowly coming along: circumnuclear disks and tori science not really well represented!
- Opportunities to join WG (open for participation)
- In the coming years a number of new radio facilities
- Major changes in radio astronomy, new opportunities, new surveys coming up

keep an eye on them!

e.g. LOFAR about to release 400 sq deg of images HETDEX area (6arcsec resolution @150MHz)