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VLBI with the SKAO

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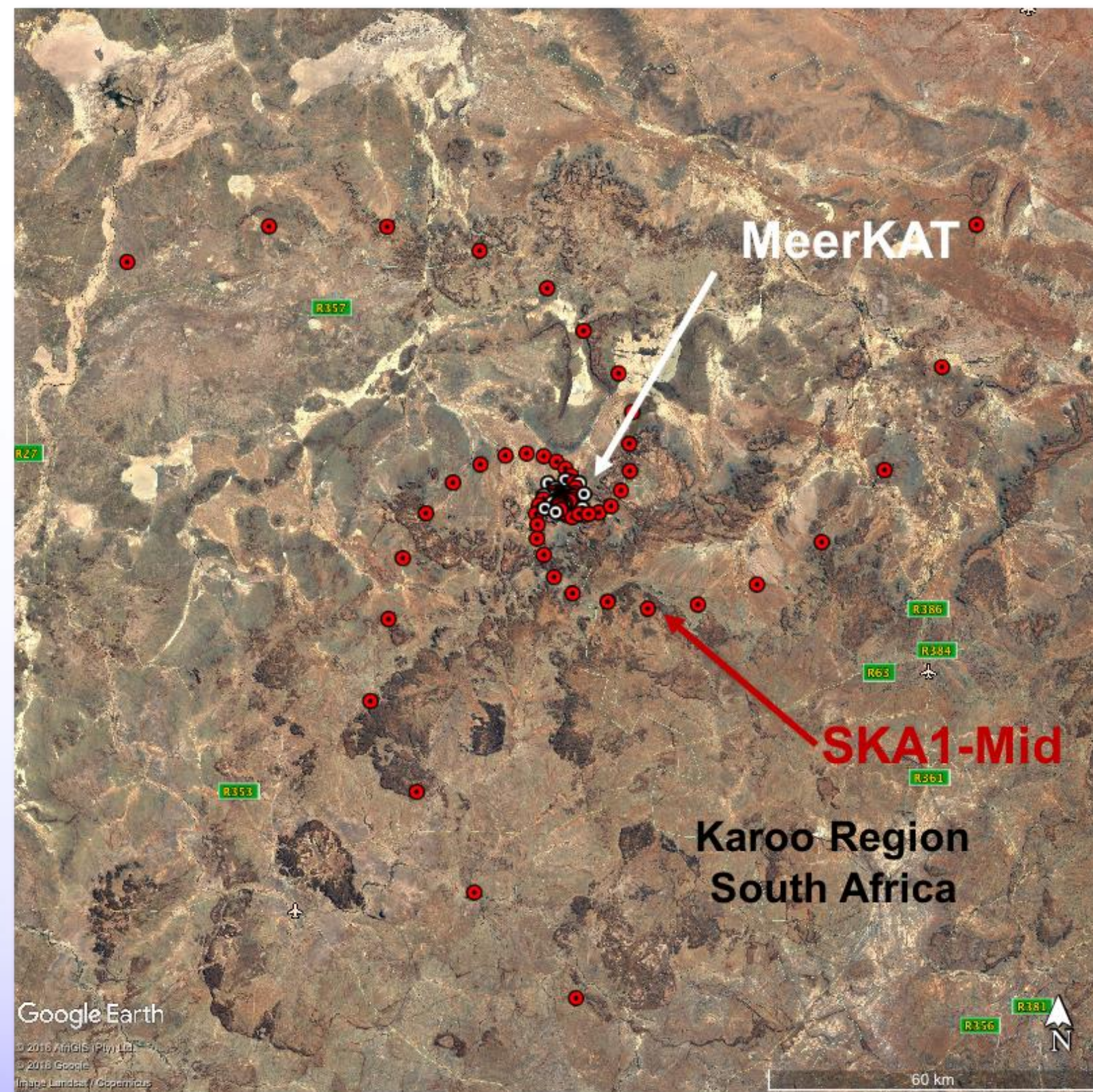


Image credit: SKAO

What is the Square Kilometre Array

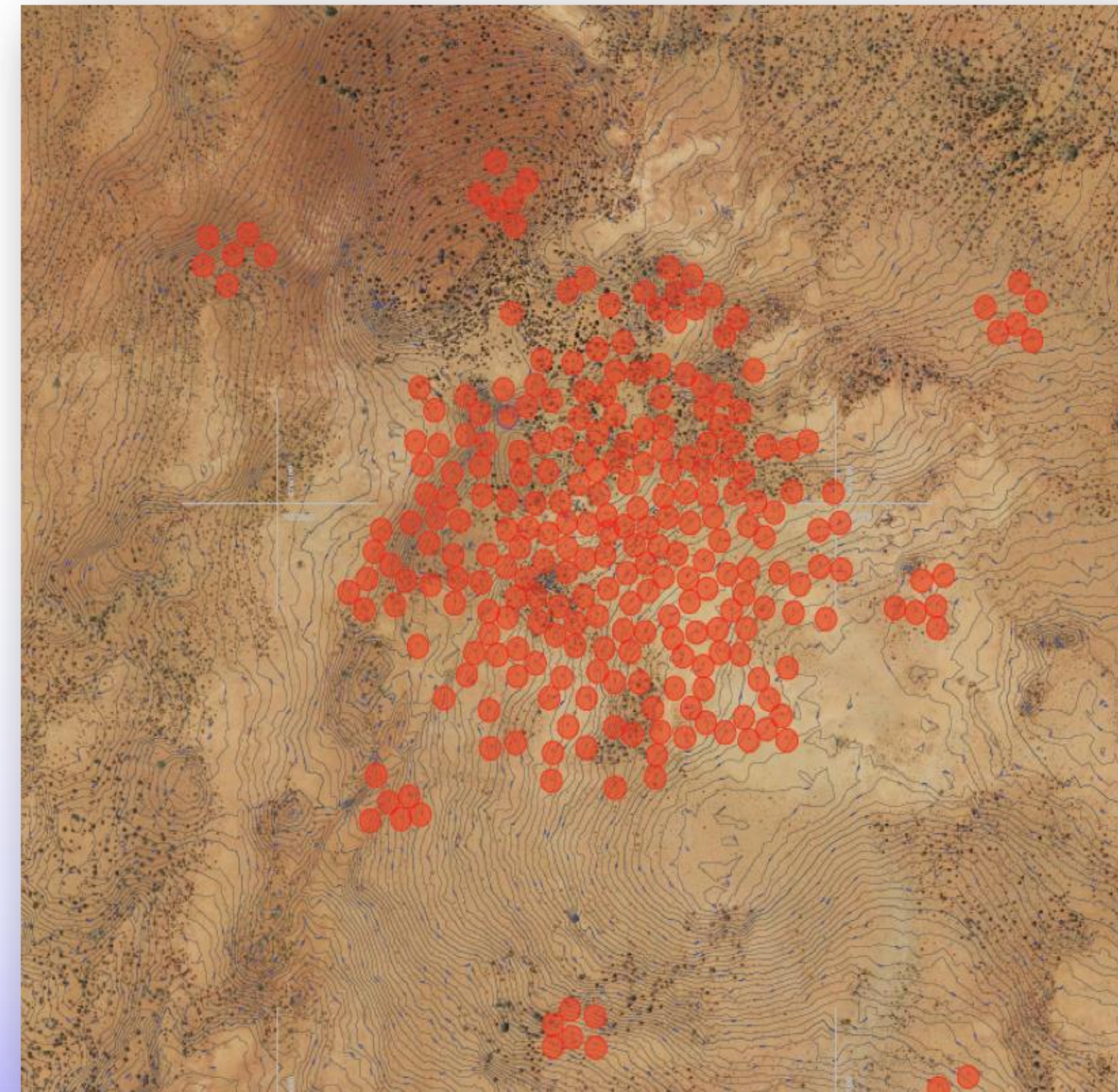
- One observatory, two telescopes, three sites

SKA-Mid - 133 15m SKA dishes and 64 13.5m Meerkat dishes at the Karoo site in South Africa



0.35-15 GHz
150 km baseline

SKA-Low - 131,072 dipole antennas distributed across 512 aperture array stations of 256 antennas each. Located in the Murchison Radio-astronomy Observatory, Western Australia.



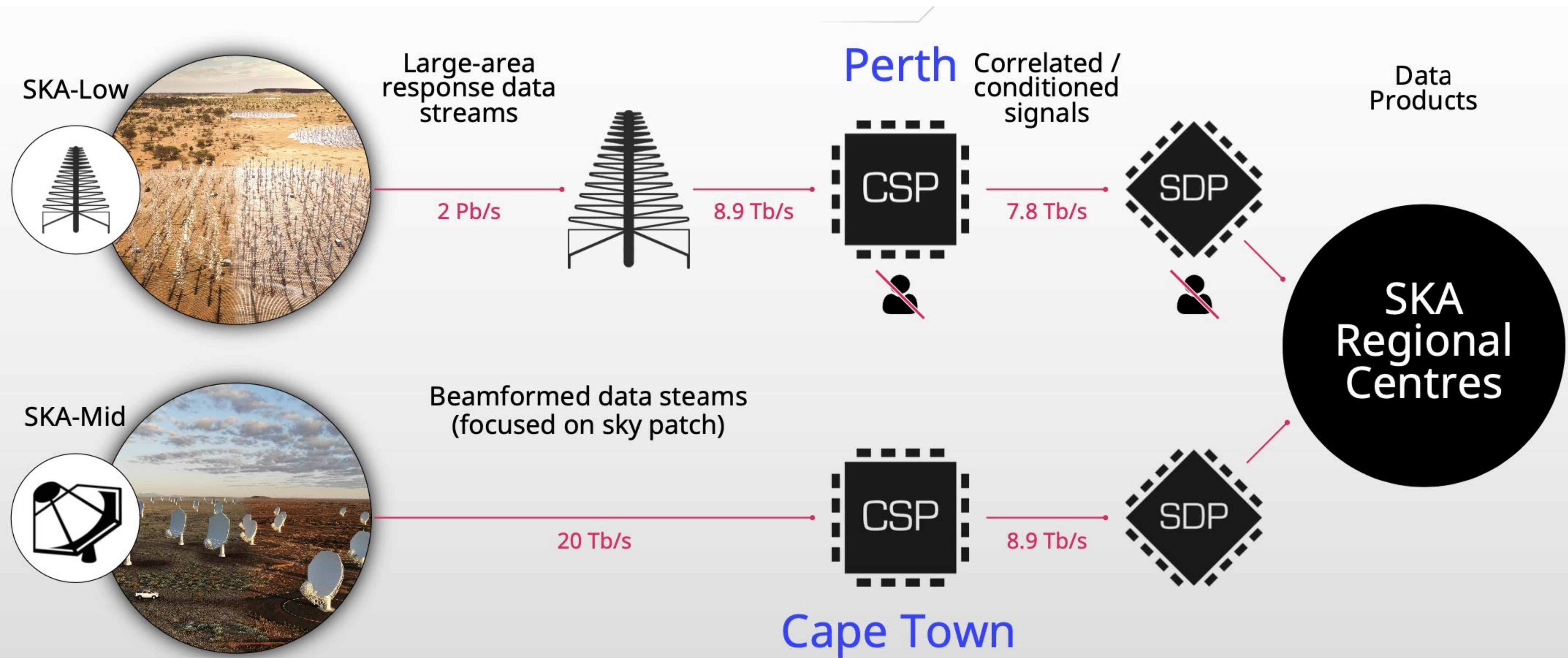
50-350 MHz
70 km baseline

SKAO HQ - Manchester, UK

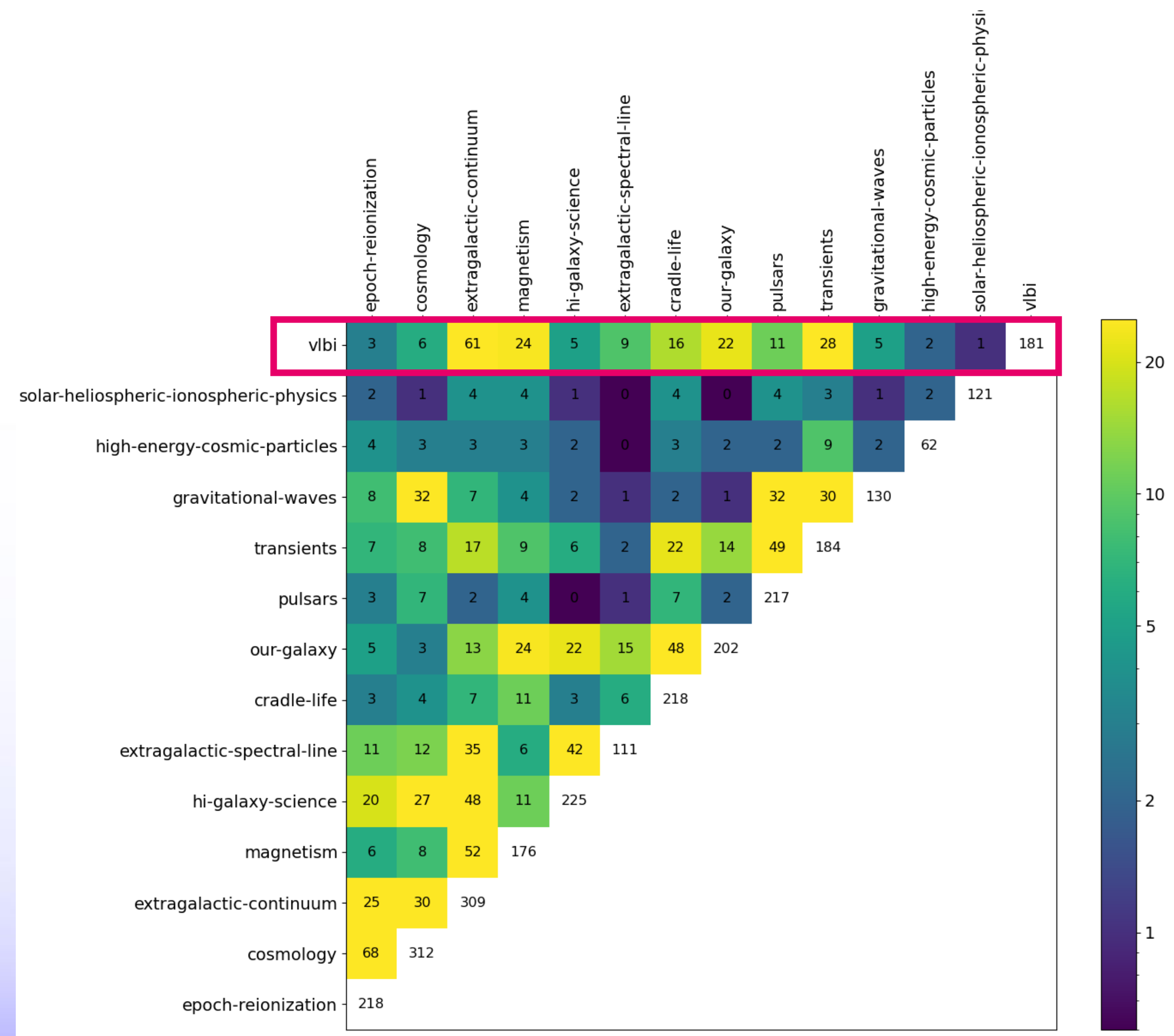
SKAO science drivers



Voltages to science

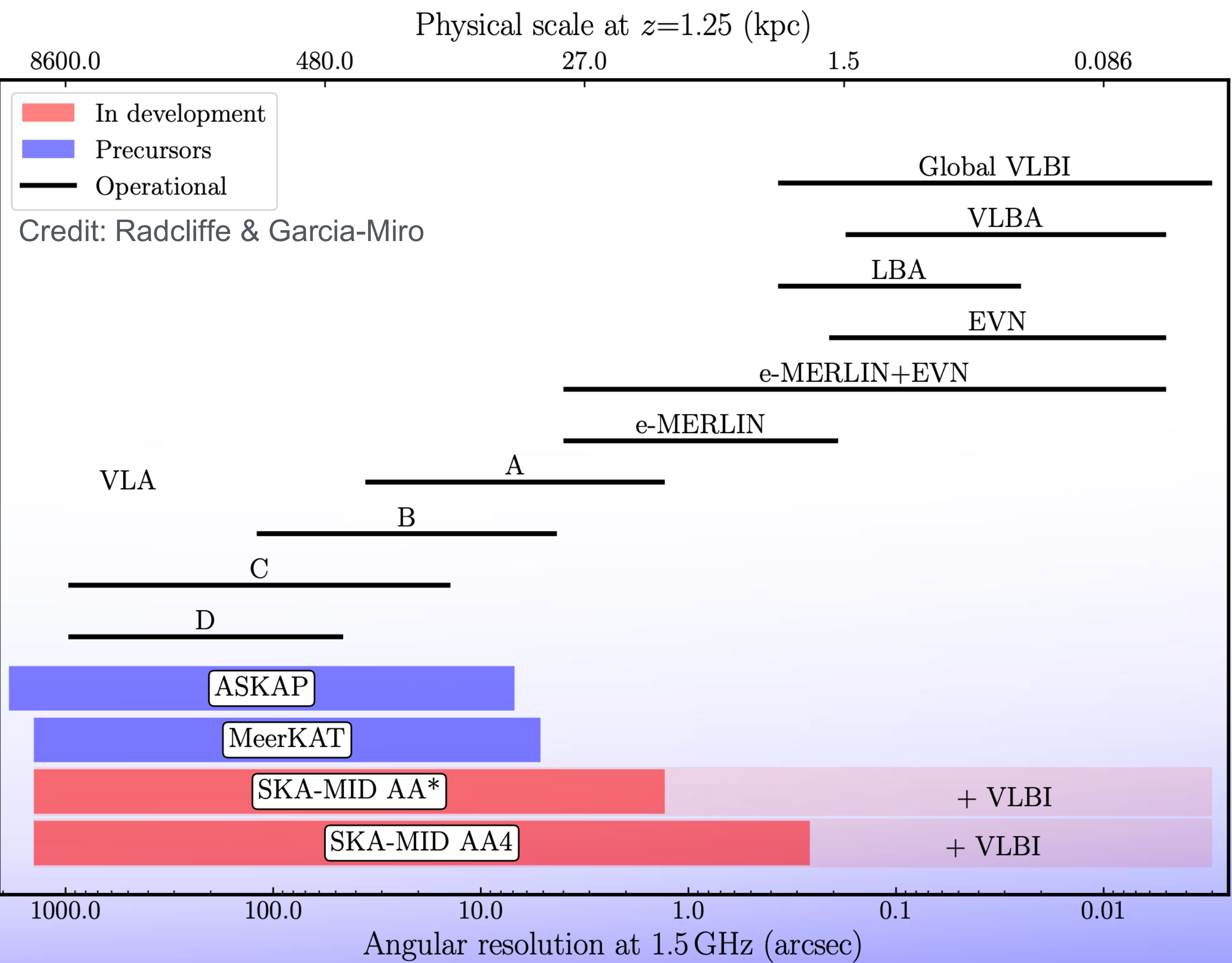


Importance of VLBI



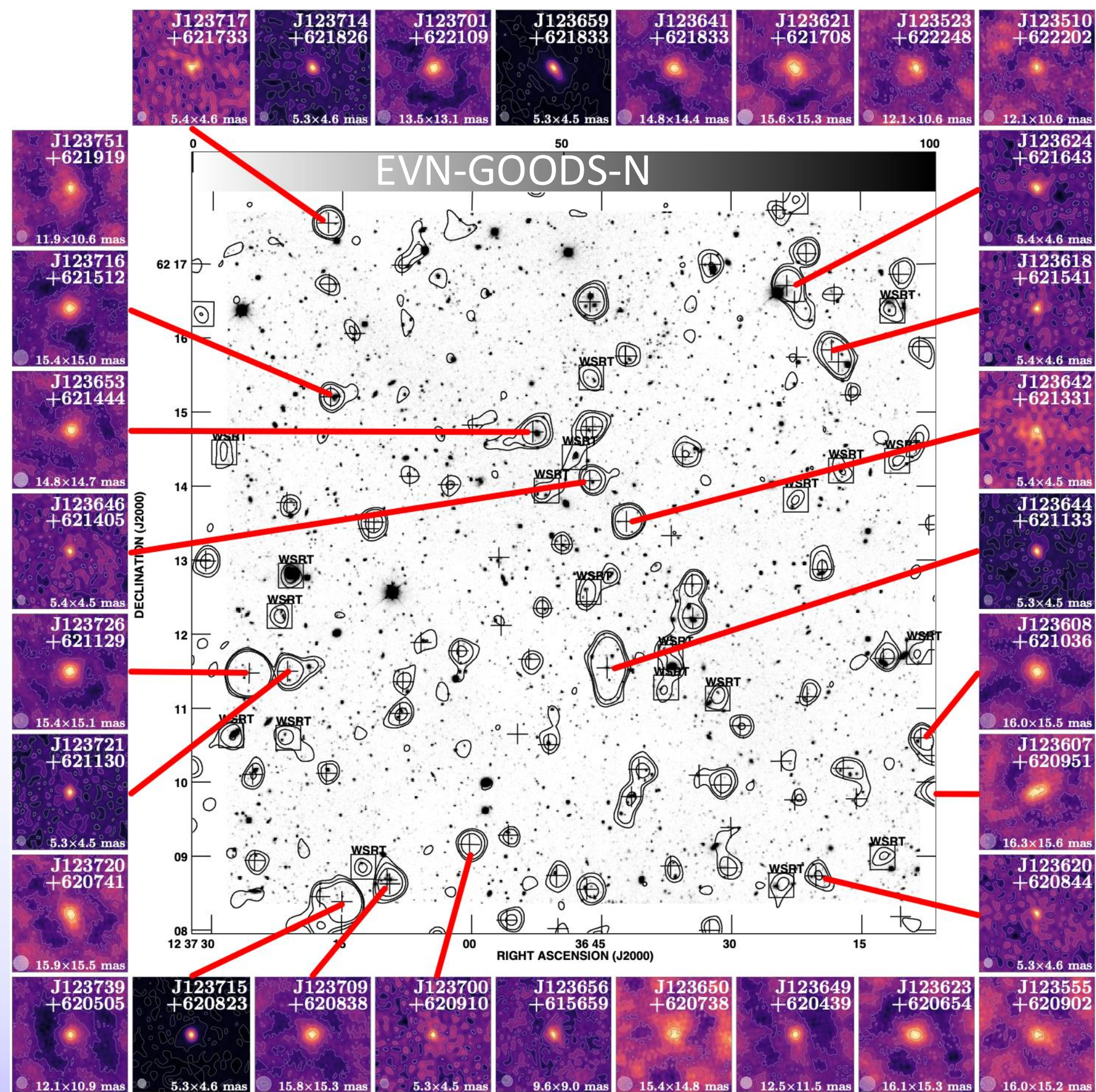
Credit: W. Williams (SKAO)

For an example, see talk by Baczko - Thursday 09:50 P4



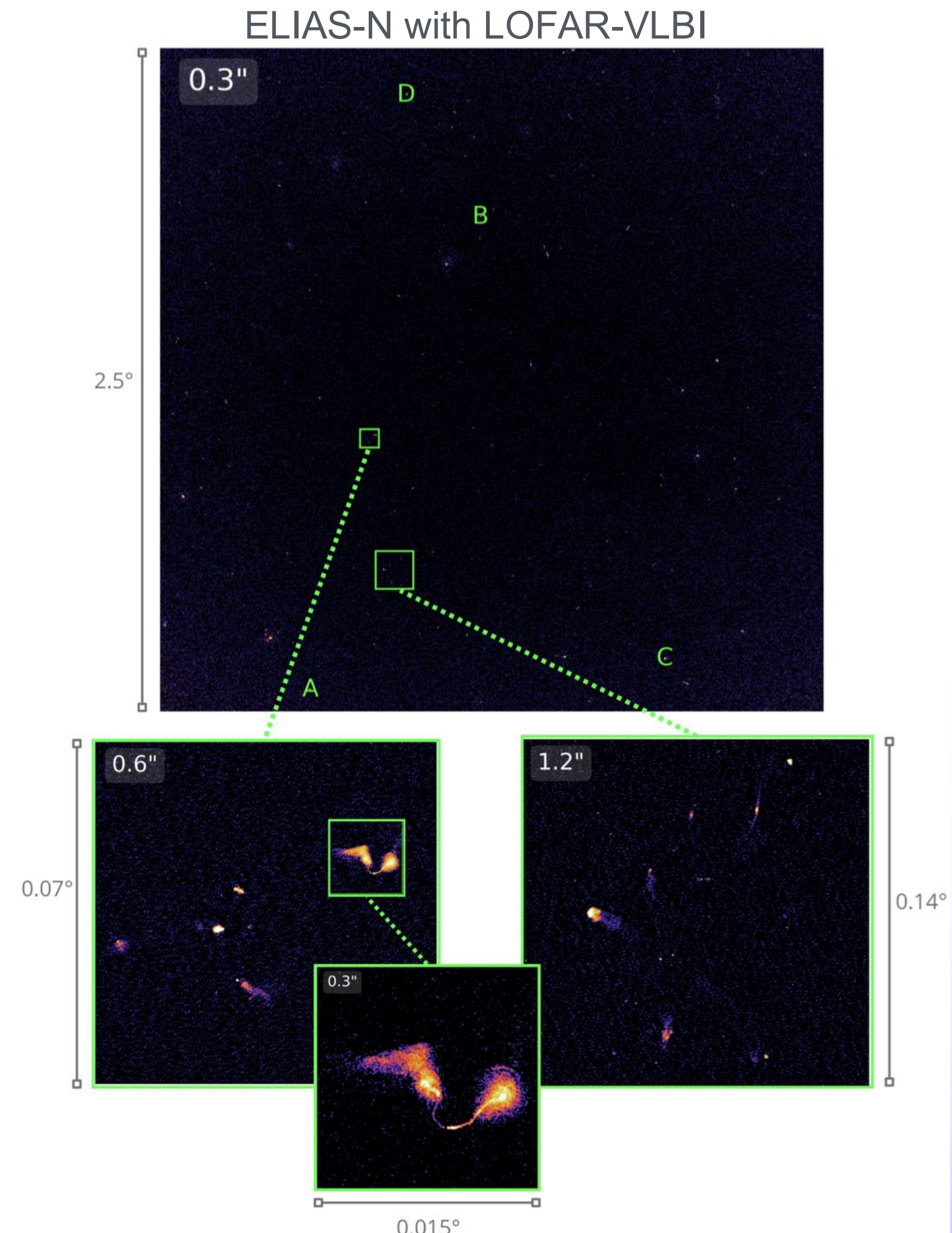
Black holes & galaxies

A unique, dust-independent, AGN identifier

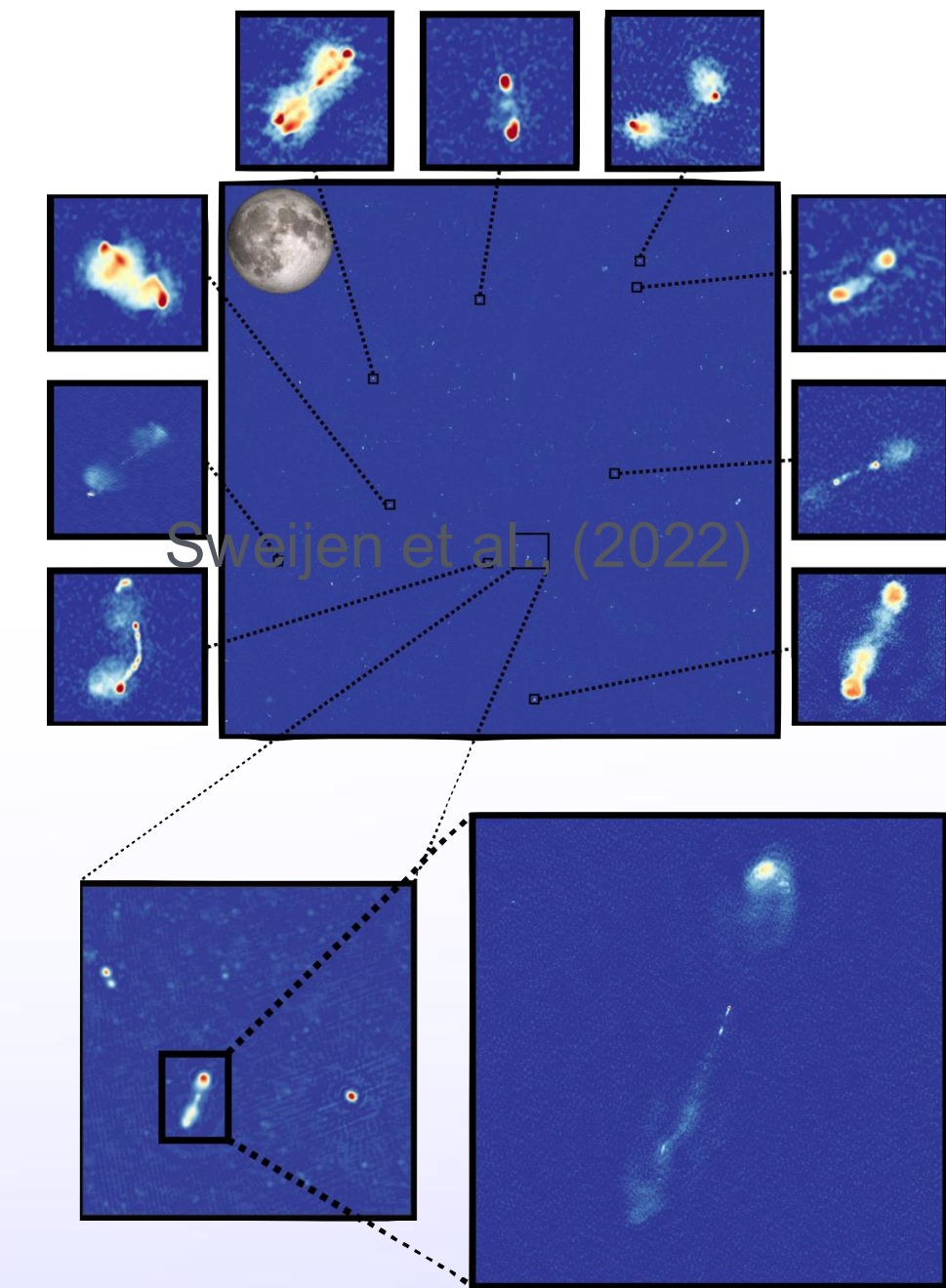


Radcliffe et al., (2018)

See also e.g., Lenc et al., (2009), Middelberg et al., (2011, 2013); Morgan et al., (2013); Herrera-Ruiz et al., (2017, 2018); Morabito et al., (2022); Njeri et al., (2023, 2024); Deane et al., (2024)

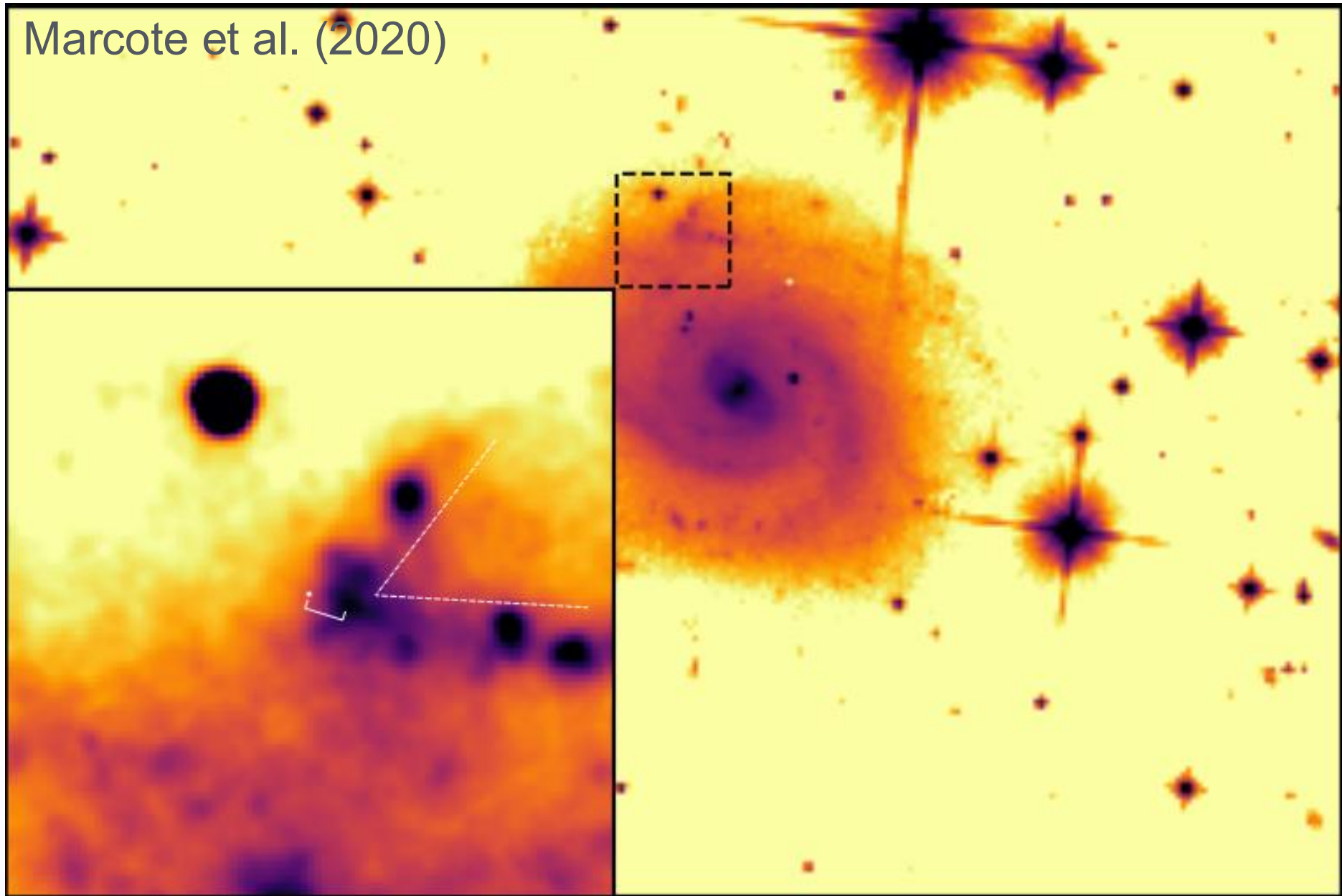


Lockman Hole with LOFAR-VLBI



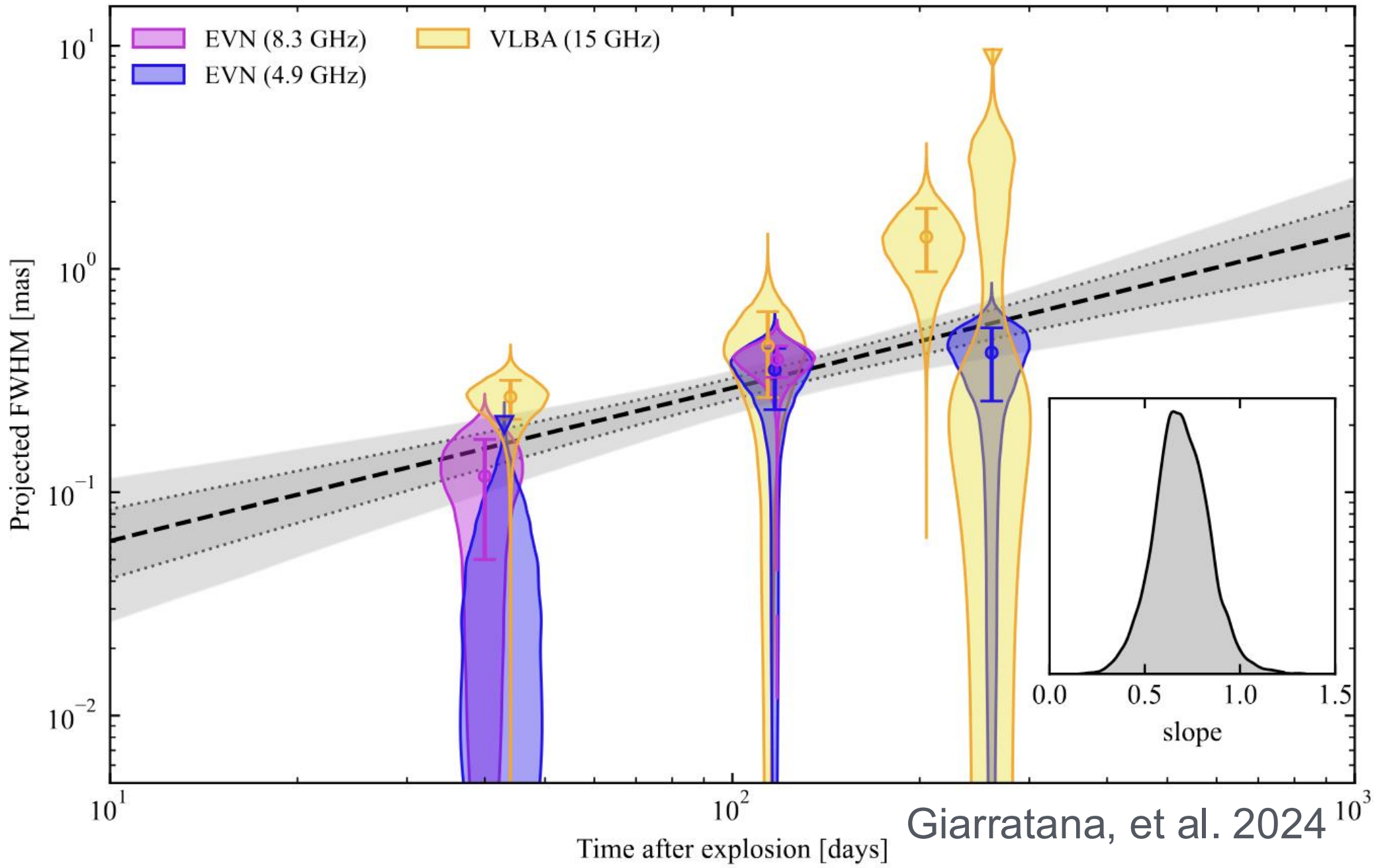
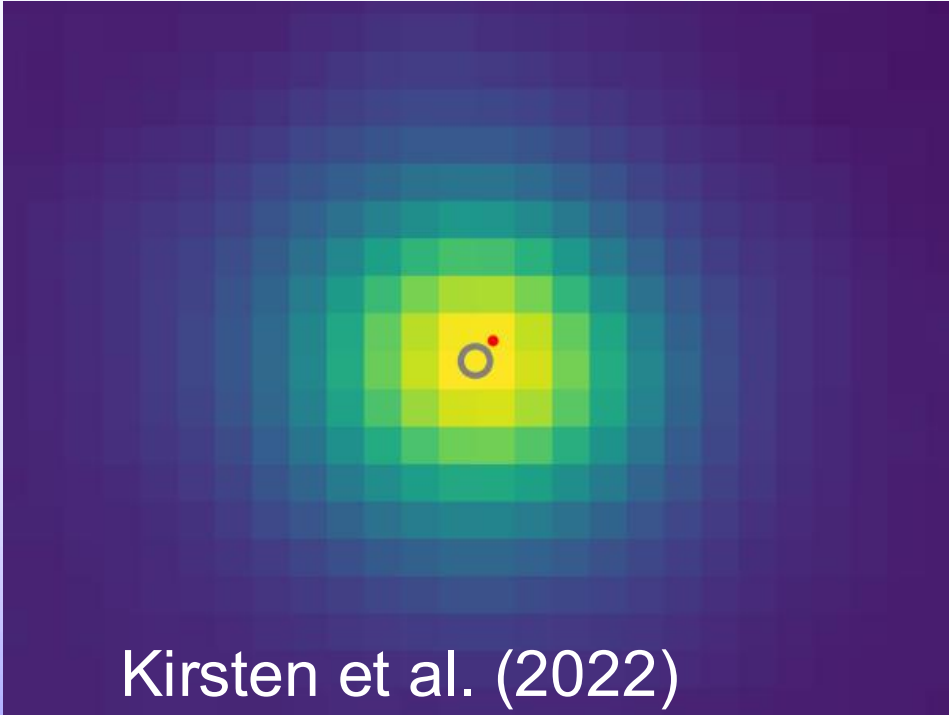
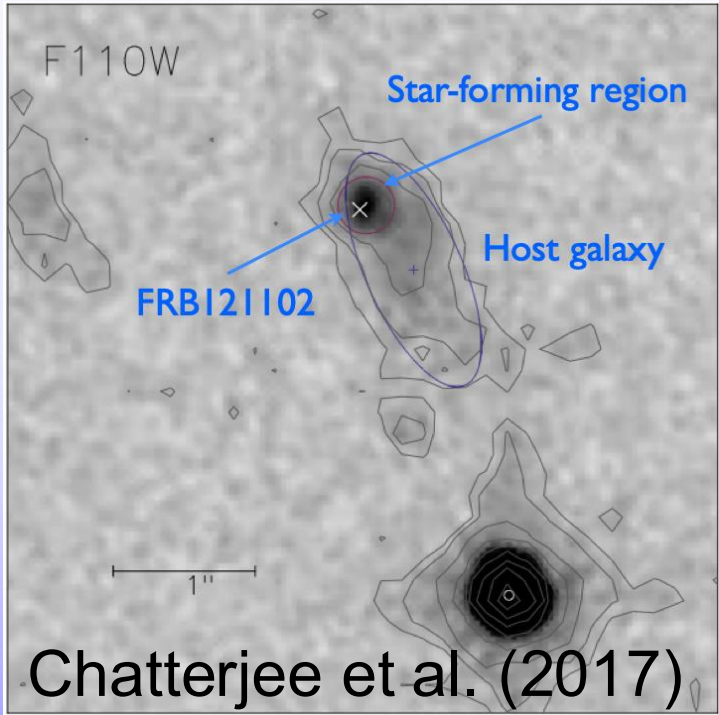
Transients

Expansion of the GRB 221009A afterglow

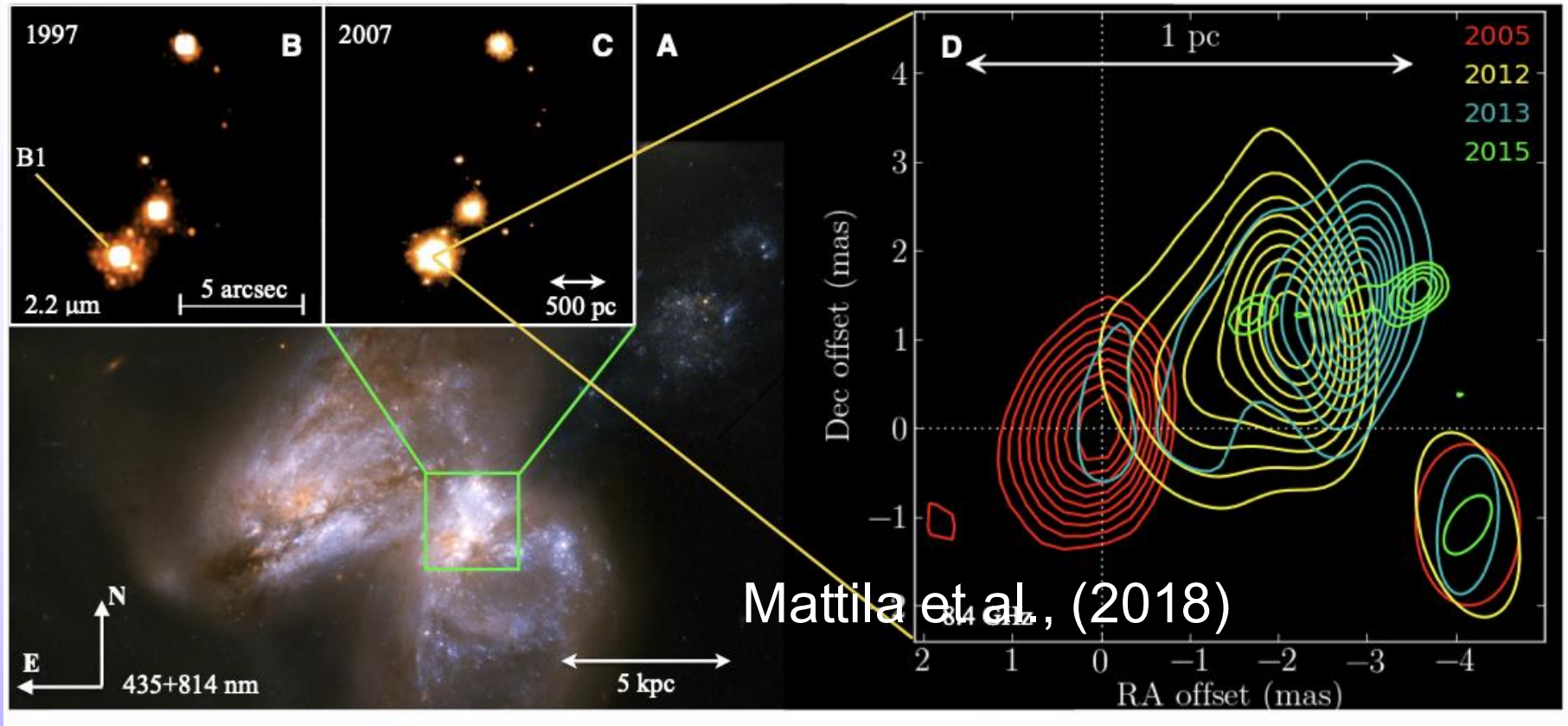


FRB localisation - FRB 20180916B

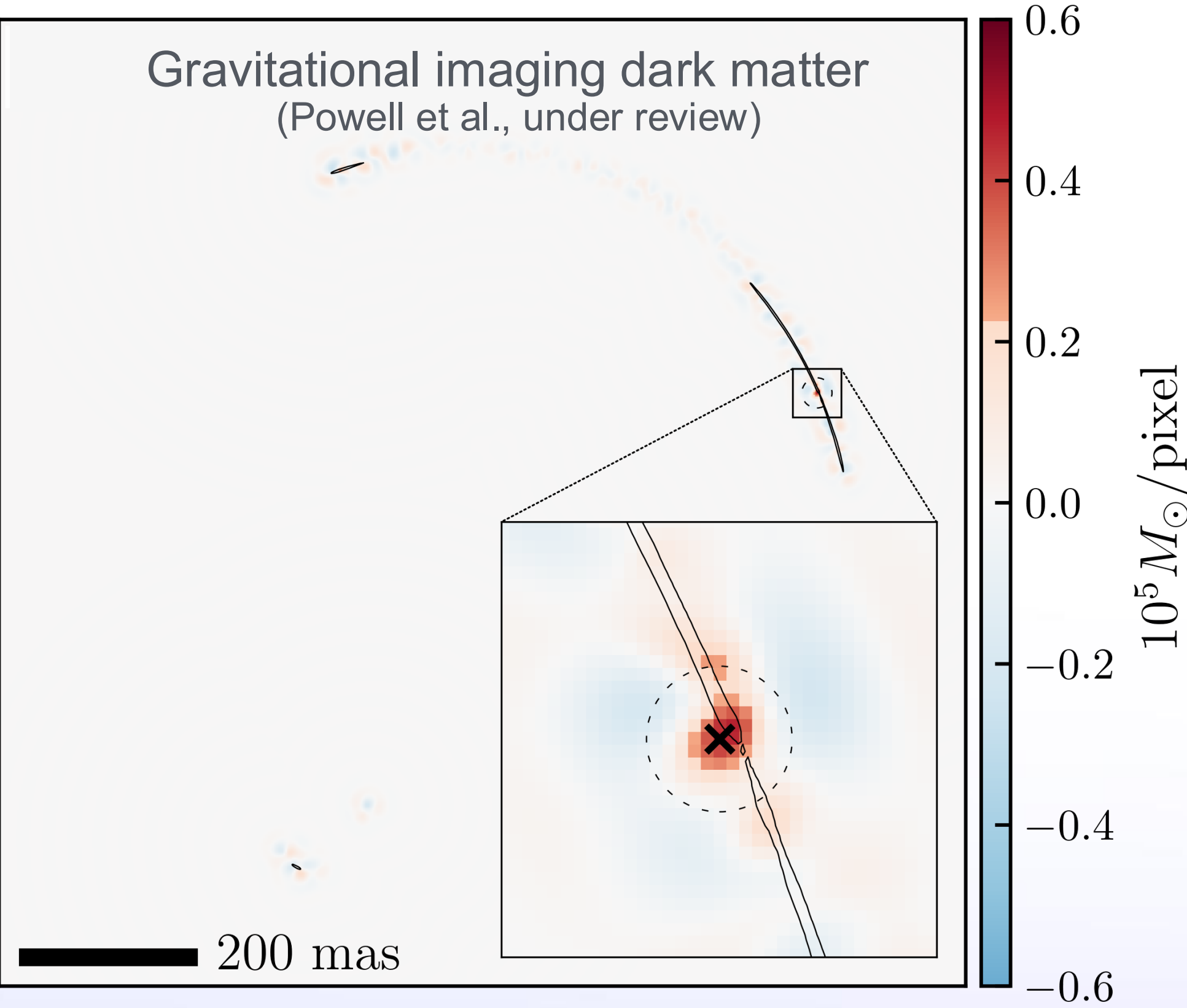
One of four localised to regions **within** galaxies



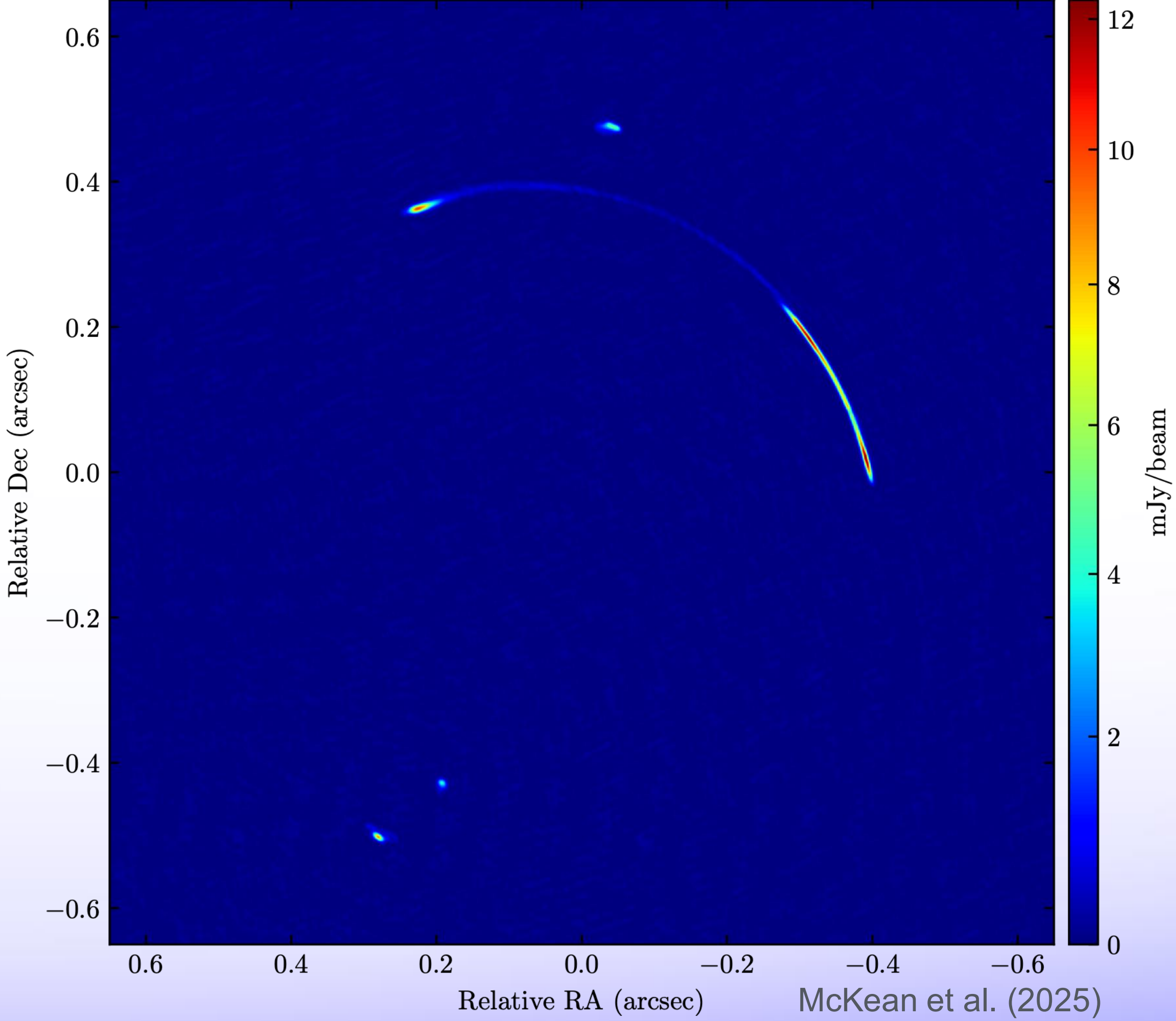
Ejecta from tidal disruption events



Dark matter and cosmology

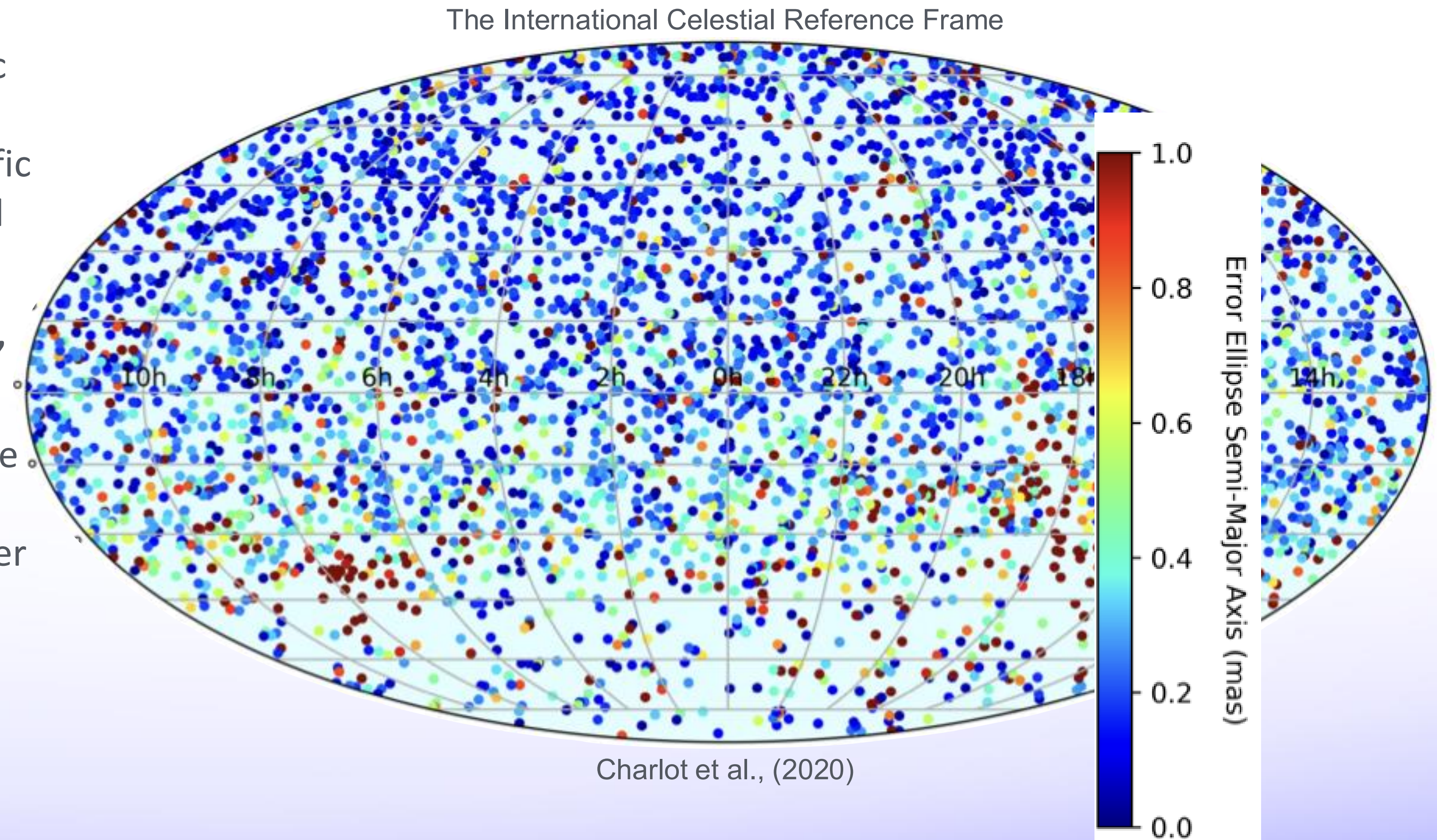


Analysis of an extended gravitational arc detected a $\sim 10^6 M_{\text{solar}}$ dark object, with a mass-concentration that is inconsistent with CDM/WDM.
(Vegetti et al., 2025)



Geodesy & astrometry

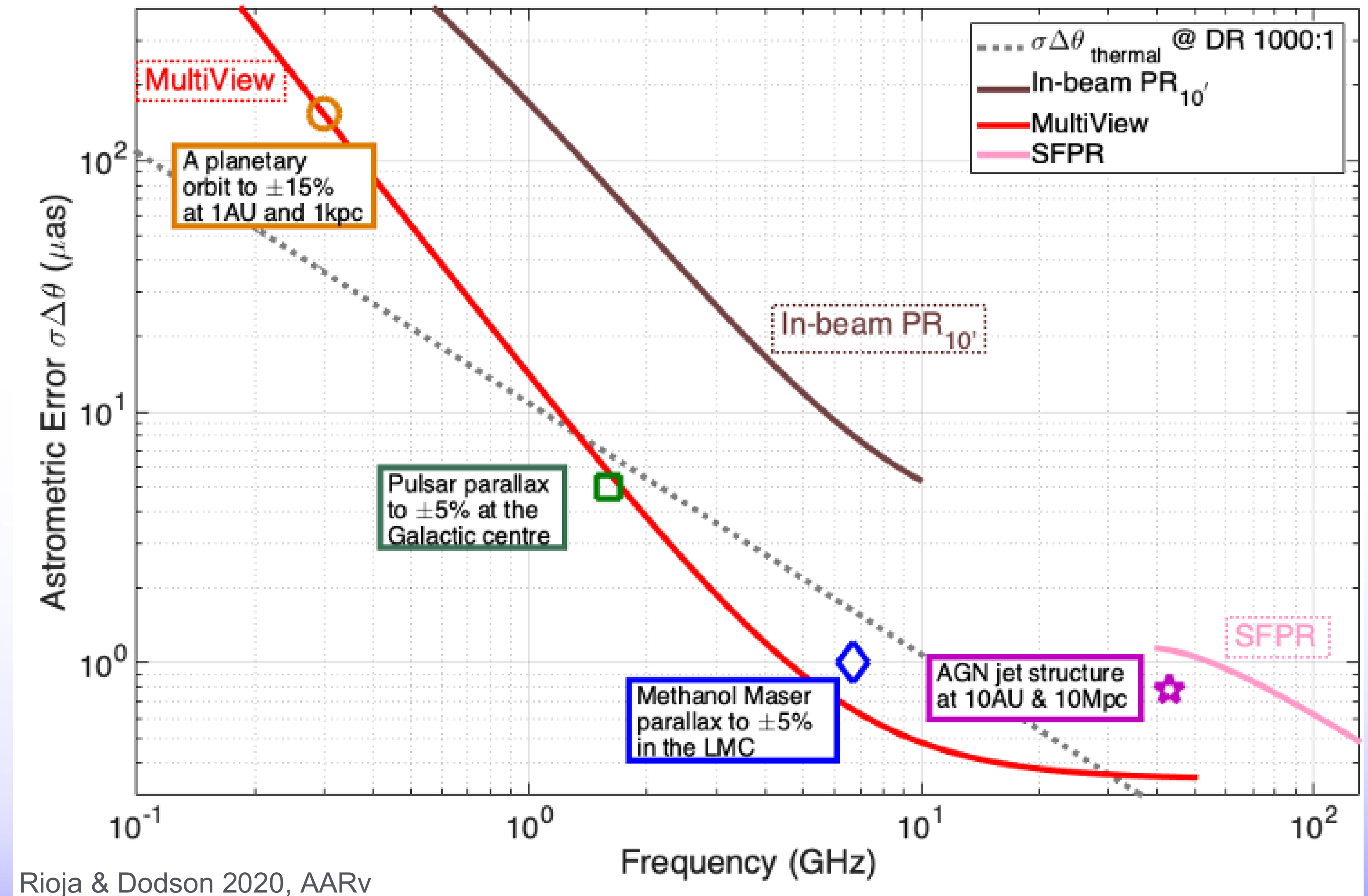
- **Geodesy** studies the Earth's dynamic size, shape, and gravitational field, playing a crucial role in many scientific disciplines with **far-reaching societal impacts**.
- VLBI provides a key role in this (e.g., measuring UT1)
- SKA-VLBI will improve accuracy of the ICRF thus improving the **terrestrial reference frame**, and help find fainter geodetic calibrators



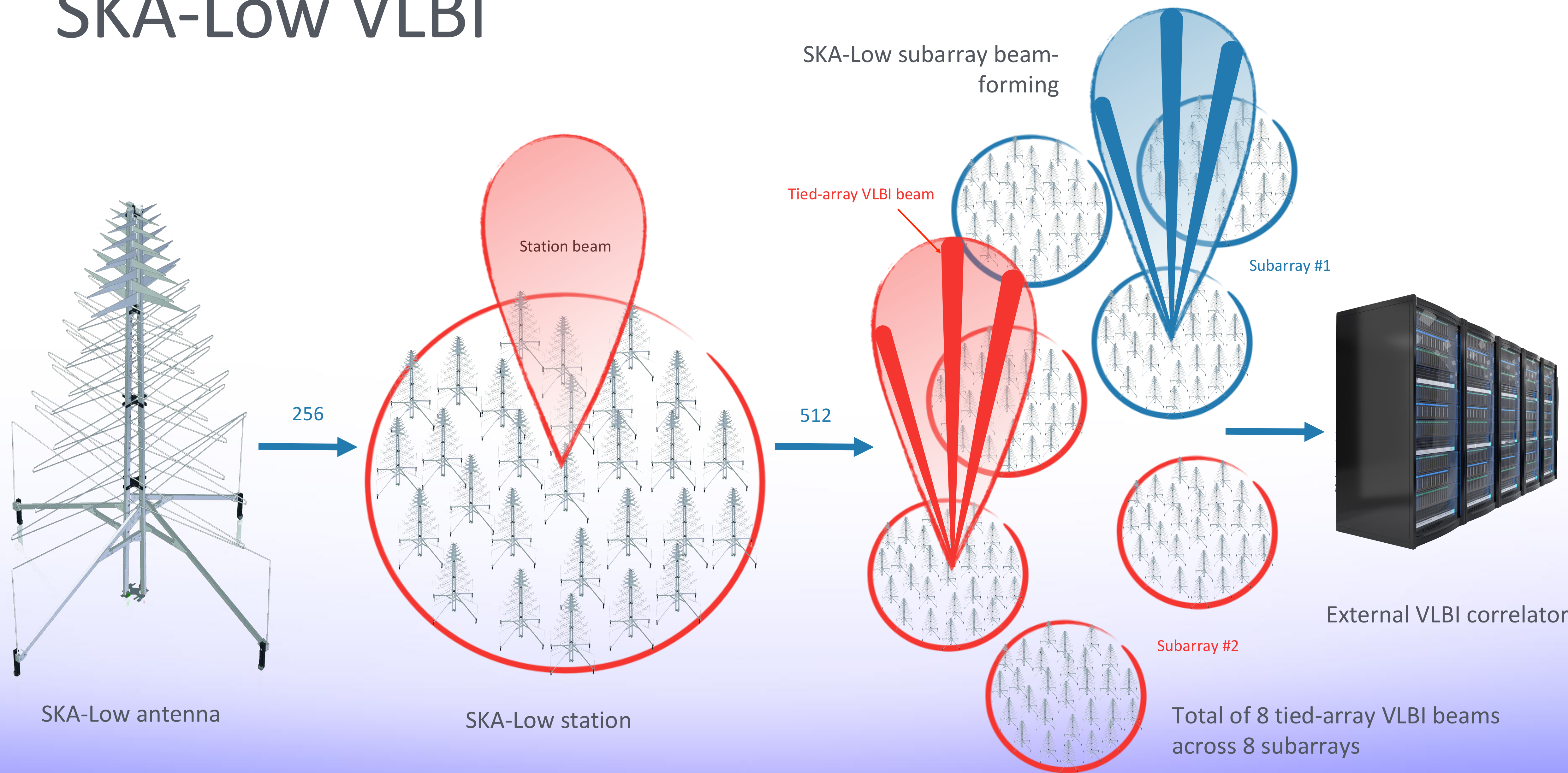
SKAO is looking at geodesy for the first time! — possible avenue for getting an African VLBI Network

Astrometric improvements

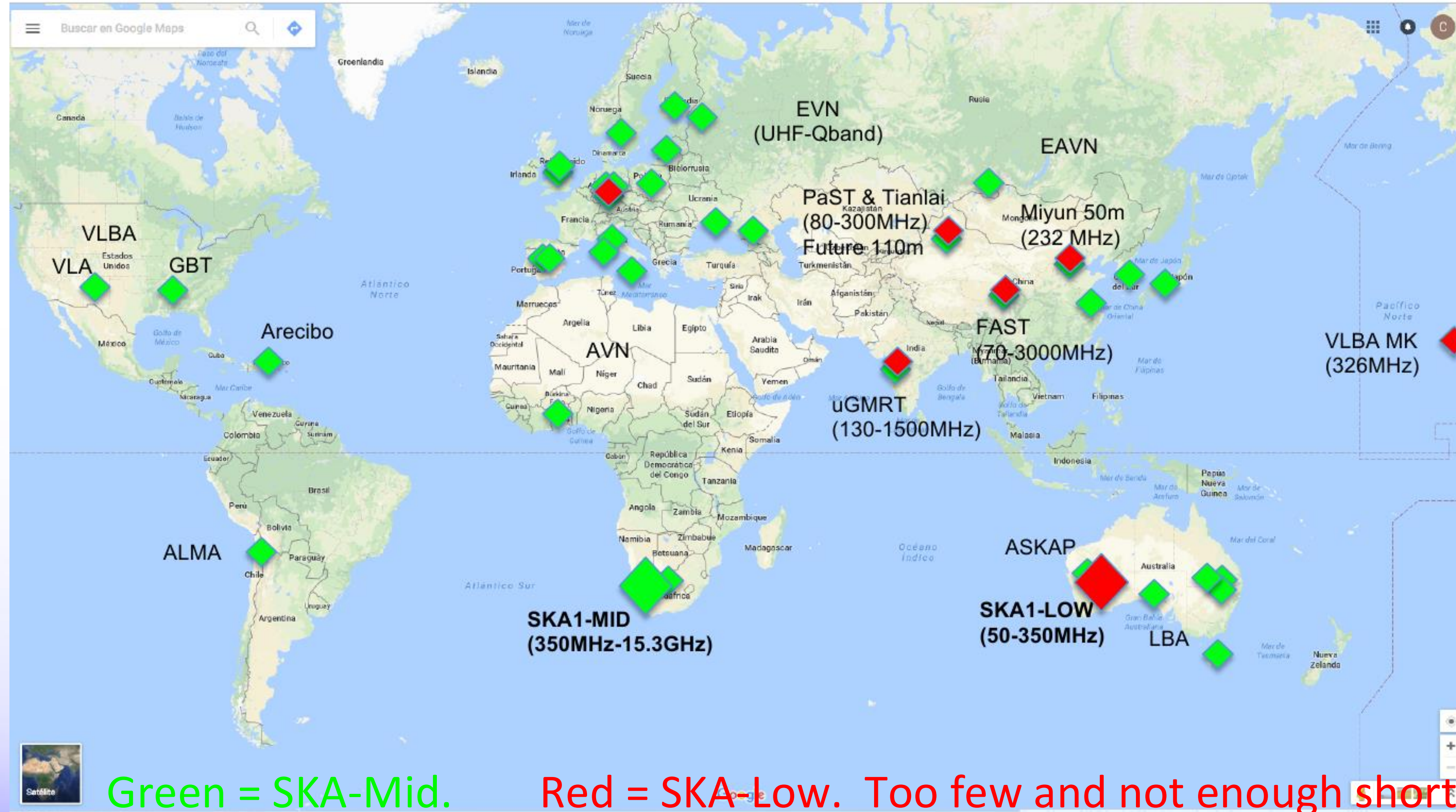
- Next generation VLBI will allow for order of magnitude increase in astrometric precision.
- SKA-VLBI with very fast switching (AA*) and multiple simultaneous Tied-Array-Beams (AA4) facilitates the transition from systematically limited at 10 micro-as to limited at **1 micro-as**, above 8 GHz, using MultiView.



SKA-Low VLBI



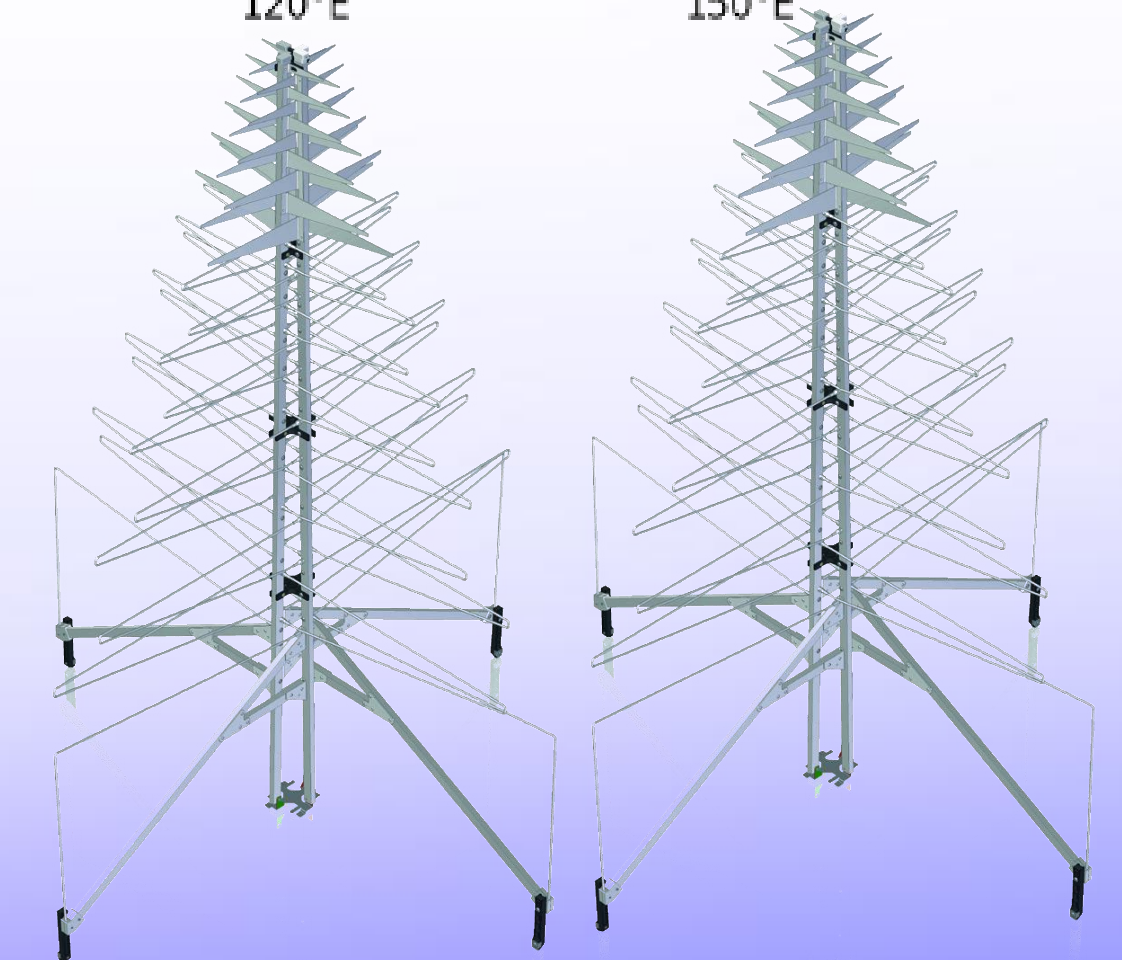
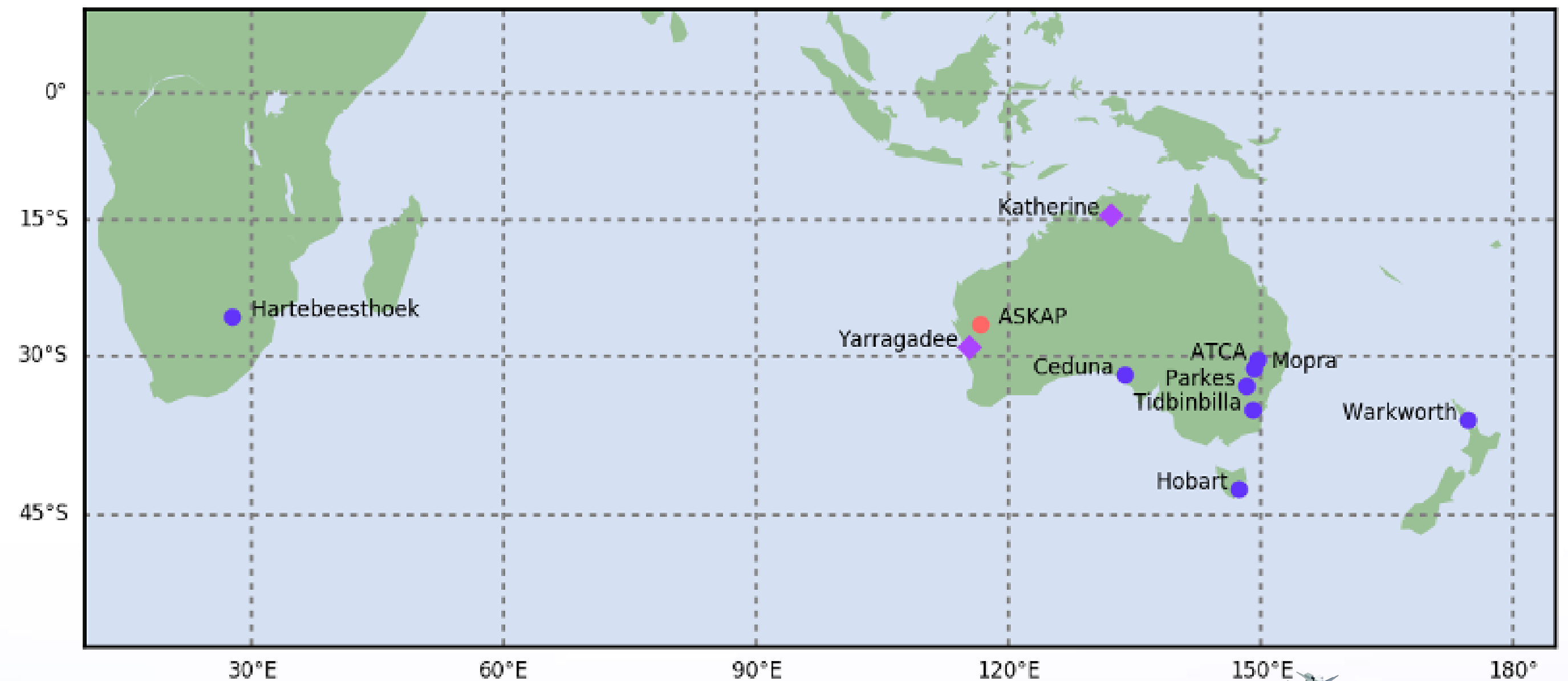
SKA-Low VLBI - complementary telescopes?



LAMBDA

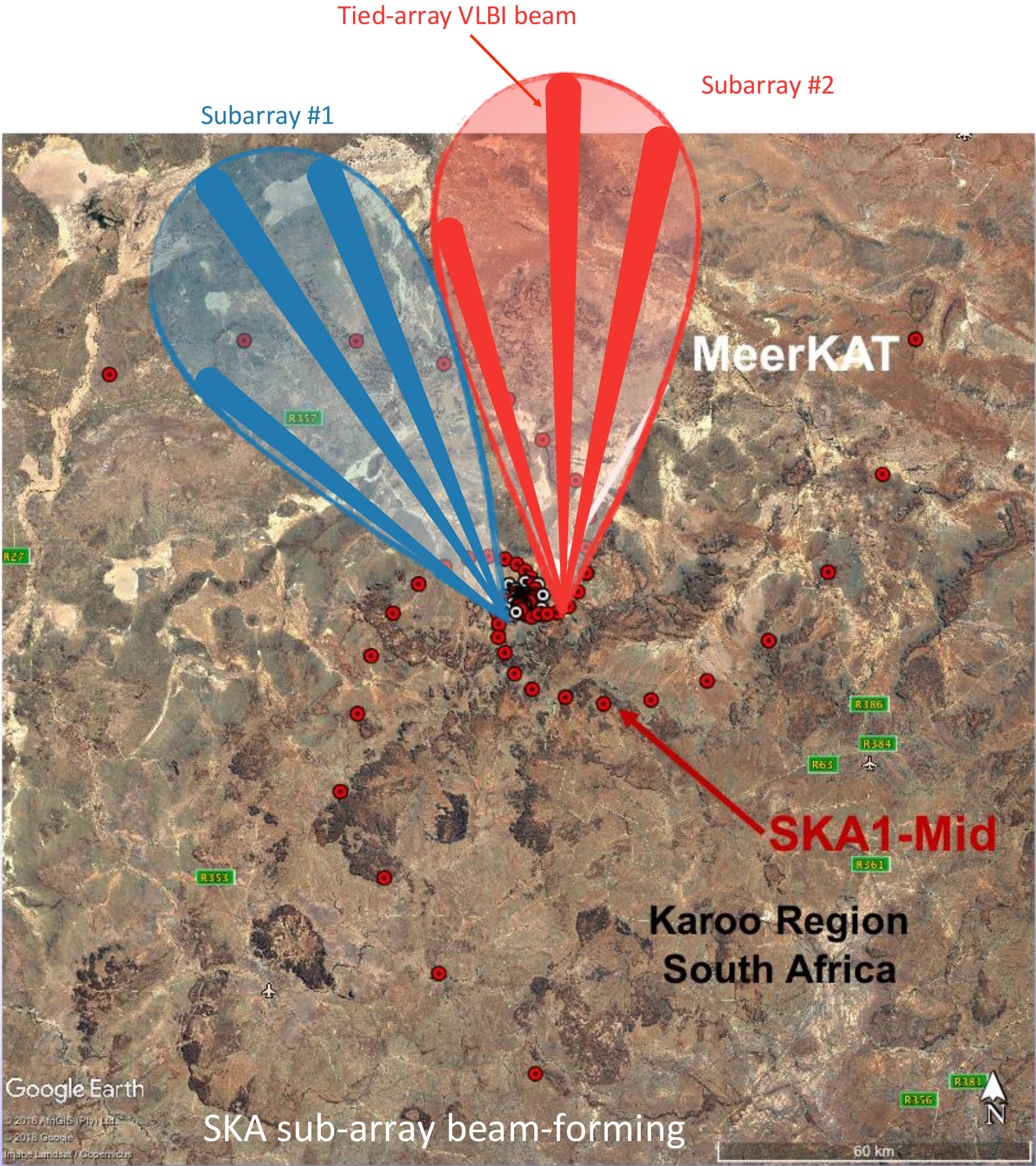
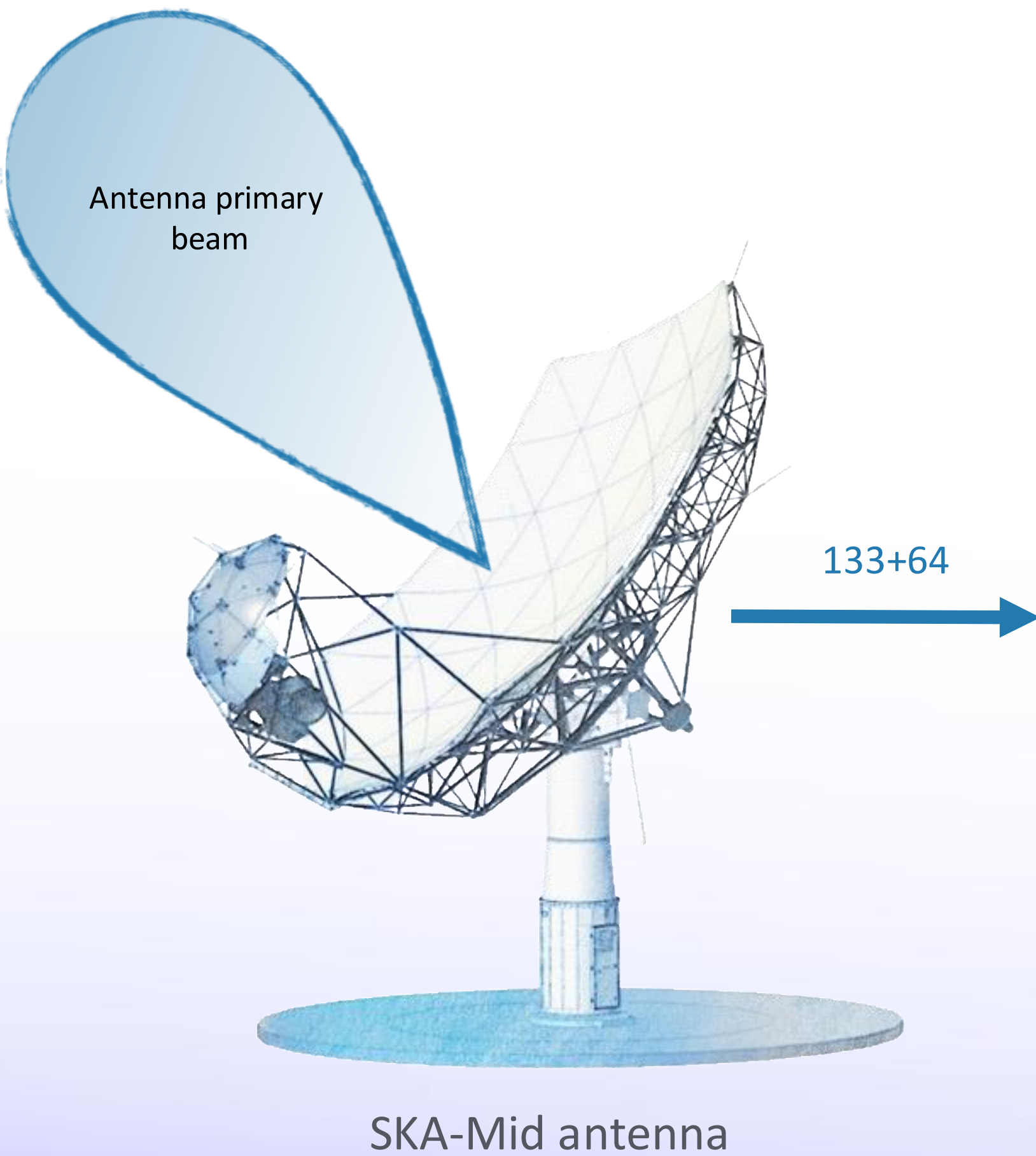
Low-frequency Australian Megametre Baseline Demonstrator Array

- Goal: Demonstrate Feasibility of Long Baseline Science with SKA-Low
- Low frequency antennas, e.g. CRAB, SKALA
 - 256 dual polarisation antennas
 - VLBI target frequency – 150-350 MHz
- Locate at existing LBA observatories (or CSIRO sites)
- Saves on site costs (power, network etc)
- Extend with new stations near existing networks and internationally
- CSIRO funding to develop LAMBDA
- Exploring options with MWA to provide a phased array output



SKA-Mid VLBI

16 subarrays with max 16 tied-array beams per subarray
Limited to a **total** of 16 tied-array beams across all subarrays
Implemented in pulsar timing

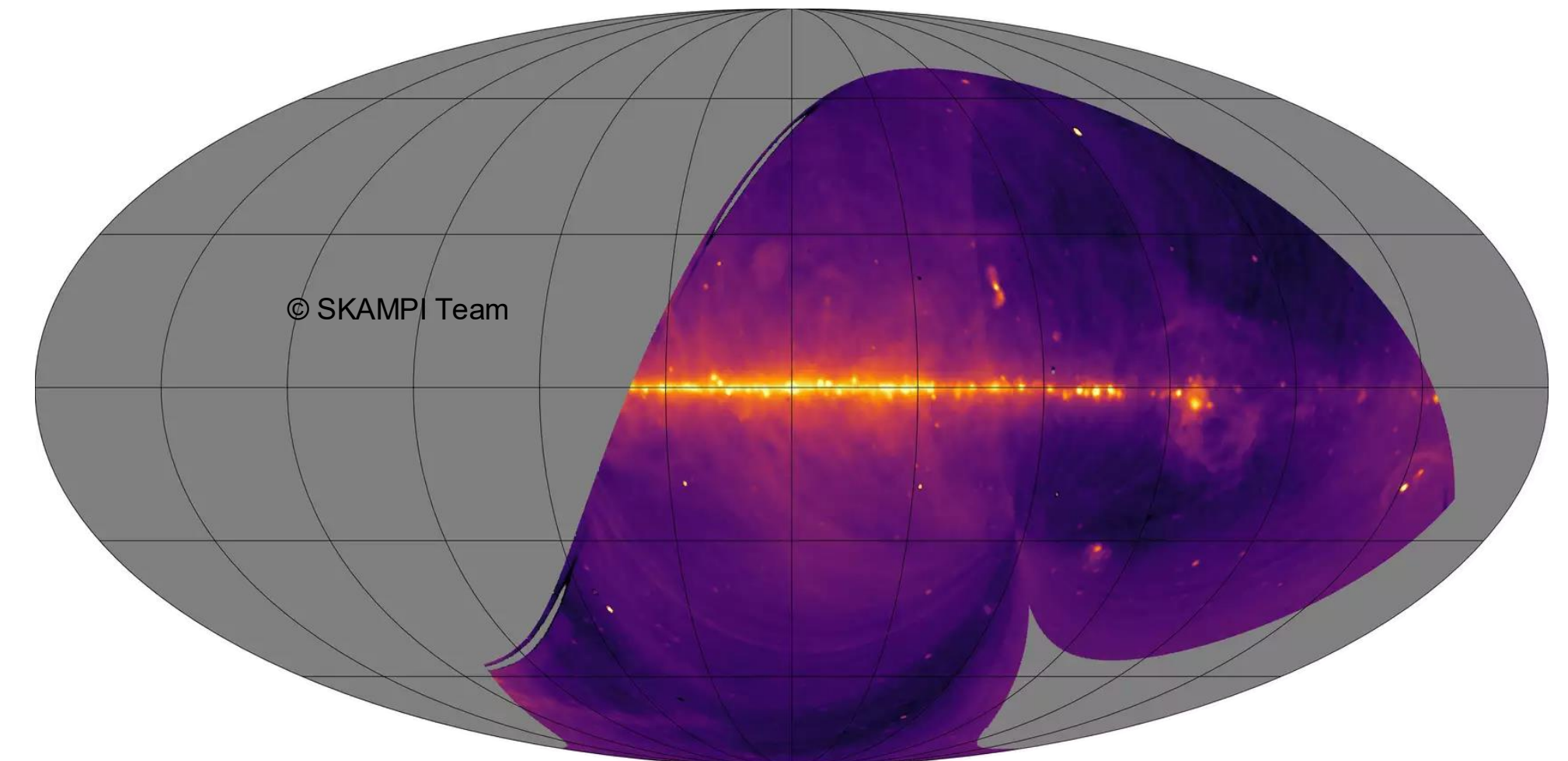


External VLBI correlator



New AVN initiatives - Botswana DZA telescope + SKAMPI

- New AVN initiatives ongoing in SA and Botswana
- Other telescope/initiatives discussions ongoing across Africa



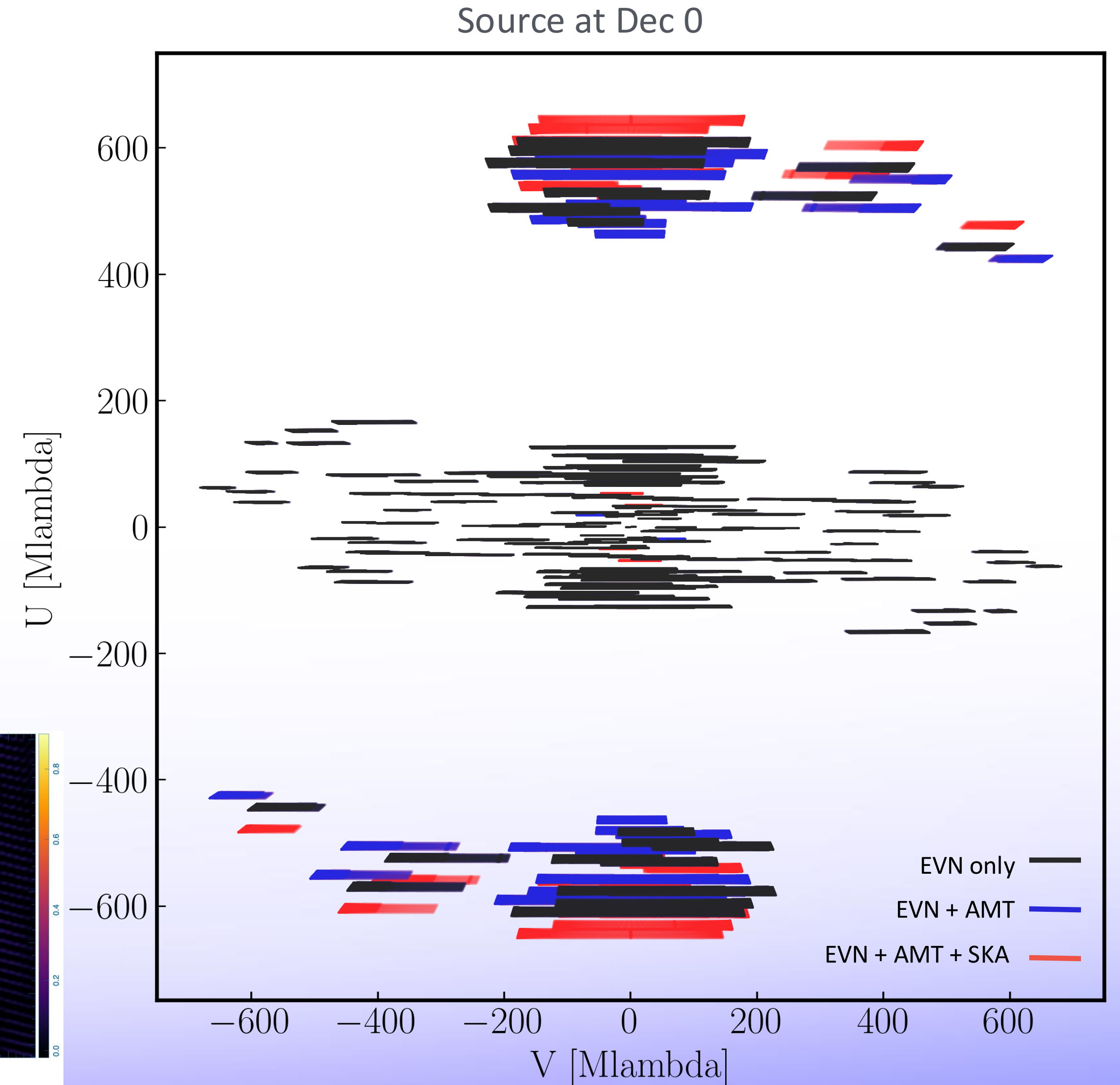
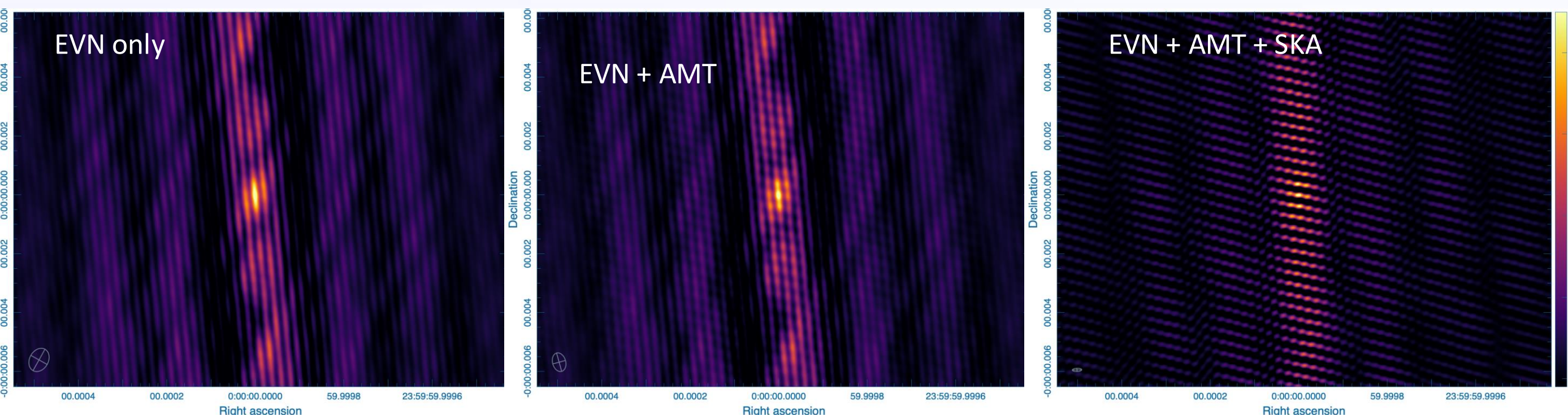
The SKA-MPIfR telescope (SKAMPI) in the Karoo, South Africa.

MoU between DZA and BIUST for the Botswana telescope



SKA-VLBI & AMT

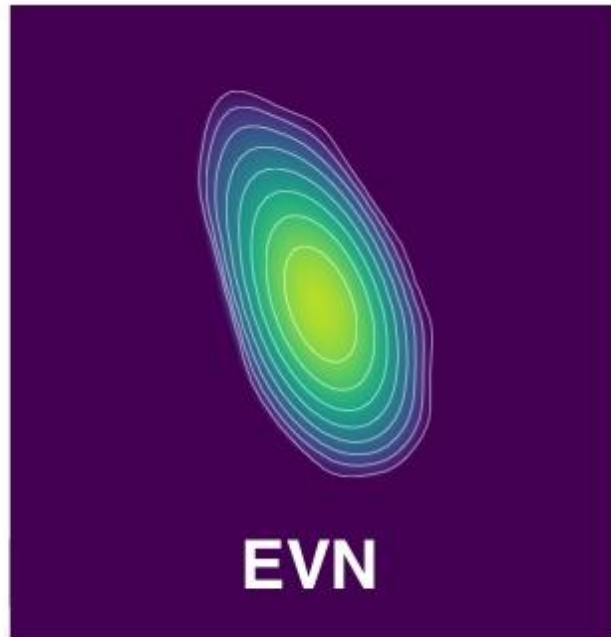
- Science synergies w/ AMT in EHT & single dish are a given.
- AMT at 22GHz would overlap with major VLBI bands & possible SKA-Mid Band 6.
 - SKA band 6 may be prioritised over band 5b given satellite constellations downlinks @ Ku-band.
- Long E-W baselines w/ LBA / VLBA provide geodetic opportunities



MeerKAT-VLBI

Illustration: Benito Marcote, JIVE.

Image credits: MeerKAT image ©SARAO; EVN map image ©Paul Boven, JIVE (satellite image: Blue Marble Next Generation, courtesy of NASA Visible Earth).



Summary

- Very Long Baseline Interferometry (VLBI) produces some of the highest angular resolution images possible which are currently unobtainable with the SKAO.
- It has key applications in many areas, including galaxy evolution, cosmology, jet physics, star-formation, astrometry, geodesy, transients and much more.
- SKAO will provide a boost in sensitivity in the Southern Hemisphere, especially when combined with the new and upcoming VLBI telescopes.

Wish to join the SKA-VLBI group?

Email jack.radcliffe@manchester.ac.uk or jun.yang@chalmers.se