

CoL-related opportunities

VLBI with the SKA1?

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Thanks, Adam Deller!

- **So much more in ‘Galactic’ radio astronomy**
 - Structure and evolution of the Galaxy
 - Star formation, high and low
 - HII regions
 - Circumstellar matter
 - Outflows and feedback
 - Role of magnetic fields
 - HI on star-formation scales
 - Stellar physics
 - Radio photospheres
 - astrometry, binaries, planets?
 - Mass-loss, circumstellar matter
 - ISM processes, life-cycle of elements
 - Radio recombination lines
 - Absorption studies, OH Zeeman
- **And related extra-Galactic**
 - Stellar population, Galaxy evolution
 - Evolution of fundamental constants
- **Planetary science**
 - spacecraft observing

Leaving out pulsars

And active binaries

Note: few of these served optimally by SKA1

Wait for SKA2?

- **Masers: OH ground satellite lines accessible to MID**

- **Evolved stars**

- Mass-loss, life cycle of elements, shaping PNe
- Stellar population over Galaxy, inner Galaxy
- Galactic structure, gravitational potential, Galactic bar

Generally, much larger samples accessible

- **Star formation**

- Excited in lowish density envelopes
- Magnetic strength through Zeeman pairs

Southern hemisphere!

- **ISM**

- Associations with Supernova shock interfaces
- Large-scale magnetic fields
- Electron distribution, interstellar scattering, through angular broadening

Best done with VLBI

- **Other Galaxies**

- Stellar populations through OH masers

Still quite challenging SKA1

- **BEWARE**

- Galactic confusion, identification at sub-arcsec needed
 - Survey power seems at too coarse resolution?
- Interference! For OH lines coming from the sky....
 - The reason why there is very little progress

- **More species accessible if MID had band 5**
 - 4.6 - 13.8 GHz!
 - Methanol 6.7 and 12 GHz, Excited OH, Formaldehyde

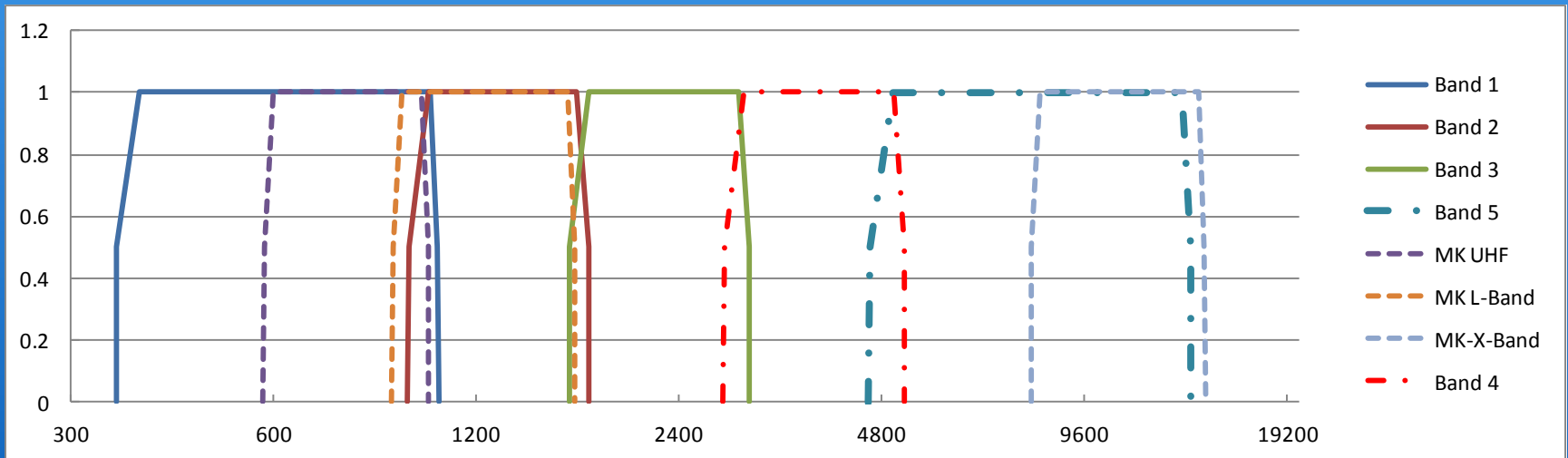


Figure 14 Receiver bands for SKA1-mid (solid and dash-dot), shown with the planned receiver bands for MeerkAT (dashed). SKA1 bands are numbered 1-5. The band-edge frequencies are provided in Table 6.

- Detailed kinematics of star formation
- Complete(r) census of Galactic distribution
 - Excitation statistics
 - Synergy with ALMA
 - 3D kinematics from monitoring
- Galactic structure
 - Tracking spiral structure
 - Still interesting when Gaia operates
- Role of magnetic fields
 - Linear polarization
 - And non-paramagnetic Zeeman
- In nearby Galaxies
- Less confusion in SKA1
 - Much less interference

Surveys

VLBI

Southern hemisphere!

VLBI astrometry

Best done with VLBI

Still quite challenging SKA1

VLBI in the baseline design

- Extension to SKA2: very long baseline extensions:
 - **“...little impact on the design of SKA1, and will not be considered further.”**
- Figure 25 Block Diagram for SKA1-survey:
 - **“VLBI TBC”**
- Data transport for SKA1 survey
 - **“No provision has been made in this budget for concurrent VLBI transmission.”**
- Synchronisation: timing
 - **“VLBI obs. may require high-precision reference to IAT.”**
 - **“VLBI and transient detection equipment, where present, will have access to time services...”**

What can SKA1 provide?

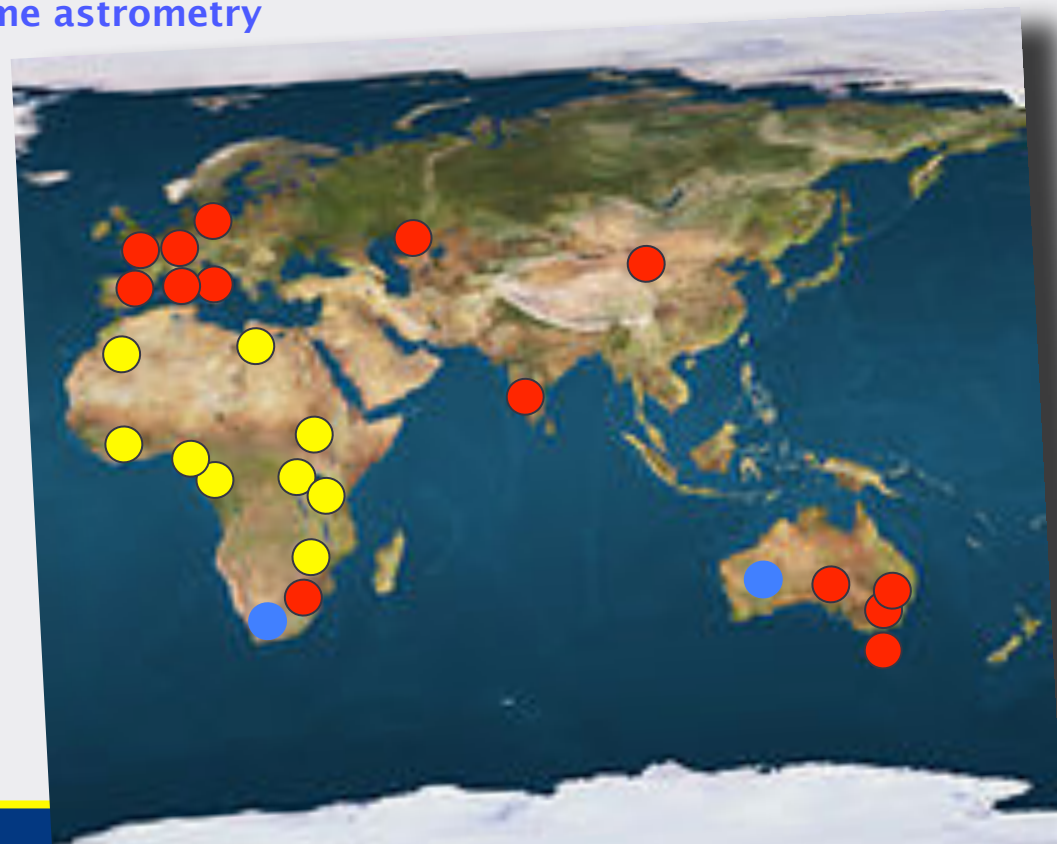
- **SKA1-MID Band 5: 2.8 Jy**
 - I think this is without MeerKAT
 - Images of $\approx 100\mu\text{Jy}$ noise 1km/s channels in 8 hr
- **SKA1-mid 1.4 GHz SEFD: 1.7 Jy**
 - SKA1-survey 1.4 GHz SEFD: 6.7 Jy
 - Again images of $\approx 100\mu\text{Jy}$ noise 1km/s channels in 8 hr
- **For comparison:**
 - Arecibo 1.4 GHz SEFD: 2.4 Jy
 - Phased EVLA SEFD: 10 Jy
 - 25m dish like VLBA SEFD: 300 Jy
- **VLBI sensitivity**
 - Dominated by SKA element
 - Sensitivity basically equal to SKA1-MID core
 - Except when combined with SKA-SUR
 - So detections with SKA1 are VLBI targets
 - Provided they are high brightness
- **And many near (in-beam) calibrators at this sensitivity**

At least an order of magnitude more sensitive

- Important for astrometry
- Important for polarimetry

But!

- **But: consider FoV:**
 - Phased SKA1-mid/SKA1-survey to 1 km: 4''
 - Arecibo: 20''
 - 25m dish like VLBA: 1800''
- **And limited VLBI links**
 - Requires AVN to be a success
 - Maybe relaxed for some astrometry



- **VLBI add-on seems worthwhile to me**
 - Especially when band 5 comes on
 - Also brought forward by pulsar and transient community
- **Is it feasible as a low-cost add-on?**
- **Special requirements needed:**
 - **Phased array with flexible multiple beam capability**
 - To control Field-of-View
 - To have sub-array on “in-beam” calibrators
 - Maybe separate data from outlier stations
 - **Compatible data definition (not hard)**
 - **Accurate timing standard**
 - **Data transport means, recording or fibre**
- **Related:**
 - **Other antennas (with similar freq coverage)**
 - **Operational correlator**
 - **Joint observing policy**
 - Especially for astrometry
 - **Feels a bit like the VLBI with ALMA problem**

- **SKA1-MID is most interesting telescope**
- **SKA2 is important to keep in view**
- **Band 5 is desired**
 - As are the MeerKAT VLBI and high frequency capabilities
- **VLBI capability should be seriously considered**
 - Right from the start
 - Brings some (new) requirements for engineering
 - Same as argued by pulsar and transient community
 - Multiple beams from sub-arrays
 - Output data stream formatting
 - Data transport to the outside VLBI world
 - High accuracy Timing distribution
 - And some boundary conditions
 - On compatible arrays

end