MeerKAT Call for Observing Proposals

Issued: 1 July 2020
Deadline for submission of proposals: 1 September 2020, 14:00 SAST (12:00 UTC)

Documentation and proposal preparation and submission tools are available off science.ska.ac.za/meerkat (we recommend use of the Chrome browser throughout). *This Call document should be read first.*

List of Contents

1 Introduction

The South African Radio Astronomy Observatory (SARAO) through this Call elicits observing proposals for MeerKAT, seeking to maximize the scientific impact of the telescope while contributing to South African scientific leadership and human capital development.

MeerKAT is a radio interferometer located in the Northern Cape province of South Africa (at 30 deg South, 21 deg East) consisting of 64 dishes with baselines of up to 8 km. Its superb sensitivity (each antenna's SEFD at L-band is similar to that of a VLA antenna), ~2000 baselines, centrally concentrated distribution (~3/4 of the dishes are located in a 1 km diameter core), substantial field of view (~1 deg FWHM at 1.4 GHz), and unblocked aperture design, make it uniquely suited to a variety of studies.

Early imaging results drawing on these capabilities include the detection of low surface brightness neutral hydrogen (Serra et al. 2019), high fidelity imaging of extended Galactic structures (Heywood et al. 2019), continuum observations exceedingly sensitive to distant star forming galaxies (Mauch et al. 2020), and broadband spectro-polarimetry across a large FoV (Cotton et al. 2020).

This is the second 'Open Time' Call for Proposals (CfP) on MeerKAT. The first CfP was limited to relatively small amounts of telescope time per proposal, was restricted to South African-based PIs, and offered an early set of telescope capabilities. This CfP is more expansive: PIs are not restricted by affiliation (Section 2), more capabilities are offered (Section 3), and observing time limits for individual proposals are larger (Section 3.1).

The preparation and submission (Sections 4–5), and review (Section 6) of proposals under this CfP will also differ substantially compared to the first one: for instance, we provide more extensive documentation (Section 3.6), alongside more capable proposal preparation and submission tools (e.g., sensitivity calculators, Section 4.2), and the review of the science cases will proceed in double-blind fashion (Section 5.2).

It is therefore very important that prospective proposers begin preparations early, whether or not they have previously submitted MeerKAT proposals, and that they contact SARAO with any questions well in advance of the deadline for submission on 1 September 2020. Also, **it is essential that all instructions related to this CfP be adhered to, as non-compliant proposals may not be reviewed.** Additionally, we encourage prospective users to familiarize themselves with the more general guidelines on MeerKAT telescope and data access.

2 Who Can Submit Proposals

Proposals submitted under this CfP may be led by any researcher (including postdocs and PhD students), regardless of affiliation.

The basic MeerKAT imaging data product consists of interferometric visibilities, at high rates (the 32K correlator mode yields at least 1 TB of data per hour). Also, MeerKAT has some particular characteristics that may require adaptation during processing by researchers only familiar with other radio interferometers. In the preparation of proposals, SARAO therefore strongly encourages collaboration between new users and those who have prior MeerKAT experience.

3 Available Capabilities and Constraints

This CfP is open for **imaging projects only**. *It is expected that **at a minimum 1000 hours of telescope time will be available through this CfP**, with all approved projects to be scheduled by no later than end 2021.*

3.1 Time limits, receivers, and correlator modes

Individual proposals are limited to a maximum request of 100 hours, including overheads (e.g., calibration, slewing), with the following further constraints:

3.1.1 L-band and 4K correlator

Projects using L-band receivers (RF band of approximately 900–1670 MHz) and the 4K mode of the correlator (4096 channels across 856–1712 MHz) have no restriction on how the overall requested time may be split among targets/fields (e.g., 100 targets for 15 minutes each, or 1 target for 25 hours, in principle are allowed – although the former example may incur substantially more overheads).

3.1.2 L-band and 32K correlator

Projects using L-band and the novel 32K mode of the correlator (32,768 channels across 856–1712 MHz) are restricted to a maximum of 50 hours overall including overheads, and furthermore have a limit of no more than 12 hours per target/field (e.g., 5 targets for 4 hours each are allowed, but 1 target for 20 hours is not).

The L-band modes are suitable for full-Stokes polarimetric work.

3.1.3 UHF band

The UHF receiver mode on MeerKAT (544–1088 MHz, with RF band of approximately 580–1015 MHz) is not yet fully commissioned. This CfP allows for **'shared-risk'** proposals using UHF together with the 4K or 32K modes of the correlator for a maximum of 12 hours including overheads.

It is particularly important that prospective users of this mode be aware of its current

limitations, and be prepared to do more work (e.g., to develop an appropriate calibration strategy), and use a more conservative approach (e.g., to deal with dynamic range limitations and direction-dependent calibration challenges associated with the increased impact of the ionosphere and wider FoV), compared to L-band modes. **Prospective users of this mode must first contact SARAO well in advance of the submission deadline to discuss suitability under this CfP.**

The UHF modes are not yet suitable for full-Stokes work.

3.2 Pilot studies

The current CfP is for Regular Open Time (OT) proposals (those requesting up to 100 hours of telescope time). It is not open to Large OT projects (those requiring more than 100 hours, possibly over several years). Future Large OT projects will ordinarily have to first demonstrate technical and/or scientific feasibility through the successful completion of smaller pilot studies (although depending on the details, such projects might be deemed to have already demonstrated readiness by comparison to prior successful suitably analogous projects).

While such studies *using the L-band modes* are possible through the current CfP, **prospective PIs of pilot projects are required to discuss their plans with SARAO well in advance of the submission deadline** to evaluate suitability.

3.3 Target-of-Opportunity requests

ToO requests are for transient targets/events that could *reasonably* be predicted to occur within the observing span associated with the current CfP, i.e., that could be triggered within a 1 year period expiring at the end of 2021. Rare enough events for which reasonable prediction of rates cannot be supported should be proposed under Director's Discretionary Time. Furthermore, a compelling ToO proposal addresses a narrow object class with well-defined science goals.

3.4 Non-standard modes

Some capabilities that prospective MeerKAT users may be familiar with using at other telescopes may not yet be available on MeerKAT (e.g., OTF mapping, particular noise-diode firing schemes, solar observations), or may have MeerKAT-specific implementations that could impact the attainment of some science goals.

Users considering potentially non-standard observing modes must discuss their plans with SARAO well in advance of the submission deadline to evaluate suitability for the current CfP. In case of doubt, please contact SARAO.

3.5 Data products

The official imaging data products provided by SARAO to MeerKAT users consist of visibilities with basic flagging, calibration solutions and reports. Continuum and spectral image cubes are also automatically generated by the Science Data Processor (SDP) pipeline

for some observations. These are primarily generated for quality assessment purposes but may be useful for some science investigations.

By default, proposals submitted under this CfP must address the feasibility of achieving their science goals on the basis of analyzing visibilities. However, proposers are encouraged to learn about the power and limitations of SDP pipeline products, and as relevant discuss with SARAO the feasibility of using these for their science applications.

3.6 Documentation on current MeerKAT capabilities

Prospective proposers are directed to documentation on telescope capabilities and constraints on the users portal for this CfP. Any remaining questions should be addressed to SARAO well in advance of the submission deadline.

4 Determining Targets for Observation and Time Requests

MeerKAT observing projects are approved to address specific science goals, alongside the targets/fields and integration time/modes required to achieve those scientific objectives. ***Newly proposed projects may not unduly clash with the* specific *science goals of previously approved active projects.***

Note that it is entirely possible to have multiple projects observing some of the same targets, to address different science goals. For instance, a project with a large sample of targets selected according to well-defined criteria may happen to observe one galaxy that is the specific focus of a separate project with distinct aims observing the same galaxy with a much longer integration and/or using different telescope modes.

In order to not clash with active projects, prospective proposers should become at least passingly familiar with those projects.

4.1 Approved projects and existing datasets

All approved MeerKAT LSPs (Large Survey Projects), and Open Time (OT) and Director's Discretionary Time (DDT) projects, are listed here.

Also, the MeerKAT data archive interface (which includes functionality such as a cone search) can be used to list all science observations done with MeerKAT, alongside useful related information (e.g., whether those data are publicly available).

Note that the data collected for many previously approved OT projects will be public on the archive by the submission deadline applicable to this CfP. Likewise, data collected for previously approved DDT projects (which by default have a 3-month proprietary period) are either already public or should become so during the remainder of 2020.

Other substantial current projects include: SARAO Legacy Surveys of the Galactic plane/center, of galaxy clusters, and of the Magellanic Clouds (all done at L-band with the 4K mode of the correlator); some SARAO Science Verification datasets; and an MPIfR-led L-band survey. Prospective proposers are encouraged to learn more about these projects.

Any questions regarding the status of existing MeerKAT datasets and how they might relate to the submission of new proposals can be addressed to SARAO well in advance of the submission deadline.

4.2 Time requests

The type and number of targets/fields requested in a proposal, along with the observing mode, must be suitably addressed in the context of the science case.

In addition, all time requests must be justified by appropriately motivated sensitivity calculations. To assist, a variety of sensitivity calculators are available, the output of which must be included with the submitted proposal.

5 Components of Proposal

All complete proposals consist of a minimum of 4 mandatory sections (cover sheets; scientific & technical justification; data analysis/management plan; output of sensitivity calculators). Depending on circumstances, proposals will contain up to 2 additional sections (status of prior MeerKAT observations; HCD plan). Information on these components follows in the remainder of this section.

5.1 Cover sheets

These are to be completed directly through the proposal submission system, which contains instructions. All attachments noted in the following sections are also submitted through the proposal submission system.

The cover sheets include fields for information such as team member details, proposal title and abstract, broad proposal subject matter (to assist with review), telescope modes requested, source lists, and integration time. Tools are available to assist with the completion of some of these items (e.g., observing run simulation tools, including selection of suitable calibrators and estimated slew time).

5.2 Science case – scientific & technical justification

This section consists of one pdf document (maximum size 10 MB), *with a strict limit of 4 numbered pages* using font size no smaller than 11 pt and with standard margins. Relevant figures/tables and references must be included within this page limit.

There can be no explicit identification of team members within this document, as it will be reviewed in double-blind fashion. In addition, refrain from style that indirectly identifies teams – e.g., instead of 'As we have shown in Author et al. (2019)', write rather 'As shown by Author et al. (2019)'.

This is the only section that may contain the scientific and technical justification for the proposal, in a self-contained fashion (note that the scientific reviewers will not have access to the cover sheets or any other section of the proposal). The following considerations

apply:

i. *This document should be written for an astronomer who is not necessarily an expert in the sub-field* (e.g., it may be assumed that the reviewer has expertise in some continuum science if they are reviewing such a proposal, but particular expertise should not be assumed on, say, galaxy clusters or star forming galaxies).

ii. The **scientific justification** portion should provide context for the science goal(s) being proposed, and it should be explicit (no generalities) as to what it aims to achieve science-wise, and also how the proposed observations, if successful, will do so. Why are these interesting questions to address – and if not novel, how does the proposed work advance on the current state of the art? If MeerKAT is the most suited instrument available for this investigation (as opposed to being one of several that could do it essentially just as well), indicate how.

iii. The **technical justification** portion should make a clear connection between the observing request (e.g., flux density limit, set of target(s), areal coverage, number of visits – which in turn quantitatively drive the overall requested time) and the specific science goals to be achieved. The RFI environment should be taken into consideration as relevant. For the purpose of sensitivity calculations, *proposers should assume the availability of 60 (not 64) antennas.* Also, any requested integration period of fewer than 8 seconds must be justified.

As relevant, note additional requirements (e.g., dynamic range) and address possible constraints (for instance, bright sources in the field, and how they'll be dealt with – e.g., by considering direction-dependent effects – if they might otherwise impact attainment of the science goals).

This section should note the overall time request, modes to be used, and identity of source(s)/field(s) to be observed. For large source lists, only the criteria need to be indicated here.

As noted in Section 3.3, **Target-of-Opportunity requests** must be narrowly tailored. Apart from addressing the specific science goals, proposals with ToO classification have to address in this section predicted event rates (reasonably expected to be triggered within a 1 year period), provide a sense of their brightness, and the triggering criteria, including what facilities will generate them.

5.3 Data analysis/management plan

This section consists of a 1-page pdf document.

Turning large amounts of MeerKAT data into science can be challenging. *A proposal with a compelling science case but an unrealistic or unclear data analysis management plan is unlikely to be ranked highly overall.*

In this section the proposers must outline their intended analysis plan and indicate the resources that they have at their disposal for the relevant tasks. These resources include:

i. Personnel with the necessary expertise. The role of each key team member, whether technical or scientific, should be outlined, and relevant experience with MeerKAT data analysis if any should be noted.

In this context, we note that having the same PIs/technical leads for too many projects (ongoing and/or new) could raise flags regarding the feasibility of completing all relevant projects in good time.

ii. Software. The status of any relevant software (e.g., pipelines still under development) should be indicated.

iii. Hardware. It's important to note whether access to the required tools and computing resources has been secured.

In this context (especially for larger/more challenging projects), it may not be sufficient to state that the data will be processed at 'X institute'; rather, the proposers should seek to make quantitative estimates of their storage and compute requirements, and indicate either that they already have access to those specifically required resources, or outline how they reasonably intend to acquire them.

As mentioned earlier, SARAO itself has a set of internal pipelines that regularly produce continuum and spectral images for some observations. Although intended primarily for quality assessment, these images may be a useful addition, or even sufficient themselves for conducting the desired science investigation.

Further to this, it may also be possible to assist South African-based observers with the execution of other pipelines at facilities such as the Centre for High Performance Computing (CHPC).

Should either of these options be of interest, PIs are required to engage early with SARAO to determine their feasibility in the context of this CfP.

5.4 Output of sensitivity calculators

The outputs of appropriate sensitivity calculators underlying the technical justification of the proposal must be submitted as attachment(s). For continuum observations, the advanced calculator should be used, with a screenshot of the output submitted as a pdf attachment. For spectral line proposals, the pdf output of its calculator should be attached. For mosaic observing of any kind, the pdf output of its calculator should also be submitted.

5.5 Status of previous observations

If any key member of the current proposal team (including, but not limited to, the PI and technical lead(s)) has been a key member of any previous MeerKAT Early Science (16-dish), Open Time or DDT proposal, this (1-page pdf document) section providing a status report for each relevant dataset must be completed.

i. If the project has already resulted in any publication, provide paper title(s) and standard

bibliographic information; optionally, also add a couple of sentences about the contents of the paper(s).

ii. If paper(s) have been submitted or are in advanced states of preparation, indicate so and outline the main results (and any technical issues if relevant). A copy of the paper draft(s) may be requested by SARAO.

iii. Otherwise, indicate the current status, and as relevant any issues – especially as they might connect to the current proposal (e.g., data analysis).

5.6 Human Capital Development (HCD)

While individual proposals need not have an HCD component – defined here as forming a significant portion of the thesis work for MSc or PhD students – *projects that do have a compelling South African HCD plan (in addition to a suitably strong science case and feasibility) will be advantaged in the review process.* The quality of the plan is more important than the quantity.

Proposals with a compelling HCD component for students not based at South African institutions will not be advantaged in the review process, but if approved may have longer than default proprietary periods.

If either of the above considerations apply, this section, consisting of a 1-page pdf document, must be completed.

In all instances below, the expected realistic role of the student within the project must be outlined.

i. For an HCD component that involves South African-based students (regardless of PI affiliation), provide as many details as are available:

a. For any student already identified, provide the degree type, start date of degree, student name & affiliation, supervisor name & affiliation(s), thesis title if available, and a sentence or two about the topic and how this proposed project connects to it (indicate whether a thesis proposal has been approved, in which case SARAO might request it).

b. For any student yet to be recruited, provide the degree type, expected start date of degree, supervisor name & affiliation(s), and indicate whether funding has already been secured and through what channel. If funding hasn't been secured, provide the expected channel through which funding will be sought and on what timescales this may happen. If a student/funding isn't identified in time (i.e., no HCD component), indicate whether there's an alternative realistic plan that could lead to publication.

ii. For an HCD component that involves students based outside South Africa, indicate degree type, student and supervisor name, affiliations, thesis title if available, and a sentence or two about the topic and how the proposed project connects to it.

6 Review of Proposals

All valid proposals received under this CfP will be evaluated on the merits of their science case and feasibility. In addition, proposals containing a South African HCD component will be evaluated on the strength of its plan. Proposals with South African-based PIs that build South African capacity for Key Science with SKA1 will be advantaged in the review process. Compelling cases for building South African science leadership capacity for SKA1 and/or for building South African HCD will improve the final ranking of a proposal compared to otherwise similar proposals.

In the first instance, different sections of proposals will be reviewed in a non-conflicted manner as follows:

i. The science case (see Section 5.2 of this document) will be reviewed by anonymous domain experts in double-blind fashion (i.e., the reviewers will not have explicit knowledge of the identity of the proposing teams), according to guidelines provided by SARAO.

ii. The data analysis/management plan (Section 5.3), outputs of sensitivity calculators (Section 5.4), and if relevant status of previous observations (Section 5.5), will be reviewed by SARAO with input from external experts as needed.

Review of the sections detailing data analysis plan and status of previous observations will inform the assessment of the overall feasibility of the proposed project.

iii. South African HCD plans (Section 5.6) will be reviewed by a South African-based panel appointed by the SARAO Managing Director (MD). We expect that focussed HCD plans with named students and secured funding will be ranked higher than those with no named students but specific and already secured funding.

An Open Time Review Panel appointed by the SARAO MD will then incorporate the above inputs and recommend to the MD a rank-ordered list of proposals suitable for scheduling on MeerKAT, together with other recommendations as relevant (e.g., partial time allocations).

After further taking into account all relevant constraints (e.g., pressure for particular LSTs or day/night-time observing), SARAO will finally group proposals into three classes: A (will be observed); B (may be observed); C (will not be observed). Following this, all PIs will receive feedback on the disposition of the proposals.

The cover sheets (Section 5.1) of approved projects may be made public.

7 Timelines

This CfP is being issued on 1 July 2020.

All documentation and tools required to prepare proposals in response to the CfP are available as of this date.

Proposals may be submitted on the submission system until 12:00 UTC on 1 September

2020.

Successful proposals will start being scheduled on MeerKAT as soon as the review process is completed and communication on outcomes is provided to PIs. This is expected to happen towards the end of 2020.

8 Proprietary Periods

By default, the data associated with any project approved under this CfP will have a proprietary period of 12 months, counting from the date of last data collection for the project. After the proprietary period expires, the visibilities, and data cubes produced automatically by the SDP pipeline if any, will become freely available through the MeerKAT data archive interface.

Approved projects that form a significant component of the thesis work of MSc or PhD students, as outlined in the HCD section of the proposal, may be considered by SARAO for proprietary periods of up to 18 months.

Note that at this point SARAO does not guarantee the storage of either visibility data or any associated image cubes substantially beyond the proprietary period of the observations. Teams may wish to arrange their own storage should they see longer term value in retaining the data.

9 Publications and Acknowledgements

We request that authors provide SARAO with copies of any papers or theses that include MeerKAT data.

Such publications should contain the following acknowledgement statement:

The MeerKAT telescope is operated by the South African Radio Astronomy Observatory, which is a facility of the National Research Foundation, an agency of the Department of Science and Innovation.

10 Contact Information

Any remaining questions pertaining to the current MeerKAT Call for Proposals should be addressed to SARAO as soon as possible in advance of proposal preparation/submission by emailing meerkat-proposals@ska.ac.za. Feedback on the documentation and tools associated with this CfP is also welcome.