

## **Draft policy for establishing a flexible EVN-lite subarray**

*Z. Paragi (JIVE), T. Venturi (IRA-INAF), J. Conway (OSO),  
S. Garrington (U. Manchester), Alastair Gunn (U Manchester), A. Zensus (MPIfR)*

### **Executive Summary**

The EVN observatories carry out coordinated single dish observations outside of the regular EVN disc-recording and real-time e-VLBI sessions, and a fraction of these observations needs to be correlated. This is currently organized in an ad-hoc way. This proposed policy lays down certain rules on how these observations should be carried out, with the goal of guaranteeing smooth operations, better organizing / reducing the workload for all parties involved (proposing teams, stations, correlator), and allowing for occasional triggers (or other observations that require flexible scheduling) on top of these. This would open up the way for including more telescopes in coordinated single dish campaigns like PRECISE, with the required resources well understood by all involved, and it would also allow for more flexible EVN operations outside of EVN sessions. It is envisaged that up to 600h of single dish observations could be organized this way in the 21-18cm, 5-6cm and 1cm bands.

These observations will be carried out on a best-effort basis with an EVN-lite subarray. The subarray composition depends on station availability. Eligible projects will require >100 hours telescope time with up to 12x6h segments to be correlated (Type 1, or background projects). Overrides by projects that require flexible subarray scheduling will be limited up to 12x6h segments (Type 2, or trigger projects). The total time commitment of stations to cm VLBI will not increase. The proposed policy outlined below has been carefully designed to minimize operational impacts in terms of EVN resources (manpower, recording media, correlation time, and user support).

### **1. Introduction**

Currently the EVN observes each year in three main sessions (regular recording), 10 days e-VLBI (real-time correlation runs), up to 6 days (144h, up to 10 blocks of minimum 12h observations) out of session, with additional Target of Opportunity experiments to address time-critical rapid-response science. The e-VLBI and SFXC developments in the past two decades have made the EVN capable of carrying out high-impact transient science projects, which led to discoveries like the precise localization of fast radio bursts (Marcote et al. 2017), and revealing the nature of binary neutron star merger outflows (Ghirlanda et al. 2019). In various EVN-wide discussions, and in particular during the concluding meeting of the NEXPreS project (“Locating Astrophysical Transients”, 13-17 May 2013, Leiden) it has been established that certain transient science cases would benefit from flexible availability for extended periods of an EVN subarray, rather than limited (in time and flexibility) services from a very sensitive, full EVN array. This has been referred to as “EVN-lite”: a concept in which the smaller dishes of the EVN would have played a major role. In the years following, EVN-lite has never formally been realized. The community interest however remained high, as was demonstrated by some initiatives (e.g., Kirsten et al. 2022).

## **Definition of an EVN-lite, out of session subarray**

The EVN resources are limited in observing time, recording media, and correlation time. But it is possible to define a subarray of EVN telescopes that is available for a substantial time, several hundred hours, outside of regular sessions. The composition of the subarray may change from observation to observation in accord with station availability, and it would not necessarily limit to small dishes only. With “EVN-lite” we refer to the fact that the projects supported would demand only limited resources from the EVN in terms of array completeness, long-term data storage, and correlation time.

## **Aims**

The aims of establishing policies for out-of-session EVN-lite subarray observations is to facilitate high-impact science projects that either require a large number of observing hours, or require the capability of flexibly scheduling (e.g. rapidly triggering) observations through most of the year, while correlation would only be needed for specific, very rare events happening. In the former case the trigger would be for correlation, based on the data obtained in a project, in the second case the trigger would be to observe a transient event reported by other instruments. These policies are needed to ensure that EVN resources are used in an optimal way, and to simplify the procedures to obtain time on EVN telescopes outside of regular EVN sessions. This would save a lot of effort to the station operators, the correlator, and the proposing teams, and may attract new users to carry out high-impact studies with the EVN. In addition, various conflicts of interests (like different groups targeting the same sources) will be brought to the EVN PC’s attention. This way the EVN and its out-of-session subarray would both operate in a transparent way. The science program of the subarray will have to be defined in a way that maximizes impact for the EVN as a whole.

## **Data storage and correlation resources**

The (up to) 600h of observations on background projects does not exceed the typical commitment of EVN stations dedicated to PRECISE in the past, but it would mean a significant increase to stations that were not part of that program. Notably, ~600h, is equivalent to adding more than a session’s worth of observing time to the current scheme. The PRECISE program (Kirsten et al. 2022) has already demonstrated that out-of-session VLBI observations using an EVN subarray for this much time is feasible (see Fig. 1). The key to the success of programs like this is that they do not require a long-term data storage for a large amount of data, and correlation time is limited to a (relatively) small number of triggers. A program like PRECISE, assuming 600h and a mixed recording of 2/1 Gbps (EVN) and 0.5 Gbps (e-MERLIN) would use about 6 PB/year, if we kept all the data. But the actual disk space used for operations is less than 100 TB, since the data can be removed on a weekly basis if there is no event found. In 2021, the number of PRECISE triggers (for data segments to correlate) was nine. These numbers do increase the load on various aspects of EVN operations, but they appear manageable. However, a policy should clearly state how much extra observing and correlation hours are available for EVN-lite subarray programs, and should maximize the disc space available for operations.

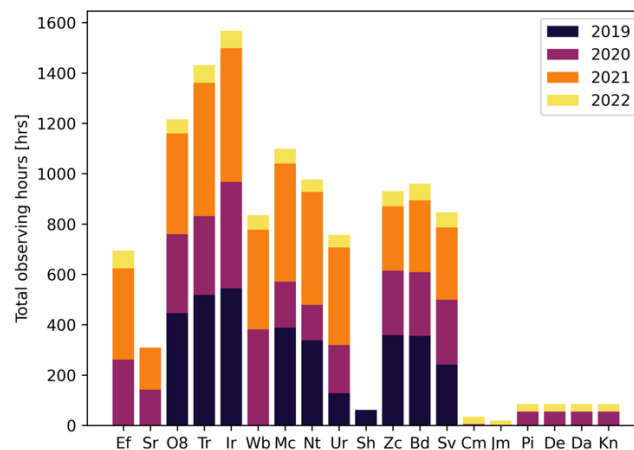


Figure 1. Observing hours by PRECISE from 2019 up to the early 2022 (Courtesy of Franz Kirsten).

## 2. Proposed policy

In the following we describe the policy for establishing an out-of-session EVN-lite subarray, to be approved by the EVN Consortium Board of Directors. The numbers stated below are indicative, they are subject to change depending on the availability of the telescopes in a given calendar year.

### Terms of agreement

- The EVN CBD agrees to establish an EVN-lite subarray available for observations up to 600 hours per year outside of regular observing sessions.
- EVN-light subarray observations are based on a best-effort basis. All EVN stations have the option to join this program.
- Individual observatories will evaluate participation in the proposed projects in a case-by-case basis.
- Even if a project is approved, participation in individual observations is subject to availability.
- Flexbuff storage load for operations will be maximized at 200 terabytes.
- Correlation time will be limited to 24 triggers, of which 12 triggers are for correlation (correlating up to 6h segments) and 12 triggers are for observing epochs (with a duration of up to 6h, see below). A 12h observation would count as using two triggers.
- The total observing time to be correlated will not exceed 144 hours per year.

### Eligibility and realization

- The EVN will maintain an open skies policy. PIs of EVN-lite projects will be encouraged to form broad and diverse (gender/country etc.), multi-disciplinary collaborations. The teams are expected to analyze and publish the data on short timescales (to guarantee smooth operations/short turnaround time).
- The available time will be advertised in the regular Call for Proposals (CfP), which will be distributed widely both within and outside of the RadioNet & ORP circles. Only

proposals received by the regular deadlines will be considered for EVN-lite subarray observations.

- Proposals are sent to the EVN PC. Projects that require Effelsberg will have to be sent to the Effelsberg Program Committee (PKE) as well.
- EVN+e-MERLIN proposals will be forwarded to the e-MERLIN TAG. These proposals must clearly justify e-MERLIN's role in achieving the science goals.
- All other stations that request it will independently evaluate the proposal through their TACs/directors.
- Two types of projects will be eligible for this mode of EVN operations:
  - 1) background projects that need lots of observing hours but require otherwise a small fraction of this to be correlated (correlation-only trigger), and
  - 2) projects that require a flexible array (trigger is for observation, e.g., to carry out rapid-response science on classical transients + transient masers).
- Background projects (Type 1 above) will need a specific proposal tailored to EVN-lite.
- Override projects (Type 2 above) will be selected from the regular proposal pool. An example is trigger proposals that so far have been supported for the regular e-VLBI sessions only. Should the array requirements meet, these could be observed with an EVN-lite subarray as well.
- While there will be no distinction between trigger projects of Type 2 to be observed in a regular e-VLBI run or with the EVN-lite subarray, the conditions for triggering will be different. To override projects scheduled in an e-VLBI run the grade of the trigger project must be higher. To schedule a trigger project out of session, the available resources should fulfil the proposal requirements regarding sensitivity and uv-coverage. These must be clearly stated in the proposal. The trigger requests can be sent up to 24h before an e-VLBI session. For out of session EVN-lite scheduling this will be up to 3 days before observations, at 8:00 UT.
- It may be possible to support more than one background projects, but the observing frequencies and the desired observing times should be harmonized in a way that does not put a lot of extra stress on telescope operations. This decision will be made by the EVN PC, taking into account the input (grades) from individual station TACs. The caveat is that trigger projects (which are time-critical) may override background projects as discussed above, irrelevant of their grade being higher or lower than the background project.
- The block schedule for EVN-lite observations will be made available at least a month in advance. The observing schedules will be checked and distributed by JIVE. Source changes in background projects is possible up to 24h before the observations start.
- For time-critical projects that do not fit in Type 1 or Type 2, Target of Opportunity (ToO) proposals remain an option. ToOs may be a vehicle to bring in more EVN stations to follow-up on targets detected in Type 2 projects, should the science and the initial results guarantee an exceptionally high impact outcome.
- User support for these projects will include help with proposal preparation, schedule checking, correlation, measurement set / IDI fits file preparation and archiving.
- For the background projects the advertised bands are 21-18cm, 5-6cm and 1cm. Note that changing receivers between projects will have the usual limitations.
- The EVN PC Chair or his/her proxy approves the Type 1 triggers for correlation, and Type 2 triggers for observation. The decision will be communicated to the proposing

team, the EVN scheduler, and the correlator. The EVN Scheduler (or proxy) informs the stations and the team running the background project.

- Following EVN PC approval of a project, preparing the observing schedule will be the primary responsibility of the proposing teams. Only standard observing setups, approved in the proposal, will be supported. These cannot be changed arbitrarily by the teams.
- After correlation, the standard data products will be placed in the EVN Archive. For background projects, this may include high-time and frequency-resolution data for millisecond-duration transient signals (raw data in filter bank, or other appropriate formats), or other special data products. Note it is the responsibility of the proposing teams to find these transient signals in the first place, but JIVE will provide some assistance.
- The data obtained in these projects will obey to the same rules as any other data collected by the EVN: one-year proprietary period for regular projects including triggers, and half a year for ToOs. However, a rapid initial publication in e.g., astronomical telegrams, and full data release (especially for Type 2 trigger projects) will be encouraged.
- The CBD approves to carry out an initial pilot for one year, to be advertised only for the 21-18cm band. It is requested that the proposing team assists the EVN Scheduler with finding suitable dates for the observations.

#### Appendix: Detailed Rules for the Pilot program for 2023

- 1) The initial trial will only offer L-band observations for background projects. Triggering at other bands will have the usual EVN limitations. For the trial only ONE background project will be selected.
- 2) For the trial, we will allow for maximum 6 observing triggers (Type 2 projects), with a total time not exceeding 72 hours. For correlation triggers of the background project (Type 1 project) the EVN PC will agree the maximum number and duration of such triggers as part of proposal evaluation.
- 3) Proposals for background projects in the 2023 trial must be submitted for the 1<sup>st</sup> October 2022 EVN deadline, such proposals will not be solicited for the 1<sup>st</sup> February and 1<sup>st</sup> June 2023 deadline.
- 4) The EVN PC Chair and the EVN Scheduler will decide if any requests for non-standard observing setups from Background projects (i.e. non-standard EVN L -band frequency ranges) will be accommodated in the background project.
- 5) The proposal from the background project team must include a commitment to provide personnel from the project to help in finding the observing days for the background project during 2023 and for supplying detailed observing schedules for the background observations. The PC will consider whether the committed resources to scheduling are sufficient as part of its proposal review. This person from the background project nominated to help with scheduling will work in close

collaboration/report to the EVN scheduler who has ultimate responsibility for ensuring that a block schedule for this EVN-lite background project is delivered to stations while the background project team is responsible (as for any EVN observations) for providing the detailed observing schedules to fill allocated background project time. The supporting scheduler supplied by the project will NOT be involved with deciding upon or scheduling any of the interrupts of the background project, these will be handled by the EVN PC Chair and EVN Scheduler in the same way that triggered observations during e-VLBI days are currently handled, except for accepting triggers up to 3 days before the run.

- 6) Background project observing time that is used for triggered projects will be compensated for by rescheduling this time in standard EVN sessions or e-VLBI days (if the background project used a non-standard setup, i.e. frequency range) there is however no guarantee that the compensating time will be able to have a non-standard EVN setup.
- 7) The call for proposals for the 1<sup>st</sup> October deadline will be issued 1<sup>st</sup> September and will include information on the EVN-lite trial.
- 8) Stations shall inform to the EVN PC Chair if they cannot commit the same time to this pilot as they have committed to PRECISE in the past by 20<sup>th</sup> August 2022.
- 9) Stations should also by 20<sup>th</sup> August 2022 inform the EVN CBD Chair and PC Chair if they need to conduct local TAC review before their station will participate in background project observations. In such cases they should also inform the PC chair of the date after 1<sup>st</sup> October by when their local review can be completed. If a station does not explicitly state that local TAC review is needed by 20<sup>th</sup> August it will be assumed that none is needed.
- 10) Stations that have already indicated they need local TAC review are Effelsberg, e-MERLIN, Sardinia, (Yebe in principle requires TAC review, but does not observe at L band and hence does not take part in this 2023 trial).
- 11) In general, for stations requiring TAC review the background proposal submitted to the EVN will be forwarded by the EVN PC chair to each TAC. In the special case of Effelsberg however the proposers of a background project must directly submit their proposal to the Effelsberg PKE via the regular deadline for 100m proposals (in early October) – this information will be clearly stated in the Call for proposals.
- 12) The deadline for a firm commitment from all stations on the number of days in 2023 they will participate in EVN-lite background observations will be communicated to the EVN PC chair and Scheduler by 31<sup>st</sup> October 2022 after which the process of setting the observing schedule for the background project in 2022 will begin.