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Should I stay, or should I go? Service and Visitor Mode at ESO's Paranal Observatory

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Since the beginning of Very Large Telescope (VLT) operations in 1998, ESO has been offering time in both Visitor Mode (VM) and Service Mode (SM). In this article we discuss the advantages and limitations of these two observing modes, explain the rationale behind the one-hour observation rule in SM, and provide some statistics comparing the usage in each mode. Community demand has been steadily growing for SM observations and is now above 80% for normal programmes (i.e., not Large or Guaranteed Time Observation programmes). Here, we highlight the benefits of VM and promote its usage to the community. We also emphasise the low demand for SM for observations in the most demanding seeing conditions.

Observing modes at Paranal

The VLT and its interferometer (VLTI) Science Operations Policy[1] defines the policies and procedures that form the basis of time allocation and operation of the VLT and its interferometer (VLTI). The document states that at least 50% of the scheduled observations will be implemented in SM in order to optimise the scientific return while adjusting the VLT/VLTI schedule to the prevailing atmospheric conditions, while at least 40% of the available time is reserved for VM. These percentages are subject to periodic adjustments, depending on the experience gained at ESO and the evolution of the community's demands.

In the 1990s SM was new territory for ESO, its user community, and ground-based observatories in general. SM at ESO, along with its supporting end-to-end data flow system (DFS), was envisaged to ensure that observations requiring the most challenging observing constraints were acquired during the right conditions, and that there was generally more flexibility to choose which observation best matched the current observing conditions. Furthermore, the observatory established calibration plans for instruments, ensuring that sets of measurements useful for both instrument health monitoring and calibration of scientific data were obtained while maximising the telescope time used for science (Hanuschik & Silva, 2002). In addition, the calibration plan was intended to be usable for a variety of scientific programmes, enabling the reuse of science data for archival research.

The DFS also included the development of tools for the definition of observations, and the provision of all necessary information and calibration files for data reduction and analysis. The ESO DFS has been flexible enough to accommodate new VLT/VLTI instruments, new programme and run types (for example, monitoring and calibration proposals, public surveys, target of opportunity and rapid response mode proposals) and a new observing mode, the designated Visitor Mode (Marteau et al., 2017). Designated VM, introduced in 2014, is limited to observing runs shorter than one night, when it is too inefficient for visiting astronomers to travel to Chile to observe. In those cases, the observer can connect from anywhere in the world via the Paranal Observatory Eavesdropping Mode (POEM) tool[2], which was introduced in 2017 and displays operational screens from the telescope in real time. See Hainaut et al. (2018) for further information about the evolution of the VLT/VLTI DFS.

At the very start of VLT operations, an effort was made to promote the then new SM, and several articles described its implementation, scheduling principles, tools and effectiveness (for example, Silva, 2001; Comerón et al., 2003). These articles, probably combined with the effective implementation of an operating model with satisfactory scientific return and the general satisfaction of SM users[3], resulted in a steadily increasing request for SM by the community. From an initial request of just under 50% in 1999, the SM request now exceeds 80% (see Figure 7 in Patat et al., 2017).

The scheduled (as opposed to requested) SM:VM ratio on the telescopes is more constant and has stayed at around 70:30 over the last decade, owing to the strong contribution of Large Programmes and Guaranteed Time Observation (GTO) proposals to VM (see Figure 1 from Primas et al., 2014). ESO schedules GTO observations in VM intentionally because operational procedures are fine-tuned during the early operation of new instruments, and there is transfer of knowledge from community experts who built the new instrument to the observatory staff. Additionally, ESO has scheduled all Spectroscopic Public Surveys in VM over the past six years.

Advantages of Visitor Mode

Visiting astronomers at ESO receive support that starts with the organisation of their travel to the telescope. ESO covers travel and accommodation expenses for one observer for each observing run allocated in VM[4]; this applies to observers affiliated to institutes in ESO Member States at the time of observing run. On Paranal, the visiting astronomers receive help from observatory staff astronomers with preparing their observing run, and they are assisted by a telescope and instrument operator and a support astronomer throughout the observing run.

The presence of visiting astronomers on Paranal is very important. It fosters a sense of ownership by the community, for whom the observatory and its suite of telescopes and instruments were built. By being present at the telescope, astronomers understand better how their data are taken and calibrated, and learn about their limitations. Visiting astronomers also have the opportunity to discuss their use of the instrument suite in Paranal face to face with ESO experts. By spending time travelling to remote observatory sites in Chile and by being present at the exciting moment when observations are appearing on the detector, an emotional link is established with the data. Indeed, this may be partly responsible for the fact that the VM publication productivity is higher than the average productivity of all normal SM programmes (Sterzik et al., 2015).

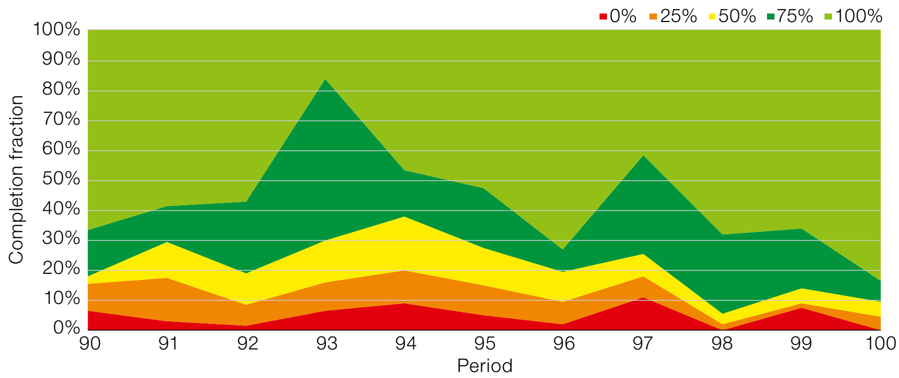


Figure 1. Visitor Mode run completion fraction.

VM is also an essential contribution to training the next generation of astronomers, who benefit significantly from an overview of the entire process involved in conducting their experiments. Astronomers with little or no observational experience, in particular graduate students and junior postdocs, are therefore encouraged to make use of VM. Observing is much more comfortable today and travelling to remote and beautiful observatory sites is something that every observational astronomer should experience at least once.

VM is not only important for the community, but also for ESO; visiting astronomers can provide direct feedback to the staff that run the operations. This feedback influences the evolution of the operational model and the services that ESO offers. Experienced observers can transfer their knowledge to the observatory staff, thereby enhancing the efficiency of the observatory for everybody. Also, seeing how the observations are run and meeting staff involved in operations facilitates later interactions when observing in SM. It provides a better understanding of the tools and communication channels at the observatory and helps observers to improve how they structure and convey their observing strategy for future observing runs.

In many cases, VM is the more efficient observing mode. Real-time decisions to optimise the observing strategy are possible only in VM. Typically, VM runs use very few different instrument setups, and there are no length restrictions for individual observation sequences. If the visitor has few targets, the overheads for telescope slew time, instrumental setup, and acquisition are minimised and the time spent integrating on the science targets is maximised.

Of course, the well-known disadvantage of VM is that the observer is at the mercy of the weather; in poor conditions, sub-optimal or partial data (or none at all) may result from a VM run. The average weather downtime on Paranal is between 10% (summer) and 15% (winter), when conditions are so bad that telescopes must be closed or no useful observations can be taken. Yet the median conditions are excellent and most visitors go home happy with lots of data (Figure 1) and ready to quickly publish interesting results (Sterzik et al., 2015).

Preference for Service Mode

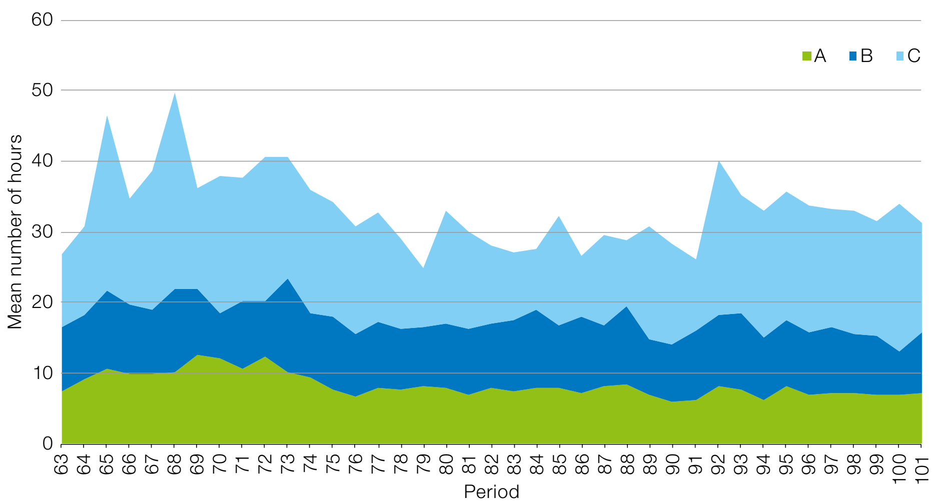
In the first decade after the year 2000 the SM *vs* VM request was stable, with about 70% of normal programmes requesting SM. Recently there has been an increase in SM requests: the VM fraction dropped from around 30% in 2012 to slightly below 20% in 2018 (Patat et al., 2017).

At around the same time, a new generation of Phase 2 observing preparation tools was released (Bierwirth et al., 2010). These tools allow the definition of complex observing strategies in SM, for example, via concatenations, groupings and time-links of observations. The tools were quickly adopted by users, and may have enhanced the perception that users do not need to be present at the telescope even if they require a more complex observing strategy.

Other possible explanations for the increasing preference for SM could be that observing programmes require less time (for example, because the second-generation instrumentation is more efficient and often offers a multiplexing capability), and/or that observing programmes request more demanding observing conditions that are most efficiently achieved in SM. Neither of these two suppositions is supported by data.

Figure 2 shows the evolution of the length of the mean SM observing run; no significant evolution for the lengths of A- or B-ranked runs has been observed since Period 75, i.e., since 2004. The C-rank class runs, are also called filler runs because they require most relaxed observing conditions. They are executed only

Figure 2. Evolution of the mean length (in hours) of allocated SM runs per rank class.



when there are no other higher-ranked SM observations, and show a larger scatter in their mean length per period, ranging between 9 and 27 hours. The mean length over all periods is 15 hours.

Figure 3 shows the evolution of the total execution time for scheduled SM runs in A and B ranks that requested 0.4- or 0.6-arcsecond seeing since the beginning of VLT operations on the four UTs and the VLTI. From this figure it is obvious that there is no difference between the A- and B-rank classes in terms of requested seeing and that 0.4-arcsecond seeing observations are almost never requested. Seeing conditions of 0.4 arcseconds are rare, occurring about 2—3% of the time. However, with sufficient SM allocation it is feasible to get such exceptionally good image quality (IQ). Moreover, 0.6-arcsecond seeing is fulfilled about 25% of the time, and the median seeing at Paranal is between 0.7 and 0.8 arcseconds. However, requests for observations with very good seeing have been dropping and now account for about 2 nights per telescope each semester. Primas et al. (2014) discuss the probability of the realisation and completion rate of demanding SM observations. Good seeing conditions, better than a median seeing of ~ 0.75 arcseconds, are undersubscribed, with most users requesting 0.8–1.0 arcseconds.

The success of SM could be attributed to an increasing confidence in the system. In addition, time requests are typically small, with the mean run length less than 2 nights, making travel to Chile inefficient (two observing nights typically require a trip lasting at least one week). Senior people may not want to go all the way to Chile regularly. It also seems that more junior people prefer to have experienced ESO staff take their observations in SM. By now, many users are accustomed to SM on Paranal and even rely on it.

In order to implement effective SM support, with about 1000 scheduled observing runs per year, ESO has developed tools and put in place well-defined procedures and rules to ensure that all users get appropriate support, enhancing the scientific return of their observations and treating everybody fairly. One of these is the so-called "Phase 1 constraint is binding" rule[5]. The targets, instrumental setup, and set of constraints requested at Phase 1 are used to define the schedule. Major changes with respect to the original plans may unbalance the schedule and cause conflicts between approved programmes. In particular, target and setup change requests are carefully evaluated and strictly controlled, because the Observatory needs to protect targets of approved programmes over later target change requests by other programmes.

Another rule that is sometimes less obvious to users, and in respect of which we frequently receive questions and waiver requests, is the "one-hour SM OB rule[5]". In the following, we summarise a recent analysis of stability in seeing, which is one of the reasons behind this rule. In so doing, we also highlight the fact that the good to very good observing conditions at Paranal are currently under-requested by the community. Strategies to improve the exploitation of these good conditions will be the topic of a forthcoming article.

Evaluation of the one-hour SM rule

At the onset of SM operations ESO introduced the rule that an SM observation block (OB), the smallest observational unit into which a given observing programme can be divided, should have a maximum length of one hour. This rule was introduced to ensure flexibility in short-term scheduling. Some users request longer OBs, and often the justification is that this will make their programme more efficient, because there will be fewer fractional overheads over the invested time. This may be correct for individual programmes and for a user who is not charged additional overheads in the case of a failed execution resulting from changing observing conditions, but it may not be correct for observatory-wide SM operations.

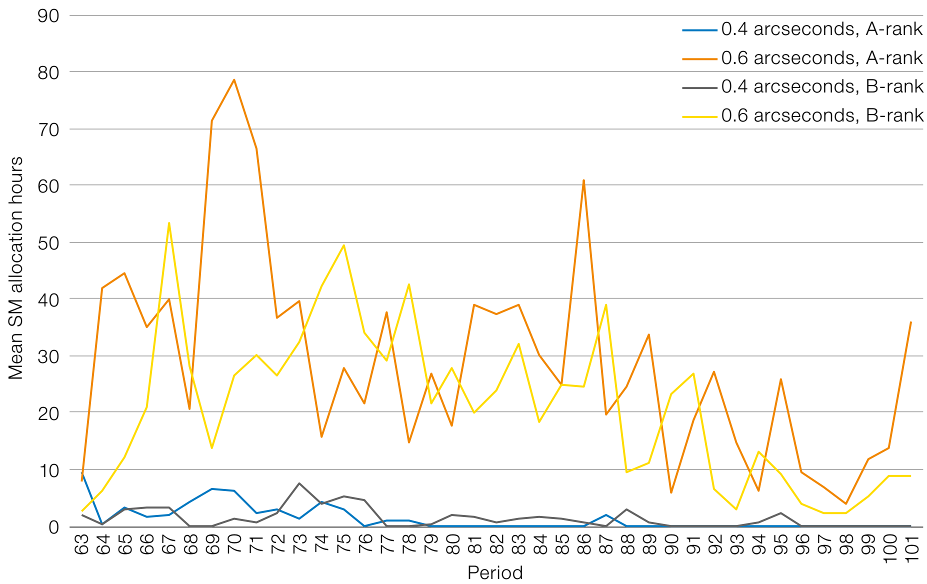


Figure 3. Mean SM allocation per telescope for best seeing runs.

The efficient scheduling and execution of SM observations is a complex function that includes calculating the possibility of scheduling OBs given the target visibility, the duration of the observation, and the probability of the observing conditions staying within the specified constraints for the entire length of the OB. Furthermore, priority is given to completion of the most time-critical and highest-ranked SM programmes. After more than 17 years of SM observations we reviewed the merits of the "one-hour SM rule" in a study that focussed on seeing as the dominant meteorological factor dictating whether or not an OB can be successfully executed.

The analysis was based on seeing measurements taken at the zenith at 500 nm with the Differential Image Motion Monitor (DIMM) every minute during the night, over a period from 1 January 2000 to 11 December 2010. We used these seeing measurements as the first order

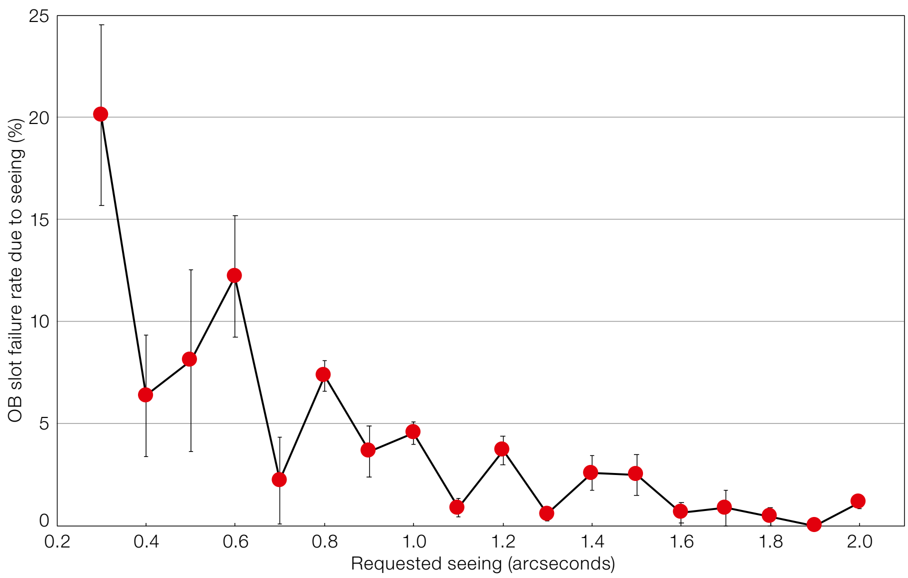


Figure 4. OB failure rate due to seeing as a function of requested seeing independent of OB length.

Requested seeing (arcseconds)	Percentage of intervals longer than one hour	Mean seeing (arcseconds) for all ~ one-hour intervals
0.6	57	0.66
0.8	63	0.87
1.0	70	1.06
1.2	76	1.29
1.4	82	1.52
1.6	82	1.70
1.8	83	1.89
2.0	87	2.11

Table 1. Results of seeing stability analysis based on DIMM data. The second column lists the percentage of time intervals that are longer than 1h for a requested seeing (column 1). The last column lists the statistically weighted mean seeing for all intervals that are 55–65 minutes long.

proxy for the resulting IQ of the science data[a] and we do not distinguish in the following between seeing requests for scheduling *vs* IQ requests in OBs.

We constructed a cumulative distribution of time interval lengths as a function of seeing. An interval starts after a waiting period of 30 minutes, during which seeing was at or below a target seeing value and ends after 10 consecutive seeing measurements above the requested value. This mimics a possible observational decision-making process at the telescope.

The results are presented in Table 1. In the case of typical seeing of 0.8 arcseconds, 63% of all intervals are longer than one hour. As expected, the fraction of time intervals longer than one hour increases as seeing gets more relaxed. Given our choice that the interval end after 10 consecutive non-compliant seeing measurements, there can be quite a range of seeing values for the one-hour-long intervals. The last column of Table 1 lists the mean seeing for all ~ one-hour intervals.

We then considered how this simulated one-hour duration OB success/failure rate estimate compares with what actually happens during SM observations on Paranal. The amount of time spent on observing OBs that are obtained during conditions outside of the specified constraints and that are considered for repetition varies from instrument to instrument. For example, AO instruments, and the VLTI have a higher fraction, on average, of unsuccessful executions. On UT1 and UT2 the fraction of observations executed out of the constraints is between 5 and 10%, while on UT3 and UT4 it is typically between 10 and 15%.

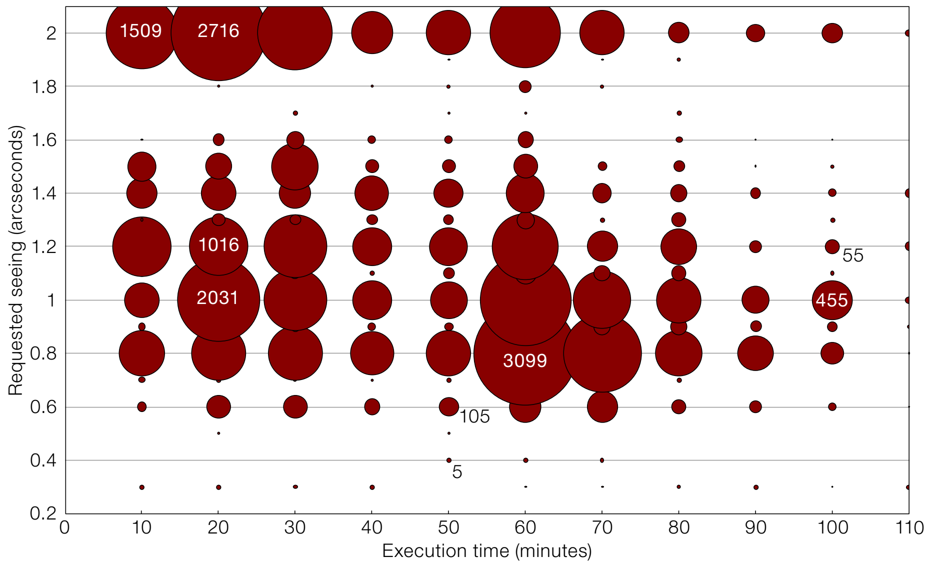
To assess the failure rate due to seeing alone, we analysed data from the night log database, where the fulfilment of all constraints, including seeing, is consistently recorded for each OB execution slot. As expected, the failure rate of OB executions due to unmet seeing constraints is higher for the most demanding OBs (Figure 4).

However, the overall failure rate is lower than implied by our analysis of seeing stability as reported in Table 1. Besides some scaling effects when converting the DIMM seeing values to IQ, these overall low failure rates suggest that OBs requiring close to median IQ (~ 0.8 arcseconds) are on average started under better initial seeing (0.6–0.7 arcseconds).

This would be a problem if the overall distribution of requested IQ were similar to or better than the statistical IQ distribution of Paranal. This would show itself if the IQ distribution of attempted OBs were skewed towards larger IQ with respect to the IQ distribution of scheduled OBs (and thus systematically resulted in unobserved requests with good IQ). However, this is not the case; the pool of available OBs binned by seeing and execution time is shown in Figure 5. We found it to be virtually indistinguishable from the distribution of attempted OBs that failed as a result of poor seeing (Figure 6). This indicates that the low failure fraction is not due to the systematic avoidance of demanding OBs, but the simple unavailability of such OBs, as already anticipated from the distribution of the requested seeing in the scheduled SM runs (Figures 3 and 5). The actual conditions on Paranal allow ESO to consistently fulfil IQ requests, since the distribution of requested IQ is more conservative than the real distribution. By implication, this also means that the fraction of failed observations is lower than the one estimated by the analysis of time intervals when seeing is stable at or below a given value.

Summarising the results of our study, an analysis of DIMM seeing stability anticipates that 37% of time intervals that started with a seeing of 0.8 arcseconds will be shorter than one hour in length. More generally, the length of time over which one can be assured of having seeing no worse than *S* is shorter for smaller values of *S*, or as shown in Table 1, the probability of successfully completing a one-hour-long OB is smaller for more demanding IQ. The one-hour limit appears to be a healthy compromise in this context, representative of the most requested values. In principle, OBs for more relaxed seeing requests could be longer, but this would have a knock-on effect penalising OBs of any length that require better seeing. In other words, two-arcsecond OBs can always be done under median or better conditions, but this is not the case for 0.6 arcseconds or even more demanding OBs.

In reality, the fraction of OB failure due to seeing constraints is about 5%. We show that this low failure rate compared to our statistical estimates of seeing stability has no negative impact on the execution of more demanding programmes. Rather, this happens because the IQ distribution of requested observations is more conservative than the average IQ distribution on Paranal. To take better advantage of the average site conditions, the community is encouraged to consider applying for slightly more stringent IQ constraints. The measures in place at Paranal to ensure the execution of more stringent observations such as these will be summarised in a forthcoming Messenger article (Anderson et al., in preparation).



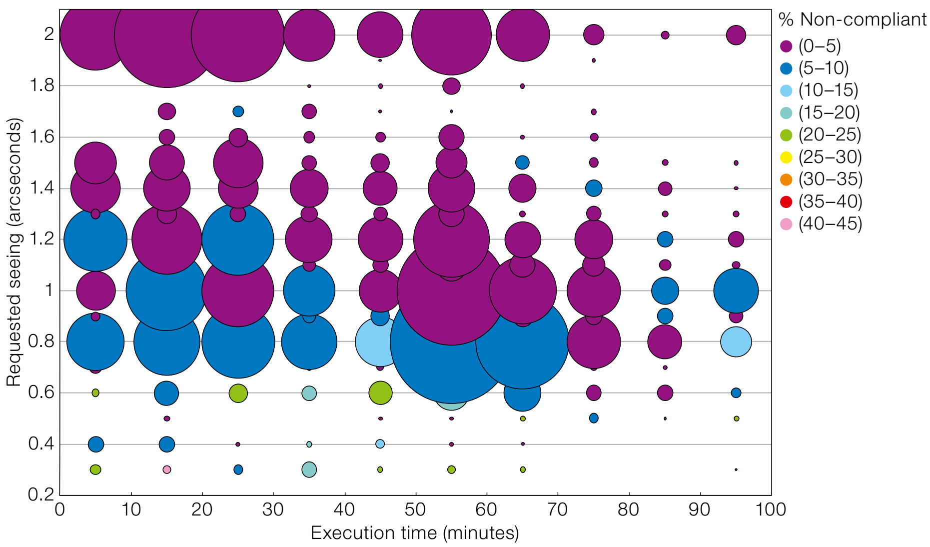


Figure 5. (Upper) Available OBs for Periods 90–97, binned as a function of execution time and requested seeing. The area of each dot is proportional to the number of OBs within the bin.

Figure 6. (Lower) OBs for Periods 90–97 binned as a function of execution time and requested seeing for which execution was not successful owing to non-compliant seeing. The area of each dot is proportional to the number of executed OBs, and the colour of the dot (see legend) indicates the percentage of the OBs with non-compliant seeing within that bin.

References

Bierwirth, T. et al. 2010, SPIE, 7737, 0W
Comerón, F. et al. 2003, The Messenger, 113, 32
Hainaut, O. R. et al. 2018, The Messenger, 171, 8
Hanuschik, R. & Silva, D. 2002, The Messenger, 108, 4
Patat, F. et al. 2017, The Messenger, 169, 5
Primas, F. et al. 2014, The Messenger, 158, 8
Sarazin, M. et al. 2008, The Messenger, 132, 11
Silva, D. 2001, The Messenger, 105, 18
Sterzik, M. et al. 2015, The Messenger, 162, 2

Links

[1] VLT/VLTI Science Operations Policy: http://www.eso.org/sci/observing/policies/Cou996-rev.pdf
[2] POEM instructions: http://www.eso.org/sci/facilities/paranal/sciops/POEM_instructions.html
[3] Results from user surveys are presented to the Users Committee at its annual meeting. Since 2012, the SM user feedback on Phase 2 support and tools has been made available online: http://www.eso.org/sci/observing/phase2/PostObservation/UserFeedback.html
[4] For GTO runs, ESO fully supports one visiting astronomer every 8 nights of the total time allocation for each GTO programme per period: http://www.eso.org/sci/observing/travel/visas-instruc.html
[5] Service Mode Policies: http://www.eso.org/sci/observing/phase2/SMPolicies.html

Notes

[a] It can be shown that image quality dependence on wavelength and airmass roughly cancel out on average.