ESO 16 METRE VERY LARGE TELESCOPE: THE LINEAR ARRAY CONCEPT

Daniel Enard
European Southern Observatory
Karl-Schwarzschild-Str. 2, D-8046 Garching

Introduction: Historical background and present organization

VLT preliminary studies were initiated at ESO as early as 1978 (1). After ESO's move from Geneva to Munich (1980) a study group chaired first by R. Wilson, then by J.P. Swings was set up and among a number of conceptual ideas that were analysed, the concept of a "limited array" emerged as the most attractive (2). A significant driver was then, interferometry; however after a theoretical analysis performed by F. Roddier and P. Lena (3), it became clear that interferometry with large telescopes would not be cost-effective in the visible range. In the IR, the situation would be more favorable but the overall efficiency would depend on factors that are not reliably known at present. The conclusion was that it might be difficult to justify a huge investment too exclusively oriented towards interferometry, such as an array of movable large telescopes, but on the other hand the possibility of a coherent coupling in the IR should be maintained as a prime requirement since new developments in detectors and in adaptive optics could make it effective and scientifically very rewarding.

After the ESO VLT workshop in Cargèse it was decided to create a fully dedicated project group in order to carry out the preliminary studies. This group was effectively created in October '83 and is expected to be fully operational by the end of '84. The project group will be advised on scientific matters by a Scientific Working Group and specialized sub-groups whose task is basically to define the various instruments and to study their feasibility; these studies will be essential to set the detailed scientific objectives and to define the relevant telescope requirements.

This description of the present VLT situation would not be complete without mentioning the 3.5 m New Technology Telescope project. This has absorbed the limited personnel resources available which might otherwise have been devoted specifically to the VLT. However, the experience thus gained, particularly in the field of active optics, will be directly applicable to the unit telescopes of the VLT and therefore represents an invaluable advance in the VLT project.

Proceedings of the IAU Colloquium No. 79: "Very Large Telescopes, their Instrumentation and Programs", Garching, April 9–12, 1984.

1. Main considerations leading to the present ESO VLT project

1.1 Array of large single dish telescopes versus the segmented mirror and the multiple mirror telescopes and the case for interferometry

The segmented mirror approach was considered briefly on only exclusively practical grounds: as already mentioned, ESO has embarked on the technology of fairly thin, deformable mirrors. When the engineering phase of the VLT will start, a lot of experience on that technology will have been gained including tests on a real telescope, so that it could be safely applicable to a larger telescope. An extrapolation by a factor of 2 seems quite a reasonable goal. There is also sufficient evidence that monolithic mirrors (either ceramic, pyrex, silica or metal) up to 8 m diameter can be made and handled. All this as well as rather strong feelings about IR background led ESO not to consider the segmented mirror for which there is neither experience available nor on-going development in Europe.

Based on 8 m monoliths, a 16 m equivalent diameter can be obtained with an array of independent telescopes or with an MMT. An array offers the possibility of long base line interferometry and would therefore be suited for work at very long wavelengths but (at least if the telescopes are fixed) it cannot provide a continuous coverage of the u,v plane. The MMT does not suffer from that limitation but its resolving power, especially at long wavelengths is much more limited. If the interferometry in the IR is deemed the most important, then an array appears preferable: some supersynthesis effect can be obtained and would partially overcome the lack of continuous coverage of the frequency plane and, because the "interferometric lab" where the beam combination will take place will be located outside the telescope, it should be easy to obtain a variable base line by means of one or two smaller auxiliary telescopes.

An MMT may offer a combined field of view of about 2 arcminutes (4) whereas that of an array would be much more limited due to the longer coupling distance. However - as pointed out in another paper at this conference (5) - it should be borne in mind that a straight optical co-adding of images from several telescopes, either MMT or array (i.e. unfilled apertures) would generate a considerable loss of imaging capacity and therefore require a considerably larger detector area, and exacerbate the pixel matching problem.

https://doi.org/10.1017/S0252921100108863 Published online by Cambridge University Press

Direct imaging at the combined focus of an unfilled array cannot be done very efficiently. Post detection combination appears to be a more adequate solution and therefore the field of view at the combined focus cannot be considered as a fundamental issue and does not give a decisive edge to the MMT over an array.

In conclusion an array of a small number of large telescopes has few and minor disadvantages but on the other hand offers a unique opportunity for long base line interferometry, optimum reliability owing to redundancy and indeed a maximum of flexibility since the telescopes can be used in many different ways, optical or post detection combination, or totally independently.

1.2 Alt-Alt versus Alt-Az

Three mirrors Coudé Alt-Alt arrangements have been considered to be potentially the best solutions to achieve an optical beam combination with the minimum number of mirrors. Their main drawback is the severe limitation of field at the Coudé focus caused by the large angle of incidence on the actively driven third mirror. This has been felt to be a major limitation in the case of a VLT in particular with respect to the active optics option for which a relatively large intermediate field (10-20 arcminutes) was considered essential. This consideration as well as other aspects analysed in greater detail in (6) led to the exclusive consideration of an Alt-Az, for which a Coudé configuration can be achieved with negligeable loss using 4 additional high efficiency small mirrors. However Alt-Alt arrangements in particular in the "BOULE" version might be an interesting solution for smaller and more specialized telescopes like the small mobile telescopes that are envisaged as auxiliary units for the interferometric set-up.

1.3 Building optimisation and cost reduction

As the efficiency of a telescope is proportional to $\langle r_o \rangle^2$, obtaining the best possible seeing is of prime concern. As stressed by N.J. Woolf (7), the observed seeing at most large telescopes is 2 to 3 times worse than the free atmospheric seeing. Assuming we find an excellent site, the problem of building optimisation consists of getting the telescope's immediate surroundings under conditions close to those of the free atmosphere. This

https://doi.org/10.1017/S0252921100108863 Published online by Cambridge University Press

could possibly be obtained with 2 opposing strategies:

a) A traditional protection of the telescope and a tight control of the dome and telescope thermics. This is in particular the strategy applied with success on some "late" conventional telescopes such as the CFHT or ESO/MPIA 2,2 m.

b) A short telescope thermal time constant and free airflow as advocated by Woolf, and proved experimentally at the MMT to be an excellent solution. This is also the solution chosen for the ESO NTT.

If one considers the essential problem of minimizing the cost of the building, it is clear that only the second strategy can be applied to a very large facility.

However, letting the air flow on the telescope presents severe problems, the most critical being wind buffetting. Thus, we are facing a contradiction: how to protect the telescope from wind buffetting while using the airflow to control the telescope temperature?

It is our belief that it should be possible to design an active wind shield that could act on the mean velocity and to some extent, modify the wind force spectral density so that the resulting wind buffetting be minimal. Tight design of the telescope structure and of its servo drives would then provide the final required stability.

This might lead to a prohibitively complex and expensive system if a very interesting characteristic common to many sites in Chile were not considered. It appears that the wind direction in the Northern part of Chile is remarkably constant and is roughly North-South. It is obviously the case at La Silla, as shown by Fig. 1 and it seems also to be true further North as shown by Fig. 2 which corresponds to standard radio soundings carried out regularly at Autofagasta by the Chilean Meteorological service.[(8)] Remarkably enough, this effect is the more pronounced at an elevation of 3000 metres which is close to the elevation of the present Chilean Observatories and that of the most promising sites in Chile for the erection of a future VLT.

https://doi.org/10.1017/S0252921100108863 Published online by Cambridge University Press

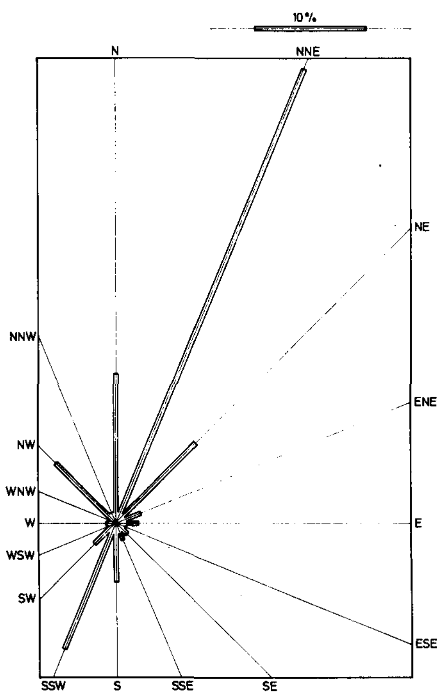

Fig. 1

Typical wind direction at La Silla

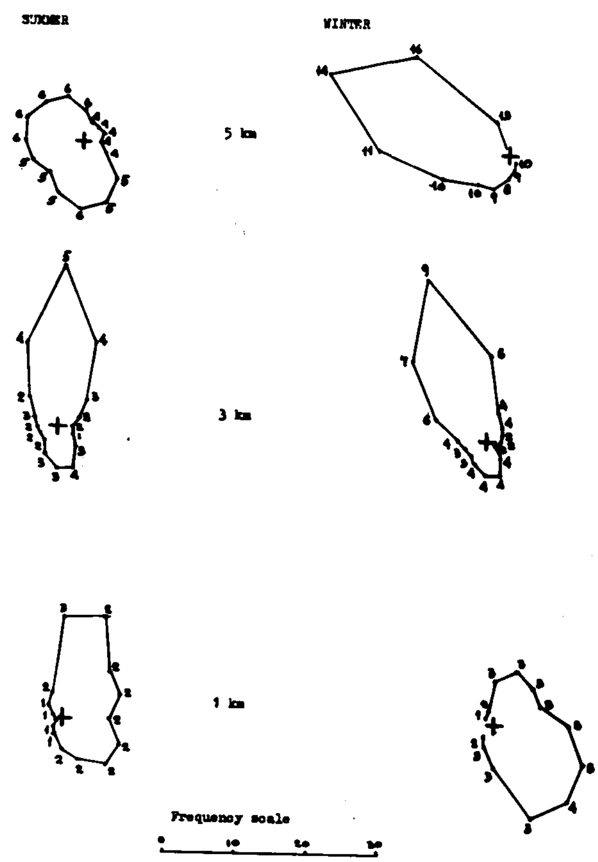

Fig. 2

Wind direction at the vertical of Autofagasta

https://doi.org/10.1017/S0252921100108863 Published online by Cambridge University Press

LINEAR ARRAY CONCEPT

4 x 8 METRES TELESCOPES

PROS	CONS
- FLEXIBILITY. Telescopes can be used combined or fully independently.	- VERY SMALL FIELD AT COMBINED FOCUS
- SHORT TIME AVAILABILITY of the first telescope. Best use of available resources.	- DISCONTINUITIES IN SPATIAL FREQUENCY COVERAGE. Limited angular information.
- "LONG" BASELINE INTERFEROMETRY. High angular resolution up to very long wavelengths.	- SITE REQUIREMENT: Long platform needed.
- LOW COST BUILDING FOR OPTIMUM SEEING	
- INDEPENDENT INTERFEROMETRIC LAB. Also usable with smaller telescopes for tests and baseline extension.	
- TECHNICAL CONFIDENCE. Modest extrapolation of existing experience (1.5 x size of 4 m equatorial mounts, active optics of ESO NTT).	
- SIMPLE, RELIABLE, EFFICIENT COUDE BEAM COMBINATION. Mirrors fixed with respect to gravity, high efficiency coatings.	
- VERY LARGE COUDE LABORATORY.	

TABLE 1

https://doi.org/10.1017/S0252921100108863 Published online by Cambridge University Press

This leads us to believe that a fixed wind shield could provide a cheap efficient protection. Actively driven openings would control the airflow according to the prevailing thermal balance and atmospheric conditions.

So as not to generate cross induced effects, the telescopes should preferably be facing the wind and have their own shield. A linear array appears, then, a suitable solution. It turns out that it also offers considerable advantages, such as a compact building, and possibility of multi-base Michelson interferometry.

The ESO Linear Array Project

The present concept is based on a linear array of four 8 metre telescopes, and provides the collecting power equivalent to a 16 metre telescope. The telescopes can be used either independently, or can be optically combined at a small field Coudé focus, or "electronically" combined (post detection), or combined by pairs for long baseline IR interferometry. Table 1 summarizes the pros and cons of the concept and table 2 summarizes the main features.

2.1 Telescopes

The telescope design will largely follow the conceptual line elaborated by R.Wilson for the ESO NTT, (9) (10) (11). Each telescope will be of the Alt-Az type with a thin, monolithic, and actively corrected prime mirror. The active control of the primary is considered essential to maintain optimum image quality, to reduce the weight of the mirror and consequently of the whole telescope structure, and to relax manufacturing tolerances. The final mirror form and thickness will have to be established considering the NTT experience, the optical machining and support system requirements and the cost of the blanks. We are thinking at present of an equivalent thickness of about 30 cm that would lead to a weight of about 37 tons.

The choice of material and nature of the prime mirror has not yet been made and several options will be explored (glass ceramic, pyrex, silica, metal, meniscus or honeycomb); The primary relative aperture will be about f/2. At the present time it is not clear whether a faster primary would be worth considering but this is not thought to be essential and probably not worthwhile economically. The aperture at the Nasmyth is prompted by 2

ESO'S LINEAR ARRAY PROJECT
4 x 8 M

CONCEPT

- Linear array of four 8 metre telescopes with either incoherent or coherent beam combination.

TELESCOPES

- 8 m thin single dish, actively controlled.
- ALT-AZ configuration, light weight structure.
- 2 Nasmyth foci F/15, $2\theta = 20$ arcminutes (+Prime Focus?)
- Short thermal time constant, fast servo response.

COUDE COMBINED FOCUS

- Small, quickly exchangeable mirrors with selective high efficiency coatings. Very small field only.
- Beam collimation after Nasmyth focus. No change of telescope configuration. Guiding and wavefront analysis at Nasmyth focus.

INTERFEROMETRY

- Long baseline 30 to 120 m. Fixed and independent interferometer.
- Rapid switch to interferometer mode by rotation of last coudé mirror.
- 2 small auxiliary telescopes for development, baseline extension, and full time operation of the interferometer.

BUILDING

- Open air telescopes.
- Active wind shield and rolling-on shelter.

OPERATION

- Remote observing from Europe.
- Flexible scheduling.
- Permanently attached and rapid switch of instrumentation.

MAIN OBSERVING GOALS

- High resolution spectroscopy at combined focus.
- Long baseline IR interferometry (till 350 μm).
- Imaging and low resolution spectroscopy at each telescope and post-detection combination.

TABLE 2

https://doi.org/10.1017/S0252921100108863 Published online by Cambridge University Press

considerations. The scale at the Nasmyth must be large enough so as to leave the possibility of multi-detector imaging using the field slicing technique (5) and the size of M2 and M3 in particular should be minimized in view of the application of high efficiency wide band coatings. In Europe, there are facilities for depositing sophisticated coatings on mirrors up to about 1.4 m diameter; keeping M2 and M3 under this limit would leave this possibility open without further investment. An aperture of f/15 would satisfy these 2 conditions.

An essential requirement for active optics is the availability of a sufficiently bright reference star and therefore of a relatively large field of view. It is indeed possible to model the flexures so that active correction may be only necessary at infrequent intervals: this would reduce the field requirement. Nevertheless we consider the possibility of correcting the mirror figure in quasi-real time through a closed loop to be a decisive factor in maintaining optical quality. We are also seriously considering the possible use of a visible reference star for adaptive correction of the seeing in the IR. The isoplanatic field at 10 μm being of the order of 10 to 20 minutes, a total field of view of 20 arcminutes would give the best chance of finding an adequately bright reference star.

The usefulness of a prime focus is not yet clear and depends on the possibility of obtaining very large detectors. If it appears possible to get efficient coatings for the secondary and Nasmyth mirrors, the prime focus would probably be abandoned for a focal reducer at the Nasmyth,[5] thus enabling a considerable simplification of the telescope and a corresponding improvement of the reliability as well as a reduction of the overall tube length. Further discussion on this point will take place soon.

2.2 Incoherent beam combination (Fig. 3)

With an Alt-Az configuration a combined Coudé focus requires a minimum of 4 to 5 additional mirrors, and the use of selective high efficiency coatings becomes mandatory. The field of view at the combined focus must be severely limited so as to keep the Coudé mirrors small and to make a quick mirror exchange possible. A field of 10 arcsec is obtained over distances of 100 metres with an average beam diameter of 300 mm. This field cannot be increased much without meeting serious problems. A set of 4 coatings for

https://doi.org/10.1017/S0252921100108863 Published online by Cambridge University Press

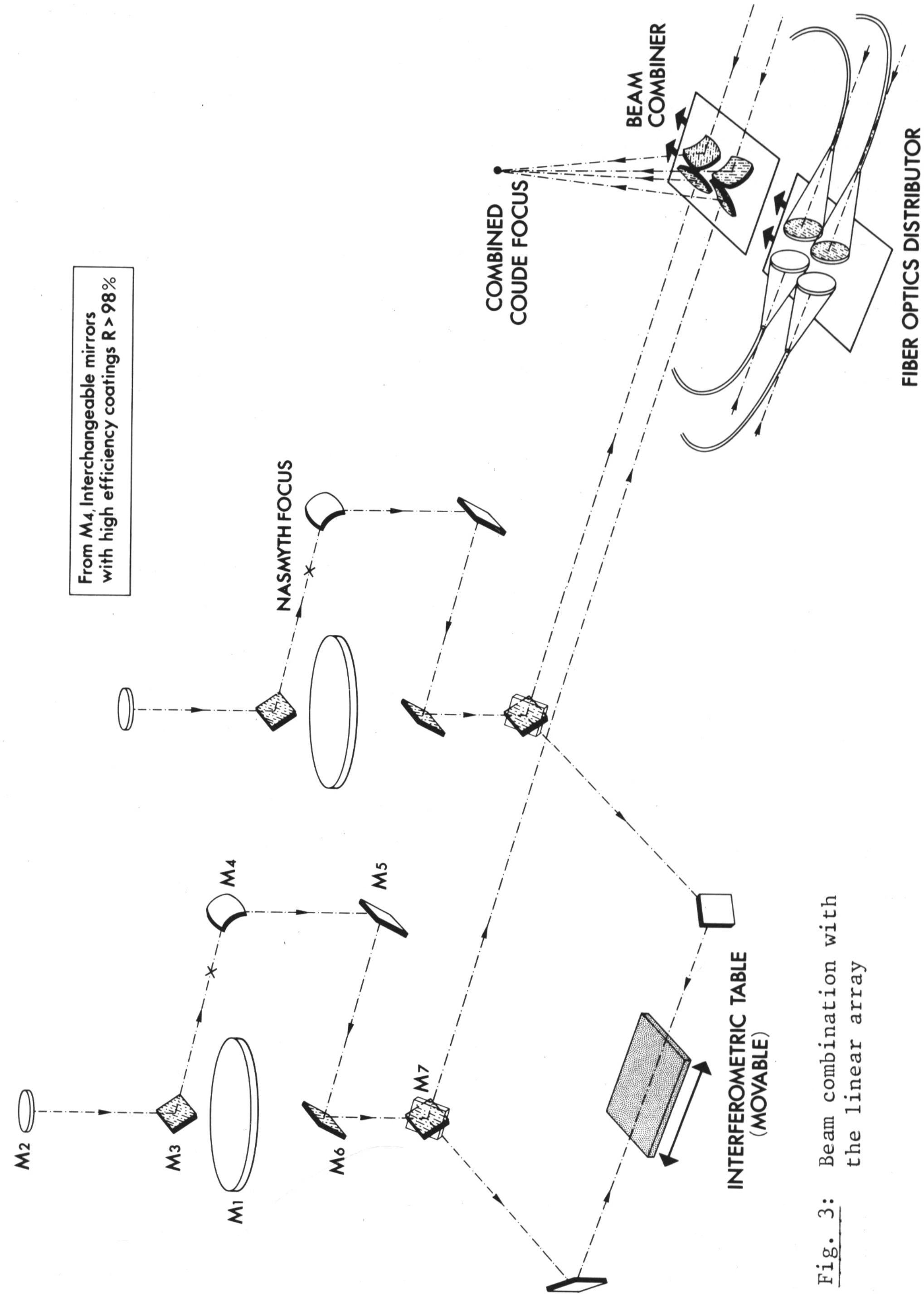

Fig. 3: Beam combination with the linear array

https://doi.org/10.1017/S0252921100108863 Published online by Cambridge University Press

U.V, blue, red, IR should cover the complete spectral range with a mean total efficiency of 94% (not including the telescope mirrors).

The basic principle is that the telescope beam is collimated after the Nasmyth focus so that the telescope works in its normal way. No change of configuration is necessary and the telescope control functions are achieved using the available off-set guider and wavefront analyser. The beam is collimated by means of either a very tight off-axis parabola or a simple Newtonian telescope. The 4 beams can be refocused and combined in different possible ways either by means of a telescope or of independent systems focusing the individual beams on fiber optics. A fiber optics distribution arrangement may be a convenient way to take full advantage of the flexibility of an array in feeding a number of fixed instruments with 1 to 4 telescope beams.

2.3 Interferometry

For the purpose of a coherent beam combination, the Coudé beams are reflected perpendicularly to the array by a simple rotation of M7. With another flat the beams from two telescopes can be combined with an equal path length in a very long room (interferometric lab.) parallel to the array in which the interferometric set-up will be allowed to move.

This combination offers an important logistic advantage: the interferometer is made independent of the telescopes and of the main Coudé room. The telescopes can thus be switched instantly to feed the interferometer at any time that the conditions are favourable.

During the development of the interferometer (that may well extend over a period of several years), it would be highly desirable to use a couple of relatively small auxiliary telescopes (1.5 metres?) so that the main array can remain fully operational during that period. They would also offer the opportunity to increase the base line (up to 300 m is deemed desirable), and would provide a full-time access to the interferometer. The auxiliary telescopes will be highly specialized and a "boule" configuration of the type used by Labeyrie at CERGA may be an inexpensive and appropriate solution.

https://doi.org/10.1017/S0252921100108863 Published online by Cambridge University Press

The number and the lengths of the bases offered by the main array will depend on the site characteristics, on the relative cost of extending the building length, and on various other trade-offs. Aspects such as the minimisation of the building cost and the optimisation of the incoherent beam combination will tend towards reducing the distance between telescopes. In this case, one will be limited to 3 baselines of about 30, 60, 90 m. A non-redundant distribution will provide up to 6 baselines, but would undoubtedly increase the overall cost. It may be preferable, therefore, to opt for a compact array and rely on the auxiliary telescopes for working at longer baselines.

2.4 Building

The building will be designed along the lines explained in 1.3; it will consist of a massive and stable platform on which the telescopes, the interferometer and the Coudé lab. will rest. A surrounding independent utility structure may reach the level of the Nasmyth platforms so as to provide easy access, and to insulate the more massive lower structure from the upper one which will be in the open air. Upwind, a fixed windshield will provide an effective protection for the telescope against wind buffetting. It will be active in the sense that variable openings will control the airflow according to the thermal balance and to wind forces. The top of the shield will consist of movable deflectors that will extend the fixed shield upwards. These deflectors will be folded down onto the fixed part when the telescope is pointing upwind so as to not interfere with the line of sight. The limiting upwind zenith-distance may be 45° or more. This limitation occurs only in one direction (northward) and the rapid deterioration of seeing will anyway make the VLT rather ineffective for large zenithal distances.

The day-time protection would be achieved by a movable shelter that would have at its back wall a series of openings which will let the airflow through without creating additional turbulence. The system will also be effective for a reversed wind direction, which happens sometimes in Chile at the beginning of the local summer. An alternative to this concept is to suppress the fixed wind shield and to have instead two smaller movable shelters moving, respectively, up and down wind.

https://doi.org/10.1017/S0252921100108863 Published online by Cambridge University Press

Fig. 4 is an artist's impression of the present concept. The width of the building has been exaggerated so as to show the various features. The real dimensions of the building would be about 140 m long and 50 m wide. Fig. 5 is a cross-section of the building showing the relative sizes of the telescope and the building. One crane can serve all the telescopes as well during the construction period as later on, for maintenance.

2.5 Site

A site with excellent seeing is a prerequisite for the VLT. The present ESO Observatory is already located on an excellent site as demonstrated by the outstanding image quality obtained at the 2.2 m telescope whose building has been very carefully designed. La Silla, is already a crowded mountain and could not accommodate the VLT; a new site has therefore to be found. Though sites anywhere in the world could be considered, there is substantial evidence that Chile offers the best chance, at least in the southern hemisphere, for an excellent site to be found. There are also obvious financial reasons to locate the VLT as close as possible to the existing ESO base.

A preliminary meteorological survey (12) (13) seems to show that, photometrically, exceptional sites exist in the northern part of Chile. The most critical parameter, however, is seeing. This is also the most difficult to evaluate.

An exhaustive investigation of a few selected sites is planned for the end of '84. First indirect methods such as scintillation, acoustic and radio soundings, balloon borne probes will be used and will be complemented as soon as possible by direct optical measurements (star trail monitors, speckle). The final goal is not only to evaluate quantitatively the resulting seeing but also owing to a better understanding of atmospheric physics to be able to forecast forthcoming seeing and transparence conditions in view of flexible scheduling. Interferometry also casts specific site requirements. First of all, the site must accommodate the long base that is planned, and also non-trivial parameters such as the speckle life-time, the isoplanatic field, and the microseismic activity will have to be considered. This is a very ambitious program for which the cooperation with several European groups active in this field will be essential.

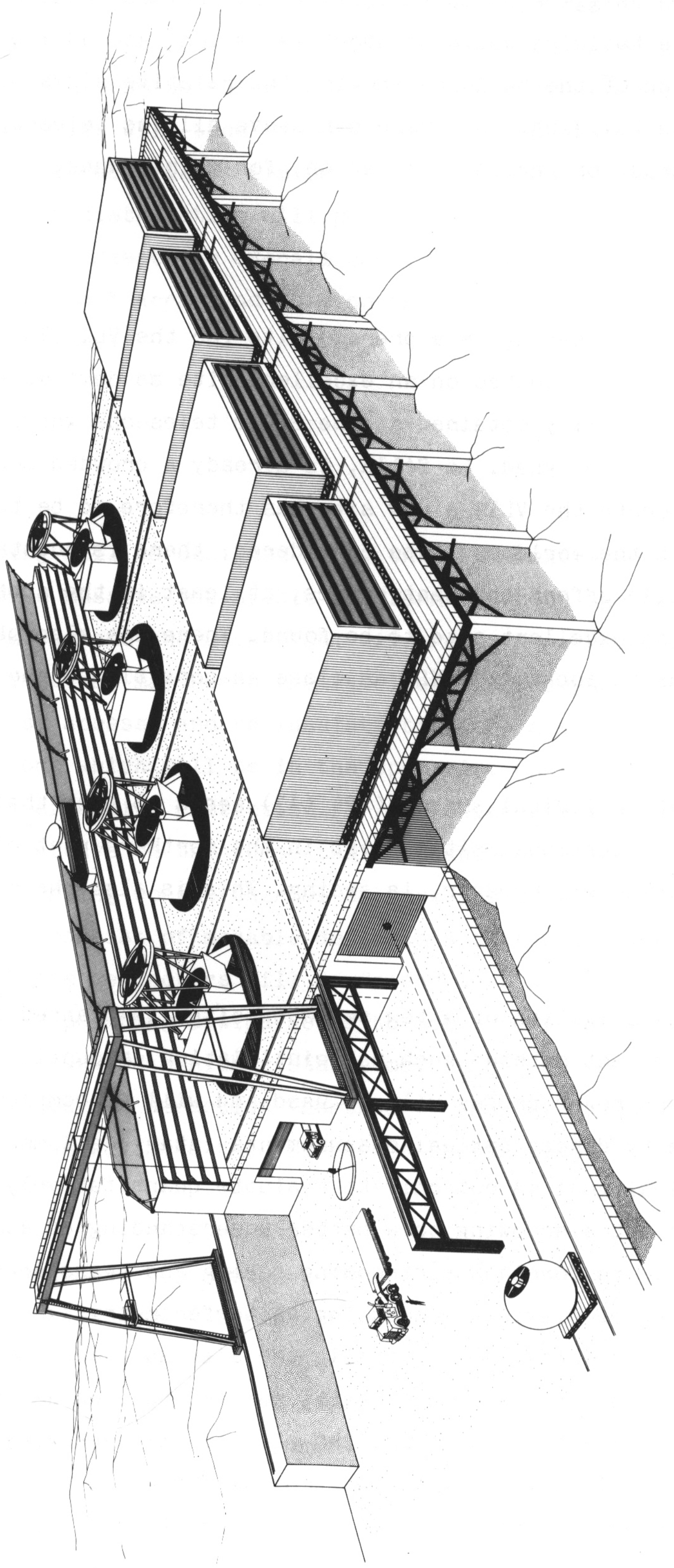

Fig. 4: Artist's impression of the linear array

https://doi.org/10.1017/S0252921100108863 Published online by Cambridge University Press

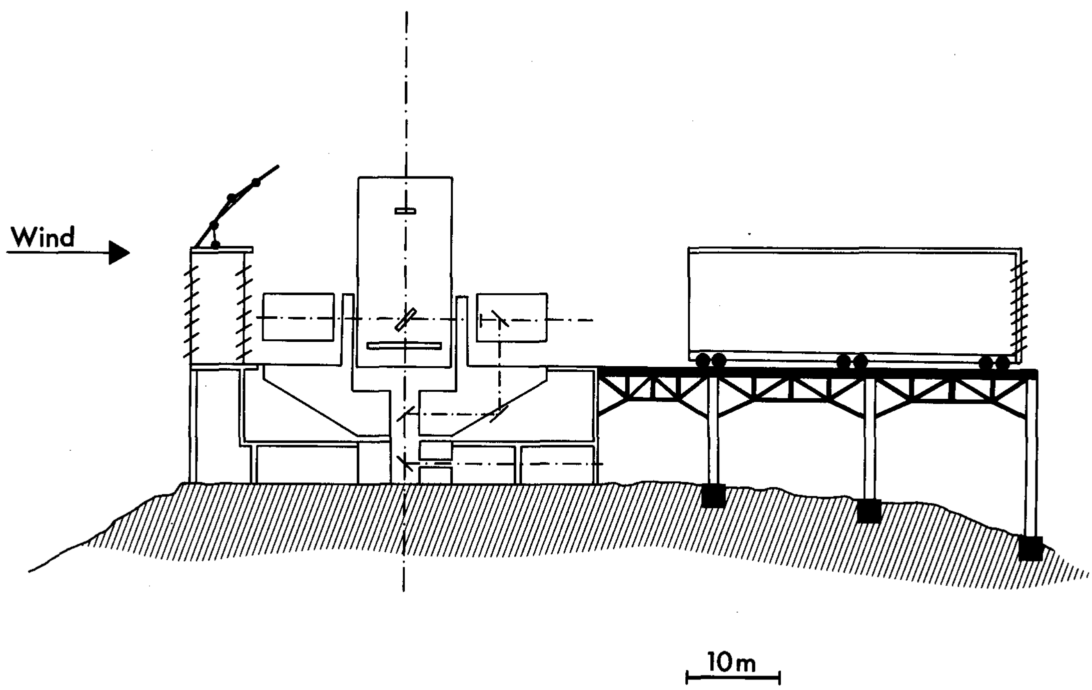

Fig. 5: Linear array. Cross section through one telescope.

2.6 Telescope operation

Looking 10 years forward, it is definitely certain that the cost and the quality of long distance communications will be such that remote observing will be considered as standard.

Remote observing will therefore be a basic design feature of the VLT as it will be for any new generation telescope. There are indeed a lot of questions that will have to be addressed, such as the number and functions of the observatory staff but this is neither an urgent nor important problem at this stage. It may, however, have some influence on the way the site will have to be developed.

Flexible scheduling, made possible by the remote observing, is also a fundamental issue that we consider essential to take full advantage of the site and of the size of the VLT. Flexible scheduling has a direct and immediate impact on the VLT concept: since atmospheric conditions are susceptible to vary rather suddenly, quick instrument change-over will be essential. This can be achieved only if the instrumentation is permanently attached to the telescope and connected to the control and data acquisition system. It would also have to be maintained on a permanent basis under operational conditions and be able to be fed by the telescope in a matter of minutes by, for instance, switching a mirror. This will certainly reduce quantitatively the available instrumentation and a detailed and early analysis of the requirements is essential. These considerations have greatly influenced the present concept in particular the way in which the beams are combined both for Coudé operation and interferometry.

2.7 Main observing goals

2.7.1 High resolution spectroscopy. This should be one of the basic applications of a VLT for which the full advantage of a 16 m aperture telescope can be obtained.

It will be done at the incoherent combined Coudé focus for single objects. It is however not excluded to use a fiber-optics combiner to observe simultaneously several objects (3 to 5 according to the instrument capability and Coudé field of view) or to perform a better

https://doi.org/10.1017/S0252921100108863 Published online by Cambridge University Press

sky subtraction. Although maximum efficiency will only be obtained under good seeing conditions, the instrumentation should be designed in such a way that mediocre seeing periods are also efficiently used. This is a particularly important requirement for high resolution spectroscopy for which the sky background is generally not the limiting factor. Excellent seeing periods should rather be reserved for those applications for which seeing is critical such as for the observation of extremely faint objects.

2.7.2 Interferometry

Interferometry in the visible is not considered. The gain that can be expected from the use of very large telescopes is too marginal and the corresponding technical requirements would probably drive the project out of a reasonable financial envelope. It is widely acknowledged that Michelson interferometry would be better done in space, therefore, only speckle work at individual telescopes is envisaged in the visible.

The situation for Michelson interferometry becomes rapidly more favourable as λ increases and particularly at wavelengths of 10 to 20 μm, it becomes quite effective with large dishes. Up to very long wavelengths (i.e. 350 μm) for which the technical problems become much eased, an array with a 100 metres baseline would still provide good resolution.

2.7.3 Direct imaging and low resolution spectroscopy

It is often believed that this type of work should exclusively be done from space where the sky brightness is lower and the instrumentation matching not a major problem. However, one should consider that the Space Telescope is only 2.4m diameter, will cost about 10 times more than a VLT and will provide only limited access to the community. Therefore, a VLT that would compensate (largely) for the handicap of being ground-based by having a larger collecting area, appears extremely cost-effective and complementary rather than competitive to a space observatory.

The remark concerning the comparison of a VLT with a space facility is also valid for the IR. However, the spatial resolution being, with

https://doi.org/10.1017/S0252921100108863 Published online by Cambridge University Press

increasing wavelengths, progressively set by the diffraction, there are further advantages in using a very large ground based telescope.[14] The prospect of an adaptive correction of the seeing may also provide an additional gain even for relatively short wavelengths. Therefore direct imaging and low resolution spectroscopy in the visible as in the IR are two fundamental goals for a VLT. They may be done at each telescope with a post-detection data co-adding. Because of the pixel matching problem this will give a better result than hypothetical large field image combination.

Multiple-object spectroscopy using a fiber-optics image combiner (MEDUSA, OPTOPUS) is also very effective and should be clearly one of the VLT observing facilities.

Conclusion:

Although the ESO VLT project is still at a very early stage of definition, a concept has been worked out which satisfies most of the initial requirements and which appears technically feasible. This concept has not yet been officially presented to the European astronomical community nor to the ESO governing bodies but has nevertheless been discussed and supported by the VLT Scientific Working Group which has welcomed it with enthusiasm. Various informal discussions with a number of European astronomers make us confident that this project has a good chance to win the support of the entire community, and to become the major European observing facility of the 90's.

References:

1. Richter, L.: ESO telescope plans for the future. Proceedings of Conference on Optical and IR Telescopes for the 1990's.

2. Swings, J.P.: ESO's VLT studies and options. Proceedings of ESO VLT Workshop. Cargèse, May '83.

3. Roddier, F. and Lena, P.: Journal of Optics (Paris). 1984. Vol. 15.

4. Enard, D.: Optical system analysis of various MMT concepts. VLT Note 36.

5. Enard, D.: Instrument matching in spectroscopy and direct imaging. This conference. (VLT Note 37).

6. Enard, D.: Comparison between Alt-Alt and Alt-Az mountings. VLT Note 35.

7. Woolf, N.J and Ulich, B.T.: ESO's Workshop on site testing. La Silla 1983.

8. Fuenzalida, H.: Meteorologic conditions in Northern Chile. ESO's workshop on site testing, La Silla 1983.

9. Wilson, R.N.: Optica Acta, 1982, Vol 29, No. 7.

10. Franza, F. and Wilson, R.N.: SPIE, VOL. 332

11. Wilson, R.N.: NTT, Predecessor of the VLT. ESO's VLT Workshop, Cargèse, May '83.

12. Ardeberg, A.: First results from initial site testing. La Silla 1983.

13. Woltjer, L.: Sites for the VLT in Northern Chile. ESO's Workshop on site testing. La Silla 1983.

https://doi.org/10.1017/S0252921100108863 Published online by Cambridge University Press

DISCUSSION

R. Wilson (G. Weigelt to D. Enard concerning the necessity of active optics and a thin mirror concept for the VLT.)

It is not correct to suppose we are planning for a very thin meniscus primary for our VLT - Daniel Enard's slide was only schematic from this point of view. Depending on what blanks are available, a fairly thin meniscus is one option, but this would need bores to allow for internal supports in the c. of g. surface. Personally, I would prefer a stiffer structure such as the egg-crate Roger Angel has proposed for the 7.6m Texas telescope. Such a structure could be in glass or metal and, in such sizes, would be very flexible compared with conventional 3.5m blanks with AR ≈ 1:6. Irrespective of how the blank is made and of what material, any 8m telescope concept will have to have some sort of active optics correction if it is going to have any change at all of meeting the specifications laid down (of the order of 0.1 arcsec). In fact, all the current very large telescope projects which are being discussed here have active optics correction as an essential part of their concept, though the principles on which the schemes function differ widely.

If we bear in mind that it is rare to find a conventional passive telescope in the 1m to 4m class which is consistently functioning within a quality of 0.5 arcsec, we can see what formidable problems specifications of the order of 0.1 arcsec pose - not only for achieving and maintaining them, but even detecting and measuring quality at this level in the presence of turbulence.

J. Nelson: It appears that your open air design will prohibit you from taking advantage of the daytime hours for infrared observing.

D. Enard: In that respect our fully open air design is not fundamentally different of, say, an open MMT building. Of course, some baffling will be required during daytime operation, but we believe this can be achieved at modest cost. But the real problem is whether daytime operation may not spoil completely the image quality during subsequent night time. This is a general problem not specific of our design. Ultimately, a compromise may be found, such as a limitation of daytime operation to a couple of hours before sunset and a couple of hours after sunrise. Here, too, flexible scheduling will be a must.

https://doi.org/10.1017/S0252921100108863 Published online by Cambridge University Press

R.G. Petrov: Have you considered a linear non-redundant array for the 8 meter telescopes in order to obtain a better coverage of the frequency plane?

D. Enard: Yes, in principle our design is not dependent on the distance between telescopes providing it is more than about 30 meters, so that any set of fixed bases can be selected. If very long bases are envisaged, the buildings should be independent but the field at the combined focus would also be reduced. Ultimately the site may set the limit.

E.H. Richardson: Why not use the Odgers-Grundmann Modification of the Labeyrie Boule Design for your large telescope, since large fields, prime, Nasmyth, Cassegrain are certainly possible?

D. Enard: We have seriously considered this possibility and have come to the conclusion that the Alt-Az mounting was better for telescopes of that size. Our argumentation was based on the pre-requisite that a large field of about 20 arc minutes was necessary to find a star bright enough to serve as reference for the active optics system. In any Alt-Alt system, this requires a mirror 3 about twice as long as for the corresponding Nasmyth. We have also considered that it might be very difficult to obtain the very high pointing and tracking accuracy that is required for our VLT. Finally if the dome can be spared, an Alt-Az mount is not necessarily more expensive and gives in many respects more confidence.

https://doi.org/10.1017/S0252921100108863 Published online by Cambridge University Press