guide for our work. Also, several thoughtful and pertinent comments were made on a variety of individual topics.

Some main trends are already clear from the answers:

• Strong demand for wide-field imaging (> 1°), visible and IR.

• Strong emphasis on survey-type work, both stand-alone and in preparation for VLT projects.

• Much demand for moderate- and high-resolution spectroscopy in the visible, moderate resolution in the IR. Strong interest in a wide-field, multi-object spectrograph (MOS) with > 400–500 fibers.

• Demand for long-term monitoring of variable sources, with requests to keep a photometric telescope on La Silla (some for polarimetry as well). Accurate standard stars for the VLT must be established.

• The role of La Silla in hands-on training of young astronomers is seen as very valuable, but second in priority to excellent science.

• Users are emphatic that La Silla must remain internationally competitive; small and medium-class telescopes continue to have valid and valuable roles to play.

General Policy Considerations

In trying to chart the course of La Silla into the future, we are guided by some of the landmarks previously set. Two of these are the report by the WG on *Scientific Priorities for the VLT Observatory* (1995) and that on *Scientific Priorities for La Silla Operations* (see *The Messenger* No. 74, p. 29, 1993). We must now carry the 1993 plans forward in mesh with the VLT project, guiding La Silla to a steady-state situation after the year 2000.

Some of the basic premises for the preparation of such plans are:

• The timetable of changes is driven primarily by the schedule of the VLT and its instrumentation.

• If preparatory work is required for VLT projects, the corresponding instrumentation on La Silla must be available in time.

• The VLT will completely outclass some current La Silla facilities. Yet, high-priority projects must be done on La Silla in the interim.

• New initiatives must be focused on the larger telescopes, which are both the main VLT partners and the most labour-intensive to run. For the smaller telescopes (< 1 m), the 1993 recommendations remain in force unless otherwise stated.

• At all times, facilities must be planned to achieve maximum operational simplification; this implies single-configuration telescopes and block scheduling of instruments as far as possible.

• The true financial impact of the proposed measures is not primarily in the direct costs, but in paving the way for a more cost-effective organisation of La Silla as a whole.

Draft Recommendations of the WG

A first rough timetable and list of actions was distributed to the Users Committee and STC in late April. It will no doubt undergo many revisions before a final version is reached, but some of its current main elements are the following:

• A careful tradeoff study of mirror size, image quality, and ease of operation is needed to define the future home of wide-field optical imaging on La Silla. Results so far indicate that the 3.6-m is unlikely to become a competitive facility.

• Wide-field imaging and medium/low-resolution spectroscopy in the near IR will remain vital. The proposed NTT instrument SOFI will cover these needs in a very cost-effective way, and the WG recommends that it be built.

• Until VLT+VISIR take over, TIMMI should be upgraded with a larger array, even temporarily, especially for ISO follow-up work.

• ADONIS should stay on the 3.6-m until CONICA + adaptive optics enter operation on the VLT.

• MEFOS and OPTOPUS lag behind contemporary efficiency by large factors and should both be retired. Competitive successors cannot be completed early enough, and time exchange agreements should be explored instead.

• A higher spectral-resolution option and efficient fiber link to the 3.6-m are essential for the long-term competitiveness of the CES.

Towards a Final Plan

The draft was discussed at length at the UC and STC meetings in May. There was a gratifying measure of support in both committees for the overall strategy of the draft as well as most individual proposals. The natural wish of users to maintain La Silla instruments in top shape until their VLT successors are in stable operation was stressed by both. The educational role of La Silla, defined as student training, met with some skepticism. The important issue is, however, the experience of those scientists who, 20 years from now, will teach a new generation of students. Hence, additional suggestions and comments will be solicited in the next version of the report.

After further discussion in the community, the WG plans to meet the UC, STC, and OPC together for a final review and refinement of the plan, and its financial implications will have consequences in the 1996 budget. Final presentation to the DG and Council follows after the November STC meeting.

In order to facilitate community access, later drafts of the report may also become available on the WWW.

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Is the Seeing Situation at the 3.6-m Telescope Irreversible?

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1. Introduction

Image quality (IQ), or the sharpness of the point spread function (PSF) at a 3.6-m instrument focus, should not fall below one arcsec (″) FWHM when external conditions are excellent, and is worse than 1.15″ FWHM most of the time (see Fig. 1). Images are hardly ever as sharp as at the NTT, the 2.2-m or the seeing monitor. This situation could be improved, and we are convinced now that in one year's time it would be possible to obtain 0.8″ FWHM long exposures with EFOSC1 routinely. This would however require a large effort during that period.

Poor IQ at the 3.6-m is not due to the site itself or to the quality of the optics (≈ 0.45″ FWHM), but rather to "mirror seeing" and to the presence of the dome. The dome is so large (30 m diameter) that residual sources of heat produce internal thermal gradients which cannot be eliminated by using the wind or any forced dome ventilation from outside, just because the dome cannot be opened sufficiently – unlike the NTT dome. Besides, obtaining thermal equilibrium with the outside all the time by means of cooling and ventilation is not realistic,

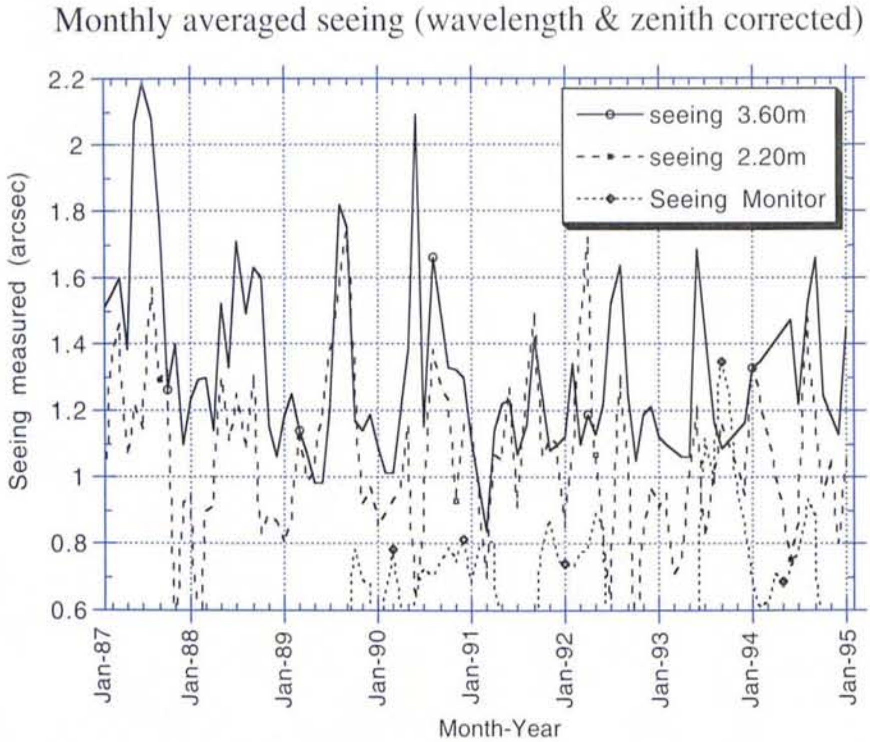

Figure 1: *Seeing recorded at La Silla 3.6-m, 2.2-m and seeing monitor telescopes from January 1987 to December 1994.*

given the enormous thermal inertia of the primary mirror (M1), the concrete floor slab and the yoke. Indeed, to obtain good images, there is only one recommendation, simple in theory: All temperatures (T°) in the dome should be within 1° and the average dome T° should remain lower than the outside temperature, by less than 1° (see ref. 1). This was widely confirmed by results obtained during seeing test runs.

Experience gained at other facilities (esp. AAT, CFHT and Kitt Peak) clearly showed the correlation between image spread and thermal inhomogeneities in the light path from the telescope slit environment to the detector. Most of the spread is caused by "local" seeing effects (dome, site, M1 or instrument). So what is needed to understand and possibly improve local seeing at the 3.6-m telescope are two sets of data, *image data* and *thermal data*. The lack of *image data*, in the form of reliable PSF FWHMs, has not permitted us up to now to tackle the seeing issue statistically. The "3.6-m Seeing Improvement Project" (ref. 2) is based on IQ measurements made by the observers themselves during their run, with the help of the night assistant. In March, observers were requested to dedicate 15 minutes per night to seeing measurements. Together with T° in the dome, seeing at other sites on La Silla and meteorological data, IQ data from EFOSC1, CASPEC and ADONIS would lead to the constitution of a database. From there, we would infer rules to set T° in the telescope environment, which would take into account changing external conditions, so that the IQ is always optimal. Cooling systems either already in place or presently being constructed (M1 surface cooling) will include fine T° adjustment capabilities for critical items such as M1.

2. A Historical Perspective

Twice in the past, a dome ventilation system was built and tested. No IQ improvement was noticed. Finally, in 1990 it was decided to build an Air Conditioning (AirCo) and a Floor Cooling (FloorCo) system, following recommendations by R. Le Poole, an engineer who studied the problem in some detail in 1990 (ref. 1). This system was operational in October 1993 just before a Come-On-Plus (CO+) run: It helped stabilise the bench T° and led to a noticeable IQ improvement (down to 0.9″) as compared to previous measurements (April and July 1993 runs). Conversely, images obtained by EFOSC1 got worse (section 4). I review Le Poole's recommendations below, then present the AirCo system.

2.1 Le Poole's Recommendations

• *Actively cool M1.* M1 was 3 to 4° warmer than ambient (in 1990). It is recommended to build an active thermal control system, which will cool M1 down to the previous night's minimum less 1°. The alternative solution is to cool down dome and floor to such an extent that T° at a height of 5 metres is 1° below last night's minimum. This assumes that all heat sources have been removed from the Cassegrain cage.

• *Insulate observing floor.* Some large heat capacities should be shielded (concrete slab, control rooms, TIMMI room, telescope base). Calculations show that both the concrete slab

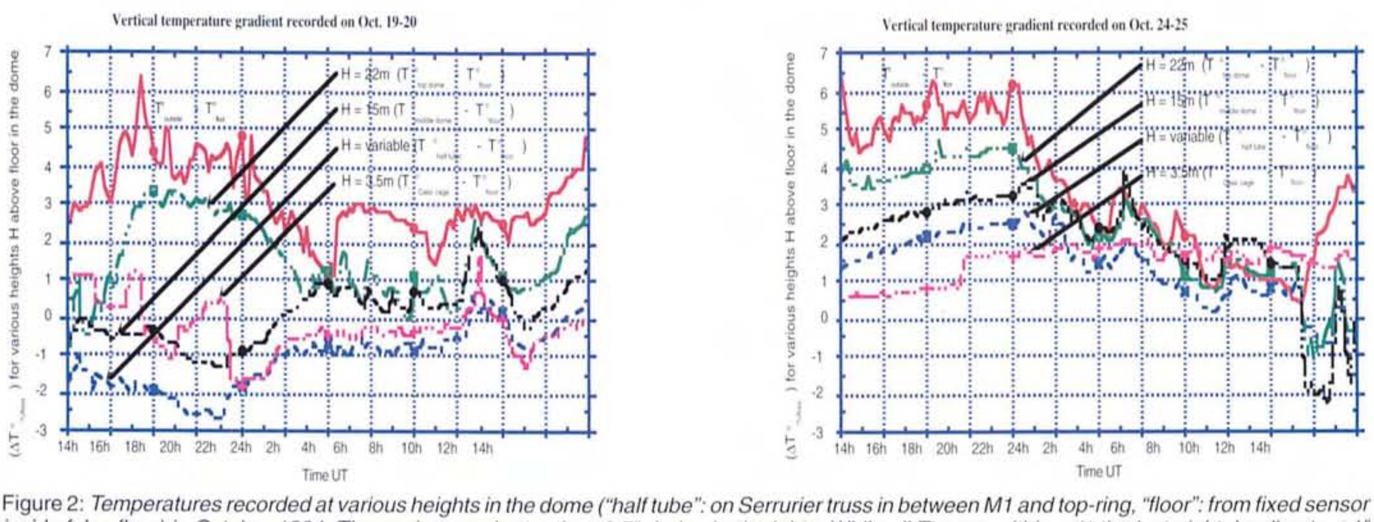

Figure 2: *Temperatures recorded at various heights in the dome ("half tube": on Serrurier truss in between M1 and top-ring, "floor": from fixed sensor inside false floor) in October 1994. The seeing was better than 0.7" during both nights. While all T° were within ≈ 1° the last night, leading to ≤ 1" FWHM PSFs, they were totally non uniform on October 19 (FWHM ≥ 1.6").*

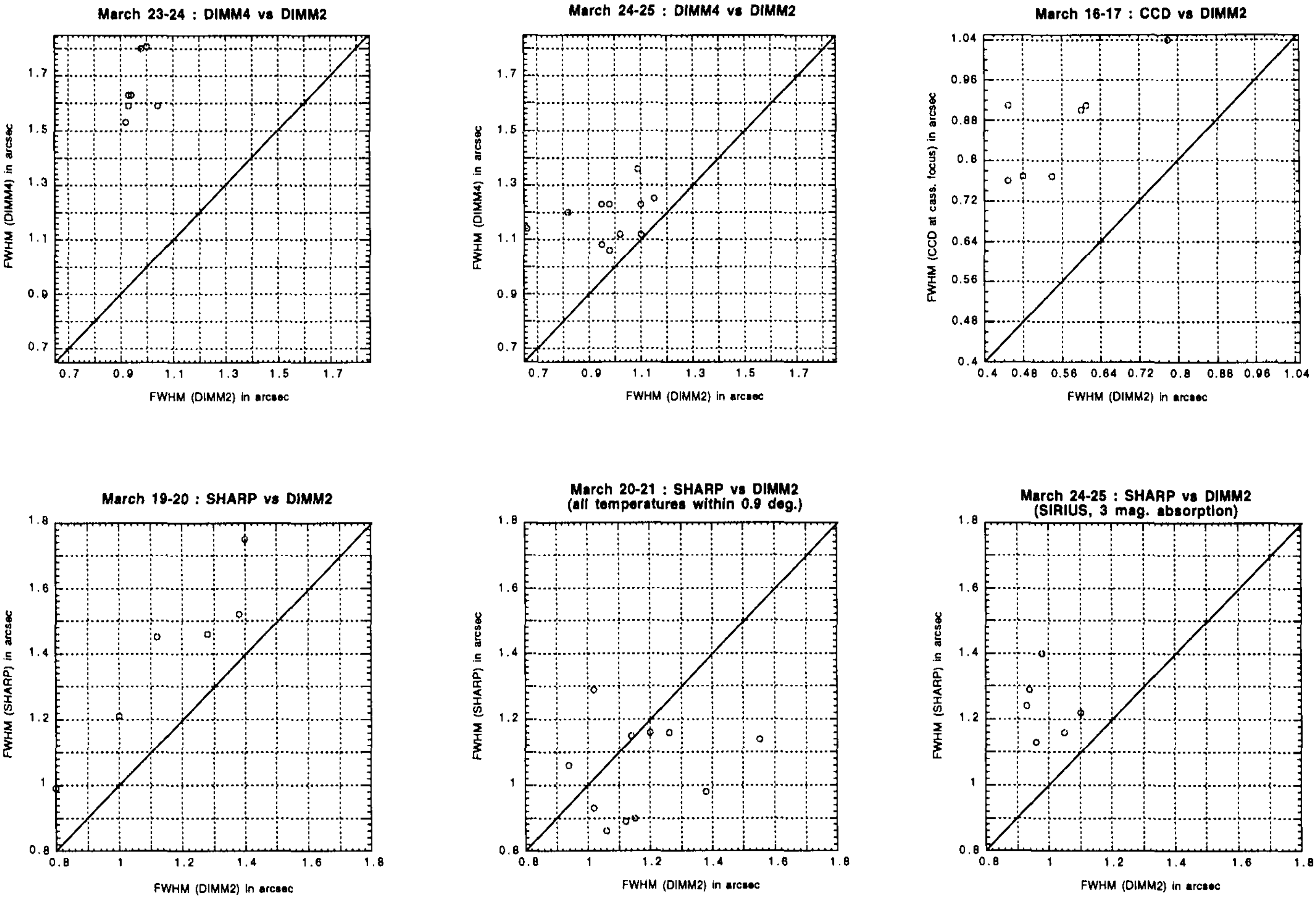

Figure 3: Seeing measurements made on several occasions in March 1995, with M1 cooled to ambient T° (T_a ±1°) and floor cooled to T_a –2°. Comparison with the seeing monitor DIMM2 gives an estimate of remaining M1 and dome seeing.

underneath the false floor and the primary mirror have thermal time constants of several days.

• *Cool dome floor and volume.* Le Poole suggests that we inject cold air upwards into the dome so as to produce a "bubble of cold air", which should help to reduce air turbulence in the open slit.

• *Ventilate dome using outside air.* 20 dome volumes per hour are needed. It was shown later that the cost – and moreover maintenance expenses – for such a system would be prohibitive, given the size and the form of the dome.

• *Cool the oil in the drives and eliminate small heat sources.* This last item refers especially to the Cassegrain cage. Still today, new instruments like ADONIS or TIMMI are mounted in the cage with large electronic racks including power supplies and other heat sources.

2.2. The "AirCo" System

All recommendations by Le Poole were implemented, except two: forced dome ventilation, for reasons given in the introduction, and M1 cooling. Indeed it was assumed that with the combination of "AirCo" and "FloorCo", M1 T° would decrease sufficiently. This did not happen: Even after reducing major heat sources in the cage in 1994 (especially by ventilating the cage and the four electronic closets inside), M1 T° still remained warmer than ambient by ≥ 1.5°. That is why it was decided in July 1994 to cool M1 (see section 5). Now, how does the AirCo system work? Cold air is injected both into the floor and at the top of the dome during the day; only the FloorCo is maintained during the night.

The system which was built for the dome is right from the "physics standpoint", even though the cold air produced is not uniformly distributed, as can be seen in Figure 2. As a result of thermal stratification, long time constant items cannot reach thermal equilibrium with their environment, because convection is inhibited. So, more ventilation is required in the dome. However, the system did not solve what was found to be the major issue: mirror seeing. For this, two systems were conceived. They are described in section 5. Also insulation would help a lot to reduce cooling expenses: Highly conductive materials should be used to avoid thermal radiation. It is suggested in particular that we wrap the telescope top end in aluminium foil.

3. "Mirror Seeing" and "Dome Seeing"

Mirror seeing is due to convection of air above the reflective surface of a mirror when it is out of temperature equilibrium with ambient air. Convective disturbances caused by a mirror being warmer than ambient cause serious image degradation: a factor of 0.35″ / °C of T° imbalance for a horizontal mirror (an average between different authors). Mirror seeing image broadening is produced by a turbulent boundary layer. Mirror seeing was identified as the major contributor to overall seeing in several conventional (pre-1985) facilities (CFHT, AAT, UH 88). It has been suggested by several authors that a flow of air across the surface of a mirror may substantially improve the seeing. The difficulty in the case of the 3.6-m mirror is that it will be impossible to maintain a laminar flow over a distance of more than a metre in the open air.

Dome seeing occurs when the air in the telescope beam up to the telescope slit is out of temperature equilibrium with outside air. Once again, this effect is worse when the dome is warmer, producing convection in the beam through the slit. It has been shown that most wavefront disturbances occur in the slit area. This was very clear on pupil images made at the 3.6-m, where bright patterns of flying shadows could be associated with both the slit area and the immediate neighbourhood over M1. This could easily be checked measuring the T° structure function in those two areas.

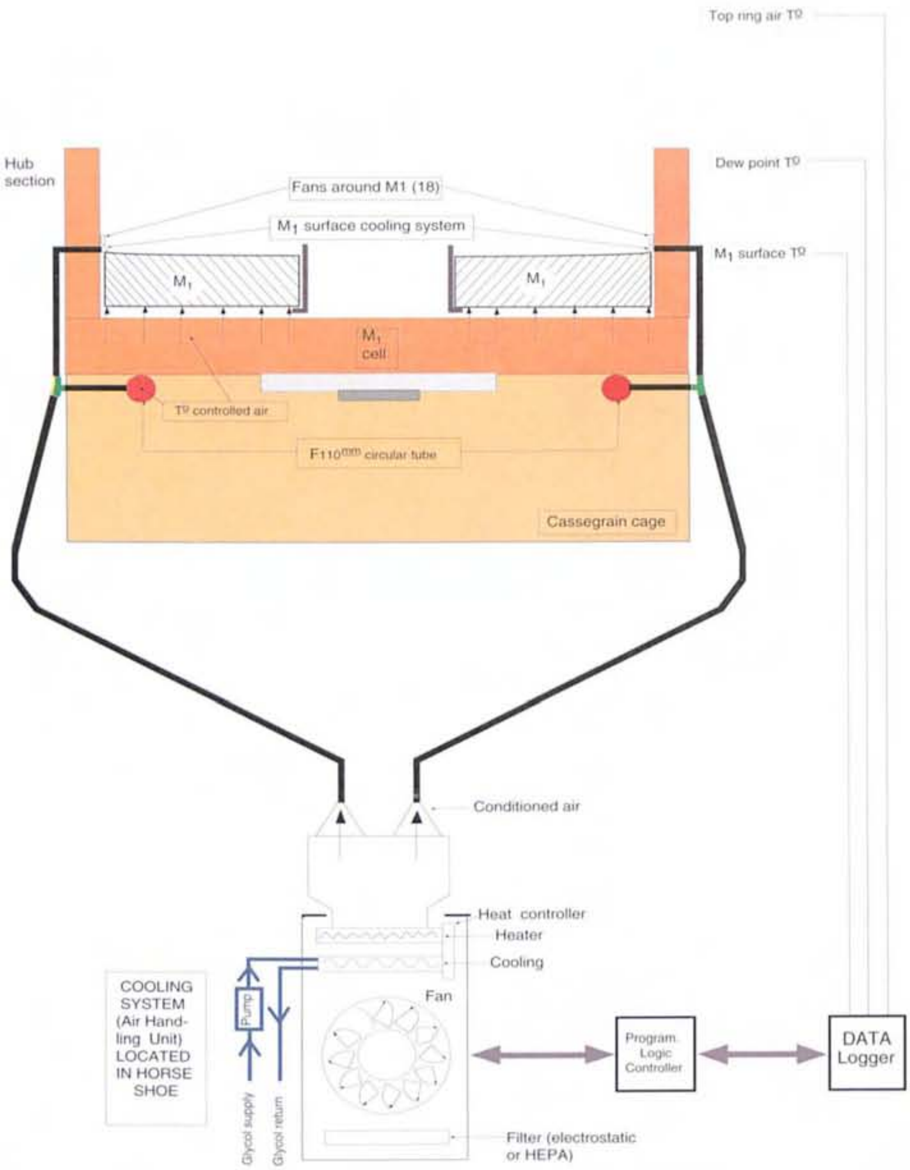

Figure 4: *M1 cooling system presently implemented (section).*

When there are no heat sources or long time constant items in the telescope beam neighbourhood, the overall seeing is not dominated by dome seeing, but rather by mirror seeing.

Those pupil images, recorded with the autoguider and an out-of-focus beam, were extremely useful in identifying problems. Several patterns of flying shadows, present on 3.6-m pupil images, never appear on NTT pupil images. Good seeing was always associated with vanishing of middle-scale flying shadow patterns. Since this phenomenon is dynamic, a picture unfortunately does not say very much.

4. EFOSC1, "Naked" CCD at the Cassegrain Focus and Come-On-Plus

The results obtained during a year with EFOSC1 and especially with Come-On-Plus (CO+) will not be presented here (see refs. 3). That will be the subject of another paper, actually in preparation. Nevertheless, Figure 3 shows the last results obtained in March with a thermal environment which sometimes approached perfection ($\Delta T \approx 0.9°$). The most significant lessons from those nights (10 nights were allocated to seeing measurements in period #54) are:

- Scientific runs: With the AirCo system alone, images got better for CO+ (0.3″ improvement on average) while EFOSC1 IQ was degraded (up to 0.5 arcsec). Internal ventilation of EFOSC1 helped, but was not enough. EFOSC1 is completely closed, CO+ completely open.
- When the dome was ventilated by the wind ($\approx$ 6 m/sec), and when M1 and the air above M1 had the same T° within 1.5°, the best images measured with a CCD were for a dome opened to the wind, telescope at 20° from zenith: $\approx$ 0.8" FWHM. This fact is well known to the observers: The wind helps the seeing!
- After reaching temperature equilibrium in the dome within 1.2° thanks to a particular T° setting (always recorded) in the dome, the same result was obtained without wind ($\leq$ 2m/sec).
- As soon as the primary mirror is warmer than the outside by $\Delta T \geq 2°$, an IQ degradation due to M1 w.r.t. the seeing monitor IQ was identified and detected: For $\Delta T = 2°$, Δ(FWHM)=0.45″ on average at the 3.6-m.

5. New M1 Cooling/Ventilation System at the 3.6-m

An air-handling unit (AHU) was installed in the telescope horse shoe. The cold air is presently sent inside a circular tube located underneath the M1 cell, and from there through the cell to the mirror bottom thanks to a number of holes in the cell up and down. A second system is under construction, where the air is split before entering the cage. The second part will feed a circular "garden hose" located above the mirror on the side. This air will be cleaned and dried before sweeping the mirror gently, day and night. T° homogeneity will be obtained during the day thanks to 18 ventilators located above M1. Calculations show that surface T° (5 cm in depth) can be changed by 1° in 3 hours, which would allow the outside T° to be followed in most cases. It is intended to use only this new system plus the FloorCo during the next few months in order to evaluate their impact on the seeing separately.

6. Conclusion

Tests made during more than a year to measure the seeing with a dome in better thermal equilibrium were encouraging: Many times we crossed the fateful threshold of 1″ with a regular instrument, reaching 0.8″ on four occasions, when in addition the primary mirror was cool. The next step is the constitution of a database, to record the seeing for a maximum of meteorological and seeing conditions. From those data and many others recorded at the same time, we will calculate a number of "IQ indicators" ($\Rightarrow$ image FWHM = f (parameter)), from which seeing properties will be inferred. From there, we should know pretty well how to tune up the ventilation/cooling system in order to get the best possible images. Then installing EFOSC2, whose pixel size is about half that of EFOSC1 (0.61″), at the 3.6-m Cassegrain focus, will allow us to really take advantage of the good seeing.

Acknowledgements

This article summarises the work of a team. Thanks to the many discus-

sions with E. Swinnen and G. Ihle, we eventually managed to obtain a more accurate picture of the 3.6-m thermal problem.

For the measurements I want to acknowledge: A. Gilliotte, T. Höög, M. Maugis, A. Pizarro and G. Timmermann. Special thanks go to C. Perrier who took the data with SHARP presented here.

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CAT/CES NEWS

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During the last week of March, a new CCD was tested on the Coudé Echelle Spectrograph's Long Camera. This CCD, ESO#38, is a LORAL/LESSER 2688 × 512 thinned, backside illuminated device (pixel size 15 × 15 μm) with anti-reflection coating. The quantum efficiency is about 80% throughout the visible wavelength range (350–800 nm) with a peak value of 90% at 700 nm. The values are better by a factor of 5 in the blue to 2 in the red than CCD#34 which is presently in use on the Long Camera (see Table 1). The high QE is obtained after flooding the CCD with intense UV light. In normal operations, it is expected that the CCD will need to be UV flooded once every month. The new chip is mounted in a continuous flow cryostat, with a hold time of about one week.

Efficiency tests were carried out which confirmed the high sensitivity of the CCD. We were, however, confronted with a degradation in resolution at high resolving powers. Specifically, a slit setting to yield a resolution of 100,000 resulted in an actual resolving power of about 70,000. The details are given in Table 2. According to the CCD detector group, the degradation in resolution is expected especially in the UV with backside illuminated devices. Due to a *field-free* region inside the device, photon-generated electrons spread to adjacent pixels, thus increasing the effective pixel size. This effect is more pronounced in the blue than in the red.

Given the above results it was decided not to offer CCD #38 to the ESO community at the start of the current period 55. For the moment, the Short Camera with CCD #9 and the Long Camera with CCD #34 are available. The stability of the UV-flooding of CCD #38 will be further tested and a solution has to be found for the degradation in resolution. Due to the very high performance of this chip, we plan to offer CCD #38 with the Long Camera starting in August 1995 after the "idle" period of the CAT telescope. The Short Camera and CCD #9 will be decommissioned and CCD #38 offered to the observers requiring a resolving power up to R = 70,000. For programmes requiring higher resolution CCD #34 will be retained. A new version of the CAT+CES Operating Manual containing the characteristics of the new configuration will also be distributed. The high QE, the low read-out noise (8 e/pixel), and the large size of CCD #38 would be a significant improvement in the performance of the CAT/CES spectrograph if a procedure for recovering the expected spectral resolution can be developed.

Some details of the characteristics of CCD #38 are provided in Tables 1 and 2.

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TABLE 1: OVERALL CAT+CES LONG CAMERA EFFICIENCY IN PERCENT

λ(Ångström)	CCD #38	CCD #34
3500	0.8	0.15
3589	2.3	0.47
4035	5.4	1.4
4435	6.9	1.1
5400	9.2	3.8
6450	10.4	5.2
8092	5.88	3.7

TABLE 2: CES LONG CAMERA + CCD #38 MEASURED RESOLUTION VS NOMINAL RESOLUTION AT 4435 Å

Nominal	FWHM (Pixels)	Measured	Meas/Nominal
40,000	5.8	39,300	0.98
50,000	4.9	46,500	0.93
60,000	4.1	55,660	0.92
70,000	3.75	60,800	0.87
80,000	3.6	63,300	0.79
90,000	3.35	68,000	0.76
100,000	3.18	71,800	0.72
110,000	3.0	76,000	0.69
120,000	2.96	77,000	0.64

The FORS Focal Reducers for the VLT – a Status Report

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Introduction

The FORS1 and FORS2 *FO*cal *R*educer/low dispersion *S*pectrographs are expected to be something like the workhorses of the VLT since they will offer a variety of observing modes in the visual and near ultraviolet wavelength range, namely

1. direct imaging (2 image scales)
2. low-dispersion grism spectroscopy
3. multi-object spectroscopy (MOS; up to 19 objects)
4. polarimetry (FORS1 only).

These modes can be combined e.g. to allow imaging polarimetry or spectropo-