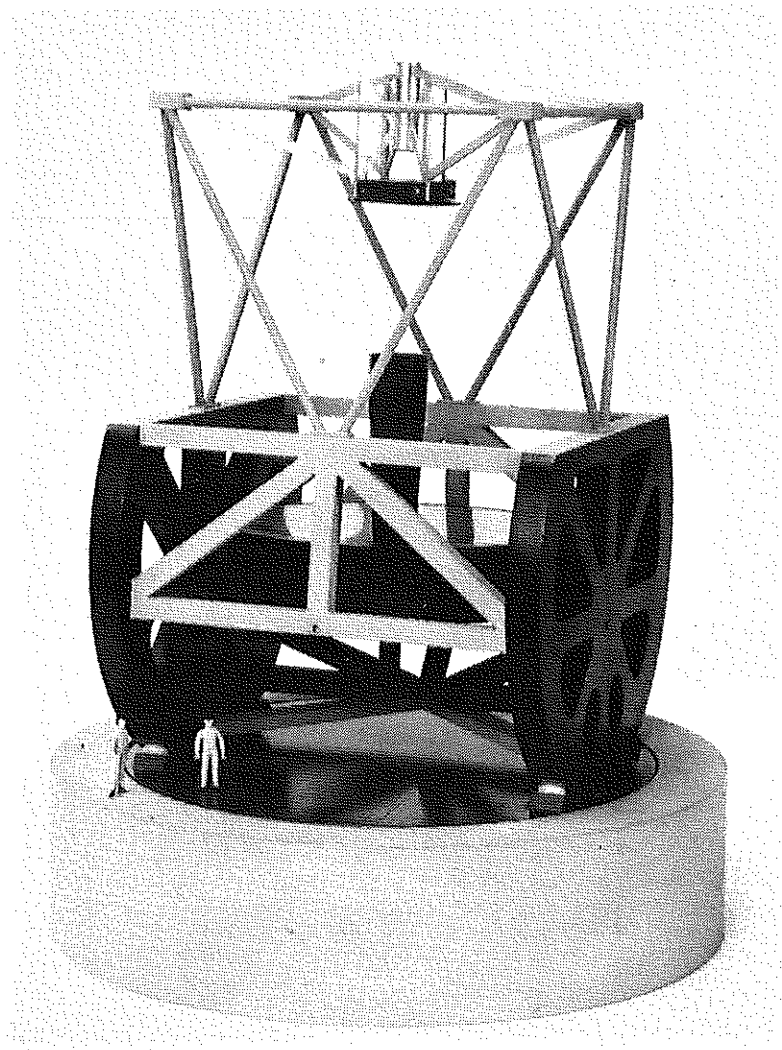
MAGELLAN PROJECT

University of Arizona Carnegie Institution of Washington The Johns Hopkins University



Las Campanas Observatory Seeing Results Through June 1990

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The Observatories of the
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ABSTRACT

Seeing data for 22 nights between November 1989 and June 1990 show that site 3 (Manqui) is better than site 2 (near the Dupont telescope) by 0.07 arcsec, consistent with the sense of the difference found for the first 61 nights. The combined results, for a total of 83 nights, indicate a difference of 0.04 $\pm$ 0.02 arcsec.

An ESO group conducted a seeing survey at Las Campanas for a period of 11 nights in November 1989 using their own portable equipment. Their data are compared with contemporaneous data from site 2; the agreement is excellent.

Some preliminary points that should enter the discussion on choosing the site for the 8–m telescope are enumerated.

I. INTRODUCTION

The purpose of this report is to publish the latest seeing data from our ongoing survey at Las Campanas Observatory. The apparatus and first results were presented in Magellan Project Report Number 14, December 1989. At that time we had accumulated 61 night's worth of seeing data, between October 1988 and May 1989. In order to reduce possible systematic differences in the instrumentation between the two sites, we interchanged the two seeing monitors in May 1989, and proceeded with the survey. Just after the switch was made a problem developed in the device at site 3, and it could not be fixed until September. (An epoxy joint broke, and the net effect was to increase the calibration data numbers. This gave spuriously good seeing data about 10 % of the time.) All the site 3 data taken between May and September were discarded. For the new measurements we recorded the calibration data too, so as to guard against a similar problem in the future. For various reasons the coverage between September 1989 and June 1990 is somewhat low, but we present the data now because it refers to the same time of year as the first dataset.

For a period of 11 nights in November and December 1989, a team of ESO personnel conducted a seeing test near our site 2, using their own portable equipment. We also present here a comparison of the results, which are interesting and very reassuring, in that the twow datasets are completely consistent. It is clear that both teams are measuring the seeing to rather high accuracy.

Finally, we begin the discussion of selecting the site for the 8–m telescope in terms of the seeing histograms and their interpretation.

II. CUMULATIVE RESULTS TO DATE

Figure 1 shows the histogram and cumulative distribution of the raw seeing data for 22 nights between November 1989 and June 1990. By raw we mean *uncorrected* for low frequency image wander (< 2Hz) or high frequency components (> 200 Hz). As discussed in report No. 14 (henceforth R14), these results are valid for site 2 and 3 intercomparisons only and must be corrected for comparison with other seeing data. Figure 2 repeats the R14 results and makes clear the fact that the small difference in median seeing between the two sites has survived the equipment interchange; in fact if anything the difference has increased – from 0.025 arsec to 0.065 arcsec, read at the 50th percentile point of the distribution.

The two datasets do not have equal weight as yet, but the qualitative result is clear: the seeing at site 3 is marginally better than that at site 2. An average of the two datasets weighted by number of 10–minute blocks gives a difference of 0.035 ± 0.02 arcsec. This is considered a two sigma result, but sigma is actually not well determined as it is dominated by the systematic uncertainties. The numerical values of the quartiles and medians for the two sites are consistent with those in R14.

Figure 3 shows the run of seeing for a good night and is included to show how well correlated the seeing is at the two sites. There are two curves drawn for each. The upper one includes image wander at frequencies lower than the lower cutoff of the device, viz., 2 Hz. It was computed by using the actual image wander data, and is consistent with an extension of the power spectrum to lower frequencies. As was the case for the R14 data, the two sites generally track each other well, although not precisely. The conclusion is that the lowered correlation is due to vagaries in the way the boundary layer carries turbulence over the telescopes.

III. COMPARISON WITH THE ESO MEASUREMENTS AT LCO

For a period of two weeks in late 1989 a team of ESO people carried out a series of seeing measurements using their own equipment set up 2 m above ground level about 200 m north of our site 2. The idea was of course to effect a direct, simultaneous, and therefore reliable comparison of the results of our two very different ways of measuring the seeing. Their apparatus is described in Sarazin and Roddier (1990 preprint). It measures the seeing differentially, and is consequently less susceptible to correlated errors such as could arise from windshake. Their upper frequency cutoff is 100 Hz. Figure 4 shows the graphical comparison for two of the nights as provided by the ESO and Las Campanas observers. The LCO seeing monitor data are the open symbols ("CARNEGIE") and the ESO data are solid or dotted lines ("CAMPANAS"). The general impression one gets is that the two data sets give very consistent results. Unfortunately, the LCO seeing data that were plotted up did not include the 12 % correction for frequency transfer through our electronics, and in fact the agreement is better than the figures would indicate. Table 1 compares the data averaged over the different nights. We have corrected our numbers for missing low frequency components by using the actual image wander data collected for one minute every ten as described in R14.

Table 1 – ESO/LCO Seeing Comparison at LCO

Date	ASM Raw	ASM + low	DIMM data	DIMM - ASM	Wind (mph)
891127	0.53	0.63	0.78	+0.15	4
891129	0.51	0.55	0.54	−0.01	11
891130	0.75	0.80	0.63	−0.17	19
891202	0.47	0.52	0.55	+0.03	14
891203	0.47	0.53	0.55	+0.02	10
891204	0.54	0.57	0.57	0.00	10
891205	0.59	0.63	0.55	−0.08	14
891206	0.54	0.58	0.66	+0.08	11
891207	0.53	0.58	0.62	+0.04	8
891208	0.59	0.63	0.63	0.00	4
891209	0.47	0.52	0.59	+0.07	6
Average	0.55	0.60	0.61	+0.01	11

Note: ASM = LCO's astronomical seeing monitor. DIMM = ESO's differential image motion monitor. The windspeed in the last column is the median value for the night.

The ESO data often has a spiky character not seen the LCO data. Most of this difference is probably due to the fact that we save distributions and plot medians for 10–minute datasets, and thus discriminate against large excursions. A potentially important difference is turbulence near ground level because the LCO apparatus is 7.6 m above ground, while the ESO equipment is 2 m above ground. No such effect can be seen.

The differences in measured seeing (DIMM – ASM) are weakly correlated with the median nightly windspeed in the sense that above 20 mph our equipment appears to show an exceess (spurious) 0.1 arsec worth of blur. In our internal site 2/site 3 comparison such an effect becomes much smaller. Yet the sense of the difference in mean windspeed between the two sites (site 3 exceeds site 2 by a couple of mph) means that ASMs on perfectly rigid mounts would show an *even greater* seeing difference between the two sites. This result will be quantified when all the data have been collected and binned into low and high windspeed groups.

The conclusion from the comparison is that both groups are measuring the seeing very accurately. Consequently, we are more confident of the site-to-site difference discussed above.

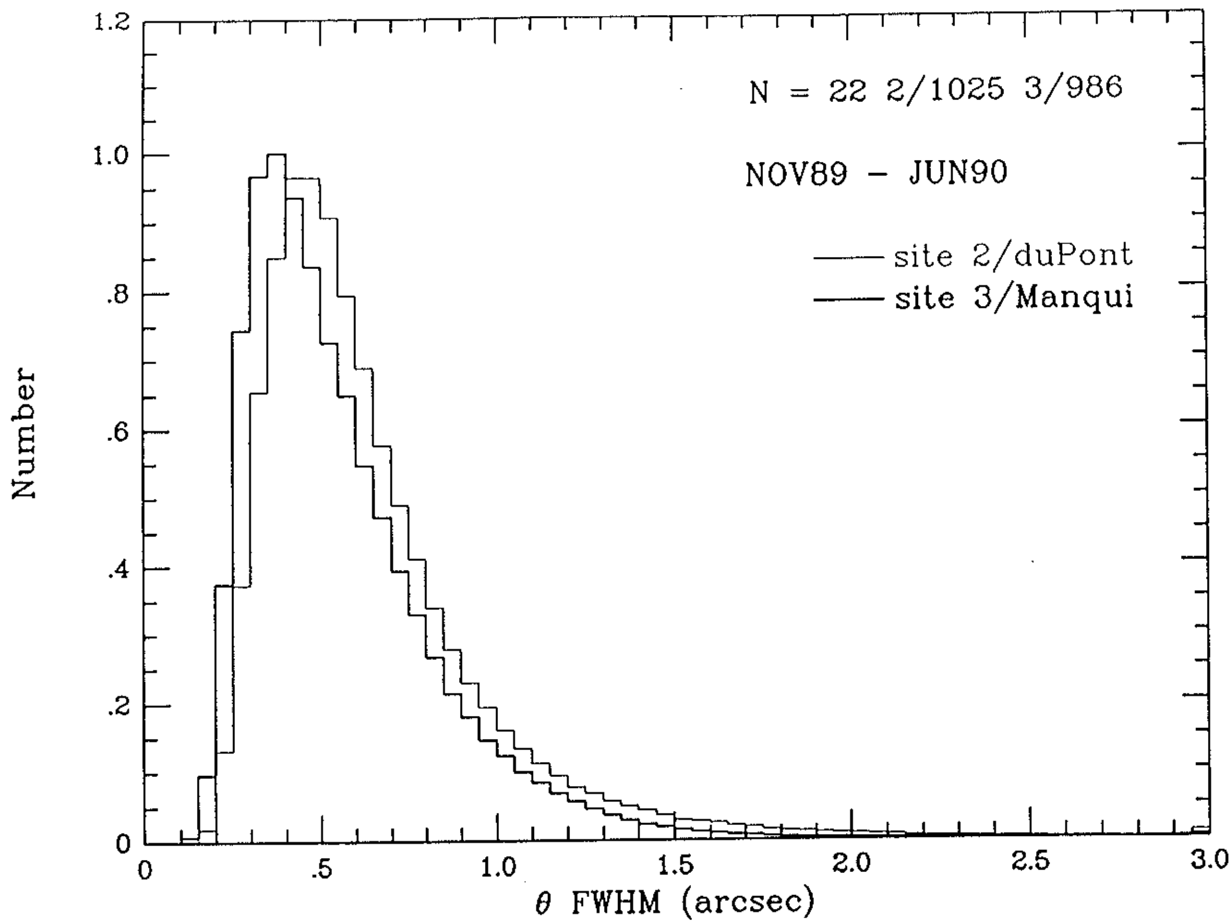
IV. DOES THE SITE 2/ SITE 3 DIFFERENCE MATTER?

The preliminary result contained in R14 and given further weight in figure 1 is that a small difference exists in the average seeing between the two sites, the higher and more isolated peak (Manqui = site 3) being slightly better. It is not possible to assess accurately the systematic uncertainties, but from the ESO/LCO comparison they would appear to be at about the level of the difference or smaller. One argument in favor of accepting the diffference is that it agrees with one's intuitive sense that the higher site ought to have better seeing. It will certainly be interesting to see the results from Las Campanas peak itself; those measurements will commence in 1990 October.

One might conclude that we should place the 8–m telescope at the site with the best seeing, even though the difference amounts to only 0.04 arcsec on average. There are two reasons to think hard about placing the 8–m telescope at site 3 (or perhaps site 4): (1) the mean windspeed increases systematically from site 2 to site 3 to site 4, averaging 13.0, 14.6, and 16.6 mph respectively. The fluctuations in the windforces (going as speed^2) will be more troublesome at site 4. (2) The desirability on logistical grounds of locating the 8–m telescope close to the DuPont.

One should assess the difference between sites 2 and 3 in light of the fact that the 8–m telescope will be equipped with some sort of active image compensation device. A full adaptive optics system will be specialized and one would not want to locate the telescope under assumptions about the efficacy of such techniques, however promising they may seem at present. A relatively simple tip–tilt system, on the other hand, probably *will* be used a good part of the time. The effectiveness of such a system in removing overall wavefront tilts is a strongly increasing function of wavelength. It also depends on the availability of a suitable reference star within the iso–wander patch, which will be about 3 arcmin in diameter. Under good, but not necessarily ideal conditions, we may be able to realize a factor of 1.5 reduction in image diameter at visual wavelengths, and somewhat better at 2 μm. So, for median seeing and a "perfect" telescope, the visual images should approach FWHM values of order $0.65/1.5 = 0.44$ arcsec. Our design goals aim at a telescope error budget of 0.3 arcsec, which pushes the median (tip–tilted) image diameter up to 0.53 arcsec FWHM. It may be difficult in practice to achieve a telescope plus dome contribution of only 0.3 arcsec. In any case a tip–tilt scheme runs into a limit imposed by the telescope at about the median seeing. The point is that *at optical wavelengths the natural seeing dominates the image diameter, whether or not a tip–tilt system is used*, and thus the difference between the two sites will not be masked by imperfect telescope performance. The situation is different at infrared wavelengths (2.2 μm), where the median seeing is $0.65/1.38 = 0.47$ arsec, and a simple tip-tilt system will decrease the image size to values that are comparable to or less than the telescope plus dome contribution. Thus the site difference is considerably less important at infrared wavelengths. Finally, in the case of a working adaptive optics system, the image diameters will shrink to values smaller than the telescope error budget (corrected for those components that the adaptive optics system will itself remove) and the sites will become indistinguishable.

The site 2/site 3 comparison will end in October 1990, and testing at Las Campanas (site 4) will begin. It should be possible to intercompare the three sites early in 1991. The question before the Science Working Group will then be: how large does the difference in seeing have to be to materially affect our choice of the site?


N = 22 2/1025 3/986
NOV89 - JUN90
site 2/duPont
site 3/Manqui
Number
0
.2
.4
.6
.8
1.0
1.2
.5
1.5
2.0
2.5
3.0
θ FWHM (arcsec)

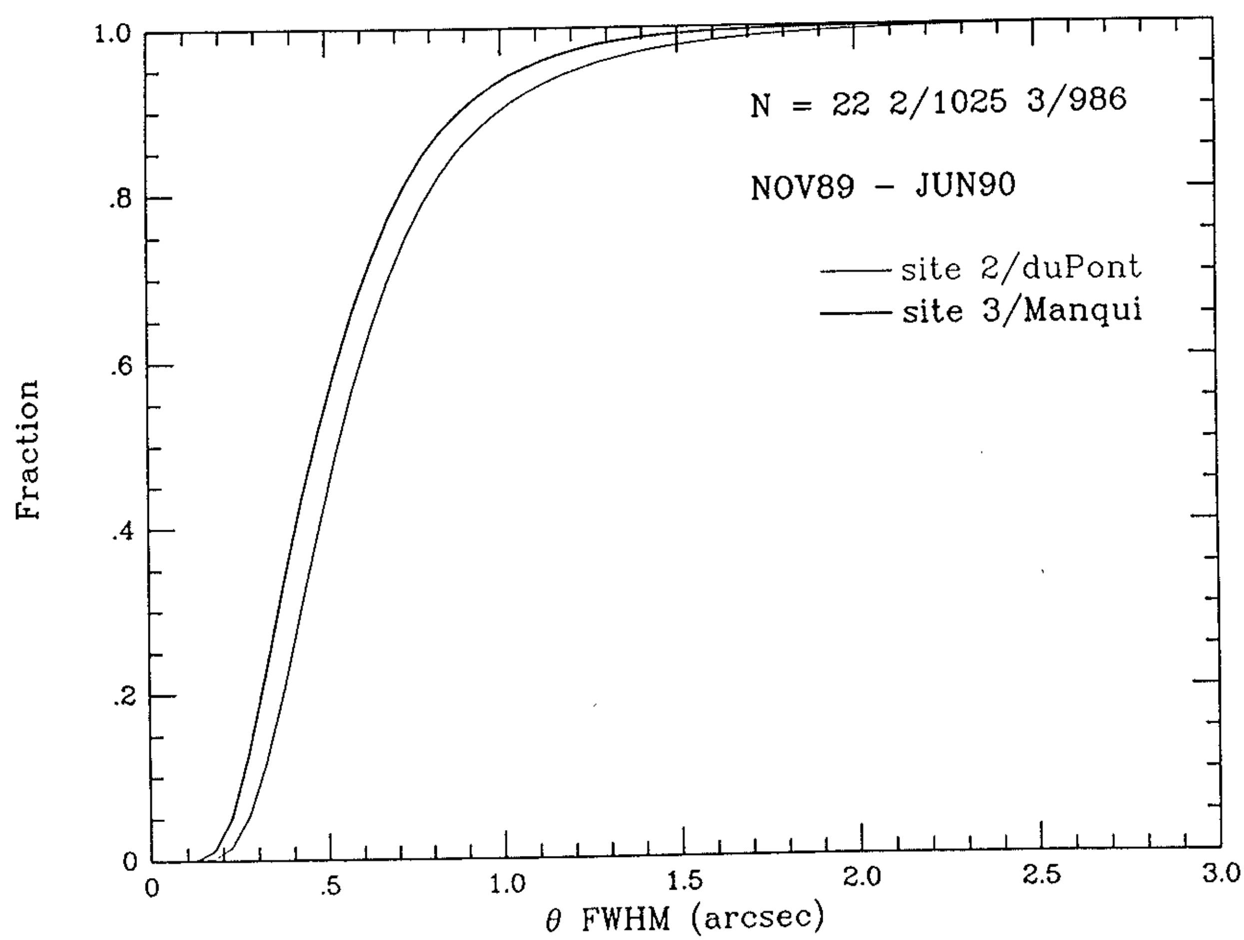
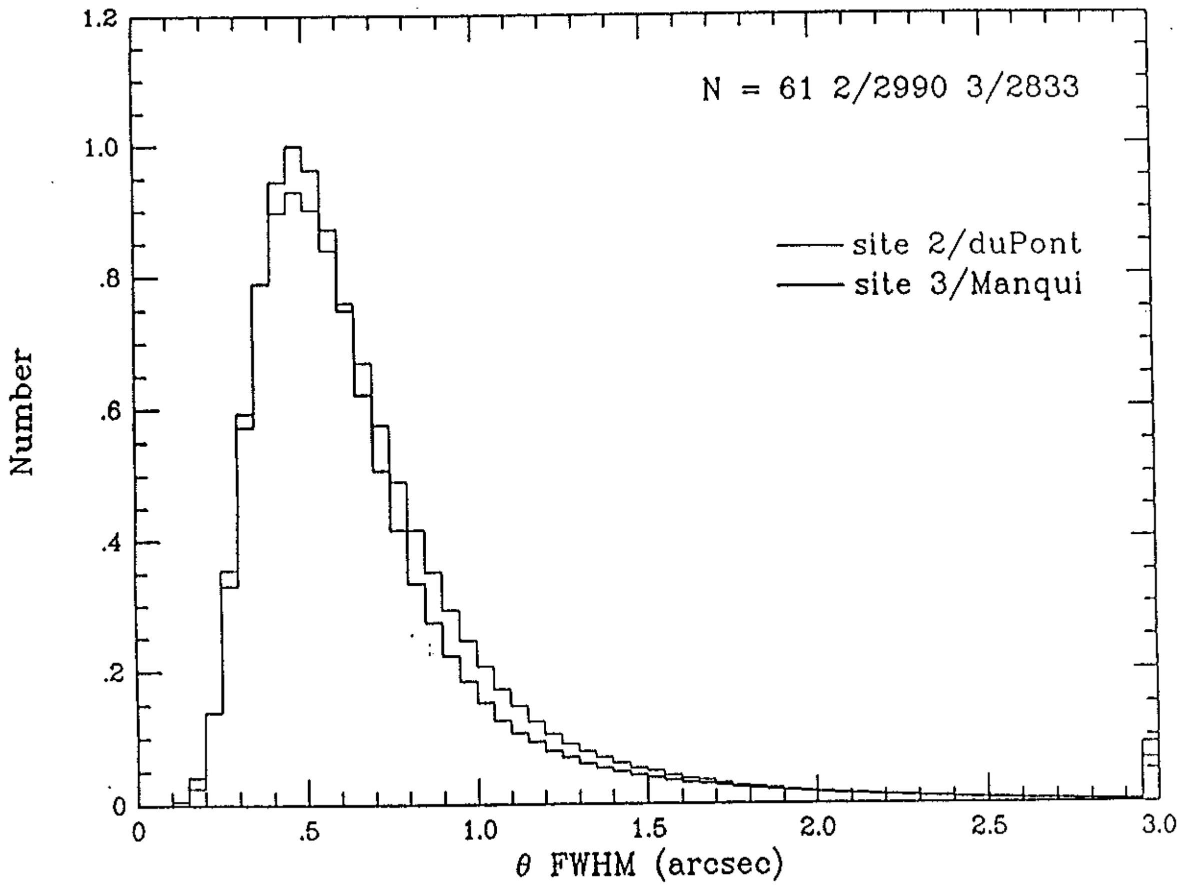
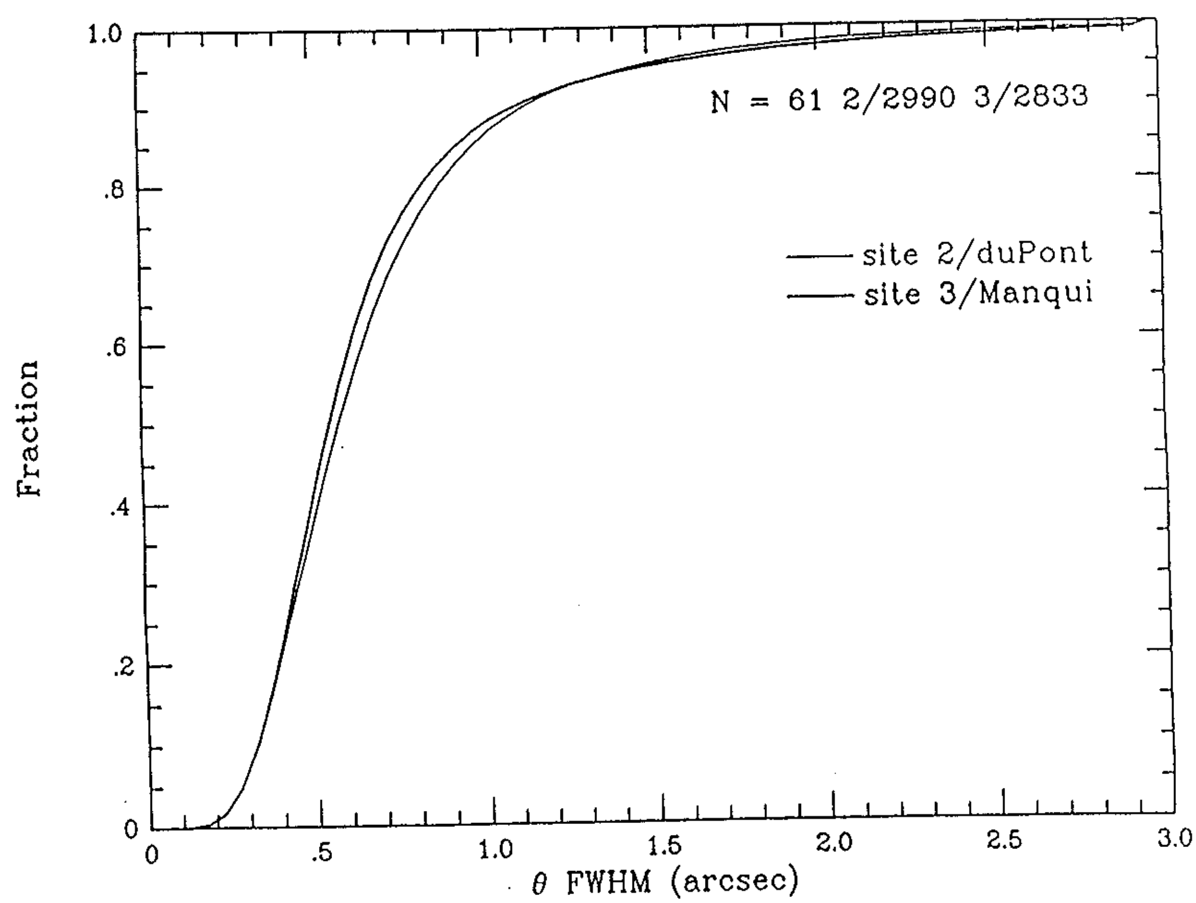

N = 22 2/1025 3/986
NOV89 - JUN90
site 2/duPont
site 3/Manqui
Fraction
0
.2
.4
.6
.8
1.0
.5
1.5
2.0
2.5
3.0
θ FWHM (arcsec)

Figure 1

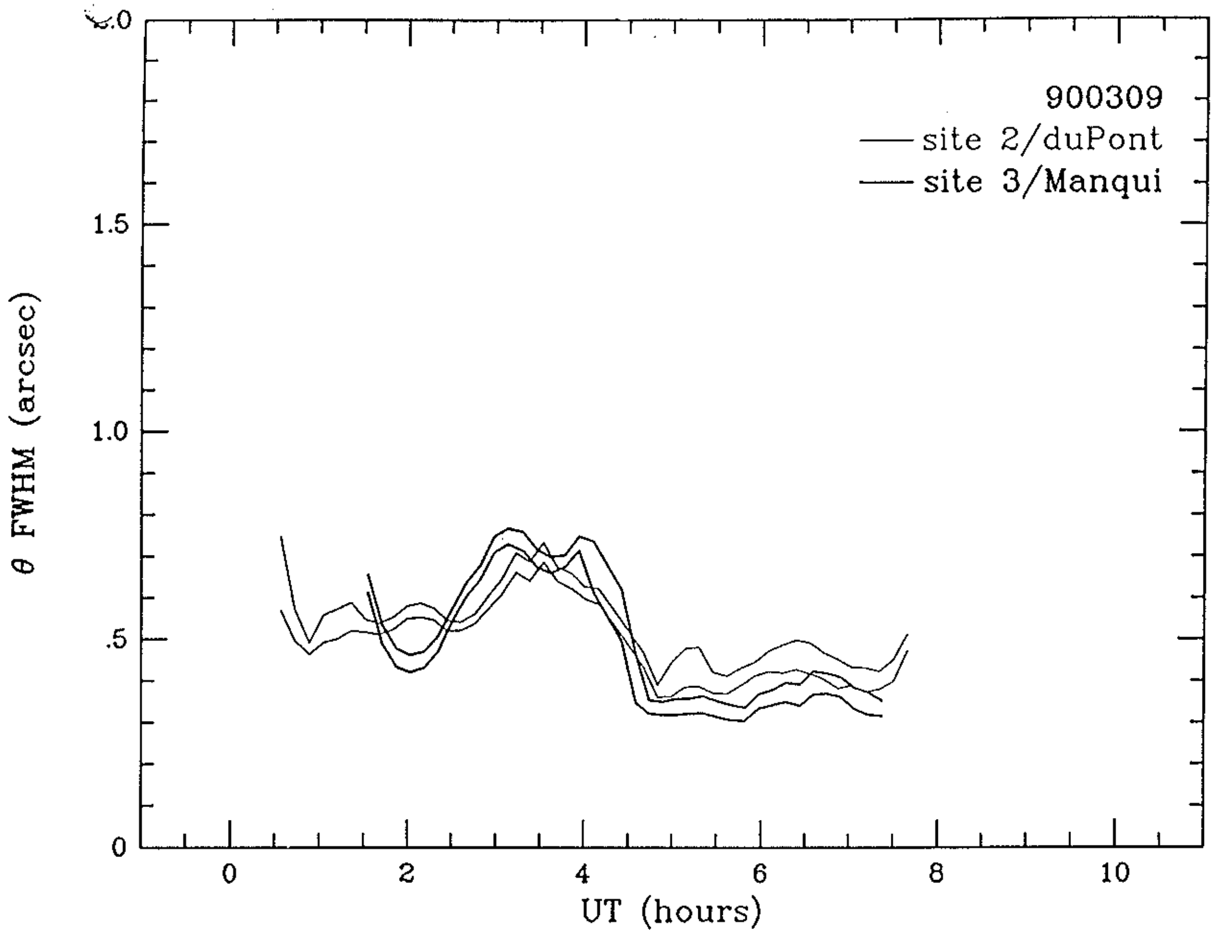


N = 61 2/2990 3/2833
site 2/duPont
site 3/Manqui
Number
θ FWHM (arcsec)



N = 61 2/2990 3/2833
site 2/duPont
site 3/Manqui
Fraction
θ FWHM (arcsec)

Figure 2

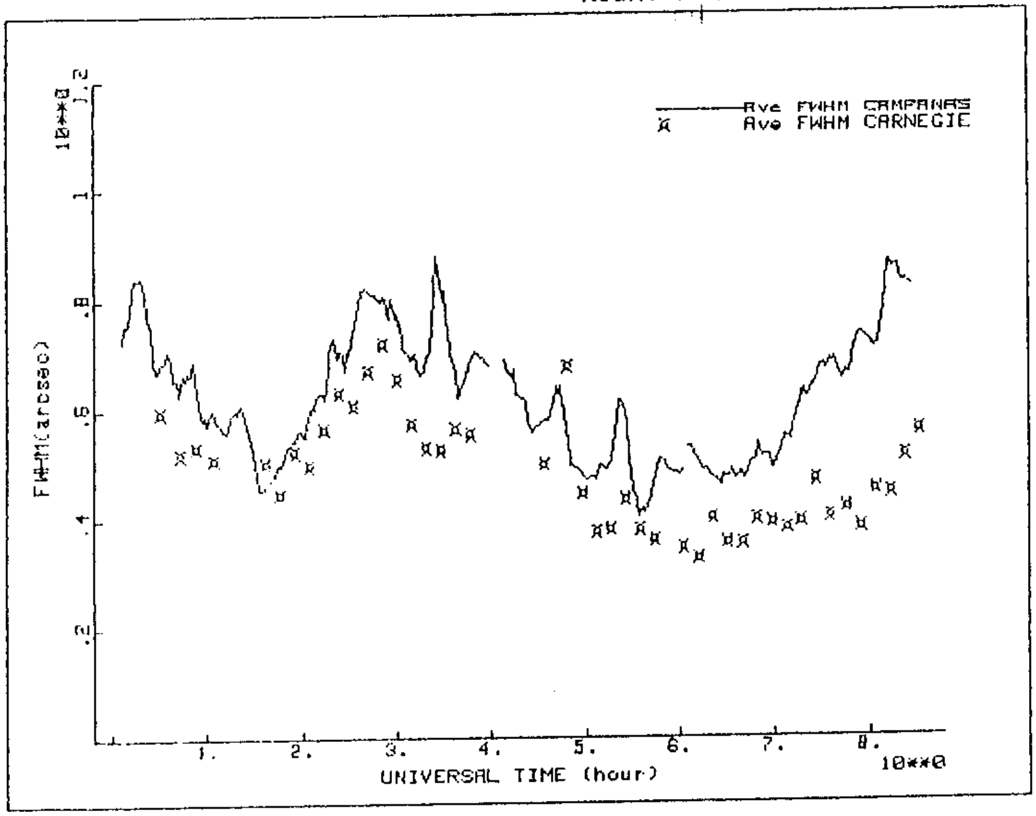


900309
site 2/duPont
site 3/Manqui
θ FWHM (arcsec)
UT (hours)
0
.5
1.0
1.5
0
2
4
6
8
10

Figure 3

SITE COMPARISON

NIGHT ENDING ON: 7 Dec 1989



File sequence : 891206M1 891206M2 891206M3 891206M4
Graphic average on 8.3 Minutes.

Seeing, arcsec at 0.5 microm., at zenith

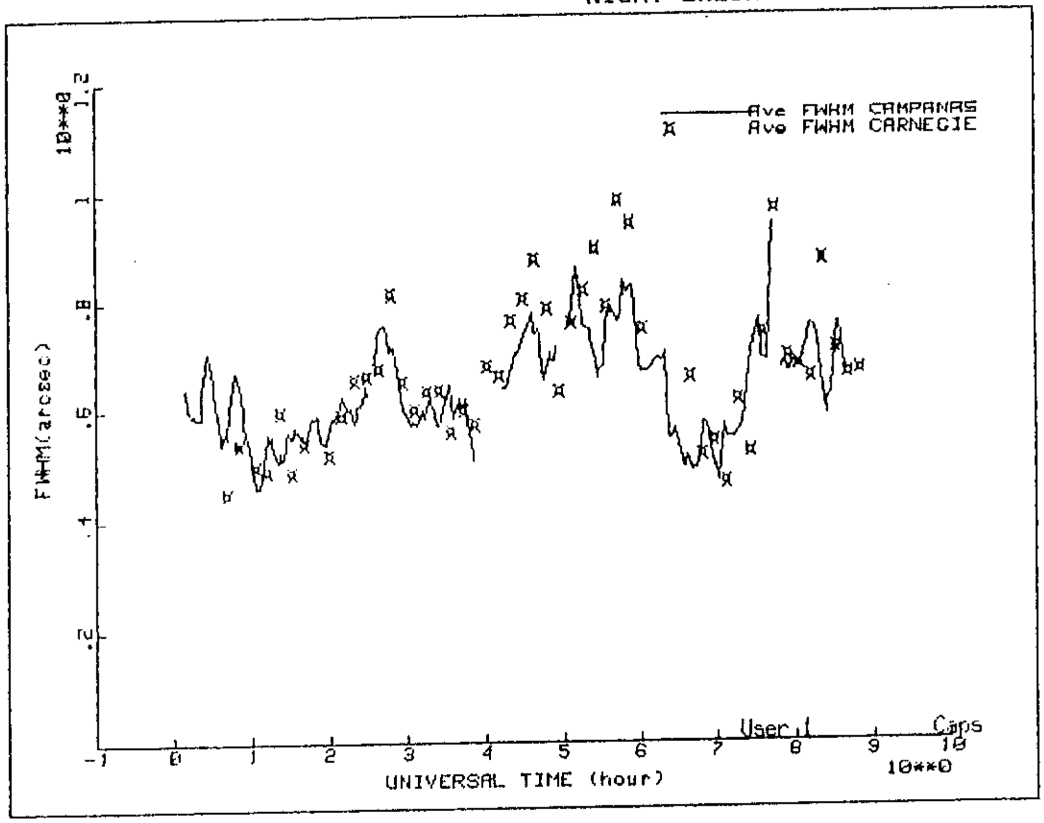
AVERAGE FWHM CAMPANAS: .62/ 320 SAMPLES. MIN: .38 MAX: .99
AVERAGE FWHM CARNEGIE: .46/ 44 SAMPLES. MIN: .31 MAX: .70
AVERAGE WIND SPEED: 0.0M/S, MIN: 0.0 MAX: 0.0
Comments :

Scintillation(%): 17
Humidity(%): 23
CARNEGIE OBSERVER: EMILIO CERDA
OBSERVER:JULIO NAVARRETE

Figure 4a

SITE COMPARISON

NIGHT ENDING ON: 30 Nov 1989



File sequence : 891129M1 891129M2 891129M3 891129M4
Graphic average on 8.3 Minutes.

Seeing, arcsec at Ø.5 microm., at zenith

AVERAGE FWHM CAMPANAS: .63/ 262 SAMPLES. MIN: .42 MAX:1.09
AVERAGE FWHM CARNEGIE: .65/ 49 SAMPLES. MIN: .43 MAX: .96
AVERAGE WIND SPEED: Ø.ØM/S, MIN: Ø.Ø MAX: Ø.Ø
Comments :

Scintillation(%): 10.25
Humidity(%): 29
OBSERVER:NAVARRETE - CERDA

Figure 4b