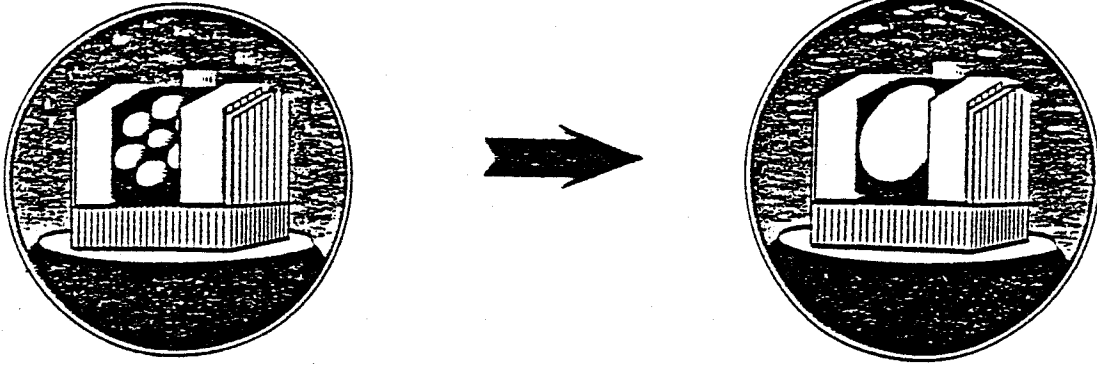


6.5 METER TELESCOPE



MMTO Conversion Technical Memorandum #96-4

Seeing Improvements Resulting from Improved Chamber Ventilation

Craig Foltz

December 11, 1996



MULTIPLE MIRROR TELESCOPE OBSERVATORY

Smithsonian Astrophysical Observatory and Steward Observatory, The University of Arizona®

Reply to: MMT Observatory
The University of Arizona
Tucson, Arizona 85721
(520) 621-1558
FAX (520) 670-5740

To: Interested Parties

From: Craig Foltz

Re: Seeing Improvements Resulting from Improved Chamber Ventilation

Date: December 10, 1996

I. Introduction

As part of the MMT Conversion Project, two large shutter panels were installed on the back of the MMT building during the period from May 2 through October 10, 1995. When the shutters are rolled to their retracted position, approximately 600 square feet of the back wall of the building is open to air flow. The shutters were designed to be used either fully-open or fully-closed; i.e. they are not used in a partially open configuration. We will eventually install louvers in the rear opening to baffle stray light, but these will be at a fixed angle and will not be used to control airflow, as are the louvers at the NTT.

The motivation for the installation of the rear shutters was to improve the airflow in the chamber in hopes to help to attain a near-isothermal condition in the observing chamber, thereby minimizing "dome seeing." This installation was in some sense an act of faith, in that no one had previously measured how much of our seeing was due to local effects, but it was clear from studies of the NNT and the ARC 3.5 m telescope enclosures that opening the rear of the building would help to flush air through the chamber. Since the MMTO has always taken every effort to improve the local seeing, the project was a natural one to undertake. Furthermore, since it could be piggy-backed onto the main building shutter modifications that were being done at the same time, the project's cost was lower than it would have been had we deferred it to a later date.

II. Comparison of Accumulated Seeing Data

We have now been using the rear shutters for more than 13 months. During this period the shutters were opened for the large majority of nights. The exceptions to this were nights when the weather conditions were changeable such that the building was opened and closed several times. Initially, the rear shutter drive was quite slow so, if storms were pending, the telescope operator might choose not to open the rear shutters. Furthermore, during periods of high winds and attendant blowing dust, the rear shutters sometimes were kept closed. Unfortunately, the data presented below

are not tagged as to whether the rear shutters were open or not, but it is certainly the case that they were open most observing nights.

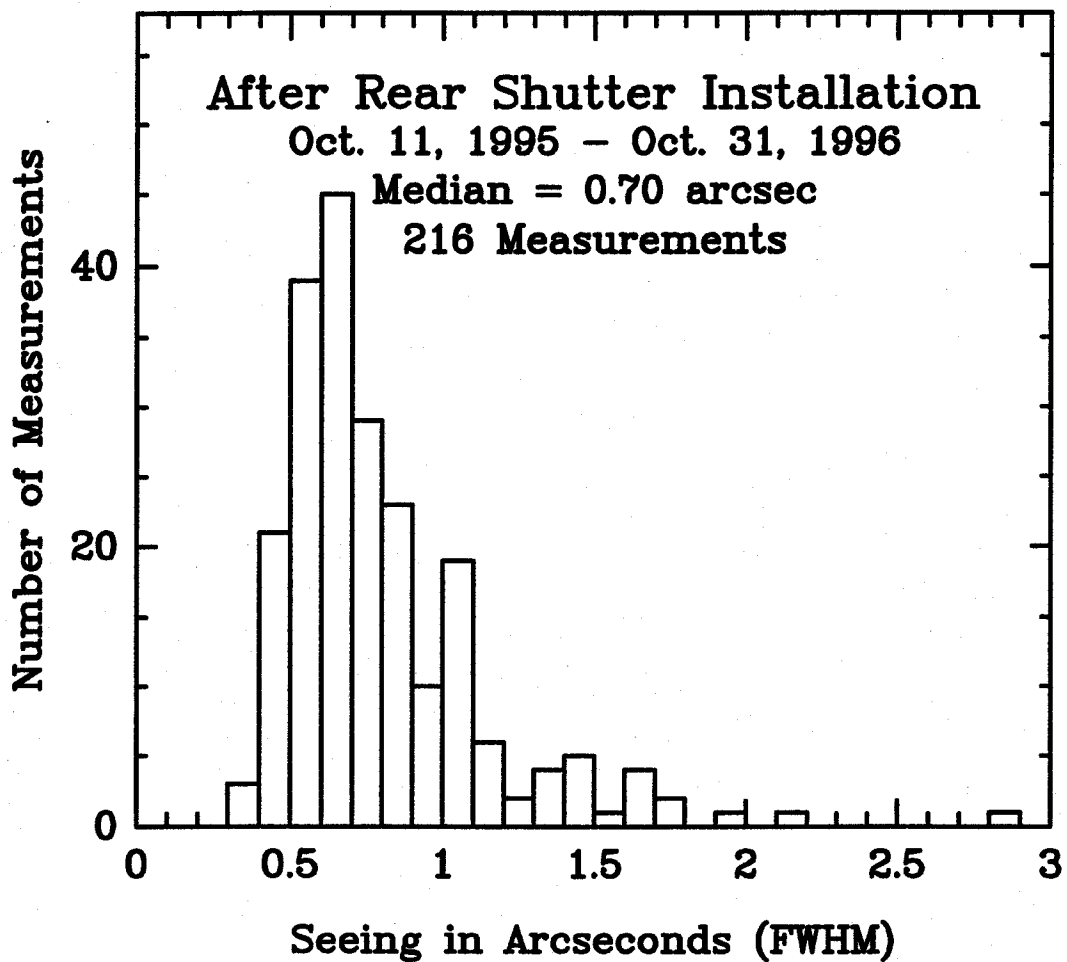
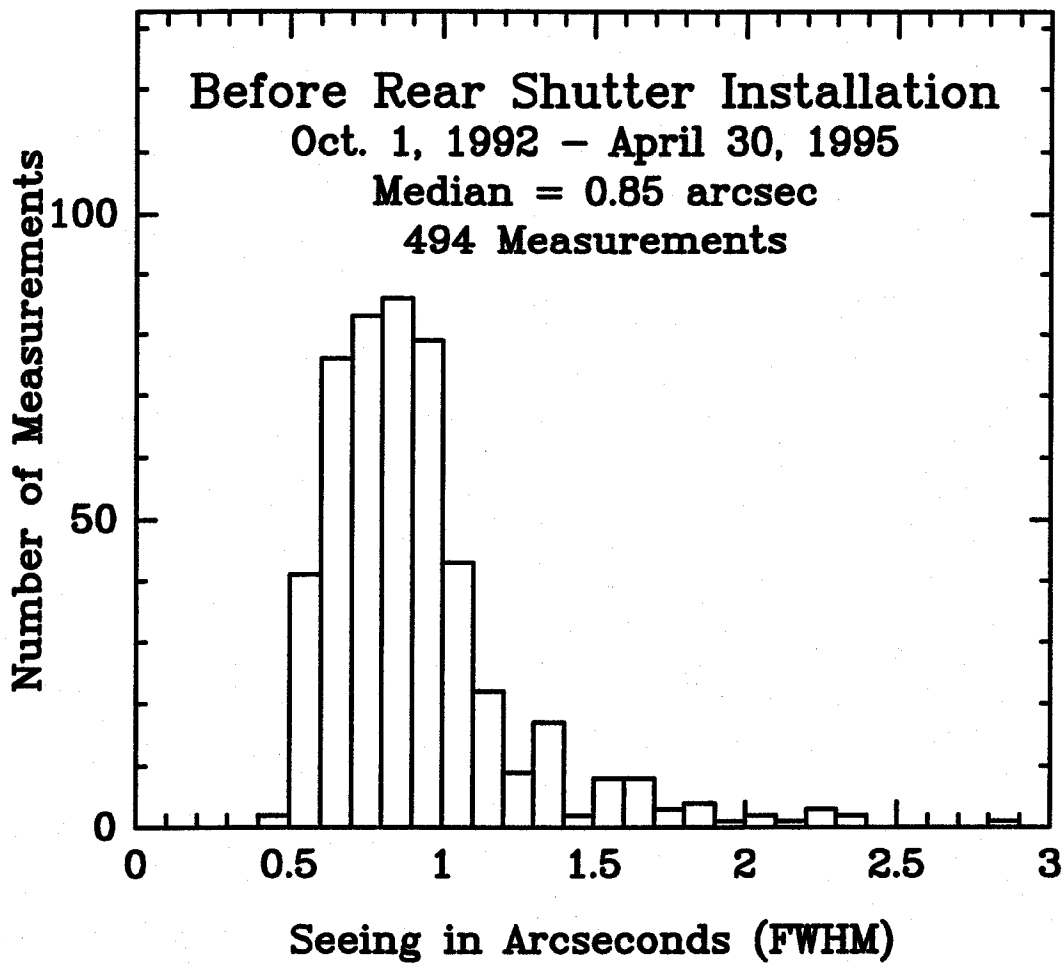
We now have accumulated sufficient data to compare the distribution of seeing measurements before and after the modification using the results of the routine nightly seeing tests. The seeing is typically measured in the morning, just prior to closing the building. The FWHM of the image of a star formed with the #7 MMT primary mirror (in telescope E) is measured from the digitized video from a Pulnix CCD in the Top Box. Details of the test are documented elsewhere and will not be repeated here, but it suffices to say that neither the camera nor the software have been modified since 1991. Seeing statistics are regularly reported in the MMT Bi-Monthly Summaries and in the Observatory's Annual Report in the *Bulletin of the American Astronomical Society*.

The two histograms below show the distribution of seeing measurements during a 2.5 year period before the installation of the shutters (494 measurements from October 1, 1992 through April 30, 1995) and the 12.5 month period after completion of the building modifications (216 measurements from October 11, 1995 - October 31, 1996). The most important difference between the two distributions is: *the median seeing decreased from 0.85 arcseconds before the shutter installations to 0.70 arcseconds thereafter*. The statistical reality of this difference is supported by a two-sample K-S test that shows that we can reject the null hypothesis that the two samples were drawn from the same parent population with more than 99.999% confidence.

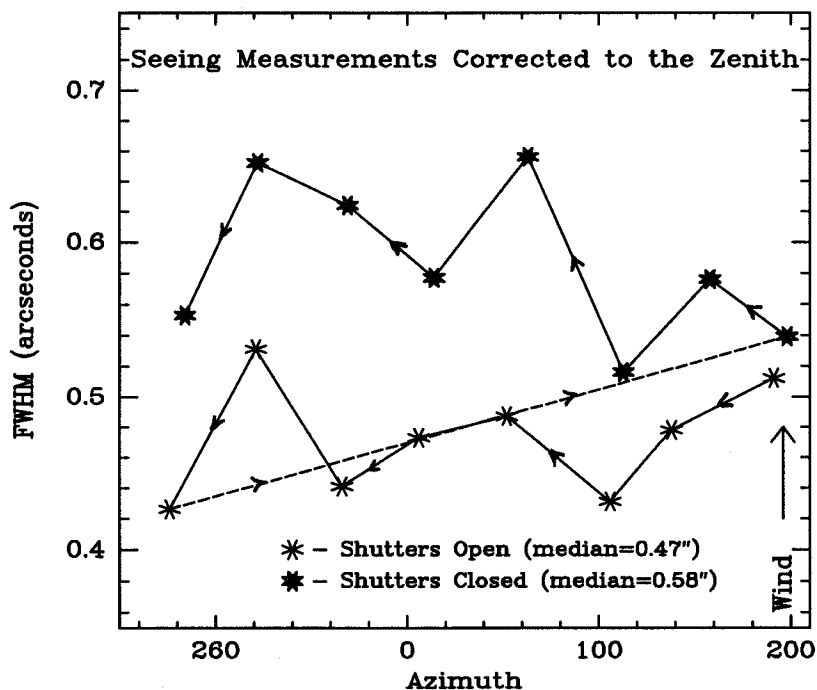
It is my impression that the distributions are not dramatically different for measurements larger than about 1 arcsecond. In fact, before the shutter installation, the seeing was 1" or larger about 26% of the time; as compared to 21% of the time thereafter. The Poisson errors on these percentages are about 3-4%, so the evidence is not compelling that significant improvement has been made when the seeing is mediocre. Probably this indicates that, when the seeing is bad, it is dominated by contributions at higher atmospheric layers.

III. Other Evidence

More, albeit equivocal, evidence that the rear opening does improve the seeing can be found in the results of a test carried out by Bob Hanson and John McAfee on the night of 1996 November 21. John did two sets of eight seeing tests, one set with the rear shutters open followed by another with the shutters closed. The temperature was stable at 44° F throughout the tests and the wind was from azimuth 192° at 24 mph at the beginning of the first set, rising to 30 mph at the beginning of the second set. Seeing tests were done covering the full range of azimuth. The first set of measurements started pointing into the wind with the rear shutter open and proceeded toward smaller azimuth until the telescope came almost full-circle. Then the rear



shutters were closed and the test was repeated. About 15 minutes elapsed between the end of the first test and the beginning of the second. The results of these tests, corrected to zenith by the cosine of the zenith distance, are plotted below. In each data set, the first point is at the extreme right of the plot with subsequent points proceeding to the left. Note that the median seeing with the shutters closed was 0.11 arcseconds larger than with them open.



Unfortunately, the test was stopped after the second set of data were taken. It would have been helpful to have run another set with the rear doors open. Clearly one cannot ascribe the differences between the two sets of measurements only to the rear doors. The seeing could have indeed been varying with time, although there is no strong trend in the shutters-open data that indicates that the seeing was degrading with time. The seeing could also have degraded as a result of higher wind speed. However, it is interesting to note that the magnitude of the improvement seen with the rear shutters open is comparable to the difference between the two historical data sets.

These data are very preliminary, and come at a considerable cost in time on the sky. I do not anticipate that we will have the luxury of repeating such tests many times. However, it is interesting that the two sets of data do seem to be correlated, implying that the deviations from uniform seeing may imply variations due to wind-building

interactions and are not of atmospheric origin. I will restrain myself from further comment on the azimuth dependence of the seeing, pending more data.

IV. Conclusion

The installation of the rear shutters was a somewhat contentious issue at the time of its planning. The rear shutters were planned well after the rest of the project and, since they came at considerable cost, they further burdened an already seriously-burdened project. As such, several parties felt that their installation should be deferred to a later date.

Although the data presented here are far from the last word, it is apparently the case that the installation of the rear shutters has resulted in an improvement in the typical seeing by about 0.1 arcsecond or more. The fractional improvement in the median seeing is about 18% and the probability that one will observe when the seeing is 0.7 arcsecond or better has doubled. In that some component of our measured image size is due to the figure and support of the MMT optics, the real improvements could be even larger.

It may never be possible to determine whether the results are "worth" the cost, but it is very heartening to see such measurable improvements in such important an area as image size.