CHARA Technical Report

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Interferometer Sites on Mt. Palomar and Kitt Peak

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1. INTRODUCTION

In TR No. 11, we examined a possible interferometer site on Mt. Wilson. This report next considers sites on Mt. Palomar and Kitt Peak. As in the previous report, we examine a number of potential three-leg, distorted Y-shaped configurations for both 5- and 7-telescope arrays. A routine is used to pick site locations to optimize $U-V$ plane coverage for an array. The basic conclusion is that the best Mt. Palomar layouts are virtually a tilted unobstructed 'standard' CHARA Y configuration (0/120/240 degree) and are actually slightly better in $U-V$ coverage to the 'standard' Y. The Kitt Peak "picnic area" site is the most asymmetric of the three sites considered thus far and yields slightly reduced $U-V$ coverage compared to Palomar. Reconstructed images with optimum arrays at either Palomar or Kitt Peak are about equally acceptable.

2. MT. PALOMAR SITE

Mt. Palomar is one of the best known sites for astronomy. Like Mt. Wilson, it is a coastal site with a cold-current inversion layer, and it should have excellent seeing, inferior only to island sites that are also above the inversion layer (Walker 1986). On the other hand, "seeing lore" has it that the Palomar site is generally inferior to Mt. Wilson. This view may be colored by the experience of the 200 in and 60 in telescopes with large dome-seeing effects. Like Mt. Wilson, the winds should be generally less than typical inland sites, an important consideration for interferometry. A detailed comparison of the seeing at this and other candidate sites will be presented in a separate Report.

The site is generally flatter than that of Mt. Wilson and has fewer trees. Figure 1 is a three-dimensional plot of the Mt. Palomar Observatory site. Proposed sites for a 7-telescope array are denoted by 100 ft high 'spikes' (as is the array center), and the location of the 200 in dome is denoted by a large dome in the Figure. The site is much less constrained by topography. The most likely site has three 'legs' centered on a site on the plateau area about 110 m from the 200 in dome, and avoiding the ASEPS-0 Array being built to the northeast of the 200 in. The azimuth directions of the legs are approximately 23°, 149°, and either 251° or 273°, respectively. (The latter array options, denoted as PY1 and PY2, are attempts to achieve a constant downward slope.) The array is thus close to a standard Y

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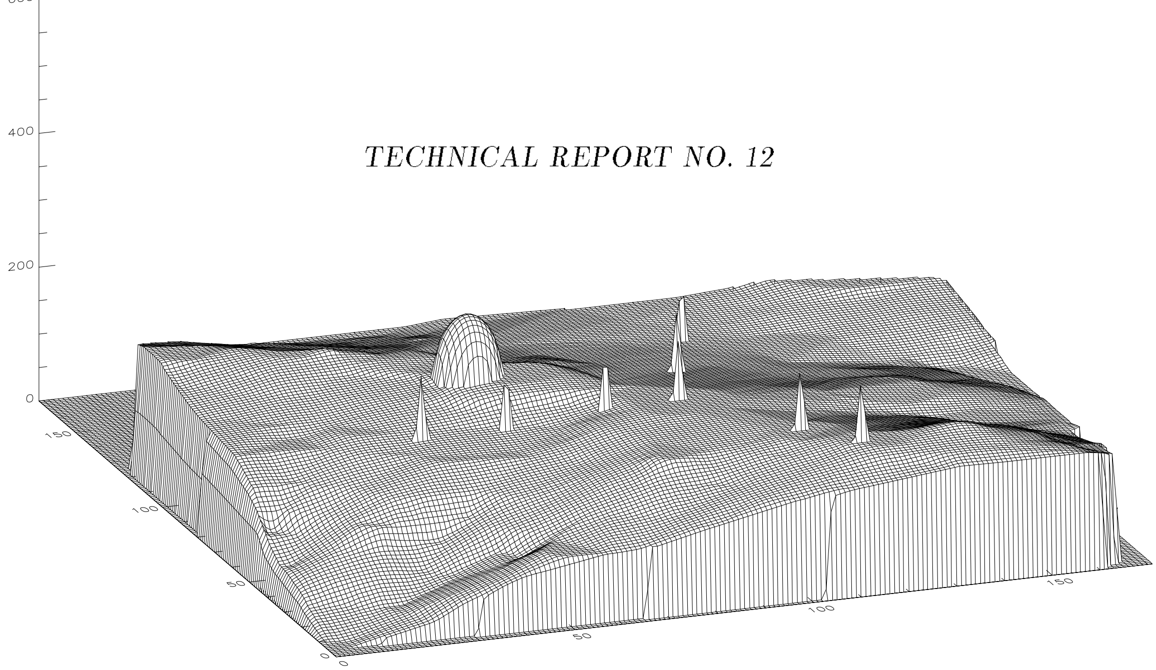


FIGURE 1. Mount Palomar site with optimum 7-telescope configuration.

configuration with 120° separating the baselines. (An exact Y configuration could probably be built, by bending the rules slightly about constant baseline slopes, or by elevating several of the domes.)

3. KITT PEAK SITE

Kitt Peak is of course another "famous" observatory site. One would expect that this site would have only fair seeing, as the CHARA group's data record from the 4-m telescope would bear out. On the other hand, the new WIYN 3.5-m telescope has a median seeing of better than an arcsecond. The largest suitable flat area at Kitt Peak is the so-called "picnic area", which has a gently rolling topography that is sharply constrained at the edges. Figure 2 shows a three-dimensional plot for this site and the locations of an optimal 5-telescope array. This is the most asymmetrical site of the three considered so far. We considered two configurations, "KPY1", and "KPY2". In the first, an attempt is made to keep the lengths the same, but vary the angles between the baselines; in the second, the angles are almost the same, but the lengths are irregular. The first configuration arms are: ENE (Azimuth=59°.3, Length=225.5 m), SW (Az=218°.8, L=175.5 m, and NW (Az=322°.9, L=190.6 m). The second configuration arms are: E (Azimuth= 83°.4, Length=213.9 m), SW (Az=206°.9, L=204.2 m, and NW (Az=325°.6, L=152.9 m). Array center locations are approximately (-110,-90) and (-140,-60), respectively in the coordinate system of Figure 3.

4. U-V PLANE COVERAGE FOR BEST TELESCOPE LAYOUTS

A method described in the 1994 CHARA Proposal was used to find optimal arrays in terms of the best $U-V$ plane coverage. A description of the method is given in Technical Report No. 11. Basically, the method calculates a weighted $U-V$ plane coverage in terms of a percentage of "cells" covered between possible baselines of 30 and 354 m. (The latter results from the 200 m baselines of the standard CHARA Y.) The weights are linear, with

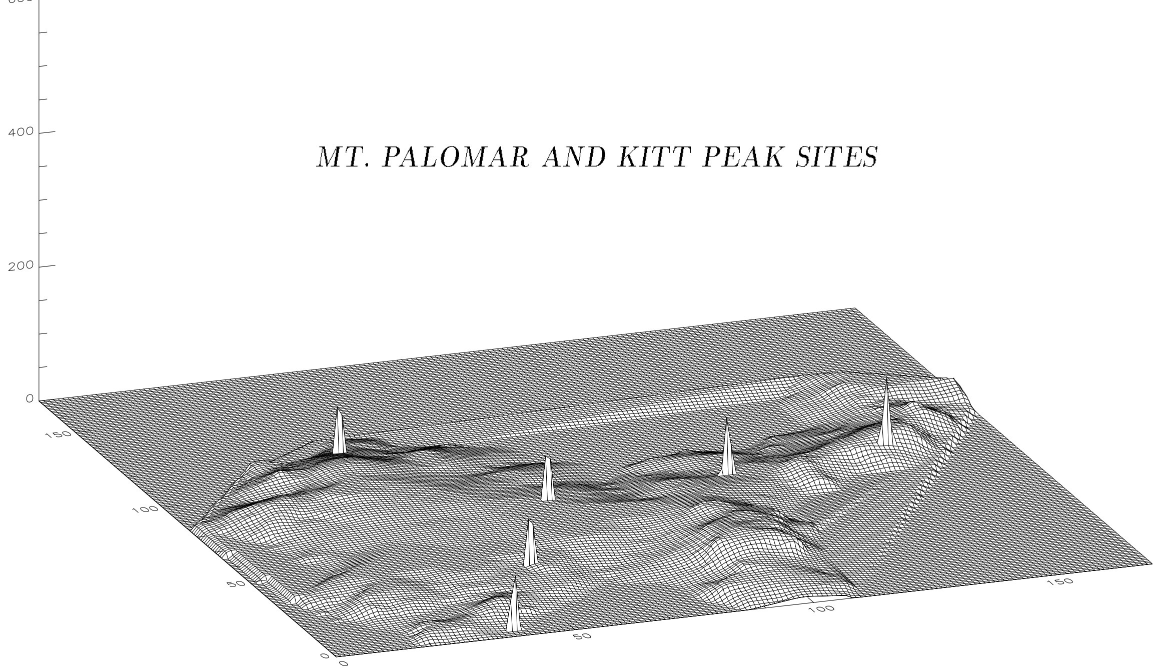


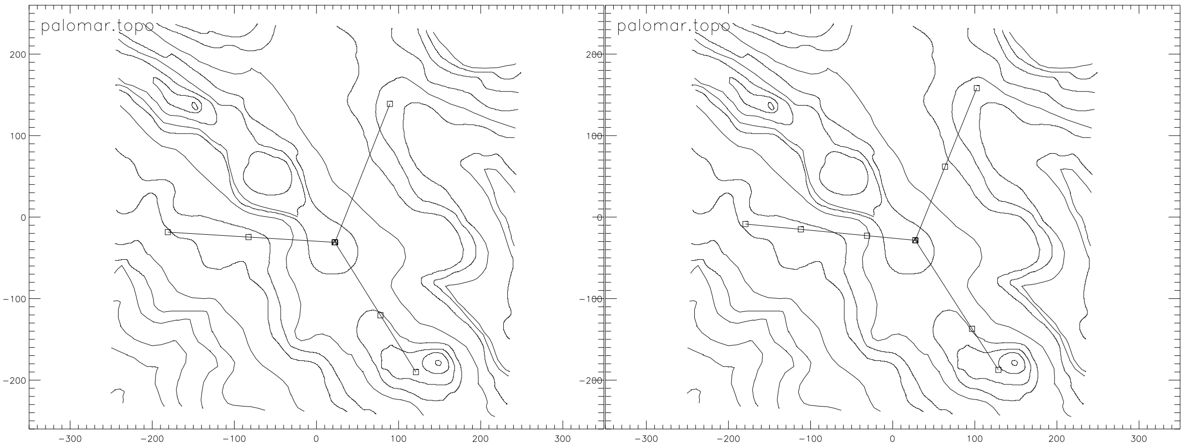
FIGURE 2. KPNO site with optimum 5-telescope configuration (KPY2).

innermost regions weighted twice as much as the outermost regions.

Table 1 shows the results of this optimization listing the $U - V$ coverages for the array configuration schemes that were considered. Note for comparison that the standard CHARA Y configuration has weighted coverages of 0.607 and 0.845 for best 5- and 7-telescope cases respectively. The PY2 (1,2,2) configuration had the best $U - V$ coverage for the Palomar site. The best Kitt Peak site was provided by the KPY2 (2,2,1) configuration. (It appears in general that it is more important to preserve the angles than the baseline lengths.) The best 5-telescope coverages were 0.652 and 0.643 for the Palomar and Kitt Peak sites, respectively. The Palomar site also had slightly better seven telescope coverage (0.887 vs. 0.847). Figures 3 and 4 show the topo maps for the best 5- and 7-telescope configurations at Palomar and Kitt Peak, respectively.

TABLE 1. $U - V$ coverage with Mt. Palomar and KPNO Y configurations.

Site	N_{tel}	N_{tel}/leg	Config.	Weighted Coverage	Comments
Mt. Palomar	5	2,1,2	PY1	0.582	
		1,2,2	PY1	0.618	
		2,1,2	PY2	0.624	
		1,2,2	PY2	0.652	Best 5-tel config.
	7	2,2,3	PY1	0.816	
		2,2,3	PY2	0.887	Best 7-tel config.
KPNO	5	2,2,1	KPY1	0.566	
		1,2,2	KPY1	0.553	
		2,1,2	KPY1	0.565	
		2,2,1	KPY2	0.643	Best 5-tel config.
	7	3,2,2	KPY1	0.794	
	7	3,2,2	KPY2	0.847	Best 7-tel config.



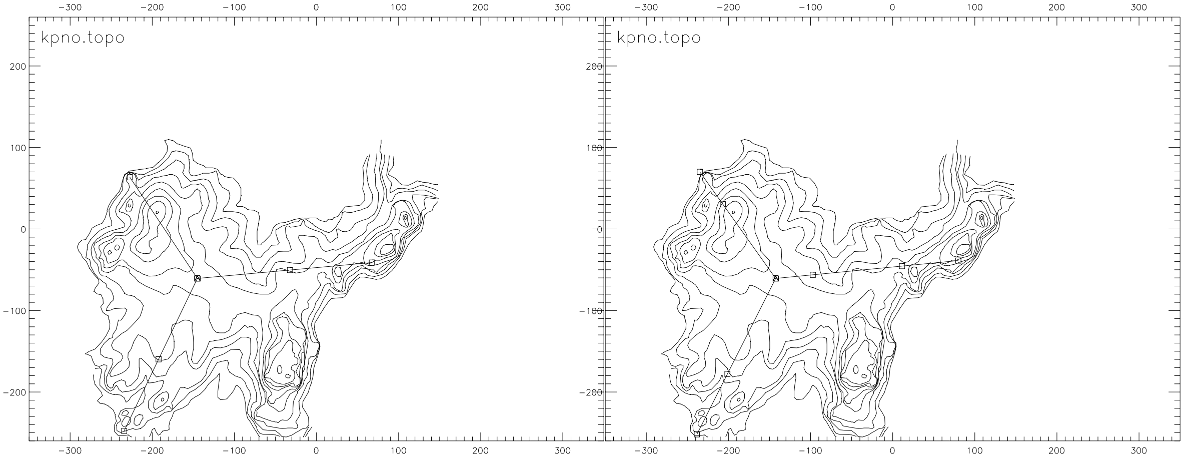


FIGURE 3. (above) Mount Palomar site with optimum 5- and 7-telescope configurations.

FIGURE 4. (below) Kitt Peak site with optimum 5- and 7-telescope configurations.

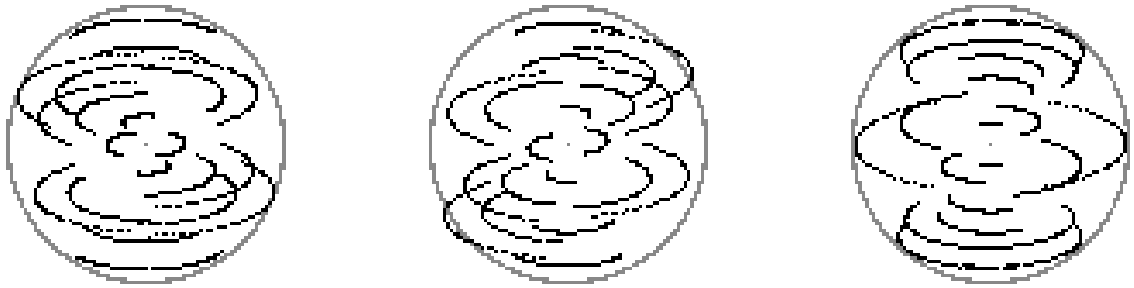
Figure 5 shows the $U-V$ plane coverage with the best 5-telescope Y arrays at Mt. Palomar and Kitt Peak versus the CHARA 'classical' Y. The coverages are all very comparable.

Figure 6 shows a similar comparison with three 7-telescope arrays. Note that the overall coverage for any of these arrays is qualitatively better than that for the corresponding 5-telescope arrays.

5. COMPARISON OF RECONSTRUCTED IMAGES WITH ARRAYS

In the section above, we have seen that in terms of the criterion of a weighted coverage, the best Mt. Palomar and KPNO Y's are almost the same, with the Mt. Palomar slightly better. (Both are even slightly better than the CHARA Y arrays.) Another comparison is to carry the process one step further and to use the arrays' $U-V$ plane coverages to reconstruct a sample image and to compare image quality with the Mt. Palomar and KPNO cases.

The $U-V$ plane coverages have been translated into reconstructed images via a procedure described in the CHARA 1994 Proposal. Basically, an interpolation is made of the complex visibilities in the $U-V$ plane for each of the arrays. The result is then Fourier-Transformed



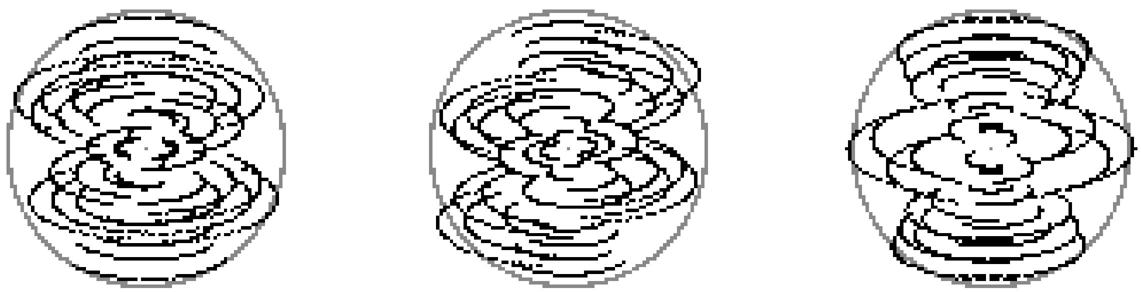


FIGURE 5. (above) UV Coverage with optimum 5-telescope configurations. Left to right: Mt. Palomar Y; KPNO Y; CHARA classical Y. The outer circle represents a 354 m separation, as in the original CHARA Y.

FIGURE 6. (below) UV Coverage with optimum 7-telescope configurations, as above.

FIGURE 7. Imaging with optimum 5-telescope configurations. Left to right: Input Object (29 CMa model); "Imaged" with best Mt. Palomar Y; "Imaged" with best KPNO Y.

to produce an image. Although this method is not quite as good as CLEAN, it has the advantage of being a quick diagnostic of potential imageing for various site locations. Figure 7 shows a reconstruction of a fairly difficult object based on a model for the star 29 CMa. The model includes a binary (low spatial frequency components) with resolved components with both tidal distortion and limb-darkening (high frequency components). The input image is at left. The other two images are those reconstructed from "observations" made with the coverages of the best Mt. Palomar and KPNO configurations (see Figures 3–4). As can be seen in this figure, the final image quality is pretty similar, with even the KPNO site producing acceptable images.

6. CONCLUSIONS

We have shown that adequate $U - V$ plane coverages can be obtained at the both the Mt. Palomar and KPNO sites. The Mt. Palomar site is slightly superior in $U - V$ coverage. However, for the 29 CMa model, the final reconstructed images are pretty similar. In terms of the sites considered so far, both Mt. Palomar (0.652) and Kitt Peak (0.643) are slightly better than Mt. Wilson (0.585) in terms of 5-telescope $U - V$ plane coverage. For the 7-telescope arrays, the coverages are 0.887, 0.847, and 0.829, respectively. The Mt. Wilson site has the advantage of an easy upgrade from a 5- to 7-telescope array, because none of the original telescope need be moved. The reconstructed images from all three arrays appear very similar, however.