CHARA Technical Report

No. 117 4 Jan 2023

CHARA Michelson Array Pathfinder: Mobile Telescope Site Selection

Chris Farrington

ABSTRACT: I present a discussion of the individual sites under consideration for the Mobile 7th telescope for the CHARA Array. The site selection criteria include science justification from the original proposal and ease of access for the telescope and related infrastructure.

1. INTRODUCTION

Prior to the submission of the CHARA Michelson Array Pathfinder (CMAP) proposal, a list of potential sites for expansion were discussed at the CHARA Futures meeting in Sept. 2017 (see TR.110). The CMAP proposal to the NSF described nine potential sites to investigate. This document will review each individually, define exact locations for the sites, and detail the potential issues that would have to be overcome if those sites are chosen for the final selection. Figure 1 shows a topographic map of the Mount Wilson Observatory and its surrounding areas with the locations of the current telescopes in red, and the potential sites in green. The ultimate science goals impacting the site selection are to obtain a small baseline triangle for imaging of large stars and to develop large baselines for increased (u,v) spatial frequency coverage and better angular resolution.

2. INDIVIDUAL SITE CONSIDERATIONS

Here we will define the potential site locations and discuss the individual criteria to be used for site selection. Table 1 below identifies each site and its location in GPS coordinates and distance from the reference telescope (S1).

Site	Location	Coordinates	X(m)	Y(m)	Z(m)	El(m)
S3	**Next to S2**	$34° 13'29''N$, $118° 03'25''W$	9.6	24.72	1.68	1729
S4	**Upper Monastery**	$34° 13'21''N$, $118° 03'29''W$	−82.16	−210.49	−10.72	1716
S5	Lower Monastery	$34° 13'18''N$, $118° 03'27''W$	−52.4	−297.2	−31.32	1696
W3	Upper Pavilion Lot	$34° 13'26''N$, $118° 03'39''W$	−344.72	−24.57	8.68	1736
W4	Lower Pavilion Lot	$34° 13'22''N$, $118° 03'46''W$	−539.3	−185.6	−1.32	1726
W5	Channel 13	$34° 13'41''N$, $118° 04'03''W$	−987.1	431.1	2.68	1730
N1	Close Northern Ridge	$34° 13'41''N$, $118° 03'34''W$	−232.5	388.31	−25.32	1702
N2	Far Northern Ridge	$34° 13'47''N$, $118° 03'42''W$	−450.3	721.68	−41.32	1686
E3	Behind CHARA Office	$34° 13'33''N$, $118° 03'24''W$	45.4	171.50	4.68	1732

TABLE 1.: Table of possible mobile telescope sites. The first two columns identify the designation of the site and where it is located. Column 3 gives the GPS coordinates for each site, and the next four columns identify the site in the baseline solution format of the CHARA Array in relation to the 0,0,0 location of S1 and the elevation above sea level on Google Earth.

Criteria for site selection:

- Transportation and ease of access
- Availability of local infrastructure
- Security and safety
- Science justification compatibility

[1]Center for High Angular Resolution Astronomy, Georgia State University, P.O. Box 5060, Atlanta GA 30302-5060
Tel: (404) 413-5484, FAX: (404) 413-5481, Anonymous ftp: chara.gsu.edu, WWW: https://www.chara.gsu.edu

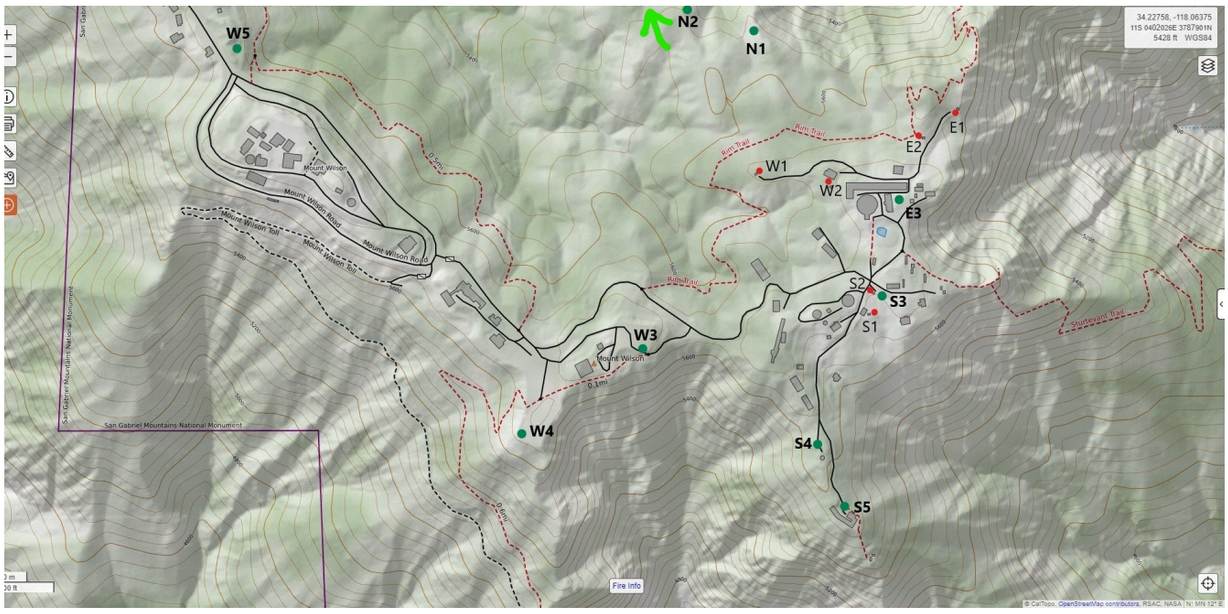


FIGURE 1.: Mount Wilson topographic map with current CHARA Array (red dots) and potential sites (Green Dots). Topographic map sourced from caltopo.com.

2.1. S3

- S3 - Next to S2 - 34° 13′29″N, 118° 03′25″W, Elevation: 1729m

In addition to being a close test-bed for the commissioning of the CMAP project, the positioning allows baselines between 17-32m in a small elongated triangle that is useful for measuring the largest supergiant stars previously too large for the current CHARA baselines. This site (Figures 2, 3, and 4) fits the primary science goal of a short baseline triangle with S1 and S2 and will be the test-bed for the telescope commissioning as it is the closest option with easiest access. Some grading and backfill will be necessary to level and expand the site for the concrete platform and pedestal. As it is close to existing power and fiber runs for the S1 and S2 telescopes, access to power and computer networks should be readily accomplished. It is within the observatory grounds, so security concerns for the site are minimal and approval for construction is determined within the observatory approval structure. Rank: 1

FIGURE 2.: Location of the S3 telescope site (marked by a stake) facing NW. The CHARA S2 dome is visible in the background.

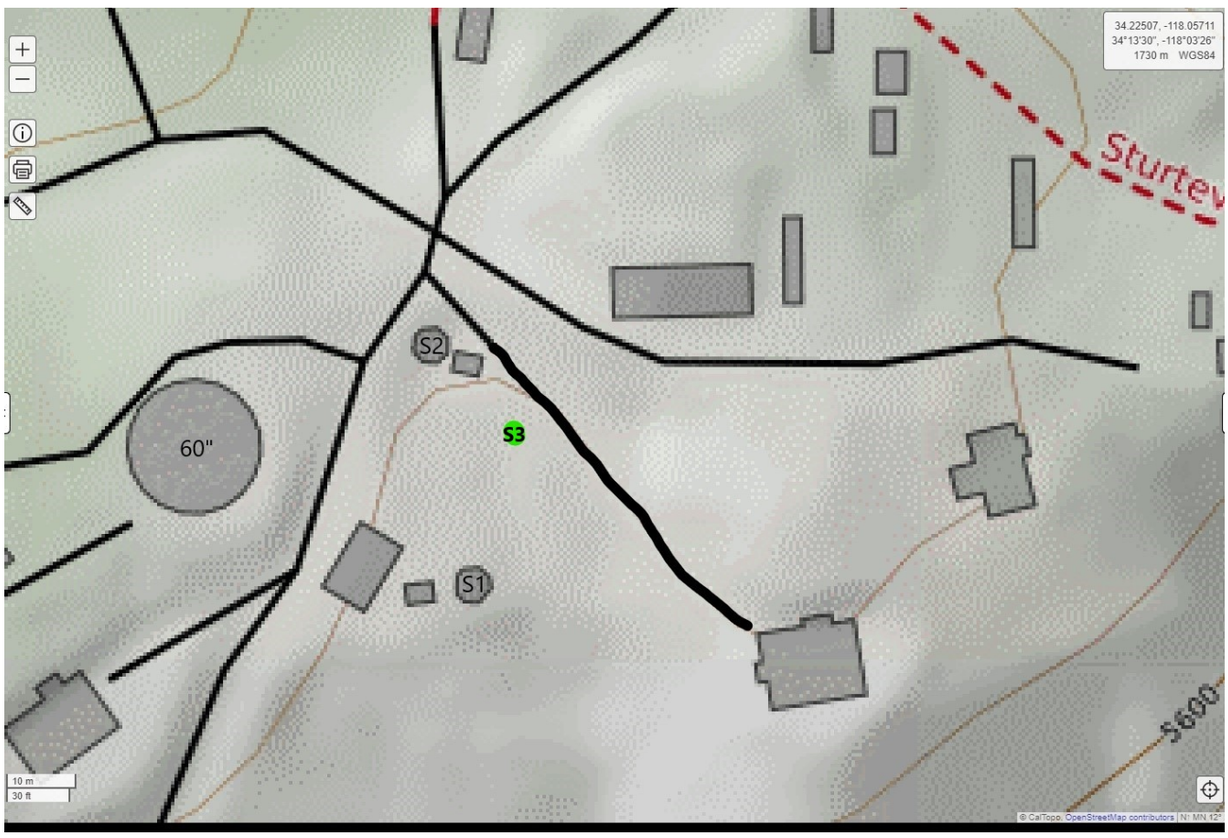
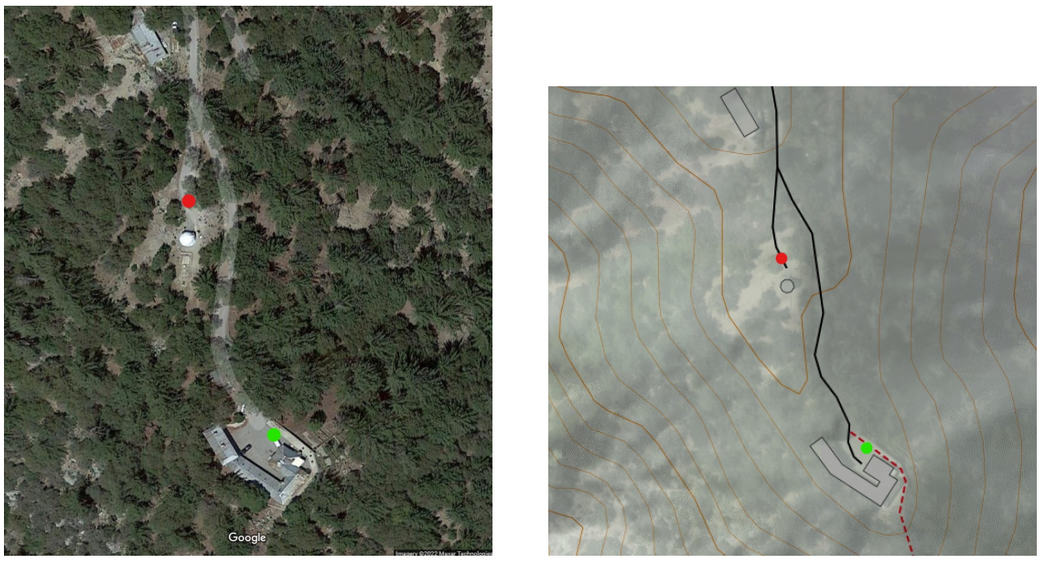


FIGURE 4.: Topographic map of location of S3 telescope site sourced from caltopo.com.

FIGURE 3.: Location of the S3 telescope site facing SW. The CHARA S1 dome is partially visible in the back left.



(a) Aerial image (b) Topographic image

FIGURE 5.: Locations of the two southern locations near the Monastery(S4 & S5). Green dot is S5 - Lower Monastery, Red dot is S4 - Upper Monastery.

2.2. S4 - Upper Monastery

- S4 - Upper Monastery - 34° 13′21″N, 118° 03′29″W, Elevation: 1717m

In the driveway to the 24" telescope dome about 200ft north of the Monastery building lies the location for the next site (red in Figure 5). On top of a ridge, and with some tree trimming, this is our first choice for the long baseline site for the first phase. This location for the mobile telescope has the disadvantage of blocking vehicle access to the dome, but we anticipate that the need for direct access will be infrequent and easily managed with scheduling for all the positions of the mobile telescope. We will need to adjust the entry driveway junction with the main road to have a more direct path and a less steep gradient. As it also is near other existing infrastructure for power and data lines, there will be little difficulty in this regard. Security and safety are similar to S3 as the site is on observatory grounds and requires less stringent measures than more remote sites.This site offers the potential of a long N-S baseline opportunity that exceeds current CHARA maximum baseline length by 200m. The sky coverage is good with minimal need to trim nearby trees (especially if the telescope is situated at the southern end of the driveway close to the dome). An image of the proposed location for the telescope pier is shown in Figure 6 as a red dot. Rank: 2

2.3. S5 - Lower Monastery

- S5 - Lower Monastery - 34° 13′18″N, 118° 03′27″W, Elevation: 1701m

This is the furthest south location possible. On the east side of the Monastery parking lot is a location that is prime for a very long N-S baseline that paired with E1 yields a baseline of 629m. Future expansion with adding the Northern arm when two mobile telescopes are available would increase this to 1093m. Access is only limited by the width of the road and the concrete embankments and trees that line it. Keeping the mobile enclosure transport width less than 14ft should allow enough clearance to move it to and from the site. The roads to S4 and S5 both have larger grades than the roads to the other sites. Consequently, there will need to be a way to secure the payload to prevent significant tipping. The S5 site is close to existing power and data lines and will only need the storage box for the power and fiber connections. Depending on the positioning in the parking lot, the concrete pillar for support of the telescope may need to be cordoned off to prevent damage by Monastery users while retaining vehicular access to the buildings. This is also one of the primary locations where we will have to break into the existing road bed to install the site pillar and platform. The Mount Wilson Institute (MWI) staff advised us about concerns of keeping this space large enough for firefighting vehicles to turn around in the parking lot, so this site is probably not feasible as a mobile telescope location. The location is shown as a green dot in Figure 5 and in the image in Figure 7. Rank: 6

FIGURE 6.: Image of the Upper Monastery S4 site. The green dot represents the proposed location of the center of the telescope pad.

FIGURE 7.: Image of the Lower Monastery S5 site. The green dot represents the proposed location of the center of the telescope pad.

2.4. W3 - Upper Pavilion Parking Lot

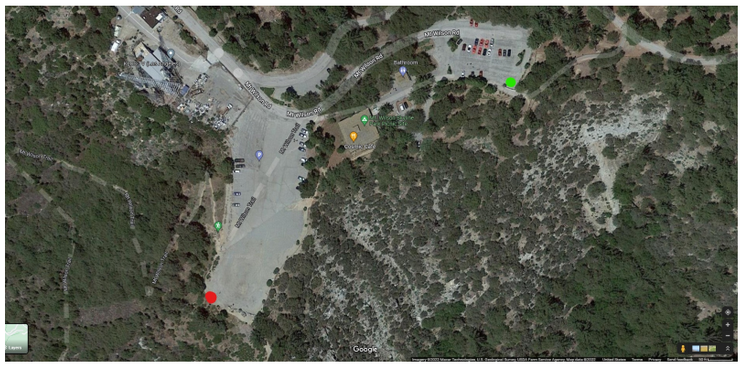
- W3 - Upper Pavilion Lot - 34° 13′26″N, 118° 03′39″W, Elevation: 1736m

This site is located in the South-East corner of the upper parking lot near the Mount Wilson Pavilion (shown as a green dot in Figures 8 and 9). This is an ideal location for a CMAP site with easy access and flat cleared land. The main access issue is the gate between the lower and upper parking lot which has a width of only 14ft. Along the primary access into the observatory proper, the site sits close enough to the Pavilion to allow access to power and data fiber without significant investment. As this site is in the more public area of the Mount Wilson Observatory, security fencing will be necessary. Good sky coverage is available without much site clearance or tree trimming. Using this site will produce baselines approximately equal to the N-S baseline with S4, but in a different orientation and significantly reduced sky coverage due to delay line path limitations. Rank: 3

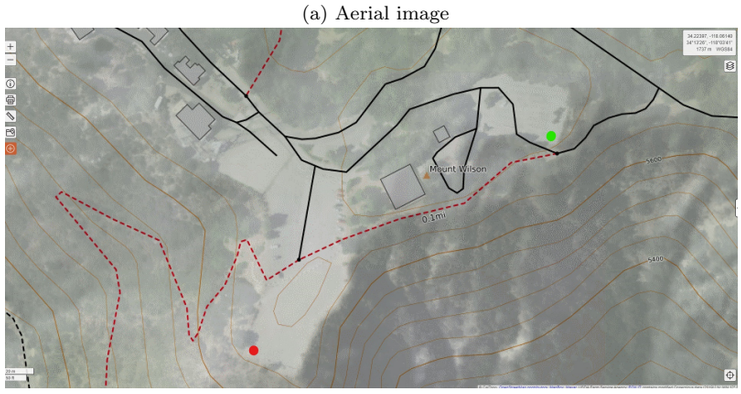
2.5. W4 - Lower Pavilion Parking Lot

- W4 - Lower Pavilion Lot - 34° 13′22″N, 118° 03′46″W, Elevation: 1723m

This site is located in the South-West corner of the lower Pavilion parking lot, overlooking Mount Harvard. While this would be an ideal location for another long baseline site (at 826m distant from E1), it will be difficult or impossible to be permitted access to the site because of its use by the United States Forest Service and firefighters as a helicopter landing site. If access could be secured, this would make the second longest baseline aside from the Channel 13 site (W5) and would be easily accessible by any and all types of telescope enclosures and transports with no restrictions. Access to power would either be leased from the nearby TV station to the North-West, or from the Pavilion. The Pavilion's internet access is direct by beam wireless from the 150ft Solar tower, but this is insufficient for our purposes. Instead we would need to install the data and science fibers that would need to routed to the east or north. The location is shown as the red dot in Figures 8 and 9. Rank: 9



(a) Aerial image



(b) Topographic image

FIGURE 8.: Locations of the two Western sites near the Pavilion building (W3 & W4). The green dot represents W3 and the red dot W4.

(a) Upper Parking Lot image

(b) Lower Parking Lot Image

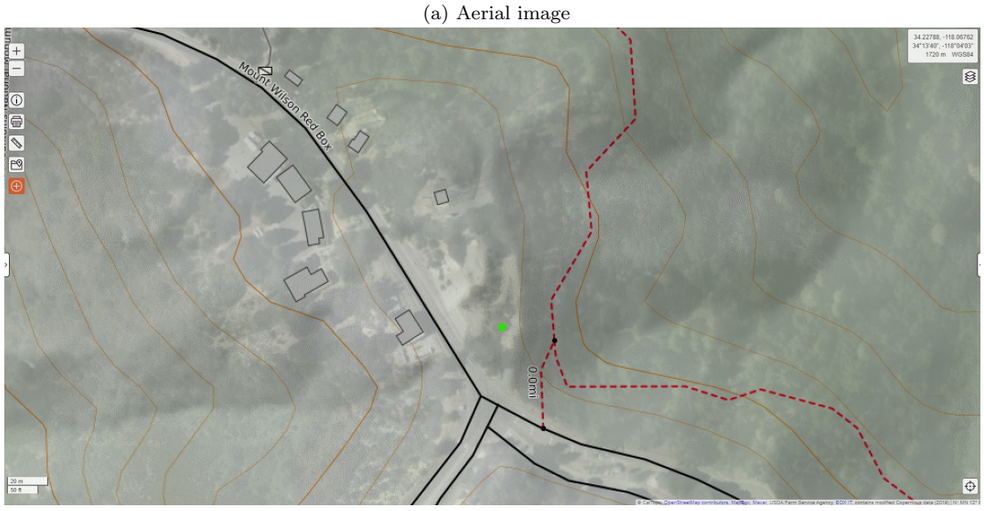
FIGURE 9.: Images of the two Western sites near the Pavilion building (W3 & W4). The green dot represents W3 and the red dot W4.

2.6. W5 - Channel 13

The decommissioned Channel 13 television station site is outside of the observatory grounds and on the far side of the Mount Wilson Circle Road. This location allows for the longest possible baseline with E1 (1119m) and fulfills the science goal of a longer than 1000m baseline. Partnership with the US Forest Service will be necessary to redevelop this location. The site is already fenced in and the lower southern part of the location is mostly flat and will not require much more than brush clearance and tree trimming. The gate access is 15ft wide and would not need to be modified if we limit the width of the enclosure. The driveway leading into the site will need to be regraded and paved as it is fairly rough in its current state. Power access should be available from the adjacent TV station attached to the northwest side of the site. Data and science fiber access will need to be discussed with the US Forest Service, CalTrans, and LA County depending on the route taken from the observatory grounds. Figures 11 and 10 show the location on the topographic map, aerial view, and ground view of the location inside the gate. Rank: 4

FIGURE 10.: Image of the location of the Channel 13 lot. Green dot is anticipated location of the center of telescope pad.

(a) Aerial image



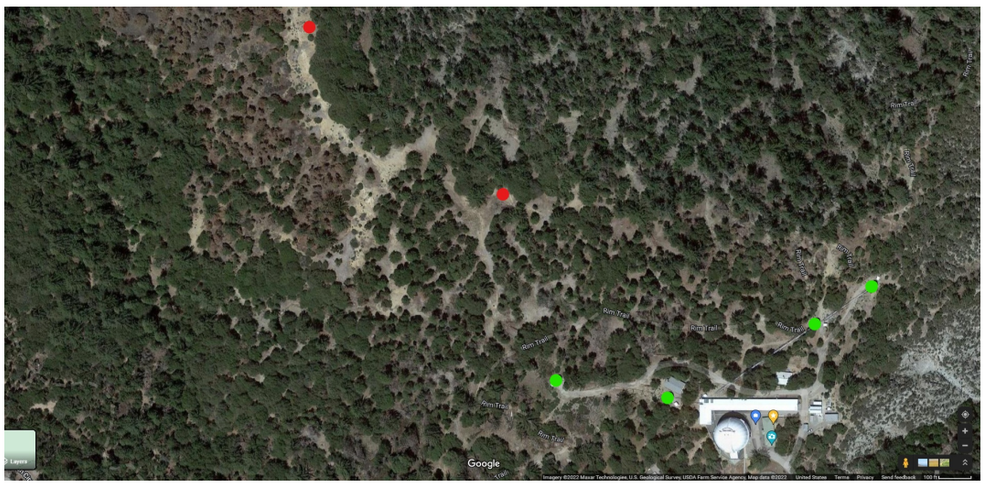
(b) Topographic image

FIGURE 11.: Locations of the western-most site at the old Channel 13 site (W5).

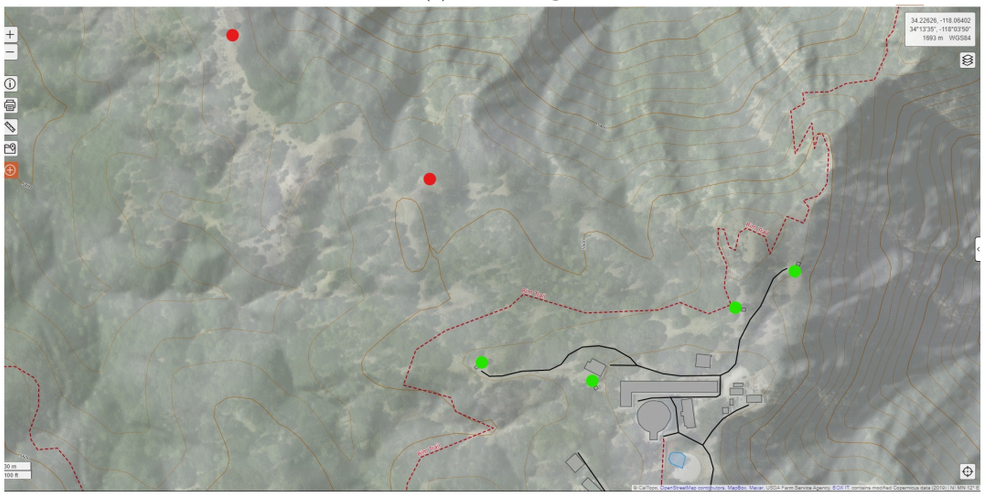
2.7. N1 & N2 - Close and Far Northern Ridge

- N1 - Close Northern Ridge - 34° 13′41″N, 118° 03′34″W, Elevation: 1720m
- N2 - Far Northern Ridge - 34° 13′47″N, 118° 03′42″W, Elevation: 1720m

These sites are located to the North and North-west of W1 along a fairly flat ridge outside the current boundaries of the observatory. We currently have no northern arms of the Array and these locations could give a larger than 1km baseline (1093m) in the North-South direction. However, there are significant hurdles to overcome to make use of these locations. As they are located in undeveloped areas of the Angeles National Forest, the US Forest Service approval is needed. Additionally, there is no infrastructure of any sort near these locations. Roads would have to be graded and cleared through undisturbed forest, power would need to be extended between either W1 or the observatory proper to the two sites, as well as data and science fibers. This would likely need to be a long term goal if desired. Figure 12 shows the locations of both sites in red, where the current CHARA Array telescopes are shown in green. Rank: 7 & 8



(a) Aerial image



(b) Topographic image

FIGURE 12.: Locations of the Northern Sites (N1 & N2). The green dots mark the locations of the existing CHARA Array telescopes, and the red dots show the locations of the two northern sites.

2.8. E3 - Behind CHARA Office

- E3 - Behind CHARA Office - 34° 13′33″N, 118° 03′24″W, Elevation: 1735m

At the top of the hill behind the CHARA Office, this site was considered for this project in the proposal but is being reserved for the future 2-m telescope expansion of the Array with both light pipe and optical fiber beam transport. This location would allow many intermediate baselines to be added to the current long and short baselines and is easily serviceable. It is on the current Array footprint, so safety and site access are already secured. Power and data access is not an issue for this location. Ranked low because at the time of preparing the CMAP proposal, we were also asking for MSIP funding to construct a central 2m telescope. Because of its importance for connecting the 3 existing arms for imaging we intend to use the space for the other potential telescope at a later date. Rank: 5

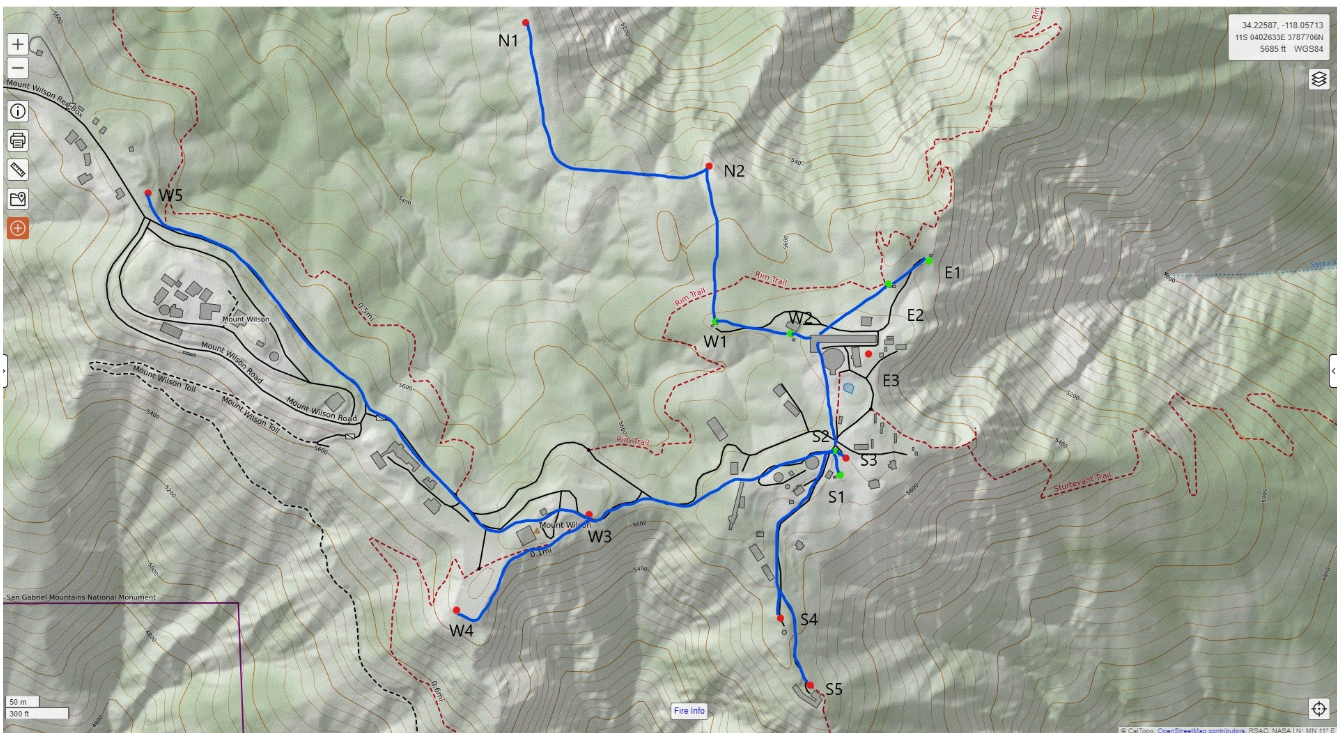


FIGURE 13.: Topographic map of Mt Wilson with all considered sites and potential fiber paths. Current array locations are shown in green, potential sites in red, and potential fiber pathways in blue.

3. FINAL SITE SELECTION

The longest possible baseline from the primary locations is E1-W5, and this would fulfill our requirement of a baseline longer than 1km. All other sites have potential for a future expansion of the Array. Possible layouts of the fiber optic cables that will connect the sites with the ople building are shown in Figure 13. The limitations of many of these sites forced us to on focus on those with the most potential for meeting the science goals and with minimal associated logistical problems. Thus, we selected the prime sites as S3, S4, and W3, shown in Figure 14 (red). S5 provides the maximum baseline length in the N-S direction, but it was removed from consideration due to firefighter access concerns.

The baselines and position angles (from north through east) for the new sites with current CHARA Array telescopes are listed in Table 2.

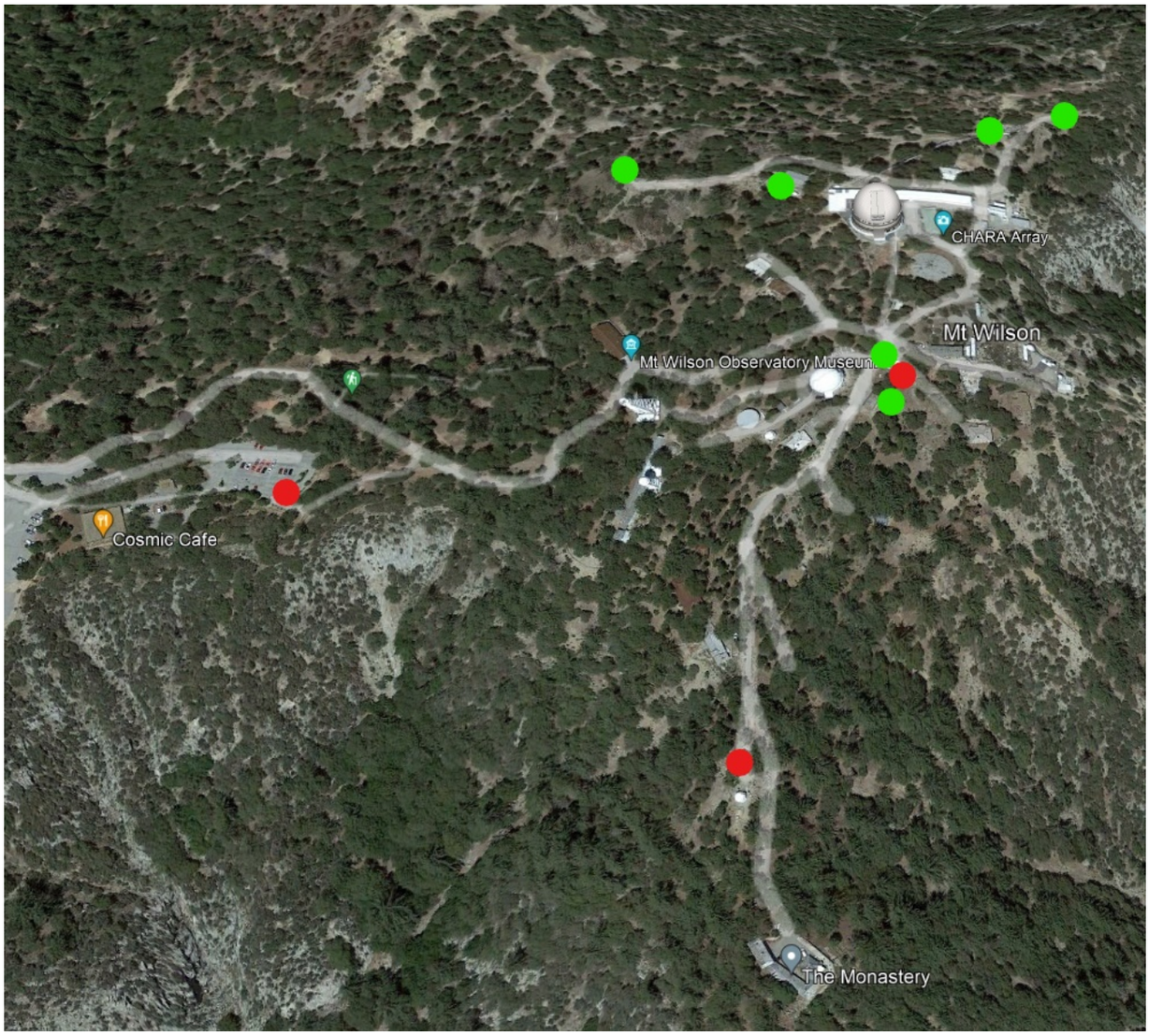


FIGURE 14.: Mount Wilson satellite map with selected sites. The selected sites marked with red dots and current CHARA Array sites are shown as green dots.

Telescope Pair	Baseline	Telescope Pair	Baseline
S3			
E1-S3	304.2m, 22.4°	E2-S3	252.4m, 13.9°
W1-S3	266.4m, 136.1°	W2-S3	191.5m, 155.7°
S1-S3	26.5m, 21.2°	S2-S3	17.7m, 119.9°
S4			
E1-S4	556.6m, 21.89°	E2-S4	503.9m, 17.62°
W1-S4	436.8m, 167.72°	W2-S4	410.2m, 1.83°
S1-S4	226.2m, 21.32°	S2-S4	256.0m, 17.38°
W3			
E1-W3	574.7m, 54.9°	E2-W3	402.5m, 42.9°
W1-W3	295.2m, 35.2°	W2-W3	355.2m, 50.9°
S1-W3	345.7m, 85.9°	S2-W3	343.9m, 80.3°

TABLE 2.: CMAP site locations paired with current CHARA Array telescopes listing baseline lengths and position angles in columns two and four.