MMA Memo 196: Options for Placement of a Second Site Test Interferometer on Chajnantor

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Abstract

We illustrate various options for placement of a second site testing interferometer on the Chajnantor site, mentioning the various scientific benefits and technical drawbacks to each option.

Introduction

We have been monitoring the atmospheric phase stability of the Chajnantor site in Chile since May, 1995. With superior phase stability and 225 GHz opacity, it seems likely that the MMA, the LMSA, and the LSA projects will all converge upon the Chajnantor area. As each project has a substantial investment in site testing equipment, including interferometers to monitor the atmospheric phase, it seemed like a good idea to explore different wasy of utilizing multiple site testing interferometers on the same site. We present seven different concepts for using two interferometers on the Chajnantor site. The concepts which we prefer are presented first.

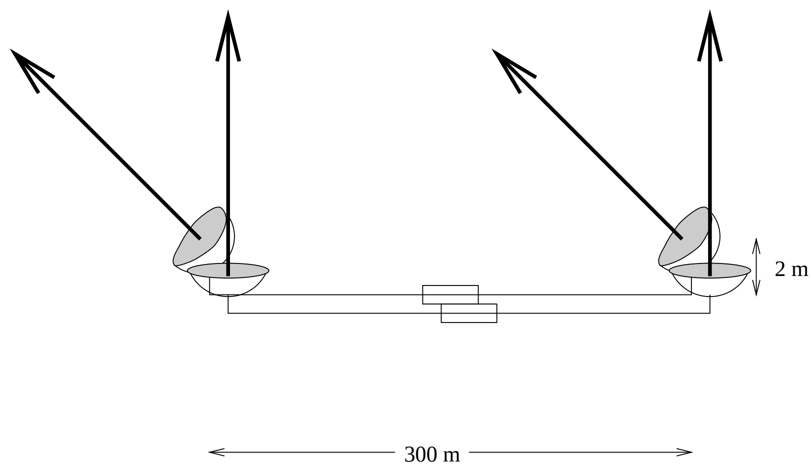


Figure 1: Option 1: The interferometers are collocated, but pointing to different satellites. As the velocity aloft can be measured from one site testing interferometer, when the wind direction is parallel with the E-W baseline (as it usually is), the time delay of turbulence crossing from one interferometer's line of site to the other's provides us a means of determining the height of the turbulence. This will also provide us with a means of estimating the evolution of the turbulence on very short time scales (ie, a few seconds). The technical drawback is that there may not be an appropriate second satellite. This is the only option presented that relies upon a second satellite.

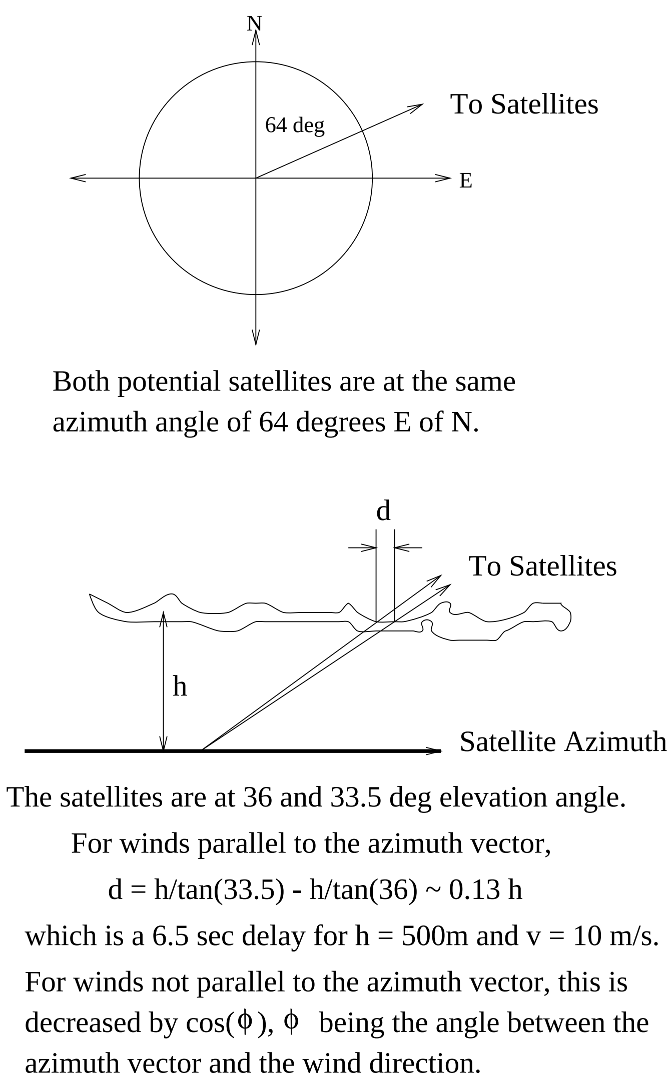
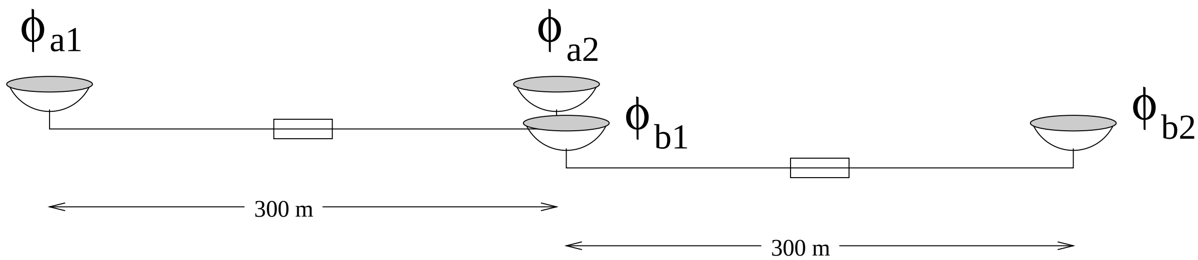


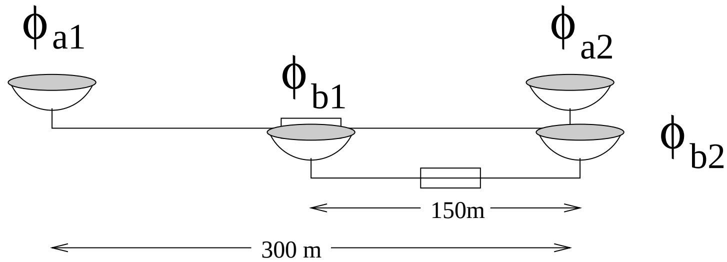
Figure 2: The geometry of *Option 1* for the Intersat 601 satellite at 36° elevation and 64°.5 azimuth (which we observe from Chajnantor) and the Intersat 605 satellite at 33.5° elevation and 64° azimuth. Under this geometry, accurate determination of the phase fluctuation delay between the two interferometers plus an accurate determination of the velocity aloft should allow us to determine the elevation of the turbulent water vapor.



$$\phi_{a2} = \phi_{b1}$$

$$(\phi_{a1} - \phi_{a2}) + (\phi_{b1} - \phi_{b2}) = \phi_{a1} - \phi_{b2}$$

Figure 3: Option 2: The interferometers are colinear, and one antenna from each interferometer is collocated. The atmospheric phase on the two collocated antennas will be the same, so adding the correlated phase of interferometer *a* to that of interferometer *b* will result in the phase one would get from an interferometer made up of the two non-collocated antennas. In the case illustrated, this gives us two 300 m baselines and one 600 m baselines. We stress that the phase difference on the third baseline does not require any special electronics, connections, or sub-second synchronization of the correlating computers; the computers should be synchronized to within a second to permit the calculation of the third baseline's phase offline from the two interferometers' data files. If two baselines of identical length are used, we can monitor the velocity of the turbulent structure and the evolution of the turbulence on 300 m size scales as it passes over the interferometer. Evolution of the turbulence is important for paired *array* phase calibration techniques that monitor the phase screen as it passes over a compact array. Another option worth considering is a non-redundant version with baselines of, say, 300 and 150 m, with an inferred third baseline of 450 m. This would require shortening the cables on the second interferometer.



$$\phi_{a2} = \phi_{b2}$$

$$(\phi_{a1} - \phi_{a2}) - (\phi_{b1} - \phi_{b2}) = \phi_{a1} - \phi_{b1}$$

Figure 4: Option 2a: Conceptually the same as Option 2, this option uses the same trick to get a third baseline which is *shorter* than 300 m. This option can monitor the velocity of the turbulent structure and the evolution of the turbulence on 150 m size scales as it passes over the interferometer. The 150 m size is important for the most compact arrays. Another option worth considering is a non-redundant version with baselines of 300 and 200 m, with an inferred third baseline of 100 m.

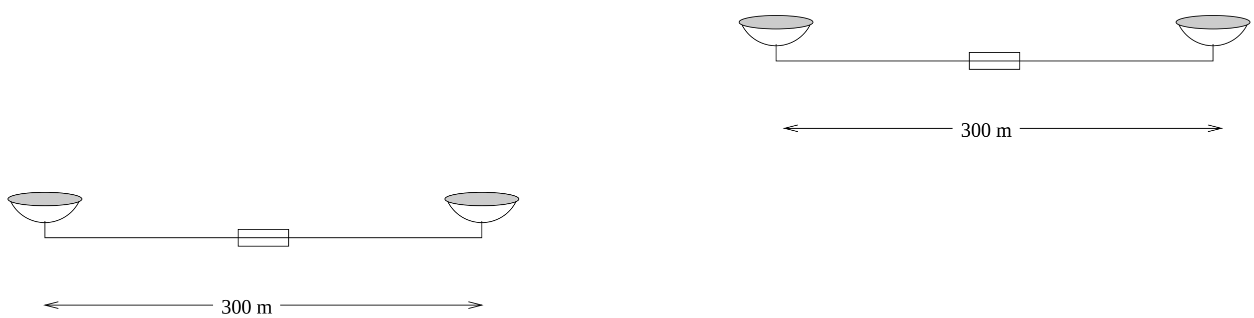


Figure 5: Option 3: Two 300 m baselines monitor the turbulence on different parts of the site. A comparison between the NRAO Chajnantor interferometer and the NRO interferometer 10 km distant at Pampa la Bola has shown that the phase stability can vary by a factor of 5-10. Placing the second interferometer 1-3 km from the existing one on the Chajnantor site would provide interesting data.

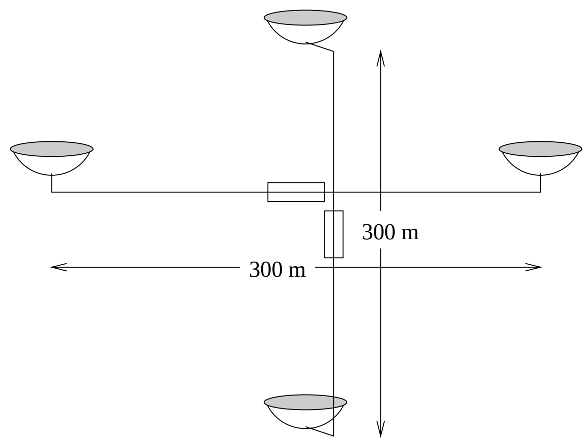


Figure 6: Option 4: Placing the interferometers in different orientations provides information on anisotropic turbulence. However, other interferometer arrays such as the VLA can study this effect already. Typically, phase fluctuations on baselines perpendicular to the wind agree with fluctuations on parallel baselines to 20 or 30%.

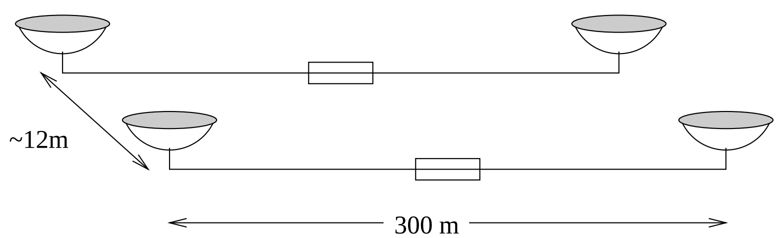


Figure 7: Option 5: Placing the antennas for the interferometer pairs 10-20 m apart would provide a test of the paired antenna calibration method. The orientation of the vector between the paired antennas is not specified, but if the interferometers were colinear parallel to the prevailing wind direction, we could also monitor evolution of the turbulence on short scales. At this point, no array is seriously considering paired *antenna* calibration.

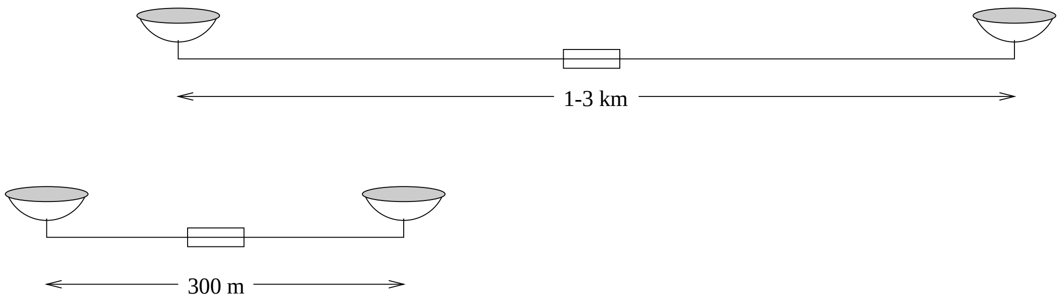


Figure 8: Option 6: The second interferometer could be installed with a much longer baseline, say 1-3 km, to provide information on the outer scale of turbulence. However, since it is well recognized that the phase problem must be solved on the shortest scales (ie, seconds), the long time scale or long spatial scale turbulence will be removed automatically and is not a particularly important issue. Furthermore, some engineering work would be required to install a phase-stable transmission line on the much longer baseline.

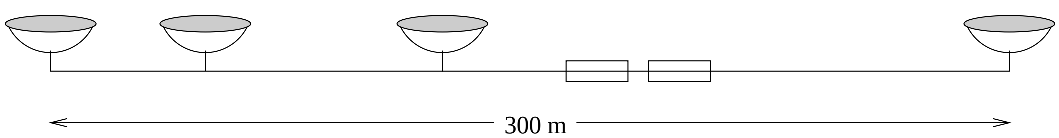


Figure 9: Option 7: All antennas could be combined into a single interferometric array, producing six correlated baselines. This provides an independent verification that the measured spatial phase structure function indeed agrees with the spatial phase structure function inferred from the temporal phase fluctuations on a single baseline. However, this comparison has been done with the five element Nobeyama phase monitor system, and can be done at astronomical arrays such as the VLA as well. Furthermore, it would require re-engineering the interferometers.