# Submillimeter Array Technical Memorandum

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## Azimuth Cable Wrap


### Summary

The SMA cable wrap was originally designed to run from AZ = -180 through AZ = +360, for a total range of 540 degrees. Since the pads on Mauna Kea have the wrong orientation, we will now have a restricted range, unless the pads or antennas can be fixed. If the range was restricted to the minimum value of 360 degrees, the time loss could be as much as 4% on a worst-case track where the source and calibrator transit on opposite sides of the zenith. However, it appears likely that we will have an effective range of slightly more than 450 degrees if no changes are made to the pads. If we orient the wrap properly, the cost could be as little as 1 long slew per track, or 0.2%. These losses are so small because the SMA antennas can slew fast,

The minimum tolerable wrap length for the SMA is 450 degrees, provided it is oriented so that the overlap covers the fourth quadrant (270 to 360 degrees). This is achievable with the current pads, provided that the center of the cable wrap is moved by +26 degrees from the original position. This implies that the center of the cable wrap should be moved from the current nominal orientation of Az=90 to Az= 116.


### Introduction

The azimuth cable wrap for the SMA limits the tracking range for the antennas. At a minimum, the wrap should allow any single source to be tracked from rise to set, whether it transits north or south of the zenith. This minimum wrap would have a single break at Az = +/- arccos( tan (lat )), or 290 degrees for latitude 19 degrees. ( This is in the standard convention where North is zero and East is 90 degrees.) Such a minimal wrap is not very good for interferometry, however. Apart from the need for a few extra degrees range to leave room for limits, we need to be able to slew efficiently between source and calibrator during an observation.

Normally source and calibrator are close together on the sky, and the slews in azimuth and elevation are fairly short. The difficult case is when the source and calibrator transit on opposite sides of the zenith, i.e. one is above declination 19 and the other is below. Typically the source and calibrator will be close in Right Ascension and therefore transit at about the same time. For the minimal wrap there is no problem before transit, since North-South slews are completely free, but after transit, the antenna must slew all the way through East to go between the sources, for an extra distance of about half a turn on average.

The next step up is a wrap which runs from -90 to +360, as at OVRO. This is the minimal wrap, plus an extra extension to permit free North-South slews in the West. Since there is now an ambiguity, with two possibilities in the fourth quadrant, it may be necessary to make one long slew near transit to switch to the correct branch of the wrap. In a really unfortunate case, where the source and calibrator are at slightly different RA, a small number of long slews might be made.

The VLA/VLBA wraps are longer still, running from -90 to +450. This extra length in the first quadrant appears to offer little advantage over the OVRO wrap, since long slews can still be required at transit, and there is an additional software complication that one or other branch must be chosen for sources which rise in the North.

The SMA wrap was designed to avoid the long slew at transit, by running from - 180 to +360. This means that no matter which branch is followed after transit, the whole azimuth range from 180 to 360 degreees is available, and long slews should be minimized. Also, there is no ambiguity in the East, so there is never any problem with starting on the wrong branch.

## Cost of a Restricted Range

The pads on Mauna Kea have a scatter of about 74 degrees p-p in their orientations, restricting our azimuth range to 466 degrees if we are unable to correct the problem. If we place our cable wrap orientation carefully, with the center roughly SE, we can achieve the -90 to + 360 range as at OVRO, but we cannot achieve the full range planned initially unless the pads or antennas can be altered. In order to decide what to do, we must evaluate the cost of the restriction in our range.

The cost of these possibilities can be weighed by looking at the observing time lost to long slews. Luckily, since the SMA antennas can slew as fast as 4 degrees per second, an extra 180 degrees of slew costs only 45 seconds, giving a much smaller impact on our observing time than with many other antennas. In the worst case, of a minimal 360 degree wrap, the average extra slew could be as much as 180 degrees, twice each calibration cycle, for a loss of 1.5 minutes / 20 minutes, or 7.5 % of the observing time. This loss applies only to the second half of a track, so the average loss would be only 4%.

If we have an OVRO-type wrap, then we may need an extra 180 degree slew once per track, for a time loss of 0.75 minutes / 8 hours, or 0.2%. Even if we get tangled up and have to do a couple of long slews, the loss will be less than 1%. There will be some extra slews associated with observations of standard flux and bandpass calibrators, but these should also cost less than 1 %, worst case. However, these types of slew may aply to more observations than the special case of calibrator and source on opposite sides of the zenith, although the slews can be minimized by careful design of the observation. All in all, I estimate that the average cost will be roughly one extra slew per track, or 0.2%.

The conclusion is that, although the original 540 degree range is preferable, the impact on the SMA of a restricted 450 degree range would be acceptable, provided that the orientation of the wrap provides an overlap in the fourth quadrant. For a loss of 0.2% it would only be worth reworking the antennas if the cost and schedule impact was rather small.

## Orientation of Cable Wrap

From the surveyed results on Mauna Kea, and assuming that the neutral point of the wrap is placed at a nominal neutral point of Az=90 relative to an ideal pad, the actual range of azimuths is -124 to +342 degrees, with the limits set by pads 6 and 7, respectively. To achieve the best range, we should move the nominal neutral point by +26 degrees to Az=116 degrees. This is specified as the azimuth of the neutral point for a correctly oriented pad. This will give us a nominal range of -98 to +368 degrees, which will comfortably allow -90 to +360 with a few degrees to spare for the placing of software and hardware limits.