ALMA Memo #292
A Possible Layout for a Spiral Zoom Array Incorporating Terrain Constraints

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ABSTRACT

A first attempt is made to fit a zoom spiral geometry into the terrain at the Chajnantor site. The objectives were to obtain a first order estimate of how terrain effected uv coverage, and to locate possible sites for the most compact part of the array. Only manual adjustments to the antenna positions were made. No attempts have yet been made to optimise for uv coverage, despite this it appears that such an array can be fitted into the terrain while preserving good uv coverage. One possible position for placing the most densely packed part of the array is identified. This region is on a slope with mean gradients of about 3 degrees. Further investigations of the geology in this region are required to see how suitable it is for building antenna foundations. The tradeoffs between ease of operations, uv coverage and the maximum gradients at which the the antenna transporter must operate should be carefully considered.

1. INTRODUCTION

This memo describes a first attempt at fitting a spiral zoom array into the terrain at the Chajnantor site. The objectives were (i) to determine possible sites for the array centre and (ii) get a first order estimate of how the uv coverage degrades when taking terrain into account. The procedure was simply to take a spiral array similar to the one presented in Memo 283 and manually rotate and shift it to avoid bad terrain features. The remaining antennas which lay in difficult terrain were then moved slightly, again manually, without any consideration for optimisation of uv coverage.

The next step would be to optimise the array in some way. This could be done by minimising uv coverage and/or beam metrics. Promising results have been obtained in reducing the peak sidelobes of spirals using the beam sidelobe minimisation program of Kogan (AIPS task CONFI, see Memos 226, 247 etc). Without terrain constraints this optimisation reduced peak sidelobes in the snapshot beam by a factor or 2 or so. The next step would be to run the sideblobe minimisation program incorporating a terrain mask constraint.

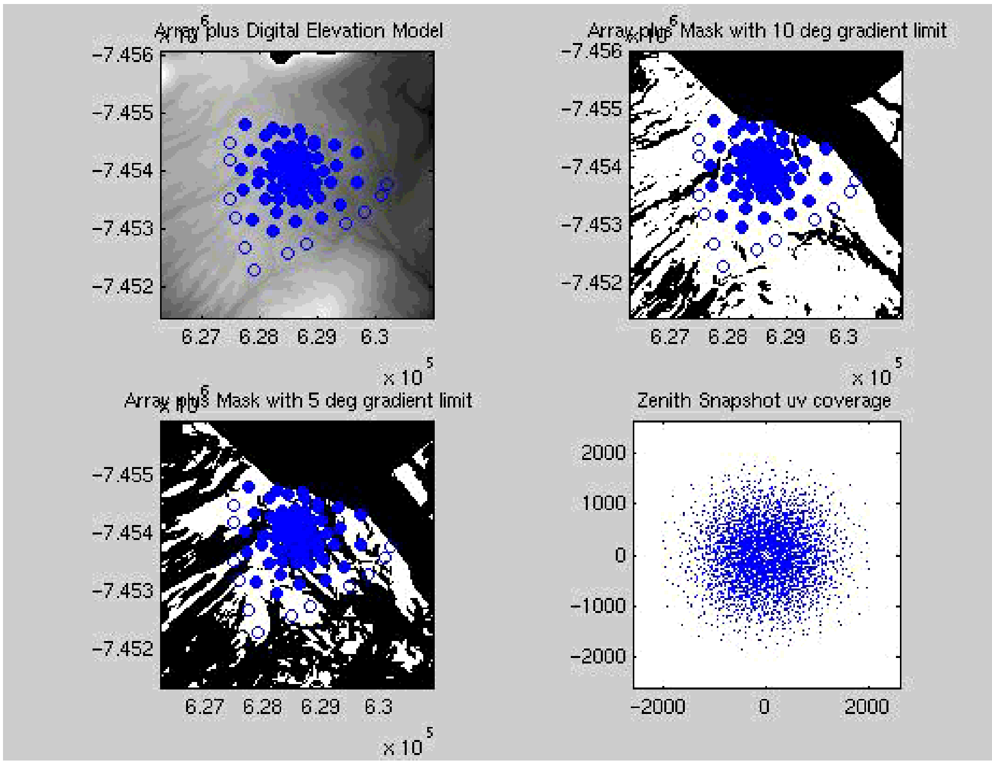

Fig 1. Overall plan of array. (Click for more detail). Top Left panel shows the array superimposed on the digital elevation model. Solid symbols are pads occupied by antennas, open symbols are unoccupied pads. Top Right. Array superimposed on 10 degree gradient terrain mask. Black indicates unsuitable regions for placing antennas, due to being too close to the gas pipeline (500m), shadowing by terrain reaching above 15 degrees elevation somewhere on the horizon, or having a local gradient greater than 10 degrees. Bottom Left. Array plus terrain mask, as above but with a 5 degree local gradient limit. Bottom Right. Zenith snapshot uv coverage given occupied pads.

2. ARRAY DETAILS

The manually fitted array is shown in the figures. As described in Section 1 the antenna pads were only placed at positions allowed by a terrain mask. The mask used (Fig 1, bottom left) incorporated a limiting gradient of 5 degrees (on a scale of order 10m as set by the pixels in the digital elevation model). This mask has been generated by B.Butler (NRAO). A 5 degree gradient limit is a somewhat arbitary choice, but is probably a good starting point. It is thought that gradients much larger than 5 degrees would probably be hard to deal with without making antenna move operations difficult and the antenna transporter expensive (though no detailed cost-benifit analysis have been done). Figure 1 shows an overall view of the Chajnantor site with the array superimposed on respectively the elevation map, 10 degree gradient mask and 5 degree gradient mask. Note that the overall 5 degree gradient and pipeline constraints (see Fig 1, Bottom left) constrain the antennas to lie within an approximately Reuleaux triangle shape. Therefore in contrast to the design presented in Conway(2000) [Memo 283] to get the largest resolution from the available real estate for <3km configurations the antennas should be placed on the perimeter of this Reuleaux triangle rather than a circle. In Figure 1 approximately 10 extra antennas have been added around this triangular perimeter, another 10-20 pads could be placed to allow the majority of the antennas to lie close to the perimeter and obtain maximum resolution.

Figures 2,3,4 show the array superimposed on the 5 degree elevation mask at different scales a factor of 2 apart. These figures show the main part of the array which is constructed from antennas on 3 tightly wound spiral arms, with 48 pads per spiral arm. Unlike in previous memos the lines tracing the three ’conceptual’ spiral arms have not been plotted; this and the fact that some antennas have been moved to avoid terrain features are the main reasons the the arrays’ spiral structure may not be immediately obvious. As described in Conway (1998, 2000) [Memos 216,283] the resolution can be gradually changed by movng antennas at the ends of the spiral arms to unoccupied pads at the centre (the ’zoom’ property).

Note that three of the Northernmost most antennas in the spiral (see Figures 3 and 4) have been shifted slightly South to avoid coming within 500m of the gas pipeline which is the currently agreed constraint. The zenith snapshot uv coverage in Fig 1 (bottom right) is calculated assuming the pads 28 to 48 on each of the spiral arms are all occupied. This plot shows that the antenna position perturbations introduced to avoid the gas pipeline and terrain do not effect the uv coverage very much.

3. LOCATION OF THE ARRAY CENTRE

The array shown in the figures is centred at Easting - 628590m, Northing - 7454000m. This position is about 1km East of the MMA container, and from a quick look appeared to be the best as far as flatness and avoiding arroyos etc was concerned; while being consistent with choosing a site close to the centre of the available area. Figure 5 shows a contour map at the array centre. The ’dense pack’ part of the uv coverage lies (see Figure 5) on a gently sloping part of the terrain with mean gradients of about 3 degrees. The position of the chosen centre is a bit north or the centre of the overall Reuleaux triangle (see Figure 1), but this doesn’t seem to effect the uv coverage very much (see Figure 1, bottom left). It would be very interesting to know more about the geological conditions at this part of site, and know whether this region is suitable for building antenna foundations. It is also very important to know whether the mean gradients found in this region are compatible with the envisioned transporter and operational specifications. A number of other possible array centres are possible if the one chosen does not prove suitable, however from the point of view of uv coverage on a zoom array it is desirable to have the most compact part of the array situated within about 1km of the centre of the overall available area. Given this there may be tradeoffs to be made between situating the dense pack part of the array on the flattest terrain and having good uv coverage and the ability to zoom.

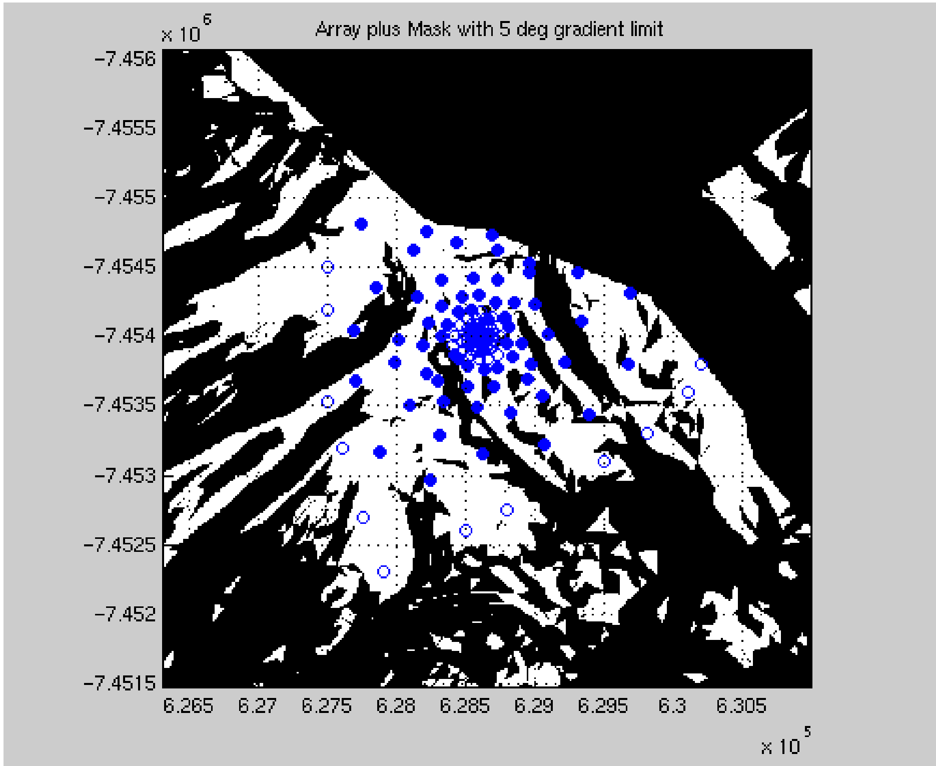

Fig 2. Array superimposed on 5 degree local gradient mask (click for more details). Filled symbols are occupied pads and open symbols unoccupied pads.

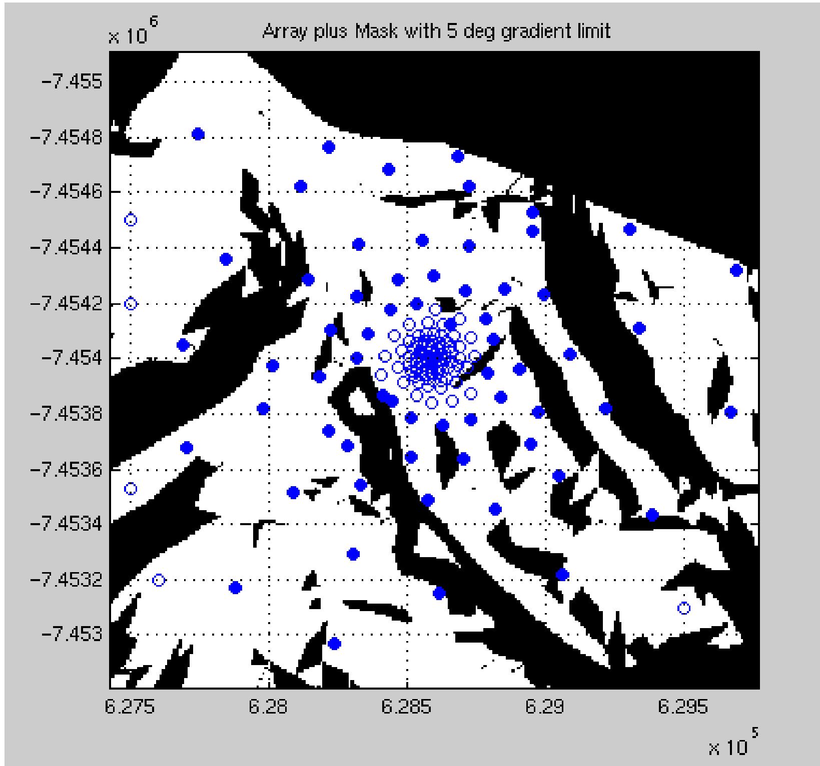

Fig 3. As Figure 2 but zoomed by a factor of 2 to show centre of array. (Cick for more detail).

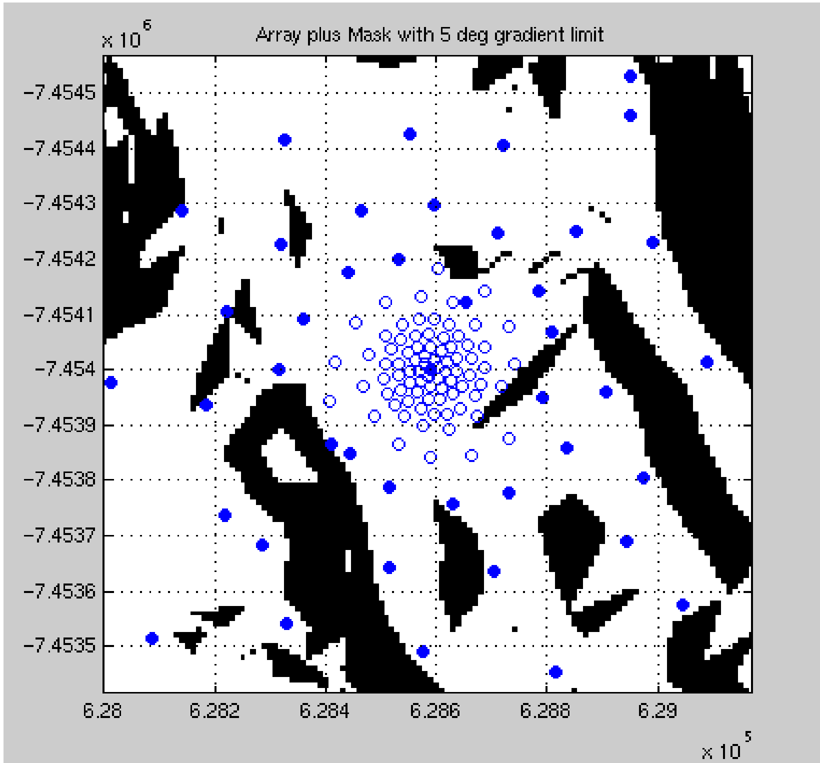

Fig 4. As Figure 2 but zoomed by a factor of 4 to show centre of array. (Click for more detail)

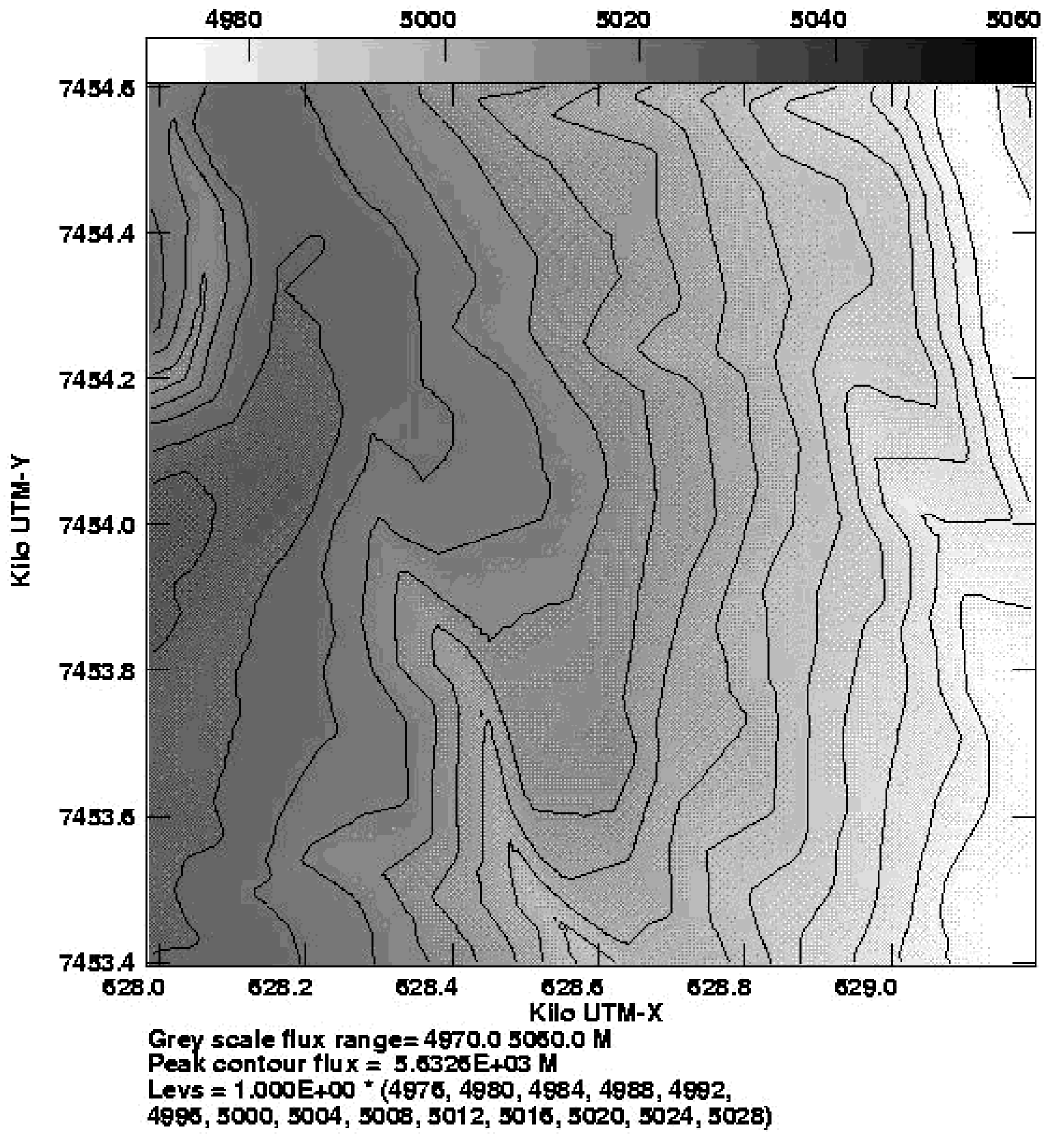

Fig 5. Contour map/grayscale showing terrain details in region of the array centre. Area plotted is the same as that plotted in Figure 4. (click for more detail).

APPENDIX - Software

The MATLAB v5.1 files used in this memo for displaying the array and terrain can be found at http://www.oso.chalmers.se/~jconway/ALMA/SOFTWARE/MATLAB/SPIRAL12