Design of the ALMA's Compact Configuration with the Road Design First.

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Abstract

At the recent PDR of the ALMA configurations (Grenoble, February 26-27, 2001) the committee selected the best brightness sensitivity as a main criterion of the compact configuration design. The best brightness sensitivity is equivalent to the most wide synthesized beam or the smallest size of the array configuration. The self shadowing of antennas requires some minimum spacing between antennas. During reconfiguration each antenna has to be accessible by the transporter. And this make even more requirement to the spacing between antennas. So it looks like that the problem of achievement of the best brightness sensitivity is equivalent to the problem of minimizing area of the road inside of the array. The previous designs of the compact configuration were leaving the road problem to the end. At the same time the road requirement can destroy the original good configuration. That is why I suggest to design the road with minimum area at the beginning and then design the configuration itself considering the roads as a topography constrain. Such an approach can be considered as a complete design because the road area is minimized since the beginning and therefore the brightness sensitivity is maximized. Optimization of the side lobes can be carried out by the standard procedure at AIPS (task CONFI) using the road constrain as a topography constrain. The road file has to be created at the standard Butler's format used for the site topography.

At this memo I give several examples of the roads and relevant configurations. The synthesized beam widths are compared with ideal hexagon configuration beam.

One of the configurations has the beam width very close to the ideal hexagon configuration of the given spacing.

1 Discussion

At the recent PDR of the ALMA configurations (Grenoble, February 26-27, 2001) the committee selected the best brightness sensitivity as a main criterion of the compact configuration design. The best brightness sensitivity is provided by the array with the most wide synthesized beam or by the smallest size of the array configuration. The self shadowing of antennas requires some minimum spacing between antennas. During reconfiguration each antenna has to be accessible by the transporter. And this make even more requirement to the spacing between antennas. So it looks like **that the problem of achievement of the best brightness sensitivity is equivalent to the problem of minimizing area of the road inside of the array configuration**. The previous designs of the compact configuration were leaving the road problem to the end, designing the configuration at the beginning. Having such a sequence of the design, the road requirement can destroy the original good configuration or the road can have a very strange shape which will make too complicate driving the transporter. That is why I suggest to design the road with minimum area at the beginning and then design the configuration itself considering the roads as a topography constrain. Such an approach can be considered as a complete design because the road area is minimized since the beginning and therefore the brightness sensitivity is maximized. Optimization of the side lobes can be carried out by the standard procedure at AIPS (task CONFI) using the road constrain as topography constrain. I have designed the roads at the shape of the regular roads: straight lines and circles.

I have wrote the AIPS task ROAD which creates the road file at the standard Butler's format used for the site topography. The task ROAD can create roads consisting of circle and radius roads. The width of the roads, the number of radius roads, the radiuses of the circle roads, the radius of turns at the roads intersections can be changed under control of the input parameters. The all area of the configuration is limited by the ellipse ring. This ring constrain limits the configuration inside of the elongated toward N-S direction ellipse. Such a shape of the configuration is required to have reasonably circular beam at the larger range of the source elevation. The size of the ellipse is determined by the input parameters also. *The room for the ACA array can be reserved inside of the configuration as an additional 'topography' constraint.* The task plots the roads at the TV or sends it to the plot file. At the same time the road file at the Butler's format recorded at the ASCII output file. This file is ready to use at the AIPS task CONFI as a topography constrain at the process of optimizing of the configuration. Additional option of the task ROAD allows to create the output file as an initial configuration with all antennas outside of the roads.

Figures (1, 2) show the examples of the roads. Each circular roads gives the access to the antennas at at both side of the road. The radius roads serve only for enter/exit. I used the two radius roads at my array design which are described lower. I think the two radius roads give enough comfort for driving the transporter. But of course the more radius as well as another design of the roads can be considered for other design.

The hexagon tile configuration is the most compact configuration and therefore it satisfies the criterion of the committee. But such a regular configuration has 100% grating side lobes. Anyway the width of the beam of the hexagon configuration can be used for estimation of the quality of the given configuration. Accidentally the number of antennas at a hexagon tile configuration (without the center element) is equal 60: the number of antennas which is considered now for the compact configuration design. Therefore a designed compact configuration with number of antennas 60 can be directly compared with the hexagon tile configuration. Figures (3) show the hexagon tile configuration and its beam pattern.

The width of the road is a very crucial parameter. The less is the width the more compact configuration can be created. The 27 meter width can allow the transporter to get off the antenna without stopping the observation by any antenna the transporter passes by ([1]), ([2]). A transporter carrying an antenna can pass between two antennas if the two are separated by 18m and if both reflectors are facing away from each other ([1]). At the recent PDR of the ALMA configurations (Grenoble, February 26-27, 2001) ([3]), it was recomended to have the width of the road ("channels") of 20m.

I have design several compact configurations with the width of the road ("channels") of 27m, which allows access to any antenna without stop of observation by any other antenna, and of 20m, which requires stop of observation by some antennas the transporter passes by. The two radius road type with both radius going to the inner circle (left plot of the Figure 1) has been selected. The found configurations after optimization of the side lobes are given at the Figures (4, 5). The relevant optimization of the side lobe is carried out for the nearest side lobes (the left plots) and for the total area of the primary beam (the right plots). For the road widths 20m I have moved as many antennas as possible to the central part of the configuration including 6 instead of 5 antennas in the central circle.

Table (1) shows the synthesized beam widths of the design configurations in comparison with "ideal" hexagon configuration at 345GHz. The optimization of the side lobes having the elongate ellipse constraint does not change the the synthesized beam width. So the the synthesized beam width for the nearest side lobe optimization is included at the Table (1). The last column of the Table (1) includes the synthesized beam width for the 27 meter roads (as well as the previous column) but with more antennas at the center including 6 antennas at the center circle. The synthesized beam width for the hexagon configuration corresponds to the spacing 20m. It would be 1.85x1.85 for the most compact configuration with the spacing 12m for 12 meter antennas.

The second column of the Table (20 meter road width) shows the beam width that is very close

Table 1: Comparison of the design configurations with "ideal" hexagon configuration.

	HEX	20m	27m	27m-6
beam width	1.112x	1.114x	0.803x	0.867
at 345GHz, "	1.111	1.038	0.779	0.815

to the ideal hexagon configuration (Table (1)). **So this configuration (Fig. 5) can be selected as a configuration satisfying the committee's criterion.**

2 Conclusion

The concept of designing a compact configuration starting with design of the road makes the configuration design straight forward and flexible. The road can be designed to have any desire shape. **The selected road type (two circle with two radii) allowed to design configuration (with 20 meter road width) (Fig. 5) which has the beam width very close to the ideal hexagon configuration (Table (1)).** Even with 27 meter road width, the better configuration with wider beam can be designed (see the last column of the Table (1)). I think the two radius roads give enough comfort for driving the transporter. But of course the more radius as well as another design of the roads can be considered for other design.

References

[1] M. S. Yun & L.Kogan, ALMA memo 320, Strawperson Donut/Doubling-Ring Configurations. 2000

[2] P. Napier, Private communication. 2001.

[3] Recomendation of the Configuration Preliminary Design Review, http://www.cv.nrao.edu/ awootten/mmaimcal/configurationpdr.html, by S. Guilloteau, March 16, 2001

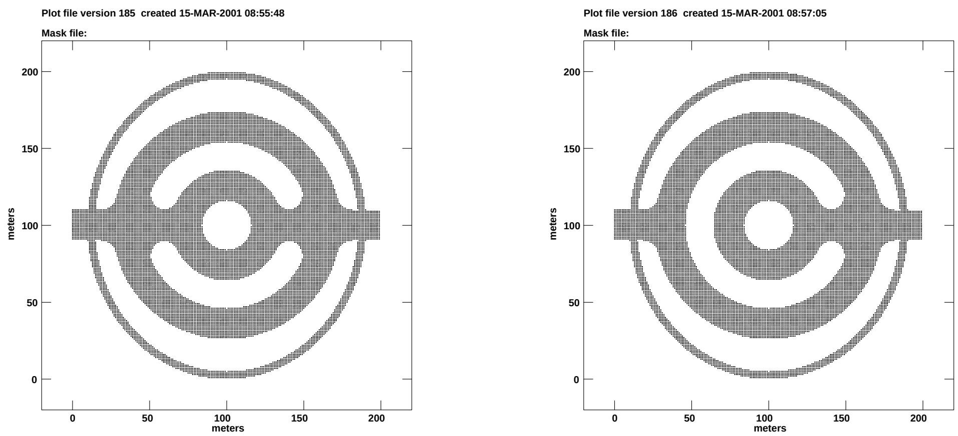

Figure 1: Examples of the roads with two radius. Only one radius goes to the inner circle at the right plot. That saves some room for antennas but complicates the driving. The width of the roads is 20m. The radius of the turns is 10m. The outside ellipse is not a road but a boundary that make antennas stay inside of the ellipse to make the configuration elongated at the N-S direction.

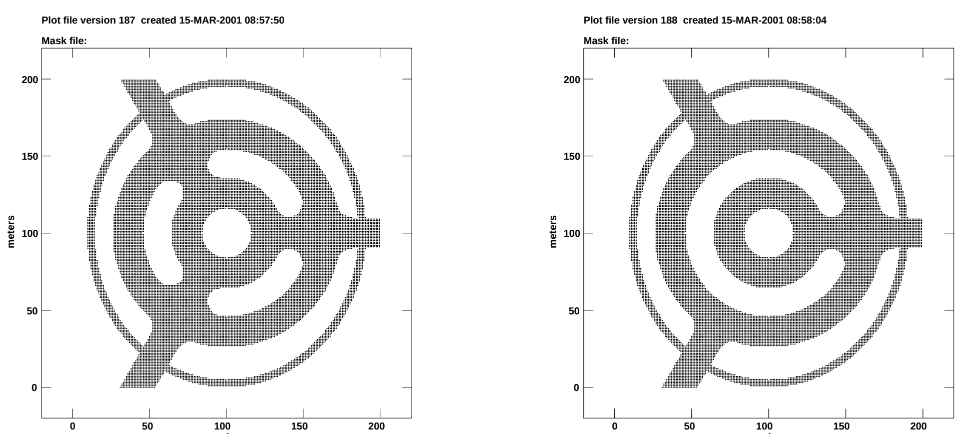

Figure 2: Examples of the roads with three radius. Only one radius goes to the inner circle at the right plot. That saves some room for antennas but complicates the driving. The width of the roads is 20m. The radius of the turns is 10m. The outside ellipse is not a road but a boundary that make antennas stay inside of the ellipse to make the configuration elongated at the N-S direction.

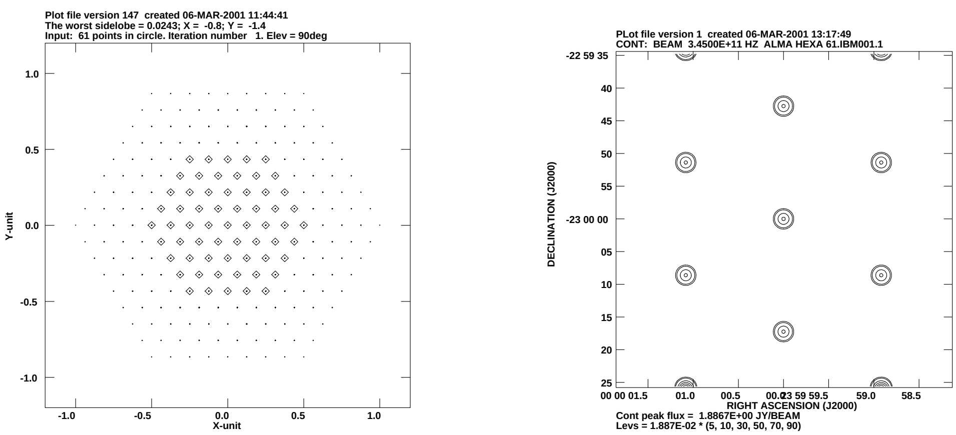

Figure 3: The hexagon tile configuration with 61 antennas at the left plot and its beam pattern at the right plot. The beam pattern shows 100% grating side lobes.

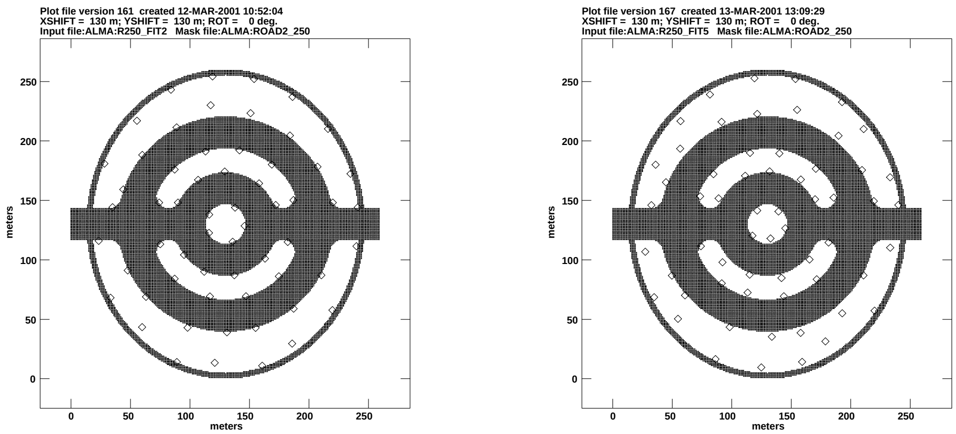

Figure 4: The configuration with the road width 27m. The maximum size of the configuration is 250m. The inner circle includes 5 antennas. All antennas can be reached by a transporter without stop of the observation. The configuration is 10%elongated at the N-S direction. The relevant optimization of the side lobe is carried out for the nearest side lobes (the left plots; side lobes ~ 0.009) and for the total area of the primary beam (the right plot; side lobes ~ 0.048)

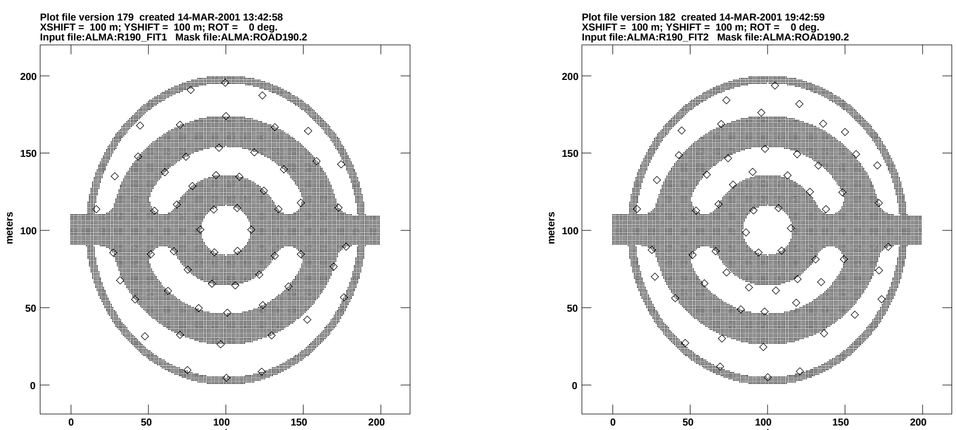

Figure 5: The configuration with the road width 20m. The maximum size of the configuration is 190m. The inner circle includes 6 antennas. Some antennas which the transporter passes by have to stop the observation. The configuration is 10%elongated at the N-S direction. The relevant optimization of the side lobe is carried out for the nearest side lobes (the left plots; side lobes ~ 0.01) and for the total area of the primary beam (the right plot; side lobes ~ 0.052)