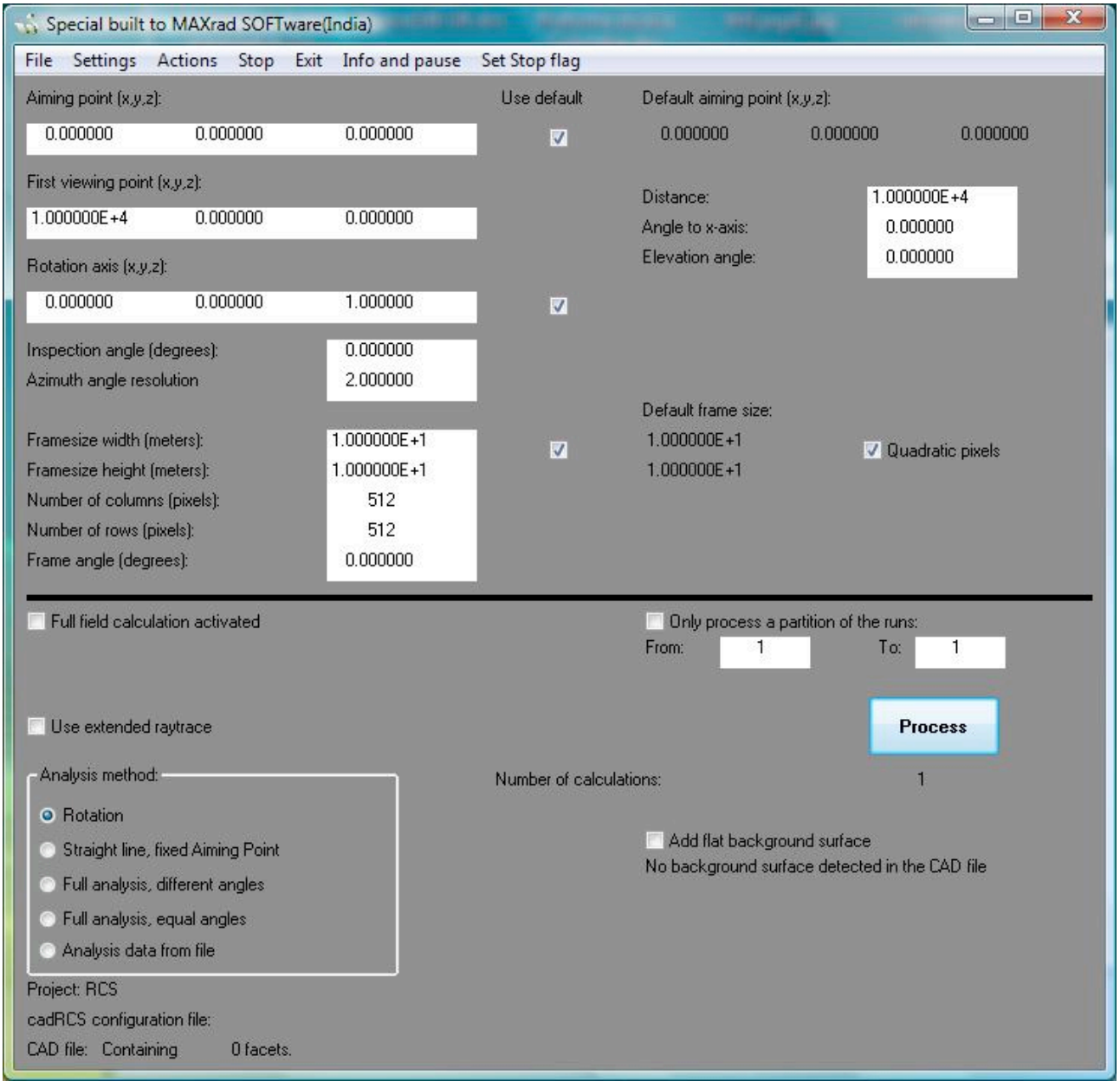
Example running cadRCS adding RAM material on a ship.

Step1 – identifying the Hot Spots.

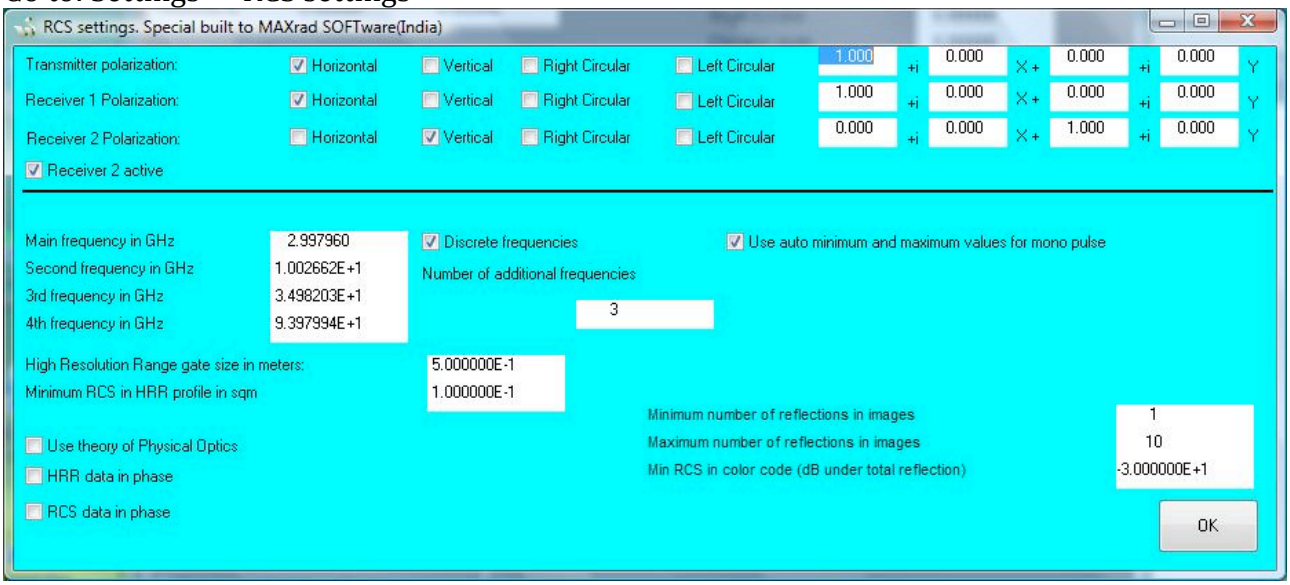
Start cadRCS and accept the license agreement.



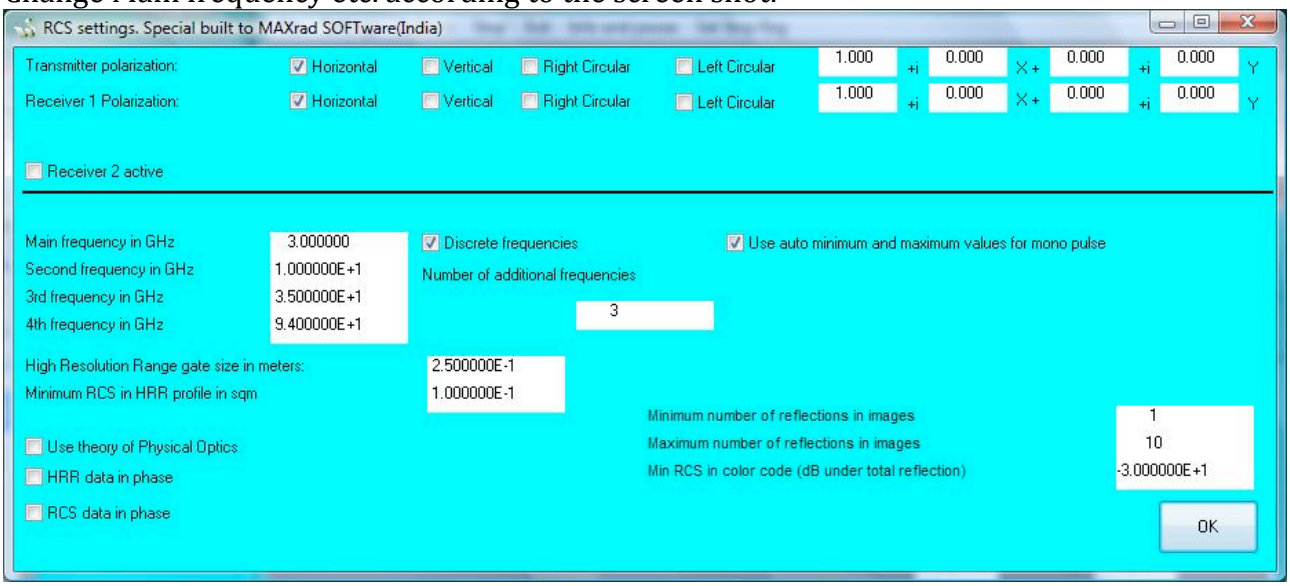
Go to: File -> Project name and working directory
Choose a directory where to save the project and a project name “Kronsort” and click “Save”.
Go to: File -> Open CAD file
Enter the CAD file of the object you want to calculate the RCS of here: “Kronsortstart.bna”

You can download the cad file at:
http://www.cadrcs.com/Downloads/Kronsort/ Kronsortstart.zip
Important the CAD file must be in meters, there are no indication in the file what the unit are!
Go to: Settings -> Change CAD position etc.
Select the option -> Move object so default aiming point = (0,0,0)
Then close the window “Change CAD position etc.”
On the main menu change the “Inspection angle (degrees): ” to 360.0 and “Azimuth angle resolution” to 1.0.
On the main menu select “Quadratic pixels”.

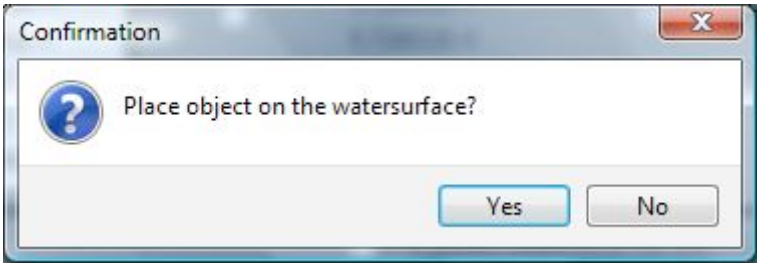
Go to: Settings -> RCS settings



Unselect “Receiver 2 active”
Change Main frequency etc. according to the screen shot:

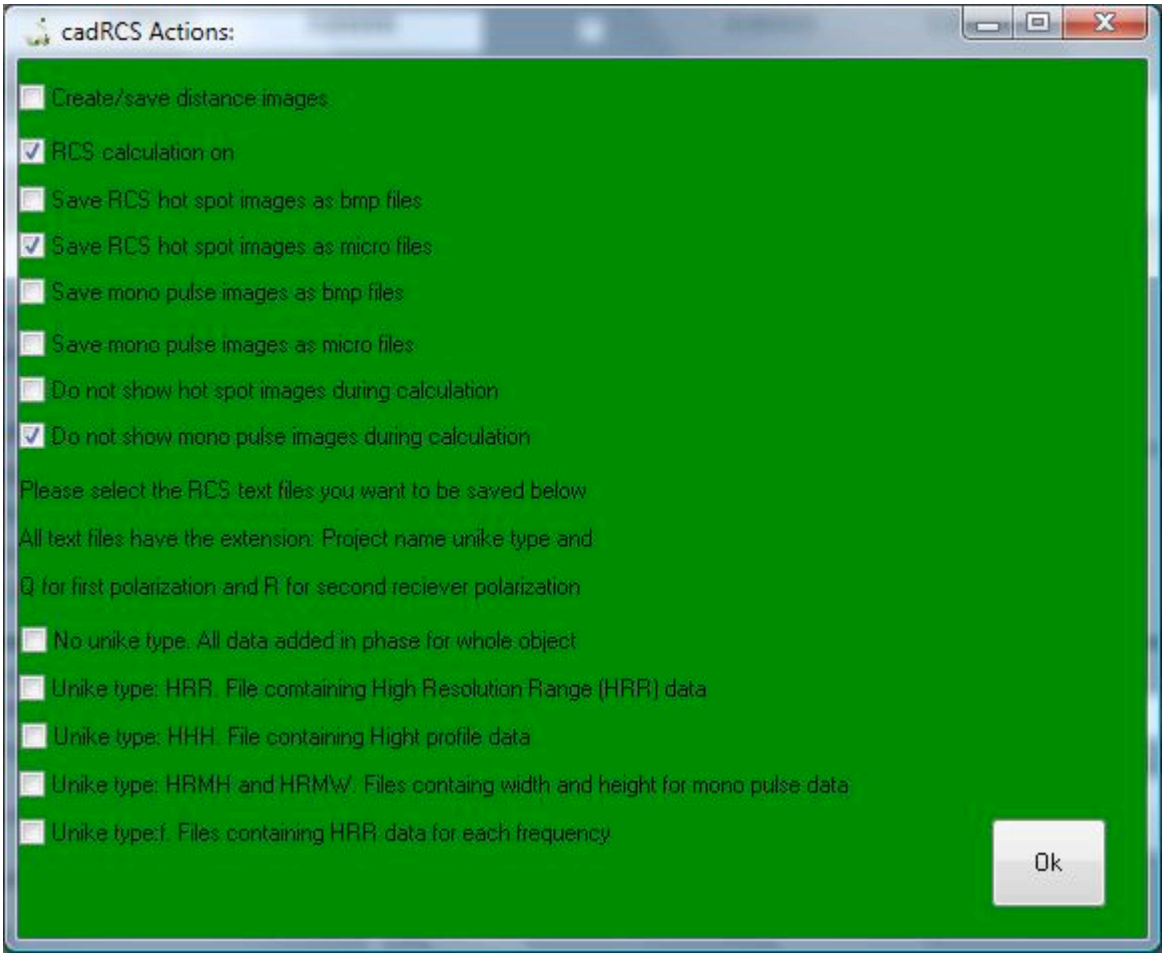


And push “OK”
On the main menu select: “Add flat background surface”



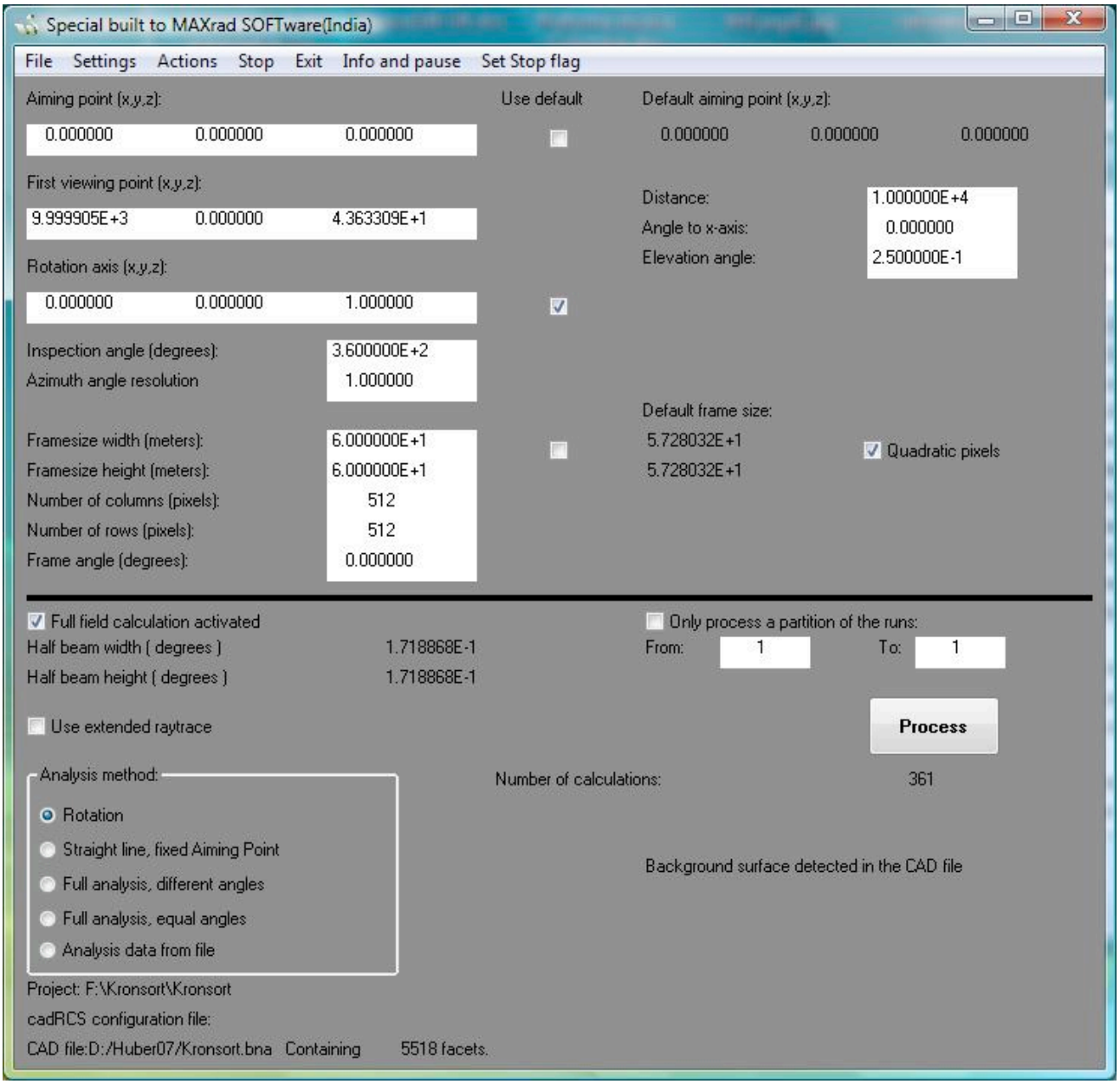
As this model are modelled without the part going under the water, then answer Yes to the question: “Place object on the watersurface?”

On the main menu change the “Framesize” to 60x60 meters.
On the main menu change the “Elevation angle:” to 0.25
Go to: Actions
On the menu:



Select “RCS calculation on”, “Save RCS hot spot images as micro files” and “Do not show mono pulse images during calculation.
And push “Ok”.

On the main menu select “Full field calculation activated”.
Then the main menu looks like this:

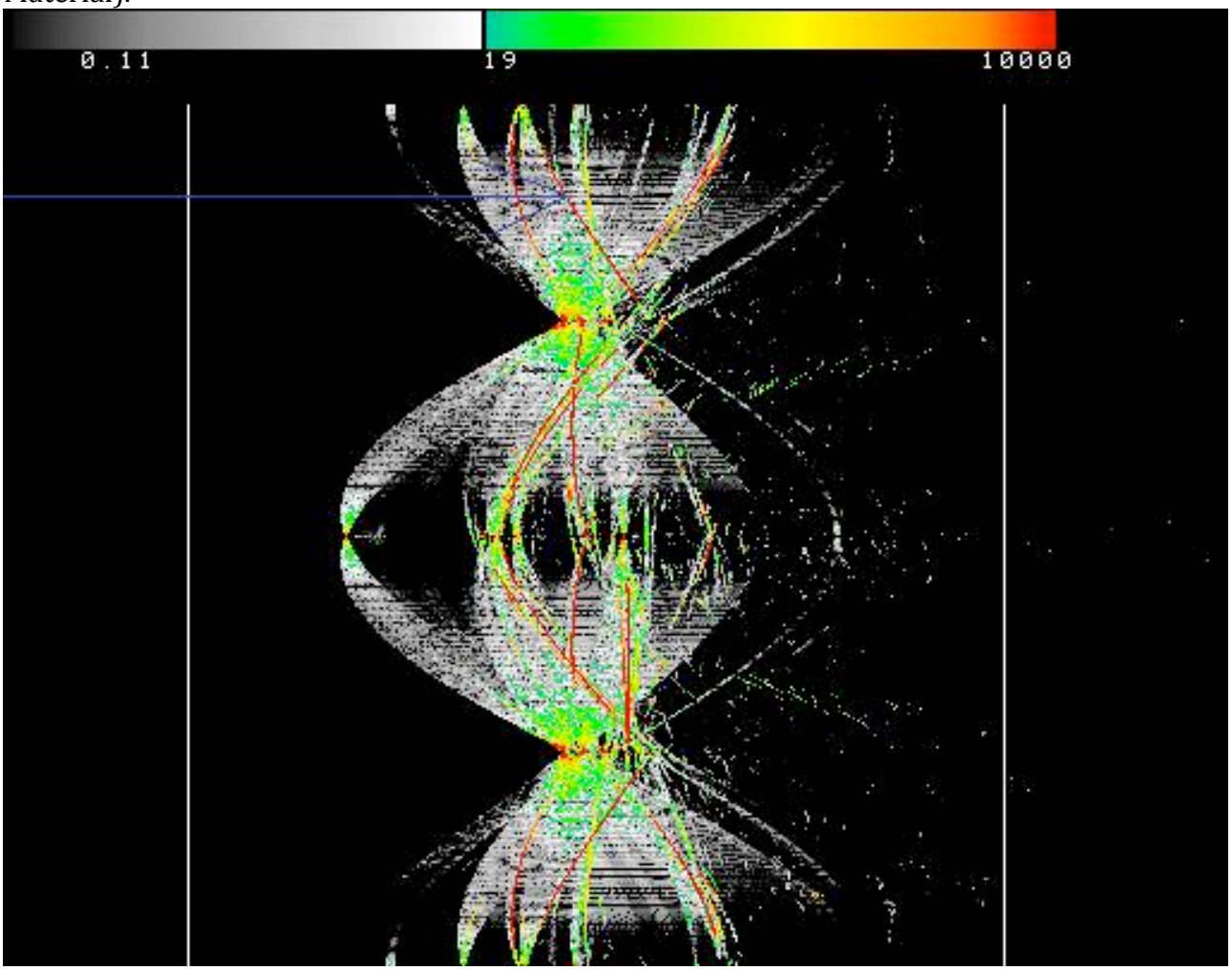


On the main menu push “Process”

Then select “Save” on the menu “saving current setup”.

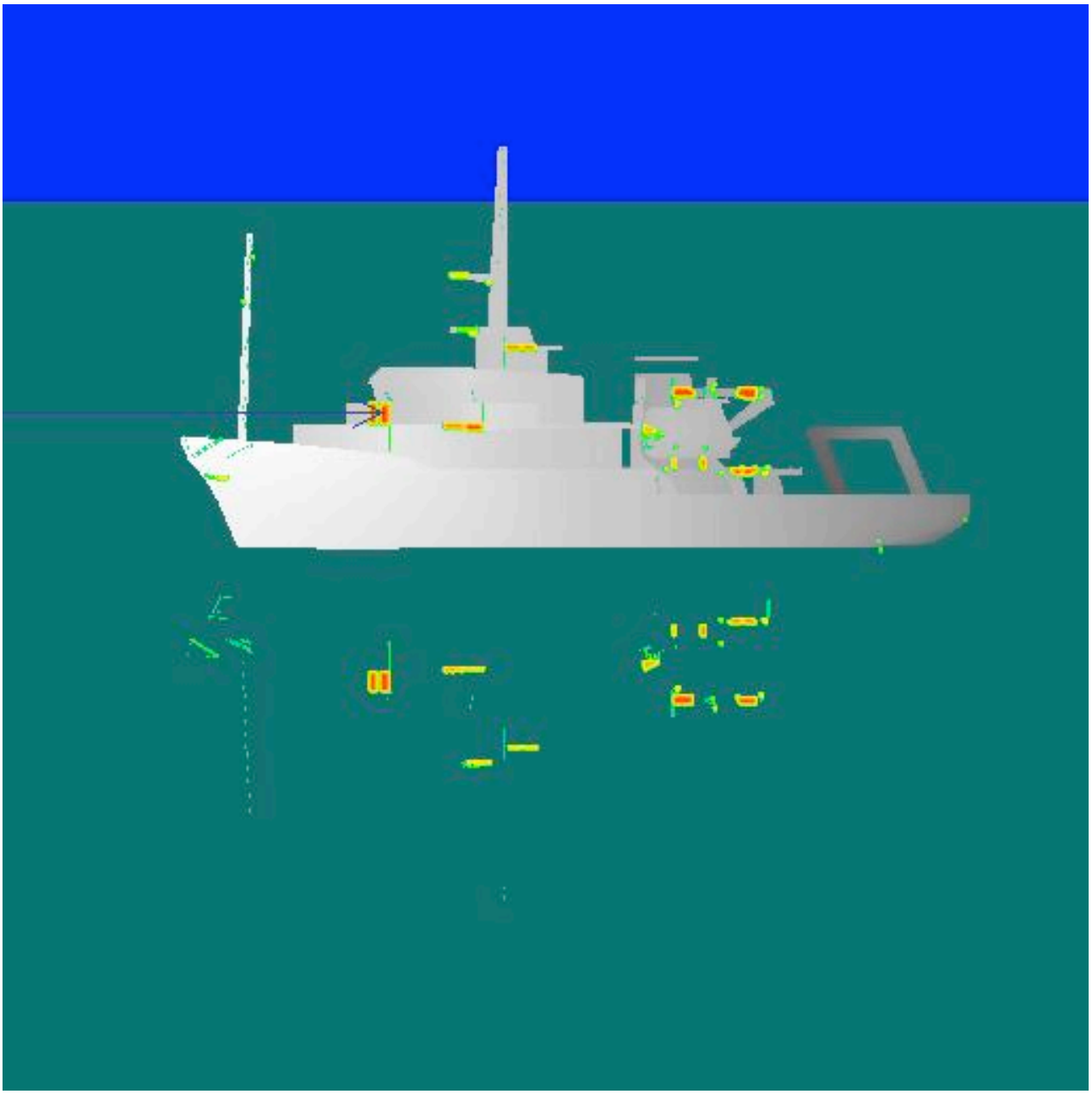
Now the calculation starts and you need to wait for it to finish.
You can see an estimate of the time needed for the calculation when cadRCS is running.
It is possible to pause the calculation in a soft way, so you can restart the calculation again from the point, where you stopped it; in that case push “Set Stop flag” once and wait for cadRCS to stop calculating and after the calculation stops you can close cadRCS. When restarting you need to go to Settings -> Import settings and choose the ini file created when the last calculation was stopped.

After finishing you close cadRCS and start movie and select all *.mic files.
In movie then push the button “Pack micro files”.
The resulting *.pmi file we then use for analyses of the calculated data.
You can download the pmi file at:
http://www.cadrcs.com/Downloads/Kronsort/ Kronsort.zip
When analysing the data it is decided to cover a part in the front with multiple reflections. Multiple reflections will give a line in the HRR (High Resolution Range Profile) plot, below you can see the blue arrow pointing at the part we want to cover with RAM (Radar Absorbing Material).



The plot is from movie showing the HRR results for 10 GHz.

By analysing the Hot Spot images with movie we find the area on the ship giving the reflection we want to cover:

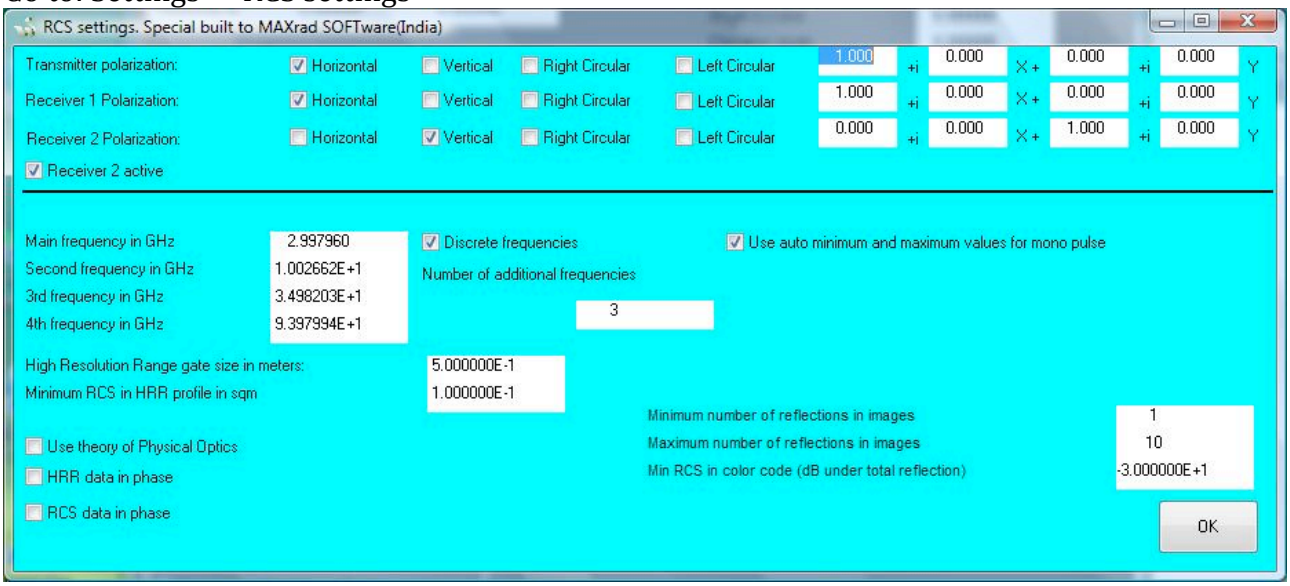


The Hot Spot image is from an azimuth angle at 45 degrees.

Step2 – covering the first Hot Spot.

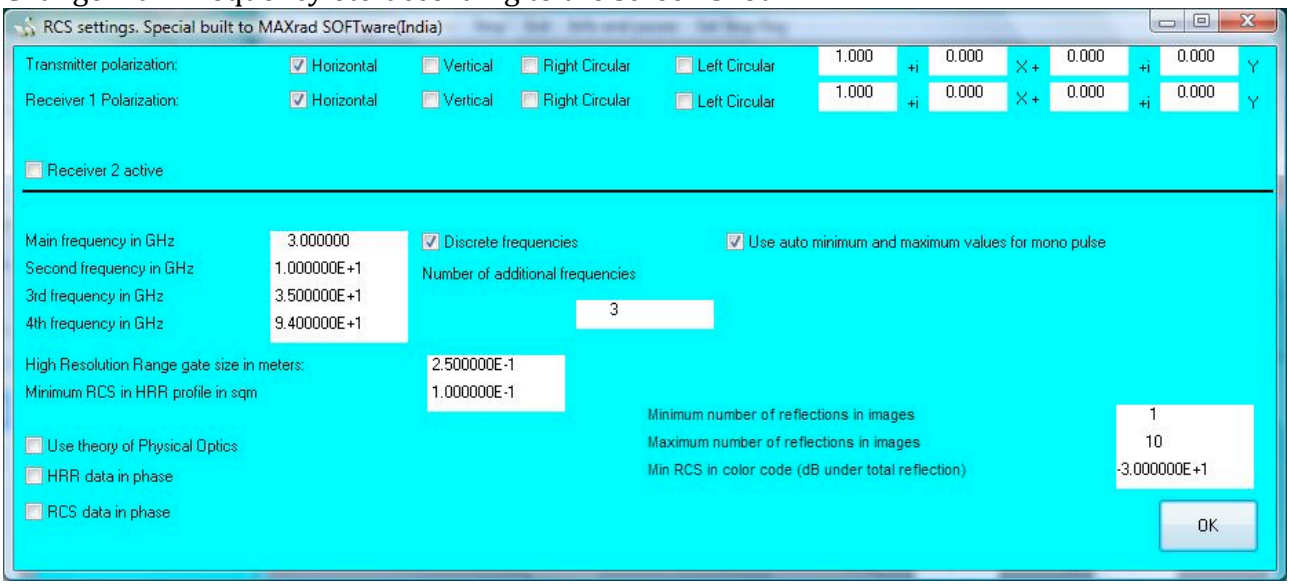
Then we start cadRCS again and do the following steps:
Go to: File -> Project name and working directory
Choose a directory where to save the new project and a project name “Kronsort” and click “Save”.
Go to: File -> Open CAD file
Enter the original CAD file from before: “Kronsortstart.bna”
Go to: Settings -> Change CAD position etc.
Select the option -> Move object so default aiming point = (0,0,0)
Then close the window “Change CAD position etc.”
On the main menu change the “Inspection angle (degrees): ” to 360.0 and “Azimuth angle resolution” to 1.0.
On the main menu select “Quadratic pixels”.

Go to: Settings -> RCS settings



Unselect “Receiver 2 active”

Change Main frequency etc. according to the screen shot:



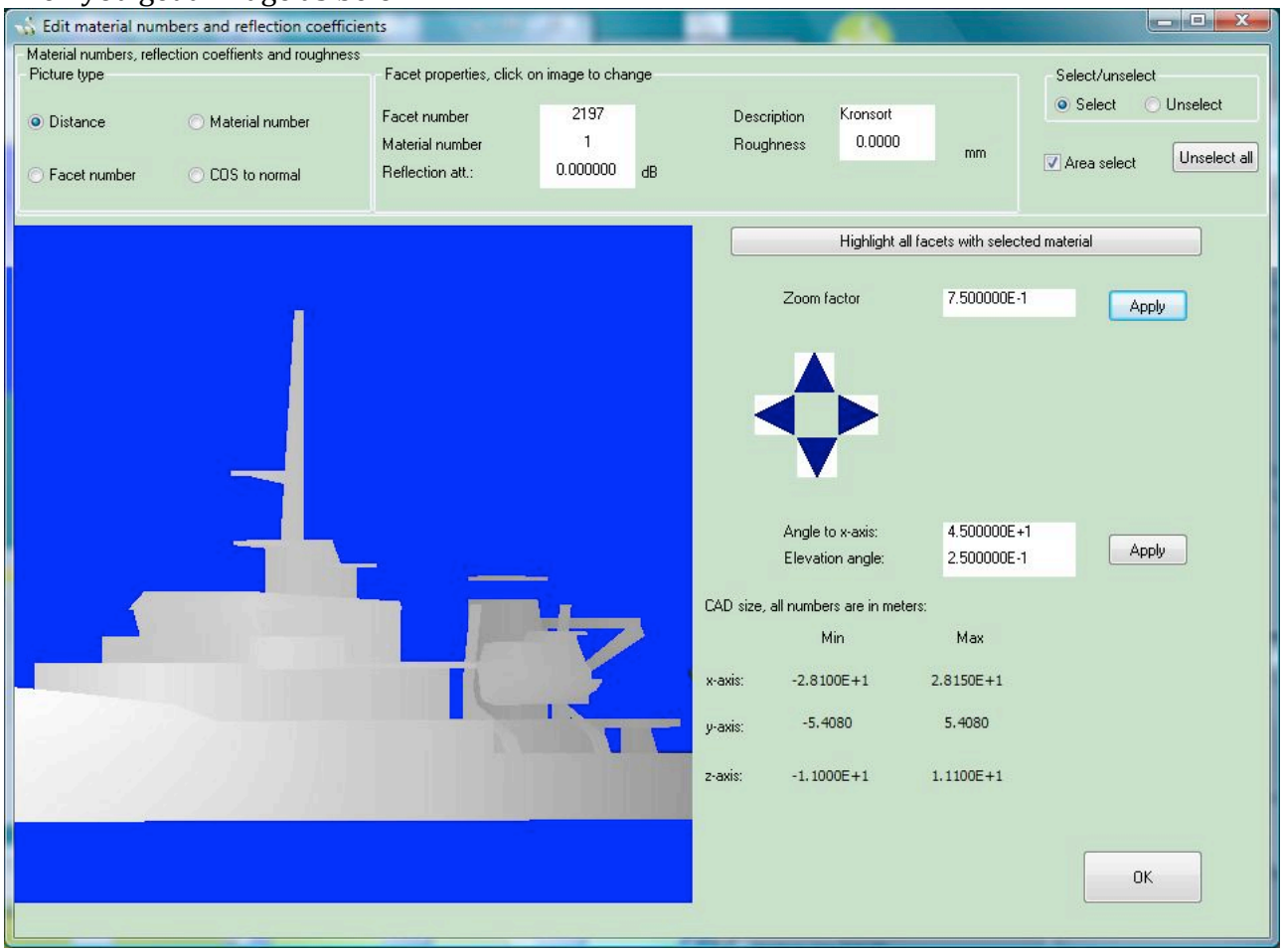
And push “OK”

Go to: Settings -> Show image to edit material numbers etc.

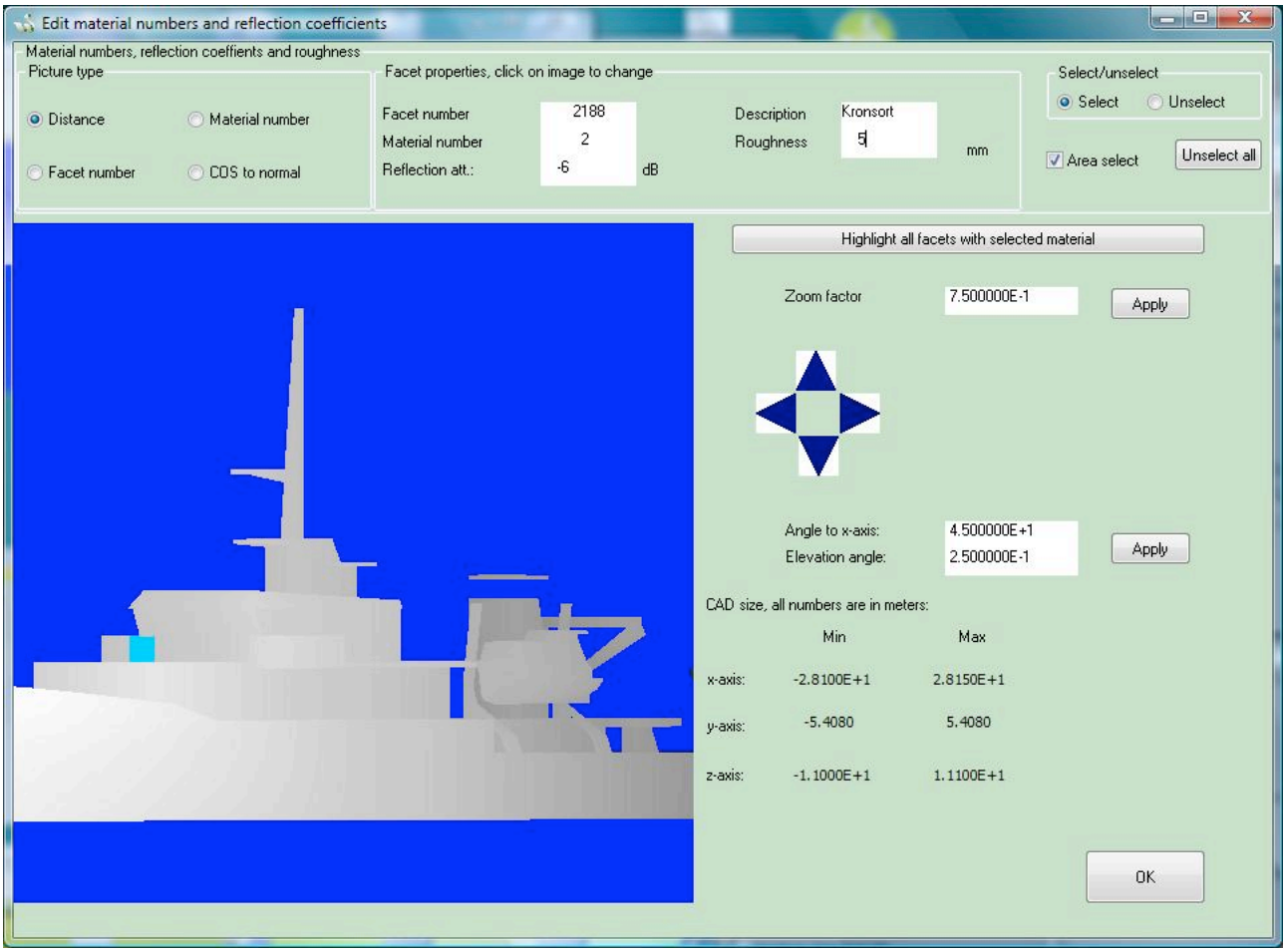
Change Zoom factor to 0.75 and Apply. The zoom factor to get the image below can be another due to different settings when importing the CAD file. Then just change zoom factor as you wish.

Change Angle to x-axis to 45.0 and Elevation angle to 0.25 and Apply.

Then you get a image as below:

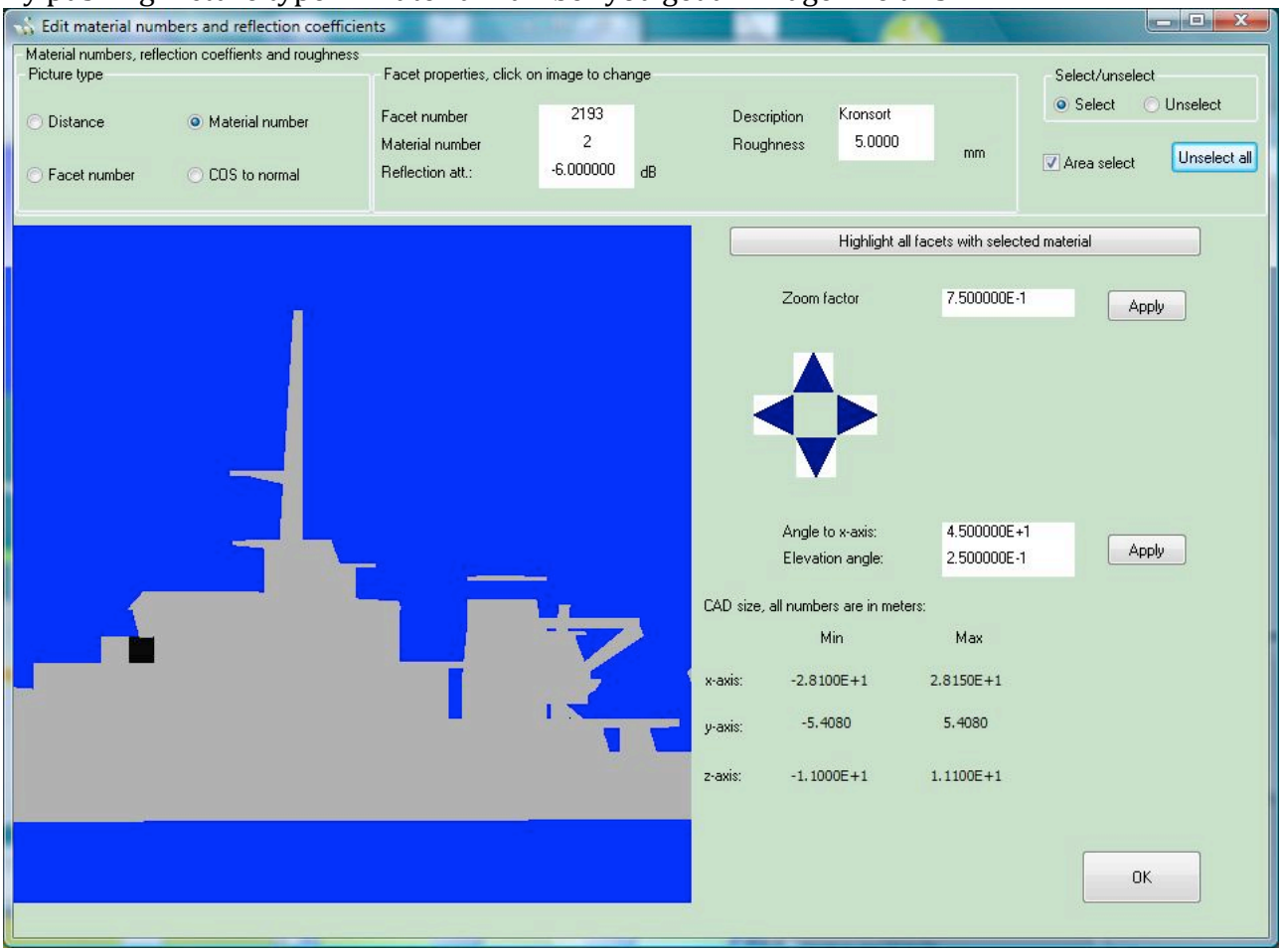


When comparing with the Hot Spot image from before the area to cover with RAM are identified and then select it with mouse click:



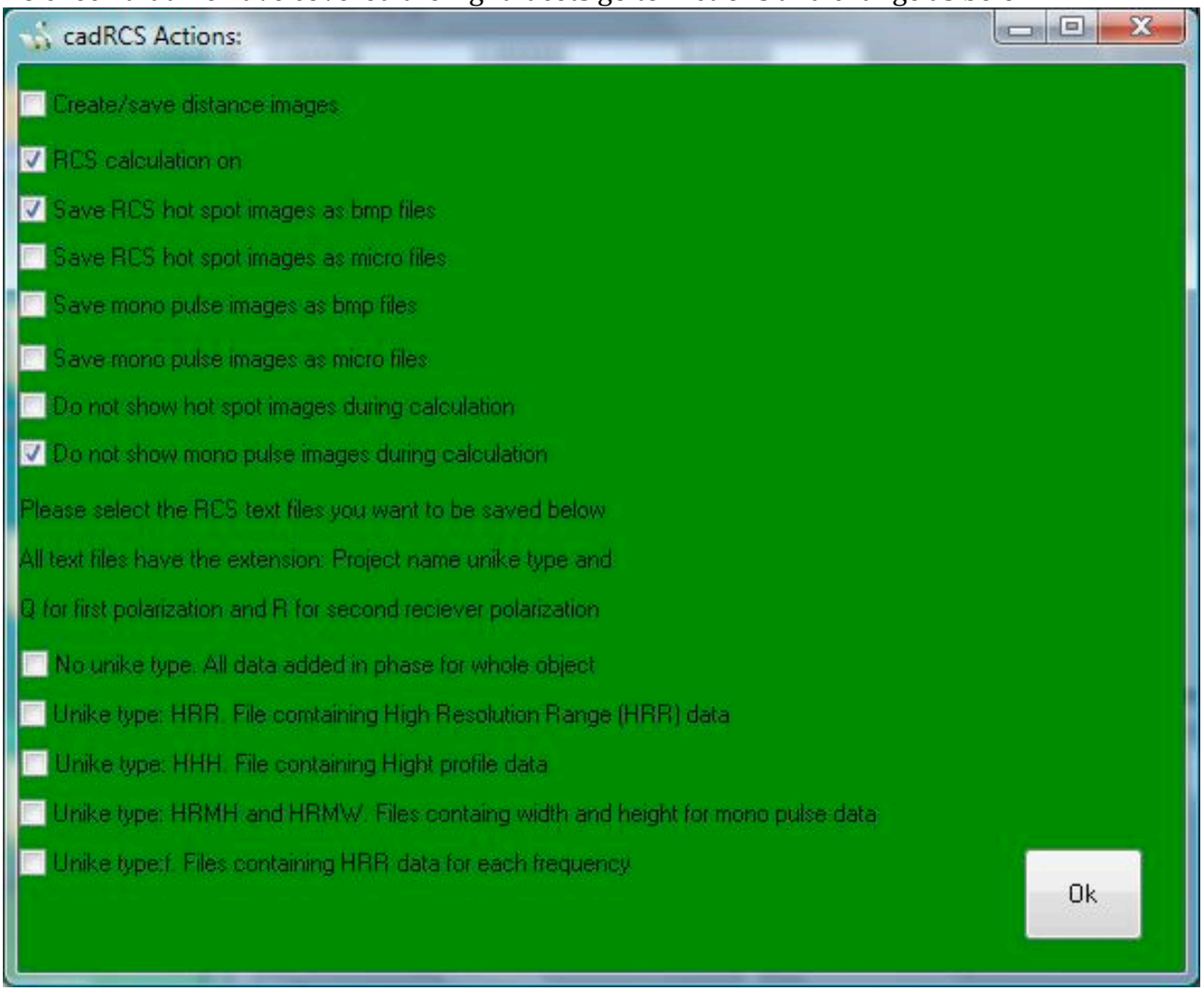
Then change Material number to 2 and Reflection att.: to -6 and Roughness to 5.
This RAM material is a special RAM paint developed for ships, it is a two component plastic paint with metalized glass fibres and the attenuation and roughness parameters are from measurements.
Then push OK.
To check that all facets we want to cover have changed to the new wanted material properties go to Settings -> Show image to edit material numbers etc.

By pushing Picture type -> Material number you get an image like this:

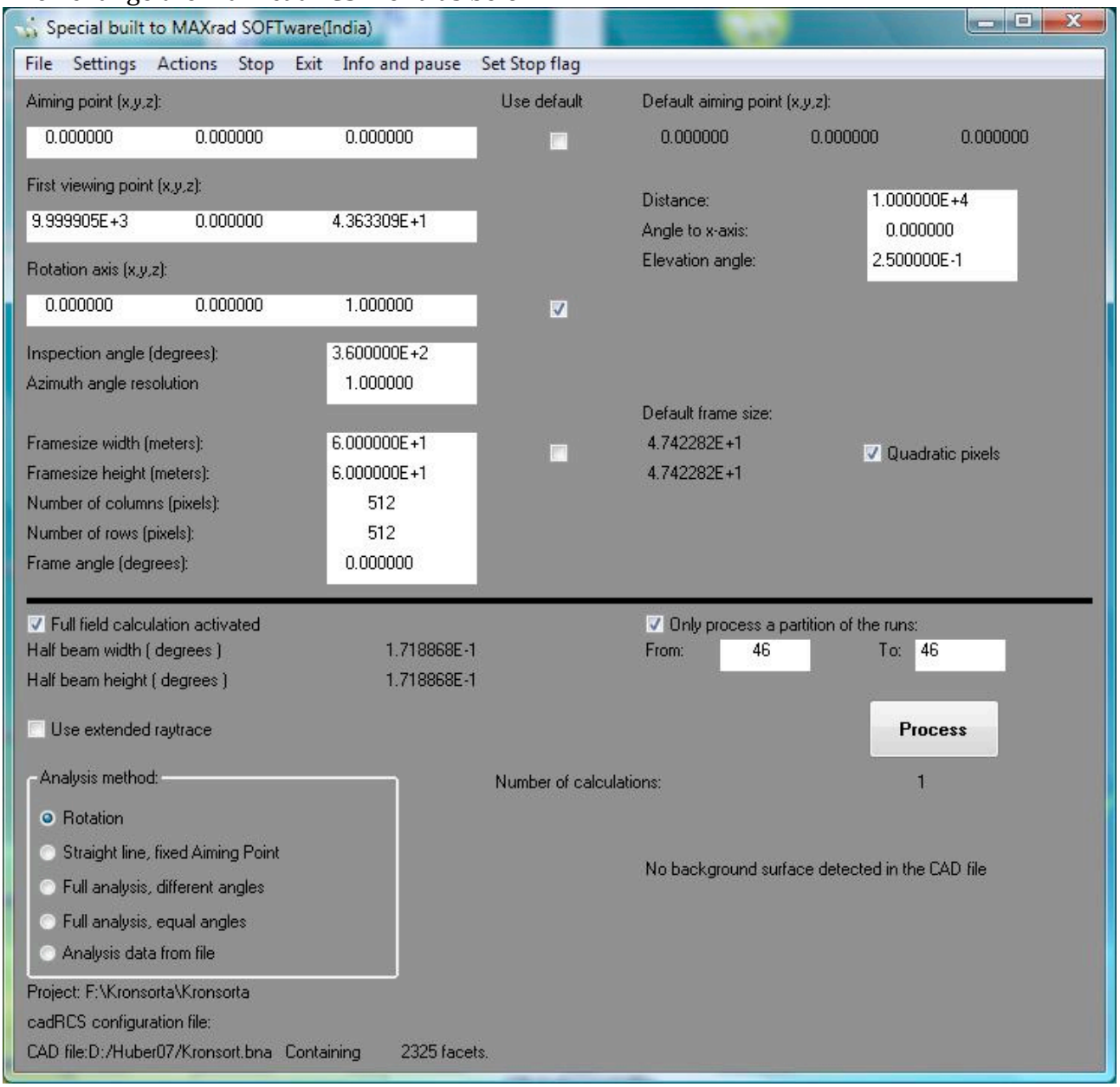


Zoom in on the black area using arrows and Zoom factor to check that all facets in this area have material number 2. Otherwise select them again and change the material number etc. as before. At the end push OK.

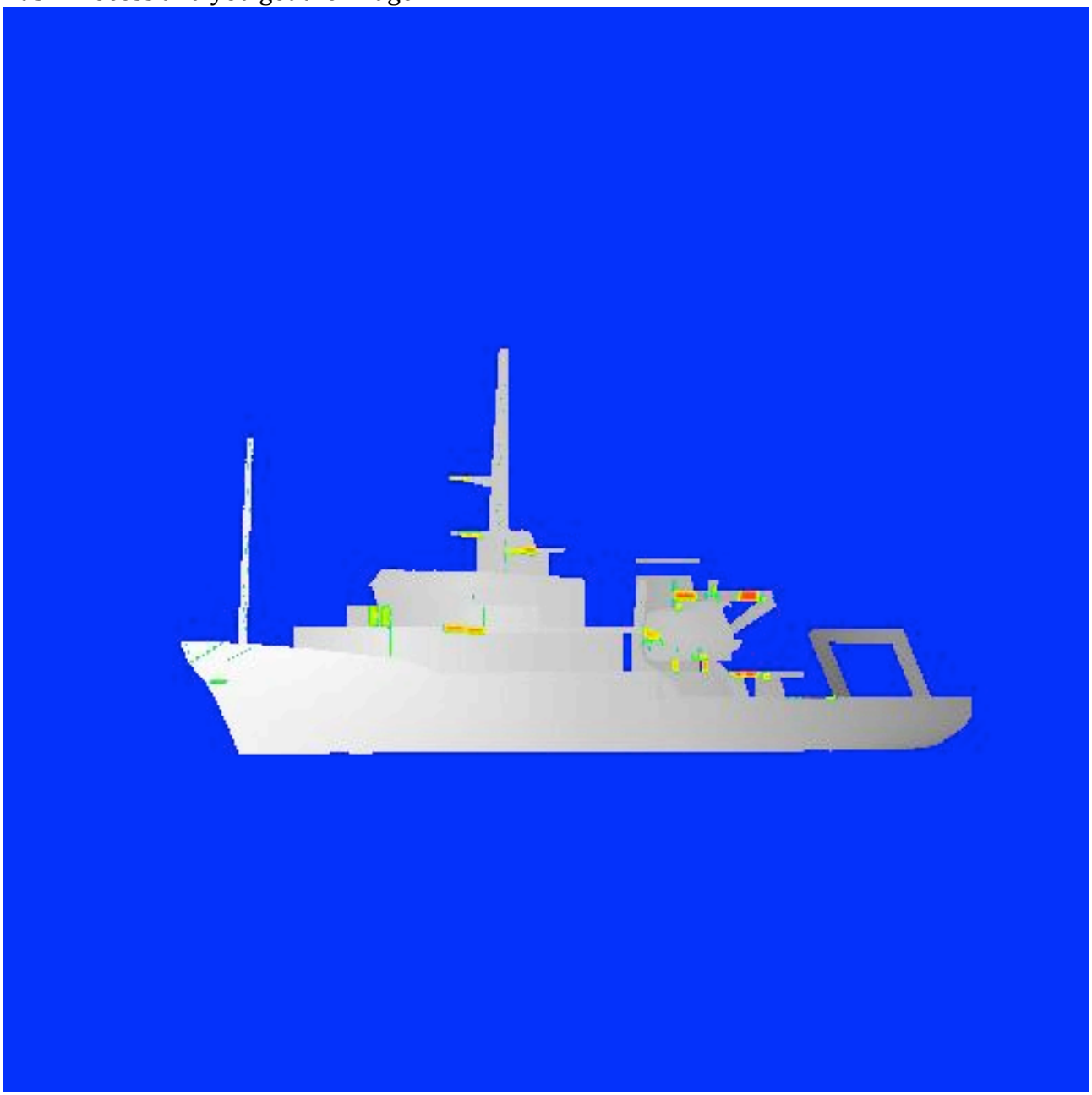
To check that we have covered the right facets go to: Actions and change as below:



Then change the main cadRCS menu as below:



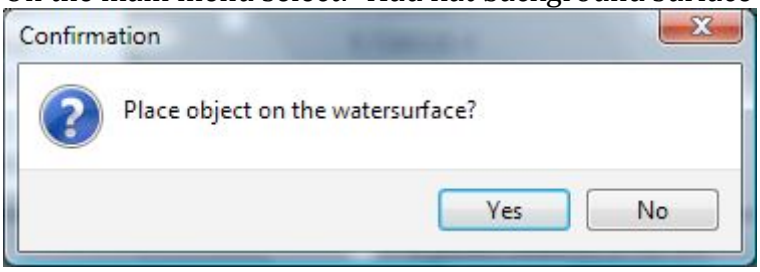
Push Process and you get the image:



When comparing with the Hot Spot image from movie you can see that we have covered the wanted area.
Then close cadRCS.

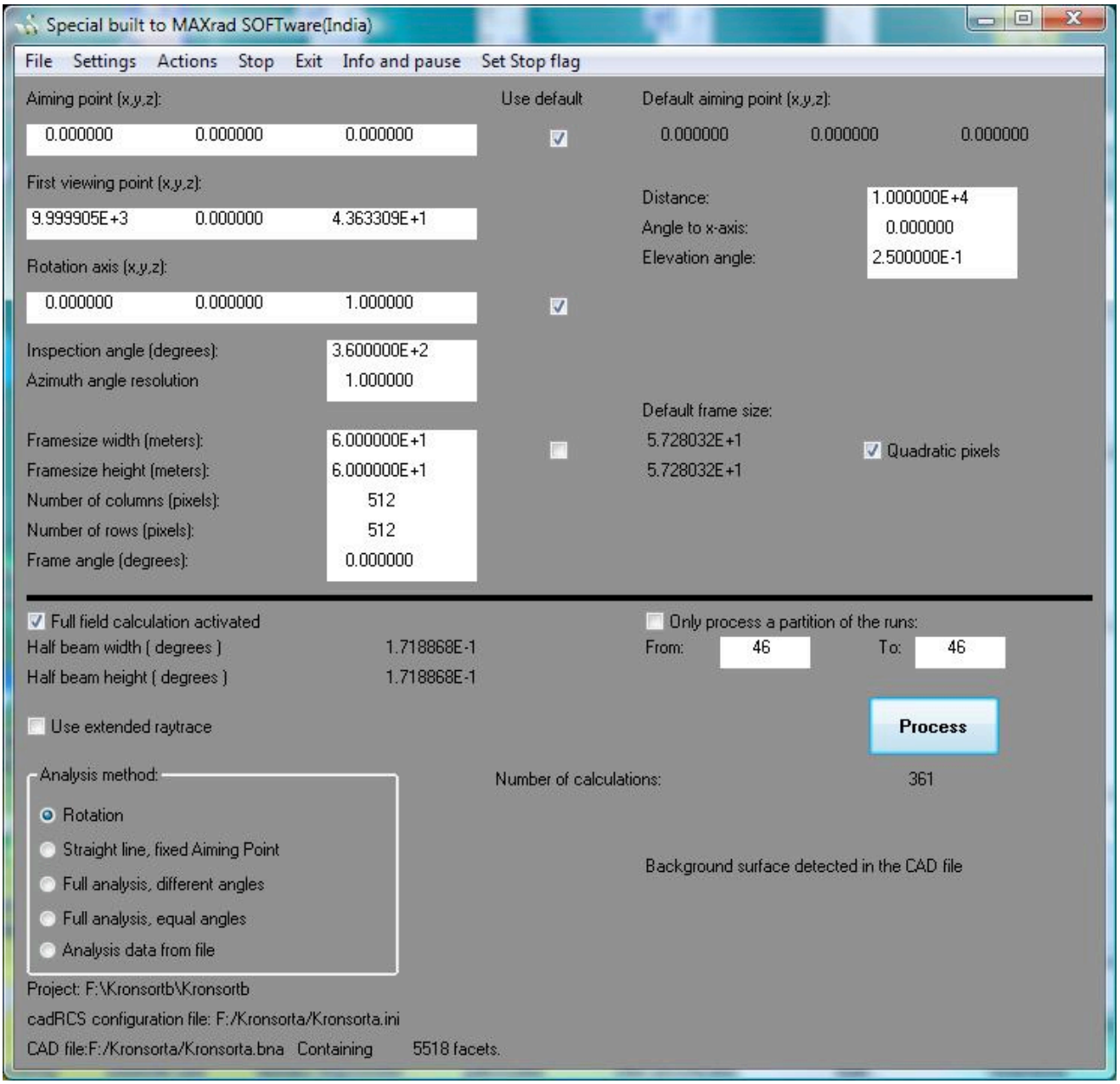
Step3 – check the result.

Start cadRCS again and go to: Settings -> Import settings and select the ini file from the last run. Then go to: File -> Project name and working directory and select a new directory and name.
On the main menu select: “Add flat background surface”



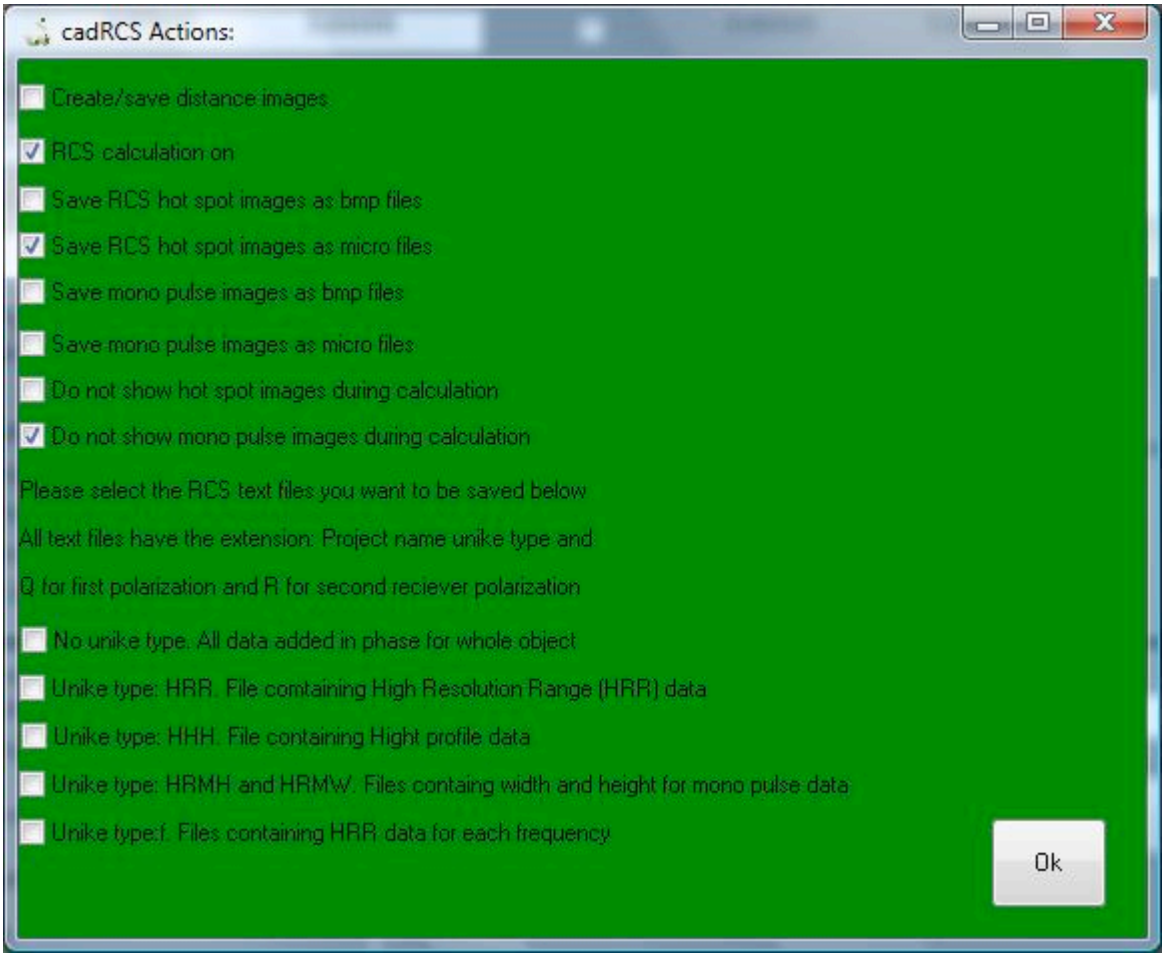
As this model are modelled without the part going under the water, then answer Yes to the question: “Place object on the watersurface?”

Then unselect “Only process a partition of the runs” and check the main menu with the following screen shot:



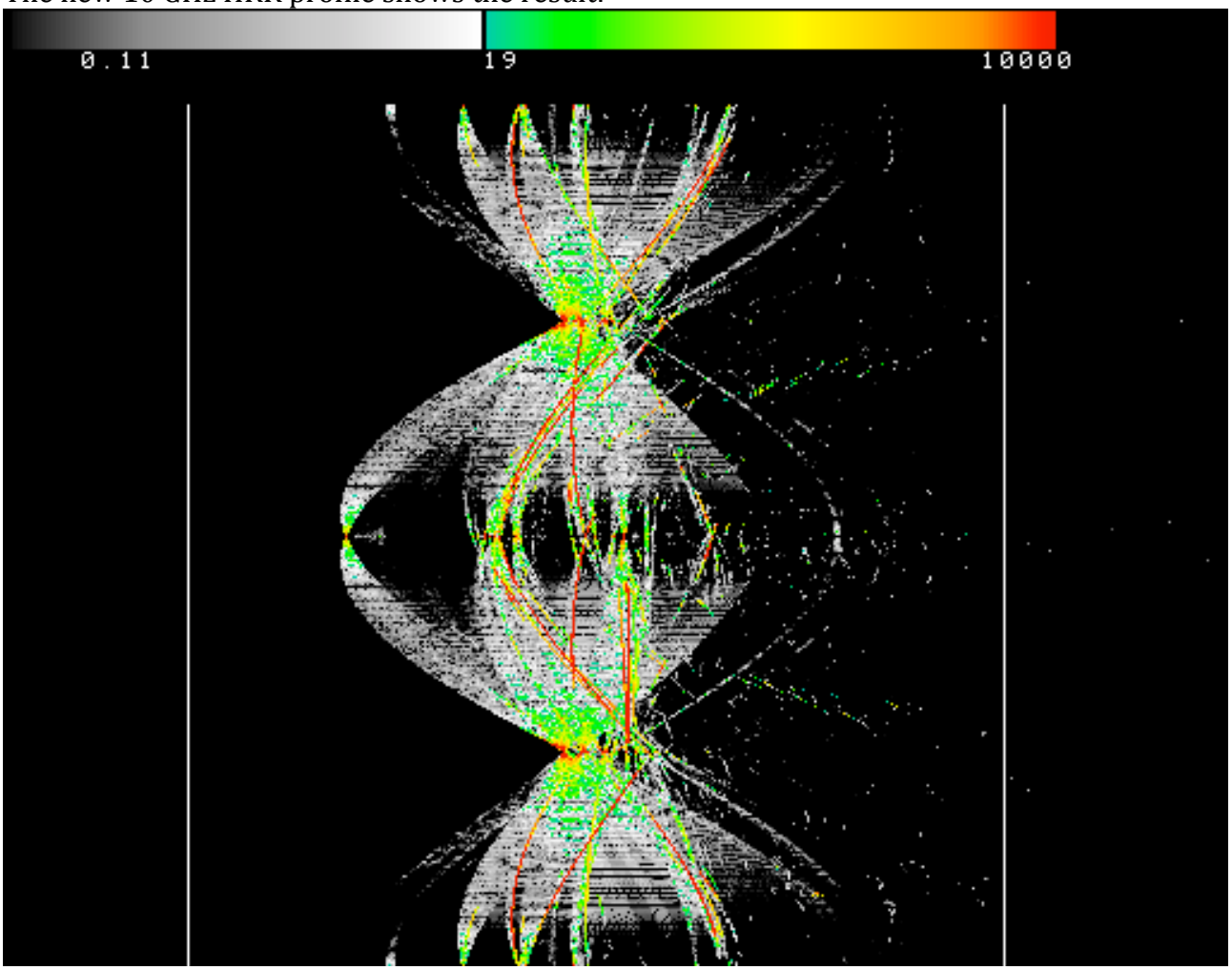
Go to: Actions

On the menu:

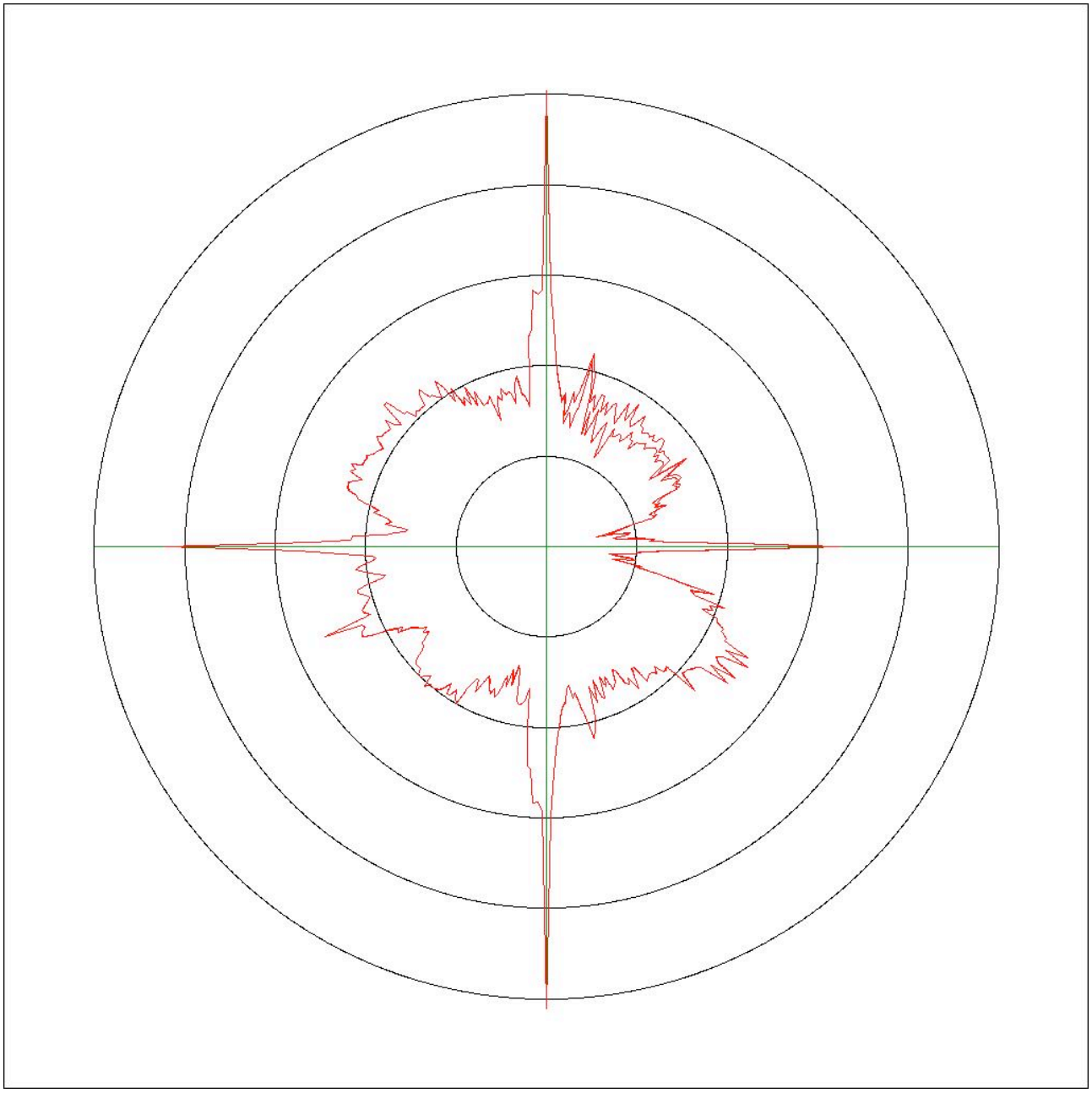


Select “RCS calculation on”, “Save RCS hot spot images as micro files” and “Do not show mono pulse images during calculation.
And push “Ok”.
Now push Process again on the main cadRCS menu and wait again a couple of hours for cadRCS to finish calculation.
After finishing you close cadRCS and start movie and select all *.mic files.
In movie then push the button “Pack micro files”.
The resulting *.pmi file we then use for analyses of the calculated data.
You can download the pmi file at:
http://www.cadrcs.com/Downloads/Kronsort/ Kronsorta.zip

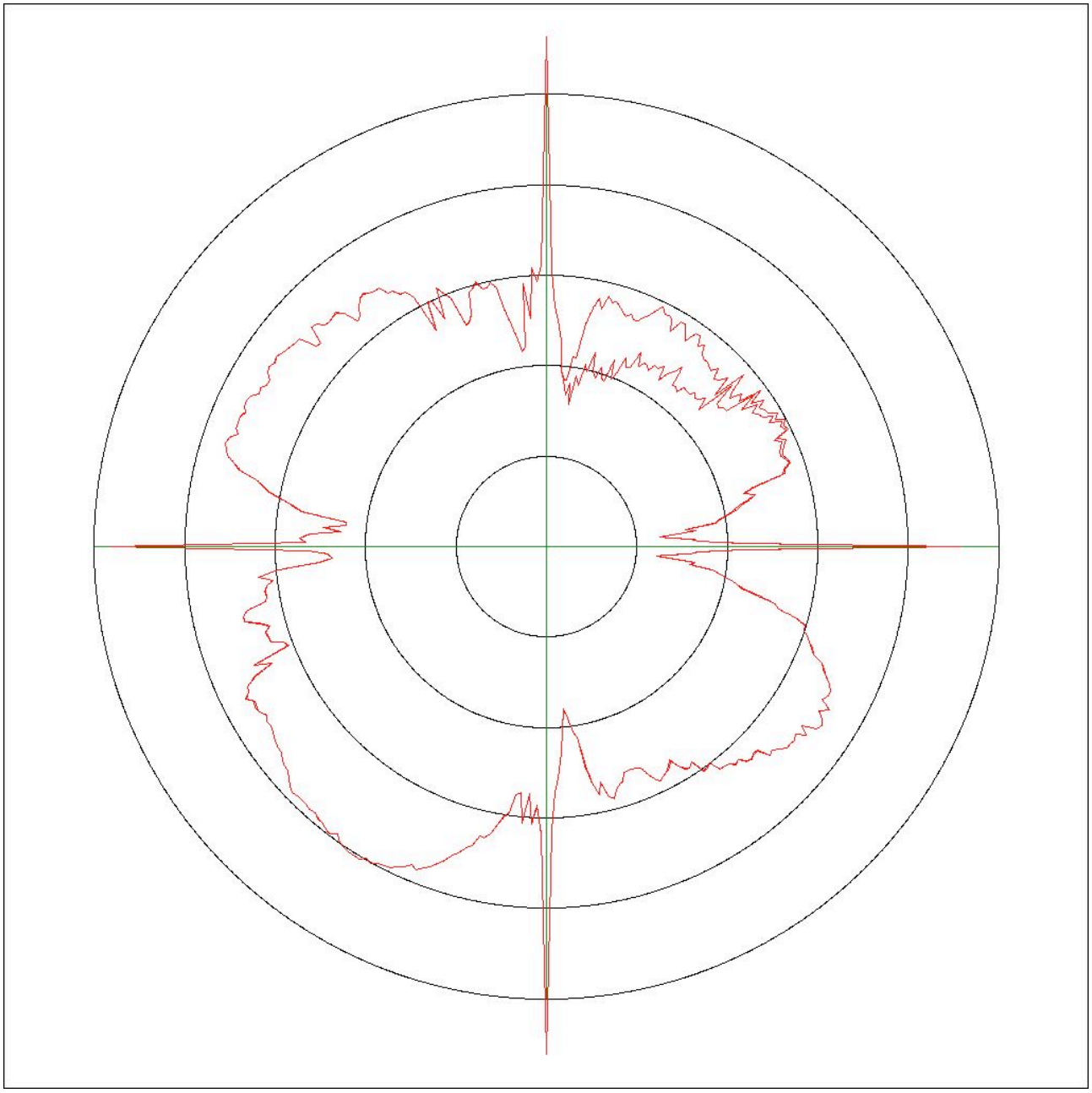
The new 10 GHz HRR profile shows the result:



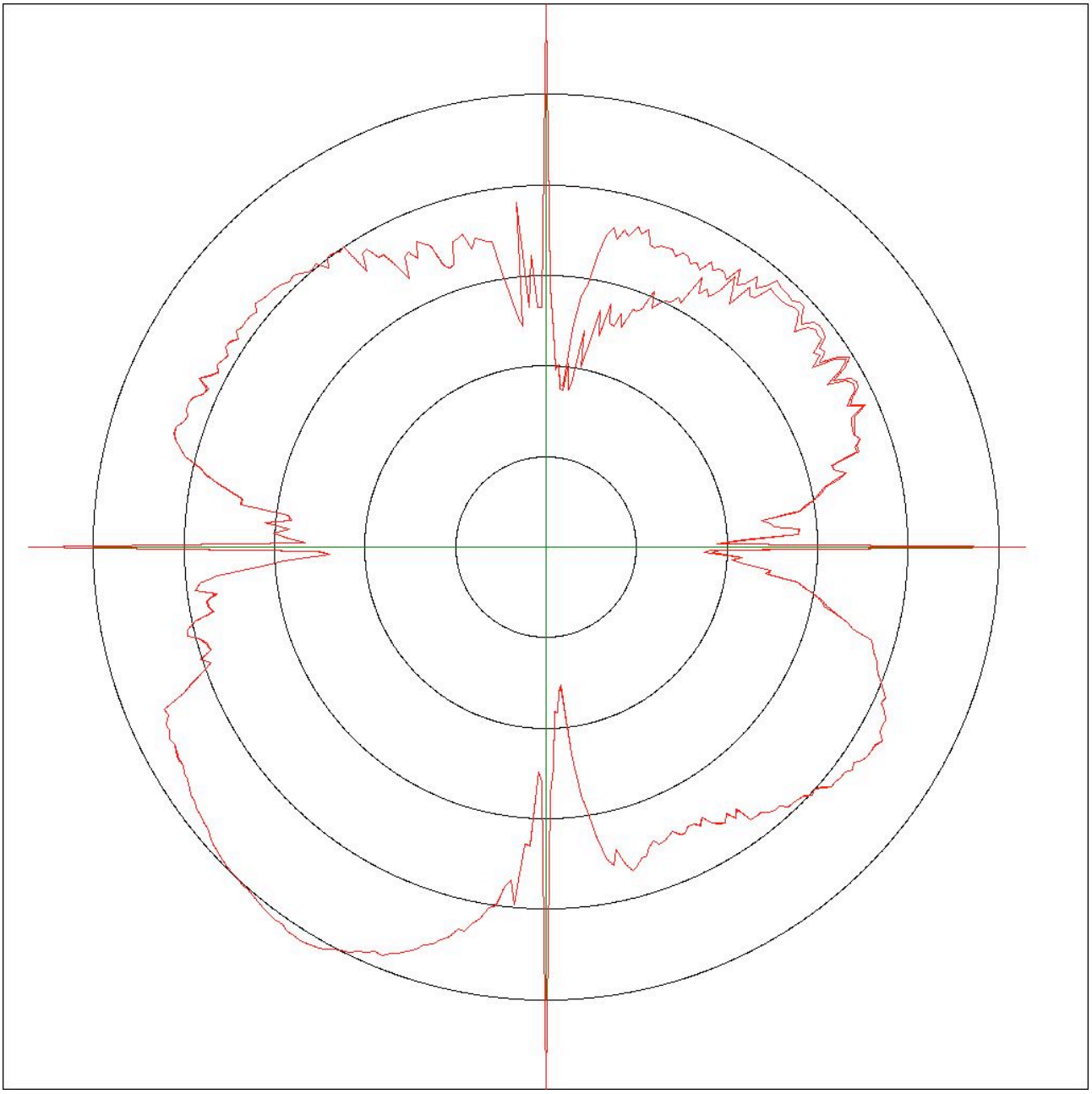
From both the first and second calculations with cadRCS without/with RAM we have the polar plots from movie, all plots are plotted as function of the azimuth angle and the data are the “Sum of range gates”. The centre value of all plots is 20 dBsqm and outer value is 70 dBsqm. The plots are put together to one plot for each frequency. The lower RCS in the first quadrant of the plots are the calculations with RAM.



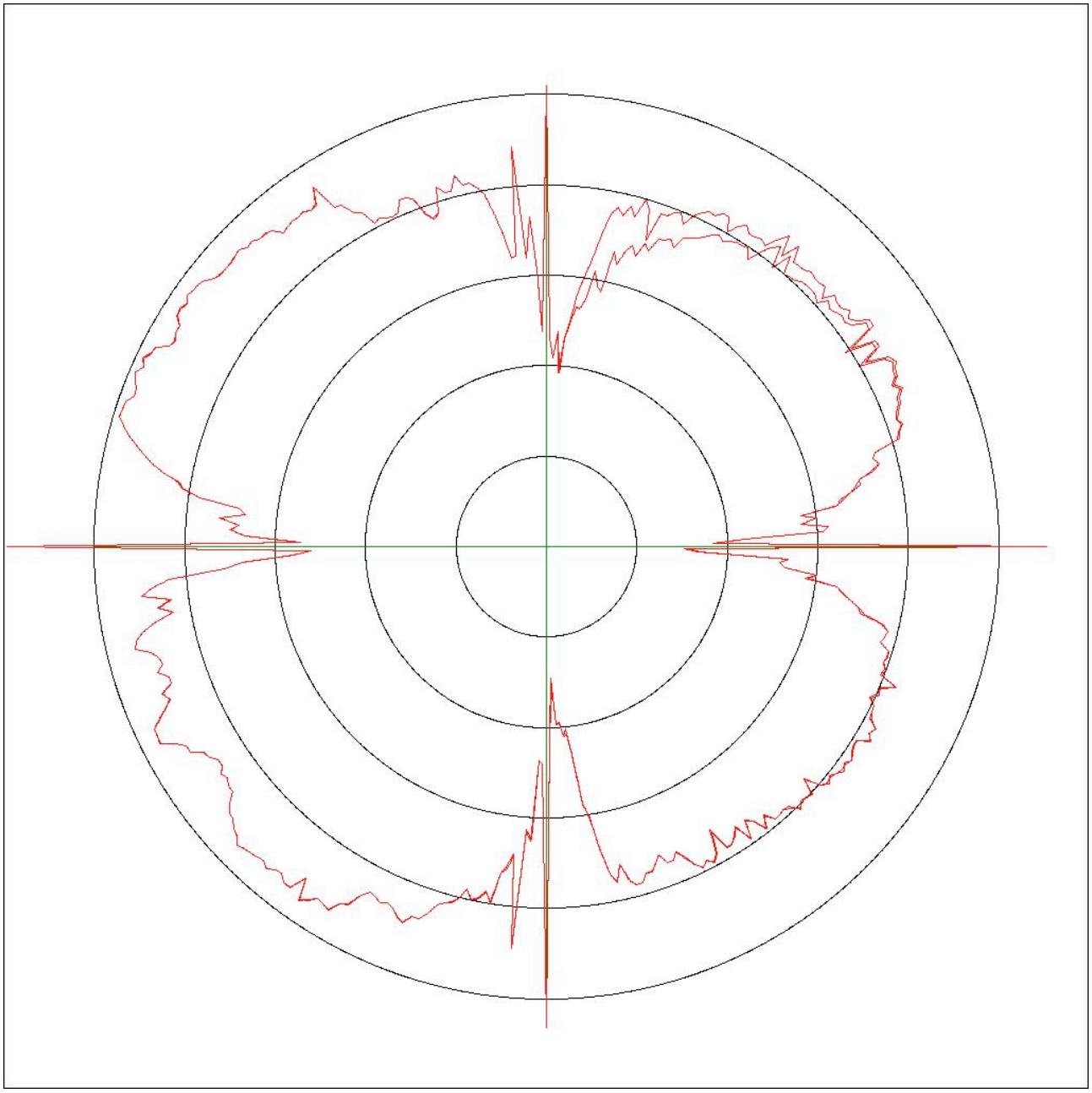
Above plot is 3 GHz.



Above plot is 10 GHz.



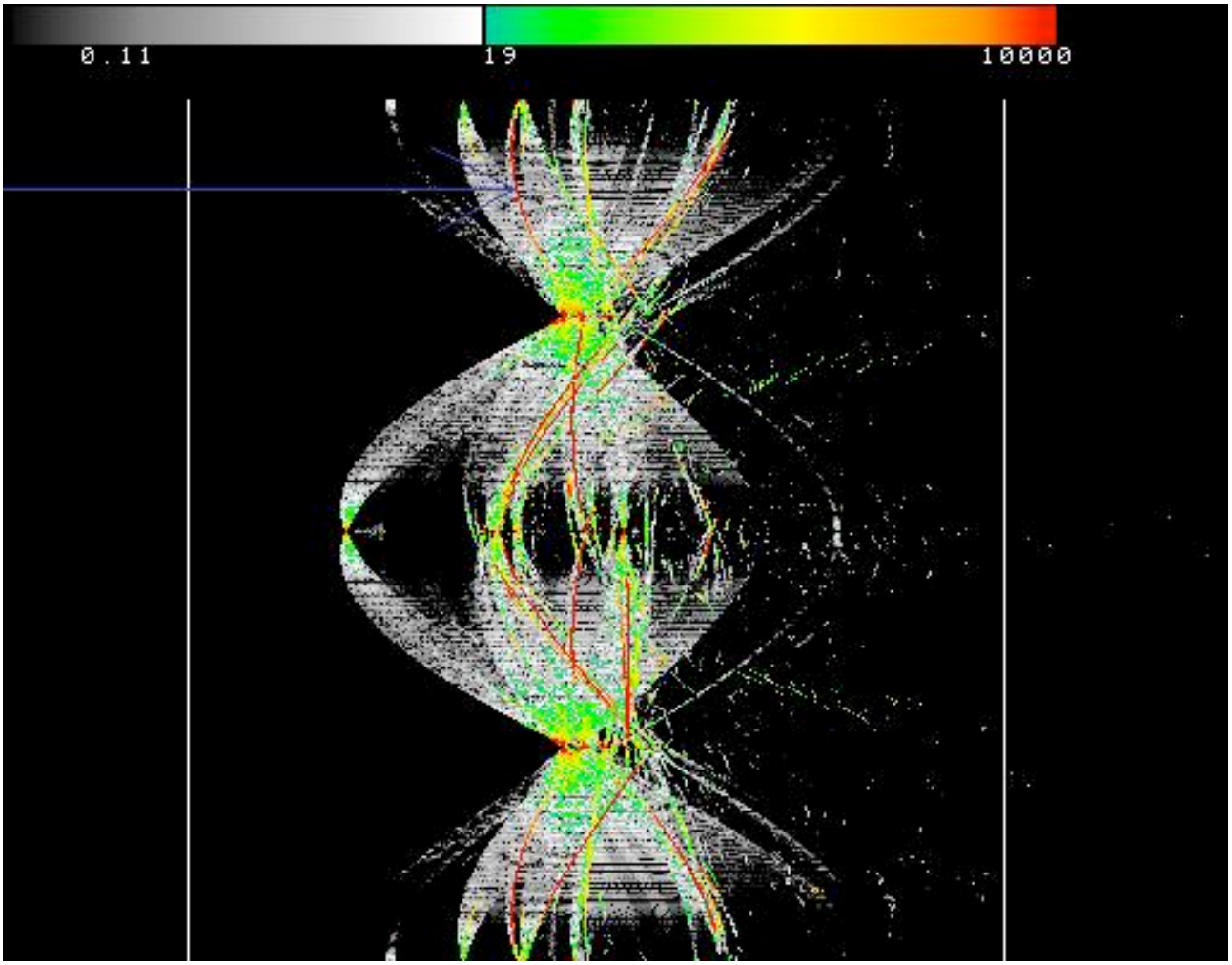
Above plot is 35 GHz.

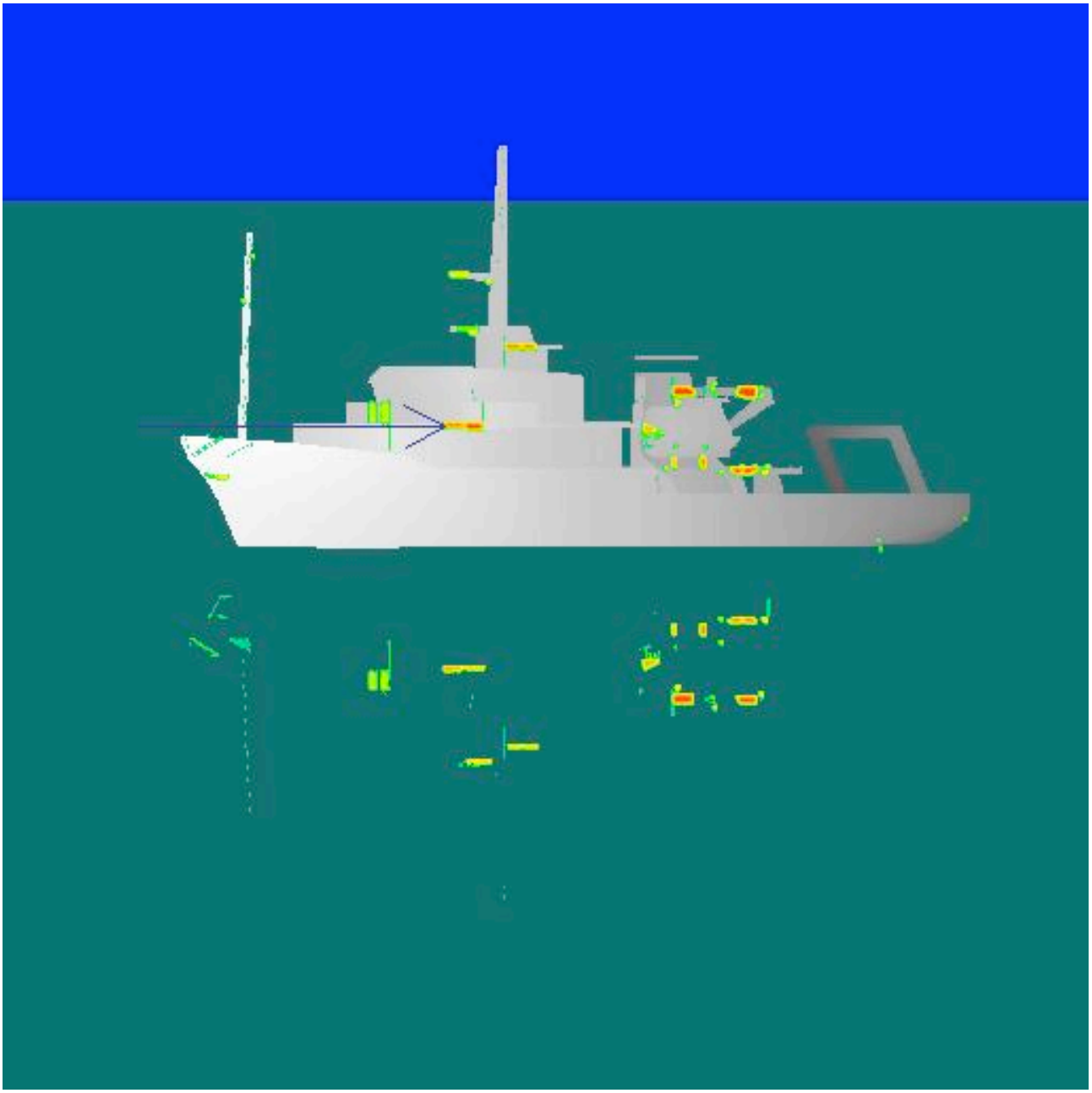


Above plot is 94 GHz.

Step4 – find and cover the next Hot Spots.

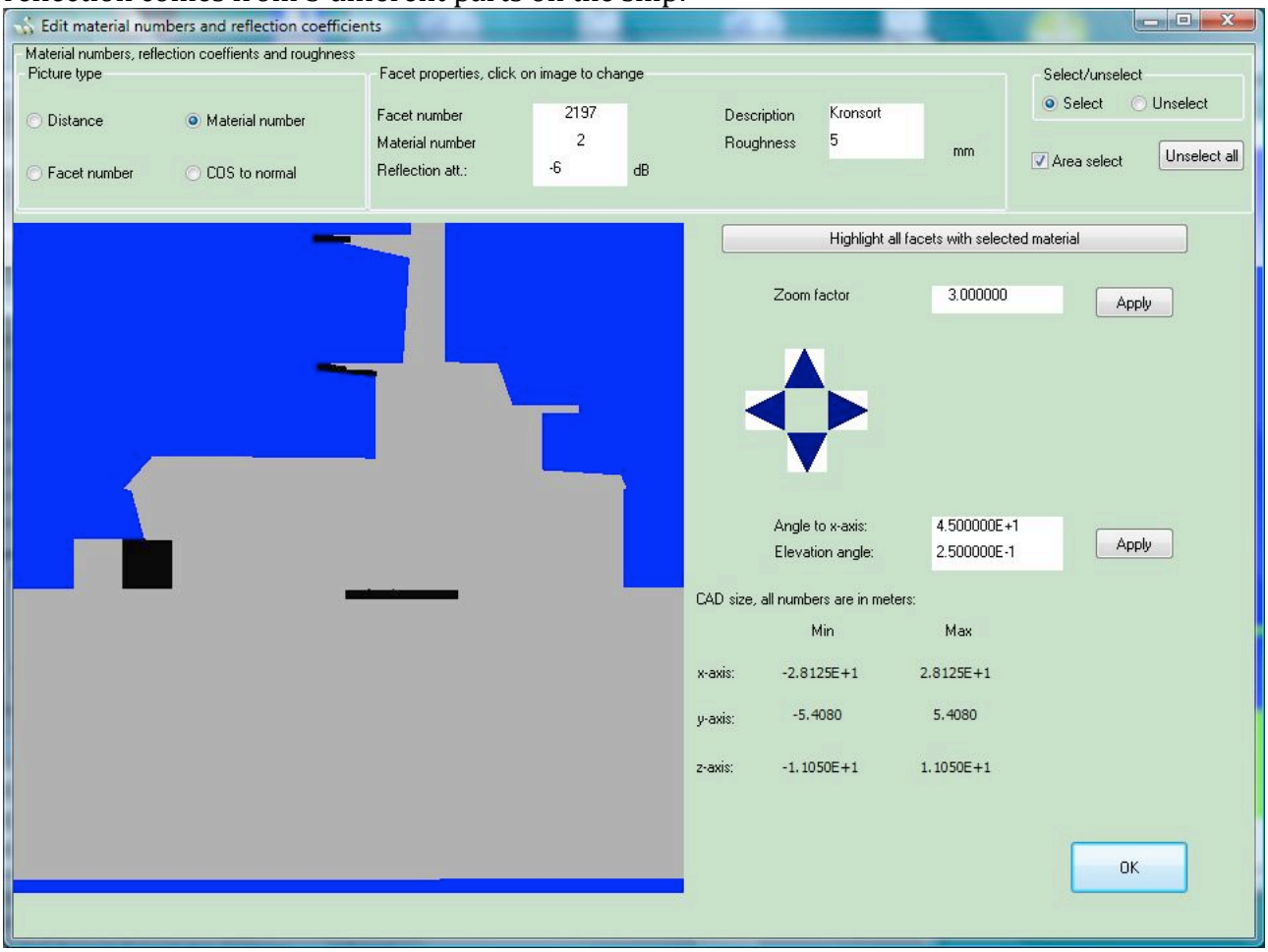
Now we take the next red line between 0 and 90 degrees; see the HRR plot and the Hot spot image at 45 degrees from the second run below.





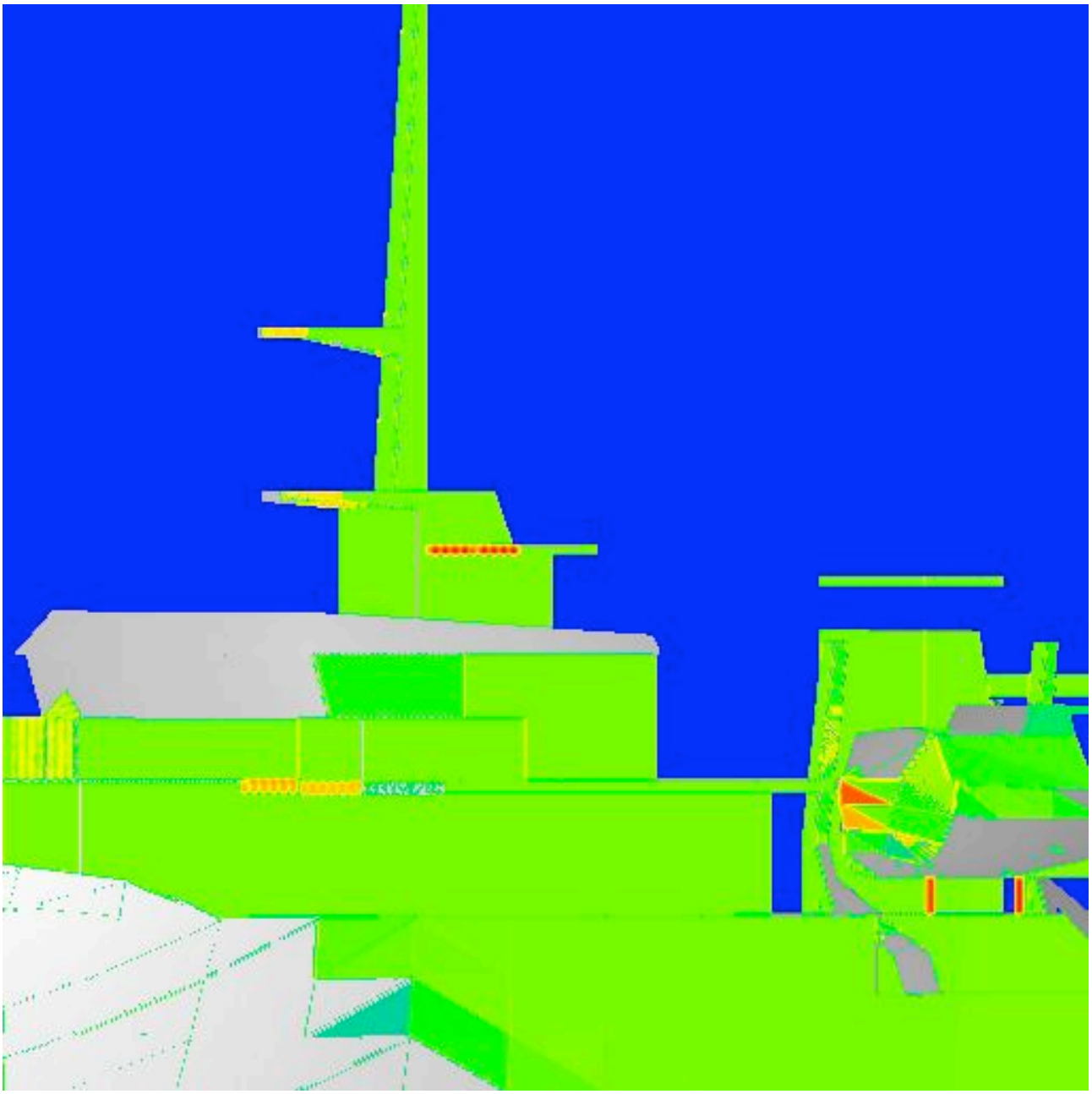
Start cadRCS again and go to Settings -> Import settings and open the *.ini file from step 2.
Go to Settings -> Show image to edit material numbers etc.

Like step 2, but this time it is only needed to change the material number of the selected area to 2 as the properties of that material already are defined. When checking the selection by showing the material number of the facets, you get an image like below – note that this reflection comes from 3 different parts on the ship:



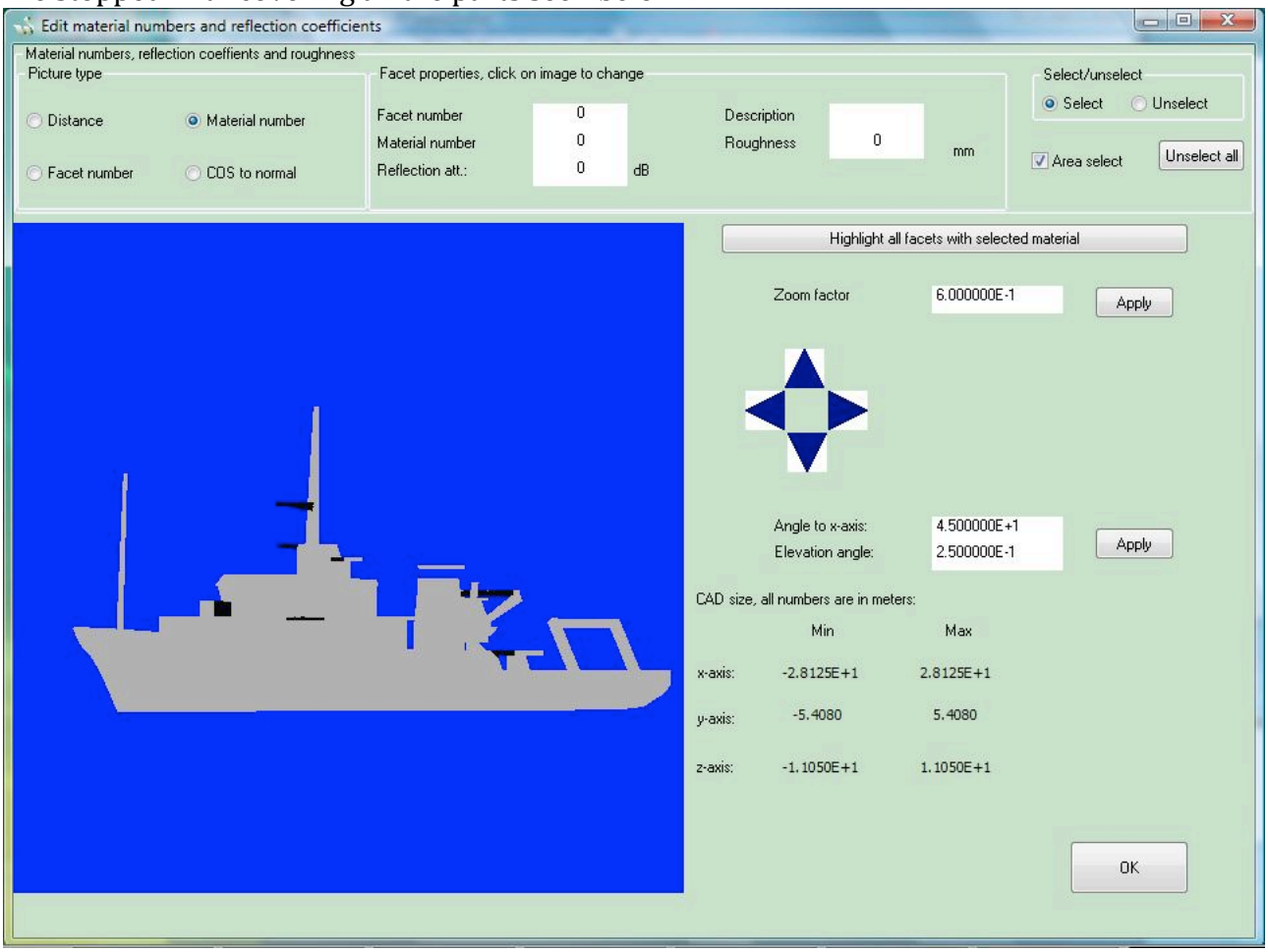
Push OK and run cadRCS – all settings are imported, but change the frame size to 20x20 meters in order to see that all are covered.

The result from running cadRCS gives the image:



Then continue removing Hot Spots in the first quadrant in the same way.

We stopped with covering all the parts seen below:

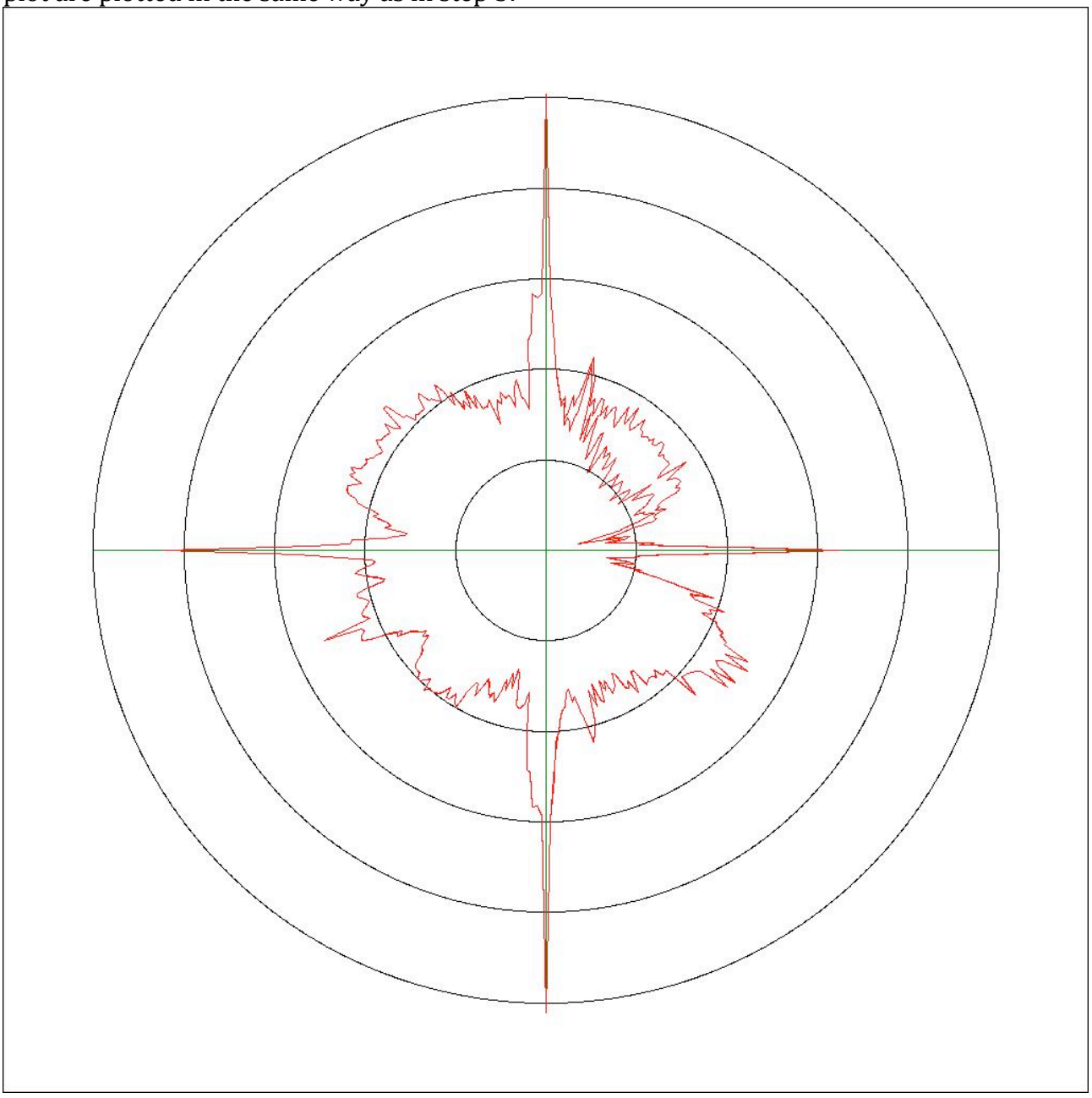


Close cadRCS.

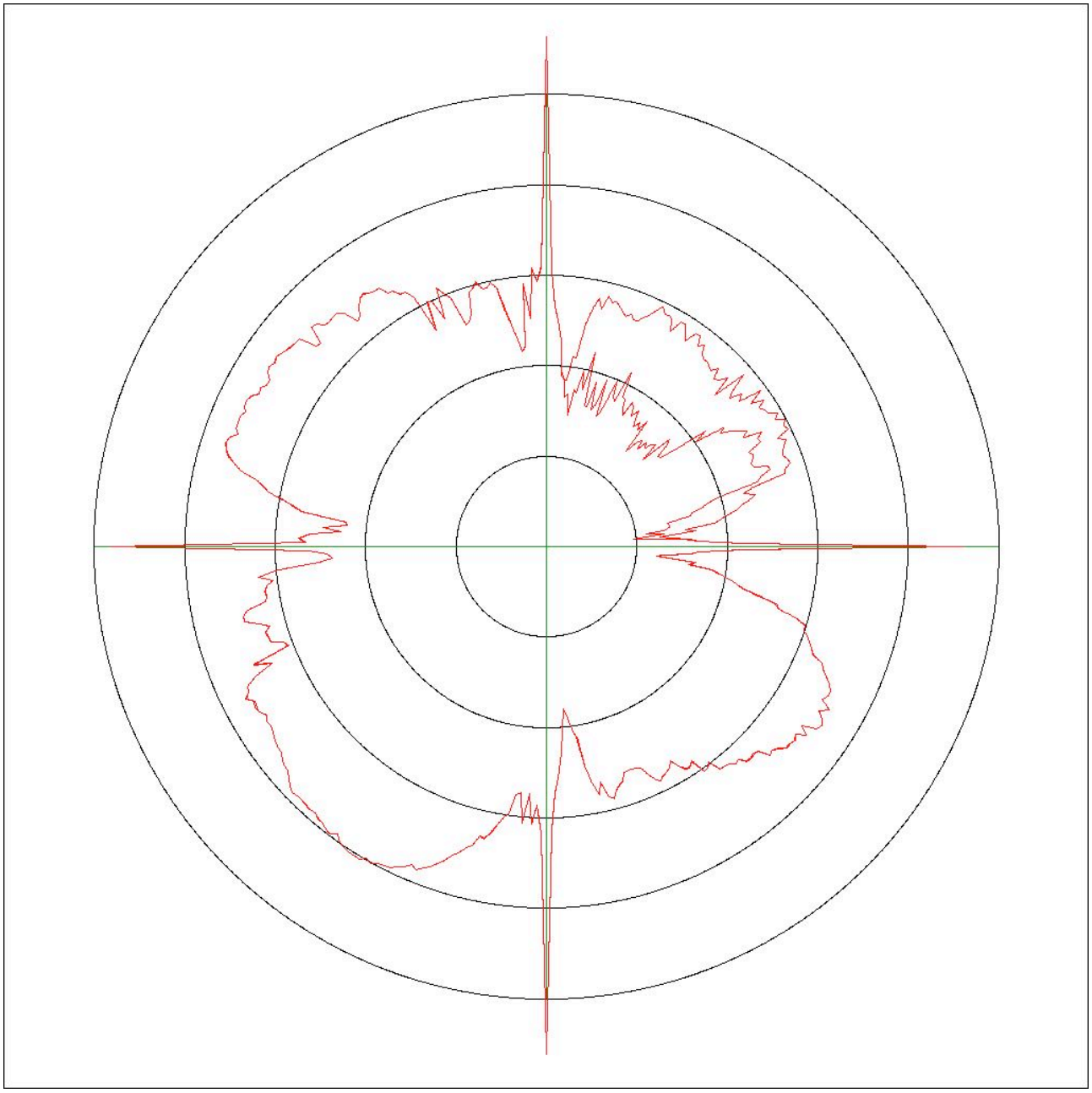
Step5 - check the result.

Follow the same actions as step3, but remember to change the image size back to 60x60 meters.
Then run cadRCS in some hours and then movie to pack the *.mic files into one pmi file.
You can download our pmi file at:
http://www.cadrcs.com/Downloads/Kronsort/ Kronsortb.zip

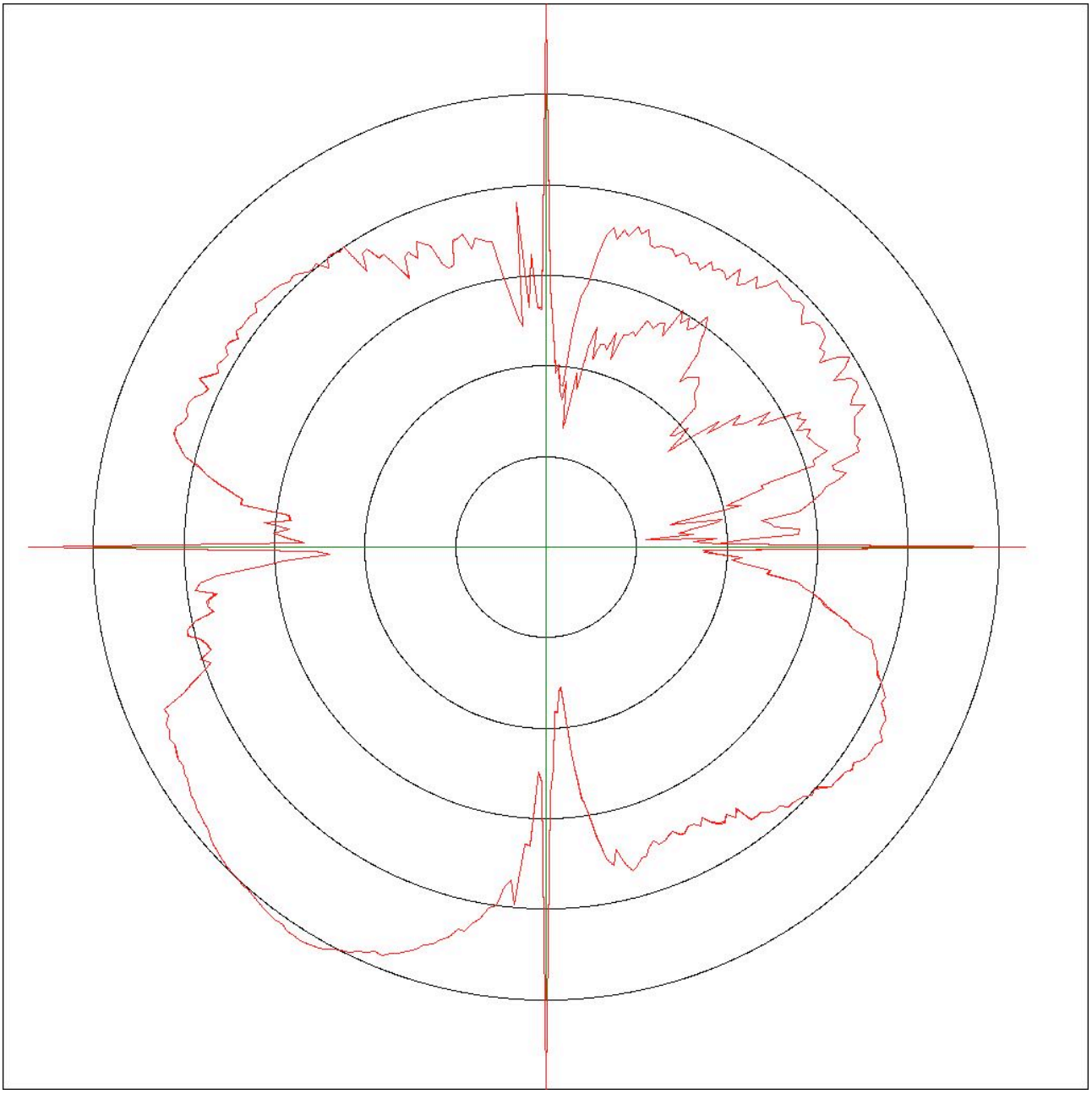
Running movie gives the resulting polar plots, compared with the original without RAM, all plot are plotted in the same way as in step 3:



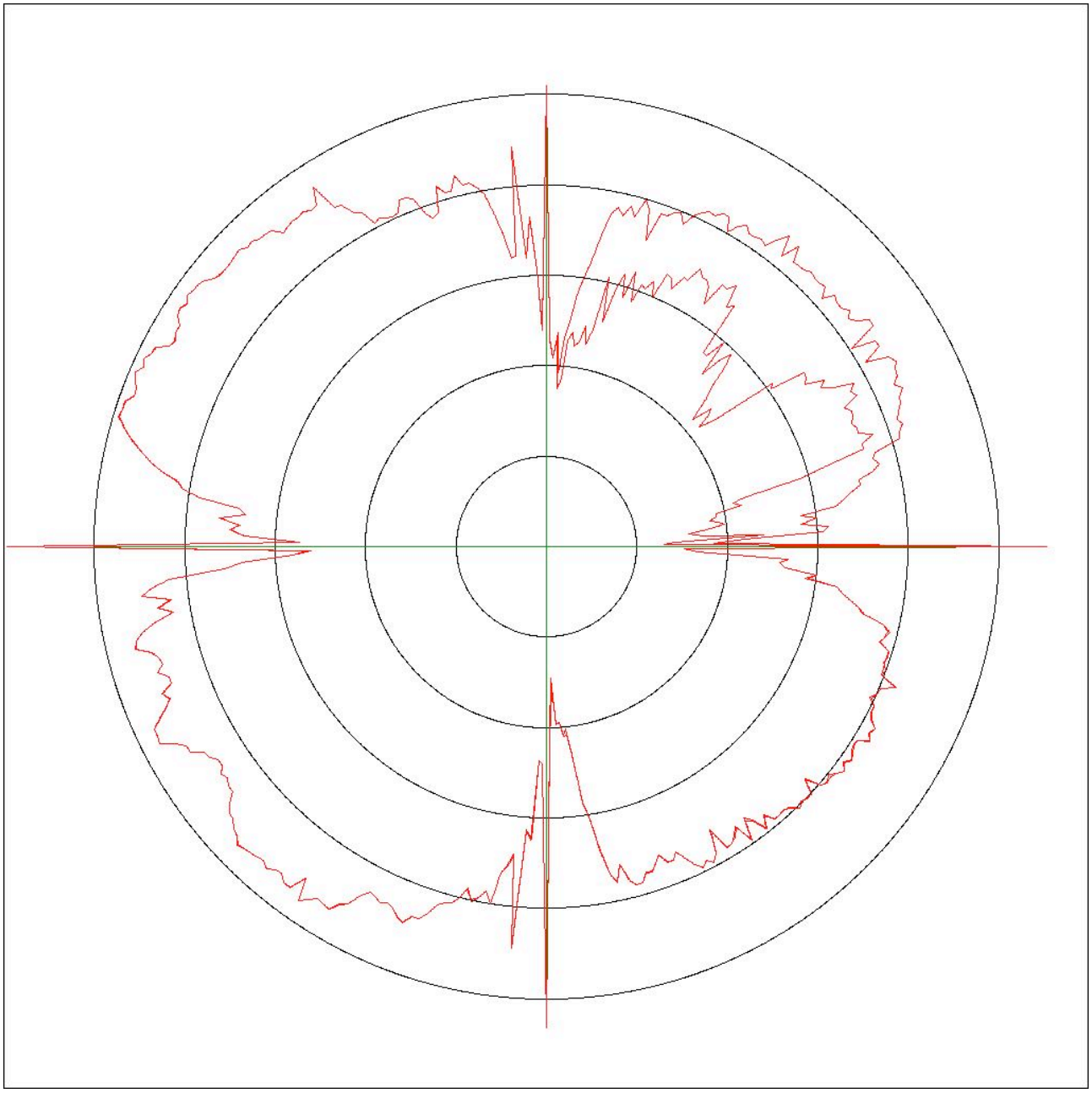
Above plot is 3 GHz.



Above plot is 10 GHz.



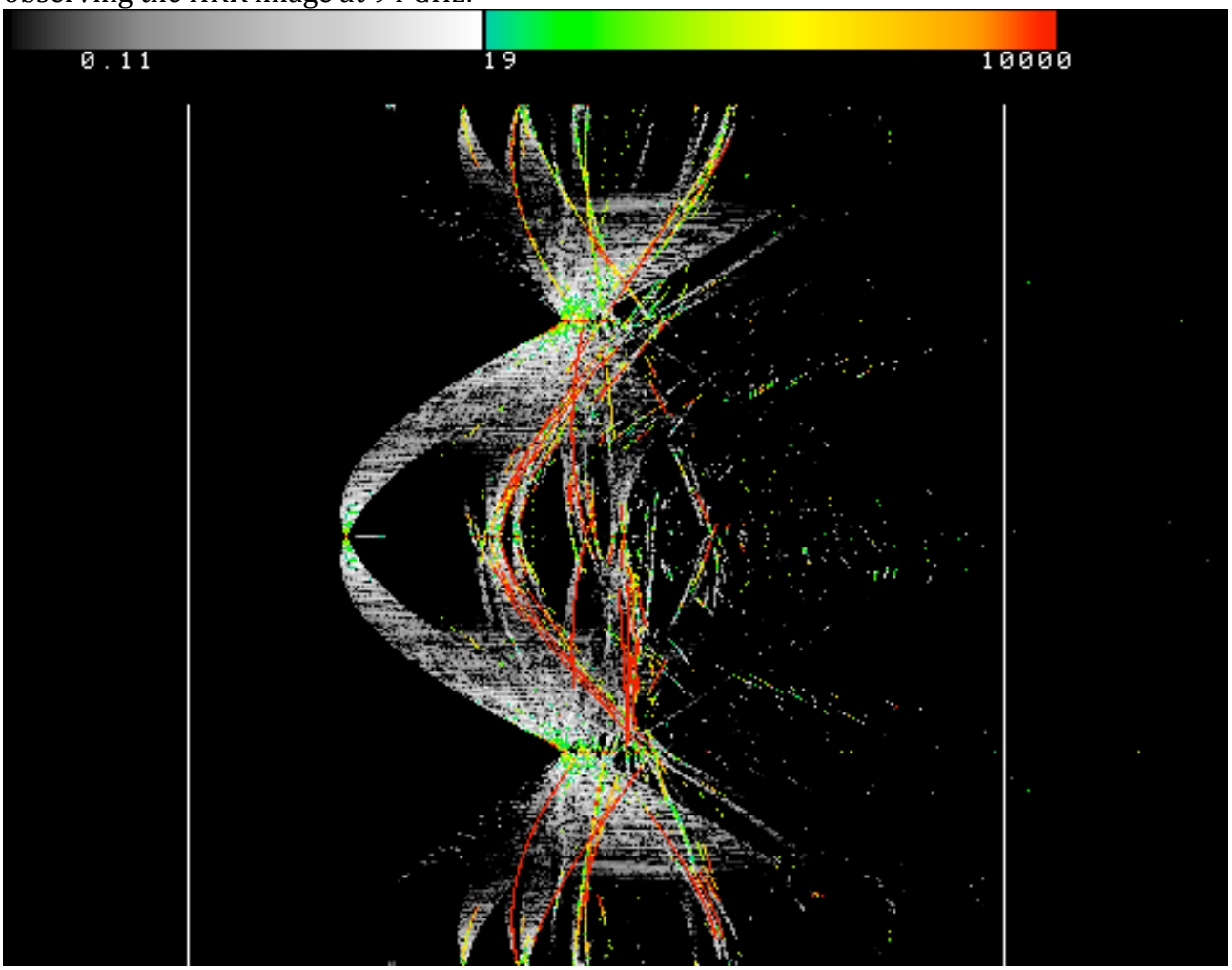
Above plot is 35 GHz.



Above plot is 94 GHz.

It is obvious that the little amount of RAM added to the ship have a big influence of the total RCS of the ship.

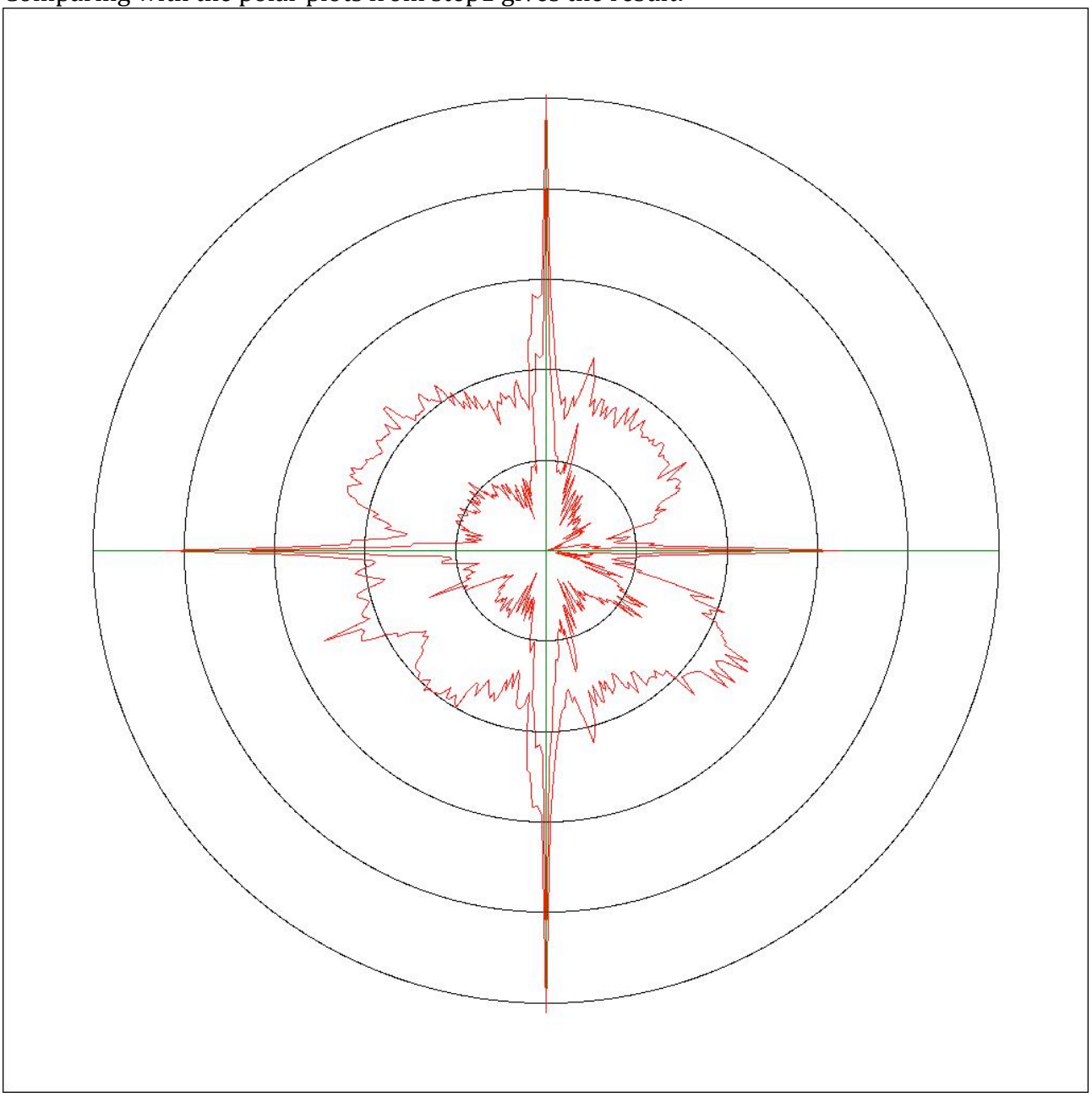
Still a lot of covering can be done in the first quadrant; this is now easier to see when observing the HRR image at 94 GHz:



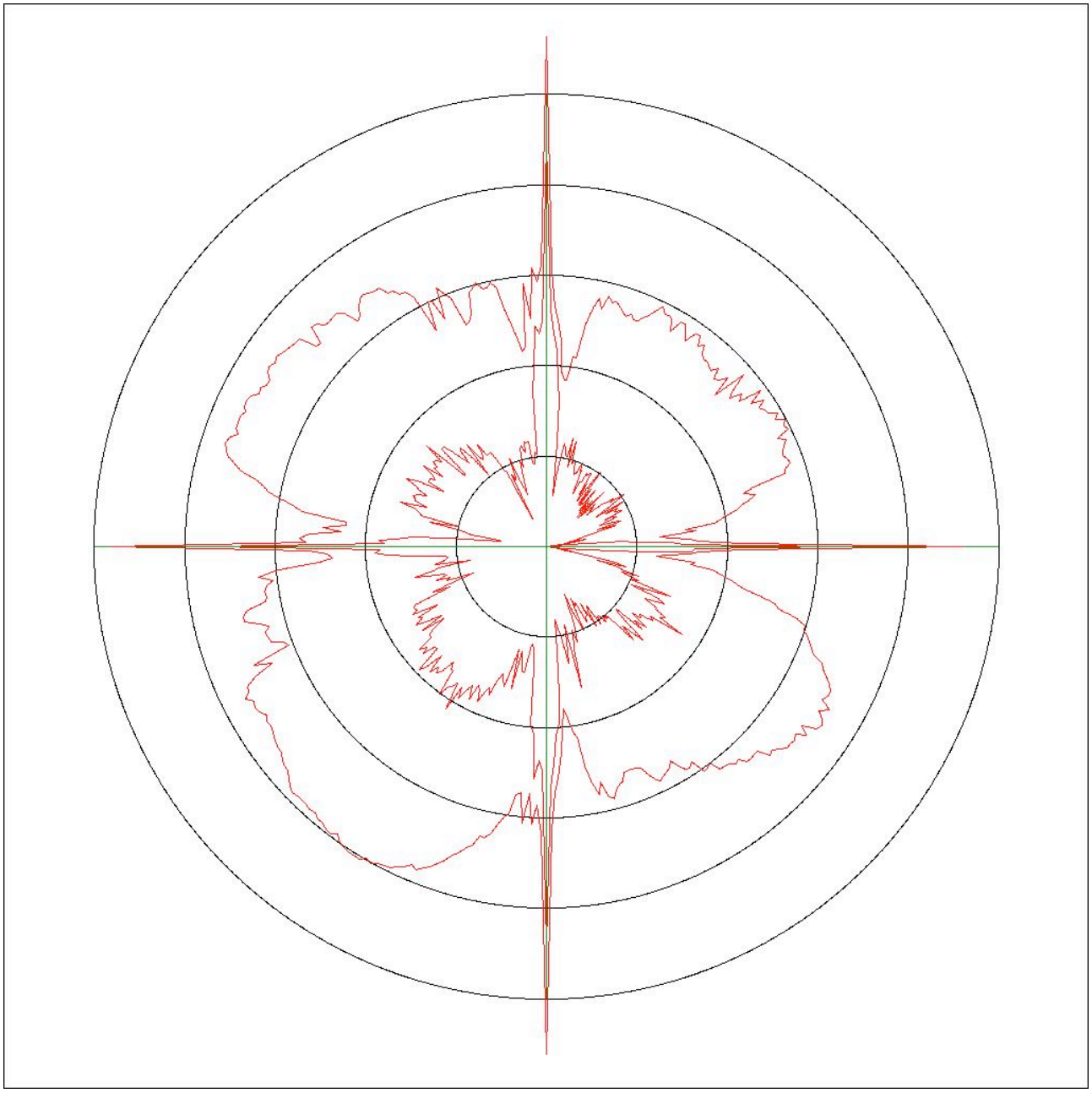
You can also try to test using better RAM with higher reflection attenuation, but in most cases this will only be a minor effect.
Only adding more RAM will make the ship RCS significant less.

Step6 – make the whole ship of RAM material.

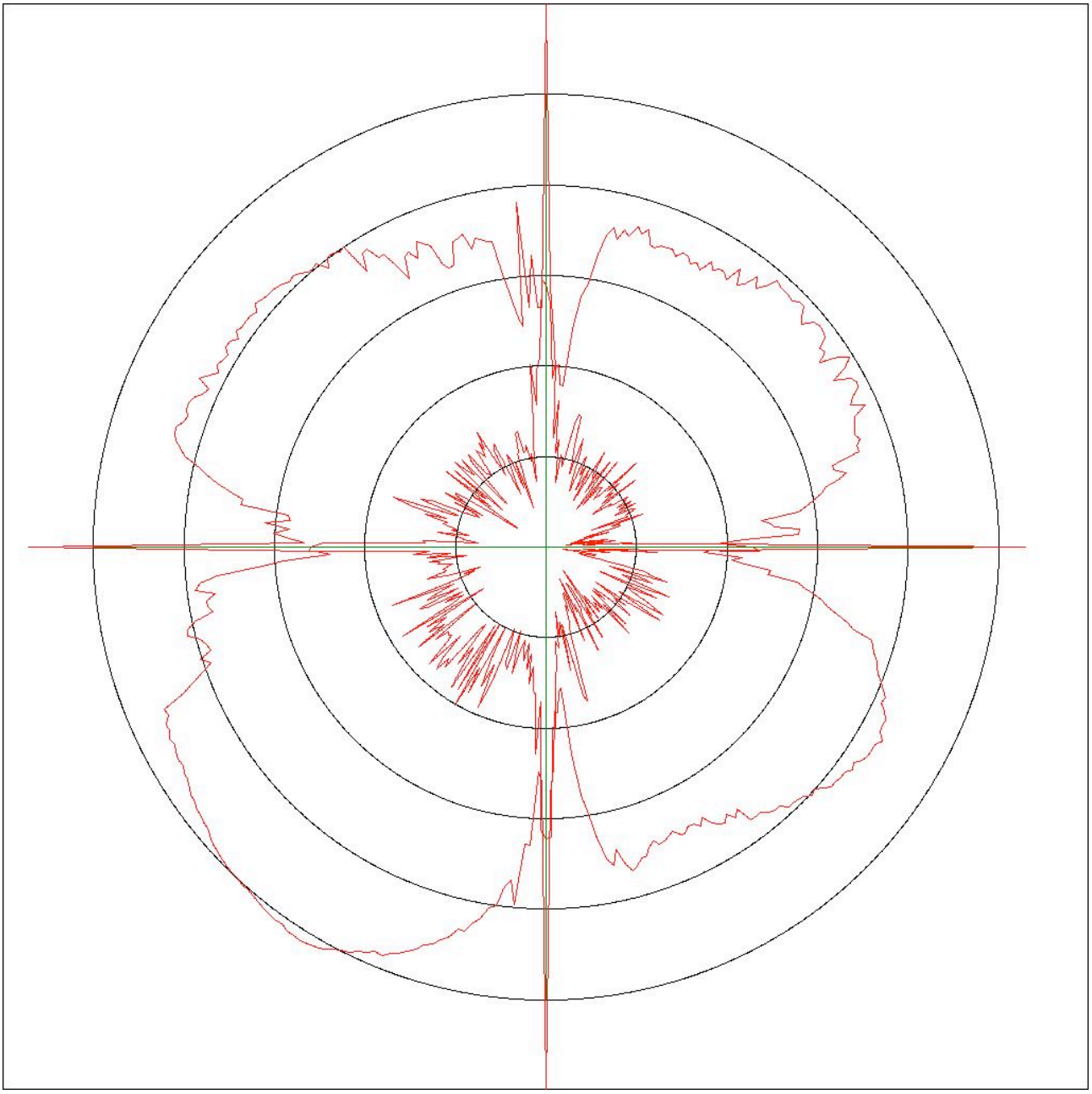
Start cadRCS and follow the instructions as in step 1, but before pushing Process, go to Settings -> Show image to edit material numbers etc.
Then click on one facet on the ship and change Reflection att.: to -6 and Roughness to 5.
Push OK and on the main menu push Process.
After cadRCS have finished the calculation start movie and pack all mic files into one pmi file.
The resulting pmi file you can download at:
http://www.cadrcs.com/Downloads/Kronsort/ Kronsortc.zip
Comparing with the polar plots from step1 gives the result:



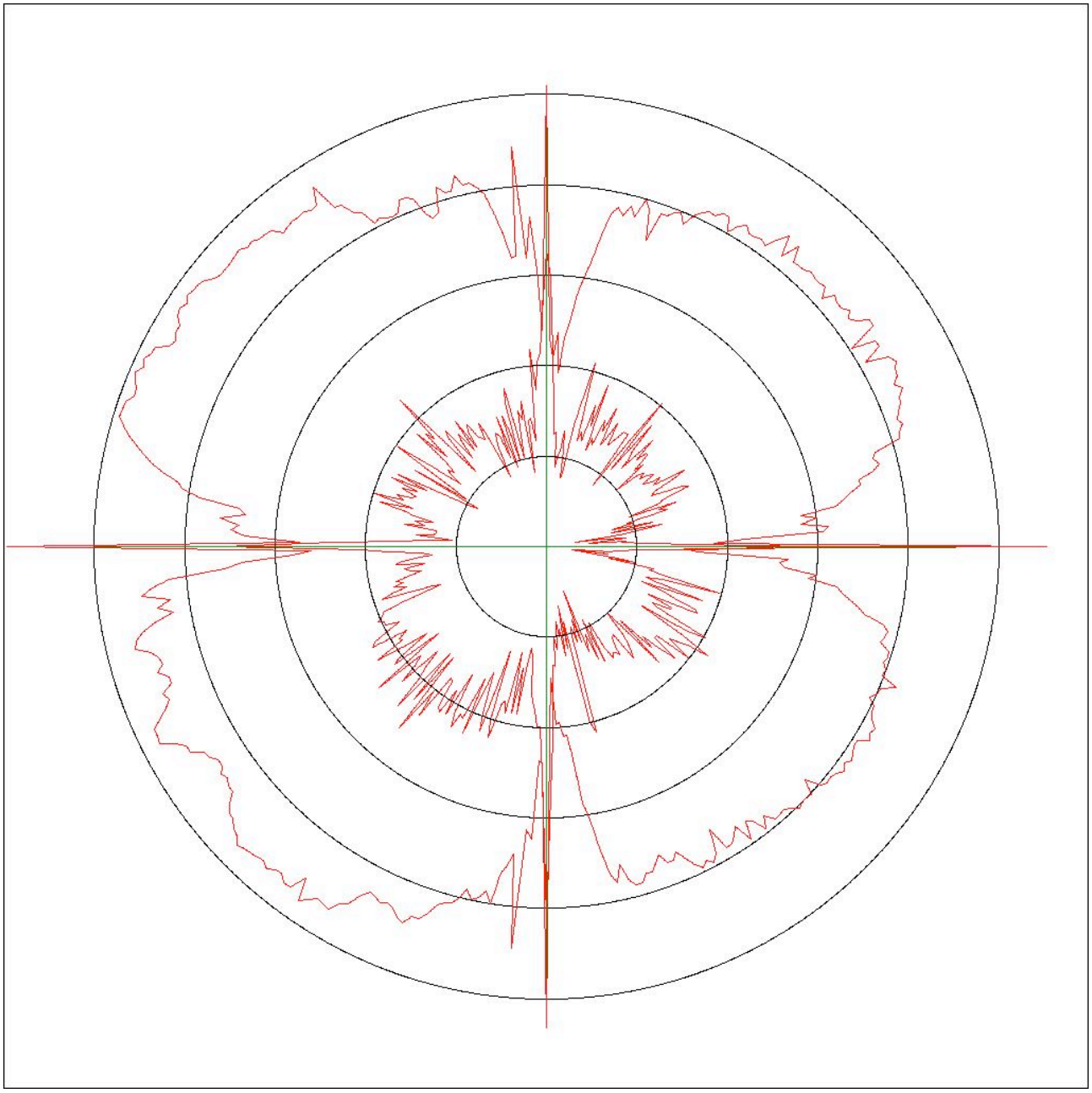
Above plot is 3 GHz.



Above plot is 10 GHz.



Above plot is 35 GHz.



Above plot is 94 GHz.

Conclusion.

As you can see from the last polar plots, the Kronsort ship was not build as a stealth ship; so if you want to make a stealth ship with RCS as low as a small fishing boat (about 10 sqm RCS), then you need the code cadRCS to make the outside structure of the ship. Our clients tell us that cadRCS is the only commercial code available with trustable results. Getting RAM (Radar Absorbing Material) working with higher attenuation reflection than 6dB is almost impossible in wet weather.