

# Building A Dome

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There are a wealth of different dome structures built during history. In this SketchUp tutorial, we shall examine the different steps towards developing a dome with (eventually) pendentives, a drum and a cupola as we can see them starting from Ancient and Medieval times up to the Classic revival (or Classicism) of the late 17th to the 19th centuries.

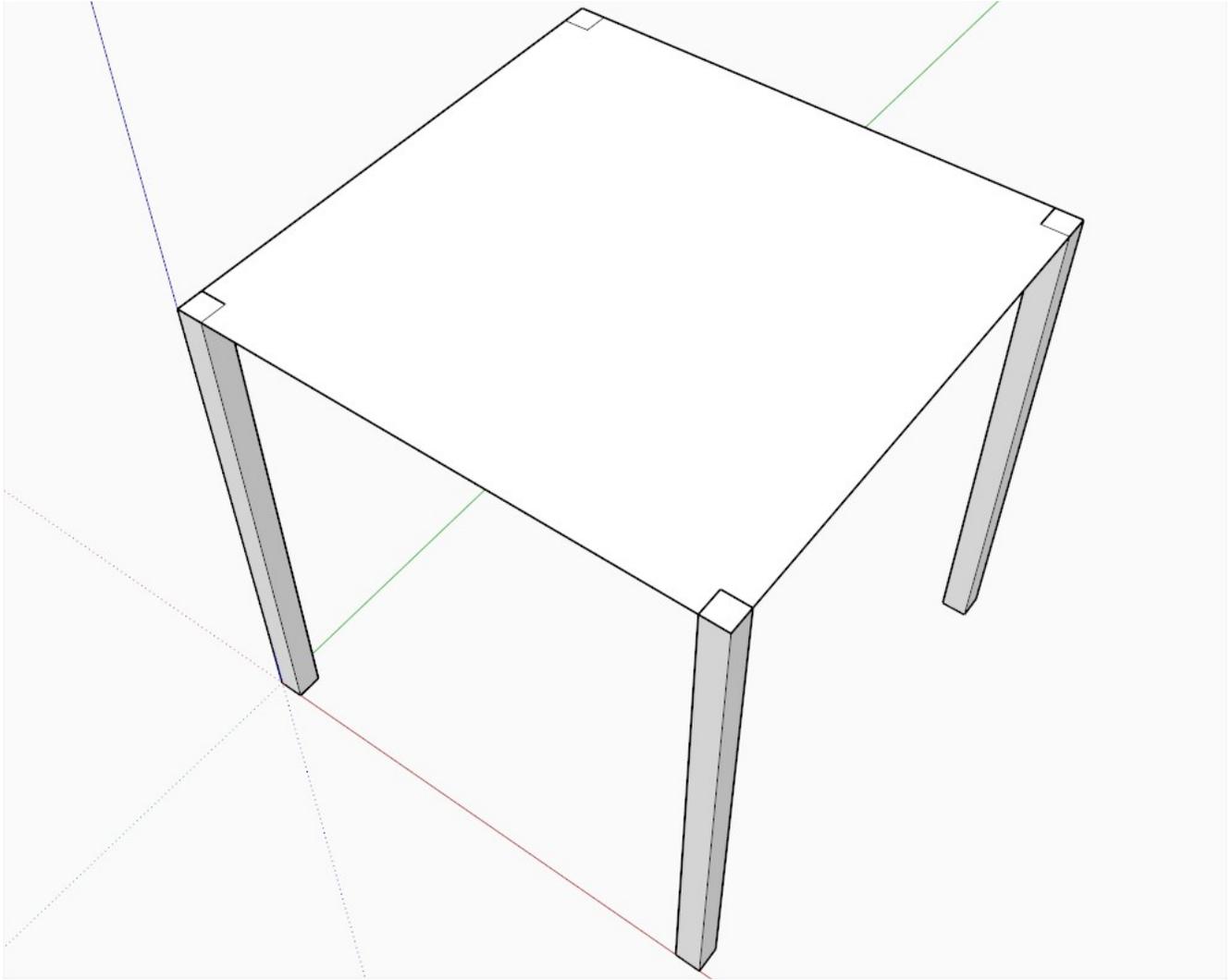
During the process, we'll use quite basic tools to build simple, basic shapes these magnificent structures are built up from.

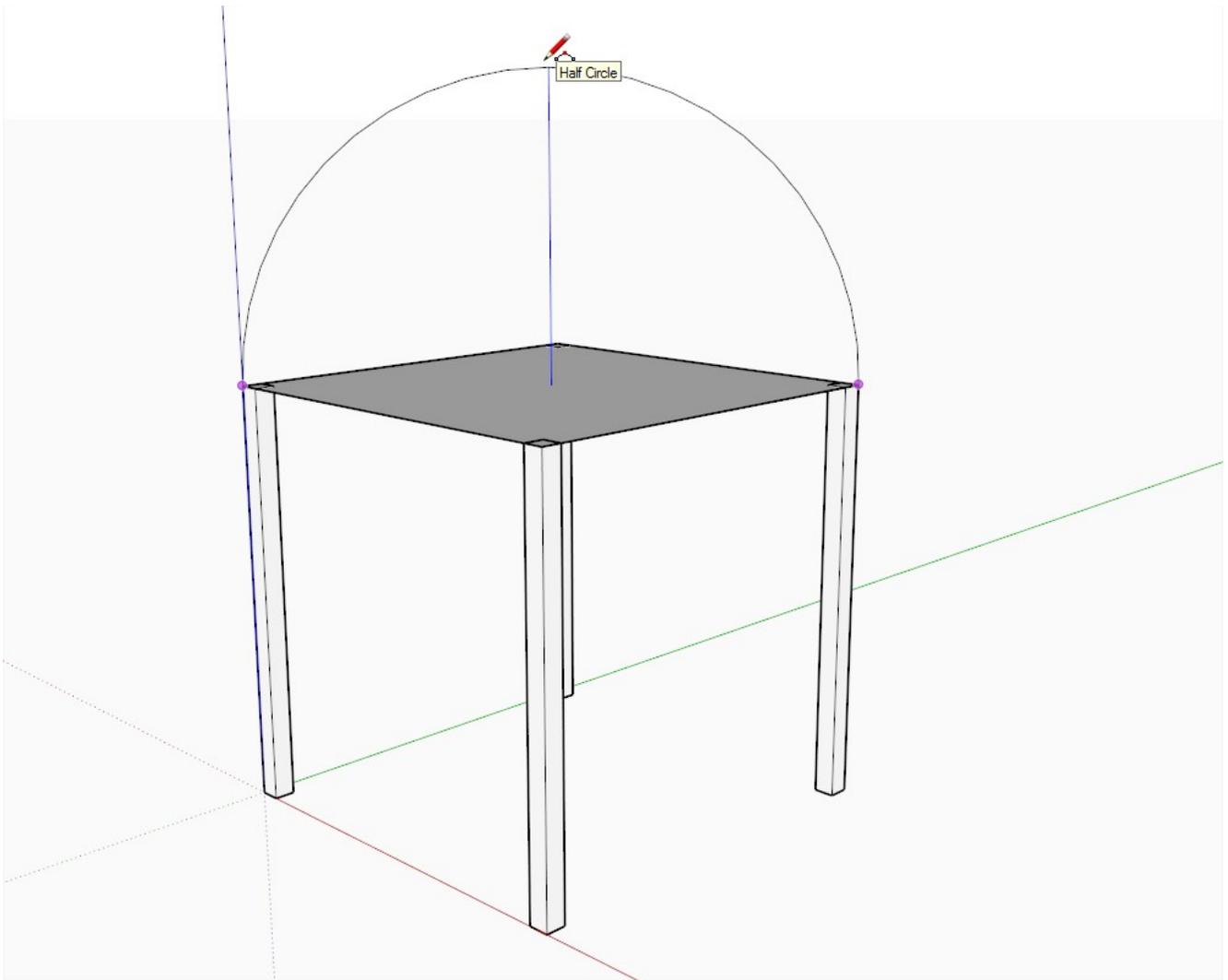
During this modelling session, it is again important to separate the boolean operations of the outer and inner shells of the dome.

## Setting up the Outer Shell:

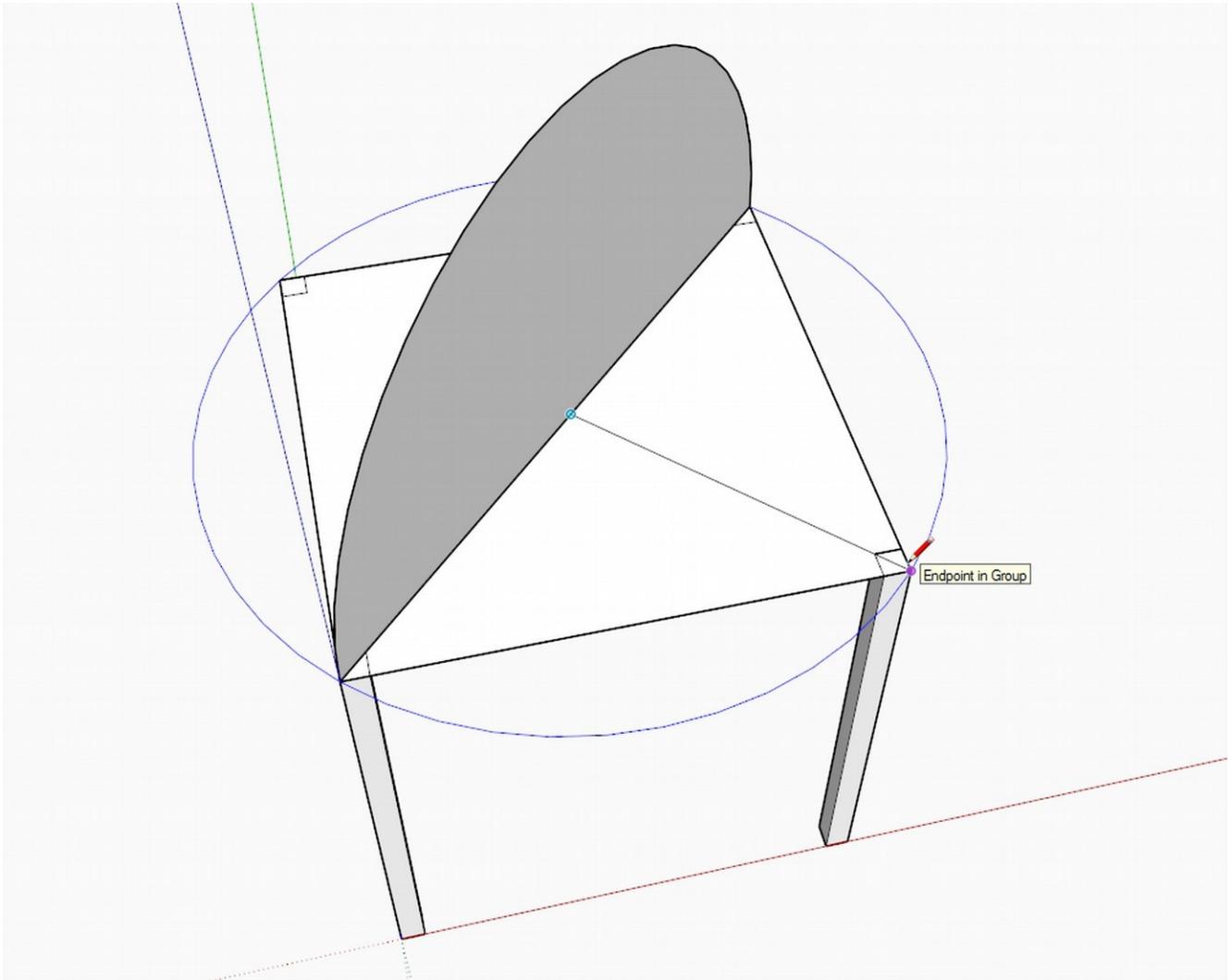
We start with four columns around a square as you did in the *Cross Vault tutorial*. Draw a square around the outermost corners of the columns and make it a group.

From the corners, draw an arc and make sure it is along the blue axis (see the blue inferencing line) and that it is a half circle.

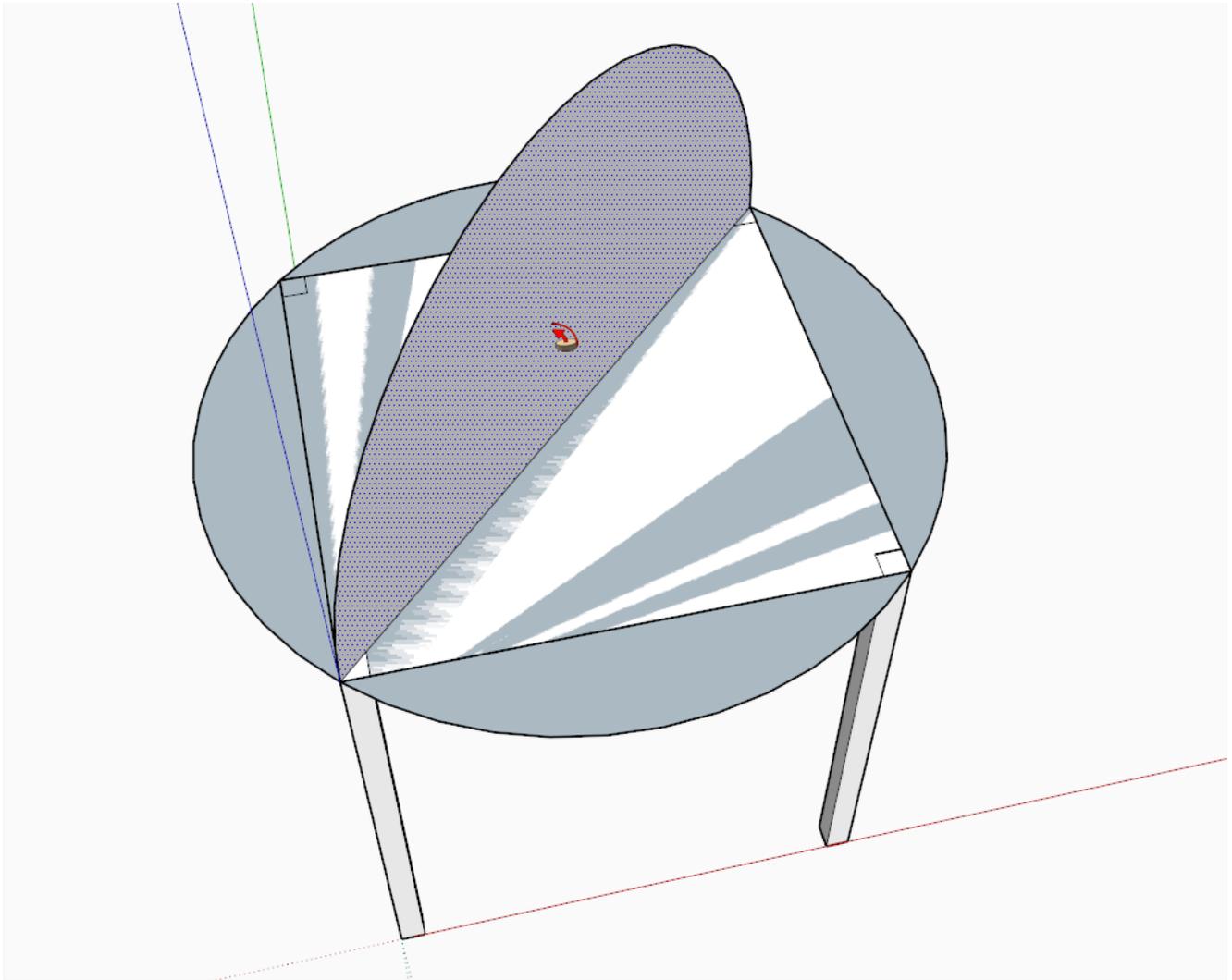




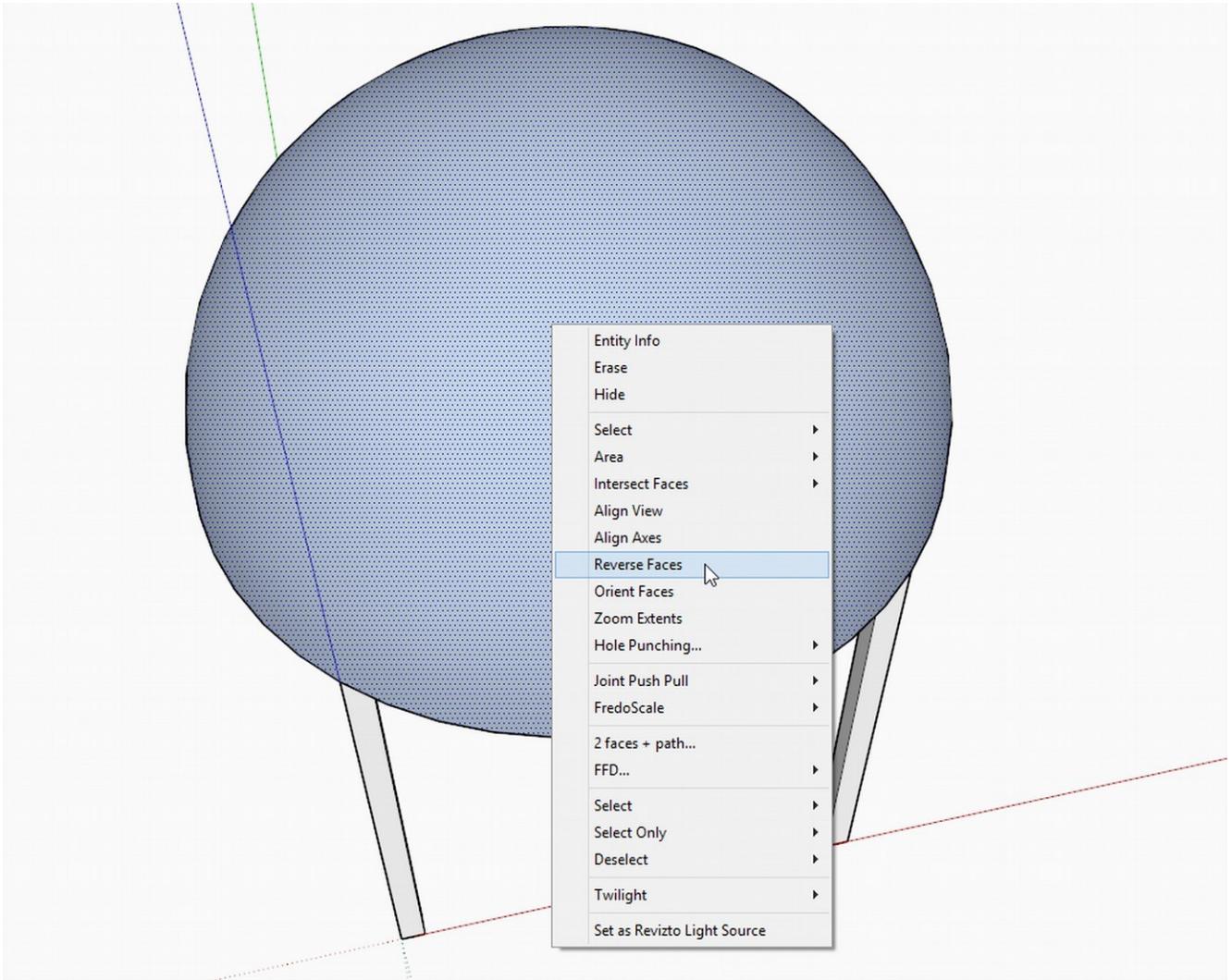
Connect the endpoints of the arc and draw a circle from the midpoint of the connecting edge to exactly the corner.



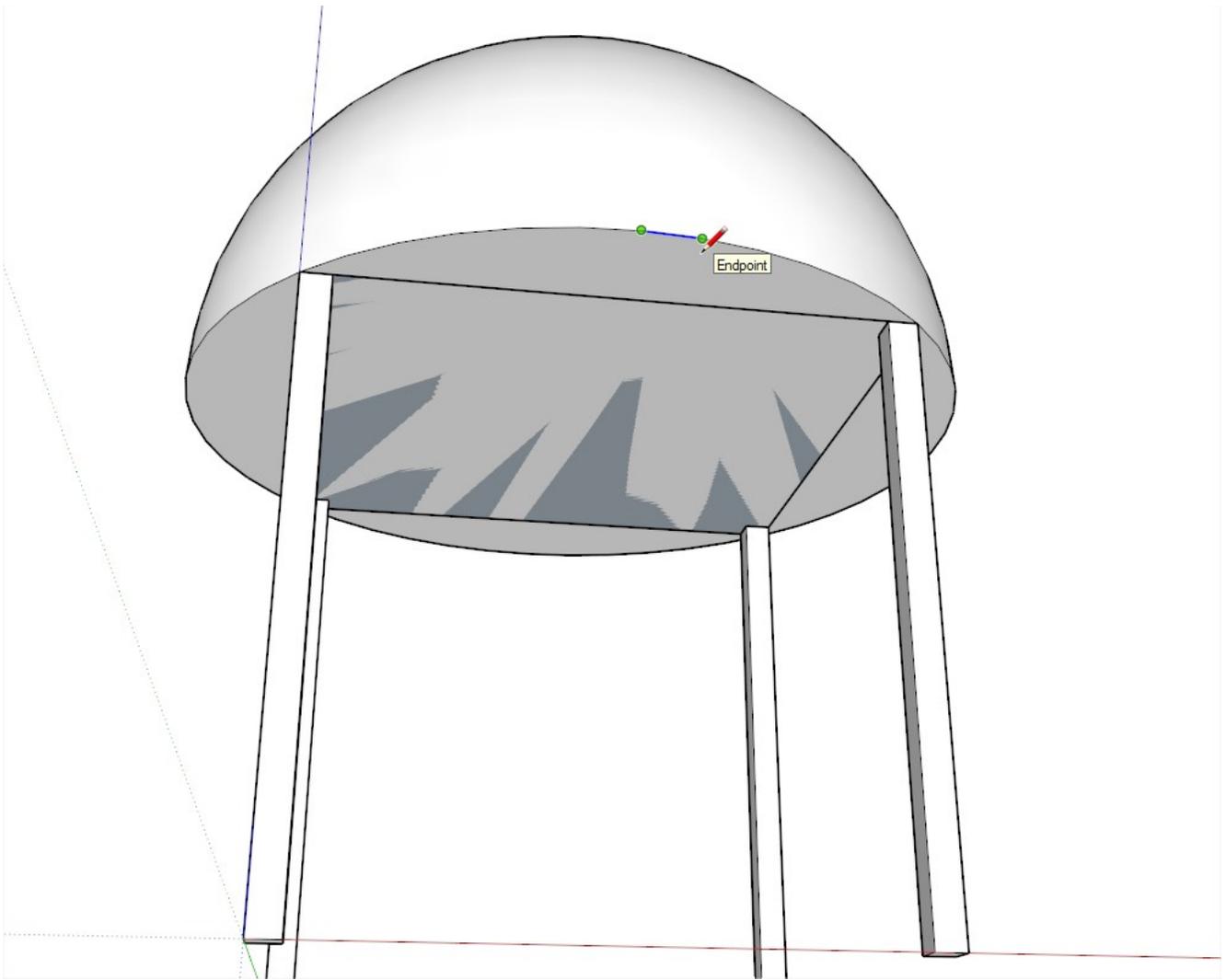
Select the edges of the circle and use the Follow me tool to lather the half circle around the circle to create the outer shell.



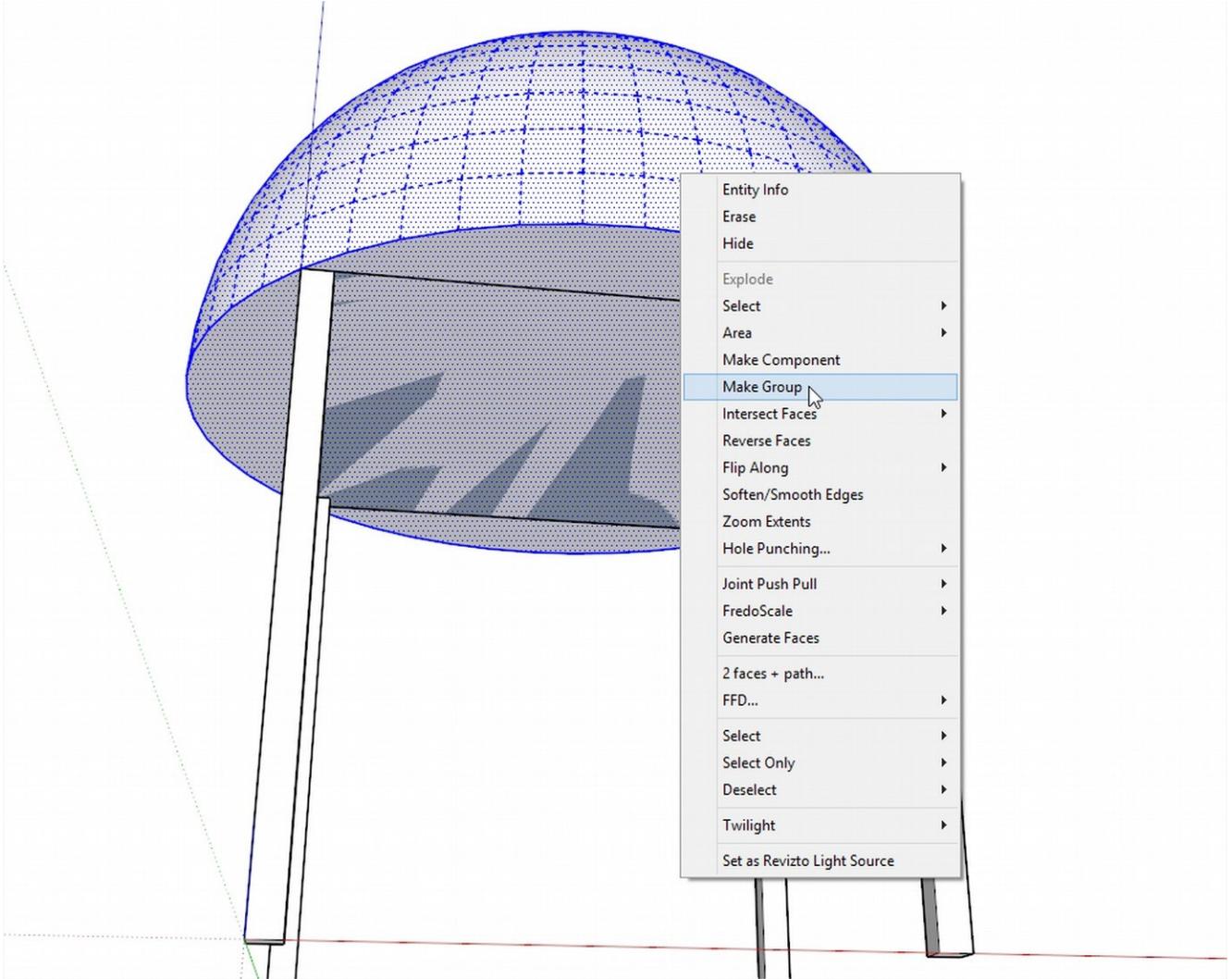
If it comes out "inside out" (i.e. the back face outside), right click and "Reverse faces".



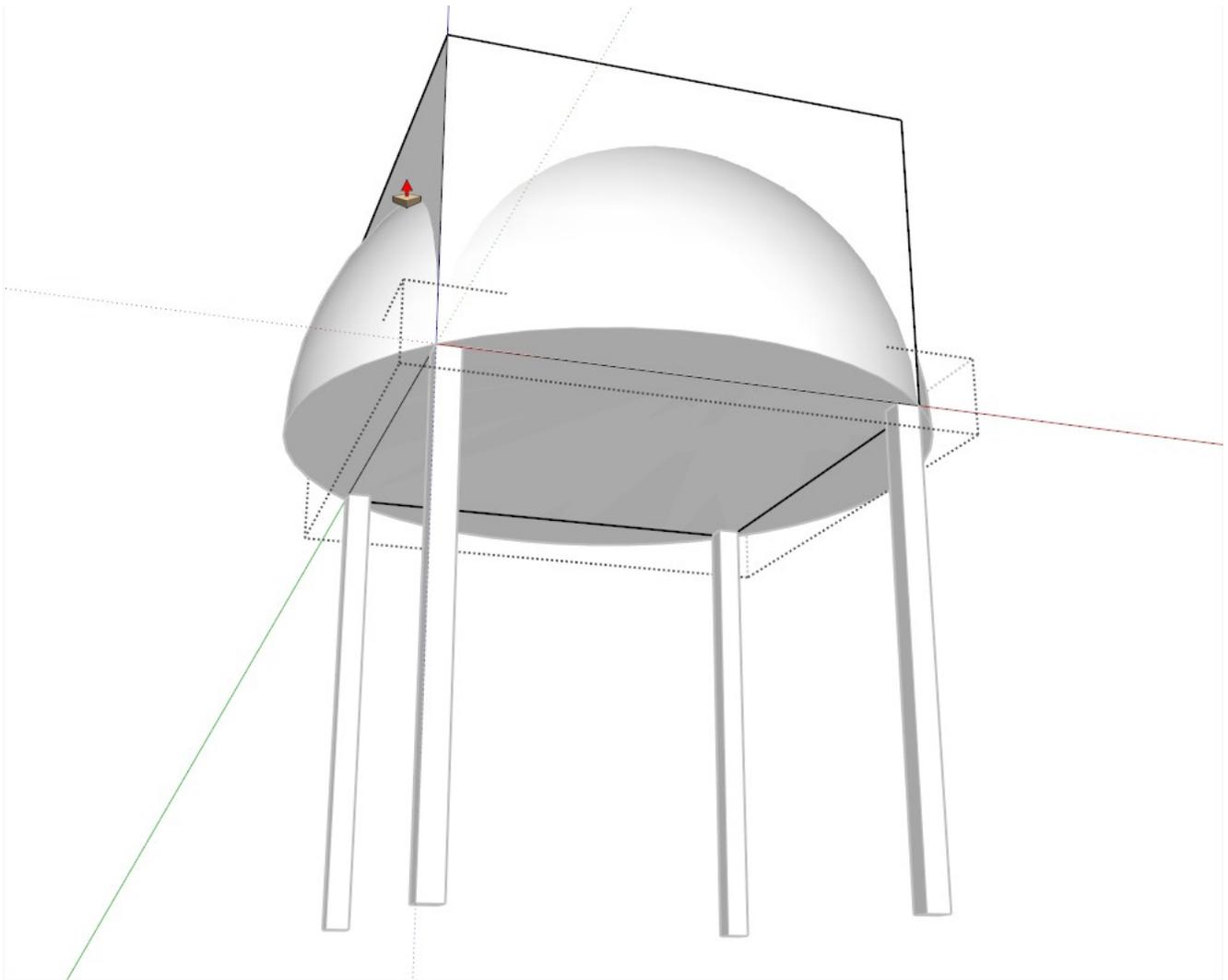
This step is only needed if you do it with the Solid tools: redraw an edge on the perimeter to close the dome's bottom so that it will be a "solid" group in the next step.



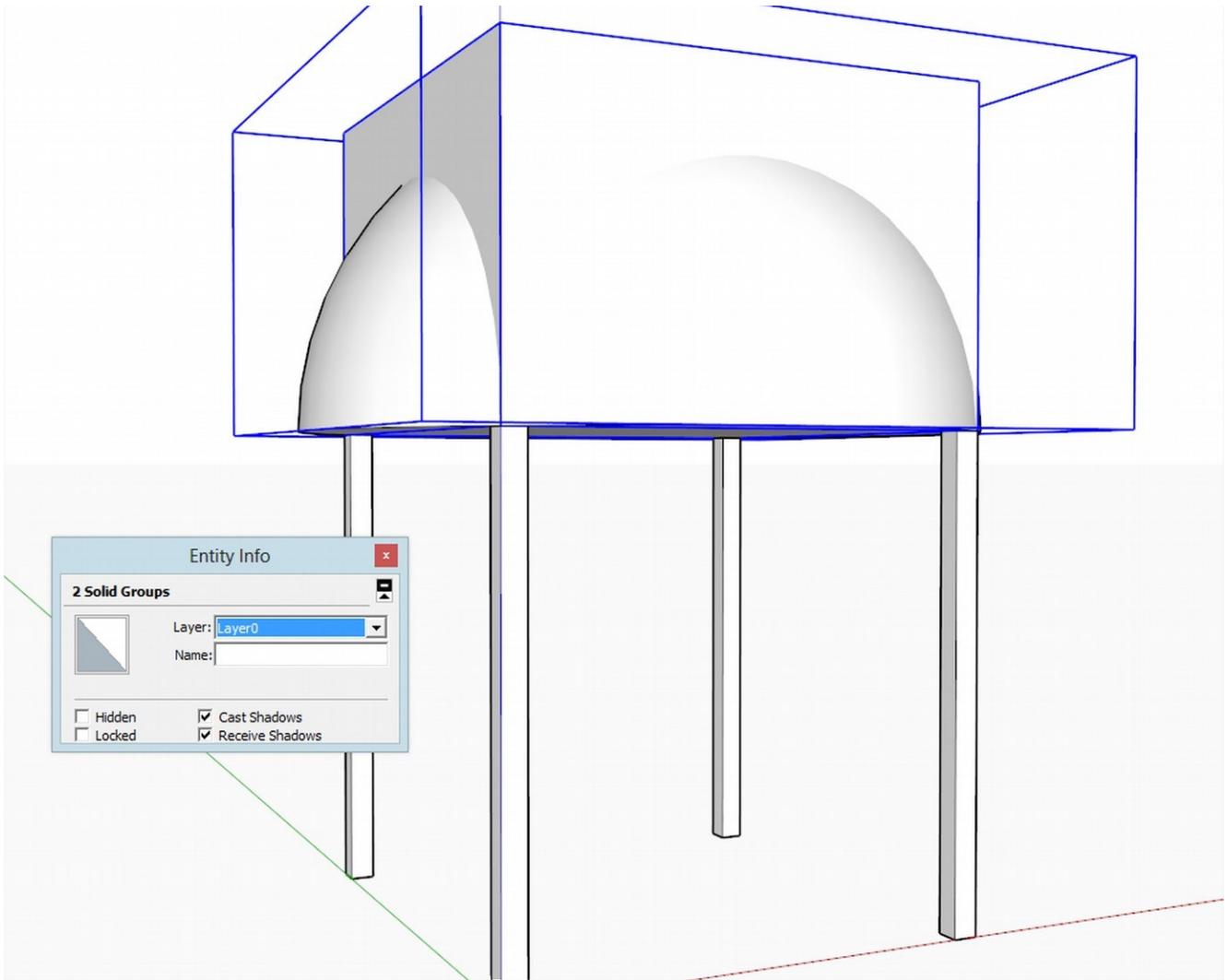
Select the whole dome (triple click on it) and make it a group.



Open the group containing our rectangle and PushPull it up enough so that it covers the dome completely.



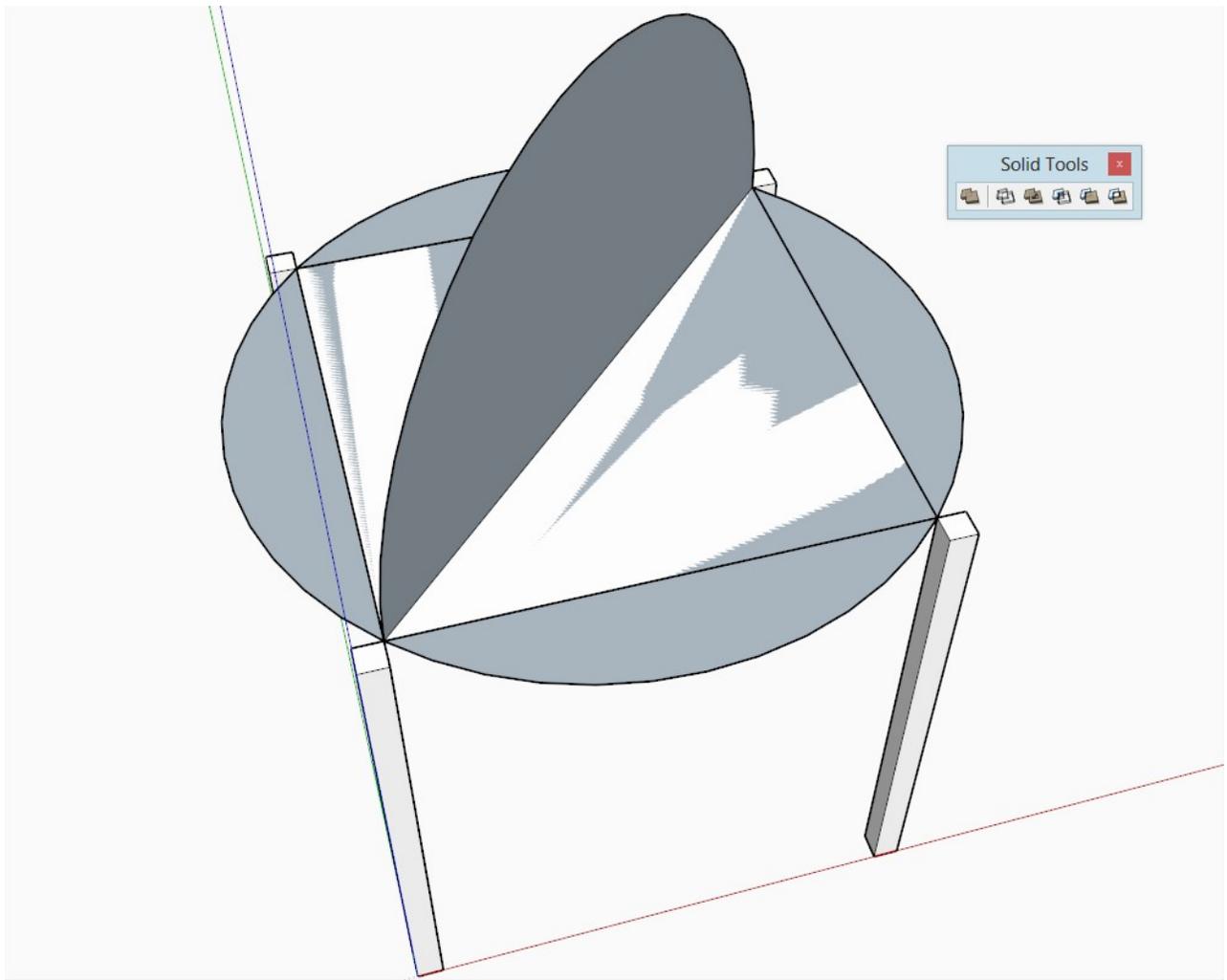
Now we have two solids to operate with.



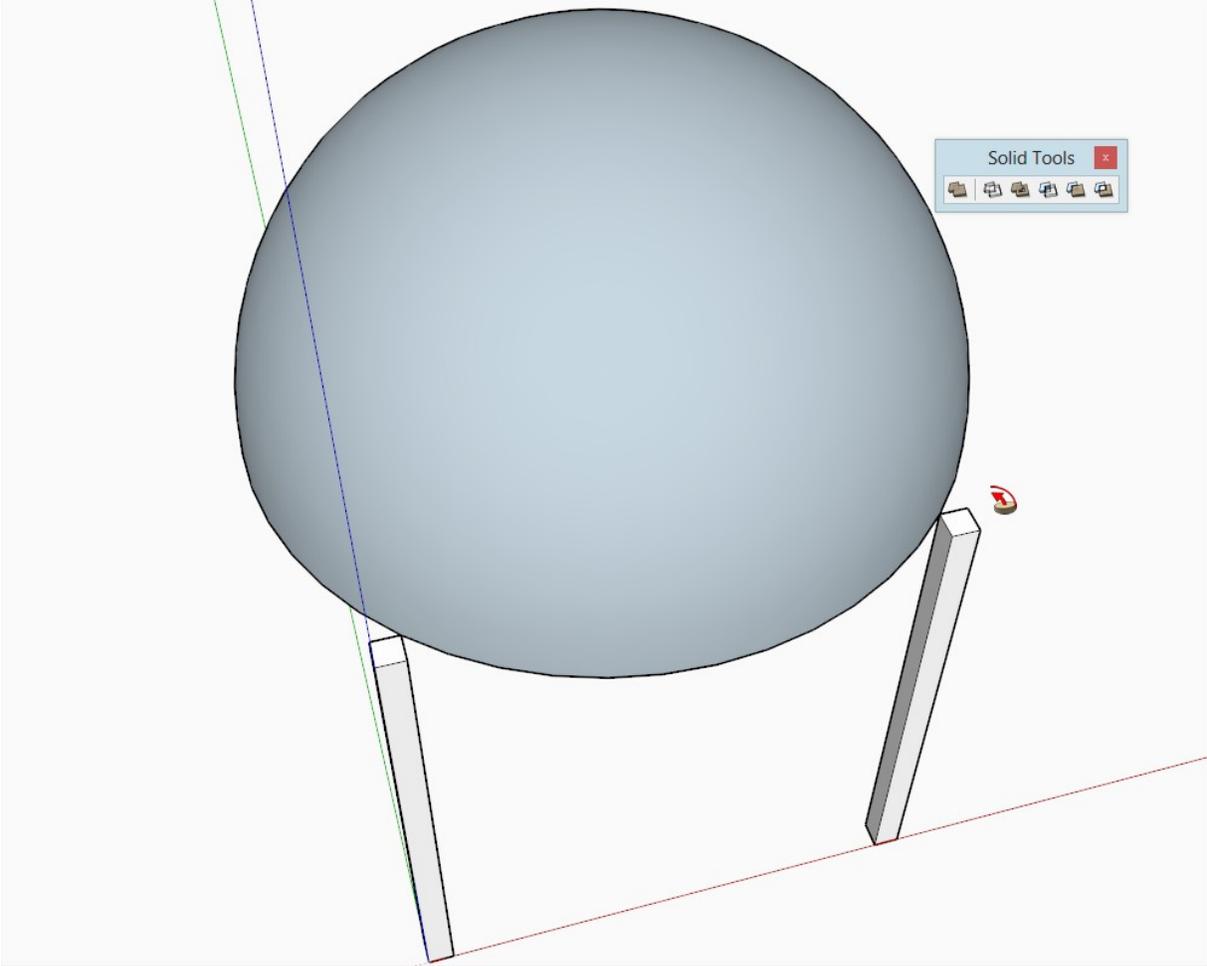
Create a new layer, put this outer shell on this layer and hide the layer for the time being.

## **Setting up the Inner Shell**

Repeat the steps under “Setting up the outer shell” only that now we draw everything snapping to the inner corners of the columns.

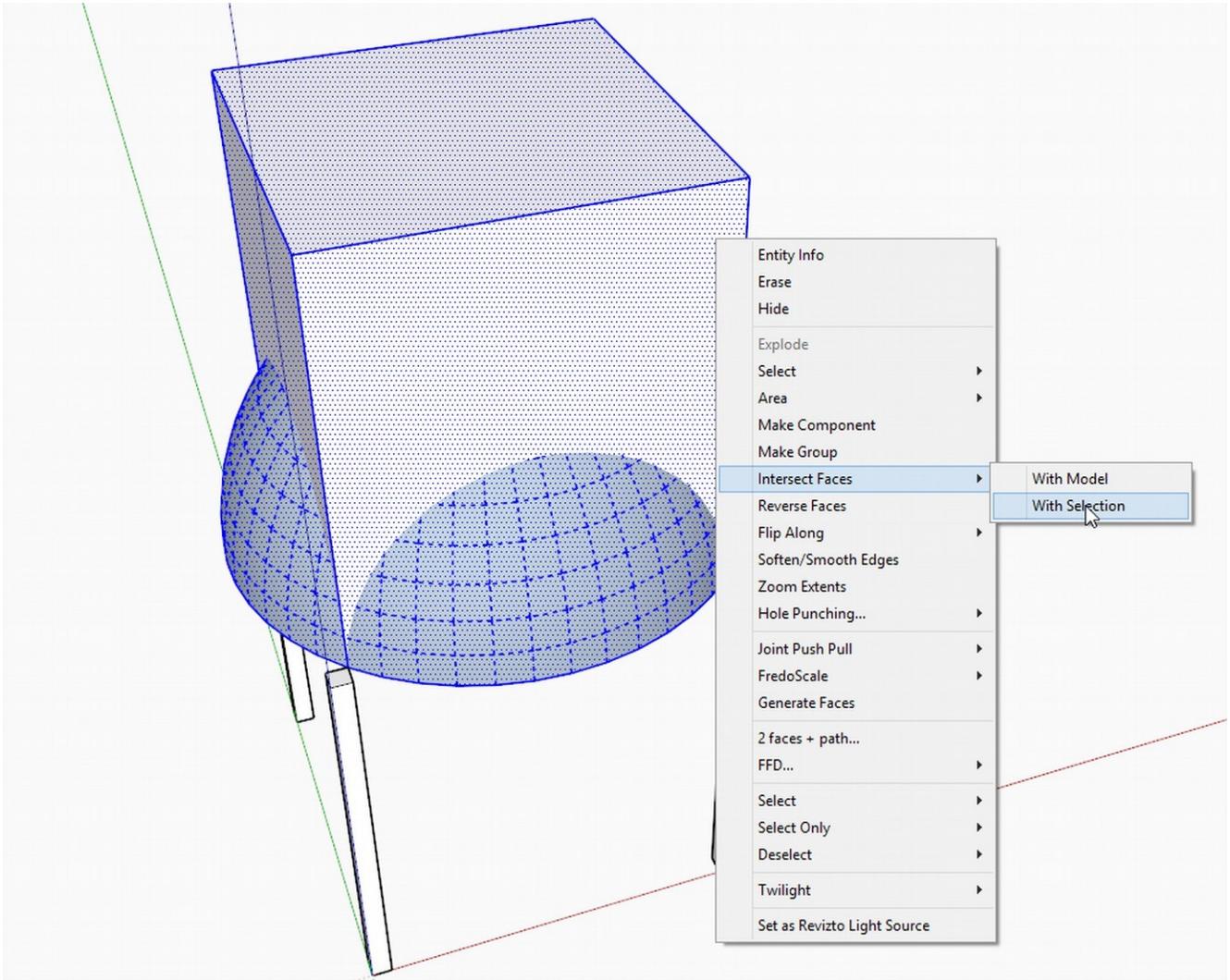


One thing is different: leave the back face upside now (as the front face surface of the dome will be inside, seen from below).

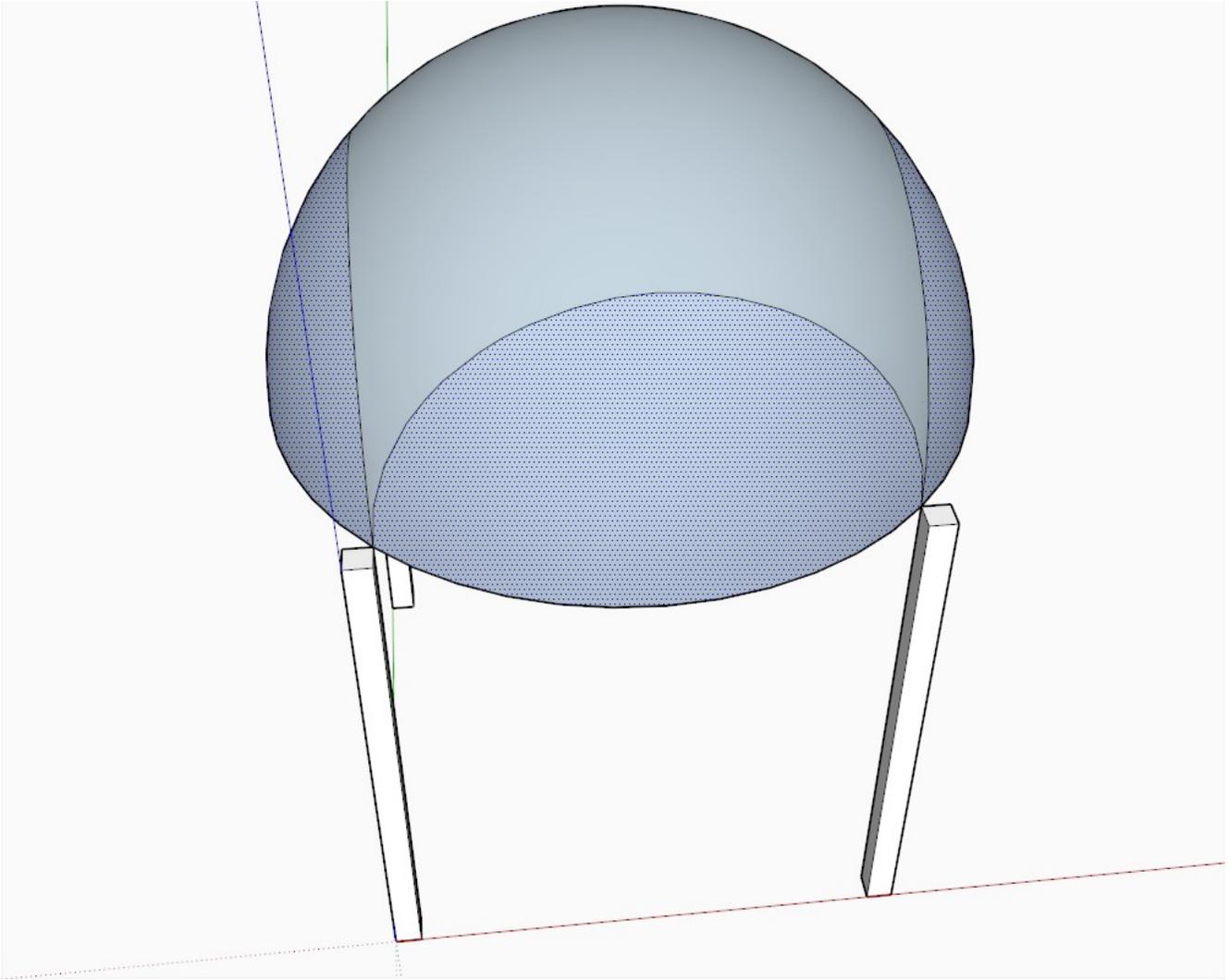


## **Intersecting with Traditional Intersect Tools:**

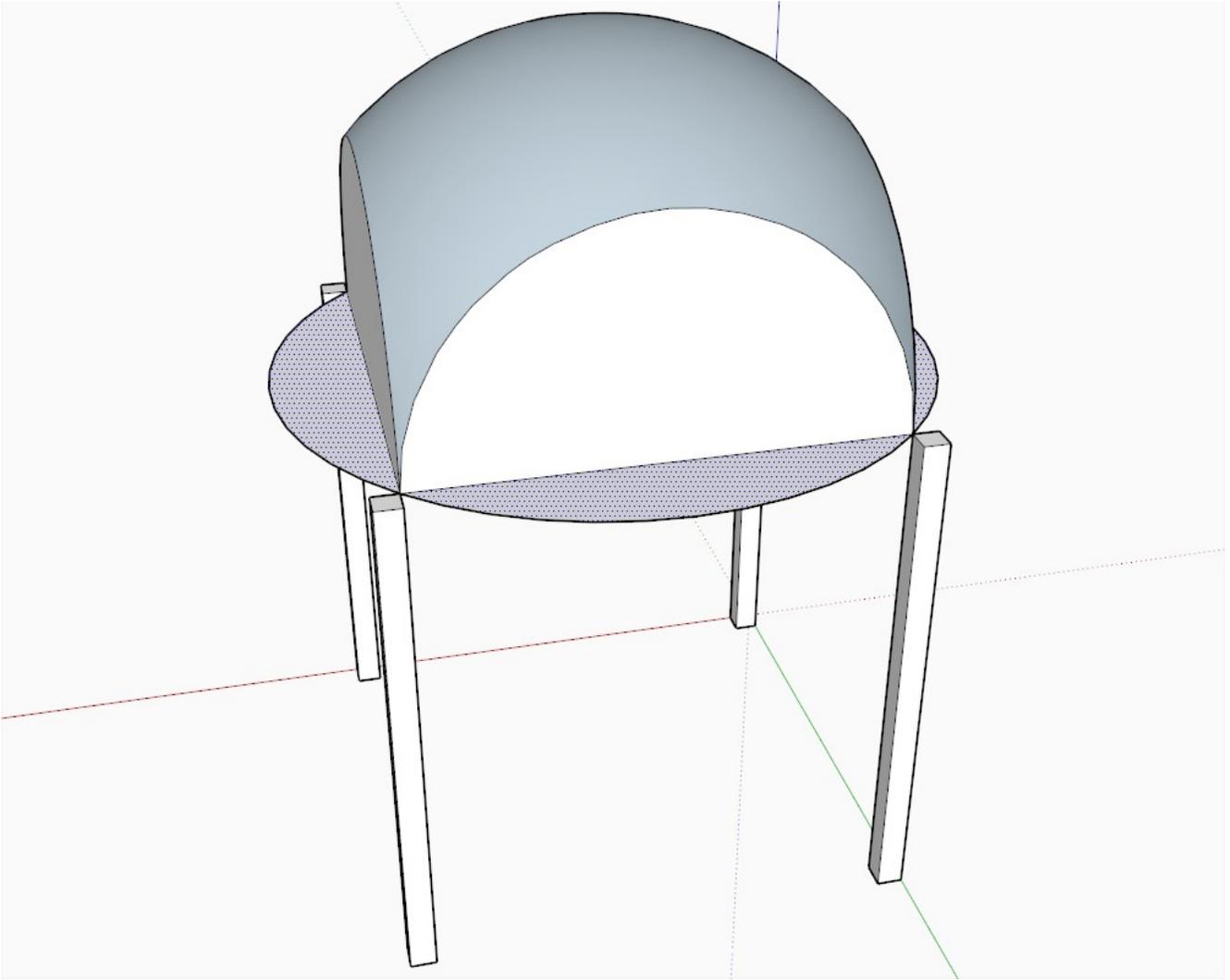
Explode both groups, right click and "Intersect with selected" (although in our case "with model" would just do the same). Pictured is the process for the inner shell. You will need to repeat this process for the outer shell.



Now comes the tedious part: I have already removed the upper, remaining parts of the box. Select these side surfaces and delete them.



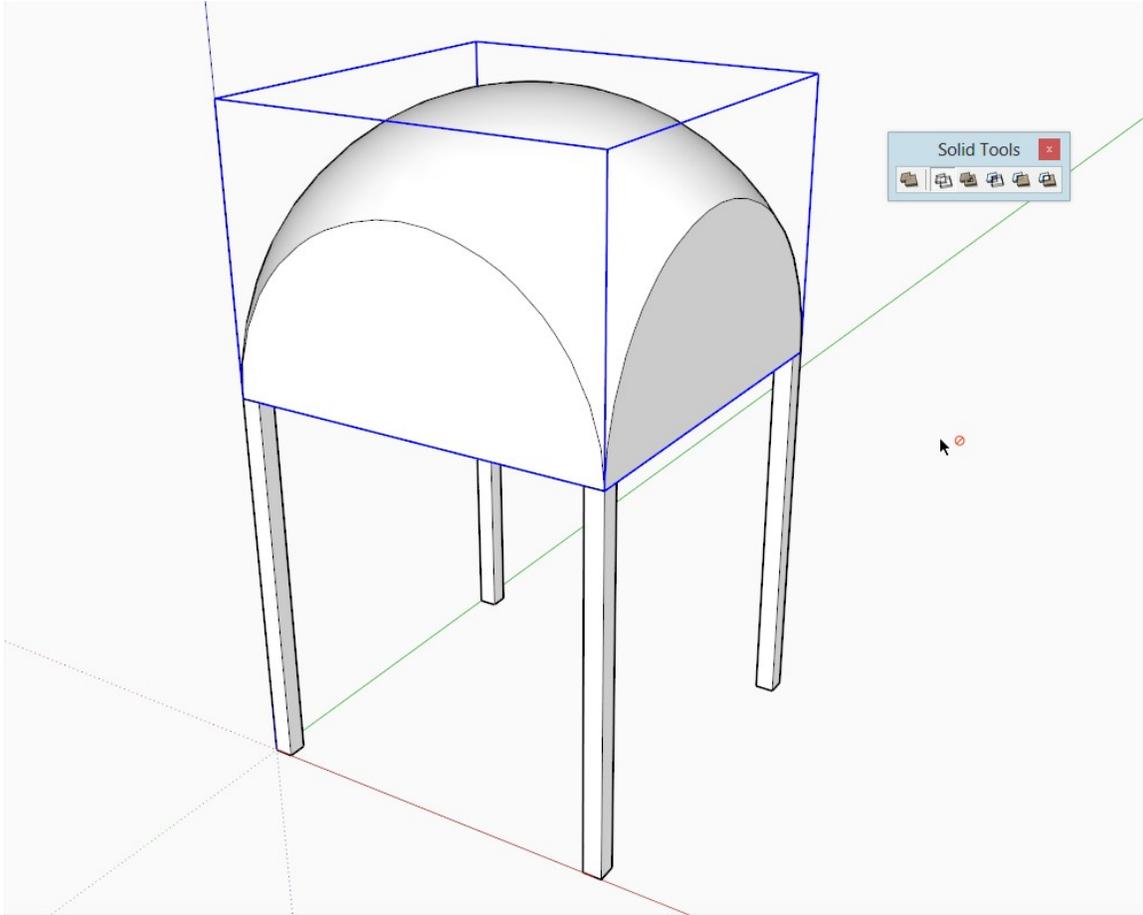
Select the remaining parts of the face of the bottom circle (if there is any at all since for this part we did not need to create it)



The remaining, stray edges are tedious to clean up but try anyway.

Create a new layer, put this inner shell on this layer and hide the layer for the time being.

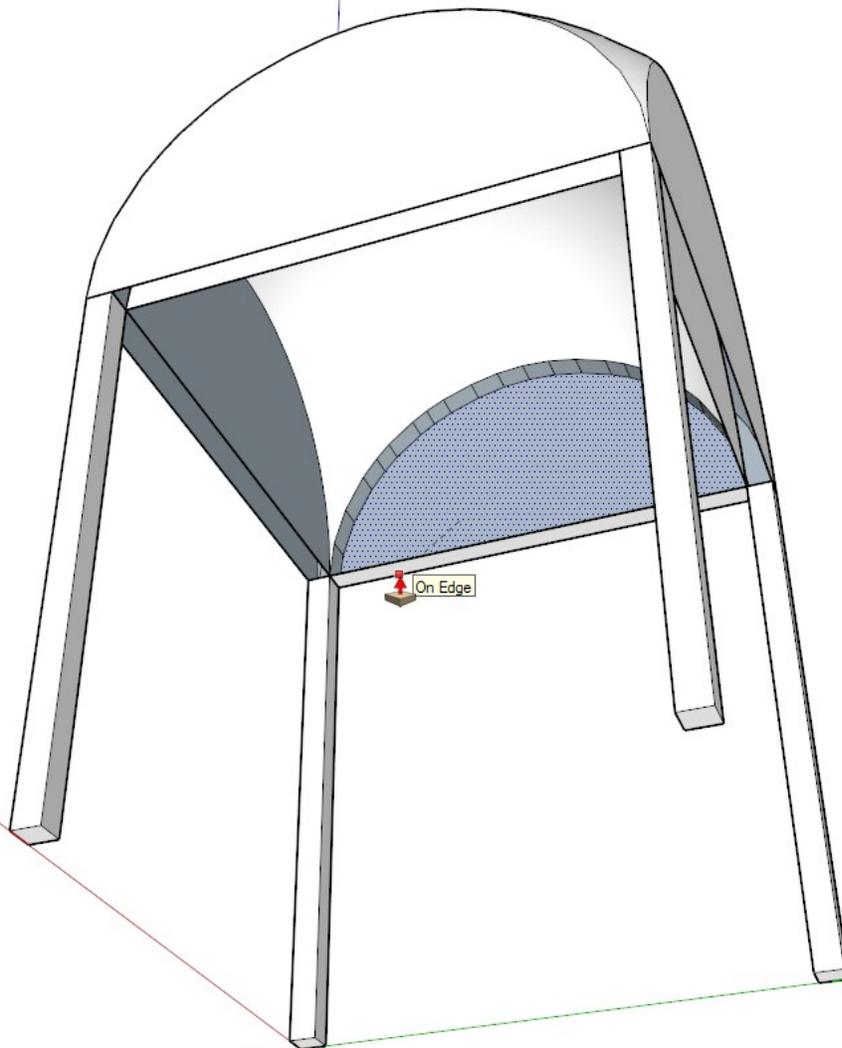
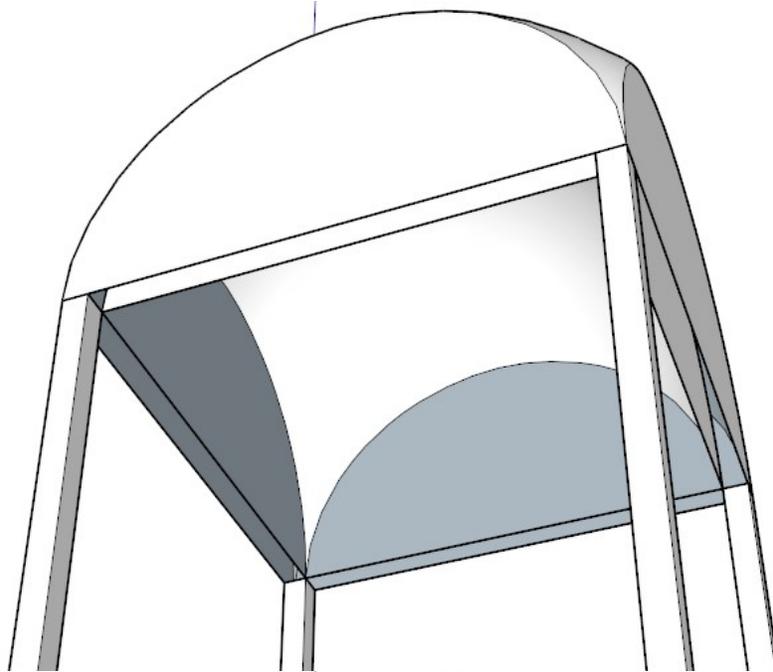
Pictured below is our outer shell.



**Repeat the above procedure for the other shell.**

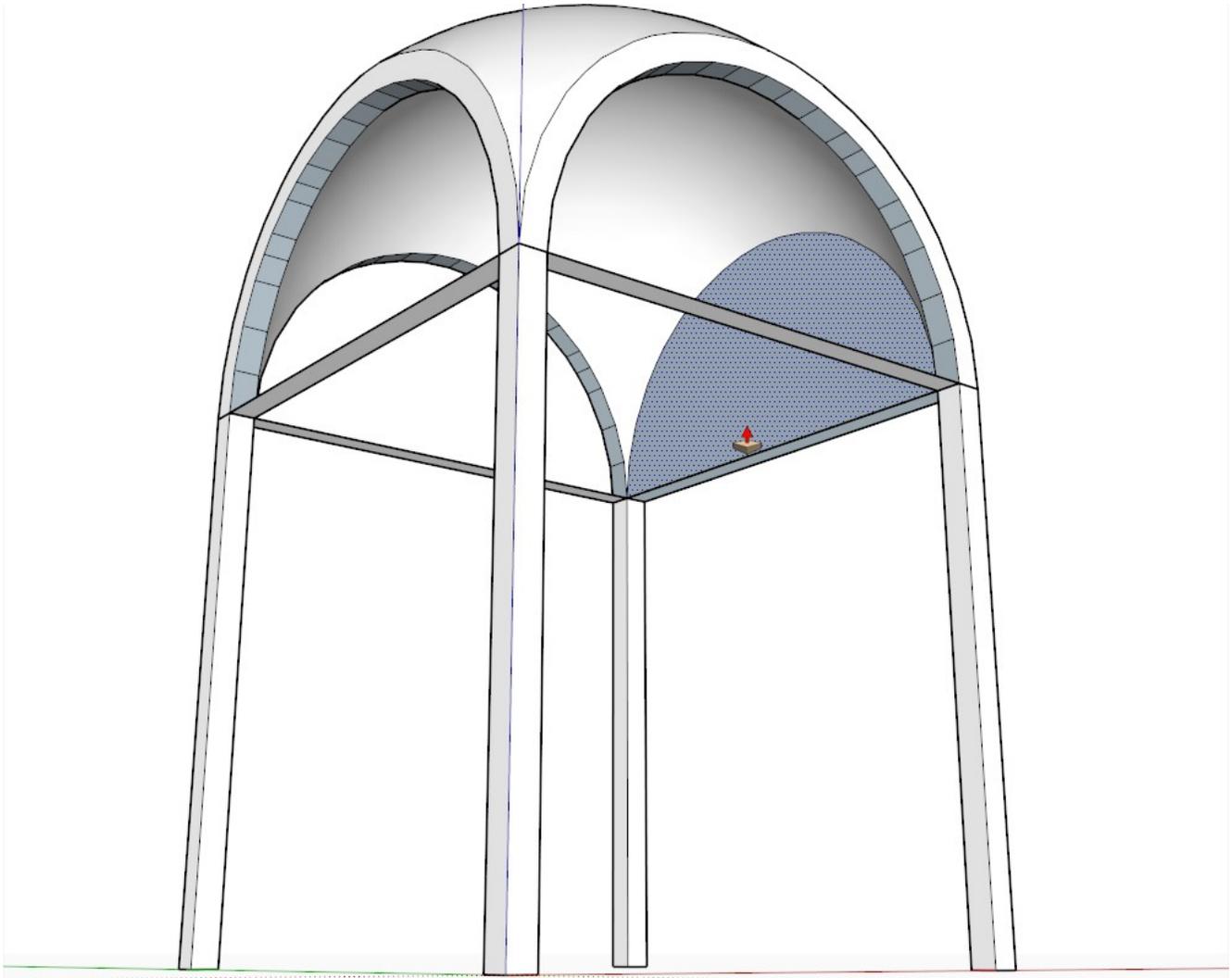
## Removing the Side Panels:

When done in either way, turn on your hidden shell layers and explode everything.

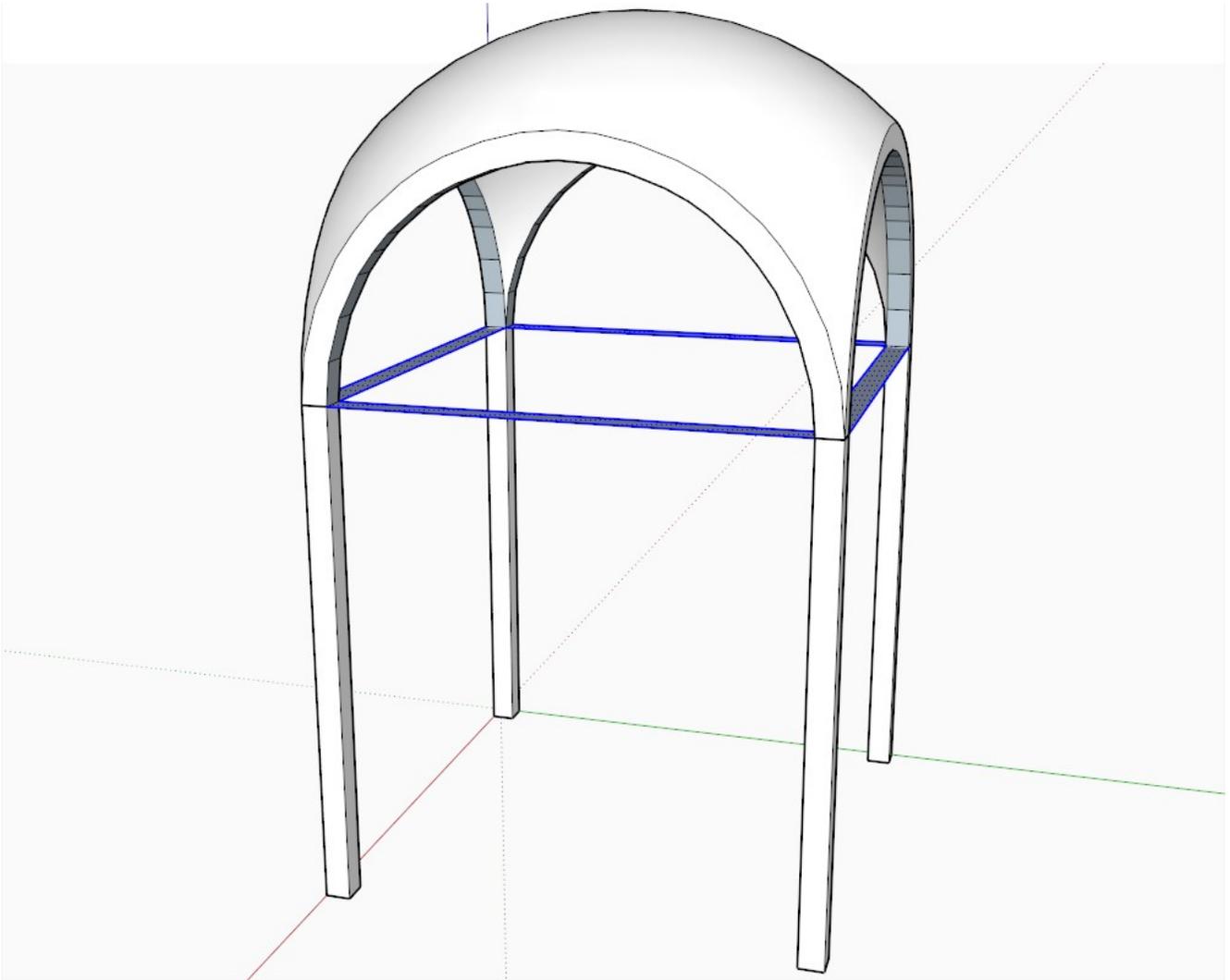


From inside out, start PushPulling the inner half circles. Make sure to snap to an outer edge or endpoint so that the PushPull tool stops exactly there and will cut the outer face properly

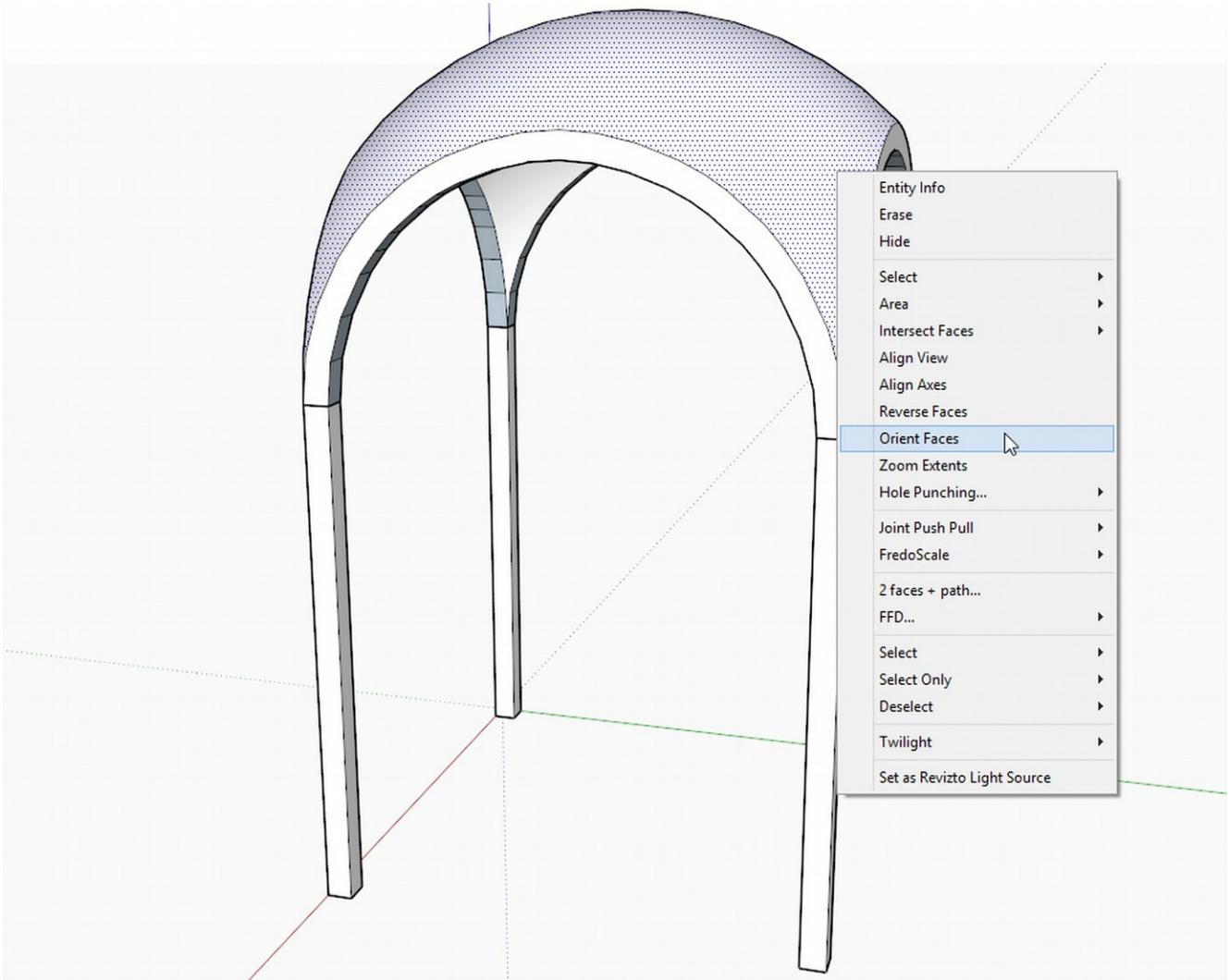
After the first PushPull (which establishes the distance you PushPulled), you can simply double click on the other faces to speed up this operation.



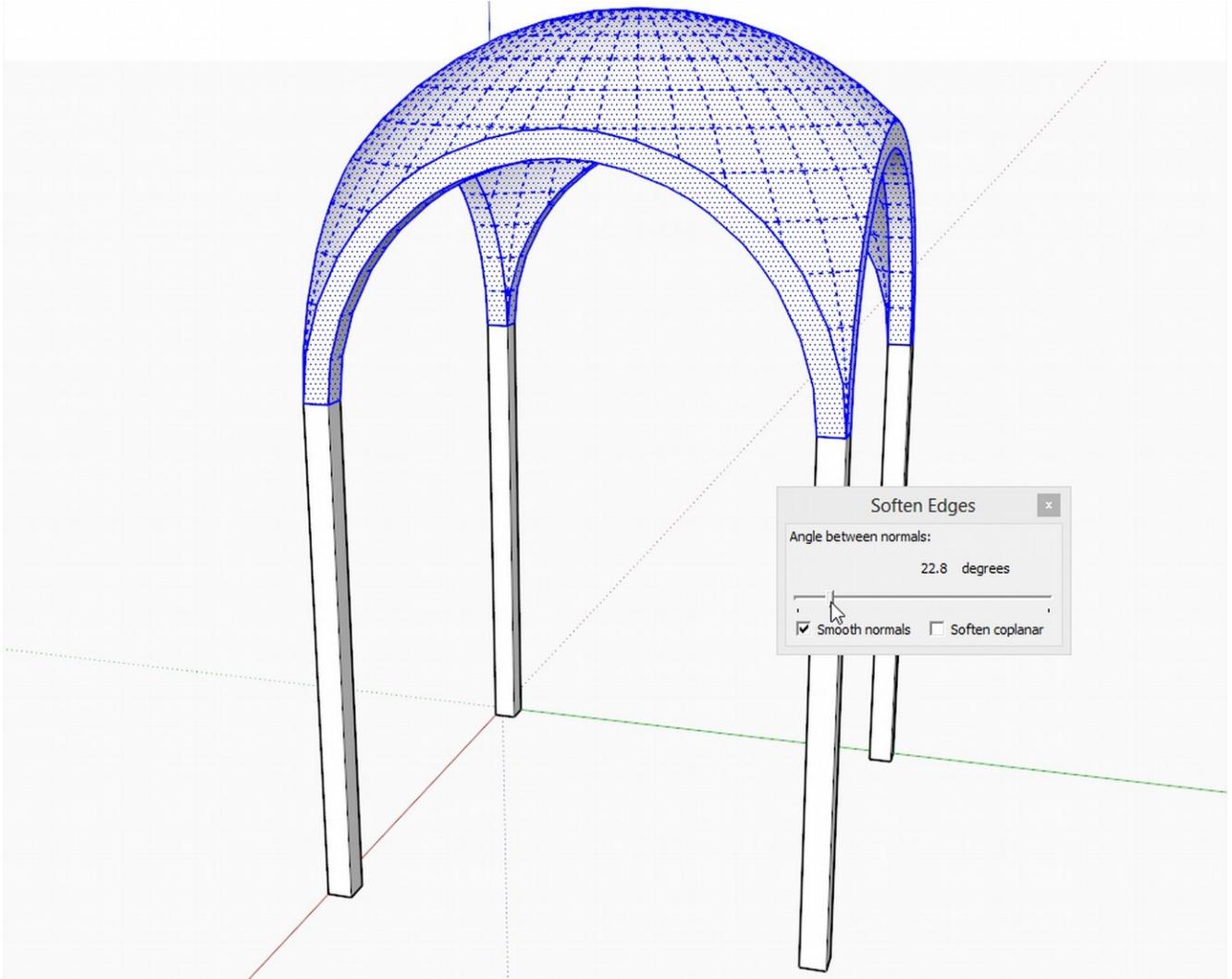
Finally select the remaining faces and connecting edges and delete them.



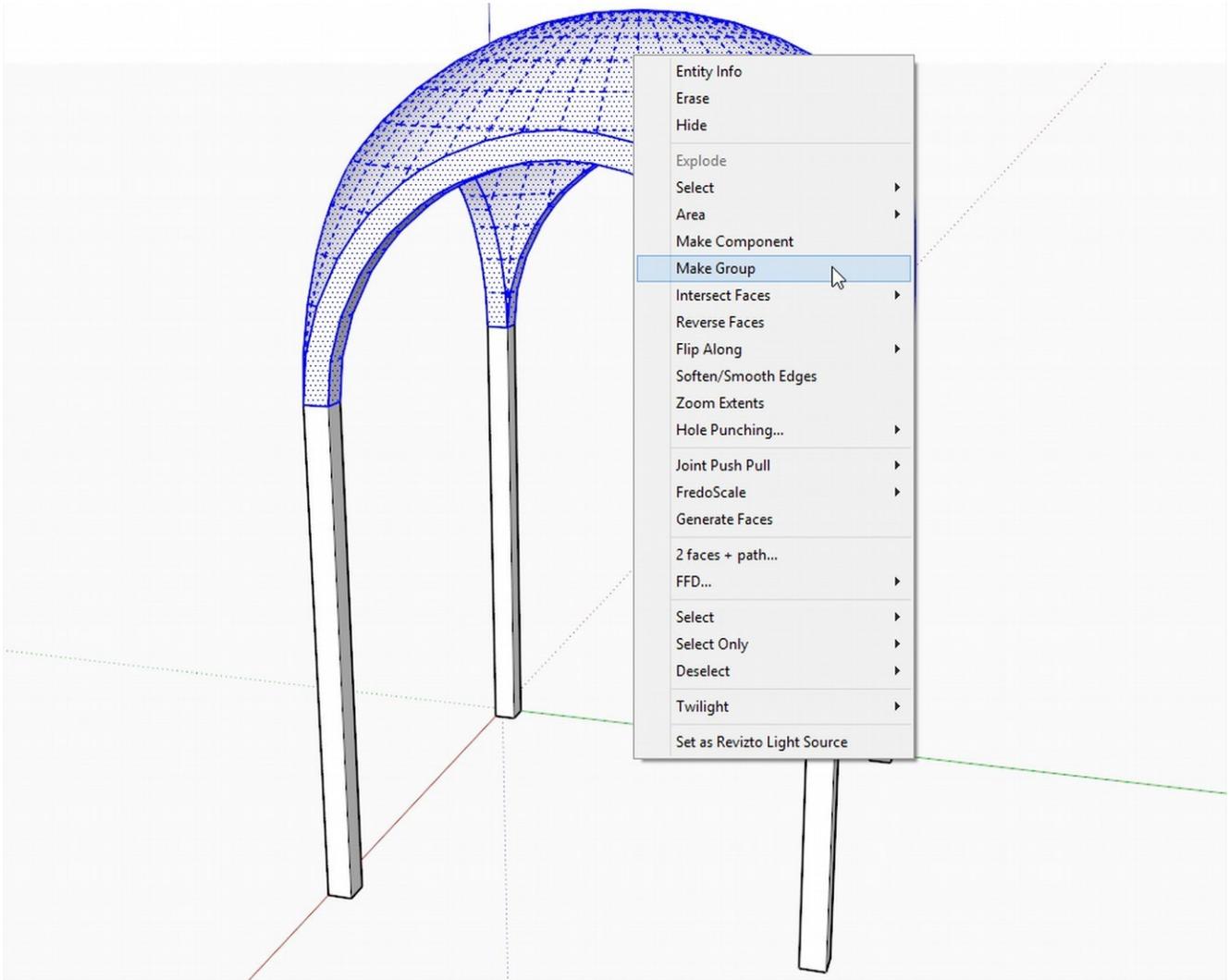
A little clean-up: right click on a front face and "Orient faces" to reverse those back faces under the arches.



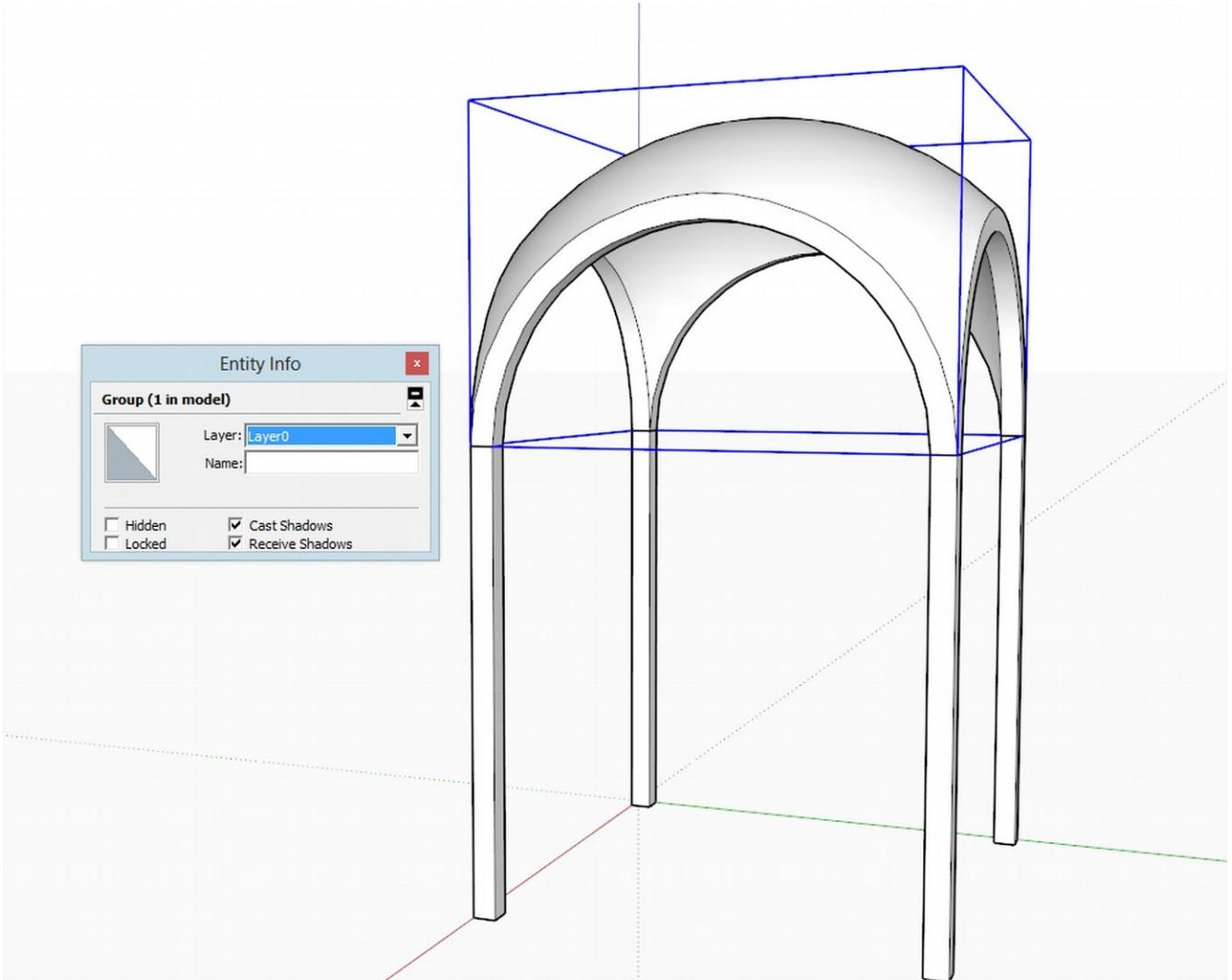
Select all (triple click), right click again and "soften/Smooth edges; you will probably only need to "touch" that slider a bit to soften the hard edges under the arches again...



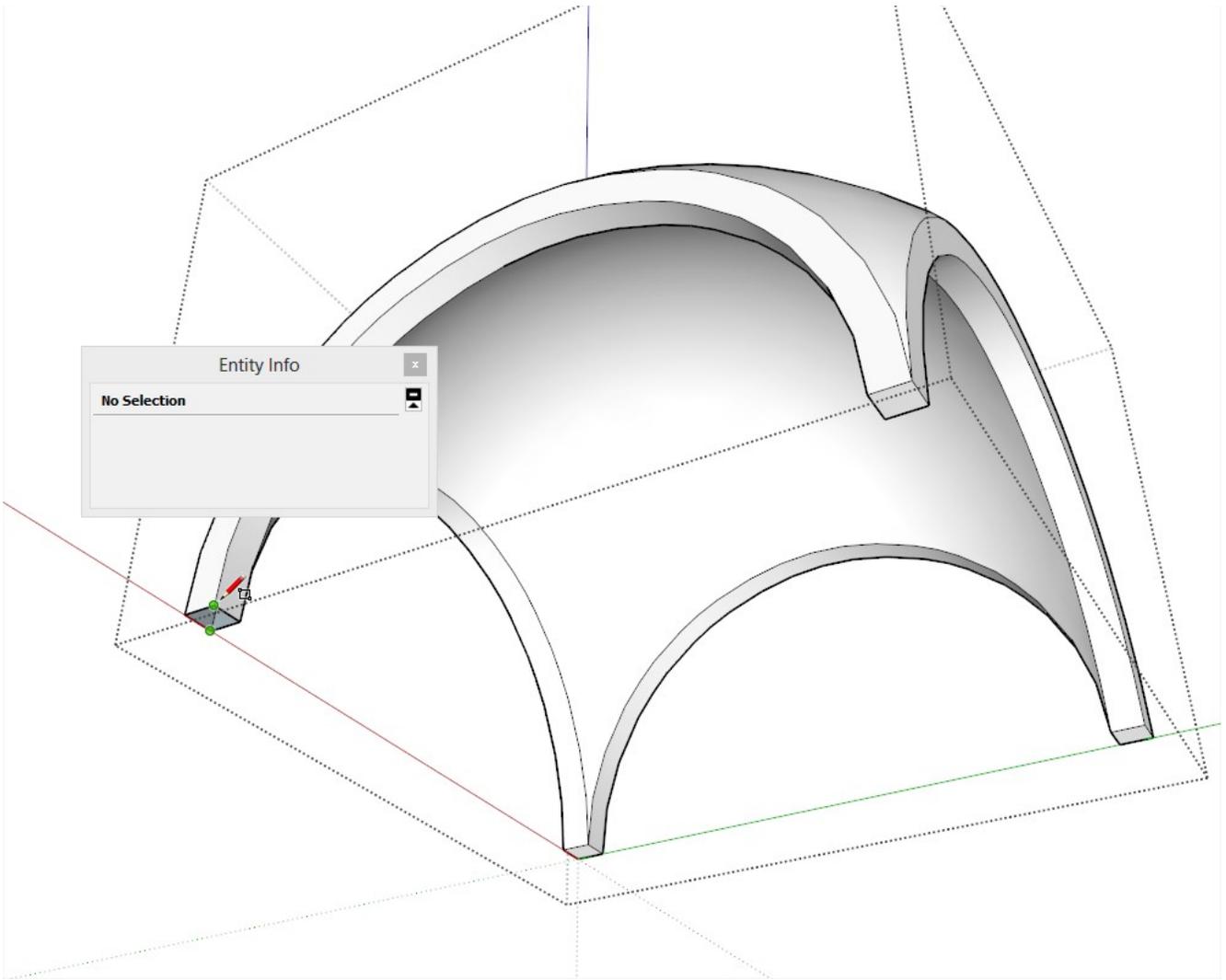
Group the whole thing...



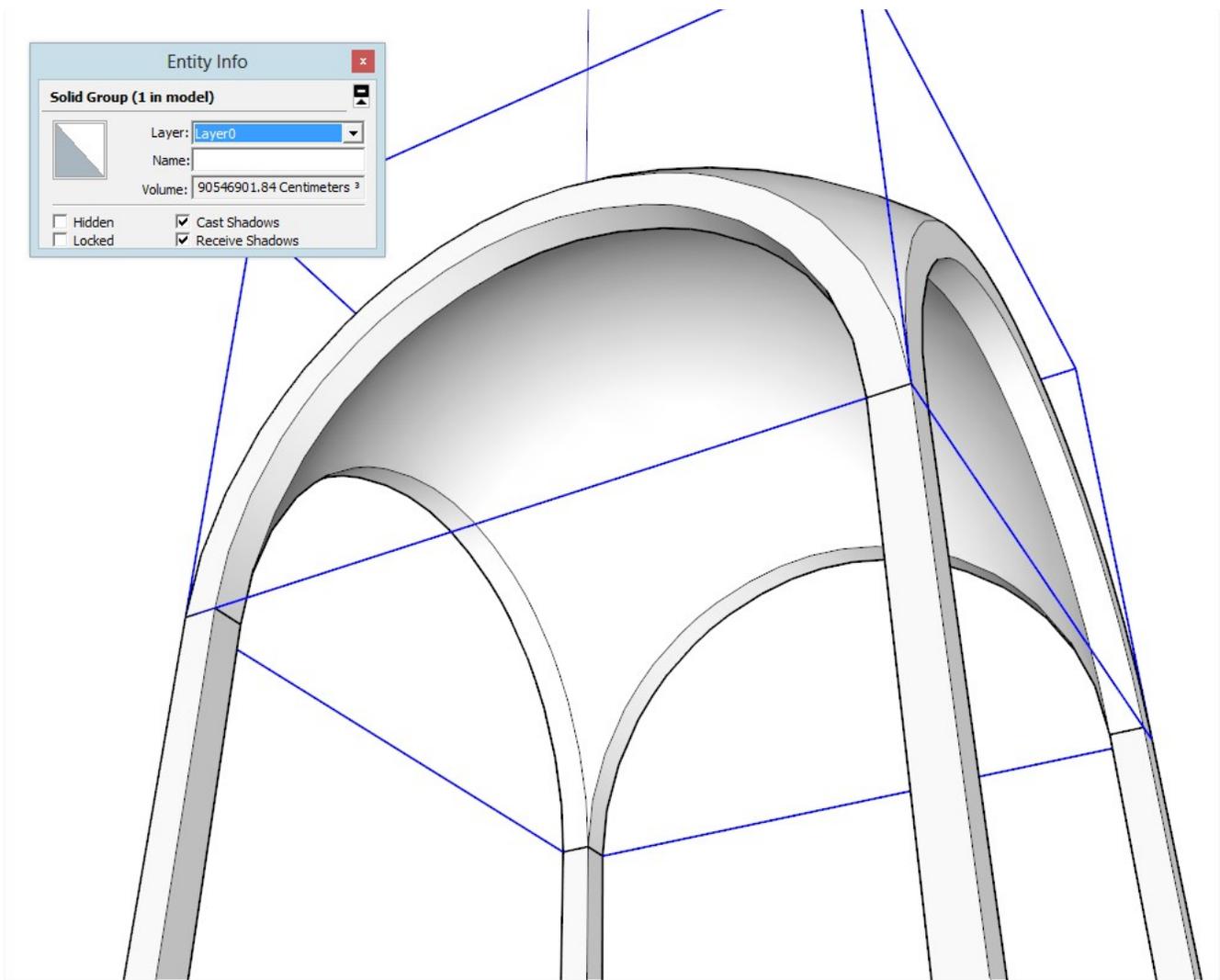
...but notice that it's not a "solid"



Hide the columns (or see the tip on pg 23), open the group and cover the bottom of the "legs" of the dome.

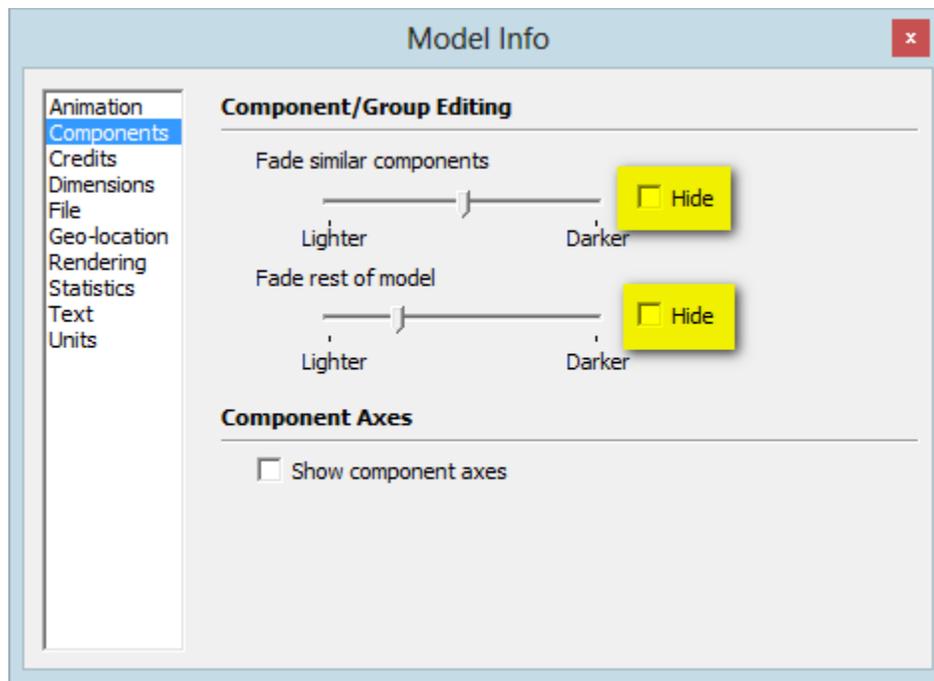


Now it is nice and solid...

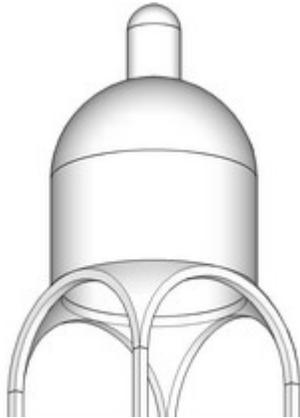


This dome could be called a "hanging dome" (the English term "dome on pendentives" comes from the Latin "pendo" meaning "hang") but this bare kind of dome is rare in architecture however (or combined with cross ribs to form a so called "Romanesque cross vault" like in the [Basilica of St Ambrose](#) in Milan).

There is a setting under Window > Model info > Components to hide similar components (or groups) or the rest of the model while editing one. Now of course it is a tedious thing to open this panel every time you need it but you can easily assign a keyboard shortcut to these functions under Preferences > Shortcuts. I have Ctrl+H to hide the rest of the model and Shift+Ctrl+H to hide similar groups/components while editing one. This can speed up modelling parts that are covered by other objects - or inside a complex model generally.



Here's a picture of where we're going now.



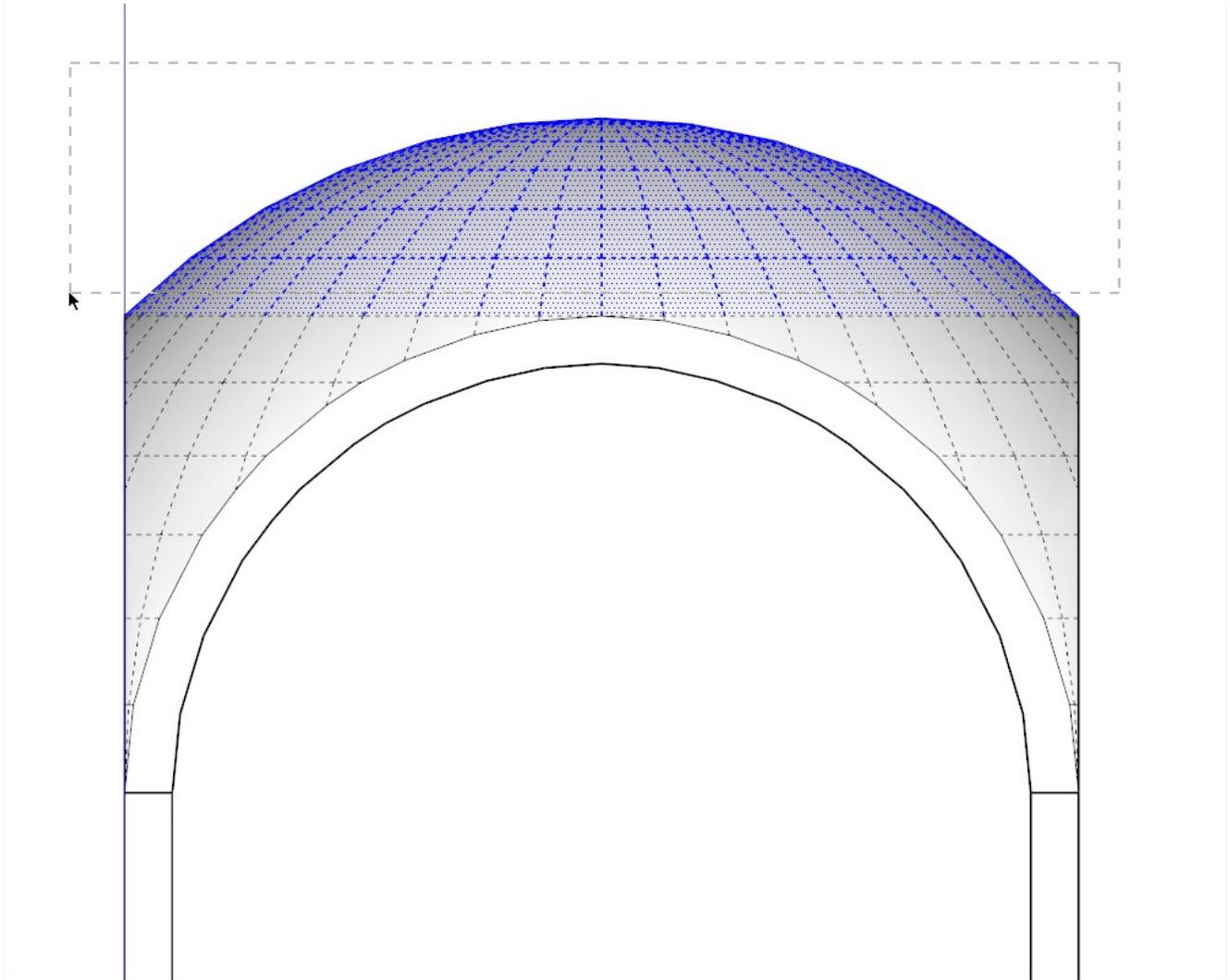
We now add different, further elements that have made great domes of architecture history what they are now although each has its functional role, too.

We are going to use the very basic SketchUp tools like the Arc, Circle, Selection and PushPull tools only.

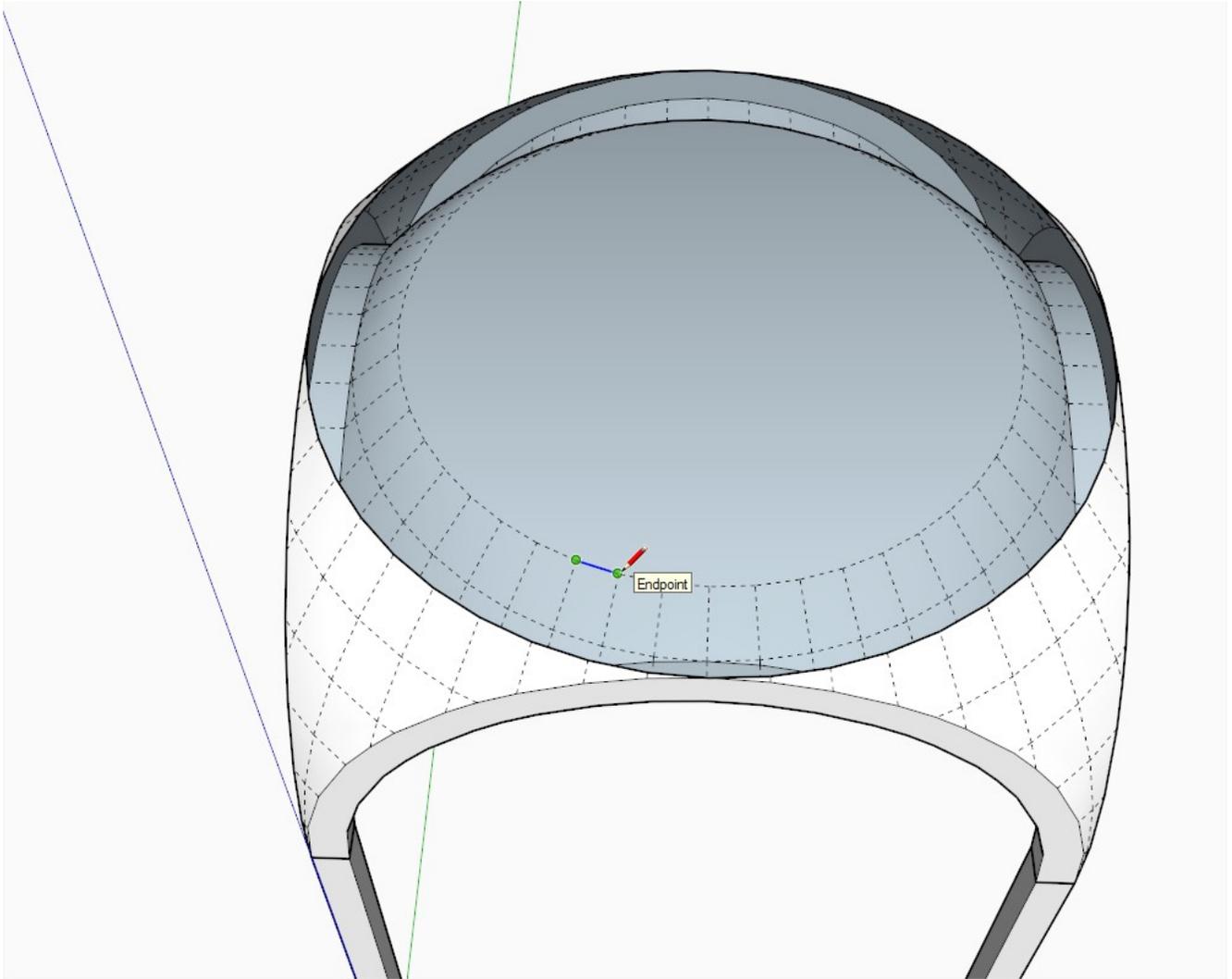
## Creating the First Opening of the Dome:

Let's start with the dome we created. Best is to explode the dome group now so that we need not keep opening it for editing all the time.

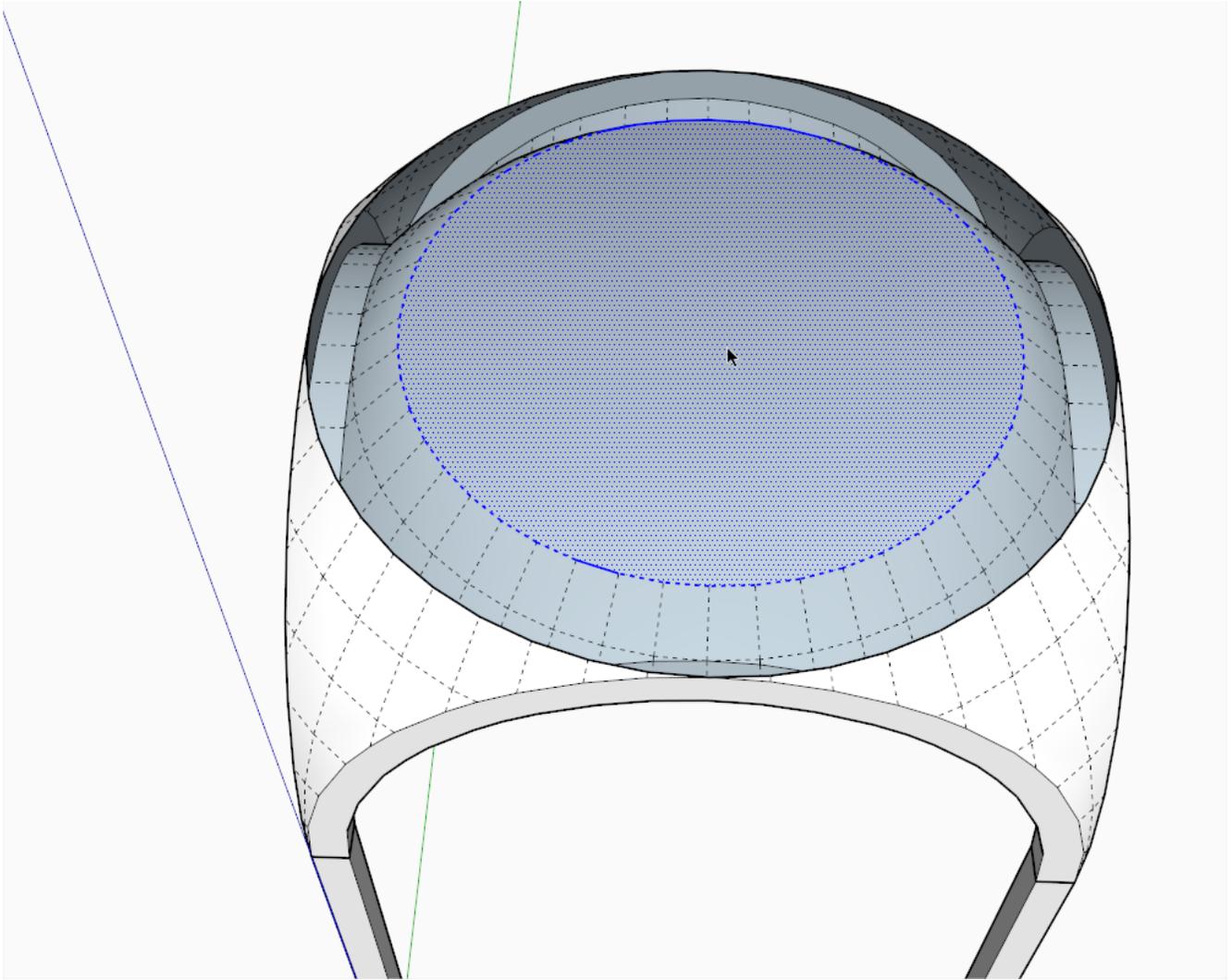
Under the Camera menu, set projection to Parallel (in case you are in Perspective as I like to model mainly) and also set one of the Standard views (say Front). With a right-to-left selection box, select everything that is above the arches and delete.



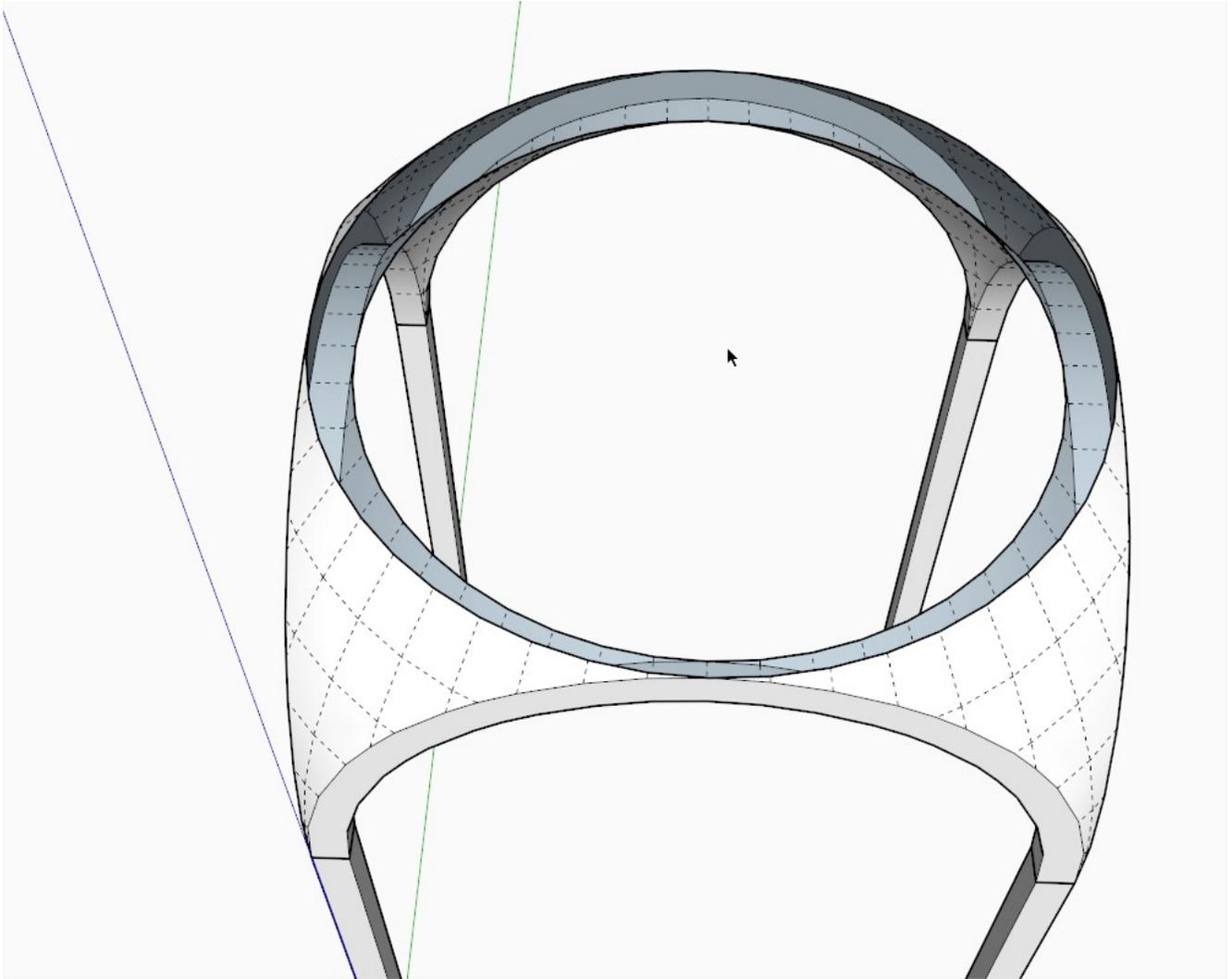
This will delete some of the inner shell as well but we need to delete more. To speed up selection, redraw one of the edges on the perimeter of the "leftover"; a face will be created like what you can see in the image.



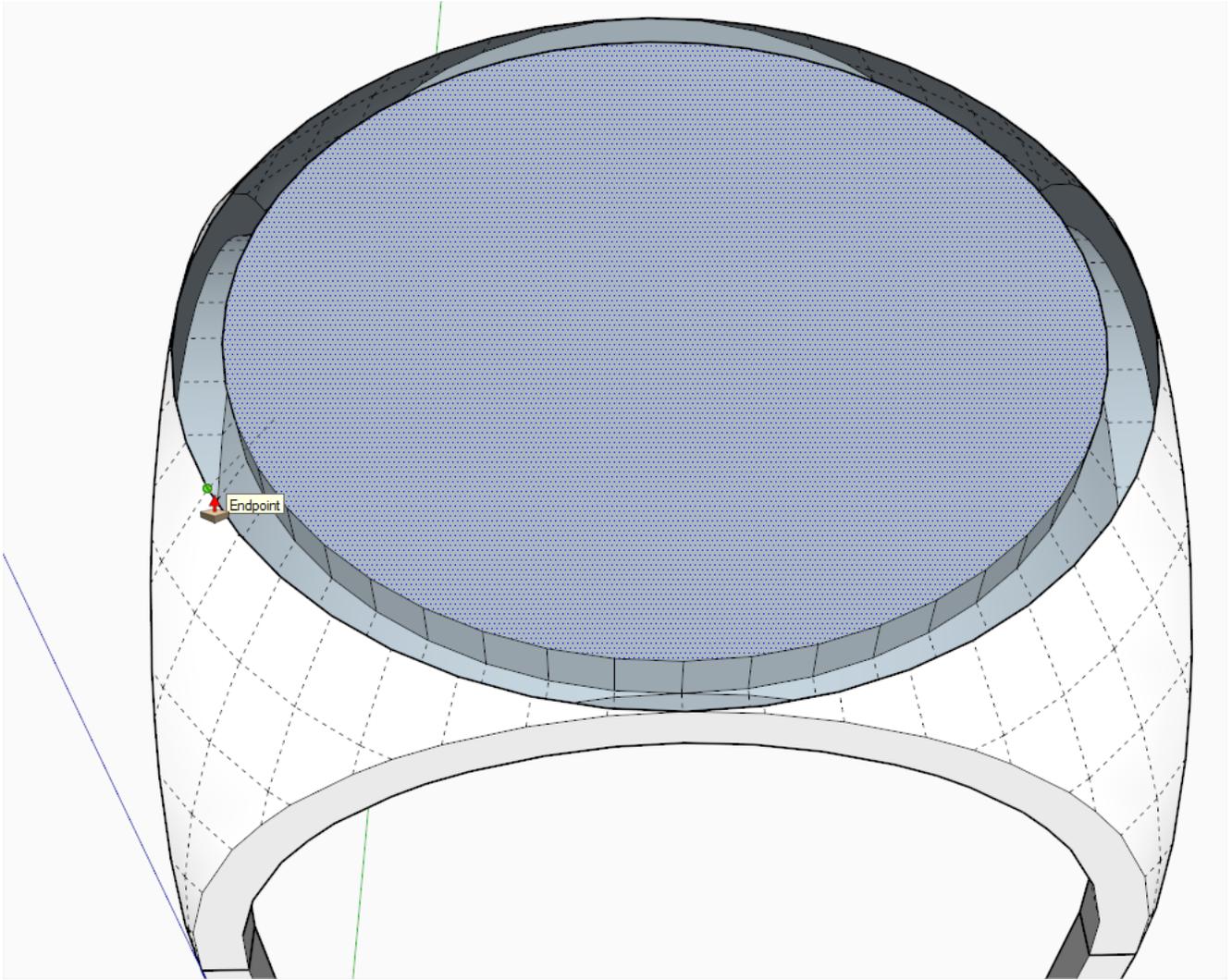
Double click on this face (this will select its perimeter too) and delete. The softened, connected edges will auto-delete themselves.



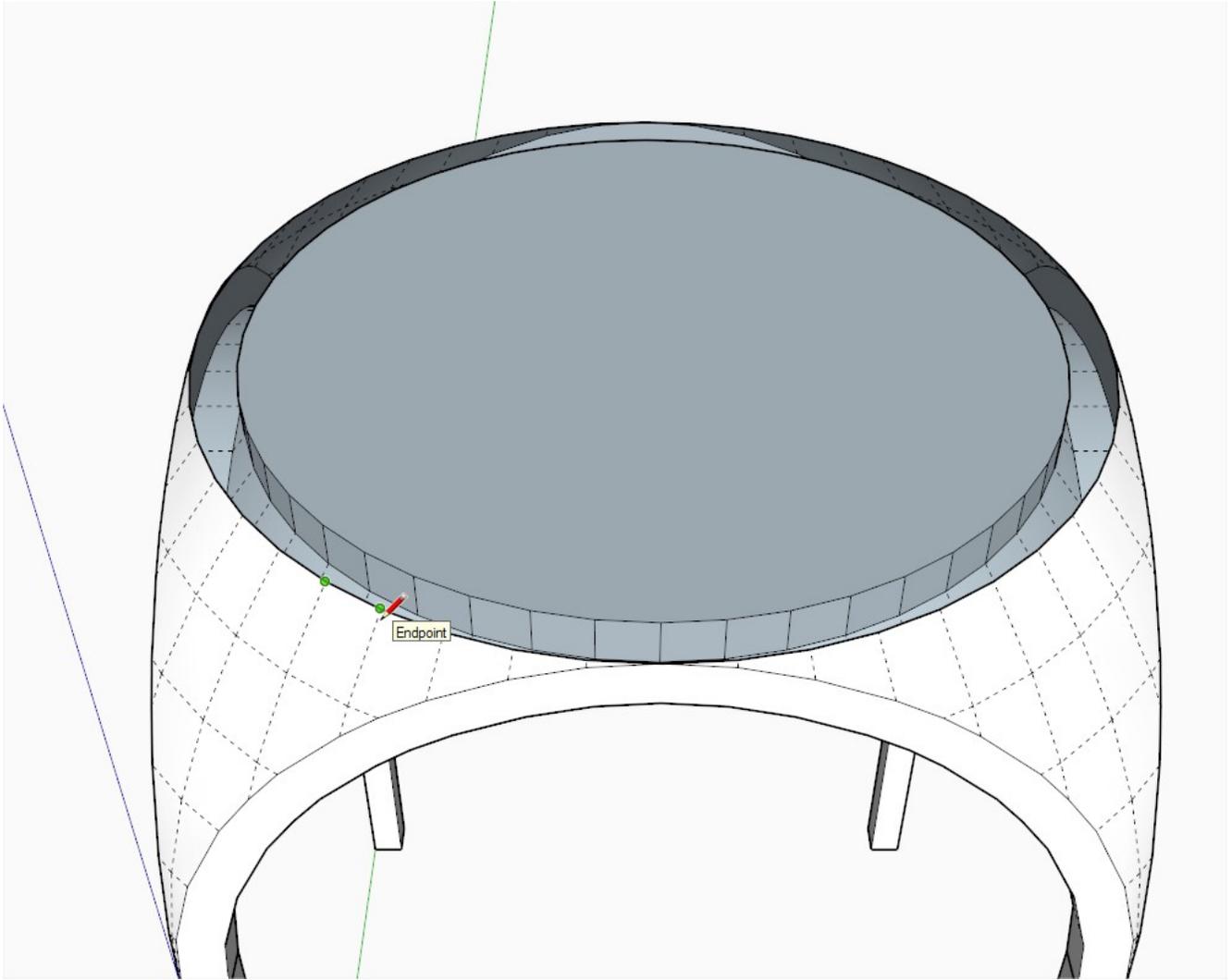
This is how it should look like: one ring of facets less than before.



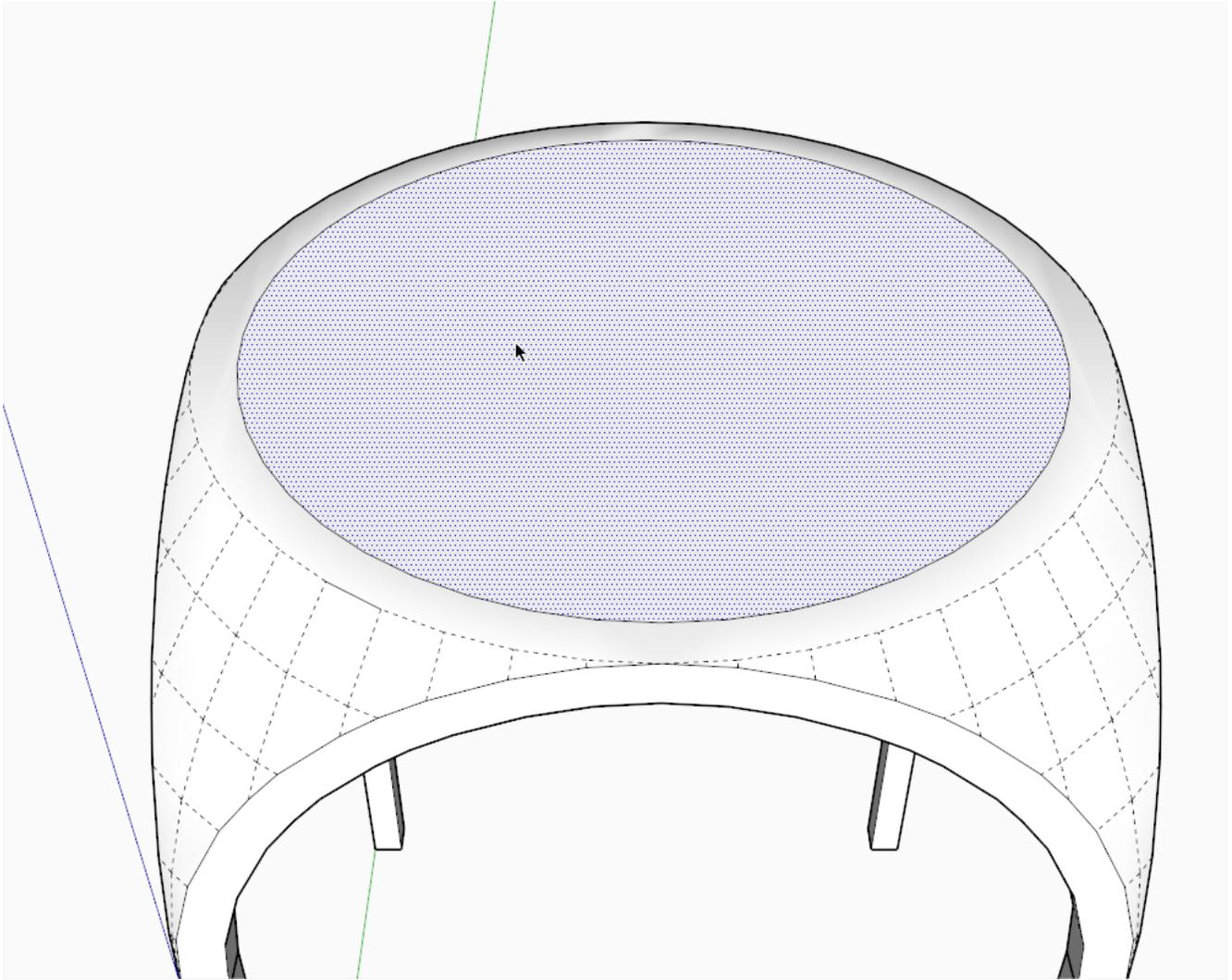
Now redraw an edge again and PushPull the face thus created to match exactly with the edge of the outer shell (snap to it with the PushPull tool).



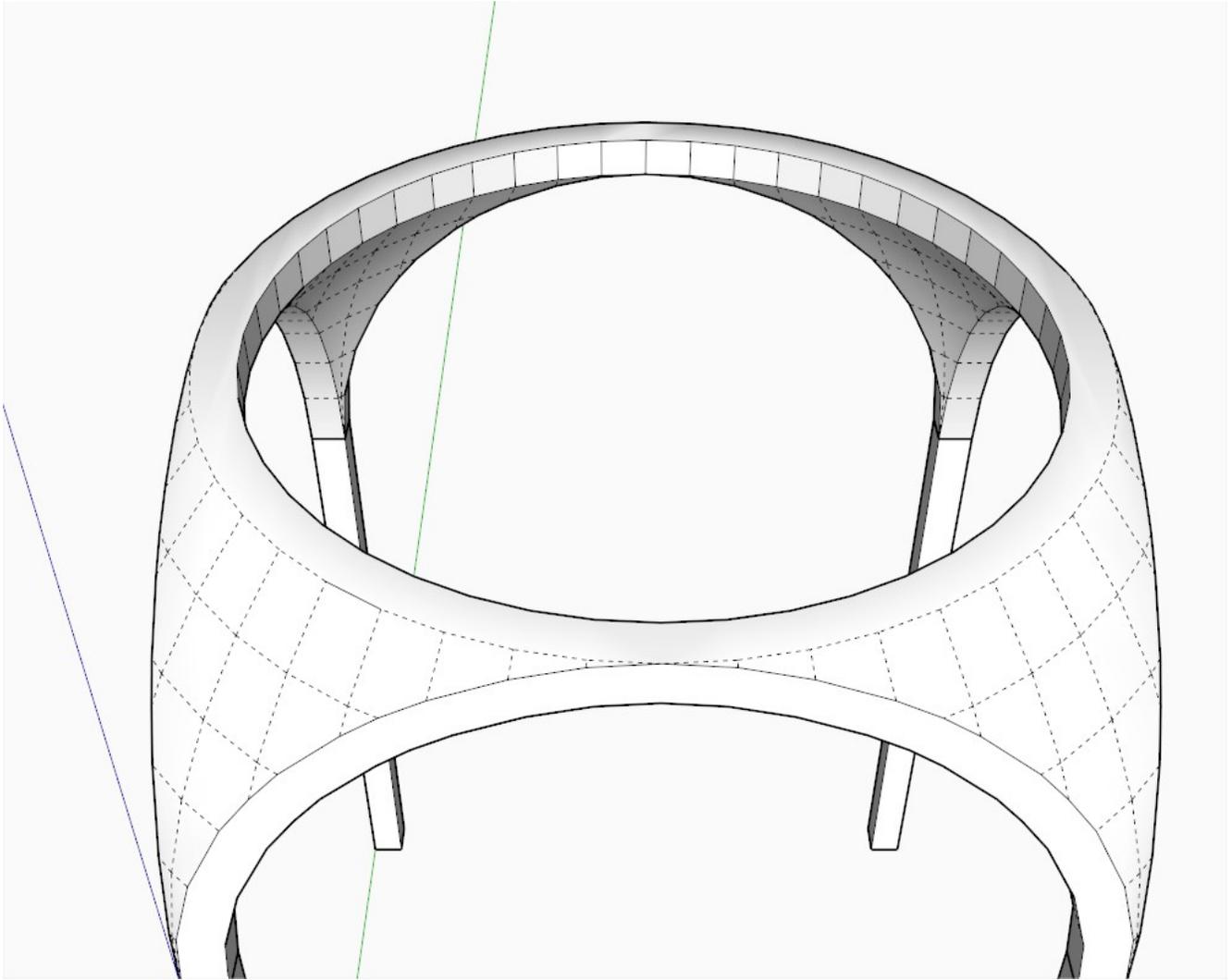
When done, redraw an edge on the outer shell, too.



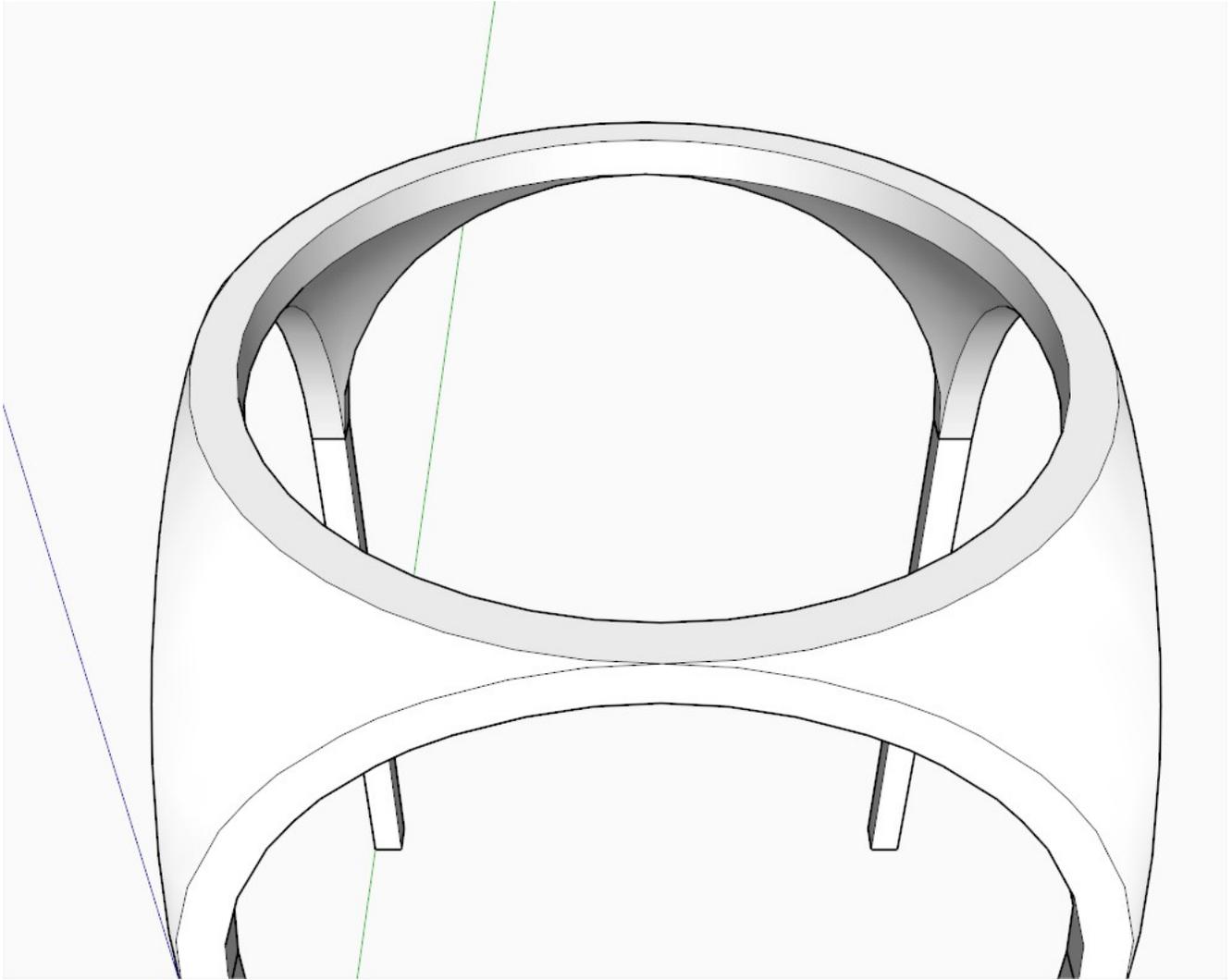
From the face created, you should be able to select that inner face highlighted in the screenshot below.



Delete it and this is what you get.



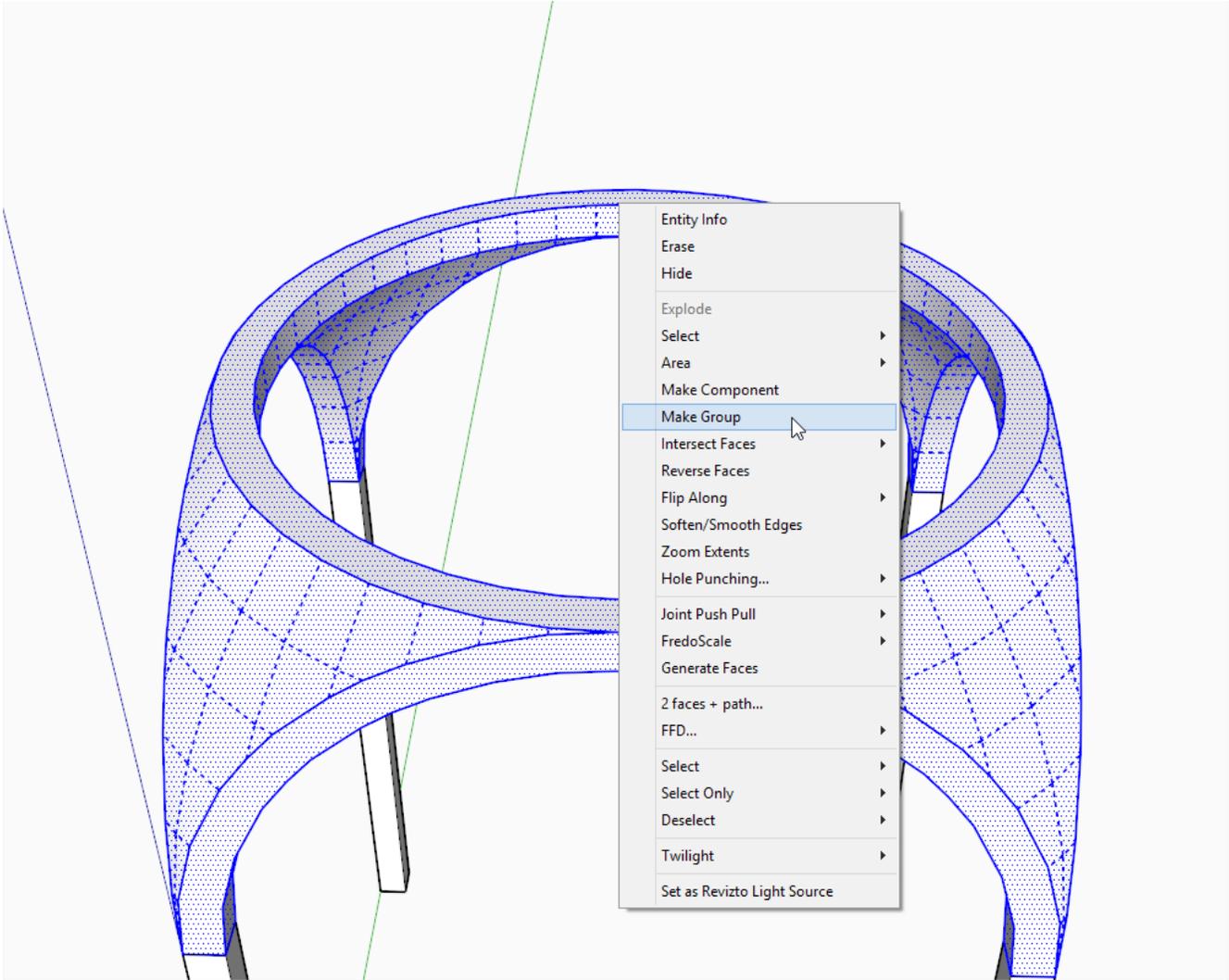
Soften the edges and turn off hidden geometry to see it in its full glory.



From below, you can now see those remnants of the inner shell of the original dome - these are called [pendentives](#). Since there are four of them, in about 8 out of 10 churches (in Churches where depiction is allowed, that is), usually the four apostles are depicted here representing the "four corners" of the World - while the magnificent dome above is the Heavenly Paradise (but let's get back to work now).



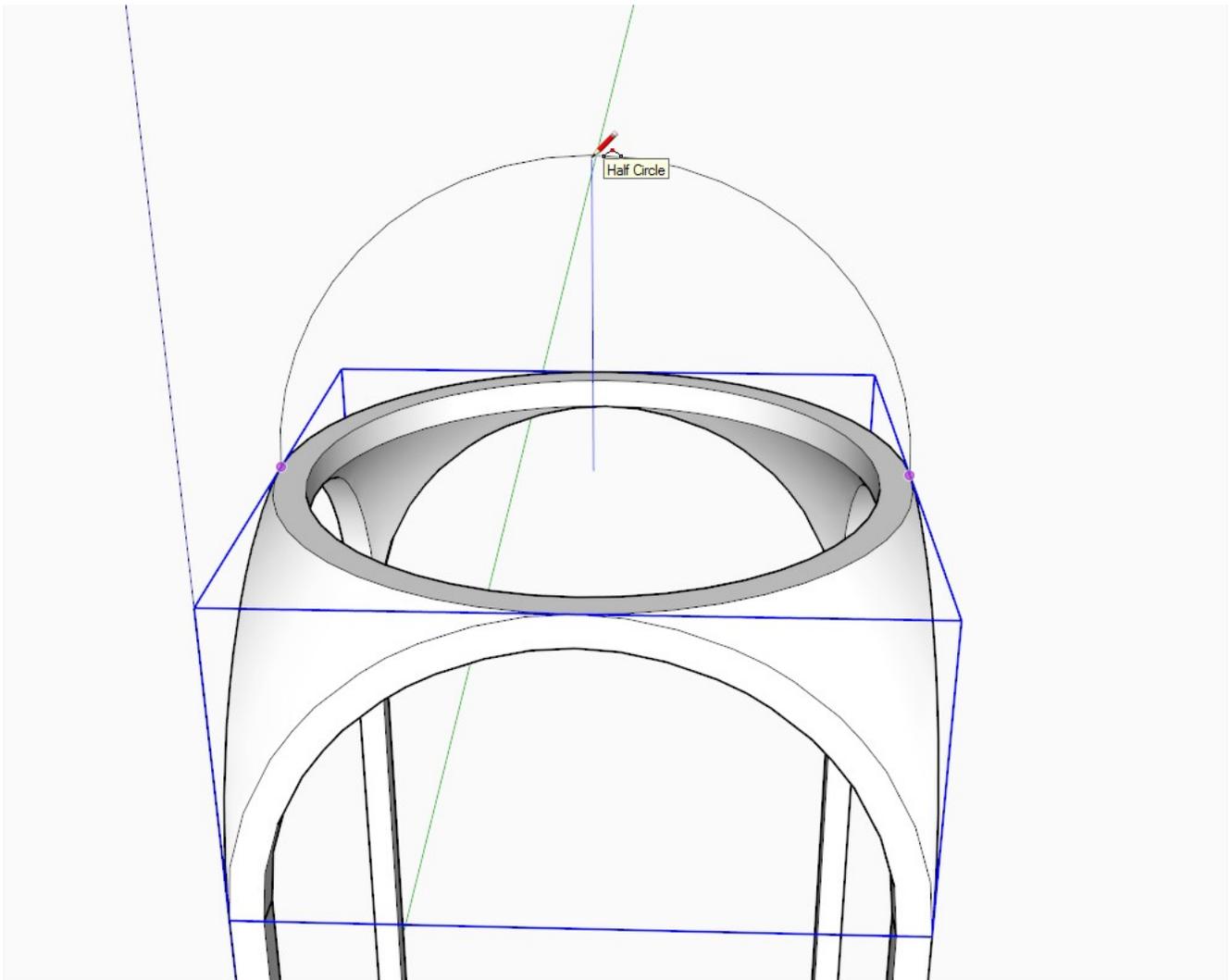
Let's make a group of what we have so far (just to keep things separately and nice and clean).



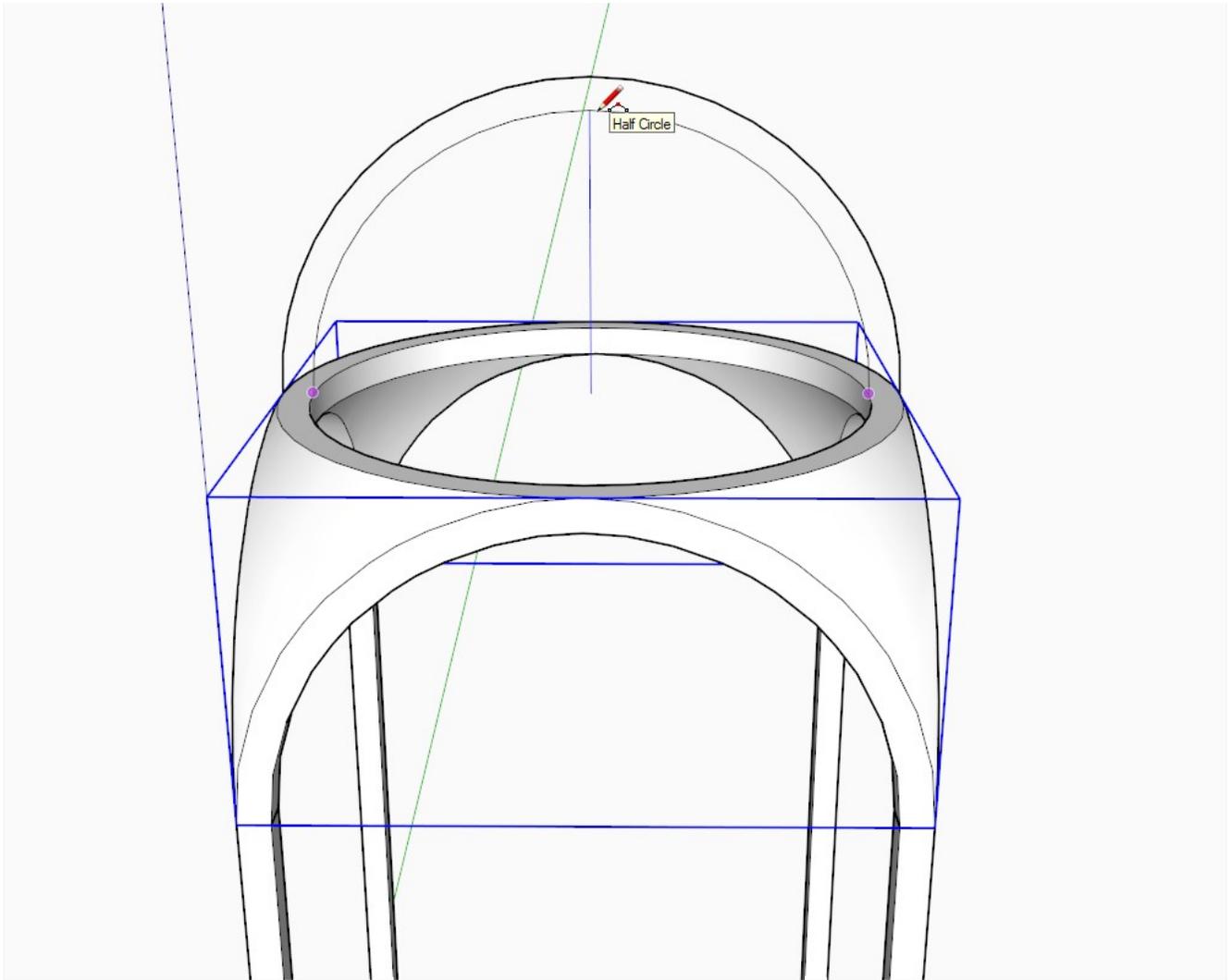
## **Building the “Standing Dome”:**

Draw an arc from one endpoint around the outer perimeter to the opposite endpoint. Make sure it's the opposite. I usually draw these in a way that the starting "span" of the arc is along an axis so you can get the inferencing. You can also start with the edge drawn two steps below and use its endpoints to start and end the arc.

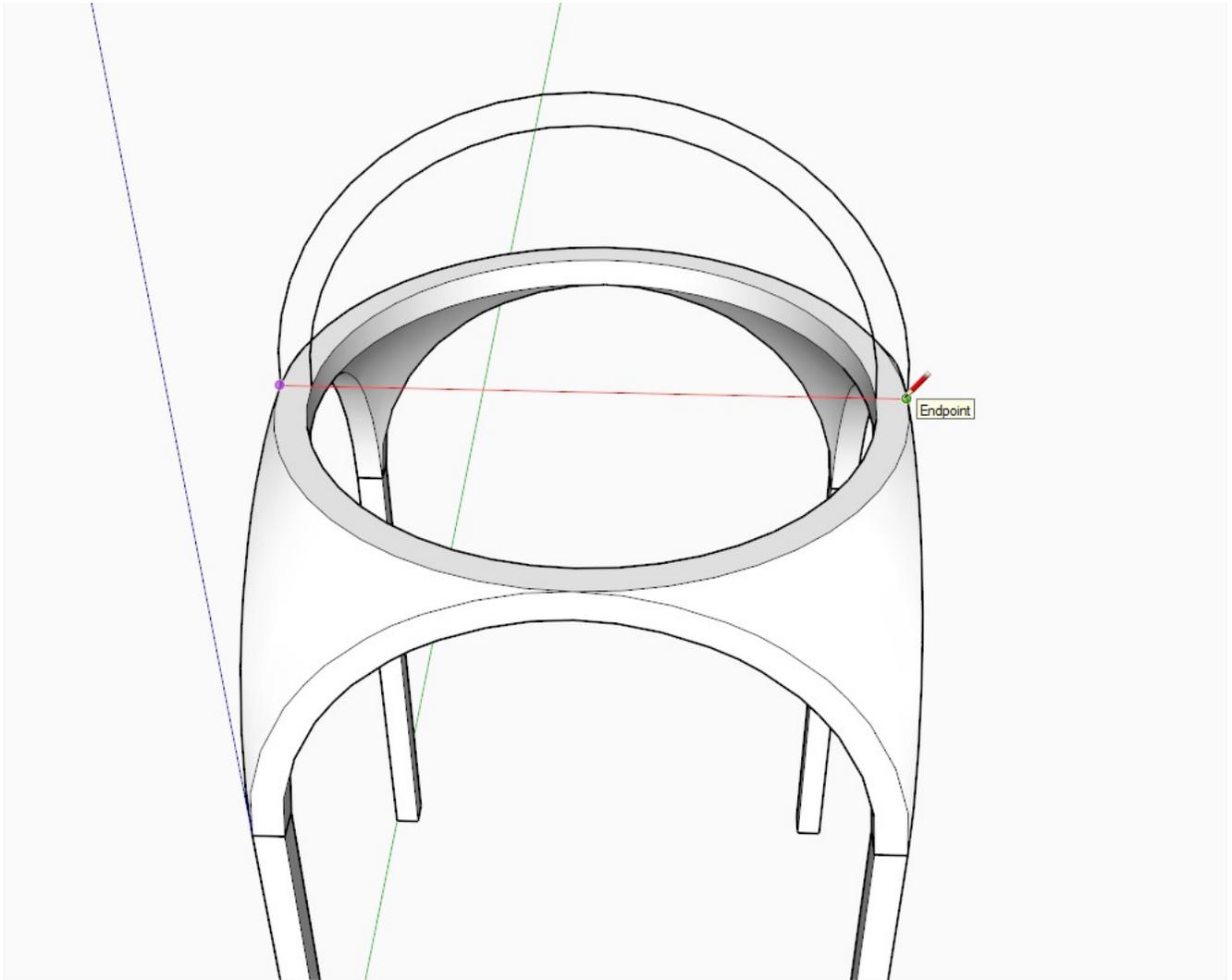
Pull it up along the blue axis and make it a half circle.



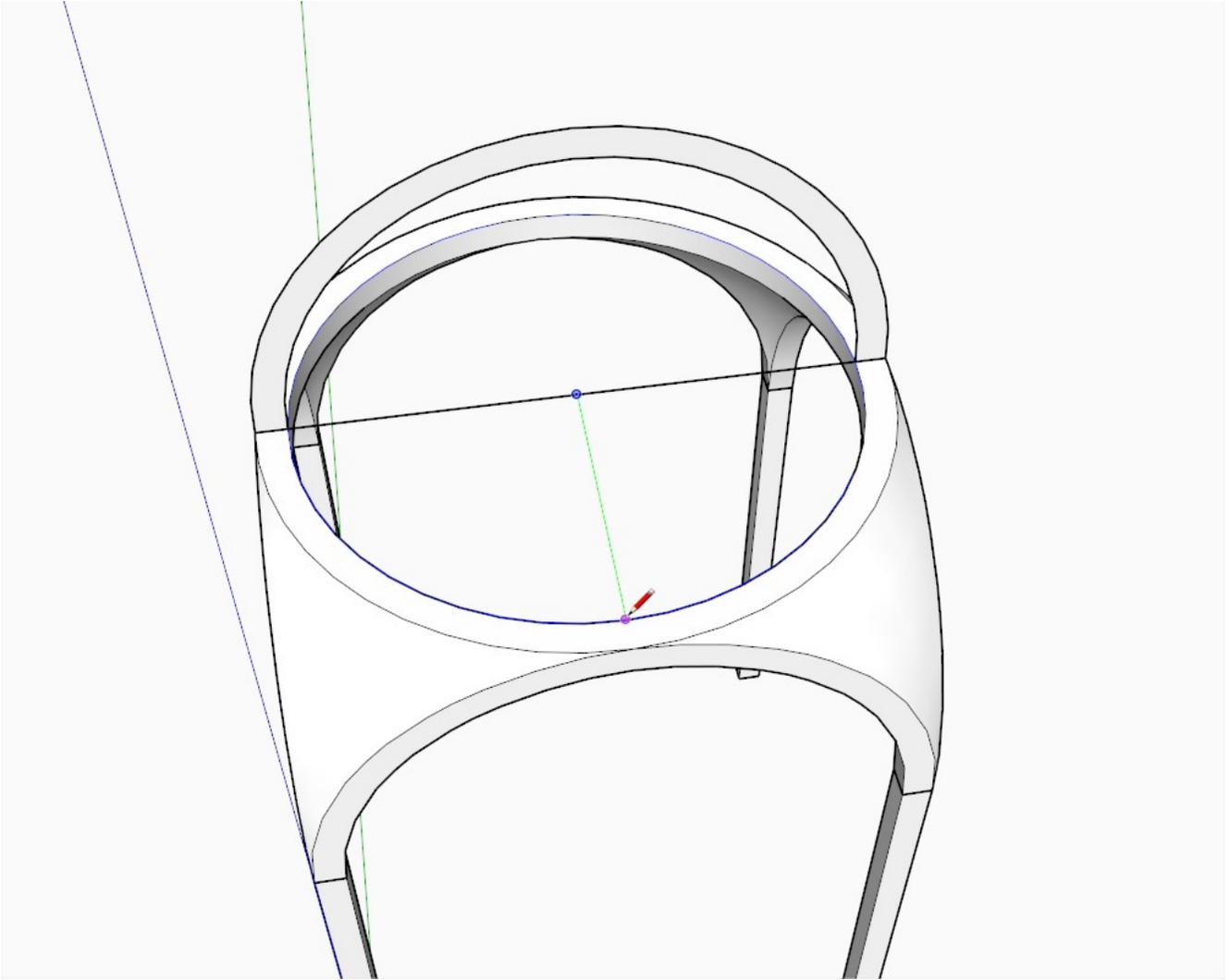
Draw the inner arc in a similar way.



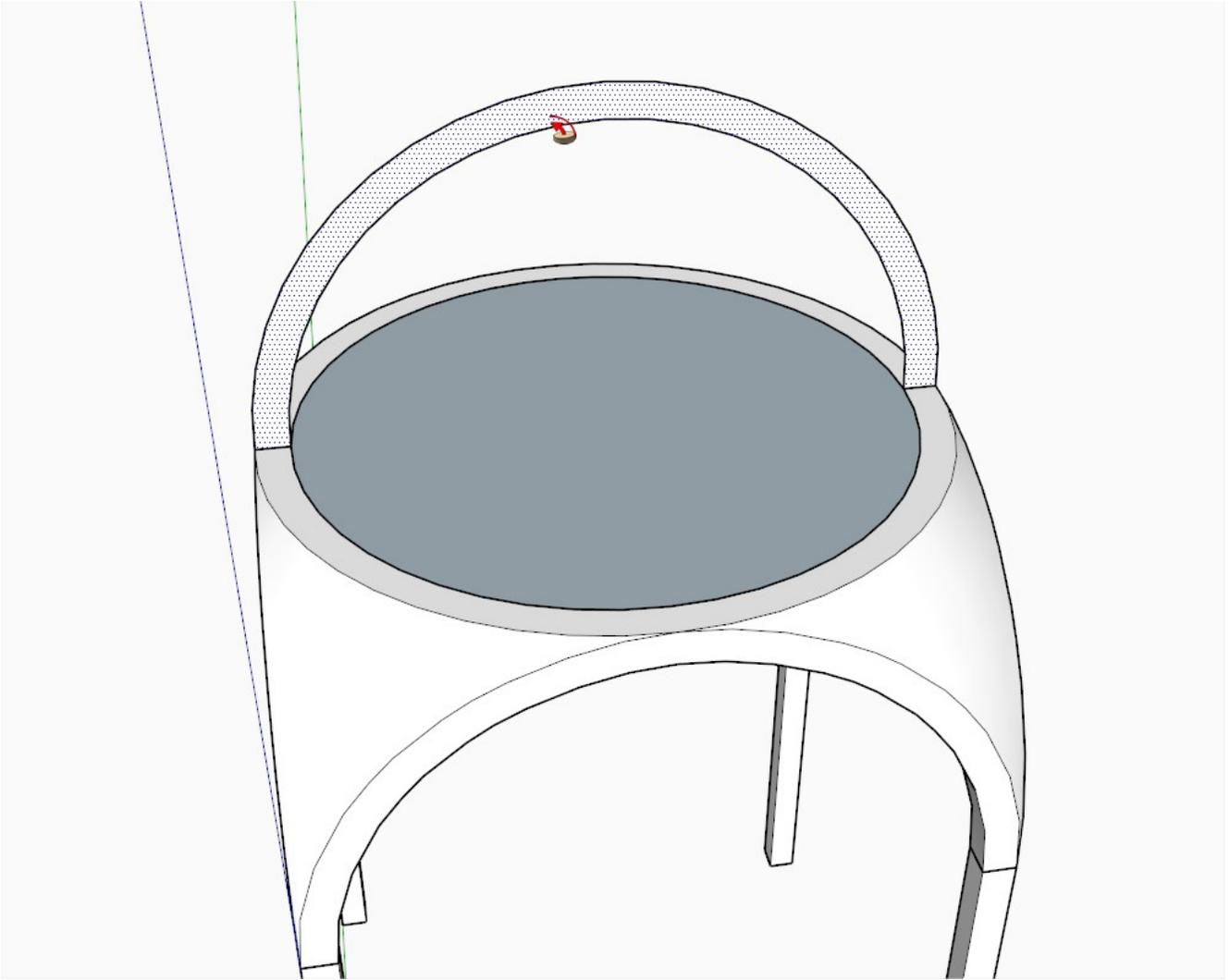
Connect the ends (also draw that line in the middle - so one, single line through the whole span will do). A face to fill the half circle will be created in the middle: delete that.



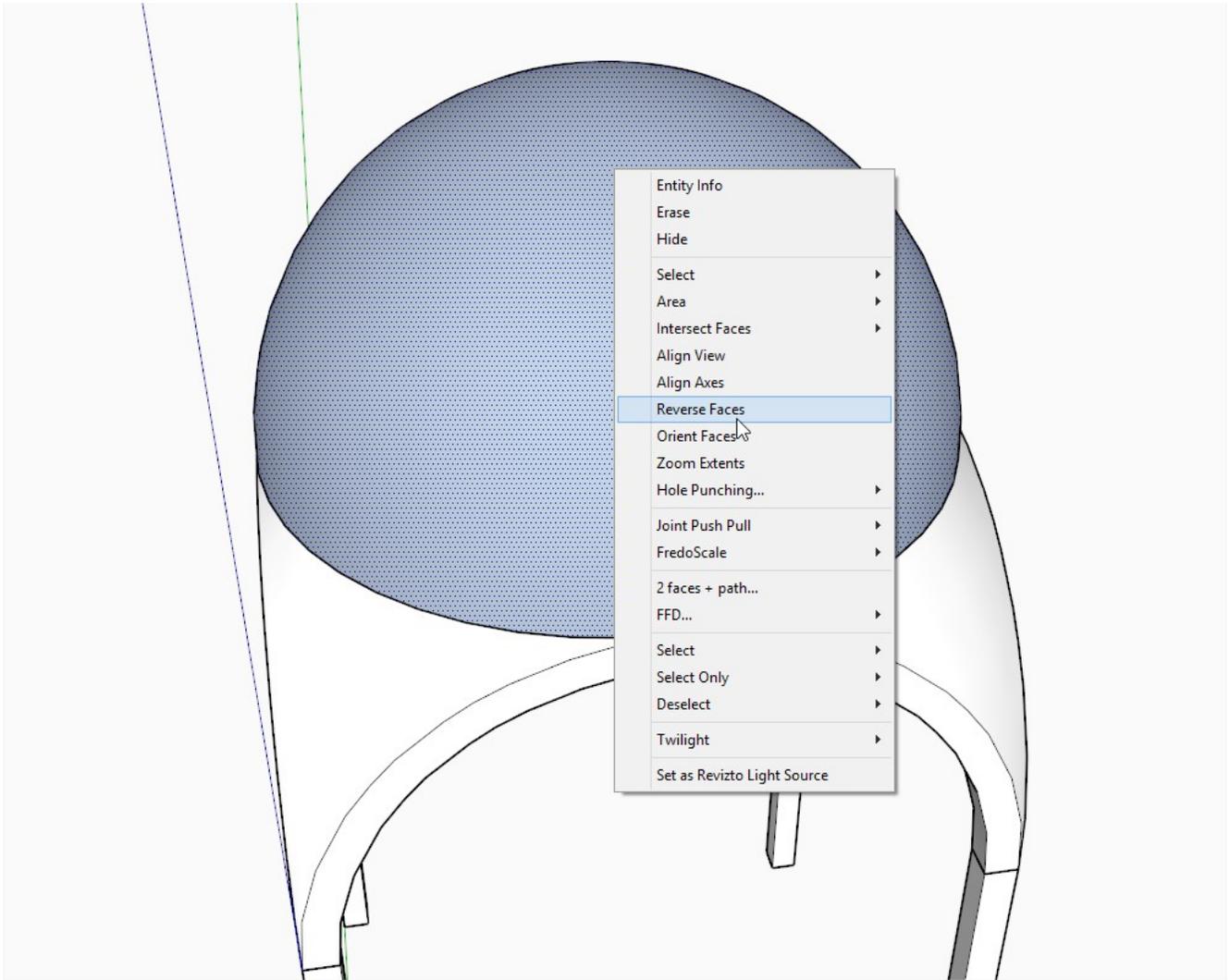
Now from the midpoint of our temporary line, draw a circle to match the inner perimeter of the opening. Make sure to snap to one of the endpoints of it (otherwise the smaller, upper dome gaining shape already won't align to the opening).



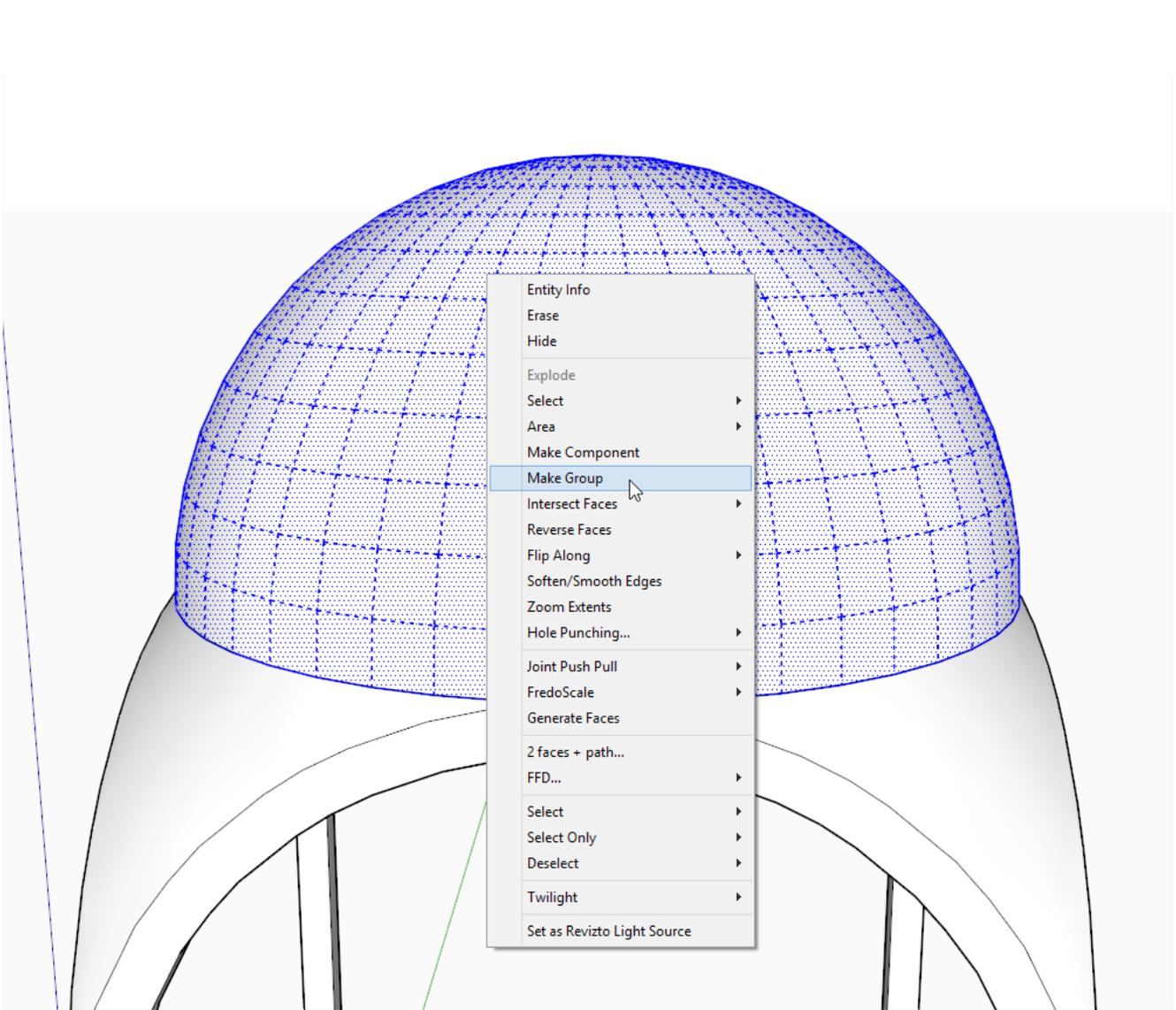
Once done, click on our new face to select it (i.e. establish a path for the Follow me tool) and Late the dome around with the Follow me tool.



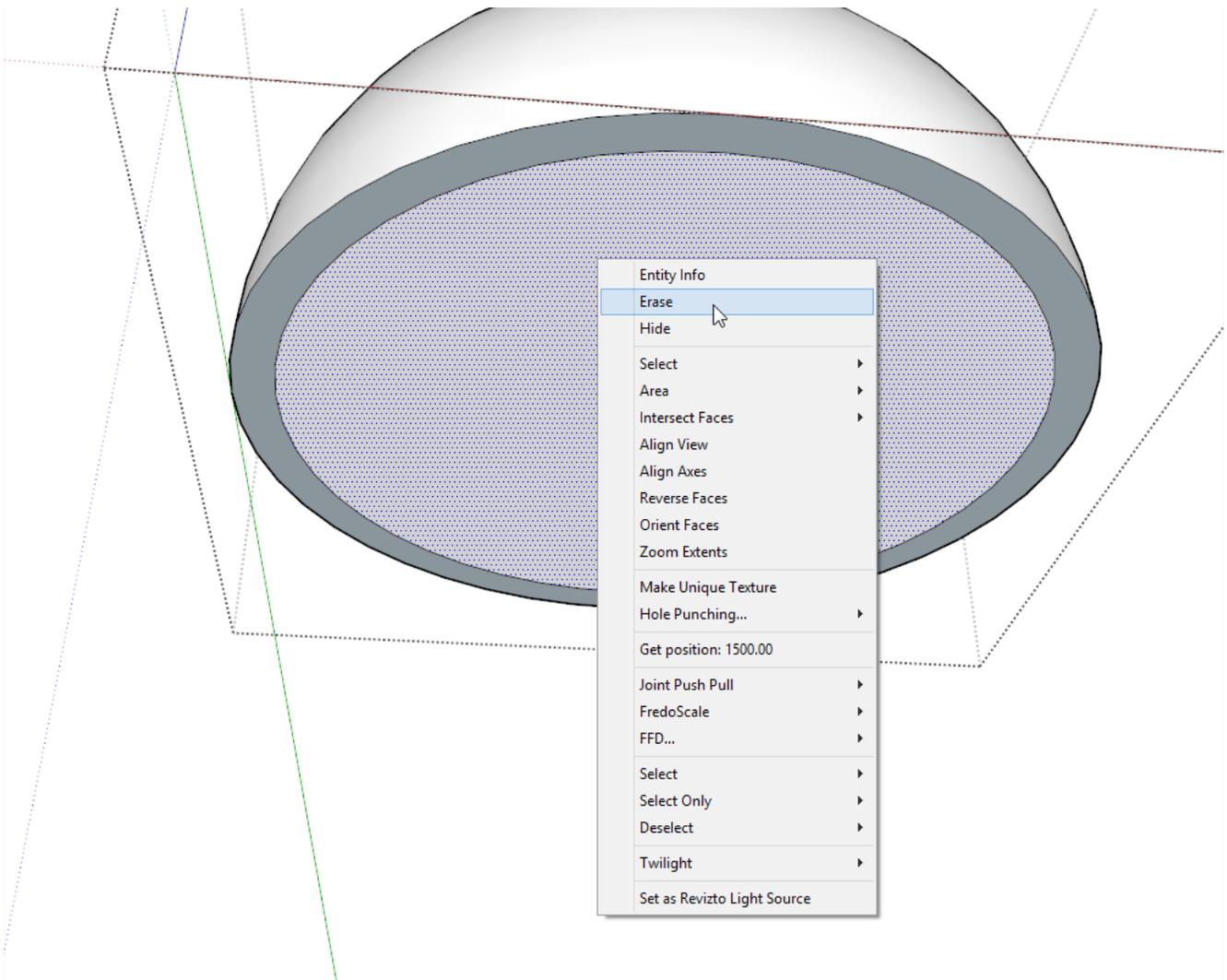
If you get a back face, reverse it now.



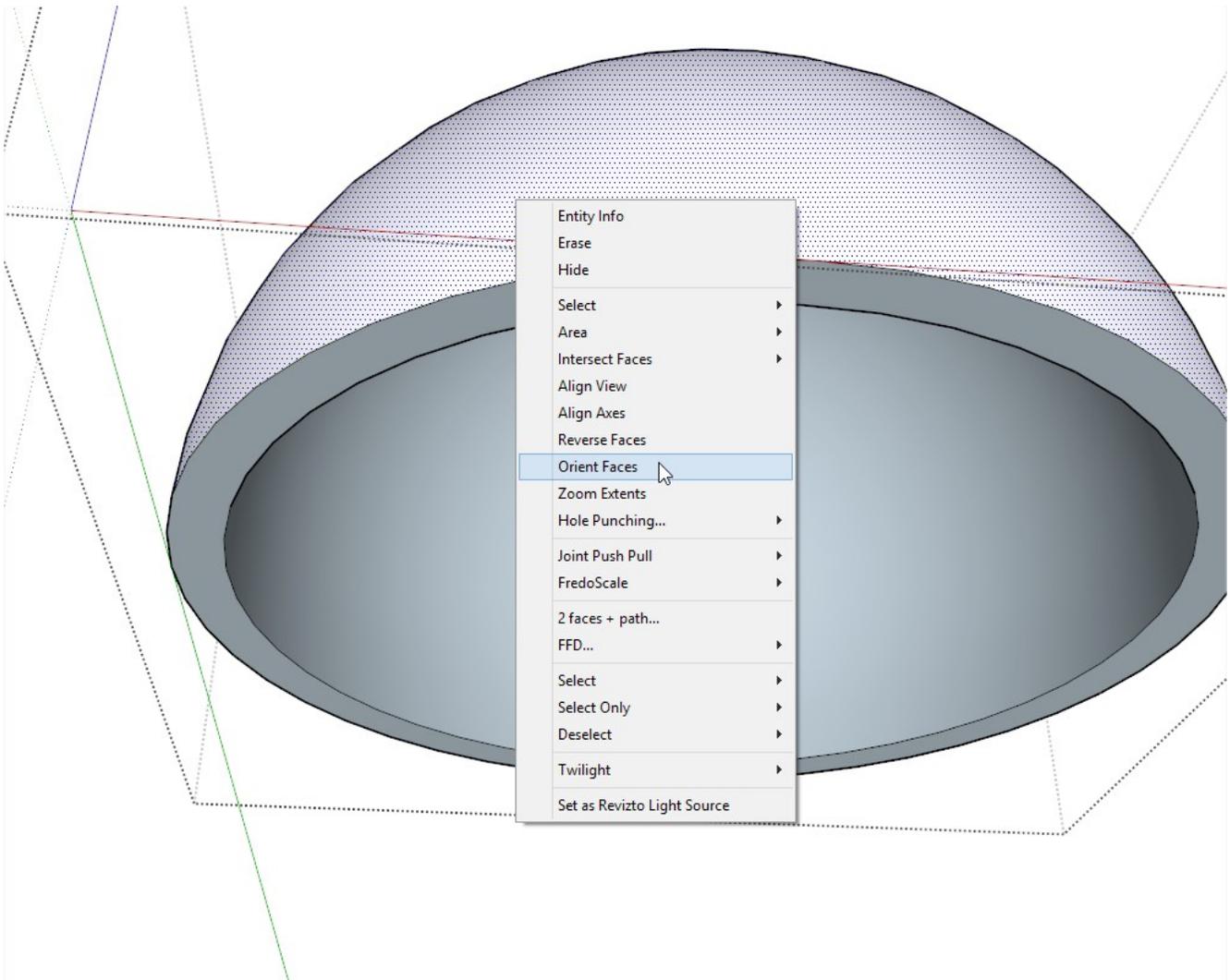
Again: grouping is always a good strategy before we advance.



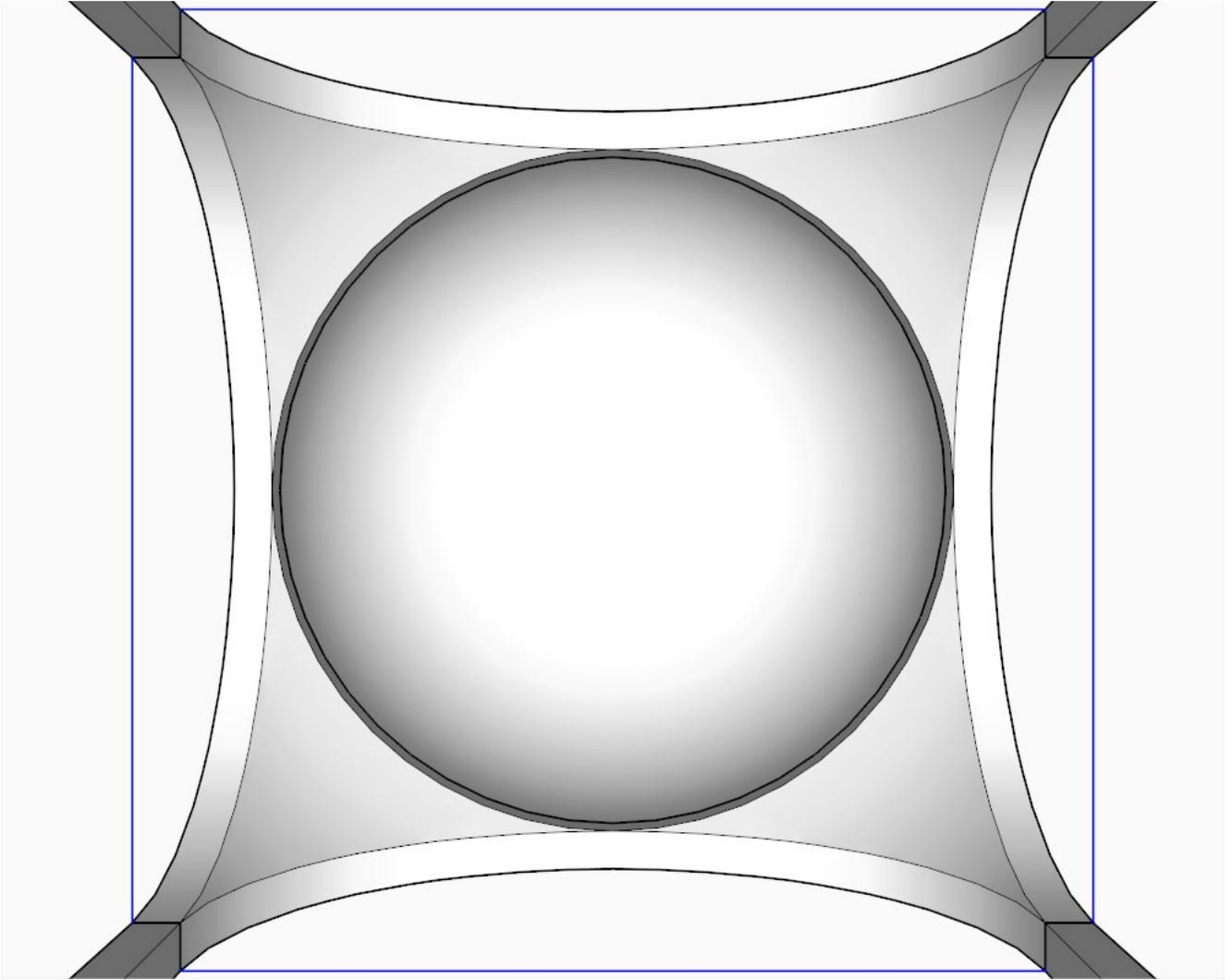
Edit the group (remember the tip on pg 23) and delete the bottom face.



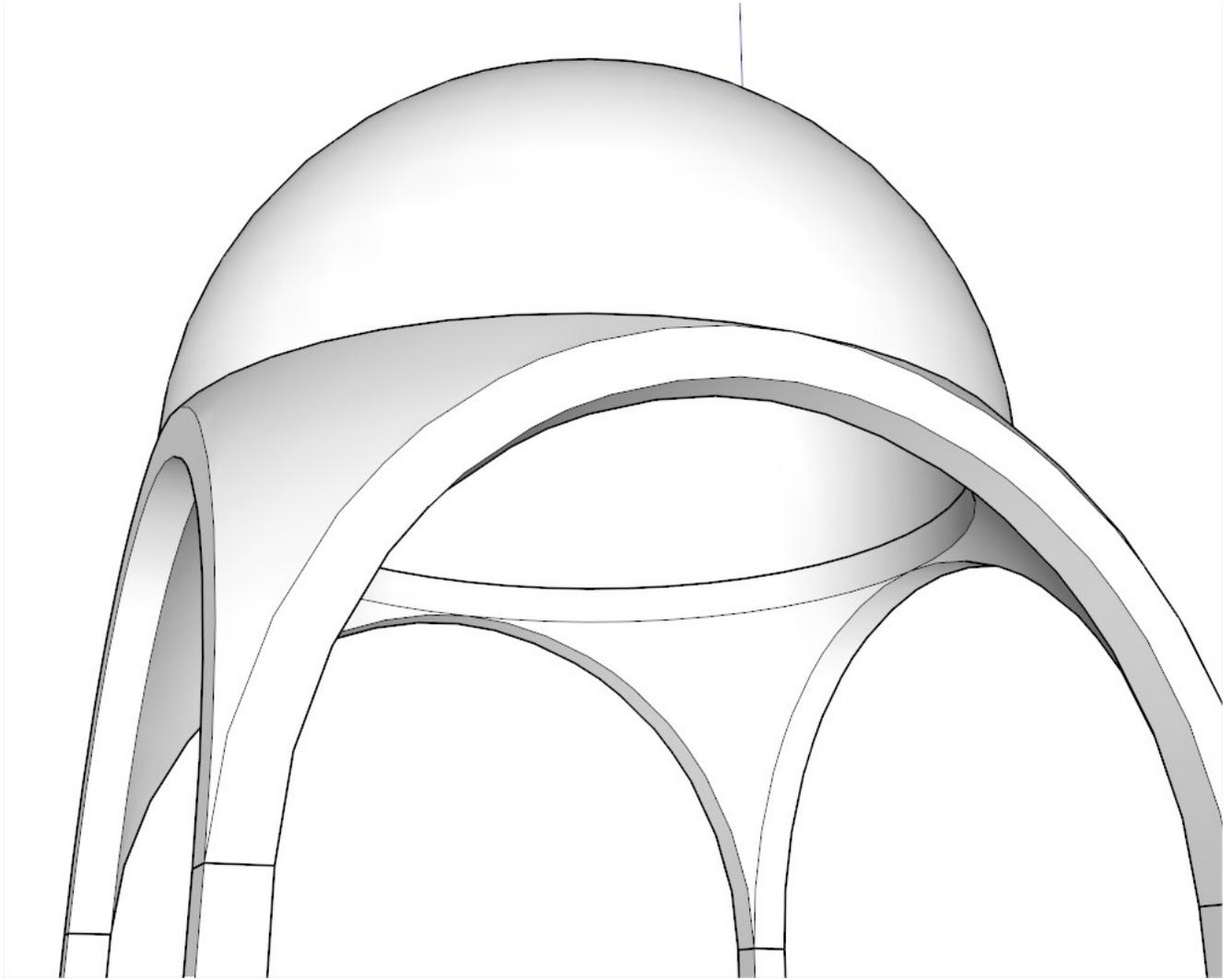
Again, make sure your faces are oriented nicely and consistently. It's a pain in the butt when one realizes that he has to reverse thousands of faces in deeply nested groups or components. Of course, if I had known that the inside is also reversed, I could have saved the step above to reverse the face on the outer shell and do it together with the inside.



And here we are where the Late Romans also were some sixteen-hundred years ago when building the [Hagia Sophia Cathedral](#) in Constantinople or the French when building the [St Peter Cathedral](#) in Angoulême (search for its arches in Google - it's a shame there's almost nothing on Wikipedia)



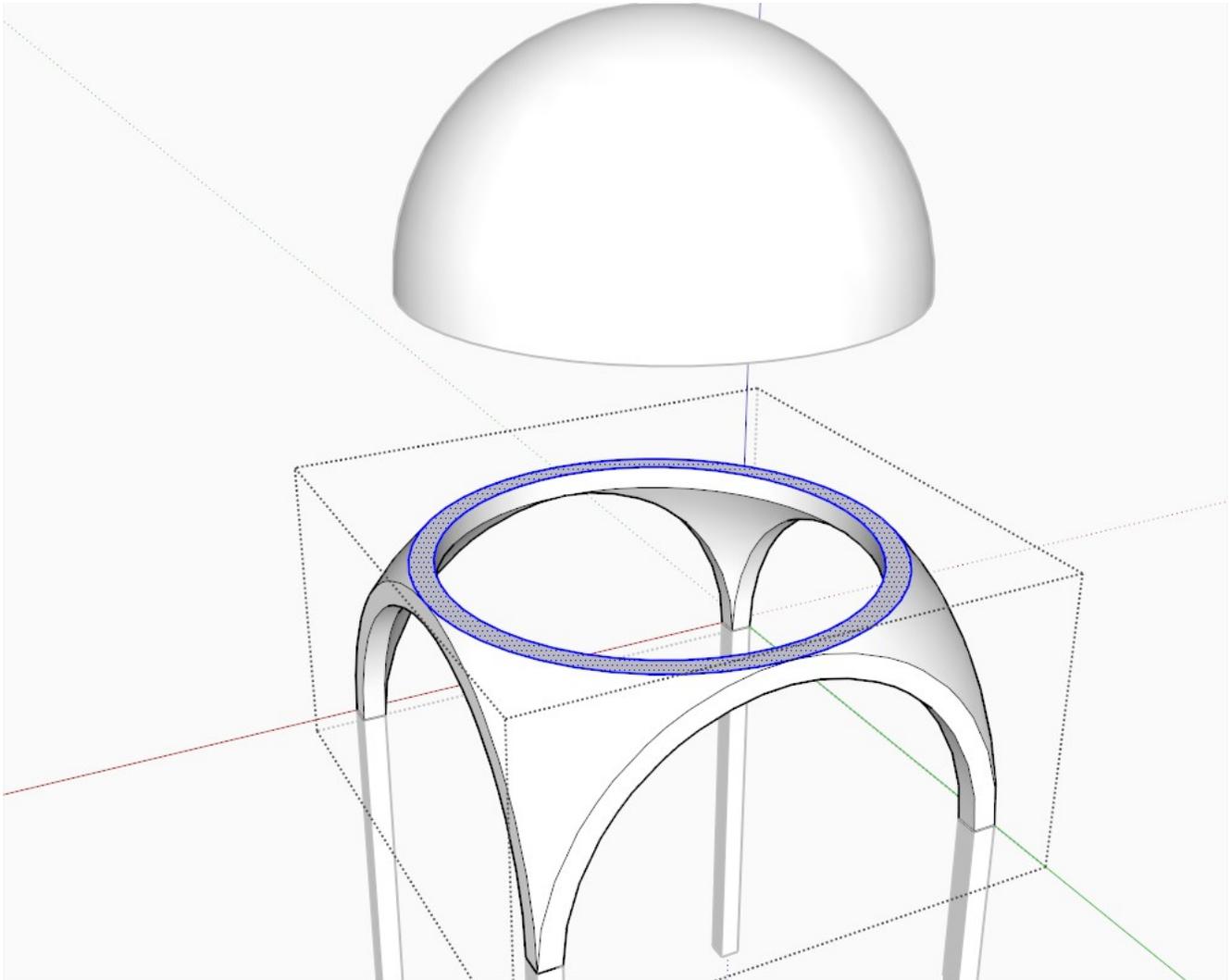
Another shot from outside (as we can now take a rest).



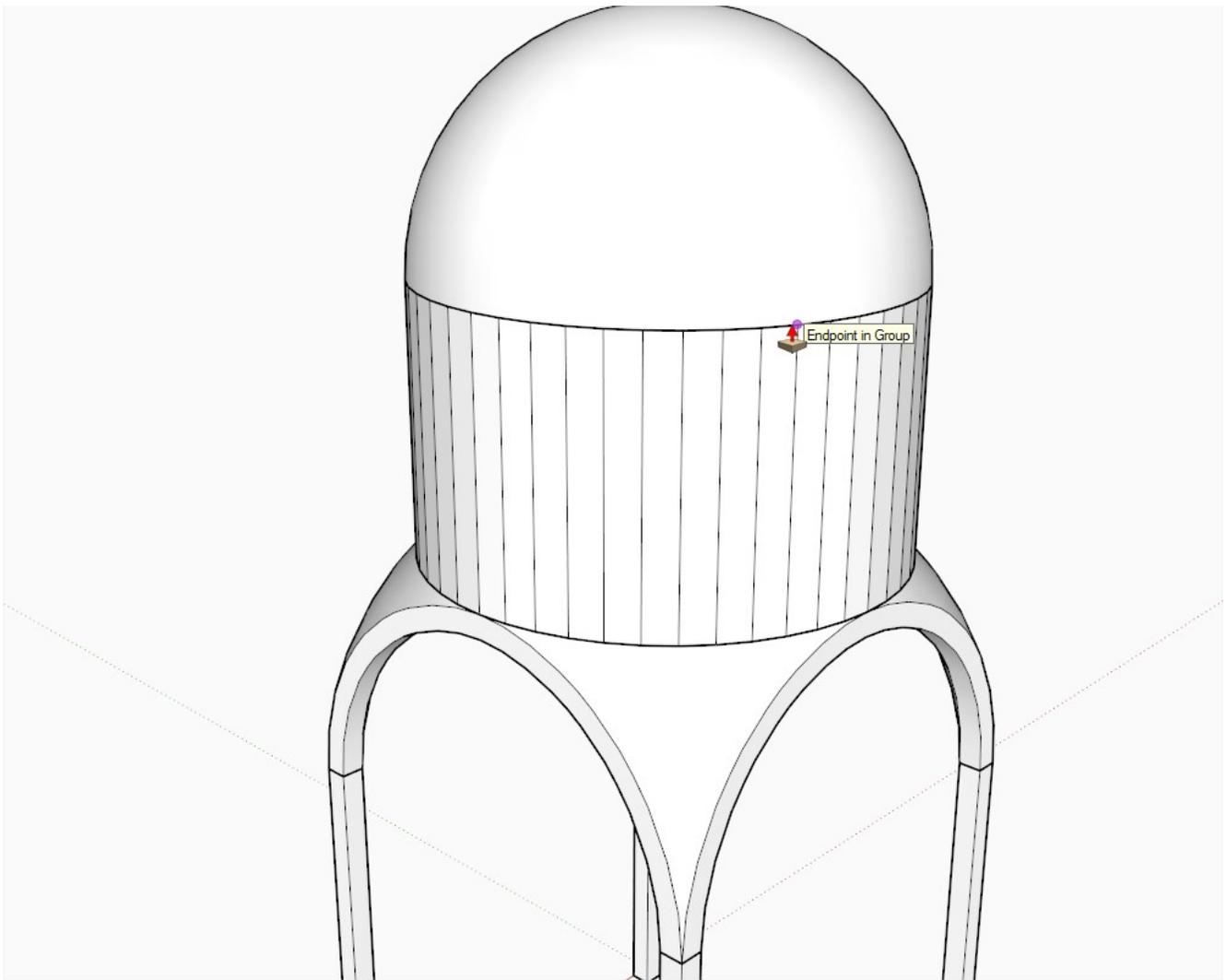
## **Building the First Dome:**

Move the upper dome up (press the Up or Down arrow key to lock its movement) as much as you wish to elevate your dome.

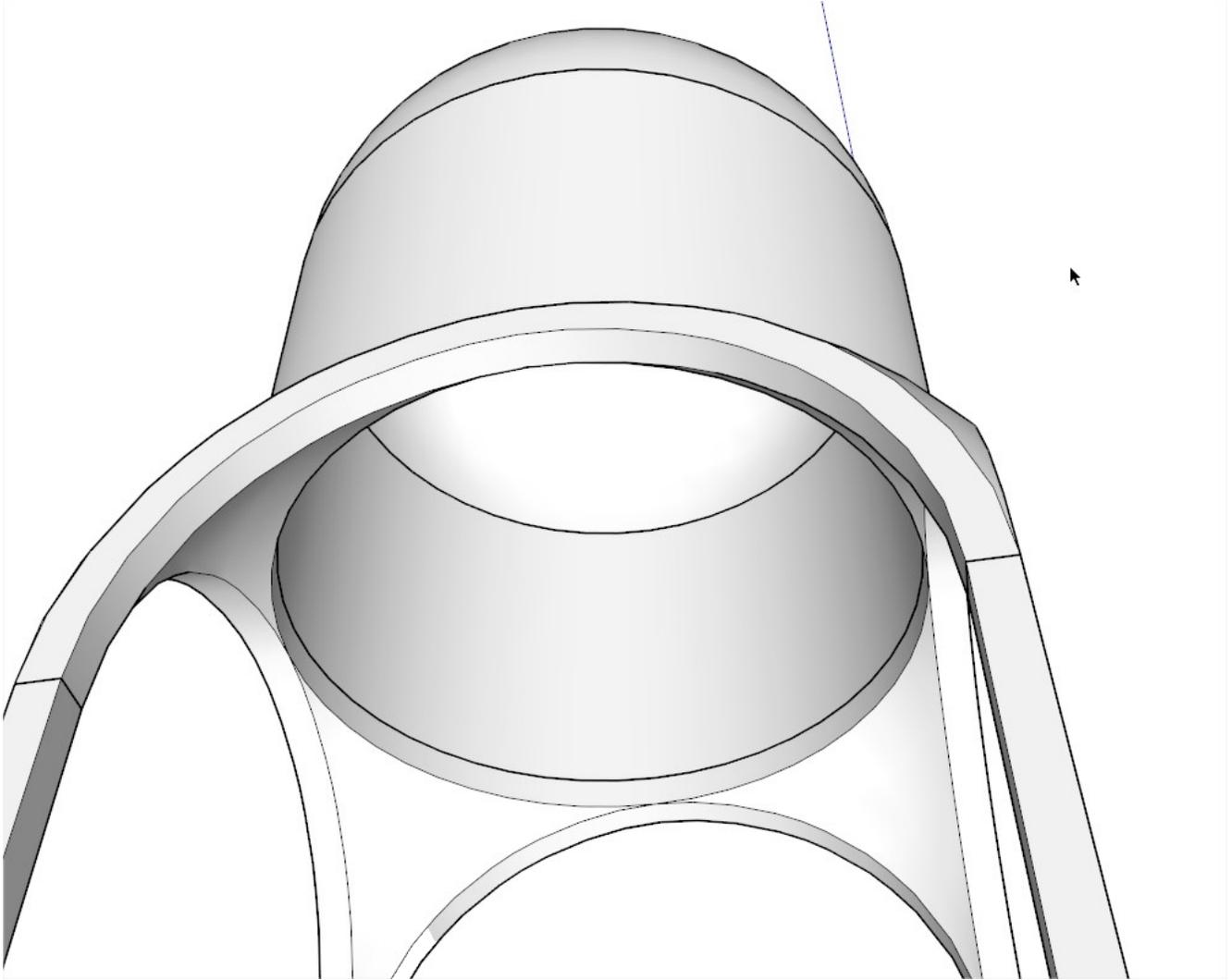
Open the earlier, pendentive group, select its top ring copy it, close the group and use the "Paste in place" command from the Edit menu (**Tip:** best is to set up a shortcut key for this, too. I have Shift+Ctrl+V to easily remember).



PushPull it up snapping to your upper dome.

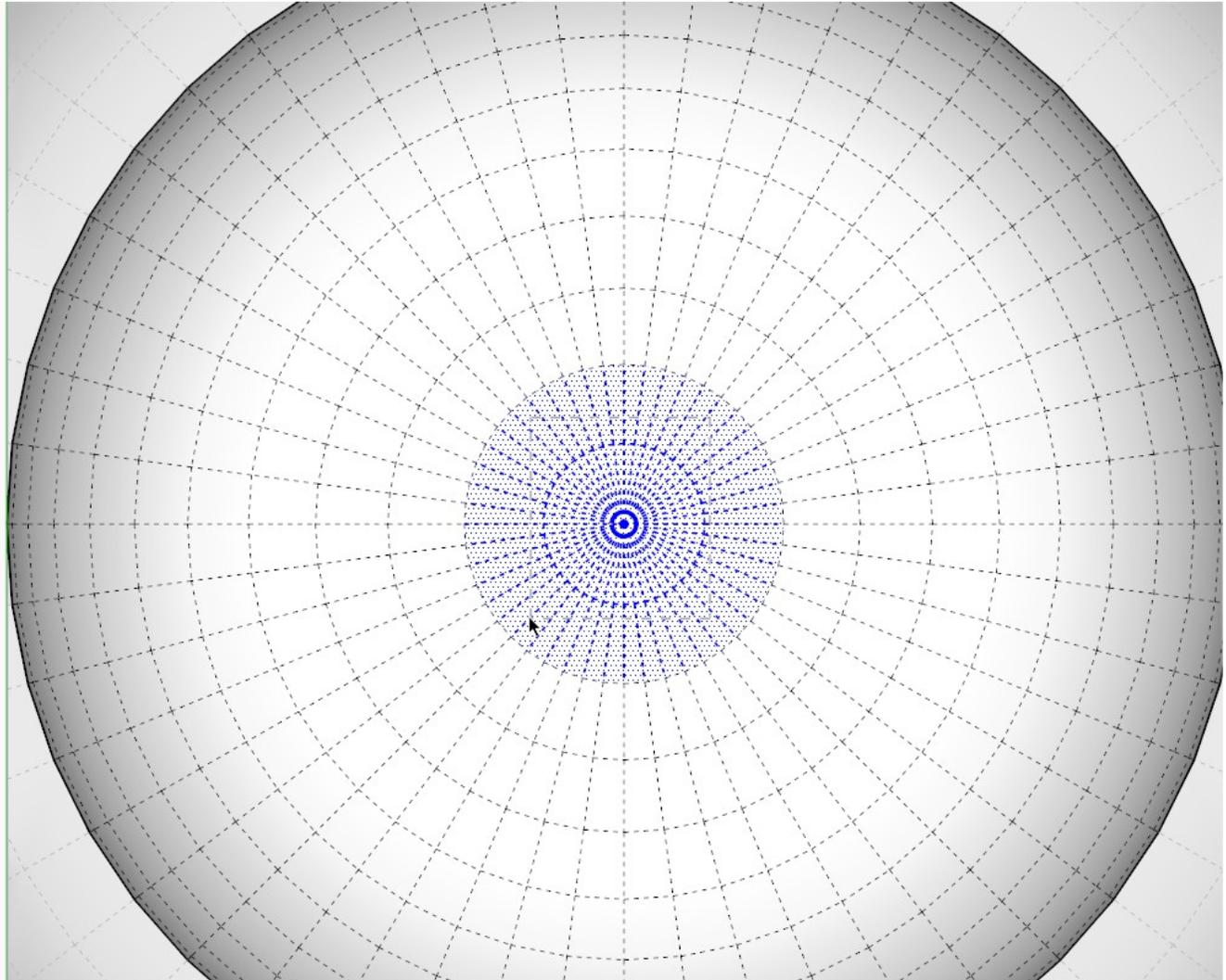


After softening the surfaces, we get this. It is called "[tholobate](#)" or "drum" and its main purpose is to provide a wall surface where windows can be opened to provide light (we'll not open windows in this tutorial but you can see *Sketchup Window in a Round Wall* or *Sketchup Arched Windows in a Curved Wall* tutorial to cut them as you wish).

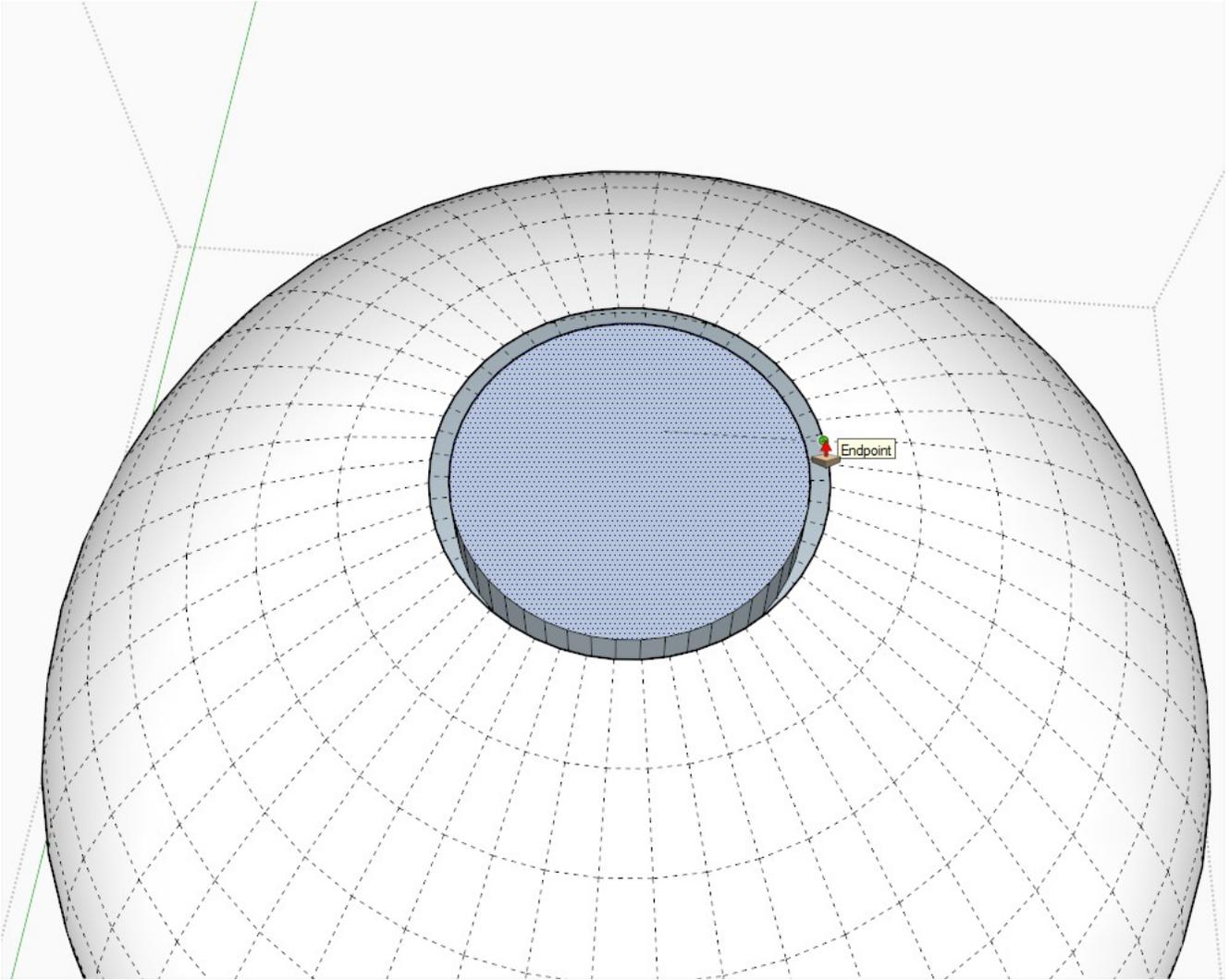


## **Cutting a Hole for the Cupola:**

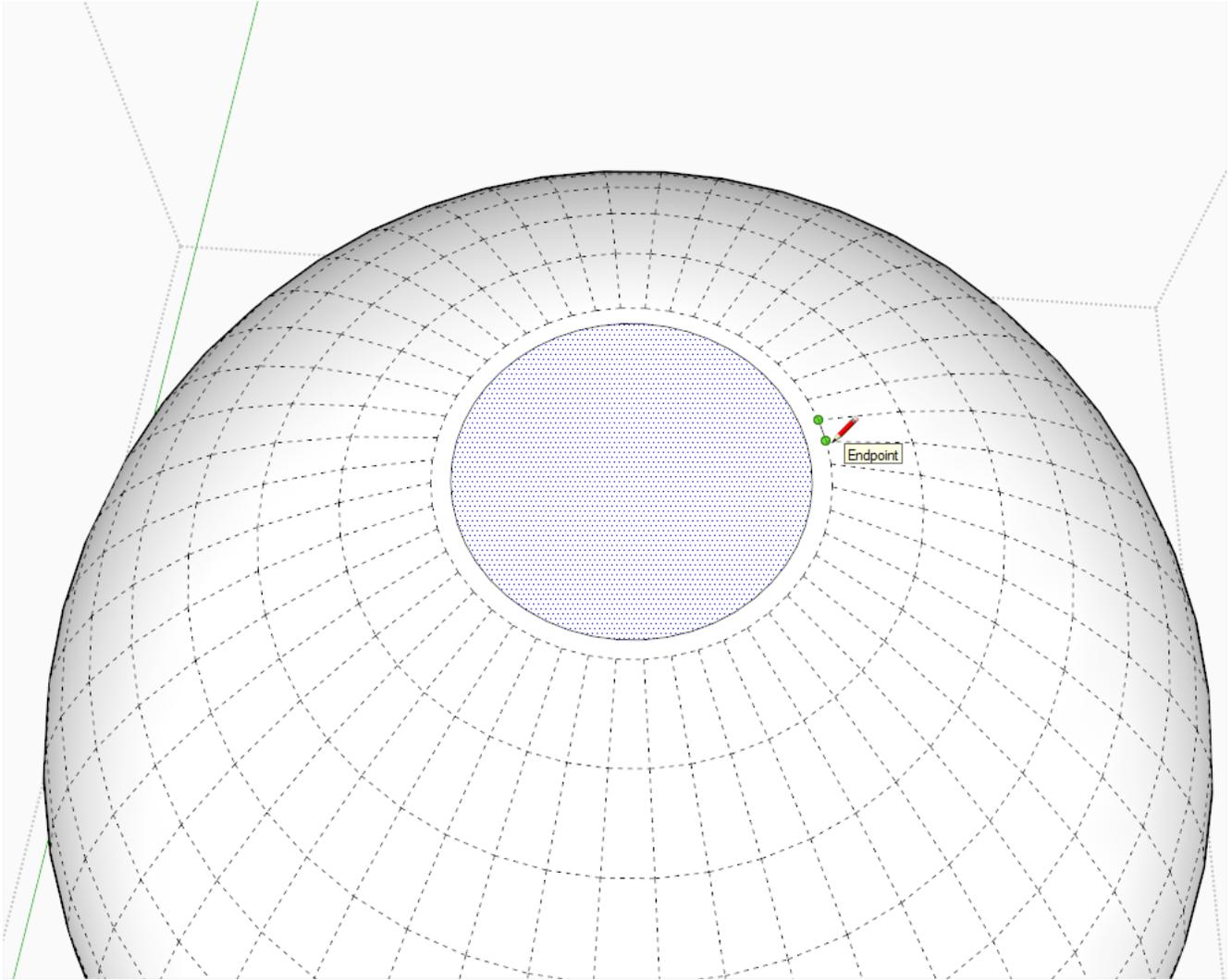
To provide even more light, the whole process above is repeated in a smaller scale on top of the raised dome. Now go to Parallel projection again and Top view. Open the upper dome group and with a right to left selection box, select the two, inner rings of facets. Delete them.



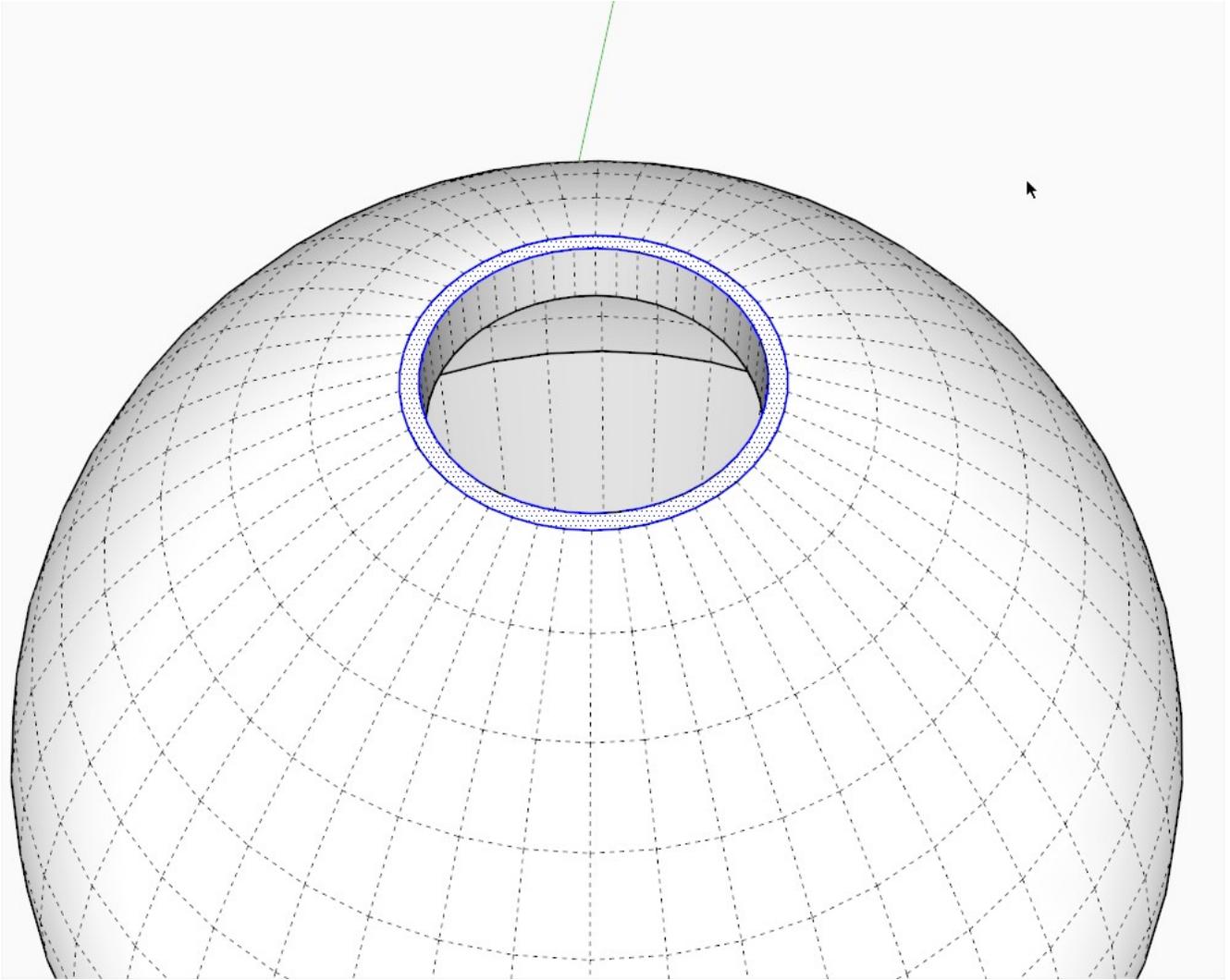
In a similar way as we created the hole in the middle in these stapes, make a smaller hole again. Redraw an edge, PushPull to exact height...



Redraw an edge, delete the inner face...

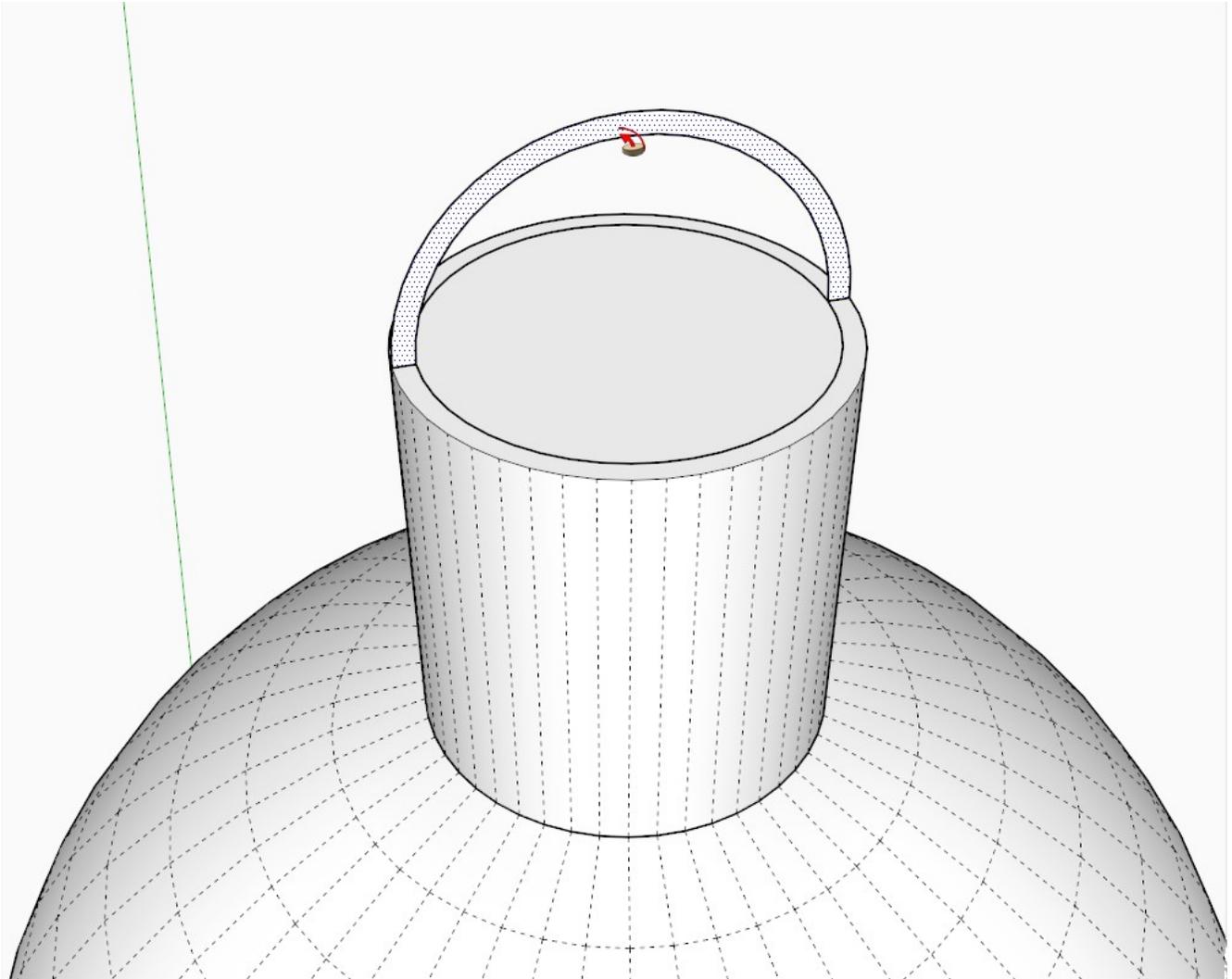


After softening, we get something like the so called "[oculus](#)" (eye) of the Ancient, Roman Pantheon. Again, copy then "Paste in place" the top ring,

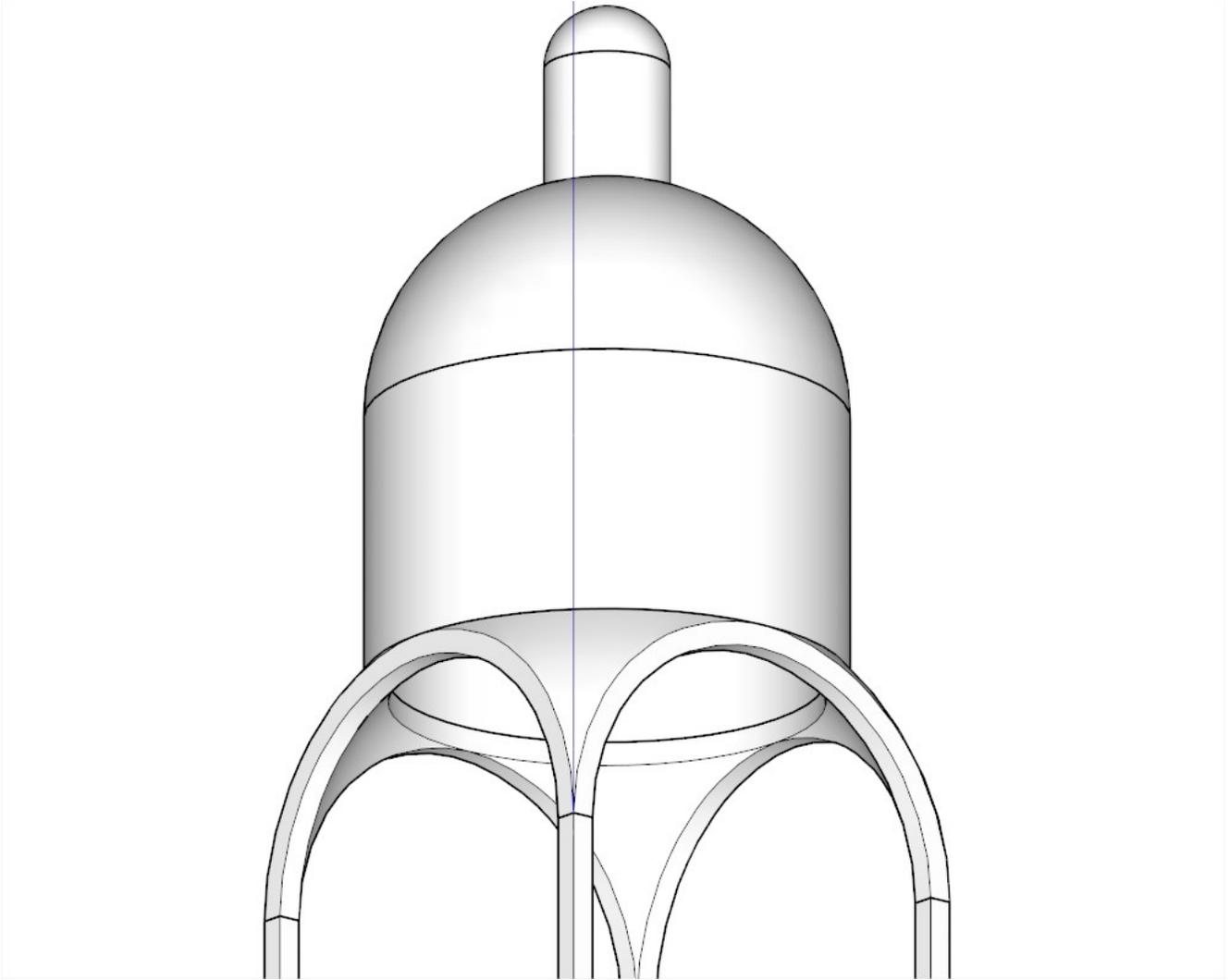


## **Building the Cupola:**

PushPull it to a proper height (cut windows if you wish) and draw a small dome at the very top of our structure.



This is what you should get.



From inside, we can recognize the [St Peter Basilica](#) in Rome or the [St Paul Cathedral](#) in London - not to speak of the [Capitol](#) in Washington DC.

