

# Zero Permeability Cubes

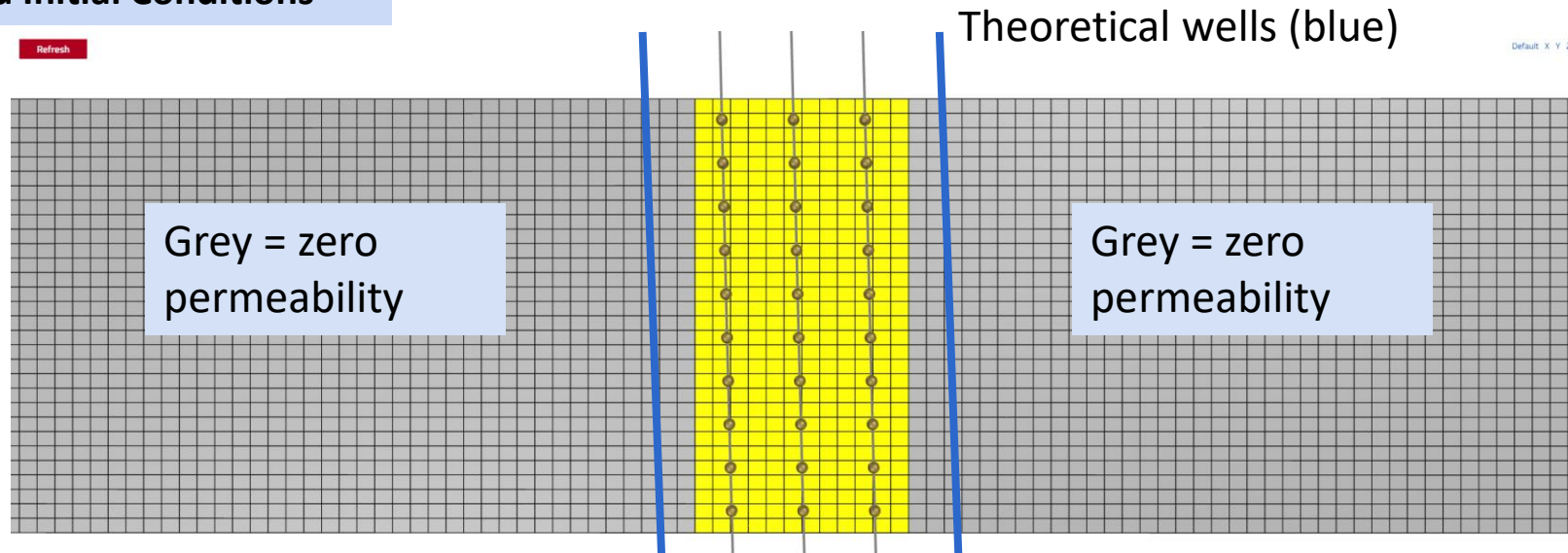
# Zero Permeability Cubes

Zero perm cubes are areas in the model where the matrix is turned off and no flow can occur. They are used as a proxy for offset production, whether it is offset wells or offset stages in the same well. Often, they are used to decrease simulation time and can be a great time saver. Although they are an approximation, if used wisely, can give very realistic answers.

- Large pads with many wells can be cut down to manageable pieces. For instance, a 10 well pad might be cut down to a 5 well pad (or less) and then upscale production.
- Modelling wells with different stage lengths.
- Refrac operations where the initial well was frac'd with just one or two stages. The refrac portion would have much smaller stage length so the zero perm cube would be used to isolate the simulated parts of the refrac.

# Zero Permeability Cubes (ZPC) - What are these?

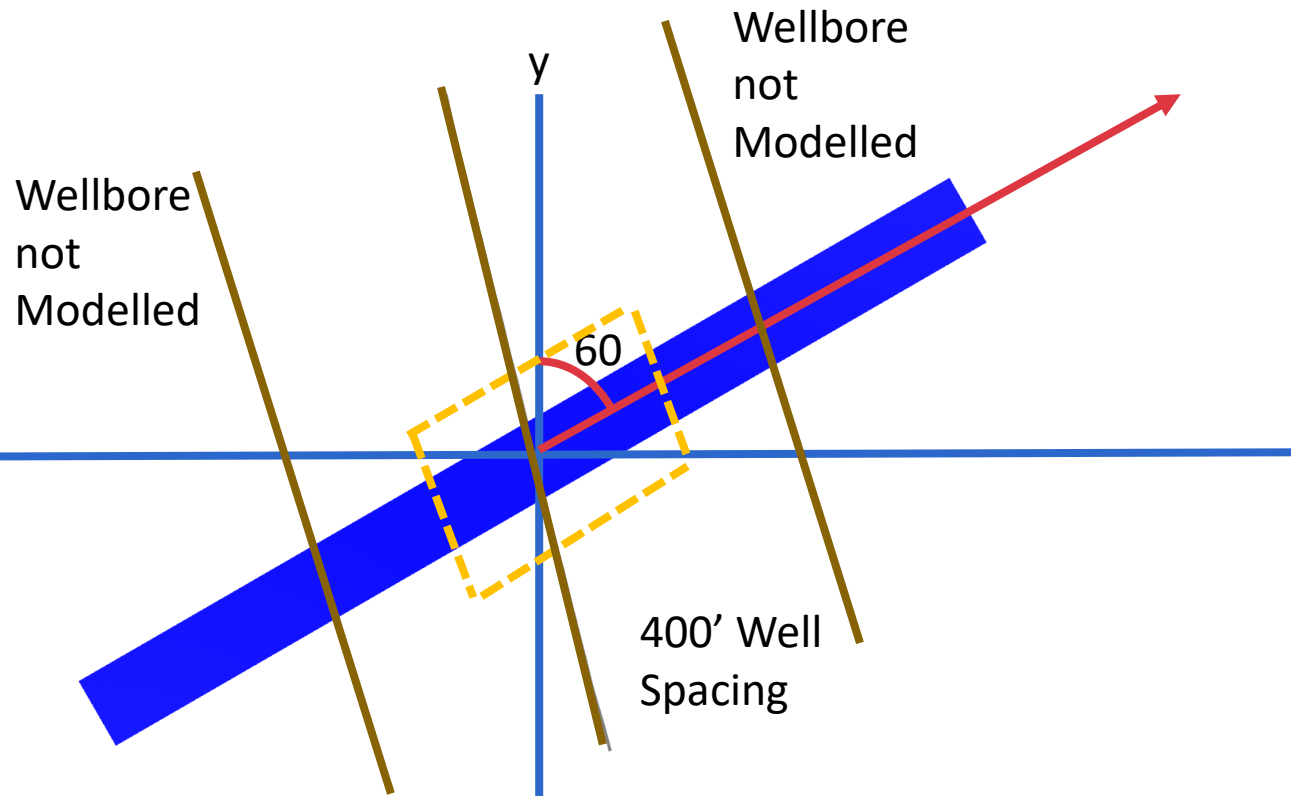
## Static Model and Initial Conditions



Zero permeability cubes are used to mimic areas of no flow boundaries. They are indicated in the visualization by greyed out areas in the matrix and in the fracture. Zero perm cubes should be off while frac'ing to allow for frac growth and leak off. Then, most often right before production starts, they are turned on to simulate production that is not be accounted for in the model.

There are two types of zero perm cubes. You can specify one cube with zero permeability *outside* of the cube. Or you can specify multiple cubes with zero permeability *inside* the cube.

# Zero Permeability Cubes (ZPC)



Note: The ZPC does not have to line up with the matrix edges.

While the meshing in ResFrac is oriented within the coordinate system for you, **the zero perm cubes are not!**

You must specify the center coordinates and the length of each side of the cube.

We are going to model the well scenario to the left. Our goal is to use a 'zero perm outside of cube', indicated by yellow box, to simulate the effects of the outside wells, without explicitly modelling them.

# Zero Permeability Cubes (ZPC) – Zero perm outside of cube

Static Model and Initial Conditions Tab – limited to just one cube

## ZERO PERMEABILITY OUTSIDE THIS CUBE [FT]

x-length [ft]  ?    y-length [ft]  ?    z-length [ft]  ?

**2** Specify the lengths of the cube in the x, y and z direction.

## CENTER FOR 'ZERO PERMEABILITY OUTSIDE THIS CUBE' [FT]

x center [ft]  ?    y center [ft]  ?    z center [ft]  ?

**1** Specify the center coordinates of the ZPC.

Zero perm outside cube rotation angle [degrees]  ?

**3** Specify the rotation of the cube from the positive y-axis.

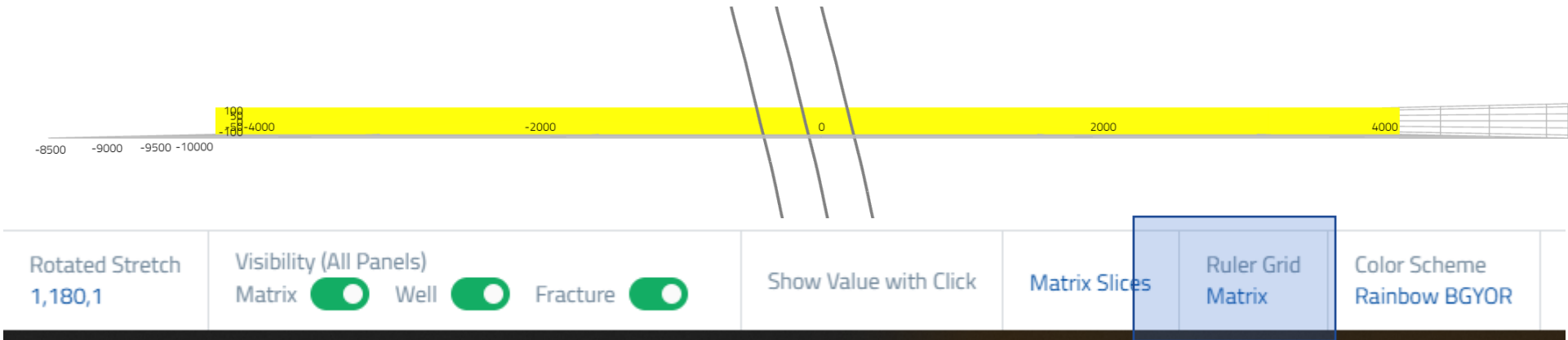
## START AND END TIMES FOR THE 'ZERO PERM OUTSIDE CUBE' [HOURS] ?

	Start time [hours] ?	End time [hours] ?	
1	300	100000000	☰

**4** Specify when the cube will activate and deactivate.

Rule of thumb. Frac with the zero-perm cube turned off. At the start of production turn the zero perm on.

# Zero Permeability Cubes (ZPC) – Center the cube



Approximate the center by setting the ruler grid to matrix in the preview panel.

- Wells and Perforations
- Meshing Options
- Fluid Model Options

## CENTER OF MATRIX REGION [FT]

Matrix center in x direction [ft]  ?

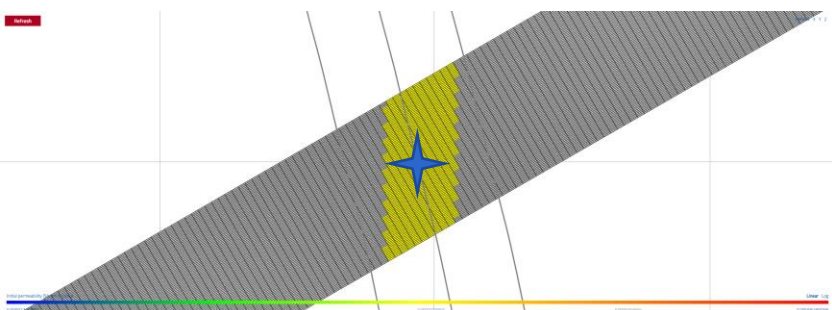
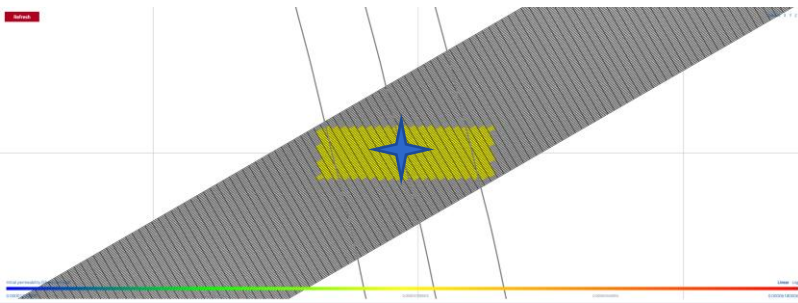
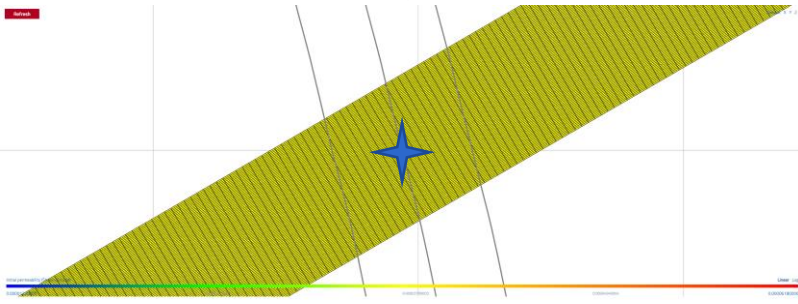
Matrix center in y direction [ft]  ?


Matrix center in z direction [ft]  ?

Use the meshing center or use the center perf location of the well in the middle (if you used the inline method of placing the perforations you can convert these to x, y and z coordinates using the 'convert perforations clusters' wizard in the Wells and Perforations tab.).

# Zero Permeability Cubes (ZPC) – Specify the lengths

Top View



The center will be defined at the meshing center which happens to have the well running through it. Use the preview plot,  built into the UI to help you see the changes you are making. Every time you make a change, hit the **Refresh** button to update the plot.

ZERO PERMEABILITY OUTSIDE THIS CUBE [FT]

x-length [ft]

y-length [ft]

z-length [ft]

Remember that the cube has not been rotated yet. The x and y lengths are aligned with the coordinate system.

ZERO PERMEABILITY OUTSIDE THIS CUBE [FT]

x-length [ft]

y-length [ft]

z-length [ft]

The x-length has been changed to 400' to match the well spacings. The y-length (and z-length) have been changed to a large number such that it extends beyond the matrix.

# Zero Permeability Cubes (ZPC) – Rotating the cube

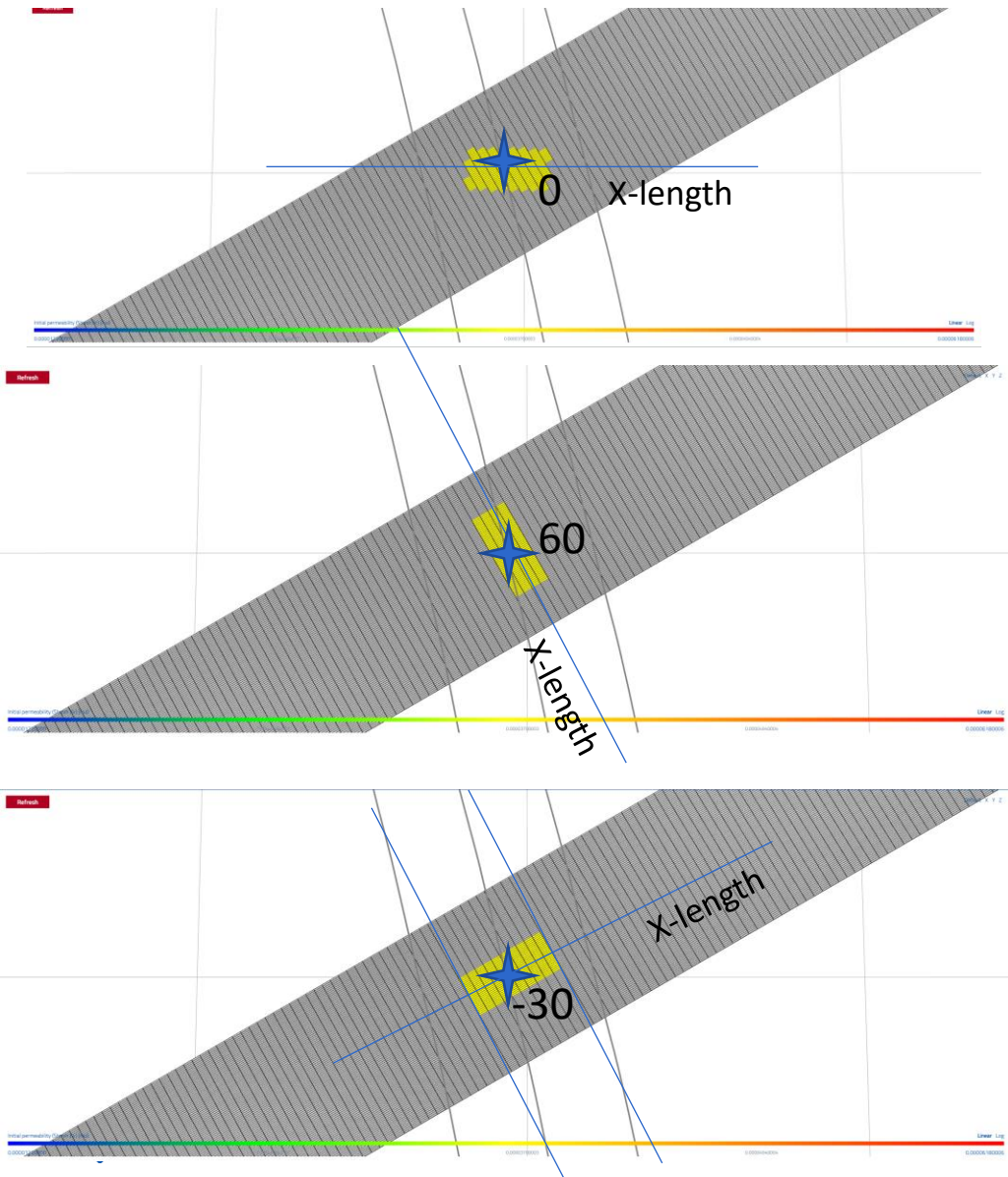
The y-length has been shrunk to better show how the cube rotates. The meshing resolution and matrix size in the Shmin direction have also been temporarily increased to show detail.

We need to calculate how much to rotate the cube.

In this example, the direction of Shmax is 60 degrees so we try rotating the cube 60 degrees. Since the x and y lengths of the cube 'follow' the rotation, we would essentially have to increase the y length of the cube to get the desired result.

In order to align the x-length of the cube with Shmax, we must rotate the x-length by -30 degrees.

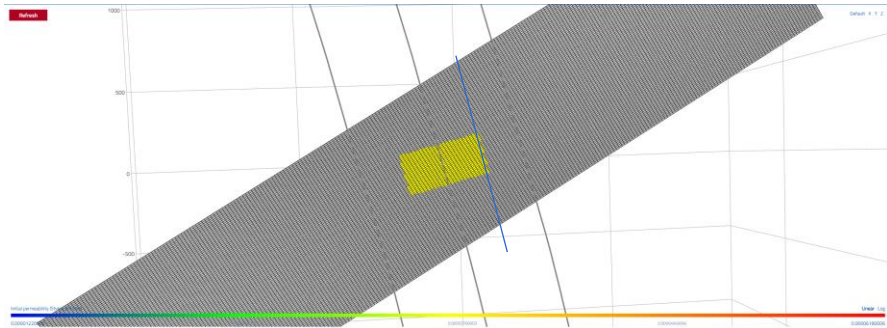
Unfortunately, in our case, the wells are not drilled orthogonally to Shmax, so we now need to account for the azimuth of the well.



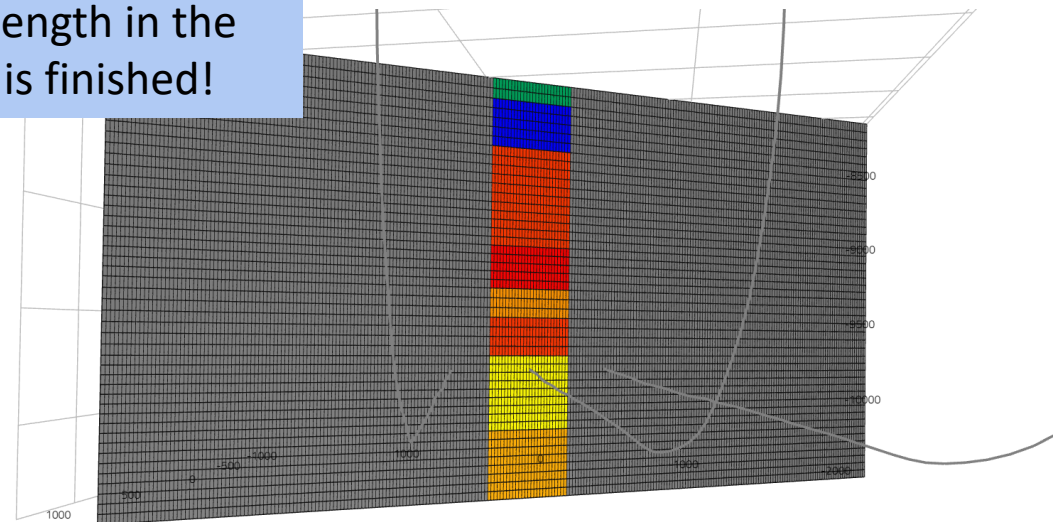
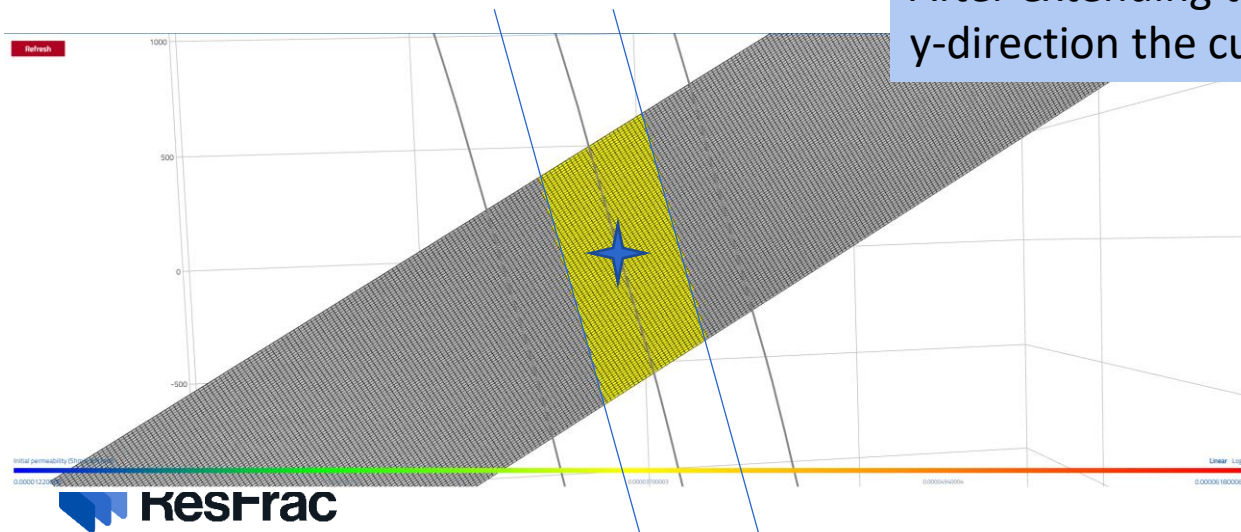
# Zero Permeability Cubes (ZPC) – Rotating the cube

The azimuth of the well is approximately -14 degrees from the positive y-axis. Now the edge of the cube is aligned with the wells and not  $S_{hmax}$ .

**You must remember!** The lengths of the cube are still specified as the x-length (or y-length) even though we have rotated the cube. Increasing the x-length for a cube rotated 90 degrees will increase the cube length in the y direction. Keep track!! This is why I often use a small cube so that I can see my changes.



After extending the length in the y-direction the cube is finished!



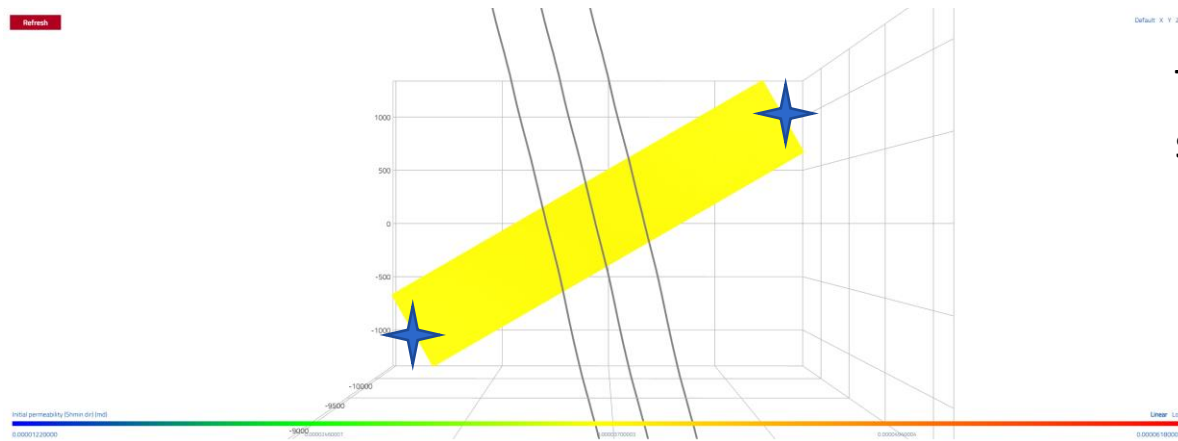
# Zero Permeability Cubes (ZPC) – Zero perm inside of cube

The same thing can be accomplished with two 'zero perm inside' of cubes. This may be desirable in cases certain parent-child cases or differing stage lengths. Additionally, multiple cubes can be specified with multiple start and stop times making these a versatile tool. Luckily, the process is essentially the same!

## Static Model Initial Conditions – Advanced

This time we will choose the center of the cube at the end of either side of the matrix.

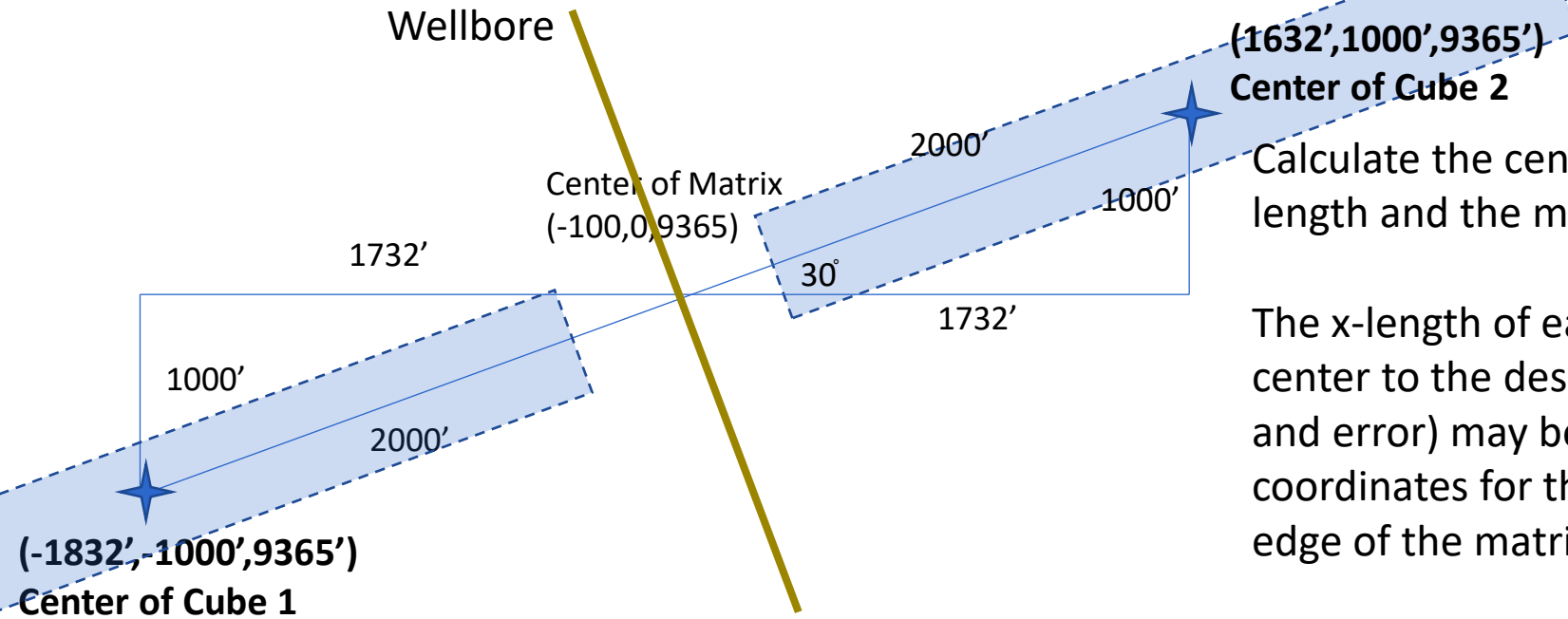
Use the matrix ruler grid to approximate or do some trig (what???)



LIST OF 'ZERO PERM INSIDE CUBE' CONSTRAINTS [FT] ?

	x-center [ft] ?	y-center [ft] ?	z-center [ft] ?	x-direction length [ft] ?	y-direction length [ft] ?	z-direction length [ft] ?	Rotation angle [degrees] ?	First start time [hours] ?
1	-1832	-1000	9365	3400	3000	5000	-13	300
2	1632	1000	9365	3400	3000	5000	-13	300

# Zero Permeability Cubes (ZPC) – Zero perm inside of cubes

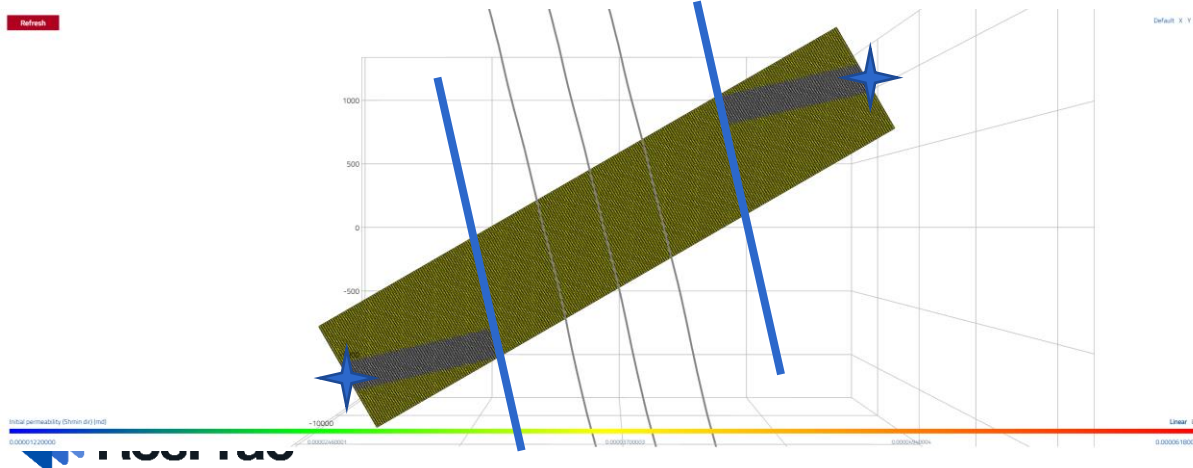


Calculate the center points of the cube using the matrix length and the meshing center.

The x-length of each cube will be the distance from the center to the desired well spacing. A little geometry (or trial and error) may be required. In this case, I calculated the coordinates for the center of the cube to be located at the edge of the matrix as shown.

The rotation will be the same = -14 degrees (not the direction of  $S_{hmax}$ )

The z and y-lengths will once again need to be large to cover the entire width of the matrix region. The figure at the left shows a short x and y-length to show how the ZPC is not aligned with  $S_{hmax}$  but with the azimuth of the wellbore.



# Zero Permeability Cubes (ZPC) – Zero perm inside of cubes

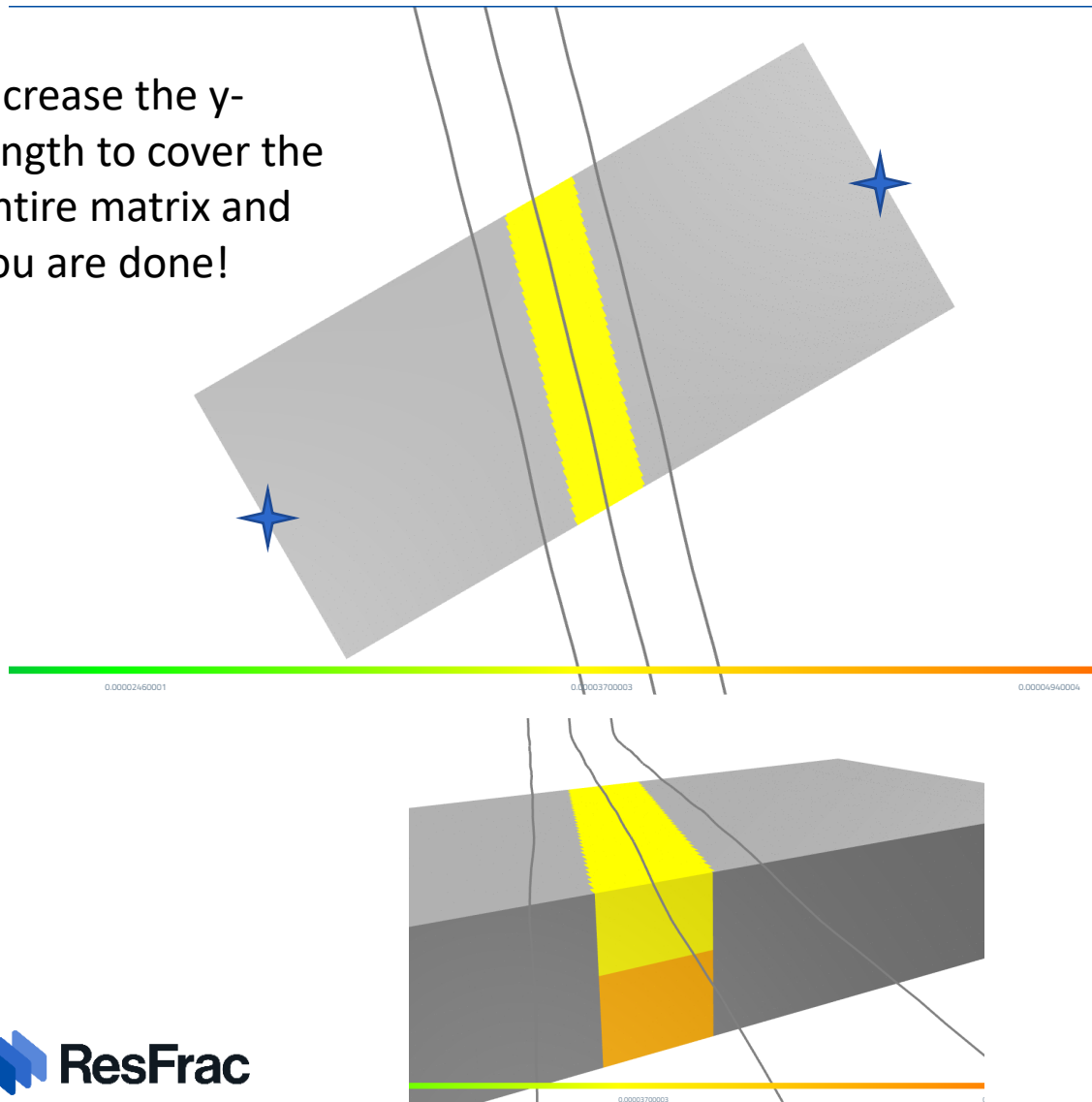
Review:

1. Determine if an inside or outside perm cube is to be used.
2. Locate the centers
3. Calculate lengths
4. Rotate
5. Indicate time for the cube to take effect (usually when production starts)

Helpful Hints:

- Temporarily increase the mesh resolution to properly see the cube.
- Start with a small cube with 0 degrees of rotation and make the x direction longer than the y so you can keep track.
- After rotating, the x-length is always the same e.g. if you rotate your cube 90 degrees and you increase the x-length, you are increasing the length in the y-direction.
- Use the preview plot and hit refresh when you make a change to ensure it is what you intended. Very helpful when using the 'trial and error' approach.
- Sometimes it is helpful to cut a matrix slice at the wellbore.
- If all else fails, draw it out on paper!

Increase the y-length to cover the entire matrix and you are done!





# Thank You!

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