Nanofabrication Process Recipe

Title:	**BEAMER Tutorial – Fracturing circles and angled features**

Lab Area(s): Lithography		**Document Type:** Fracturing	
Tool(s): EBPG 5000+ or EBPG 5200		**Author(s):** Jash Banker	
Date: March 31, 2020		**Group Name:** Painter Group	
Description:	In this tutorial we will discuss the various fracturing methods available in BEAMER and focus particularly on 'Segment' fracturing which is a BEAMER capability that allows circles and rectangles to be treated as primitives.		
More Info: [Layout Beamer Manual](#)		**Email Contact:** jbanker@caltech.edu	

For most of this tutorial I will focus on the result of fracturing a circle which is 50 nm in diameter and is defined on a 1 nm grid. This means the CAD file is approximating the circle as a polygon with a large number of vertices as shown below:
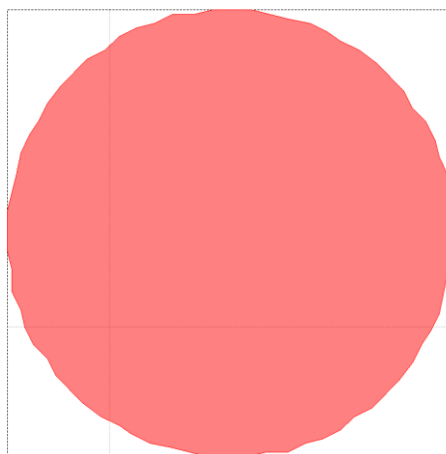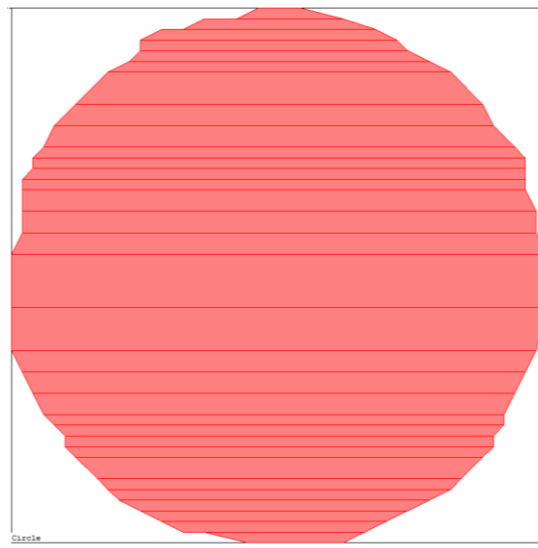

You can choose how to fracture this shape in BEAMER, in the Export (Out GPF) module under Fracturing Mode.
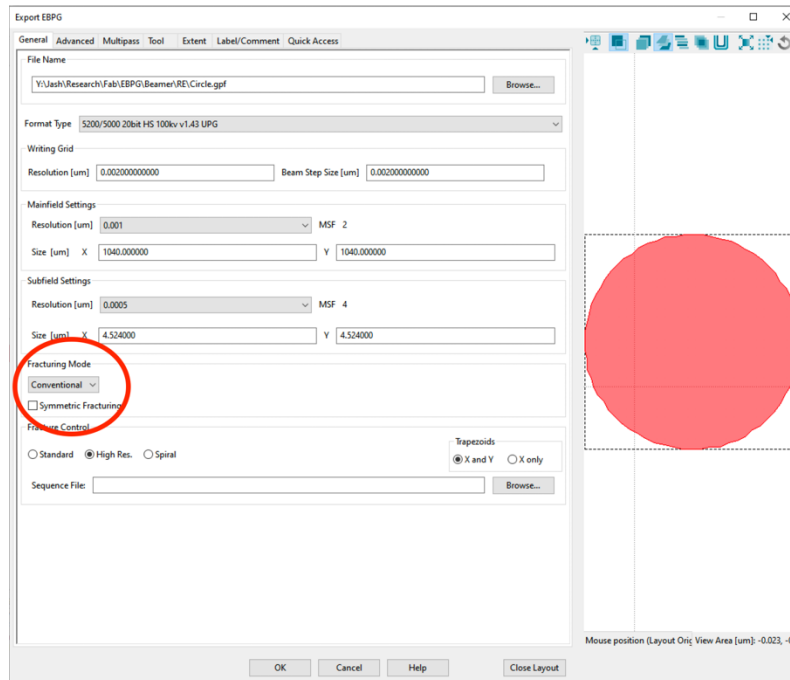
1. <u>**Fracturing Mode: Conventional**</u>

    Conventional fracturing will divide the circle into polygons while respecting the original vertices from the CAD file. The output of this looks like:

    Clearly, this does not look like a nice rounded circle.

2. <u>**Fracturing Mode: LRFT (Large Rectangle Fine Trapezoid)**</u>

    As the name suggests, this mode will try to fit a large rectangle in the middle and then go around the edges and fill in smaller trapezoids. It will still respect the vertices of the original file.
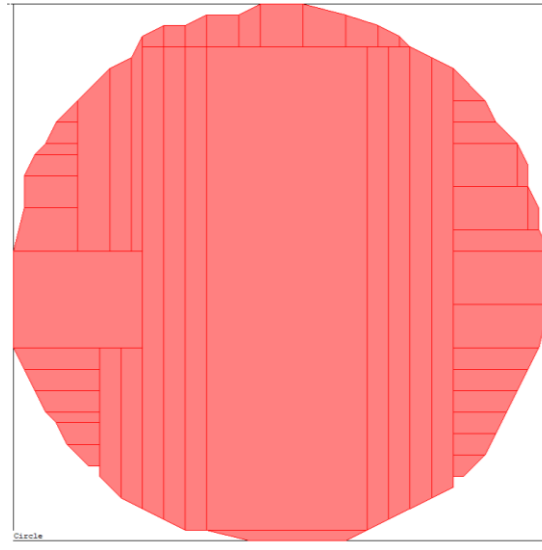
Still doesn't look great.

3. <u>Fracturing Mode: Curved</u>

This mode is able to recognize circles and tries to optimize the fracturing by moving around vertices. The output is shown below:
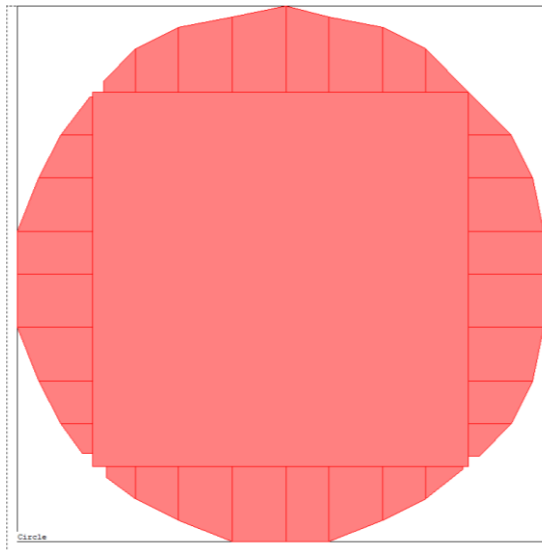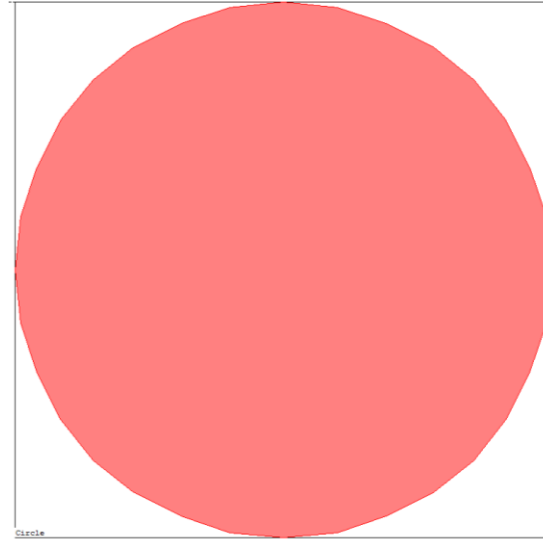

This looks slightly better but still not perfect.

4. <u>Fracturing Mode: Segment</u>

The Segment is able to recognize circles and treat them as primitives (meaning they will not be fractured into smaller polygon shapes). To use this mode, be sure to select the 'UPG' option under Format type.
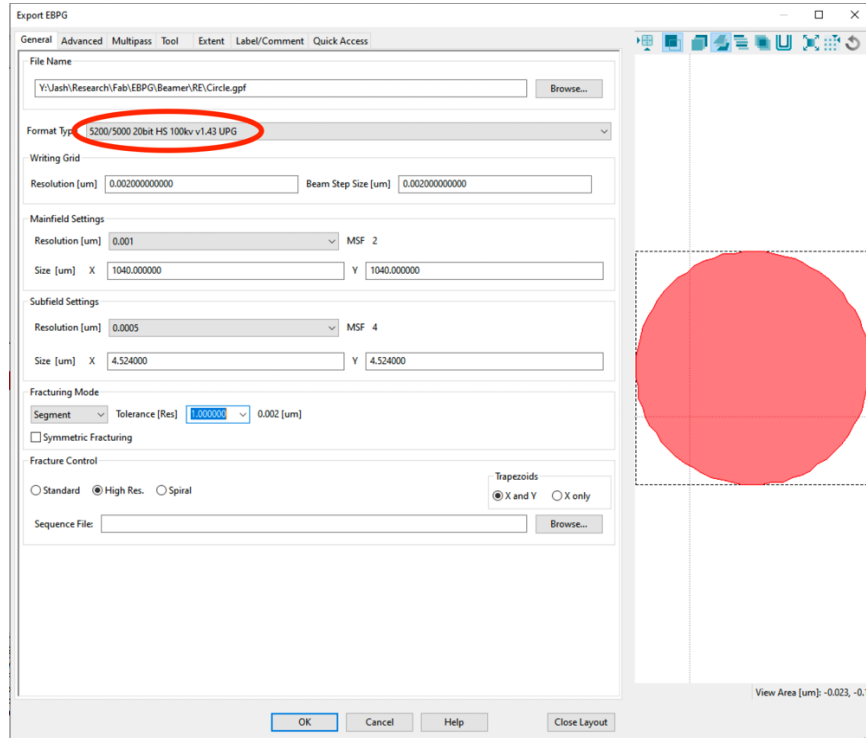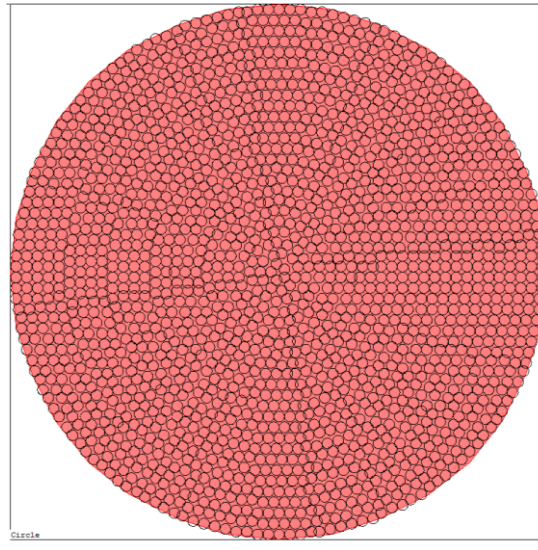
The output of segment fracturing is shown below:

As you can see, the circle is no longer broken up into smaller polygons but is instead recognized as a primitive. We can also see how this circle will be filled by enabling 'view beam shots'. (in the Viewer click on the button circled below)
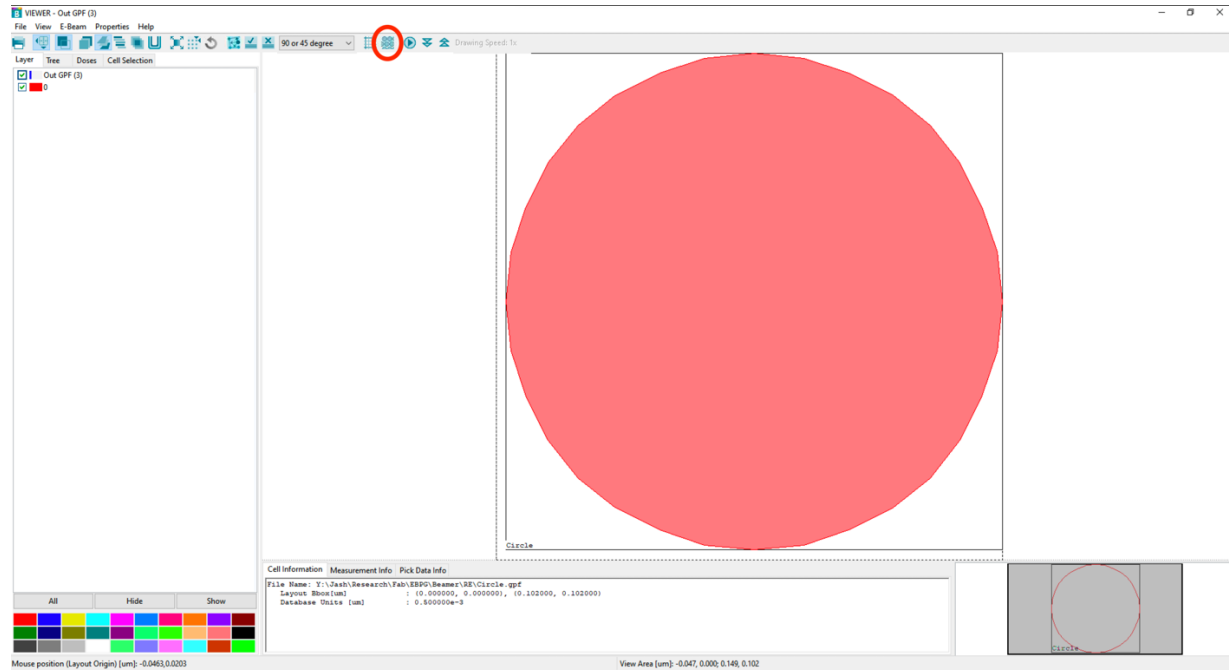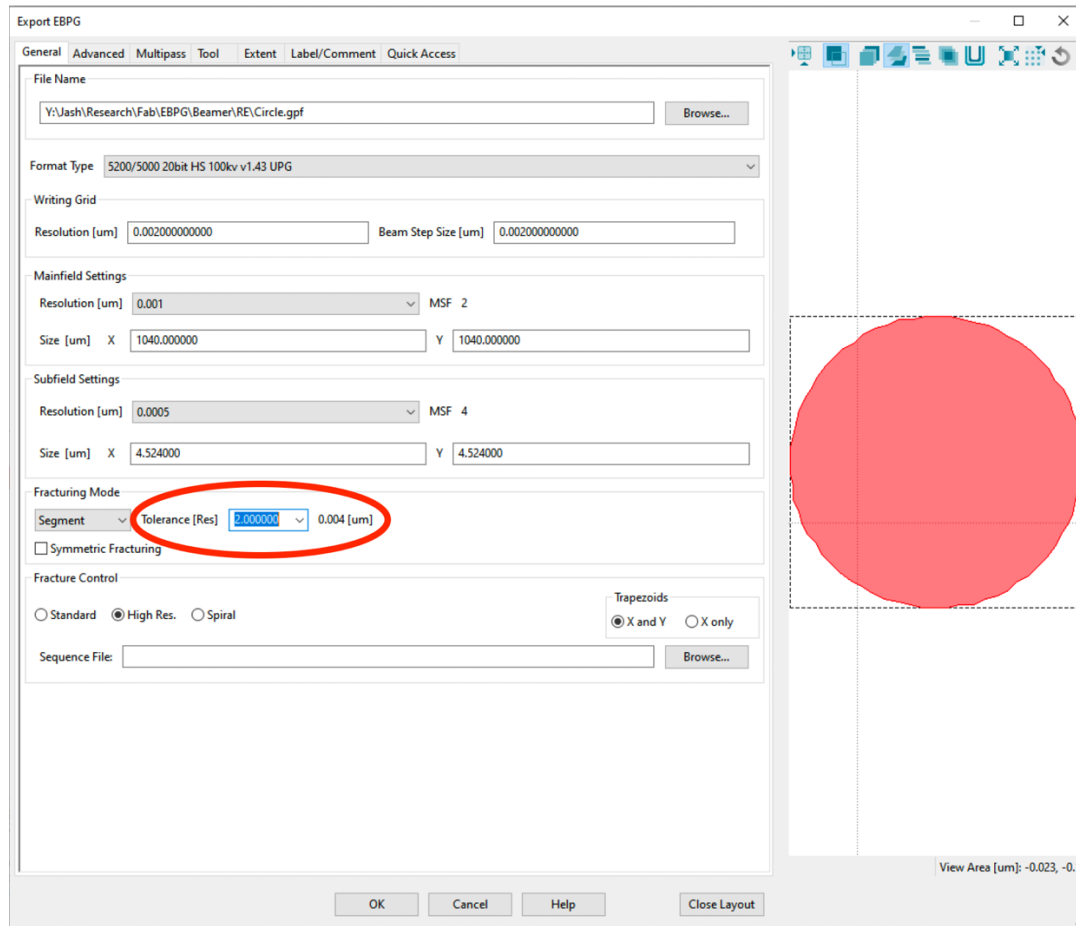
You should be able to see the individual beam shots now

Further, if we view the writing order (CircleWriteOrder), we see that the circle is being filled in a nice spiral fashion. This is pretty much perfect!
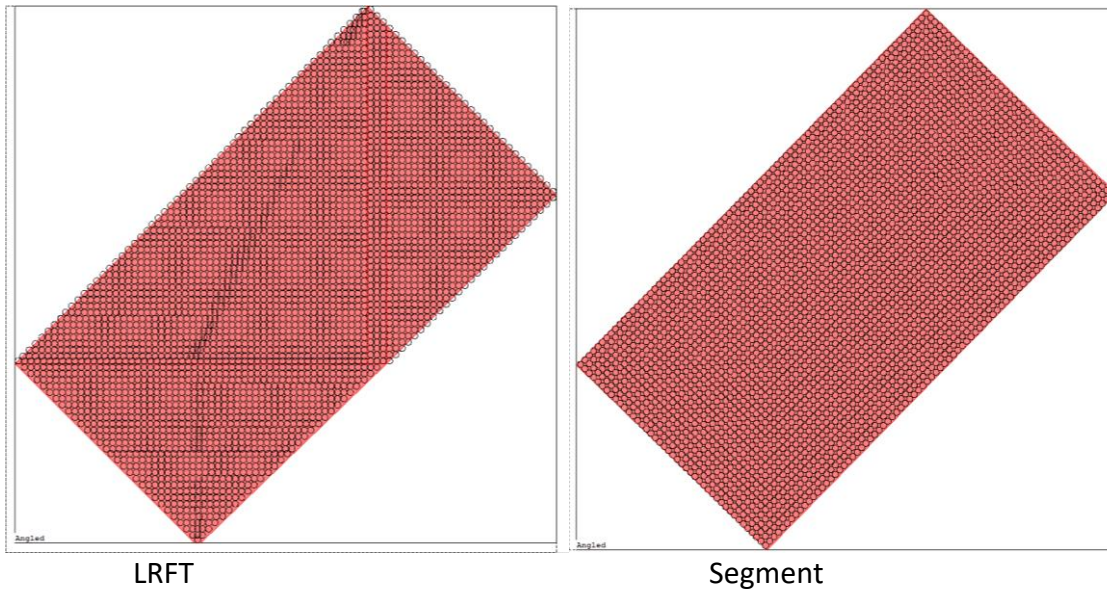
Note: You may need to play with the tolerance setting in segment mode to make BEAMER recognize your circle.

Segment mode is also able to recognize rectangles that are at an angle, as primitives. For example, here is a comparison of LRFT vs Segment mode for fracturing a rectangle at a 45 degree angle.
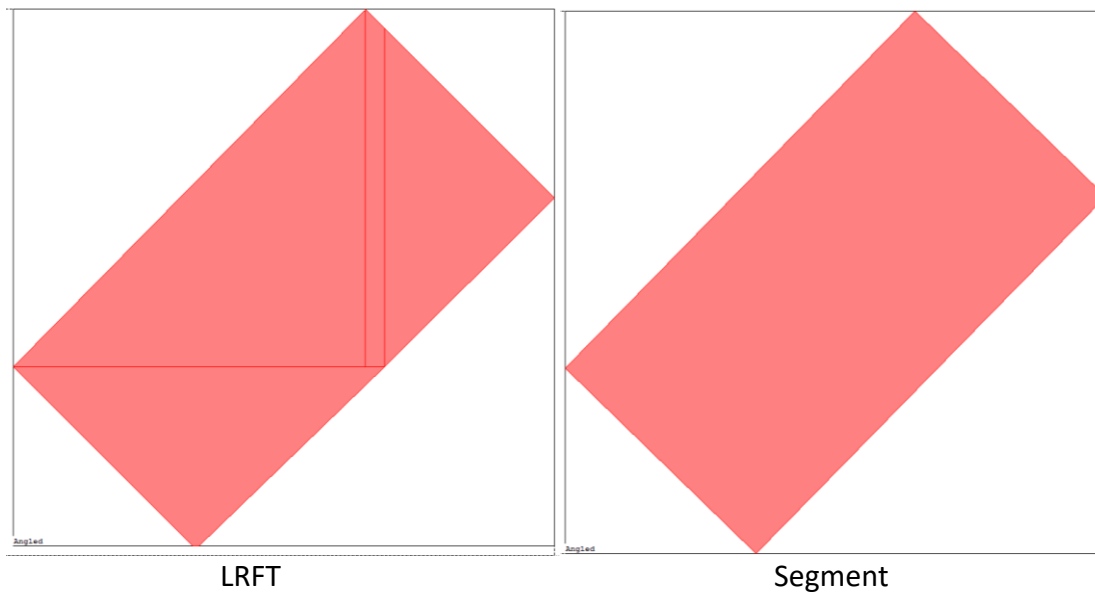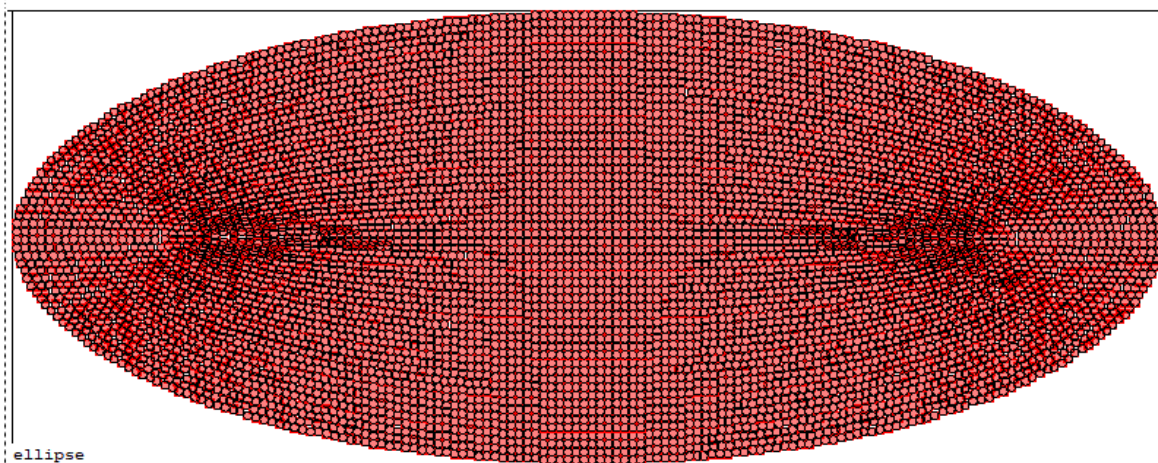

LRFT   Segment

With the beamshots:

LRFT   Segment

Finally, I would like to point out that segment mode can only recognize circles and rectangles. It cannot recognize ellipses for example. I have found that the Sequence mode seems to do a good job of fracturing ellipses as shown below:

Segment mode

ellipse
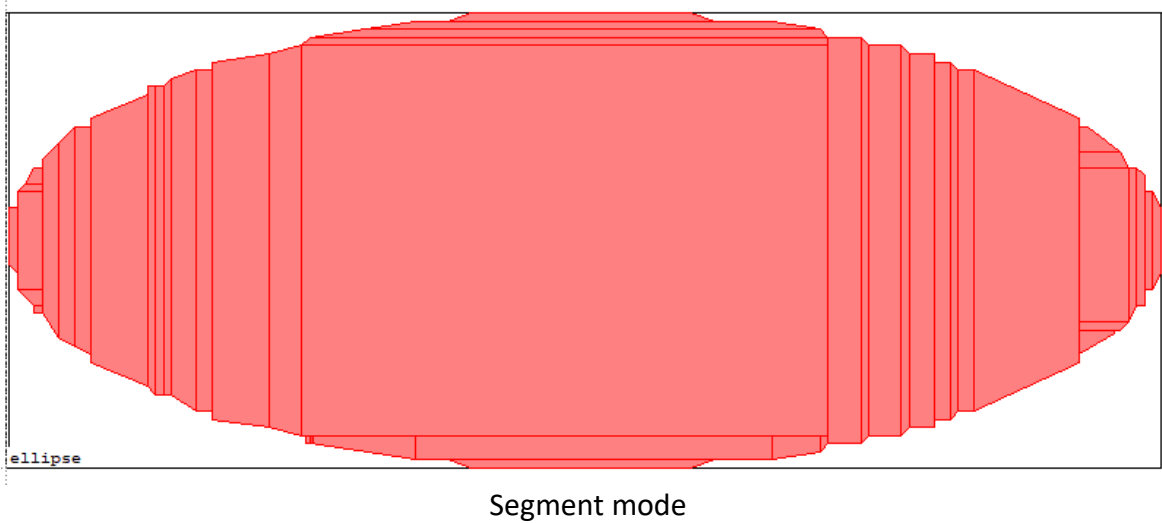
Sequence mode

A full discussion of Sequence mode however, is out of the scope of this tutorial.