

# Workshop 8.4 3D Elbow Part

15.0 Release

Fluid Dynamics

Structural Mechanics

Electromagnetics

Systems and Multiphysics

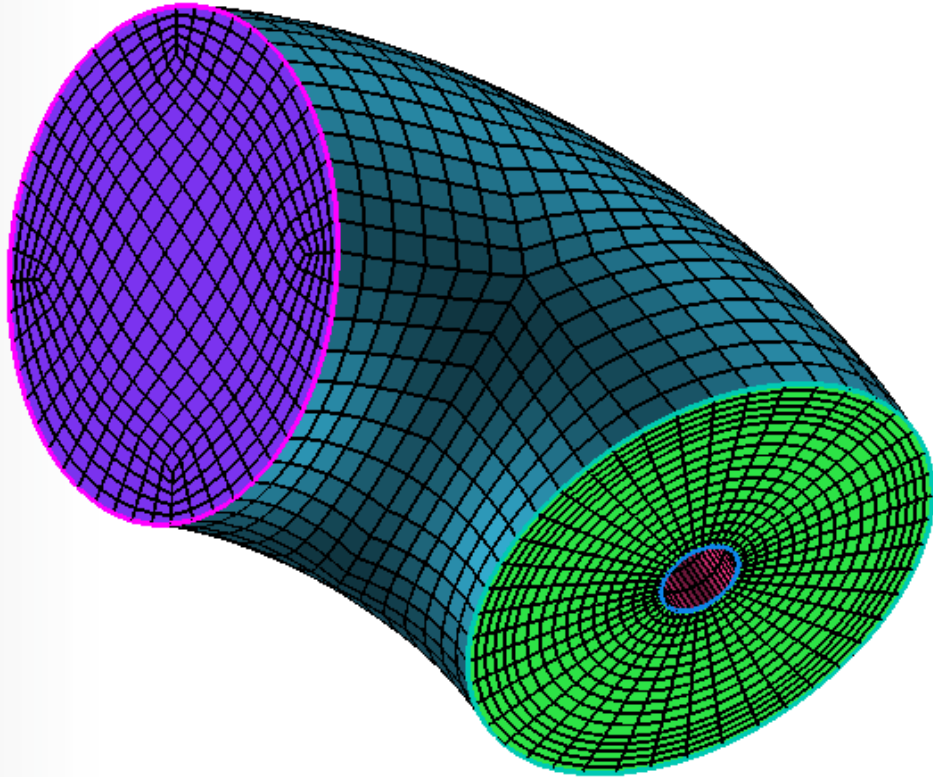
## Introduction to ANSYS ICEM CFD

## ■ 3D Elbow Junction

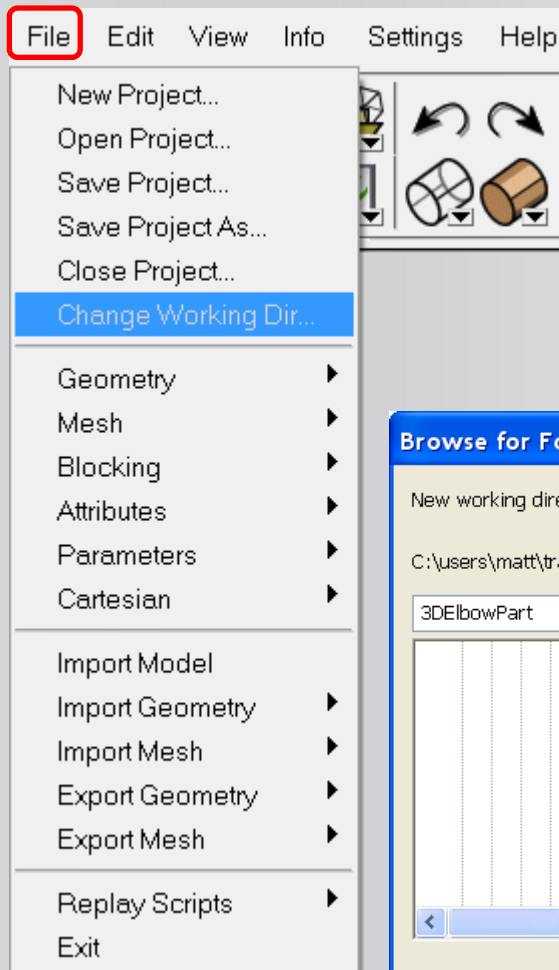
- This is a simplified model of an exhaust or intake port which passes over a valve stem

## ■ This tutorial demonstrates

- Two uses of O-grid
  - One to capture geometry
  - The other to fix corner mesh in cylindrical tube geometry
- Use of various vertex movement techniques to fit blocking to the geometry and improve mesh quality
- Scan plane

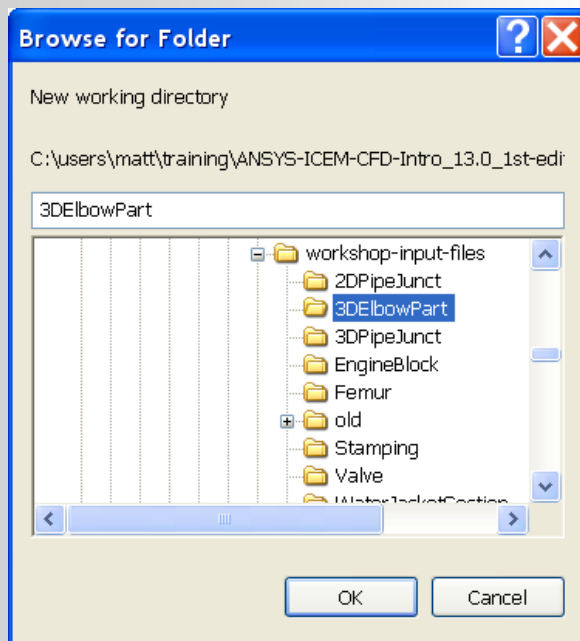


# Set Working Directory



## ■ Set Working Directory

- Select **File > Change Working Dir...**
- This will pop up a directory selection window. Select the **3DElbowPart** directory where the geometry exists.
  - All output files will be saved in this working folder
  - Opening any files will default to this working directory
- Opening a project or creating a new project is not necessary
- You can open and save files independently (geometry (\*.tin), blocking (\*.blk), mesh (\*.uns), etc...)



# Open Geometry

File Edit View Info Settings Help

New Project...  
Open Project...  
Save Project...  
Save Project As...  
Close Project...  
Change Working Dir...

Geometry

Mesh

Blocking

Attributes

Parameters

Cartesian

Import Model

Import Geometry

Import Mesh

Export Geometry

Export Mesh

Replay Scripts

Exit

Open Geometry...

Save Geometry...

Save Geometry As...

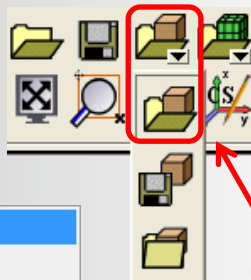
Save Visible Geometry As...

Save Only Some Geometry Parts As...

Save Geometry As Version...

Import Parameters...

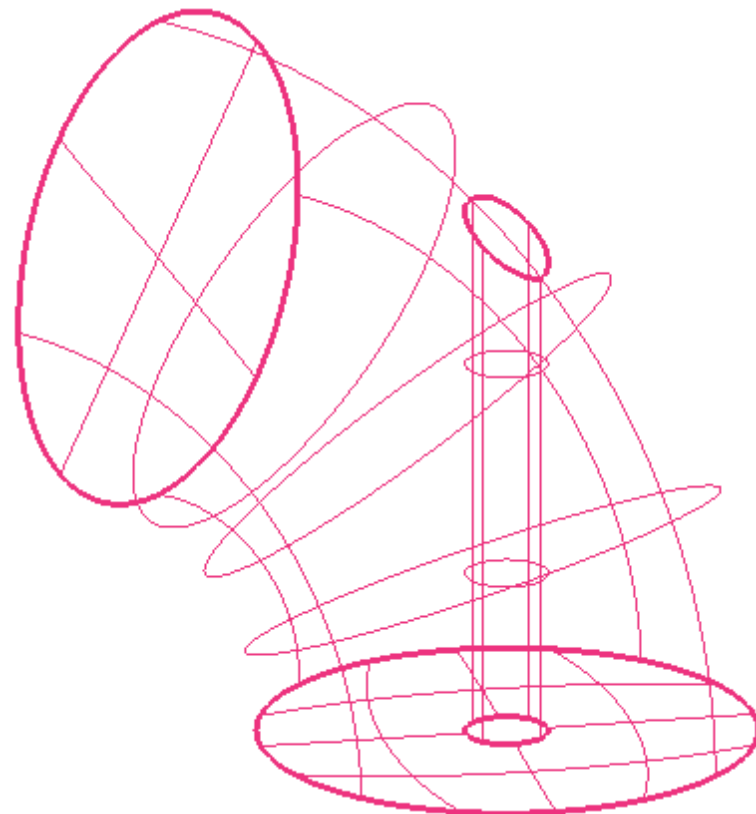
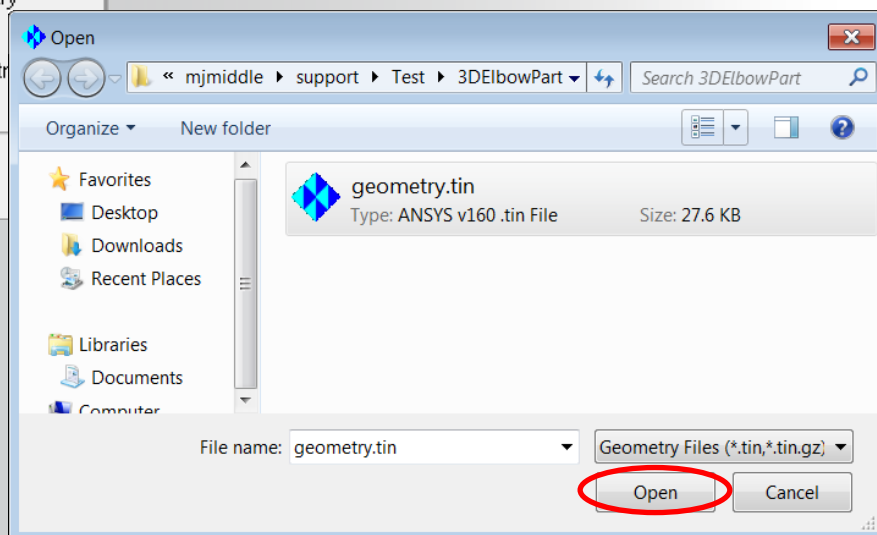
Close Geometry...



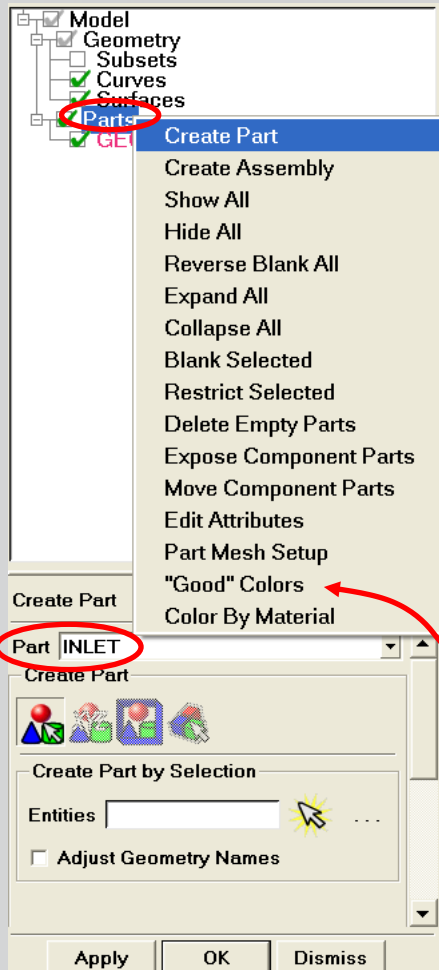
Or  
use  
quick  
icon

## Open Geometry

- **File > Geometry > Open Geometry**
- Choose “geometry.tin” file
- Click **Open**

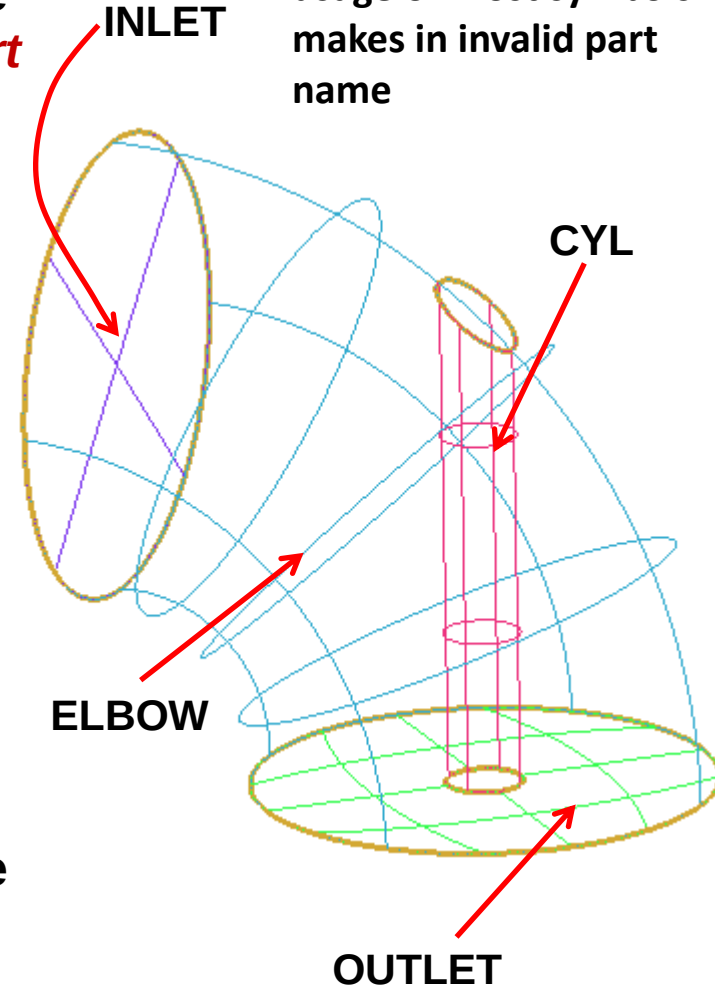


# Part Creation

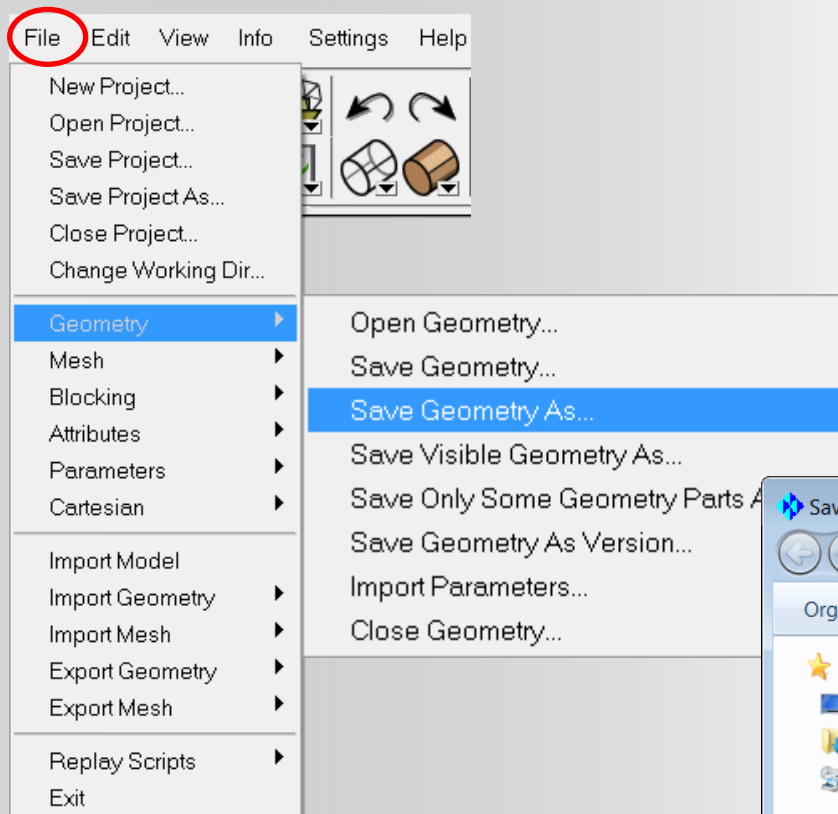


- Turn on **Geometry > Surfaces** in the model tree
- Right-click on **Parts** in the tree and select **Create Part**
- Enter **INLET** as the **Part** name
- Select **Create Part by Selection** 
  - Select  the surface at the min-x end of the pipe and middle click to accept
- Repeat with different names for the other parts as shown
- Middle click when done
- Right-click on **Parts** in the tree and select **"Good" colors**

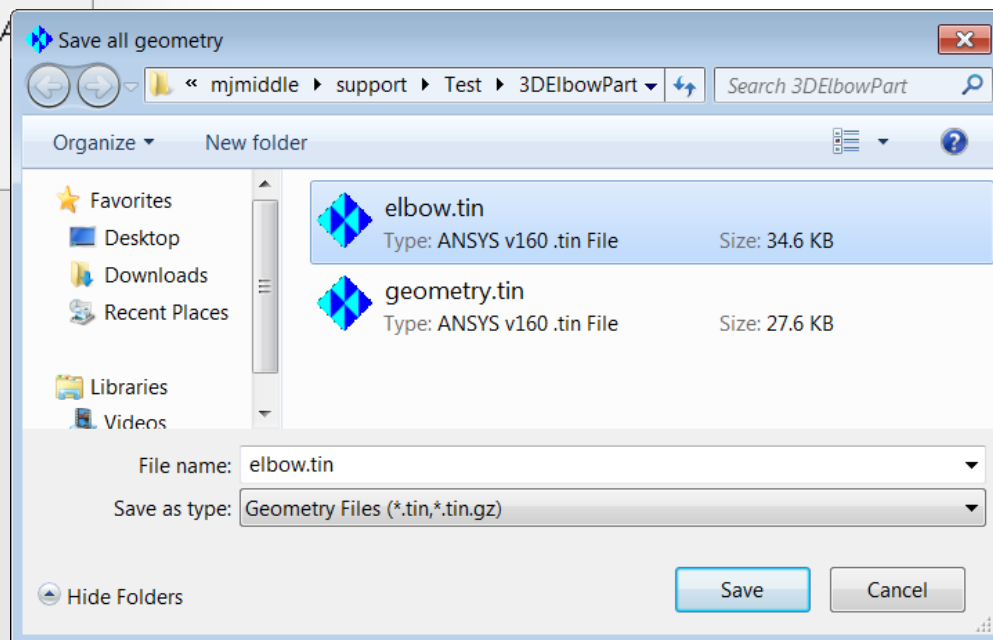
Beginning a part name with a number or the usage of most symbols makes in invalid part name



# Save Geometry

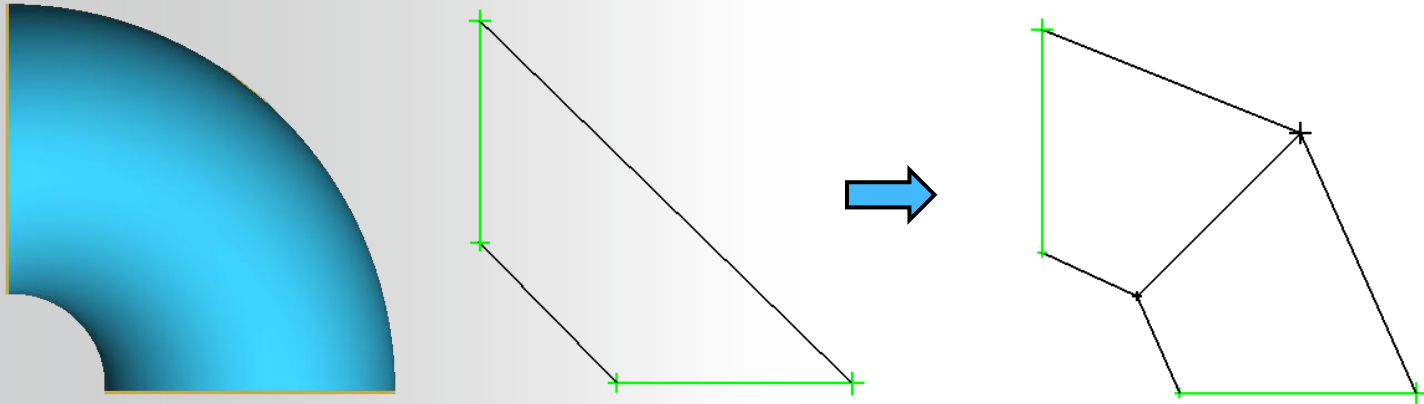


- ***File > Geometry > Save Geometry As...***
  - The part changes will be saved to the geometry
  - It's good practice to save to a new name instead of overwriting, so you can always go back

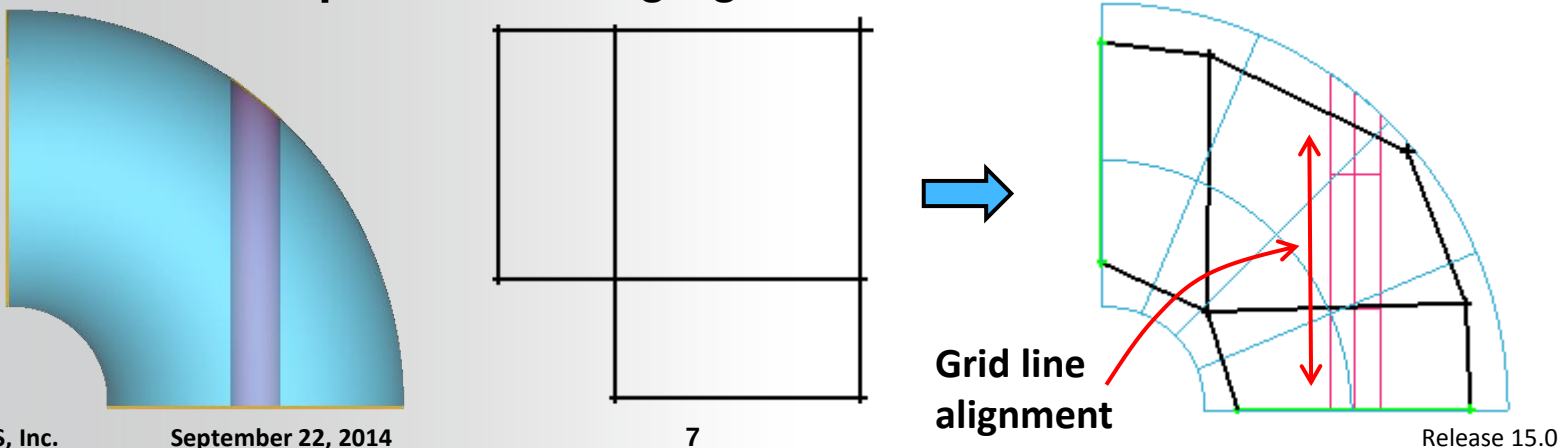


# Decide on Topology

- Tubes are normally one-block topologies
  - Splits are added later where tubes bend a lot



- But because of the valve stem hole, we must choose a less-desired L-shaped topology
  - This makes it possible to align grid lines with the valve stem

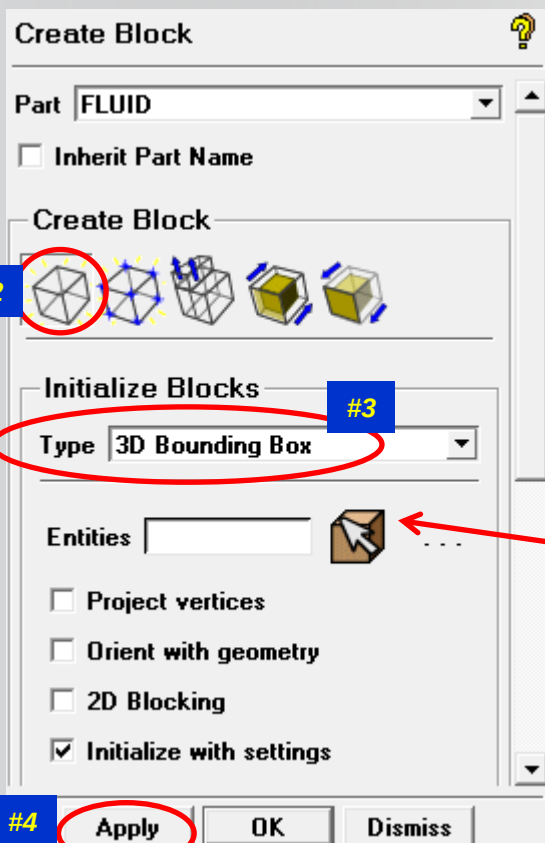


# Initialize Blocking

- Select **Blocking > Create Block > Initialize Blocks**



#1



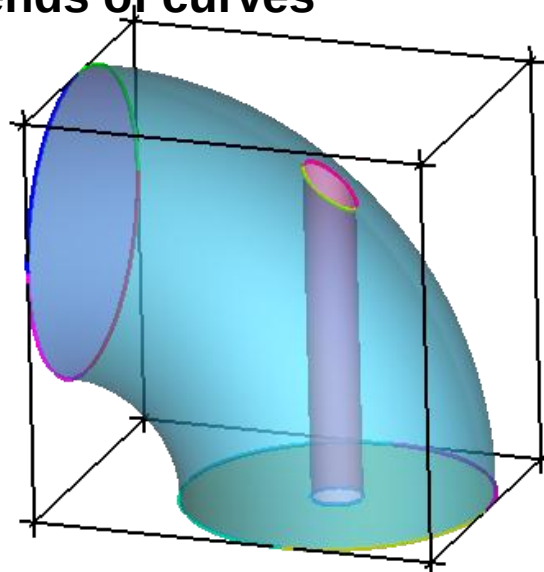
#2

#3

#4

- Enter **FLUID** for the **Part**
- Set **Type** to **3D Bounding Box** (default)
- Click **Apply**
- This creates one block which encloses the entire geometry
- Curves automatically change color (colored separately instead of by part) to allow you to see the ends of curves

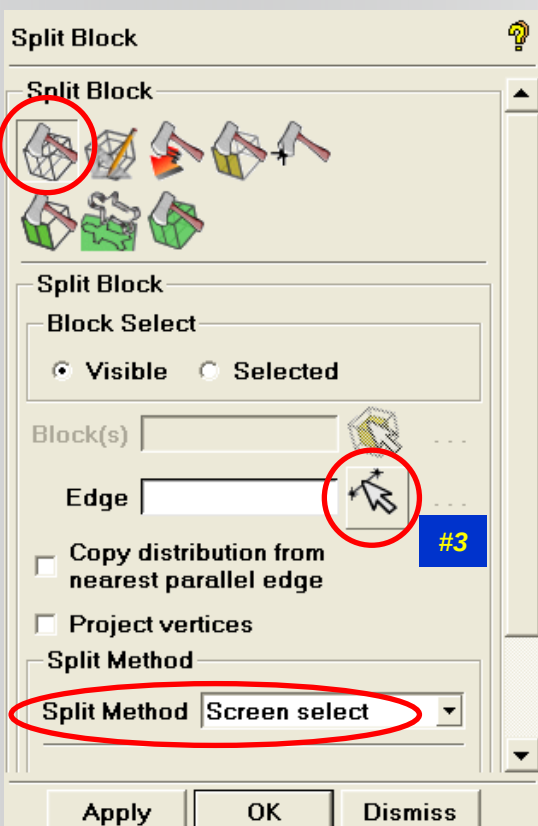
If no geometry is selected, the block will be around everything



# Split to Create Topology



#1



#2

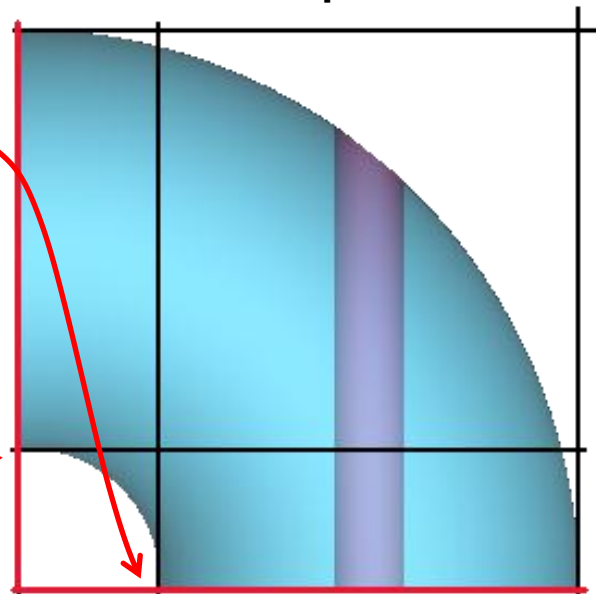
#3

- Split the block at 2 locations

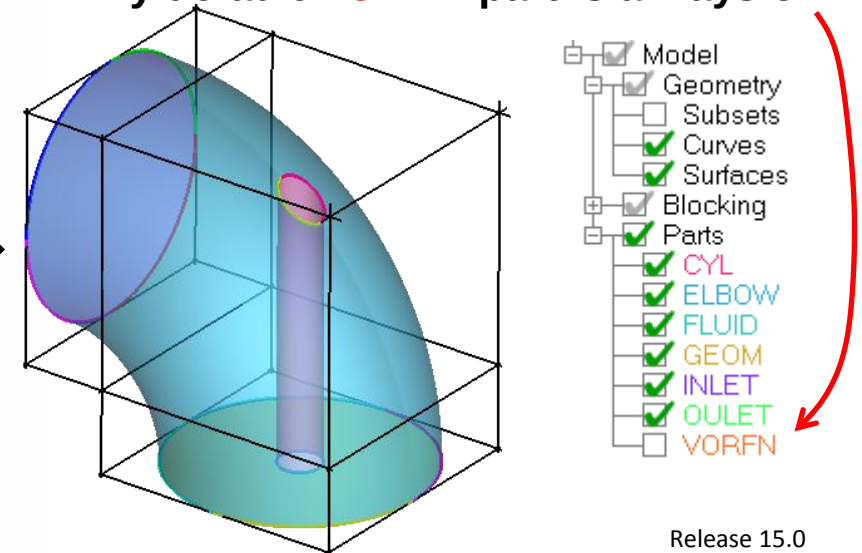
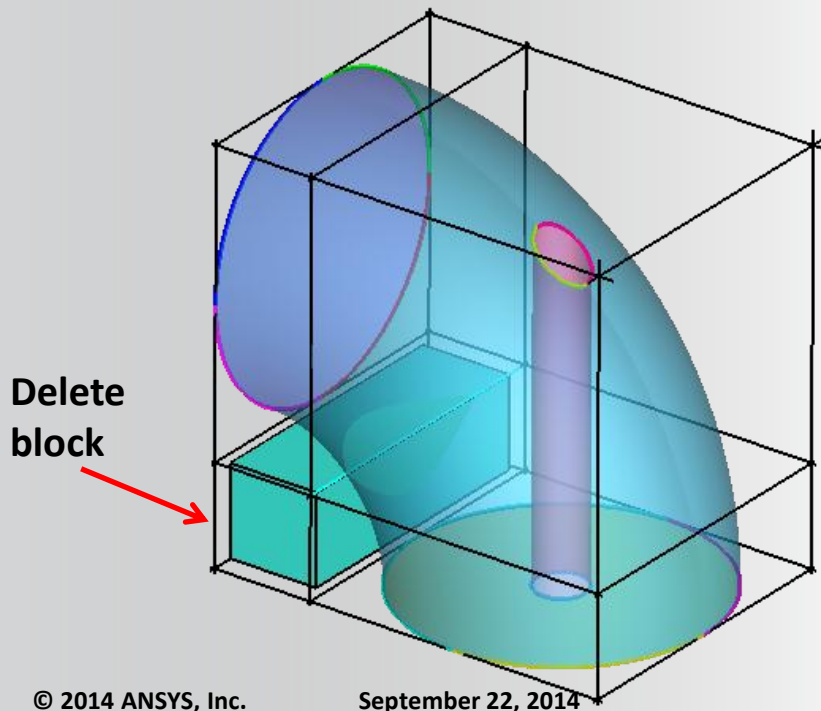
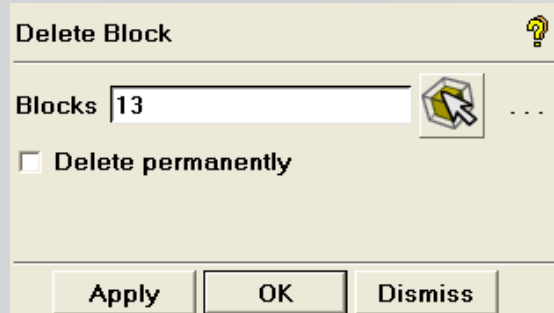
- Select **Blocking > Split Block > Split Block**
- **Split Method** is **Screen select**
  - Left click  and hold on the edge to split
  - The new edge will be normal to the edge that you select
  - Hold left mouse button and drag the split to desired location
  - Middle mouse to complete

Split this edge  
for the vertical  
split

Split this edge for  
the horizontal  
split



# Delete Blocks



## Delete Block

- Select **Blocking > Delete Block**
- Select bottom left corner block as shown
- **Apply** or middle mouse
- Middle mouse again to exit selection
- This doesn't actually delete the blocks. It moves them to the part, VORFN, so they can be used again, if desired
- To actually delete the blocks, select **Delete permanently** (changes indices)
- By default **VORFN** part is always off

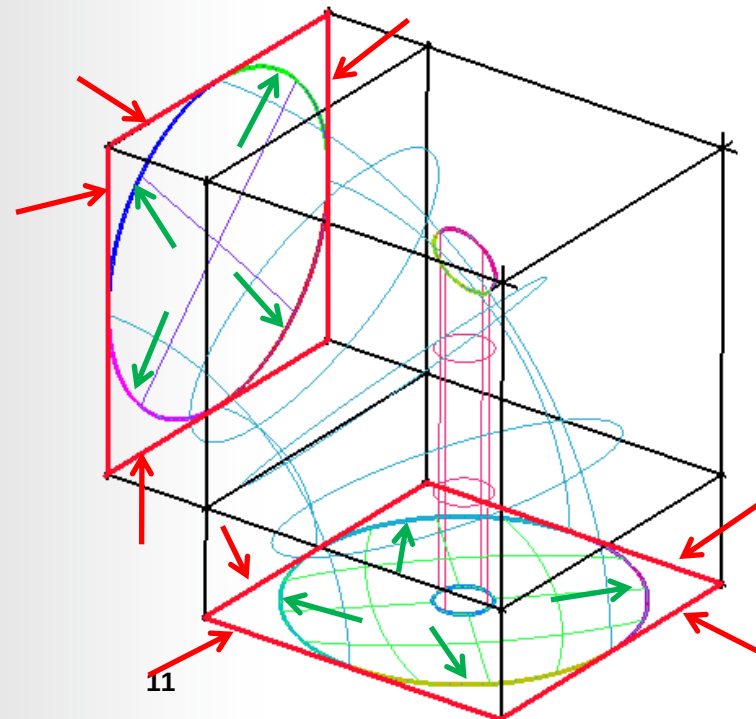
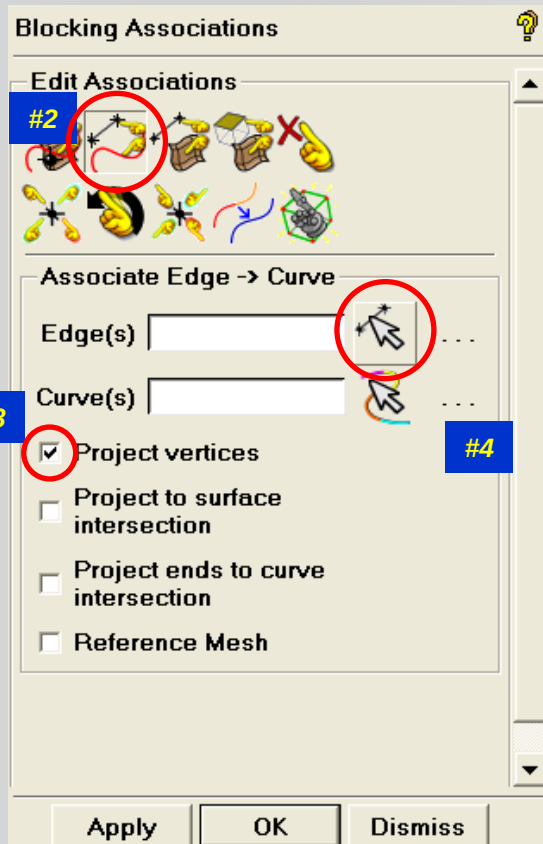
# Associate Edges to Curves

## Associate Edges

- Select **Blocking > Associate > Associate Edge to Curve**
- Enable **Project vertices**
  - This will automatically project vertices on associated curves after completion of the operation.
- Select the  4 edges bounding an INLET or OUTLET of the elbow, then the 4 curves at the same end
- Repeat for the other end of the elbow



#1

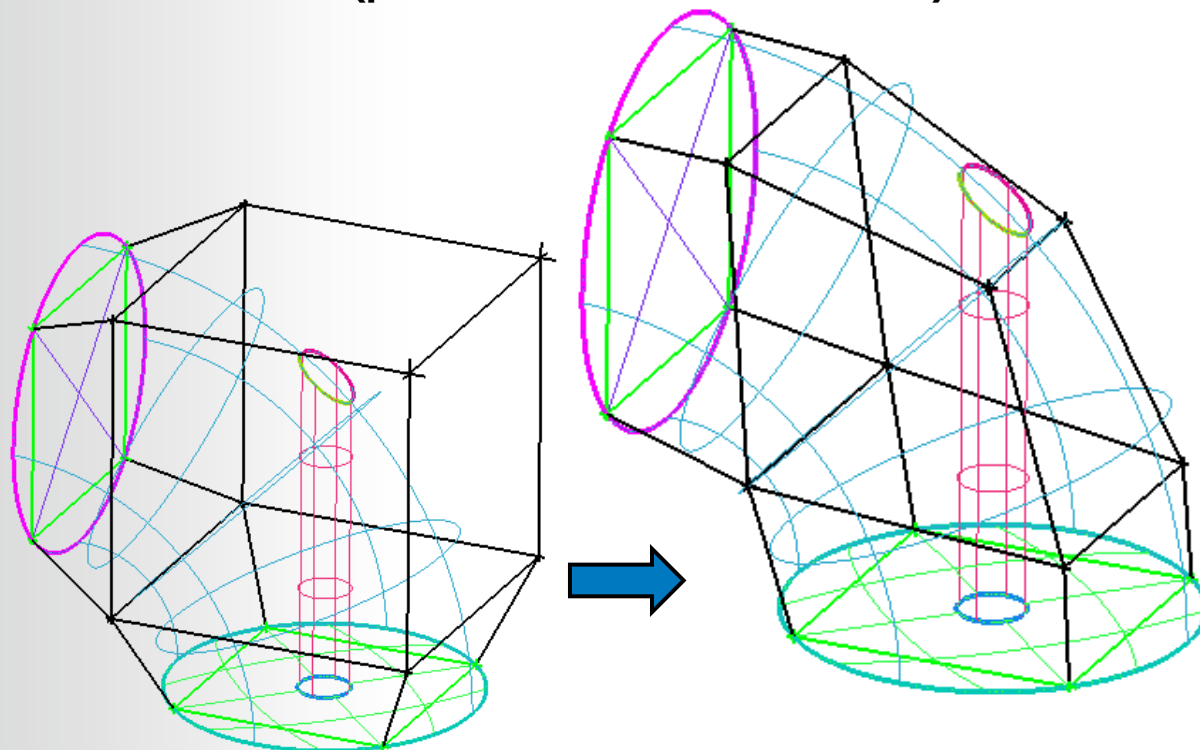
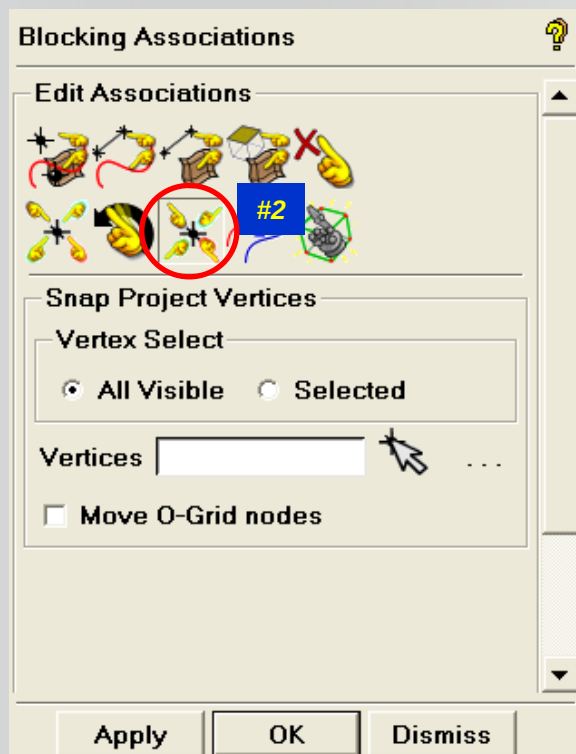


# Move Vertices



## ■ **Blocking > Associate > Snap Project Vertices**

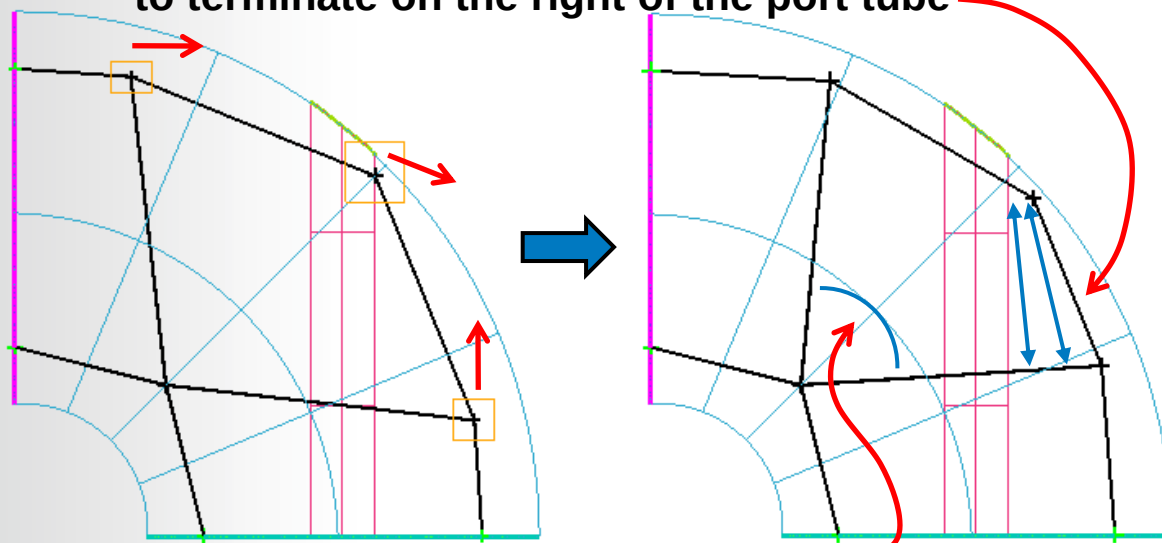
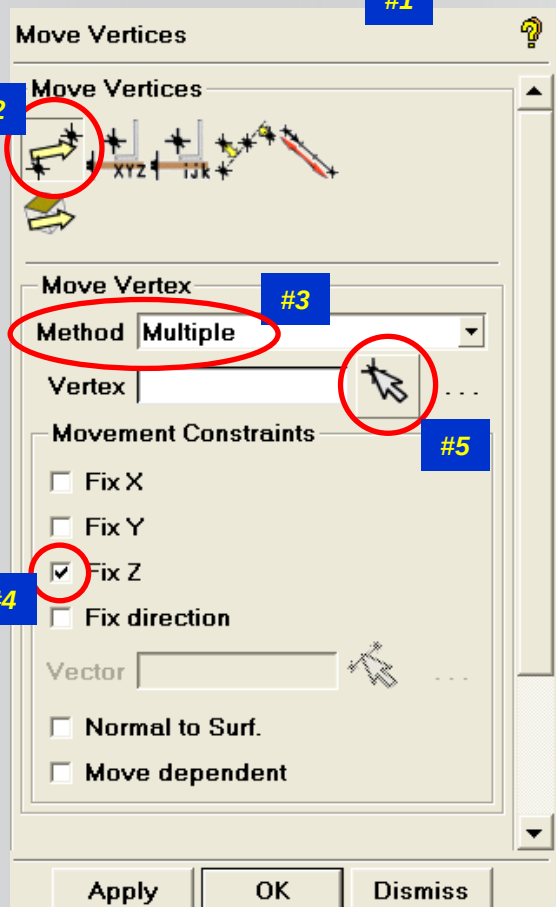
- With **All Visible** toggled on, press **Apply**
- All vertices will move to the nearest location on their assigned geometry entity
- All external vertices and edges (black or white) are, by default, assigned to the **NEAREST ACTIVE** (part turned on in model tree) surface



# Move Vertices – Multiple Method

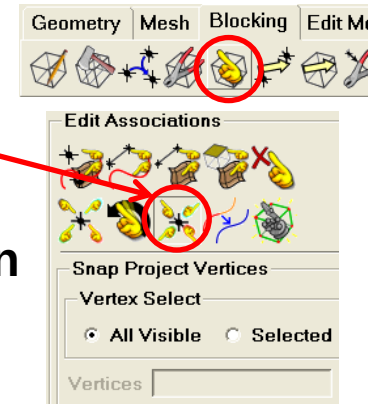
## Blocking > Move vertex > Move Vertex

- Set **Method** to **Multiple**
- **Fix Z**
- Select the +Z axis at the lower right
- Press the **select vert(s)** button
- Left click, drag and release to draw a box and select 2 vertices within that box as shown below
- Middle click, hold and drag the vertices as shown below for 3 locations
- There needs to be room for the vertical grid lines to terminate on the right of the port tube



L-grids are best with angle slightly less than 90°

# Create First O-Grid



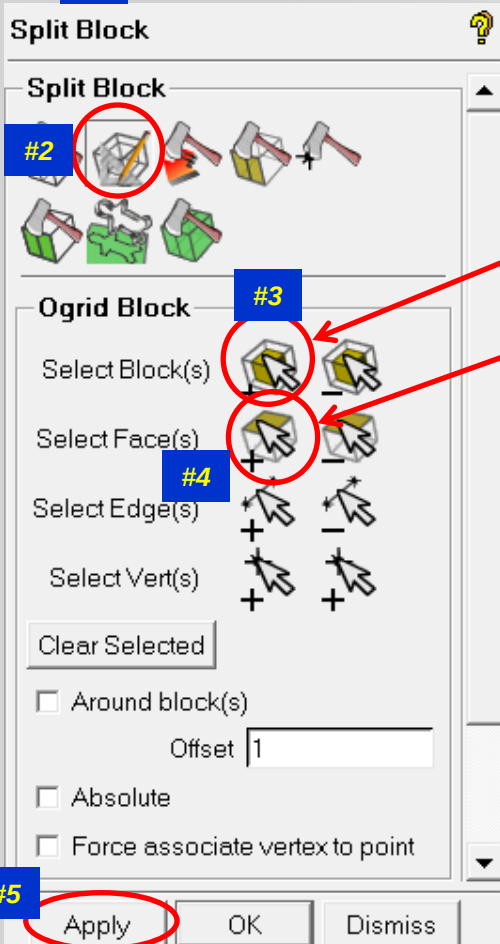
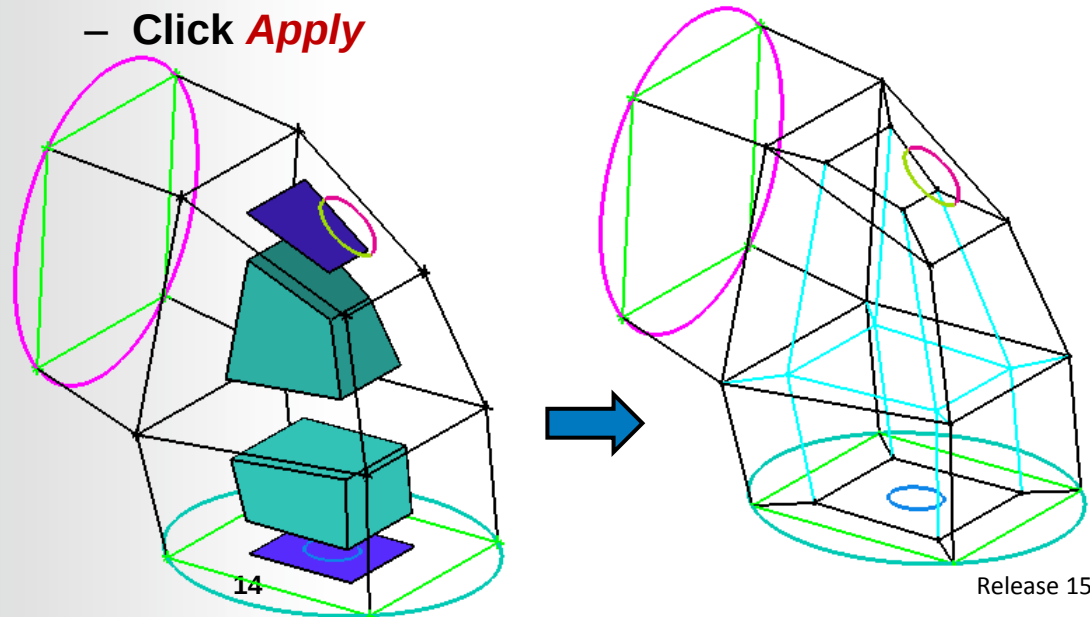
- First **snap project vertices** since they were moved slightly off geometry from previous operation

## O-Grid Creation

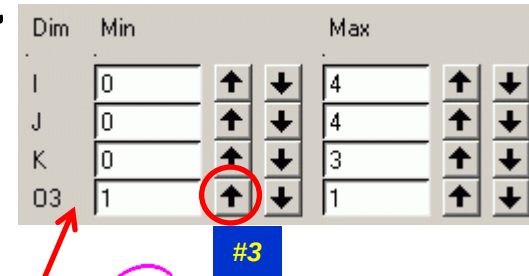
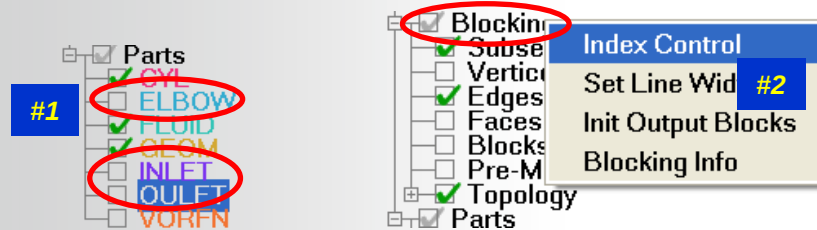
- Select **Split Block > OGrid block**

- Select highlighted 2 blocks and middle click to confirm.
- Select top and bottom faces as shown to pass O-grid through these faces. Middle click to confirm.

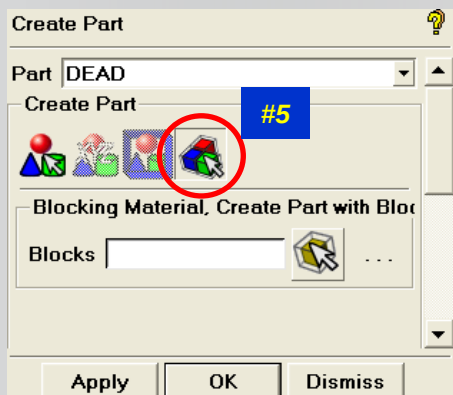
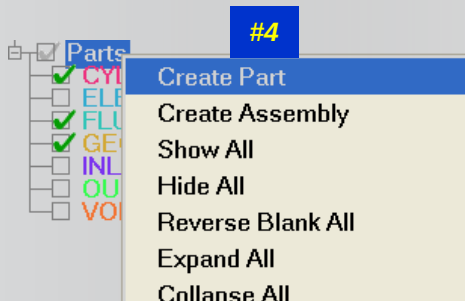
- Click **Apply**



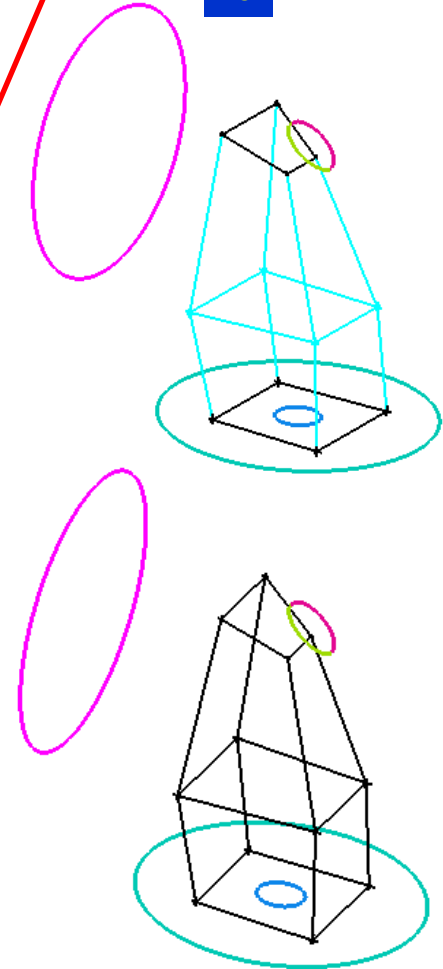
# Move Blocks to Different Part



- Turn off **ELBOW**, **INLET**, and **OUTLET**
- Right click on **Blocking** in the model tree and select **Index Control**
- Set the O3 index (the O-grid direction) from 1 to 1
- Right Click on **Parts** > **Create Part**
- Enter **DEAD** for the part name
- Select **Blocking Material, Add Blocks to Part**



- Press '**v**' on the keyboard with (mouse over model window) for all visible blocks, middle click to exit selection
- Note the edges turn from blue (internal) to white (or black) when they become external or between parts
- Vertices and edges between different parts default to surface association

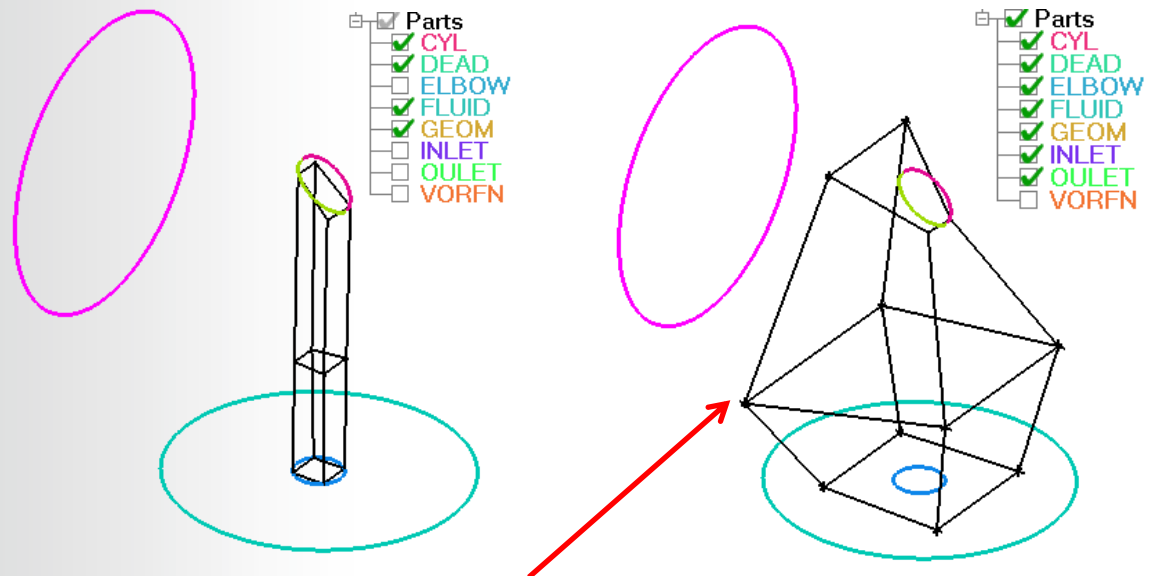
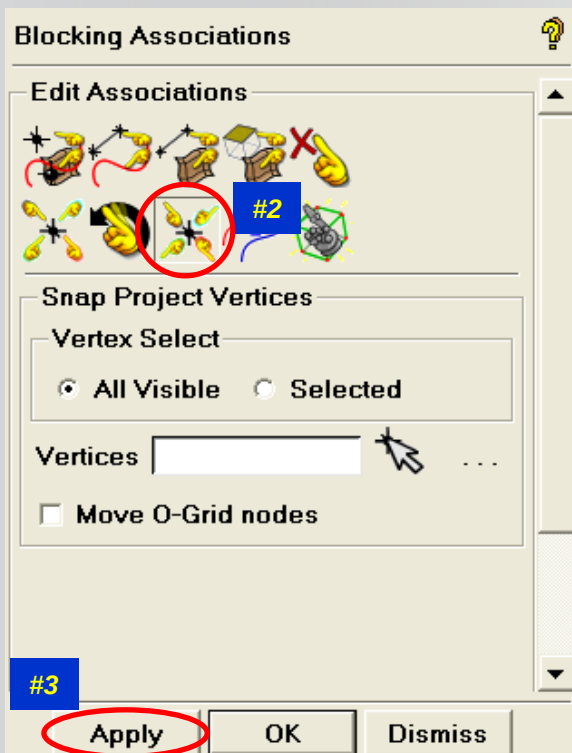


# Move Vertices



## ■ **Blocking > Associate > Snap Project Vertices**

- With **All Visible** toggled on, press **Apply**
- All the visible vertices, which are surface associated due to the previous block movement to another part will move to the nearest surface
- It is very important to note these vertices move to the NEAREST ACTIVE surface. If the ELBOW part were left active, some of the vertices would jump to the outer surfaces



This happens if the other parts are left active

# Edge Associations

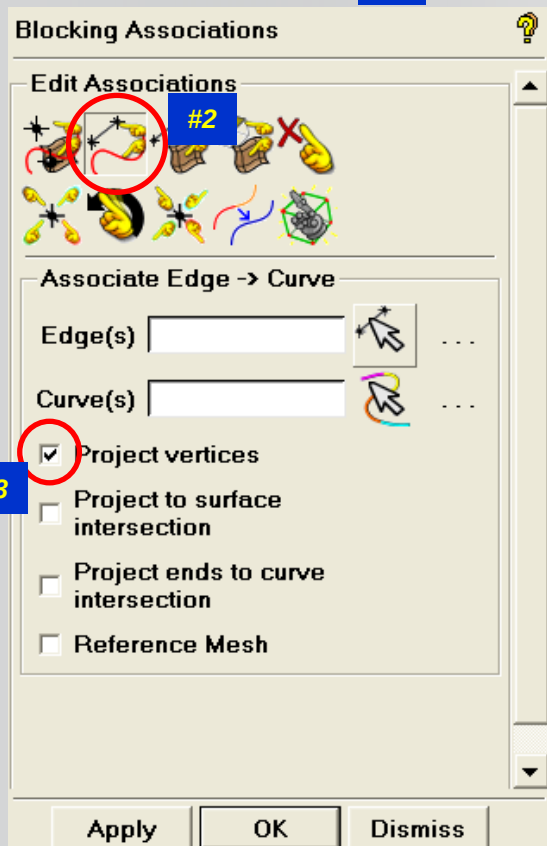
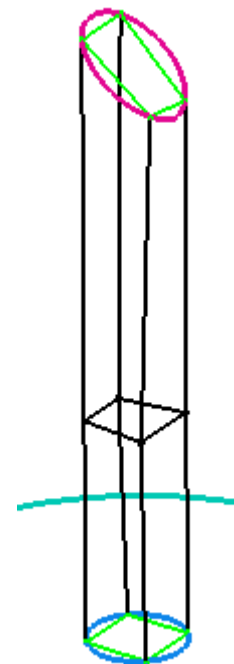
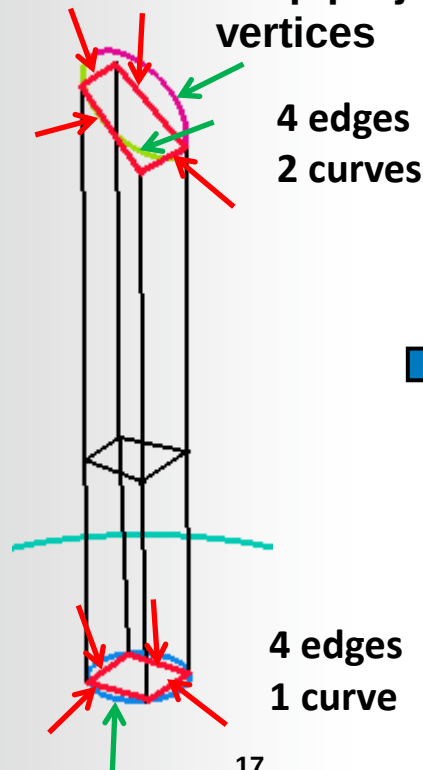


#1

- Select **Blocking > Associate > Associate Edge to Curve**

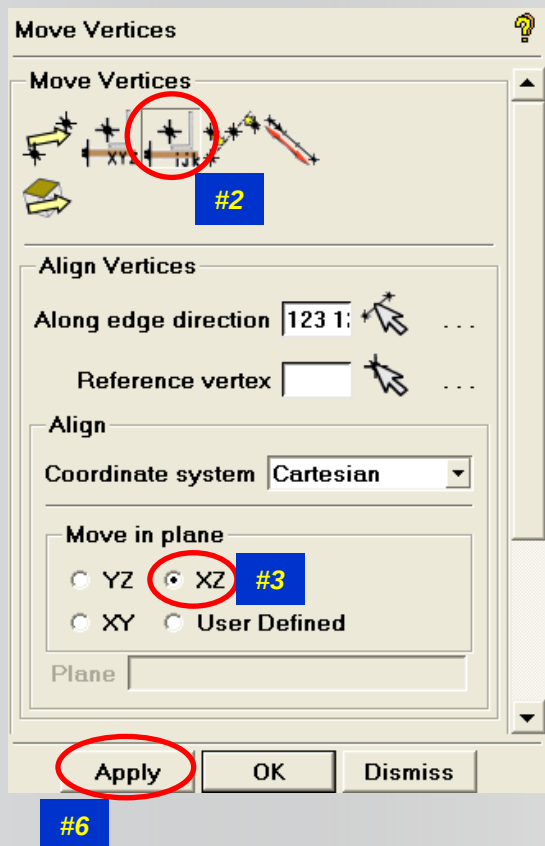
– Turn on **Project vertices**

- Select the 4 edges and related curves(s) at each end of the cylinder
- With **Project vertices** ON, it does the snap project immediately for the selected vertices



#3

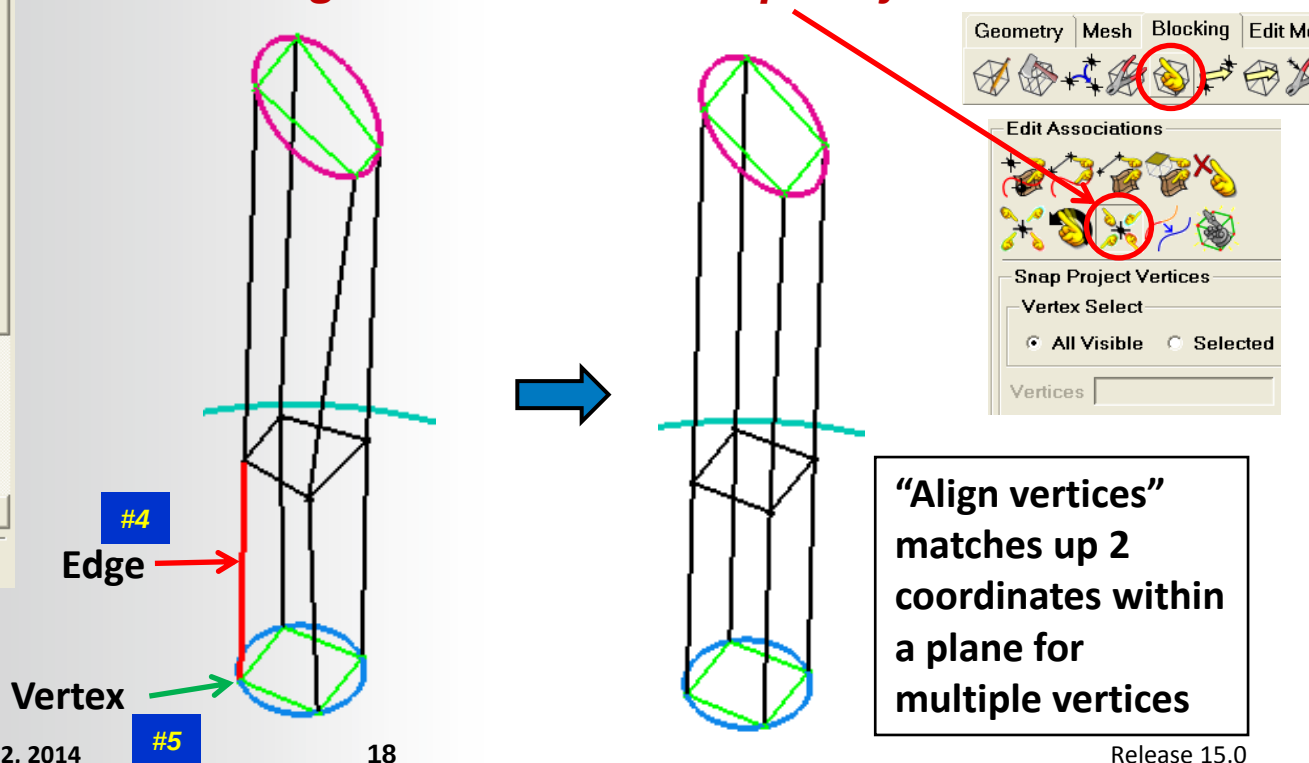
# Move Vertices – Align Vertices



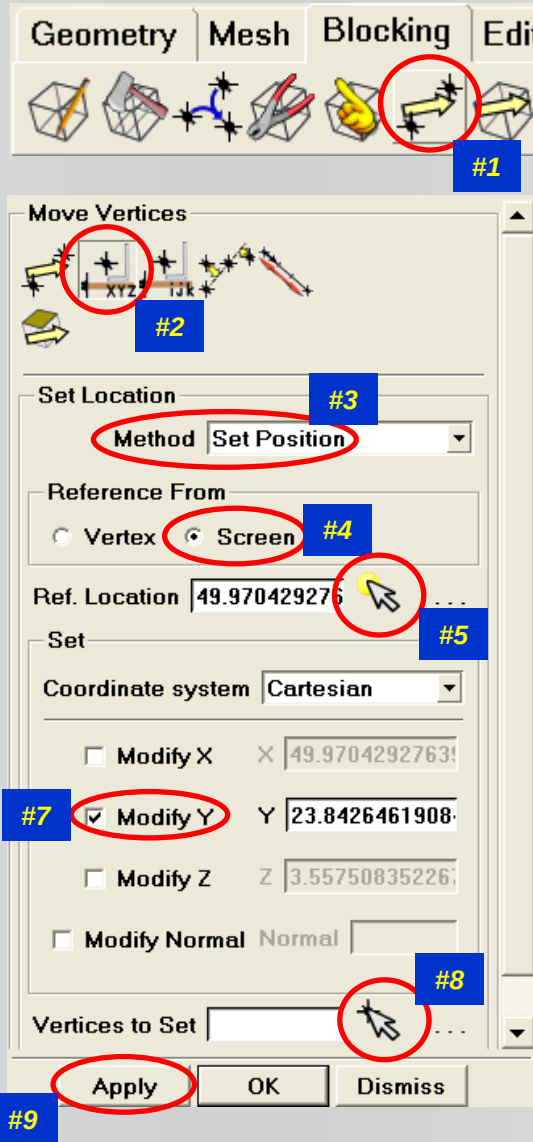
## ■ *Blocking > Move Vertex > Align Vertices*

- Select one of the edges along the length of the cylinder
- Select any vertex at the OUTLET end
- Set *Move in plane* to *XZ*
- *Apply*

## ■ *Blocking > Associate > Snap Project Vertices*



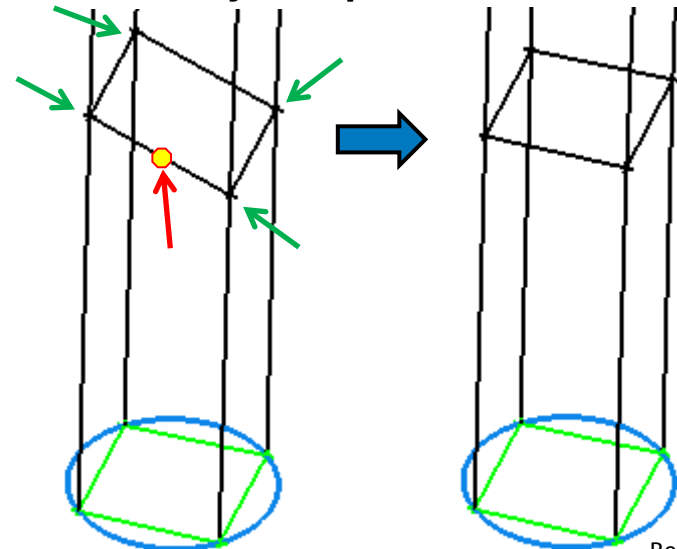
# Move Vertices – Set Location



## Blocking > Move Vertex > Set Location

- Set **Method** to **Set Position** (default)
- For **Reference From**, choose **Screen**
- For **Ref. Location**, press the **Select Location(s)** button  and then **Toggle allow on Mesh/Block selection** button 

- Select roughly the middle of the edge shown. You'll need to zoom in. Middle click. (Turn surfaces off)
- Turn on **Modify Y**
- For **Vertices to Set**, Select the **Select vert(s)** button,  and select the 4 vertices just up from **OUTLET**. Middle click
- **Apply**

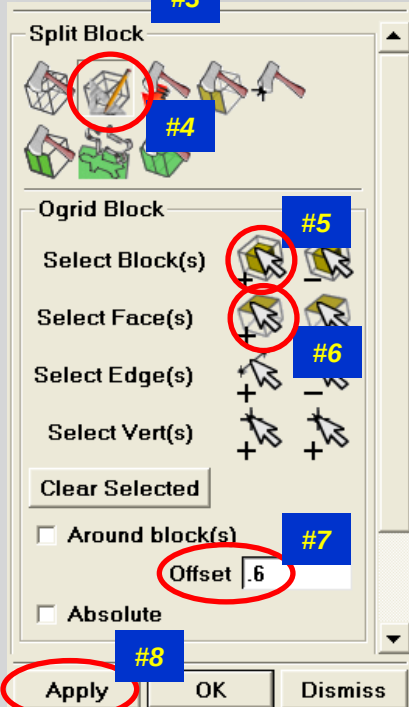


"Set location" sets coordinates to one specific value

# Create Second O-Grid



#3



#4

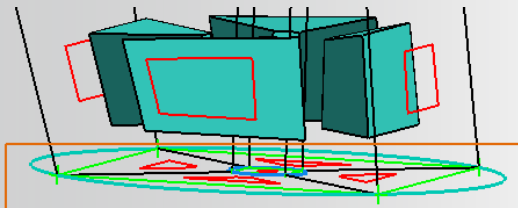
#5

#6

#7

#8

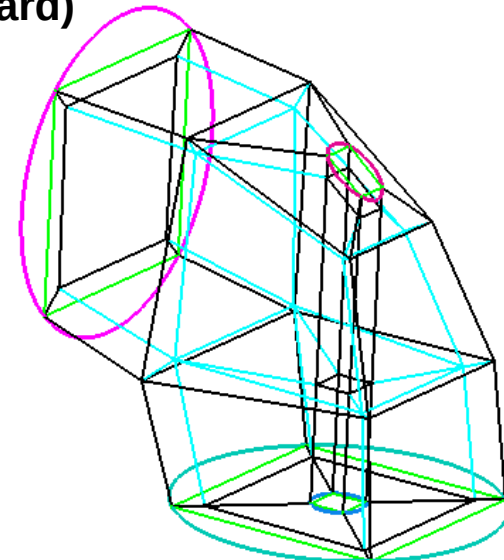
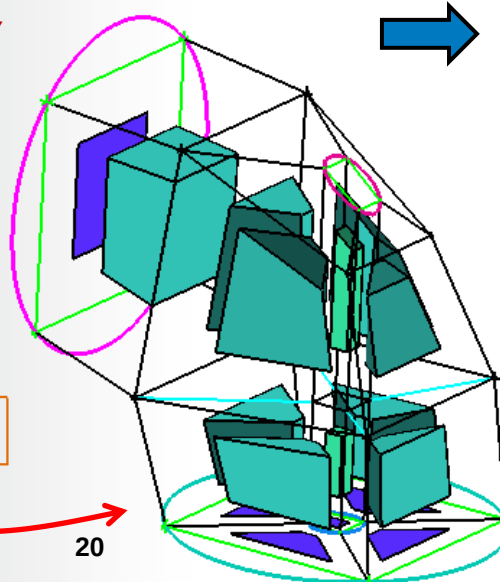
View OUTLET  
faces down  
the edge and  
box select



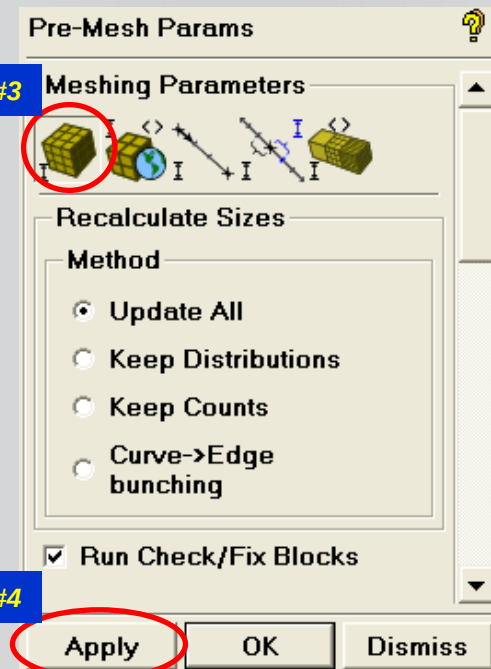
#1

#2

- First press **Reset**, then **Done** in the index control
  - Reset shows the full blocking
- Blocking > Split Block > O-grid Block**
  - Press the **Select block(s)** button  and add all the blocks by typing 'v' or box selecting everything
  - Press the **Select face(s)** button  and select 1 face at the inlet and 5 faces at the outlet. Middle click.
  - Set **Offset** to **0.6** (Every O-grid radial edge will be 0.6 of its original length) (same function as **Rescale Ogrid** which can be done afterward)
  - Apply**



# Surface Mesh Sizes



## Mesh > Part Mesh Setup

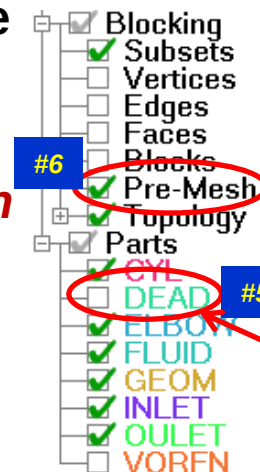
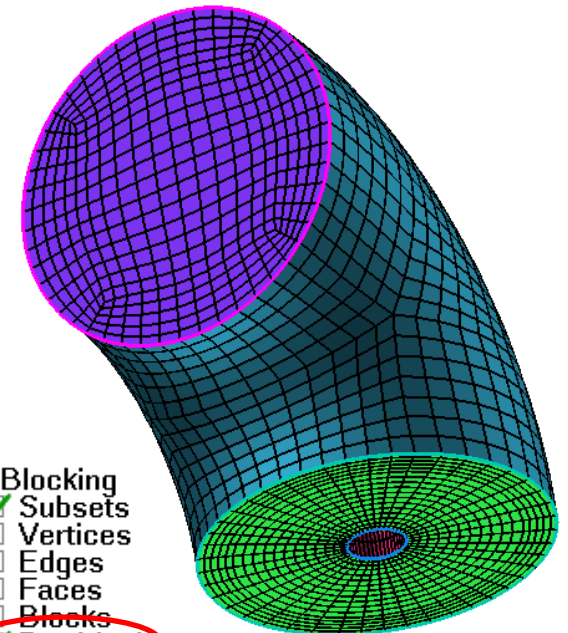
- Set sizes as indicated
- **Apply** and **Dismiss**

## Blocking > Pre-Mesh Params > Update Sizes

- Accept defaults and **Apply**
- This transfers surface and curve sizes to the blocking edges

- Turn off **DEAD** part
- Turn on **Pre-Mesh** in the tree and press **Yes** to recompute
- Right-click on **Pre-mesh** and select **Solid & Wire**
- Turn on **ELBOW**, **INLET**, and **OUTLET**

| part   | prism                    | hexa-core                | max size | height | height ratio |
|--------|--------------------------|--------------------------|----------|--------|--------------|
| CYL    | <input type="checkbox"/> |                          | 5        | 1      | 1.2          |
| DEAD   | <input type="checkbox"/> | <input type="checkbox"/> |          |        |              |
| ELBOW  | <input type="checkbox"/> |                          | 5        | 1      | 1.2          |
| FLUID  | <input type="checkbox"/> | <input type="checkbox"/> |          |        |              |
| GEOM   | <input type="checkbox"/> |                          | 5        |        |              |
| INLET  | <input type="checkbox"/> |                          | 5        | 0      | 0            |
| OUTLET | <input type="checkbox"/> |                          | 5        | 0      | 0            |

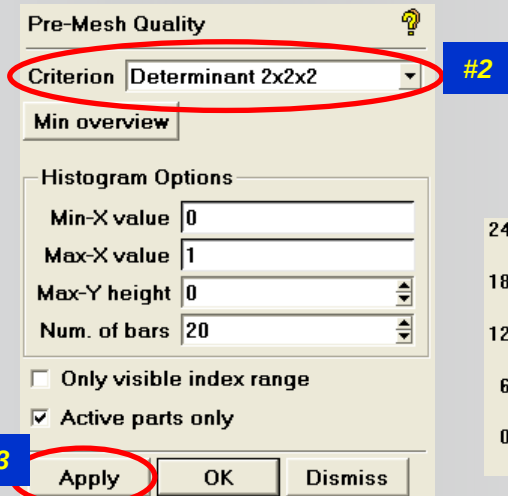


Parts containing blocks will not have mesh computed if off during the compute pre-mesh

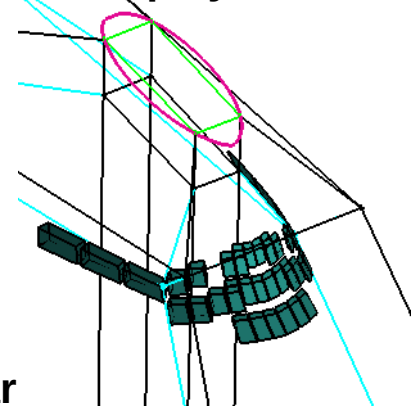
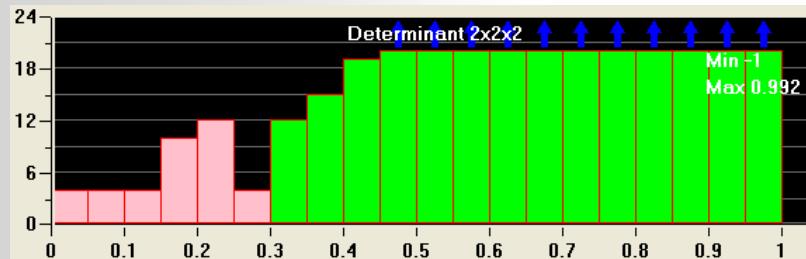
# Pre-Mesh Quality



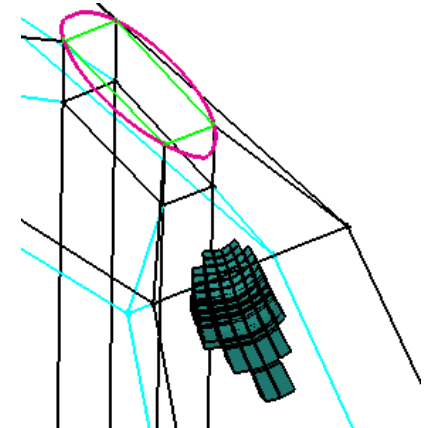
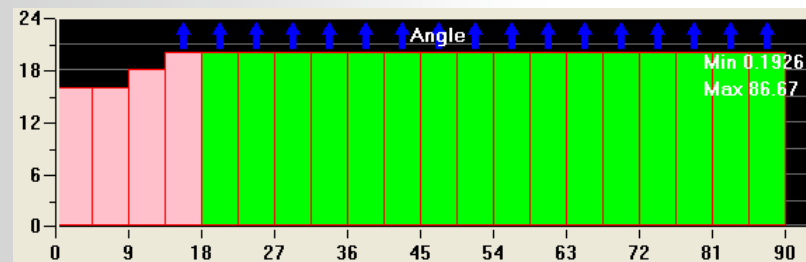
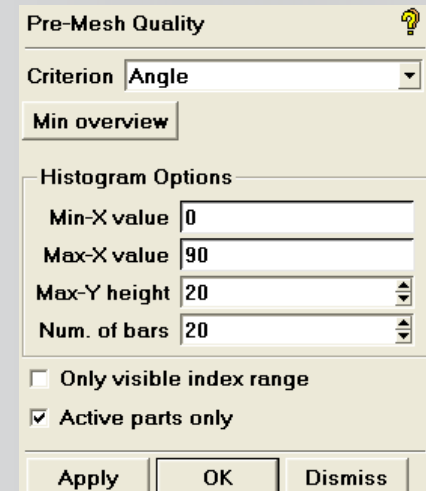
- First turn off **Pre-mesh**
- **Blocking > Pre-Mesh Quality Histograms**



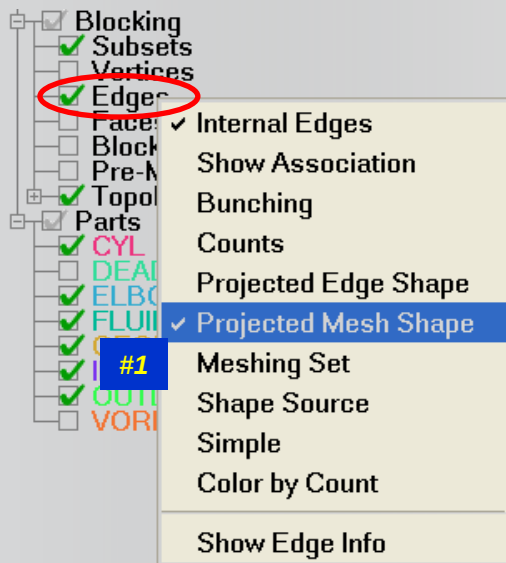
- Set **Criterion** to **Determinant 2x2x2**
- **Apply**
- Click on the first few histogram bars to display the elements (< 0.3)



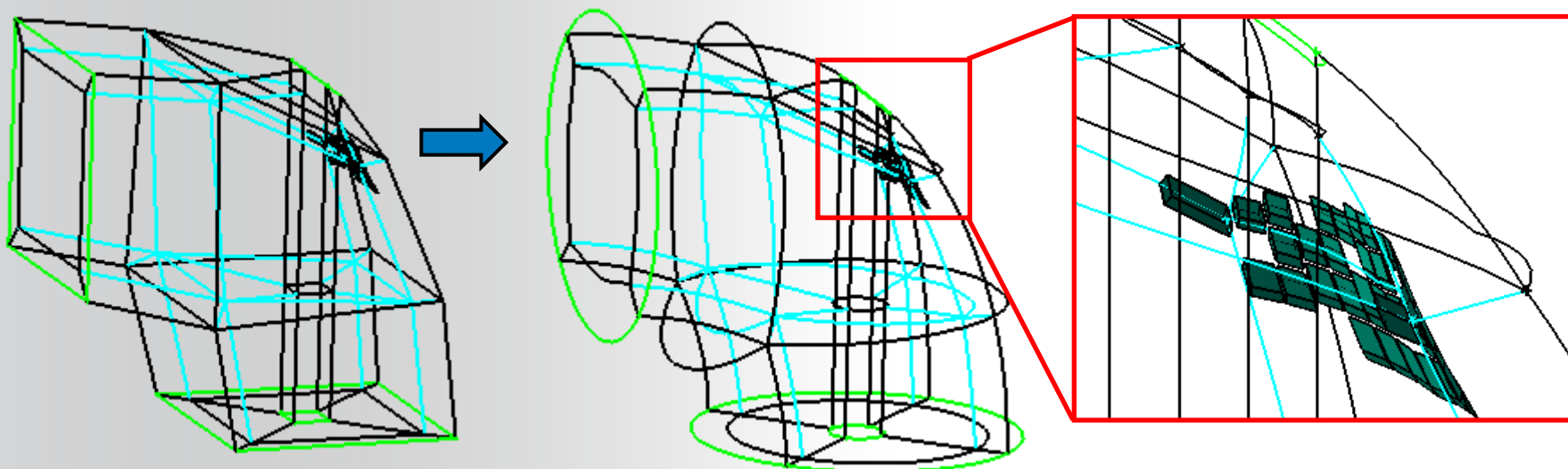
- Set **Criterion** to **Angle** and do similar
  - Below 18 degrees



# Projected Shape of Edges



- Sometimes it's hard to see which block the bad elements are in. Viewing the edges with their projected shape along with the elements may make this apparent
- In the model tree, right click on **Edges** > **Projected Mesh Shape**
  - Each time a change is made to the blocking, it will constantly ask to recompute the mesh, so use this tool only for inspection, then turn OFF when done.
  - The bad determinants will be in the inner block

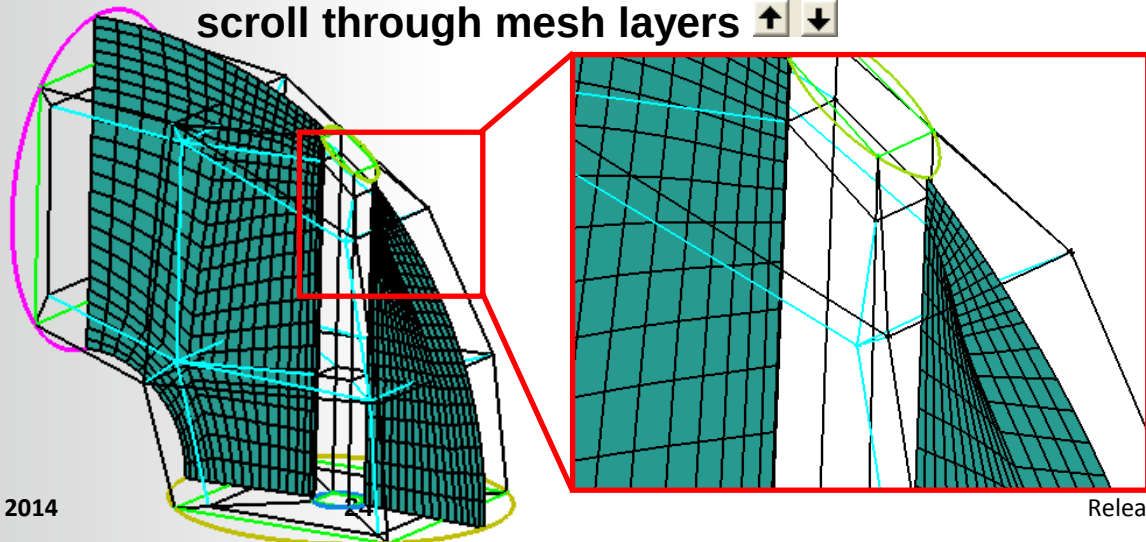
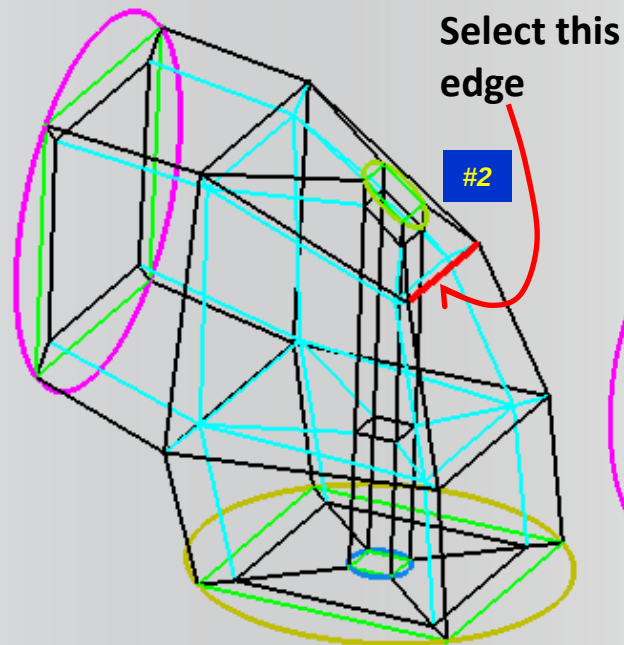
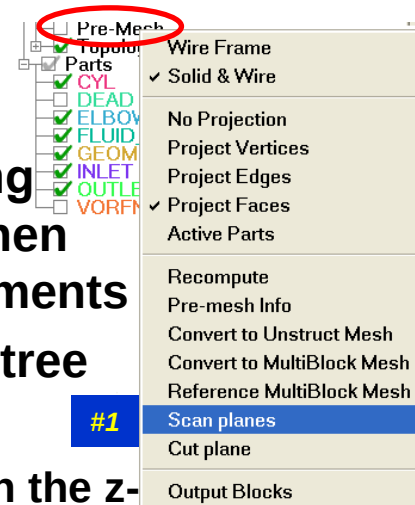
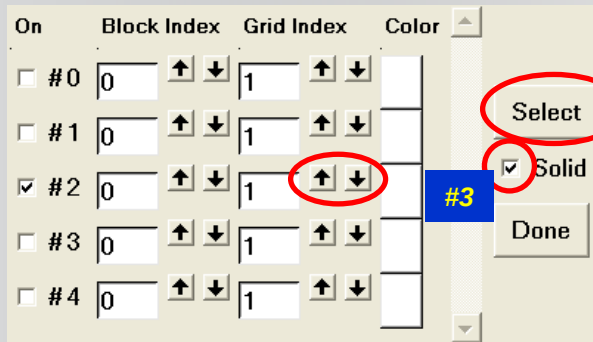


# Scan Plane

- If you can't make out what is wrong when viewing the bad elements, then view a scan plane through the elements

- **Pre-mesh > Scan planes** in model tree

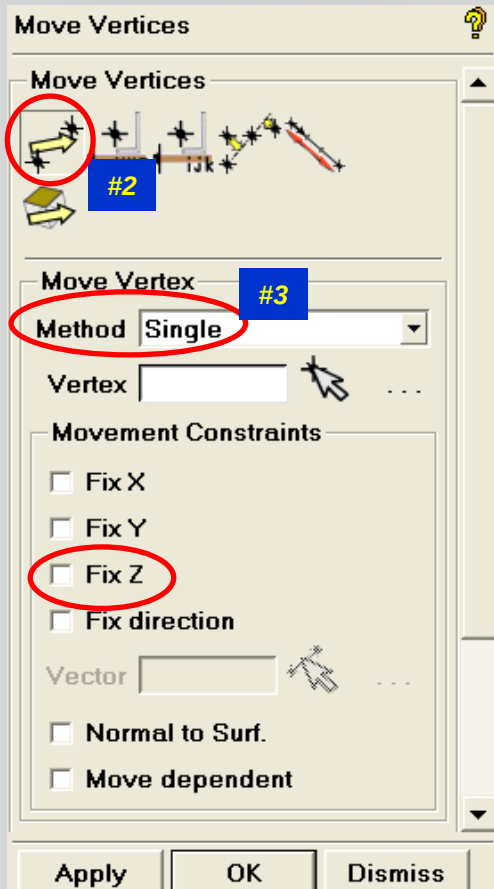
- Press **Select** button
- Select one of the edges running in the z-direction as shown below
- The scan plane will be normal to the selected edge
- This will turn on **#2** dimension (k vector)
- Check ON **Solid**
- The **Grid Index** arrows will allow you to scroll through mesh layers **↑ ↓**



# Improving Quality

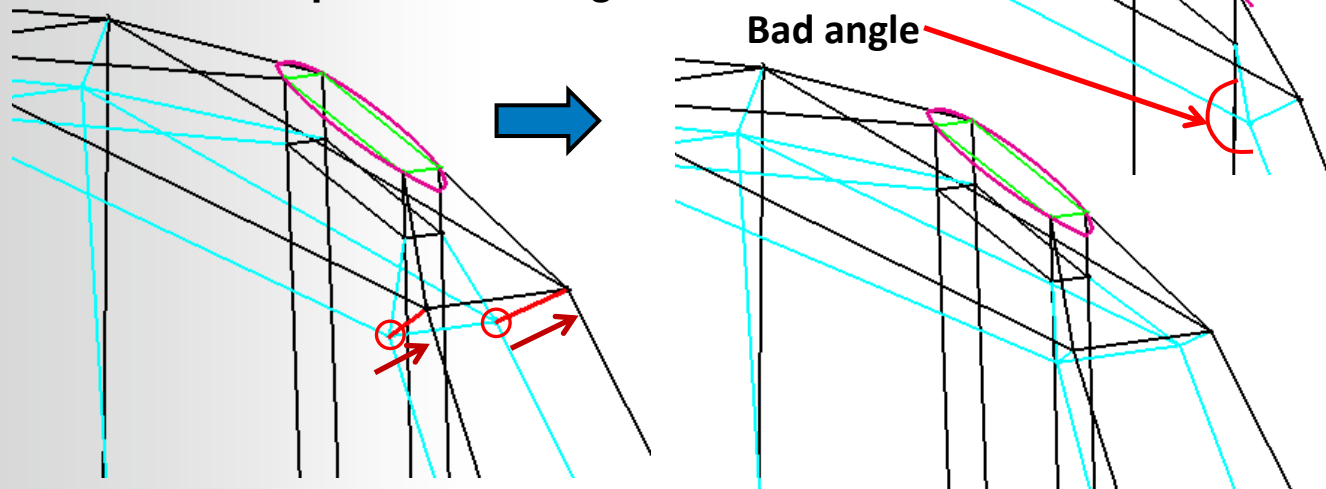


#1



## Blocking > Move Vertex > Move Vertex

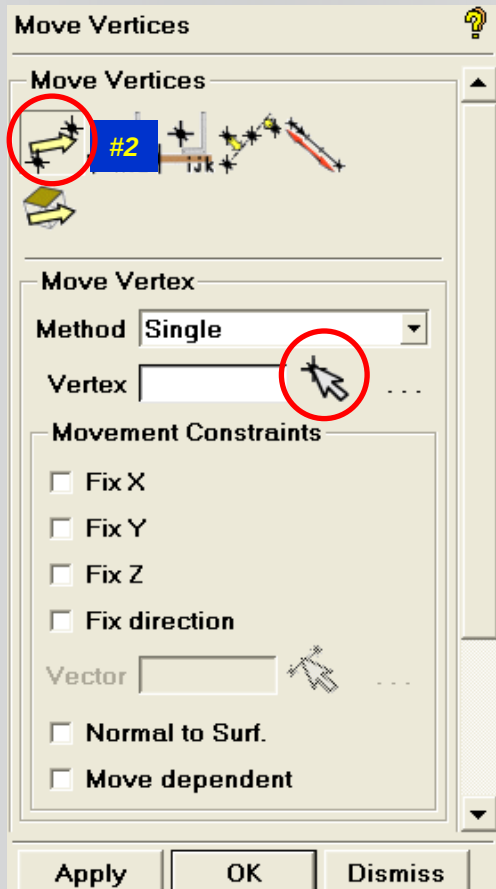
- Set **Method** to **Single**
- Turn off **Fix Z**
- Improve angles by moving the indicated internal/un-projected vertices toward the elbow surface
- Left-click and hold CLOSE to one vertex, **ON THE EDGE** (which highlights red) extending to the surface. Move it slightly outward, and release. It will constrain to moving along the red edge
- Repeat for the other vertex
- Middle click when done
- This improves the angles a little bit



# Improving Quality



#1

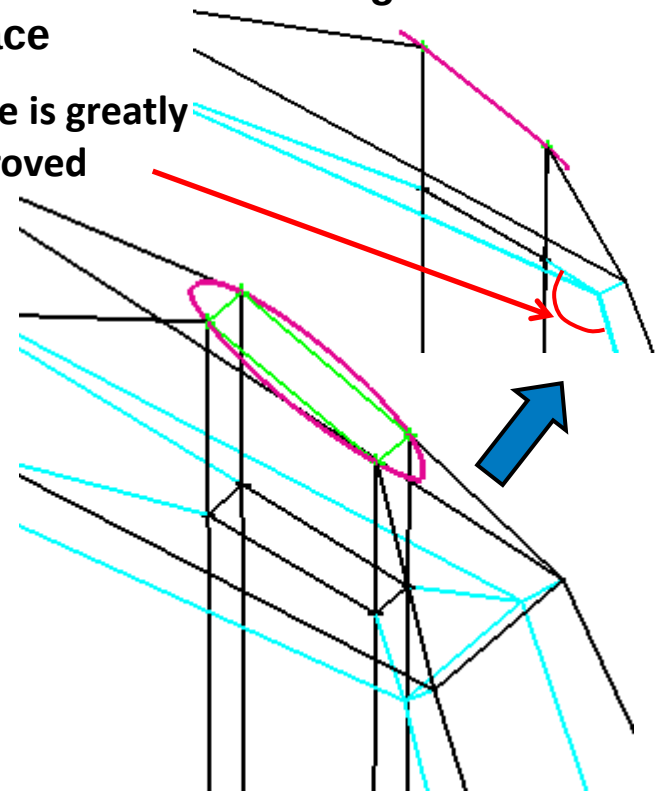
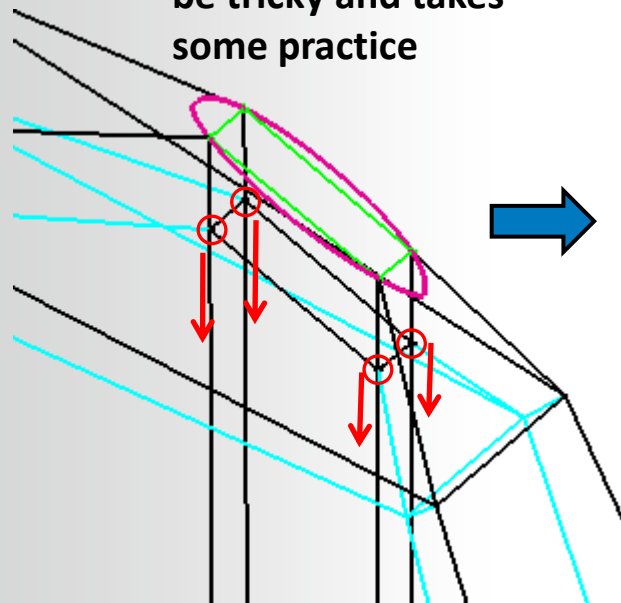


## Blocking > Move Vertex > Move Vertex

- Improve angles more drastically by moving the indicated vertices on the cylinder down
- Left-click, hold, and drag each vertex down, one at a time
- Surface associated vertices will slide along the NEAREST ACTIVE surface

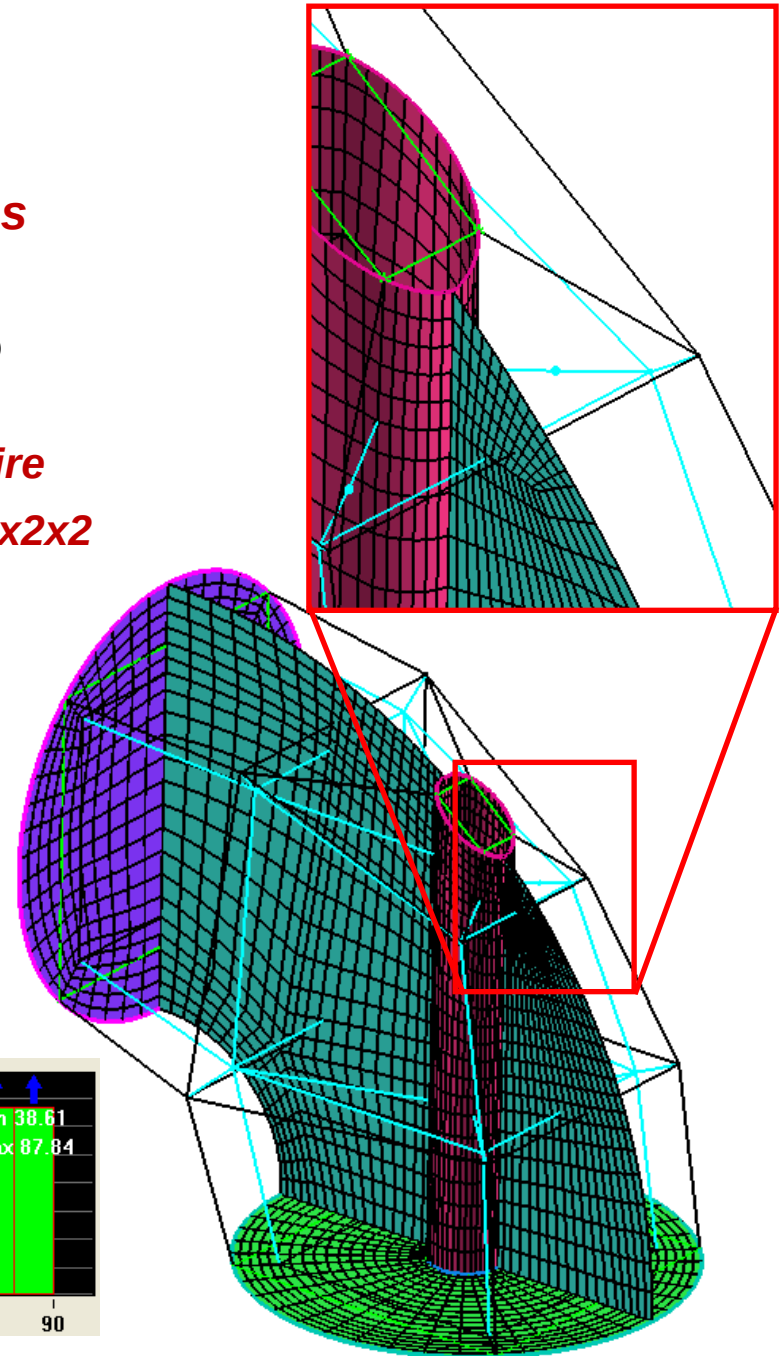
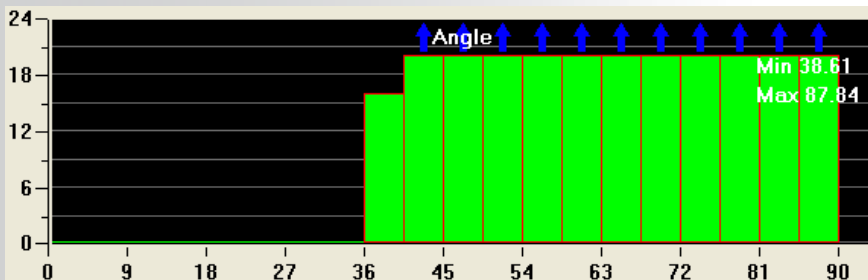
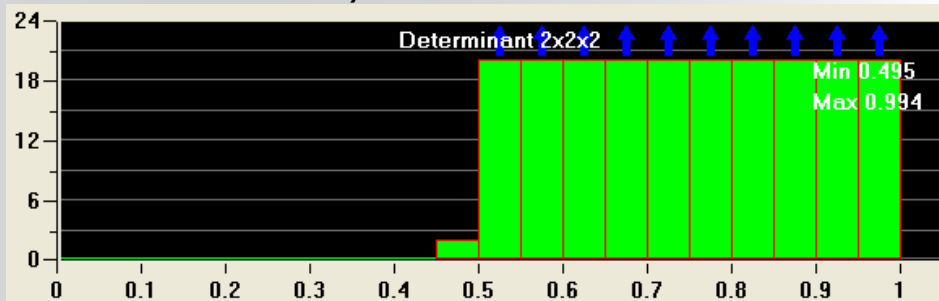
Sliding vertices along surfaces can be tricky and takes some practice

Angle is greatly improved

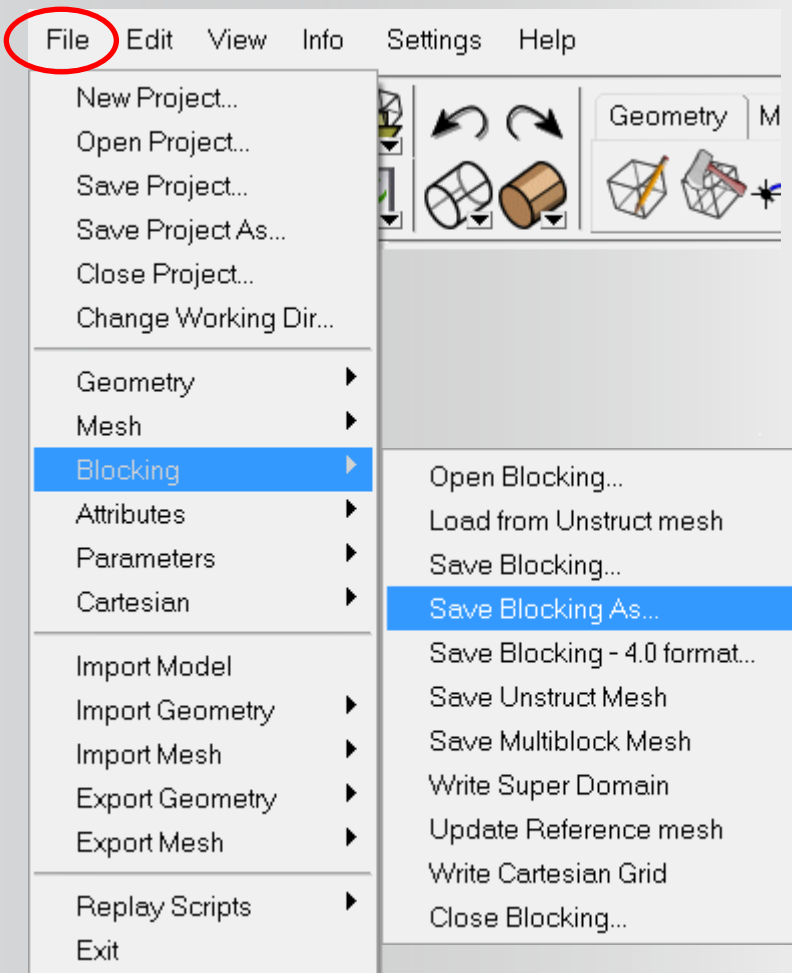


# Pre-Mesh Quality

- **Blocking > Pre-Mesh Params > Update Sizes**
  - Accept defaults and **Apply**
  - Turn on **Pre-Mesh** in the tree and press **Yes** to recompute
  - Right-click on **Pre-Mesh** and select **Solid & Wire**
  - Re-check quality for **Angle** and **Determinant 2x2x2**
  - Further adjustments may be necessary
  - Move vertices, split edges, adjust node distribution, etc.



# Save Blocking



- ***File > Blocking > Save Blocking As...***

- It's good practice to save blockings frequently, incrementing a number (1,2,3...) each time so that you can go back to a previous point, in case you find out a topological strategy will not work

