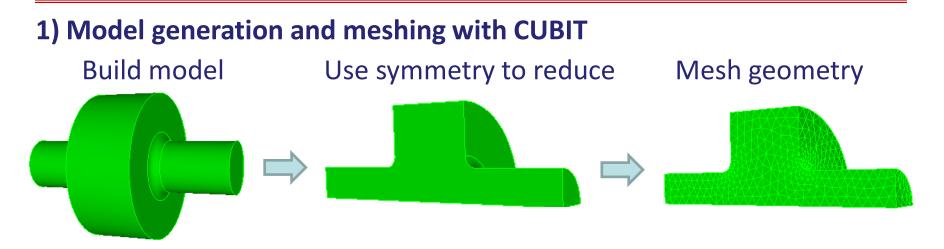
Modeling and Meshing with CUBIT

CUBIT full documentation and code access instructions at <u>http://cubit.sandia.gov</u>.



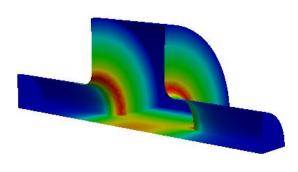
Simulation Workflow



2) Apply ACE3P solver

Rι	JN		Or	nega3P
233544	Sep	3	11:59	logfile.output mode.10.1.191206E+09.m0 mode.10.2.064482E+09.m1
450	Jul	10	08:47	model1.ncdf o3p.in output
5285	Jul	22	09:26	sample.input vector1/

3) Visualize with ParaView





CW10

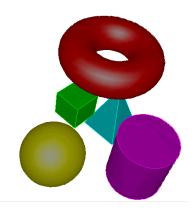
• **CUBIT** basics

- Model generation Pillbox cavity
 - Model generation and meshing with journal files
- o Meshing
 - Mesh quality checking



Creating Geometry in **CUBIT**

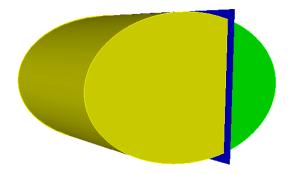
- CUBIT can create many analytic geometries from scratch and in decomposition
- Seven geometry primitives types are available and accessed with the Create button
- CUBIT creates the geometry with the GUI
 or with command line syntax: CUBIT> help create





Geometry Booleans & Webcutting

- Geometry Booleans define the shape of a Body based on overlapping regions
 - Subtract Remove regions of overlap
 - Intersect Delete all except regions of overlap
 - Unite Combine all regions
- Webcutting slices 1 Body into 2 Bodies
 - Plane
 - Cylinder
 - Extended Surface
 - Intersection with "Tool"



CUBIT Basic Tutorial

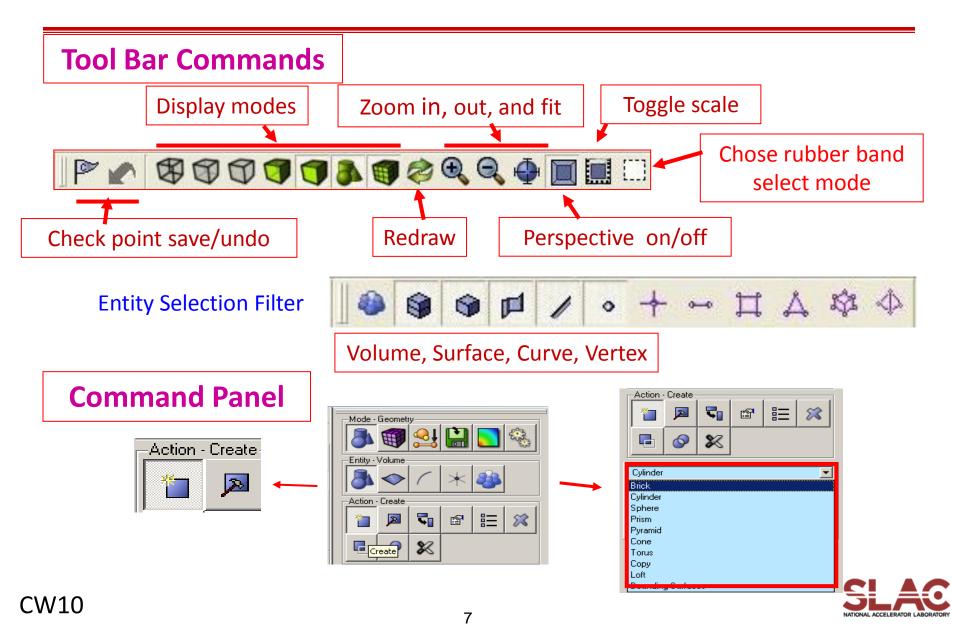
Working with the CUBIT GUI

Drop Down Menus Toolbar Commands 前 Cubit 11.0 <u>- 0 ×</u> File Edit View Display Tools Help P 🖉 🕼 🗊 🗊 🗊 🖡 🍘 🖶 🔗 🍳 🗬 🛄 🗐 🕘 🚳 🔗 🗗 🖊 Þ B -Mode - Geometry ٩::6 * Full Tree ID Properties Name Entity - 😪 Assemblies \star 🗄 🚟 Boundary Conditions 🗄 🐴 Groups -- 🏫 Volumes Command **Entity Tree** Panel **Graphics Window** -Perform Action 9 🖬 🕈 🕱 📚 Value Property 7 _ X **Properties** CUBIT> CUBIT> CUBIT> Page CUBIT> CUBIT> **Command** Line CUBIT> CUBIT> CUBIT> CUBIT> CUBIT> CUBIT> CUBIT> 、Script 入 Command 人 Error 人 History ノ Working Directory: D:/projects-a/high-gradient-xband/choke-mode-cell/coaxial-coupler-cell-v4/coaxial-coupler-c



 \otimes

Tool Bar Commands & Command Panel



• **CUBIT** basics

- Model generation Pillbox cavity
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Configuration Options

Tools->Options

 \circ History



Uncheck "Use Starting Directory"

○ Change to work directory

oLayout->Cubit Layout

oCheck "Use Labels on Buttons"

	Options	? 🔀		Ø Options		? 🔀	
W10	Custom Tools Display General General Geometry Defaults History Lobel Defaults Mouse Post Processor Quality Defaults	Command Line History Maximum Number of Commands Image: Filter Out Comment Lines Command Input Image: Limit Input Window Text Maximum Number of Lines 1024 Image: Limit Input Window Text Maximum Number of Lines Journaling Image: Journal Command History Directory: and Settings/cw10/My Documents/CUBIT 12.1 Browse Image: Use Starting Directory File Name: InstruyO1.jou Image: Use Default File Name		Custom Tools Display General Geometry Defaults History Loubit Label Defaults Label Defaults Layout Mouse Post Processor Quality Defaults	Command Line Workspace Show Script Tab Look and Feel Use Labels on Buttons Preferred Location Under Construction		SL/
			9			NAT	TIONAL ACCELERATO

Create **CUBIT** Model for a pillbox cavity with **GUI**

-Mode -	Geometr	y			
Geom.	쮌 Mesh	SC BC	Export	D Post	
-Entity -	Volume-				
8	♦ Surface	Curve	× Vertex	asset and the second se	
Action					•
Create	R	Tran	Pref	List	💢 Delete
	1	X			

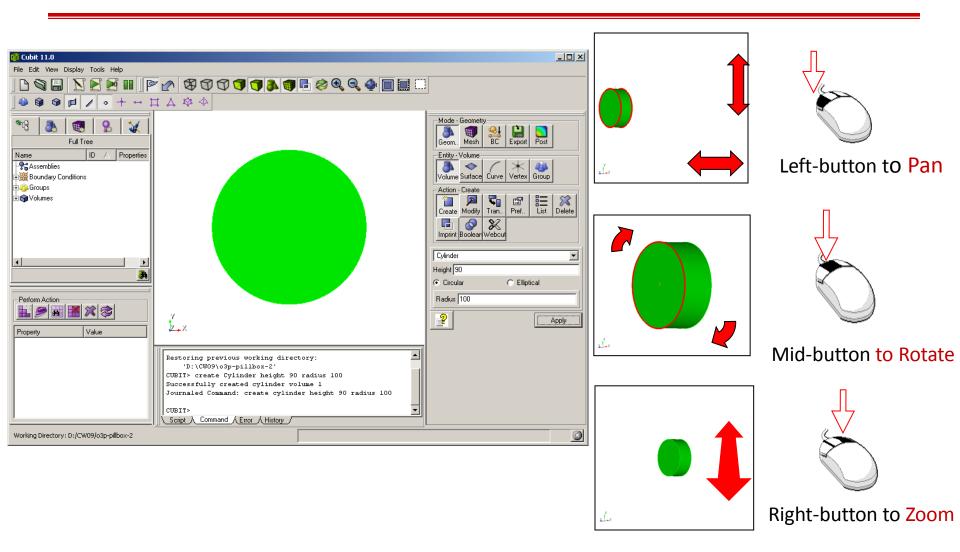
Mode - Geometry	
Geom Mesh BC Export	Post
Entity - Volume	
	New York Contract Con
Action - Create	
Create Modify Tran Pref.	List Delete
Imprint 2 ocut	
Brick	•
-Brick Dimensions	
X (width) 10	
Y (height)	
Z (depth)	
2	Apply

Geom.	\diamond	SC BC	Export	Post	
Action - Create	Surface Create Modify	Curve	Vertex Pref	Group) Delete
Cylinder Height 90		Webcut 3			<u> </u>
Circula Radius	_ \		C Ellipt		\pply
		4)	(<u>5</u>



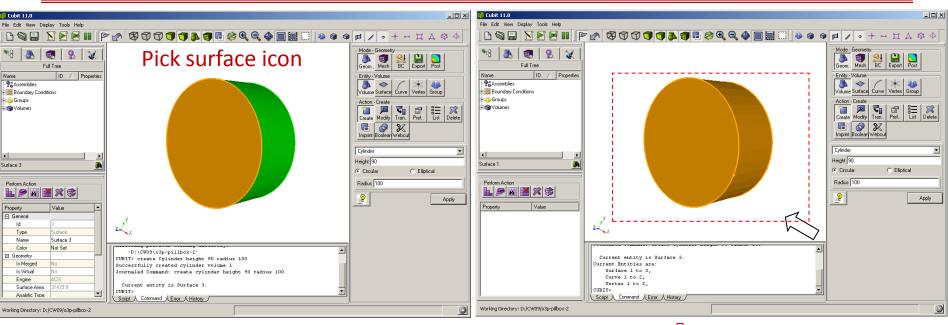
CW10

Using the 3 button Mouse





Select One or a Group of Surfaces



Put curser on surface **V** Left button click to pick

Similarly for selecting a curve



- 1. A selection box appears when move the mouse
- 2. Fully cover the surfaces to be selected
- 3. (curves and vertexes also selected if the curve and vertex icons on top selected)



ID Input Fields

```
Done Selecting
Select Other...
Insert Selection
Reject Selection
Select All
Clear Selections
Highlight
Zoom To
Draw
Visibility Off
Measure
Mesh
Delete Mesh
List Info
Delete
```

These options only apply when something is selected in the graphics window **Right clicking** in the input field will display an additional command menu

Done Selecting – Move to next field in dialog

Select Other – Used when picking from graphics window. Cycles through nearby entities

Insert Selection - Add a new selection without changing existing selection

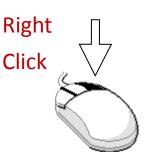
Reject Selection – Removes most recently added id

Select All – Select all input type entities

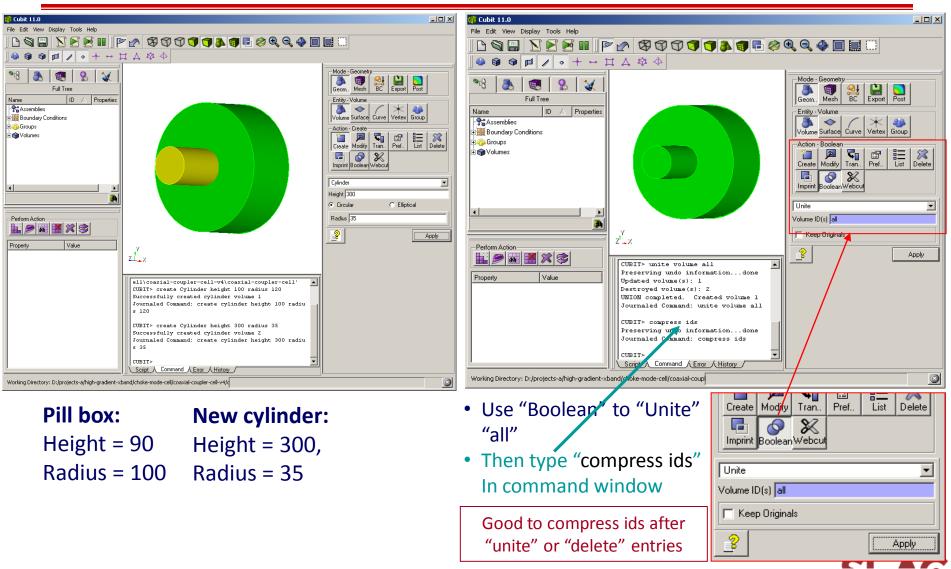
Clear Selections – Remove all ids from input field



Mostly use "Visibility off" "All visible"

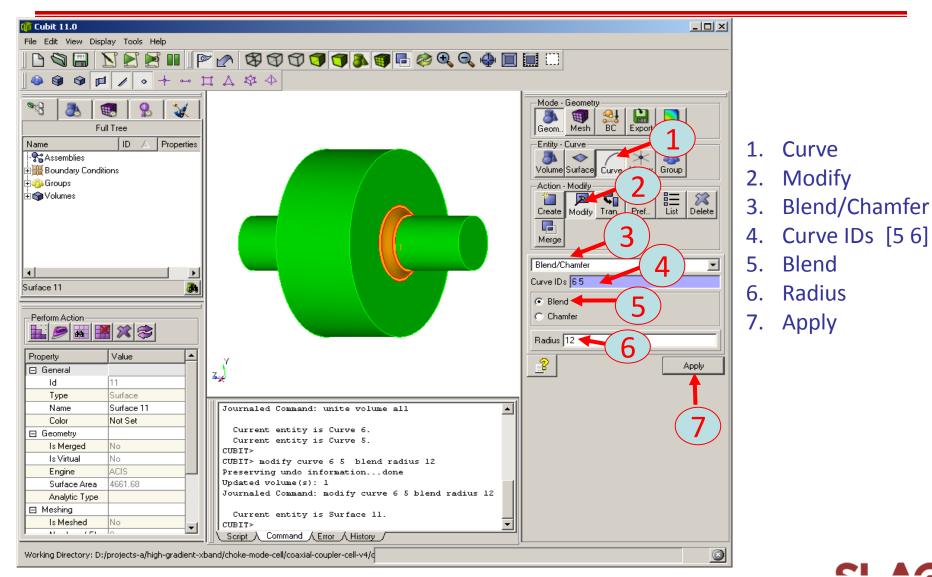


Adding beam pipe to pillbox cavity

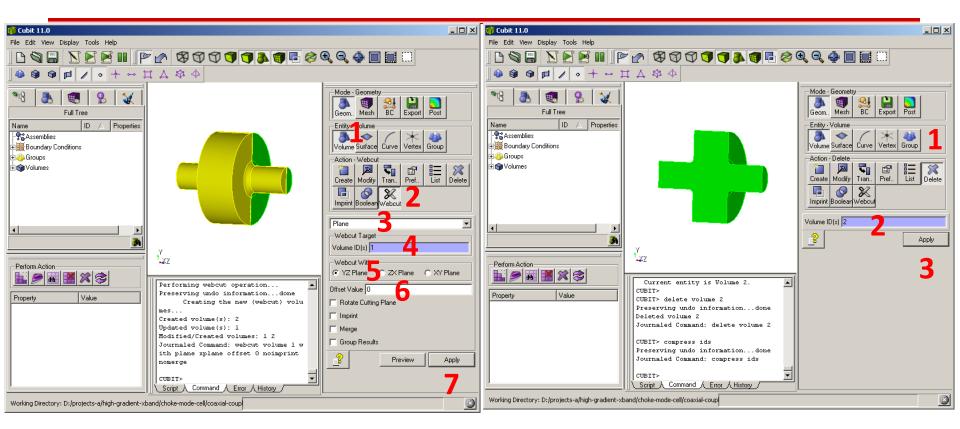


CW10

Rounding the Iris of the pillbox with beampipe



Use symmetry to reduce ½ of the cavity



- 1. Volume
- 2. Webcut
- 3. Plane
- 4. Volume IDs [1]
- 5. YZ Plane
- 6. Offset Value [0]
- 7. Apply

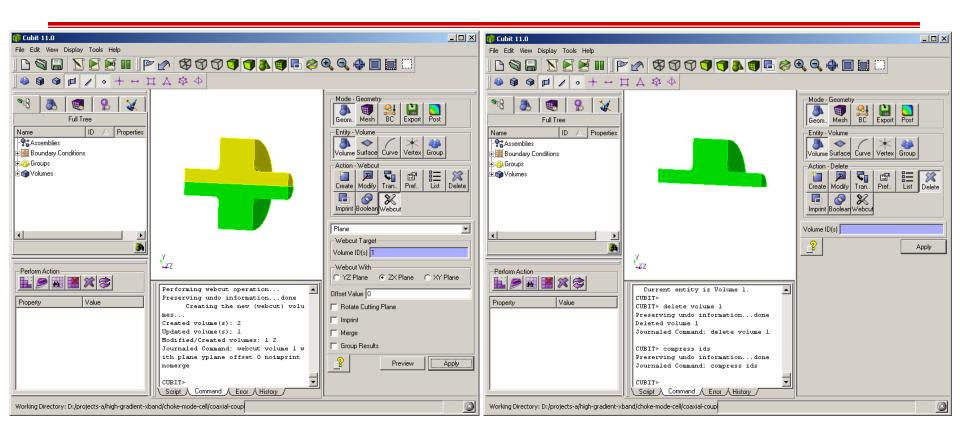
CW10

- 1. Delete
- 2. Volume ID [2]
- 3. Apply

"compress ids" in command window



Reduce to ¼ with Webcut, XZ Plane and Delete



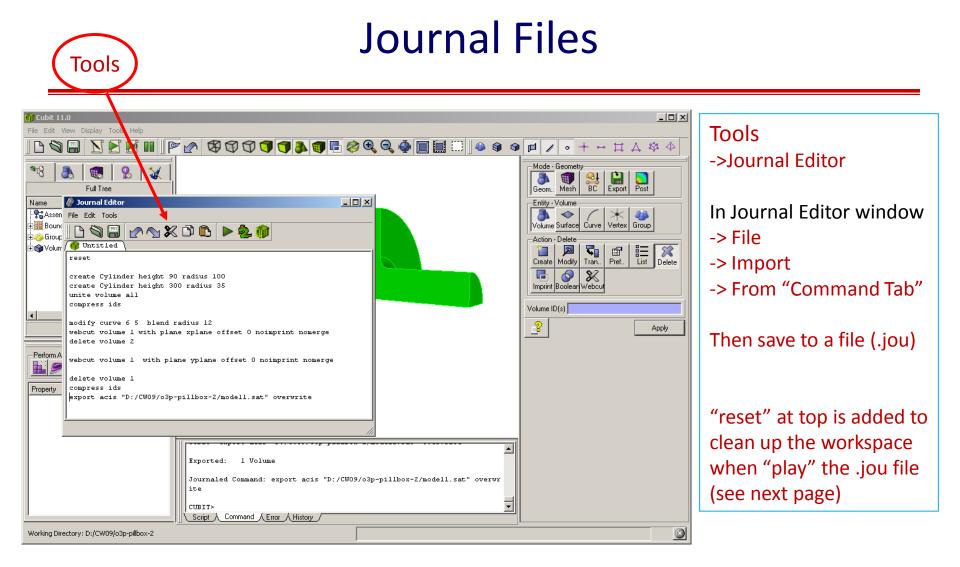
"compress ids"



Save the Model in ACIS (.sat) Format

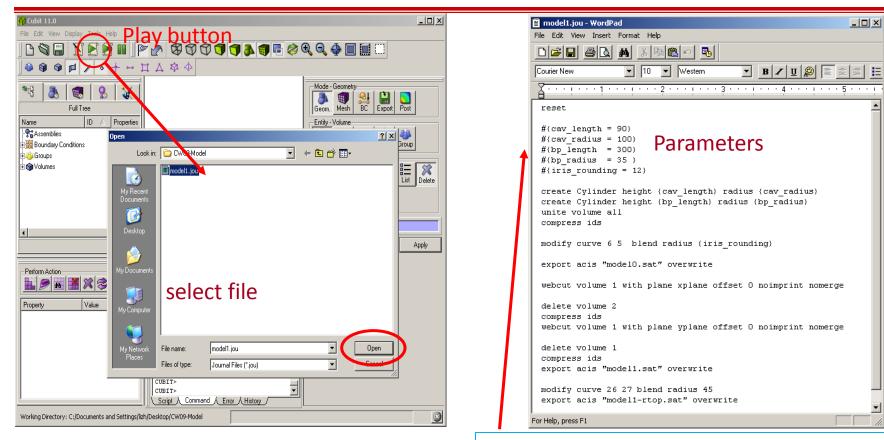
🙀 Cubit 11.0	1
File Edit View Display Tools Help Export File Save in: CW09-Model + C + C + C + C + C + C + C + C + C +	 1. File 2. Export 3. Save 4. Finish
CUBIT> compress ids Preserving undo informationdone Journaled Command: compress ids Current entity is Surface 2.	Curve ID(s):
Working Directory: D:/projects-a/high-gradient-xband/choke-mode-cell/coaxial-coup Image: Cubic arc arc arc arc arc arc arc arc arc ar	Cancel Finish







Same CUBIT Model with Parameterized Journal File



- 1. Have model1.jou saved
- 2. Click the "play" button
- 3. Select the .jou file
- Open -> will run through commands in .jou file, model generated

CW10



Replace numbers with variables in { } brackets

Define Variables #{cav length = 90} #{cav radius = 100}

Create Cylinder height {cav length} radius {cav_radius}

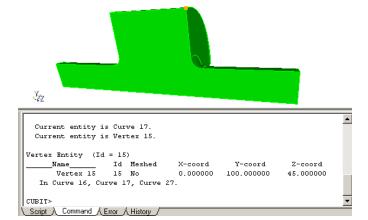


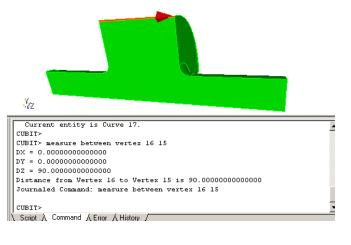
Checking Model Dimensions

- \circ $\,$ Find coordinate of a vertex $\,$
 - Select Vertex Filter
 - Pick a vertex
 - In command window: type "list vertex <#>"
 - Lists the coordinate
- o Measure distance
 - Pick two vertices
 - Right click window area and chose "measure"
 - Distance is shown in command window
- o Measure length of line segment
 - Select Line Filter
 - Pick a line

CW10

Right click window area and chose "measure"







• **CUBIT** basics

- Model generation Pillbox cavity
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Meshing with **CUBIT** GUI

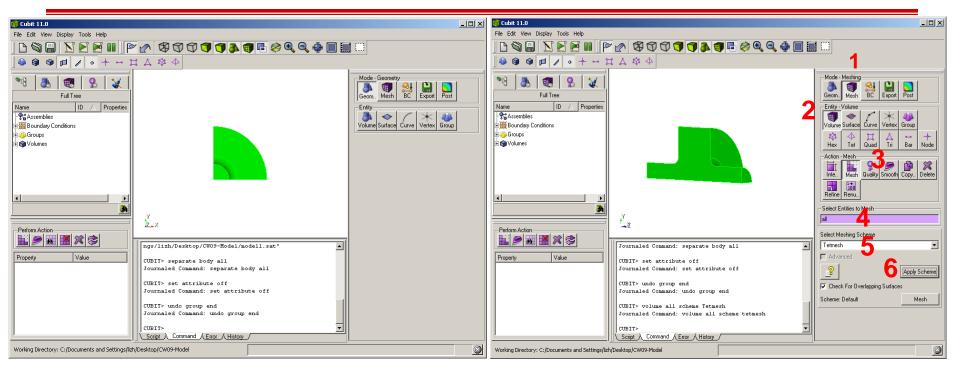
🚅 cubit 11.0	1 Cubit 11.0
File Ex View Display Tools Help	File Edit View Display Tools Help
$\square \bigcirc \bigcirc$	$\square \bigcirc \blacksquare \square $
Timport File	
Importance Importance Importance I	Full Tree ID Properties Wanne ID Properties Bounday Conditions Export Options - Ct/u/Desktop/CW09-Model/model.sot 2 x Stoppis Show Each While Importing Ippore Free Surfaces 2 separate Muhi/Volume Bodies Ippore Free Surfaces Separate Muhi/Volume Bodies Ippore Free Surfaces 2 separate Muhi/Volume Bodies Ippore Free Surfaces Separate Muhi/Volume Bodies Ippore Free Surfaces Cancel Ippore Free Vertices Import Antholes Import Antholes Import Antholes Import Antholes Import Antholes Import directory is "C: Nocuments and Settings/Lish/Desktop/CW09-H Odd1' Otstration complementation on the ender cellice Stop / CW09-Hode1" Stop / CW09-Hode1" Stop / CW09-Hode1" Stop / CW09-H Stop / CW09-Hode1" Stop / CW09-Hode1" Stop / CW09-H
Working Directory: C:/Documents and Settings/izah/Desktop/CW09-Model	Working Directory: C:/Documents and Settings/Ikih/Desktop/CW09-Model

- Import solid model (model1.sat, e.g.)
- File
 - -> Import
 - -> click the file name (in default directory)
 - -> Open

Select "Separate Multi-Volume Bodies"



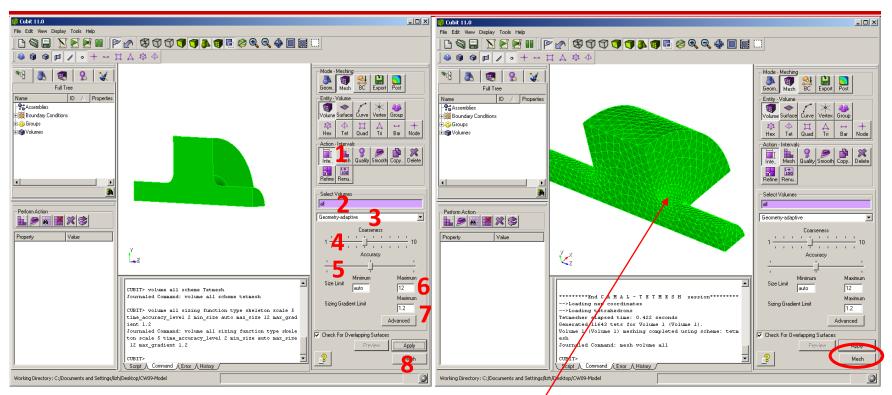
Import Solid Model & Choose Tetmesh



- 1. Mesh
- 2. Volume
- 3. Mesh
- 4. Select Entries to Mesh {all}
- 5. Select Meshing Scheme {Tetmesh}
- 6. Apply Scheme



Set Element Size & Generate Mesh

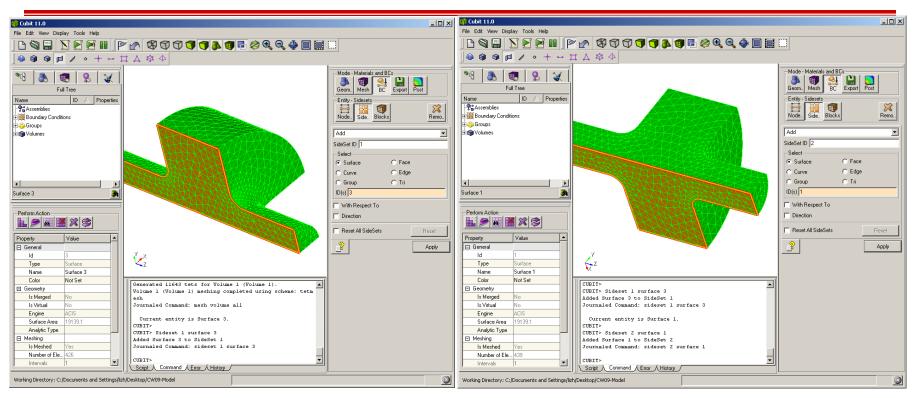


- 1. Intervals
- 2. Select Volume {all}
- 3. Select {Geometry-adaptive}
- 4. Coarseness {5}
- 5. Accuracy middle {=2}
- 6. Advanced:
- 7. Size Limit Maximum->12
- 8. Sizing Gradient Limit {1.2}
- CW10 9. Apply

Smaller mesh size around curved surfaces {adaptive} <u>Click "Mesh"</u> <u>to mesh</u>



Apply BC at Interior & Exterior Surfaces

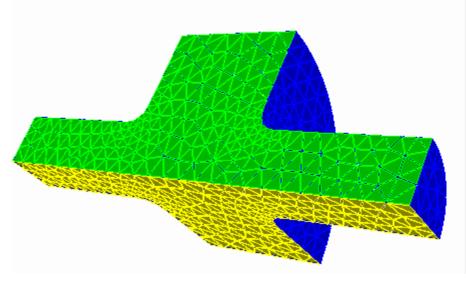


- 1. Add
- 2. SideSet ID {1}
- 3. Surface
- 4. IDs {all except 1 7}
 - (all the surfaces except the two symmetry planes)
- 5. Apply



Check Boundary IDs

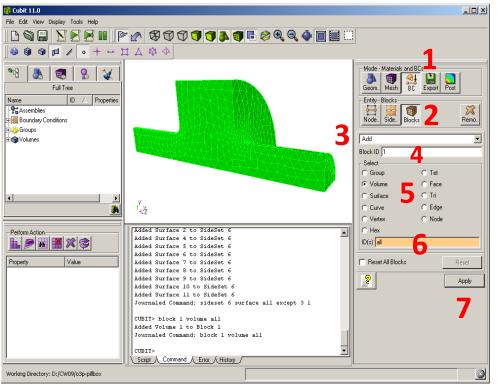
- Add surface 1 to sideset 2
- Add surface 7 to sideset 3
- Draw sidesets



Mode - Materials and BCs	
Entity - Sidesets Node. Side Bloc	X Remo.
Draw	•
SideSet ID(s) all	
Pick Color	
🔽 Clear Display	
F Reset All SideSets	Reset
2	<u>A</u> pply



Set "Block ID" for Material Attributes



History /	<u> </u>
BC	
Blocks	
Add	
4	

4. 1

1.

2.

3.

- 5. Volume
- 6. all

7. Apply

CW10

	Post
Entity - Blocks Node. SideBloc	Xemo.
Element Type	•
Block ID(s)	
Select	
C Nodes C Curve	es
C Surfaces C Volur	nes
Volumes	
C Hex C Tetra	
C Hex8 C Tetra	4
C Hex9 C Tetra	8
C Hex20 C Tetra	10
C Hex27 C Tetra	14
Reset All Blocks	Reset
<u></u>	<u>A</u> pply

- 1. BC
- 2. Blocks
- 3. Element Type
- 4. Block ID(s): 1
- 5. Volumes
- 6. Tetra10
- 7. Apply





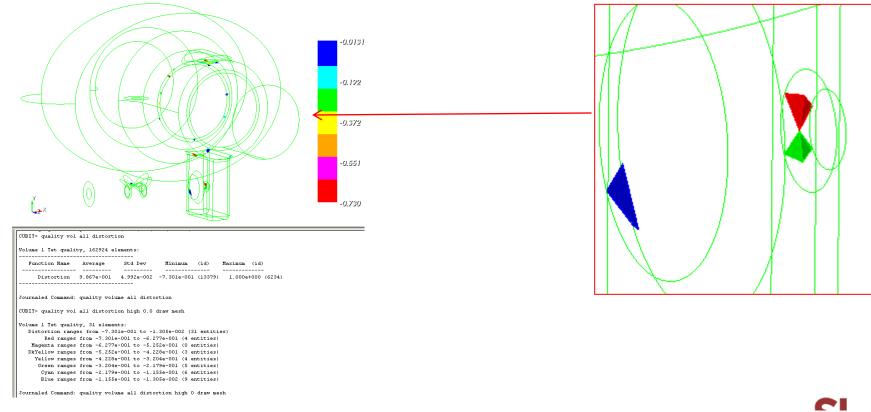
Tips

- One should set the BC sideset and material IDs (blocks) and "Element type" before the meshing command (enables mesh quality checking during meshing).
- But you can only "draw" the sideset "colors" after the mesh is generated.

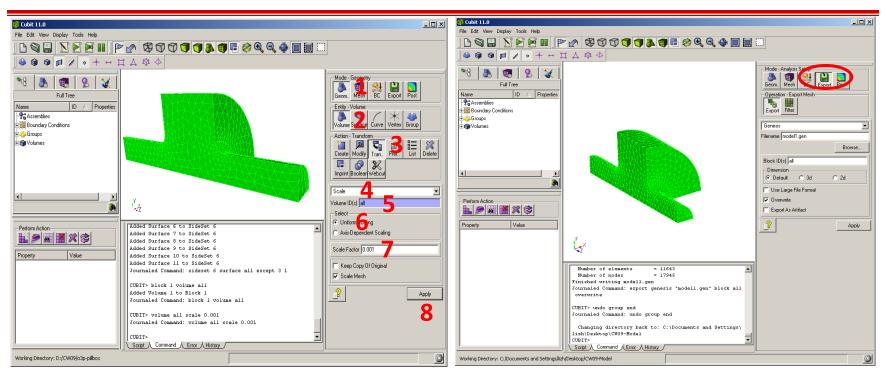


Check Mesh Quality

 Command (type in command window) quality vol all distortion quality vol all distortion high 0.0 draw mesh



Scale Units



- 1. Geometry
- 2. Volume
- 3. Transform
- 4. Scale
- 5. "all"
- 6. Uniform Scaling
- 7. "0.001"
- 8. Apply

CW10

Use smaller units when creating the model and meshing, e.g. mm Scale to meters for calculation - ACE3P uses standard units



Export the Mesh

○ File->Export Save as type: Genesis (*.g* *.gen*) ○ Finish 🝿 Cubit 12.1 Export File File Edit View Display Save in: 🗀 cw10_work New New

🖏 Open...

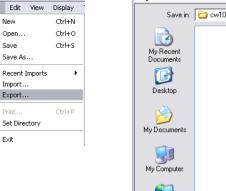
Import..

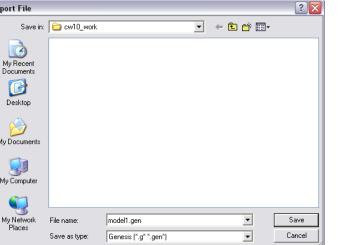
Export...

Ӓ Print...

Exit

🔚 Save







○ Import "Command tab" into Journal Editor

Votitled	🧳 Journal Editor
<pre>Untitled Undergroup begin set attribute on import acis "C:/Douments and Settings/lich/Desktop/CW09-Hodel/model.sat" set attribute off wolume all scheme Tetmesh volume all scheme Tetmesh volume all scheme Tetmesh Siderest 1 surface 3 Siderest 1 surface 3 Siderest 6 surface all except 3 1 block i element type tetral0 volume all scheme type tetral0 volume all sche 0.001 undo group begin set large exclus file off ergort Genemes "modell.gen" block all overwrite</pre>	File Edit Tools
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	unao group ena

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CW10

Convert and Check the Mesh

• In a terminal:

Convert Genesis file to NetCDF format for ACE3P
 acdtool meshconvert cubitq netcdf in.gen out.ncdf

 Check mesh connectivity and quality acdtool mesh stats out.ncdf

Check for inverted tetrahedra (if Tetra10)
 acdtool mesh check out.ncdf

Straighten inverted tetrahedra (if Tetra10)
 acdtool mesh fix mesh.ncdf mesh_fixed.ncdf

acdtool mesh stats Output

TOTALS: elements: 7530 coordinates: 1728

ASPECT RATIO:

min = 1.07028 max = 2.32866 average = 1.55955 std dev = 0.196946

SHAPE MEASURE:

min = 0.351915 max = 0.996323 average = 0.820372 std dev = 0.100069

ELEMENT VOLUME:

min = 7.59101e-09 max = 5.57899e-07 average = 1.20845e-07 std dev = 7.88559e-08

BOUNDING BOX:

min = (0, 0, -0.15)max = (0.1, 0.1, 0.15)

EDGE LENGTH:

min = 0.00357312 max = 0.0227063 average = 0.0102788 std dev = 0.00300348

Euler Characteristic: Surf Euler Char = 2 Vol Euler Char = 1 Euler Char is OK.



acdtool mesh check Output

Check whether there are invalid quadratic tetrahedral elements...

Total Volume is 0.00133192

Total Number of invalid second order tetrahedral elements (ISOTE) is: 0



Mesh Verification & Convergence

- Smooth transition from coarse to dense regions
- Small feathers have good mesh representation
- Use "Draw sideset #" to check boundary setup
- **Do not** start with very dense mesh
- Start with a reasonable coarse mesh
 - \odot Element size ~ 1/10 1/15 of wavelength
 - Smooth mesh on curved surfaces
- $\,\circ\,$ Refine the mesh to check accuracy
- Check mesh quality every time

