FRANC3D Training Workshop: Part 5

Finite Element (FE) Model Import

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PROCESS Optimization CORPORATION

Workshop Agenda

- Part 1: Introduction to Fatigue and Damage Tolerance
- Part 2: Introduction to Fracture Mechanics Analysis
- Part 3: Introduction to FRANC3D
- Part 4: FRANC3D User Interface
- Part 5: Finite Element (FE) Model Import
- Part 6: Crack Insertion
- Part 7: Static Crack Analysis & SIF Computation
- Part 8: SIFs from FE Analysis
- Part 9: Crack Growth
- Part 10: SIF History & Fatigue Life
- Part 11: Miscellaneous Topics

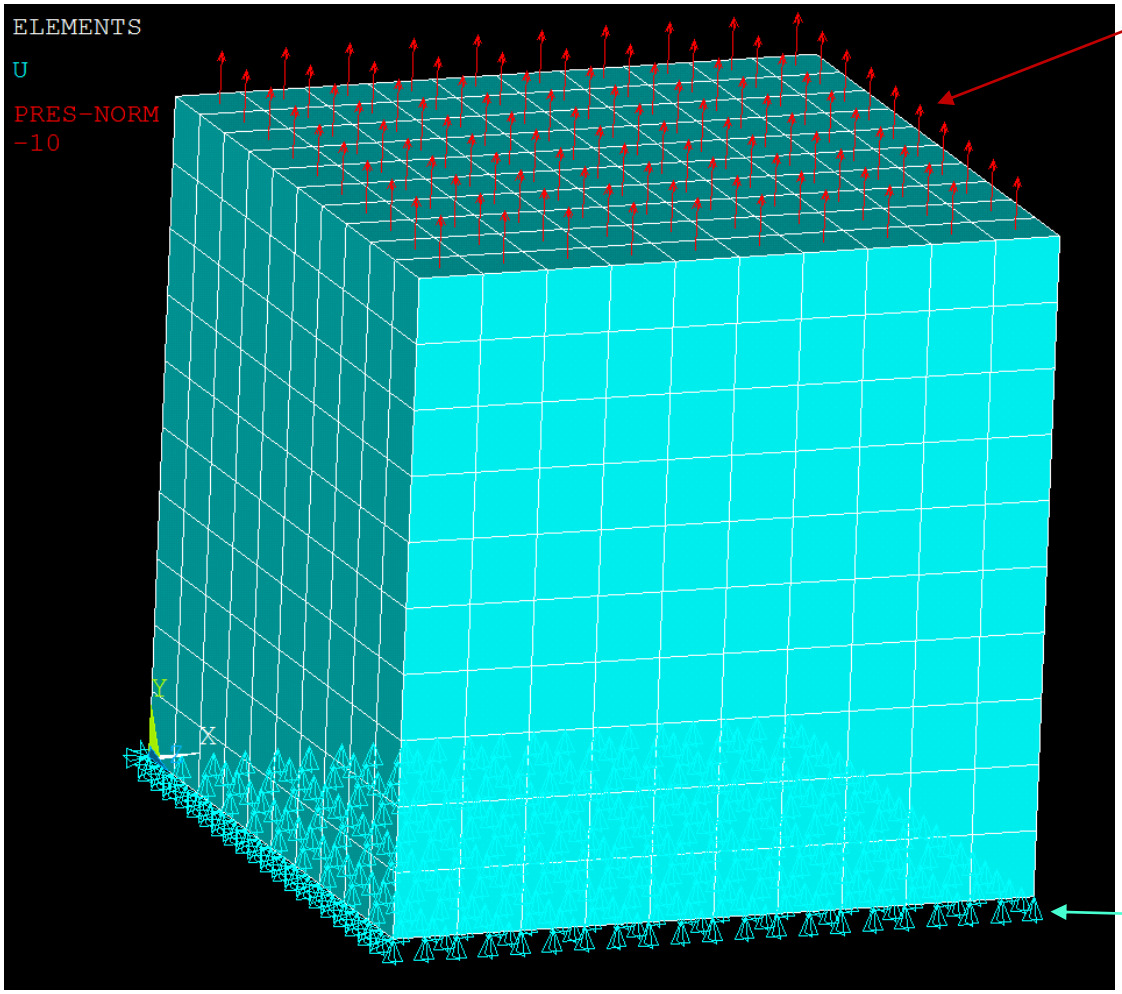
Finite Element (FE) Model Import

- Supported Input FE Model Files
- Options for Importing Uncracked FE Models
- Boundary Condition Surfaces
- Export Model
- Demo & Hands On: FE Model Import

Supported Input FE Files

- FRANC3D supports the following input finite element files:
  - ANSYS: *.cdb files
    - The .dat file from ANSYS WorkBench is supported, but a working ANSYS version must be accessible as FRANC3D executes ANSYS in the background to convert the .dat into a .cdb
  - ABAQUS: *.inp files
  - NASTRAN: *.bdf (*.nas,*.dat) files

Import a FE Model – a simple cube



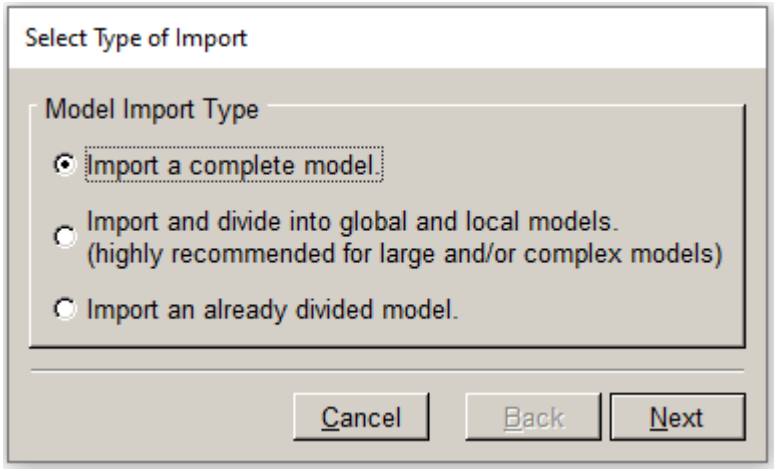
surface traction

constraint

Importing Uncracked FE Models

Three options for importing uncracked FE Models:

- Import a complete model
- Import and divide the model in FRANC3D
- Import an already divided model

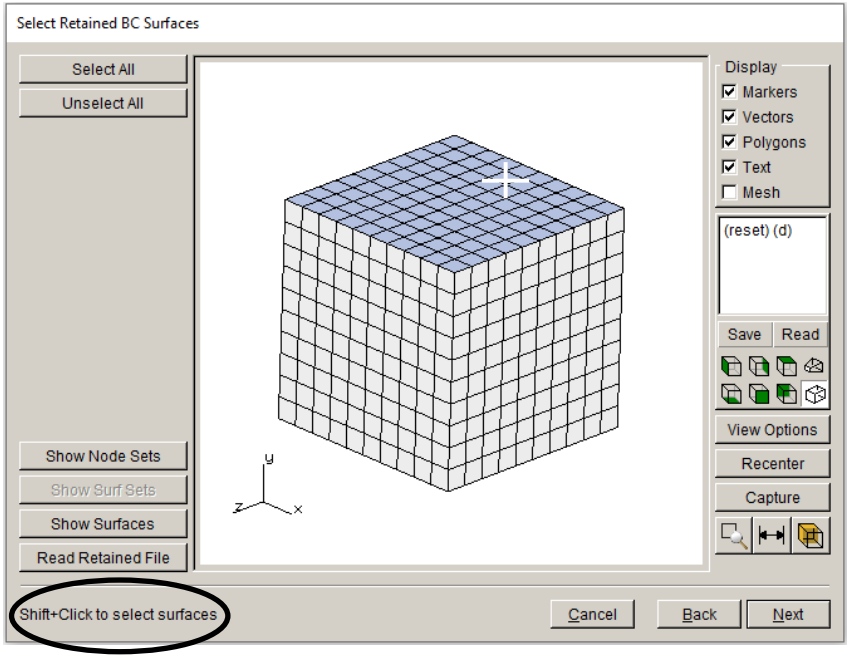


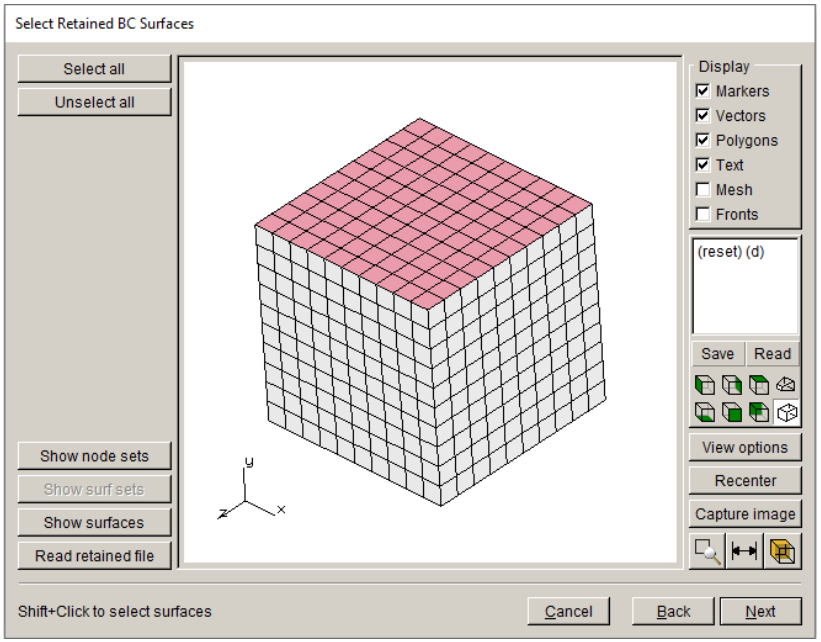
Depending on the selection, different dialogs are displayed after **Next**.

Start with importing a complete model - the complete cube.

Boundary Condition Surfaces

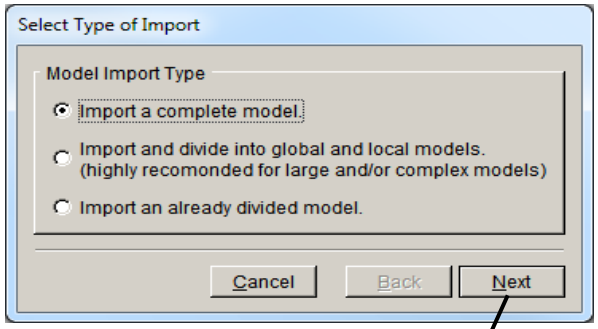
- After importing the finite element into FRANC3D, **Select Retained BC Surfaces** dialog is displayed
- Any surface that has boundary conditions will be highlighted in blue
- Using the **Select All** button, the blue surfaces will be colored red



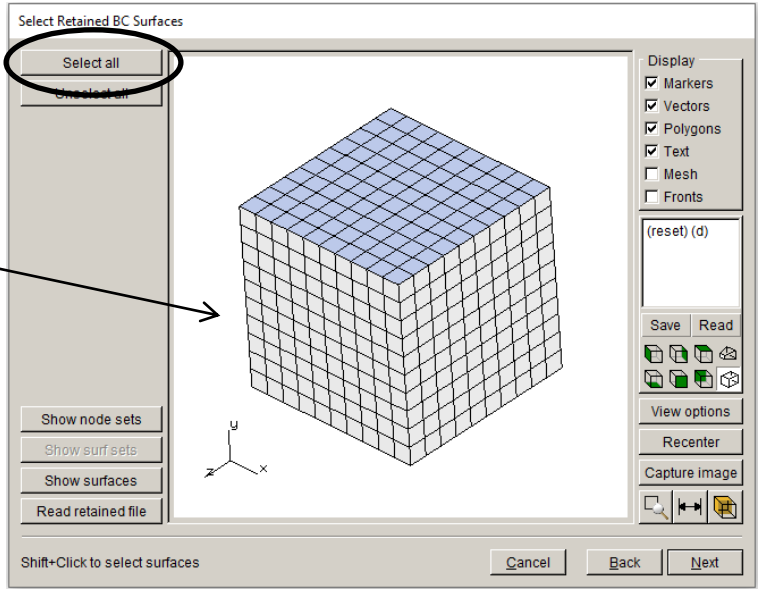


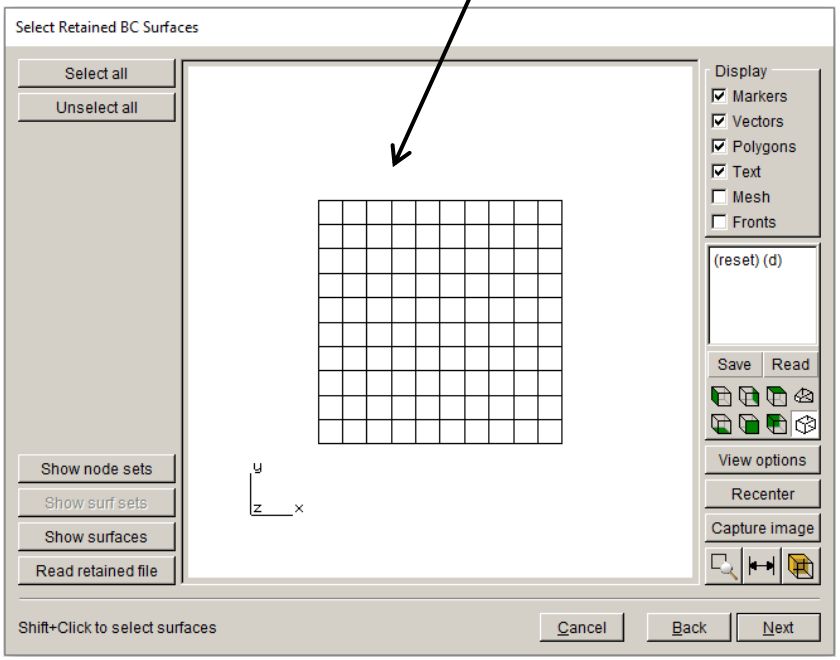
NOTE: do not retain facets where a crack will be inserted.

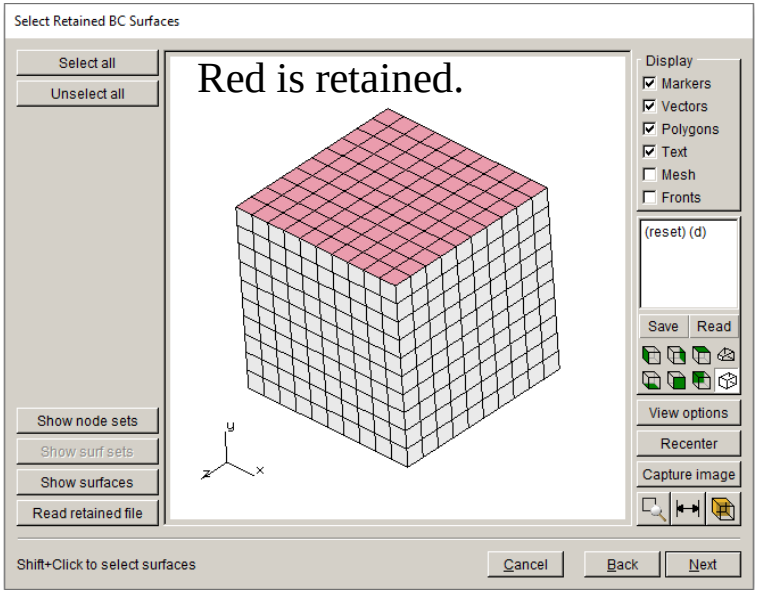
Importing a Complete Model



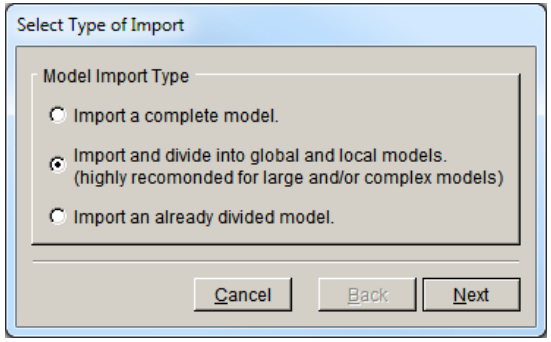
Use left mouse button to rotate model.



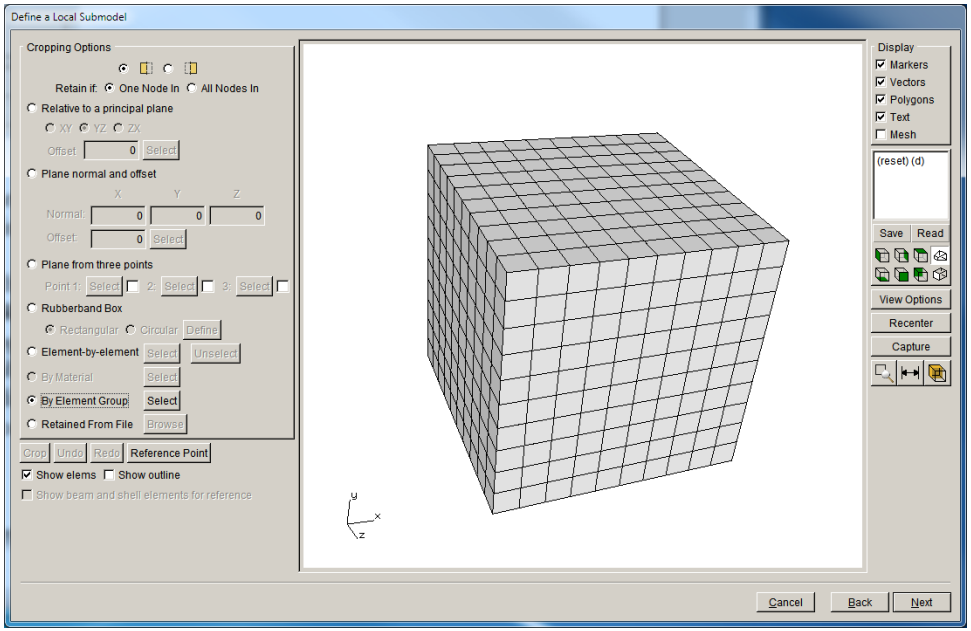




Import and Divide the Model in FRANC3D



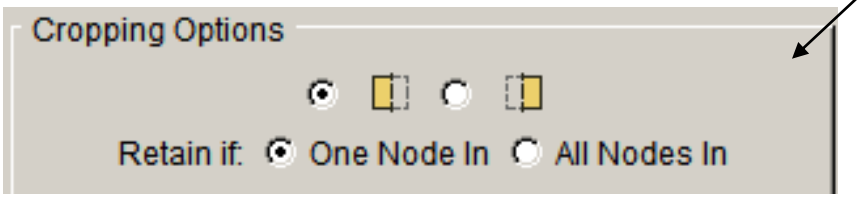
After importing the FE Model, the **Define Local Submodel** dialog box will appear

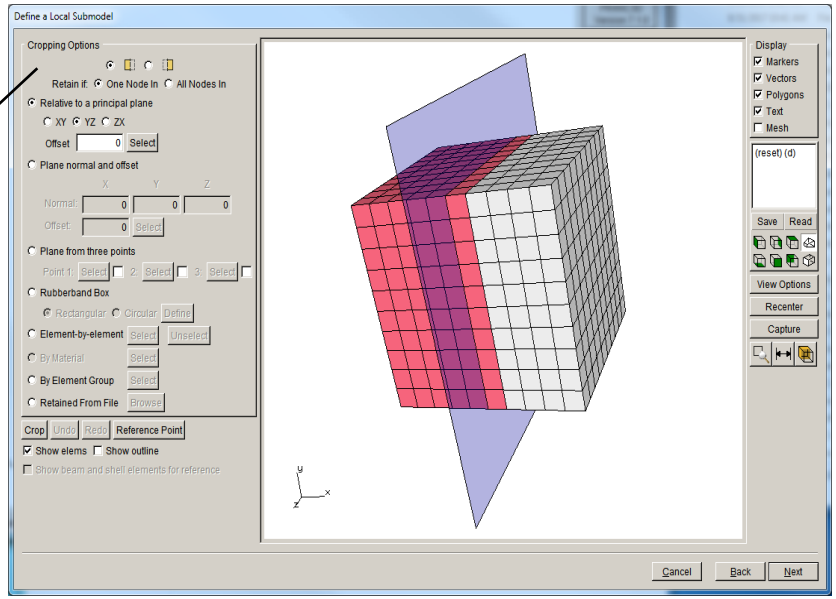


- FRANC3D has several options for extracting a sub-model.
- After extracting the sub-model, the **Select Retained BC Surfaces** dialog is displayed if the sub-model has boundary conditions, node sets, or surfaces.
- The size of the local submodel should be based on the extent of crack growth and the geometry of the model

Import and Divide the Model in FRANC3D

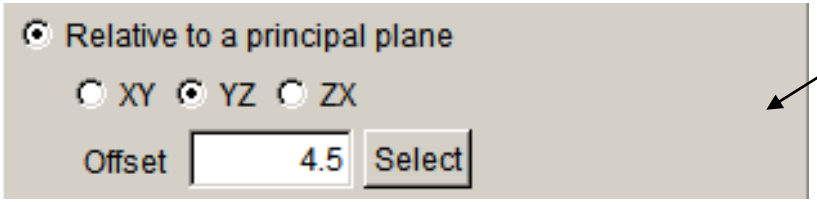
- Cropping Options
  - Allow one to specify which ‘side’ of the selection plane or box is selected
  - Selected elements are colored red

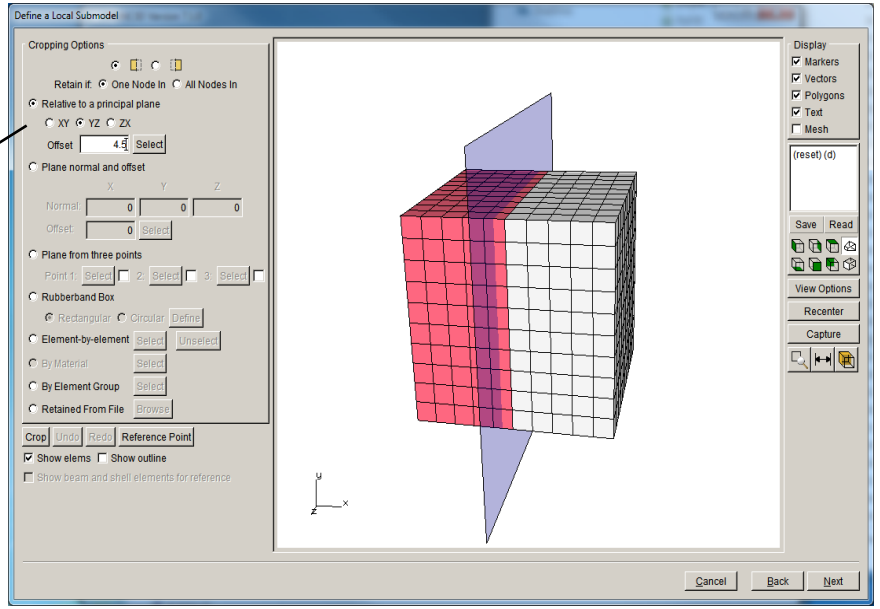




Import and Divide the Model in FRANC3D

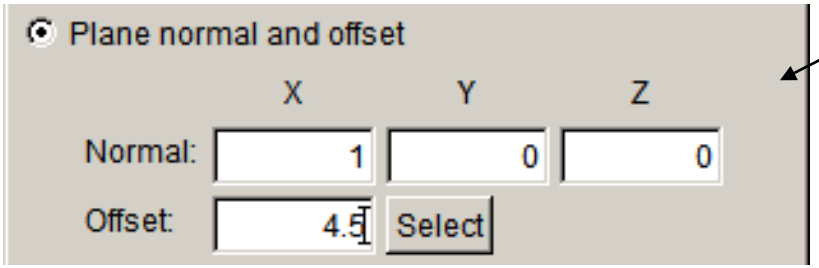
- Relative to a principal plane:
  - Allows one to choose a plane that is aligned with the Cartesian axe
  - Plane can be offset from the origin

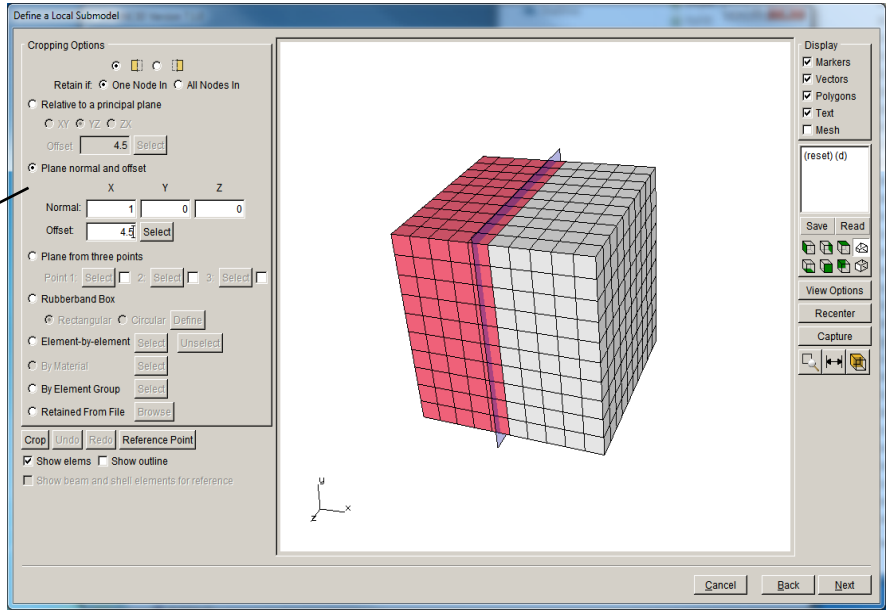




Import and Divide the Model in FRANC3D

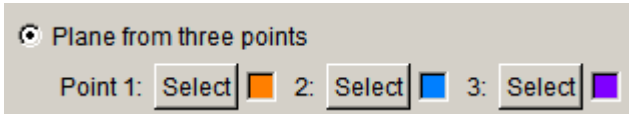
- Plane normal and offset
  - Allows one to define a plane that is normal to the unit vector defined by the x, y and z coordinates
  - Plane can be offset from the origin

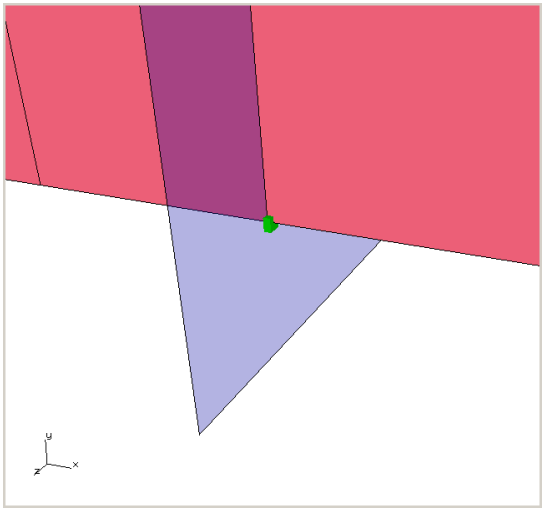


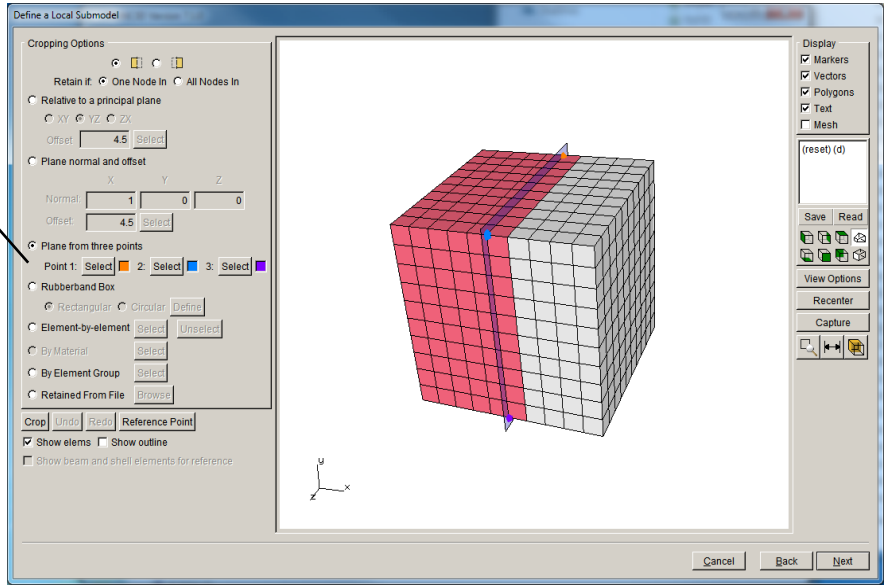


Import and Divide the Model in FRANC3D

- Plane from three points
  - Allows one to define a plane based on the selection of three points
  - Use the (cross) cursor to pick the point; three points of a triangle will define the plane

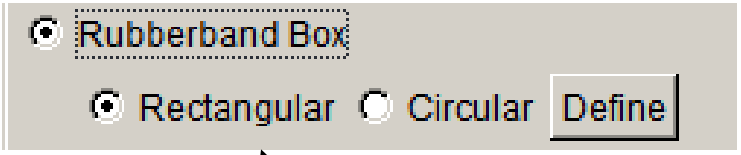


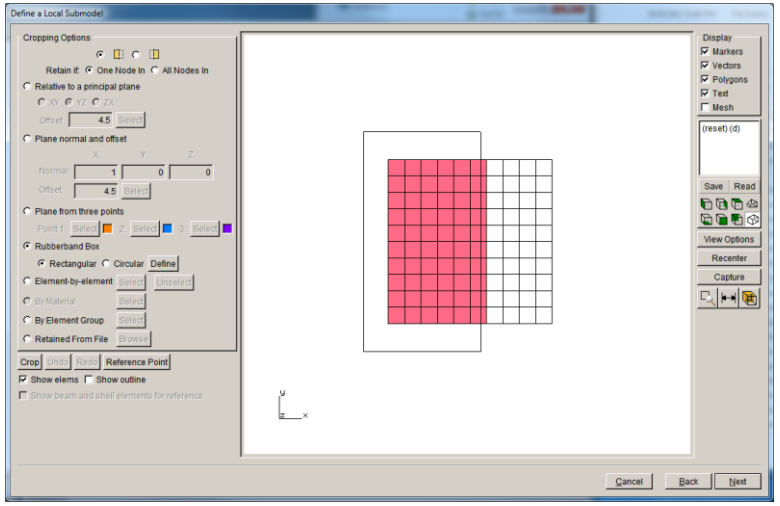


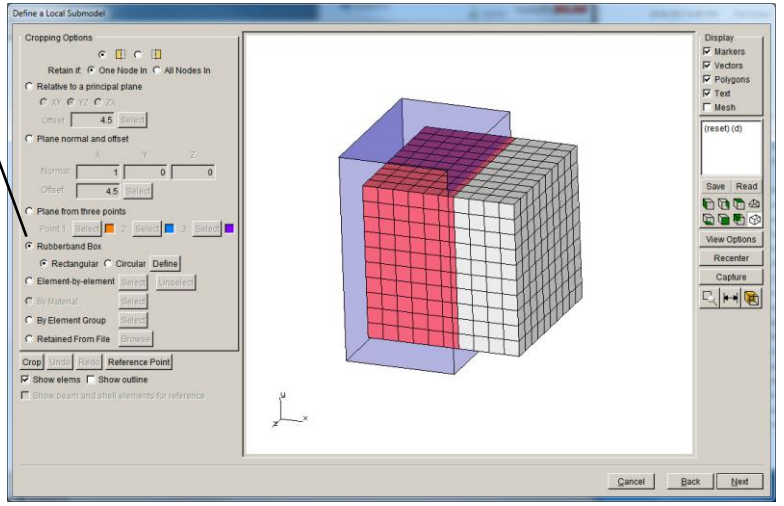


Import and Divide the Model in FRANC3D

- Rubberband box
  - Allows one to define a box (or cylinder) using the left-mouse button to drag the outline on the screen

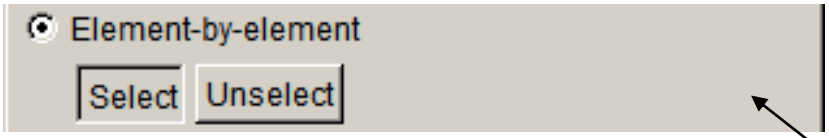


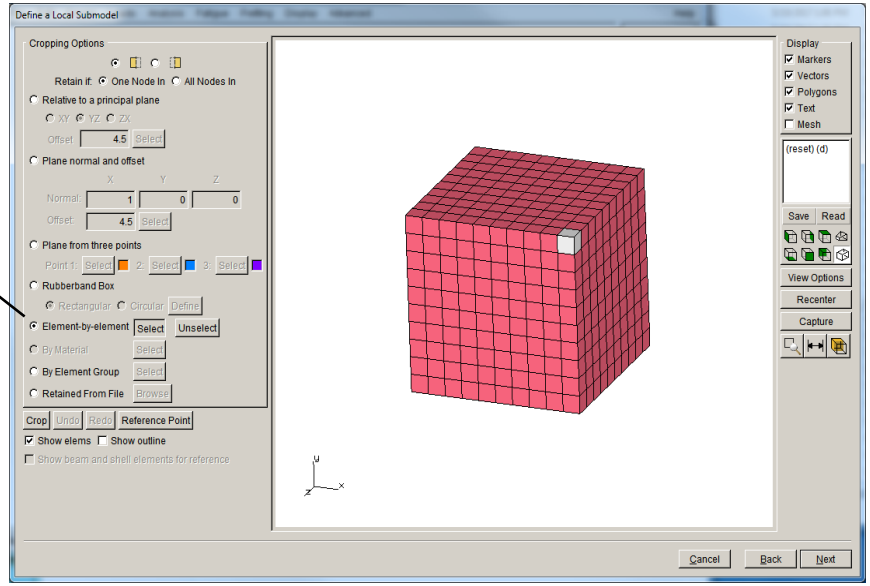




Import and Divide the Model in FRANC3D

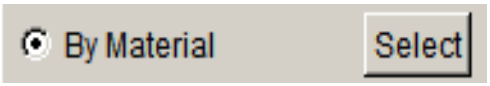
- Element by element
  - Allows one to select (or unselect) individual elements
  - User presses the **Select** button and then uses the left-mouse button to select elements one at a time

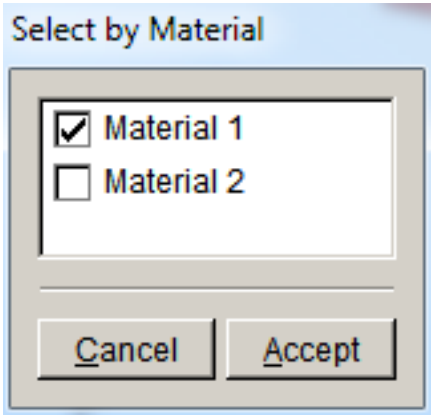


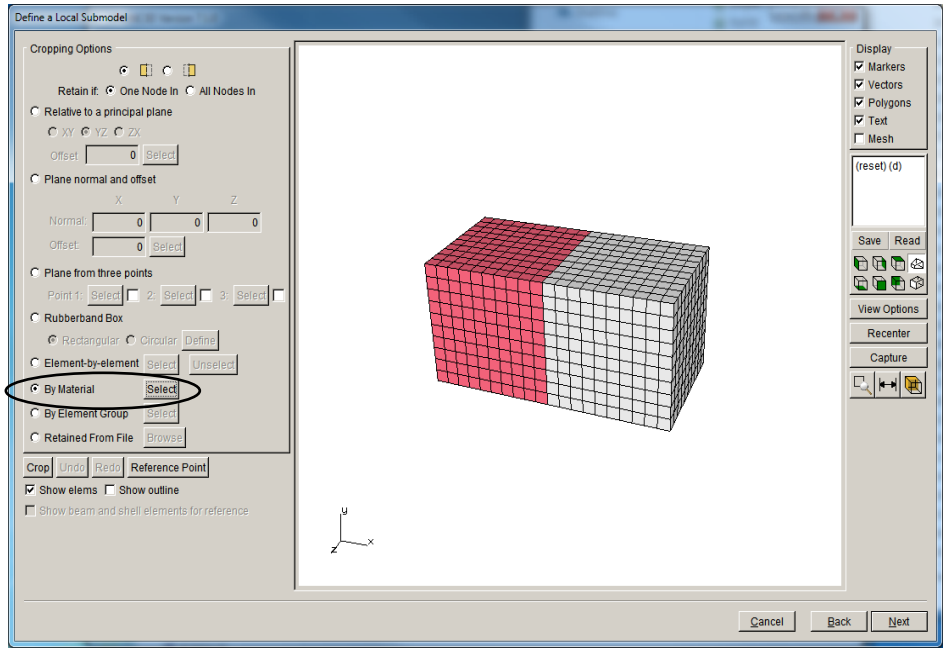


Import and Divide the Model in FRANC3D

- By material
  - Allows one to select elements based on material ID

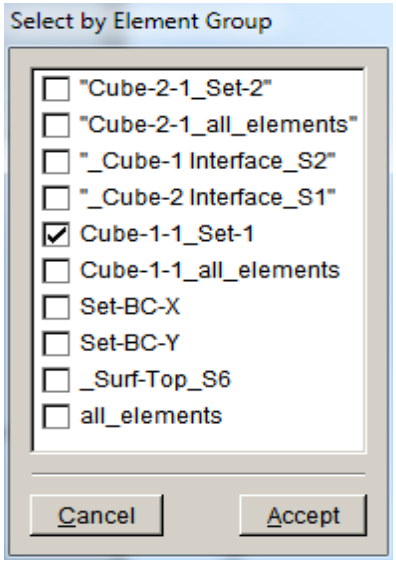


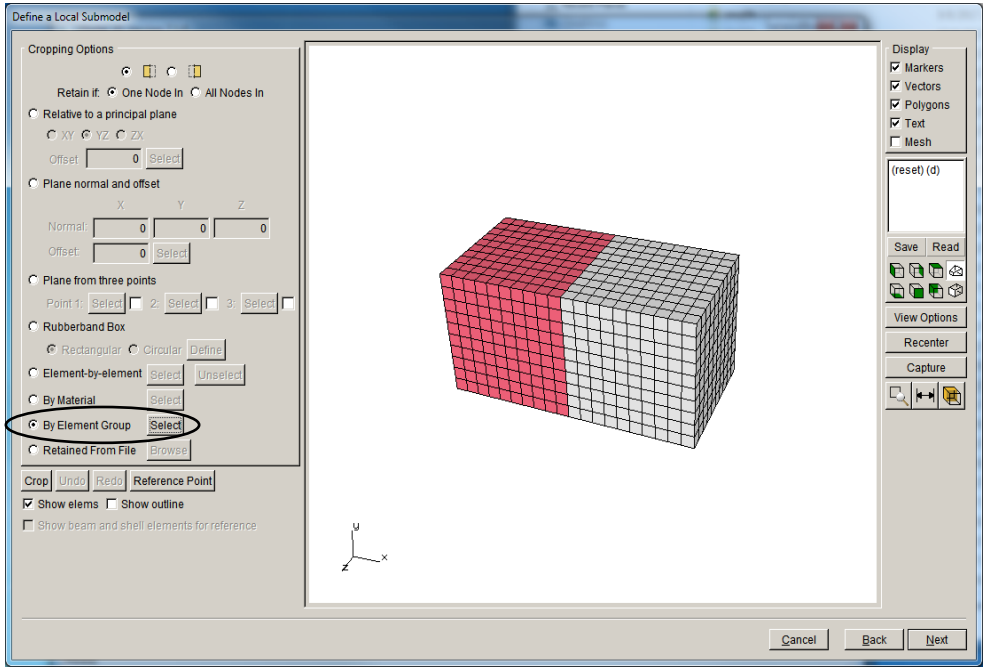




Import and Divide the Model in FRANC3D

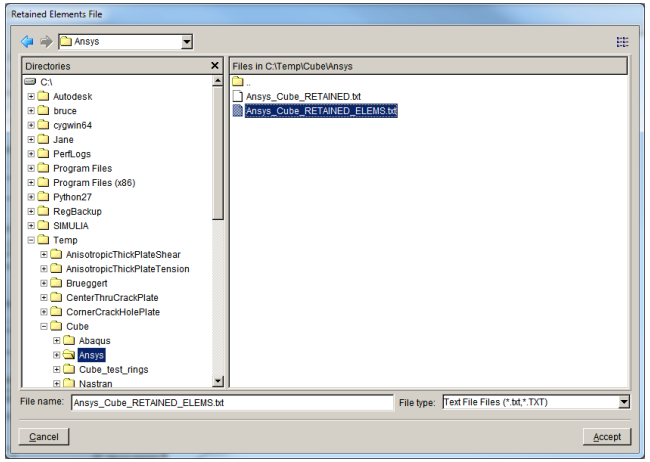
- By element group
  - Allows one to select elements based on an element group name

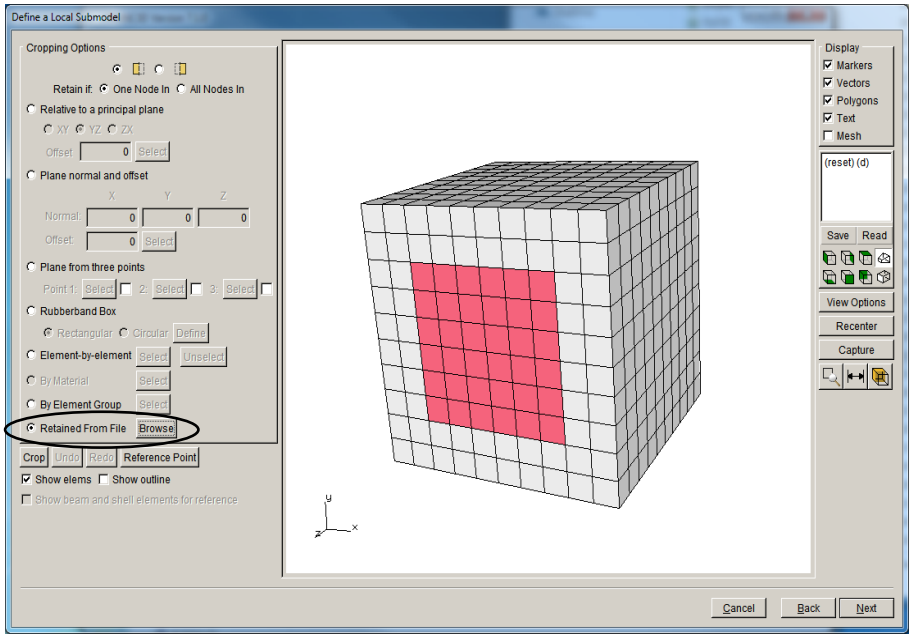




Import and Divide the Model in FRANC3D

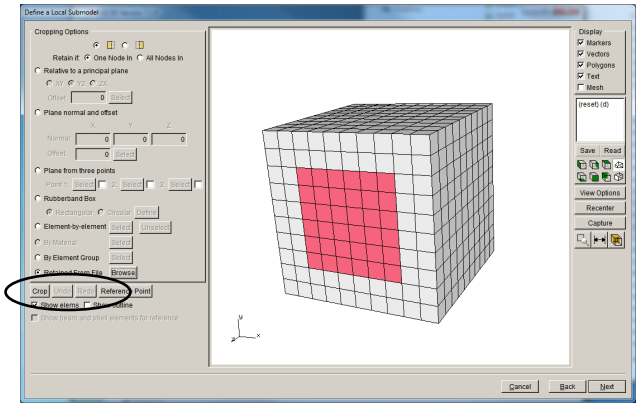
- Retained from file
  - Allows one to select element IDs from a .txt file
  - Useful for re-selecting elements that were selected during a previous import

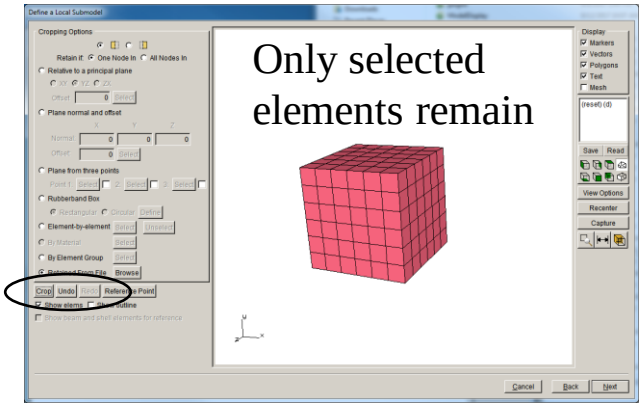




Import and Divide the Model in FRANC3D

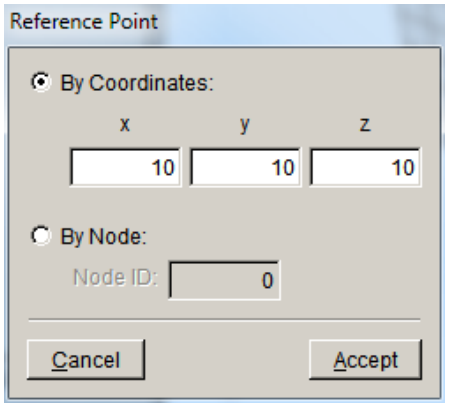
- Crop, Undo and Redo
  - The **Crop** button at the bottom on the left side performs the actual cropping operation
  - Once the selection is made, elements are cropped by pressing the **Crop** button
  - Un-selected elements are removed
  - User can **Undo** or **Redo** cropping operations
  - Multiple selections and crops can be performed in sequence

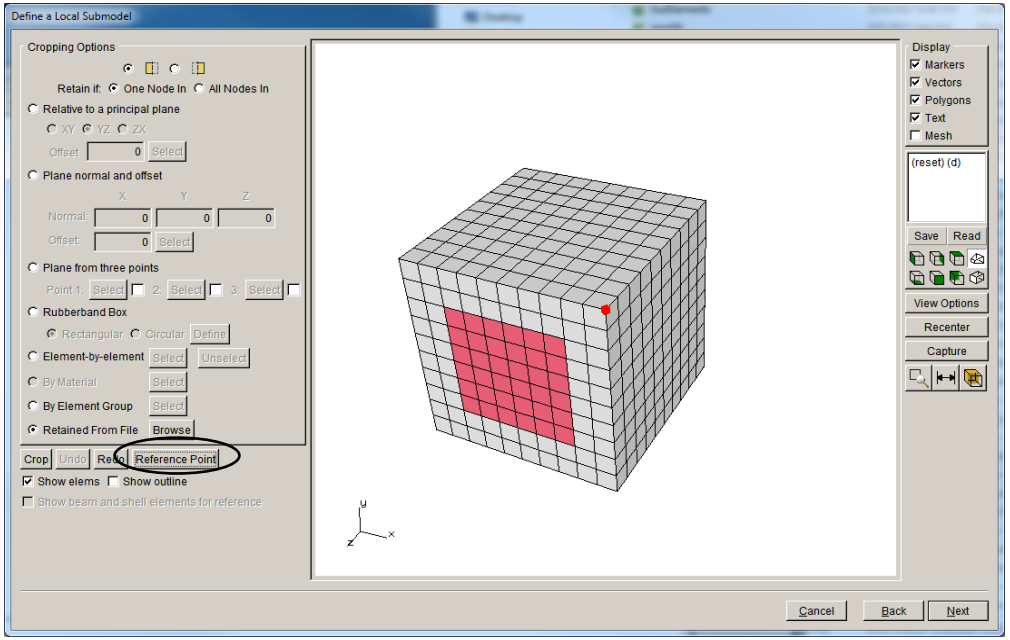




Import and Divide the Model in FRANC3D

- Reference Point
  - The user can select a node or xyz coordinates for a reference point in the model. The center of rotation is automatically adjusted to this position.



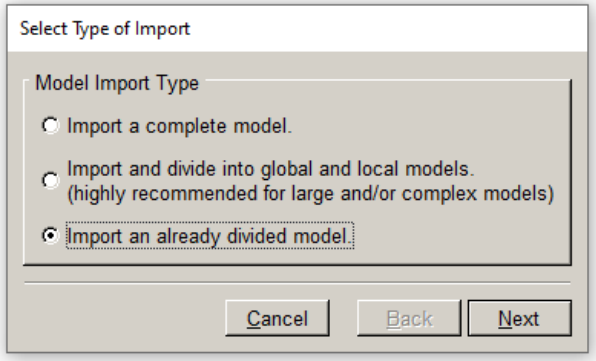


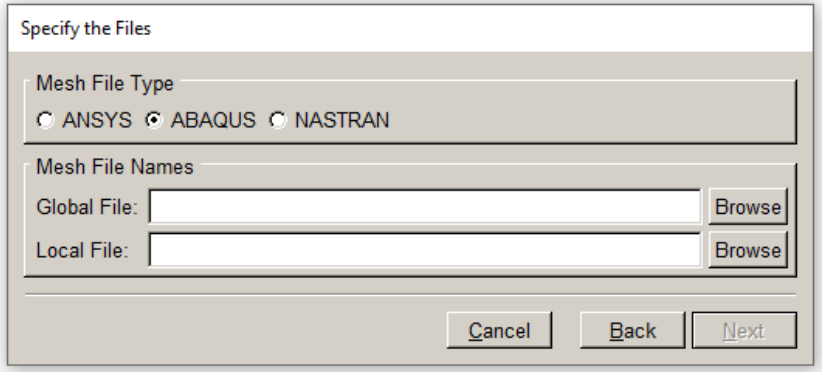
Import and Divide the Model in FRANC3D

- Once an element set has been selected and cropped, the following files are saved:
  - Local model
  - Global model
  - File with the base file name followed by _RETAINED_ELEMS.txt
    - Contains the element IDs for the local model
    - Can be used with the Retained From File option in defining the local submodel dialog box
    - Can be re-used during playback of a session log
- Note that local and global models can be recreated by the using the original FE model and the _RETAINED_ELEMS.txt file
- FRANC3D tools automatically create an AUTO_CUT_SURF for the local portion and a GLOBAL_CONNECT_SURF for the global portion

Import Already Divided Model

- If the user has already divided the FE model into global and local model files, these files can be imported directly.



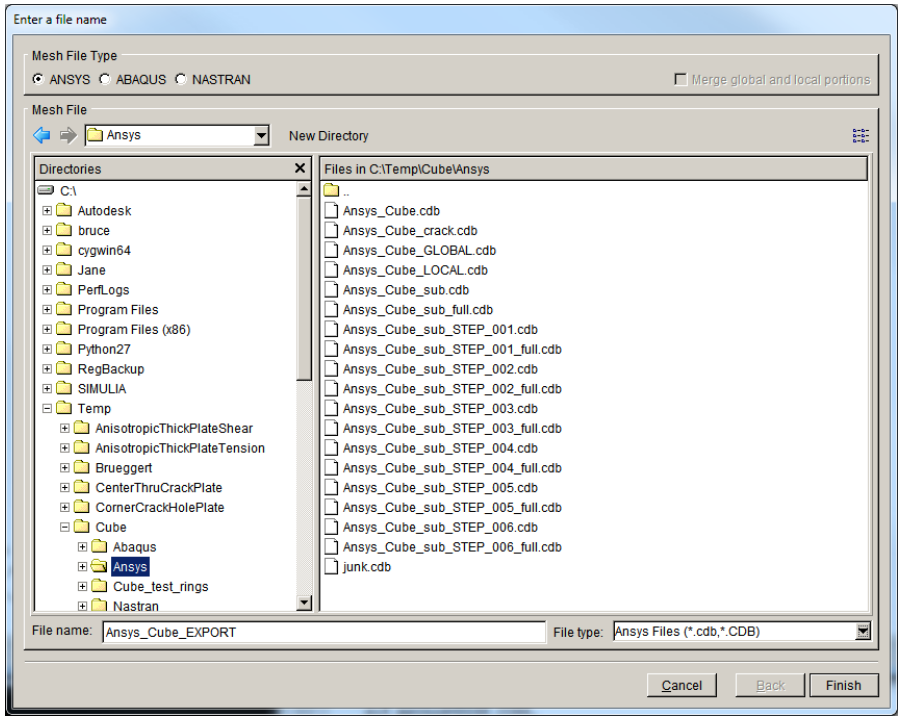


Import Already Divided Model

- This option can be used:
  - Once _LOCAL and _GLOBAL FE files are saved using the second option (import and divide) in FRANC3D
  - If the FE model is divided using other tools/software
    - It is important to remember to collect the node sets (components) that define the cut-surface between the local and global portions so that these can be selected later when merging the cracked-remeshed local portion with the global portion

Export Model

- File **Export** menu item can be used to save the FE model data without saving the FRANC3D .fdb
- User selects the analysis FE model type and enters the file name
- Used to convert FE model files from one type to another



Note that FRANC3D tries to "pass-through" as much of the FE data as possible, so converted files might have data that is not compatible.

Demo & Hands On (Homework): FE Model Import

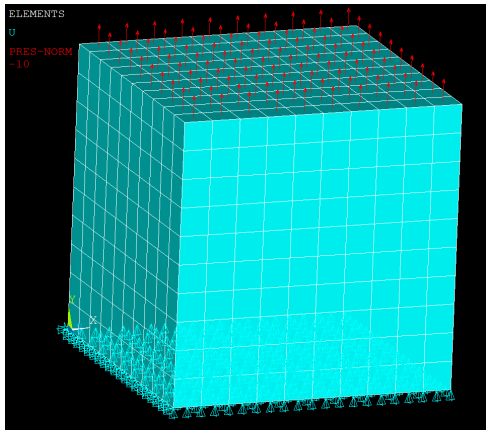
FRANC3D Documentation

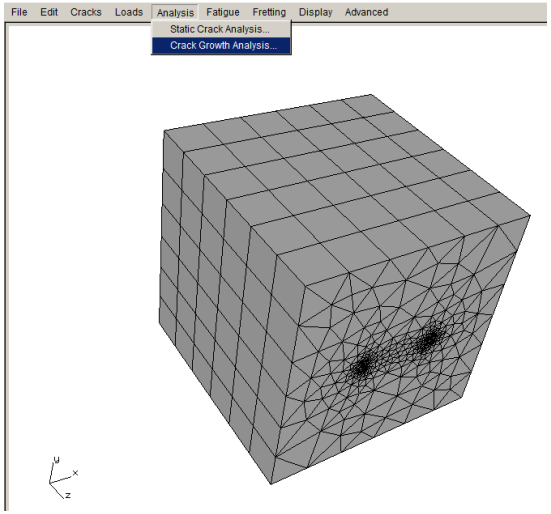
- Download & Install Instructions
- Brochure
- Reference Manual
- Tutorial for ABAQUS Users
- Tutorial for ANSYS Users
- Tutorial for NASTRAN Users
- Tutorial for SIERRA Users
- Tutorials 2-14
- User's Guide
- Command Line & Python Interface
- Benchmark Reference

Training Slides

- Download Files

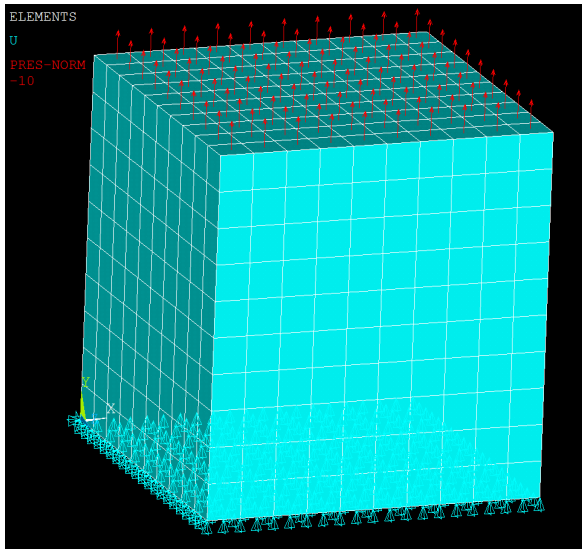
Tutorial #1:
Crack Insertion and Growth in a Cube



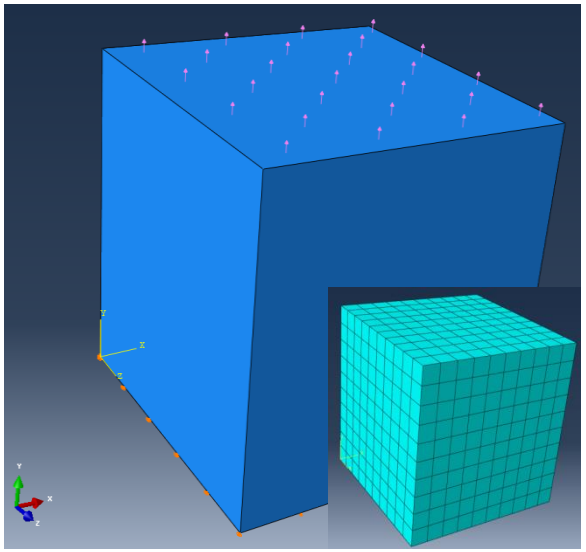


http://www.fracanalysis.com/software.html

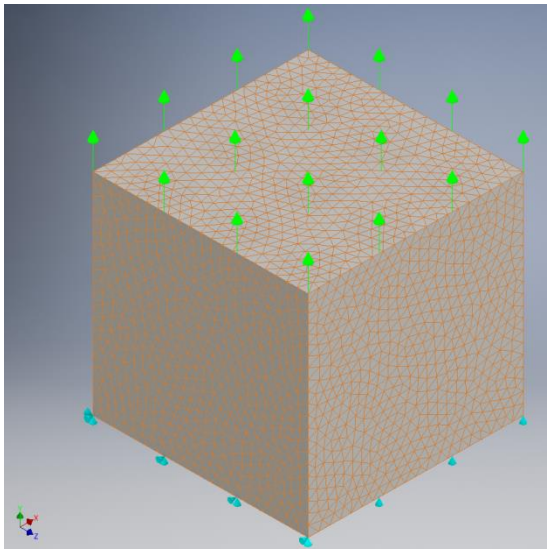
FRANC3D Tutorial 1



ANSYS

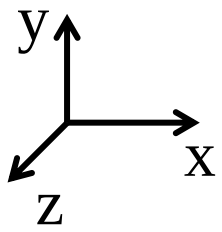


ABAQUS



NASTRAN

- 10x10x10 cube; units of length are mm
- subdivide edges for meshing using 10 to 20 subdivisions
- use quadratic brick or tetrahedral elements
- material properties: E=10000 MPa and ν=0.3
- uniform traction (a negative pressure) on the top surface of 10 MPa in Y-direction
- bottom surface constrained in the y-direction, bottom left edge is also constrained in the x-direction, and the point at the origin is also constrained in the z-direction



FRANC3D Tutorial 1

Step 1: Build the FE model or use the pre-made model

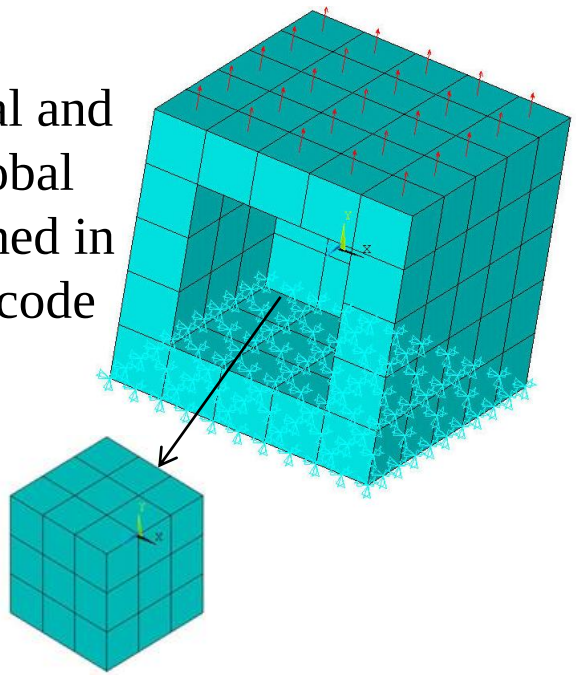
- from FAC downloads

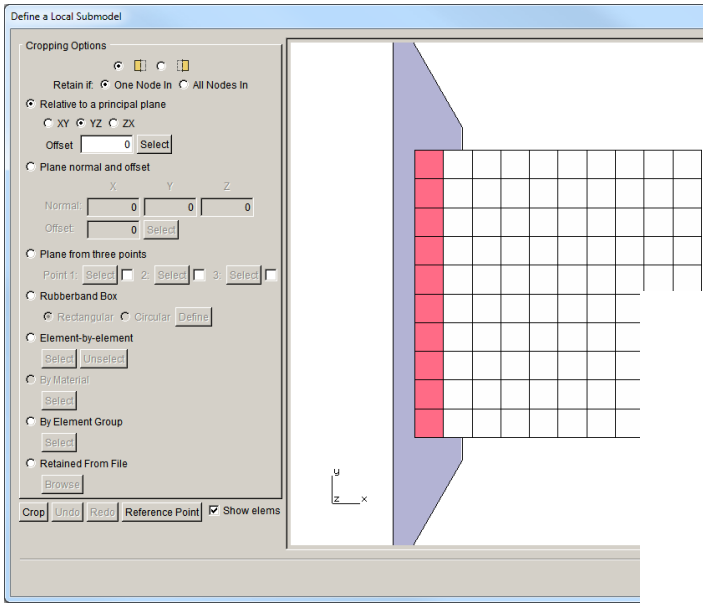
Step 2: Extract local sub-model portion

- node component/set for cut-surface(s) automatically created
- write local and global portions as separate model files
- local and global FE data automatically made consistent

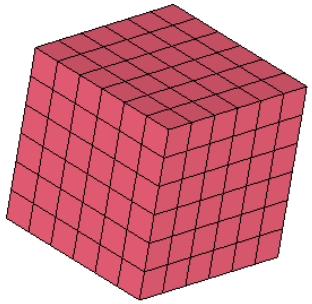
Step 3: Import sub-model portion into FRANC3D

Local and global defined in FE code





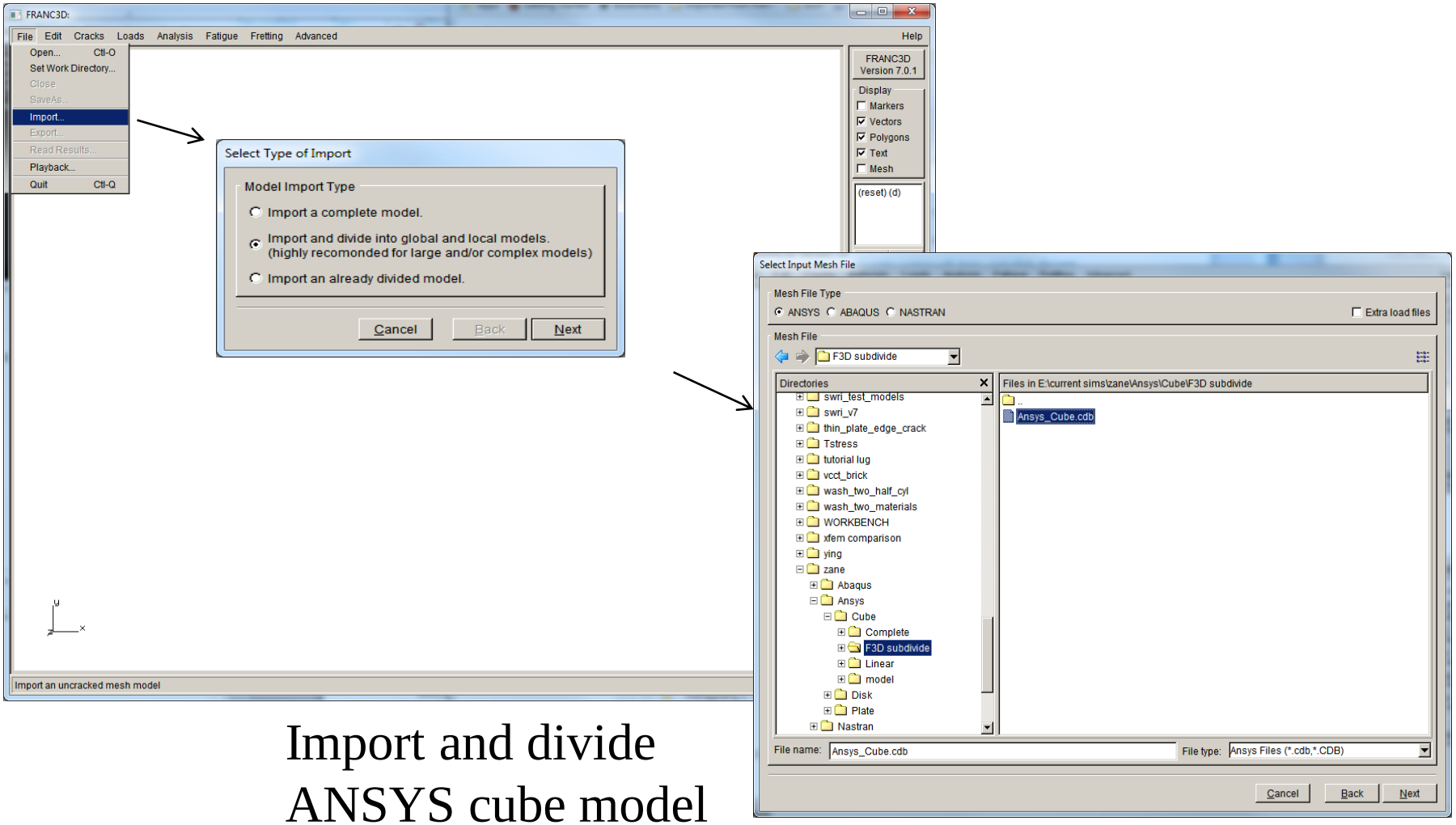
Local and global defined in FRANC3D



Demo/Hands On (Homework): Importing and Dividing FE Model

FRANC3D Tutorial 1 – Import FE Model

For Step 2 when using FRANC3D:

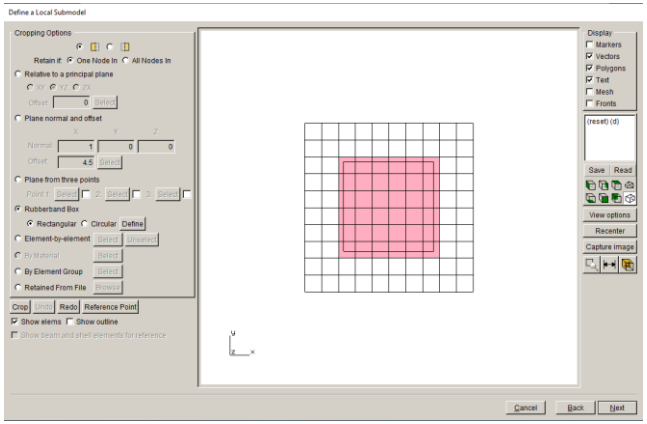


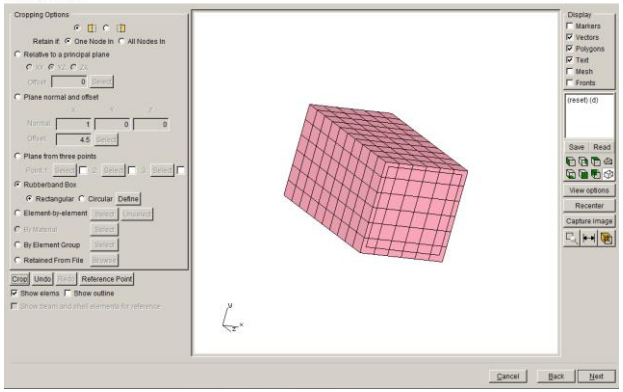
Import and divide ANSYS cube model

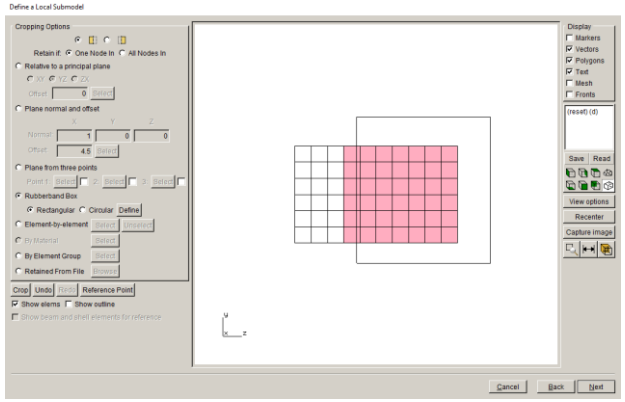
FRANC3D Tutorial 1 – Import FE Model

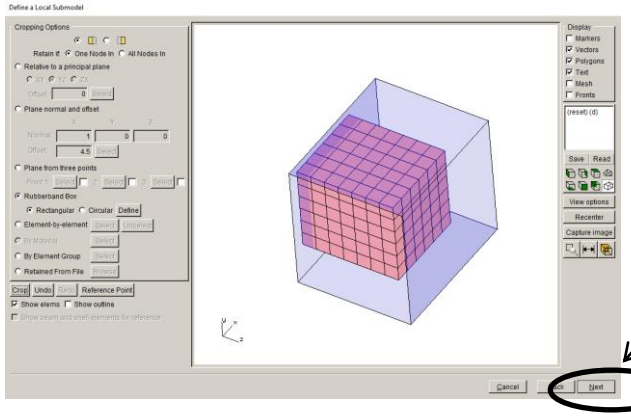
Submodel Tool:

- Elements shown in red are retained when the model is **Crop**ped
- Rubberband Box tool demonstrated







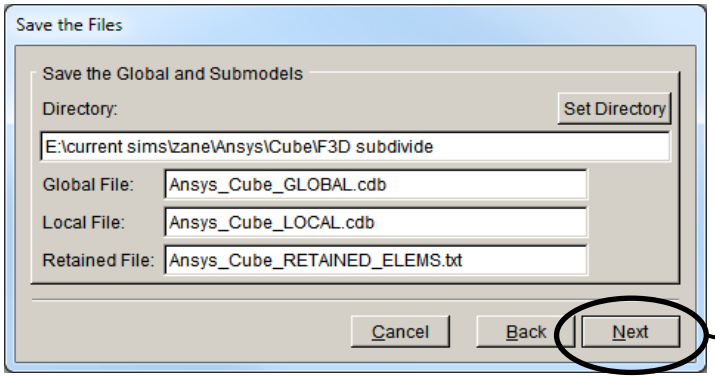


After selecting the elements to retain and using the **Crop** button – select **Next**.

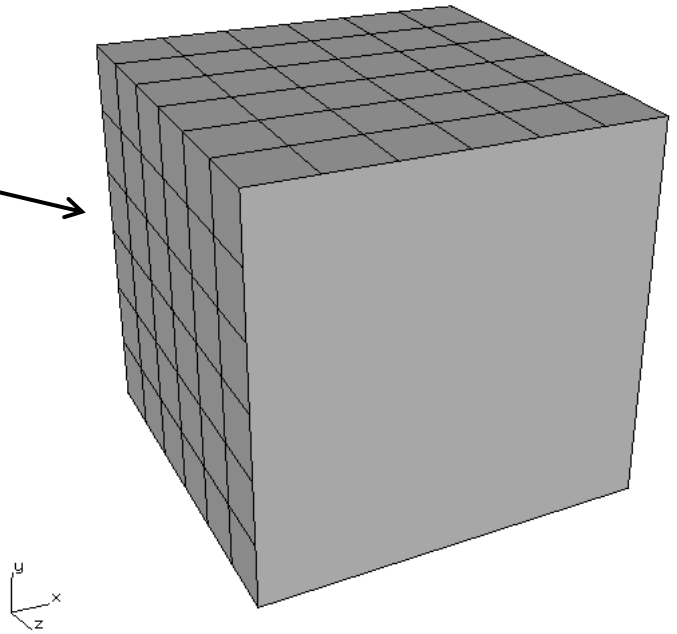
FRANC3D Tutorial 1 – Import FE Model

Submodel Tool:

- Local and global portions saved along with the list of retained elements; the latter allows for scripted restarts (*i.e.*, playback).



Cut-surface mesh facets retained



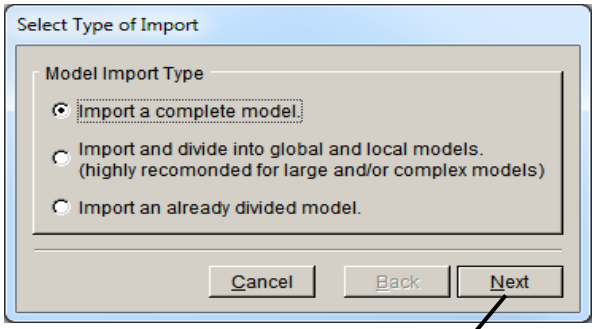
Note that there are no boundary conditions on this particular (local) sub-model selection.

Demo/Hands On (Homework): Importing Complete FE Model

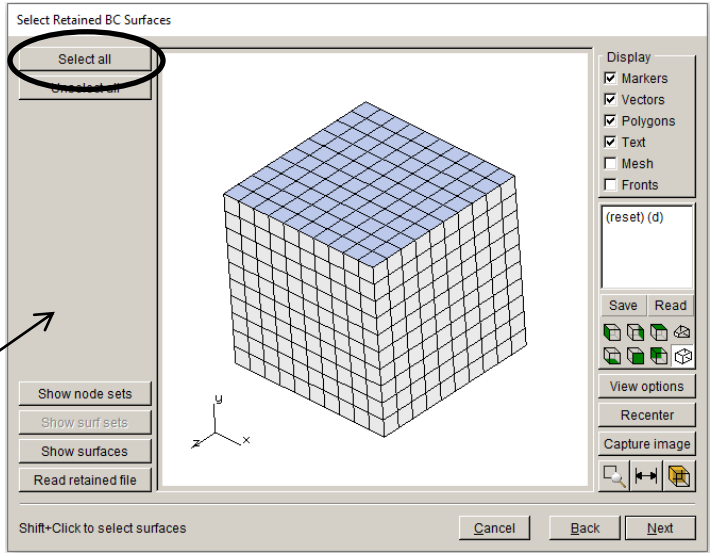
Note: you need to **File** → **Close** the prior import.

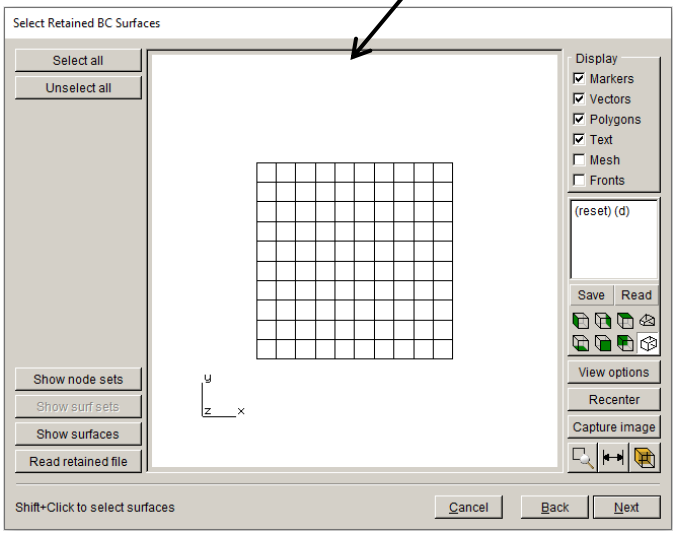
Importing Full Model

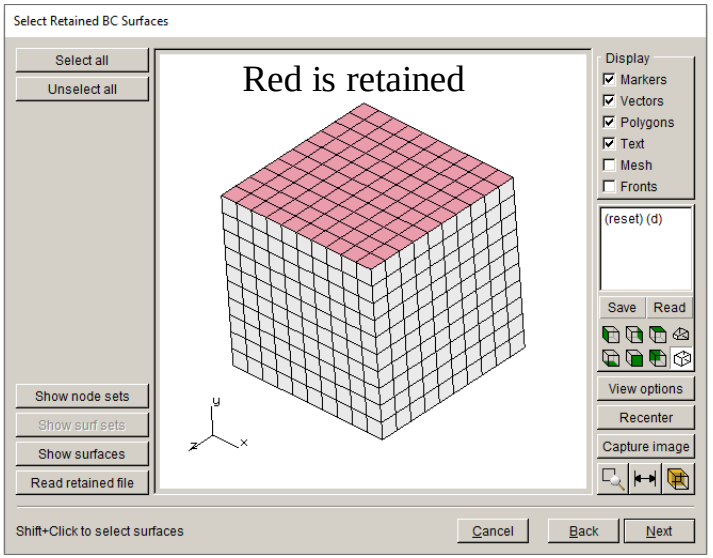
Import complete cube model:



Use mouse to rotate model

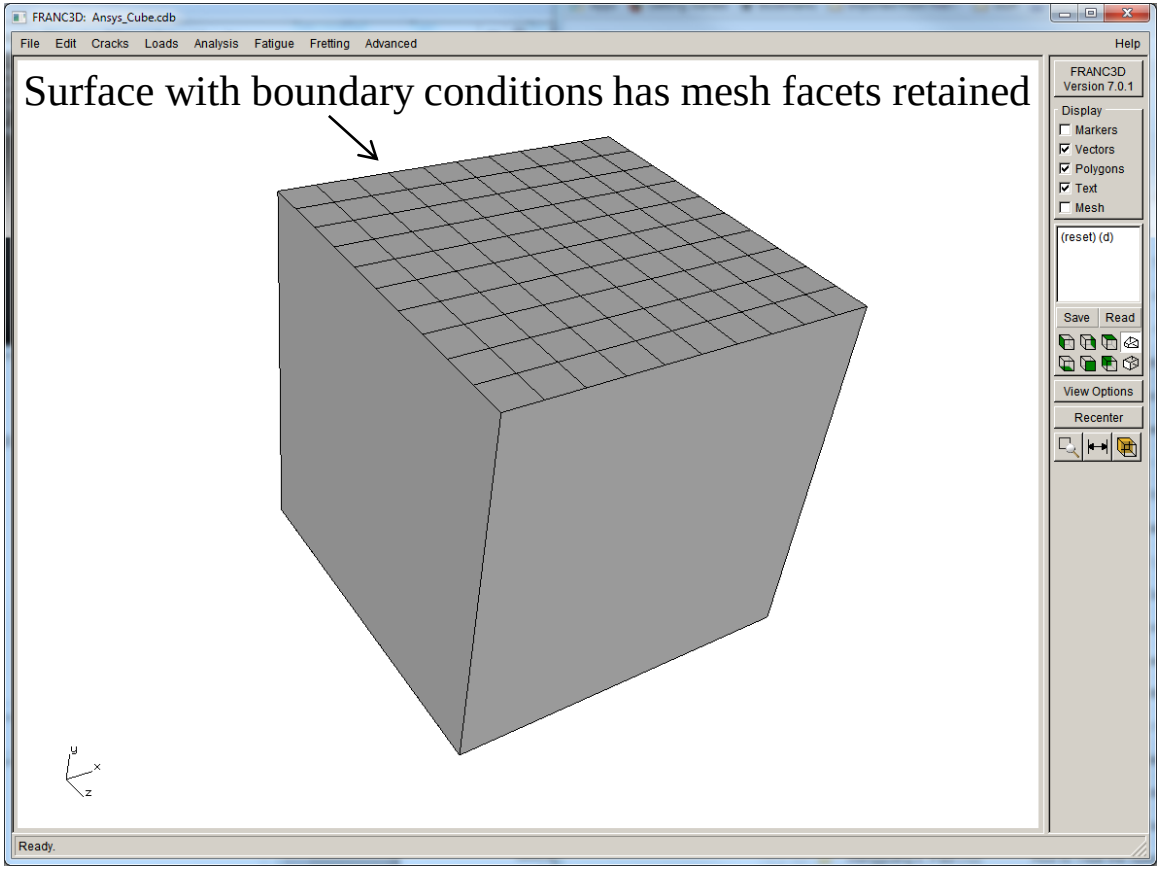






FRANC3D Tutorial 1 – Import FE Model

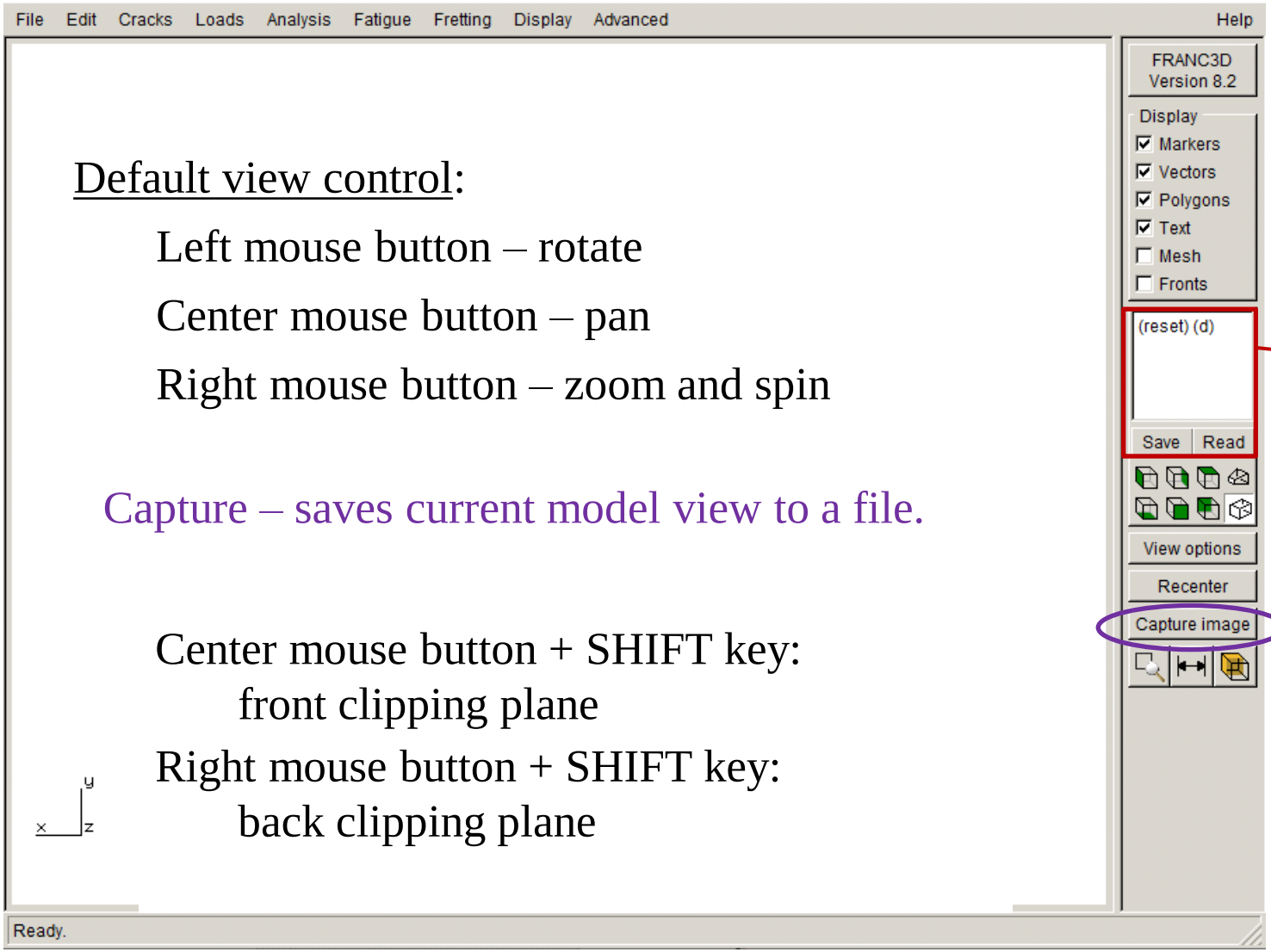
Surface mesh facets are retained where boundary conditions are applied *and selected to be retained*.



Reminder – you can not insert a crack into a surface where facets are retained.

Demo/Hands On (Homework): Viewing the Model

FRANC3D Tutorial 1 – Camera Position



Default view control:

Left mouse button – rotate

Center mouse button – pan

Right mouse button – zoom and spin

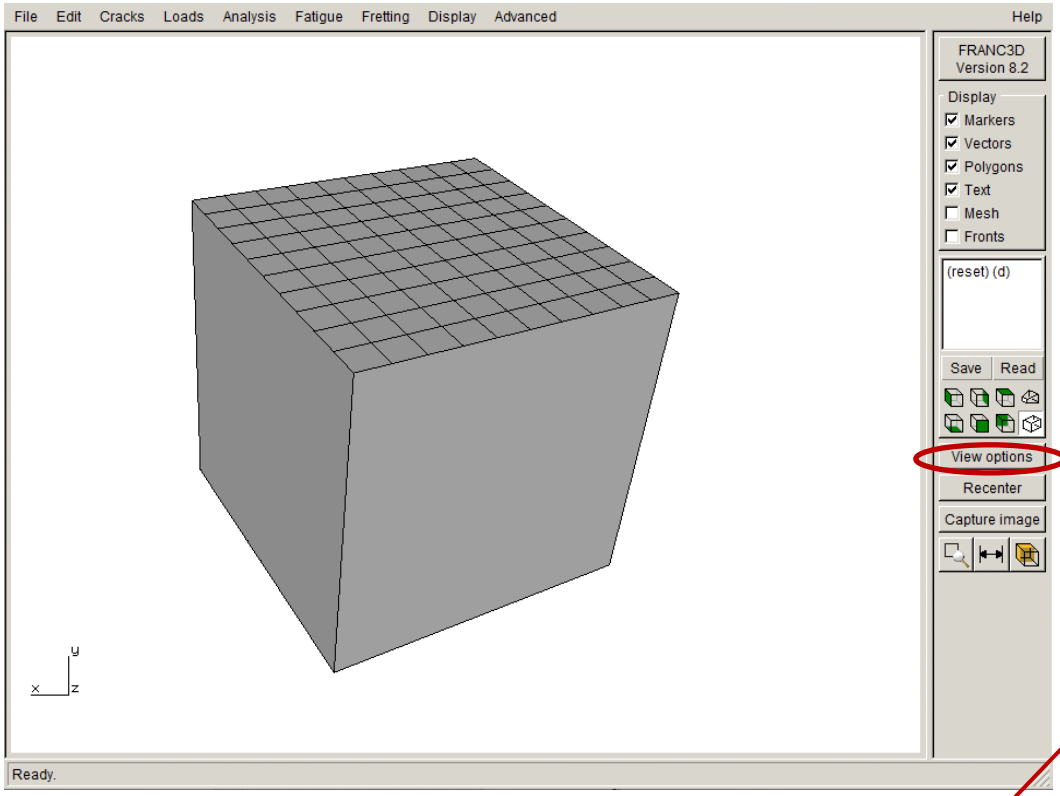
Capture – saves current model view to a file.

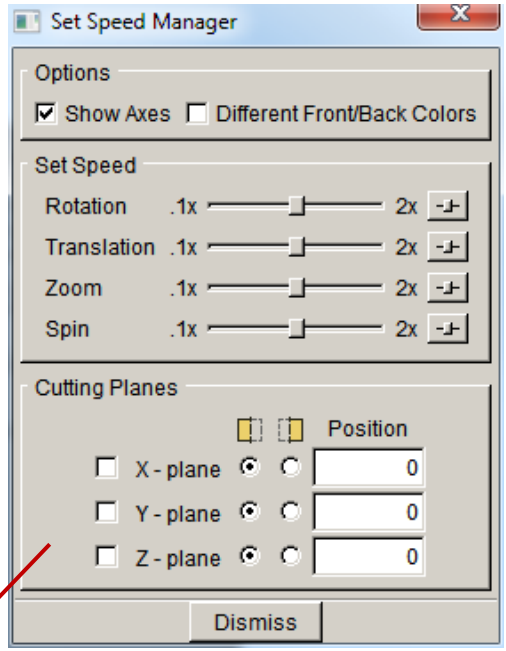
Center mouse button + SHIFT key:
front clipping plane

Right mouse button + SHIFT key:
back clipping plane

Saved camera positions provide easy way to quickly change to different views.

FRANC3D Tutorial 1 – View Options



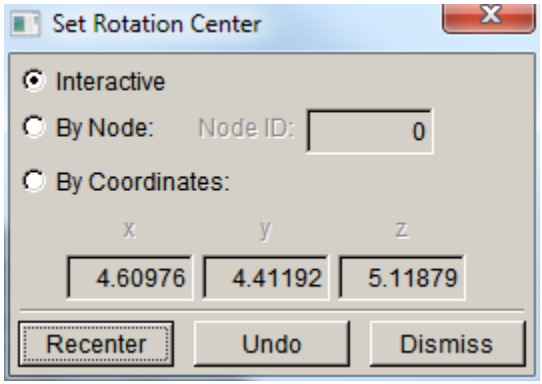


Controls the speed of rotation, translation and zooming when "moving" the model with the mouse.

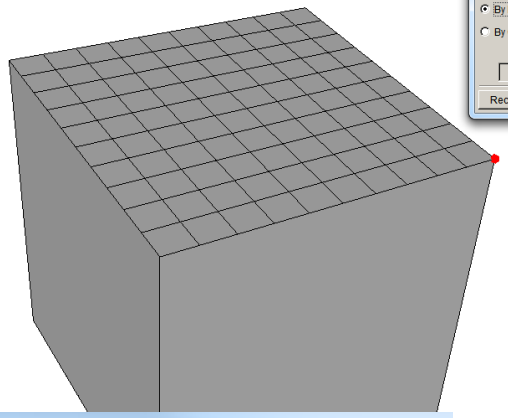
Allows user to cut away a portion of the model based on cutting planes aligned with the global Cartesian axes.

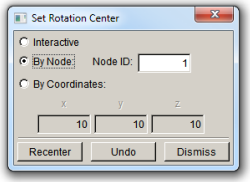
FRANC3D Tutorial 1 – Recenter

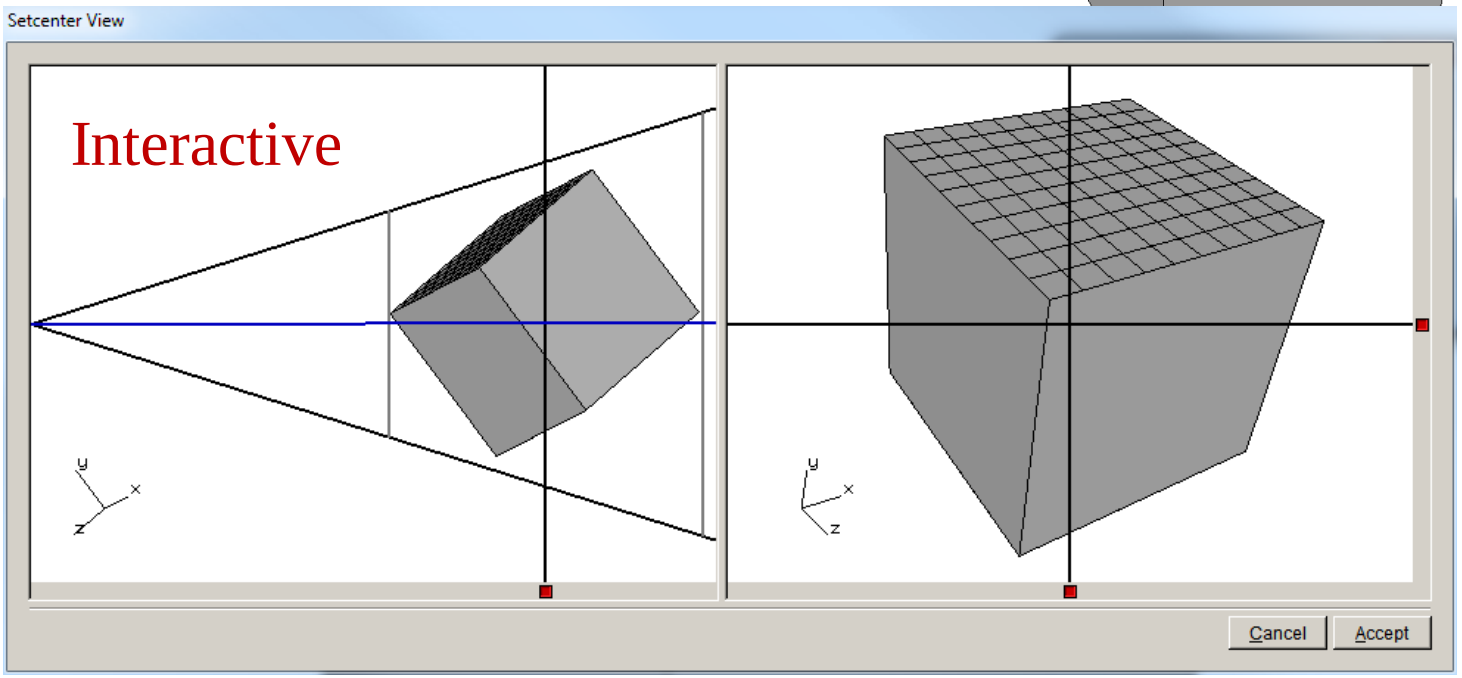
(or use Ctrl key and left mouse button)



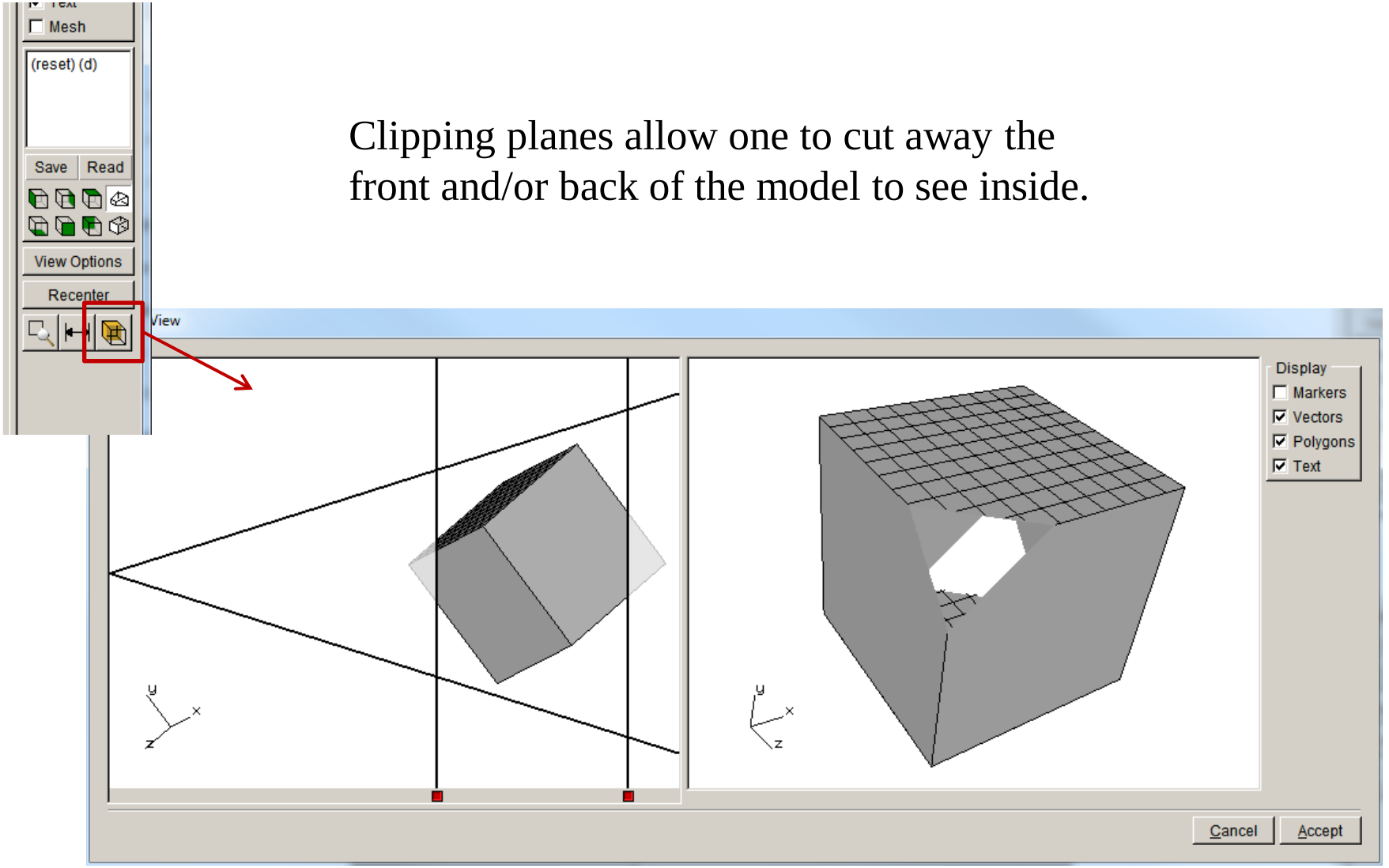
Default center of rotation is the center of the model.





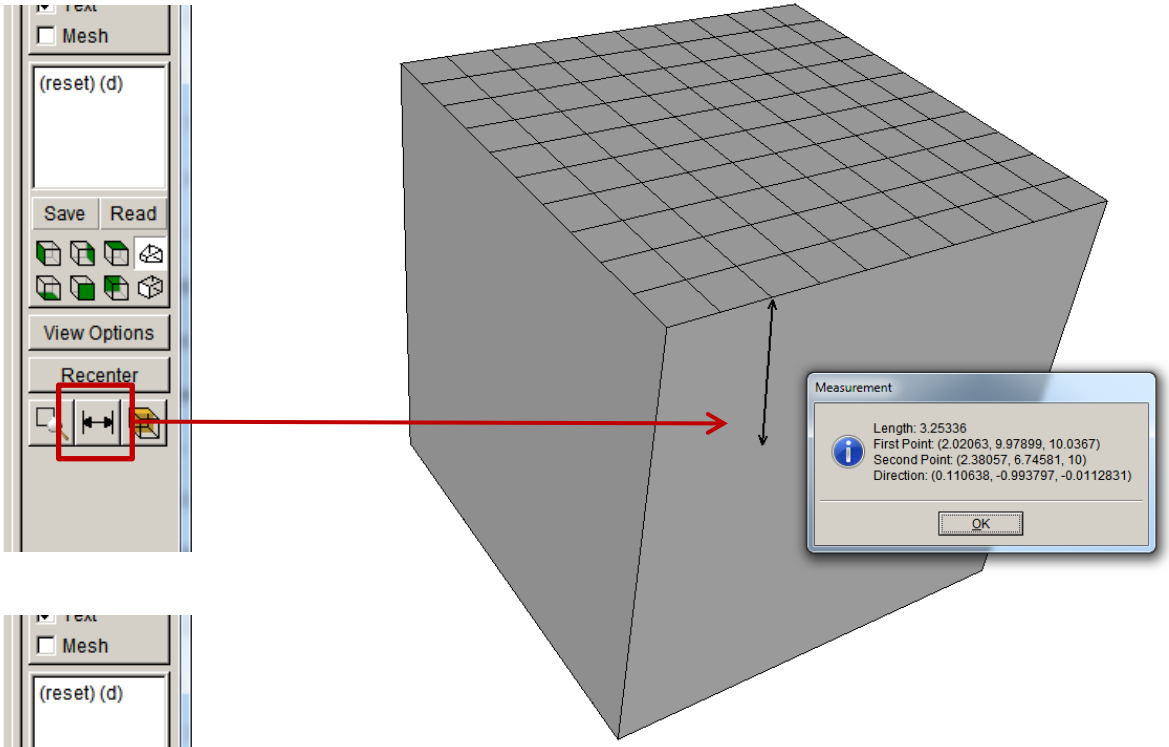


FRANC3D Tutorial 1 – Clipping Planes

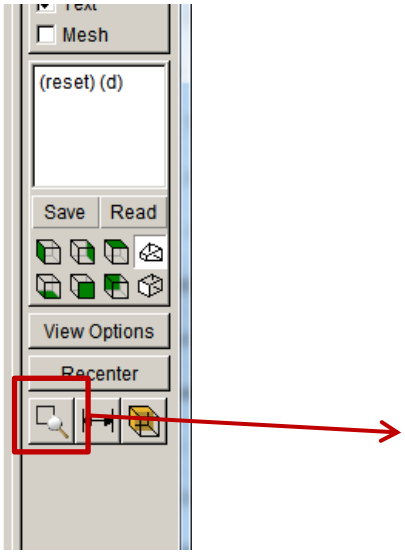


Clipping planes allow one to cut away the front and/or back of the model to see inside.

FRANC3D Tutorial 1 – Measure & Box Zoom



Measurement tool gives the length on the surface or the coordinates for a single point (if you don't drag the mouse).



Box zoom tool allows one to drag a box to zoom in on a region of the model.

End Part 5