BUILDING DATA VISUALIZATION CAPACITY

Summer Webinar Series

July 21 - 24, 2020

UTSA The University of Texas at San Antonio™

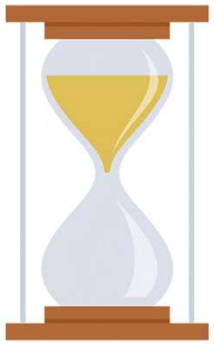
Byrd Data Visualization Laboratory

PURDUE UNIVERSITY

Website: https://tinyurl.com/yctfhc6l

Administrivia & Logistics

- Take a moment to provide feedback for yesterday's session: You've got data now what?
- Feedback link located at the bottom of Day 2 Web page, can also be accessed from here https://tinyurl.com/y2yjncwn



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About Me

Vetria Byrd
Assistant Professor
Byrd Data Visualization Lab, Director
Purdue University

- Vetria Byrd, PhD
- Assistant Professor
- Purdue University
  - Department of Computer Graphics Technology
  - Polytechnic Institute
- Byrd Data Visualization Lab, Director
- Founder and Organizer of BPViz: Broadening Participation in Visualization Workshop

2020 | 2019 | 2018 |2016 |2014

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Webinar Organizers

Vetria Byrd
Assistant Professor
Byrd Data Visualization Lab, Director
Purdue University

Ritu Arora
Assistant Vice President of Research Computing
University of Texas at San Antonio

Brent League
Director of Research Computing Support
University of Texas at San Antonio

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Webinar Goals and Objectives

Goal

Introduce participants to data visualization

Objectives

1. Examine what data looks like, define data visualization.
2. Illustrate how data visualization can improve understanding of the story within the data.
3. Introduce the data visualization process.
4. Explore different data visualization paths.

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1 minute Recap

Day 2: You’ve got data now what?

Understanding Data

1. What real life behavior does the data reflect?
2. What are the strengths of the data source(s)?
3. What are the weaknesses of the data source(s)?
4. What information is emphasized?
5. At what level of granularity is the data provided?
6. What is the scope of the data?

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Recommended Readings

Quick and Easy Read

7 things you should know about...
Data Visualization

7 things you should know about...
Data Visualization II

Available on the webinar website's Resources page

EDUCAUSE Learning Initiative
advancing learning through IT innovation
www.educause.edu/eli

We are here

Schedule	Topic	Skill Level
Day 0	Download and Install	Beginner
Day 1	Introduction to data visualization	Beginner
Day 2	You've got data now what?	Beginner/Intermediate
Day 3	Introduction to scientific Visualization	Intermediate/Advanced
Day 4	Visualization hackathon	Advanced

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INTRODUCTION TO PARAVIEW

Day: Thursday, July 23, 2020
Time: 1PM - 3 PM (CST)/2PM - 4PM (EST)
Skill level: Intermediate/Advanced

This seminar provides an introduction to scientific visualization using ParaView. An overview of the visualization process is presented by exploring the scientific visualization pipeline followed by hands on experience with ParaView.

Agenda

- Introduction
  - Scientific Visualization
  - Scientific Visualization Pipeline
  - Common Sci-vis Techniques
- Introduction to ParaView
- Hands-on Exercises

Data Visualization Process

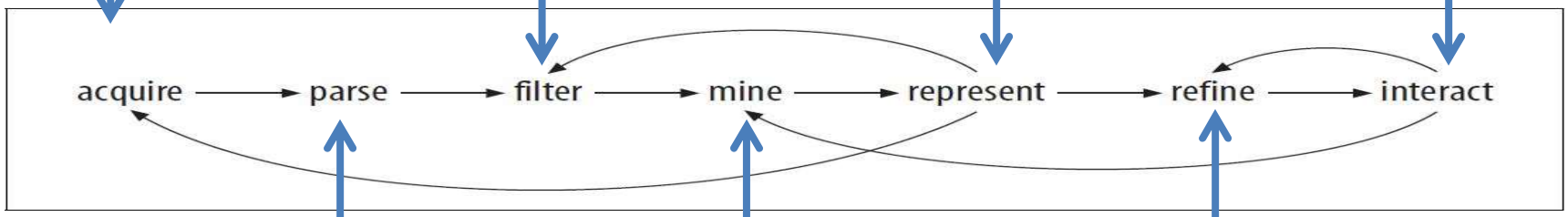
An iterative process

obtain the data

remove all but the data of interest

choose a basic visual model, such as a bar graph, list or tree

Add methods for manipulating the data or controlling what features are visible



provide structure

apply methods from statistics or data mining to discern patterns or place the data in mathematical context

improve the basic representation to make it clearer and more visually engaging

Adopted from Visualizing Data: Exploring and Explaining Data with the Processing Environment by Ben Fry, O'Reilly (p 15)

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Scientific Visualization

- Primarily concerned with the visualization of three-dimensional phenomena (architectural, meteorological, medical, biological, etc.),
- Where the emphasis is on realistic renderings of volumes, surfaces, illumination sources, and so forth, perhaps with a dynamic (time) component.

Wikipedia.com

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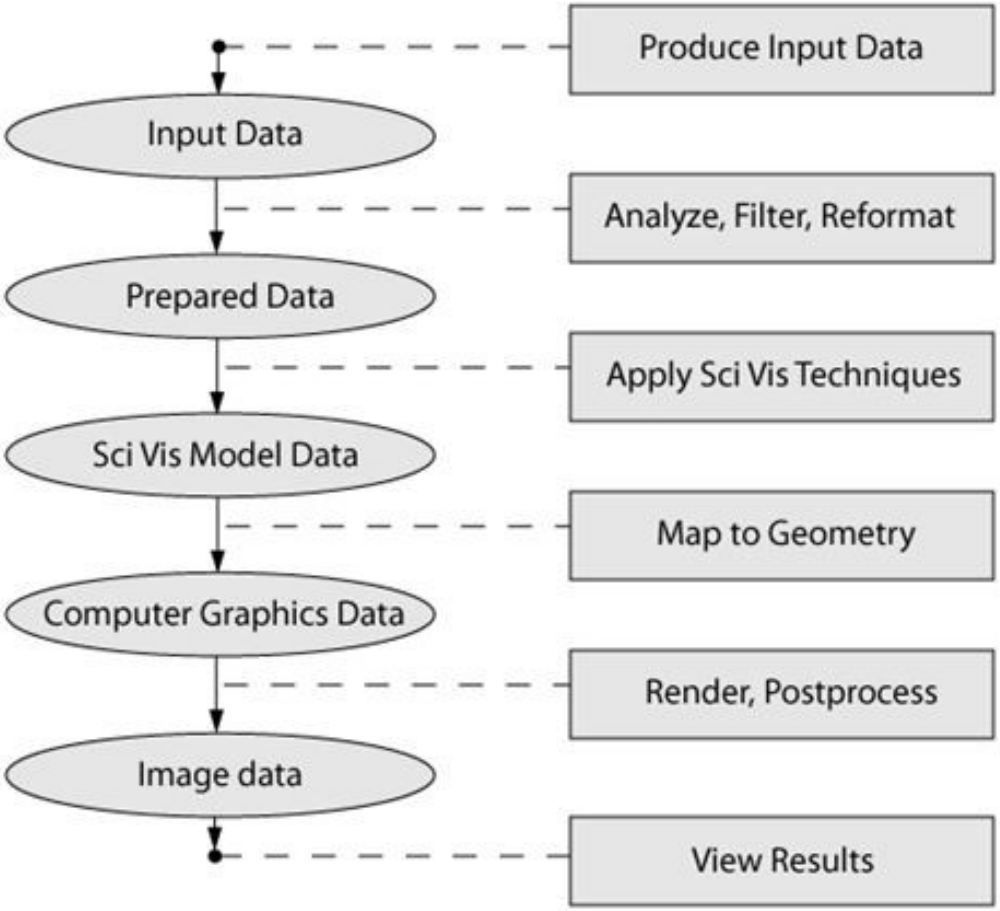
Scientific Visualization Pipeline

What's Missing?



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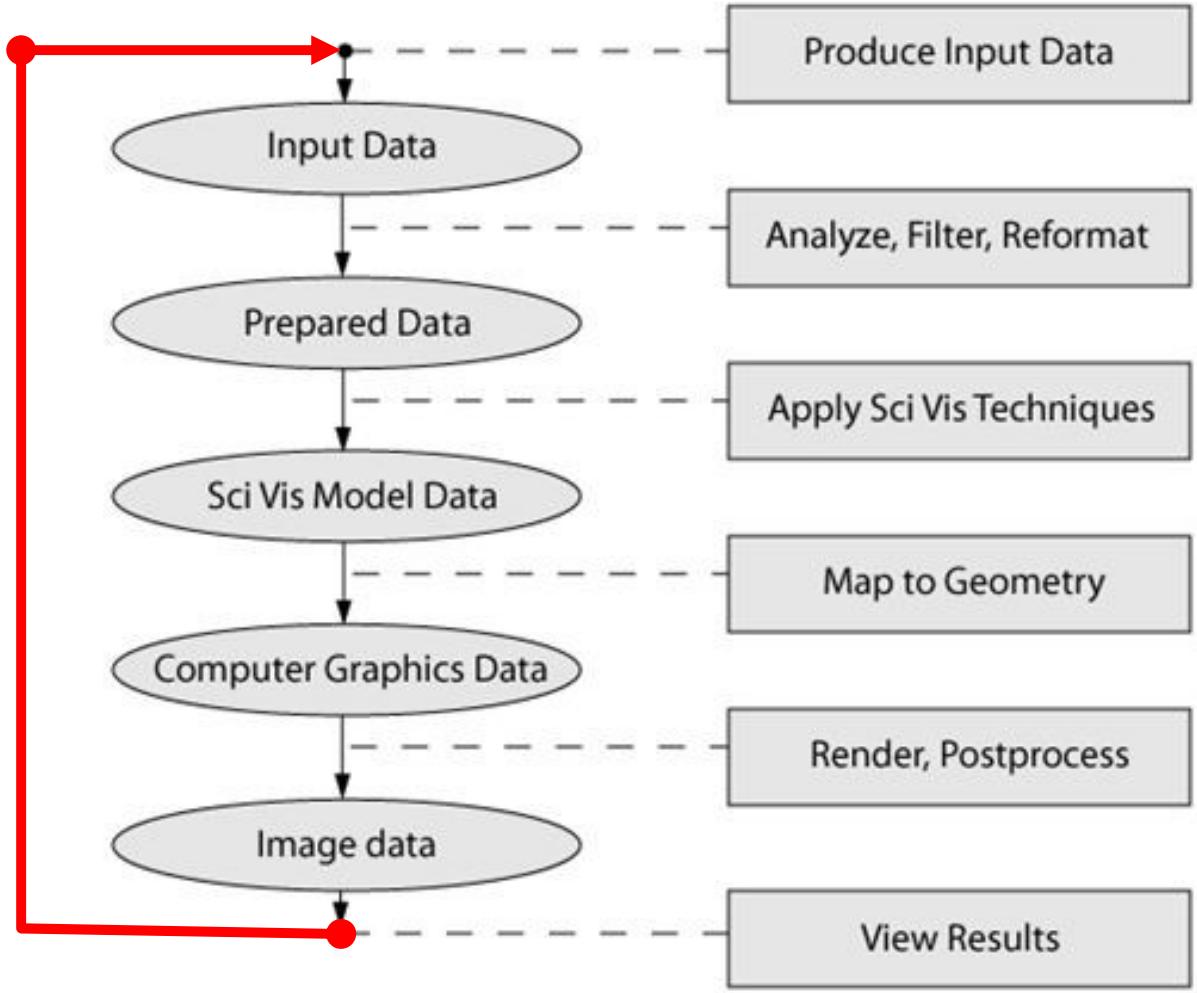
http://www.bu.edu/tech/research/training/tutorials/introduction-to-scientific-visualization-tutorial/the-scientific-visualization-pipeline/

Scientific Visualization Pipeline



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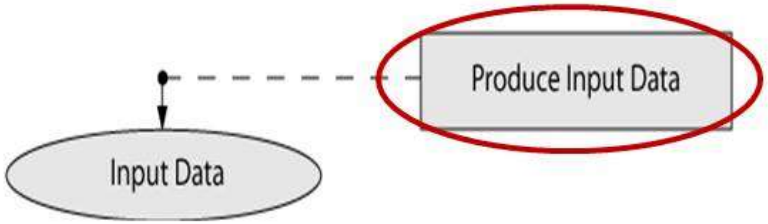
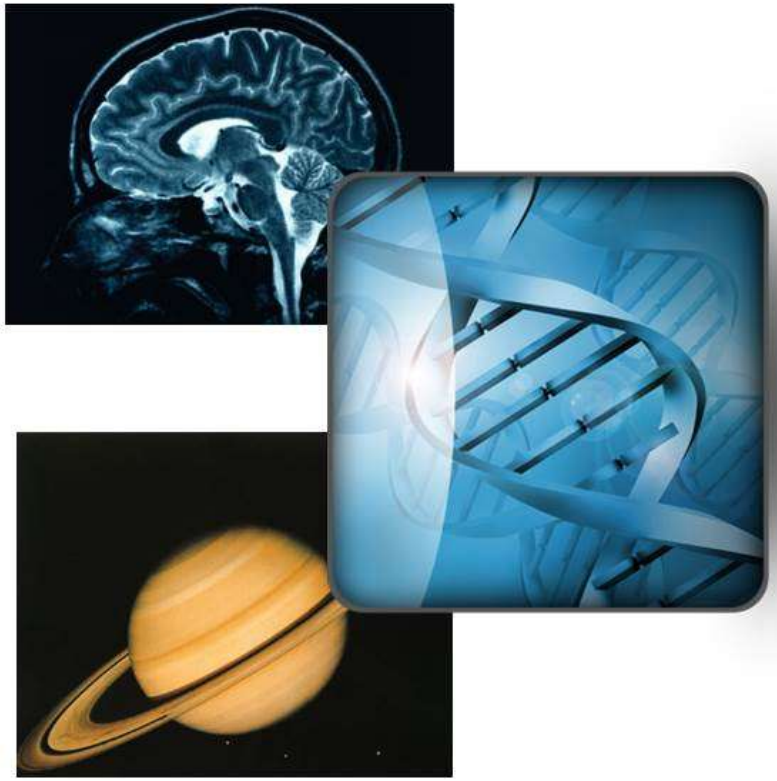
http://www.bu.edu/tech/research/training/tutorials/introduction-to-scientific-visualization-tutorial/the-scientific-visualization-pipeline/

Scientific Visualization Pipeline: Step 1 . . .

Produce Data



- Simulated Data
- Images
- Numerical
- Some measured value
- Observed Phenomena



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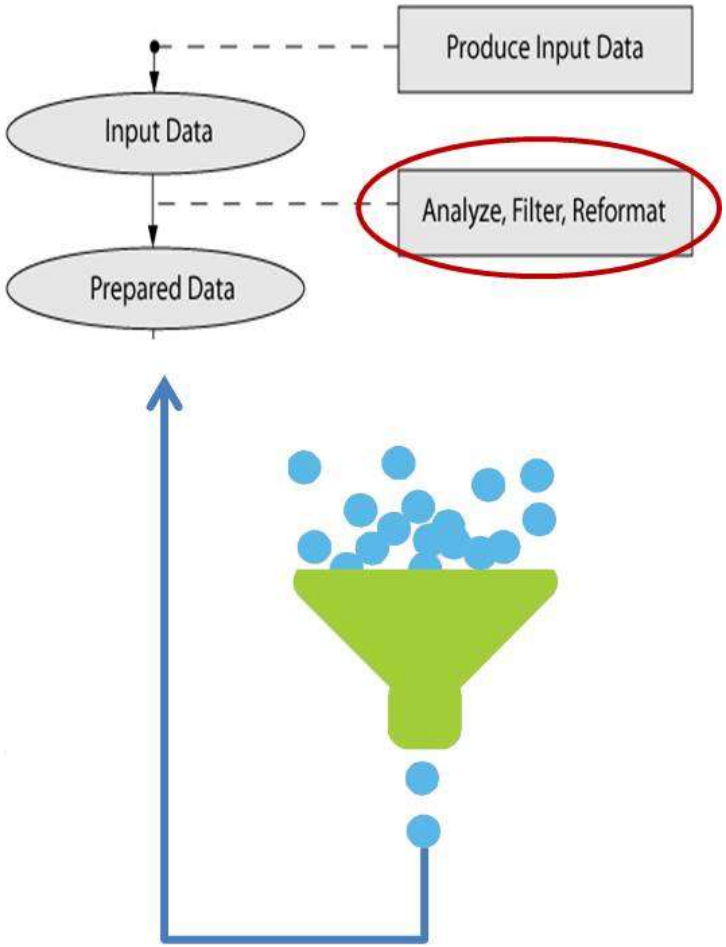
Adopted from
http://www.bu.edu/tech/research/training/tutorials/introduction-to-scientific-visualization-tutorial/the-scientific-visualization-pipeline/

Scientific Visualization Pipeline: Step 2 . . .

Analyze, Filter, Reformat

- Cleaning up the data
  - Removing noise
  - Replacing missing values
  - Clamping values to be within a specific range of interest
- Performing operations to yield more useful data



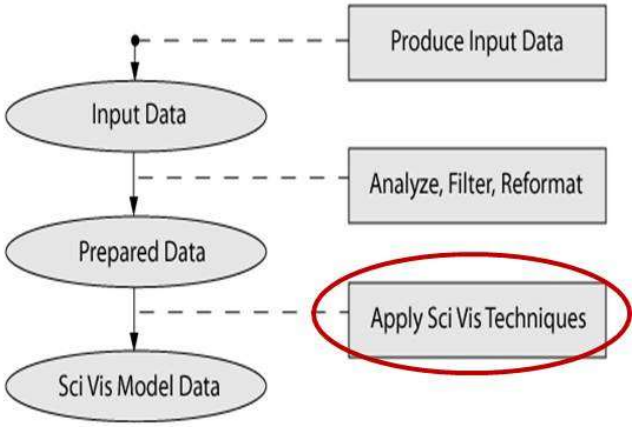
Adopted from http://www.bu.edu/tech/research/training/tutorials/introduction-to-scientific-visualization-tutorial/the-scientific-visualization-pipeline/

Scientific Visualization Pipeline: Step 3

Apply SciVis Techniques

- Converts raw information into something more understandable

- Visually extracting meaning from a scientific data set using various techniques



Contour

Clip

Threshold

Glyphs

Streamlines

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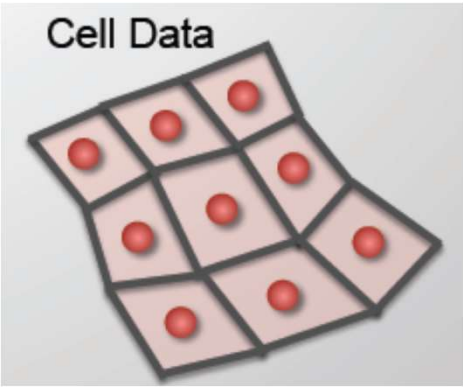
Adopted from
http://www.bu.edu/tech/research/training/tutorials/introduction-to-scientific-visualization-tutorial/the-scientific-visualization-pipeline/

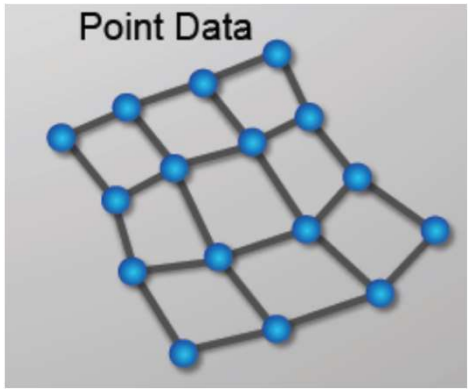
Scientific Visualization Pipeline

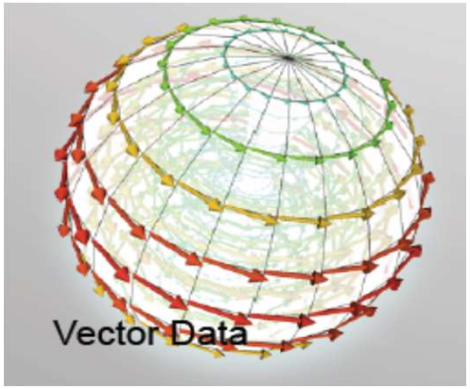
Step 4 . . .

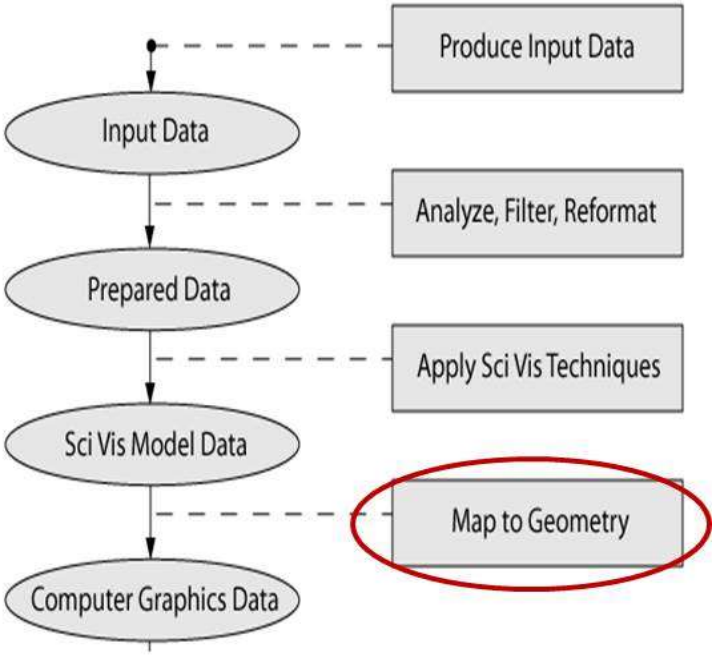
Map to Geometry



- Scalars, vectors, tensors
- 1D, 2D, 3D
- Mesh



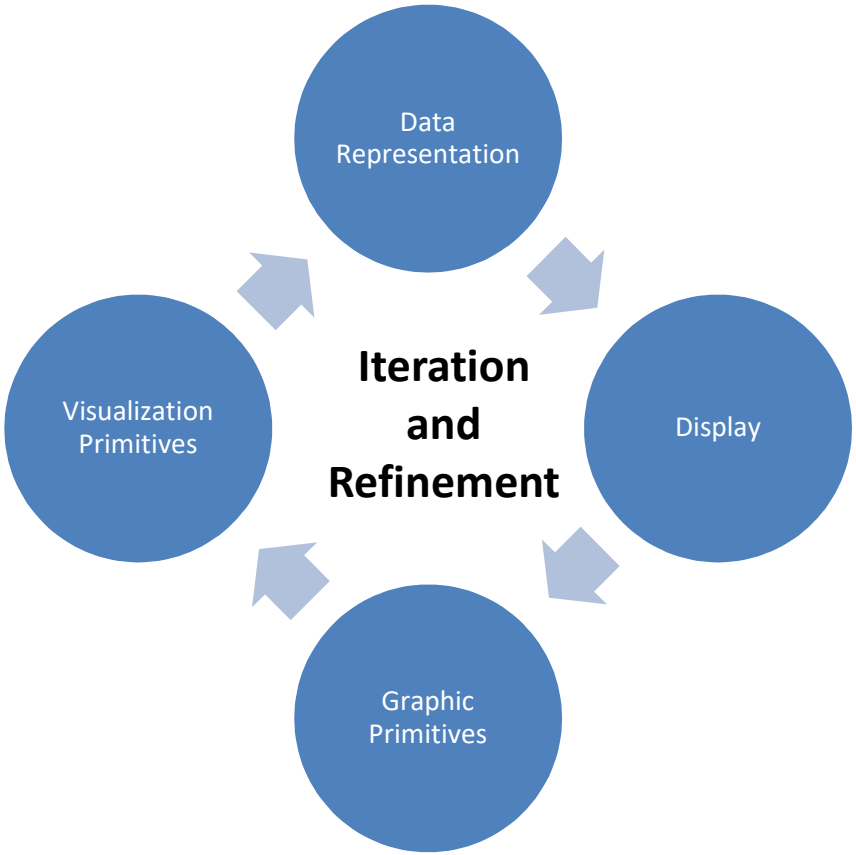


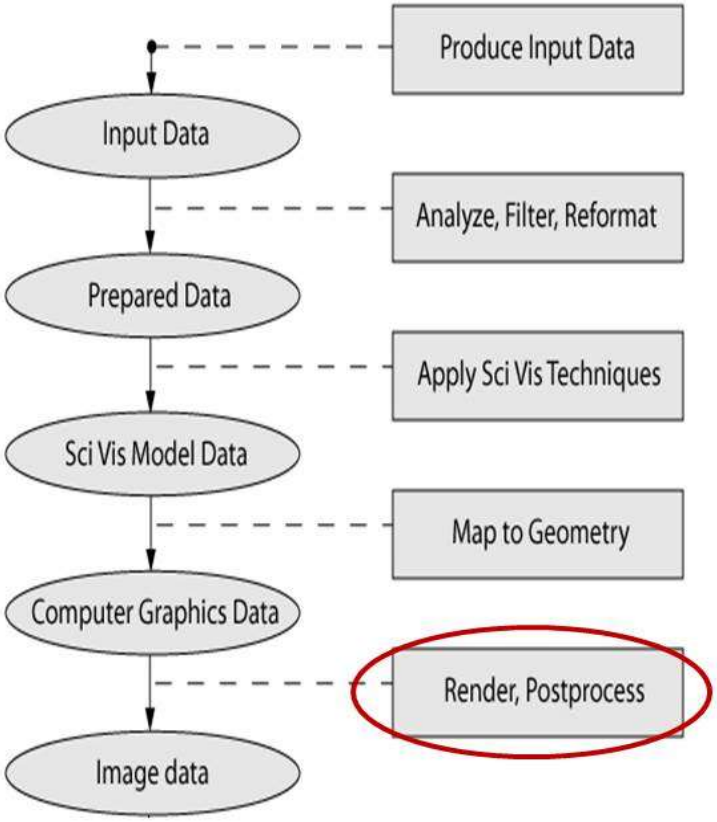


Adopted from
http://www.bu.edu/tech/research/training/tutorials/introduction-to-scientific-visualization-tutorial/the-scientific-visualization-pipeline/

Scientific Visualization Pipeline: Step 5 . . .

Render, Post Process



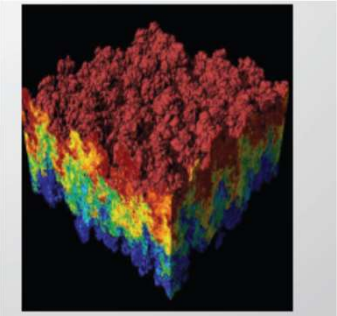


Adopted from
http://www.bu.edu/tech/research/training/tutorials/introduction-to-scientific-visualization-tutorial/the-scientific-visualization-pipeline/

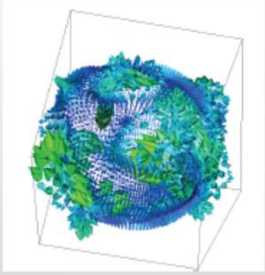
Scientific Visualization Pipeline: Step 6 . . .

View Results

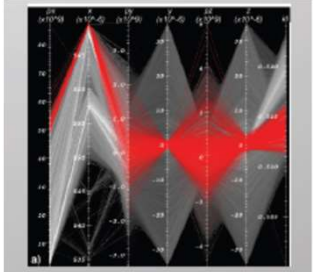
Output from ParaView



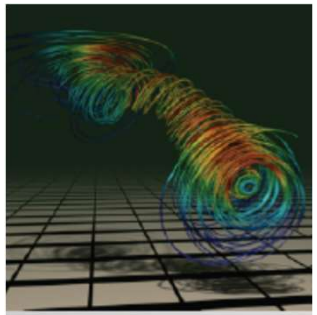
Pseudocolor Rendering



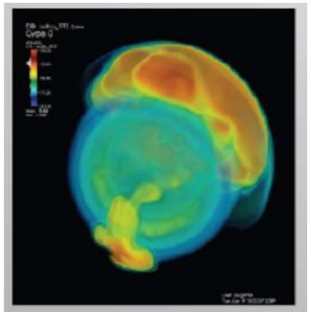
Vector / Tensor Glyphs



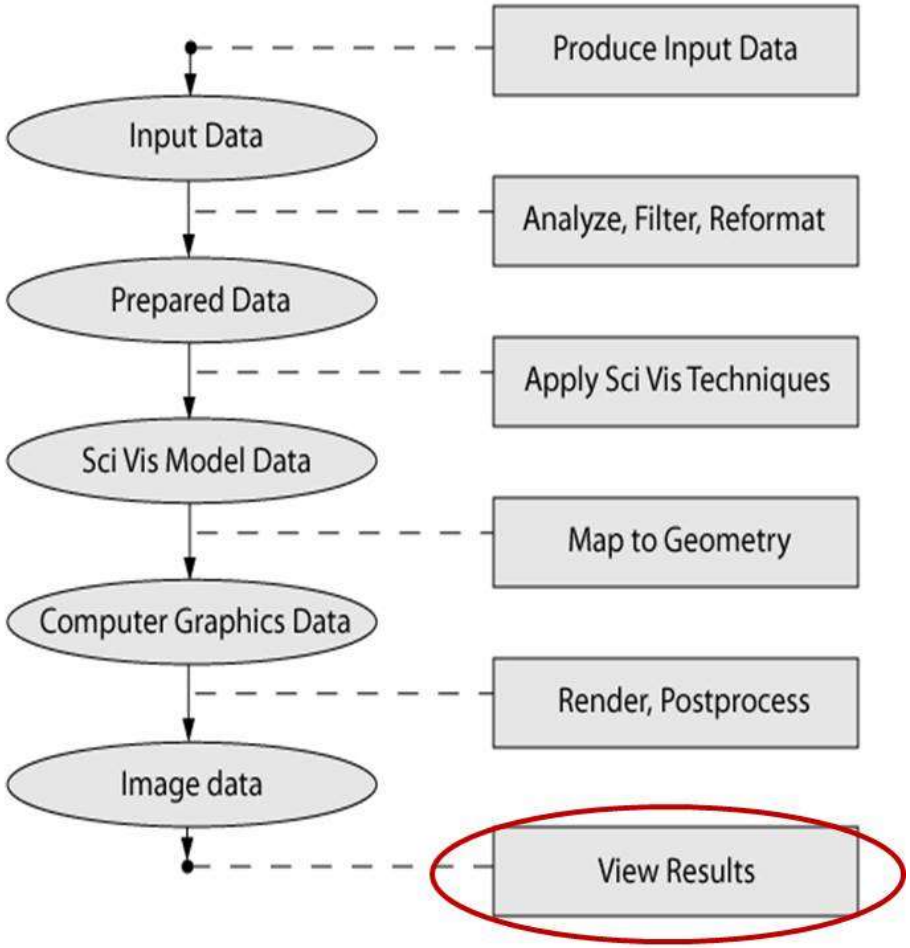
Parallel Coordinates



Streamlines



Volume Rendering



Adopted from http://www.bu.edu/tech/research/training/tutorials/introduction-to-scientific-visualization-tutorial/the-scientific-visualization-pipeline/

Visualization Scales with HPC

Large data produced by large simulations produce large visualization results and require large visualization resources

Resampling, Application, . . .

Resolution to Capture Feature Detail

Visualization Toolkit (VTK)

- Open source, multiplatform
- Supports distributed computation models
- Extensible modular architecture
- Available for 3D computer graphics, image processing and visualization

- Collection of C++ libraries
- Leveraged by many applications
- Divided into logical areas
  - Filtering
  - Information Visualization
  - Volume Rendering
- Cross platform, using OpenGL
- Wrapped in Python, Tool Command Language (Tcl) and Java

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Visualization Toolkit (VTK)

ParaView is an end-user application with support for

- Parallel Data Archiving
- Parallel Reading
- Parallel Processing
- Parallel Rendering
- Single node, Client-Server, MPI Cluster Rendering

ParaView

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More ParaView Features

Feature	Paraview
Standalone GUI	Yes
Scriptable (Python)	Yes
API	C++, Python
Ability to Embed Graphics window custom GUI	Yes (with C++ API and Qt GUI)
Plugin Architecture	Yes

http://www.mantidproject.org/Visit_vs_Paraview

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Introduction to Scientific Visualization Using

ParaView

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ParaView

- Multi-platform parallel data analysis and visualization application
- Mature, feature-rich interface
- Good for general purpose, rapid visualization

Mac

Windows

Linux

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Current Funding

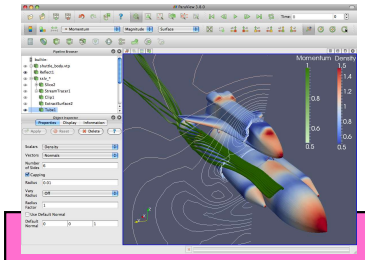
- ARL
- ERDC
- US Army (SBIR)
- US Air Force (STTR)
- ONR
- Support Contracts
  - Electricity de France
  - Microsoft

- Other contributors
  - Swiss National Supercomputing Centre
  - DOE SLAC
  - Ohio State
  - Mississippi State
  - RPI

Data Ranges

- Used for all ranges of data size.
- Landmarks of usage:
  - 6 billion structured cells (2005).
  - 250 million unstructured cells (2005).
  - Billions of AMR cells (2008).
  - Scaling test over 1 Trillion cells (2010).
  - 6.33 billion unstructured cells in Catalyst (2016).

ParaView Application Architecture

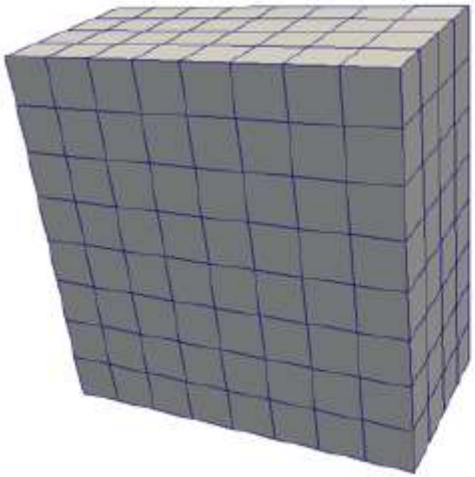


ParaView Client	pvpython	ParaWeb	Catalyst	Custom App
UI (Qt Widgets, Python Wrappings)				
ParaView Server				
VTK				
OpenGL	MPI	IceT	Etc.	

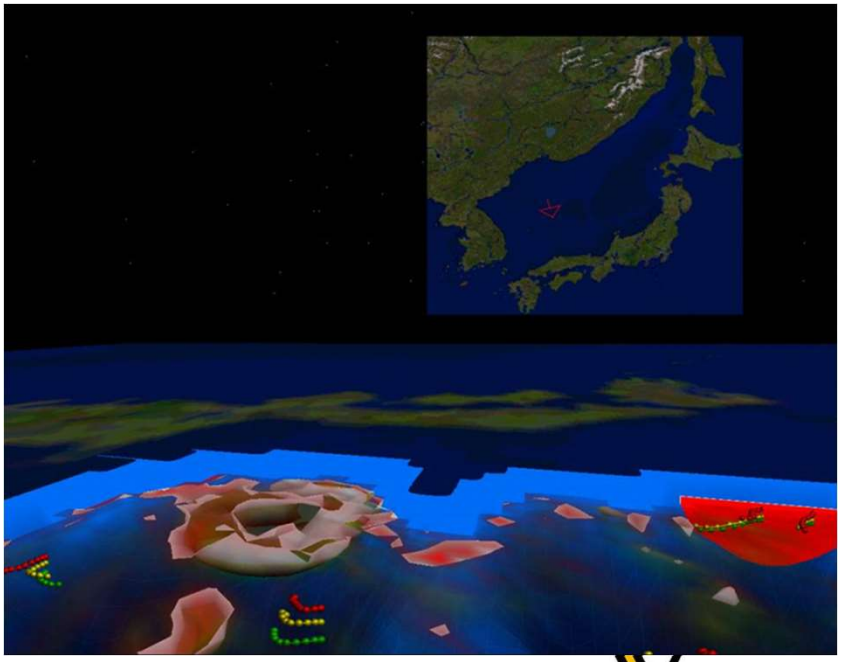
ParaView Development

- Started in 2000 as collaborative effort between Los Alamos National Laboratories and Kitware Inc. Sandia has been a major contributor since 2005.
  - ParaView 0.6 released October 2002.
- Paraview 3.0 release in May 2007.
  - GUI rewritten to be more user friendly and powerful.
- ParaView 4.0 released in June 2013.
  - Properties panel redesign for smoother interaction.
- ParaView 5.0 released in January 2016.
  - Updated to OpenGL 3.2 features. Huge performance improvements.
- ParaView 5.4 latest version

Supported Data Types



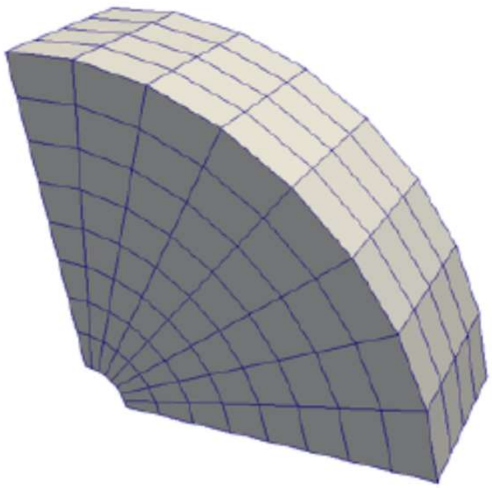
Uniform Rectilinear (Image Data)
A uniform rectilinear grid is a one- two- or three- dimensional array of data. The points are orthonormal to each other and are spaced regularly along each direction.



Grid – regular structure, all voxels (cells) are the same size and shape

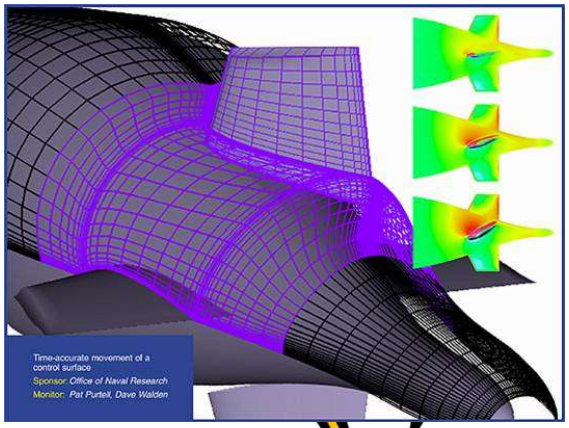
Adopted from The ParaView Tutorial, The Basics of Visualization, version 3.98

Supported Data Types



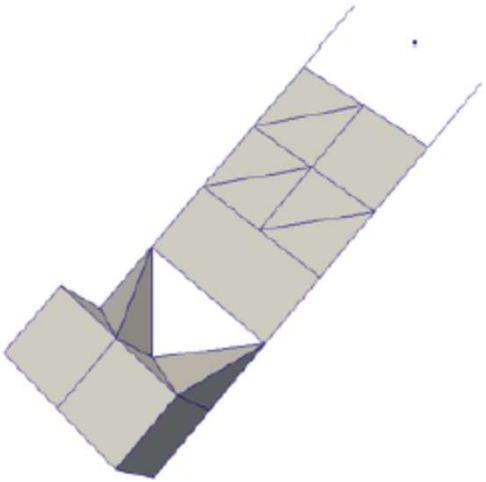
Curvilinear (Structured Grid)
Curvilinear grids have the same topology as rectilinear grids. However, each point in a curvilinear grid can be placed at an arbitrary coordinate (provided that it does not result in cells that overlap or self intersect). Curvilinear grids provide the more compact memory footprint and implicit topology of the rectilinear grids, but also allow for much more variation in the shape of the mesh.

Curvilinear – regularly gridded mesh shaping function applied



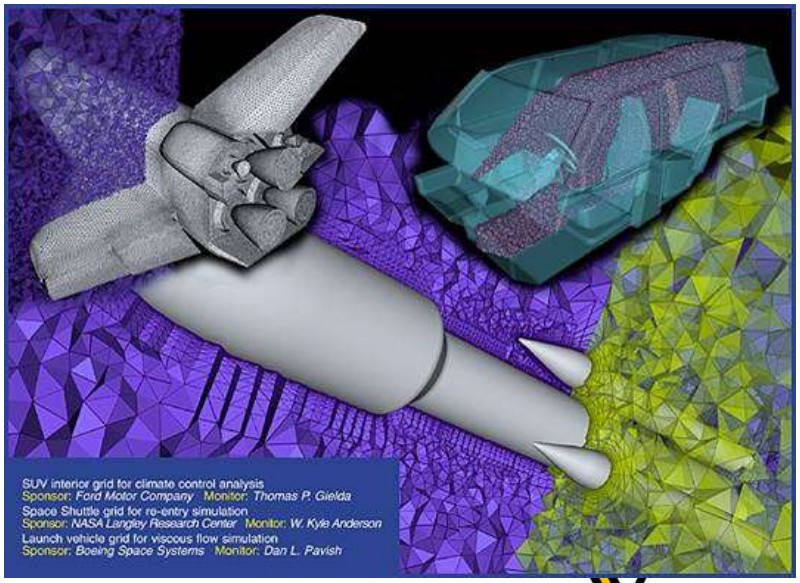
Adopted from The ParaView Tutorial, The Basics of Visualization, version 3.98

ParaView Supported Data Types



Unstructured Grid
Unstructured data sets are composed of points, lines, 2D polygons, 3D tetrahedra, and nonlinear cells. They are similar to polygonal data except that they can also represent 3D tetrahedra and nonlinear cells, which cannot be directly rendered.

Unstructured grid – irregular mesh typically composed of tetrahedra, prisms, pyramids, or hexahedra



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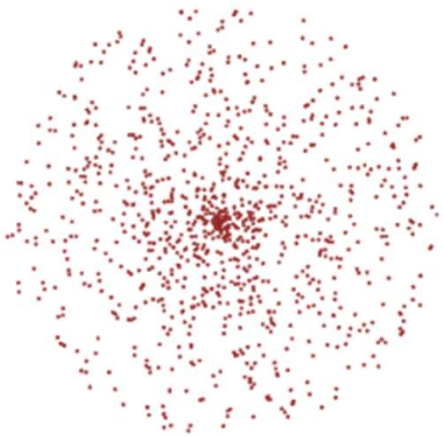
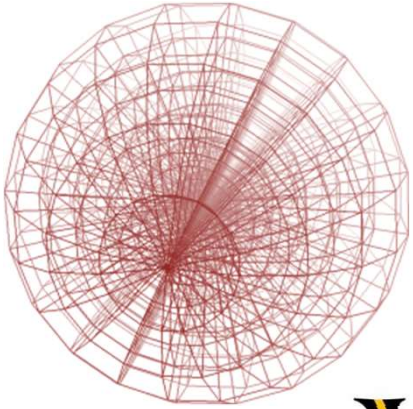
Adopted from The ParaView Tutorial, The Basics of Visualization, version 3.98

Supported Data Types

- Point data
- Polygonal data
- Images
- Multi-block
- Adaptive Mesh Refinement (AMR)
- Time series support





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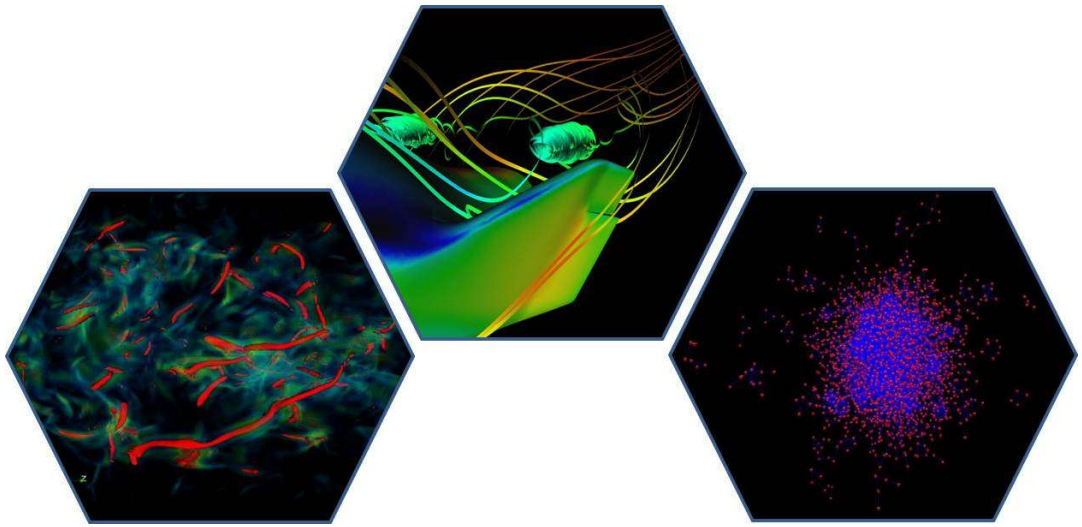
SUPPORTED VISUALIZATION ALGORITHMS

- Isosurfaces
- Cutting planes
- Streamlines
- Glyphs
- Volume rendering
- Clipping
- Height maps
- & more

ParaView



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ParaView SPECIAL FEATURES

- Supports derived variables
- Scriptable via Python
- Saves animations
- Can run in parallel / distributed mode for large data visualization

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ParaView SUPPORTED FILE FORMATS

- ParaView Data (.pvd)
- VTK (.vtp, .vtu, .vti, .vts, .vtr)
- VTK Legacy (.vtk)
- VTK Multi Block (.vtm, .vtmb, .vtmg, .vthd, .vthb)
- Partitioned VTK (.pvtu, .pvti, .pvts, .pvtr)
- ADAPT (.nc, .cdf, .elev, .ncd)
- ANALYZE (.img, .hdr)
- ANSYS (.inp)
- AVS UCD (.inp)
- BOV (.bov)
- BYU (.g)
- CCSM MTSD (.nc, .cdf, .elev, .ncd)
- CCSM STSD (.nc, .cdf, .elev, .ncd)
- CEAucd (.ucd, .inp)
- CMAT (.cmat)
- CTRL (.ctrl)
- Chombo (.hdf5, .h5)
- Claw (.claw)
- Comma Separated Values (.csv)
- Cosmology Files (.cosmo, .gadget2)
- Curve2D (.curve, .ultra, .ult, .u)
- DDCMD (.ddcmd)
- Digital Elevation Map (.dem)
- Dyna3D(.dyn)
- EnSight (.case, .sos)
- Enzo boundary and hierarchy
- ExodusII (.g, .e, .exe, .ex2, .ex2v.., etc)
- ExtrudedVol (.exvol)
- FVCOM (MTMD, MTSD, Particle, STSD)
- Facet Polygonal Data
- ProSTAR (.cel, .vrt)
- Protein Data Bank (.pdb, .ent, .pdb)
- Raw Image Files
- Raw NRRD image files (.nrrd)
- SAMRAI (.samrai)
- SAR (.SAR, .sar)
- SAS (.sasgeom, .sas, .sasdata)
- SESAME Tables
- SLAC netCDF mesh and mode data
- SLAC netCDF particle data
- Silo (.silo, .pdb)
- Spheral (.spheral, .sv)
- SpyPlot CTH
- Spy Plot (.case)
- Stereo Lithography (.stl)
- TFT Files
- TIFF Image Files
- TSurf Files

Many more . . .

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VISUALIZATION PIPELINE

- All processing operations (filters) produce data sets
- Can further process the result of every operation to build complex visualizations
  - Extract a cutting plane,
  - Apply glyphs (i.e. vector arrows) to the result
    - Gives a plane of glyphs through your 3D volume

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VISUALIZING DATA USING PARAVIEW

Three Basic Steps:

- First your data must be **read** into ParaView
- Next, you may apply any number of **filter**s that process the data to generate, extract, or derive features from the data
- Finally, a viewable image is **render**ed from the data

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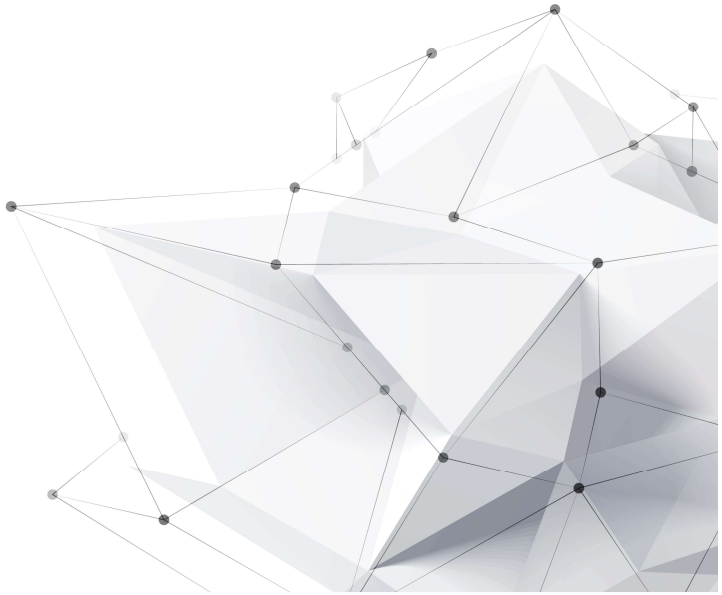
ParaView 5.8

Let's get started . . . .



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Training Data

Webinar training data available on the Webinar Website

GETTING STARTED WITH PARAVIEW

ParaView

Bluewaters Webinar: Introduction to ParaView
Estimated time: 1 hr

Summary: This seminar provides an introduction to scientific visualization using ParaView. An overview of the visualization process is presented by exploring the scientific visualization pipeline followed by hands on experience with ParaView. ParaView is an open-source, multi-platform, parallel data analysis and visualization application built upon the Visualization Toolkit (VTK) Library. Participants will work with a small dataset (provided) to become familiar with ParaView functions and capabilities.

SUMMER WEBINAR FILES

ParaView 5.8 [Download]

Data files:
headsq.vti
Rectgrd2.vtk

Additional training data files can be downloaded from the ParaView Website

https://www.paraview.org/Wiki/The_ParaView_Tutorial

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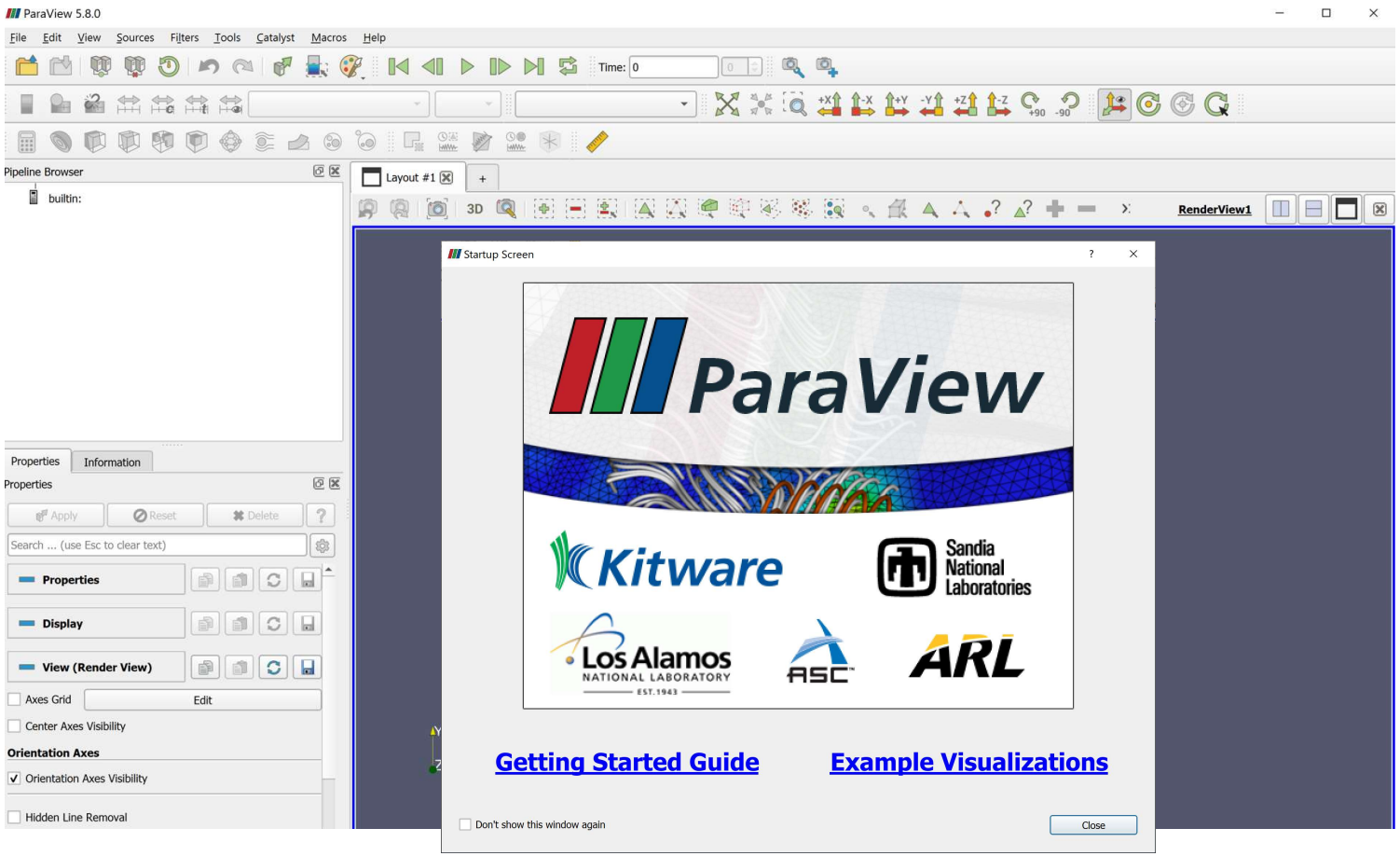
Basic Usage

ParaView User Interface



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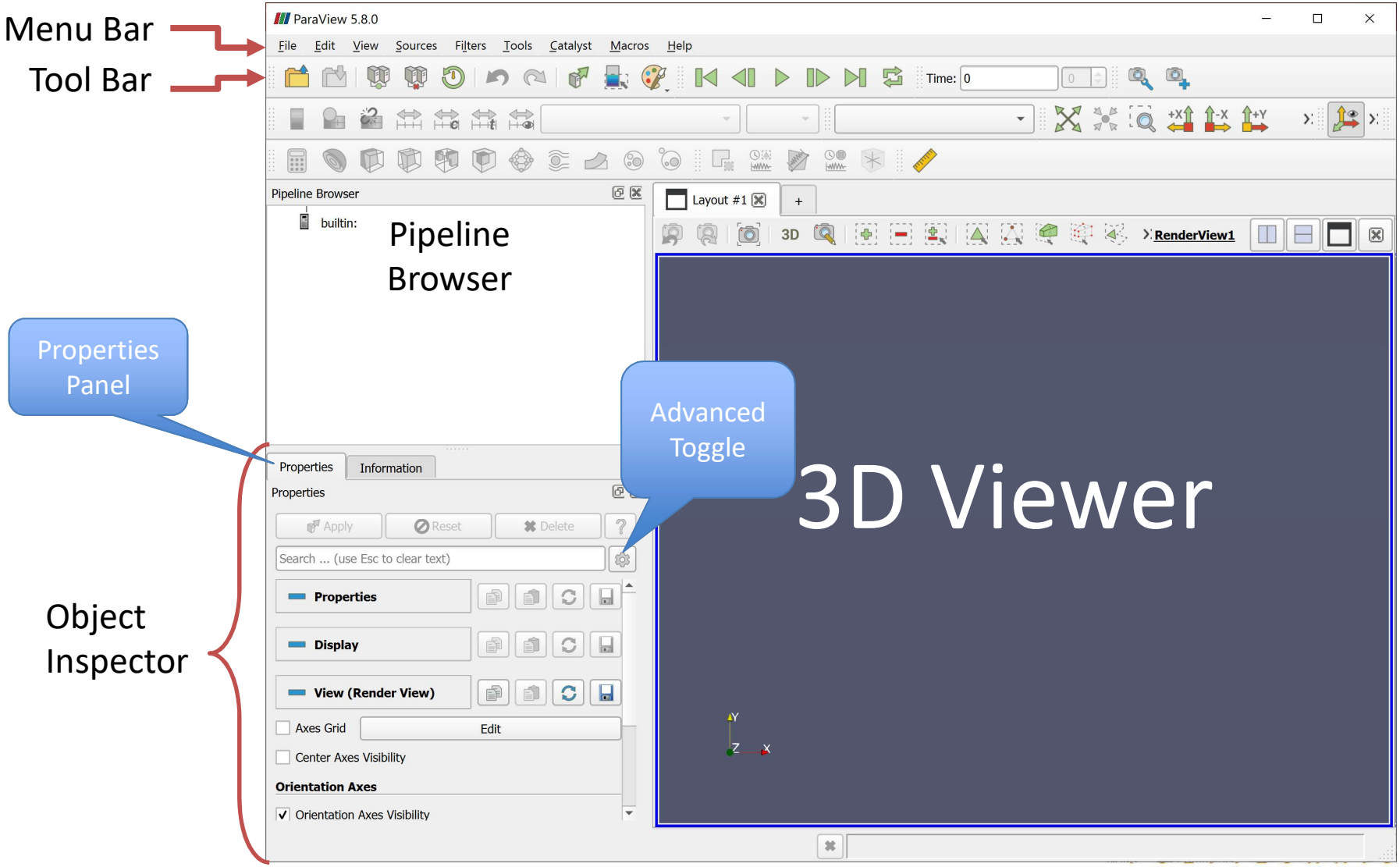
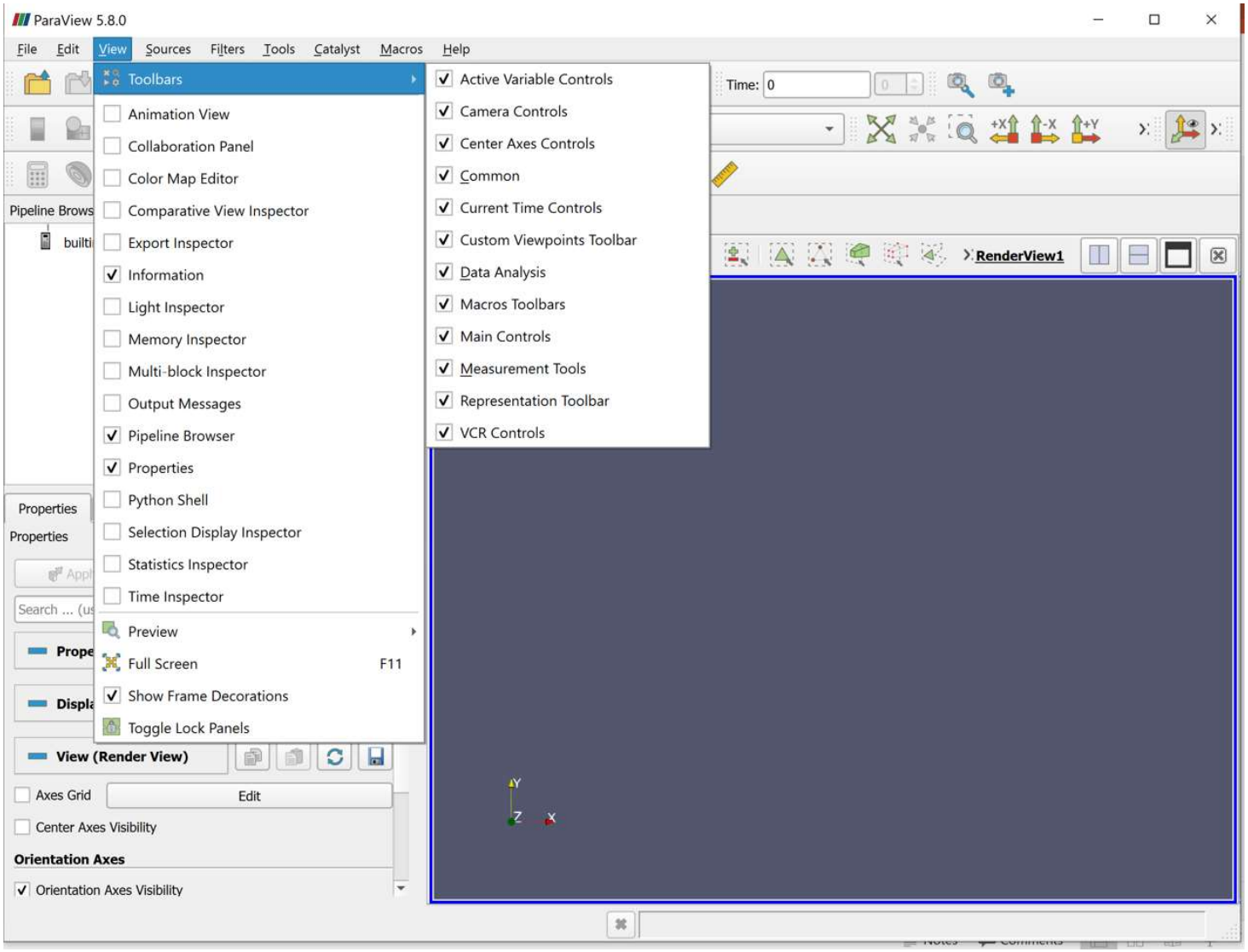
ParaView User Interface

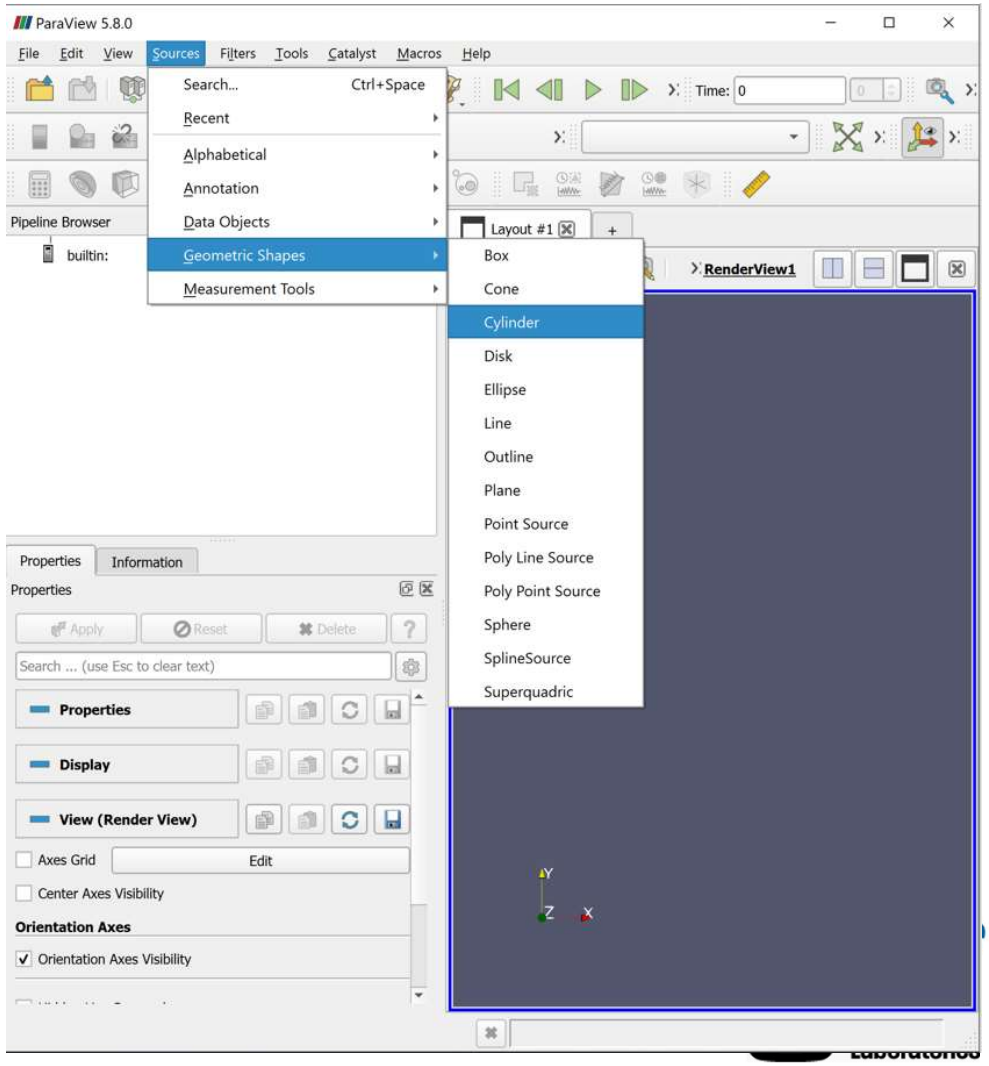


Getting Back GUI Components



Creating a Cylinder Source

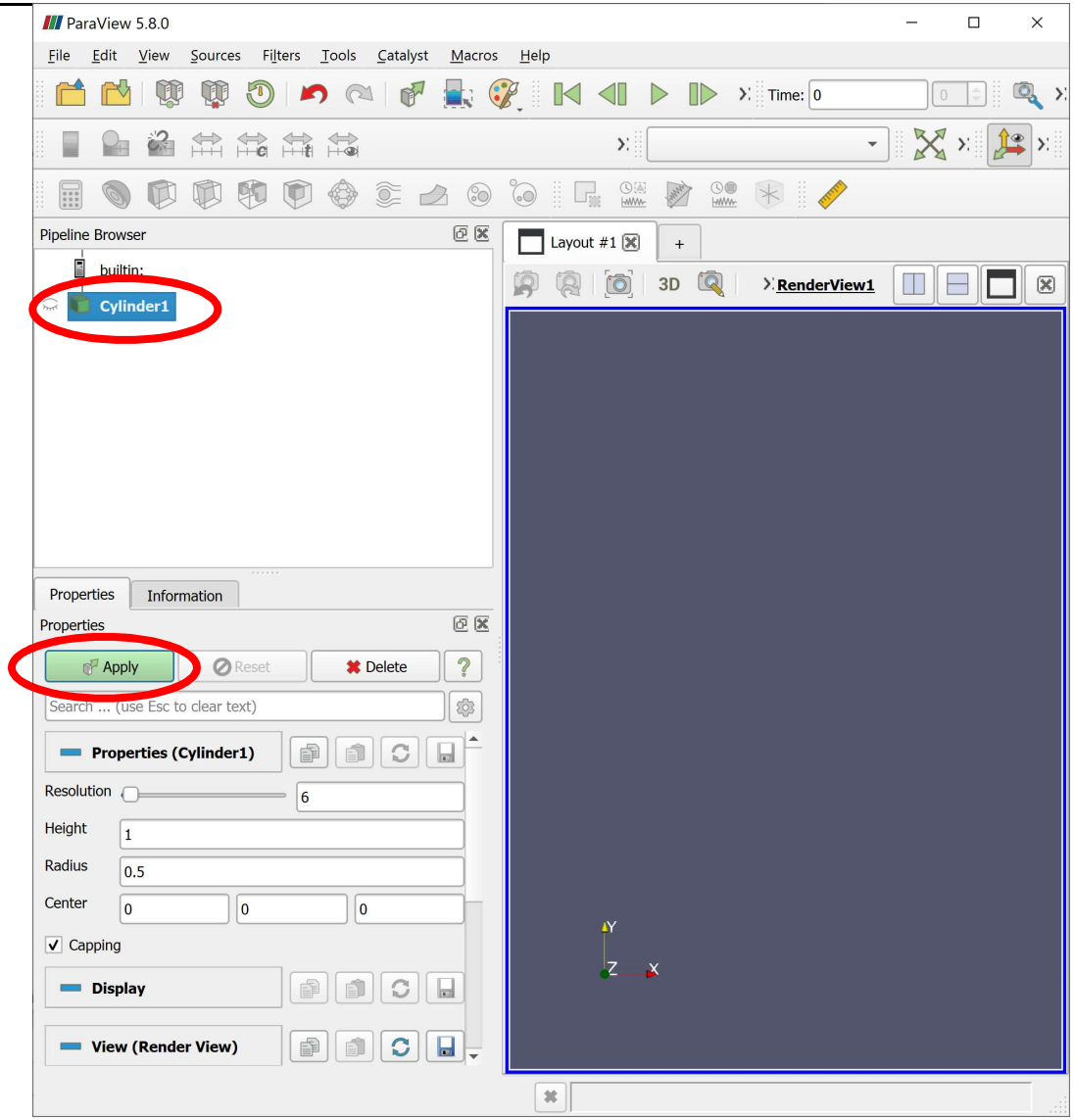
1. Go to the Sources menu.
2. Select Geometric Shapes.
3. Select Cylinder



Creating a Cylinder Source

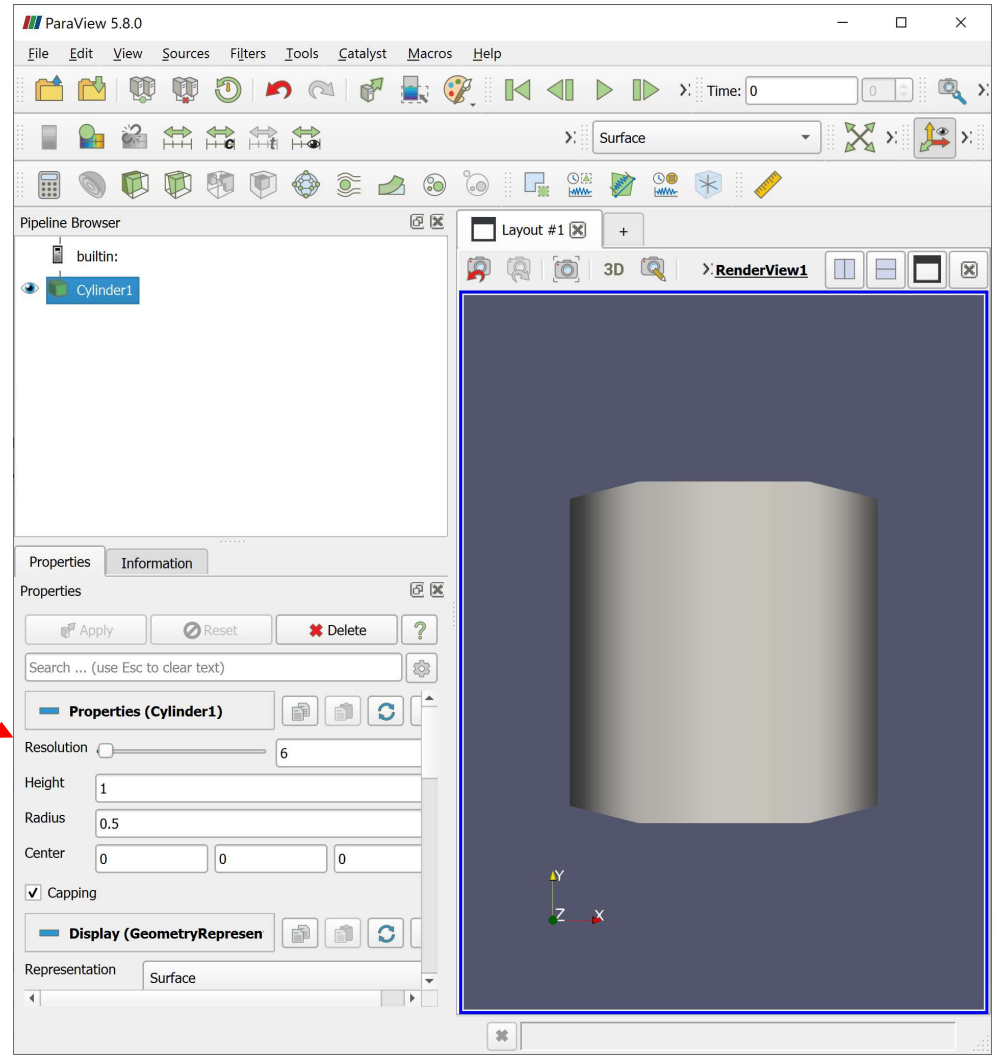
- A cylinder1 object should appear in the pipeline browser

Click the Apply button to accept the default parameters.



Creating a Cylinder Source

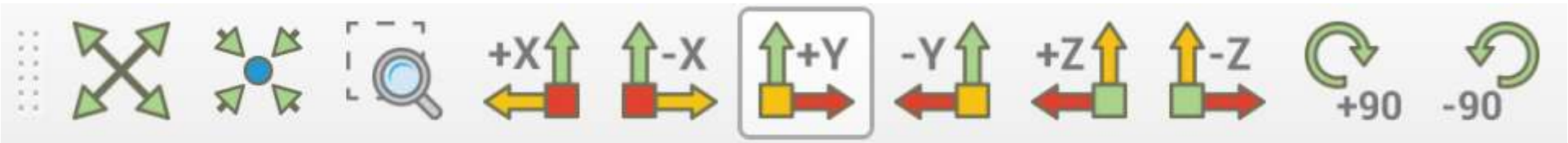
- Explore the resolution feature by adjusting the Resolution slider or type in a value



Click the Apply button to accept changes.

Simple Camera Manipulation

- Drag left, middle, right buttons for rotate, pan, zoom.
  - Also use Shift, Ctrl, Alt modifiers.
  - Also try holding down x, y, or z.



Pipeline Object Controls

Using Auto Apply

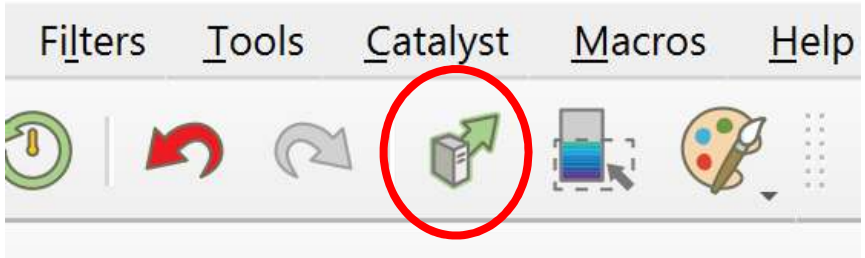
1. Click Auto Apply. 
2. Change the Resolution parameter again. 

3. Note that the visualization automatically updates without having to hit Apply.

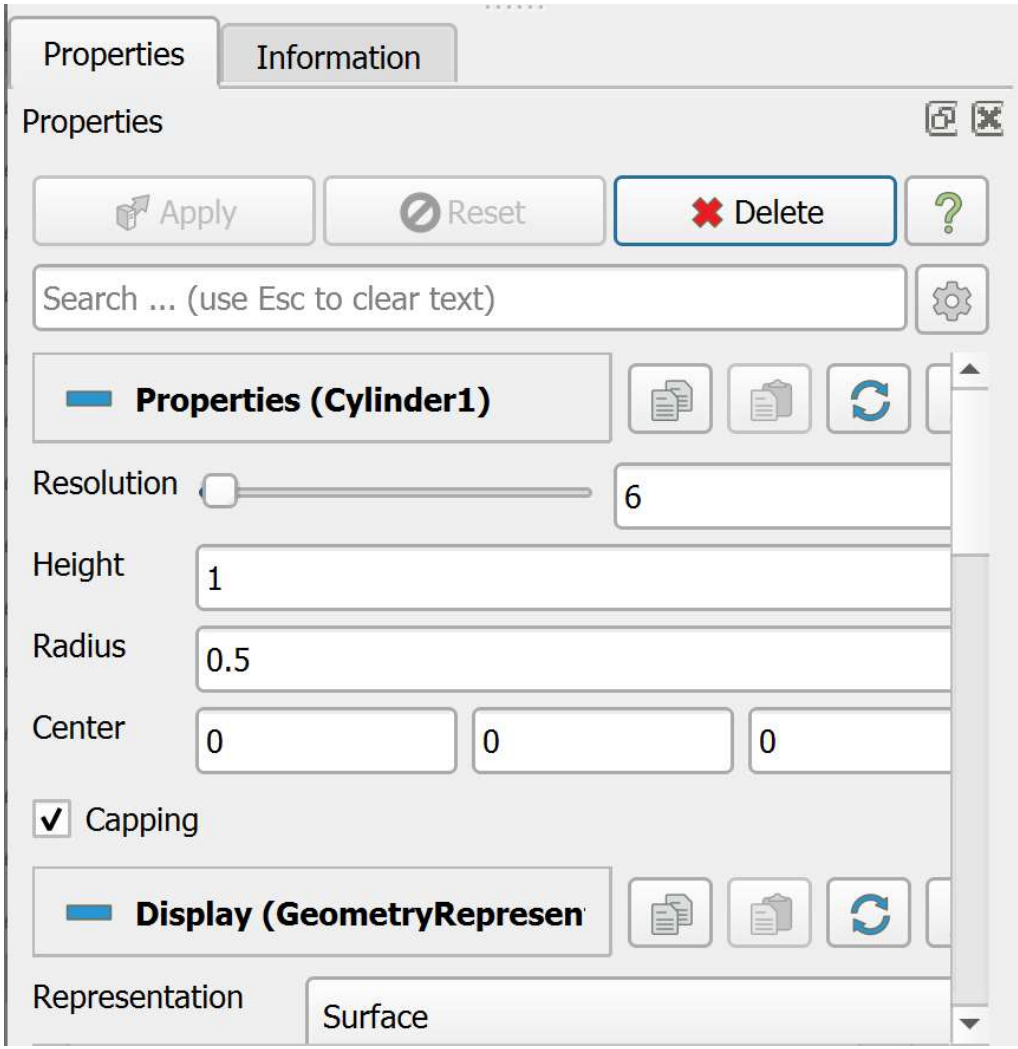
Using Auto Apply

1. Click  to apply changes to parameters automatically.
2. Change the Resolution parameter again. 

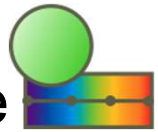
3. Note that the visualization automatically updates without having to hit Apply.

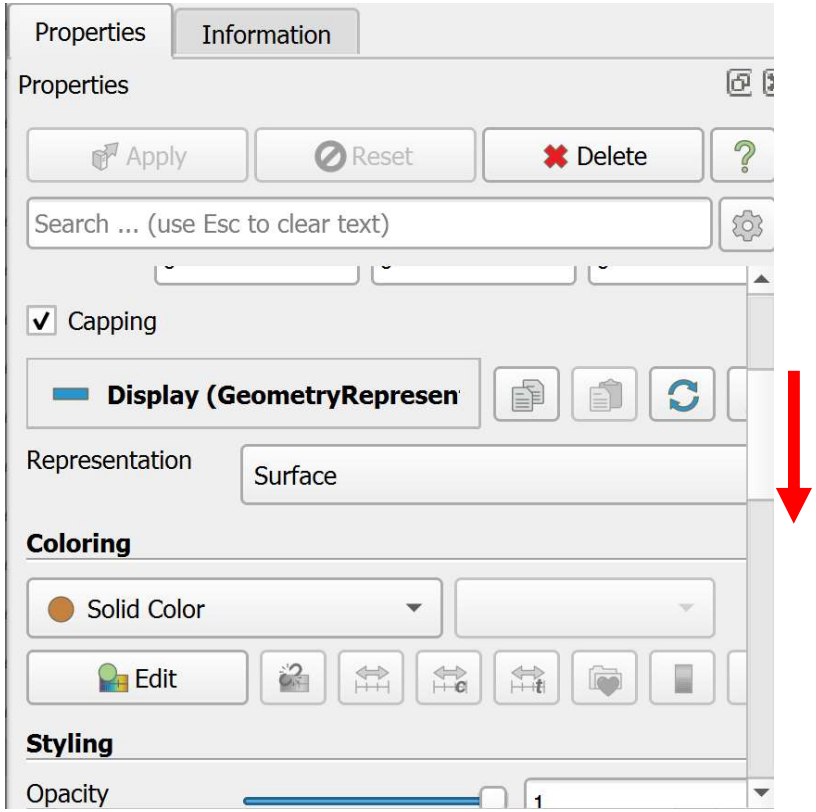


Display Properties

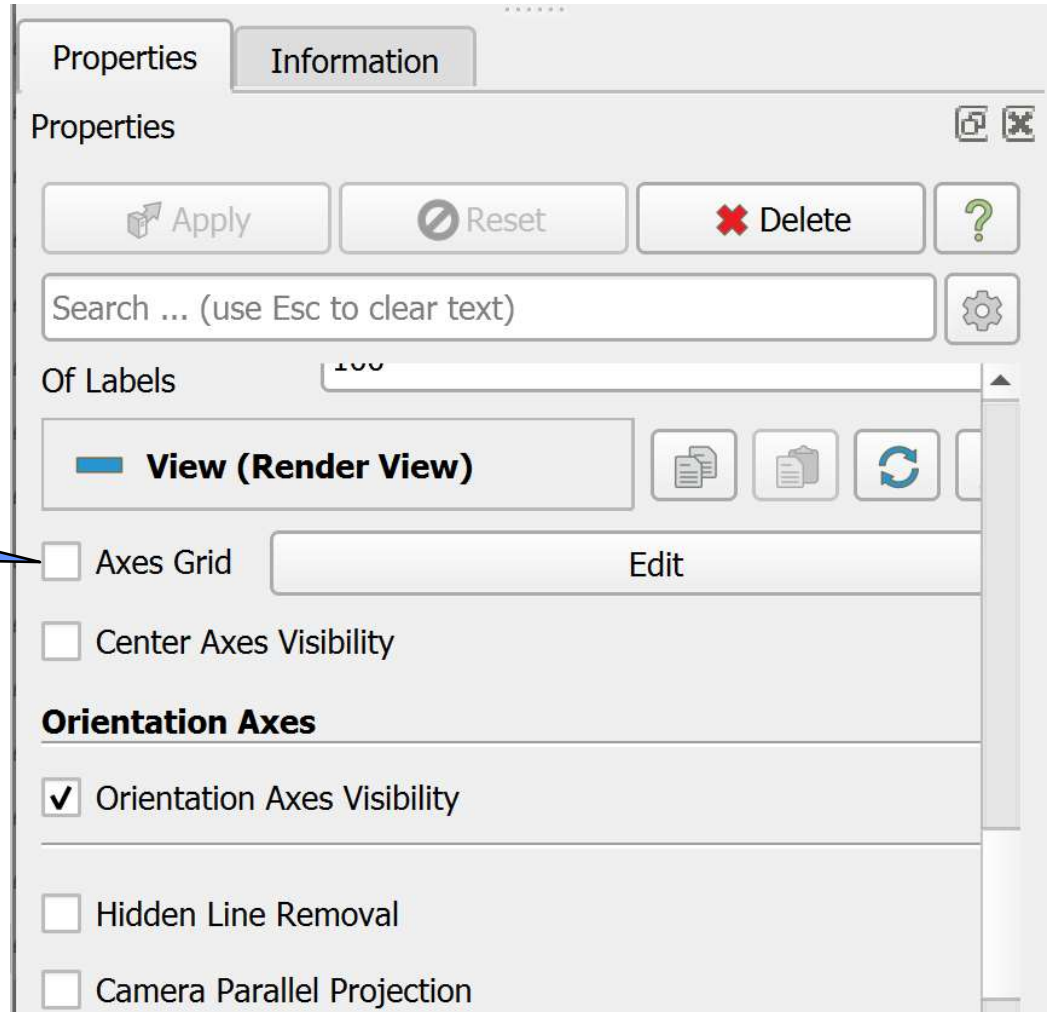


Change Render Properties

1. Scroll down to the Display (Geometry Representation) section.
2. Click the  Edit button. (This button is replicated in the toolbar.)
3. Select a new color for the cylinder and click OK



Render View Options

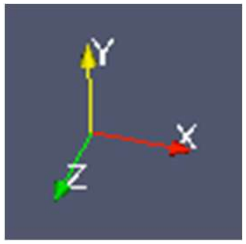


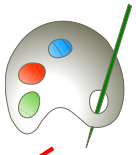
Check to turn on the Axis Grid

Scroll down

Changing the Color Palette

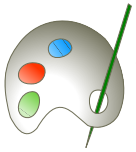
1. Make sure the orientation axes are visible in the lower left corner. 



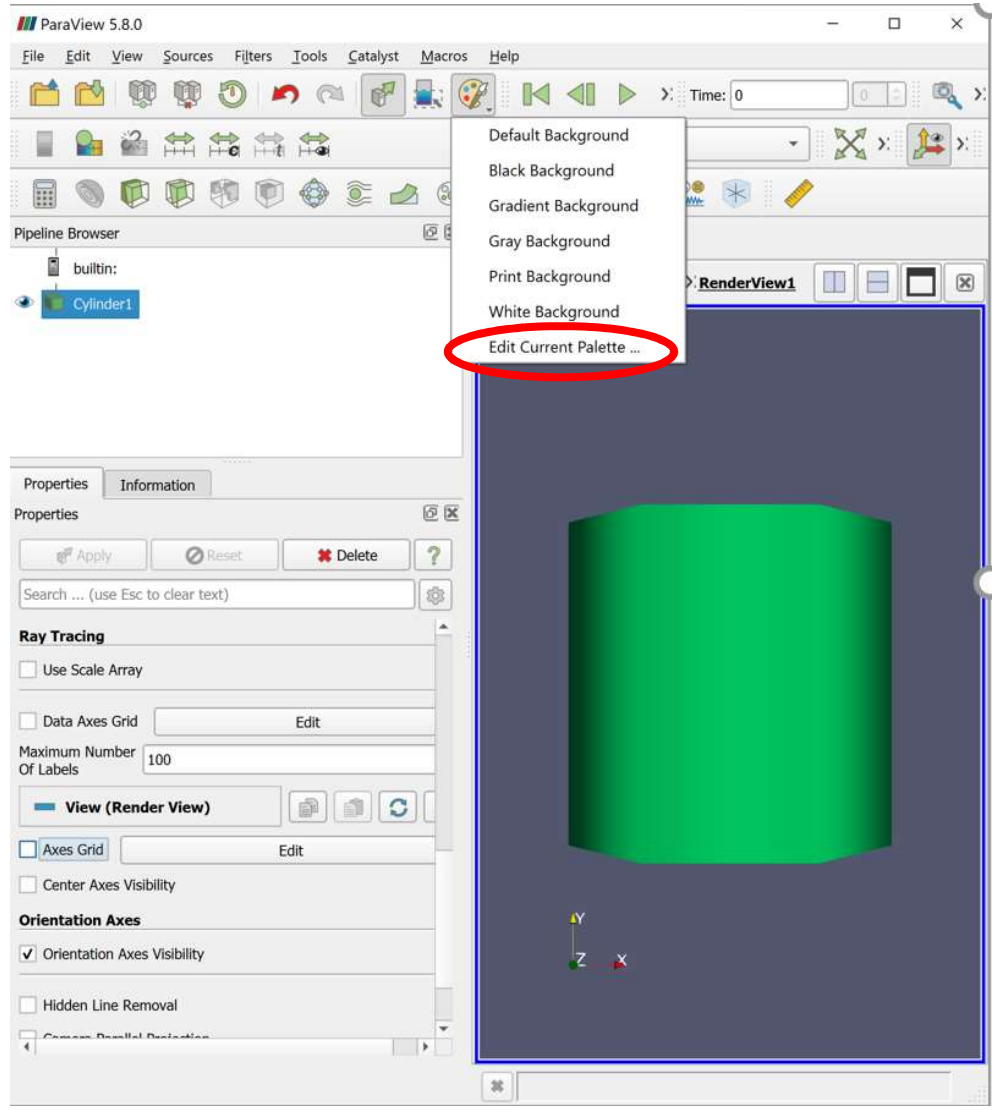
2. Click the color palette button  and change the colors.

3. Try several color palettes or edit the current color palette

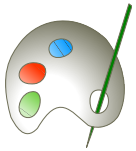
Color Palettes



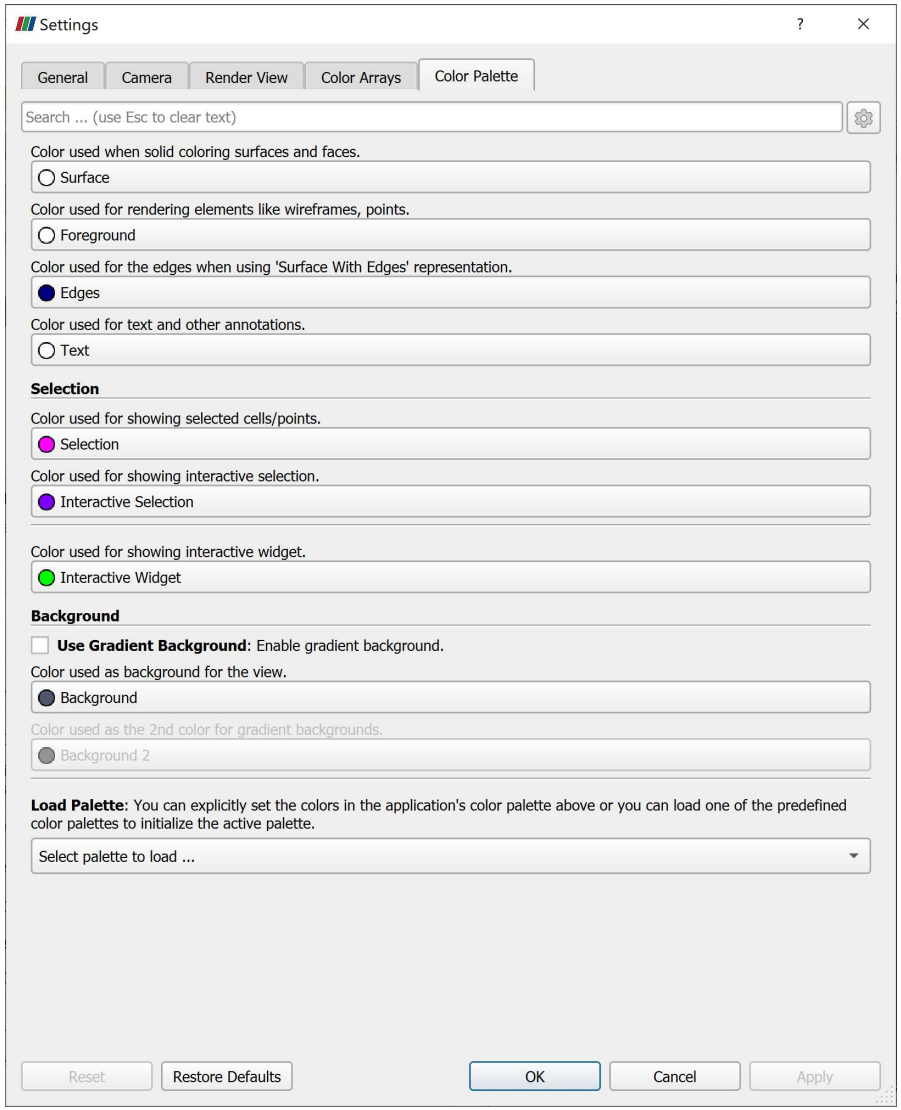
→ Edit Current Palette…



Color Palettes

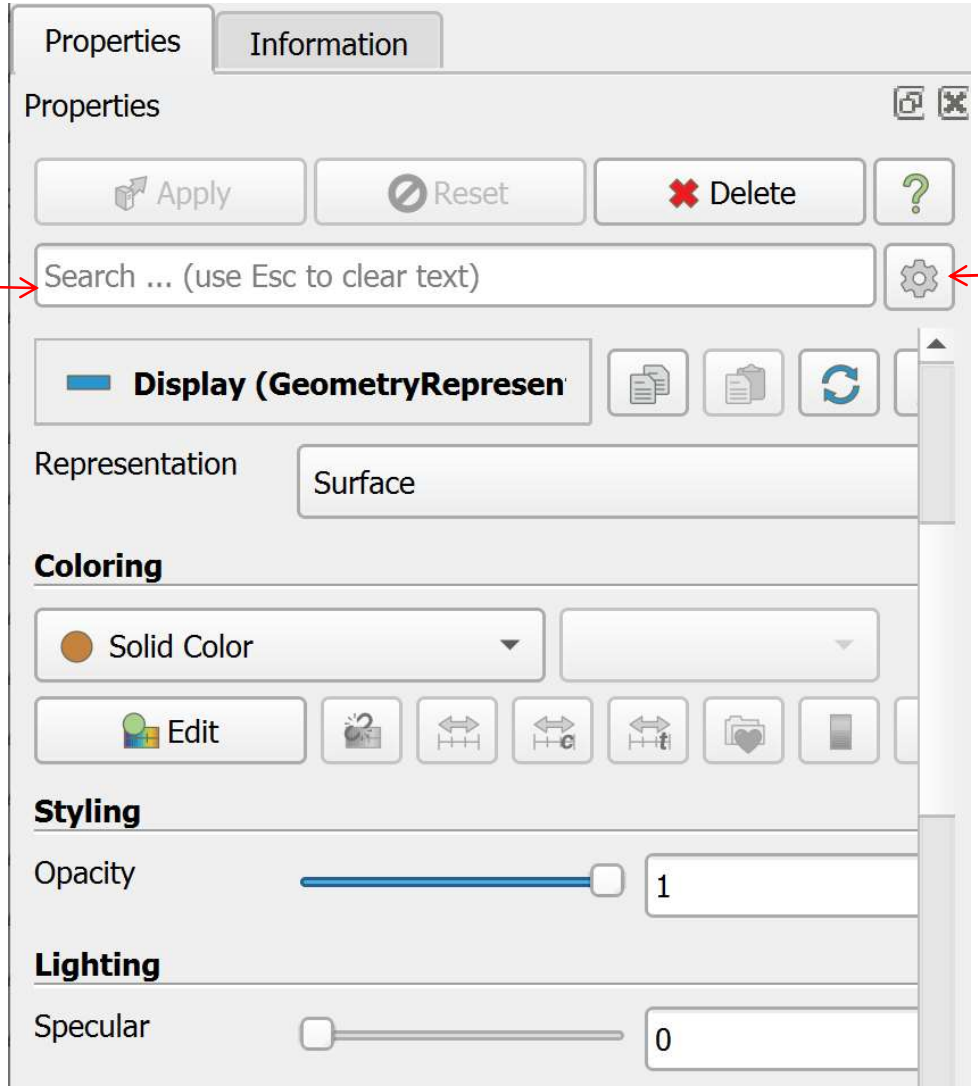


→ Edit Current Palette…



Advanced Properties

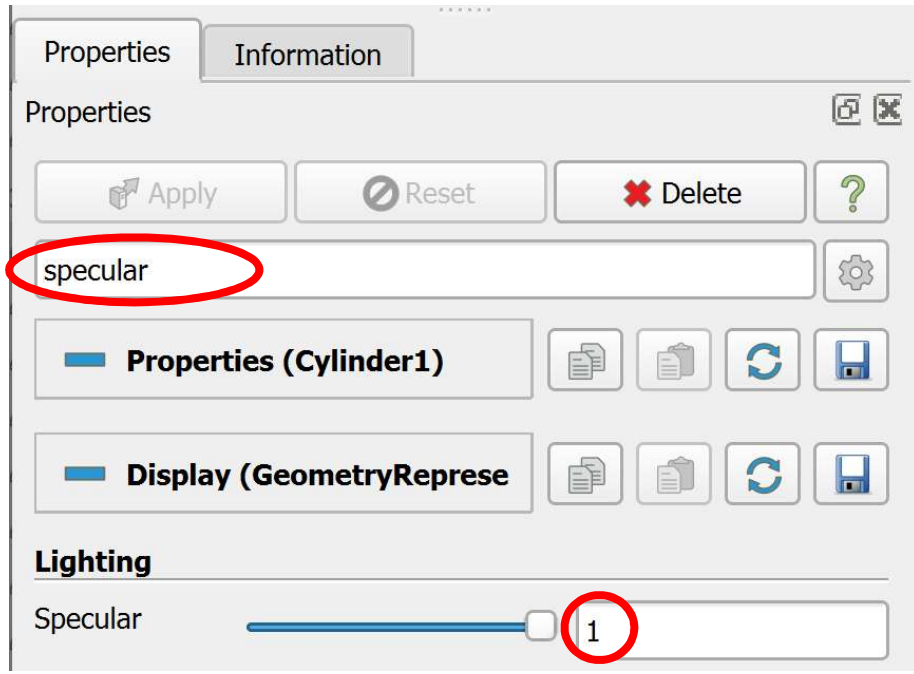
Search Properties



Toggle Advanced Properties

Searching Properties

1. Type “specular” in the properties search box
2. Changing Specular value to 1 (makes the cylinder shiny)



Try typing in the following in to the search box (one at time) to explore other properties:

- Axes Grid
- Opacity
- Lights

Undo Redo

Undo

Redo

Camera Undo

Camera Redo

Creating a Cylinder Source

1. Go to the Sources menu and select Geometric Shapes.
2. Select Cylinder
3. Click the Apply button to accept the default parameters.
4. Increase the Resolution parameter.
5. Click the 

button (if needed) again.
6. Now, delete the Cylinder1 object (make sure it is selected in the pipeline browser)

Training Data

Webinar training data available on the Webinar Website

GETTING STARTED WITH PARAVIEW

ParaView

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Tutorial Datasets

- RectGrid2.vtk
- headsq.vti

<u>Sample data file</u>

- header.txt
- xCoordinates.txt
- yCoordinates.txt
- zCoordinates.txt
- lookUpTable.txt

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What are we going to do?

- Load Data File
- Extract Isosurfaces from the data
- Create contours, clip contours, slice contours
- Volume Rendering
- Saving your Data
- Getting your data into Paraview
- Introduction to ParaView and Python Scripting
- Additional Resources

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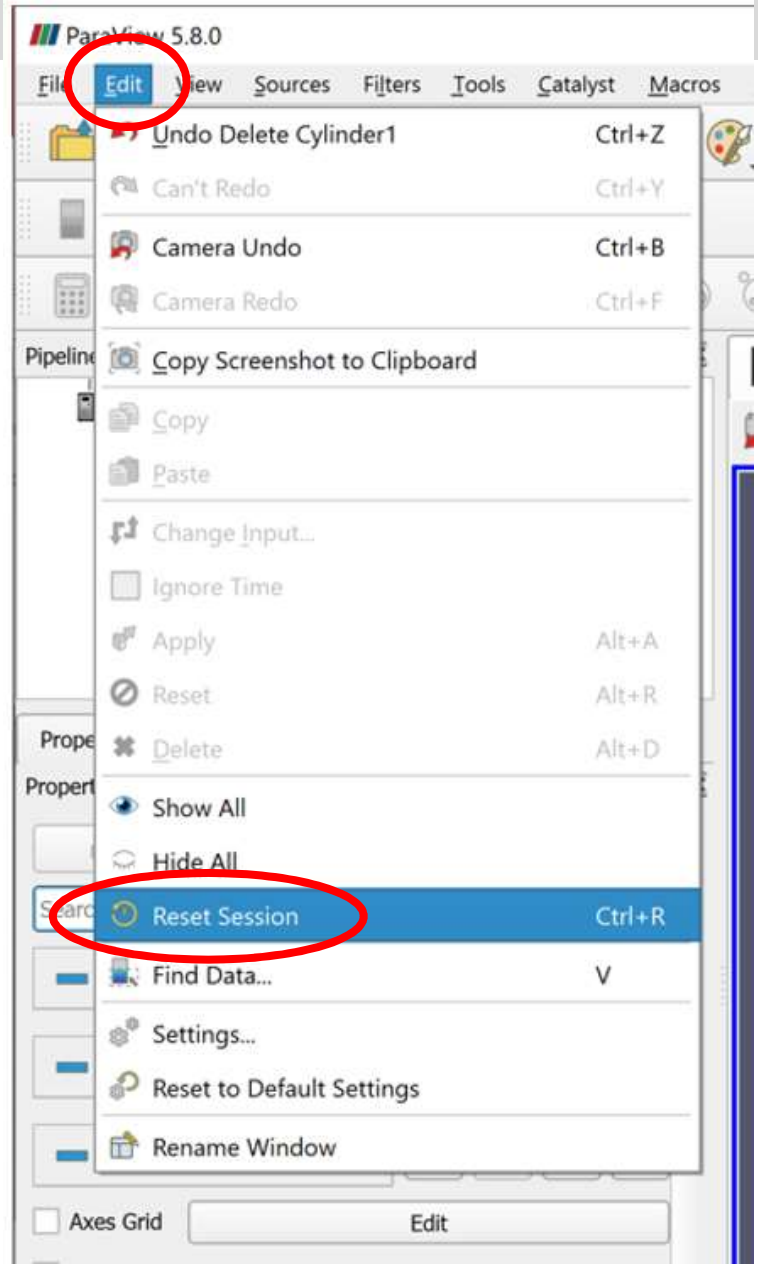
Good to Know

Reset ParaView

Undo Redo

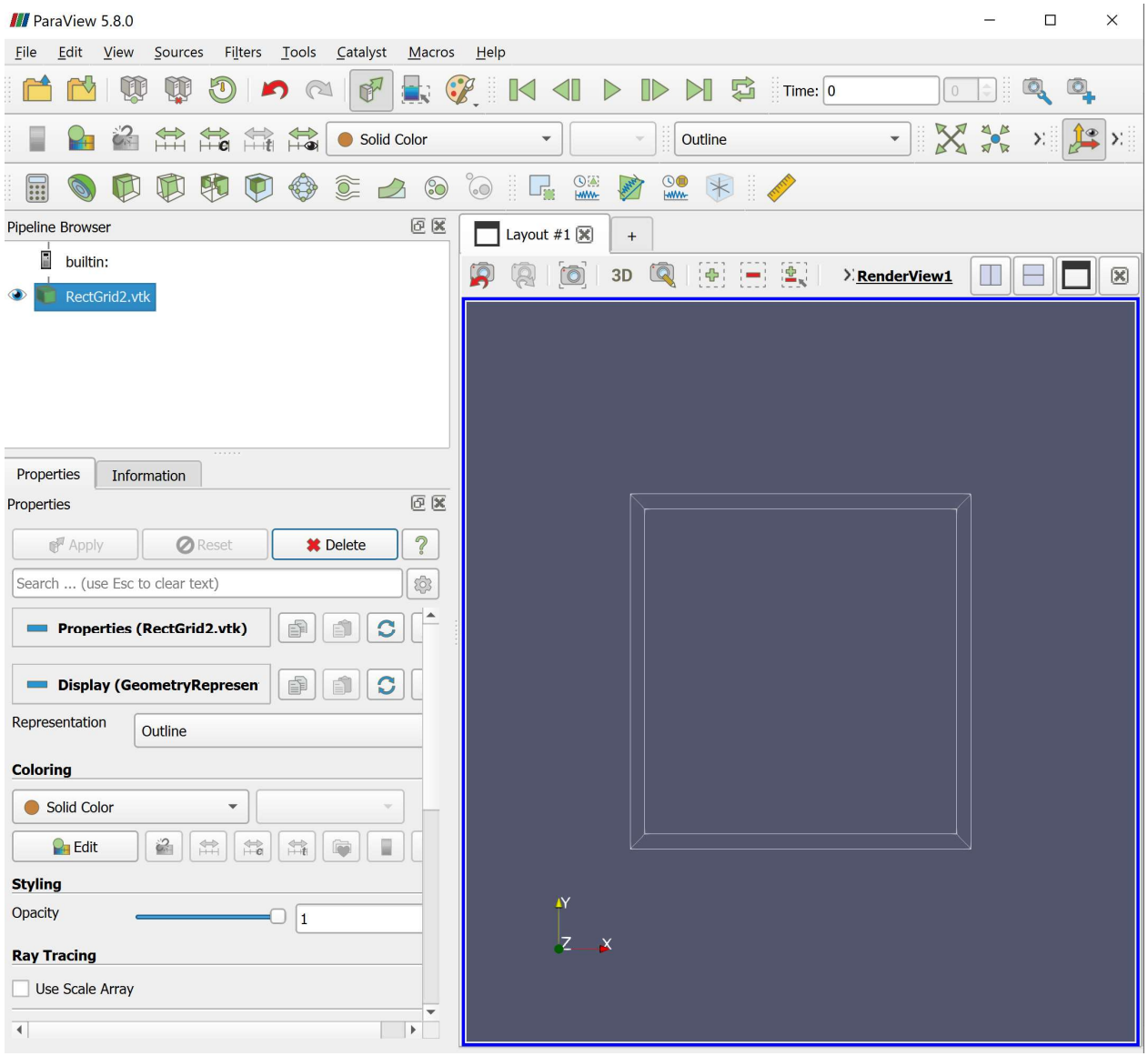
Undo

Redo



Open Data File: RectGrid2.vtk

- Locate **RecGtrid2.vtk**
- Click **File** → **Open**
- Select **RectGrid2.vtk**
- Click **OK**



Sample rectilinear grid

```
# vtk DataFile Version 2.0
Sample rectilinear grid
ASCIIDATASET RECTILINEAR_GRID
DIMENSIONS 47 33 11
X_COORDINATES 47 float
-1.22396 -1.17188 -1.11979 -1.06771 -1.01562 -0.963542
-0.911458 -0.859375 -0.807292 -0.755208 -0.703125 -0.651042
-0.598958 -0.546875 -0.494792 -0.442708 -0.390625 -0.338542
-0.286458 -0.234375 -0.182292 -0.130209 -0.078125 -0.026042
0.0260415 0.078125 0.130208 0.182291 0.234375 0.286458
0.338542 0.390625 0.442708 0.494792 0.546875 0.598958
0.651042 0.703125 0.755208 0.807292 0.859375 0.911458
0.963542 1.01562 1.06771 1.11979 1.17188
Y_COORDINATES 33 float
-1.25 -1.17188 -1.09375 -1.01562 -0.9375 -0.859375
-0.78125 -0.703125 -0.625 -0.546875 -0.46875 -0.390625
-0.3125 -0.234375 -0.15625 -0.078125 0 0.078125
0.15625 0.234375 0.3125 0.390625 0.46875 0.546875
0.625 0.703125 0.78125 0.859375 0.9375 1.01562
1.09375 1.17188 1.25
Z_COORDINATES 11 float
0 0.1 0.2 0.3 0.4 0.5
0.6 0.7 0.75 0.8 0.9
POINT_DATA 17061
SCALARS scalars float
LOOKUP_TABLE default
0 0 0 0 0 0
0 0 0 0 0 0
0 0 0 0 0 0
0 0 0 0 0 0
0 0 0 0 0 0
:
```

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Create Isosurfaces

Contour – extracts the points, curves, or surfaces where a scalar field is equal to a user-defined value.

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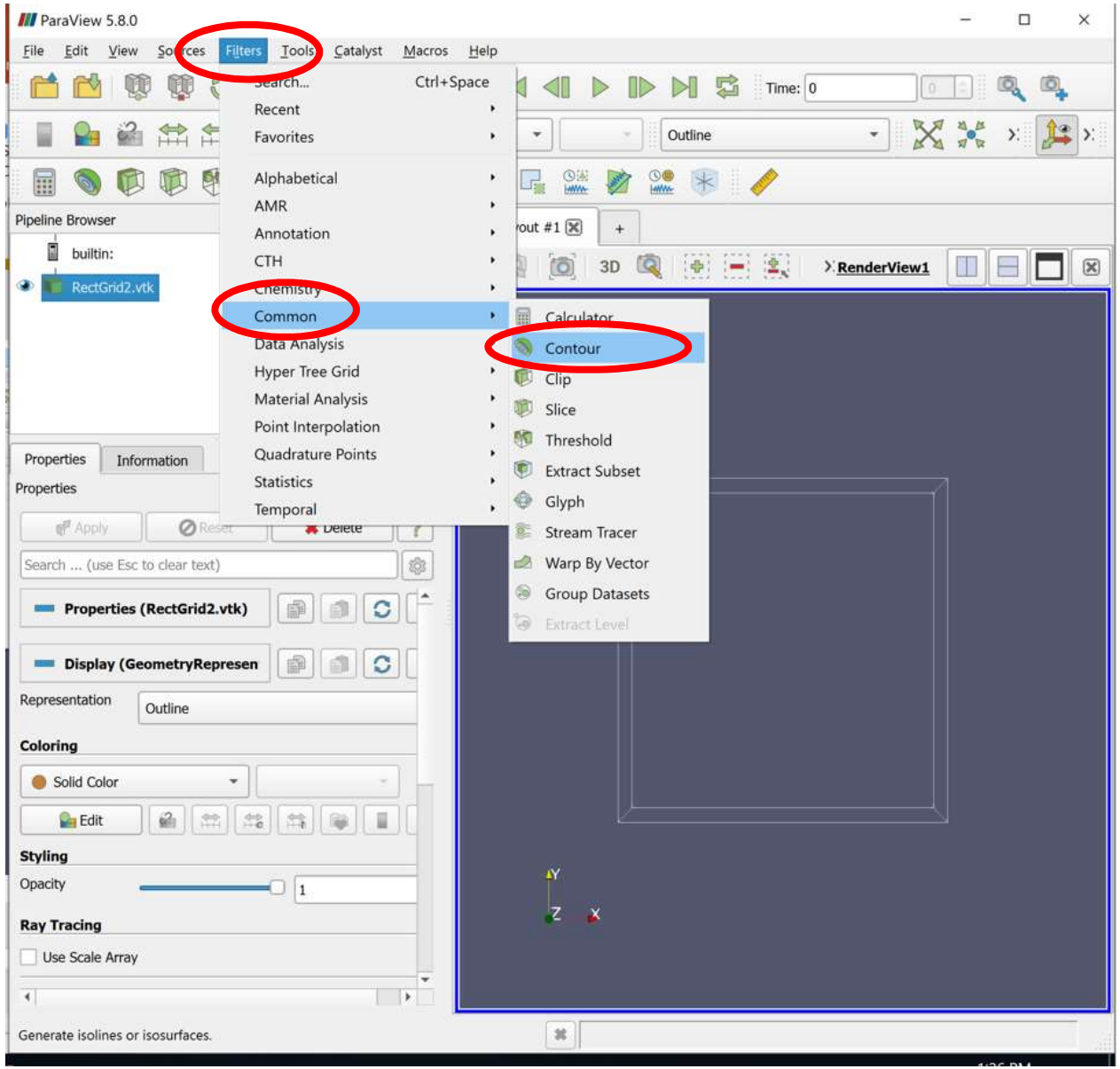
Create Isosurface

Click on RectGrid2.vtk

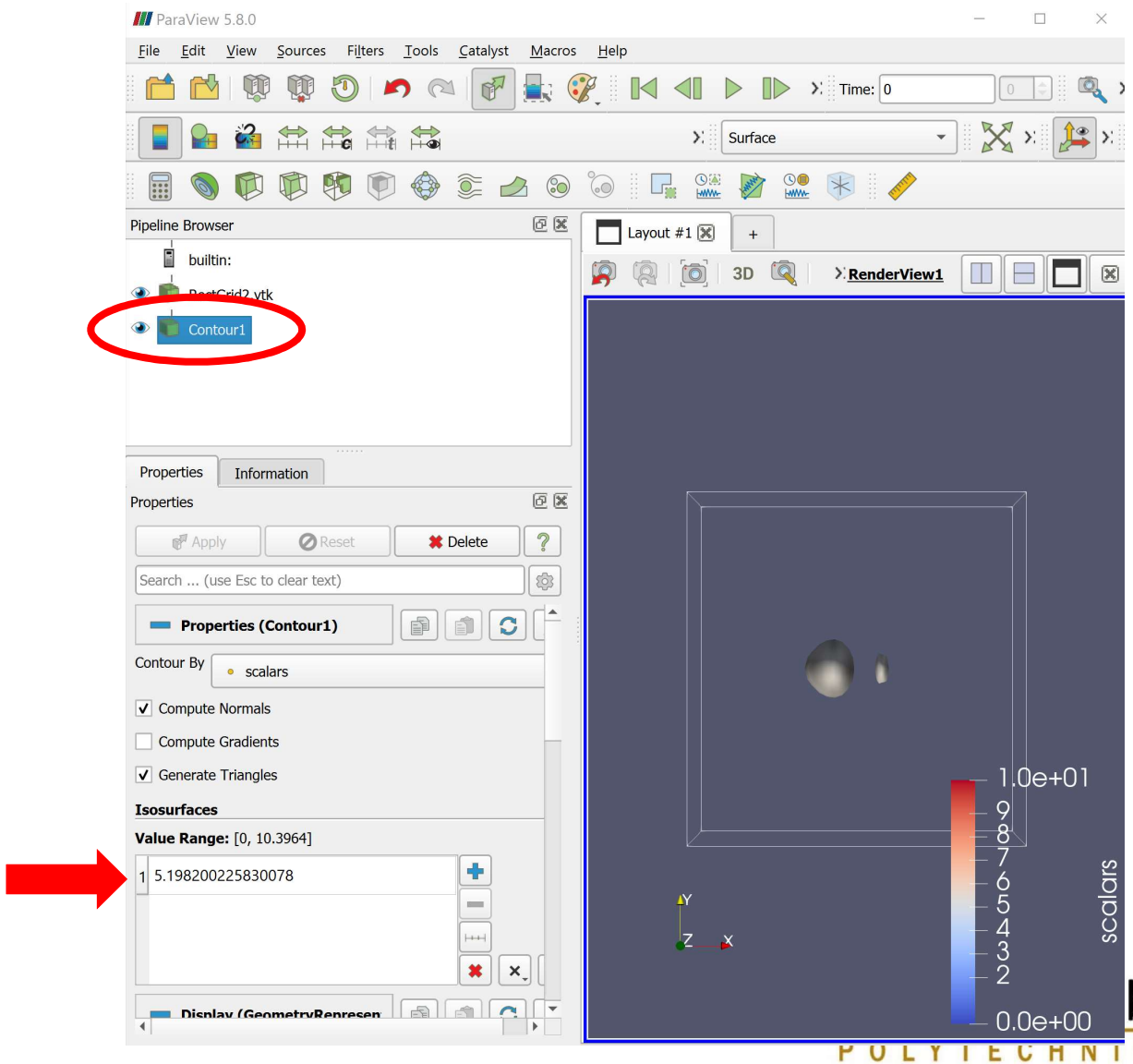
Select

- Filters
- Common
- Contour



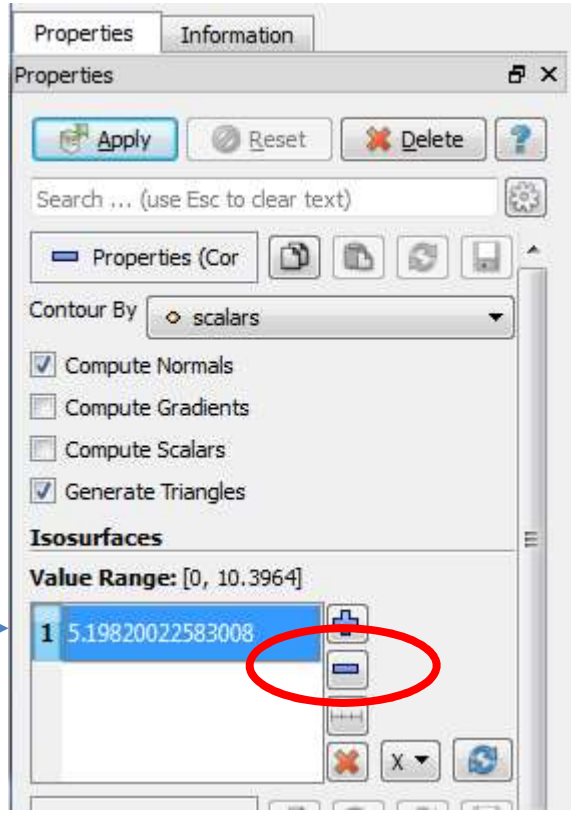
Should see

- New object in Pipeline Browser
- One (1) value in the value range box



- Select the value in the <u>Value Range</u> window

- Click the minus sign in the value range box to Delete the value



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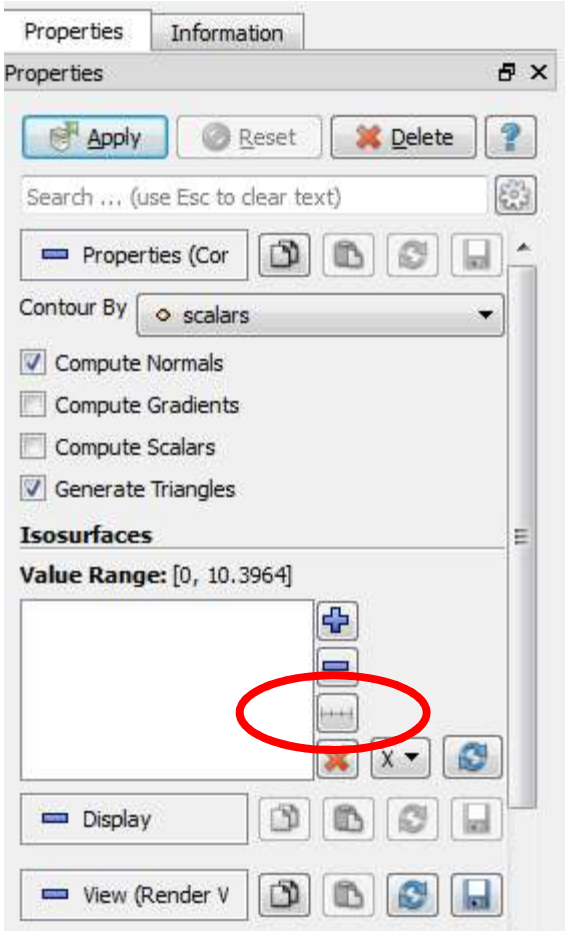
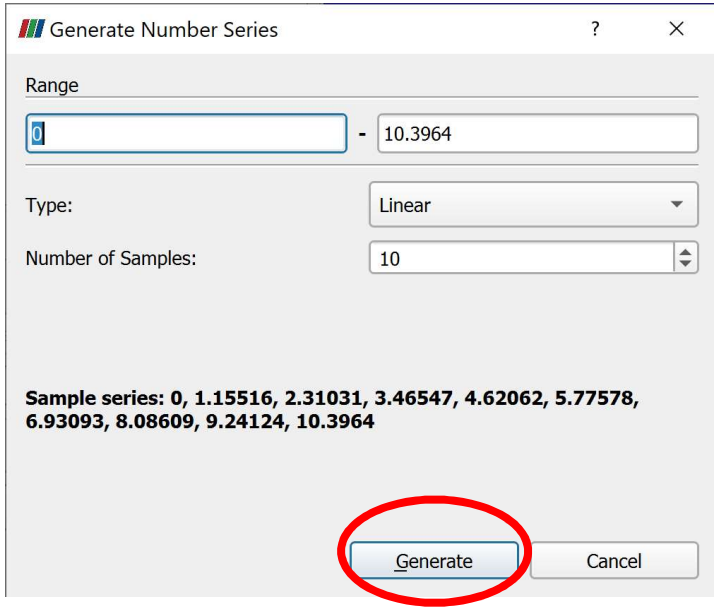
Click the Add a range of values button



Click **Generate**



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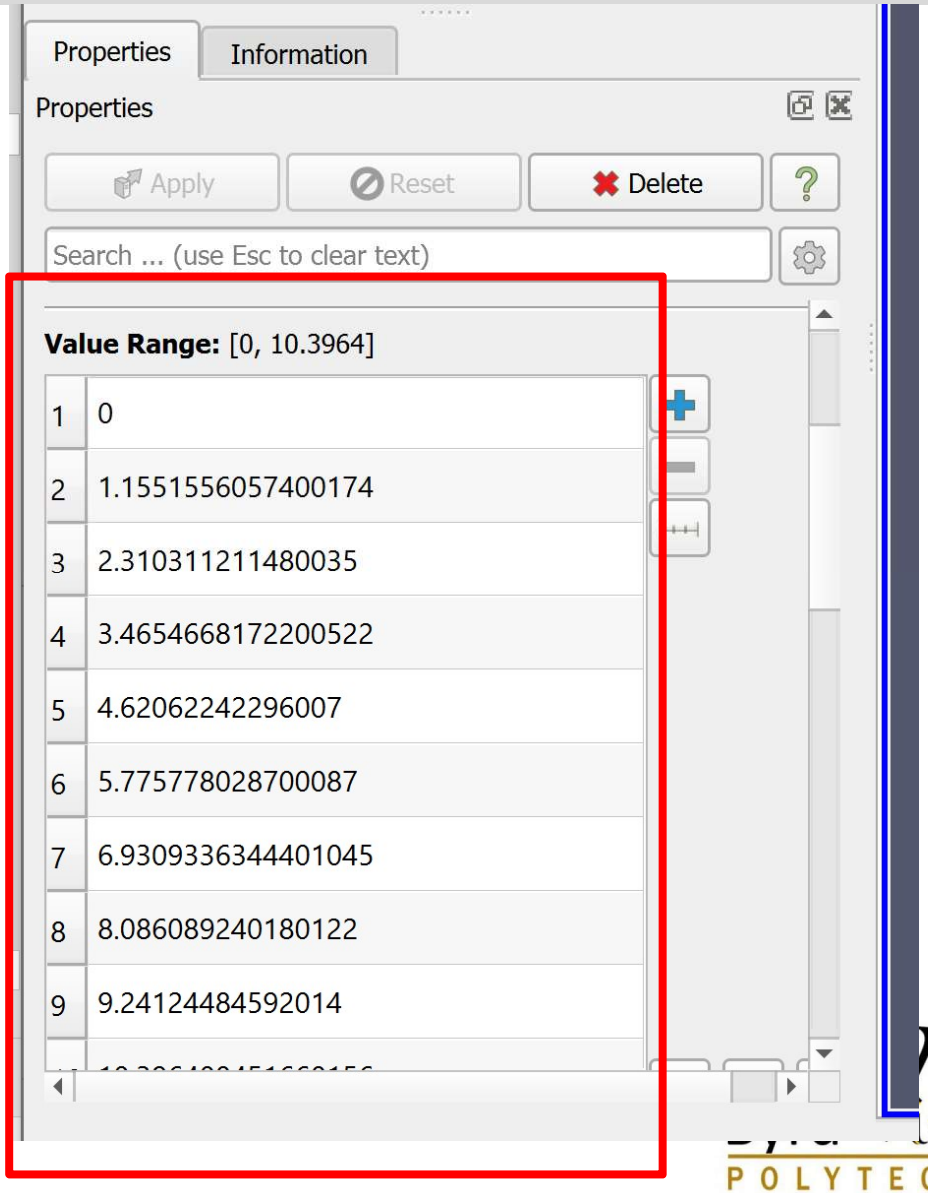
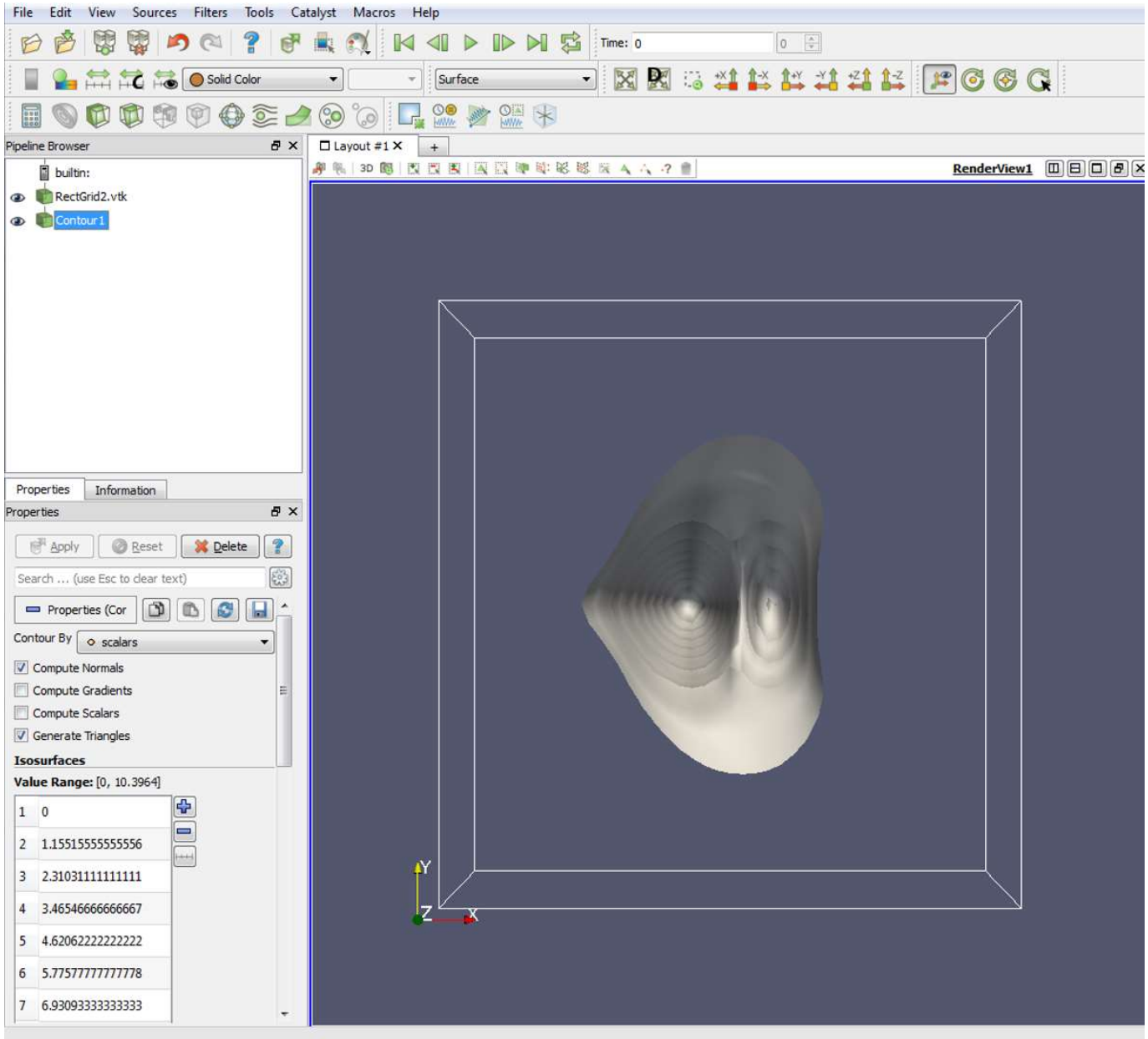
Should see

- A range of values in the Value Range box
- Values range from the min and max values entered in the previous dialog box

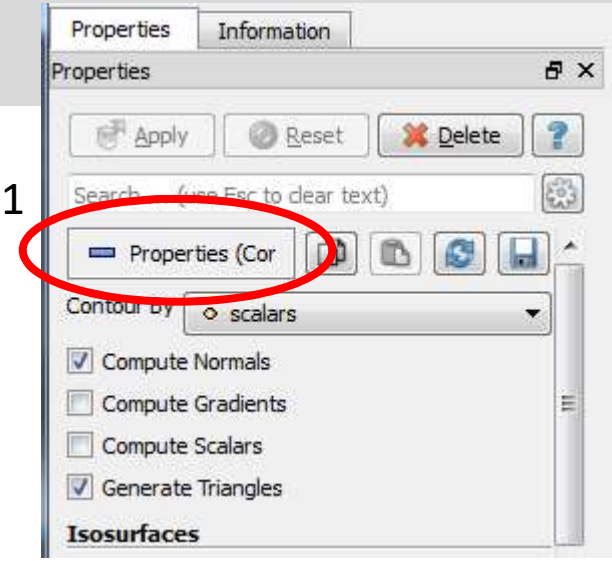


Should see

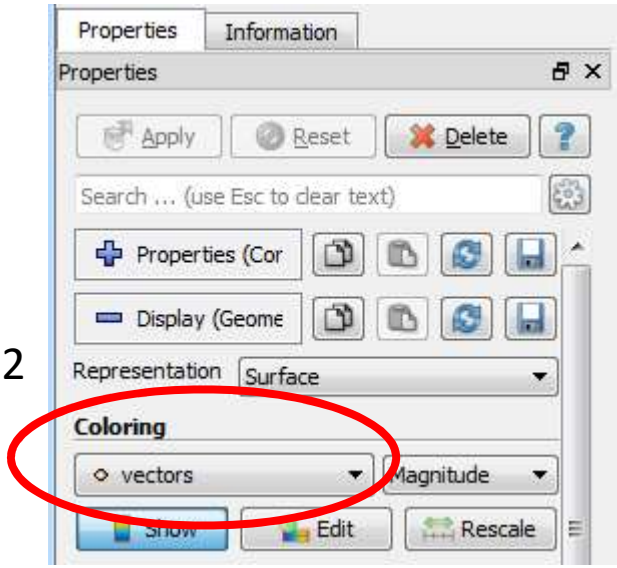
- Rendering in the 3D viewer
- Use your mouse to explore (rotate) the output

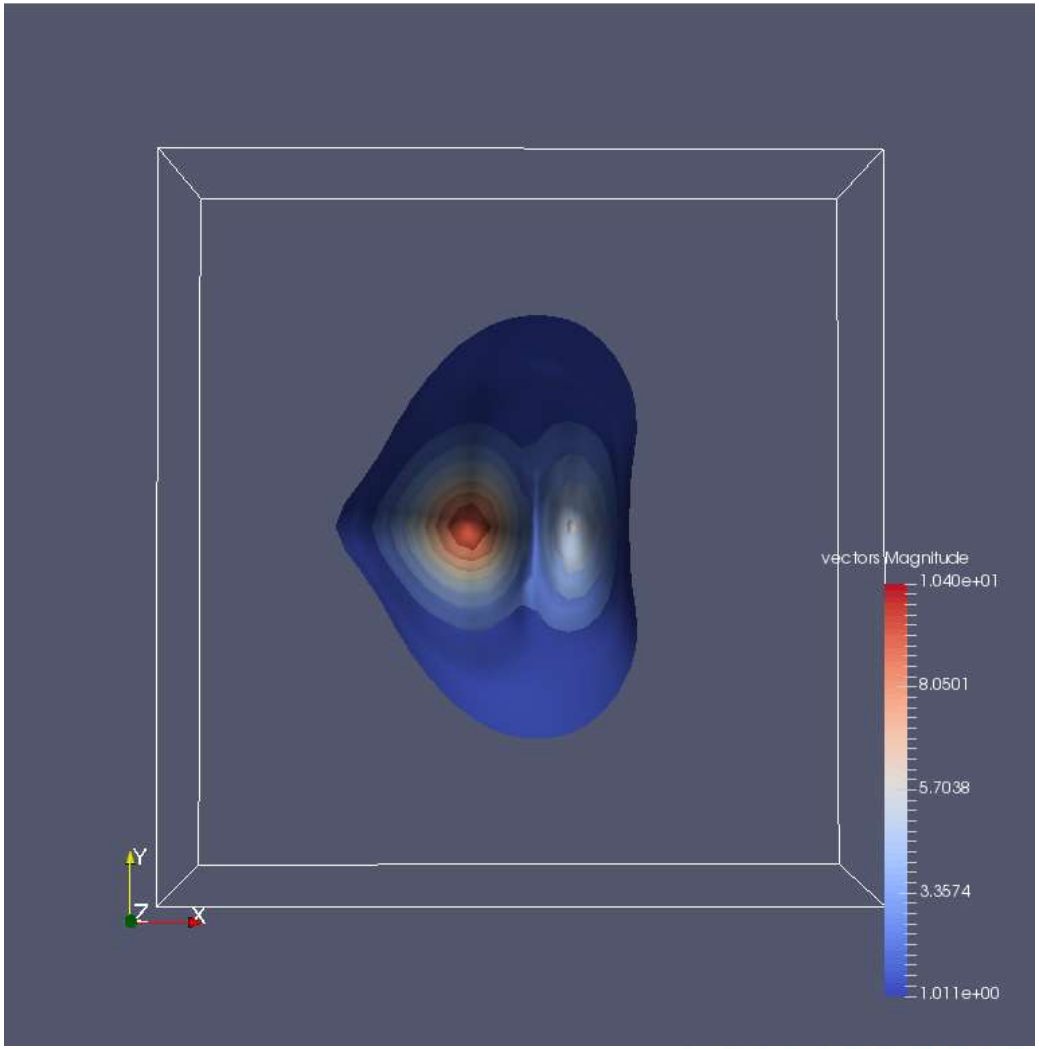


Step 1


Properties
Information
Properties
Apply
Reset
Delete
Search ... (use Esc to clear text)
Properties (Cor
Contour By
scalars
Compute Normals
Compute Gradients
Compute Scalars
Generate Triangles
Isosurfaces

Step 2

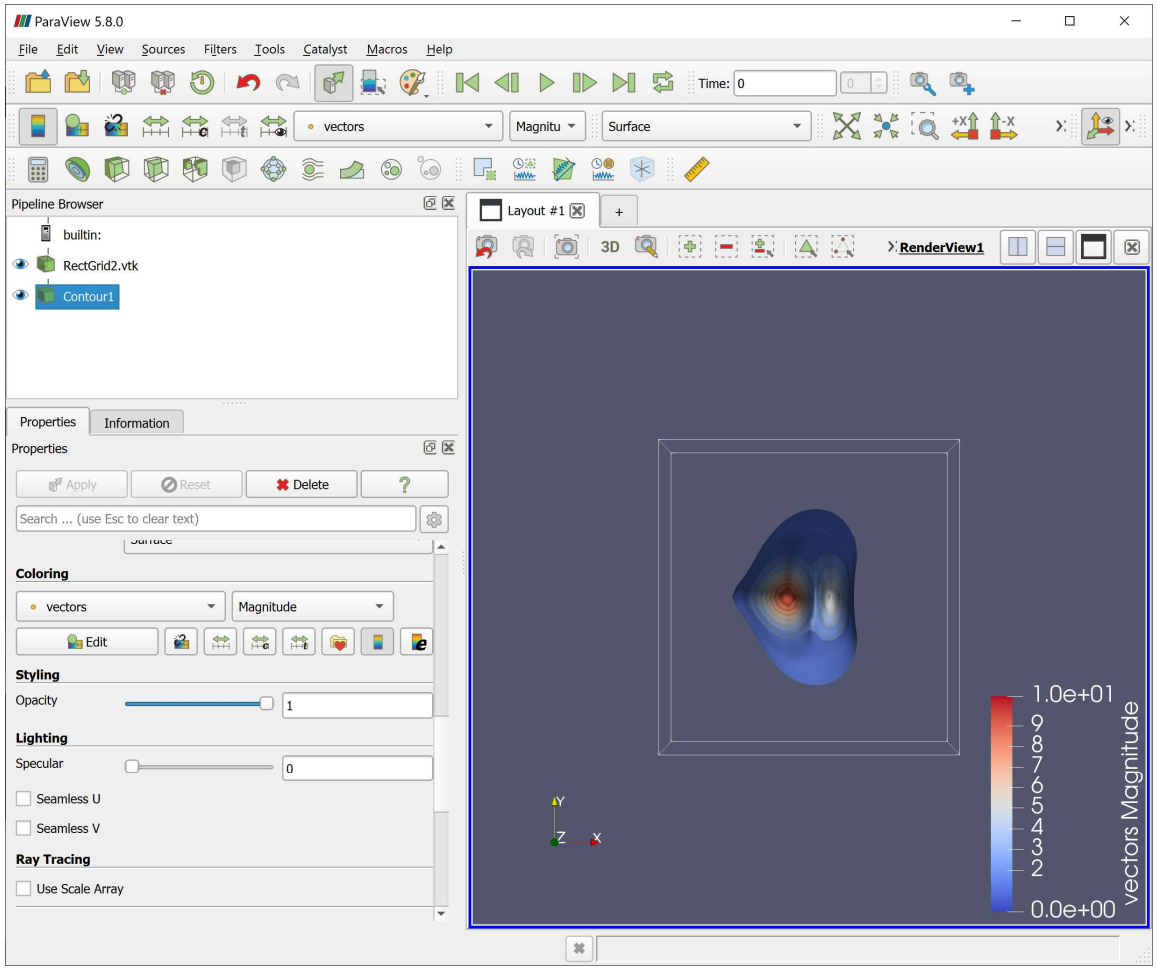

Properties
Information
Properties
Apply
Reset
Delete
Search ... (use Esc to clear text)
Properties (Cor
Display (Geome
Representation
Surface
Coloring
vectors
Magnitude
Show
Edit
Rescale


vectors Magnitude
1.040e+01
8.0501
5.7038
3.3574
1.011e+00
Y
Z
X

CREATE ISOSURFACES

SUMMARY OF STEPS

- Click Filters → Common → Contour
- Remove all values in Value Range Box
- Click Add a range of values
- Set values (Or accept default)
- Click Apply
- Set Color By property: vectors



Clip Isosurfaces

Clip – Intersects the geometry with a half space. The effect is to remove all the geometry on one side of a user-defined plane.

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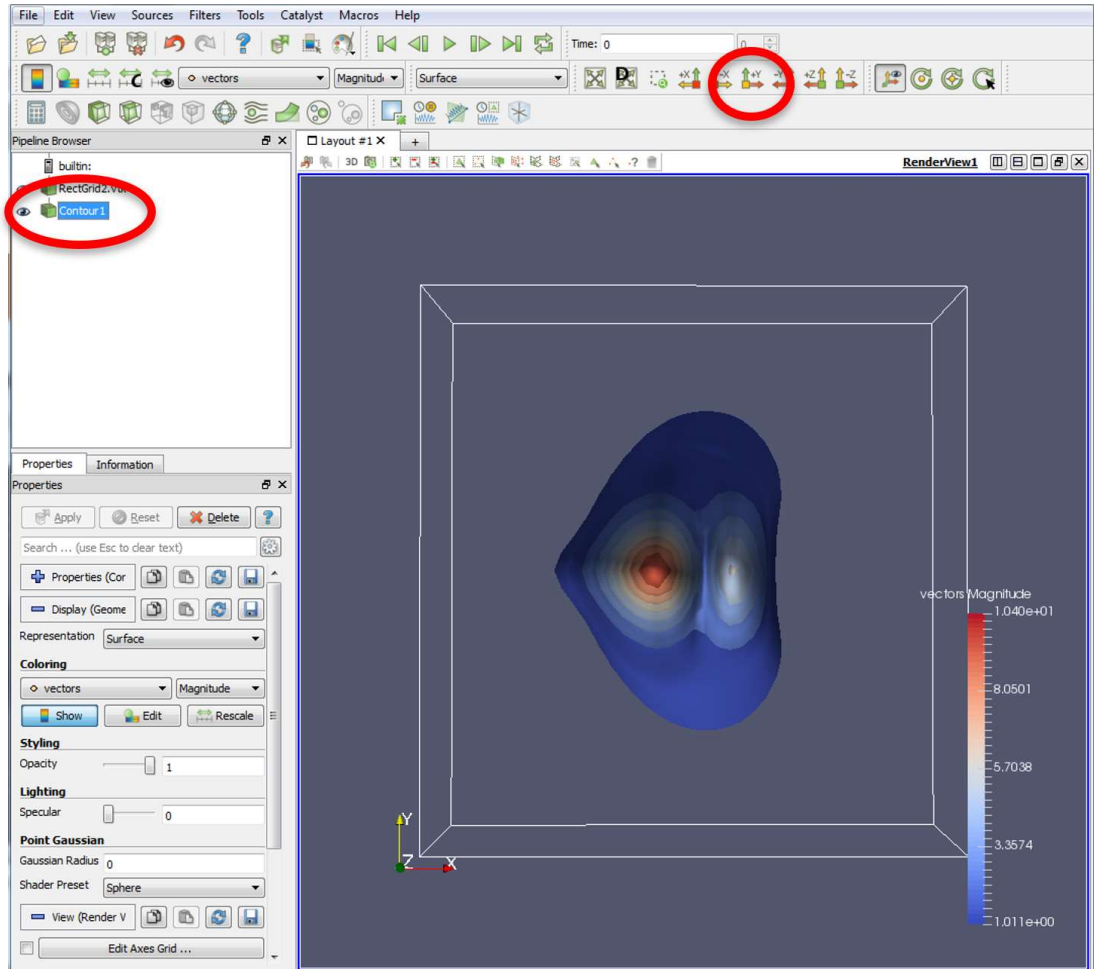
CLIP ISOSURFACES

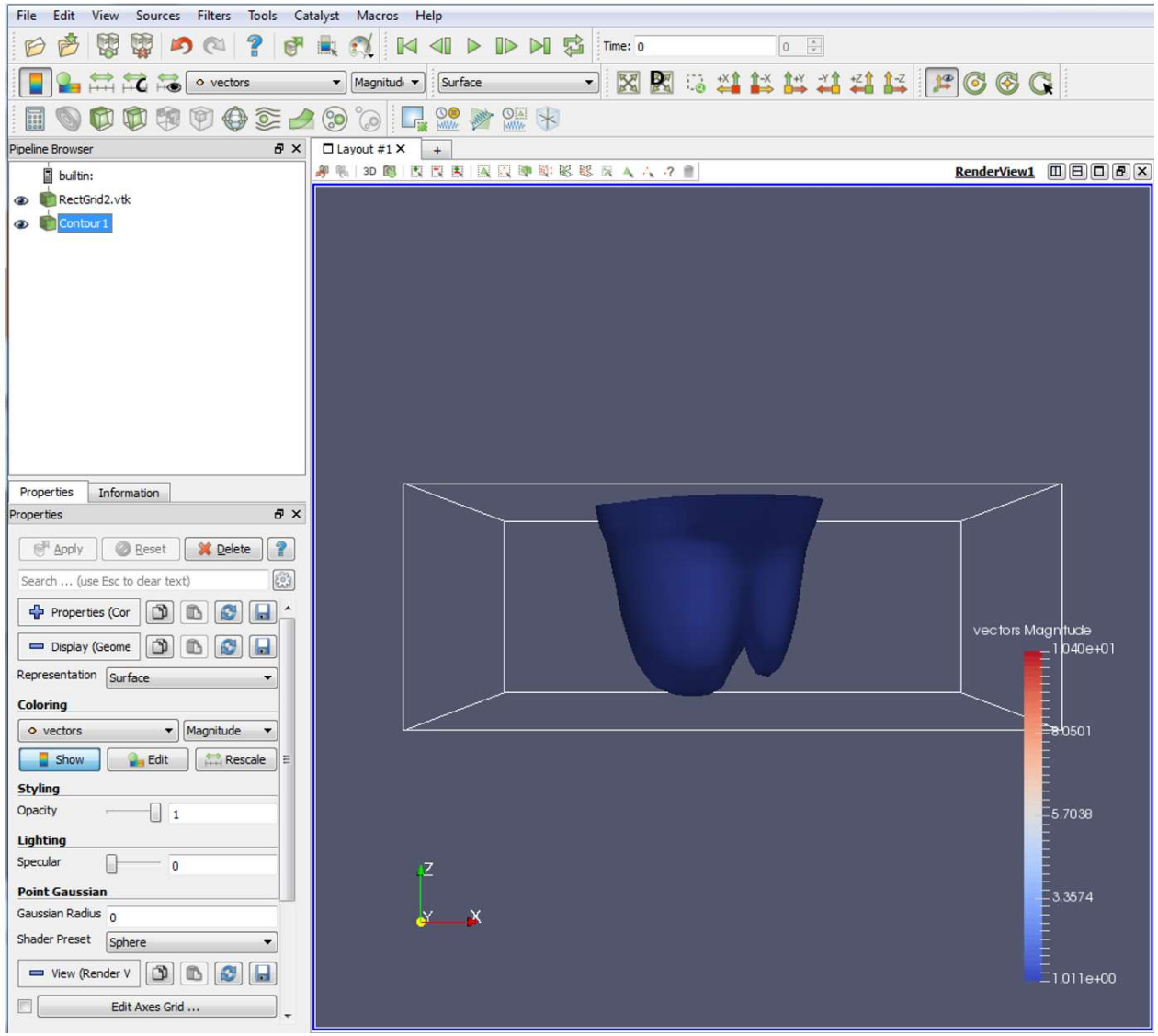
- Make sure Contour 1 is selected (highlighted in blue)
- Set View Direction to +Y



Create a new Clip filter:

Select:

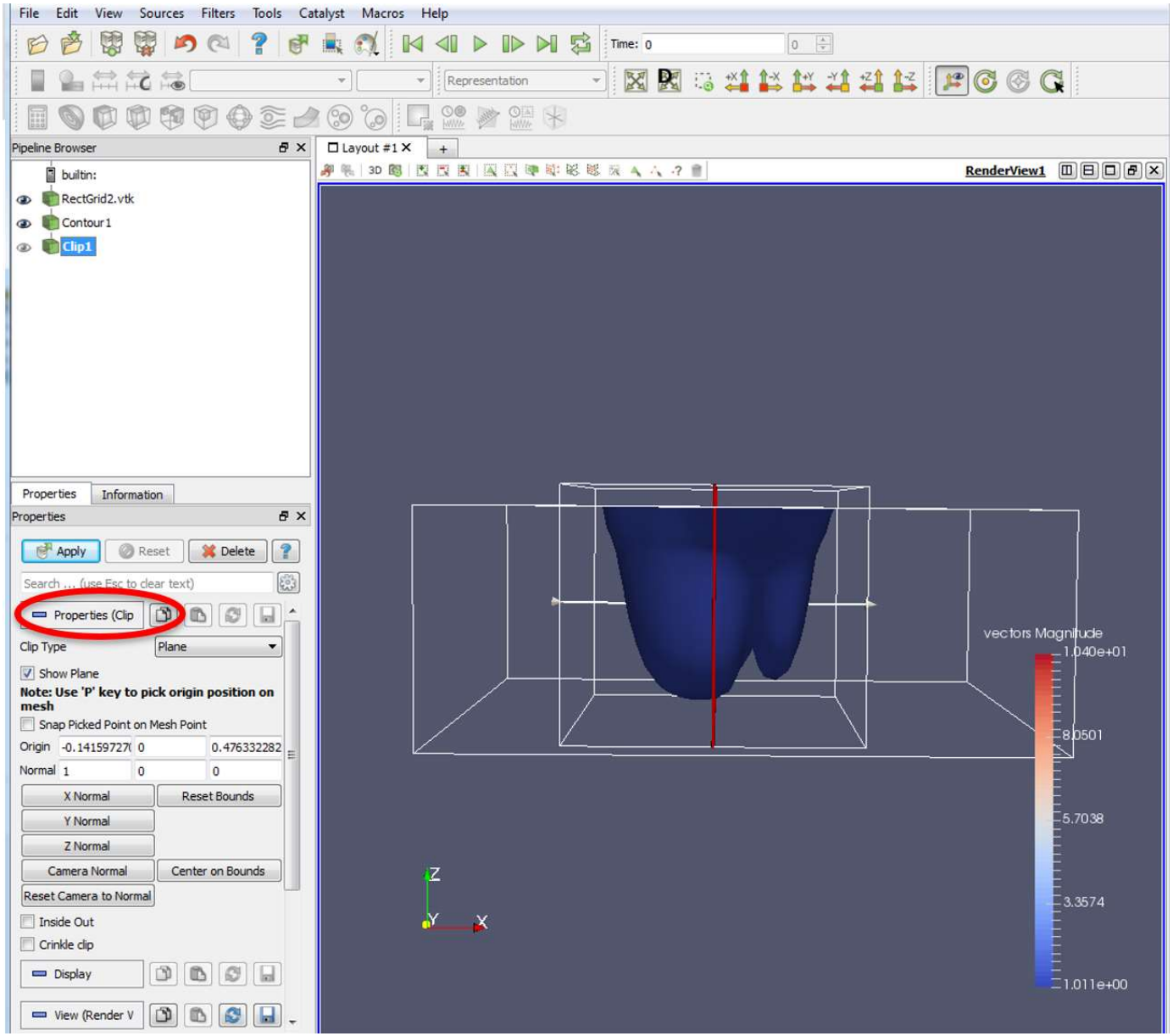
- Filters
- Common
- Clip



Should see

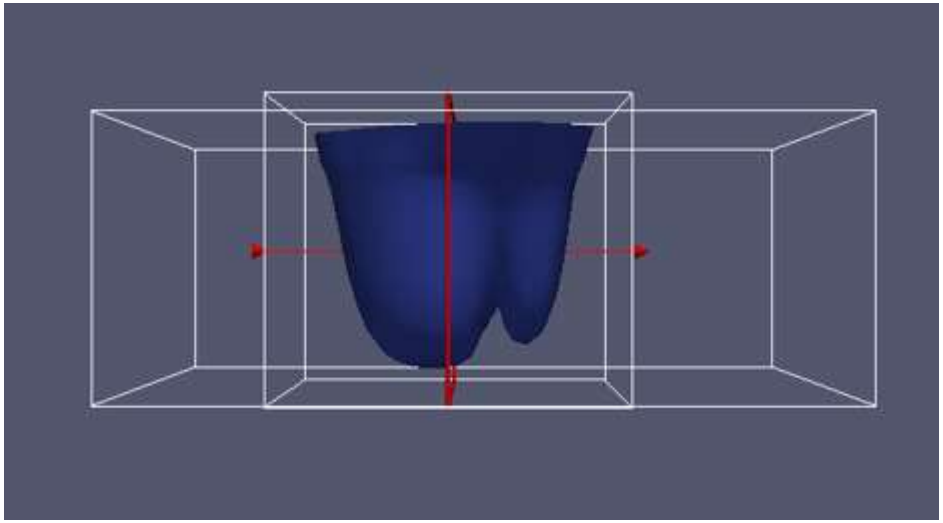
- Clip object in Pipeline Browser
- Clipping Plane

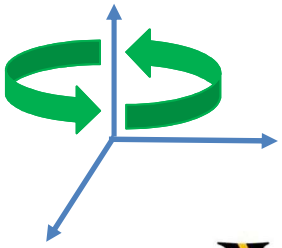
If you do not see the clipping plane click the properties button



POSITION THE CLIPPING PLANE

- Using the mouse, hover over the arrow head (will change color – red)
- Press the mouse button, keep it pressed and rotate the clipping plane; arrow points out of the screen towards you





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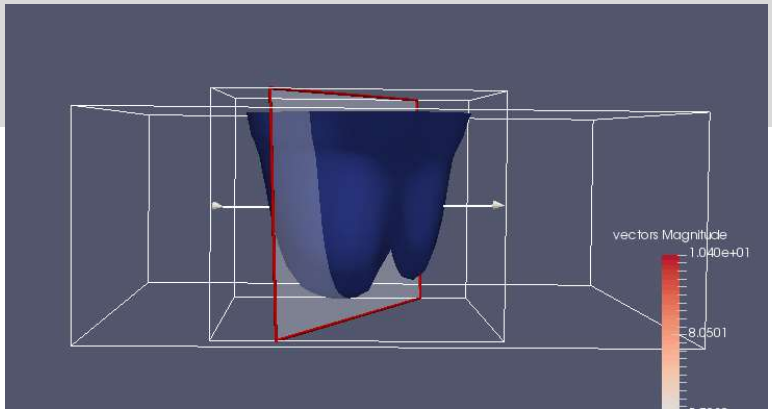

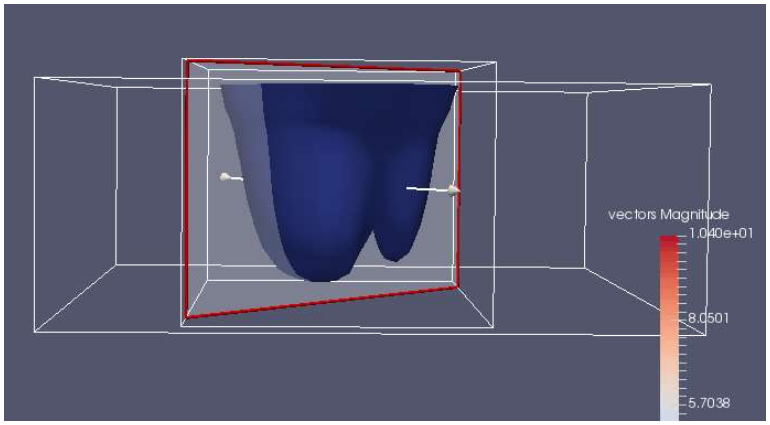

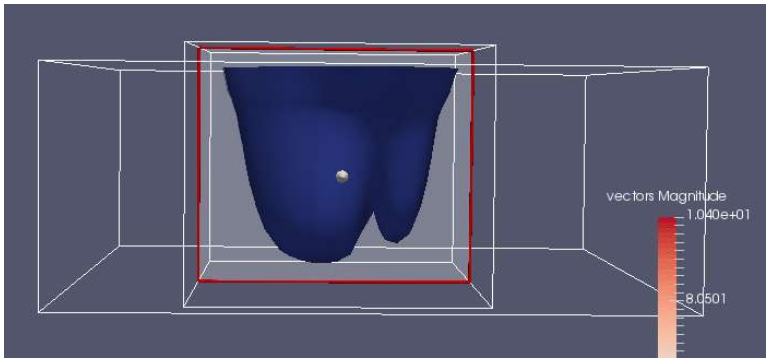

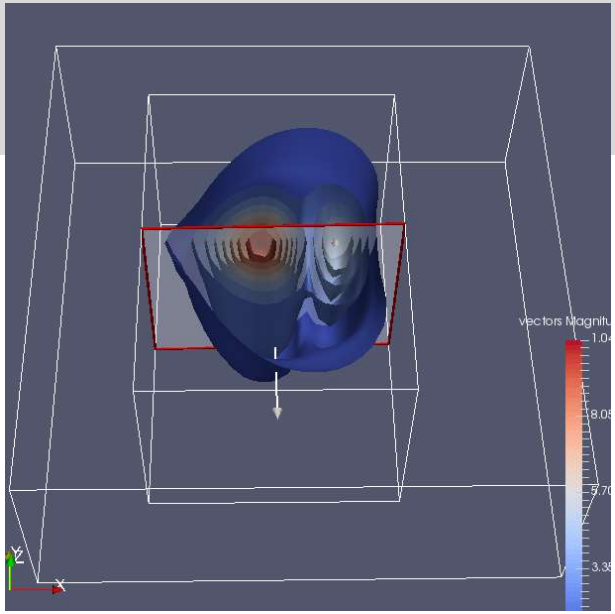

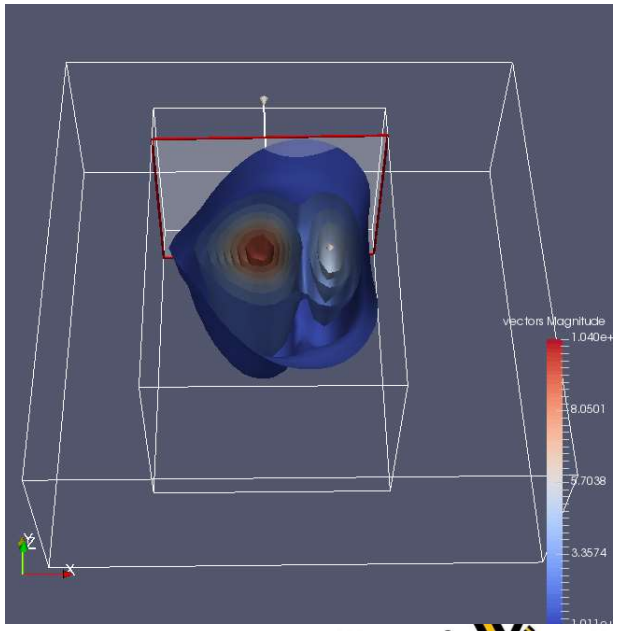

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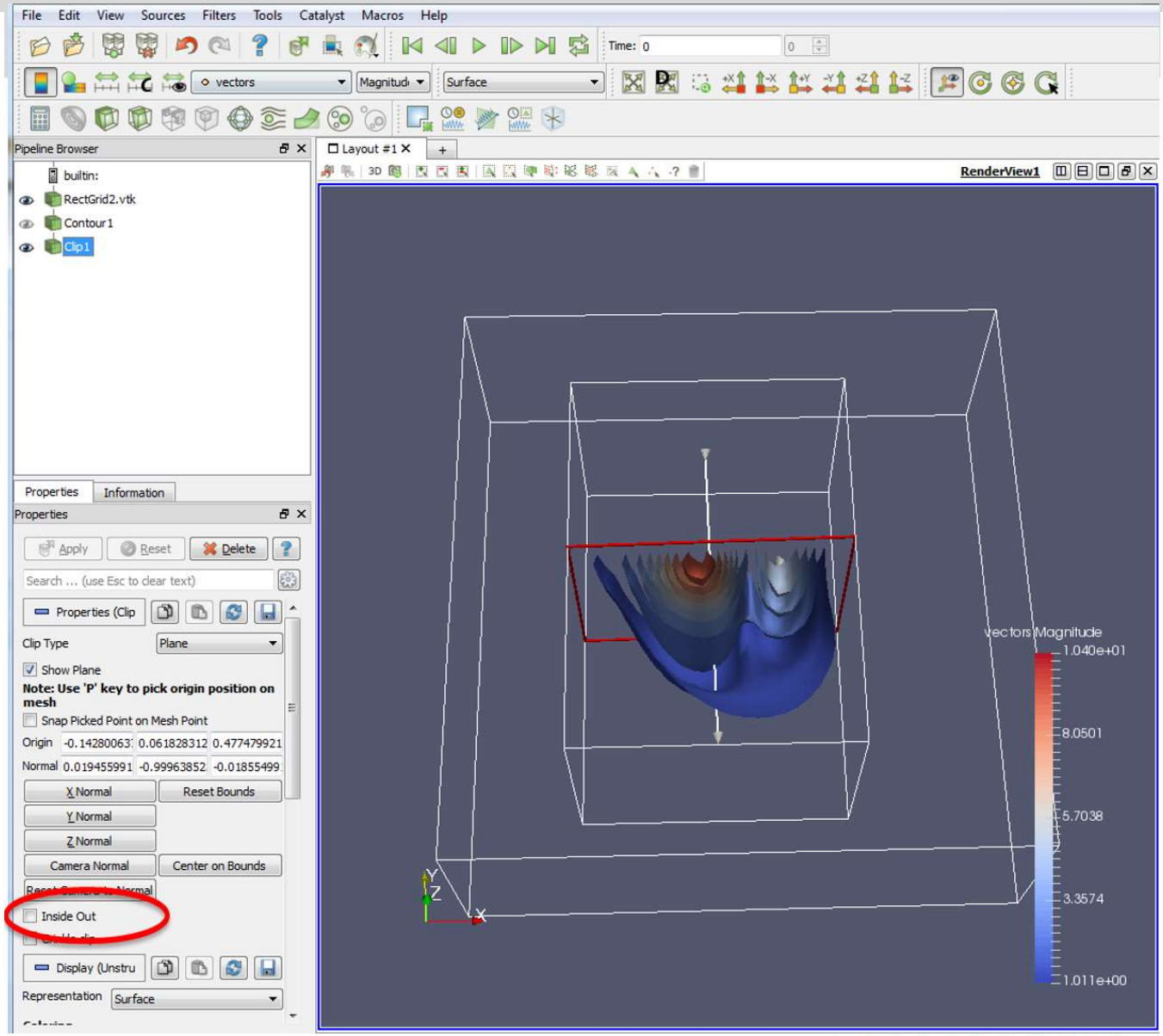
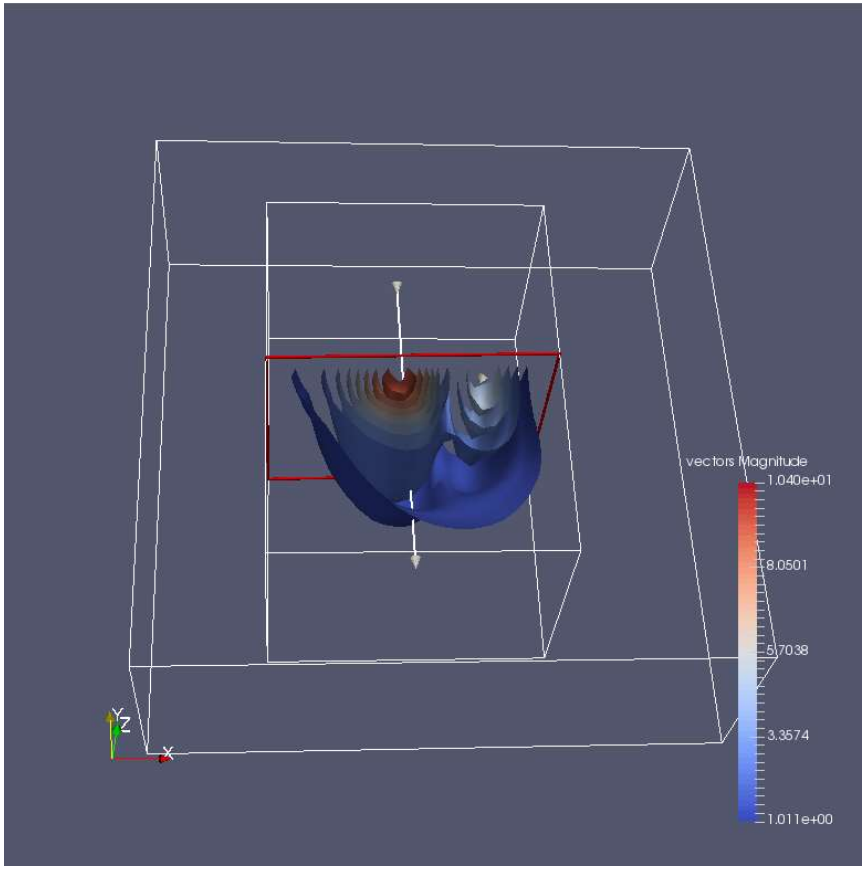
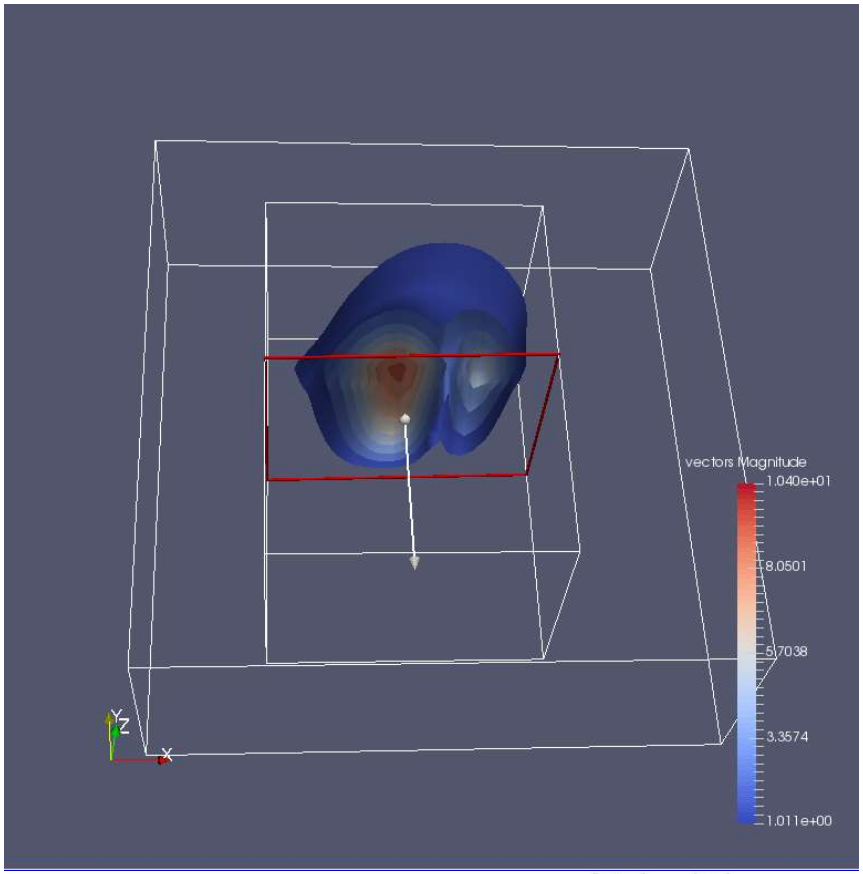
When done: Click **Apply**

- Click the Inside Out box to switch the clipping plane
- Click Apply



INSIDE OUT FEATURE



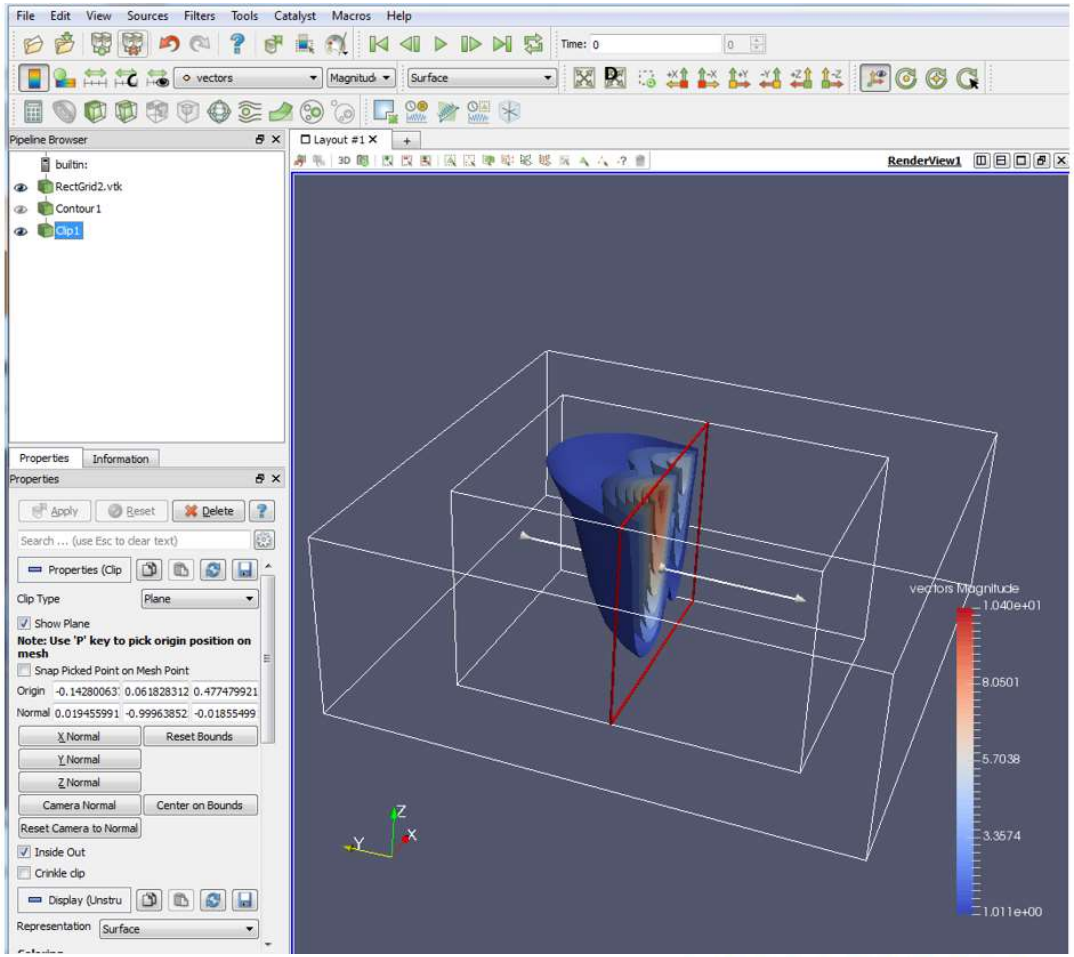


Byrd Vis Lab
POLYTECHNIC

CLIP ISOSURFACES

SUMMARY OF STEPS

- Click +Y view button
- Click Filters→ Common → Clip
- Position the clipping plane (move arrow point to desired position)
- Click Apply
- Check Inside Out check box to switch the clipping plane view

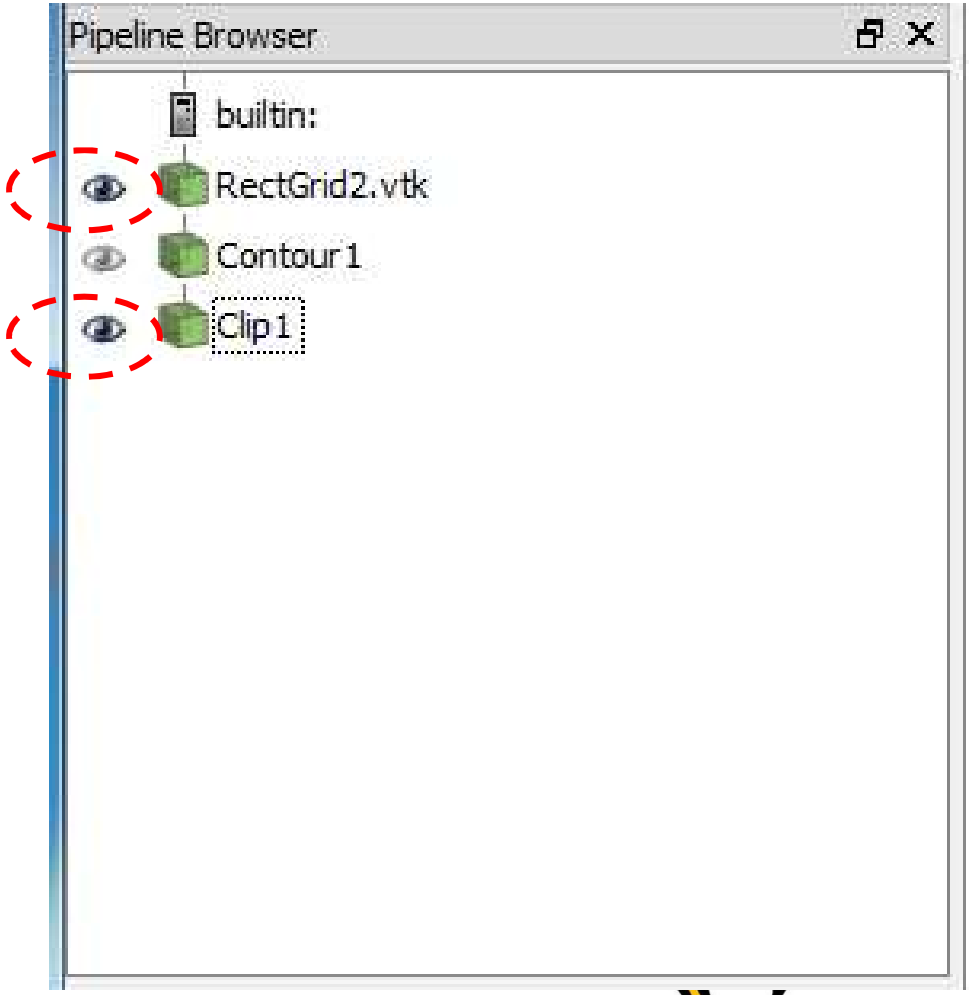


Slice Isosurfaces

Slice – Intersects the geometry with a plane. The effect is similar to clipping except that all that remains is the geometry where the plane is located.

PURDUE
POLYTECHNIC

- Make visible
  - RectGrid2.vtk
  - Clip1



- To make an object visible click the eye icon to the left of the object

- Contour 1 should **NOT** be visible for the next task

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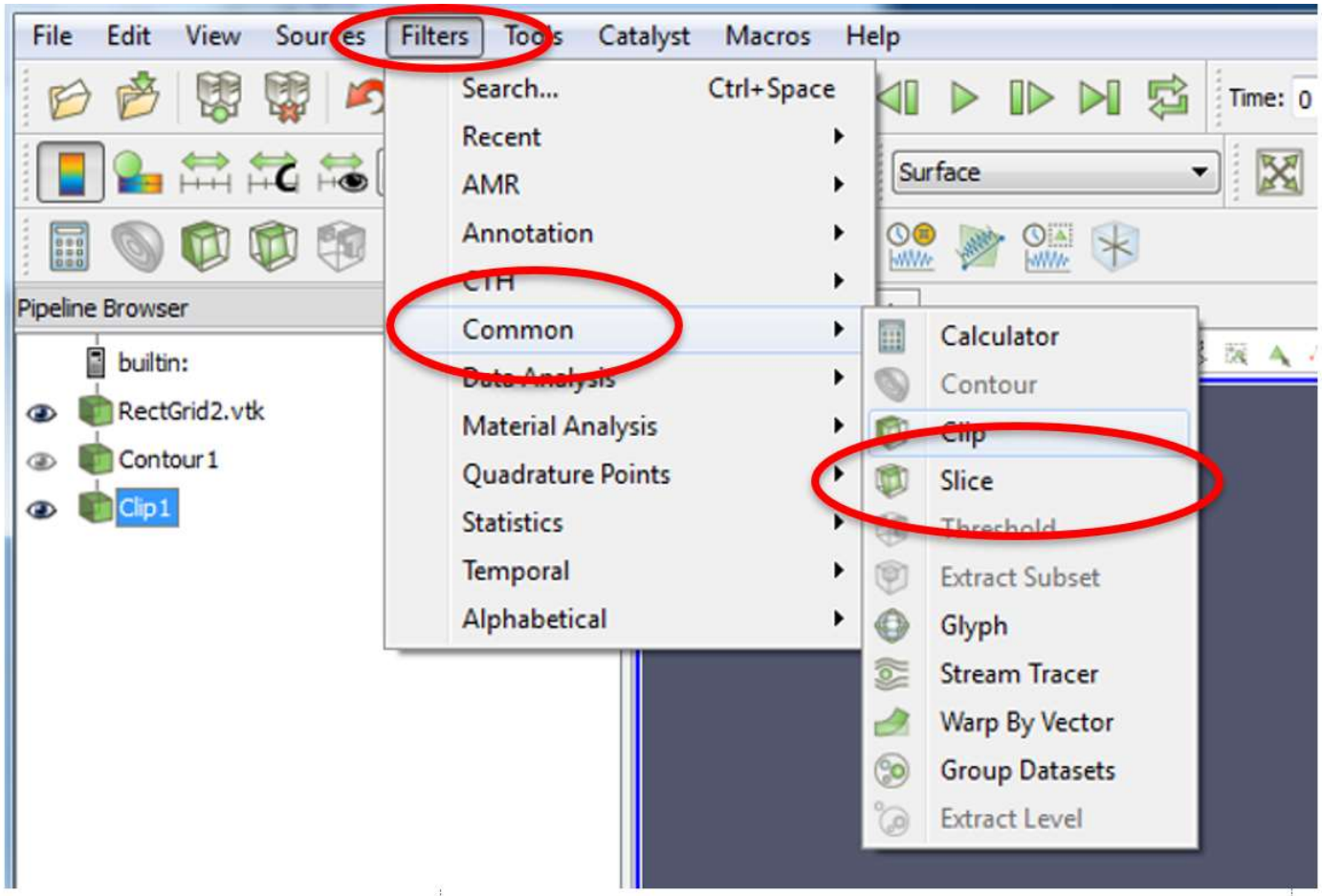
POLYTECHNIC

SLICE ISOSURFACE

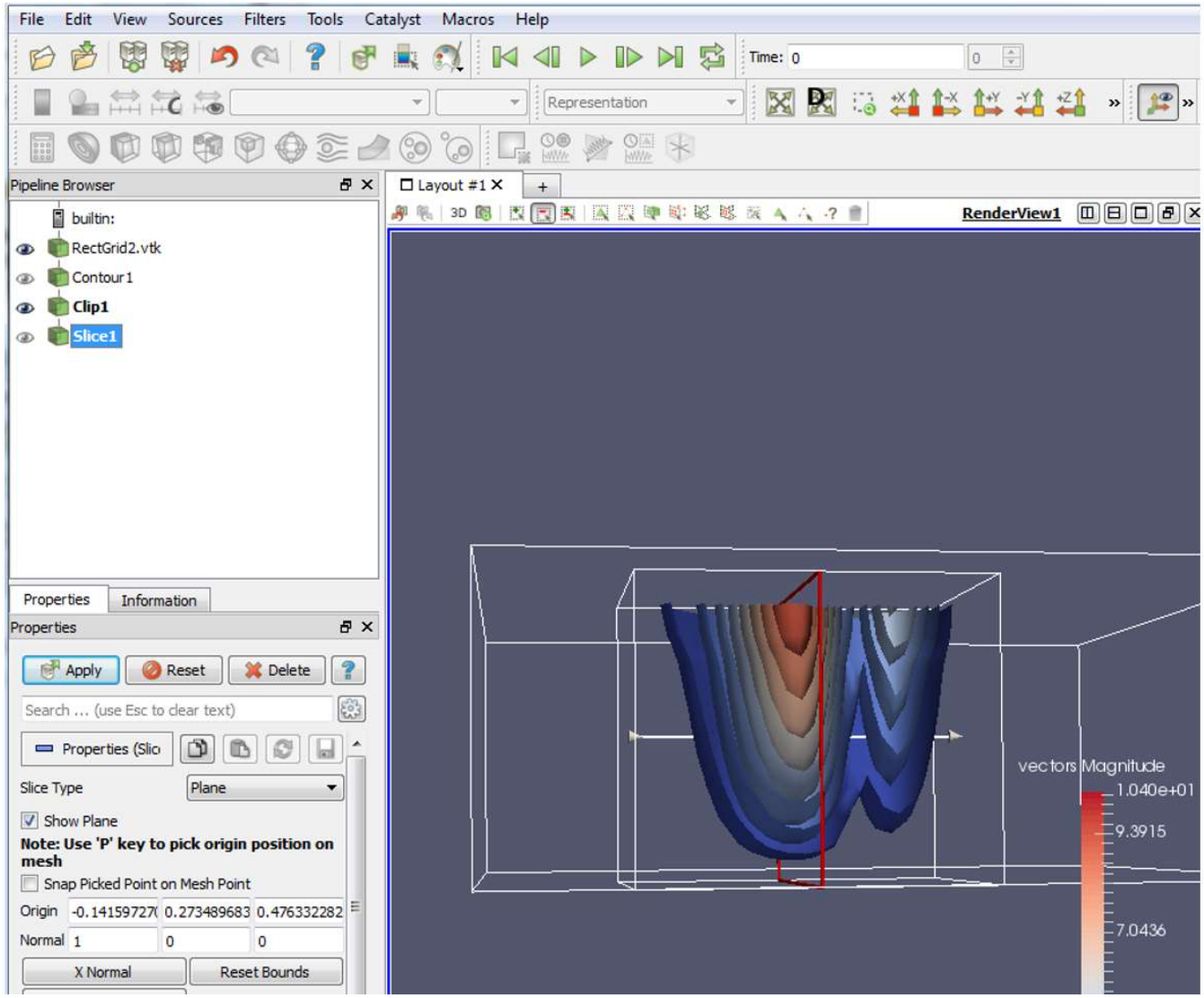
Select Clip 1

- Filters
- Common
- Slice



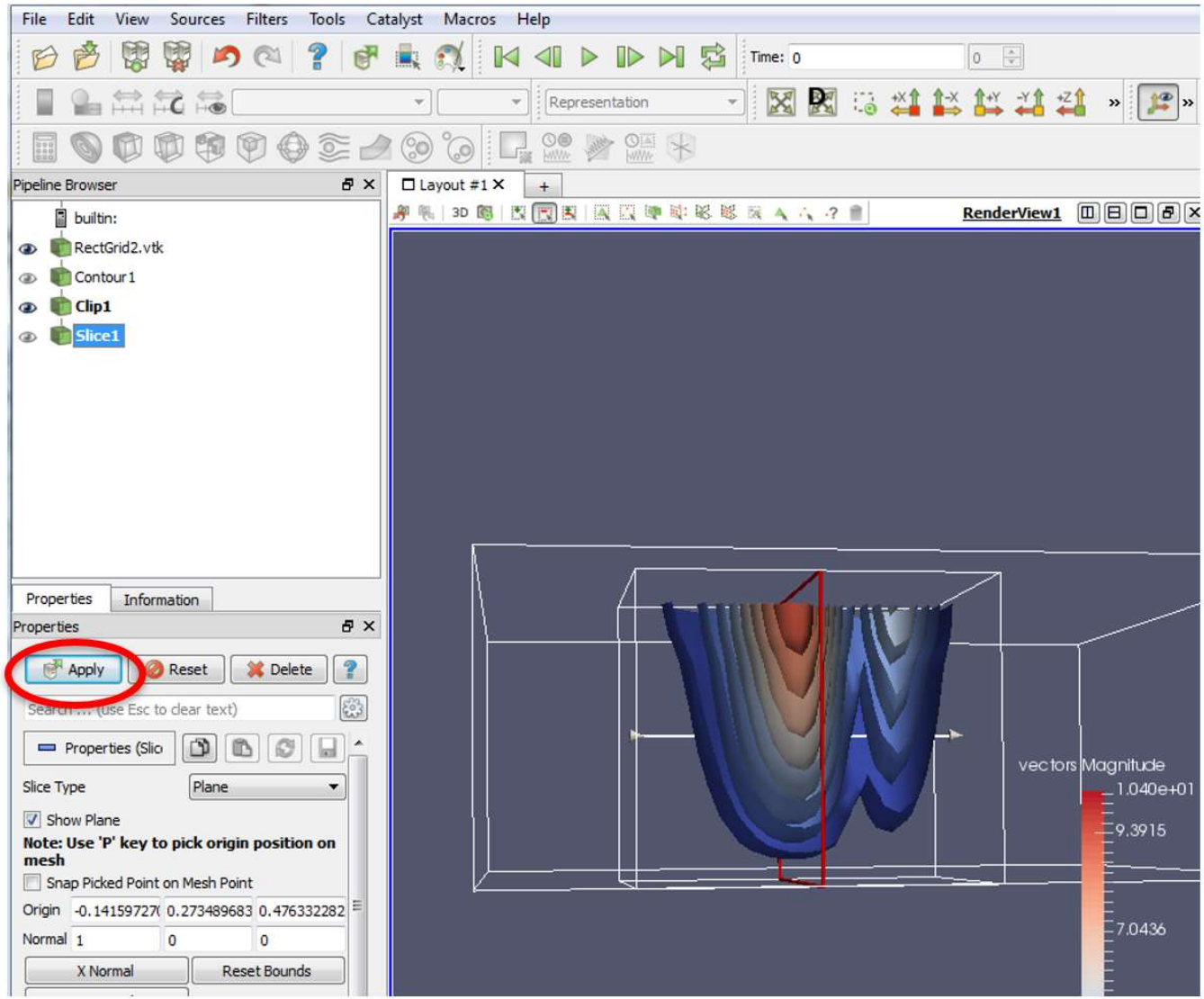
Should see

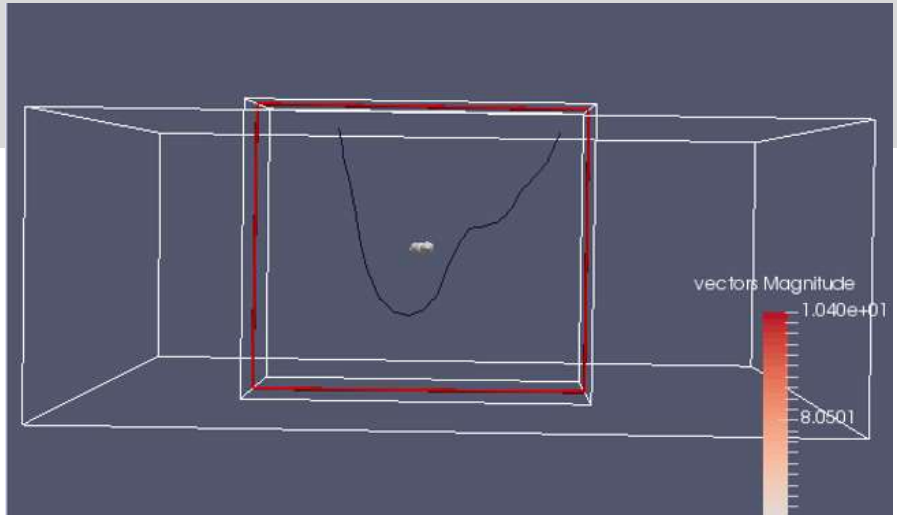
- Slice1 object in Pipeline Browser
- Slicing Plane with arrow in 3D window

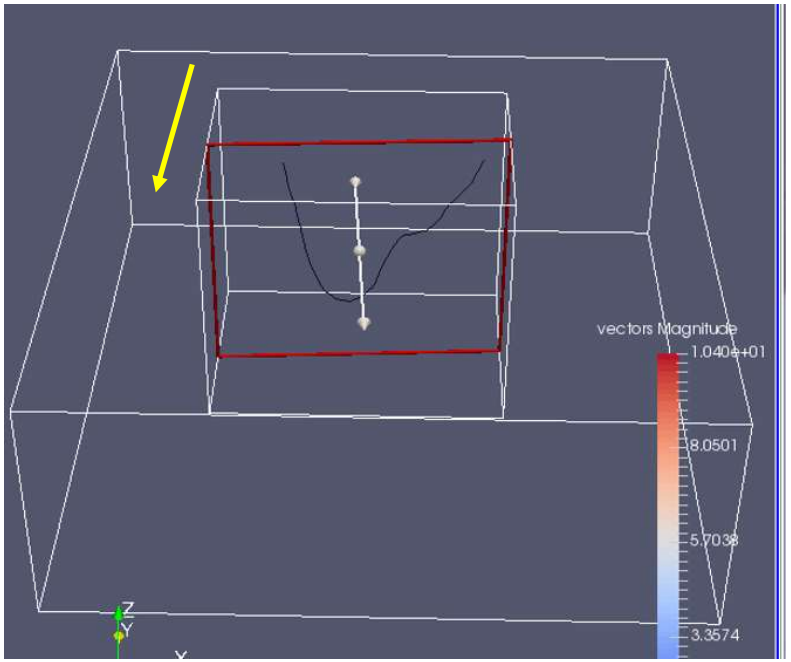


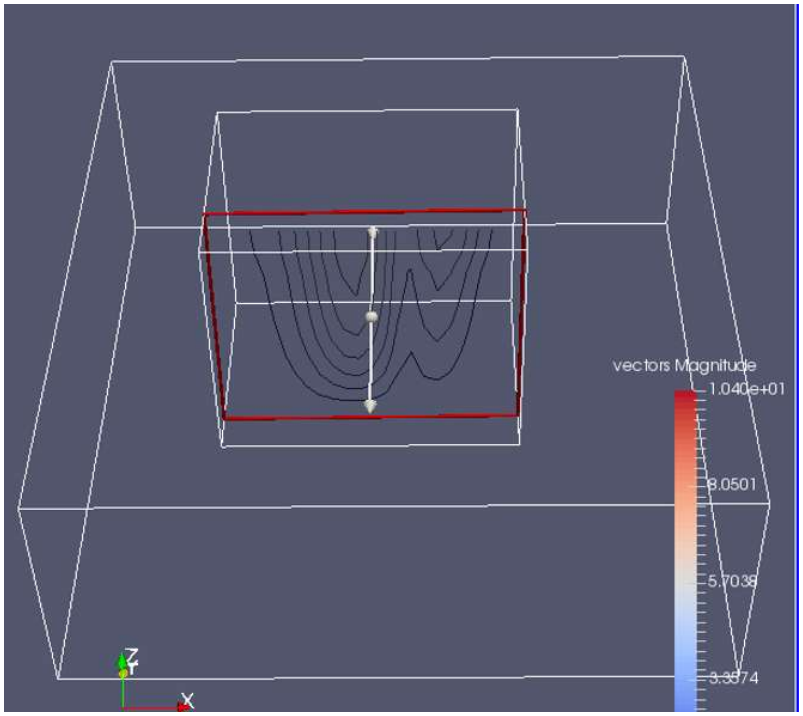
Position the slicing plane (move arrow point to desired position)

Click **Apply** if the viewer window does not automatically update









You can move the slicing plane along the axis to see a different slice

Click **Apply** to see changes

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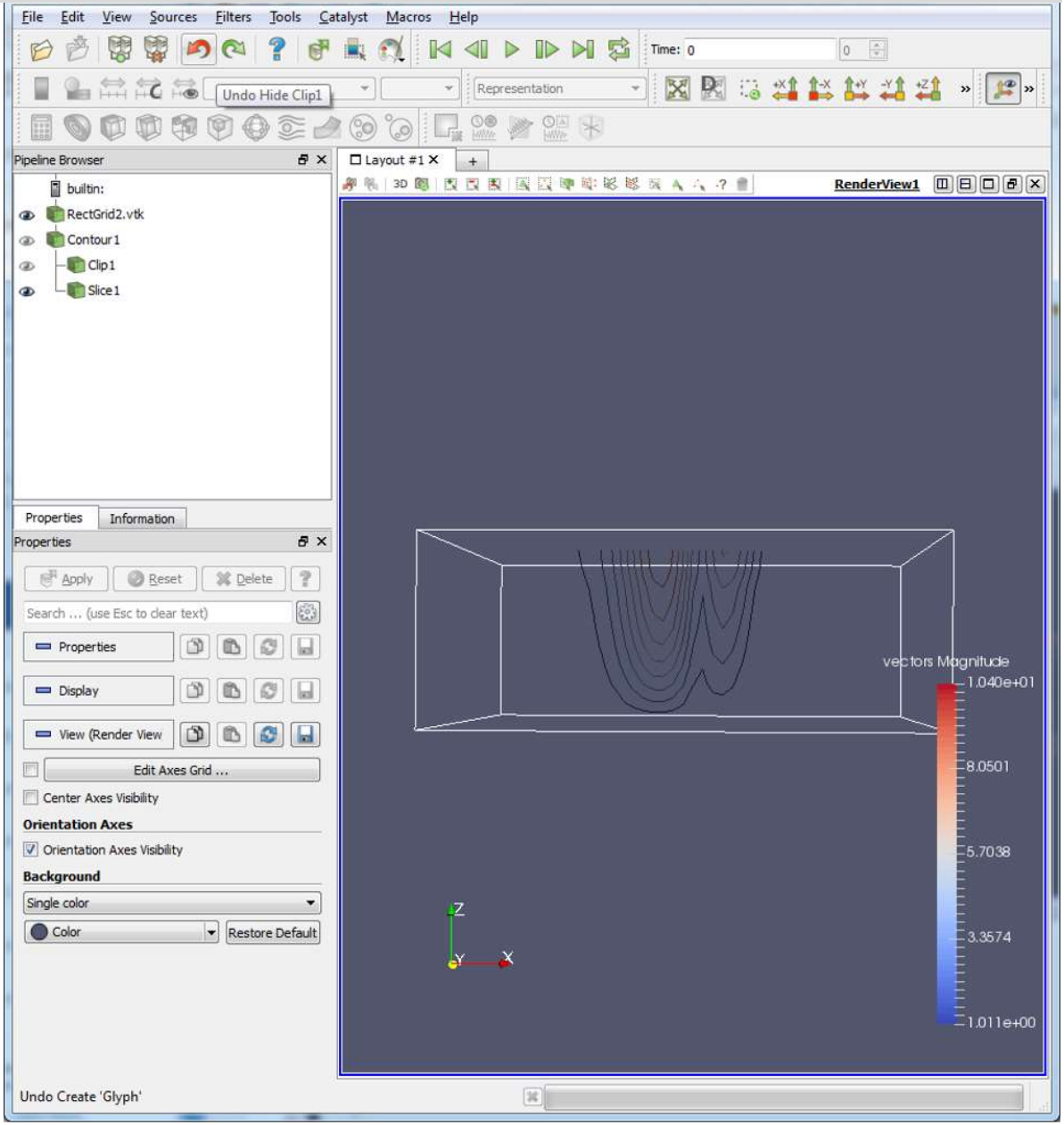
POLYTECHNIC

SLICE ISOSURFACE

SUMMARY OF STEPS

- Select **Clip1** Object
- Select **Filter**
- Select **Common**
- Select **Slice**
- Position Slicing Plane
- Click **Apply**

Slice - Intersects the geometry with a plane. The effect is similar to clipping except that all that remains is the geometry where the plane is located



What have we done?

Recall Three Basic Steps:

- First your data must be **read** into ParaView
- Next, you may apply any number of **filter**s that process the data to generate, extract, or derive features from the data
- Finally, a viewable image is **render**ed from the data

Opened simple data file **RectGrid2.vtk**

Applied filters:

Contour, Slice, Clip

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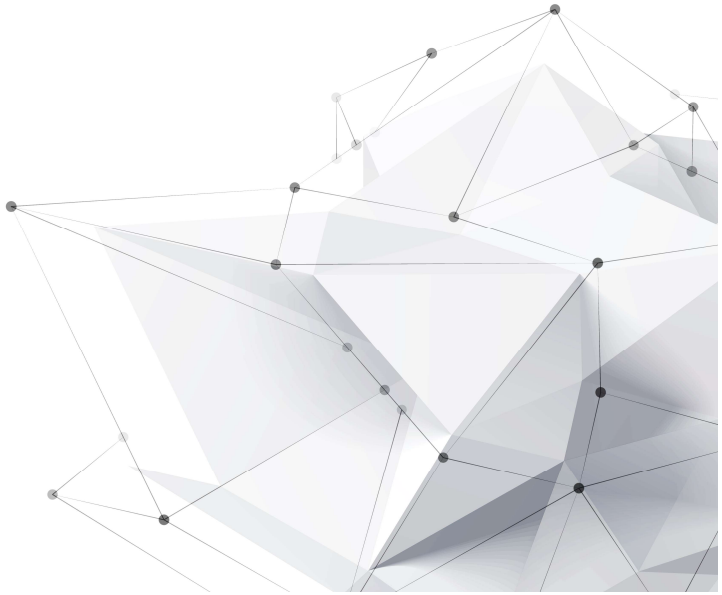
POLYTECHNIC

Introduction to ParaView

Part II: Hands-On-Exercise



PURDUE
POLYTECHNIC

What have we done?

Recall Three Basic Steps:

- First your data must be **read** into ParaView
- Next, you may apply any number of **filter**s that process the data to generate, extract, or derive features from the data
- Finally, a viewable image is **render**ed from the data

Opened simple data file **RectGrid2.vtk**

Applied filters:

Contour, Slice, Clip

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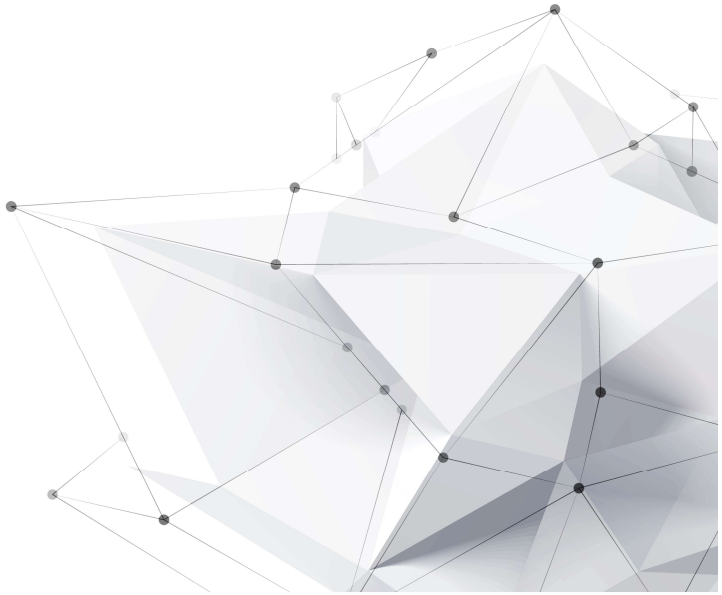
POLYTECHNIC

Let's try a more complex data set

headsq.vti

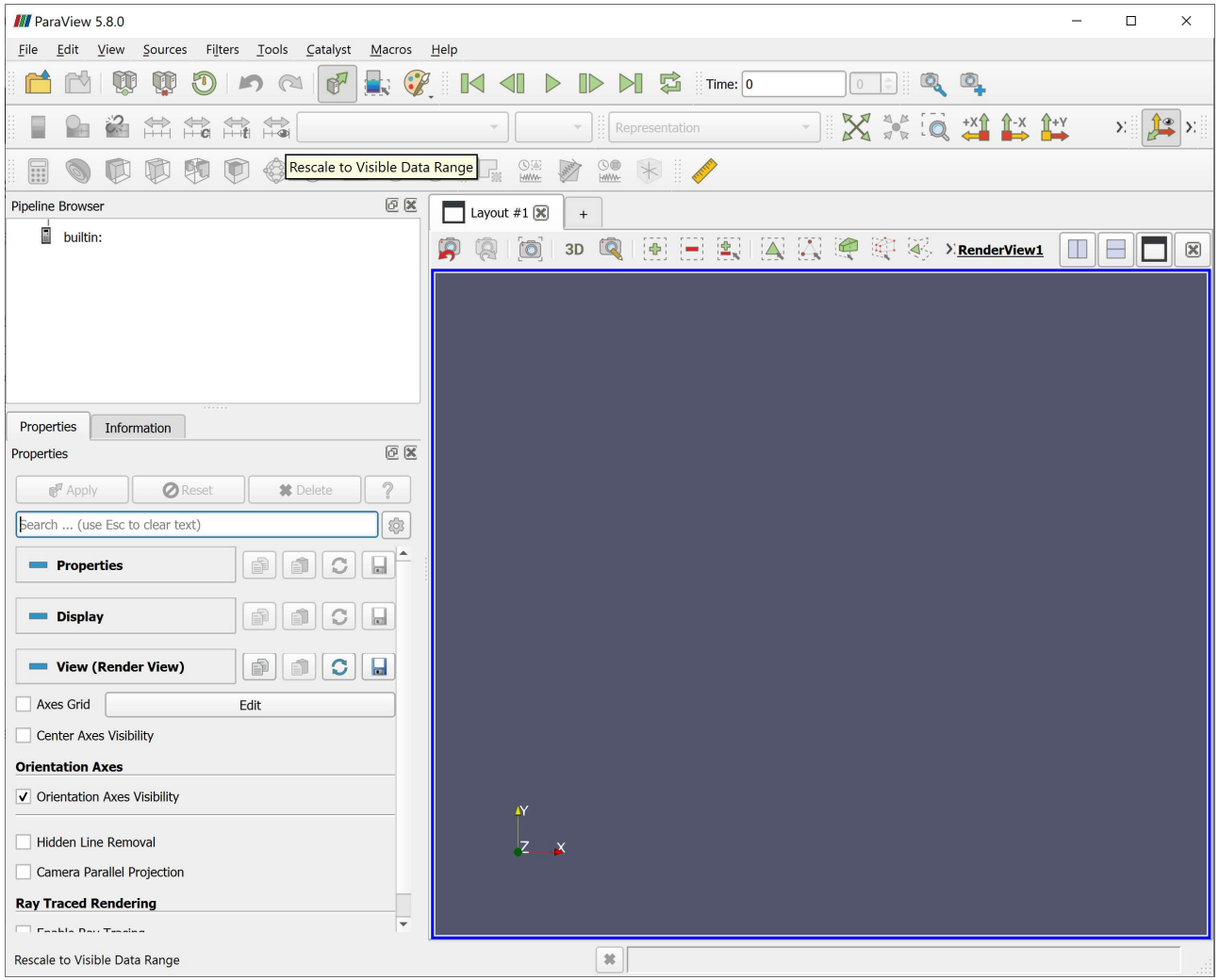


PURDUE
POLYTECHNIC

In preparation for the next section

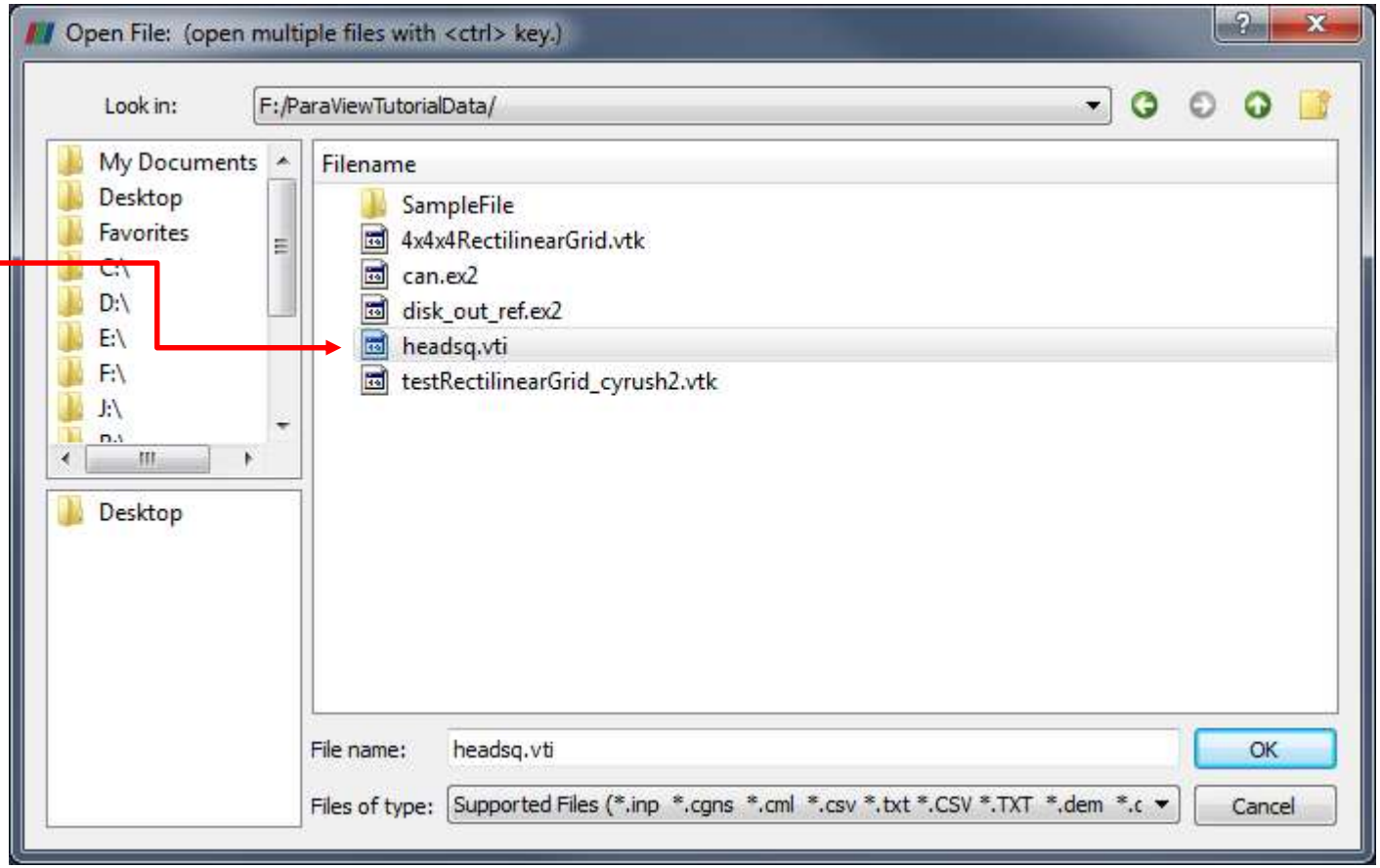
- Edit
- Reset Session

Your Interface should look like this



Locate File: headsq.vti

File
Open
headsq.vti



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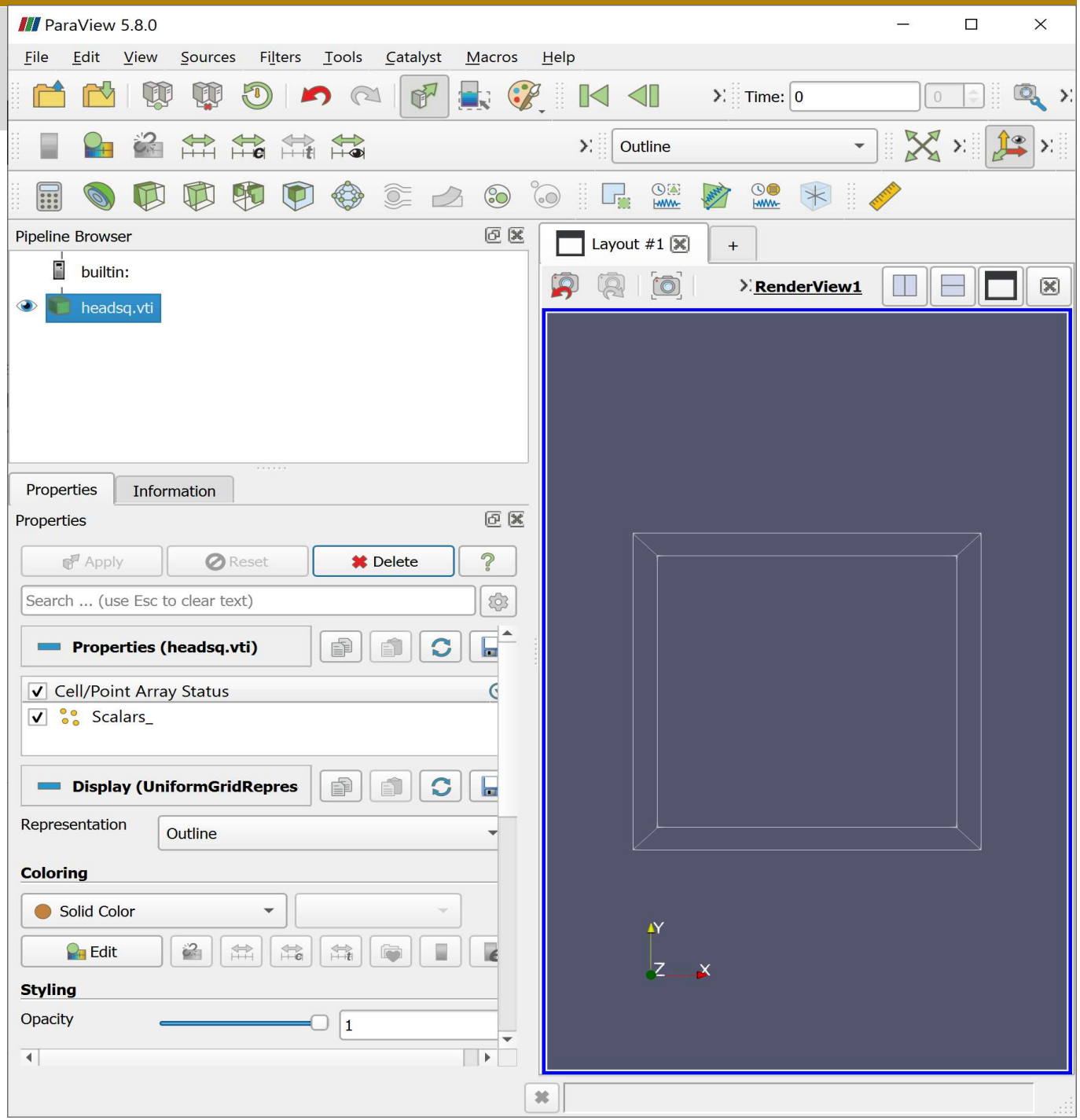
ParaView

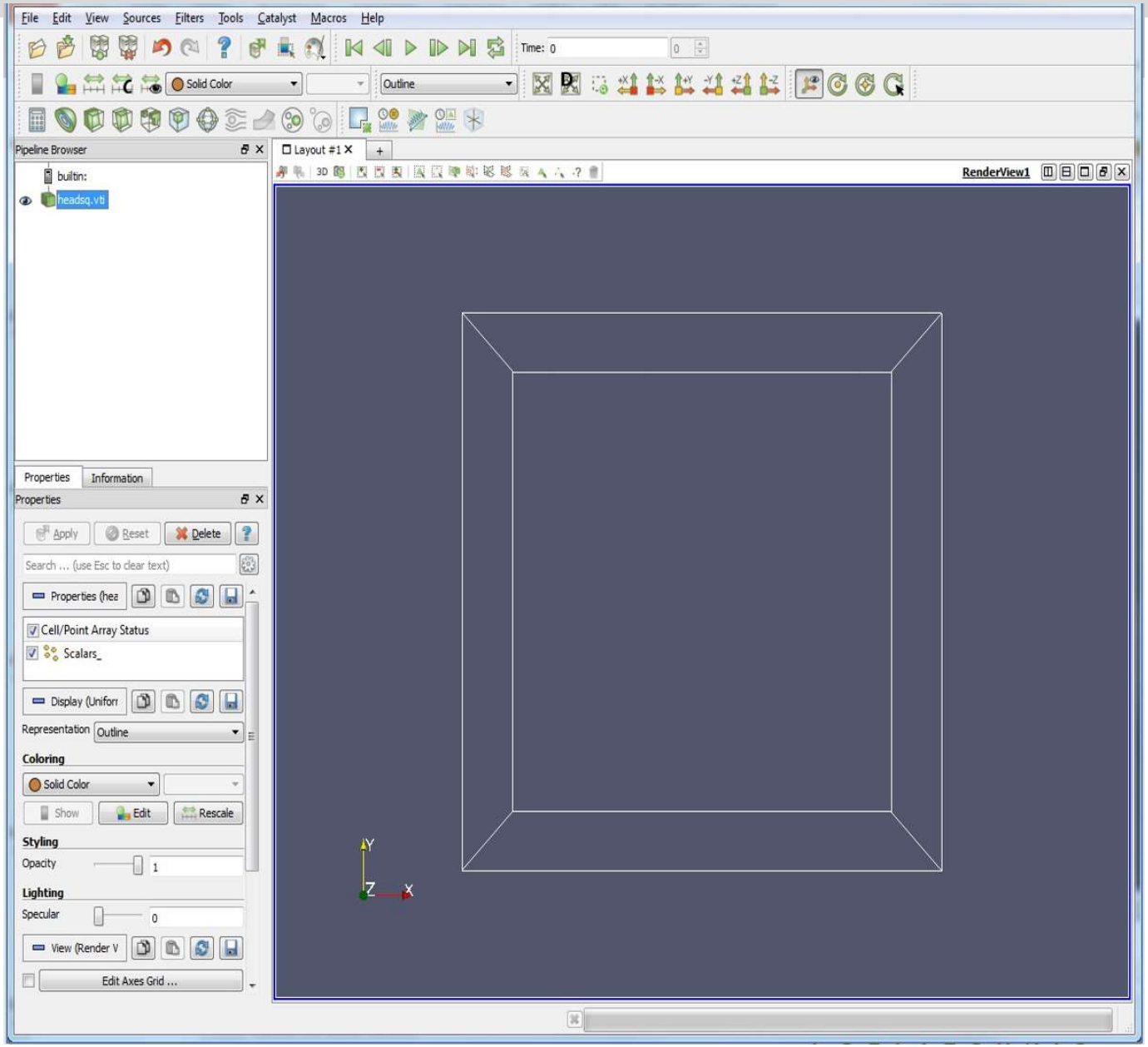
- New Object in Pipeline Browser

- Click **Apply** to update the viewer window if necessary.



ParaView

- **Should see** a bounding box in the 3D viewer window



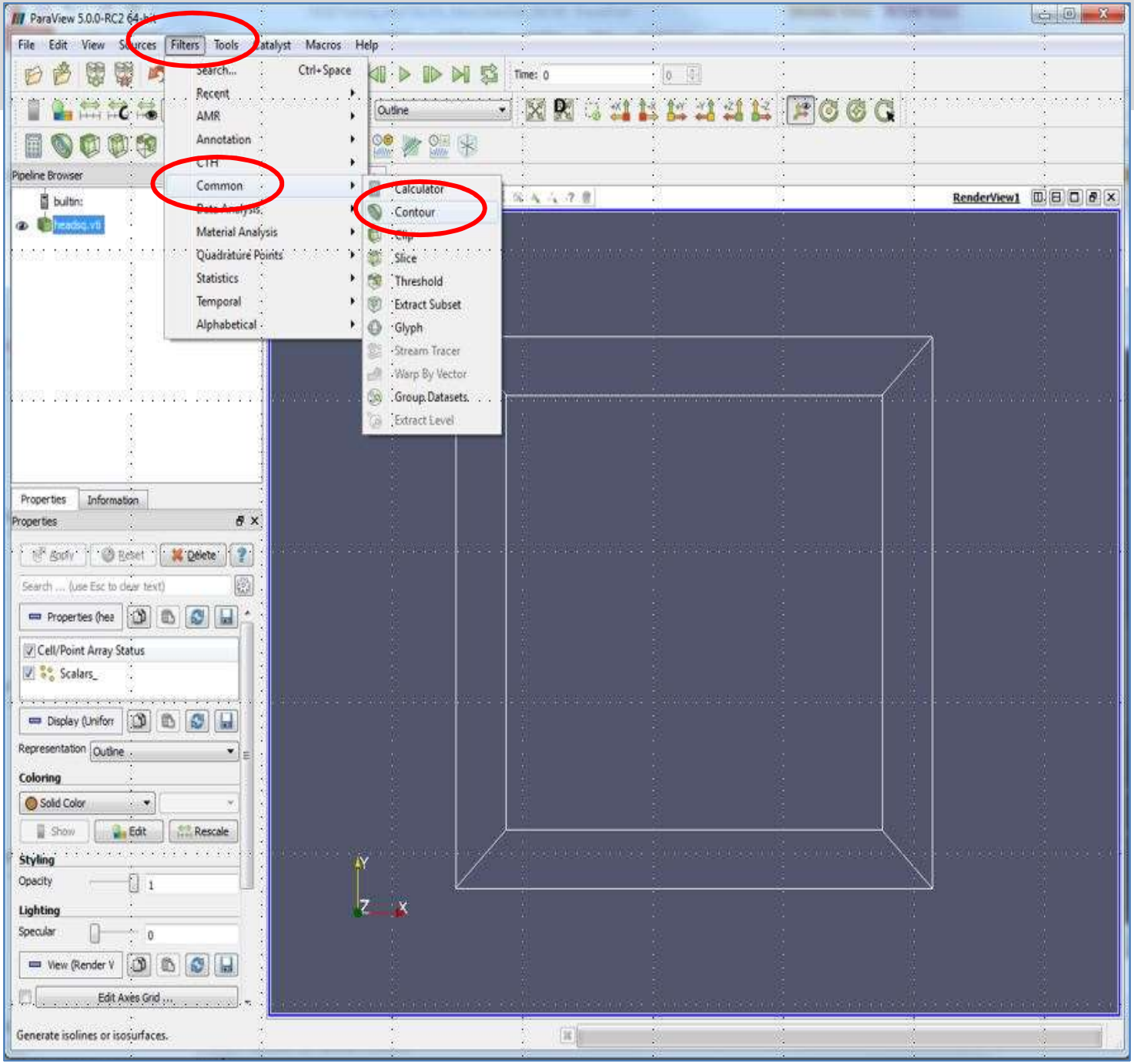
Create an Isosurface

Select:

→ Filters

→ Common

→ Contour

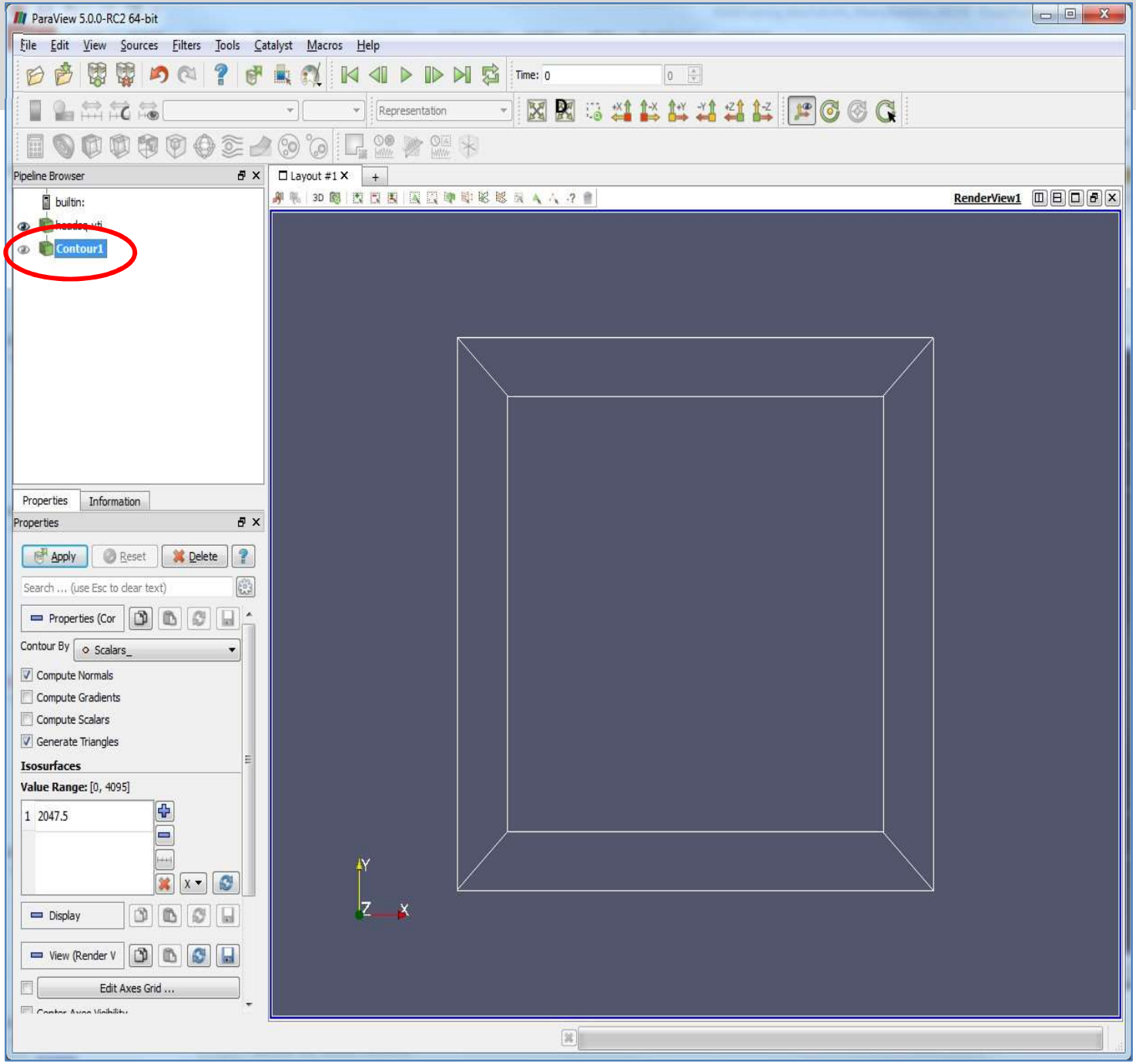


ParaView

- A new object appeared in the pipeline browser (Contour 1)

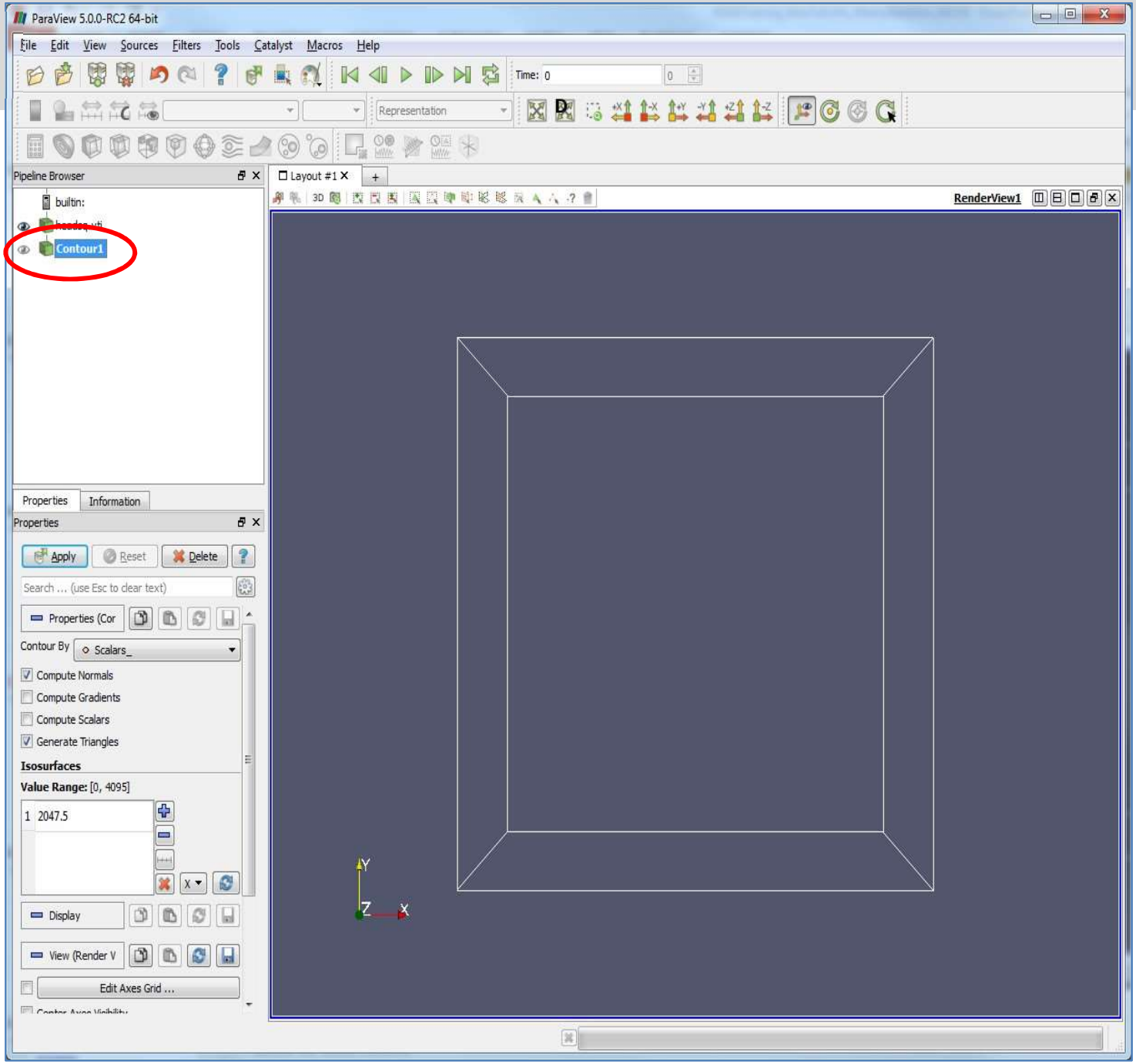
Contour – Extracts the points, curves, or surfaces where a scalar field is equal to a user-defined value.

The surface is often also called an ***isosurface***.



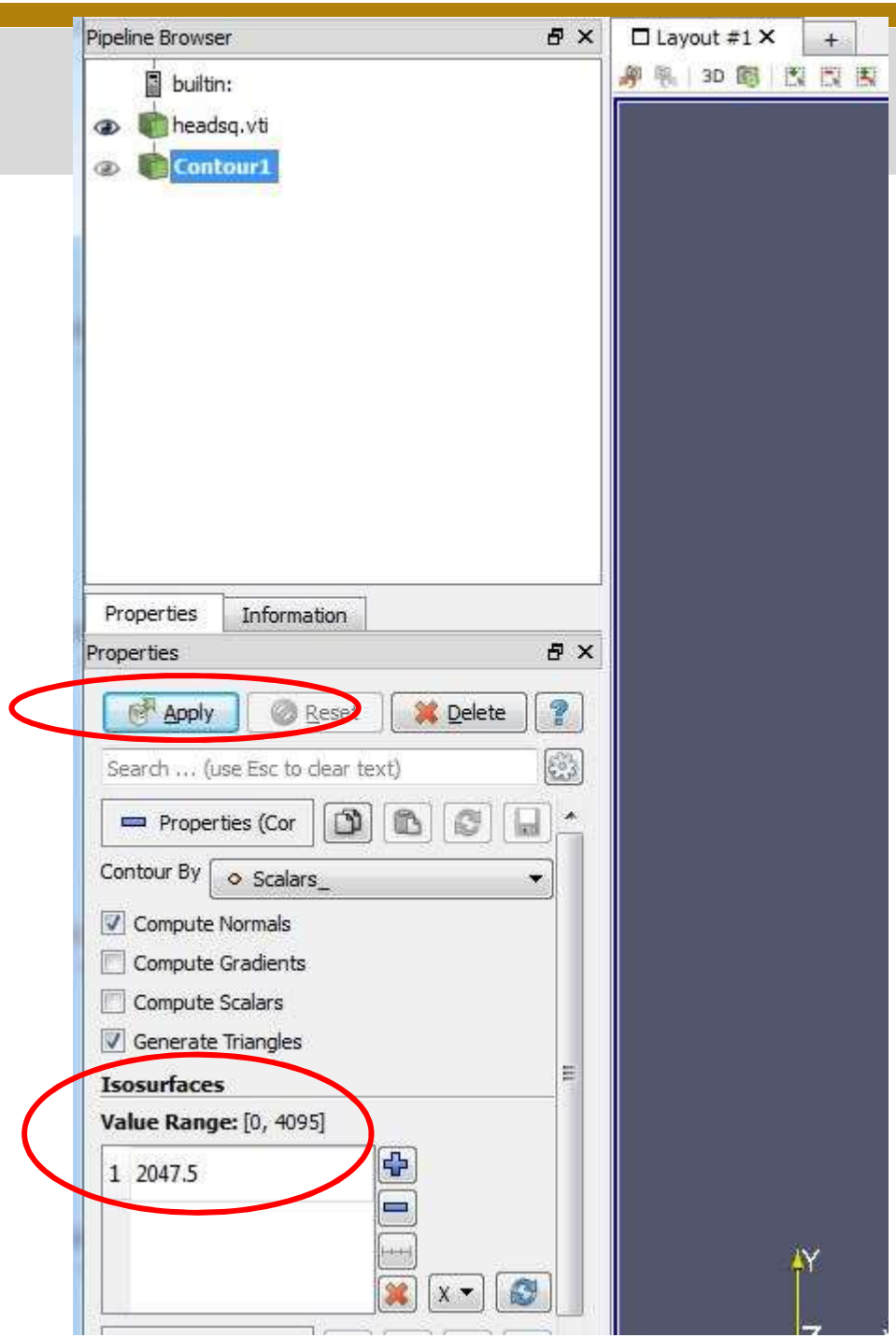
ParaView

- Value Range for the data set is now visible



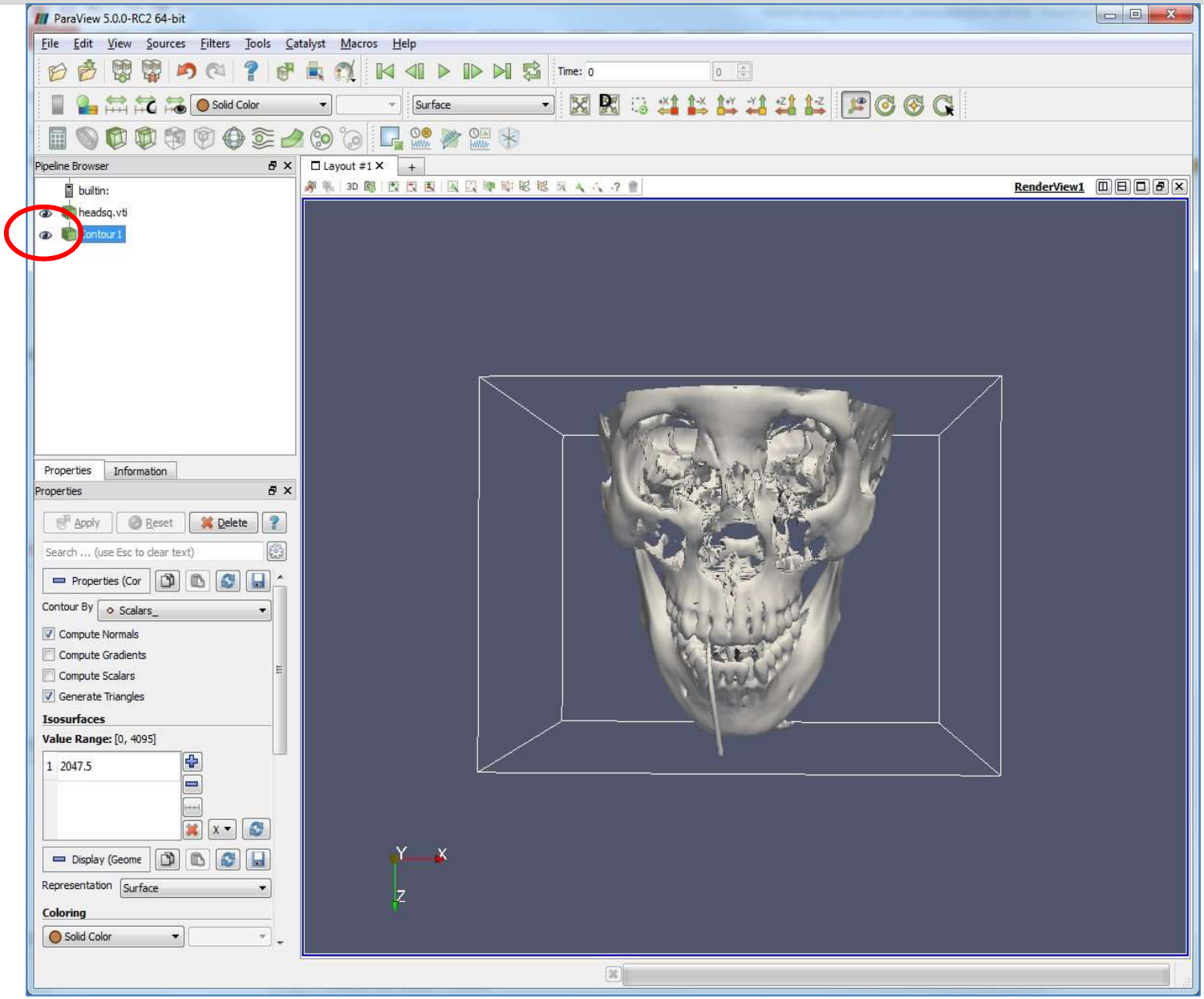
ParaView

- Value Range for the data set is [0, 4095]
- Only one value is showing: 2047.5
- Click **Apply** to see what points, curves, or surfaces in the dataset have a value of 2047.5

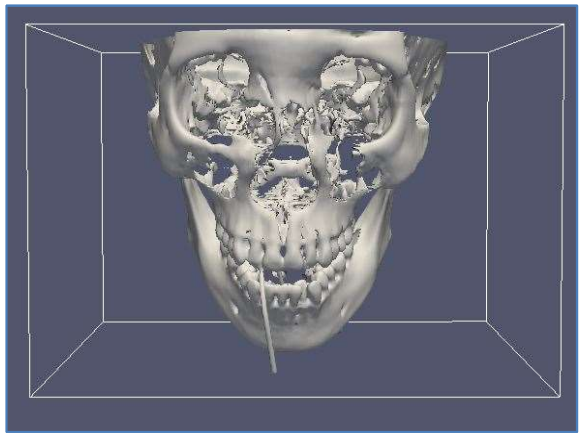


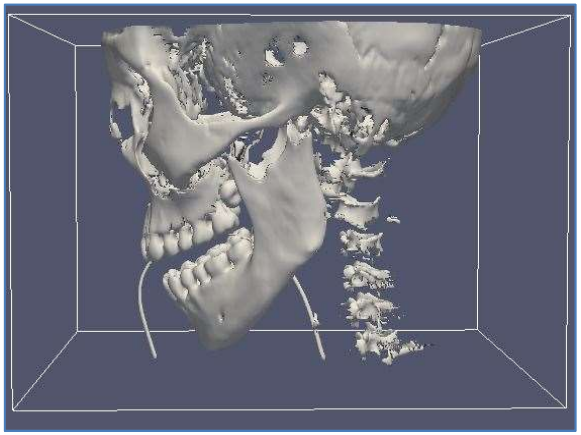
ParaView

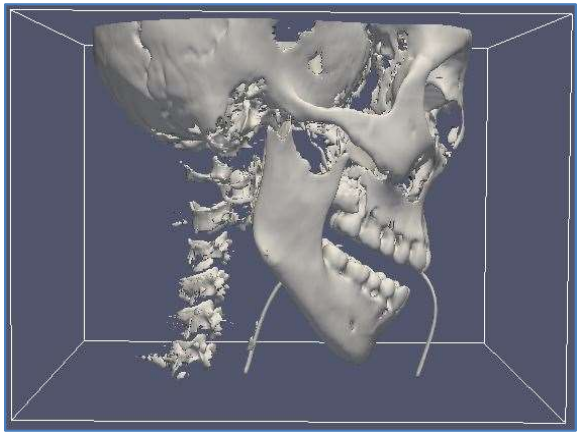
- If you do not see anything in the 3D window click the eye icon next to Contour1 in the Pipeline Browser
- This allows you to toggle between views in the 3D Viewer

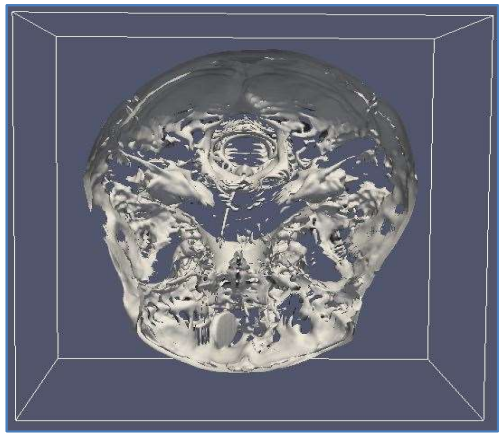


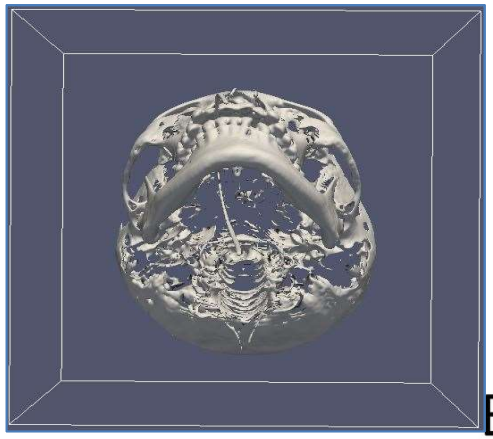
Visually Explore Dataset











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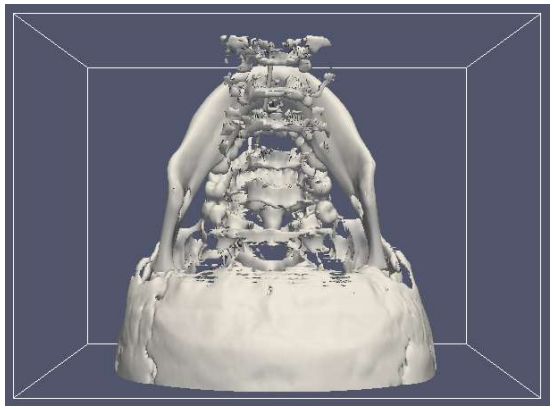
Visually Explore Dataset

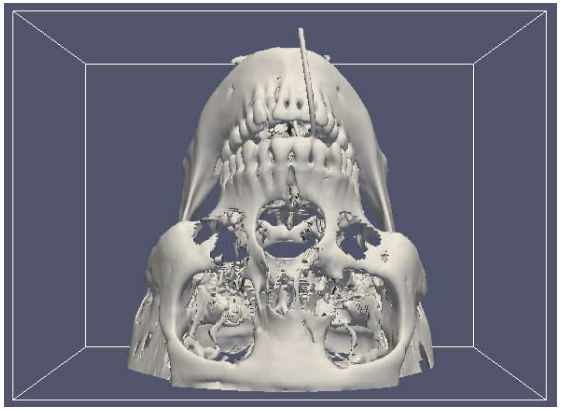
+X

-X

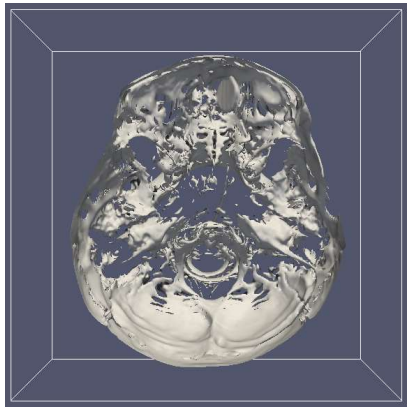


+Y

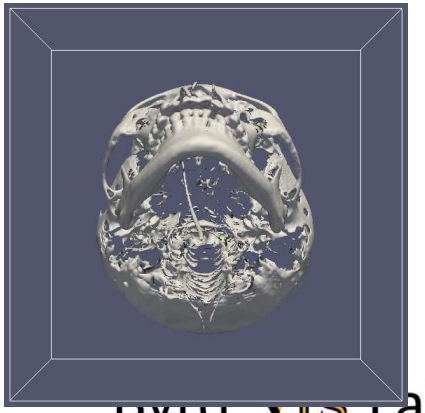
-Y



+Z



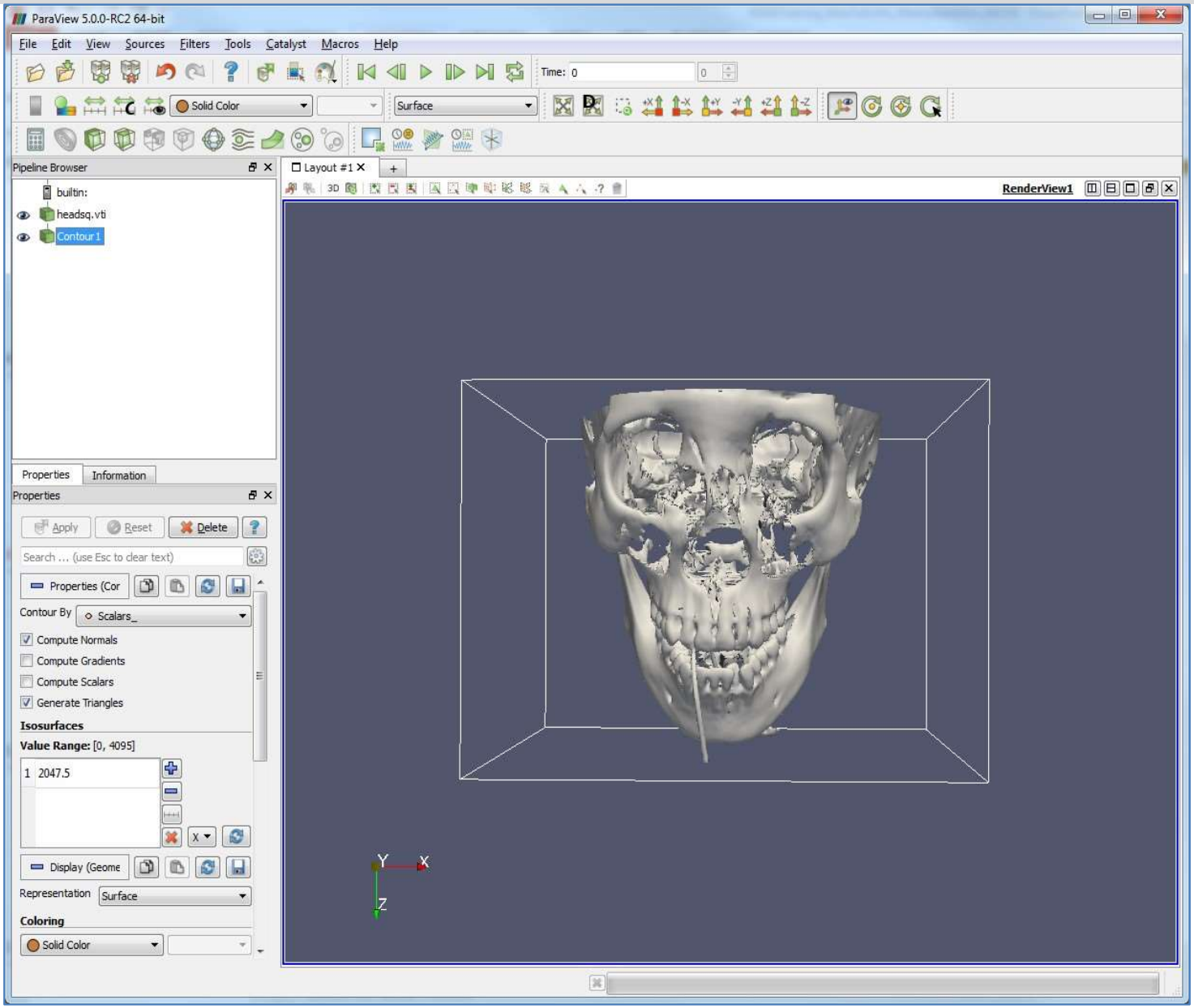
- Z



ParaView

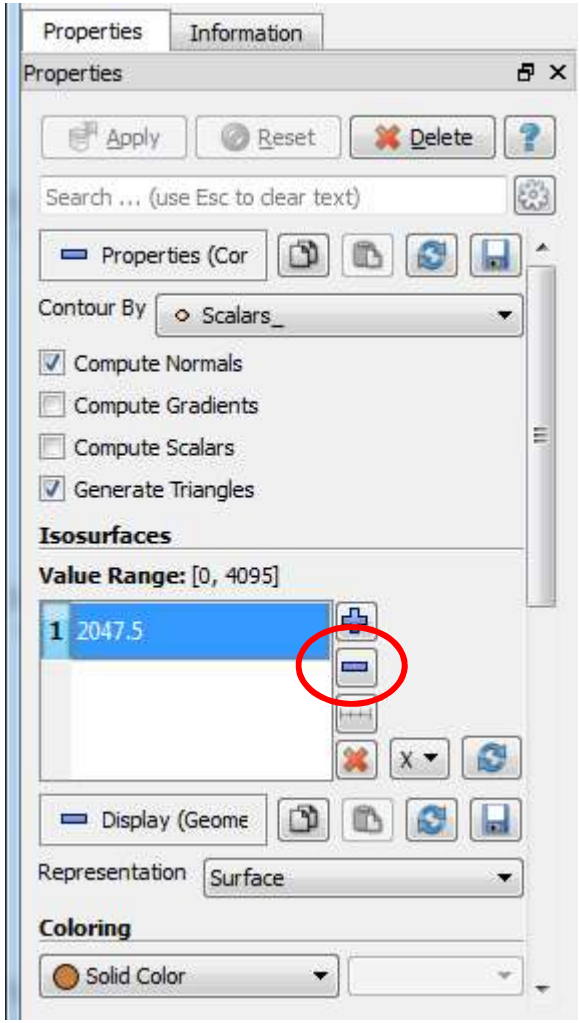
You should be here

Pipeline Browser
→ Two objects
→ Value Range
[0, 4095]



Isosurfaces

- Select 2047.5 showing in Value Range
  - Selecting the value 2047.5 highlights the value
- Delete that value (click the minus button to remove all values)



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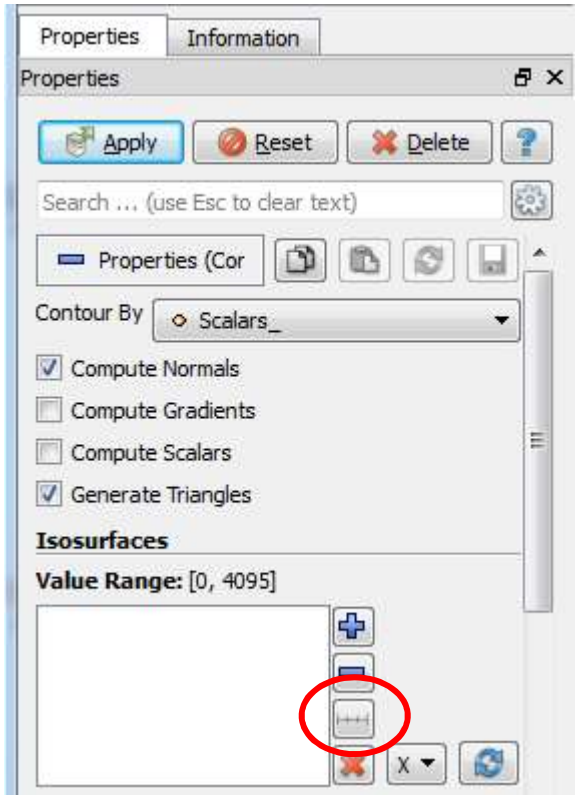
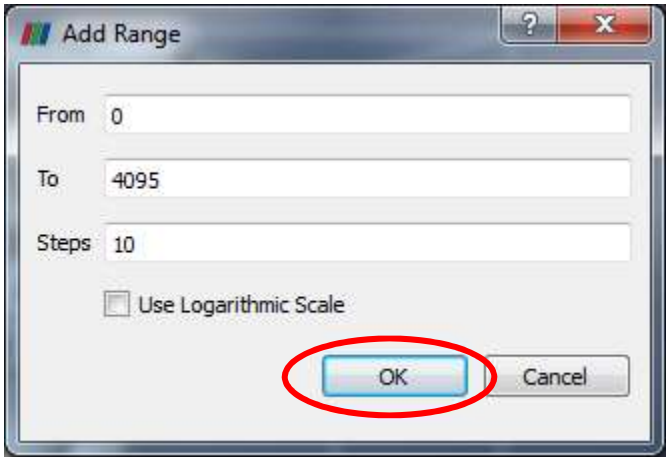
Isosurfaces

- Click the button below the minus button to: **Add a Range Of Values**

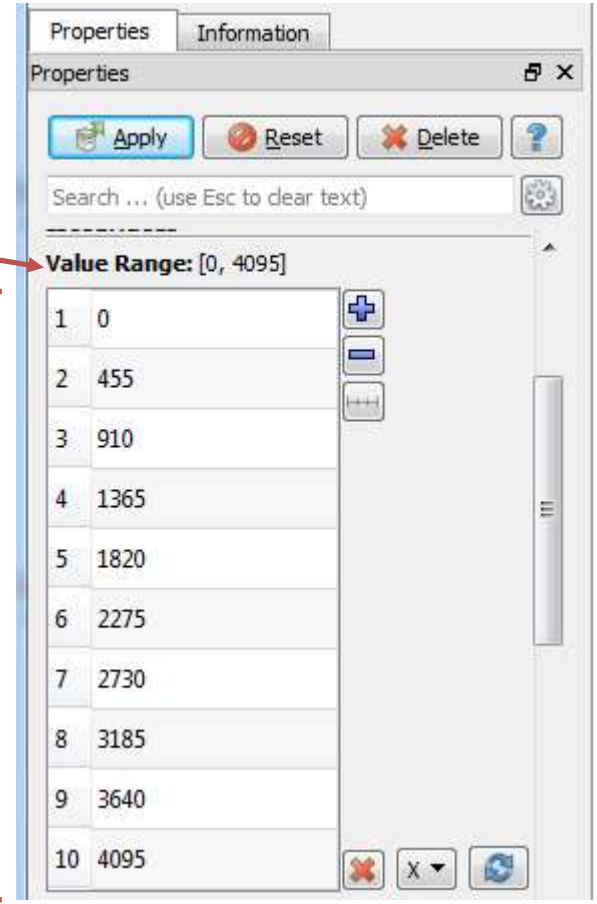


- Should see the Add Range Window
  - Use this window to set the range of values
  - For this tutorial
    - Min: 0
    - Max: 4095
  - Feel free to pay around with the range (between 0 and 4905)
  - Click **OK**



Isosurfaces

- Notice the Value Range: [0, 4095]
- There are 10 values (steps) showing values between 0 and 4095



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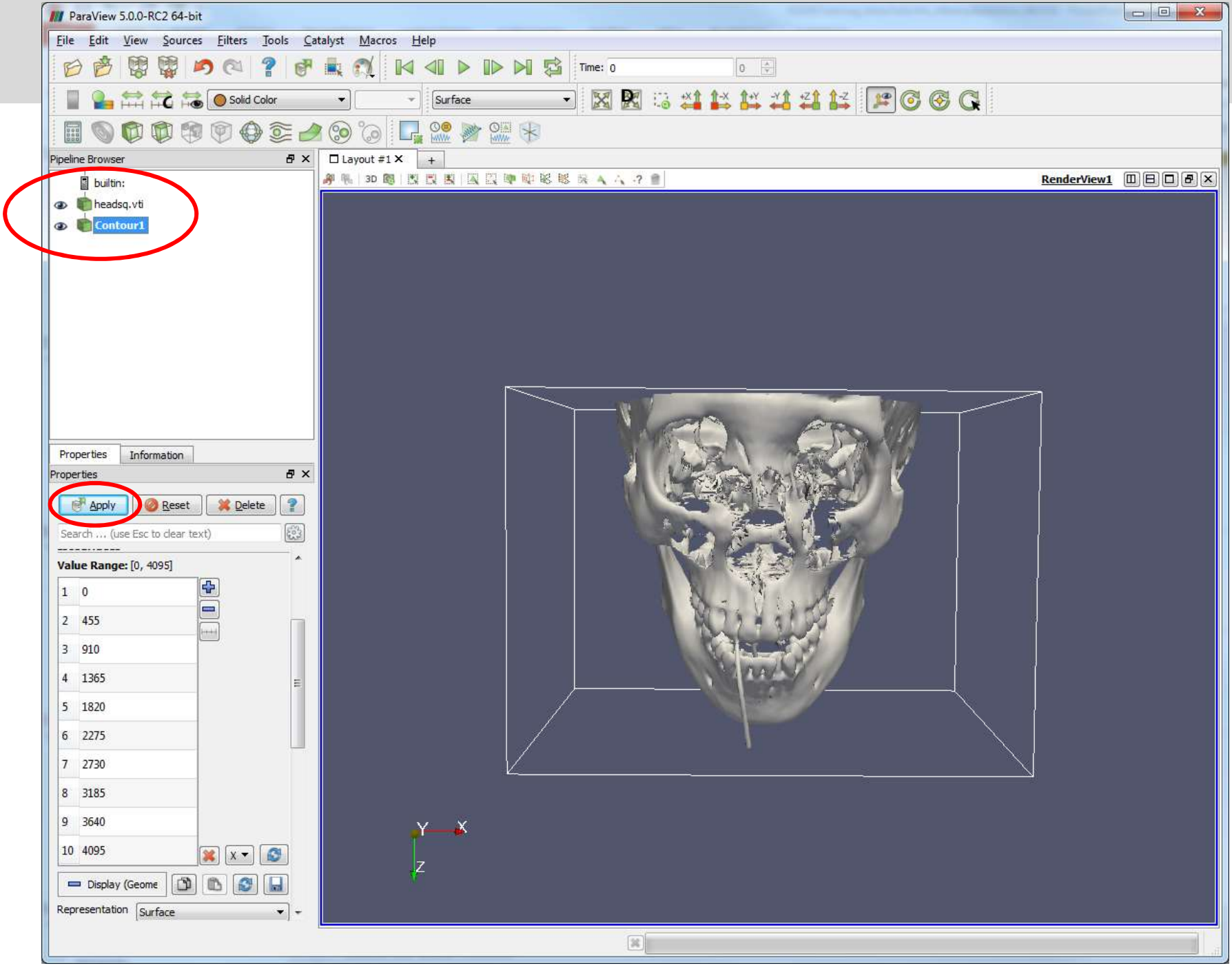
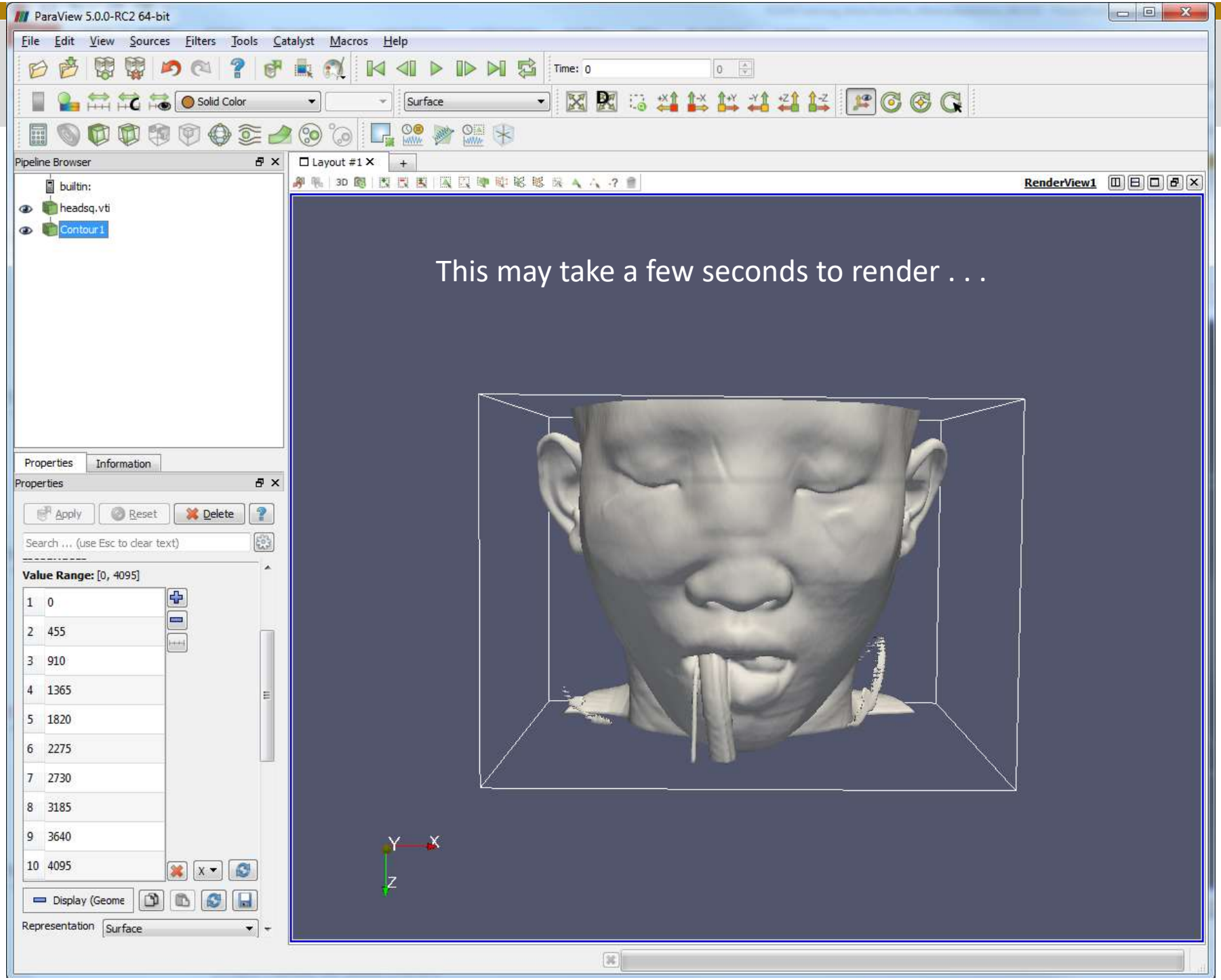
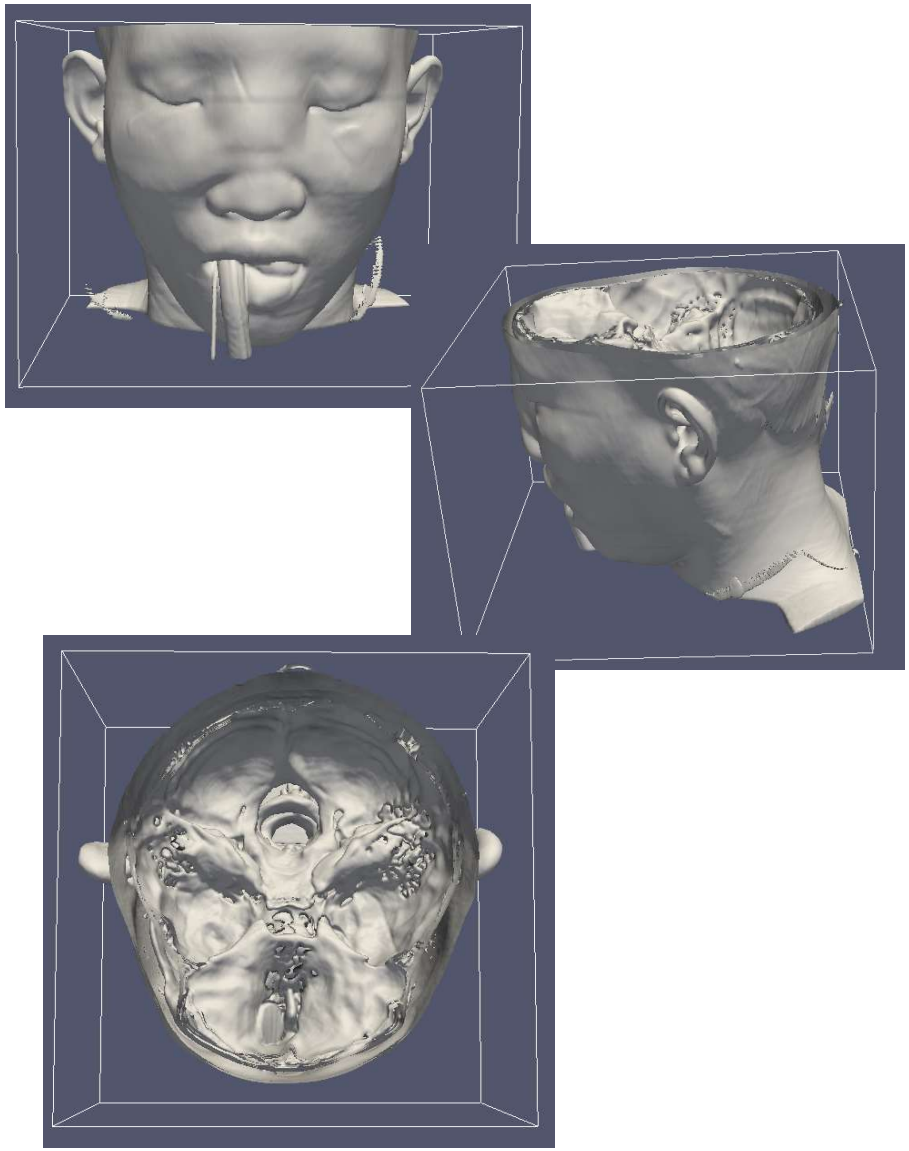
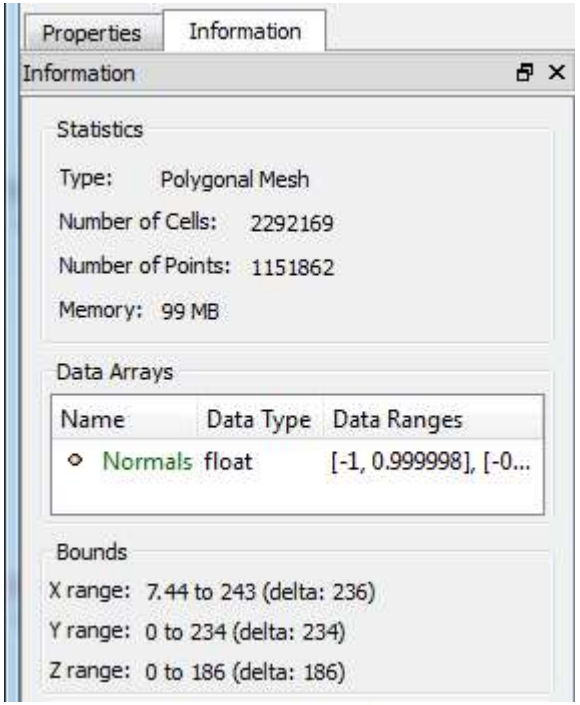

ParaView 5.0.0-RC2 64-bit
File Edit View Sources Filters Tools Catalyst Macros Help
Time: 0
Solid Color
Surface
Pipeline Browser
builtin:
headsq.vti
Contour1
Layout #1
RenderView1
Properties
Information
Apply
Reset
Delete
Search ... (use Esc to clear text)
Value Range: [0, 4095]
1 0
2 455
3 910
4 1365
5 1820
6 2275
7 2730
8 3185
9 3640
10 4095
Display (Geome
Representation
Surface
Y
X
Z


ParaView 5.0.0-RC2 64-bit
File Edit View Sources Filters Tools Catalyst Macros Help
Time: 0
Solid Color
Surface
Pipeline Browser
builtin:
headsq.vti
Contour1
Layout #1
RenderView1
This may take a few seconds to render . . .
Properties
Information
Apply
Reset
Delete
Search ... (use Esc to clear text)
Value Range: [0, 4095]
1 0
2 455
3 910
4 1365
5 1820
6 2275
7 2730
8 3185
9 3640
10 4095
Display (Geome
Representation
Surface
Y
X
Z

Explore the rendering . . .





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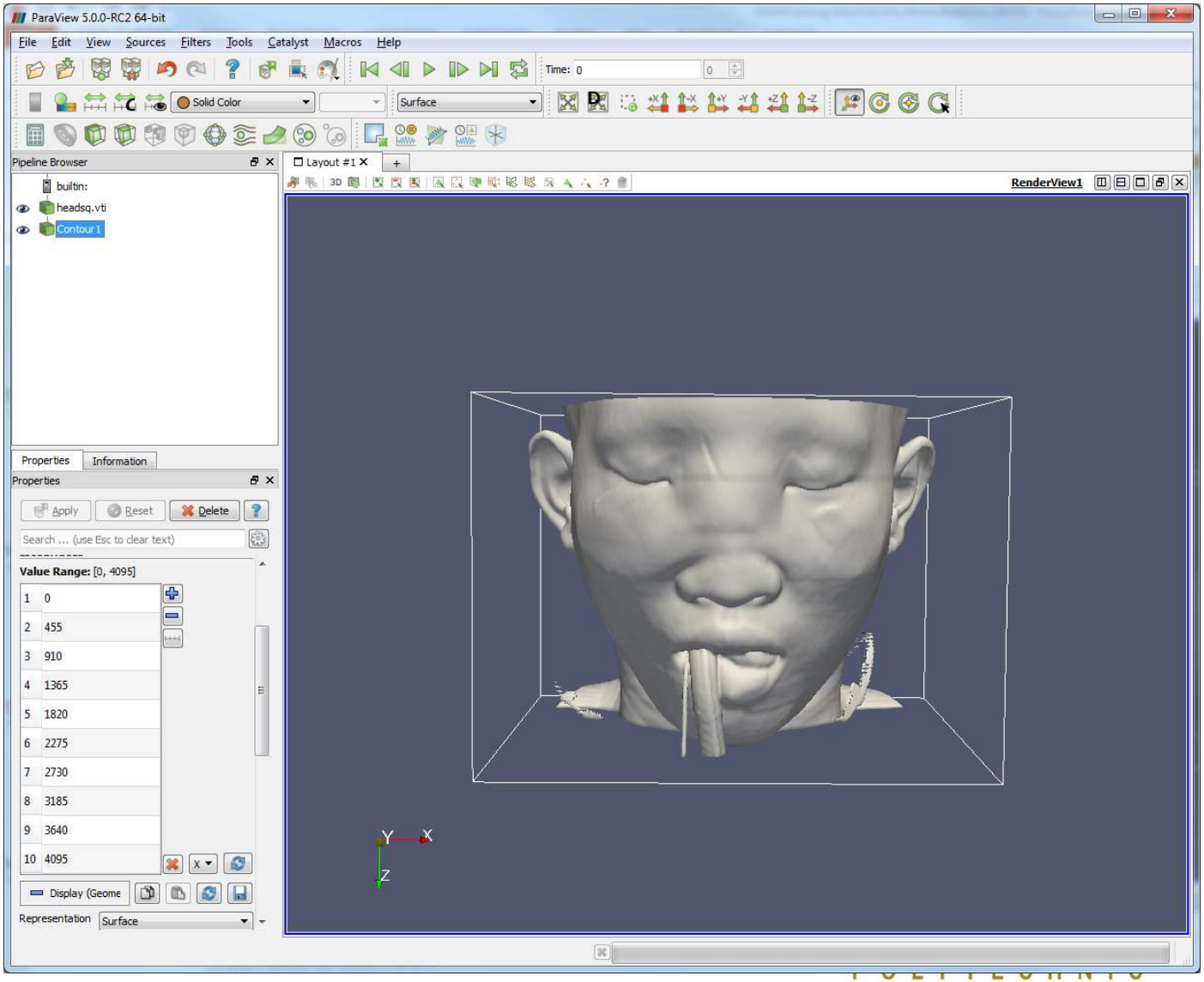
POLYTECHNIC

You should be here . . .

Contour – Extracts the points, curves, or surfaces where a scalar field is equal to a user-defined value.

The surface is often also called an ***isosurface***.



Explore the data set

Vary the **Set Value Range**

From	To	Step	What do you get?
1500	2500	10	
2500	3500	10	
2999	3500	20	
3500	4000	20	
2000	2999	10	
3000	3999	10	

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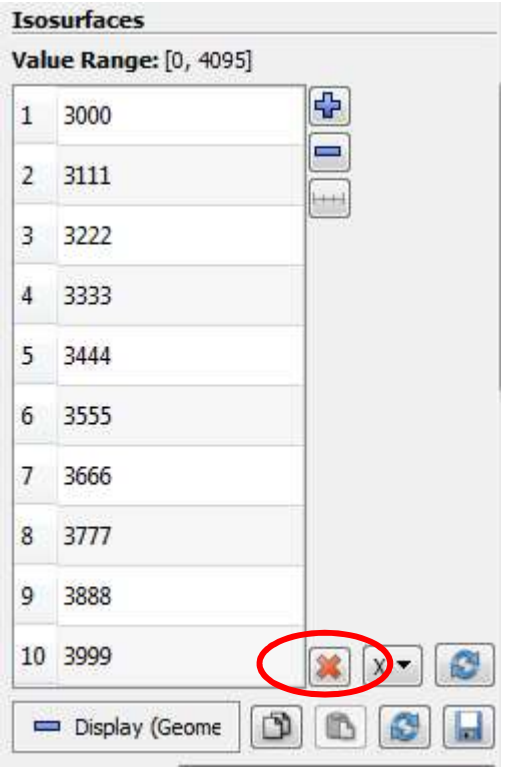
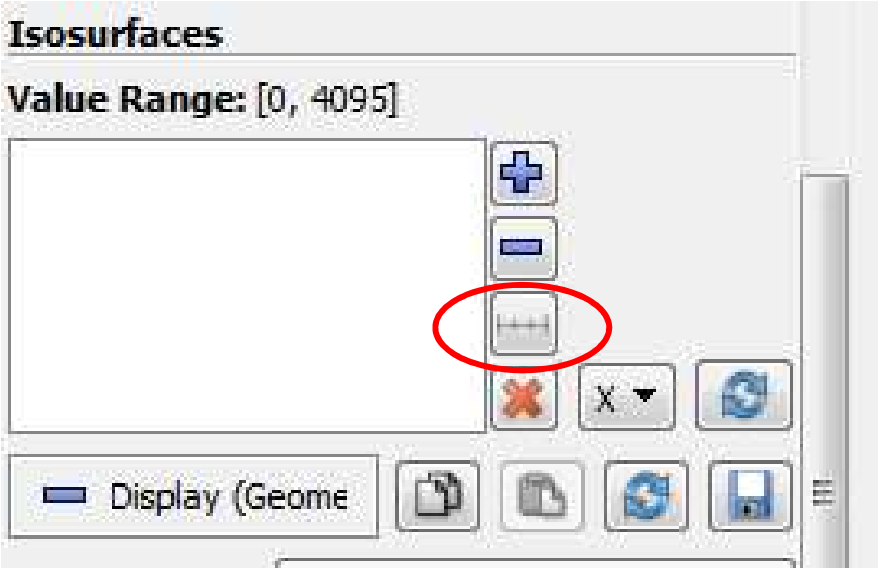
Reset Values

1 Click red X – Remove all entries



2 Click Add a range of values button



3 Click OK

4 Click Apply

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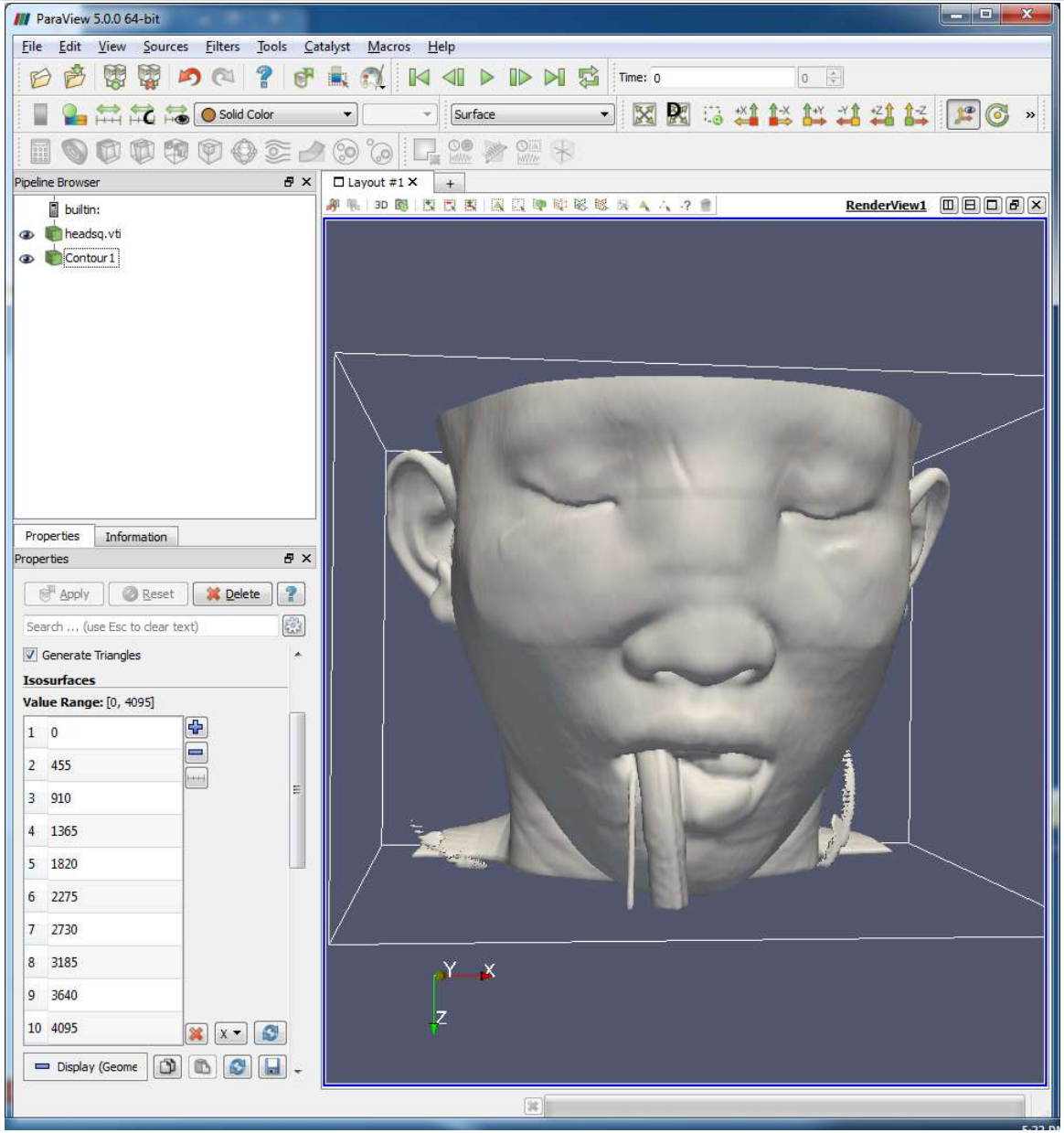
You should be here



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Clip Isosurface

- CLIP - Intersects the geometry with a half space.
- The effect is to remove all the geometry on one side of a user-defined plane.

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Clip Isosurface

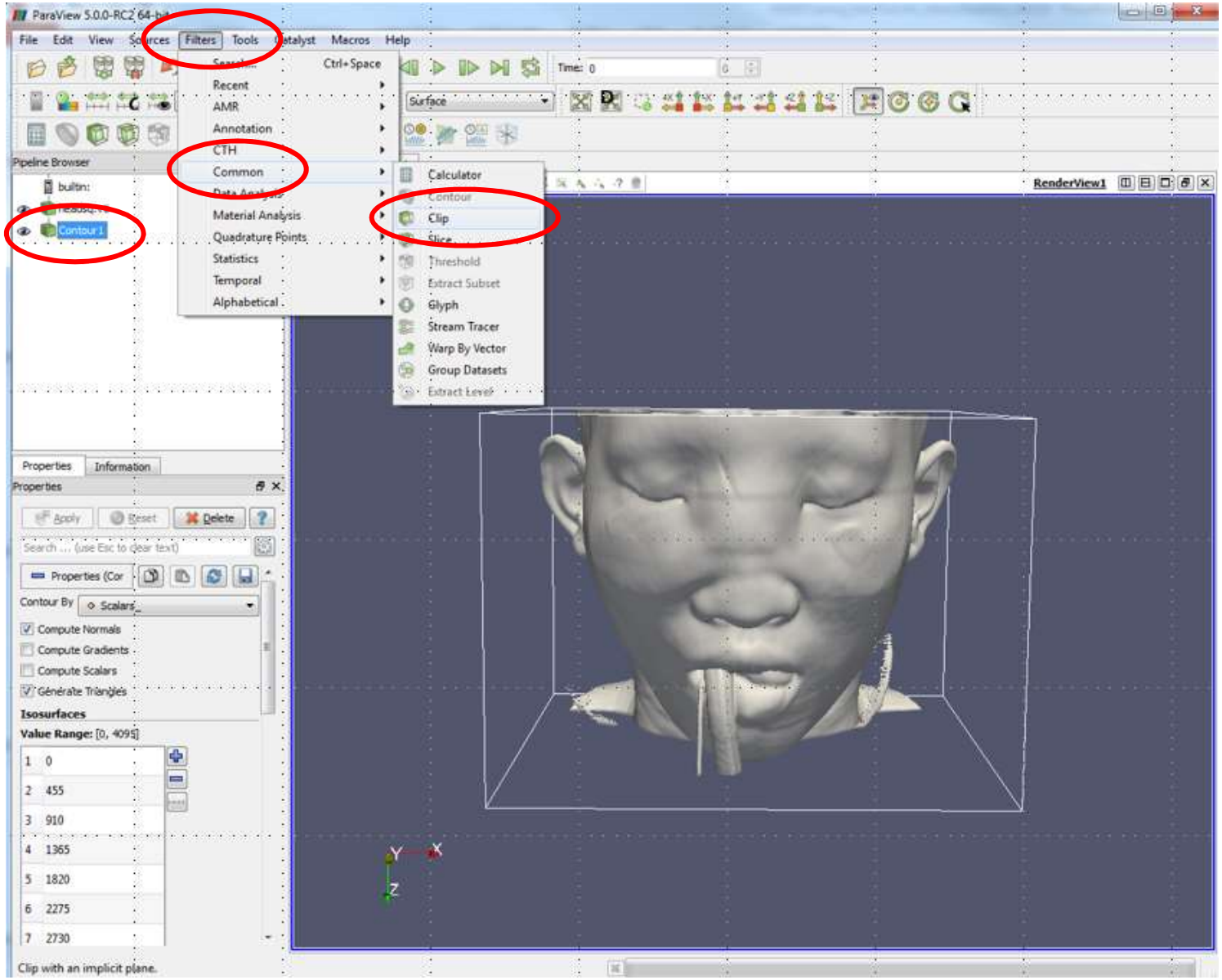
Select:

→ Contour 1 *(in pipeline Browser)*

→ Filters

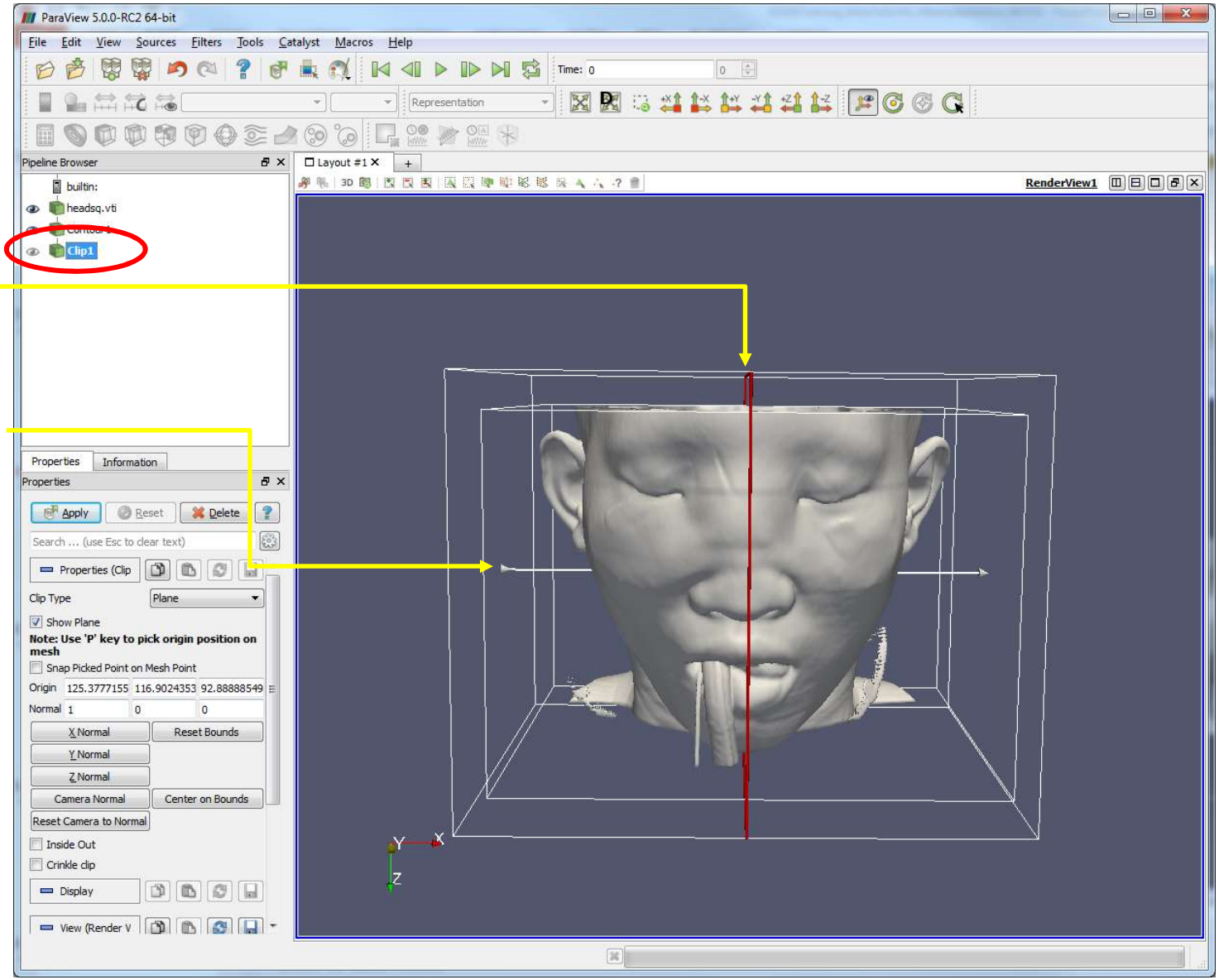
→ Common

→ Clip



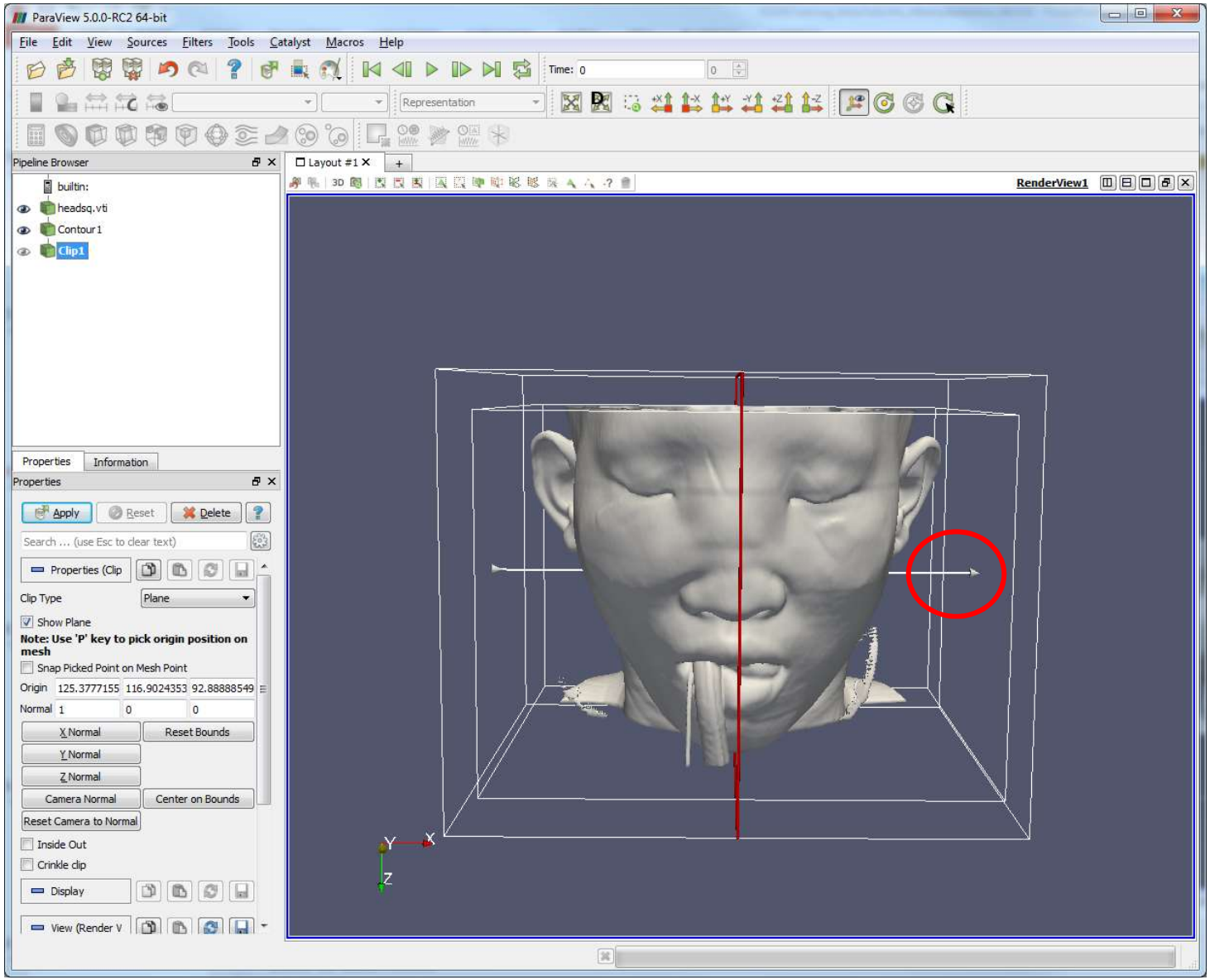
Clip Isosurface

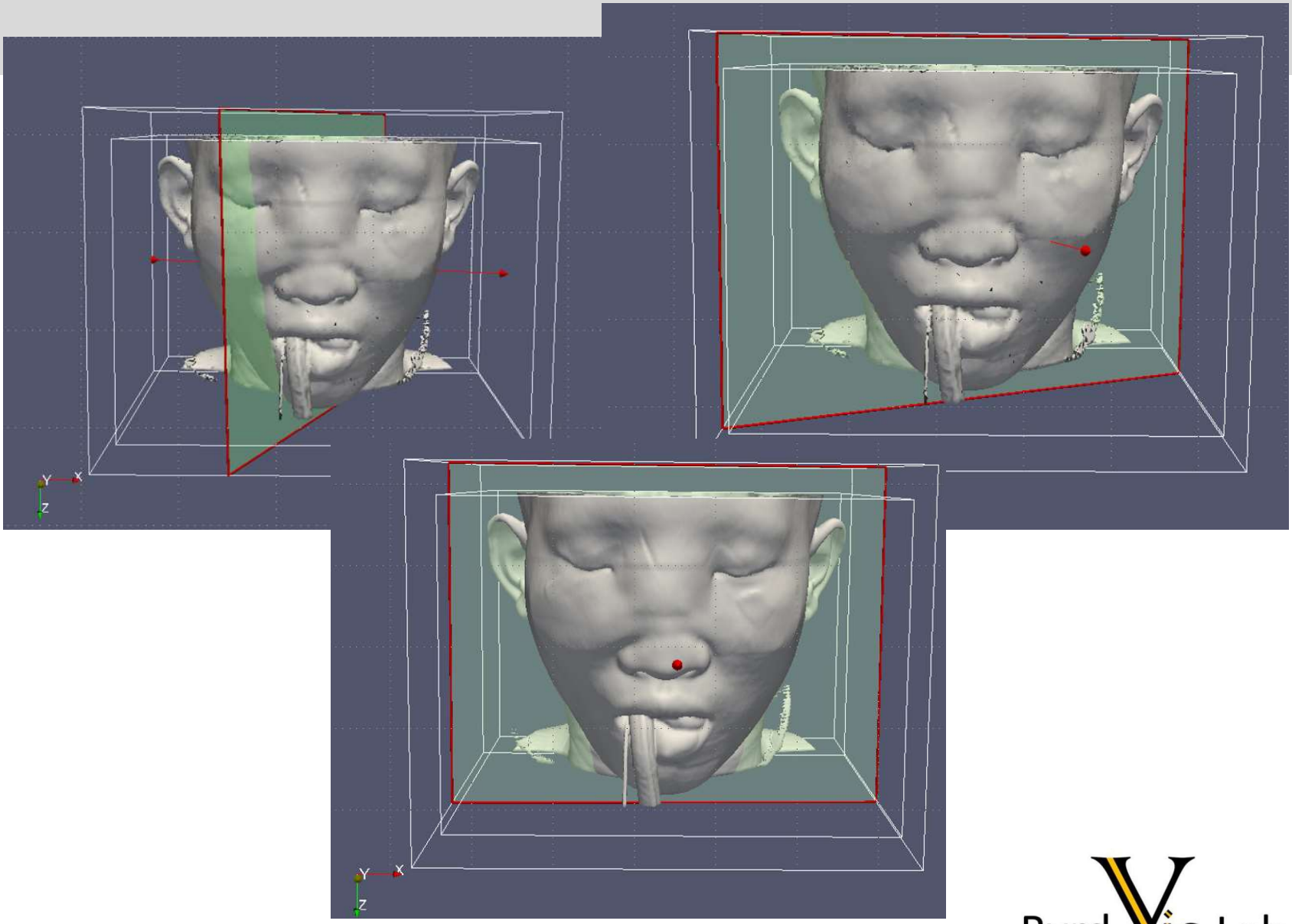
- A new object appeared in the pipeline browser (Clip 1)
- Clipping plane (see red vertical line and horizontal arrow)



Clip Isosurface

- Select the arrow point (arrow turns red)
- Rotate (drag) the arrow point until the arrow is pointing out of the screen toward you)





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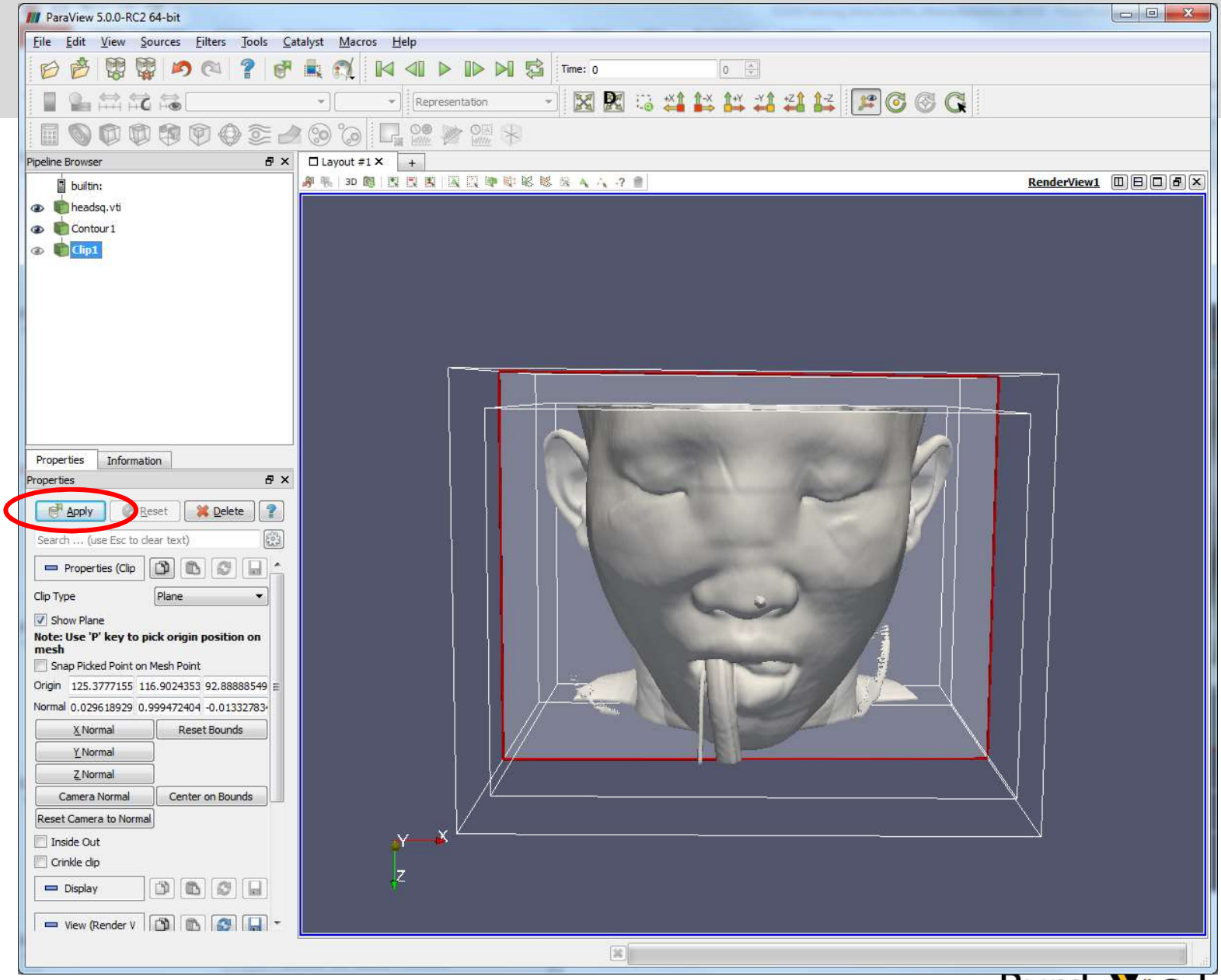

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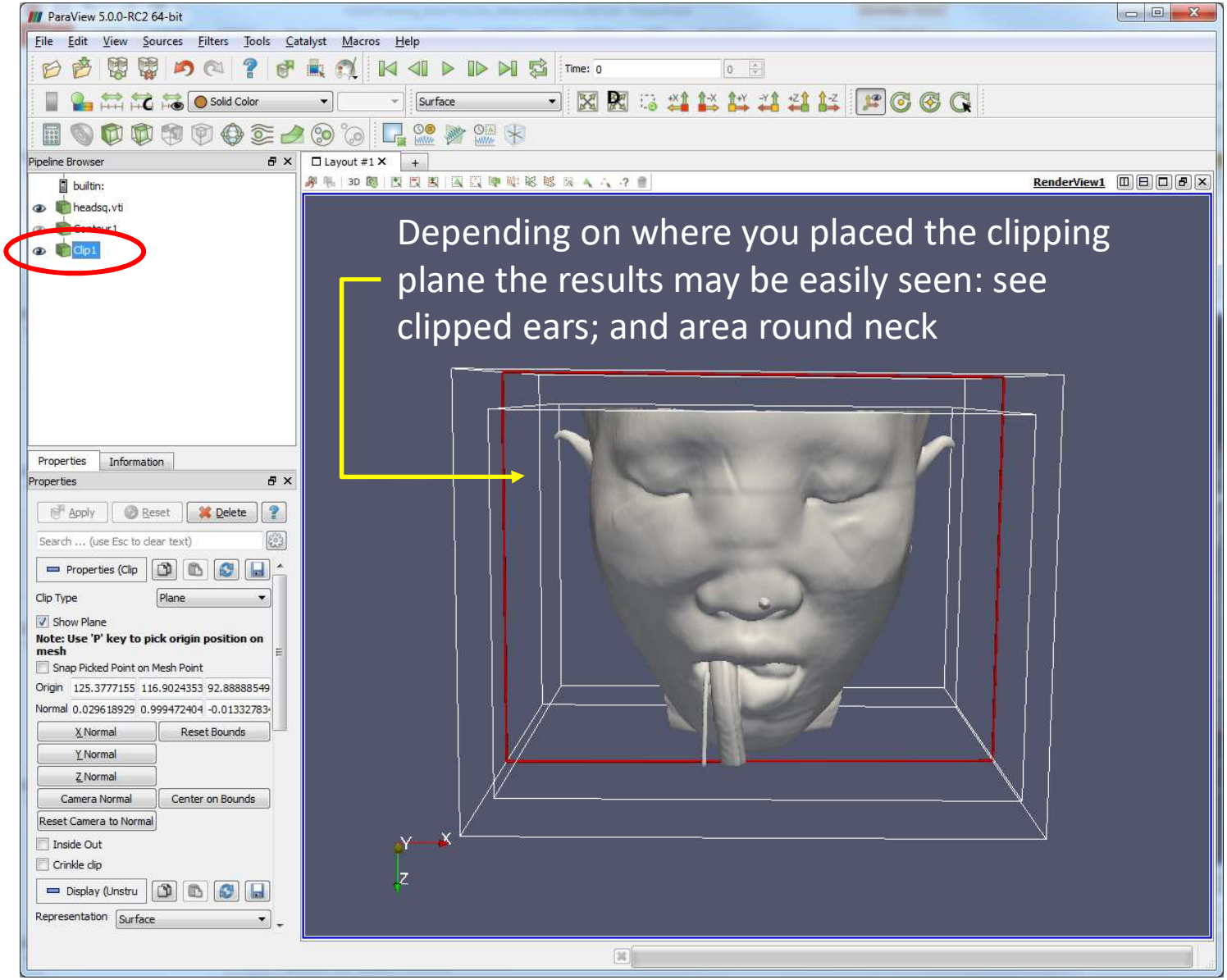
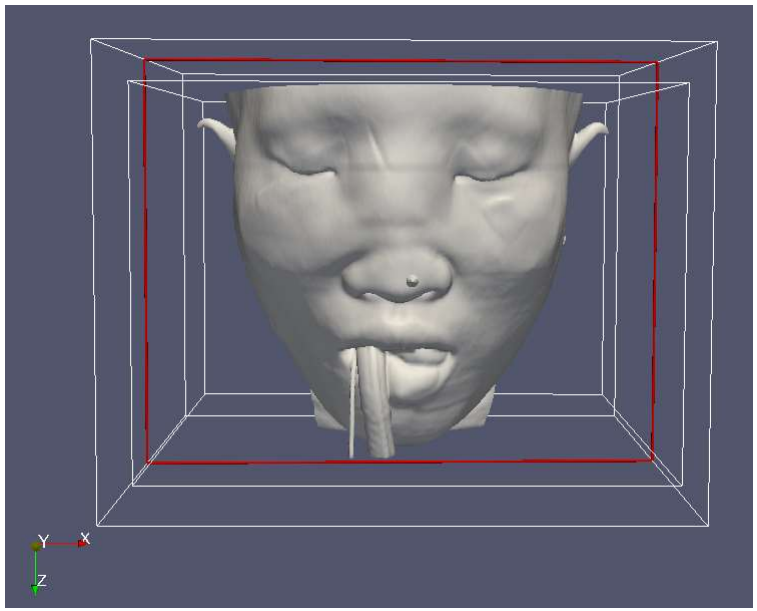
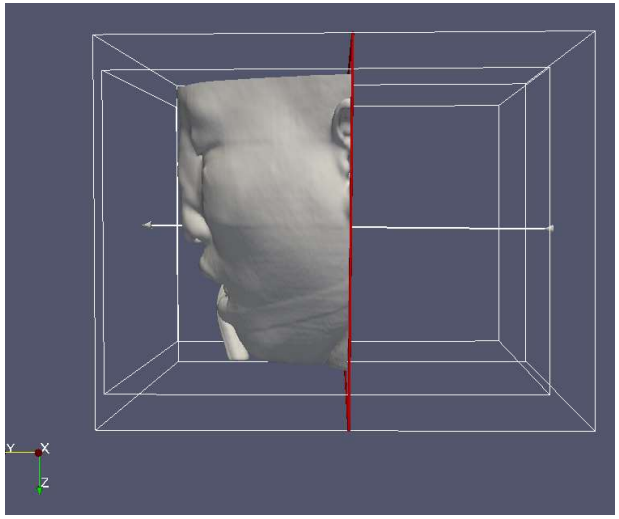
Clip Isosurface

- Make sure the eye icon is not greyed out on the Clip1 object in the Pipeline Browser

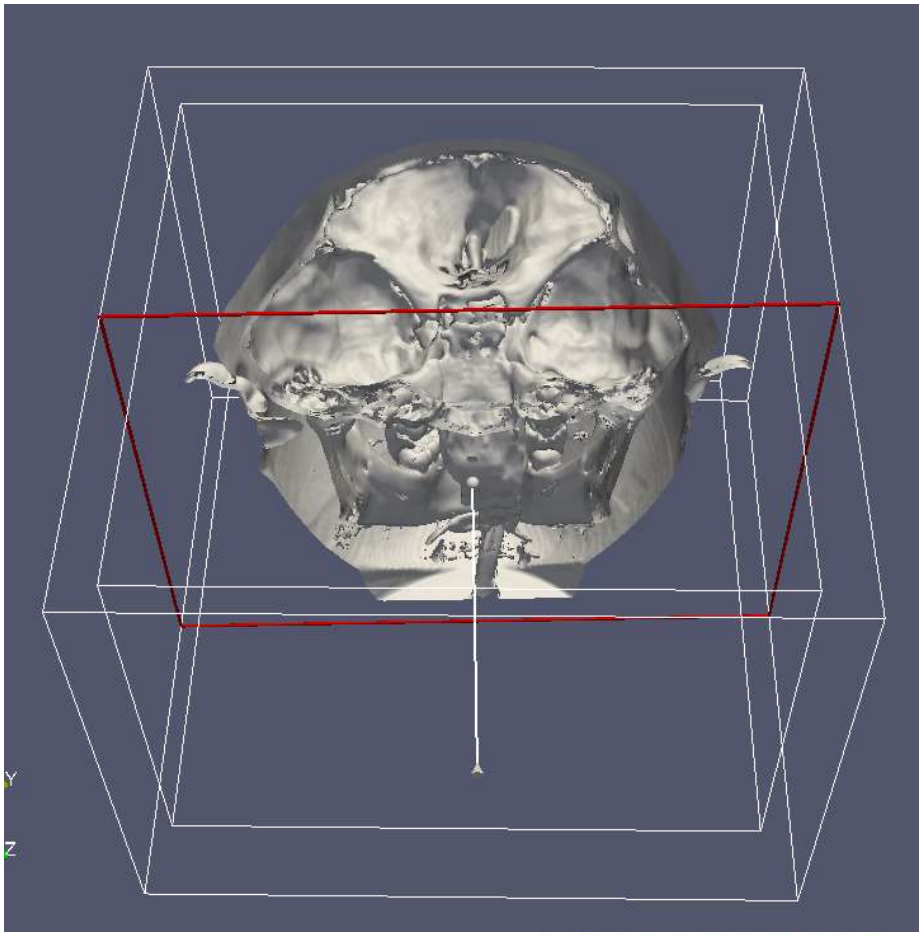


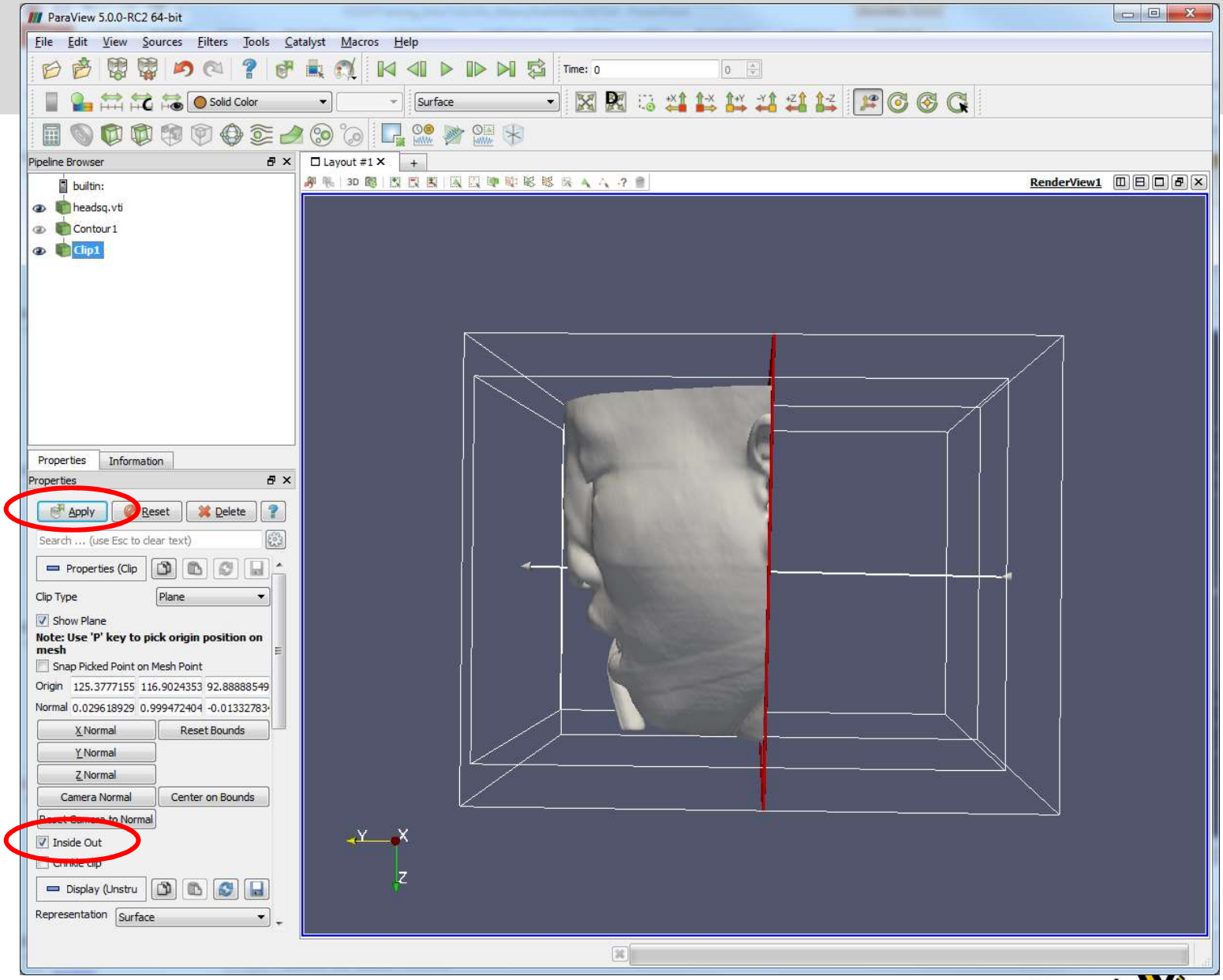
Clip Isosurface





Rotating the view reveals the clipped isosurface





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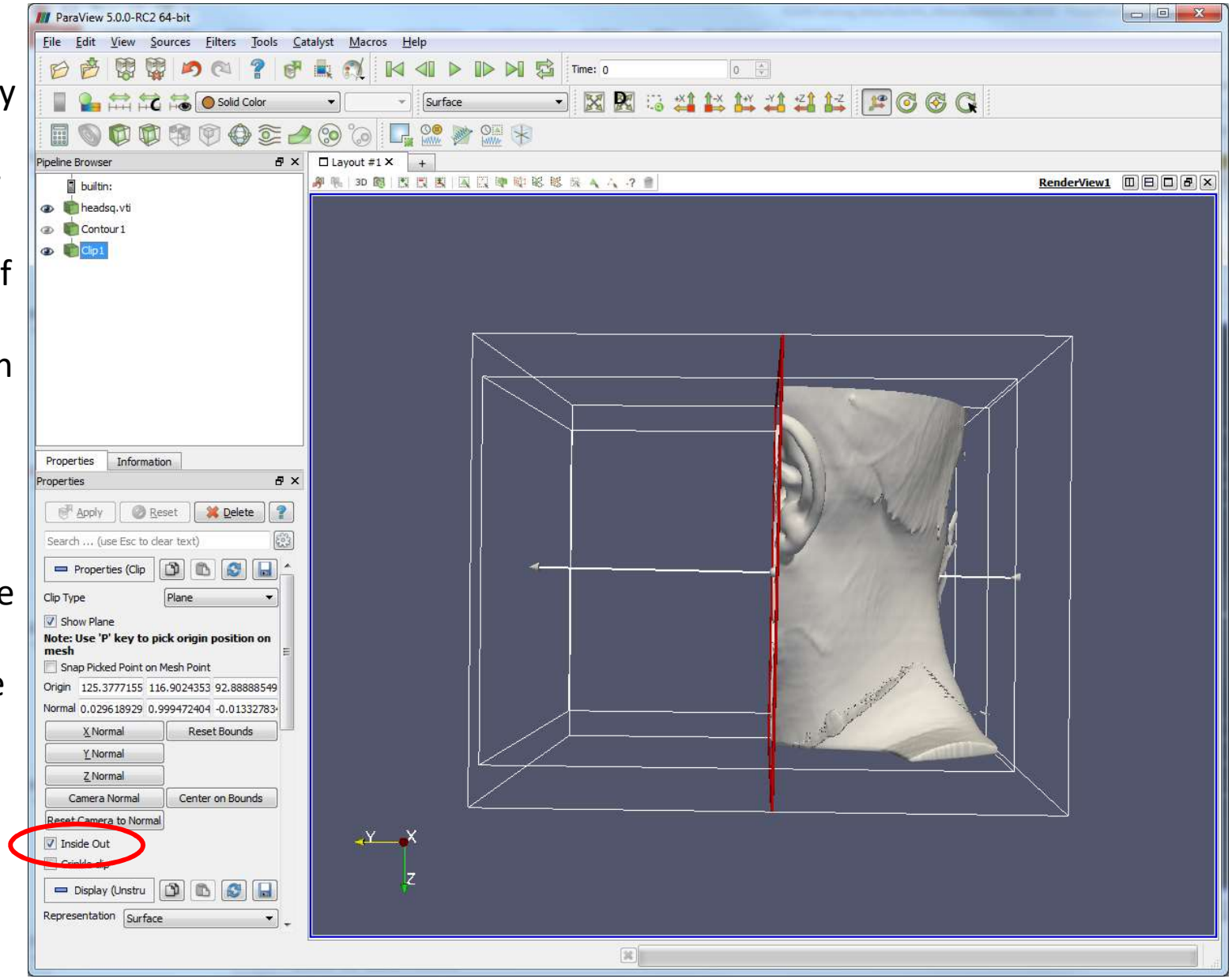
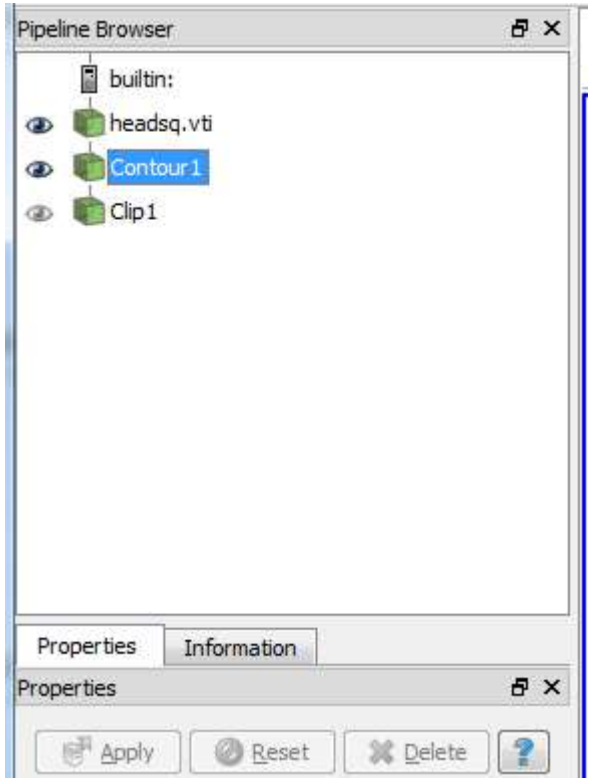
Inside Out Property

- If this property is set to 0, then clip filter will return that portion of the dataset that lies within the clip function.
- If set to 1, the portions of the dataset that lie outside the clip function will be returned instead



Slice Isosurface

- Click the eye icon next to Clip1 in the pipeline browser *(hide the clip plot)*
- Select **Contour 1**



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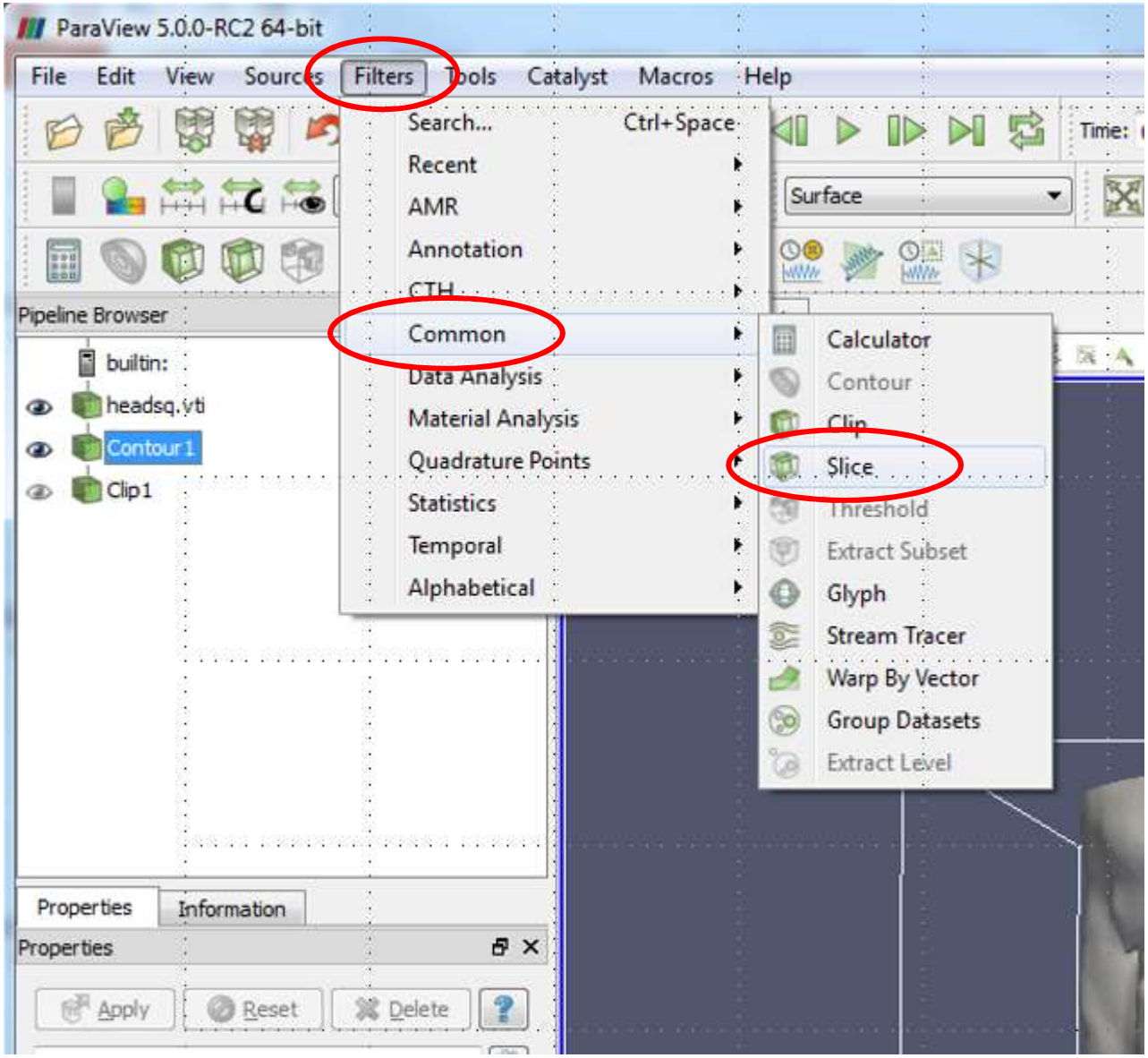
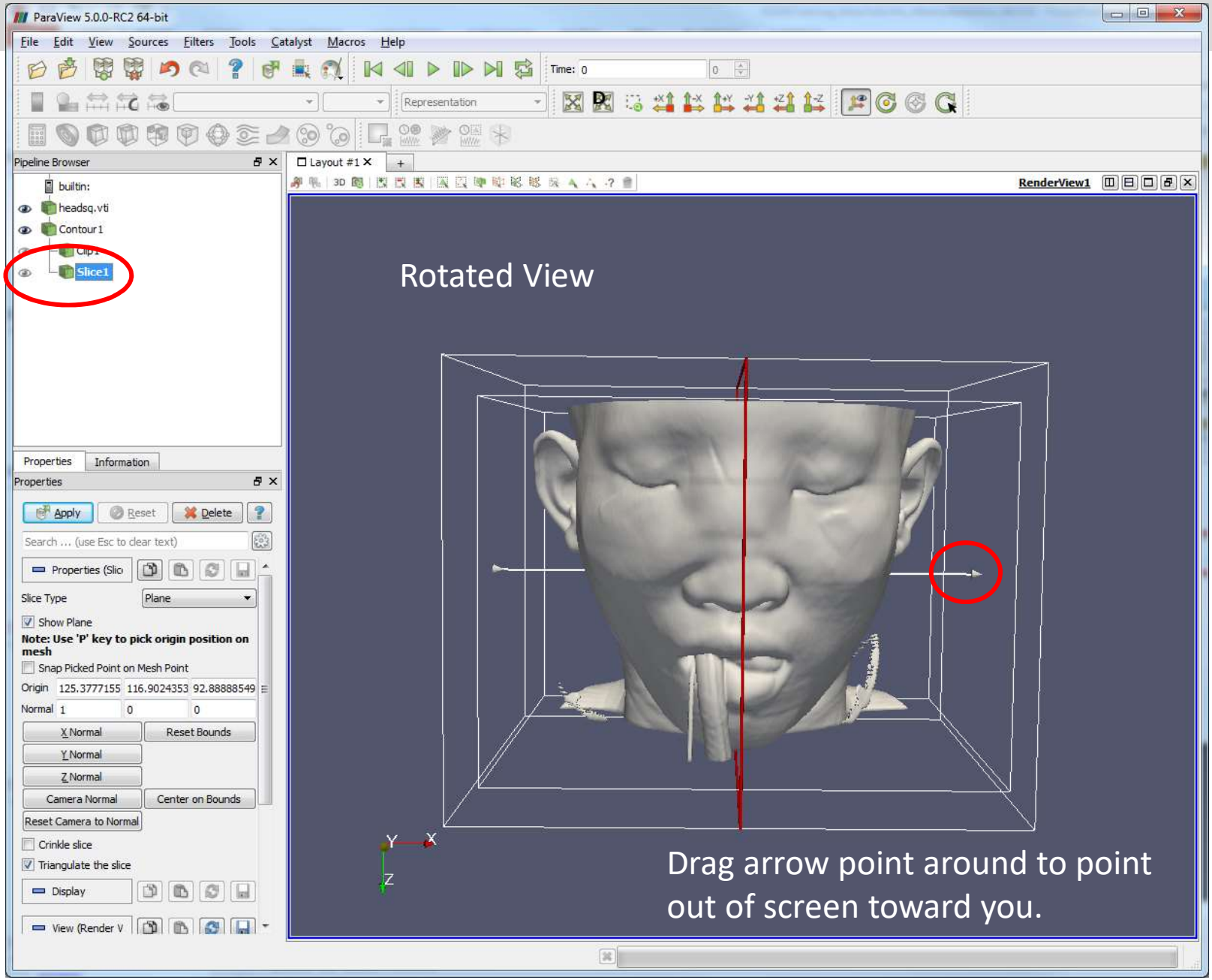
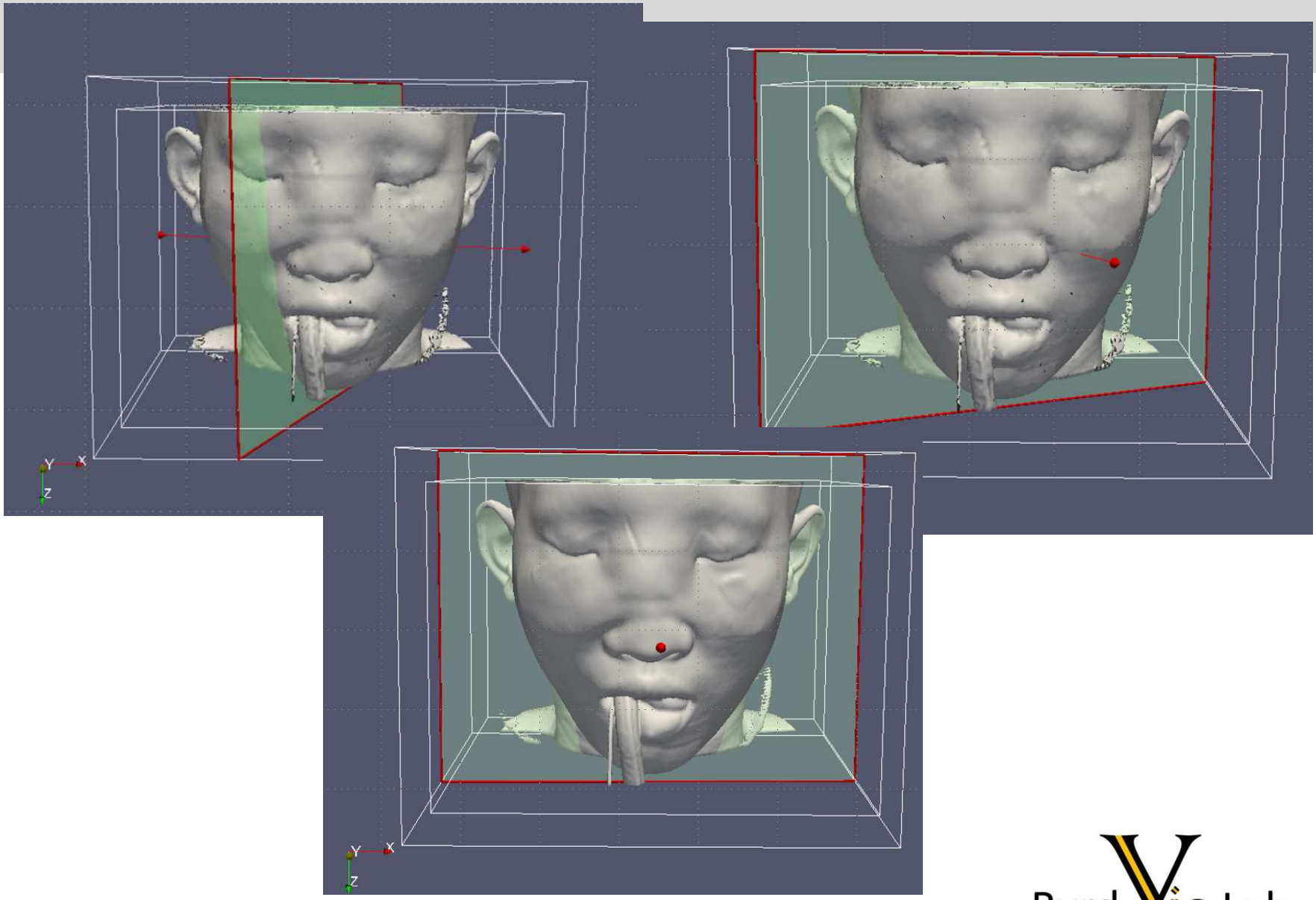
Slice Isosurface

Select

- Filters
- Common
- Slice




ParaView 5.0.0-RC2 64-bit
File Edit View Sources Filters Tools Catalyst Macros Help
Time: 0
Representation
Pipeline Browser
builtin:
headsq.vti
Contour1
Clip1
Slice1
Layout #1
RenderView1
Rotated View
Properties Information
Properties
Apply Reset Delete
Search ... (use Esc to clear text)
Properties (Slic
Slice Type Plane
Show Plane
Note: Use 'P' key to pick origin position on mesh
Snap Picked Point on Mesh Point
Origin 125.3777155 116.9024353 92.88888549
Normal 1 0 0
X Normal
Reset Bounds
Y Normal
Z Normal
Camera Normal
Center on Bounds
Reset Camera to Normal
Crinkle slice
Triangulate the slice
Display
View (Render V
Y
X
Z
Drag arrow point around to point out of screen toward you.



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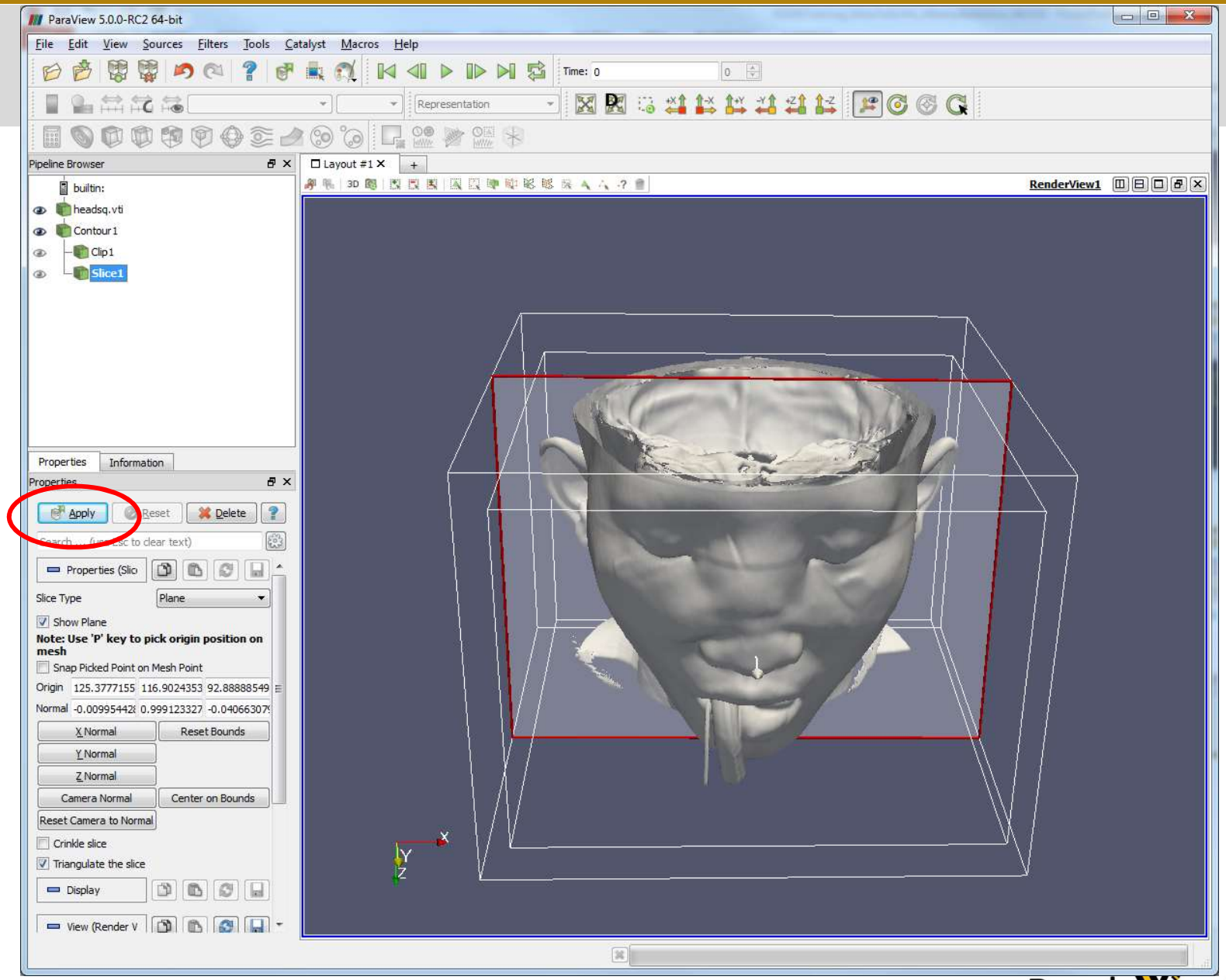

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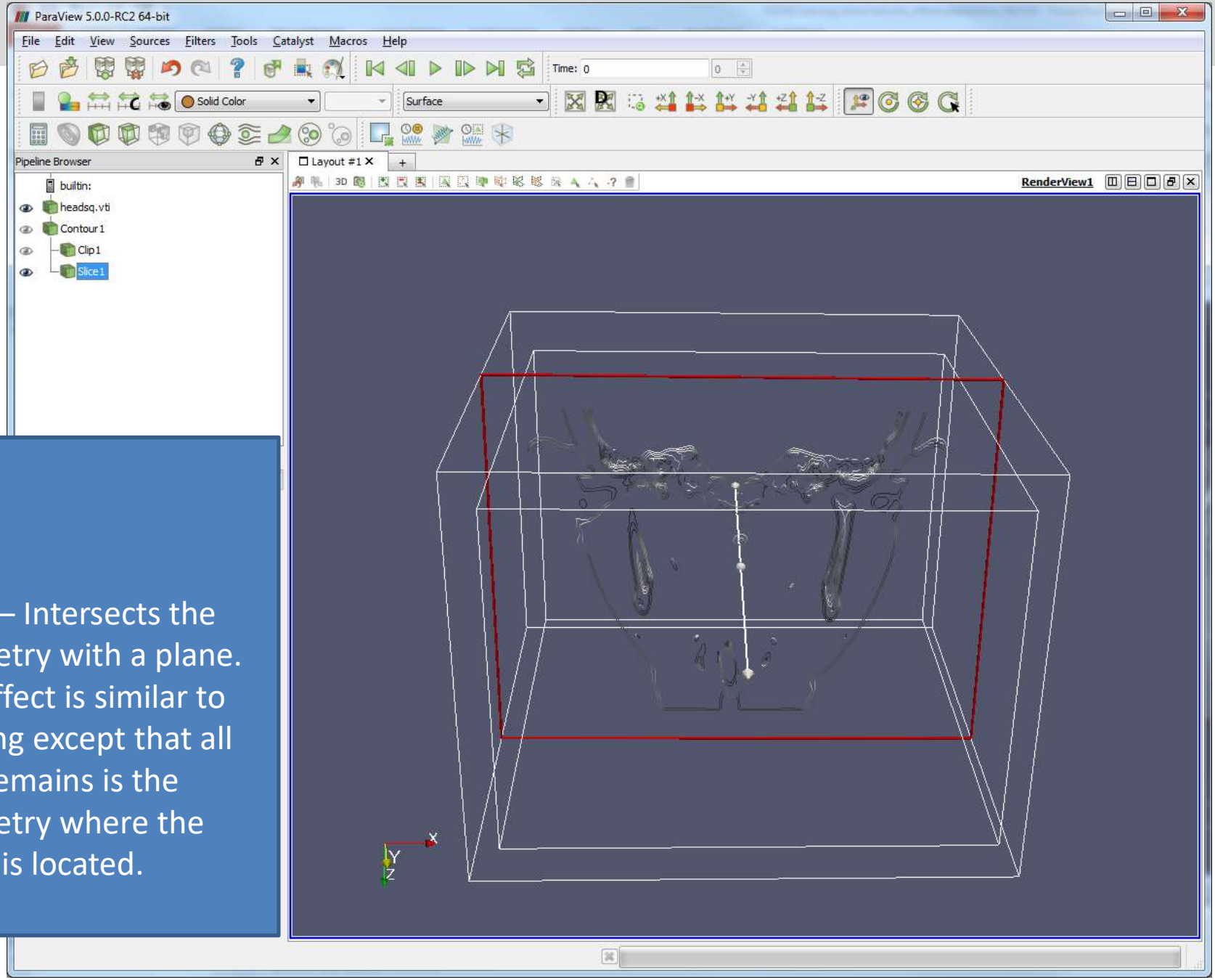
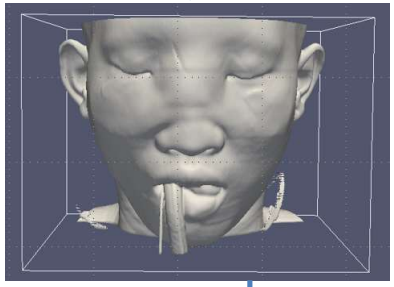
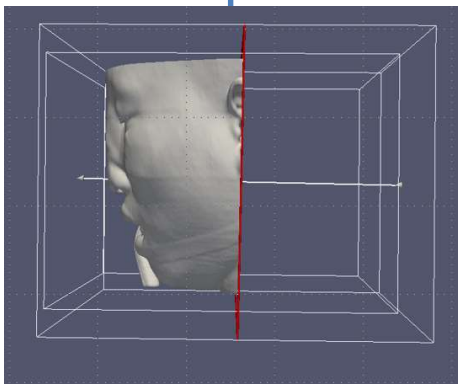


SLICE – Intersects the geometry with a plane. The effect is similar to clipping except that all that remains is the geometry where the plane is located.

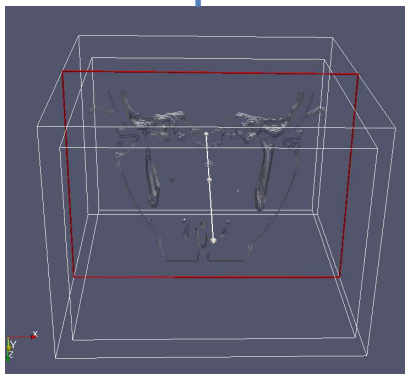
PIPELINE BROWSER

headsq.vti

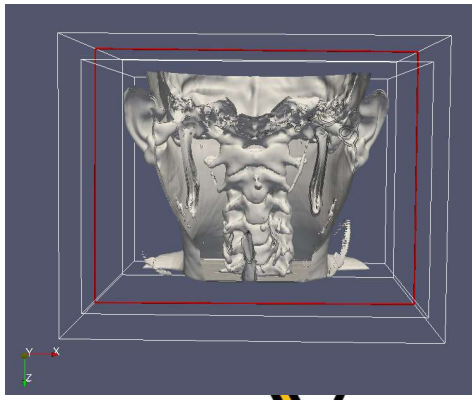




+



→



Q: How do we combine (show) the Clip and Slice views at the same time?

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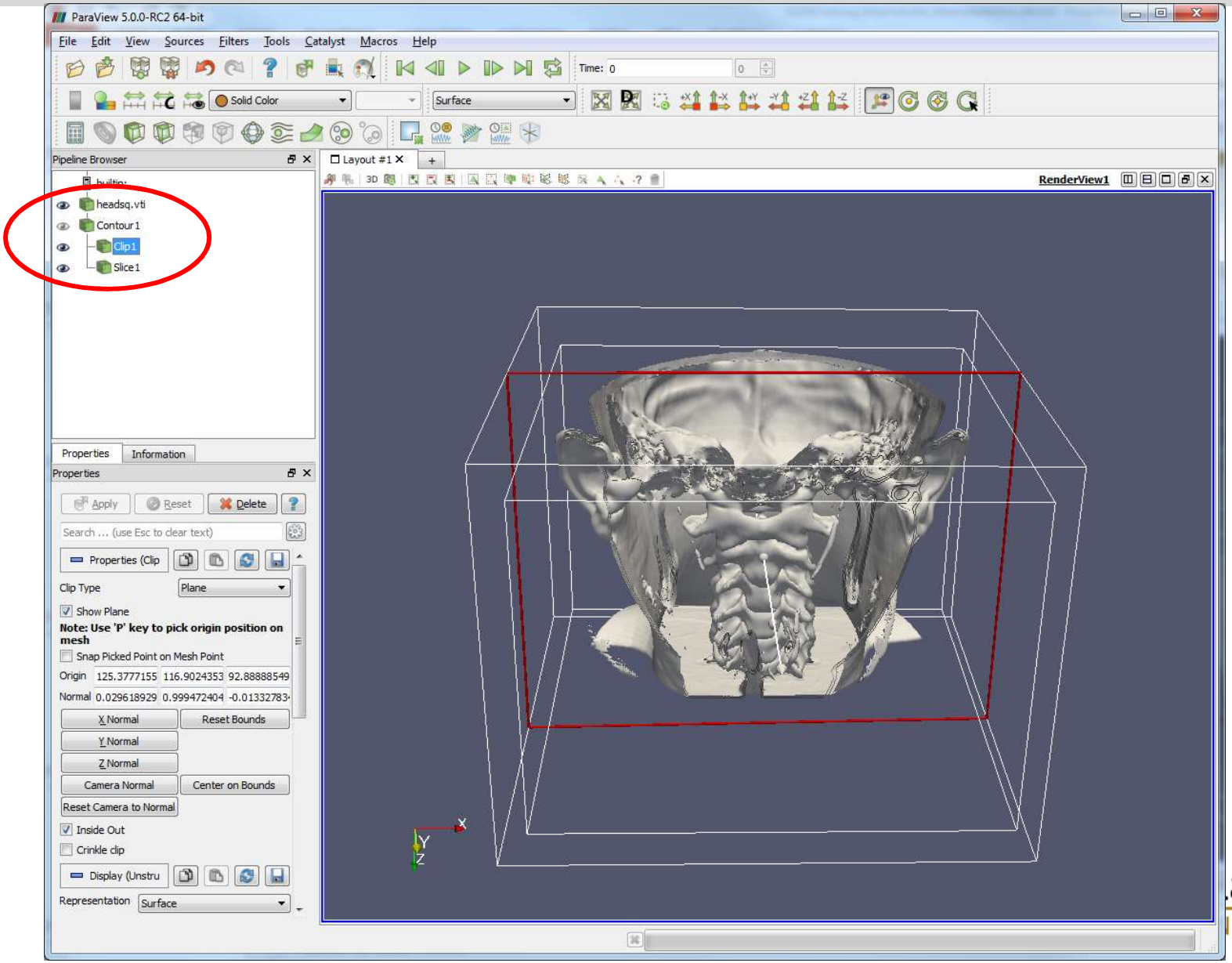
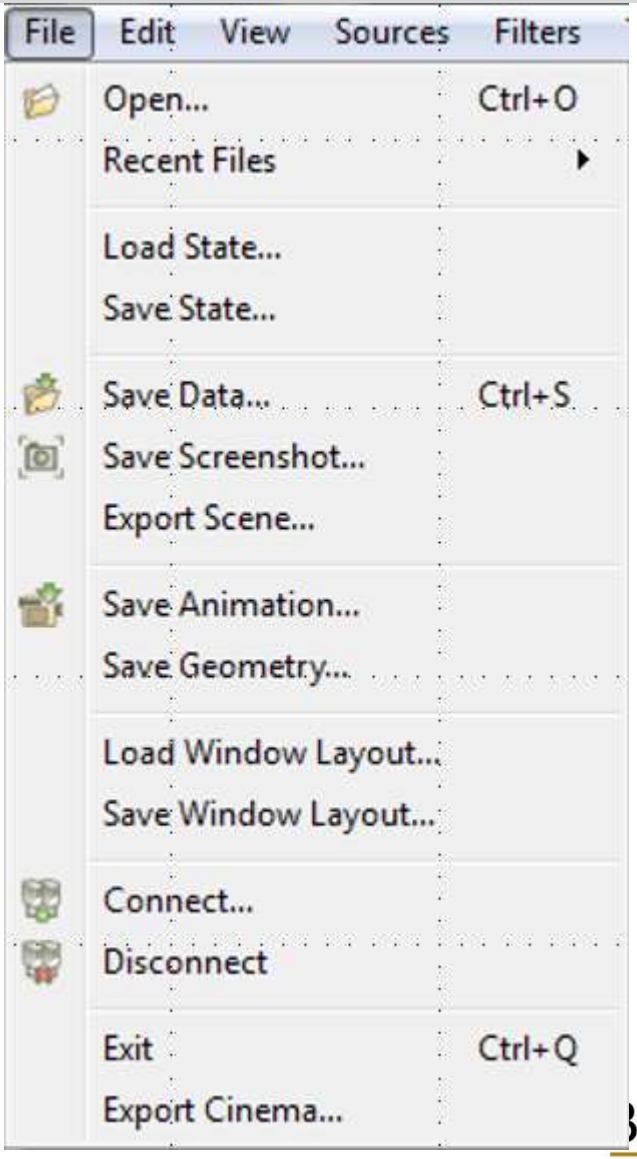

ParaView 5.0.0-RC2 64-bit
File Edit View Sources Filters Tools Catalyst Macros Help
Time: 0
Solid Color
Surface
Pipeline Browser
builtin:
headsq.vti
Contour1
Clip1
Slice1
Layout #1
RenderView1
Properties
Information
Apply
Reset
Delete
Search ... (use Esc to clear text)
Properties (Clip
Clip Type
Plane
Show Plane
Note: Use 'P' key to pick origin position on mesh
Snap Picked Point on Mesh Point
Origin 125.3777155 116.9024353 92.88888549
Normal 0.029618929 0.999472404 -0.01332783
X Normal
Reset Bounds
Y Normal
Z Normal
Camera Normal
Center on Bounds
Reset Camera to Normal
Inside Out
Crinkle clip
Display (Unstru
Representation
Surface
X
Y
Z

Many Options to Save Your Work



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Save Your Work

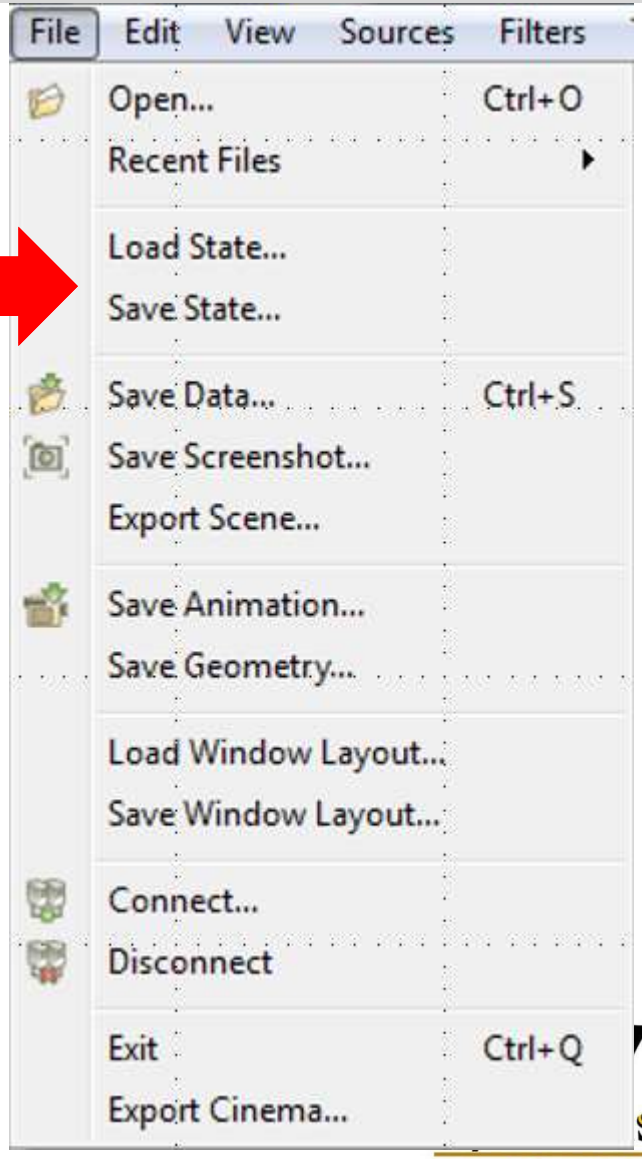
Save State

save the state of the visualization pipeline itself,
including all the pipeline modules, views, their layout, and their properties.

This is referred to as the application state or,
just, state.

In paraview, you can save the state using the File Save State. . . menu option.

Conversely, to load a saved state file, you can use File Load State. . . .



Save Your Work

Save Data

You can save the dataset produced by any pipeline module in ParaView, including sources, readers, and filters.

To save the dataset in paraview, begin by selecting the pipeline module in the Pipeline browser to make it the active source.

For modules with multiple output ports, select the output port producing the dataset of interest.

To save the dataset, use the File Save Data menu or the button in the Main Controls toolbar. You can also use the keyboard shortcut Ctrl + S (or + S).

The Save File dialog will allow you to select the filename and the file format. The available list of file formats depends on the type of the dataset you are trying to save.

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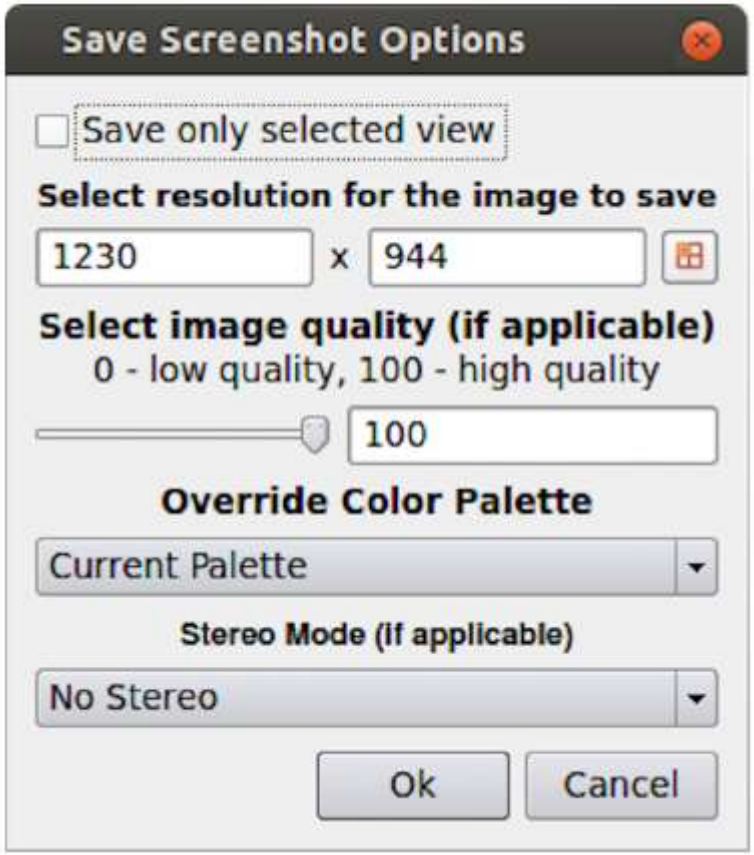
Save Your Work

Save Screenshot

To save the render image from a view in paraview, use the File Save Screenshot menu option. This will pop up the Save Screenshot Options dialog (Figure 8.3).

This dialog allows you to select various image parameters, such as image resolution and image quality (which depends on the file format chosen).



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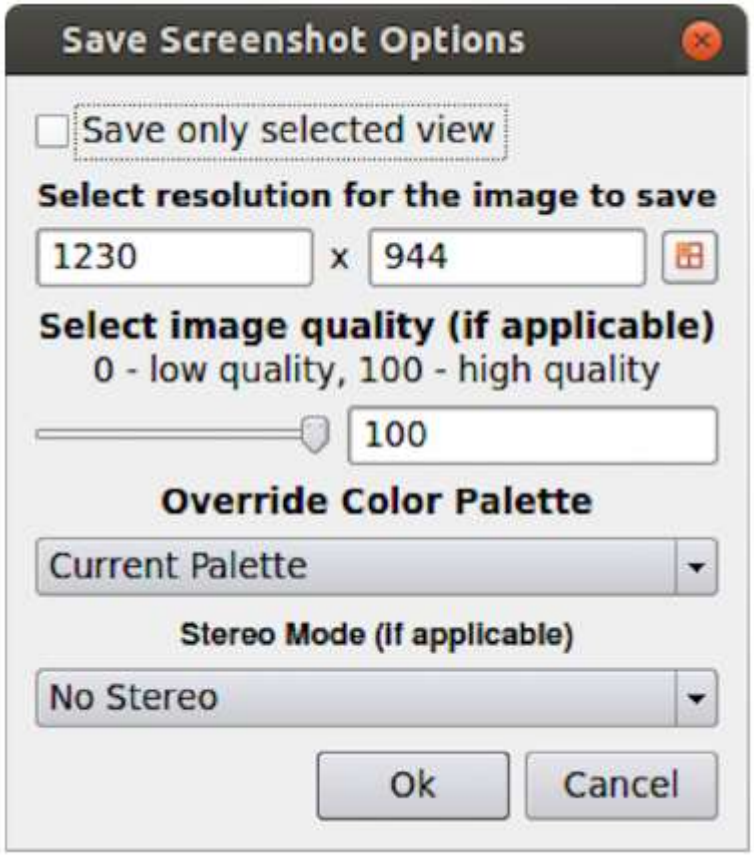
Save Your Work

Save Screenshot continued . . .

The dialog also provides an option to change the color palette to use to save the image using Override Color Palette.

By default, paraview will save rendered results from the active view. Optionally, you can save an image comprising of all

the views layed out exactly as on the screen by unchecking the Save only selected view button.



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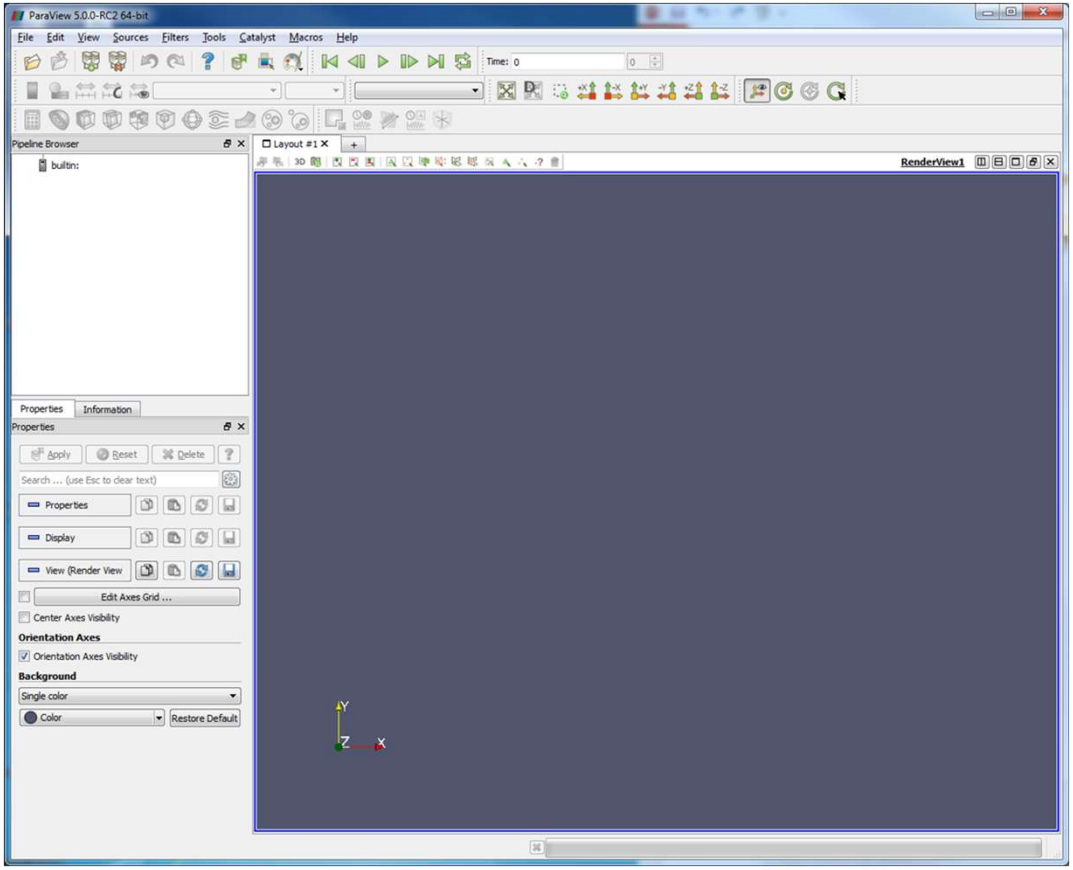
In preparation for the next section

- Edit
- Reset Session

You should be here



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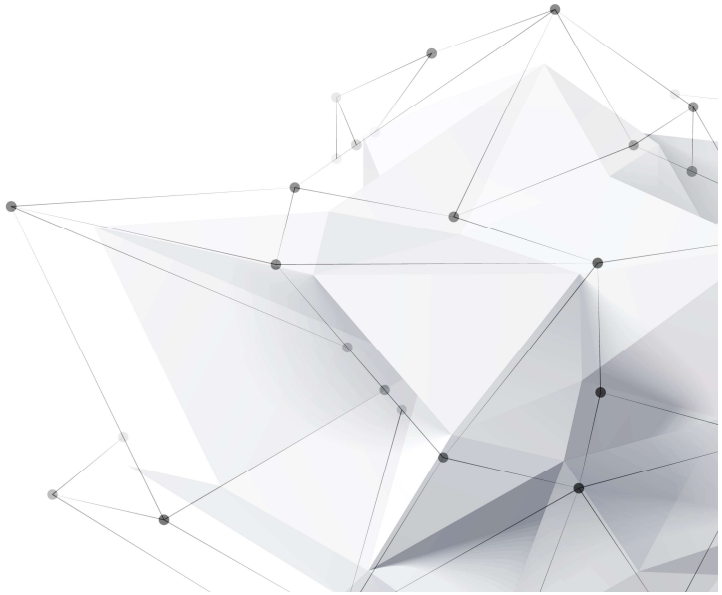
Introduction to ParaView

Part III: Getting Data Into VTK File Format



PURDUE
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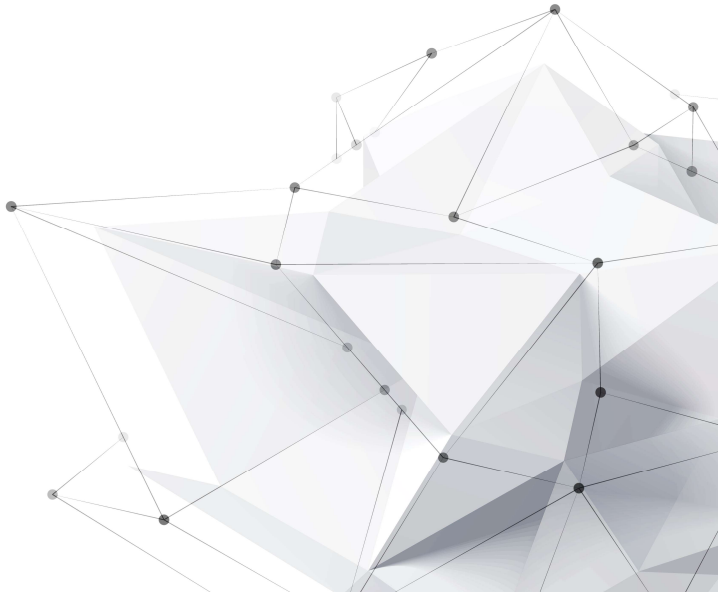
Getting Your Data Into VTK File Format

Sample File



PURDUE
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Supported Data Formats

- VTK (http://www.vtk.org/VTK/img/file-formats.pdf)
- EnSight
- Plot3D
- Various polygonal formats
- Users can write data readers to extend support to other formats
- Conversion to the VTK format is straightforward

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VTK Simple Legacy Format

VTK simple legacy format (http://www.vtk.org/VTK/img/file-formats.pdf)

- ASCII or binary
- Supports all VTK grid types
- Easiest for data conversion

```
# vtk DataFile Version 2.0                ] (1)
Really cool data                          ] (2)
ASCII | BINARY                            ] (3)
DATASET type                              ] (4)
...
POINT_DATA n                              ] (5)
...
CELL_DATA n
...
```

Part 1: Header

Part 2: Title (256 characters maximum, terminated with newline \n character)

Part 3: Data type, either ASCII or BINARY

Part 4: Geometry/topology. *Type* is one of:

```
STRUCTURED_POINTS
STRUCTURED_GRID
UNSTRUCTURED_GRID
POLYDATA
RECTILINEAR_GRID
FIELD
```

Part 5: Dataset attributes. The number of data items *n* of each type must match the number of points or cells in the dataset. (If *type* is FIELD, point and cell data should be omitted.

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Simulated Temperature

The data

- Simulated temperature values
- Sample size: 100 x 100
- Rectilinear Grid

100 100

20.18	20.36	20.54	20.73	20.93	21.13	21.35	21.58
20.36	20.72	21.08	21.46	21.85	22.26	22.68	23.14
20.53	21.07	21.61	22.17	22.75	23.36	23.99	24.67
20.70	21.41	22.13	22.86	23.63	24.42	25.26	26.15
20.86	21.74	22.62	23.53	24.47	25.45	26.48	27.57
21.02	22.05	23.10	24.17	25.28	26.43	27.64	28.92
21.17	22.35	23.54	24.77	26.03	27.35	28.73	30.18
21.31	22.63	23.96	25.33	26.74	28.21	29.74	31.35
21.44	22.88	24.35	25.85	27.40	29.00	30.67	32.43
21.56	23.12	24.71	26.33	28.00	29.73	31.52	33.41
21.66	23.34	25.04	26.77	28.54	30.38	32.29	34.28
21.76	23.53	25.33	27.15	29.03	30.96	32.96	35.05
21.85	23.70	25.58	27.50	29.46	31.47	33.56	35.73
21.92	23.85	25.81	27.80	29.83	31.91	34.07	36.31
21.99	23.98	26.00	28.05	30.14	32.29	34.50	36.79
22.04	24.09	26.16	28.26	30.41	32.60	34.86	37.18
22.09	24.18	26.29	28.44	30.62	32.85	35.14	37.50
22.12	24.25	26.40	28.57	30.78	33.04	35.35	37.73
22.15	24.30	26.48	28.67	30.91	33.18	35.51	37.89
22.17	24.34	26.53	28.74	30.98	33.27	35.60	37.99
22.18	24.36	26.56	28.78	31.03	33.31	35.64	38.02
22.18	24.37	26.57	28.78	31.03	33.31	35.63	38.00
22.18	24.36	26.55	28.77	31.00	33.27	35.58	37.92
22.17	24.34	26.53	28.73	30.95	33.20	35.48	37.80
22.15	24.31	26.48	28.66	30.87	33.10	35.35	37.65
22.13	24.27	26.42	28.58	30.76	32.97	35.19	37.45
22.11	24.23	26.35	28.49	30.64	32.81	35.00	37.23
22.08	24.17	26.27	28.37	30.49	32.63	34.79	36.97

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vtk Format

 # vtk DataFile Version 2.0
Rectilinear grid of temperature values
ASCII
DATASET RECTILINEAR_GRID

```
# vtk DataFile Version 2.0                ] (1)
Really cool data                          ] (2)
ASCII | BINARY                            ] (3)
DATASET type                              ]
...                                       ] (4)
POINT_DATA n                              ]
...                                       ] (5)
CELL_DATA n                               ]
...                                       ]
```

Part 1: Header

Part 2: Title (256 characters maximum, terminated with newline \n character)

Part 3: Data type, either ASCII or BINARY

Part 4: Geometry/topology. *Type* is one of:

```
STRUCTURED_POINTS
STRUCTURED_GRID
UNSTRUCTURED_GRID
POLYDATA
RECTILINEAR_GRID
FIELD
```

Part 5: Dataset attributes. The number of data items *n* of each type must match the number of points or cells in the dataset. (If *type* is FIELD, point and cell data should be omitted.

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vtk Format

```
# vtk DataFile Version 2.0
Rectilinear grid of temperature values
ASCII
DATASET RECTILINEAR_GRID
* DIMENSIONS 100 100 1

X_COORDINATES 100 float
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52
53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76
77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99

Y_COORDINATES 100 float
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52
53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76
77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99

* Z_COORDINATES 1 float
0
```

* Although this is a 2D grid, the z-coordinate must be included and represented in the DIMENSIONS

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vtk Format

```
# vtk DataFile Version 2.0
Rectilinear grid of temperature values
ASCII
DATASET RECTILINEAR_GRID
DIMENSIONS 100 100 1
X_COORDINATES 100 float
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52
53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76
77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99
Y_COORDINATES 100 float
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52
53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76
77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99
Z_COORDINATES 1 float
0
* POINT_DATA 10000
SCALARS temperature float
LOOKUP_TABLE default
```

* x-dimension * y-dimension * z-dimension

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vtk Format

```
# vtk DataFile Version 2.0
Rectilinear grid of temperature values
ASCII
DATASET RECTILINEAR_GRID
DIMENSIONS 100 100 1
X_COORDINATES 100 float
0 1 2 3 4 5 6 7 8 9 10  11  12  13  14  15  16  17  18  19  20  21  22  23  24  25  26  27  28  29  30  31  32  33  34
35  36  37  38  39  40  41  42  43  44  45  46  47  48  49  50  51  52  53  54  55  56  57  58  59  60  61  62  63  64
65  66  67  68  69  70  71  72  73  74  75  76  77  78  79  80  81  82  83  84  85  86  87  88  89  90  91  92  93  94
95  96  97  98  99
Y_COORDINATES 100 float
0 1 2 3 4 5 6 7 8 9 10  11  12  13  14  15  16  17  18  19  20  21  22  23  24  25  26  27  28  29  30  31  32  33  34
35  36  37  38  39  40  41  42  43  44  45  46  47  48  49  50  51  52  53  54  55  56  57  58  59  60  61  62  63  64
65  66  67  68  69  70  71  72  73  74  75  76  77  78  79  80  81  82  83  84  85  86  87  88  89  90  91  92  93  94
95  96  97  98  99
Z_COORDINATES 1 float
0
POINT_DATA 10000
SCALARS temperature  float
LOOKUP_TABLE default
20.18 20.36 20.54 20.73 20.93 21.13 21.35 21.58 21.82 22.09 22.38 22.70 23.06 23.46 23.92 24.44 25.05 25.77
26.63 27.68 28.99 30.68 32.90 35.99 40.50 47.61 60.00 84.65 142.03 300.00 300.00 300.00 300.00 300.00
300.00 300.00 300.00 289.04 288.50 287.82
:
:
```

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SAMPLE DATA FILE

Data Files:

Header.txt
xCoordinates.txt
yCoordinates.txt
zCoordinates.txt
lookUpTable.txt

lookUpTable.txt also contains the data points

Task:

Combine these files into one file and save the file with the .vtk file extension

SampleData.vtk

Remember what you name the file.

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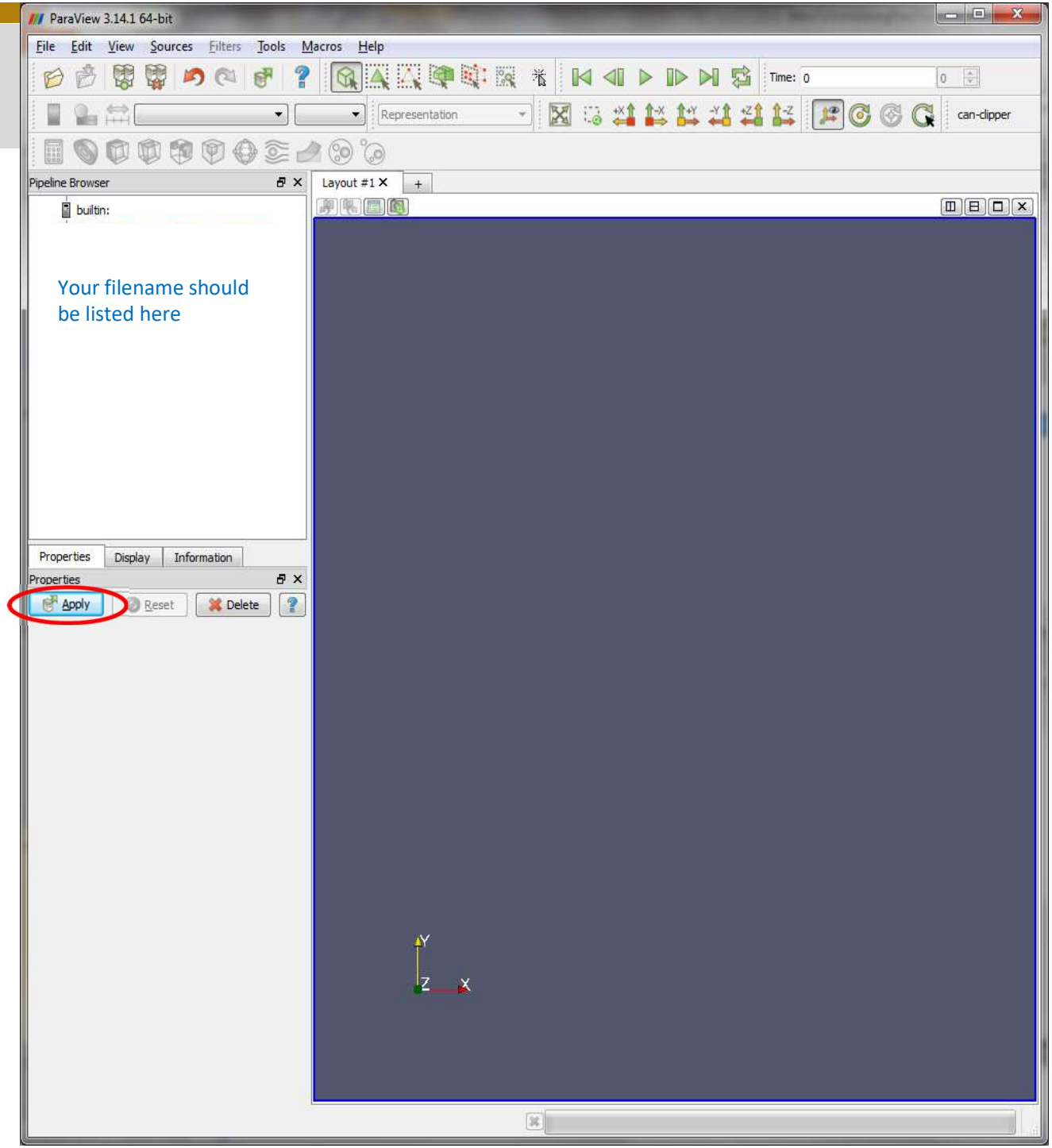
- Open data file (the file that you just created and saved
- Click **Apply**



EXERCISE: VISUALIZE SAMPLE DATA

Add Contour Plot

Set the Range of Values

From 20.01

To: 300

Step 10

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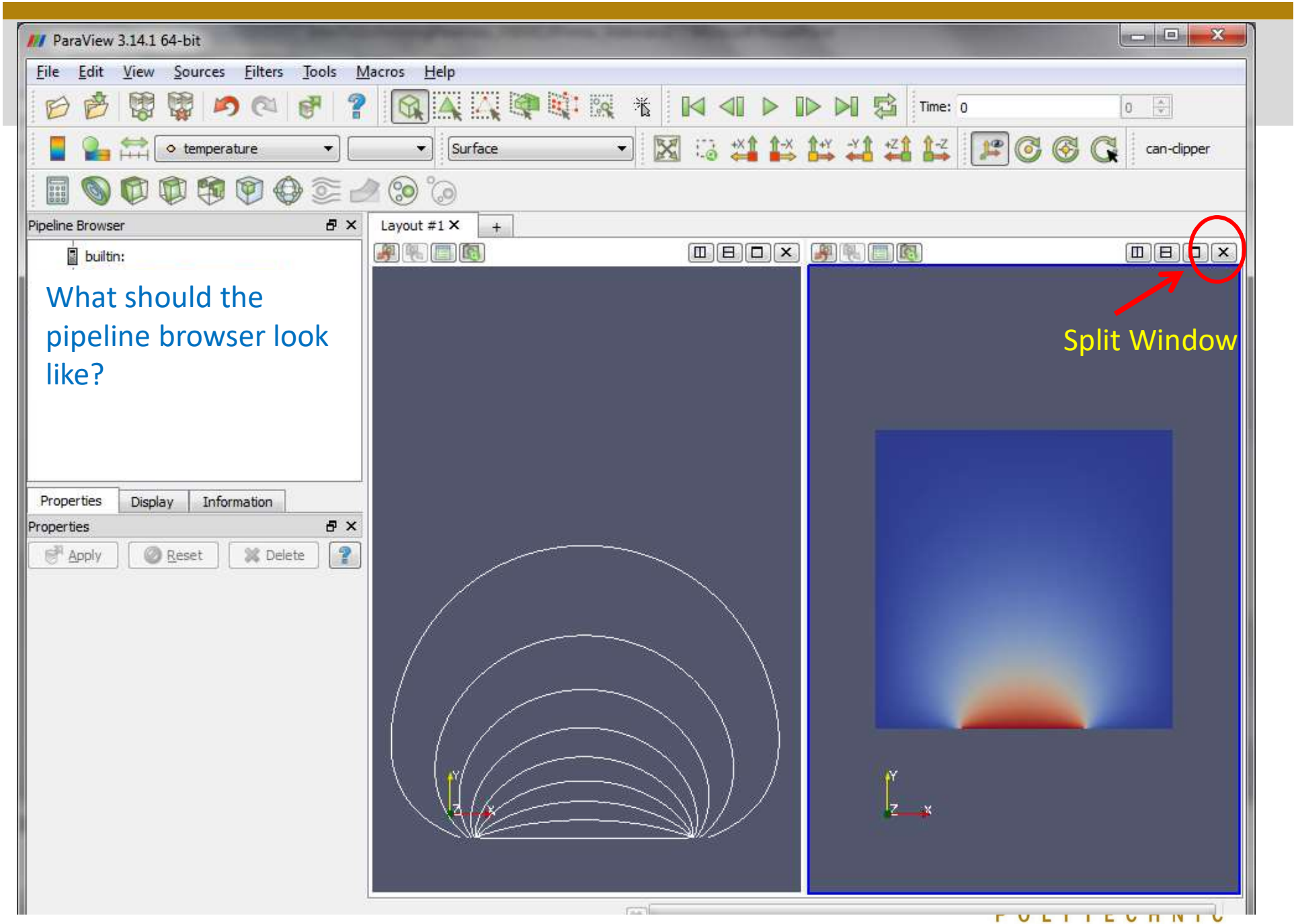
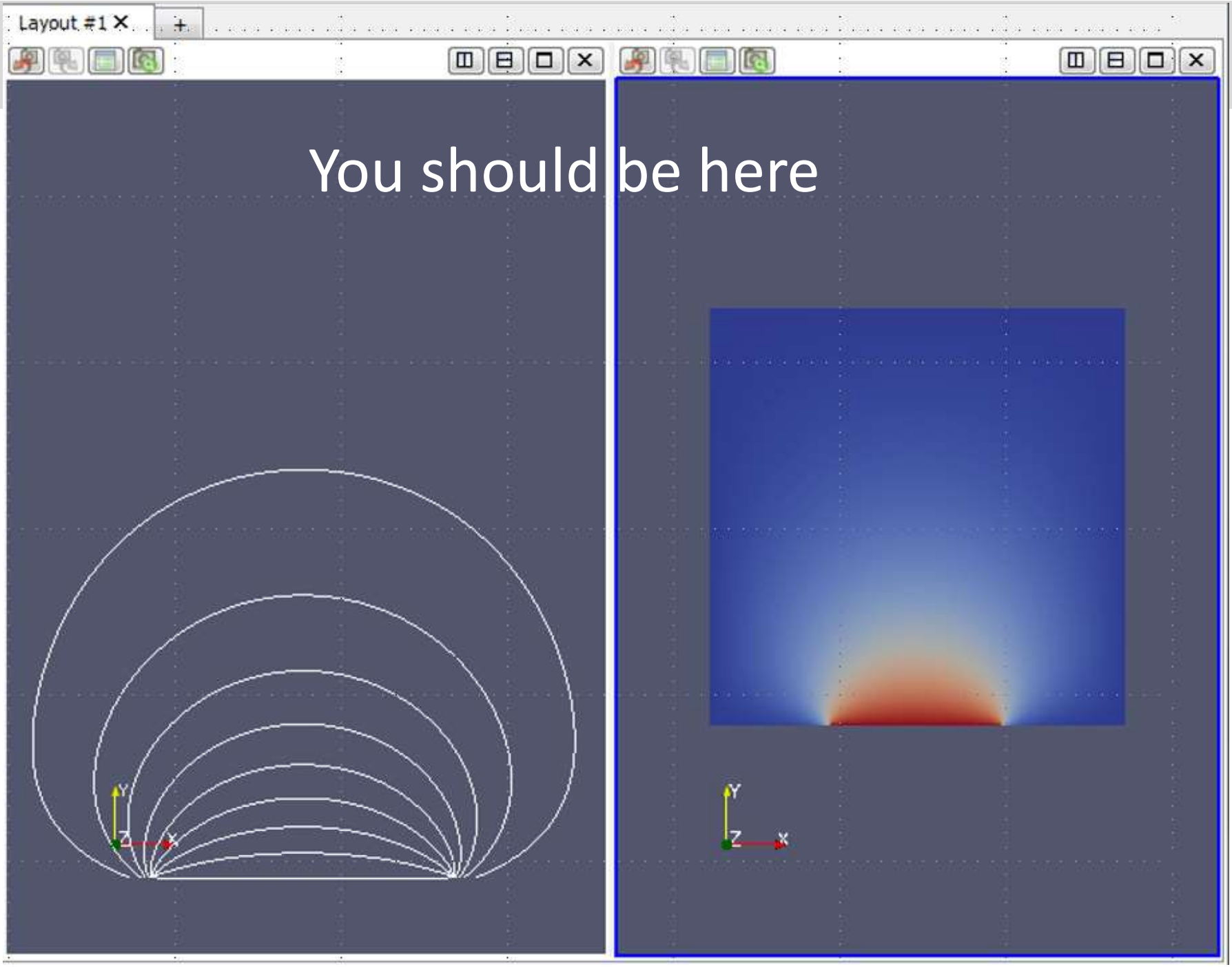

ParaView 3.14.1 64-bit
File Edit View Sources Filters Tools Macros Help
Time: 0
temperature
Surface
can-clipper
Pipeline Browser
builtin:
What should the pipeline browser look like?
Layout #1
Split Window
Properties Display Information
Properties
Apply Reset Delete


Layout #1
You should be here
Y
Z
X
Y
Z
X

Filters in ParaView

- Filters
- Alphabetical

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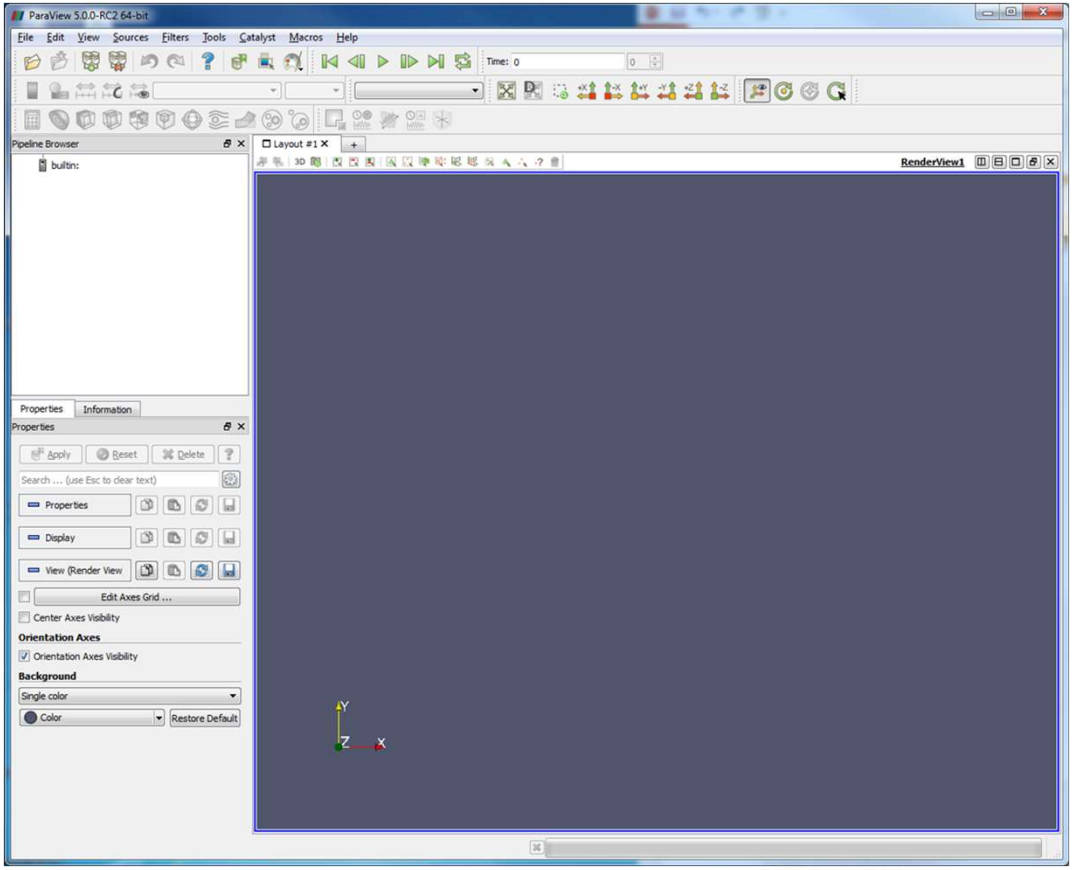
In preparation for the next section

- Edit- Reset Session
- Select an object in the Pipeline Browser
- Click the Delete button (or right click, then Delete)
- To select multiple objects press and hold the CTRL key while selecting objects

You should be here



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More Training Data

Download your preferred archive format from ParaView website

http://www.paraview.org/Wiki/The_ParaView_Tutorial

- **The ParaView Tutorial Data** (in tar/gzip)
- **The ParaView Tutorial Data** (in zip)
- **ParaView Scripts** (in tar/gzip)

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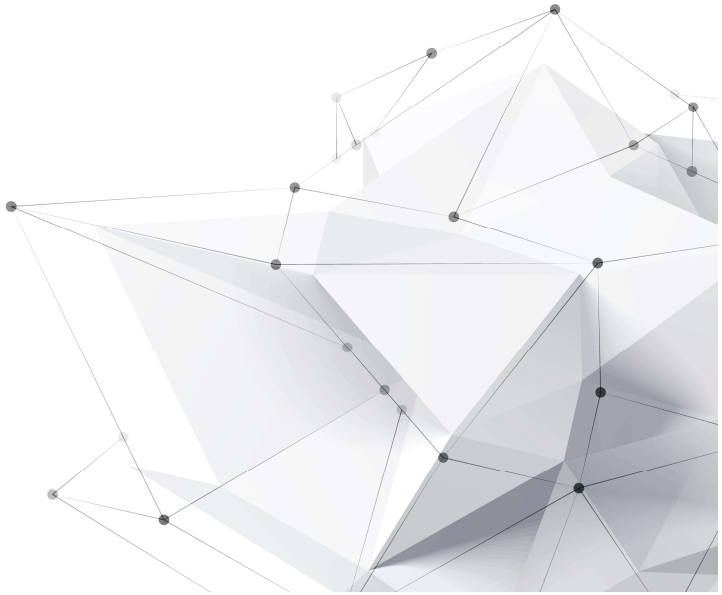
Wrapping Up



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ADDITIONAL RESOURCES

http://www.paraview.org

ParaView User's Guide: Downloaded with ParaView

ParaView Sample Data

http://www.paraview.org/Wiki/The_ParaView_Tutorial

ParaView/Python Scripting – KitwarePublic

http://www.paraview.org/Wiki/ParaView/Python_Scripting

ParaView Server Manager

http://www.paraview.org/ParaView/Doc/Nightly/www/py-doc/paraview.servermanager.html

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GET ADDITIONAL HELP

SEE HELP MENU

ParaView Guide – Comprehensive user guide for ParaView

Help – online help for file readers and filters

Online Tutorials – in depth tutorials for ParaView

Online Blogs – informative blog posts on new features in ParaView

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What’s next?

Day 4

Day 4: The pièce de résistance!

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