



13th Summer School on **SCIENTIFIC VISUALIZATION**

Introduction to Paraview GUI

Ivan Spisso - [i.spisso@cineca.it](mailto:i.spisso@ Cineca.it)
SuperComputing Applications and Innovation Department



OUTLINE

PART A

- What is Paraview
- The GUI
- Sources
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- Text annotation
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- Save figures

PART B

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- Vectors visualization
- Streamlines
- Plotting over line
- Select data
- Create a custom filter
- Animations
- Time dependent data



What is Paraview

ParaView is an open-source, multi-platform application designed to visualize data sets of varying sizes from small to very large. The goals of the ParaView project include developing an open-source, multi-platform visualization application that supports distributed computational models to process large data sets. It has an open, flexible, and intuitive user interface

(ref <http://www.itk.org/Wiki/ParaView>)

To date, ParaView has been demonstrated to process billions of unstructured cells and to process over a trillion structured cells. ParaView's parallel framework has run on over 100,000 processing cores.

ParaView's key features are:

- An open-source, scalable, multi-platform visualization application.
- Support for distributed computation models to process large data sets.
- An open, extensible, and intuitive user interface.
- An extensible, modular architecture based on open standards.
- A flexible [BSD 3-clause license](#).
- Commercial maintenance and support.





PARAVIEW: a standard de-facto

ParaView is used by many academic, government, and commercial institutions all over the world.

ParaView runs on distributed and shared memory parallel as well as single processor systems and has been successfully tested on Windows, Linux, Mac OS X, IBM Blue Gene, Cray XT3 and various Unix workstations and clusters.

ParaView is downloaded roughly 100,000 times every year.

ParaView also won the HPCwire Readers' Choice Award and HPCwire Editors' Choice Award for Best HPC Visualization Product or Technology.





Obtaining Paraview & Official Resources

- **Main website:**
<http://www.paraview.org/>
- **Download page:**
<http://www.paraview.org/paraview/resources/software.php>
- **Resources (video):**
<http://www.paraview.org/paraview/resources/webinars.html>
- **Resources (wiki):**
<http://www.paraview.org/Wiki/ParaView>



The big picture

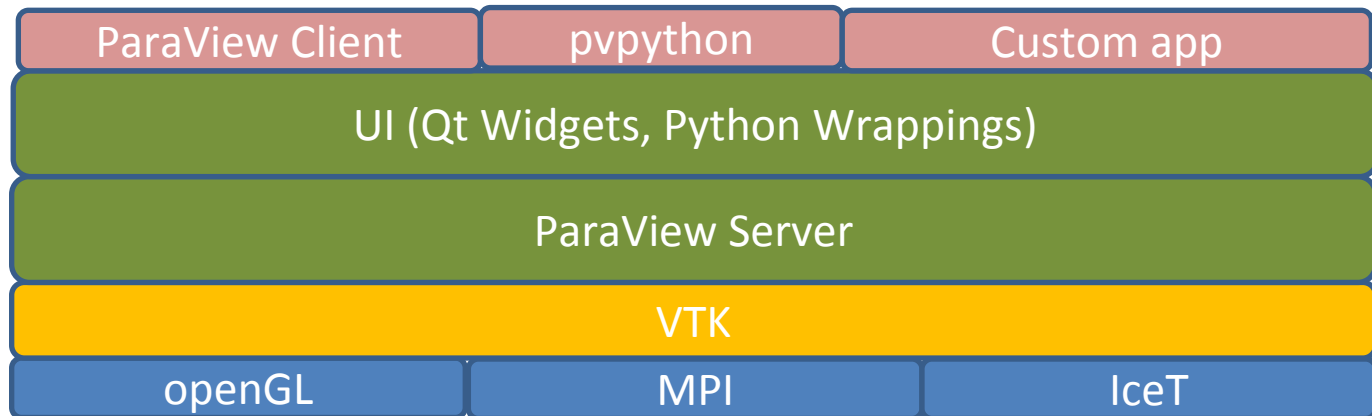
The application most people associate with ParaView is really just a small client application built on top of a tall stack of libraries that provide ParaView with its functionality.

Under the hood, ParaView uses the Visualization Toolkit as the data processing and rendering engine and has a user interface written using the Qt cross-platform application framework.

ParaView comes with a pvpython application that allows you to automate the visualization and post-processing with Python scripting.

A ParaView Server library provides the abstraction layer necessary for running parallel, interactive visualization. It relieves the client application from most of the issues concerning if and how ParaView is running in parallel.

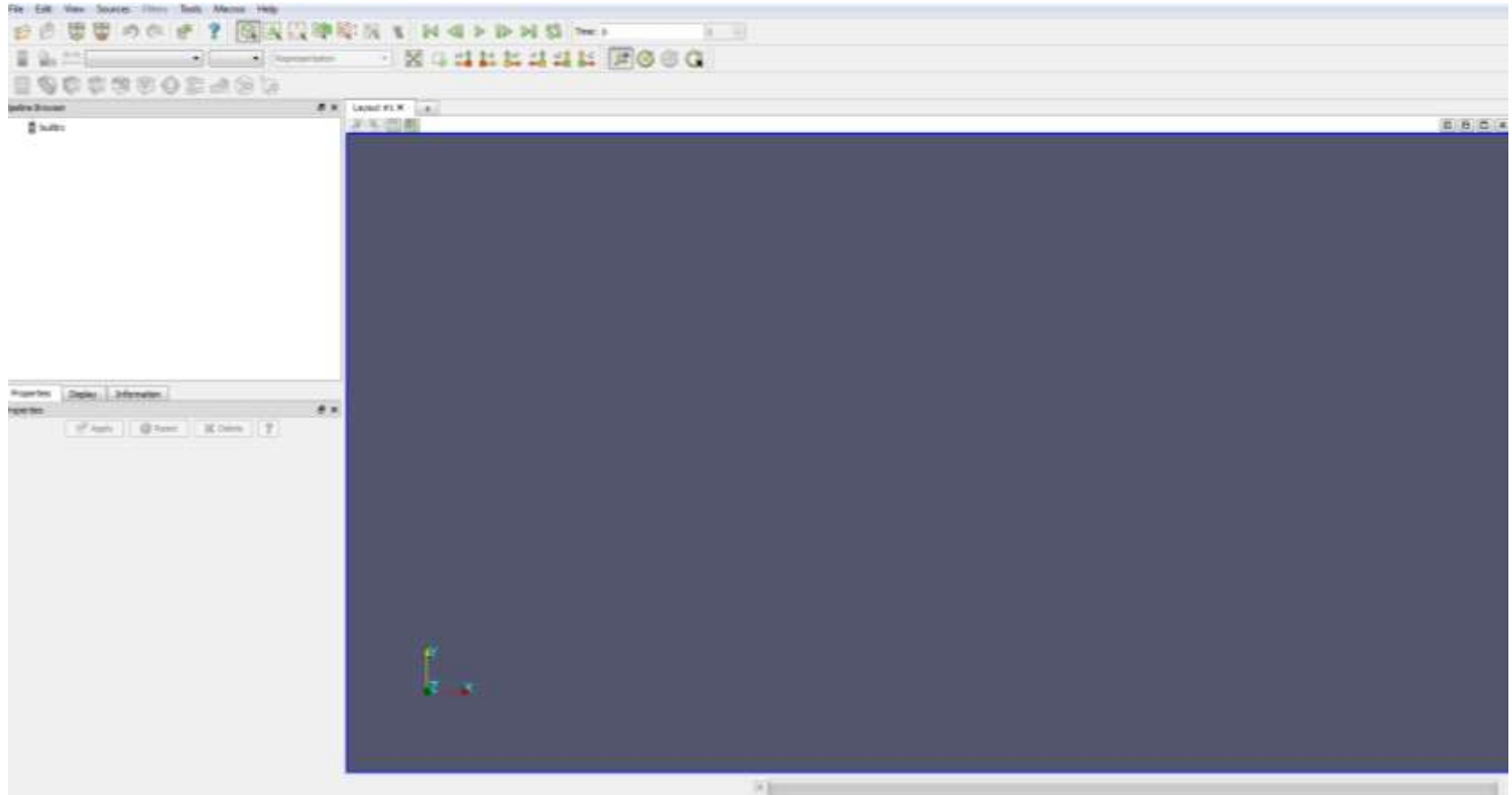
The Visualization Toolkit (VTK) provides the basic visualization and rendering algorithms.





GUI

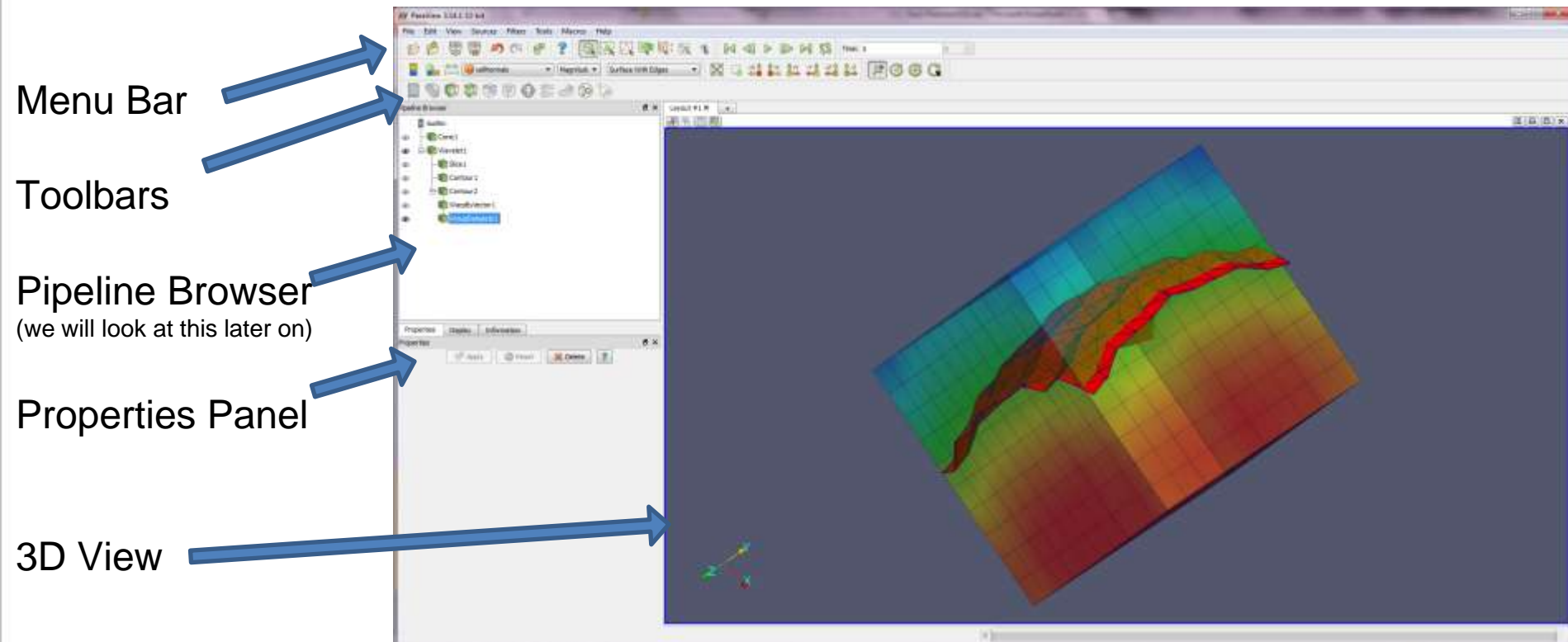
Launch the Paraview application on your pc





GUI elements

http://www.paraview.org/Wiki/ParaView/Users_Guide/Introduction#User_Interface



One very important thing to keep in mind when using ParaView is that the GUI is very modal. At any given time you will have one "active" module within the visualization pipeline, one "active" view, and one "active" selection.



GUI elements definition

Menu Bar As with just about any other program, the menu bar allows you to access the majority of features.

Toolbars The toolbars provide quick access to the most commonly used features within ParaView.

Pipeline Browser ParaView manages the reading and filtering of data with a pipeline. The pipeline browser allows you to view the pipeline structure and select pipeline objects. The pipeline browser provides a convenient list of pipeline objects with an indentation style that shows the pipeline structure. [#The Pipeline Concept](#)

Properties Panel The properties panel allows you to view and change the parameters of the current pipeline object. The properties are by default coupled with an Information tab that shows a basic summary of the data produced by the pipeline object.

3D View The remainder of the GUI is used to present data so that you may view, interact with, and explore your data. This area is initially populated with a 3D view that will provide a geometric representation of the data.

/Menu-bar/help (!)

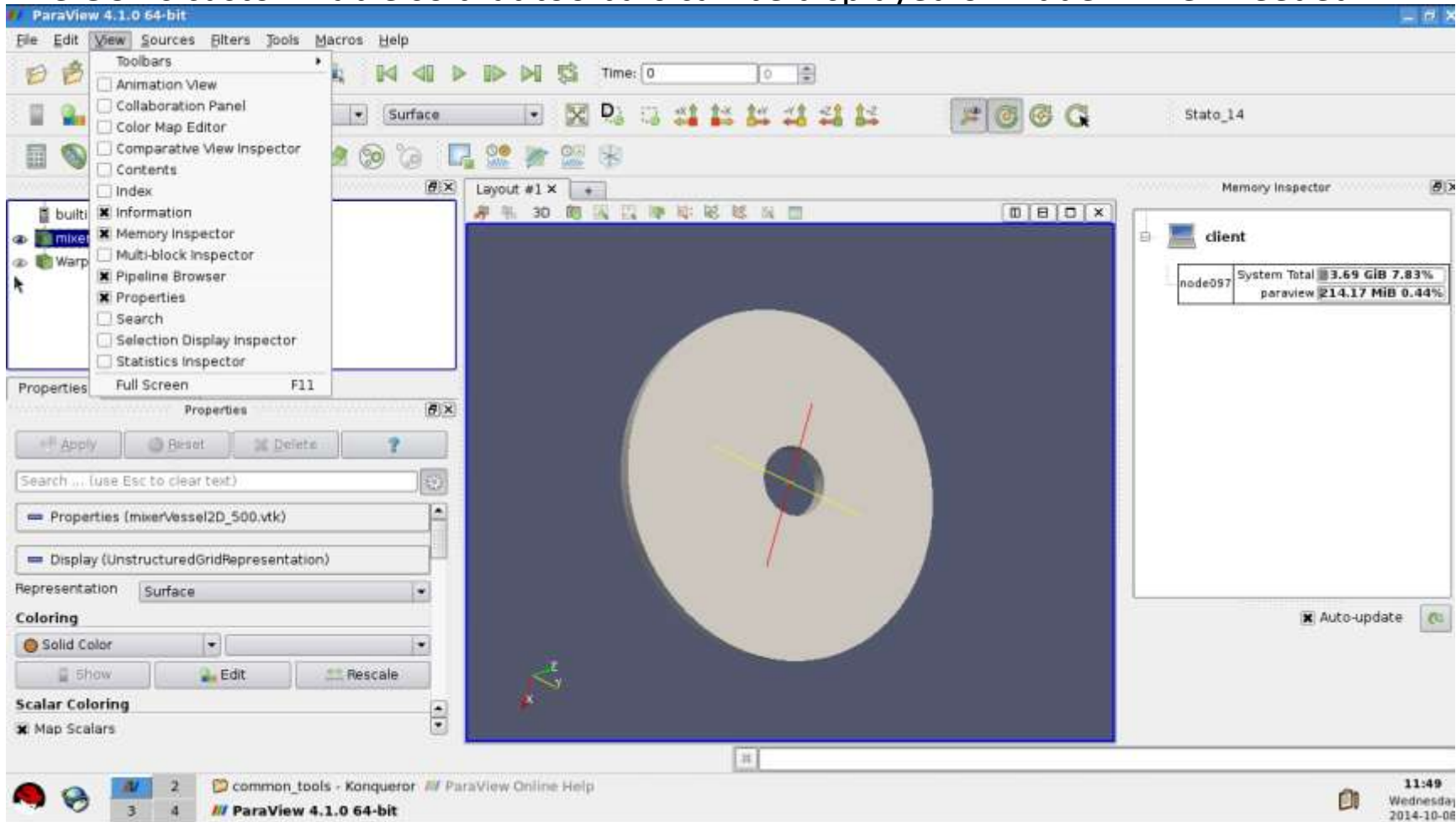
The screenshot shows the ParaView 3.9.1-RC2-64-bit interface. A 'ParaView Online Help' window is open, displaying the 'Sources' section. The left sidebar shows a tree view with 'Sources' selected. The main content area lists various source types with their names and descriptions.

Name	Description
3D Glyph	Create a 3D glyph (e.g., arrow, cross, dash, etc.)
3D Text	3D geometric representation of a text string
Annotate Time	Shows the animation time as text annotation in the view
Arrow	3D arrow with a long cylindrical shaft and a cone for the tip
Axes	Three lines representing the axes - red line along X, green line along Y, and blue line along Z
Box	Create a box with specified X, Y, and Z lengths
Cone	Create a 3D cone of a given radius and height
Cylinder	Create a 3D cylinder of a given radius and height
Data Object Generator	Parses a string to produce composite data objects consisting of simple templated datasets
Disk	Create a 3D disk with a specified inner and outer radius
Hierarchical Fractal	Test source for AMR with HierarchicalDataSet
Hyper Tree Grid	Hyper tree grid representing a tree-based AMR data set
Line	This source creates a line between two points. The resolution indicates how many segments are in the line.
Mandelbrot	Representation (assigned char) of the Mandelbrot set in up to 3 dimensions
Octree Fractal	Test source for octree with Mandelbrot fractal
Outline	3D outline of the specified bounds
Plane	Create a parallelogram given an origin and two points. The resolution indicates the number of division along each axis of the plane.
Point Source	Create a point cloud of a certain size, radius, and center
Programmable Source	Executes a user supplied python script to produce an output dataset.
Sphere	Create a 3D sphere given a center and radius.
SphereSource	Tessellate parametric functions.
Superquadric	Create a superquadric according to the theta and phi roundness parameters. This one source can generate a wide variety of 3D objects including a box, a sphere, or a torus.
Text	The Text source generates a table containing text.
Time Source	Produces a single cell uniform grid with data values that vary over a sin() wave from t=0 to t=1 (radius).
Rule	This is a line source that can be used to measure distance between two points
Wavetlet	Create a regular rectangular grid in up to three dimensions with values varying according to a periodic function.



Personalize your GUI

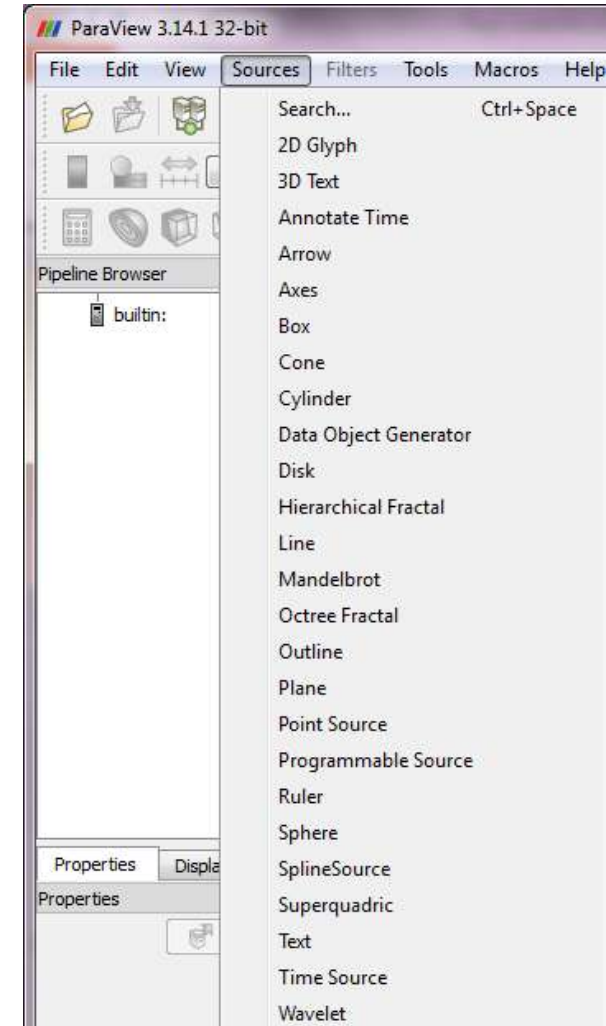
The GUI is customizable so that toolbars can be displayed or hidden when needed.





Sources

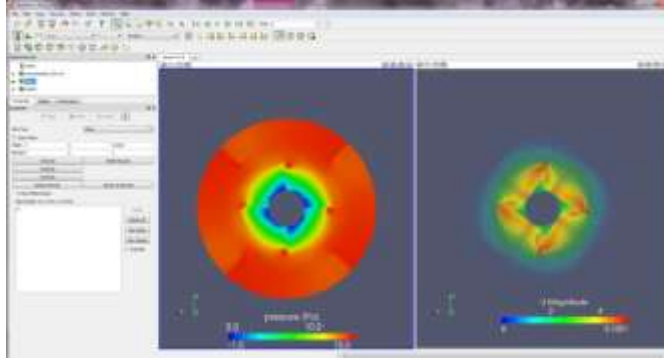
Data can be uploaded into ParaView 3D scene using VTK source objects or loading files (readers).



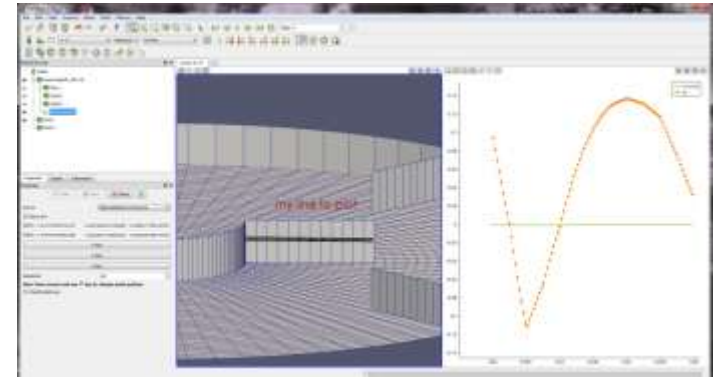


Multiple views

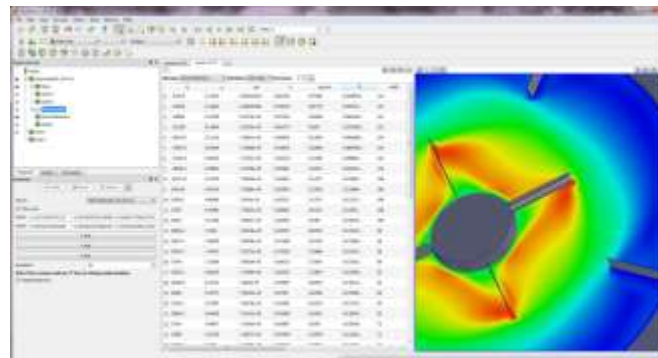
- 3d + 3d



- 3d + 2d

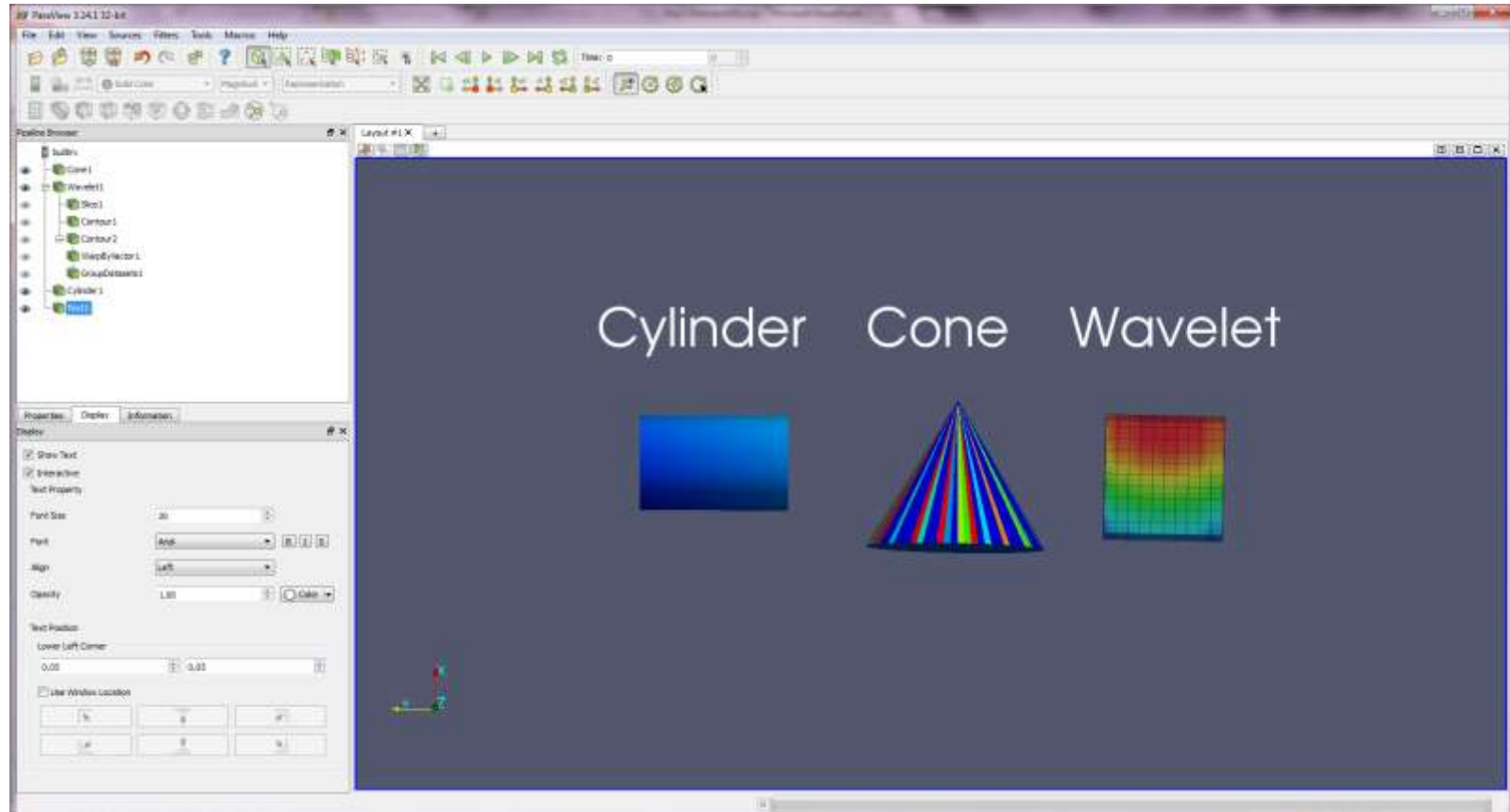


- 3d + table





Sources





3D objects manipulations

Test the usage of your mouse buttons:

- **Left button:** rotation
- **Right button:** panning
- **Middle button:** zooming



Camera control basics

Set camera location

Set zoom

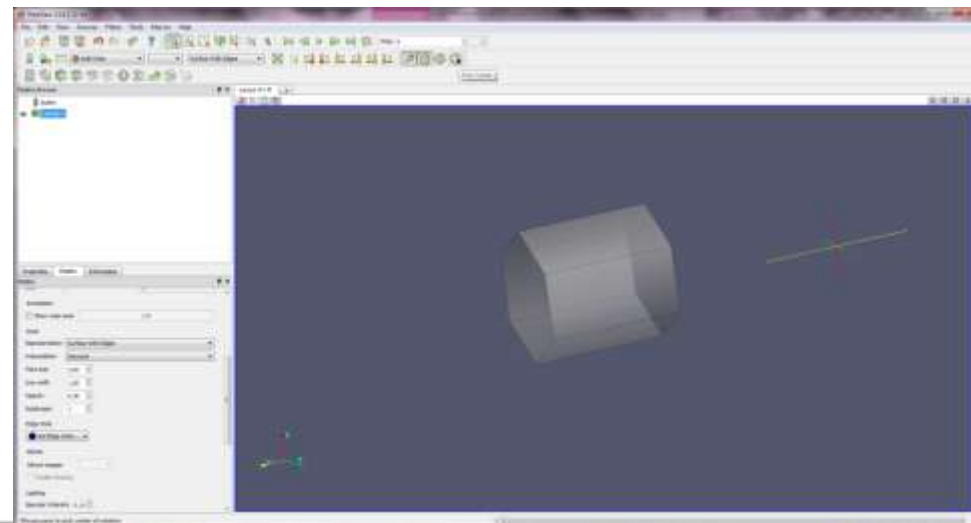
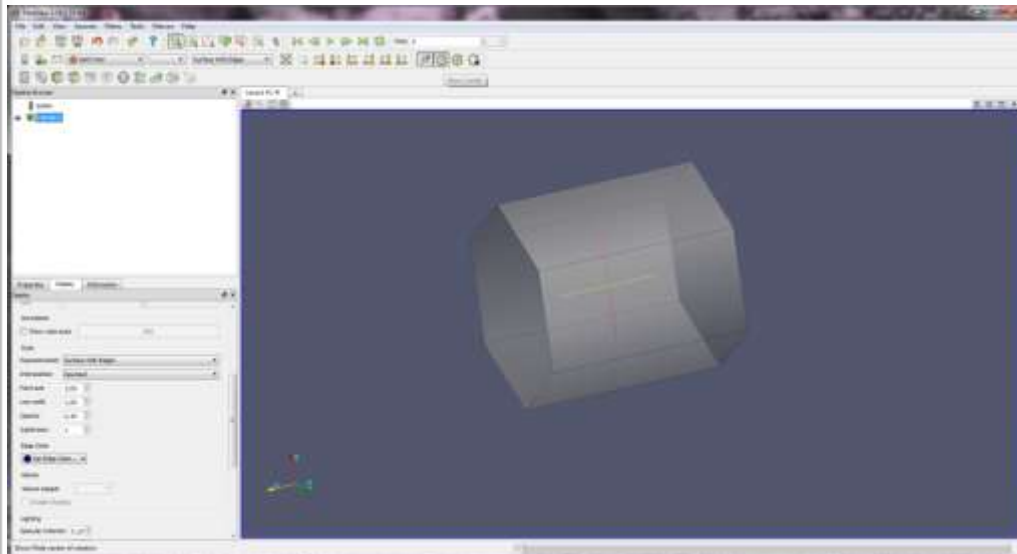


Set view on/off for
axis and center of
rotation






Change center of rotation





Apply/Reset Undo/Redo

Apply: click on the apply button to 'sync' your data state. (Automatic apply of changes button ) , ParaView was designed to operate on large datasets, for which any given operation could take a long time to finish. In this situation you need the Apply button so that you have a chance to be confident of your change before it takes effect. The highlighted Apply button is a reminder that the parameters of one or more filters are out of sync with the data that you are viewing.

[Making Mistakes](#)

Reset: click this button to restore the default configuration state.

Undo: go back to the previous state

Redo: return to the state you changed back

Camera Undo: same as above but for camera views changes

Camera Redo: same as above but for camera views changes



Main objects menu



Properties



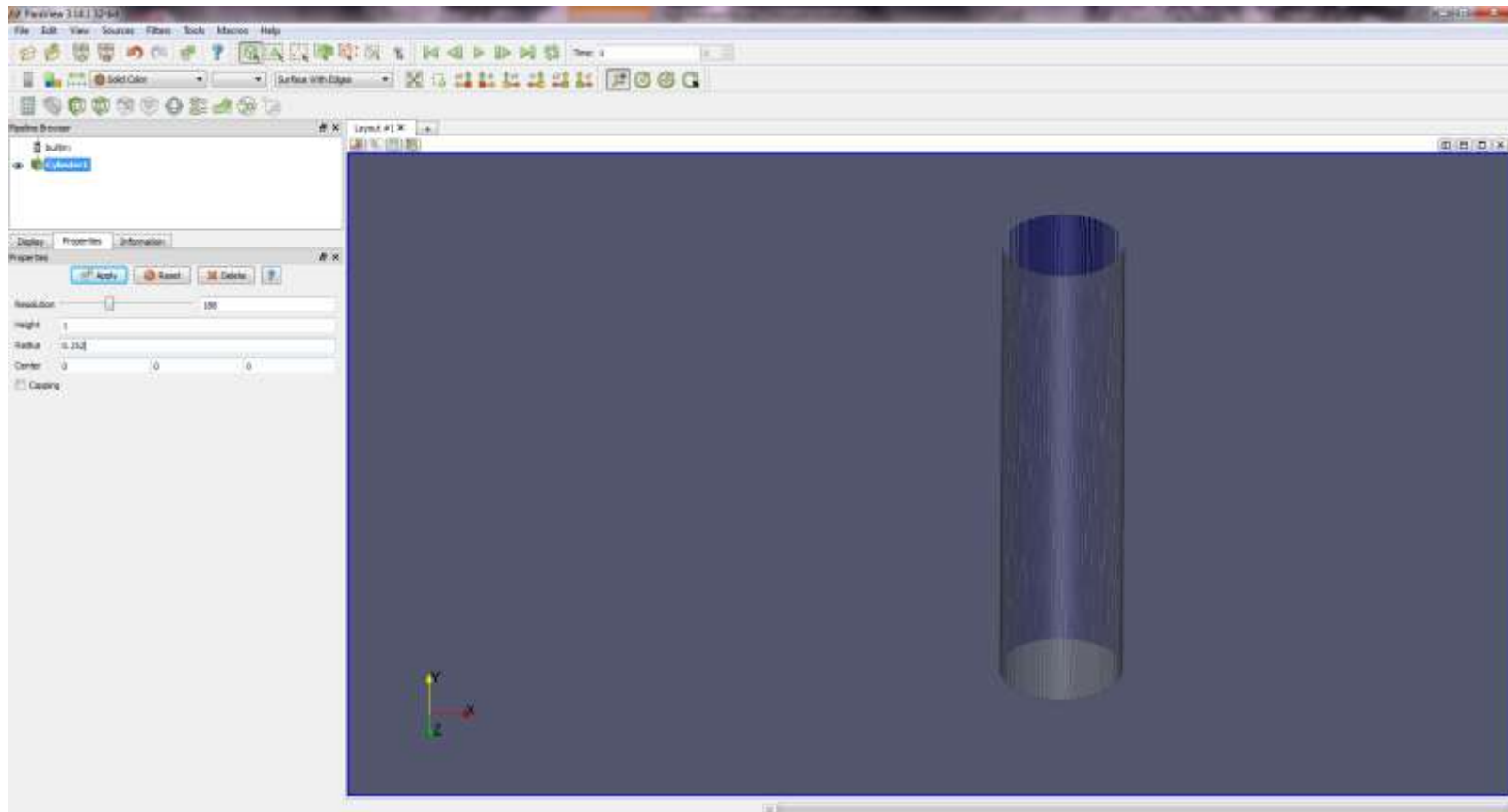
Display



Informations



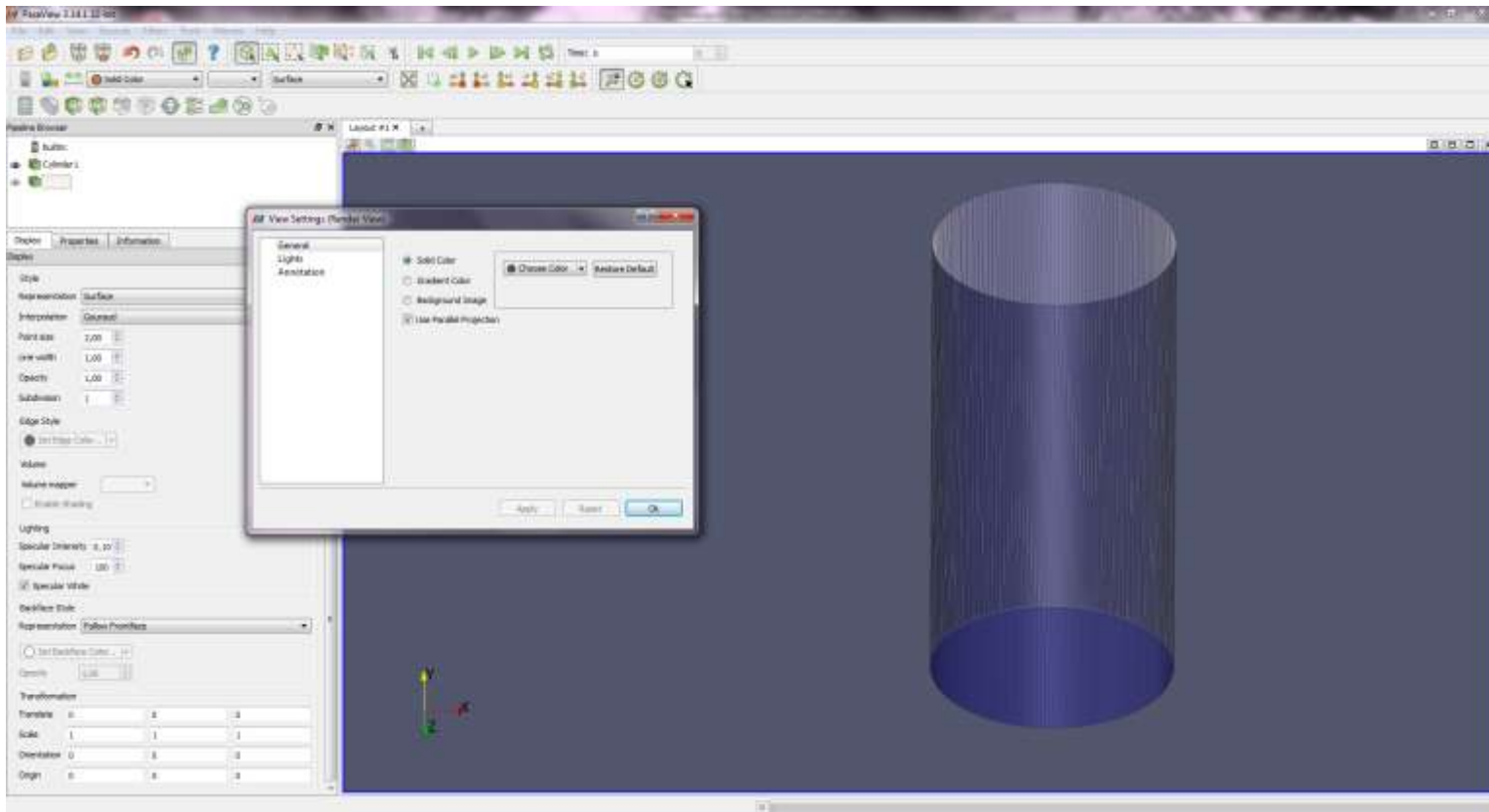
Change object properties





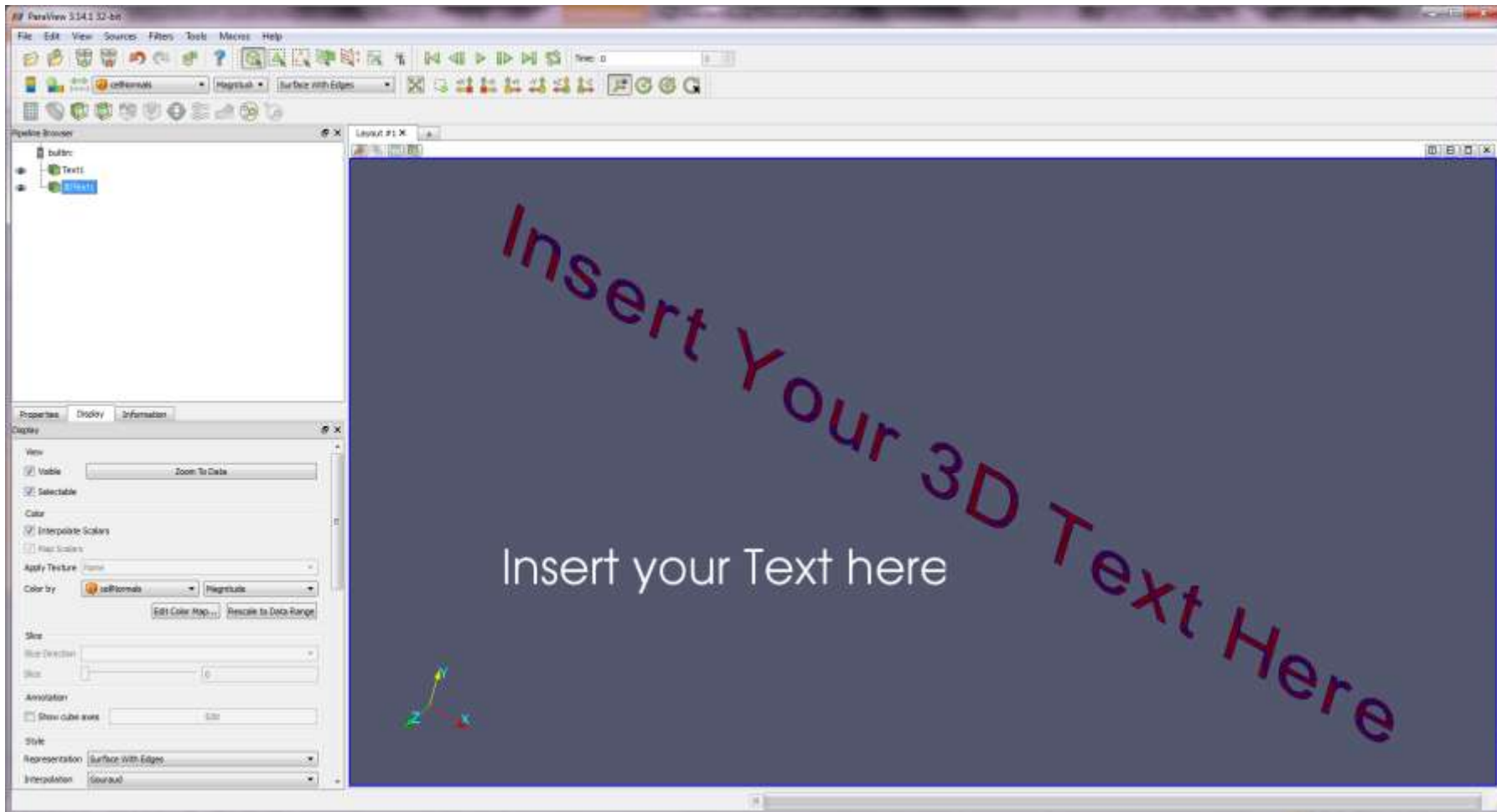
Display

Play with different display options for this object.



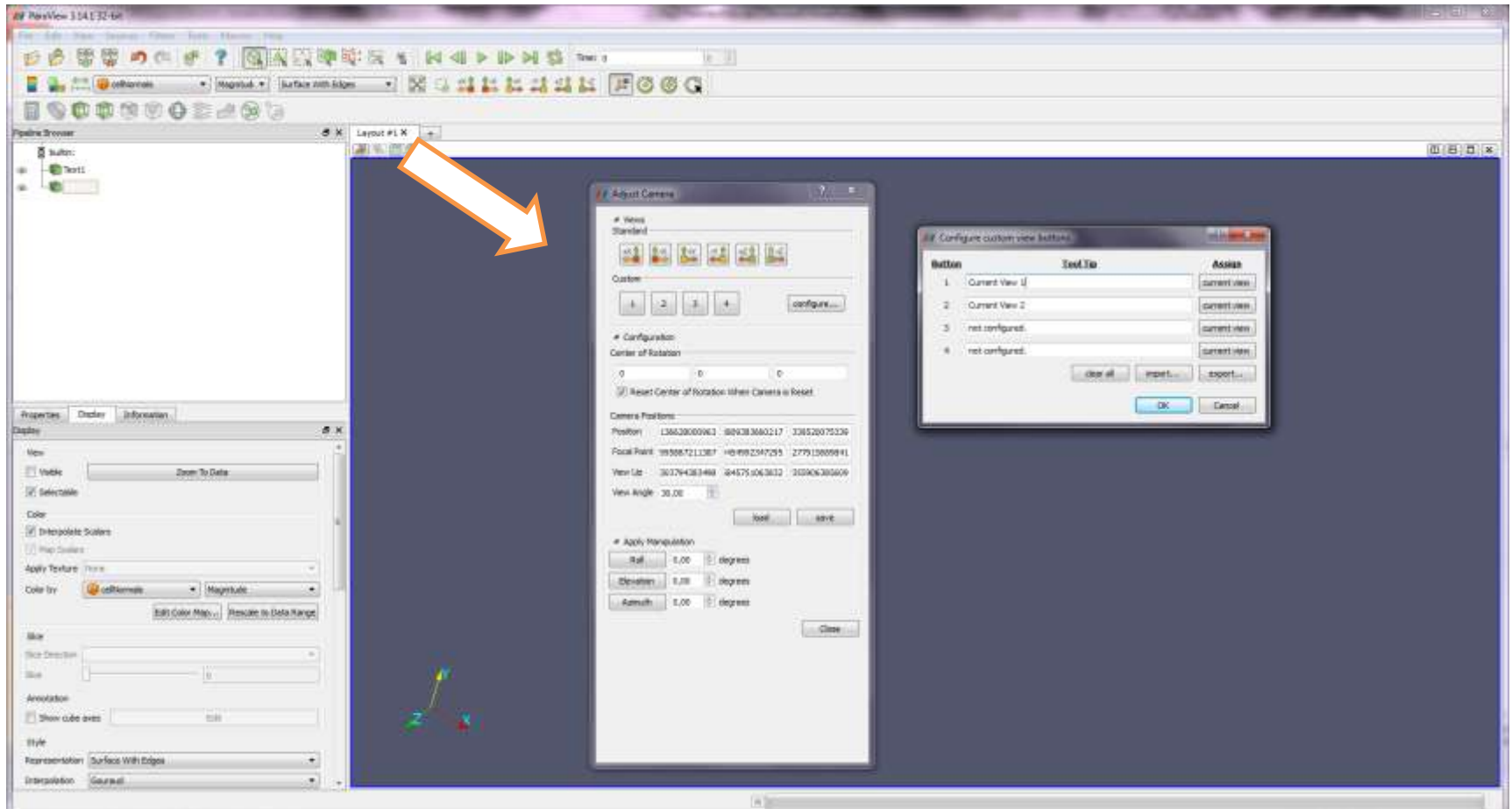


Text annotation





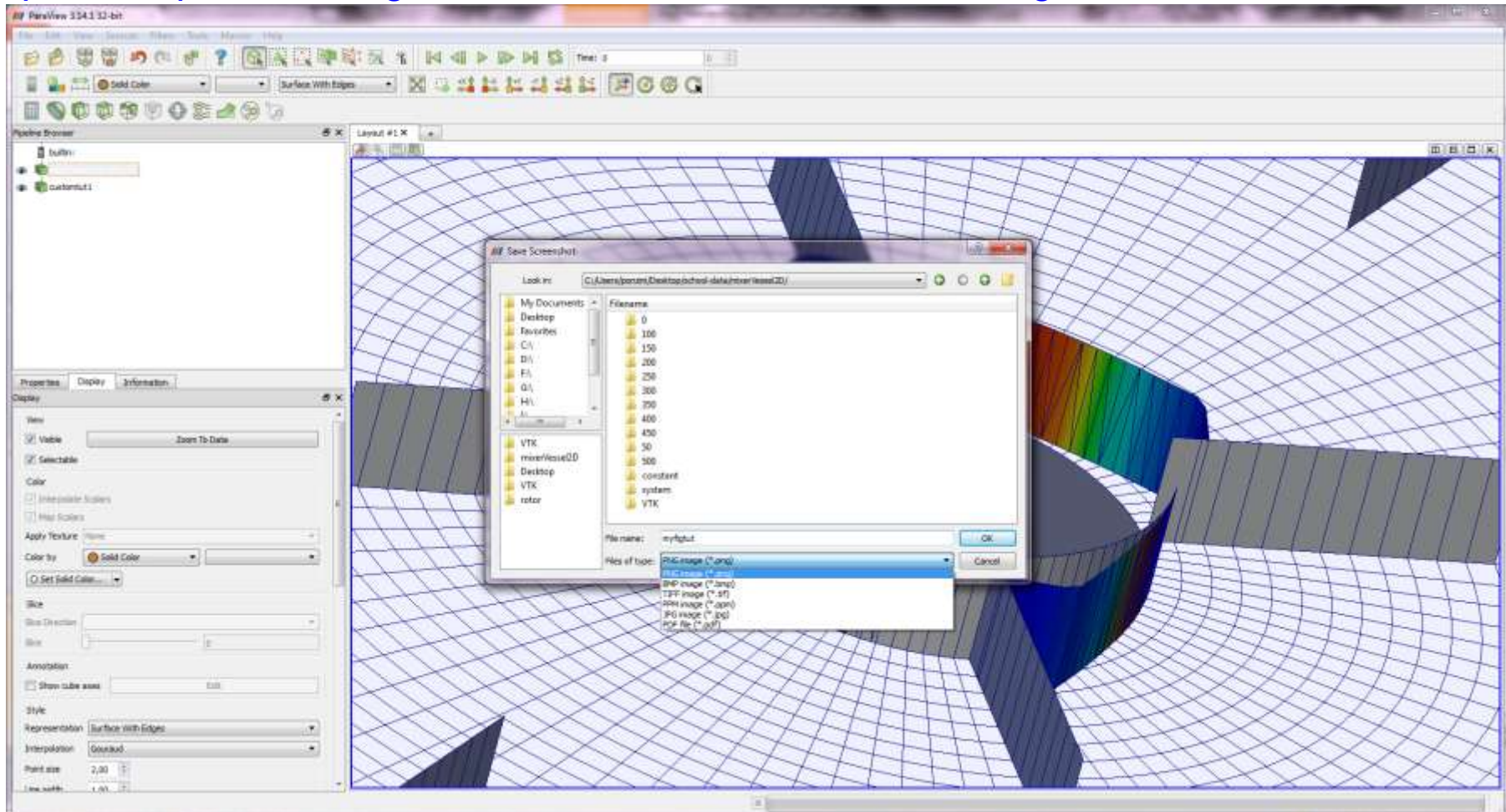
Views Management





Save figure

http://www.paraview.org/Wiki/ParaView/Users_Guide/Saving_Data



Loading data

http://www.paraview.org/Wiki/ParaView/Users_Guide/Loading_Data

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)

CAM NetCDF (.nc, .ncdf)

CCSM MTSD (.nc, .cdf, .elev, .ncd)

CCSM STSD (.nc, .cdf, .elev, .ncd)

CEAucd (.ucd, .inp)

CMAT (.cmat)

CML (.cml)

CTRL (.ctrl)

Chombo (.hdf5, .h5)

Claw (.claw)

Comma Separated Values (.csv)

Cosmology Files (.cosmo, .gad-get2)

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

Flash multiblock les

Fluent Case Files (.cas)

GGCM (.3df, .mer)

GTC (.h5)

GULP (.trg)

Gadget (.gadget)

Gaussian Cube File (.cube)

JPEG Image (.jpg, .jpeg)

LAMPPS Dump (.dump)

LAMPPS Structure Files

LODI (.nc, .cdf, .elev, .ncd)

LODI Particle (.nc, .cdf, .elev, .ncd)

LS-DYNA (.k, .lsdyna, .d3plot, .d3plot)

M3DCL (.h5)

MFIX Unstructured Grid (.RES)

MM5 (.mm5)

MPAS NetCDF (.nc, .ncdf)

Meta Image (.mhd, .mha)

Miranda (.mir, .raw)

Multilevel 3d Plasma (.m3d, .h5)

SAMRAI (.samrai)

SAR (.SAR, .sar)

SAS (.sasgeom, .sas, .sasdata)

SESAME Tables

SLAC netCDF mesh and mode data

SLAC netCDF particle data

Silo (.silo, .pdb)

Spherical (.spherical, .sv)

SpyPlot CTH

SpyPlot Case (.case)

SpyPlot History (.hscsth)

Stereo Lithography (.stl)

TFT Files

TIFF Image Files

TSurf Files

Tecplot ASCII (.tec, .tp)

Tecplot Binary (.plt)

Tetrad (.hdf5, .h5)

UNIC (.h5)

VASP CHGCA (.CHG)

VASP OUT (.OUT)

VASP POSTCAR (.POS)

VPIC (.vpc)

VRML (.wrl)

Velodyne (.vld, .rst)

VizSchema (.h5, .vsh5)

Wavefront Polygonal Data (.obj)

WindBlade (.wind)

XDMF and hdf5 (.xmf, .xdmf)

XMol Molecule

NASTRAN (.nas, .f06)

Nek5000 Files

Nrrd Raw Image (.nrrd, .nhrd)

OpenFOAM Files (.foam)

PATRAN (.neu)

PFLOTRAN (.h5)

PLOT2D (.p2d)

PLOT3D (.xyz, .q, .x, .vp3d)

PLY Polygonal File Format

PNG Image Files

POP Ocean Files

ParaDIS Files

Phasta Files (.pht)

Pixie Files (.h5)

ProSTAR (.cel, .vrt)

Protein Data Bank (.pdb, .ent, .pdb)

Raw Image Files

Raw NRRD image les (.nrrd)



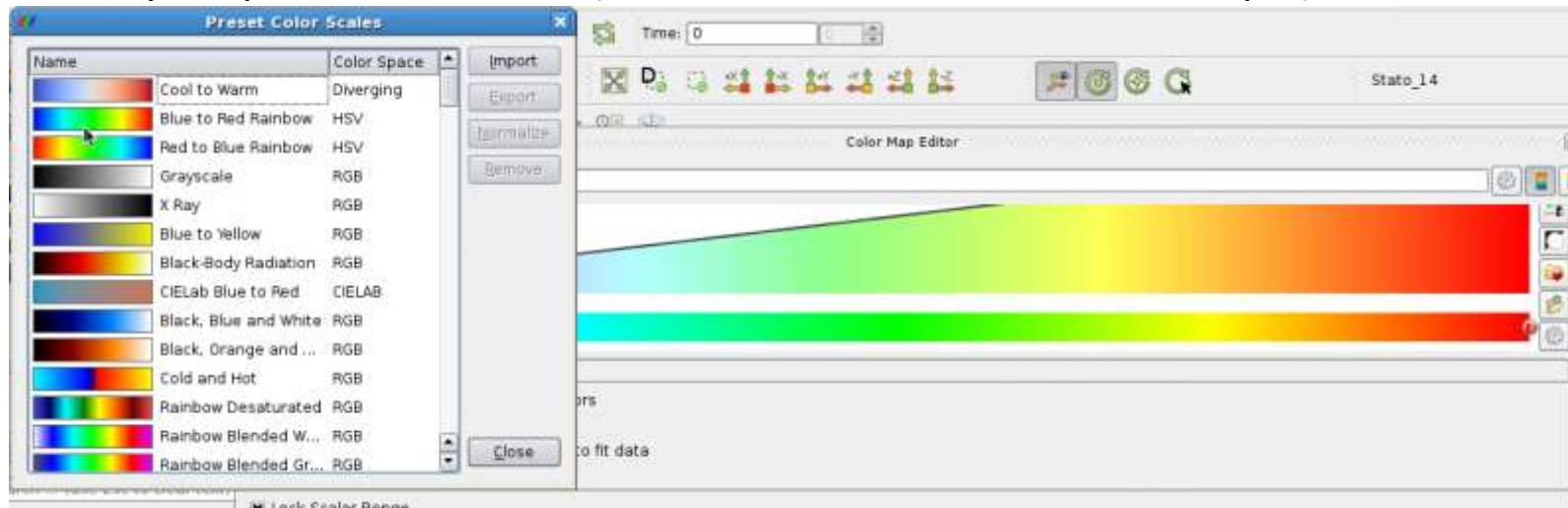
Loading your data (no filtering)

- Load the data file provided for the school.
(mixerVessel2D_500.vtk)
- Inspect available variables and ranges.
- Adjust view and display settings as learned above.
- Adjust representation and coloring
- Adjust text and legend



U + k field

- Select surface view + U magnitude
- Scale the data range
- Show label and colorbar
- Add a text to your scene and manage
- Change legend dimensions, format, position and range
- Save an image
- Redo the same for k value
- Choose your preset color scale (Blue to Red Rainbow in the example)





ParaView 4.1.0 64-bit

File Edit View Sources Filters Tools Macros Help

Time: 0

U Magnitude Surface

Stato_14

Pipeline Browser

- builtin:
 - mixerVessel2D_500.vtk
 - mixerVessel2D_500.vtk

Properties Information

Properties

Apply Reset Delete ?

Search ... (use Esc to clear text)

- Properties (mixerVessel2D_500.vtk)
- Display (UnstructuredGridRepresentation)

Representation Surface

Coloring

U Magnitude

Show Edit Rescale

Scalar Coloring

- Map Scalars
- Interpolate Scalars Before Mapping

Styling

Layout #1 x

3D

Y-Axis

U Magnitude

4.83

0.000564

3D

Y-Axis

k

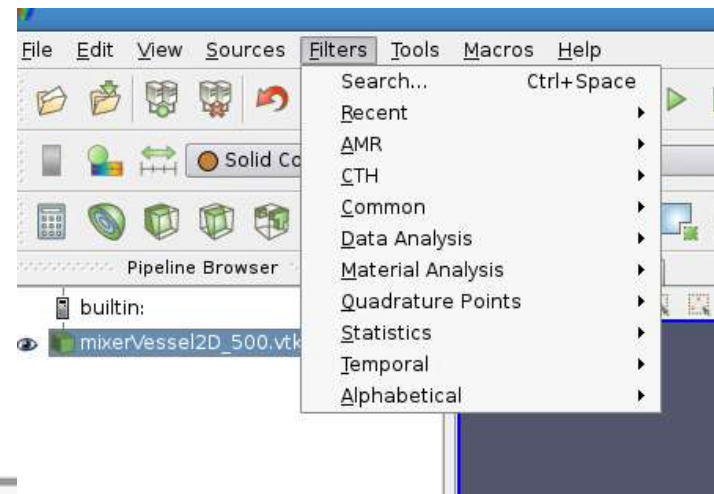


END OF PART A



Filtering in Paraview / Manipulating Data

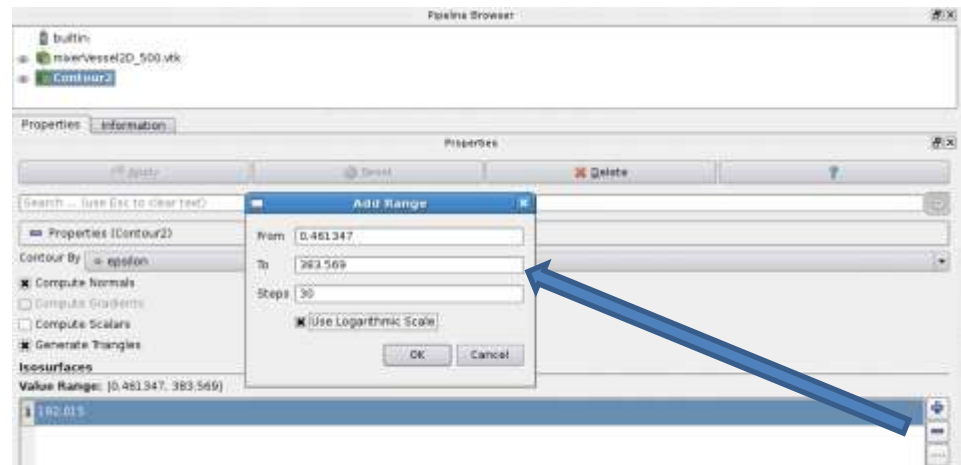
- It is often necessary to process the raw data in various ways. Examples include slicing into the data to make the interior visible, extracting regions that have particular qualities, and computing statistical measurements from the data.
- All of these operations involving taking in some original data and using it to compute some derived quantities.
- A **filter** is the basic tool that you use to manipulate data
- If data is a noun, then a filter is the verb that operates on the data. Filters operate by ingesting some data, processing it and producing some other data.
- ParaView creates **filters** when you open data files and instantiate new filters from the Filters menu.
- The set of filters you create becomes your visualization pipeline, and that pipeline is shown in ParaView's Pipeline Browser.





Filtering parameters and properties

- Each time a dataset is opened from a file, a source is selected, a filter is applied, or an existing reader, source, or filter is selected in the Pipeline Browser
- ParaView updates the Object Inspector for the corresponding output dataset
- From **the Properties** tab you modify the parameters of the filter, fine tuning what it produces from its input (if any)
- The specific controls and information provided on the tab then are specific to the particular vtkAlgorithm you are working with, but all filters have at least the Apply, Reset, Delete and ? (help) controls.
- The help button brings up the documentation for the filter in ParaView's help system in which the input restrictions to the filter, output type generated by the filter, and descriptions of each parameter are listed.
- The Delete button removes this filter from the pipeline. The delete button is only enabled when there are no filters further down the pipeline that depend on this filter's output.
- [Managing the Pipeline](#)





List of common filters

Calculator Evaluates a user-defined expression on a per-point or per-cell basis.

Contour Extracts the points, curves, or surfaces where a scalar field is equal to a user-defined value. This surface is often also called an iso-surface.

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

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.

Threshold Extracts cells that lie within a specified range of a scalar-field.

Extract Subset Extracts a subset of a grid by defining either a volume of interest or a sampling rate.

Glyph Places a glyph, a simple shape, on each point in a mesh. The glyphs may be oriented by a vector and scaled by a vector or scalar.

Stream Tracer Seeds a vector field with points and then traces those seed points through the (steady state) vector field.

Warp (vector) Displaces each point in a mesh by a given vector field.

Group Datasets Combines the output of several pipeline objects into a single multi-block data set.

Extract Level Extract one or more items from a multi block data set.



Other Filters

Recent The list of most recently used filters sorted with the most recently used filters on top.

AMR A set of filters designed specifically for data in an adaptive mesh refinement (AMR) structure.

CTH Filters used to process results from a CTH simulation.

Common The most common filters. This is the same list of filters available in the filters toolbar and listed previously.

Cosmology This contains filters developed at LANL for cosmology research.

Data Analysis The filters designed to retrieve quantitative values from the data. These filters compute data on the mesh, extract elements from the mesh, or plot data.

Material Analysis Filters for processing data from volume fractions of materials.

Statistics This contains filters that provide descriptive statistics of data, primarily in tabular form.

Temporal Filters that analyze or modify data that changes over time. All filters can work on data that changes over time because they are executed on each time snapshot. However, filters in this category will introspect the available time extents and examine how data changes over time.

Alphabetical An alphabetical listing of all the filters available. If you are not sure where to find a particular filter, this list is guaranteed to have it. There are also many filters that are not listed anywhere but in this list.



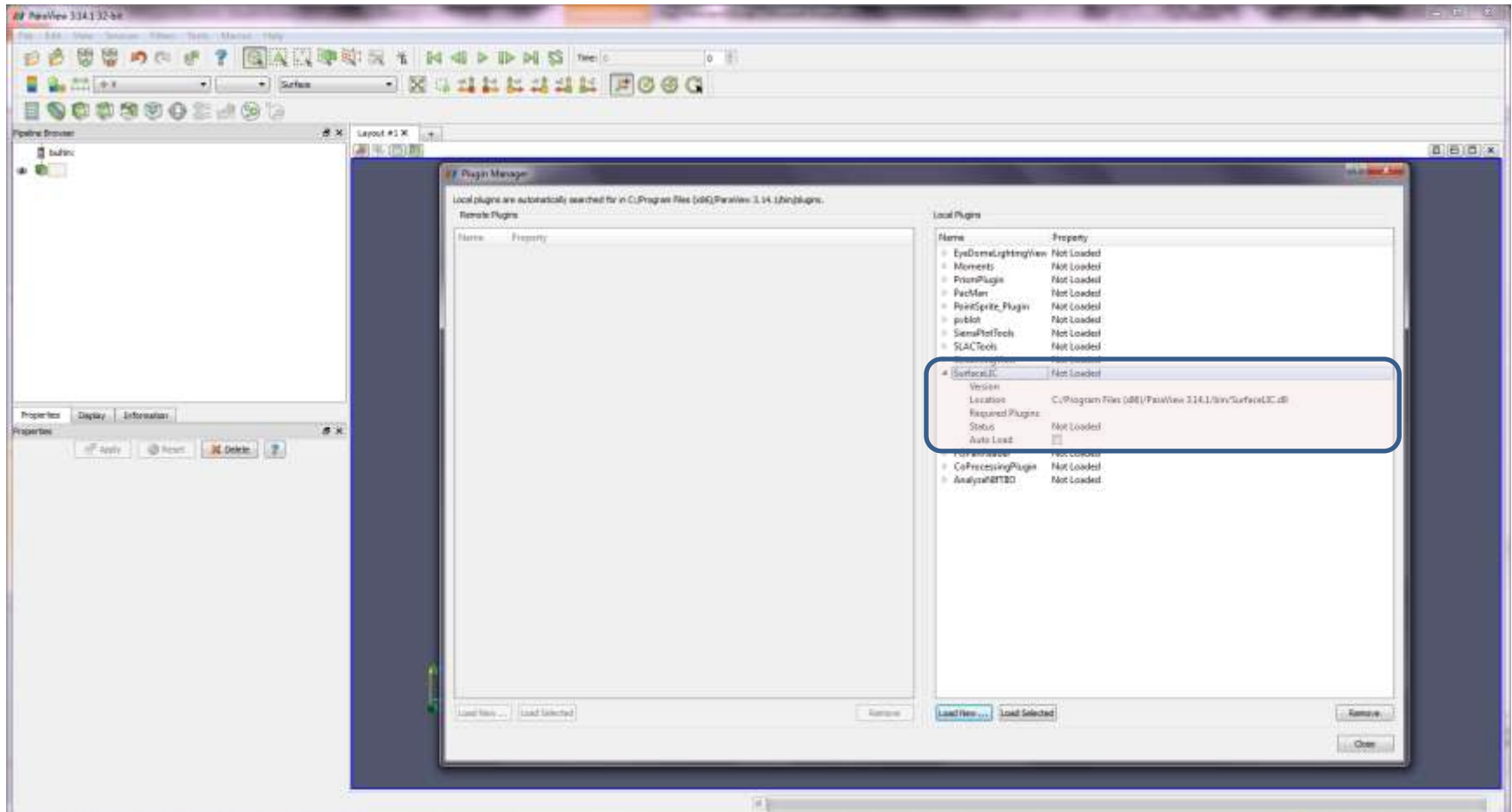
Other Filters

The screenshot displays a software interface with a menu bar at the top containing 'Filters', 'Tools', 'Macros', and 'Help'. Below the menu bar is a search field and a 'Ctrl+Space' shortcut. The main area is a scrollable list of filter categories and individual filter names. The categories are: Filters, Tools, Macros, and Help. The filters are listed in four columns:

- Column 1:** AMI: Contour, AMI Dual Clip, Annotate Time Filter, Append Attributes, Append Datasets, Append Geometry, Block Scalars, Calculator, Cell Centers, Cell Data to Point Data, Clean, Clean Cells to Grid, Clean to Grid, Clip, Clip Closed Surface, Clip Generic Dataset, Compute Derivatives, Connectivity, Contingency Statistics, Contour, Contour Generic Dataset, Curvature, DB, Decimate, Delaunay 2D, Delaunay 3D, Descriptive Statistics, Elevation, Extract AMI Blocks, Extract Block, Extract CTM Parts, Extract Cells By Region, Extract Edges, Extract Generic Dataset Surface, Extract Level, Extract Selection, Extract Subset, Extract Surface, FFT Of Selection Over Time, FOF/50D Halo Finder, Feature Edges, Gaussian Resampling, Generate Ids, Generate Quadrature Points, Generate Quadrature Scheme Dictionary, Generate Surface Normals, Glyph, Glyph With Custom Source.
- Column 2:** Gradient, Gradient Of Unstructured DataSet, Grid Connectivity, Group Datasets, Histogram, Image Data to Point Set, Integrate Variables, Interpolate to Quadrature Points, Intersect Fragments, Iso Volume, K Means, Level Scalars, Linear Extrusion, Loop Subdivision, Mask Points, Material Interface Filter, Median, Merge Blocks, Mesh Quality, Multicorrelative Statistics, Normal Glyphs, Octree Depth Limit, Octree Depth Scalars, Outline, Outline Corners, Outline Curvilinear DataSet, Particle Pathlines, ParticleTracer, Plot Data, Plot Global Variables Over Time, Plot On Intersection Curves, Plot On Sorted Lines, Plot Over Line, Plot Selection Over Time, Point Data to Cell Data, Principal Component Analysis, Probe Location, Process 3D Scalars, Programmable Filter, Python Calculator, Quantic Clustering, Random Vectors, Rectilinear Data to Point Set, Rectilinear Grid Connectivity, Reflect, Resample With Dataset, Ribbon, Rotational Extrusion.
- Column 3:** Scatter Plot, Shrink, Slice, Slice Generic Dataset, Smooth, Stream Tracer, Stream Tracer For Generic Datasets, Stream Tracer With Custom Source, Subdivide, Surface Flow, Surface Vectors, Table To Points, Table To Structured Grid, Temporal Cache, Temporal Interpolator, Temporal Shift Scale, Temporal Snap-to-Time Step, Temporal Statistics, Tessellate, Tetrahesalize, Texture Map to Cylinder, Texture Map to Plane, Texture Map to Sphere, Threshold, Transform, Triangle Strips, Triangulate, Tube, Warp By Scalar, Warp By Vector, Youngs Material Interface, Iso-and-del-and-iso-and-smooth.



Other customized filters





Working with filters over data

Perform basic filtering on the data provided for the school

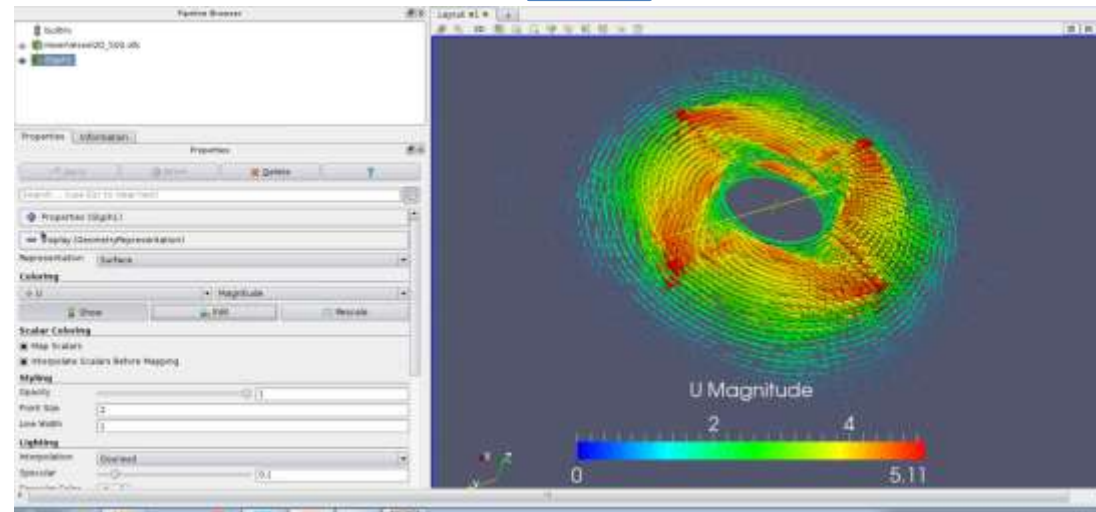
- Slicing
- Iso-surface
- Extract surface
- Clipping
- Vectors
- Streamlines



Vectors Visualization, glyph filter

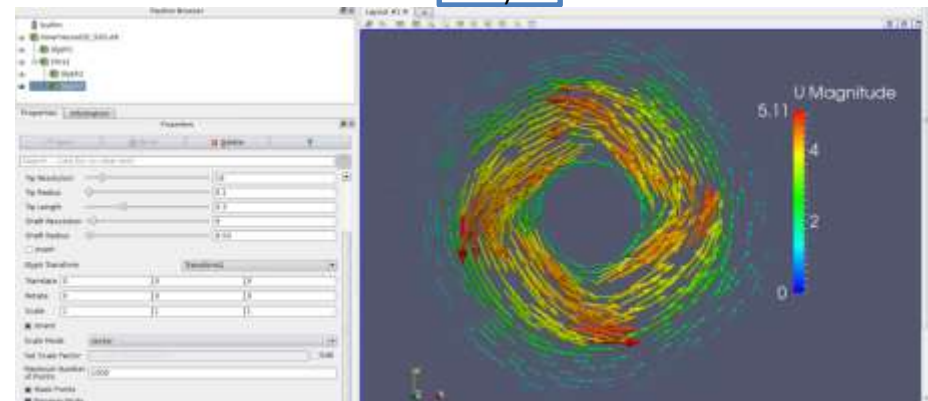
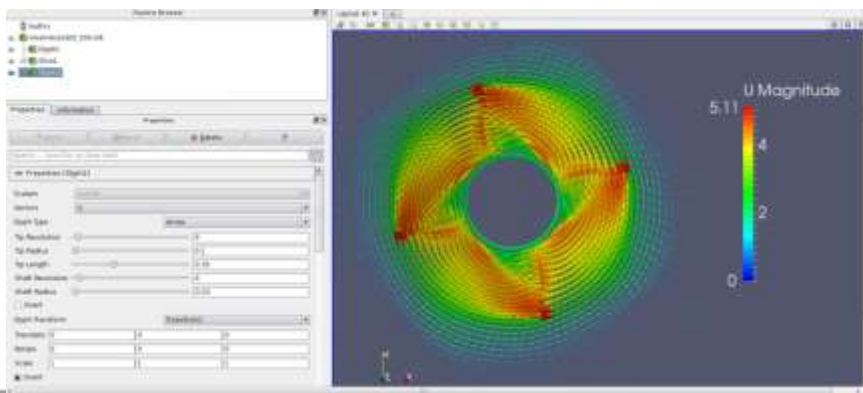
- Select filter for 3d vectors, 1)
- Select a slice normal to z axis
- Select 2d vectors on the slice 2)
- Modify vectors aspects 3)

1)



2)

3)



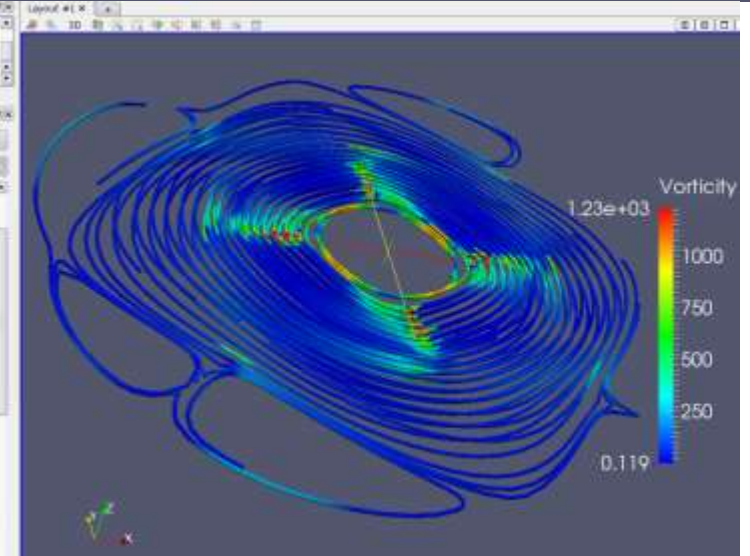
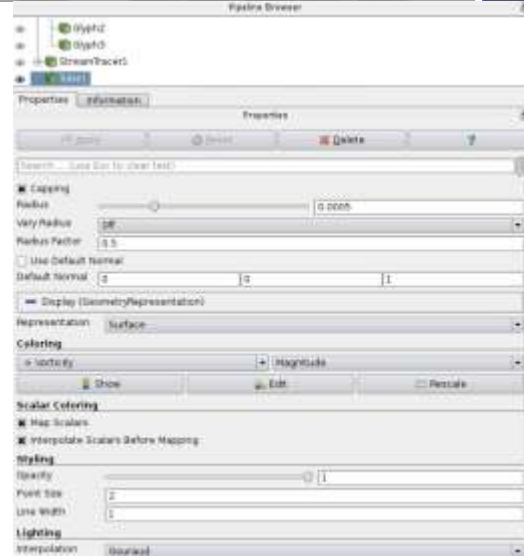
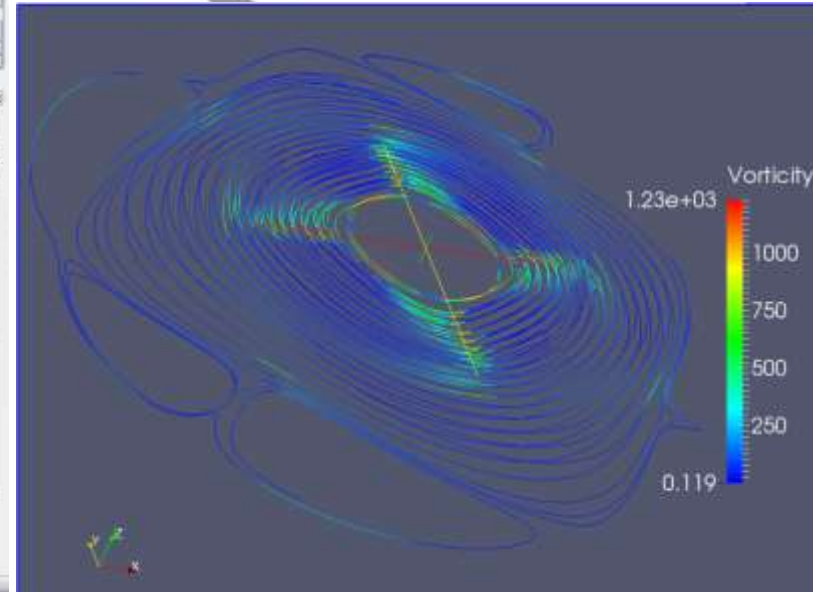
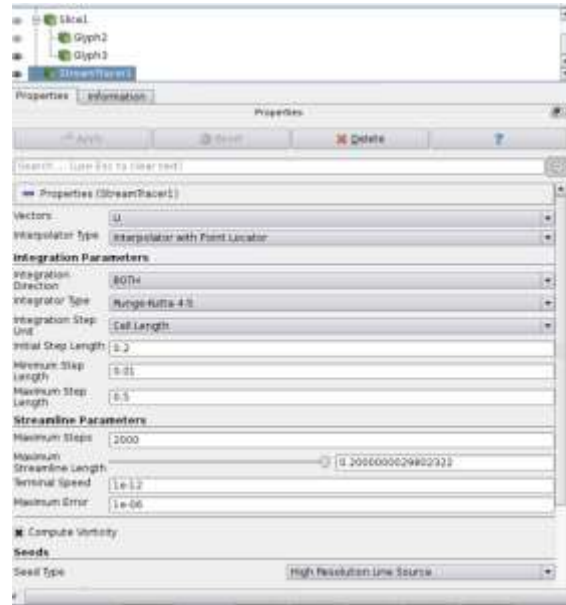
Streamlines

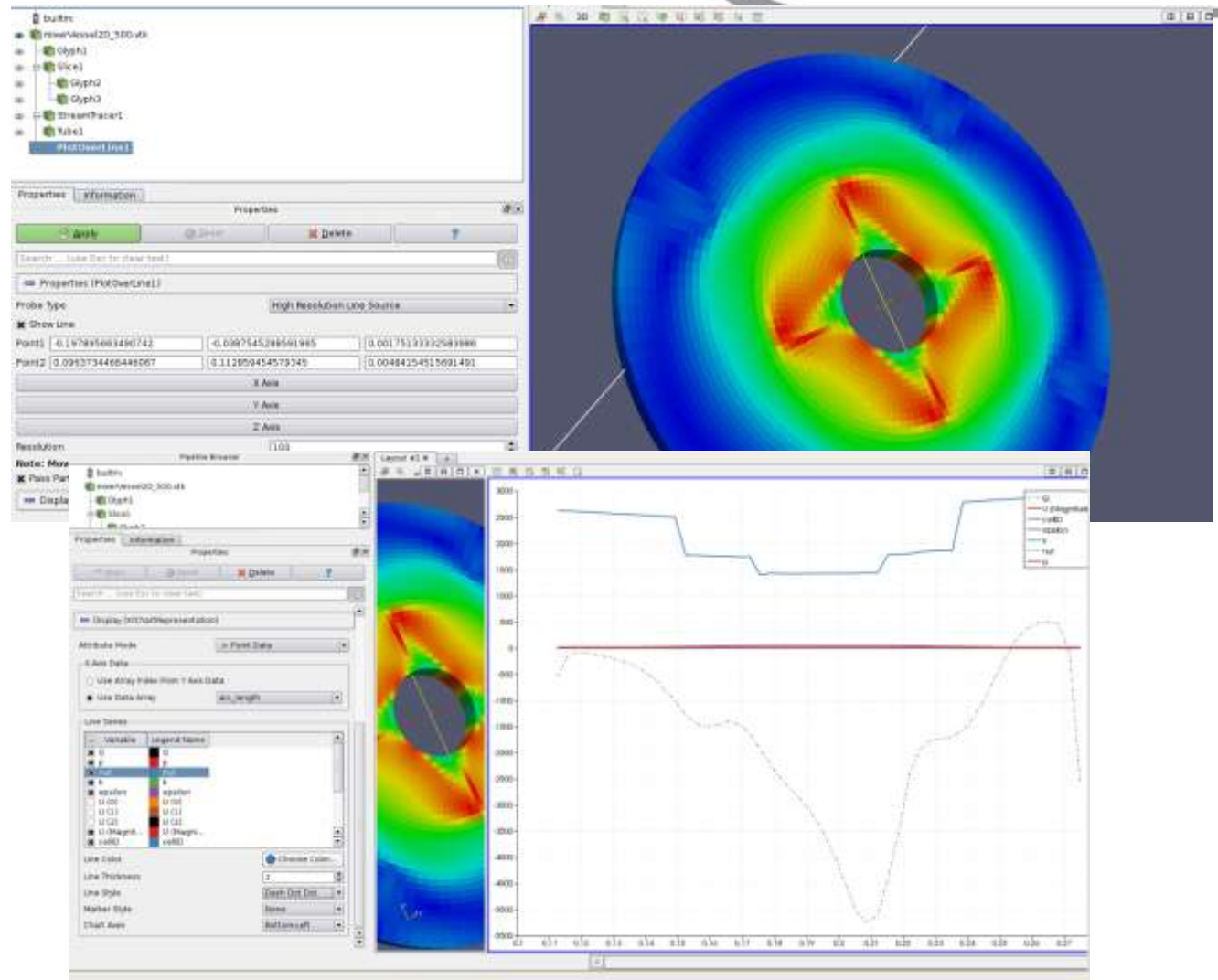
Integrate streamlines in a vector field



Summer
School on
SCIENTIFIC
VISUALIZATION

- Insert streamlines by line
- The input is given by the the vtkDataSet, that is the mixervessel*.vtk
- Use the default value with seed Type High Res. Line source
- Change stream properties
- Color by rotation
- Enhance streams using tubes
- Properties for streamlines







Data selection

Another mechanism for creating selections is by specifying a selection criteria. For example, suppose you want to select all cells where the pressure value is between a certain threshold. In such cases, you can use the Find Data dialog. The Find Data dialog performs a dual role: not only does it enable specifying the selection criteria but also show details of the selected elements in a spreadsheet. This makes it easier to inspect the selected elements.

The screenshot shows the ParaView 4.1.0 GUI. The 'Find Data' dialog is open, showing a search for 'Pressure' in the 'mmsrVessel2D_500.vtk' file. The search criteria are set to 'Pressure' with a range from 14 to 15.9. The 'Current Selection' is shown as 'mmsrVessel2D_500.vtk:0'. Below the dialog, a table displays the selected cells:

Cell ID	Cell ID	Value	Min	Max
0	275	-446749	14.385	0.000
1	286	-32561.1	14.0303	0.002
2	287	-151538	15.8764	0.000

The main visualization area shows a 2D mesh of a vessel with a pressure map. The pressure values are color-coded, with a color bar on the right ranging from 14 (blue) to 15.9 (red).

The screenshot shows the ParaView 4.1.0 GUI with the Pipeline Browser and Properties panel. The Pipeline Browser shows the following pipeline:

- mmsrVessel2D_500.vtk
- Clip1
- PlotOverLine1
- ExtractSelection1

The Properties panel shows the properties for 'ExtractSelection1'. The 'Type' is 'Query' and the 'Expression' is 'Pressure >= 14'. The 'Copied Selection (Active Selection Changed)' is also shown.

The main visualization area shows a 3D visualization of the vessel mesh with a pressure map. The pressure values are color-coded, with a color bar on the right ranging from 14 (blue) to 15.9 (red).

The Statistics Inspector shows the following data:

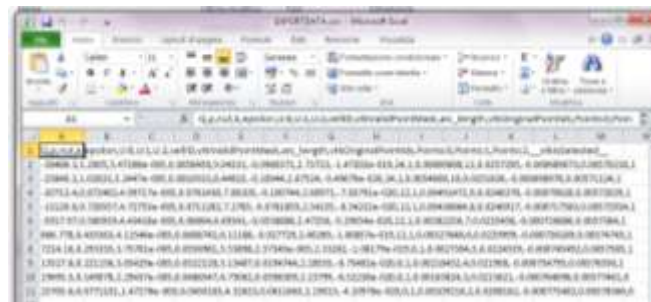
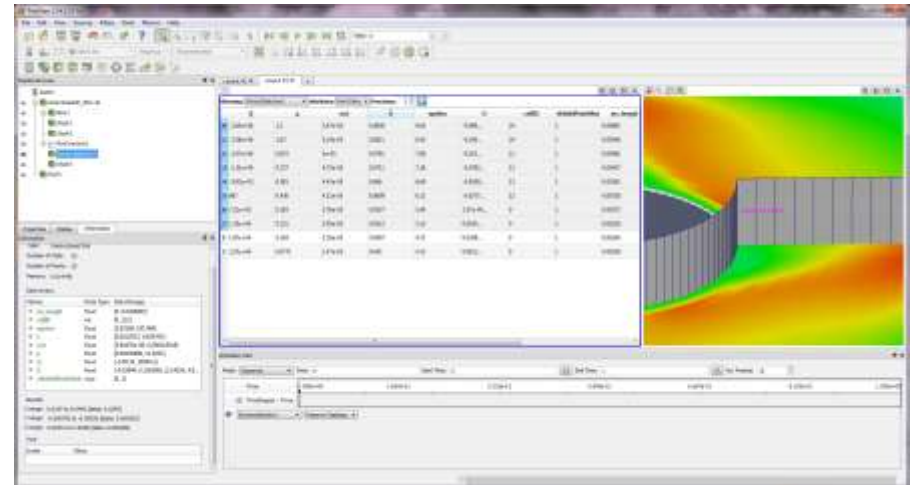
Name	Data Type	No. of Cells	No. of Points	Memory (MB)	Geometry Size (M)	Spatial Bound
mmsrVessel...	Unstructured Grid	3072	8528	0.635	Unavailable	[-0.1, 0.1], [-1, 0]
Clip1	Unstructured Grid	1600	3486	0.341	Unavailable	[-3.29e-18, 0.1]
PlotOverLine1	Polygonal Mesh	1	101	0.015	Unavailable	[0, 0.1], [0, 0]
ExtractSel...	Unstructured Grid	764	1824	0.199	0.277	[-0.1, 0.1], [-1, 0]



Data saving

http://www.paraview.org/Wiki/ParaView/Users_Guide/Selection

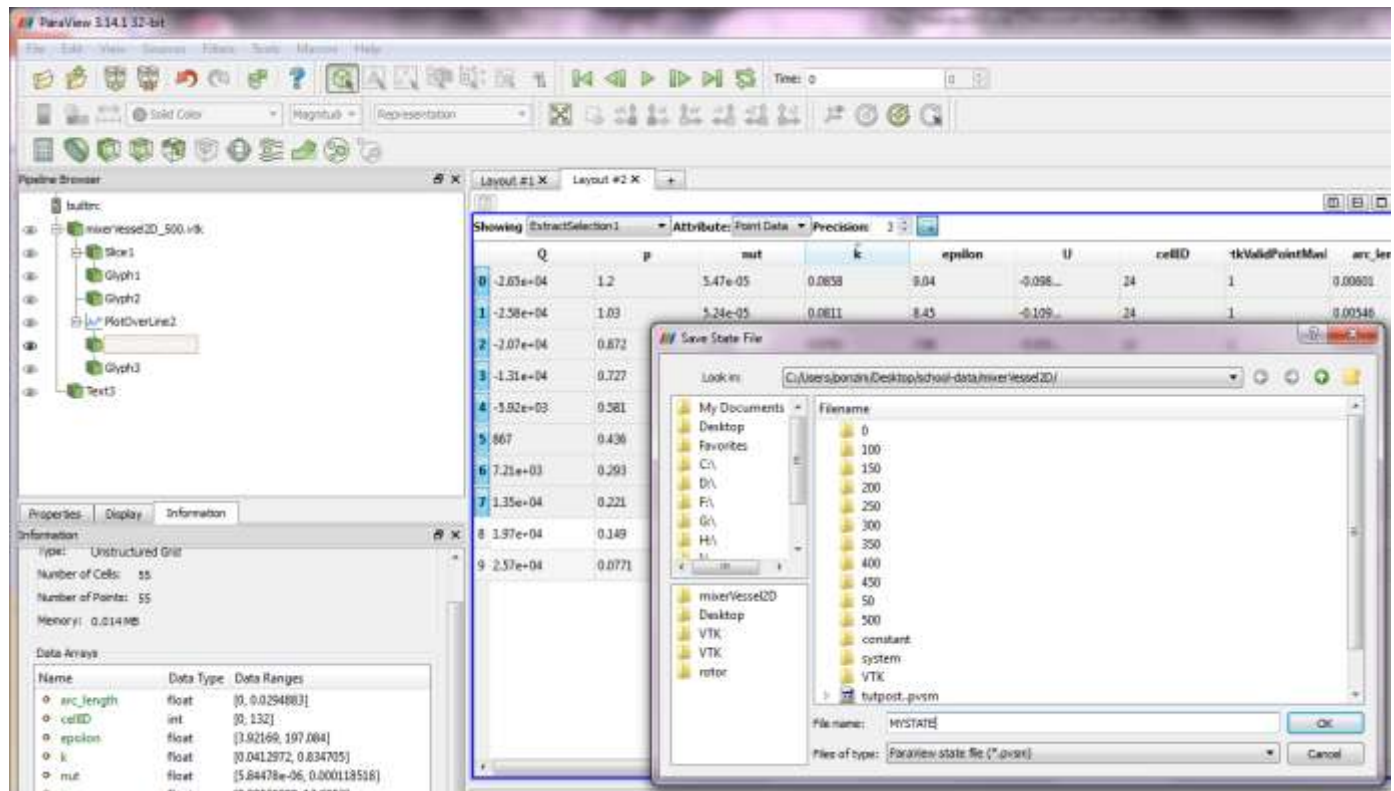
- Select your data





Save a pipeline as a scene

Save the obtained pipeline a PV scene for future processing by loading the scene back into ParaView.

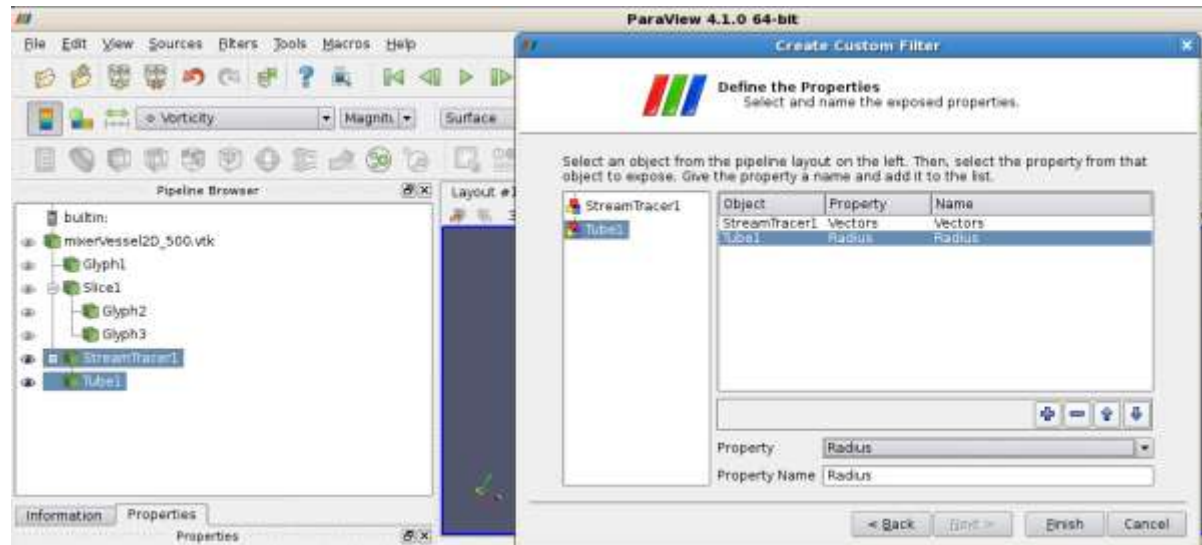
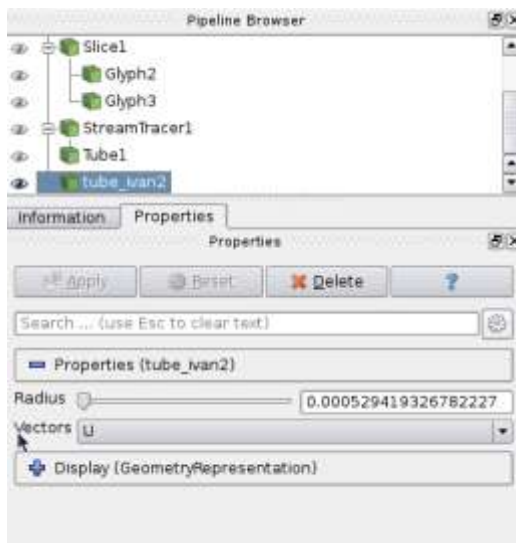
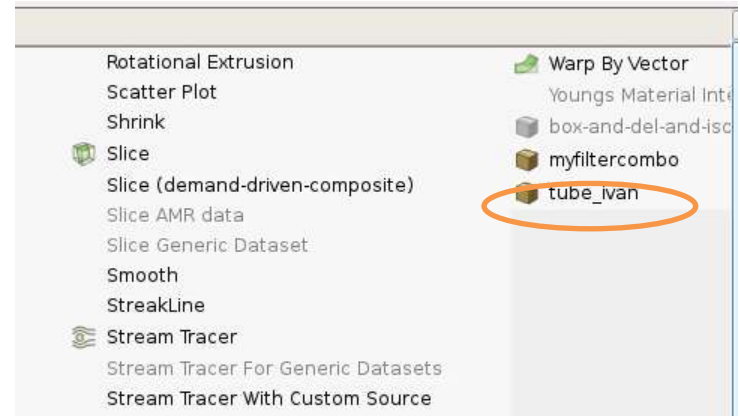




Build and use a new filter from a pipeline

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

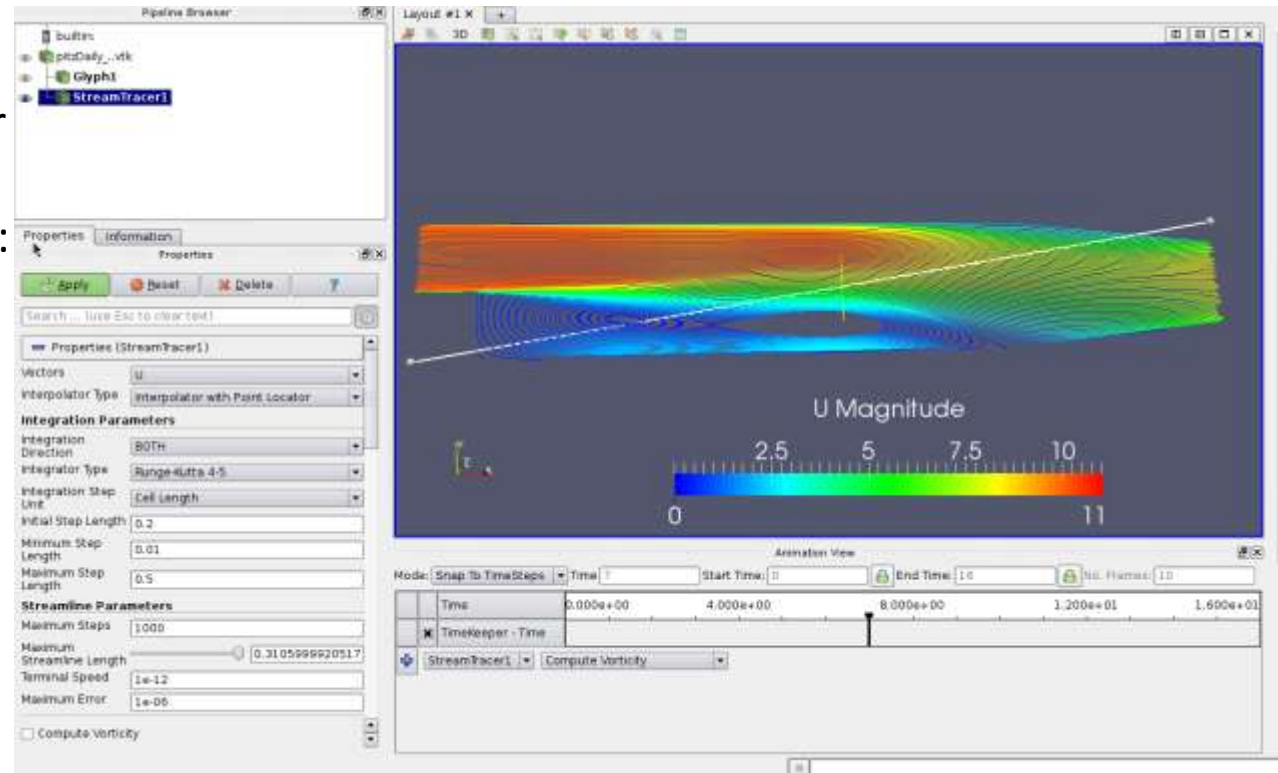
- Create a custom filter by grouping a pipeline
- Save the filter
- Close and re-load your custom filter





Tutorial 1

- Load the data provided for the tutorial
- Process the data to obtain:
 - ✓ Glyph of U
 - ✓ StreamTrace of U
 - ✓ Animate over time
 - ✓ Save the animation





Tutorial2

- Load the data provided for the tutorial
- Process the data to obtain:
 - ✓ Smaller dataset to process (by clipping)
 - ✓ Contour plot of iso-Q
 - ✓ Extract the isosurface
 - ✓ Smooth
 - ✓ Save the surface for future visualization
 - ✓ Color by velocity or pressure or both and compare
 - ✓ Build a filter that will do all the work in a single click
 - ✓ Add text and colorbar
 - ✓ Save meaningful visualizations

