

Scientific Visualization with ParaView

Geilo Winter School 2016

Andrea Brambilla (GEXCON AS, Bergen)

Outline

- Part 1 (Monday)
 - Fundamentals
 - Data Filtering
- Part 2 (Tuesday)
 - Time Dependent Data
 - Selection & Linked Views
- Part 3 (Thursday)
 - Python scripting

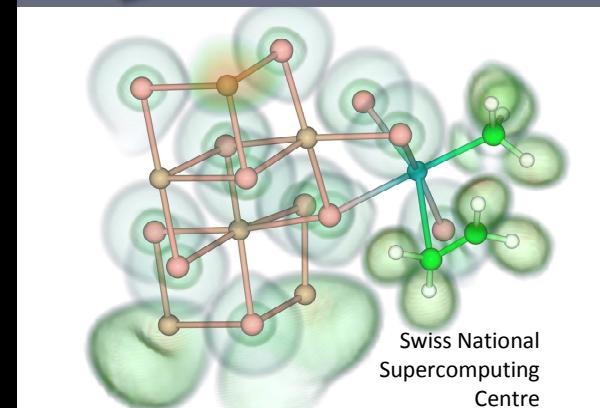
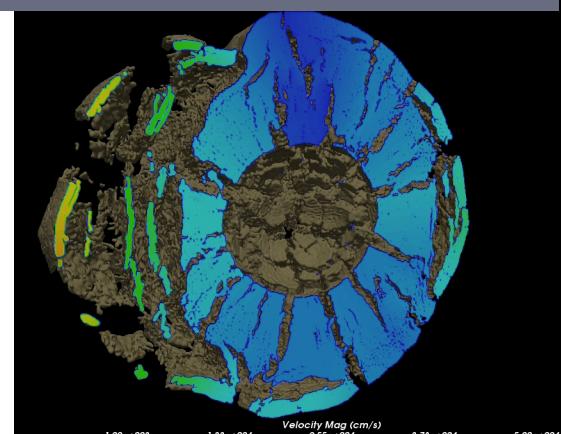
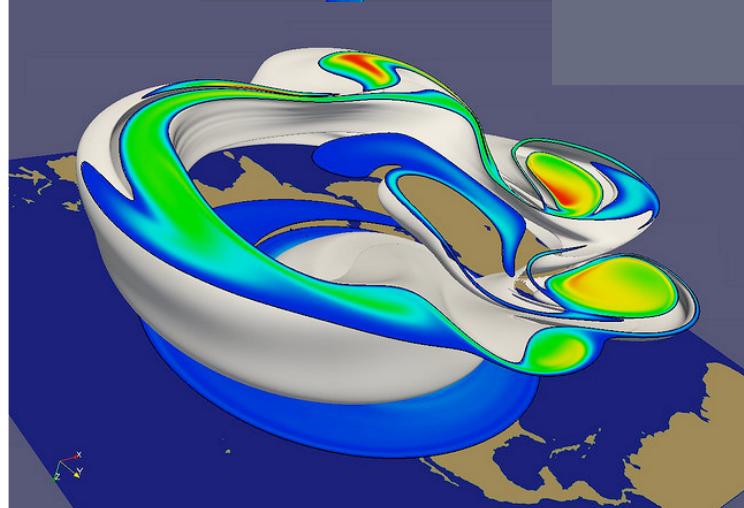
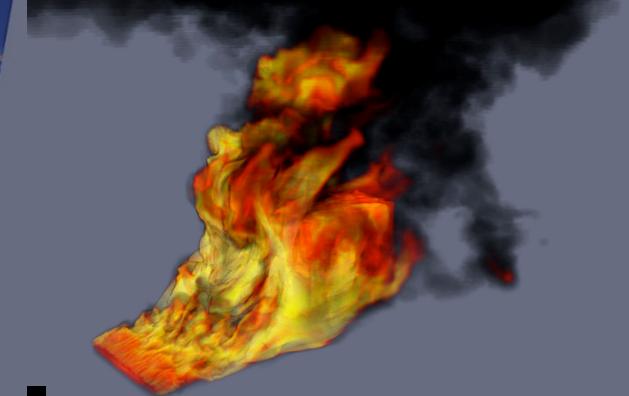
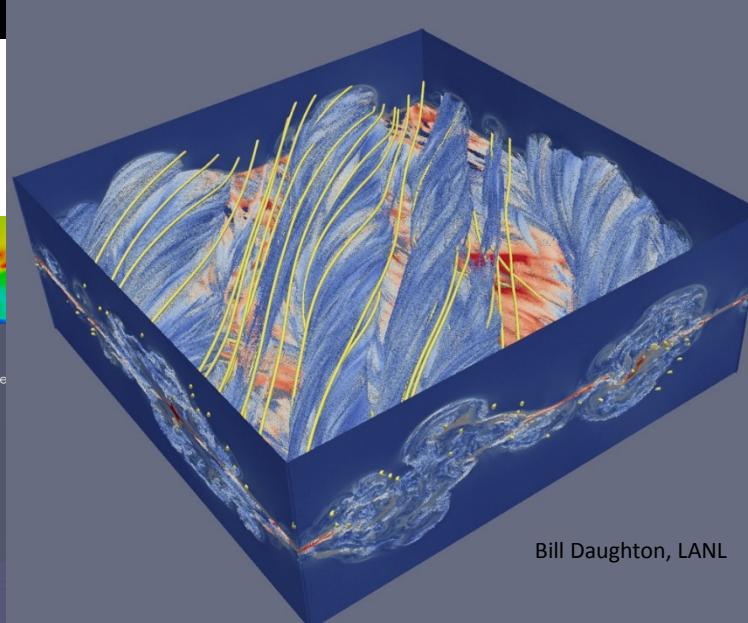
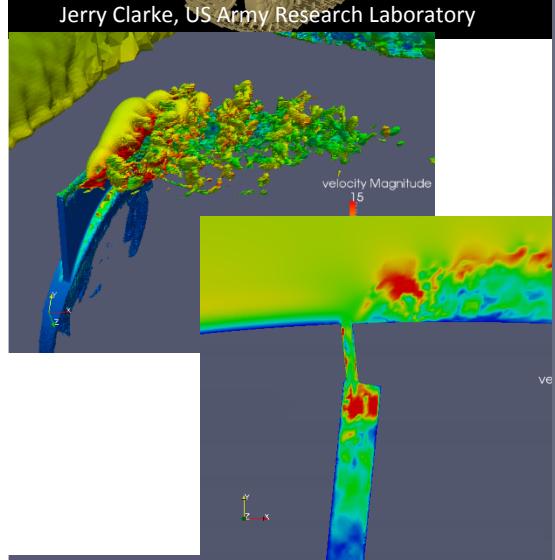
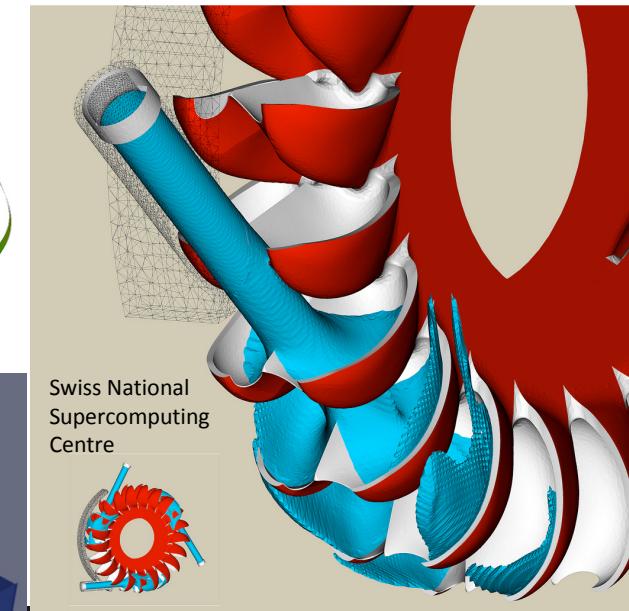
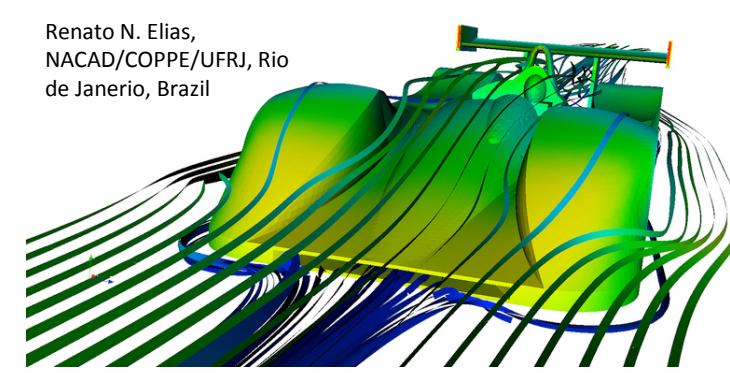
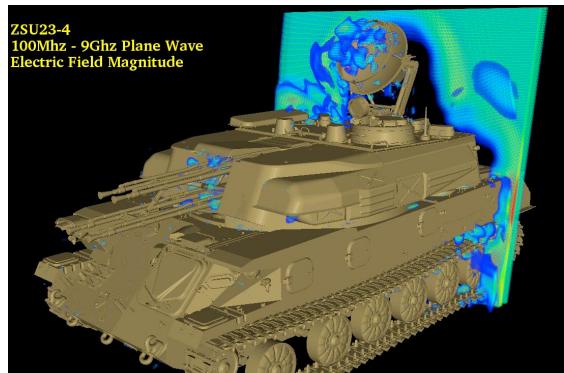
Requirements

- Install ParaView 4.4
 - <http://www.paraview.org> → Download
- Get example material
 - http://www.paraview.org/Wiki/The_ParaView_Tutorial
 - Additional data on the thumb drives
- On the thumb drives:
 - ParaView installers
 - Tutorial data
 - These slides, VTK Documentation (useful for python)

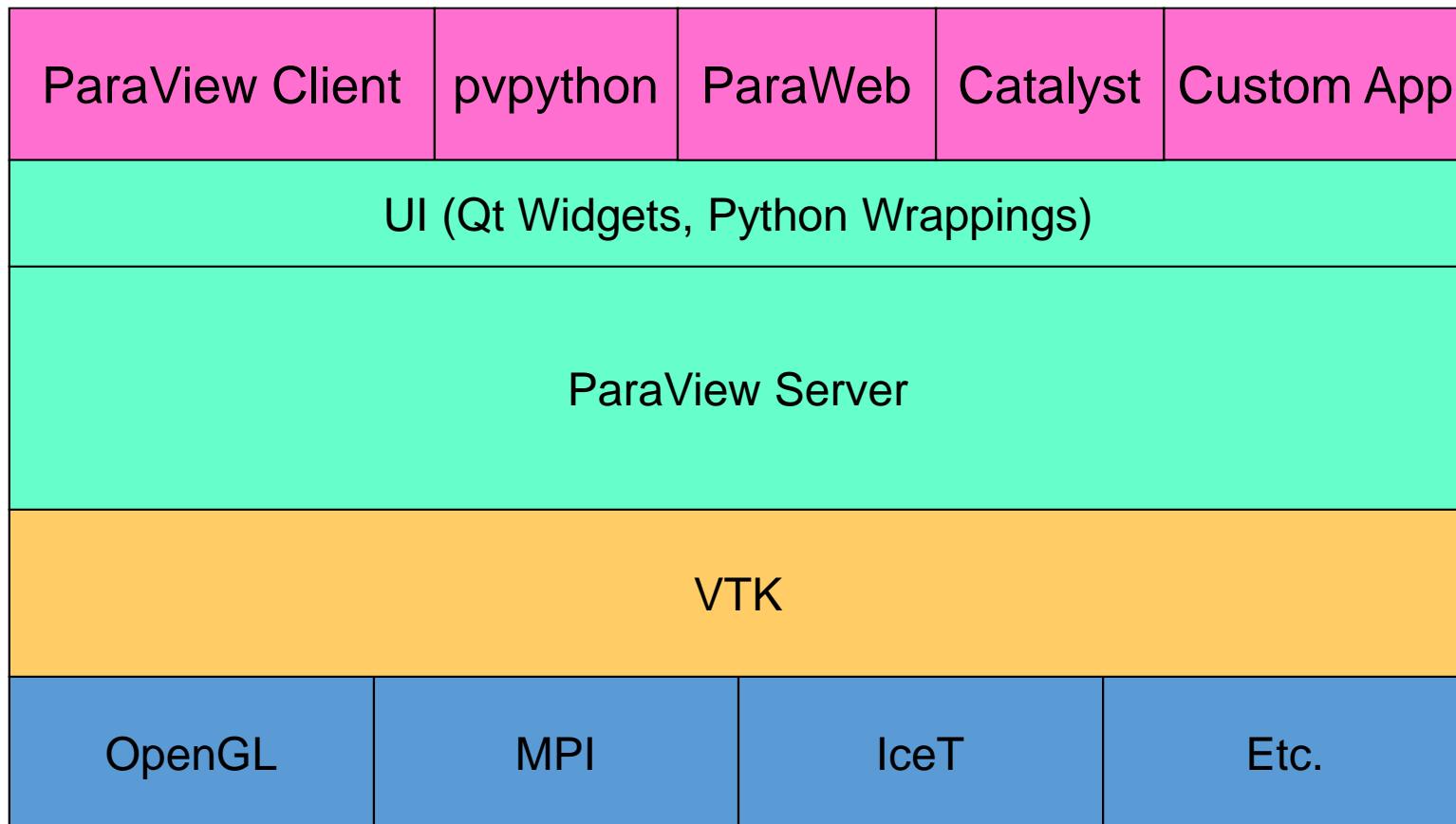
Introduction

What is ParaView?

- An open-source, scalable, multi-platform visualization application.
- Support for distributed computation models to process large data sets.
- An open, flexible, and intuitive user interface.
- An extensible, modular architecture based on open standards.
- Large user community, both public and private sector.
- A flexible BSD 3 Clause license.



ParaView Application Architecture

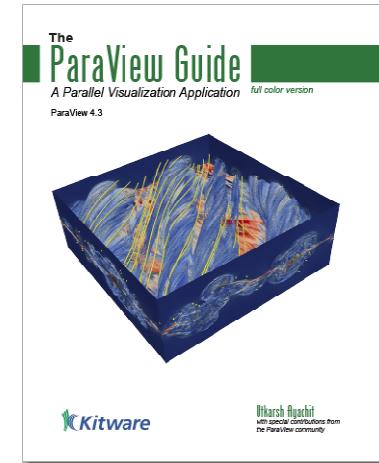


ParaView Development

- Started in 2000 as collaborative effort between Los Alamos National Laboratories and Kitware Inc. (lead by James Ahrens)
 - ParaView 0.6 released October 2002
- September 2005: collaborative effort between Sandia National Laboratories, Kitware Inc. and CSimSoft to rewrite user interface to be more user friendly and develop quantitative analysis framework
 - ParaView 3.0 released in May 2007
- ParaView 4.0 released in June 2013
- ParaView 5.0 recently released

More Information

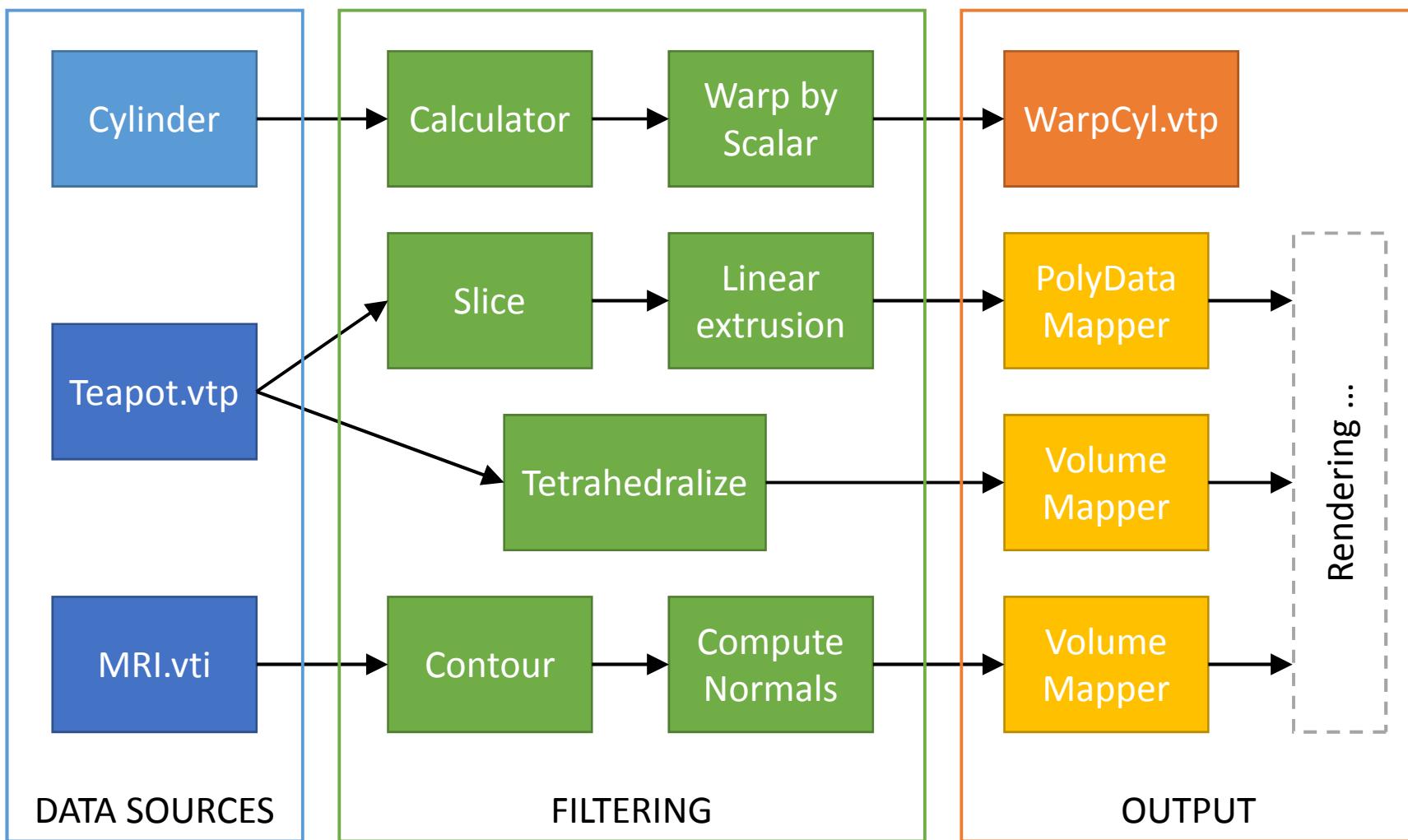
- Online Help – F1
- *The ParaView User's Guide*
 - <http://www.paraview.org/paraview-guide/>
- The ParaView web page
 - www.paraview.org
- ParaView mailing list
 - paraview@paraview.org



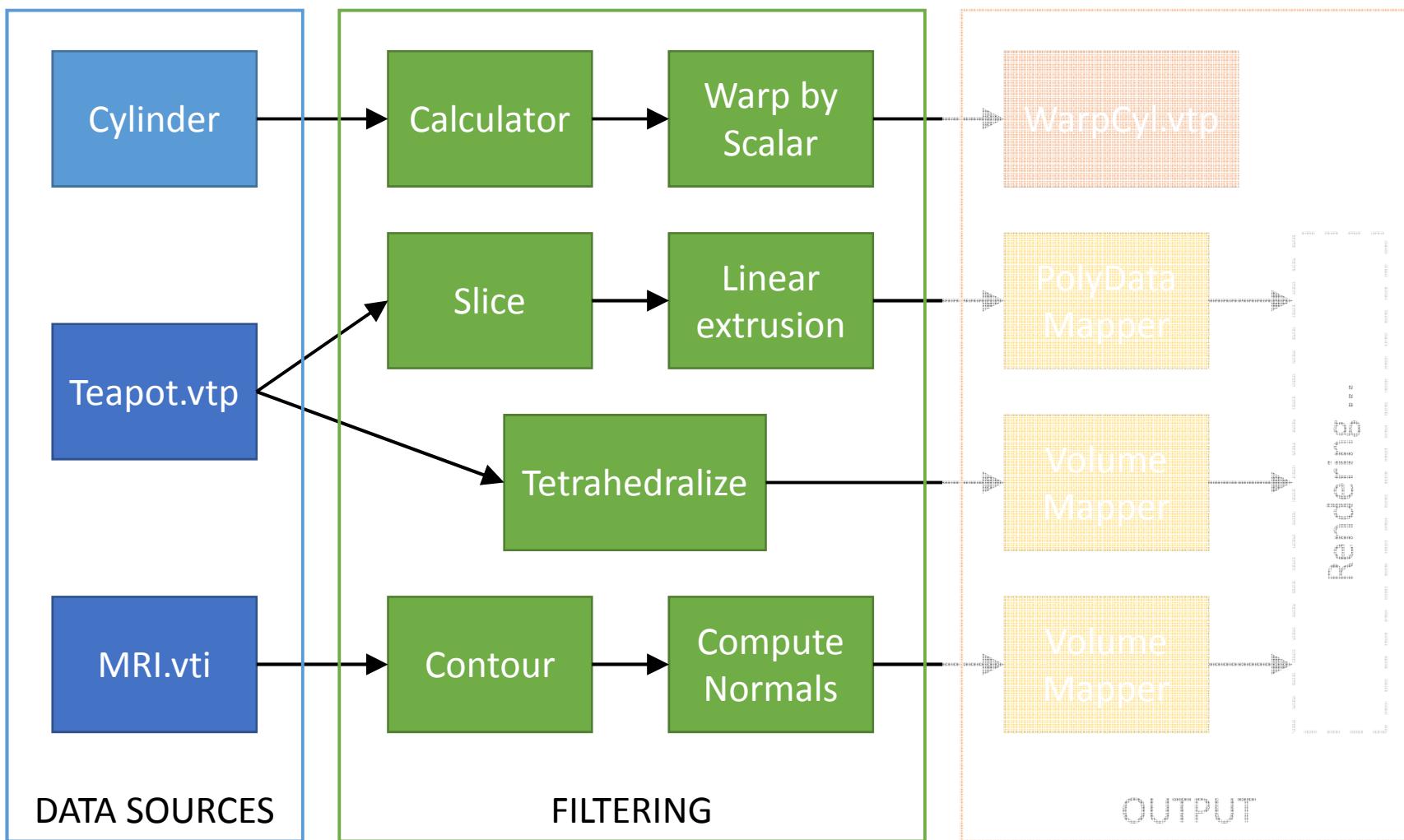
The image is a screenshot of the ParaView website. The header includes the ParaView logo and navigation links for About, Flavors, Domains, Resources, Developer Tools, Download, and a search bar. Below the header is a banner for "SOURCE" magazine, specifically the "Paraview's Python Programmable Filters in Geophysics" issue, with a "Read now" button. To the right of the banner is a "ParaView Blog Posts" section listing several recent articles. The main content area features a "Welcome to ParaView" section with a brief introduction and a "Download the Latest Version of ParaView" section with a download button for "ParaView Version 4.4". There are also buttons for "Contact Us", "Learn More", "Kitware Open Source", and "Request a New Feature".

Basic Usage

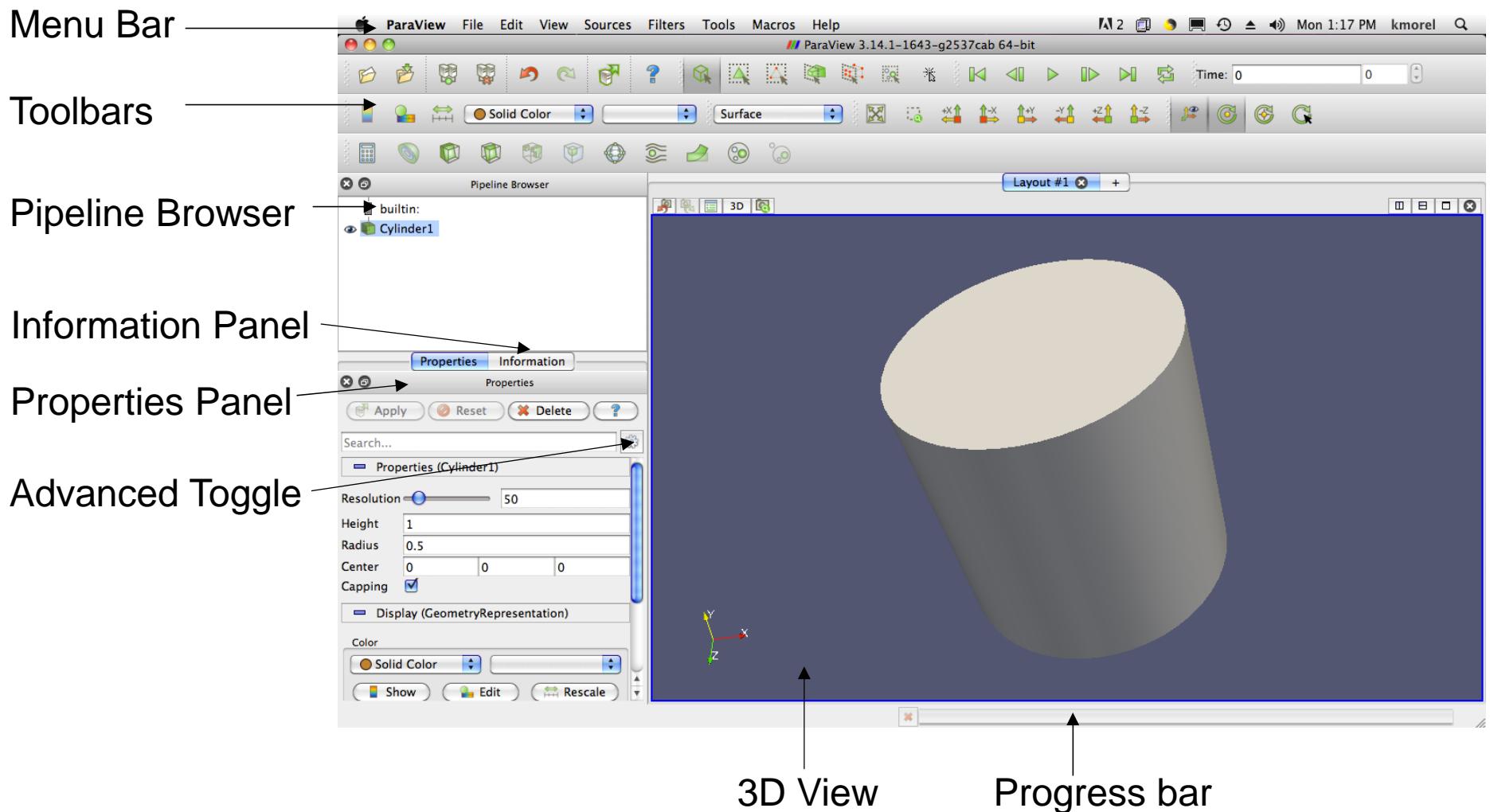
ParaView Visualization Pipeline



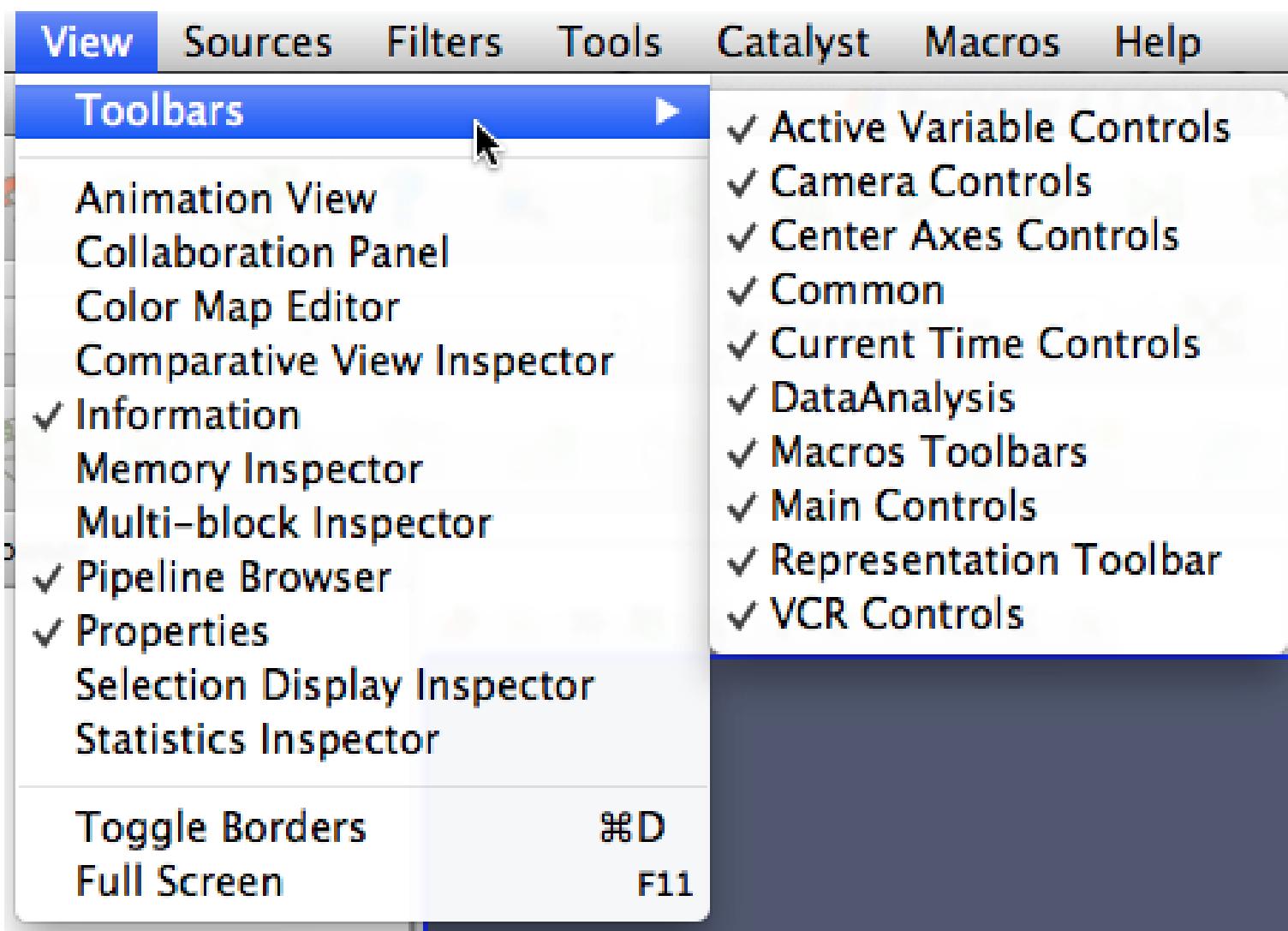
ParaView Visualization Pipeline



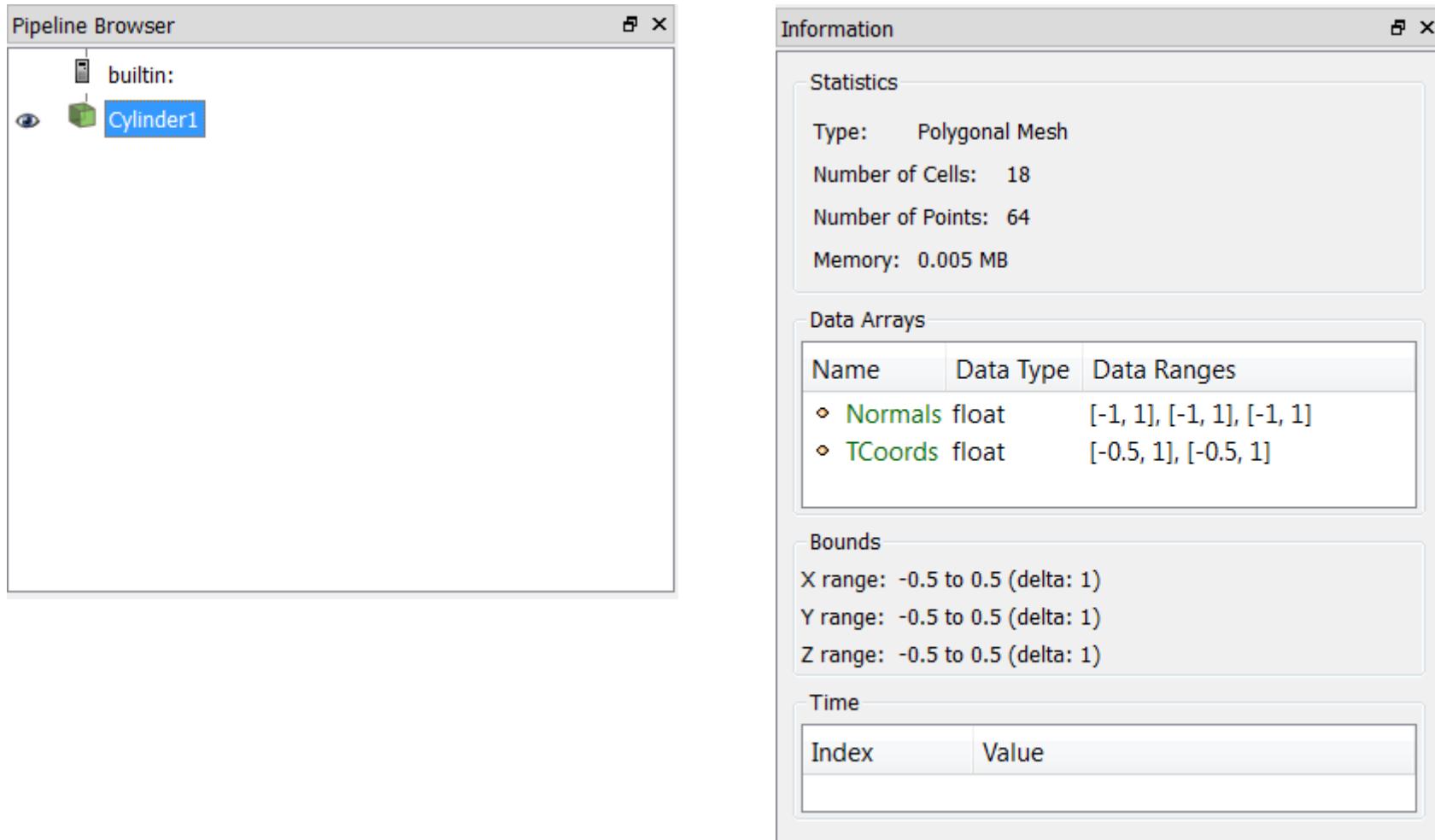
User Interface



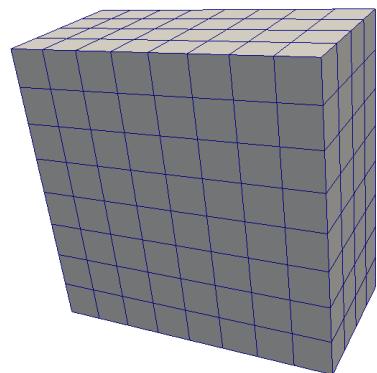
Getting Back GUI Components



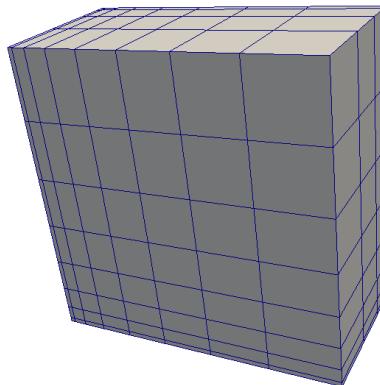
Pipeline and Information Panels



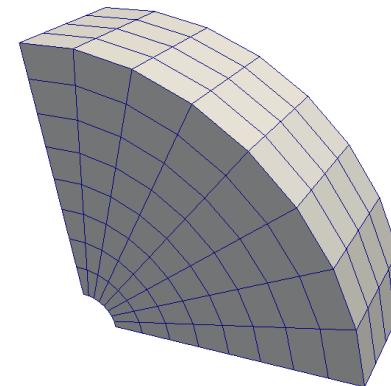
Data Types



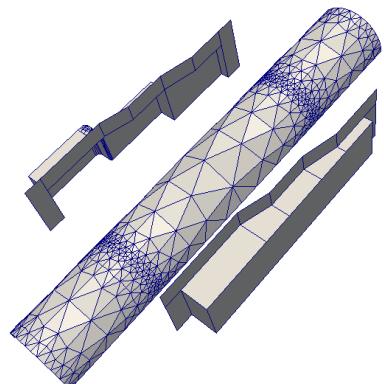
Uniform Rectilinear
(vtkImageData)



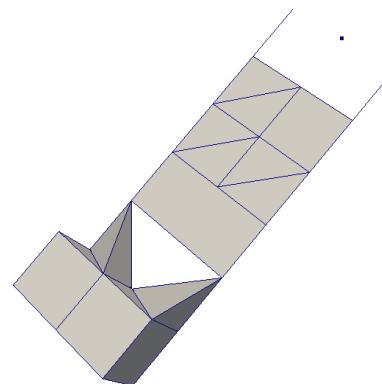
Non-Uniform Rectilinear
(vtkRectilinearData)



Curvilinear
(vtkStructuredData)



Polygonal
(vtkPolyData)



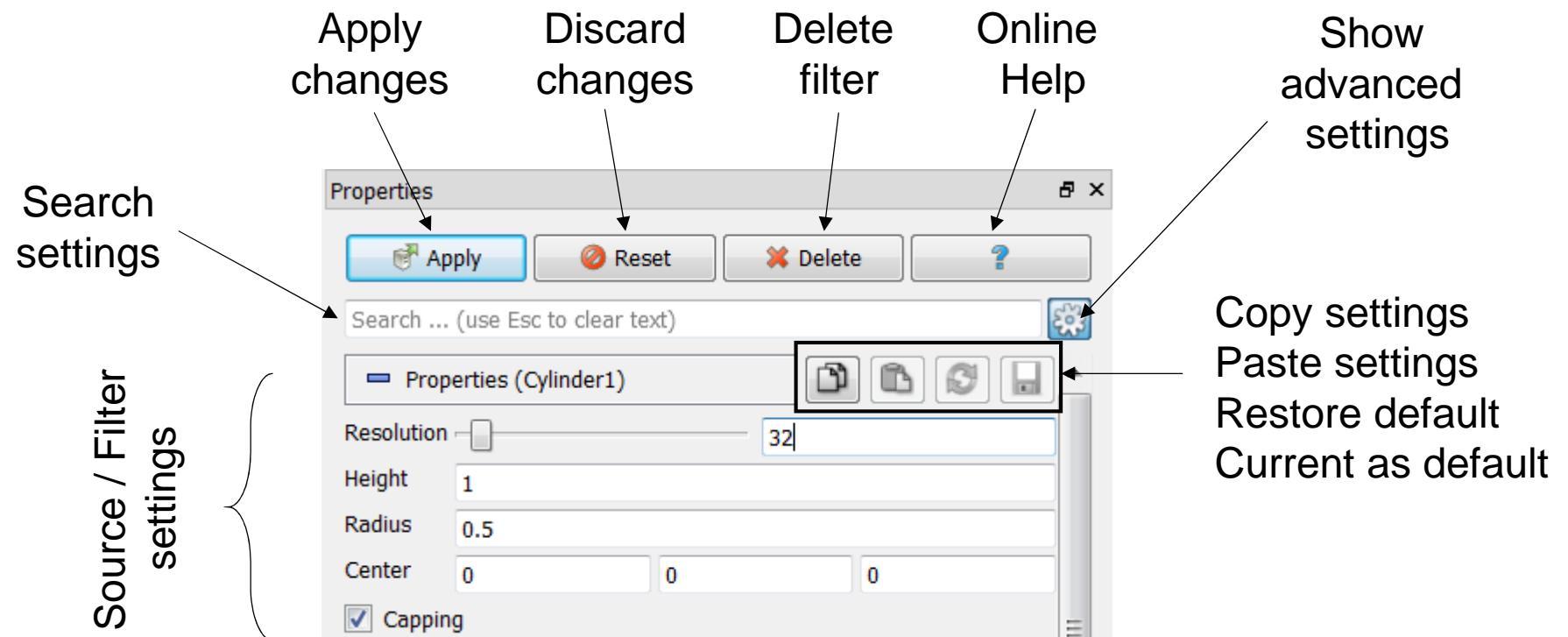
Unstructured Grid
(vtkUnstructuredGrid)

Multi-block

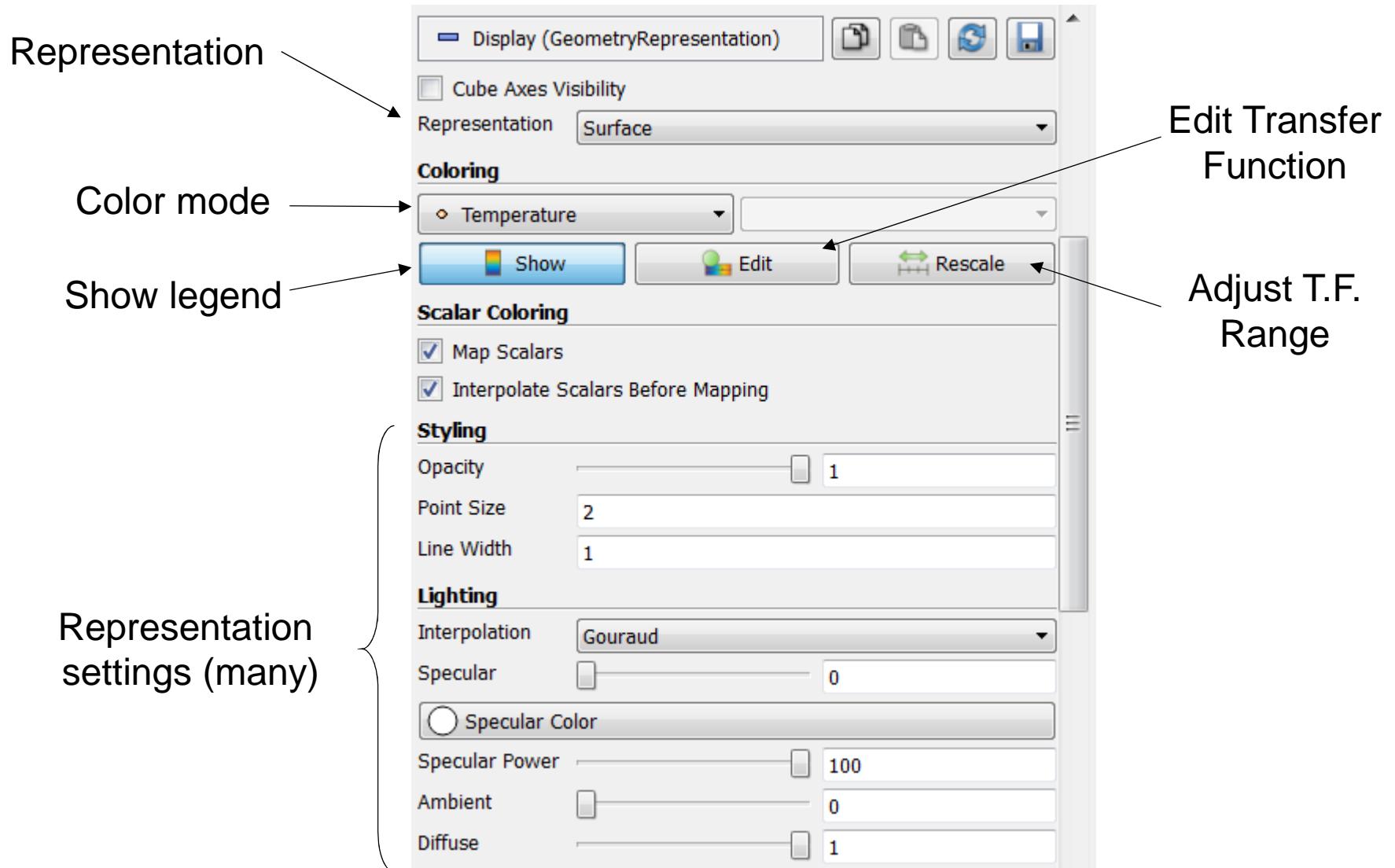
Hierarchical Adaptive
Mesh Refinement
(AMR)

Hierarchical Uniform
AMR
Octree

Properties Panel (1)

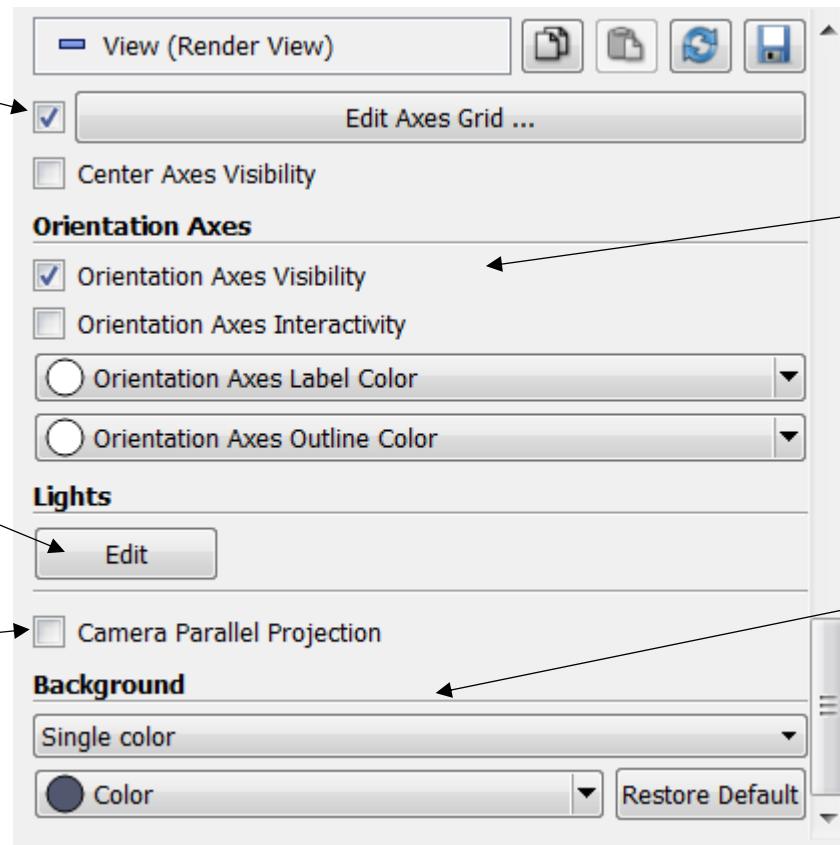


Properties Panel (2)



Properties Panel (3)

Axes w/ ticks
in the scene



Orientation
axes in 3D

Light
settings

Camera
projection

Background
settings

Creating a Cylinder Source

1. Go to the *Source* menu and select *Cylinder*
2. Click the *Apply* button to accept the default parameters.



3. Increase the *Resolution* parameter



4. Click the *Apply* button again

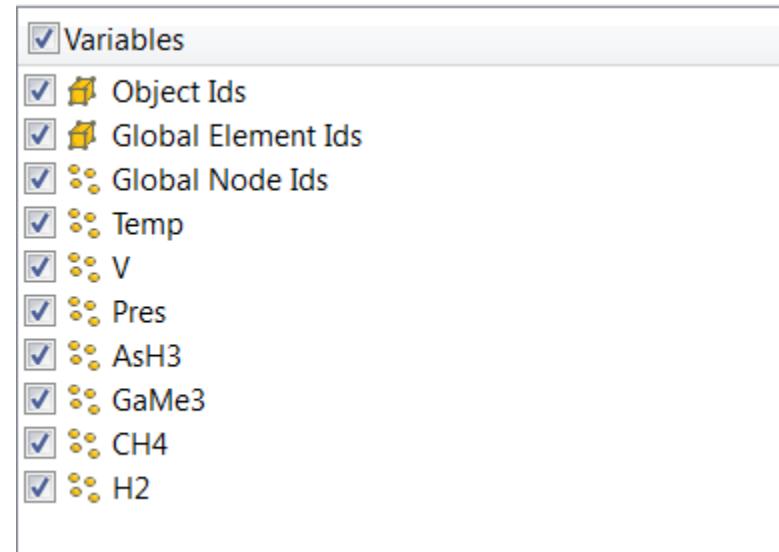


5. Click the Delete button to delete the cylinder



Loading a data file

1. Go to the *File* menu and select *Open*
2. Locate and select the file *disk_out_ref.ex2*
3. In the Properties panel, select the variable arrays to load
4. Click 

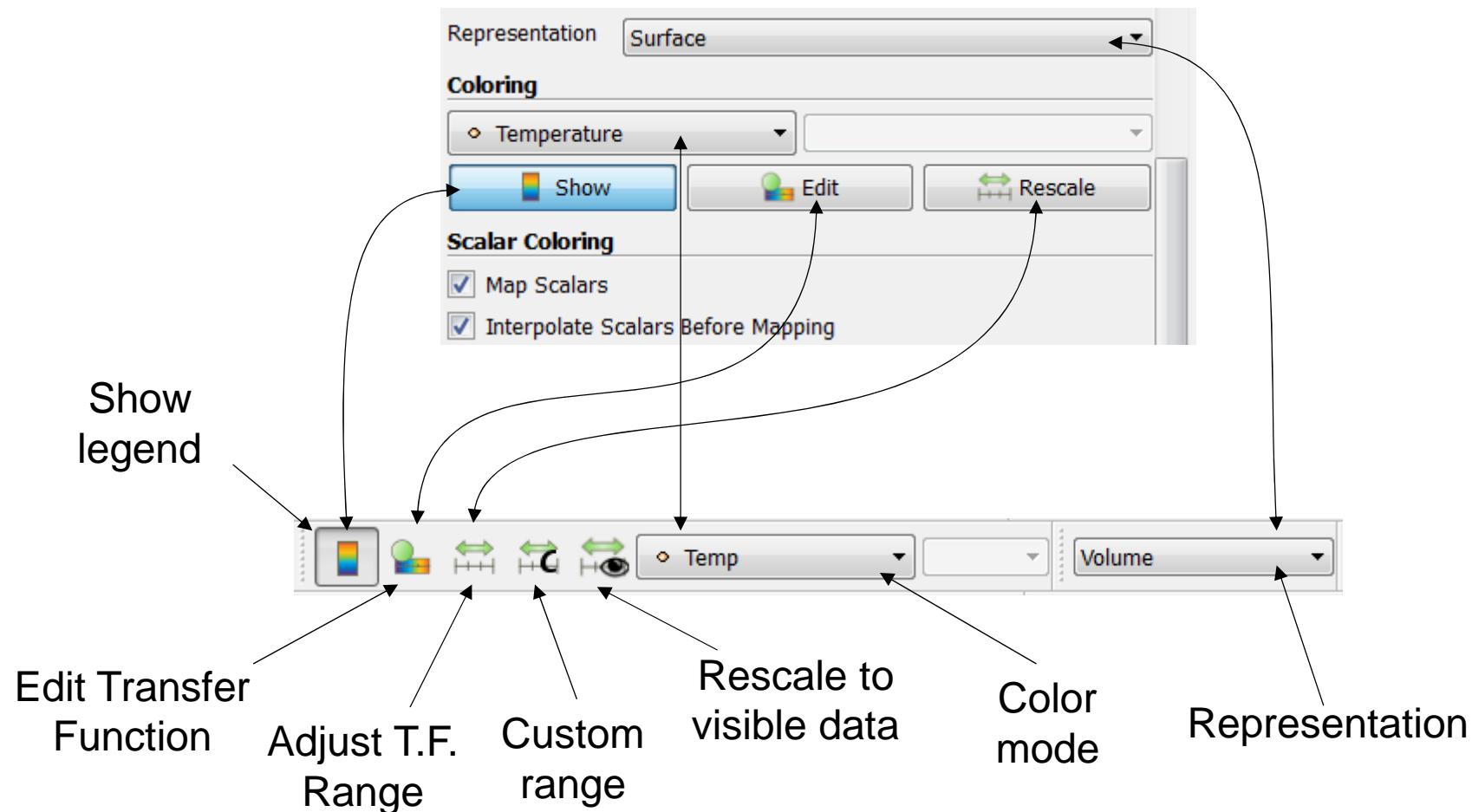


Supported File Types

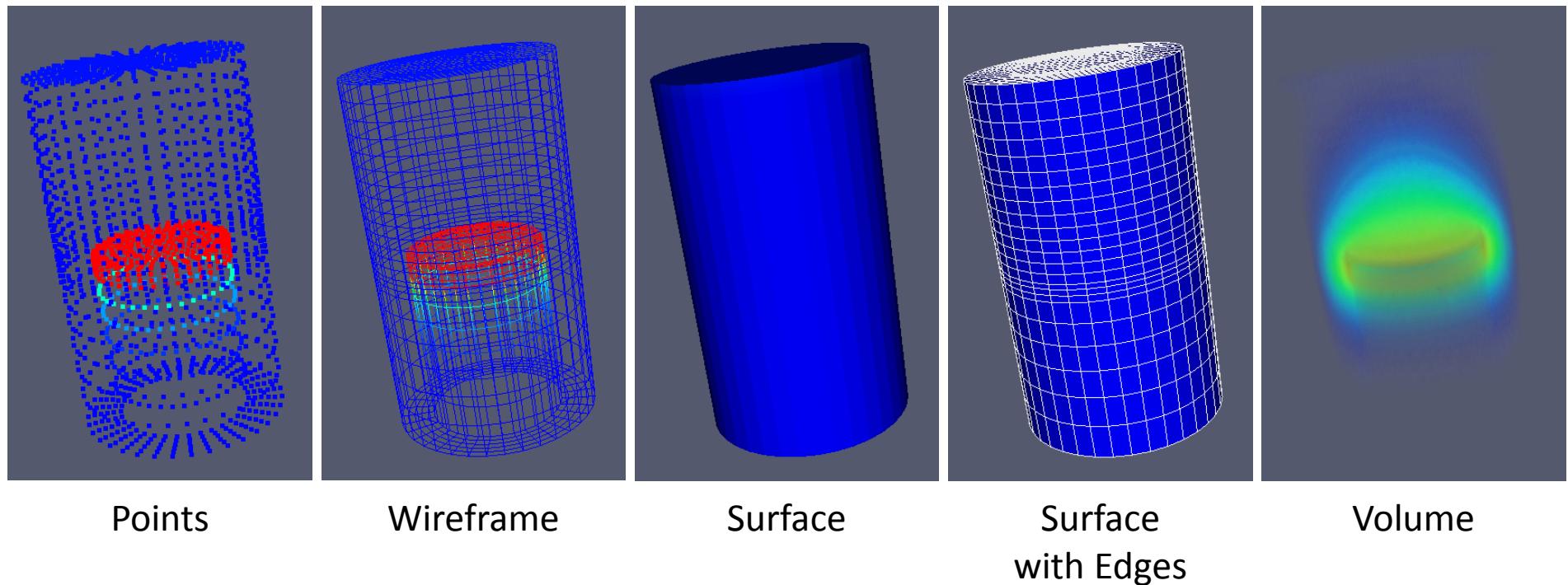
- ParaView Data (.pvda)
- VTK (.vtpl, .vtu, .vti, .vts, .vtr)
- VTK Legacy (.vtk)
- VTK Multi Block (.vtmb,.vtmb,.vtmg,.vthd,.vthb)
- Partitioned VTK (.pvtu, .pvti, .pvtis, .pvtr)
- ADAPT (.nc, .cdf, .elev, .ncd)
- ANALYZE (.img, .hdr)
- ANSYS (.inp)
- AVS UCD (.inp)
- BOV (.bov)
- BYU (.g)
- CAM NetCDF (.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, .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
- Flash multiblock files
- Fluent Case Files (.cas)
- GGCM (.3df, .mer)
- GTC (.h5)
- GULP (.trg)
- Gadget (.gadget)
- Gaussian Cube File (.cube)
- JPEG Image (.jpg, .jpeg)
- LAMMPS Dump (.dump)
- LAMMPS Structure Files
- LODI (.nc, .cdf, .elev, .ncd)
- LODI Particle (.nc, .cdf, .elev, .ncd)
- LS-DYNA (.k, .lsdyna, .d3plot, d3plot)
- M3DCI (.h5)
- MFIX Unstructured Grid (.RES)
- MM5 (.mm5)
- MPAS NetCDF (.nc, .ncdf)
- Meta Image (.mhd, .mha)
- Miranda (.mir, .raw)
- Multilevel 3d Plasma (.m3d, .h5)
- NASTRAN (.nas, .f06)
- Nek5000 Files
- Nrrd Raw Image (.nrrd, .nhdr)
- 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 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)
- Spherical (.spherical, .sv)
- SpyPlot CTH
- SpyPlot (.case)
- SpyPlot History (.hscth)
- 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 (.xmlf, .xdmf)
- XMol Molecule

Geometry Representations

Properties panel VS Representation toolbar



Geometry Representations



Simple Camera Manipulation

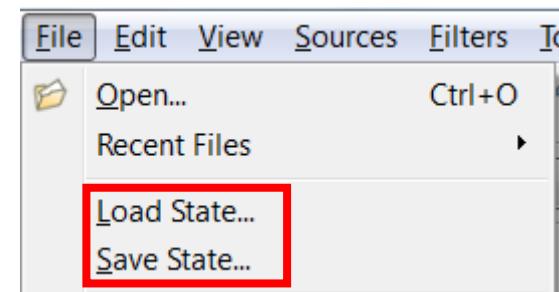
- Drag left, middle, right buttons for rotate, pan, zoom
 - Additional options with Shift, Ctrl, Alt modifiers
 - If no middle button, use Shift + right button



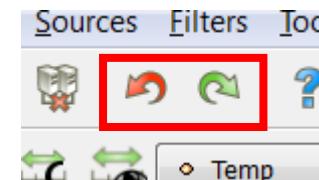
- Save screenshots
 - File -> Save screenshot ... (export as an image)
 - File -> Export scene ... (depends on the view)

Keep in mind

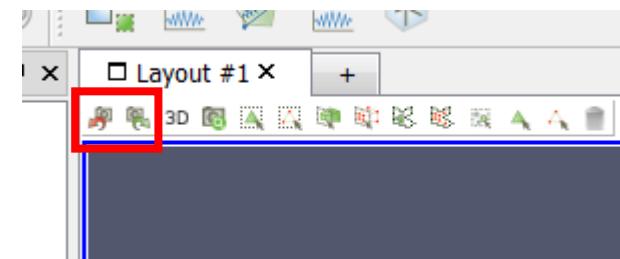
- You can save/load your settings and pipeline



- You can undo/redo operations

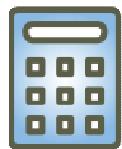


- You can undo/redo camera movements



Data Filtering

Common Filters



Calculator



Contour



Clip



Slice



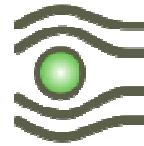
Threshold



Extract Subset



Glyph



Stream Tracer



Warp (vector)

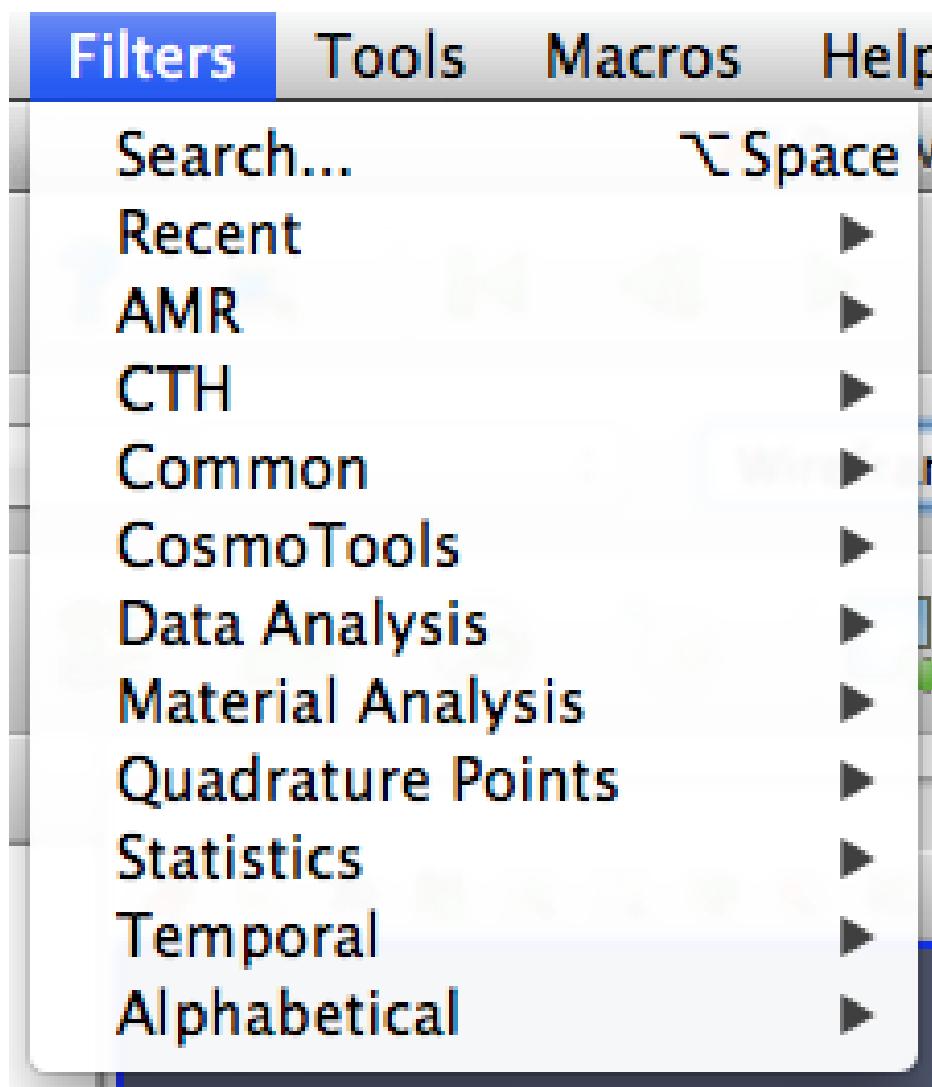


Group Datasets



Extract Level

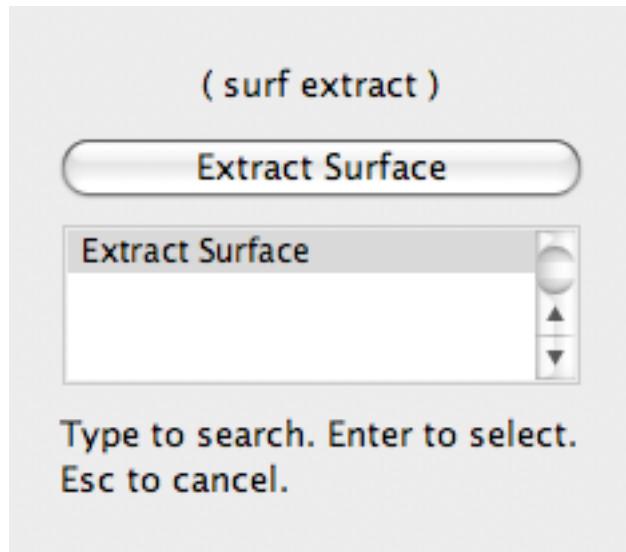
Filters Menu



Filters Menu

Filters	Tools	Catalyst	Macros	H
Search... Ctrl+Space				
Recent				
AMR				
Annotation				
CTH				
Common				
Data Analysis				
Material Analysis				
Quadrature Points				
Statistics				
Temporal				
Alphabetical				
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				
Compute Quartiles				
Connectivity				
Contingency Statistics				
Contour				
Contour Generic Dataset				
Convert AMR dataset to Multi-block				
Curvature				
D3				
Decimate				
Delaunay 2D				
Delaunay 3D				
Descriptive Statistics				
Elevation				
Environment Annotation				
Extract AMR Blocks				
Extract Bag Plots				
Extract Block				
Extract CTH Parts				
Extract Cells By Region				
AMR Connectivity				
AMR Contour				
AMR CutPlane				
AMR Dual Clip				
AMR Fragment Integration				
AMR Fragments Filter				
Add Field Arrays				
Angular Periodic Filter				
Annotate Attribute Data				
Annotate Global Data				
Annotate Time Filter				
Append Attributes				
Append Datasets				
Append Geometry				
Glyph				
Glyph With Custom Source				
Gradient				
Gradient Of Unstructured DataSet				
Grid Connectivity				
Group Datasets				
Histogram				
Image Data To AMR				
Image Data to Point Set				
ImageResampling				
Integrate Variables				
Interpolate to Quadrature Points				
Intersect Fragments				
Iso Volume				
K Means				
Legacy Glyph				
Level Scalars(Non-Overlapping AMR)				
Level Scalars(Overlapping AMR)				
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				
ParticlePath				
ParticleTracer				
Pass Arrays				
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 Id Scalars				
Programmable Filter				
Python Annotation				
Python Calculator				
Quadric Clustering				
Random Attributes				
Random Vectors				
Rectilinear Data to Point Set				
Rectilinear Grid Connectivity				
Reflect				
Resample AMR				
Resample With Dataset				
Ribbon				
Rotational Extrusion				
Scatter Plot				
Shrink				
Slice				
Slice (demand-driven-composite)				
Slice AMR data				
Slice Along PolyLine				
Slice Generic Dataset				
Smooth				
StreakLine				
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 Particles To Pathlines				
Temporal Shift Scale				
Temporal Snap-to-Time-Step				
Temporal Statistics				
Tensor Glyph				
Tessellate				
Tetrahedralize				
Texture Map to Cylinder				
Texture Map to Plane				
Texture Map to Sphere				
Threshold				
Transform				
Transpose Table				
Triangle Strips				
Triangulate				
Tube				
Warp By Scalar				
Warp By Vector				
Youngs Material Interface				

Quick Launch



- Used for searching for filters by name
- Keyboard shortcut
 - Ctrl-space (Windows & Linux)
 - Alt-space (Apple)

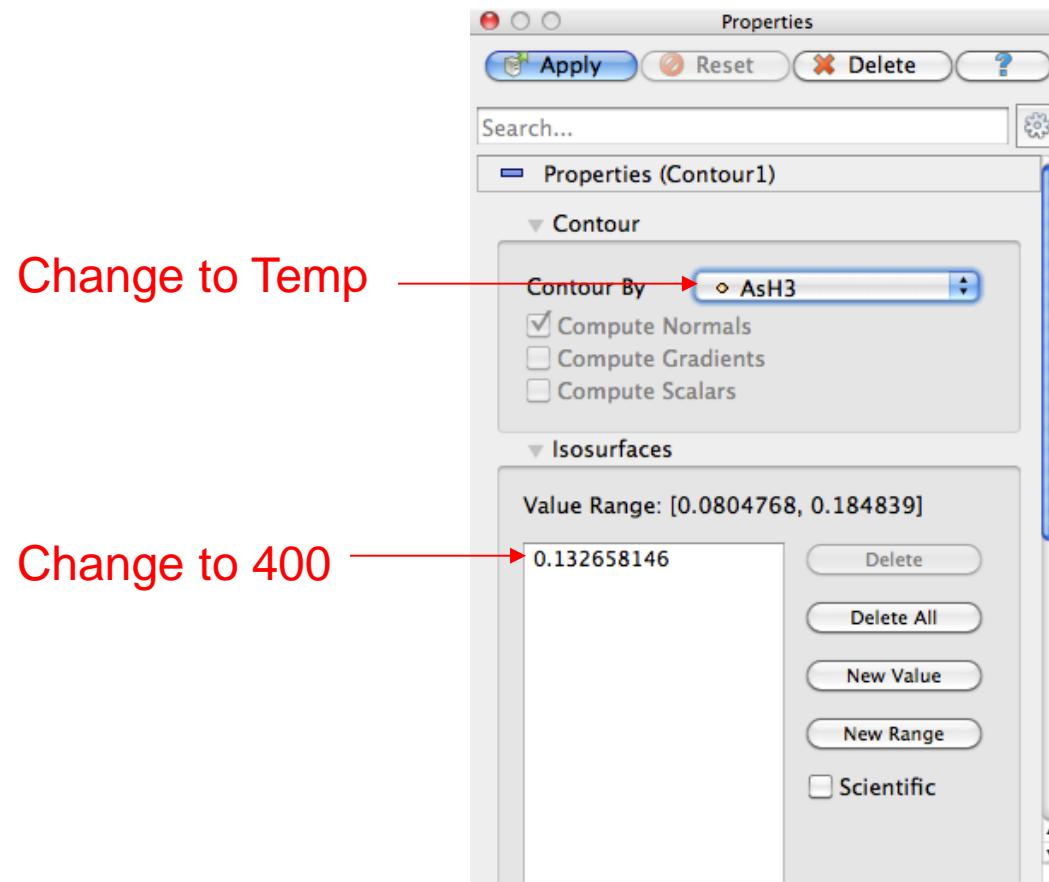
Apply a Filter

1. Make sure that disk_out_ref.ex2 is selected in the pipeline browser.
2. Select the contour filter.



Apply a Filter

3. Change parameters to create an isosurface at Temp = 400K.



Apply a Filter

1. Make sure that disk_out_ref.ex2 is selected in the pipeline browser.
2. Select the contour filter.
3. Change parameters to create an isosurface at Temp = 400K.
4.  Apply



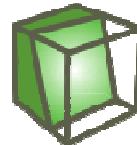
Create a Cutaway Surface

1. Select disk_out_ref.ex2 in the pipeline browser.
2. From the quick launch, select Extract Surface.

3.



4. Create a Clip filter.



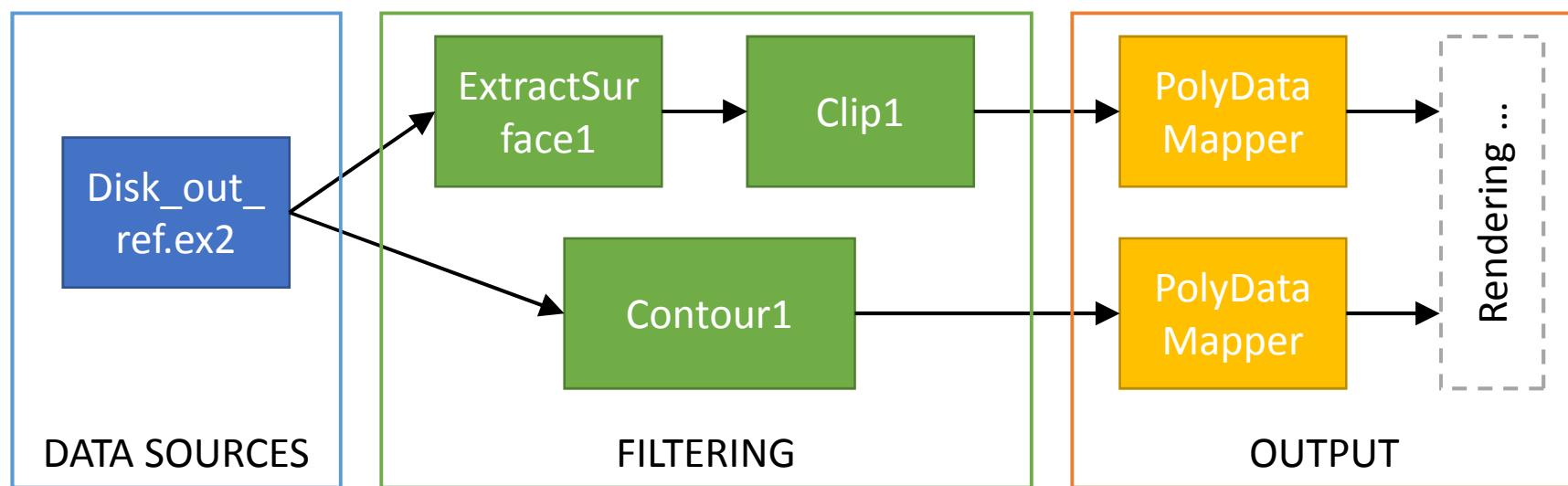
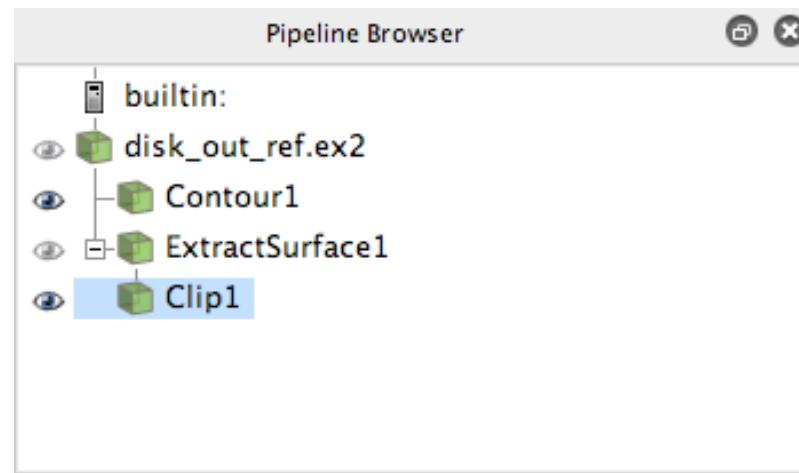
5. Uncheck Show Plane.



6.

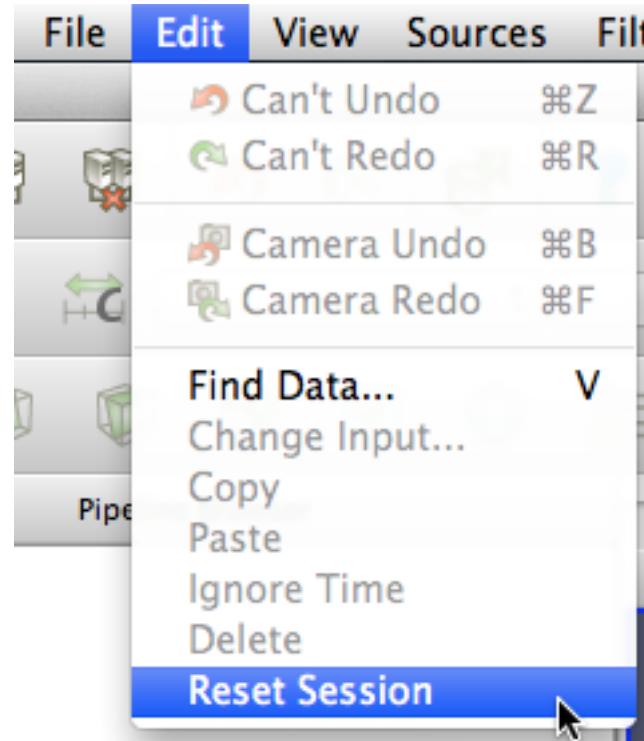


Pipeline Browser Structure

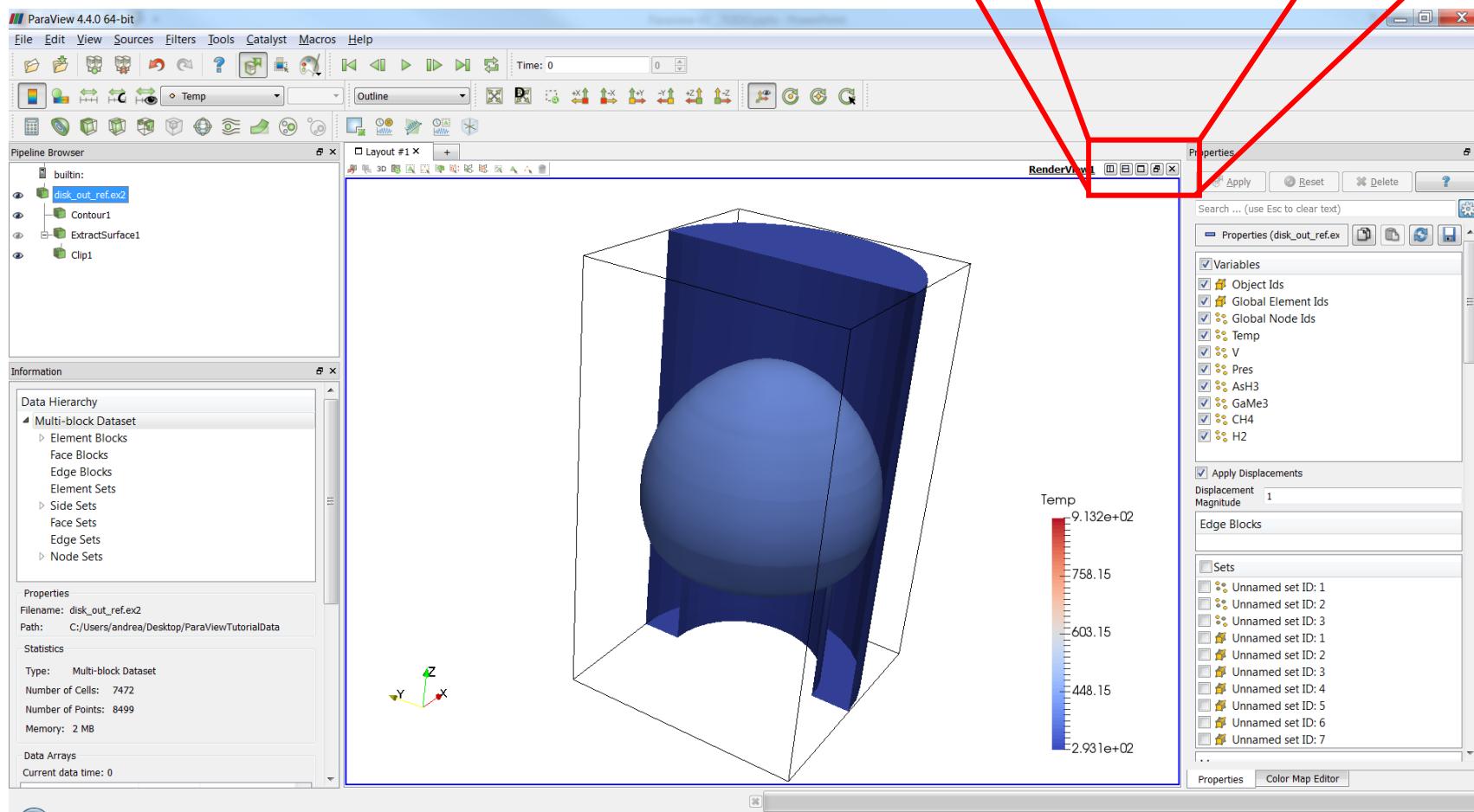


Reset ParaView

Edit → Reset Session



Multiview

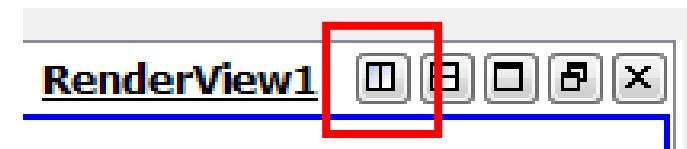


Multiview

1. Open disk_out_ref.ex2 (all variables)
2. Add a Clip Filter 
3. 
4. Uncheck Show Plane. Show Plane
5. Color surface by Pres.
6. 

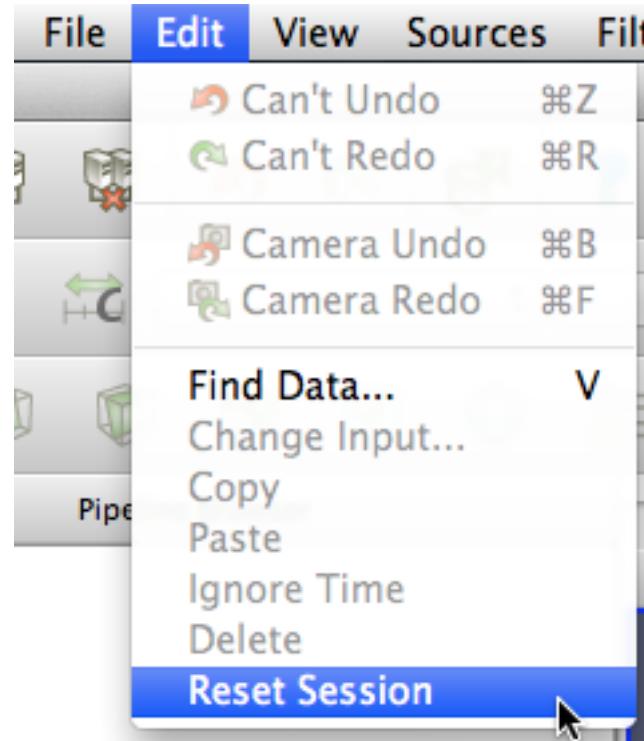
Multiview

6. Split the view horizontally
7. Make Clip1 visible
8. Color surface by Temp
9. Right-click view, Link Camera...
10. Click other view
11. Modify a view, changes are applied to both
12. Swap views dragging them with the mouse



Reset ParaView

Edit → Reset Session



Streamlines

1. Open disk_out_ref.ex2 (all variables)

2. Add Stream Tracer



3.  Apply

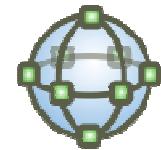
4. From the quick launch, select Tube



5.  Apply

Improve Streamlines

6. Select StreamTracer1
7. Add a Glyph filter
8. Change Vectors to V
9. Change Glyph Type to Cone
10.  Apply

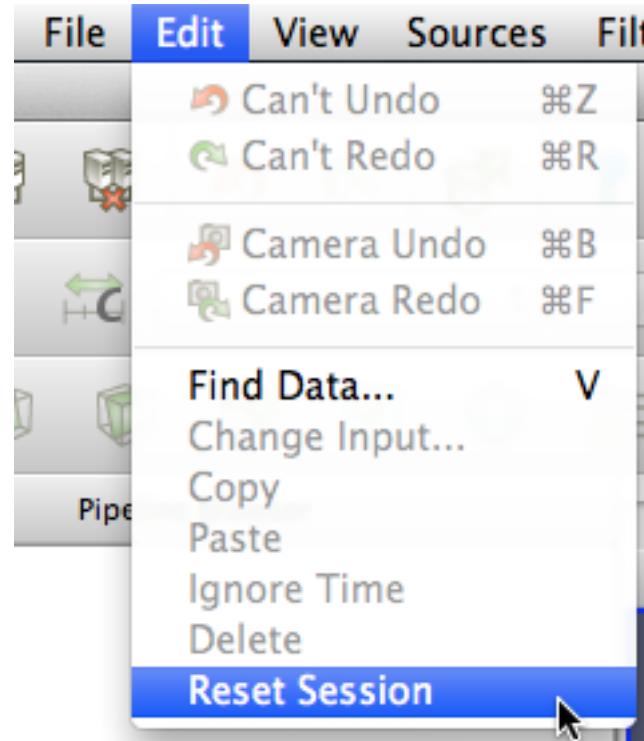


Getting Answers

- Where is the air moving the fastest? Near the disk or away from it? At the center of the disk or near its edges?
- Which way is the plate spinning?
- At the surface of the disk, is air moving toward the center or away from it?

Reset ParaView

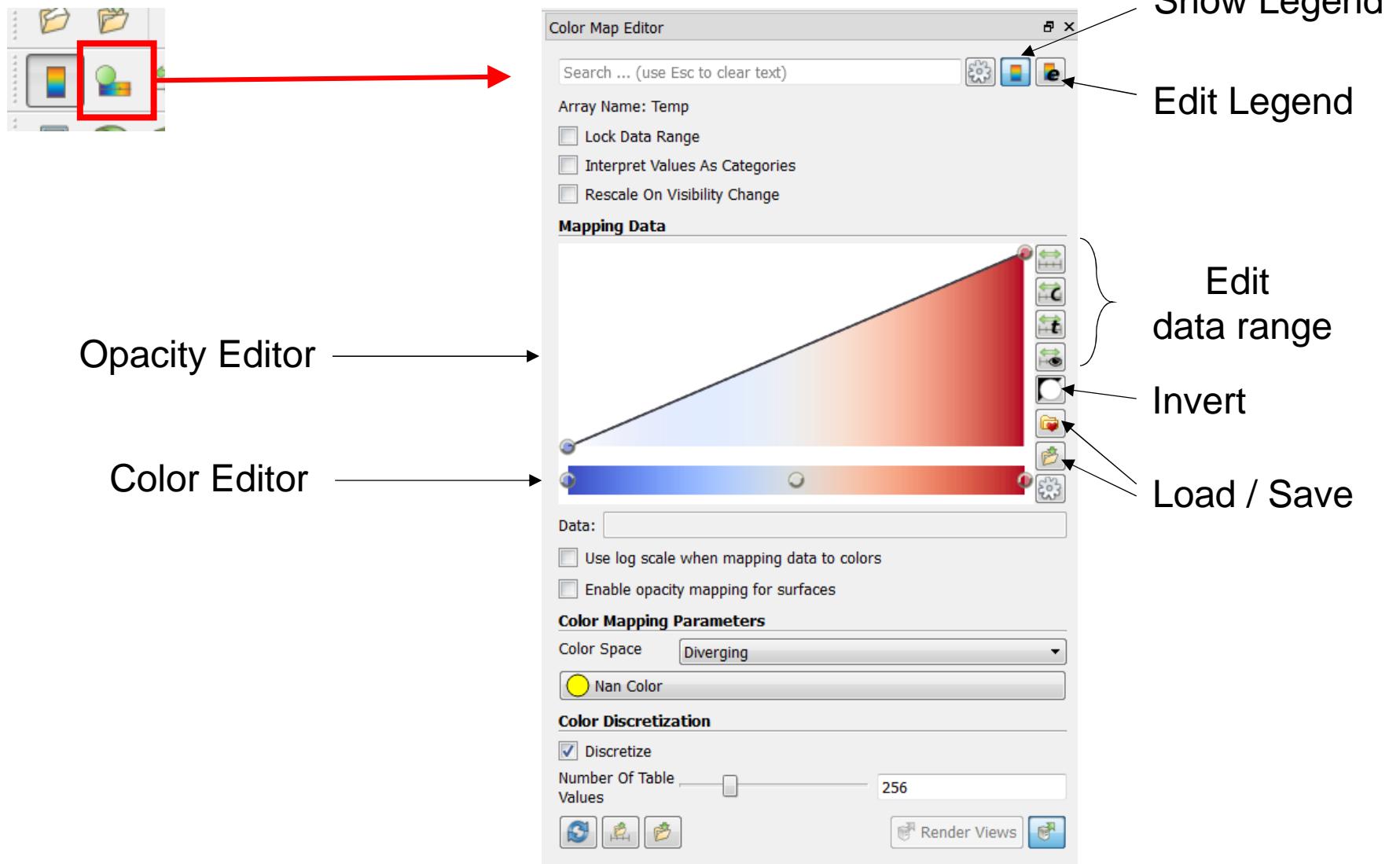
Edit → Reset Session



Volume Rendering + Surface Geometry

1. Open `disk_out_ref.ex2` (all variables)
2. Add an Extract Surface and a Clip filter 
3. Select `disk_out_ref.ex2`
4. Change variable viewed to Temp
5. Change representation to Volume

Transfer Function Editor

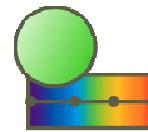


Transfer Function Editor

- Opacity Editor
 - Left click: add/move control point
 - Left double click: edit slope
 - Right click: select (can move together)
 - Mouse wheel: zoom
- Color Editor
 - Left click: add/move control point
 - Left double click: edit color
 - Mouse wheel: zoom

Modify Transfer Function

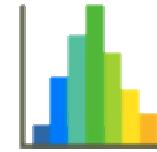
1. Select disk_out_ref.ex2
2. Click Edit Color Map
3. Click Choose preset
4. Select Black-Body Radiation
5. Try adding and changing control points



If you see nothing, try changing the Volume Rendering Mode parameter!

Histograms

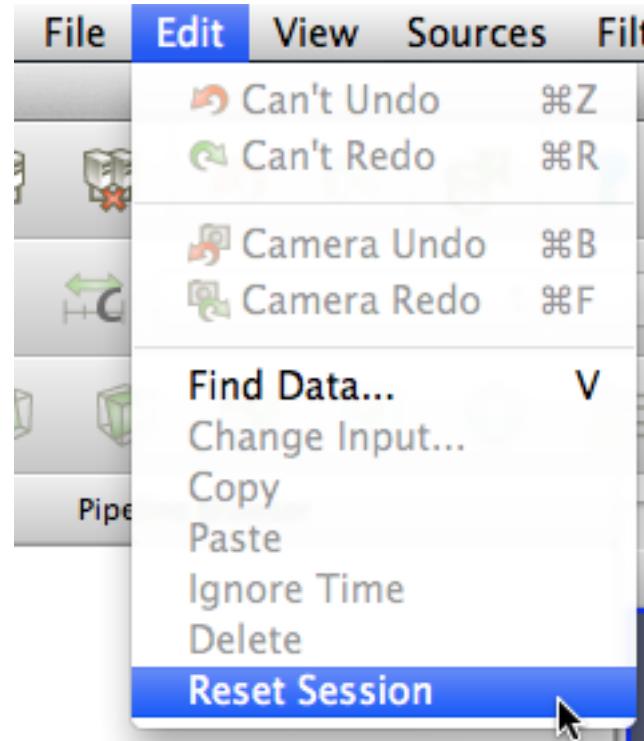
1. Select `disk_out_ref.ex2`
2. Add a **Histogram** filter
3. Change variable to Temp
4. Set Bin count to 32



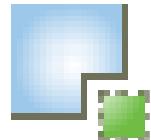
The histogram can be useful for setting up the Transfer Function for volume rendering

Reset ParaView

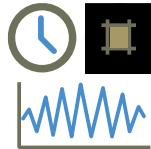
Edit → Reset Session



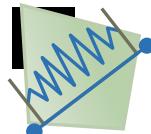
Common Data Analysis Filters



Extract Selection



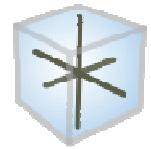
Plot Global Variables Over Time



Plot Over Line



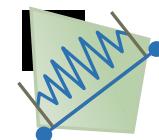
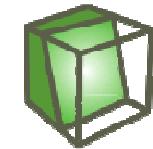
Plot Selection Over Time



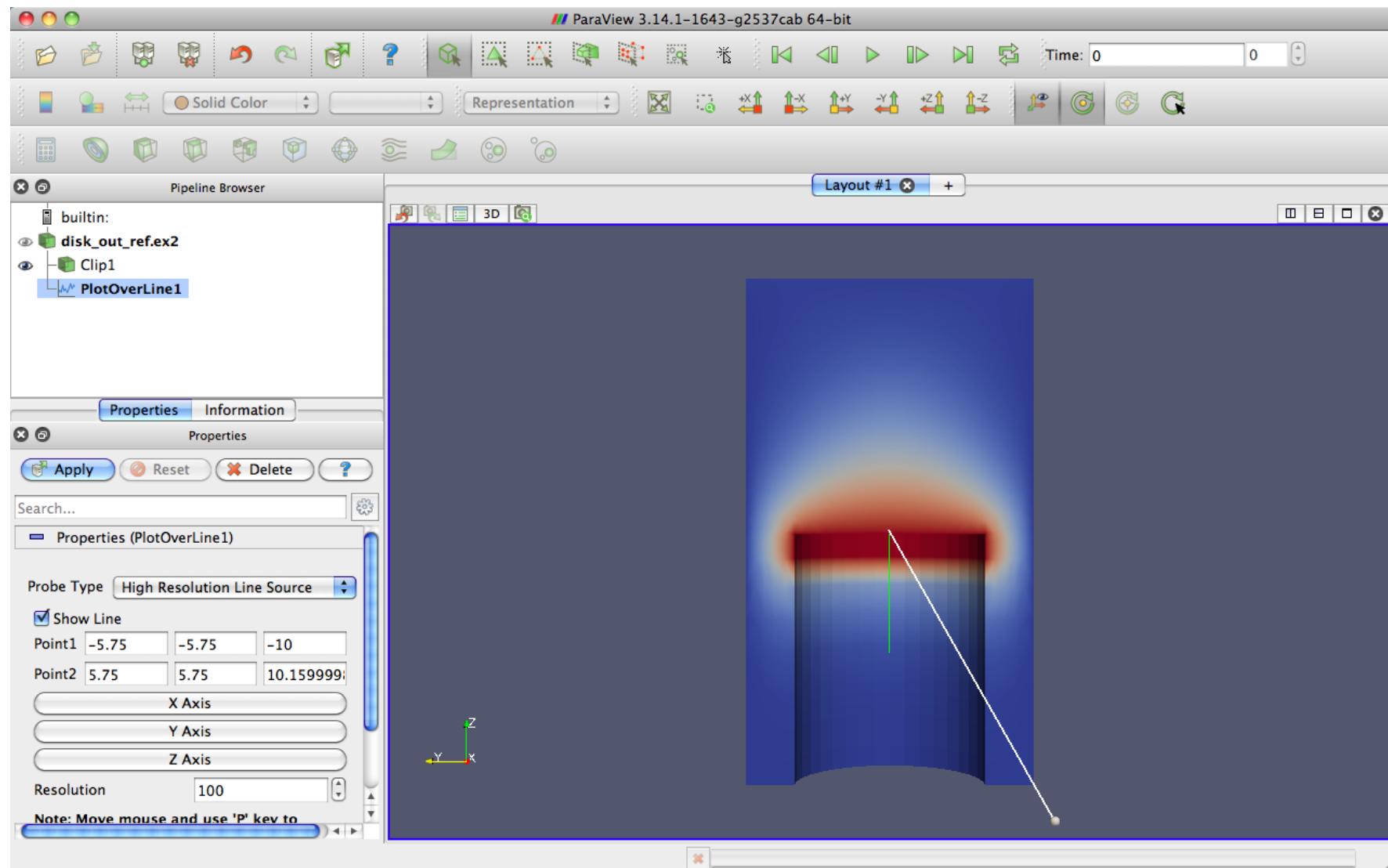
Probe Location

Plotting

1. Open disk_out_ref.ex2 (all variables)
2. Add a Clip Filter
3. Uncheck Show Plane
4. Select disk_out_ref.ex2
5. Add Plot Over Line filter.



3D Widgets



Interacting with Plots

- Left, middle, right buttons to pan and zoom.
- Mouse wheel to zoom
- Reset view to plot ranges



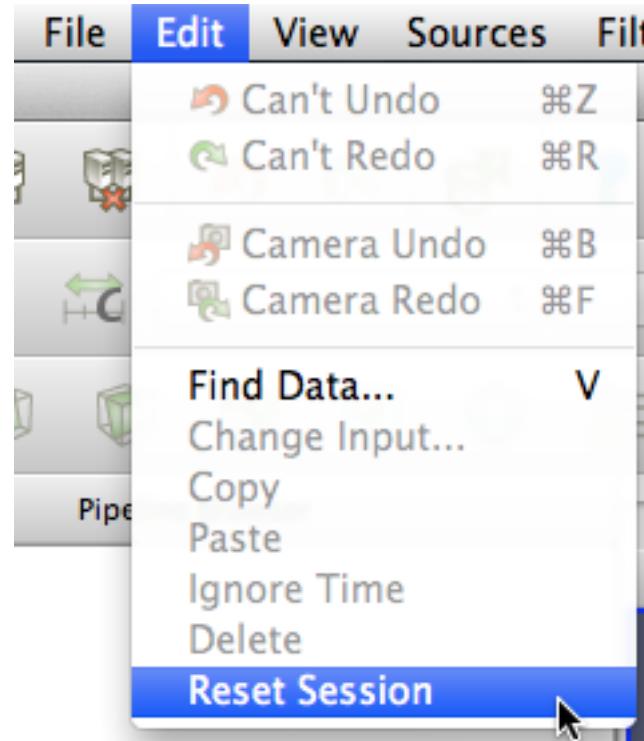
- Plots are views, they can be dragged around

Adjusting Plots

- Different attributes can have different orders of magnitude
1. In Display section of properties panel, turn off all variables except Temp and Pres
 - Pres will be too small to be visualized
 2. Select Pres in the Display options
 3. Change Chart Axis to Bottom – Right.

Reset ParaView

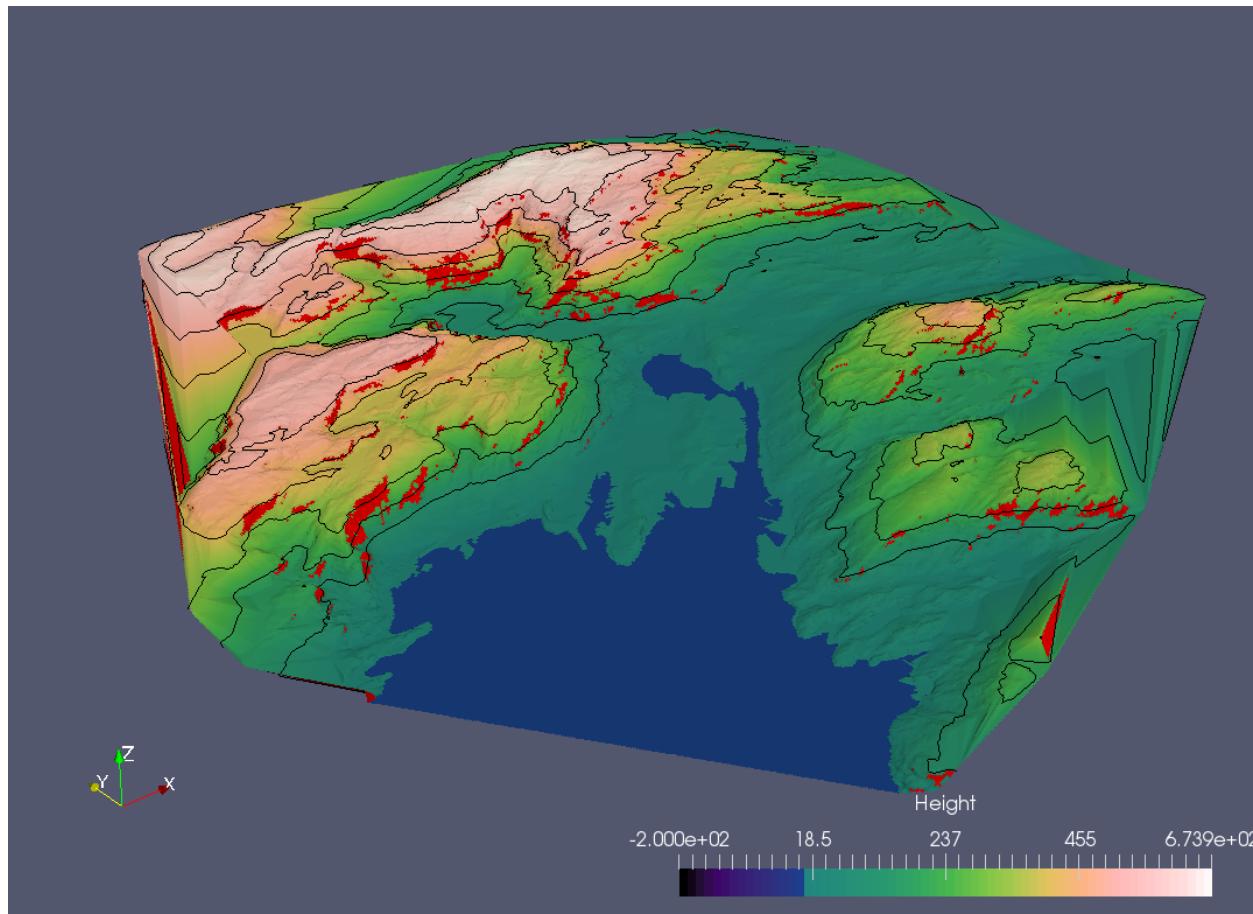
Edit → Reset Session



Exercises

- Exercise 1
 - Load Bergen terrain dataset
 - Remove invalid data (Height = -9999)
 - Make it 3D using the Height data
 - Set a suitable color map
 - Display height curves every 100m
 - Display in red the steepest regions
- Suggested filters: Calculator, Contour, Extract Subset, Gradient (or Gradient of Unstr. Grid), Histogram (use custom bin range), Threshold, Warp by Scalar

Exercises



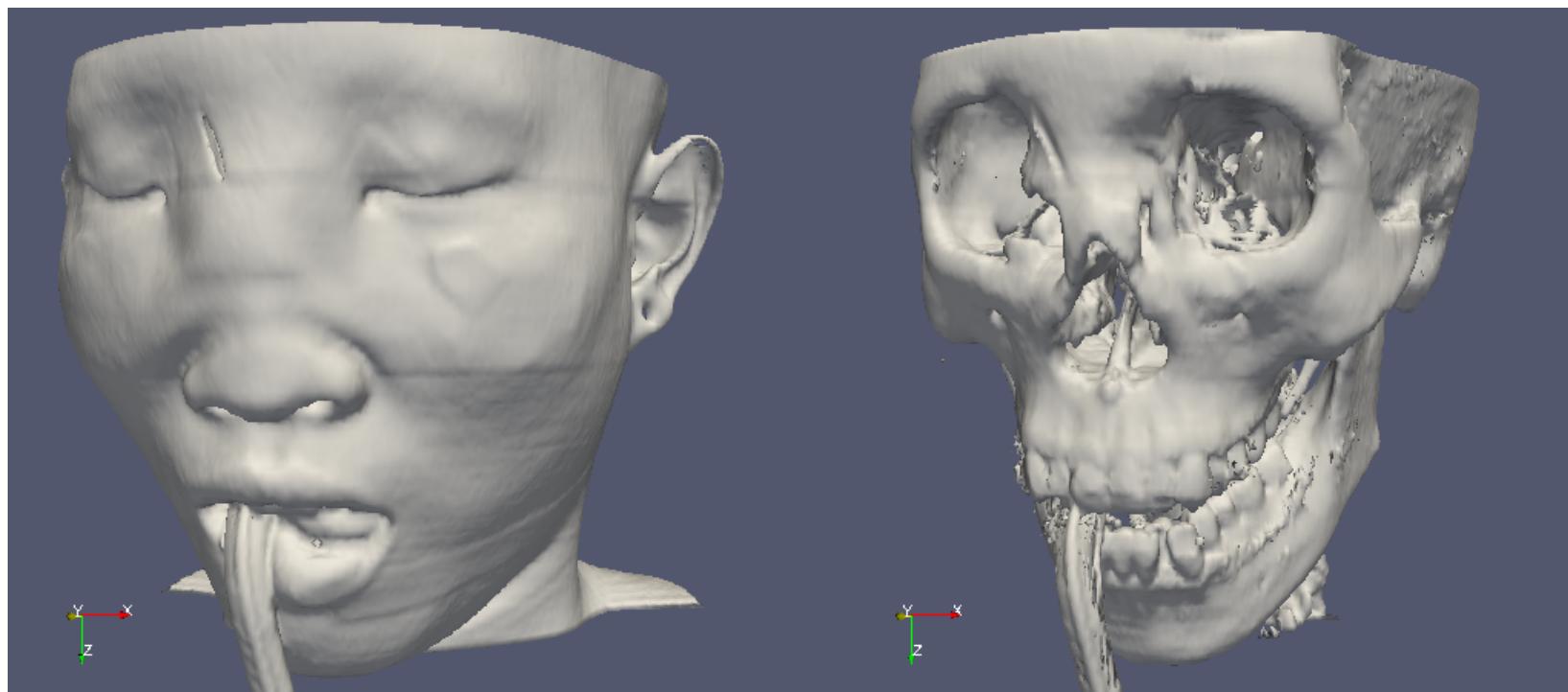
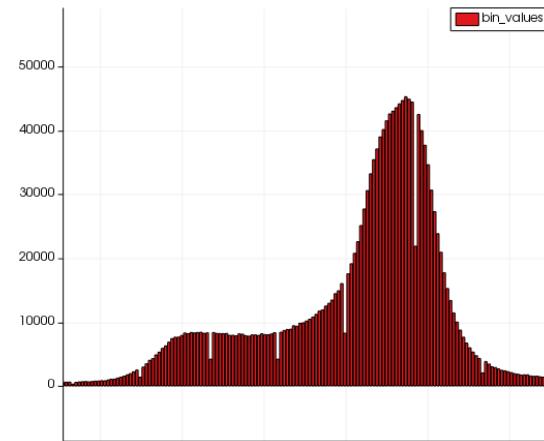
Exercises

- Exercise 1 - Bonus
 - Show a tree every 20 pixel on terrain between 200m and 400m
 - Show tangent curves of the gradient vector field, at a suitable resolution
 - Use various sources, Append Geometry, Extract Subset, Glyph with Custom Source, Stream tracer with Custom Source, Threshold, Warp by Scalar, ...

Exercises

- Exercise 2
 - Load headsq.vti
 - Find data values associated with tissue types
 - In multiple views and multiple layouts, show
 - A stack of slices
 - A surface representing the skin, and one for the skull
 - A volume emphasizing high values of gradient magnitude
 - A volume showing what's wrong with this guy
 - In a new layout
 - Highlight what you have found
 - Plot values across the interesting area
 - Create a slice through the interesting area
 - Use Contour, Histogram, Probe, Polyline, Slice, etc.

Exercises



Exercises

