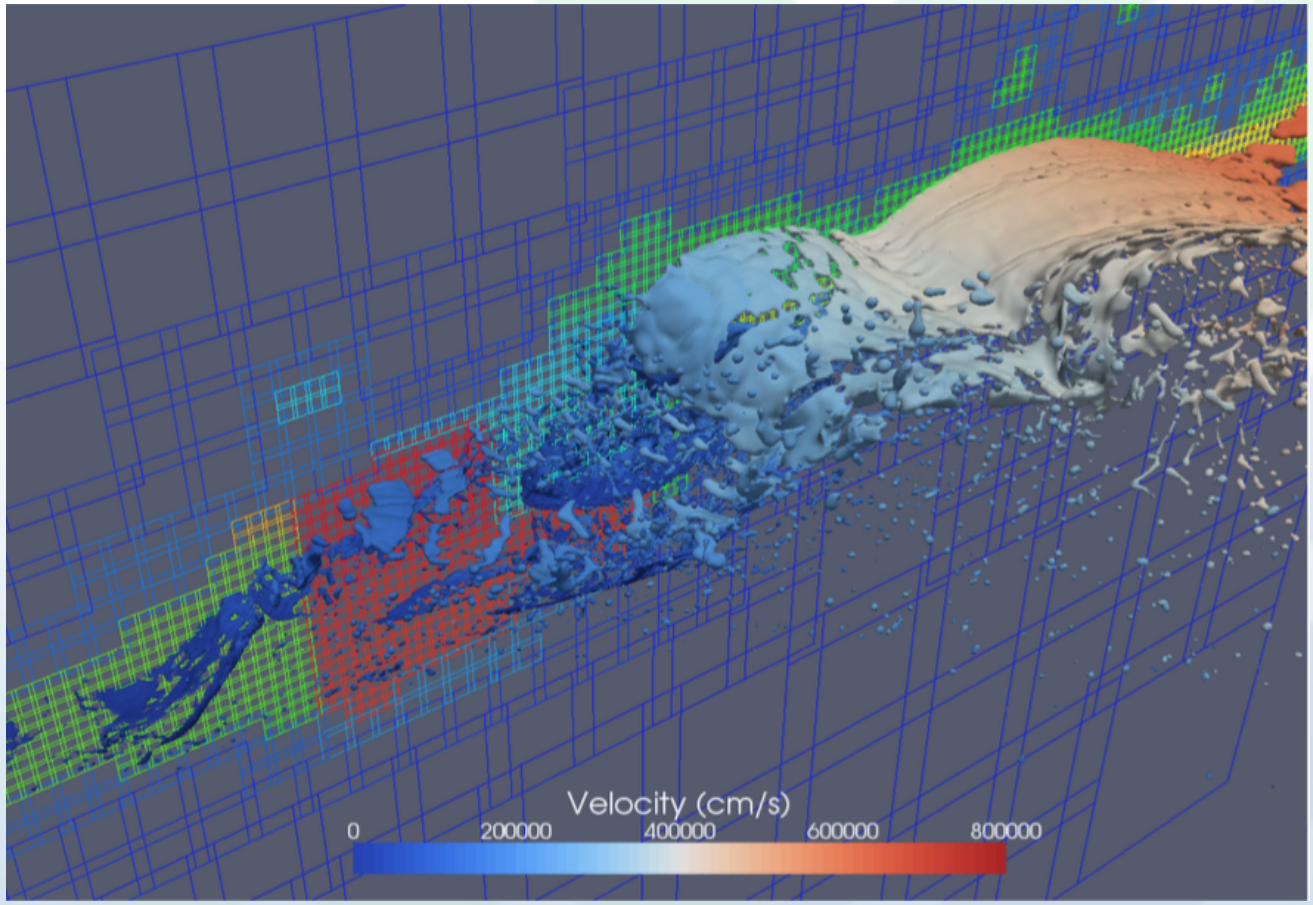
Large Scale Visualization with ParaView

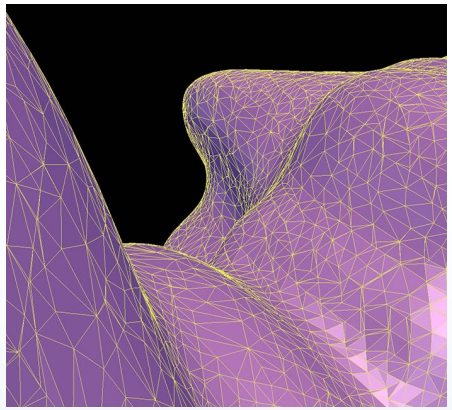
Dan Lipsa
Staff R&D Engineer



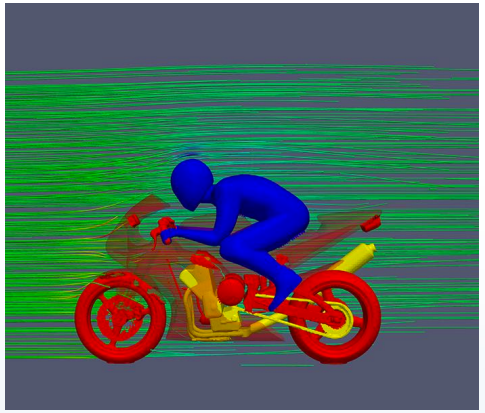
CTH Simulation with billions of cells visualized with ParaView. ParaView Tutorial.

Kitware

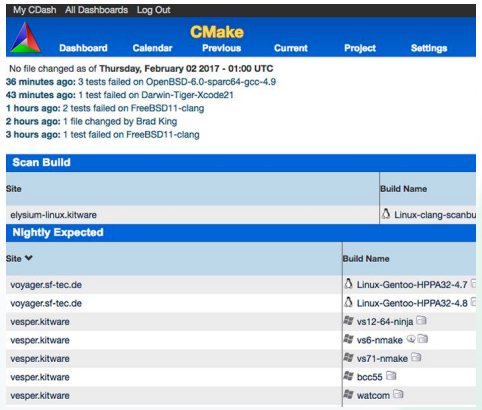
Kitware Inc.



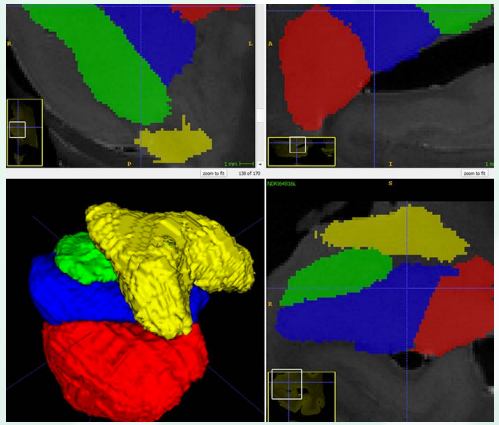
VTK



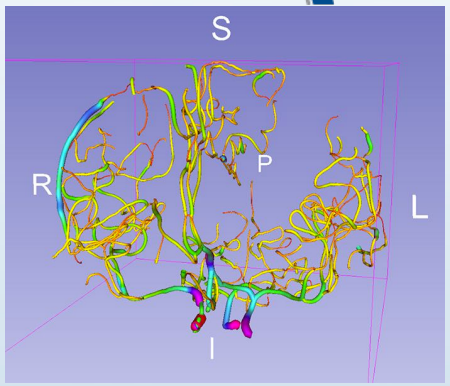
ParaView



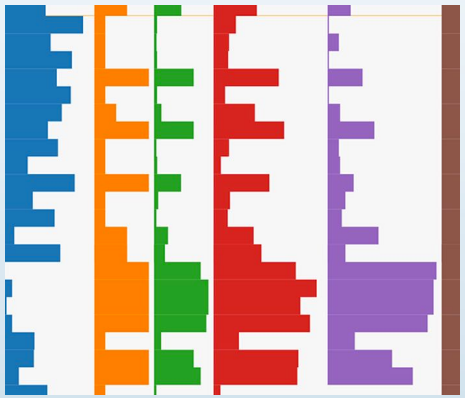
CMake



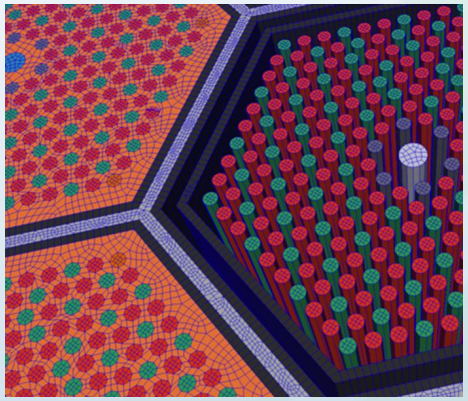
itk



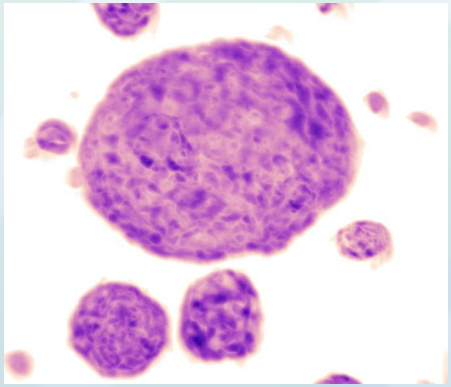
3DSlicer



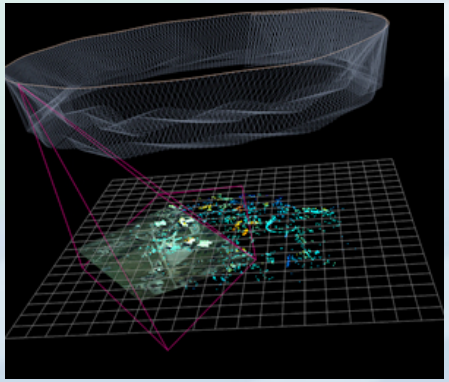
Resonant



CMB



tomviz



KWIVER

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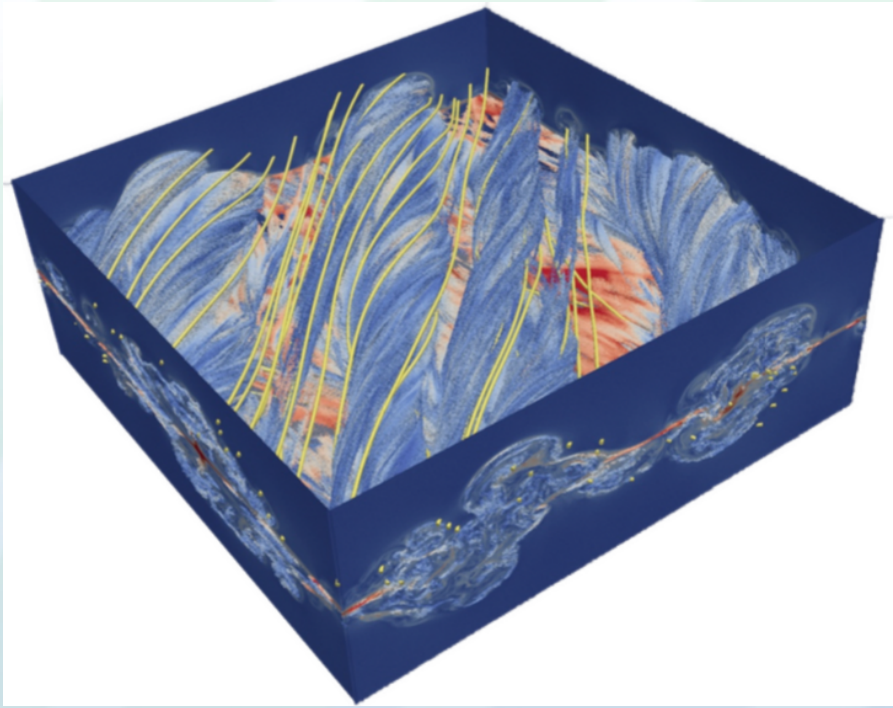
Contents

- What is ParaView?
- User interface: the Pipeline Browser and the Object Inspector: Filters, Representations and Views. Finding Data and Selection.
- Running ParaView in parallel.
- ParaView Tutorial: Ex 2.1-2.xx

Install ParaView 5.4.0
Windows: Install PuTTY
Mac OS: Install XQuartz



VPIC simulation with 3.3 billion structured cells. Image courtesy of Bill Daughton, LANL

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What is ParaView?

An **open-source application** and **framework** for **display** and **analysis** of scientific datasets.

Record setting in-situ simulation run: First in-situ run to exceed one million MPI processes.

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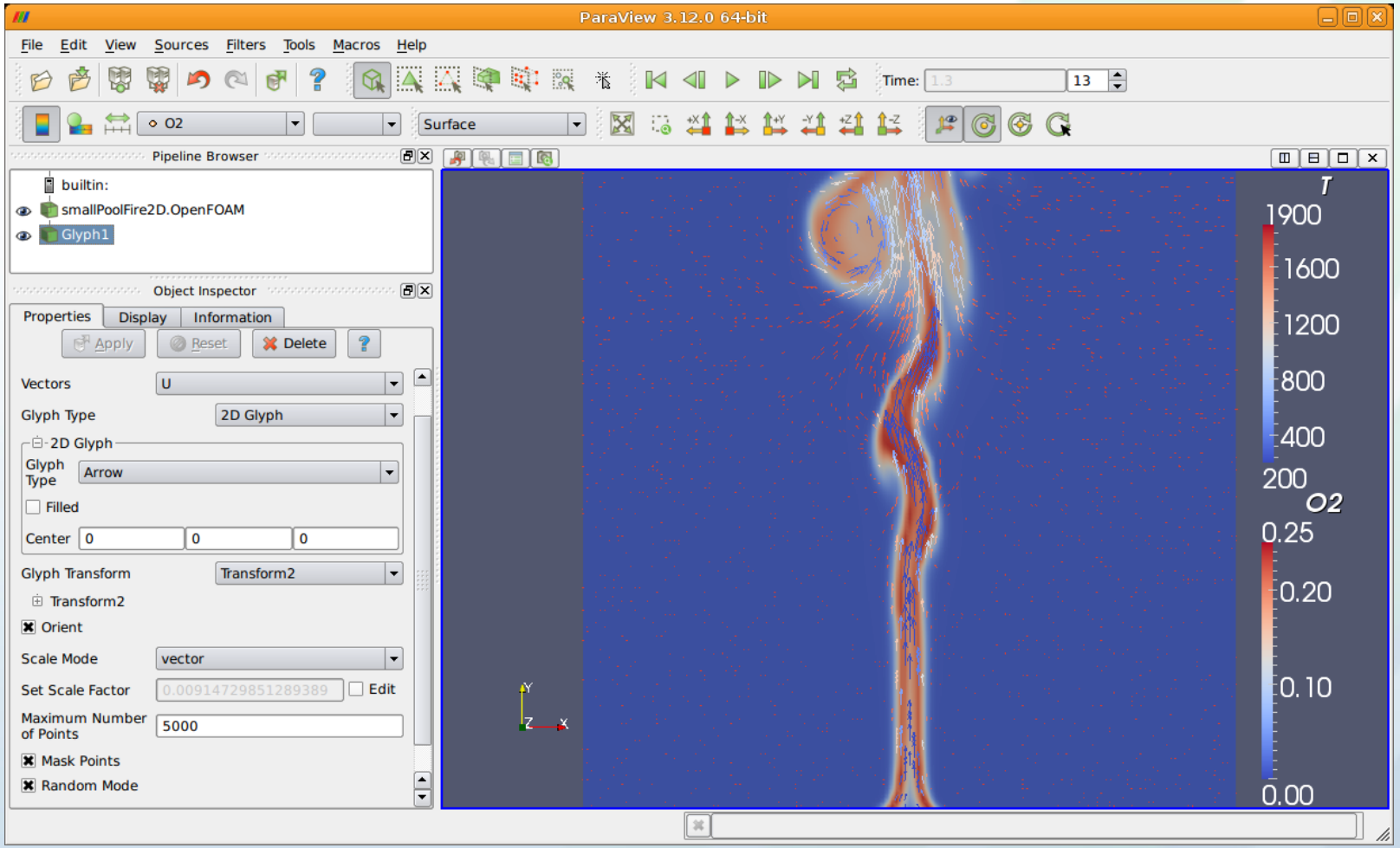
ParaView on the Desktop



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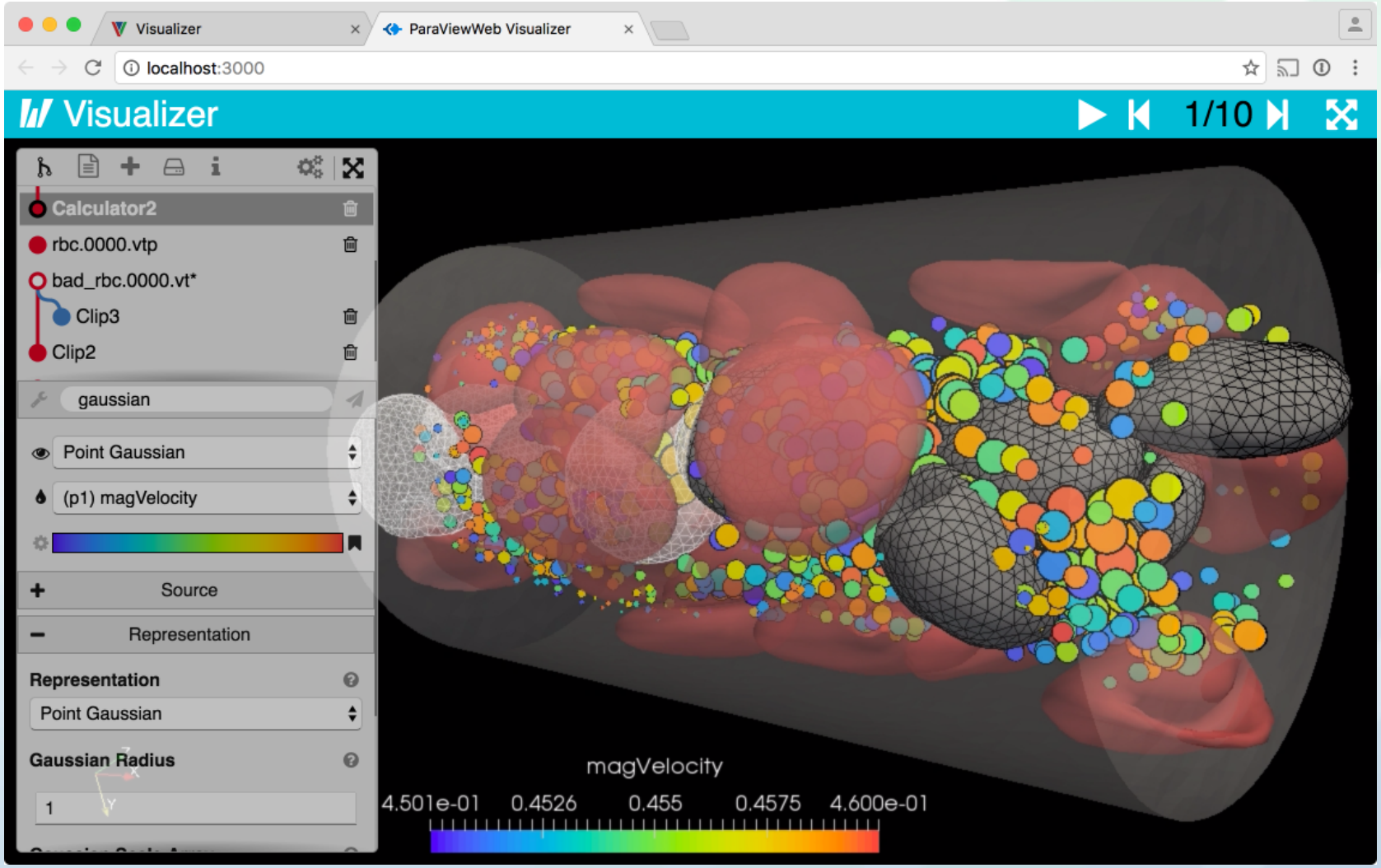
ParaView on the Web



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ParaView Scripting - Python

Python scripts can control ParaView with or without the GUI in order to create reproducible and customizable visualizations.

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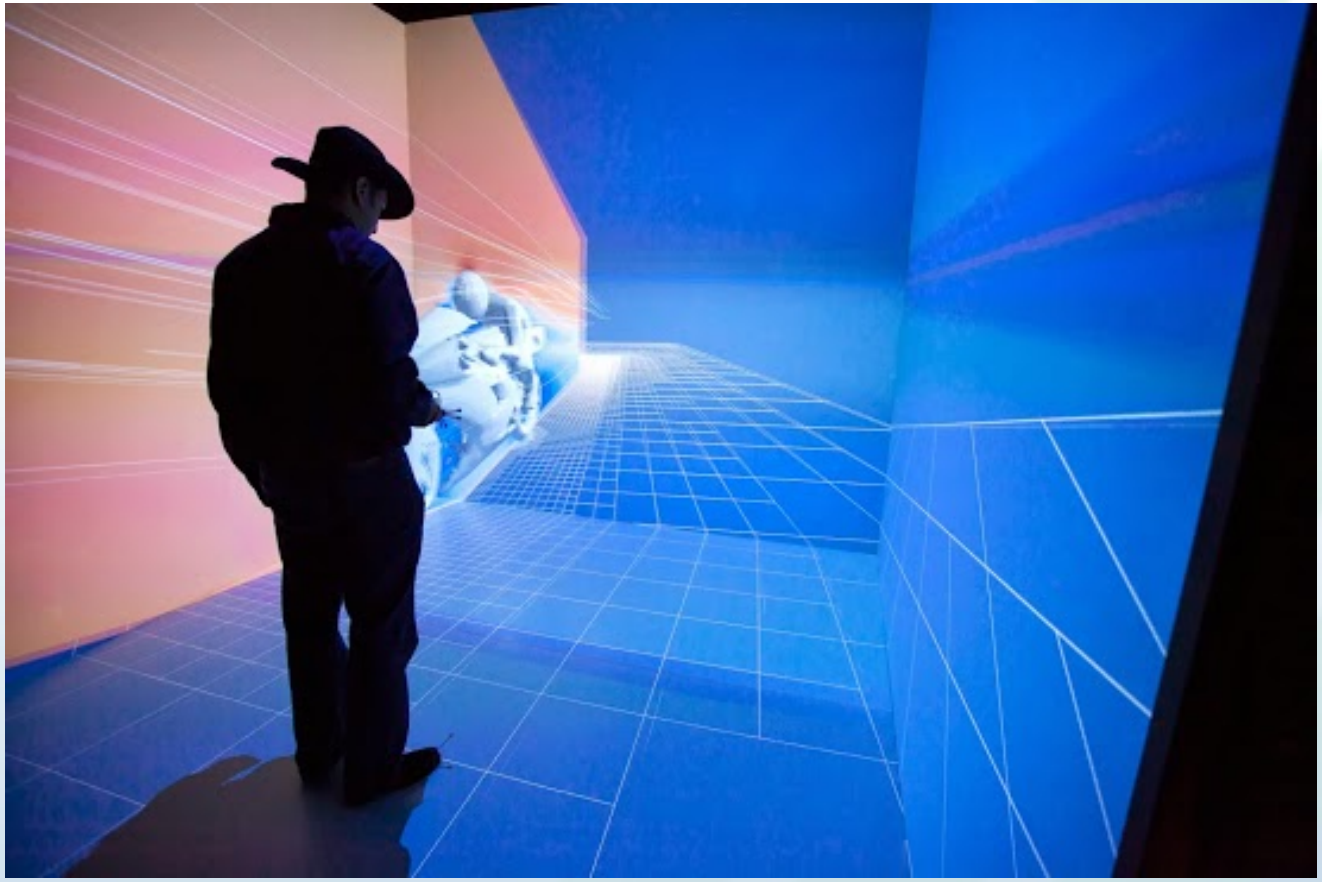
ParaView Immersive



ParaView for HPC

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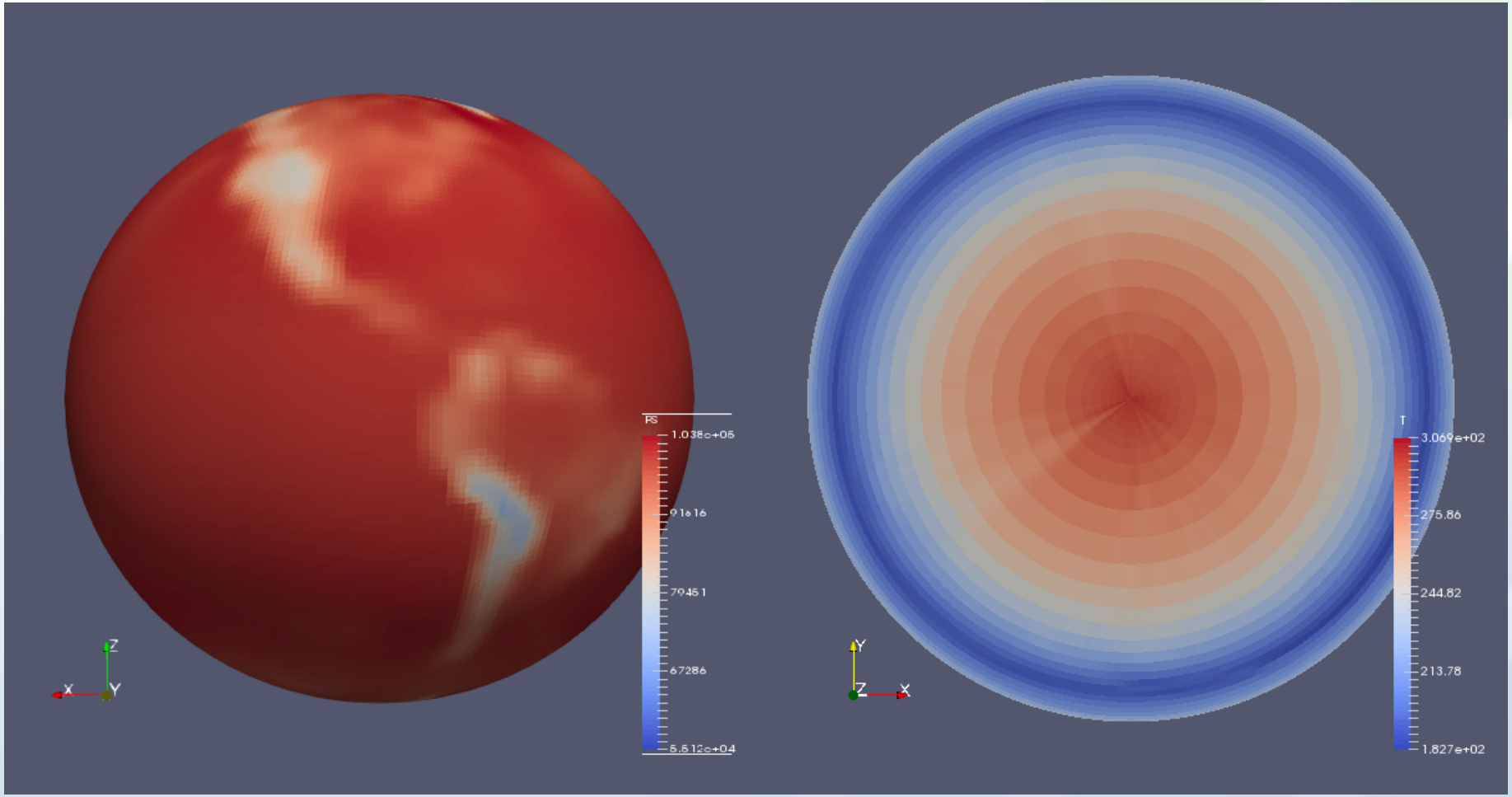
ParaView InSitu (ParaView Catalyst)



Community Atmosphere Model (CAM5) 2D (PS) 3D data (T), Spectral Element dynamic module.

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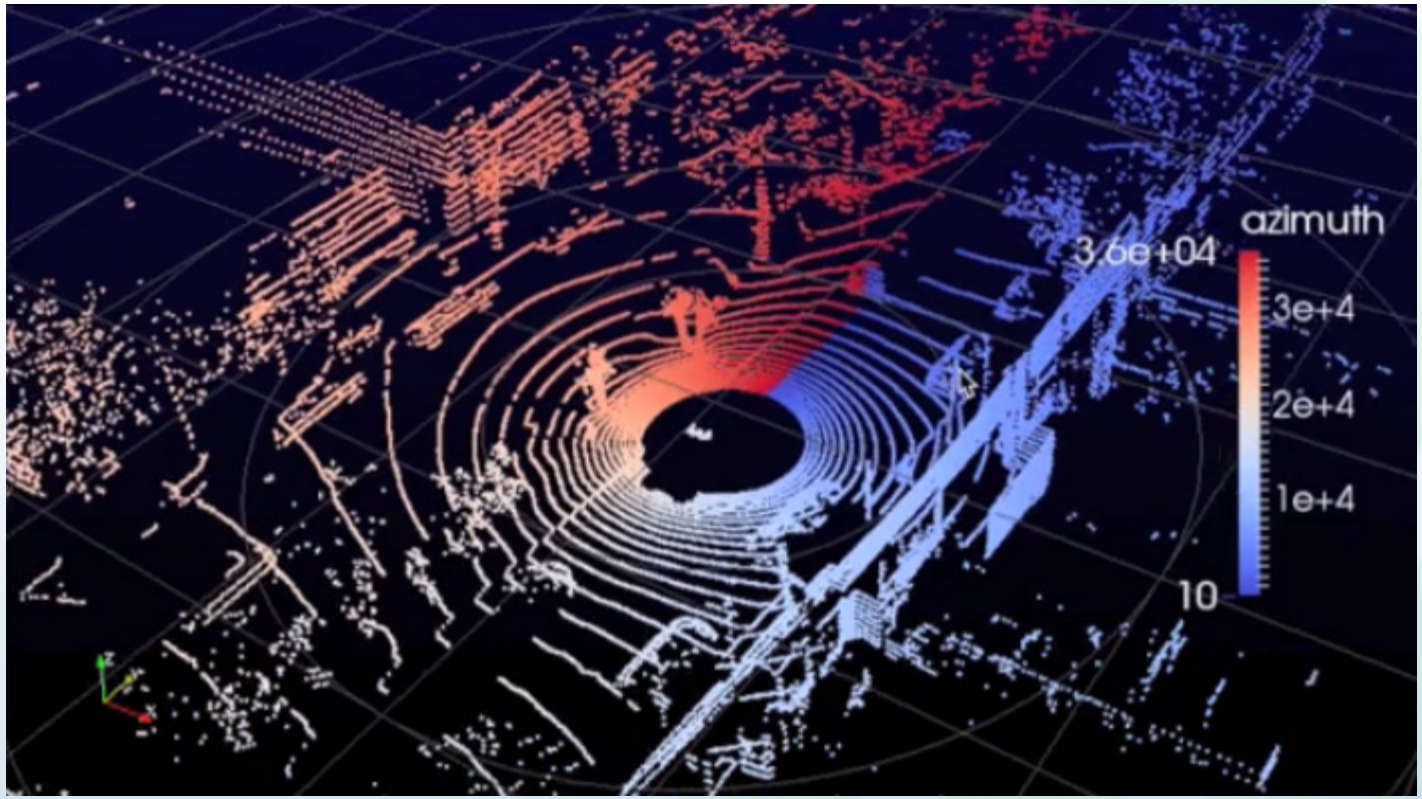
ParaView Custom Application: VeloView



Visualization of 3D LIDAR data.

Kitware

User Interface

Menu Bar

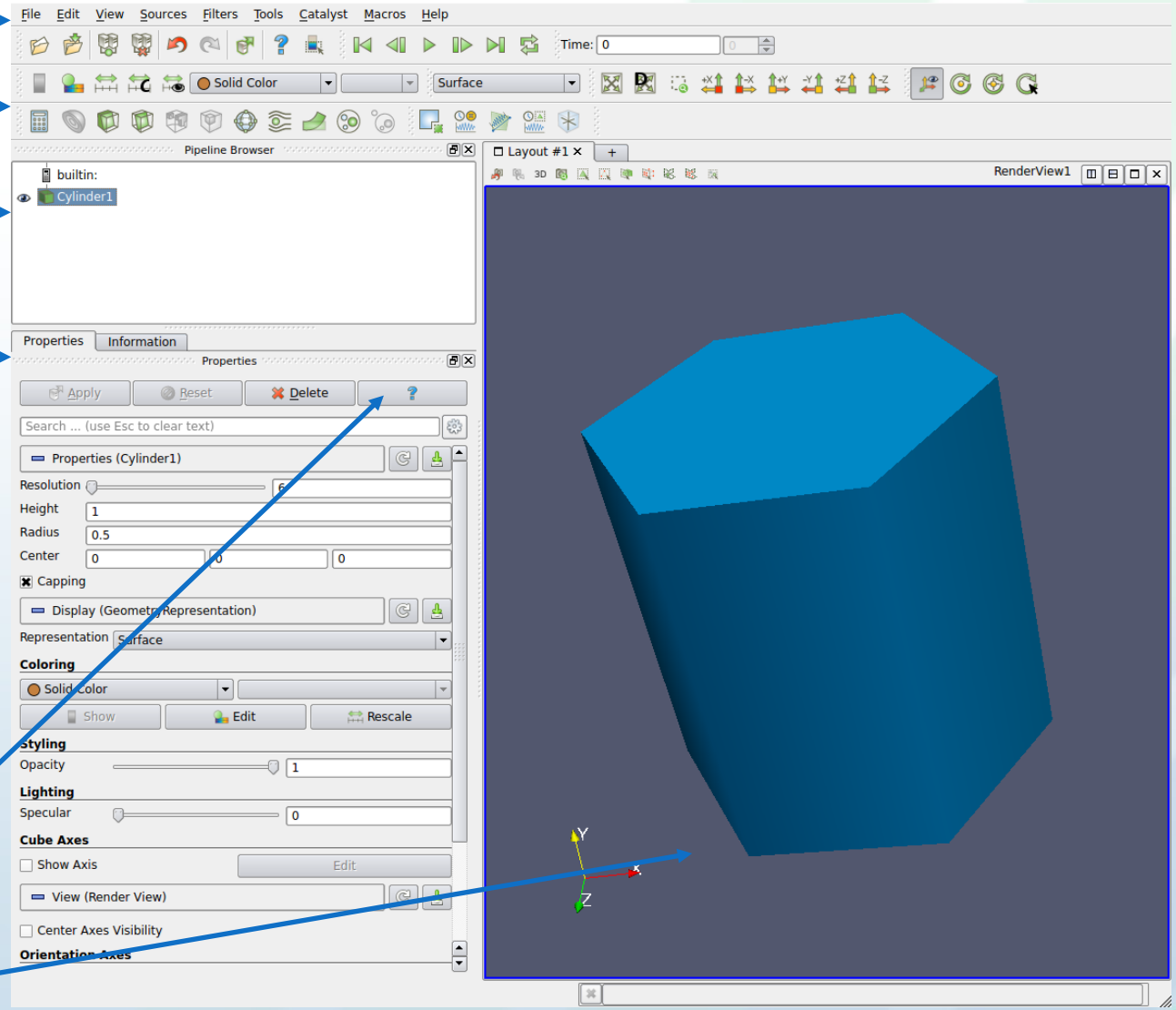
Toolbars

Pipeline Browser

Object Inspector
Properties Tab
Properties
Display
View
Information Tab

Filter reference

View(s)



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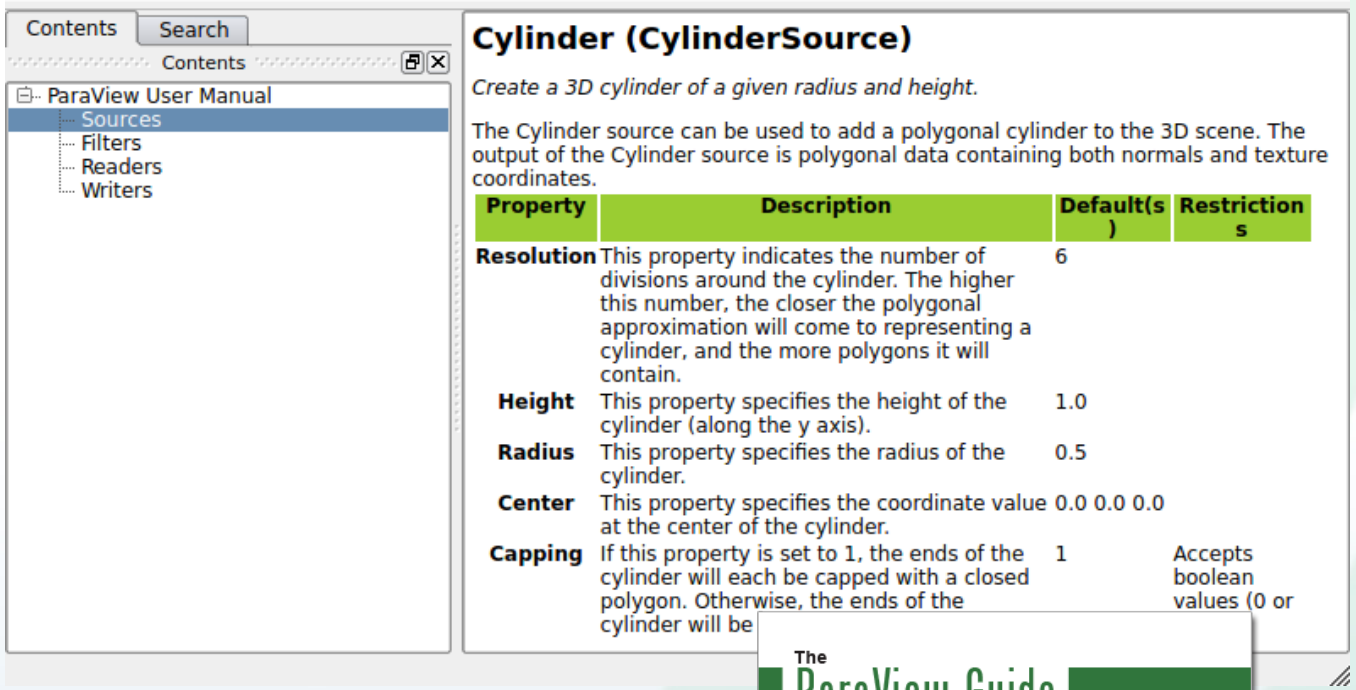
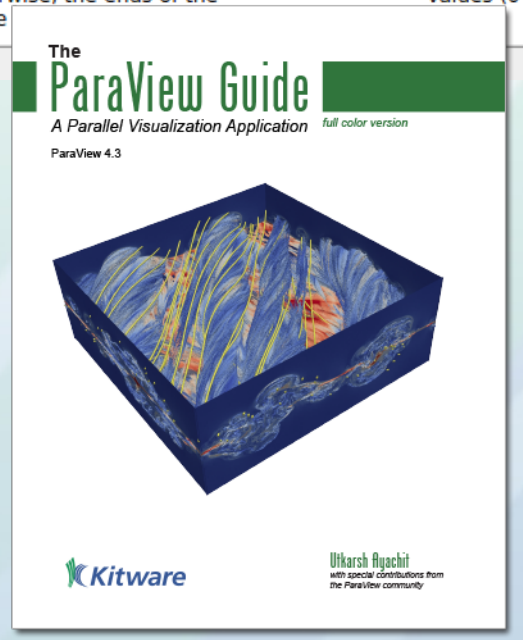
Help



- Getting Started With ParaView
- The ParaView Guide
- Filter Reference
- The ParaView Tutorial
- Example Visualizations
- ParaView Mailing Lists
- ParaView Wiki
- http://www.paraview.org/documentation/



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How to Use ParaView

1. **Read in data**: File → Open
   - Tune **reader properties**
   - Over 100 file formats supported
2. **Add a filter** to process data:
   - Change **Filter properties**
   - **Repeat Step 2** as needed
3. Modify **Display properties**
4. Tune **View properties**
5. Save datasets, rendered results (screenshot or animation) or ParaView state

Apply

Apply

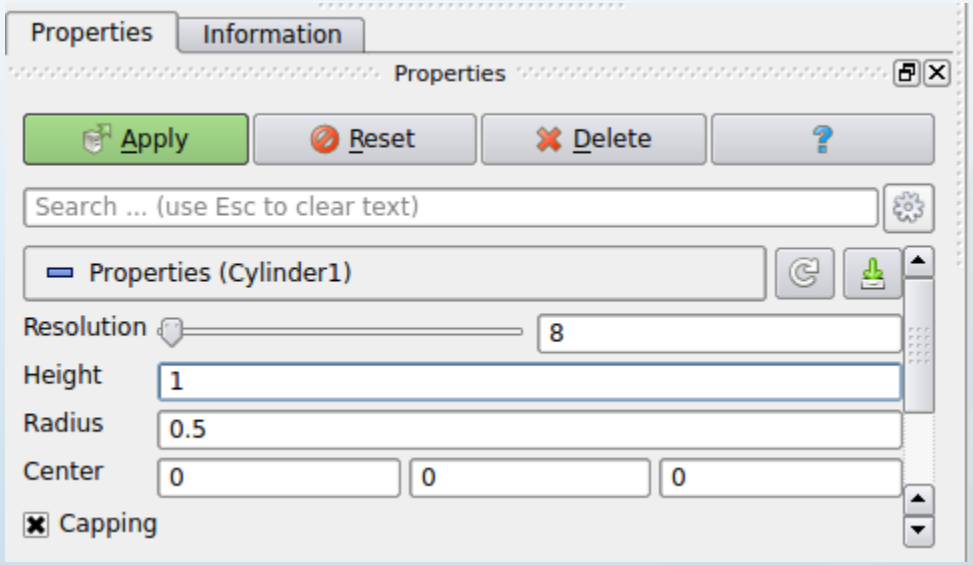
Edit → Undo

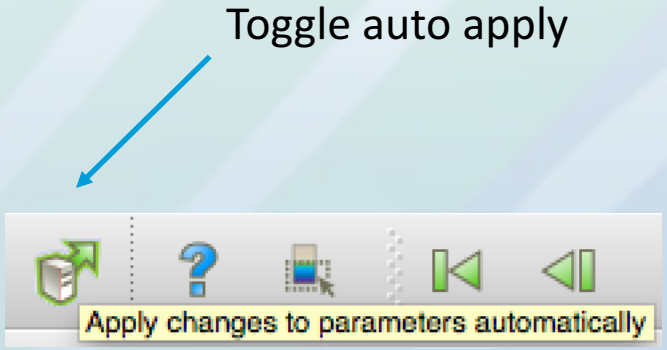
Filter (Pipeline object) = an algorithm that operates on data
Reader, Writer, Source

Kitware

Filter Properties and the Apply Button

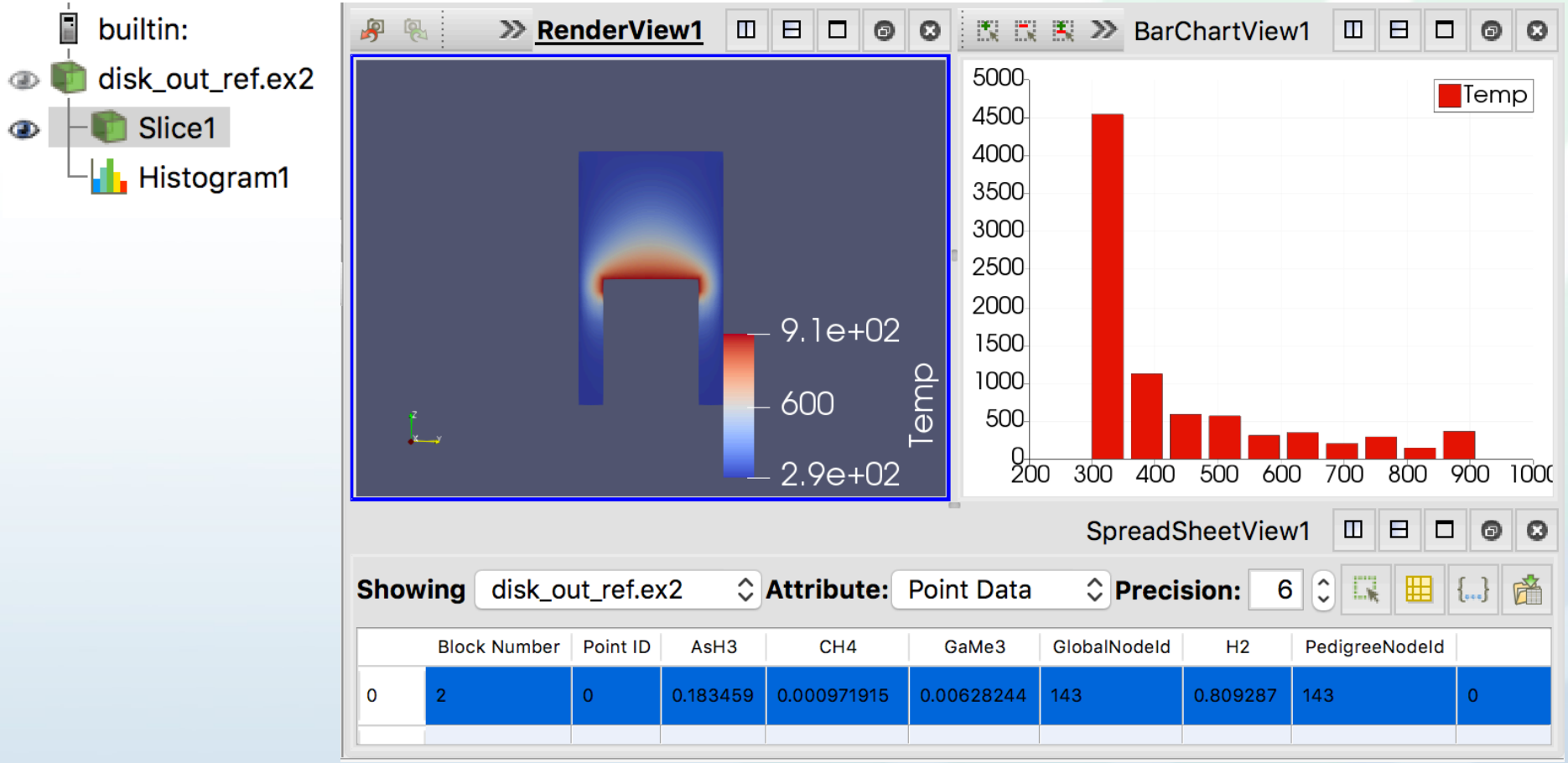
- Active Filter properties
- ParaView is meant to process large data – it might take a long time when changing a filter property.





Kitware

Multiple Views – Render View Active



- Buttons: Split (Vertical, Horizontal), Maximize, Restore, Close

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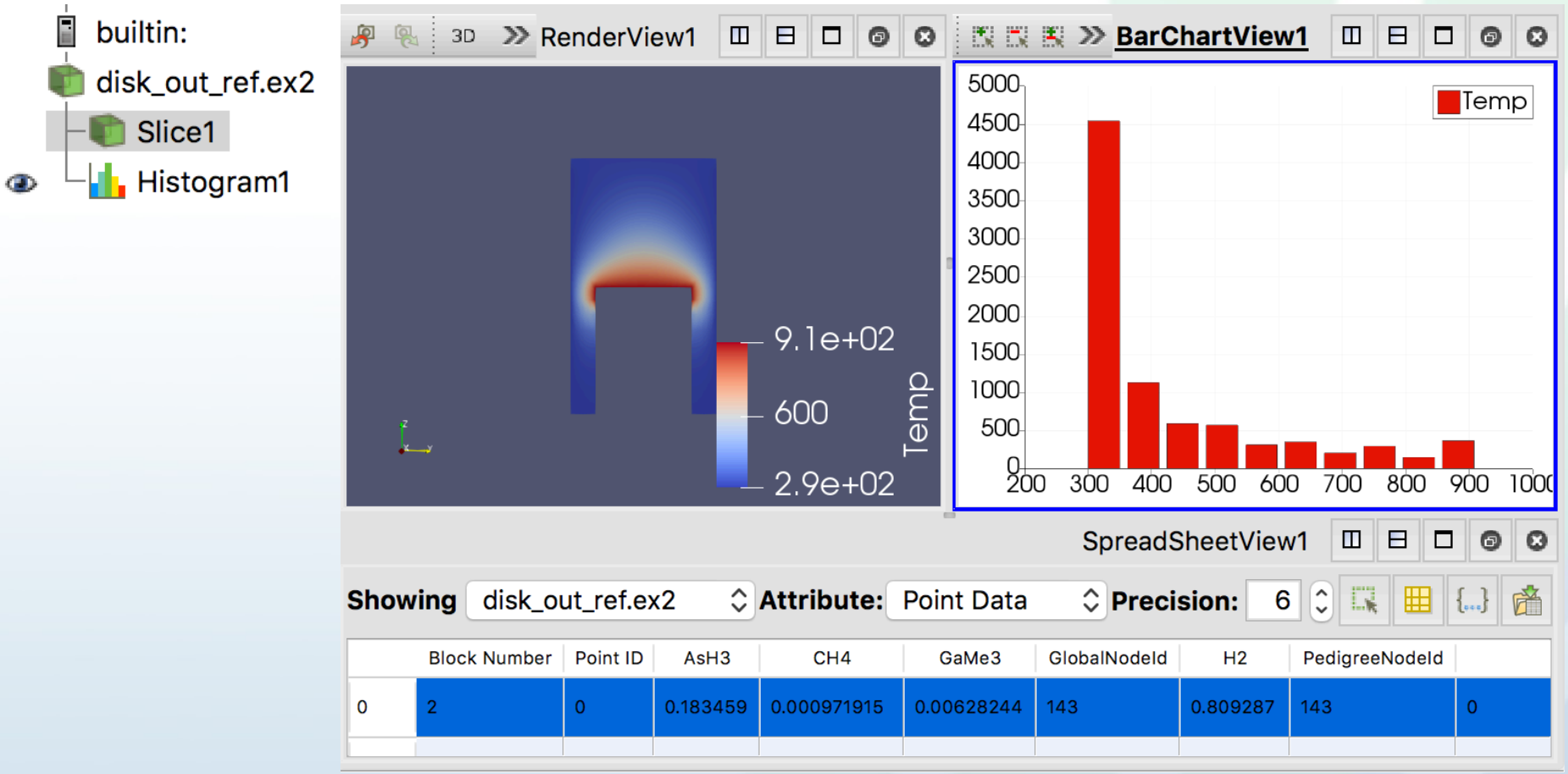
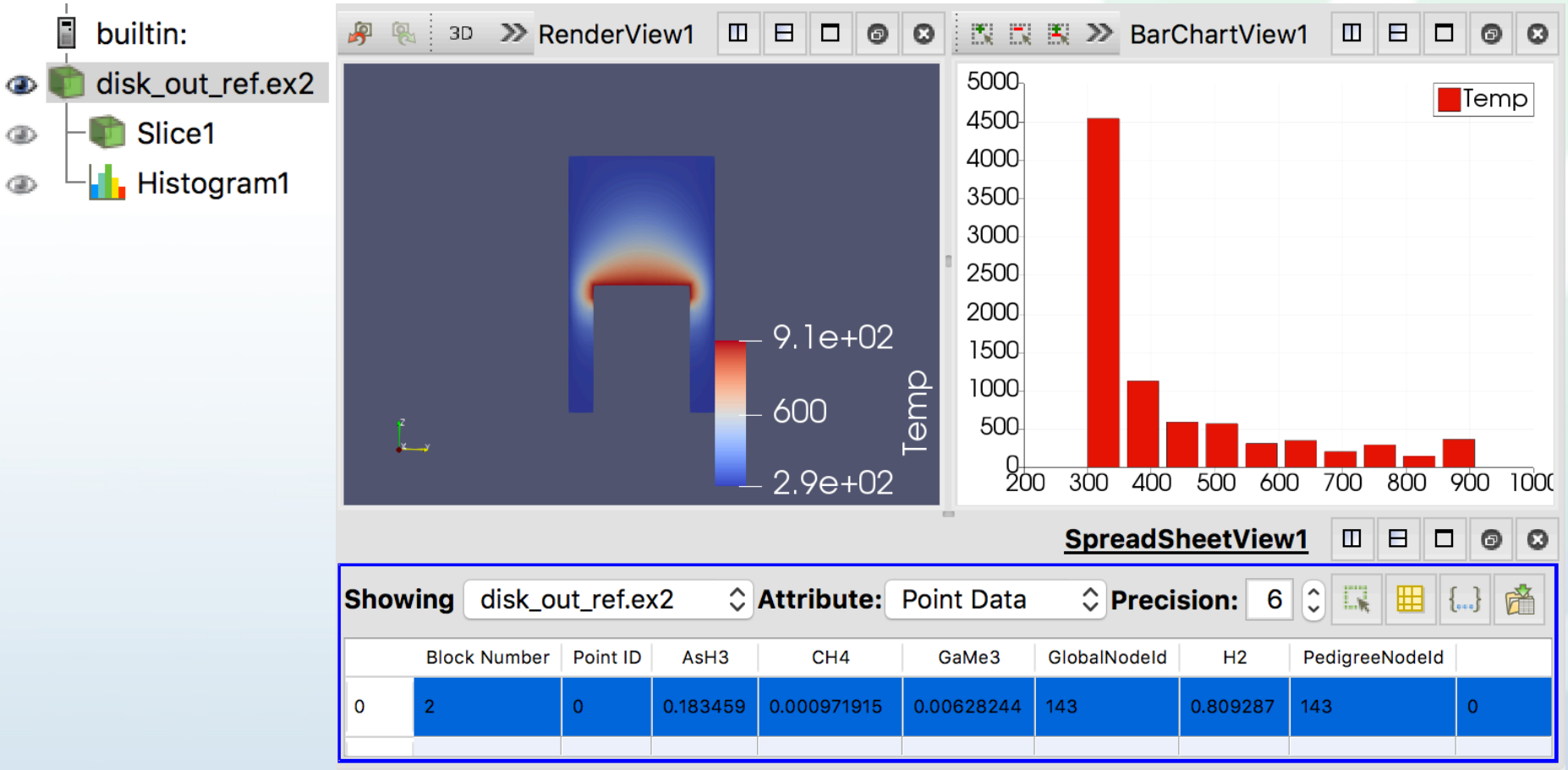
Multiple Views – BarChartView Active



Kitware

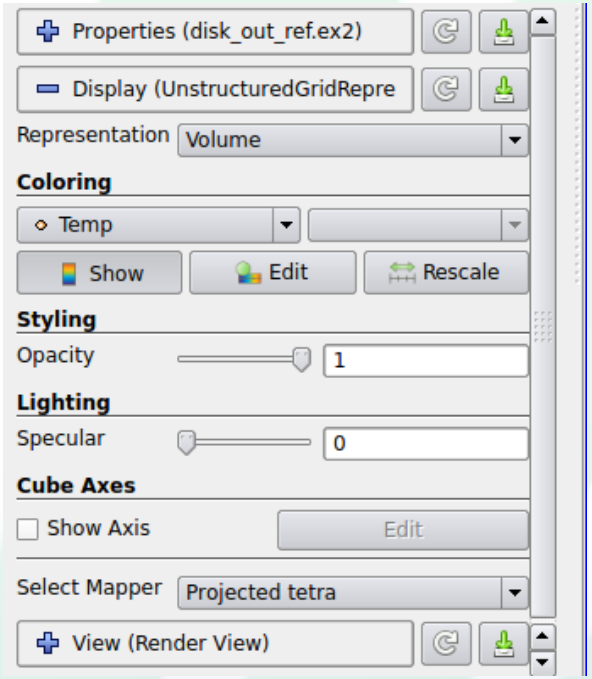
Multiple Views – Spreadsheet Active

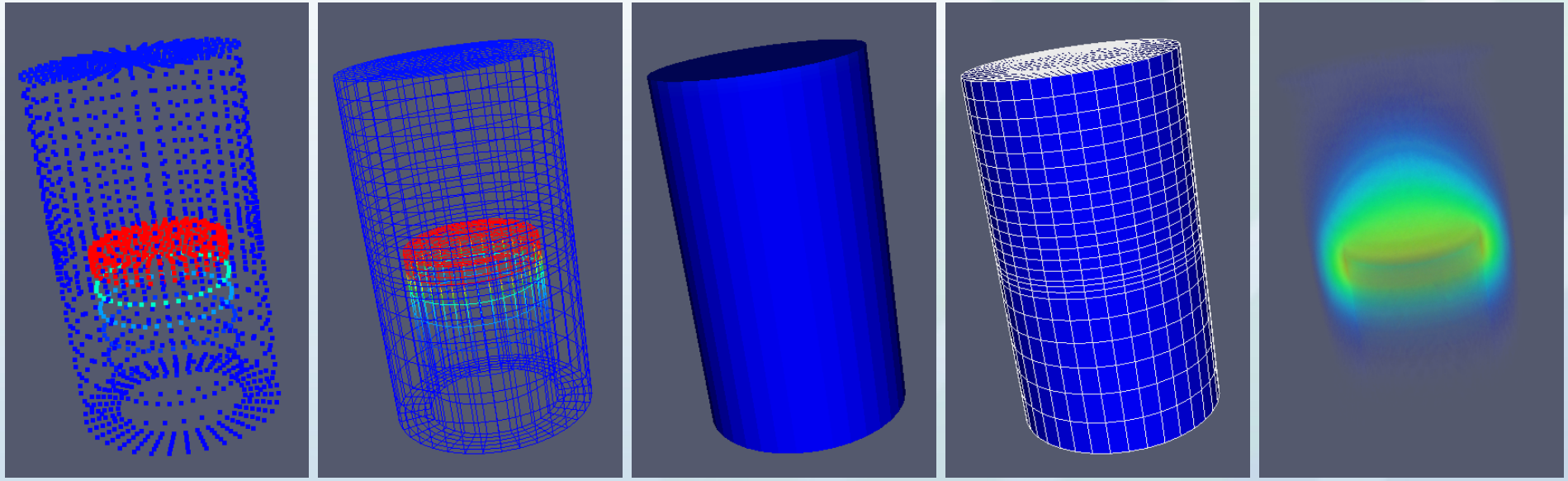


Kitware

Display Properties

- **A Representation** (a display): object that stores visual characteristics a data set in a view
- Display Properties are associated with the Active Filter and Active View.

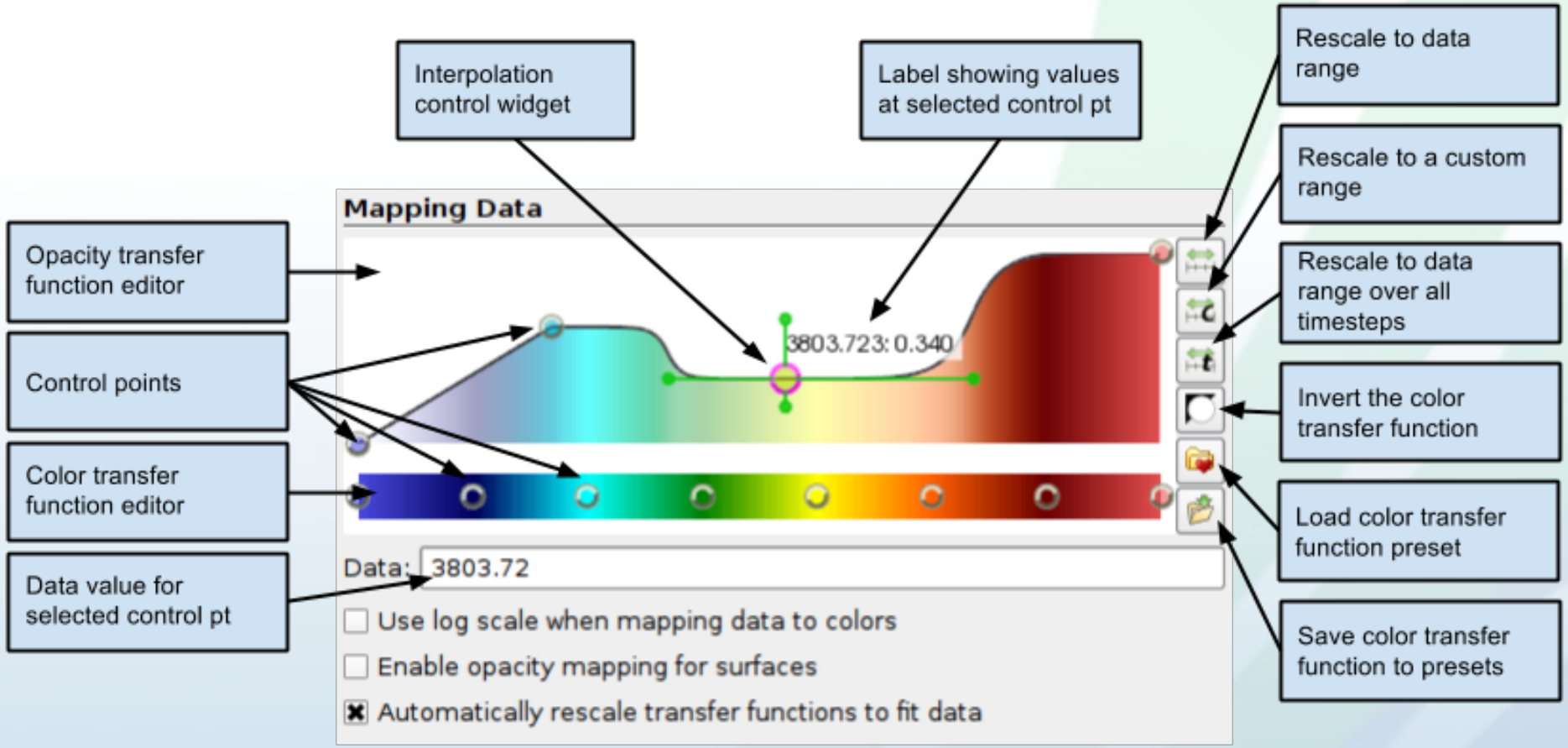




Points | Wireframe | Surface | Surface with Edges | Volume

Kitware

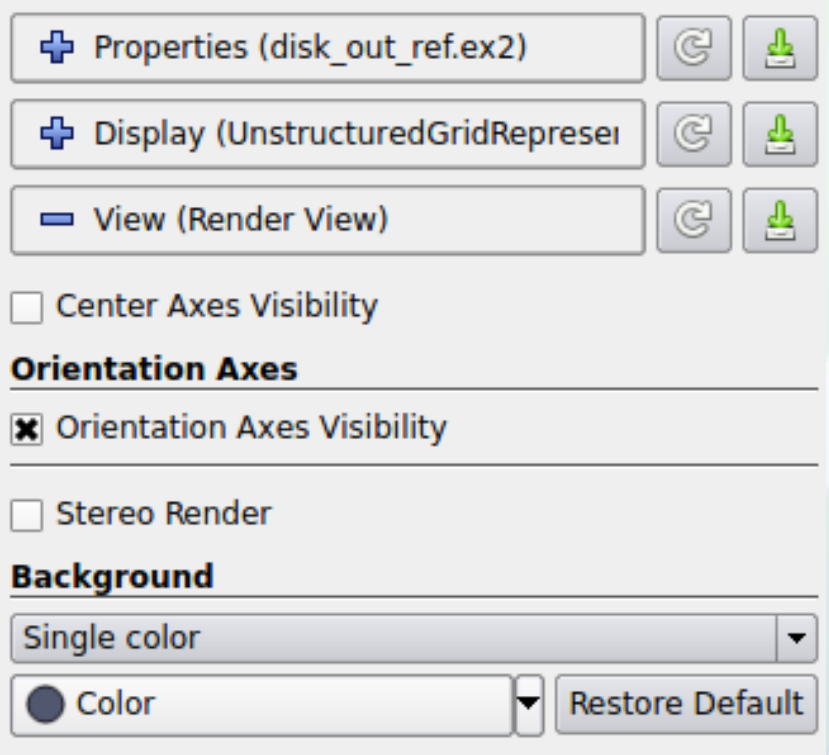
Color Map (Transfer Function) Editor



Kitware

View Properties

Properties associated with the Active View

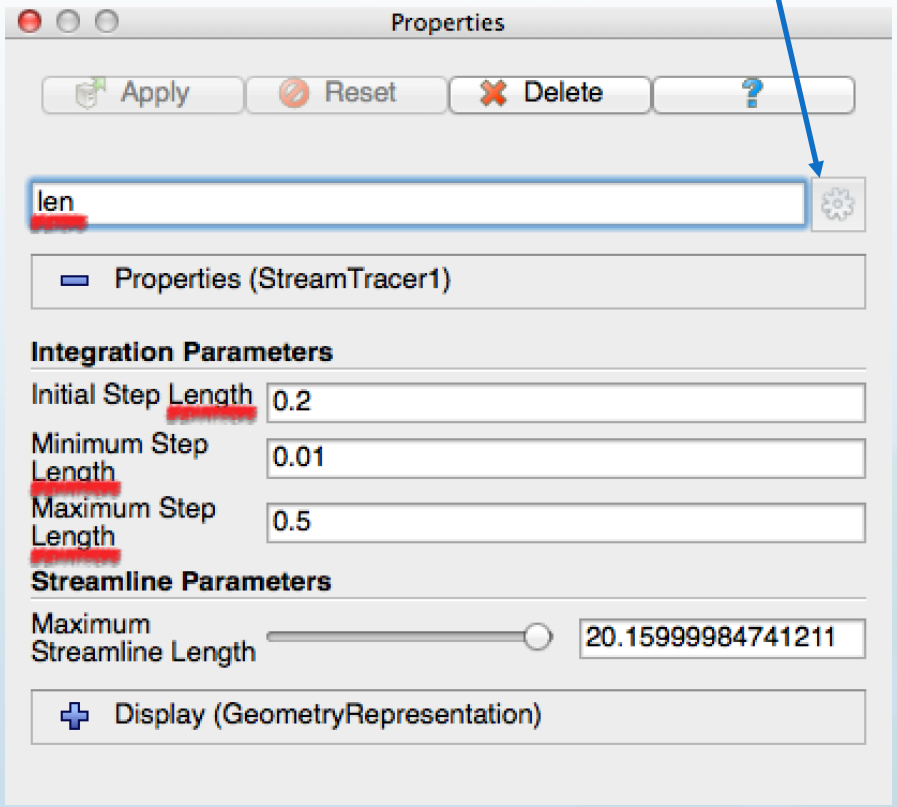


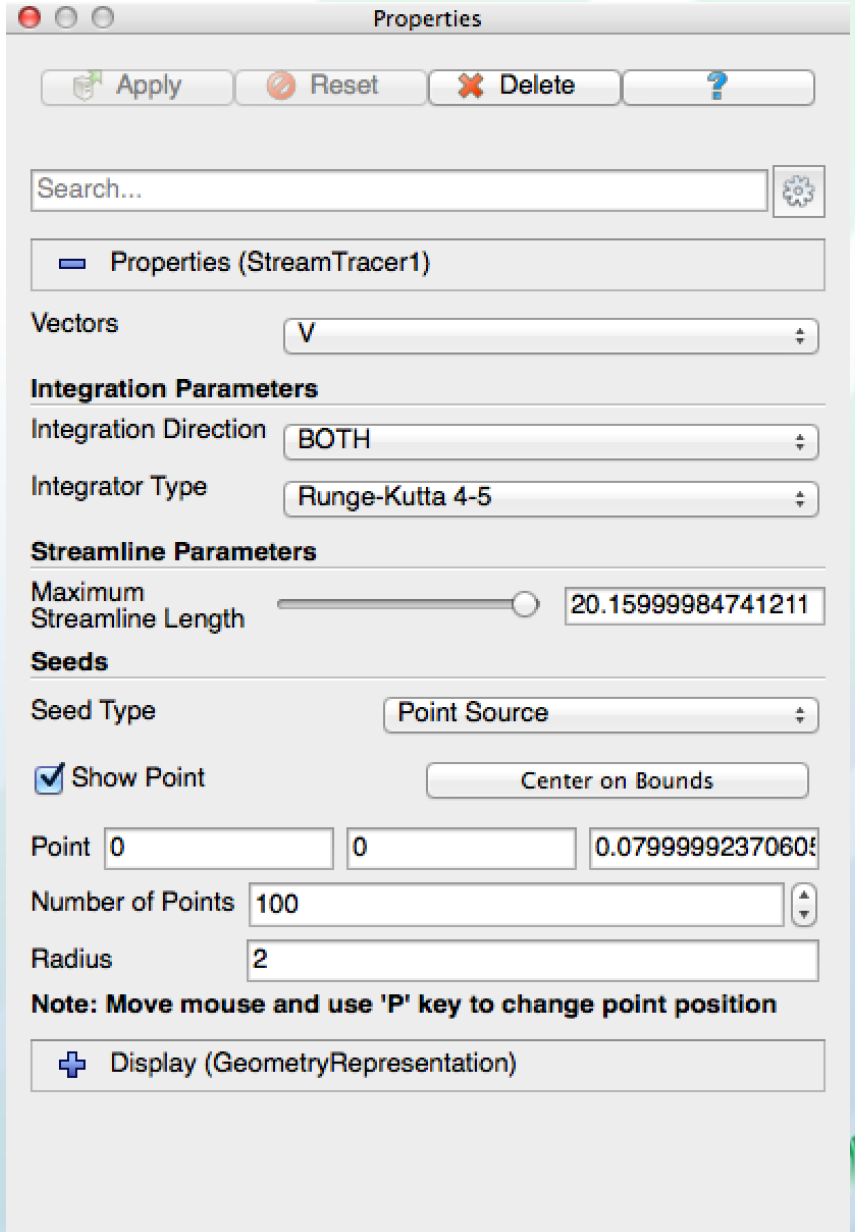
Kitware

Find properties (for Filters, Displays and Views)

- Search for properties
- Toggle on/off advanced properties

Advanced Properties

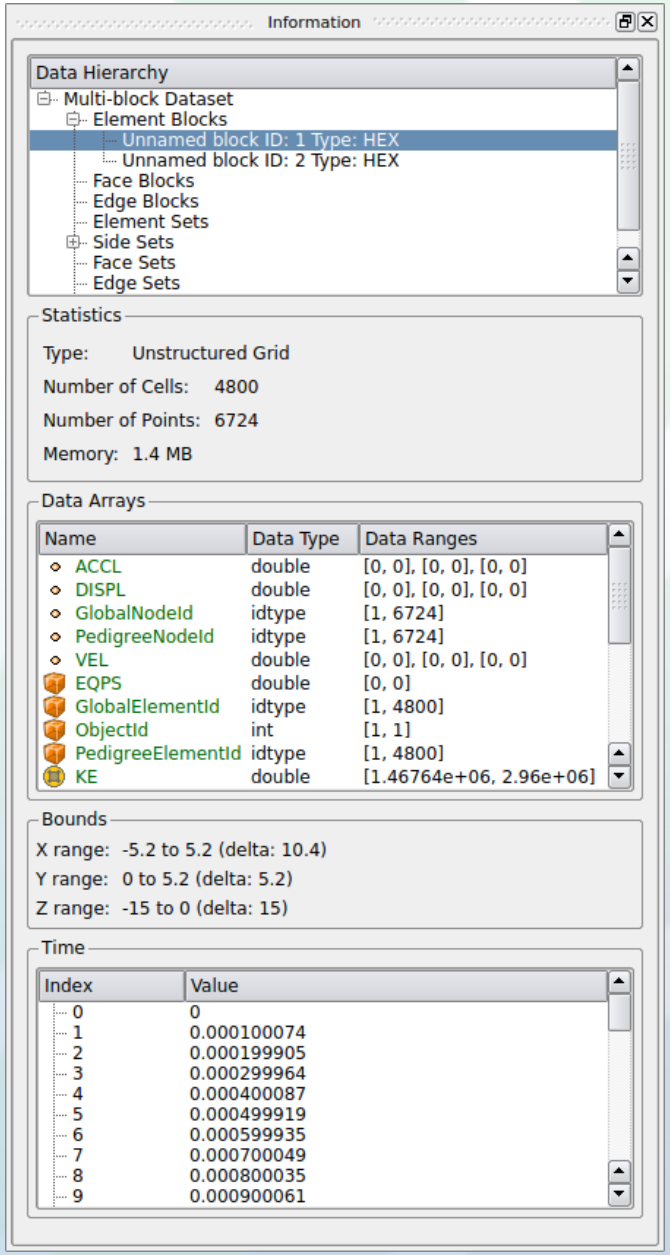




Kitware

Object Inspector Information Tab

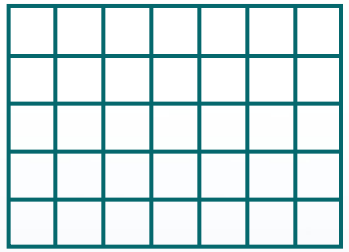
- Information about the Active Filter's output
- Dataset Type
- Size (Bytes, #points, #cells)
- Geometric bounds
- Structured bounds
- Arrays:
  - Name
  - Association (=point, =cell)
  - Data Type
  - Data Ranges (and scalar/vector)
- Temporal Domain



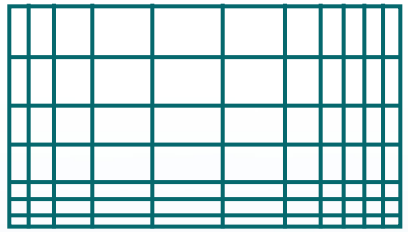
Kitware

ParaView Dataset Types

vtkImageData

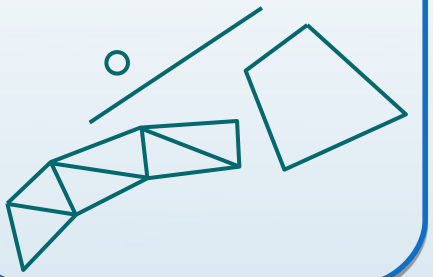


vtkRectilinearGrid

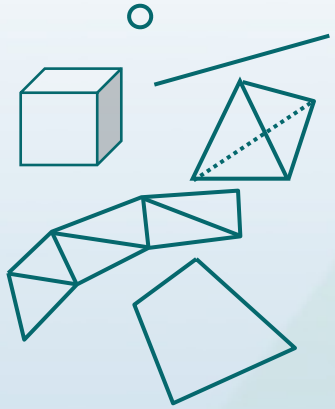


vtkStructuredGrid

vtkPolyData



vtkUnstructuredGrid



Multi-blocks

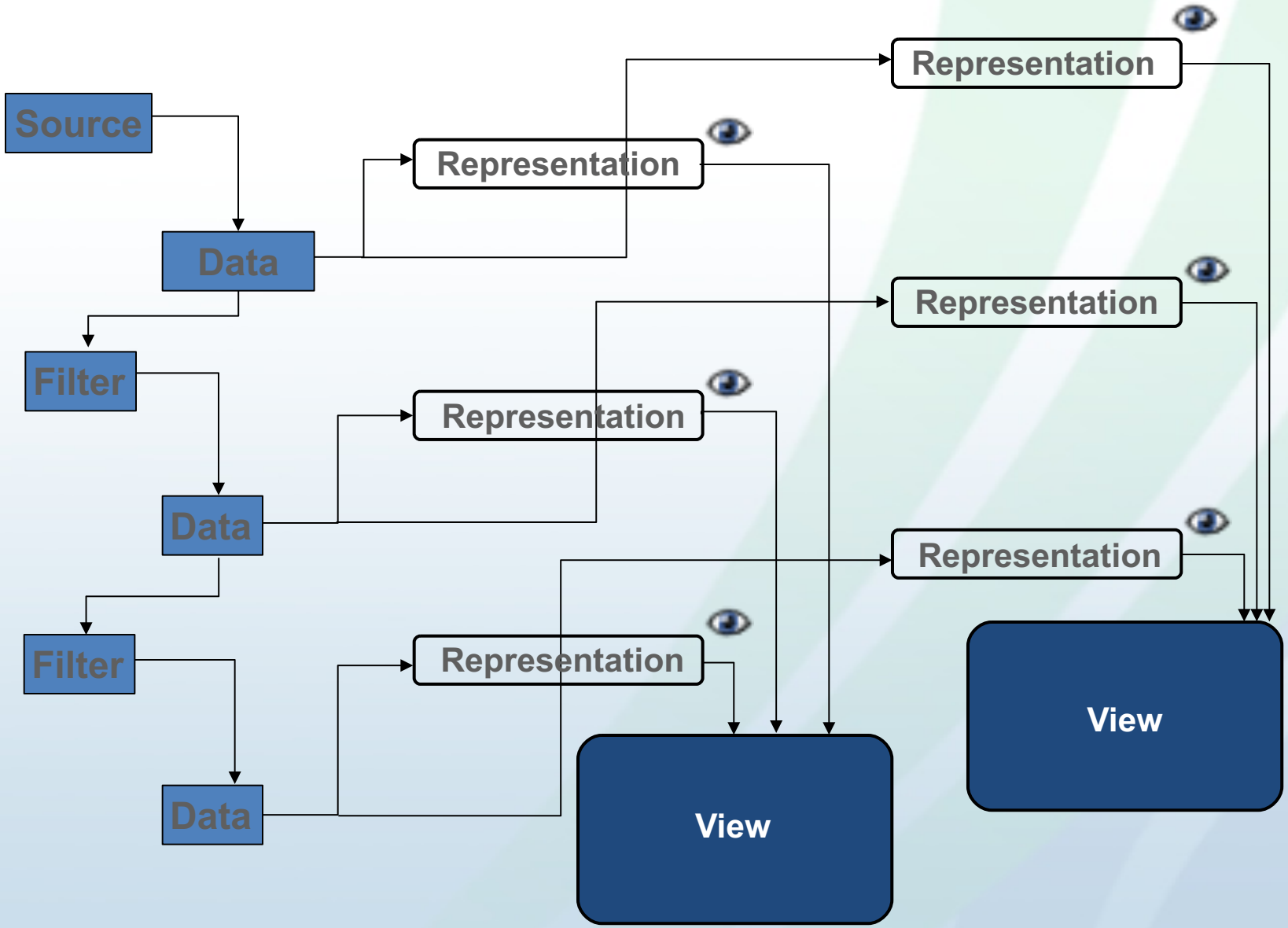
AMR

Time-varying data

- points, cells
- values associated points and/or cells: scalars, vectors, tensors

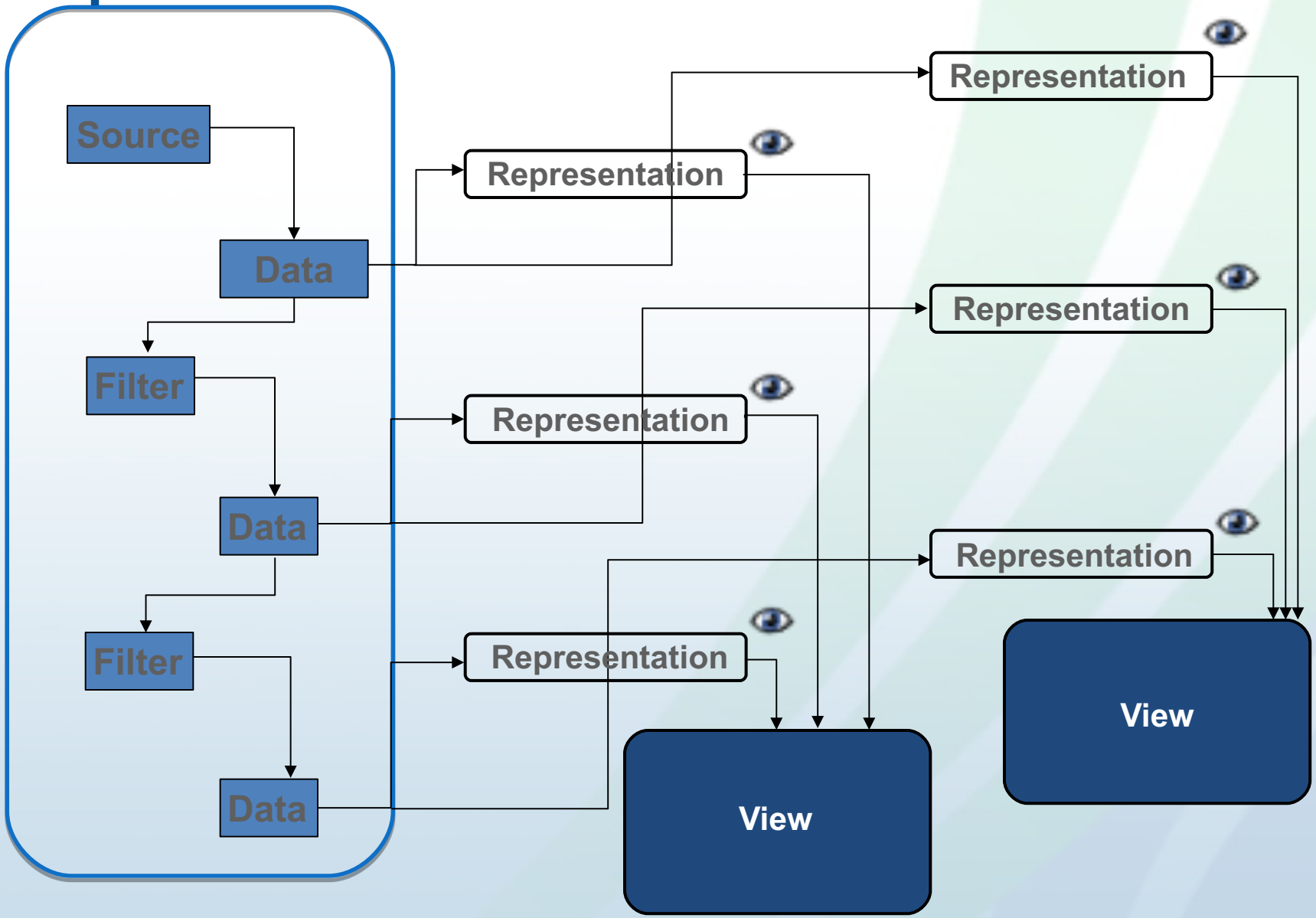
Kitware

Multi-View Visualization Pipeline



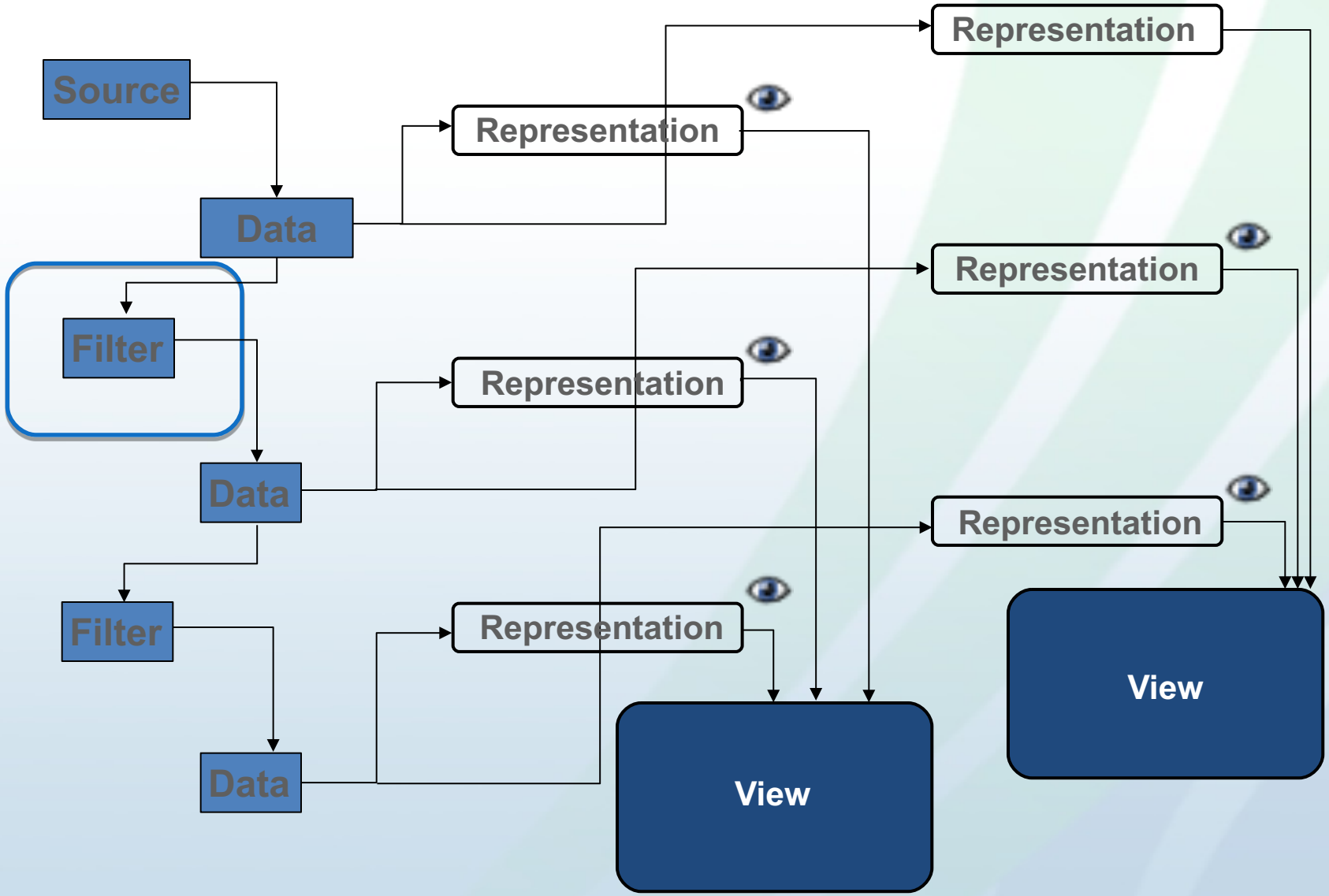
Kitware

Pipeline Browser



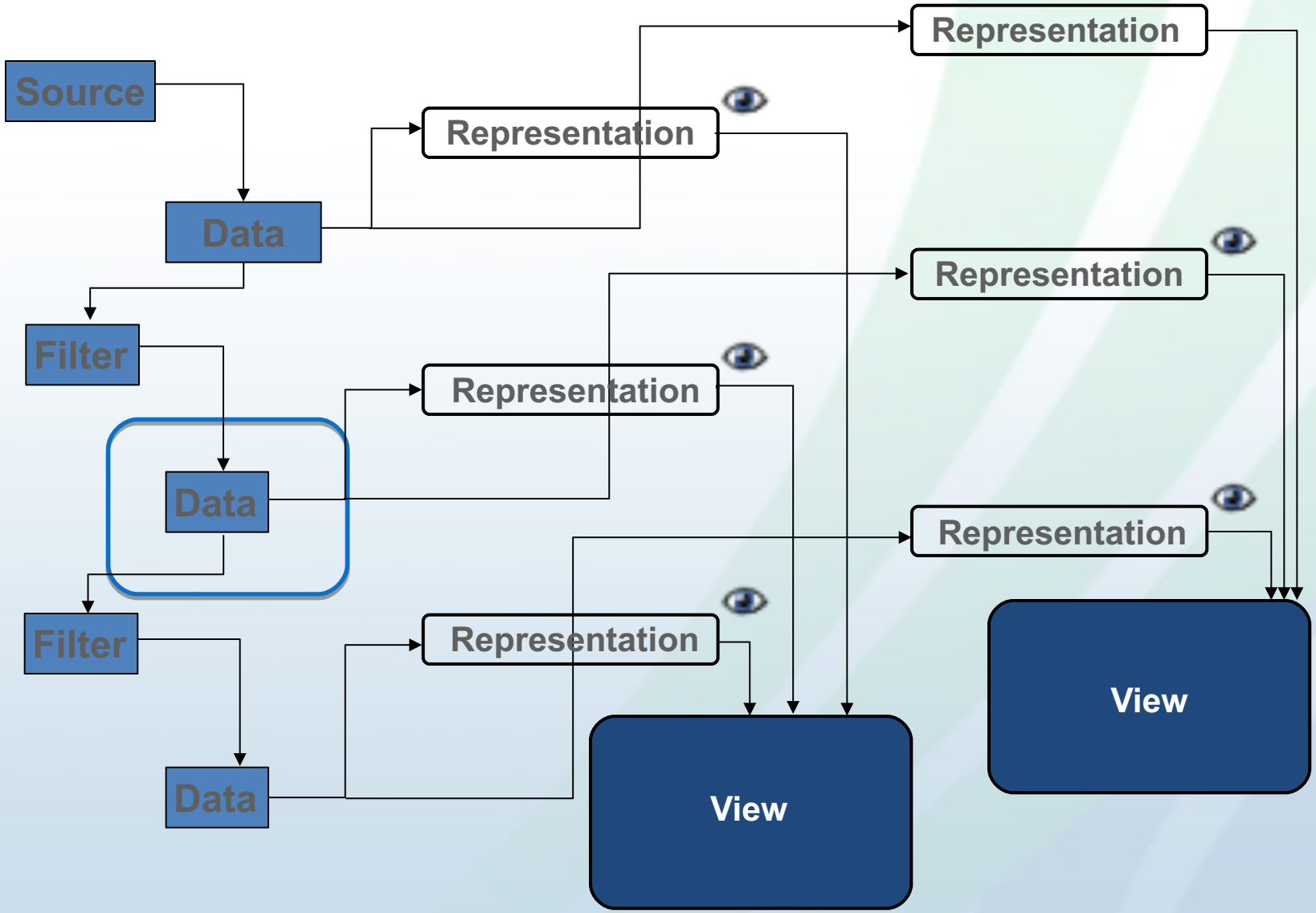
Kitware

Filter Properties – acts on active filter



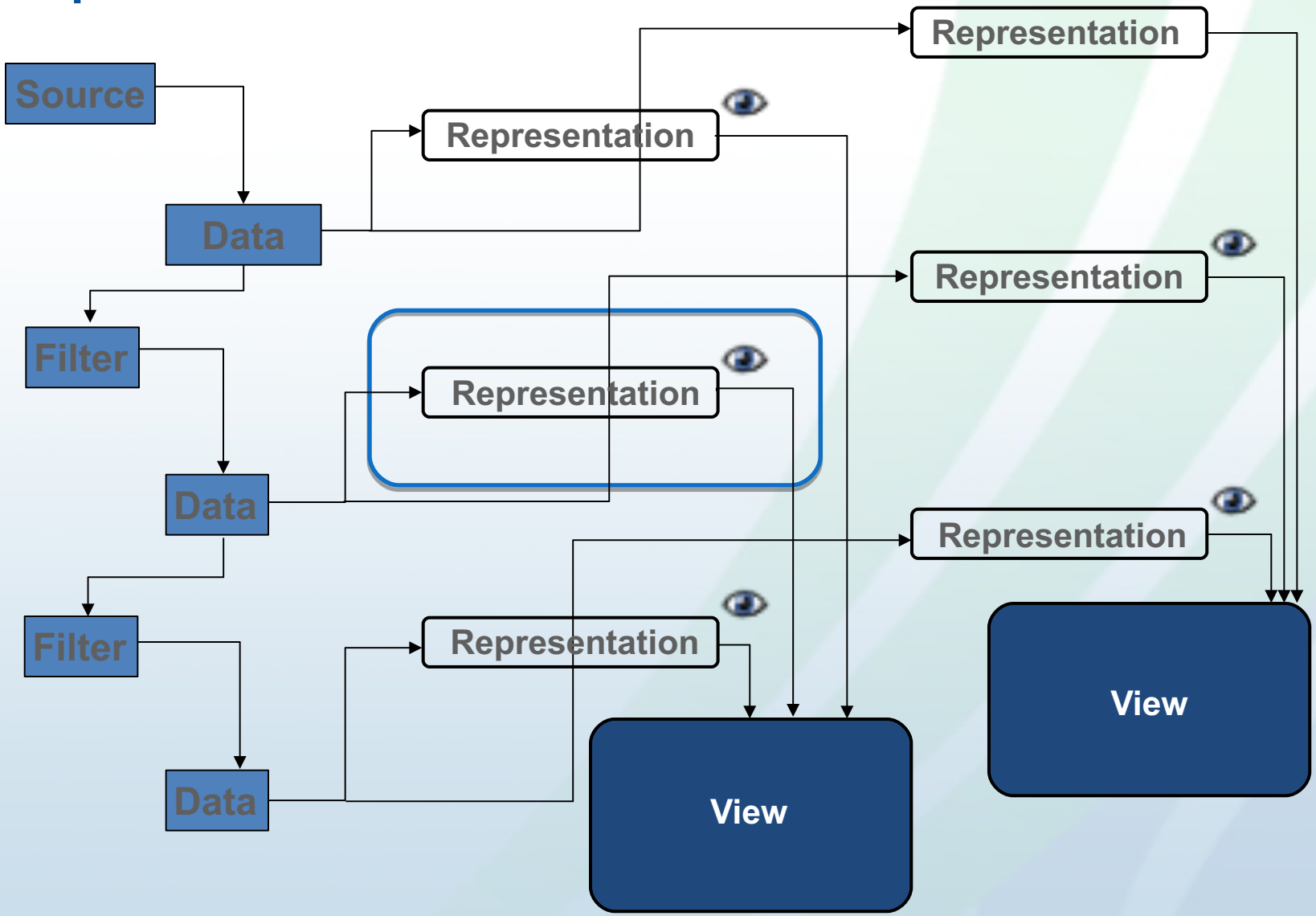
Kitware

Information Tab – shows output data for the active filter



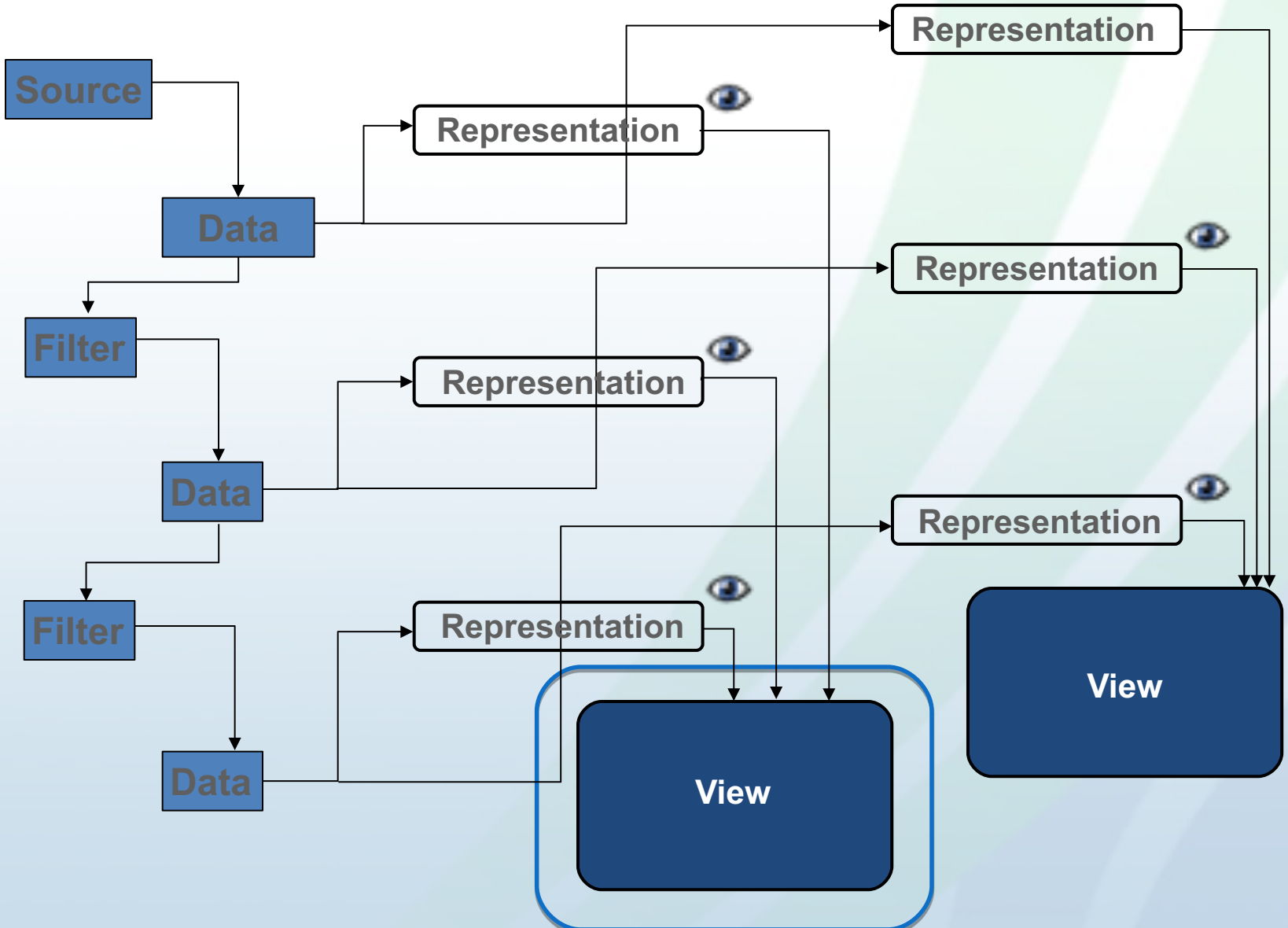
Kitware

Display Properties – representation properties for active filter and view



Kitware

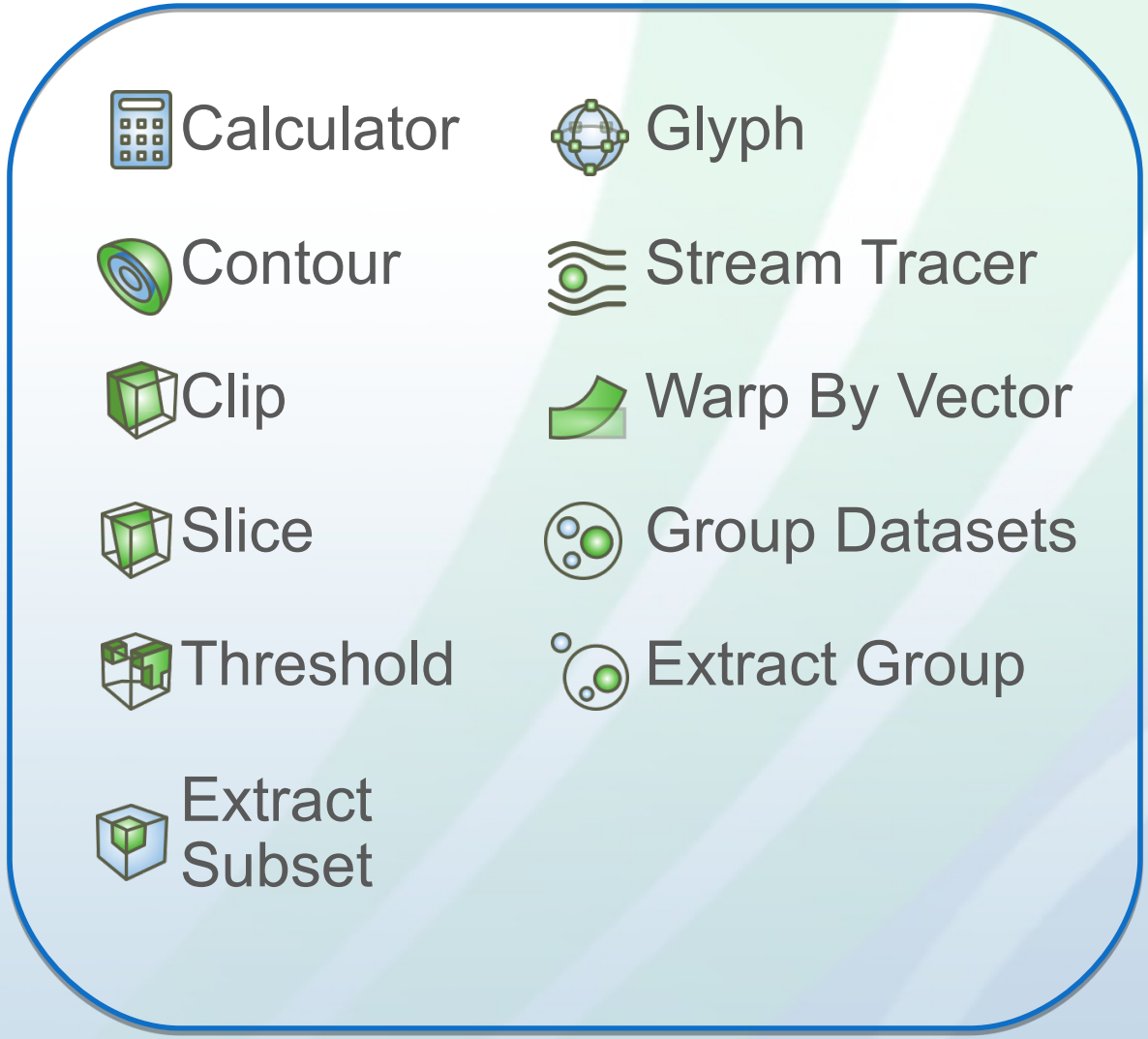
View Properties – acts on active view



Kitware

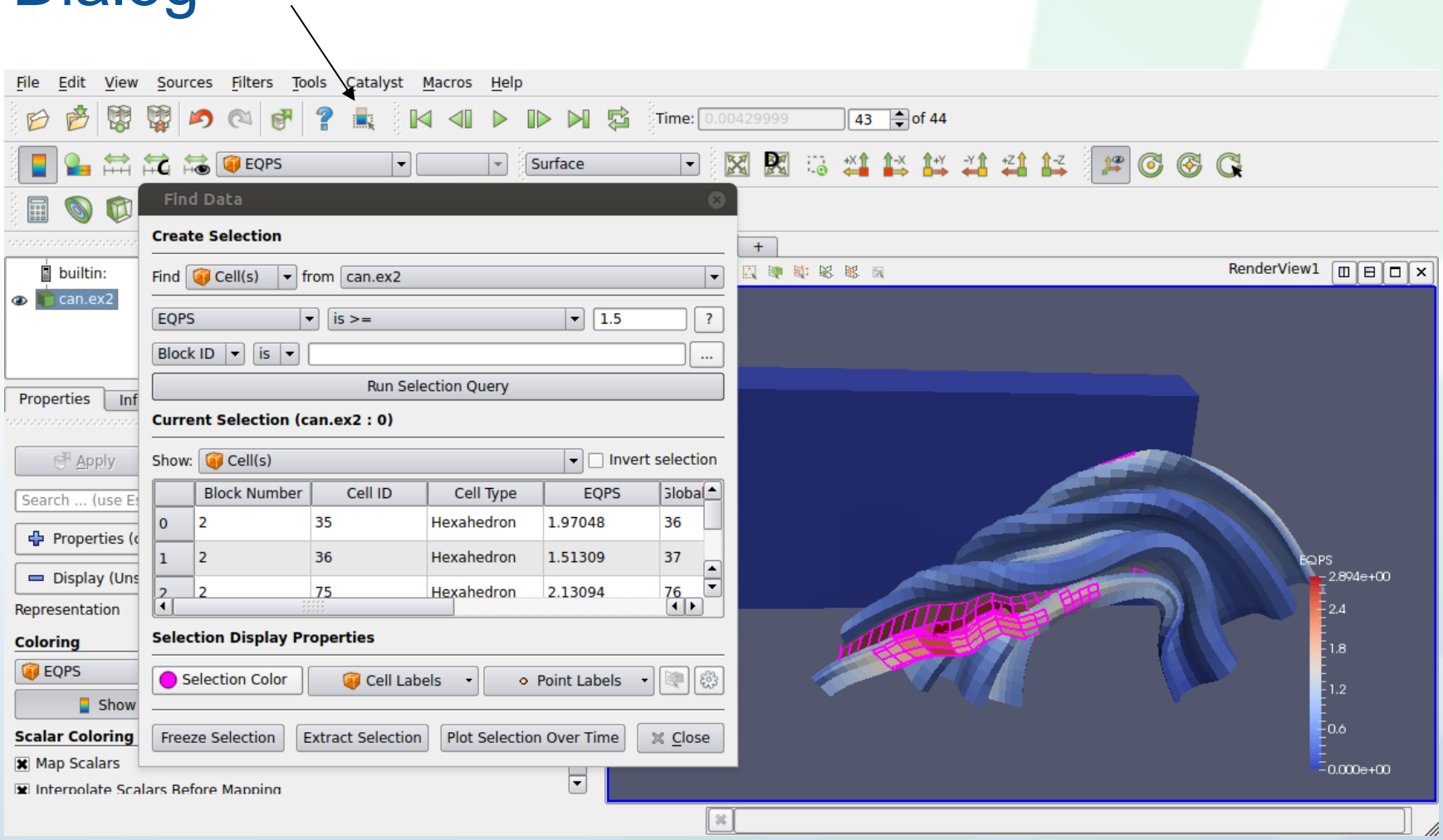
Filters

- Filters Menu
  - Recent
  - Common
  - Data Analysis
  - Statistical
  - Temporal
  - Alphabetical
- Quick Launch
  - PC/Linux
  - *CTRL-Space*
  - Mac
  - *ALT-Space*
- Apply Undo/Redo



Kitware

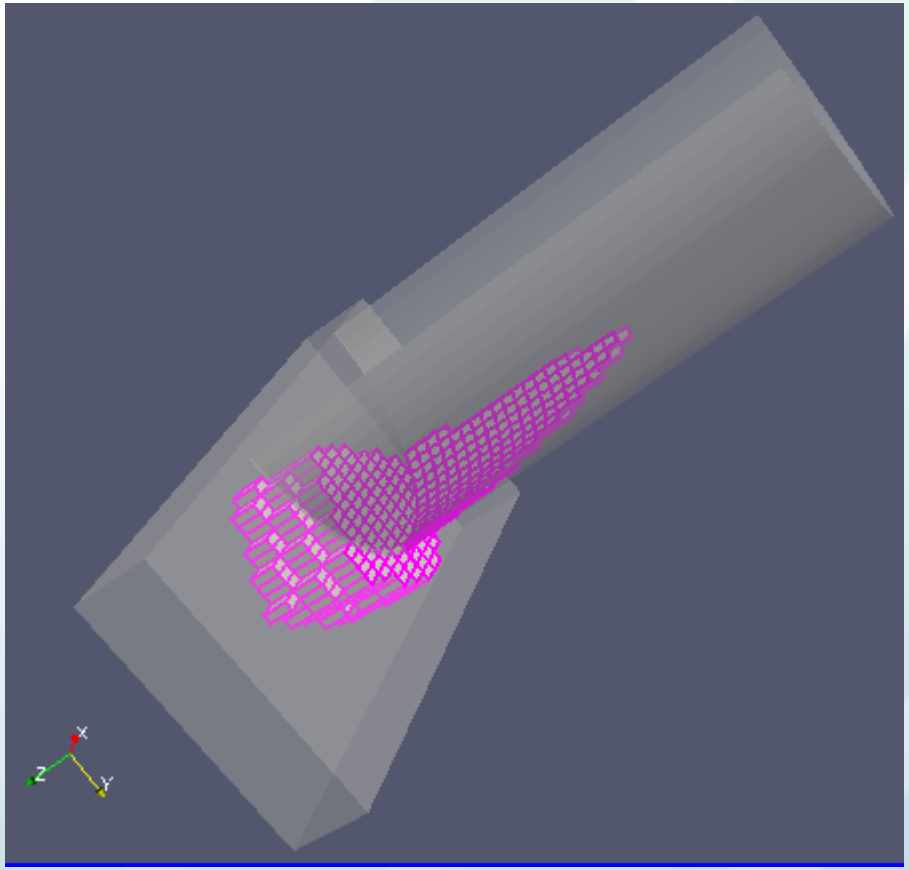
Query Data by Attributes Values – Find Data Dialog



Kitware

Query Data Visually - Selection

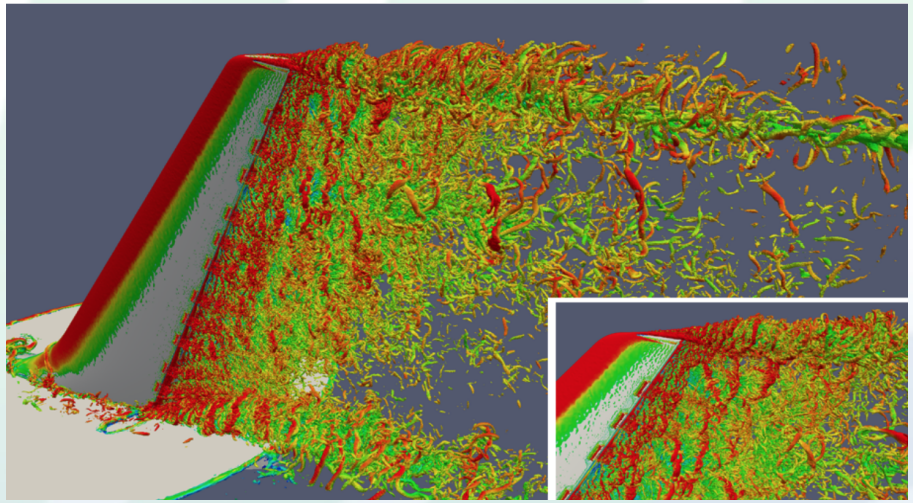
- Visually select interesting data shown in all compatible views can then label, extract etc
  -  ‘Select Cells On’ to get nearest cells
  -  Select Points On’ to get nearest points
  -  ‘Select Cells Through’ to get all cells intersecting a frustum
  -  ‘Select Points Through’ for selecting points inside a frustum
  - Select Points/Cells With Polygon
  - Select Block
  - Interactive Select Point/Cells
  - Hover Points/Cells



Kitware

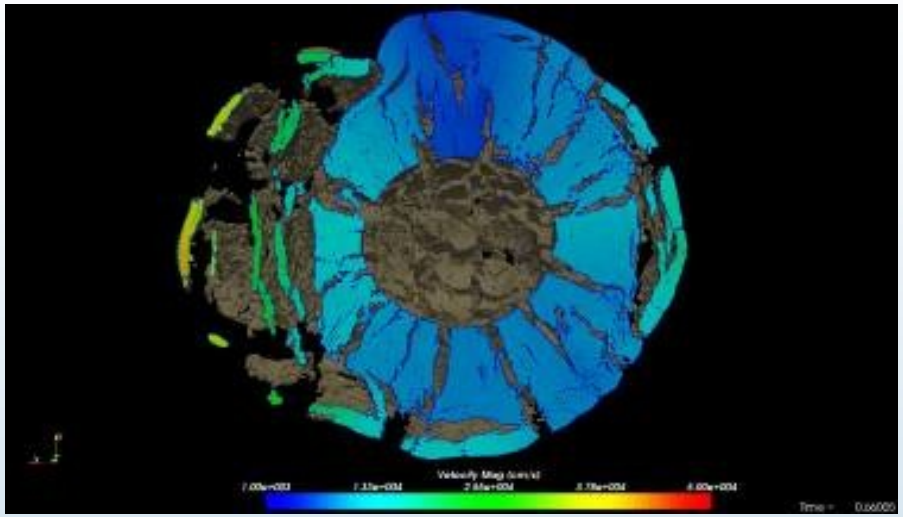
Exporting data, images, state

- File → Save *
  - Active filter's **data**, prompted for file format
    - List of file formats given in help primarily kitware
    - formats + exodus, ensight, xdmf/hdf5, csv
  - **Screenshot** (image)
  - In a format for **high quality rendering**
    - eps, pdf, ps, svg, pov, vrml, webgl, x3d, x3db
  - **Movie**
    - Image sequence, avi, ogg, ffmpeg → avi
  - **State**
    - for restoring ParaView state later

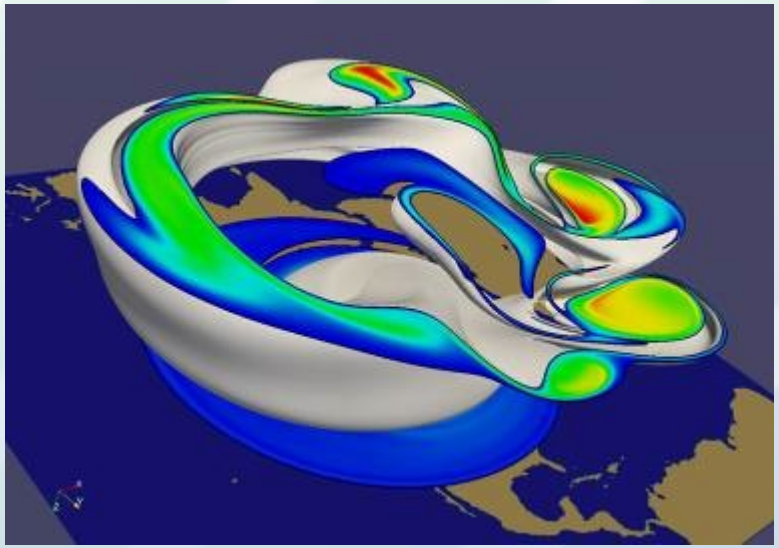


In-situ vis. 1.3 billion cells, 256K MPI processes, Image courtesy of Michel Rasquin, ANL

Large Data processed by ParaView



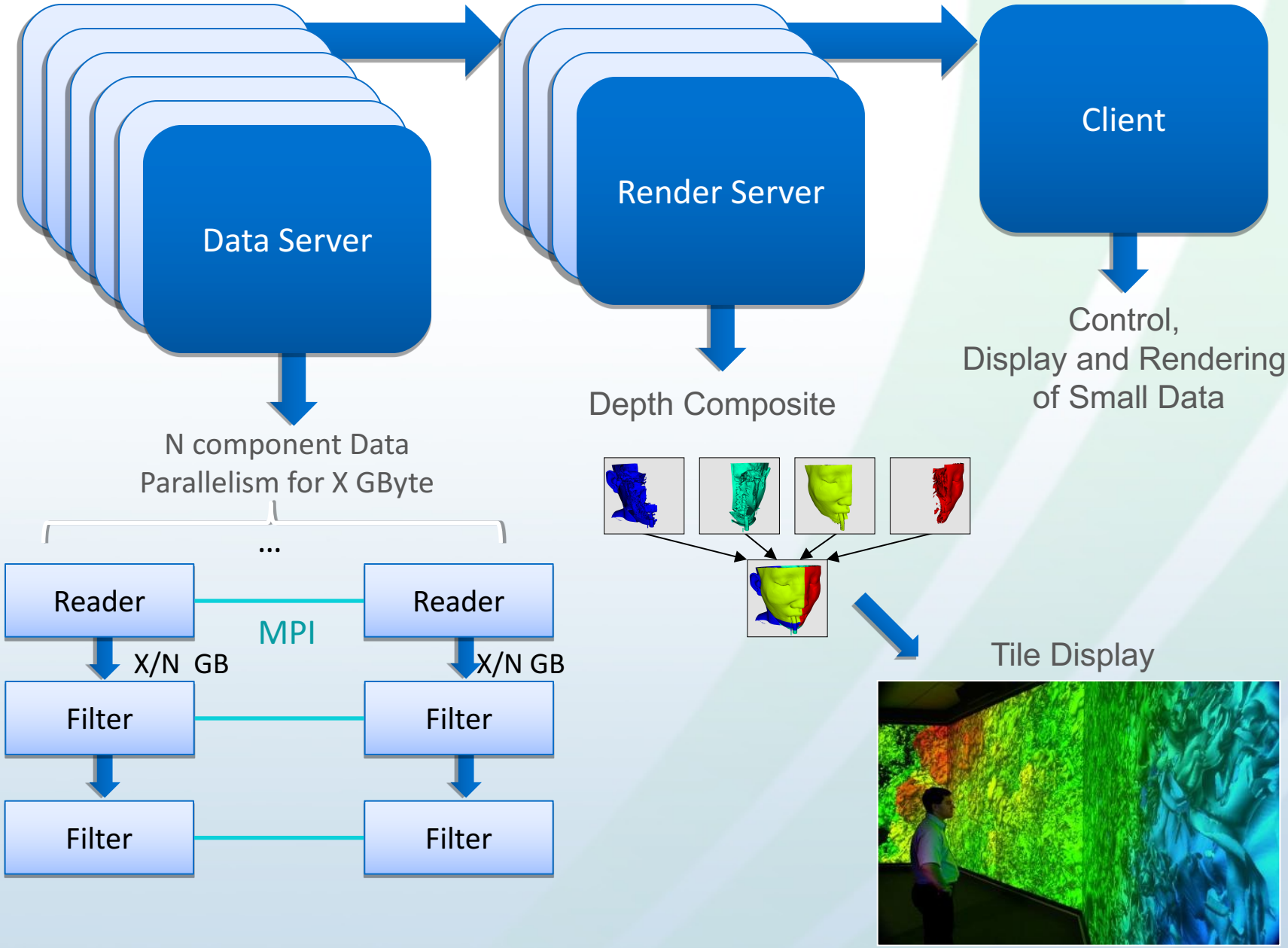
1 billion cell asteroid
detonation simulation



1 billion cell
weather simulation

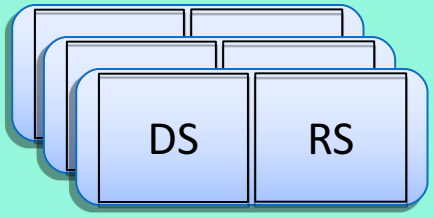
source: Sandia National Lab

Kitware


Data Server
Render Server
Client
Control,
Display and Rendering
of Small Data
Depth Composite
N component Data
Parallelism for X GByte
...
Reader
Reader
MPI
X/N GB
X/N GB
Filter
Filter
Filter
Filter
Tile Display

ParaView's Running Modes

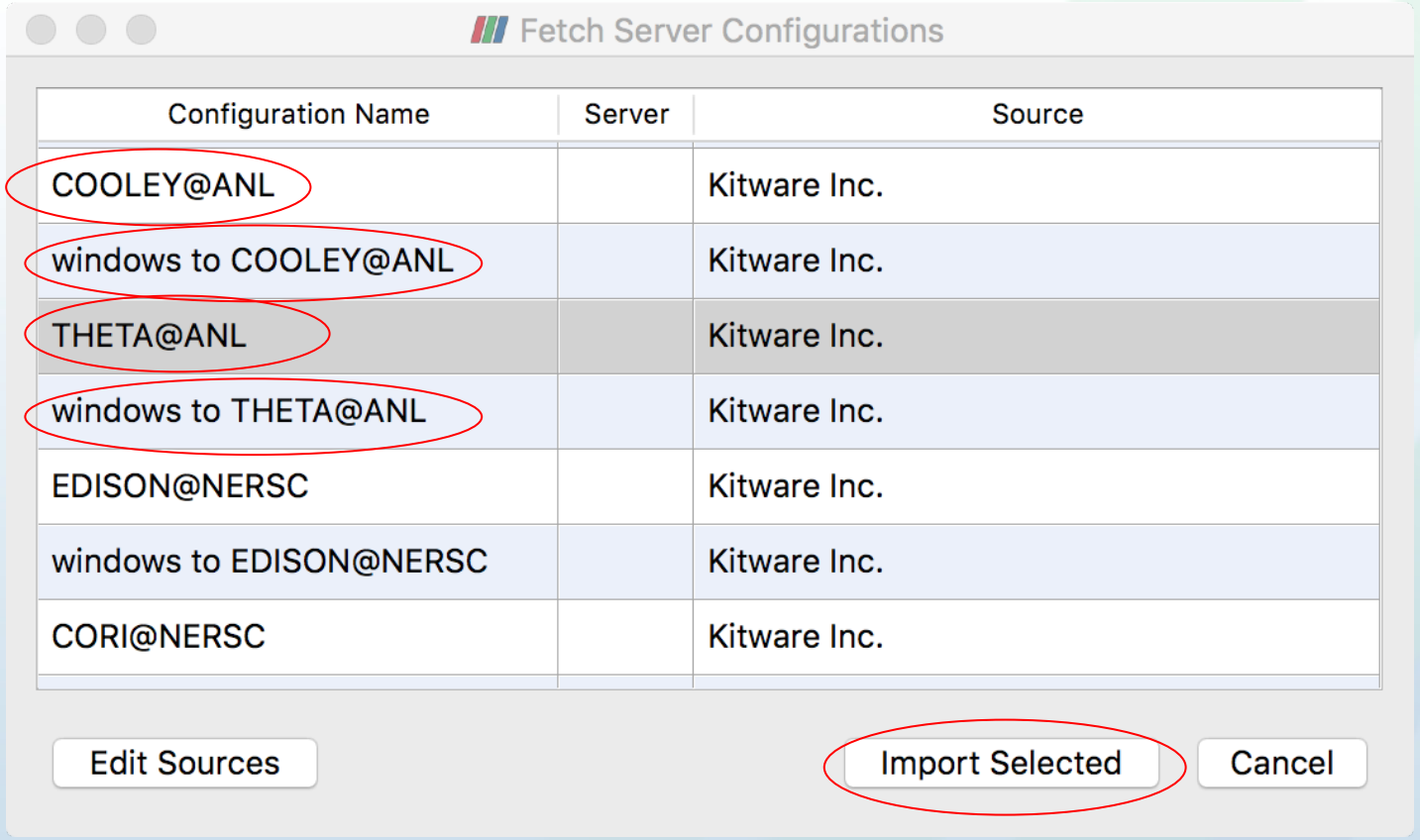
Builtin aka Standalone aka Serial		all components within one process (client may be GUI or pvpython) `paraview || pvpython`
Combined Server		data processing and parallel rendering in MPI job of combined processes. control from TCP connected client. `mpiexec -n x pvserver &; paraview #` or `pvpython  #+ Connect`

Batch		server is an MPI job which directly runs a python script
		`mpiexec -n x pvbatch \`
		`vis_script.py`

DS = data server
RS = render server

Fetch Server Configuration

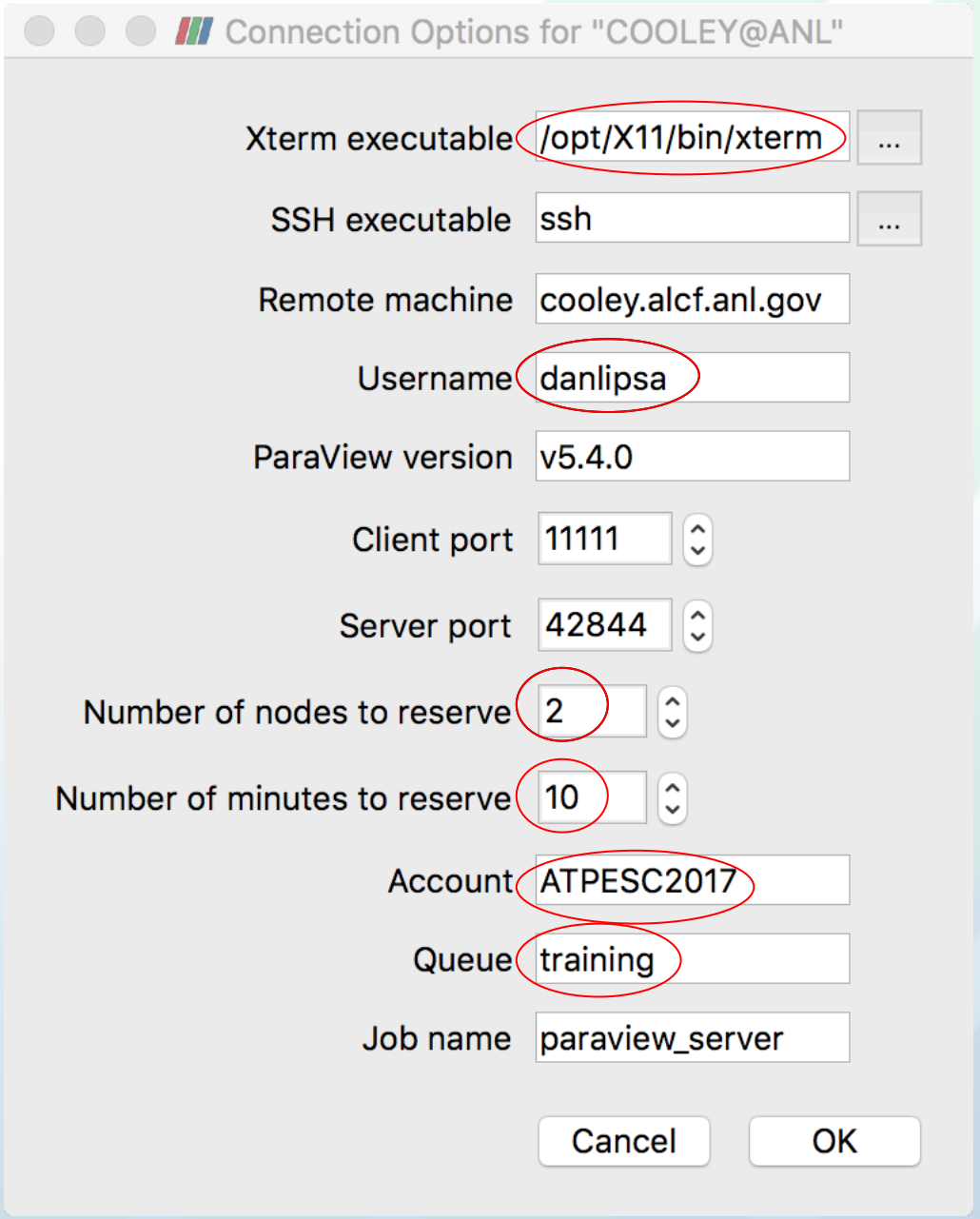
- File > Connect > Fetch Servers



Kitware

Connect

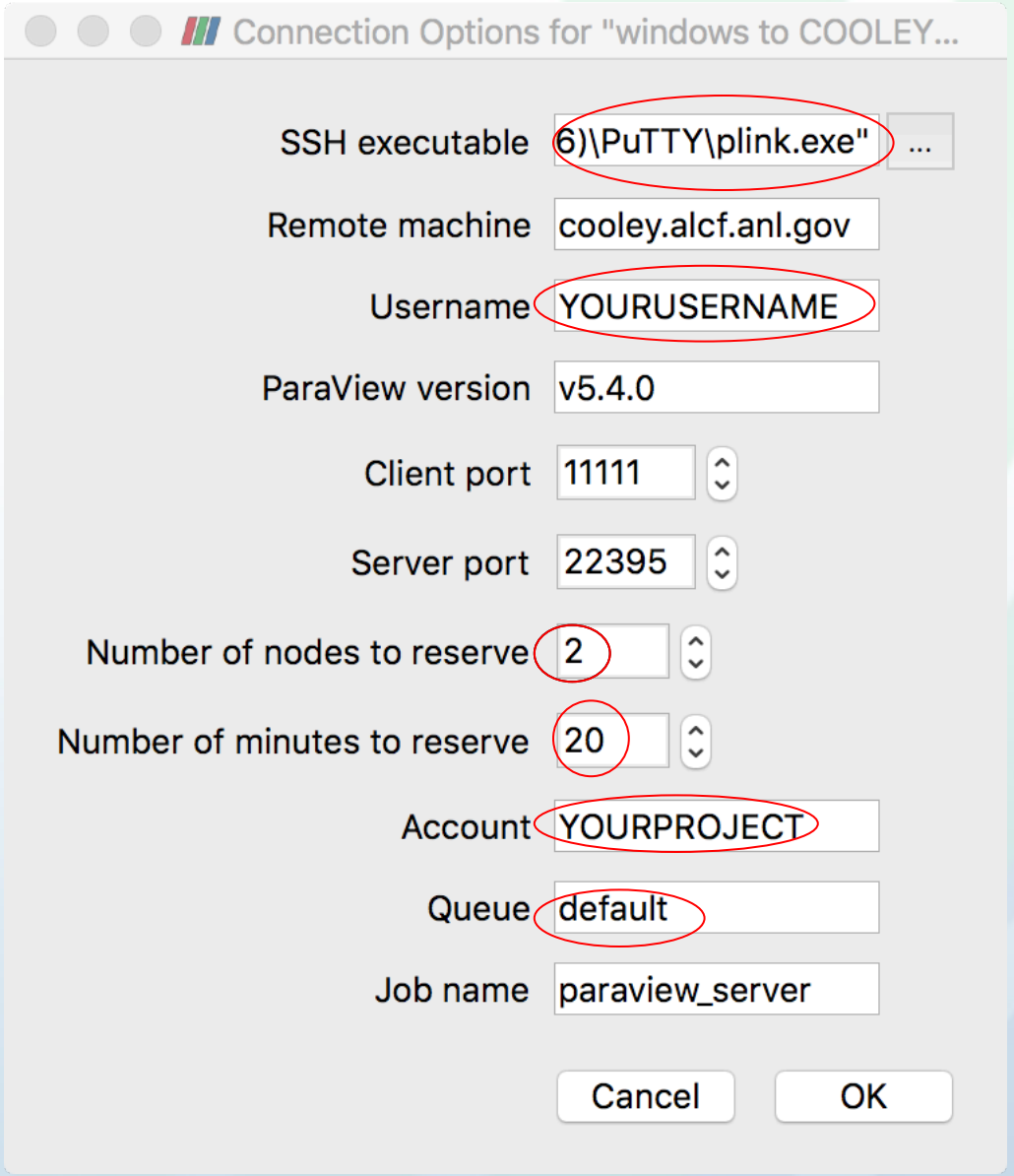
Mac Os: Install Xquartz



Kitware

Connect

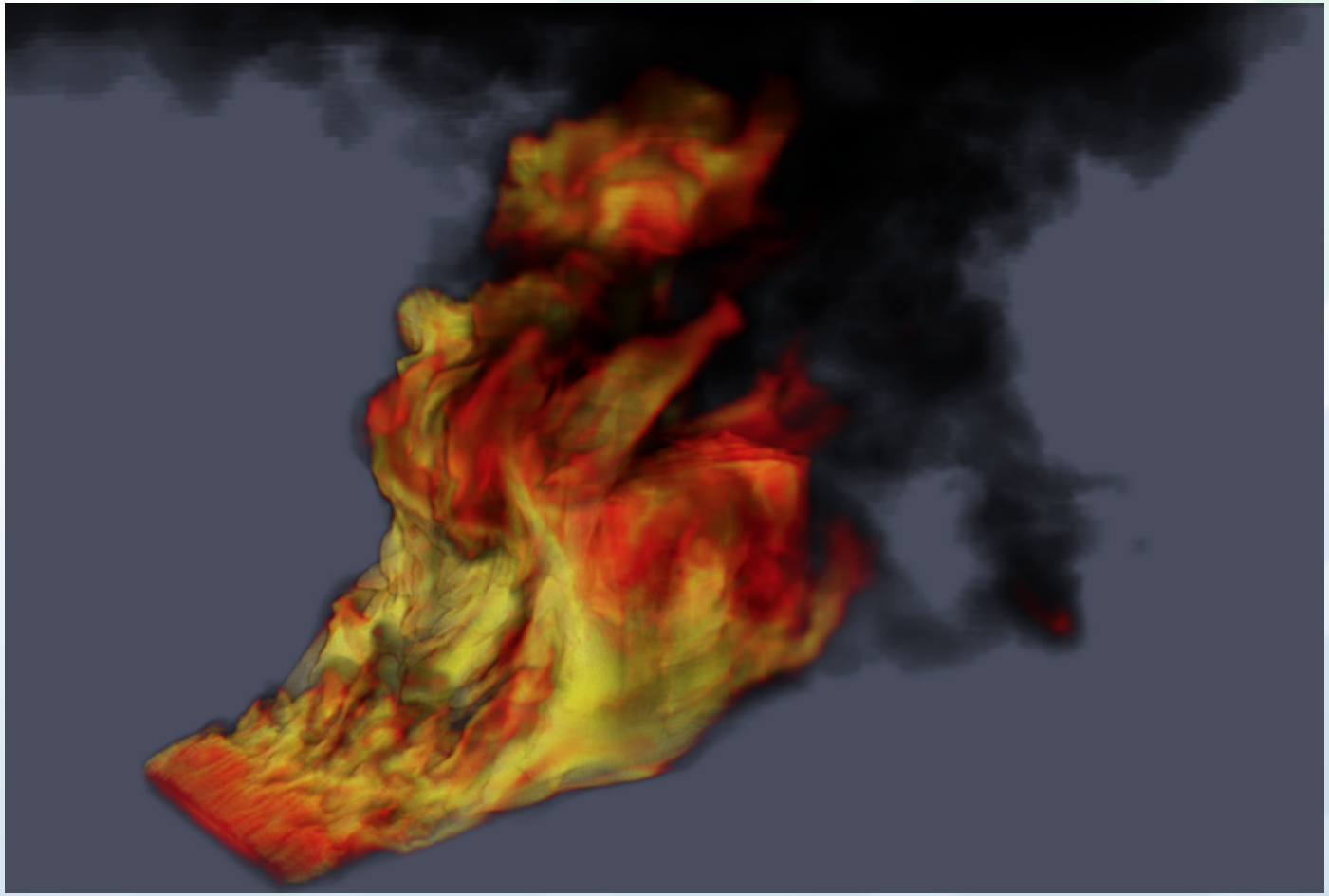
Windows: Install PuTTY



Kitware

ParaView Tutorial

Help > ParaView Tutorial
Exercises 2.1 – 2.36



Syrinx-Calore simulation with 10 million unstructured hexahedra cells. ParaView Tutorial.

Kitware