Data visualization with Paraview

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The workshop will span over 2 days

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http://bit.ly/paraviewday1

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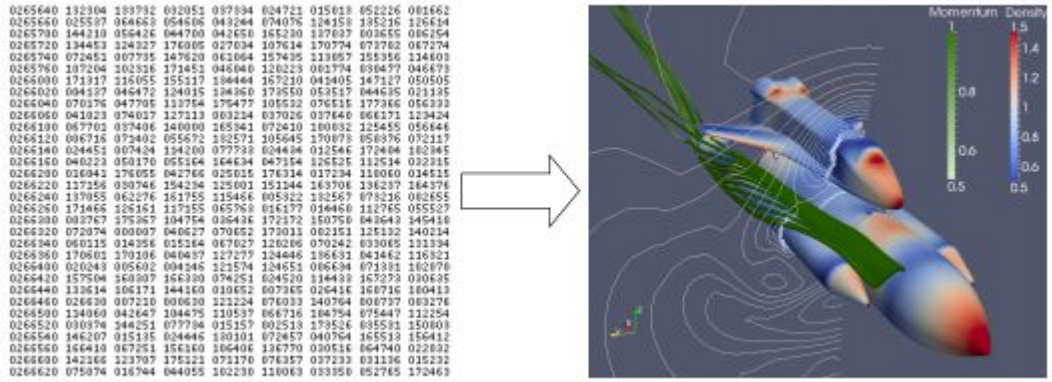
Data visualization basics

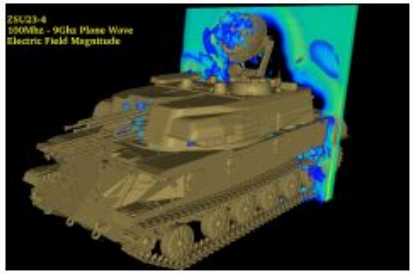
Science viz: 2D and 3D

- Simulations, measured data, etc.
- Raw data -> conversion -> human-readable data

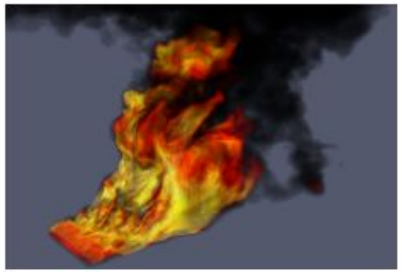


Data viz: 3 steps

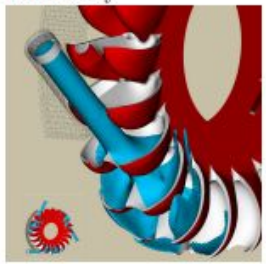
- Read data
- Modify data
- 2D or 3D rendering



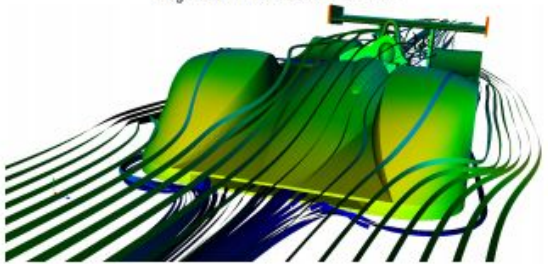
ZSU23-4 Russian Anti-Aircraft vehicle being hit by a planar wave. Image courtesy of Jerry Clarke, US Army Research Laboratory.



A loosely coupled SIERRA-Fuego-Syrinx-Calore simulation with 10 million unstructured hexahedra cells of objects-in-crosswind fire.



Simulation of a Pelton turbine. Image courtesy of the Swiss National Supercomputing Centre



Airflow around a Le Mans Race car. Image courtesy of Renato N. Elias, NACAD/COPPE/UFRJ, Rio de Janerio, Brazil

Data viz: 3 steps

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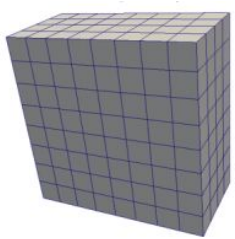
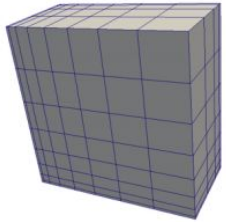
- Read (Paraview = “reader”)
- Modify (Paraview = “filters”)
- Rendering (Paraview = interactive or “writers”)

Paraview = spatial data

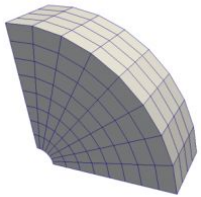
Main data type: “mesh”: not all categories are equivalent on disk



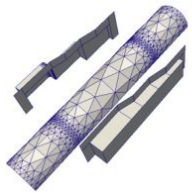
Uniform Rectilinear (Image Data)
A uniform rectilinear grid is a one- two- or three- dimensional array of data. The points are orthonormal to each other and are spaced regularly along each direction.



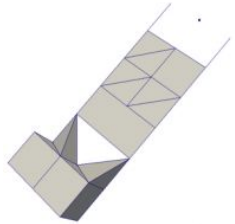
Non-uniform Rectilinear (Rectilinear Grid)
Similar to the uniform rectilinear grid except that the spacing between points may vary along each axis.



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.



Polygonal (Poly Data)
Polygonal data sets are composed of points, lines, and 2D polygons. Connections between cells can be arbitrary or non-existent. Polygonal data represents the basic rendering primitives. Any data must be converted to polygonal data before being rendered (unless volume rendering is employed), although ParaView will automatically make this conversion.



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.

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Paraview basics
1 - Reading data

Is everything ok?

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Let’s take a few seconds to fire up Paraview and make sure that everything works!

Interface (UI)

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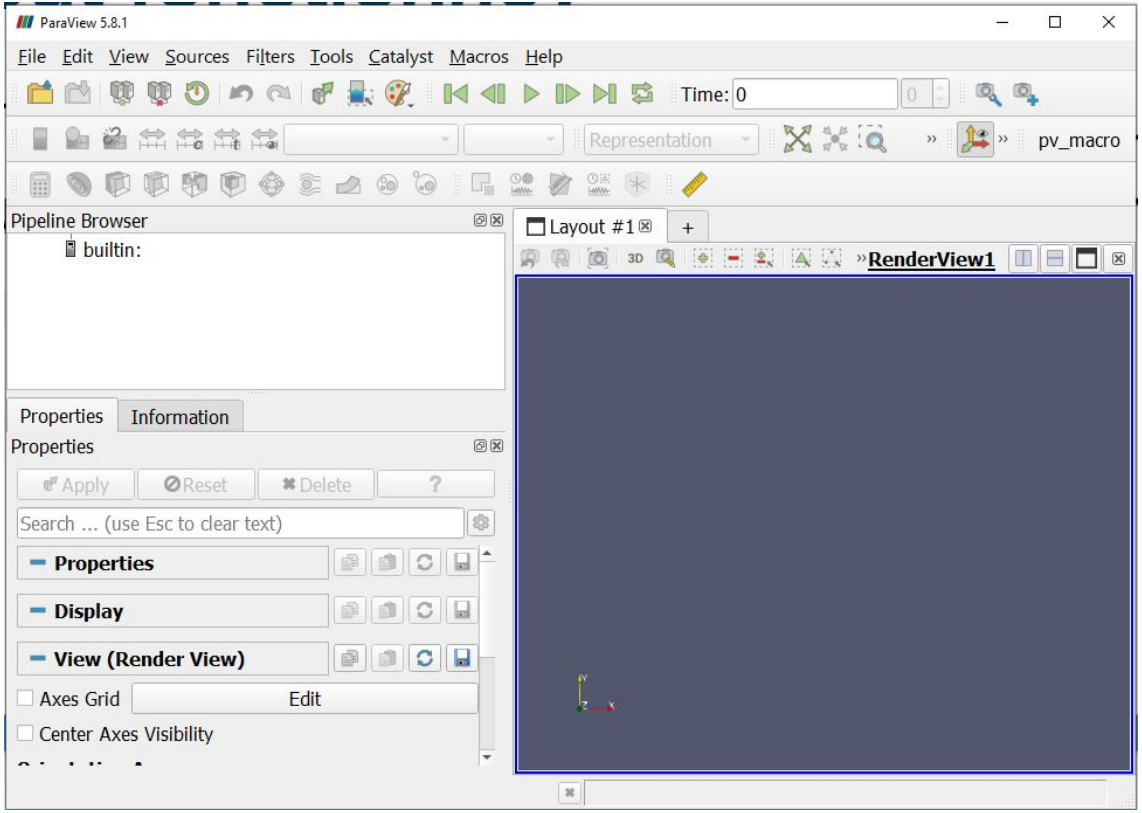
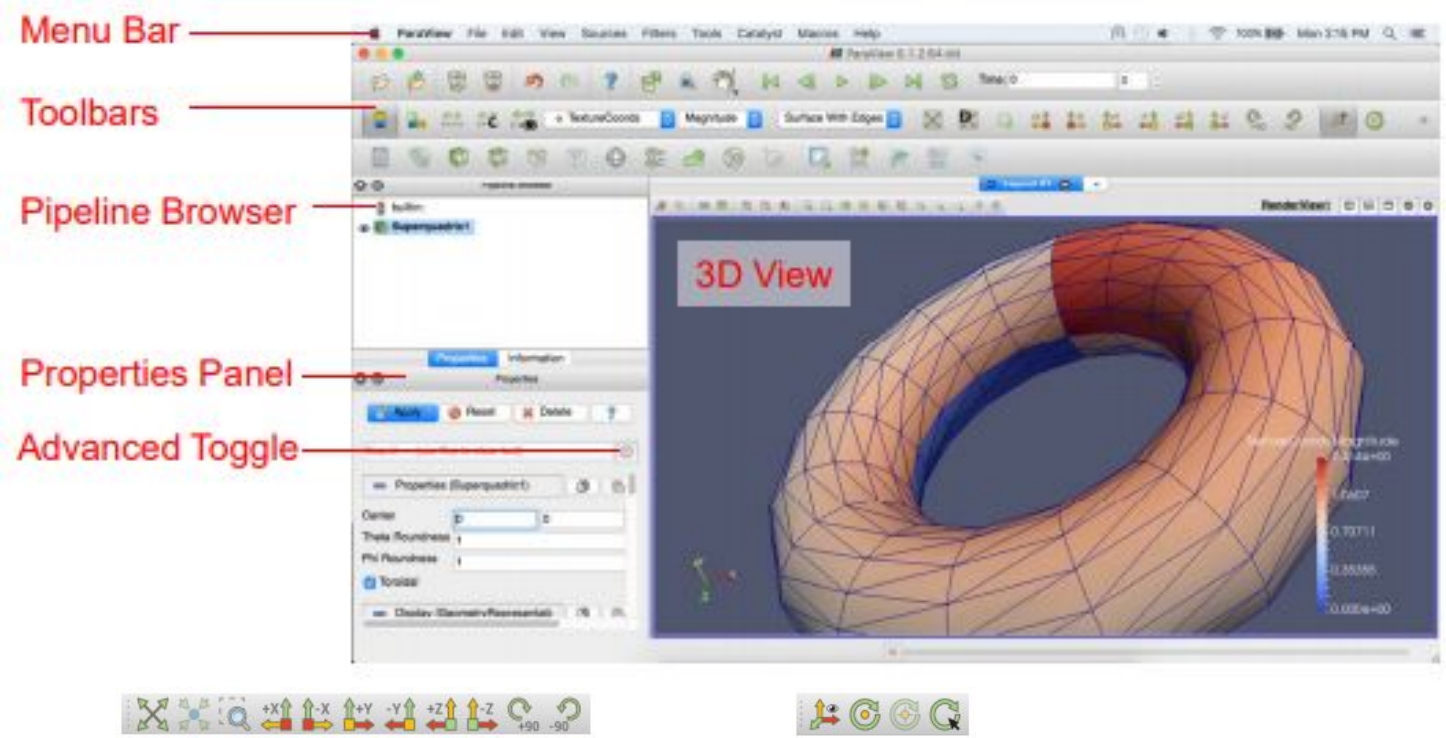
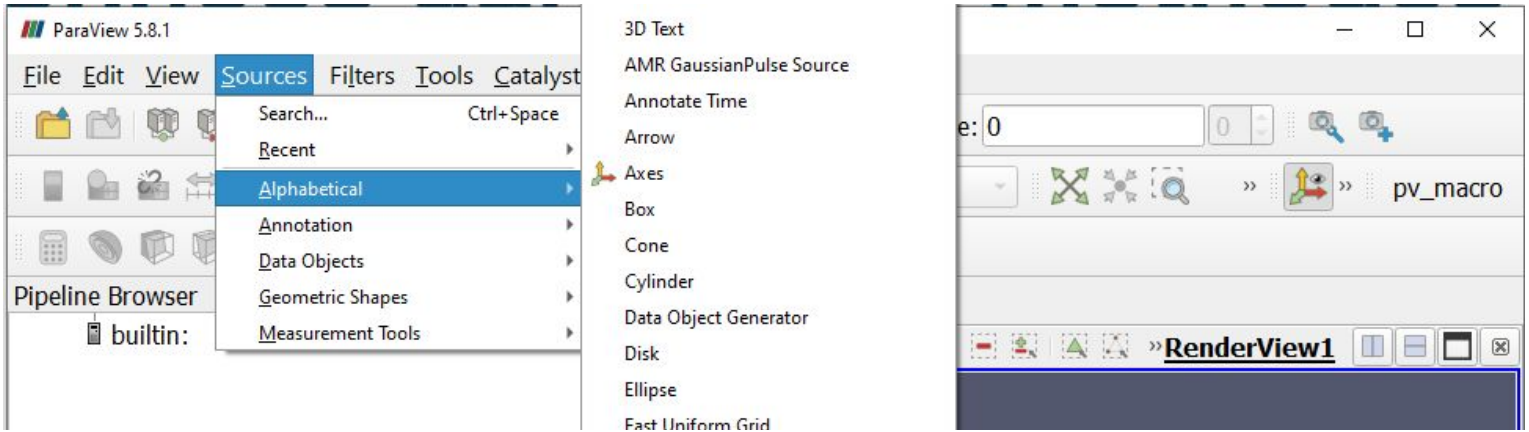


Interface (UI)



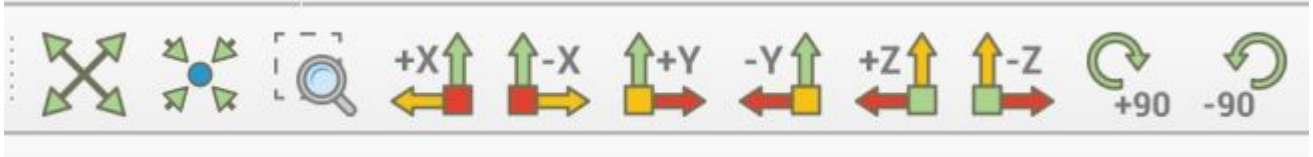
Data in PV: 2 methods

1. Create a source
   - Those are already available!

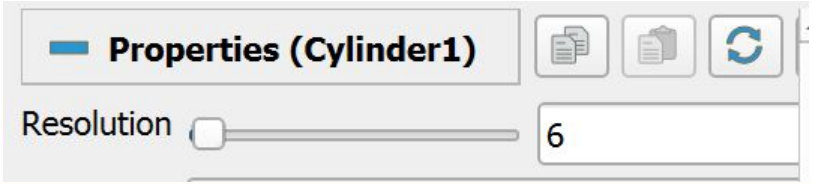


Exercise 1: sources

- Sources -> Geometric Shapes -> Cylinder
- Properties menu -> Apply
- Rotate, translate using top menu



- Change visualization parameters



Group exercise 1

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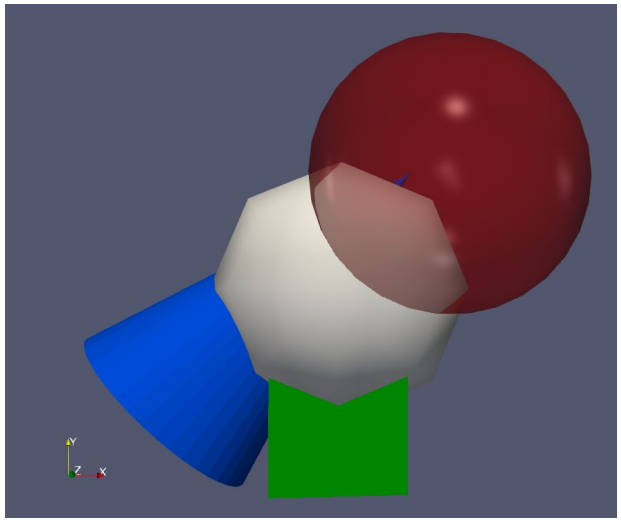
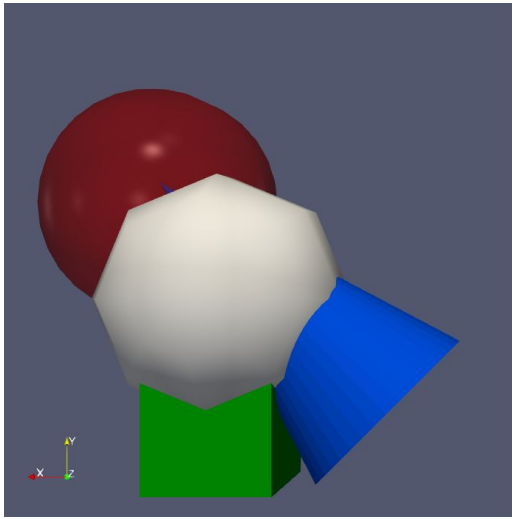
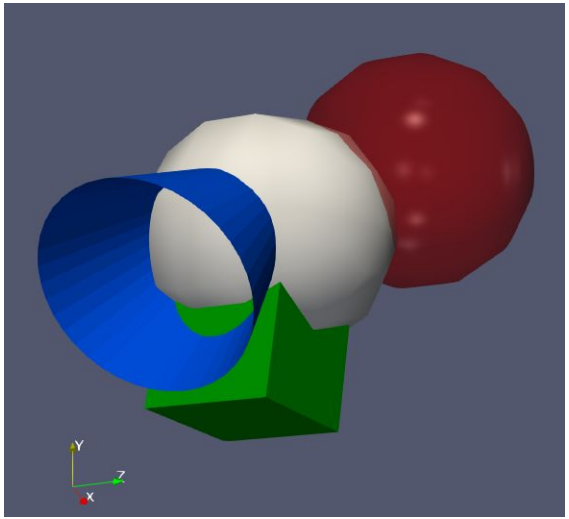
Recreate this







Data in PV: 2 methods

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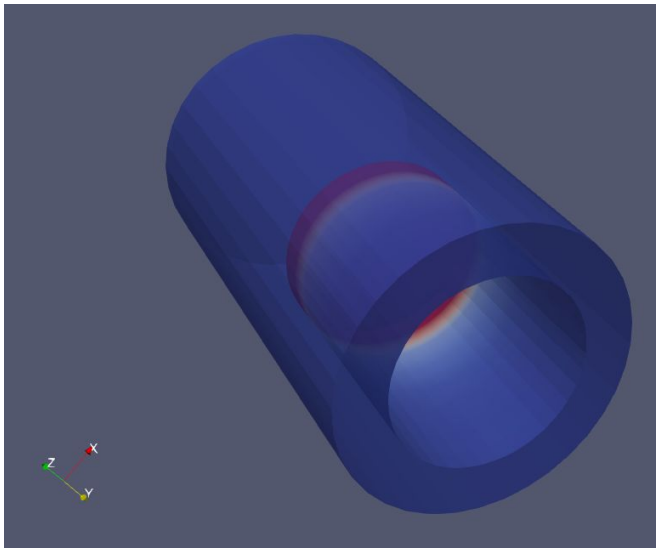
1. Create a source
   - Those are already available!
2. Read data from file
   - PV knows 200+ formats
   - Might need some additional info from you
   - PV will ask if needed

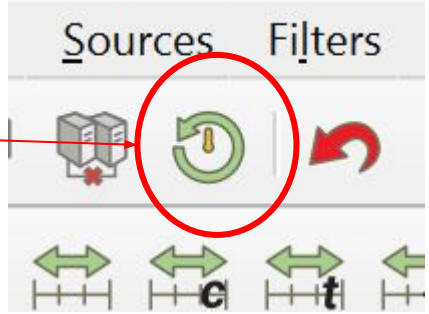
Example file: Heated disk

- .ex2 = binary file named ExodusII
- Airflow around heated disk



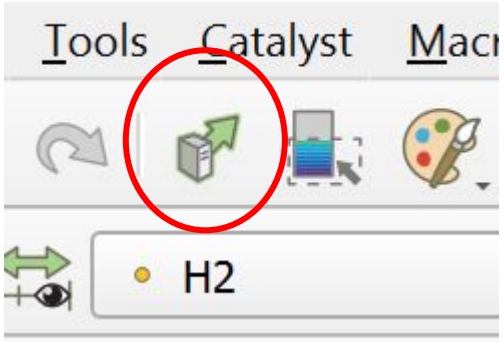
Exercise 2: “readers”

- Reset
- File -> Open -> Examples : disk_out_ref.ex2
- Check all variables -> Apply
- Modify visualization



Beware!

The auto-apply button may or may not be the death of your computer!



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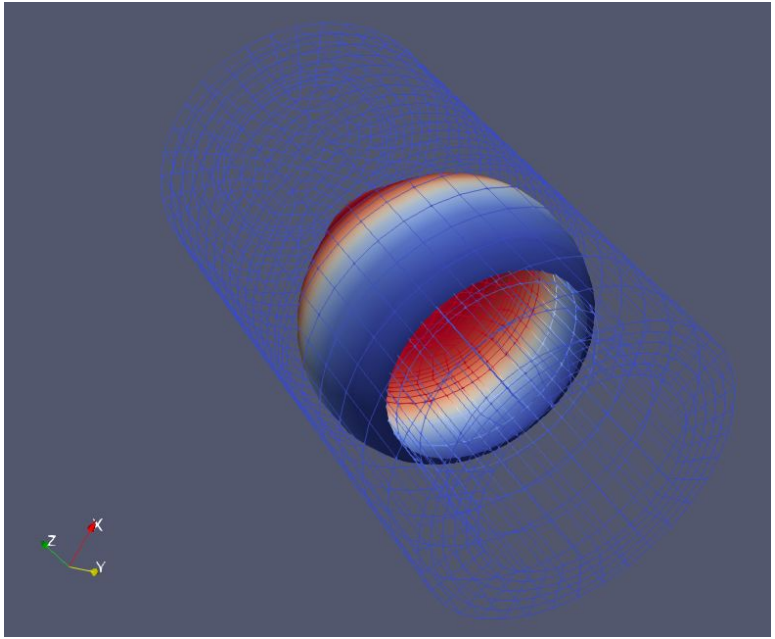
Paraview basics
2 - Filters

Filters help you understand data

- Cylinder a little boring on its own
- Complex data to visualize
- Visible info = on the surface
- Interesting info = inside (invisible)



PV: filters as objects

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- Filter= functional unit
- Modify data
  - Extract data
  - Generate new data
  - Extrapolate features...
- Attached to readers, sources, or other filters

Visualization pipeline

Many available filters

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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 **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.

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.

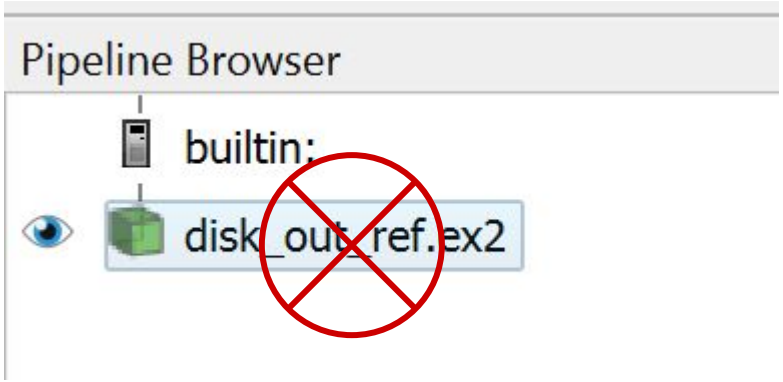
Warp (vector) Displaces each point in a mesh by a given vector field.

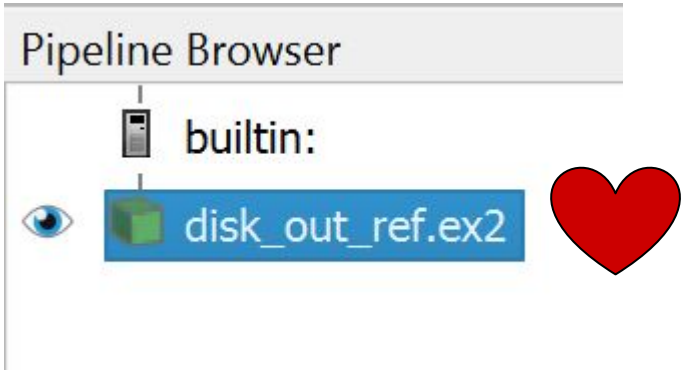
Group Datasets Combines the output of several pipeline objects into a single multi block data set.

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

Exercise 3: applying filters

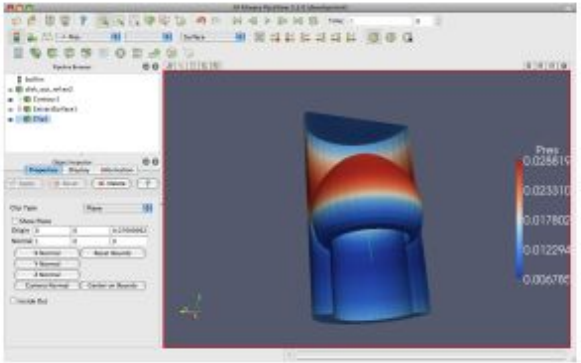
- On disk-out_ref.ex2
- Contour filter
- Modify parameters
- Inspect results

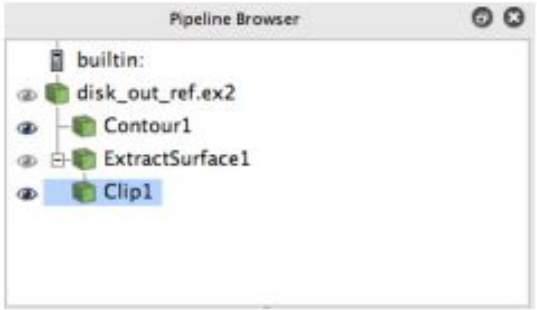


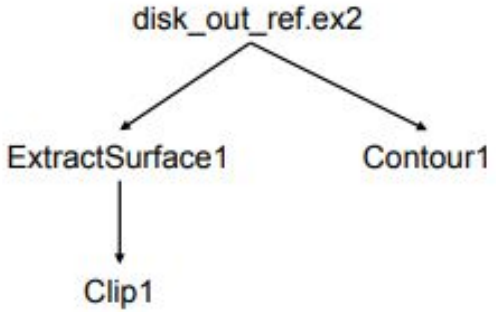


Pipeline: filter filters

- We could stick to just one filter
- But filters are of the same class as reader
  - One can apply a filter to a filter







Exercise 4: create a pipeline

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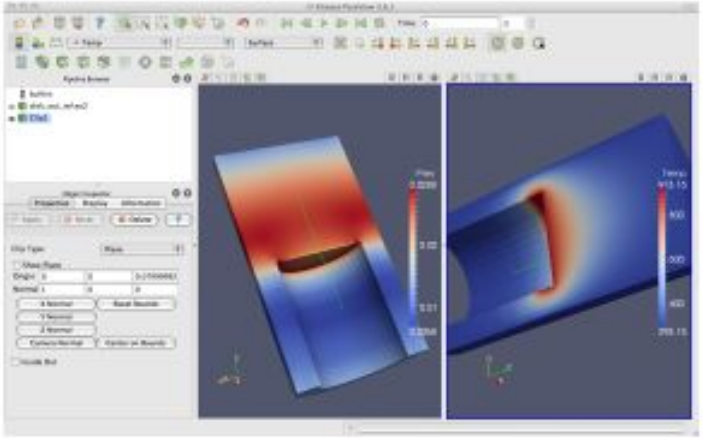
- Filter 1 : extract surface -> Apply
- Select Extract Surface 1
- Filter 2 : Clip
- Show plane: uncheck -> Apply

Multiple data = multiple views

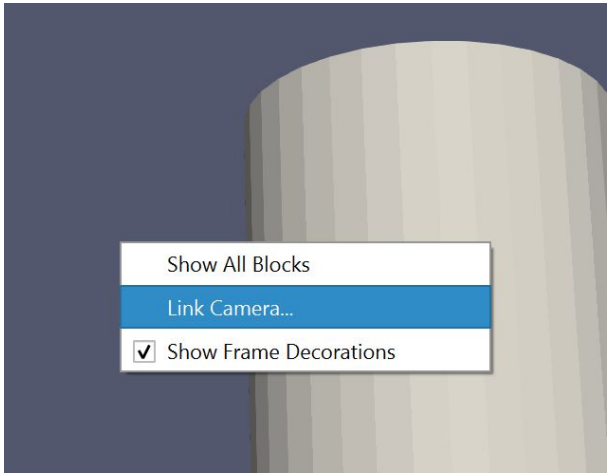
The heated disk dataset contains multiple variables, including temperature and pressure.

It is possible to visualize them side by side.



Exercise 5: Multiviews

- Top right icon 
- Select empty canvas and make clip visible
- Color: temp
- Link both cameras



Compare information for better comprehension

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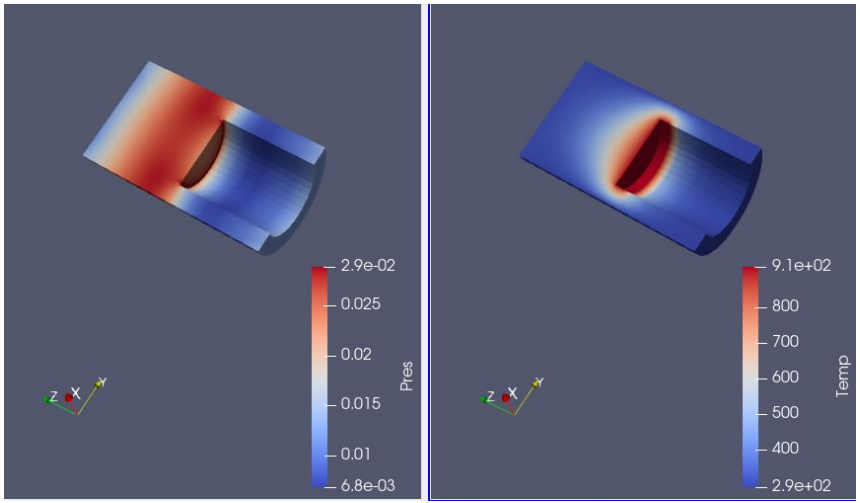
- Temp higher in front of disk
- Pressure higher at some distance
  - 2 forces in pressure:
    - Gravity
    - Air density vs temperature
  - Max pressure when 2 forces are equal



Airflow visualization = vectors

- Velocity field
- Streamlines in PV
  - Curve in space always tangent to field vector
  - Think of it as a particle always bouncing on vectors

Exercise 6: Streamlines

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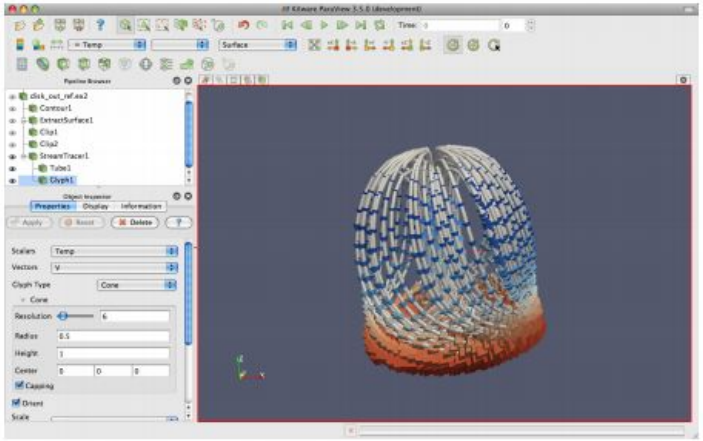
- Reset + disk_out_ref.ex2
- Filter : stream tracer filter + Seed type: point source + Show sphere unchecked
- Add direction to lines
  - filter: Tube + Apply
  - StreamTracer1
  - Filtre Glyph + type: cone + orientation array: V + scale array: V + scale factor
  - Color: temp

Easier to understand airflow

- Airflow rotates towards center of disk
  - You can display disk
- Velocity changes with temperature



Group exercise 2

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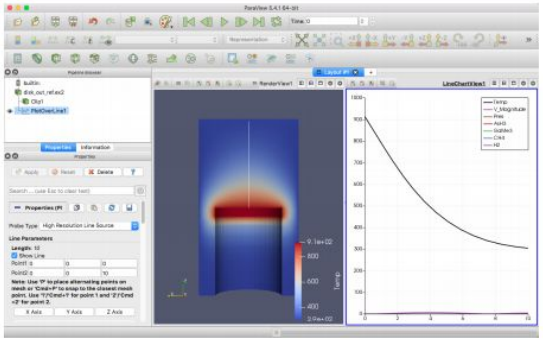
Do it again with pressure

In what direction does the disk rotate?

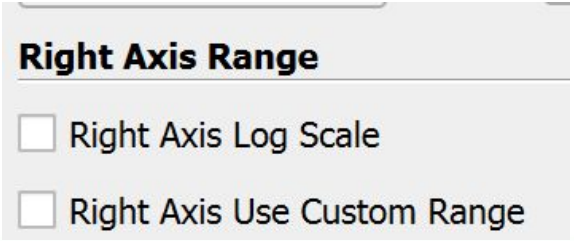
Quantitative filters, graphs

- Many qualitative filters
- Quantitative needs : e.g. graphs
  - Sub-menu “data analysis”
- 2D results



Exercise 7: graph Temp and Pres

- Reset + disk_out + clip + show plane unchecked
- Select disk_out
- Filter: plot over line
- Points (0,0,0) and (0,0,10)
- Select Temp and Pres in graph
- Pres: bleu
- Chart axes Bottom-right



Group exercise 3

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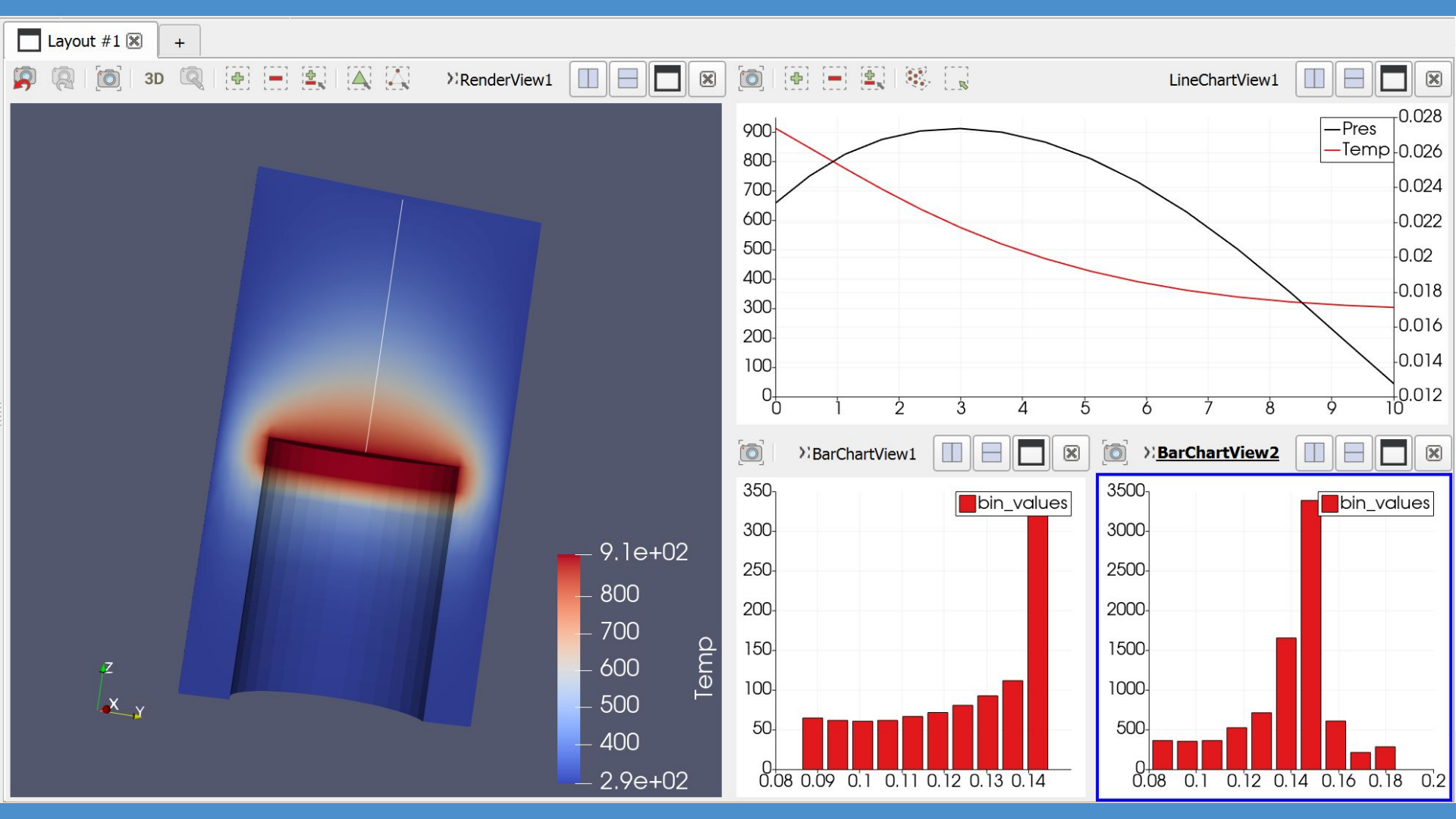
Try histogram filter

Filter on disk_out_ref.ex2 and on PlotOverLine1

How do you explain the results?


Layout #1
+
3D
RenderView1
LineChartView1
9.1e+02
800
700
600
500
400
2.9e+02
Temp
Z
X
Y
Pres
Temp
BarChartView1
BarChartView2
bin_values
bin_values

Volume rendering

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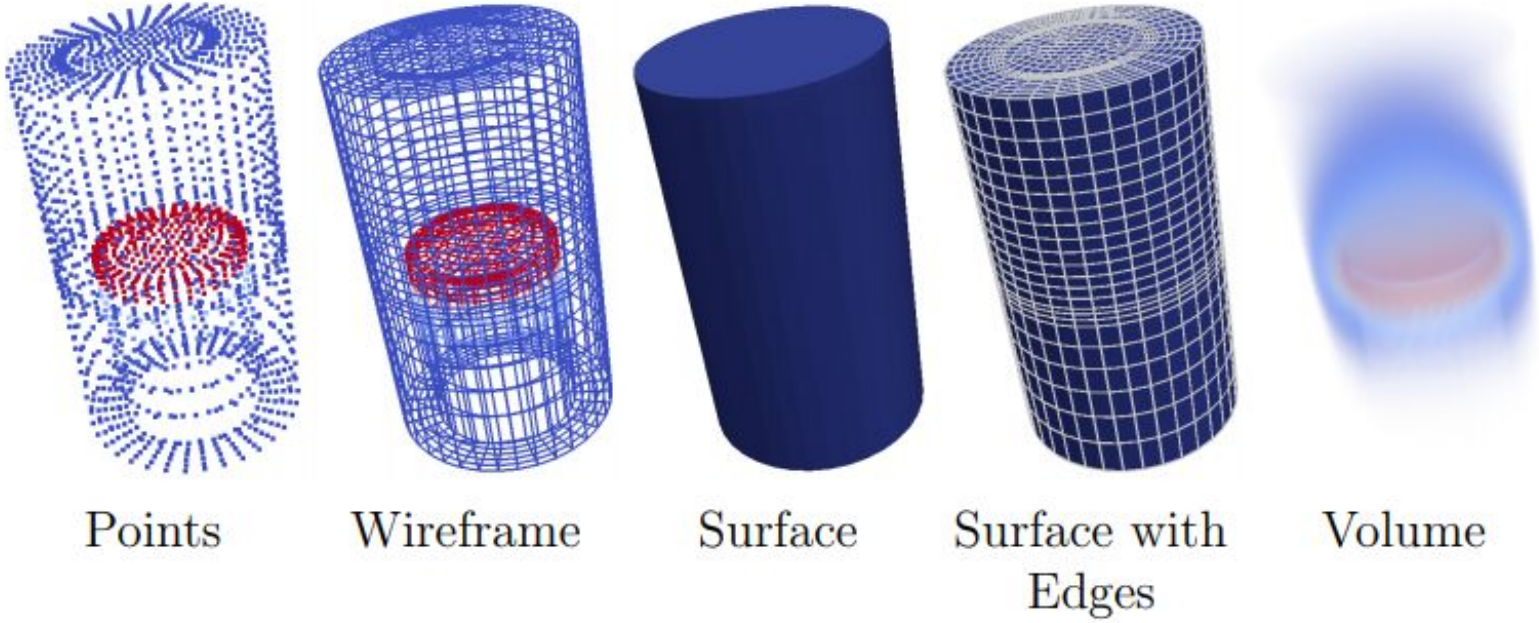
PV can render volumes many different aways



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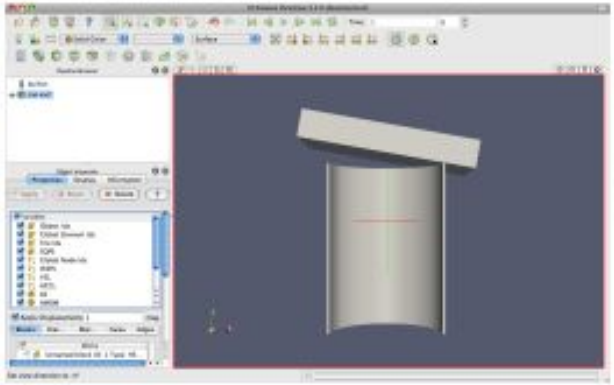
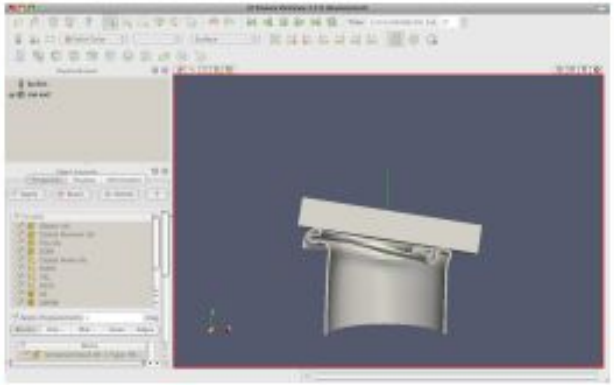
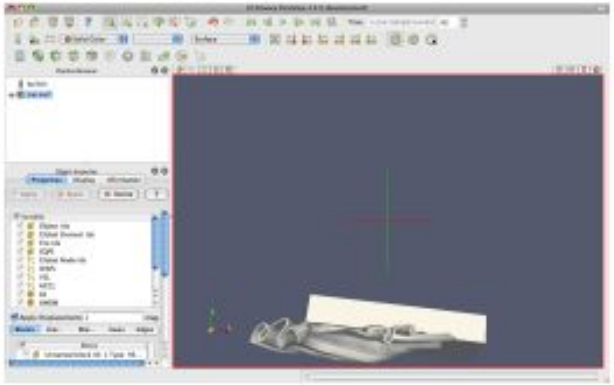
PV when data changes over time

- Heated disk data set = snapshot
- PV can analyze data that evolves with time







PV when data changes over time

- Non representative data sampling: issues with viz
  - PV tries to read the whole sequence: slow
  - PV only consider one step of time

- Beware! This could be hard on your old machine!

Exercise 9: temporal data

- Reader: can.ex2
- View - Animation view
- Camera orientation + Play
- First step
- Color: EQPS + Play
- Last step -> rescale (the last step often contains most of the range)

- Play
- Resample if needed or select “custom data range”
- Slow but ideal: “over all time steps”

Play around with time scales

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- Arbitrary video length
  - More images: “fast”, fluid
  - Fewer images: “slow”, choppy
- Lengthening video (set it to 100!)
  - Longer, fewer images, choppy
- Choppy video?:
  - Filter: temporal interpolator (try it in a split view!)

Move the camera around

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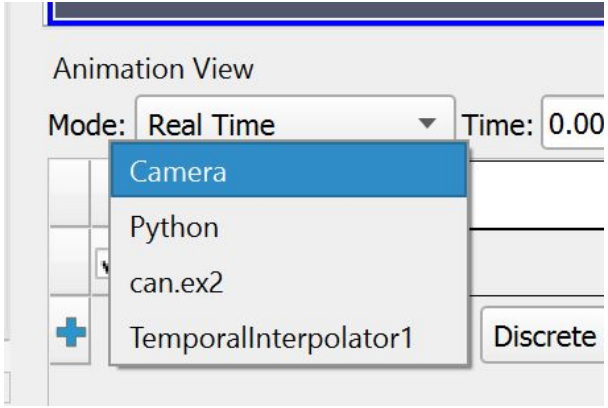
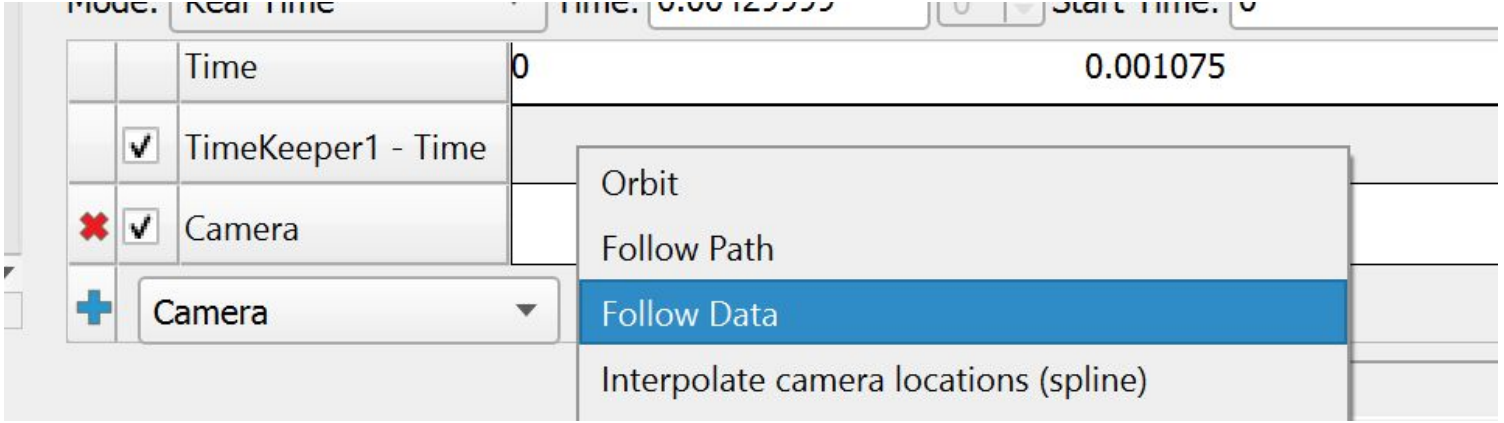
You can create custom views during an animation:

- Camera + orbit + “+”
- Play
- Double-click camera
- Edit path



Let the camera follow data



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Paraview Basics
3 - Preparing and exporting rendered images

Publishing rendered data

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- Good visualization = good message
  - Good annotations
  - Sometimes needs added descriptions
  - Good palettes: e.g. No rainbows!
  - Select appropriate format: image or video

Annotations inside PV

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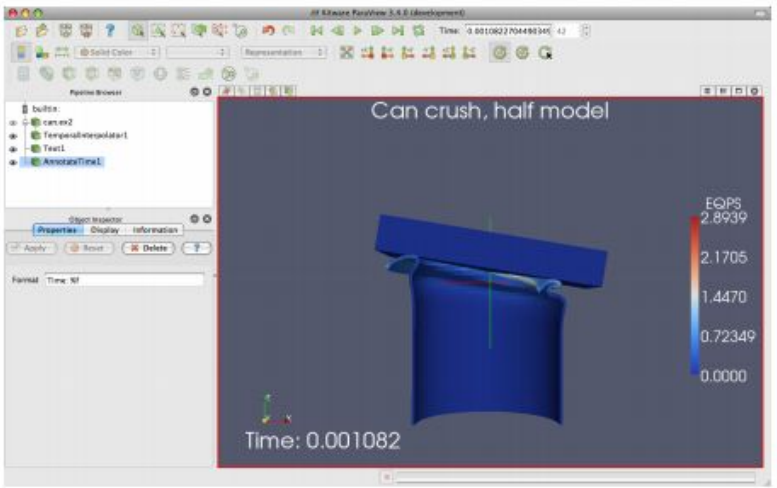
It’s possible to annotate images outside of PV but it’s best done within PV, even more if data change over time!



Exercise 10: video annotation

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- Texte - static
  - Sources -> annotations -> text + Apply
  - Choose corner
  - Lower left corner + mouse
- Time - dynamic
  - Sources -> annotation -> annotate time + Apply
  - Play

Saving files

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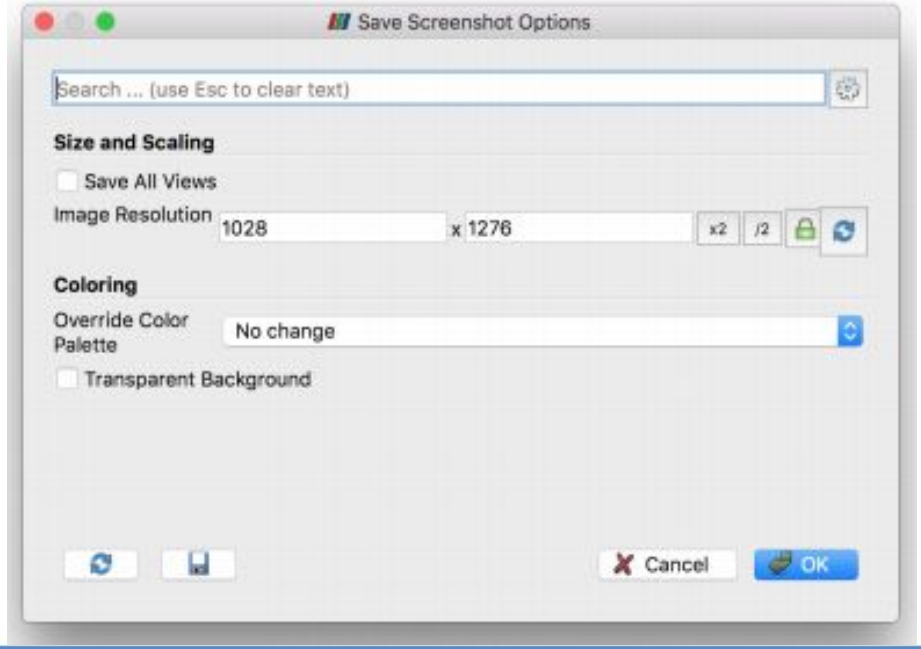
Pretty similar when saving images or videos



Exercise 11: Saving an image or a video

- Reset, can.ex2
- Recenter with +Y
- Color: GlobalNodeID
- Saving image
  - File -> save screenshot
  - Coloring: to ignore palette, change background color, add transparency.
- Saving video
  - File -> save animation
  - Avi = low quality
  - OGV: open source
  - Flipbook: do that inside an empty folder!

Annotating and saving selected parts

You can only annotated a region of interest

- Specific annotation
- Tracking of the region of interest in the video
- Analyzes on ROI, etc.