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# **Elmer** Post-processing utilities

ElmerTeam CSC – IT Center for Science

#### **Visualization capabilities of Elmer suite**

ElmerPost is basically ok but has some limitations

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- Somewhat outdated look and feel
- Output resolution same as window resolution
- Only one view at a time
- No parallel functionality
- Limited feature list compared to Paraview
- Currently building challenges
- VTK-widget in ElmerGUI
  - Minimalistic visualization mimicing ElmerPost functioality
- Visualization tools beyond Elmer suite as mainly used
  - Paraview!

### Visualization tools – Poll (3/2014)

#### What visualization software do you use?

You may select up to 10 options ElmerPost 12 18% 11% ElmerGUI VTK postprocessor 1 7 Paraview 41% 27 ViSit 5% - 3 0 No votes Mayavi Gmsh 2 3% GiD 1 2% 8% Matlab 5 gnuplot 4 6% 8% Something else (please specify) 5 Total votes : 66 Submit vote

#### **Exporting 2D/3D data: ResultOutputSolve**



- Apart from saving the results in .ep format it is possible to use other postprocessing tools
- ResultOutputSolve offers several formats
  - vtk: Visualization tookit legacy format
  - vtu: Visualization tookit XML format
  - Gid: GiD software from CIMNE: http://gid.cimne.upc.es
  - Gmsh: Gmsh software: http://www.geuz.org/gmsh
  - Dx: OpenDx software
- Vtu is the recommended format!
  - offers parallel data handling capabilities
  - Has binary and single precision formats for saving disk space
  - Suffix .vtu in Post File does this automatically



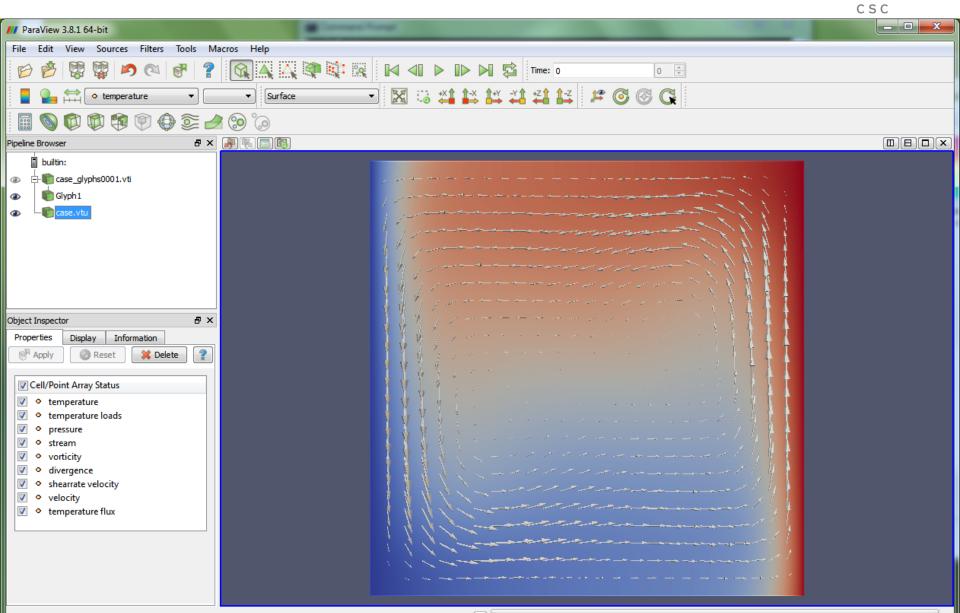
#### **Exporting 2D/3D data: ResultOutputSolve**

An example shows how to save data in unstructured XML VTK (.vtu) files to directory "results" in single precision binary format.

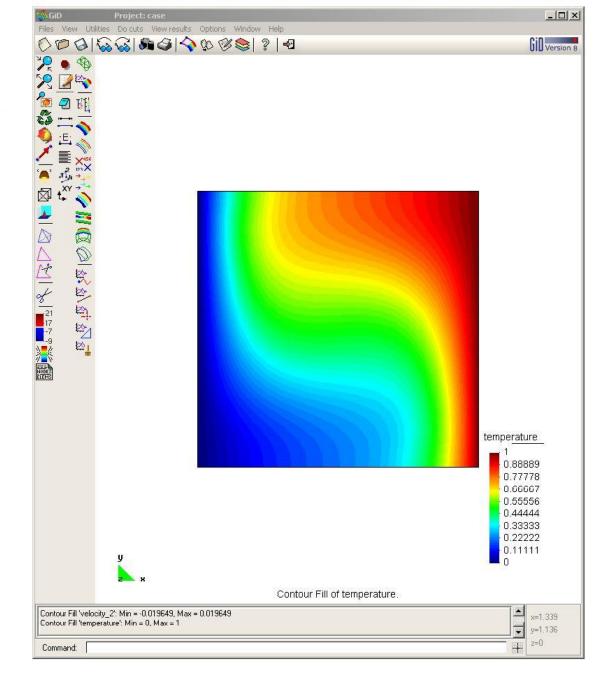
```
Solver n
Exec Solver = after timestep
Equation = "result output"
Procedure = "ResultOutputSolve" "ResultOutputSolver"
Output File Name = "case"
Output Format = String "vtu"
Binary Output = True
Single Precision = True
End
```

Basic functionality also just by adding suffix **.vtu** to the **Post File** in simulation section

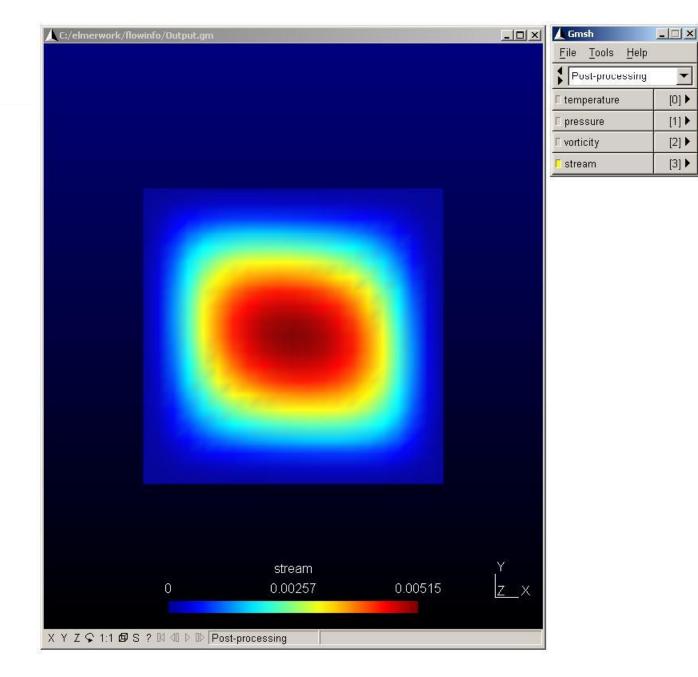
#### **Case: View in Paraview**



#### Example: view in GiD



#### Example: view in Gmsh



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[3] 🕨



### **Visualization with Paraview**

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#### **Exporting 2D/3D data: ResultOutputSolve**

By setting suffix for **Post File** to **.vtu** paraview format is saved automatically.

An example shows how to save data in unstructured XML VTK (.vtu) files to directory "results" in single precision binary format.

```
Solver n
Exec Solver = after timestep
Equation = "result output"
Procedure = "ResultOutputSolve" "ResultOutputSolver"
Output File Name = "case"
Output Format = String "vtu"
Binary Output = True
Single Precision = True
Save Geometry Ids = True
End
```

#### **Filename conventions**

- Suffix of unstructured XML based VTU file is .vtu
- Timesteps numbered #step
- Partitions numbered with #partpar#step
- Holder for vtu files in parallel is .pvtu



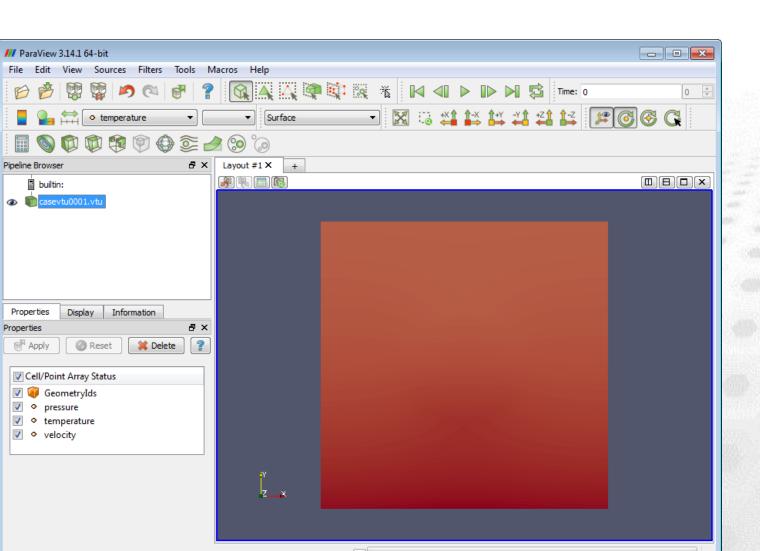
#### Loading data

/// ParaView 3.14.1 64-bit	
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Pipeline Browser           III         Open File: (open multiple files with < ctrl> key.)	
□ builtin:       Look in:       C:/elmerwrk/Viz/       ▼       ○       ○       ○	
Properties       Displat         Properties       Ei         File name:       casevtu0001.vtu         File name:       casevtu0001.vtu         File name:       casevtu0001.vtu         File name:       casevtu0001.vtu         OK       File name:       casevtu0001.vtu         OK       File name:       casevtu0001.vtu	

Note: Paraview may have several datasets at the same time!

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#### Solid color



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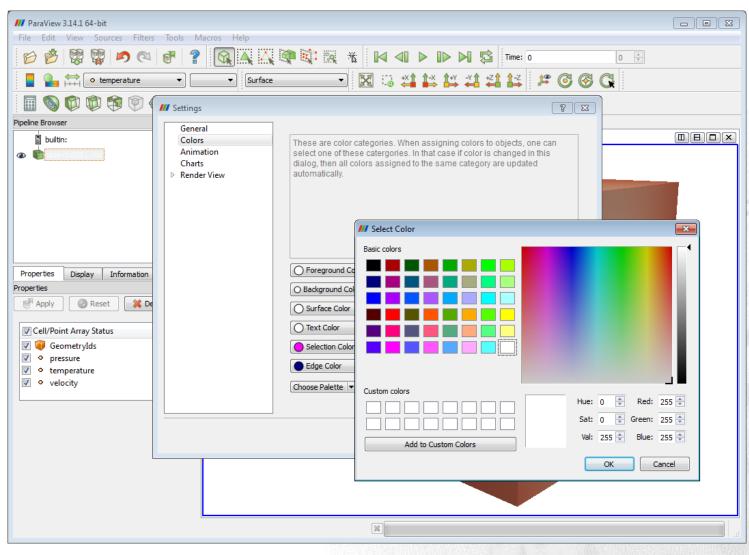
\*

#### **Moving object in Paraview**



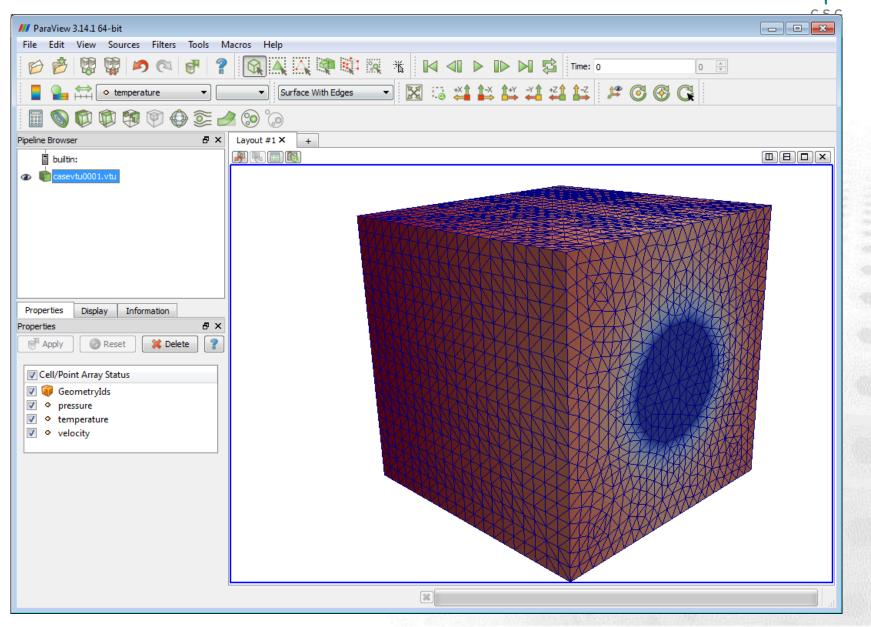
- Rotate
  - Mouse: Left bottom
- Scale
  - Mouse: Right bottom
- Translate
  - Mouse: Center bottom

#### Setting background color



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#### **Color mesh with surface + edges**



AMR Contour

AMR 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 D3

Decimate

Delaunay 2D

Delaunay 3D

**Descriptive Statistics** 

Elevation

Extract AMR Blocks

Extract Block

Extract CTH 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/SOD Halo Finder

Feature Edges

Gaussian Resampling

Generate Ids

Generate Ouadrature Points

Generate Ouadrature Scheme Dictionary

Generate Surface Normals

Glyph Glyph With Custom Source

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
- A Plot Selection Over Time Point Data to Cell Data
  - Principal Component Analysis Probe Location
  - Process Id Scalars
- { } Programmable Filter Python Calculator Quadric Clustering

Random Vectors Rectilinear Data to Point Set

Rectilinear Grid Connectivity Reflect

Resample With Dataset

Ribbon

Rotational Extrusion

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 Tetrahedralize Texture Map to Cylinder

Texture Map to Plane Texture Map to Sphere

Threshold Transform Triangle Strips

Tube

2

Warp By Scalar

2 Warp By Vector

Youngs Material Interface

builtin: case0001.pvtu Ð Connectivity1 ۲ Slice1 Glvph1

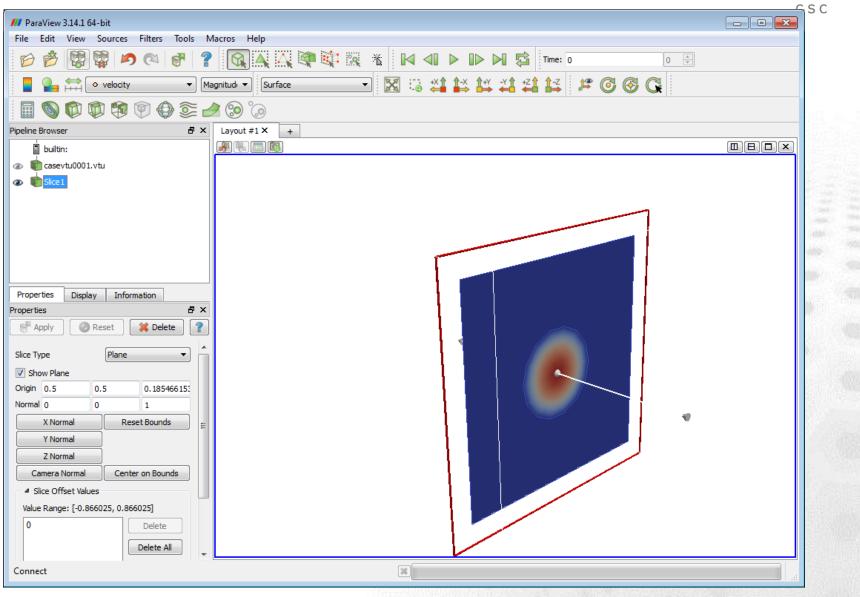


Paraview uses extensively *filters* to create new datasets

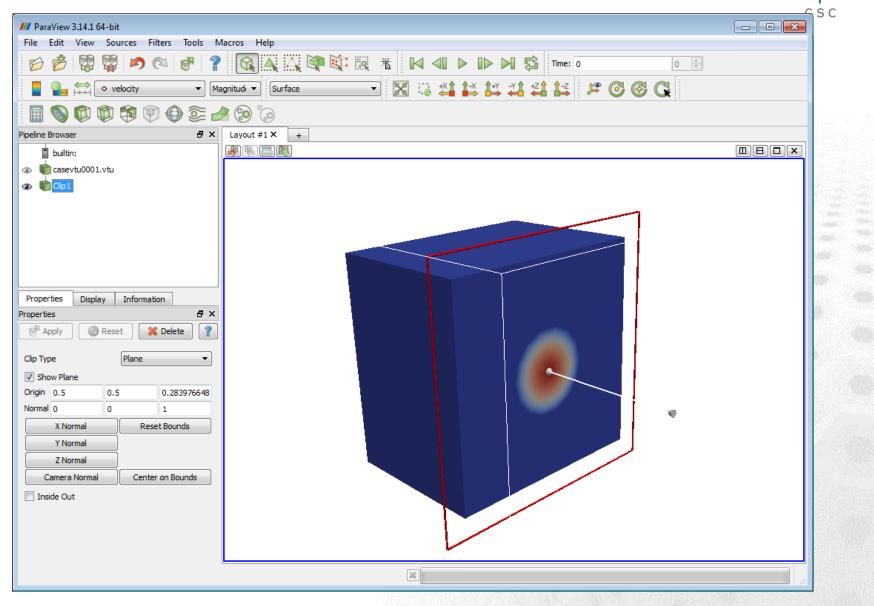
- Filters and datasets may be set active or passive by clicking the eve
- Several datasets may be visualized at the same time

Triangulate

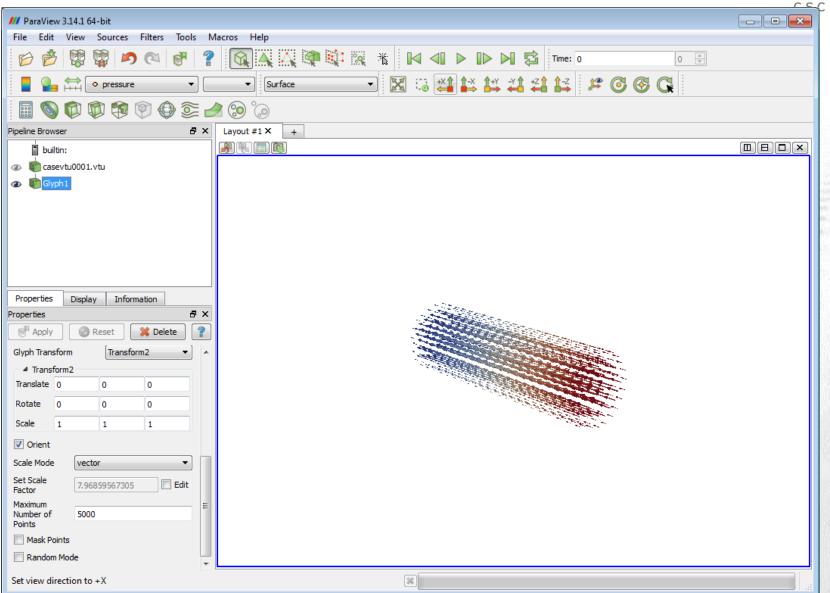
#### **Plotting a slice**



#### **Plotting a clip**



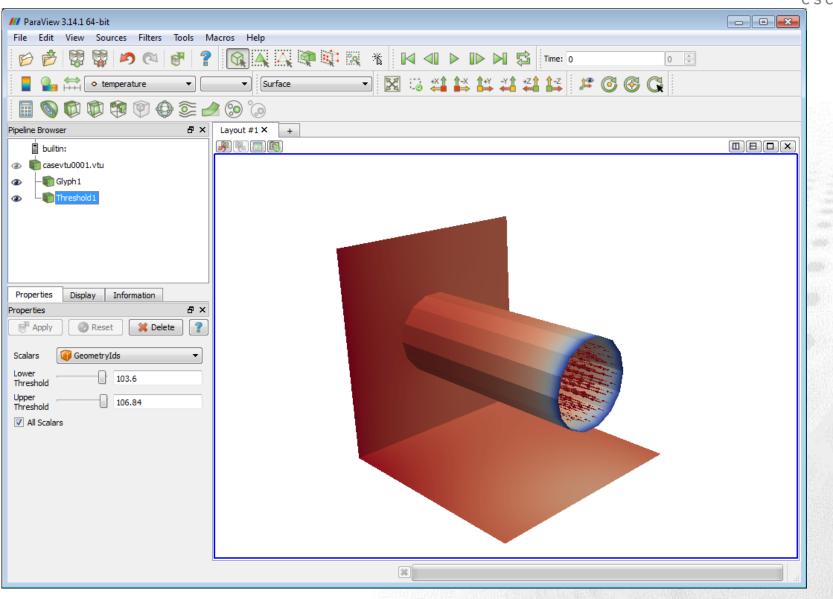
#### **Vector plot**



#### **Vector plot + opaque solid surface**

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Pipeline Browser 🗗 🗙	Layout #1 X +	
builtin: Casevtu0001.vtu Glyph1 Properties Display Information Display Style Representation Surface Interpolation Gouraud Point size 2,00 ÷ Line width 1,00 ÷ Opacity 0,10 ÷ Subdivision 1 ÷		
Edge Style		
Volume		
Volume mapper Projected tetra 🔻		

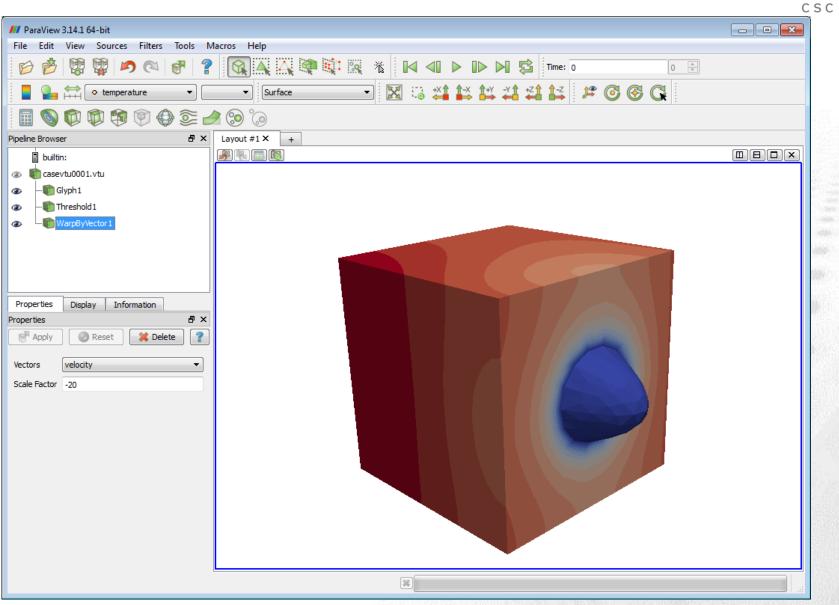
#### Vector plot + solid surface with Id treshold



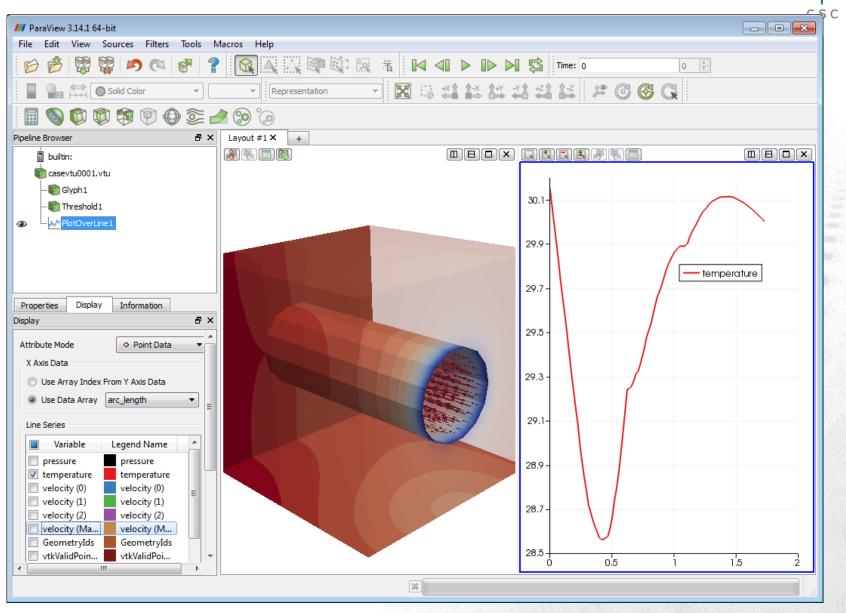
### **Change of colormap**

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/// ParaView 3.14.1 64-bit	
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Color Scale Color Legend	3 6 G
Render View Immediately Save Choose Preset	
Pipeline Brow	
Image: Object of the second secon	
Use Logarithmic Scale	
Automatically Rescale to Fit Data Range	
Minimum: 10 Maximum: 34.3139	
Rescale Range Rescale to Data Range Rescale to Temporal Range	
Use Discrete Colors	
Resolution 16	
Properties	
Display	
View	
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✓ Interpolate Scalars	1
✓ Map Scalars	r
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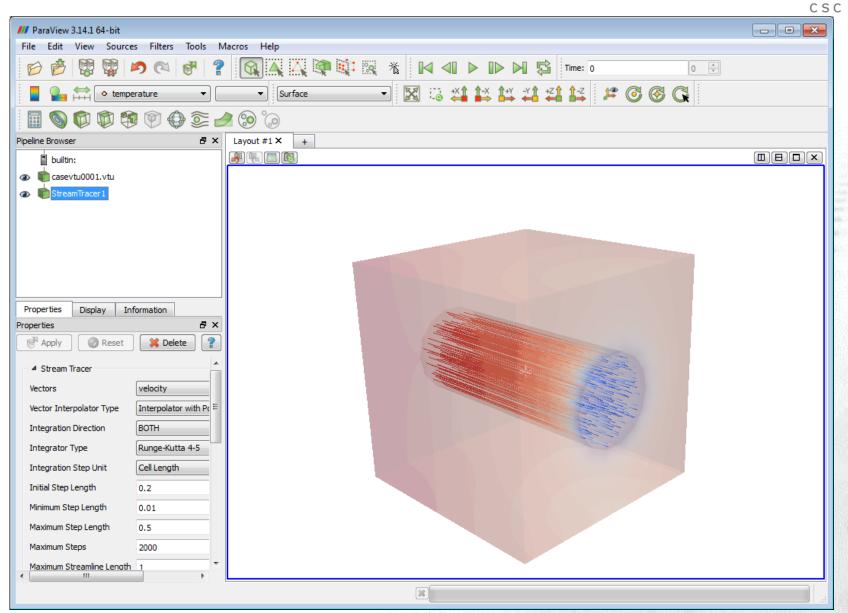
#### **Deformation – WarpByVector filter**



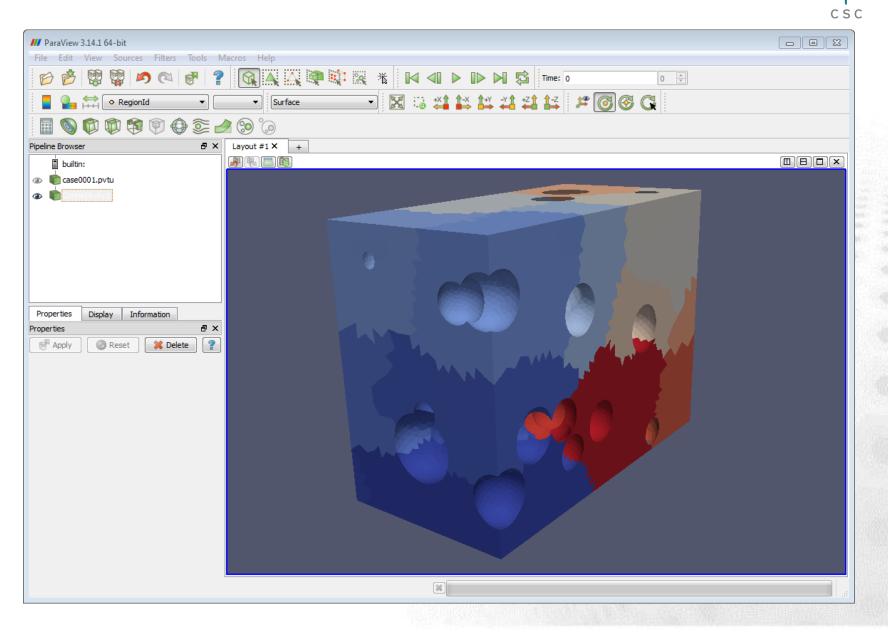
#### **Plot line – PlotOverLine filter**



#### **Streamlines – Filter StreamTracer**



#### **Partitioning – Connectivity filter**

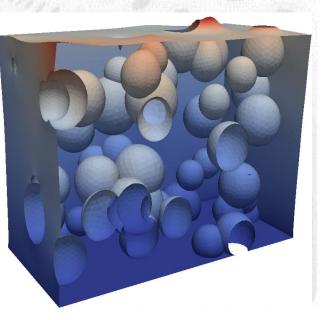


#### File size in Paraview output

- Memory consumption of vtu-files (for Paraview) was studied in the "swiss cheese" case
- Saving just boundaries in single precision binary format may save over 90% in files size compared to full data in ascii
- With larger problem sizes the benefits are amplified

Binary output	Single Prec.	Only bound.	Bytes/ node
-	Х	-	376.0
Х	-	-	236.5
Х	Х	-	184.5
Х	-	Х	67.2
Х	Х	Х	38.5

Simulation Peter Råback, CSC, 2012.



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### **Saving figures**

Image: ParaView 3.14.1 64-bit         File       Edit       View       Sources       Filters       Tools       Macros       Help         Image: ParaView 3.14.1 64-bit       Image: ParaView 3.14.1 64-bit       Image: ParaView 3.14.1 64-bit       Image: ParaView 3.14.1 64-bit         Image: ParaView 3.14.1 64-bit       Image: ParaView 3.14.1 64-bit       Image: ParaView 3.14.1 64-bit       Image: ParaView 3.14.1 64-bit         Image: ParaView 3.14.1 64-bit       Image: ParaView 3.14.1 64-bit       Image: ParaView 3.14.1 64-bit       Image: ParaView 3.14.1 64-bit         Image: ParaView 3.14.1 64-bit       Image: ParaView 3.14.1 64-bit       Image: ParaView 3.14.1 64-bit       Image: ParaView 3.14.1 64-bit         Image: ParaView 3.14.1 64-bit       Image: ParaView 3.14.1 64-bit       Image: ParaView 3.14.1 64-bit       Image: ParaView 3.14.1 64-bit         Image: ParaView 3.14.1 64-bit       Image: ParaView 3.14.1 64-bit       Image: ParaView 3.14.1 64-bit       Image: ParaView 3.14.1 64-bit         Image: ParaView 3.14.1 64-bit       Image: ParaView 3.14.1 64-bit       Image: ParaView 3.14.1 64-bit       Image: ParaView 3.14.1 64-bit         Image: ParaView 3.14.1 64-bit       Image: ParaView 3.14.1 64-bit       Image: ParaView 3.14.1 64-bit       Image: ParaView 3.14.1 64-bit       Image: ParaView 3.14.1 64-bit         Image: ParaView 3.14.1 64-bit       Image: ParaView 3.14.1 64-bit       Image: ParaView 3.14.1 64-bit	
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	20

#### **Saving animations with Paraview**

- The only packing method that comes with Paraview by default is motion AVI
- It is advicable to save the animation as separate files
- You may use ElmerClips to make mpg animations of the separate png figures



## **Visualization with ElmerPost**

#### How to write files for ElmerPost

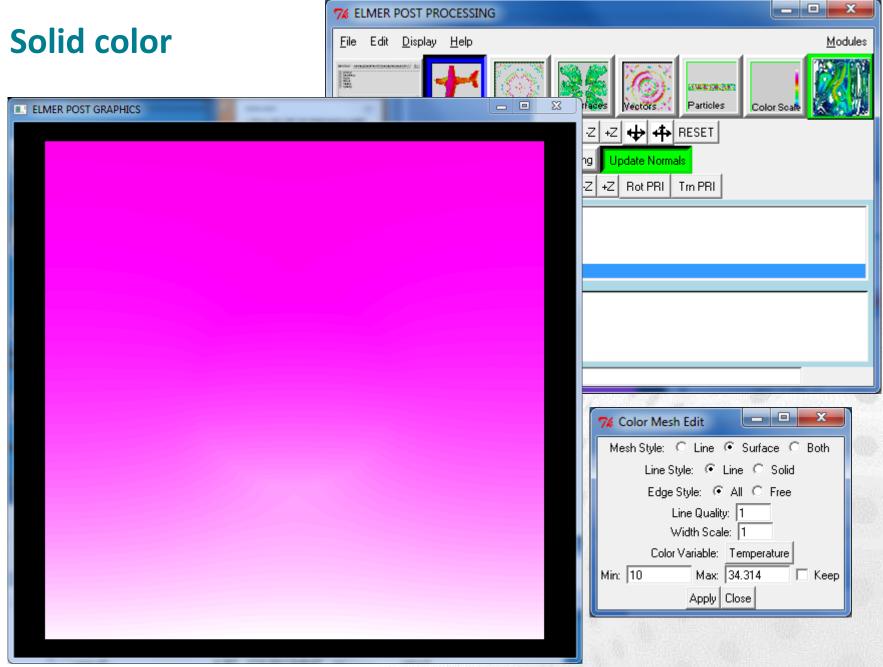
- Default suffix is .ep
- May be requested in Simulation section Post File = case.ep
- Or using ResultOutputSolver with
  Output format = ElmerPost



#### Loading data

- Assume data in case.ep
- File -> Open ->
   case.ep
- Here the timesteps are chosen
- If element edges or sides are not defined for BCs they may have to be created here

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76 Read Model File
Status: Header Read
Options:
Generate Surface Element Sides
🔲 Generate Volume Element Sides
🔲 Generate Volume Element Edges
File Information:
Nodes: 11949 Elements: 69792 Timestps: 2 DOFS: 5 Vector: Velocity Scalar: Pressure Scalar: Temperature
Select timesteps:
First: 1 Last: 1 Increment 1 All
Select file:
Model file: C:/elmerwrk/Viz/case.ep Browse
Read header Read file OK Close



#### **Moving object in ElmerPost**



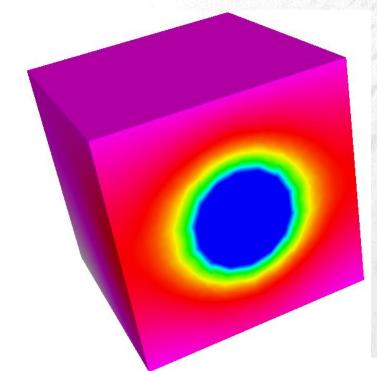
- Rotate
  - Mouse: Right bottom
  - Click:
  - Command line, e.g.: rotate 30 45 60
- Scale
  - Mouse: Both bottoms
  - Click: 🕁 🕁
  - Command line: scale 1 10 1
- Translate
  - Mouse: Left bottom
  - Click: ◄◄¥♠
  - Command line: translate 1 2 3

#### Setting background color

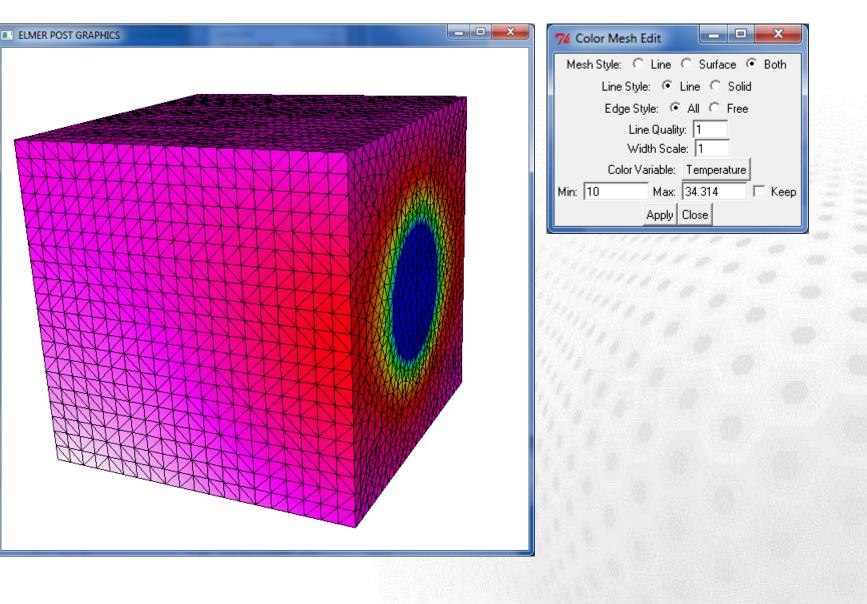
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#### Click:

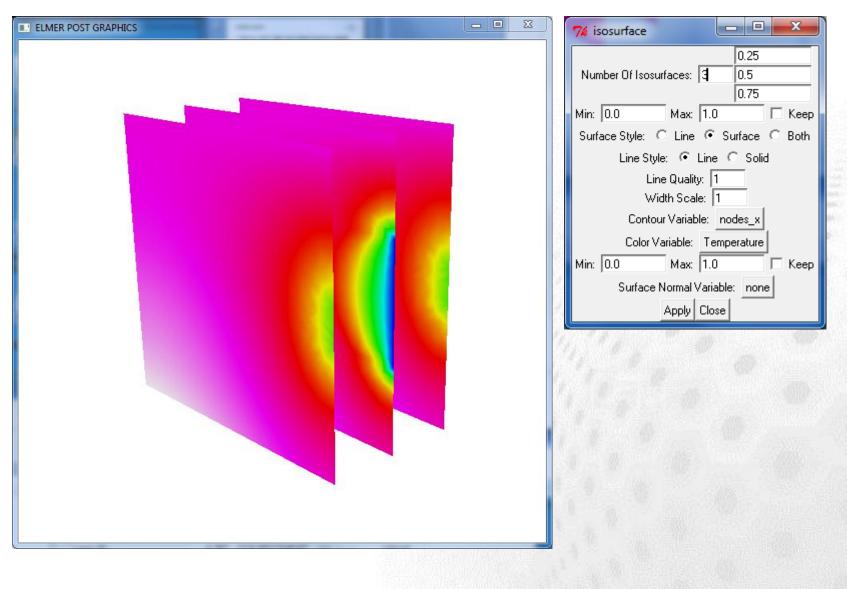
- Edit -> Background
- Set 100.0 100.0 100.0 for white
- Command line
  - background 100 100 100



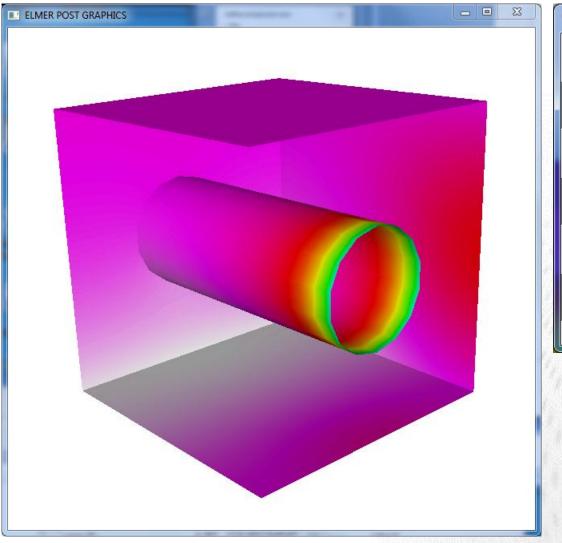
#### **Color mesh with surface + edges**



#### **Plotting isosurfaces**

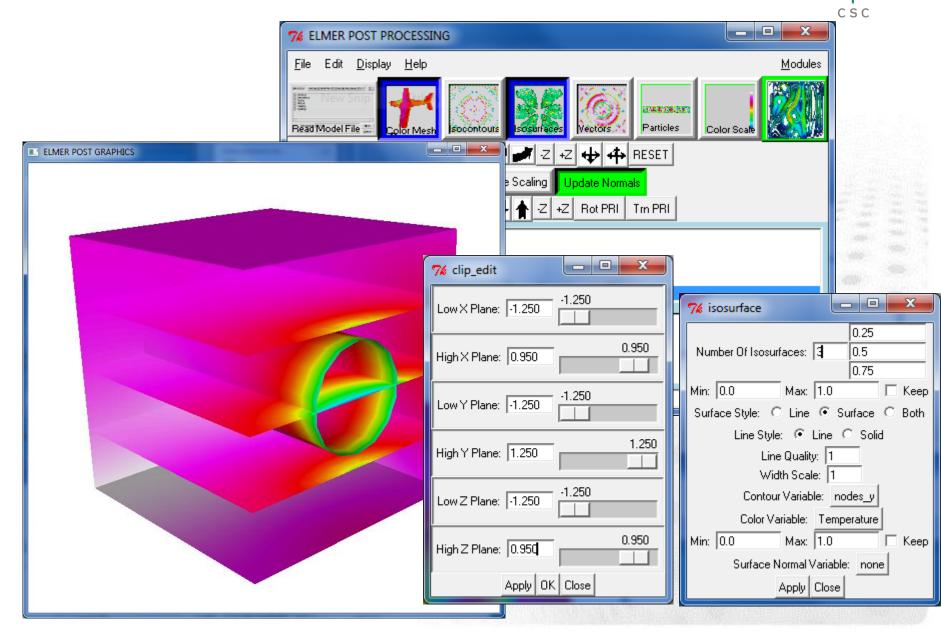


# Using clip planes



% clip_edit	_ <b>_</b> X
Low X Plane: -1.250	-1.250
High X Plane: 0.950	0.950
Low Y Plane: -1.250	-1.250
High Y Plane: 1.250	1.250
Low Z Plane: -1.250	-1.250
High Z Plane: 0.950	0.950
Apply OI	K Close

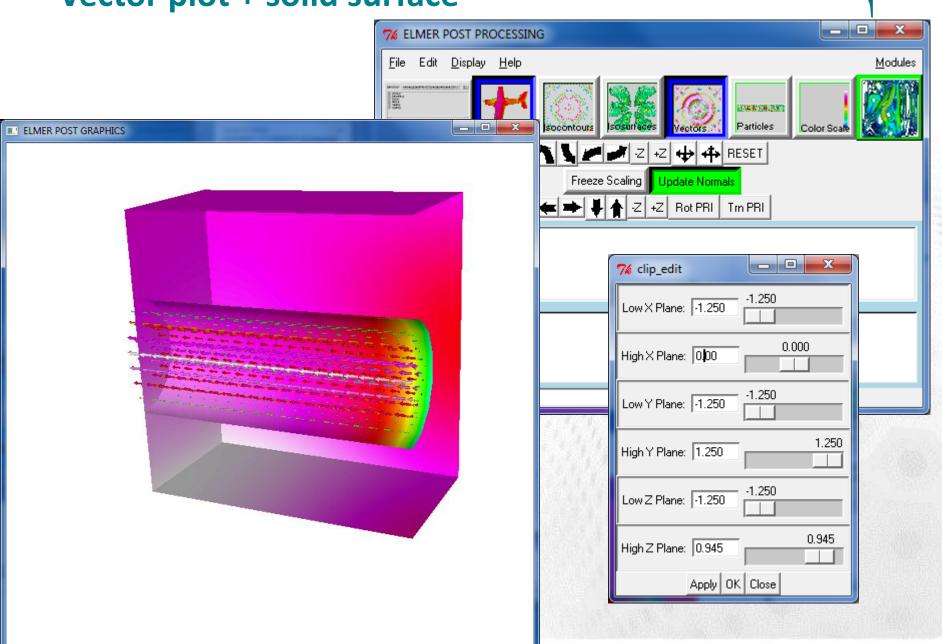
#### **Isosurface + surface plot + clip planes**

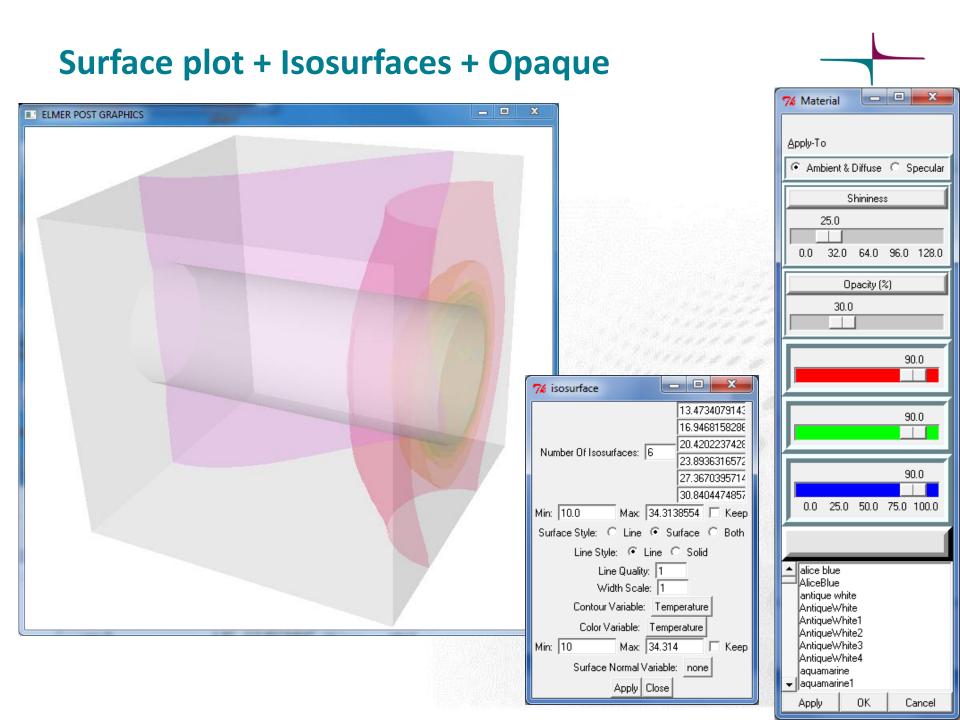


# **Vector plots**

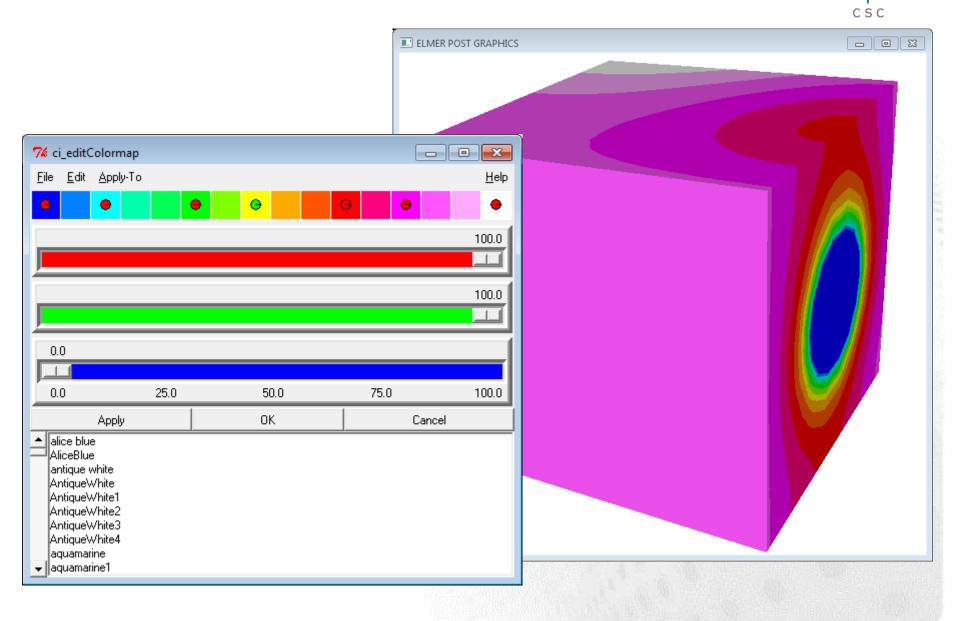
ELMER POST GRAPHICS	7% vector
	Vector Length Scale:   Line Style:   Line Quality:   1   Width Scale:   1   Threshold Variable:   none   Min:   0.0   Max:   1.0   Color Variable:   Velocity_abs   Length Variable:   Velocity_abs   Arrow Variable:   Velocity_abs   Arrow Variable:   Velocity_abs

## **Vector plot + solid surface**

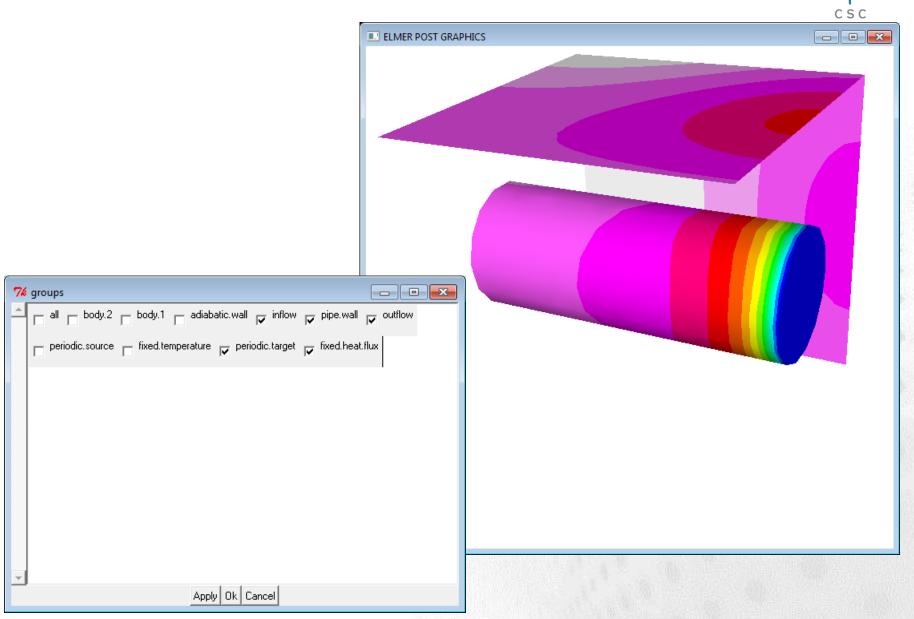




# **Change of colormap**



## Selecting active geometric entities

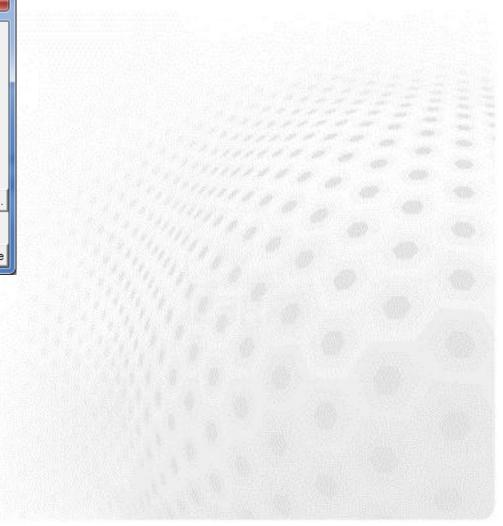


# **Saving figures**



#### File -> Save Image -> jpg

7% Save Screen	_ <b>D</b> X
Save as:	
C Postscript	
✓ Fit PS to page	
O PPM Image	
JPG Image	
Select file:	
File Name: 📕	Browse
	Save Close



## **Deformation in geometry**



- Assume displacement field in variable "Displacement"
- Set in command windows: math n0=nodes math nodes=n0+Displacement
- Replot

#### **Conclusions**



- Use Paraview and VTU format
- For large visualizations ViSiT could be an option

