# ParaView Basics

DEBAJYOTI MONDAL

# VTK File Format

There are two different styles of file formats available in VTK. The simplest are the legacy, serial formats that are easy to read and write either by hand or programmatically.

However, these formats are less flexible than the XML based file formats. The XML formats support random access, parallel I/O, and portable data.

*We will focus on the ASCII legacy file format as it is easier to parse and read in our own software.*

# VTK File Format

The legacy VTK file formats consist of five basic parts:

• The first part is the file version and identifier. This part contains the single line:
# vtk DataFile Version x.x.

• The second part is the header. The header consists of a character string terminated by end-of-line character \n. The header is 256 characters maximum.

• The next part is the file format. The file format describes the type of file, either ASCII or binary. On this line the single word ASCII or BINARY must appear.

# VTK File Format

- The fourth part is the dataset structure. The geometry part describes the geometry and topology of the dataset. This part begins with a line containing the keyword DATASET followed by a keyword describing the type of dataset. Then, depending upon the type of dataset, other keyword/data combinations define the actual data.

- The final part describes the dataset attributes. This part begins with the keywords POINT_DATA or CELL_DATA, followed by an integer number specifying the number of points or cells, respectively. (It doesn't matter whether POINT_DATA or CELL_DATA comes first.)

- Other keyword/data combinations (if any) define the actual dataset attribute values (i.e., scalars, vectors, tensors, normals, texture coordinates, or field)

**Example**

# vtk DataFile Version 2.0 — Header

Really cool data — Title

ASCII | BINARY — Type

DATASET *type* — Geometry/topology

...

POINT_DATA *n* — Dataset attributes

...

CELL_DATA *n*

...

# VTK File Format

- A lookup table using the RGBA color specification, associated with the scalar data, can be defined as well. Dataset attributes are supported for both points and cells. We will use default.

- Each type of attribute data has a *dataName* associated with it. This is a character string (without whitespace) used to identify a particular data. The *dataName* is used by the VTK readers to extract data.

- More than one attribute data of the same type can be included in a file. For example, two different scalar fields defined on the dataset points, pressure and temperature, can be contained in the same file.

# VTK File Format

- SCALARS *dataName dataType*

  $s_0$

  $s_1$

  ...

  $s_{n-1}$

- VECTORS *dataName dataType*

  $v_{0x}\ v_{0y}\ v_{0z}$

  $v_{1x}\ v_{1y}\ v_{1z}$

  ...

  $v_{(n-1)x}\ v_{(n-1)y}\ v_{(n-1)z}$

The first step in creating the VTK file is to write the file header and data point description to a text file:

```
# vtk DataFile Version 2.0
Example Teapot data file
ASCII
DATASET POLYDATA
POINTS 2082 FLOAT
  3.50000E+00   2.19615E+00   1.80000E+01
  3.45947E+00   2.28939E+00   1.80538E+01
  3.45117E+00   2.35599E+00   1.80923E+01
 (continue with remainder of data coordinates)
```

Polygonal data is defined by the **POINTS**, VERTICES, LINES, POLYGONS, or TRIANGLE_STRIPS sections.

None of the keywords VERTICES, LINES, POLYGONS, or TRIANGLE_STRIPS is required.

- The first line defines this file as a VTK data file.
- The second line is an arbitrary title
- The third line defines this file as ASCII format
- The fourth line defines the data as POLYDATA. There are many different data types available, but this format is used to define point data.
- The fifth line defines how many data points there are and that they are type FLOAT.
- The remaining lines are the (x,y,z) coordinates for each of the 2082 data points.

In the visualization, the data will correspond to the color of each data point. If you just want to see the grid, you can simply add values of "1.0" for each data point. In this example, I will assign the data as the z-coordinate of the point.

```
POINT_DATA 2082
SCALARS Z-dimension float
LOOKUP_TABLE default
  1.80000E+01
  1.80538E+01
  1.80923E+01
```

- The first line of this block says that 2082 data points will follow. These data points correspond to the 2082 coordinates listed above.
- The second line defines these as SCALAR values, gives a user-defined title of "Z-dimension", and then defines the type as "float"
- The third line shows that the data is a LOOKUP_TABLE (i.e. one-to-one correspondence between data points and coordinates)
- The fourth and remaining lines are the data itself

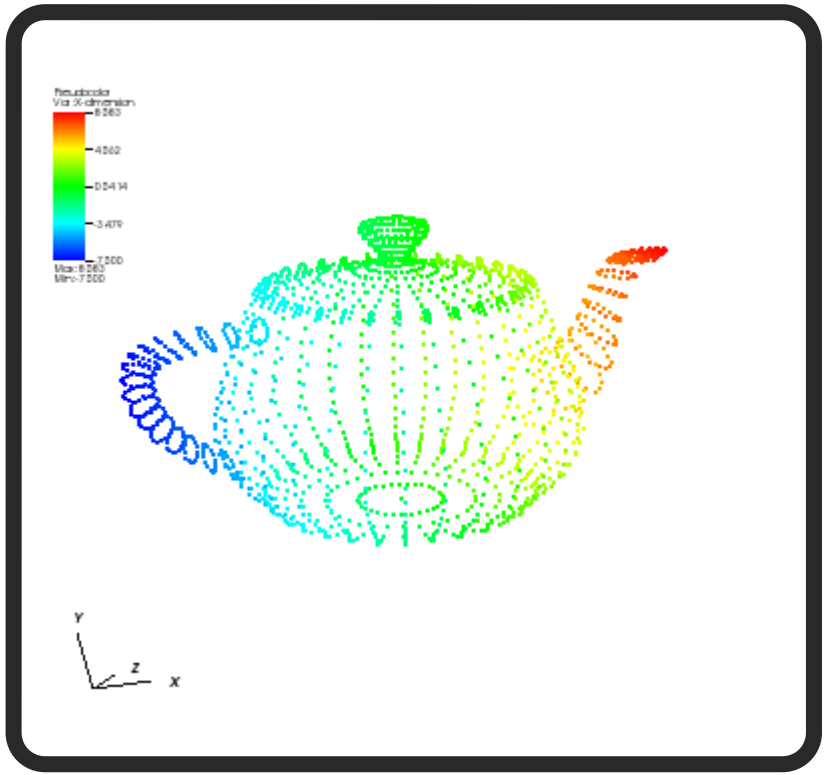
There can be multiple data sets in the same file. In this example, we will include another data set that shows the X-dimensions of the data points.

Additional datsets are added by including more data blocks, but without the "POINTS_DATA" line. This "POINTS_DATA" line should only be included once per file.

```
SCALARS X-dimension float
LOOKUP_TABLE default
  3.50000E+00
  3.45947E+00

 (continue with remainder of 2082 data values in the second dataset)
```

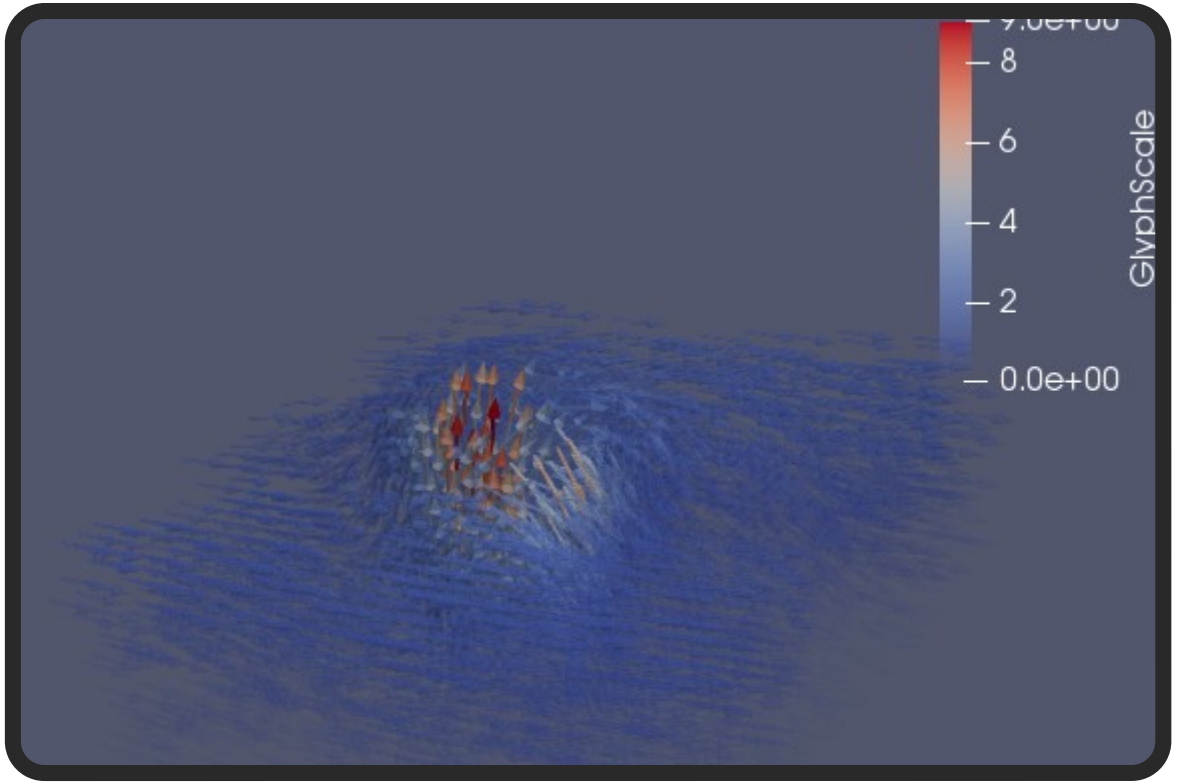
# Open ParaView

# Example: teapot.vtk



```
# vtk DataFile Version 2.0
Sample rectilinear grid
ASCII
DATASET RECTILINEAR_GRID
DIMENSIONS 47 33 11
X_COORDINATES 47 float
-1.22396 -1.17188 -1.11979
.....
Y_COORDINATES 33 float
.....
Z_COORDINATES 11 float
.....
POINT_DATA 17061
SCALARS scalars float
LOOKUP_TABLE default
.....
VECTORS vectors float
.....
```

# Example: RectGrid.vtk

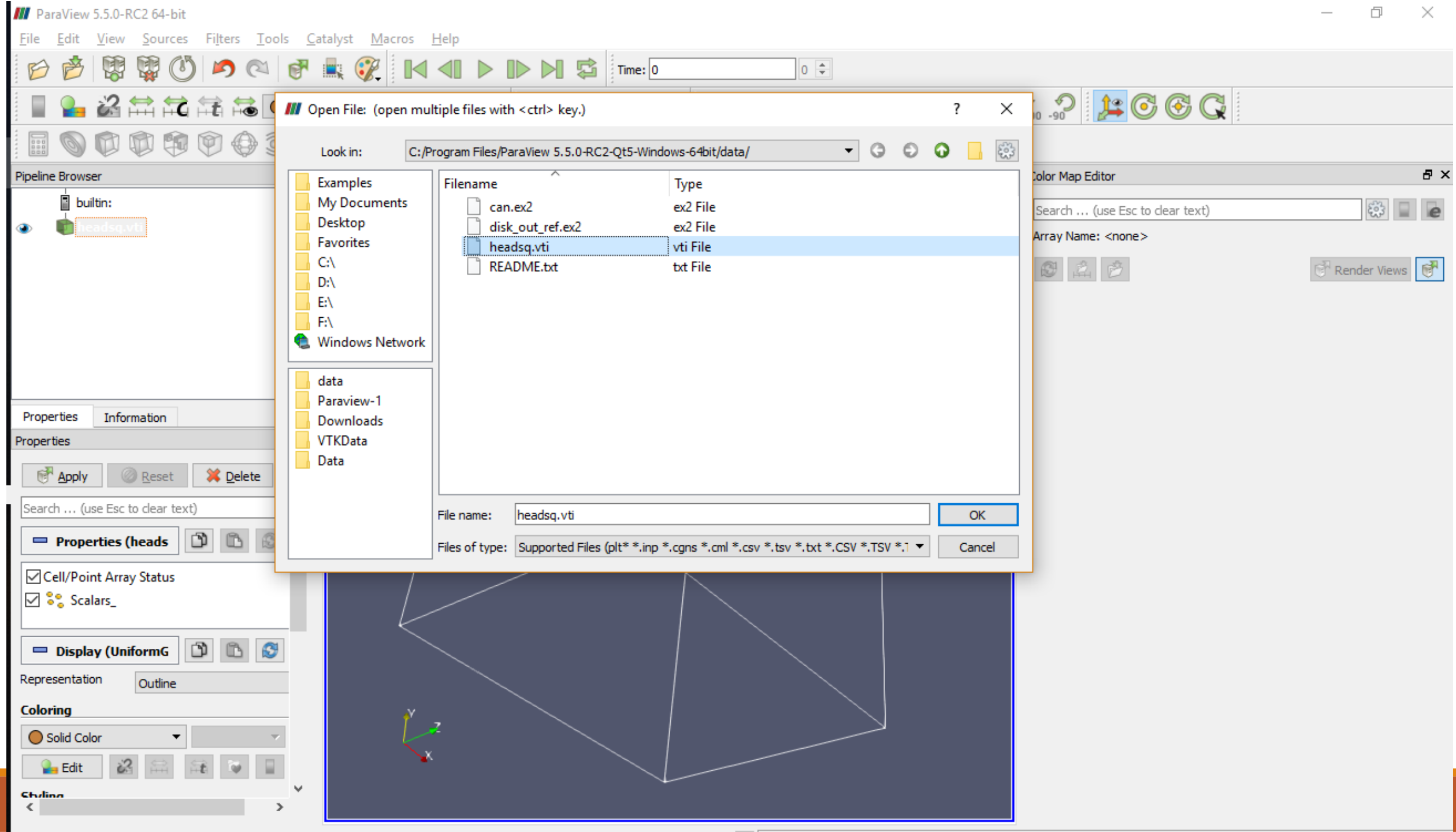


```
# vtk DataFile Version 2.0
Sample rectilinear grid
ASCII
DATASET RECTILINEAR_GRID
DIMENSIONS 2 2 2
X_COORDINATES 2 float
0 1
Y_COORDINATES 2 float
0 1
Z_COORDINATES 2 float
0 1

POINT_DATA 8
SCALARS scalars float
LOOKUP_TABLE default
5.9 .2 .9 .8 .9 .1 .9 .2

VECTORS vectors float
1.338182 -1.0105356 1.619273 0.325472 0.0101632 0.306248
0.0730082 0.0330933 0.0144899 0.0779212 0.0353807 0.018293
0.163913 0.0185081 -0.0010734 0.162884 0.0180696 -0.0009607
0.0768074 -0.0122758 0.0487514 0.0741287 -0.0153087
0.0650711
```

# Example: test.vtk

# VTI File Format

```
<?xml version="1.0"?>
<VTKFile type="ImageData" version="0.1" byte_order="LittleEndian"
compressor="vtkZLibDataCompressor">
<ImageData WholeExtent="0 255 0 255 0 93" Origin="0 0 0" Spacing="1 1 2">
        <Piece Extent="0 255 0 255 0 93">
                <PointData Scalars="Scalars_">
                        <DataArray type="UInt16" Name="Scalars_“ format="appended"
                                        RangeMin="0"  RangeMax="4095"  offset="0"  />
                </PointData>
                <CellData>     </CellData>
        </Piece>
</ImageData>
<AppendedData encoding="base64">
Askjdhbfaimeicfaowemhaciefojamogocemjoawrgcpwe,pojcasilefea,fica.....
</AppendedData>
</VTKFile>
```


ParaView 5.5.0-RC2 64-bit
File Edit View Sources Filters Tools Catalyst Macros Help
Time: 0
Open File: (open multiple files with <ctrl> key.)
Look in: C:/Program Files/ParaView 5.5.0-RC2-Qt5-Windows-64bit/data/
Examples
My Documents
Desktop
Favorites
C:\
D:\
E:\
F:\
Windows Network
data
Paraview-1
Downloads
VTKData
Data
Filename Type
can.ex2 ex2 File
disk_out_ref.ex2 ex2 File
headsq.vti vti File
README.txt txt File
File name: headsq.vti
OK
Files of type: Supported Files (plt* *.inp *.cgns *.cml *.csv *.tsv *.txt *.CSV *.TSV *.
Cancel
Pipeline Browser
builtin:
headsq.vti
Color Map Editor
Search ... (use Esc to clear text)
Array Name: <none>
Render Views
Properties Information
Properties
Apply Reset Delete
Search ... (use Esc to clear text)
Properties (heads
Cell/Point Array Status
Scalars_
Display (UniformG
Representation Outline
Coloring
Solid Color
Edit
Styling

ParaView 5.5.0-RC2 64-bit

File Edit View Sources Filters Tools Catalyst Macros Help

Time: 0

Solid Color | Outline

Pipeline Browser

builtin:

headsq.vti

Properties | Information

Properties

Apply | Reset | Delete

Search ... (use Esc to clear text)

Properties (heads

Cell/Point Array Status

Scalars_

Display (UniformG

Representation Outline

Coloring

Solid Color

Edit

Styling

Layout #1

3D

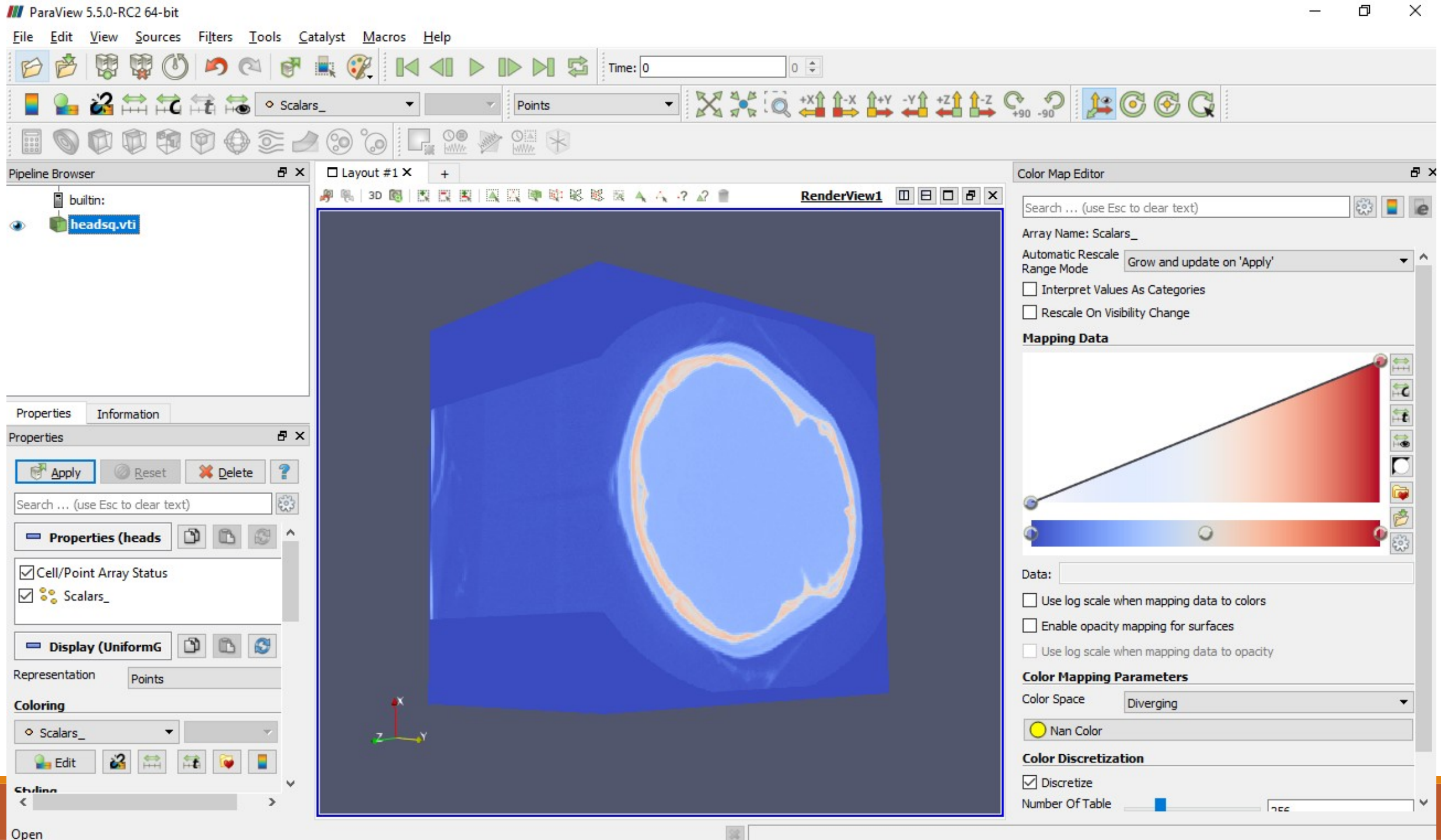
RenderView1

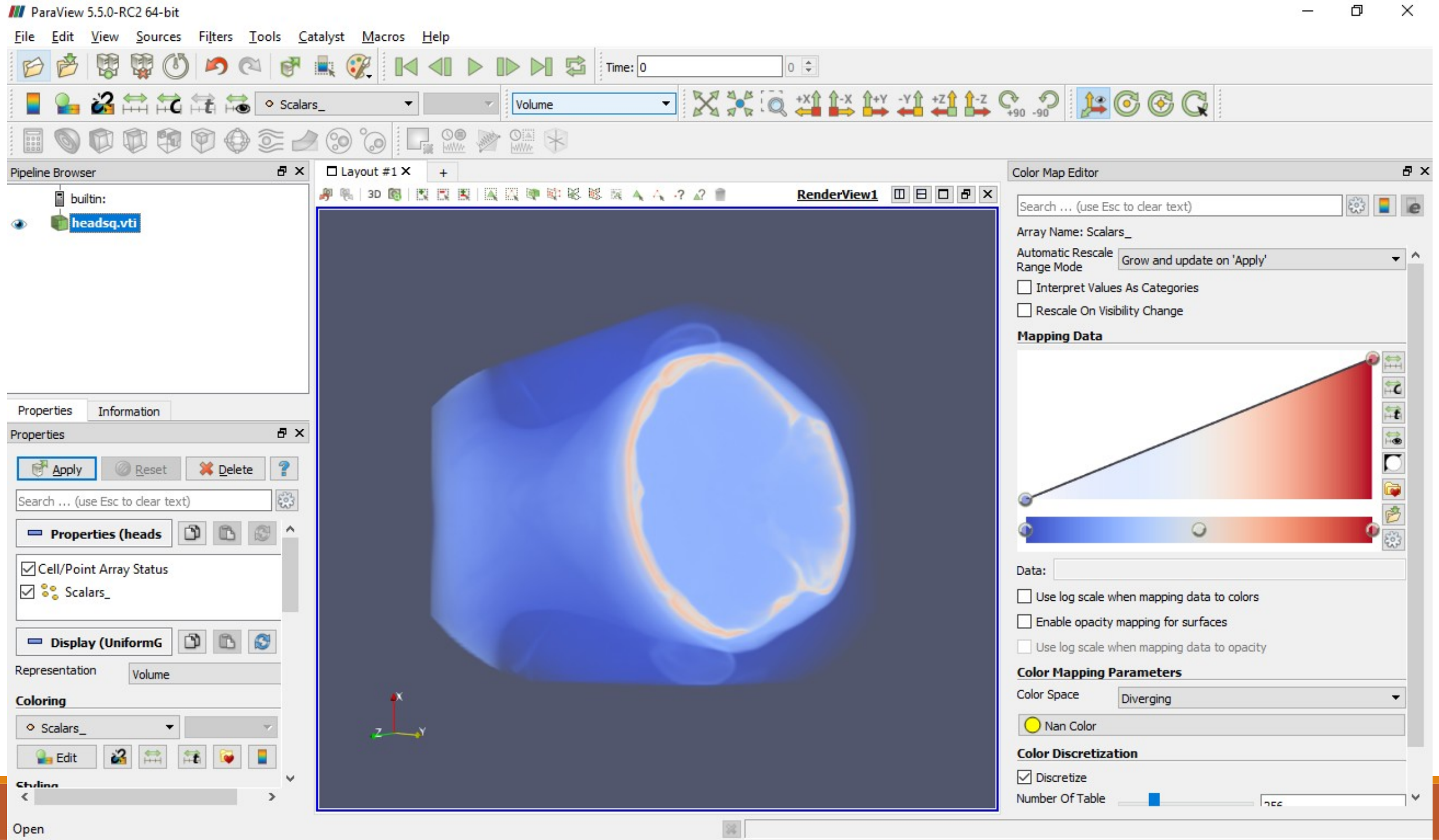
Color Map Editor

Search ... (use Esc to clear text)

Array Name: <none>

Render Views


ParaView 5.5.0-RC2 64-bit
File Edit View Sources Filters Tools Catalyst Macros Help
Time: 0
Scalars_
Points
Pipeline Browser
builtin:
headsq.vti
Layout #1
RenderView1
Color Map Editor
Search ... (use Esc to clear text)
Array Name: Scalars_
Automatic Rescale Range Mode
Grow and update on 'Apply'
Interpret Values As Categories
Rescale On Visibility Change
Mapping Data
Data:
Use log scale when mapping data to colors
Enable opacity mapping for surfaces
Use log scale when mapping data to opacity
Color Mapping Parameters
Color Space
Diverging
Nan Color
Color Discretization
Discretize
Number Of Table
Properties
Information
Properties
Apply
Reset
Delete
Search ... (use Esc to clear text)
Properties (heads
Cell/Point Array Status
Scalars_
Display (UniformG
Representation
Points
Coloring
Scalars_
Edit
Styling
Open


ParaView 5.5.0-RC2 64-bit
File Edit View Sources Filters Tools Catalyst Macros Help
Time: 0
Scalars_
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Pipeline Browser
builtin:
headsq.vti
Layout #1
RenderView1
Color Map Editor
Search ... (use Esc to clear text)
Array Name: Scalars_
Automatic Rescale Range Mode
Grow and update on 'Apply'
Interpret Values As Categories
Rescale On Visibility Change
Mapping Data
Data:
Use log scale when mapping data to colors
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Use log scale when mapping data to opacity
Color Mapping Parameters
Color Space
Diverging
Nan Color
Color Discretization
Discretize
Number Of Table
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Reset
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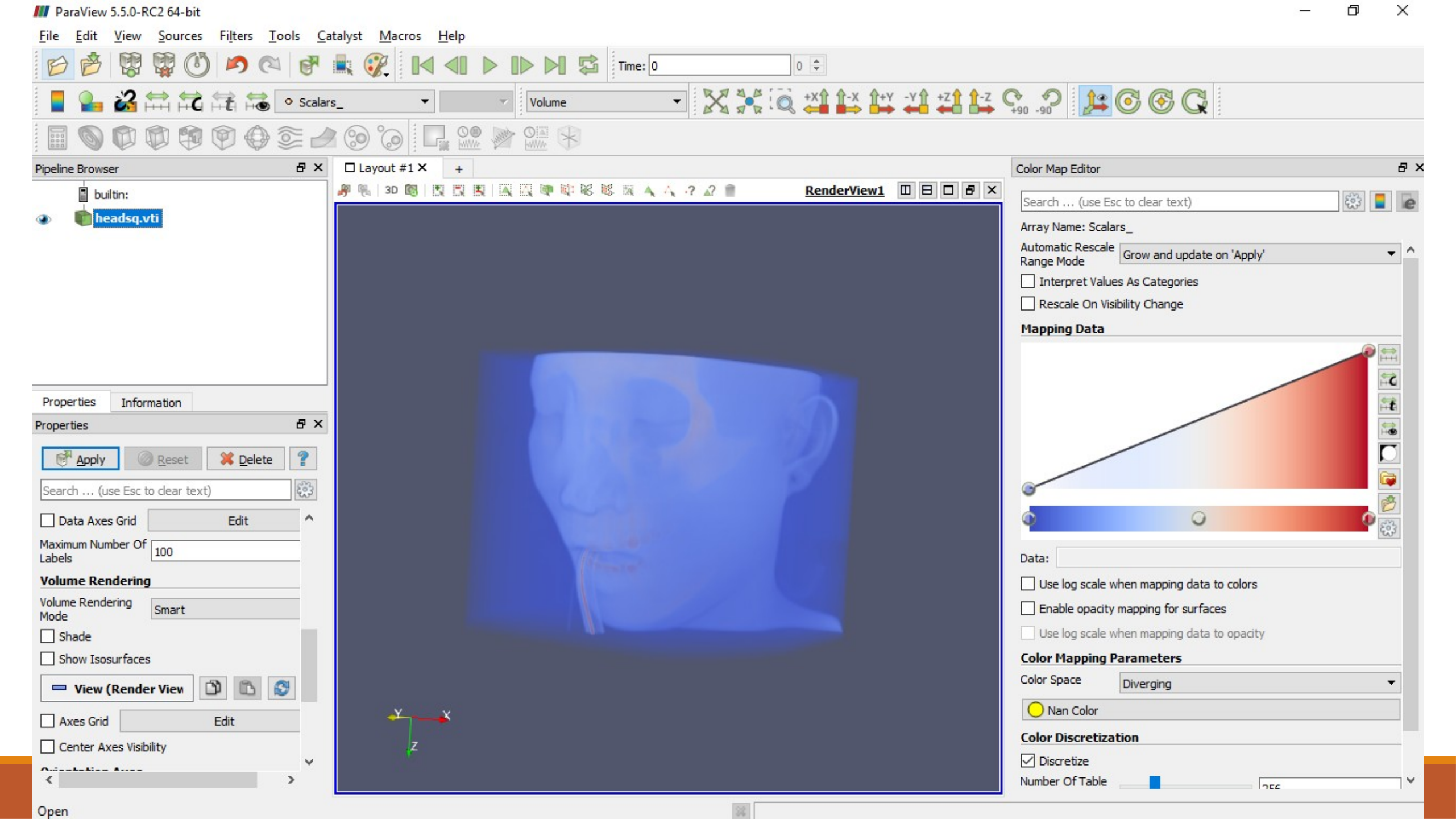
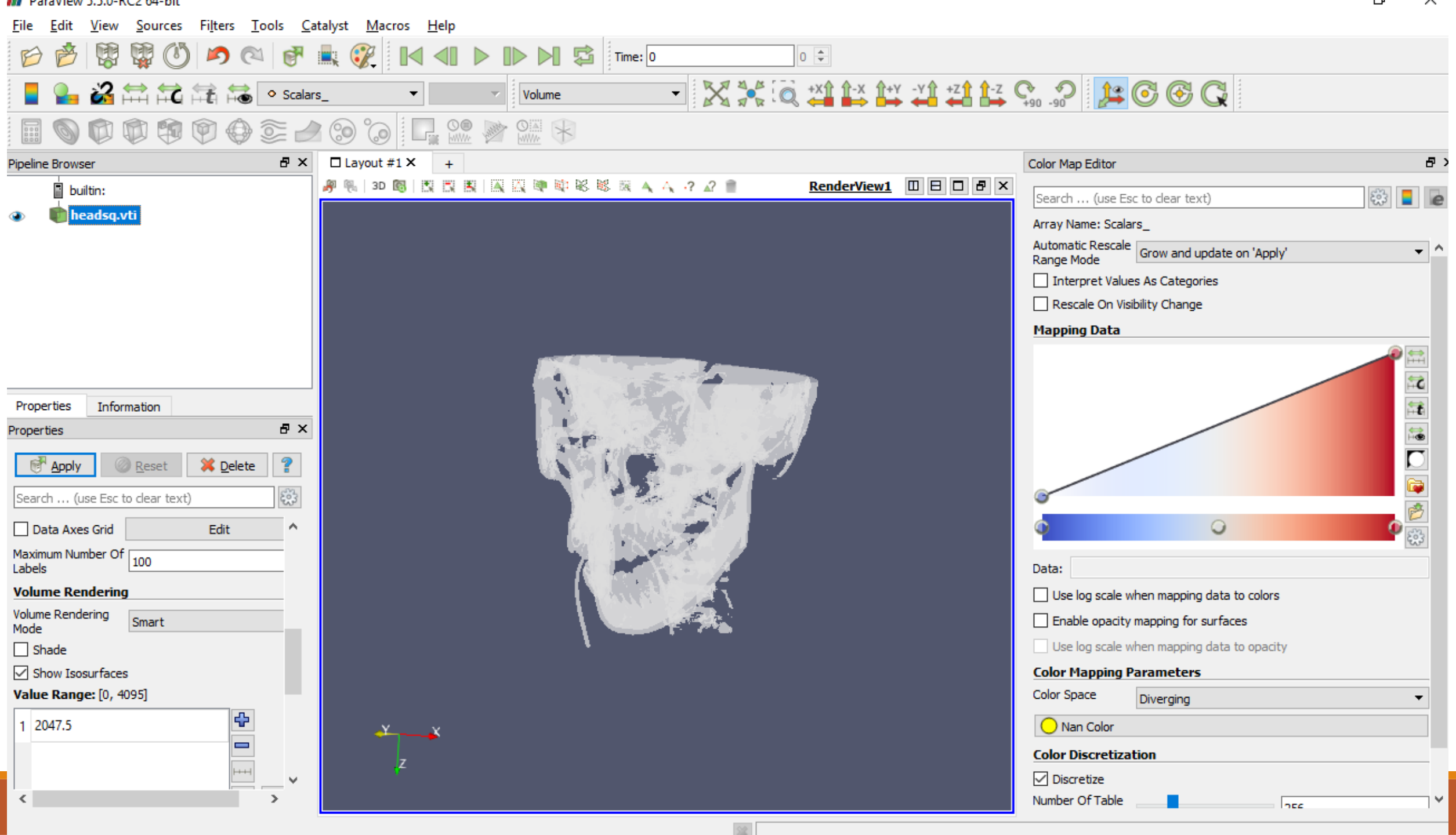
Search ... (use Esc to clear text)
Properties (heads
Cell/Point Array Status
Scalars_
Display (UniformG
Representation
Volume
Coloring
Scalars_
Edit
Open


ParaView 5.5.0-RC2 64-bit
File Edit View Sources Filters Tools Catalyst Macros Help
Time: 0
Scalars_
Volume
Pipeline Browser
builtin:
headsq.vti
Properties Information
Properties
Apply Reset Delete
Search ... (use Esc to clear text)
Data Axes Grid Edit
Maximum Number Of Labels 100
Volume Rendering
Volume Rendering Mode Smart
Shade
Show Isosurfaces
View (Render View
Axes Grid Edit
Center Axes Visibility
Layout #1
3D
RenderView1
Color Map Editor
Search ... (use Esc to clear text)
Array Name: Scalars_
Automatic Rescale Range Mode Grow and update on 'Apply'
Interpret Values As Categories
Rescale On Visibility Change
Mapping Data
Data:
Use log scale when mapping data to colors
Enable opacity mapping for surfaces
Use log scale when mapping data to opacity
Color Mapping Parameters
Color Space Diverging
Nan Color
Color Discretization
Discretize
Number Of Table
Open


ParaView 5.5.0-RC2 64-bit
File Edit View Sources Filters Tools Catalyst Macros Help
Time: 0
Scalars_
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Pipeline Browser
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headsq.vti
Properties Information
Properties
Apply Reset Delete
Search ... (use Esc to clear text)
Data Axes Grid Edit
Maximum Number Of Labels 100
Volume Rendering
Volume Rendering Mode Smart
Shade
Show Isosurfaces
Value Range: [0, 4095]
1 2047.5
Layout #1
3D
RenderView1
Color Map Editor
Search ... (use Esc to clear text)
Array Name: Scalars_
Automatic Rescale Range Mode Grow and update on 'Apply'
Interpret Values As Categories
Rescale On Visibility Change
Mapping Data
Data:
Use log scale when mapping data to colors
Enable opacity mapping for surfaces
Use log scale when mapping data to opacity
Color Mapping Parameters
Color Space Diverging
Nan Color
Color Discretization
Discretize
Number Of Table

ParaView 5.5.0-RC2 64-bit

File Edit View Sources Filters Tools Catalyst Macros Help

Time: 0

Scalars_ Volume

Pipeline Browser

builtin:

headsq.vti

Properties Information

Properties

Apply Reset Delete

Search ... (use Esc to clear text)

Labels 100

**Volume Rendering**

Volume Rendering Mode Smart

Shade

Show Isosurfaces

**Value Range:** [0, 4095]

1 3500

Open

Layout #1

3D

RenderView1

4.1e+03
3000
2000
1000
0.0e+00
Scalars_

Color Map Editor

Search ... (use Esc to clear text)

Array Name: Scalars_

Automatic Rescale Range Mode Grow and update on 'Apply'

Interpret Values As Categories

Rescale On Visibility Change

**Mapping Data**

Data:

Use log scale when mapping data to colors

Enable opacity mapping for surfaces

Use log scale when mapping data to opacity

**Color Mapping Parameters**

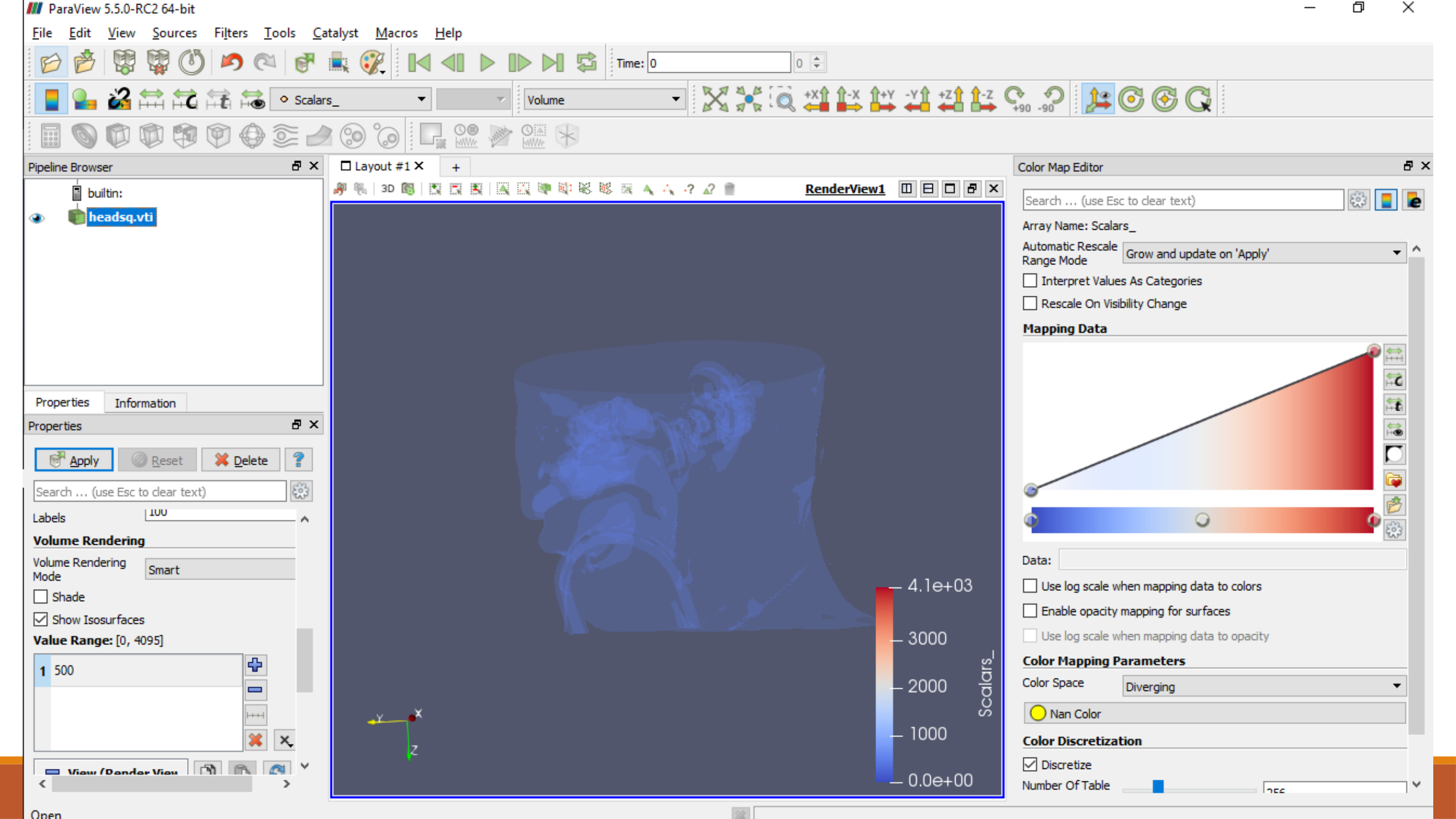
Color Space Diverging

Nan Color

**Color Discretization**

Discretize

Number Of Table


ParaView 5.5.0-RC2 64-bit
File Edit View Sources Filters Tools Catalyst Macros Help
Time: 0
Scalars_
Volume
Pipeline Browser
builtin:
headsq.vti
Properties Information
Properties
Apply Reset Delete
Search ... (use Esc to clear text)
Labels
Volume Rendering
Volume Rendering Mode
Smart
Shade
Show Isosurfaces
Value Range: [0, 4095]
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Layout #1
RenderView1
4.1e+03
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Search ... (use Esc to clear text)
Array Name: Scalars_
Automatic Rescale Range Mode
Grow and update on 'Apply'
Interpret Values As Categories
Rescale On Visibility Change
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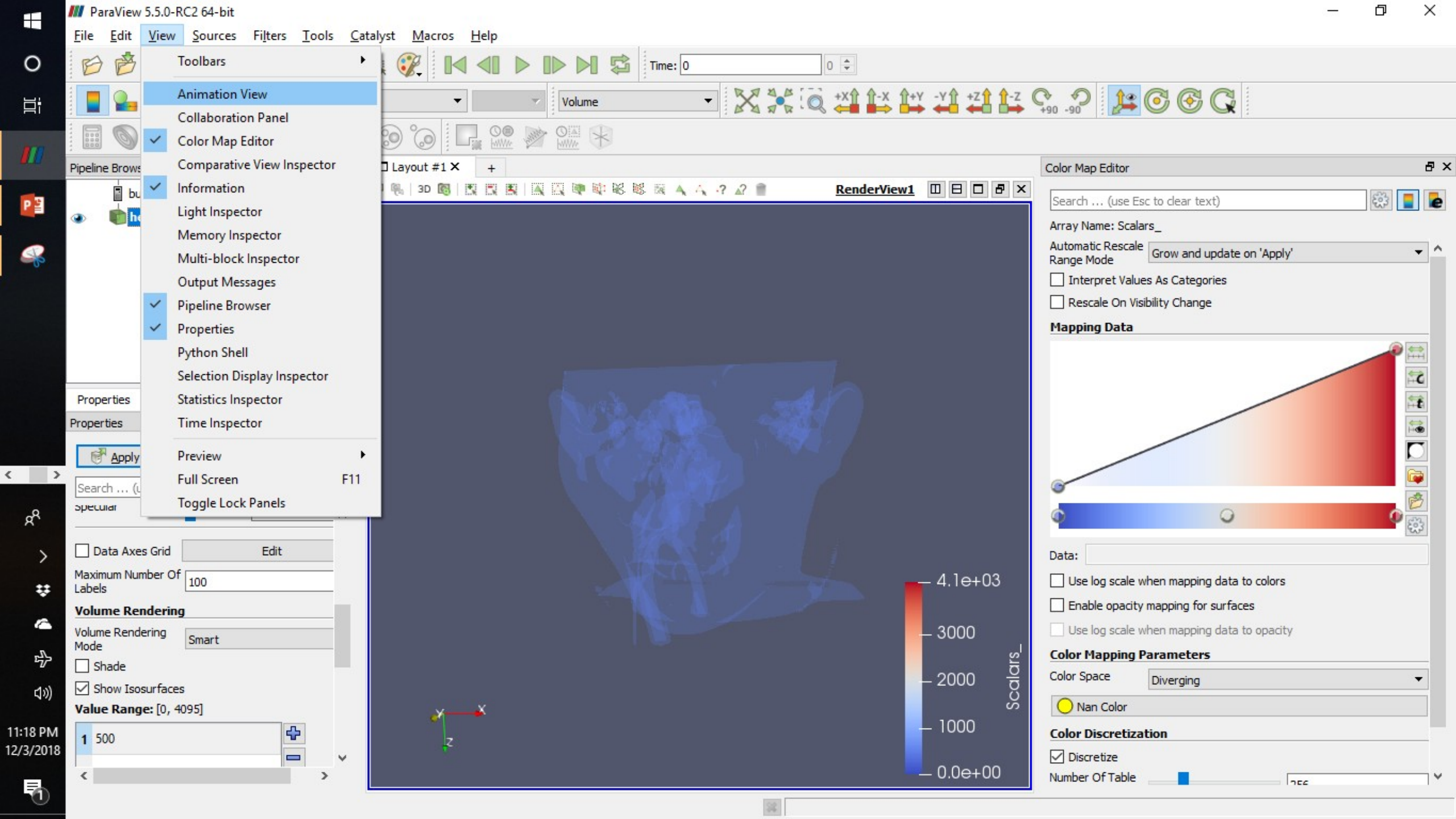
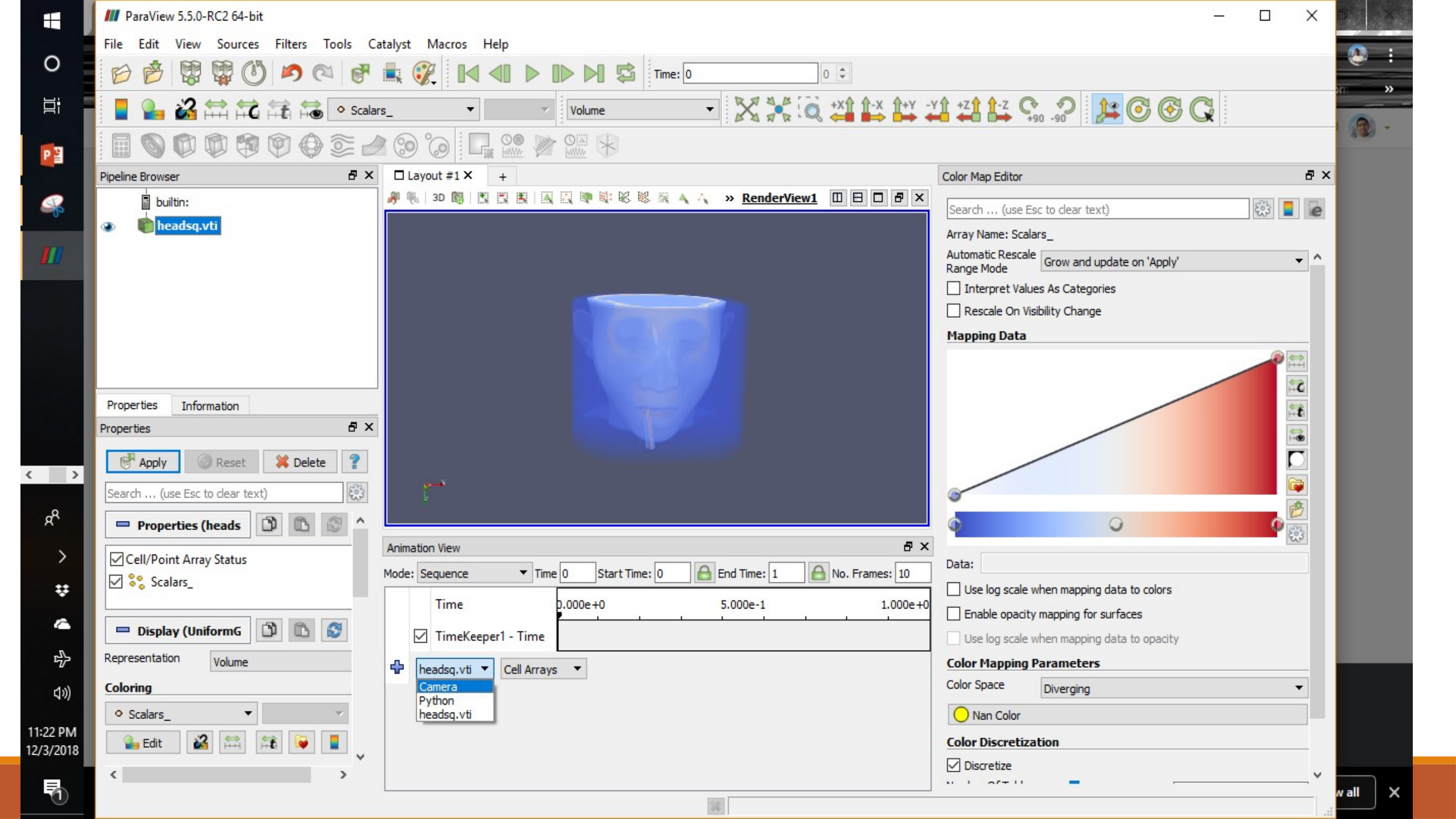
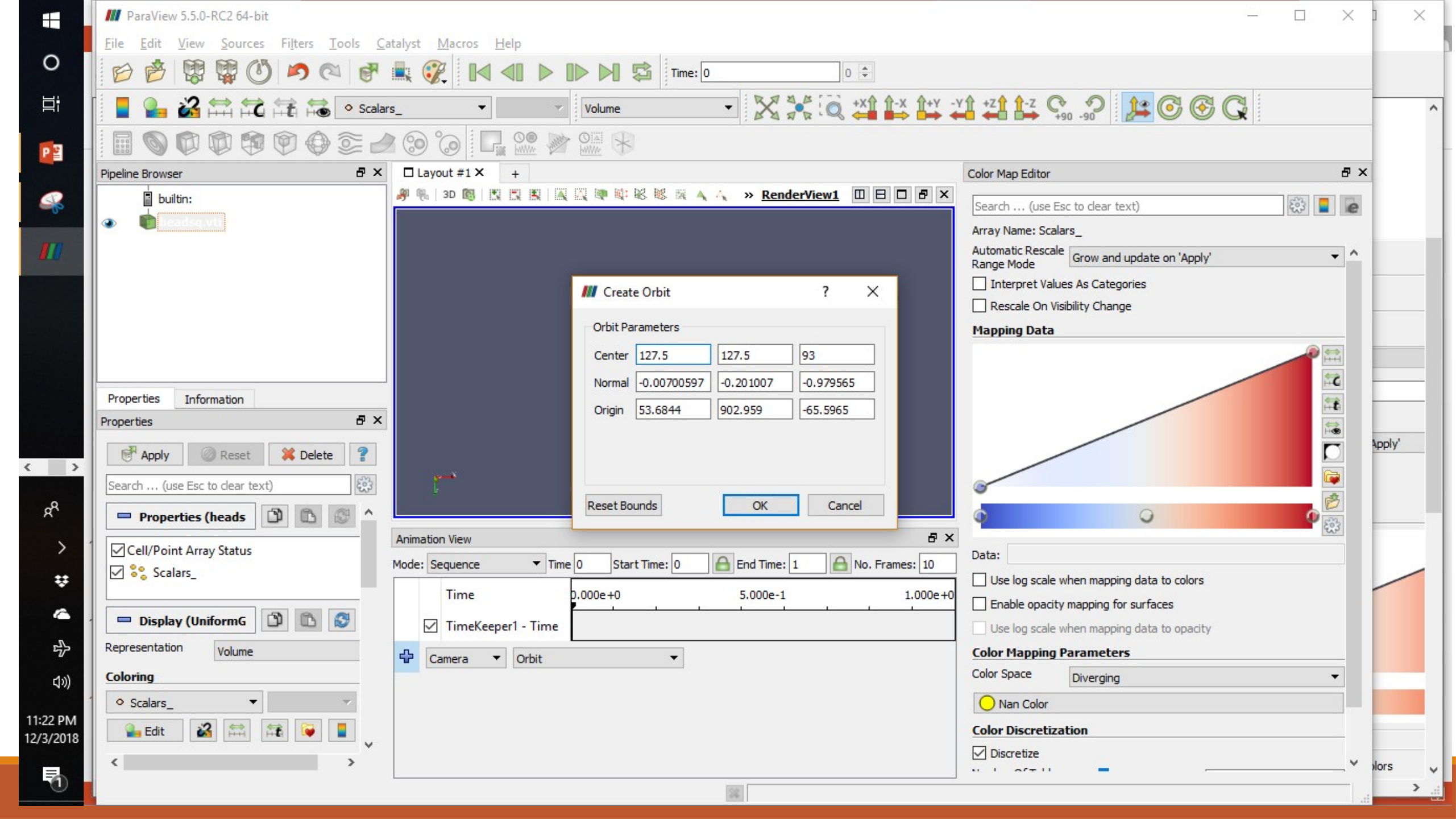
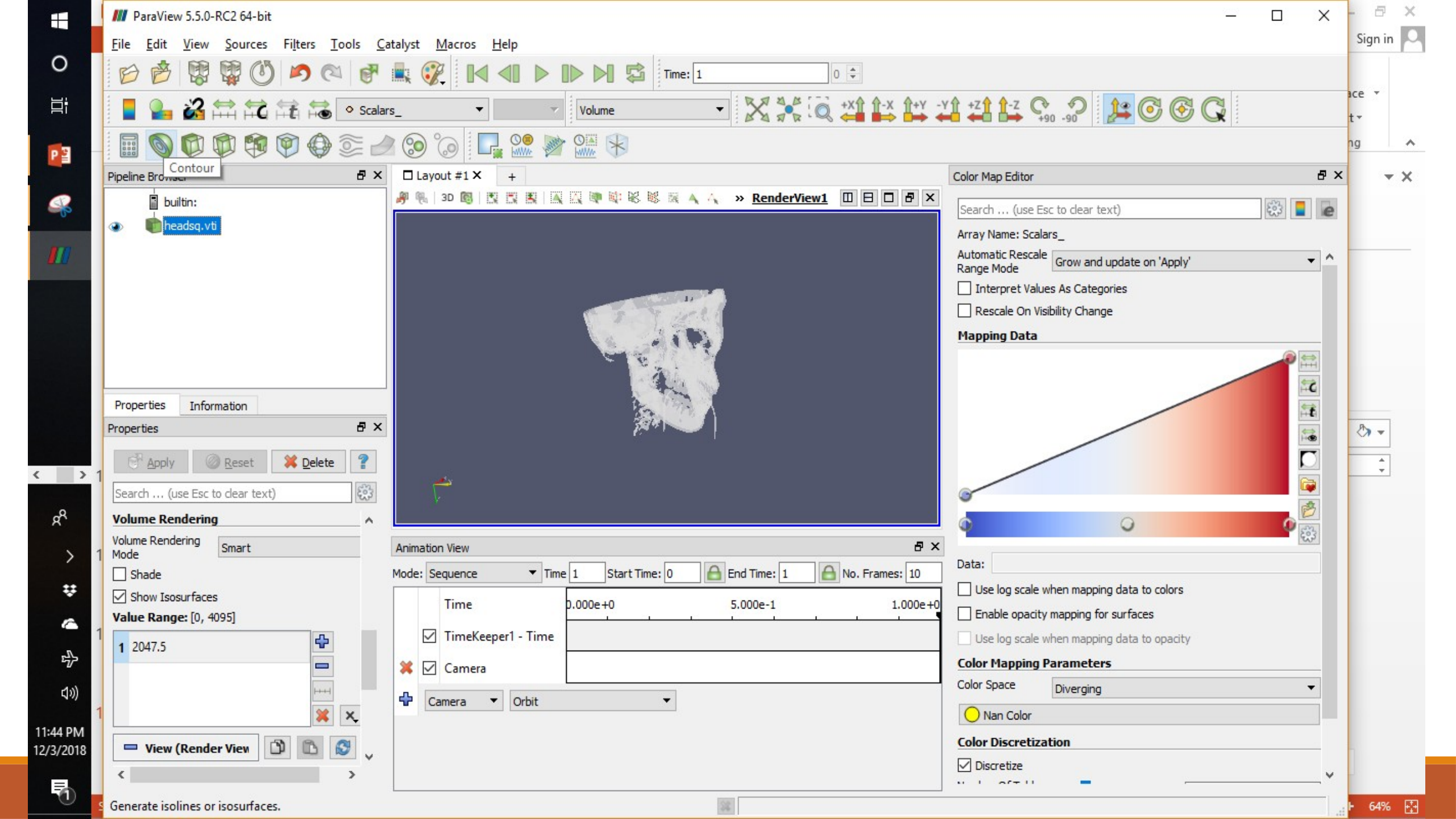
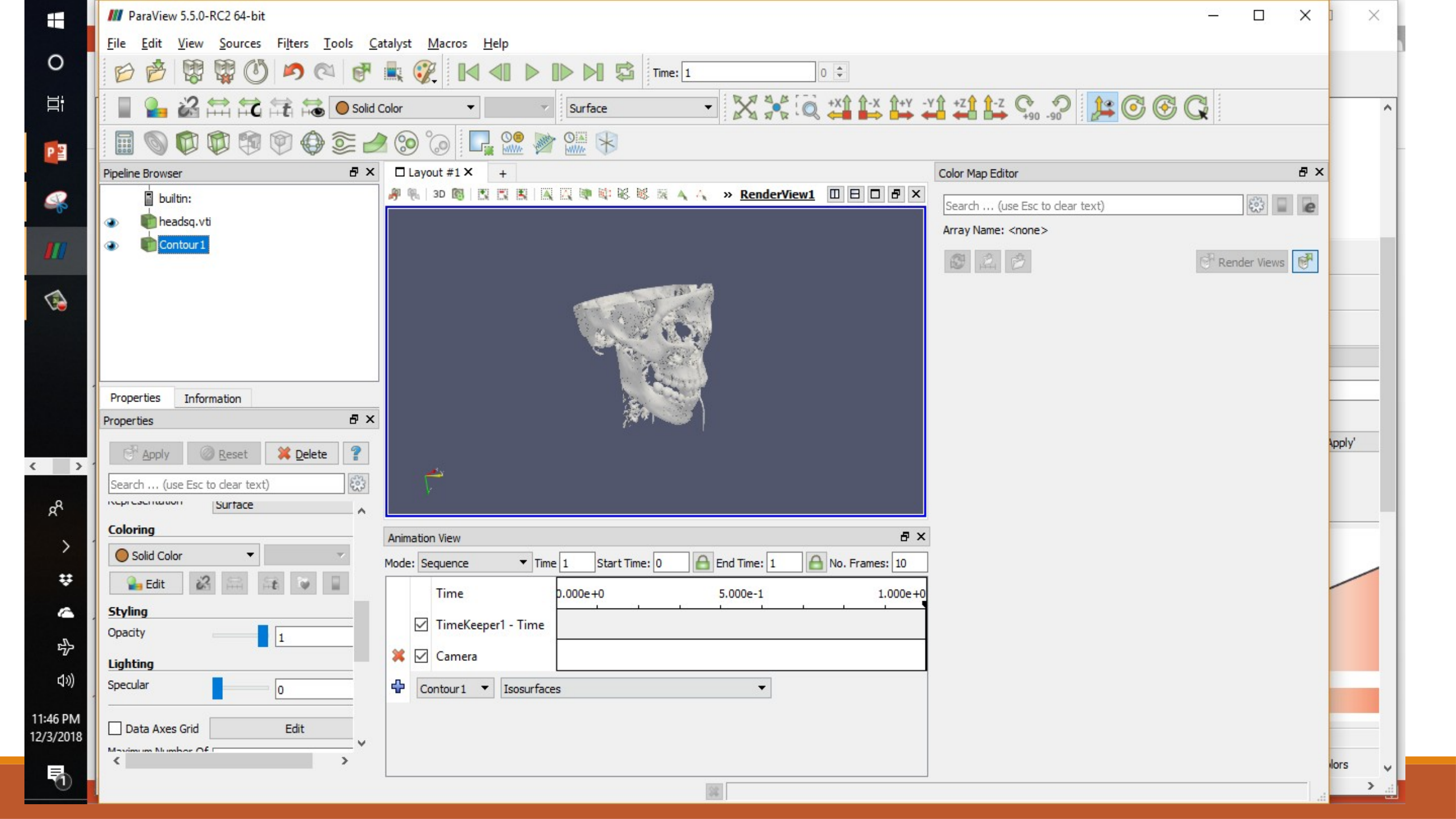
Use log scale when mapping data to colors
Enable opacity mapping for surfaces
Use log scale when mapping data to opacity
Color Mapping Parameters
Color Space
Diverging
Nan Color
Color Discretization
Discretize
Number Of Table
Open


ParaView 5.5.0-RC2 64-bit
File Edit View Sources Filters Tools Catalyst Macros Help
Toolbars
Animation View
Collaboration Panel
Color Map Editor
Comparative View Inspector
Information
Light Inspector
Memory Inspector
Multi-block Inspector
Output Messages
Pipeline Browser
Properties
Python Shell
Selection Display Inspector
Statistics Inspector
Time Inspector
Preview
Full Screen F11
Toggle Lock Panels
Time: 0
Volume
Layout #1
RenderView1
Color Map Editor
Search ... (use Esc to clear text)
Array Name: Scalars_
Automatic Rescale Range Mode
Grow and update on 'Apply'
Interpret Values As Categories
Rescale On Visibility Change
Mapping Data
Use log scale when mapping data to colors
Enable opacity mapping for surfaces
Use log scale when mapping data to opacity
Color Mapping Parameters
Color Space
Diverging
Nan Color
Color Discretization
Discretize
Number Of Table
Properties
Apply
Data Axes Grid
Edit
Maximum Number Of Labels
100
Volume Rendering
Volume Rendering Mode
Smart
Shade
Show Isosurfaces
Value Range: [0, 4095]
1 500
4.1e+03
3000
2000
1000
0.0e+00
Scalars_
11:18 PM
12/3/2018


ParaView 5.5.0-RC2 64-bit
File Edit View Sources Filters Tools Catalyst Macros Help
Time: 0
Scalars_
Volume
Pipeline Browser
builtin:
headsq.vti
Layout #1
RenderView1
Color Map Editor
Search ... (use Esc to clear text)
Array Name: Scalars_
Automatic Rescale Range Mode
Grow and update on 'Apply'
Interpret Values As Categories
Rescale On Visibility Change
Mapping Data
Properties
Information
Properties
Apply
Reset
Delete
Search ... (use Esc to clear text)
Properties (heads
Cell/Point Array Status
Scalars_
Display (UniformG
Representation
Volume
Coloring
Scalars_
Edit
Animation View
Mode: Sequence
Time 0
Start Time: 0
End Time: 1
No. Frames: 10
Time
TimeKeeper1 - Time
0.000e+0
5.000e-1
1.000e+0
headsq.vti
Cell Arrays
Camera
Python
headsq.vti
Data:
Use log scale when mapping data to colors
Enable opacity mapping for surfaces
Use log scale when mapping data to opacity
Color Mapping Parameters
Color Space
Diverging
Nan Color
Color Discretization
Discretize
11:22 PM
12/3/2018


ParaView 5.5.0-RC2 64-bit
File Edit View Sources Filters Tools Catalyst Macros Help
Time: 0
Scalars_
Volume
Pipeline Browser
builtin:
Layout #1
RenderView1
Create Orbit
Orbit Parameters
Center 127.5 127.5 93
Normal -0.00700597 -0.201007 -0.979565
Origin 53.6844 902.959 -65.5965
Reset Bounds
OK
Cancel
Color Map Editor
Search ... (use Esc to clear text)
Array Name: Scalars_
Automatic Rescale Range Mode
Grow and update on 'Apply'
Interpret Values As Categories
Rescale On Visibility Change
Mapping Data
Properties
Information
Apply
Reset
Delete
Cell/Point Array Status
Scalars_
Display (UniformG
Representation
Volume
Coloring
Edit
Animation View
Mode: Sequence
Time 0
Start Time: 0
End Time: 1
No. Frames: 10
Time
TimeKeeper1 - Time
0.000e+0
5.000e-1
1.000e+0
Camera
Orbit
Data:
Use log scale when mapping data to colors
Enable opacity mapping for surfaces
Use log scale when mapping data to opacity
Color Mapping Parameters
Color Space
Diverging
Nan Color
Color Discretization
Discretize
11:22 PM
12/3/2018


ParaView 5.5.0-RC2 64-bit
File Edit View Sources Filters Tools Catalyst Macros Help
Time: 1
Scalars_
Volume
Contour
Pipeline Browser
builtin:
headsq.vti
Layout #1
RenderView1
Color Map Editor
Search ... (use Esc to clear text)
Array Name: Scalars_
Automatic Rescale Range Mode
Grow and update on 'Apply'
Interpret Values As Categories
Rescale On Visibility Change
Mapping Data
Properties
Information
Properties
Apply
Reset
Delete
Search ... (use Esc to clear text)
Volume Rendering
Volume Rendering Mode
Smart
Shade
Show Isosurfaces
Value Range: [0, 4095]
1 2047.5
View (Render View
Animation View
Mode: Sequence
Time 1
Start Time: 0
End Time: 1
No. Frames: 10
Time
TimeKeeper1 - Time
Camera
0.000e+0
5.000e-1
1.000e+0
Camera
Orbit
Data:
Use log scale when mapping data to colors
Enable opacity mapping for surfaces
Use log scale when mapping data to opacity
Color Mapping Parameters
Color Space
Diverging
Nan Color
Color Discretization
Discretize
Generate isolines or isosurfaces.
11:44 PM
12/3/2018
Sign in
64%


ParaView 5.5.0-RC2 64-bit
File Edit View Sources Filters Tools Catalyst Macros Help
Time: 1
Solid Color
Surface
Pipeline Browser
builtin:
headsq.vti
Contour1
Layout #1
RenderView1
Color Map Editor
Search ... (use Esc to clear text)
Array Name: <none>
Render Views
Properties
Information
Properties
Apply
Reset
Delete
Search ... (use Esc to clear text)
Representation
Surface
Coloring
Solid Color
Edit
Styling
Opacity
1
Lighting
Specular
0
Data Axes Grid
Edit
Animation View
Mode: Sequence
Time 1
Start Time: 0
End Time: 1
No. Frames: 10
Time
0.000e+0
5.000e-1
1.000e+0
TimeKeeper1 - Time
Camera
Contour1
Isosurfaces
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12/3/2018

ParaView 5.5.0-RC2 64-bit

File Edit View Sources Filters Tools Catalyst Macros Help

Time: 1

Solid Color | Surface

Pipeline Browser

builtin:
headsq.vti
Contour1

Properties Information

Properties

Apply Reset Delete

Search ... (use Esc to clear text)

Representation Surface

**Coloring**

Solid Color

Edit

**Styling**

Opacity 1

**Lighting**

Specular 0

Data Axes Grid Edit

Maximum Number Of

Layout #1

3D

RenderView1

Animation View

Mode: Sequence Time 1 Start Time: 0 End Time: 1 No. Frames: 10

Time 0.000e+0 3.333e-1 6.667e-1 1.000e+0

TimeKeeper1 - Time

Camera

Contour1 - Isosurfaces (-1) 0 0

Contour1 Isosurfaces

11:47 PM
12/3/2018