Visualizing BOUT++ data with VisIt

BOUT++ Mini Workshop 2014

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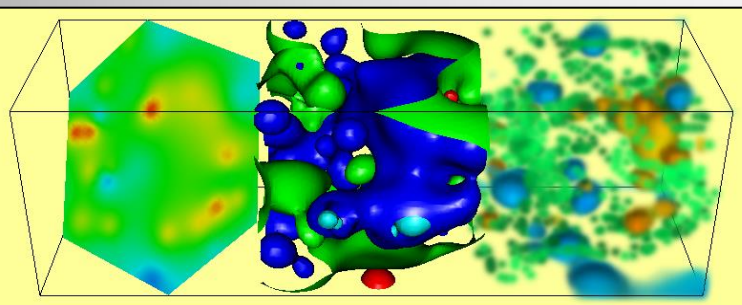
Overview

- Overview of VisIt (10 min)
- Getting your BOUT++ data into VisIt (10 min)
- Visualizing BOUT++ data (20 min)
- Additional resources (3 min)
- Closing remarks and questions (2 min)
- Hands on tutorial (30 min)

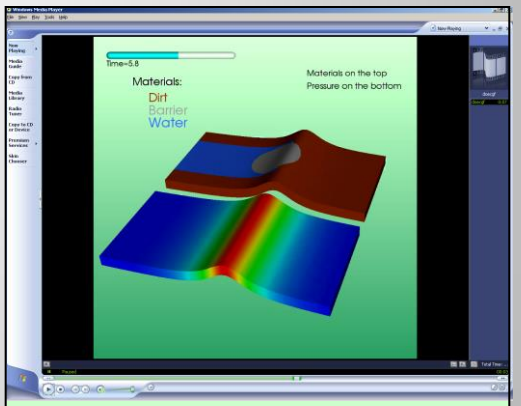
VisIt is an open source, richly featured, turnkey application for scientific data analysis and vis

- Utilizes a plugin architecture for extensibility
  - Rendering methods
  - Data manipulation
  - Data readers
- Utilizes a client/server architecture
- Provides a scalable/parallel server
- Multiple interfaces
  - A graphical user interface
  - A python scripting interface
  - A java library interface
- Multi-platform support – Unix, Windows, MacOS

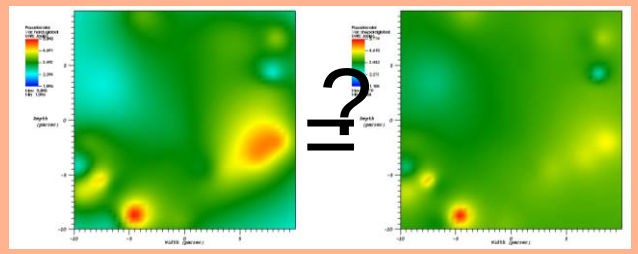
Major use cases



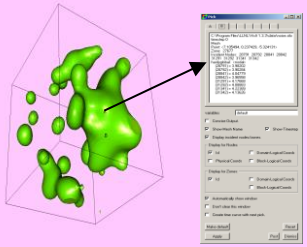
Data Exploration



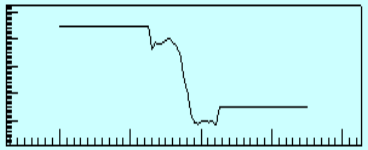
Presentations



Comparative Analysis

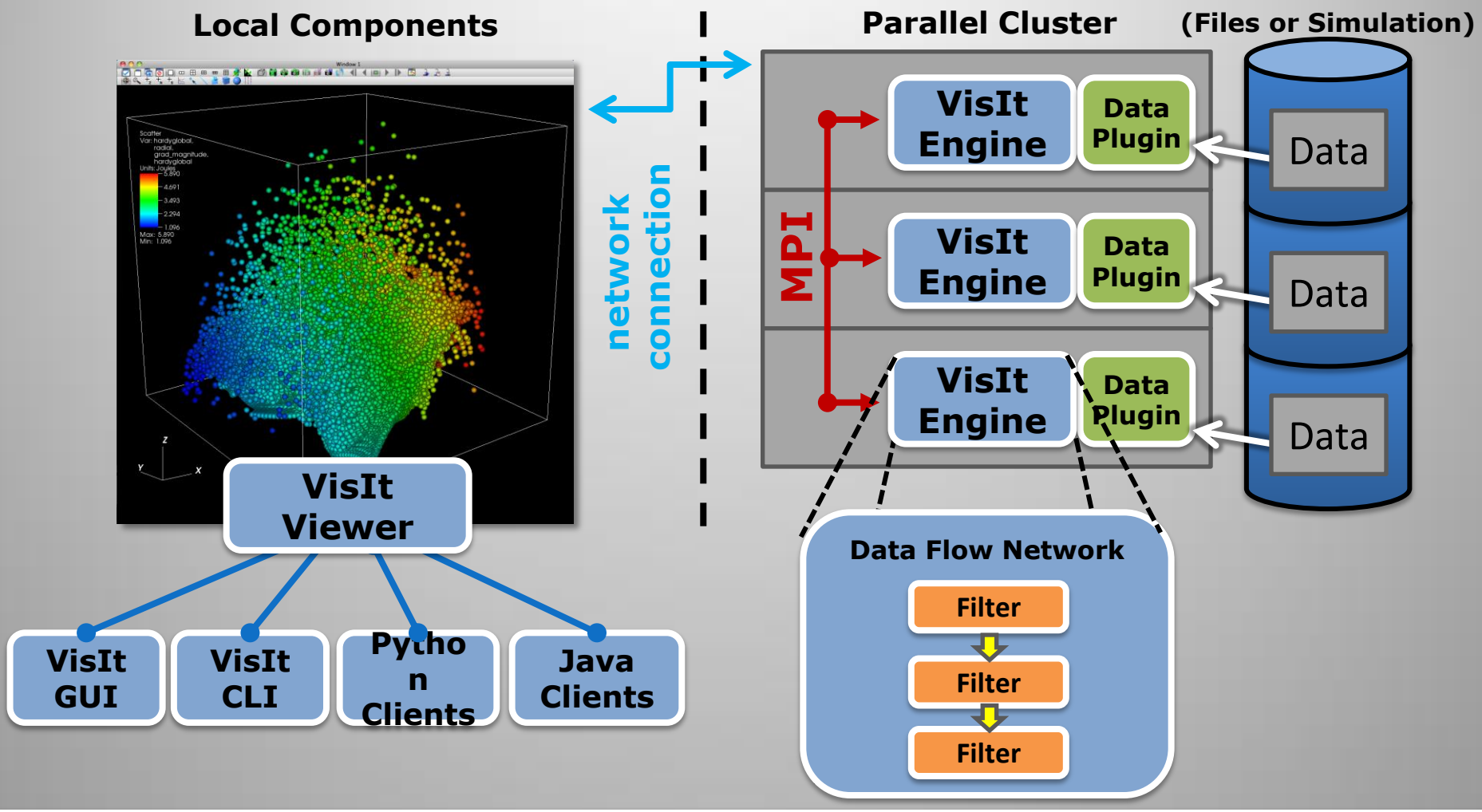


Visual Debugging

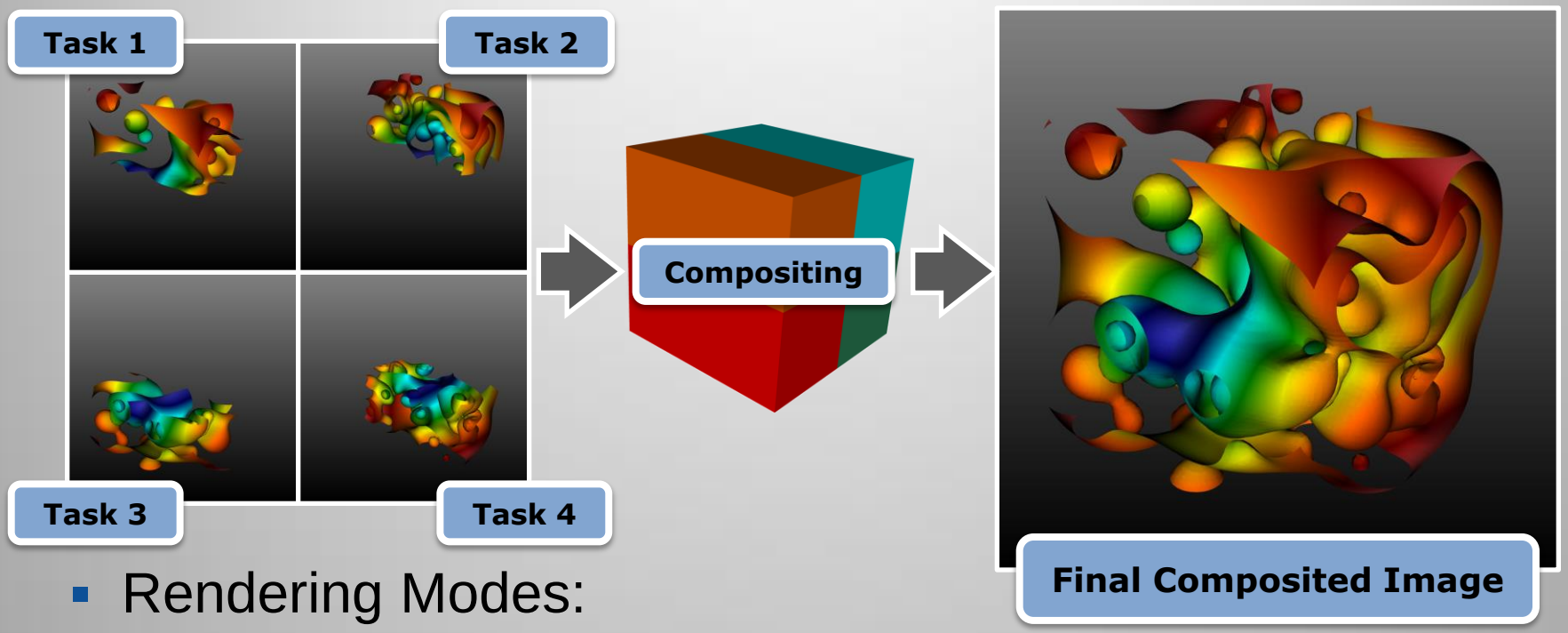


Quantitative Analysis

VisIt employs a parallelized client-server architecture.



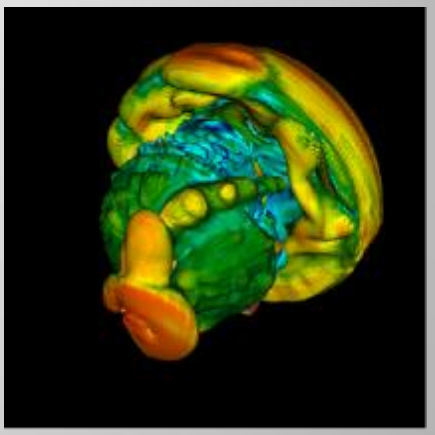
VisIt automatically switches to a scalable rendering mode for large data sets.

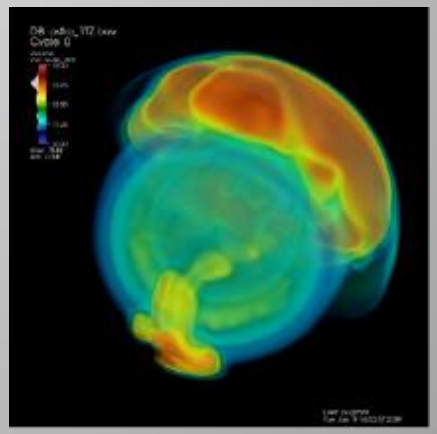


- Rendering Modes:
  - Local (hardware)
  - Remote (software or hardware)
- Beyond surfaces:
  - VisIt also provides scalable volume rendering.

VisIt scales well on current HPC platforms.

Machine	Architecture	Problem Size	# of Cores
Graph	*X86_64*	***20,001³ (8 Tz)***	*12K*
Dawn	BG/P	$15{,}871^3$ (4 Tz)	64K
Franklin	Cray XT4	$12{,}596^3$ (2 Tz)	32K
JaguarPF	Cray XT5	$12{,}596^3$ (2 Tz)	32K
Juno	X86_64	$10{,}000^3$ (1Tz)	16K
Franklin	Cray XT4	$10{,}000^3$ (1Tz)	16K
Ranger	Sun	$10{,}000^3$ (1Tz)	16K
Purple	IBM P5	$8{,}000^3$ (0.5 Tz)	8K





Scaling Studies of Isosurface Extraction and Volume Rendering[1] (2009)

Getting your data into VisIt

- VisIt requires your data to be stored as a NETCDF file
- The data must be stored with the appropriate conventions to be recognized as a BOUT++ file
  - If you use the incorrect conventions then VisIt will treat the file as a generic NETCDF file and you will only be able to render the data as multi-dimensional arrays.
  - When you store it using the correct conventions VisIt will automatically transform it into your real geometry

The format of the solution file

Terminal

File Edit View Search Terminal Help

```
edge83{brugger}38: ls
D3D_144382.02510_x516y64_psi080to120mer.nc
heatflux_DIIID144382_2500_nosheath_t770.nc
te_DIIID144382_2500_nosheath_t770.nc
edge83{brugger}39: ncdump -h te_DIIID144382_2500_nosheath_t770.nc
netcdf te_DIIID144382_2500_nosheath_t770 {
dimensions:
        x = 155 ;
        strlen = 42 ;
        strlen2 = 30 ;
        strlen3 = 3 ;
        z = 64 ;
        y = 64 ;
        x2 = 516 ;
        t = 155 ;
variables:
        float timestep(x) ;
        double timescale ;
        char gridname(strlen) ;
        char variablename(strlen2) ;
        char unit(strlen3) ;
        float te(t, x2, y, z) ;
        short zperiod ;
}
edge83{brugger}40: ncdump -v gridname te_DIIID144382_2500_nosheath_t770.nc
netcdf te_DIIID144382_2500_nosheath_t770 {
data:
 gridname = "D3D_144382.02510_x516y64_psi080to120mer.nc" ;
}
                                                        1,1           All
```

Grid file

Solution files

Necessary variables

Must be in t, x, y, z order

Name of grid file

The format of the grid file

Terminal

File Edit View Search Terminal Help

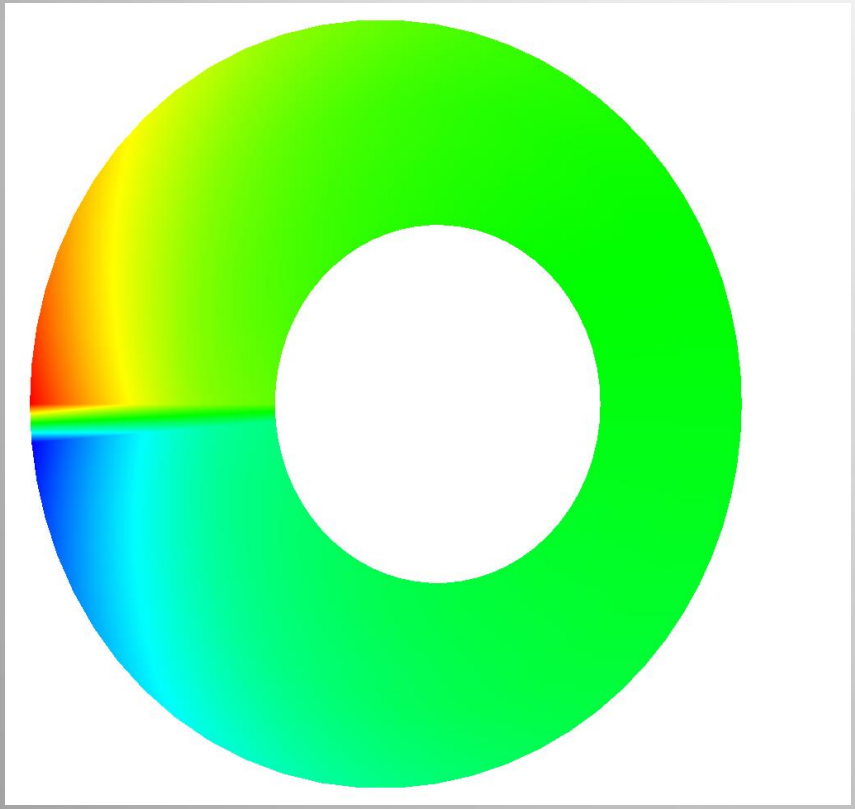
```
edge83{brugger}43: ncdump -h D3D_144382.02510_x516y64_psi080to120mer.nc
netcdf D3D_144382.02510_x516y64_psi080to120mer {
dimensions:
        y = 64 ;
        x = 516 ;
        x2 = 3 ;
        x3 = 2 ;
variables:
        short nx ;
        short ny ;
        int ixseps1 ;
        short ixseps2 ;
        int jyseps1_1 ;
        int jyseps1_2 ;
        int jyseps2_1 ;
        int jyseps2_2 ;
        int ny_inner ;
        float dx(x, y) ;
        float dy(x, y) ;
        float ShiftAngle(x) ;
        float zShift(x, y) ;
        float pol_angle(x, y) ;
        double ShiftTorsion(x, y) ;
        float Rxy(x, y) ;
        float Zxy(x, y) ;
        float Bpxy(x, y) ;
        float Btxy(x, y) ;
        float Bxy(x, y) ;
        float hthe(x, y) ;
                                                        59,1-8        46%
```

Necessary variables

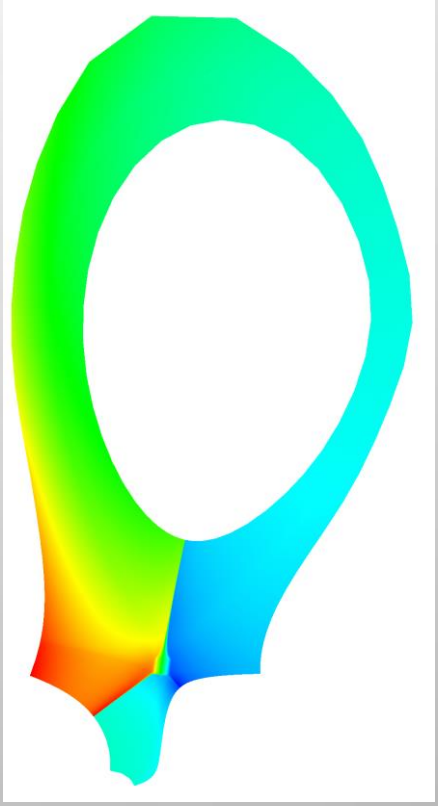
When things go wrong

- Use "`ncdump -h field_file`" to check that the required variables are present
- Use "`ncdump -v gridname field_file`" to check that the gridname is correct
- Use "`ncdump -h grid_file`" to check that the required variables are present
- Use "`visit -debug 4`" and look at the resulting "vlog" files for a message that may indicate the probem.

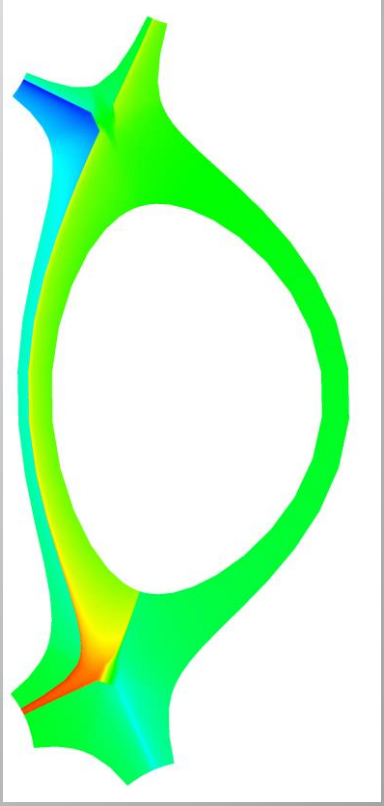
VisIt automatically detects the standard grid configurations (circular,1X, 2X)



Circular grid



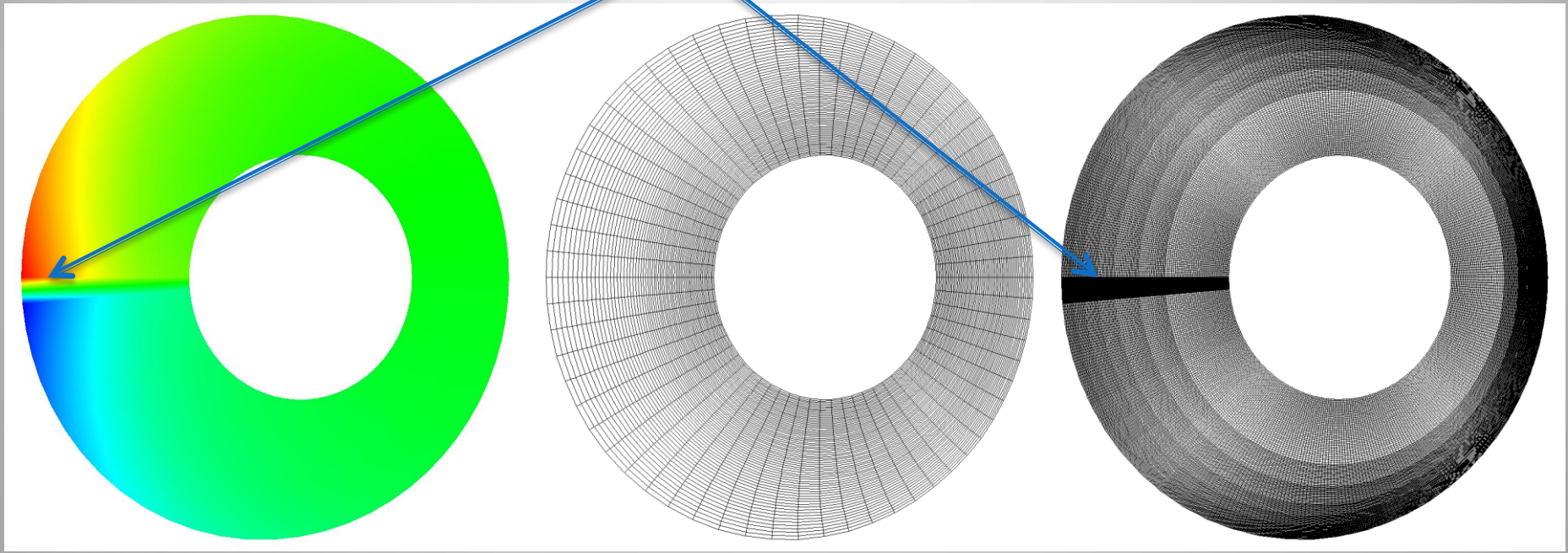
1 X grid



2 X grid

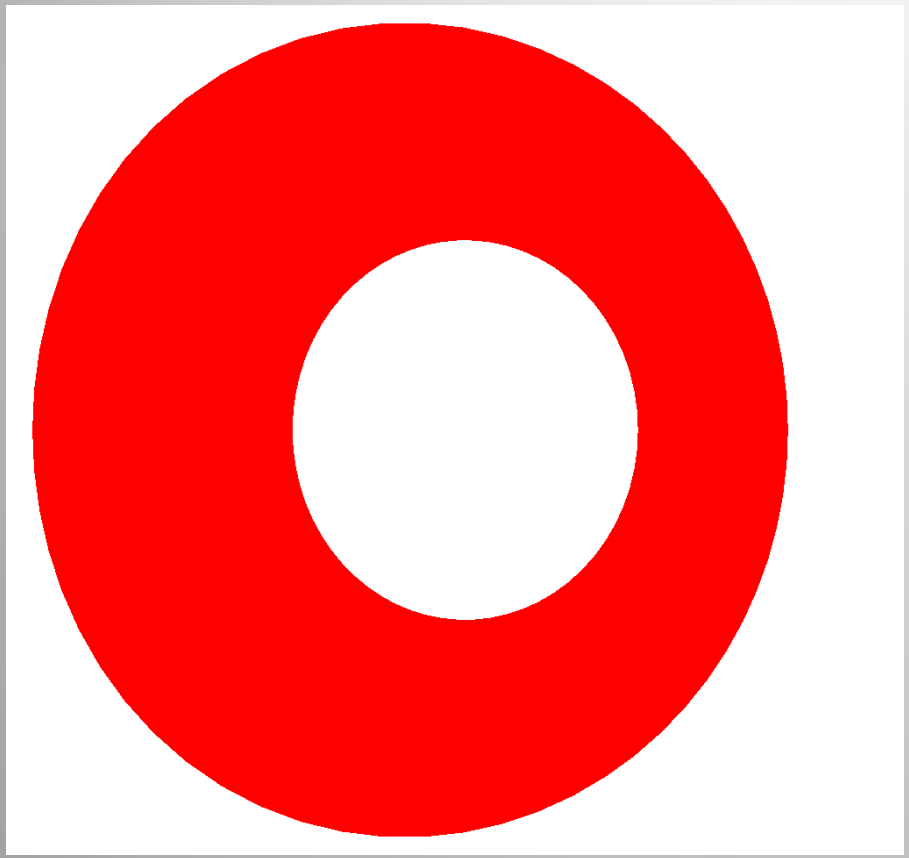
VisIt adaptively refines the grid based on zShift

Large jump in zShift leads to a lot of refinement

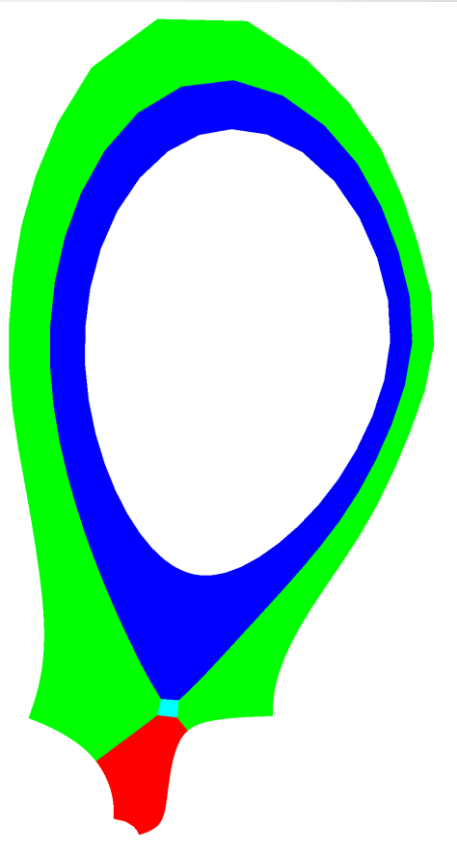


zShift | Original grid | Refined grid

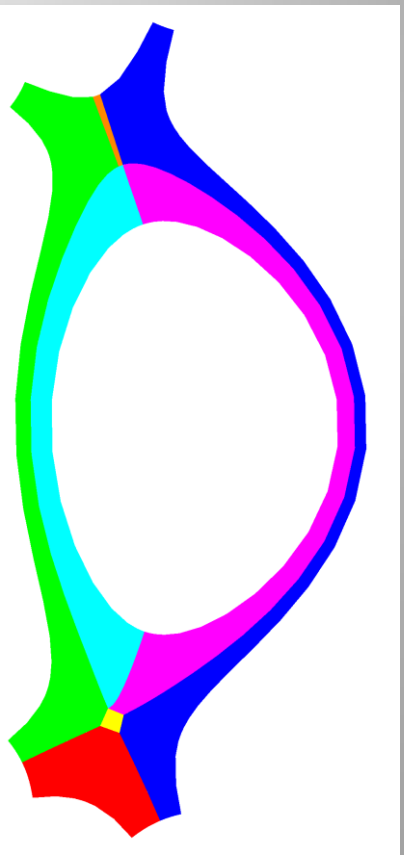
VisIt will break the grid into several structured pieces



Circular grid

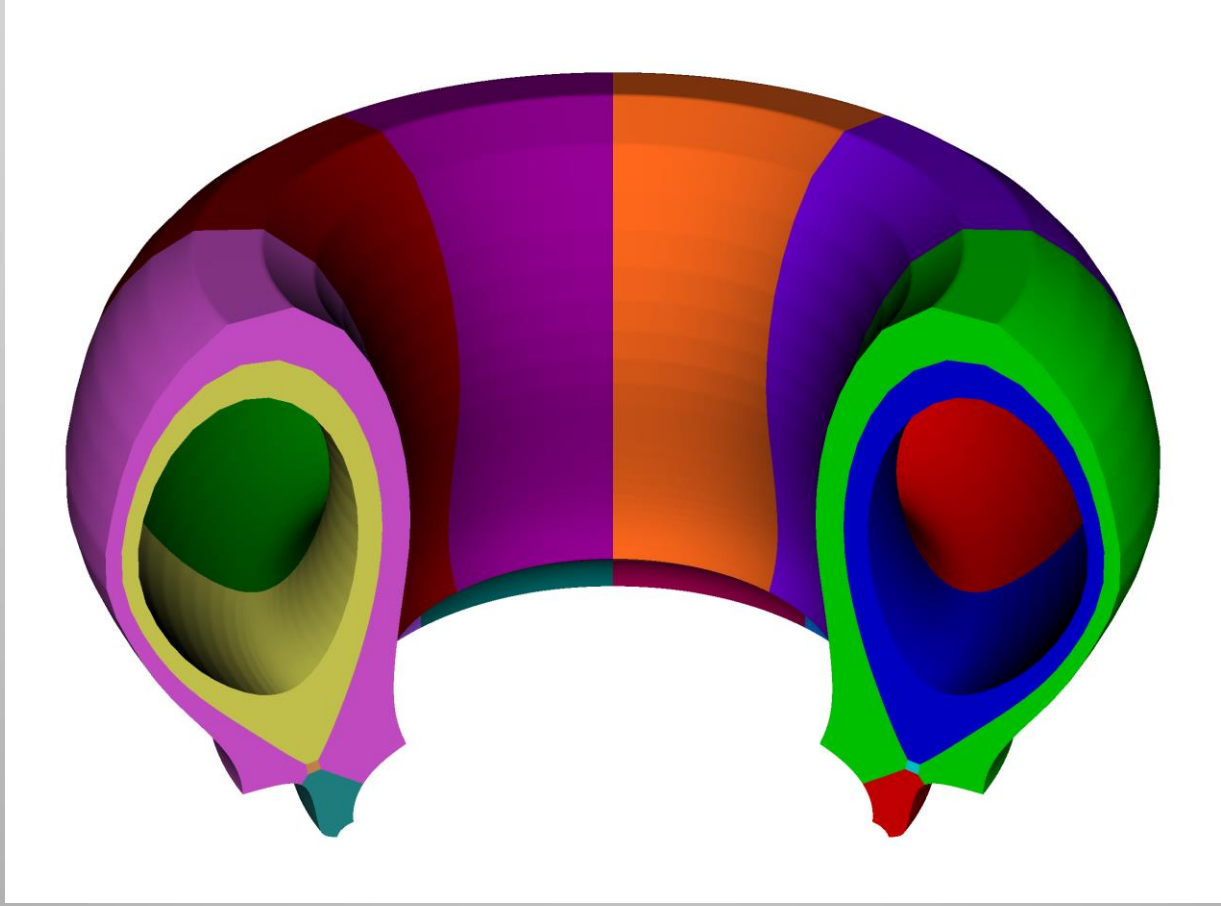


1 X grid



2 X grid

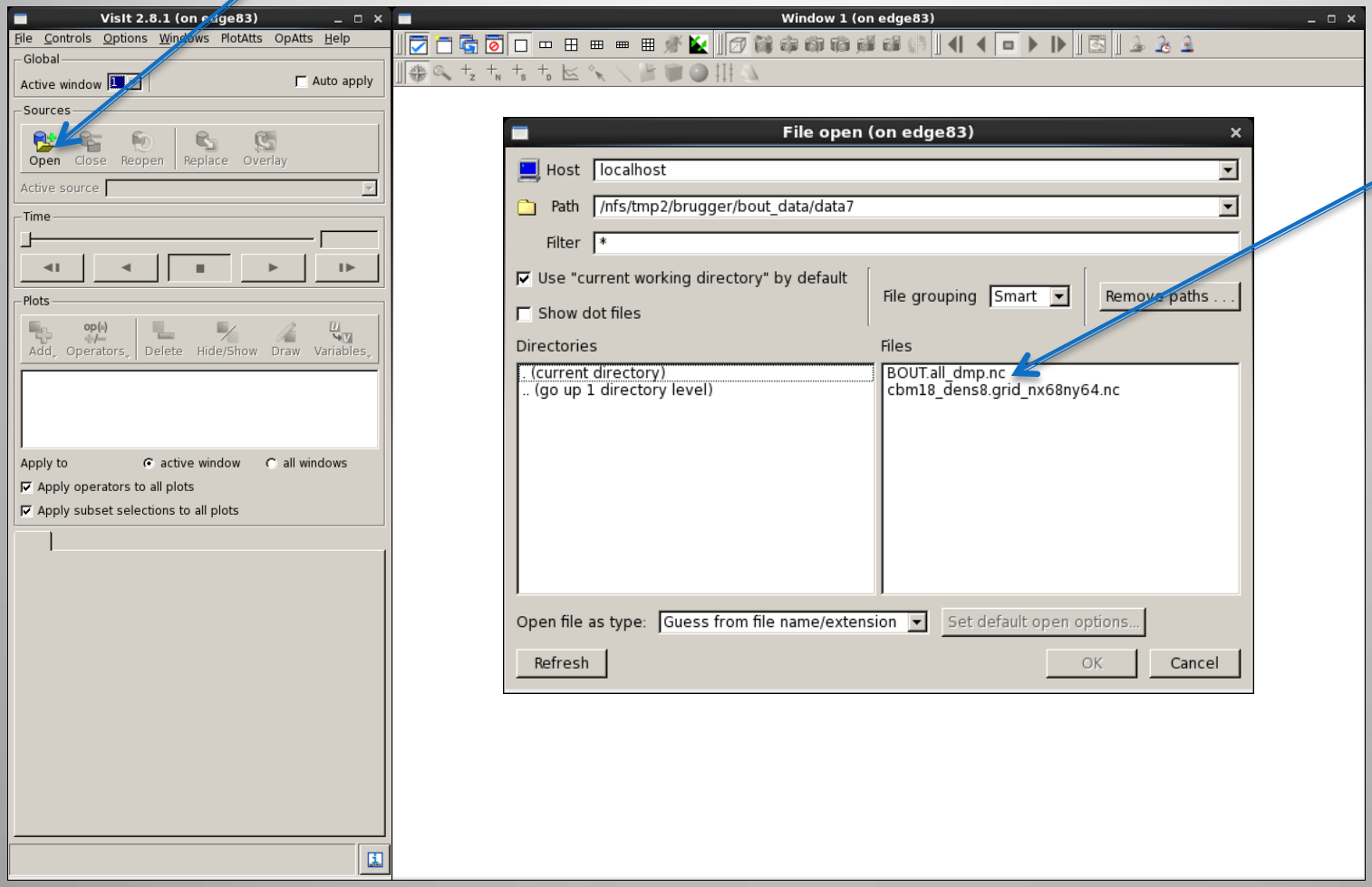
VisIt will also create structured blocks as it replicates the blocks around the taurus



A 1 X grid with zPeriod = 8 gives 4 * 8 = 32 grids

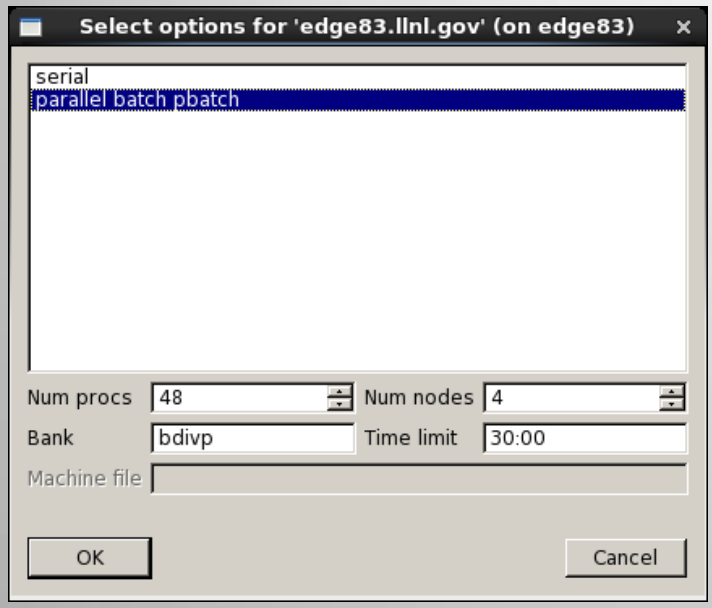
Opening a BOUT file

Select the open icon to open a file



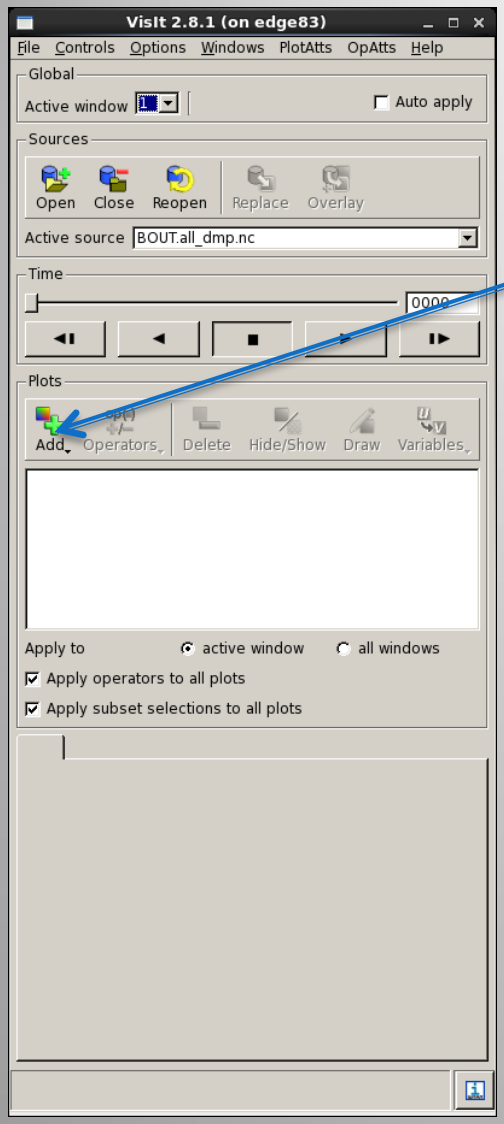
Open the Solution file

Running in parallel

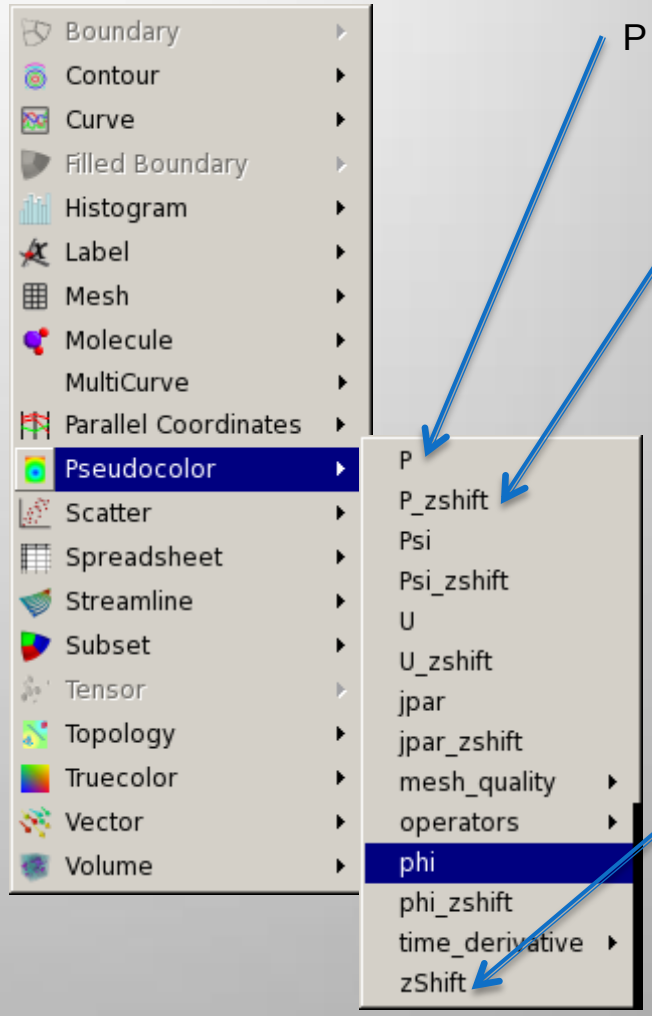


- When you open the first file VisIt will prompt you to start a compute engine
- Choose a parallel one
- Don't use more processors than blocks
- E.g. 1 X grid with zperiod=8 gives 32 blocks so use 32 processors (using more or less won't hurt, but may result in lower performance or wasting cpus)

Selecting variables to display



Press the Add icon to bring up the list of plots and then the list of variables

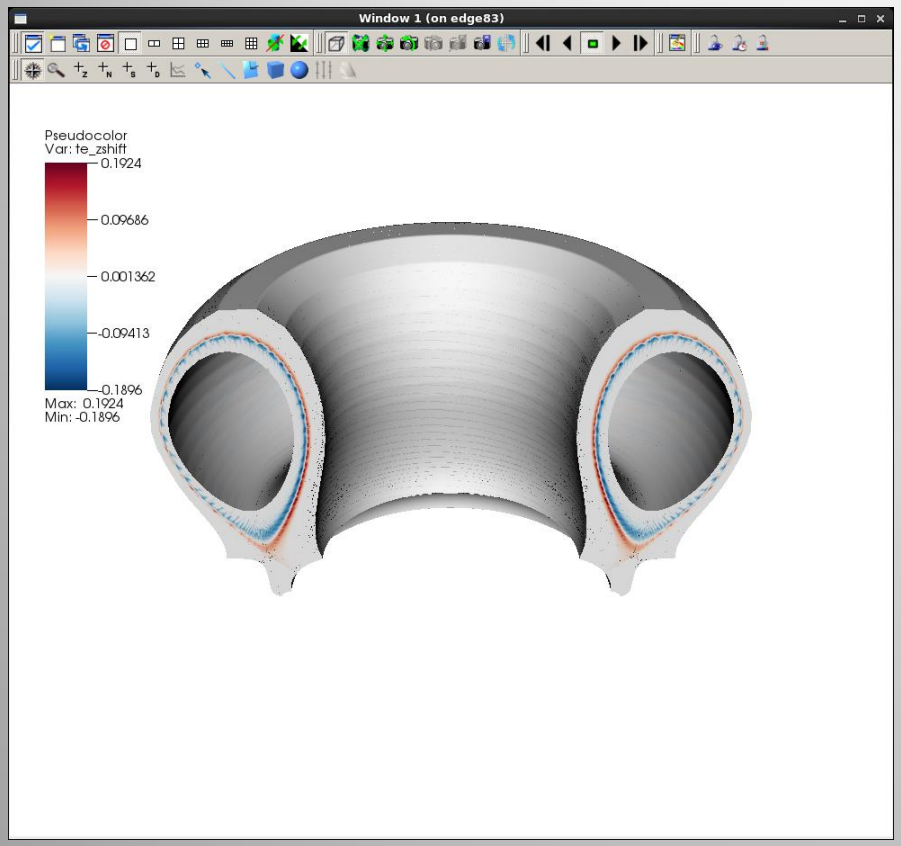


P in 3d

P in 3d with zShift applied

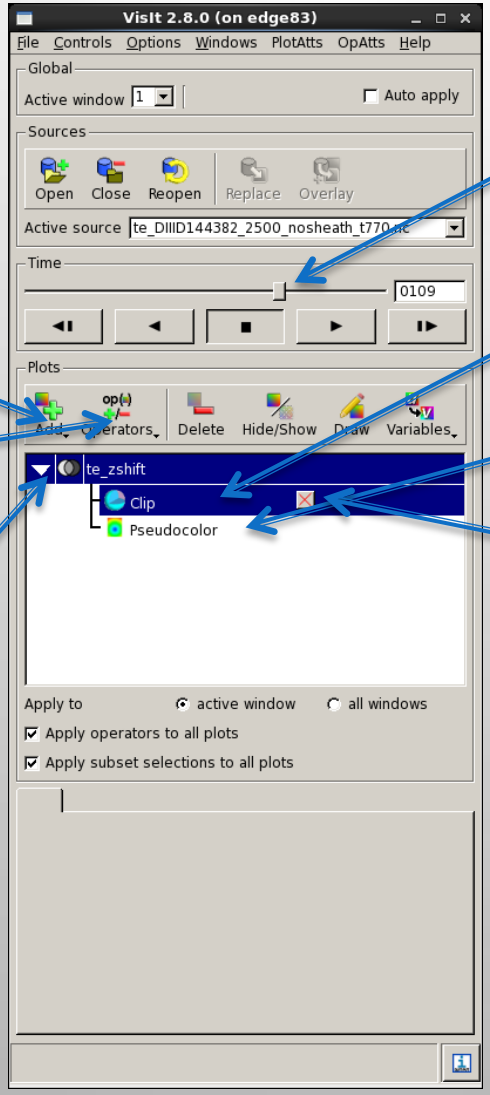
zShift in 2d

Creating a simple plot



- This is a pseudo color plot of electron temperature with a clip applied
  - If you don't either slice or clip the 3d data it will be very boring
- It has a non-standard color table
- It has some annotations removed, the color bar is enlarged from the default

Creating a simple plot – specifics



Icon to add plots

Icon to add operators

Downward facing triangle expands the plot

Time slider to change the time state

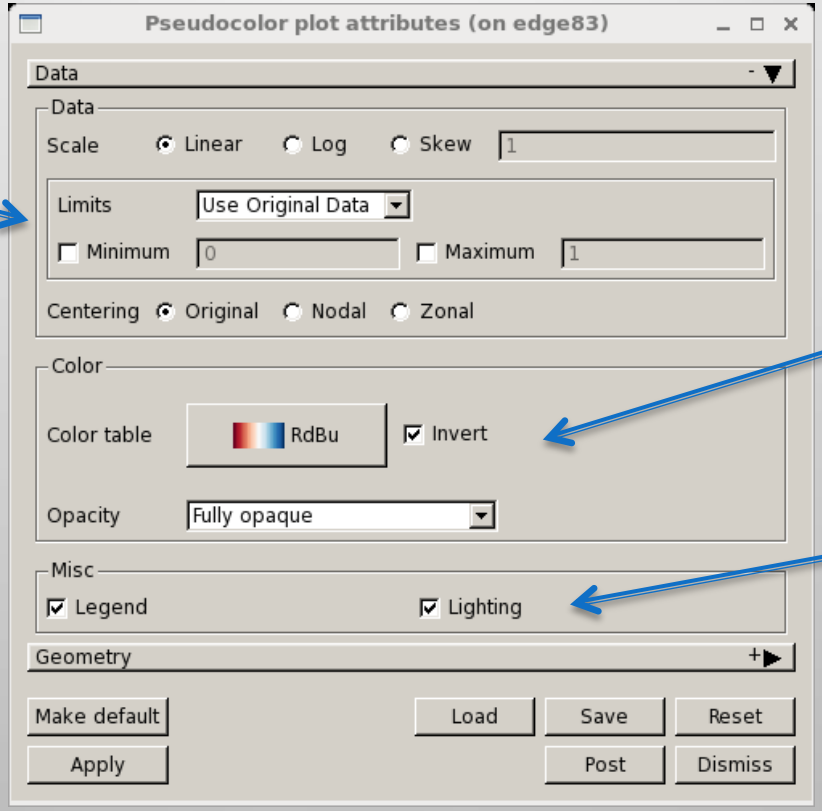
Clip operator, double click to bring up the clip attributes

Pseudo color plot, double click to bring up the pseudo color attributes

Click to remove the clip operator

Creating a simple plot – the pseudo color attributes

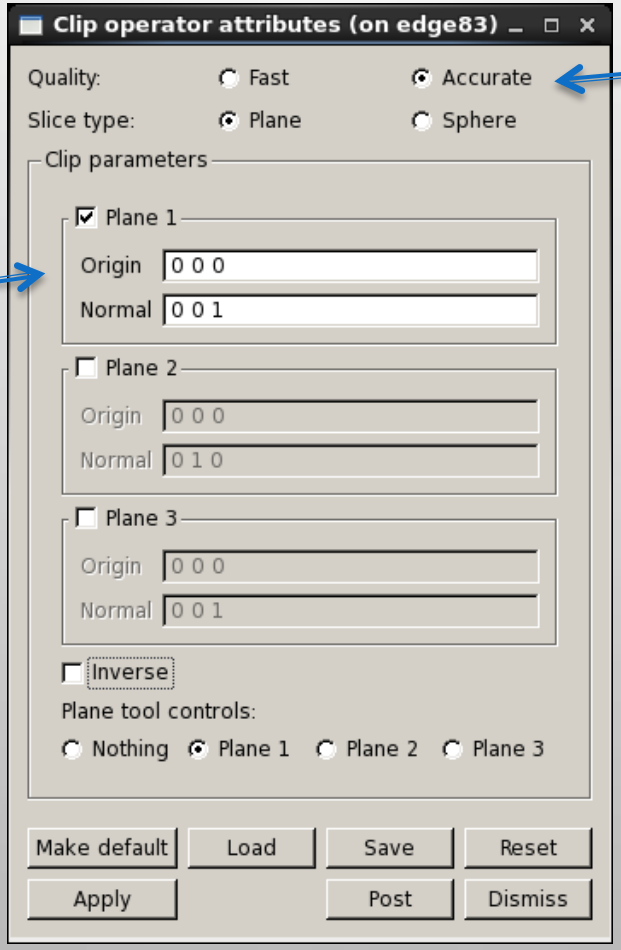
Use the limits to set a specific range to color the data. Useful for maintaining the scale with time animations



Click on the color table icon to select a different color table. You may want to invert it.

You may want to turn off lighting on slices

Creating a simple plot – the clip attributes



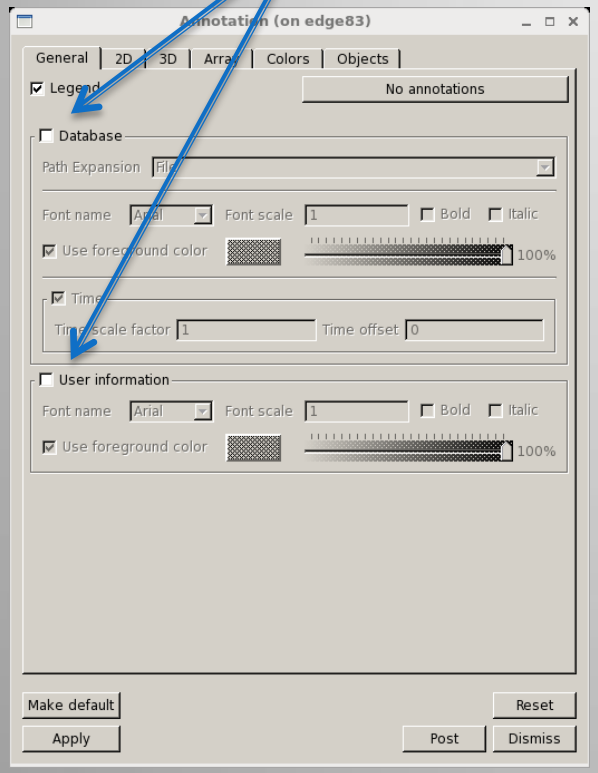
Accurate is usually the best

Set the origin and normal for up to 3 planes.

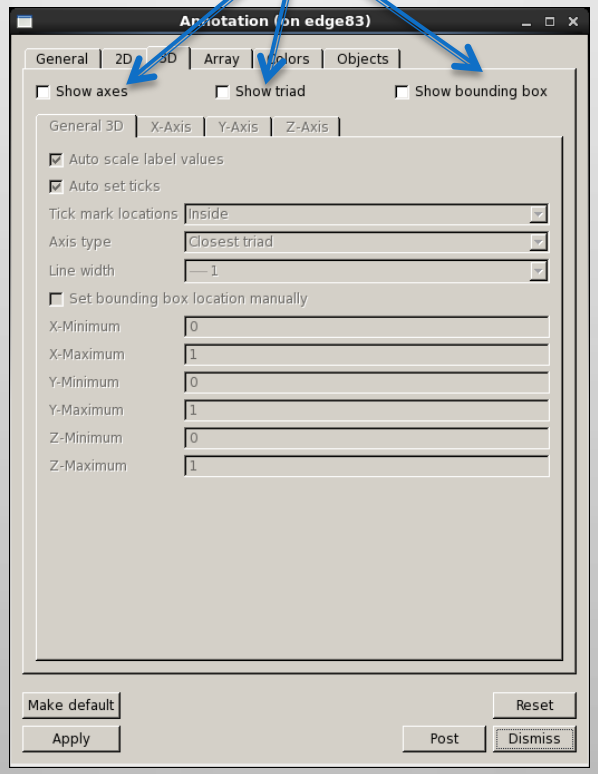
- 1 plane removes a half
- 2 planes remove a quarter
- 3 planes remove an octant

Creating a simple plot – annotations

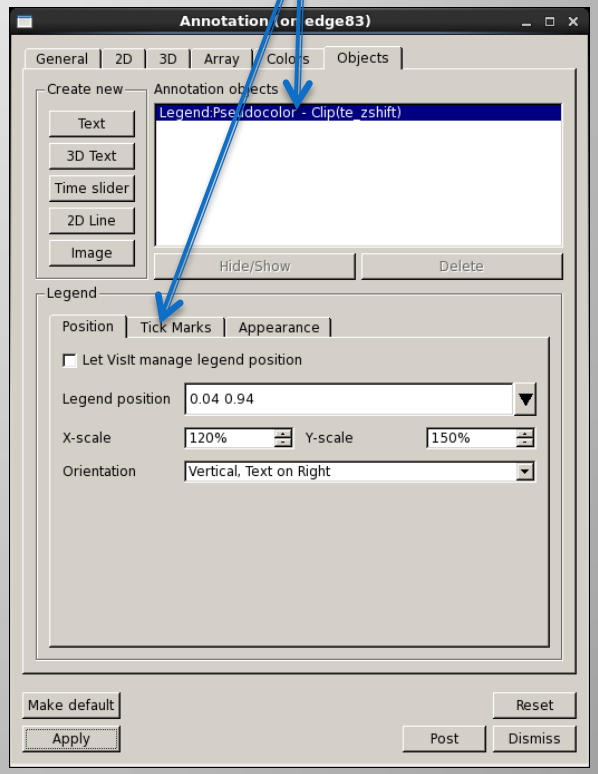
Turn off the database and user information titles



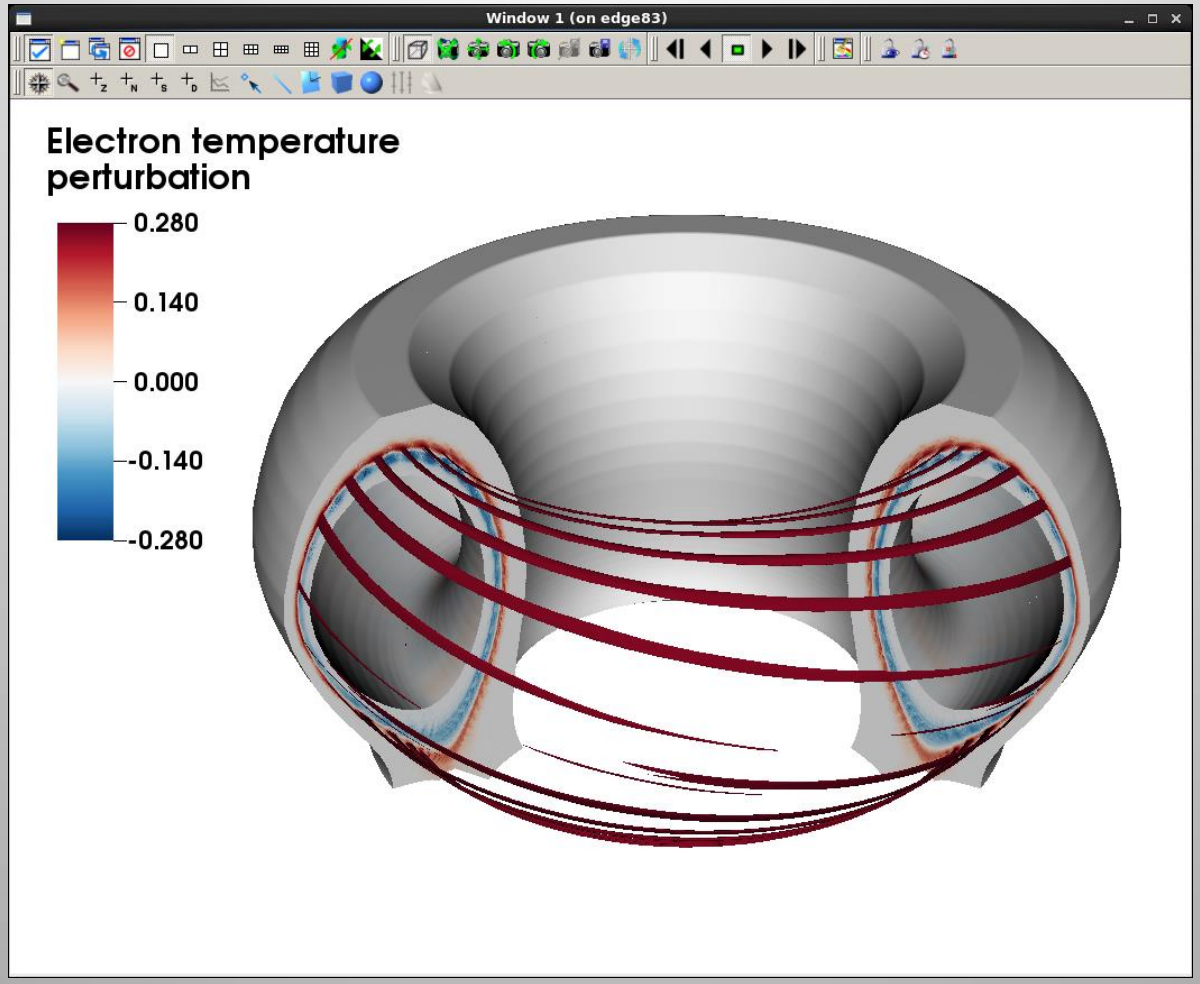
Turn off the axes and bounding boxes



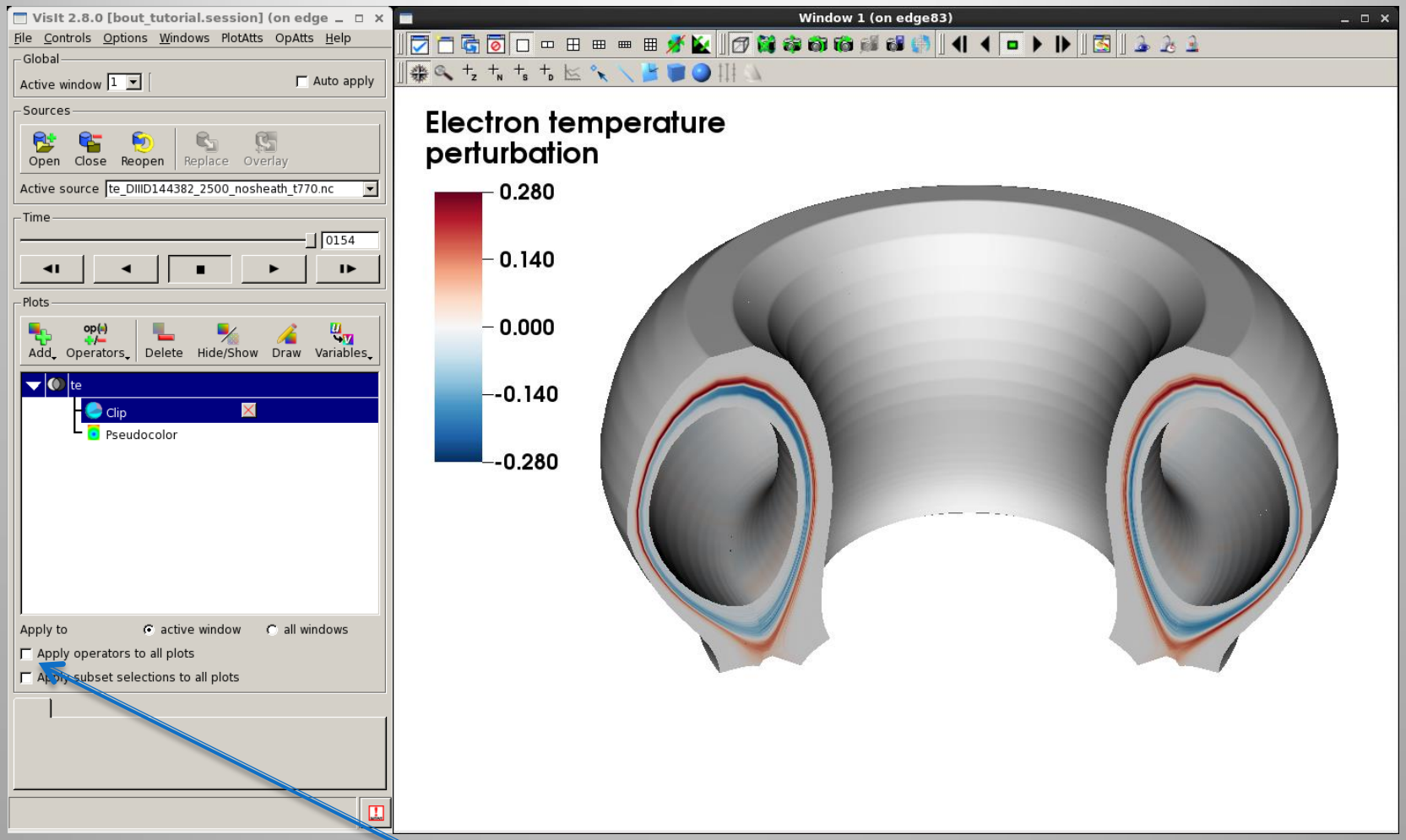
Set the legend attributes.
You can also add lines and titles.



Creating a more sophisticated image

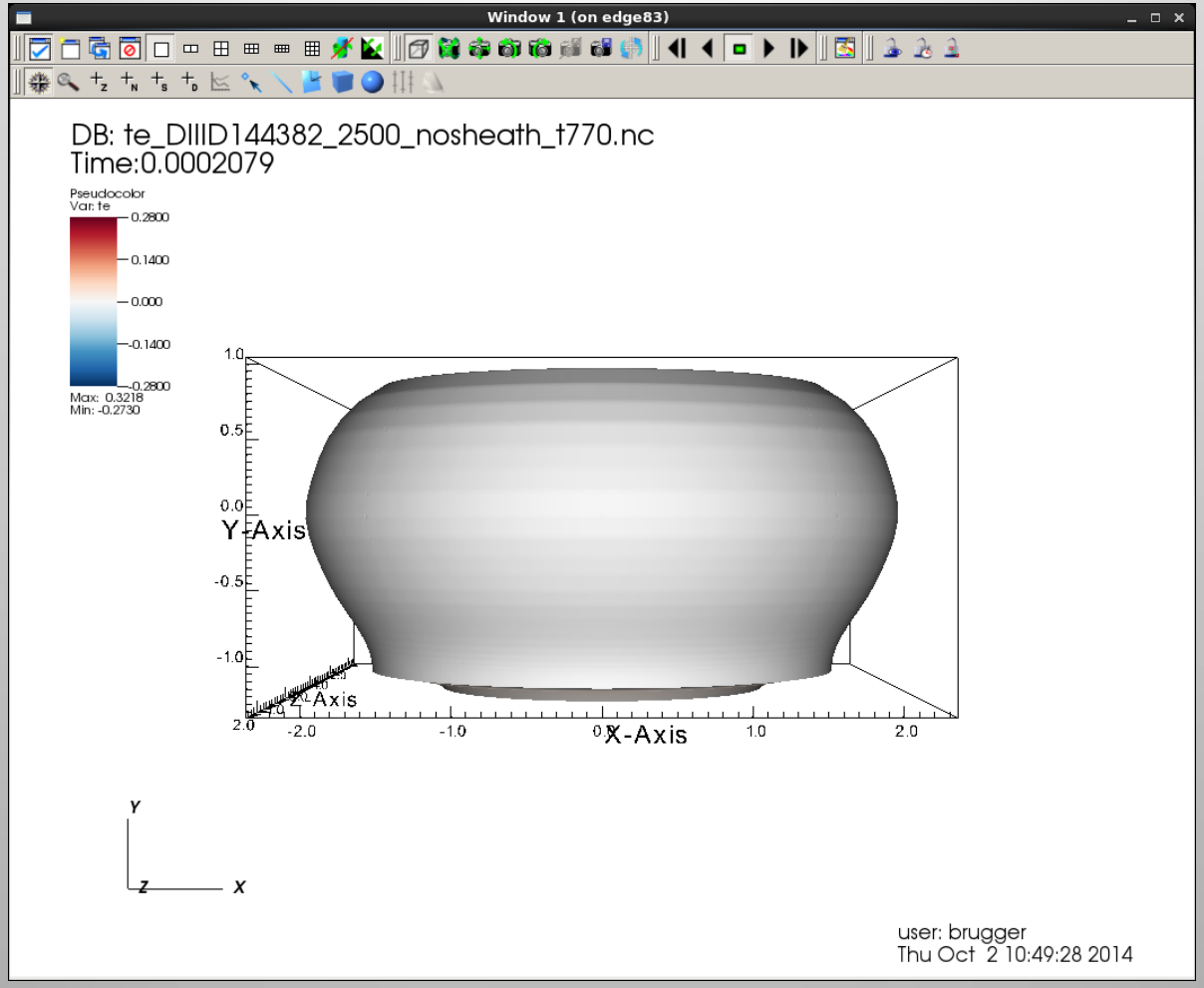


Step 1: Create a pseudo color of te with a clip to show the interior



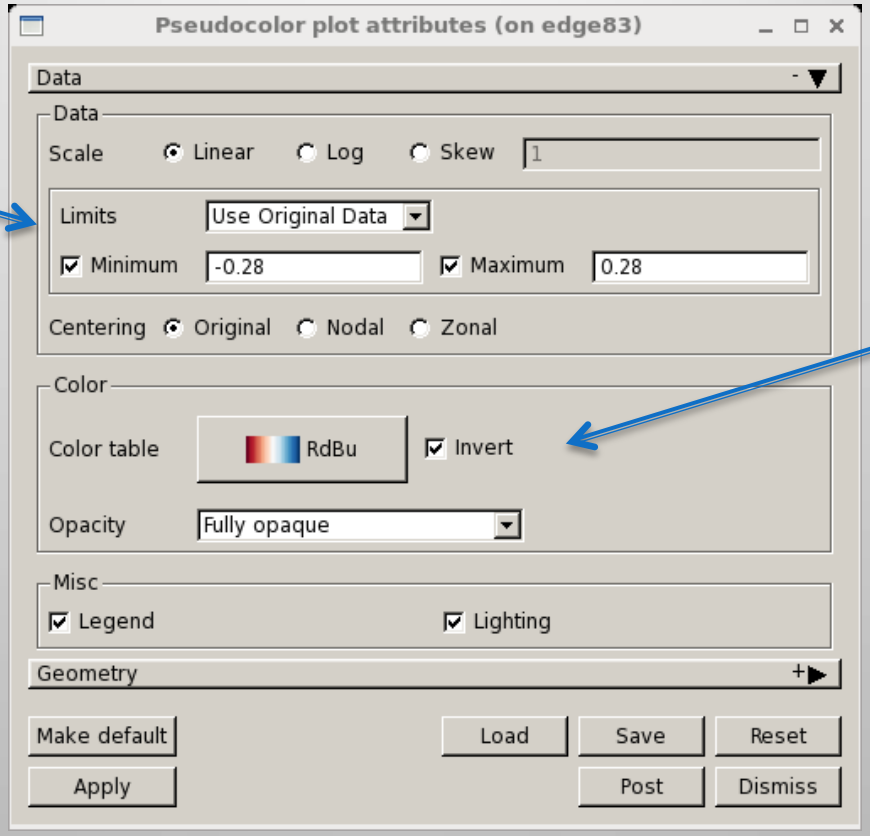
Make sure these are unchecked

Start with a pseudo color plot of te



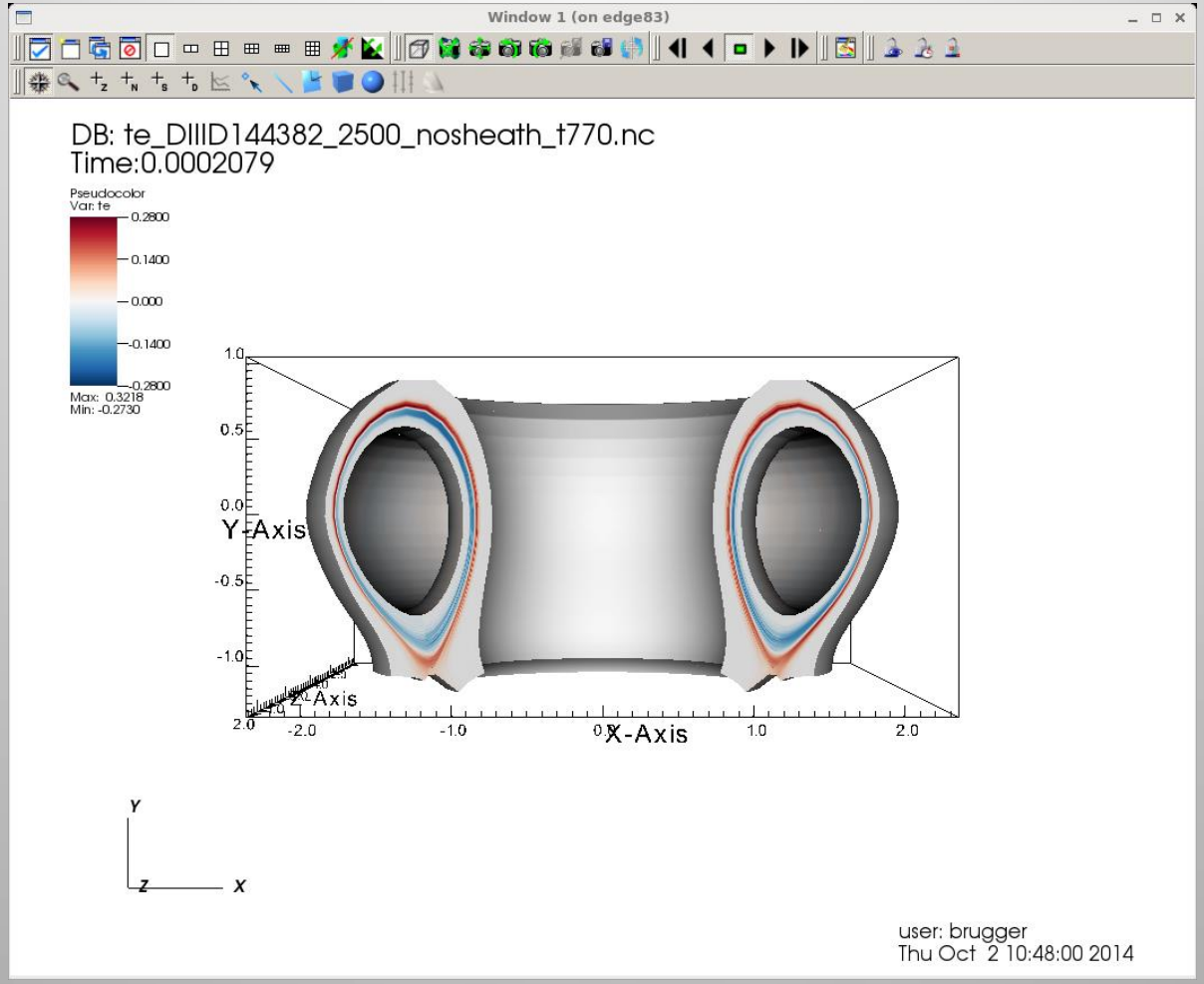
Adjust the pseudo color attributes

Use the limits to set a specific range to color the data. Useful for maintaining the scale with time animations

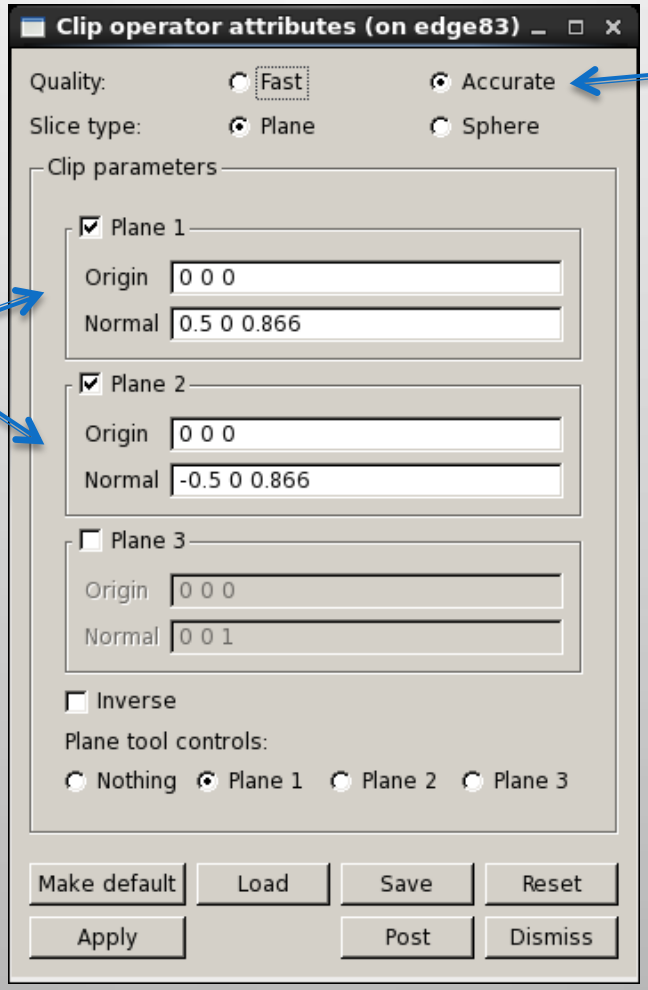


Click on the color table icon to select a different color table. You may want to invert it.

Clip out the front third of the taurus



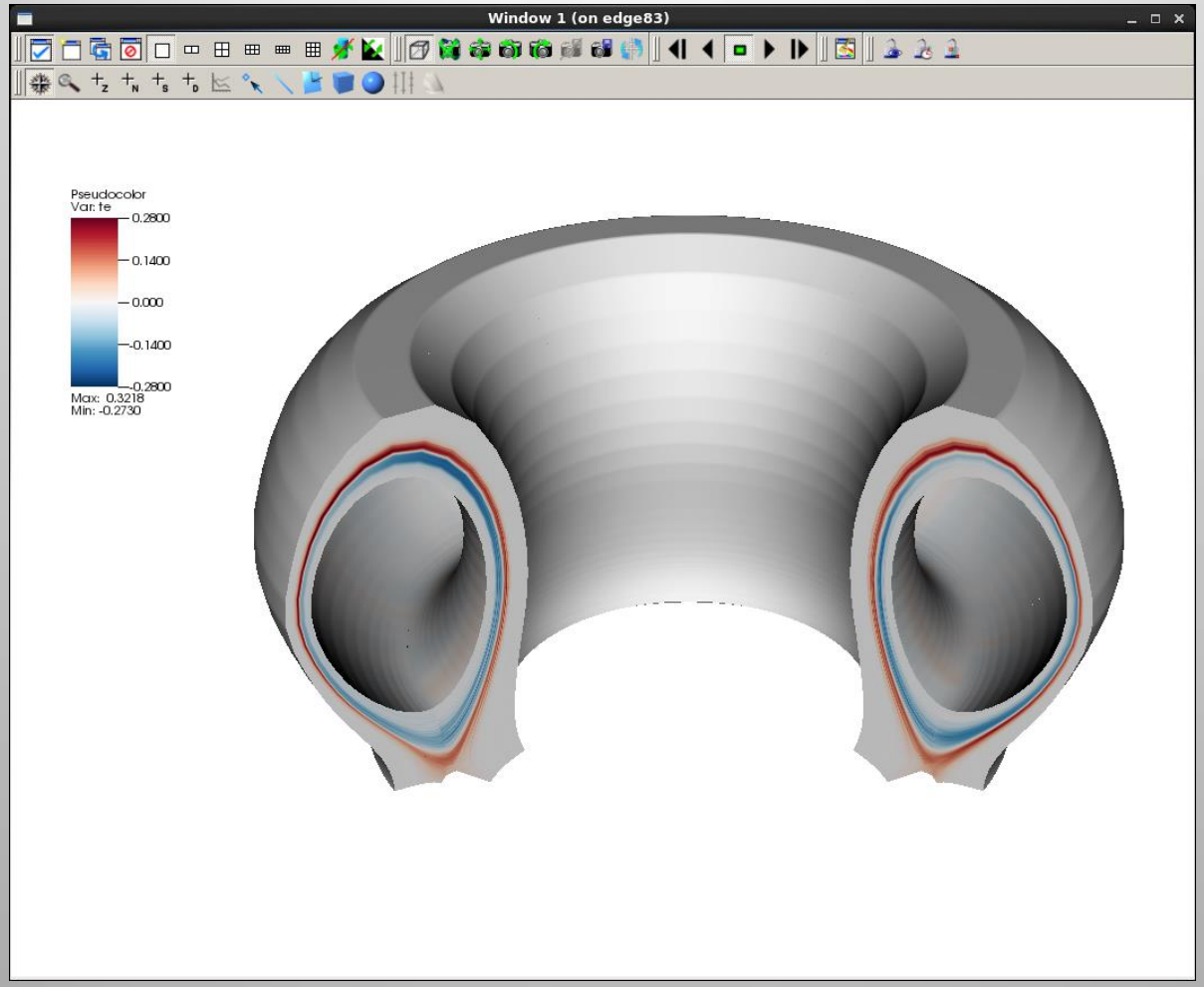
Clipping out the front third of the taurus



Accurate is usually the best

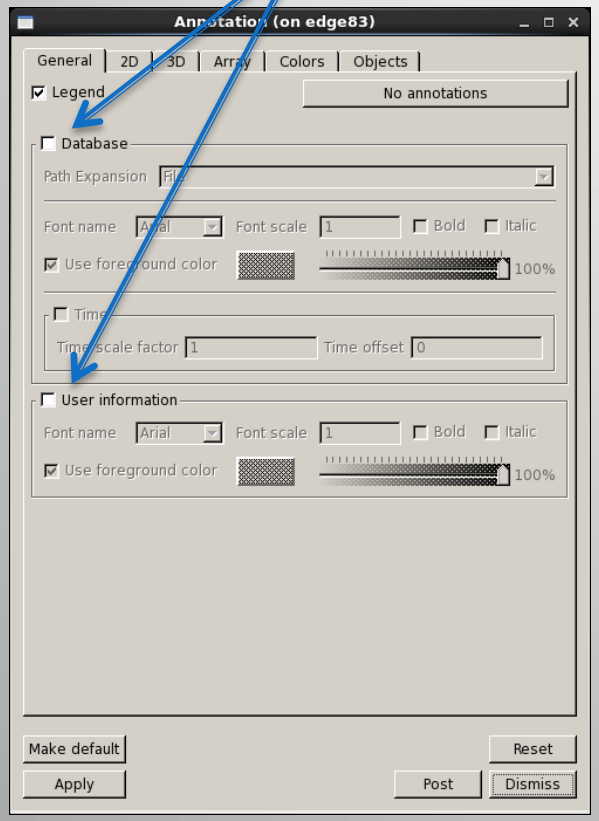
Set the origin and normal for 2 planes. 2 planes remove a quarter.

Remove the unnecessary annotations and change the view

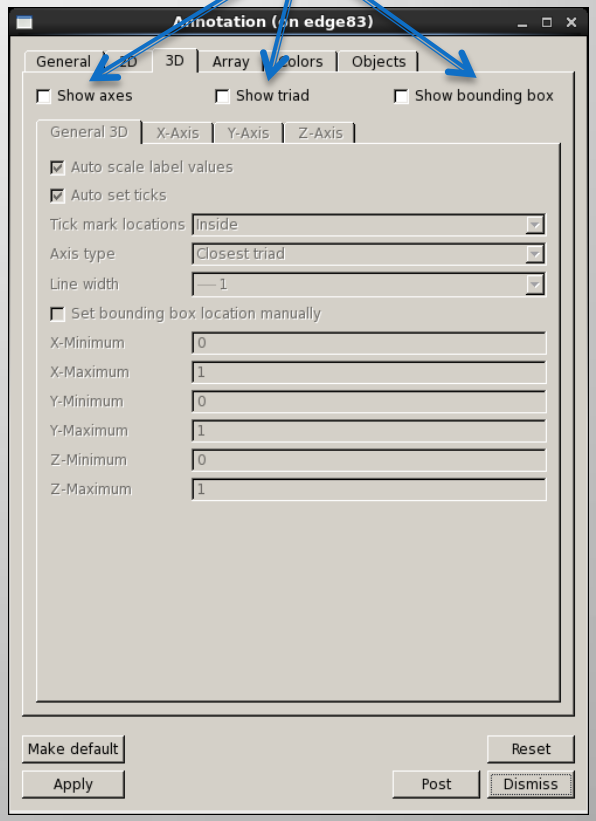


Removing the unnecessary annotations

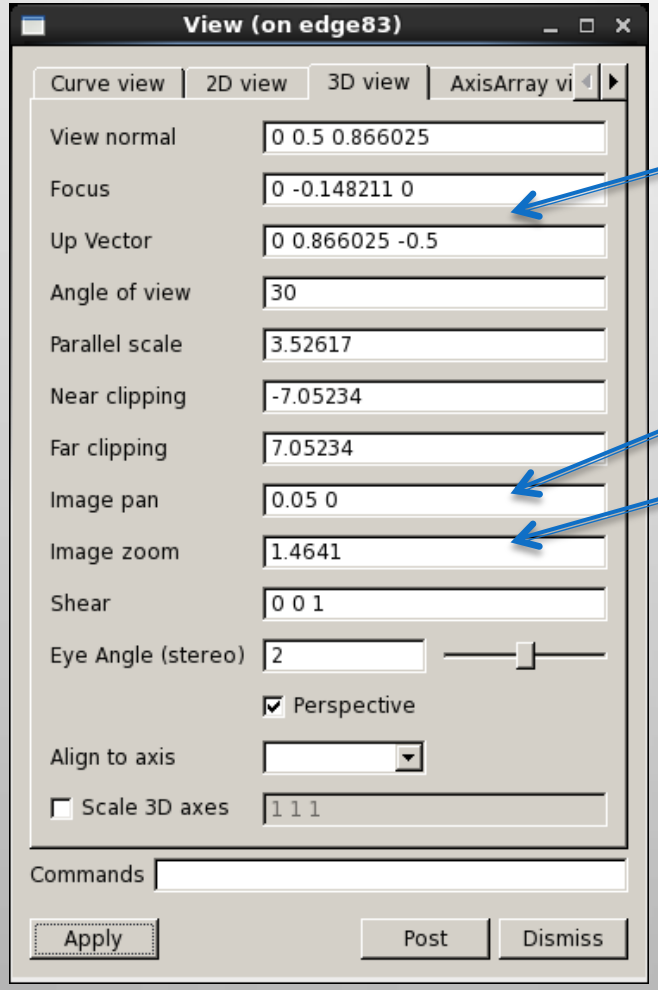
Turn off the database and user information titles



Turn off the axes and bounding boxes



Adjust the view with the interactive tools and fine tune with the view attributes

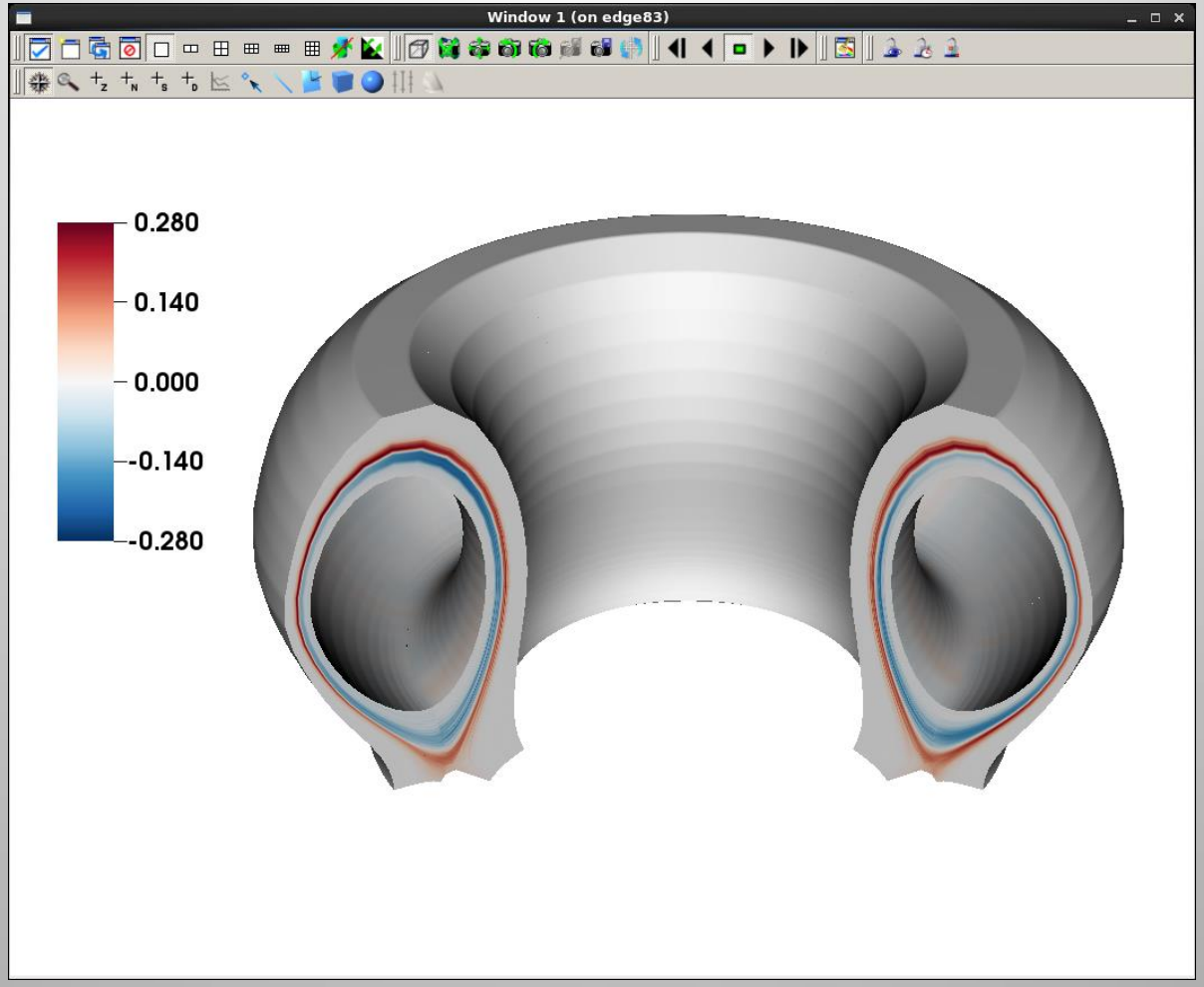


Orientation settings

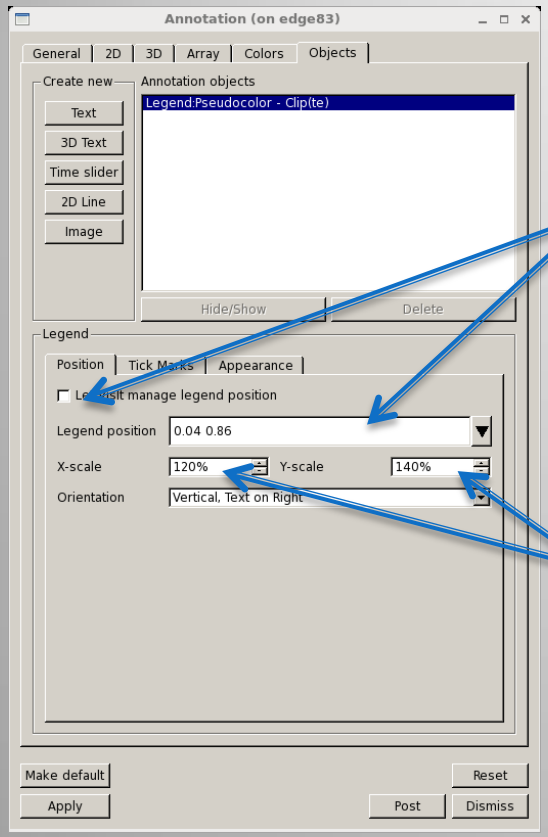
Image panning settings

Image zooming settings

Adjust the legend attributes

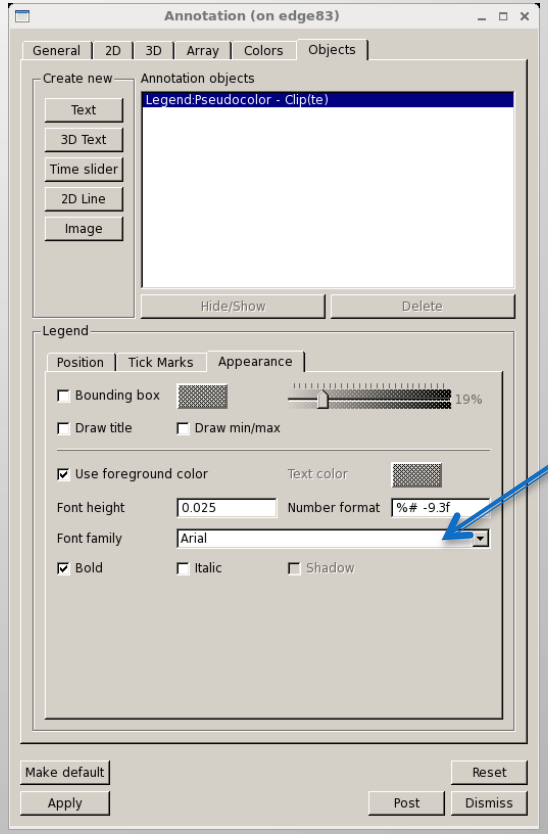


Adjusting the legend attributes



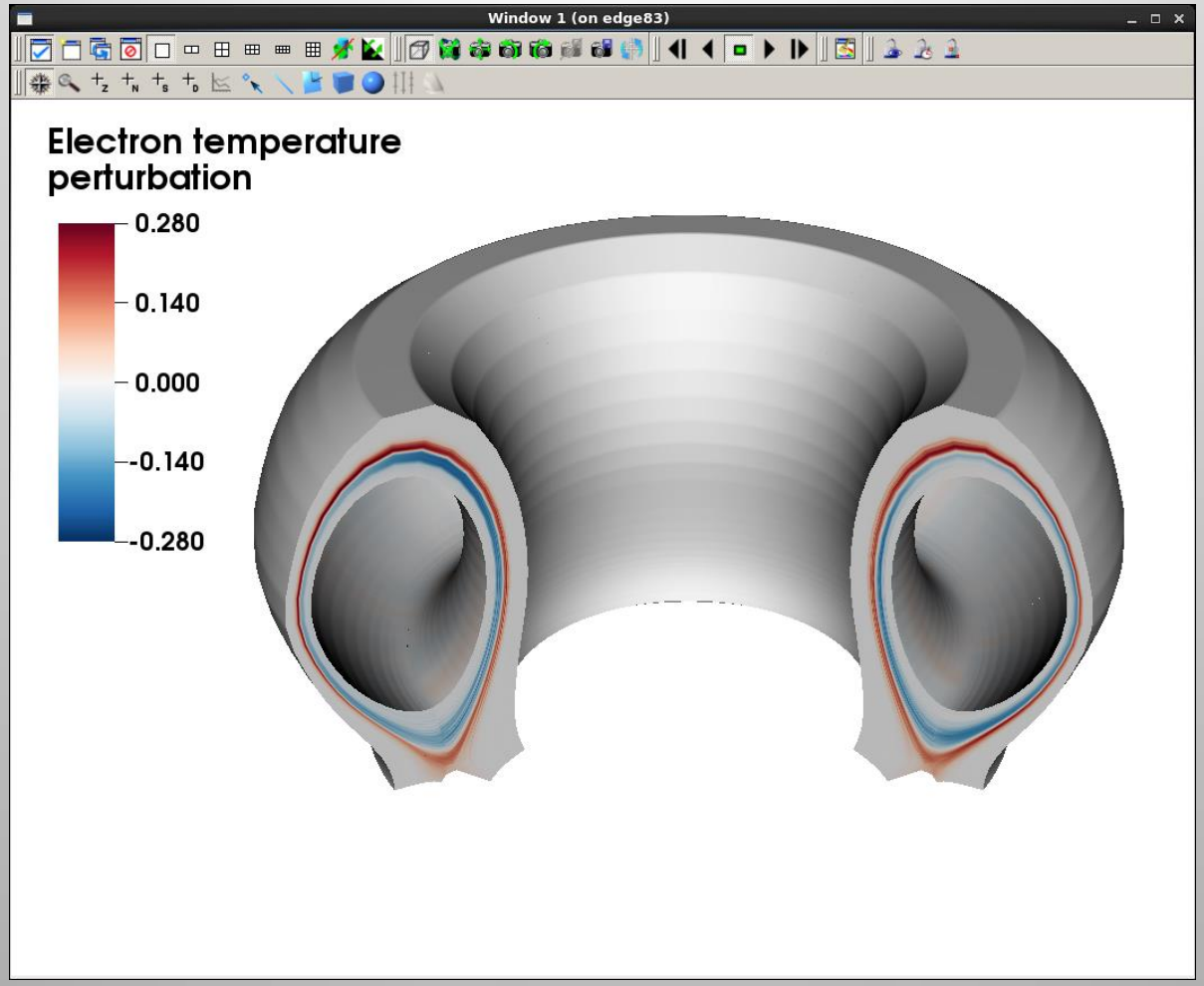
The legend position

The legend size

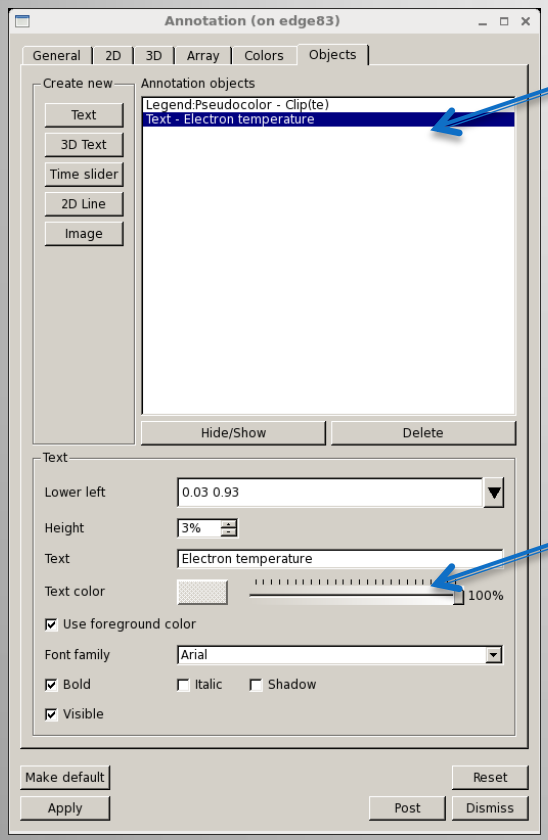


The font

Add the titles for the legend

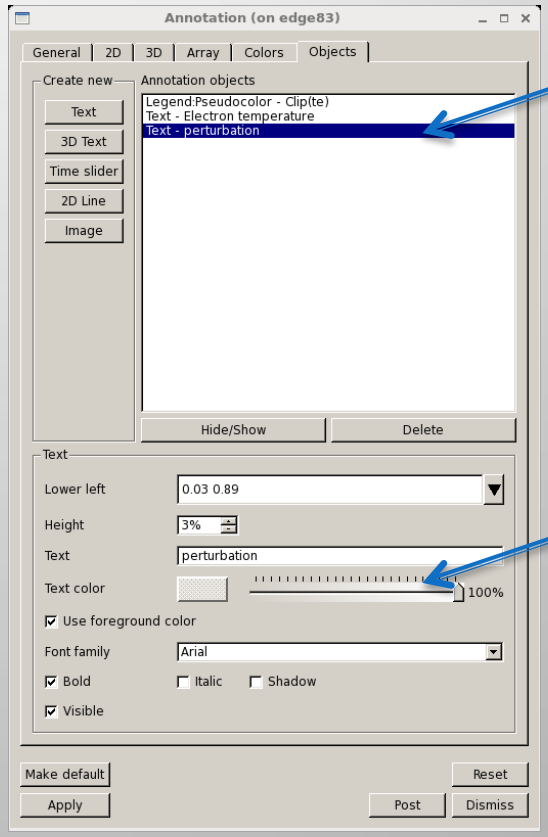


Adding the titles for the legend



1st line of title

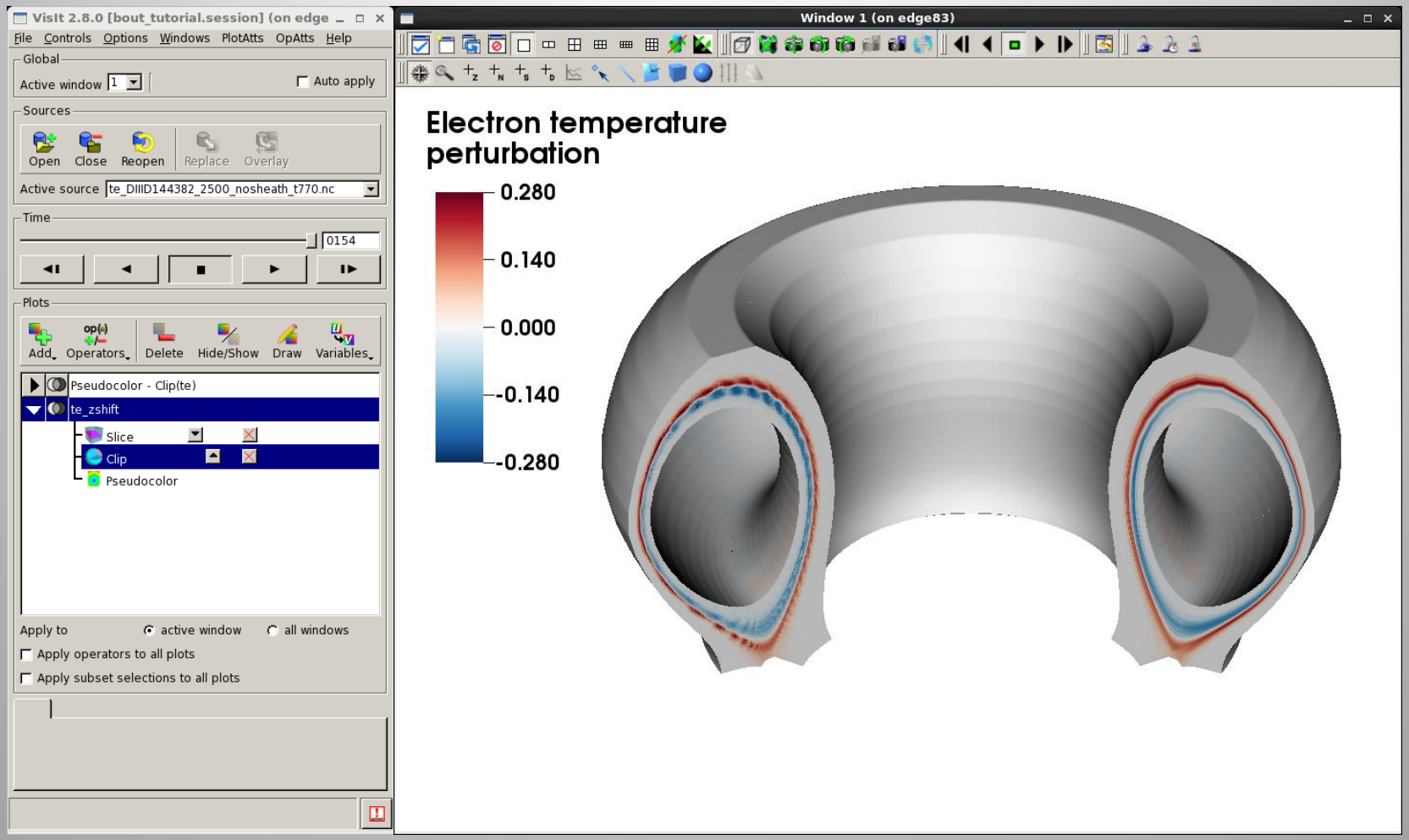
Title properties



2nd line of title

Title properties

Step 2: Add a pseudo color plot of te_zshift on a slice

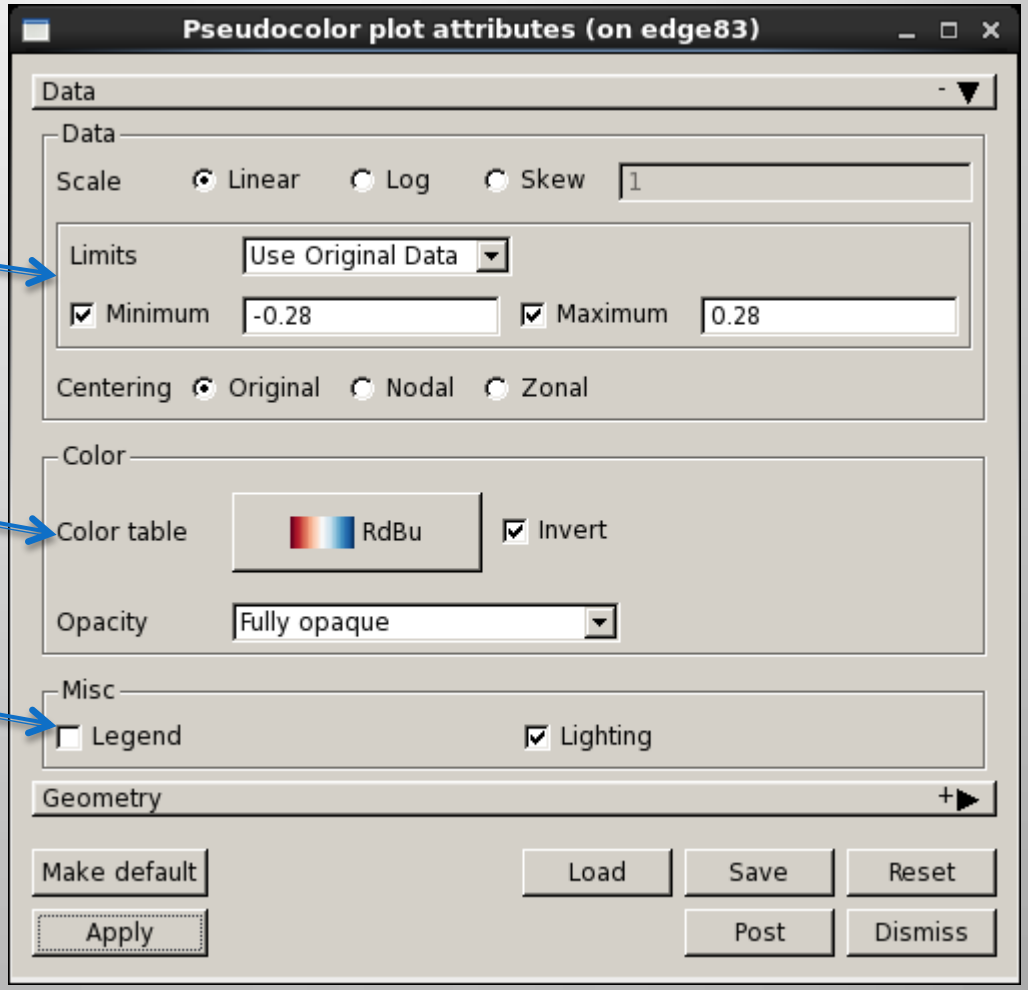


Set the pseudo color attributes

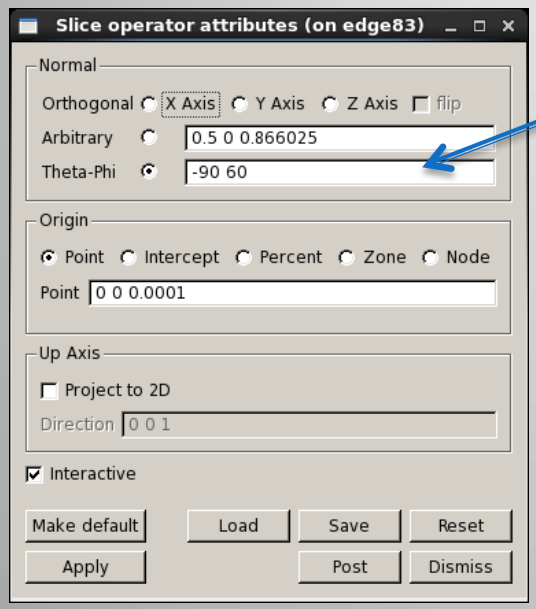
Set the same limits as the other pseudo color plot.

Set the same color table as the other pseudo color plot

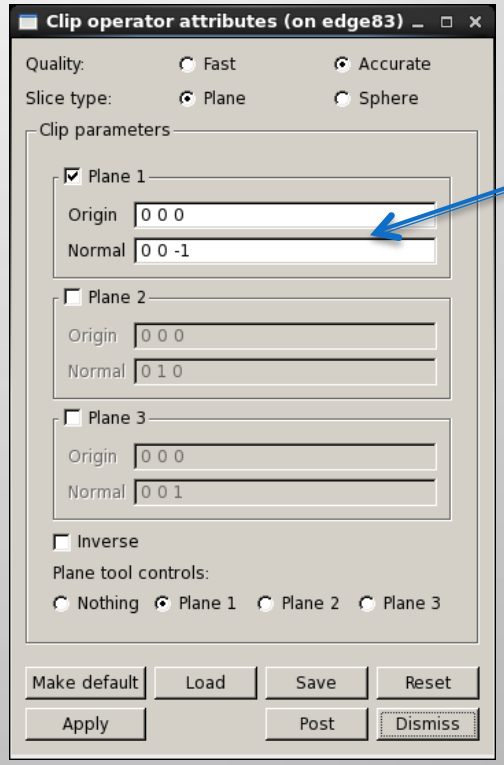
Turn off the legend



Set the slice and clip attributes

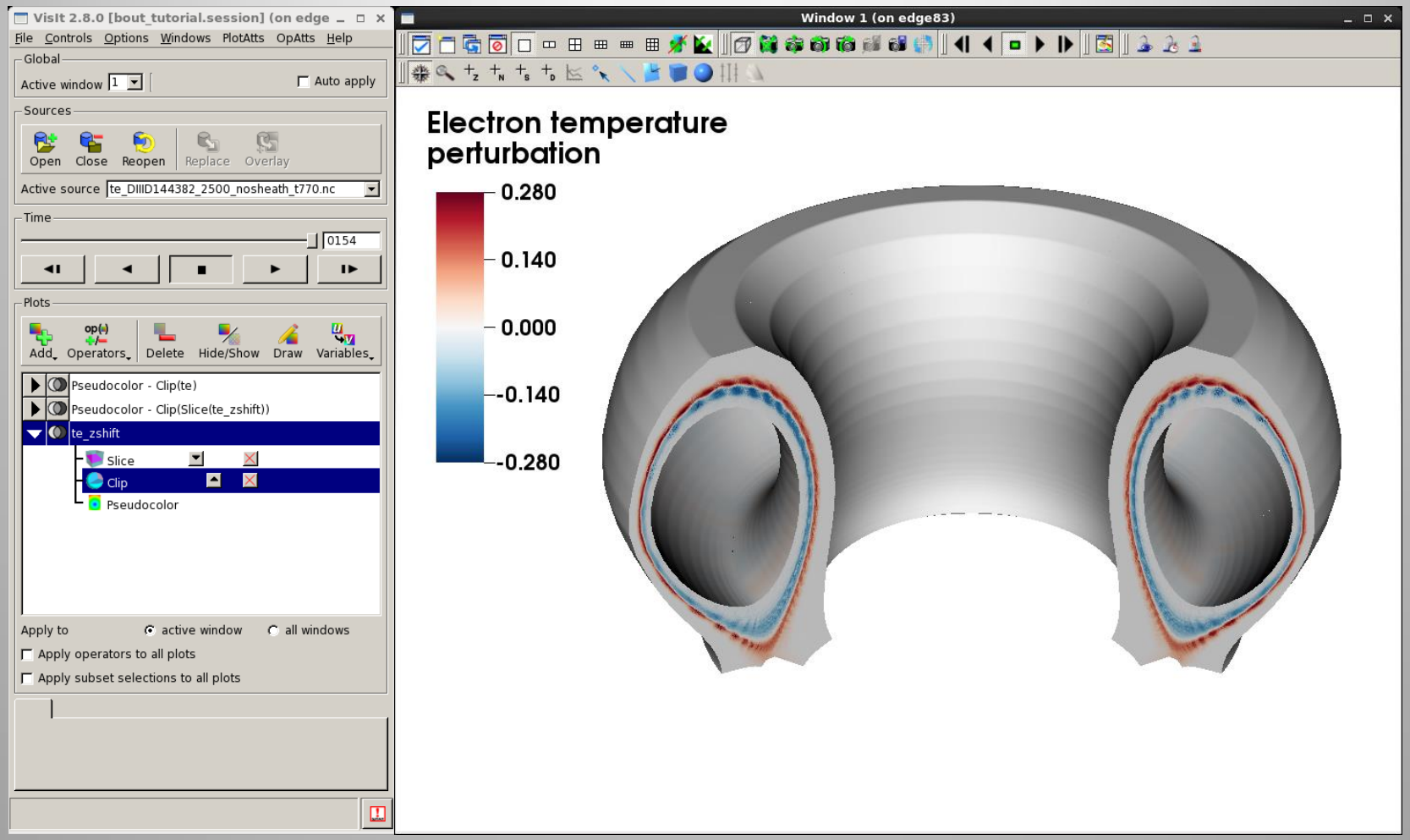


The slice attributes



The slice operator creates 2 intersections. Remove the unwanted one.

Step 3: Add a second pseudo color plot of te_zshift on the other slice

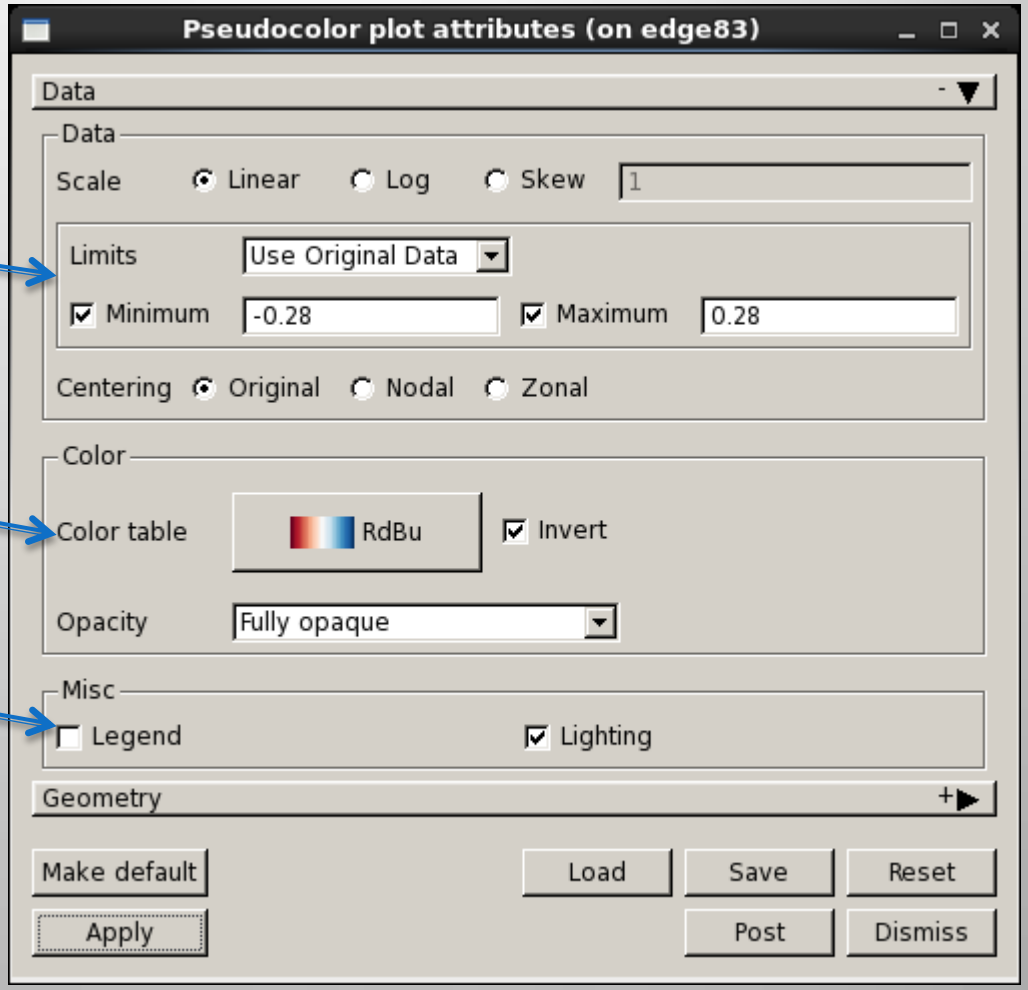


Set the pseudo color attributes

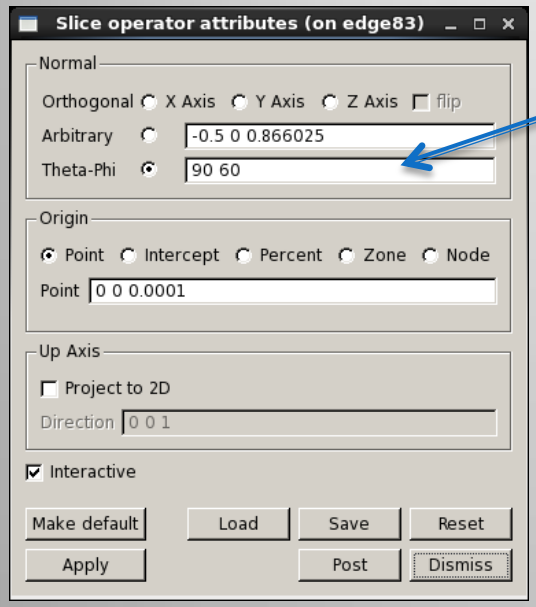
Set the same limits as the other pseudo color plot.

Set the same color table as the other pseudo color plot

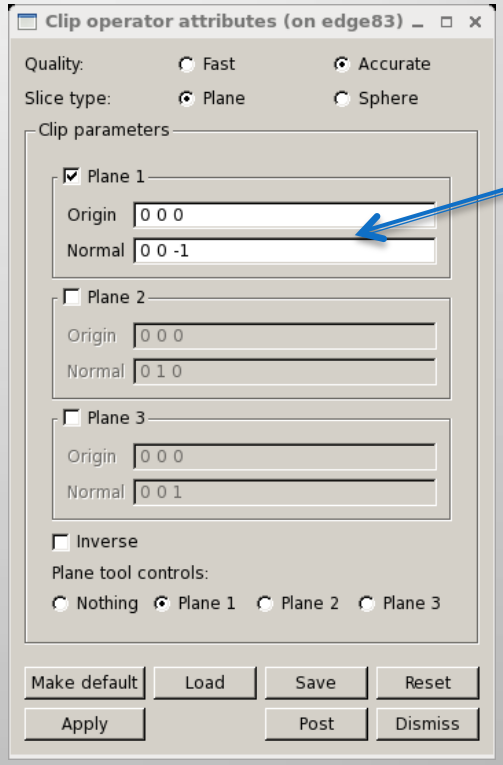
Turn off the legend



Set the slice and clip attributes

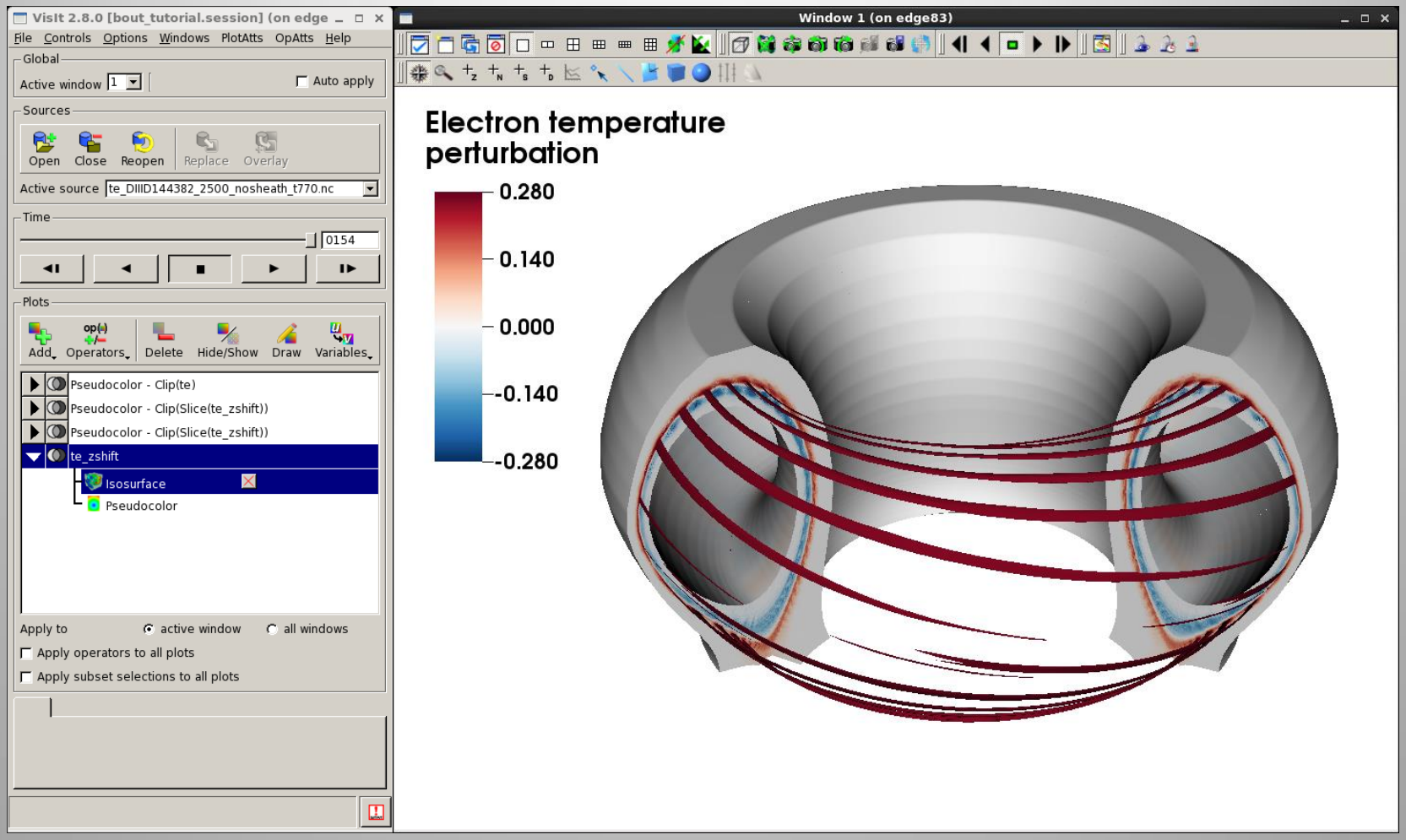


The slice attributes



The slice operator creates 2 intersections. Remove the unwanted one.

Step 4: Add a pseudocolor plot with an iso surface operator

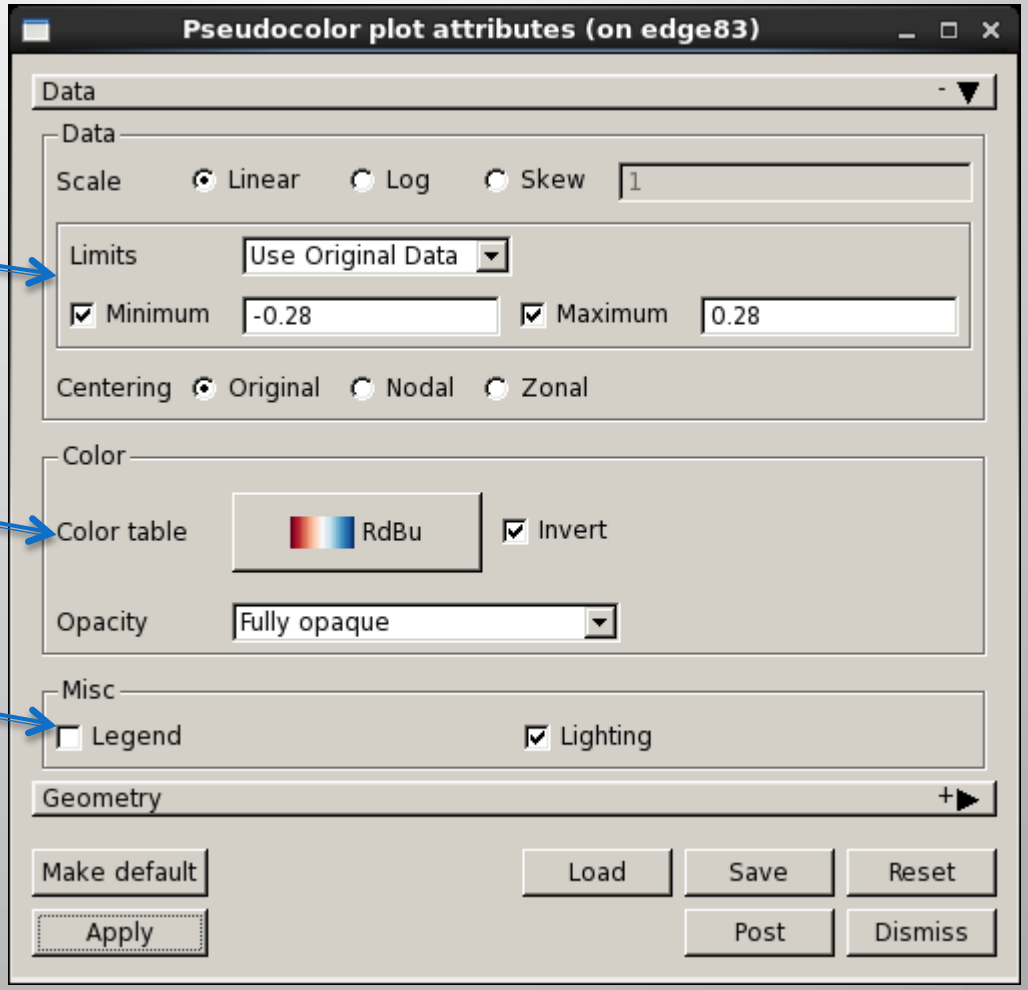


Set the pseudo color attributes

Set the same limits as the other pseudo color plot.

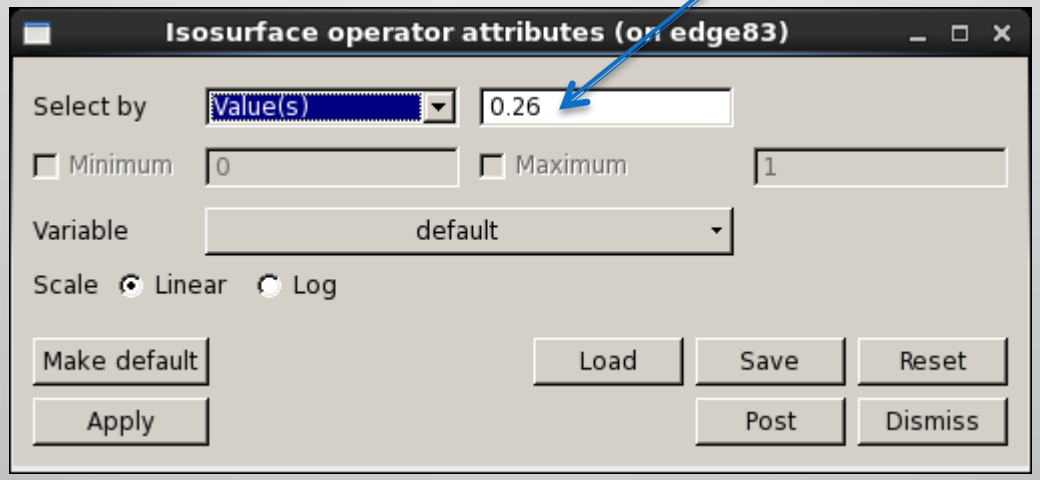
Set the same color table as the other pseudo color plot

Turn off the legend

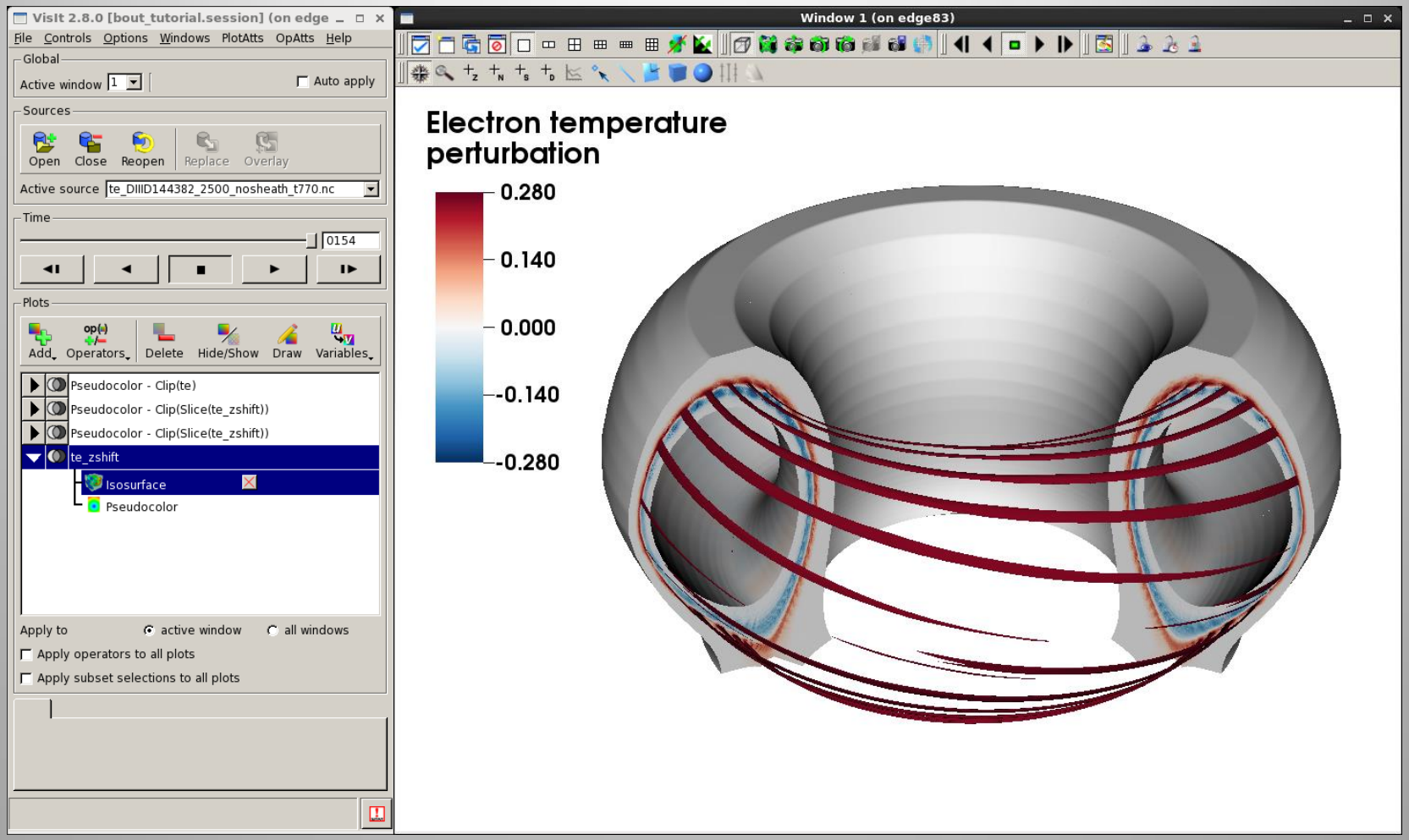


Set the iso surface attributes

Set the value of the iso surface



The final result



How to get help when you run into trouble

- VisIt Users Mailing List
  - Address: visit-users@elist.ornl.gov
  - Info: https://elist.ornl.gov/mailman/listinfo/visit-users
  - Archive: https://elist.ornl.gov/pipermail/visit-users/
- VisIt Users Wiki
  - http://www.visitusers.org
- Reference Manuals
  - https://wci.llnl.gov/simulation/computer-codes/visit/

Manuals & Other Documentation

- Getting Started Manual
- Users Manual
- Python Interface
- Getting Data Into VisIt
- VisIt Class Slides
- VisIt Class Exercises

Hands on tutorial

- Run on NERSC
  - ssh –Y username@carver.nersc.gov
  - /usr/common/graphics/visit/bin/visit
- Download VisIt and install it on your local machine
  - https://wci.llnl.gov/simulation/computer-codes/visit/executables/