

# Art of Scientific Visualization

## Introduction to VisIt



Ken Chen (陳科榮)

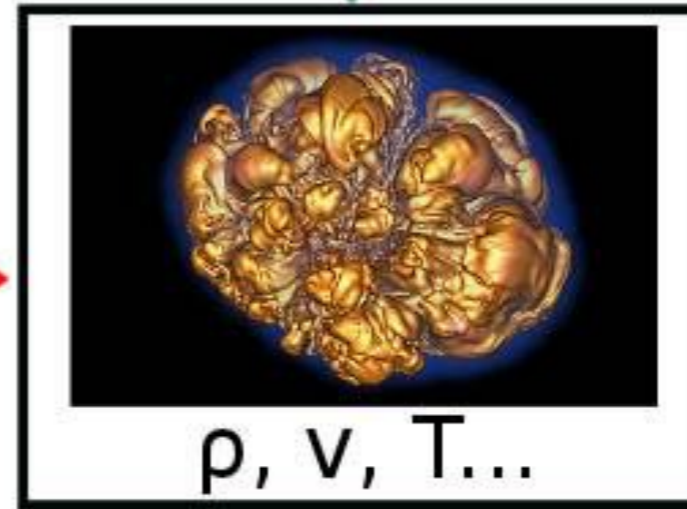
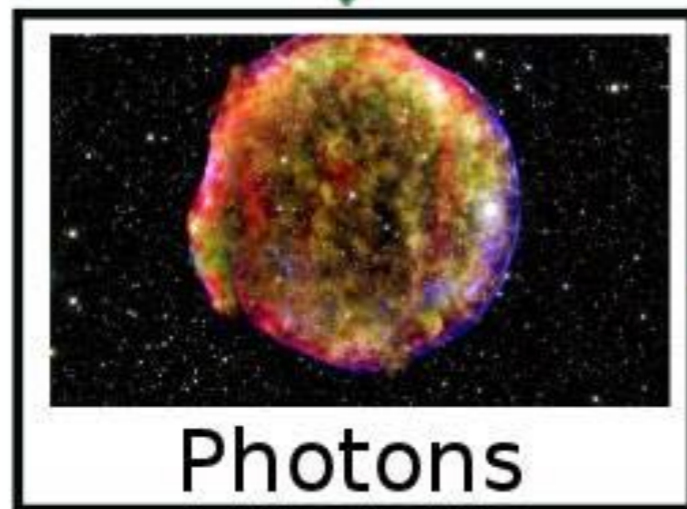
ASIAA

AFD School, NTHU, 09/04/2019



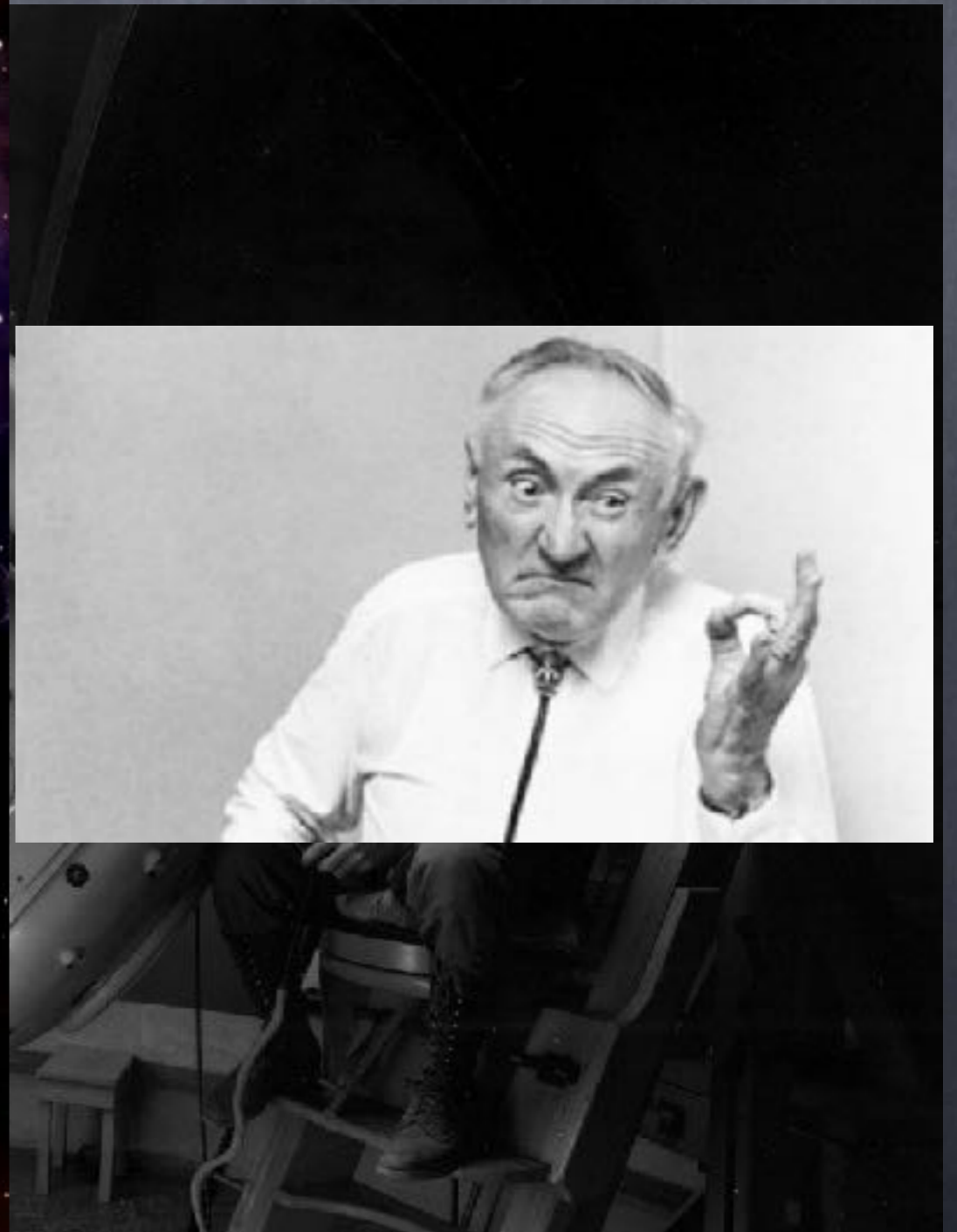
# Astrophysical Research

## Astrophysical Explosions





# Observer's Perspective





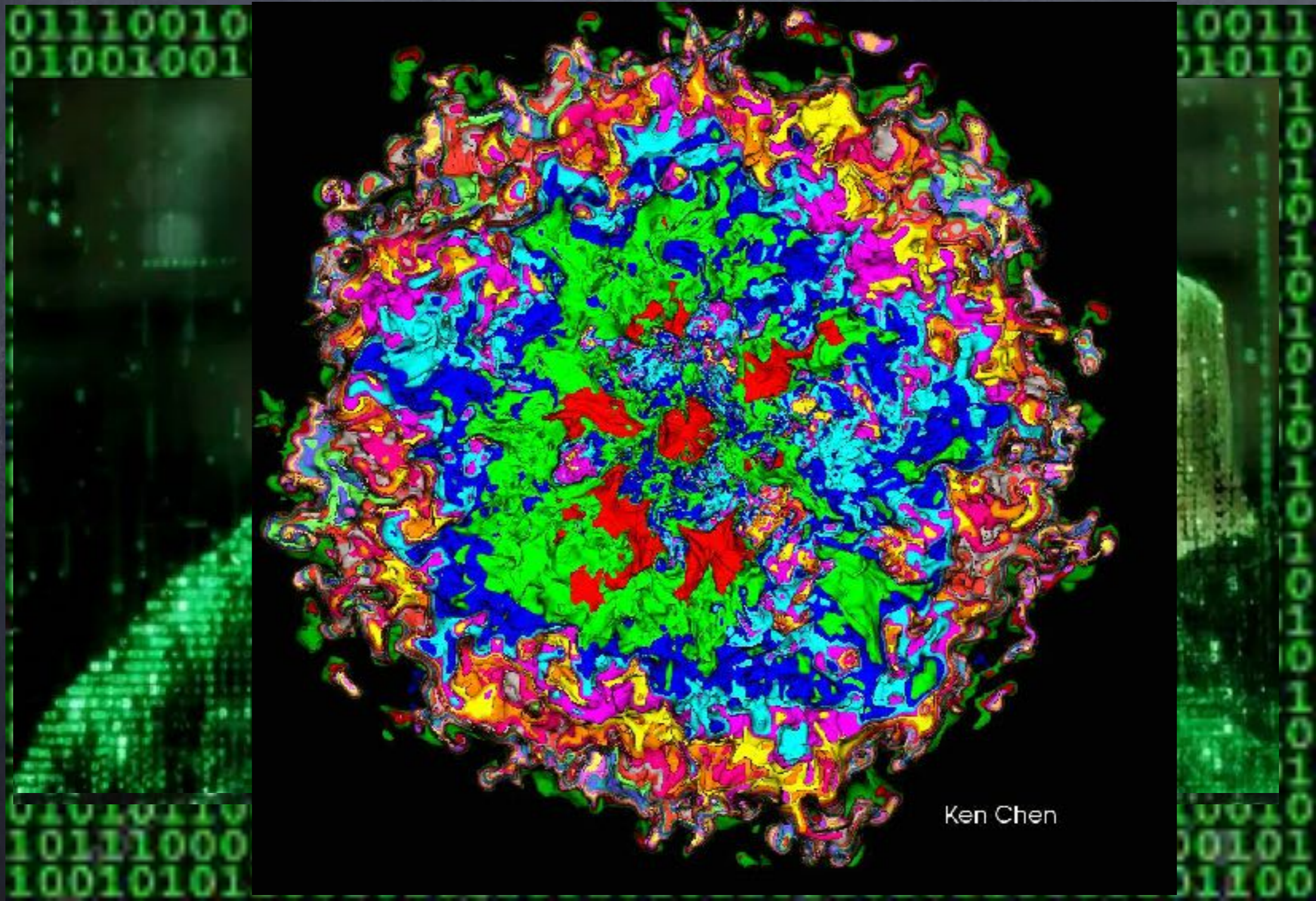
# Telescopes for Theorists and Simulators





# Visualization

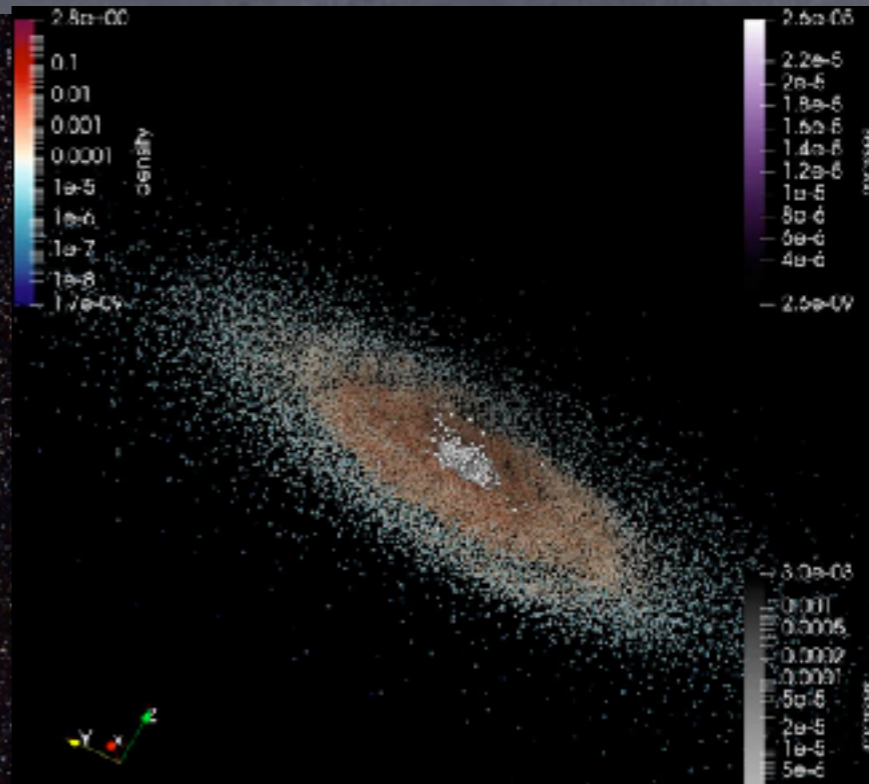
a way to make the invisible visible



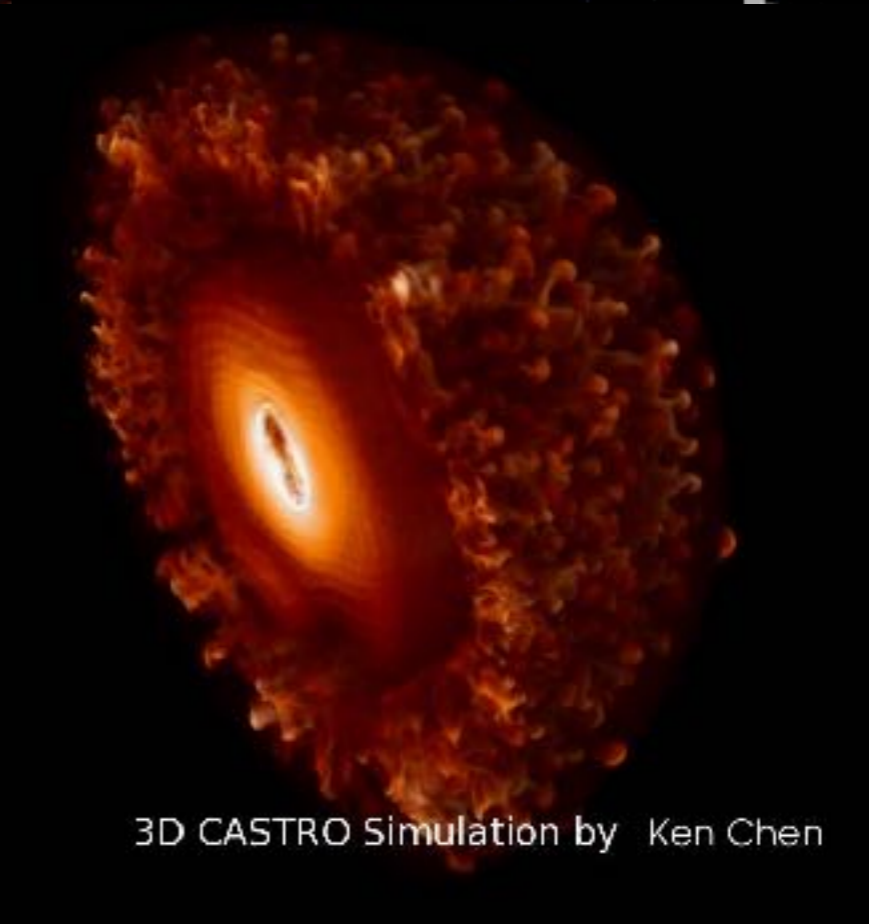
Ken Chen



# Simulations and Observations



x-ray Image of Tycho's Supernova Remnant  
(NASA/CXC/Rutgers/K.Eriksen et al.)



3D CASTRO Simulation by Ken Chen



# Supernova Explosions



Nordhaus+ 2011



# Cosmic Structure Formation

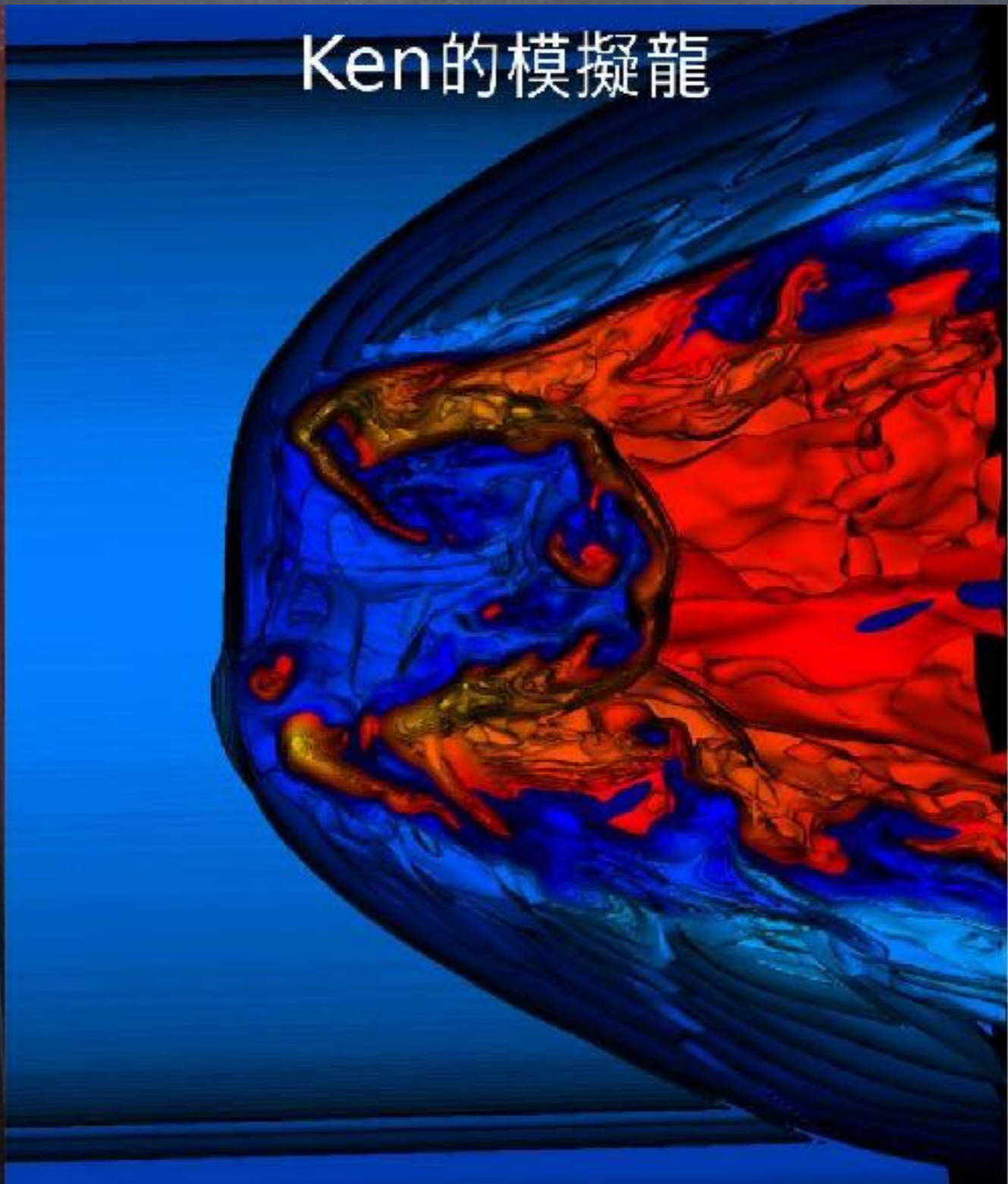


# Fun Stuff

淺草寺的神龍



Ken的模擬龍

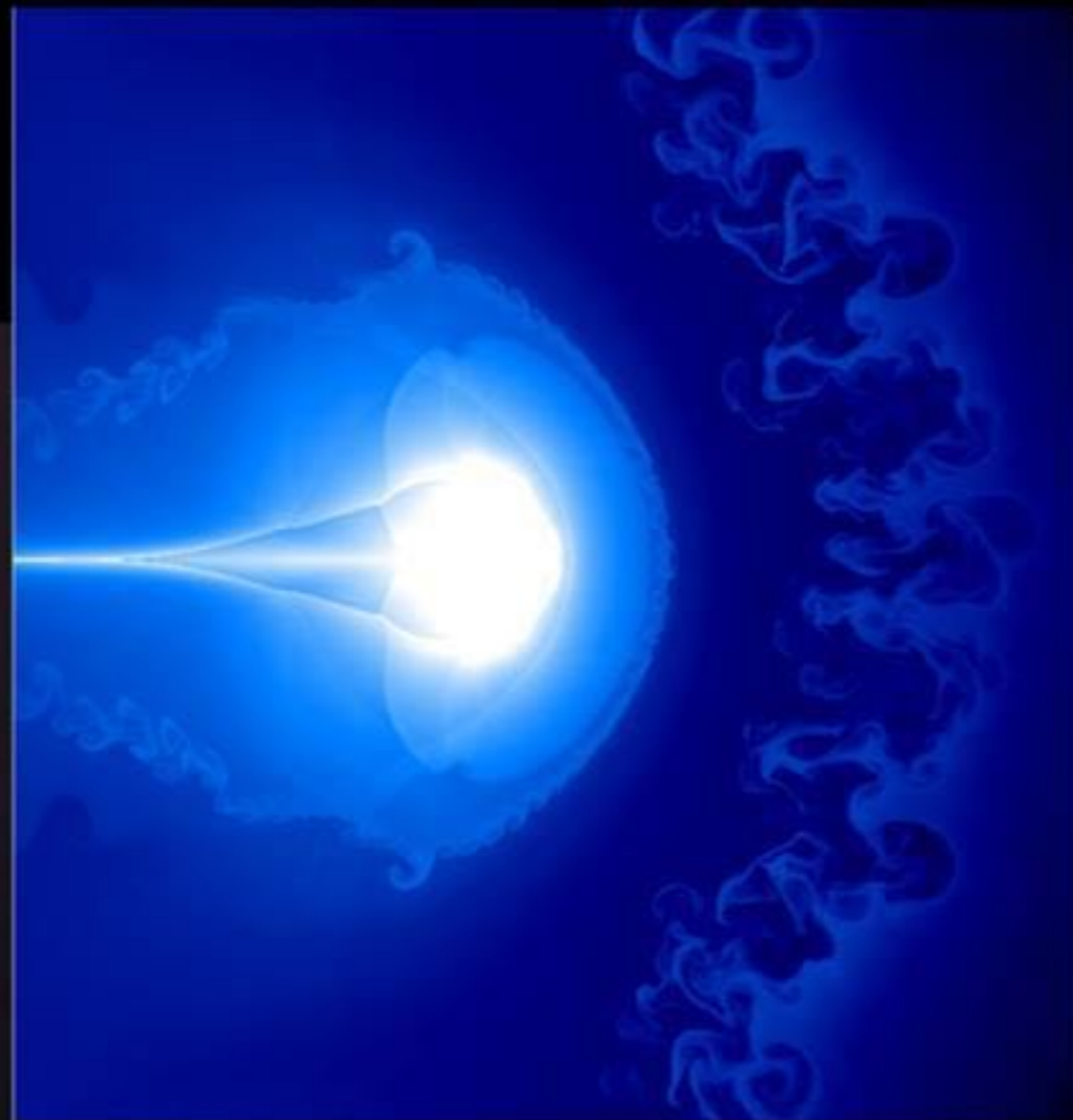




# More Fun Stuff

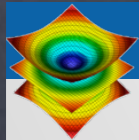


CAPCOM



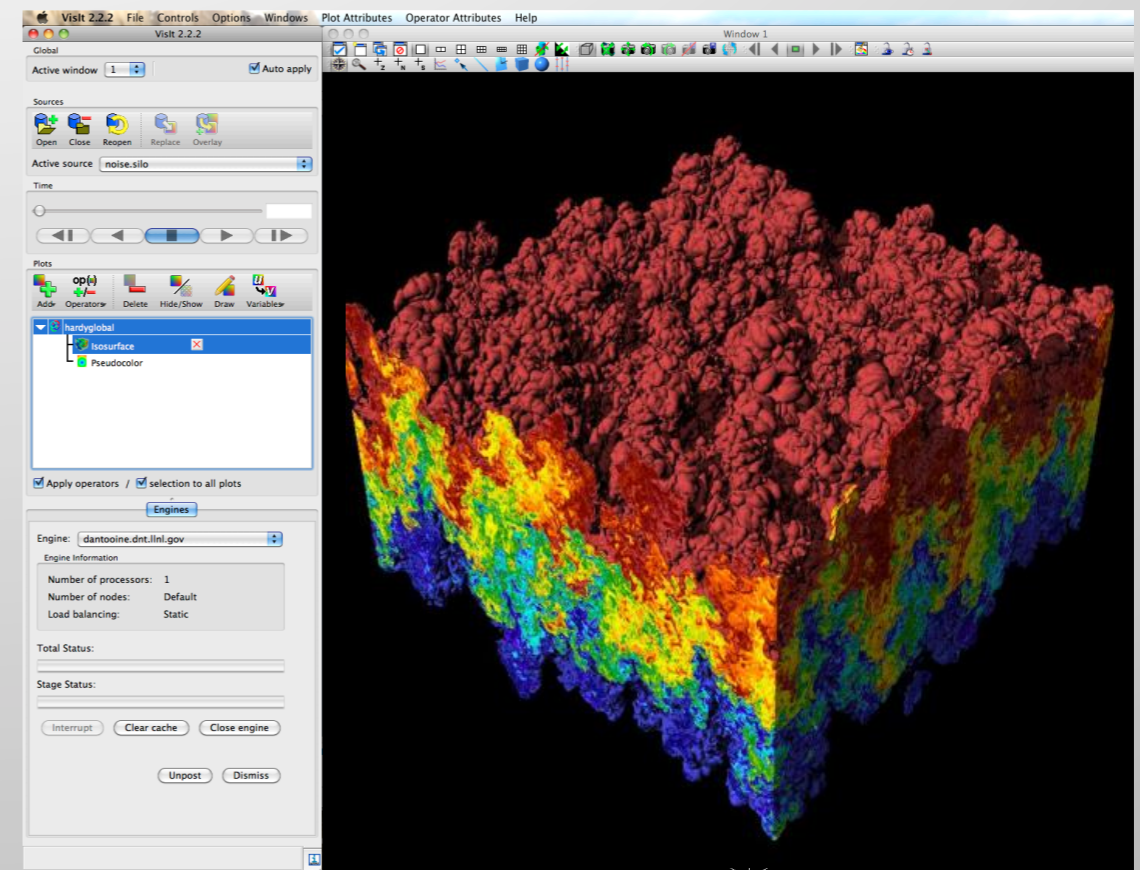
Ken Chen





# VisIt is an open source, turnkey application for data analysis and visualization of mesh-based data.

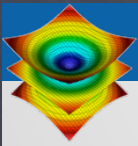
- Production end-user tool supporting scientific and engineering applications.
- Provides an infrastructure for parallel post-processing that scales from desktops to massive HPC clusters.
- Source released under a BSD style license.



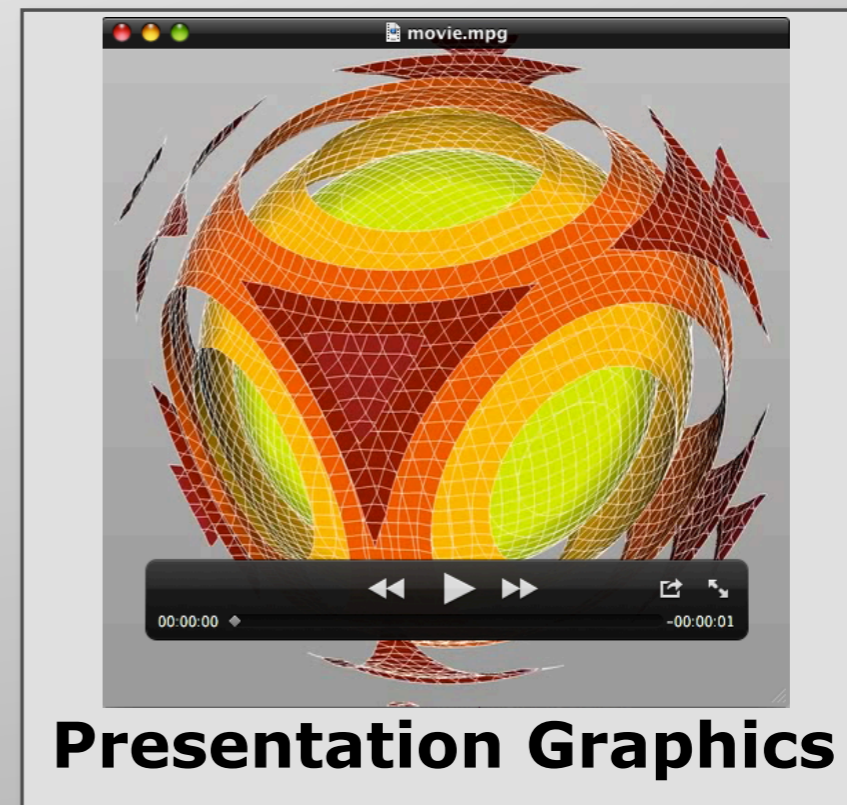
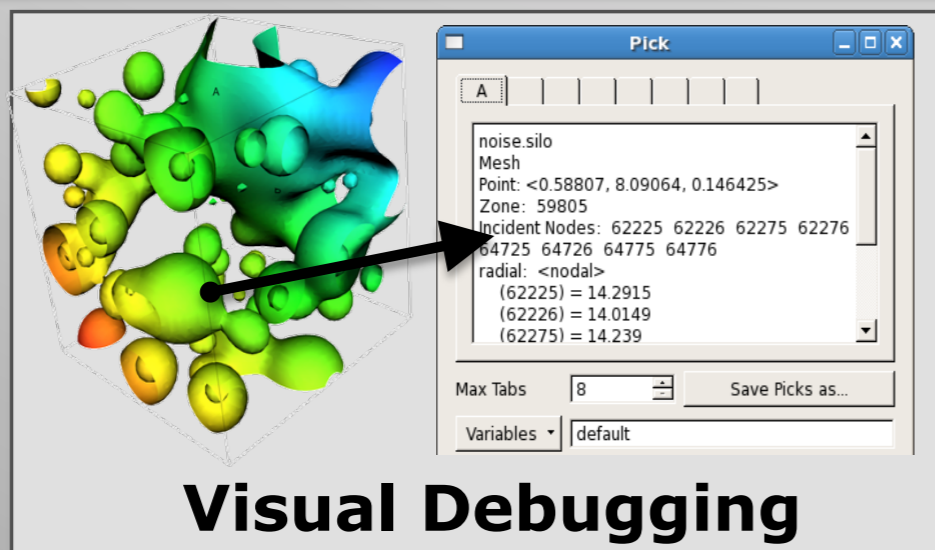
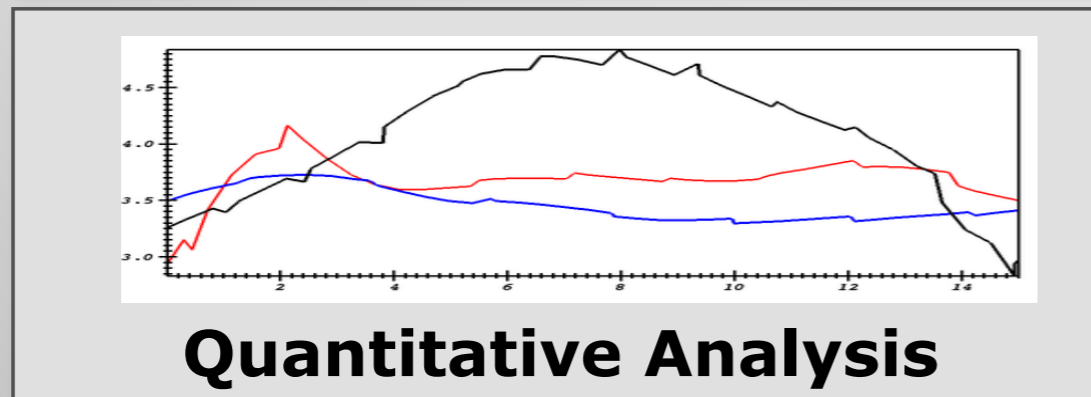
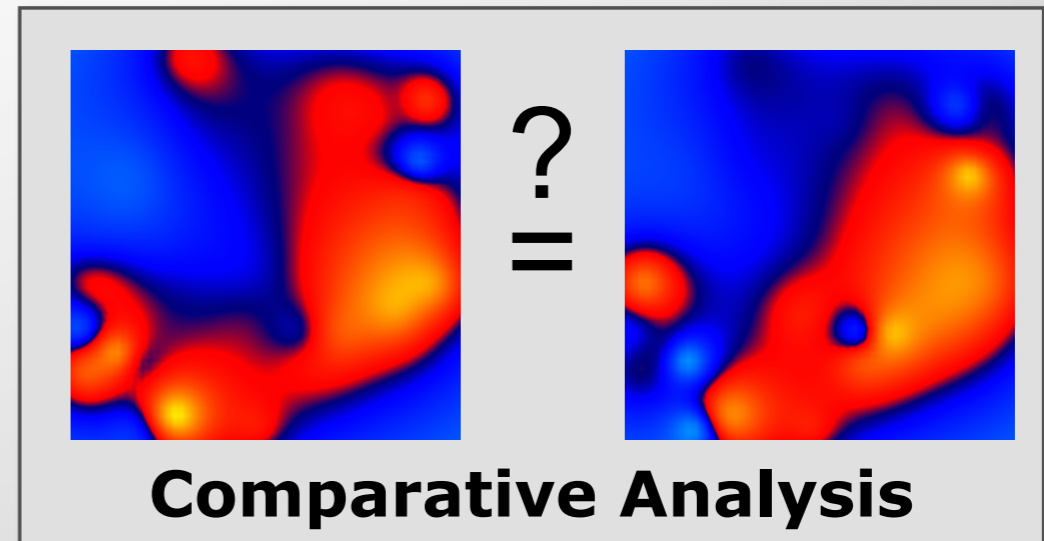
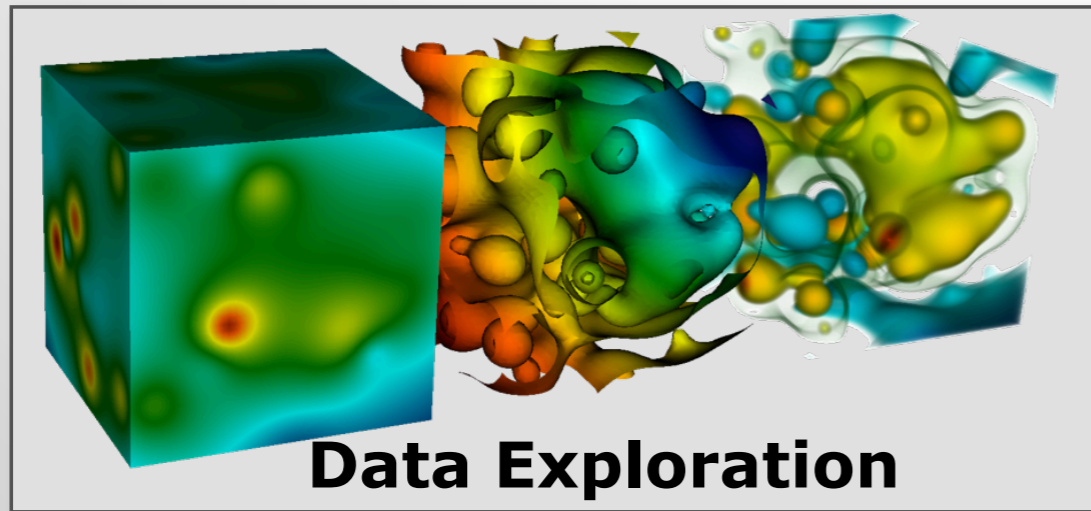
**Density Isovolum of a  
3K<sup>3</sup> (27 billion cell) dataset**

Slides From LLNL training course

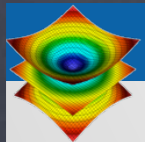




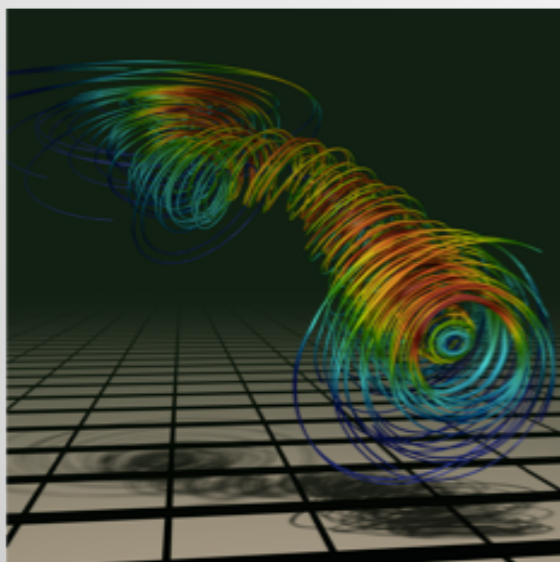
# VisIt supports a wide range of use cases.



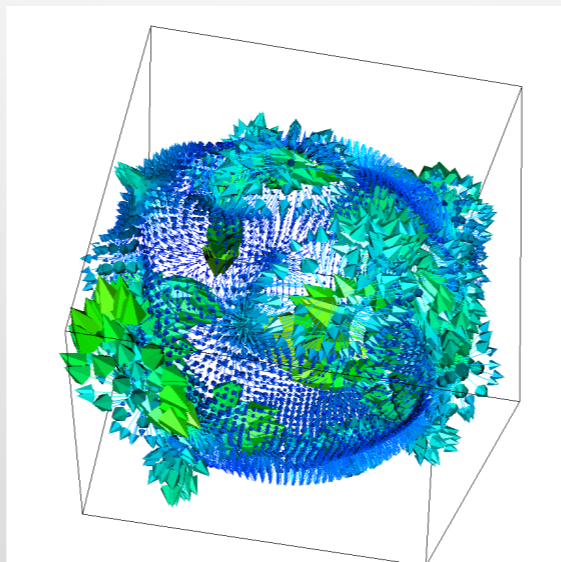




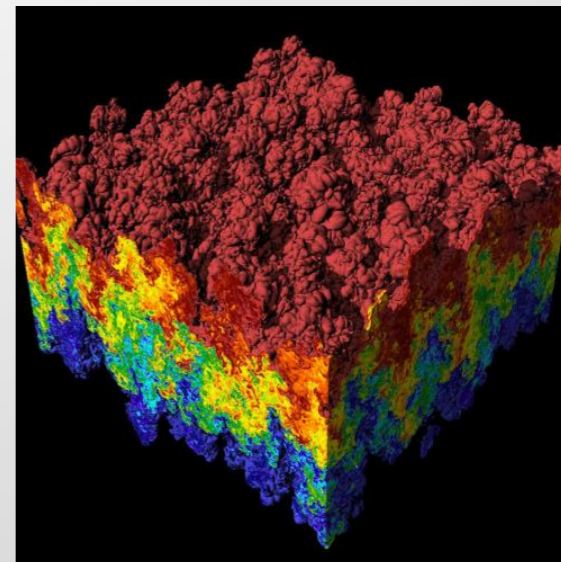
# Examples of VisIt's visualization capabilities.



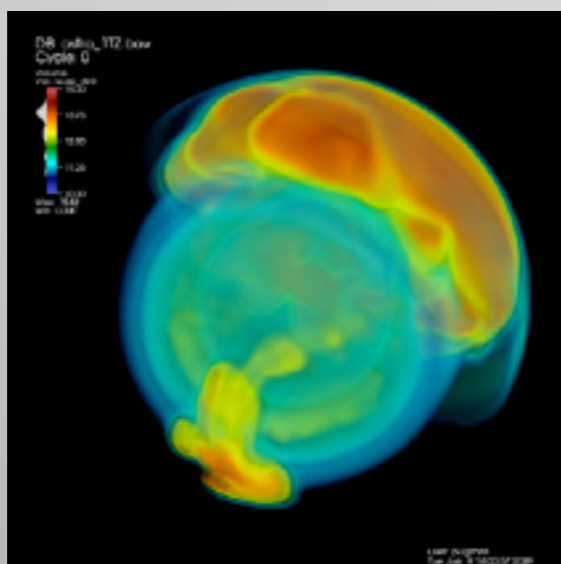
Streamlines



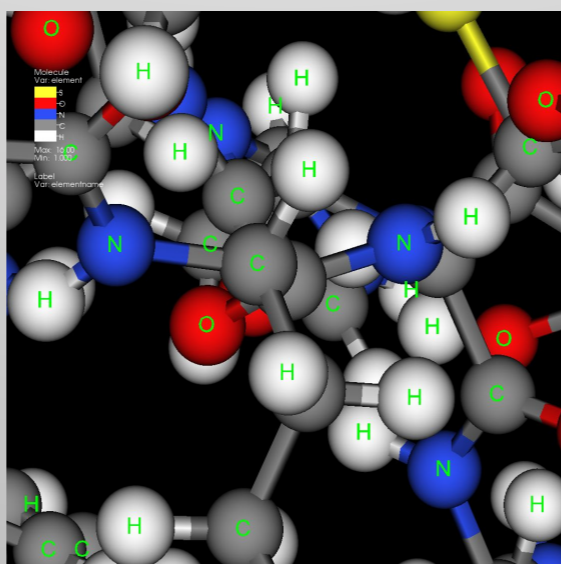
Vector / Tensor Glyphs



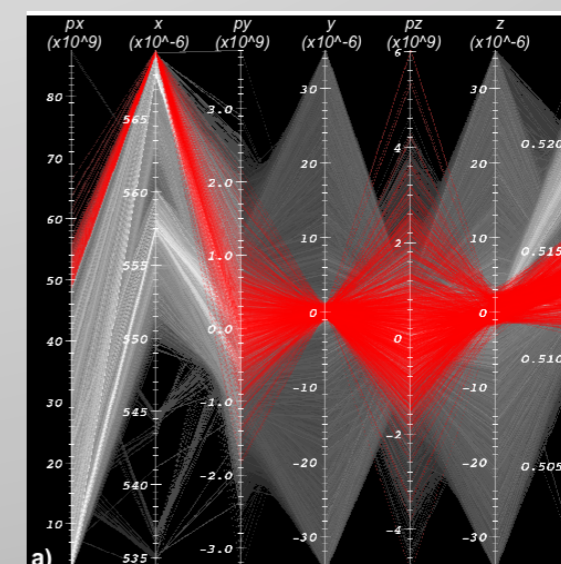
Pseudocolor Rendering



Volume Rendering

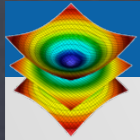


Molecular Visualization

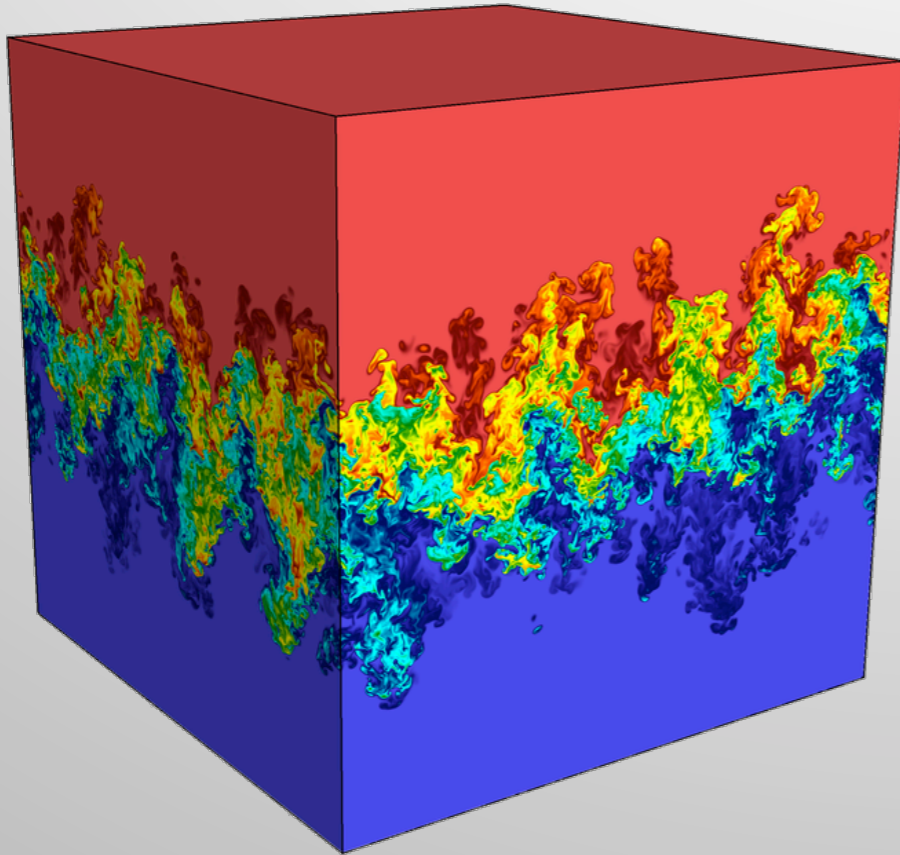


Parallel Coordinates

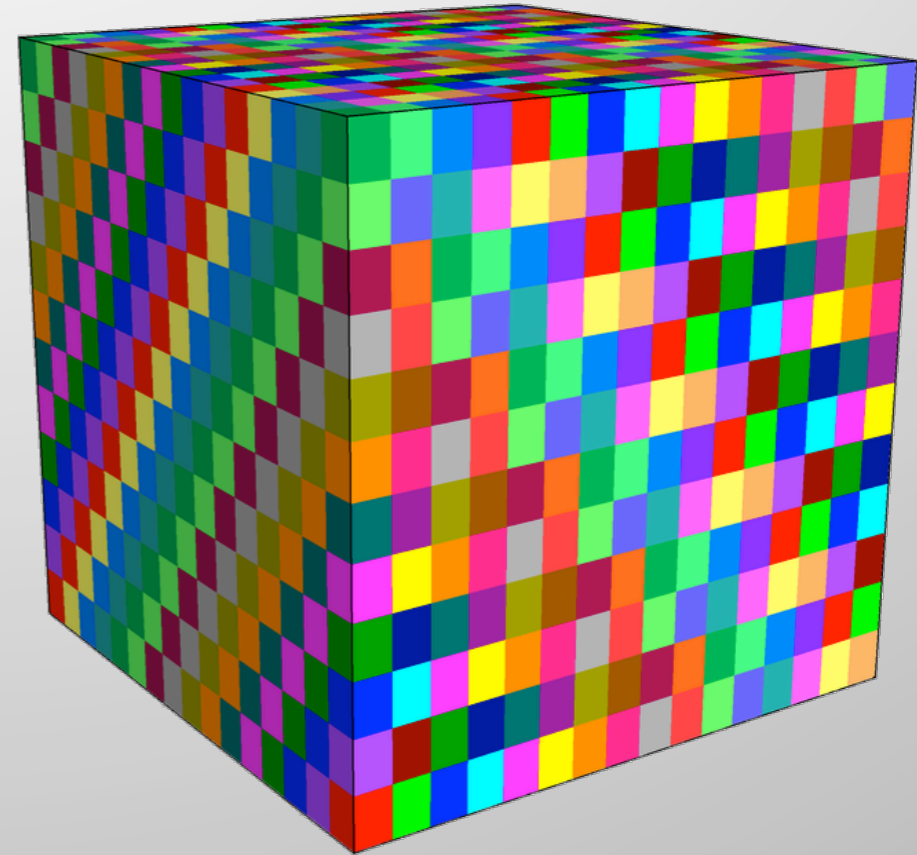




**VisIt uses MPI for distributed-memory parallelism on HPC clusters.**



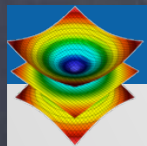
**Full Dataset**  
(27 billion total cells)



**3072 sub-grids**  
(each 192x129x256 cells)

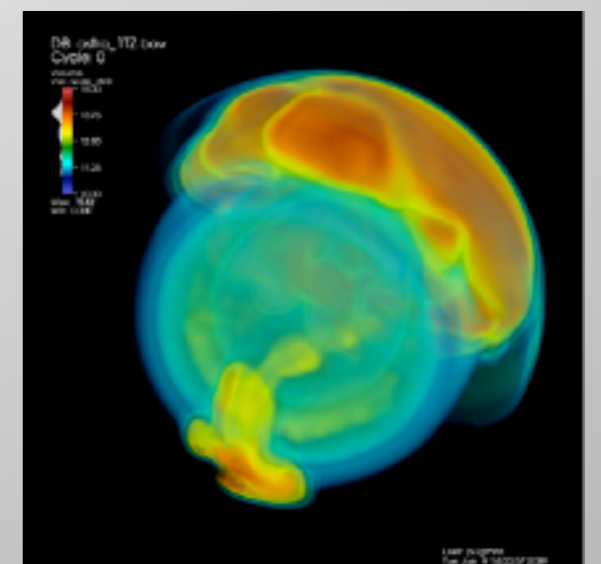
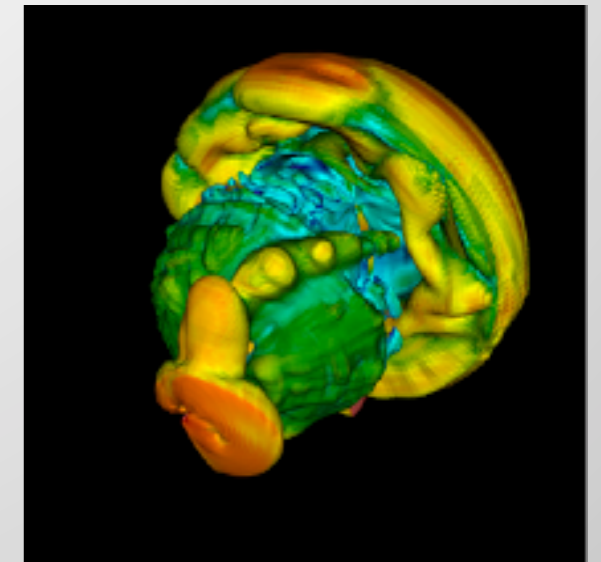
**We are enhancing VisIt's pipeline infrastructure to also support threaded processing.**





# VisIt scales well on current HPC platforms.

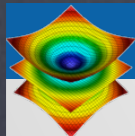
Machine	Architecture	Problem Size	# of Cores
<i>Graph</i>	X86_64	<b>20,001<sup>3</sup> (8 T cells)</b>	12K
Dawn	BG/P	15,871 <sup>3</sup> (4 T cells)	64K
Franklin	Cray XT4	12,596 <sup>3</sup> (2 T cells)	32K
JaguarPF	Cray XT5	12,596 <sup>3</sup> (2 T cells)	32K
Juno	X86_64	10,000 <sup>3</sup> (1 T cells)	16K
Franklin	Cray XT4	10,000 <sup>3</sup> (1 T cells)	16K
Ranger	Sun	10,000 <sup>3</sup> (1 T cells)	16K
Purple	IBM P5	8,000 <sup>3</sup> (0.5 T cells)	8K



*Scaling Studies of Isosurface Extraction and Volume Rendering (2009)*

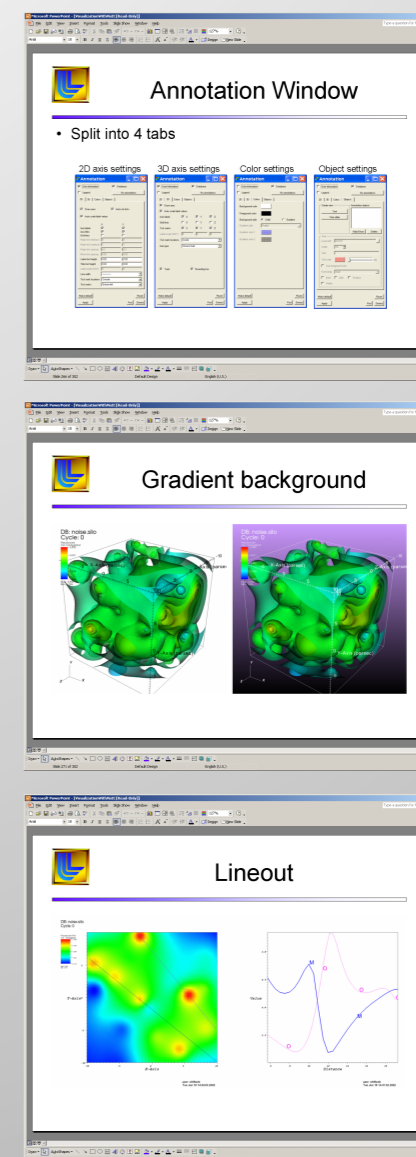
VisIt is also used daily by domain scientists.





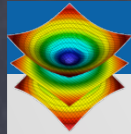
# The VisIt team focuses on making a robust, usable product for end users.

- Regular releases (~ 6 / year)
  - Executables for all major platforms
  - End-to-end build process script ``build\_visit``
- Customer Support and Training
  - [visitusers.org](http://visitusers.org), wiki for users and developers
  - Email lists: [visit-users](mailto:visit-users), [visit-developers](mailto:visit-developers)
  - Beginner and advanced tutorials
  - VisIt class with detailed exercises
- Documentation
  - “Getting data into VisIt” manual
  - Python interface manual
  - Users reference manual



*Slides from the VisIt class*

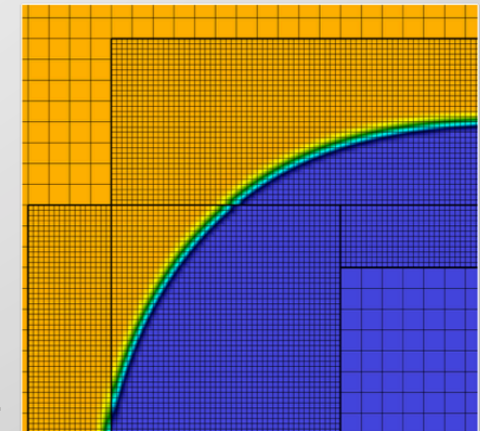
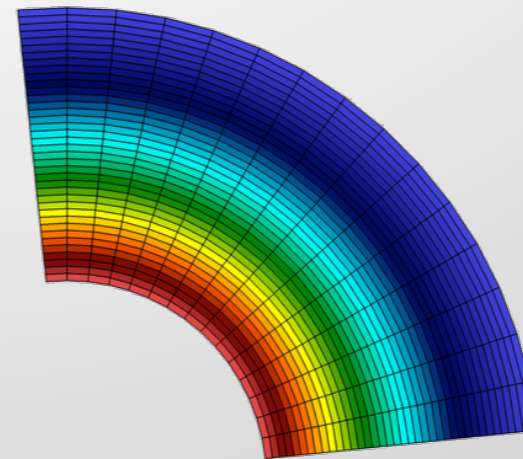




# VisIt provides a flexible data model, suitable for many application domains.

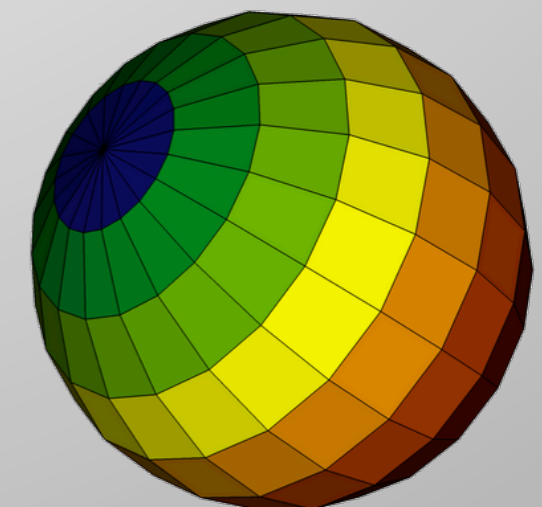
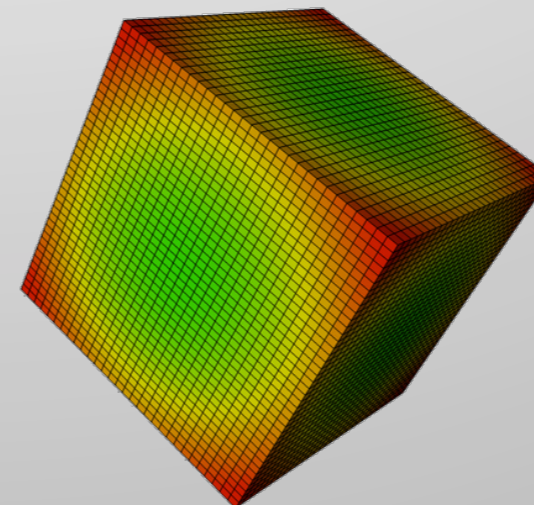
## ■ Mesh Types:

- Point, Curve, 2D/3D  
Rectilinear, Curvilinear, Unstructured
- Domain Decomposed, AMR
- Time Varying



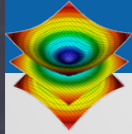
## ■ Fields:

- Scalar, Vector, Tensor, Material volume fractions, Species

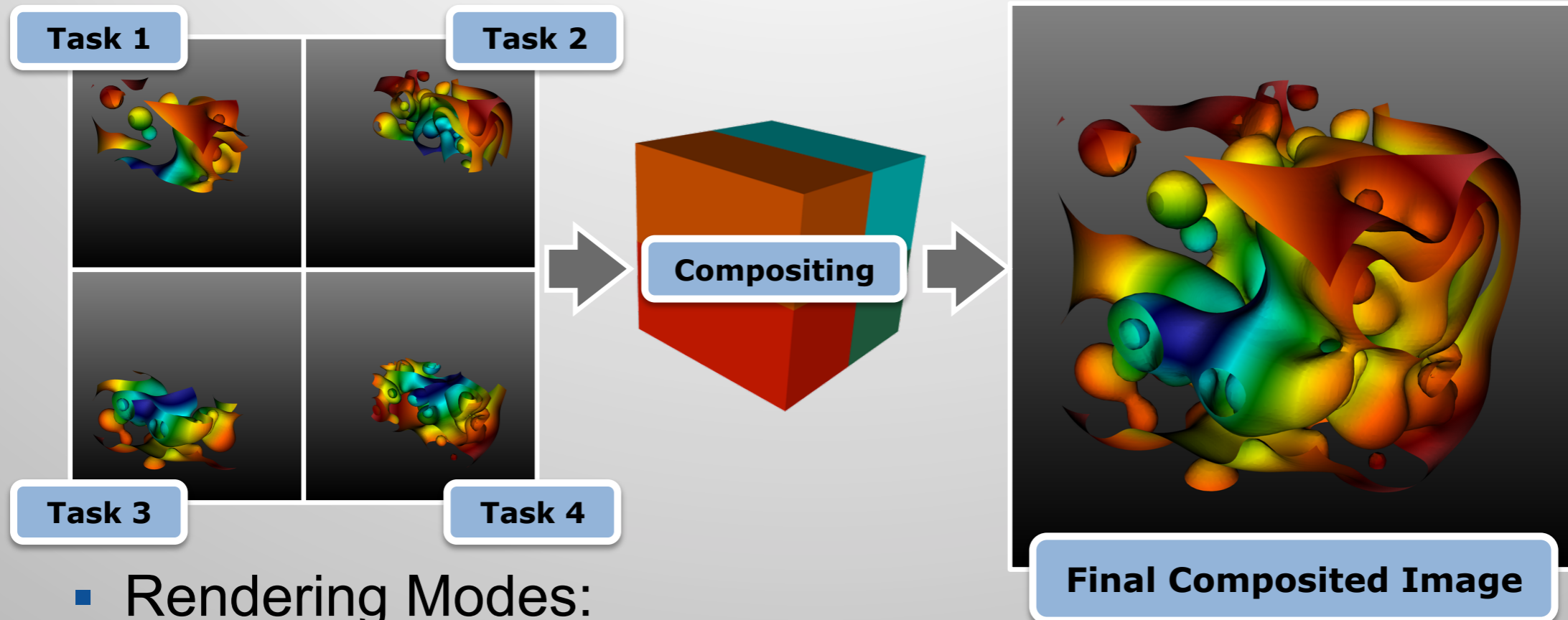


VisIt currently supports over 110 file formats.



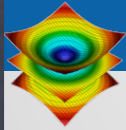


# VisIt automatically switches to a scalable rendering mode for large data sets.



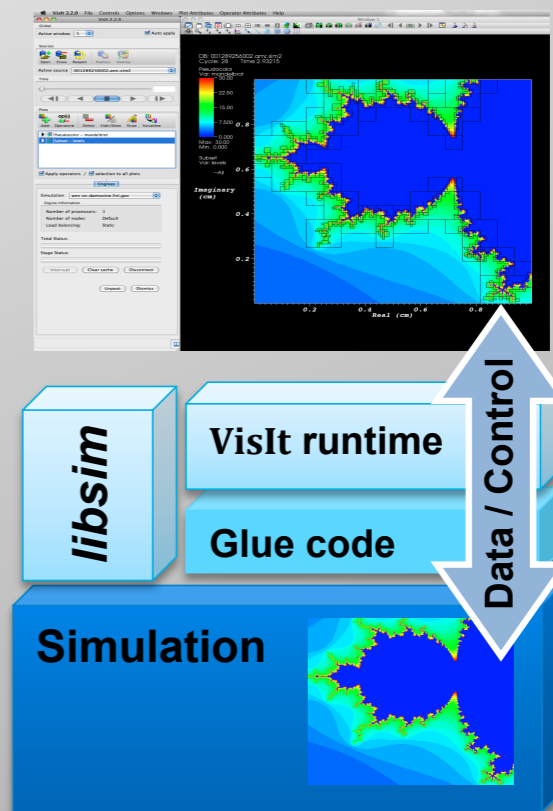
- Rendering Modes:
  - Local (hardware)
  - Remote (software or hardware)
- Beyond surfaces:
  - VisIt also provides scalable volume rendering.



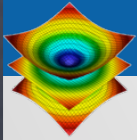


# VisIt's infrastructure provides a flexible platform for custom workflows.

- C++ Plugin Architecture
  - Custom File formats, Plots, Operators
  - Interface for custom GUIs in Python, C++ and Java
- Python Interfaces
  - Python scripting and batch processing
  - Data analysis via Python Expressions and Queries.
- *Libsim* library
  - Enables coupling of simulation codes to VisIt for in situ visualization.





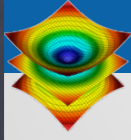


# VisIt: What's the Big Deal?

- Everything works at scale
- Robust, usable tool
- Features that span the “power of visualization”:
  - Data Exploration
  - Confirmation
  - Communication
- Features for different kinds of users:
  - Visualization Experts
  - Code Developers
  - Code Consumers

**Healthy future: Vibrant Developer and User Communities**



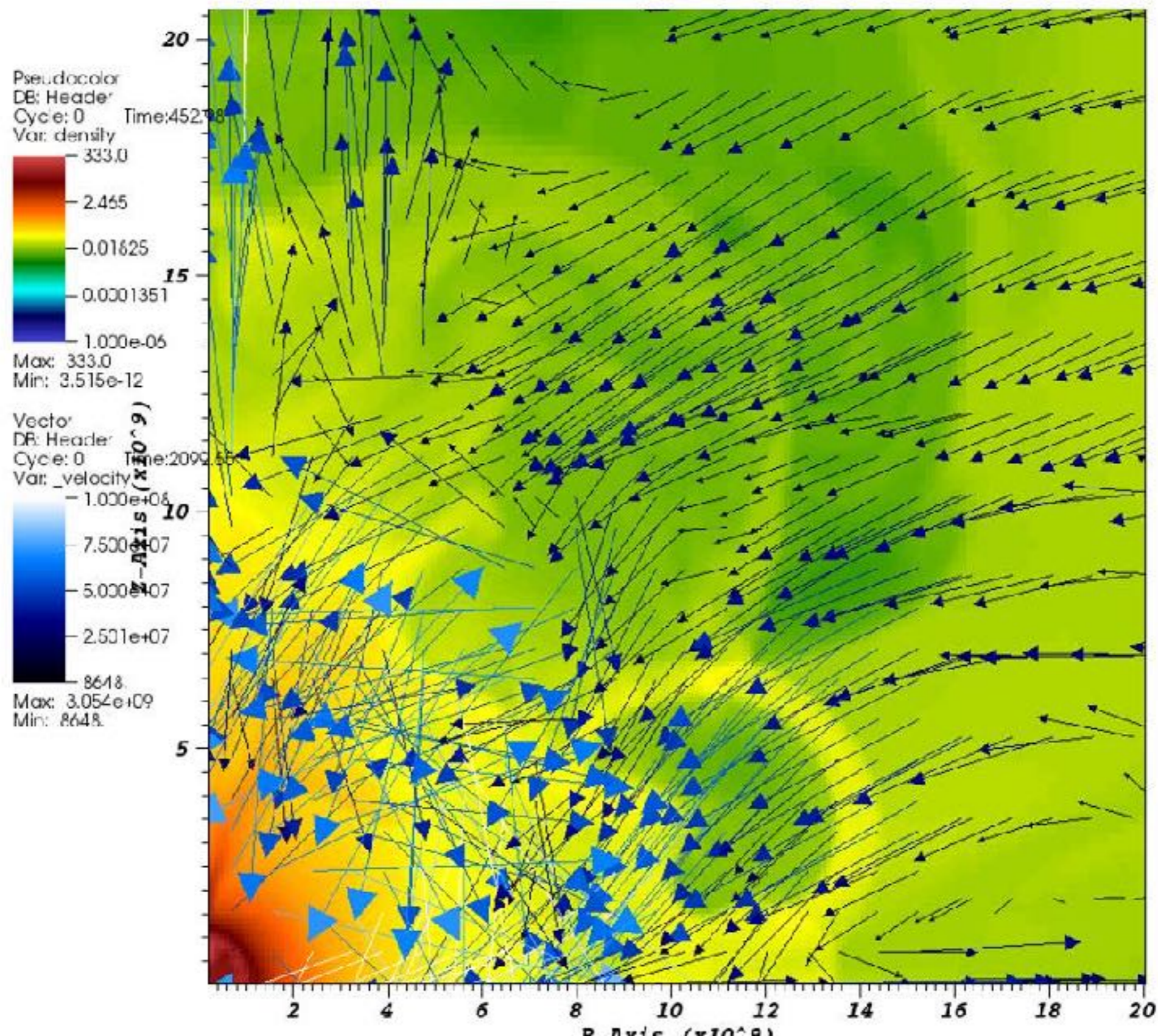


# Resources

- **User resources:**
  - Main website: <http://www.llnl.gov/visit>
  - Wiki: <http://www.visitusers.org>
  - Email: [visitusers@ornl.gov](mailto:visitusers@ornl.gov)
  
- **Development resources:**
  - Email: [visit-developers@ornl.gov](mailto:visit-developers@ornl.gov)
  - SVN: <http://portal.nersc.gov/svn/visit>

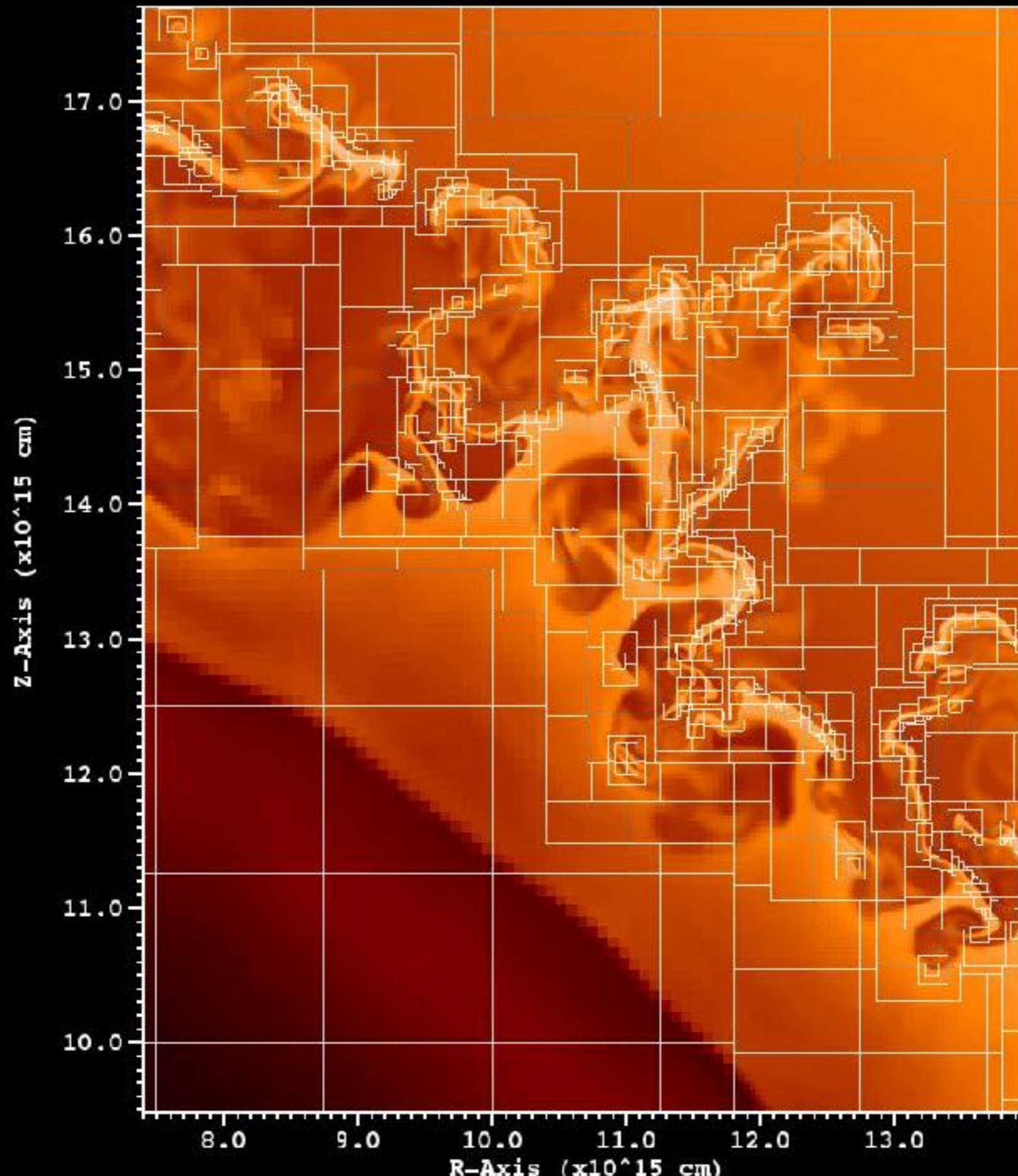


# 2D Pseudocolor + Vector (Fallback in a supernova)

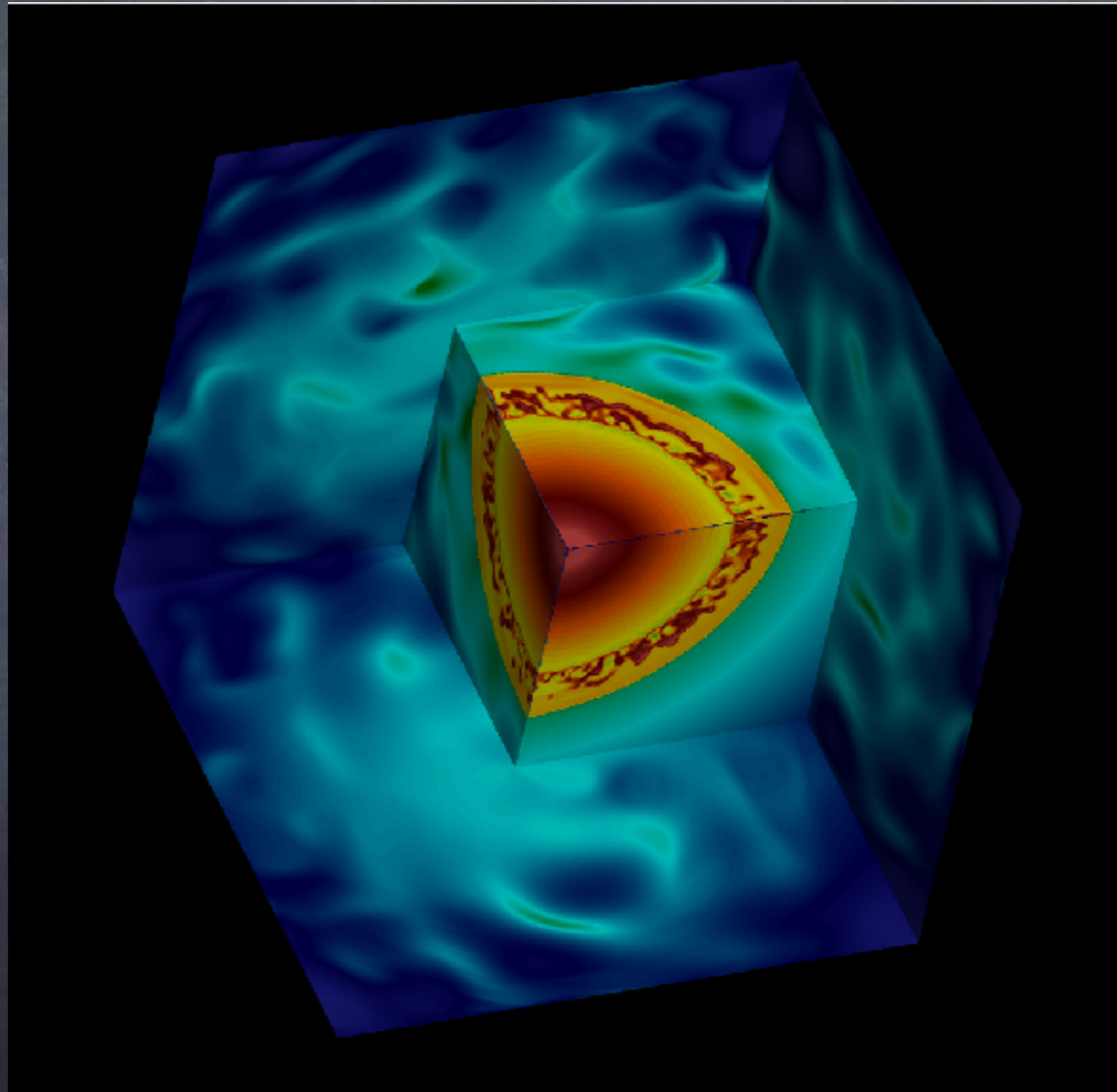




# 2D Pseudocolor + Mesh

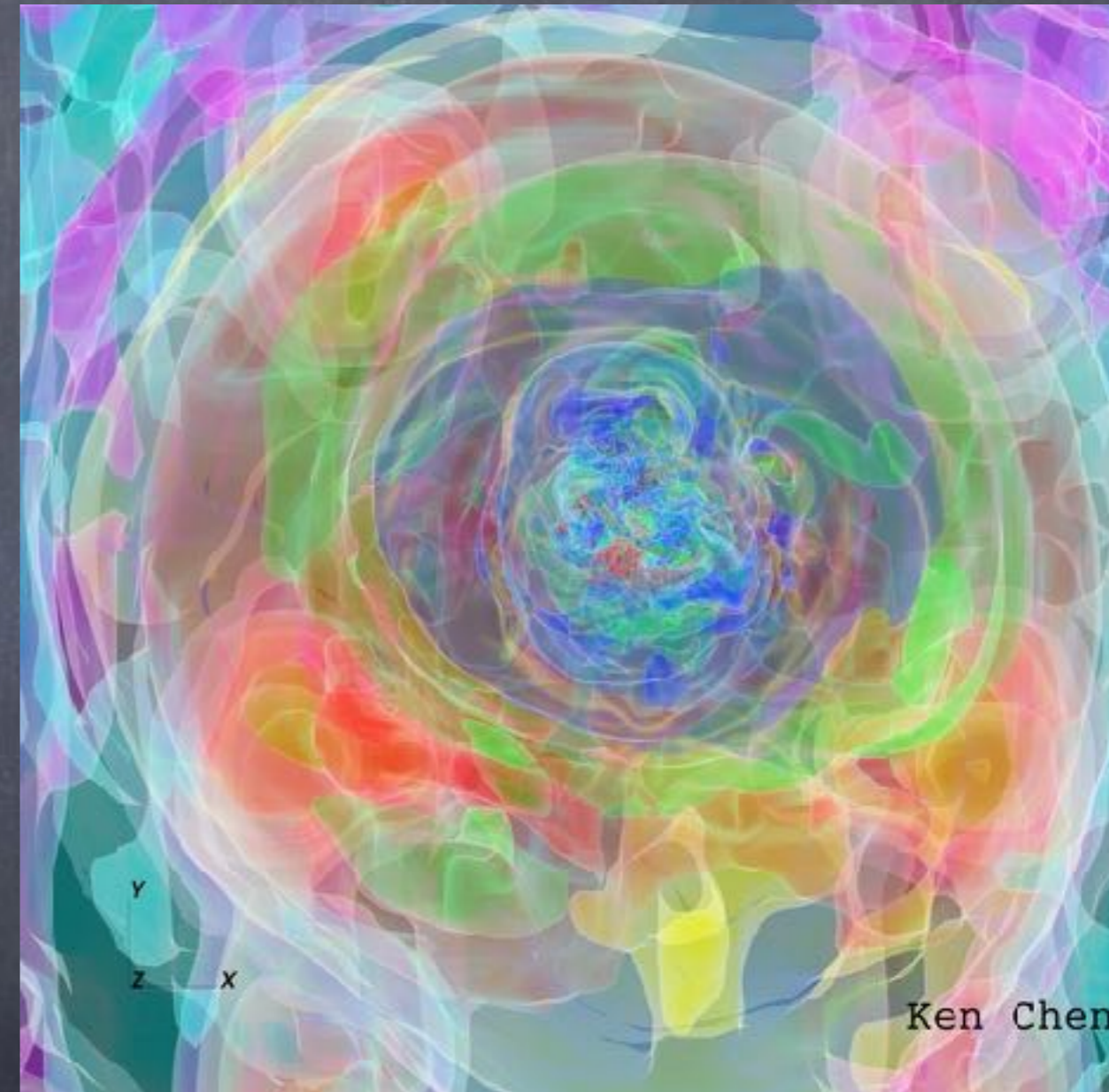
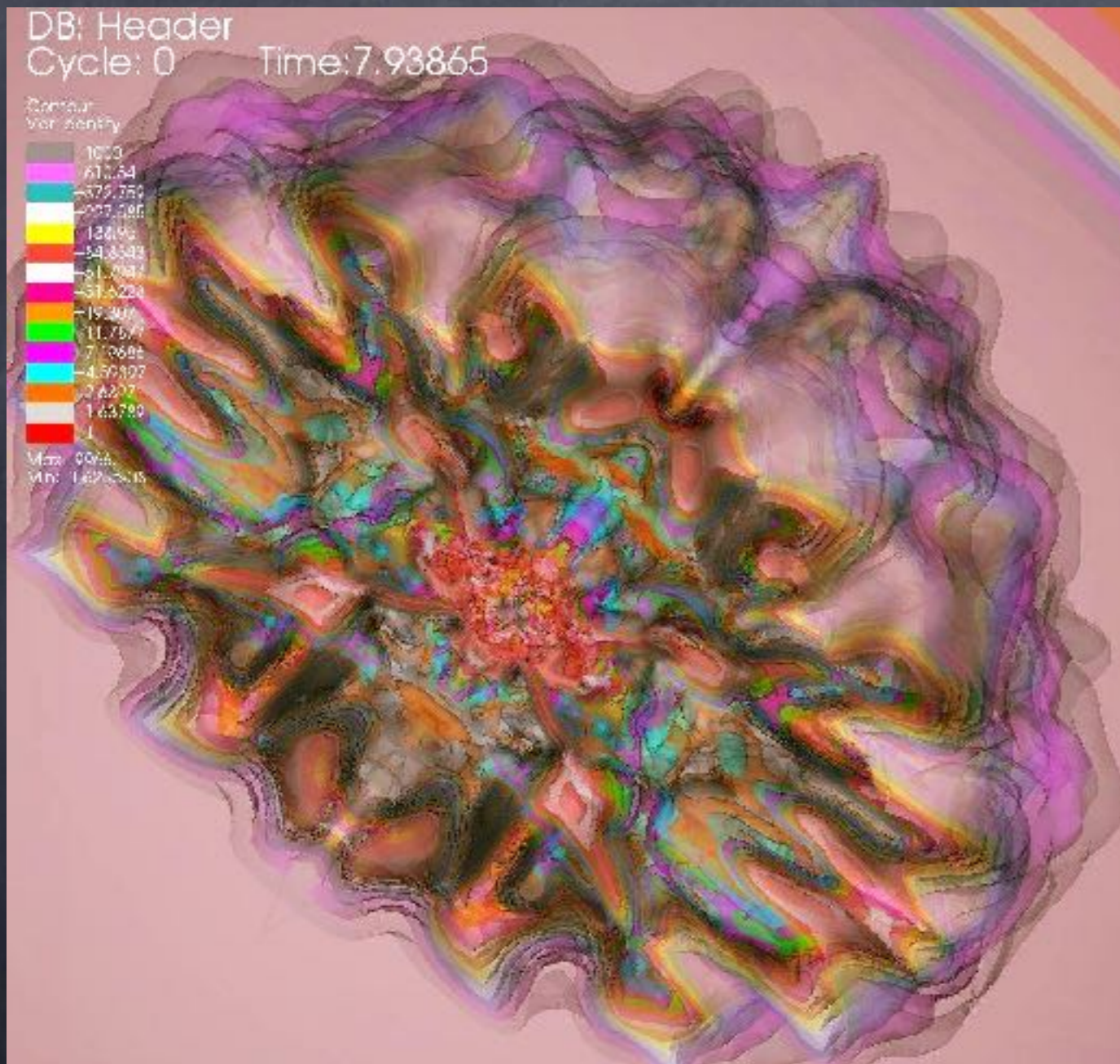


# 3D Volume Rendering of a Supernova



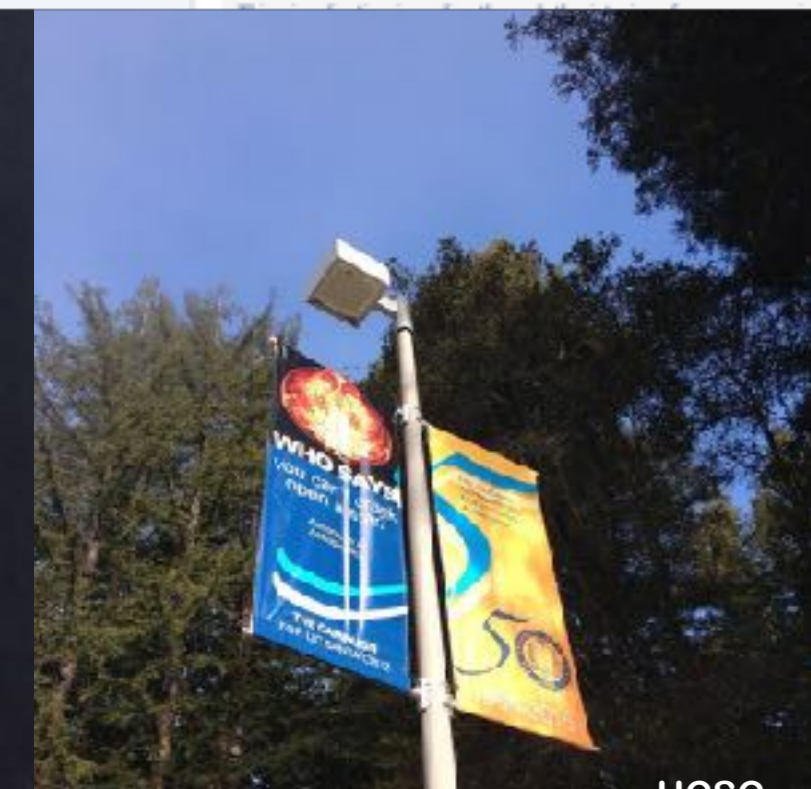
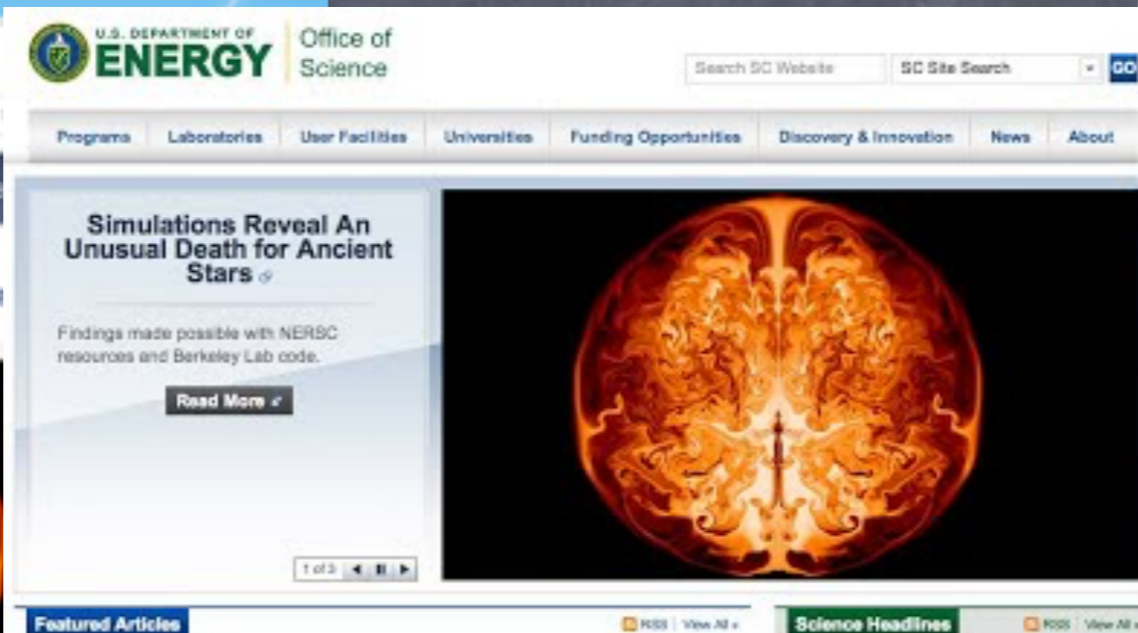


# 3D isosurface of a Supernova





# Visual Impacts I





# Visual Impacts II

**nature.com**

07 February 2013



**A dying star's massive outburst**

Observations of the final weeks of a massive star, just over a month before it exploded as a supernova, are reported in *Nature* this week.

Ke-Lung Chen/ Univ. Minnesota

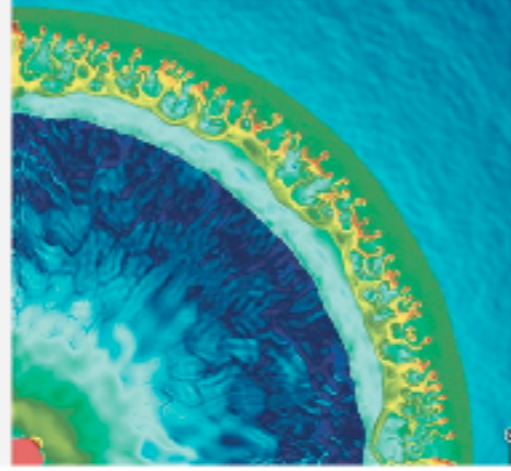
**Latest news**

- Europe bets on drug discovery
- Seven days: 1-7 February 2013
- Landsat 8 to the rescue

[More news from nature](#)

**YAHOO! NEWS**

NEWS FOR YOU



NEWS FOR YOU

- Stipula's death and recovery: the most of America's politics
- Is the world's most powerful engine still a diesel? Think again: Diesel's engine
- Barney's World: The Great Wonders and Discoveries of Our Generation
- Stipula's death and recovery: the most of America's politics
- Stipula's death and recovery: the most of America's politics

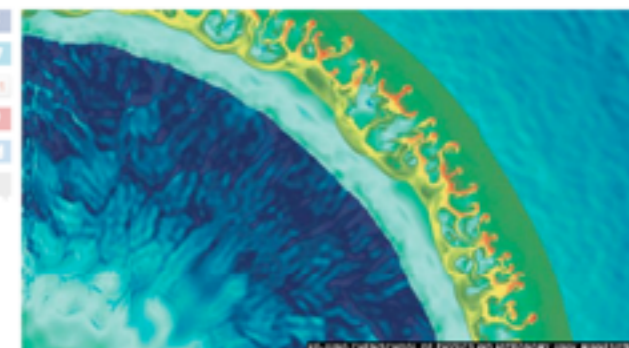
BOOK NOW!

APOLLO

**The Weather Channel**

Supernova Alert! Astronomers Spot Warning Outburst

Charles G. Chou, SPACE.com | Published Feb 18, 2013, 11:39 AM EST



The image shows a simulation of a collision between two shells of matter ejected by a massive star in two subsequent pulsational pair-instability supernova eruptions, only years apart, just before the star dies. Image released Feb. 7, 2013.

Most Popular Today

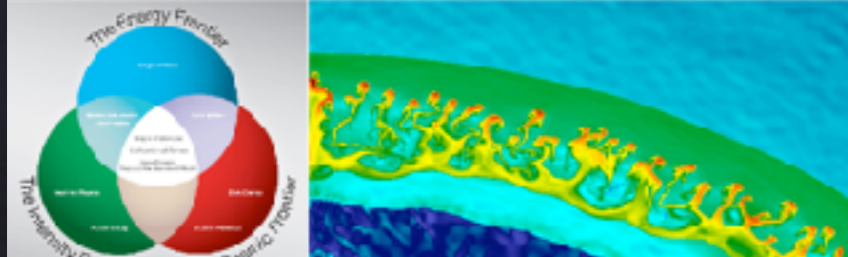
PHOTOS: Gwyneth Jones

PHOTOS: Gwyneth Jones

PHOTOS: Gwyneth Jones

**Large Scale Computing and Storage Requirements for High Energy Physics: Target 2017**

Report of the NERSC Requirements Review  
Conducted September 11-12, 2012



**UNIVERSITY OF MINNESOTA**

Driven to Discover™

Volume 77, Number 1

**Supercomputing Institute**

for Advanced Computational Research

a unit of the Office of the Vice President for Research

**Spring 2011 Research Bulletin**

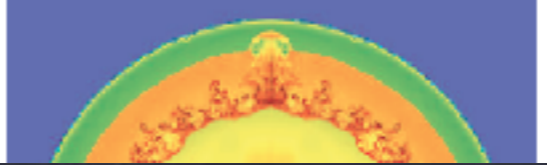
Physics and Astronomy

**Simulations of Thermonuclear Supernovae From Very Massive Stars**

Understanding the evolution of the first stars in the universe is one of the main frontiers of modern cosmology. The first stars hold the key to understanding the formation of the first heavy elements and the first galaxies in the universe. Current models suggest that the first stars were very massive, with typical masses greater than 100 times the mass of our sun, which suggests that some of them might have died as energetic thermonuclear explosions.

Under these conditions, plasmas convert into electron-positron pairs, which reduces the radiative pressure and triggers a rapid contraction of the core. During the contraction, the central temperature and density increase, leading to explosive burning of oxygen and silicon. The energy released by the burning raises the pressure high enough to halt the contraction and cause an explosion.

By studying PISNe, Professor



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# Visual Impacts III

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## The incredible image of a psyche supernova: Researchers simulate superluminous stellar explosion in

- Ran first 2D simulations of superluminous supernovae with supercomputers
- These types of supernovae shine up to 100 times brighter than normal
- Many suspect they are driven by highly magnetized neutron stars, not black holes

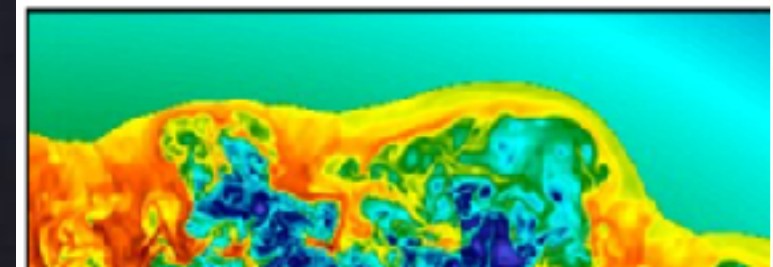
By CHEYENNE MACDONALD FOR DAILYMAIL.COM  
PUBLISHED: 23:47 GMT, 3 February 2017 | UPDATED: 01:14 GMT, 5 February 2017

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In a move that sounds like something out of a sci-fi movie, researchers at the National Energy Research Scientific Computing Center are conducting the first 2D simulations of superluminous supernovae on supercomputers.

These massive stellar explosions shine up to 100 times brighter than normal supernovae, and were only first spotted in the late 1990s.

Researchers say the effort will help improve our understanding of the physical conditions that give rise to these ultra-bright objects.



# NERSC

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## National Energy Research Scientific Computing Center

SIMULATIONS REVEAL THE INVISIBLE CHAOS OF SUPERLUMINOUS SUPERNOVAE

Astrophysicists are running 2D simulations on NERSC to better understand the physical conditions that create rare superluminous supernovae.

[Read More](#)

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LAWRENCE BERKELEY NATIONAL LABORATORY

U.S. DEPARTMENT OF ENERGY

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## Invisible Chaos of Superluminous Supernovae

For the first time, astrophysicists are running 2D simulations to better understand the physical conditions that create rare superluminous supernovae.



# Visualization Prizes

We will select the best visualization from the projects among different groups, please submit your beautiful pictures to :

[kjchen@asiaa.sinica.edu.tw](mailto:kjchen@asiaa.sinica.edu.tw)

*by Ken Chen*