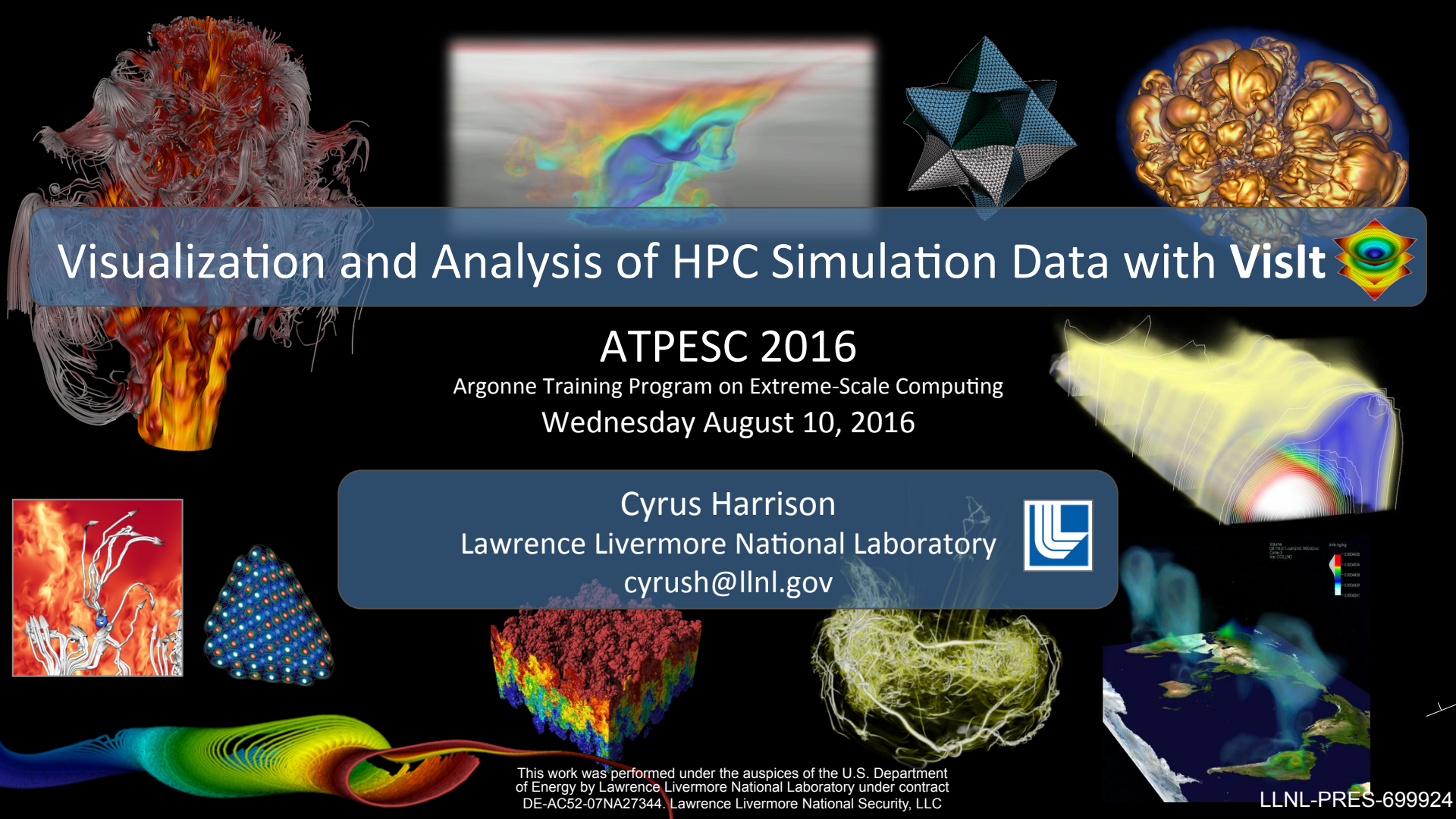


Visualization and Analysis of HPC Simulation Data with **VisIt**

ATPESC 2016

Argonne Training Program on Extreme-Scale Computing

Wednesday August 10, 2016

Cyrus Harrison

Lawrence Livermore National Laboratory

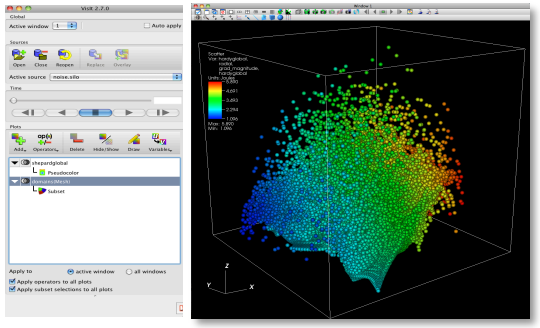
cyrush@llnl.gov

This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract DE-AC52-07NA27344. Lawrence Livermore National Security, LLC

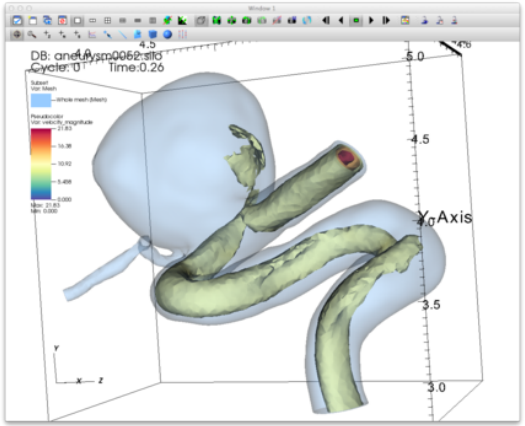
LLNL-PRES-699924

ATPESC 2016 Outline

- **Talk**
  - VisIt Project Introduction (10 min)
  - Guided Tour of VisIt (20 min)
  - Exploration of an Aneurysm Simulation (30 min)



- **Additional Hands-on Materials**
  - Exploration of a Water Flow Simulation
  - Volume Rendering
  - Advanced Movie Making



Tutorial Resources

- **Tutorial Prep**
  - http://visitusers.org/index.php?title=Tutorial_Preparation
- **Example Datasets**
  - http://visitusers.org/index.php?title=Tutorial_Data
- **Aneurysm Simulation Exploration**
  - http://visitusers.org/index.php?title=Blood_Flow_Aneurysm_Tutorial
- **Additional Tutorial Materials**
  - http://visitusers.org/index.php?title=VisIt_Tutorial
- **Cyrus' Email:** cyrush@llnl.gov

Tutorial Data Acknowledgements

Aneurysm Simulation Dataset

Simulated using the LifeV (http://www.lifev.org/) finite element solver.

Available thanks to:

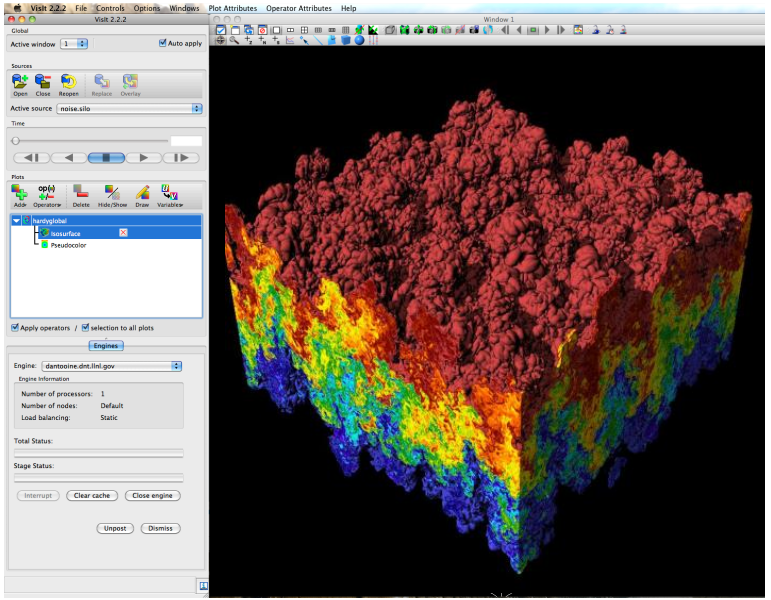
- Gilles Fourestey and Jean Favre
  Swiss National Supercomputing Centre (http://www.cscs.ch/)



VisIt Project Introduction

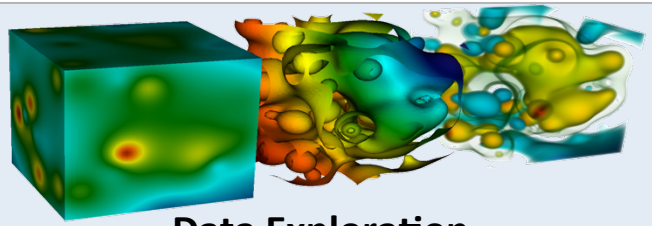
VisIt is an open source, turnkey application for data analysis and visualization of mesh-based data.

- 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.

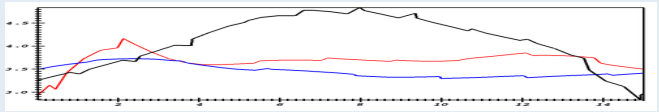


Pseudocolor plot of Density
(27 billion element dataset)

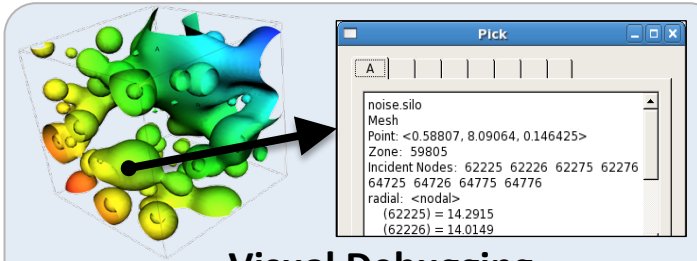
VisIt supports a wide range of use cases.



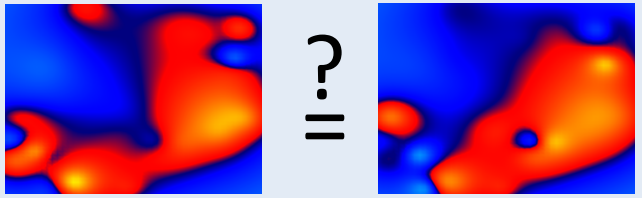
Data Exploration



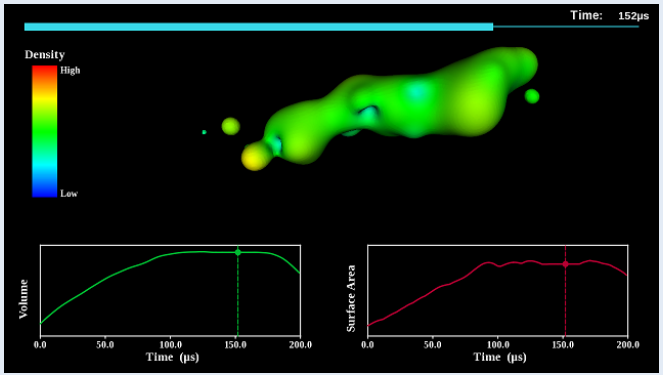
Quantitative Analysis



Visual Debugging

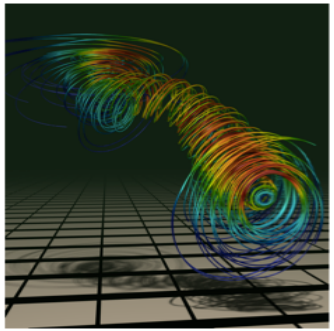


Comparative Analysis

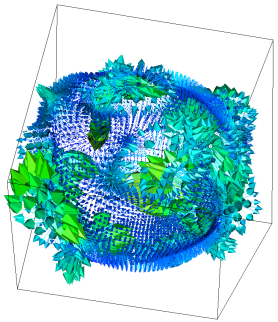


Presentation Graphics

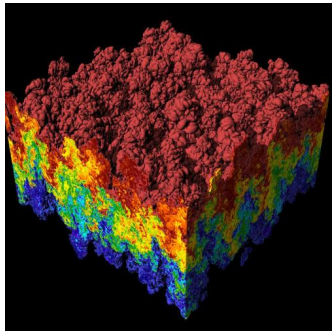
VisIt provides a wide range of plotting features for simulation data across many scientific domains.



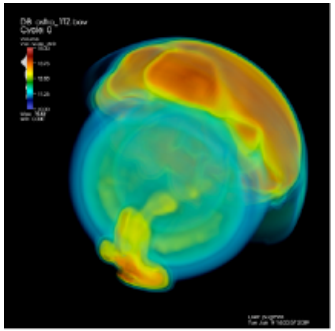
Streamlines / Pathlines



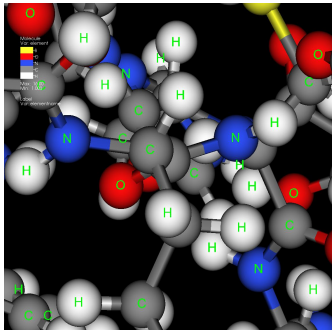
Vector / Tensor Glyphs



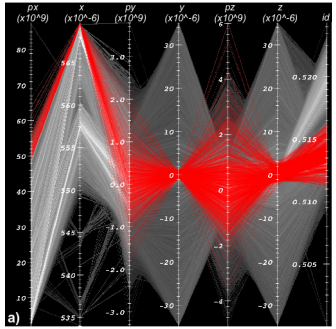
Pseudocolor Rendering



Volume Rendering

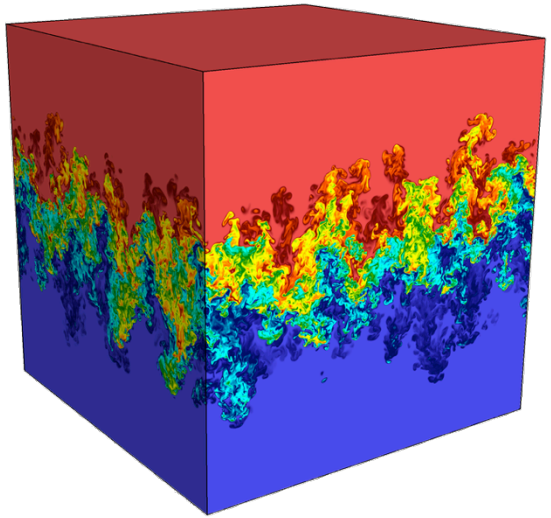


Molecular Visualization

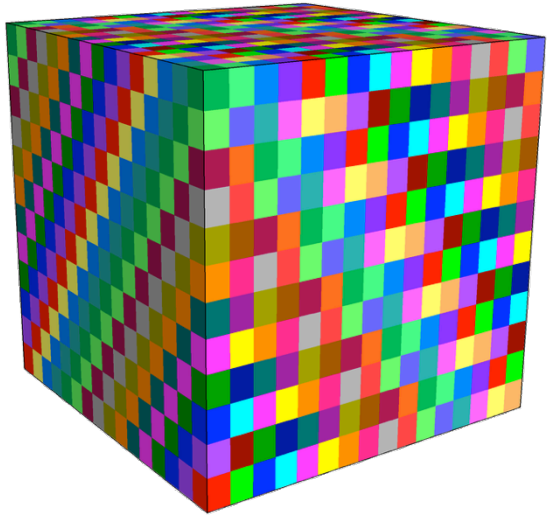


Parallel Coordinates

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



Full Dataset
(27 billion total elements)

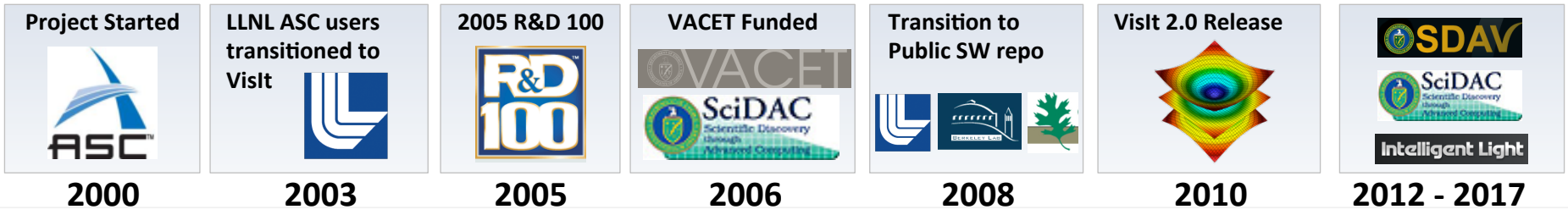


3072 sub-grids
(each 192x129x256 cells)

We are enhancing VisIt's pipeline infrastructure to support threaded processing and many-core architectures.

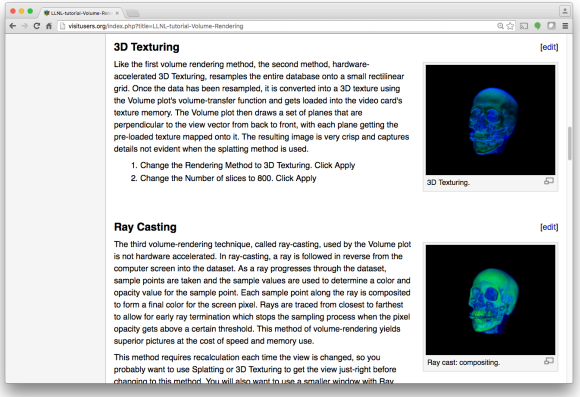
VisIt is a vibrant project with many participants.

- The VisIt project started in 2000 to support LLNL's large scale ASC physics codes.
- The project grew beyond LLNL and ASC with research and development from DOE SciDAC and other efforts.
- VisIt is now supported by multiple organizations:
  - LLNL, LBNL, ORNL, UC Davis, Univ of Utah, Intelligent Light, …
- Over 75 person years of effort, 1.5+ million lines of code.

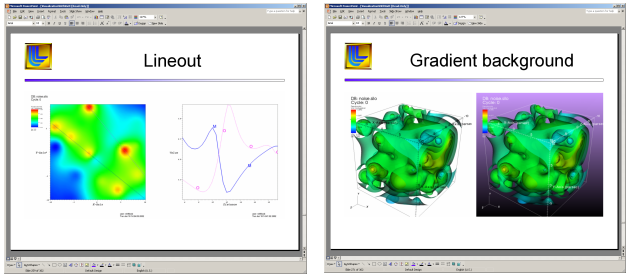


The VisIt team focuses on making a robust, usable product for end users.

- **Regular Releases (~ 6 / year)**
  - Binaries for all major platforms
  - End-to-end build process script ``build_visit''
- **User Support and Training**
  - visitusers.org, wiki for users and developers
  - Email lists: visit-users, visit-developers
  - Beginner and advanced tutorials
  - VisIt class with detailed exercises
- **Documentation**
  - Getting Data Into VisIt Manual
  - Python Interface Manual
  - Users Reference Manual



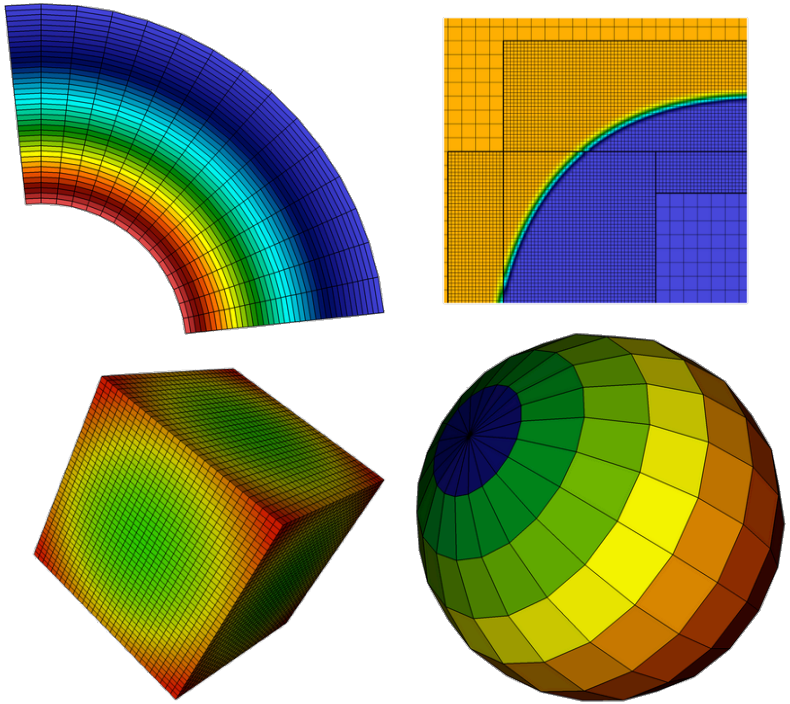
Tutorials on visitusers.org



VisIt class materials

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
  - Primarily linear element support, limited quadratic element support
- **Field Types**
  - Scalar, Vector, Tensor, Material Volume Fractions, Species



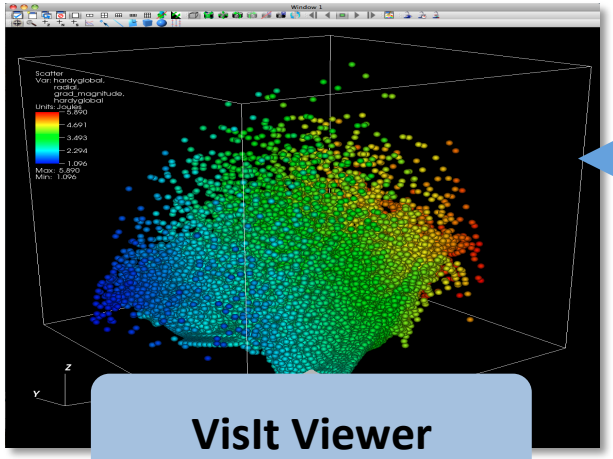
VisIt supports more than 110 file formats.

“How do I get my data into VisIt?”

- Experiment with the *visit_writer* utility:
  - http://visitusers.org/index.php?title=VisItWriter
- Write to a commonly used format:
  - VTK, Silo, Xdmf, PVTK
- Consult the Getting Data Into VisIt Manual and its associated source code examples.

VisIt employs a parallelized client-server architecture.

Client Computer



VisIt Viewer

VisIt GUI | VisIt CLI | Python Clients | Java Clients

network connection

Parallel HPC Cluster

MPI

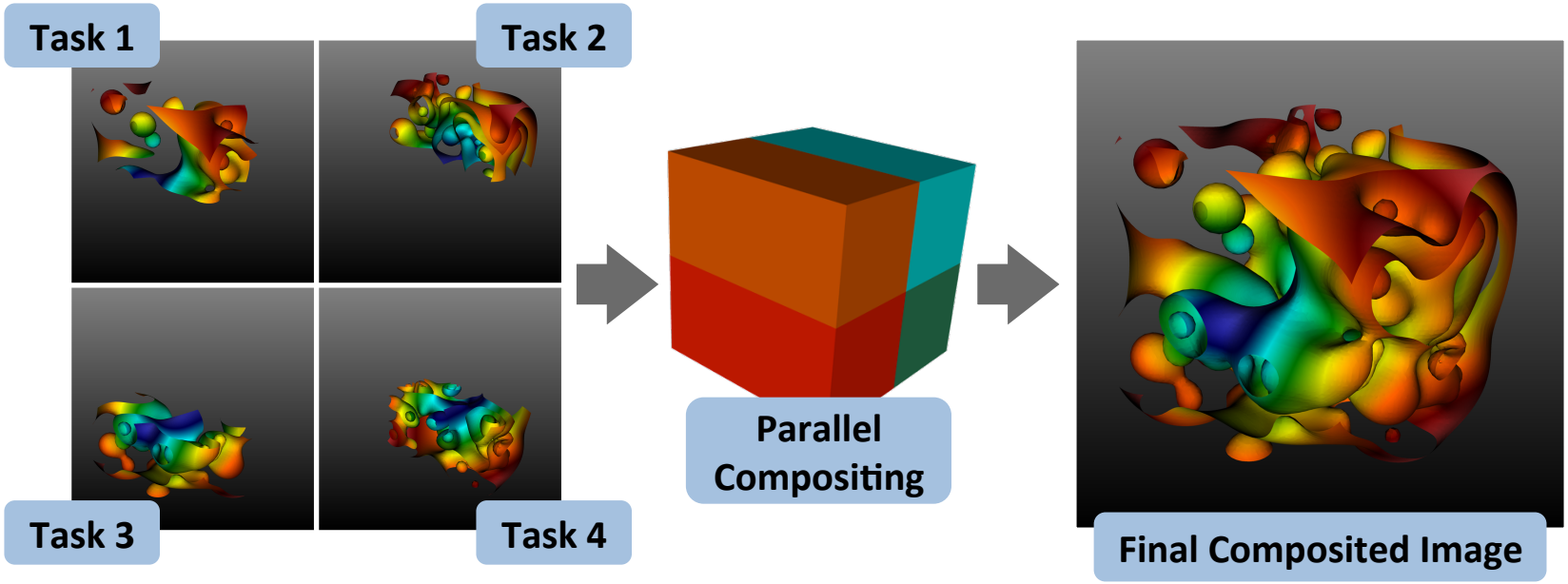
VisIt Engine + Data Plugin → Data

VisIt Engine + Data Plugin → Data

VisIt Engine + Data Plugin → Data

(Files or Simulation)

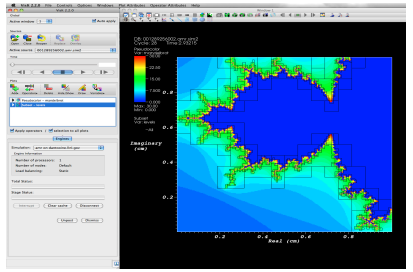
VisIt automatically switches to a scalable rendering mode when plotting large data sets on HPC clusters.

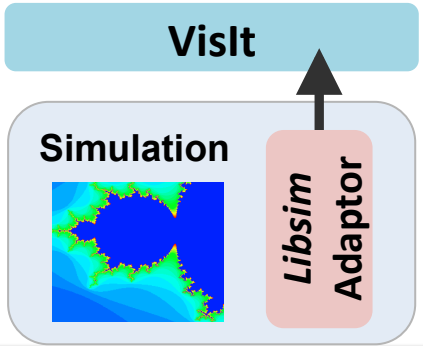


In addition to scalable surface rendering, VisIt also provides scalable volume rendering.

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
- **In-Situ Coupling**
  - VisIt's *Libsim* library allows simulation codes to link in VisIt's engine for in situ visualization





VisIt is used as a platform to deploy visualization research.

- **DOE ASCR Research Collaborations:**

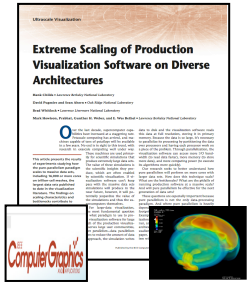
2006 – 2011

2012 – 2017

SDAV

Scalable Data Management, Analysis, and Visualization

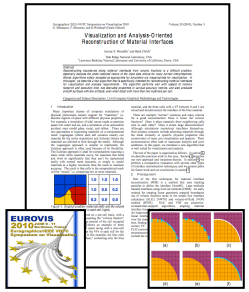
- **Research Focus:**
  - Light weight In Situ Processing
  - Node Level Parallelism
  - Distributed Memory Parallel Algorithms



Scaling research
Scaling to 10Ks of cores and trillions of cells.



Algorithms research
How to efficiently calculate particle paths in parallel.



Algorithms research:
Reconstructing material interfaces for visualization



Methods research:
How to incorporate statistics into visualization.

VisIt is a robust, usable tool, that provides a broad set of visualization capabilities for of HPC simulation data.

- **Provides Features that span the "power of visualization"**
  - Data Exploration
  - Confirmation
  - Communication
- **Provides Features for different kinds of users**
  - Visualization Experts
  - Code Developers
  - Code Consumers

VisIt is actively developed and has vibrant developer and user communities.

Guided Tour of VisIt

- **Materials from:**
  - http://visitusers.org/index.php?title=VisIt-tutorial-basics
  - http://visitusers.org/index.php?title=VisIt-tutorial-data-analysis
  - http://visitusers.org/index.php?title=VisIt-tutorial-Python-scripting

VisIt's interface is built around five core abstractions.

- **Databases**: Read data
- **Plots:** Render data
- **Operators:** Manipulate data
- **Expressions:** Generate derived quantities
- **Queries:** Summarize data

Aneurysm Simulation Exploration

http://visitusers.org/index.php?title=Blood_Flow_Aneurysm_Tutorial

Additional Hands-on Materials

- **Water Flow Simulation Exploration**
  - http://visitusers.org/index.php?title=Water_Flow_Tutorial
- **Volume Rendering**
  - http://visitusers.org/index.php?title-Visit-tutorial-Volume-Rendering
- **Advanced Movie Making**
  - http://visitusers.org/index.php?title=Visit-tutorial-Advanced-movie-making

Resources

- **Presenter Contact Info:**
  - Cyrus Harrison: cyrush@llnl.gov
- **User resources:**
  - Main website: http://www.llnl.gov/visit
  - Wiki: http://www.visitusers.org
  - Email: visitusers@ornl.gov
- **Developer resources:**
  - Email: visit-developers@ornl.gov
  - SVN: http://visit.ilight.com/svn/visit/


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National Laboratory