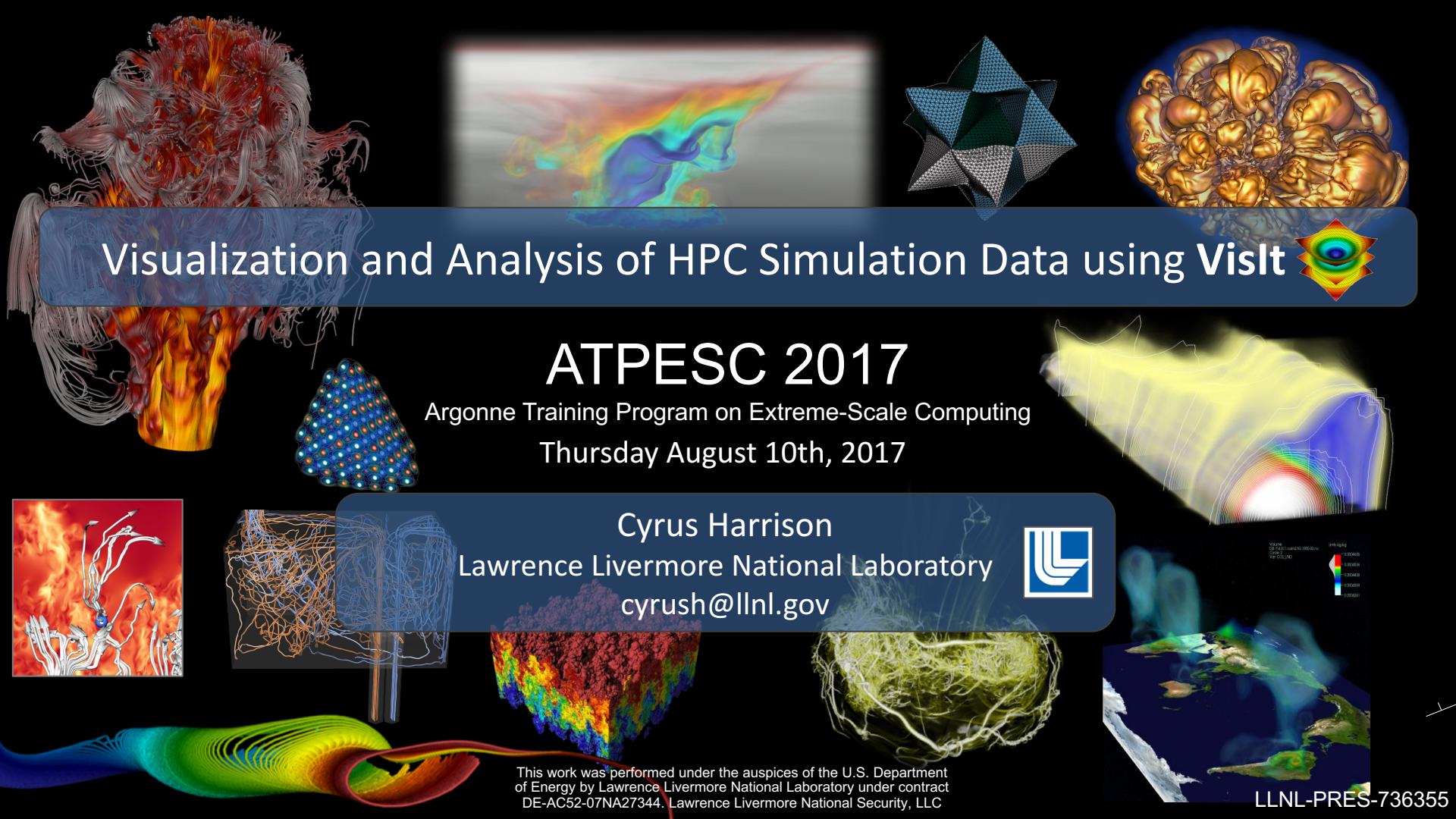

Visualization and Analysis of HPC Simulation Data using **VisIt**

ATPESC 2017

Argonne Training Program on Extreme-Scale Computing

Thursday August 10th, 2017

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LLNL-PRES-736355

ATPESC 2017 Outline

- VisIt Project Introduction (30 min)

  {Lunch!}

- Hands-on: (1.5 hours)
  - Guided tour of VisIt
  - Water Flow Simulation Exploration
  - Visualization of an Aneurysm (Blood Flow) Simulation

Tutorial Resources

- **Tutorial Materials**
  - http://visitusers.org/index.php?title=VisIt_Tutorial
  - **Tutorial Preparation**
    - http://visitusers.org/index.php?title=Tutorial_Preparation
  - **VisIt Binaries (download VisIt 2.12.3)**
    - https://wci.llnl.gov/codes/visit/executables.html
  - **Example Datasets**
    - http://visitusers.org/index.php?title=Tutorial_Data

Tutorial Data Acknowledgements

Aneurysm Simulation Dataset

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

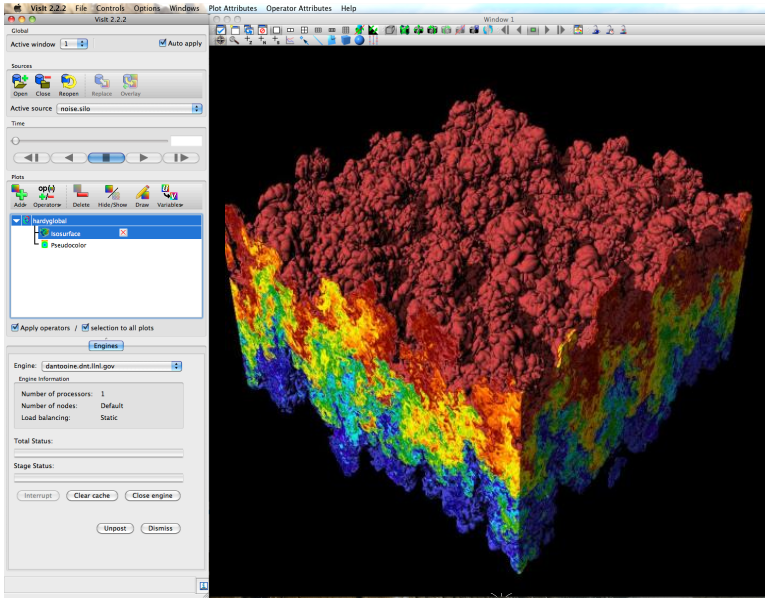
Available thanks to:

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

VisIt Project Introduction

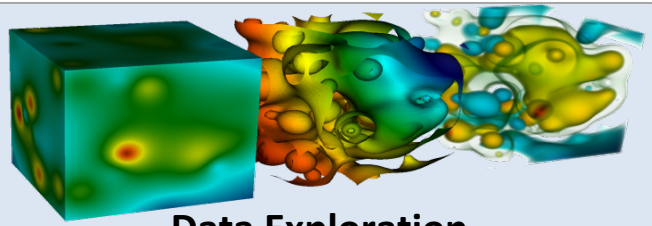
VisIt is an open source, turnkey application for data analysis and visualization of mesh-based data.

- 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.

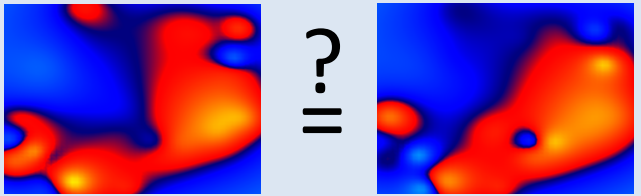


Pseudocolor plot of Density
(27 billion element dataset)

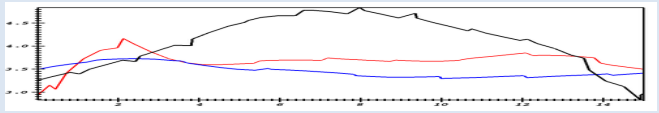
VisIt supports a wide range of use cases.



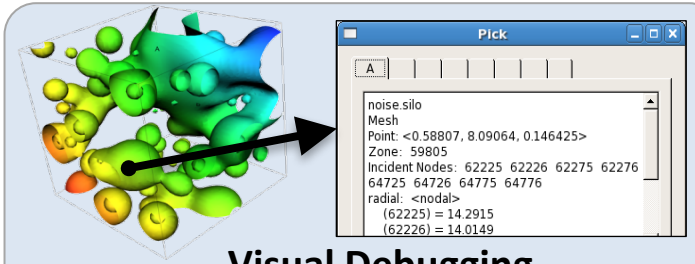
Data Exploration



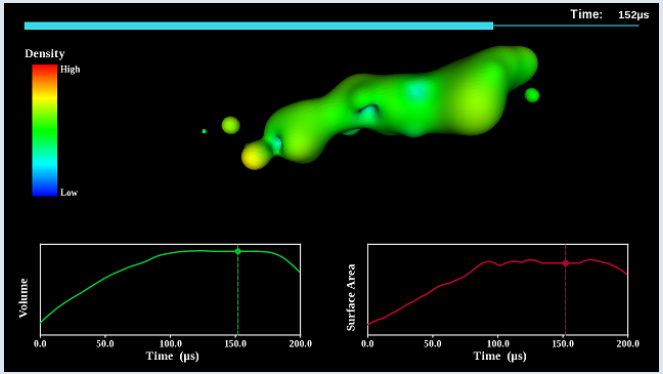
Comparative Analysis



Quantitative Analysis

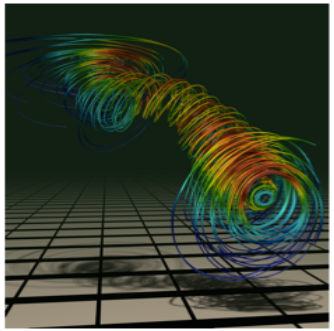


Visual Debugging

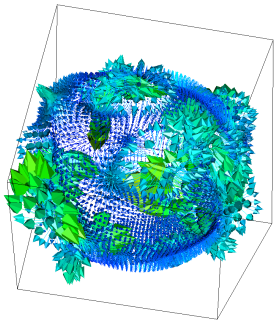


Presentation Graphics

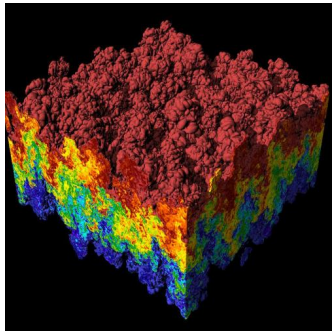
VisIt provides a wide range of plotting features for simulation data across many scientific domains.



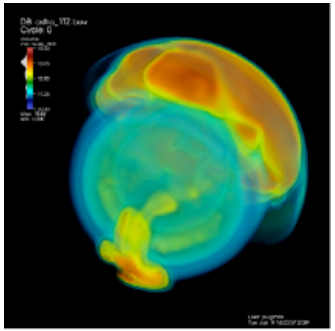
Streamlines / Pathlines



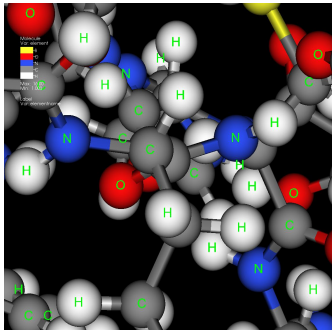
Vector / Tensor Glyphs



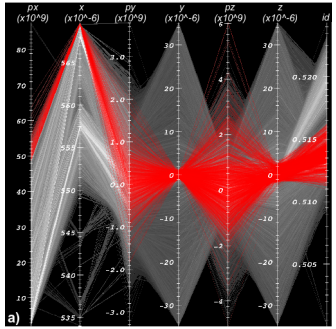
Pseudocolor Rendering



Volume Rendering

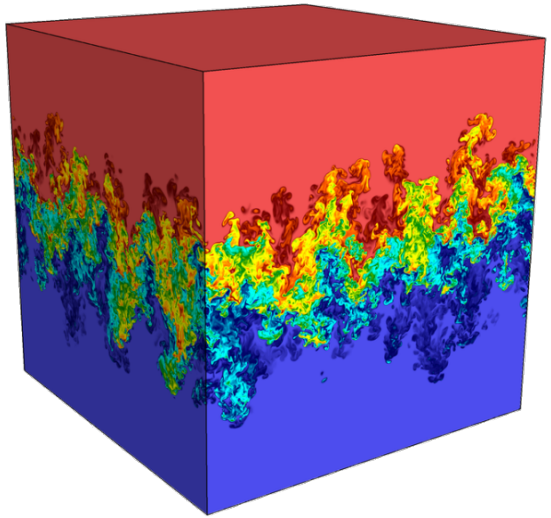


Molecular Visualization

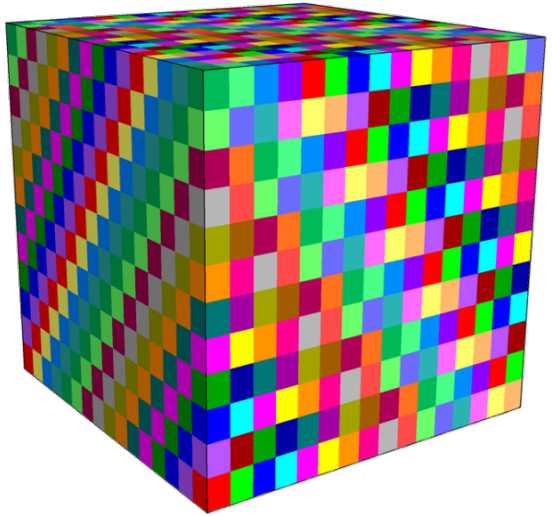


Parallel Coordinates

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



Full Dataset
(27 billion total elements)

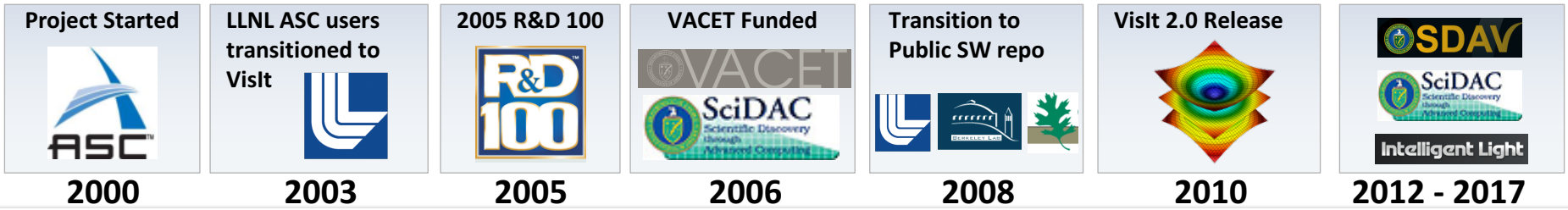


3072 sub-grids
(each 192x129x256 cells)

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

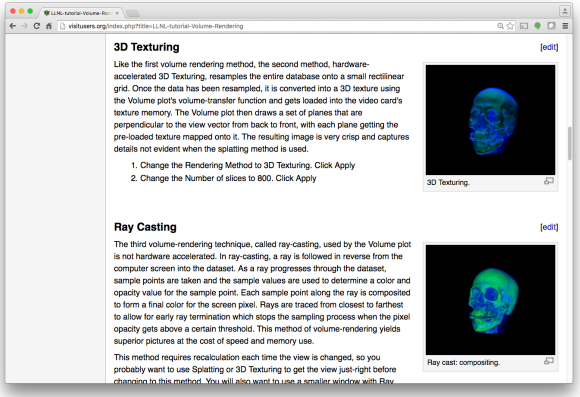
VisIt is a vibrant project with many participants.

- 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, Univ of Oregon, Univ of Utah, Intelligent Light, …
- Over 75 person years of effort, 1.5+ million lines of code.

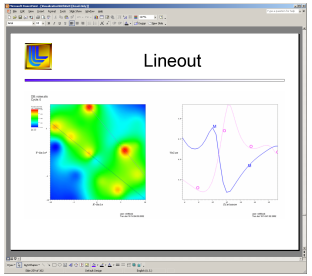


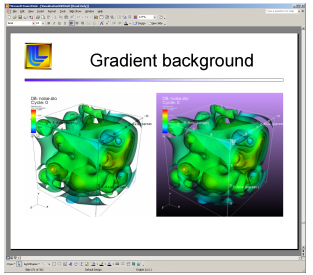
The VisIt team focuses on making a robust, usable product for end users.

- **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

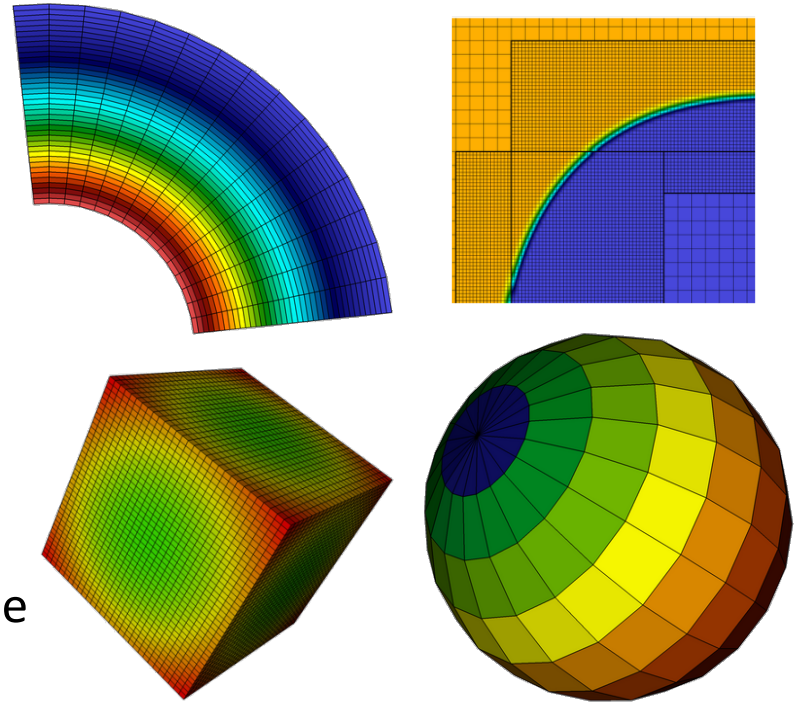




VisIt class materials

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

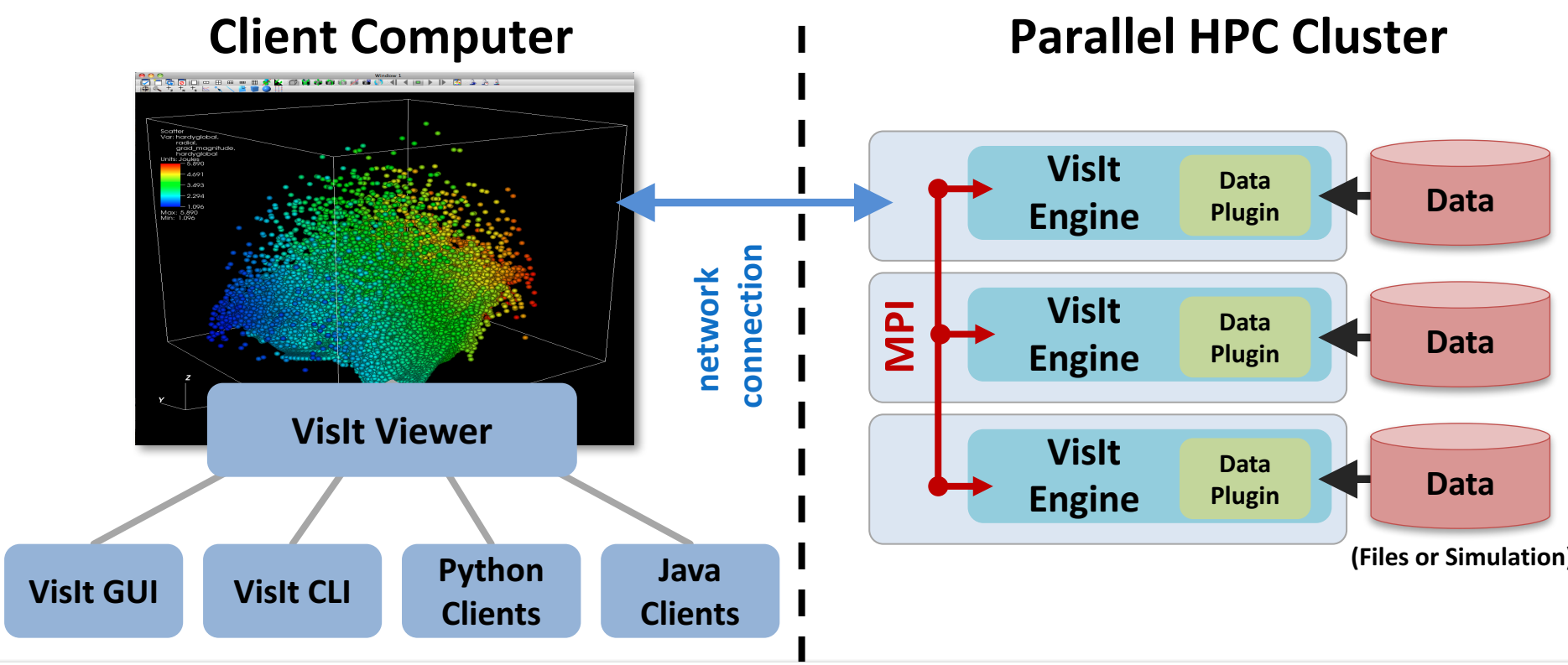


VisIt supports more than 110 file formats.

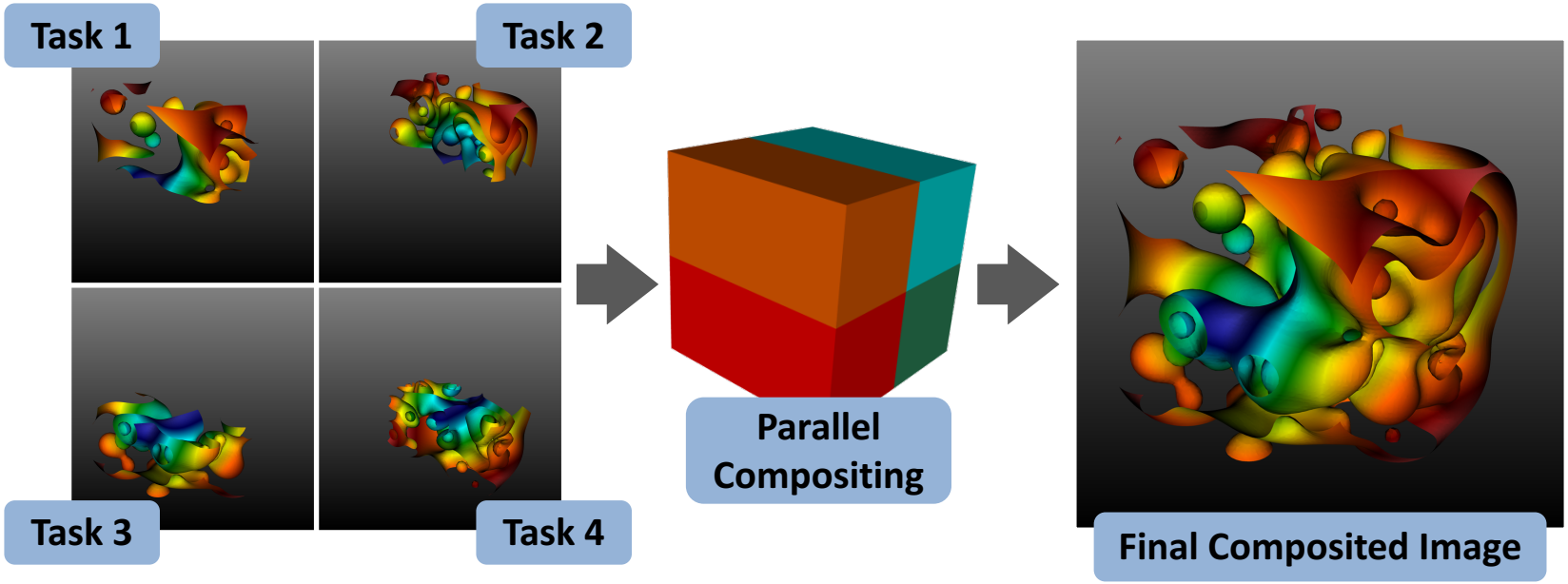
“How do I get my data into VisIt?”

- The *PlainText* database reader can read simple text files (CSV, etc)
  - http://visitusers.org/index.php?title=Using_the_PlainText_reader
- 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.



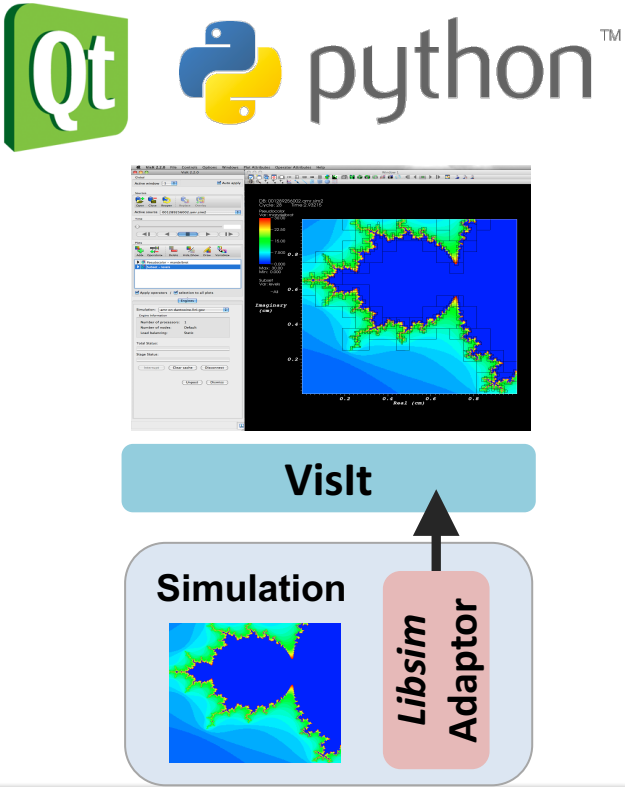
VisIt automatically switches to a scalable rendering mode when plotting large data sets on HPC clusters.



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

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

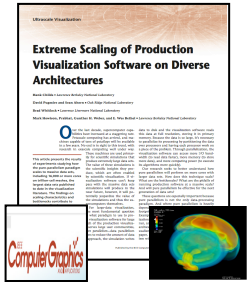
- **C++ Plugin Architecture**
  - Custom File formats, Plots, Operators
  - Interface for custom GUIs in Python, C++ and Java
- **Python Interfaces**
  - Python scripting and batch processing
  - Data analysis via Python Expressions and Queries
- **In-Situ Coupling**
  - VisIt's *Libsim* library allows simulation codes to link in VisIt's engine for in situ visualization



VisIt is used as a platform to deploy visualization research.

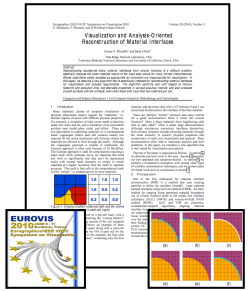
- **DOE ASCR Research Collaborations**

- **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

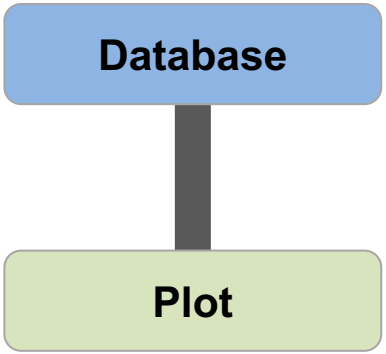
Methods research:
How to incorporate statistics into visualization.

VisIt's interface is built around five core abstractions.

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

Examples of VisIt Pipelines

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



Open a database, which reads from a file
(Example: Open file1.hdf5)

Make a plot of a field in the database
(Example: Pseudocolor plot of *density*)

Examples of VisIt Pipelines

- **Databases**: Read data
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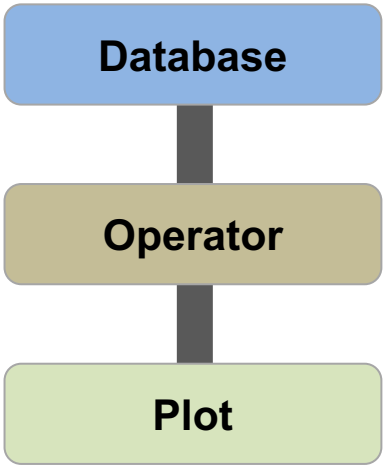


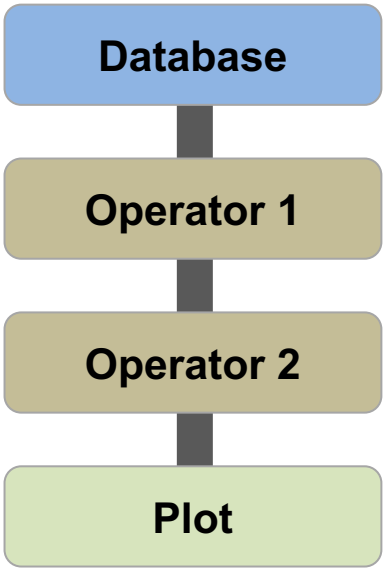
Open a database, which reads from a file
(Example: Open file1.hdf5)

Apply an operator to transform the data
(Example: Slice operator)

Make a plot of the result
(Example: Pseudocolor plot of *density*)

Examples of VisIt Pipelines

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



Open a database, which reads from a file
(Example: Open file1.hdf5)

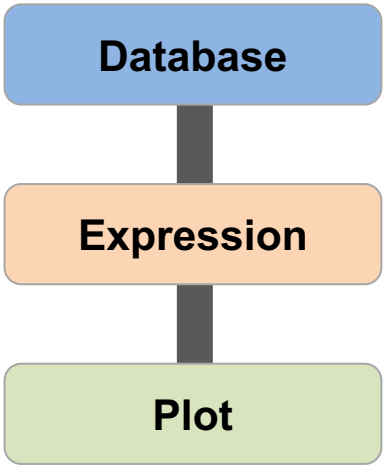
Apply an operator to transform the data
(Example: Slice operator)

Apply a second operator to transform the data
(Example: Elevate operator)

Make a plot of the result
(Example: Pseudocolor plot of *density*)

Examples of VisIt Pipelines

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



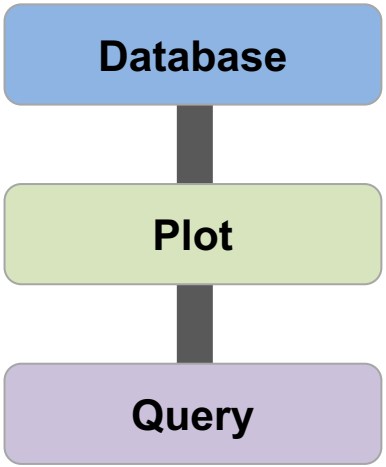
Open a database, which reads from a file
(Example: Open file1.hdf5)

Create derived quantity from existing fields
(Example: *speed = magnitude(velocity)*

Make a plot of the result
(Example: Pseudocolor plot of *speed*)

Examples of VisIt Pipelines

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



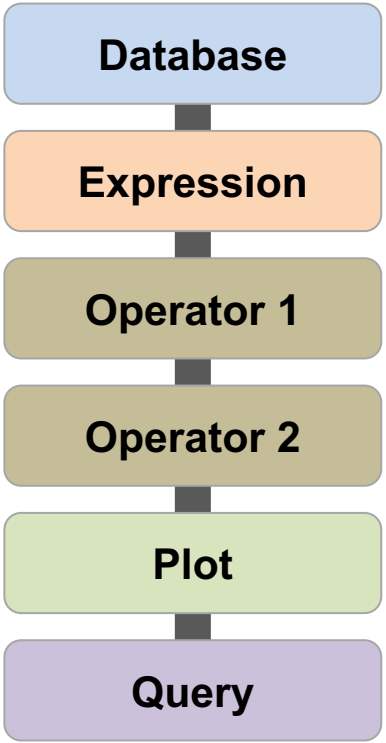
Open a database, which reads from a file
(Example: Open file1.hdf5)

Make a plot of a field in the database
(Example: Pseudocolor plot of *density*)

Extract quantitative information
(Example: integrate *density* to find *mass*)

Examples of VisIt Pipelines

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



Open a database, which reads from a file
(Example: Open file1.hdf5)

Create derived quantity from existing fields
(Example: *speed = magnitude(velocity)*

Apply an operator to transform the data
(Example: Slice operator)

Apply a second operator to transform the data
(Example: Elevate operator)

Plot a field
(Example: Pseudocolor plot of *speed*)

Extract quantitative information
(Example: Maximum speed over cross-section)

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.

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/

Hands-on Session

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

Aneurysm Simulation Exploration

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

Water Flow Simulation Exploration

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

Additional Hands-on Materials

- **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