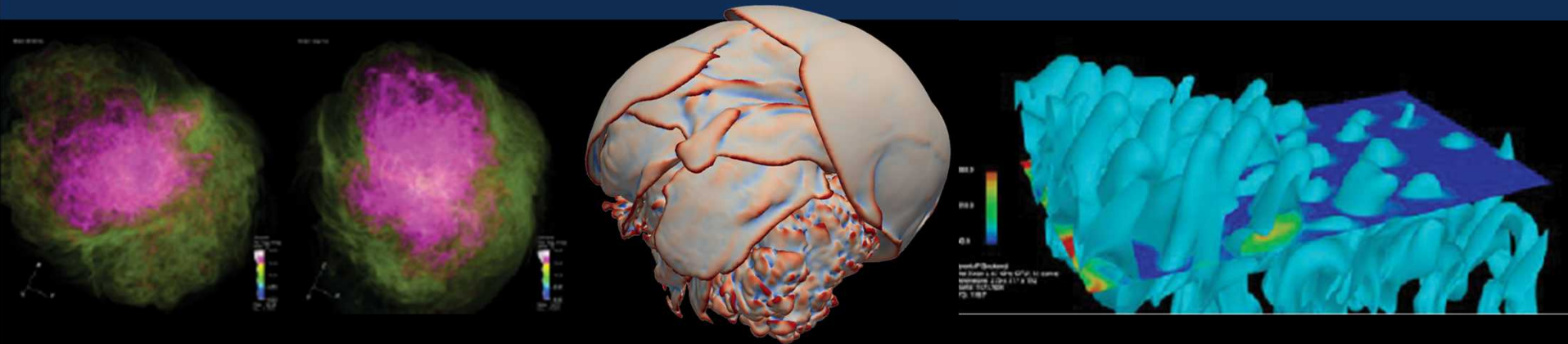


*Exceptional service in the national interest*



XVis

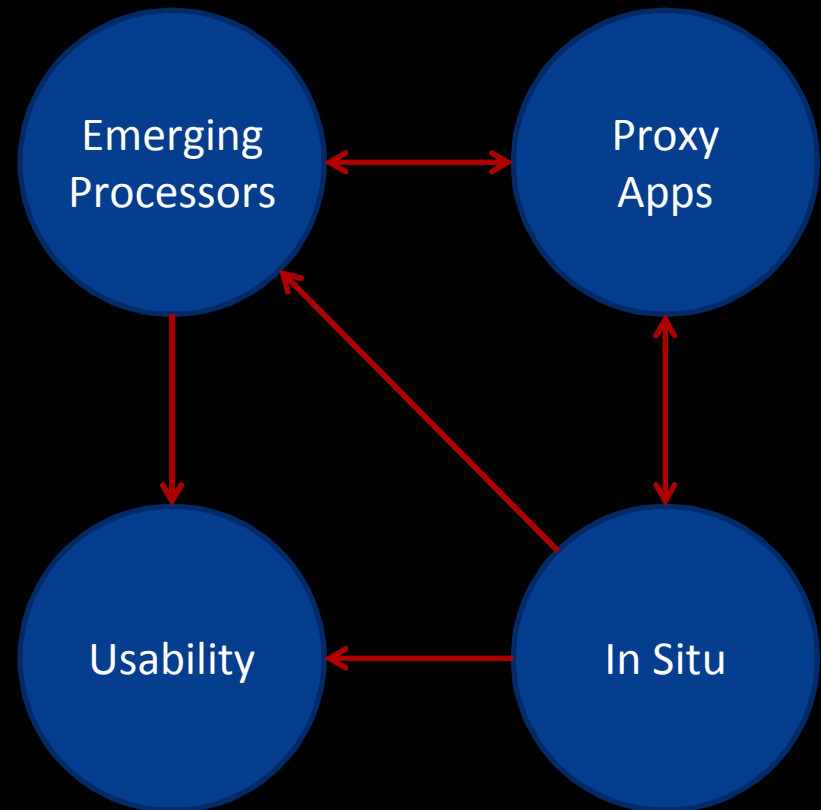
ASCR SDMA&V PI Meeting

January, 2015

Kenneth Moreland Sandia National Laboratories

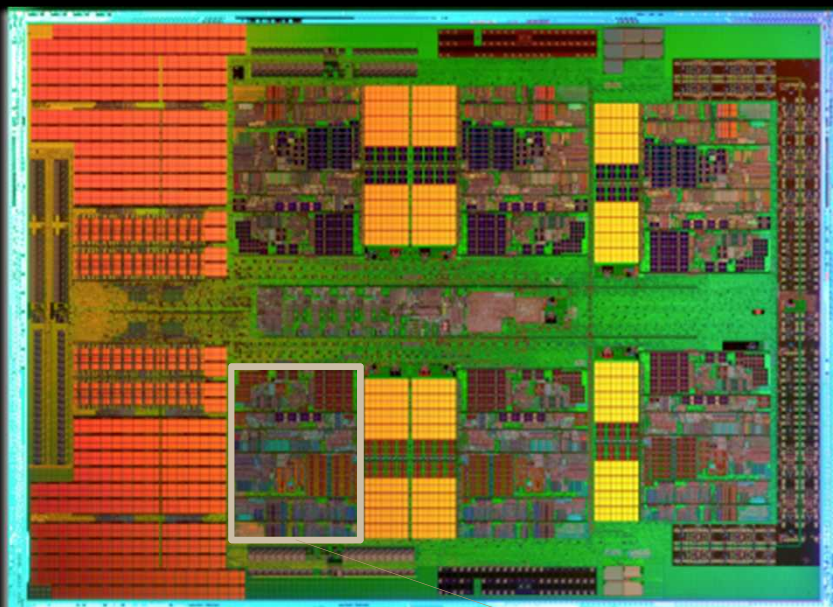
# XVis Overview

- Preparation for complexity of extreme-scale visualization
- Address 4 interlocking challenges: Emerging Processors, In Situ, Usability, and Proxy Applications
- 6 partnering institutions
  - Sandia (Kenneth Moreland)
  - Oak Ridge (Jeremy Meredith)
  - LANL (Chris Sewell)
  - Kitware (Berk Geveci)
  - UC Davis (Kwan-Liu Ma)
  - U Oregon (Hank Childs)



# Challenge 1: Emerging Architecture

Key Players: Sandia, Kitware, ORNL, LANL

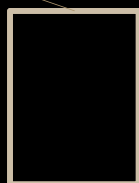


1mm

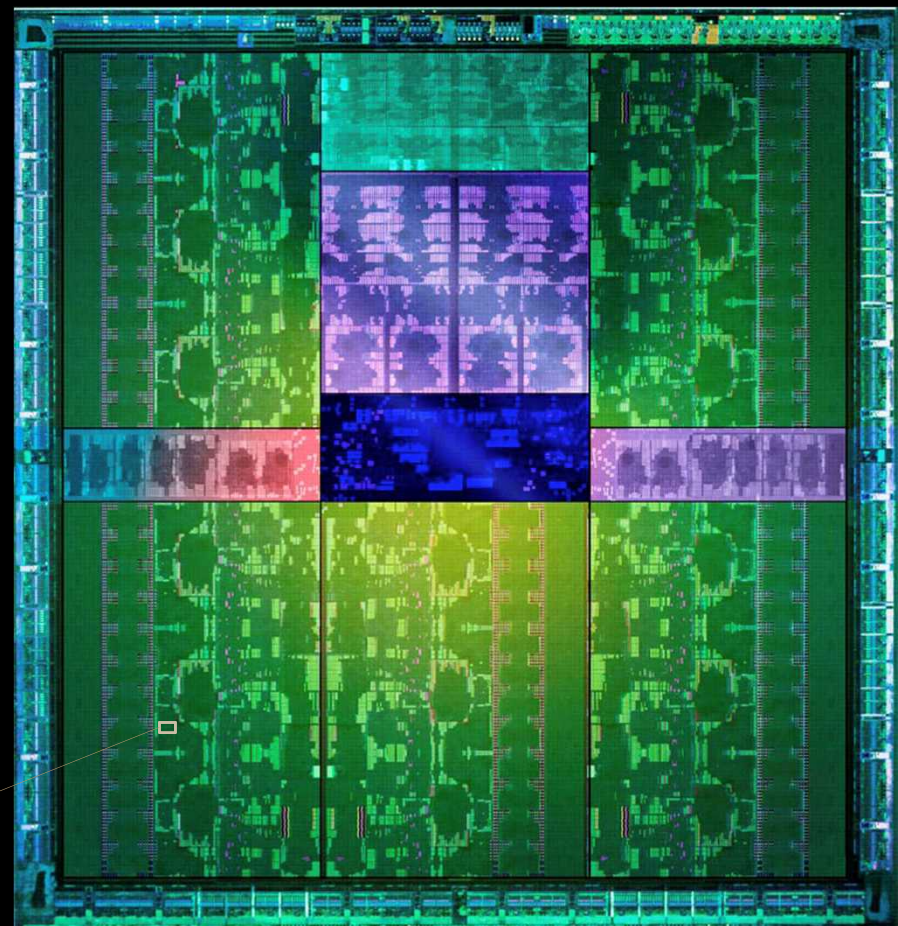
## AMD x86

Full x86 Core  
+ Associated Cache  
6 cores per die  
MPI-Only feasible

1 x86  
core



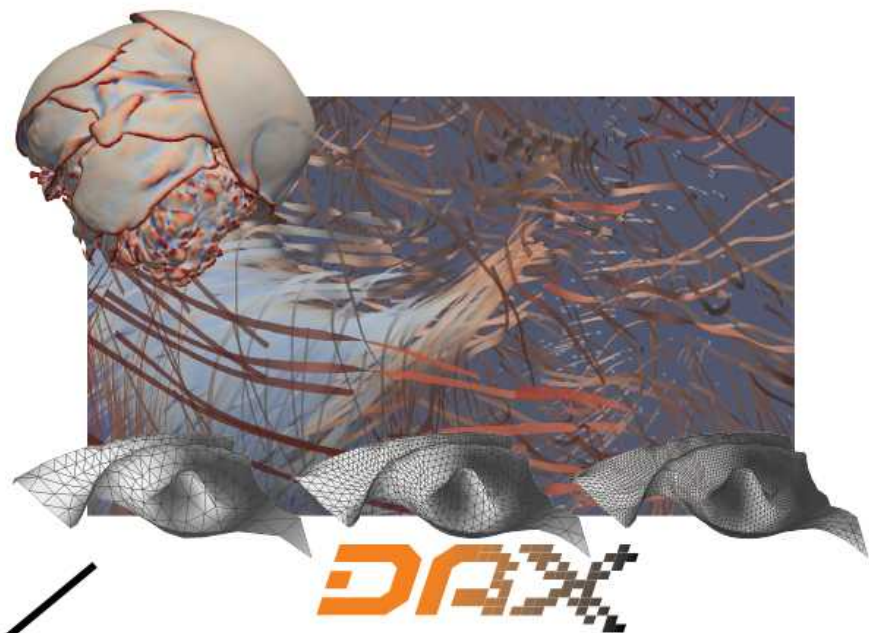
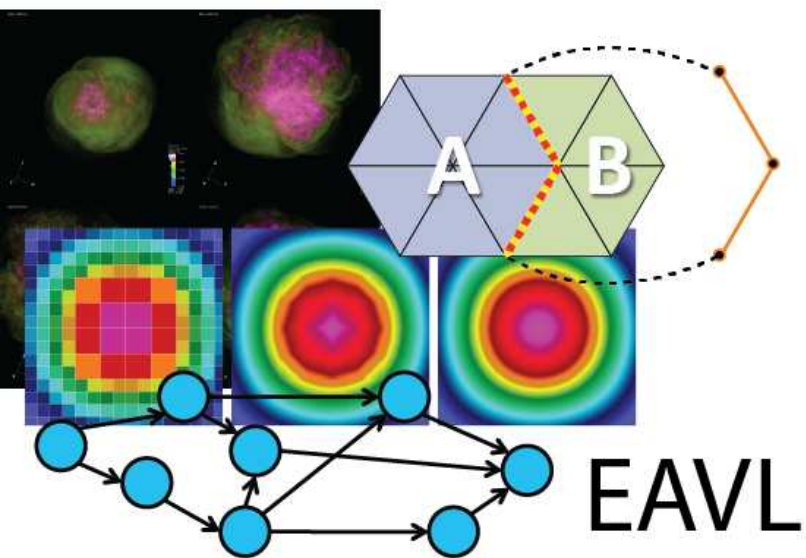
1 Kepler  
"core"



## NVIDIA GPU

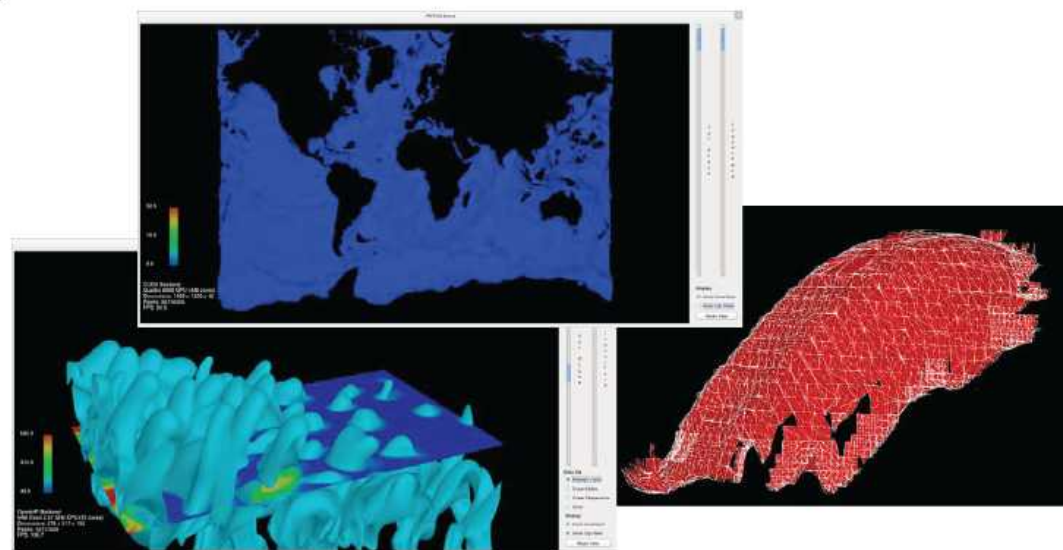
2,880 cores collected in 15 SMX  
Shared PC, Cache, Mem Fetches  
Reduced control logic  
MPI-Only not feasible





VTk-m

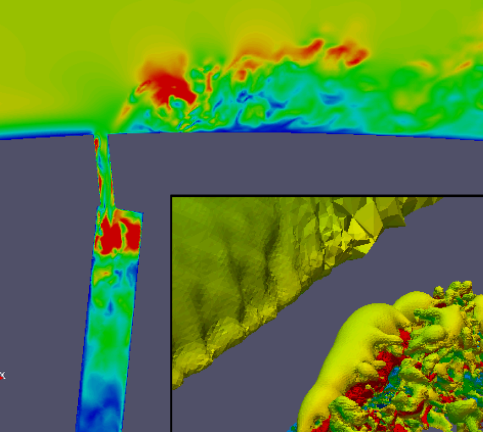
PISTON



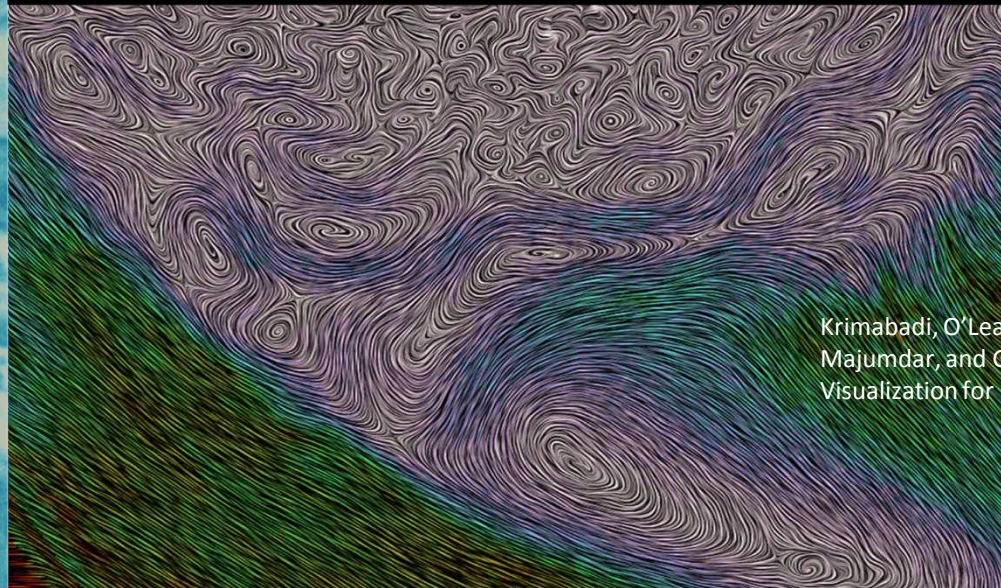
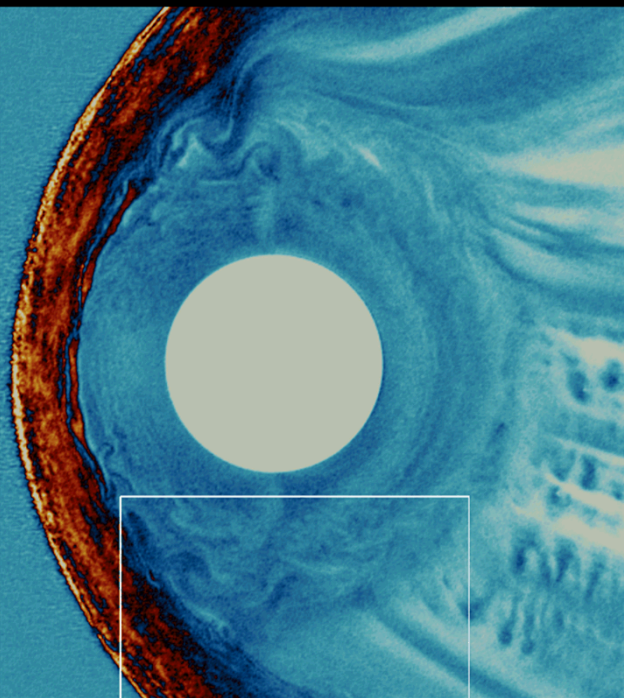
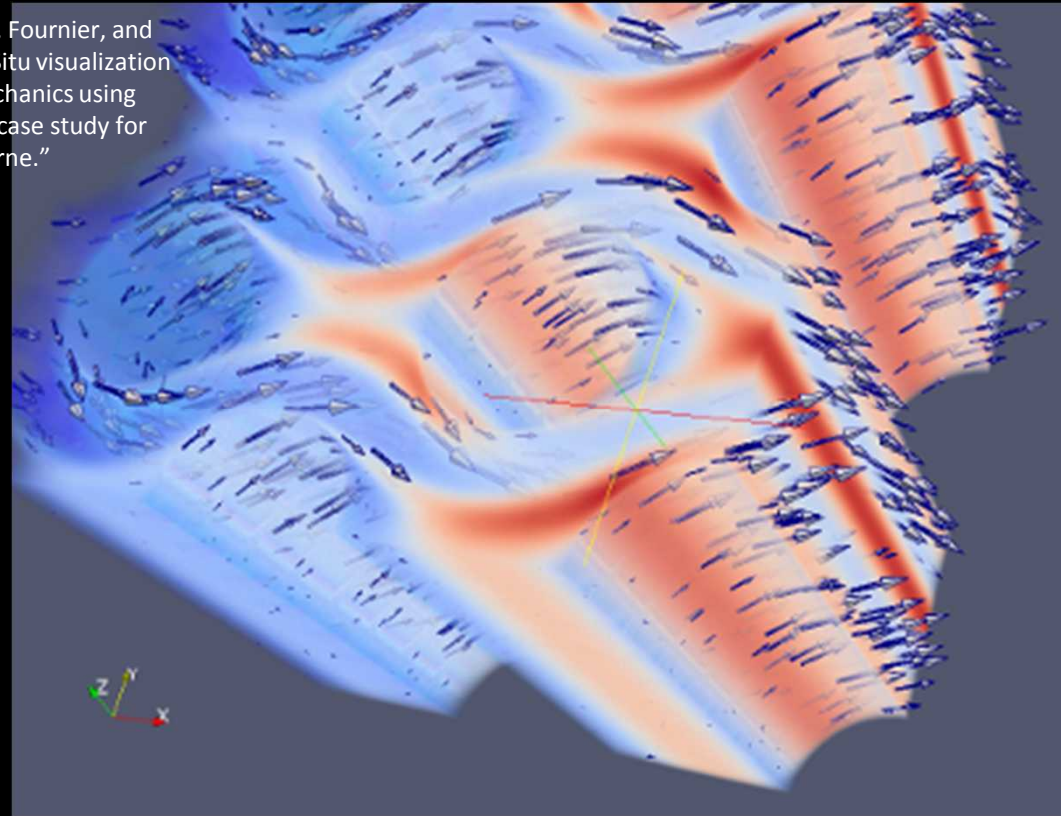
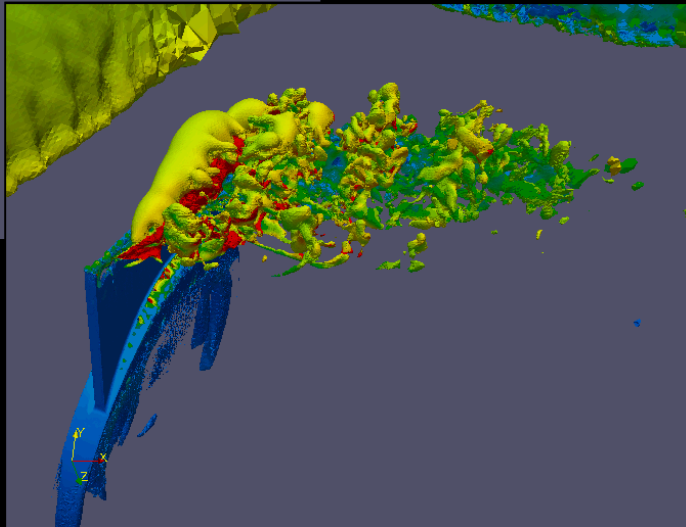
# Challenge 2: In Situ

Key Players: Kitware, ORNL, LANL, UC Davis, U Oregon





Lorendeau, Fournier, and Ribes. "In-Situ visualization in fluid mechanics using Catalyst: a case study for Code\_Saturne."

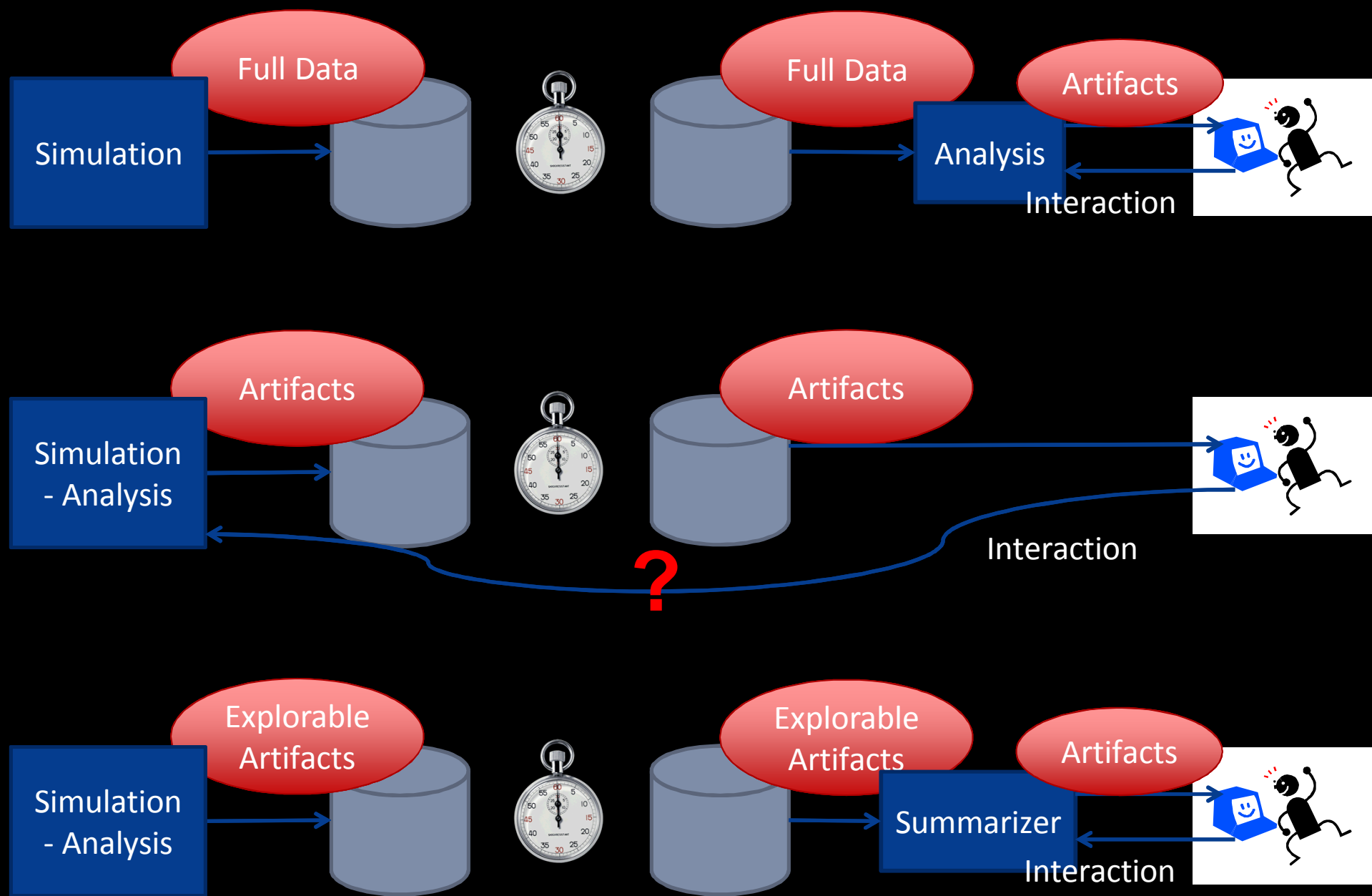


Krimabadi, O'Leary, Tatineni, Loring, Majumdar, and Geveci. "In-Situ Visualization for Global Hybrid Systems."

# Challenge 3: Usability

Key Players: UC Davis, U Oregon





# Challenge 4: Proxy Analysis

Key Players: Sandia, ORNL

# Mini App Plans

- Topology Generation
  - Iterating over geometry
  - Traversing topology incidence
  - Compacting variable output arrays
  - Welding incident components
- Streamlines
  - Pathline integration
  - Search Structures
- Rendering
  - Image synthesis
  - Image reduction





# XVis: Visualization for the Extreme-Scale Scientific-Computation Ecosystem

**Kenneth Moreland**  
Sandia National Laboratories



**Berk Geveci**  
Kitware, Inc.



**Jeremy Meredith**  
Oak Ridge National Laboratory



**Chris Sewell**  
Los Alamos National Laboratory



UNIVERSITY OF OREGON

**Kwan-Liu Ma**  
University of California at Davis

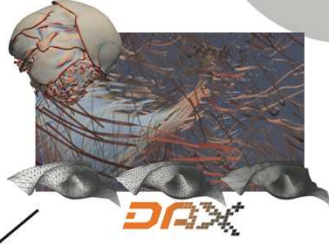
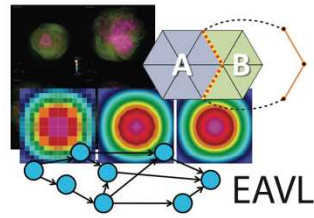


**Hank Childs**  
University of Oregon

## Emerging Processor Technology

One of the biggest recent changes in high-performance computing is the increasing use of accelerators. Accelerators contain processing cores that independently are inferior to a core in a typical CPU, but these cores are replicated and grouped such that their aggregate execution provides a very high computation rate at a much lower power. Current and future CPU processors also require much more explicit parallelism. Each successive version of the hardware packs more cores into each processor, and technologies like hyperthreading and vector operations require even more parallel processing to leverage each core's full potential.

XVis brings together collaborators from the predominant DOE projects for visualization on accelerators and combines their respective features in a unified visualization library named VTK-m. VTK-m will allow the DOE visualization community, as well as the larger visualization community, a single point to collaborate, contribute, and leverage massively threaded algorithms.



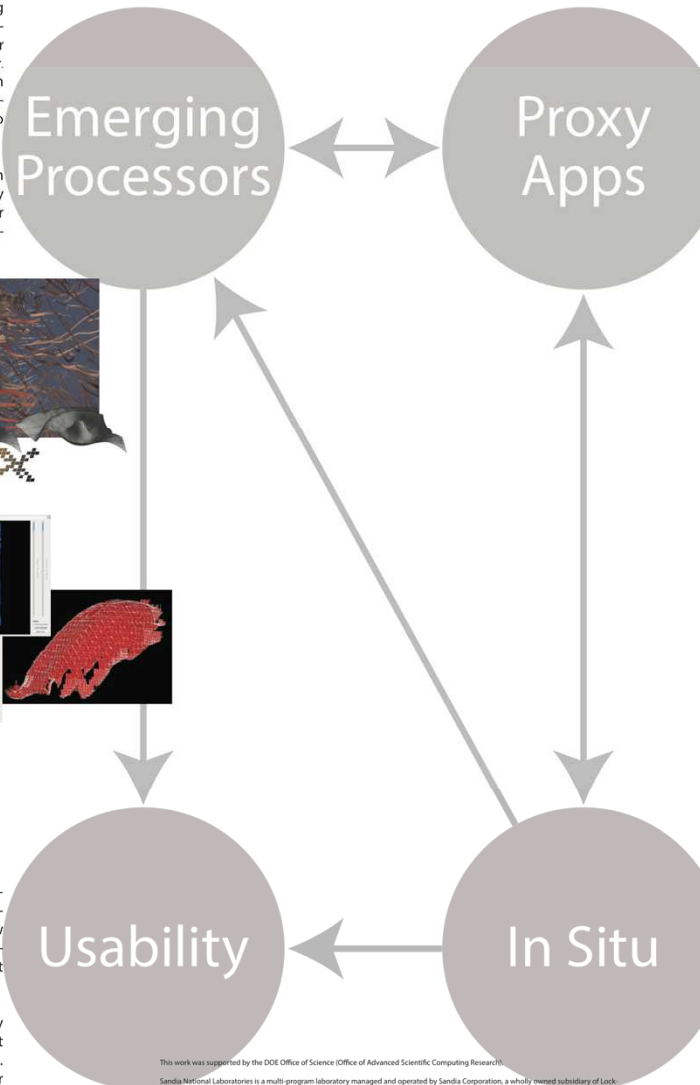
**VTK-m**

**PISTON**

## Usability

A significant disadvantage of using a workflow that integrates simulation with visualization is that a great deal of exploratory interaction is lost. Post hoc techniques can recover some interaction but with a limited scope or precision. Little is known about how these limitations affect usability or a scientist's ability to form insight. XVis performs usability studies to determine the consequences of *in situ* visualization and proposes best practices to improve usability.

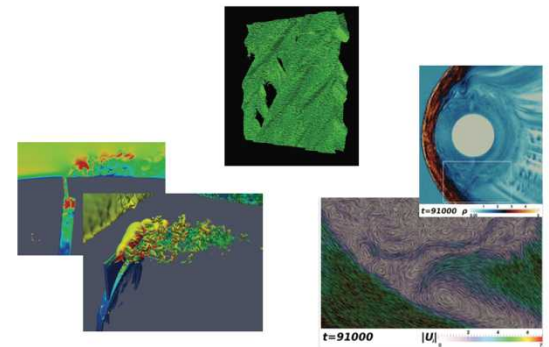
Unlike a scalability study, which is always quantitative, XVis' usability studies are mostly qualitative. Our goal is not to measure user performance; rather, we want to learn about the limitations and benefits of incorporating *in situ* methods in scientists' workflows. These studies reveal how the simulation, hardware, and users respond to a particular design and setting.



## Proxy Analysis

The extreme-scale scientific-computation ecosystem is a much more complicated world than the largely homogeneous systems of the past. There is significantly greater variance in the design of the accelerator architecture than is typical of the classic x86 CPU. *In situ* visualization also yields complicated interactions between the simulation and visualization that are difficult to predict. Thus, the behavior observed in one workflow might not be indicative of another.

To better study the behavior of visualization in numerous workflows on numerous systems, XVis builds proxy applications that characterize the behavior before the full system is run. We start with the design of mini-applications for prototypical visualization operations and then combine these with other mini-applications to build application proxies that characterize the behavior of larger systems. The proxy analysis and emerging processor technology work are symbiotic. The mini-applications are derived from the VTK-m implementations, and the VTK-m design is guided by the analysis of the mini-applications.



## In Situ Integration

Fundamental physical limitations prevent storage systems from scaling at the same rate as our computation systems. Although large simulations commonly archive their results before any analysis or visualization is performed, this practice is becoming increasingly impractical. Thus, the scientific community is turning to running visualization *in situ* with simulation. This integration of simulation and visualization removes the bottleneck of the storage system.

Integrating visualization *in situ* with simulation remains technically difficult. XVis leverages existing *in situ* libraries to integrate flyweight techniques and advanced data models to minimize resource overhead. Within our *in situ* visualization tools, XVis integrates existing visualization algorithms and those incorporating emerging processor technology. XVis also studies the latest techniques for new domain challenges and for post hoc interaction that reconstructs exploratory interaction with reduced data.

This work was supported by the DOE Office of Science (Office of Advanced Scientific Computing Research).

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