Large-Data Software Defined Visualization on CPUs

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2015 Rice Oil & Gas HPC Workshop

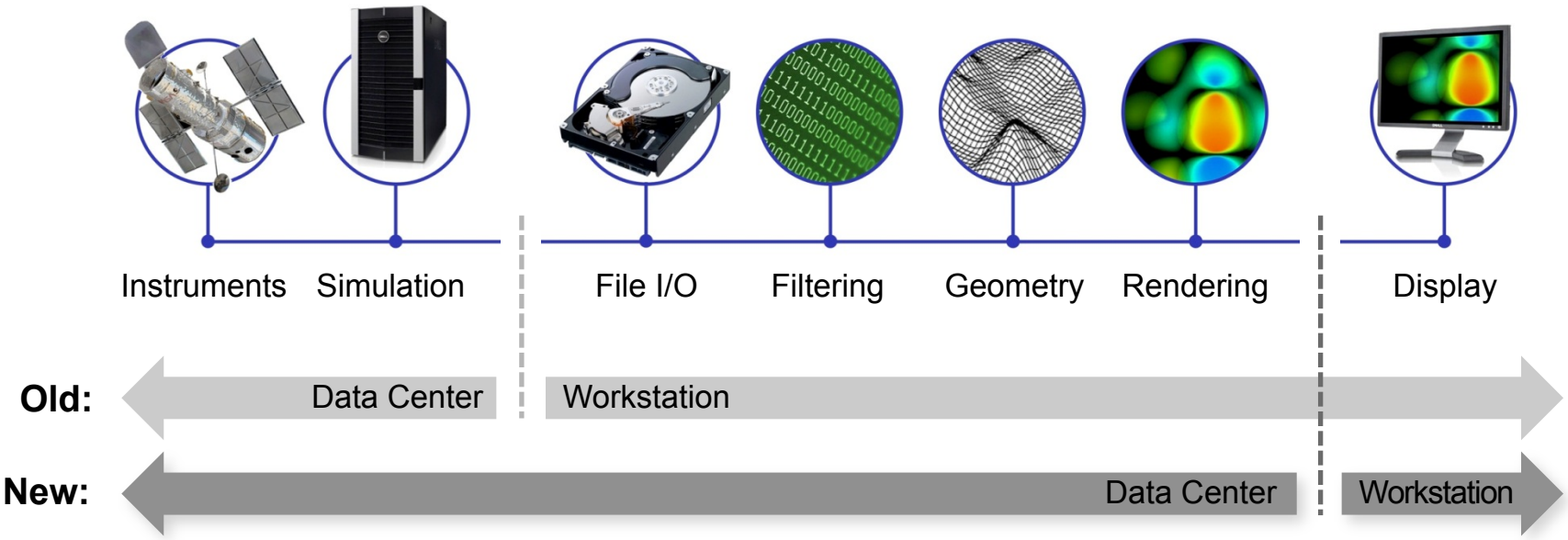
Trend: Increasing Data Size

- Measuring / modeling increasingly complex phenomena
- Rendering is typically performed on discrete accelerators

Implications

- Interactivity harder to achieve
- Requires moving data ➔ bandwidth, storage, security issues
- Limits usage models (e.g. for in-situ visualization, computational steering)
- Limits scalability for visualization
- Increased spatial / temporal resolution: more difficult to interpret visually

Corollary: Workflow Moving into Data Center…



Software Defined Visualization

The concept of doing visualization / rendering entirely in software on CPUs

- Treats visualization as another form of parallel compute
  - Enables vis on compute resources without requiring special purpose hardware and APIs
- Advantages
  - Access to large memory
  - No need to move data
  - Enables different models of rendering
  - Based on standard open source development tools / programming paradigms
  - Homogenous system design: general purpose nodes

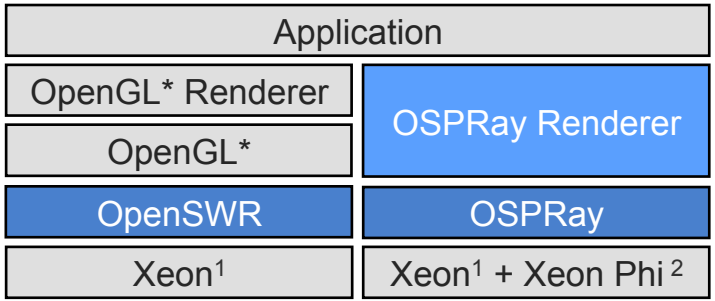
Software Defined Visualization: Our Approach

Option 1: Support existing APIs (OpenGL*)

- Works with existing applications
- No code changes or recompilation required
- ➔ **OpenSWR** software rasterizer

Option 2: Enable new functionality and improved performance through a new API

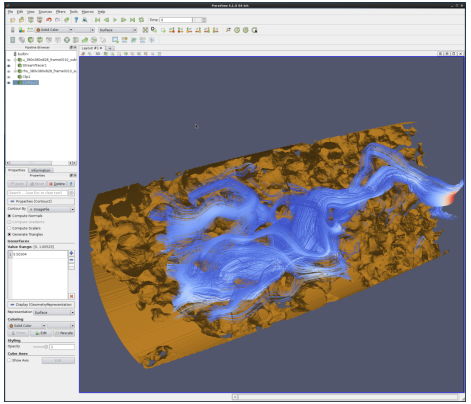
- Good option for new applications
- Some effort required to enable existing applications
- ➔ **OSPRay** ray tracing based rendering engine



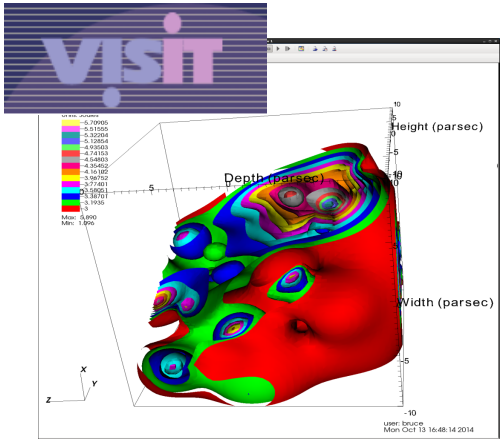
[1] Intel® Xeon® processor, [2] Intel® Xeon Phi™ coprocessor.

OpenSWR Software Rasterizer

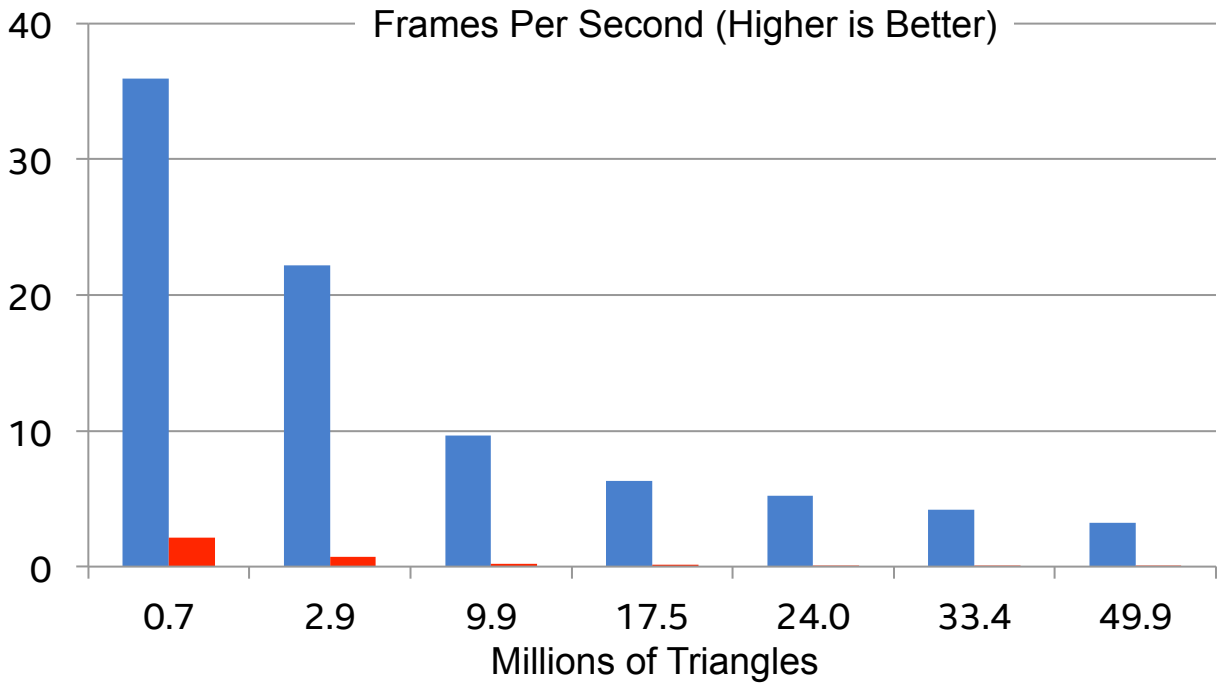
ParaView



- High performance open source software implementation of OpenGL*
  - Fully multi-threaded and vectorized for Intel® CPUs
  - Leverages community development effort (Mesa*)
- Drop in replacement for OpenGL* library
- Implements an increasing subset of OpenGL* as required by vis applications



OpenSWR Performance (Single Node, vs Mesa)



■ Intel® Xeon® E5-2687W v3
Intel Software Rasterizer 1.4
2 x 10 cores, 3.1 GHz

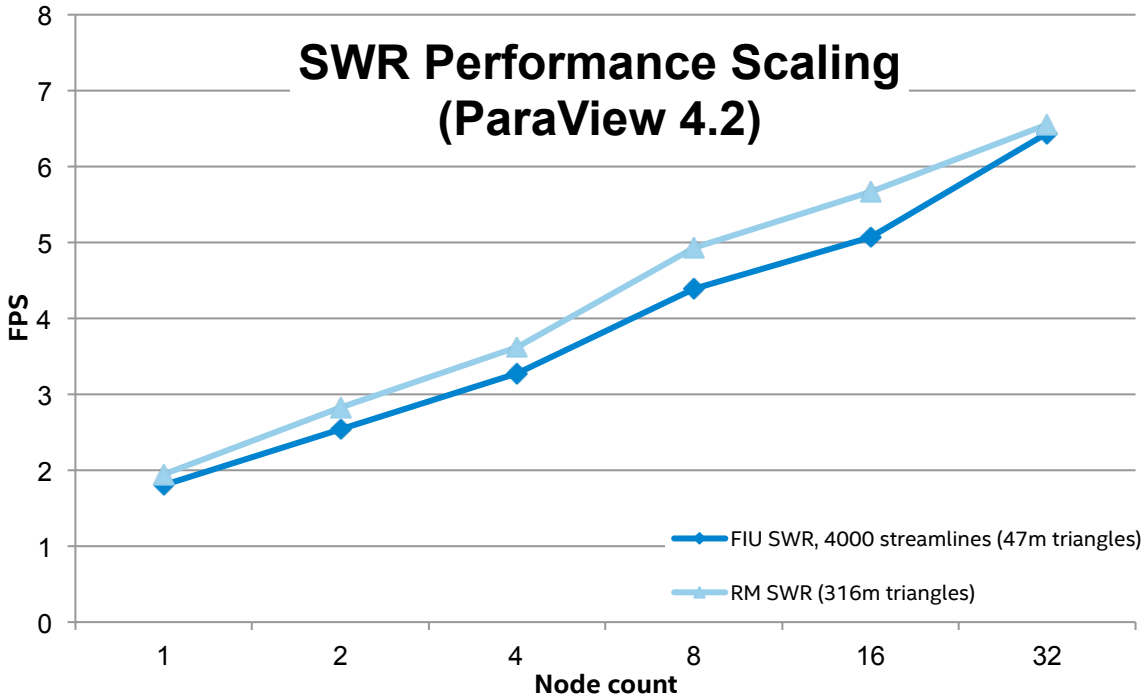
■ Intel® Xeon® E5-2687W v3
Mesa 10.2, Gallium-LLVMPipe
2 x 10 cores, 3.1 GHz

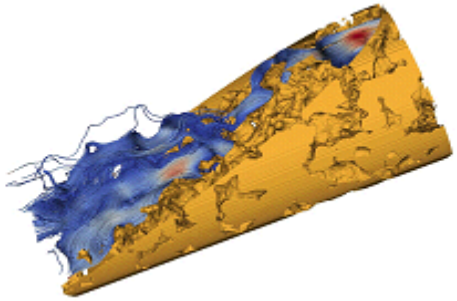
ParaView 4.1, Kitware build
OpenGL 1.4, Display Lists
Image Resolution: 1920 x 1080

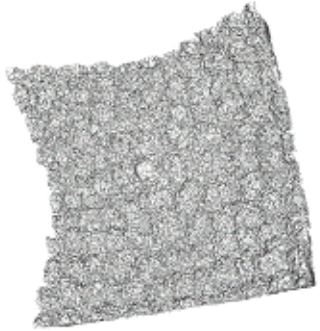
Source: Intel

Software and workloads used in performance tests may have been optimized for performance only on Intel microprocessors. Performance tests, such as SYSmark and MobileMark, are measured using specific computer systems, components, software, operations and functions. Any change to any of those factors may cause the results to vary. You should consult other information and performance tests to assist you in fully evaluating your contemplated purchases, including the performance of that product when combined with other products. For more information go to http://www.intel.com/performance.

OpenSWR Performance (Multi-node)







Results measured on TACC Stampede cluster (dual-socket Intel Xeon® E5-2680, 32GB per node, NVIDIA K20 discrete GPUs, 5GB) and based on internal Intel analysis.

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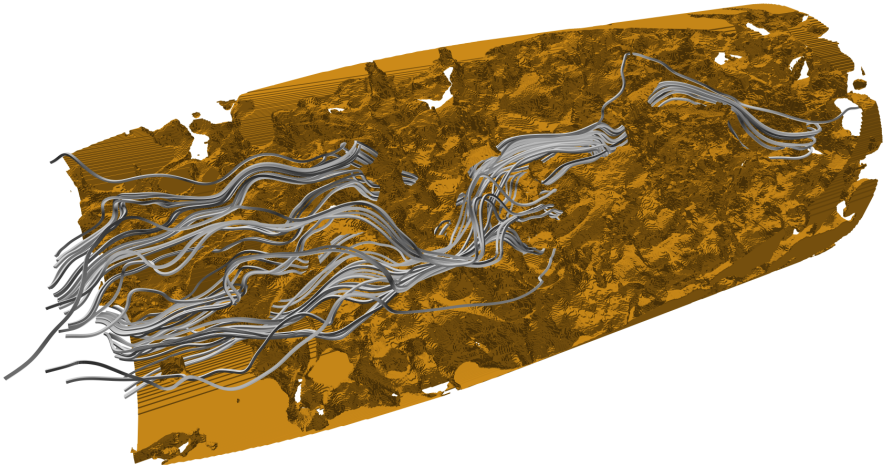
OpenSWR Software Rasterizer

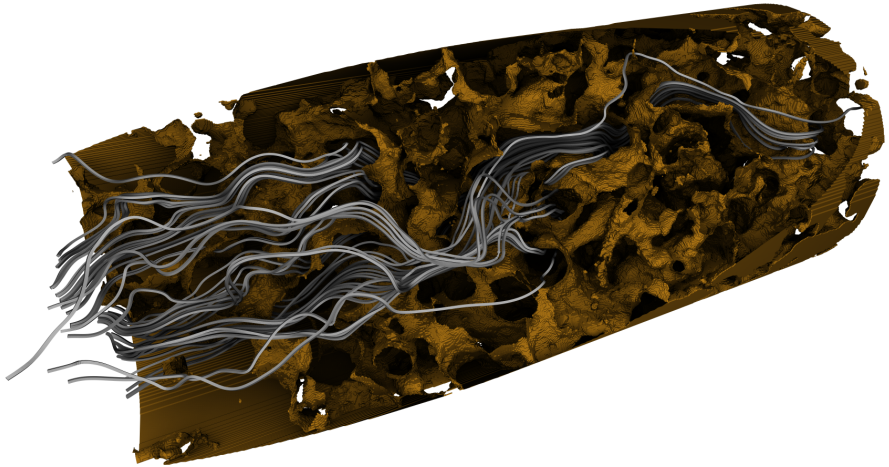
- Open source: Apache 2.0 license
- Alpha released in December 2014
  - Currently supports OpenGL* 1.4
  - OpenGL* 2.x support coming soon
- Current users:
  - TACC, Kitware, University of Tennessee
- Download at: http://www.openswr.org

OSPRay Ray Tracing Based Rendering Engine

- High performance, scalable open source rendering API
- Enables expanded functionality
  - Additional visual cues (shadows, ambient occlusion, etc.)



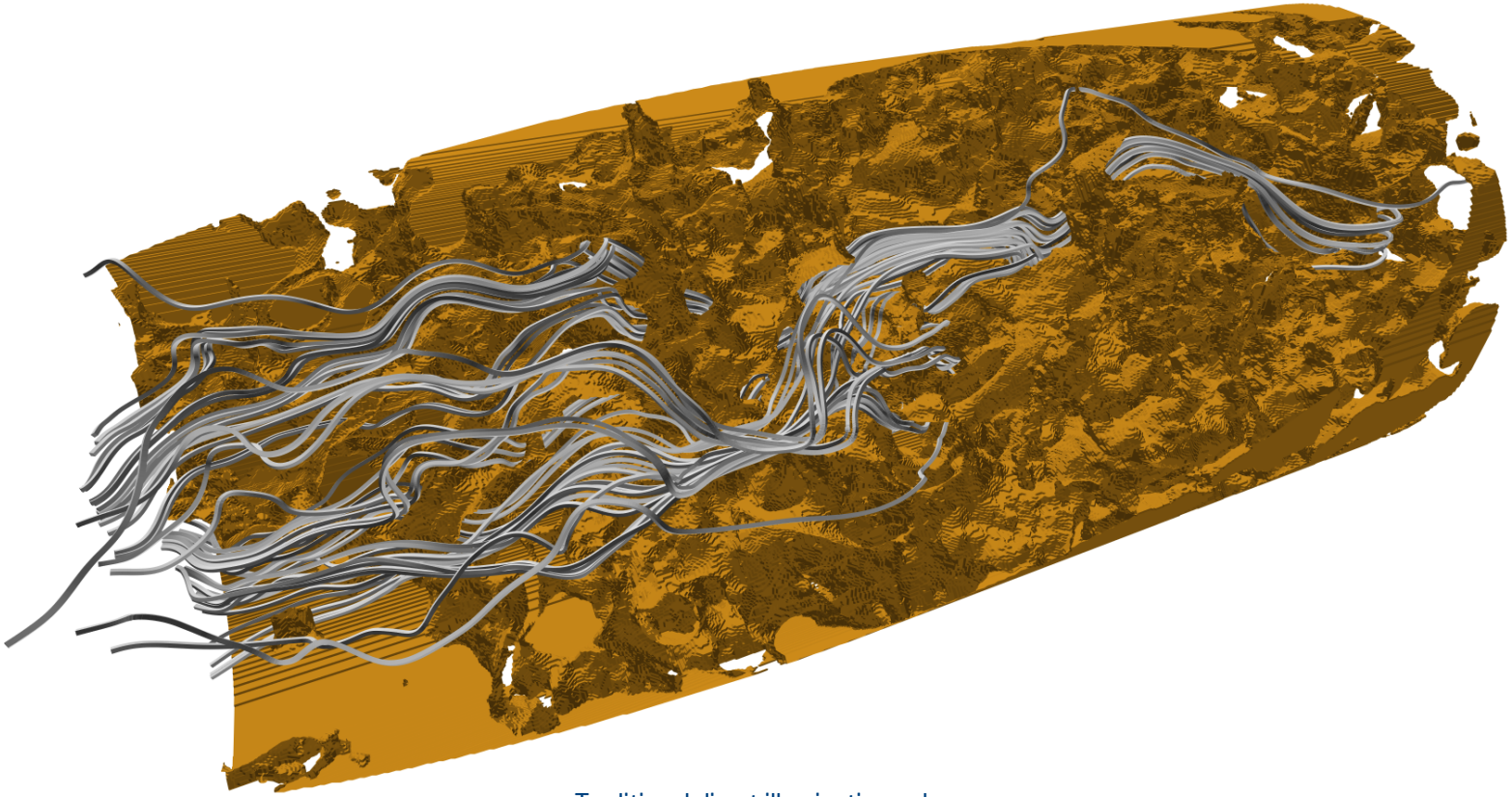
Traditional direct illumination only



With ambient occlusion

FIU Ground Water Flow data set courtesy of Florida International University and TACC.

OSPRay: Additional visual cues example



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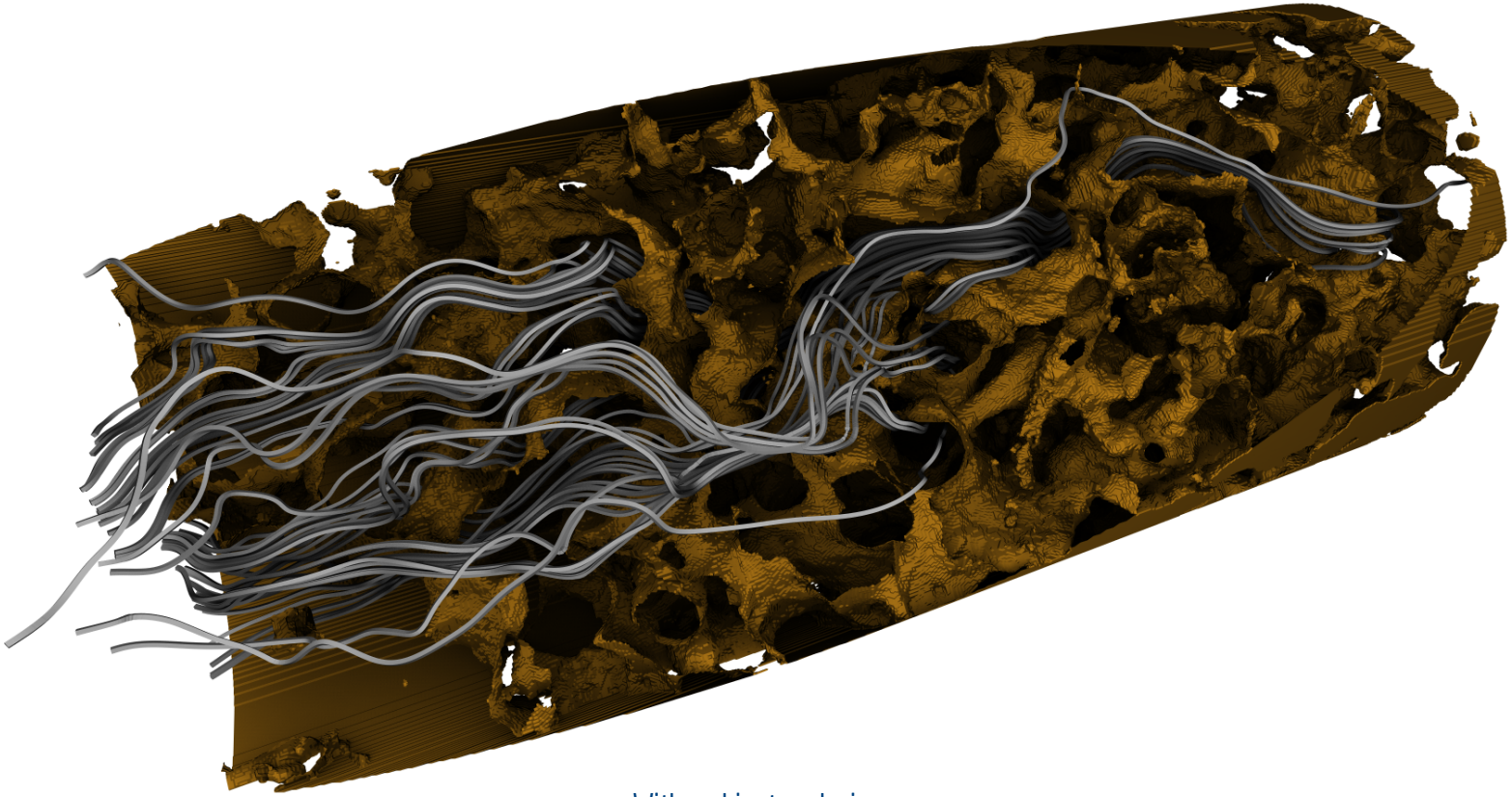
OSPRay: Additional visual cues example

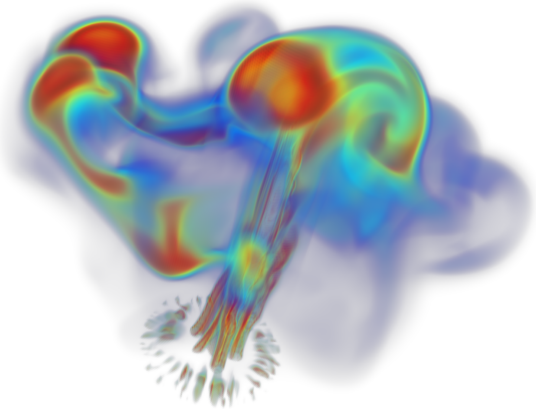


With ambient occlusion

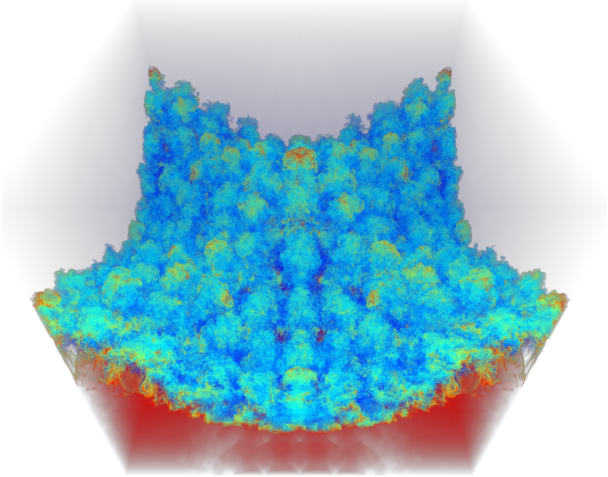
FIU Ground Water Flow data set courtesy of Florida International University and TACC.

OSPRay Ray Tracing Based Rendering Engine

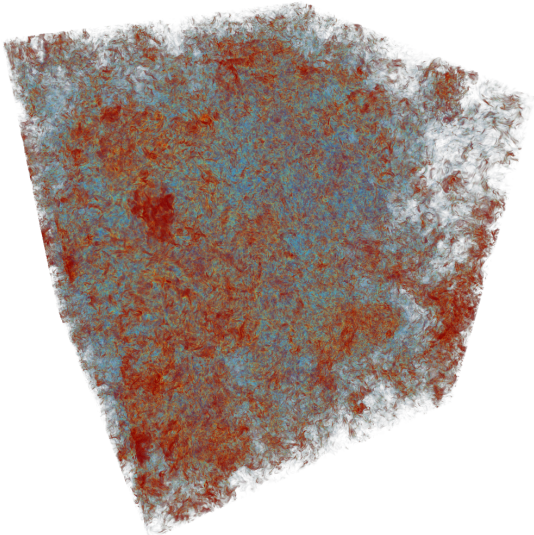
- High performance, scalable open source rendering API
- Enables expanded functionality
  - Volume rendering



Heptane volume (256^3). Data courtesy SCI Institute, University of Utah.



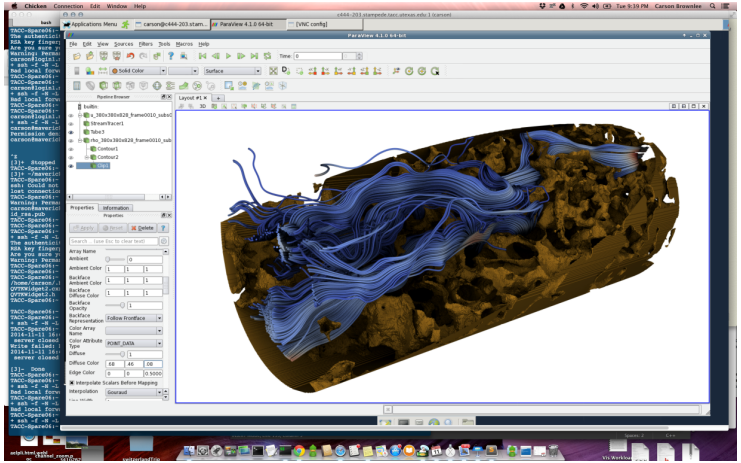
Richtmyer-Meshkov volume (2048^3 uint8, 8 GB). Data courtesy TACC.



Isotropic Turbulence volume (2048^3 float, 32 GB). Data courtesy TACC.

OSPRay Ray Tracing Based Rendering Engine

- Provides improved performance
  - Fully multi-threaded and vectorized for Intel® CPUs and Intel® Xeon Phi™ coprocessors
  - Data parallel (multi-node) rendering
- Integrating into select vis applications
  - VTK*
  - ParaView*
  - VisIt*



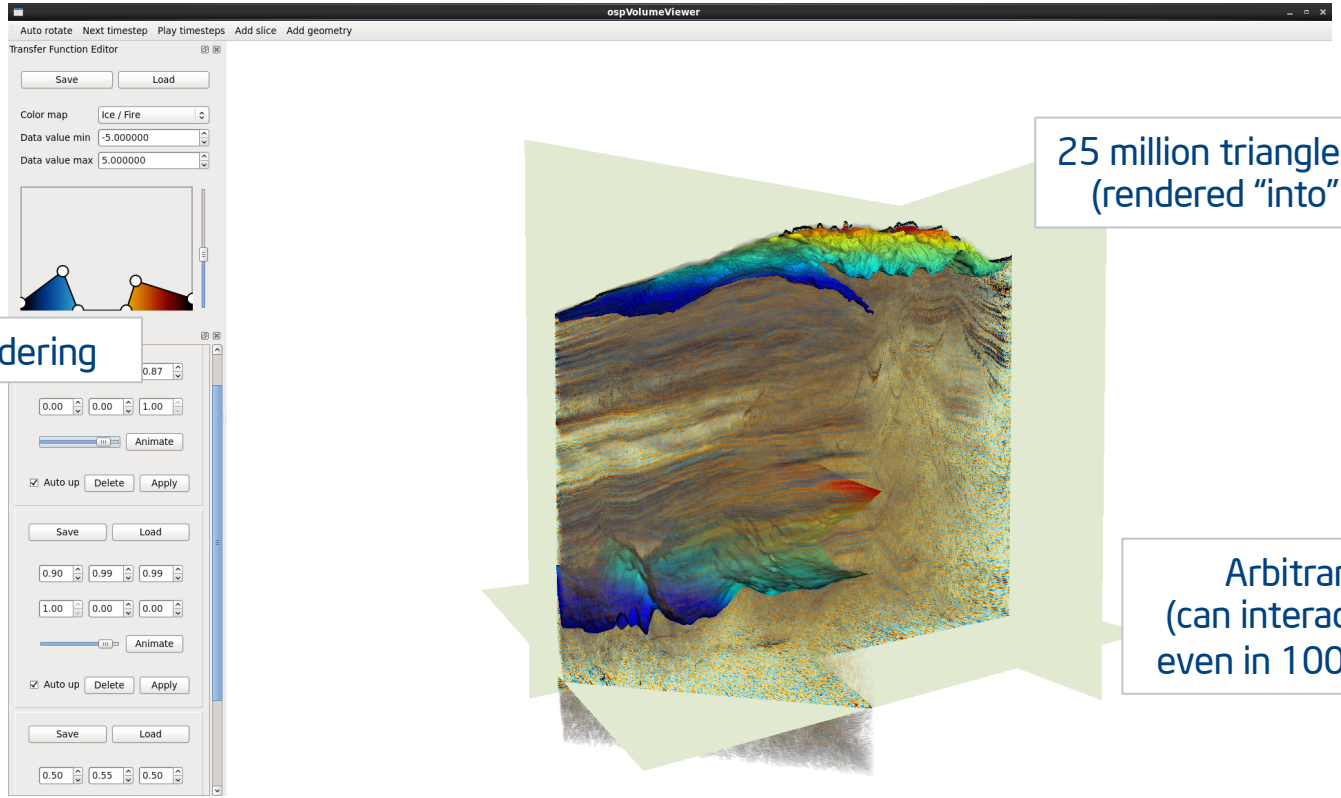
OSPRay Ray Tracing Based Rendering Engine

- Open source: Apache 2.0 license
- Alpha released in December 2014
- Current users: TACC, Kitware, University of Tennessee, University of Utah, SURVICE Engineering
- Download at: http://www.ospray.org

Applications to Oil & Gas Visualization

- Large data is a key challenge
  - Data sets often 100 GB to 1.5 TB in size (and beyond!)
  - Large data can be more difficult to visually interpret
- Existing vis tools often not well optimized
- By rendering on CPUs…
  - We have access to larger memory
  - Have access to additional rendering techniques
  - Can use HPC systems for visualization

OSPRay Demo Volume Viewer (animation)



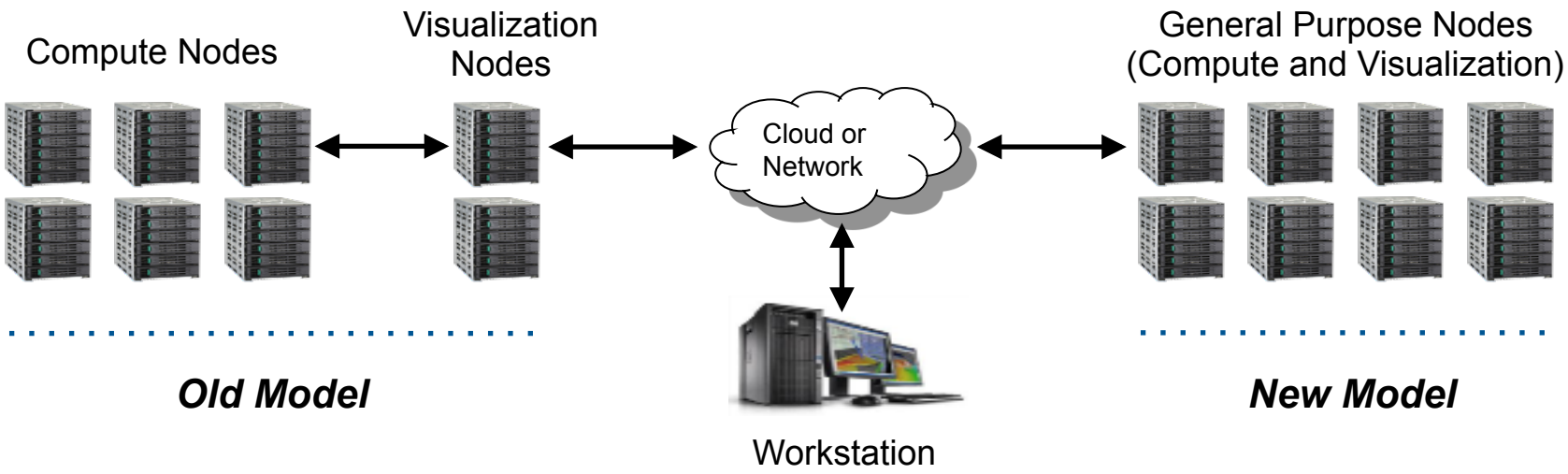
Volume rendering

25 million triangle "horizons" (rendered "into" volume)

Arbitrary slicing (can interactively move even in 100GB volumes)

Data: University of Texas at Austin, Bureau of Economic Geology

Summary: Software Defined Visualization



- OpenSWR (http://www.openswr.org)
- OSPRay (http://www.ospray.org)

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