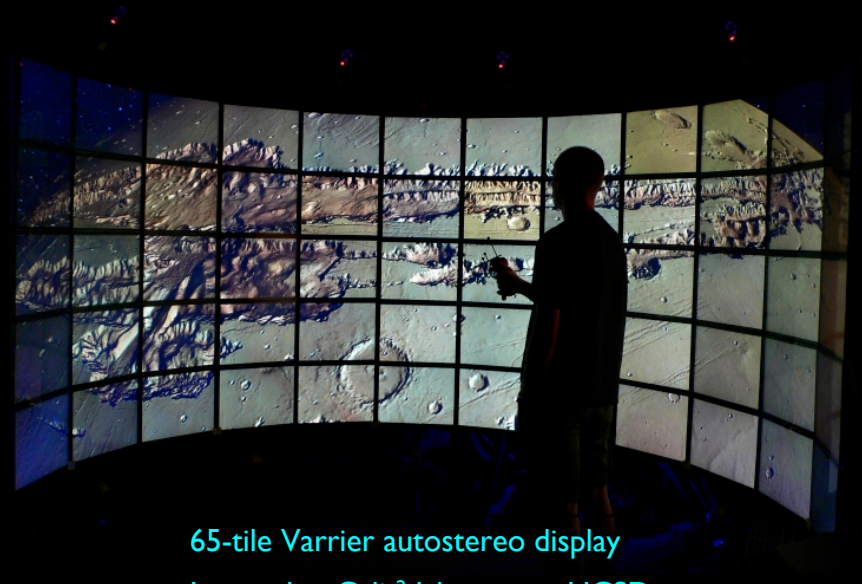
Argonne NATIONAL LABORATORY

... for a brighter future

Virtual Environments for Visualization



65-tile Varrier autostereo display

Located at Calit^2 laboratory, UCSD

Image courtesy Robert Kooima

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Mathematics and Computer Science Division

UltraVis
SciDAC Institute for Ultrascale Visualization

www.ultravis.org

U.S. Department of Energy

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Office of Science
U.S. DEPARTMENT OF ENERGY

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What This Talk is About

Some gentle persuasion and hopefully some information too

- Motivate:
  - -scale, complexity, interaction
- Dispel some myths:
  - -information bandwidth and expense
- Conclude that:
  - -we should be studying (and funding) new devices
- Review a case study:
  - -Peterka et. al SPIE SD&A 2009

But first, a definition. What is virtual reality, or a virtual environment?

Virtual world, immersion, sensory feedback, and interactivity
-Bill Sherman and Alan Craig, Understanding Virtual Reality

* PRESENCE *

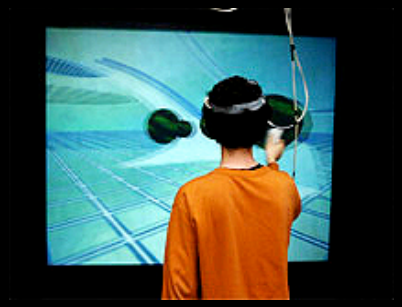
Definition by example: You know it when you see it

Be the data

Stereo

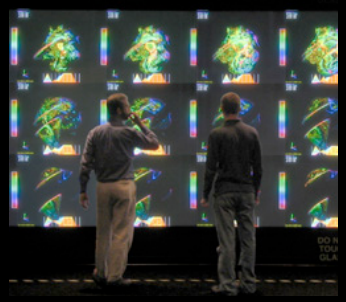
HMD

CAVE



GeoWall

Mono



Power Wall

Tiled Display

Autostereo

Varrier

Personal Varrier

Dynallax

Mythbusters 1

The devices we have are good enough.

Consider the following hypothetical scenario. In the next 5 years, a 10 PF supercomputer computing $10K^3$ dataset (1 trillion data elements) per time step. What does this mean at the end of the science pipeline?

Property	Future	Current
Data size	10 K ^3 (1 trillion elements / time step)	2K ^3 (4 billion elements / time step)
Image size	10 K ^2 (100 megapixels)	2K ^2 (4 megapixels)
Information bandwidth	400 MB x 60 Hz = 24 GB/s	16 MB x 60 Hz = 1 GB/s

Mythbusters 2

My brain is overloaded.

Resource	Human Capability	Current Device Capability
Spatial resolution	126 M receptors (equiv. 50 color Mpixel)	4 Mpixel
Field of view	180 degrees	60 degrees
Temporal resolution	80 Hz	60 Hz
Dynamic range	trillions of colors (16 bit color)	8 bit color
Image bandwidth	32 GB/s	1 GB/s

Above does not consider stereo. Human stereo acuity:
At 40cm, a depth of .12mm can be resolved.

Keys to success:

-Funding

-Show that increased information bandwidth leads to understanding

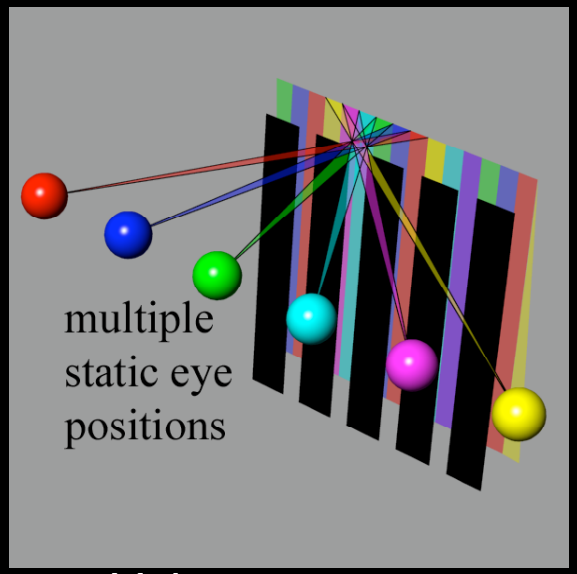
-Educate ourselves in human factors literature (IEEE VR, ACM SIGGCHI, Presence)

"Overload is a failure of design, not an attribute of information."

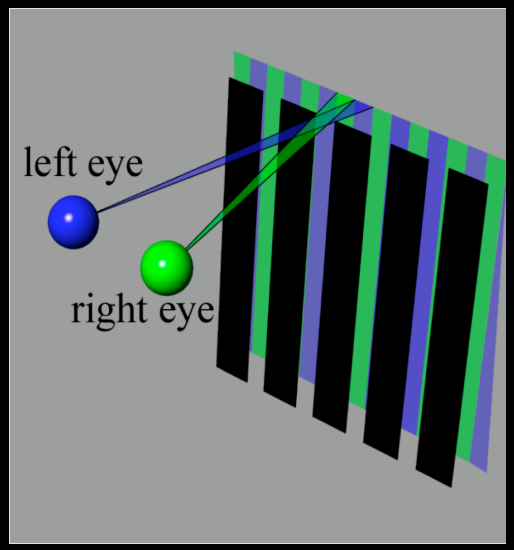
-Edward Tufte

Autostereo Primer

How do they do that?



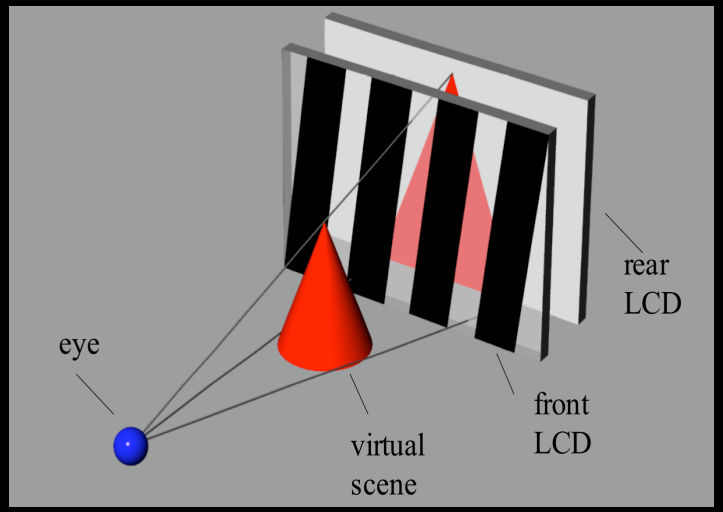
Multiview passive parallax barrier



2-view passive parallax barrier

Autostereo benefits

- More direct, human-like interface
- Less gear
- Easier to multiplex into other tasks



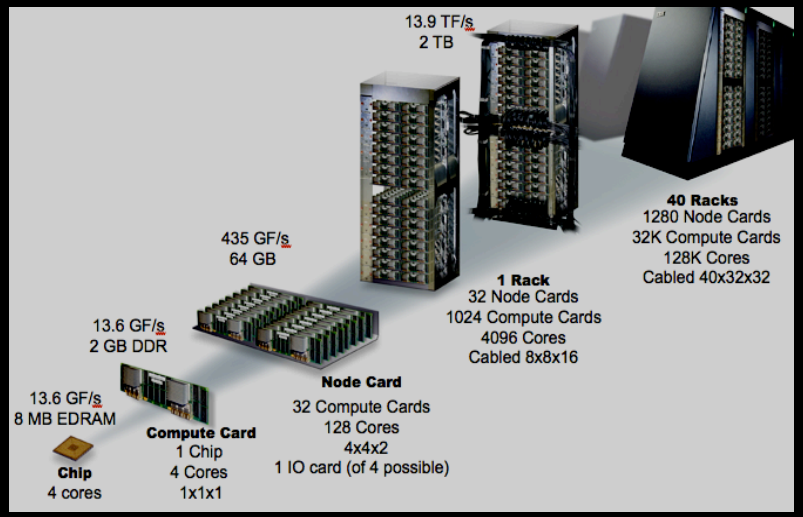
2-view active parallax barrier

Stereo benefits

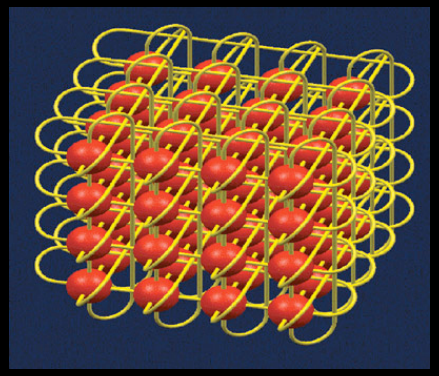
- Powerful depth cue, accurate depth measure
- Disambiguate nearby data
- Increase visual bandwidth
- Increase data density, prevent clutter

Leadership Computing to Autostereo Viewing

Back end: computation, communication, and storage

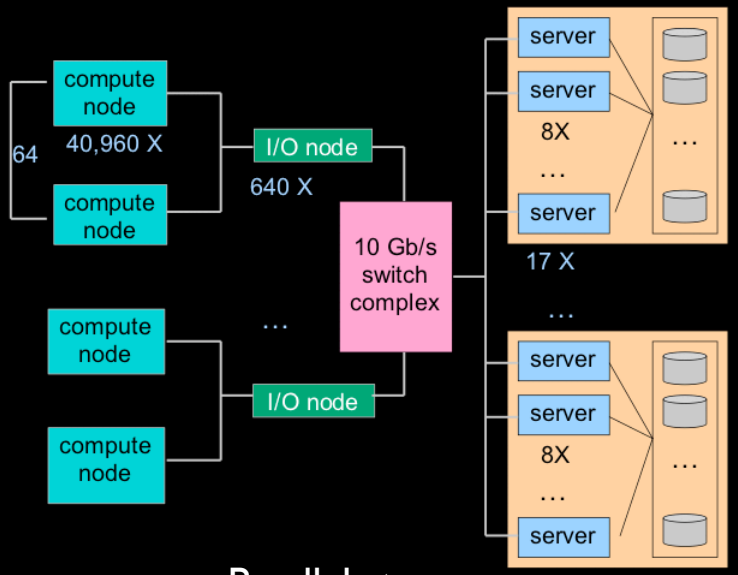


Scalable compute architecture



3D torus interconnect

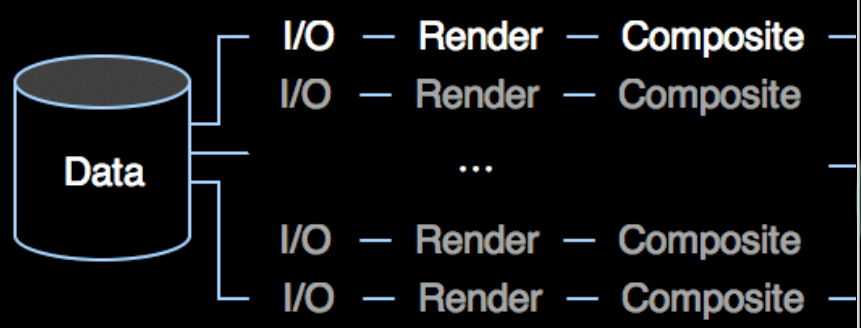
Argonne Leadership Computing Facility



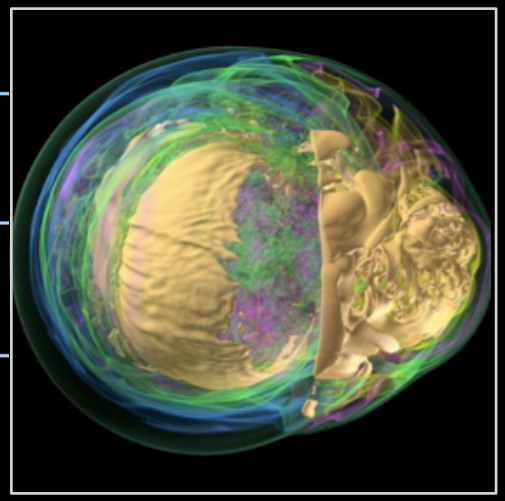
Parallel storage

Software: Parallel Volume Rendering

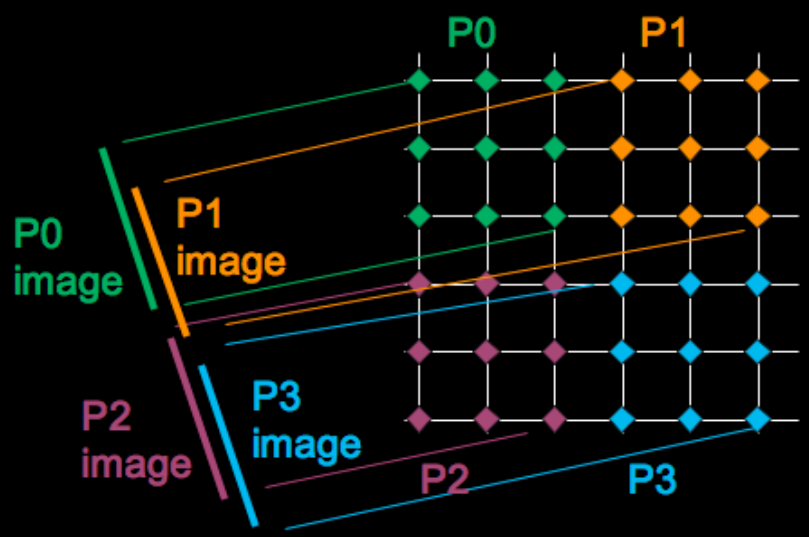
Divide, conquer, reunite



Parallel structure



Entropy in core collapse supernova



Sort last rendering

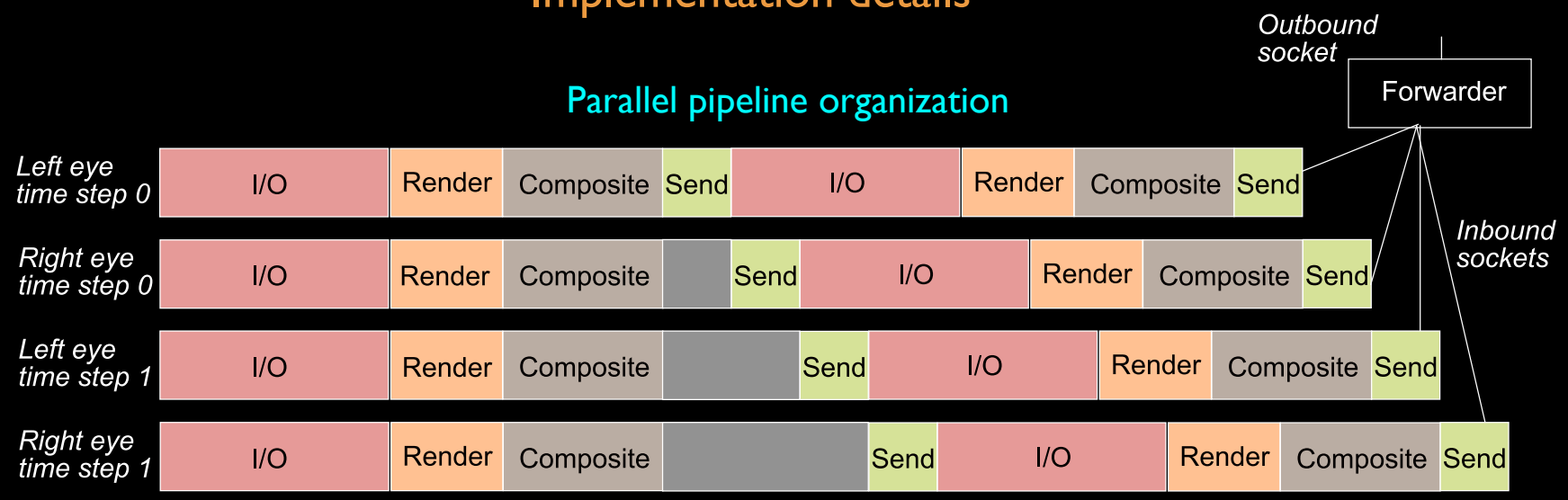
Core collapse supernova shock wave simulation, on a structured grid of 864^3 data elements.

Data courtesy of John Blondin (NCSU) and Tony Mezzacappa (ORNL)

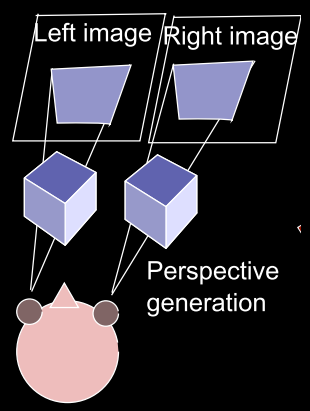
Parallel Volume Rendering in Stereo

Implementation details

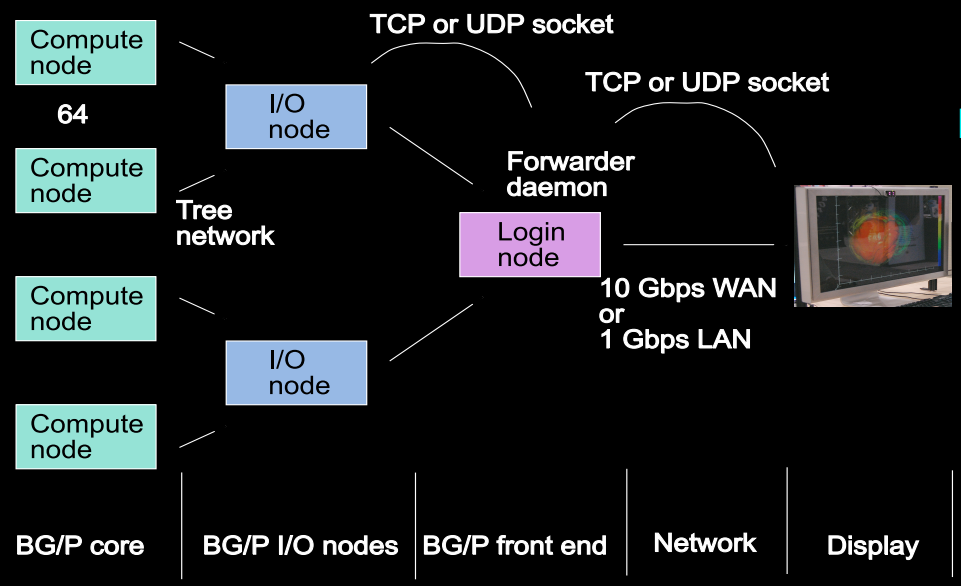
Parallel pipeline organization



Perspective ray casting



Data path



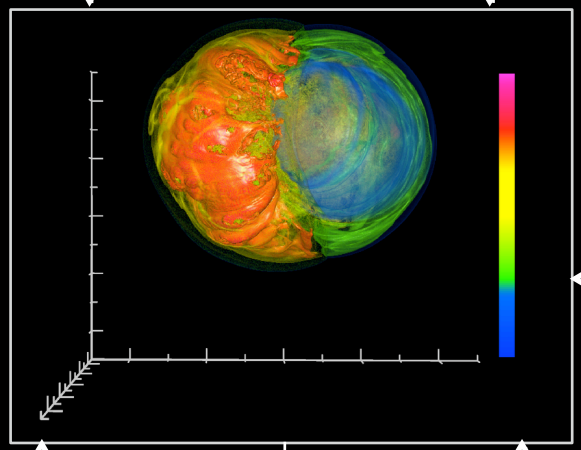
Dynamic View Client (dvc)

A lightweight library to support VR applications

Over-under stereo image

Left image header	12 bytes
Left image pixels Rows 0-799 of total	800^2 * 3 bytes
Right image header	12 bytes
Right image pixels Rows 800-1599 of total	800^2 * 3 bytes

Display



System config

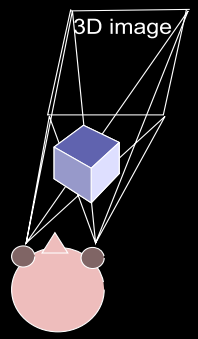
```
Barrier = "passive"
Screens = { 2560, 1600, 0, 0,
533.407, 8.306, .0075,   0.00240, .75, }
Corners = { -1.0521,   2.8136,  -1.8,
 2.1042,   0.0,   0.0,    0.0,   1.3177,
 0.0, }
…
```

App config

```
TexturePolygon = { 1200, 1200, 680, 0, }
ReceivePort = 5052
RemoteControl = "n"
…
```

Dvc lib

- -GPU image interleaving
- -Head tracking
- -Navigation, interaction
- -Tiling, synchronization
- -Streaming
- -Stand alone / cluster



Small OpenGL program

```
int main(int argc, char* argv[]) {
  dvc_run(argc, argv, &init_scene, &draw_scene);
}
…
```

Interaction

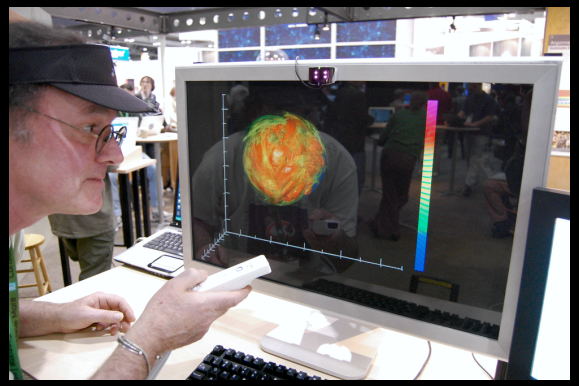
Head tracking, navigation, work environments

Scientist workstation

Direct interaction

Common / demo space

Tetherless face tracking



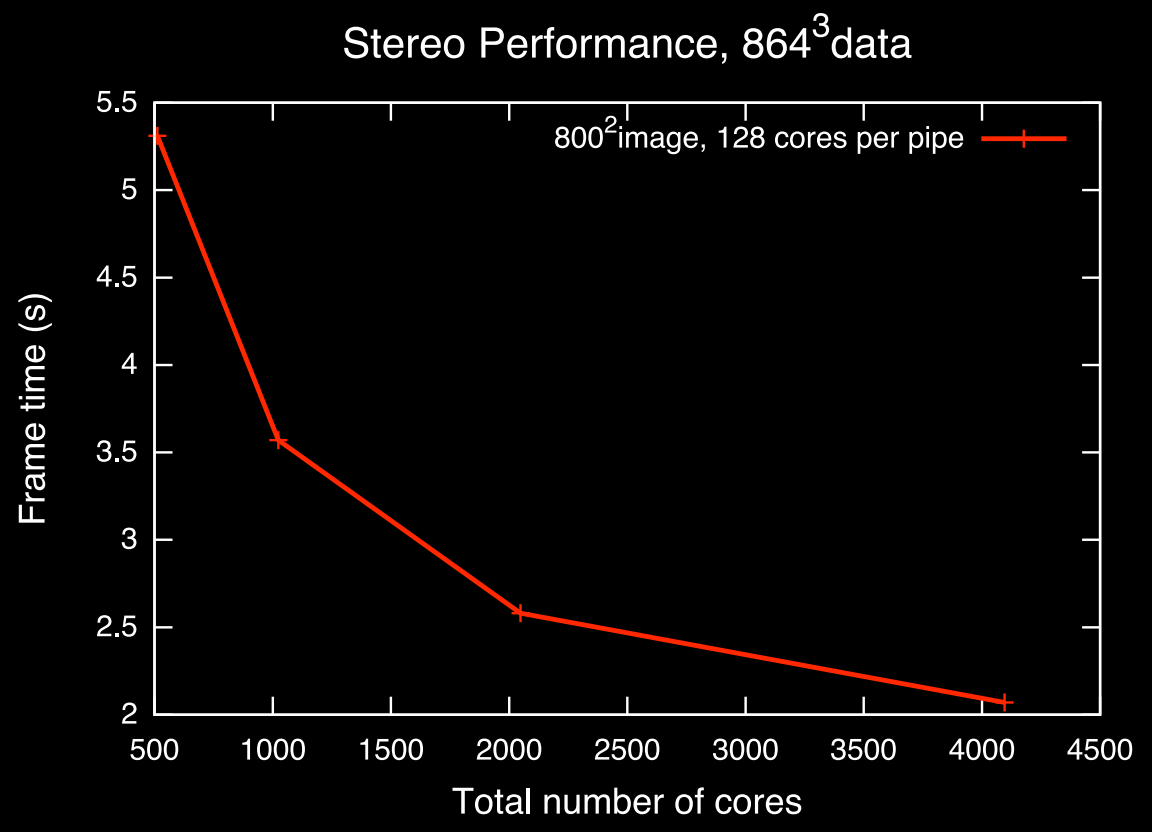
SC08 show floor

Successes

Lessons learned and the road ahead

Successes

- end-end modest scale functionality
- 3 hr demo: volume rendered 3600 time steps, 8.6 terabytes of data
- supercomputer back end - autostereo front end
- client-side interaction



Challenges, to do

- server side interaction
- improve performance
- quantify perception
- integrate other vis sources

Initial reactions

- Fabulous! (Tony Mezzacappa)
- More subdued reactions as well

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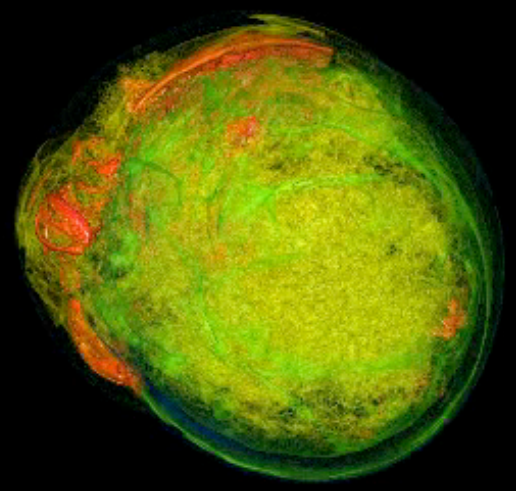

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