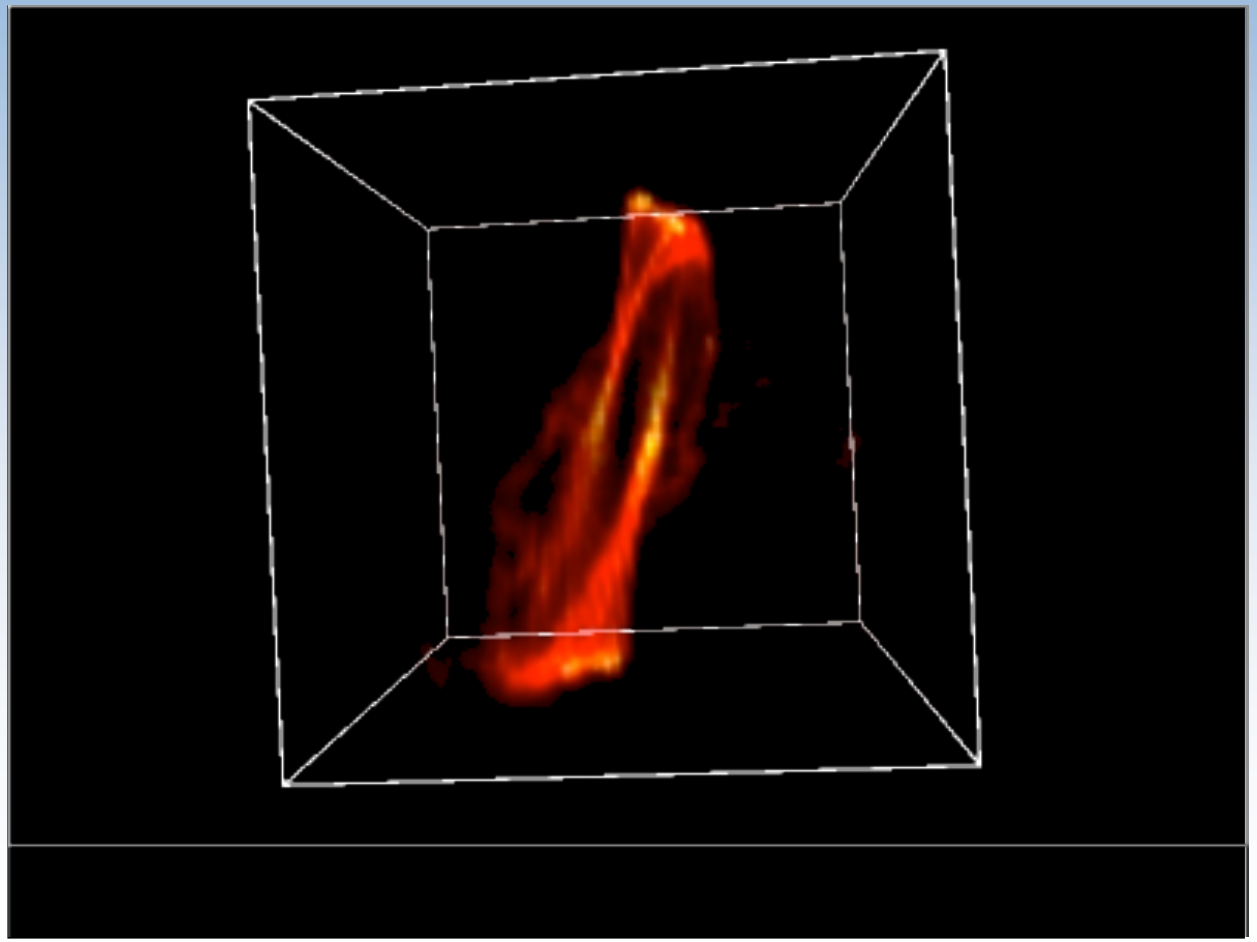
3D Visualization



THINGS datacubes courtesy Erwin De Blok

Christopher Fluke

& David Barnes

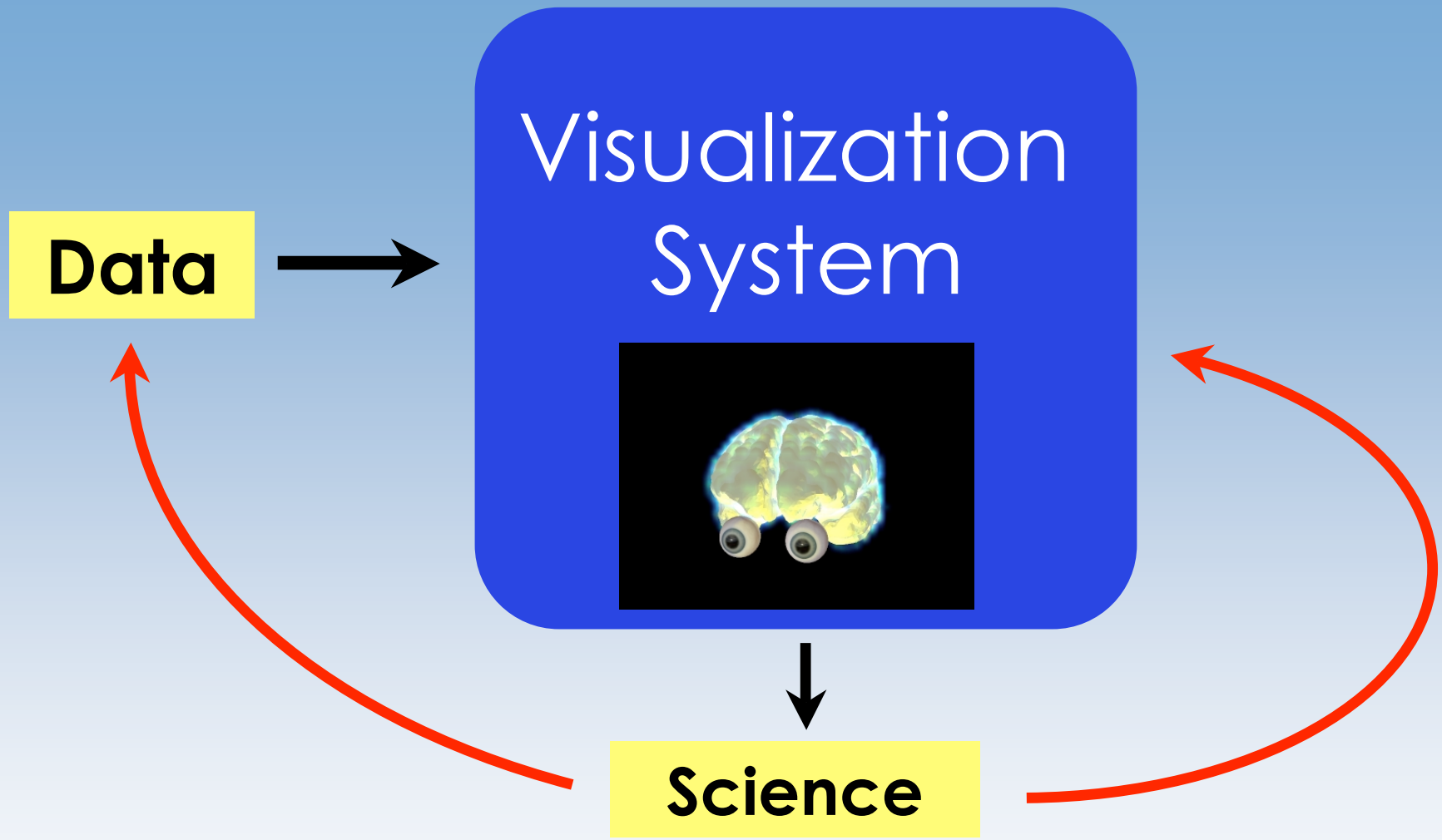
SWINBURNE

CENTRE FOR ASTROPHYSICS AND SUPERCOMPUTING

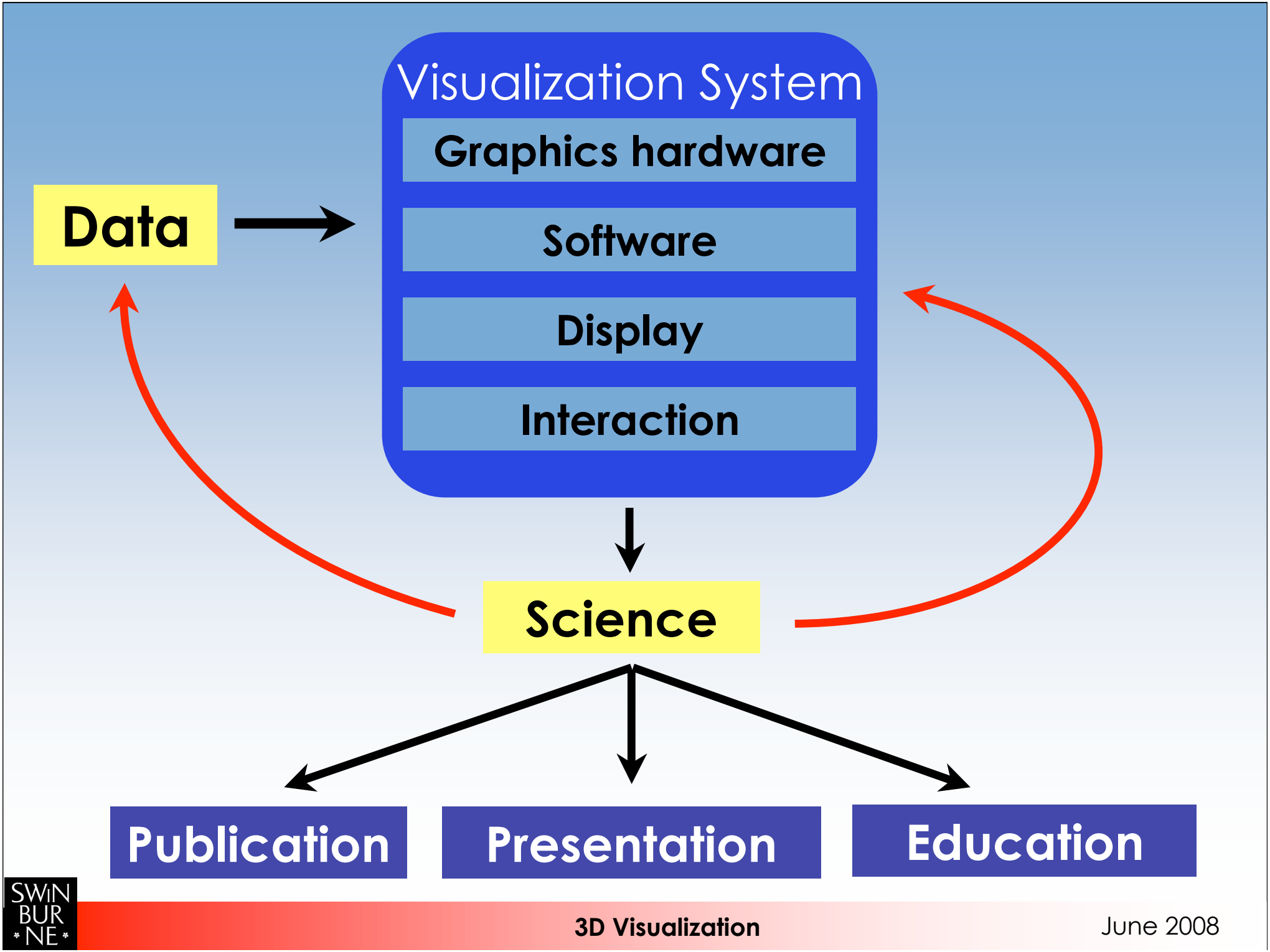
Gas and Stars in Galaxies
A Multi-Wavelength
3D Perspective

Astronomy Datasets

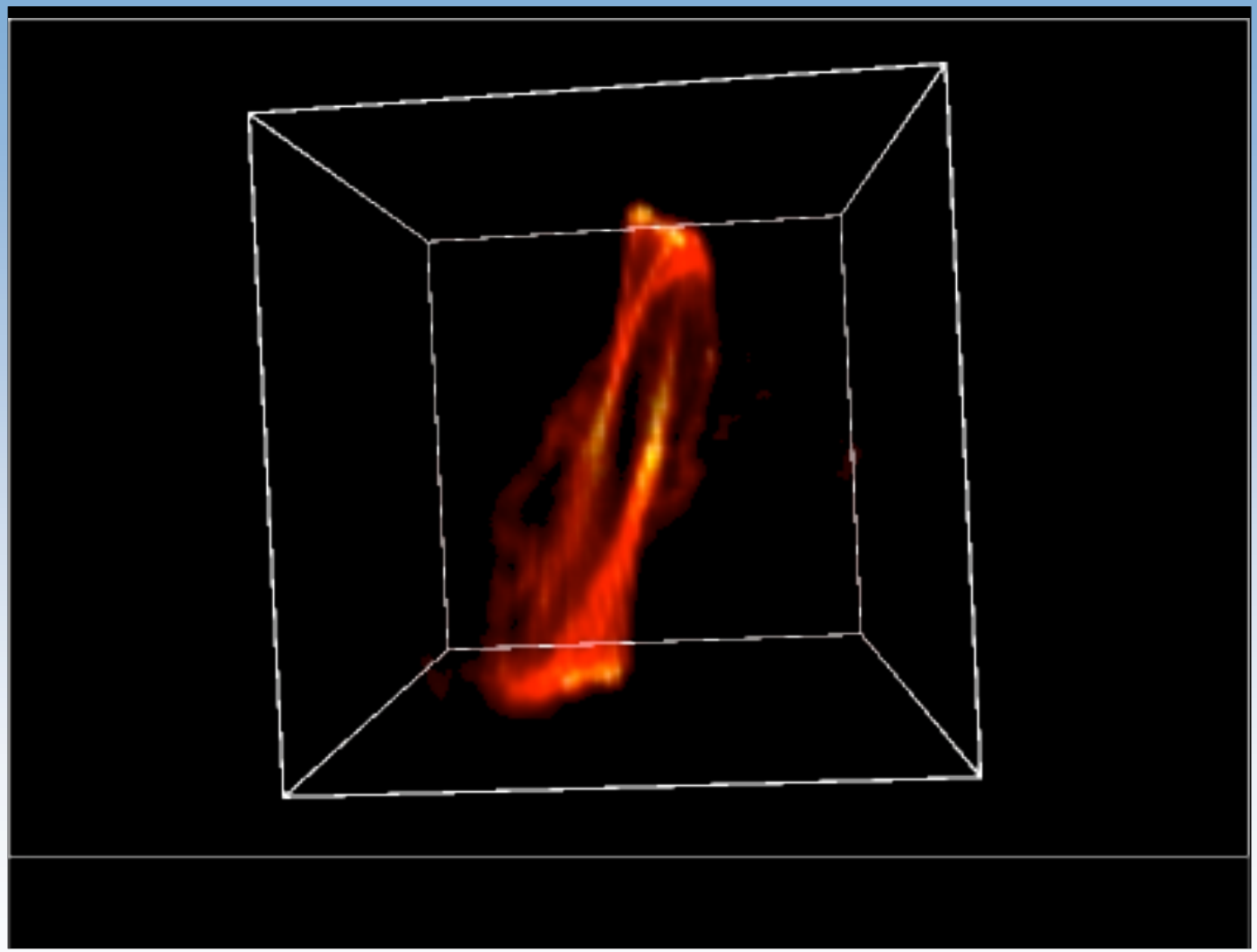
- Increasingly multi-dimensional (N ≥ 3)
  - e.g. Spectral data cubes, N-body simulations
- Increasingly multi-wavelength
  - e.g. THINGS, NUGA, VO
- Include gridded and non-gridded data
- 3D visualization: opportunity to maximize scientific return from data



Data visualization: planning, data collection, reduction, comprehension, presentation


Visualization System
Graphics hardware
Software
Display
Interaction
Data
Science
Publication
Presentation
Education

How to interpret complex structures?



THINGS datacube; S2PLOT visualization

Moment maps | Slices | Isosurfaces | Volume rendering

Commercial

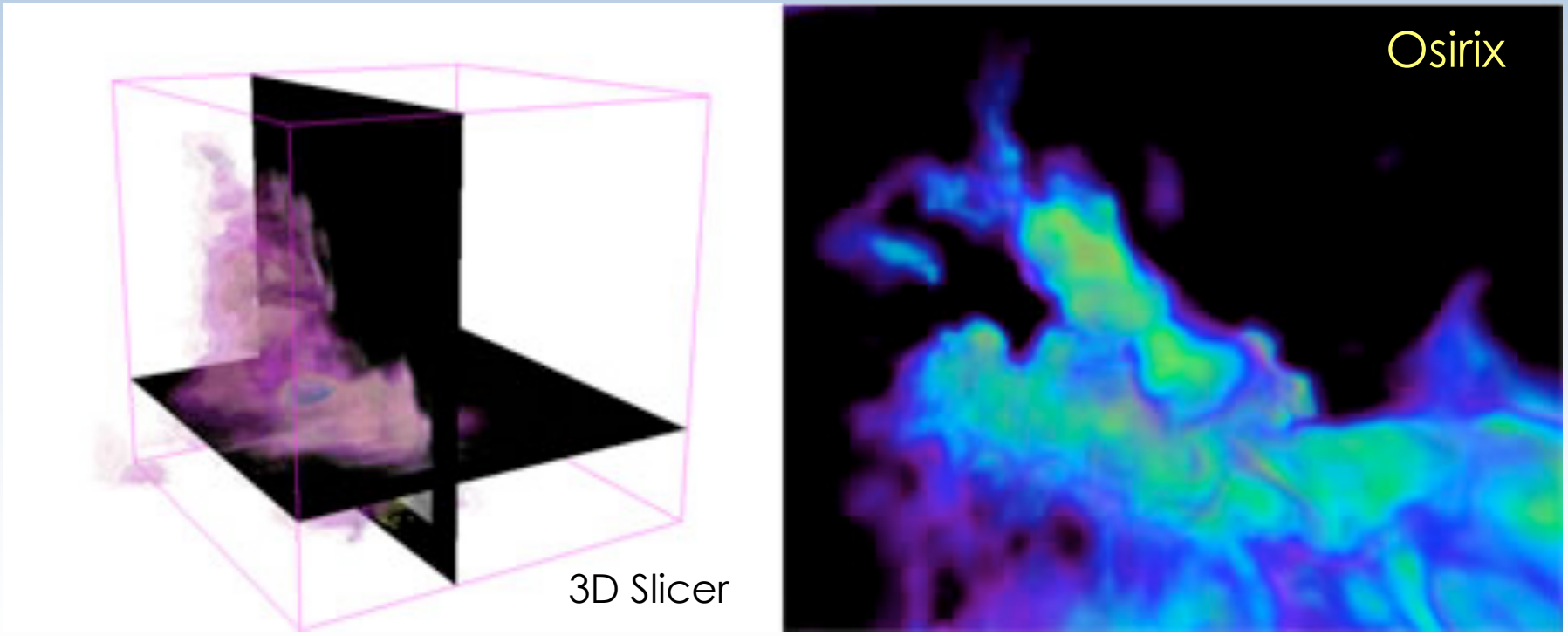
E.g. IDL, AVS/Express, IRIS Explorer

– Lots of functionality vs. costly licenses?

Open Source

E.g. Paraview, VisIt, Drishti

– Lots of functionality, free vs. not designed for astronomy tasks?



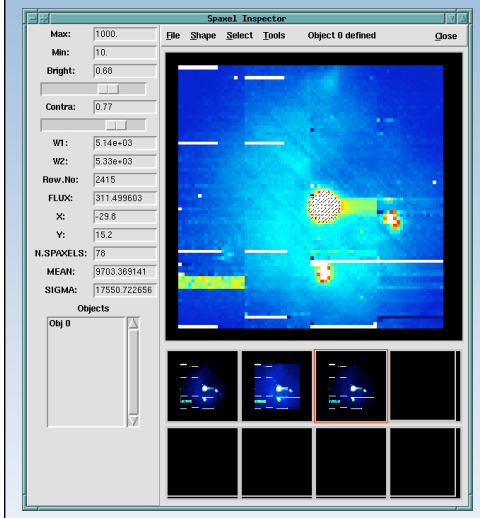
3D Slicer

Astronomical Medicine Project (e.g. Borkin et al. 2007, AAS)

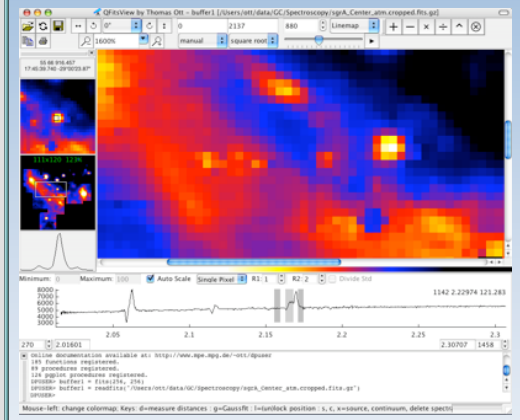
Astronomy packages

E3D, QFITSView, VisIVO, Karma, Gaia, TIPSY, SPLASH, ...

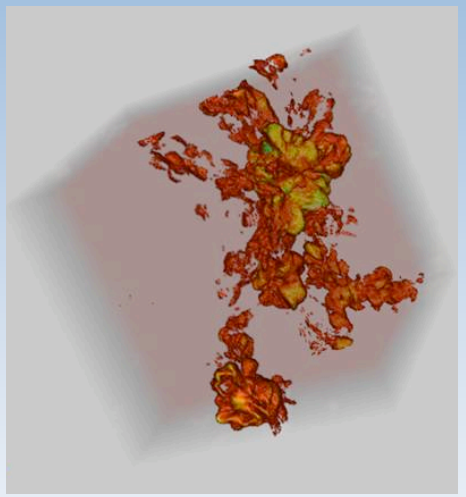
- Do one job and do it well
- Flexibility? Platforms supported? Display types supported?



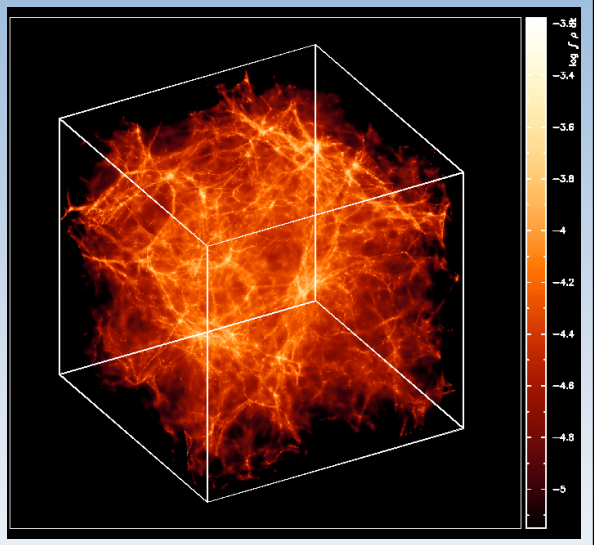
E3D



QFITSView



VisIVO



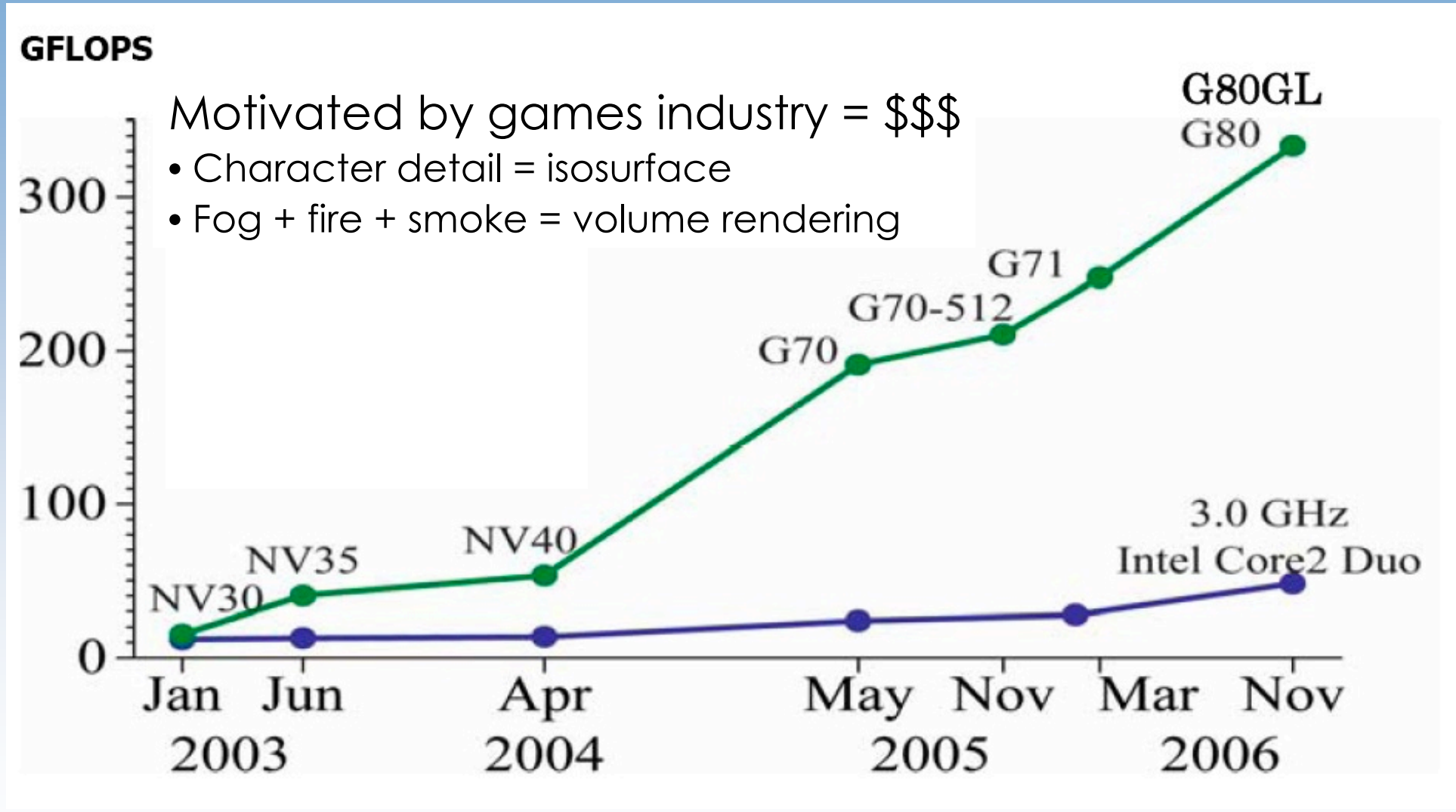
Splash

Custom Code

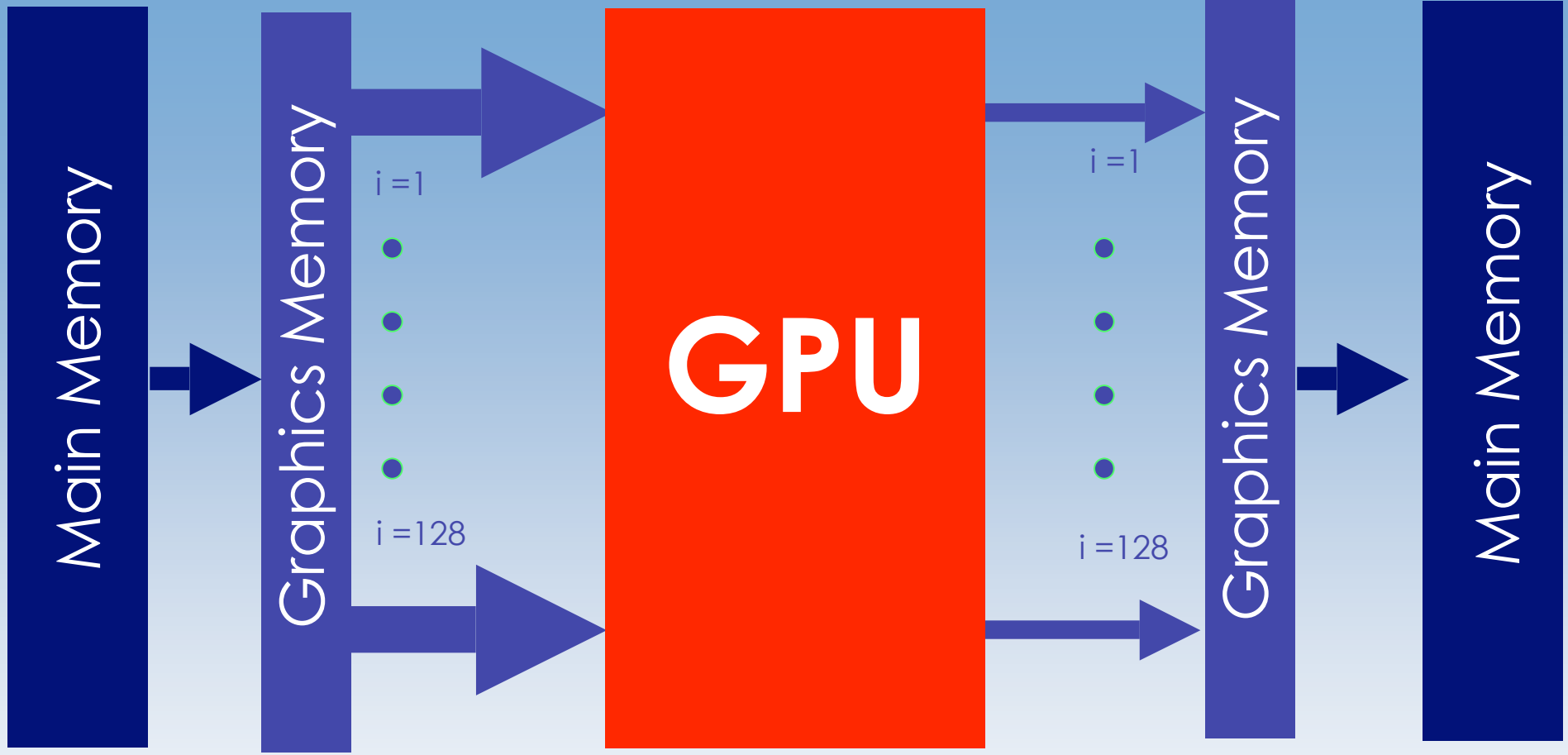
VTK, OpenGL, PGPLOT, S2PLOT

- Do anything you want!
- Need to write your own software

Graphics Processing Units (GPUs)



Floating-Point Operations per Second for the CPU and GPU
NVIDIA CUDA Programming Guide V1.0 (2007)



- Parallel stream processor
- Fills pixels in parallel
- Great for rendering large datasets
- Programmable (e.g. CUDA "C-Programming")

Real-time 3D texture volume rendering

NVIDIA GeForce 9600 GT

GPU Memory: 1 GB

512 px x 512 px texture = 1 MB/texture

512 textures = 512 MB

Memory bandwidth: 60 GB/sec

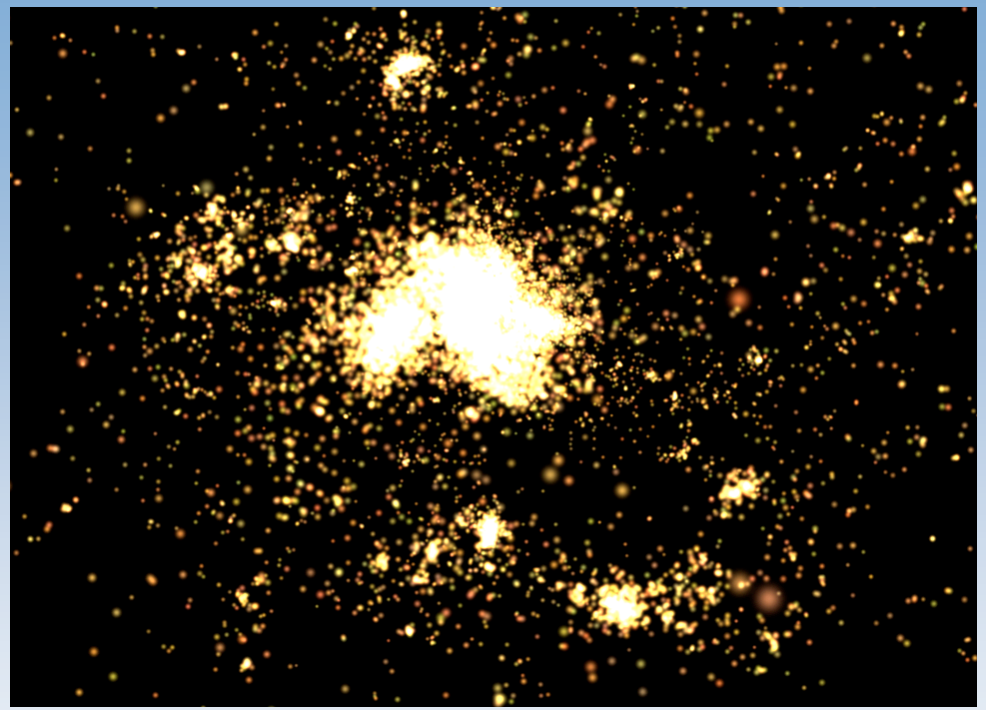
Real-time stereo: 25 fps * 2 eyes = 50 fps

M_{bw} = 1 MB/texture * 512 textures * 50 fps = 26 GB/s

Pixel fill rate: 20 Gpix/sec

R_{pix} = 50 fps * 512^2 pixels * 512 textures = 6.4 Gpix/s

Real-time N-body + visualization



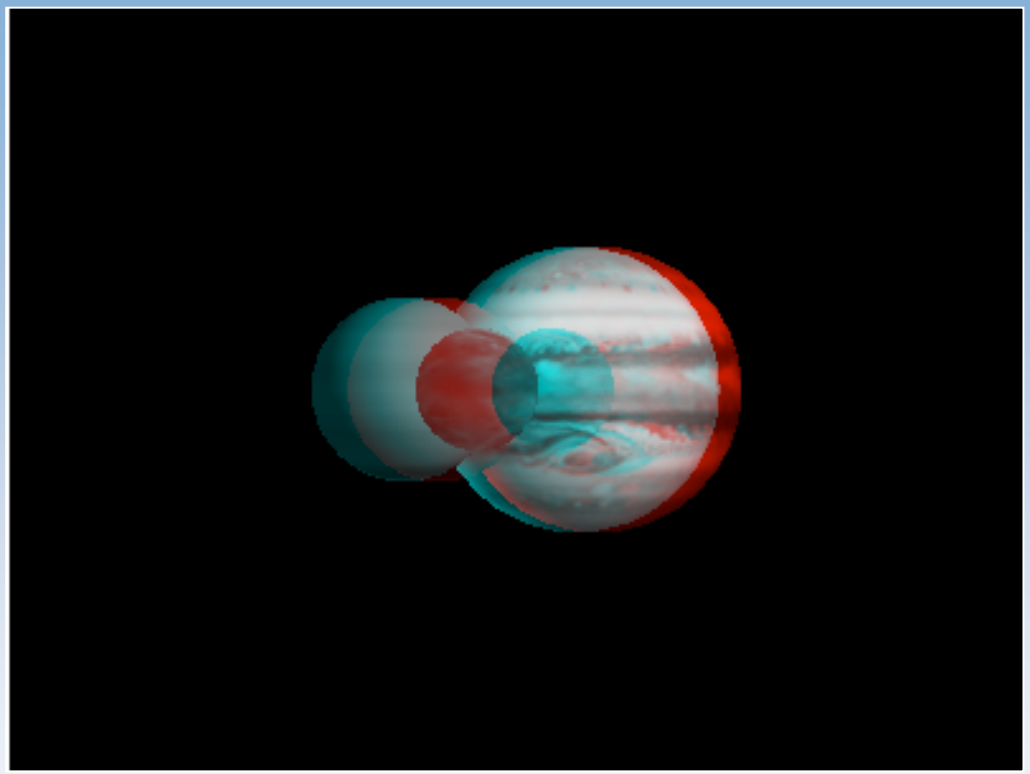
Nyland et al. 2008, GPU Gems 3, NVIDIA

- 16,384 particles on NVIDIA GeForce 8800 GTX GPU
- Sustained performance of 200 gigaflops

See also:

- Hamada & Itaka, 2007, arXiv:astro-ph/0703100
- Portegies Zwart et al. 2007, NA, 12, 641

I can't see (3D) without my glasses

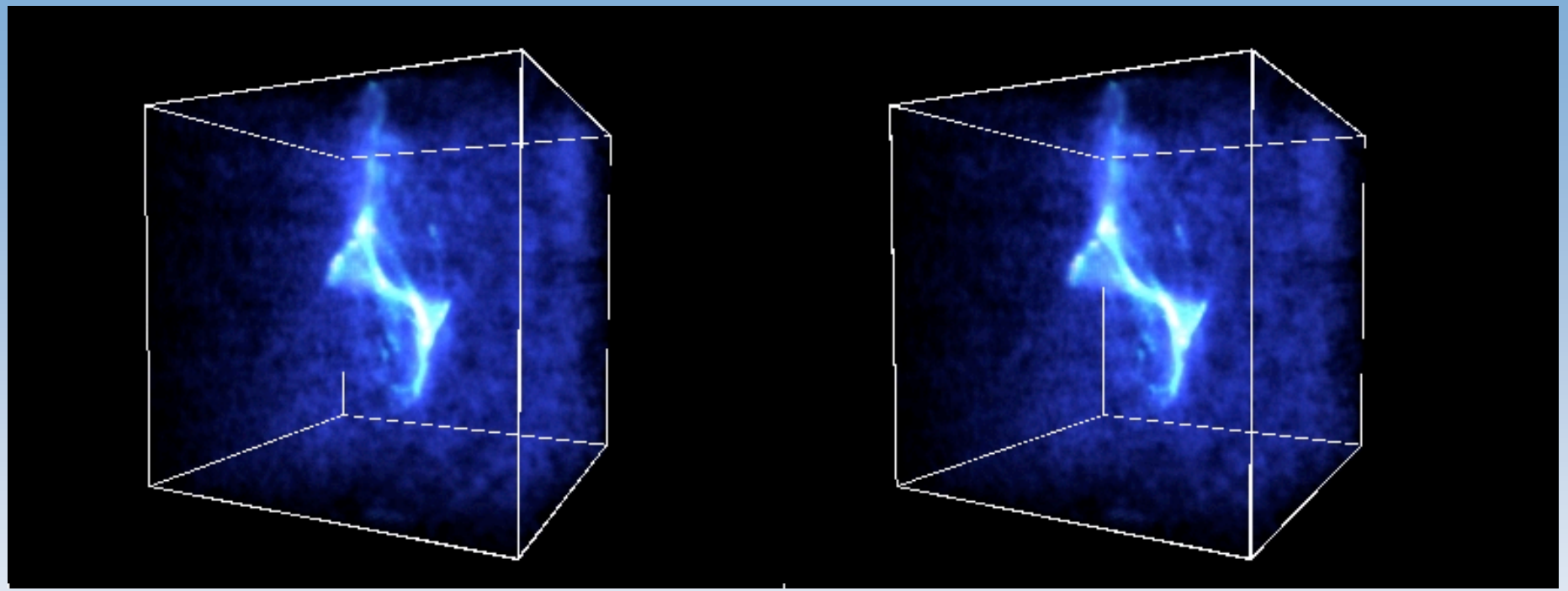


Left Eye **Right Eye**

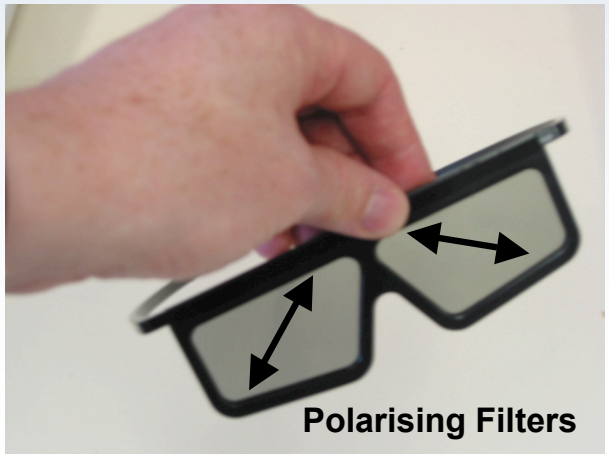
Anaglyph

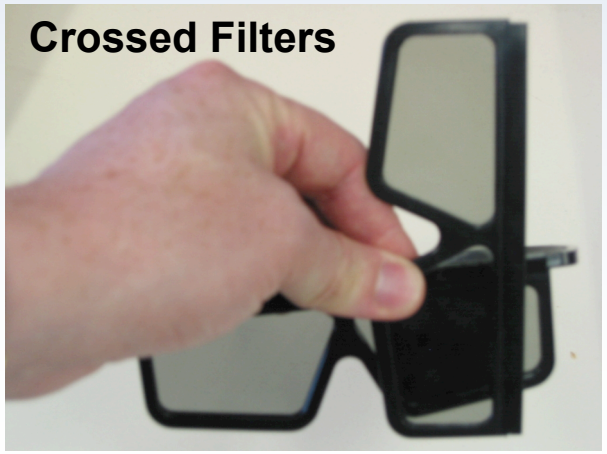
See Fluke et al. (2006)

I can't see (3D) without my glasses

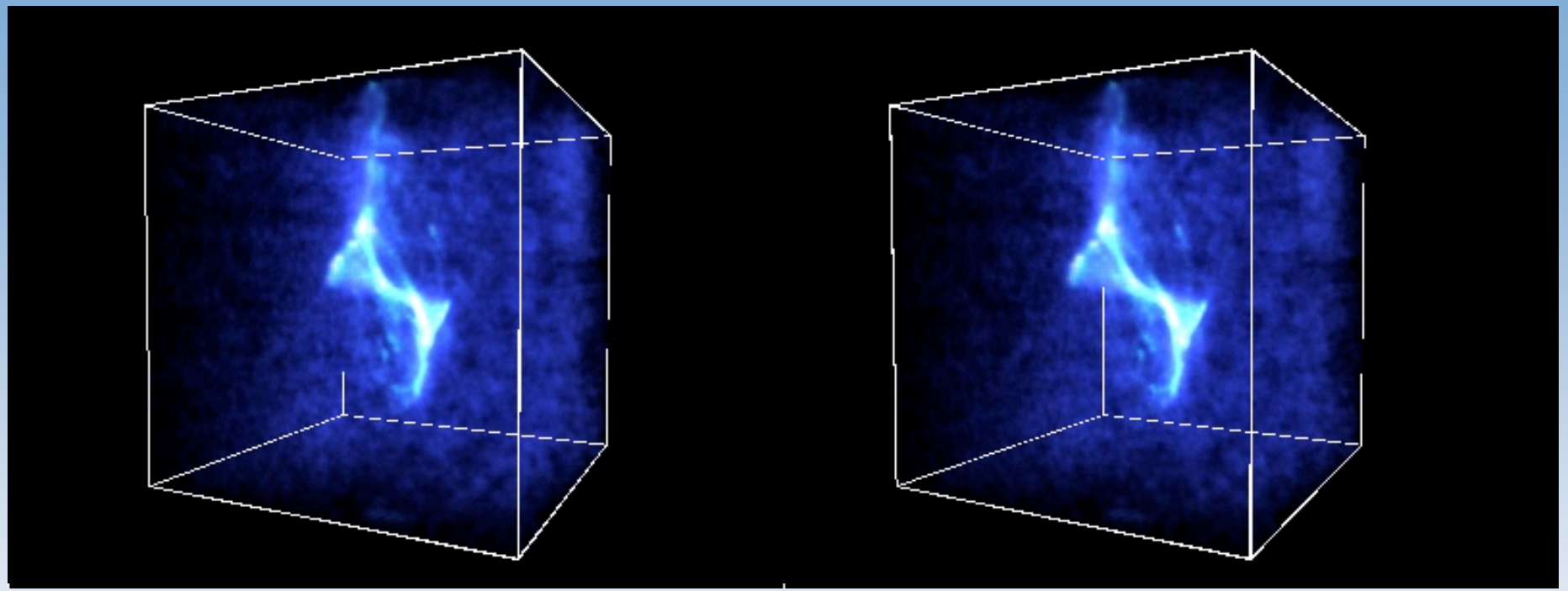


Left Eye Passive polarizing glasses **Right Eye**



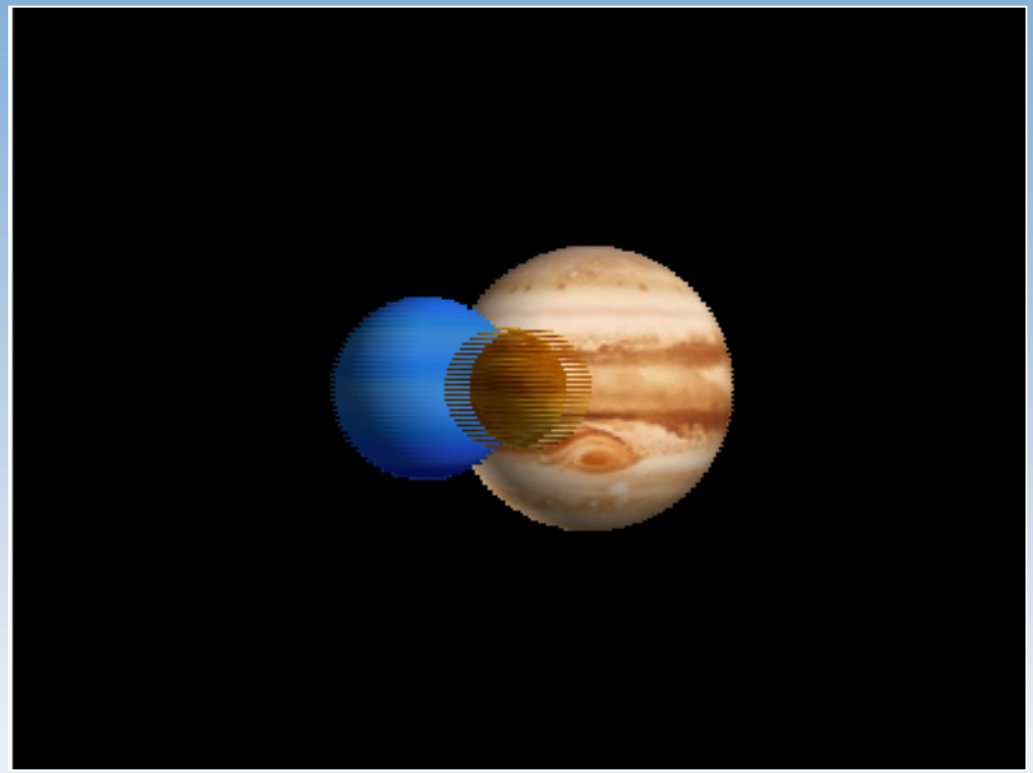


I can't see (3D) without my glasses



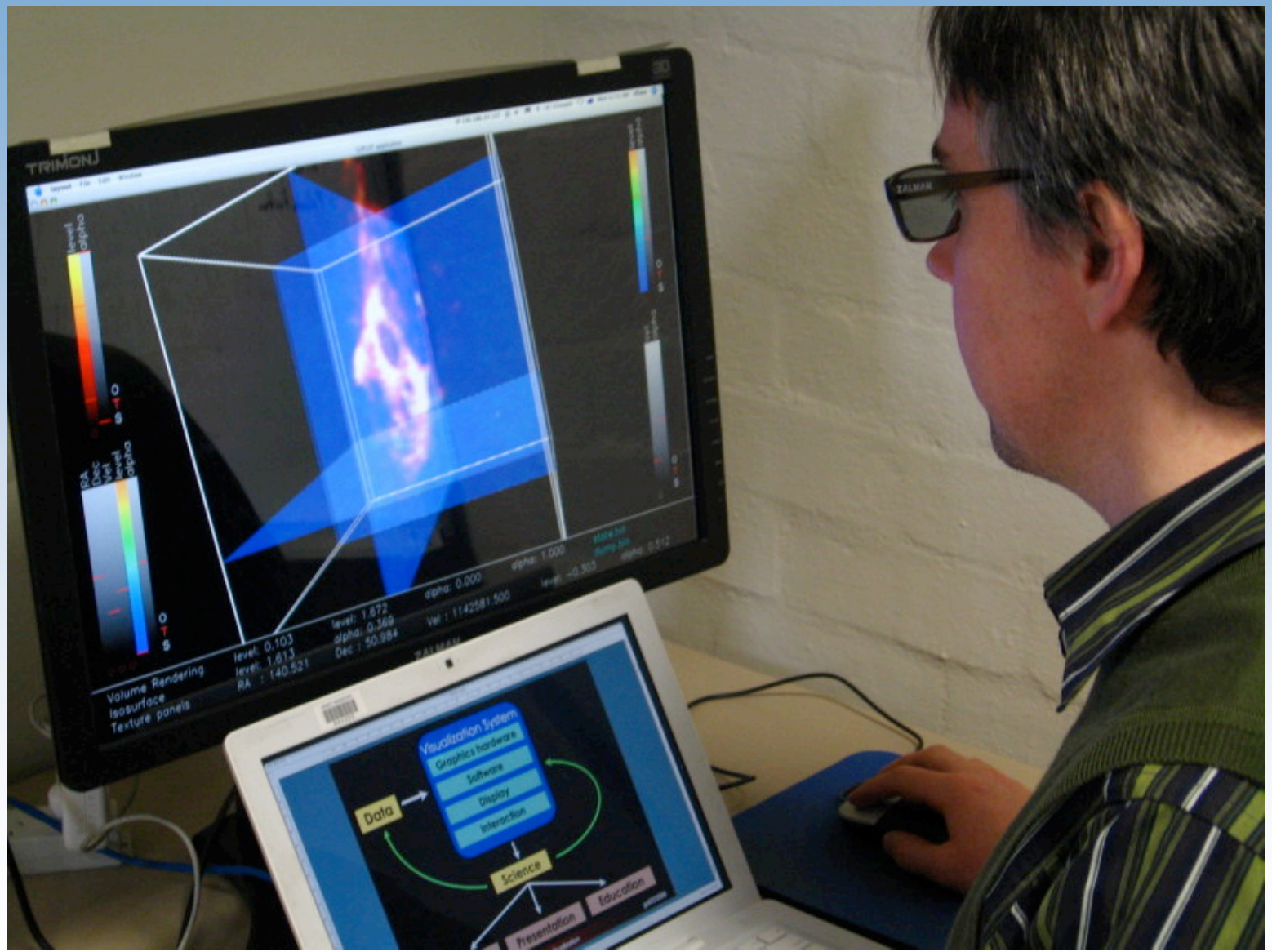
Left Eye Infinitec (interference/colour notch filter) **Right Eye**

I can't see (3D) without my glasses



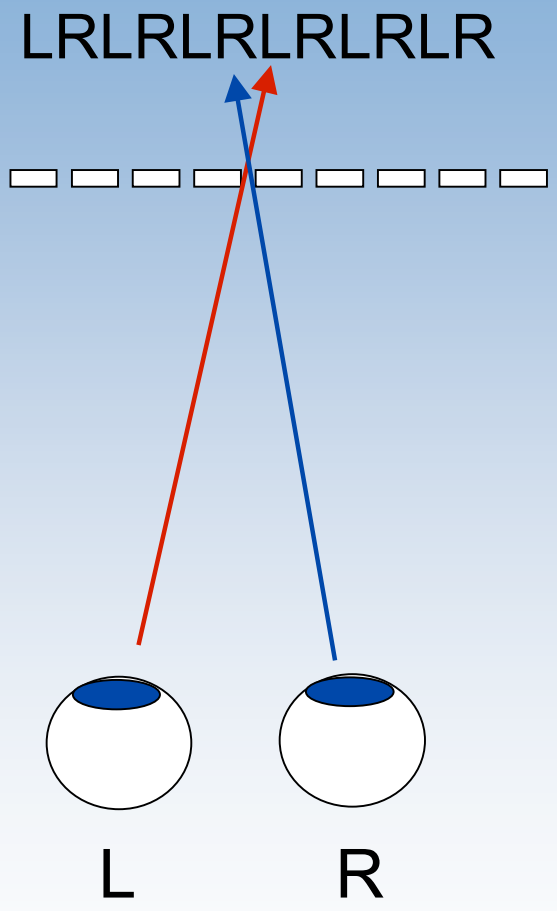
Interleaved

Zalman Trimon 2D/3D Display

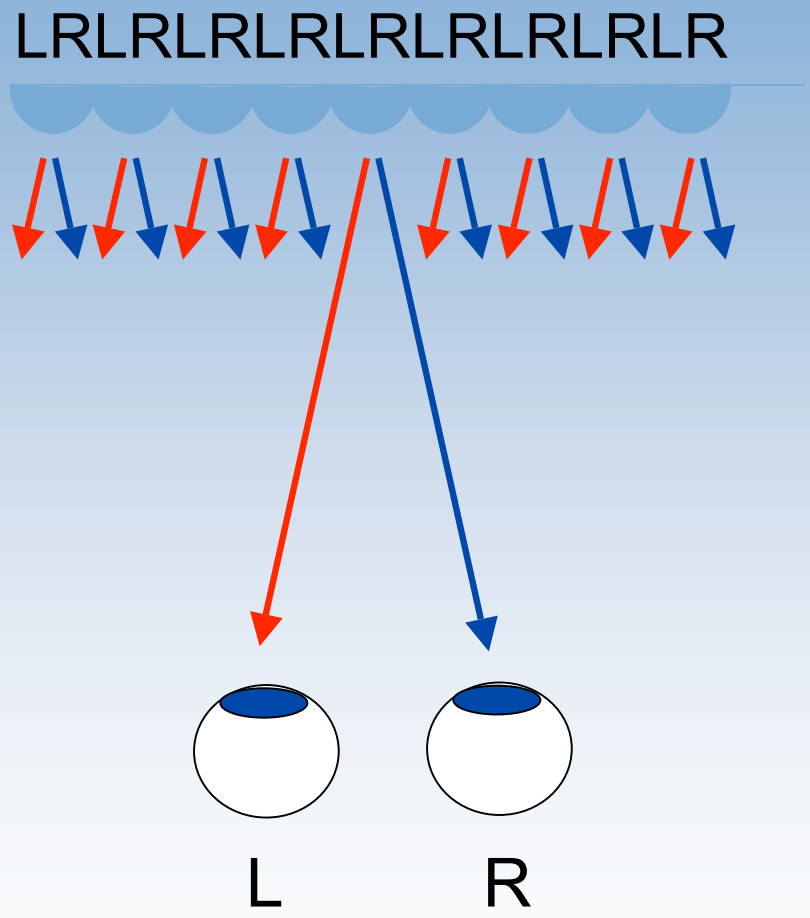


A low-cost, easy to use, stereo 3D display

Autostereoscopic Displays

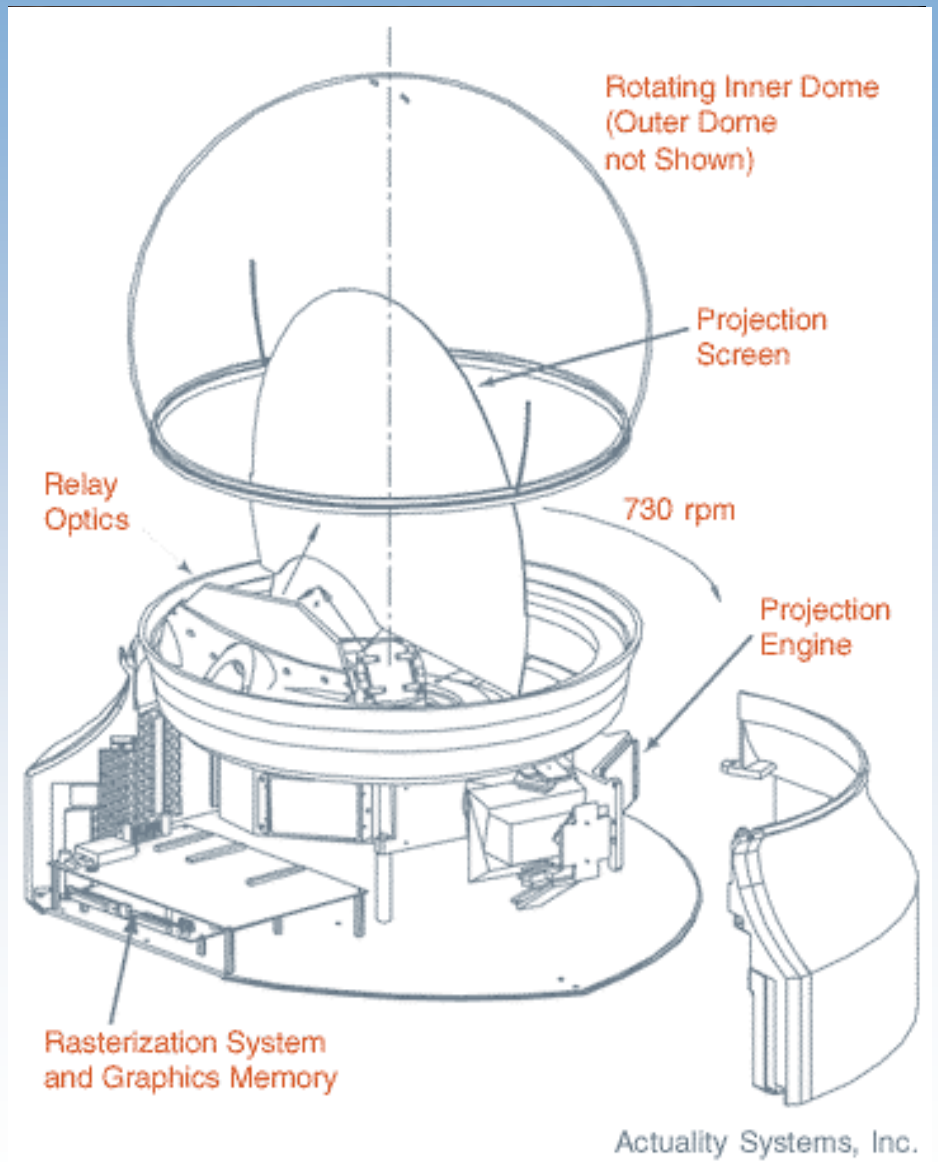


Parallax barrier



Lenticular lens screen

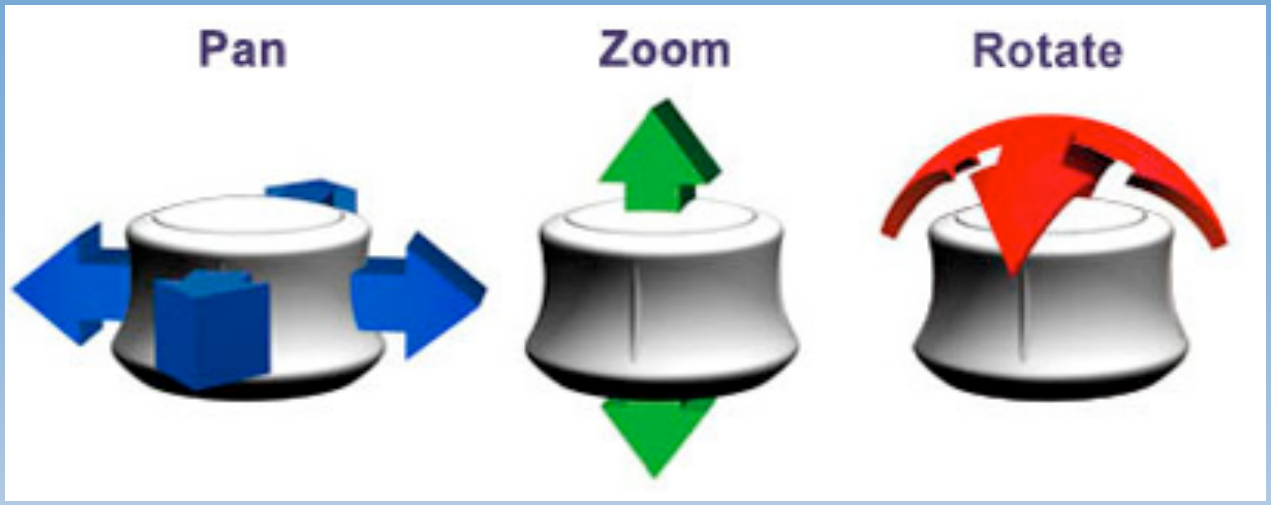
Volumetric displays



Actuality Systems Inc.
Perspecta

- 198 images of 768x768 pixels
- ~100 million voxels
- 80,000 Euro!

- Other systems:
  - Felix 3D
  - Genex



3Dconnexion Space Navigator

"optimize your productivity by 30%"

Nintendo Wii Remote

- 3-Axis accelerometer
- IR Video camera
  - Roll, pitch, yaw.
- Additional IR sensors
  - X,Y,Z relative positions

Gesture recognition?

Digital Publishing

Early 90s

- ApJ publishes movies on video tapes
- ADS Abstract Service begins
- ADS provides scanned articles

Late 90s

- Portable Document Format (PDF)

May 2007

- Adobe Acrobat 3D Version 8 … 3D-PDF

3D PDF + JavaScript = Interactive publications

- Barnes & Fluke (2008)

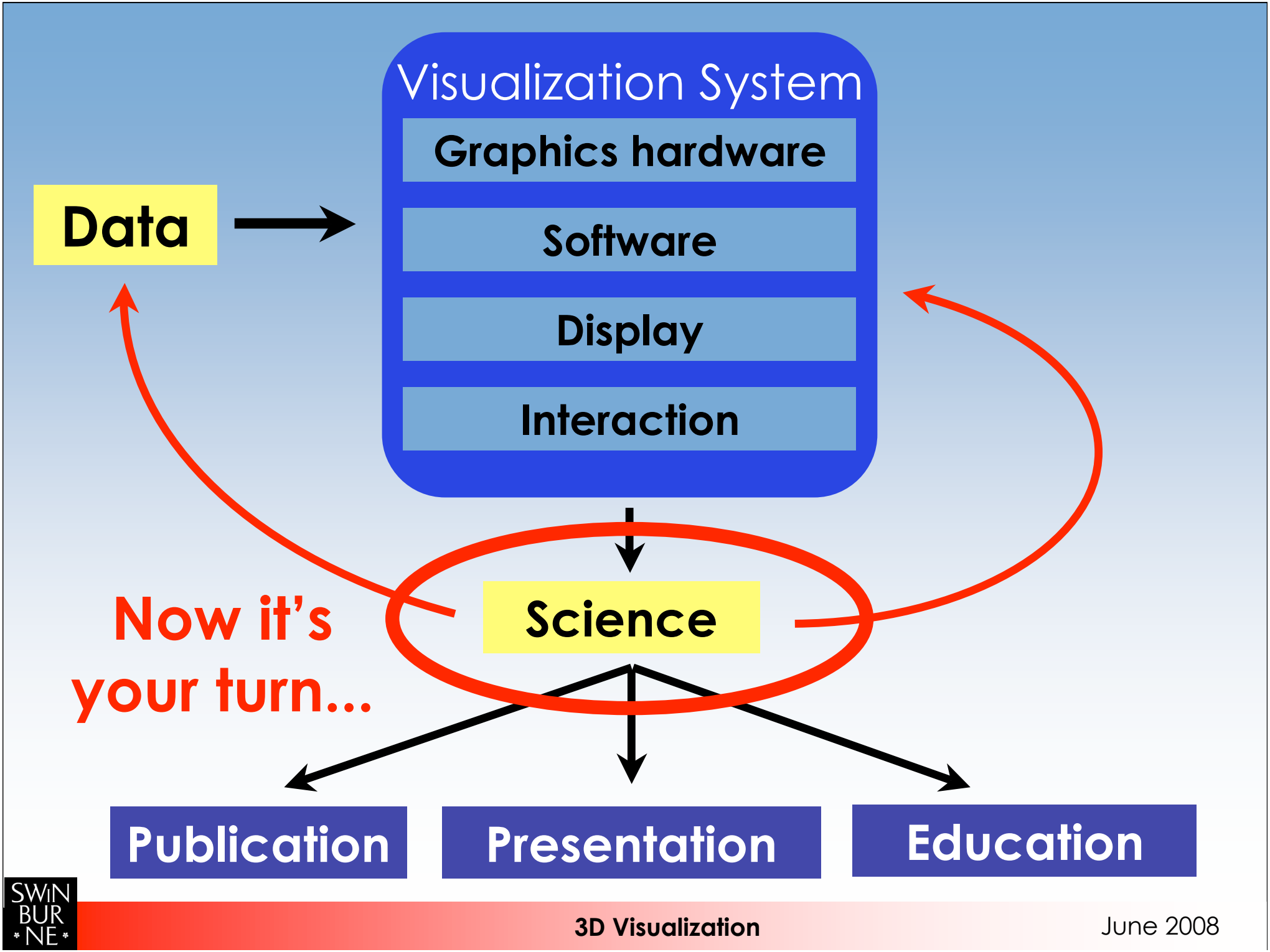
You have been watching...

This presentation was originally given using s2slides built on S2PLOT

http://astronomy.swin.edu.au/s2plot

Integrated 3-d visualization with slides

Same presentation would work in stereo!


Visualization System
Graphics hardware
Software
Display
Interaction
Data
Science
Now it's your turn...
Publication
Presentation
Education