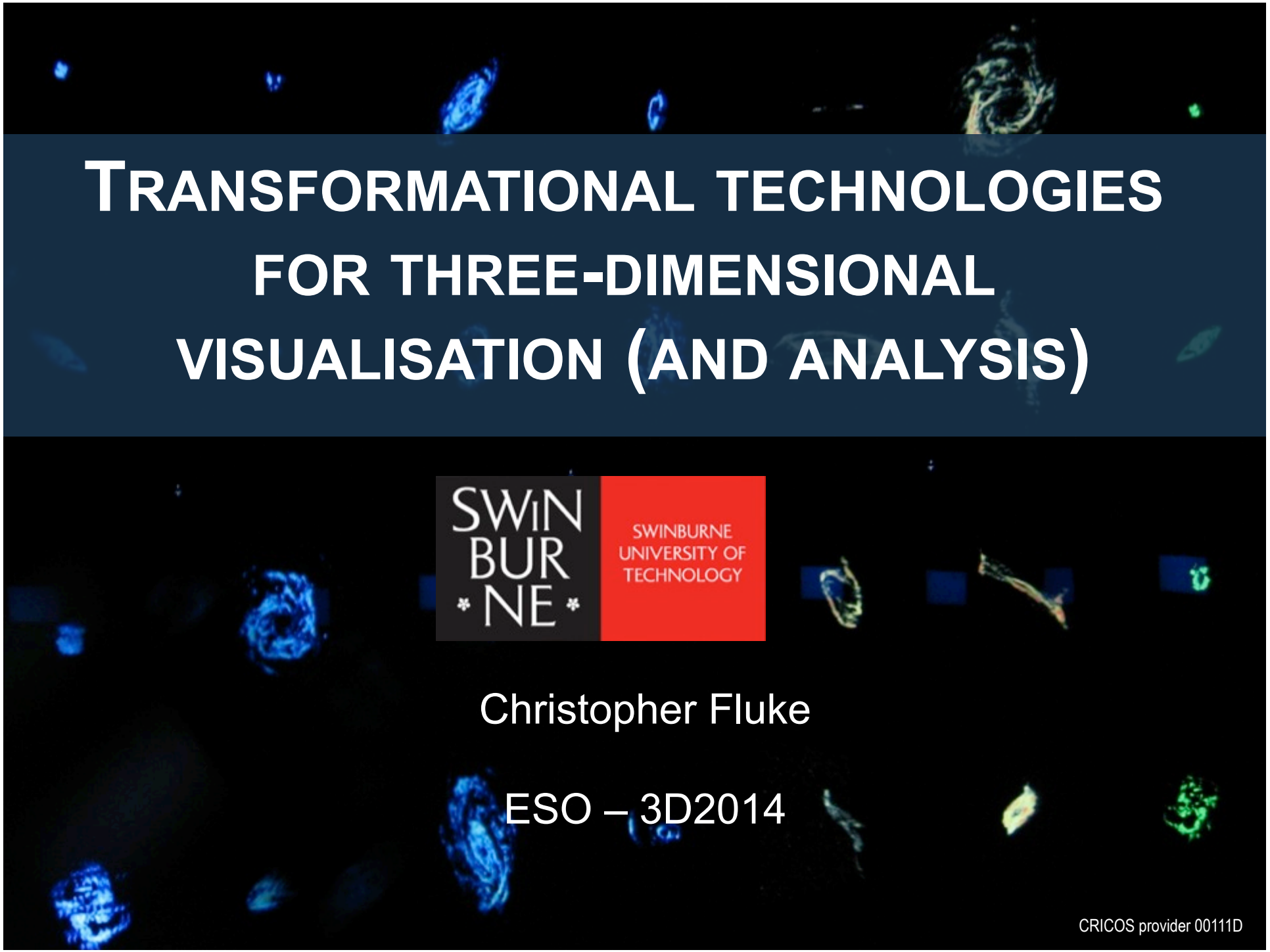


TRANSFORMATIONAL TECHNOLOGIES FOR THREE-DIMENSIONAL VISUALISATION (AND ANALYSIS)

SWINBURNE UNIVERSITY OF TECHNOLOGY

Christopher Fluke

ESO – 3D2014

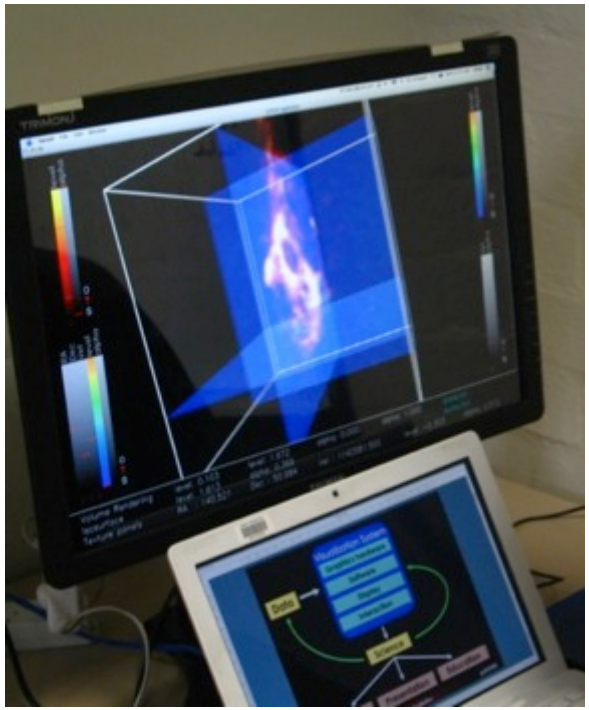
Thank you…

Key Collaborators:

- David Barnes
  Monash University e-Research Centre, VLSCI Life Sciences Computation Centre
- Amr Hassan
  Swinburne University of Technology

3D2014

- Carlos De Breuck and the SOC for the invitation to speak

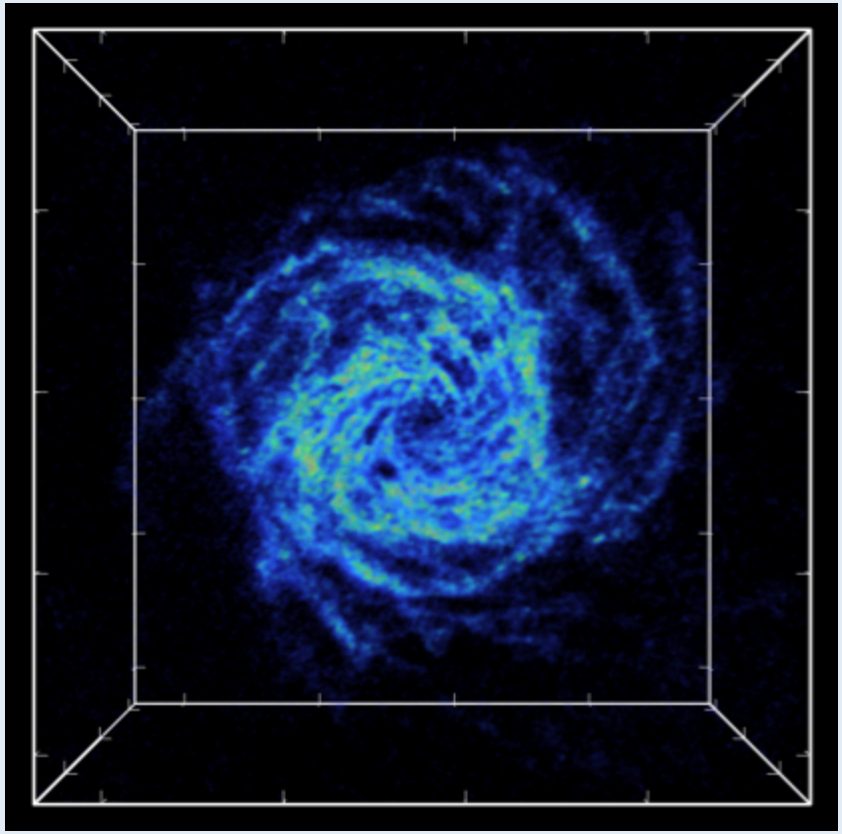


Not to scale…

Presents a serious **challenge** to traditional **desktop-based visualisation** and **analysis**

Three-dimensional Spectral Cube Visualisation

- **Qualitative – easy**
  - Look at data



NGC 628 in HI

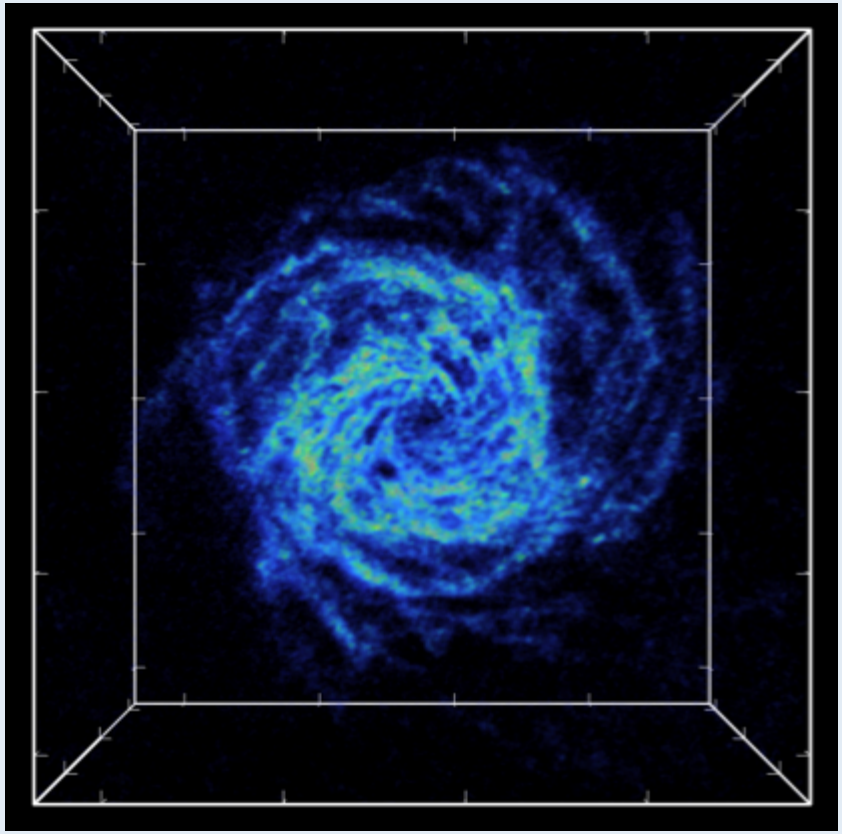
Data: THINGS survey
http://www.mpia-hd.mpg.de/THINGS/Data.html
Vis: S2PLOT, Volume Render, 256x256x72 voxels

Three-dimensional Spectral Cube Visualisation

- **Qualitative – easy**
  - Look at data

Package	Rendering 2D	Rendering 3D	Techniques
3D Slicer		•	Volume Rendering, Isosurface, and Label Map
AIPS++/CASA	•		Raster, 2D Contouring, and Vector
Amira	•	•	Most Volume, Surface, and Scatter Visualization
AstroMD	•	•	Scatter Plot, Isosurface, and Volume Rendering
DVR		•	Volume Rendering
Glnemo	•	•	3D Scatter Plot, and 2D Contouring
Glnemo2	•	•	3D Scatter Plot
GNUPlot	•	•	Scatter Plot
Hubble in a Bottle		•	Volume Rendering
IDL	•	•	Most Volume, Surface, and Scatter Visualization
IFRIT	•	•	Volume Rendering, Stream Tube, Isosurface, and 2D Contouring
Karma	•	•	Raster, Volume Rendering, and 2D Contouring
OpenDX	•	•	Most Volume, Surface, and Scatter Visualization
Osirix		•	Volume Rendering, and Isosurface
Paraview	•	•	Most Volume, Surface, and Scatter Visualization
PartiView	•	•	Scatter Plot
RVS	•		Raster, and 2D Contouring
S2Plot	•	•	Volume Rendering, Isosurface, Vector Map, and 2D Contouring
SPLASH		•	Volume Rendering, Vector Plot, and 2D Contouring
StarSplatter		•	Scatter Plot
TIPSY		•	Scatter Plot, and 2D Contouring
TopCat	•	•	Scatter Plot, and Line/Spherical Plot
VisIVO		•	Scatter Plot, Isosurface, Volume Rendering, and 2D Contouring
VOPlot3D	•	•	Scatter Plot, Surface Plot, and Histogram

Table 3. Hassan & Fluke (2011), PASA



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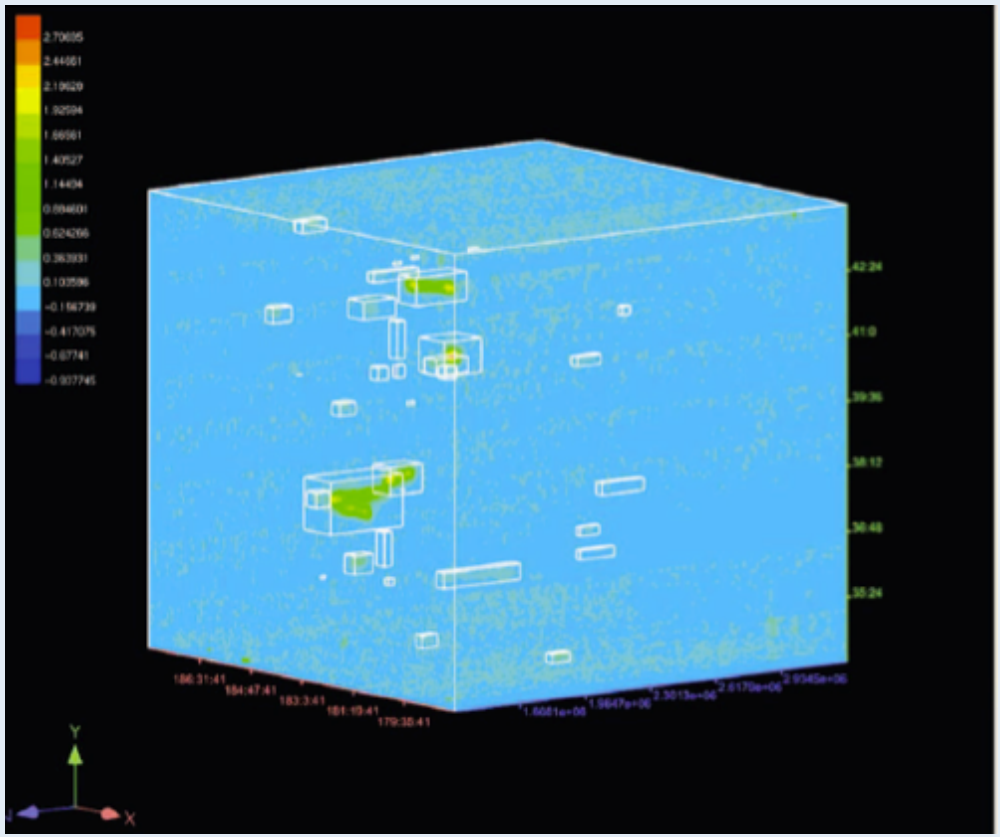
Three-dimensional Spectral Cube Visualisation

- **Qualitative – easy**
  - Look at data
- **Comparative – harder**
  - Model + data

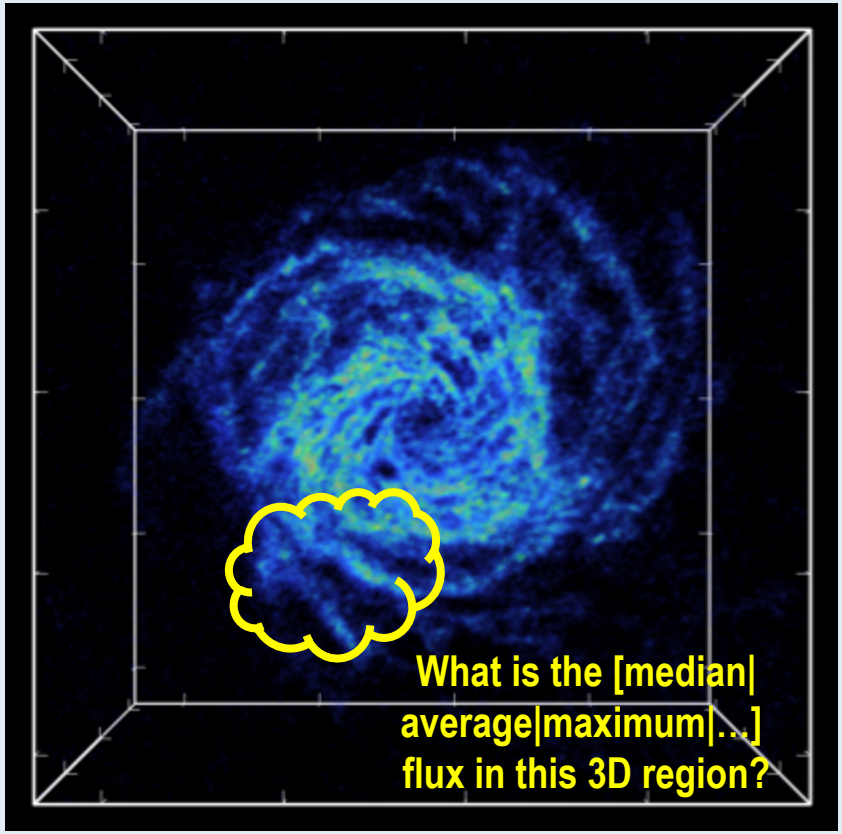


Duchamp source-finder catalogue overlaid on volume rendering.

Data: Ursa Major galaxy cluster at 21cm (V.Kilborn)
Image: Hassan, Fluke, Barnes, 2011, ADASS XX

Three-dimensional Visualisation

- **Qualitative – easy**
  - Look at data
- **Comparative – harder**
  - Model + data
- **Quantitative – hardest**
  - Dynamic selection
  - Statistics
  - “Operators”



NGC 628 in HI

Data: THINGS survey
http://www.mpia-hd.mpg.de/THINGS/Data.html
Vis: S2PLOT, Volume Render, 256x256x72 voxels

Practical (hmm) 3D alternatives?

Credit: NASA

Spaceball

Wand

Transformational Technology #1: Leap Motion

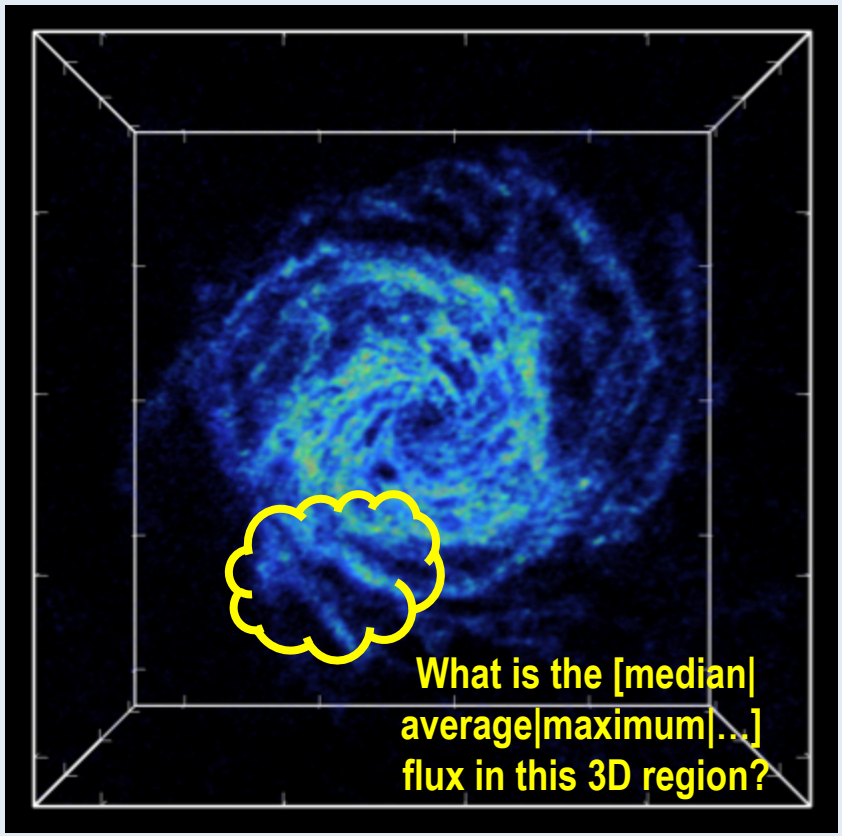
Leap Development Board V.05 courtesy Leap Motion Inc.
Hands courtesy Eleanor

Transformational Technology #1: Leap Motion

Quantitative 3D Visualisation

- Dynamic selection
- Statistics
- “Operators”

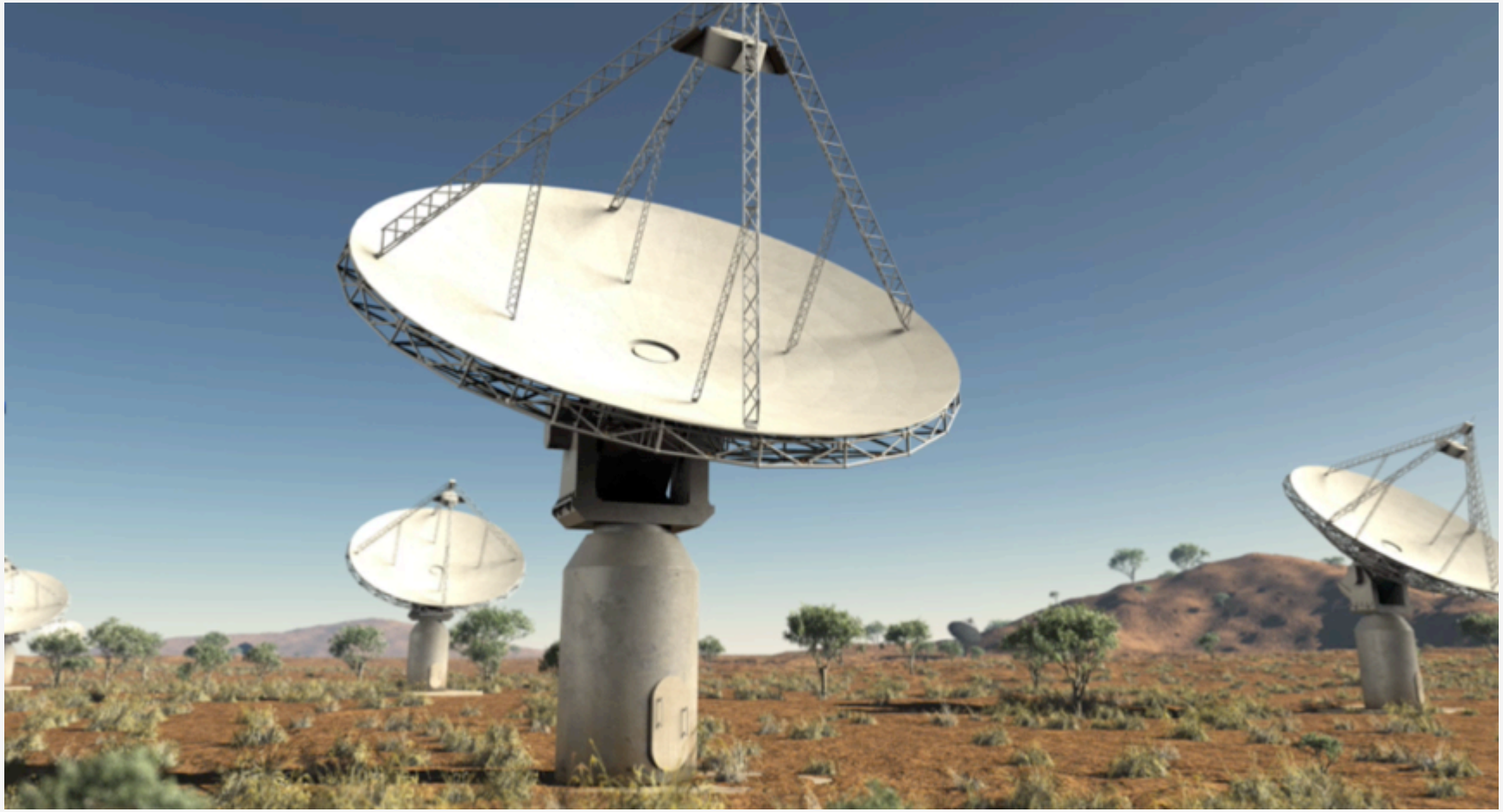
Opportunity to understand/support this mode



NGC 628 in HI

Data: THINGS survey
http://www.mpia-hd.mpg.de/THINGS/Data.html
Vis: S2PLOT, Volume Render, 256x256x72 voxels

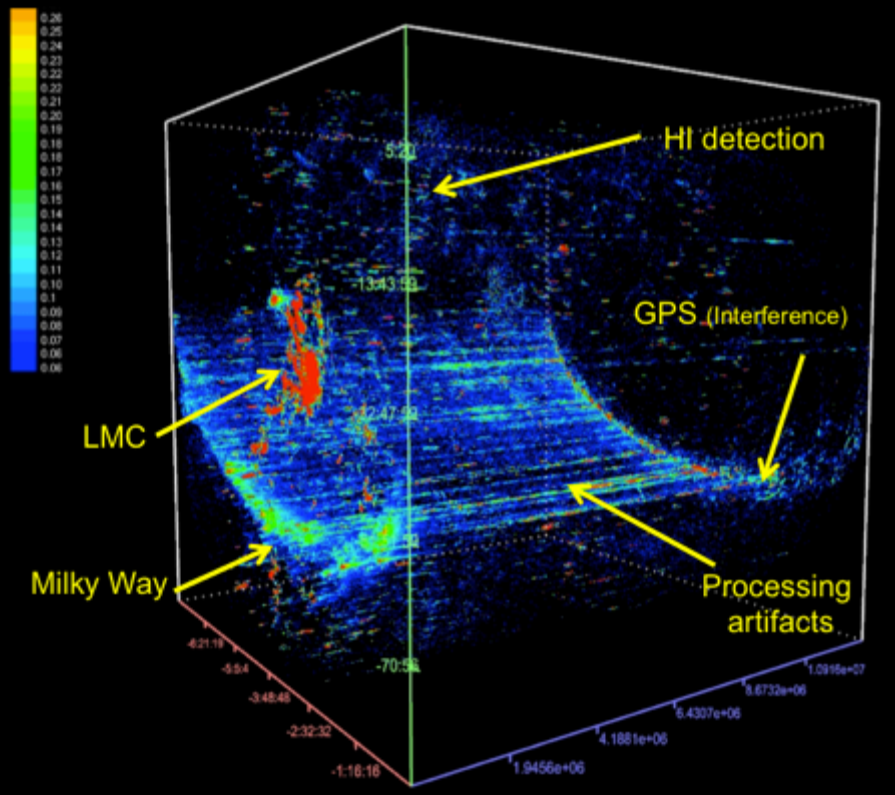
Case Study: Real-time, interactive terascale visualisation



Credit: Swinburne Astronomy Productions

WALLABY: The ASKAP HI All-Sky Survey

B.Koribalski (ATNF), L.Staveley-Smith (ICRAR) + 100 others…



387 HIPASS cubes
1721 x 1721 x 1024 = 12GB

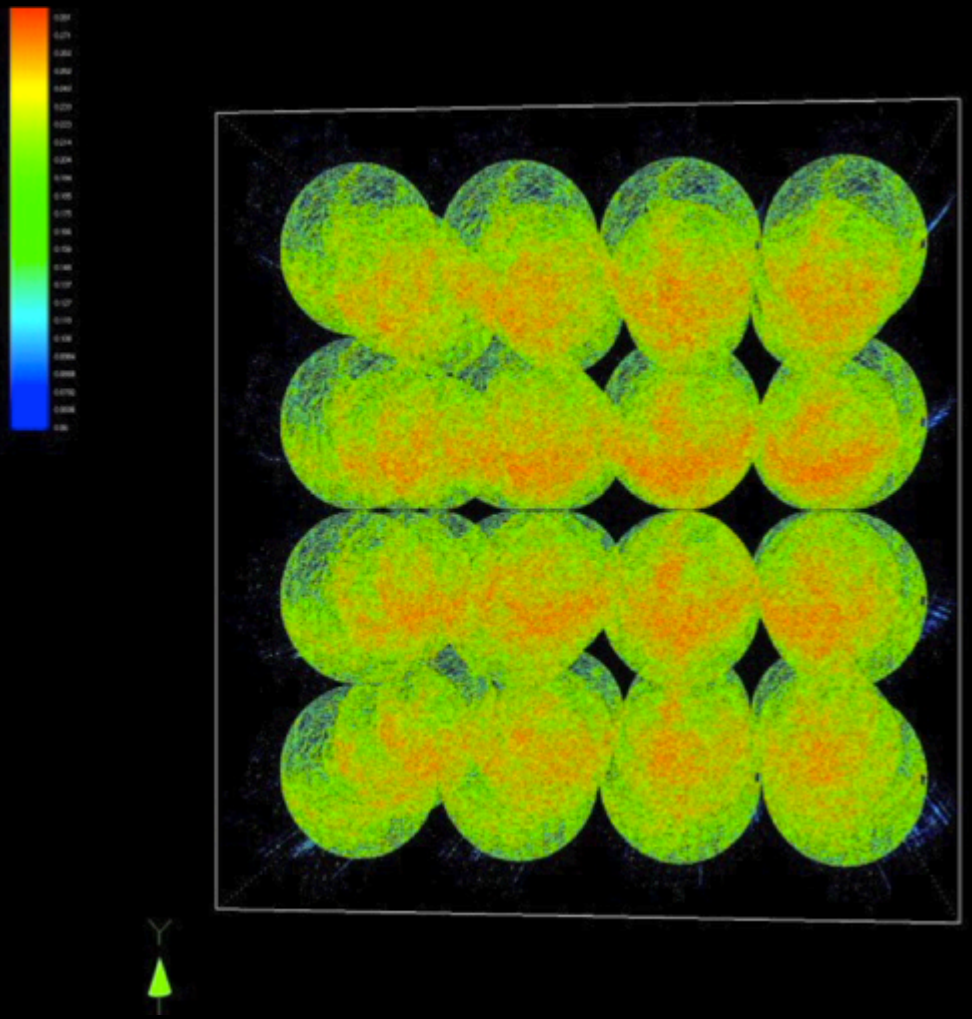
Data: Russell Jurek (ATNF)/HIPASS
Vis: Amr Hassan

- Redshifted 21-cm HI
- 75% of sky covered
- z = 0.26 ~ 3 Gyr look-back
- ~0.5 million new galaxies

Potential data products
4096 x 4096 x 16384 channels
~ 1TB per cube
[x1200 cubes]

Can we support real-time, interactive ***visualisation*** and ***data analysis?***

Yes we can!



48 x HIPASS

- 4 x 4 x 3
- 6884 x 6884 x 3072
- **542.33 GB**
- **5-10 frames/second**
- Hassan et al. (2013)

gSTAR

- Graphics Processing Unit Supercomputer

Courtesy A.Hassan

Transformation Technology #2: GPU

Massively parallel

Programmable*

Computational co-processors

Providing 10x-100x speed-ups

For many scientific problems

At low cost (TFLOP/$)

(But you can't use existing code)

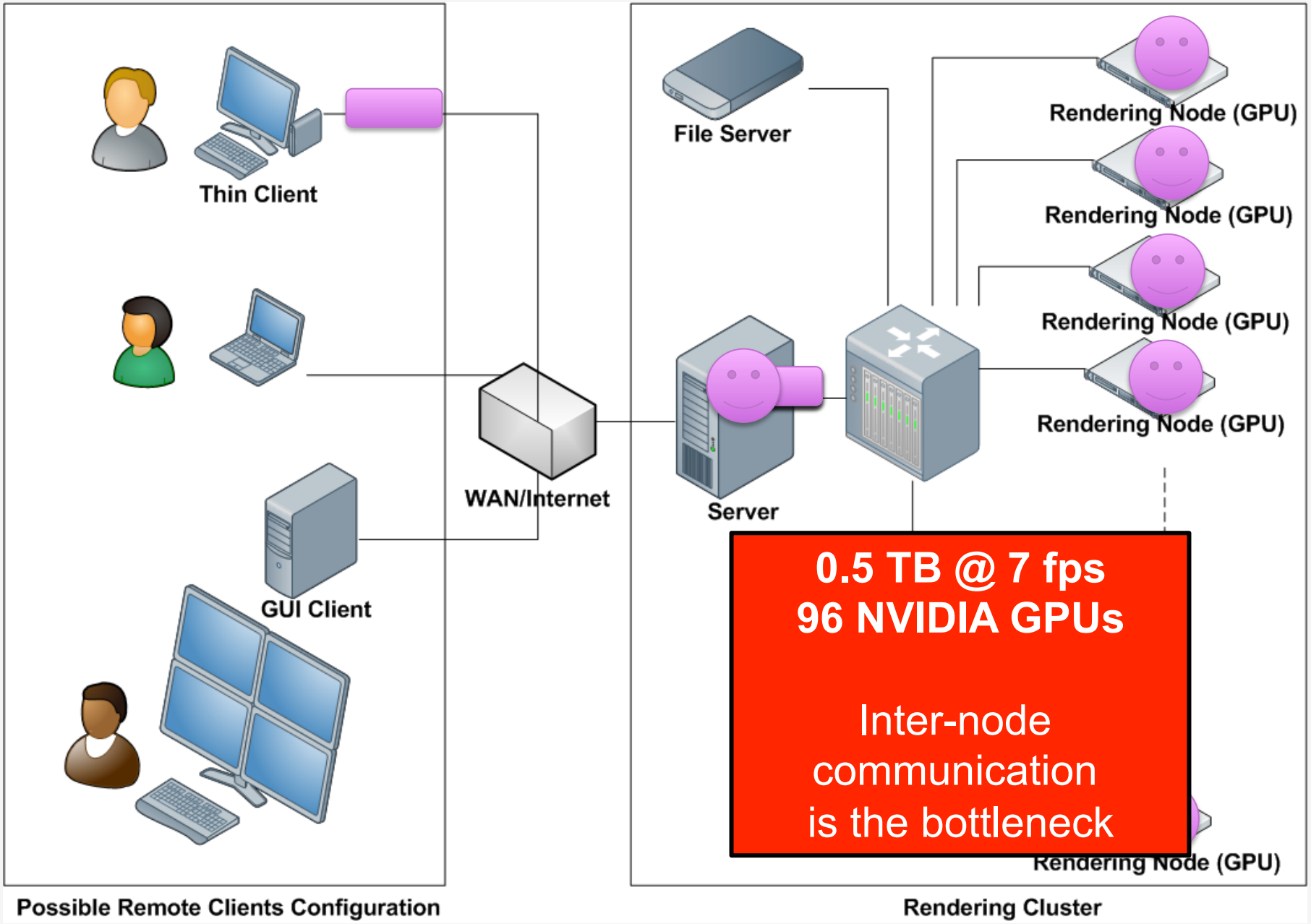
[* CUDA, OpenCL, PyCUDA, Thrust, OpenACC, CUFFT, cuBLAS ….]

NVIDIA Kepler K40

SP: 4.29 TFLOP/s
DP: 1.43 TFLOP/s

AMD FirePro W9000

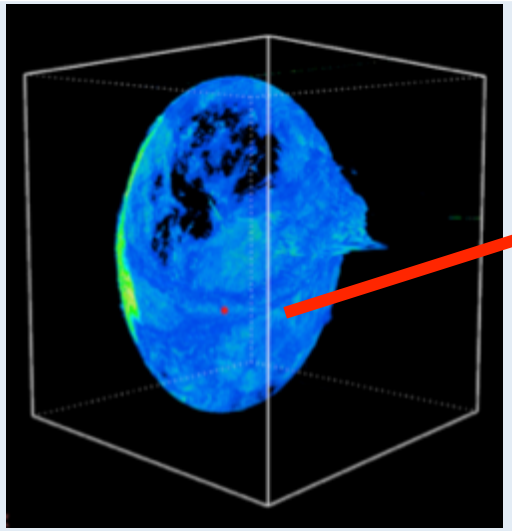
SP: 4.0 TFLOP/s
DP: 1.0 TFLOP/s



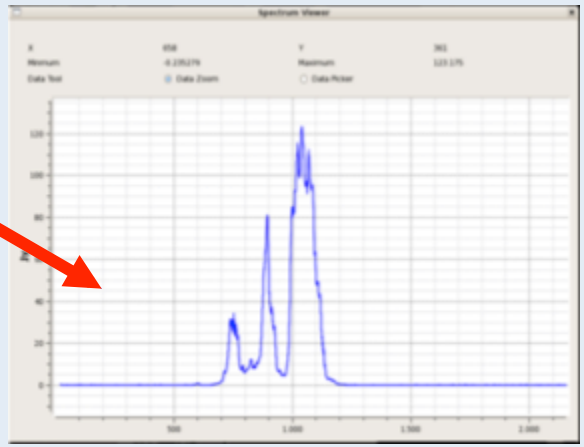
For details see: Hassan et al. (2011), NewA and Hassan et al. (2012), PASA

Analysing **0.5 Tbyte** (on 96 GPUs)

Task	Description	Time
Histogram	Visit each data point once	~4 sec
Global mean and standard deviation	Summarizing whole dataset into single value(s)	~2 sec
Global median	Multiple iterations to convergence (Torben's method)	~45 sec
3D spectrum tool	Quantitative data interaction: click for spectrum	20 msec

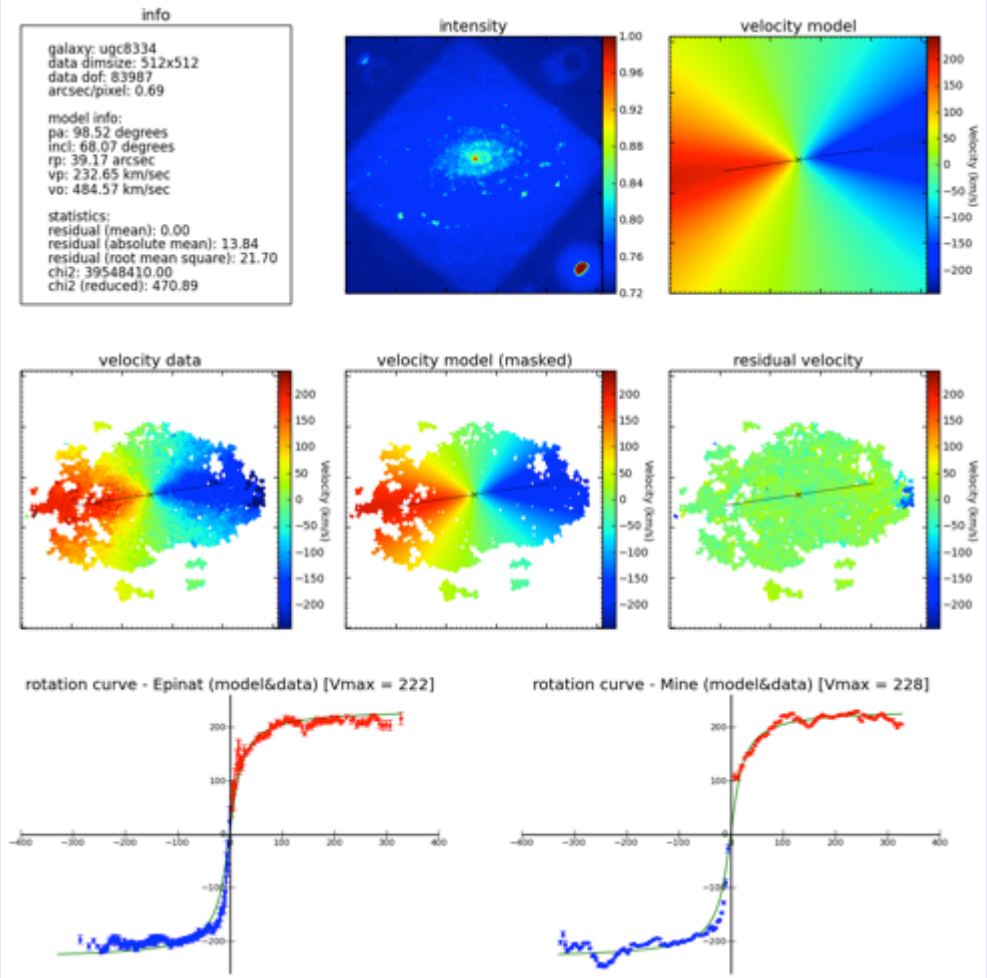


Interactive 3D quantitative visualisation

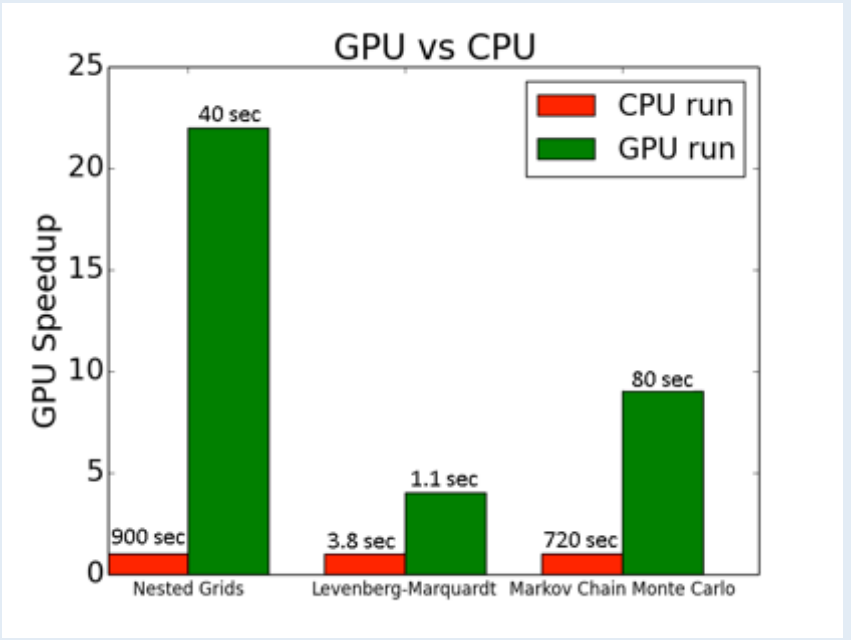


Data: GASS (N.McClure-Griffiths; ATNF)

GPU-accelerated kinematic model fitting



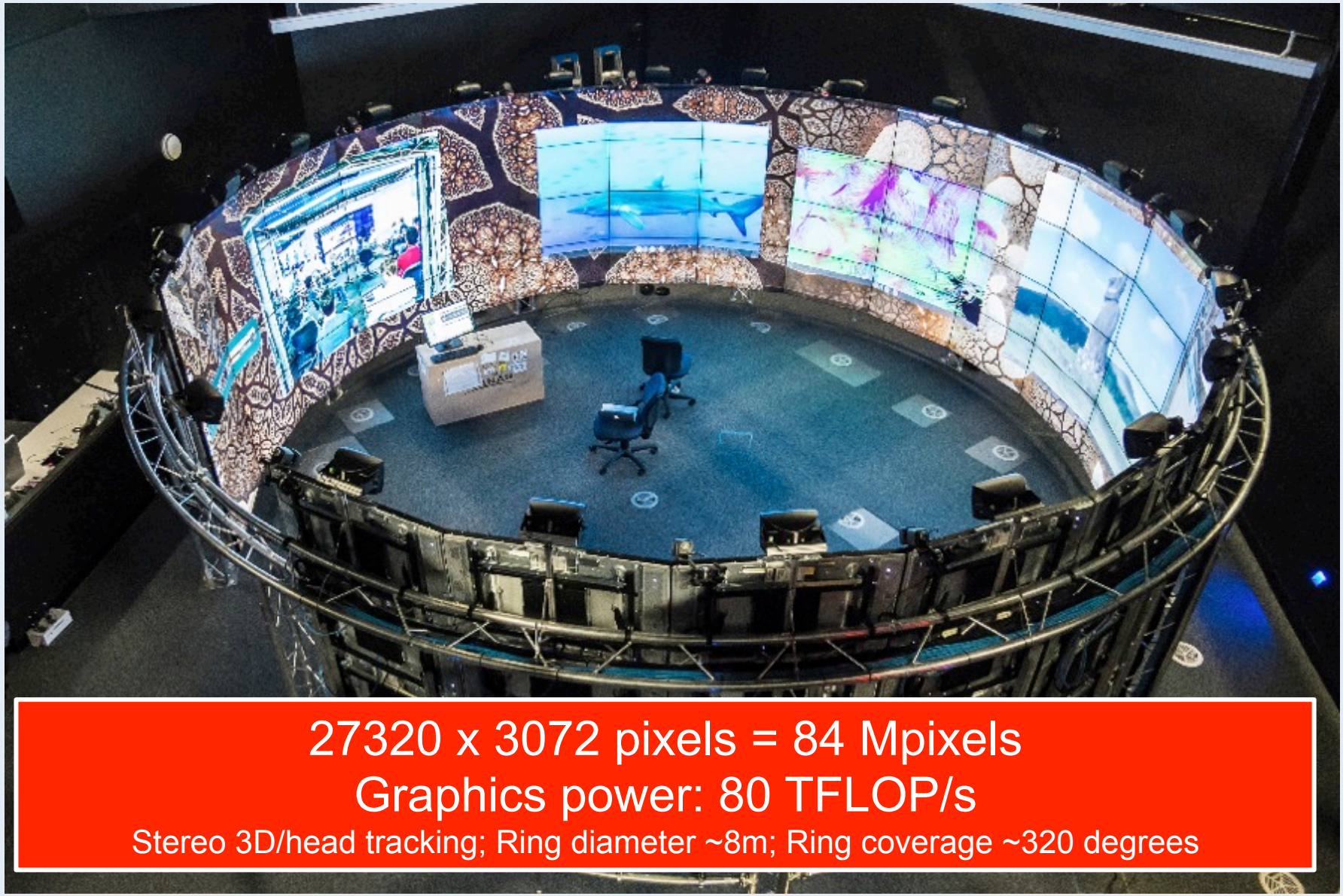
George Bekiaris
(+ Karl Glazebrook, Bob Abraham)



Gassendi HAlpha survey of SPirals (GHASP)
Epinat et al. 2008a,2008b

What do you get if you cross a **GPU supercomputer** with a high-end, **immersive visualisation** environment?

Transformation Technology #3: CAVE2@Monash

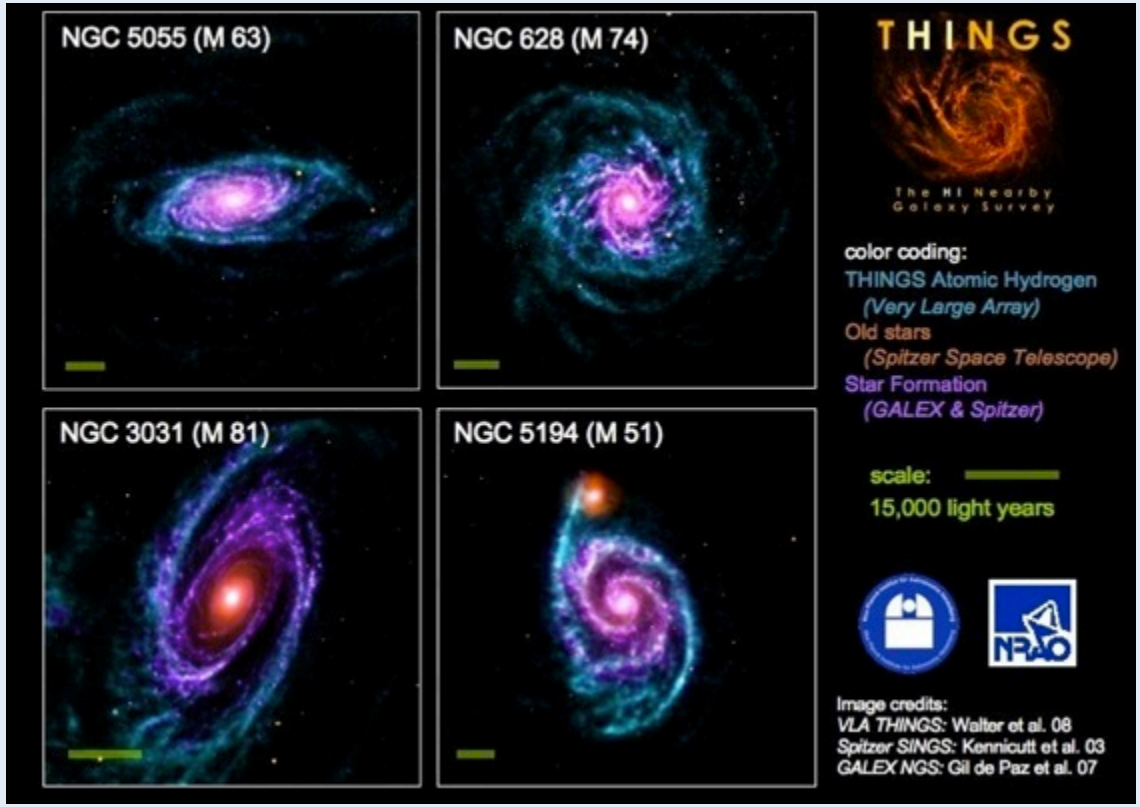


27320 x 3072 pixels = 84 Mpixels
Graphics power: 80 TFLOP/s
Stereo 3D/head tracking; Ring diameter ~8m; Ring coverage ~320 degrees

Image: Monash University

CAVE2 = 80 individual stereoscopic panels

Use the CAVE2 to look at lots of **THINGS** at one time…



The HI Nearby Galaxy Survey

- 7” angular and 5 km/s velocity resolution
- 34 objects
- 3 < D < 15 Mpc
- Walter, F. et al. 2008, AJ, 136, 2563

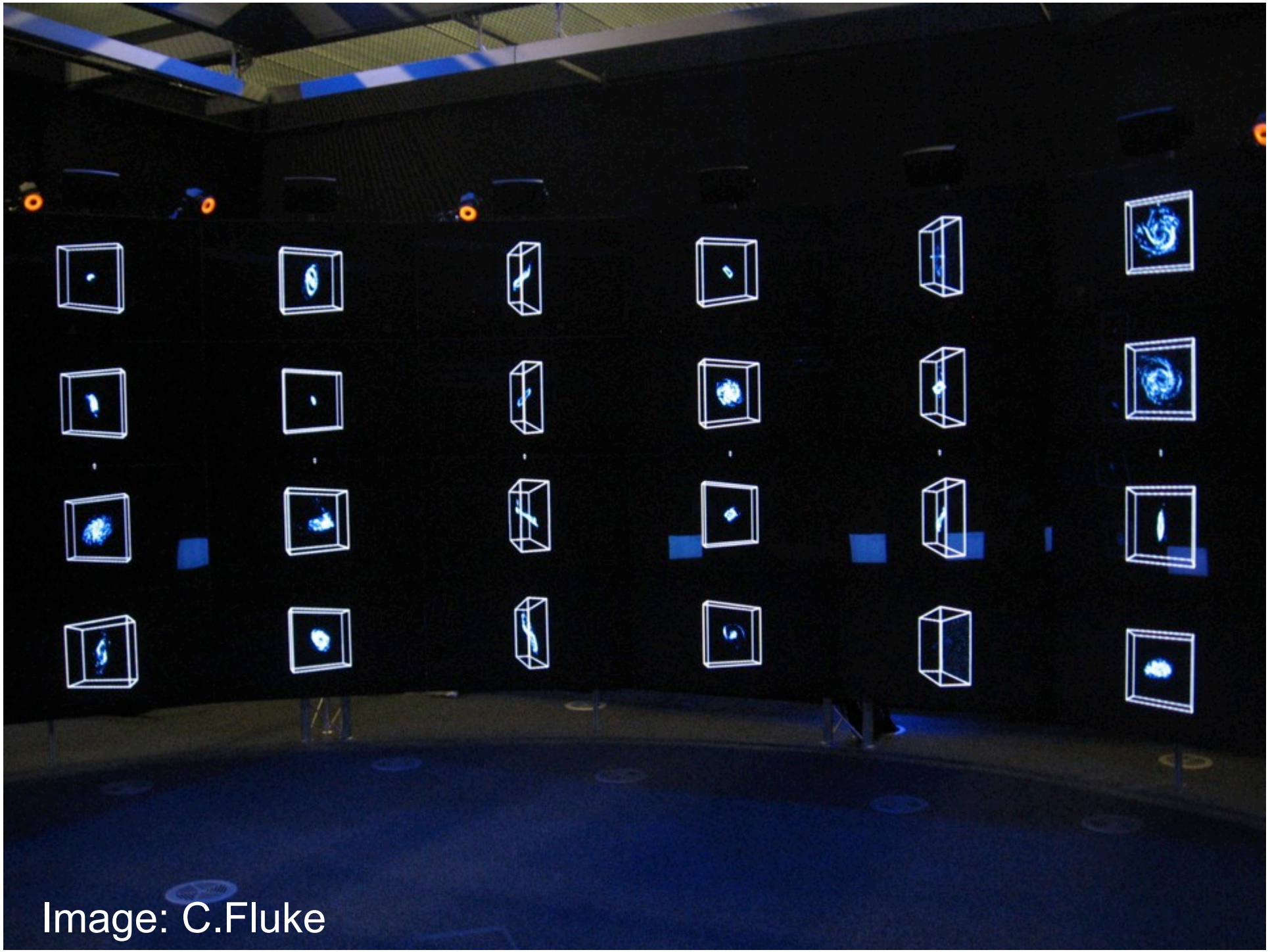
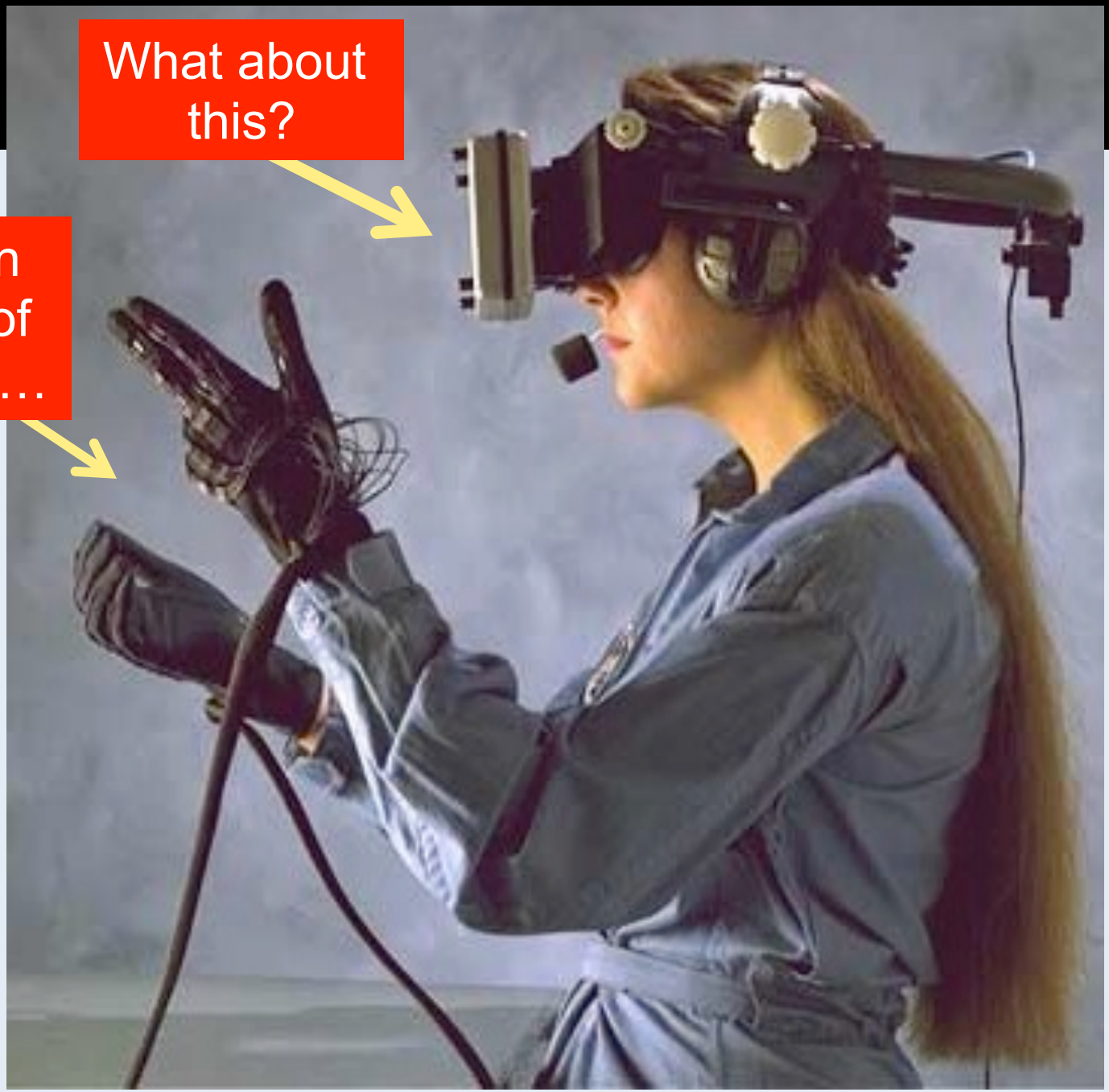


Image: C.Fluke

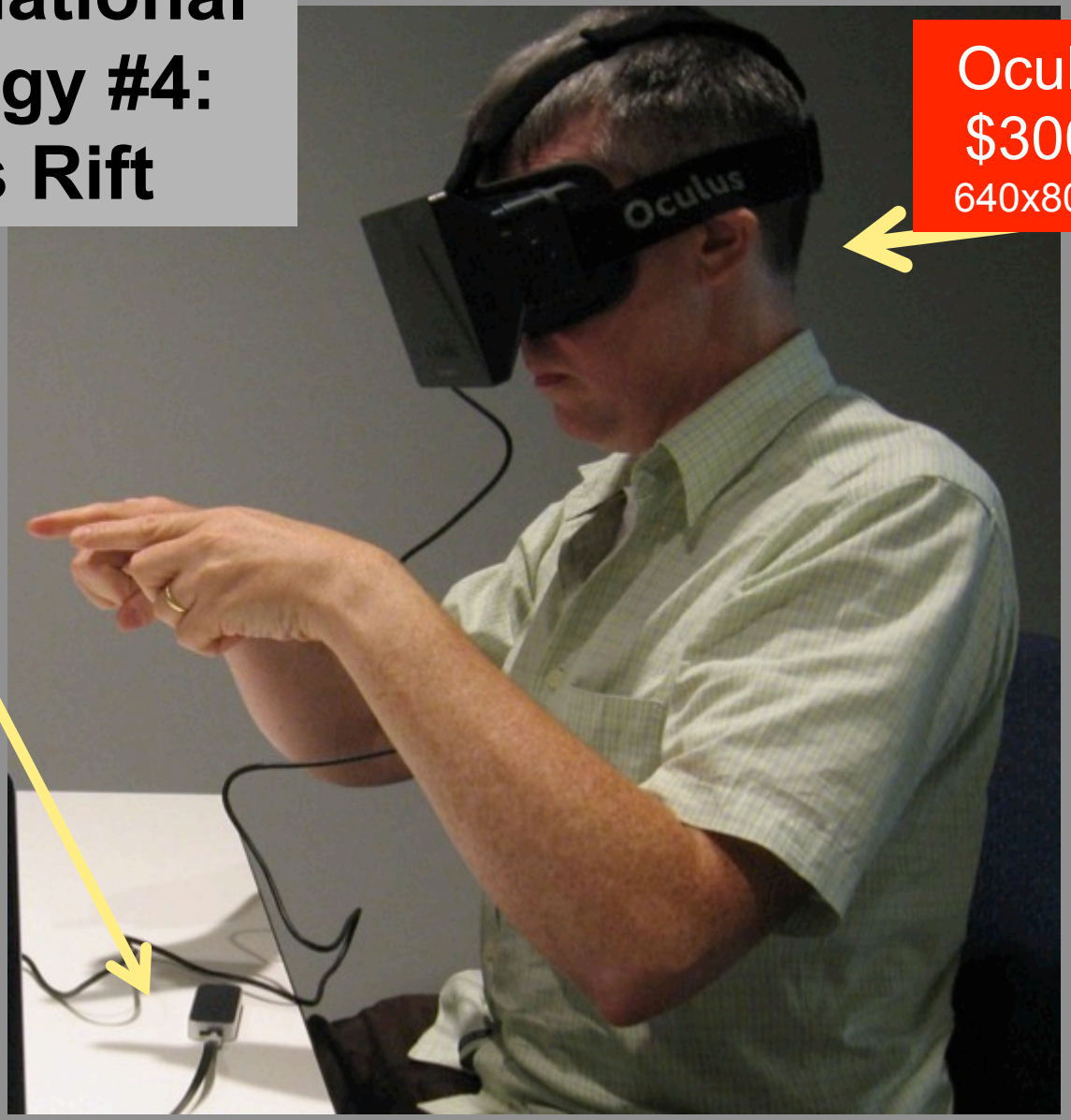
We can't all get to the CAVE2.

Can we bring that experience to the desktop?



Credit: NASA

Transformational Technology #4: Oculus Rift



Oculus Rift
$300 USD
640x800 per eye

Leap Motion

Credit: C.Fluke

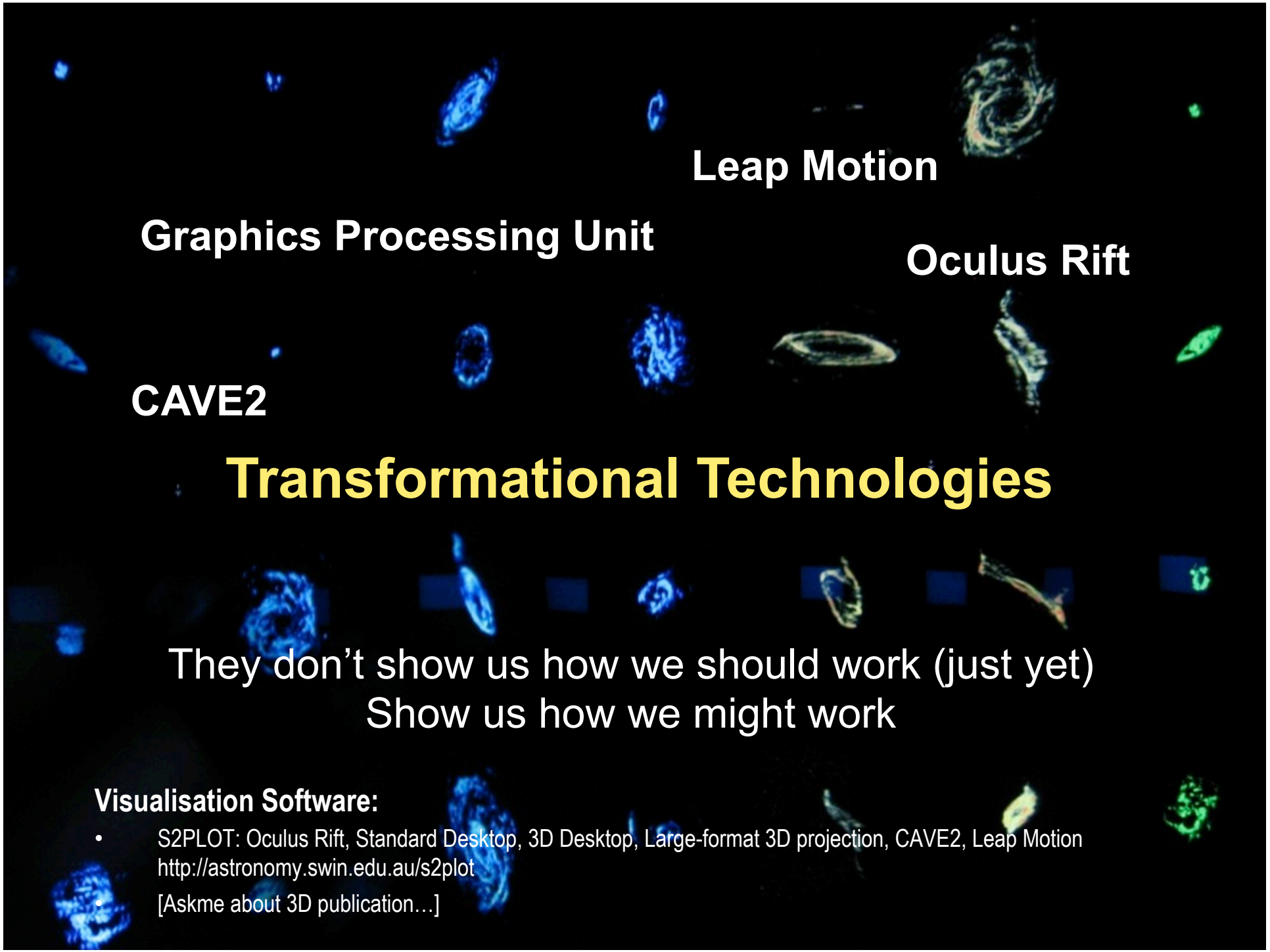
The **volume** of **data** from **spectral cube surveys** is on the **rise**

Number of spectral data cubes
Size of individual data cubes

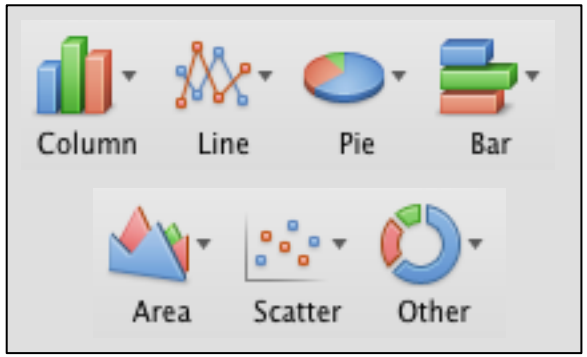
Presents a serious **challenge** to traditional **desktop-based visualisation** and **analysis**

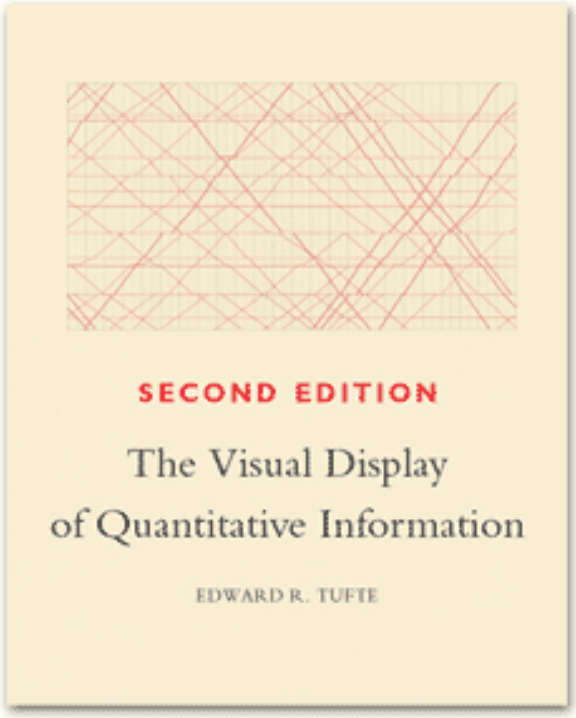
Transformational technologies

allow us to explore the non-traditional

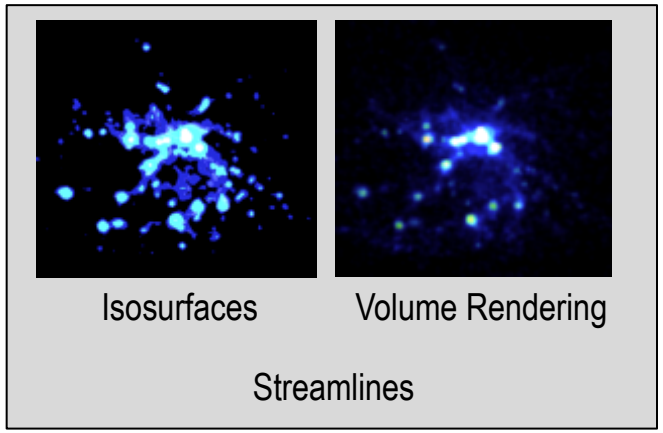

Leap Motion
Graphics Processing Unit
Oculus Rift
CAVE2
Transformational Technologies
They don't show us how we should work (just yet)
Show us how we might work
Visualisation Software:
• S2PLOT: Oculus Rift, Standard Desktop, 3D Desktop, Large-format 3D projection, CAVE2, Leap Motion
http://astronomy.swin.edu.au/s2plot
• [Askme about 3D publication…]

If I have 2D data, I should plot it in 2D





If I have 3D data, I should plot it in 3D



"Behind" "Inside"

Static vs Dynamic

- Motion parallax
- Interactive, camera control
- Toggling of components

The Process – Commercial license solution (2008)

What goes on in your office

S2PLOT
(VRML output)

Adobe Acrobat 3D
Windows license
or
Adobe Acrobat 10 Pro
Tetra4D 3D PDF plug-in
Windows license

Barnes & Fluke (2008), NewA

What you publish

Adobe Reader
Version 8.0 or higher

S2PLOT

- Free, open source software (V3.2.1)
- Powerful programming interface
- C/C++/Fortran (Python)

- Barnes et al. (2006), PASA, 23, 82
- http://astronomy.swin.edu.au/s2plot

The Process – Free, open source solution (2013)

What goes on in your office

S2PLOT
(PRC output)

LaTeX
Movie9 or Movie15 style
libHaru PDF library
Adobe 3D JavaScript
Asymptote: the Vector Graphics Language

Barnes et al. (2013), PloS ONE

What you publish

Adobe Reader
Version 8.0 or higher

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