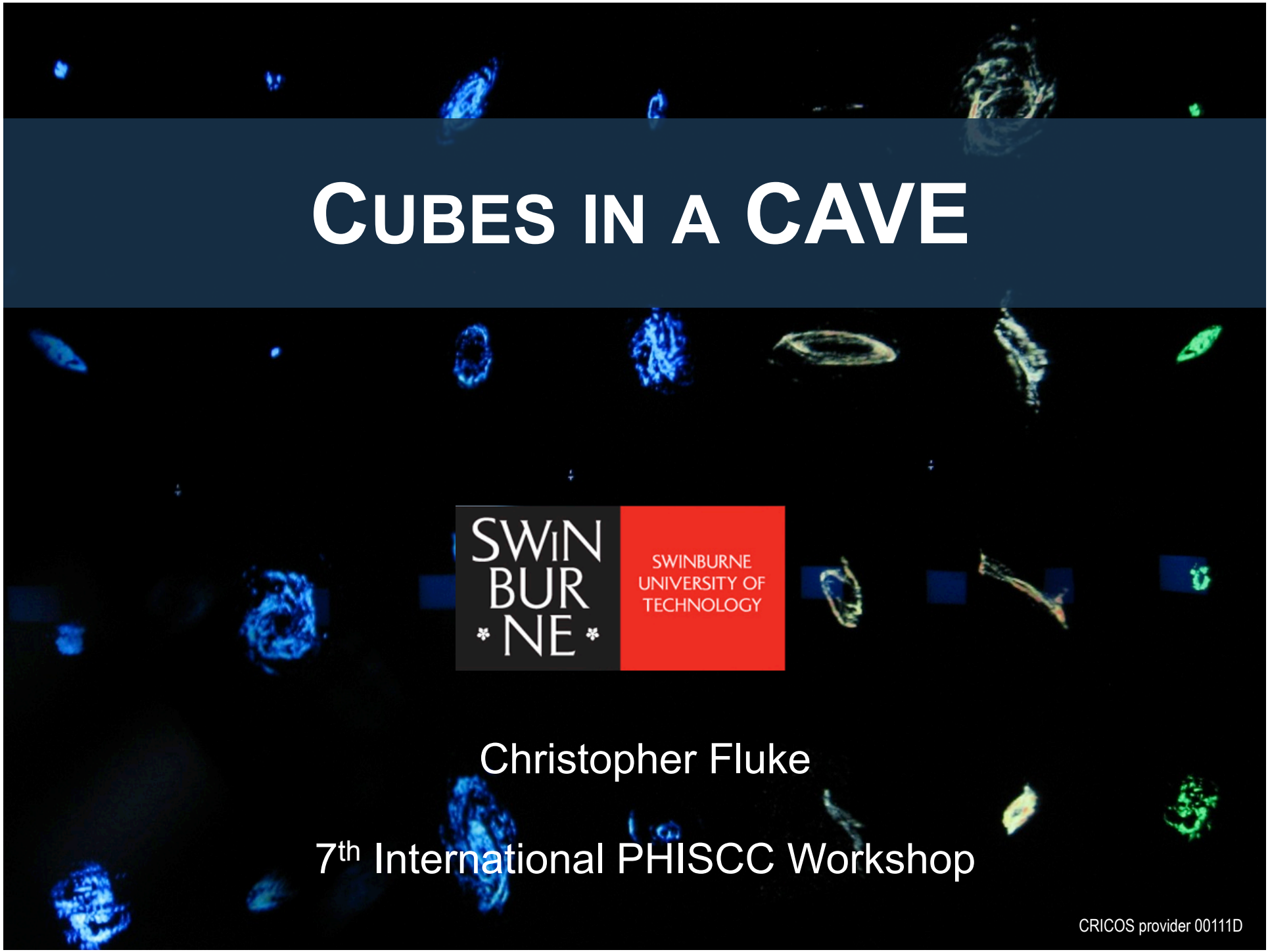


CUBES IN A CAVE

SWINBURNE UNIVERSITY OF TECHNOLOGY

Christopher Fluke

7th International PHISCC Workshop

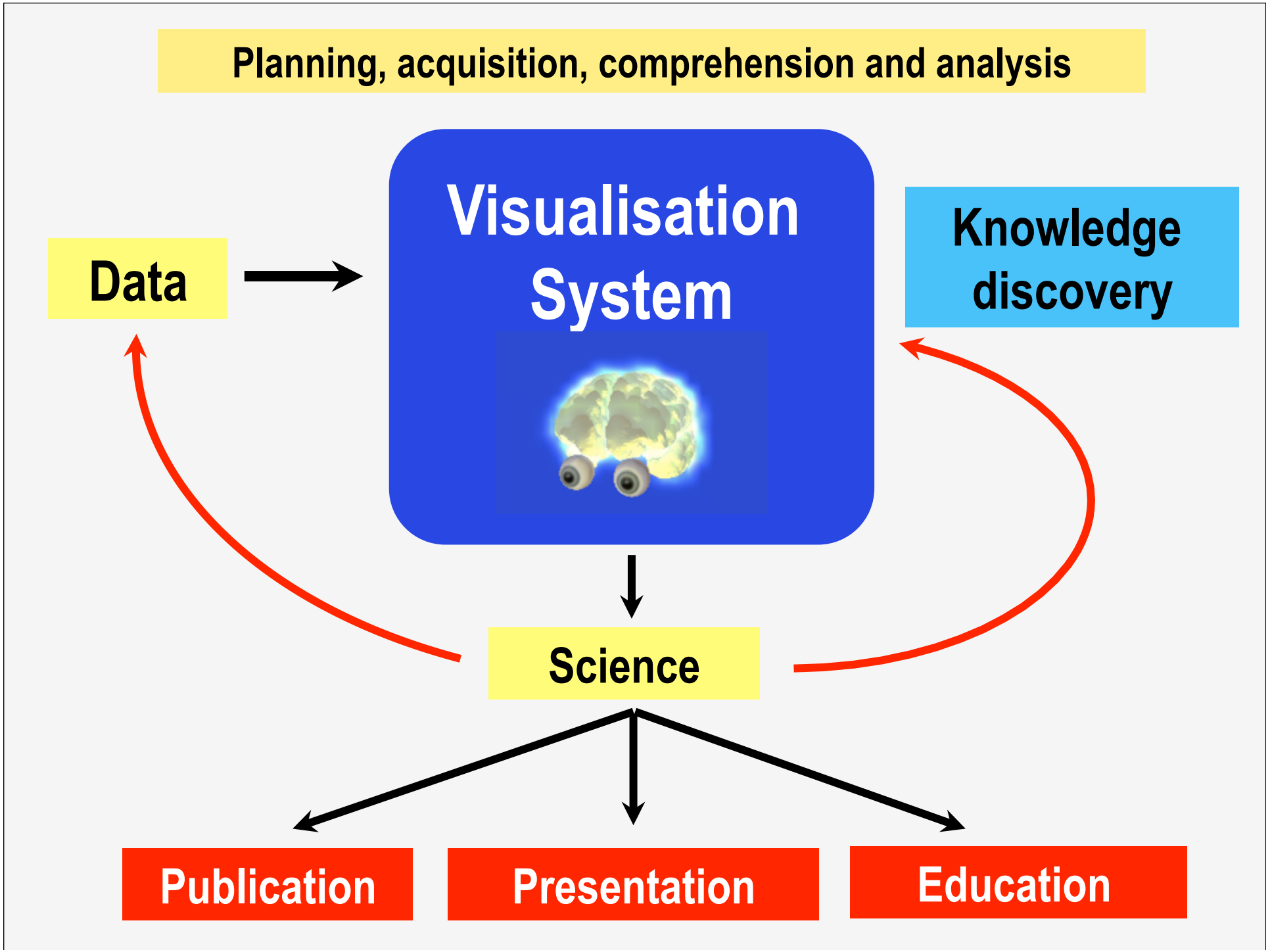
Thank you…

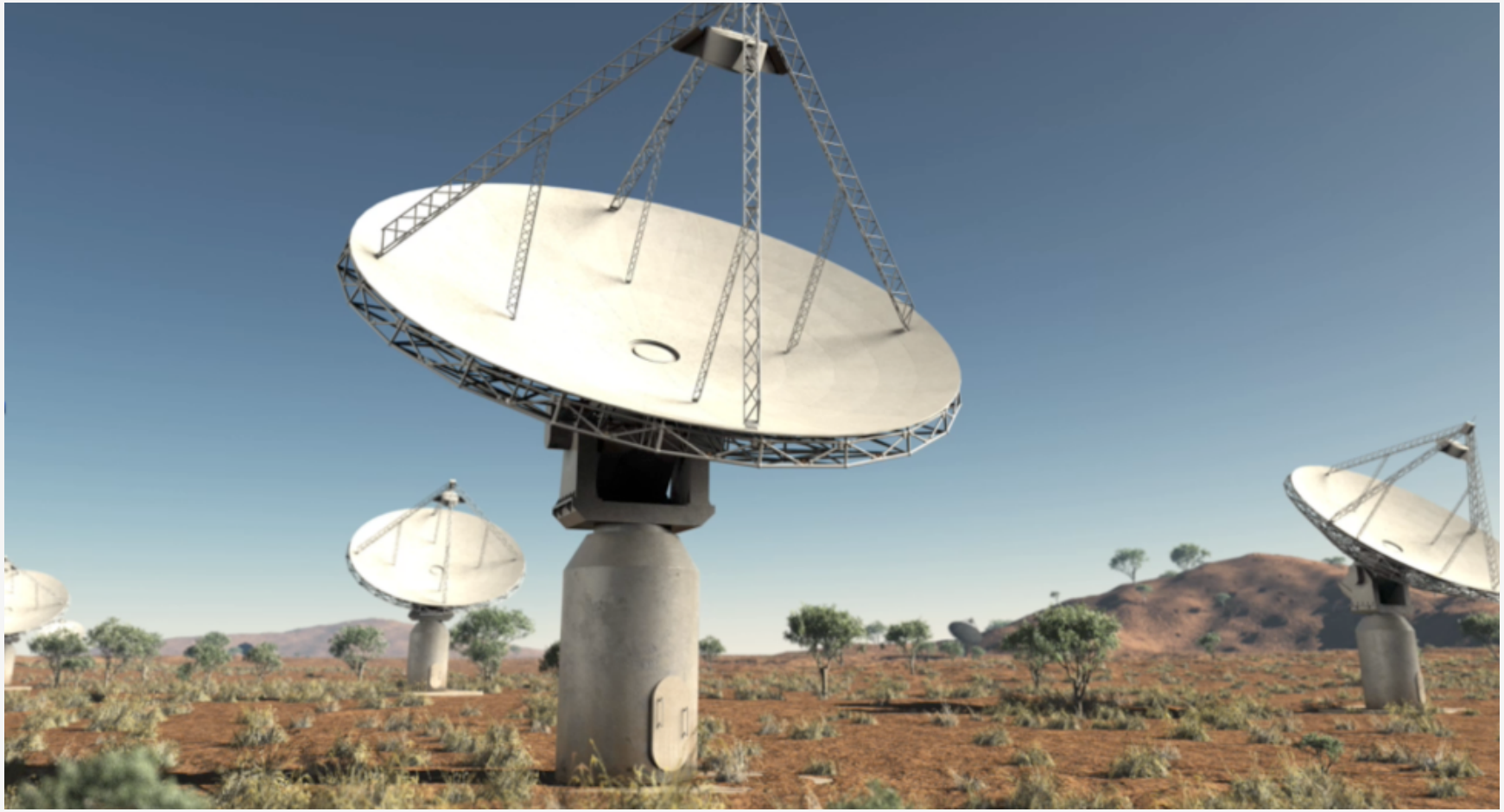
Key Collaborators:

- David Barnes
  Monash University e-Research Centre, VLSCI Life Sciences Computation Centre
- Amr Hassan (Swinburne)
- Bernard Meade (Swinburne/University of Melbourne)
- George Bekiaris (Swinburne)
- Yuri Benovitski (Monash/Bionics Institute)
- Govinda Poudel (Monash Biomedical Imaging)

7th International PHISCC Workshop

- Thanks to Thijs van der Hulst and the SOC for the invitation to speak


Planning, acquisition, comprehension and analysis
Data
Visualisation System
Knowledge discovery
Science
Publication
Presentation
Education



Credit: Swinburne Astronomy Productions

WALLABY: The ASKAP HI All-Sky Survey

Redshifted 21-cm HI; 75% of sky covered; z = 0.26 ~ 3 Gyr look-back

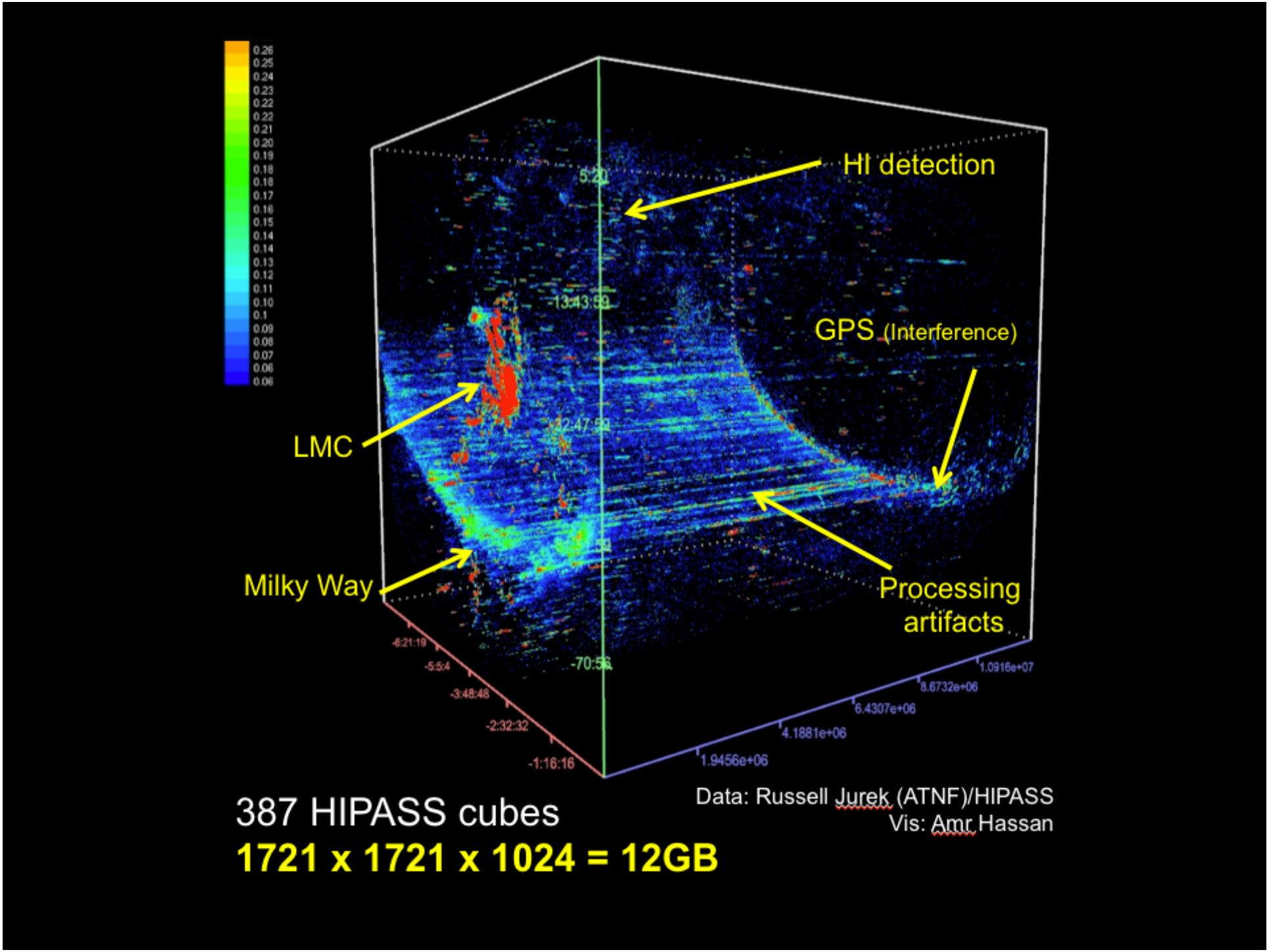
B.Koribalski (ATNF), L.Staveley-Smith (ICRAR) + 100 others…

Wallaby Data Products

Many very large files

4096 x 4096 x 16384 channels

~ 1TB per cube x 1200 cubes


HI detection
GPS (Interference)
LMC
Milky Way
Processing artifacts
387 HIPASS cubes
1721 x 1721 x 1024 = 12GB
Data: Russell Jurek (ATNF)/HIPASS
Vis: Amr Hassan

Wallaby Data Products

Many very large files

4096 x 4096 x 16384 channels

~ 1TB per cube x 1200 cubes

Can we support real-time, interactive ***visualisation*** and ***analysis*** of a WALLABY cube (e.g. quality control, alternative source-finders)?

Even more individual small files

~0.5 million new galaxies [+ false detections]

What fraction of these will we ever look at? (e.g. confirmation, morphology, discovery)

The increasing **volume** of **data** from **HI surveys**...

(**Number of spectral data cubes** × **Size of individual data cubes**)

…presents a serious **challenge** to traditional **desktop-based visualisation** and **analysis**...

…need to investigate new and emerging alternatives now.

Can we support real-time, interactive ***visualisation*** and ***analysis*** of a WALLABY cube (e.g. quality control, alternative source-finders)?

Graphics Processing Units

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

Image: http://www.nvidia.com

AMD FirePro W9000

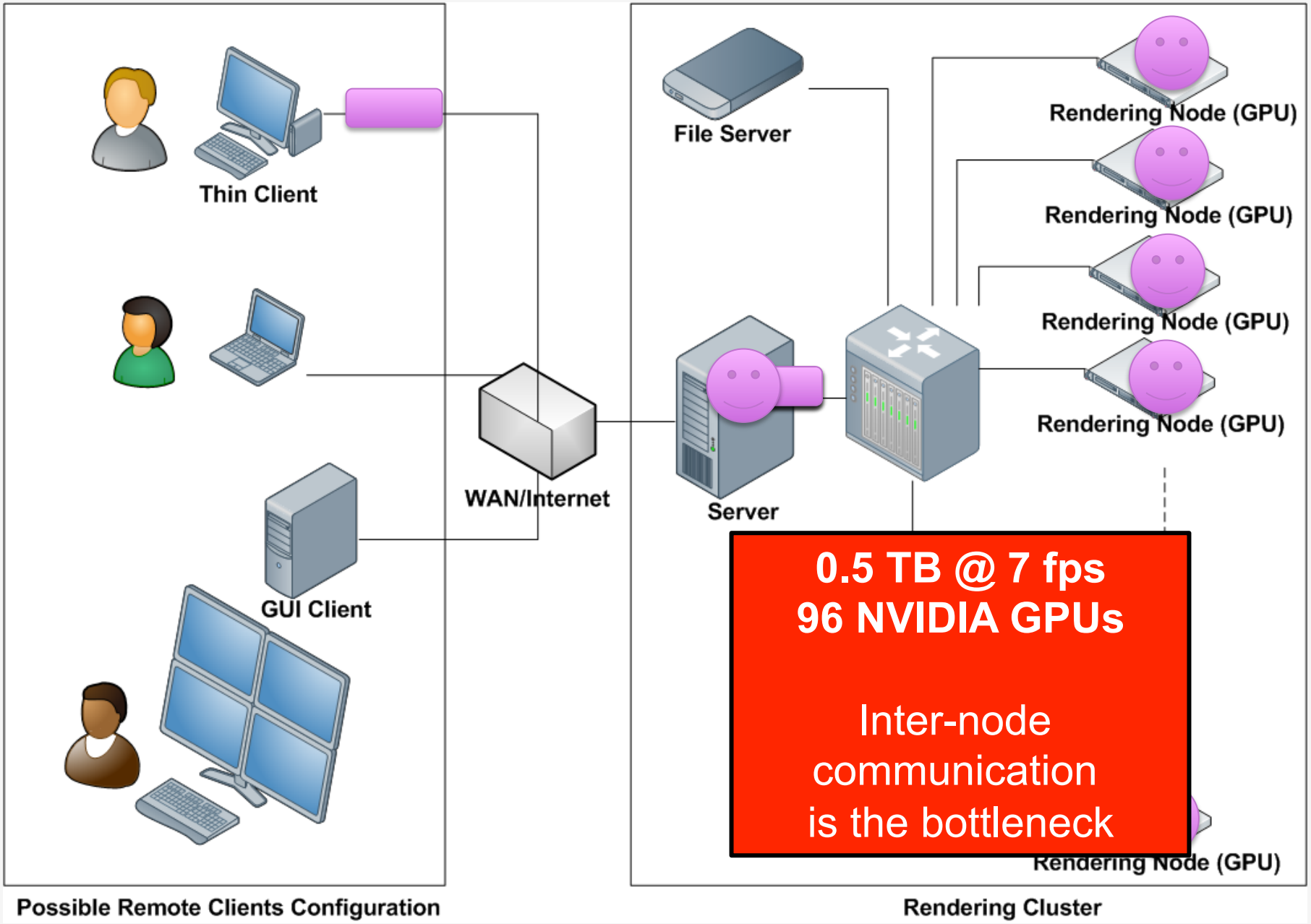
SP: 4.0 TFLOP/s
DP: 1.0 TFLOP/s

Image: http://www.amd.com


gSTAR
GPU Supercomputer for Theoretical Astrophysics Research
sgi
sgi
sgi
sgi
Australia's first fully-indoor national astronomy facility [AAL/EIF/Swinburne]
Credit: Gin Tan

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

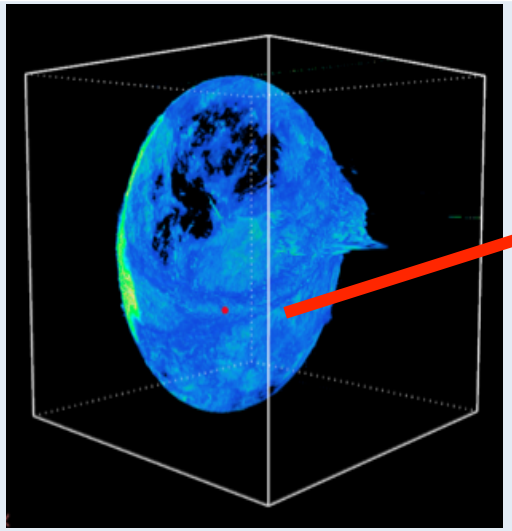
Courtesy A.Hassan



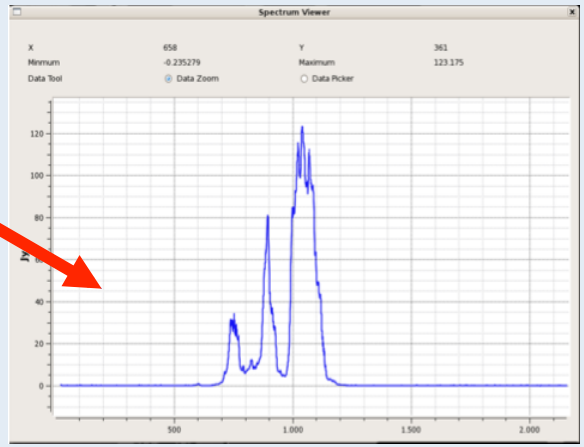
For details see: Hassan et al. (2011), NewA and Hassan et al. (2012), PASA

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)

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

CAVE2@Monash University

27320 x 3072 pixels = 84 Mpixels

Graphics power: 80 TFLOP/s

Stereo 3D/head tracking; Ring diameter ~8m; ~320 degrees FOV

Collaboration + Accelerated Discovery

Cave Automatic Virtual Environment (CAVE)

Image: Wikimedia Commons

1992: Electronic Visualization Lab, University of Illinois, Chicago

Tiled Display Walls = Commodity displays

8000×8000 pixel volume rendering of the HIPASS dataset on the CSIRO Optiportal at Marsfield, NSW.
Data: R. Jurek (ATNF) from 387 HIPASS cubes.
Vis: A.Hassan
Image: C.Fluke

Plenty of TDWs out there…

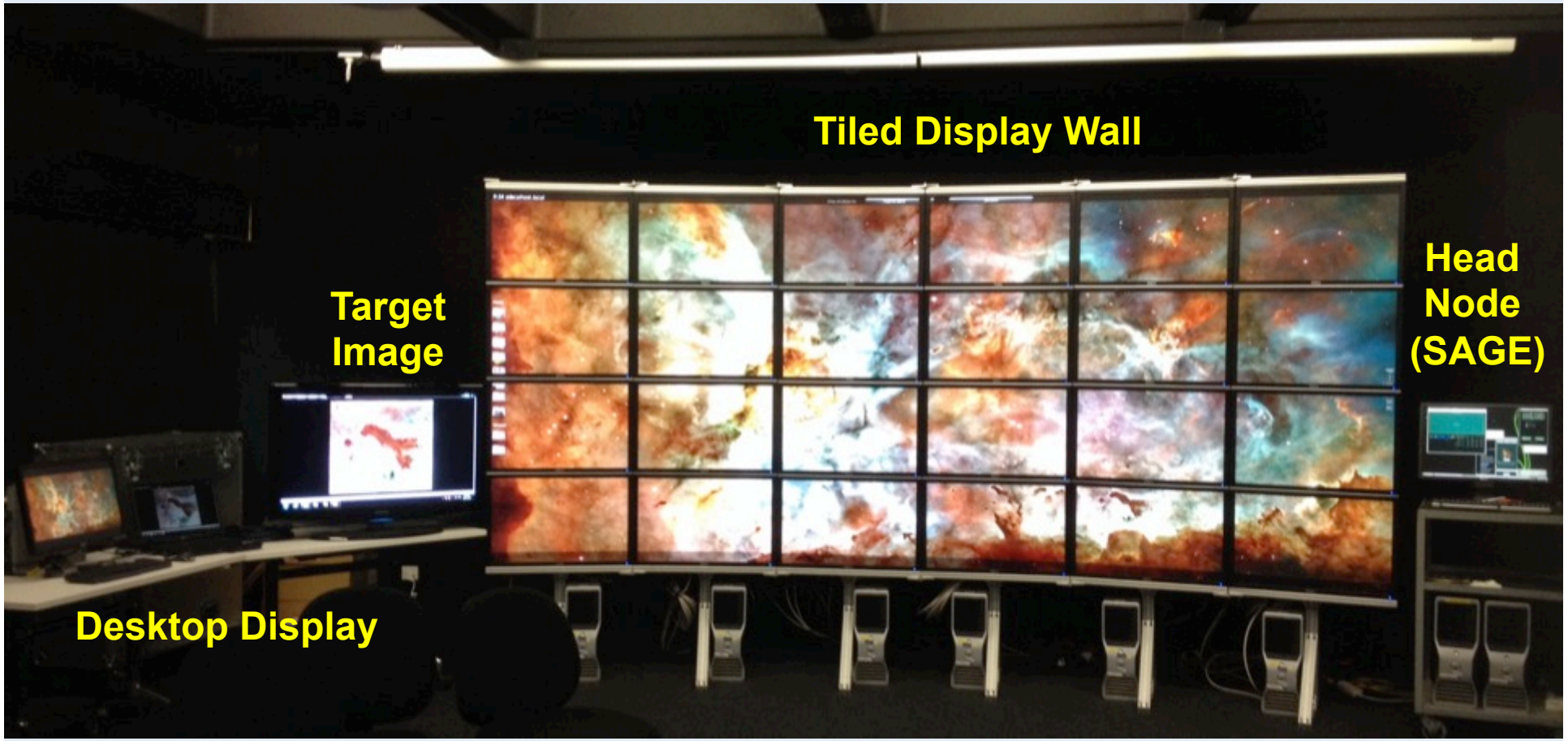
…many list astronomy as a use case…

…very little evidence of actual use.

What are they actually good for?

(Meade et al. *in prep*)

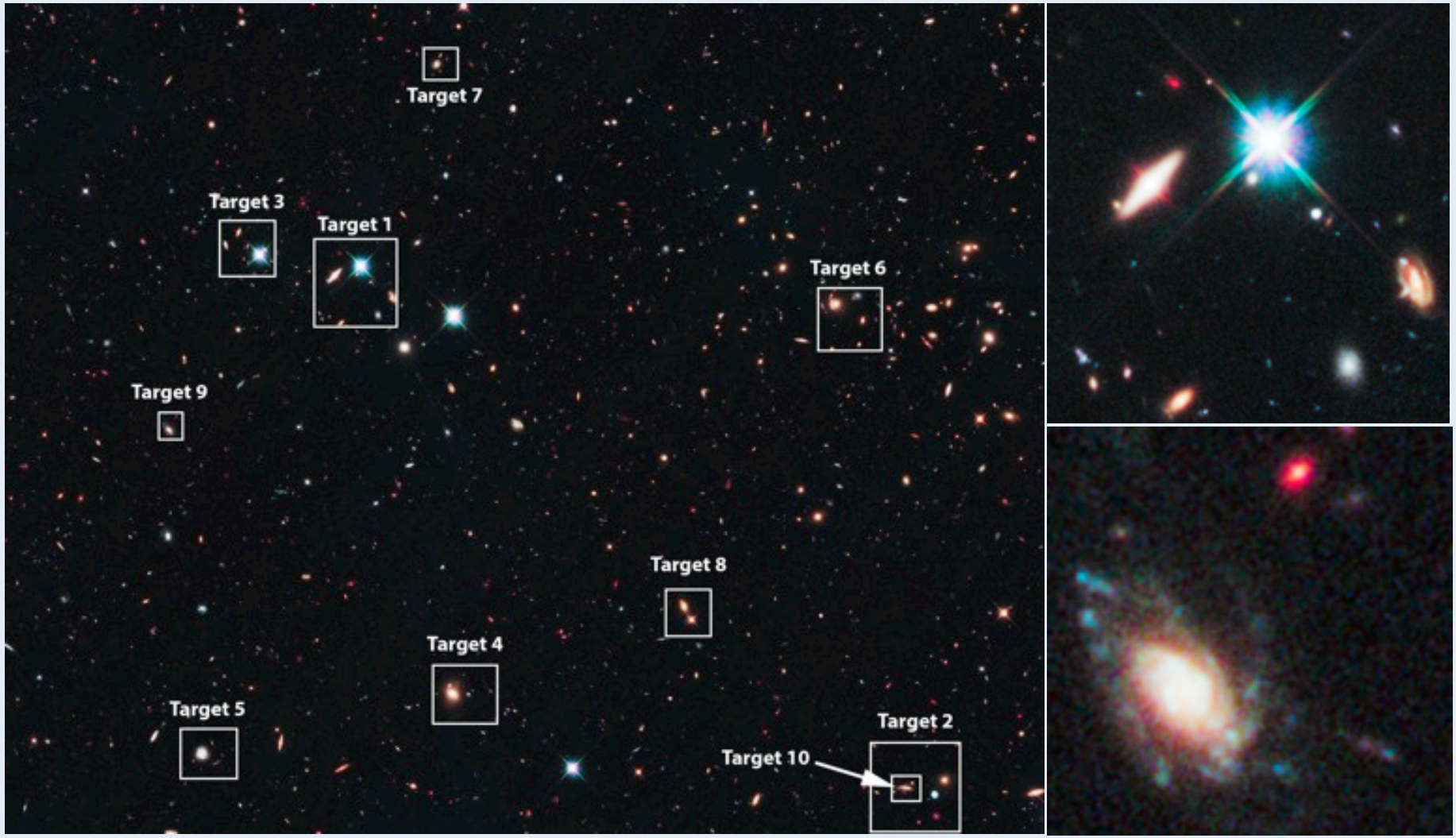
Experiment configuration: OzIPortal



15360 x 6400 pixels = 98.3 Megapixels

Data: NASA, ESA, N.Smith (UCB), and the Hubble Heritage Team (STScI/AURA)
Photo: B.Meade

Example: Galaxy Search



Images: NASA, ESA, A.Riess (STScI and JHU), D.Jones and S.Rodney (JHU), S.Faber (UCSC), H.Ferguson (STScI), and the CANDELS team.

“Search success rate”

Category	Number	Desktop	Tiled Display Wall
Astronomer	12	71%	81%
Non-astronomer	29	57%	63%
Collaboration	16	82%	89%
Overall	57	70%	77%

Most thought they did better on the TDW than reality!

Most thought TDW thought to be more “suitable” for the task

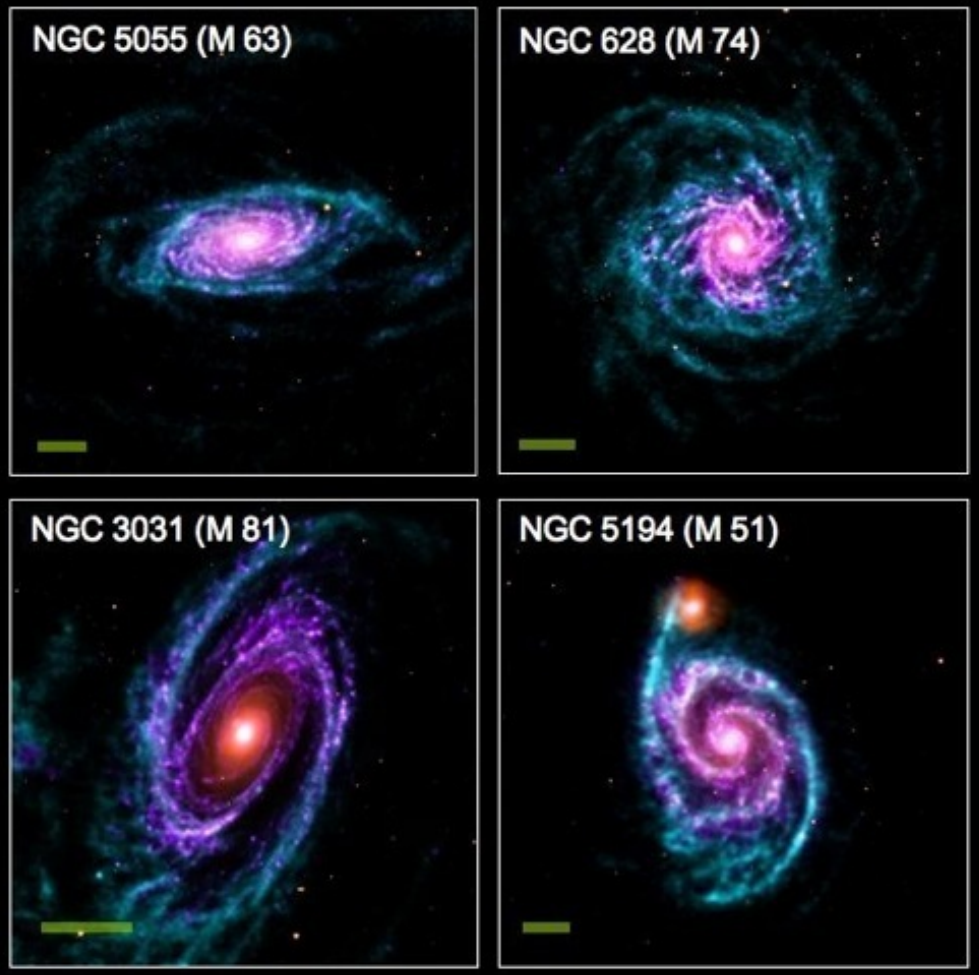
We observed *how* people use the displays

CAVE2 = 80 individual stereoscopic panels

Use the CAVE2 to look at lots of things at one time…

CAVE2 = 80 individual stereoscopic panels

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

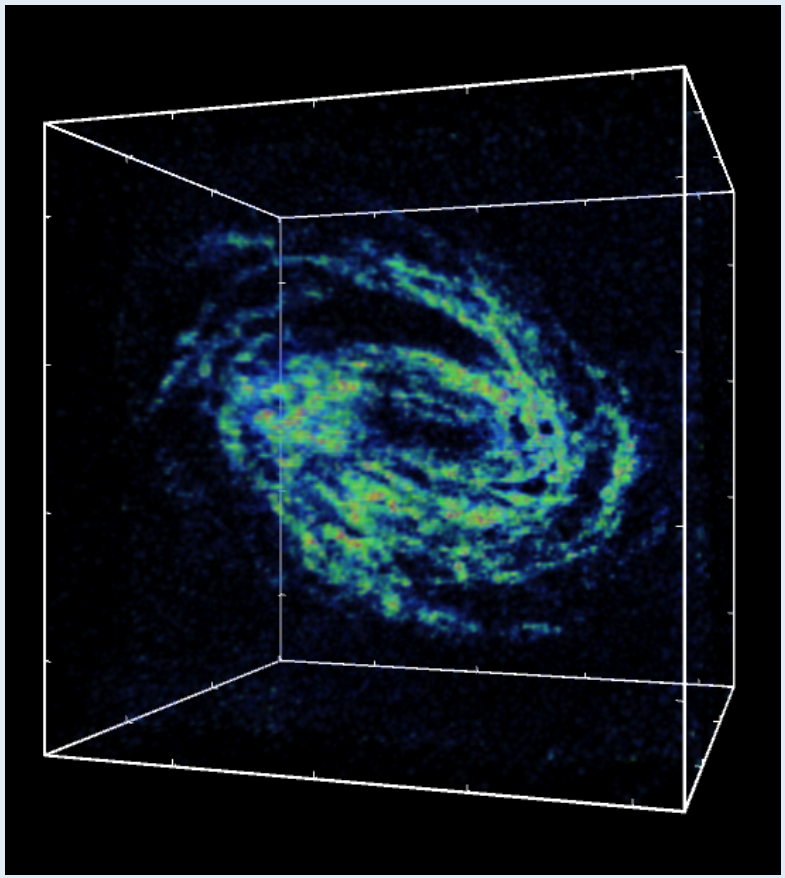


The HI Nearby Galaxy Survey

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

Image credits:
VLA THINGS: Walter et al. 08
Spitzer SINGS: Kennicutt et al. 03
GALEX NGS: Gil de Paz et al. 07

The S2PLOT programming library



Demonstration:
s2fits prototype
(NGC6946)

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

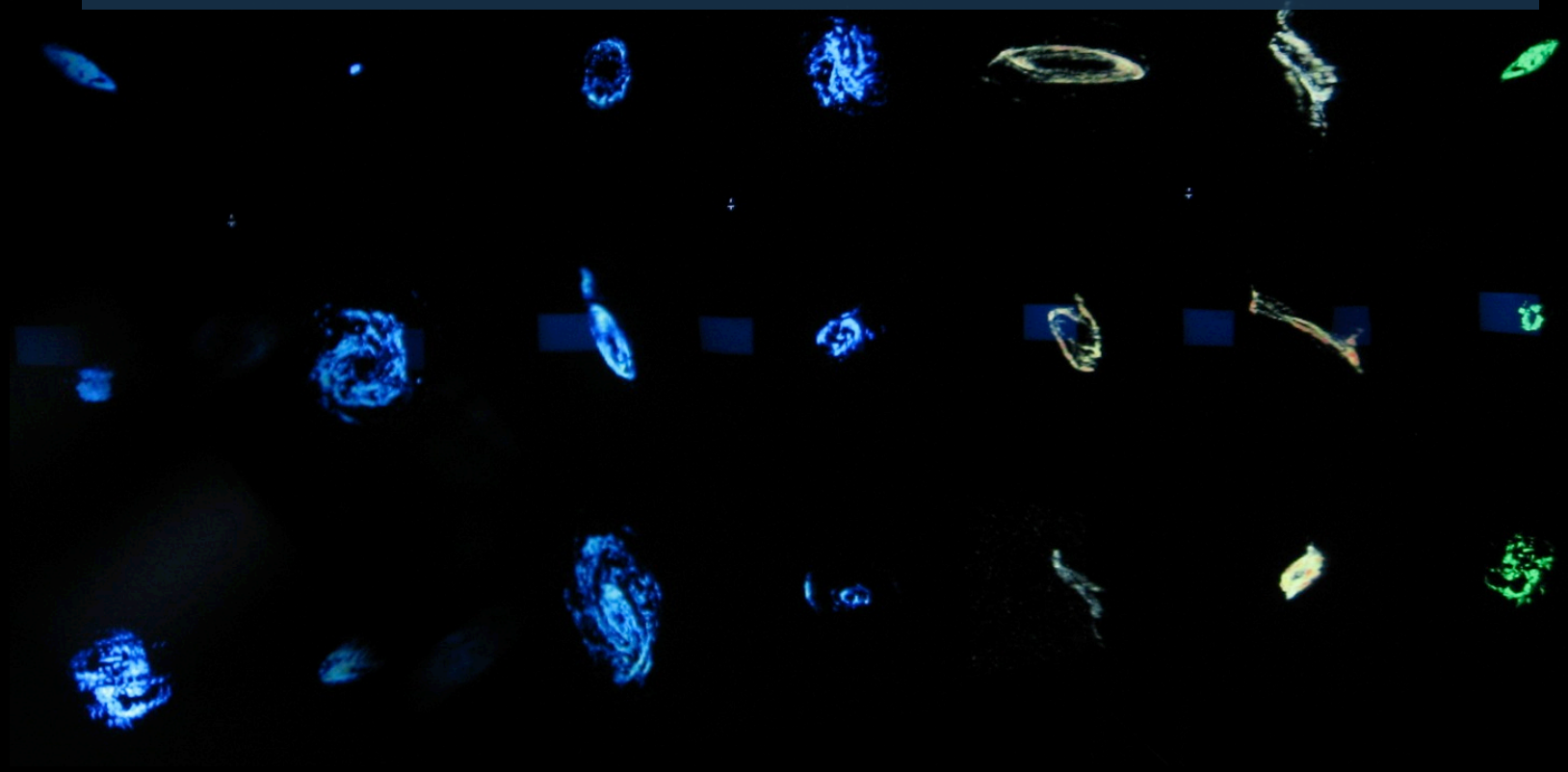
- Barnes et al. (2006), PASA, 23, 82
- http://astronomy.swin.edu.au/s2plot

- Support for advanced displays
- Support for interactive 3D PDF
  - Barnes & Fluke (2008) New Astronomy
  - Barnes et al. (2013) PLoS ONE

Performance: 160 (320?) THINGS-style data cubes

Sort by property; Sort by eye

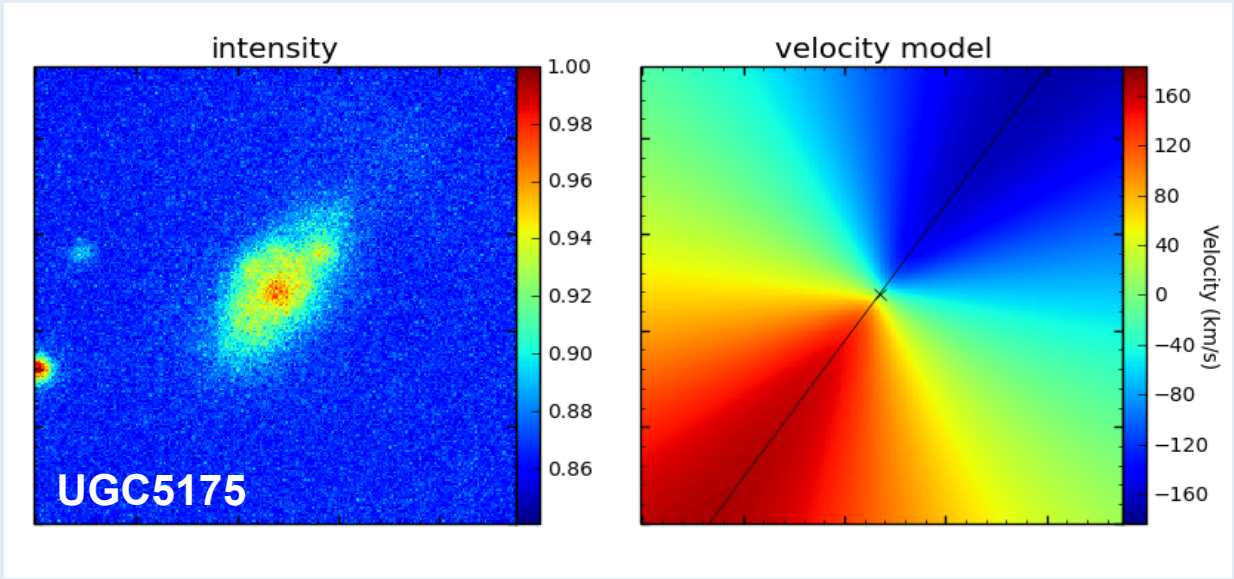
Interact with individual object + apply to all

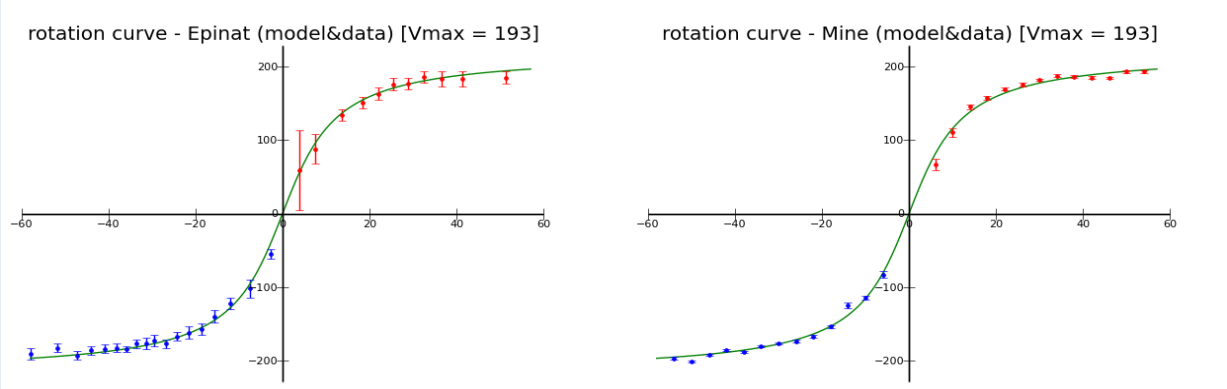


CAVE2 = GPU Supercomputer + Visualisation environment

What else can we do with all of those GPUs?

Accelerating Kinematic Modeling (Bekiaris et al. in prep)

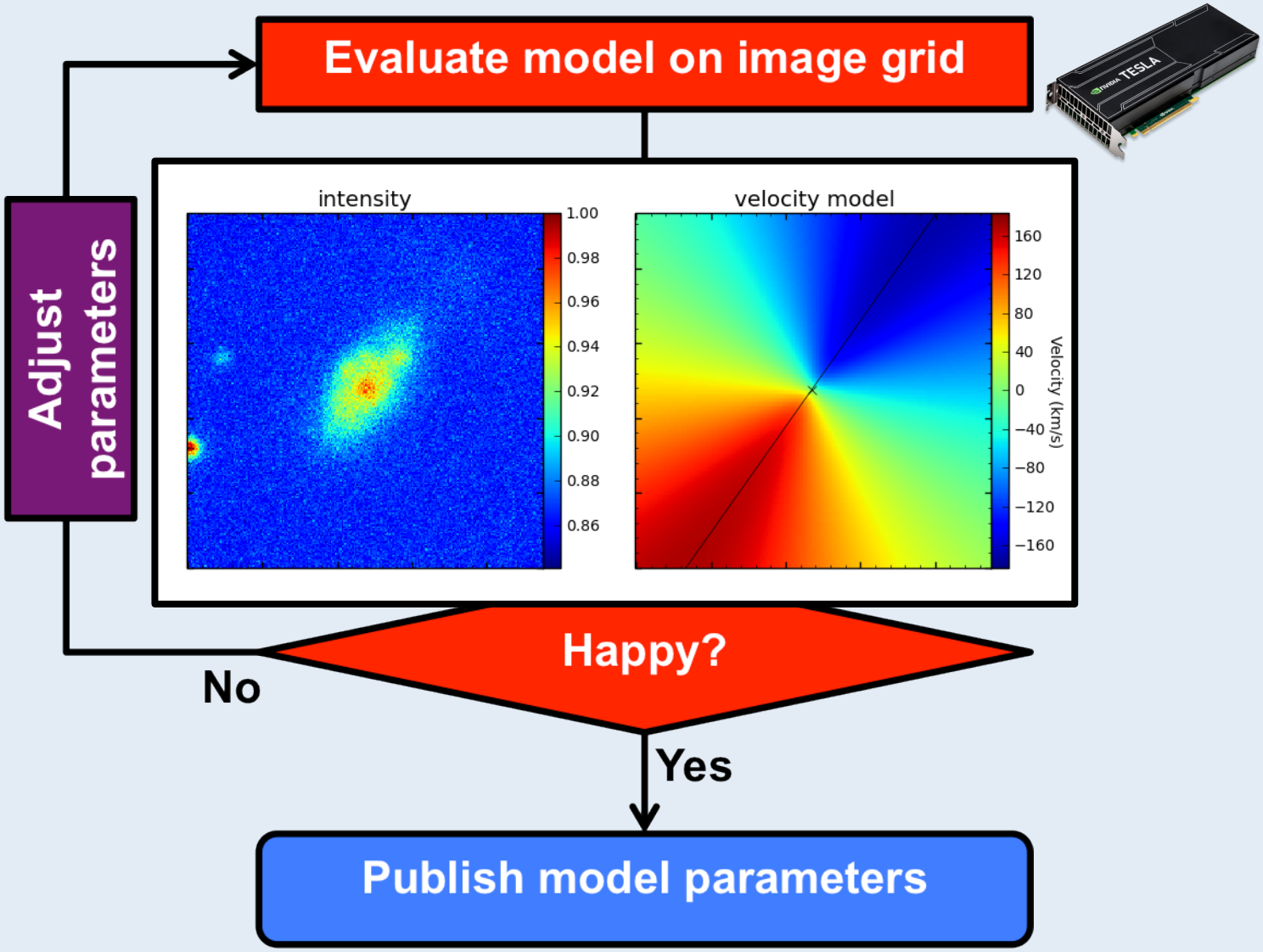




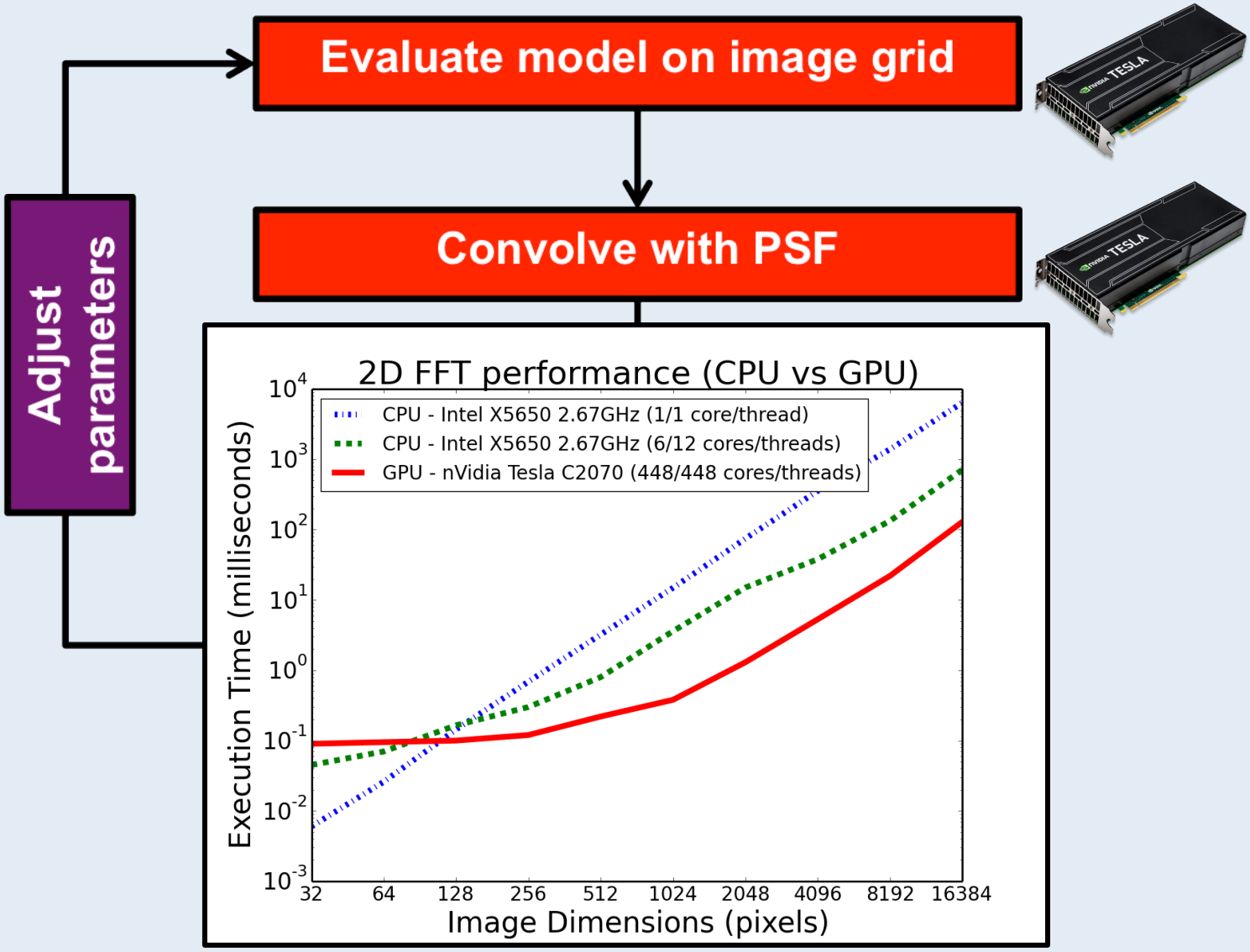
Credit: George Bekiaris

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

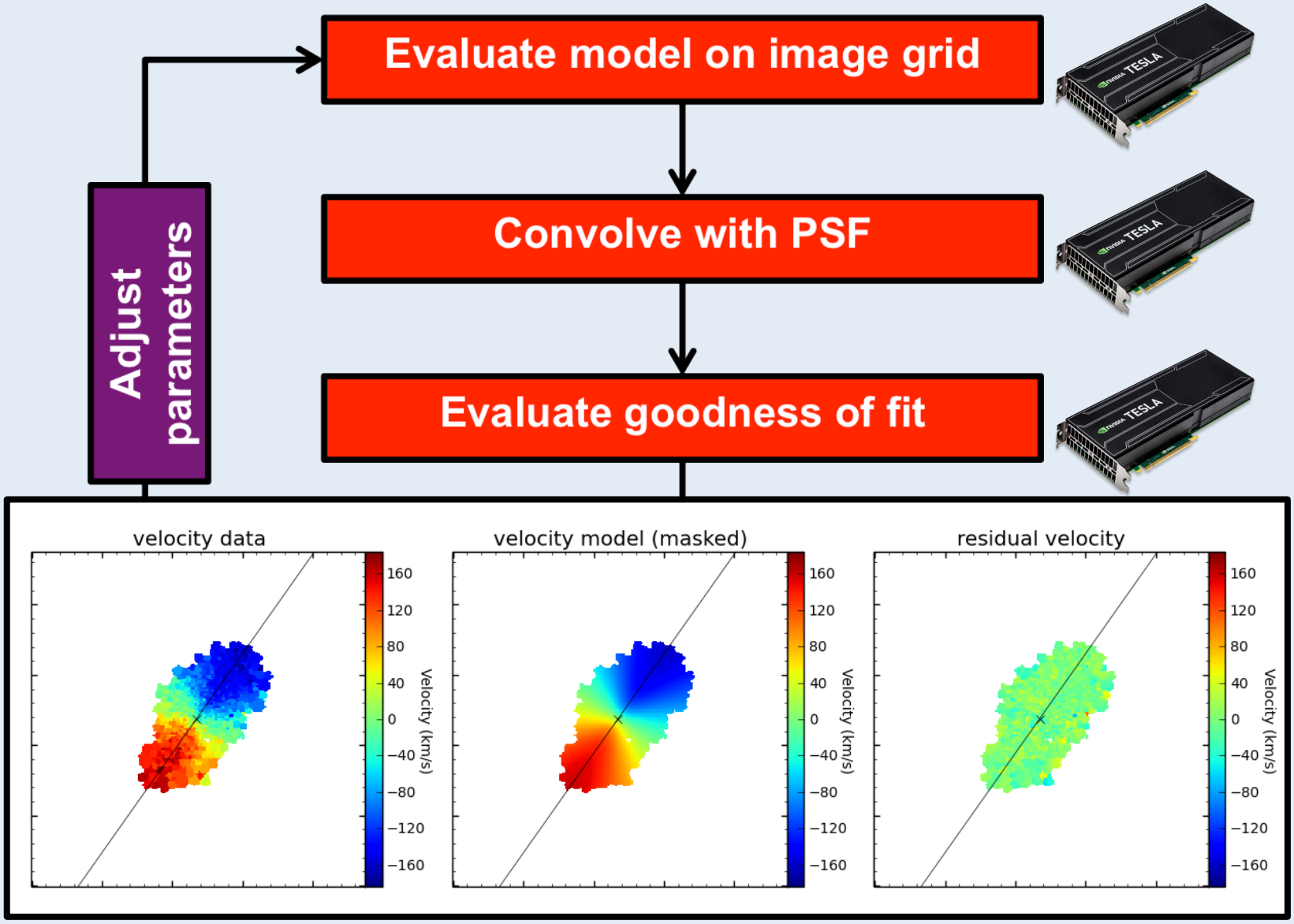
Algorithm


Evaluate model on image grid
intensity
velocity model
1.00
0.98
0.96
0.94
0.92
0.90
0.88
0.86
160
120
80
40
0
−40
−80
−120
−160
Velocity (km/s)
Adjust parameters
Happy?
No
Yes
Publish model parameters

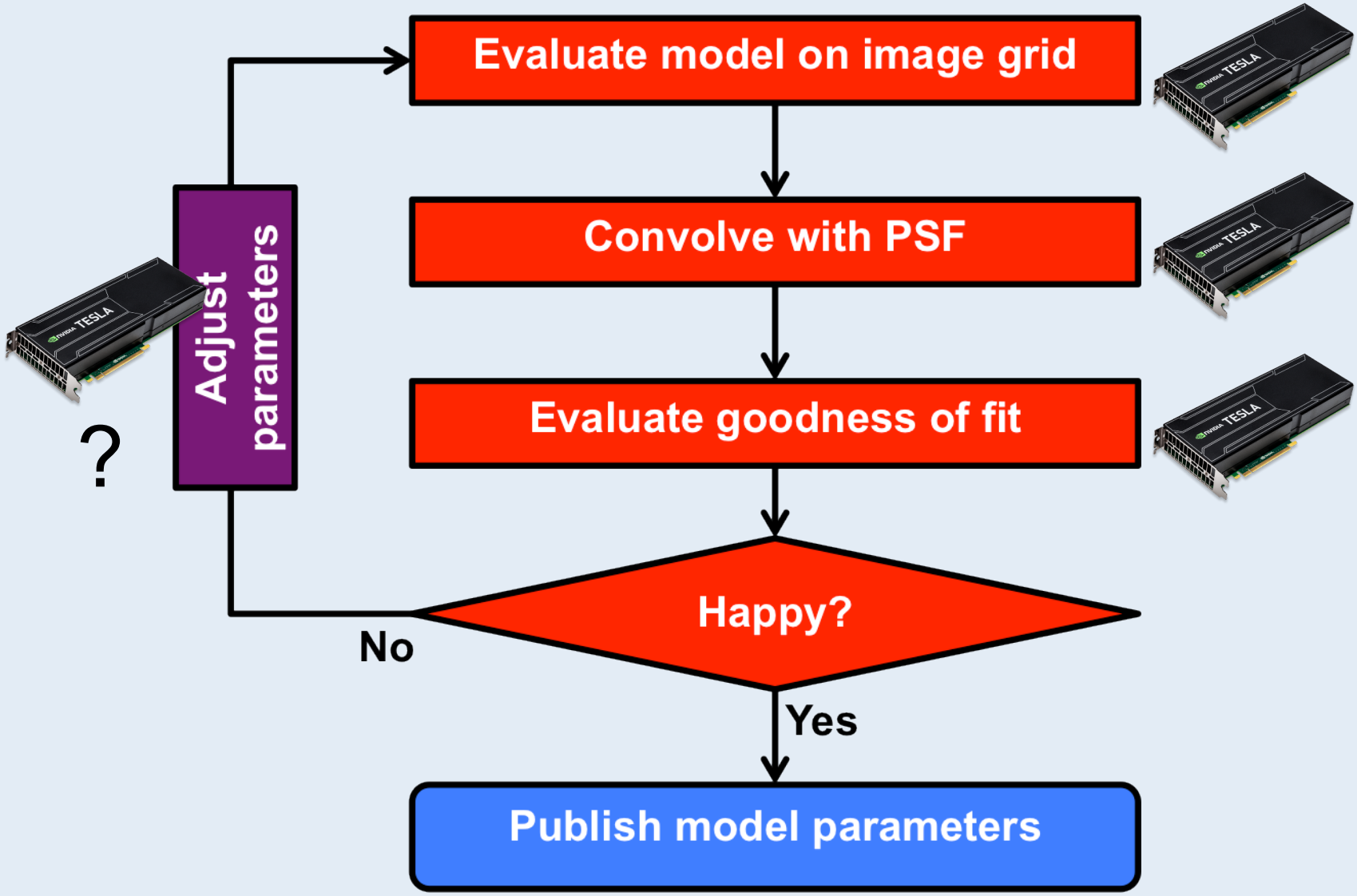
Algorithm


Evaluate model on image grid
Convolve with PSF
Adjust parameters
2D FFT performance (CPU vs GPU)
CPU - Intel X5650 2.67GHz (1/1 core/thread)
CPU - Intel X5650 2.67GHz (6/12 cores/threads)
GPU - nVidia Tesla C2070 (448/448 cores/threads)
Execution Time (milliseconds)
Image Dimensions (pixels)
32
64
128
256
512
1024
2048
4096
8192
16384

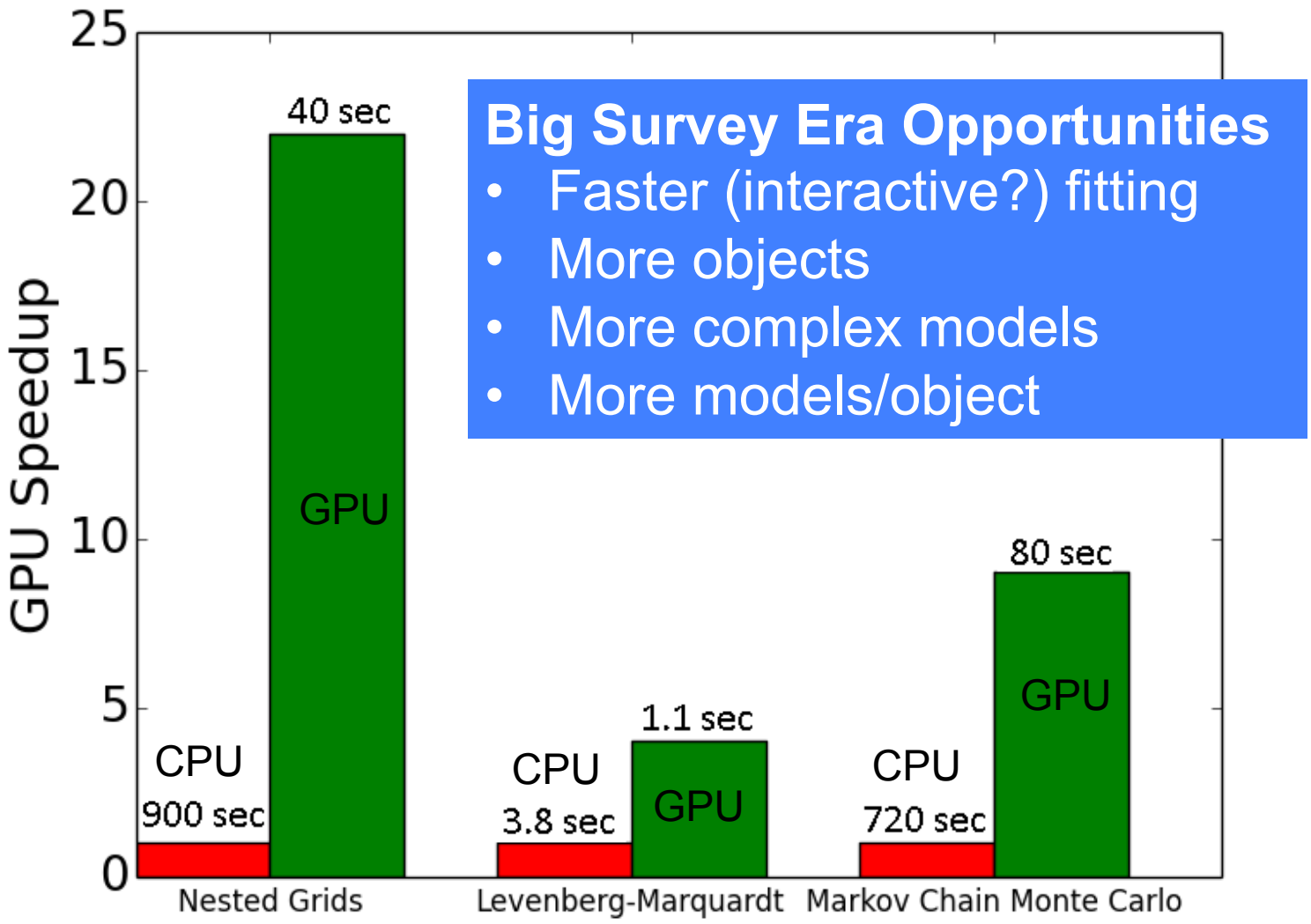
Algorithm


Evaluate model on image grid
Convolve with PSF
Evaluate goodness of fit
Adjust parameters
velocity data
velocity model (masked)
residual velocity
160
120
80
40
0
−40
−80
−120
−160
Velocity (km/s)

Algorithm


Evaluate model on image grid
Convolve with PSF
Evaluate goodness of fit
Happy?
No
Yes
Adjust parameters
?
Publish model parameters

Preliminary results



Big Survey Era Opportunities

- Faster (interactive?) fitting
- More objects
- More complex models
- More models/object

The increasing **volume** of **data** from **HI surveys**...

(**Number of spectral data cubes** × **Size of individual data cubes**)

…presents a serious **challenge** to traditional **desktop-based visualisation** and **analysis**...

…need to investigate new and emerging alternatives now.