Visualisation: Projects 2012

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Introduction

- Employment background includes visualisation in Architecture, Brain Science, Astrophysics.
- Currently Director of the iVEC@UWA Centre (The iVEC facility at UWA)
- Manage visualisation laboratory: Machines that leverage the capabilities of the human visual system.

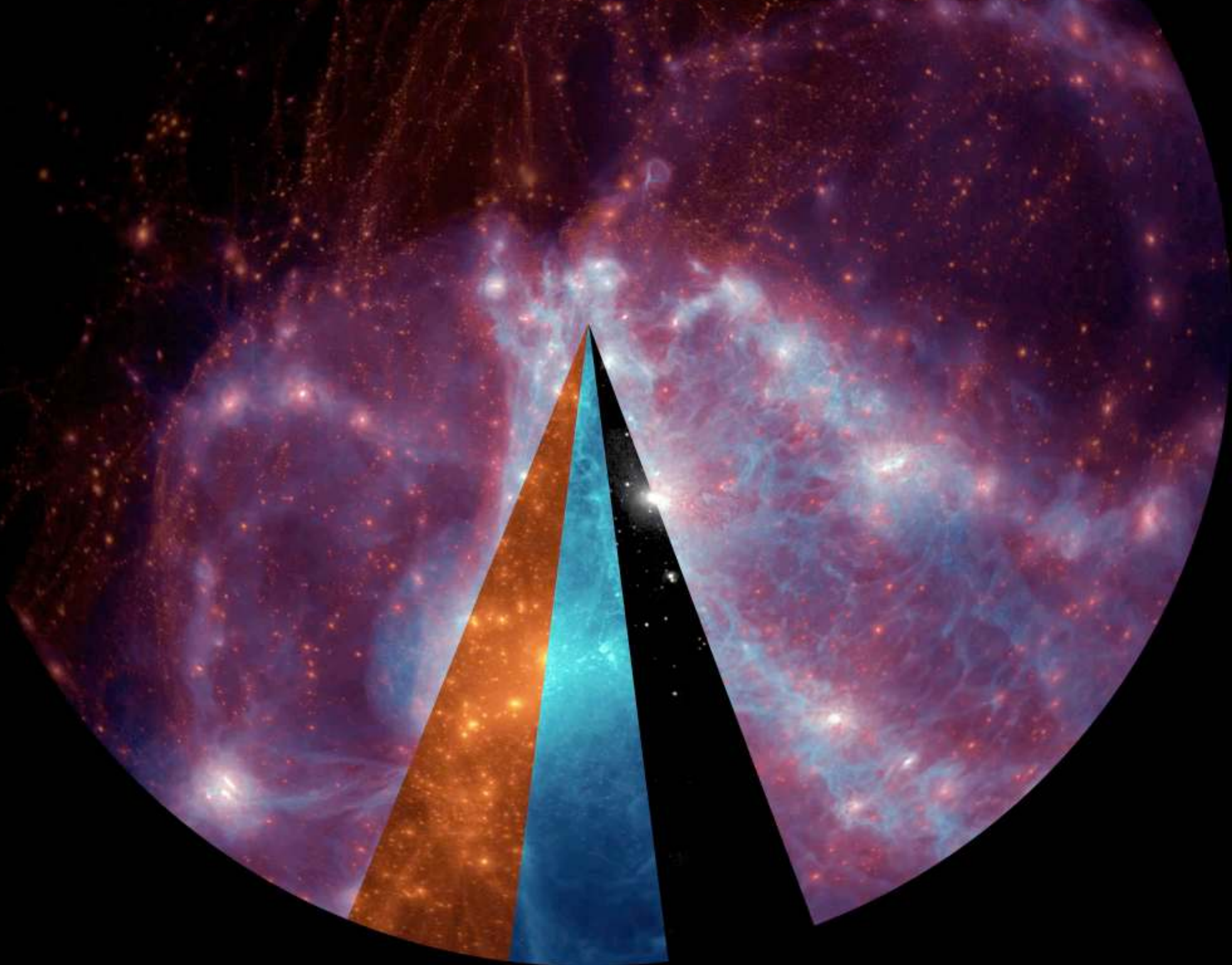
<u>Contents</u>

Visualisation

- Definition in the context of science/data visualisation
  "The use of (advanced) computer graphics and algorithms to provide insight".
- "Turning data into images and animations".
- Finds application across a wide range of disciplines.
- Often employs novel display technologies and user interfaces.
- Frequently requires high performance computing and sophisticated algorithms.
- Outcomes
  - Revealing something new within datasets.
  - Finding errors within datasets.
  - Communicating to peers.
  - Communicating to the general public.

DARK: Astrophysics

- Digital fulldome production discussing the nature of DarkMatter: the missing 80% of the Universe.
- http://darkthemovie.info
- Consists of
  - filming performed with the LadyBug-3, 360 degree x 140 degree video camera (see later).
  - visualisation of extremely large astrophysics simulations.
- Rendering for the visualisations performed on the same supercomputer on which the simulations were performed.
- Three cosmological simulations were performed: large scale structure of the Universe, small and large galaxy formation.
- Example of visualisations that were
  - originally created for the researchers also being deployed for public education.
  - presented on an immersive display, a hemispherical dome.
  - generated on iVEC supercomputers.

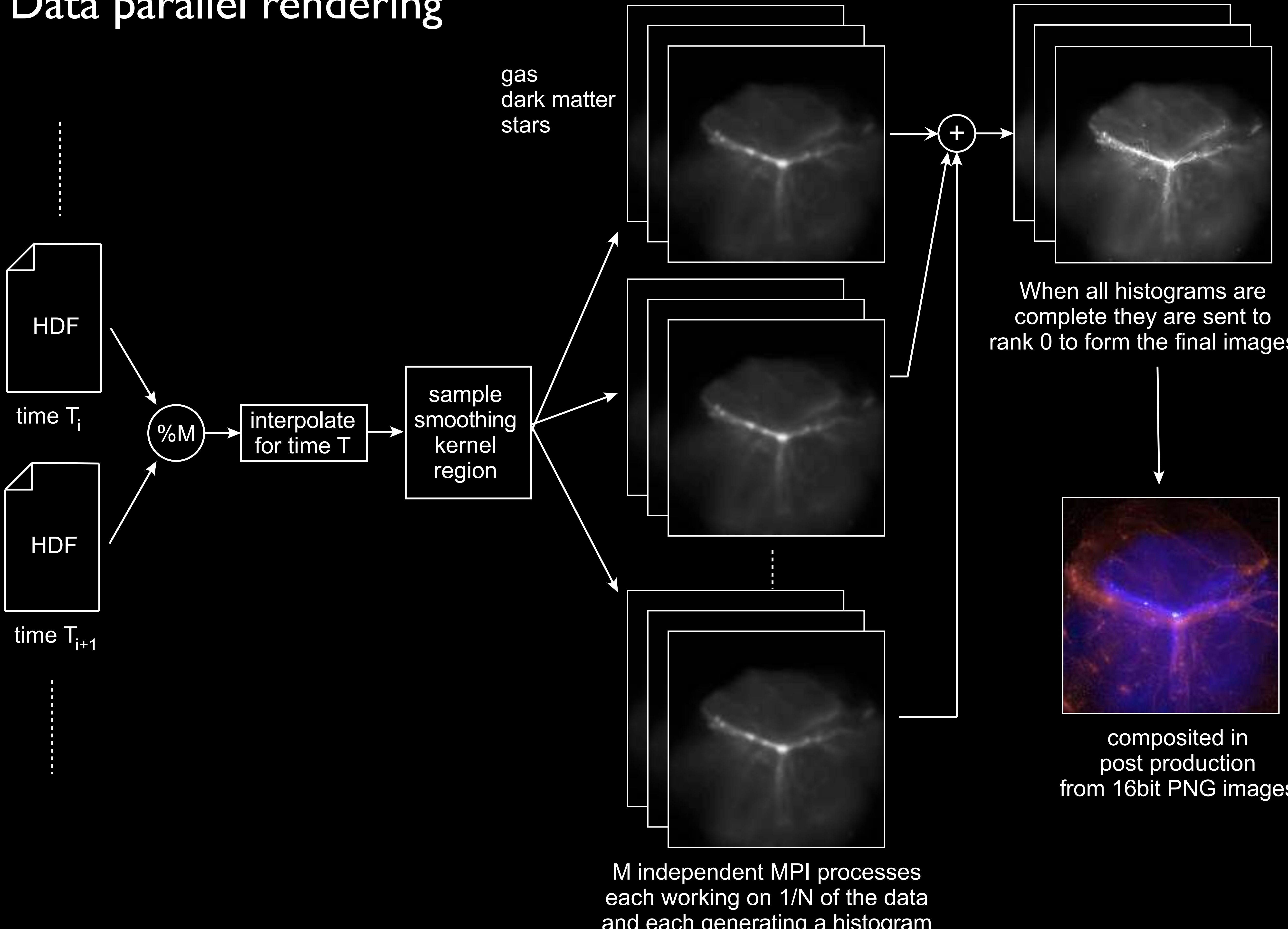


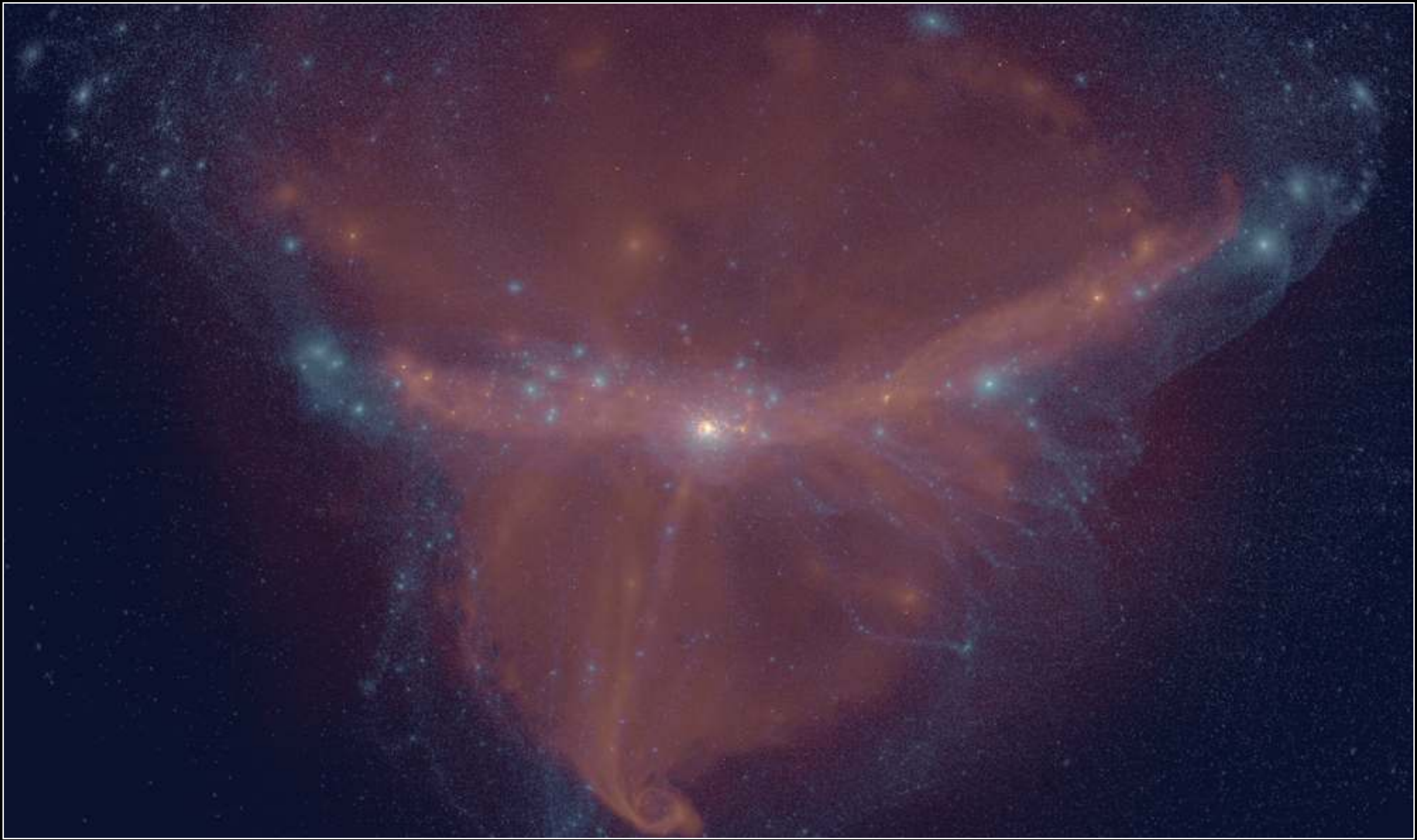
Challenges

- 1 billion “particles”. Actually harder than that, particles are not points but have a region of influence.
- Each time step is close to a 1/3 TB file, potentially hundreds of time steps to capture galaxy formation.
- Animations rendered at 4Kx4K, 8 x HD resolution.

- While it is generally preferred for visualisations to be realtime/interactive it is not always possible. May be due to the shear volume of data, or the requirement for visual fidelity.
- High performance computing is mostly about parallel processing.
[single processor cores are not increasing significantly in speed]
- No commercial software that can handle the data volumes, compute visualisations in reasonable time and represent the data correctly.
- Shortcuts or approximations may not capture important features.
- These visualisations are rendered in parallel using custom algorithms.

Data parallel rendering





4K x 4K fisheye renders

High resolution imaging: Projects in 2012

- Still photography
  - Gigapixel photography
  - Image mosaics
- Applications in site recording, geoscience, heritage.
- Video
  - 360 degree video (LadyBug 3 camera)
  - 4K video (Red camera)
  - HD stereoscopic filming
- Applications in sports science and cultural heritage.

Gigapixel photography

- Sensors in cameras are limited, what if one wanted a higher resolution image.
- Solution is to take many photographs in a grid and stitch them together.
- Solution is used in Astronomy (Hubble Space Telescope), Microscopy, Geology, etc.

40,000 by 20,000 pixels

Hurleys darkroom, Mawsons hut (Antarctica), courtesy Peter Morse.

Example: Biological imaging

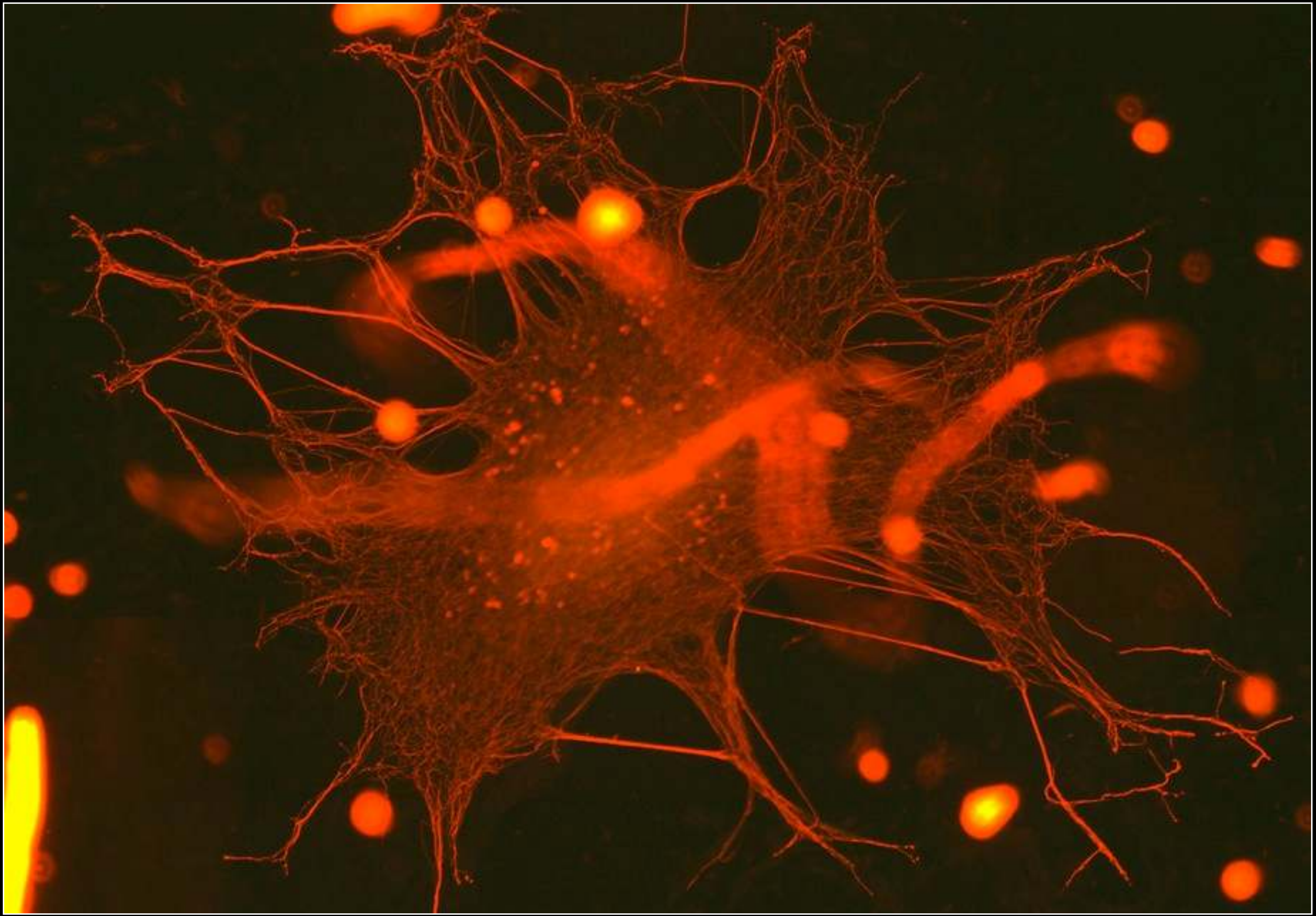
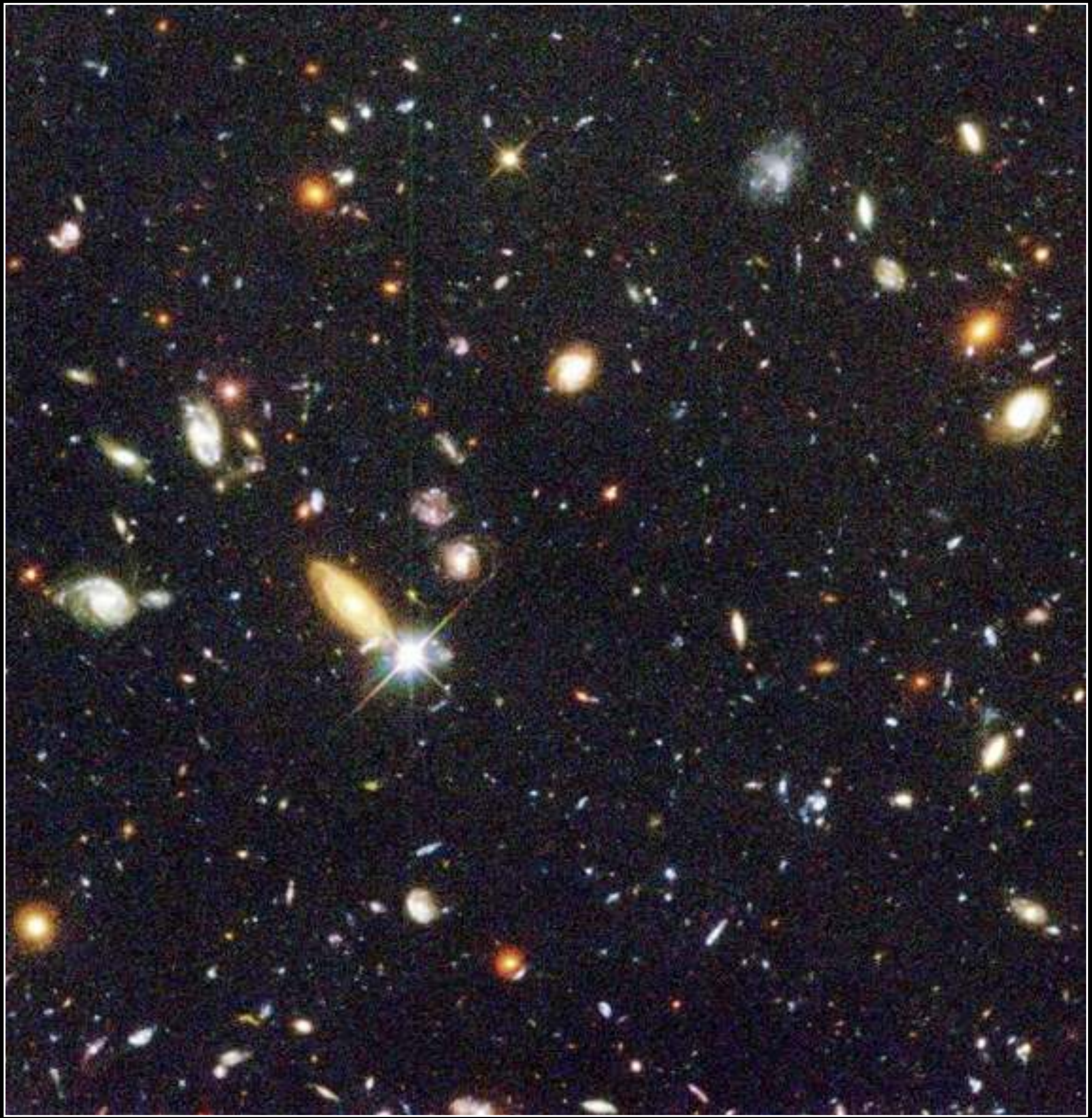


Image courtesy CMCA, UWA

11,000 x 8,000 pixels

Example: Hubble Deep Field



Hubble deep field, 340 images.

Project: Wanmanna (rock art site)

13 x 3 grid

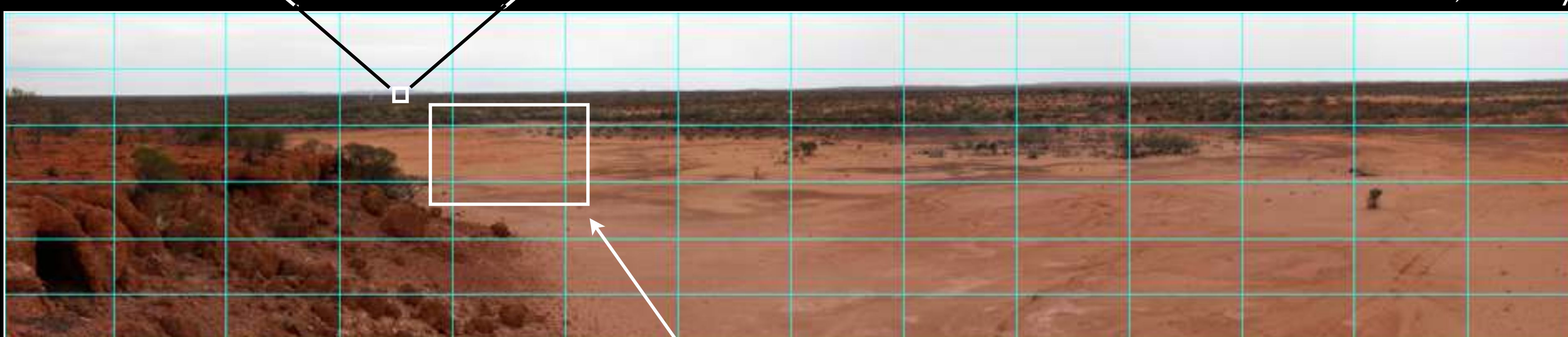
40,000 x 10,000 pixels

Project: ASKAP site

First ASKAP dish

Canon EOS 5D MkII camera
and gigapan mount

ASKAP site, Boolardy

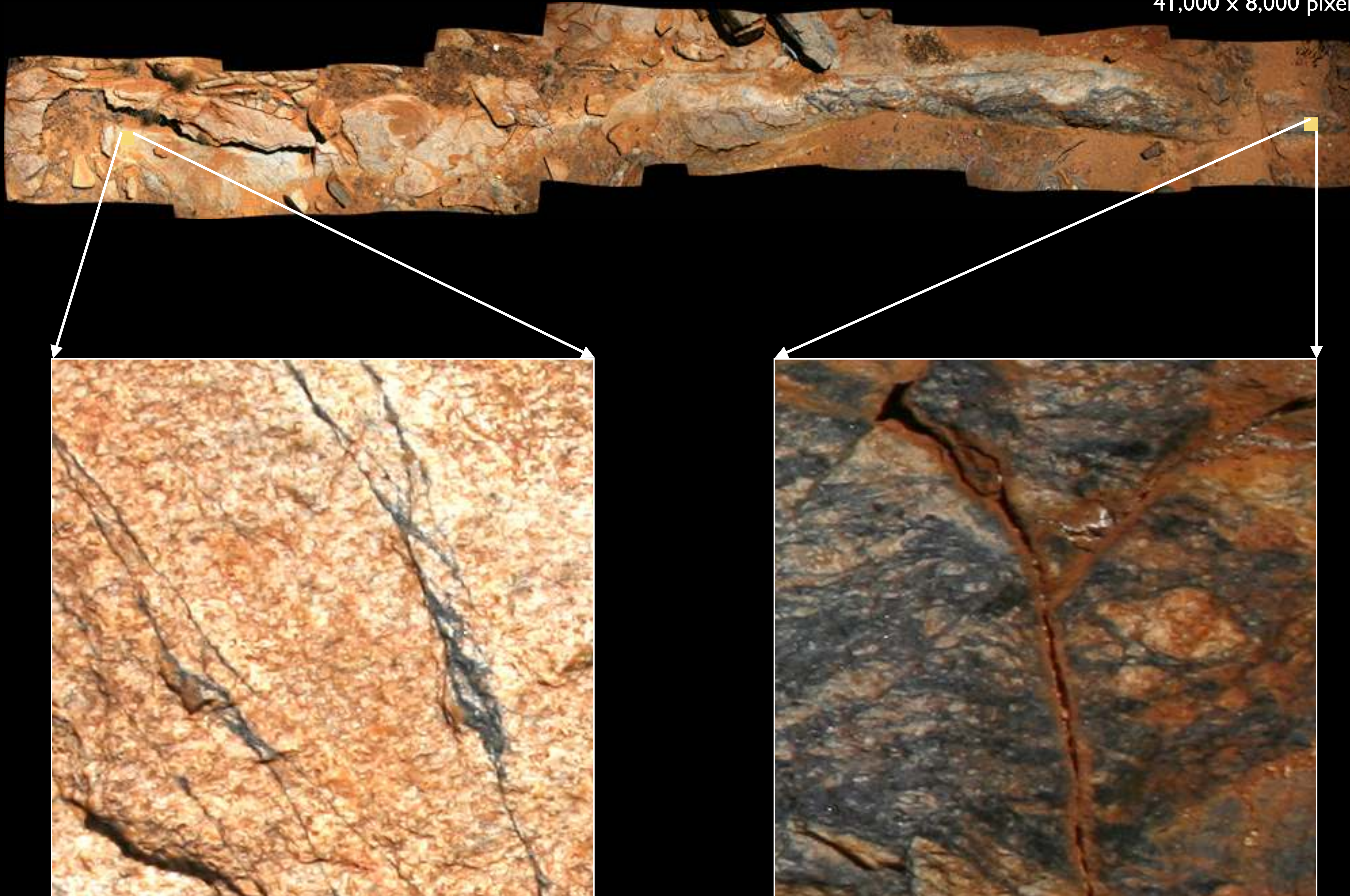


21 MPixels, Canon EOS 5D Mk11

Total: 1.5 GPixels

Image mosaics: Geology

41,000 x 8,000 pixels



Courtesy Ivan Zibra

Project: Clarence Shipwreck

45,000 x 15,000 pixels

Tiled displays

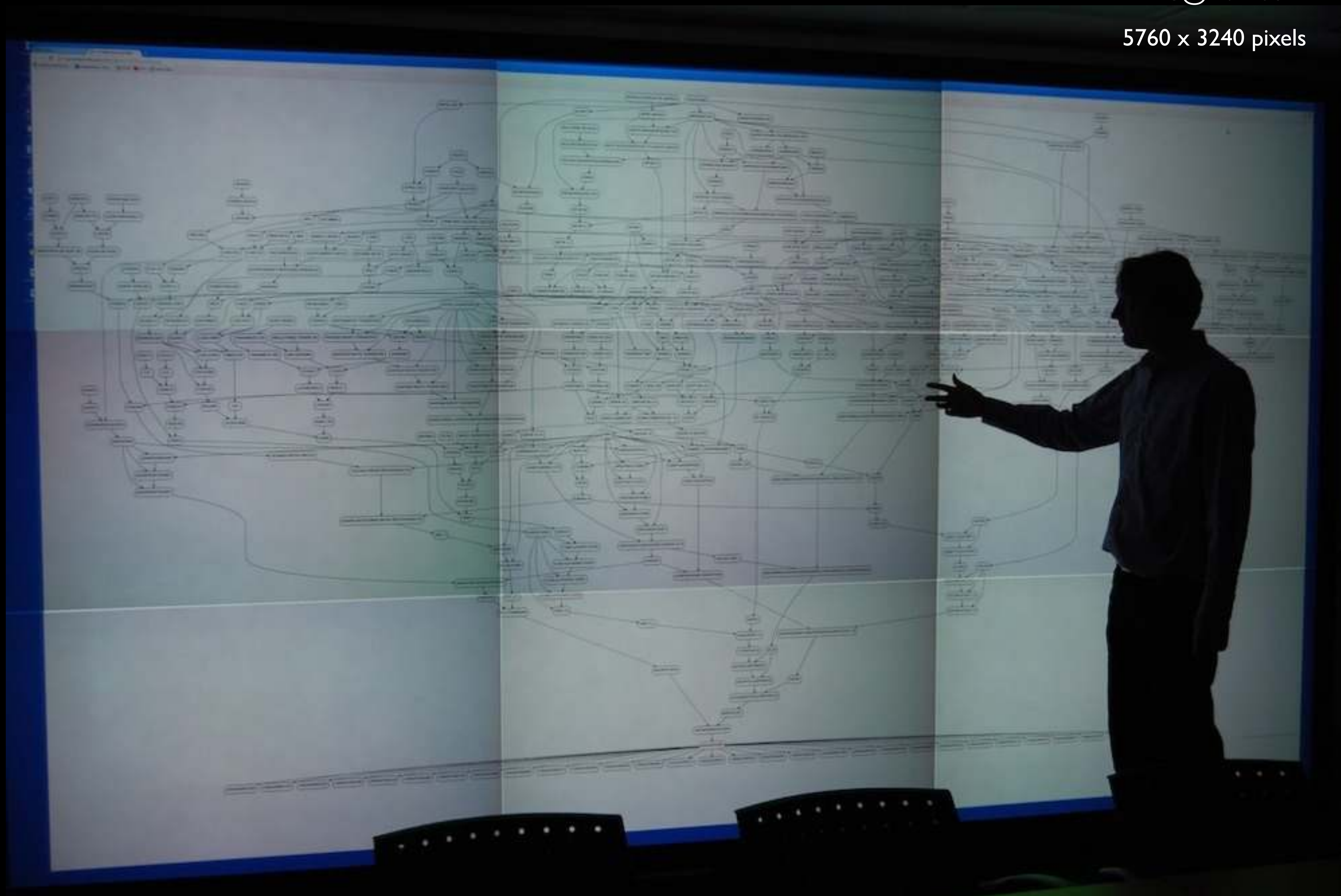
- High resolution displays are often employed to study these images.
- Avoids the "Google Earth Effect"
  - zoom in to see detail but lose the context.
  - zoom out to see the context but lose detail.
- Zooming is achieved by physically moving closer or further away from the wall.

HD display

iVEC@UWA
32MPixels
(6400 x 5120 pixels)

Cape Lambert
(NearMap, 5cm resolution)

Tiled displays



iVEC@Murdoch

5760 x 3240 pixels

360 video capture

5400 x 2700 pixels

Hashibektashi Dancers

Project: iJiao

- 360 degree video of various Taiping Qingjiao, also known as the Jiao festival.
- “The festivals, held throughout Hong Kong, appease the ghosts and give thanks to the deities for their protection. They take place every year or every five, eight, or ten years, depending on local customs. The religious rituals involved are meant to purge a community and prepare it for a new beginning.”
  [Sarah Kenderdine]

5400 x 2700 pixels

AVIE

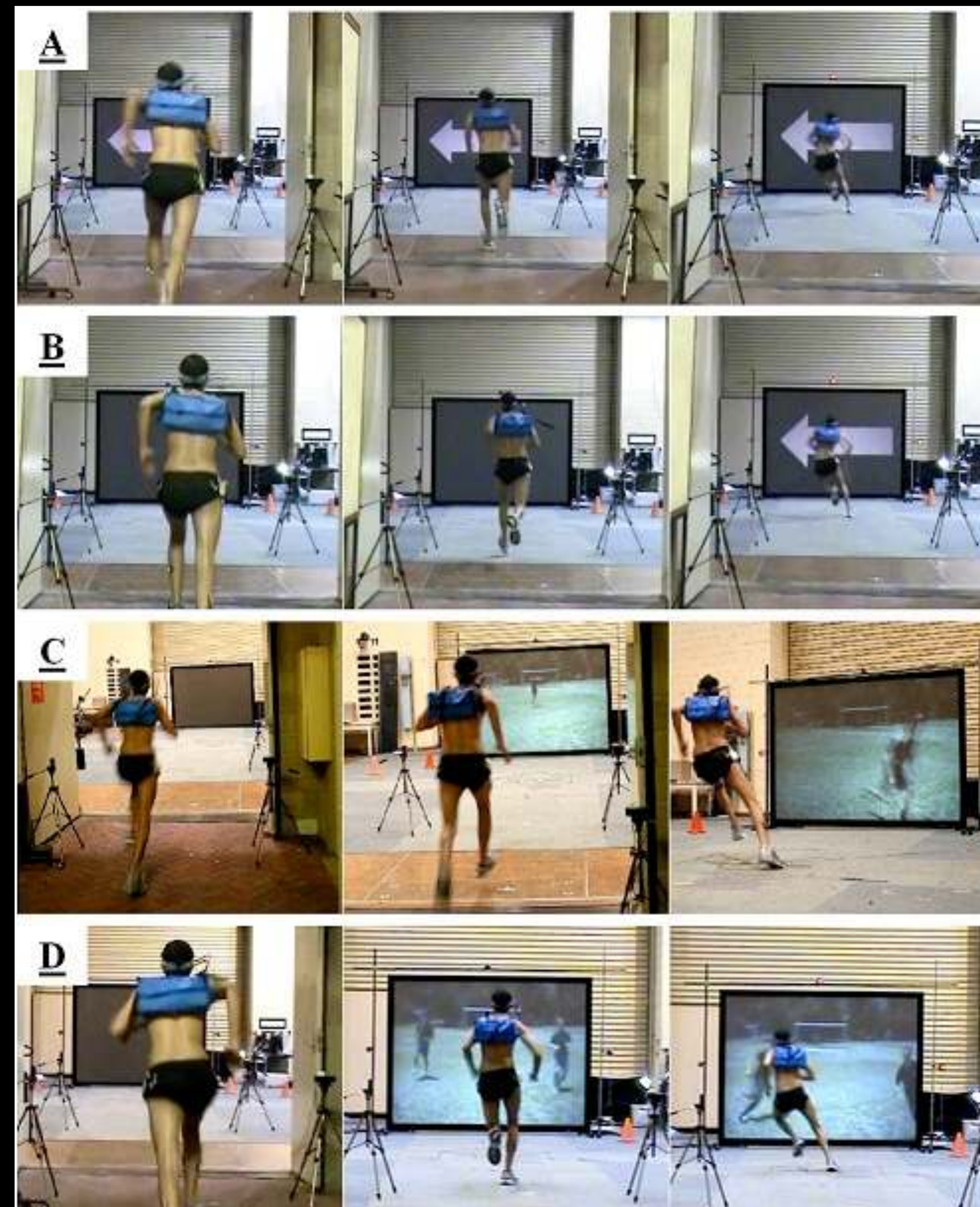
School of Creative Media, CityU, Hong Kong

Project: Sports science

- 4K filming for immersive dome environment.
- Red Scarlet camera and fisheye lens.

Project: HD Stereoscopic filming in Sports science

- Challenge is to get a correct sense of depth.
- Achieved with precise control of the recording optics.

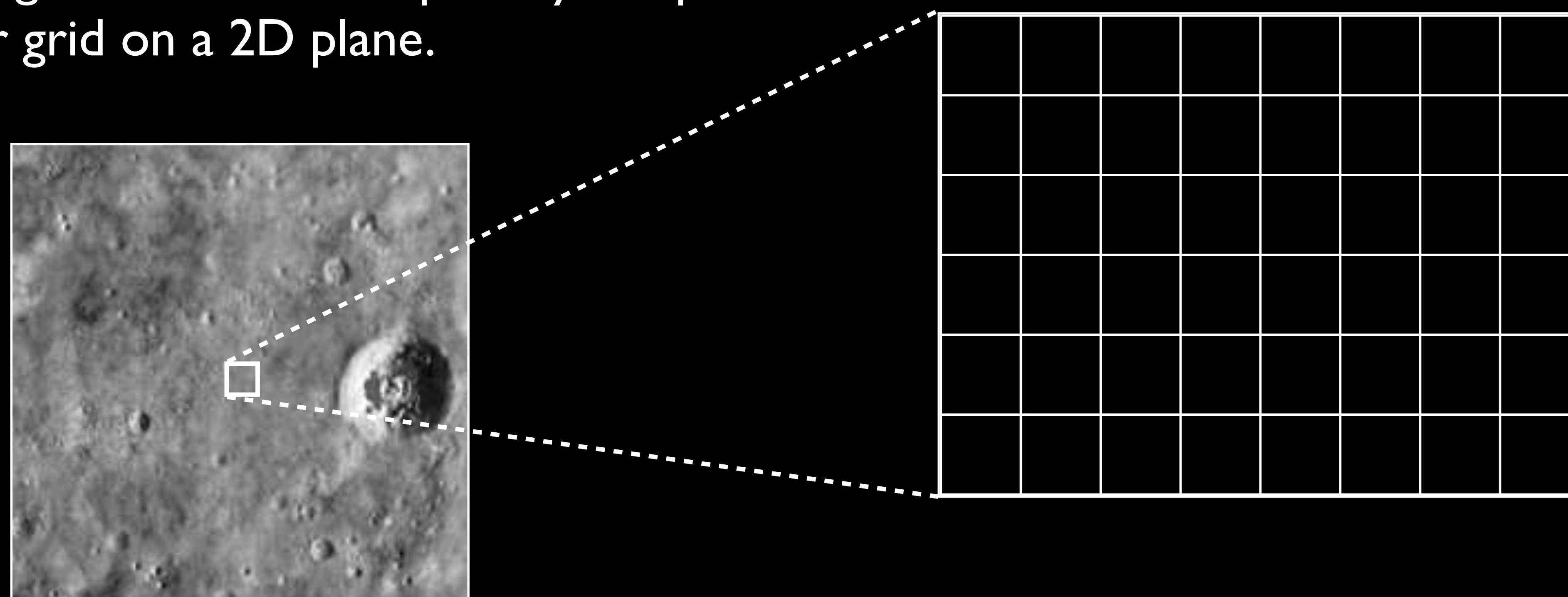


Pausiris: Volume rendering

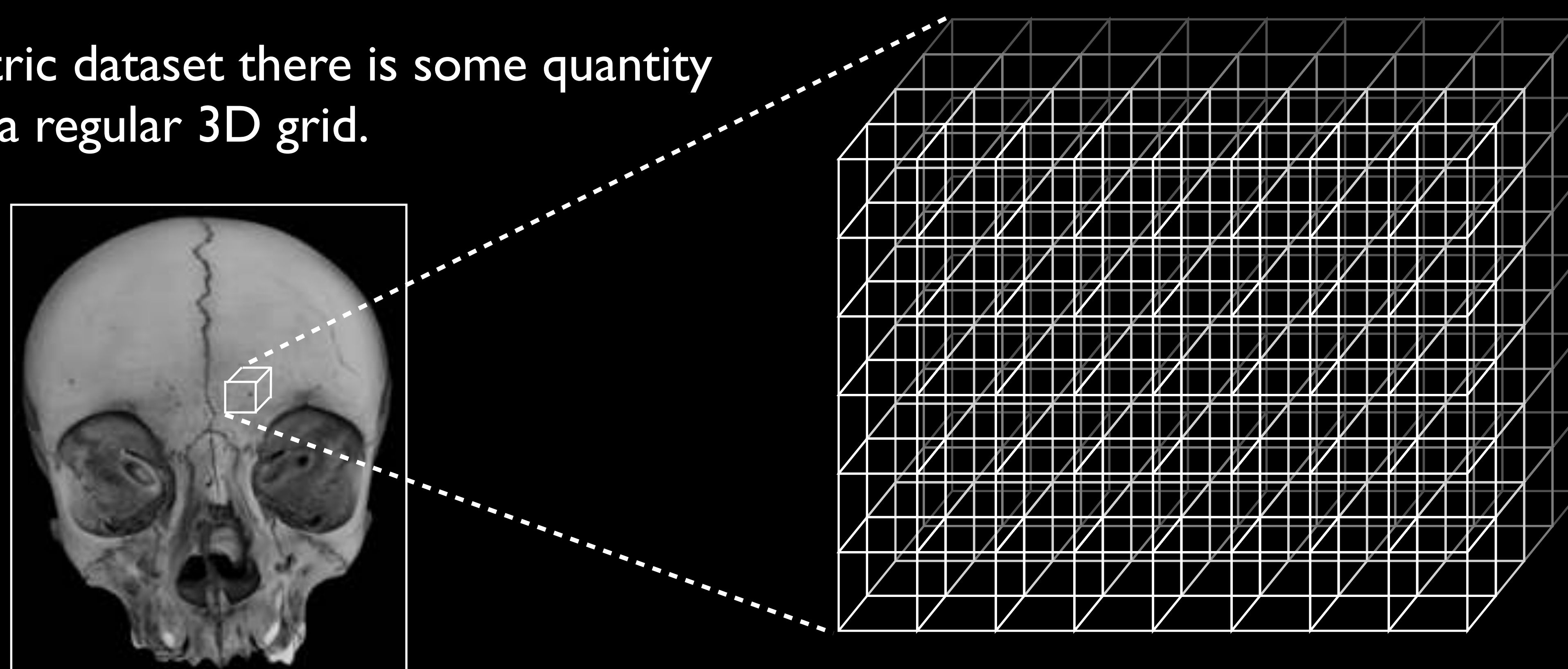
- Installation at MONA
  Museum of Old and New Art, Hobart.
- http://paulbourke.net/exhibition/MONA/
- Volumetric datasets are encountered across a wide range of disciplines: medical scanners, microCT scanning, astronomy surveys, finite element data in engineering, climate models ...

Volumetric data

- A digital image contains some quantity sampled on a regular grid on a 2D plane.



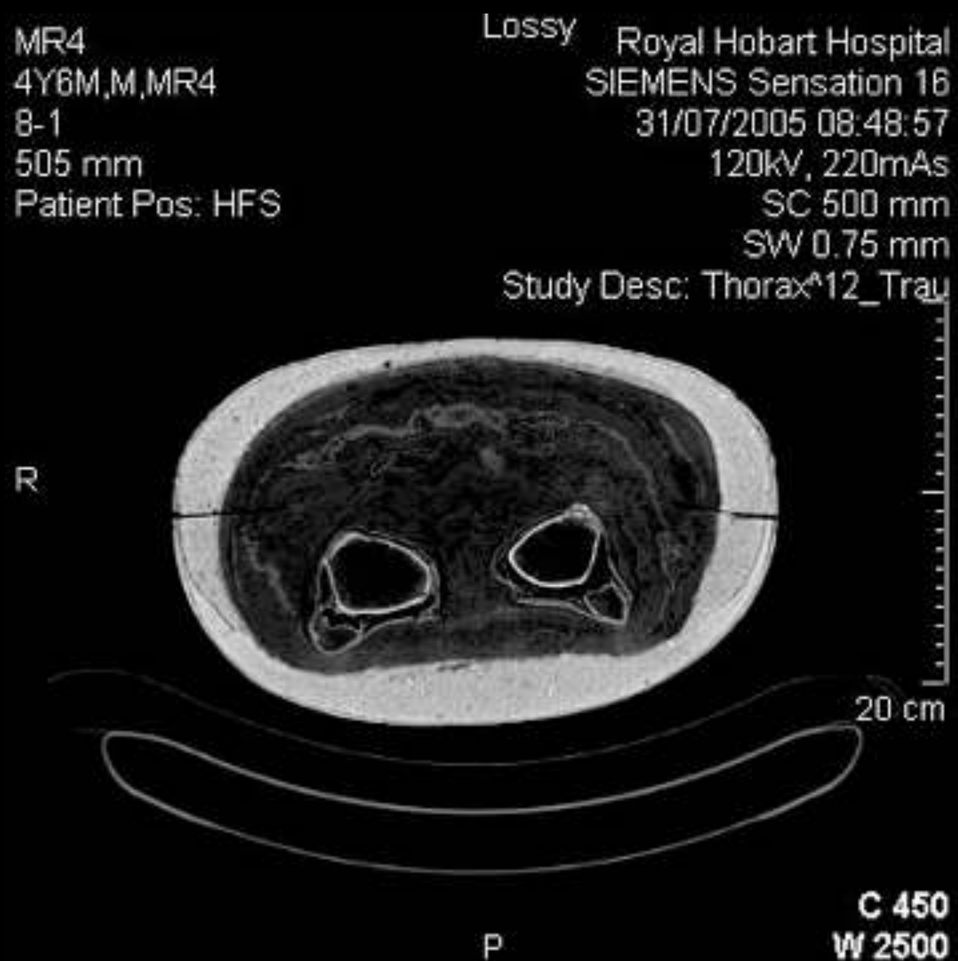
- In a volumetric dataset there is some quantity sampled on a regular 3D grid.

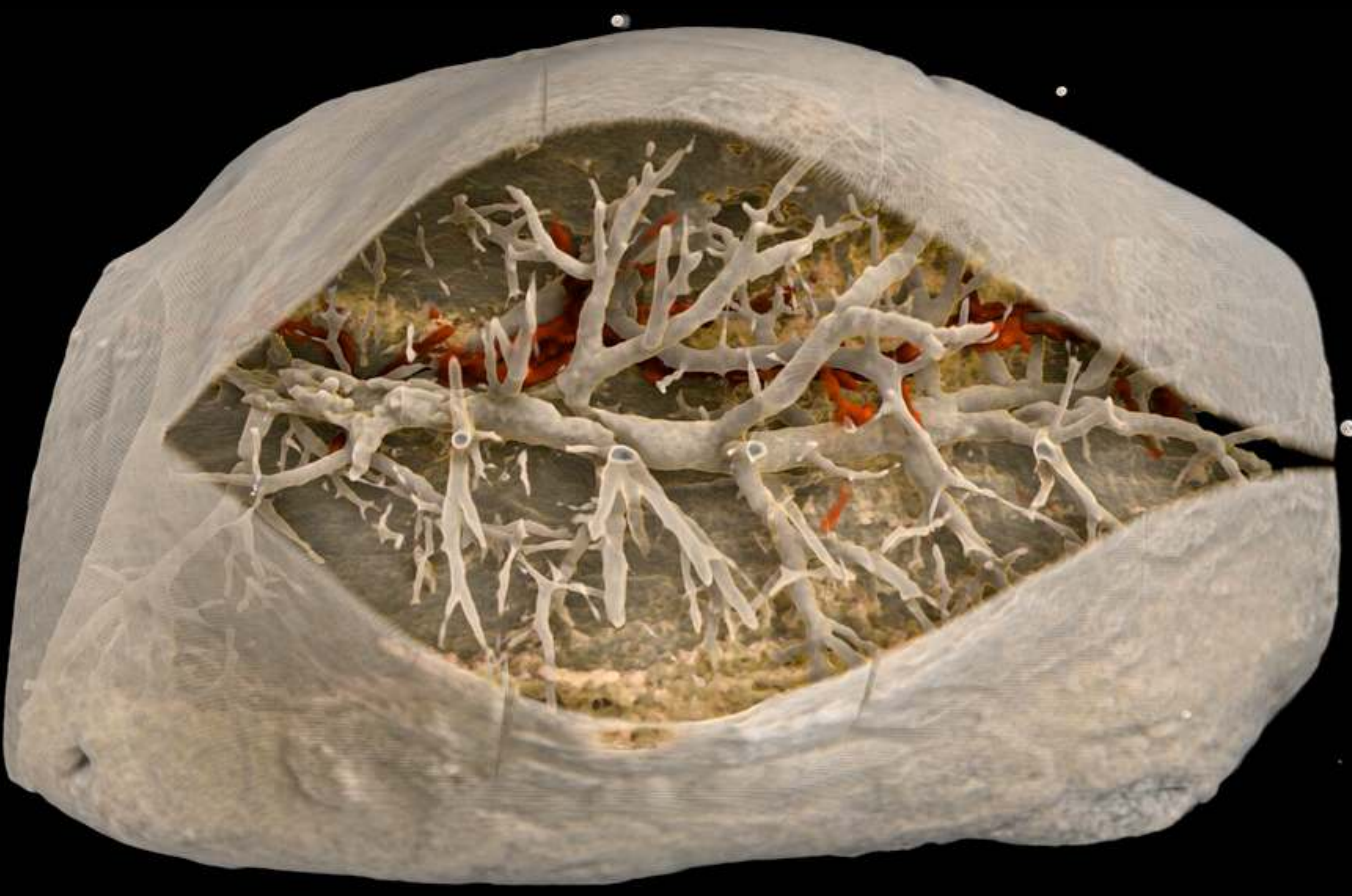


Volume visualisation

- The process of exploring and revealing the structure/interior of a volumetric dataset.
- Volume visualisation is largely the process of mapping voxel values (eg: density) to transparency and colour).
- Volume visualisation is a good example of the use of graphics accelerators, current APIs are ideal for the volume rendering algorithms based upon ray marching.

Volume visualisation

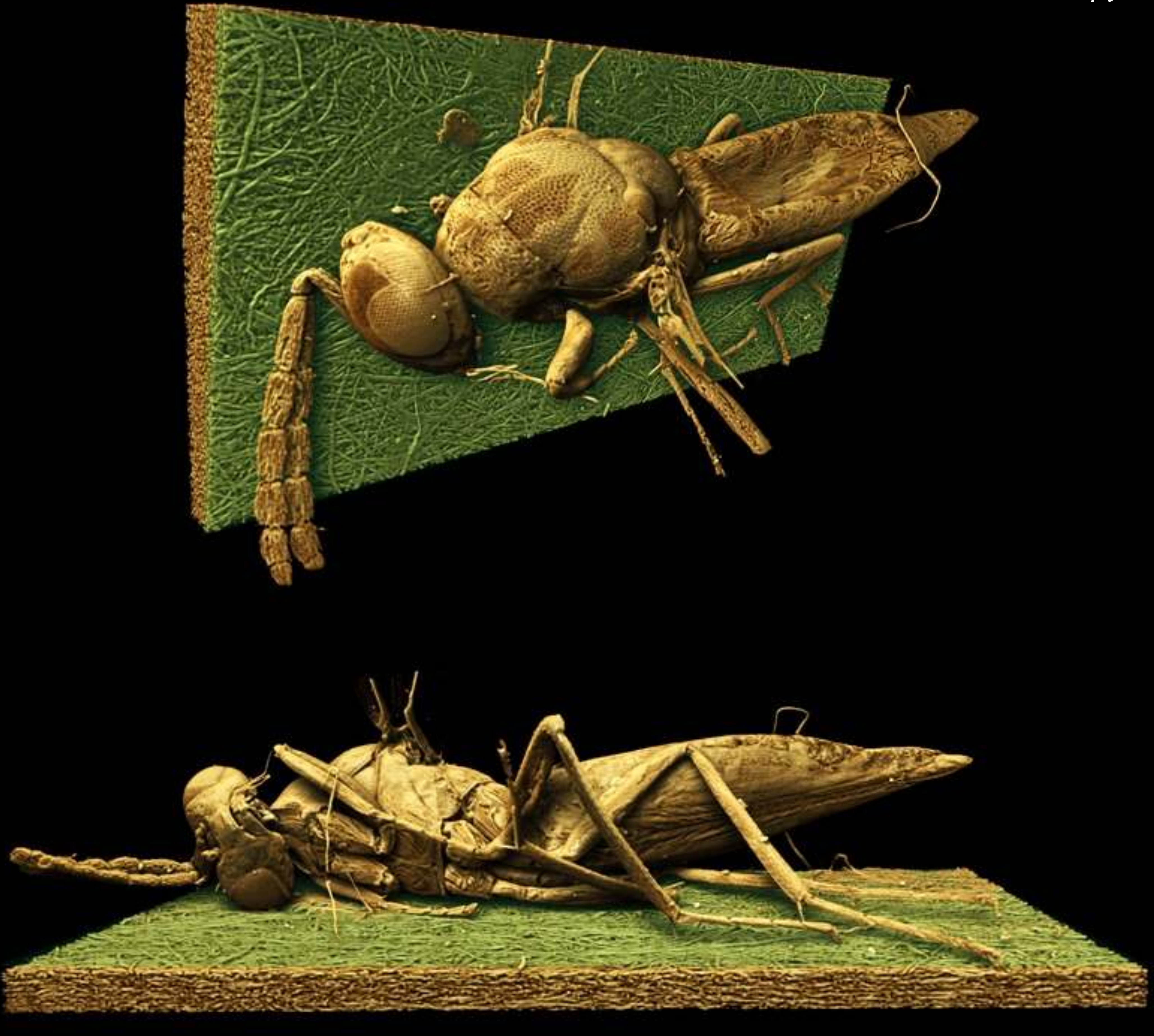


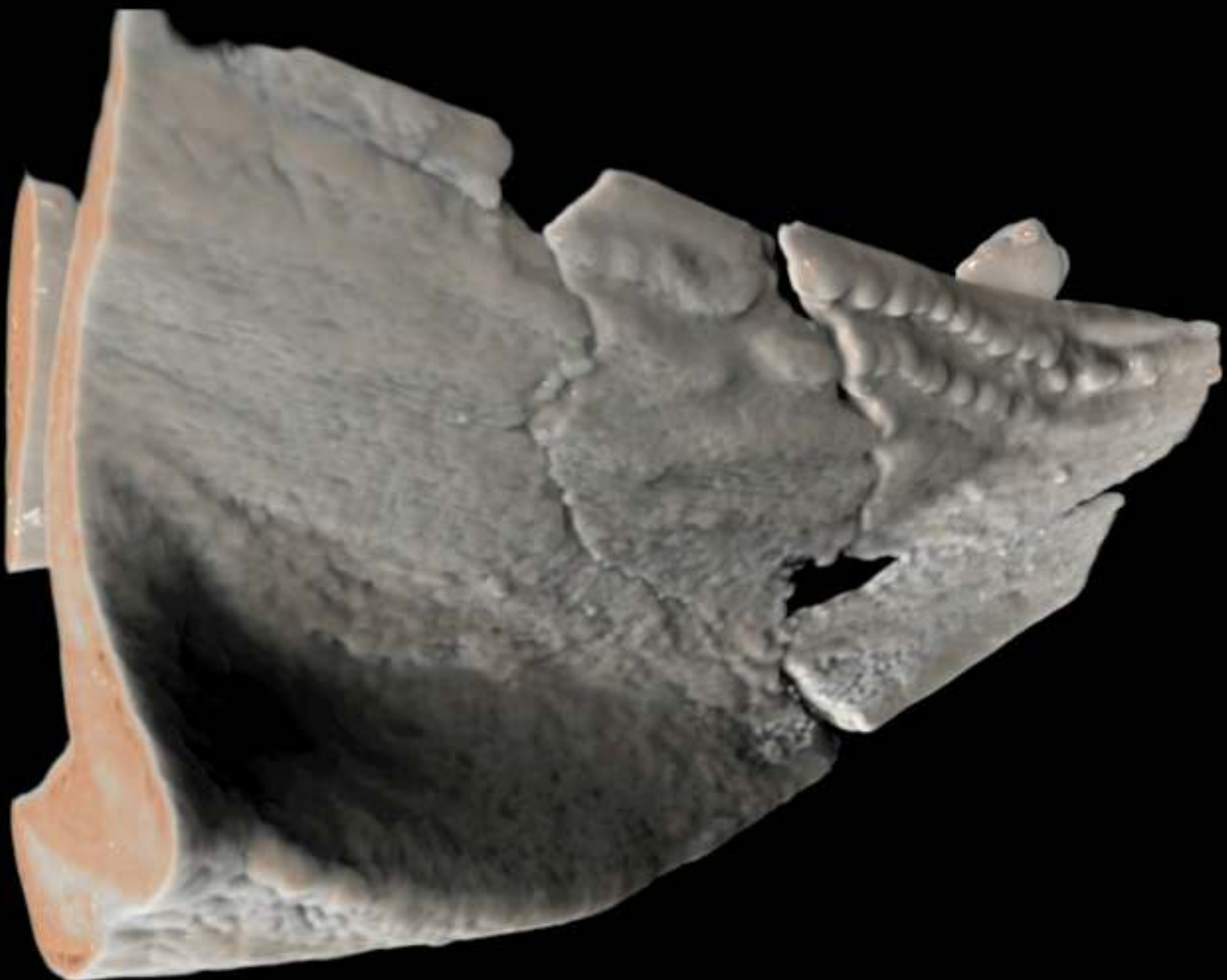


Rabbits liver, cancer research

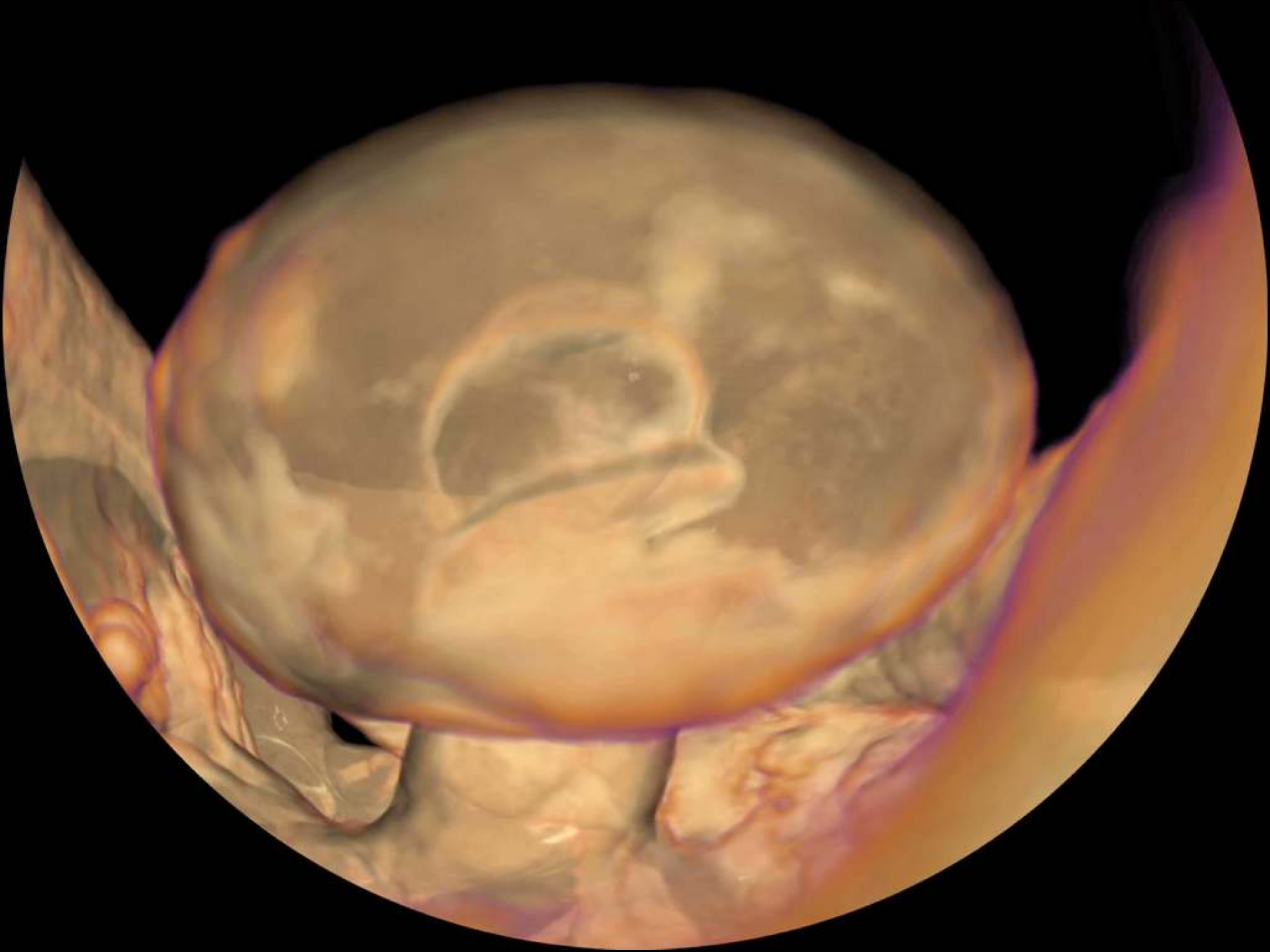
Courtesy Ajay Limaye

Courtesy John LaSalle, CSIRO





Rows of raised cusps are visible along the jaw bone making up the back of the placoderm pharynx.



3D reconstruction

- Goal: Automatically construct 3D geometry solely from a number of photographs.
- Similar to traditional photogrammetry but employs different algorithms.
- Applications
  - creating 3D assets, eg: virtual environments, serious gaming
  - structural analysis, eg: geology
  - research data sets
- Wish to avoid any in-scene markers required by some solutions. Often impractical (access) or not allowed (heritage).
- Want to target automated approaches as much as possible. [Current site surveys recorded 100's of objects].

Algorithm/pipeline outline

- Compute lens calibration (only done once)
- Read images, correct for lens, and compute feature points between them (eg: SIFT - scale invariant feature transform)
- Compute camera positions and other intrinsic camera parameters
- Create sparse 3D point cloud, called “bundle adjustment” (eg: Bundler)
- Create dense point cloud (eg: PMVS2 - patch-based multi-view stereo)
- Form mesh from dense point cloud (eg: ball pivoting)
- Reproject images to derive texture segments
- Optionally simplify mesh (eg: quadratic edge collapse decimation) and fill holes
- Export in some suitable format (eg: OBJ files with textures)

Low photograph count: 2.5D

- A relatively low number of photographs are required for 2.5D facades.
- Degree of concavity determines the number of photographs required.
  Can't reconstruct what cannot be seen.
- Facades typically require between 3 and 6 images.
- Photographs can be orientated at any angle.
- Each object takes perhaps 15 sec to capture,
  10 minutes (on average) to process.






Ho Ann temple, Terrenganu

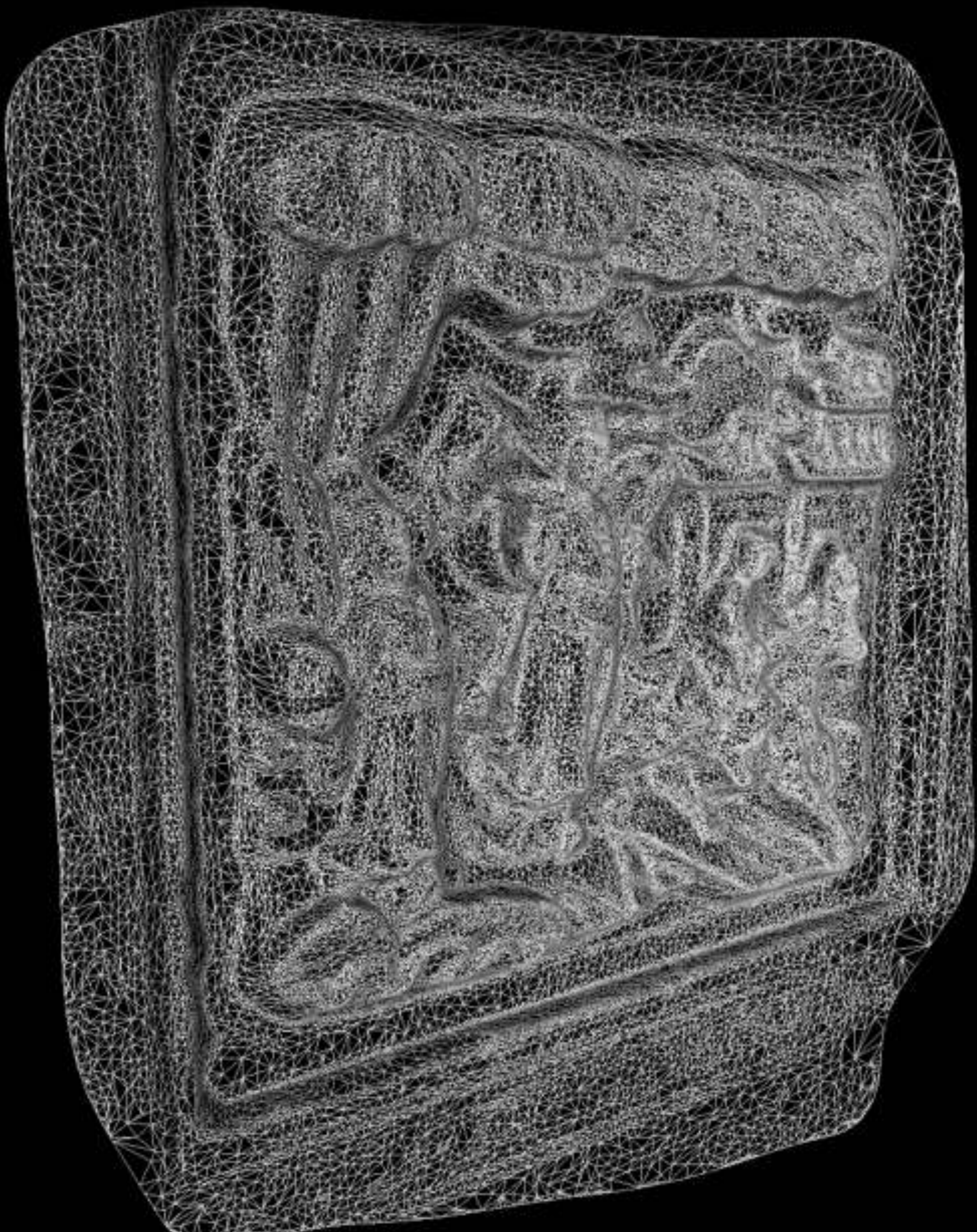


Image relighting

Full 3D objects

- Require significantly more images.
- Move to more rigorous capture: fixed focal lens combined with precise lens calibration.

Aphrodite (Lady of Cythera)
33 images

Rock art example



18 images


Cape Lambert (West Australia)

Limitations

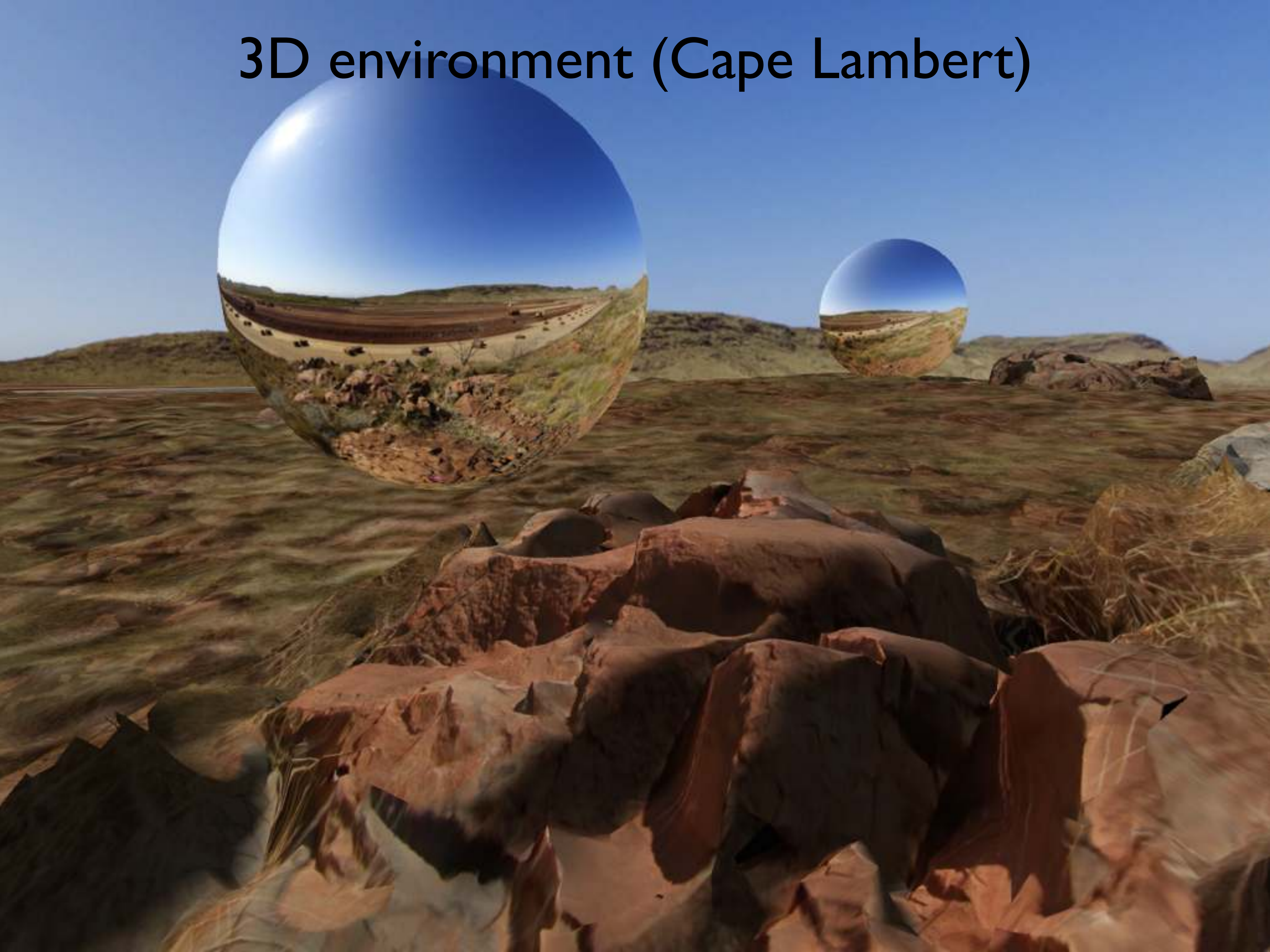
- Baked on shadows.
- Movement of the object during capture, eg: grass in the wind.
- Thin structures, eg: grass.
- Access to all sides of 3D object can be problematic.

Site/data exploration

- Present the site, rock art, and meta data through two technologies
  - image base virtual tours
  - full 3D environments
- These not only give a global sense of the site but form an interface to
  - gigapixel images
  - 360 panoramas
  - standard photographic record
  - traditional meta data collected
- In the case of 3D environments one can experience the site in novel/engaging environments
  - iDome
  - stereoscopic 3D
  - cylindrical rooms

Image based tour (Wanmanna)

3D environment (Cape Lambert)



3D tourist

- I find myself taking photographs suited to 3D reconstruction while travelling.
- Sitting in my hotel at night processing the results and uploading the 3D mesh to make it available online.

HMAS Sydney Cairn,
near Canarvon

Questions

For all those who dismissed Erich von Däniken.
In case you doubted aliens visited West Australia.