Projects from 2011

Paul Bourke

Contents

- Cosmology visualisations, in collaboration with Dr Alan Duffy (ICRAR, UWA) and Dr Rob Crain (Leinden Observatory, the Netherlands).

- Visualisation in cultural heritage, in collaboration with the School of Creative Media, City University, Hong Kong.

- Volume visualisation for a exhibition in an art museum, in collaboration with Dr Peter Morse.

Visualisation of cosmological simulations

- Present three examples: "COSMOS", "GIMIC", and "KINETIC".

- Characteristics:
  - Large numbers of points, minimum 200 million, maximum 1 billion (COSMOS).
  - Generally three types of particles: Dark Matter, Stars, Gas.
  - Relative numbers of each type of particle may vary over time.
  - Each point has a region of influence, smoothing kernel.
  - Typically have multiple parameters per particle.
    Interest here in position, velocity (for time interpolation), mass, smoothing radius.

- Requirements / goals:
  - Explore pipelines the researchers can use.
  - High impact images and animations.
  - High resolution fisheye images for digital planetarium projection.
    Targeting typically 3K square for an inhouse fulldome production and
    up to 8K square for high end planetariums, eg: Macau, Hong Kong, Beijing.
  - Support for multiple projection types: orthographic, perspective, fisheye, spherical.
  - Produce all images as 16bit PNG to give enough dynamic range for postproduction effects.

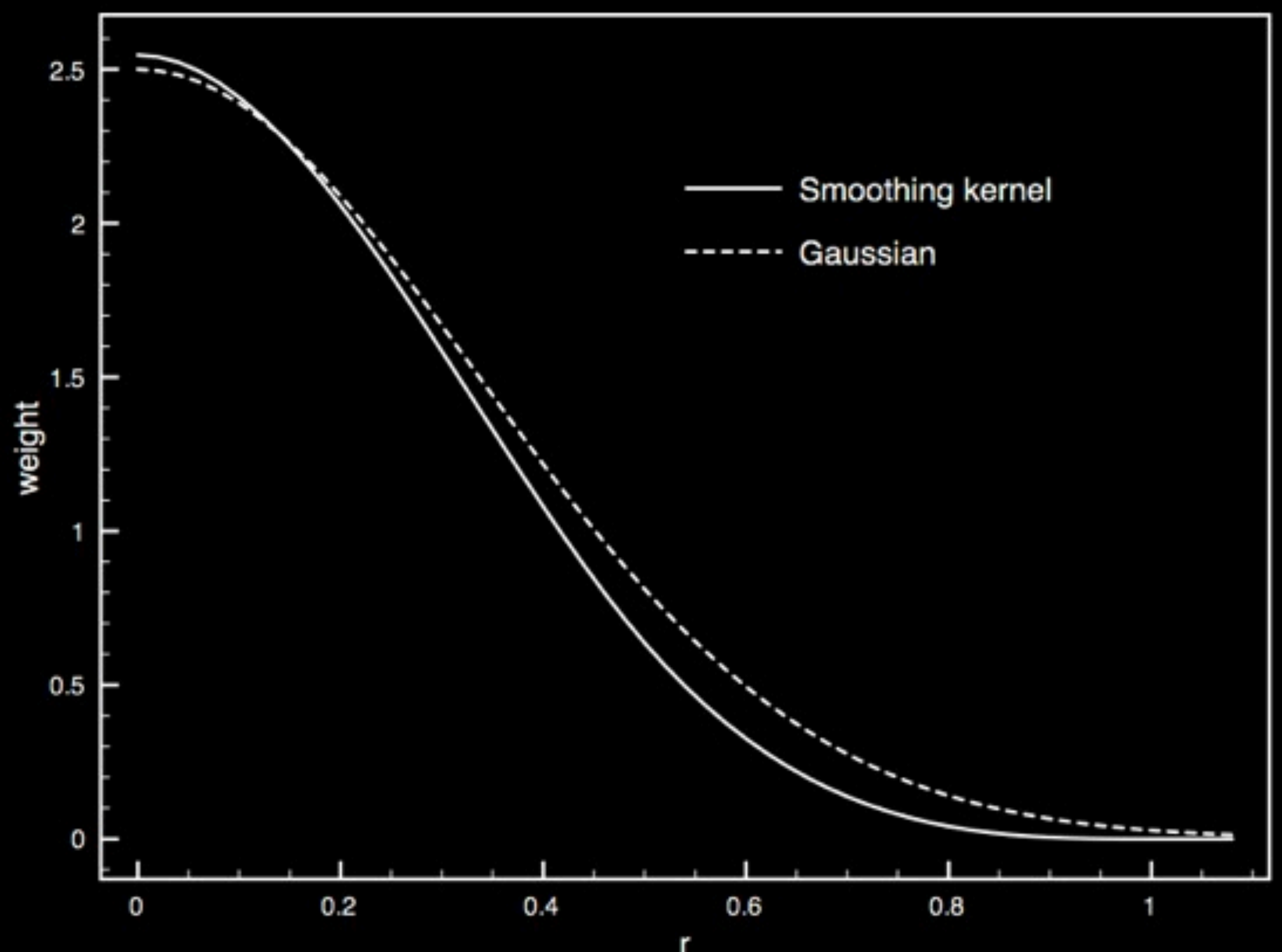
Gadget

Code base is Gadget (actually our private Gadget3 version). It's a C based code for cosmological N-body/SPH simulations on massively parallel computers with distributed memory. It uses an explicit communication model that is implemented with the standard MPI communication interface. It computes gravitational forces with a hierarchical tree algorithm (optionally in combination with a particle-mesh scheme for long-range gravitational forces) and represents fluids by means of smoothed particle hydrodynamics (SPH). It is both highly optimised and stable, and readily portability to supercomputers using standard libraries.

Alan Duffy

Smoothing kernel

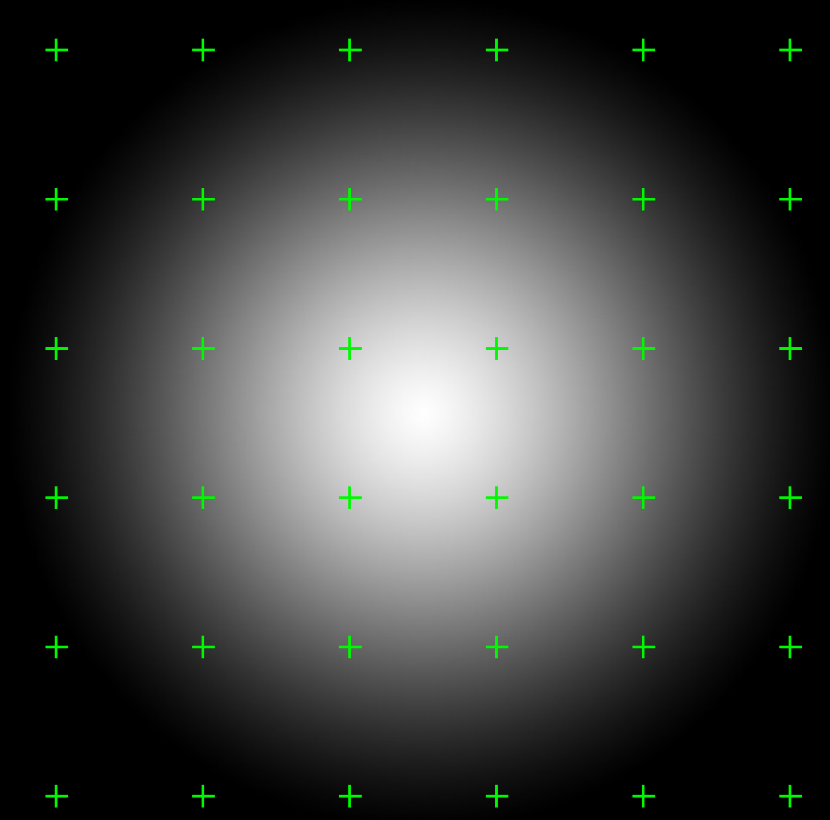
- 3D functions of radius, similar to a "point spread function" in optics. Note this is used within the simulation software so not an arbitrary choice for the visualisations.
- For particles without a smoothing kernel (eg: stars) a Gaussian is used which allows the same pipeline to be employed. Use a single standard deviation, star mass determines the amplitude.



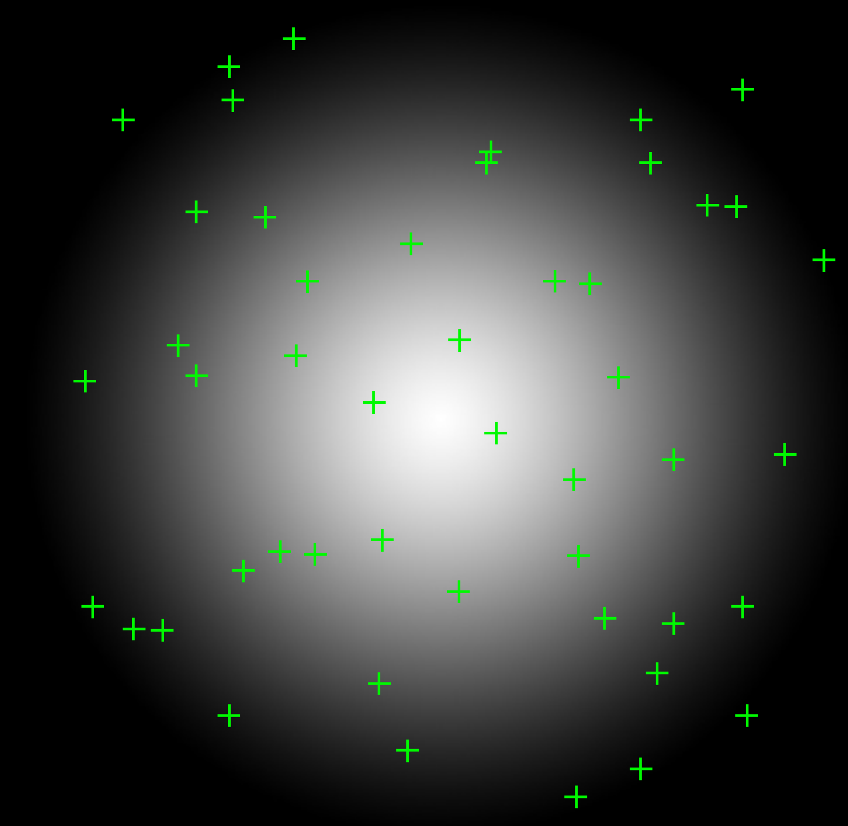
$$W(r) = \begin{cases} \dfrac{8\left(1 - 6\left(1 - \frac{r}{s}\right)^2 + 6\left(1 - \frac{r}{s}\right)^3\right)}{\pi s^3} & r < \frac{s}{2} \\ \dfrac{16\left(1 - \frac{r}{s}\right)^3}{\pi s^3} & \frac{s}{2} \le r < s \\ 0 & r \ge s \end{cases}$$

Smoothing kernel

- Easier to deal with when sampling into a volume.
  Decided not to do this here due to resolution constraints.
- Smoothing kernel radii are not necessarily “local”, sampling into a volume an be expensive.
- Implemented smoothing kernel by sampling (regular or stochastic) in 3D. Points are then projected onto plane, cylinder, or spherical surface. The image is then a histogram the projected points contribute their kernel weighted mass to.
- Only works because of the very large number of points, smooth histogram image forms quickly.
- Advantage of being able to form image with speed/quality trade-off.



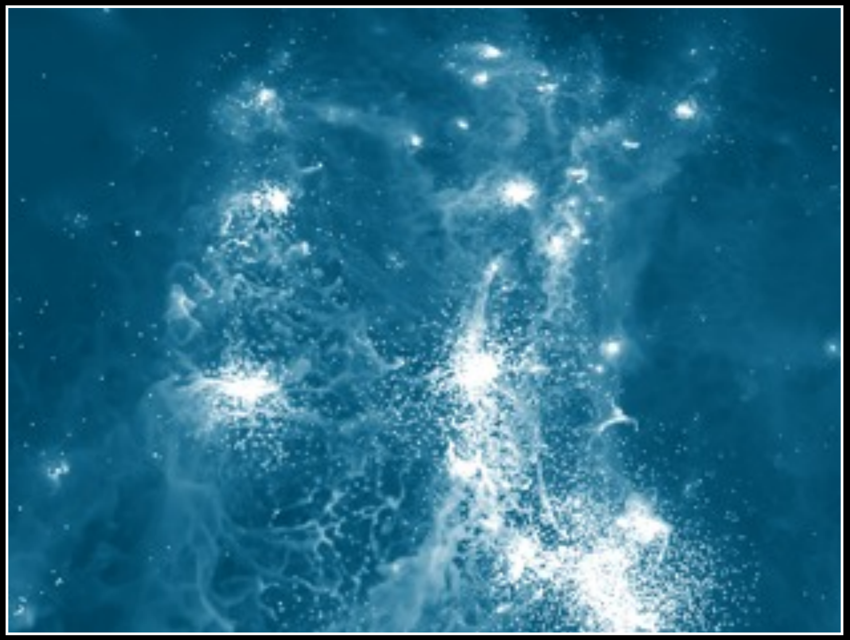
Uniform sampling



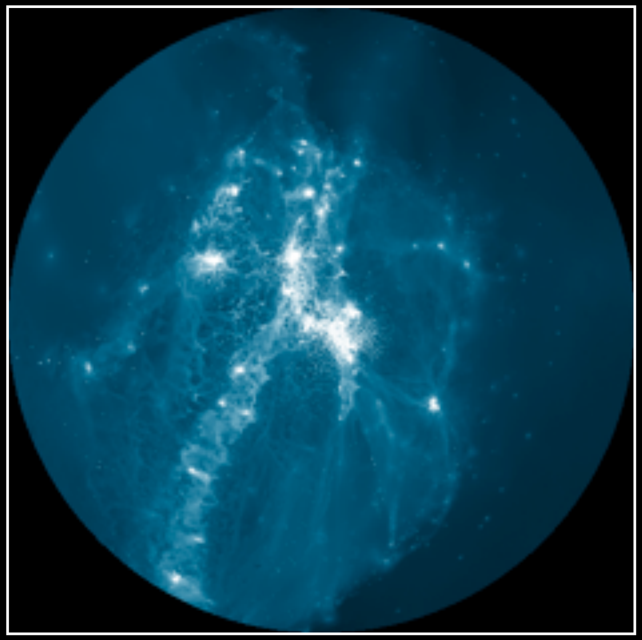
Random sampling

Projections

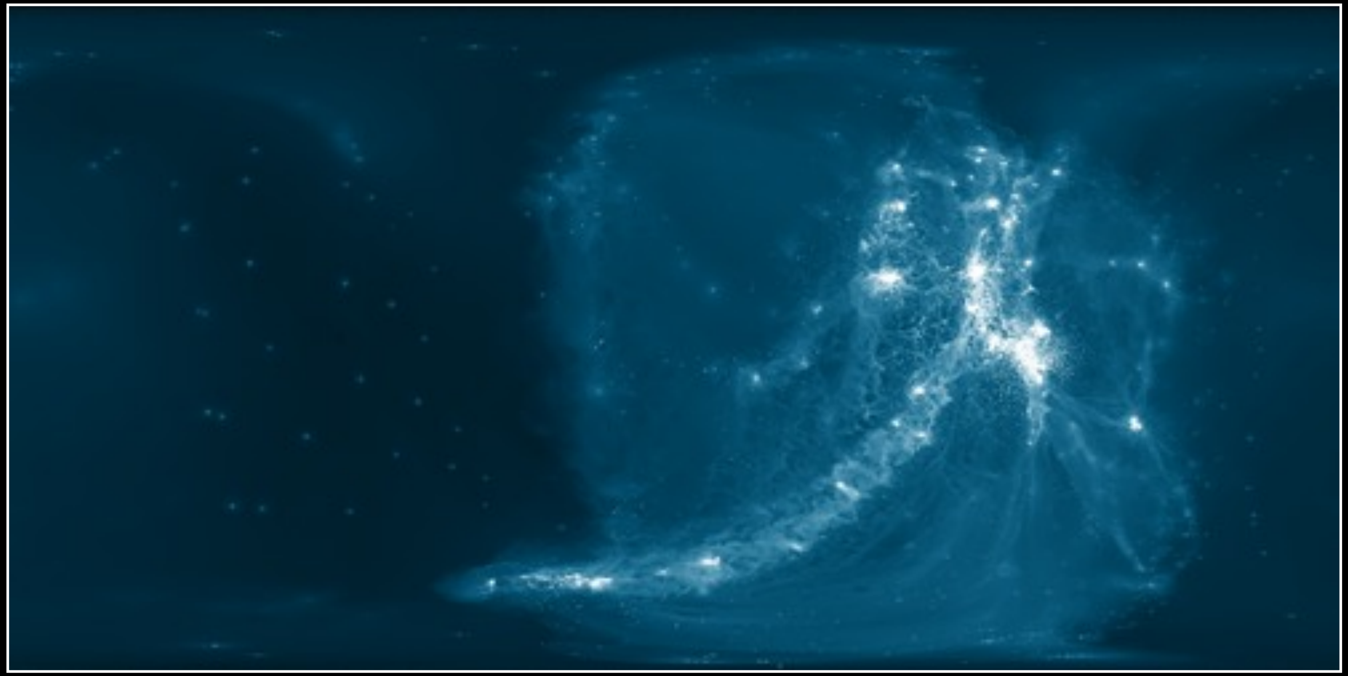
Orthographic



Perspective



Fisheye



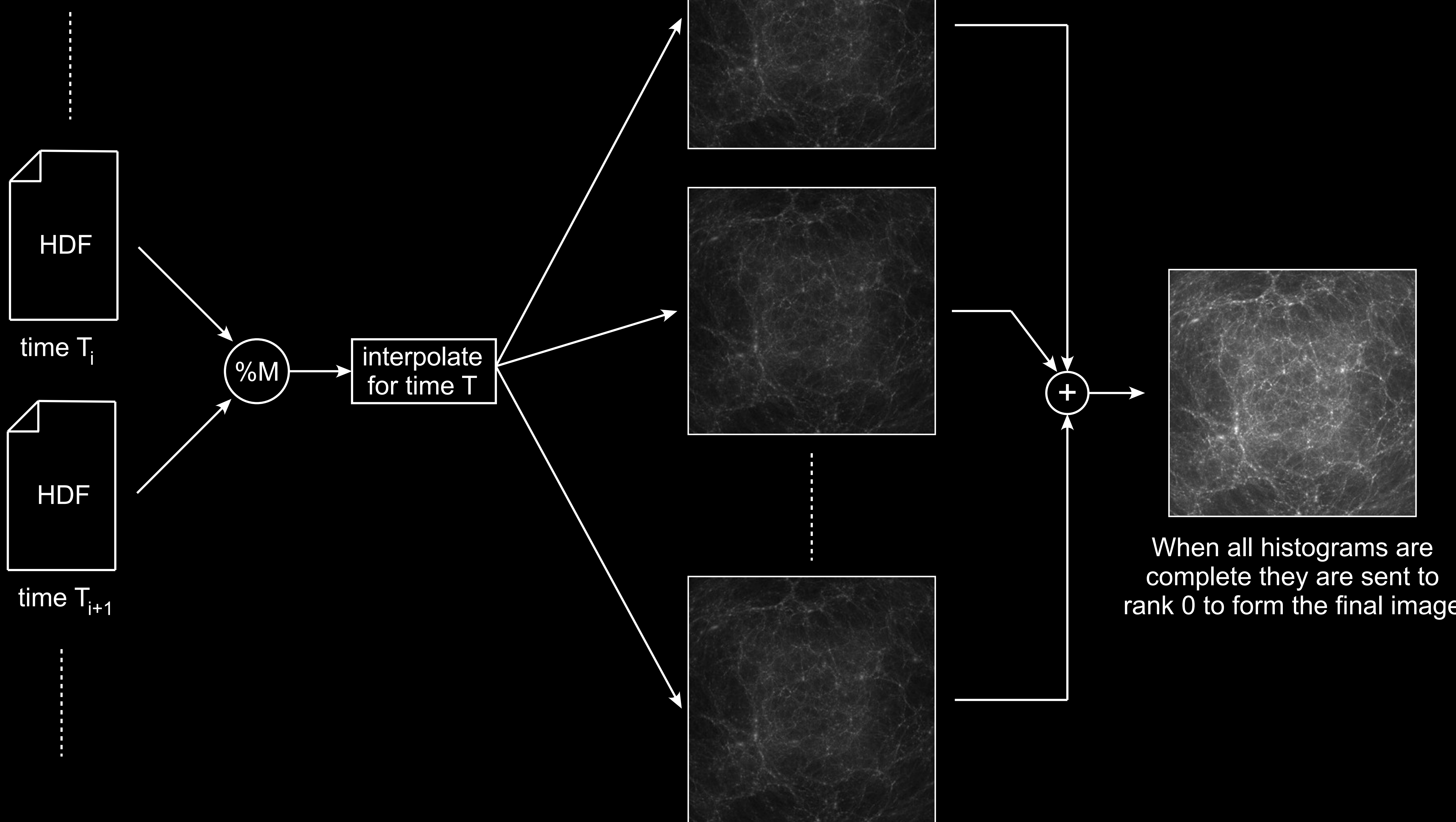
Spherical

Cylindrical

COSMOS

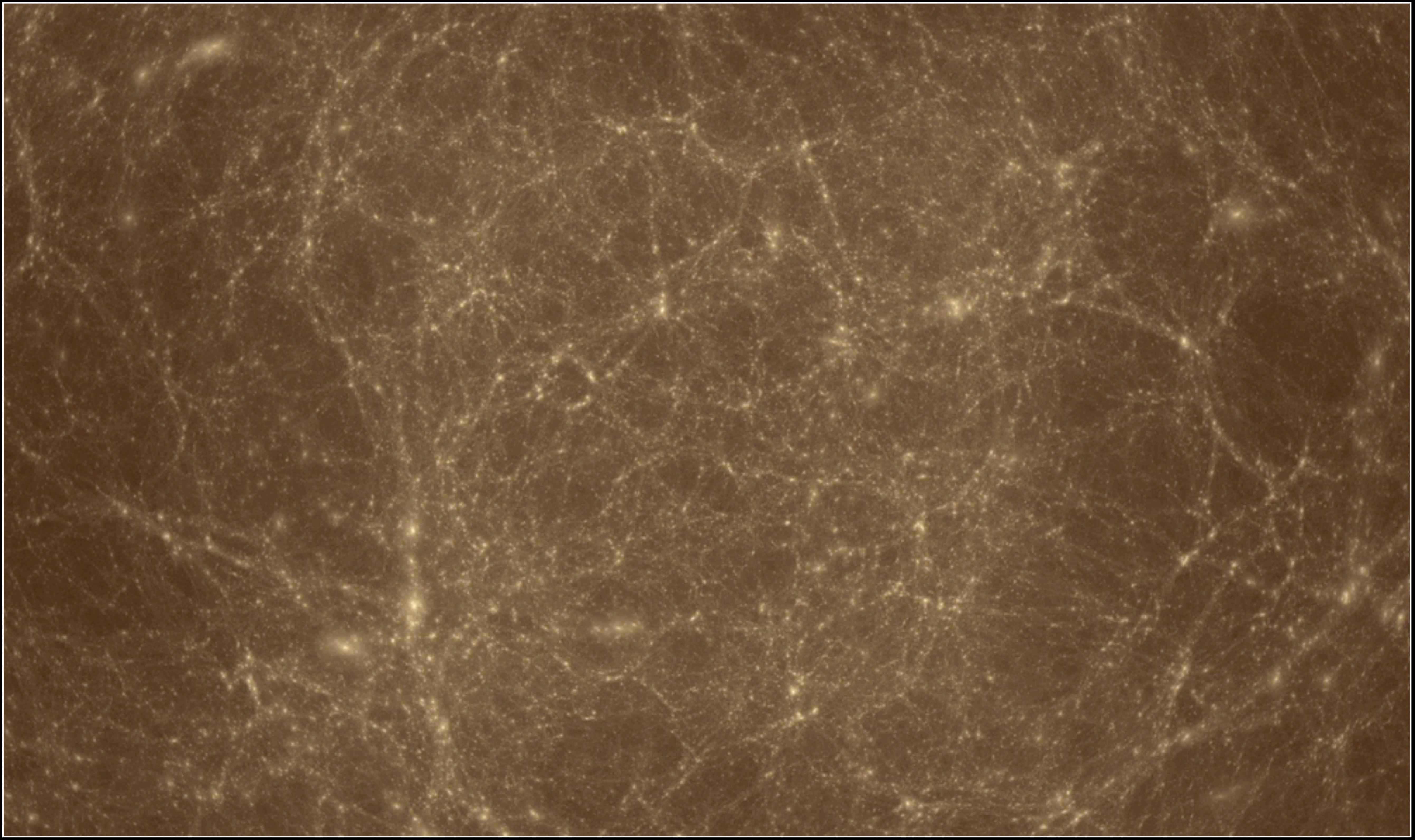
- Simulation within a cubic region (periodic bounds) of the Universe just after the Big Bang.
- 600 million light years on each side of the cube.
- Shows dark matter collapsing over 14 billion years of cosmic time, forming filaments and collapsing haloes of the Cosmic Web.
- Note there is no smoothing kernel here, the images look smooth and continuous due to the 1 billion+ particles per time step.
- Even at 3Kx3K, if the whole dataset is in shot then on average there are over 100 points per pixel (if they were distributed uniformly).
- The final image is essentially a histogram formed on the projection plane.
- Original simulation computed on vayu (NCI).
  Used 1024 cores, 2.8TB RAM, took 19 hours (~20,000 CPU hours)
  Rendering performed on epic (iVEC).

Rendering pipeline



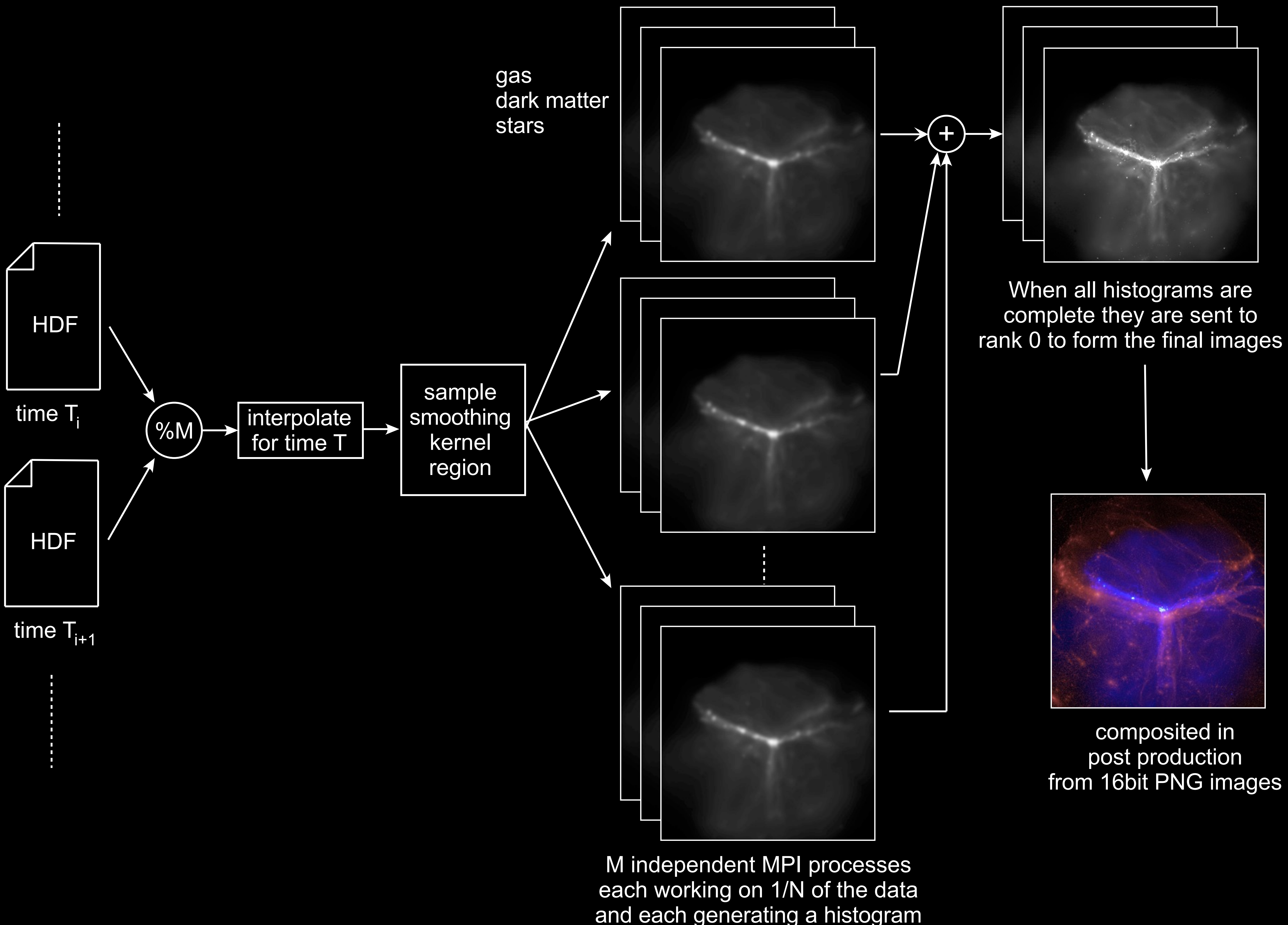
$N = 10^6$ points each timestep

M independent MPI processes each working on 1/N of the data and each generating a histogram

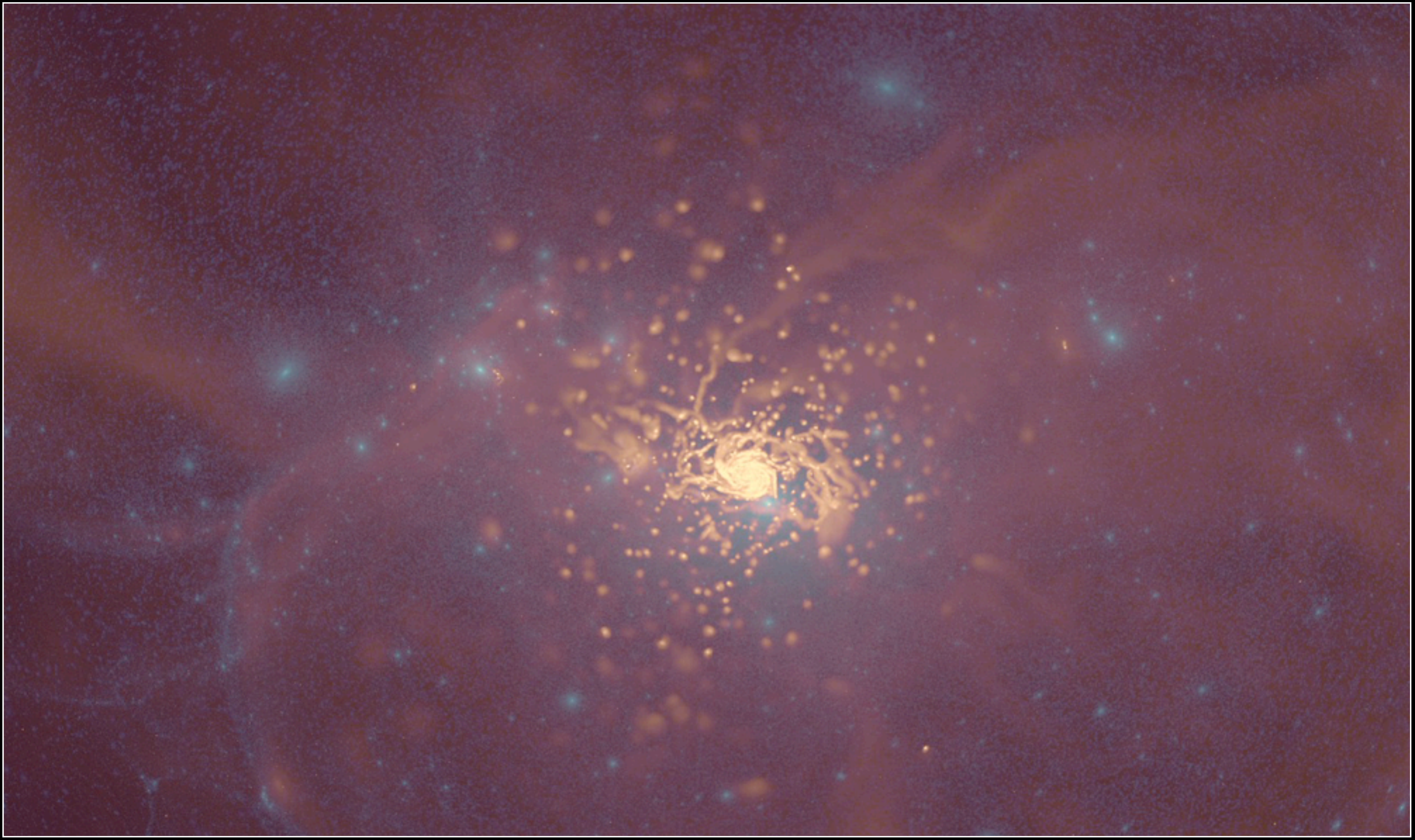


GIMIC

- Simulates the formation of a Dwarf Galaxy, similar to the Large Magellenic Cloud.
- The formation of these galaxies is a violent dynamic process.
- Dark Matters forms in filaments along which gas flows into the central disk where star formation occurs.
- Computed on cosma (Durham University).
  Used 32 CPUs, 92 hours (~3,000 CPU hours).
  Rendering performed on epic (iVEC).

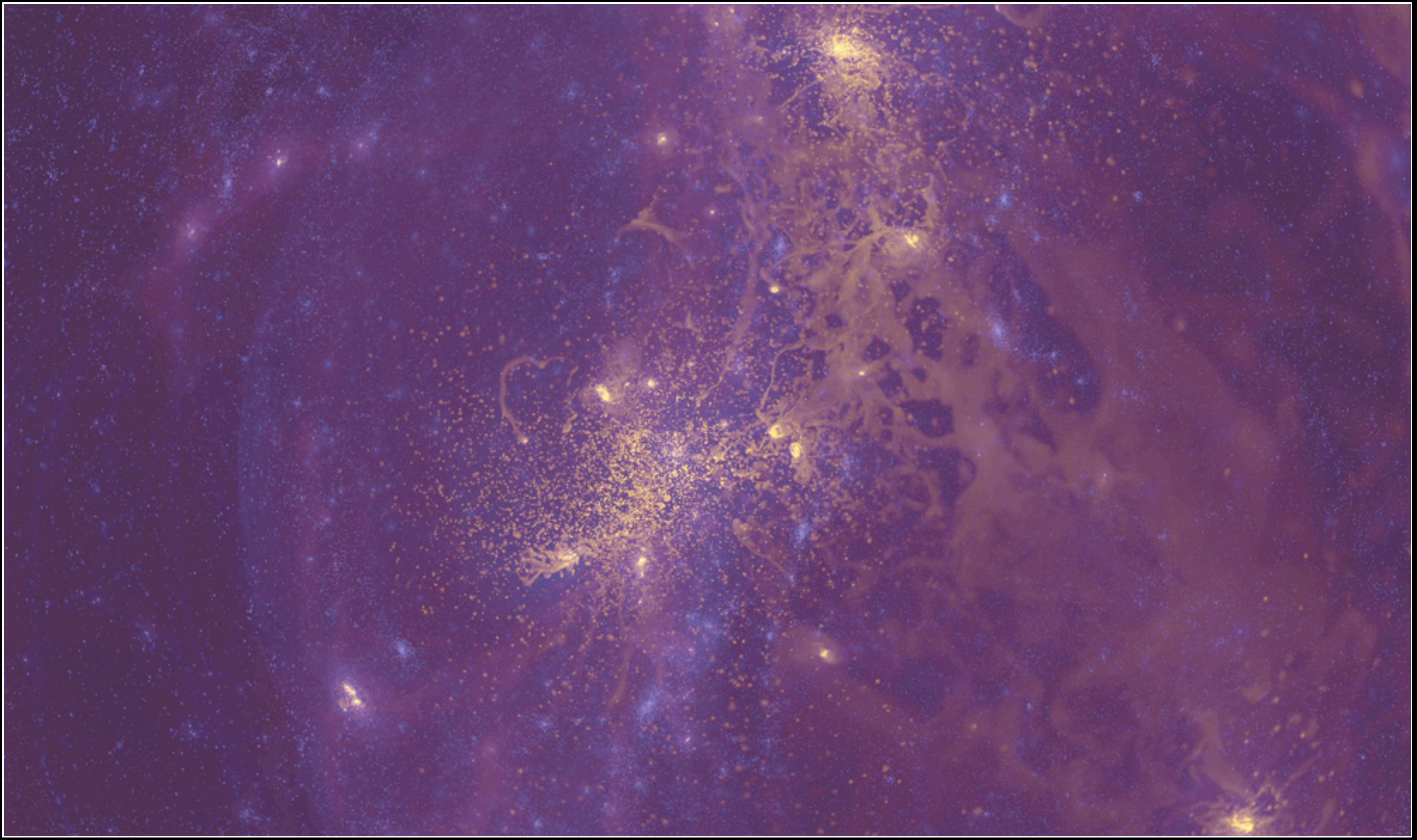


HDF
time T_i
HDF
time T_{i+1}
%M
interpolate for time T
sample smoothing kernel region
gas
dark matter
stars
+
When all histograms are complete they are sent to rank 0 to form the final images
composited in post production from 16bit PNG images
M independent MPI processes each working on 1/N of the data and each generating a histogram



KINETIC

- Simulation of the formation of a Spiral Galaxy similar to our own Milky Way but about half the current age.
- The Gas follows the Dark Matter along the filaments.
- Each of the small satellite galaxies are about the same mass as the GIMIC Galaxy.
- Computed on epic machine (iVEC).
  Used 1024 cores, 2.05TB RAM, took 470 hours (~500,000 CPU hours).
  Rendering performed on epic (iVEC).



Visualisation in cultural heritage

- Place Turkiye

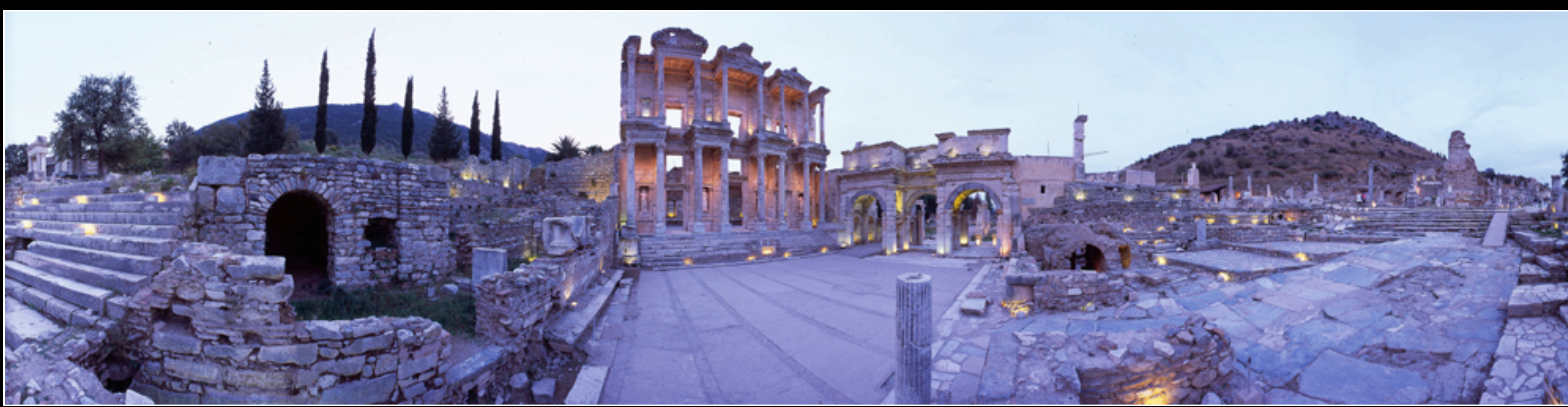
- iJiao

- Both involve immersive displays: stereoscopic cylindrical display or iDome.
- Both in conjunction with the School of Creative Media, City University of Hong Kong.

Stereoscopic panoramas

42,000 pixels x 12,000 pixels

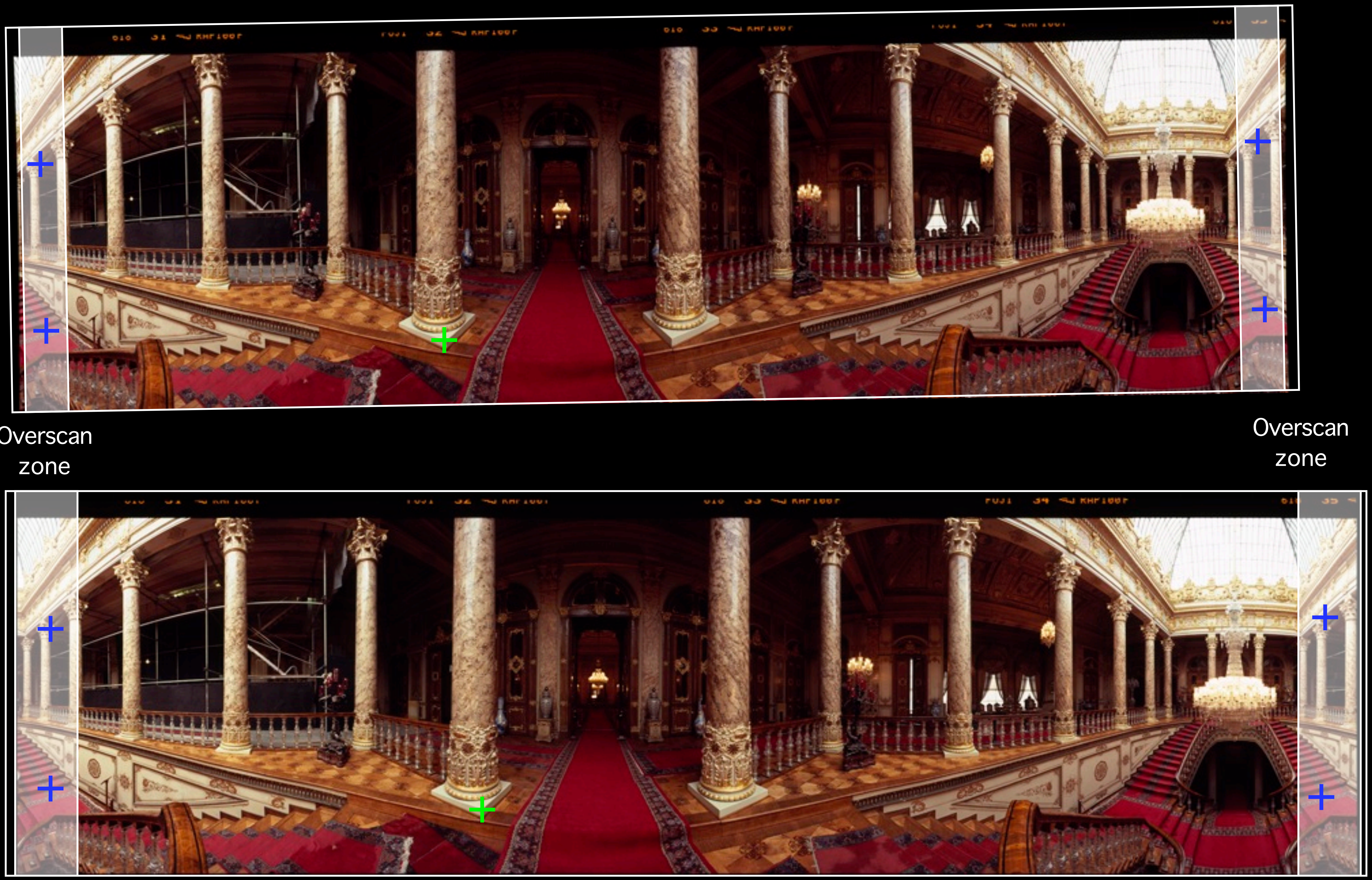
Left eye



Right eye

Ephesus. Courtesy Sarah Kenderdine, Jeffrey Shaw

Alignment / registration of stereoscopic cylindrical pair



Zero parallax distance

Two pairs of matching points in each panorama

City University Hong Kong: School of Creative Media

360 x 150 degree video

5400 x 2700 pixels

Whirling Dervishes, Orient Express train station

Navigable movie in the iDome

Sample shoots

Borusan Philharmonic Orchestra

Yeni (New) Mosque

Hashbecktashi Dancers

Whirling dervishes: Orient Express Train Station

360 video for cylindrical displays

Yeni (New) Mosque

Hashbecktashi Dancers

Traditional potter

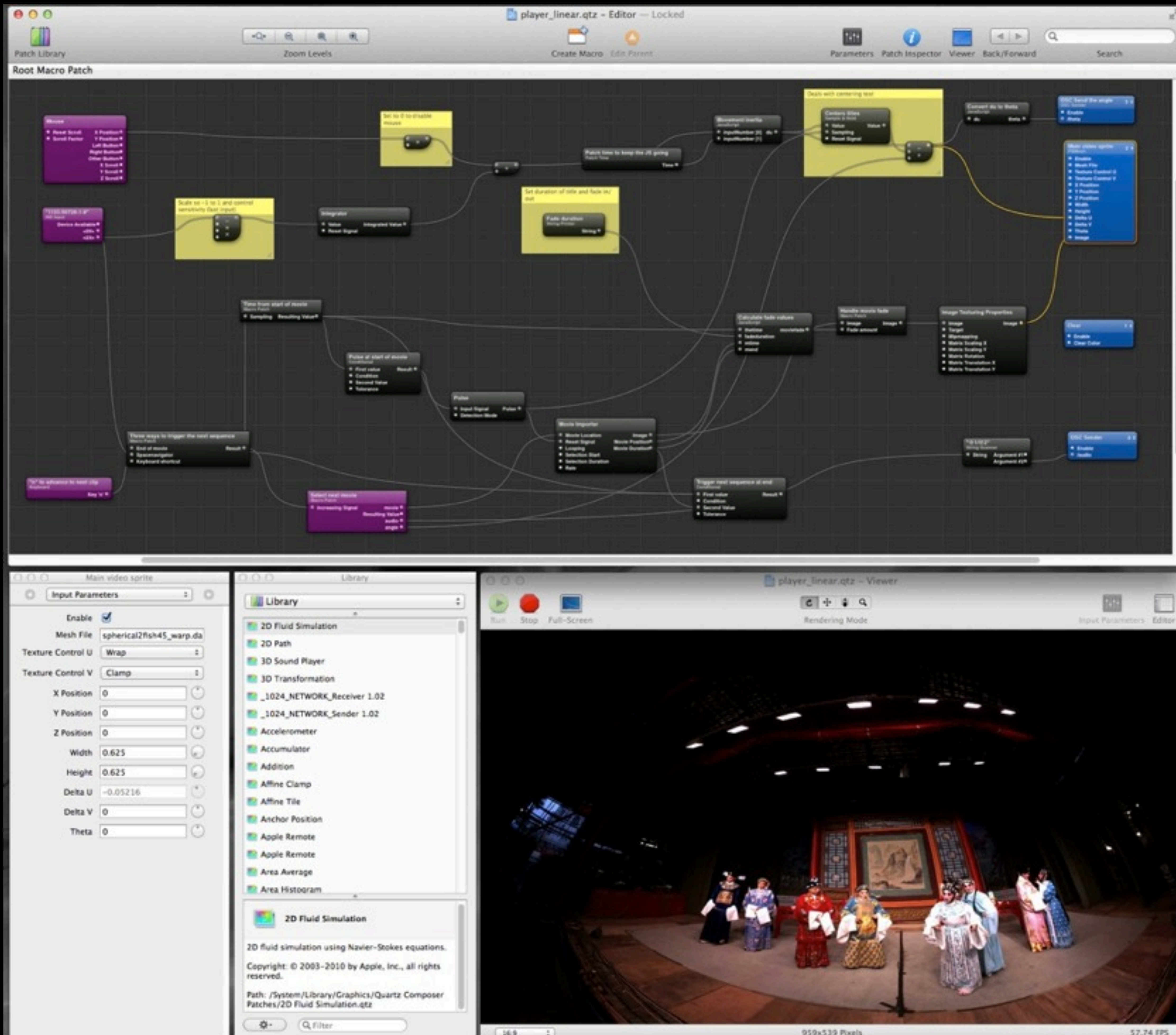
Traditional potters

Didn’t enjoy myself at all.

The “Castle”, Cappadocia

iJiao

- Showcase of cultural heritage of China.
- Venue: Main Gallery, Hong Kong Central Gallery.
- 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]



player_linear.qtz – Editor — Locked
Patch Library
Zoom Levels
Create Macro
Edit Parent
Parameters
Patch Inspector
Viewer
Back/Forward
Search
Root Macro Patch
Main video sprite
Input Parameters
Enable
Mesh File
spherical2fish45_warp.da
Texture Control U
Wrap
Texture Control V
Clamp
X Position
0
Y Position
0
Z Position
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Width
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Height
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Delta U
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Library
Library
2D Fluid Simulation
2D Path
3D Sound Player
3D Transformation
_1024_NETWORK_Receiver 1.02
_1024_NETWORK_Sender 1.02
Accelerometer
Accumulator
Addition
Affine Clamp
Affine Tile
Anchor Position
Apple Remote
Apple Remote
Area Average
Area Histogram
2D Fluid Simulation
2D fluid simulation using Navier-Stokes equations.
Copyright: © 2003-2010 by Apple, Inc., all rights reserved.
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Input Parameters
Editor
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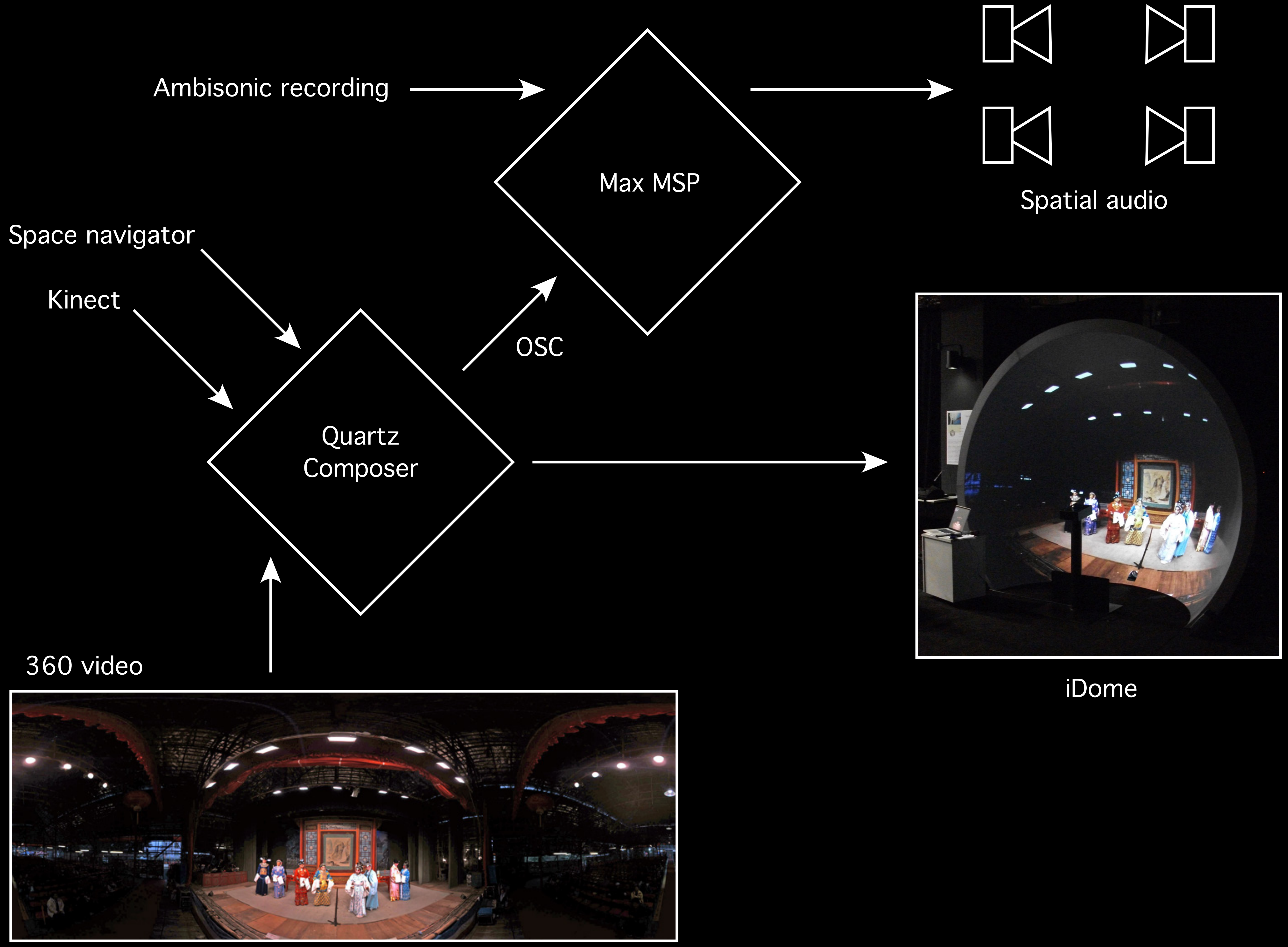


Ambisonic recording
Max MSP
Spatial audio
Space navigator
Kinect
OSC
Quartz
Composer
360 video
iDome

Volume visualisation for a public exhibition: Pausiris

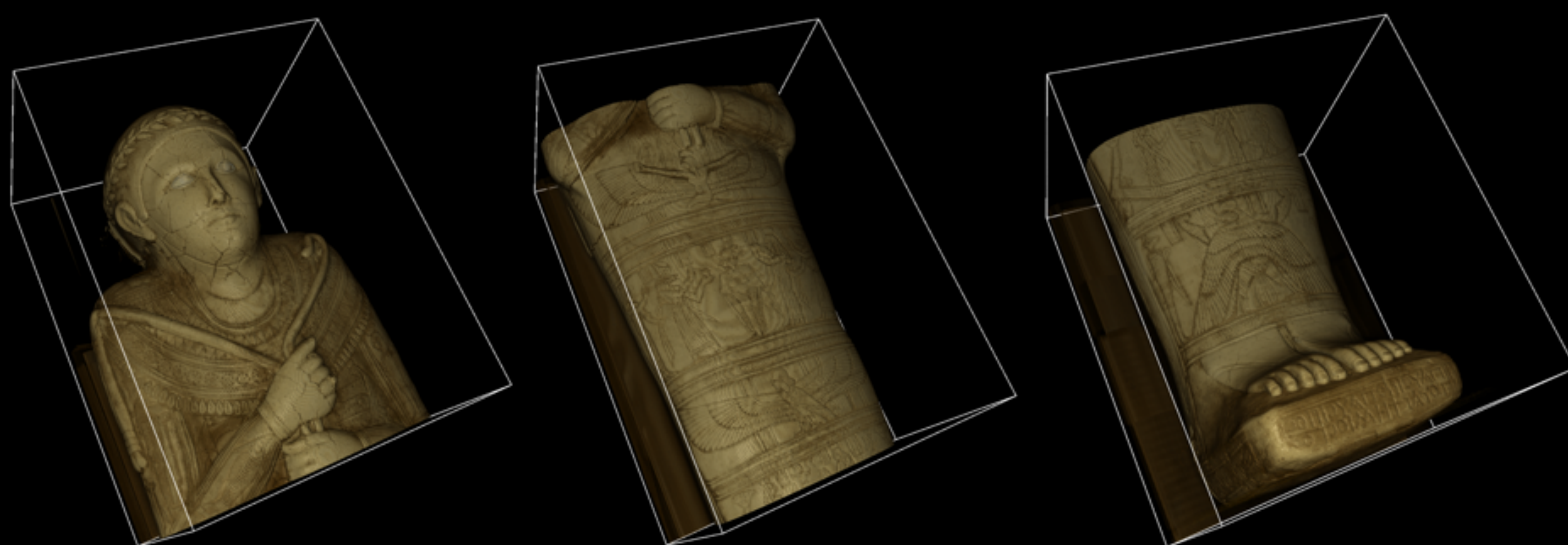
- MONA: Museum of Old and New Art, Hobart, Tasmania. Opened on the 21st January 2011.
- Responsible for an exhibition based upon the Pausiris mummy, in collaboration with Peter Morse.
- Volume rendering from a high resolution CAT scan data using Drishti.

Data/projection overview

- Each frame of the movie is rendered at 4000 x 1500 pixels, intended to run at 30fps.
- The display case comprises of two WUXGA (1920 x 1200 pixel) projectors.
- Each frame of the movie is split in half (plus an overlap) and sent to each projector. The overlap portion is edge blended to form a seamless 3600 x 1200 pixel image.
- Geometry correction and edge blending is performed in realtime to allow for recalibration if the hardware geometry changes and edge blending adjustments as the projectors age.
- Playback is controlled by network messages: start, stop, pause triggered from laser scanning of the gallery that detects visitors entering and exiting.

Data alignment challenge

- CAT scans were performed in three sections to increase resolution and the scanner carry through wasn't long enough for the whole case.
- Top two sections only required translation and only in one plane.
- Last section required translation in one plane and rotation about the axis perpendicular to the plane.
- Limited overlap (+/- 40 voxels) between top two sections, plenty of overlap (+/- 210 voxels) between lower two sections.



Brute force 3D cross correlation

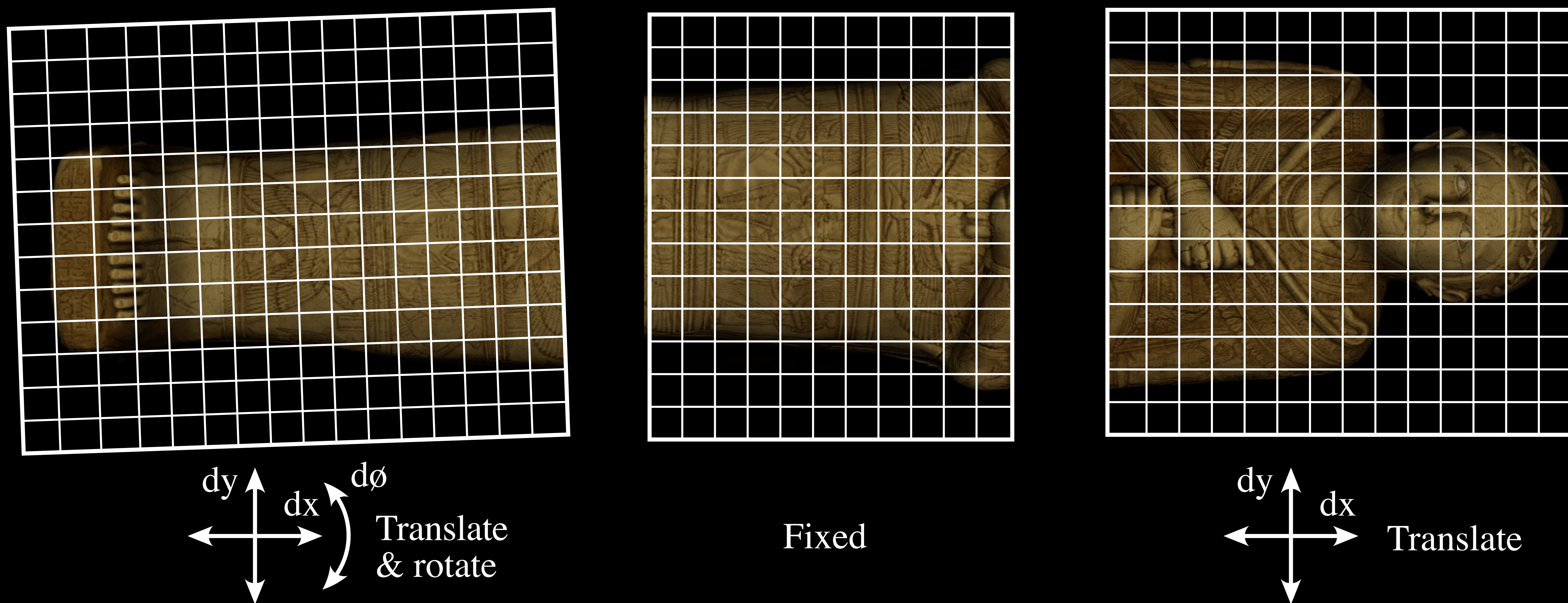


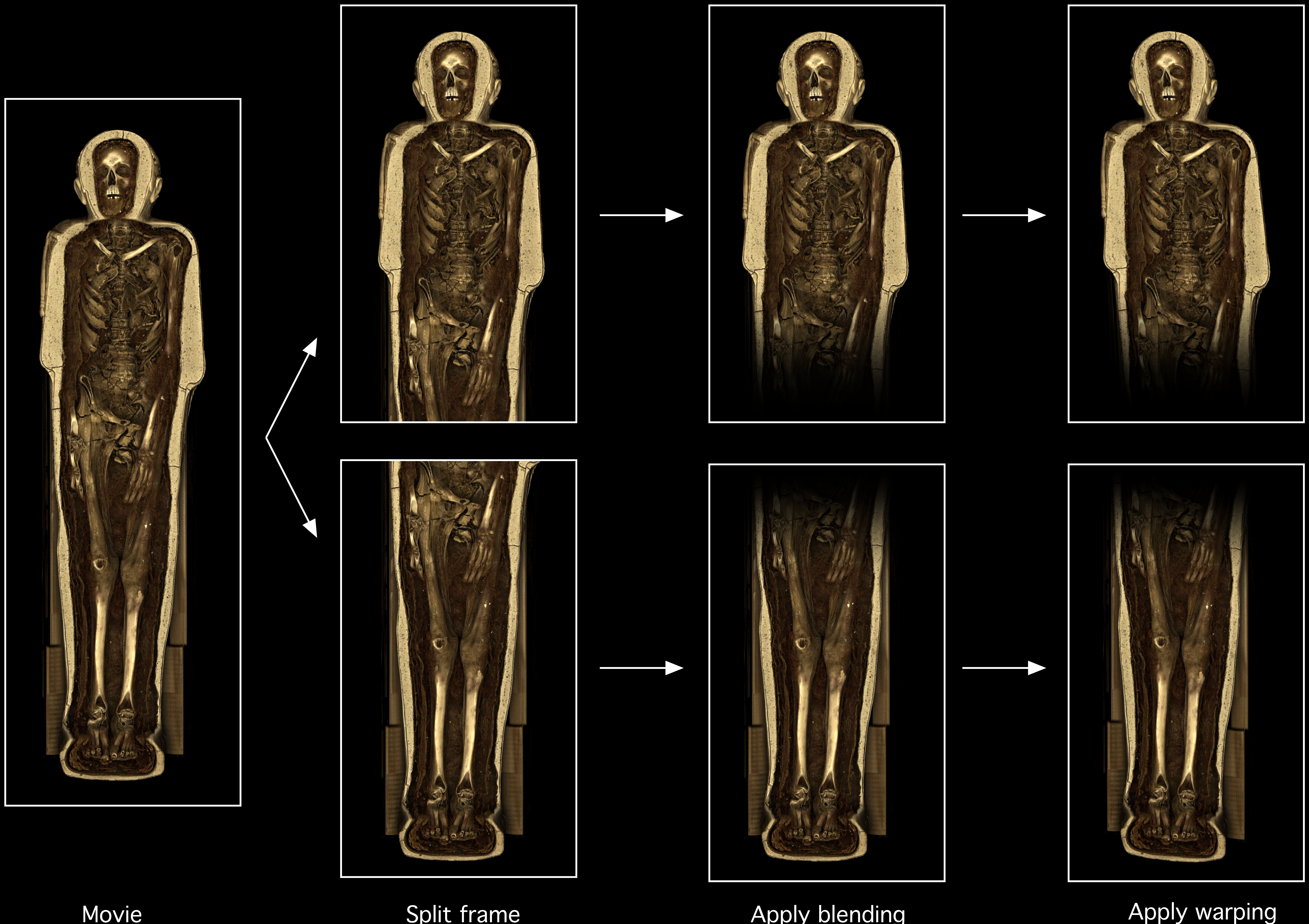
image mean

$$r(dx,dy,d\o) = \Big(T(dx,dy)\,\Big\langle R(d\o)\,\Big\langle I_1(i,j,k)\Big\rangle\Big\rangle - \overline{I}_1\Big)\Big(I_2(i,j,k) - \overline{I}_2\Big)$$

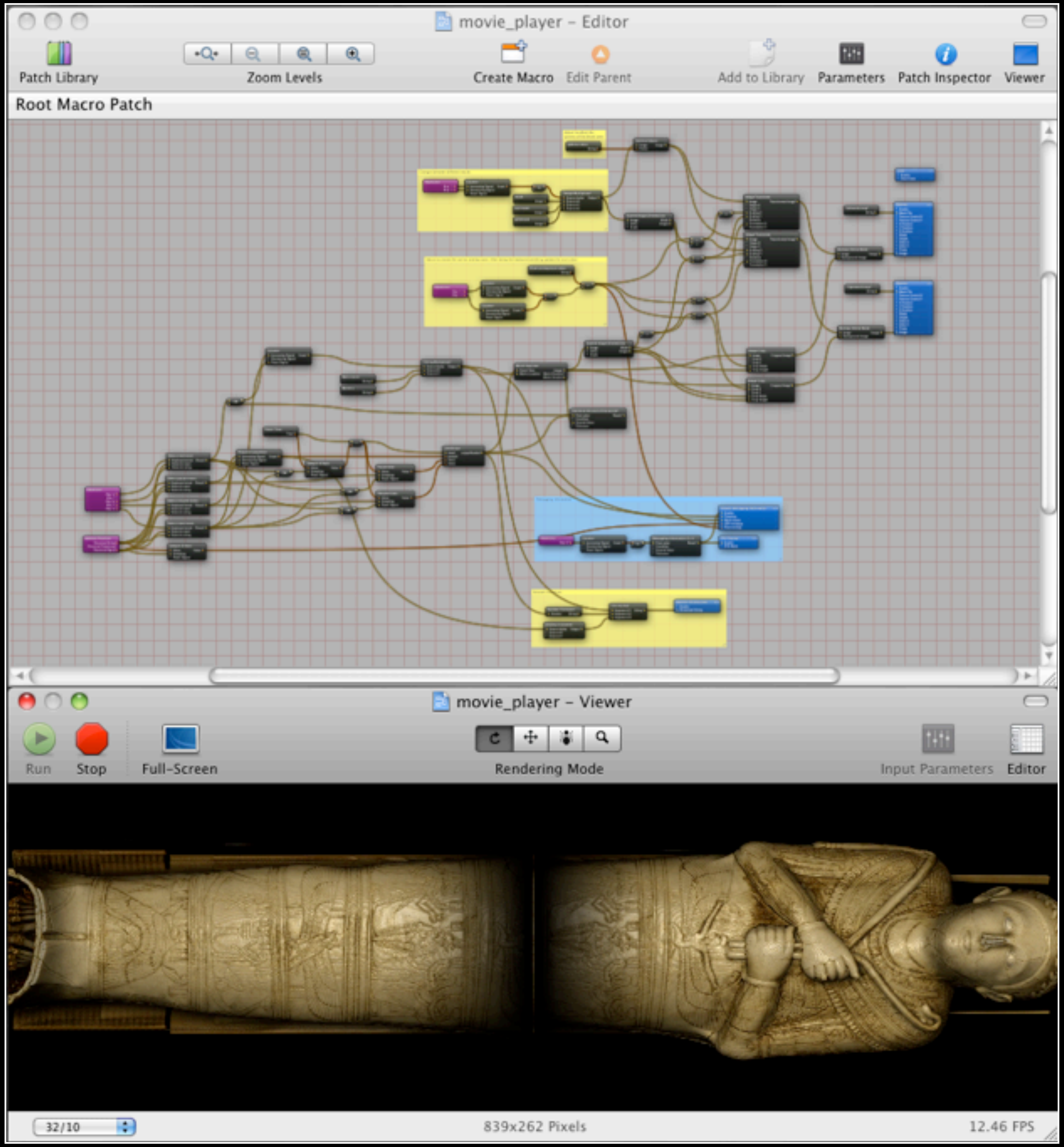
translate rotate adjusted image fixed image

correllation coefficient, find maximum over a range of dx,dy,dø

Realtime processing pipeline



Quartz Composer playback



Dual 1920x1200 pixel projector rig

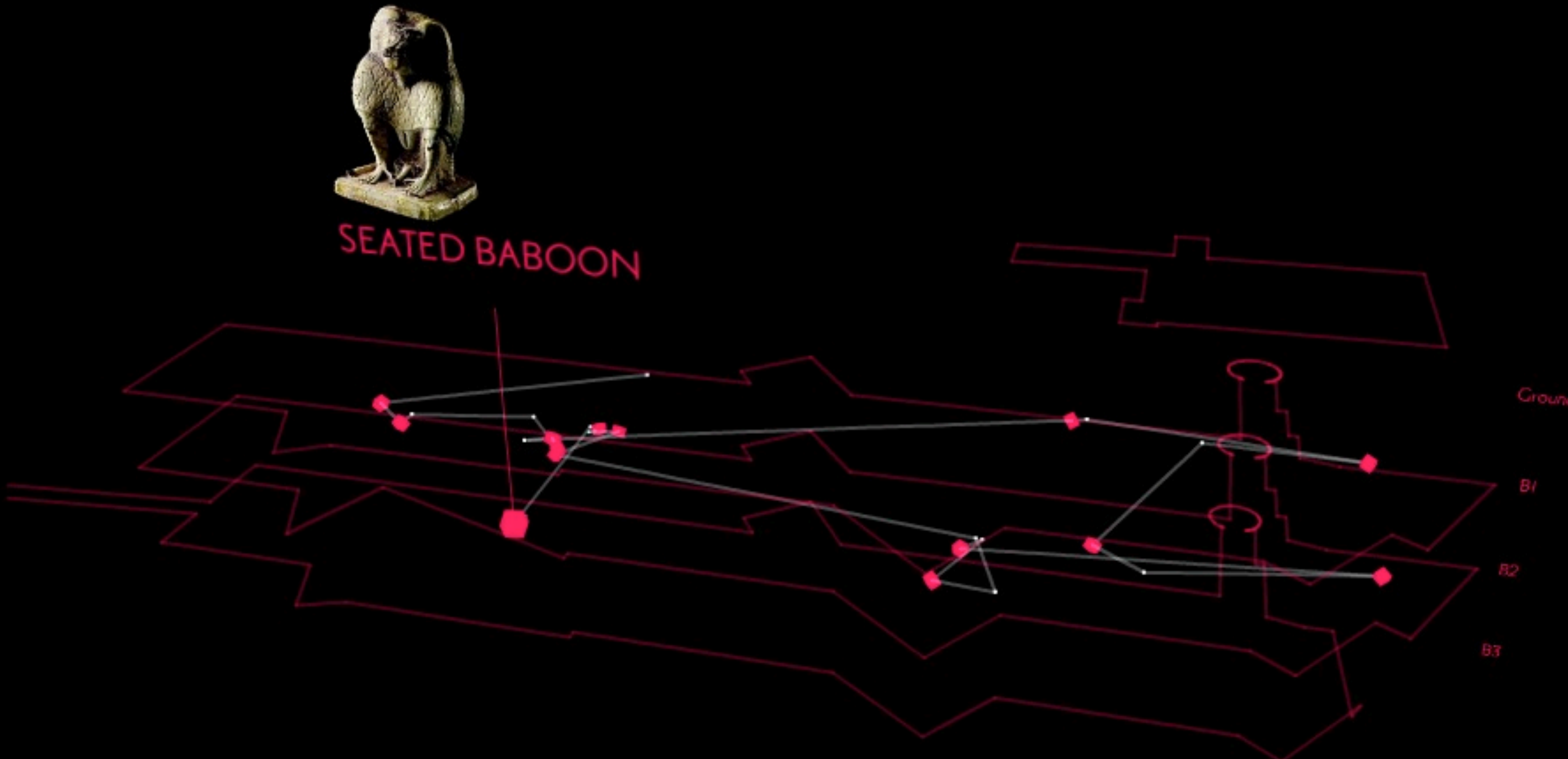
Pausiris gallery

- Room is filled with water containing black dye.
- Only 2-3 people allowed in at one time.

Not without some stress: 24 hours before the opening

~1400 iPodTouch units, 280 per charging cabinet

- Location aware iPods, accurate to within a 3m diameter using time of flight to base stations.
- Loaded with information and curatorial comment on each exhibit/gallery, there is no signage in the entire museum.
- Voting system: “love” or “hate”. Can be used as the basis for changing the galleries.



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Navigate your tour via the 3D model above, or via the artwork listings to the right.

Click and drag your cursor over the 3D model to rotate the perspective. Each pink cube represents an artwork you viewed on The O.

Click on a work to view it's interpretive material. This will appear in the far right column.

If you've made more than one visit to Mona use the dropdown menu below to select which visit you wish to view.

VIEWED WORKS

NEIGE ET RENARD HATE
Léopold Rabus

WHEN THE NIGHT FALLS, SECRET LAKES COME OUT (CESARE PACIOTTI) HATE
Amie Dicke

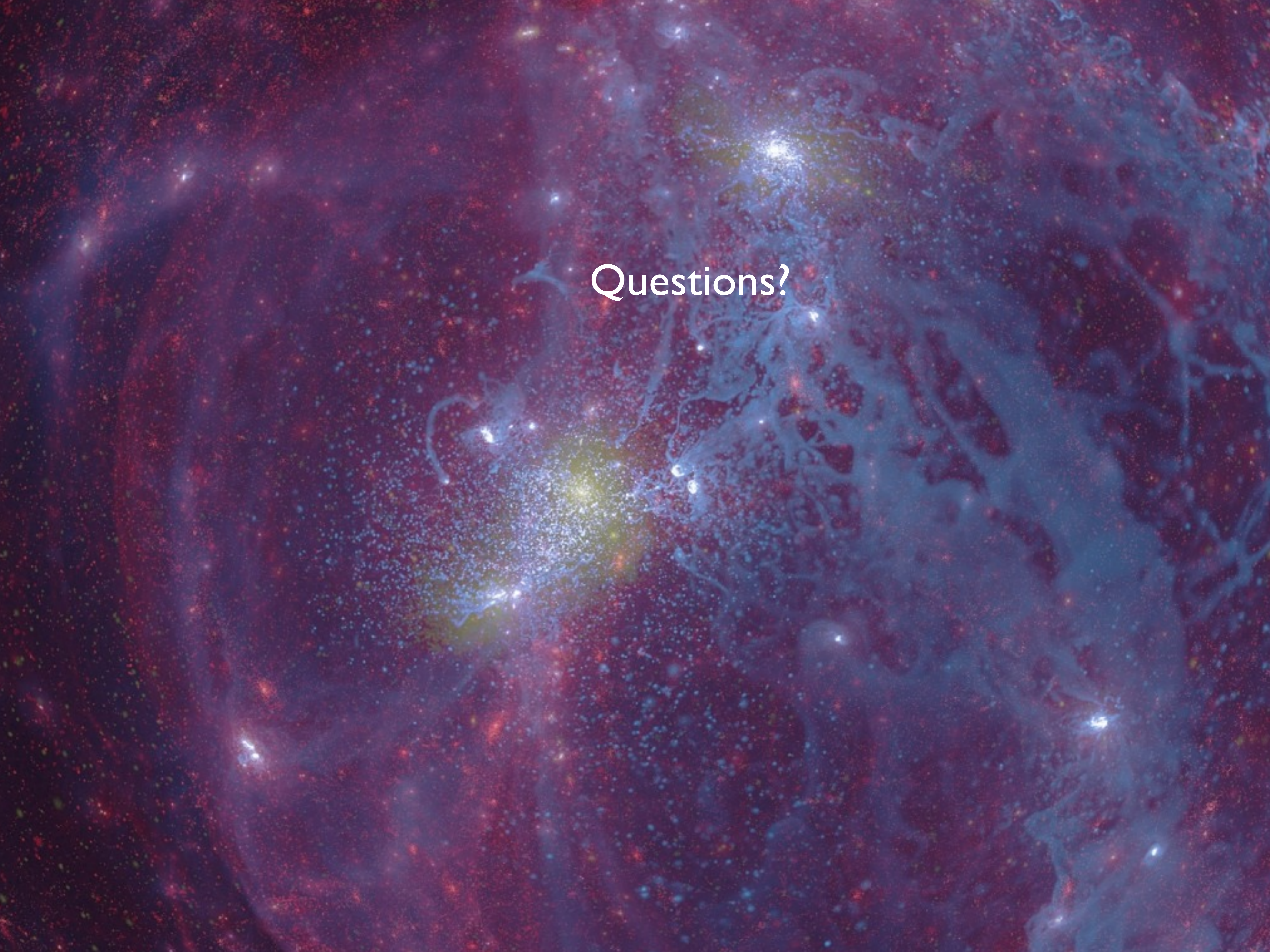
PORTRAIT OF A MAN: WILLIAM WORDSWORTH, 1770-1850, FROM LIFE MASK
Joanna Kane

HEAD OF A MAN LOVE

ECONOMICAL STUDY ON THE SKIN OF

NEIGE ET RENARD
LÉOPOLD RABUS

Mixed media on canvas, two panels
Born 1977, Neuchâtel, Switzerland, where he


Questions?