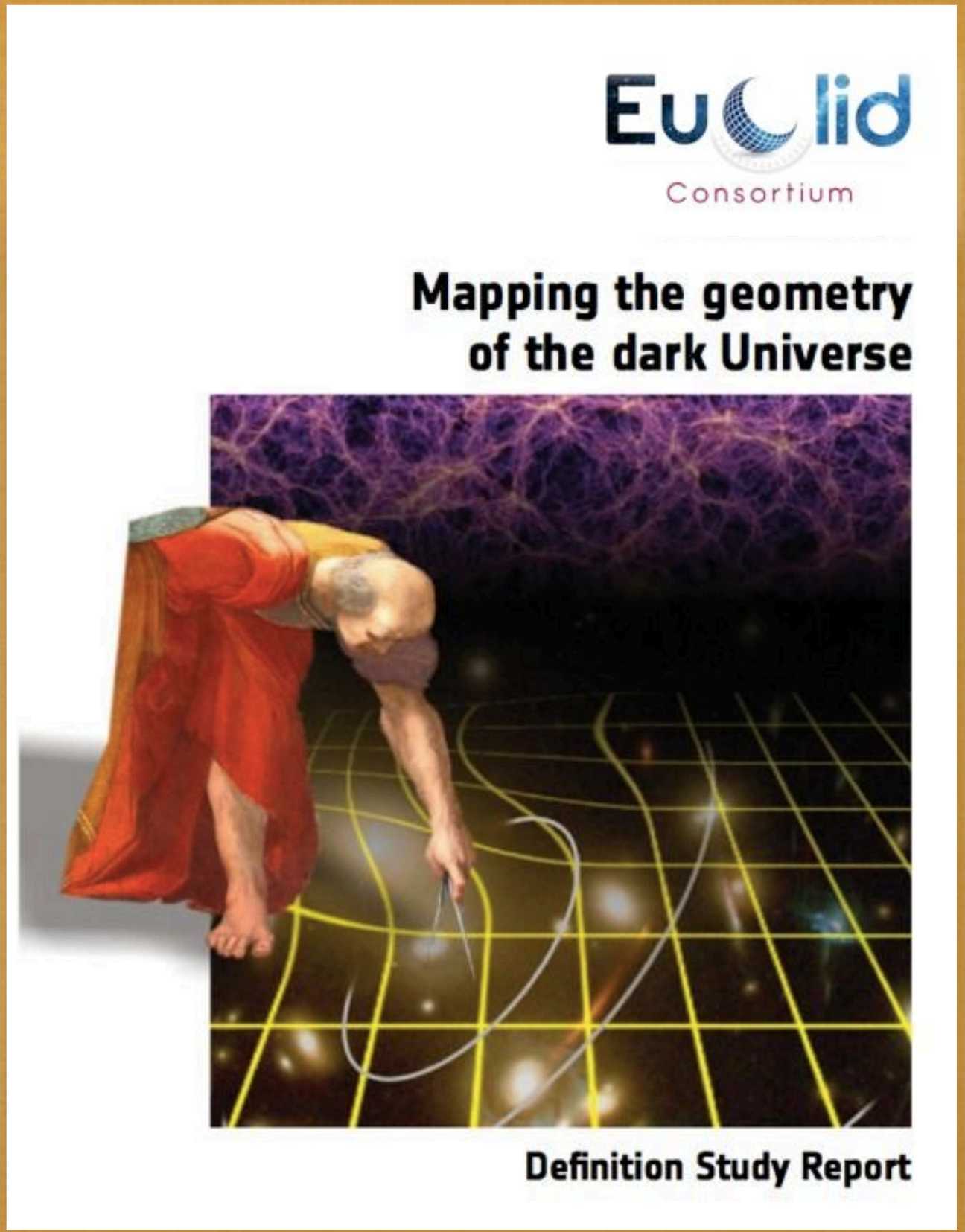
Why Signal Processing ?

- Remove instrumental effects and calibrate data: **reduction**
- Remove the instrumental and atmospheric Point Spread Function (PSF): **deconvolution**
- Interpret interferometric data (reconstructing images): **aperture synthesis**
- Pattern and shape recognition/measurement: **scientific measurement**

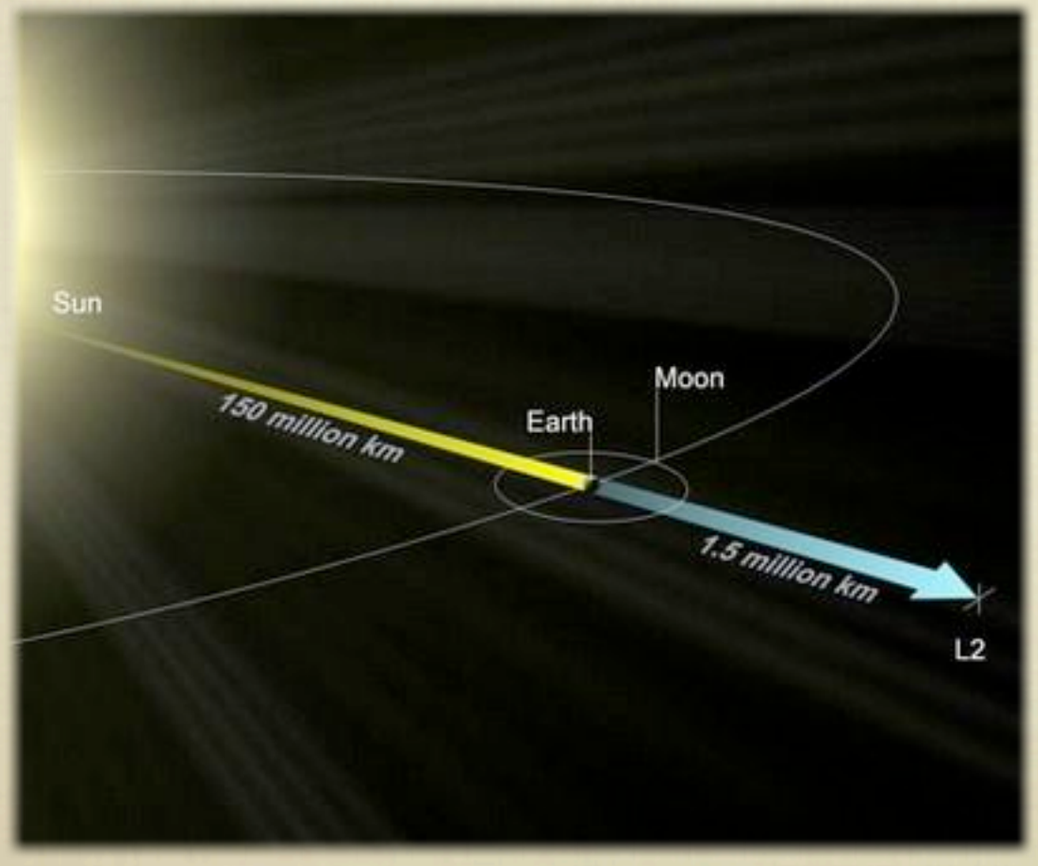
The ESA EUCLID space mission

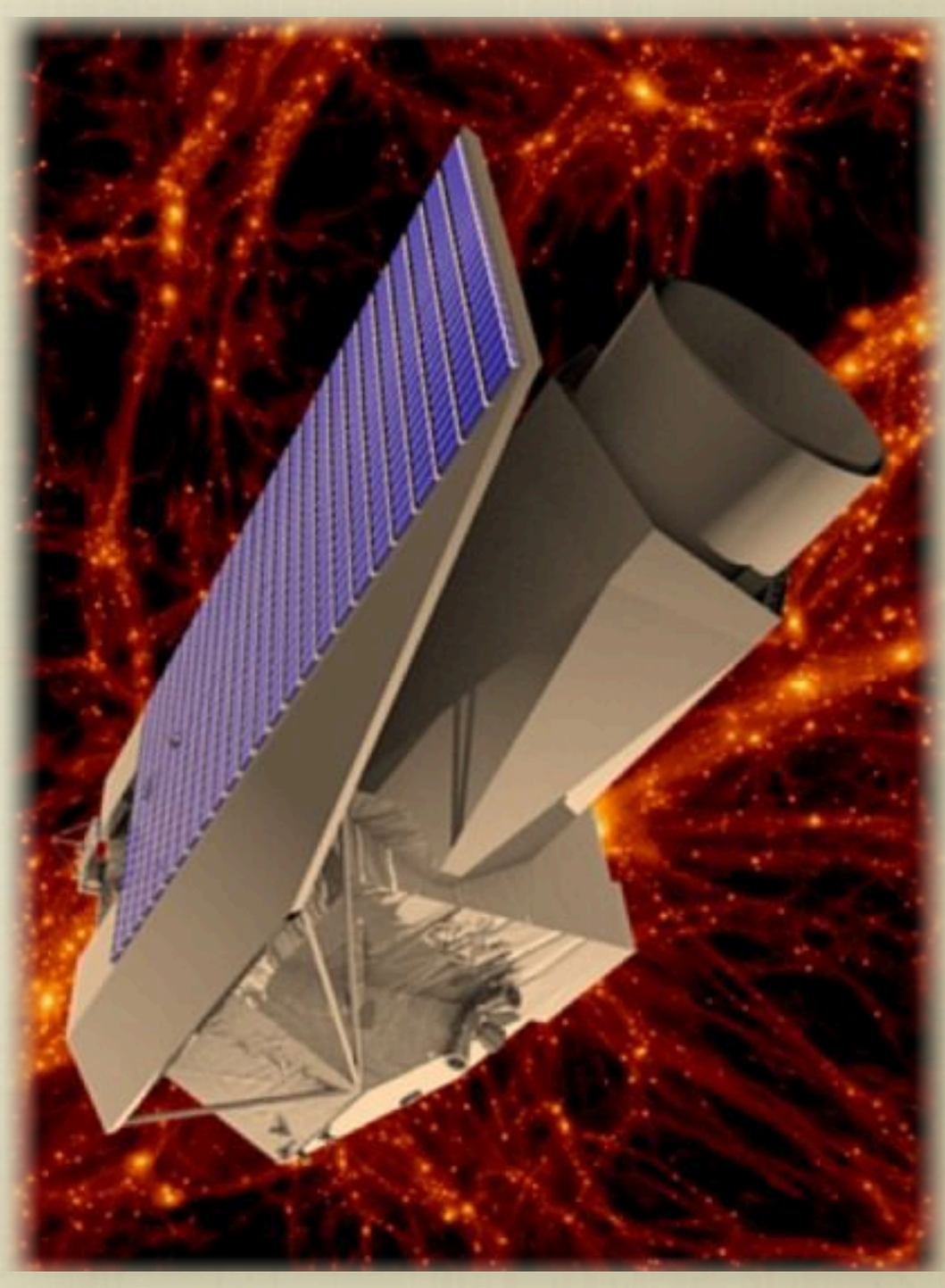
- Mapping the cosmic web
- Measuring the cosmological parameters



EUCLID: A Cosmology Machine (2020)

- ESA M-class mission
- 1.2m space telescope with a wide field **optical** and **near-IR** camera + near-IR **spectroscopy**





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EUCLID Mission Summary

The main cosmological probes in EUCLID will be:

1- Weak Gravitational Lensing

2- Baryonic Acoustic Oscillations (BAO)

3- Galaxy Cluster Counts

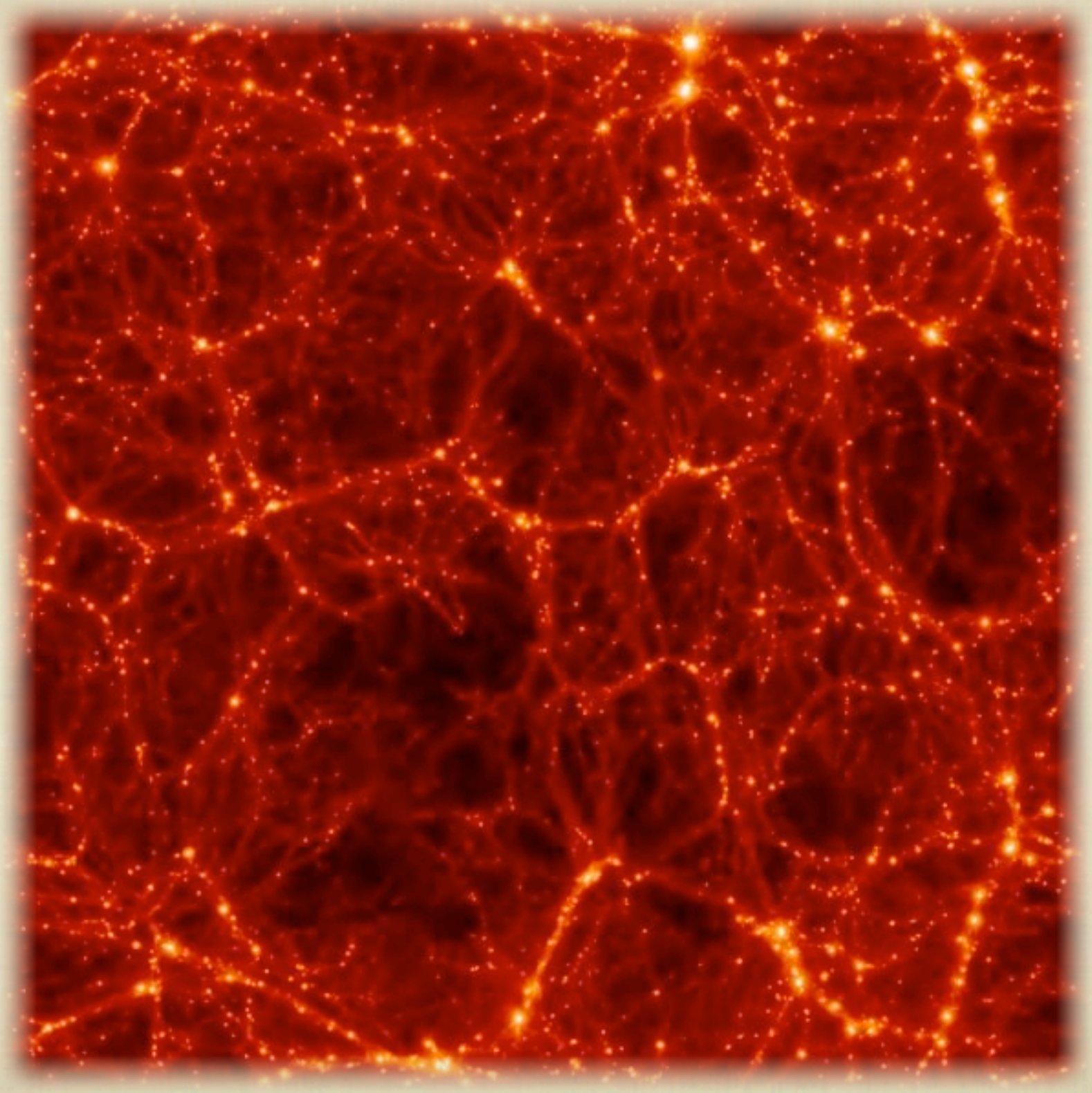
In synergy with:

1- Other Space Missions

2- Ground Based Surveys

Also requires synergy with other fields of science

Simulated View of the Cosmic Web



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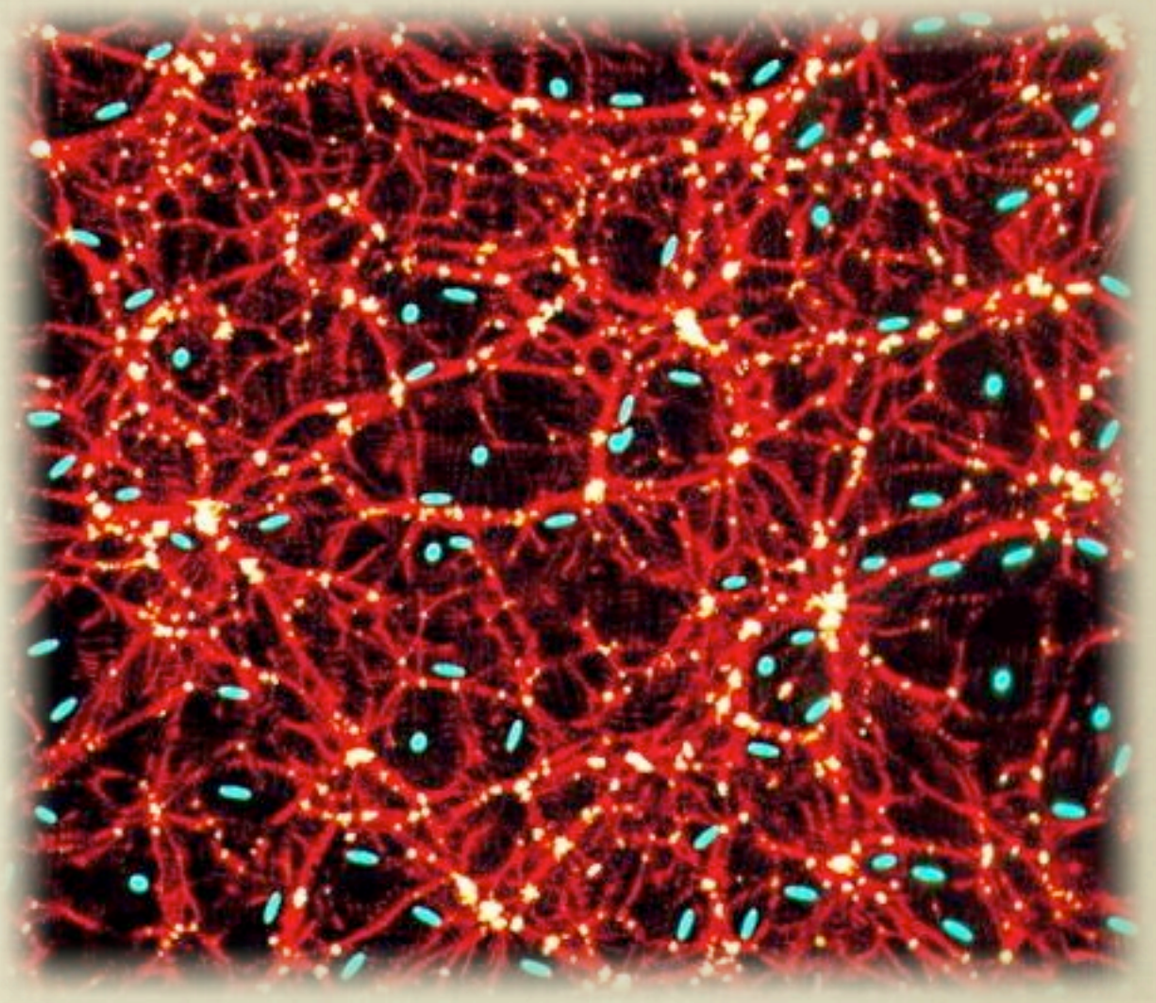
Weak Lensing by Large Scale Structures

- The weak lensing signal is seen in projection on the plane of the sky.

- Galaxies (here in blue) are seen **stretched** (statistically) as compared with their shape in the absence of lensing.

- Detection through the correlation function of the measured galaxy ellipticities (shapes).



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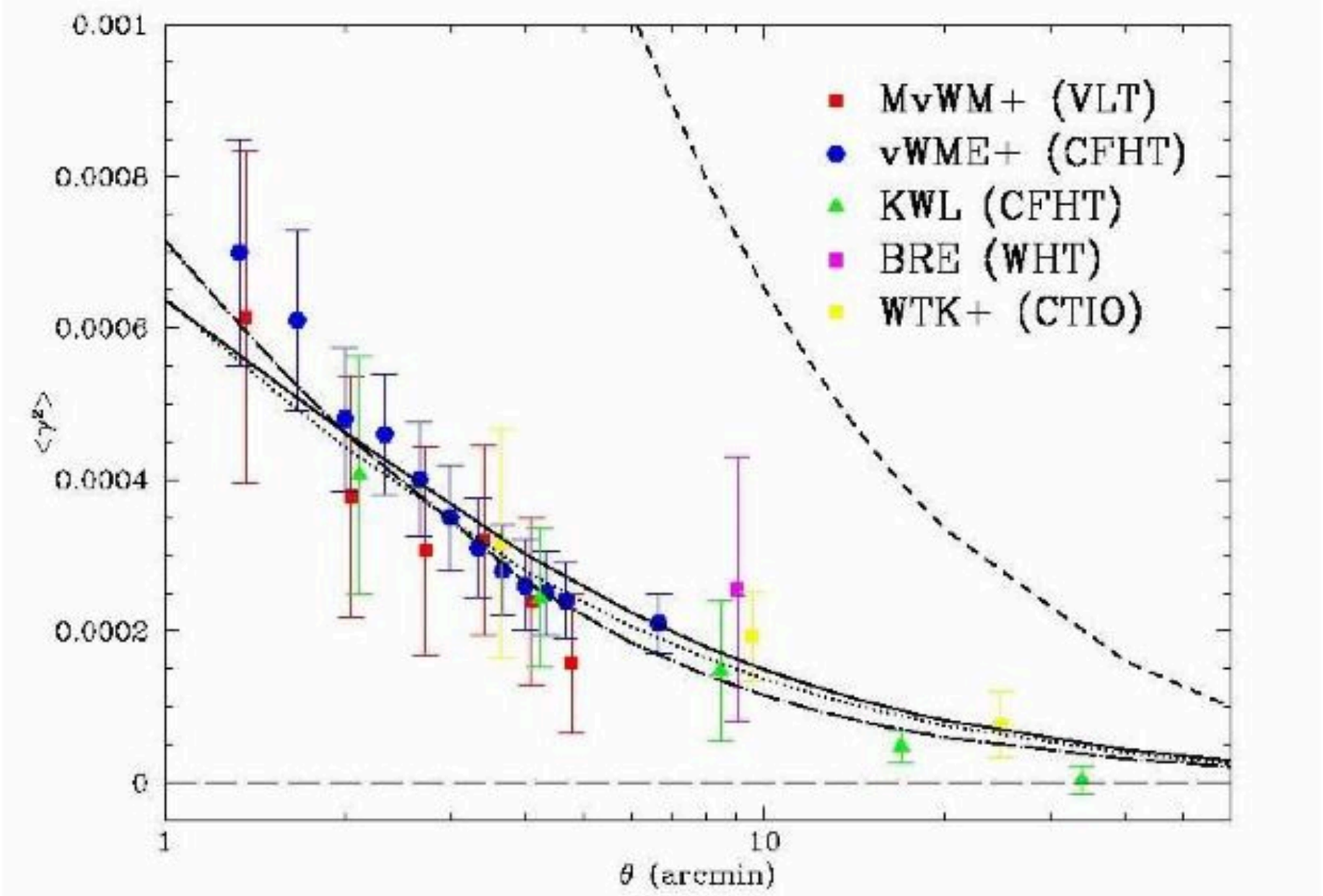
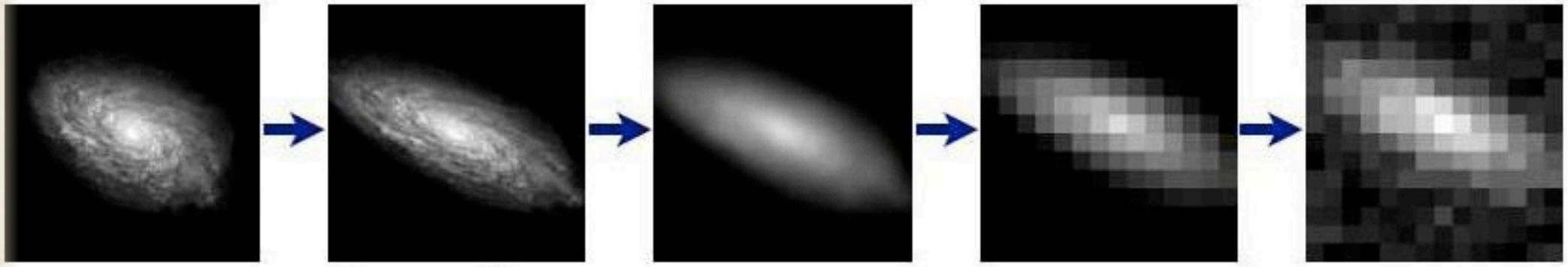
Weak Lensing by Large Scale Structures (2000)



EUCLID: all About Measuring Galaxy Shapes !

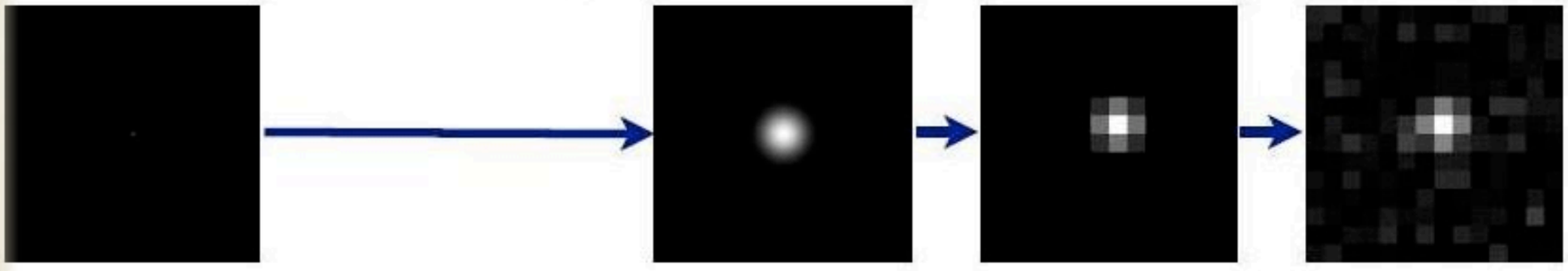
The Forward Process.

Galaxies: Intrinsic galaxy shapes to measured image:



Intrinsic galaxy (shape unknown) | Gravitational lensing causes a ***shear (g)*** | Atmosphere and telescope cause a convolution | Detectors measure a pixelated image | Image also contains noise

Stars: Point sources to star images:



Intrinsic star (point source) | Atmosphere and telescope cause a convolution | Detectors measure a pixelated image | Image also contains noise

Typical EUCLID Data

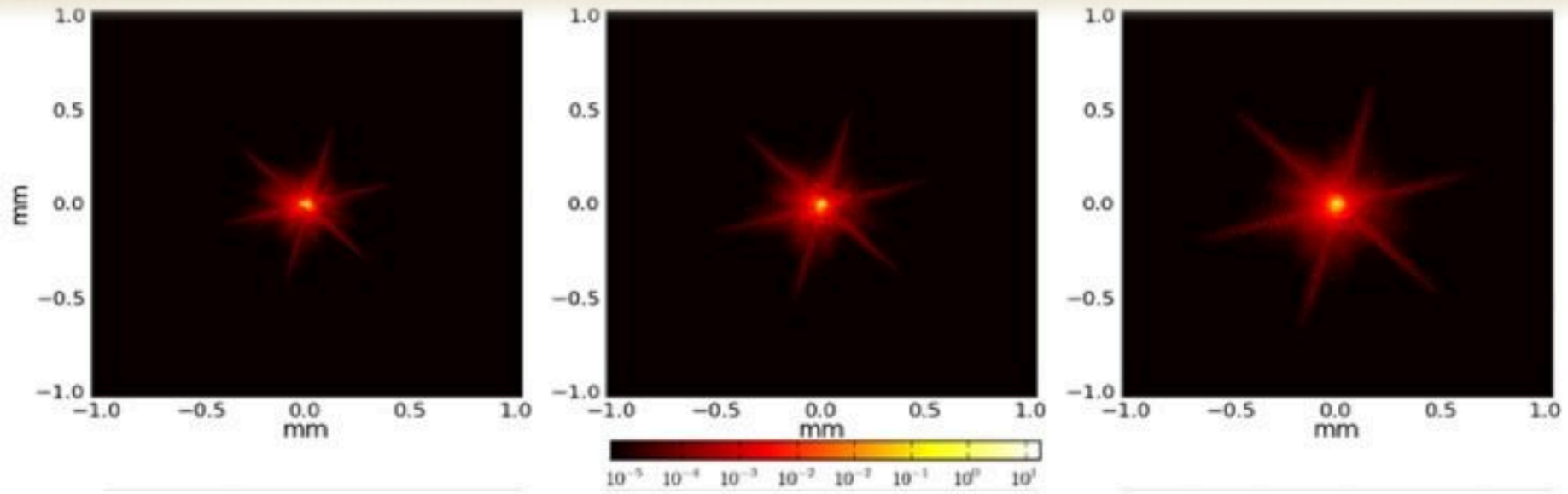
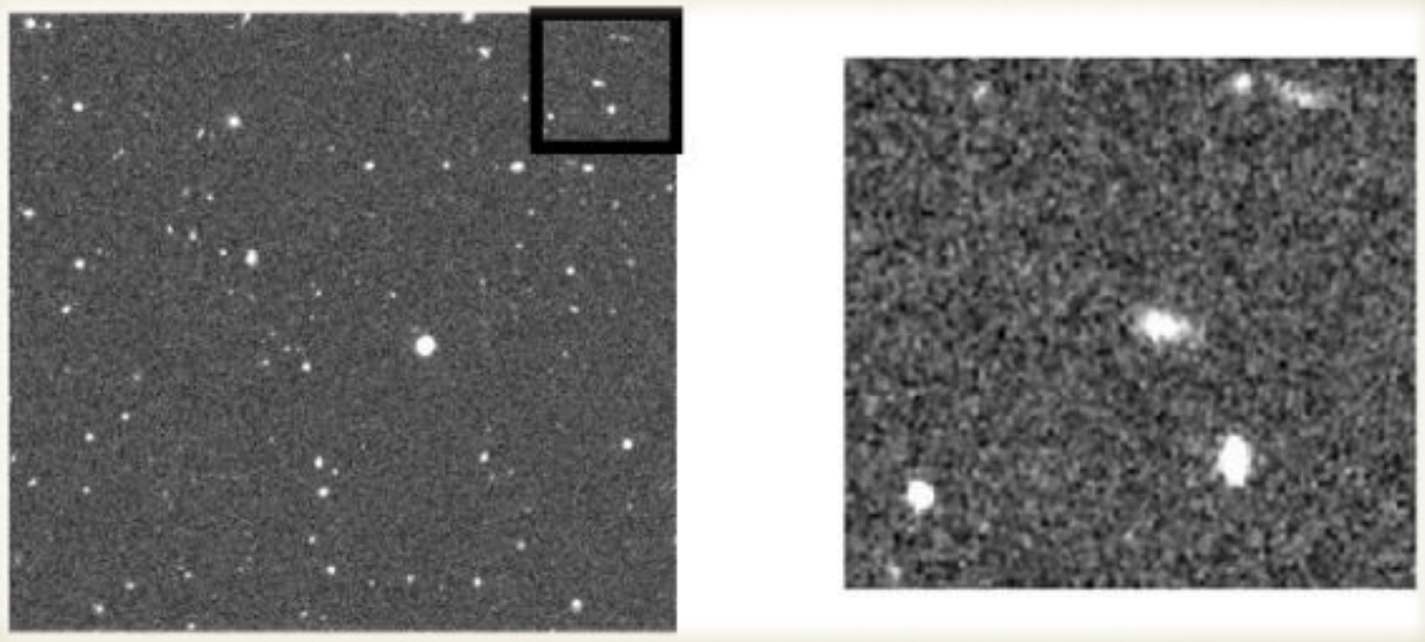


Figure 6.6: The point spread functions (left = Y band, middle = J band & right = H band) on a log scale generated at the focal plane positions where the image quality is worst (largest EE50 & EE80). These PSF are constructed from accurate optical, pointing stability and detector models and are used as reference in other performance evaluations

- **Top**: Point Spread Function at different wavelengths
- **Bottom**: a typical galaxy used for «shape measurement»



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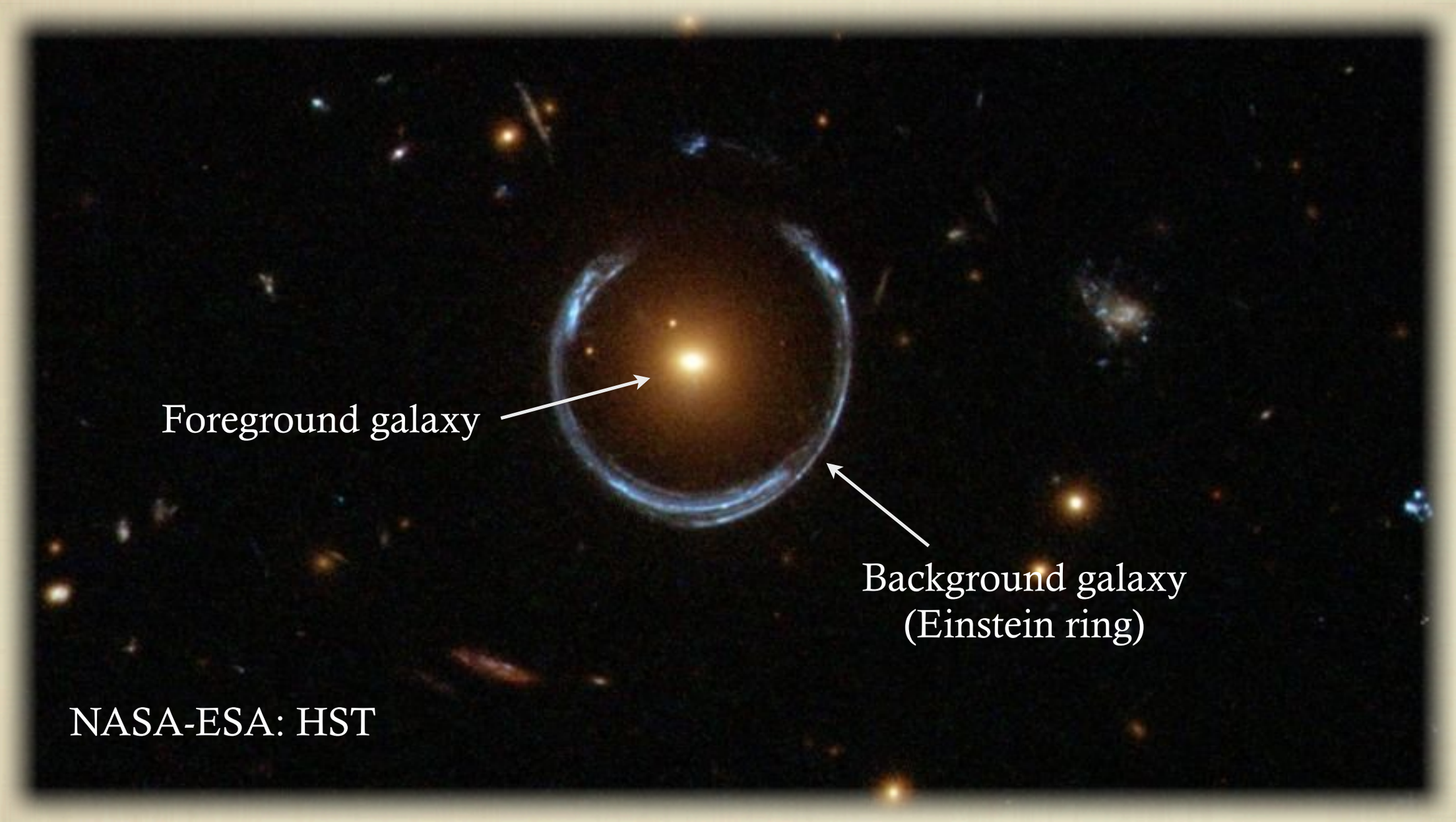
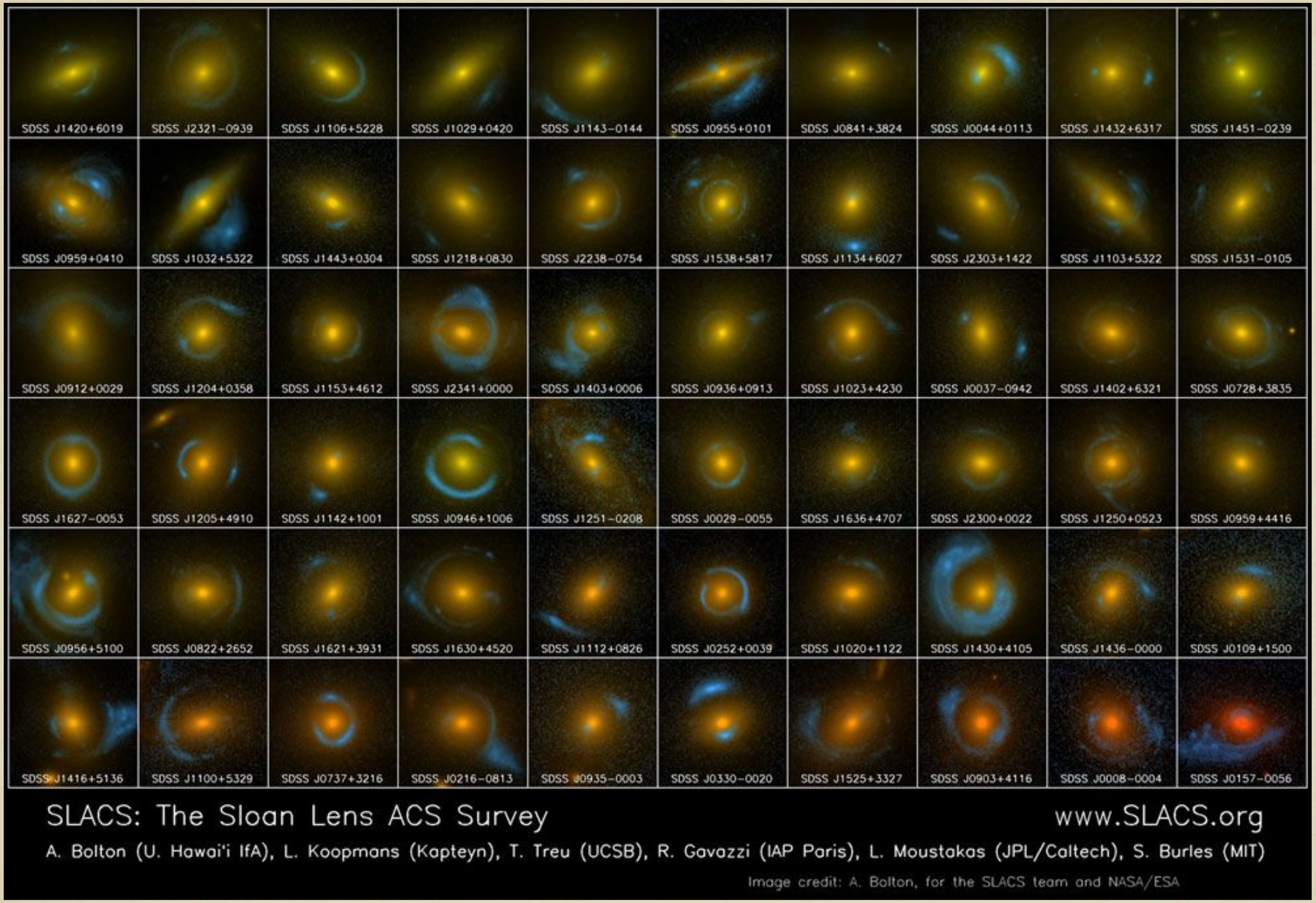
Also Strong Gravitational Lensing



Allows us to measure the **total mass (dark + visible)** in the Einstein radius

~300 Strong Lenses Known so Far (SLACS sample)



EUCLID will find ~100 000 Lenses

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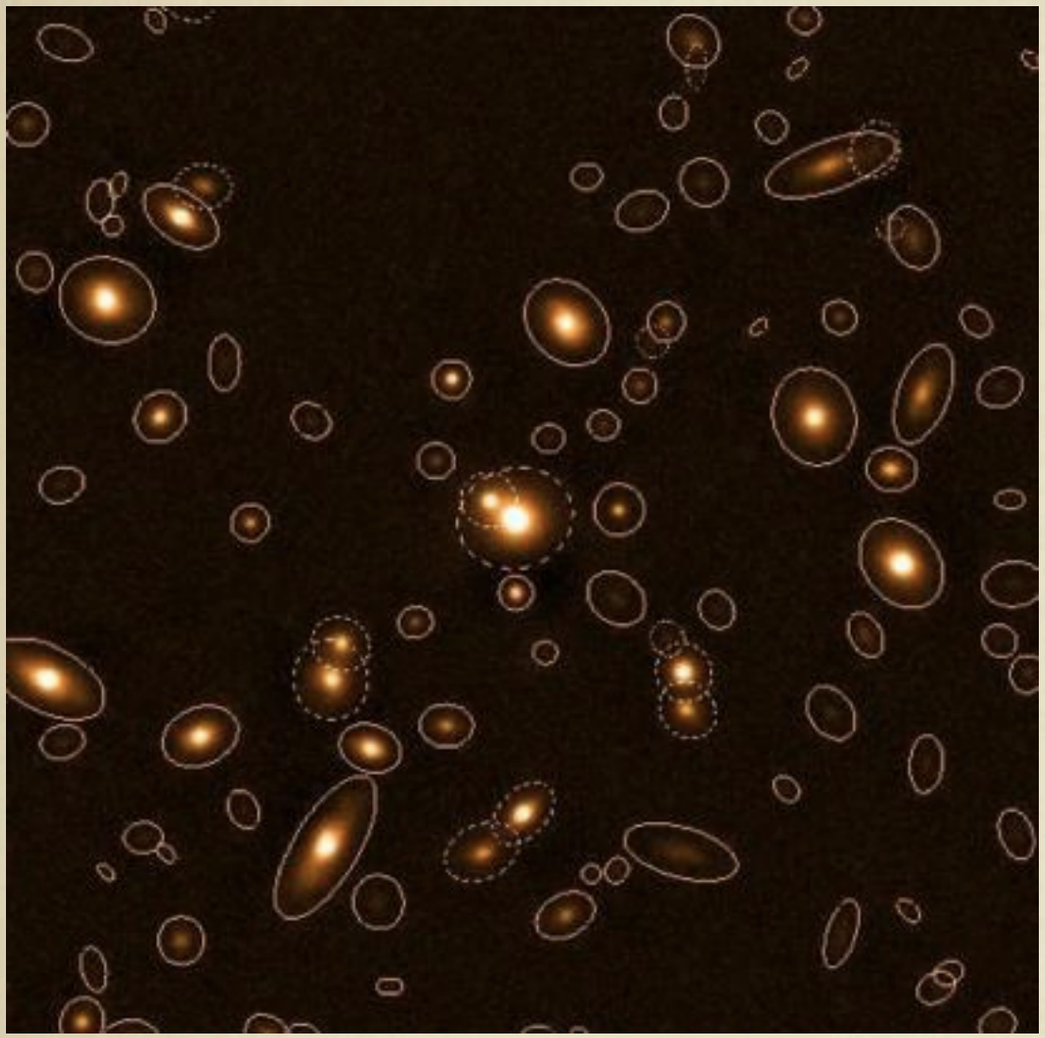
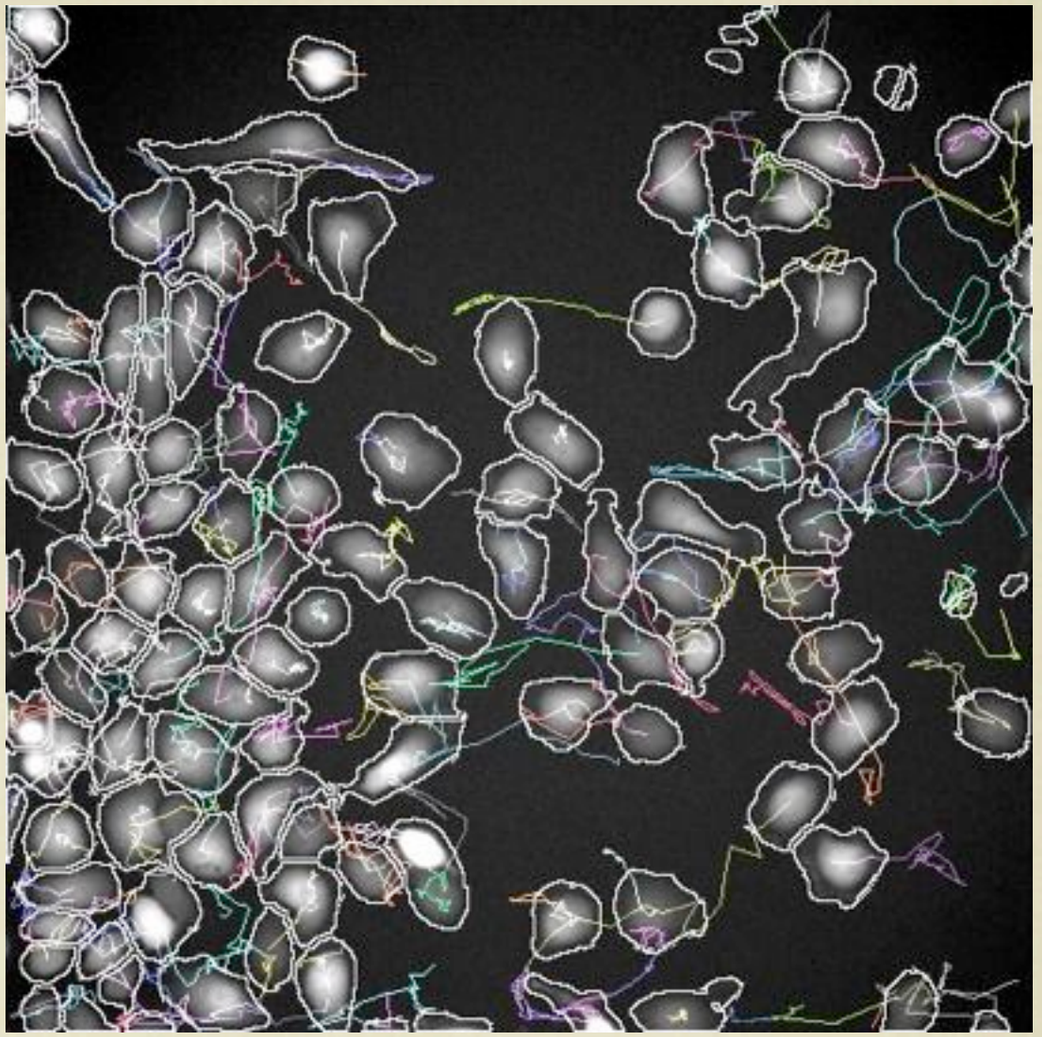
Synergies: Pattern Recognition

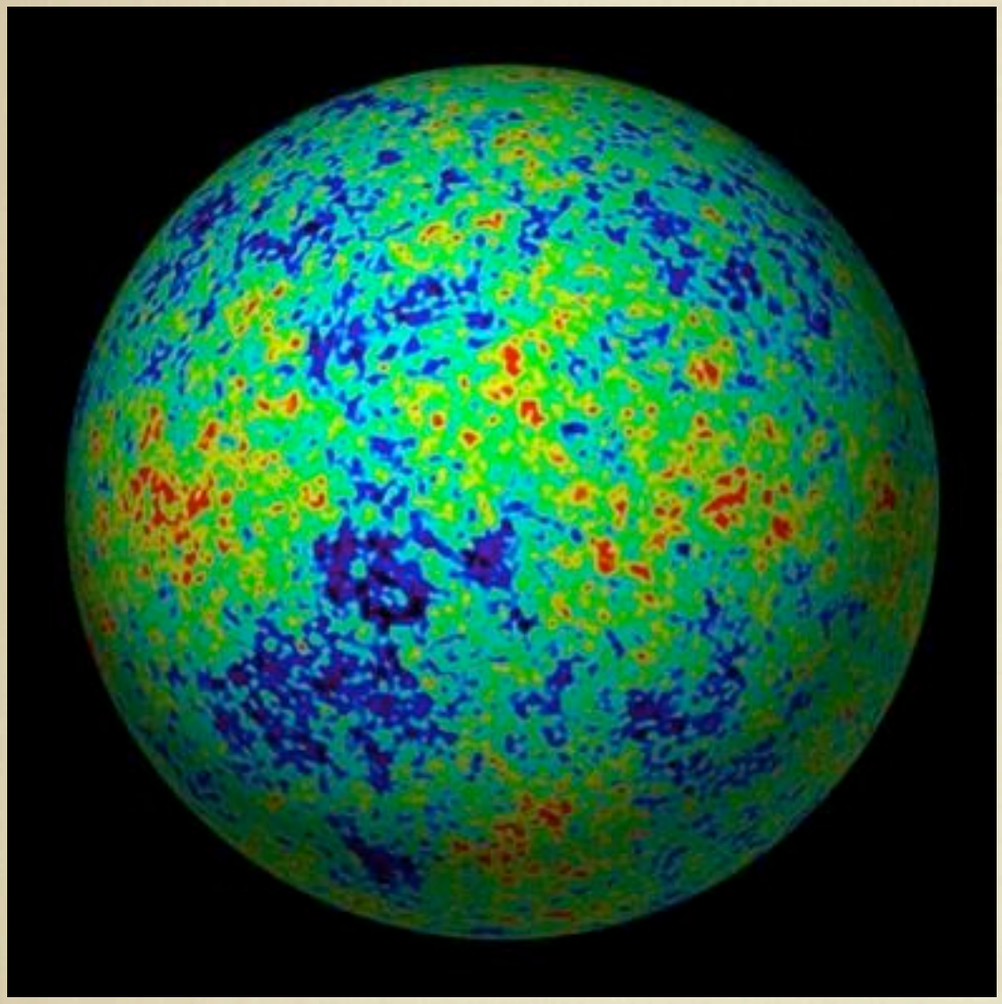


Astrophysics
Galaxy finder



Biomedical Imaging
Cell tracker

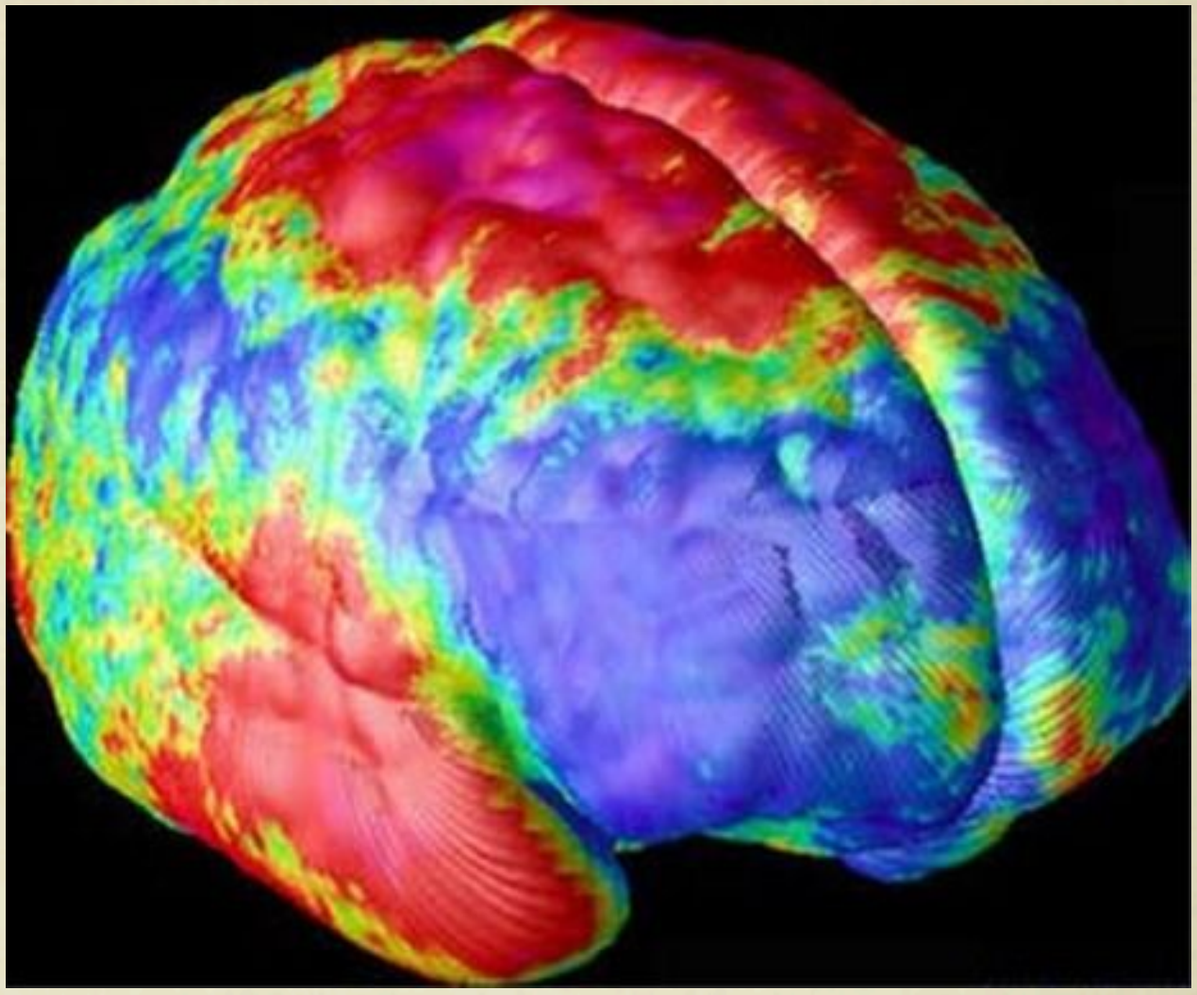
Synergies: Common Topologies



Astrophysics

Sky background

Temperature variations

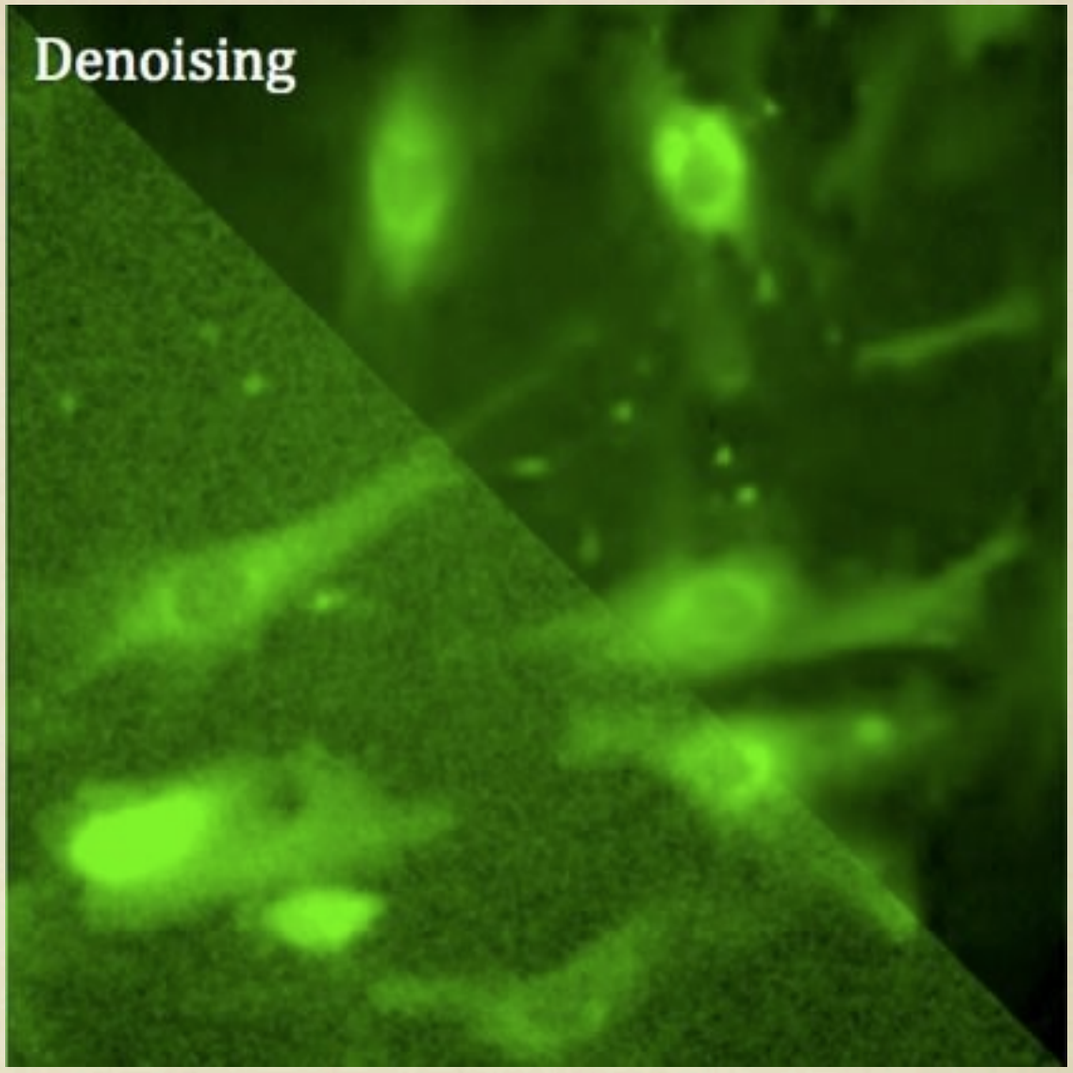


Biomedical Imaging

Cortical thickness

Synergies: Image Denoising

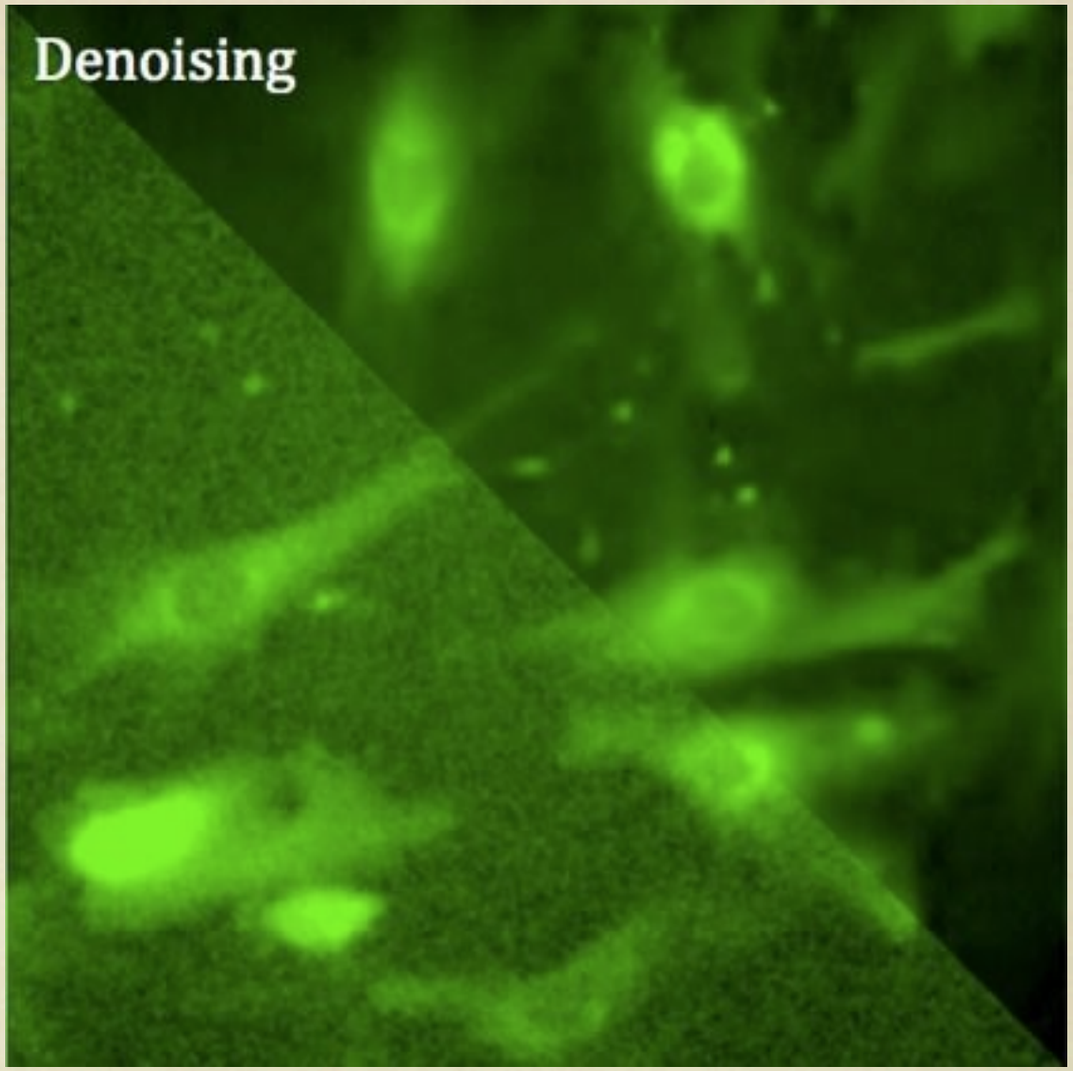
Astrophysics



Biomedical Imaging

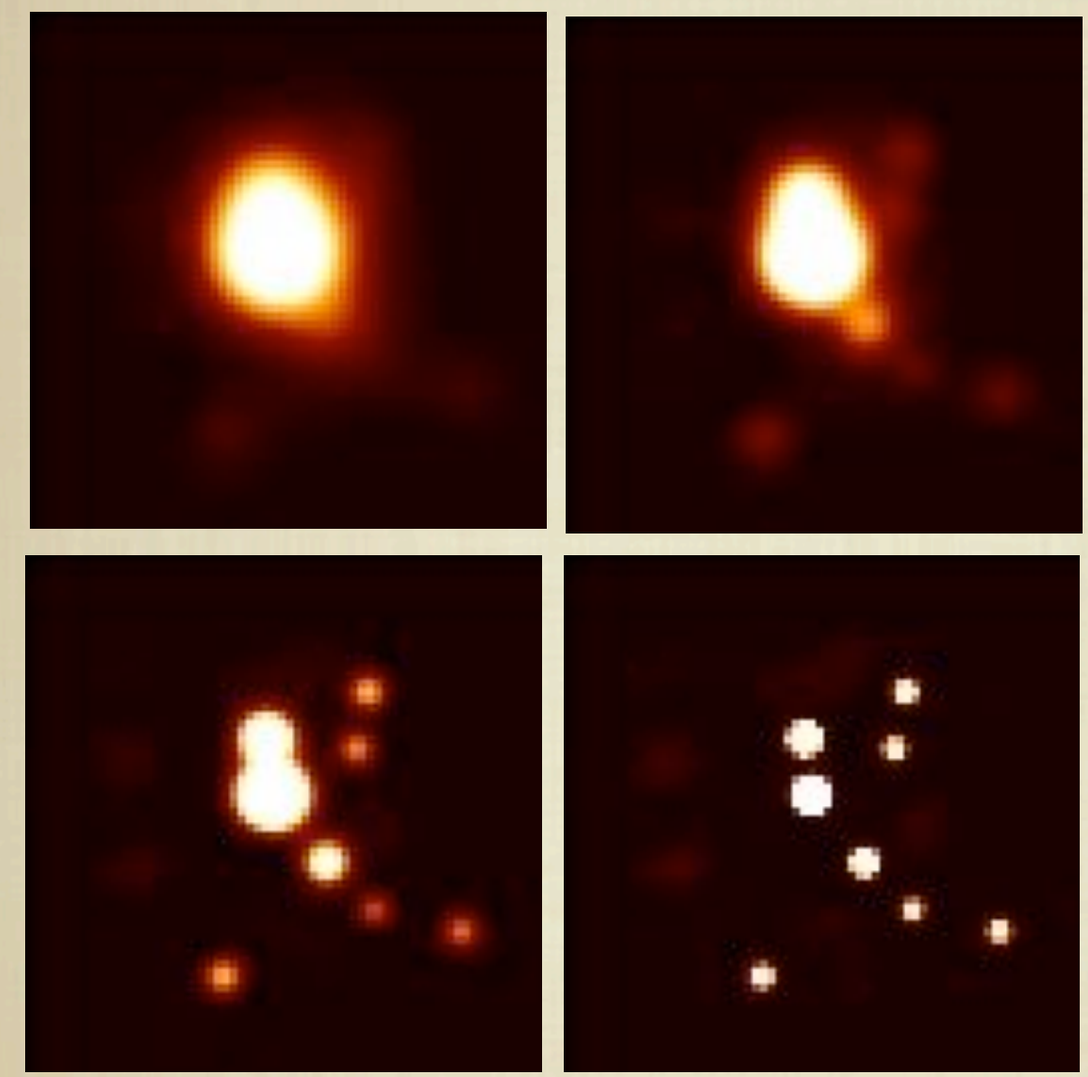
Synergies: Image Denoising

Astrophysics

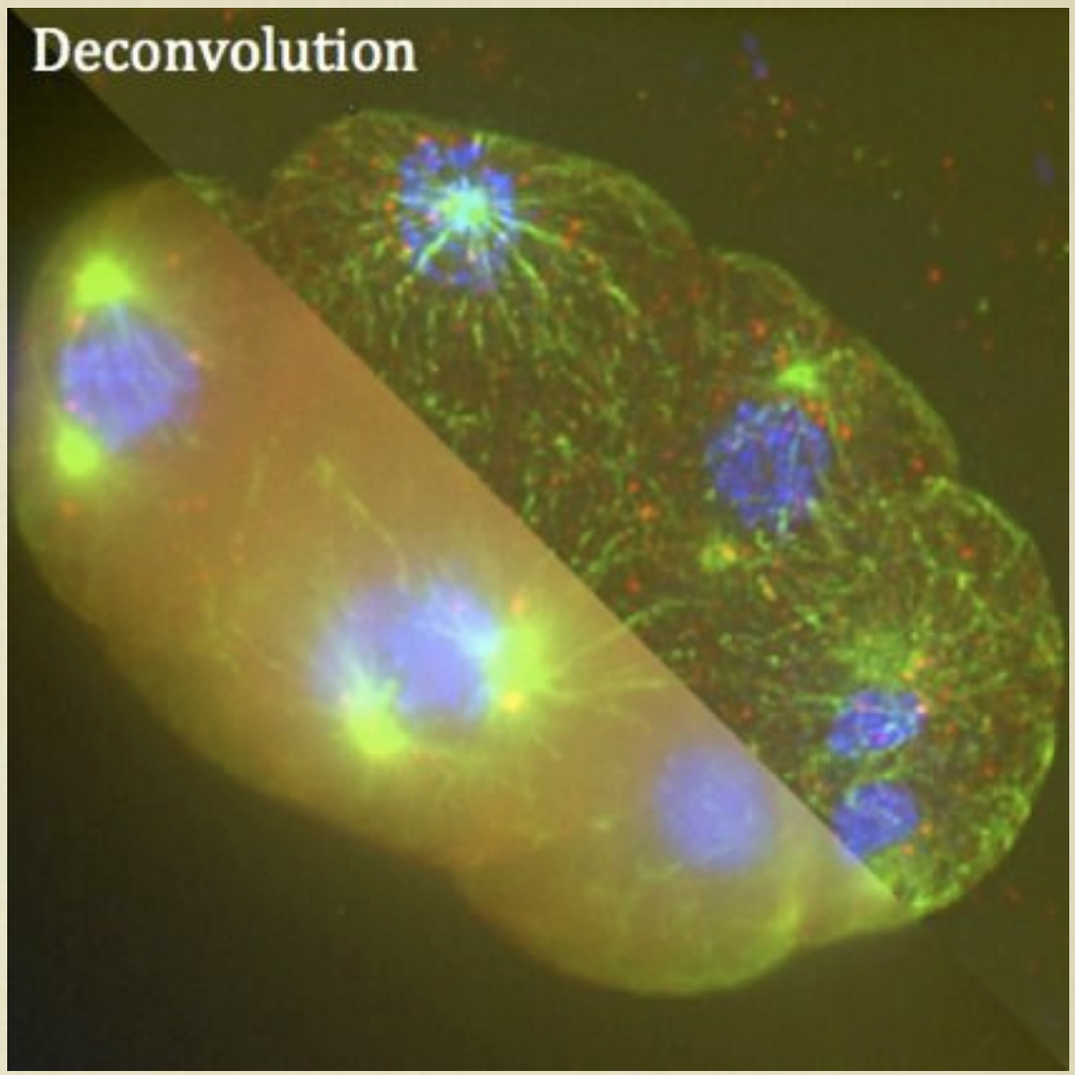


Biomedical Imaging

Synergies: Image Deconvolution

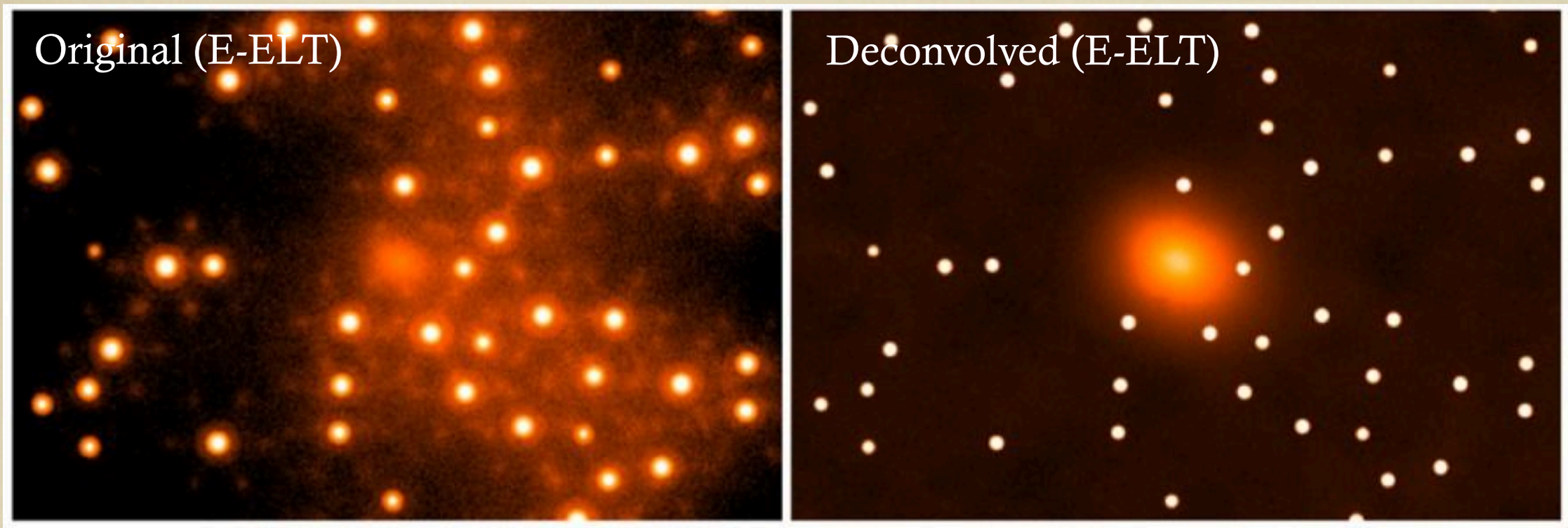


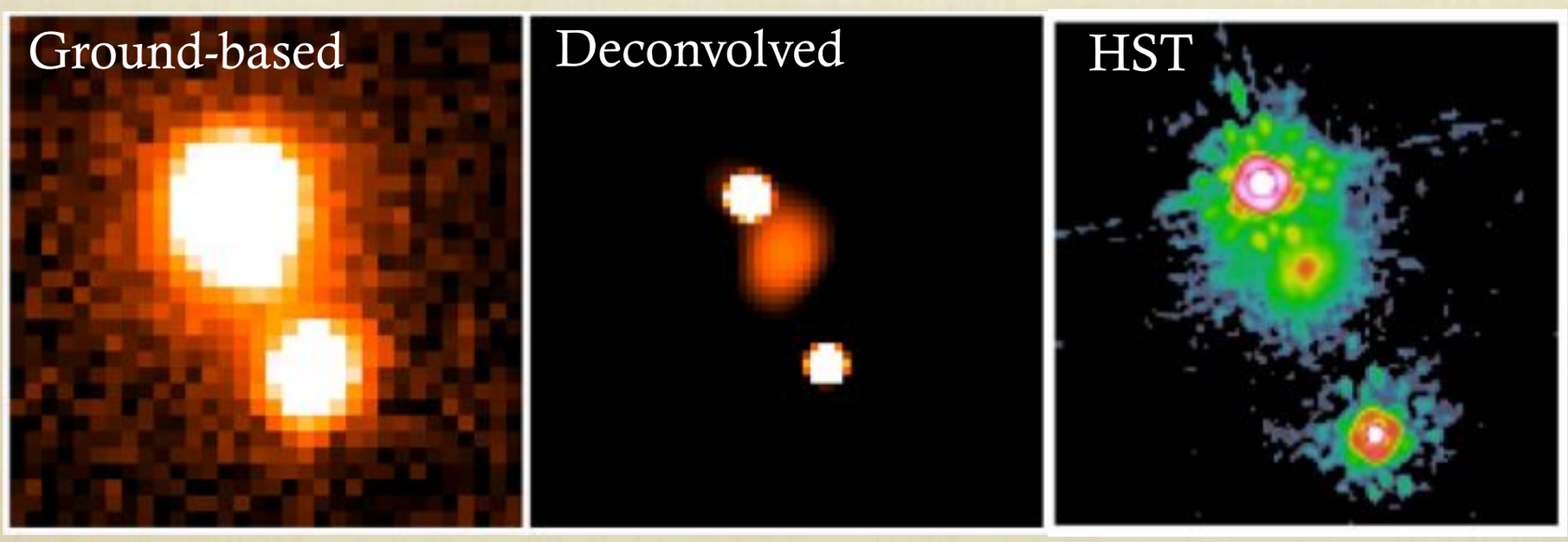
Astrophysics



Biomedical Imaging

Examples of Deconvolution at LASTRO





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Privileged Situation at EPFL

- **Biomedical Imaging Group** (Prof. Unser):
  - deconvolution, denoising, splines
- **5 Signal Processing Laboratories** (incl Profs. Thiran, Vandergheynst, Vetterli):
  - Segmentation, registration
  - Sparse representation, compressive sensing, aperture synthesis
- **Data-Intensive Applications and Systems Laboratory** (Prof. Ailamaki): Data indexing, system architecture
- **Center for Biomedical Imaging** (EPFL, Unil, UniGE, HUG, CHUV)

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