

The background of the slide is a high-resolution astronomical image of a deep space field. It features a vast number of stars of varying brightness and colors, including white, yellow, and red. Several galaxies are visible, including a prominent spiral galaxy in the lower right corner and a bright, irregularly shaped galaxy in the lower left. The overall scene is a rich, dark tapestry of cosmic objects.

Looking into the dark:
A visualisation wish-list for the
Virtual Observatory

Andrew Hopkins

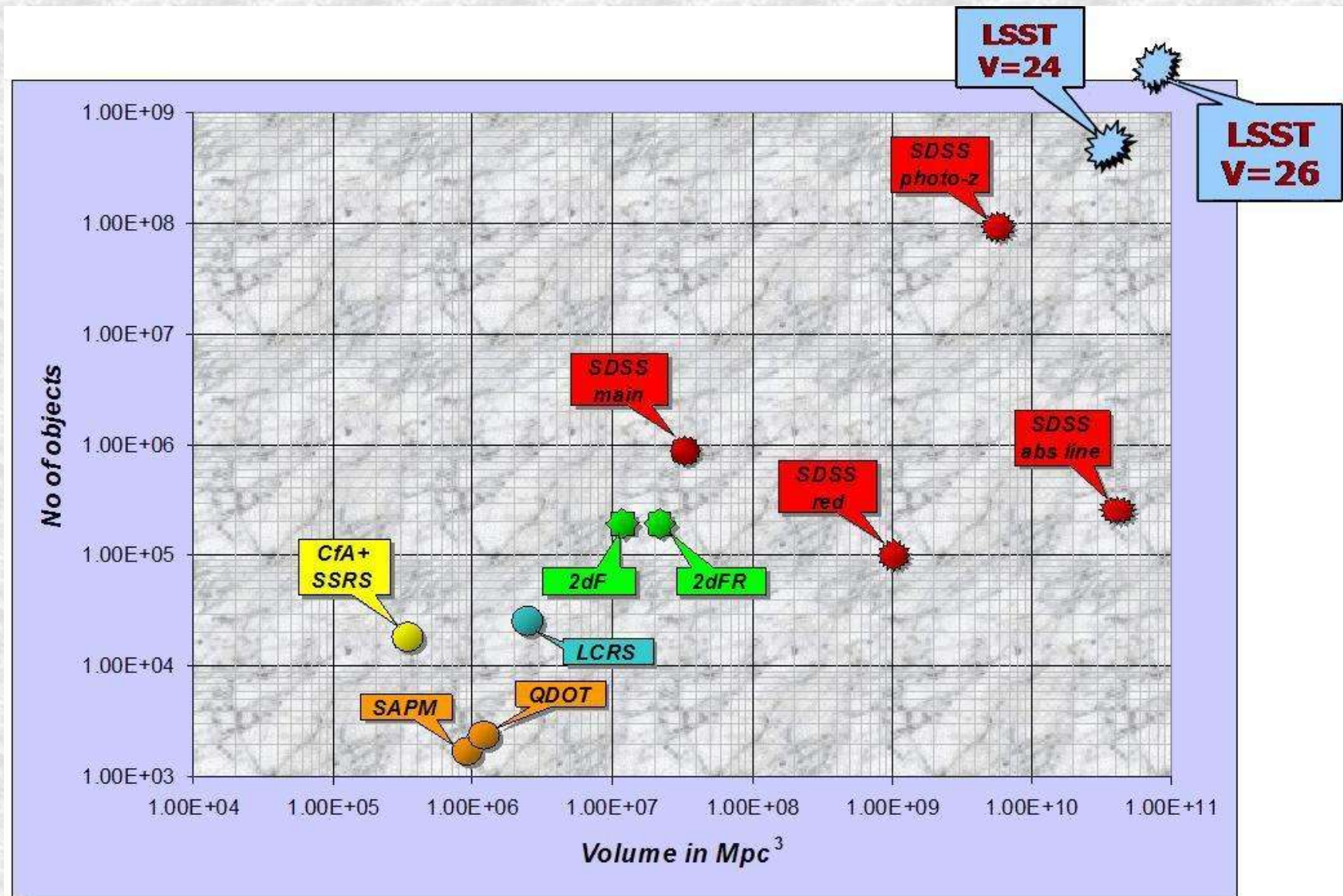
Universities of Sydney and Pittsburgh

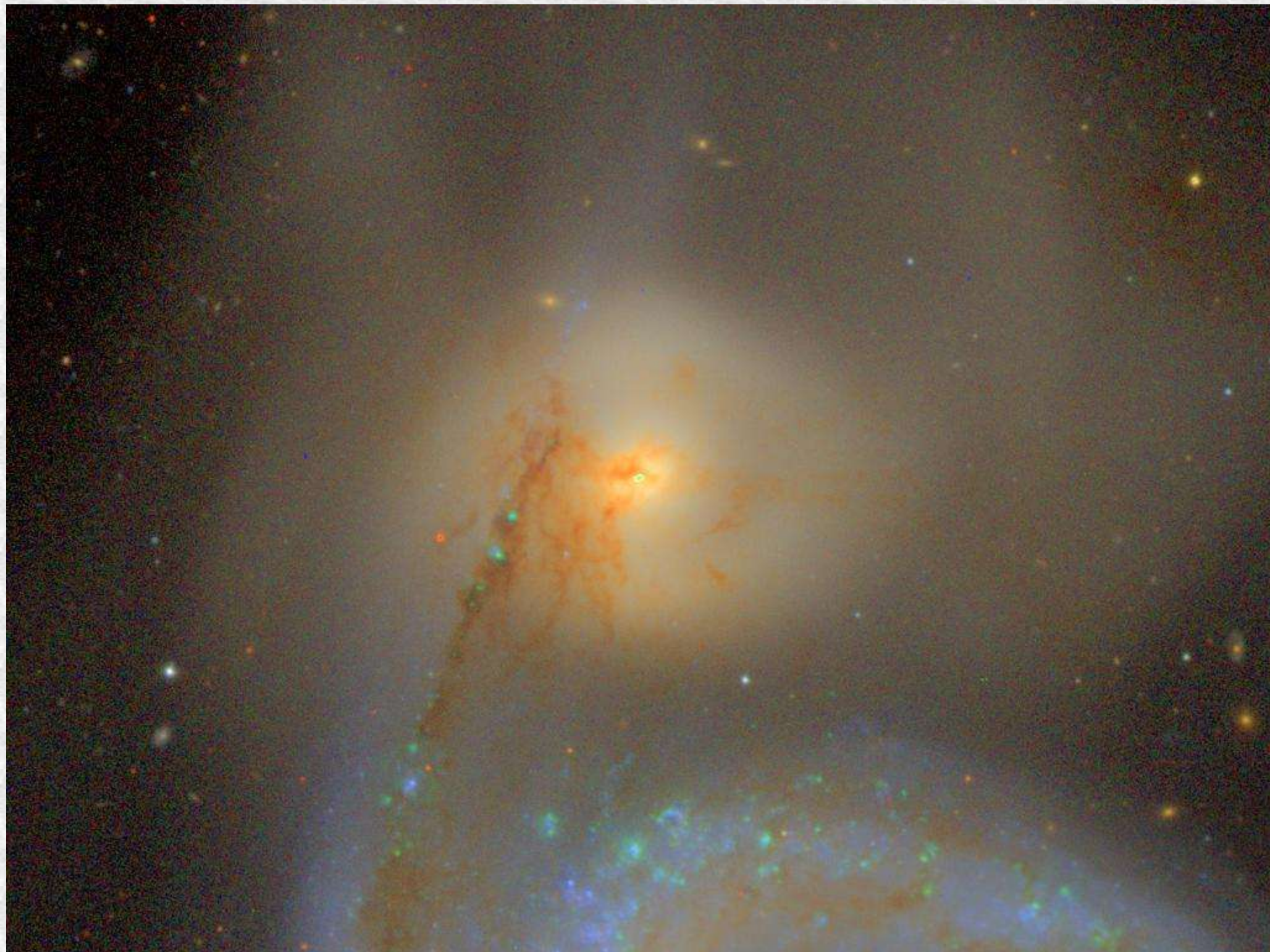
From the Macquarie dictionary:

Look: ... *-n.* ... 16. a visual search or examination.

Dark: ... *-n.* 5. absence of light;...
6. ignorance.

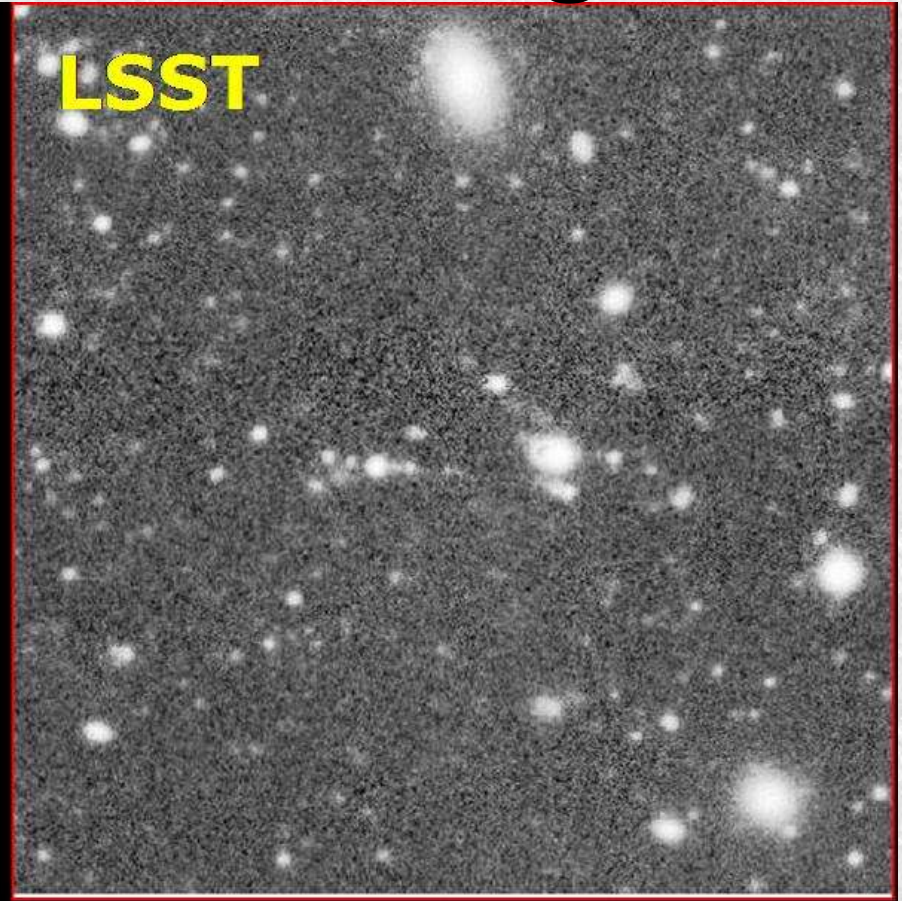
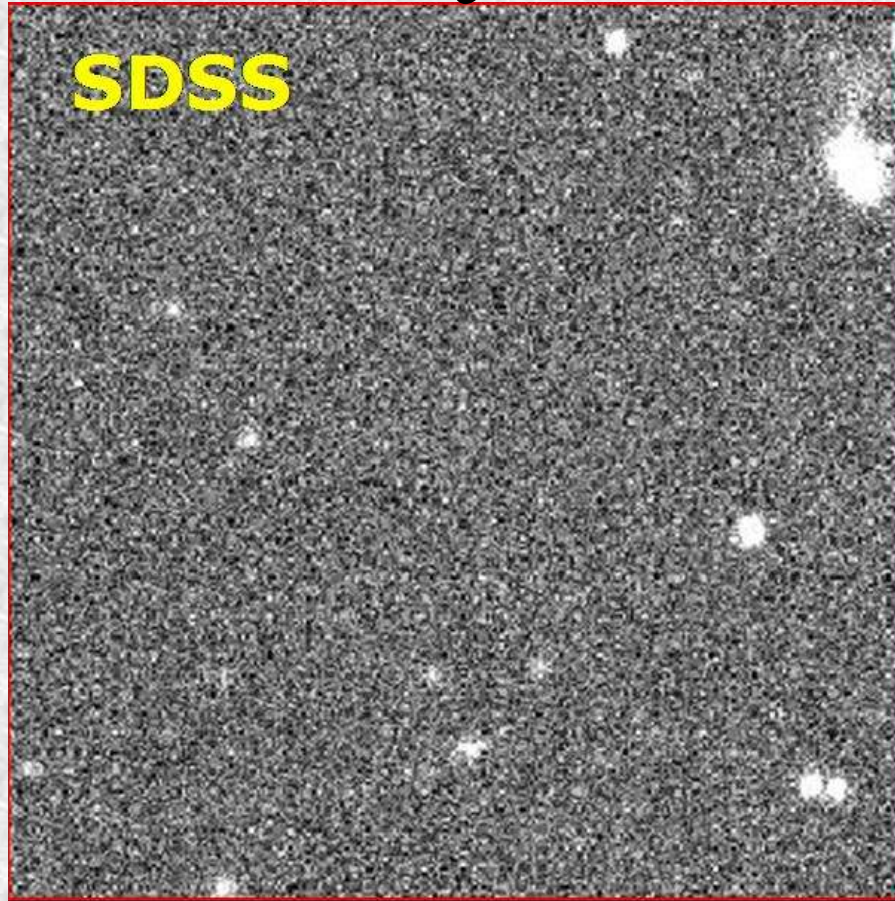
The Data Avalanche





Five years

Three nights



An incomplete list

- A few specific cases where analysis tools exist or are being developed, and good visualisation tools are necessary to support the analysis.
- Suggestions for an environment that may make some visualisation tools more accessible and easy to interact with.
- The concepts here may be able to be generalised and implemented as more widely applicable tools by clever visualisation experts.

Anomaly detection

- ▶ Bayesian classification and expectation-maximisation (EM) using high dimensional parameter space.
- ▶ Outliers can be identified as interesting for further investigation.
- ▶ Huge datasets make the straightforward process of identification and follow-up much more complex and time-consuming.
- ▶ Tools for exploring data to make this process quick and easy would facilitate research.

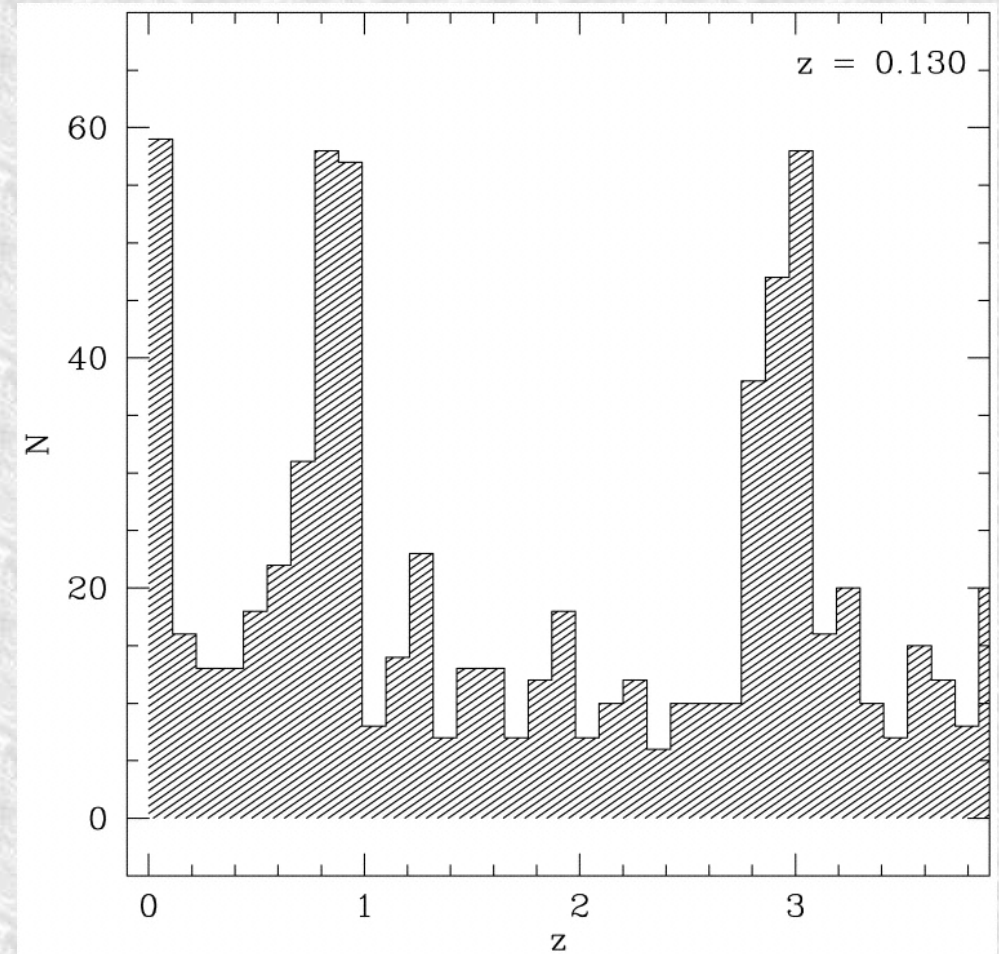
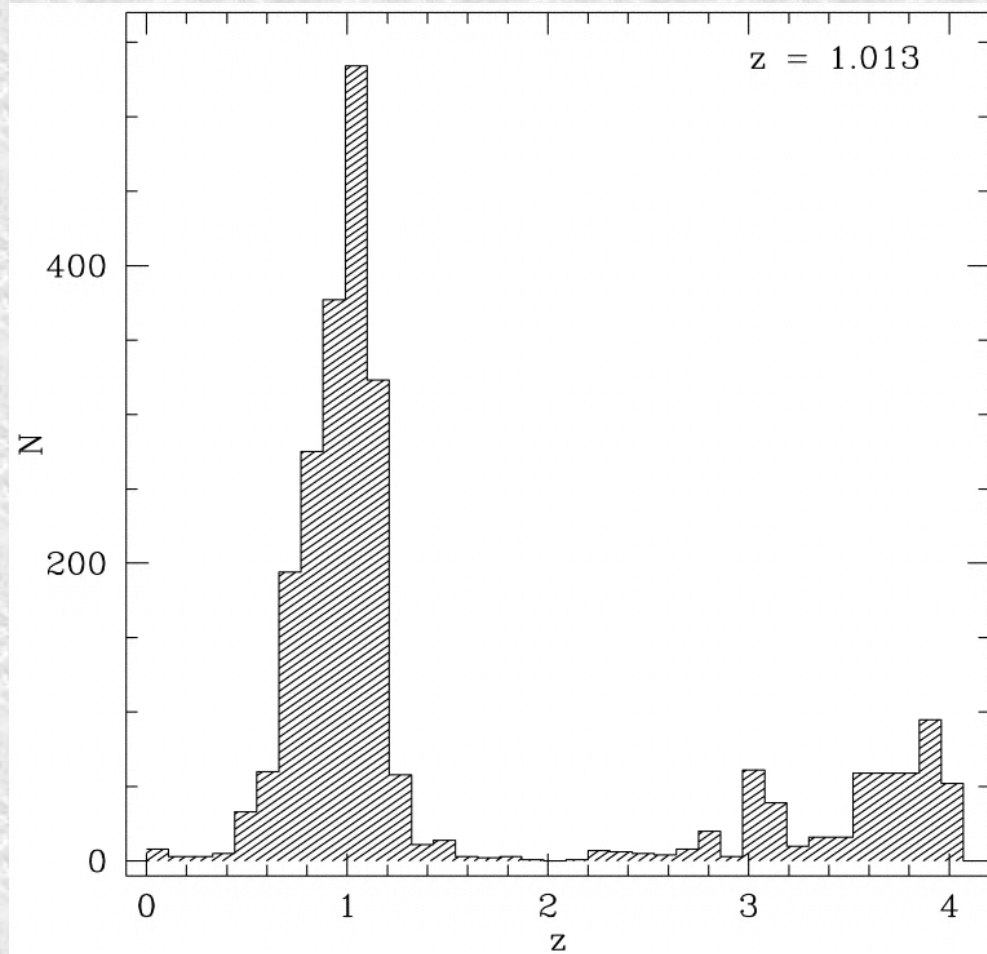
Minimum spanning trees

- Looks for relationships between measurements in high-dimensional parameter space.
- Varying levels of correlation between parameters is complex to display in two or even three dimensions.
- Identifying correlations within data provides valuable scientific insight into physical processes underlying measured properties.
- New tools necessary to allow this technique to be applied to existing and future survey data.

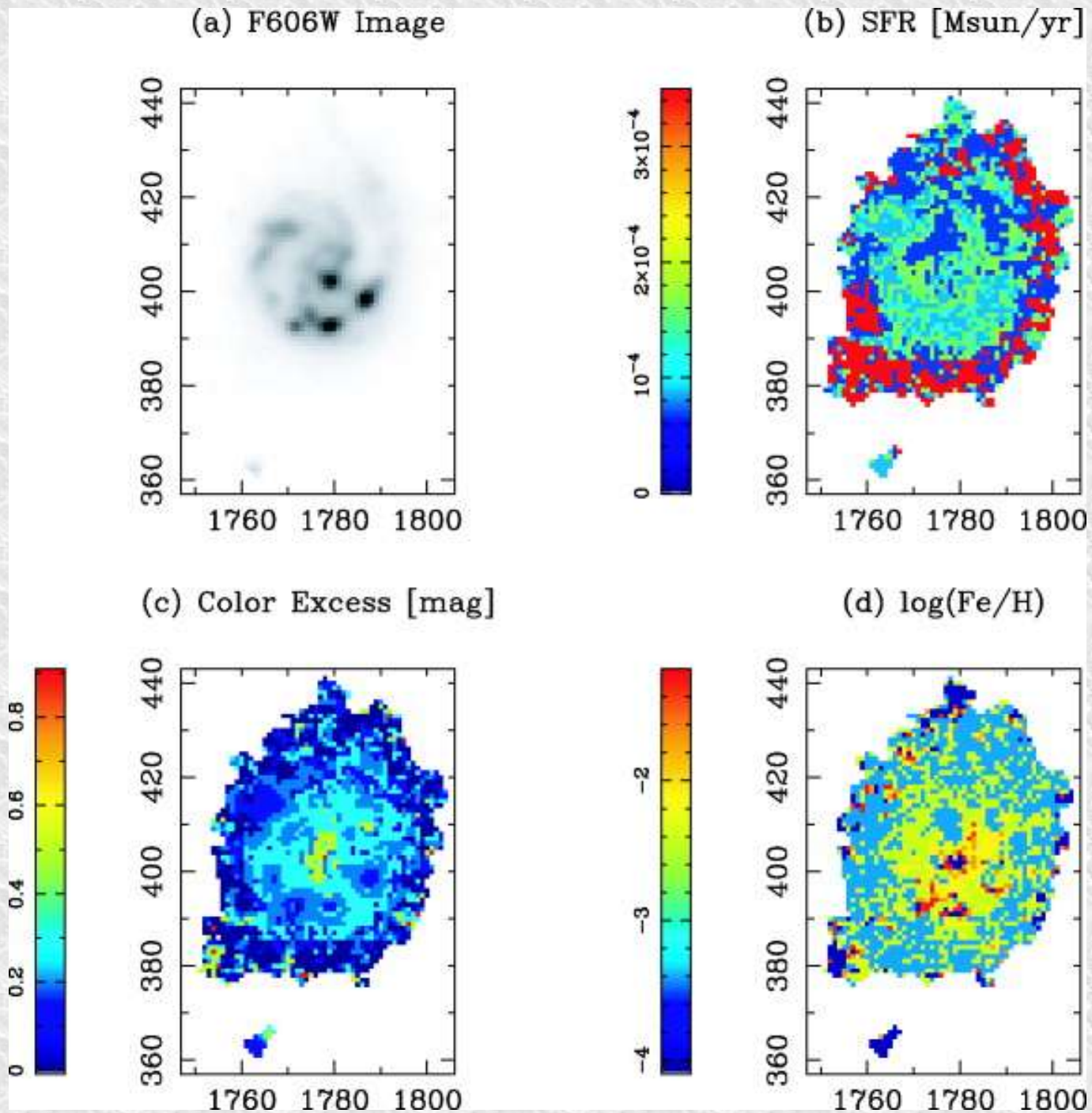
Pixel-z

- Uses SED fitting to each pixel of a galaxy image.
- Given a library of SED templates of known age, metallicity, SFR, obscuration, these values can be determined for each pixel.
- Error images corresponding to each parameter are also generated.
- This technique can be used to generate “Fossil Images” for galaxies, by using the SED histories, to explore how galaxies may have looked at an earlier stage in their evolution.

Pixel-based redshift histograms

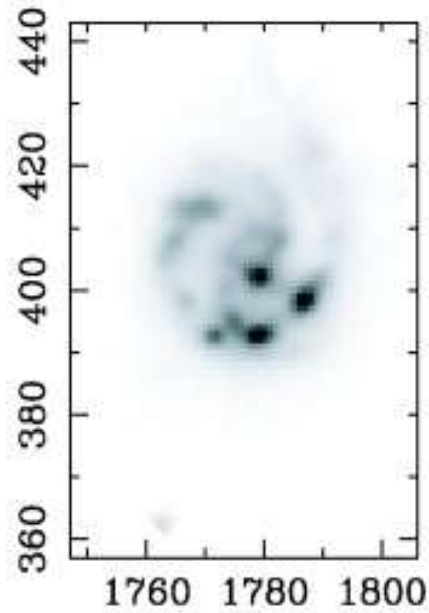


Conti et al., 2003 AJ 126, 2330

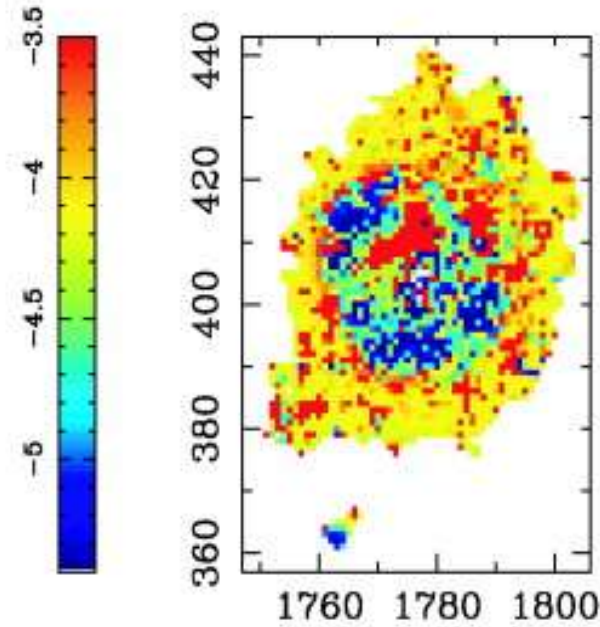


Conti et al., 2003 AJ 126, 2330

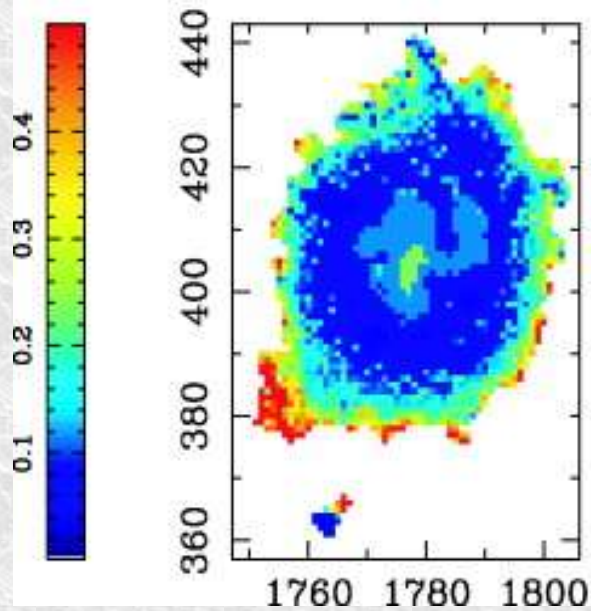
(a) F606W Image



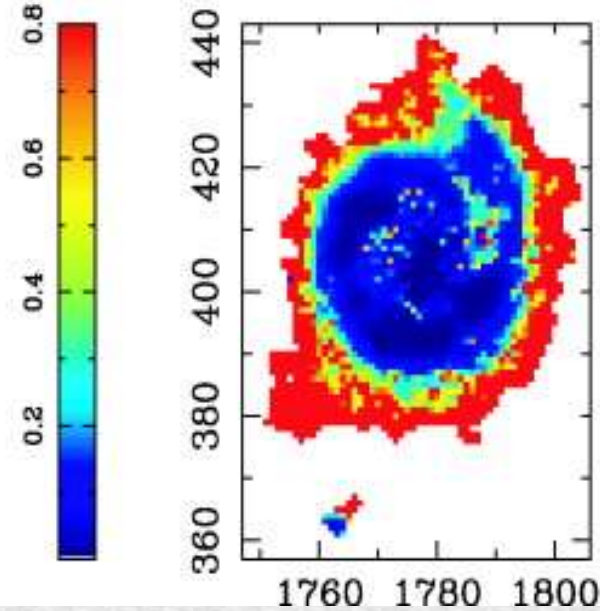
(b) $\log(\sigma_{\text{SFR}})$ [Msun/yr]



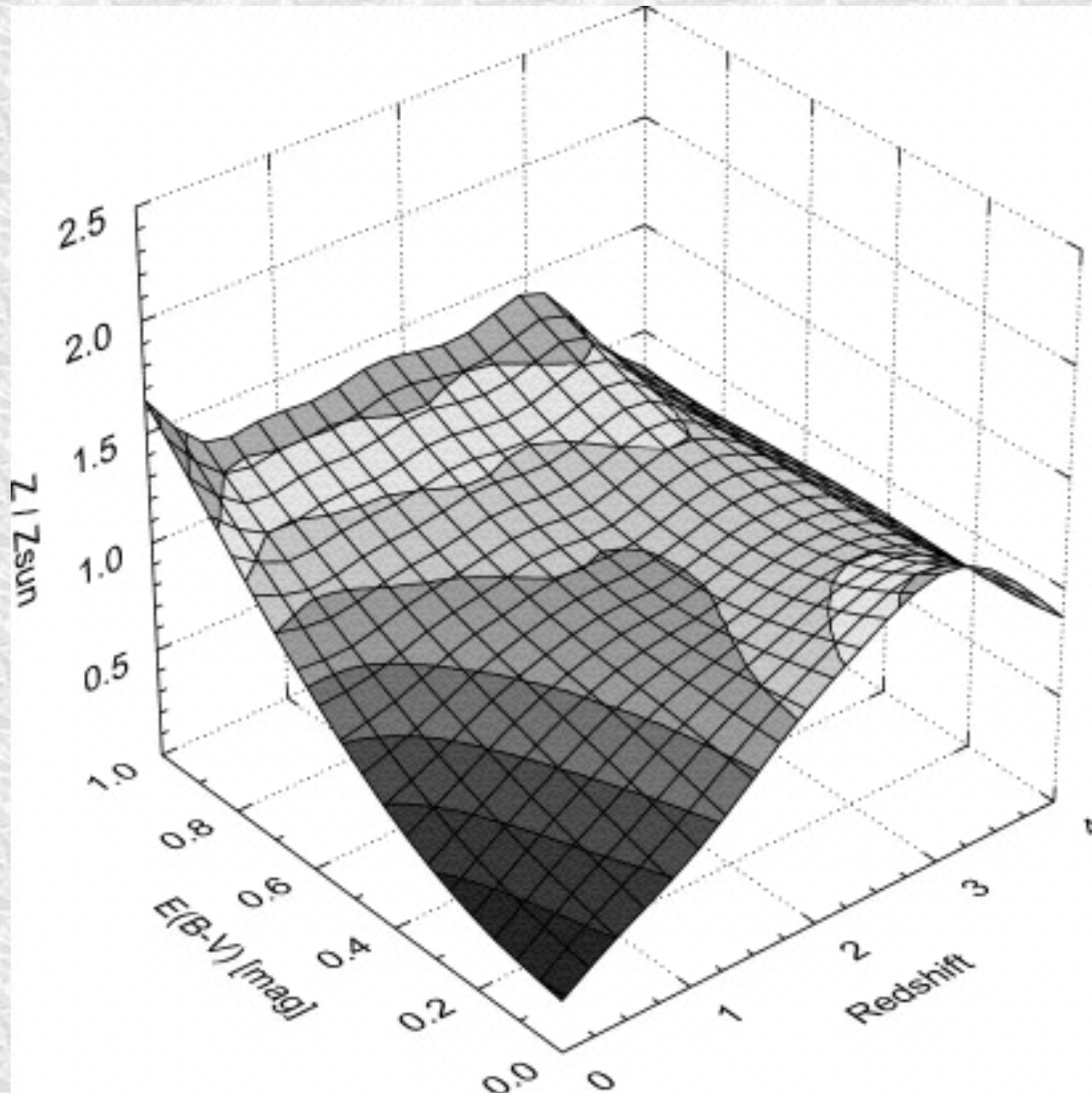
(c) Color Excess Error



(d) $\log(\text{Fe}/\text{H})$ Error

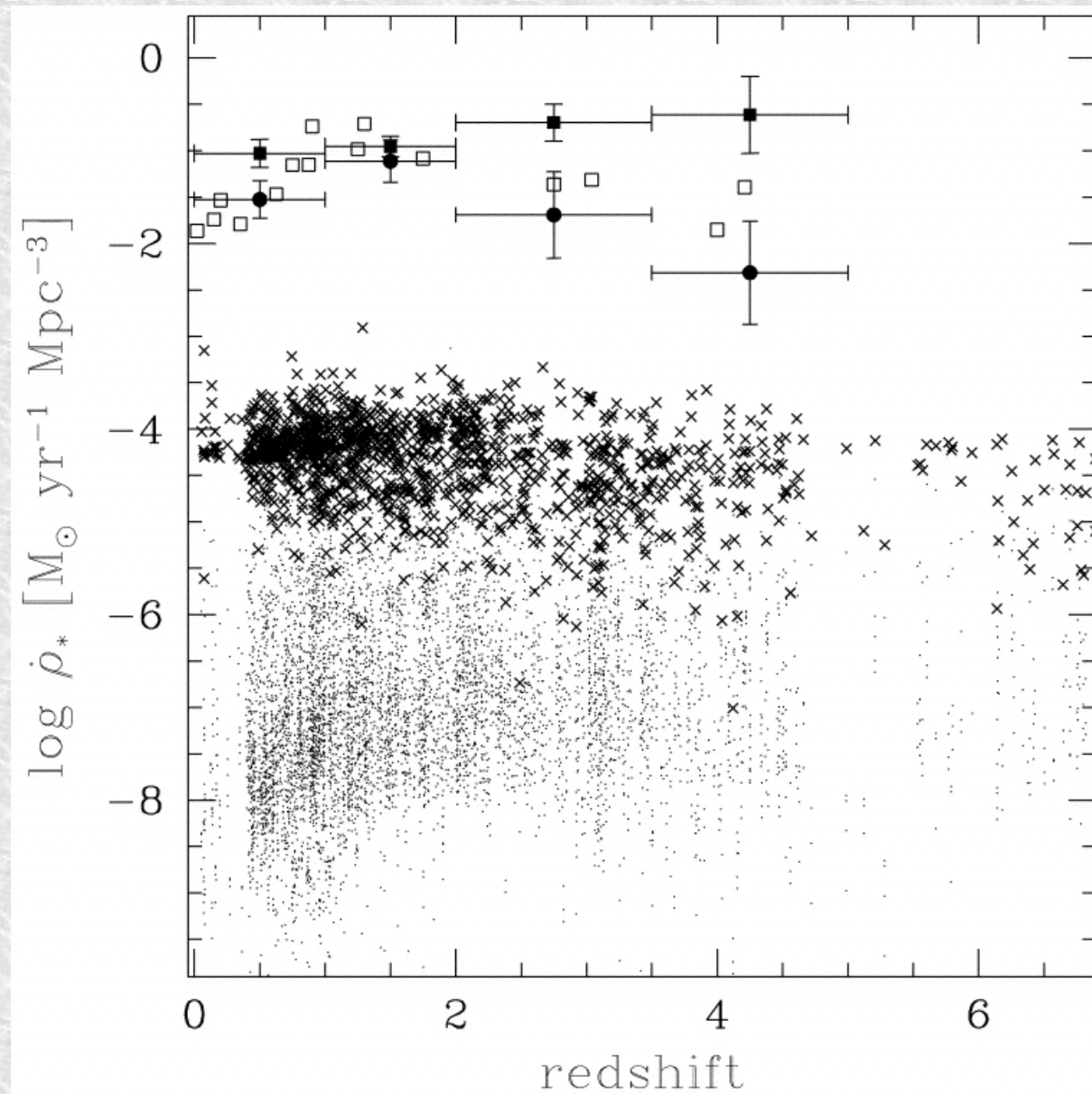


Metallicity-Obscuration vs Redshift



Conti et al., 2003 AJ 126, 2330

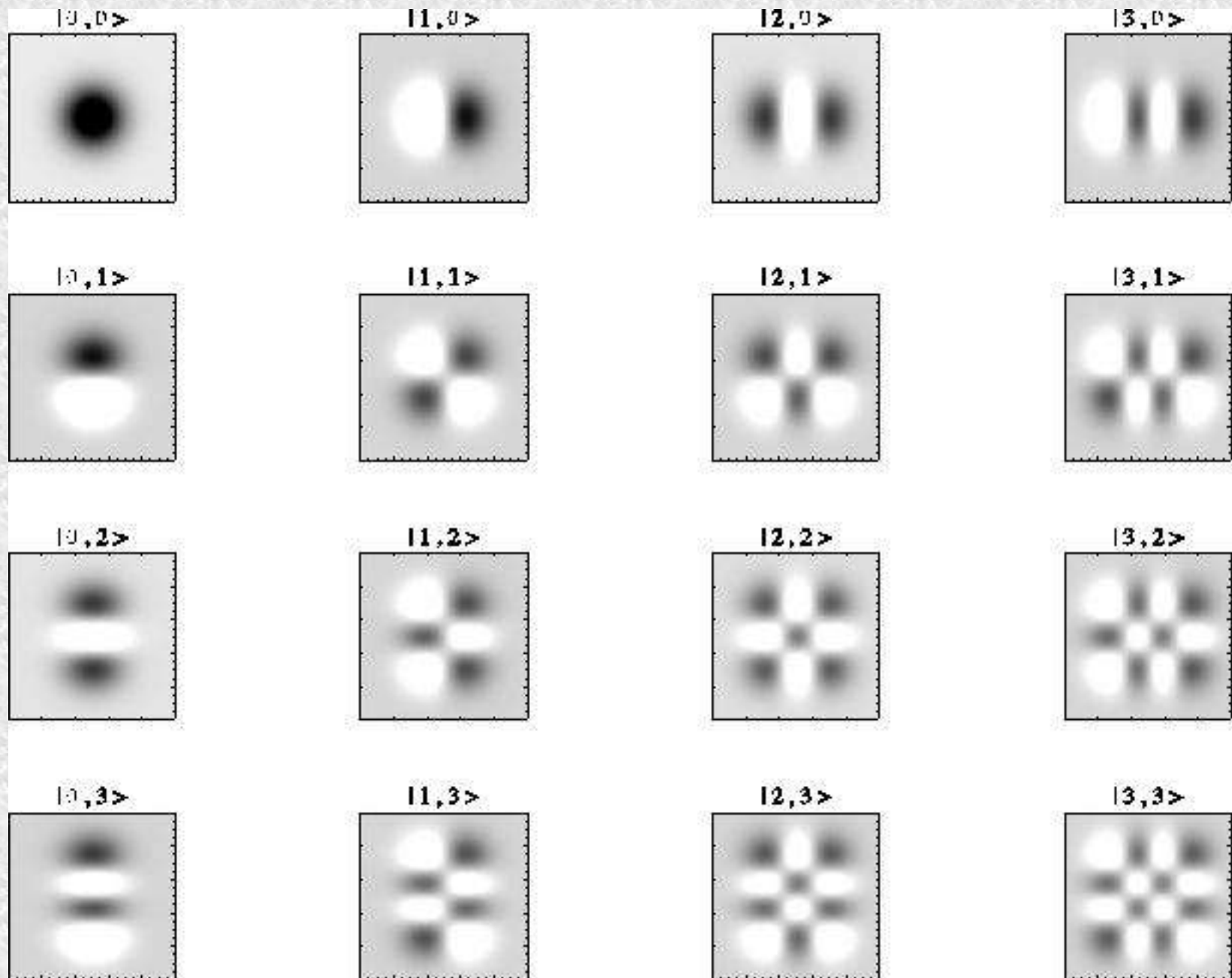
Star formation rate density vs Redshift



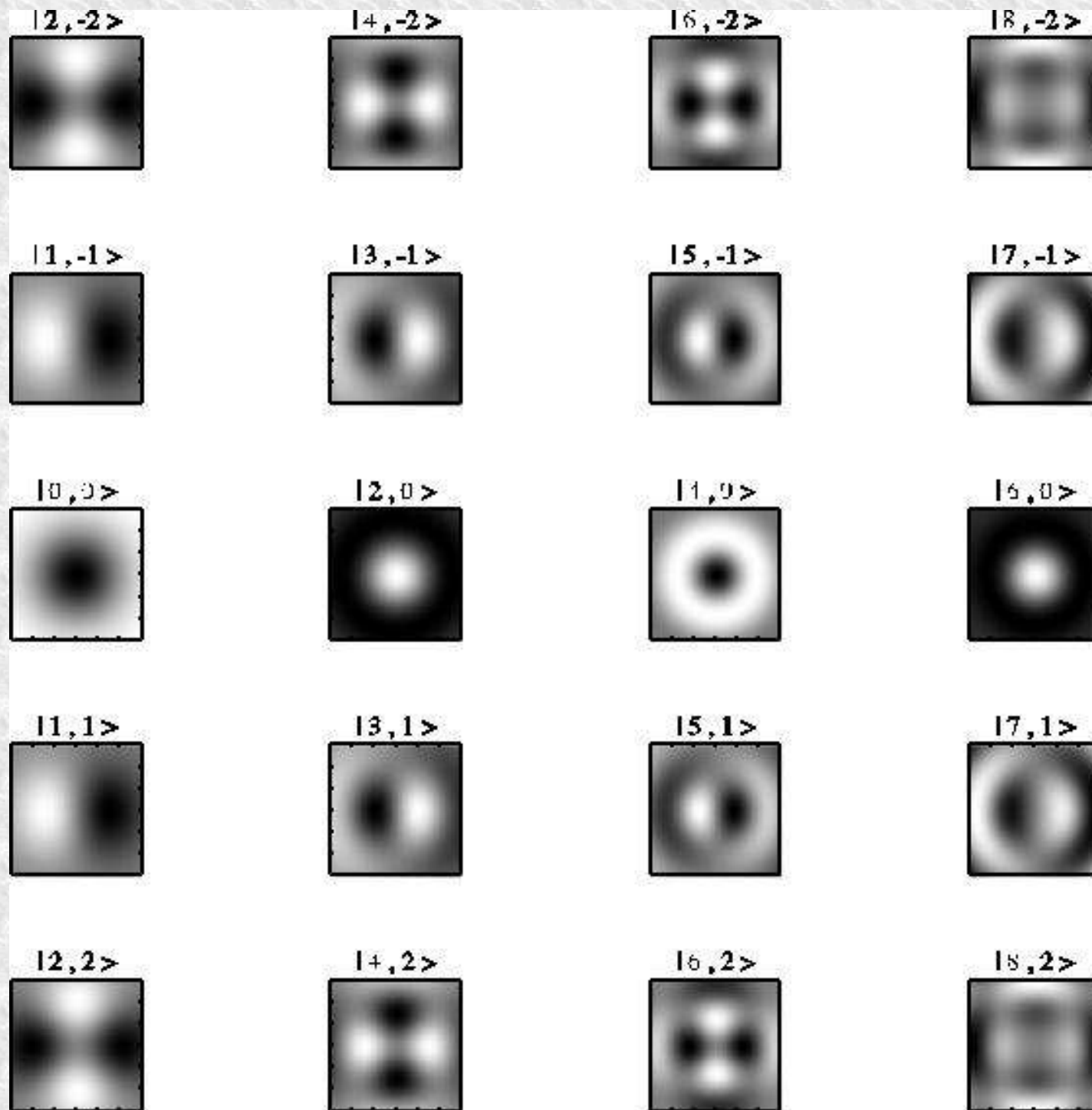
Conti et al., 2003 AJ 126, 2330

Quantitative Multiwavelength Morphologies

- Uses “shapelets” (Hermite polynomials) as a basis function for decomposing images.
- Uses multiwavelength image information.
- Uses PCA (KL-transform) to reduce the dimensionality in the final shapelet basis space. Each of the final principal components contains unique spectro-morphological information.
- Uses a gaussian mixture model to separate galaxies in the final principal component space and derive classifications.

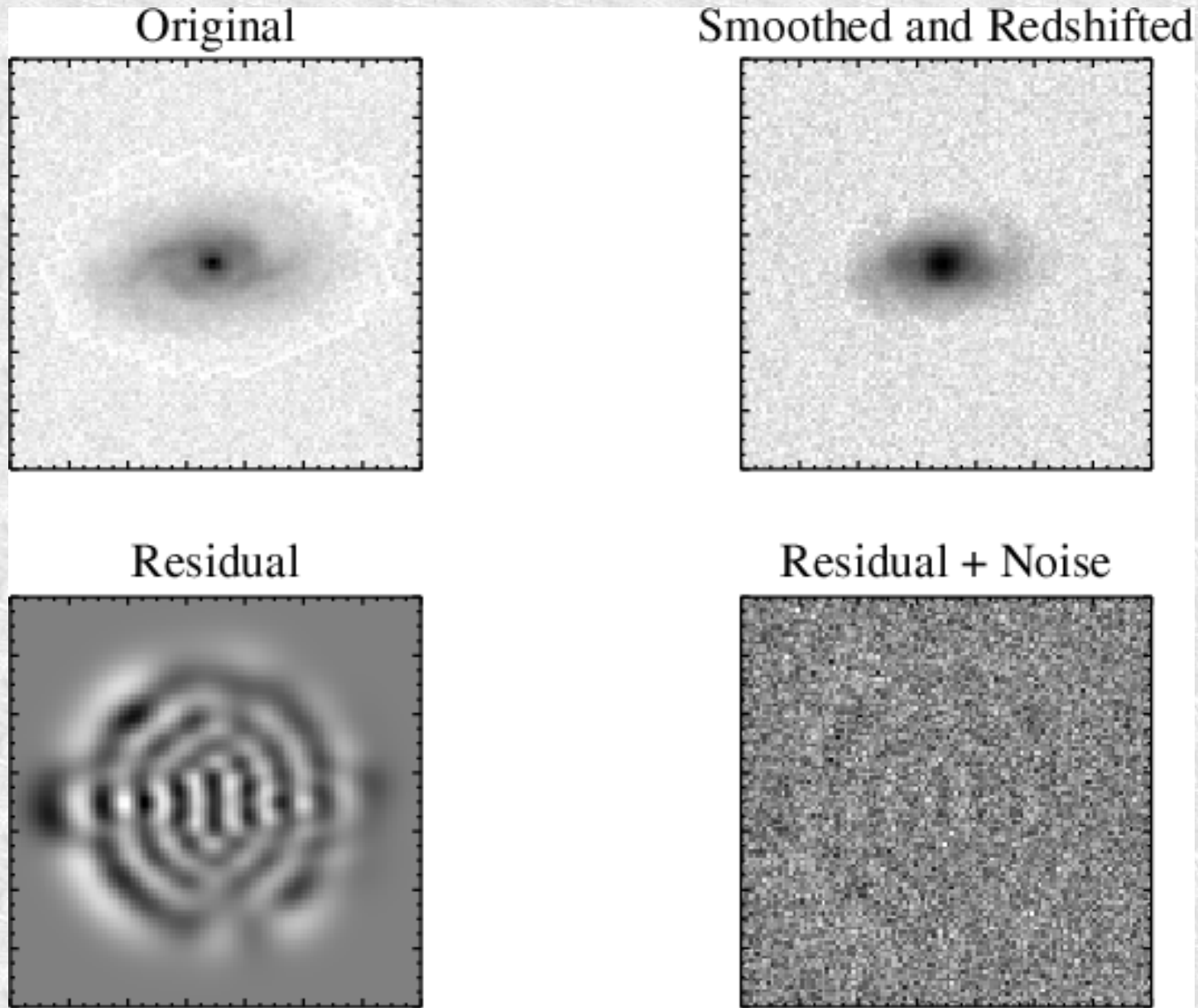


Kelly & McKay 2004, AJ, 127, 625



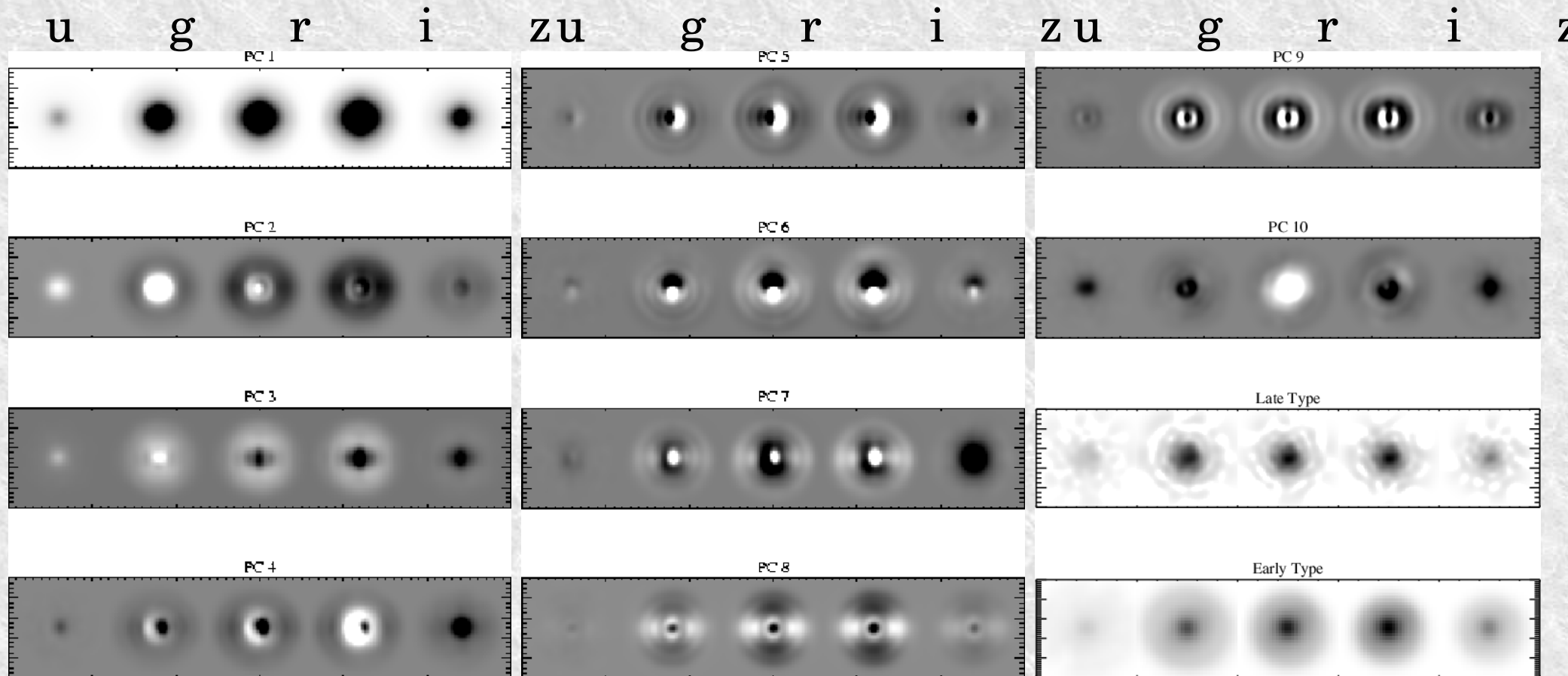
Kelly & McKay 2004, AJ, 127, 625

Galaxies resampled



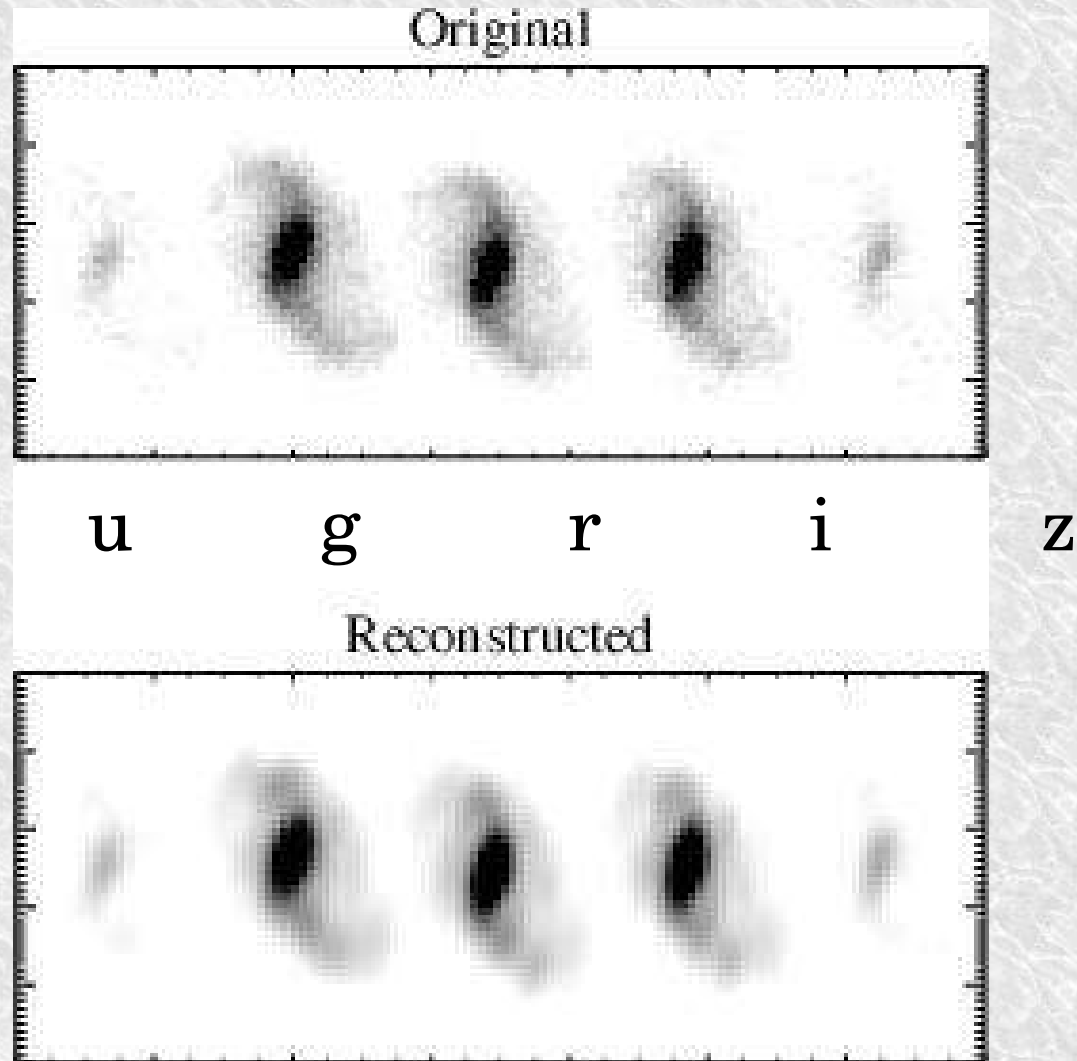
Kelly & McKay 2004, astro-ph/0401441

The first 10 “Eigenmorphologies”

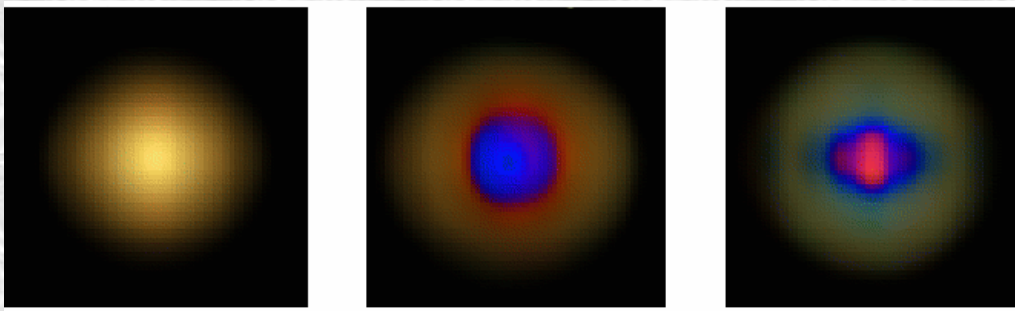


Kelly & McKay 2004, astro-ph/0401441

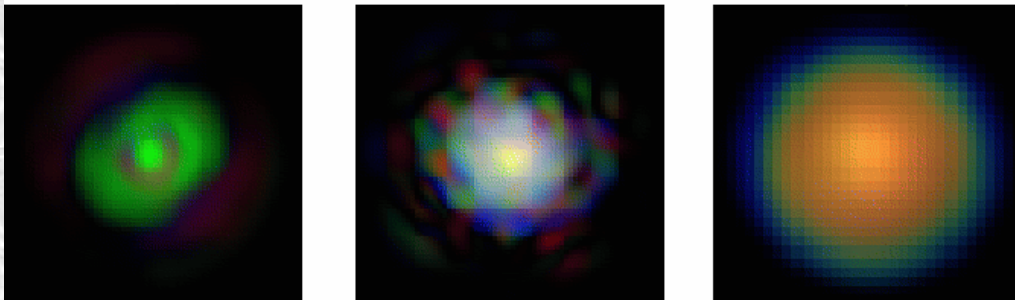
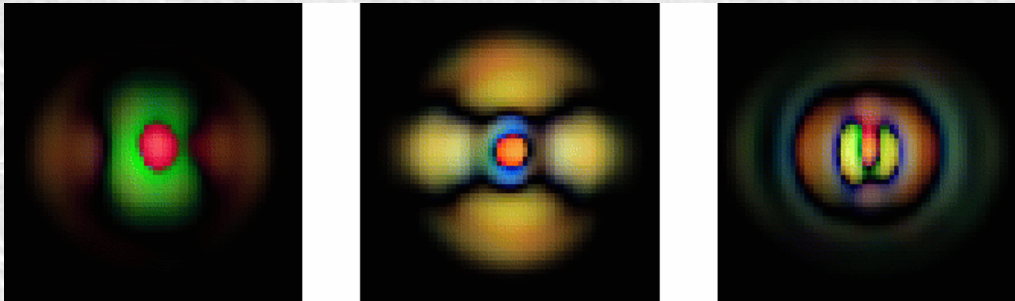
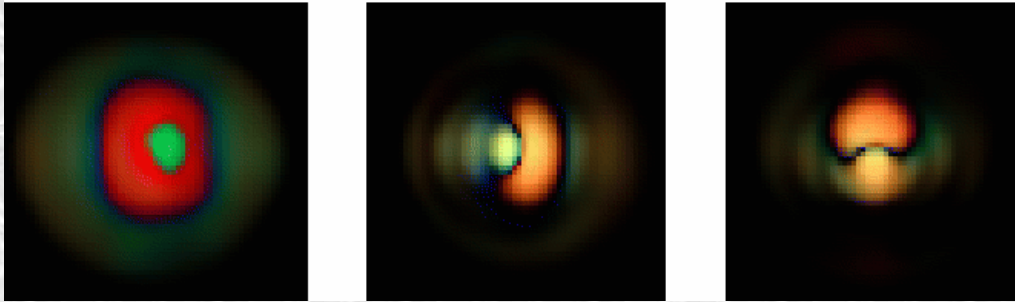
Image reconstruction



Kelly & McKay 2004, astro-ph/0401441

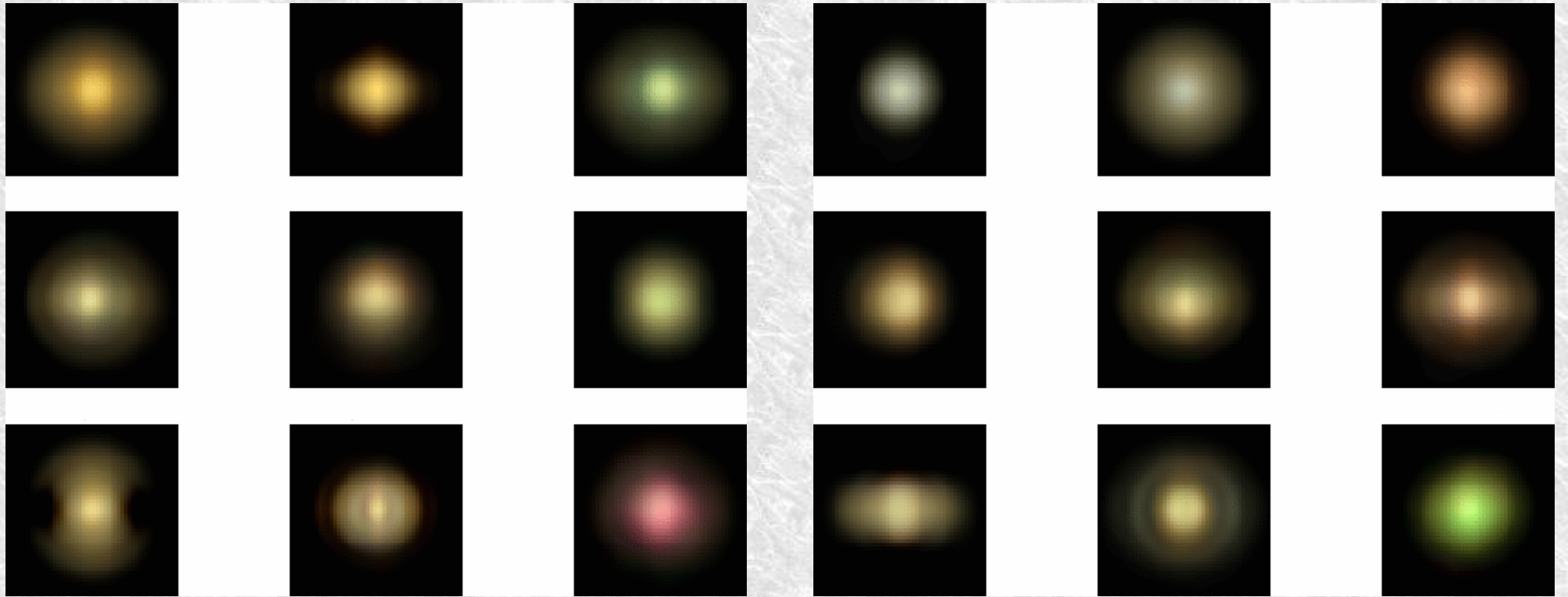


gri color composite images
from the energy (v_i^2) for
each eigenmorphology



Kelly & McKay 2004, astro-ph/0401441

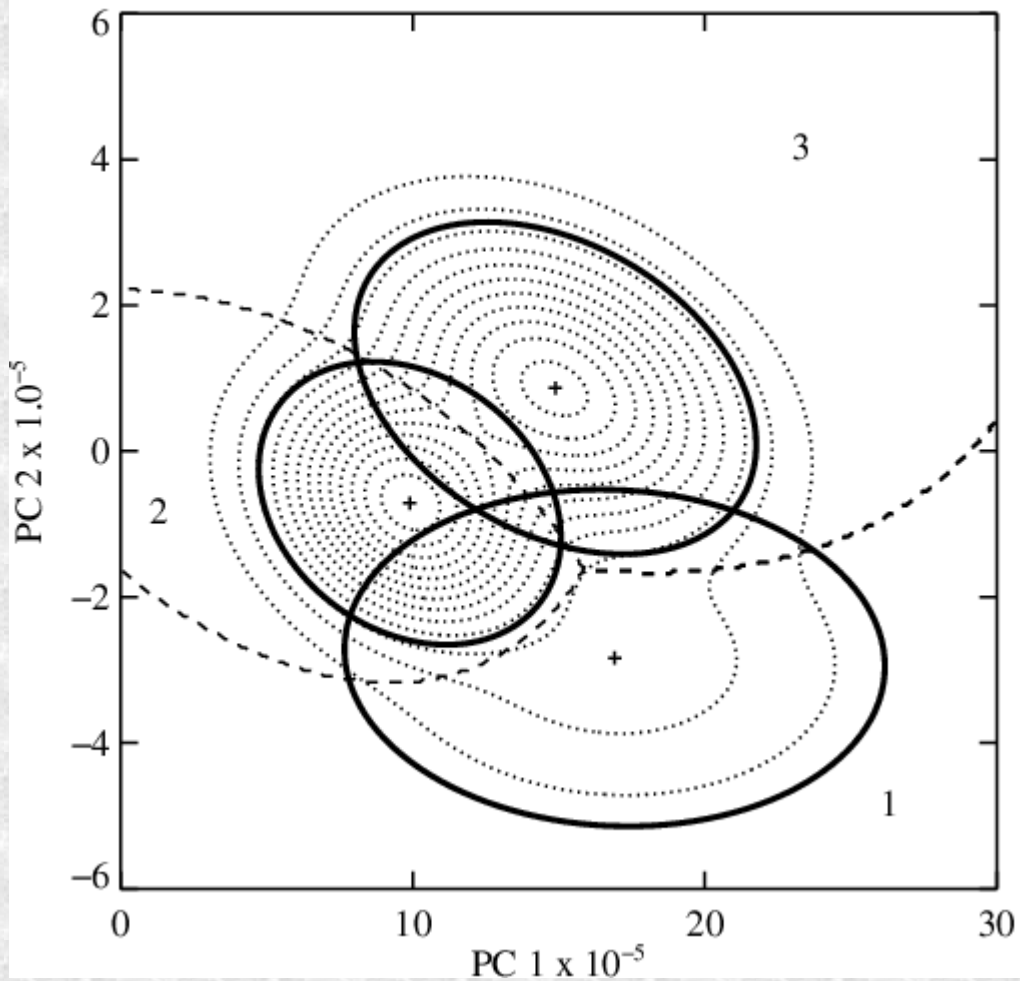
Adding and subtracting v_i to v_1



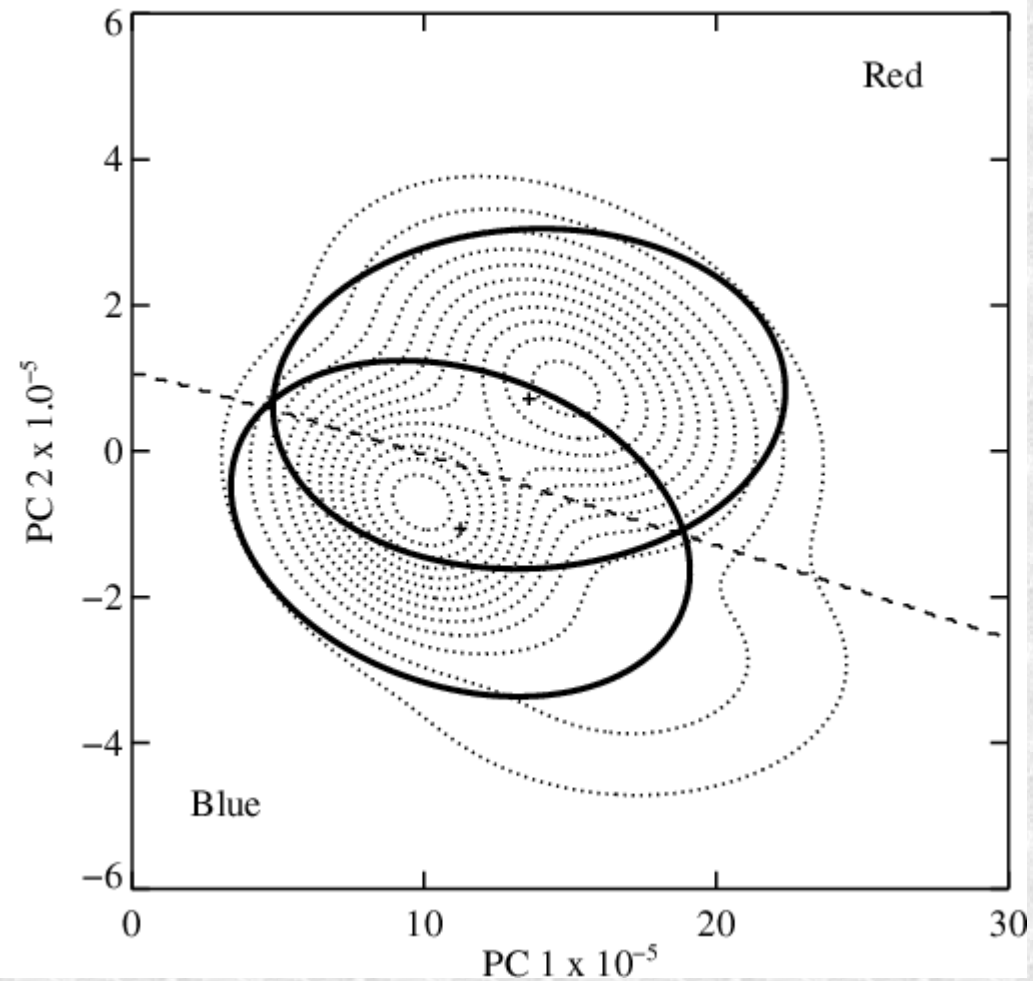
Kelly & McKay 2004, astro-ph/0401441

Classification

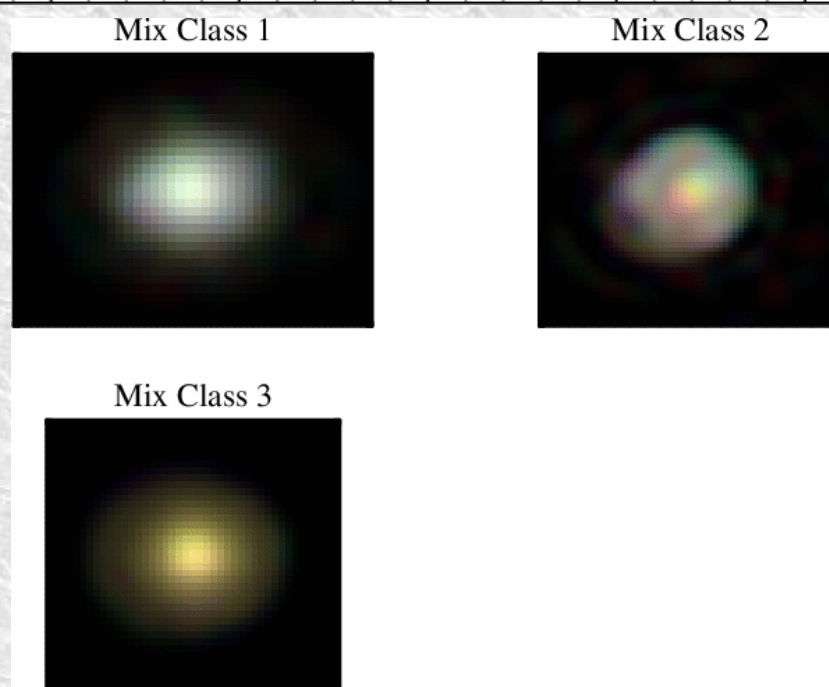
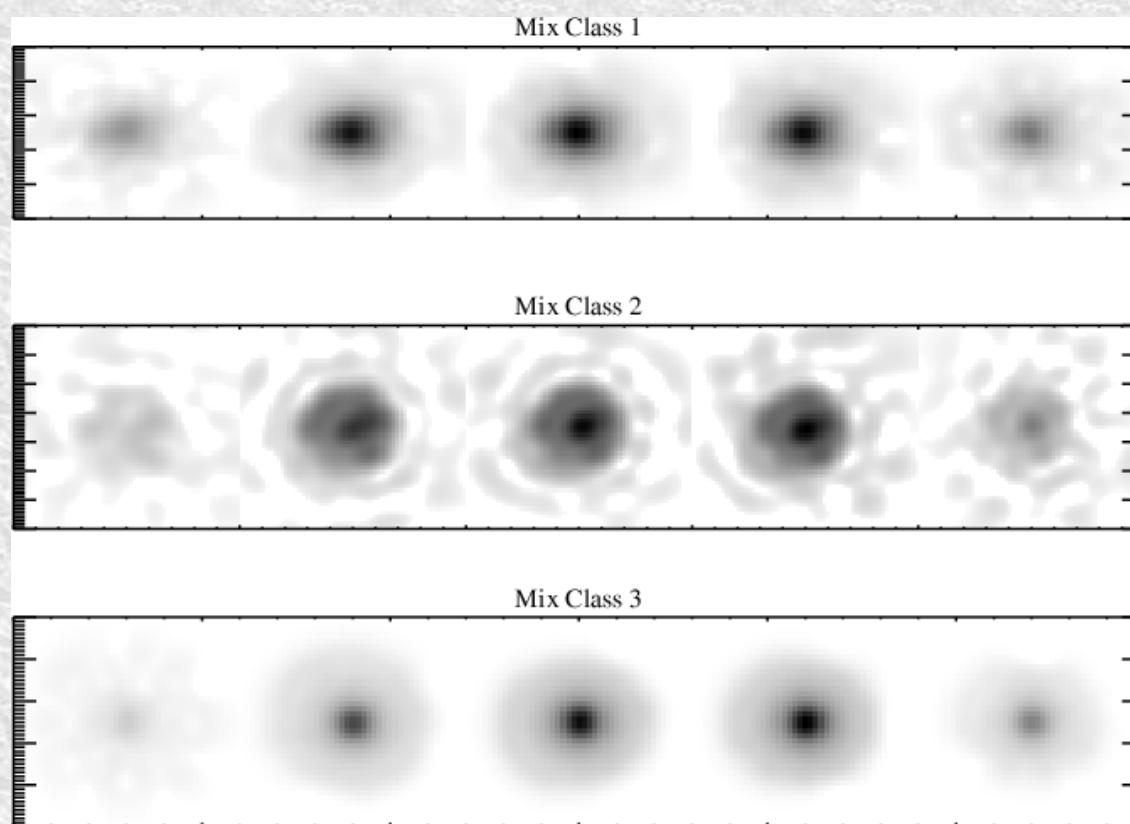
Mixture Model Classification



$u - r$ Classification



Kelly & McKay 2004, astro-ph/0401441



Kelly & McKay 2004, astro-ph/0401441

WESIX

Web-Enabled Source Identification with X-matching

<http://frank.phyast.pitt.edu:8080/wsext/>

- ▶ <http://www.us-vo.org/projects/tools.cfm>
Developer: Simon Krughoff (simon@phyast.pitt.edu)
- ▶ Webservice that provides access to Sextractor and a crossmatching facility (openskyquery) over the internet.
- ▶ All processing is done server-side. Interactive plotting is available as is image/catalog display and manipulation through Aladin.
- ▶ Can be accessed either via the web or programmatically.

Welcome to the homepage of WSextractor

There are just six steps to getting your source catalog back.
If you are interested in testing out this service,
here is a test file that works.

Step 1: Specify the file you want to upload

/home/simon/images/756/ Browse...

Step 2: Select the catalog you would like to crossmatch with.

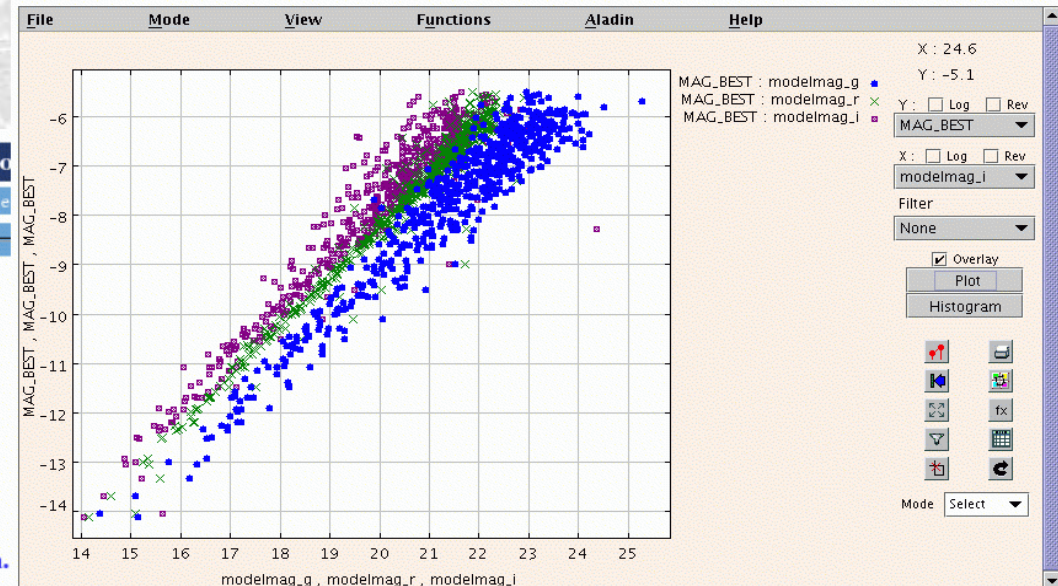
ROSAT
GALEX
DLS
RC3
SDSS
SDSSDR2

Step 3: Submit your file for processing

Submit

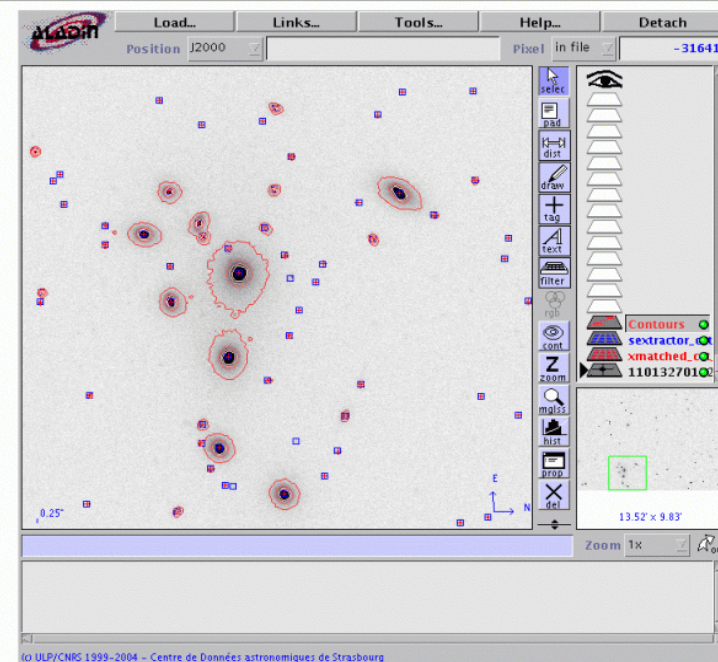
Contact US-VO help desk with any problems

The Output should show up here



CDS · Simbad · VizieR · Aladin · Catalogues · Nomenclature · Bibli · Tutorial · Developer's corner

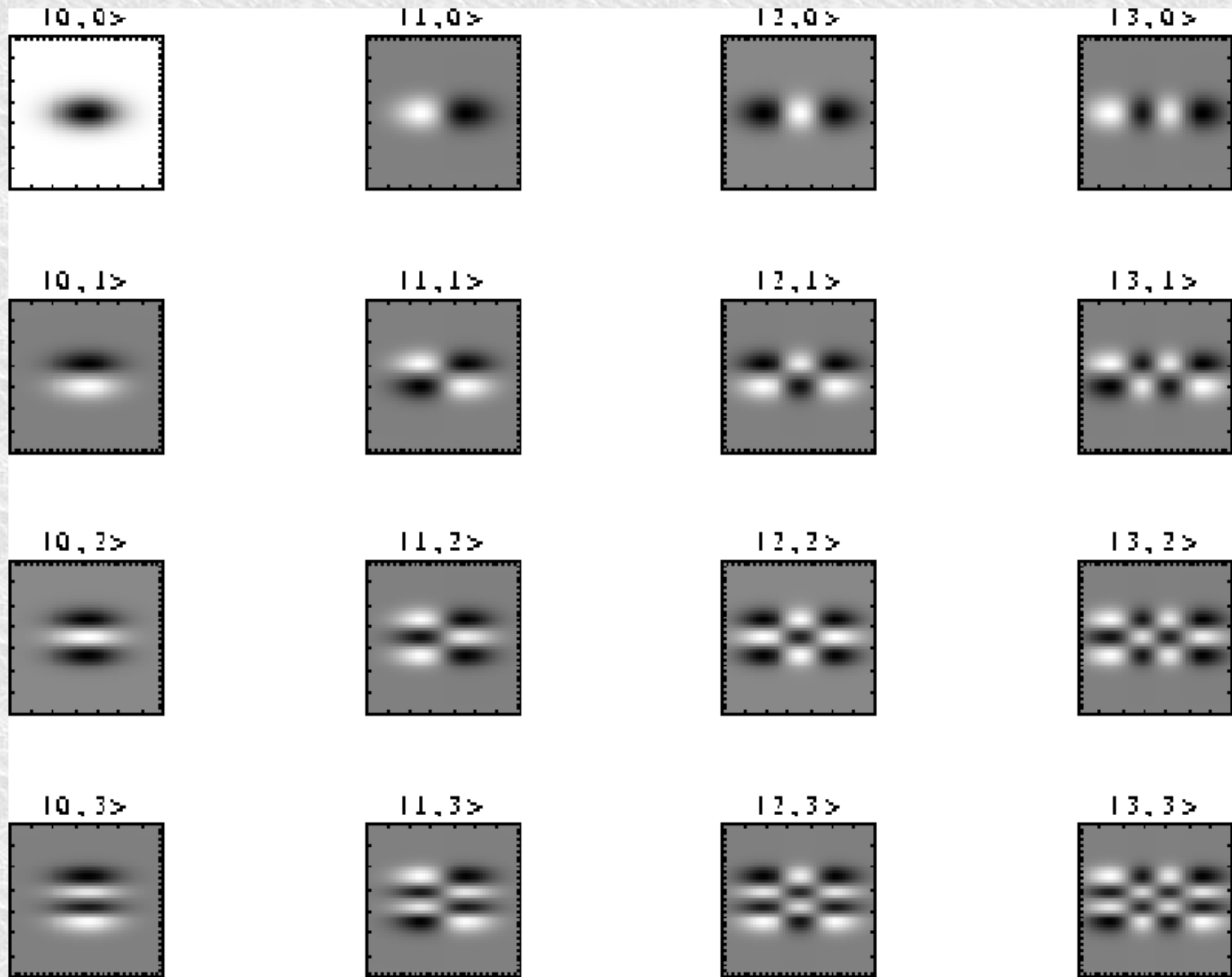
Aladin sky atlas



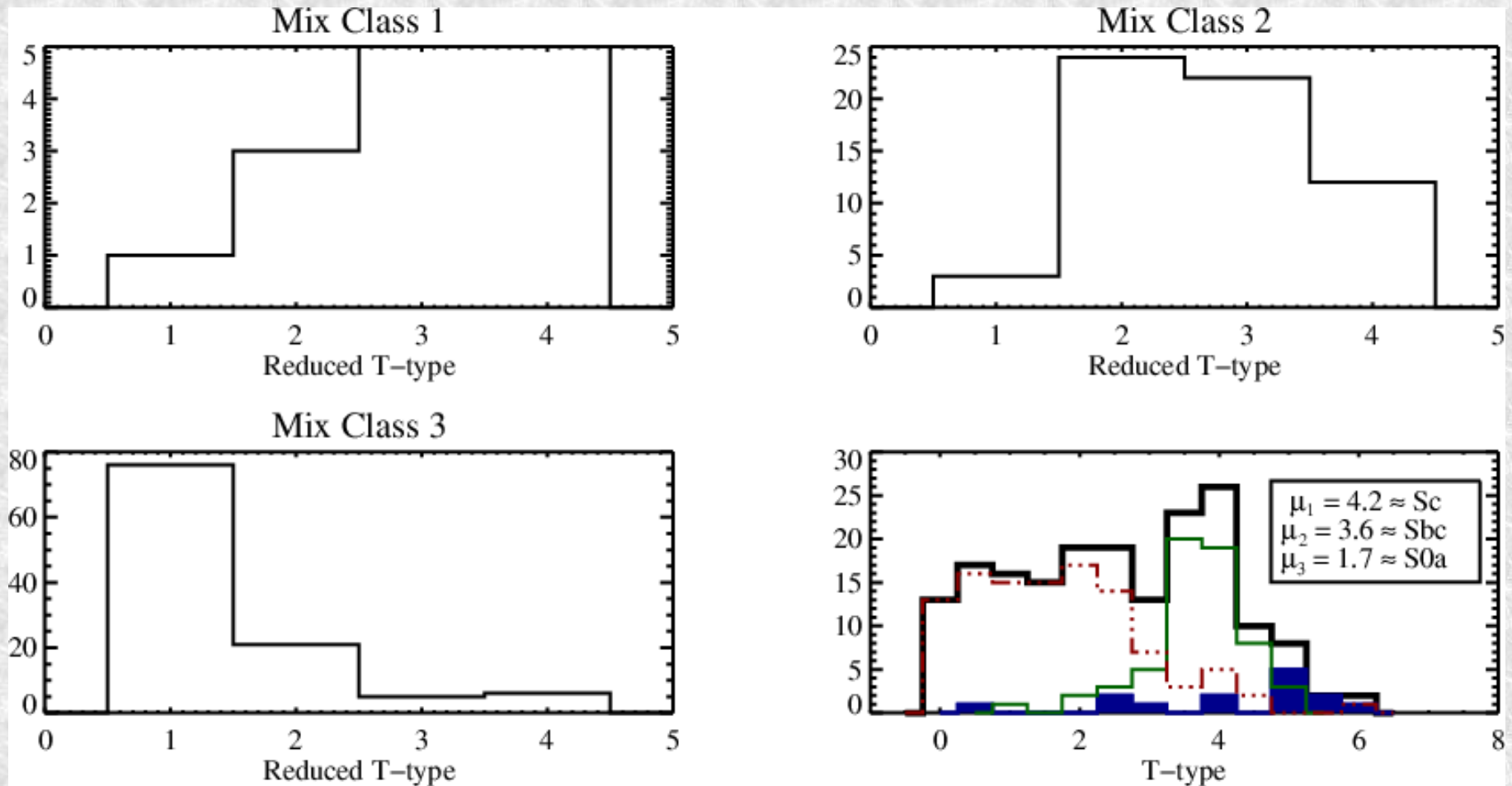
Simon Krughoff
email: simon@phyast.pitt.edu

Wish-list

- ◆ Integrated tools for data-analysis (anomaly detection, minimum spanning trees) and visualisation (viewing images of anomalous outliers, examples of parameter correlations).
- ◆ New tools for visualising complex data structures (spatially distributed physical parameters, pixel-z) and morphological information (QMM).
- ◆ Make tools available as webservices, for access and interaction with existing analysis tools



Classification



Kelly & McKay 2004, astro-ph/0401441