Paris-Saclay Center for Data Science

Galaxy deblending with Deep Learning

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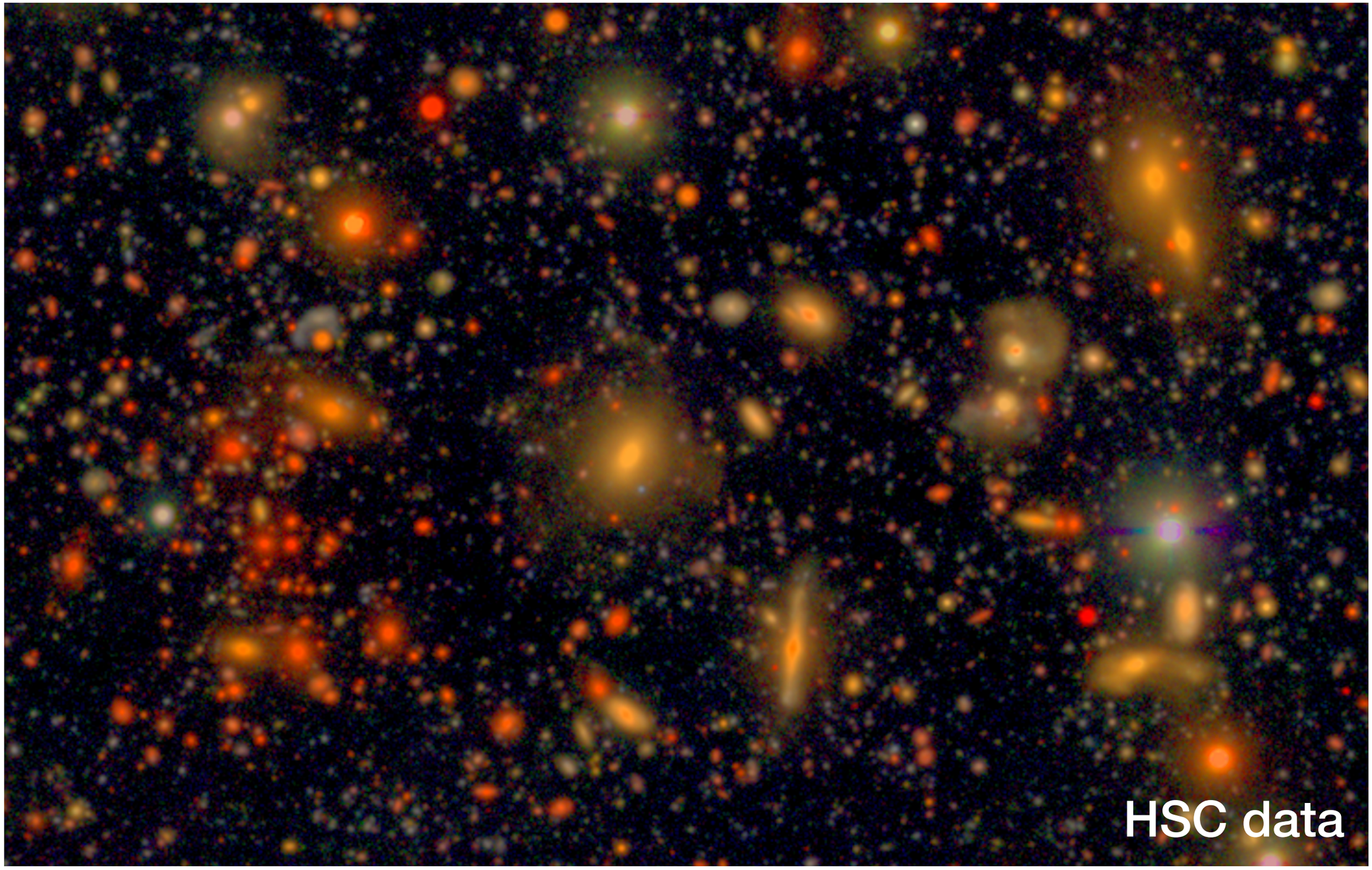
Image from galaxy survey

HSC on COSMOS



Deblending

- Measuring the **flux** and **shape** of individual galaxies is **difficult** in a deep field where many galaxies overlap

- **Goal : assign pixels to objects**

- Galaxies are “transparent”
  => no obscuration

- Noisy images

Deblending (recent work)

Image reduction in astro— traditionally

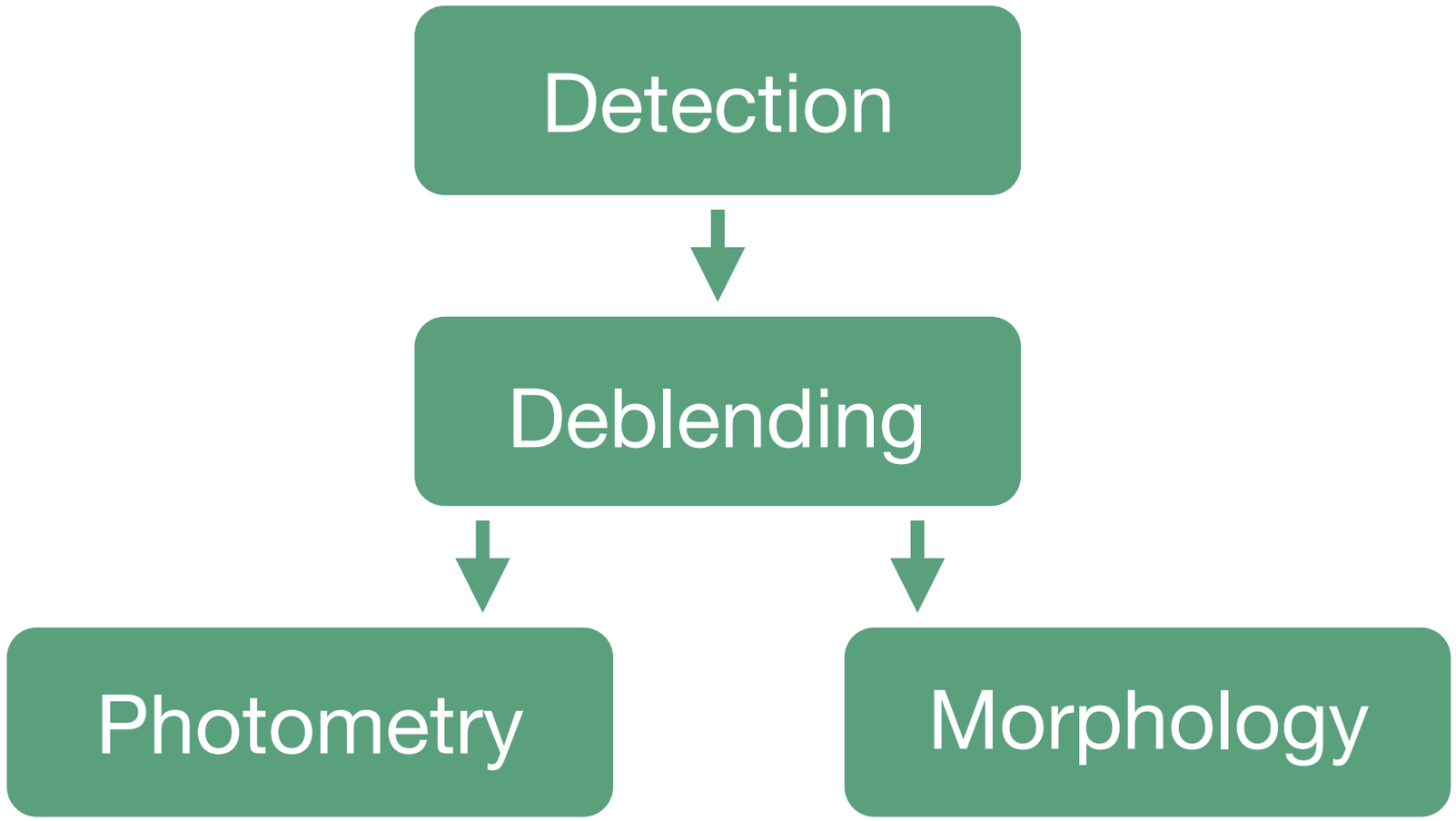
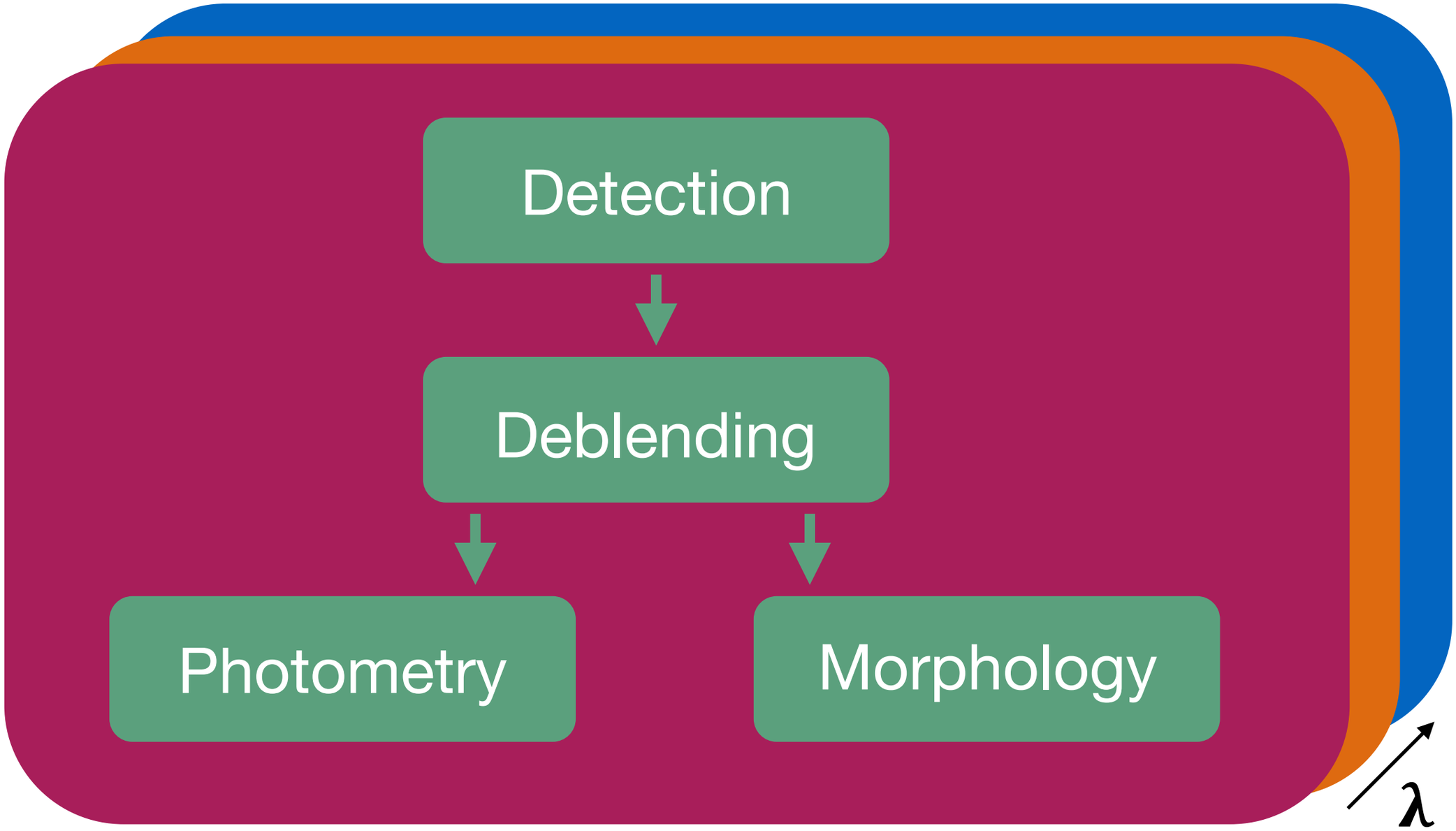


Image reduction in astro — state of the art



Forward modeling — MuSCADeT

Morpho Spectral Component Analysis (MCA)

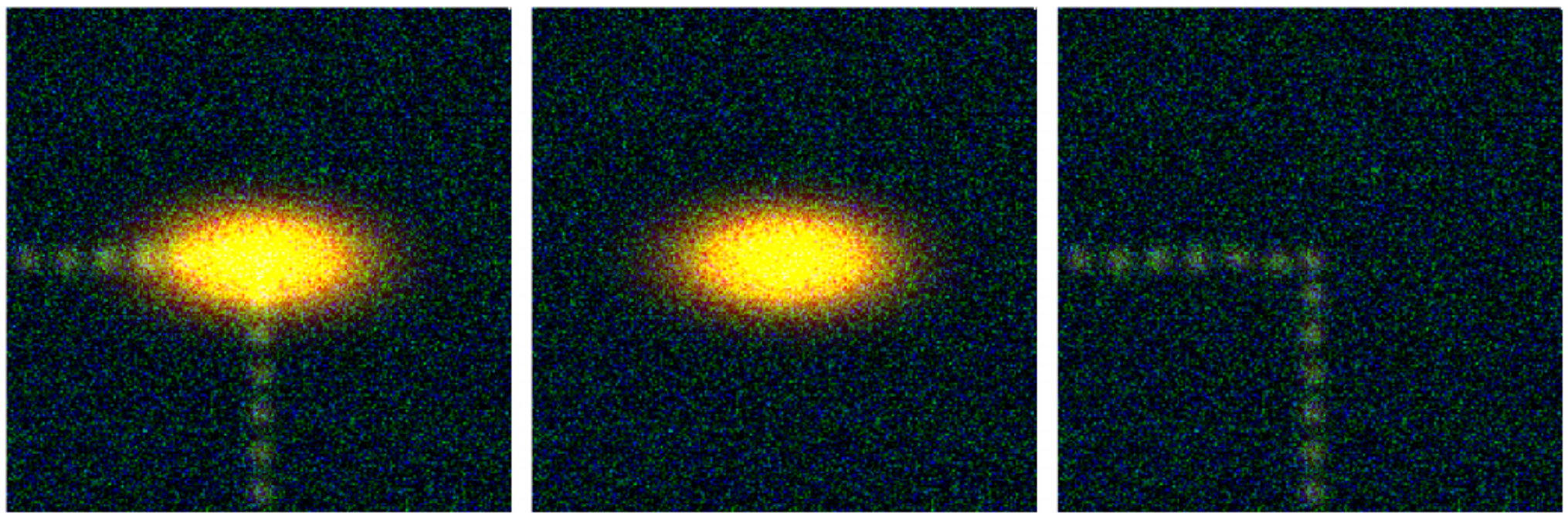


Fig. B.1. Separation of blended sources at low S/N. From left to right are shown the original simulated images, the original image after subtraction of the blue component as estimated from `MuSCADeT`, the original image after subtraction of the red component and the residual image after subtraction of both components.

Joseph+16

Forward modeling — NMF

- Color should be useful, photo-z are dangerous
- Star/Galaxy separation is not obvious: non-parametric
- Objects are somehow "compact", mostly symmetric

$$\text{scene} = \sum_k \text{SED}_k \times \text{Morphology}_k + \text{noise}$$

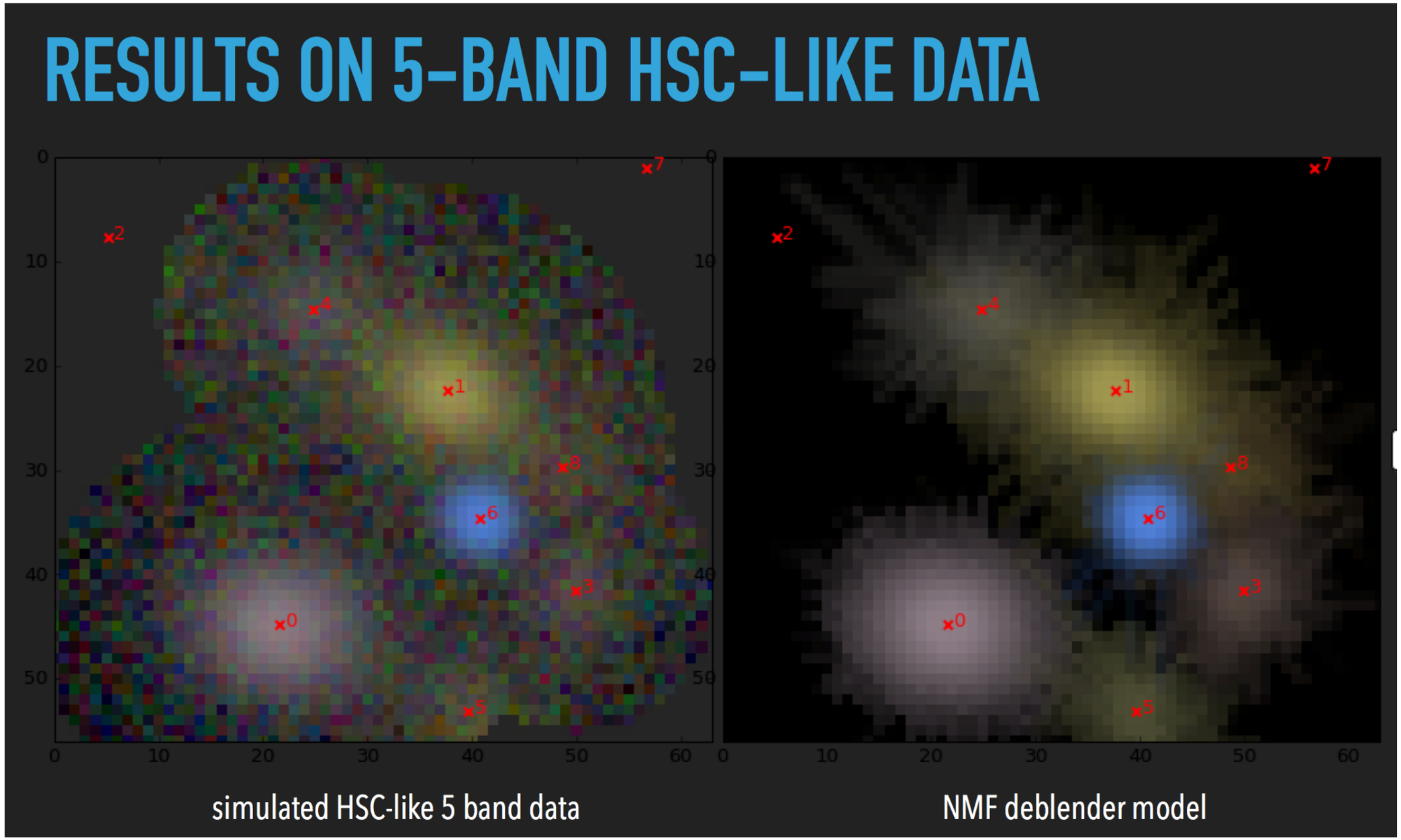
$$Y = A \cdot S + \text{noise}$$

$$(Y \in \mathbb{R}^{B \times N}, A \in \mathbb{R}^{B \times K},\ S \in \mathbb{R}^{K \times N})$$

$$||Y - A \cdot S||_2^2 + g(A, S)$$

Melchior+17 in prep.

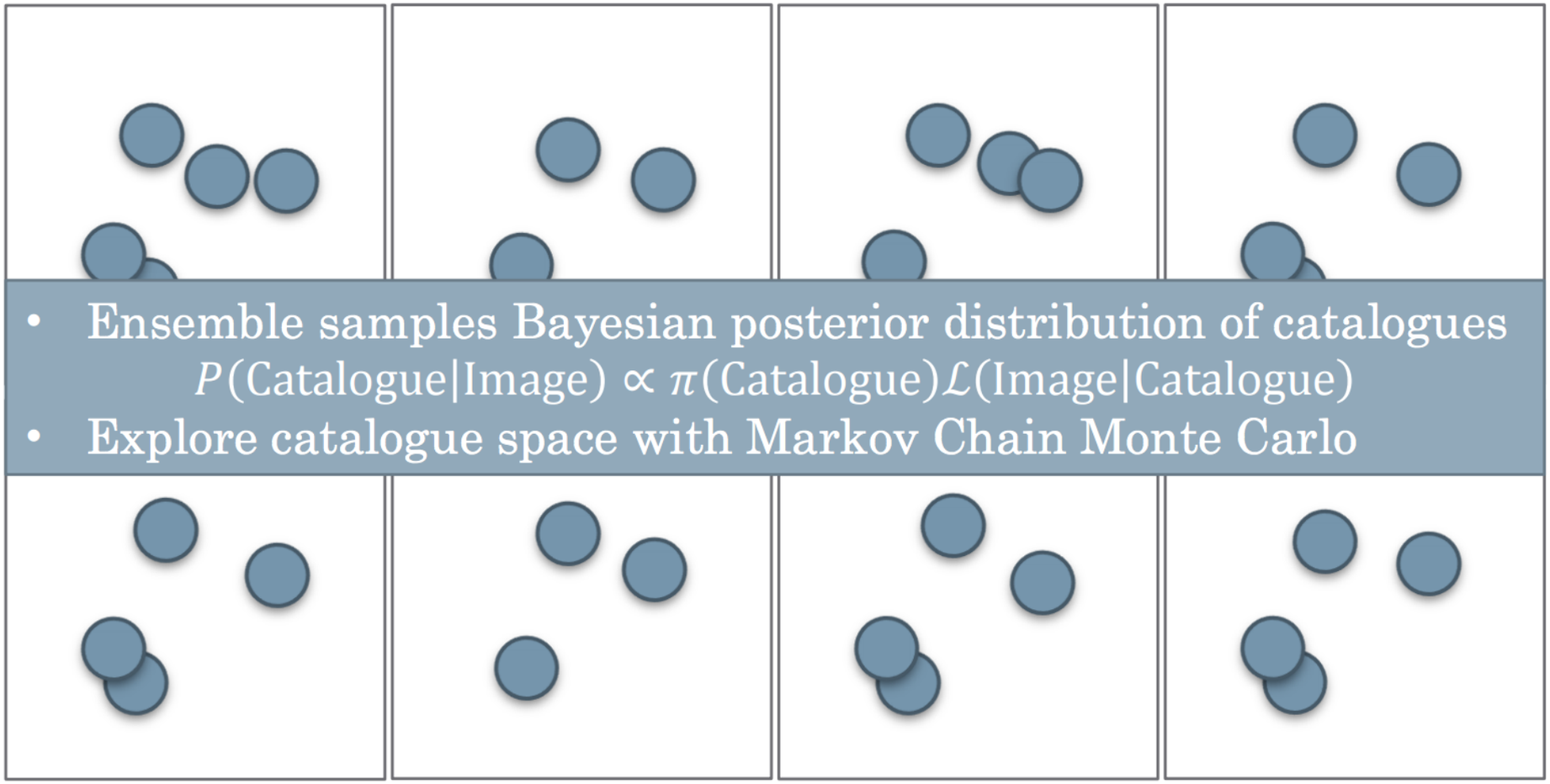
Forward modeling — NMF



Melchior+17 in prep.

Probabilistic cataloguing

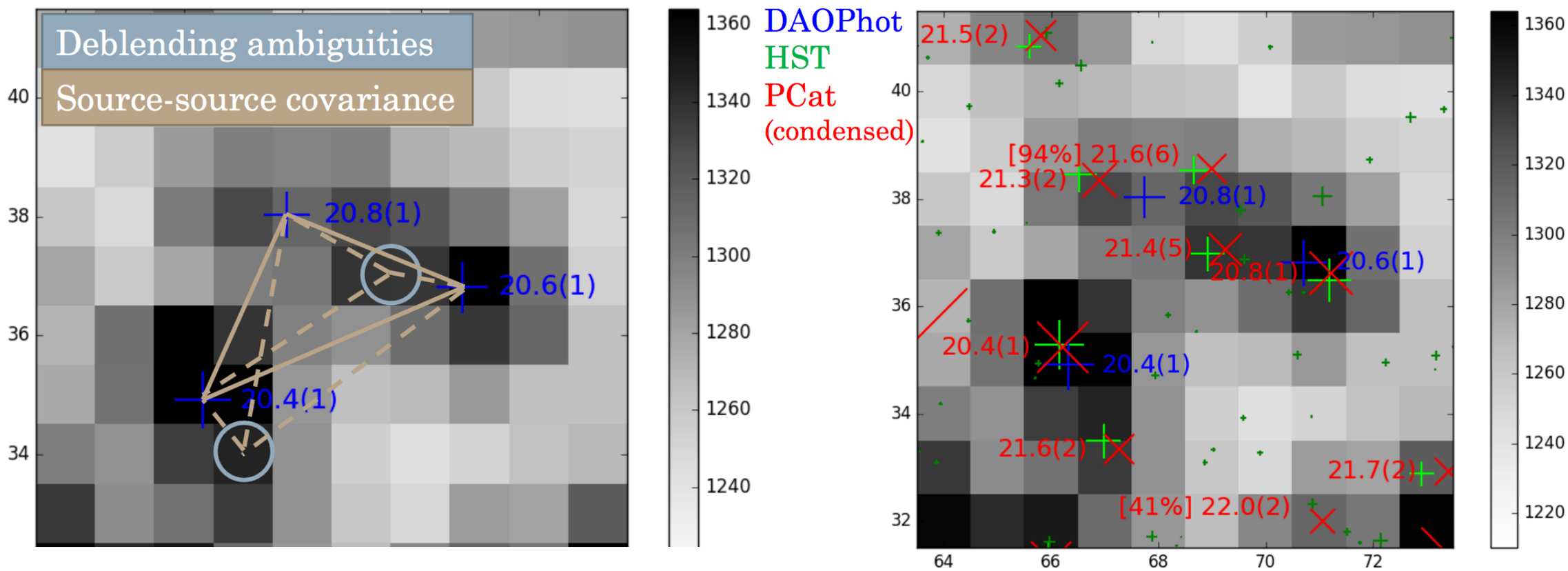
- Infer an ***ensemble of catalogues***
- Naturally handles deblending ambiguities and source-source covariance



Portillo+17

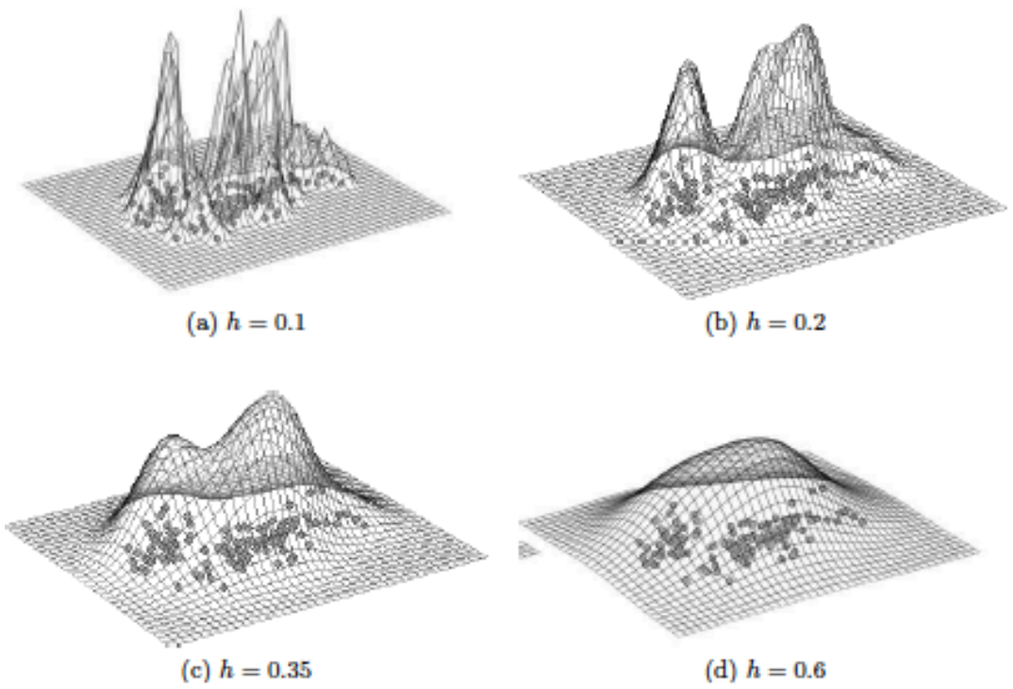
Probabilistic cataloguing

Condensed catalog

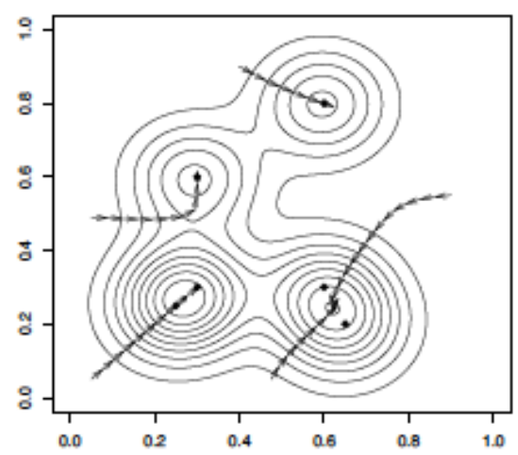


Portillo+17

Topological clustering — ASTErIsM



(a) $h = 0.1$ (b) $h = 0.2$ (c) $h = 0.35$ (d) $h = 0.6$



fast hill climbing

$$\mathbf{x}_{t+1} = \frac{\sum_{i=1}^{n} K\left(\frac{\mathbf{x}_t - \mathbf{x}_i}{h}\right) \mathbf{x}_i}{\sum_{i=1}^{n} K\left(\frac{\mathbf{x}_t - \mathbf{x}_i}{h}\right)}$$

$x_t - x_{t+1} < \varepsilon$ ←

Tramacere+17

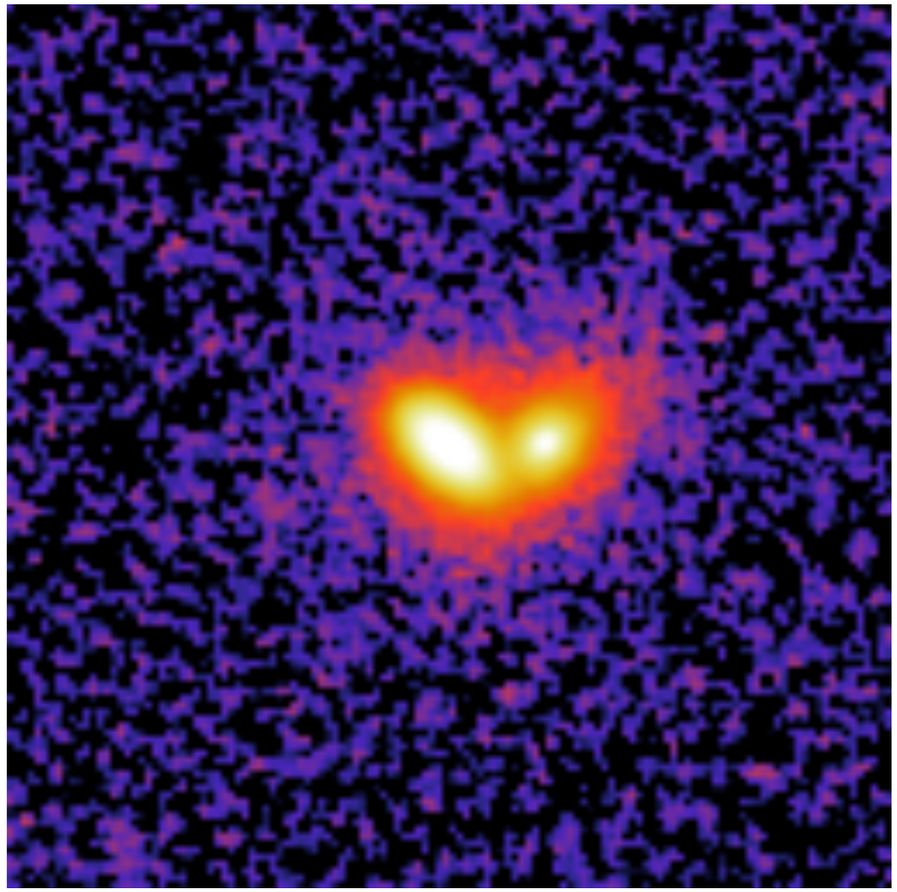
RAMP

Why a DL challenge on deblending ?

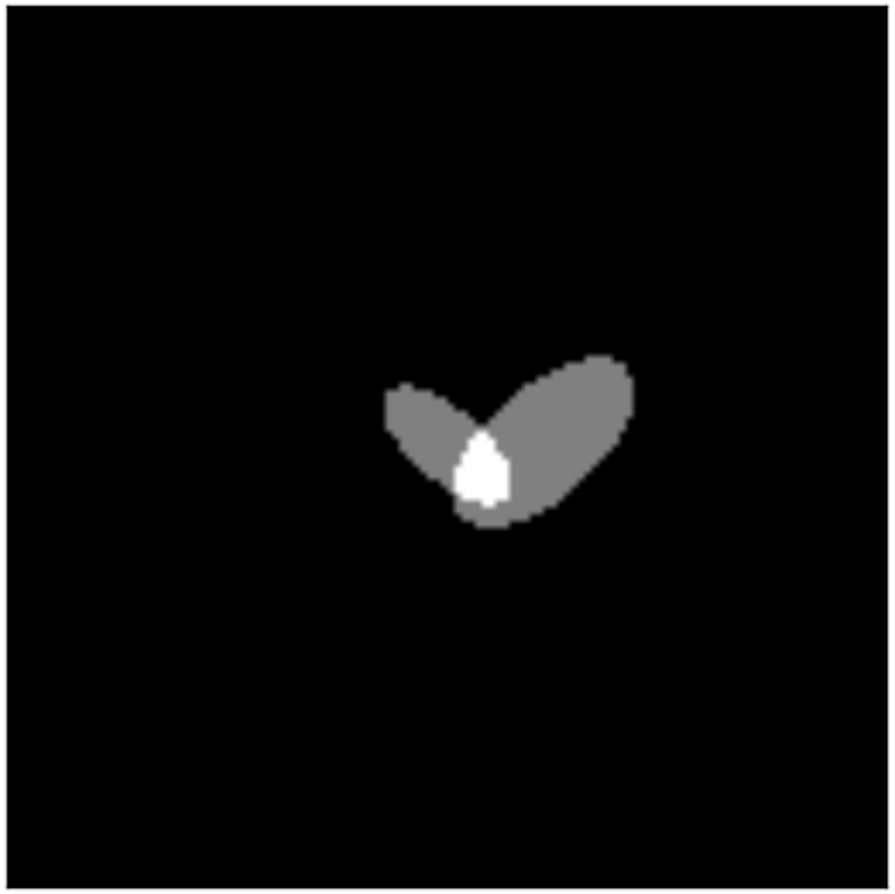
- **Deblending** is a good topic for a challenge
  - difficult but not impossible
  - needed for current and upcoming galaxy surveys

- **Deep Learning** is the outsider tool
  - growing interest in astrophysics
  - huge possibilities but no recipe to create the best architecture

Simulations



input image : X



3-σ contours : y_true

Data from the ground..

…could be labeled from space

Status

Community involved => workshop in June 2017

RAMP starting kit under development

- Metric identified
- Data set not yet finalised

Challenge to be organised soon