Détection et segmentation dans les images hyperspectrales astronomiques MUSE

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Outline

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1. Introduction: the detection problem
2. Models
   - A. Hypothesis testing-based detection
   - B. Bayesian segmentation : Markov fields
   - C. Bayesian segmentation : Markov trees
3. Results
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   - B. On real data
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The MUSE hyperspectral imager

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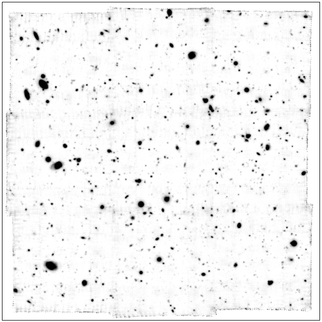

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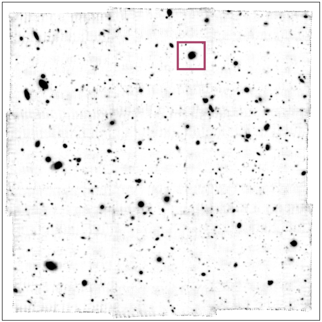

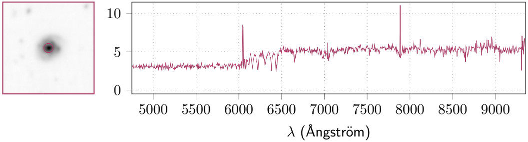

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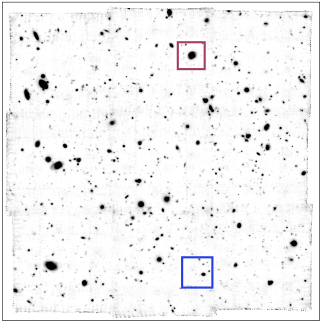
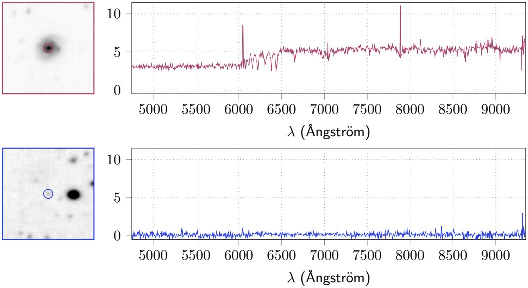
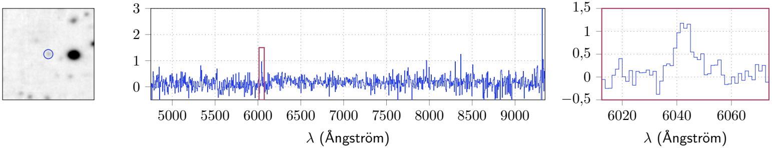




ESO/MUSE Consortium

The detection problem



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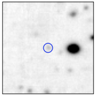

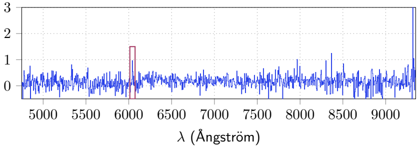

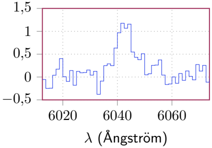

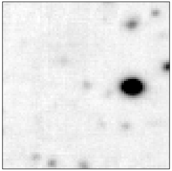

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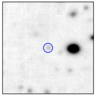

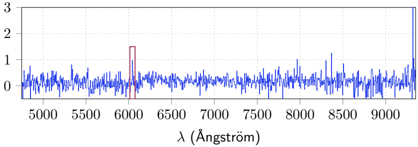

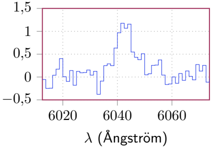

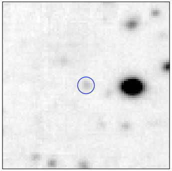

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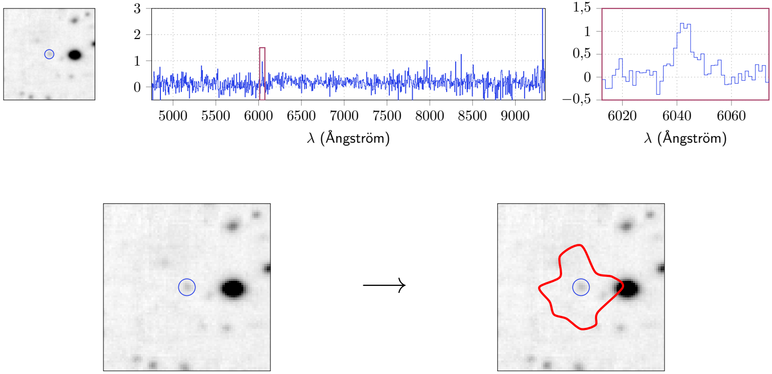

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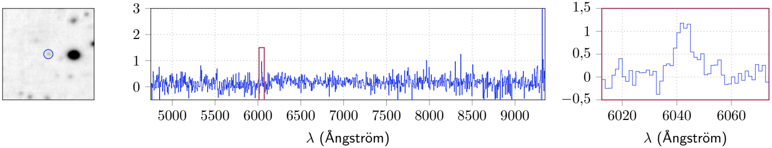

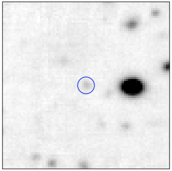

$\longrightarrow$

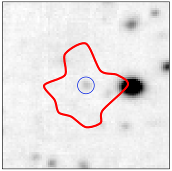

Image $\mathbf{y} \longleftrightarrow$ Result $\hat{\mathbf{x}}$

Outline

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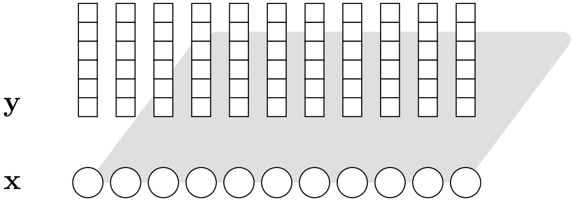
A bit of modeling

How to solve the detection problem ?
We need a model for $\mathbf{x}$, $\mathbf{y}$, and their relation.



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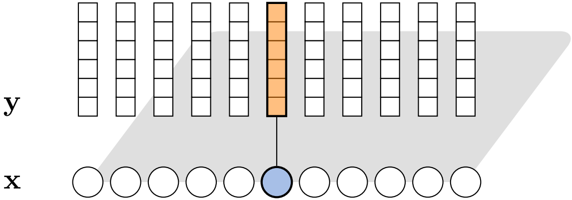

The first approach : hypothesis testing.
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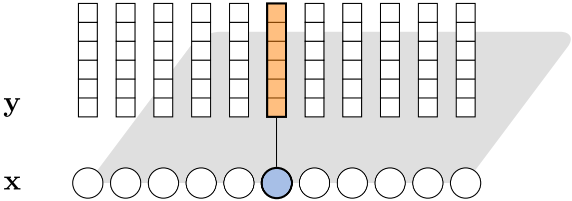
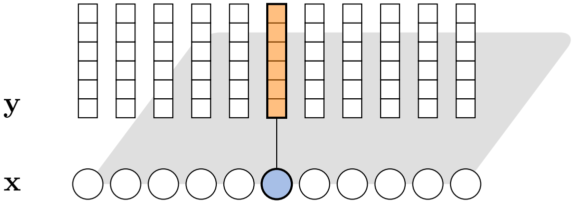


The first approach : hypothesis testing.
Given this spectrum, what is the more likely option ?
Requirement: a model for $p(y|x)$

- noise model

A bit of modeling (II)



The first approach: hypothesis testing with convolution. (HT)

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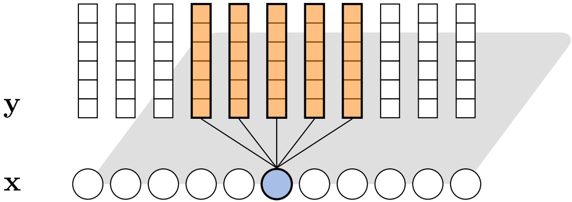

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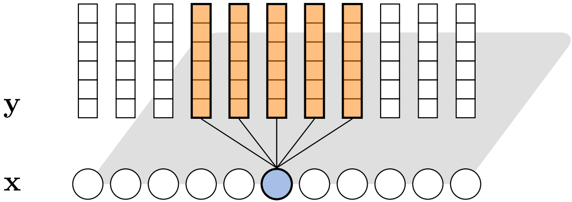

The first approach: hypothesis testing with convolution. (HT)

Given this spectra set, what is the more likely option ?

Requirement: a model for $p(y|x)$

- noise
- convolution

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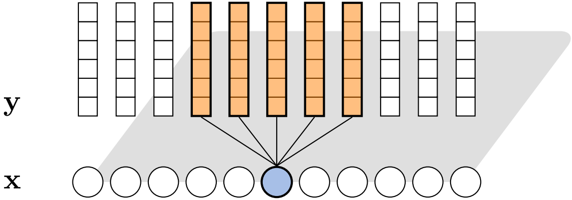
A bit of modeling (III)

In HT, neighboring decisions are **independent**.
A prior is required to improve the results.



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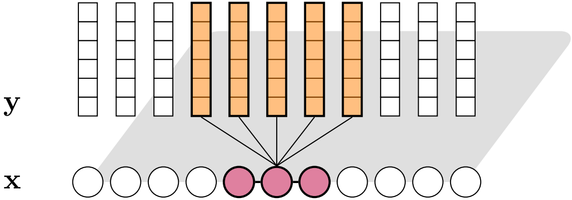

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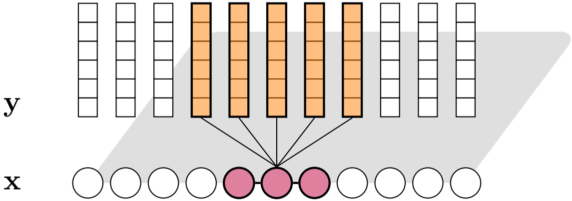

The second approach: pairwise Markov fields (PMF)

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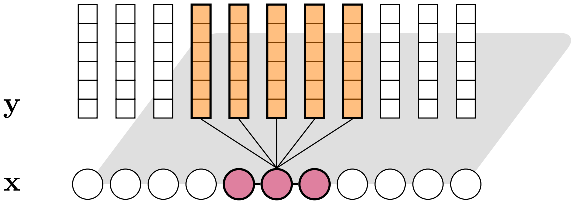


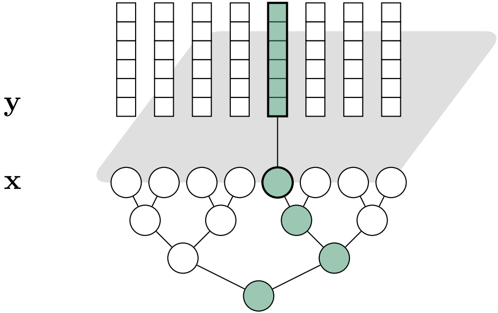
The second approach: pairwise Markov fields (PMF)
Requires models for:

- $p(y|x)$: noise and convolution
- $p(x)$: Markov field $\implies$ spatial smoothness

Outline

A bit of modeling (IV)

What about large-scale interactions ?
We need to change the kind of prior.



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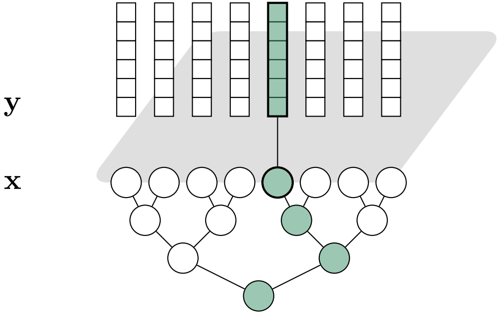

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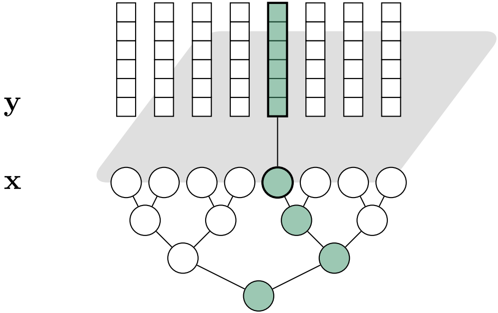

The third approach: Triplet Markov Trees (TMT)
Requires models for:

- $p(y|x)$: noise and no convolution
- $p(x)$: Markov tree $\implies$ hierarchical coherence

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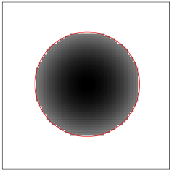
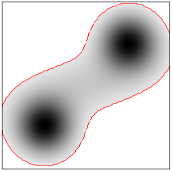
Synthetic data

Experimental setting:

- "halo" and "filament"
- variable intensities





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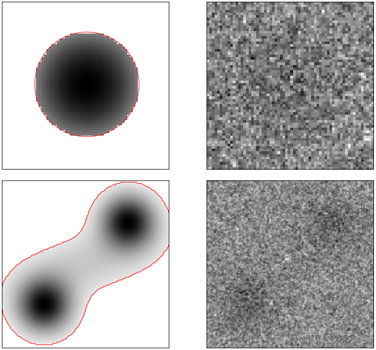

Synthetic data

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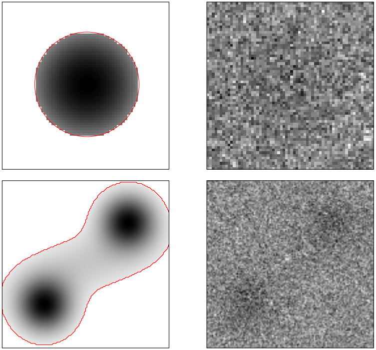
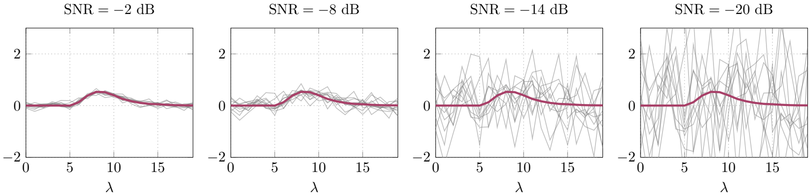
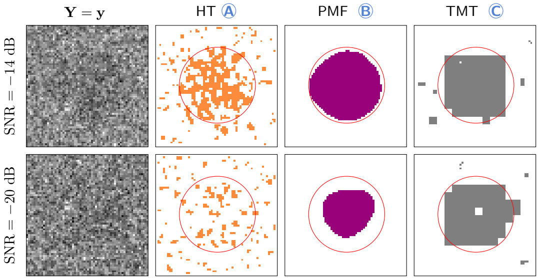
- pseudo-MUSE noise
- $\mathrm{SNR} \in [-20\ \mathrm{dB}, 6\ \mathrm{dB}]$





Results on synthetic images



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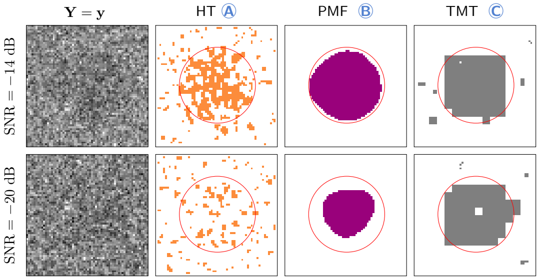

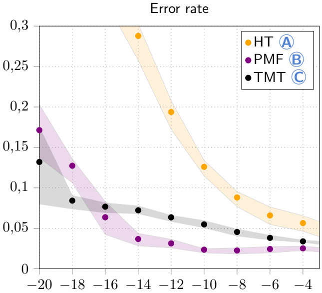

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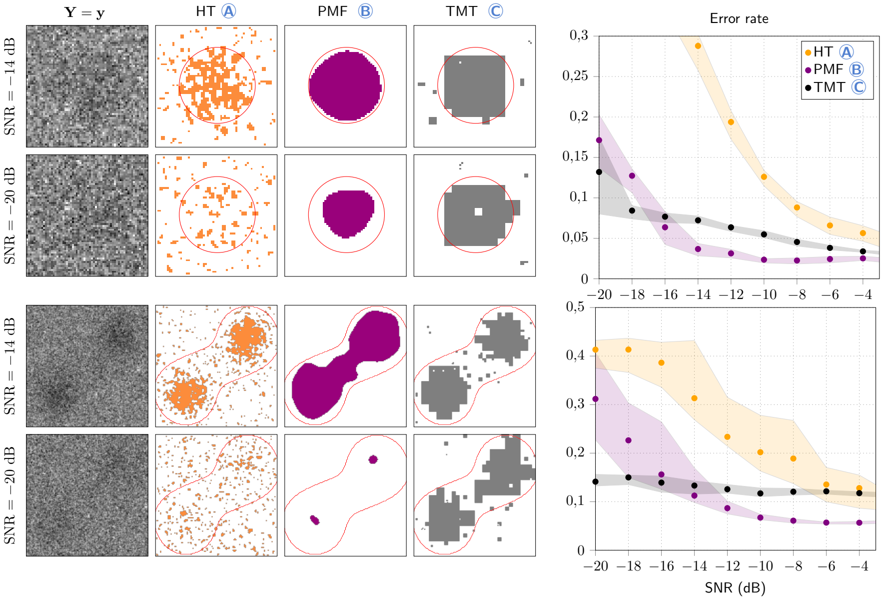

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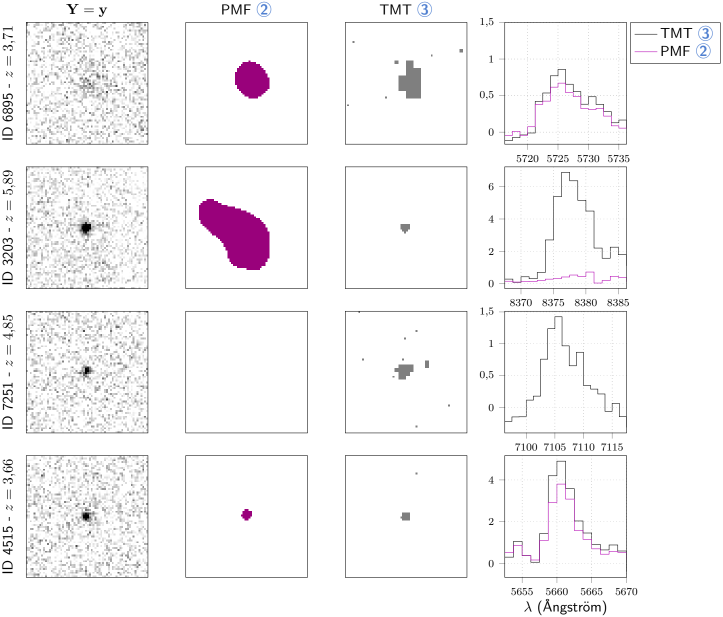
Real images: a sample



A (simple) sample study

A simple study over MUSE UDF cubes.
242 isolated objects : no close neighbor, contamination, etc.

Criteria :

- spectral shape
- spatial extent

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59,5 %

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A (simple) sample study

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242 isolated objects : no close neighbor, contamination, etc.

Criteria :

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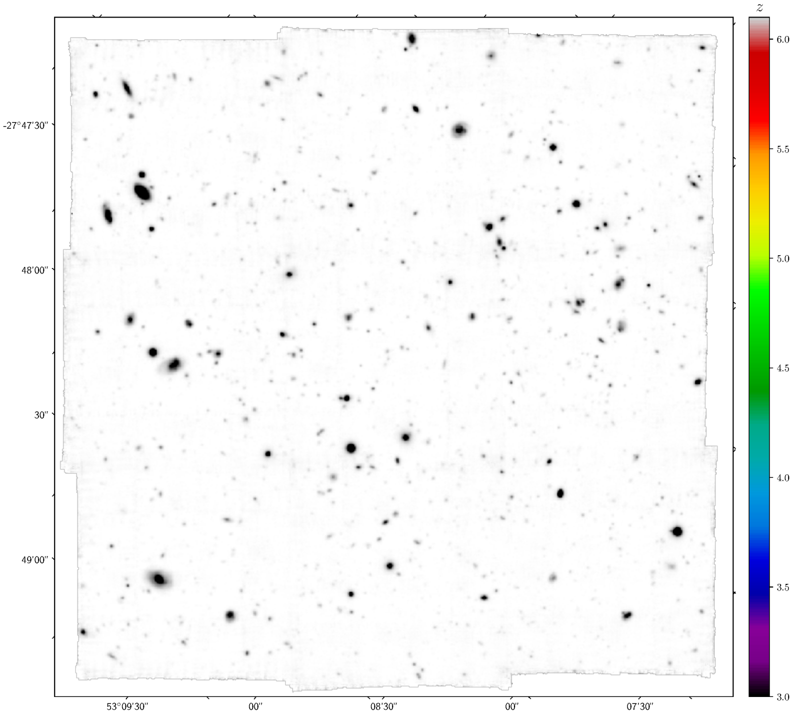
Results:

- PMF detection
- TMT additional detection
- small spatial extent
- no detection



-27°47'30"
48'00"
30"
49'00"
53°09'30"
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07'30"
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4.5
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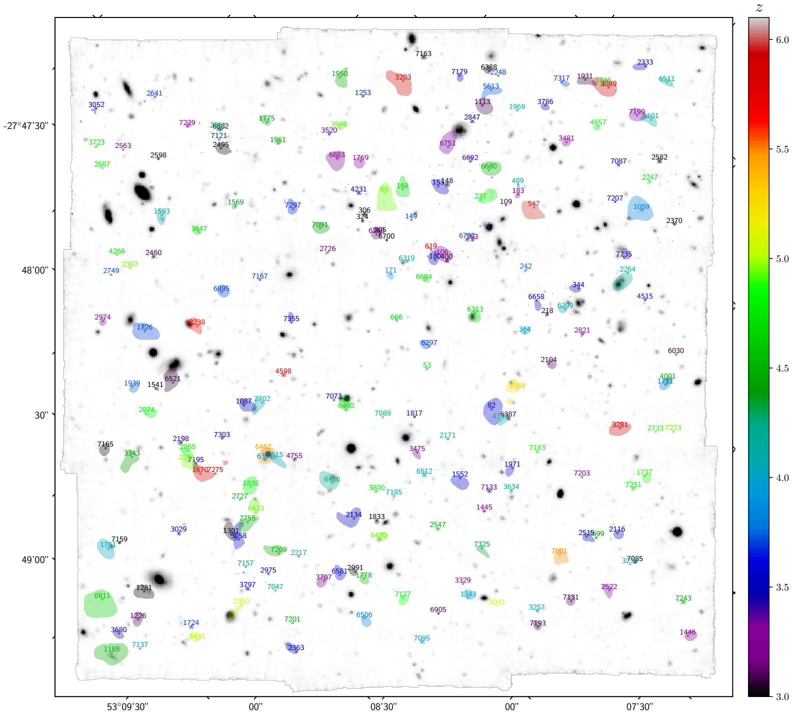
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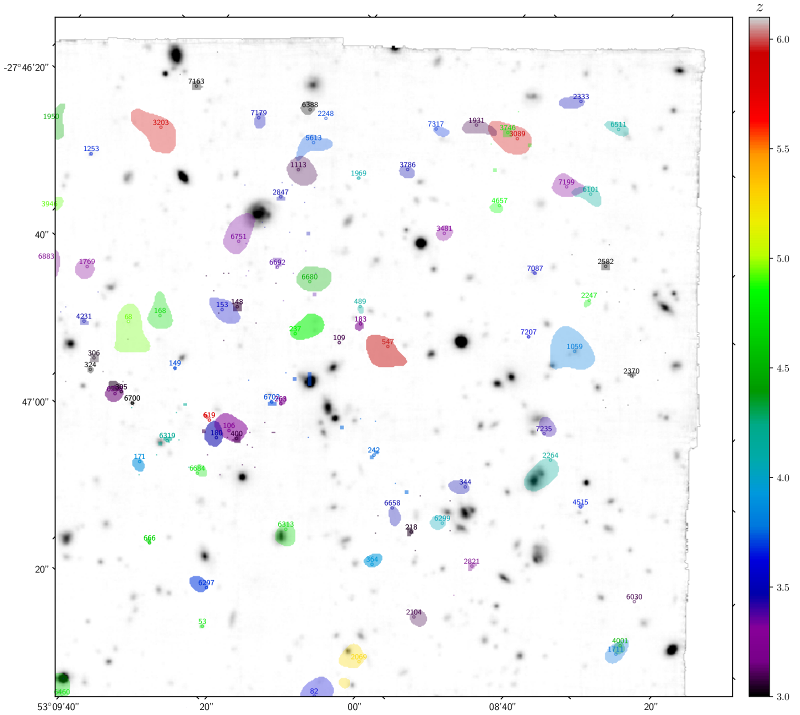

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7317
1931
3746
3089
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6511
3786
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4515
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218
6313
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Conclusions

Outcomes:

- 3 detection models/methods
- in most cases: Pairwise Markov Fields
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- adaptive optics

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