

Automatic Modelling and Object Identification in Radio Astronomy

Richard Fuchs, Jakob Knollmüller, Lukas Heinrich, Torsten Enßlin

International Conference on Machine Learning for Astrophysics
2nd Ed. - ML4ASTRO2

Catania, Italy, 8-12 July 2024

richard.fuchs@tum.de



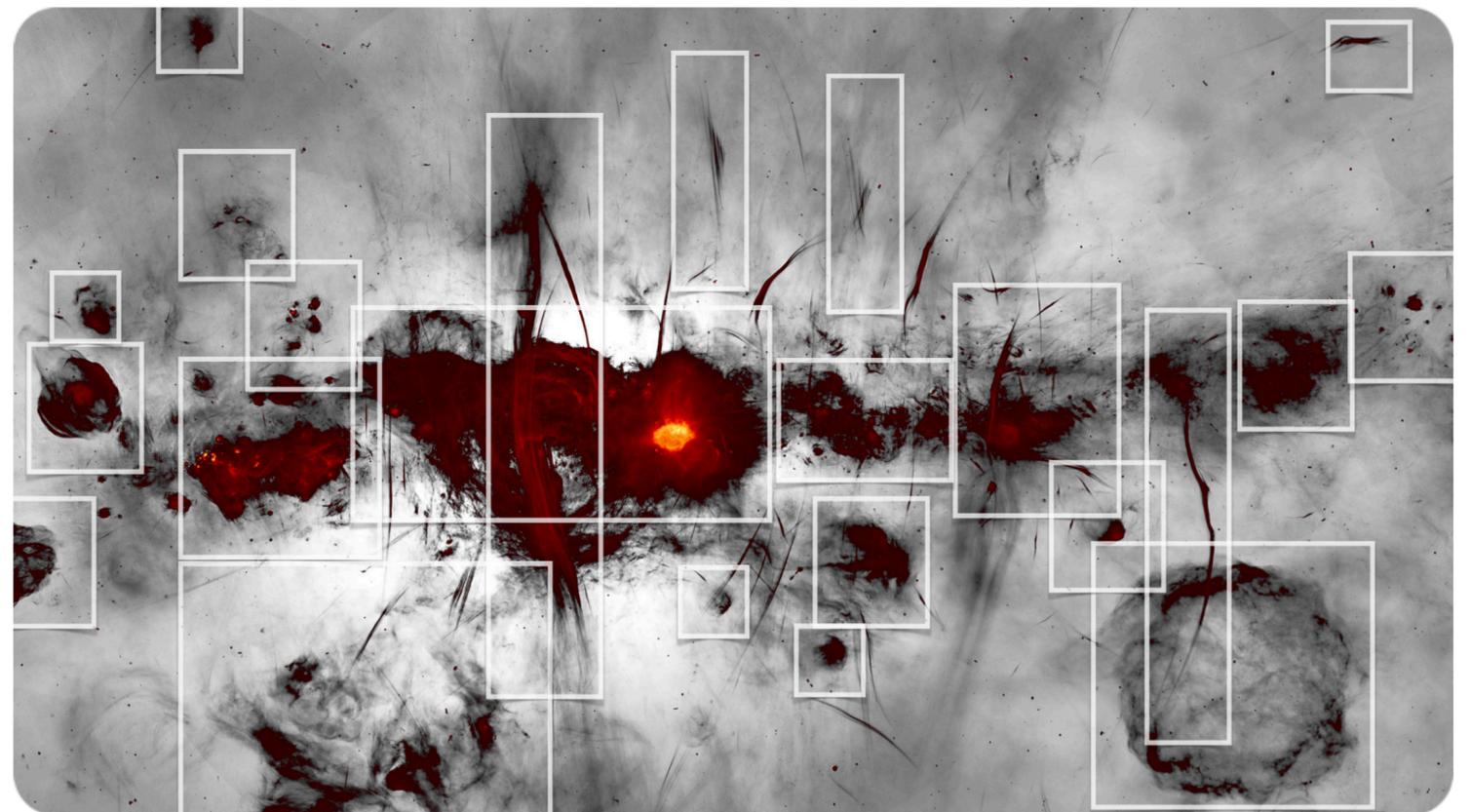
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I. Heywood u. a. „The 1.28 GHz MeerKAT Galactic Center Mosaic“. In: The Astrophysical Journal 925.2 (2022), S. 165.

Bayesian Imaging

Measurement equation

$$d = R s + n$$

Bayesian Imaging

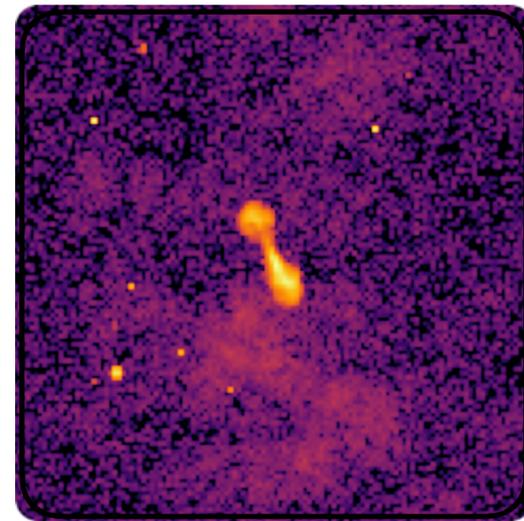
Measurement equation

$$d = R s + n$$

Synthetic image data

- noisy 2D images
- unit response

$$R = 1$$



Bayesian Imaging

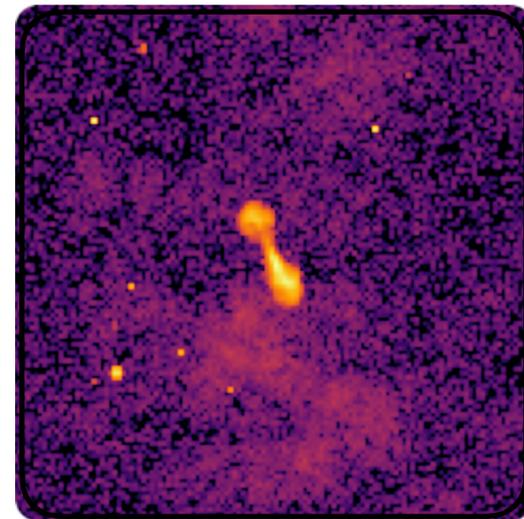
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Bayes' theorem

$$P(s | d) = \frac{P(d | s) P(s)}{P(d)}$$

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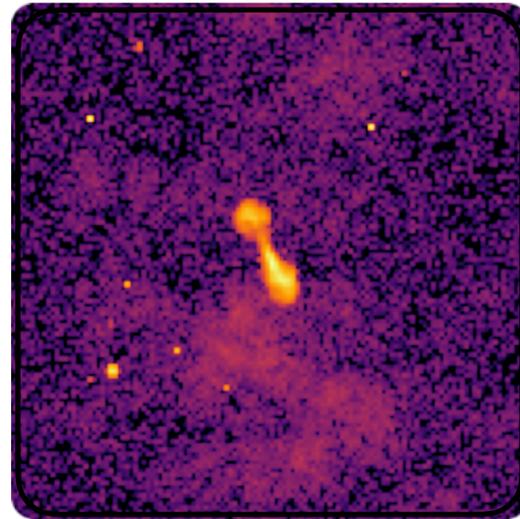
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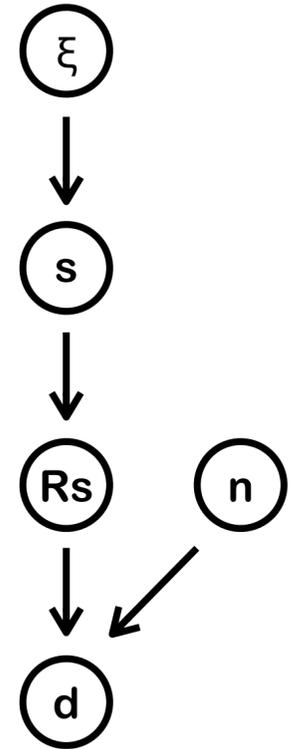
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Generative models



Bayesian Imaging

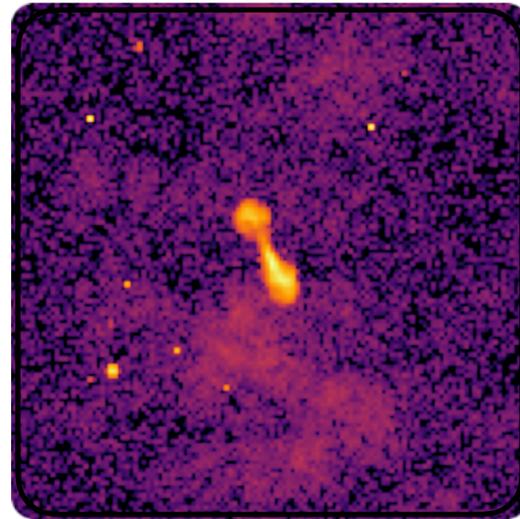
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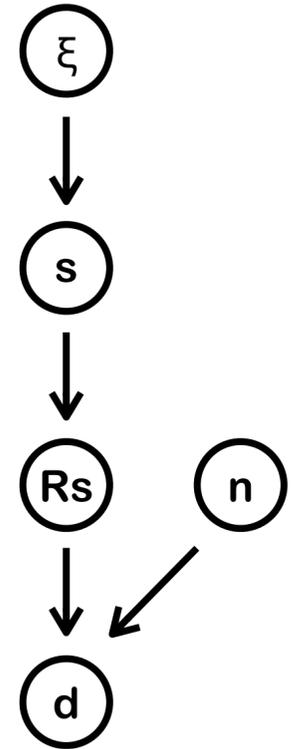
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Generative models

Diffuse emission

- positive, correlated & flexible



Bayesian Imaging

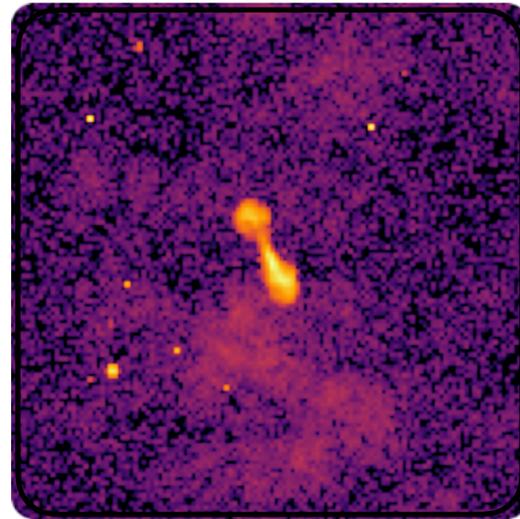
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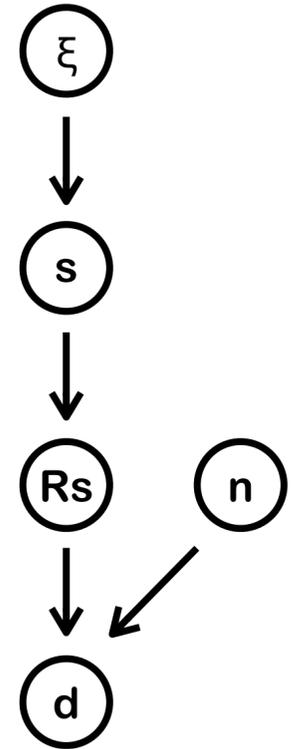
Generative models

Diffuse emission

- positive, correlated & flexible

Point sources

- positive & independent



Bayesian Imaging

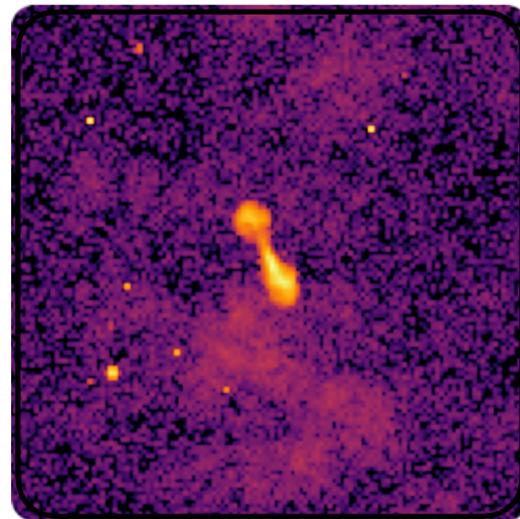
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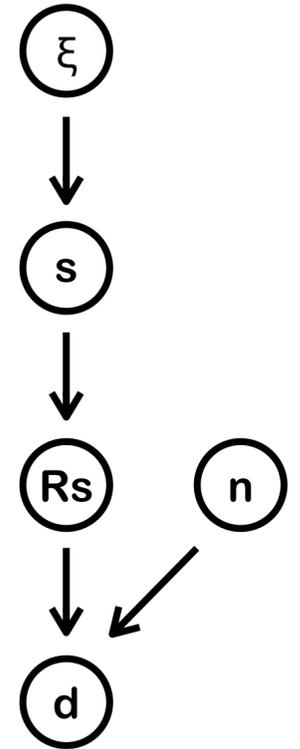
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Approximate the posterior



Bayesian Imaging

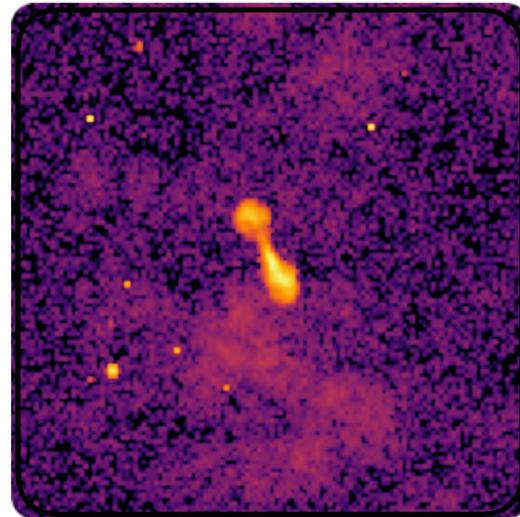
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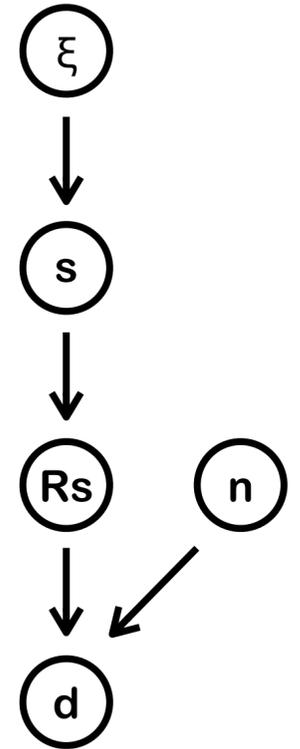
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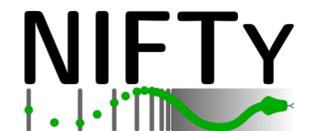
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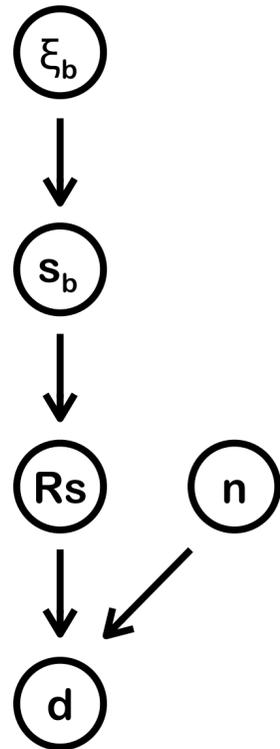


Approximate the posterior



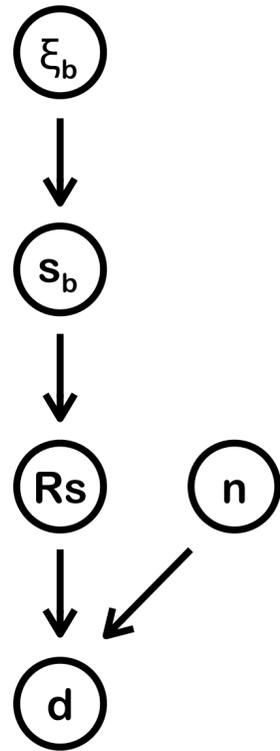
Model & Optimization

Sky description

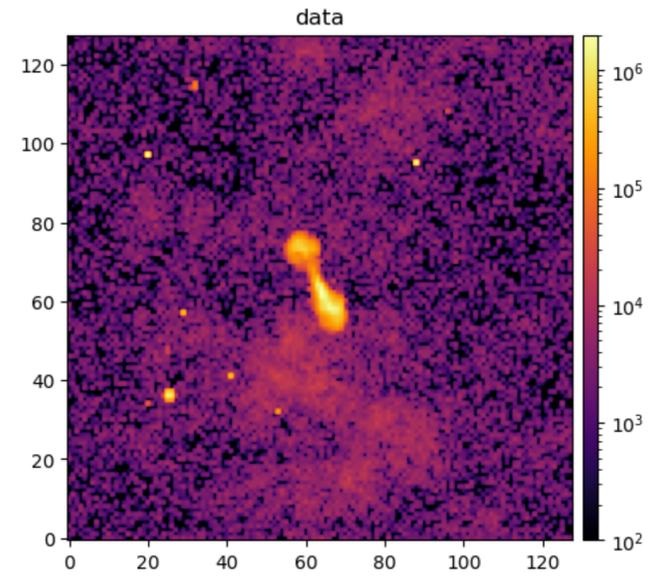


Model & Optimization

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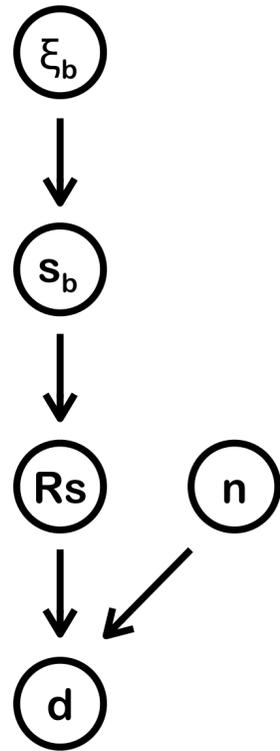


Synthetic image data

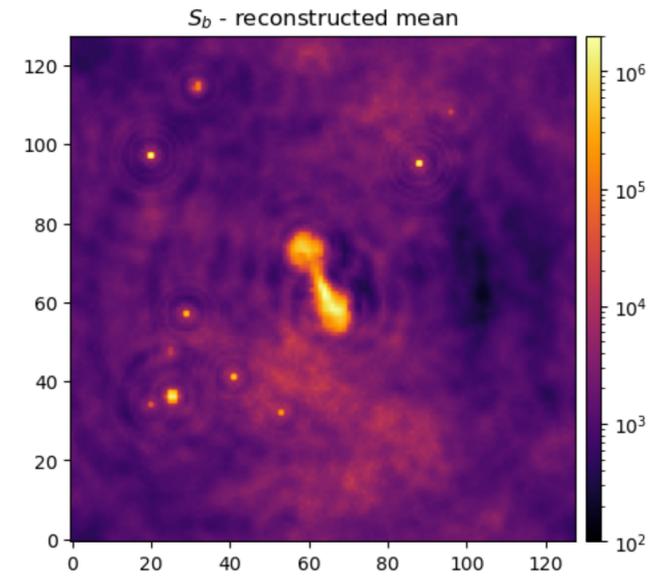


Model & Optimization

Sky description

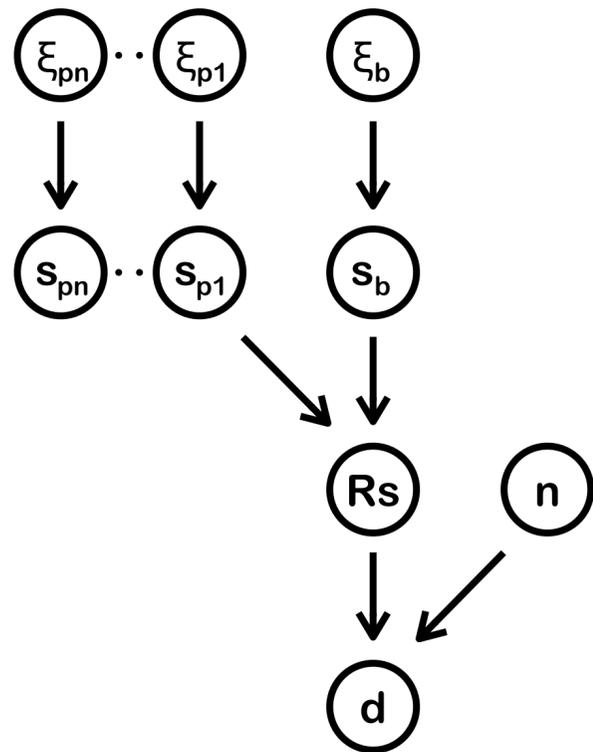


Reconstructed components

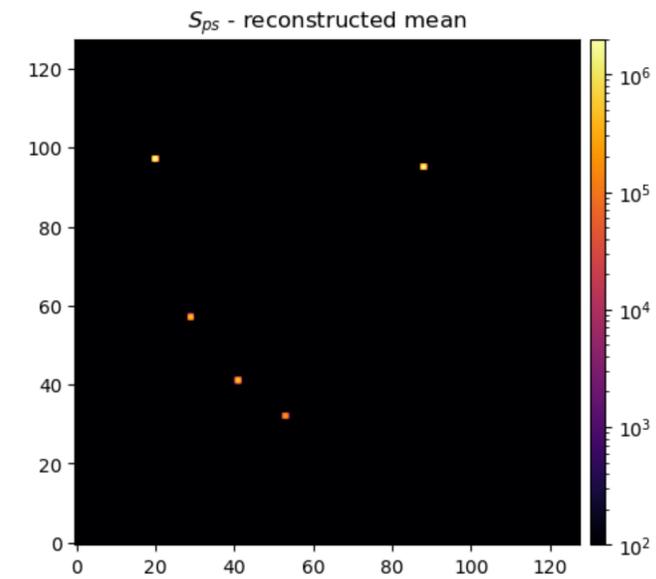
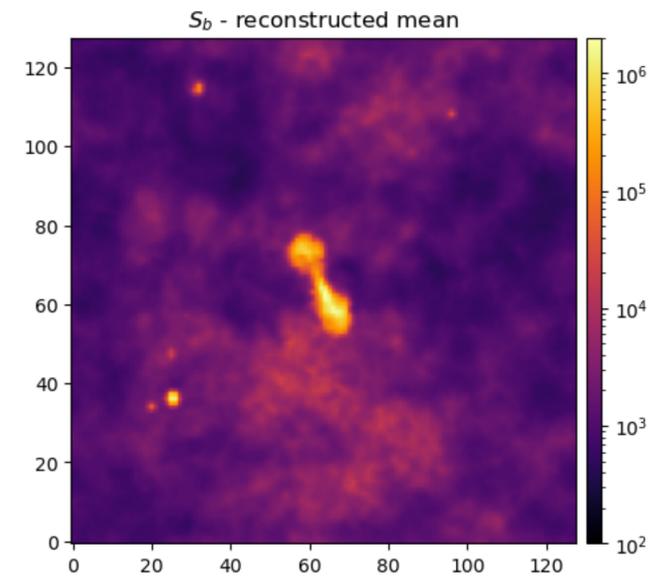


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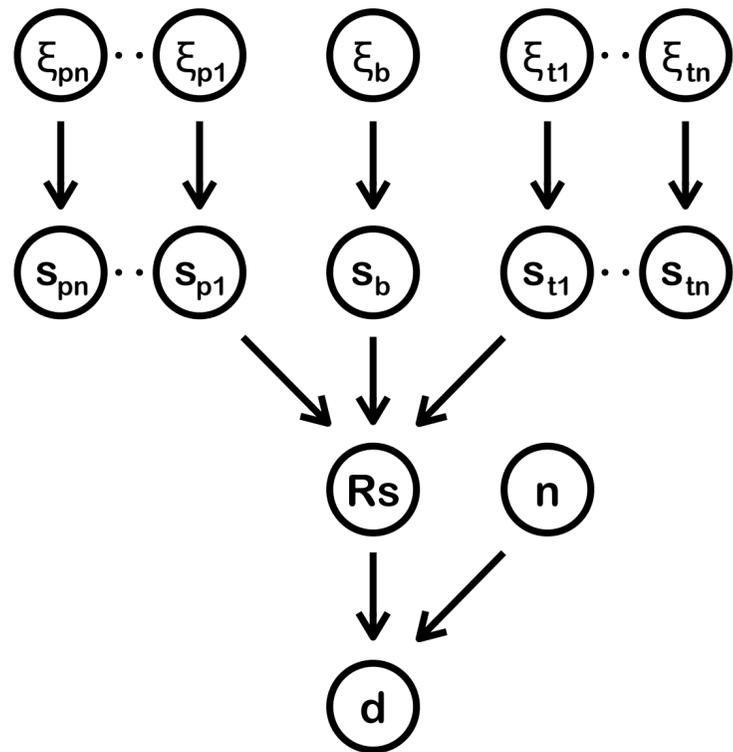


Reconstructed components

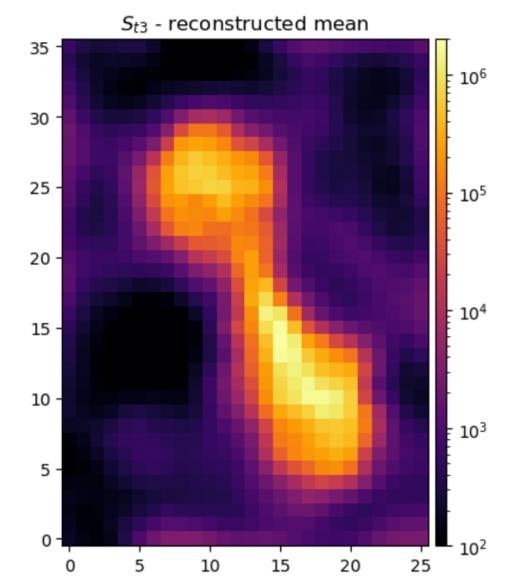
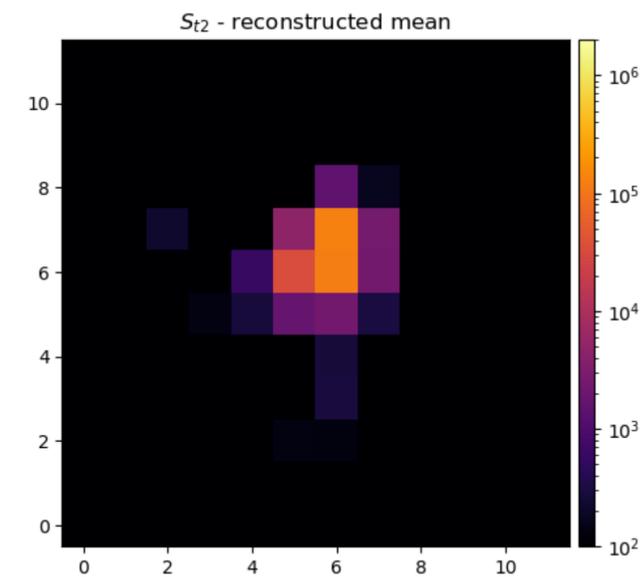
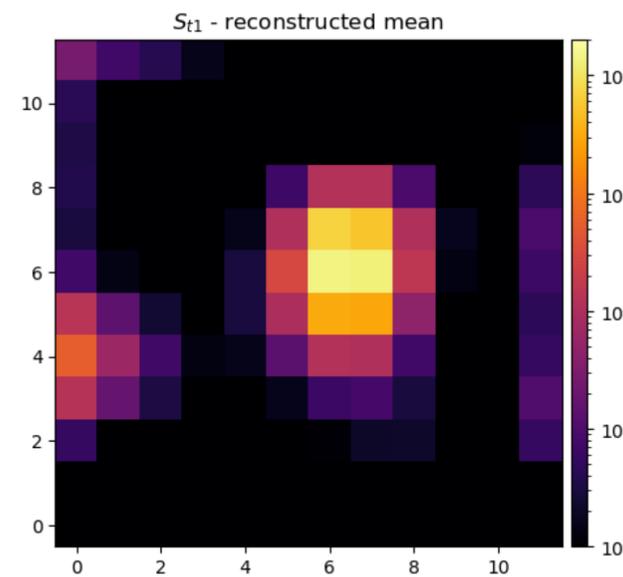
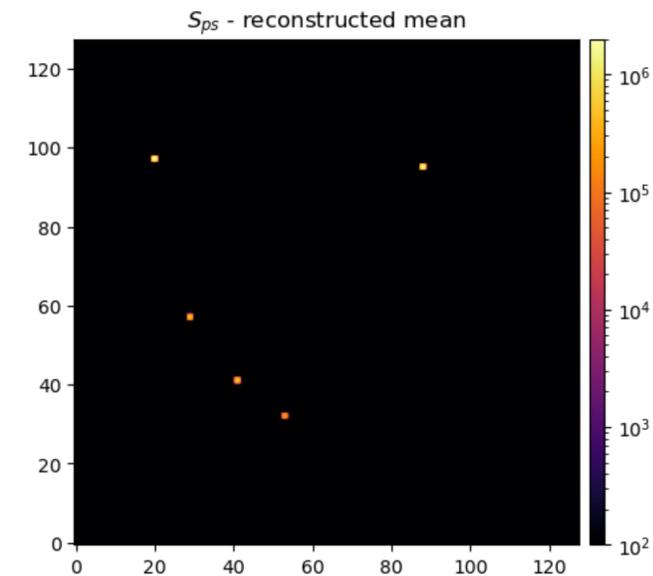
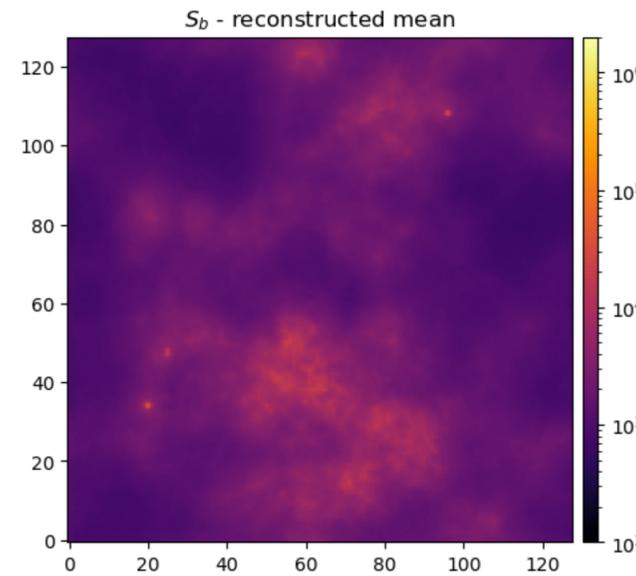


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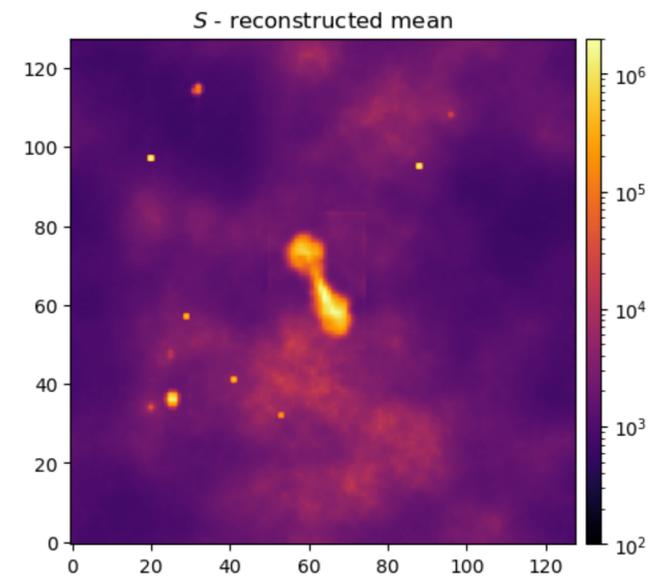
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Reconstructed components



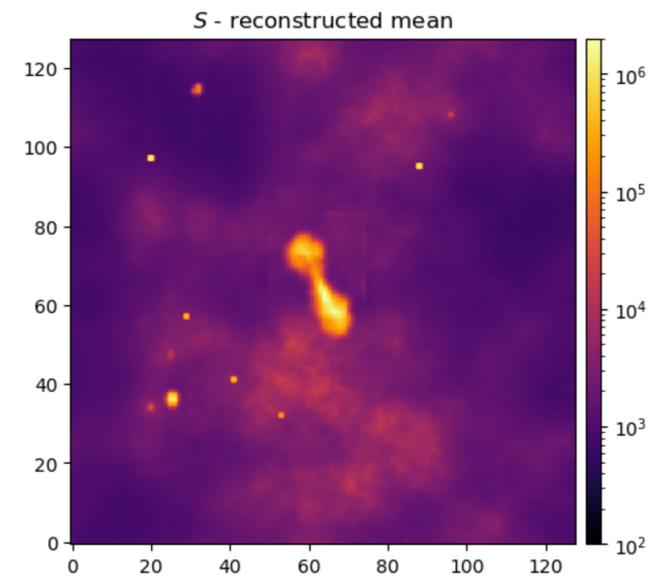
Object Identification



Object Identification

Challenges

- precise localization
- unknown number of objects

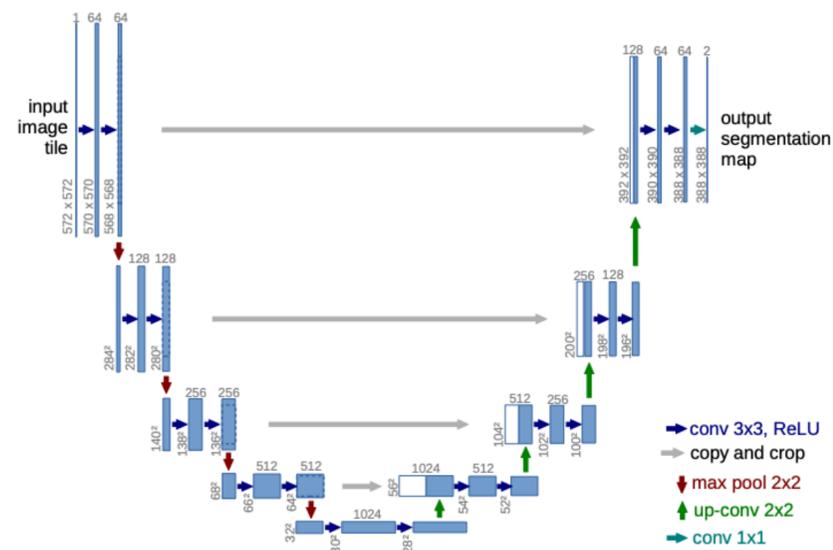
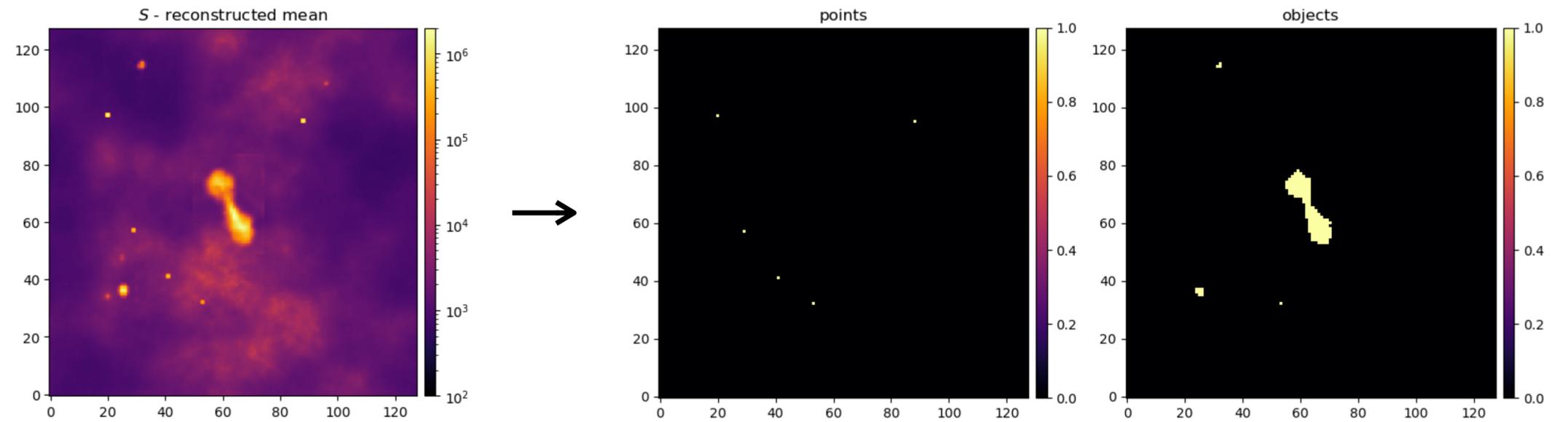


Object Identification

Challenges

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U-Net architecture



<https://arxiv.org/abs/1505.04597>

Object Identification

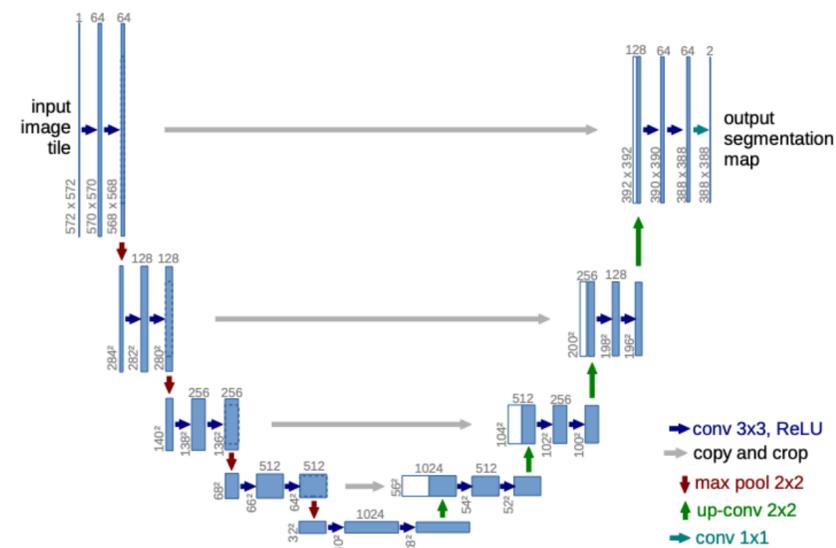
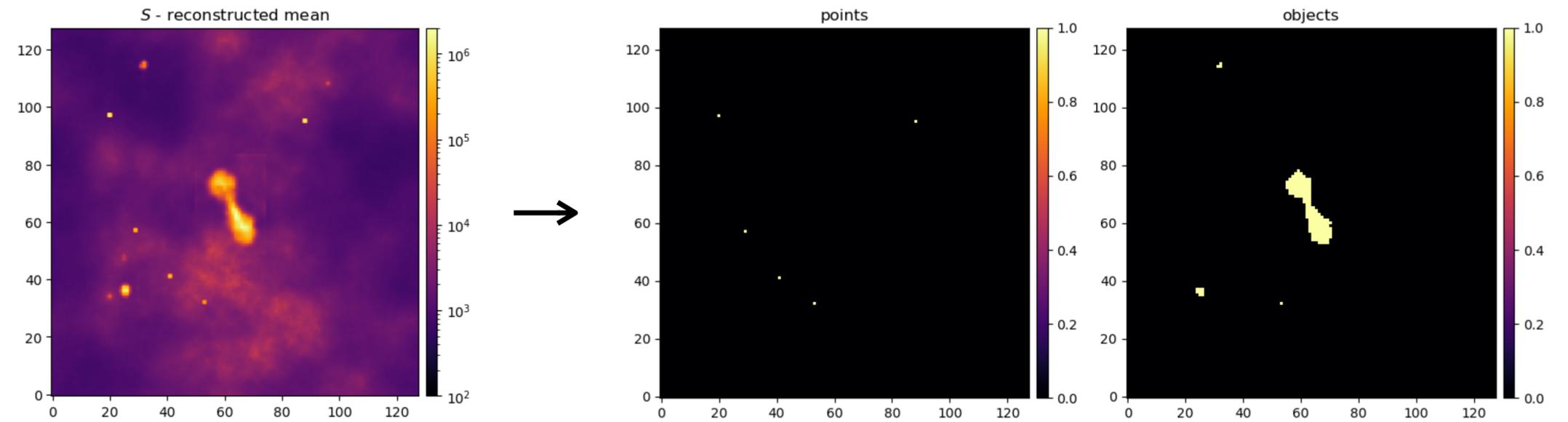
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U-Net architecture

Training data

- RadioGalaxyDataset *



* <https://zenodo.org/records/7692494>

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Object Identification

Challenges

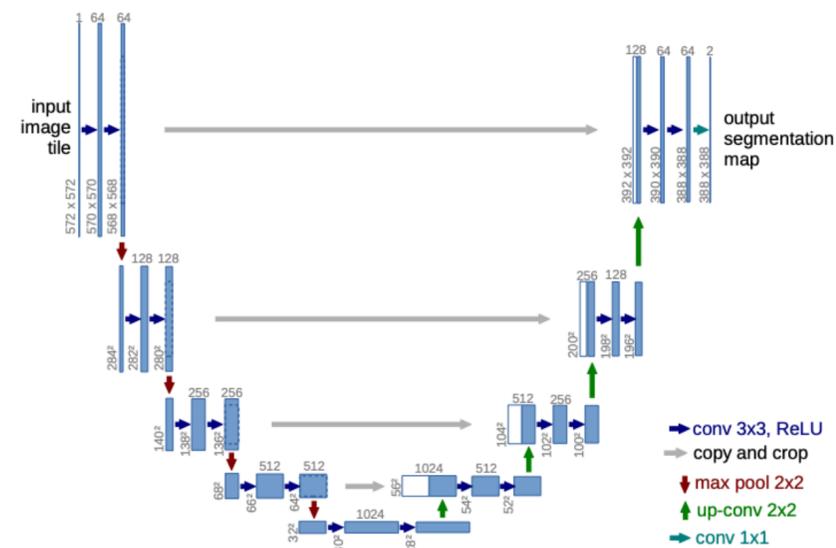
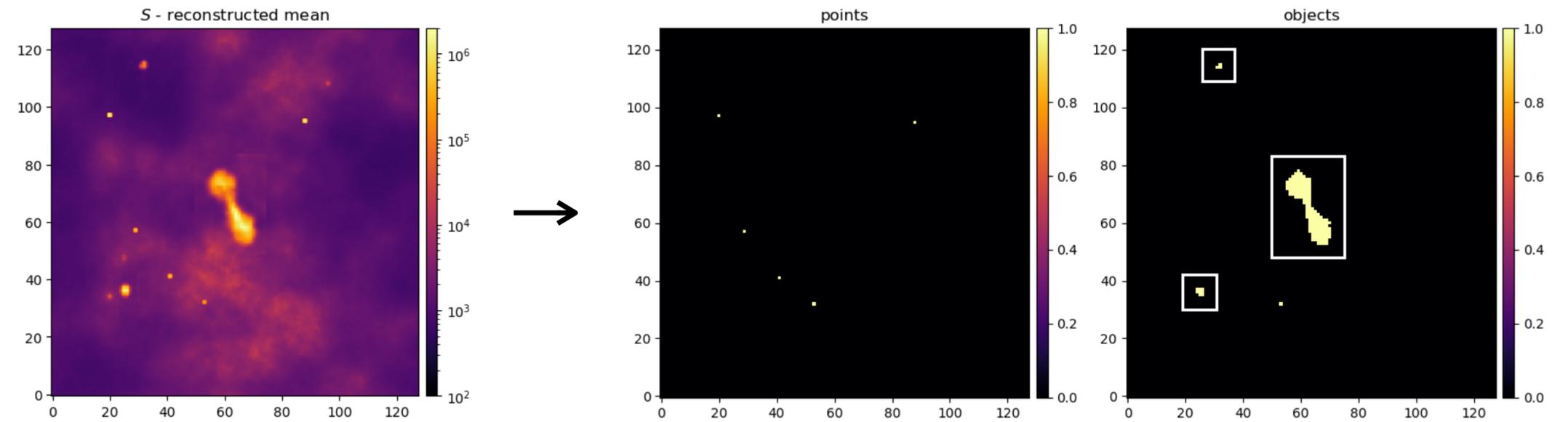
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DBSCAN



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Iterative Method

Steps

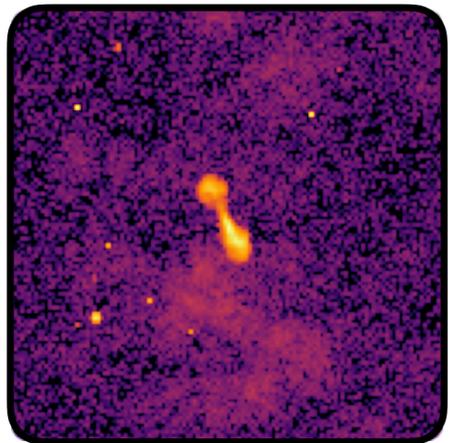
- (a) identification
 - (b) modeling
 - (c) optimization
-

Iterative Method

Steps

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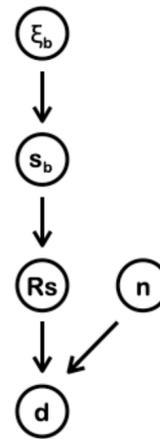
(data)



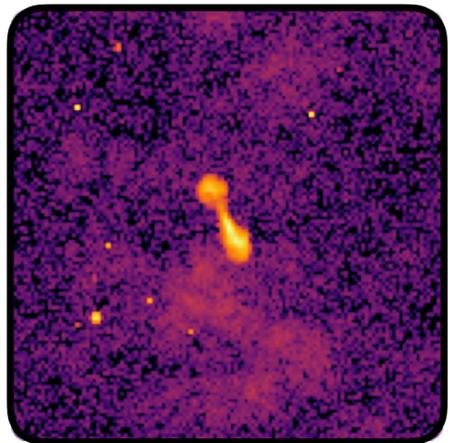
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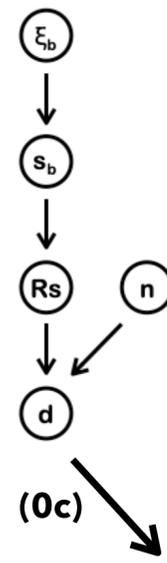
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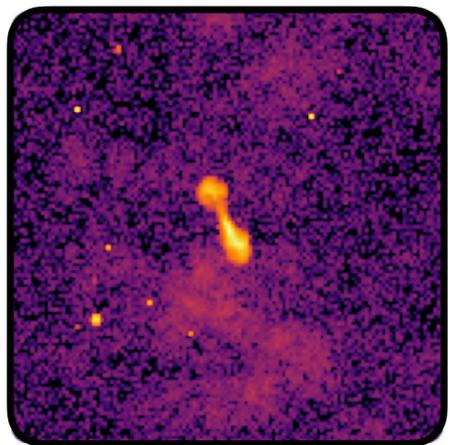
Iterative Method

Steps

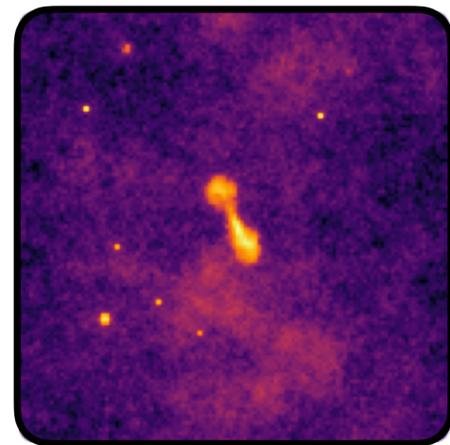
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(data)



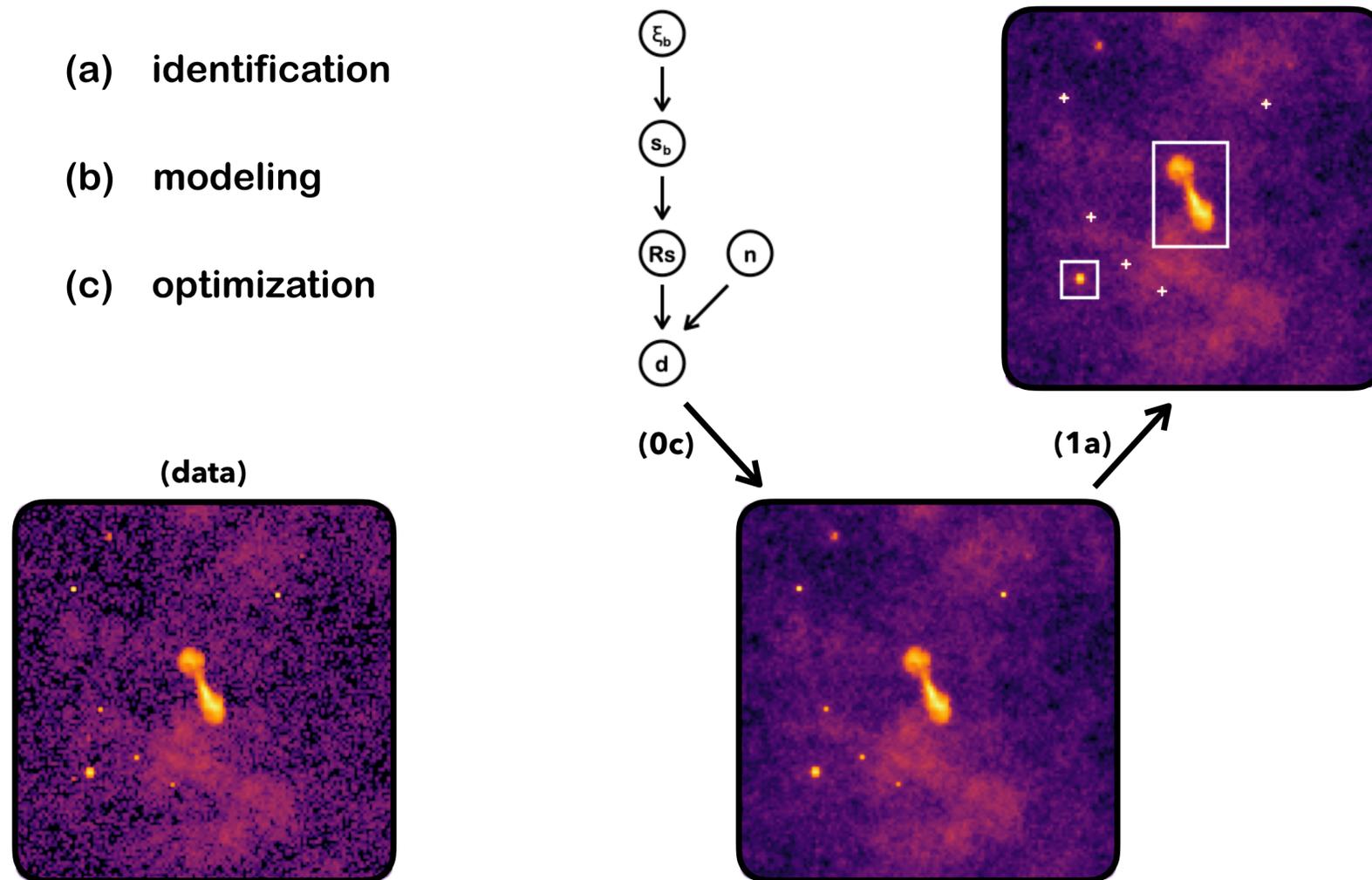
(0c)



Iterative Method

Steps

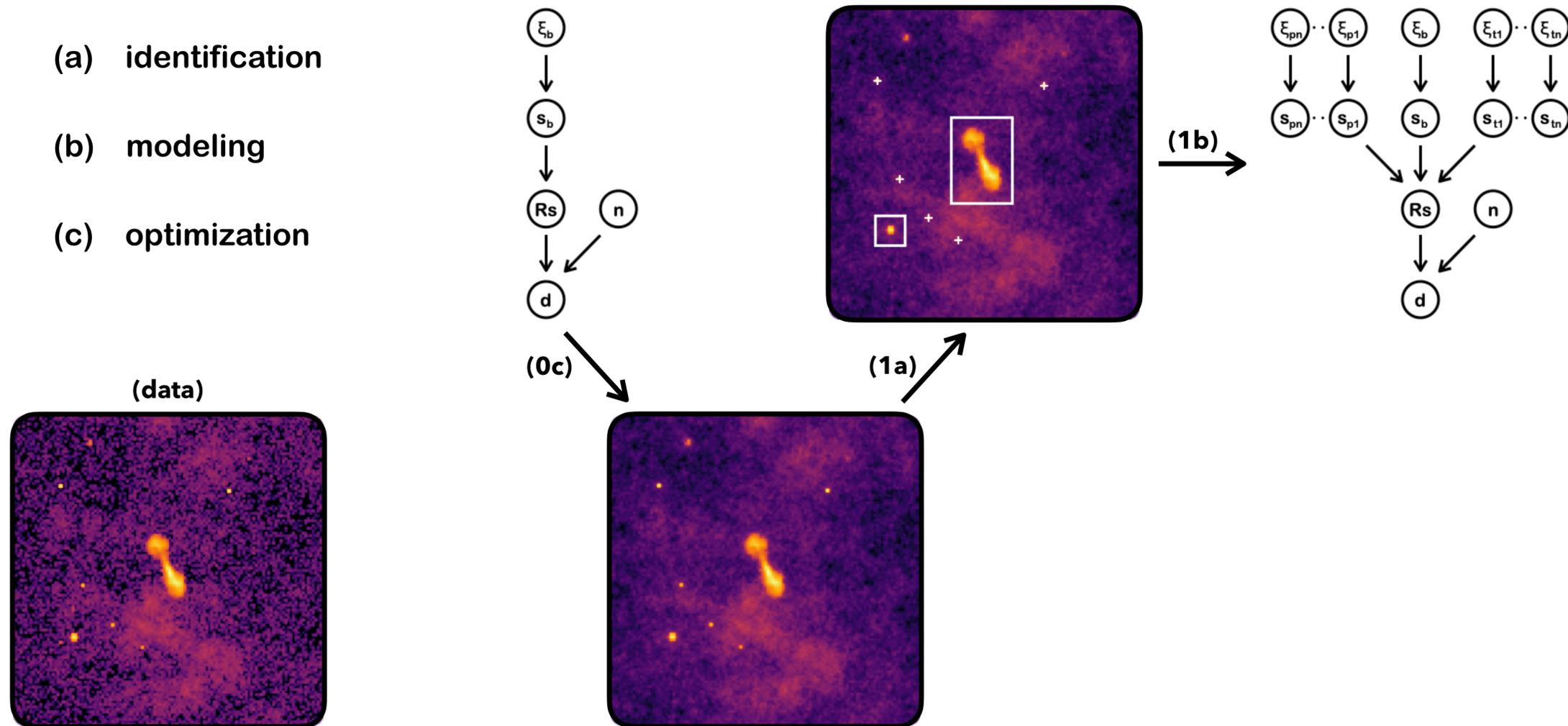
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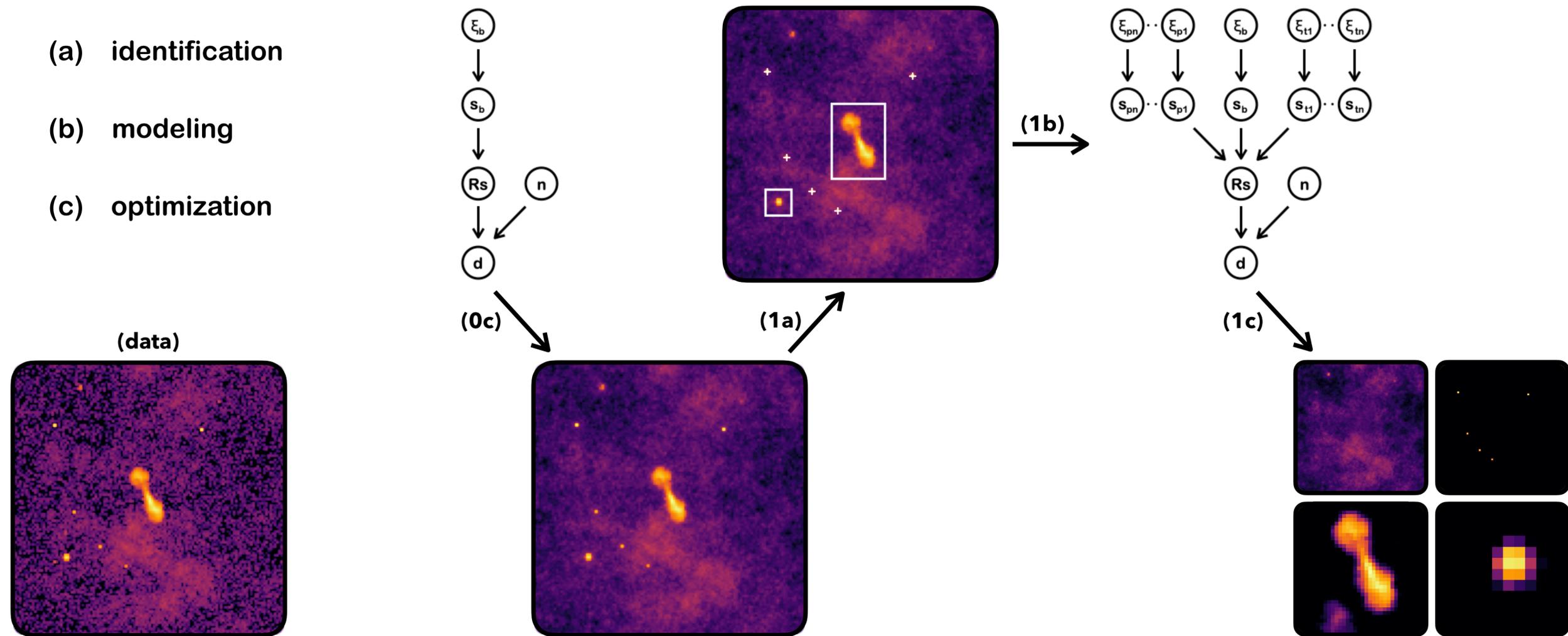
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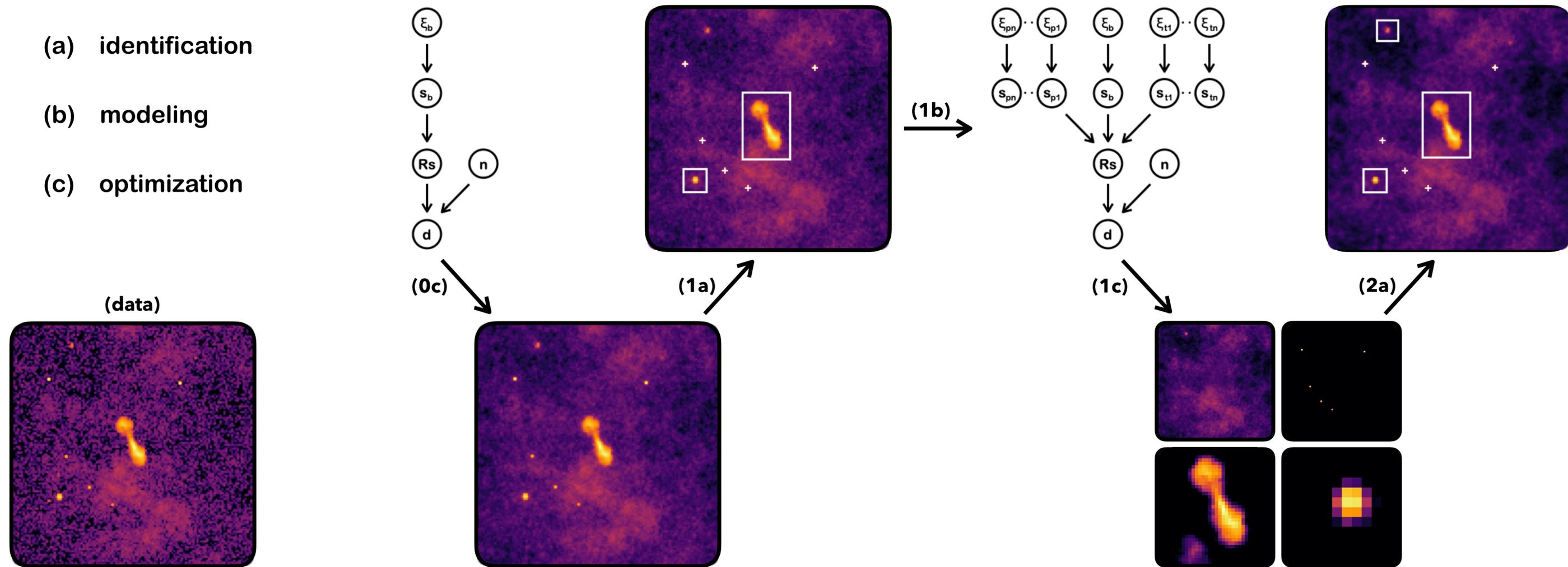
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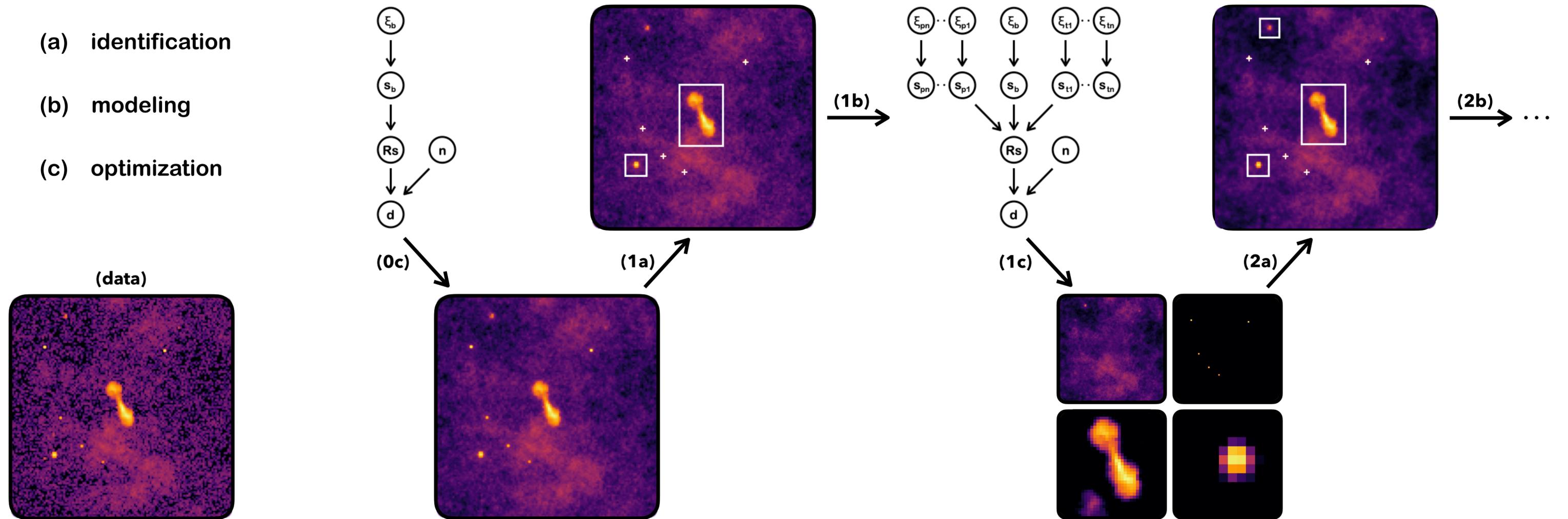
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