



Spatially Variant Point Spread Functions for Bayesian Imaging

Vincent Eberle,
Margret Westerkamp, Matteo Guardiani,
Julia Stadler, Philipp Frank, Philipp Arras,
Torsten Enßlin

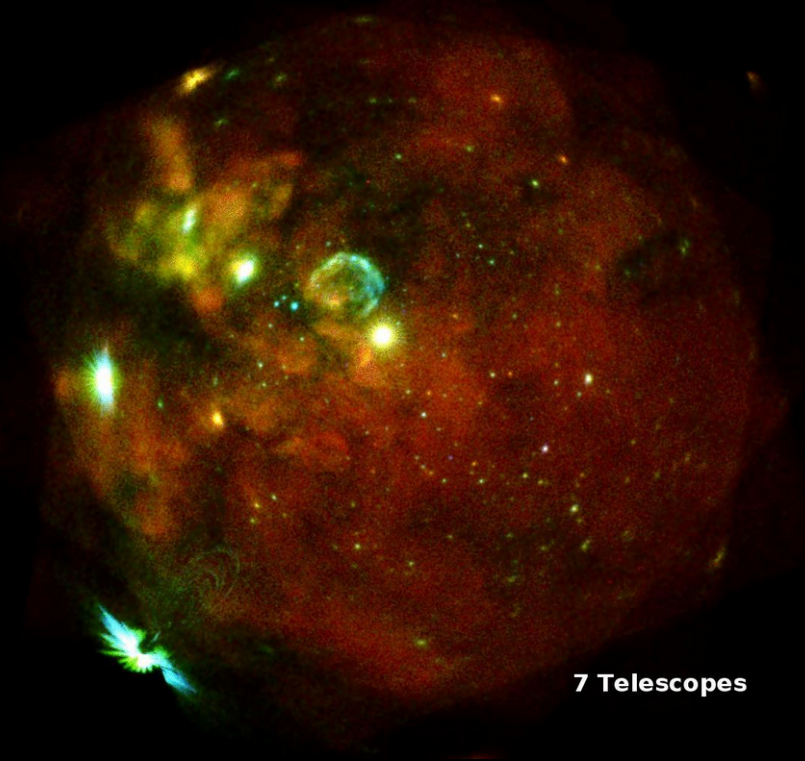
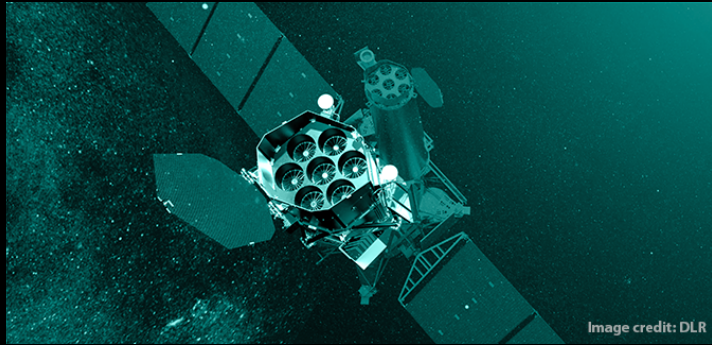
Machine Learning for
Astrophysics 2nd Edition
Catania, Italy
10th July



MAX PLANCK INSTITUTE
FOR ASTROPHYSICS

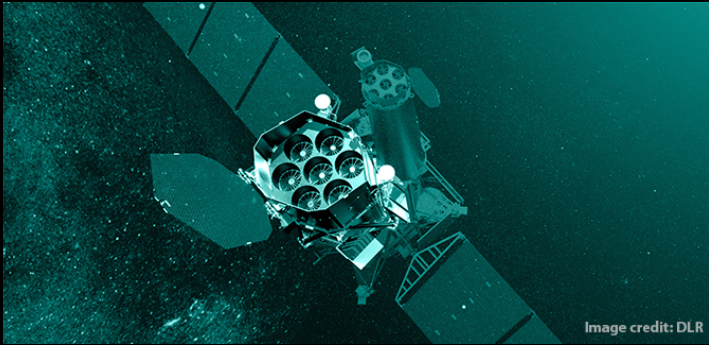


Motivation

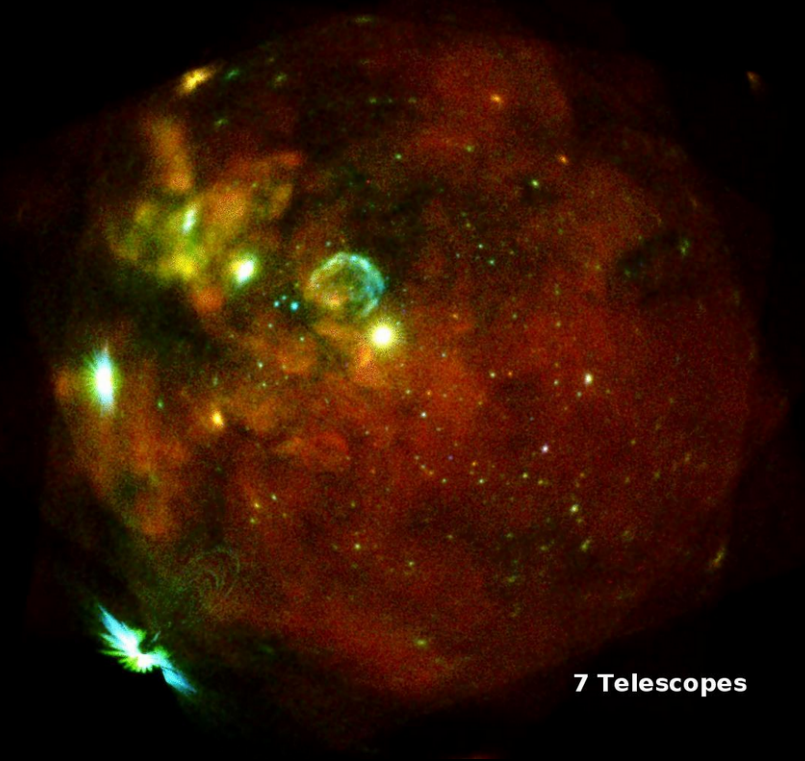


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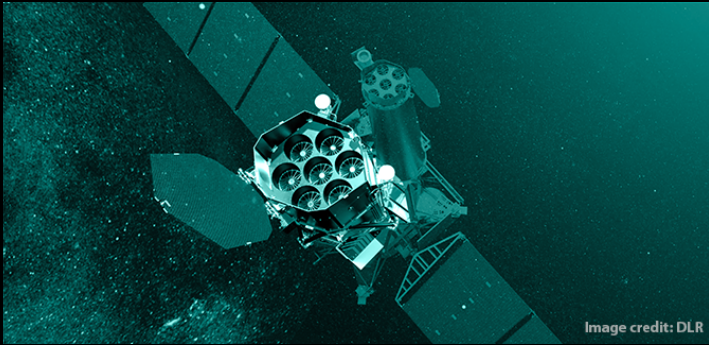


X-ray telescopes (e.g. eROSITA, Chandra) suffer from nuisance effects, e.g.



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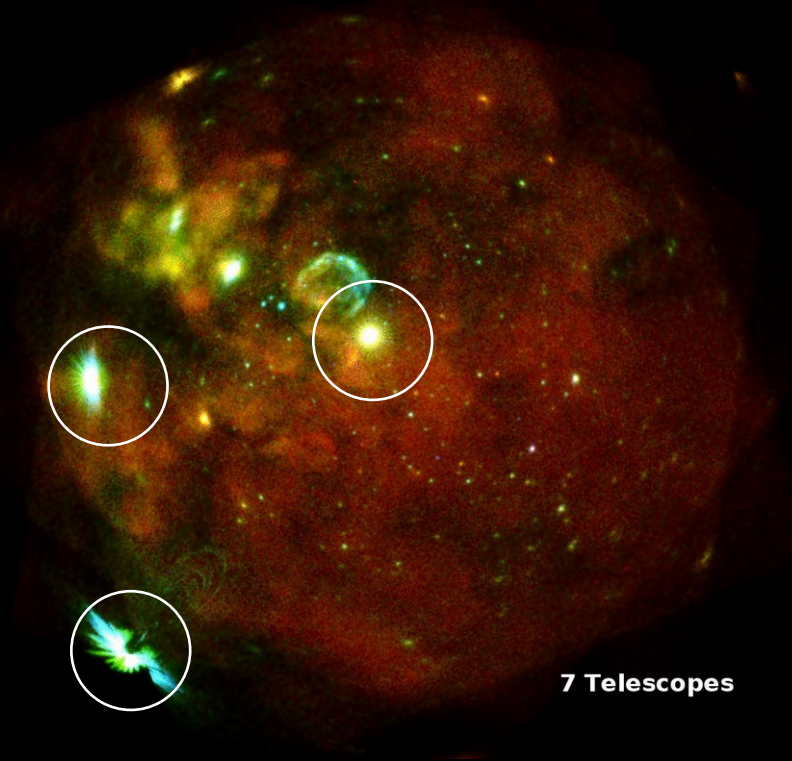


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Problems

Spatially Variant Point Spread Functions (PSF)



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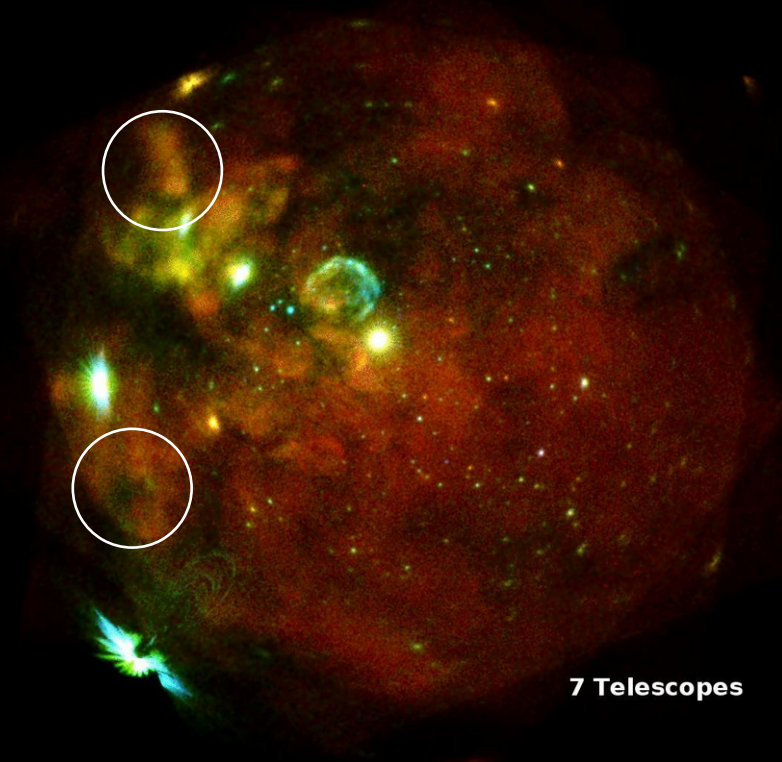
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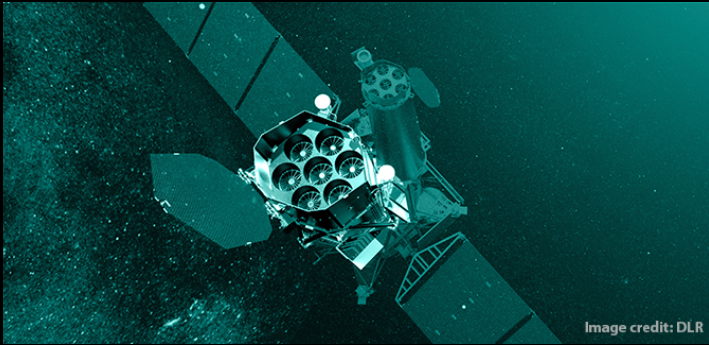
Spatially Variant Point Spread Functions (PSF)

Shot Noise



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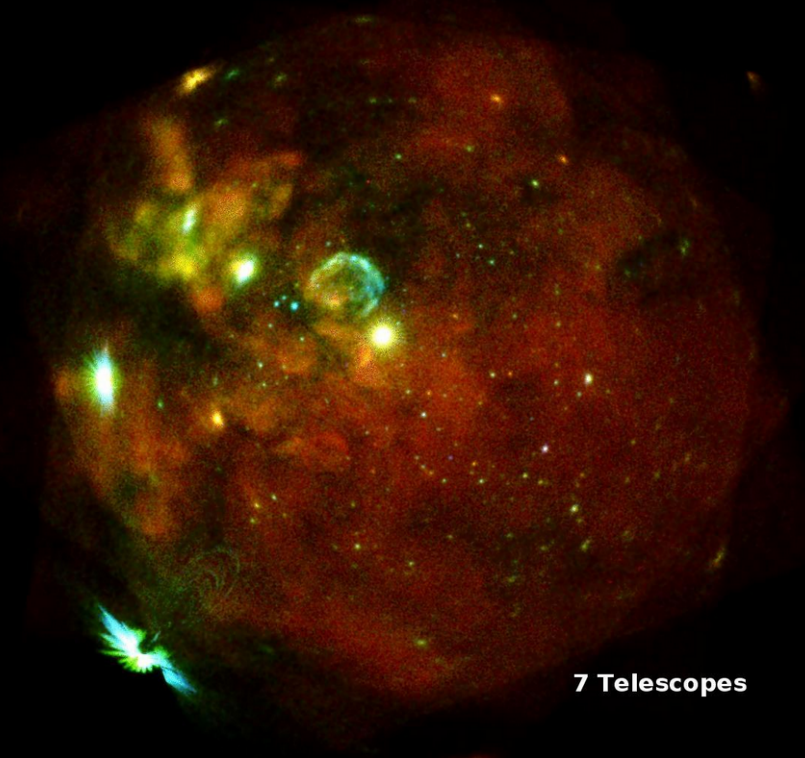
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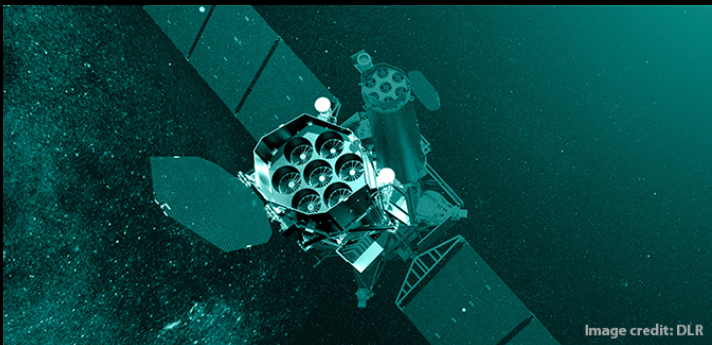
Shot Noise



Solutions

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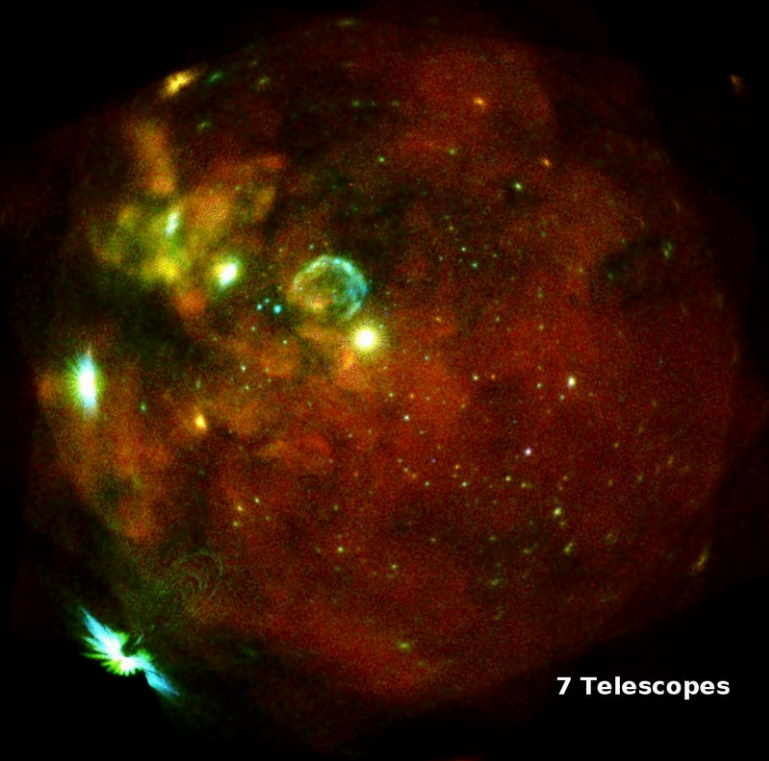


Shot Noise



Solutions

Bayesian Imaging
&
Generative Models



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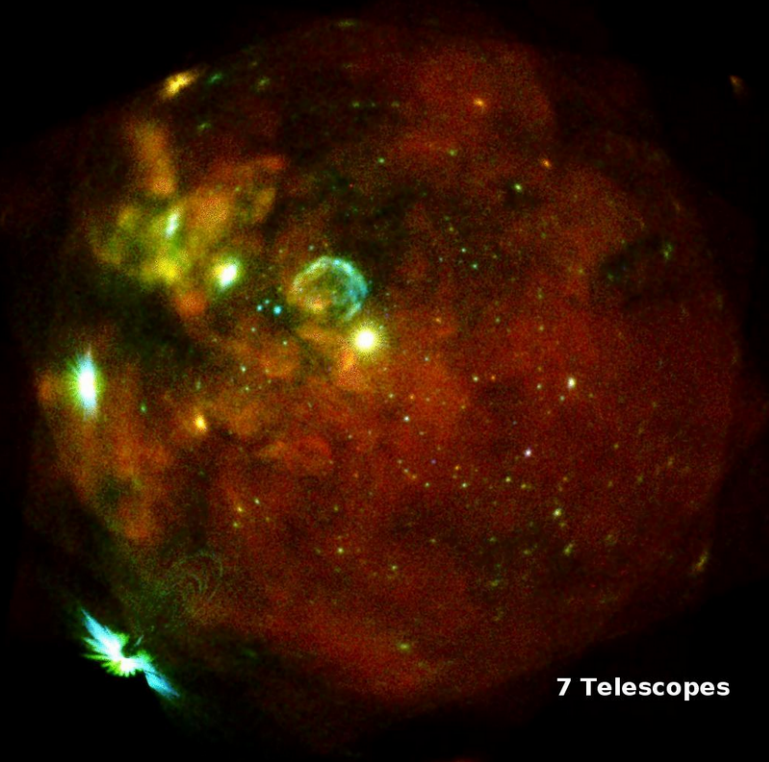
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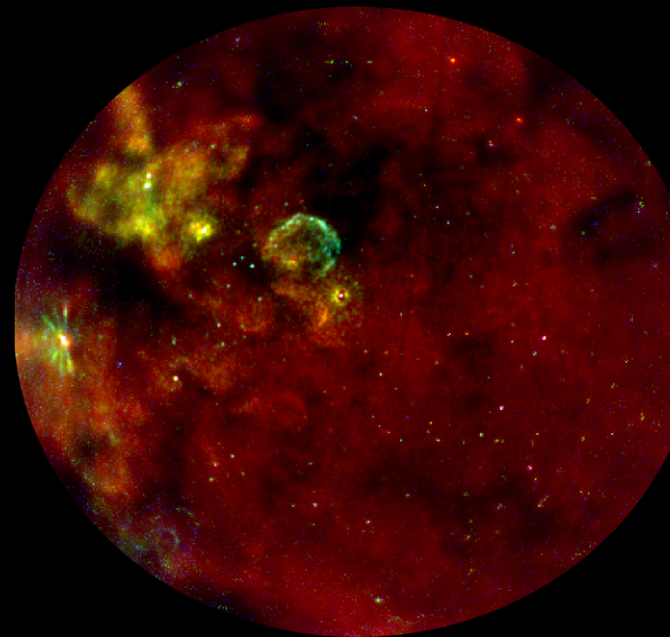
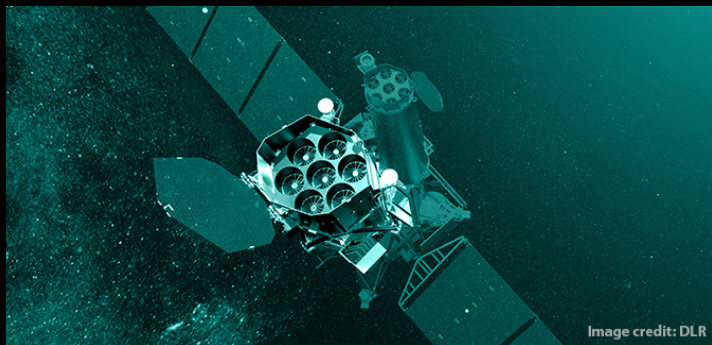
Patched Interpolated Convolution

Bayesian Imaging
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Eberle, Guardiani, Westerkamp et al 2024 in preparation



Generative Models for Bayesian Imaging



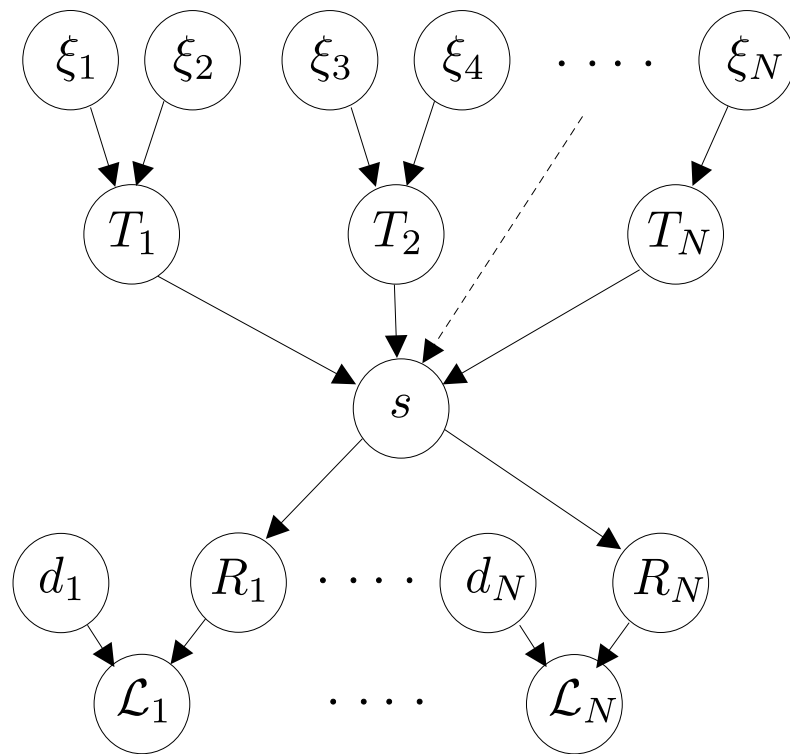
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$$\mathcal{P}(s|d) \propto \mathcal{P}(d|s)\mathcal{P}(s)$$



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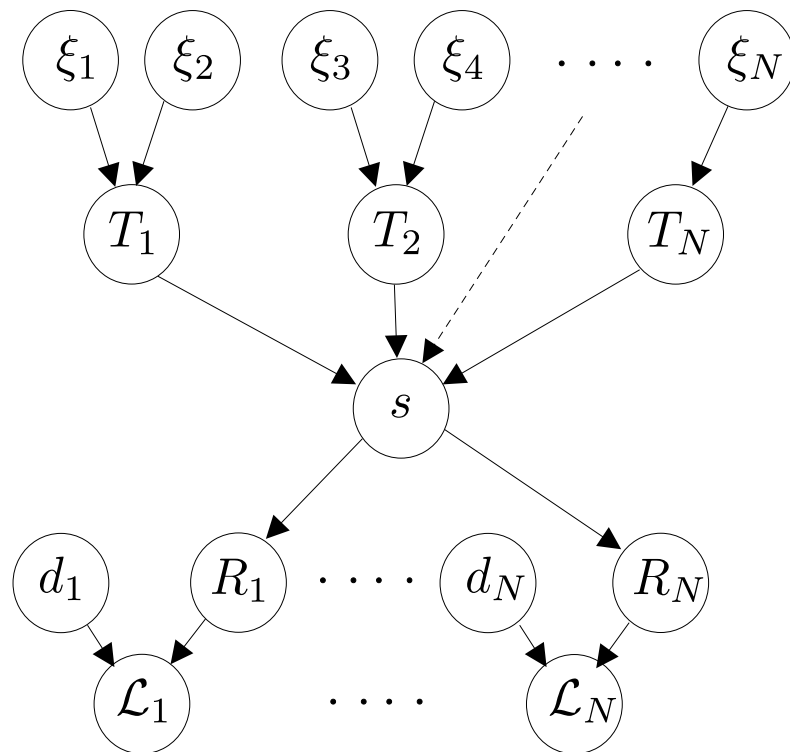


Generative Models for Bayesian Imaging

Framework: Numerical Information Field Theory

<https://github.com/NIFTy-PPL/NIFTy>

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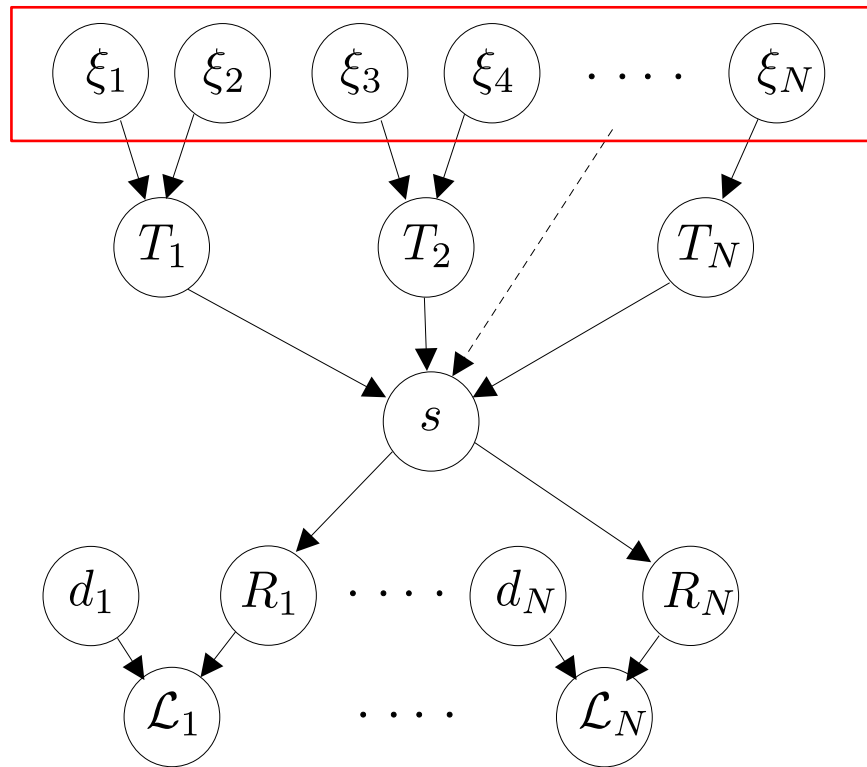
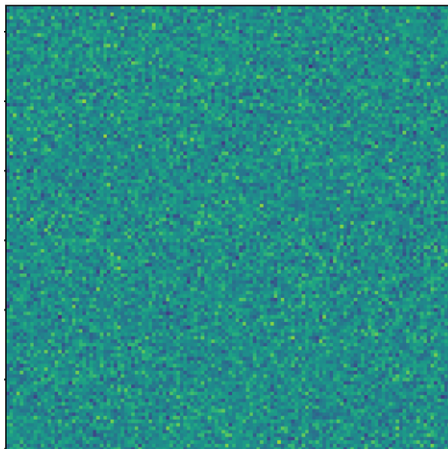


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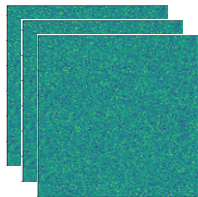




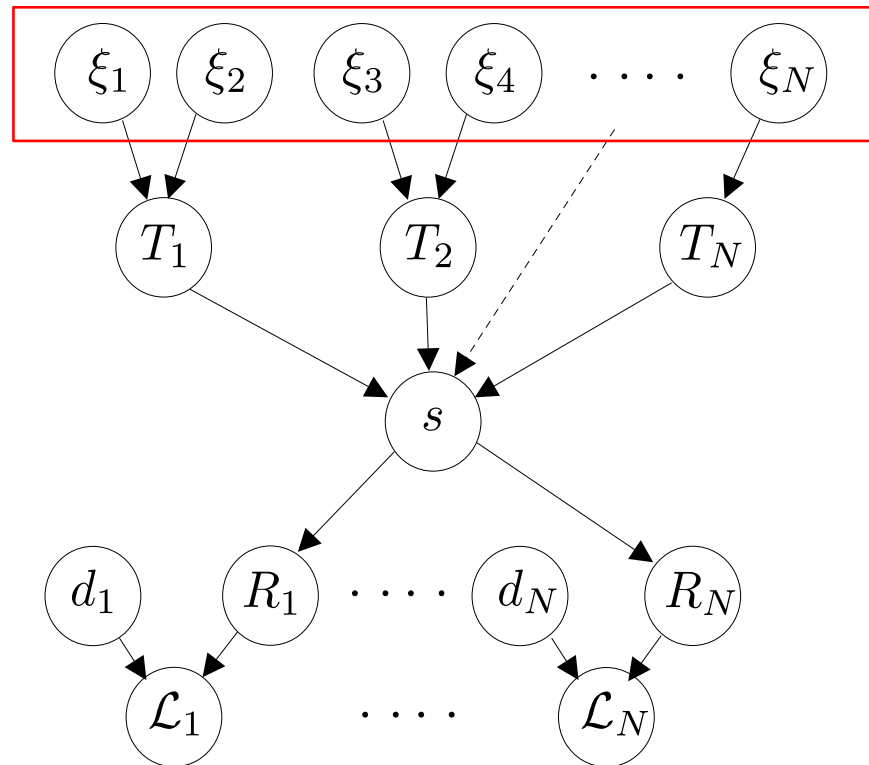
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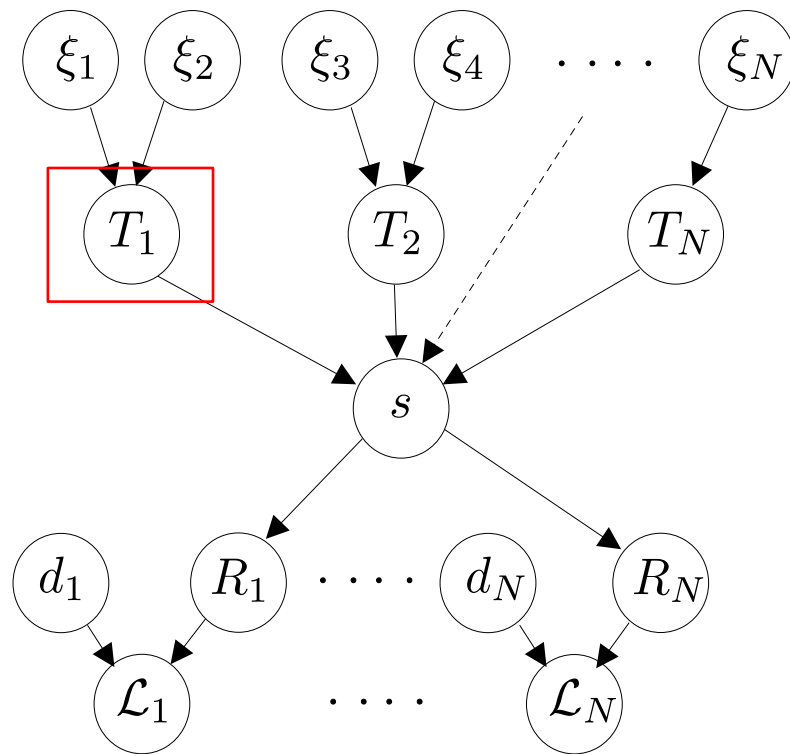
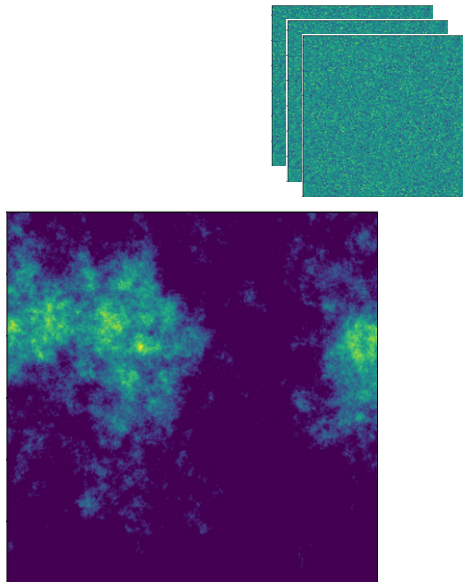


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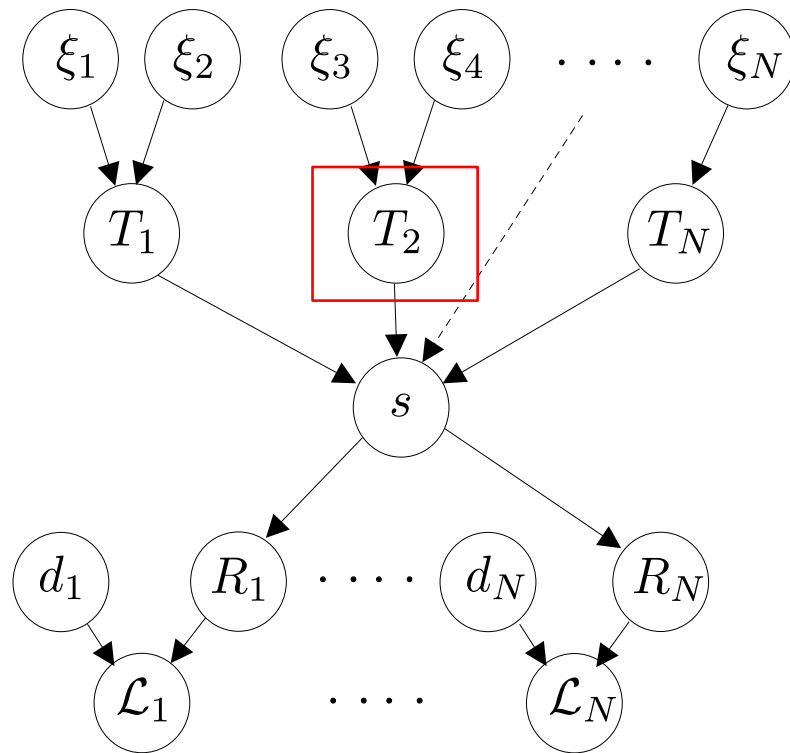
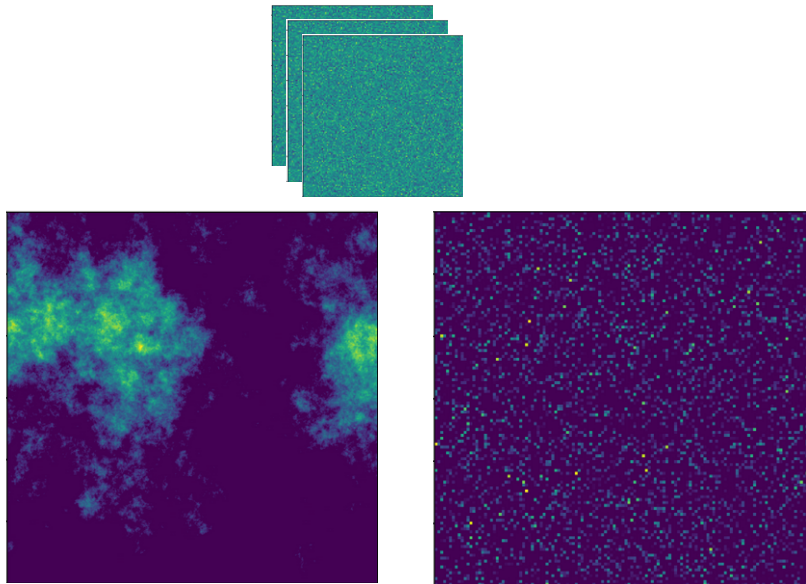


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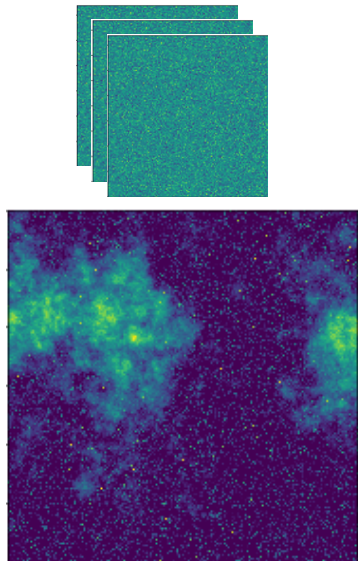




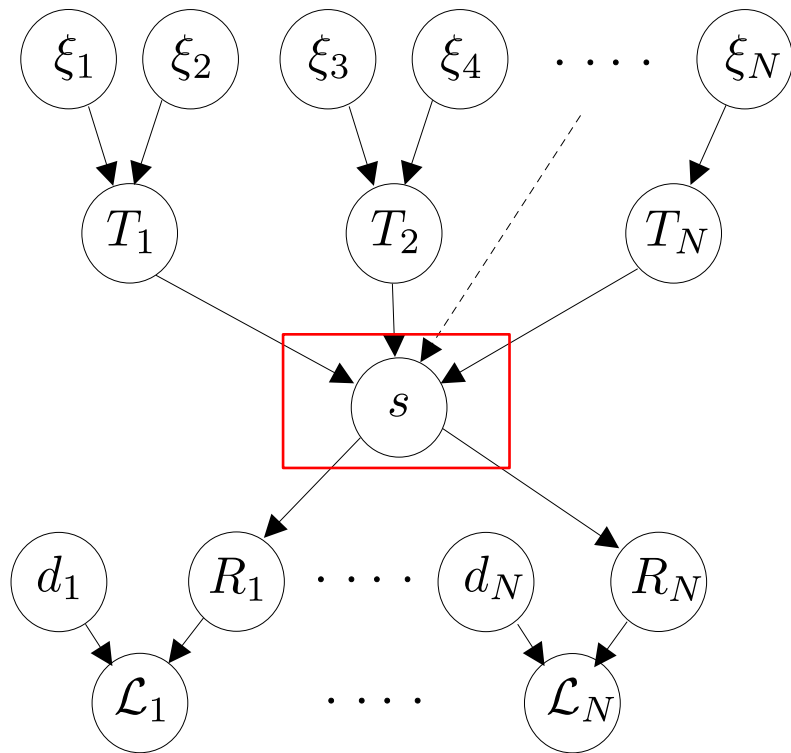
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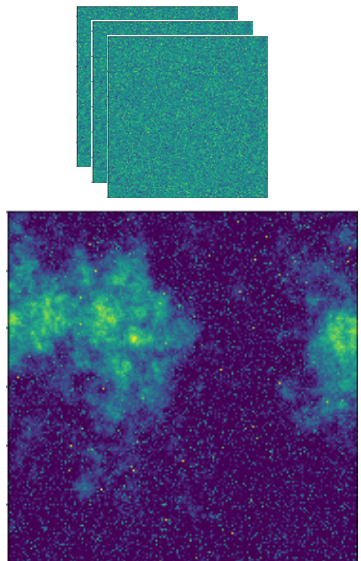




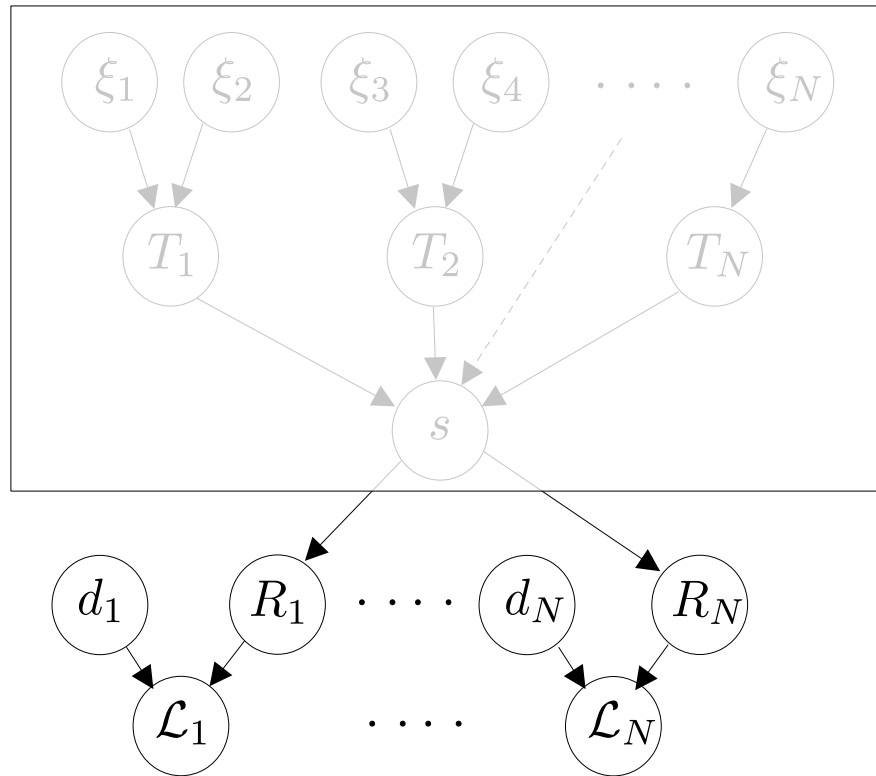
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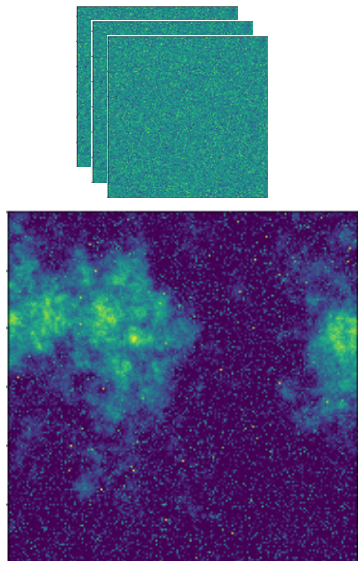




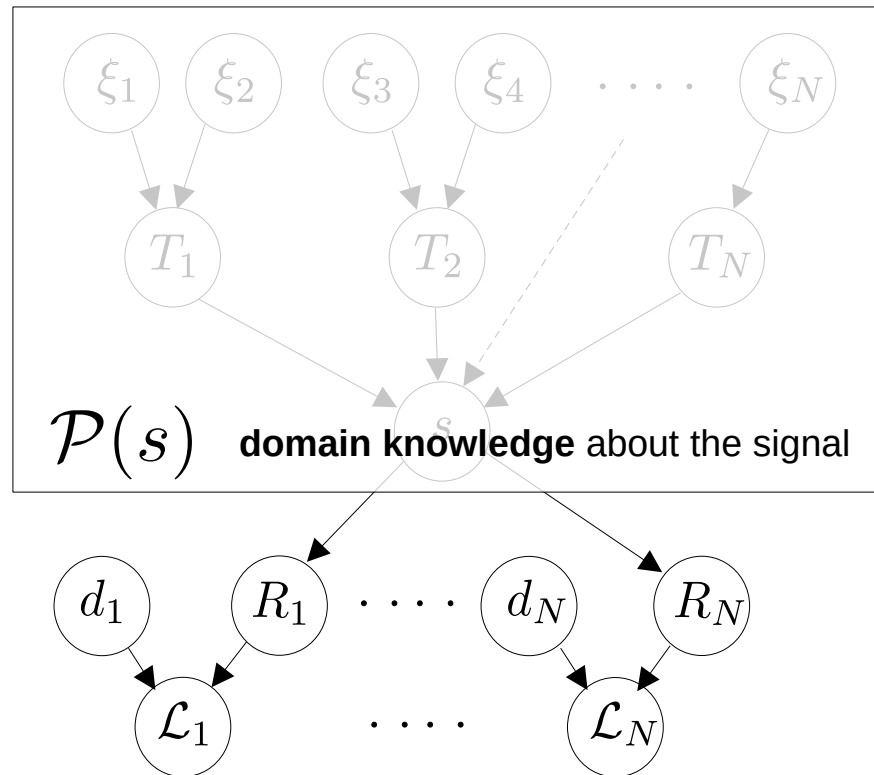
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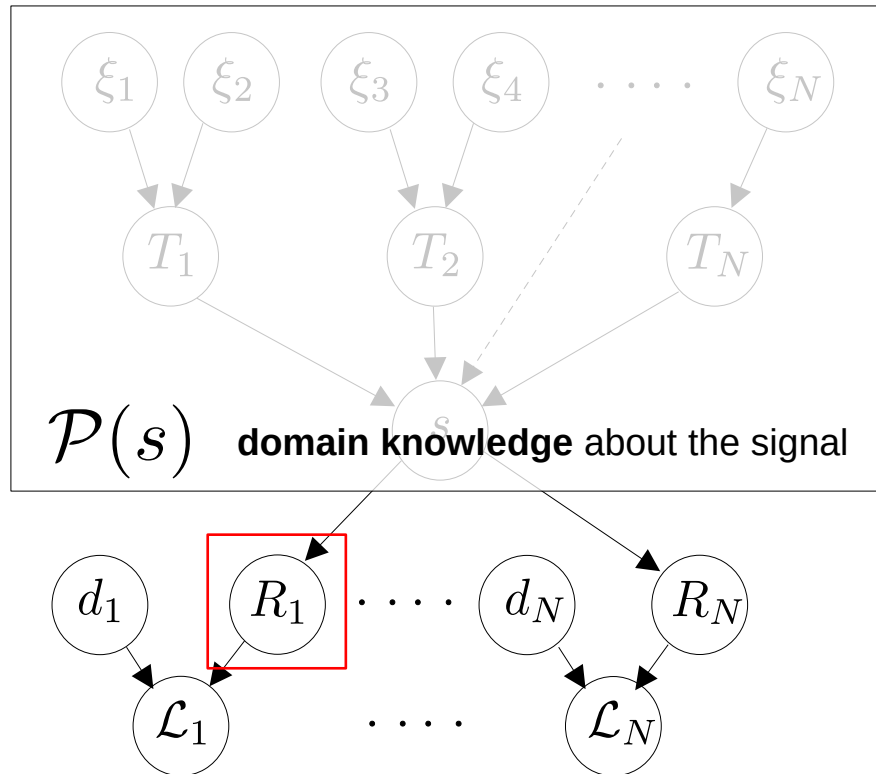
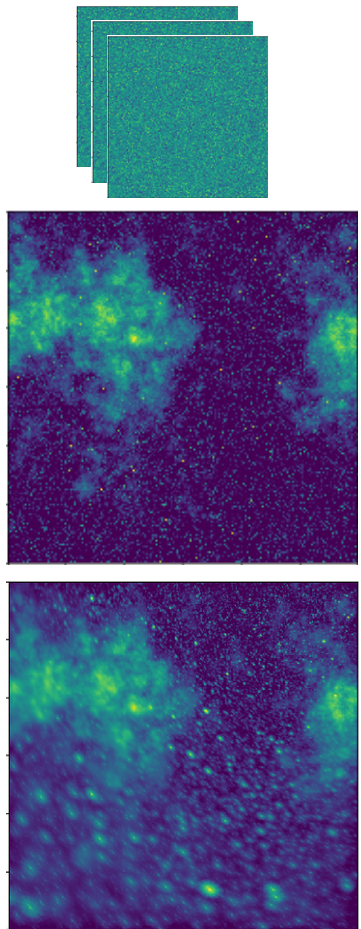


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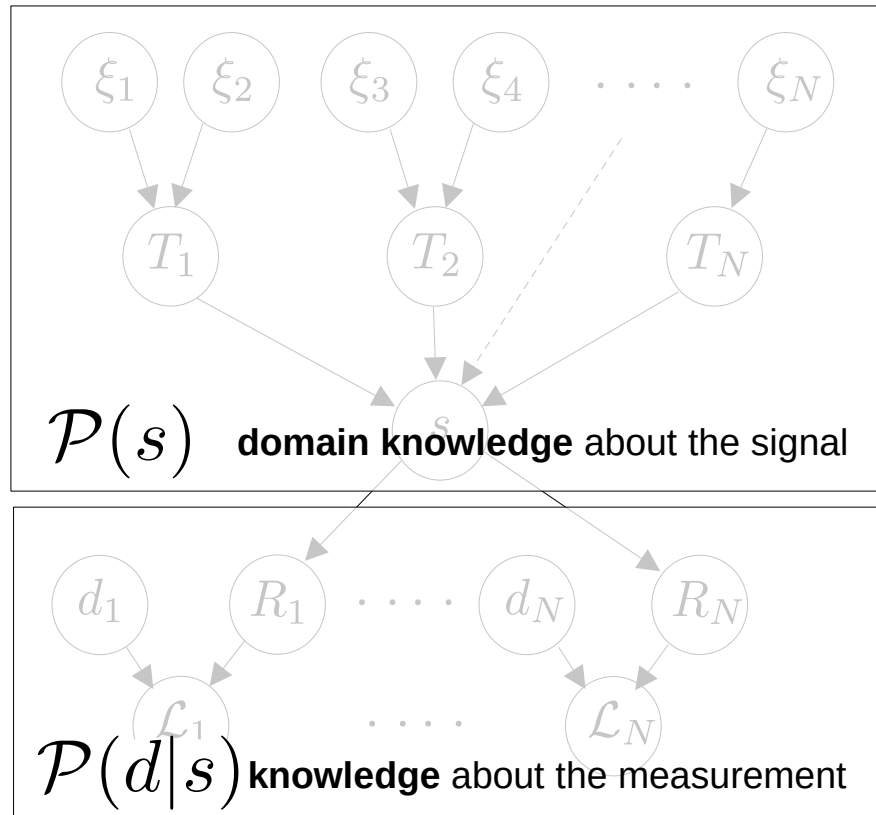
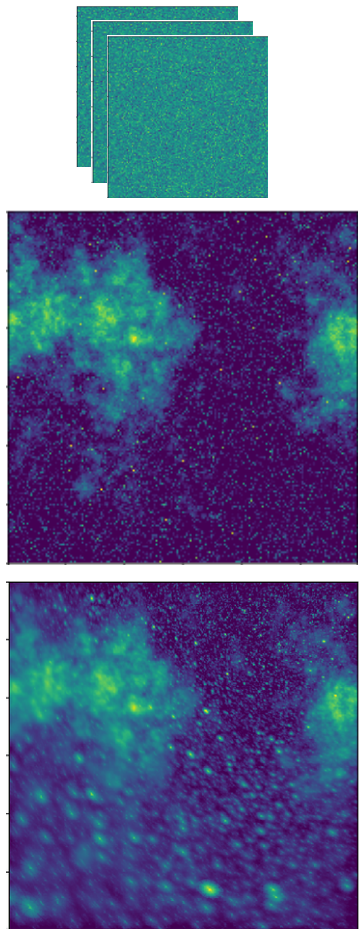


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Spatially Variant PSF

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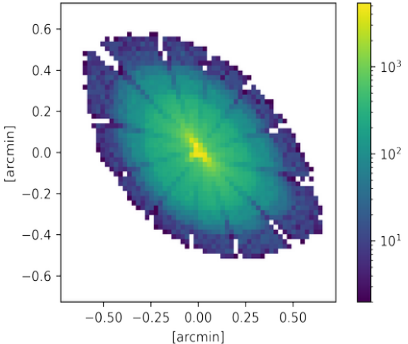
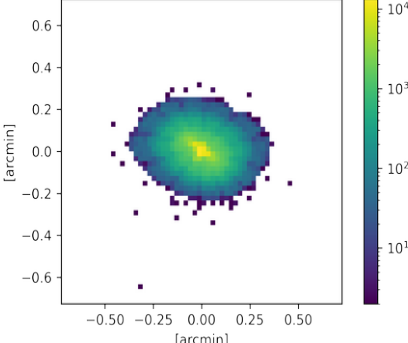
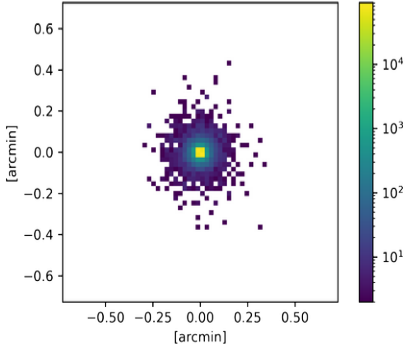
Patched Interpolated Convolution

[Nagy, James G., and Dianne P. O'Leary. "Fast iterative image restoration with a spatially varying PSF." Advanced Signal Processing: Algorithms, Architectures, and Implementations VII. Vol. 3162. SPIE, 1997.]

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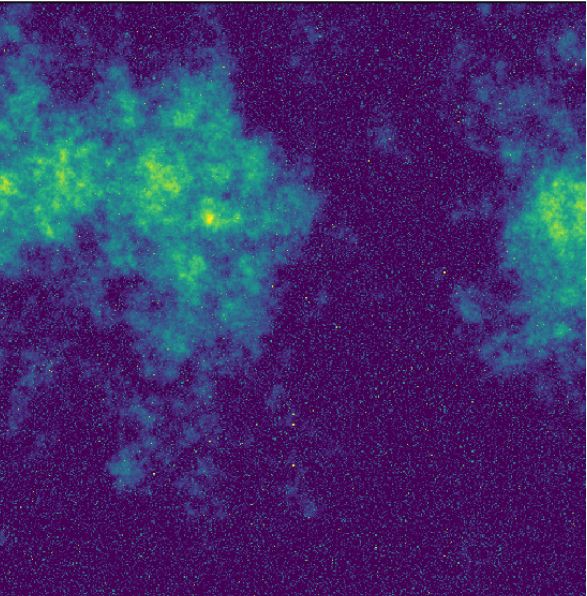


Simulated with marx

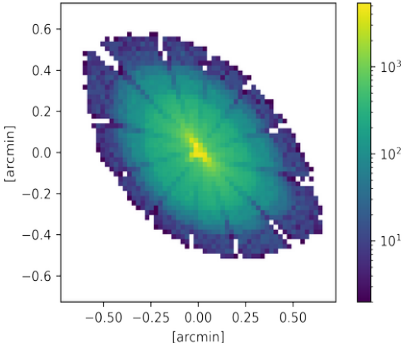
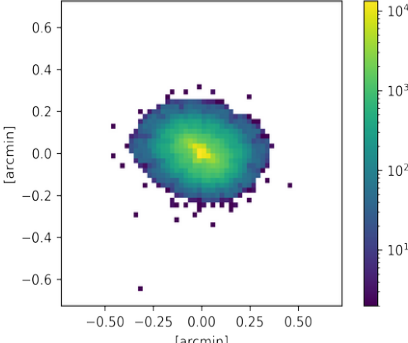
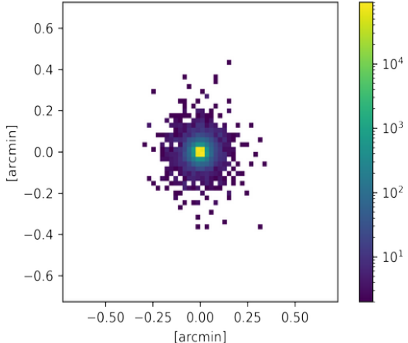
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X-ray Sky

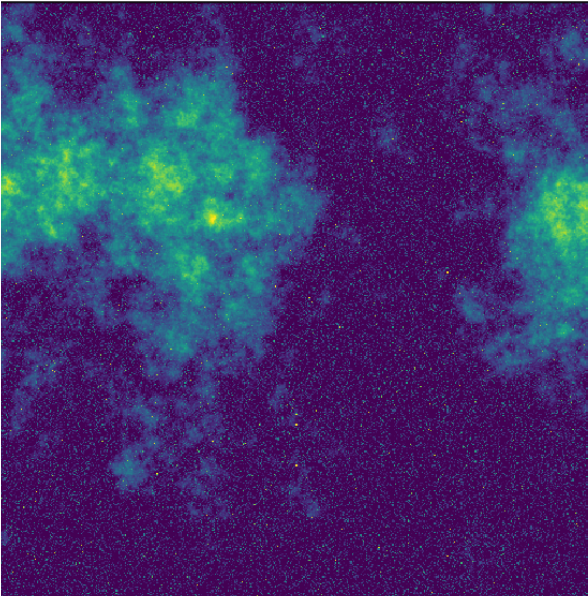


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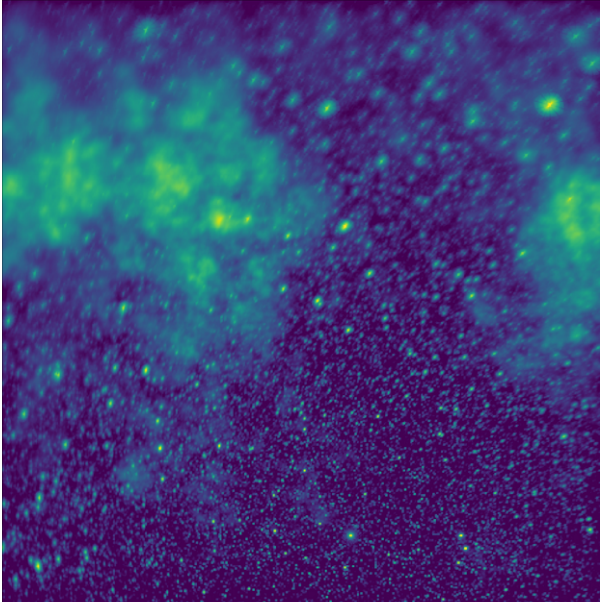
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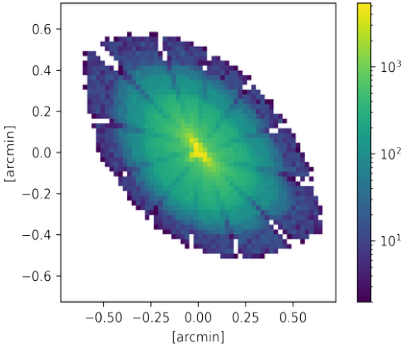
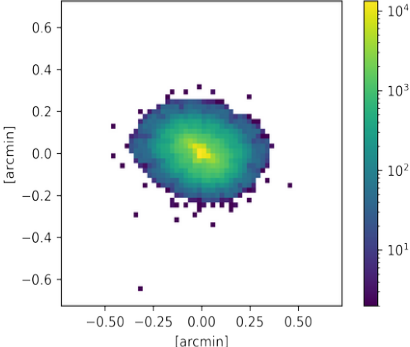
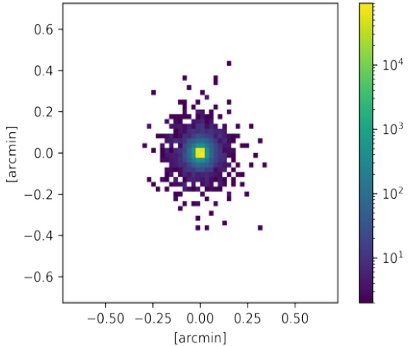
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Observed by Chandra

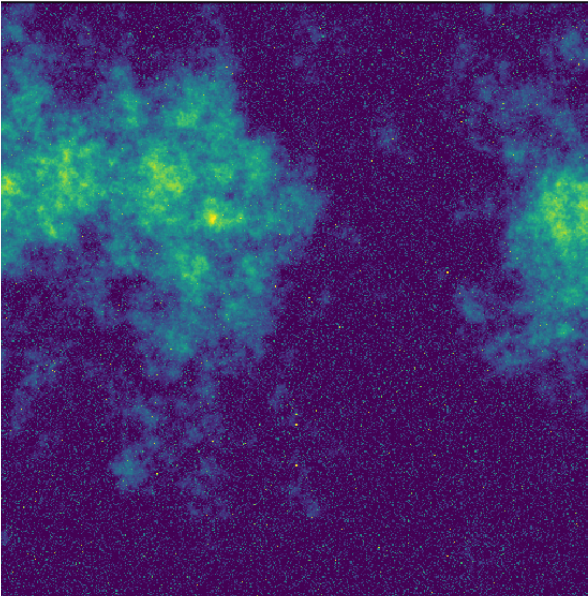


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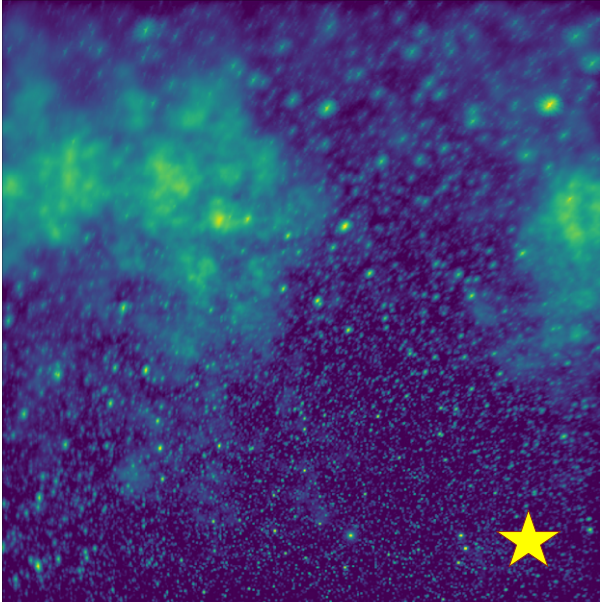
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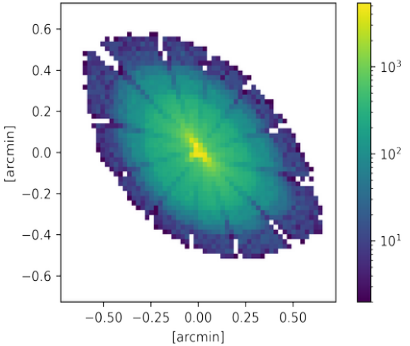
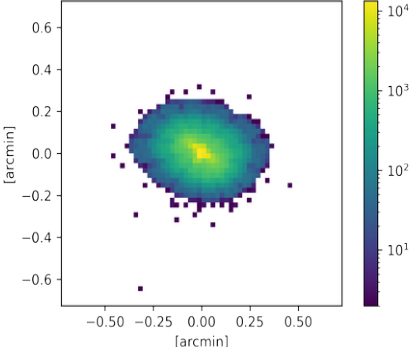
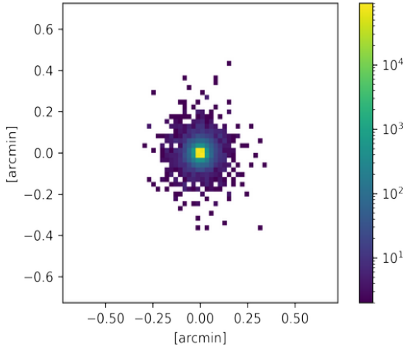
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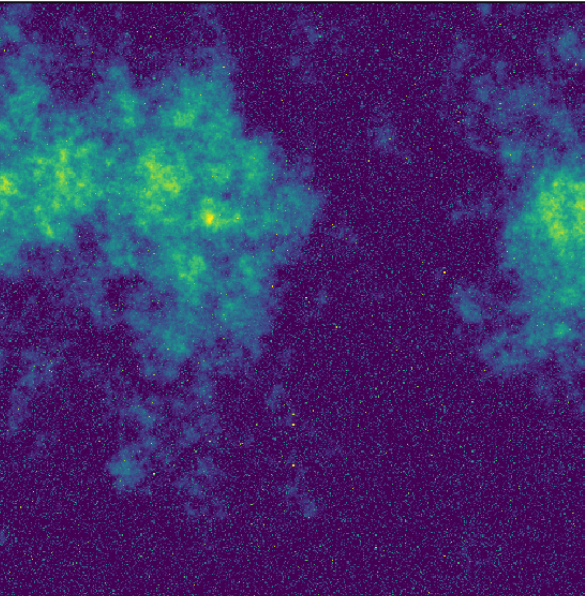


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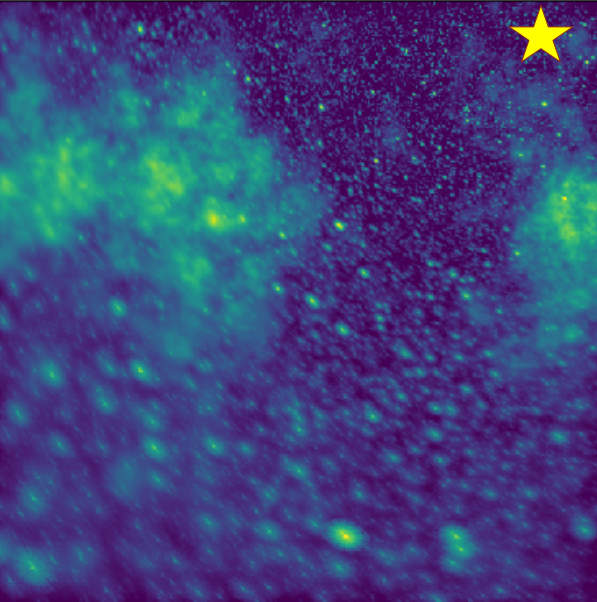
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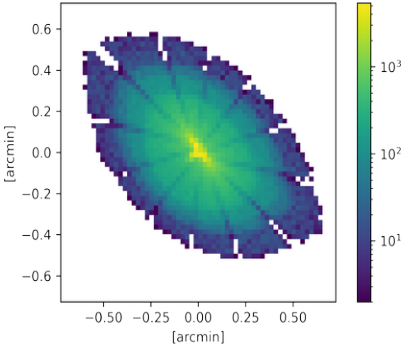
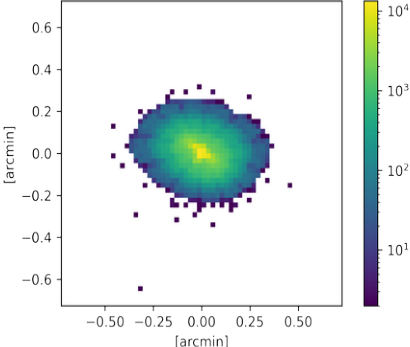
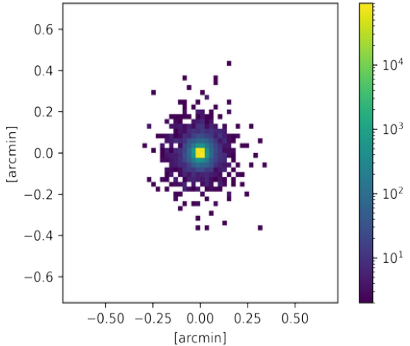
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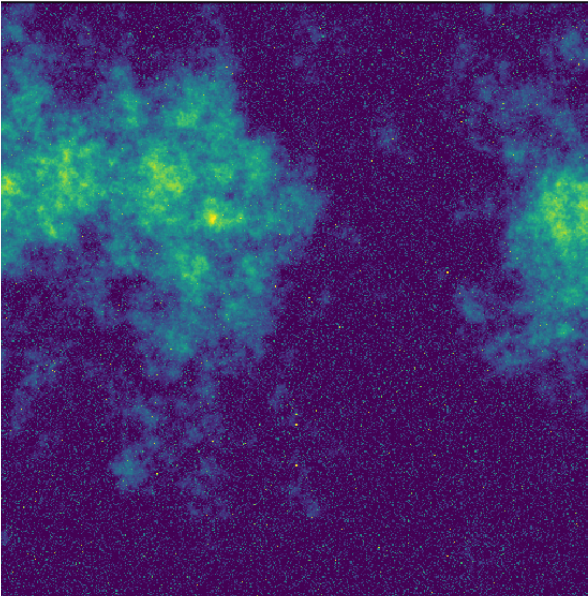


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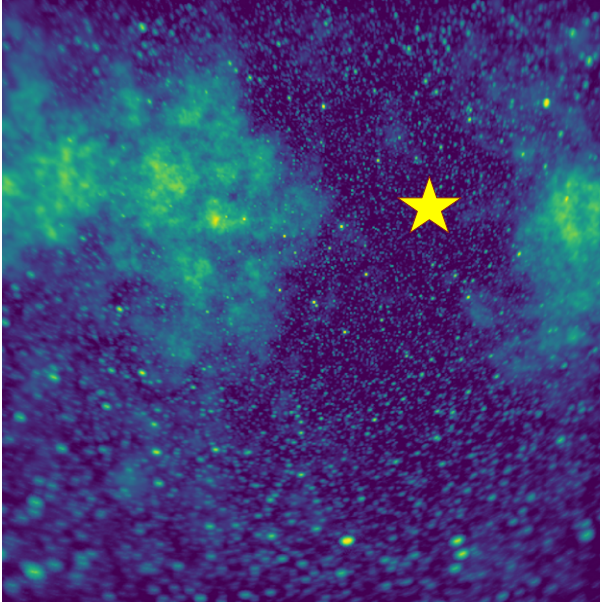
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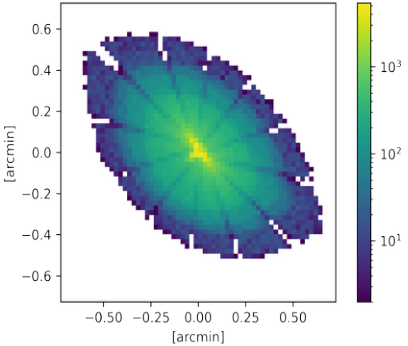
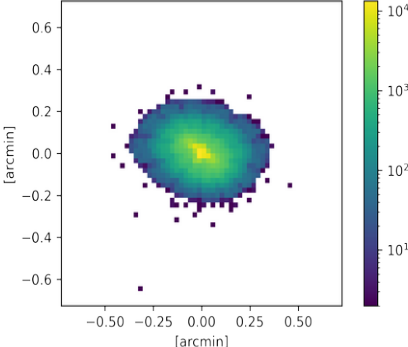
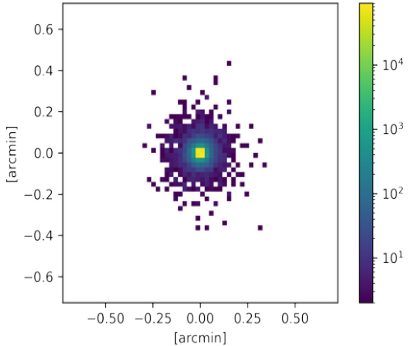
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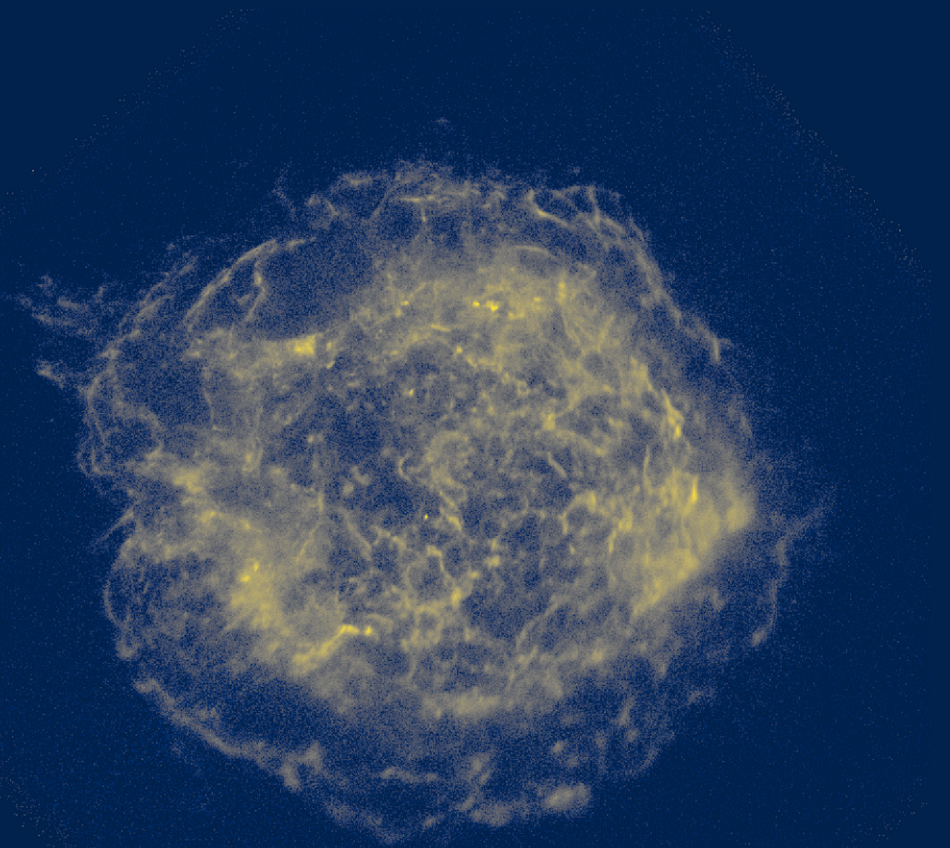


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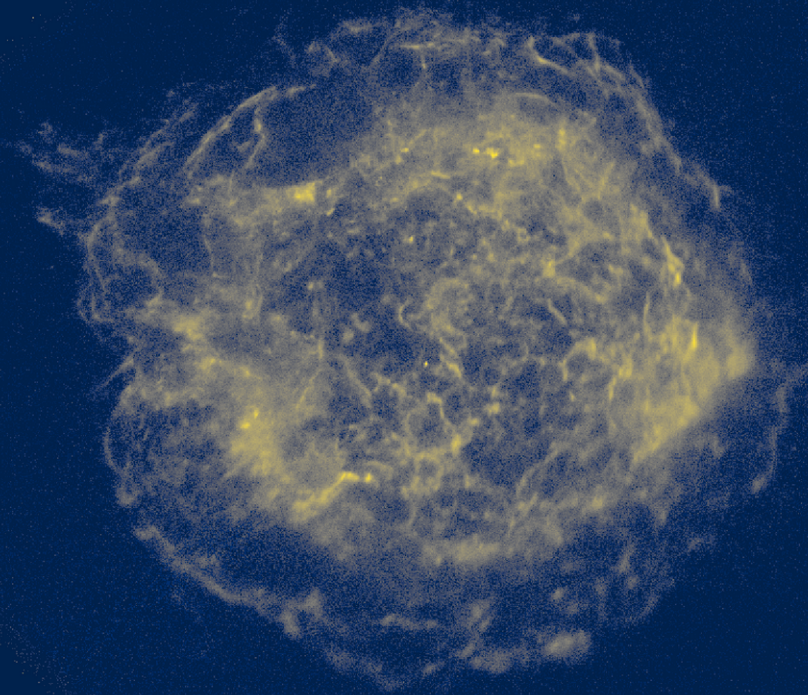
Cassiopeia A



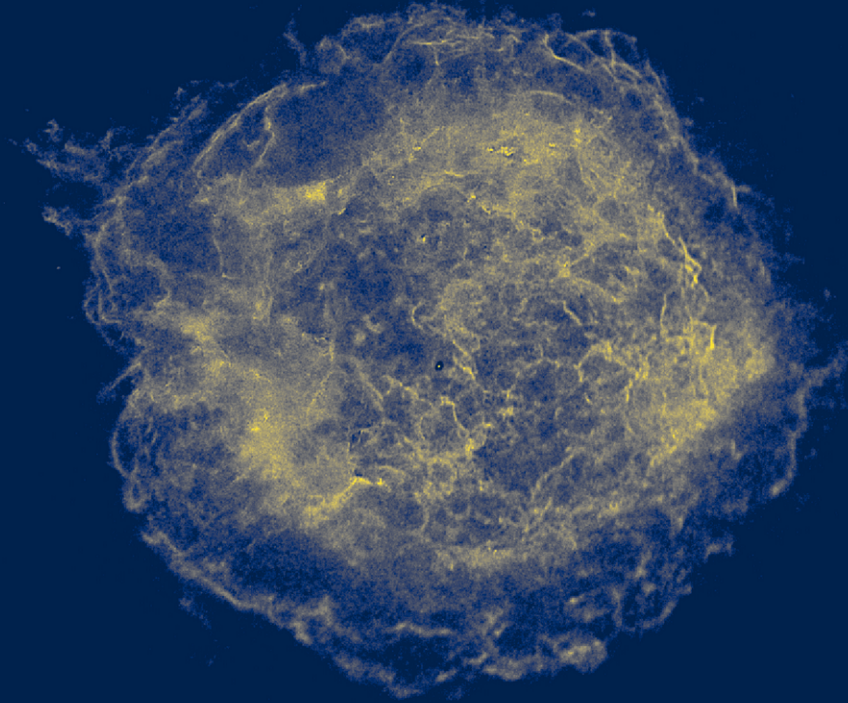
Data

Cassiopeia A

[Eberle et al. 2024] in preparation



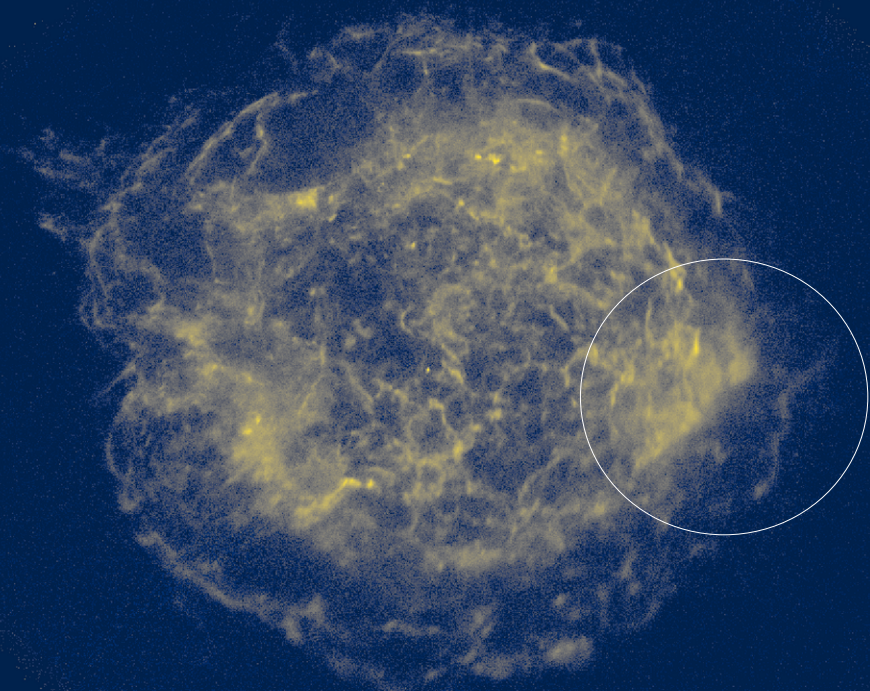
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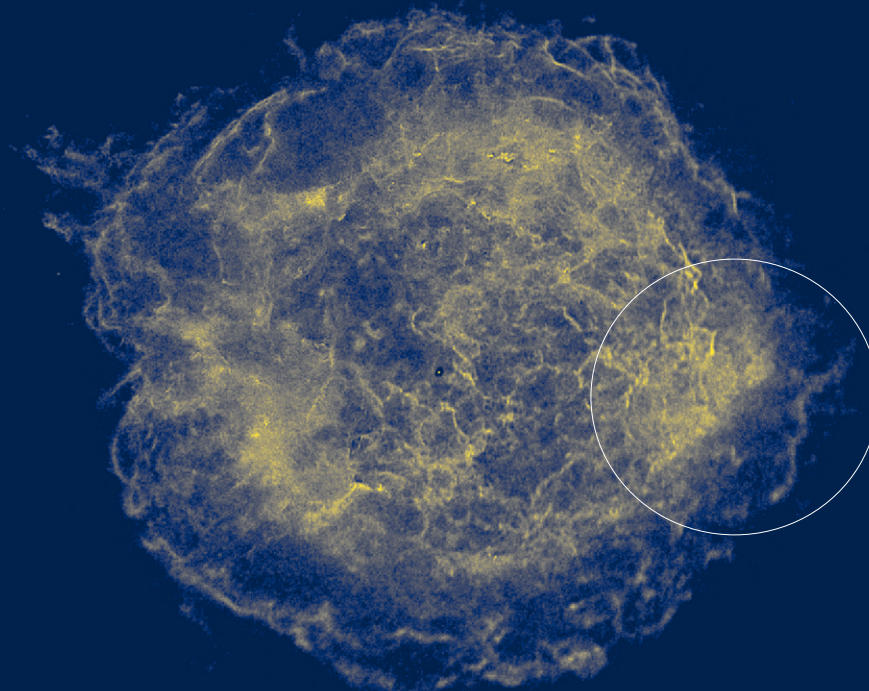
Reconstruction

Cassiopeia A

[Eberle et al. 2024] in preparation



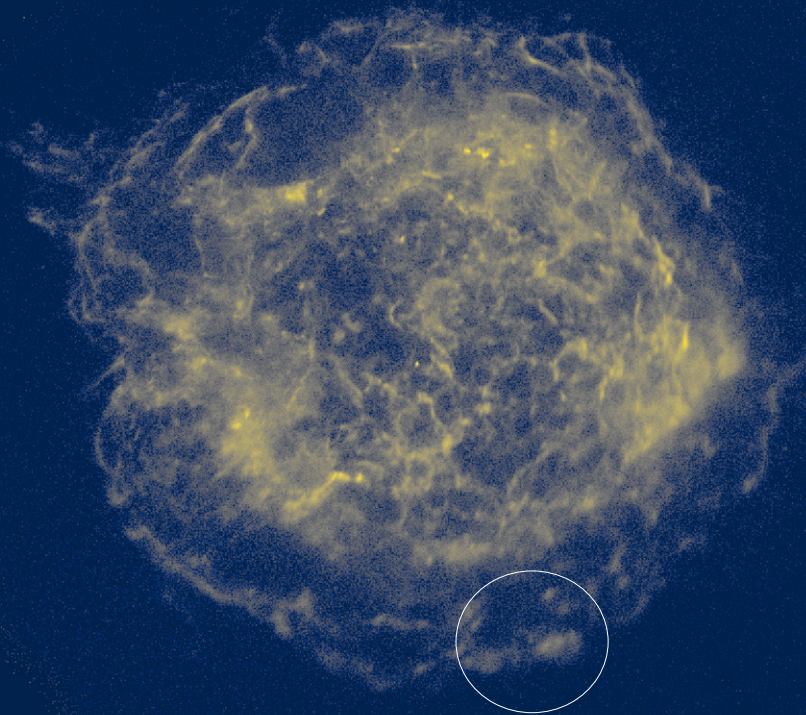
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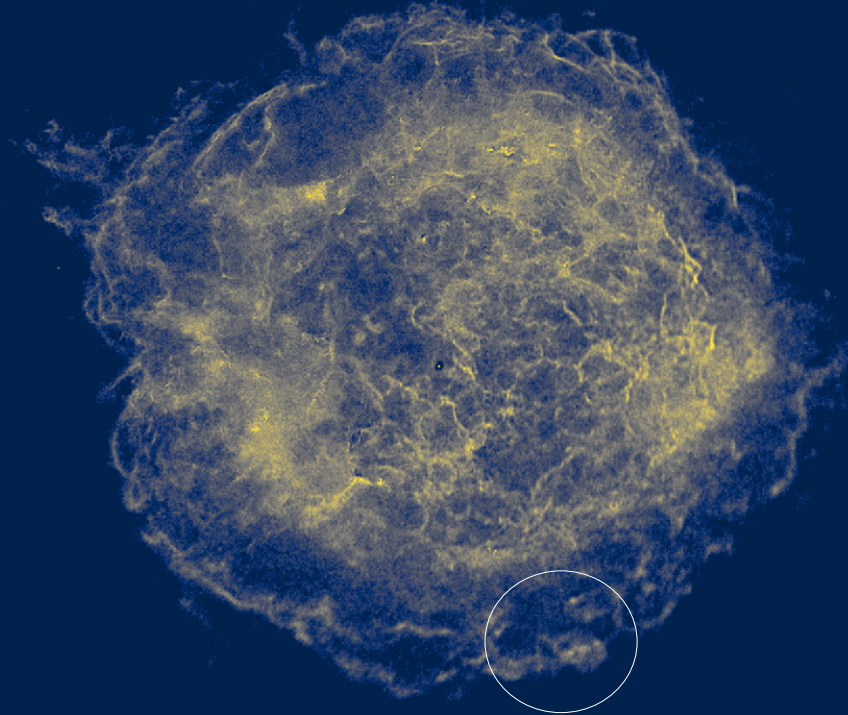
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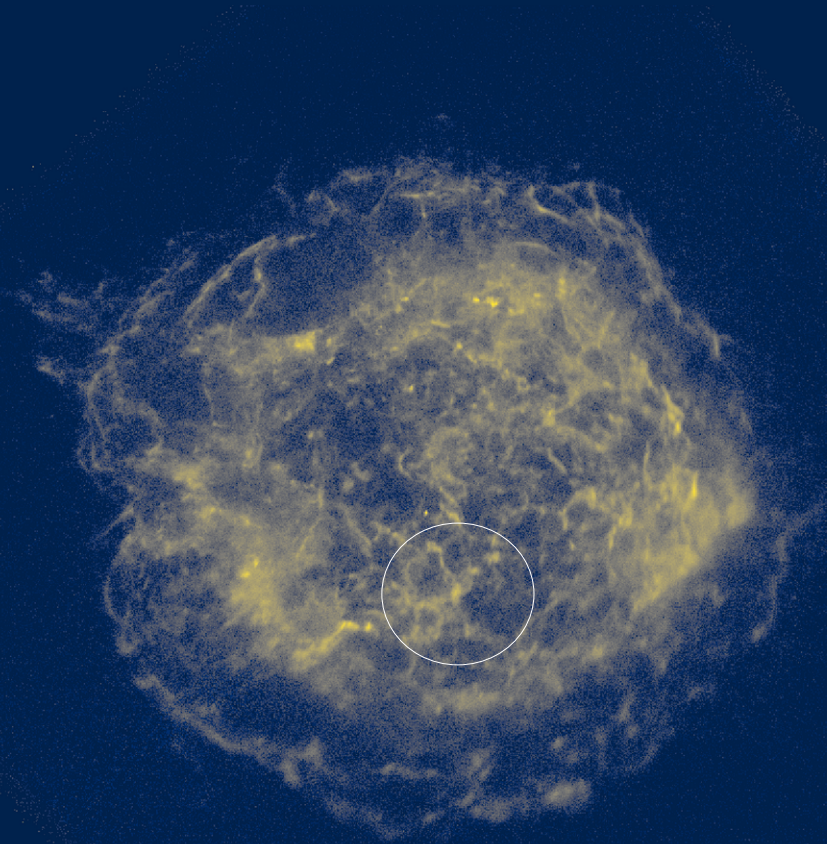
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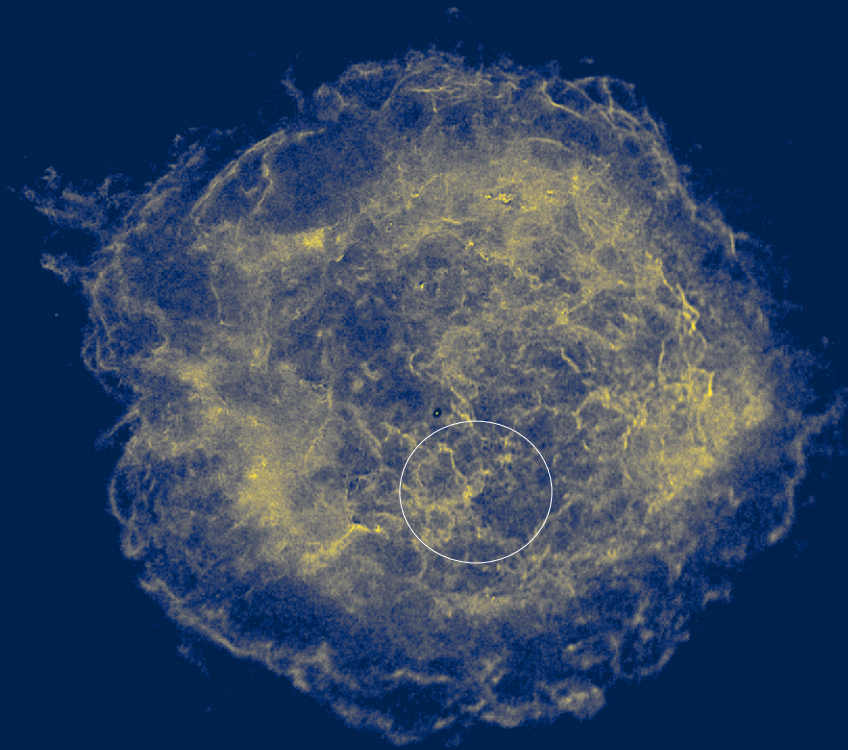
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Data



Reconstruction

Summary

- Removal of spatially variant PSF is possible, despite Poisson noise

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You want to know more about Bayesian Imaging, NIFTy or PSF Representation?

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Bayesian Imaging of the Spatio-Spectral X-Ray Sky
Margret Westerkamp - Tomorrow 9:40

Thank you for your attention!

YOUR FUTURE IS HARD TO SEE.
I CAN MAKE OUT SOME HAZY
DETAILS IN THE CENTER, BUT
THE OFF-AXIS COMPONENTS
ARE PARTICULARLY UNCLEAR.



WIZARDS NEVER DID FIGURE OUT
HOW TO FIX SPHERICAL ABERRATION.

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