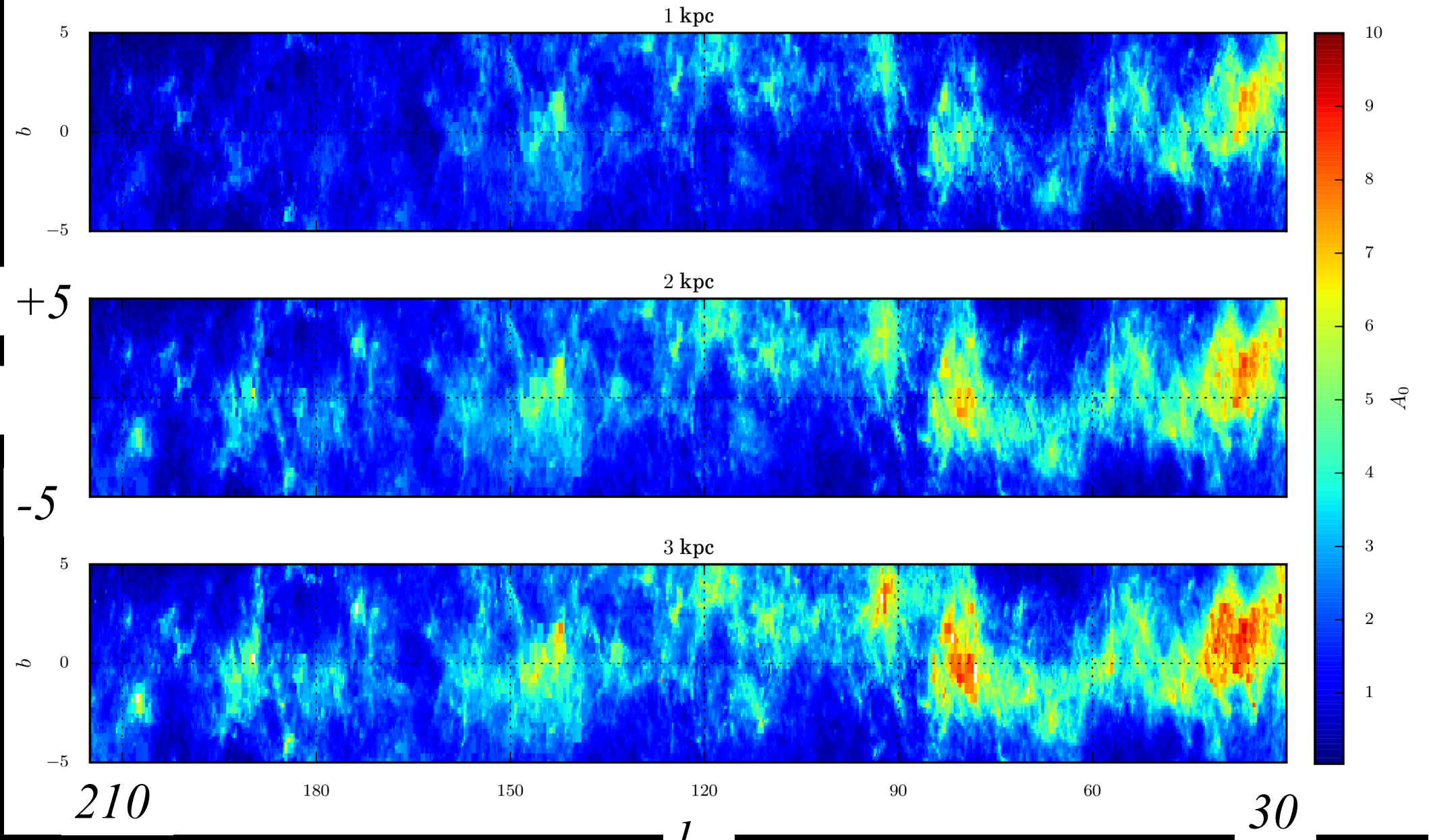
Three-dimensional extinction mapping using Gaussian random fields

Stuart Sale

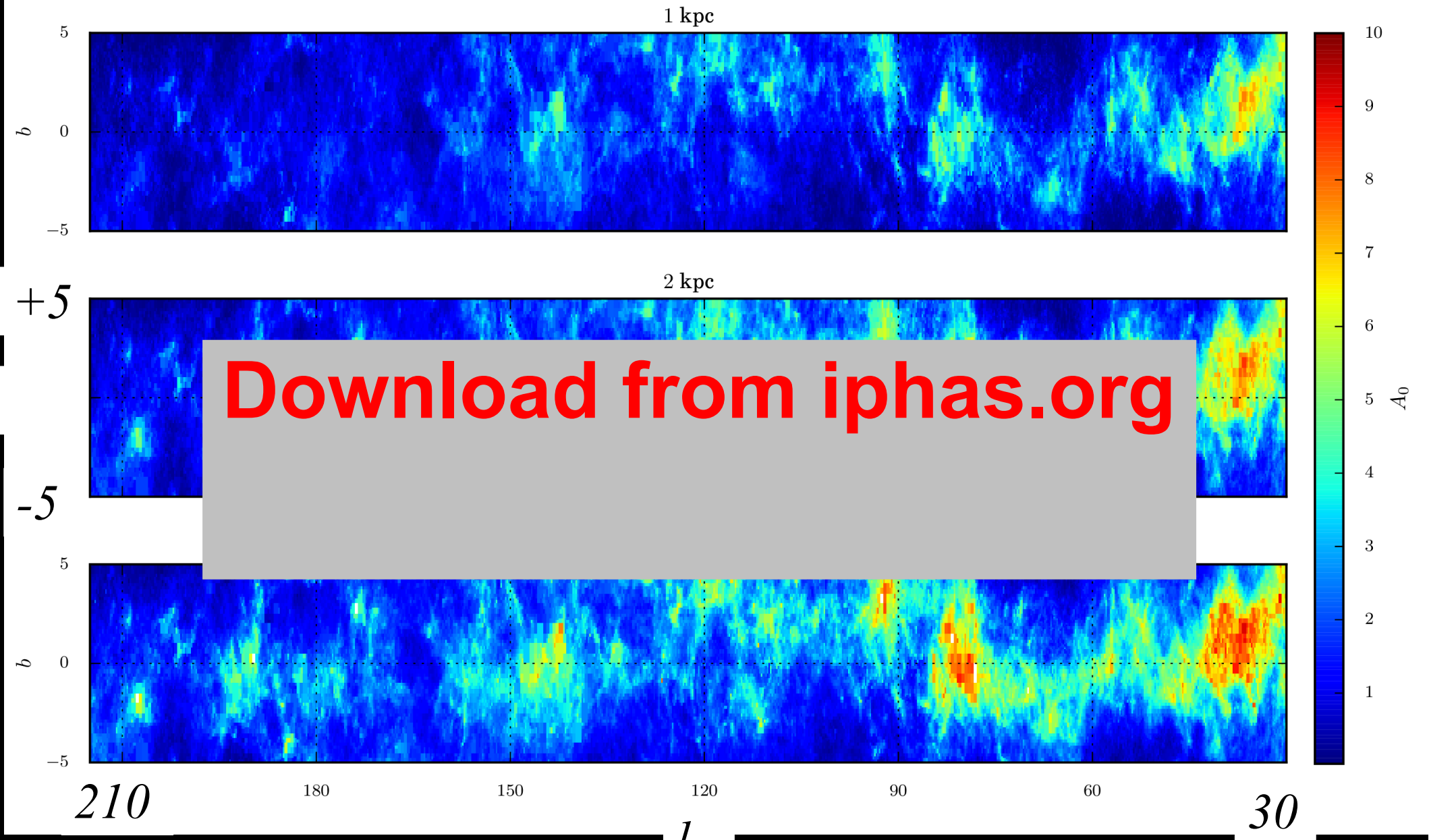
+ John Magorrian, Janet Drew, Geert Barentsen, Hywel Farnhill, IPHAS consortium

UNIVERSITY OF OXFORD

Sale et al. (2014)



Sale et al. (2014)



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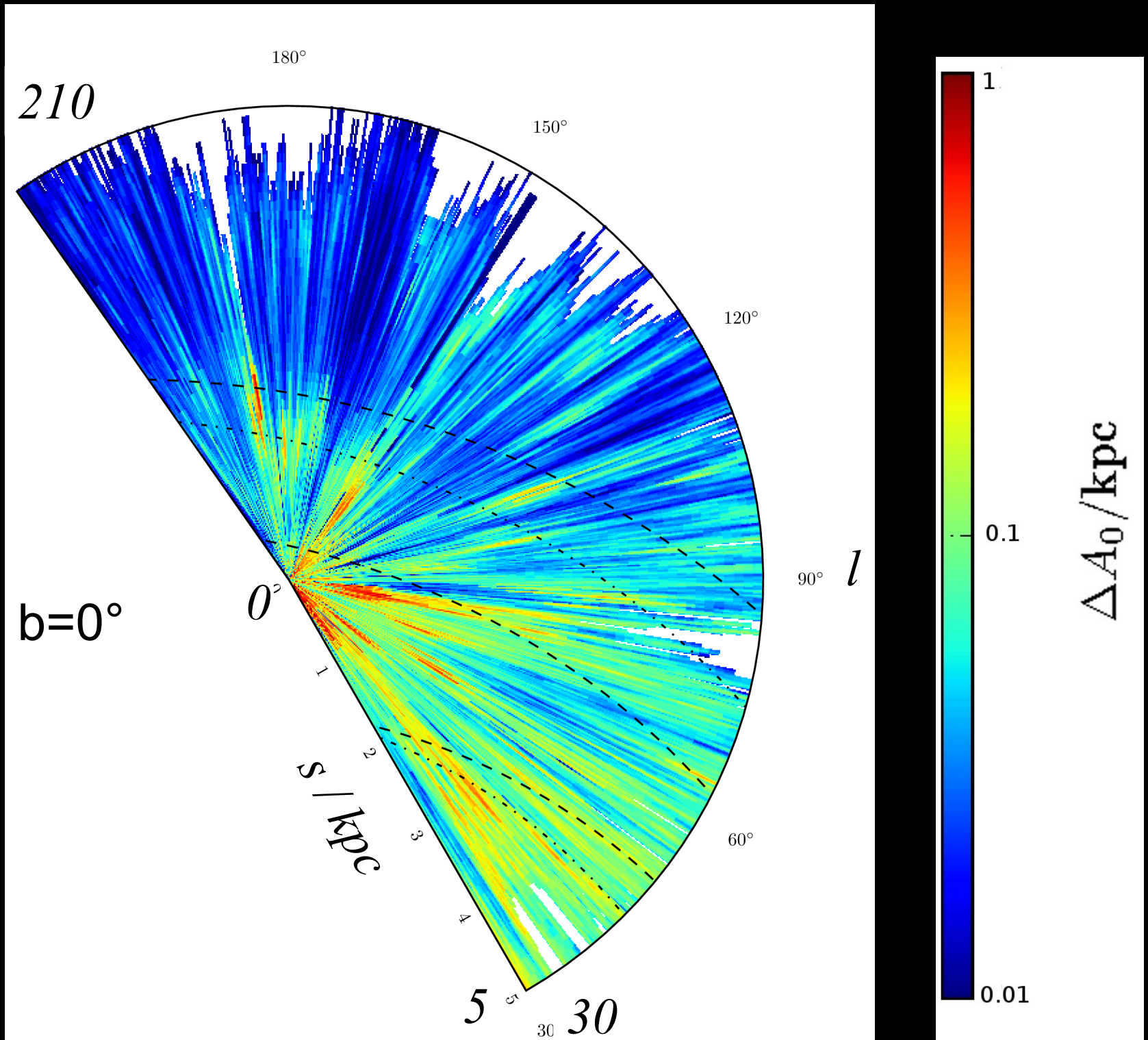
180°
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5
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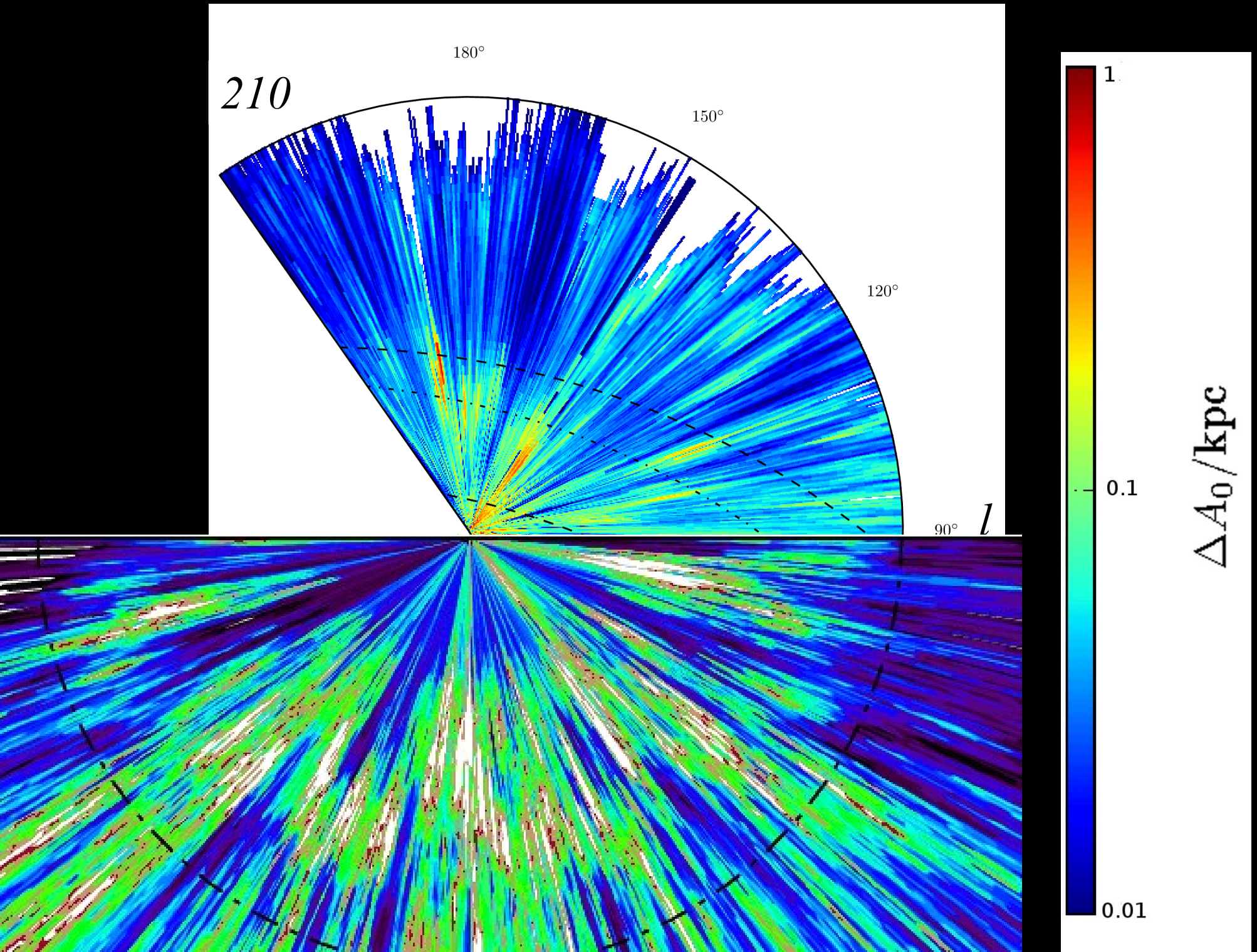
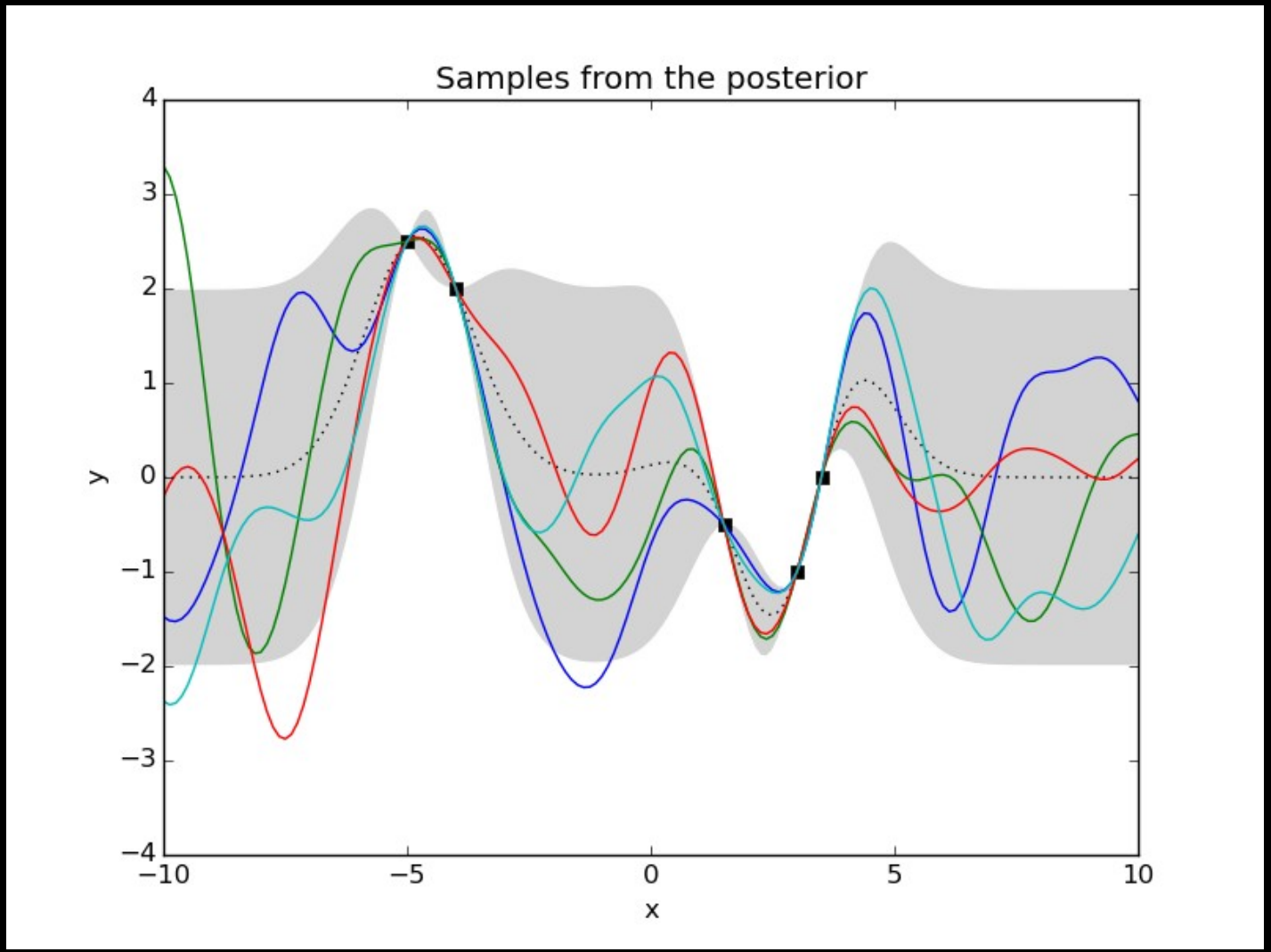
ΔA_0 / kpc


210
180°
150°
120°
90°
l
1
0.1
0.01
ΔA_0 / kpc

The solution?

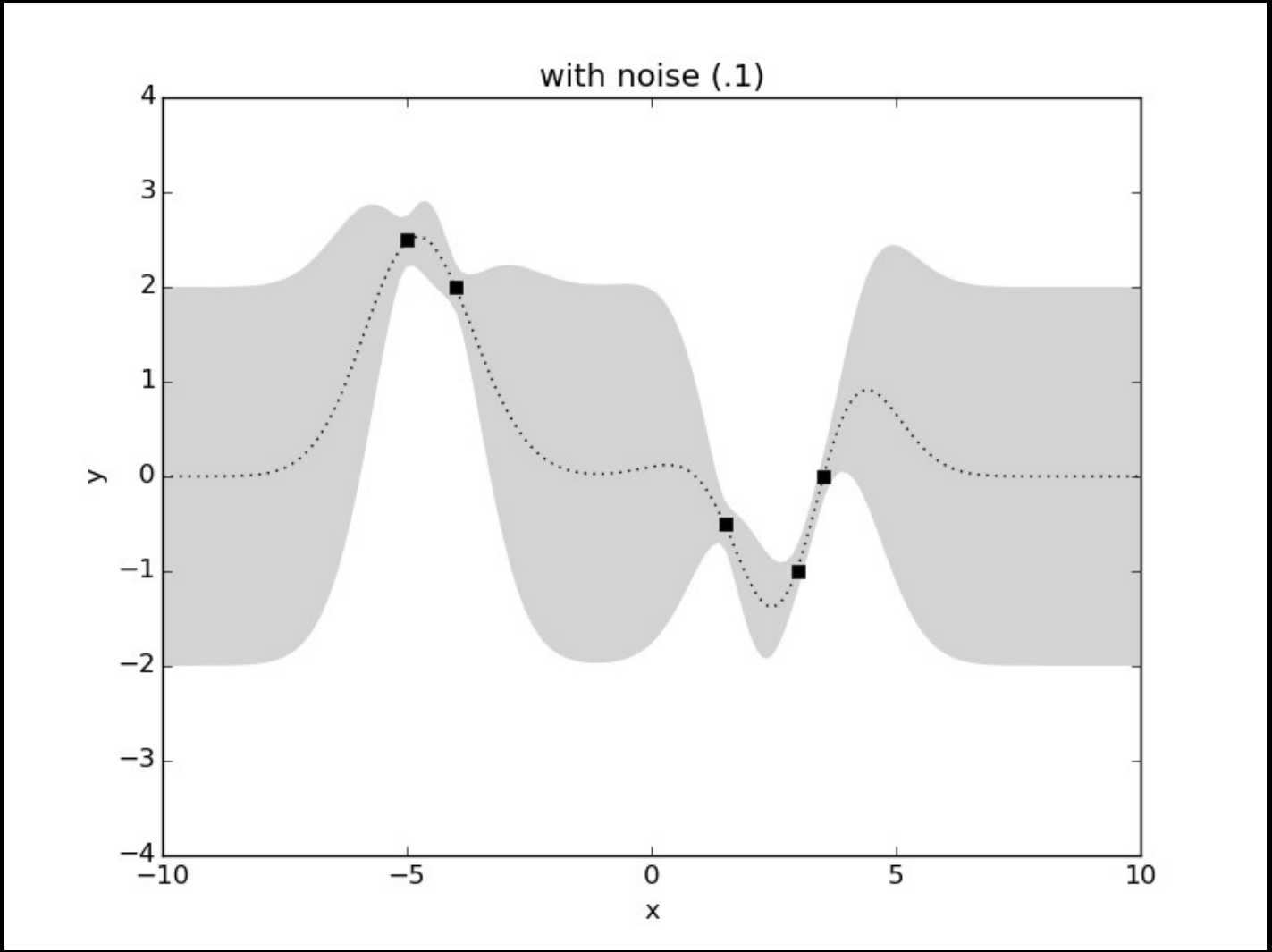
- Gaussian random fields
  - Gaussian processes in 2D or 3D space
- Continuously varying
  - Different values at every point
  - Limit of infinitely many infinitely small bins
- Value at one point correlated with values nearby

Gaussian Processes



Gaussian Processes

- Then add noise to data



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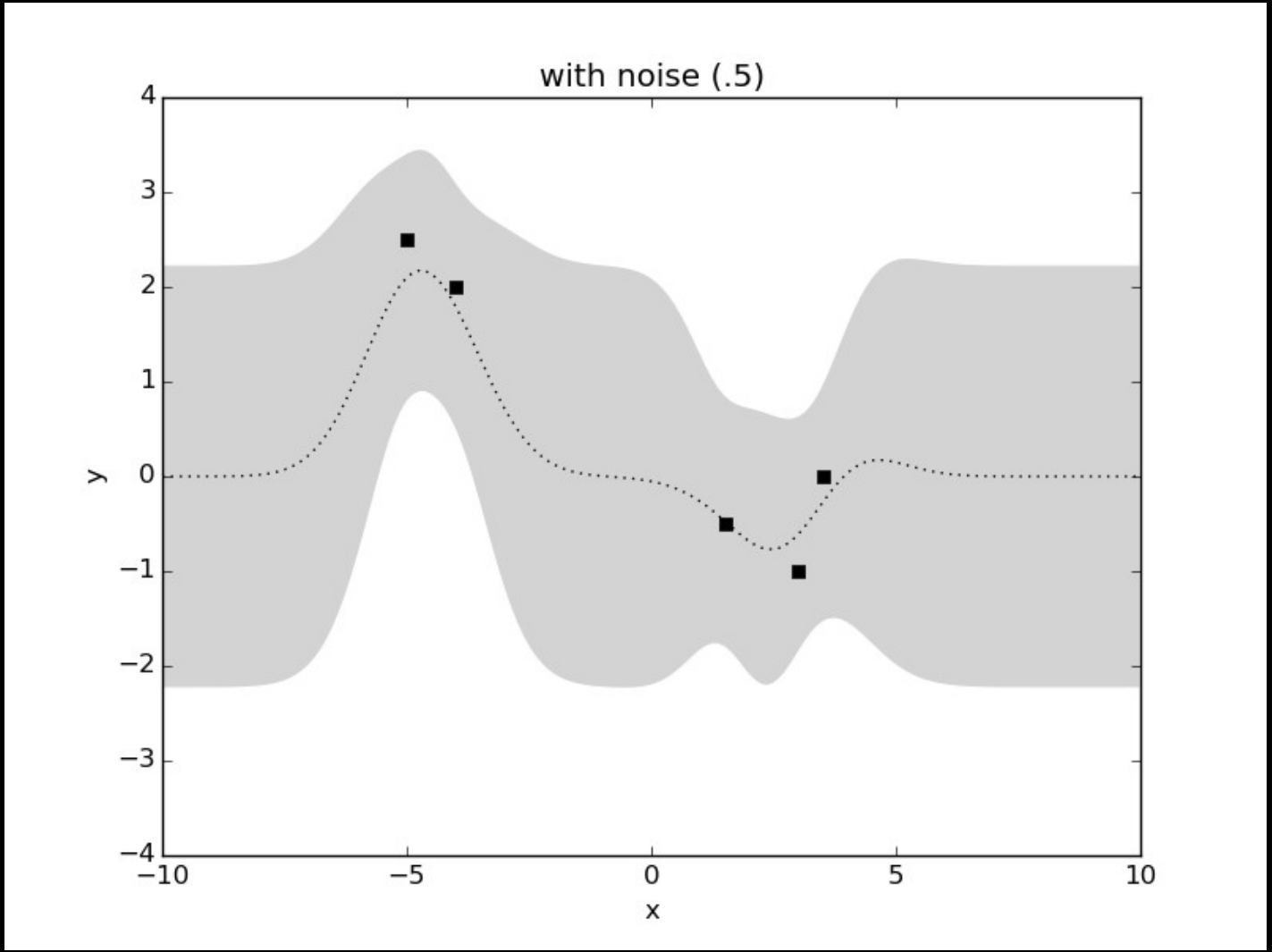
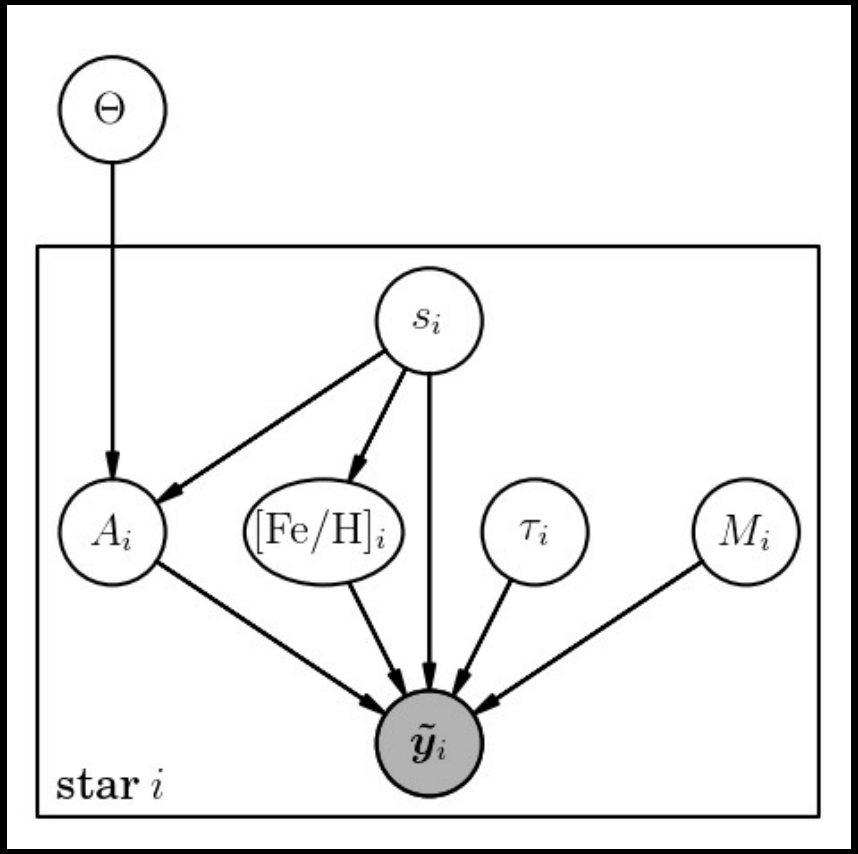


- Want to find p(***s***, ***A***, Θ | ***y***)
- p(***A*** | ***s***, Θ) is the GP
  p(***A*** | ***s***, Θ) ~ N(m(Θ) , C)
- Use MCMC to sample



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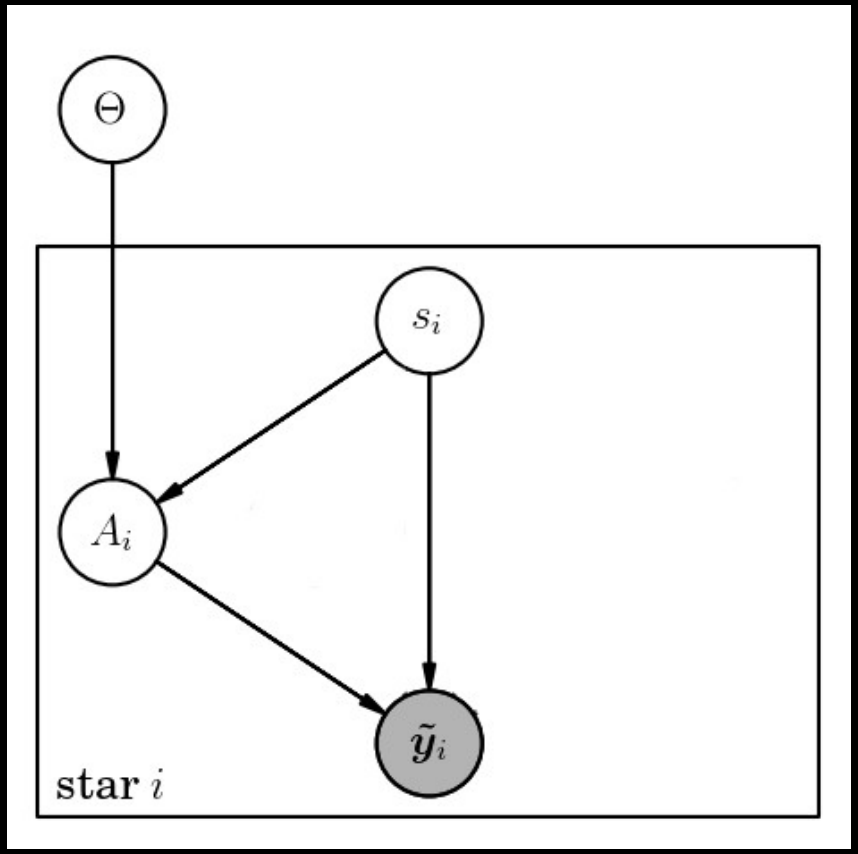
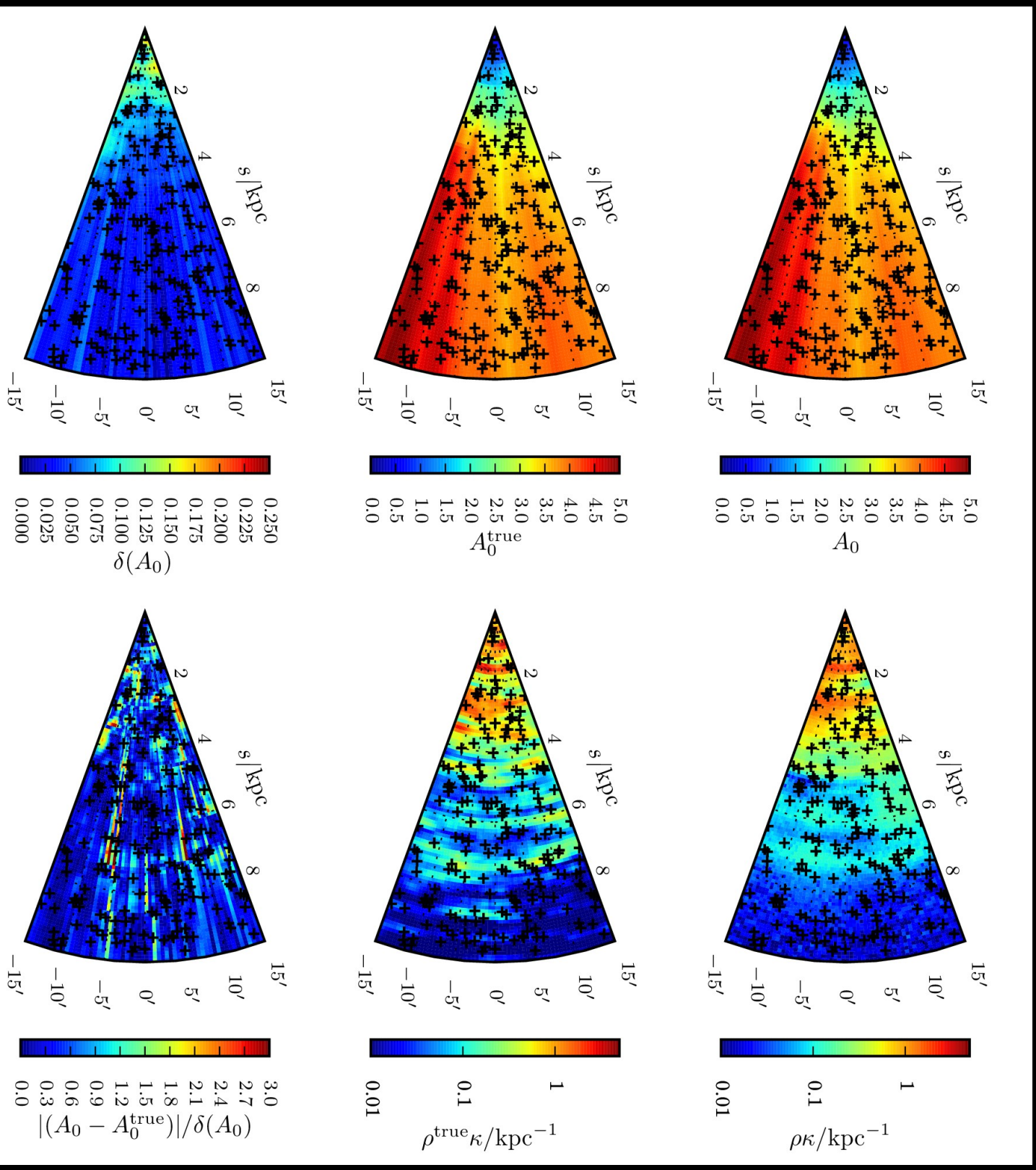


Uncertainty

'True' A

Measured A

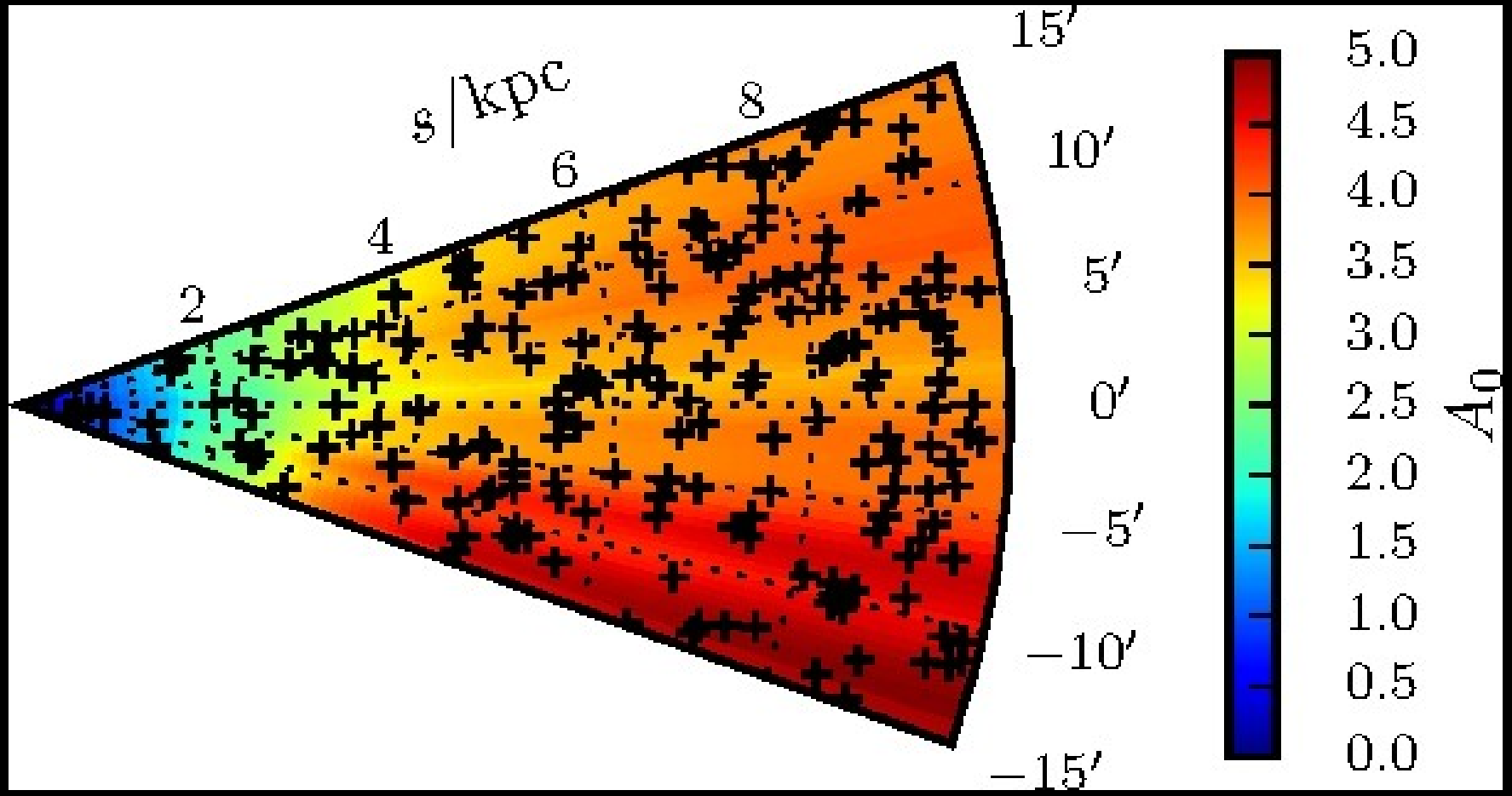


Residual

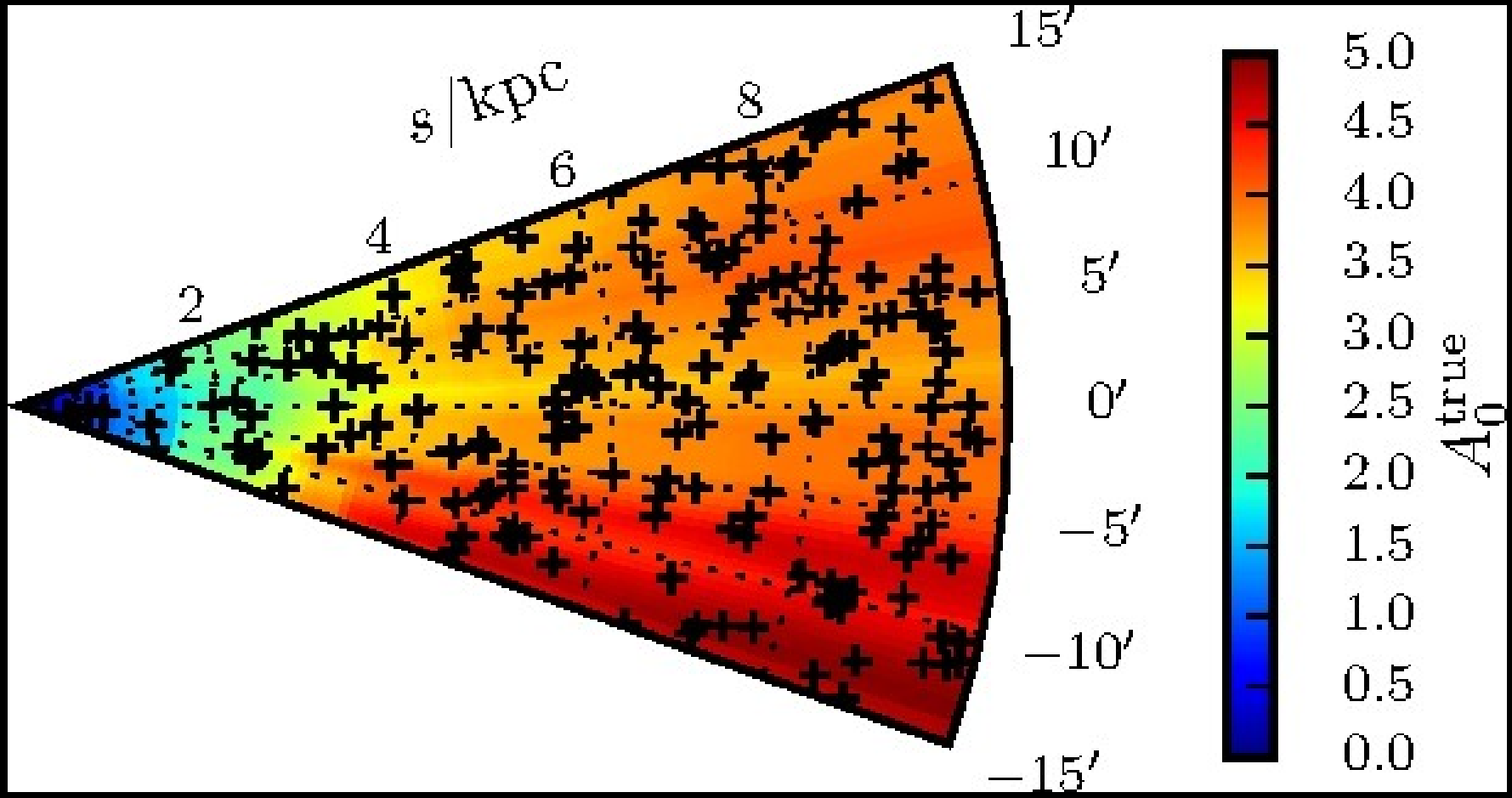
'True' ρ

Measured ρ

Measured A



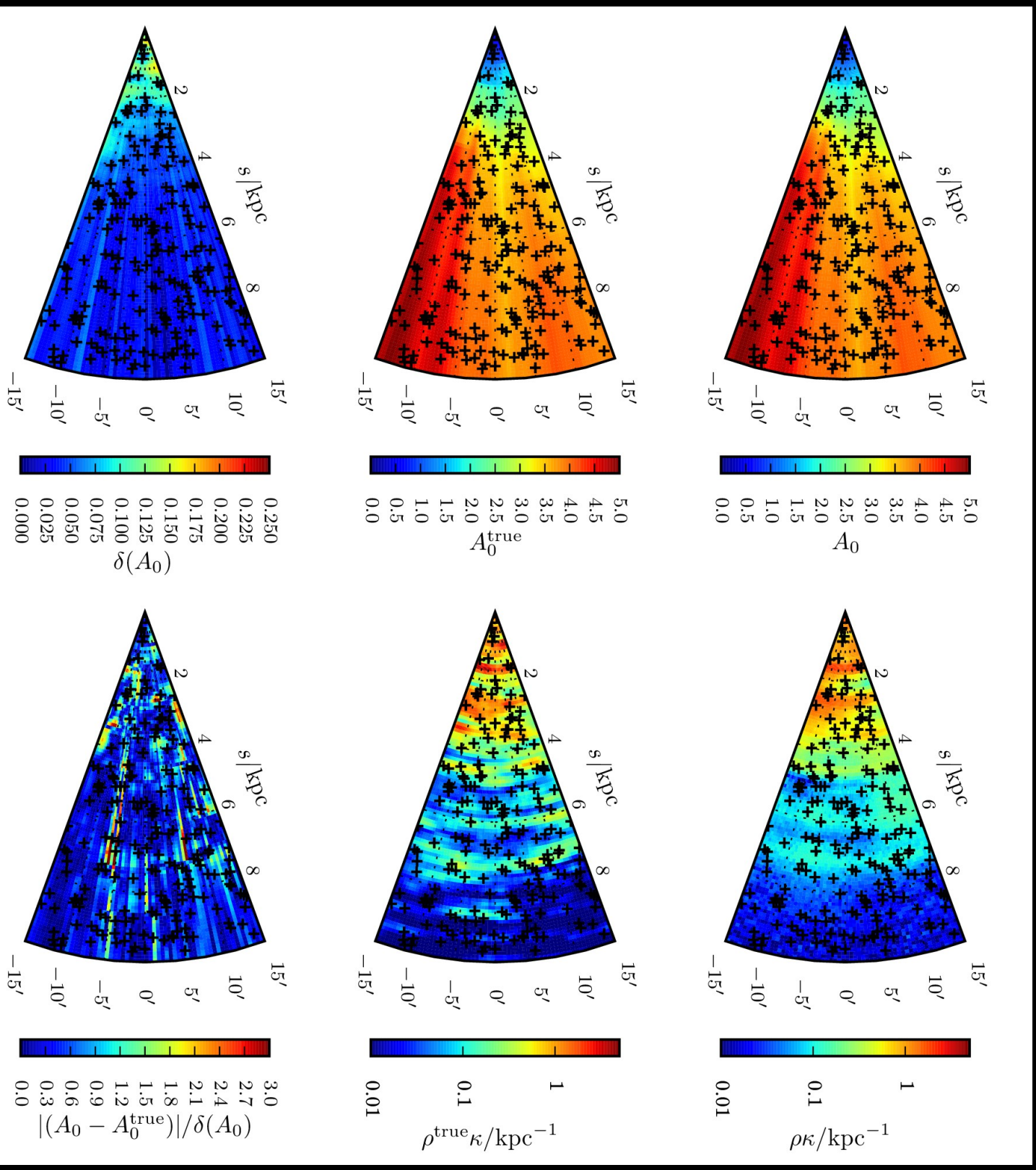
'True' A



Uncertainty

'True' A

Measured A



Residual

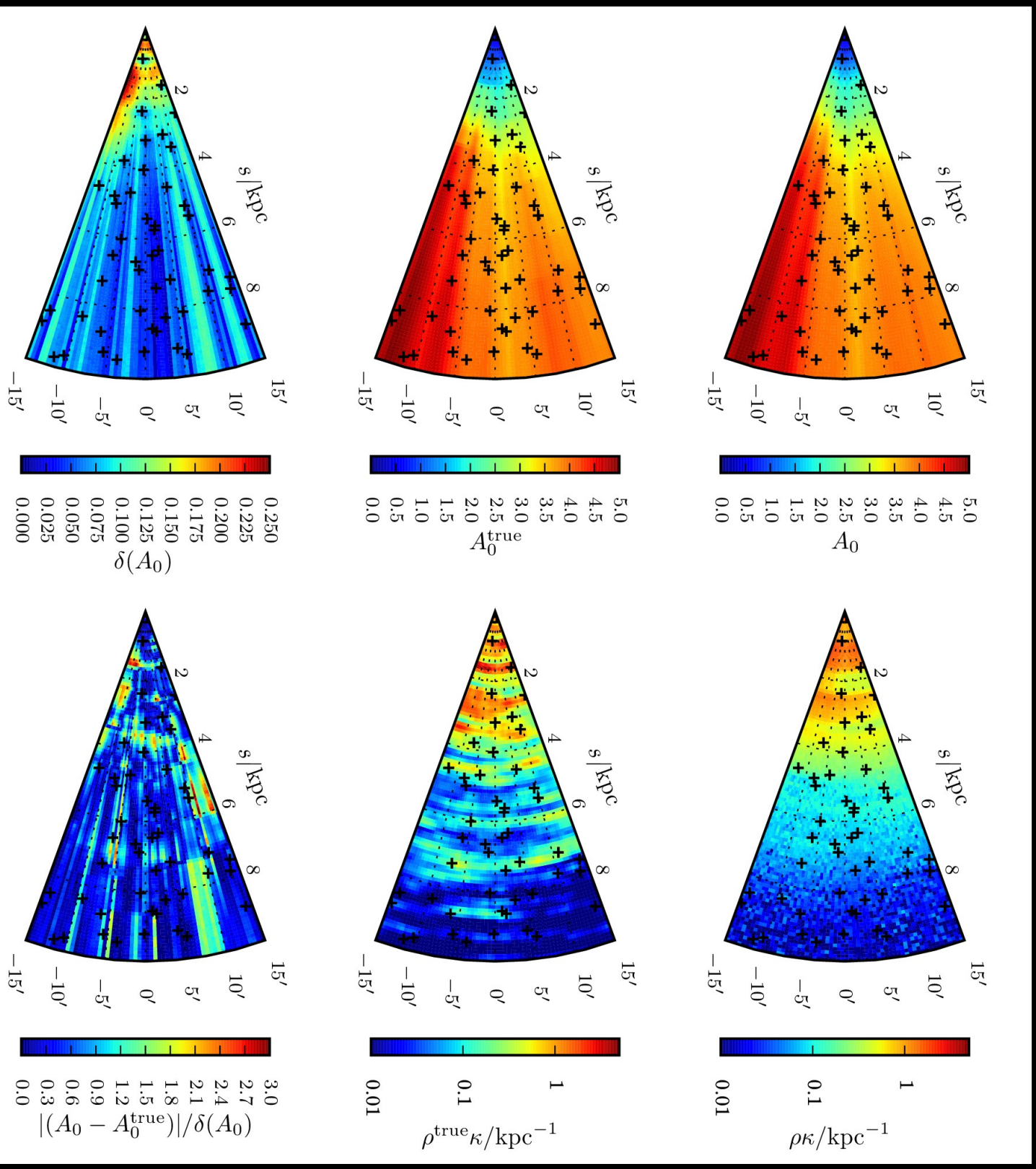
'True' ρ

Measured ρ

Uncertainty

'True' A

Measured A

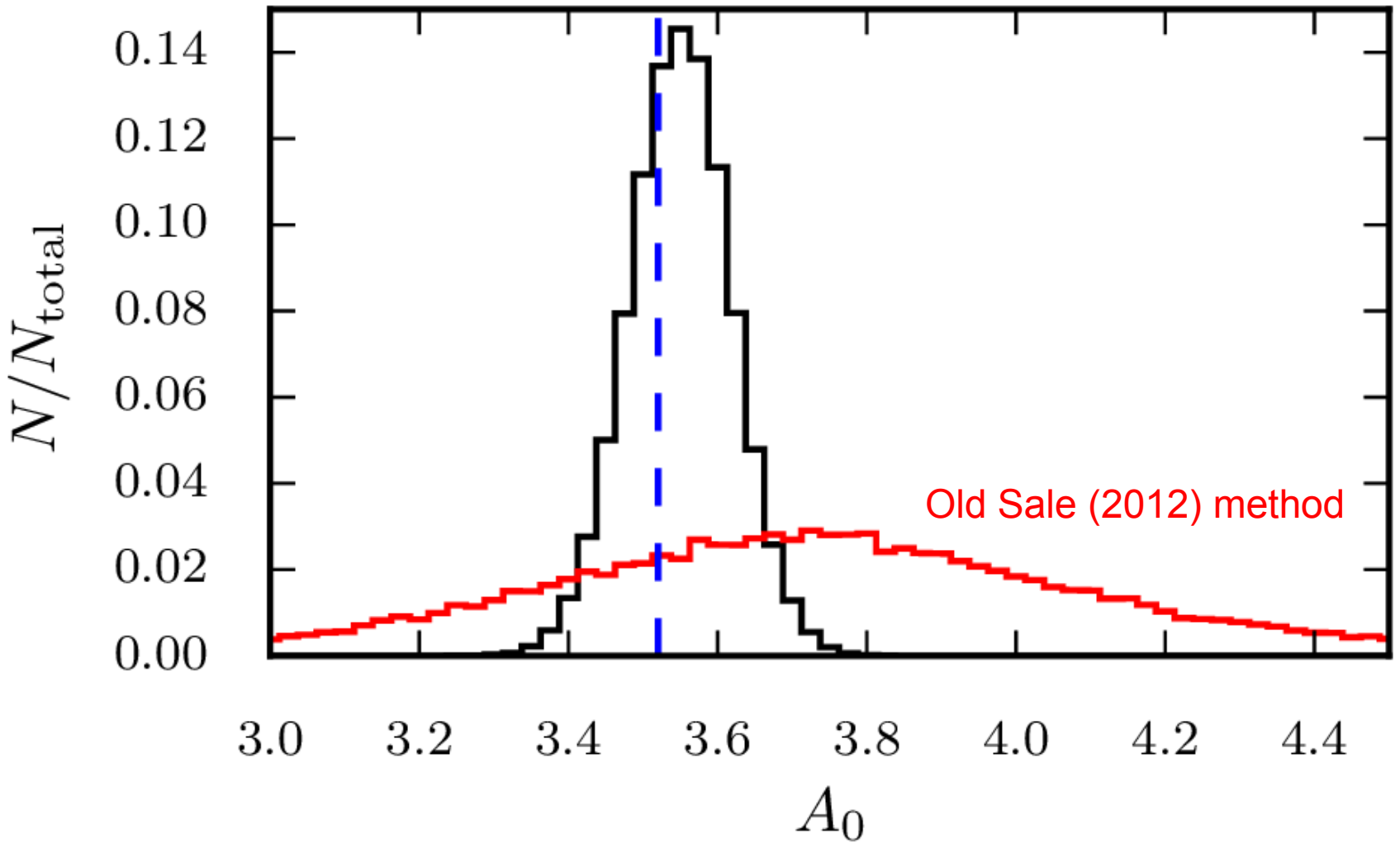


Residual

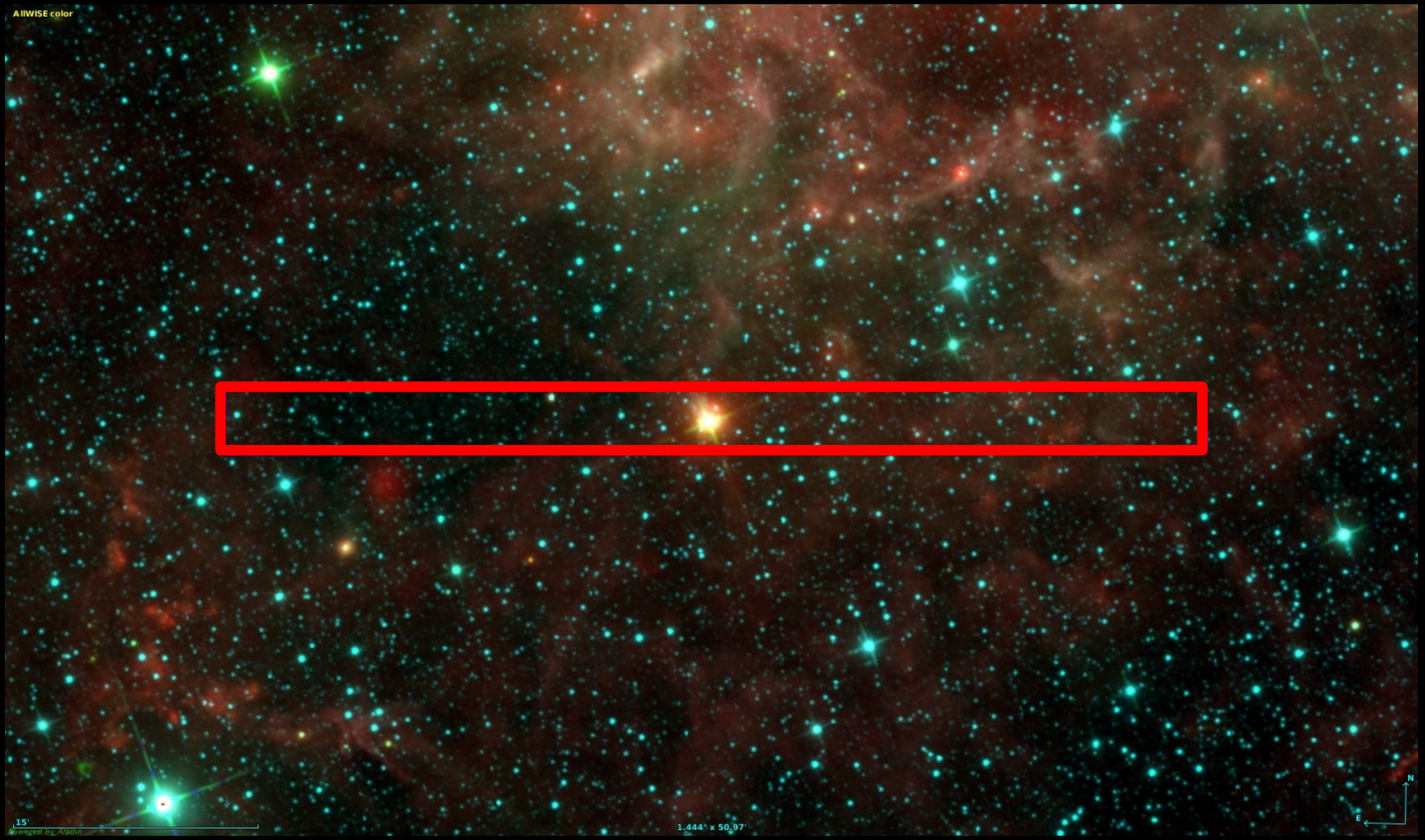
'True' ρ

Measured ρ

A(5kpc, 0') – Posterior distributions of extinction from single simulation



Real Data



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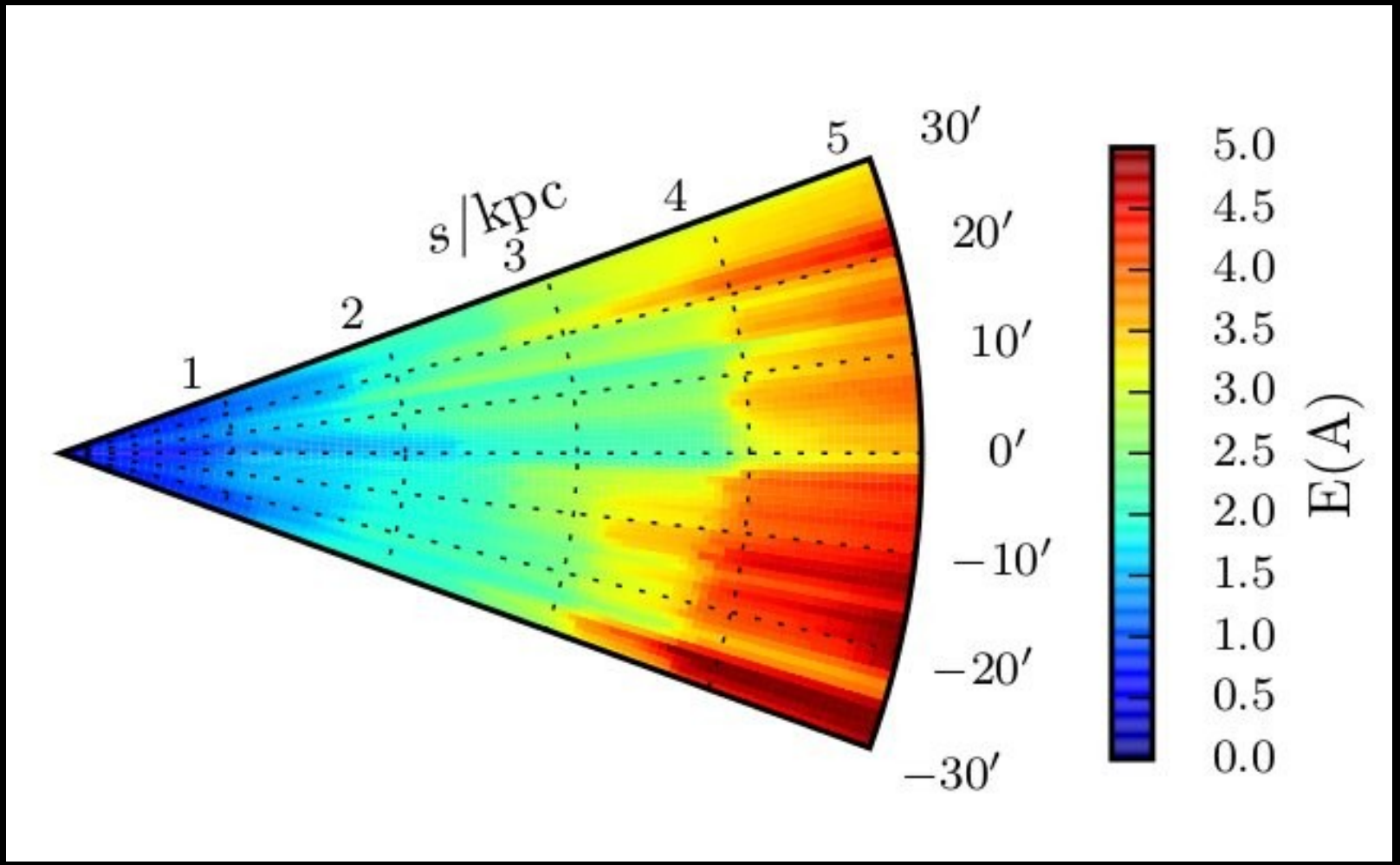

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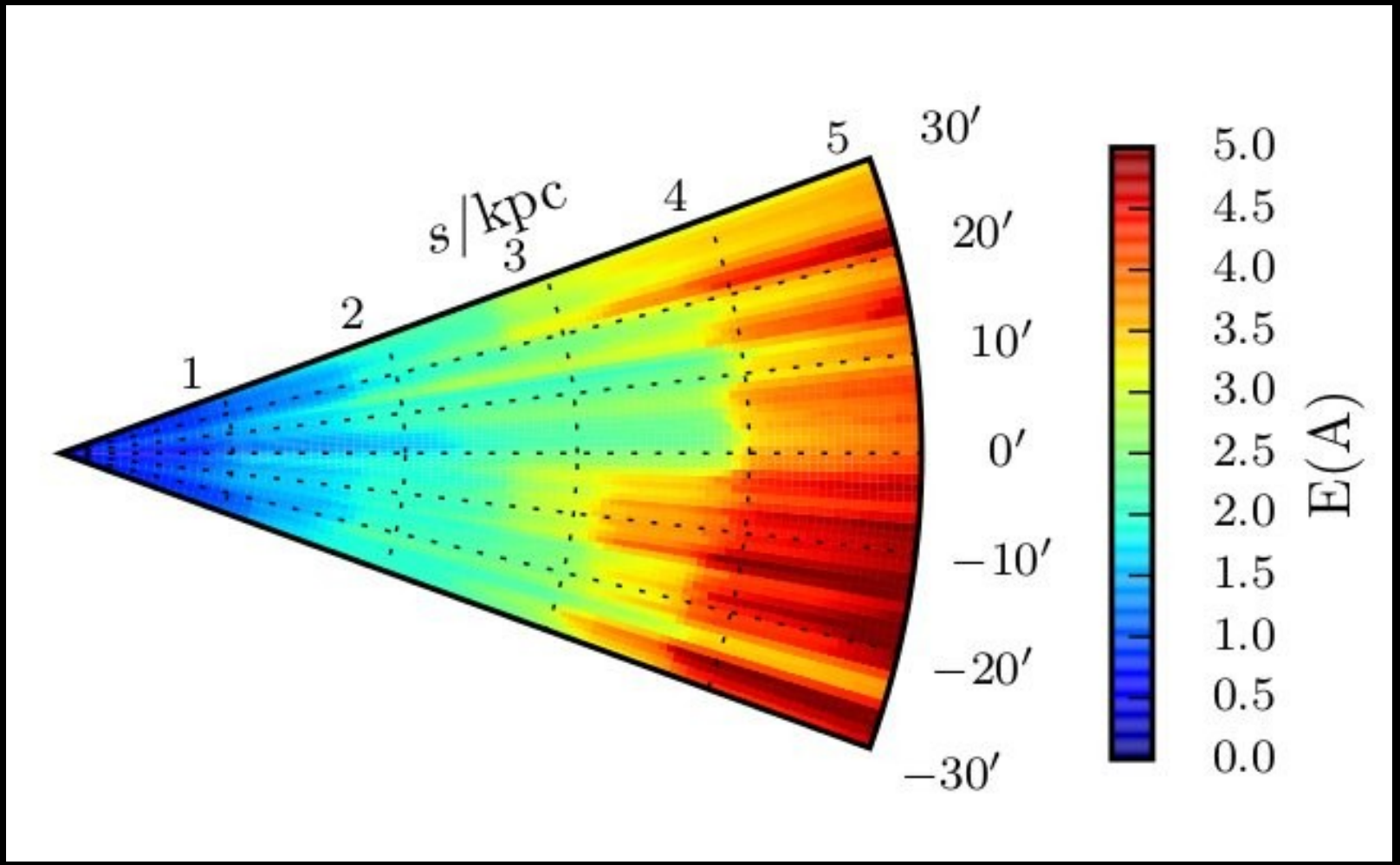

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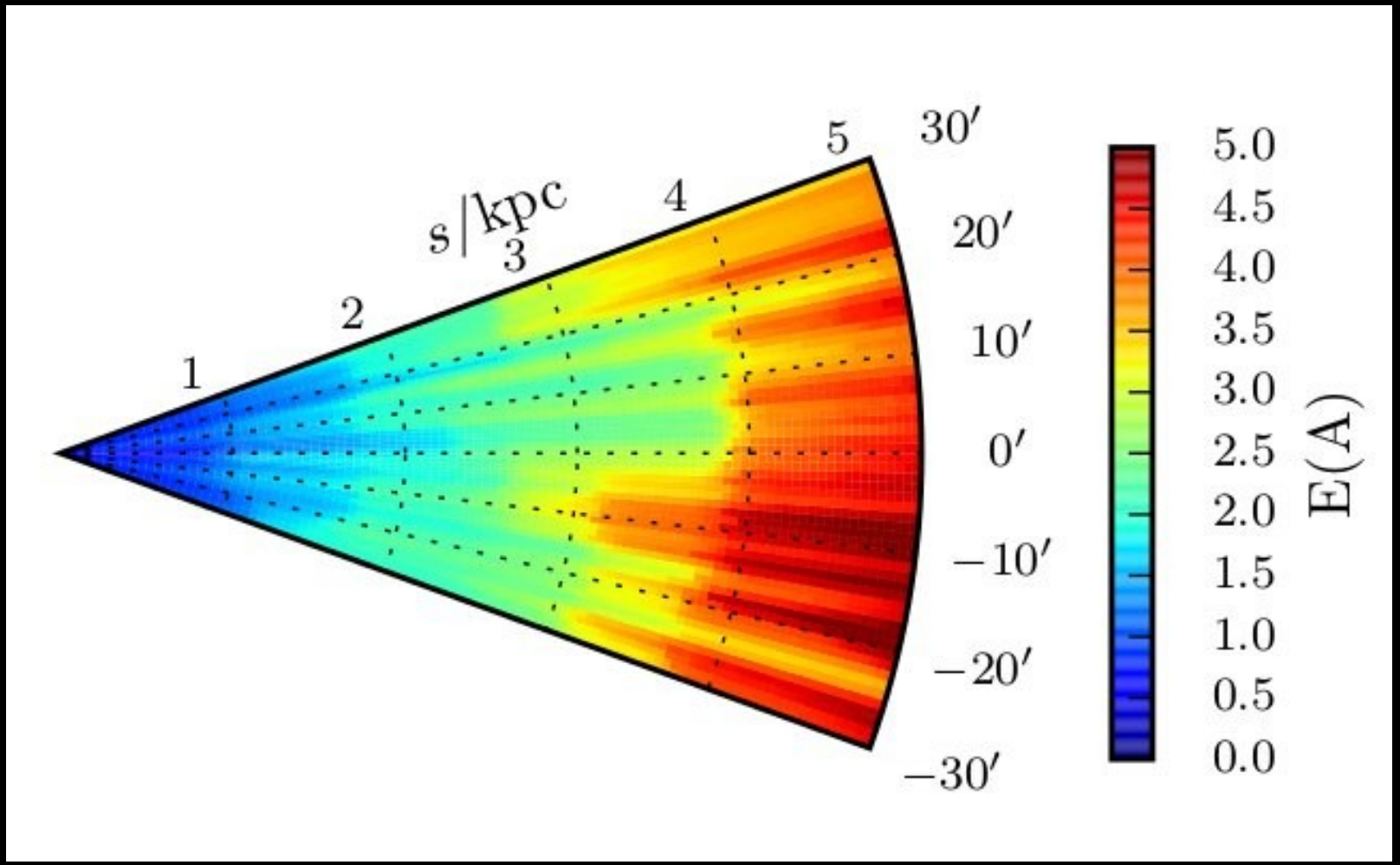

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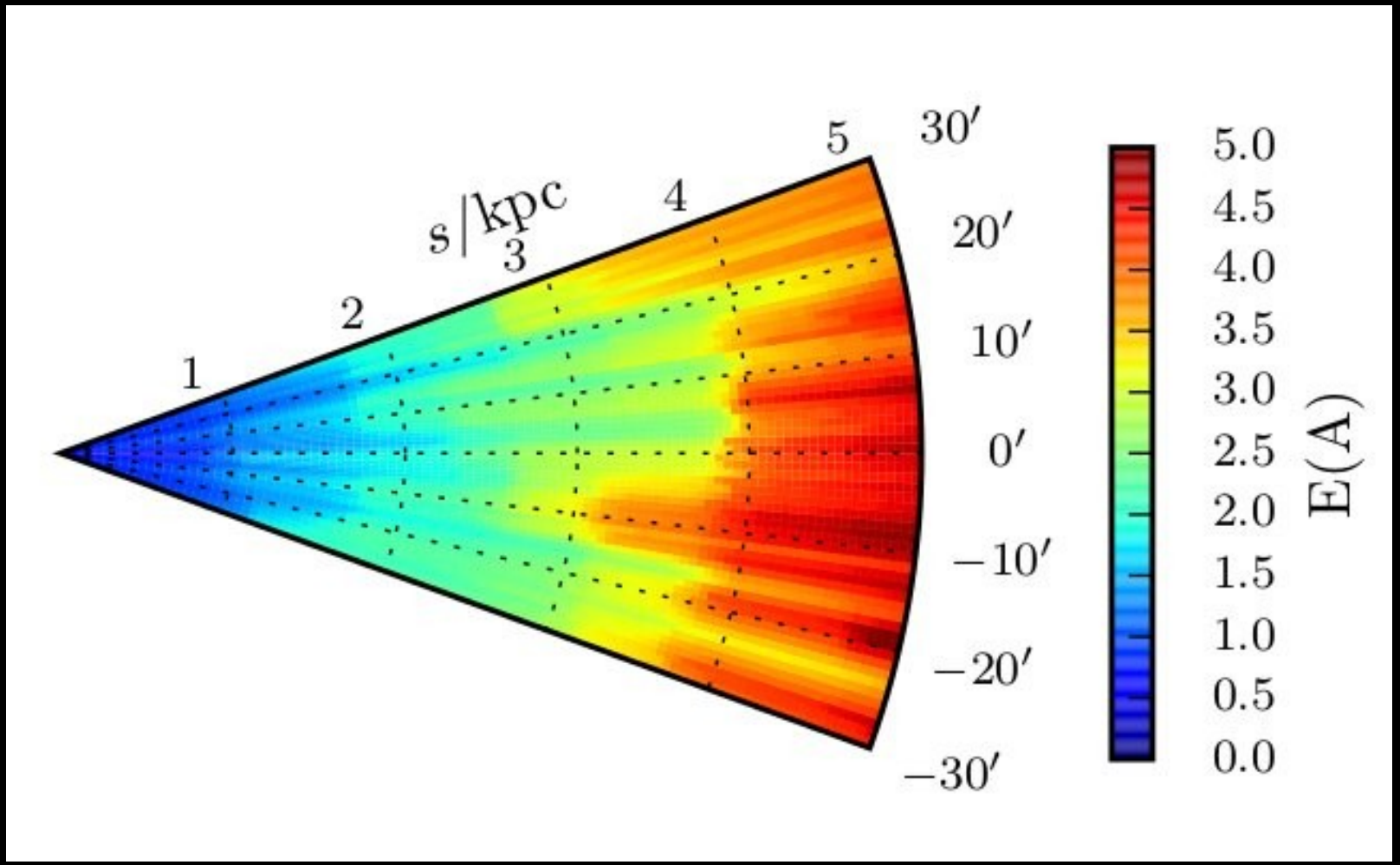

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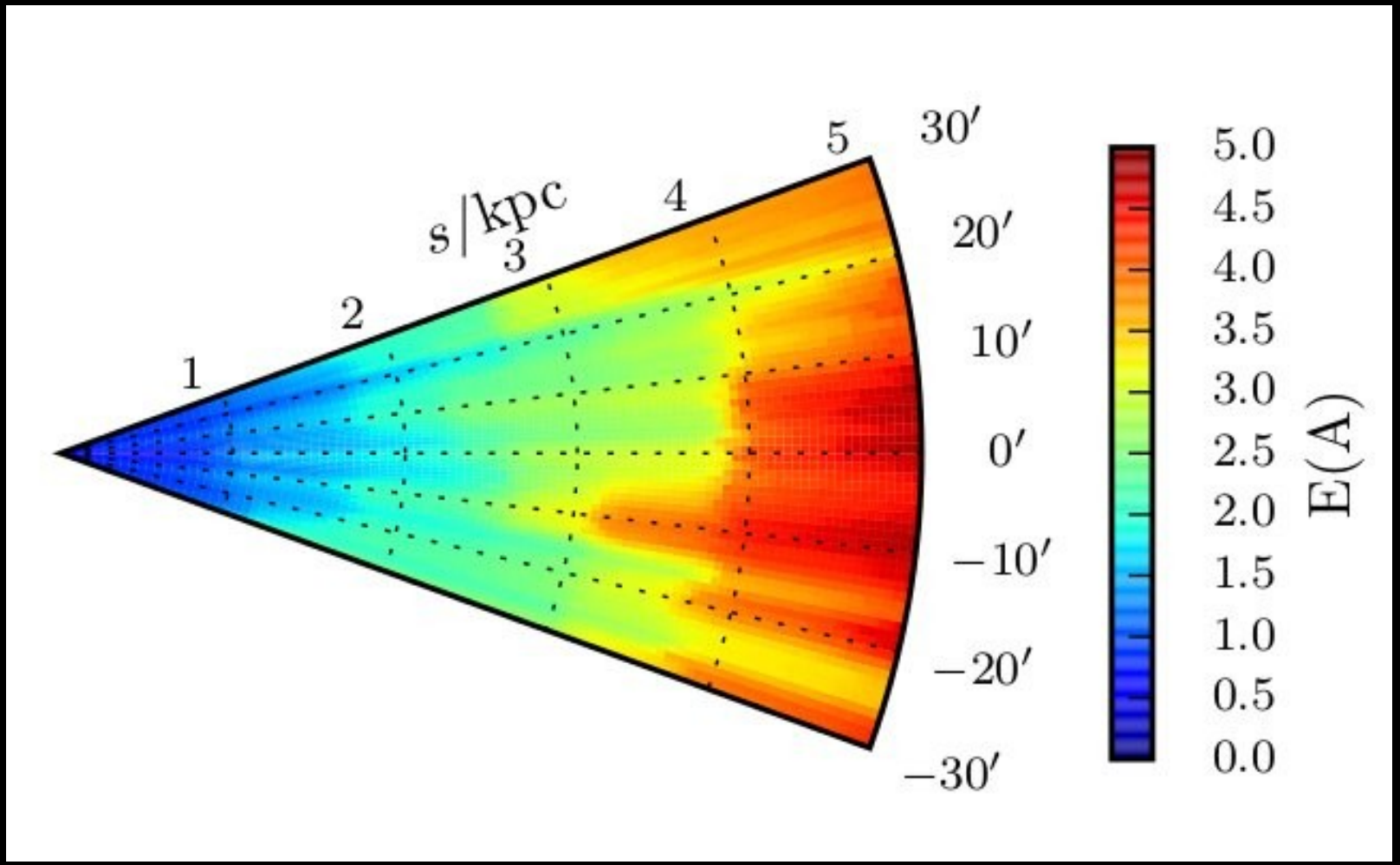

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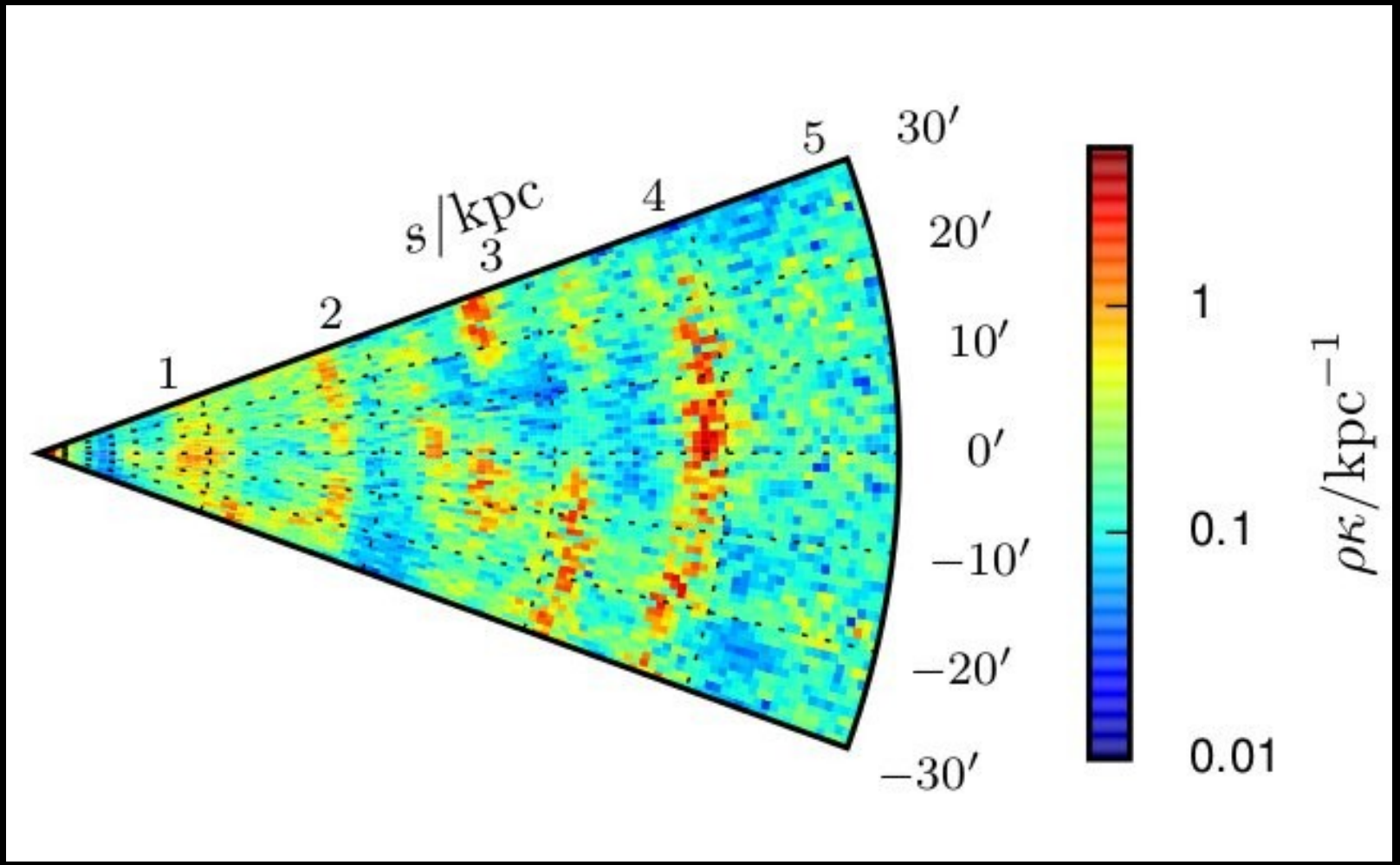
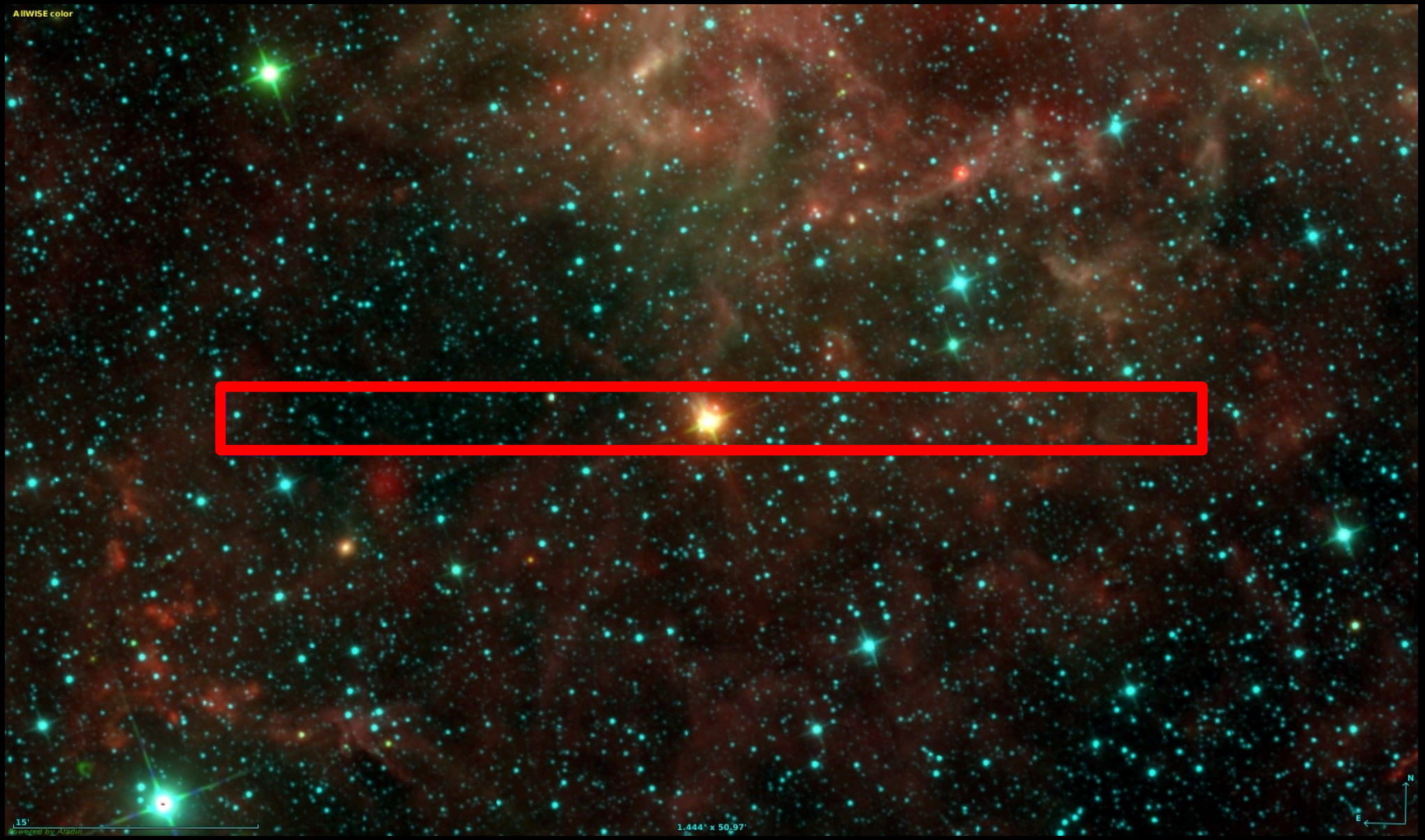
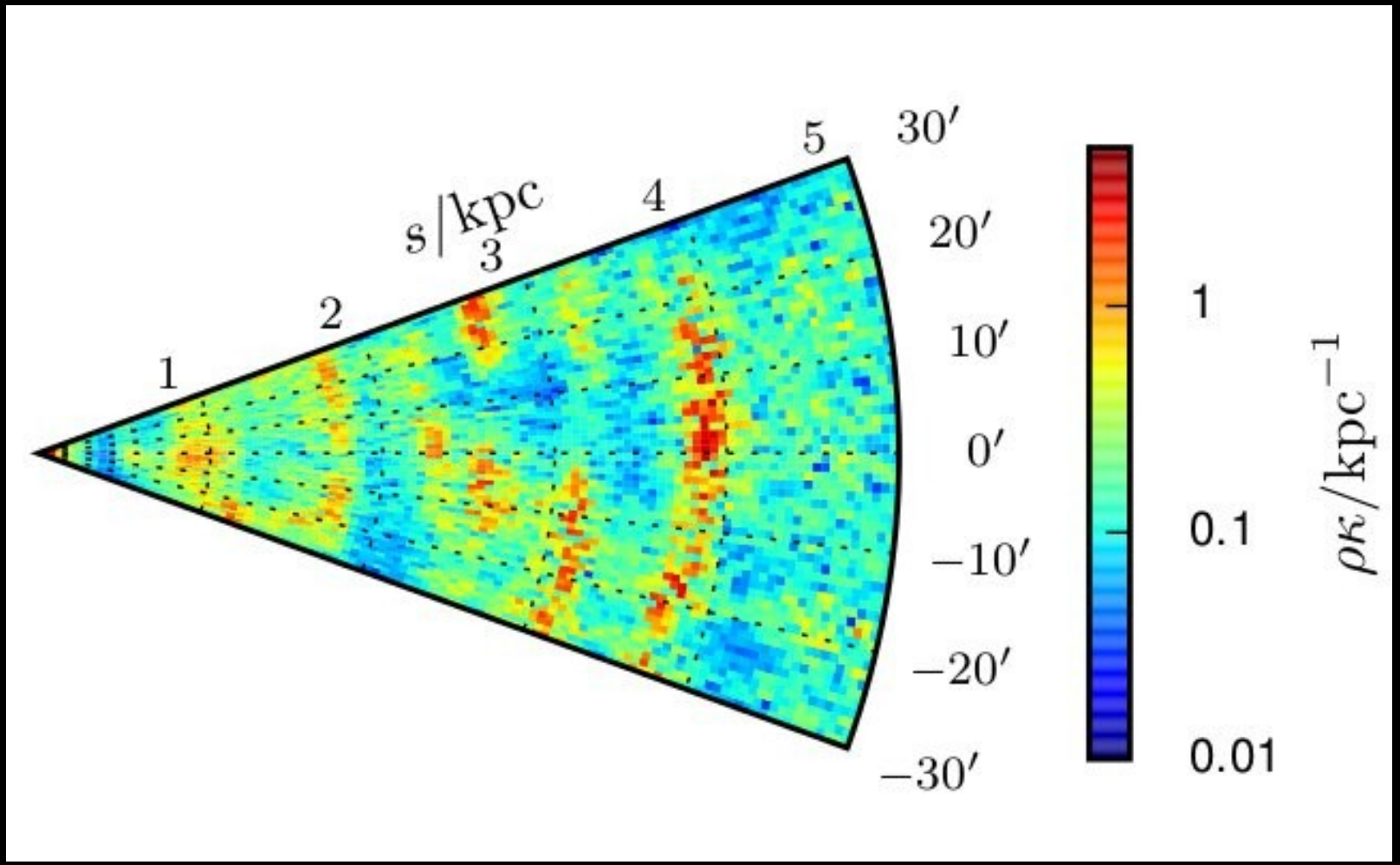
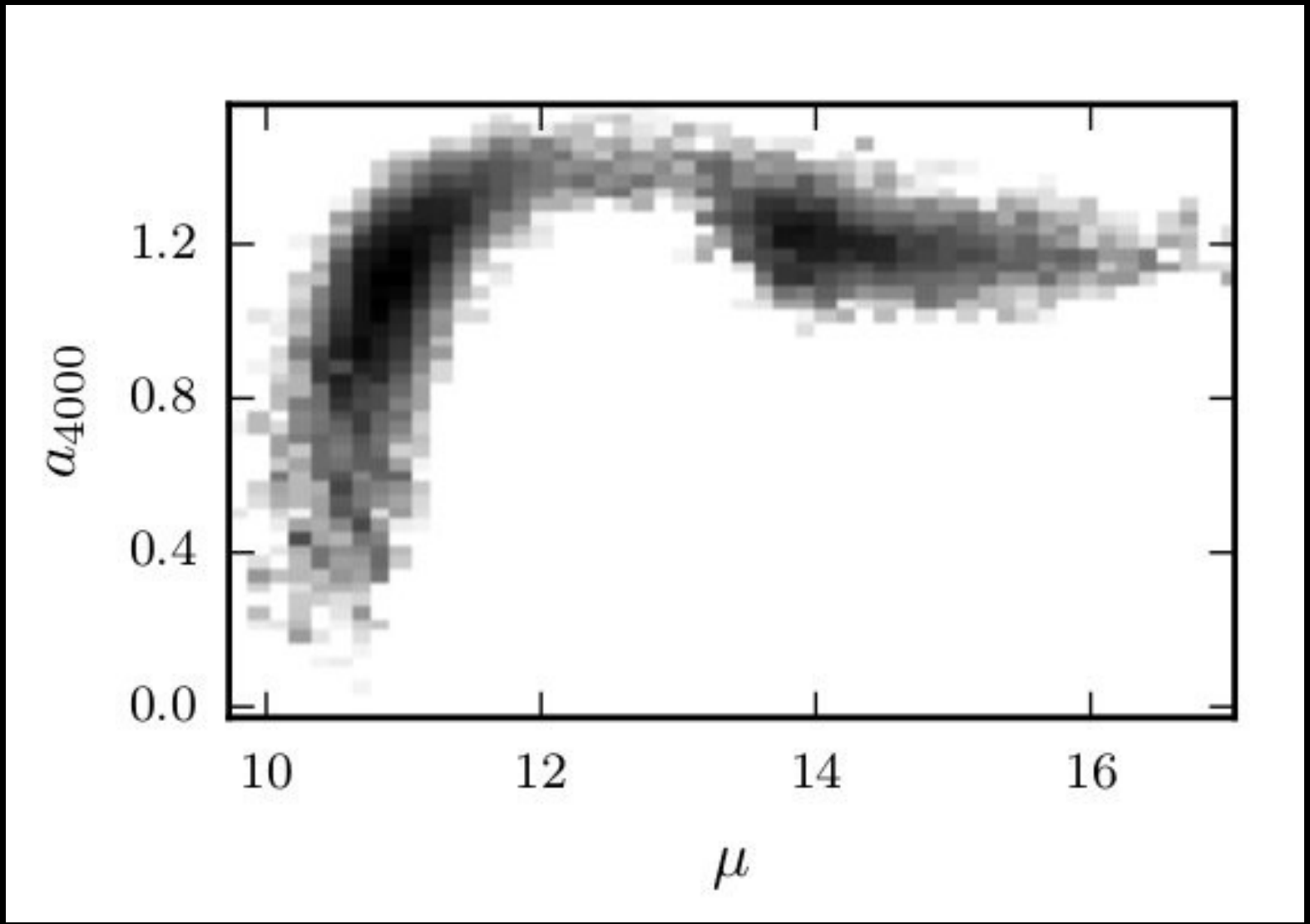


Real Data - IRAS 23151+5912



Real Data - IRAS 23151+5912

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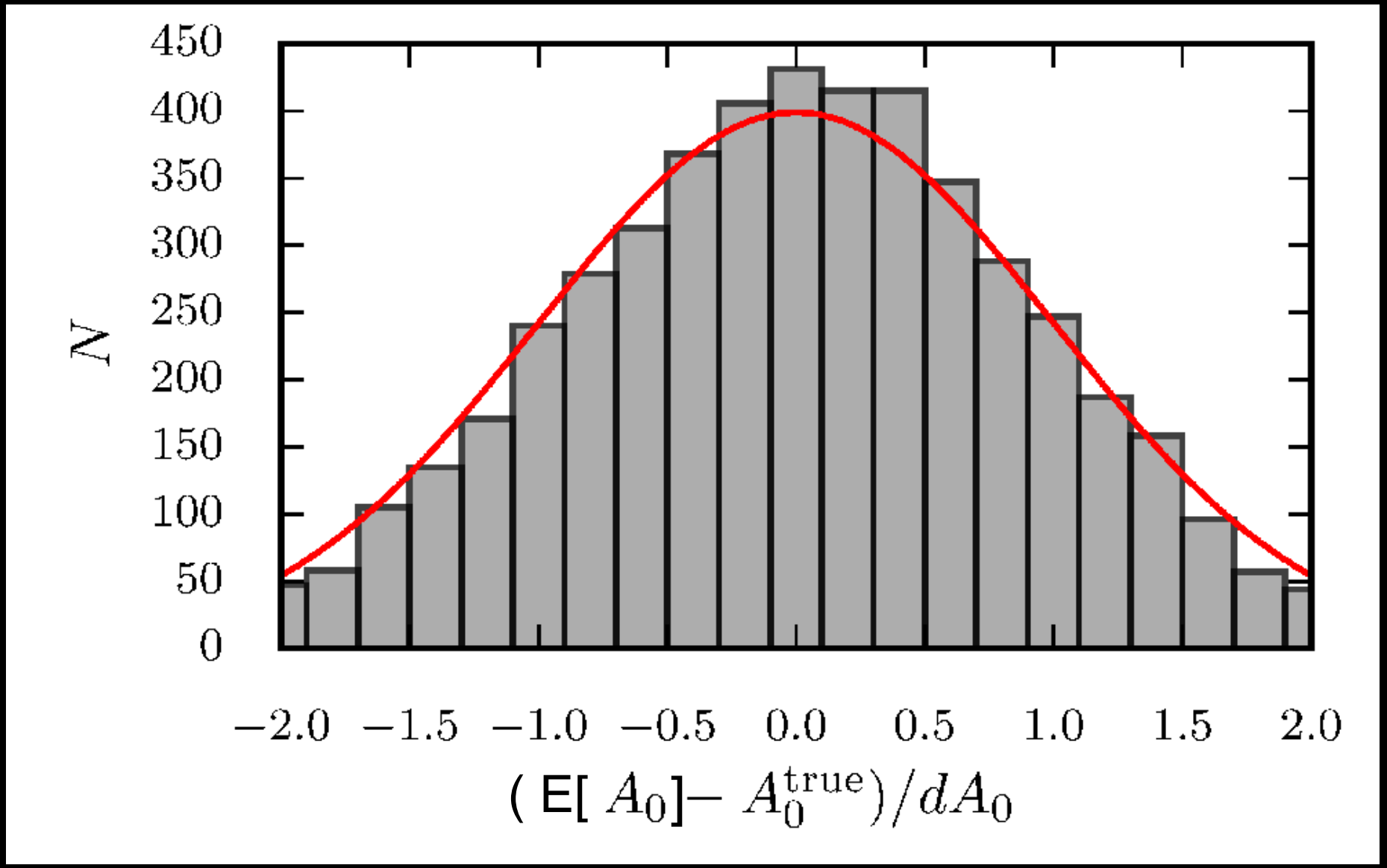
10
12
14
16
μ

Summary

- Extinction is a powerful probe of ISM
- Existing 'voxelised' methods struggle to produce realistic maps
- Using GRFs we can produce more precise & accurate maps

Sale (2012), MNRAS, 427, 2119
Sale, Drew, Barentsen, et al. (2014), MNRAS, 443, 2907
Sale & Magorrian (2014), MNRAS, 445, 256
Sale & Magorrian, MNRAS submitted, arxiv:1411.5024

A(5kpc, 0') – 5000 independent simulations