

The Galactic 3D large-scale Distribution of Dust from Astrometric Data

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Why 3D Dust

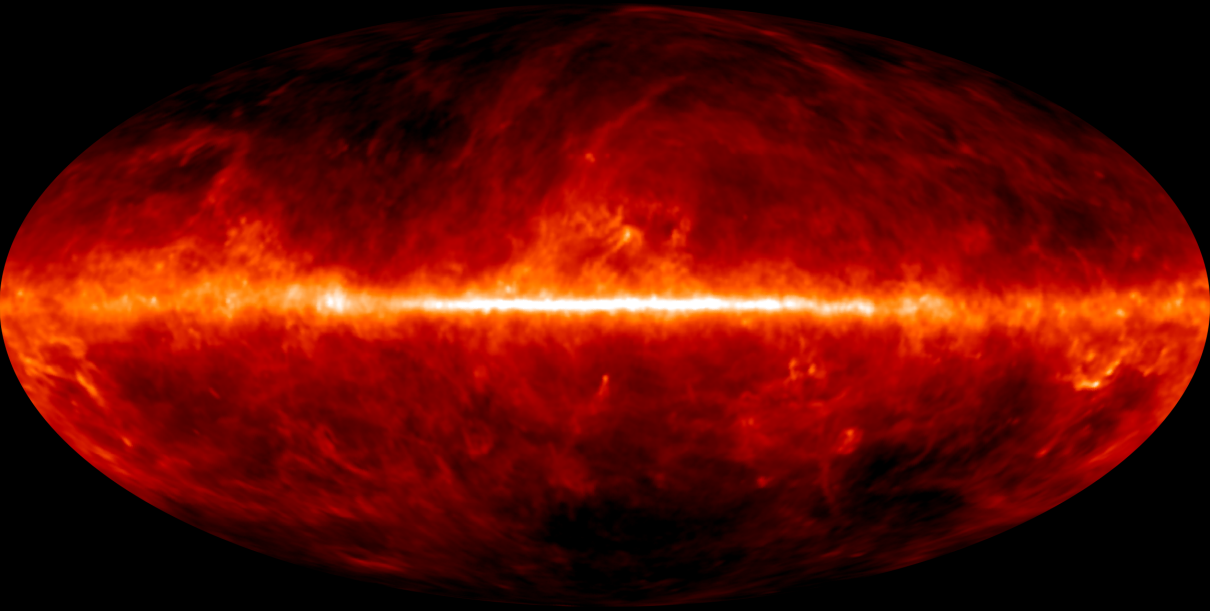
Hierarchical Bayesian Model of 3D Dust

3D Dust Extinction Map

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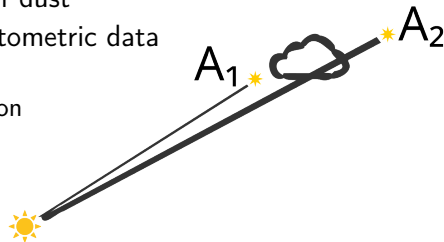


Problems

- Measurements are always plane-projected views of dust
- Map making = deprojecting astrometric and photometric data
 - Astrometric data yields endpoint
 - Photometric data yields integrated dust extinction

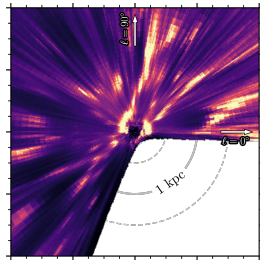
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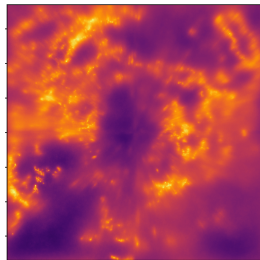
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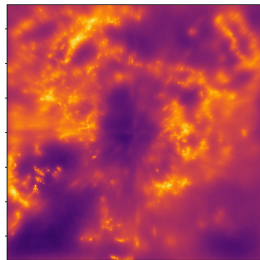
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Goal: **Large-scale** “smooth” dust density

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Idea

$$P(\rho|d) = \text{—————}$$

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Idea

$$P(\rho|d) = \frac{P(d|\rho) \cdot P(\rho)}{P(d)}$$

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Prior

$$P(\rho)$$

- Positivity via $\rho = e^\tau$
- Smooth τ via Gaussian Process (GP) with Matérn-like kernel
- Efficient GP for τ via Iterative Chained Refinement¹

¹Edenhofer et al. 2022.

Likelihood

$$P(d|\rho)$$

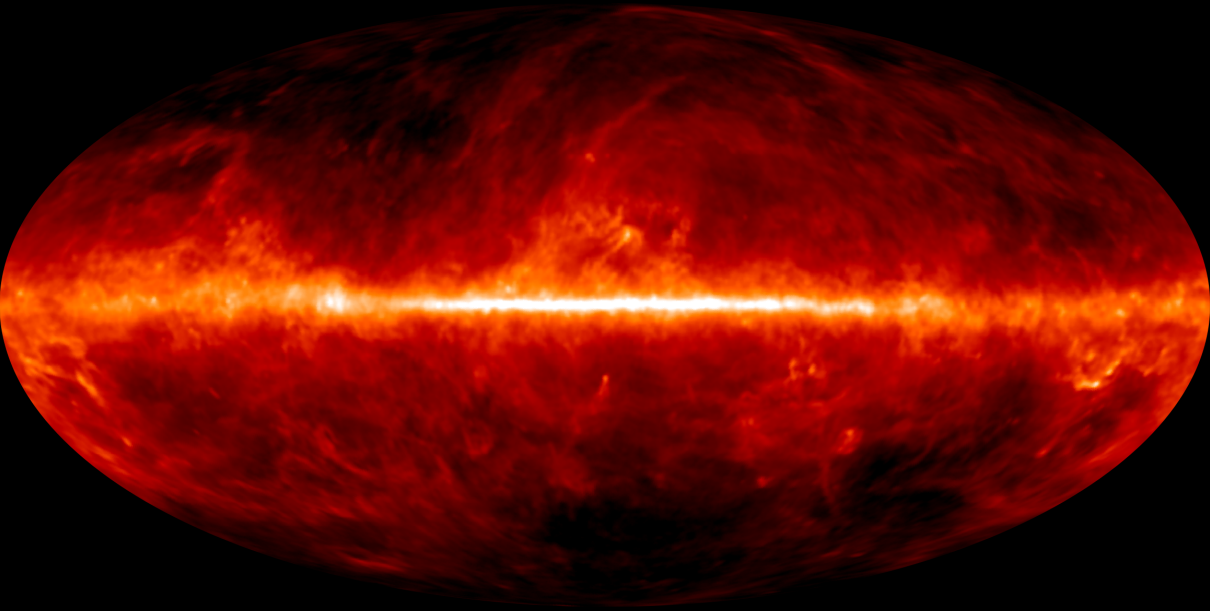
- Map ρ to data-space with line-of-sight (LOS) integrals
- Data from Gaia DR2, ALLWISE, PANSTARRS, and 2MASS²
- Compare LOSs of ρ to data d via Student's T-Likelihood
- Many intricacies due to imprecise distances to stars, etc.

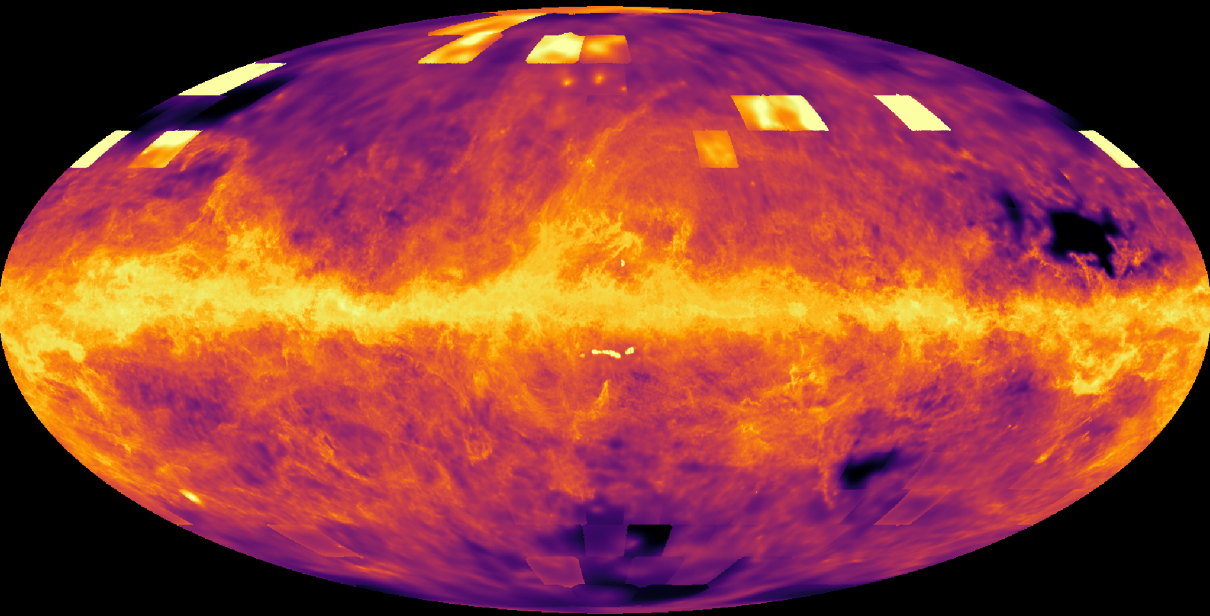
²Anders et al. 2019; A. B. d. A. Queiroz et al. 2018.

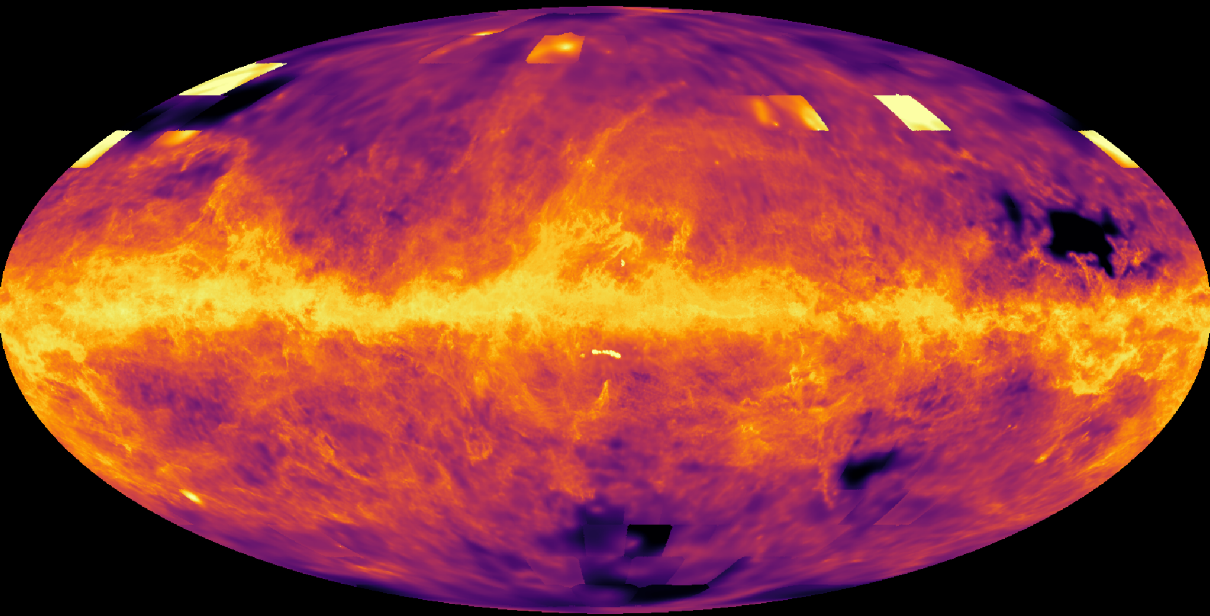
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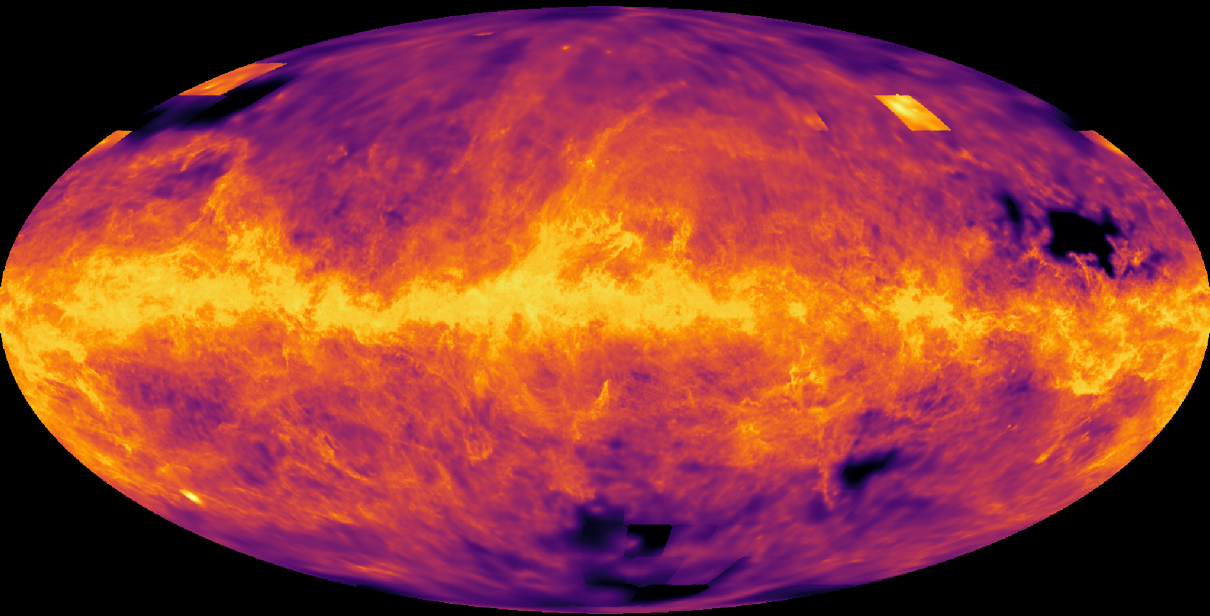
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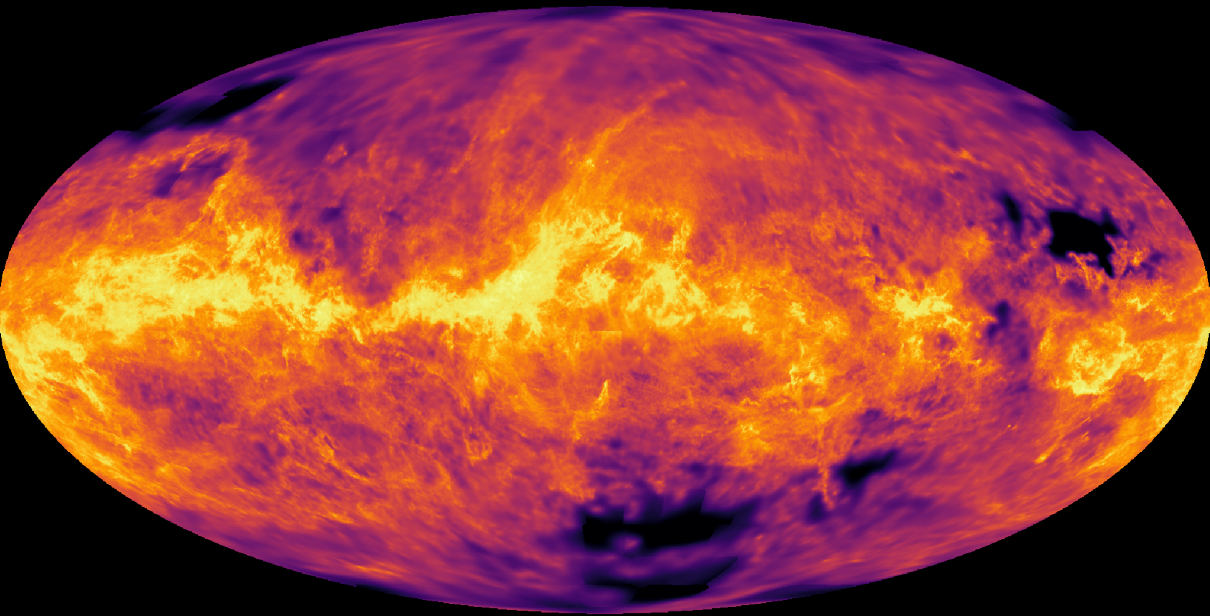
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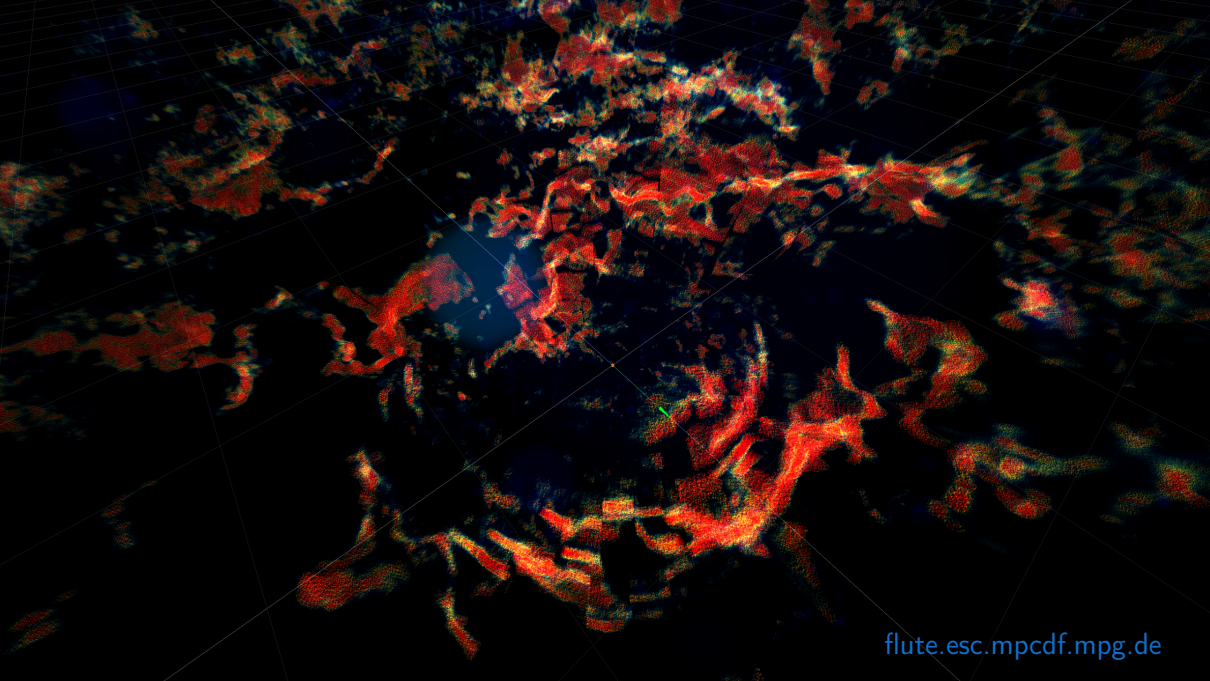












Our Map

- 4 kpc radial extent (up to 16 kpc but 4 – 16 kpc unreliable)
- 2' angular resolution ($18 \times$ our previous reconstruction)
- 122 Billion voxels/parameters ($400 \times$ our previous reconstruction)
 - Spread across 424 cones
 - Stitch cones together within the reconstruction

Our Map

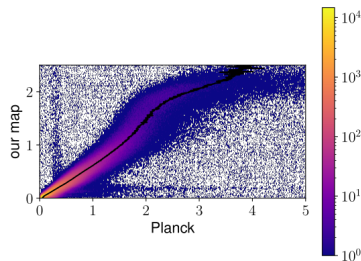
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- Consistency checks!

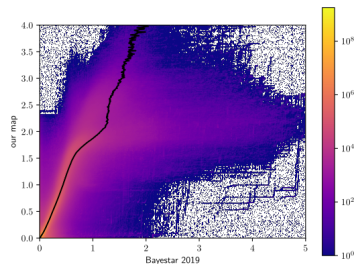
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- Planck dust map



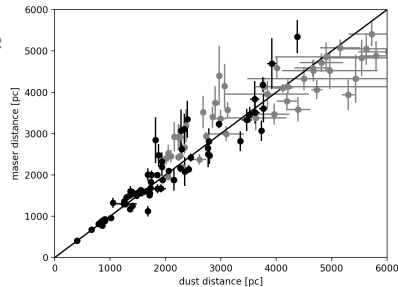
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- Competing reconstructions



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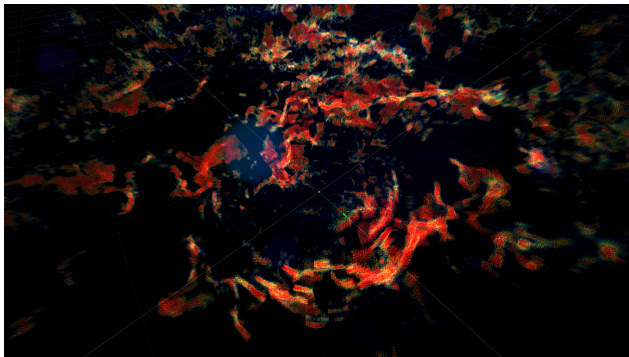
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- Planck dust map
- Competing reconstructions
- Masers



Our Dusty Milky Way

Access the Reconstruction via our
Galactic Cartography Portal at
flute.esc.mpcdf.mpg.de

edh@mpa-garching.mpg.de
Gordian Edenhofer
[arXiv:2204.11715](https://arxiv.org/abs/2204.11715)



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