

A Search for Tidal Tails in Carina

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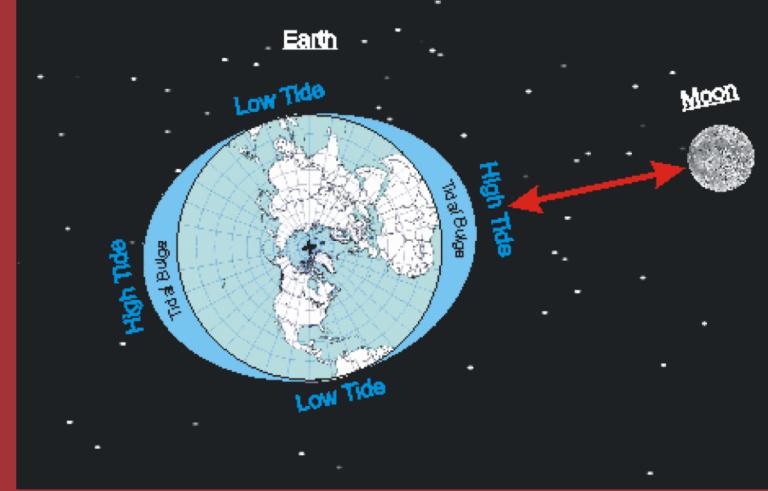
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Tidal Effects

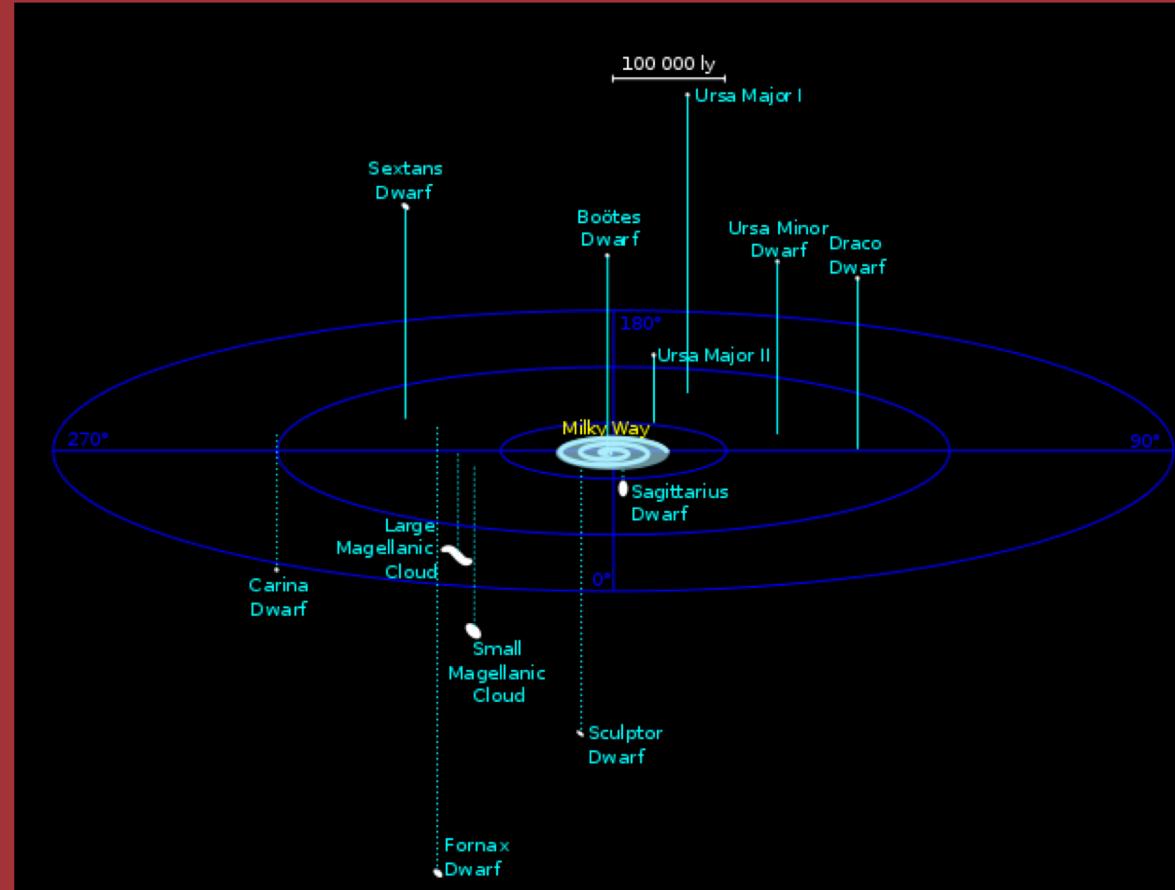
- Gravity acts on mass and can cause tidal shifts
 - Evident in the oceans on earth
 - Same concept applies to objects in space
 - Gravity can warp matter
 - Gravity can warp distribution of matter in large structures
 - Gravity can warp light
 - Gravitational lensing





Satellite Galaxies

- Orbit the galactic center of a galaxy
- Still uncertainty on their formation
- Can provide a wealth of information
 - Star formation
 - Large scale cosmological models
 - Galactic evolution





Missing Satellite Problem

- Dark Matter models give computer simulations that are relatively accurate
- Simulations predict thousands of satellite galaxies, while dozens are seen
- Presents astronomers with three (main) options
 - Our theories are wrong
 - The galaxies are too faint to be detected
 - Predicted size of galaxies is too big

The Carina Dwarf

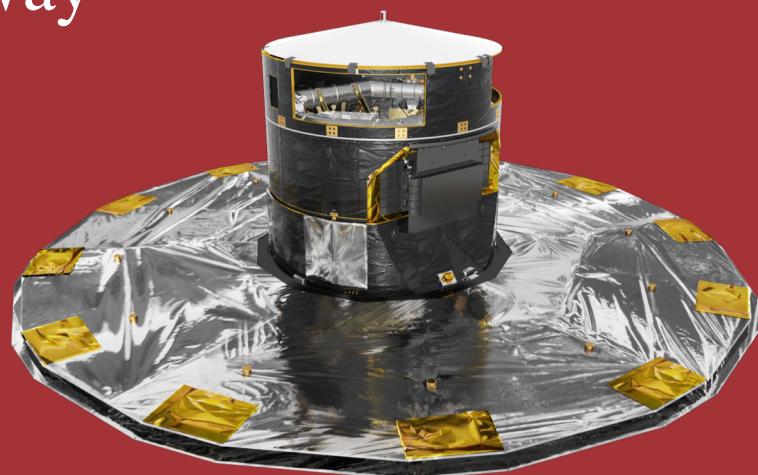
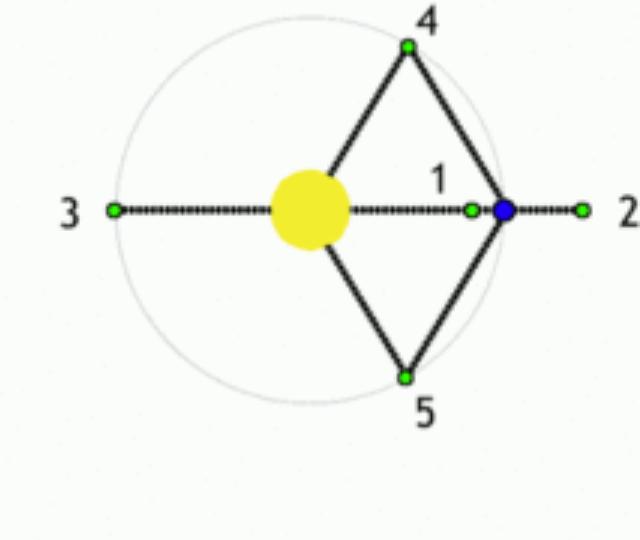
- 1600 light years in diameter
- 330 ± 30 kilo-light years away
- 2 distinct stellar populations
 - 13 and 3 billion years old
- Low on galactic latitudes
 - Disk stars can pose problem

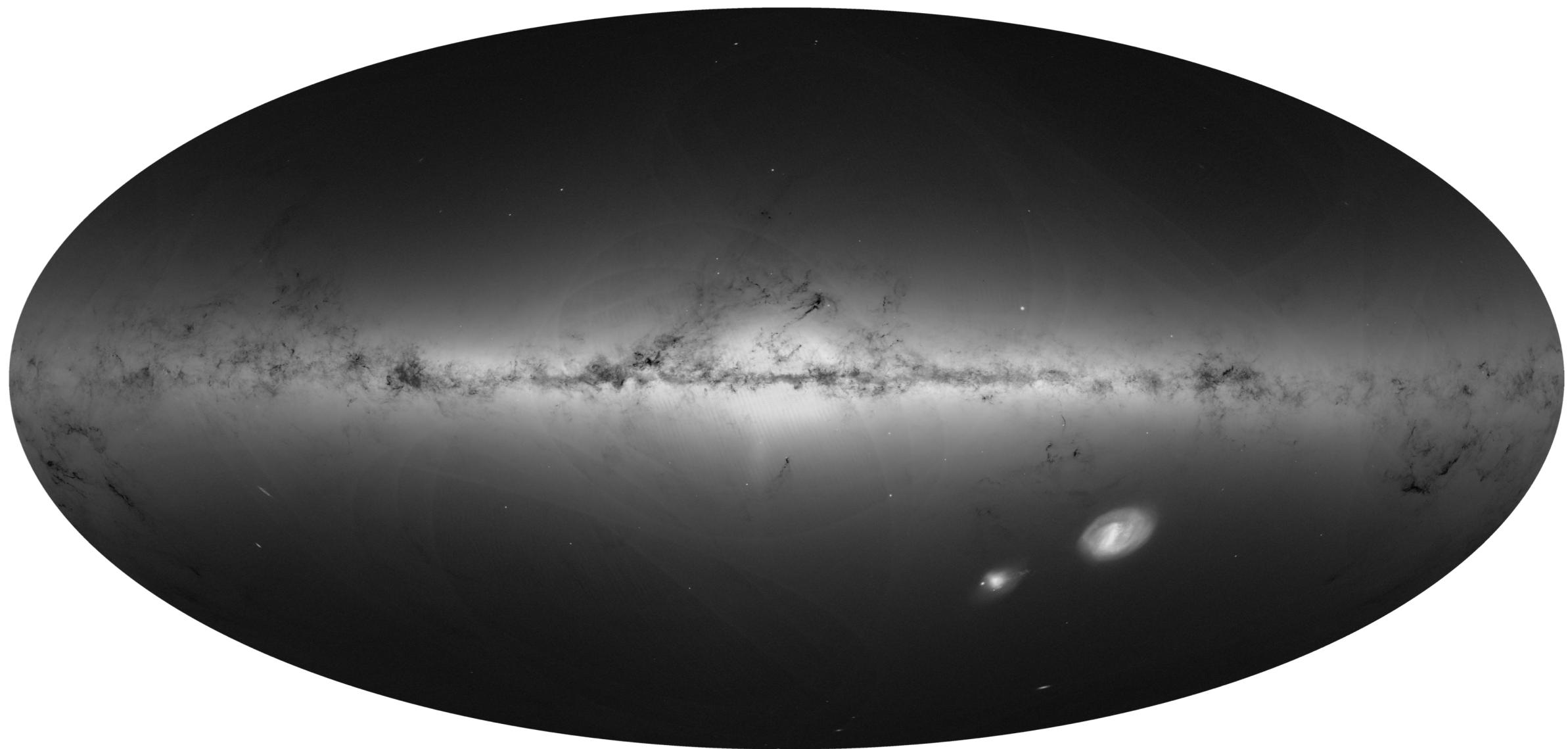


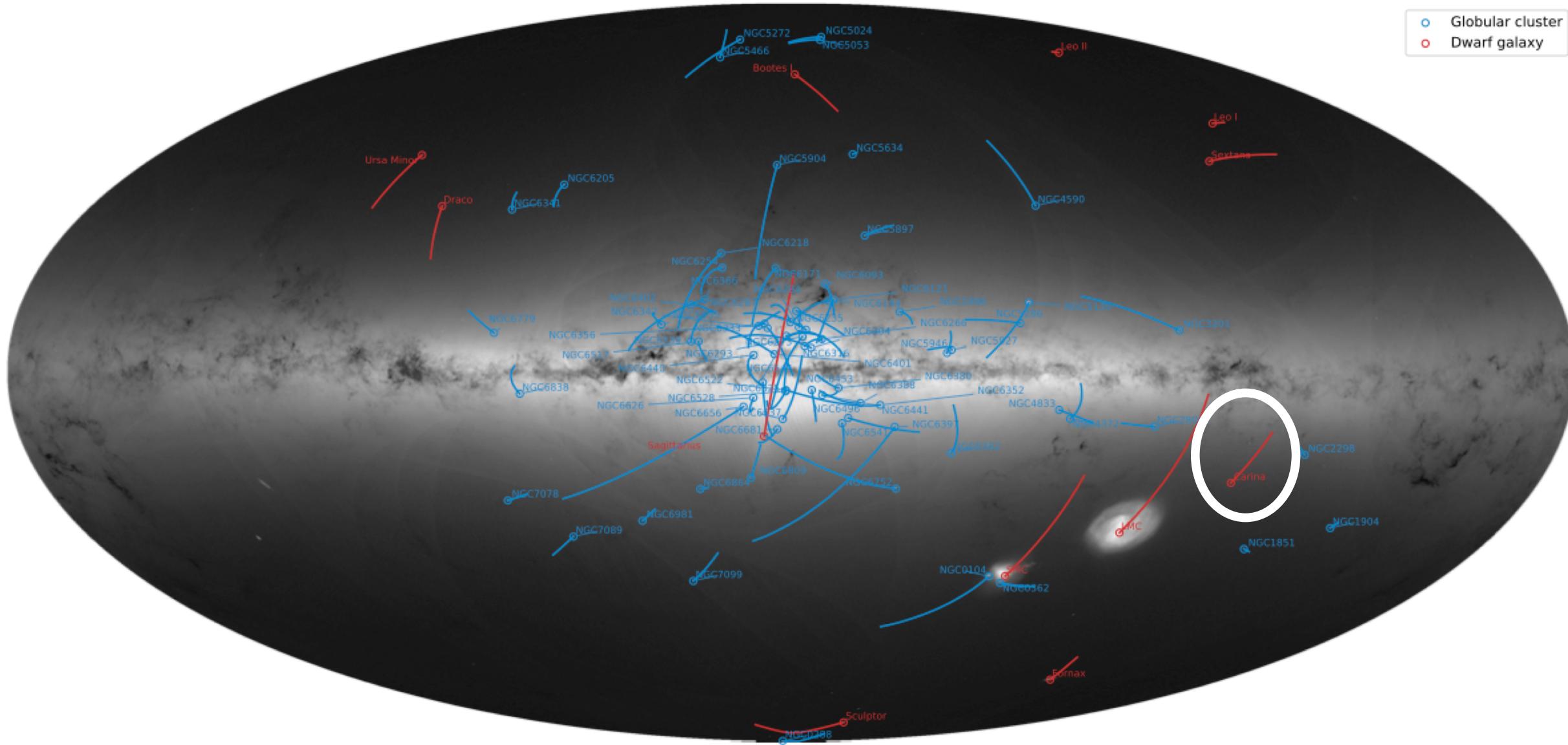


The Gaia Satellite

- Launched in December 2013
 - Reached L2 in January 2014
- Photometry and astrometry for most of the Milky Way
- Telescope properties
 - 1.45×0.5 m primary mirror
 - 937.8 Megapixels over 106 CCD's



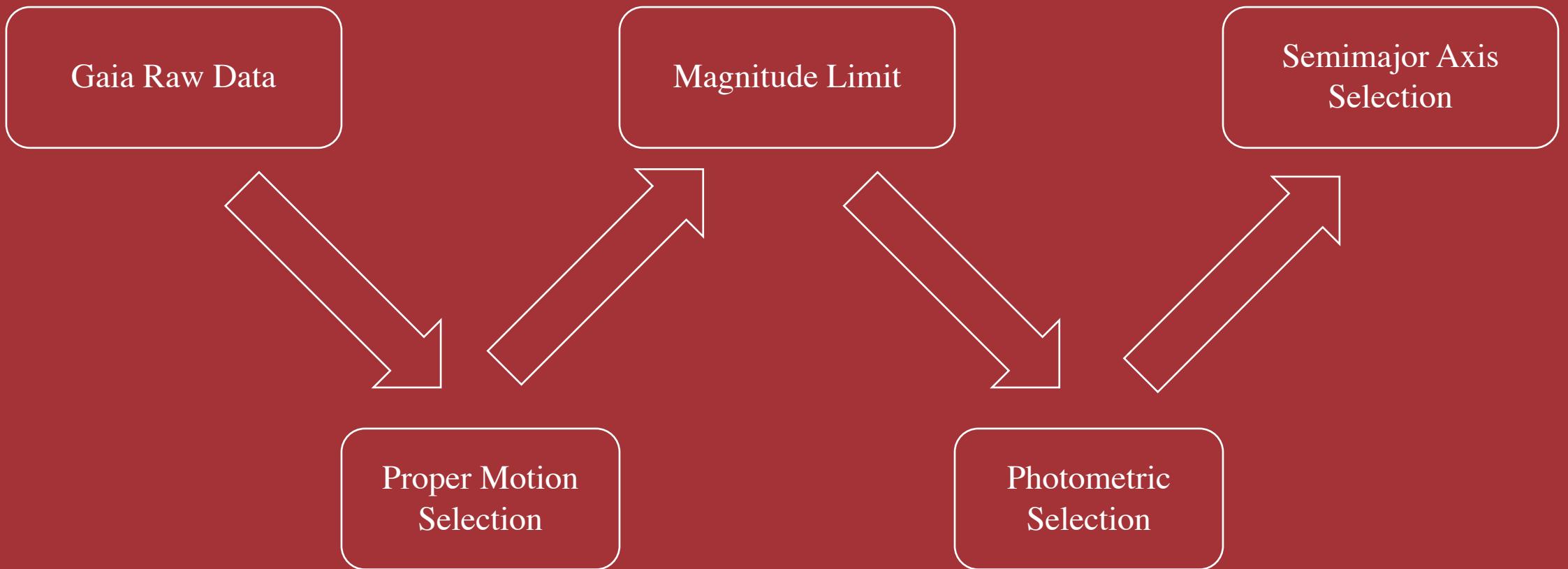




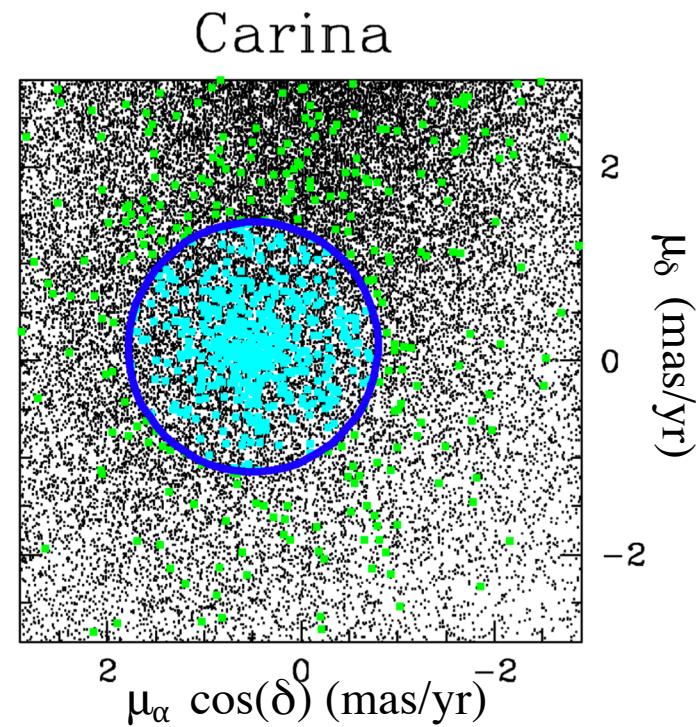
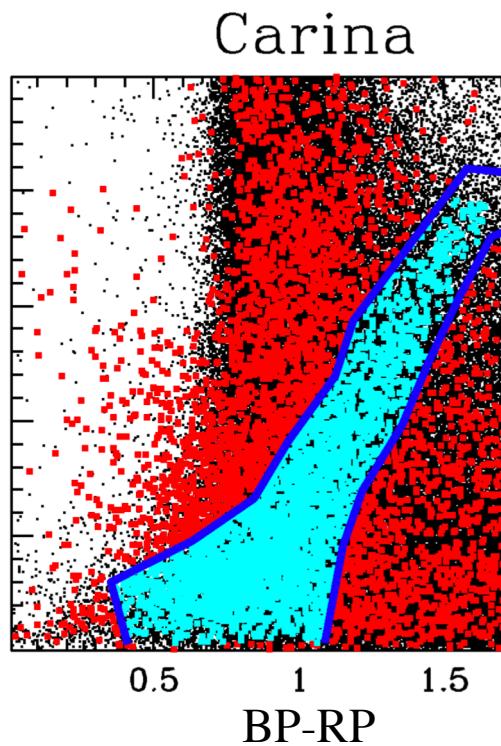
Summary

- Gaia DR-2 provides data on 1.6 billion stars (Gaia Collaboration 2018a)
 - Includes proper motion and parallax
- Dwarf satellite galaxies are remnants from Milky Way formation
- Carina member stars indicate it was once more massive
- Tidal tails could provide clues to history of Carina
- Using Gaia data, we searched for low-surface-density tidal features

Data Flow

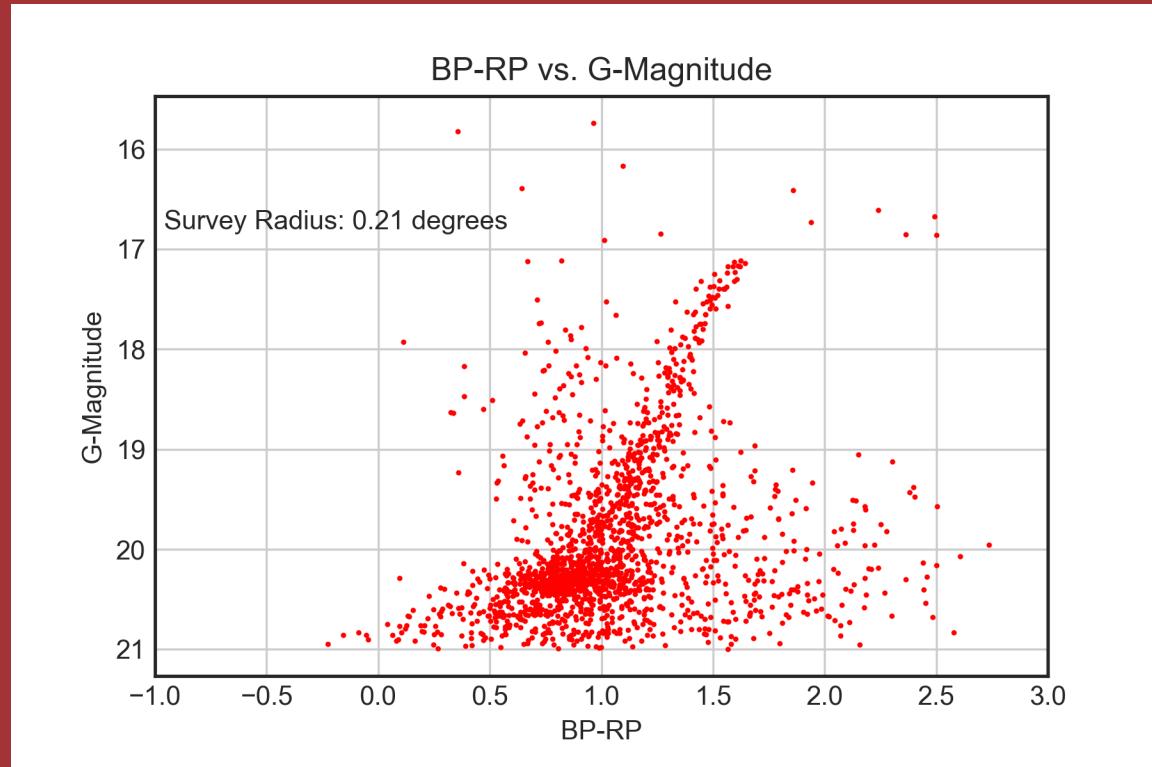


Data Flow



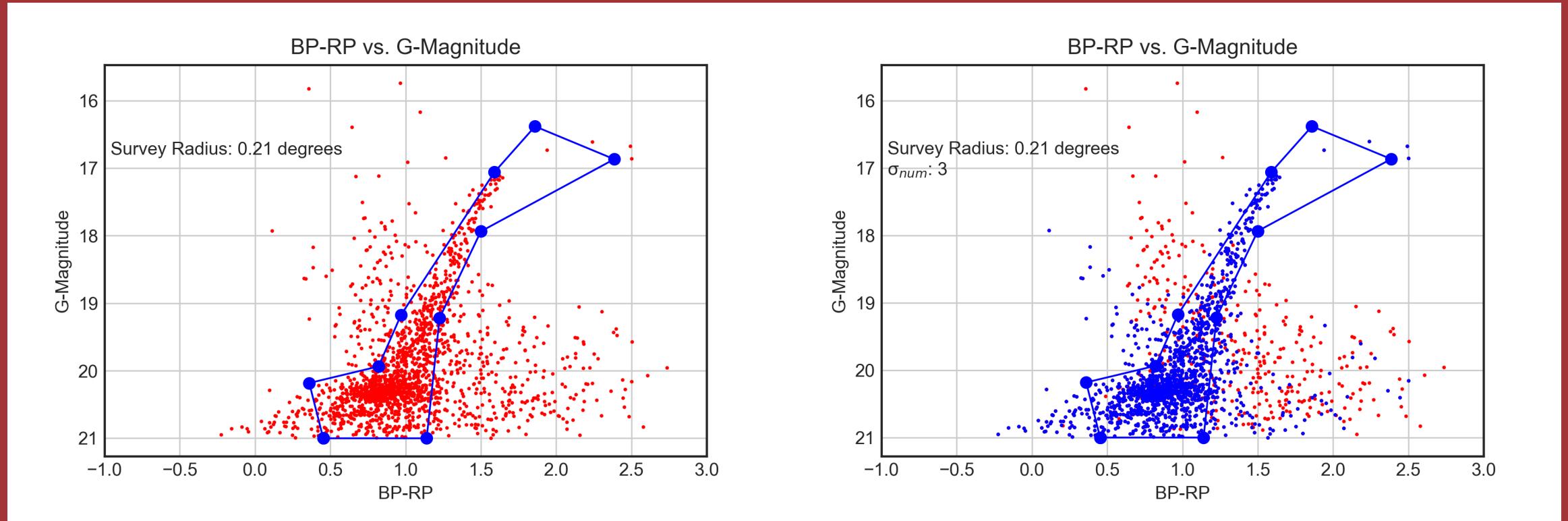
Gaia Collaboration et al. (2018b)

Data Flow



- An initial survey radius of 0.21 degrees contains mainly Carina member stars
- The color magnitude diagram clearly shows the giant branch and red clump
- The diagram guided the selection of bounds

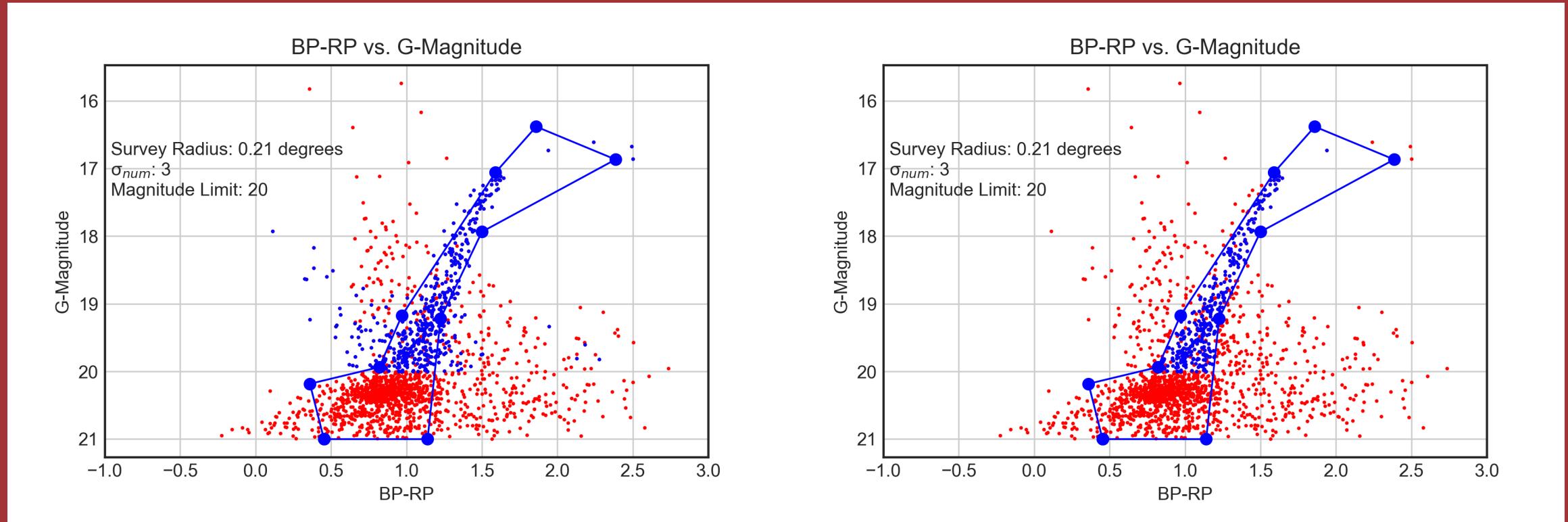
Data Flow



Bounds on the color-magnitude diagram

Proper motion selection

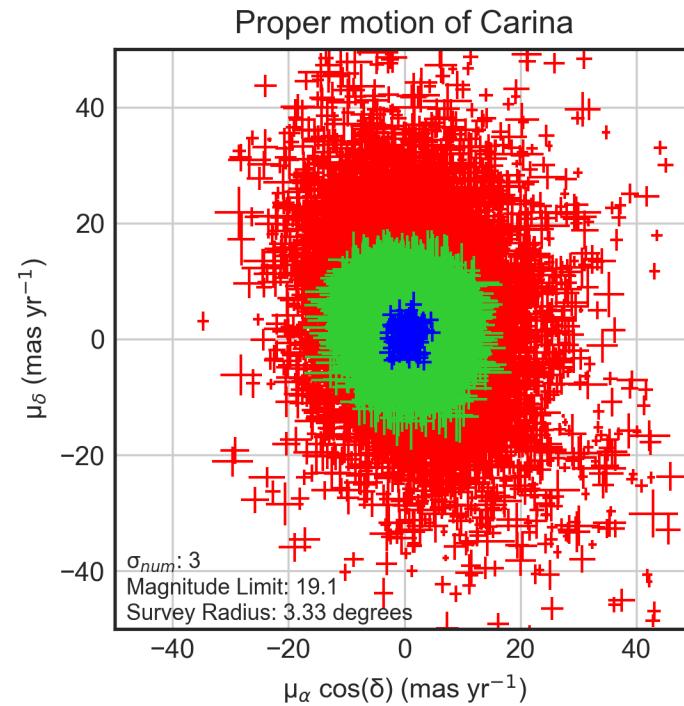
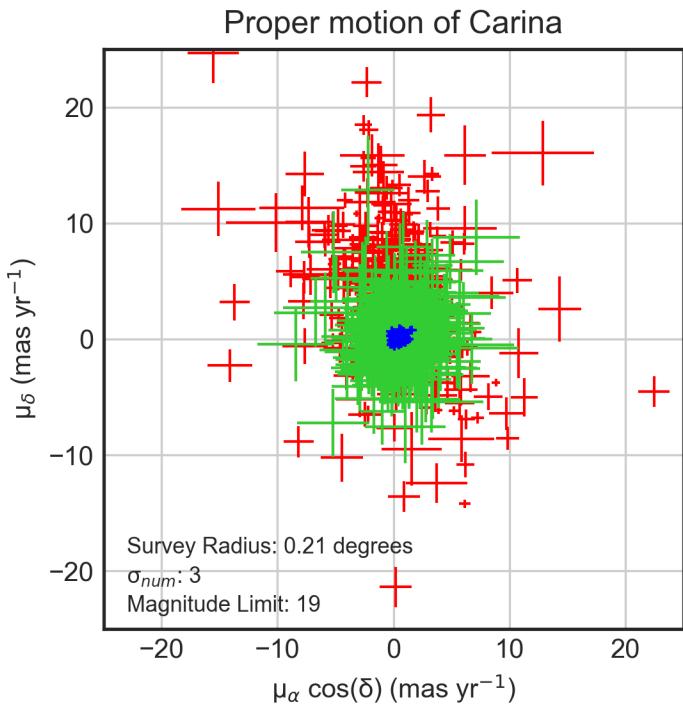
Data Flow



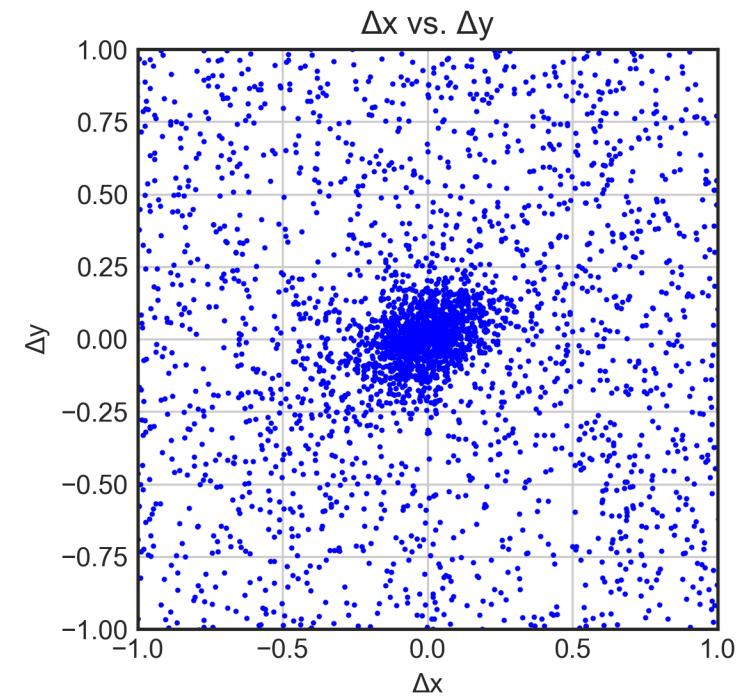
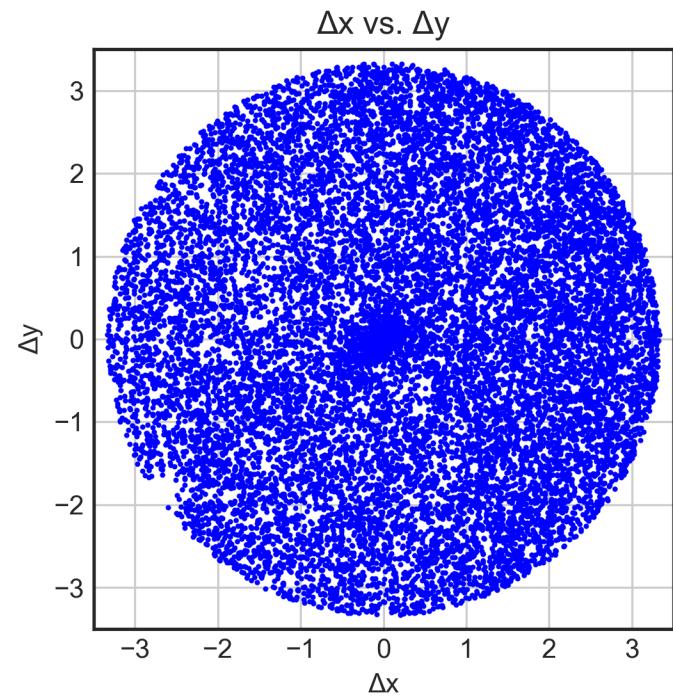
Magnitude limit

Photometric and Semi-major axis selection

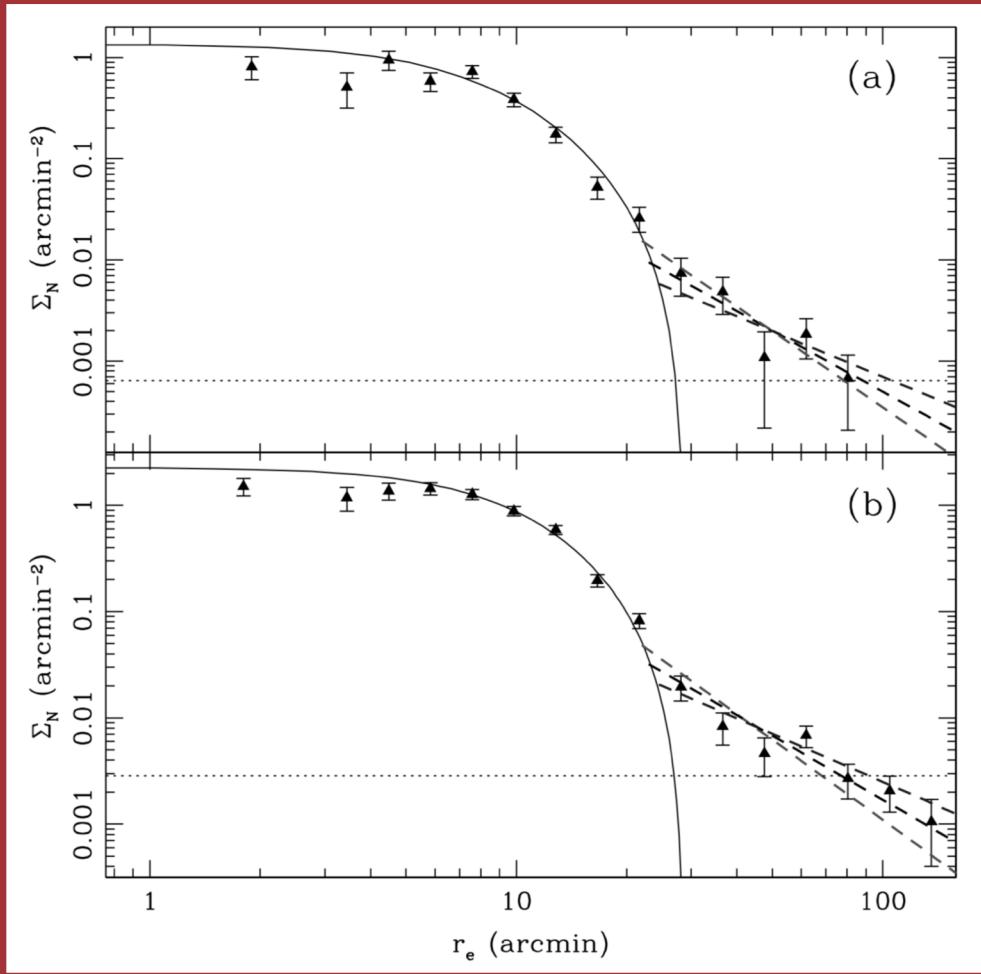
Proper Motion Problems



Tangent Plane Projection

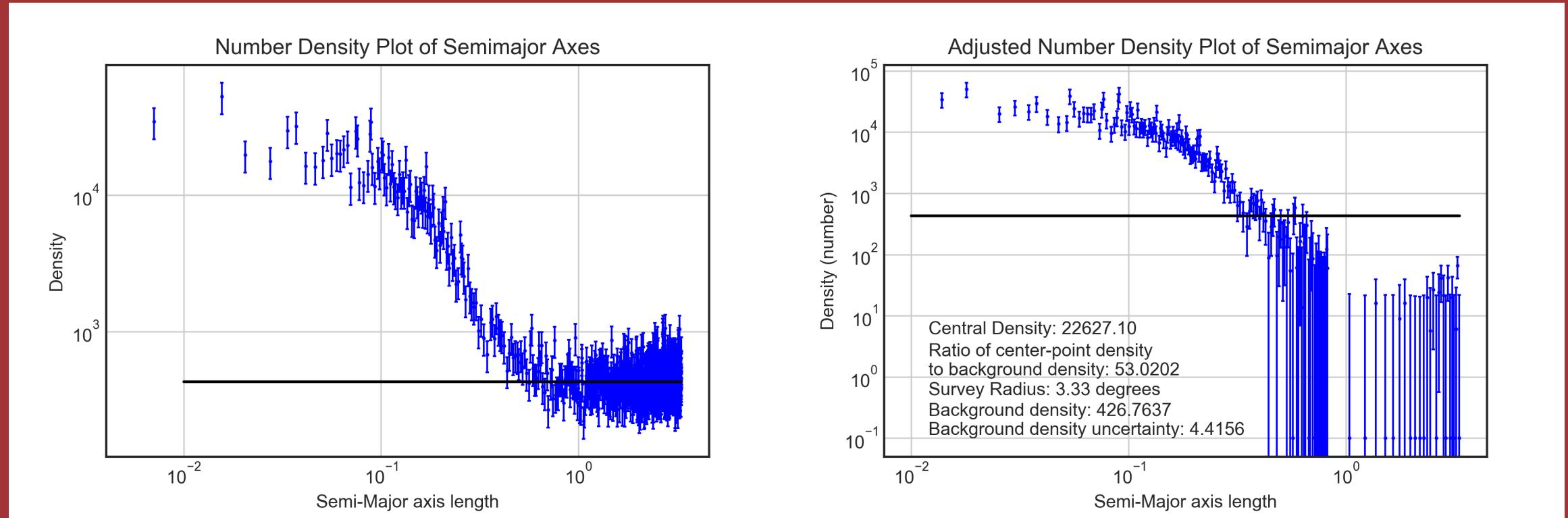


Previous findings

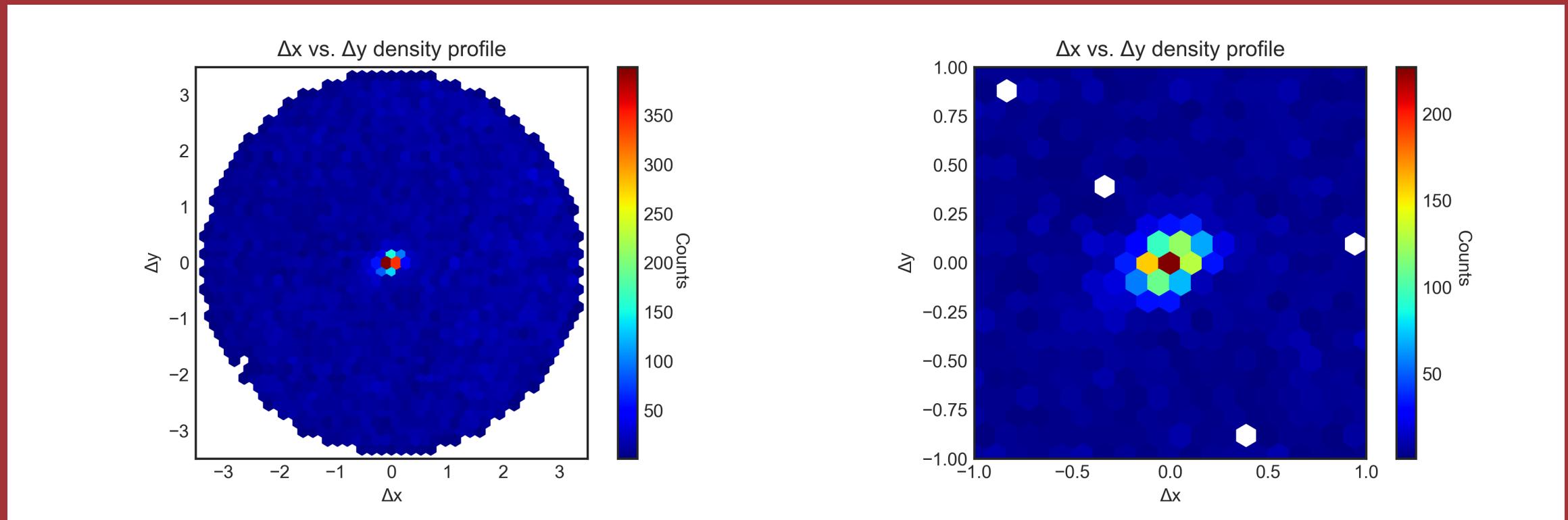


Munoz et. Al., 2006

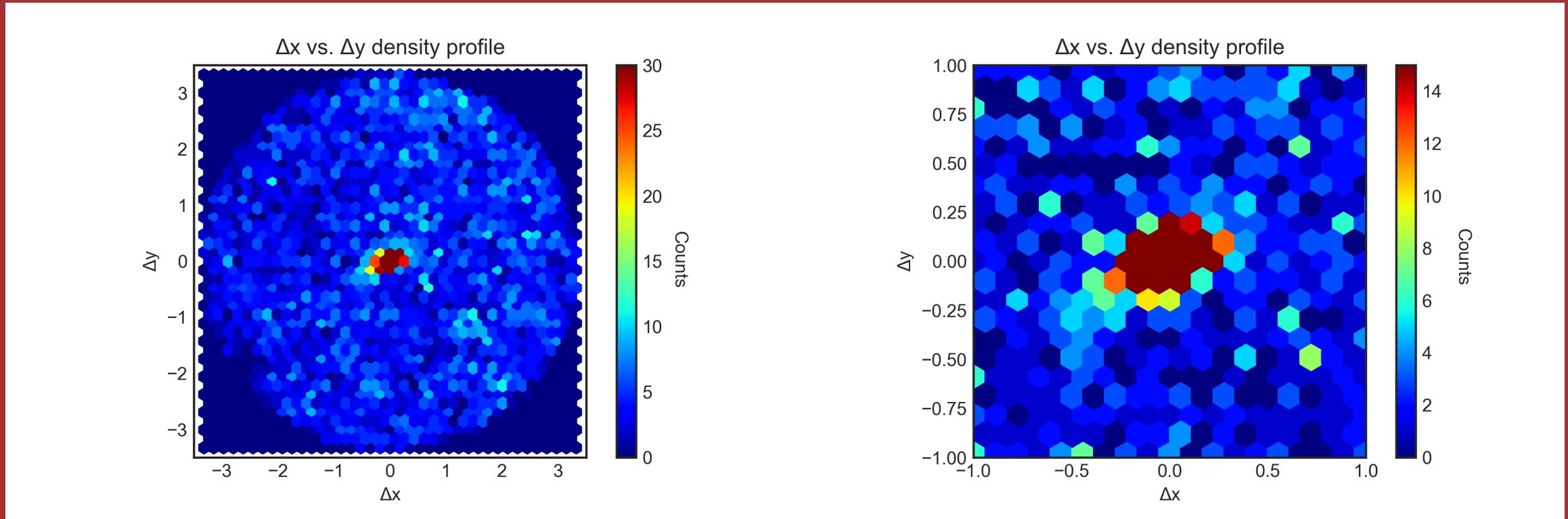
Radial Density Plots Before and After Background Subtraction



Tangent Plane Projection



Tangent Plane Projection



Conclusion

- No evidence of large-scale tidal tails
- Possible small-scale structure close to the galaxy
- No strong evidence of tidal effects in the radial profile
 - In conflict with Munoz et al. (2006)
- Future Gaia data releases will provide more precise data
 - Will allow better removal of foreground non-members using photometry and proper motions
 - Hence, allowing searches for fainter structures at larger radii

References

- Gaia Collaboration, Helmi, A., van Leeuwen, F., et al. 2018b, A&A, in press (arXiv:1804.09381)
- Muñoz, R. R., Majewski, S. R., Zaggia, S., et al. 2006, ApJ, 649, 201
- Gaia Collaboration, Brown, A.G.A., Vallenari, A., et al. 2018a, A&A, in press (arXiv:1804.09365)

Tools

- Matplotlib
- Rutgers University – New Brunswick
- Jupyter

Images

- ESO, and Y Beletsky. “VLT Panorama.” *Wikipedia.org*, 4 Apr. 2011, commons.wikimedia.org/wiki/File:Panoramic_Large_and_Small_Magellanic_Clouds.jpg.
- ESA. “GAIA All Sky Map.” *Www.esa.int*, 25 Apr. 2018, www.esa.int/spaceinimages/Images/2018/04/Gaia_s_new_map_of_star_density.
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