INFLUENCE OF THE MILKY WAY BAR ON HYPERVELOCITY STAR TRAJECTORIES

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CONTEXT

- **Hypervelocity stars** (HVS) are stars ejected from the center of the Milky Way via a **dynamical interaction** between a stellar binary and the super massive black hole, **Sgr A*** [1].
- The **Milky Way bar** influences the trajectory taken by HVS as they escape the Milky Way, deflecting them towards the bar.
- We use **computer simulations** measure **the deflection angle** between HVS position and velocity vectors in the Galacocentric rest frame (**β**); and **if this deflection is observable** (figure 1).
- Understanding how the bar influences HVS trajectory is necessary in order to use HVS as tools to answer more fundamental questions about galactic structure.

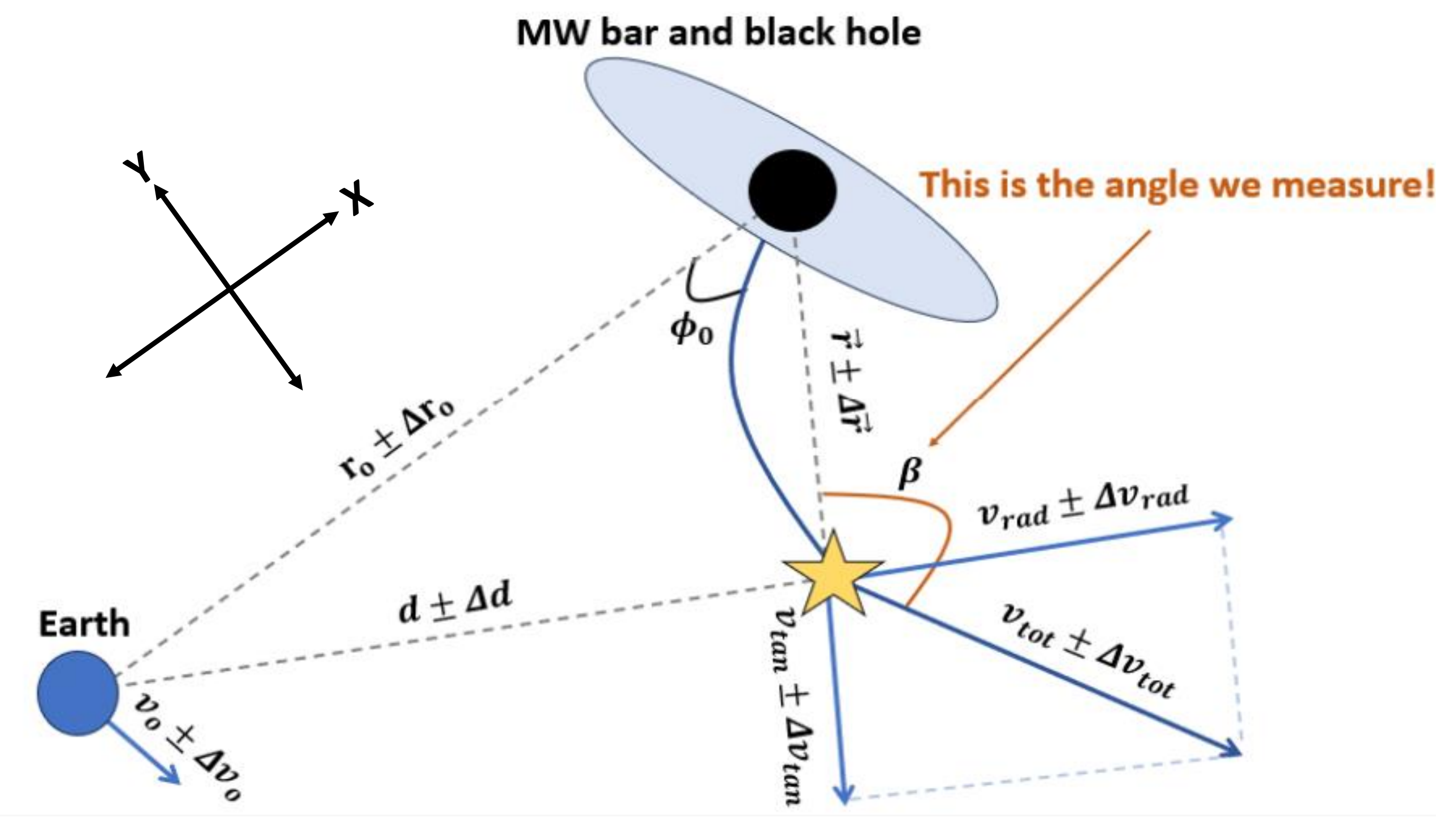

Figure 1: Diagram of the observational set up

METHOD

Creating the Sample

- We use the program Speedystar to produce initial conditions for a mock population of HVS [2].
- We then propagated the mock population through a Milky Way potential comprised of the galactic disk, bulge, central black hole, dark matter halo and the bar [3].
- We determine the apparent magnitude of each mock HVS in the Gaia bands using the MIST model grids [4].

Analysis

- We calculated the deflection angle β for all HVS fast enough to escape the Milky Way (figure 2).
- A subsample of observable HVS were selected to identify what portion of the population would appear in the Gaia data release 4 (DR4) radial velocity catalogue.
- Observational uncertainties in parallax, position, proper motion, and radial velocity based on Gaia DR4 predicted performance were applied to the subsample (figure 3) [5, 6]. Each measurement was sampled over to replicate observational conditions and determine whether the influence of the Milky Way bar is detectable in Gaia DR4.

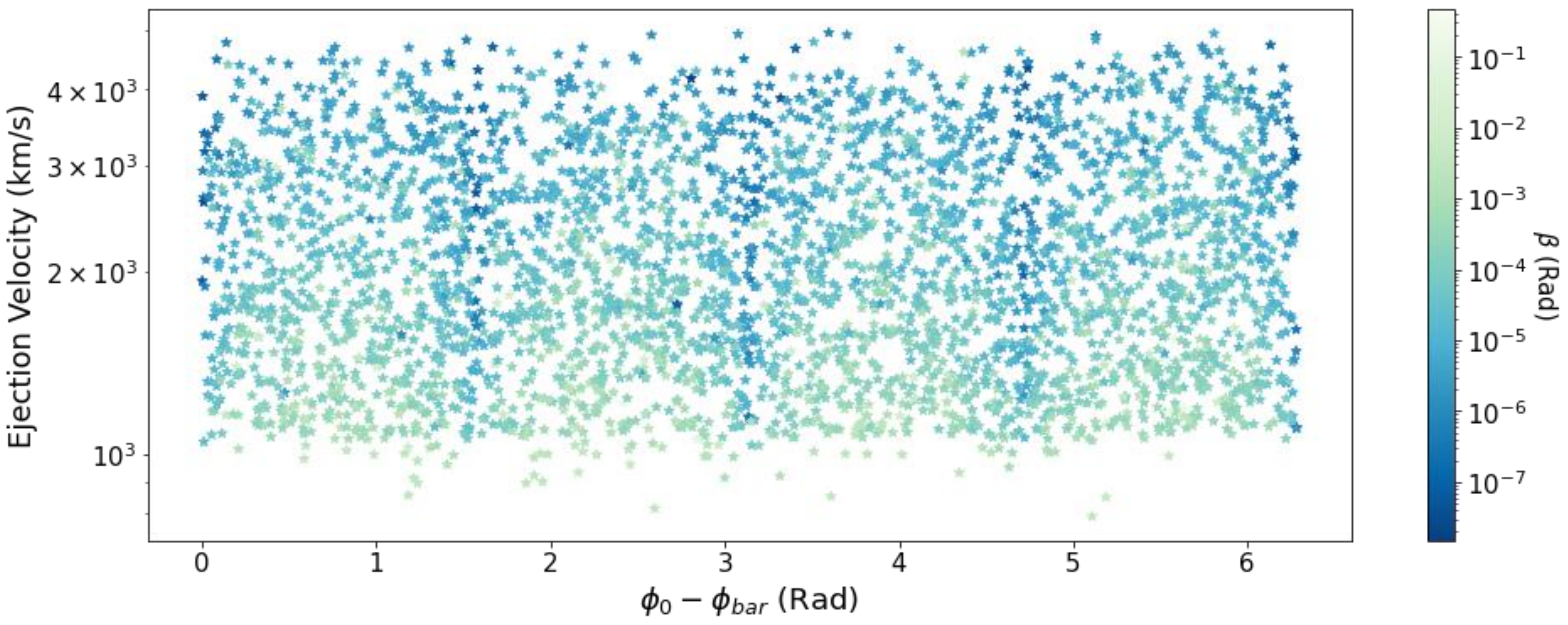

Figure 2: Ejection velocity vs the initial ejection angle and the coloured by size of β for the entire population. ϕ_0 is the initial ejection angle and ϕ_{bar} is the angle between the bar and the sun GC line.

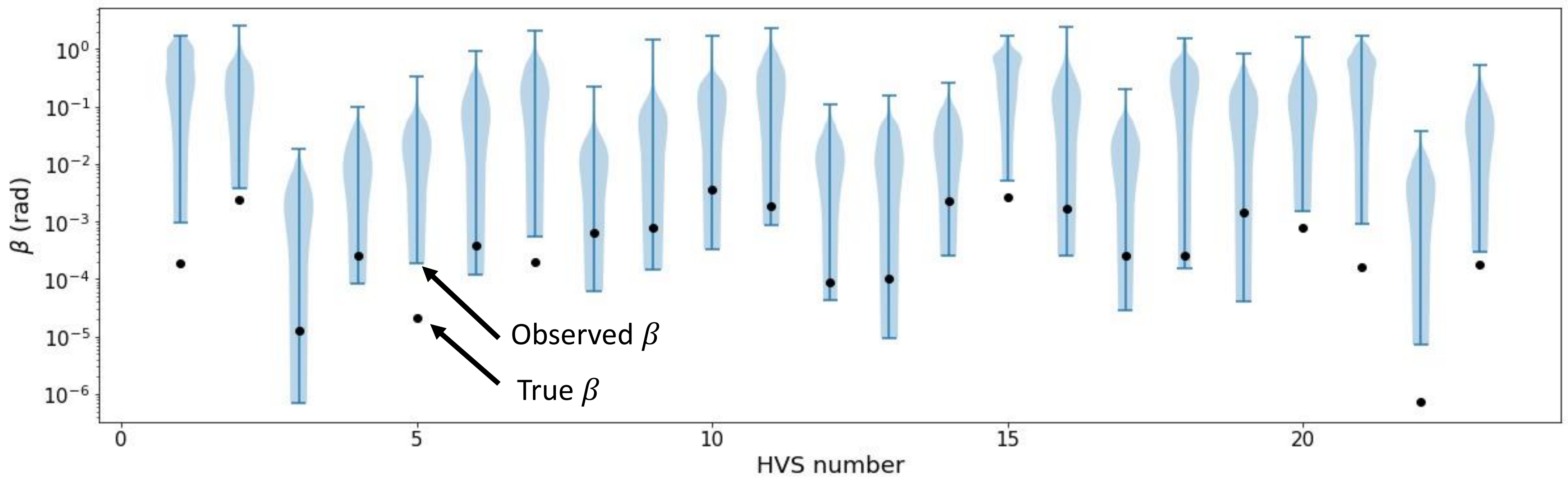

Figure 3: Blue bars plot observational uncertainty in β, with the true β value marked with a black dot for every observable HVS.

CONCLUSIONS

Bar deflection (β)

- The Milky Way bar produces maximum deflections in β up to the order 10^{-1} rads. However; observable deflections in β are between 10^{-4} to 10^{-3} rads.
- There is a weak dependence of β on the ejection velocity. HVS with higher ejection velocity are deflected less as they escape the Galactic Center faster and therefore are influenced less by the bar.
- HVS ejected parallel or perpendicular to the bar have the smallest values of β. This is due to the symmetry of the potential. These stars have trajectories directly radially outwards from their initial ejection location.

Observability

- For stars detectable in Gaia DR4, β is at most 10^{-2} rads.
- Among HVS detectable in Gaia DR4, measurement uncertainties will not be precise enough to constrain the true value of β.
- Uncertainty in parallax is the biggest contributor to measurement error, contributing nearly the same amount of uncertainty alone as all the measurement errors combined (figure 4). Improved constraints on the parallax are needed to reliably measure β.

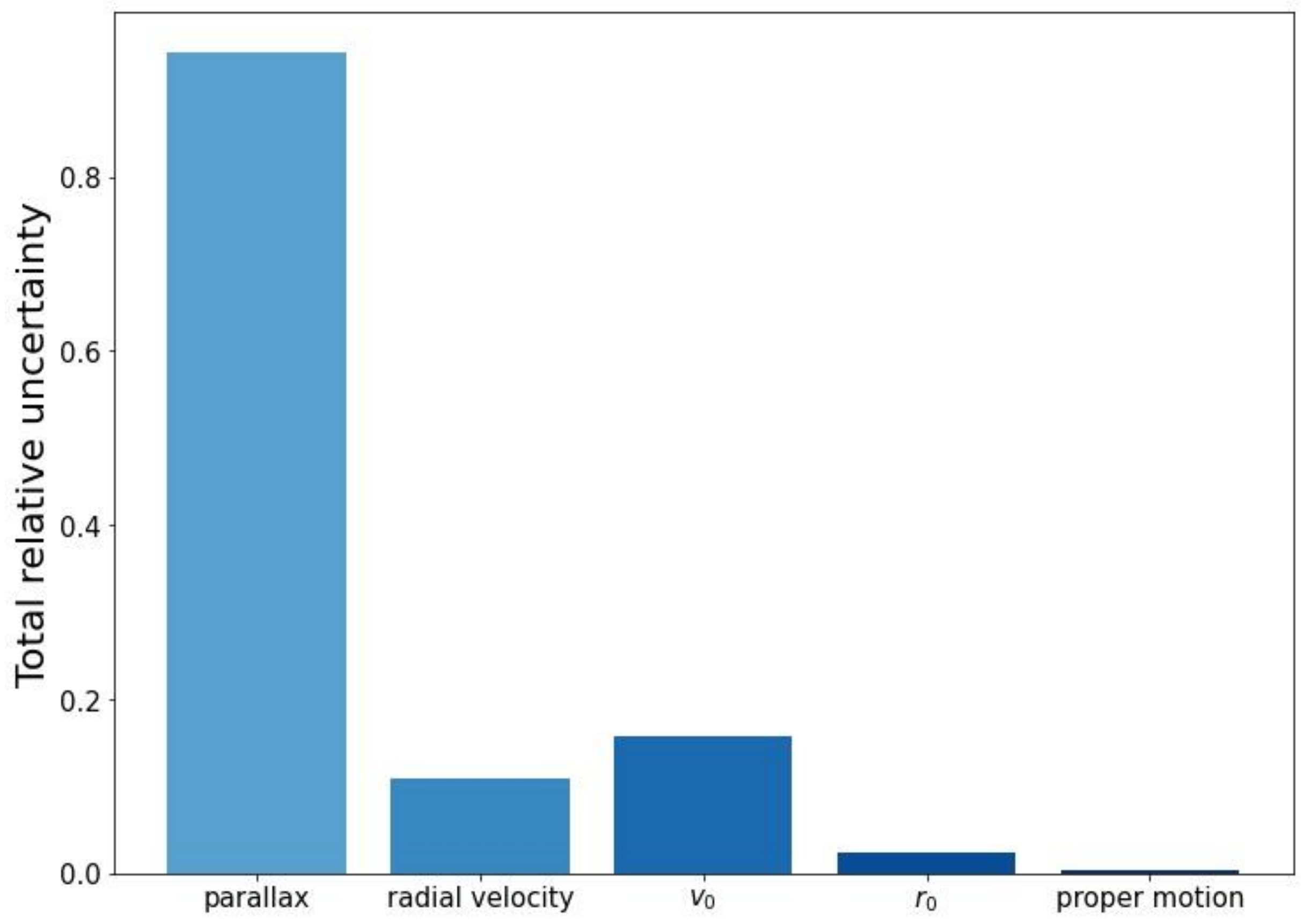

Figure 4: Plots $\Delta\beta_{single\ source}/\Delta\beta_{all\ sources}$ to illustrate how uncertainty in individual measurements contribute to the overall uncertainty in β.

Next Steps

- Model Gaia DR5/GaiaNIR uncertainties to investigate how HS detection improves and how β can be further constrained in the future
- Include the Large Magellanic Cloud in the potential model and investigate how its inclusion influences HVS trajectory and detection.

References and Acknowledgements

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Sources: [1] Hills J. G., 1988, Nature, 331, 687; [2] Evans F. A. et al., 2022, MNRAS, 517, 3469; [3] Bovy J., 2015, ApJS, 216, 29; [4] Choi J. et al., 2016, ApJ, 823, 102; [5] Everall A. et al., 2021, MNRAS, 502,1908; [6] Brown A. G. A., 2019, The Gaia Universe. P. 18