

Abstract

Our picture of the structure of the Milky Way is becoming increasingly detailed as continuous advances in astrometry are made with high-precision instruments such as GAIA. However, given our difficult observational position within the Galaxy, the picture is far from conclusive. On the other hand, the statistics of detected VHE sources has reached a level where details of the Galactic structure can influence the observations. In this contribution, we estimate the position of the Sun above the Galactic plane from the latitudinal profile of HGPS sources. We find model-dependent values in the range 60-108 pc, which are consistently larger than more precise measurements at other wavelengths. Our result implies that the observed source distribution is probably influenced by local features in addition to the position of the Sun.

Purpose

- Starting point
 - Latitudinal distribution of sources in the H.E.S.S. Galactic plane survey (HGPS) catalogue shows north-south asymmetry
 - Possibly an observational effect from the Sun being offset to the Galactic plane

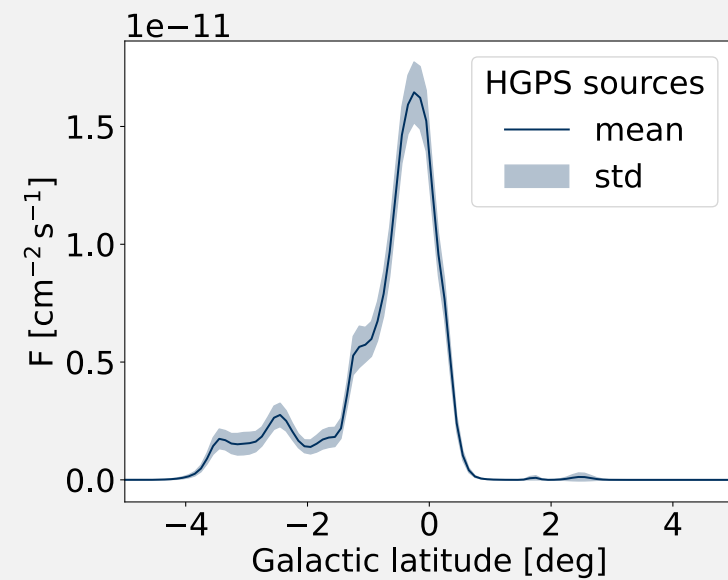


Figure 1: Latitude profile of HGPS sources.

- Aim
 - Estimation of the Sun's height z_{\odot}
 - Using population synthesis, compare different models for the spatial distribution of VHE γ -ray sources as in [1] (mPWN, mSNR, mSp4)

Method

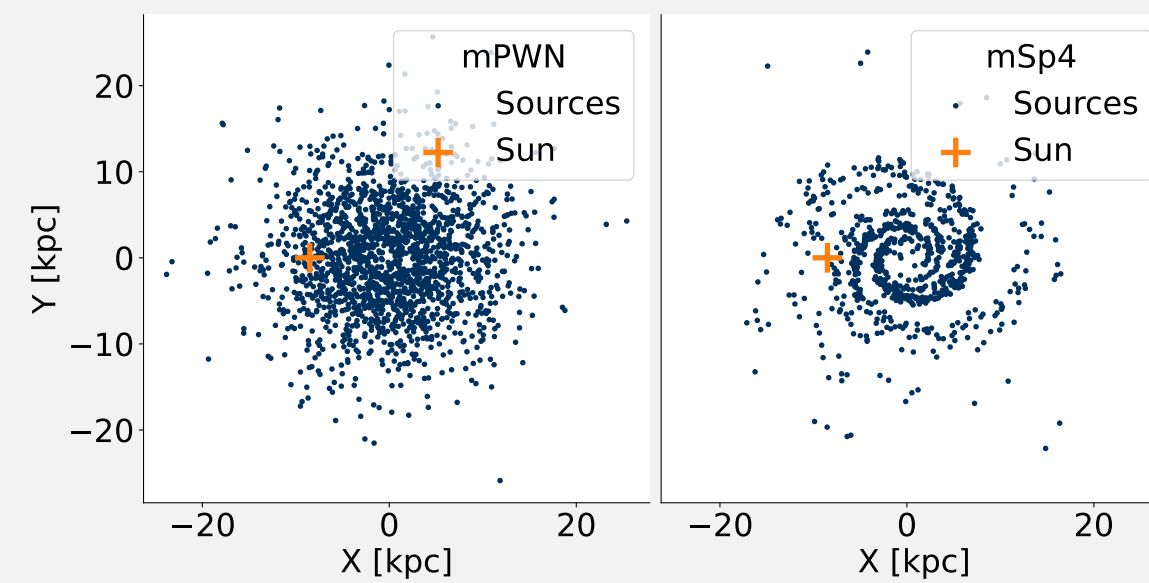


Figure 2: Two simulated source populations for different models of the spatial distributions.

- Simulate $n = 1000$ populations for each model
- For each synthetic population, calculate flux F in $m = 200$ latitude bins ($|b| \leq 10^\circ$) for detectable sources
- Minimise negative log-likelihood for HGPS sources considering a Gaussian distribution $\mathcal{N}(x | \mu, \sigma)$ with 30% systematic error on measured flux

$$\mathcal{L}(z_{\odot}) = \prod_{j=1}^m \text{Prob}(F_{\text{hgps}}(b_j) | z_{\odot}) \quad (1)$$

$$\text{Prob}(F_{\text{hgps}}(b) | z_{\odot}) = \frac{1}{n} \sum_{i=1}^n \mathcal{N}(F_{\text{hgps}}(b) | F_{\text{model},i}(b), 0.3 \cdot F_{\text{model},i}(b)) \quad (2)$$

Conclusion

- Measurements of VHE γ -ray sources are sensitive to the global structure of the Milky Way
- The asymmetry seen in the latitudinal profile of HGPS sources can partly be explained by the Sun's position being offset to the Galactic plane
- Our estimates of the Sun's height are model dependent and lie in the range 60-108 pc
- Despite the large uncertainties, our estimates lie consistently above more precise measurements at other wavelength, pointing towards local structures additionally affecting the VHE source distribution

Validation

- Procedure
 - Creation of 10^4 synthetic populations with randomly sampled z_{\odot} (z_{true}) for each model
 - Estimation of z_{\odot} (z_{reco}) with the described method
- Result
 - The method yields an unbiased estimate
 - The error is ~ 30 pc

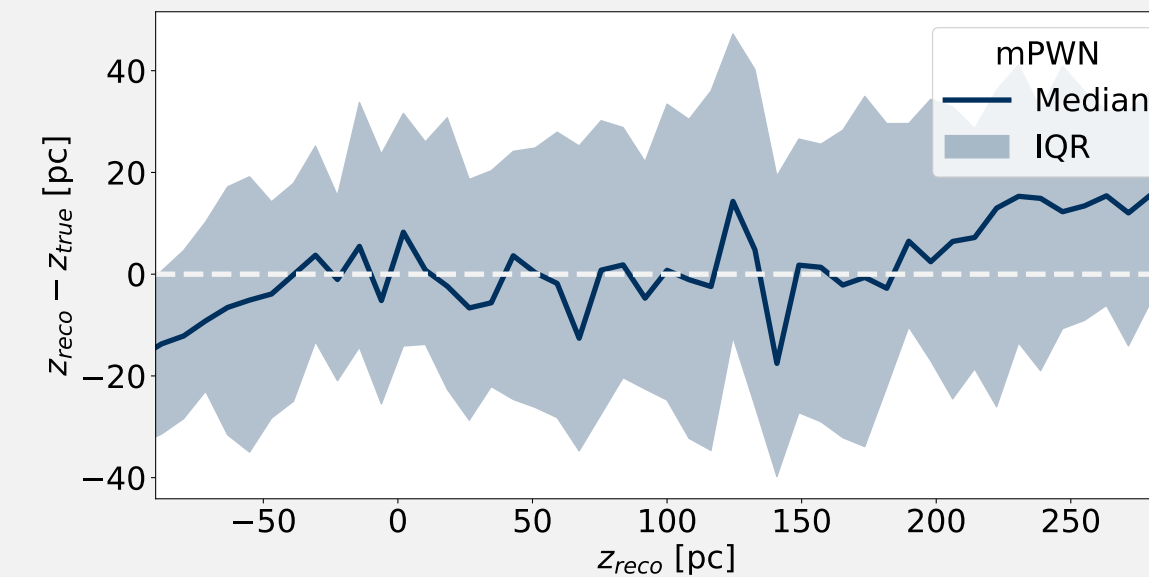


Figure 3: Reconstruction error, i.e. difference between simulated position of the Sun, z_{true} , and reconstructed position, z_{reco} , as function of z_{reco} . The solid line depicts the median over simulated populations with corresponding z_{reco} , while the shaded region depicts the interquartile range.

Result

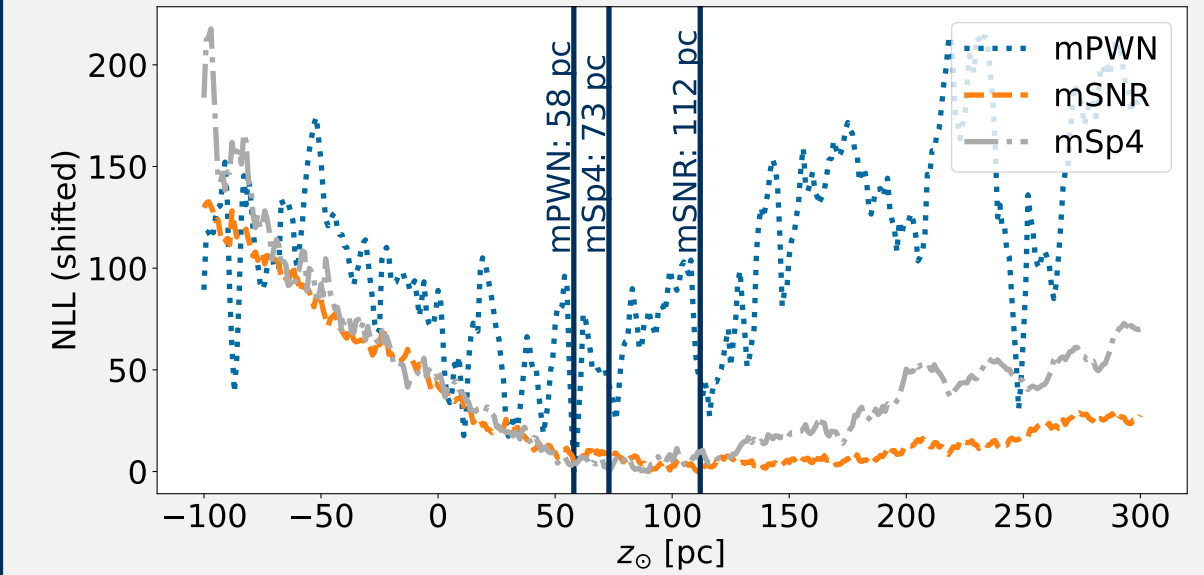


Figure 4: Negative log-likelihood (NLL) as function of z_{\odot} , shifted such that $\min(NLL) = 0$. Vertical solid lines mark the minimal values for the three models from which z_{reco} is derived.

- Final values and errors calculated from the distribution $P(z_{\text{true}} | z_{\text{reco}})$ derived from simulations
- Values are consistently larger than recent measurements ($z_{\odot} \sim 20$ pc) [2,3]

| | mPWN | mSNR | mSp4 |
|------------------|------------------|------------------|-------------------|
| z_{\odot} [pc] | 60^{+25}_{-31} | 59^{+32}_{-24} | 108^{+69}_{-37} |

Table 1: Estimates of the Sun's position over the Galactic plane. Given are the median and interquartile range of the respective $P(z_{\text{true}} | z_{\text{reco}})$ distribution.

References

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- T. Karim and E.E. Mamajek, *Revised geometric estimates of the North Galactic Pole and the Sun's height above the Galactic mid-plane*, MNRAS **465** (2017) 472 [1610.08125].
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Authors



Constantin Steppa
steppa@uni-potsdam.de



Kathrin Egberts
kathrin.egberts@uni-potsdam.de