Calibration of the TRGB method using Galactic Globular Clusters

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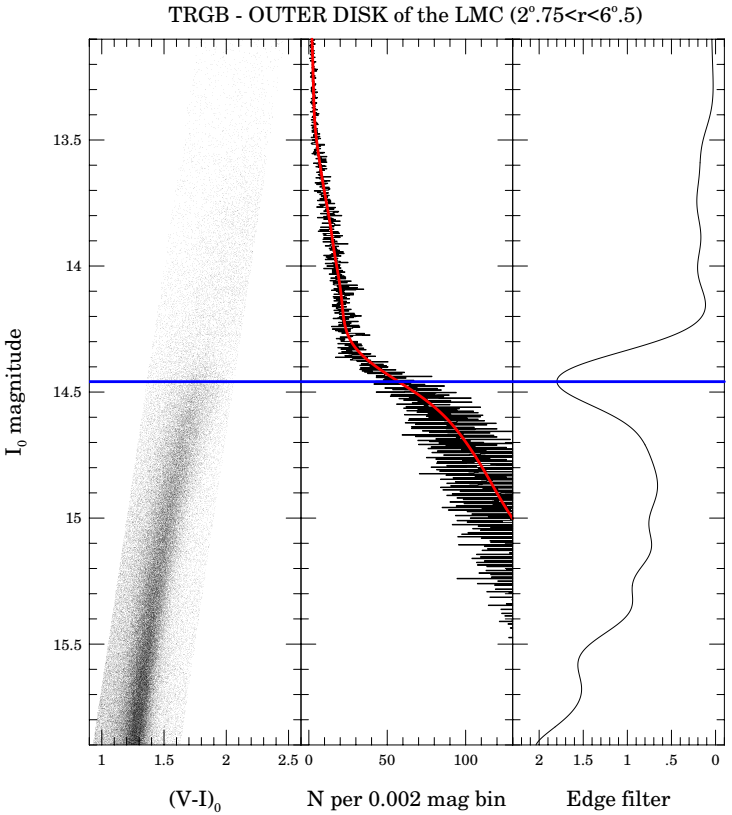
Overview Talk

- Introduction
- Sample of GCC, and the TRGB
- Methodolgy: distance or parallax space
- Statistical corrections
- (Preliminary) Conclusions

Introduction

Tip of the Red Giant Branch

- Use edge-detection method, or LF-fitting
- Typically in the I-band



Udalski et al. (2025)
"The Ultimate I-band Calibration of the TRGB Standard Candle"
$M_{\rm I} = -4.022 \pm 0.006(stat.) \pm 0.033(syst.)$

(Li & Beaton 2024 in "The Hubble Constant Tension"; 2403.17048)

TRGB in GCC

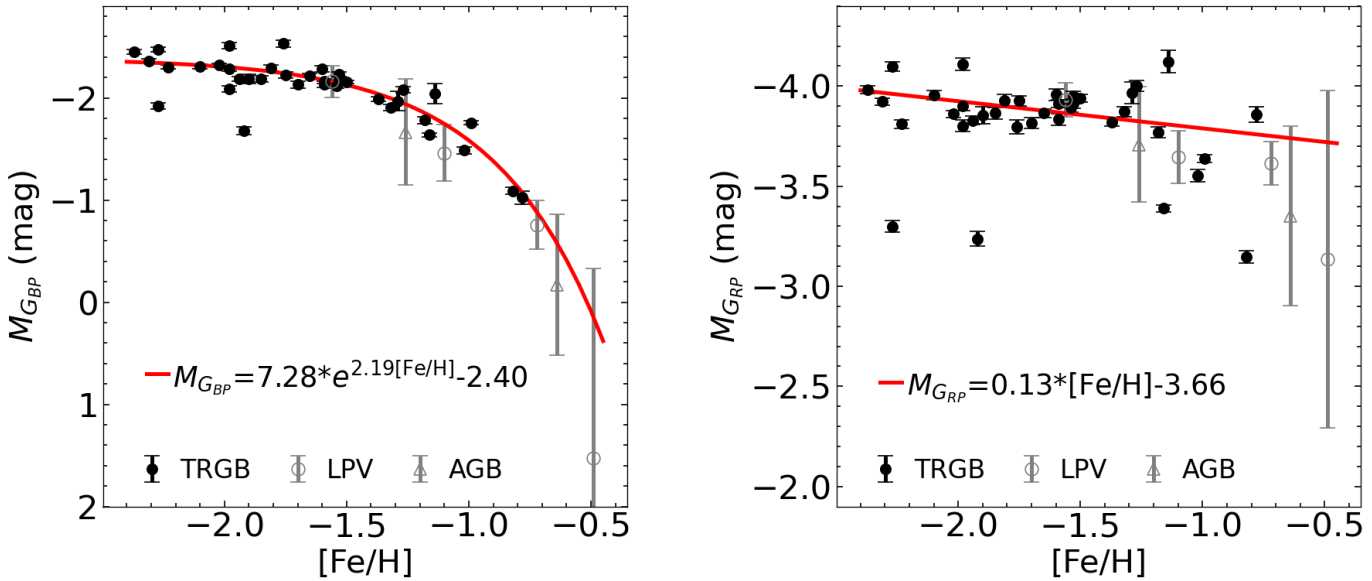
Hybrid-method:
Cerny et al. (2020) ;
Cruz-Reyes, Anderson & Lengen(2026)

Using absolute or relative distances construct a composite CMD, and then perform edge-detection.
(ZAHB + EB in ω Cen ;
GDR3 parallaxes to GCC (Lengen et al. 2026))

$$M_{\rm I} = -4.056 \pm 0.02(stat) \pm 0.10(sys)$$
$$M_{\rm I} = -3.948^{+0.037}_{-0.034}$$

TRGB in GCC

Individual GCC:
Shao et al. 2025: 43 selected clusters with at least 1000 members from Vasiliev & Baumgardt (2021)



$$M_{\rm I} = 10.47 \cdot \exp(3.92 \cdot [Fe/H]) - 4.017$$

I, V, $B_{\rm p}$, $R_{\rm p}$, J, K

This work

Shao et al. 2025: 43 selected clusters with at least 1000 members from Vasiliev & Baumgardt (2021)

Basis is *Gaia* data: G, R_p, B_p data, SID.

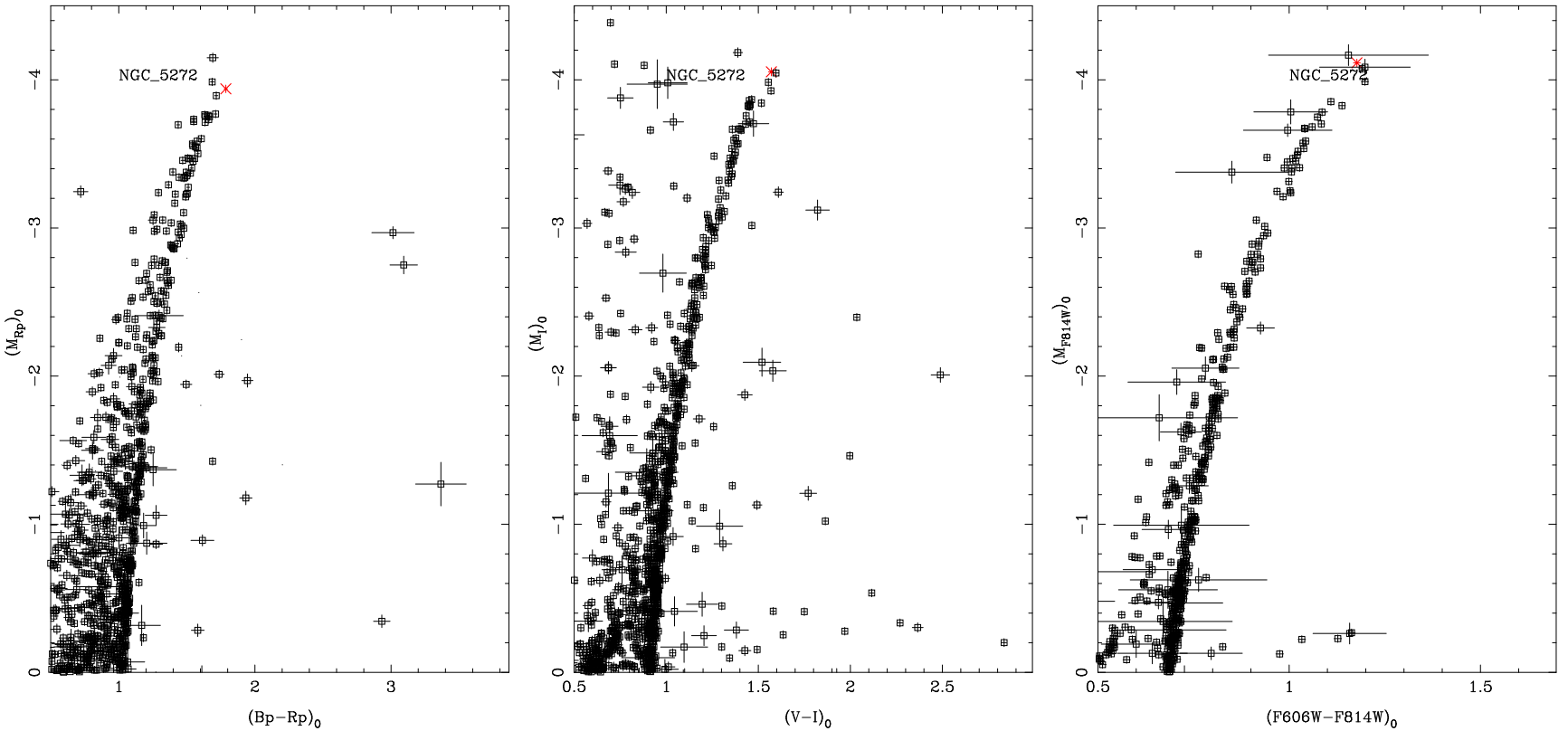
Distances from Baumgardt & Vasiliev (2021)

Name	GEDR3 parallax dist. [kpc]	GEDR3 kin. dist. [kpc]	HST kin. dist. [kpc]	Subdwarf dist. [kpc]	Star Count dist. [kpc]	Lit. dist. [kpc]	Mean distance [kpc]	N_{Tot}
NGC 104	$4.367^{+0.189}_{-0.174}$	4.533 ± 0.067	4.522 ± 0.085	$4.406^{+0.165}_{-0.159}$	4.779 ± 0.197	$4.512^{+0.040}_{-0.039}$	$4.521^{+0.031}_{-0.031}$	33
NGC 288	$7.692^{+0.731}_{-0.615}$	9.814 ± 0.576	9.098 ± 0.348	$9.333^{+0.350}_{-0.338}$	8.798 ± 0.446	$8.983^{+0.096}_{-0.095}$	$8.988^{+0.089}_{-0.088}$	23
NGC 362	$9.099^{+0.317}_{-0.296}$	8.267 ± 0.646	9.202 ± 0.321	$8.790^{+0.330}_{-0.318}$	8.707 ± 0.374	$8.770^{+0.114}_{-0.112}$	$8.829^{+0.096}_{-0.096}$	21
NGC 1261	-	-	16.775 ± 0.872	$16.293^{+0.611}_{-0.589}$	16.680 ± 0.726	$16.353^{+0.205}_{-0.202}$	$16.400^{+0.192}_{-0.190}$	15
NGC 1851	-	-	11.440 ± 0.320	$12.303^{+0.462}_{-0.445}$	12.376 ± 0.528	$12.017^{+0.156}_{-0.154}$	$11.951^{+0.134}_{-0.133}$	18
NGC 1904	-	-	-	-	-	$13.080^{+0.182}_{-0.179}$	$13.078^{+0.181}_{-0.179}$	13
NGC 2298	-	-	-	$10.000^{+0.471}_{-0.450}$	7.471 ± 1.208	$9.890^{+0.175}_{-0.172}$	$9.828^{+0.170}_{-0.167}$	10

I-band from Stetson

HST ACS data (F606W, F814W) from Sarajedini (through the CDS)

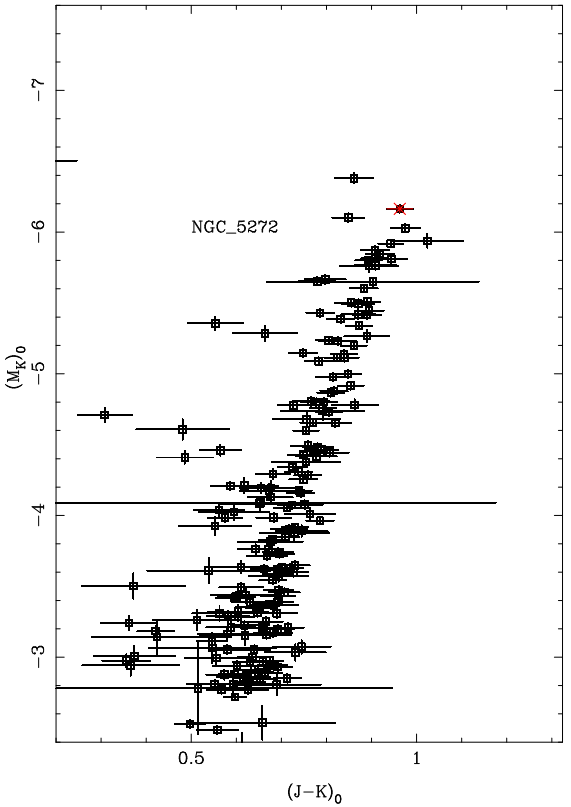
This work

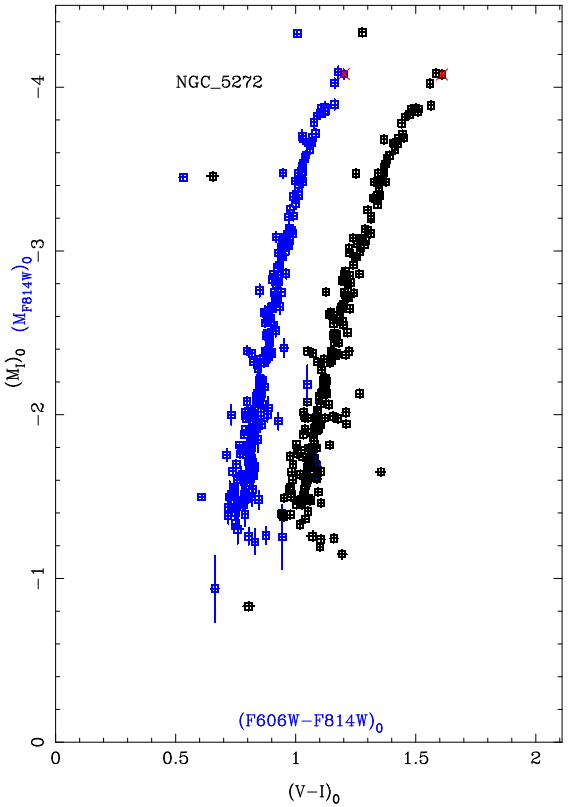


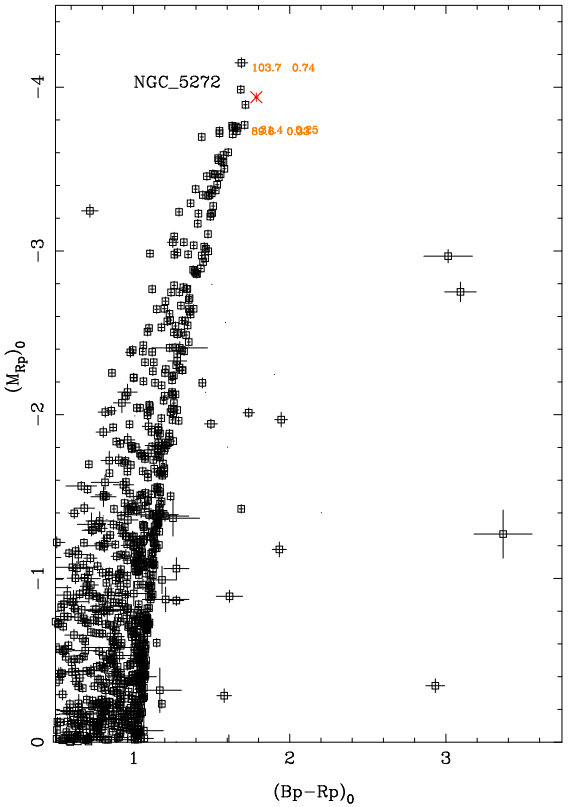
Take all stars from slightly brighter to 1.5 mag fainter in R_p (over all clusters)

List of about 6500 RGB stars is correlated with 2MASS, Gaia synthetic photometry, Gaia LPV catalog, LPV catalog of Clement et al. (2001)

This work


NGC_5272
$(M_K)_0$
$(J-K)_0$


NGC_5272
$(M_I)_0$ $(M_{F814W})_0$
$(F606W-F814W)_0$
$(V-I)_0$


NGC_5272
$(M_{Rp})_0$
$(Bp-Rp)_0$

Formulation

$$M_0 = m_0 - 5 \log d + 5 = f(x)$$

where $f(x)$ can either be a linear $l(x) = a + b\,x$
or exponential $e(x) = a\ \exp(b\,x) + c$
(following Shao et al.) and where x can be the [Fe/H] or the dereddened colour.

$$\pi\, 10^{0.2\ (m_0 - 10)} = F(x) \tag{1}$$

where $F(x)$ can either be the linear $L(x) = 10^{0.2\ (a + b\,x)}$
or exponential $E(x) = 10^{0.2\ (a\ \exp(b\,x) + c)}$

Statistical correction

1) PARSEC tracks (Bressan 2012)
Age, $\log\ L$, $\log T_{\rm eff}$, mass, and abundances of
H, He, C, N, and O ([Fe/H]) of all points in the RGB phase within 1 dex in $\log\ L$ below the TRGB were stored.
2) This information is fed to the YBC PARSEC bolometric correction tool (Chen et al. 2019)
3) $N_{\rm mc}$ simulations of N= 20 ... 5000 stars.
3a) Store magnitudes of true TRGB.
3b) Randomly draw N RGB stars.
3c) The brightest is taken as the simulated TRGB star.
How many are within 1.5 mag in Rp.
3d) Calculate the difference in magnitudes between simulated and true TRGB star.
3e) Take the median over the $N_{\rm mc}$ simulations as representative.

Results

Statistical correction in an individual cluster

N=10 $R_{\rm p}, I \sim 0.15$, $K_{\rm s} \sim 0.20$ mag

N=15 $R_{\rm p}, I \sim 0.034$, $K_{\rm s} \sim 0.036$ mag

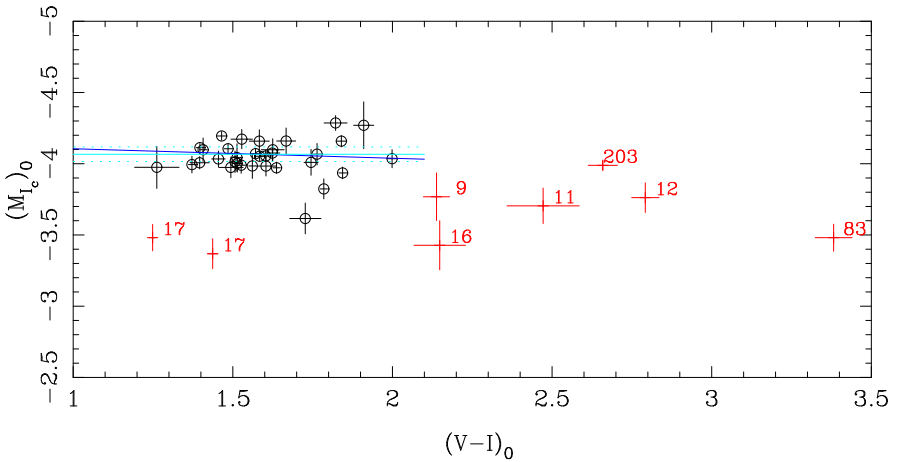
N=85 $R_{\rm p}, I \sim 0.016$, $K_{\rm s} \sim 0.018$

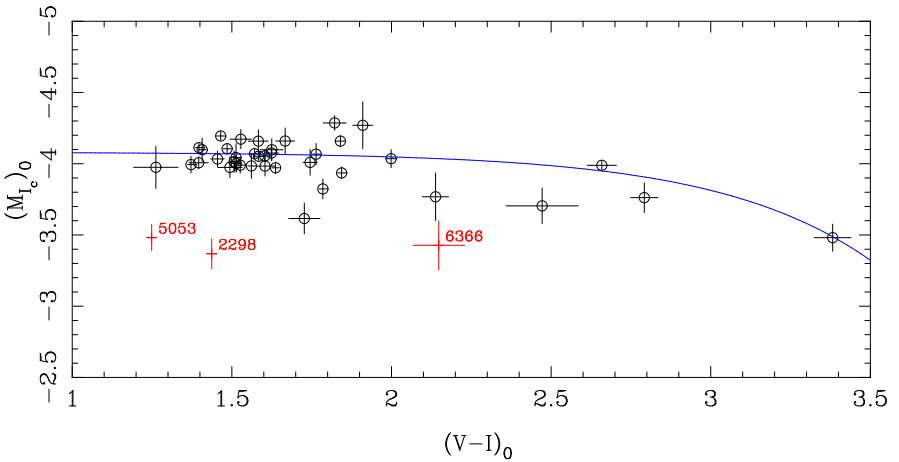
Solving in distance space using

Vasiliev & Baumgardt (2021)

Solving in parallax space using

Lengen et al. (not for all clusters!)

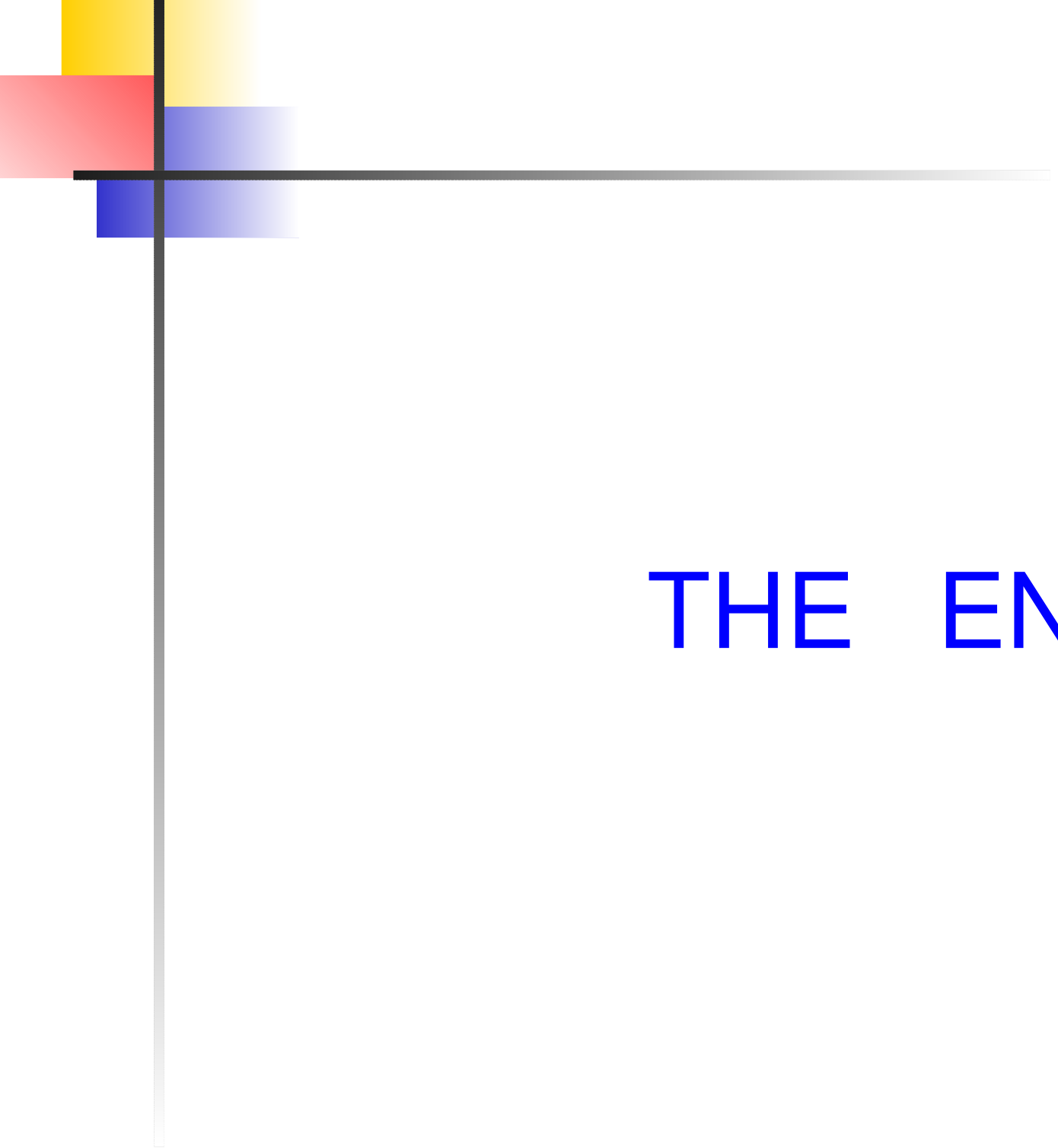




Summary

Type of fit		[Fe/H]	Colour
Linear Distance		-4.08	-4.07
Exponential Distance		-4.09	-4.08
Linear Parallax		-3.87	-3.86
Exponential Parallax		-3.85	-3.87
Lin. Dist.	No St. Corr	-4.03	
Exp. Dist.	No St. Corr	-4.04	
Lin. Plx.	No St. Corr	-3.82	
Exp. Plx.	No St. Corr	-3.81	
Linear Parallax	1/VB21	-4.07	
Exponential Parallax	1/VB21	-4.10	

Vasiliev & Baumgardt (2021) and Lengen et al. (2026) distance lead to different results.
Statistical correction makes TRGB about 0.05 mag brighter.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