# Bayesian analysis of stellar parameters in PTPS

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## Introduction

Mass is the most important parameter which determines internal structure and evolution of a star. In case of planet searches with the precise radial velocity measurements technique the stellar mass is required to estimate the minimum mass of a planetary companion. Precise mass determinations for stars are not simple, though. Best stellar mass measurements come from the Third Kepler Law which describes motion of two orbiting bodies. In the case of eclipsing binaries masses can be measured with an accuracy that depends on the quality of observational data only. Indirect stellar mass estimates usually use other characteristics adequate to the evolutionary stage i.e.: for the main sequence star the Eddington mass-luminosity relation (Eddington 1924), for white dwarfs the mass-radius relation (Panei et al. 2000). Another approach to obtain stellar mass is to compare stellar evolutionary models (Bertelli 2008; Bressan 2012) with available observational data delivered (detailed spectroscopically determined atmospheric parameters, photometry and parallaxes) for instance by isochrone fitting or bayesian probability approach.
The sample of stars comes from ongoing PennState-Toruń Centre for Astronomy Planet Search (PTPS, Niedzielski & Wolszan 2008) focused on detecting and characterazing planetary systems around stars at various evolutionary stages. It contains 332 relatively bright, field stars, mostly giant with G8-K2 spectral type. Atmospheric parameters required to mass, age and luminosity estimation was determined by Zieliński et al. (2012). Astrophysical parameters estimated by $\chi^2$ fitting of stellar atmospheric parameters are also presented there.

## Bayesian probability approach

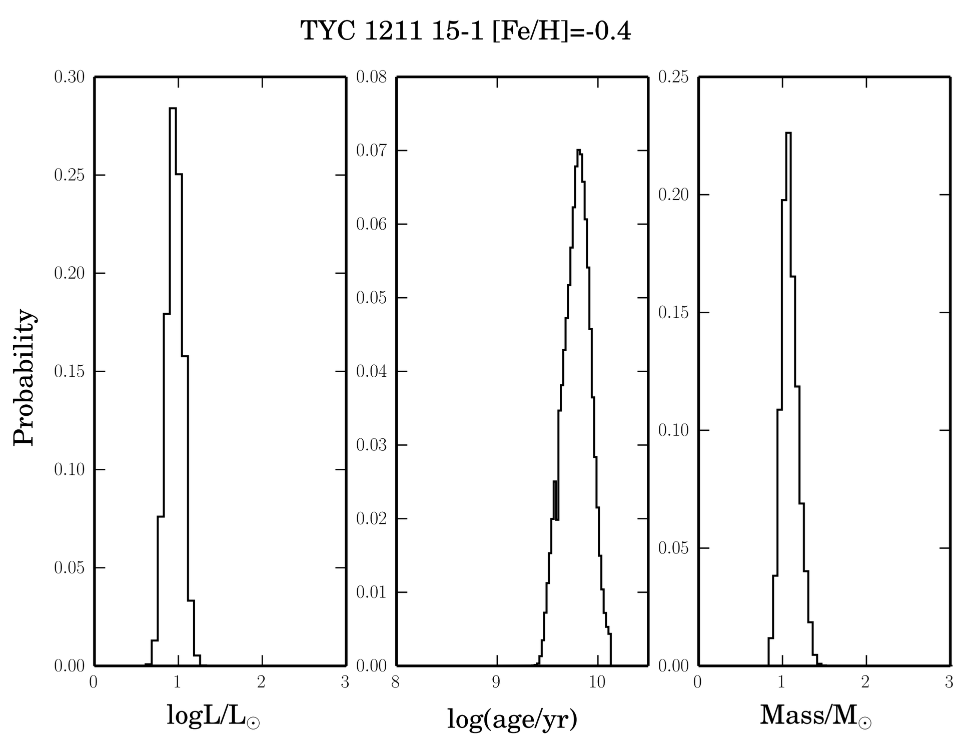
We implemented method based on Jorgensen & Lindegren (2005) formalism and modified by da Silva et. al. (2006) to avoid statistical biases and to take error estimates of observed quantities into consideration. For given star, represented by full set of available atmospheric parameters: $[Fe/H]_* \pm \sigma_{[Fe/H]_*}$, $\log T_{eff*} \pm \sigma_{\log T_{eff*}}$, $\log g_* \pm \sigma_{\log g_*}$ and $\log L_* \pm \sigma_{\log L_*}$ (if parallax available) and isochrone of $[Fe/H]$ and age $t$ we calculated in the range $[M_i^1, M_i^2]$ the probability:

$$P_{12} \propto \int_{M_i^1}^{M_i^2} \phi(M_i) dM_i \cdot \exp\left(-\chi^2\right)$$

with

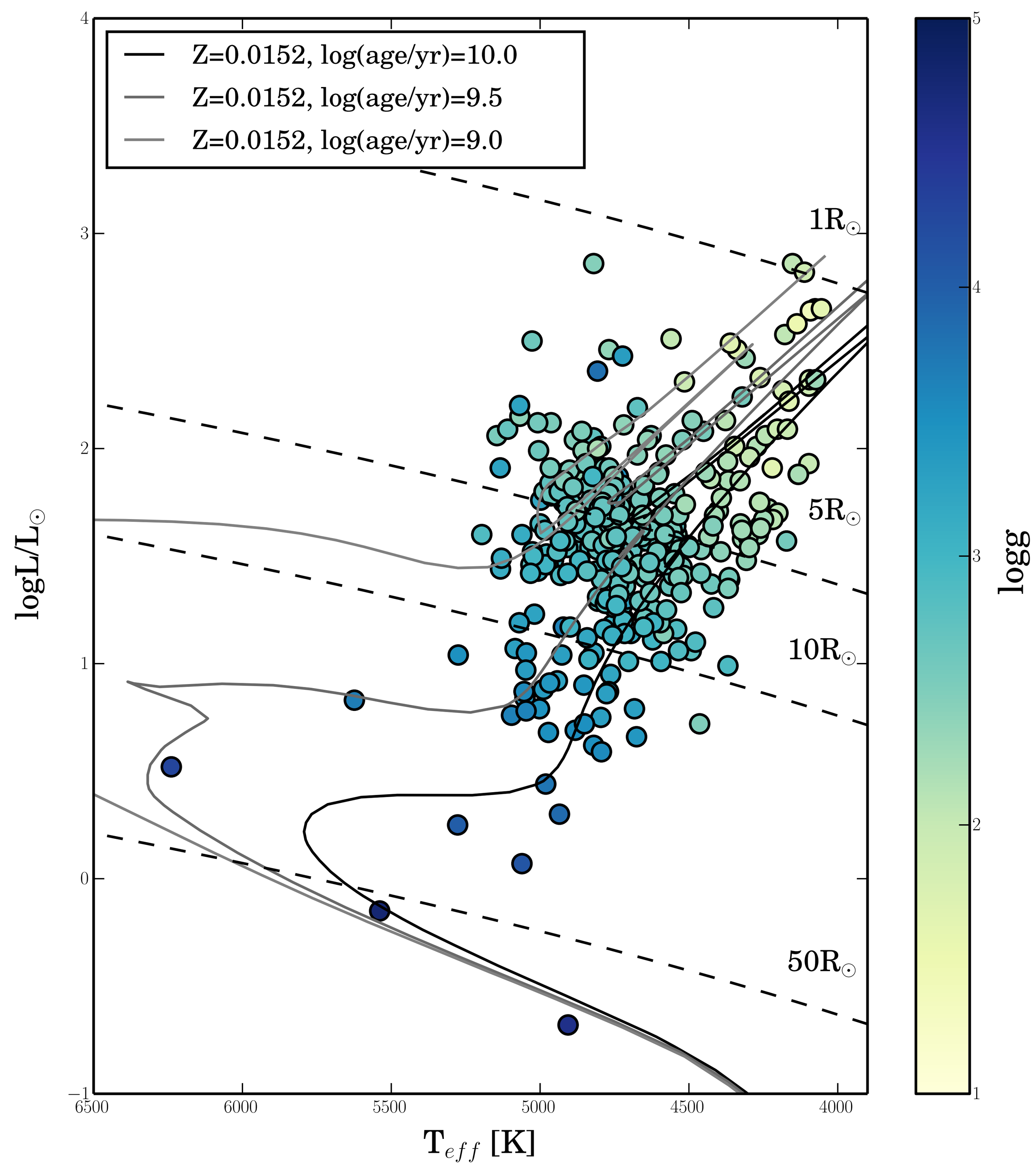
$$\chi^2 = \frac{(\log g - \log g_*)^2}{\sigma^2_{\log g_*}} + \frac{(\log T_{eff} - \log T_{eff*})^2}{\sigma^2_{\log T_{eff*}}}$$

and $\phi(m) \propto m^{-2.35}$ is the Initial Mass Function (Salpeter 1955). We further follow the procedure detailed in da Silva et. al. (2006) and calculate searched quantities (e.g. mass, luminosity and age) and their uncertainties from basic parameters (mean, variance) of the normalized PDFs. In comparison with other parameters the widest distribution and the lowest probability peak is present in the case of log(age/yr). As a consequence stellar ages obtained here are most uncertain.

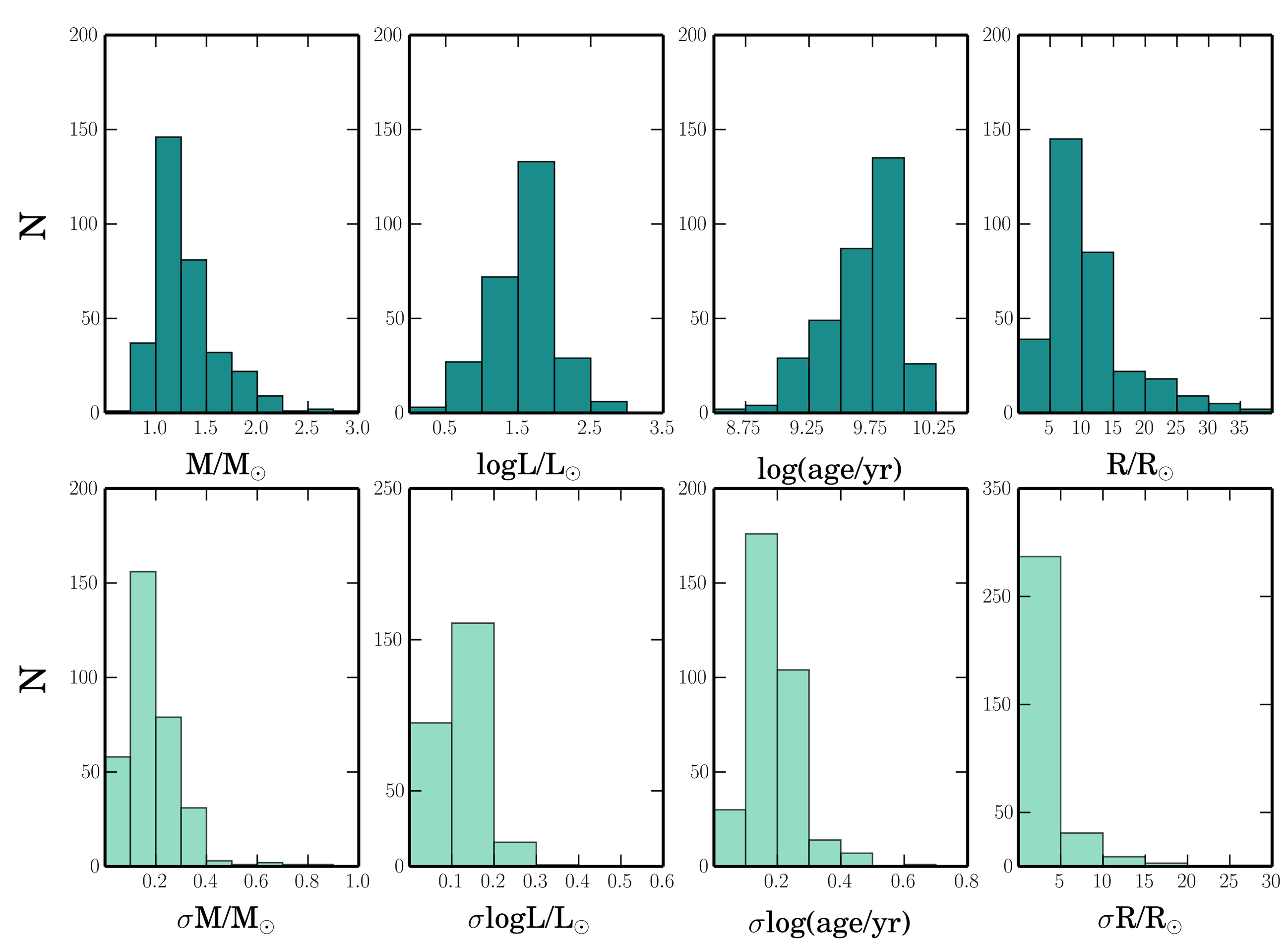



Example of PDF for TYC 1211 15.

## HRD for 332 PTPS stars

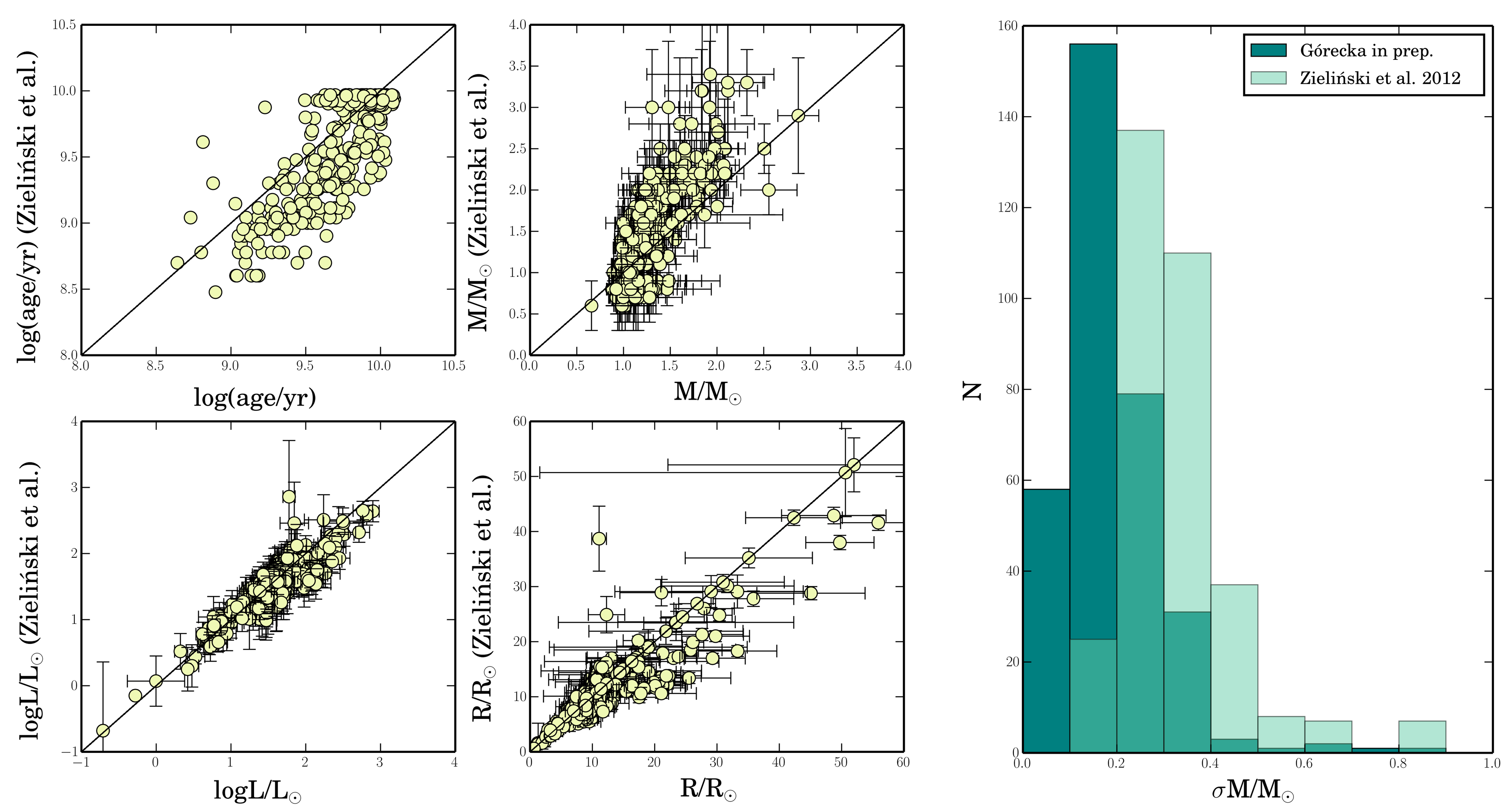



## Stellar parameters




Because of well estimated logarithm of surface gravity we implemented this parameter instead of absolute magnitude like da Silva et al. (2006).

## Comparison with Zieliński et al. 2012




Stellar masses obtained here, with average value of 1.3M$_\odot$ are generally lower (0.88) than those of Zieliński et al. (2012) - 1.5 M$_\odot$ but the abundant population of stars with masses is now absent. The resulting stellar masses are also more precise.

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