Unifying the CNO in the Galaxy

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1. INTRODUCTION & BACKGROUND

Our understanding of how the Milky Way formed is entering a new era. With surveys such as WEAVE, DESI, and 4MOST delivering millions of stellar spectra, the challenge is no longer obtaining data, but ensuring that chemical abundances measured by different instruments and pipelines can be directly compared.

To help address this, we are building a homogeneous, high-precision reference for carbon, nitrogen, and oxygen abundances using the ESO UVES archival data. Our goal is ambitious: to measure C, N, and O for every available high-resolution UVES spectrum. Starting with a sample of metal-poor stars with [Fe/H] < −2.0, creating a benchmark dataset that can be used to calibrate and homogenise abundances across present and future spectroscopic surveys.

C, N, and O are among the most important tracers of stellar nucleosynthesis and Galactic chemical evolution. Their abundances provide key constraints on the formation history of the Milky Way and the nature of its earliest stellar populations.

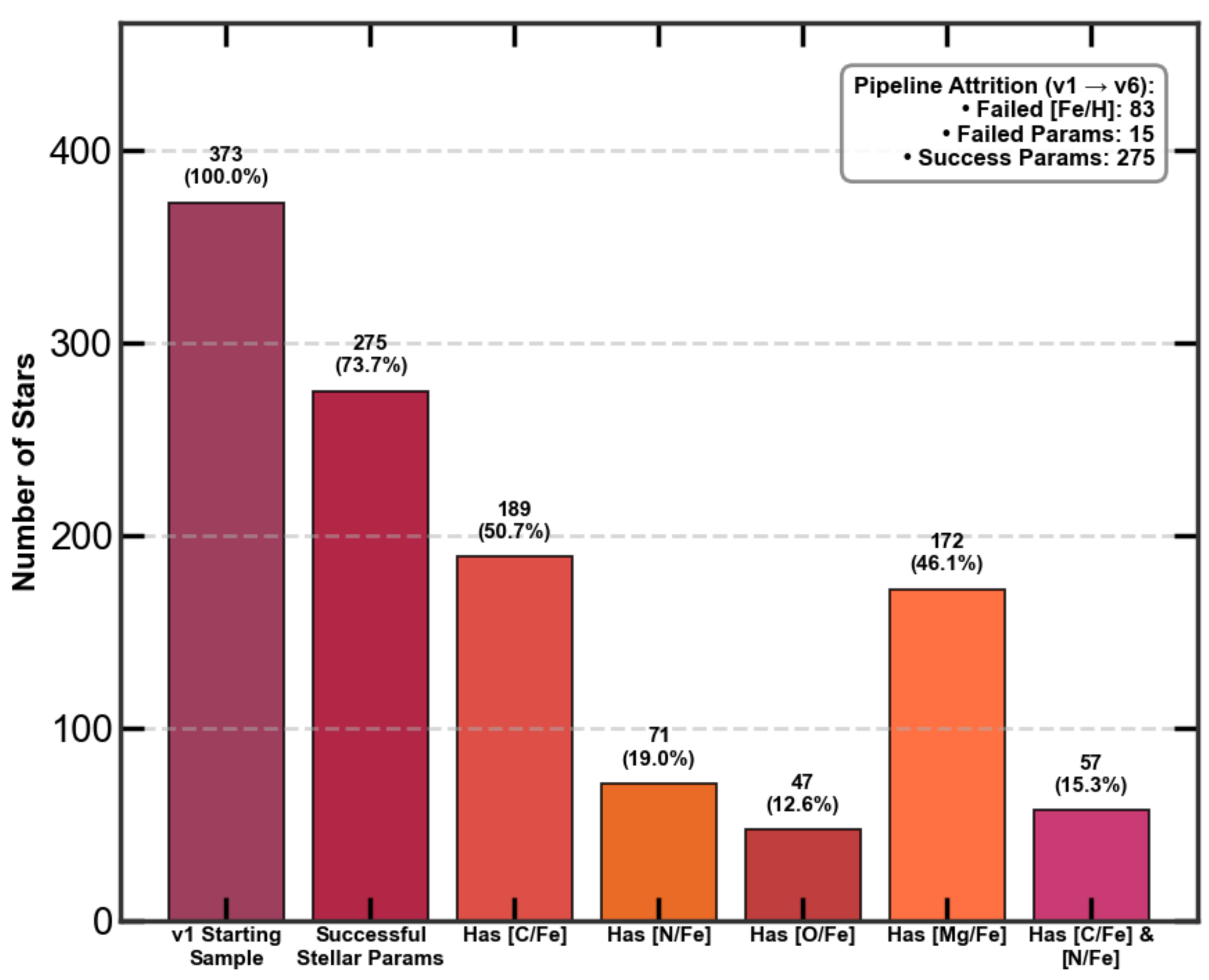


Figure 1 Sample size during all the steps of the pipeline

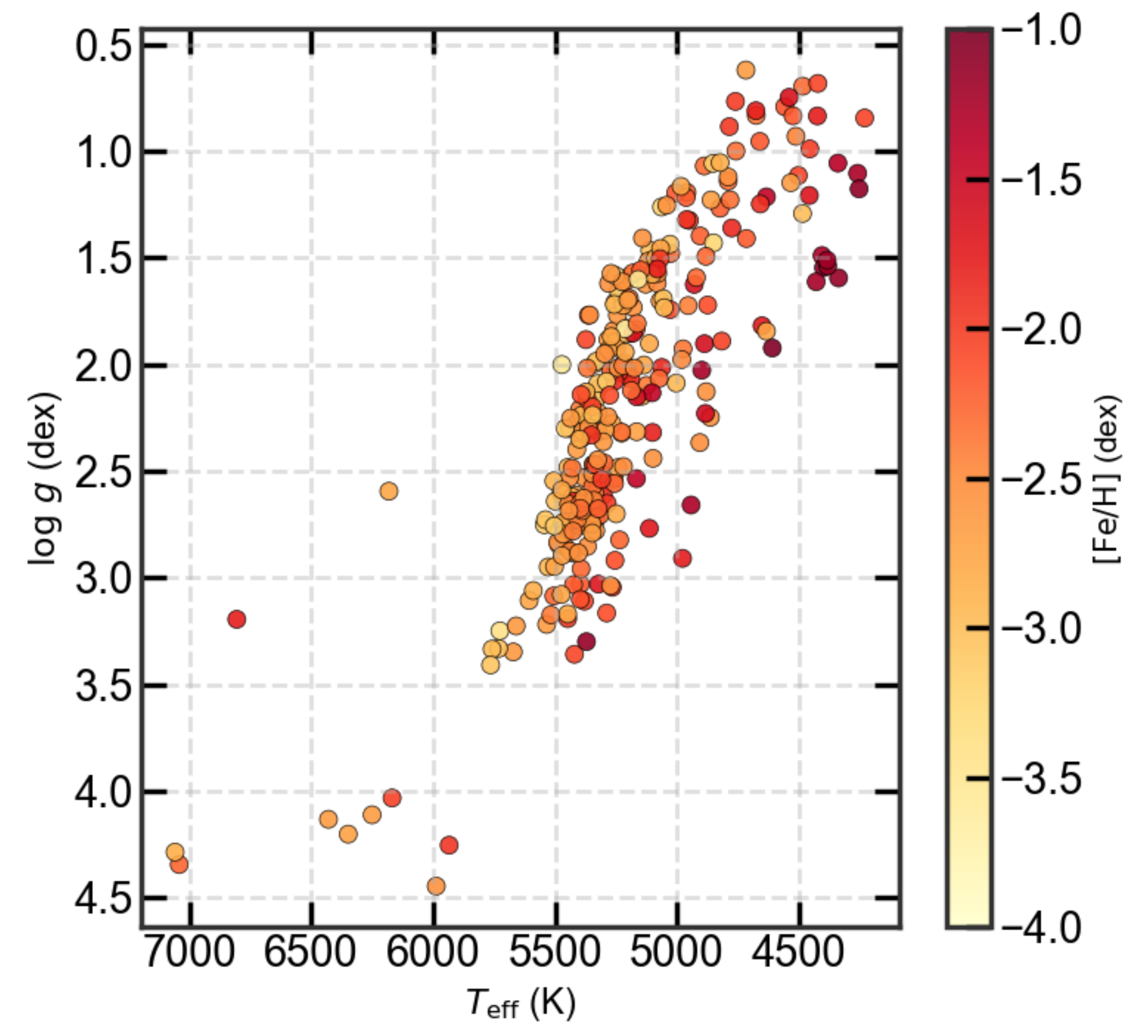


Figure 2 Kiel diagram of the derived stellar parameters

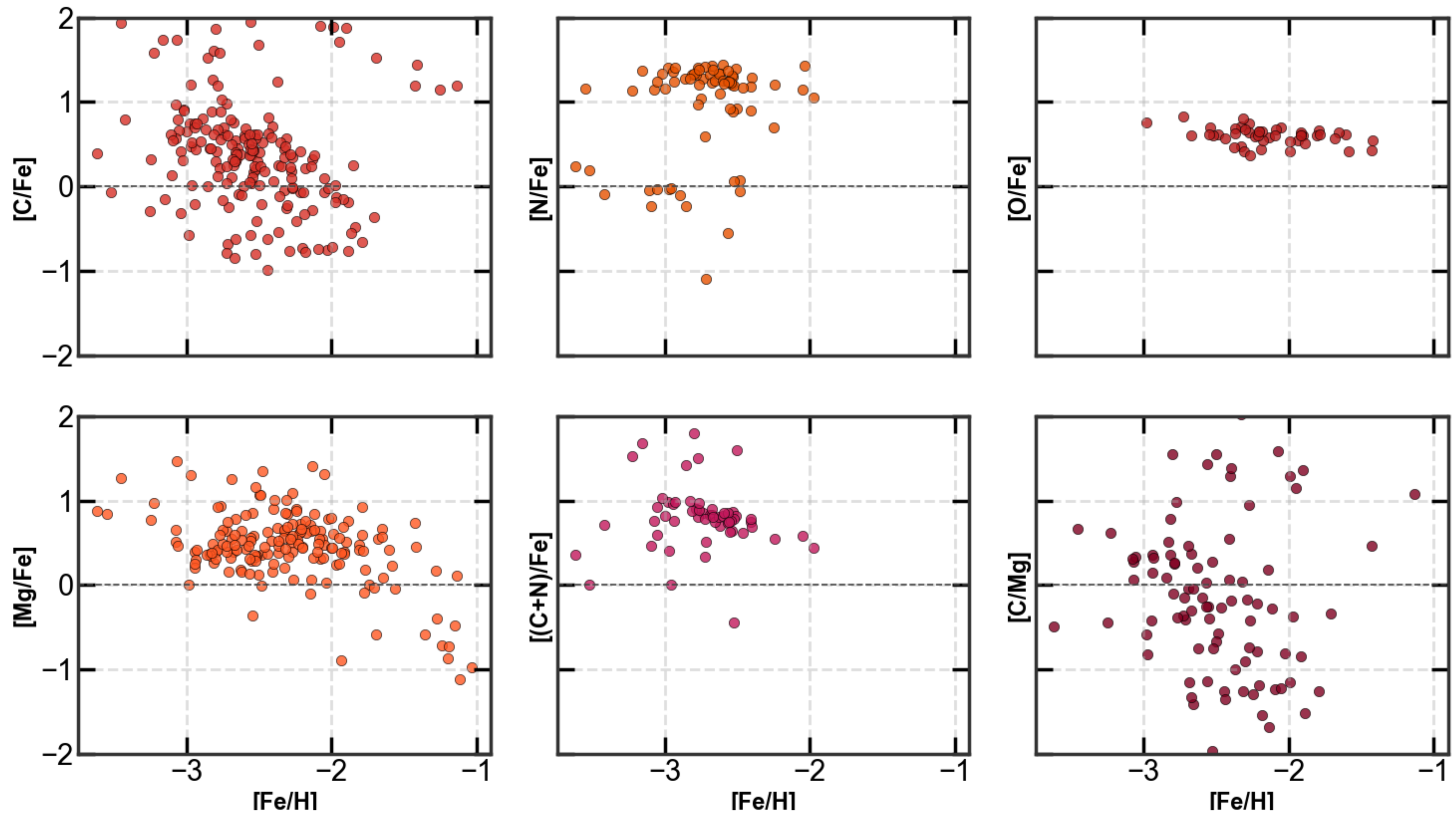
2. METHODS

2.1. STELLAR PARAMETERS

We determined the stellar parameters from Gaia-based bolometric corrections using the code described in Casagrande & VandenBerg (2018), combined with the InfraRed Flux Method for T_{eff} implemented in the *colte* code (Casagrande et al. 2021). This procedure follows the implementation developed by Luca Casagrande, combining Gaia photometry, parallaxes, stellar masses (assumed M = 0.8 Msun), and bolometric corrections from Casagrande, combined with Fe II abundances, in an iterative framework.

Starting from an initial estimate of the atmospheric parameters, bolometric corrections are used to derive the surface gravity … while the InfraRed Flux Method is used to determine the T_{eff}, which has iron and log g dependency. MARCS (Gustafsson et al. 2008) atmospheric models are then used to measure Fe II abundances through an automatic fit in TSFitPy.

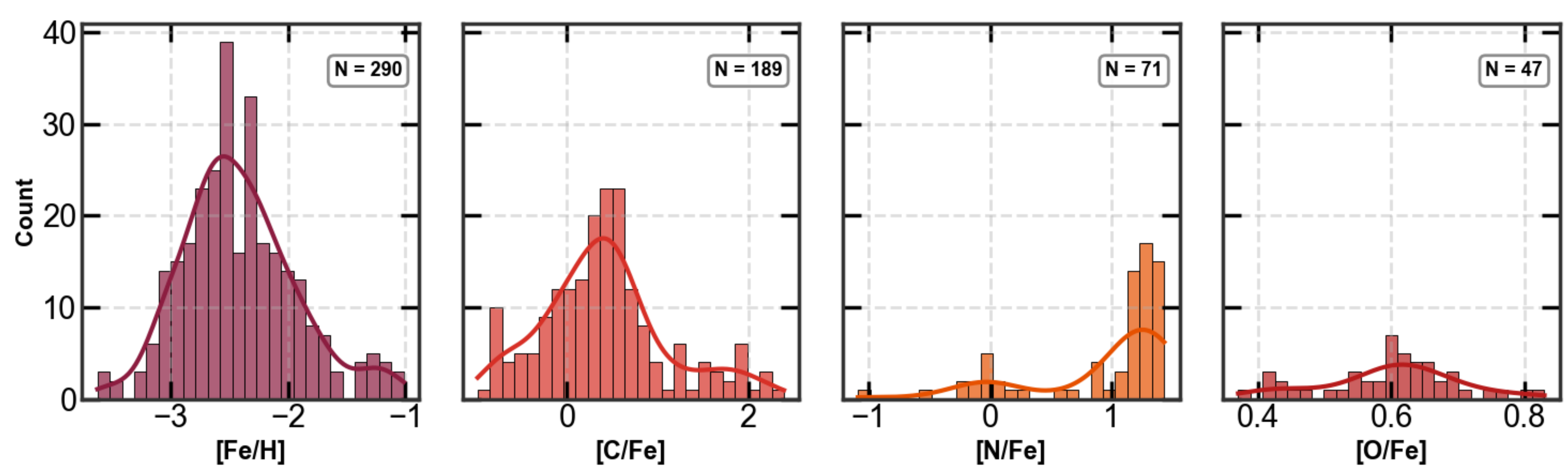
The process is repeated until simultaneous convergence of T_{eff}, log g, and [Fe/H] is achieved. This approach provides a physically consistent set of stellar parameters while avoiding the well-known NLTE biases affecting Fe I-based spectroscopic analyses.

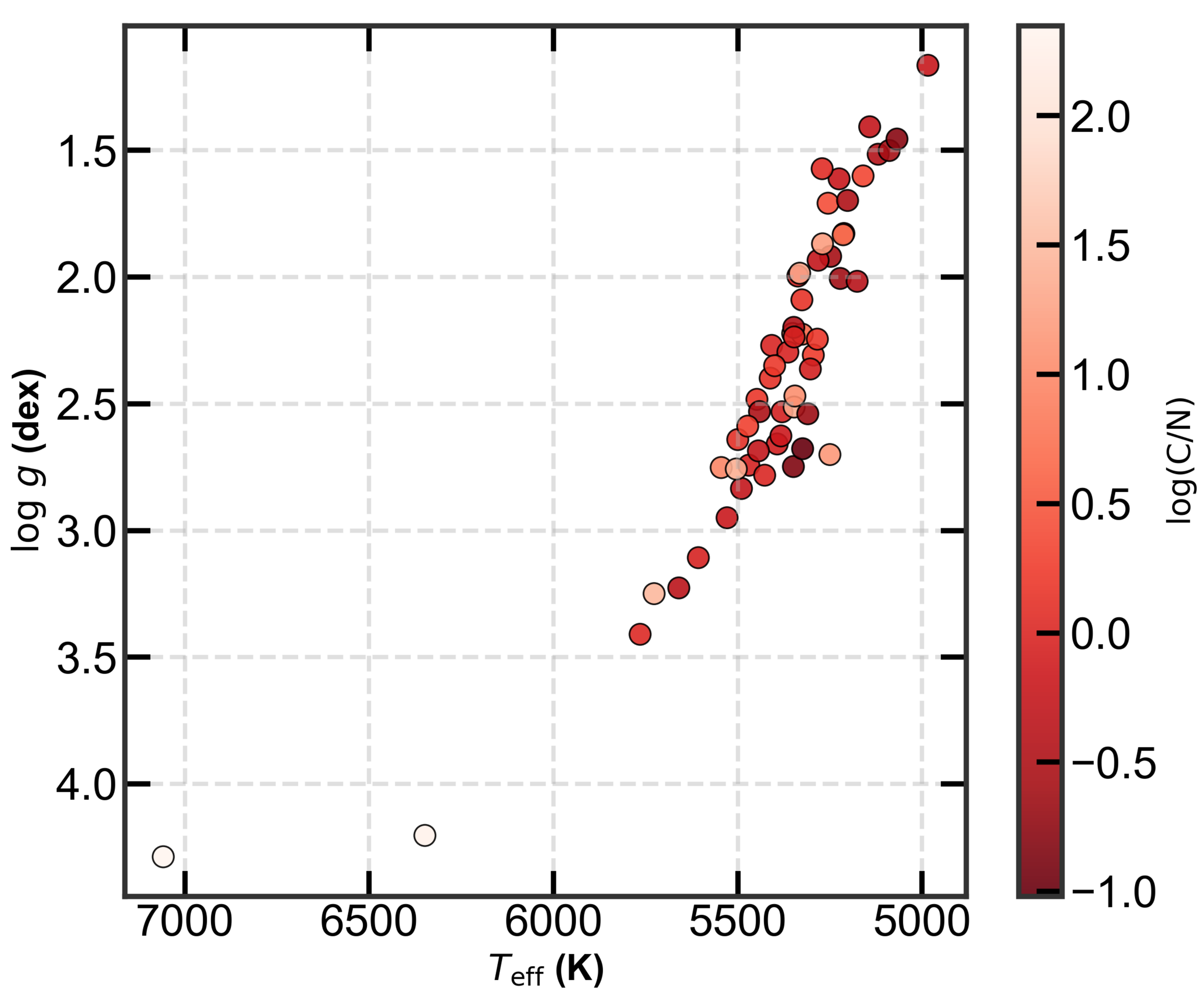


2.2. C,N, AND O ELEMENTAL ABUNDANCES

Oxygen abundances were first determined through a careful, star-by-star analysis of the 183 spectra covering the [O I] 6300 Å region. For the 47 stars with a clear and uncontaminated[O I] feature, the oxygen abundance was derived directly from the spectra. For the remaining stars, where the line was heavily contaminated by telluric absorption and no reliable oxygen measurement could be obtained, we adopted a fixed oxygen abundance of [O/Fe] = +0.60 dex, representative of metal-poor halo stars. This approach provides a stable molecular equilibrium for the synthesis of CH and CN features.

Carbon and nitrogen abundances were subsequently determined with TSFitPy, an automated spectral fitting framework built around Turbospectrum, through a second iterative procedure (Gerber et al. 2023; Plez 2012). Carbon abundances were measured from the CH G band near 4300Å, while nitrogen abundances were derived from the CN molecular band at 3838 Å. Because the strengths of the CH and CN molecular features are intrinsically coupled through molecular equilibrium, carbon and nitrogen abundances were solved iteratively until convergence was reached. At each iteration, the updated carbon abundance was used to recompute the nitrogen abundance, and vice versa, ensuring a self-consistent molecular equilibrium solution.





5. DISCUSSION

We present an automated iterative framework for determining stellar parameters and C, N, and O abundances in metal-poor stars while minimising NLTE systematics. The pipeline successfully converges for the current sample. An expanded analysis of a bigger sample is underway.

6. REFERENCES

Casagrande & VandenBerg, 2018, MNRAS, L102, L107
Casagrande et al. 2021, MNRAS, 2684, 2696
Gerber, J.M., Magg, E., Plez, B., et al. 2023, A&A, 669, A43
Gustafsson, B., Edvardsson, B., Eriksson, K., et al. 2008, A&A, 486, 3, 951