Galactic Palaeontology: Uncovering the Assembly History of the Milky Way using its Surviving Stars

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Palaeontology?

This field is the study of the Milky Way through its stars, much like the study of dinosaurs using their fossils[1].

Our project focused on halo stars; they provide insights into early-universe events (collisions, accretion,...).

In galactic paleontology, analyzing the chemical composition of stars is a key tool for tracking star formation and chemical enrichment. We're working with data from the Dark Energy Spectroscopic Instrument (DESI)[2].

A gap in the research

DESI provides an order of magnitude more than any other spectroscopic survey! However, chemical abundances have not yet been measured from the DESI spectra. This project aims to fill that gap.

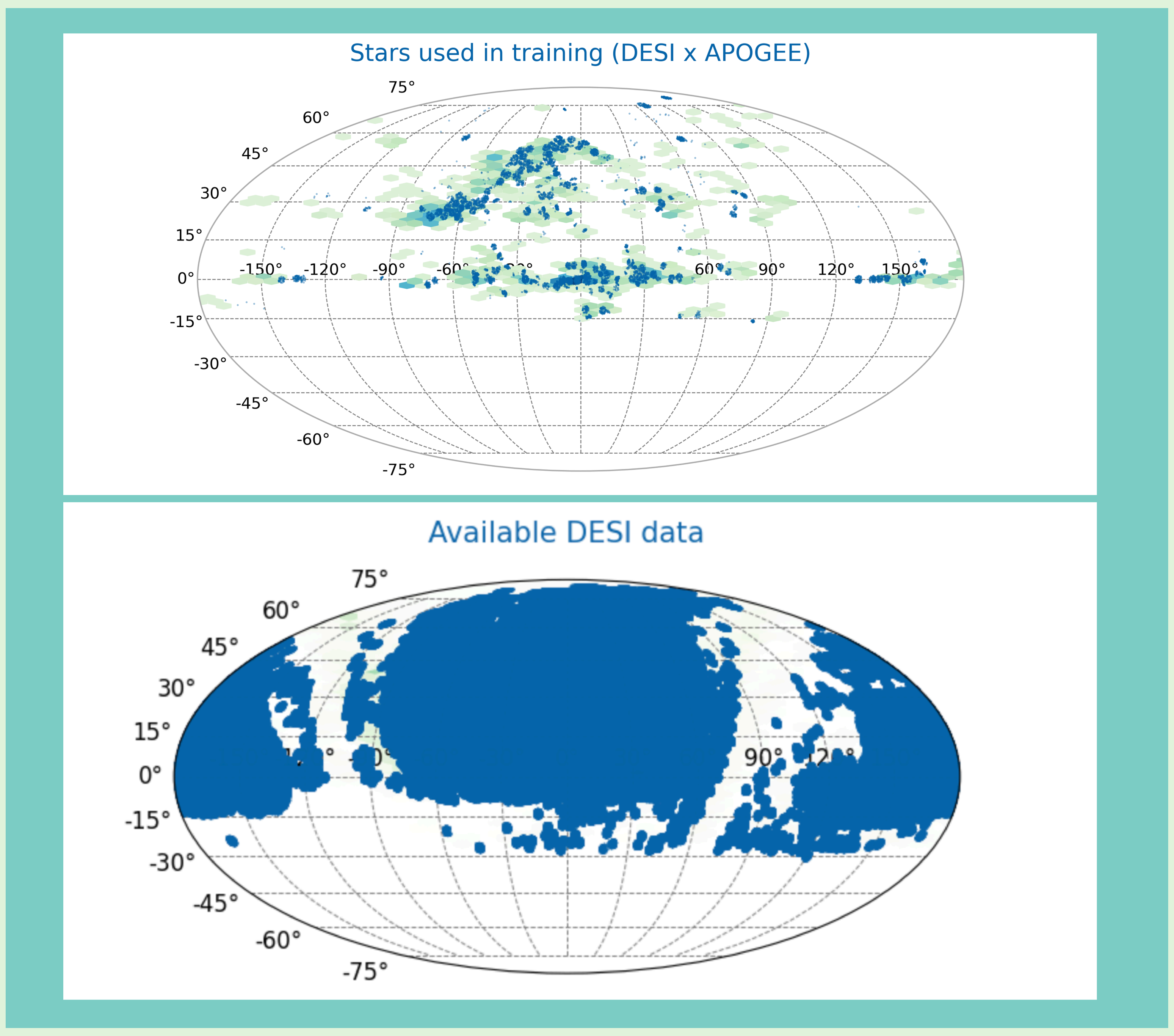
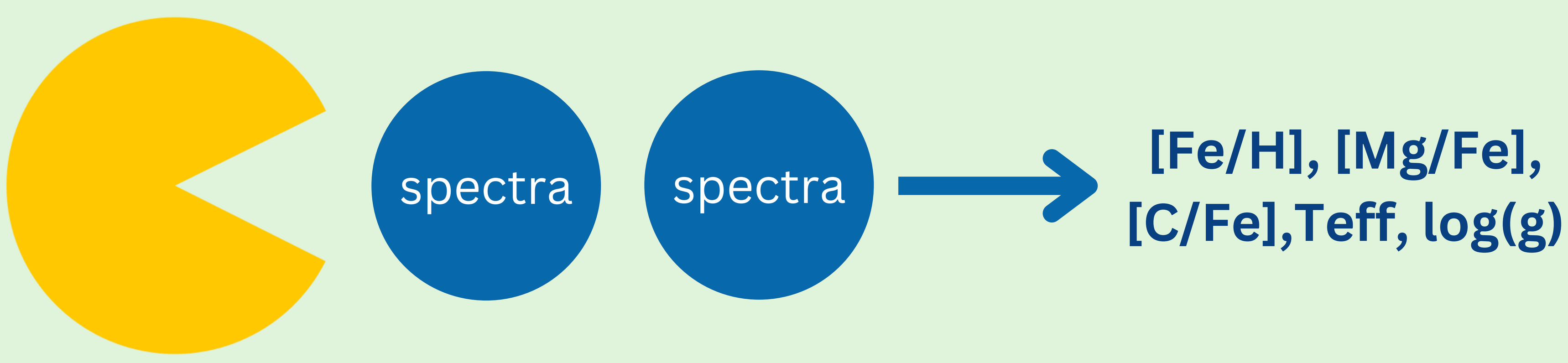


Fig 1, DESI (bottom) and crossmatched (top) data, showing the extreme size difference

However, the data itself is not high-resolution. Therefore, we trained a neural network on APOGEE, a higher-resolution data set[3]. We crossmatched APOGEE with DESI's observations and used DESI spectra to derive both abundances and stellar parameters directly.

Machine Learning!



The model itself has a

- Custom loss function
- Neural network with 5 hidden layers, using PyTorch[4] standardized with median/IQR

Promising results!

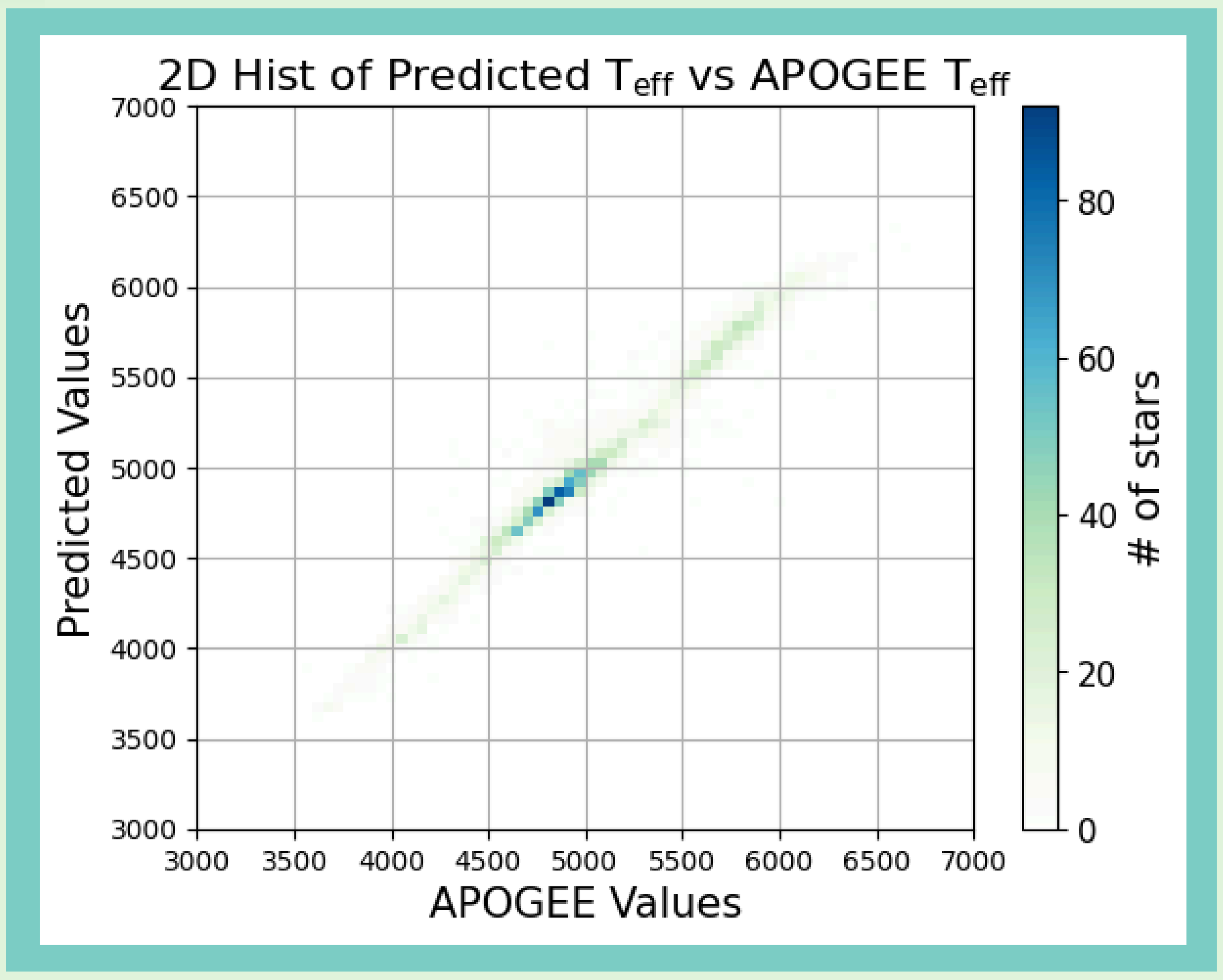


Fig 2, 2D histogram showing the agreement between our model and the APOGEE data

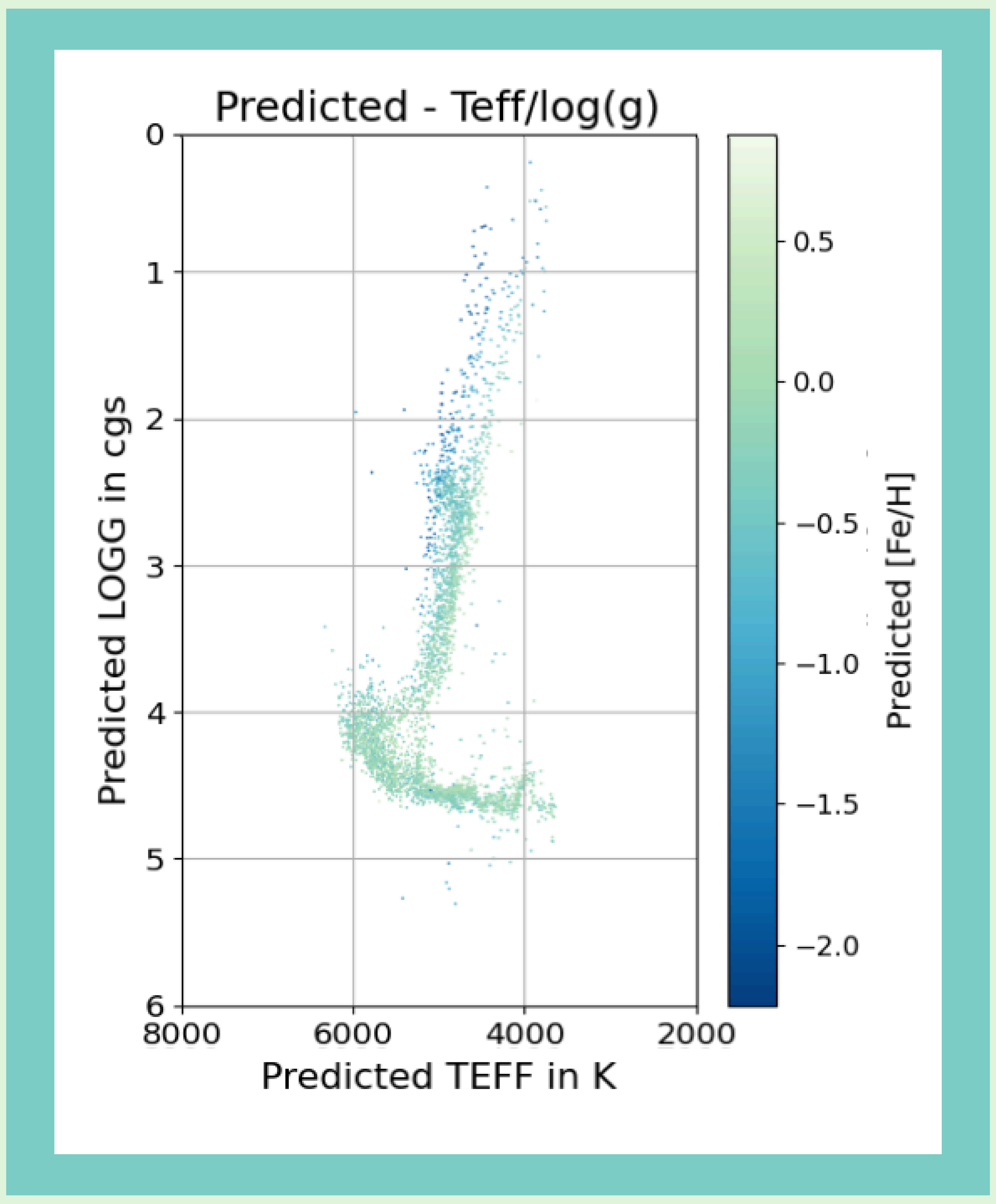


Fig 3, model's predictions from the model for log(g), teff and metallicity plotted as the expected diagram

Our results have shown us that:

- The success that can come from applying these machine-learning techniques to data
- DESI spectra still have difficulties that lead to 'wiggles', gaps and other plot issues
- The standard deviation of residuals within, for example, 0.08 for [Fe/H]

The potential for future work includes:

- Applying the model to all available DESI spectra (currently running it on 31,000 stars!)
- Generate errors with the predictions
- Science applications! What does this data tell us?
- Add more abundances

1. Collazos Rozo JA. Galactic Archaeology, 2023, https://arxiv.org/pdf/2308.08492
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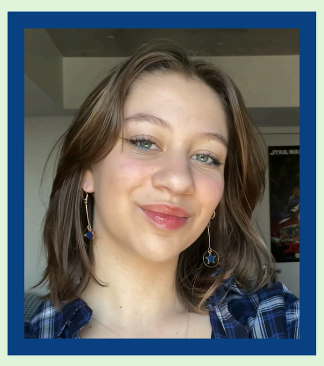
3. Pérez AG, et al, The Astronomical Journal. 2016;151(6):144-144. doi:https://doi.org/10.3847/0004-6256/151/6/144
4. Paszke A, et al, arXiv.org. Published 2019. https://arxiv.org/abs/1912.01703



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