Can we really use chemical properties of red-giant stars as age indicators ?

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Abstract: Using improved **population synthesis approach** and new **stellar evolution models** we attempt to evaluate the possibility to derive ages of clump stars from their chemical properties. A new version of the Besançon Galaxy model (BGM) is used in which new stellar evolutionary tracks are included. **The impact of mixing on chemical composition of the stellar photosphere has a significant impact on the determined stellar age from the observed [C/N] ratio.** We clearly show that transport processes occurring in RGB stars should be taken into account in the determination of ages for future Galactic archaeology studies.

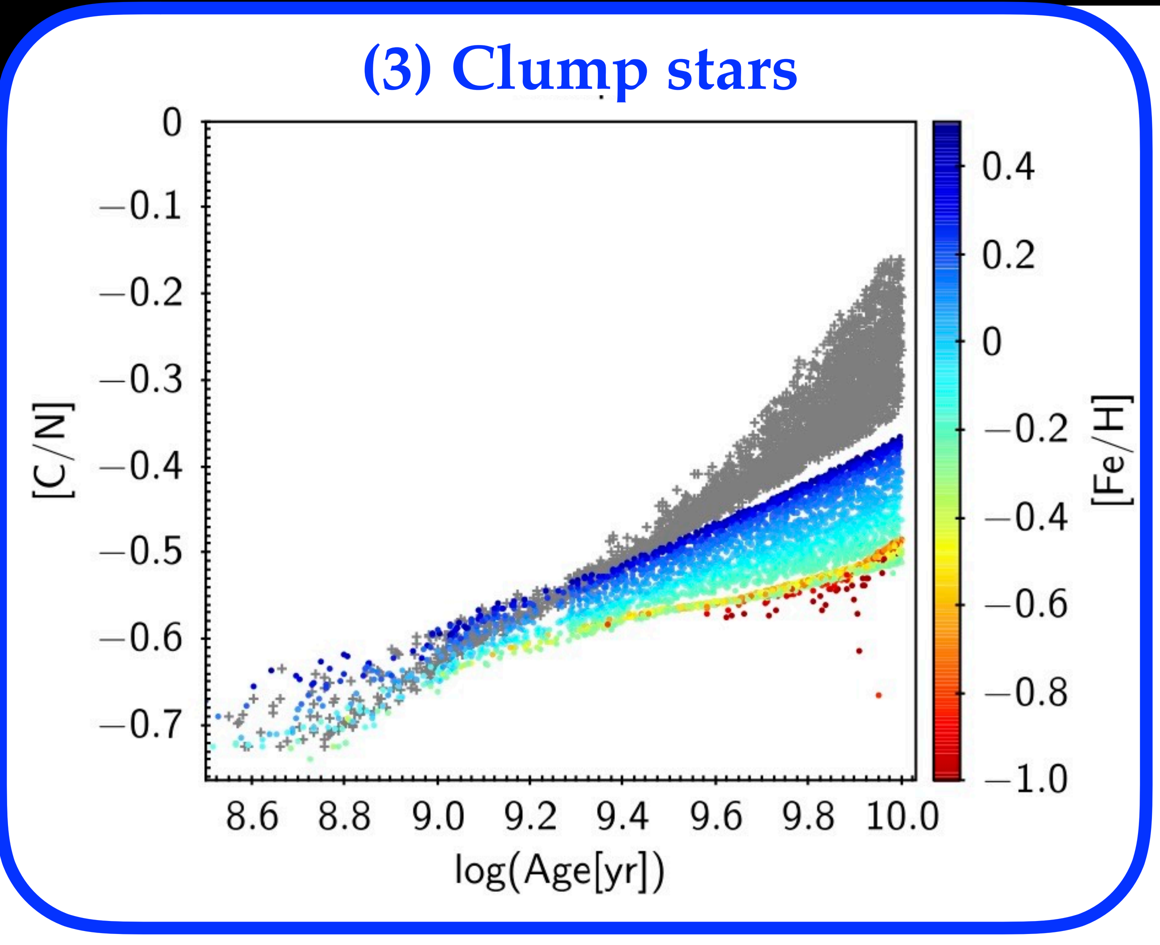
MODELS

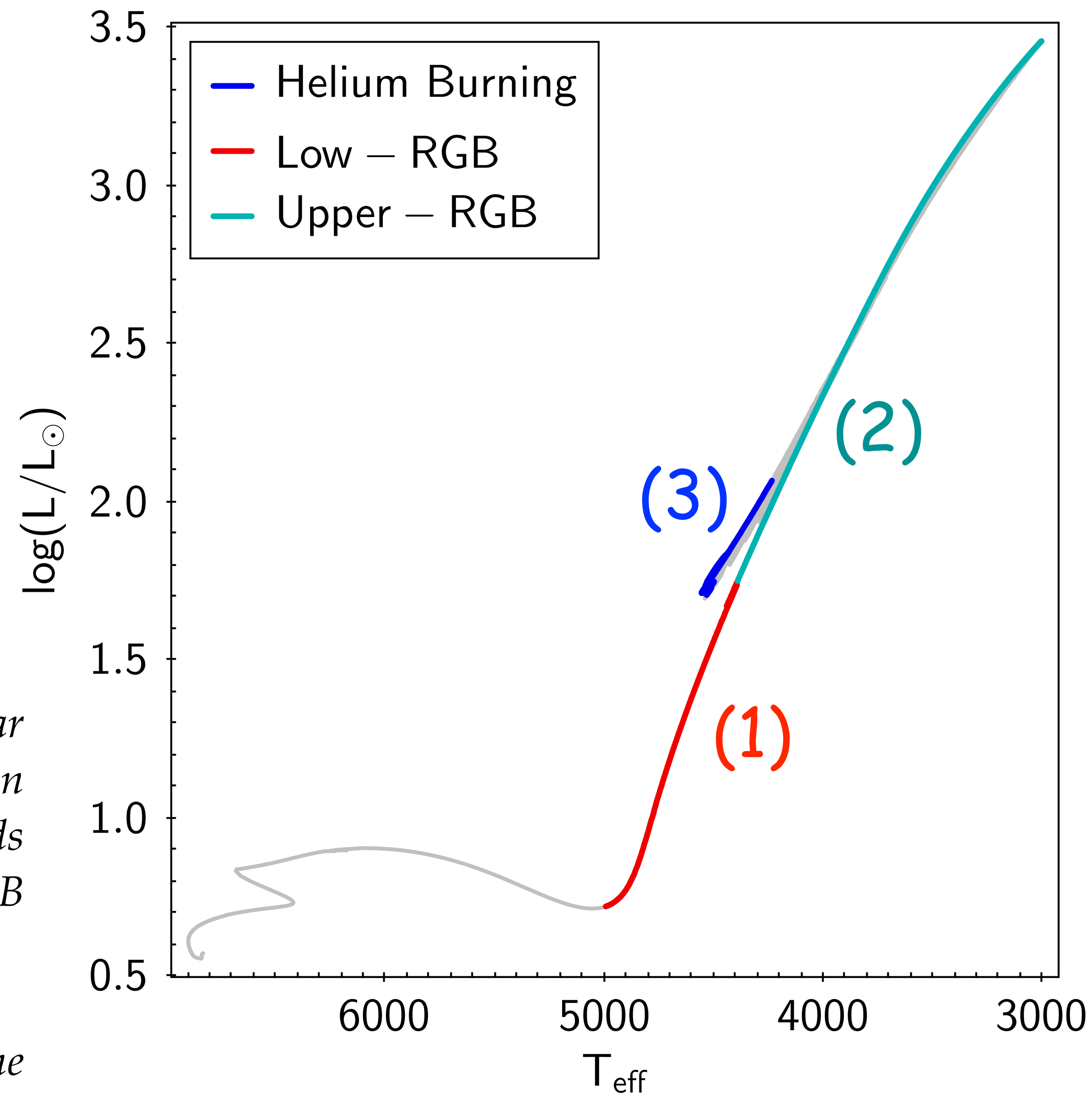
- **Besançon Galaxy Model** (BGM, e.g. Robin et al 03): model using the **population synthesis approach** that simulates observations of the sky with errors and biases.

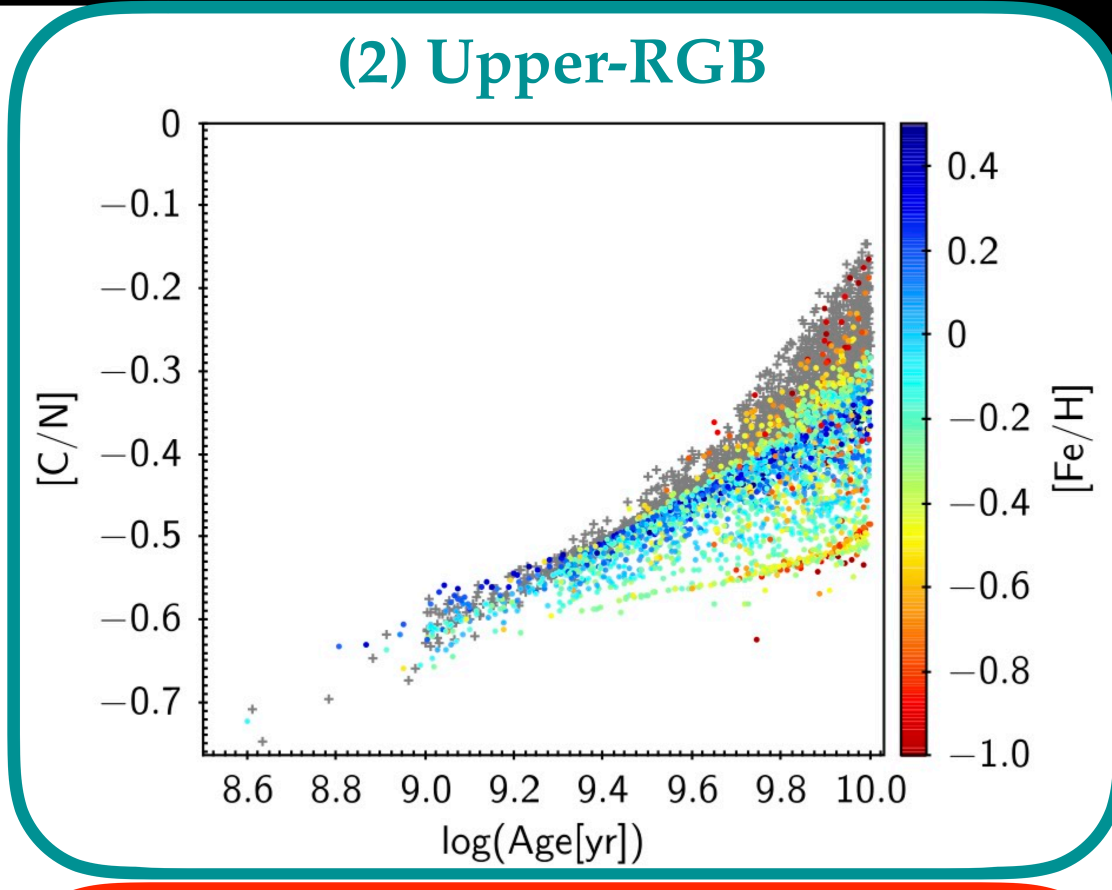
- **Stellar evolution models**, used in the BGM, were computed using the **STAREVOL** code (e.g. Lagarde et al 12b)

(1) **Standard models** (no mixing mechanism other than convection)

(2) Models taking into account **thermohaline instability** which governs the surface chemical properties of low-mass RGB stars (e.g. Charbonnel & Lagarde 10).







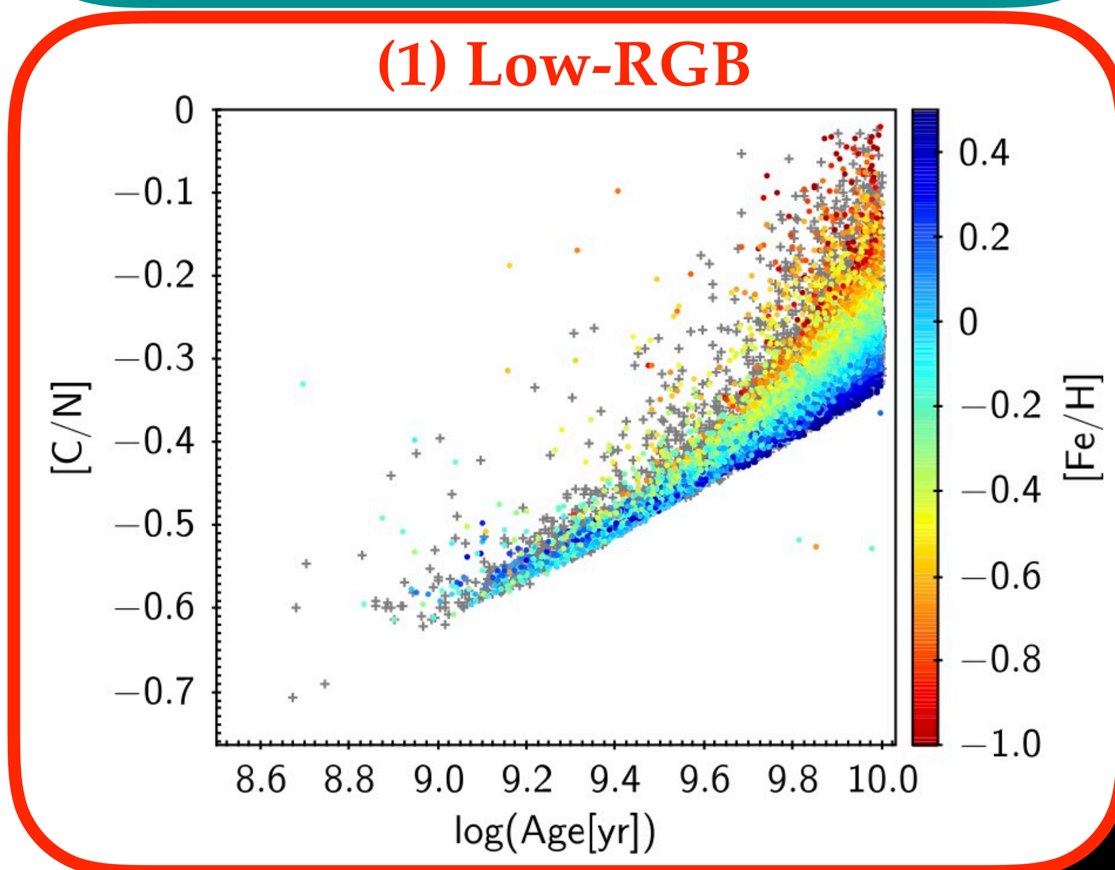


Fig1: Surface abundance of [C/N] as a function of stellar ages, colour-coded by metallicity, for a synthetic thin disc computed with the BGM. Each panel corresponds to different evolutionary states (low-RGB, upper-RGB and clump) as shown in the HRD on the middle panel.

Simulations including or not the effect of thermohaline instability are shown as colour-dots and grey crosses respectively.

SOME RESULTS

- As thermohaline instability changes the surface abundances in C and N after the bump on the red giant branch, **large dispersion of [C/N] with age are noticeable for upper-RGB stars** (see Fig1 panel n°2).
- Since thermohaline instability does not significantly affect the surface chemical properties of clump stars, **relationships between [C/N] and stellar ages can be established** (see Fig1. panel n°3). Using **the new version of the BGM**, we derive mean **relations between [C/N] and age**, usable to estimate ages for thin-disc red-clump giants, when their metallicity is known.

$$log(Age[yr]) = \begin{cases} 1.932 \cdot [C/N]^2 + 7.904 \cdot [C/N] + 13.27 \\ \quad \text{for} -0.20 \leq [Fe/H] \leq -0.10 \\ 1.317 \cdot [C/N]^2 + 6.329 \cdot [C/N] + 12.50 \\ \quad \text{for} -0.05 \leq [Fe/H] \leq +0.05 \\ -2.766 \cdot [C/N]^2 + 1.845 \cdot [C/N] + 11.13 \\ \quad \text{for} +0.15 \leq [Fe/H] \leq +0.25. \end{cases}$$

- Contrarily to previously derived relationships, ours take into account **the natural spread in mass and metallicity of the underlying population**, and allows for the **inclusion of selection biases in the surveys**.
- The difference between stellar ages derived from standard models and from models taking into account thermohaline instability can be up to **~50% depending on the stellar metallicity** (see Fig 2).

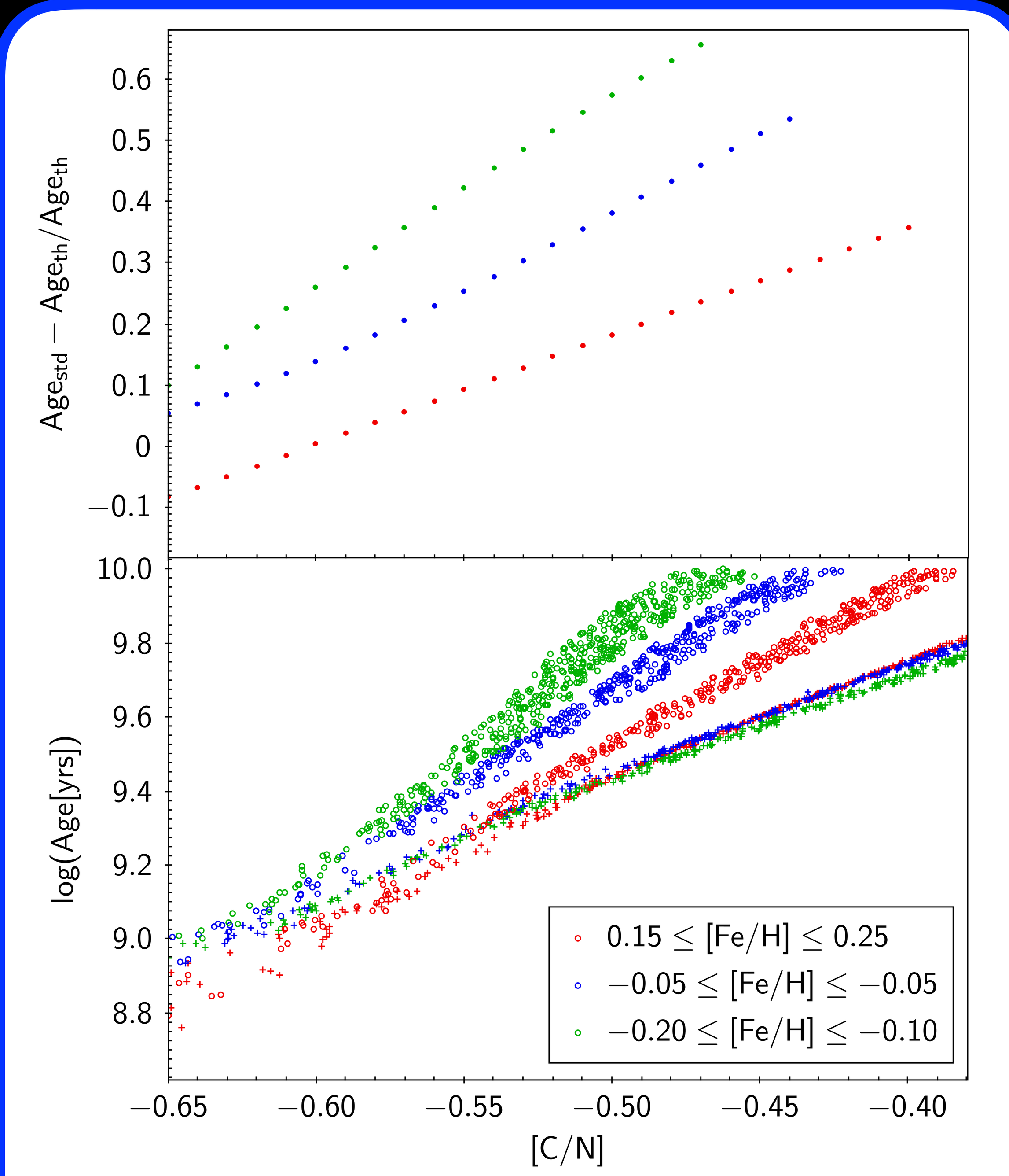


Fig2: *Stellar ages of clump stars deduced from standard (crosses) and models including thermohaline (open circles) as a function of [C/N] for a synthetic thin disc computed with the BGM (bottom panel). Comparison between these two determinations (top panel). Stars are divided in three metallicity bins.*

Transport processes occurring in red-giant stars should be taken into account in the determination of ages for future Galactic archaeology studies.