Understanding the formation and evolution of galaxies remains one of the central challenges in Galactic archaeology (Bland-Hawthorn & Gerhard 2016). The ability to map the kinematic and chemical properties of stars has revealed that the different components of the Milky Way (bulge, disc, and halo) are key to unravelling Galactic evolution. Present-day disc galaxies often exhibit distinct thin and thick discs. However, the formation mechanisms of these two components and the timing of their emergence remain open questions. Disc of galaxies serve as laboratories for studying star formation, resonance-driven migration, as well as secular evolution and external perturbations. Nevertheless, their detailed structure and the nature of the stellar populations tracing them, particularly in the Milky Way, are still actively debated.

To investigate the influence of the cosmic environment that has shaped the Milky Way's history, I am using chemo-dynamic parameters from the most recent data release of the Gaia mission, which provide new chemical diagnostics for tracing the duration of spiral arms (Barbillon et al. 2025a). I observed very clear radial gradients and azimuthal fluctuations in the abundance maps of α-elements for both young (<150 Myr) and old (>2 Gyr) stellar populations, with amplitudes that depend on the chemical element considered (Kobayashi & Taylor 2023). These radial and azimuthal abundance fluctuations, also observed in metallicity (Poggio et al. 2022), are discussed in the context of various theoretical scenarios and quantitatively compared to a two-dimensional chemical evolution model that incorporates multiple spiral arm patterns (Spitoni et al. 2019, 2023). Furthermore, by taking advantage of the NEXUS idealised galaxy simulations (Tepper-García et al. 2021) and the NewHorizon cosmological zoom-in simulations (Dubois et al. 2021), I have studied in detail the evolution of Milky Way-like galaxies to better interpret observational data. In both simulations, we recovered spiral arm signatures across stellar populations of different ages, from the oldest to the youngest age bins, and also detected these signatures using chemistry alone as a diagnostic tool. From a kinematic perspective, stars within spiral arms exhibit a lower velocity dispersion than those outside the arms. These differences are more pronounced for older populations and are also observed in Gaia data when comparing the old and young stellar samples from my first paper (Barbillon et al. 2025a). Similar trends have also been highlighted in other types of simulations (Ardévol et al. 2025). Together, observations and simulations call into question the age of the stellar populations best suited for studying spiral arms (Barbillon et al., in prep.). Combining different stellar populations, various tracers (such as gas and dust), and simulations will bring a new perspective to the analysis of the Galactic disc and provide a better understanding of the processes that have shaped it.