Observations are not always observed

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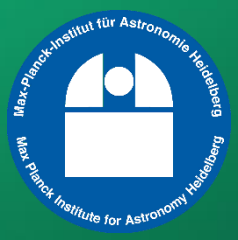
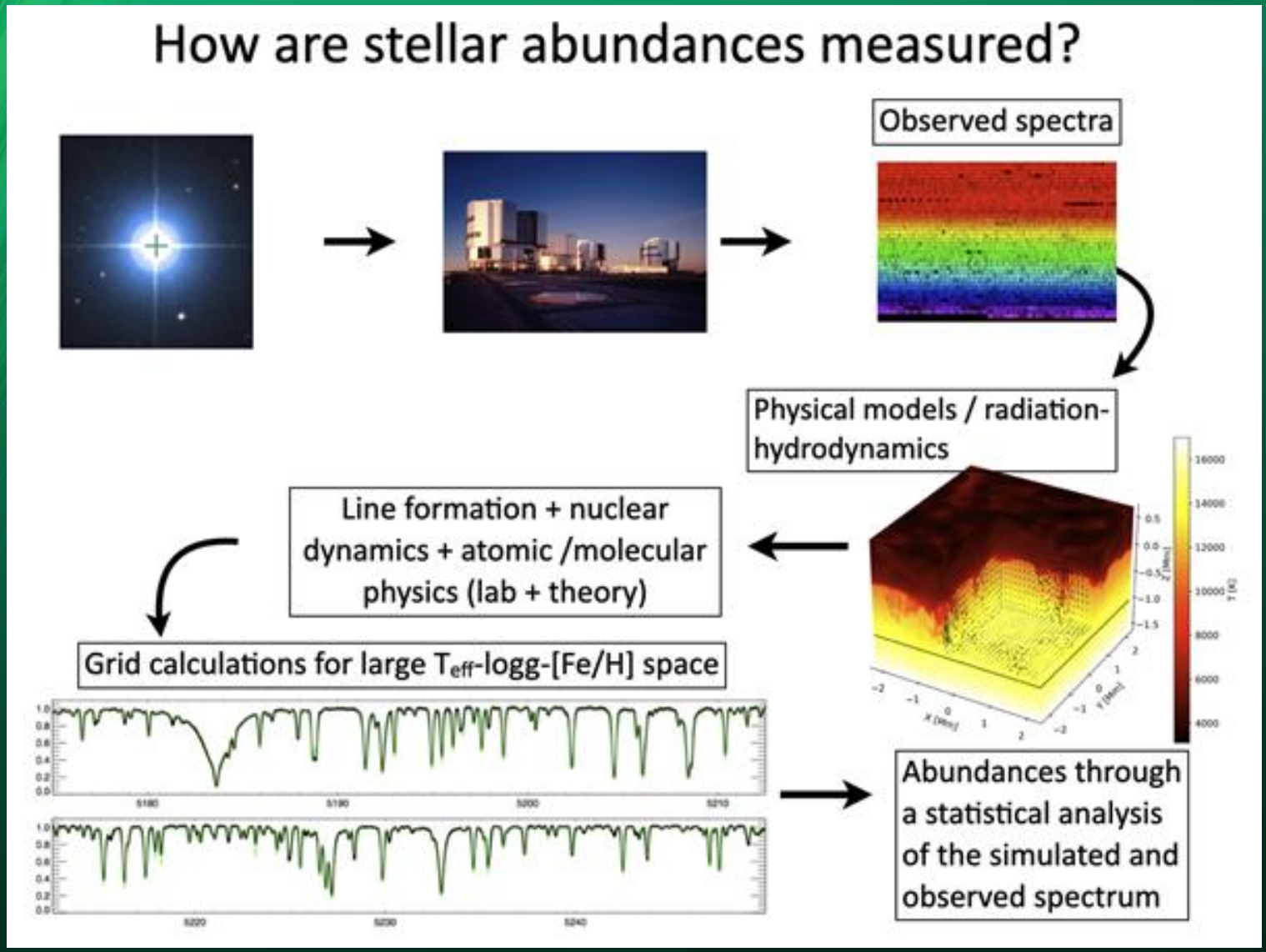
In collaboration with: M. Bergemann, A. Kučinskas, H.-G. Ludwig, R. Hoppe, P. Eitner, et al.



Galactic Chemical Evolution (GCE)

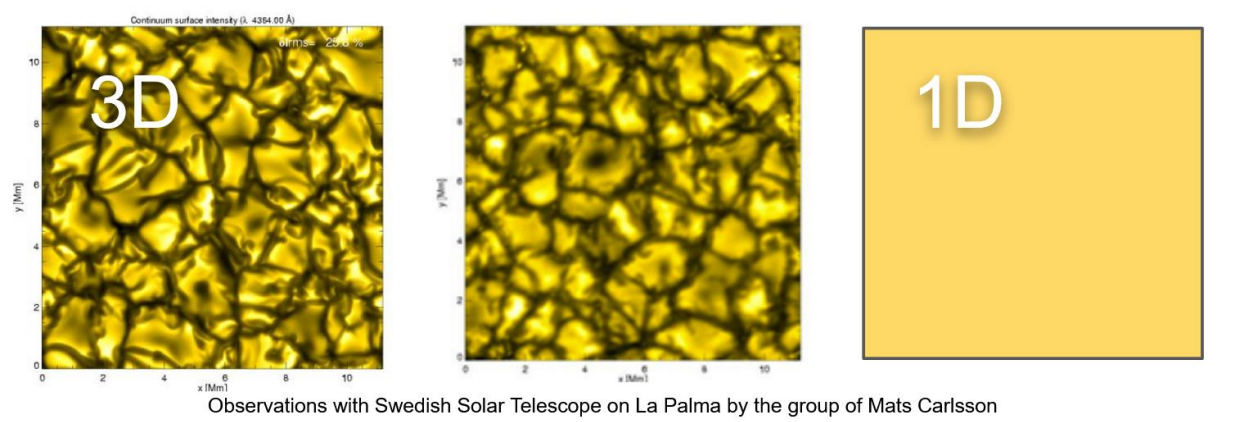
- Understanding GCE unlocks origin of chemical elements and history of our galaxy
  - impact of mergers and secular evolution on Galactic disk
- On one side we have models of stellar evolution, nucleosynthesis, stellar yields
- Comparing to observed abundances patterns gives us an idea what is still missing

Abundances are not observed!

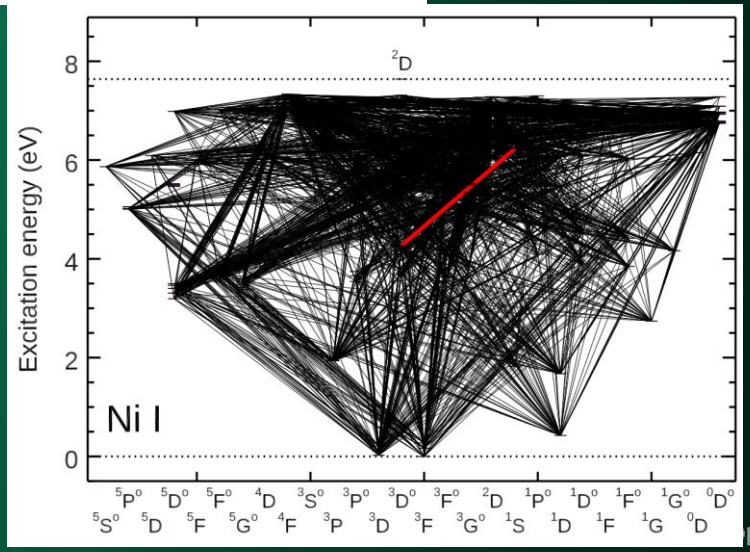


Standard approach

- 1D hydrostatic model atmospheres



- Local thermodynamic equilibrium (LTE) spectrum synthesis

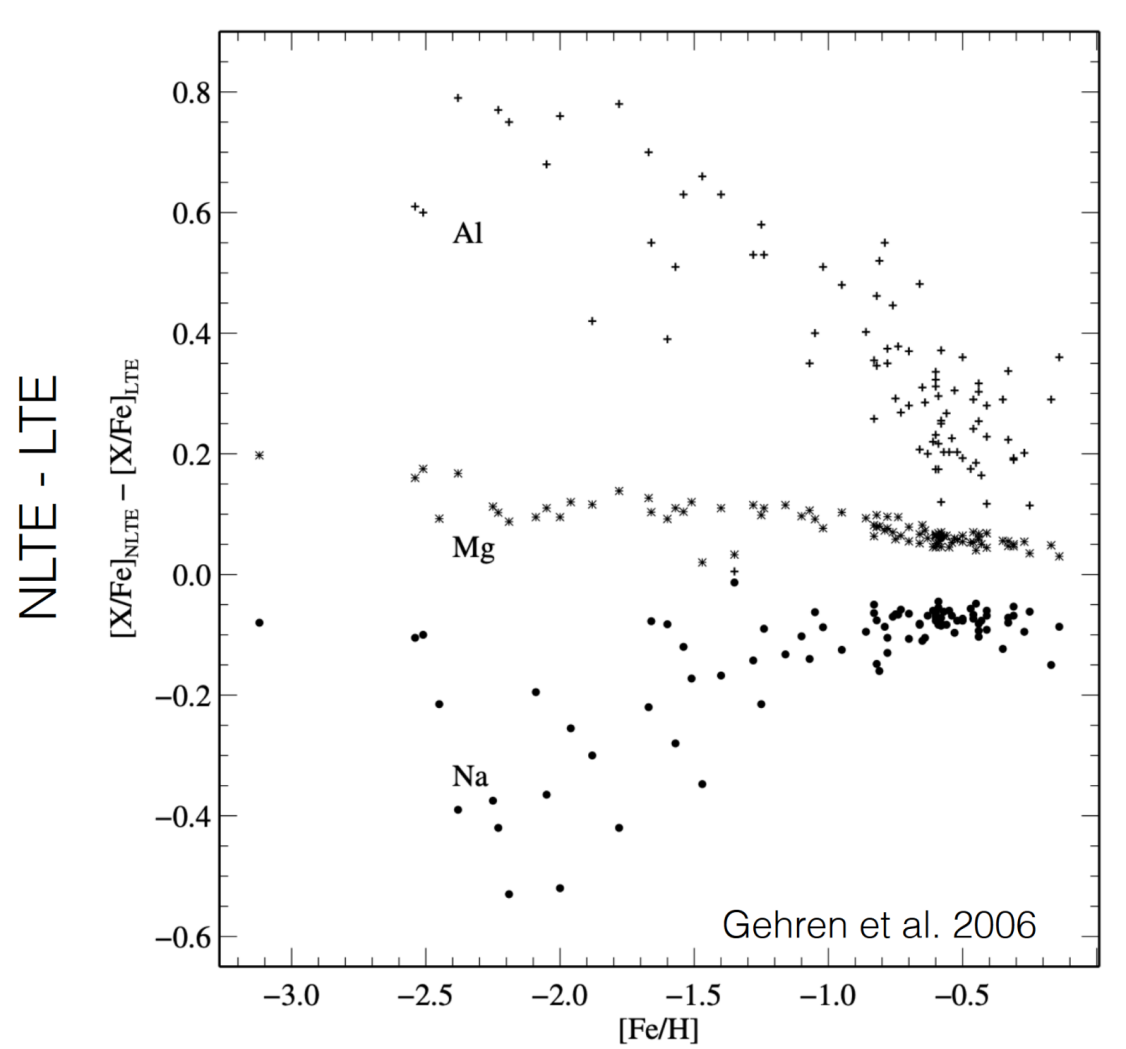


Bergemann et al. (2021)

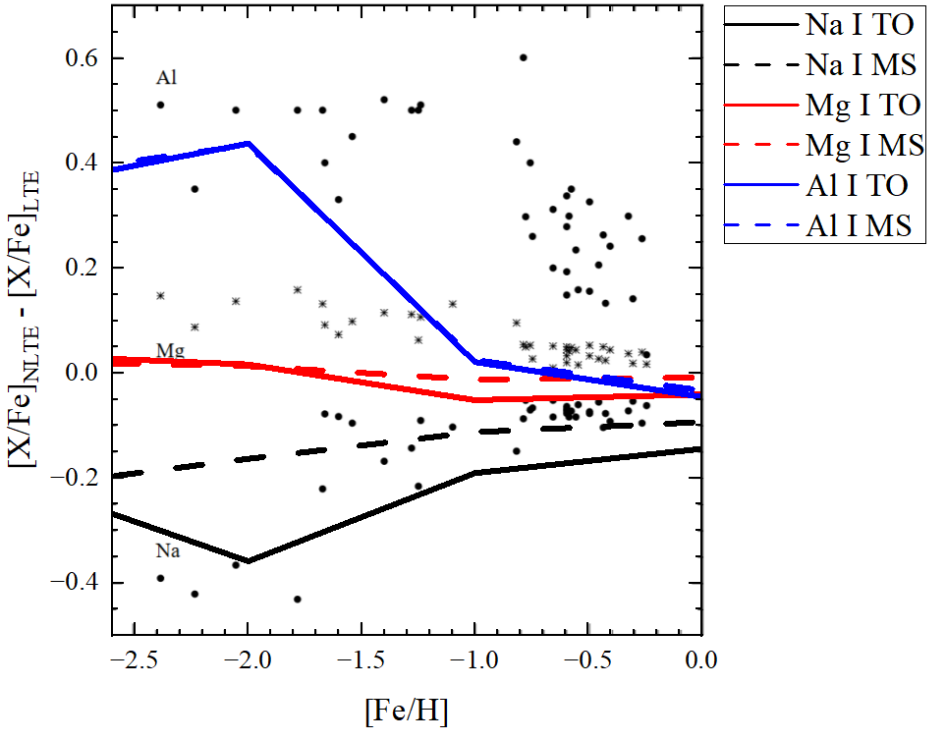
Galactic chemical evolution surveys

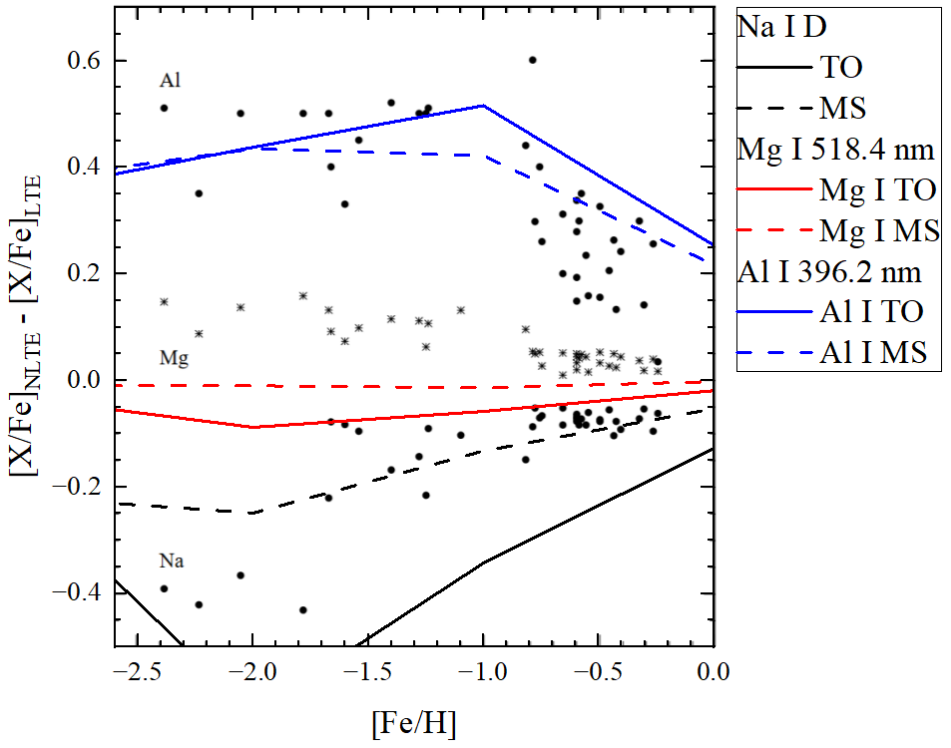
- (Almost) exclusively in 1D LTE
- When (and how) is it worth to go from 1D LTE to 3D NLTE?
- 1D hydrostatic model atmosphere: few minutes on a laptop
- 3D hydrodynamic model atmosphere: from 1000 CPU h (low resolution, dwarf) to 1000 000 CPU h (giants)
- Atom model needs accurate atomic data: photoionization, line transitions, collisional transitions with e^- and H I, as well as 1000+ CPU h

NLTE effects can be significant!

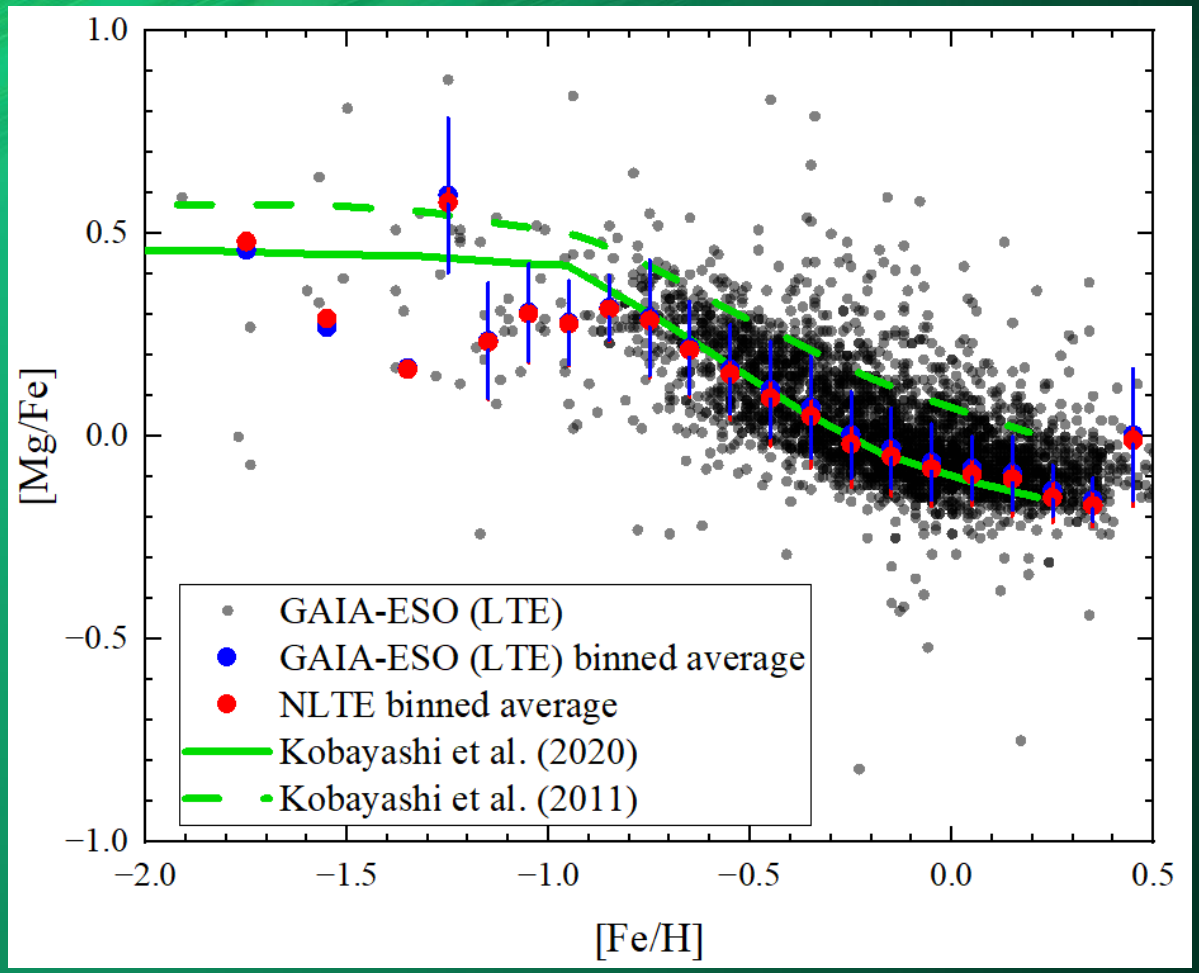


Choice of spectral lines matters



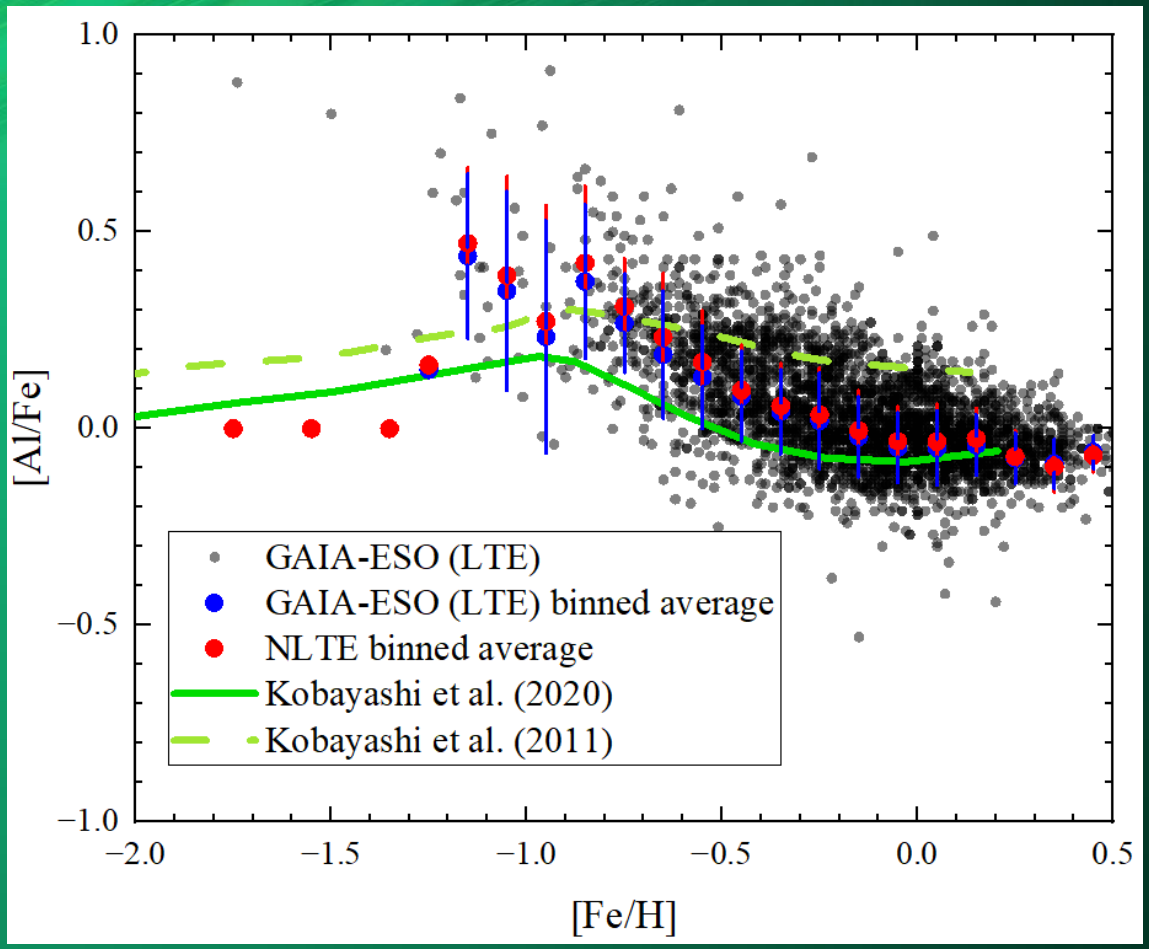


Application to GCE



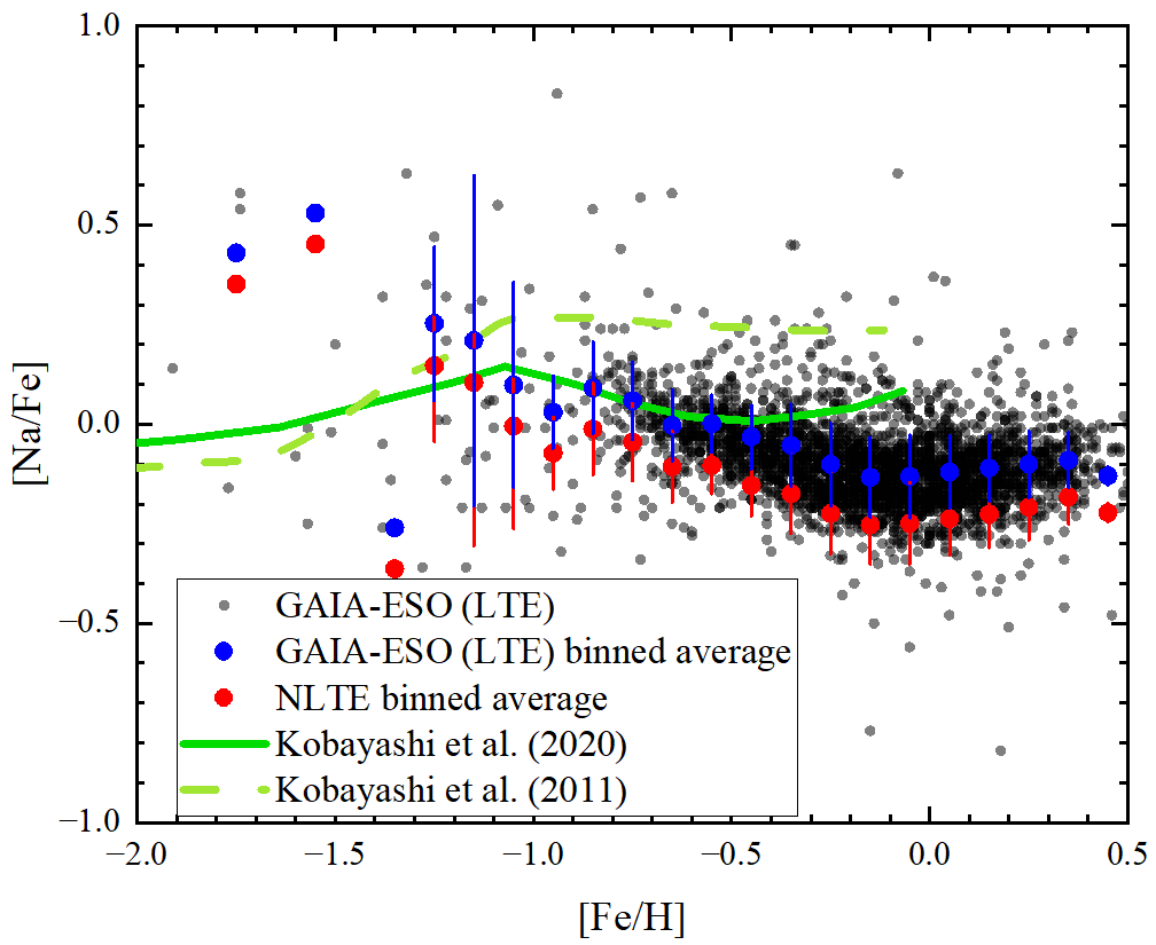
GCE models already explain solar neighborhood well, NLTE effects are small

Application to GCE



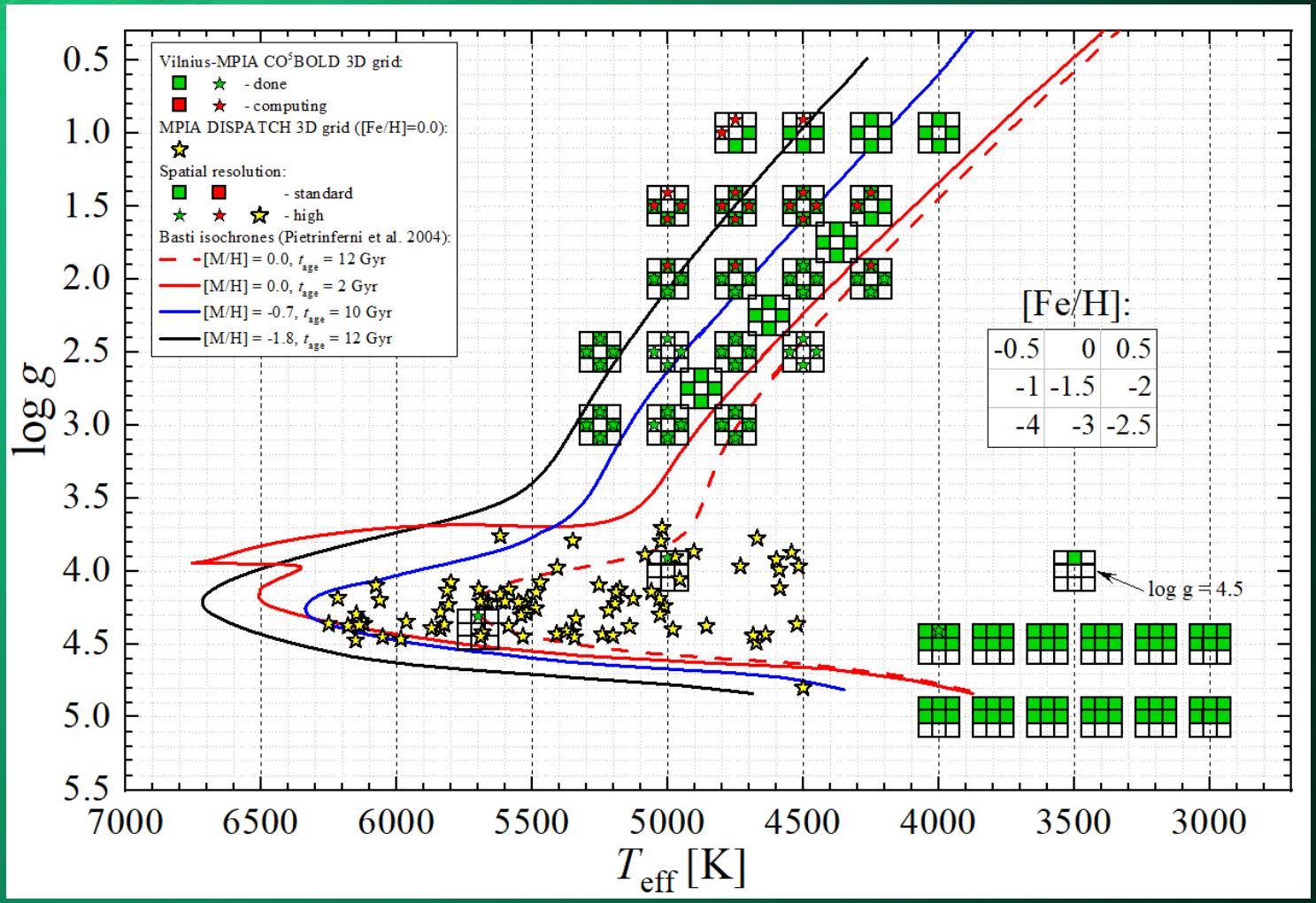
NLTE effects are small because 396.2 nm line is too blue

Application to GCE



NLTE effects are significant. GCE models are not close

Room for expansion!



Conclusions

- Observational surveys rely on simplifications of 1D LTE spectrum synthesis
- 1D LTE can be a reasonable approximation (e.g., Mg) compared to GCE models
- In many cases it is not (especially in metal-poor regimes)
- To obtain abundances at accuracy of 0.1 dex or better, it has to be proven how (in)significant 3D NLTE effects are

Thank You!