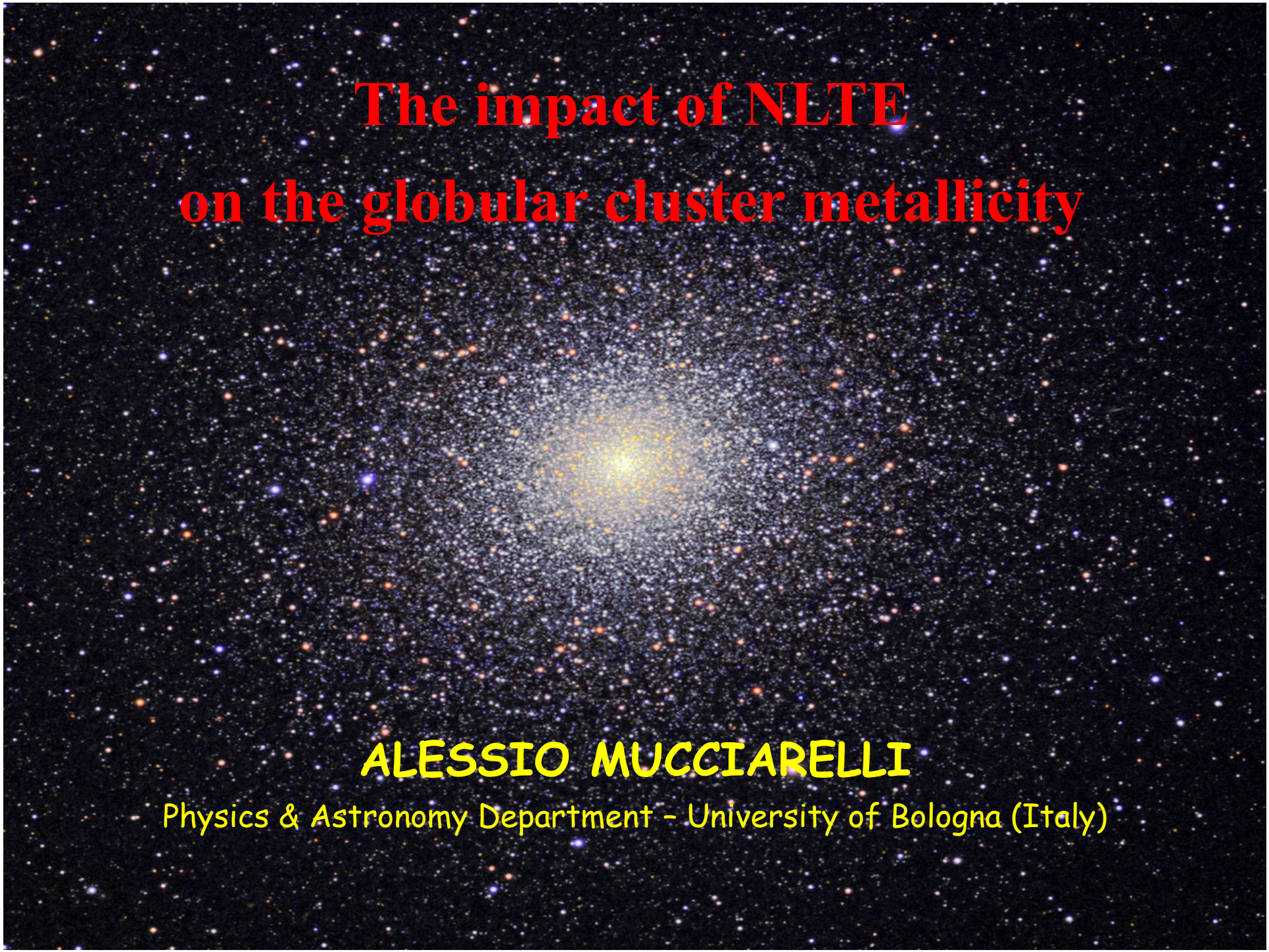
The impact of NLTE
on the globular cluster metallicity
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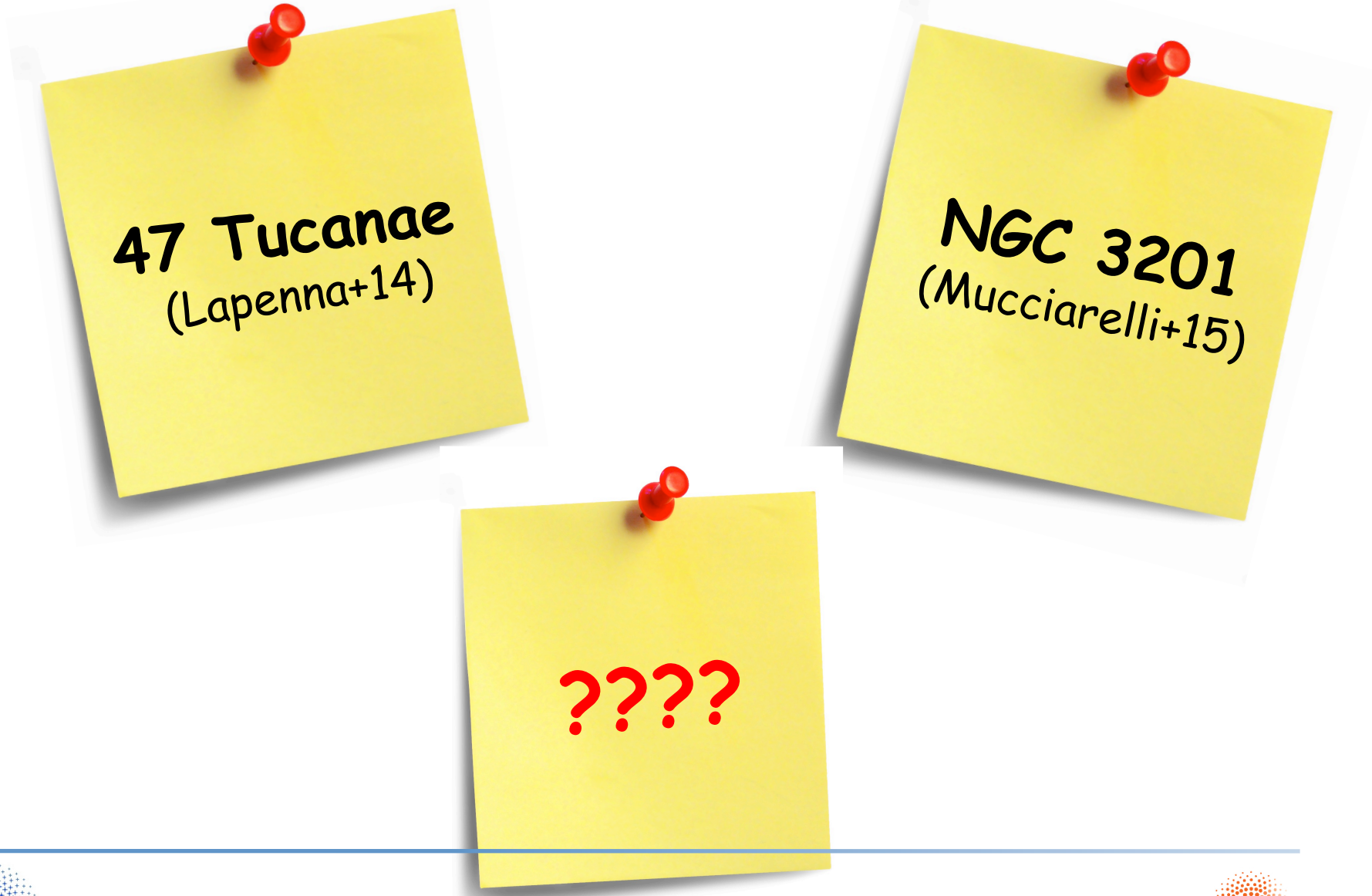
Cosmic-Lab

- 5-year project
- *Advanced Research Grant* funded by the European Research Council (ERC)
- PI: Francesco R. Ferraro (Dip. of Physics & Astronomy – Bologna University)
- AIM: **to understand the complex interplay between dynamics & stellar evolution**
- HOW: using **globular clusters** as cosmic laboratories and

Blue Straggler Stars
Millisecond Pulsars
Intermediate-mass Black Holes

} as probe-particles

Outline: Fe abundance in 3 globular clusters

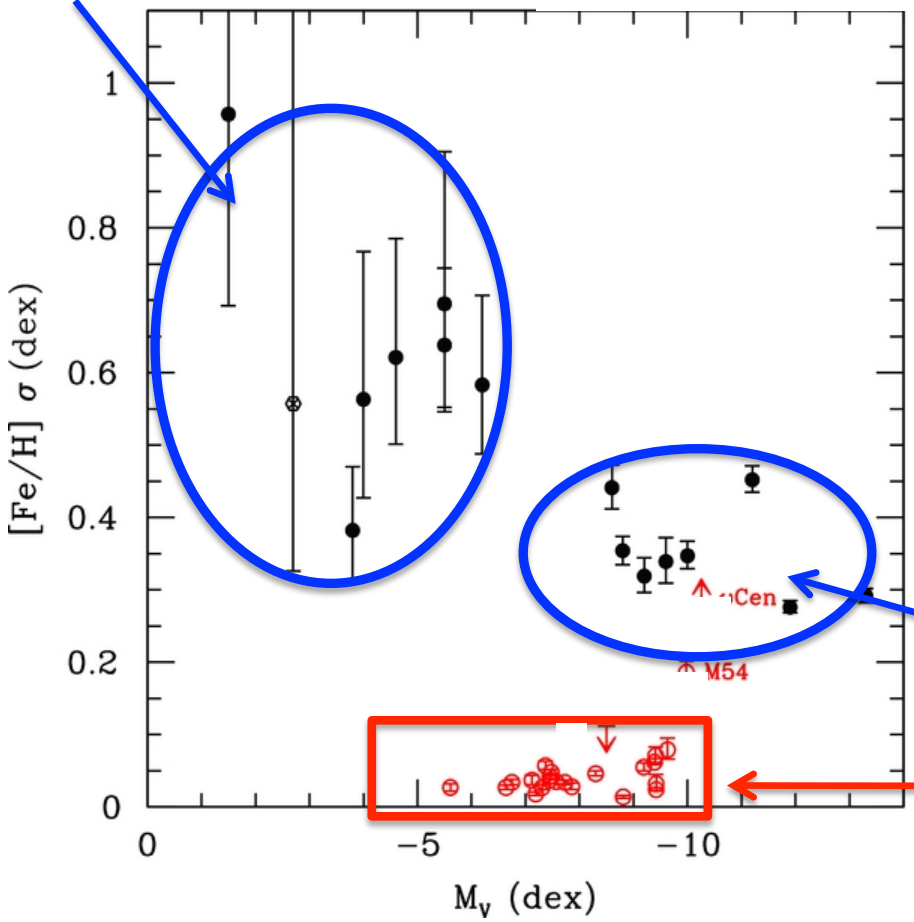


GOLDEN RULE

Genuine GCs are homogeneous in their Fe content
(and Fe-peak elements)

Ultra-faint dwarfs

Willman & Strader (2012)



The homogeneity in Fe is the main chemical fingerprint of GCs

… with some exceptions
(anomalous GCs with Fe spread)
Omega Centauri, Terzan 5, M54
…
but also M22, M2, NGC3201…

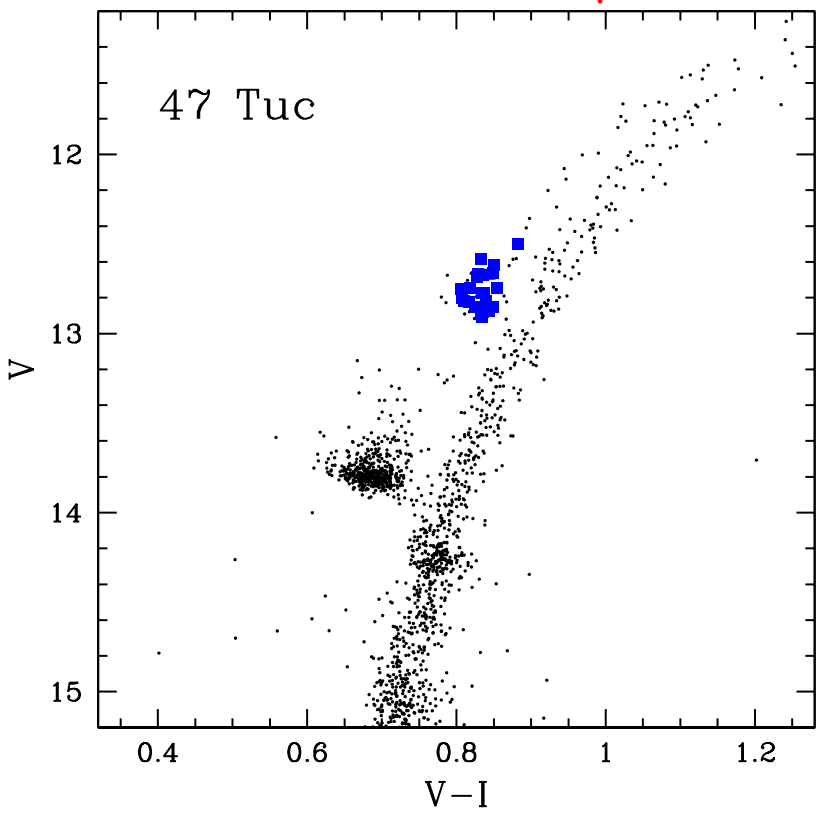
dSphs

GCs (spread < 0.05 dex)

AGB stars in 47 Tucanae

24 AGB stars observed
with FEROS@MPG/ESO
R~48000 , S/N > 70

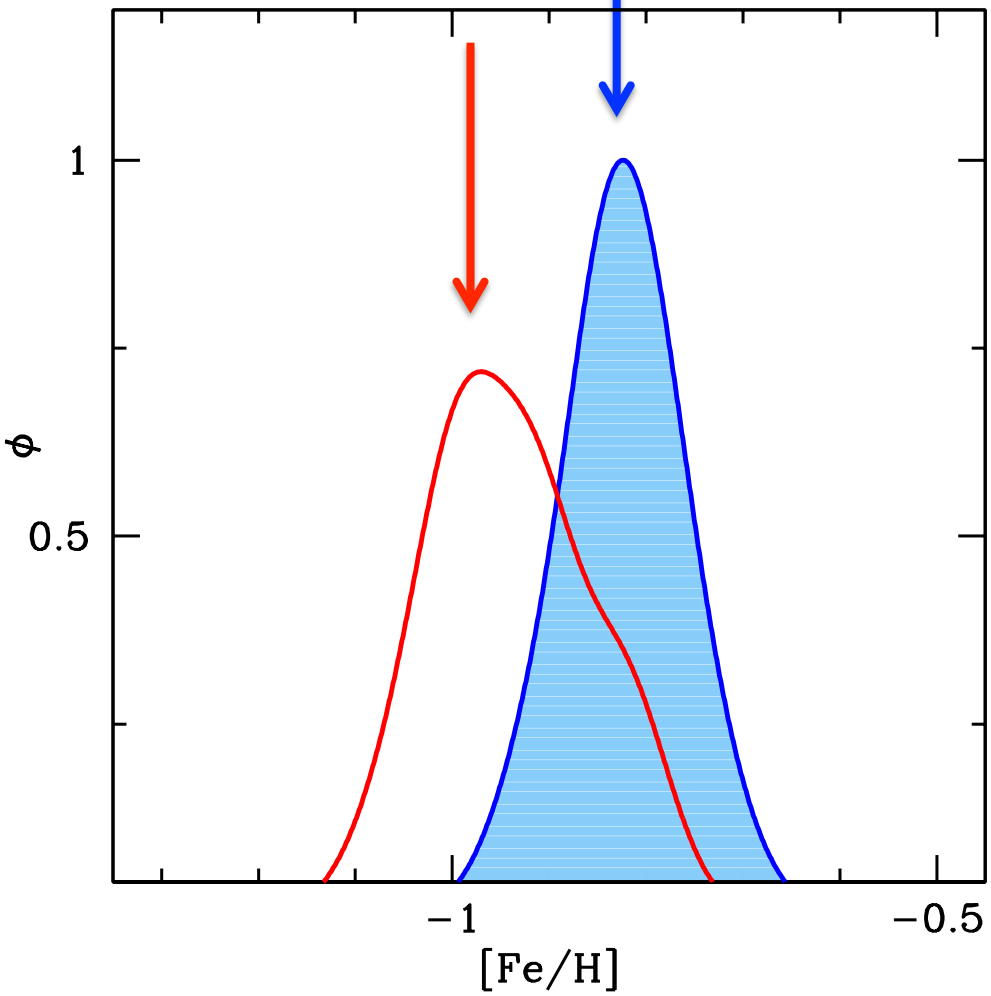
Lapenna+14



T_{eff} and logg from the best-fit theoretical isochrone

[FeII/H]=-0.83±0.01

[FeI/H]=-0.94±0.01



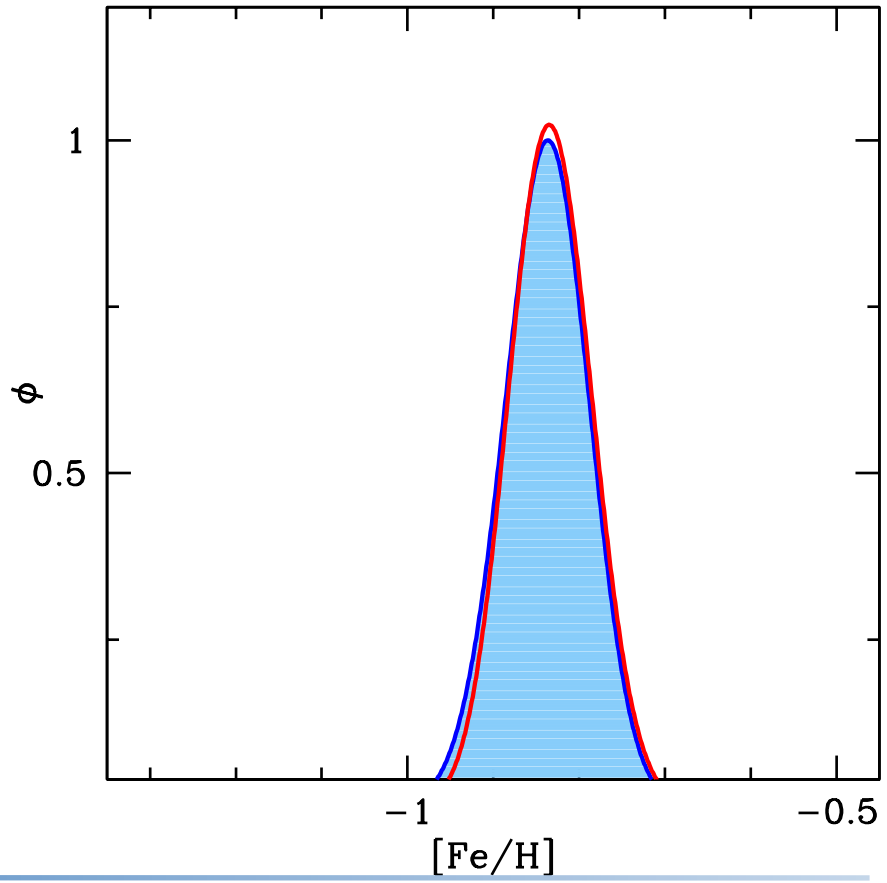
RGB stars in 47 Tucanae

11 RGB stars observed
with FLAMES-UVES@VLT
R~45000 , S/N > 50

[FeI/H]=-0.83±0.01

[FeII/H]=-0.84±0.01

Homogenous analysis:
- Same linelist
- Same model atmospheres
- Same method to derive T_{eff}, logg…



Checks

- ✓ The adopted linelist well reproduces FeI and FeII in Arcturus and the Sun

- ✓ Both spectroscopic and photometric T_{eff} provide the same results

- ✓ To reconcile FeI and FeII we need to decrease logg (FeII is sensitive to logg, at variance with FeI), but …

  - [FeI/H] ~ [FeII/H] ~ -1.0 dex
    too low abundance, large difference with the RGB stars

  - the spectroscopic logg imply low stellar masses, ~0.4 M_{SUN}
    (too low mass for a GC AGB star, ~0.7 M_{SUN} for 47Tuc)

The discrepancy between FeI and FeII in AGB stars cannot be explained with uncertainties/errors in the adopted analysis procedure

The same effect observed in the GC M62 (see Lapenna's poster)

*"...when you have eliminated all which is impossible, then whatever remains, however improbable, must be the **truth**"*

Sherlock Holmes

A possible explaination

Departure from Local Thermodynamical Equilibrium (LTE) assumptions

In NLTE:
neutral lines (Fe I) are affected
(lower abundance when we use LTE calculations)
single ionized lines (Fe II) unaltered

The best way to derive the Fe abundance

Photometric gravities
+
Fe II lines

WARNING !!!
Several works use the spectroscopic gravities,
including those about the clusters with Fe spread

The case of NGC3201

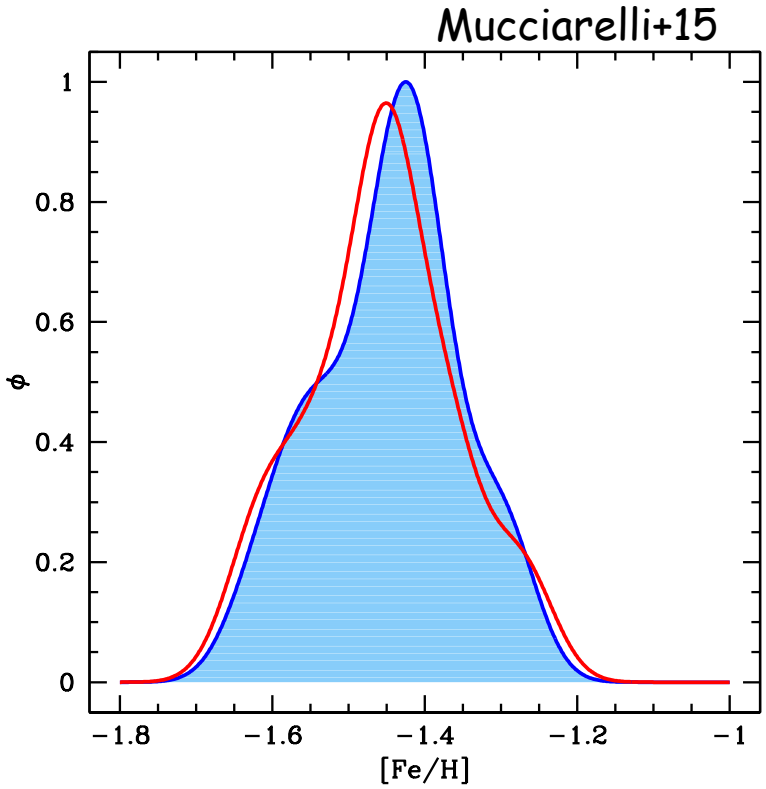
Simmerer+13: analysis of 21 giant stars (FLAMES-UVES)
A 0.4 dex wide metallicity distribution
(Analysis based on spectroscopic logg)

The case of NGC3201

Spectroscopic logg

[Fe I /H] = -1.46 (σ=0.10)

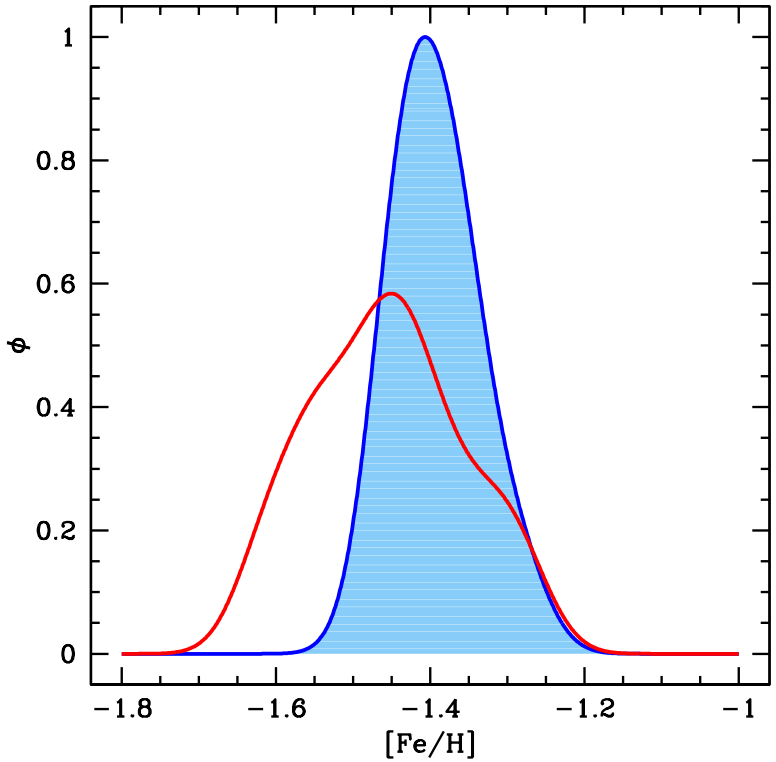
INTRINSIC FE SPREAD !!!

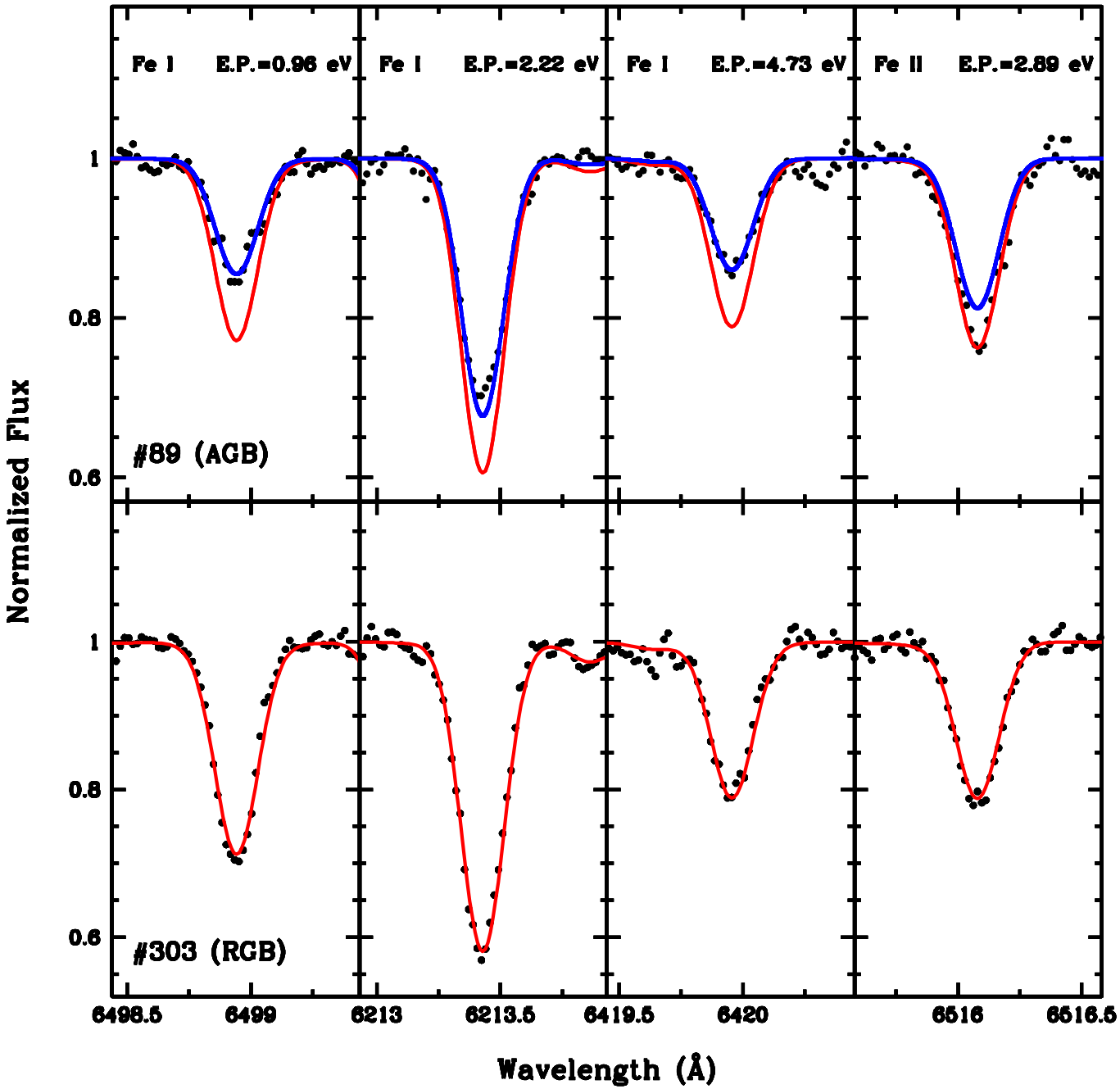


Photometric logg

[Fe I /H] = -1.46 (σ=0.10)
[Fe II /H] = -1.40 (σ=0.05)

Fe II : NO intrinsic Fe spread !!!





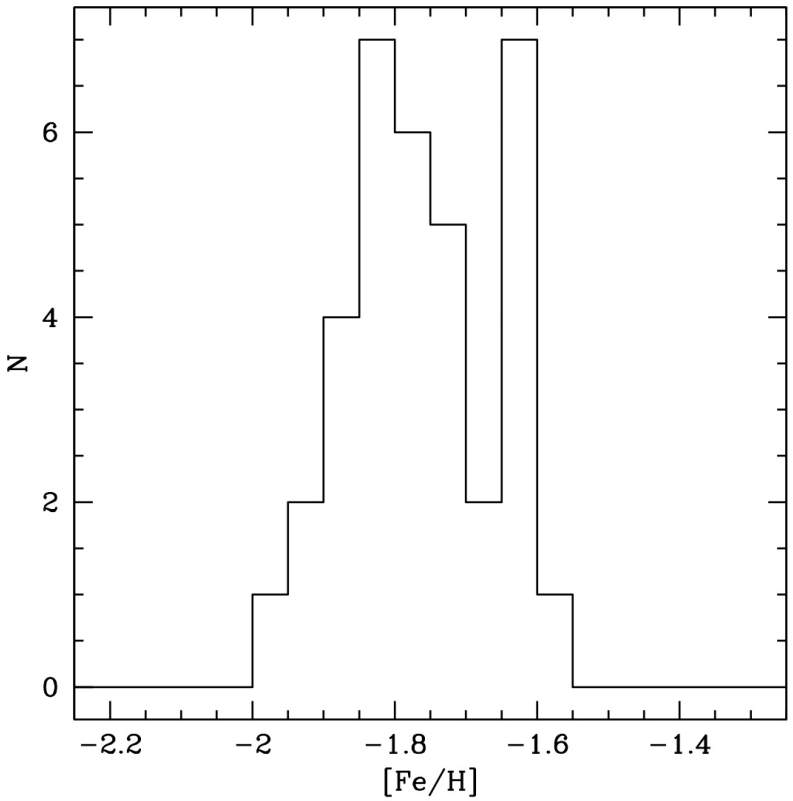
Fe abundance from Fe I lines

Fe abundance from Fe II lines

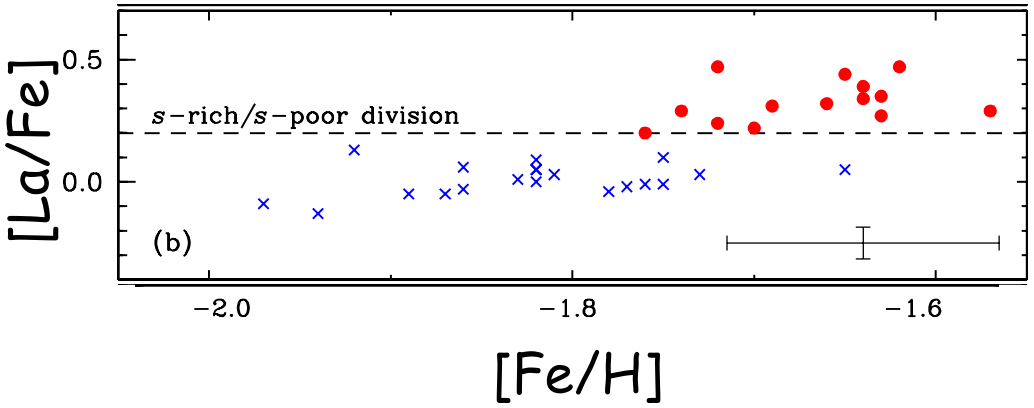
Fe abundance from Fe I lines

The case of M22

data from Marino+09,+11



Marino+11



Two groups of stars with:
- different [Fe/H]
- different s-process elements
- different C+N+O …

… but based on spectroscopic logg

Re-analysis of the 17 stars by Marino+09 (FLAMES-UVES)

Spectroscopic logg

[Fe I /H] = -1.92 (σ=0.13)

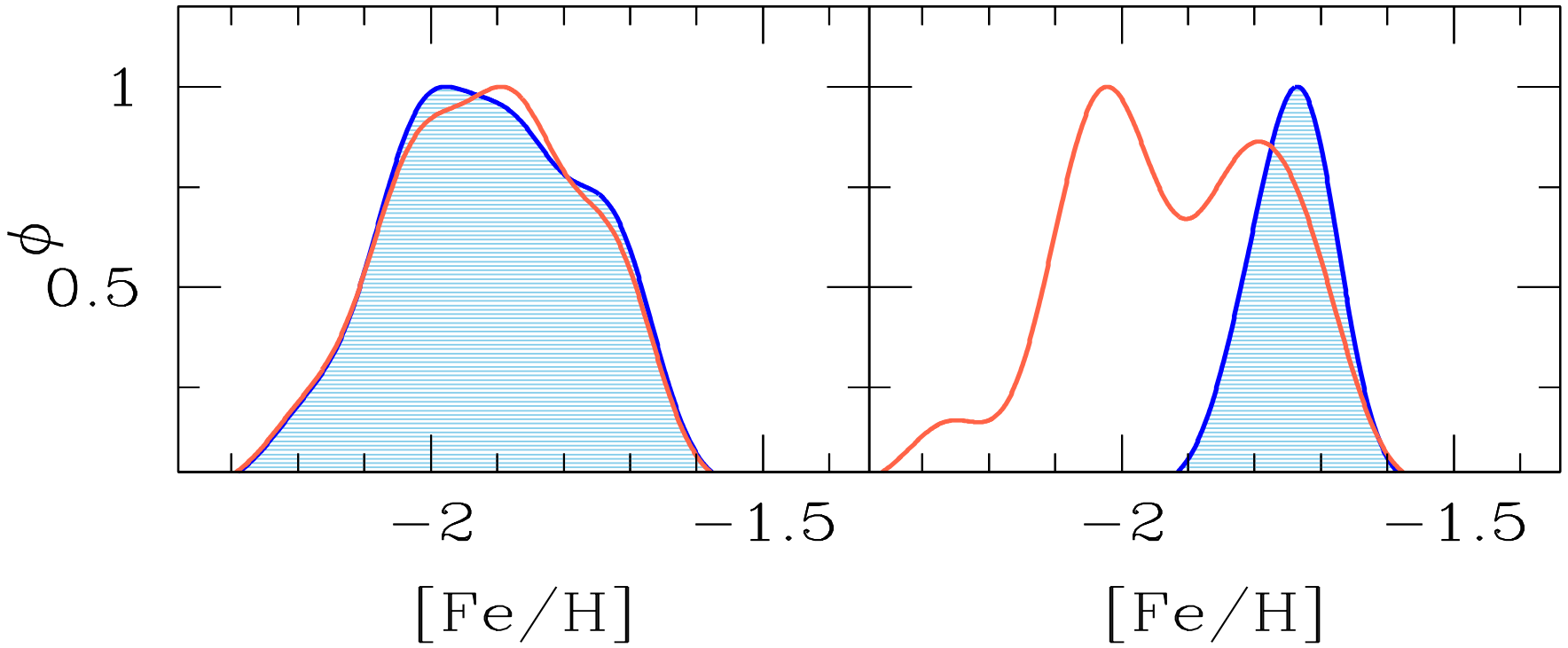
INTRINSIC FE SPREAD !!!

Photometric logg

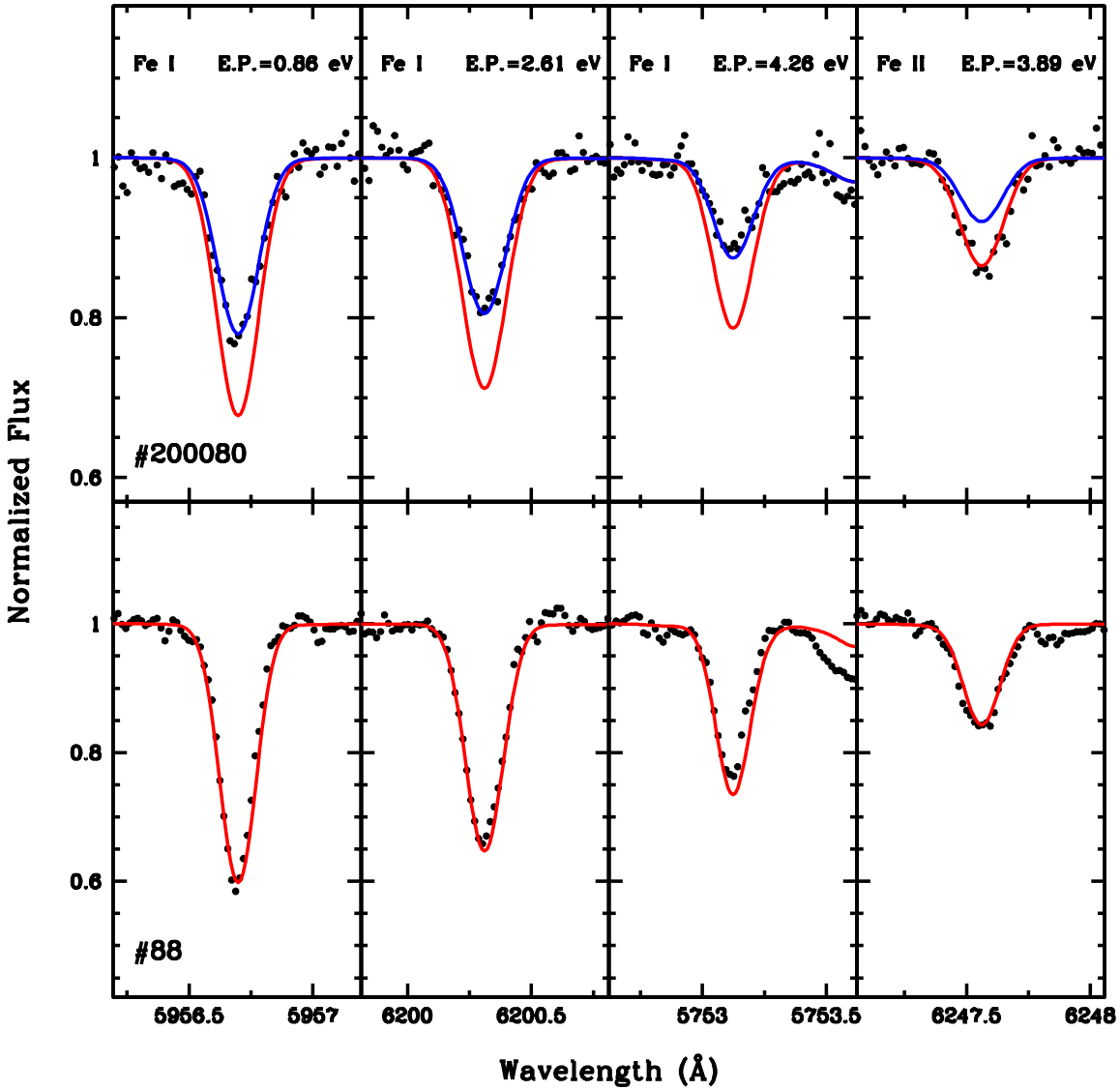
[Fe I /H] = -1.92 (σ=0.16)
[Fe II /H] = -1.75 (σ=0.04)

Fe II : NO intrinsic Fe spread !!!

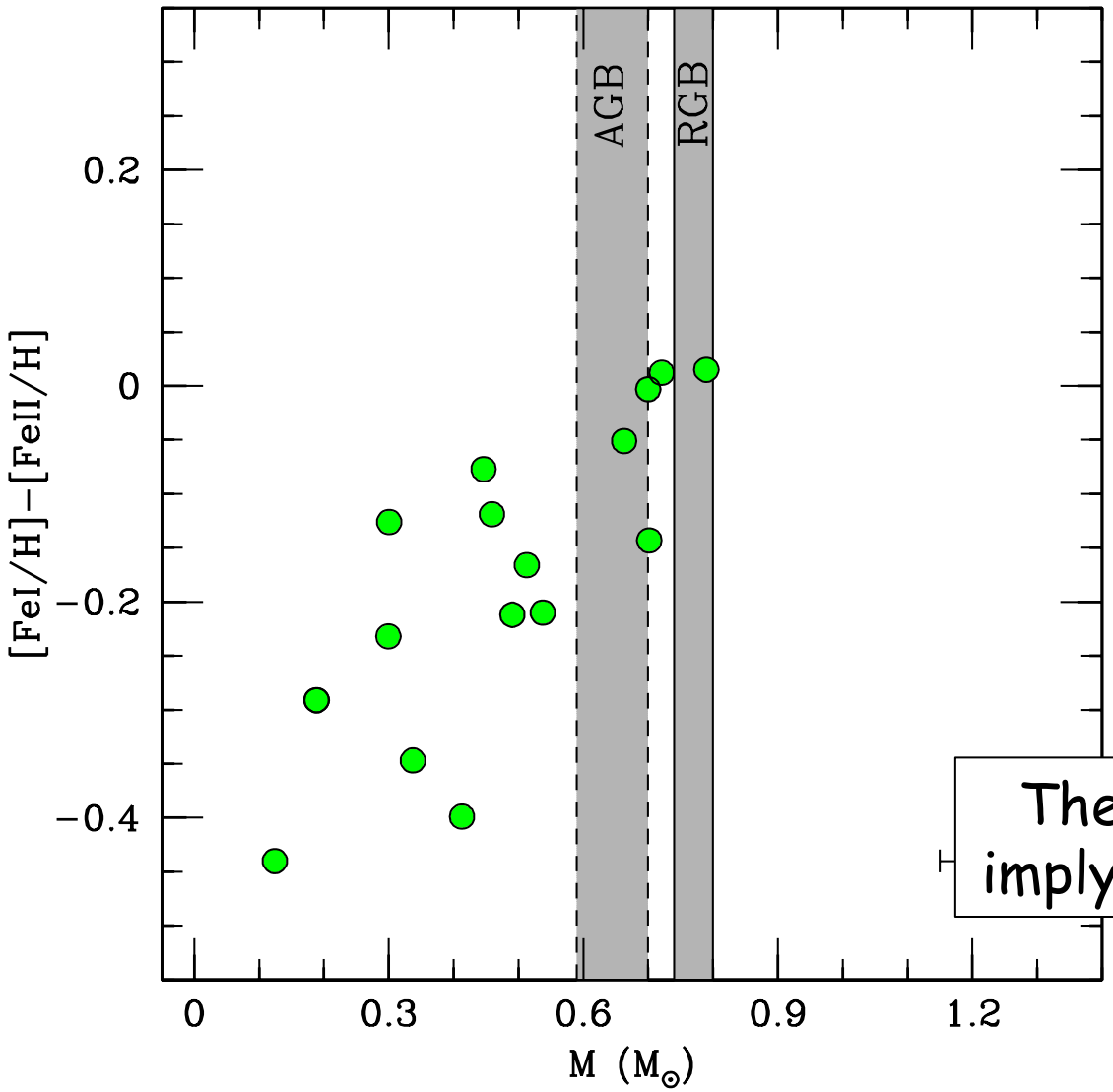
Mucciarelli et al. , submitted



The case of M22



The case of M22



The spectroscopic gravities imply unreliable stellar masses

Conclusions

- The AGB stars show NLTE effects at variance with the RGB stars
- The best way to avoid spurious effects is:
  Fe II lines + photometric logg
- With this approach NGC3201 and M22 turns out to be mono-metallic

Future perspectives