Gaia FGK Benchmark Stars and metal-poor stars

SPICA/ISSP Science meeting

Caroline Soubiran
Laboratoire d'astrophysique de Bordeaux

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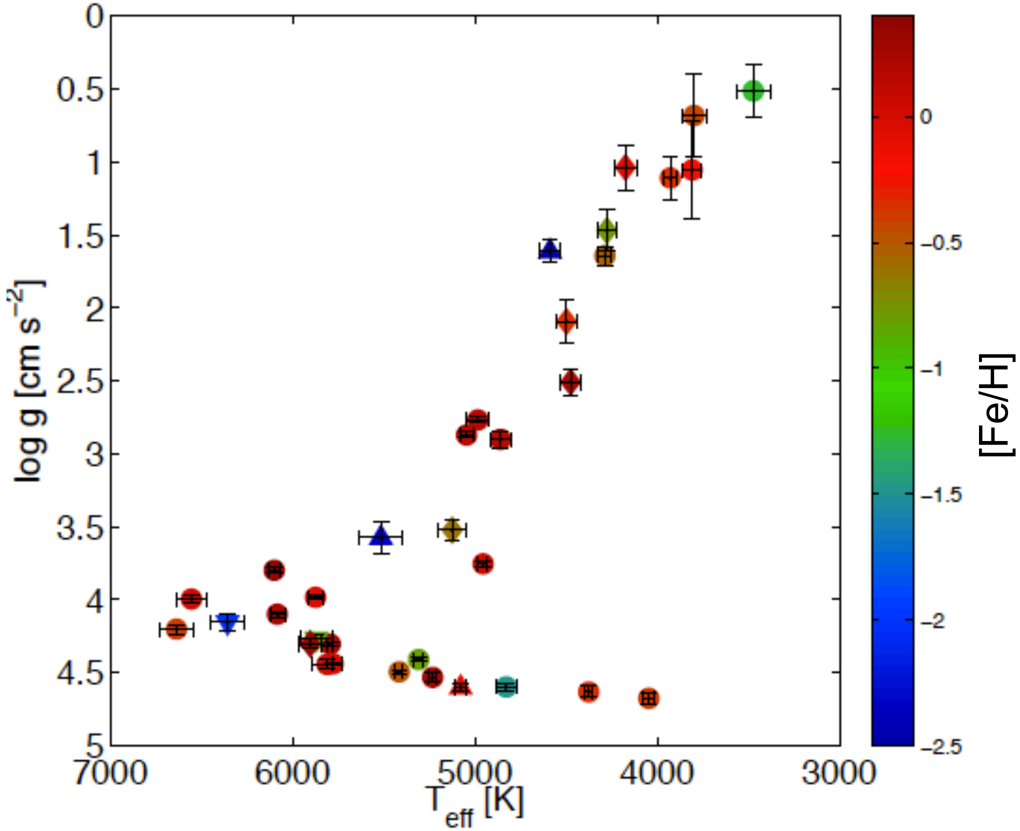
The Gaia FGK Benchmark Stars

- Gaia needs to anchor its stellar astrophysical parameters on a set of well-characterized stars spanning the HR diagram and the full metallicity range
- Spectroscopic surveys that massively derive atmospheric parameters and abundances (e.g. RAVE, GALAH, Gaia ESO, WEAVE,..) need reference stars to assess their results and calibrate them
- Atmospheric parameters and abundances from different origins need to be consistent
- Stellar models need to be improved from observational constraints

→ The GBS were defined to address these needs

The Gaia FGK Benchmark Stars

- The GBS are reference stars defining the **fundamental Teff and logg** scales, independently of spectroscopy and atmosphere models



Heiter et al. 2015

$$T_{\mathrm{eff}} = \left(\frac{F_{\mathrm{bol}}}{\sigma}\right)^{0.25} (0.5\,\theta_{\mathrm{LD}})^{-0.5}$$

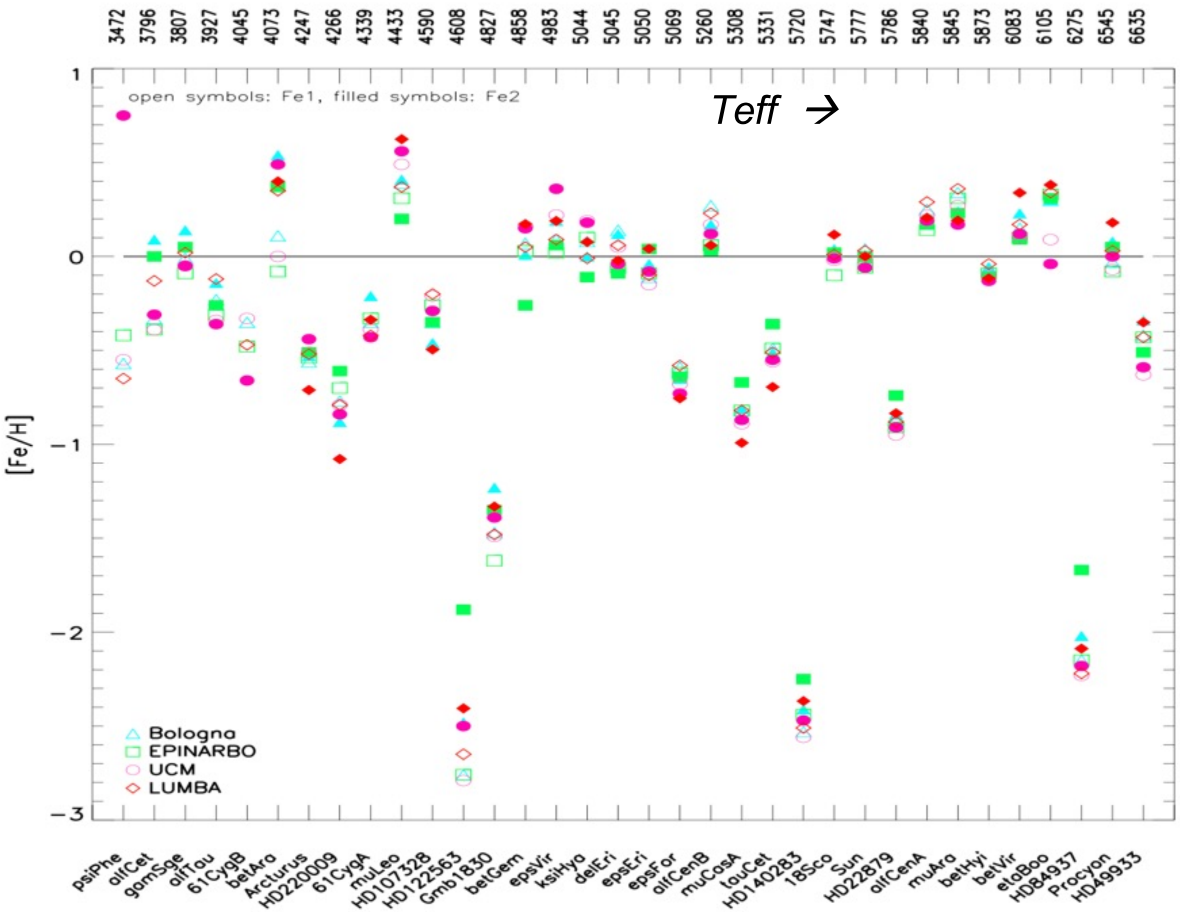
$$g = \frac{GM}{(0.5\theta_{\mathrm{LD}}/\pi)^2}$$

- observable quantities with minor dependencies on theoretical assumptions

Ongoing project : Extension to ~200 GBS

The Gaia FGK Benchmark Stars

- The GBS define a common abundance scale for large spectroscopic surveys



Jofré et al. 2014

The Gaia FGK Benchmark Stars

Paper I **Gaia FGK benchmark stars: Effective temperatures and surface gravities**
Heiter+ 2015A&A...582A..49H

Paper II **The Gaia FGK benchmark stars. High resolution spectral library**
Blanco-Cuaresma+ 2014A&A...566A..98B

Paper III **Gaia FGK benchmark stars: Metallicity**
Jofré+ 2014A&A...564A.133J

Paper IV **Gaia FGK benchmark stars: abundances of α and iron-peak elements**
Jofré+ 2015A&A...582A..81J

(Papers I–IV: **V1**)

Paper V **Gaia FGK benchmark stars: new candidates at low metallicities**
Hawkins+ 2016A&A...592A..70H

Paper VI **Gaia FGK benchmark stars: opening the black box of stellar element abundance determination**
Jofré+ 2017A&A...601A..38J

The Gaia FGK Benchmark Stars Version 2.1 → intermediate version (no new interferometric diameter)
Jofré+ 2018RNAAS...2..152J

→ **V3:** more stars + better distribution of atmospheric parameters + higher precision

The Gaia FGK Benchmark Stars V3

The GBS-V3 collaboration

The GBS - V3

$$T_{\rm eff} = \left(\frac{F_{\rm bol}}{\sigma}\right)^{0.25} (0.5\,\theta_{\rm LD})^{-0.5}.$$

$$g = \frac{GM}{(0.5\theta_{\rm LD}/\pi)^2}$$

The GBS - V3

$$T_{\text{eff}} = \left(\frac{F_{\text{bol}}}{\sigma}\right)^{0.25} (0.5\,\theta_{\text{LD}})^{-0.5}$$

$$g = \frac{GM}{(0.5\theta_{\text{LD}}/\pi)^2}$$

Interferometric diameters from literature:

- JMDC, Duvert+2016
- Salsi+2020
- ..

The GBS - V3

$$T_{\text{eff}} = \left(\frac{F_{\text{bol}}}{\sigma}\right)^{0.25} (0.5\,\theta_{\text{LD}})^{-0.5}$$

From Gaia DR3 or Hipparcos

$$g = \frac{GM}{(0.5\theta_{\text{LD}}/\pi)^2}$$

The GBS - V3

$$T_{\rm eff} = \left(\frac{F_{\rm bol}}{\sigma}\right)^{0.25} (0.5\,\theta_{\rm LD})^{-0.5}$$

Computation from
- fluxes in different passbands from VOSA
- extinction values from 3D maps (Vergely+2022)
- SED fitting (Creevey+2015)

$$g = \frac{GM}{(0.5\theta_{\rm LD}/\pi)^2}$$

The GBS - V3

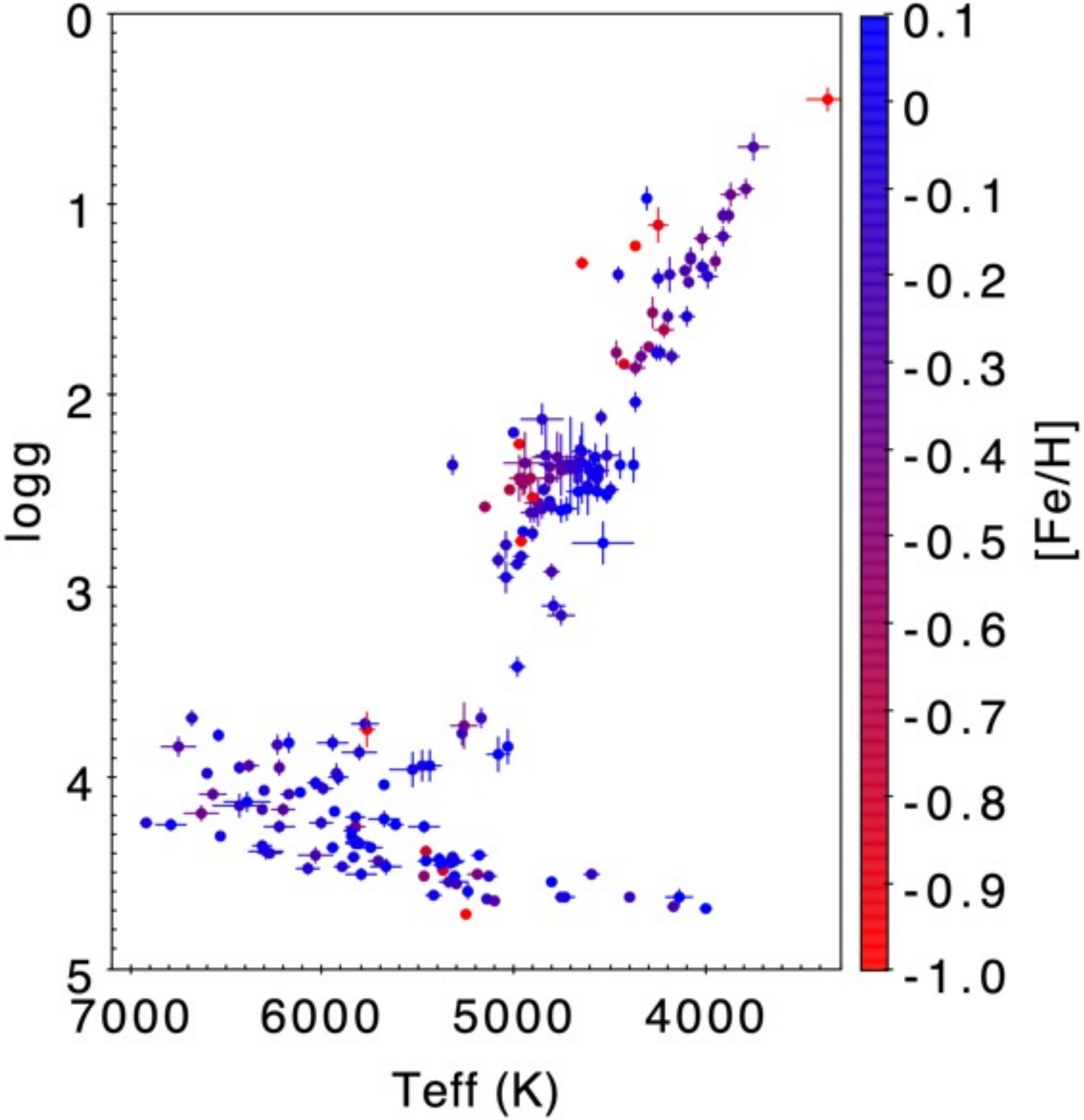
$$T_{\rm eff} = \left(\frac{F_{\rm bol}}{\sigma}\right)^{0.25} (0.5\,\theta_{\rm LD})^{-0.5}$$

Computation from

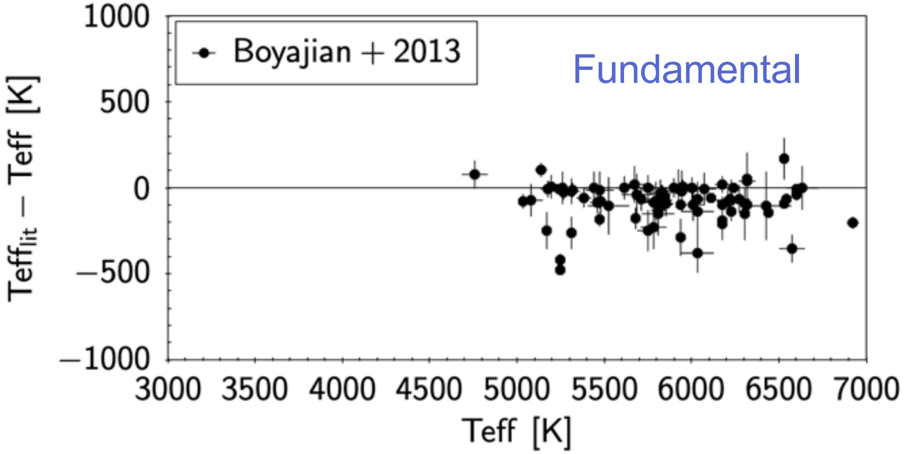
- Teff (from Fbol and ThetaLD)
- Luminosity (from Fbol and parallax)
- [Fe/H] from spectroscopy
- stellar evolution tracks (BaSTI, STAREVOL)
- Code SPInS (Lebreton & Rees 2020)

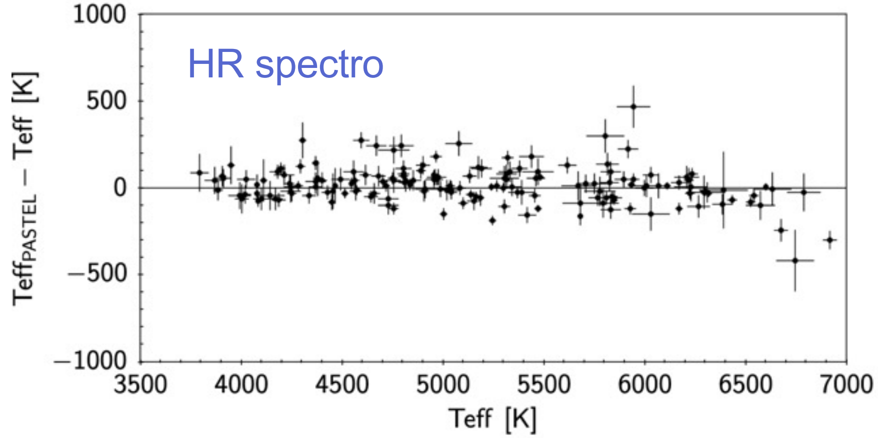
$$g = \frac{GM}{(0.5\theta_{\rm LD}/\pi)^2}$$

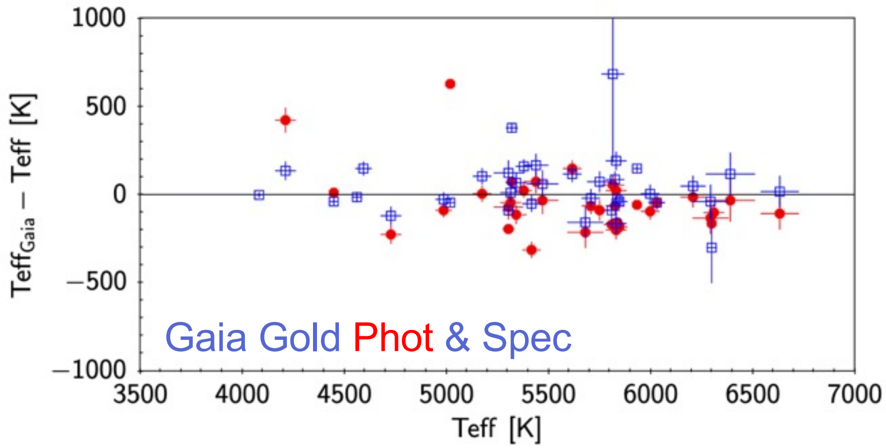
The Gaia FGK Benchmark Stars version V3 *(in prep.)*

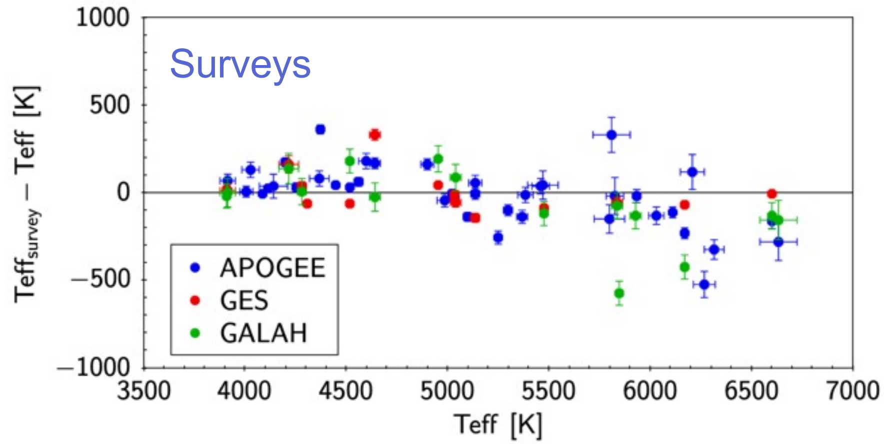


Our fundamental Teff vs other

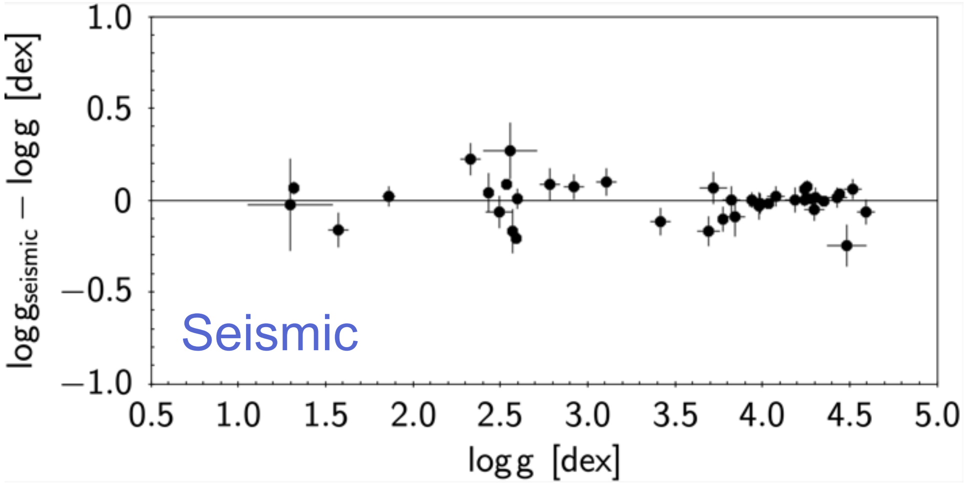


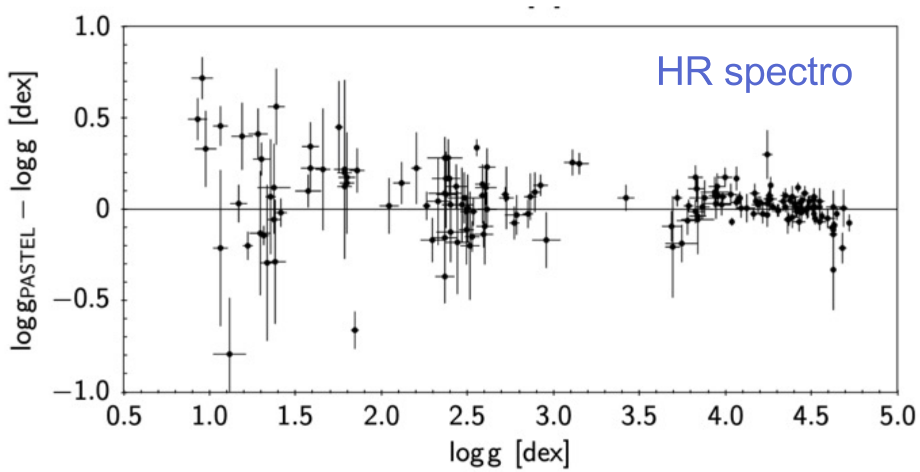


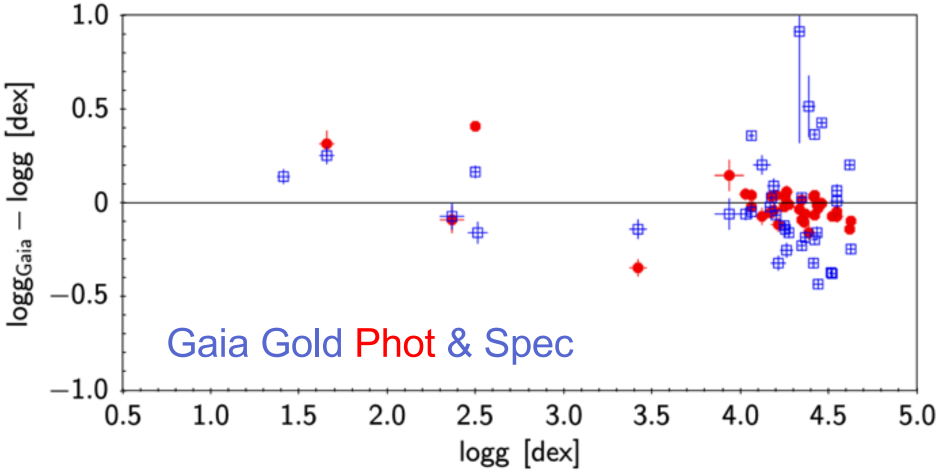


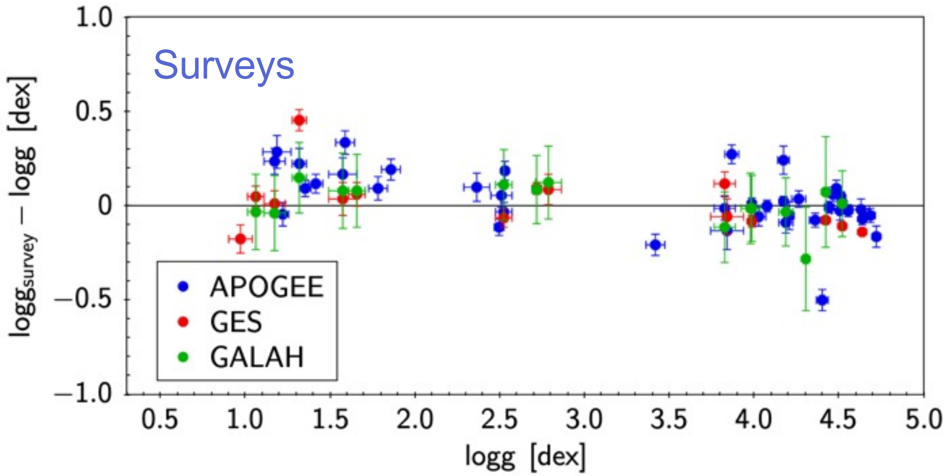


Our fundamental logg vs other

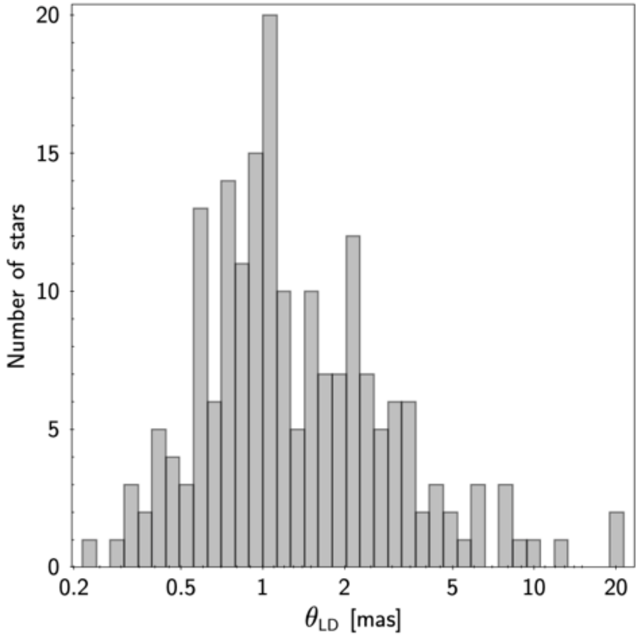


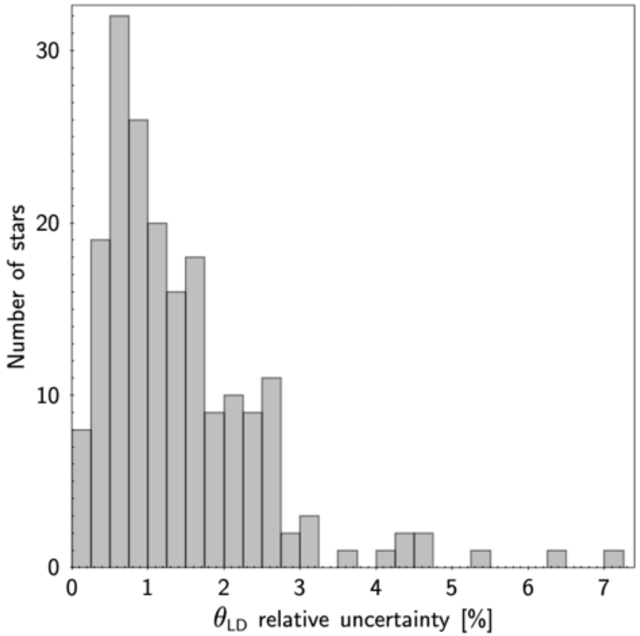


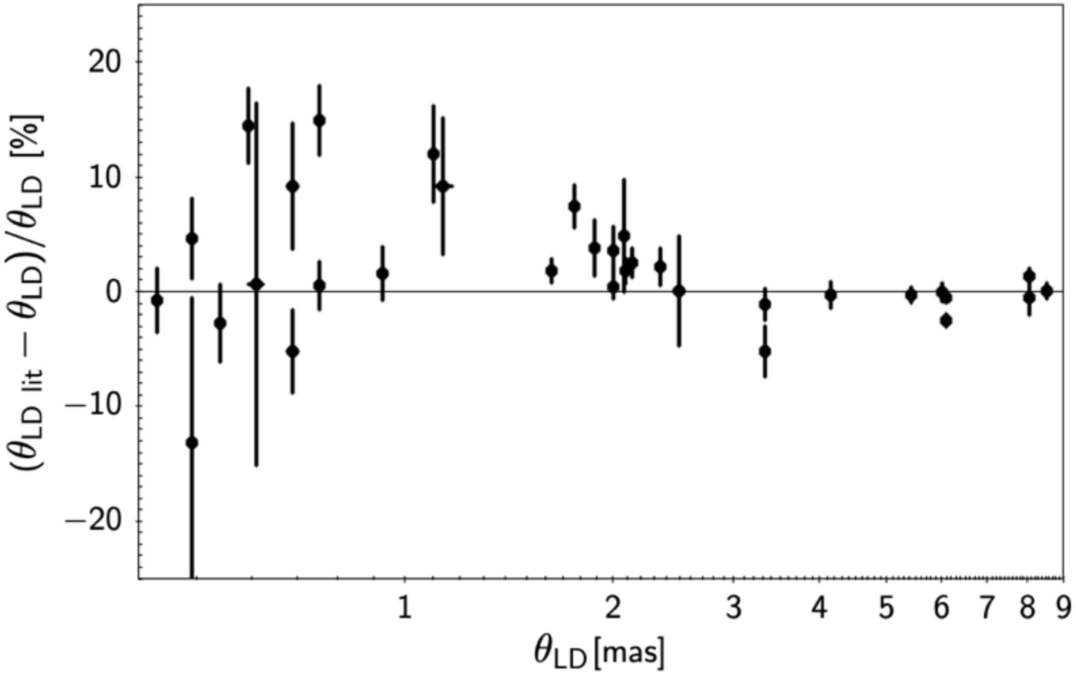




The Gaia FGK Benchmark Stars version V3 *(in prep.)*

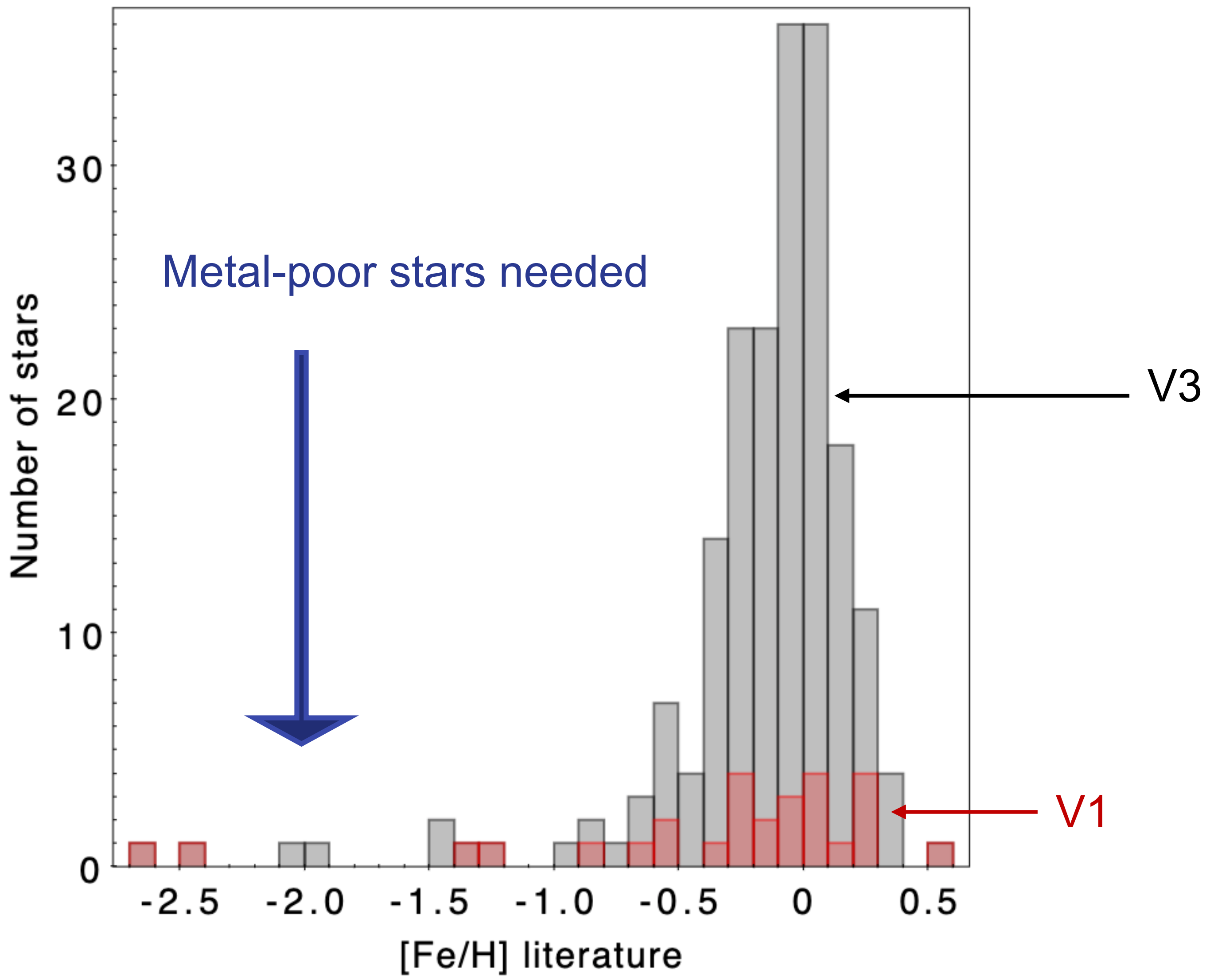






Homogenenity and precision of angular diameters to be improved

The Gaia FGK Benchmark Stars version V3 *(in prep.)*



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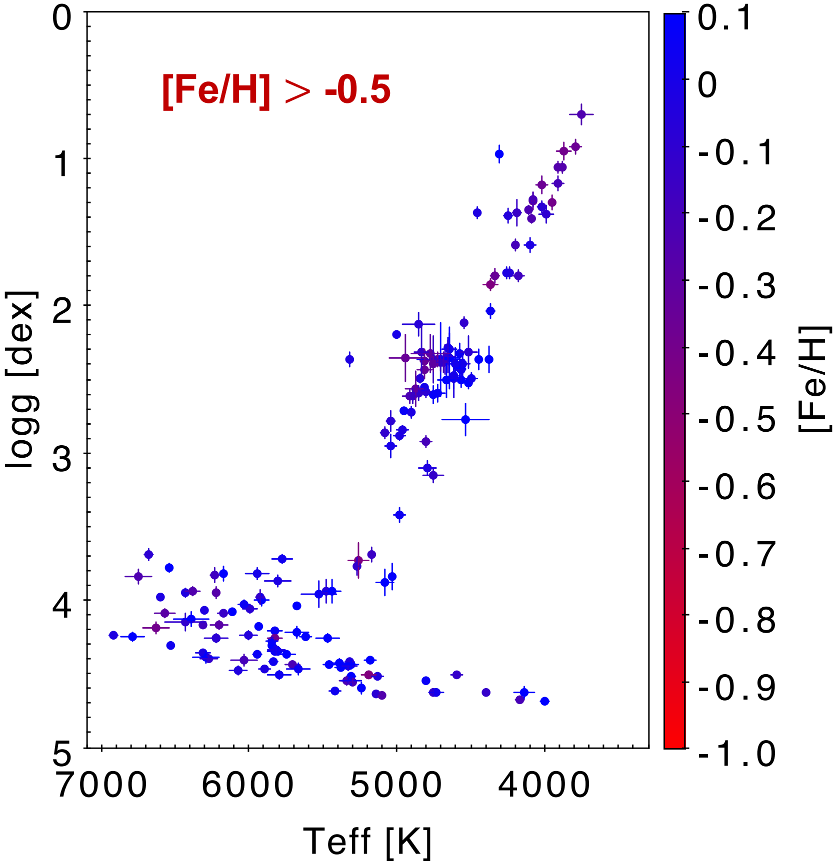
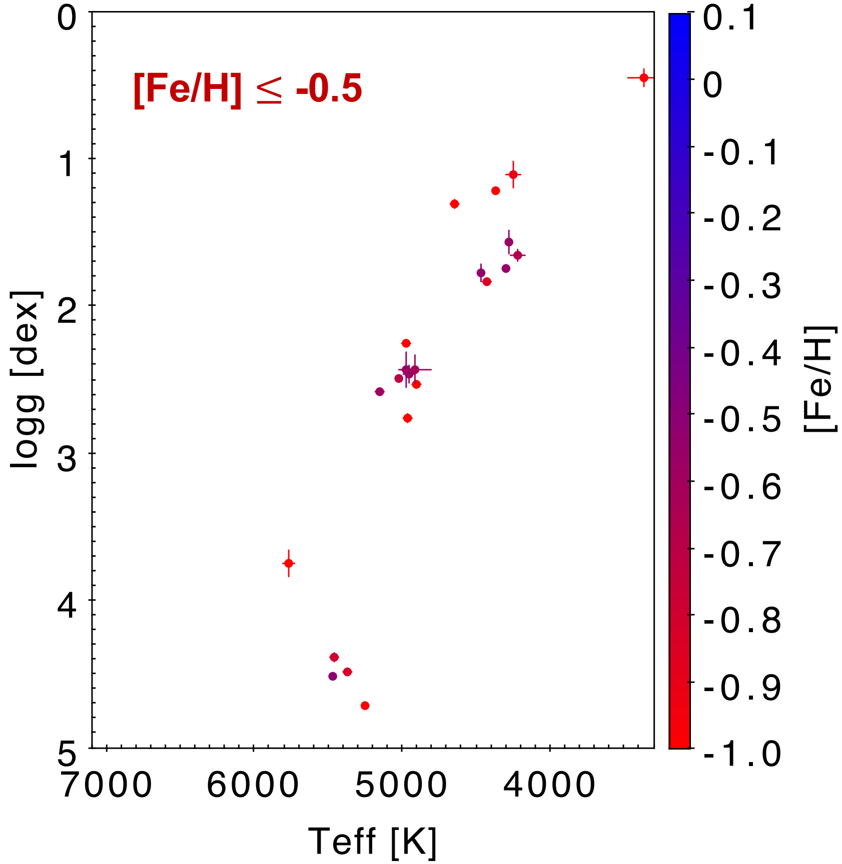




There are targets appropriate for SPICA observations that can fill the metal-poor side !

Towards GBS-V4

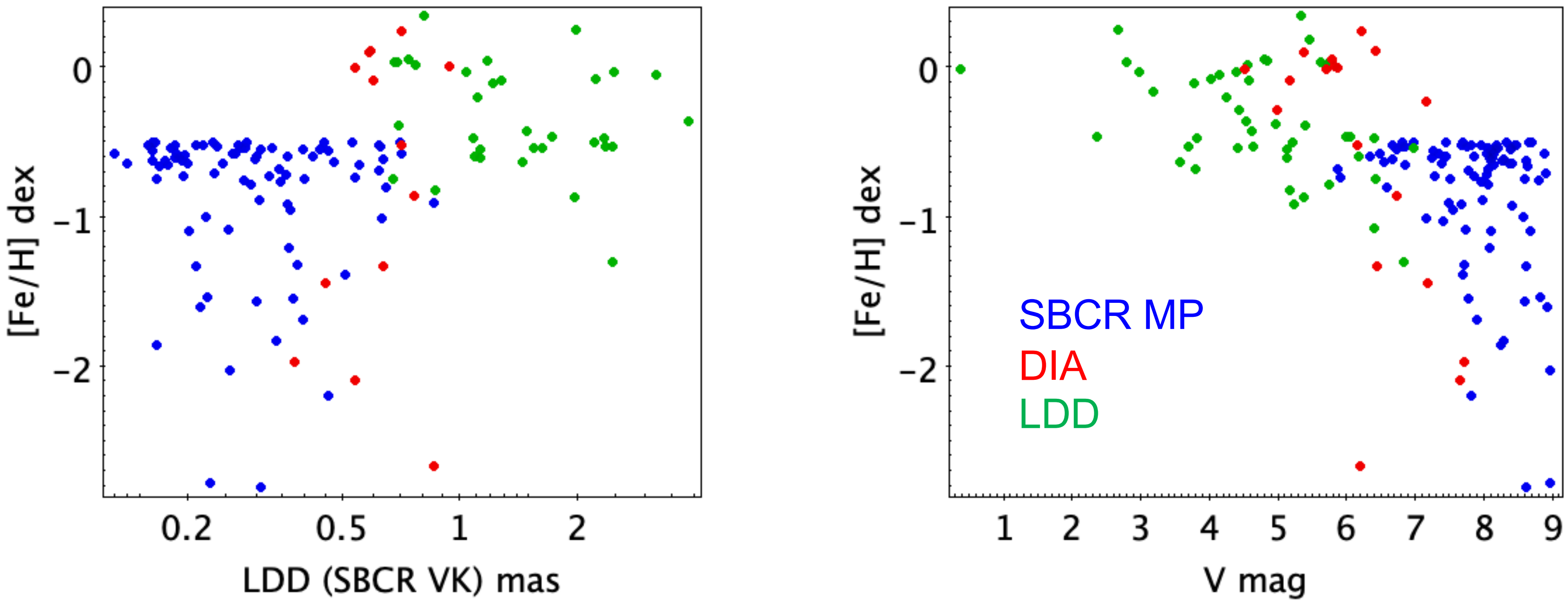
- More homogeneous and accurate (1%) angular diameters
- More metal-poor stars (to be used also for SBCR MP)

VLTI/PIONIER
- **P112-P113**
- **38 stars**
- **DEC<-20°**
- **LDD > 0.8 mas**

CHARA/SPICA
- **2024+**
- **156 stars**
- **DEC>-20°**

+ 148 GBS-V3 already in ISSP

Towards GBS-V4



156 SPICA targets

Summary

- Accurate and homogeneous LDD needed for the GBS
- MP stars to be added to the GBS

- GBS V4 can be observed with combination of PIONIER and SPICA
- 146 stars already in ISSP (+ seismic targets, exoplanet hosts)
- 158 targets for new observations with SPICA

- GBS V4 will benefit to SBCR: impact of metallicity on SBCR and LMC distance (theoretical results from Salsi+22)

- GBS also important in the context of PLATO: WP125 (benchmark stars) and WP122 (SBCR and metal poor exoplanet host stars)

  - need of tools to follow a multi-paremeters space survey (Teff, logg, [Fe/H]) in order to manage list of stars and priorities