Homogeneous and self-consistent stellar parameters of ARIEL targets:
The description of the method and the first sample

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on behalf of the Stellar Characterisation WG

Ariel Workshop 25-27 May 2022

WG STRUCTURE AND MEMBERS

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CONSORTIUM SYNERGIES

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DATA ANALYSIS and OBSERVATIONS

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ATMOSPHERIC PARAMETERS

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ABUNDANCES

E. Delgado-Mena (IA/U. Porto), V. Adibekyan, M. Van Der Swaelmen

ACTIVITY INDEXES

S. Benatti (OA Palermo), G. Bruno, G. Micela, +

AGE, MASS, RADIUS

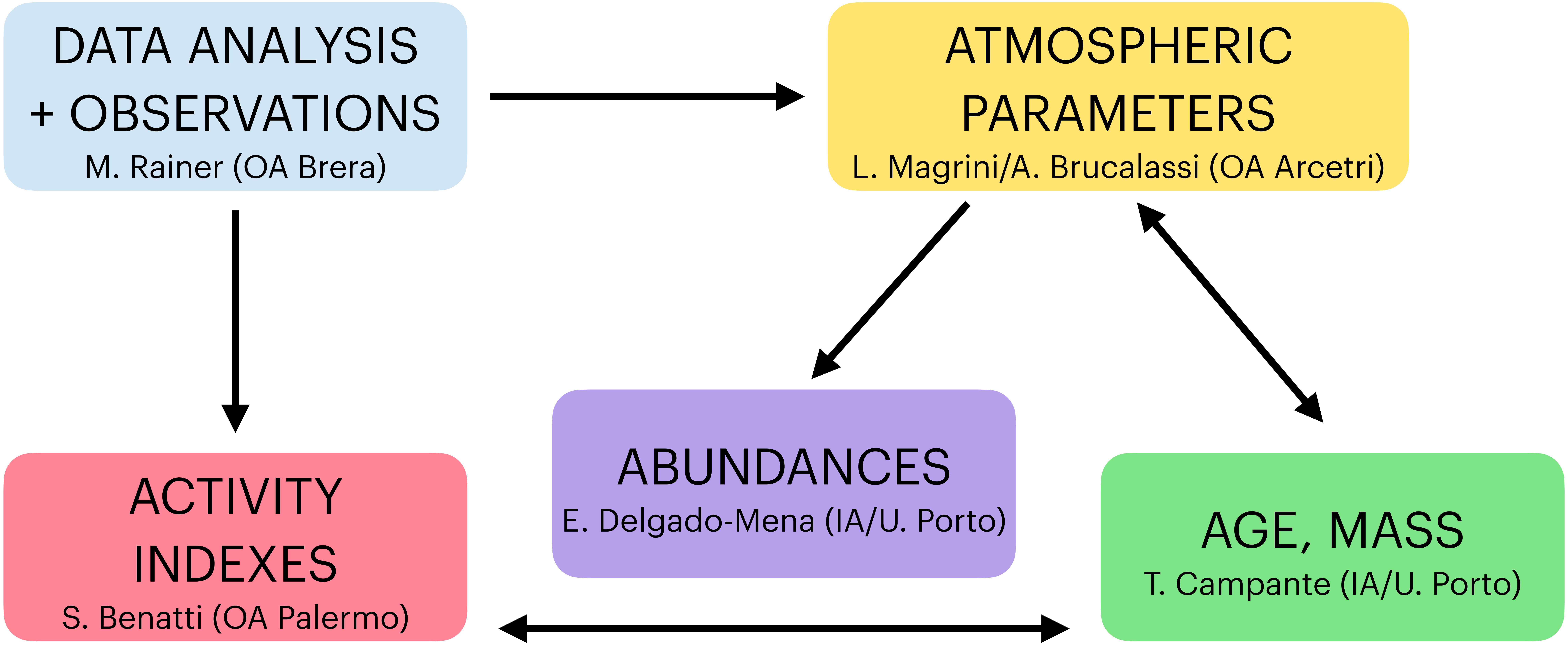
T. Campante (IA/U. Porto), D. Bossini, G. Sacco

GENERAL AIM

- observational methodology of Ariel is based on differential spectroscopy to measure planetary signals of 10-50 ppm relative to the star
- **importance of precisely characterising all the properties of the host stars**
- uniform methodology for the analysis of all Tier 1 stars (Danielski et al. 2021).

SUB-WG WORKFLOW

METHODS: model dependent and empirical



DELIVERABLES

ATMOSPHERIC PARAMETERS

Tables at CDS for the first 187 targets

ACTIVITY INDEXES

ARIEL STELLAR CATALOGUE

@ARIEL WEBSITE

ABUNDANCES

(Na, Al, Mg, Si, C, N, O)

AGE, MASS, RADII

Observational campaign

Starting from 2019, we are conducting an observational campaign to collect high resolution (R > 50,000), high S/N (S/N=120 at 600 nm) spectra for all the ARES targets without good enough public data.

The main part of the campaign focuses on echelle spectrograph on 4-8m sized telescopes, and we also have some dedicated time with OES at the Ondrejov observatory on a 2m telescope.

We are also conducting a variability and activity monitoring campaign on a smaller sample of selected targets, using photometry and high resolution spectroscopy with small-size telescopes.

Observational campaign

I. Stellar parameters and abundances

Instrument	Characteristics	Campaign info
UVES@VLT	Optical, R≈70,000	3 proposals accepted, 1 submitted
HARPS-N@TNG	Optical, R=115,000	2 proposals accepted, 1 almost submitted (deadline May 27^{th})
PEPSI@LBT	Optical, R=50,000	1 proposal accepted, 1 submitted
CARMENES@CAHA	Optical (R=94,600) NIR (R=80,400),	1 Large Program proposal accepted and ongoing
HDS@Subaru	Optical, R≈80,000	Proposal submitted
OES@Ondrejov	Optical, R=50,000	First spectra acquired, observations ongoing

Observational campaign

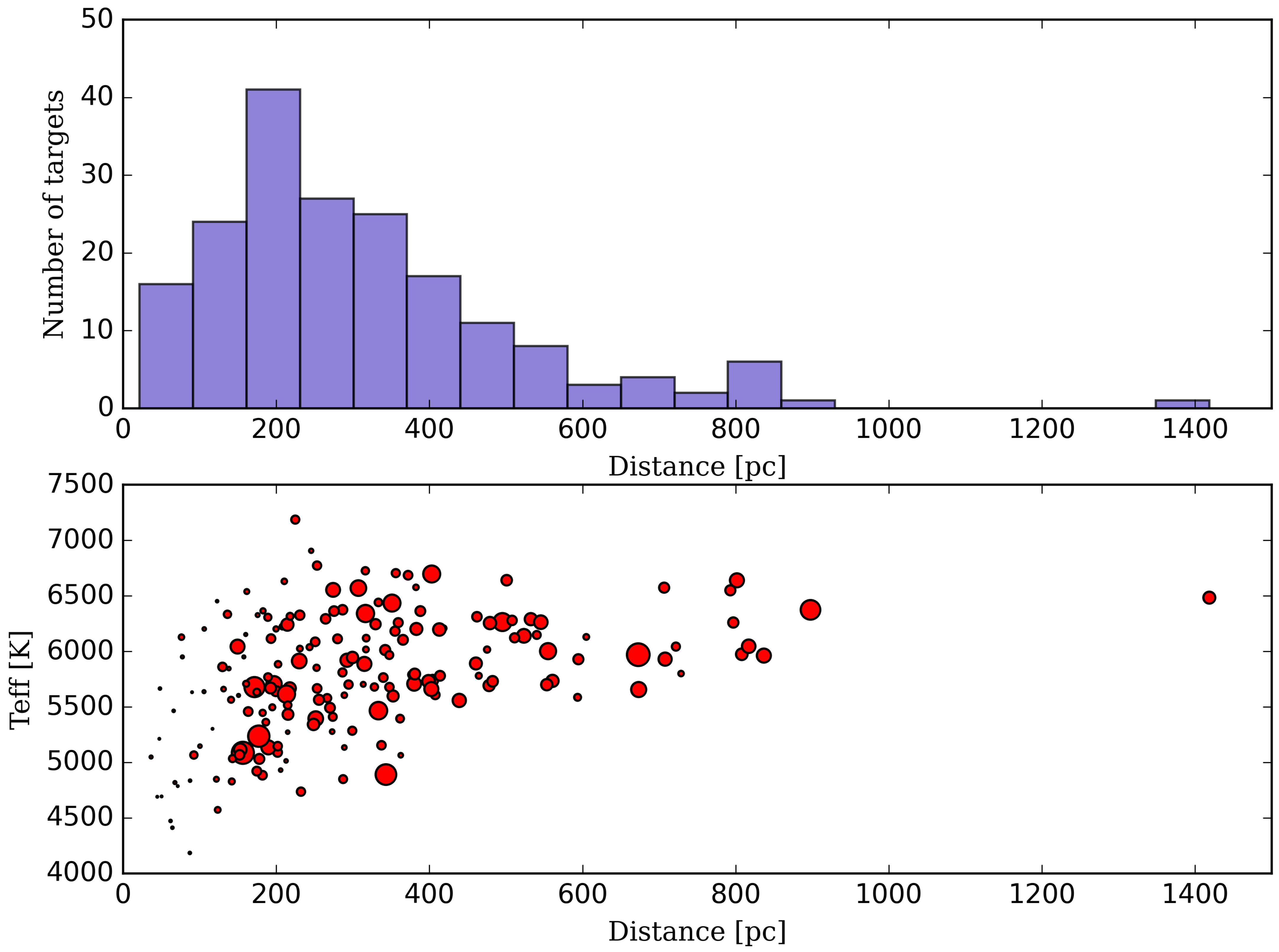
II. Stellar variability and activity

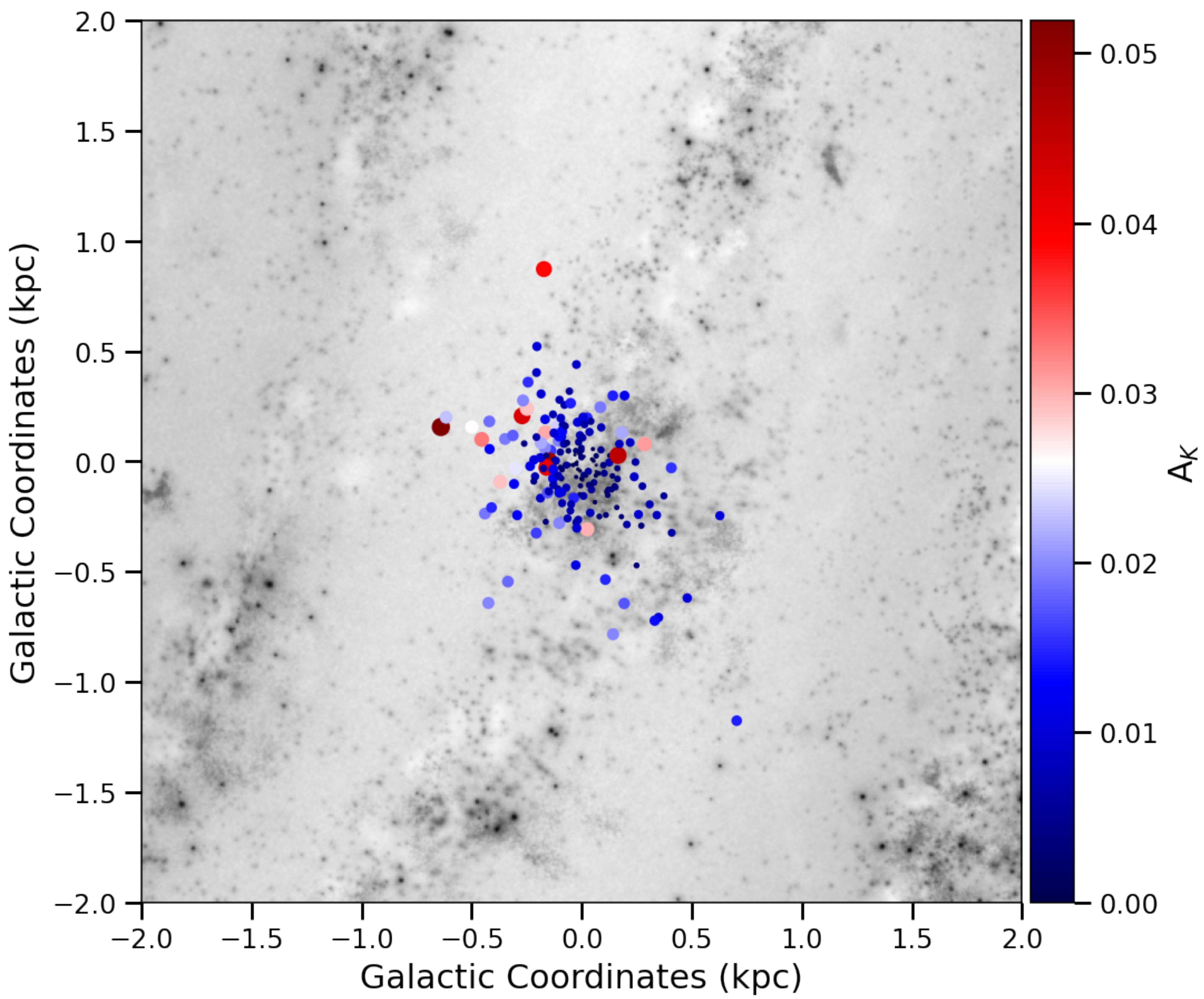
Observatory	Characteristics	Campaign info
Tartu	Optical mid-res spectroscopy and photometry	Interaction with the Stellar Activity subWG, feasibility study performed
REM	Photometry	1 proposal accepted
Asiago	Optical, $R \leq 28{,}700$	1 Large Program proposal accepted, observations ongoing

THE FIRST SAMPLE

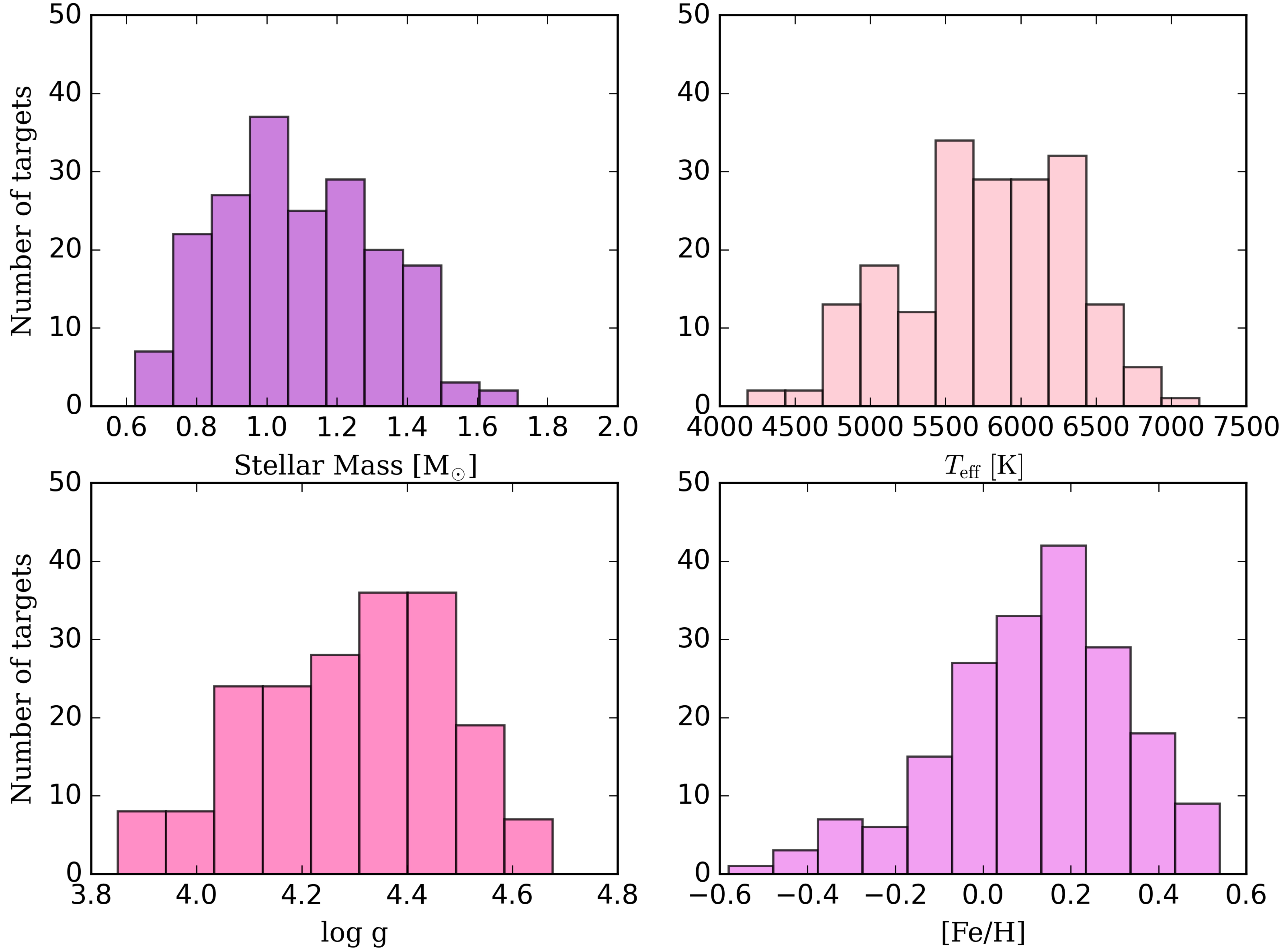
B21	HARPS-Archive	UVES-VLT	HARPS-N TNG	PEPSI LBT
123	33	20	7	4

Paper I (Magrini et al 2022)	FGK
Paper II (Tsantaki et al. in prep)	Fast rotators
Paper III	M dwarfs



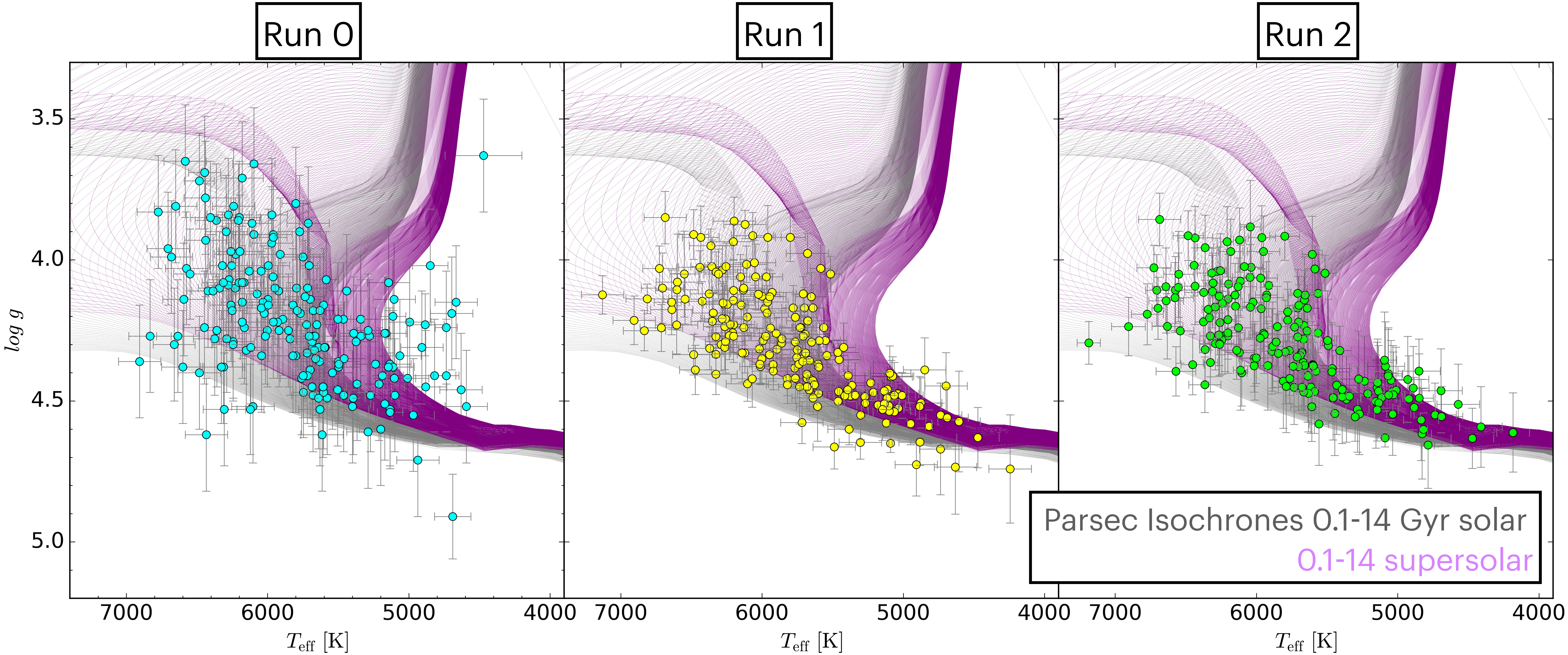


THE FIRST SAMPLE



- Solar-type MS stars
- [Fe/H] peaks at slightly super-solar metallicity
- Typical mass ~ 1 Msun

THE SPECTRO-PHOTOMETRIC ANALYSIS



Spectral analysis only

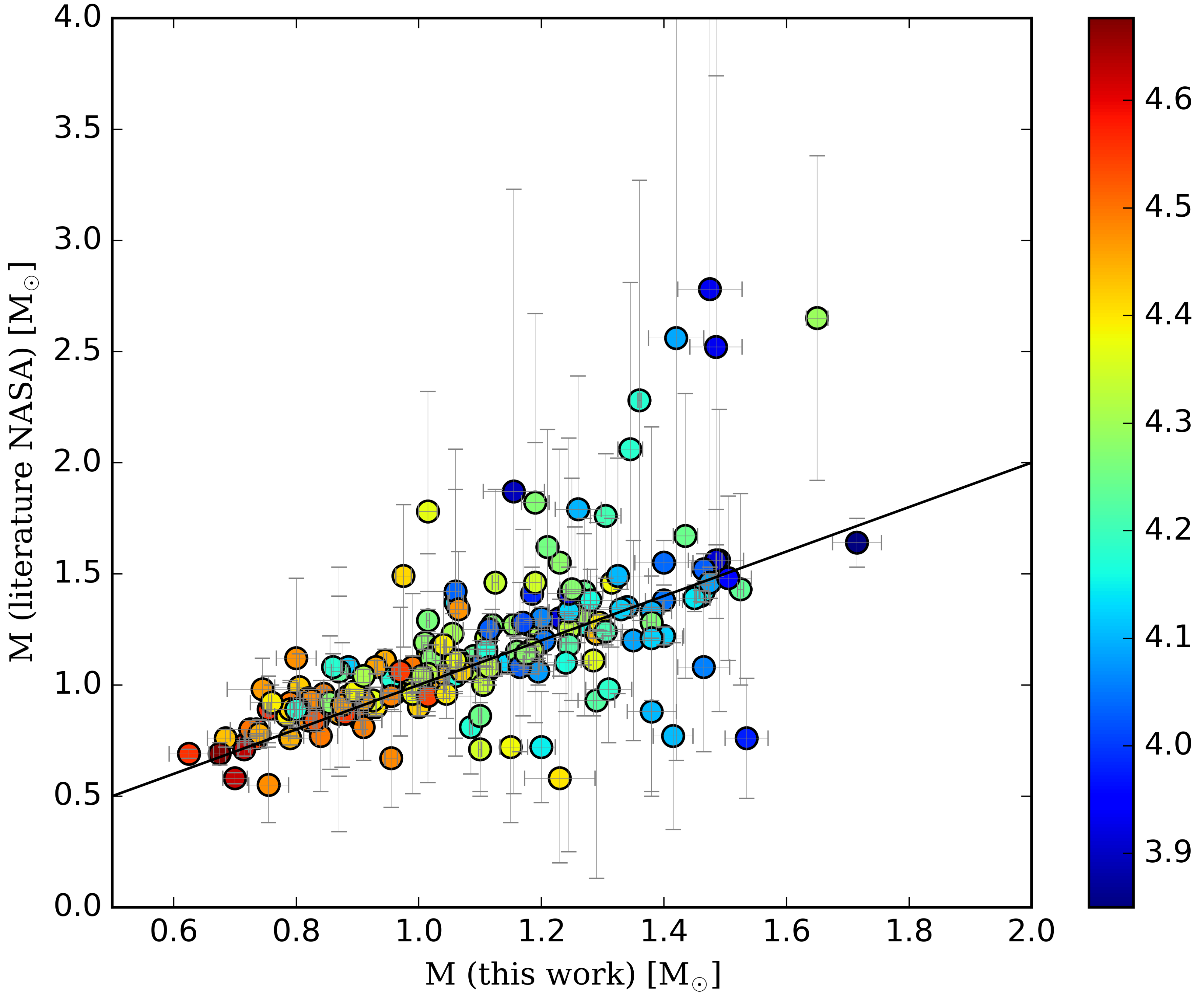
Mass determination

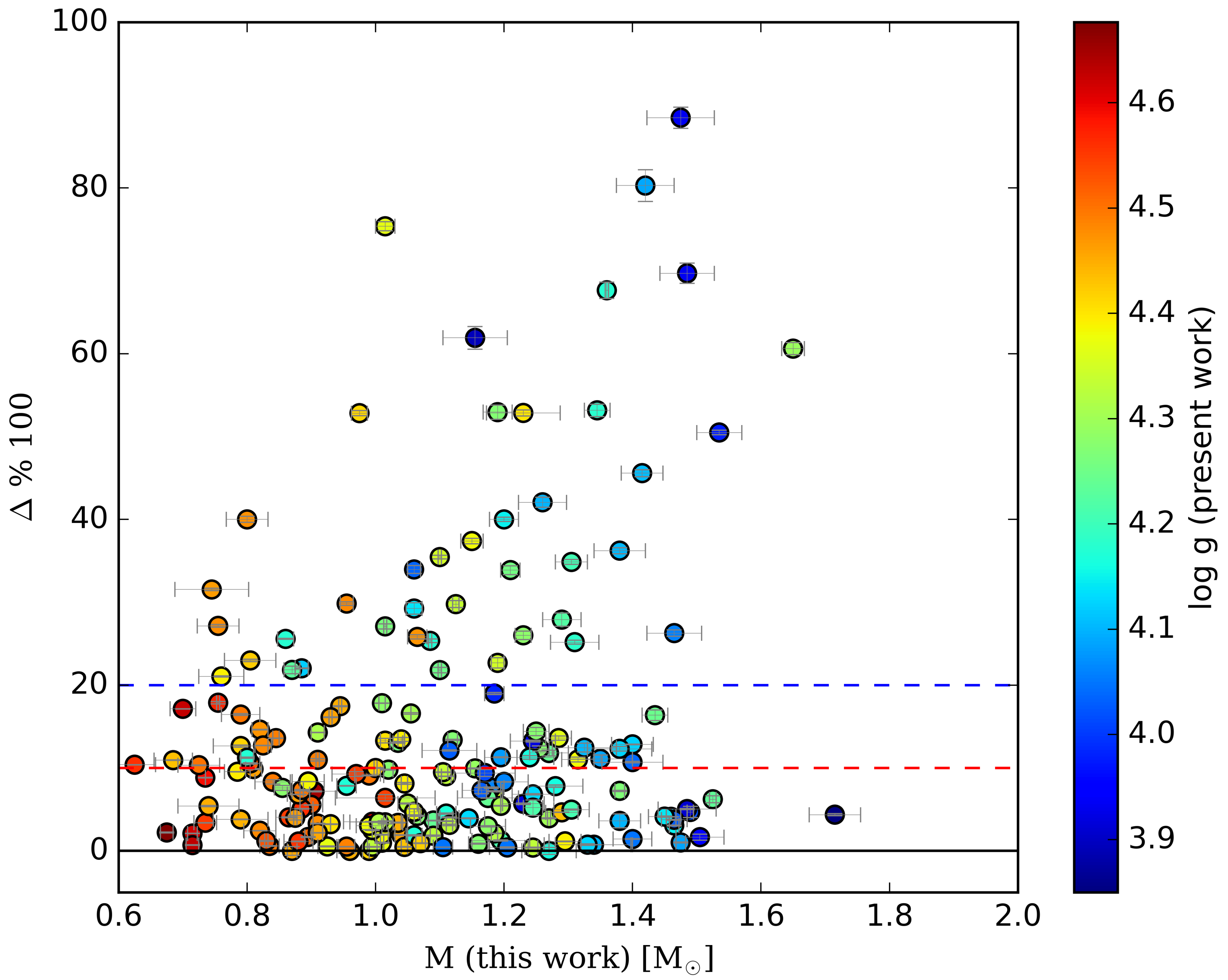
Spectral analysis with gravity from Gaia eDR3 and self-consistent mass (from sWG-mass)

New Mass

Spectral analysis with gravity from Gaia eDR3 and new mass (from sWG-mass)

THE NEW STELLAR MASSES





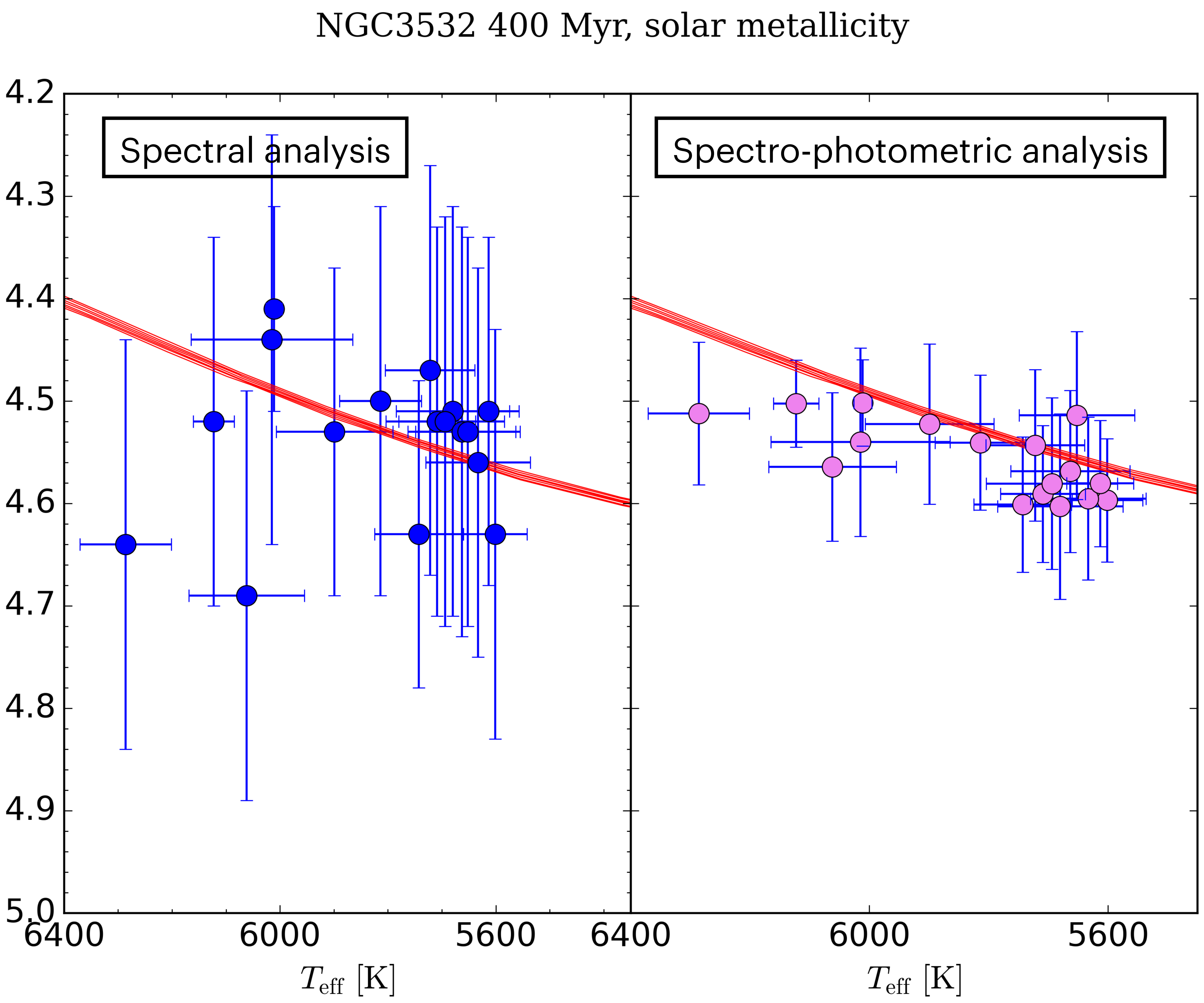
Stellar mass precision directly reflect on:

- the determination of the planetary mass,
- our understanding of planetary interiors
- the physical processes operating in their atmospheres
- planetary formation and evolutionary histories

THE VALIDATION SAMPLE

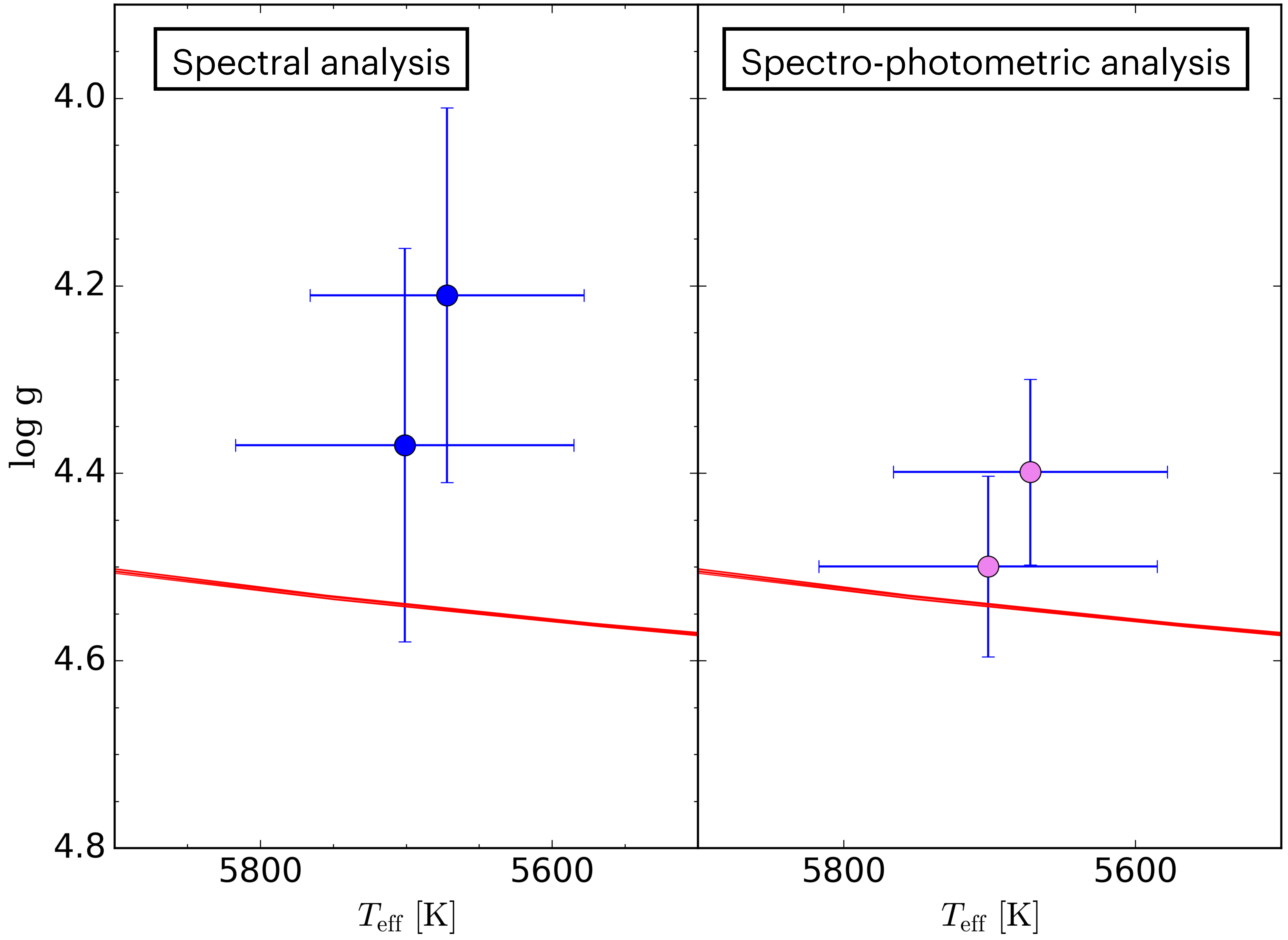
Open clusters:

- Ages from Gaia eDR3
- High-res spectra
- Same spectro-photometric analysis (no priors)

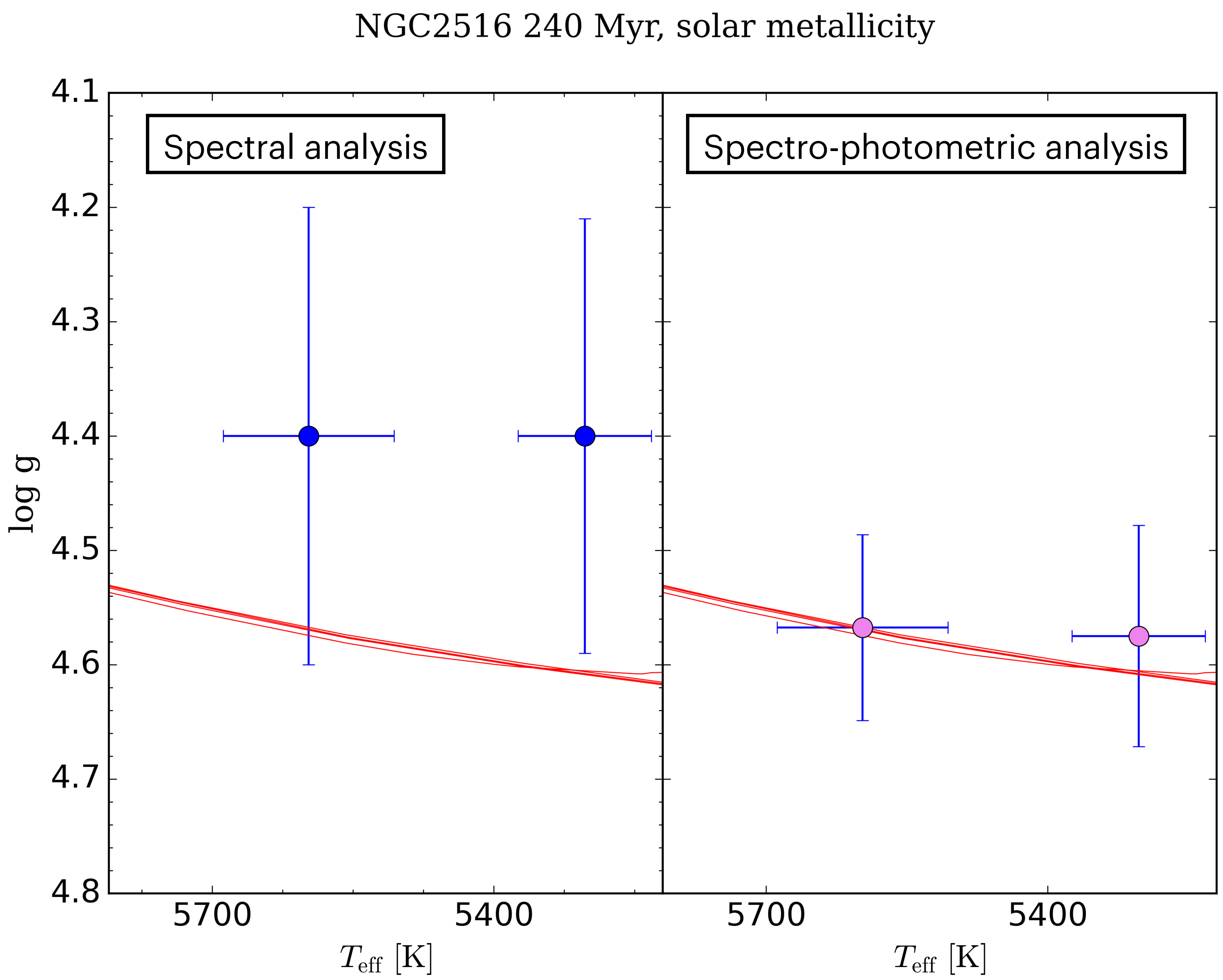


THE VALIDATION SAMPLE

NGC6633 690 Myr, solar metallicity

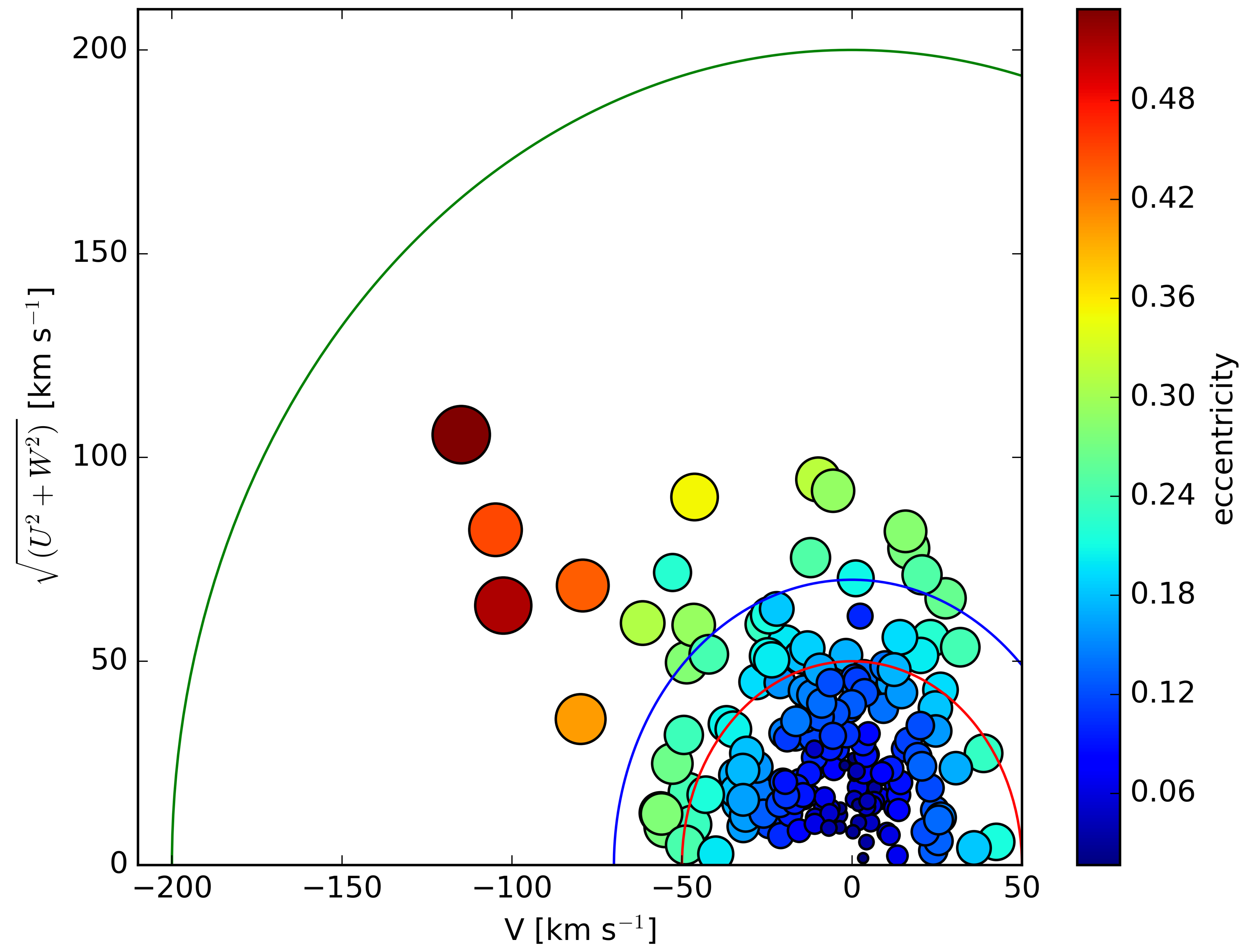


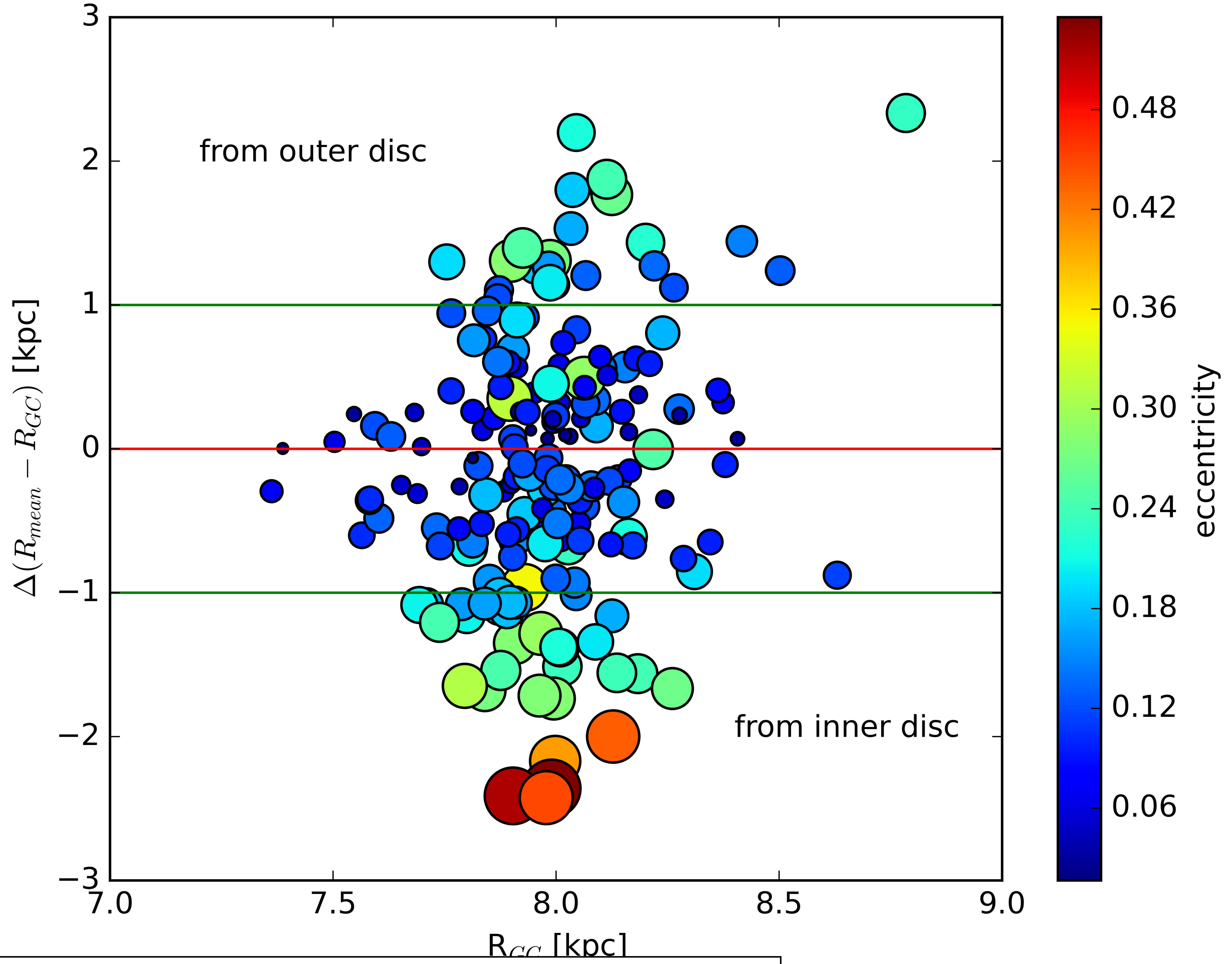
THE VALIDATION SAMPLE



THE KINEMATIC CHARACTERISATION

The dynamical history of stars, including stellar age and kinematics, impact the distribution and the architecture of planets in our Galaxy





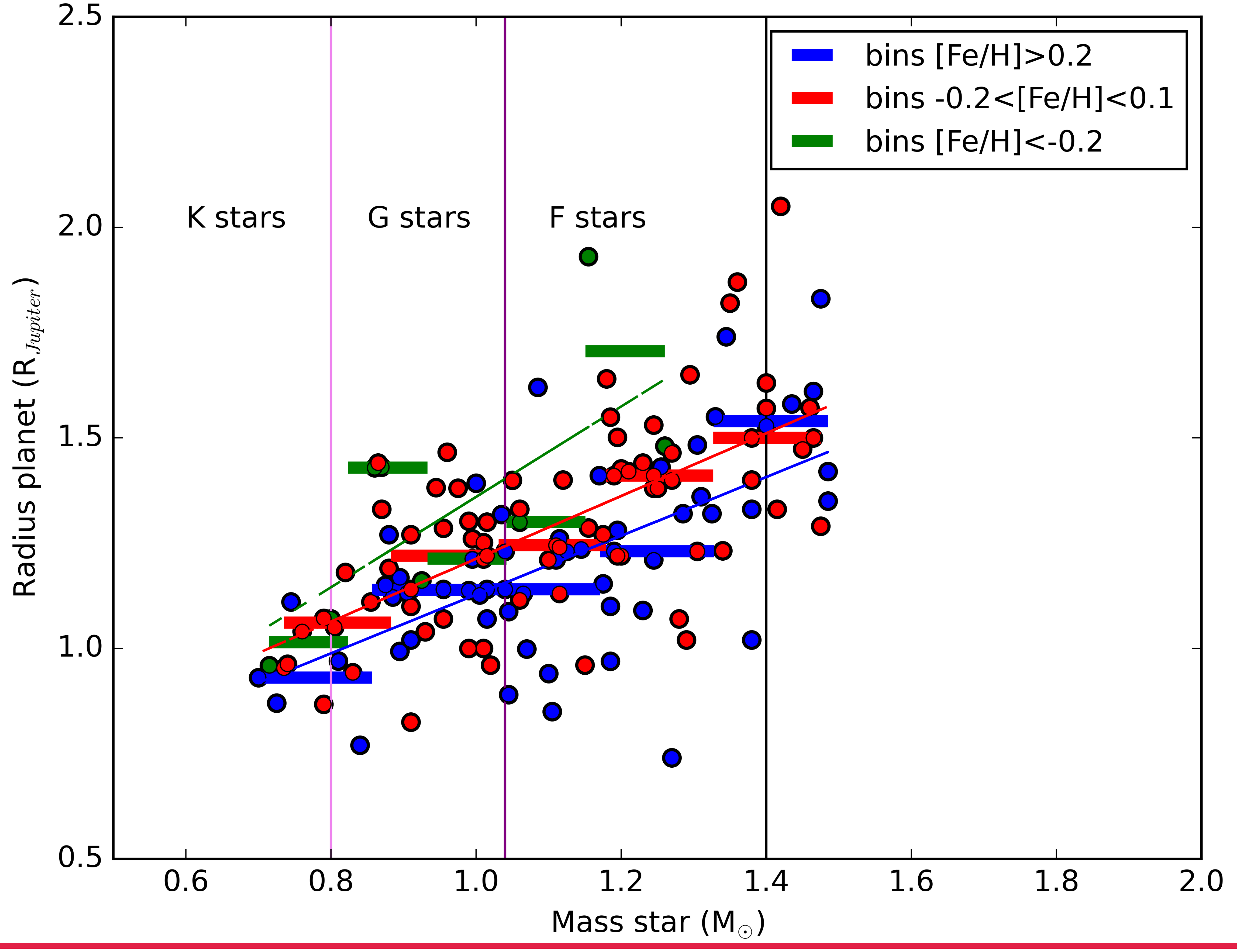
- Gaia eDR3 to compute orbits and velocity components
- Thin and Thick disc populations
- Elliptical orbits —> migrating stars from inner and outer disc

FIRST APPLICATIONS

Planetary systems: NASA exoplanet catalogue

Stars: our stellar parameters

Larger planets around more massive stars



Planets around more massive stars tend to be richer in gas, with higher H-He mass fractions, and are larger (Lozovski+21)

Metallicity dependence: heavy elements accreted by the giant planets around higher metallicity stars translates into higher densities and more compact radii than in lower metallicity environments (e.g. Suárez Mascareño et al. 2021).

FIRST APPLICATIONS

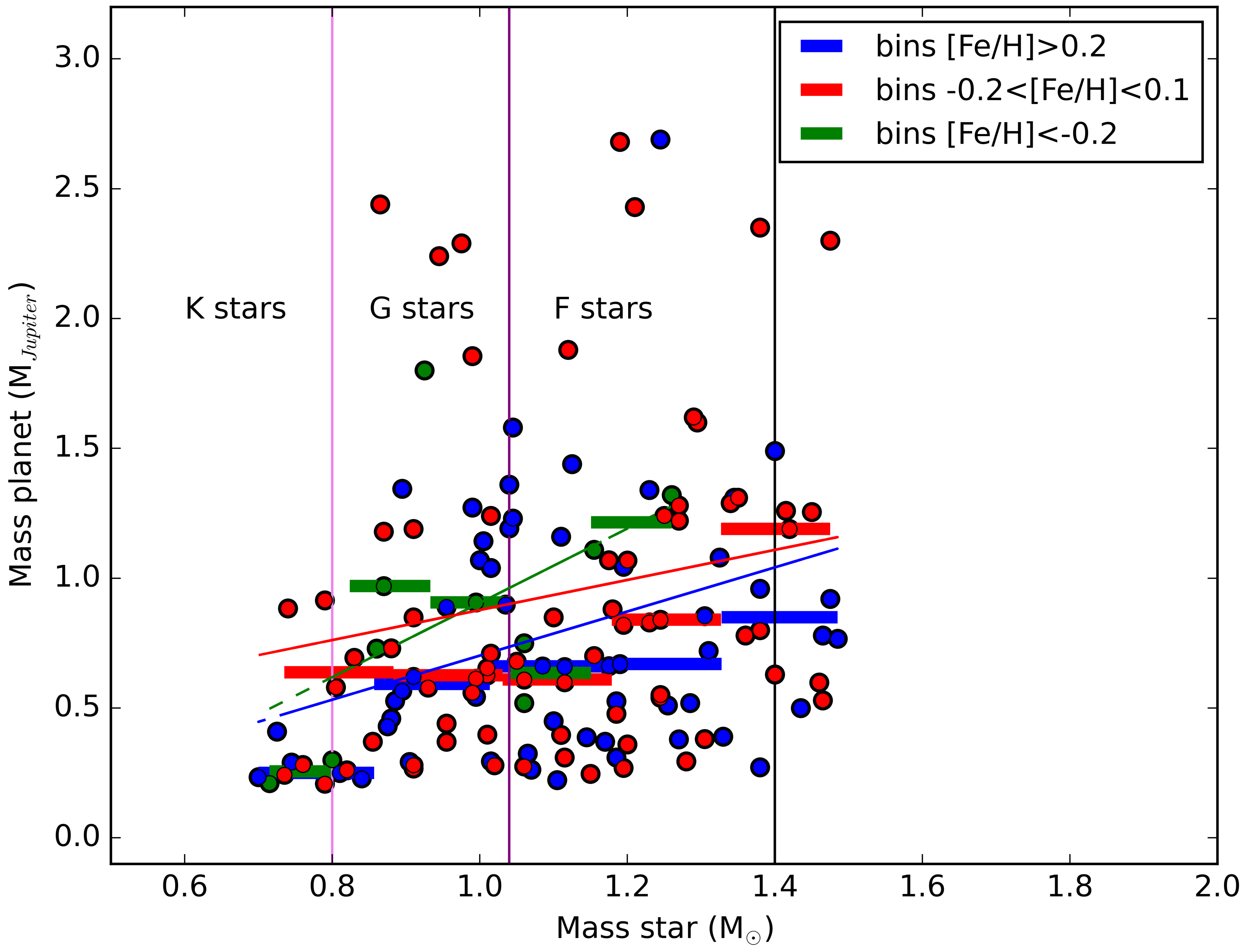
Planetary systems: NASA exoplanet catalogue

Stars: our stellar parameters

- the average planetary mass increases by about 50% from super-solar to sub-solar metallicities.

- the corresponding growth in radius, however, results in volumes about twice as large

- **the giant planets around stars with sub-solar metallicity should be less dense than their counterparts around more metallic stars**



THE NEXT STEPS:

- **Abundance analysis —>** subWG-Abundances, by E. Delgado-Mena (Porto), INAF participation
- **New observations —>** subWG-Observations, by M. Rainer (INAF)
- **Spectral analysis of M dwarf and >F and fast rotators stars —>** subWG-stellar-parameters
- **Stellar ages and masses** —> subWG-ages-masses, INAF participation
- **Stellar activity**—> see the talk of Serena