Asteroseismology model calibration

A. Miglio, J. Montalban, B. Mosser, P. Ventura

WP127: seismic constraints from ageing stars

European Research Council
Established by the European Commission

ASTERO CHRONOMETRY

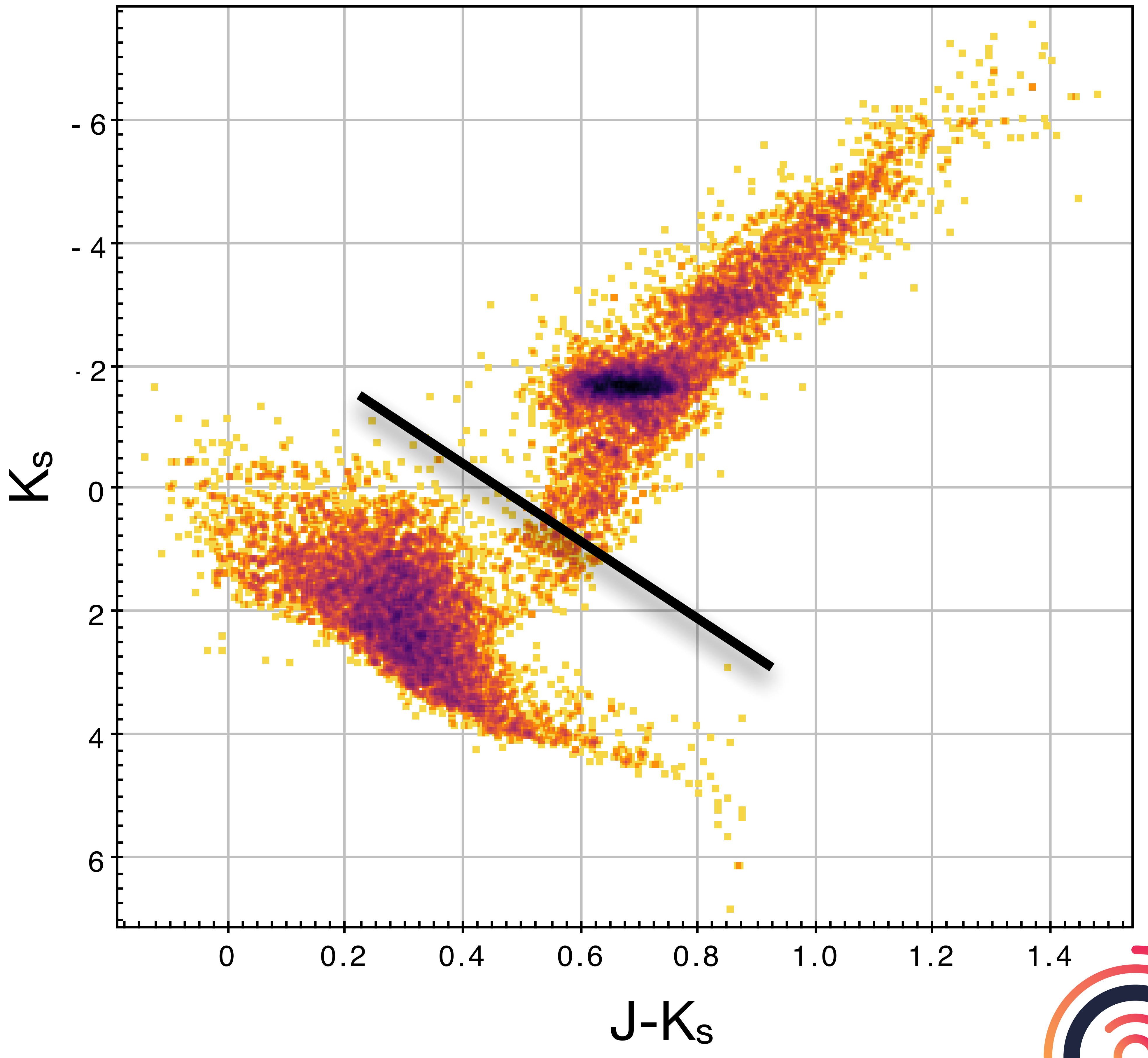
UNIVERSITY OF BIRMINGHAM
SCHOOL OF PHYSICS AND ASTRONOMY

STELLAR ASTROPHYSICS CENTRE

AIM

- what which stars are we referring to

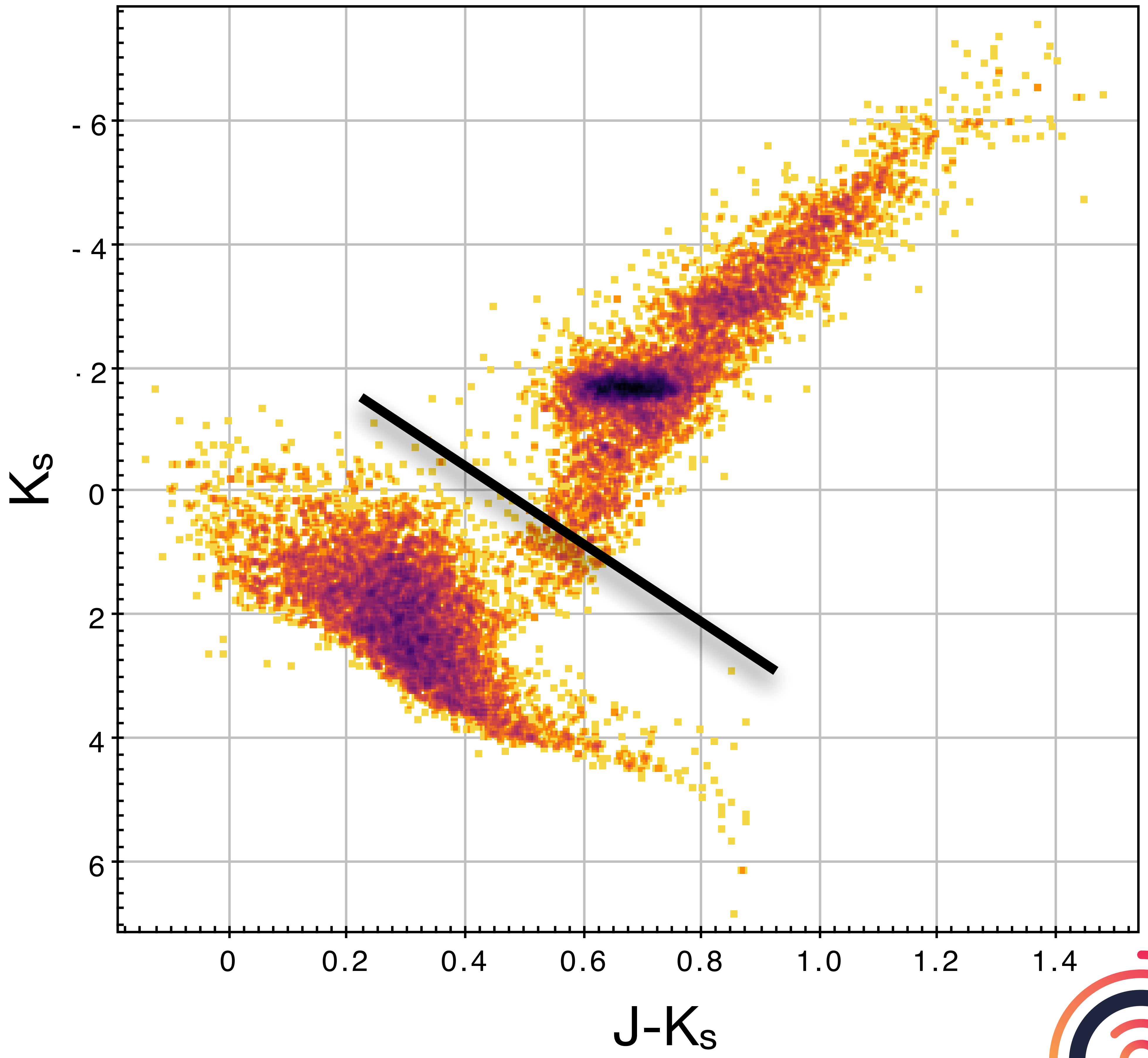
TESS S-CVZ



AIM

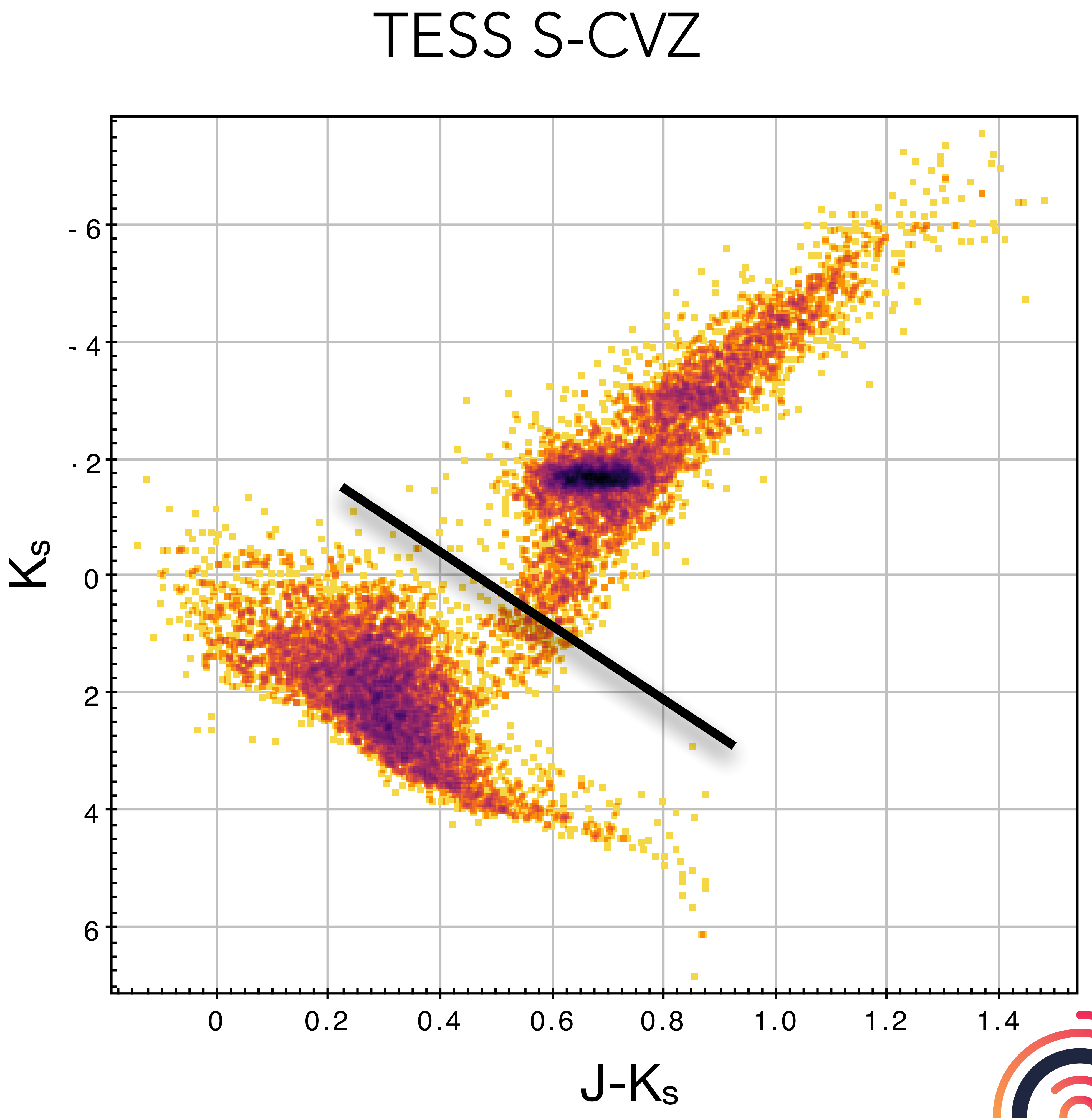
- what — which stars are we referring to
- why — are they relevant for PLATO's core science

TESS S-CVZ



AIM

- what — which stars are we referring to
- why — are they relevant for PLATO's core science
- how — can we maximise $\frac{\text{scientific return}}{\text{number of targets}}$



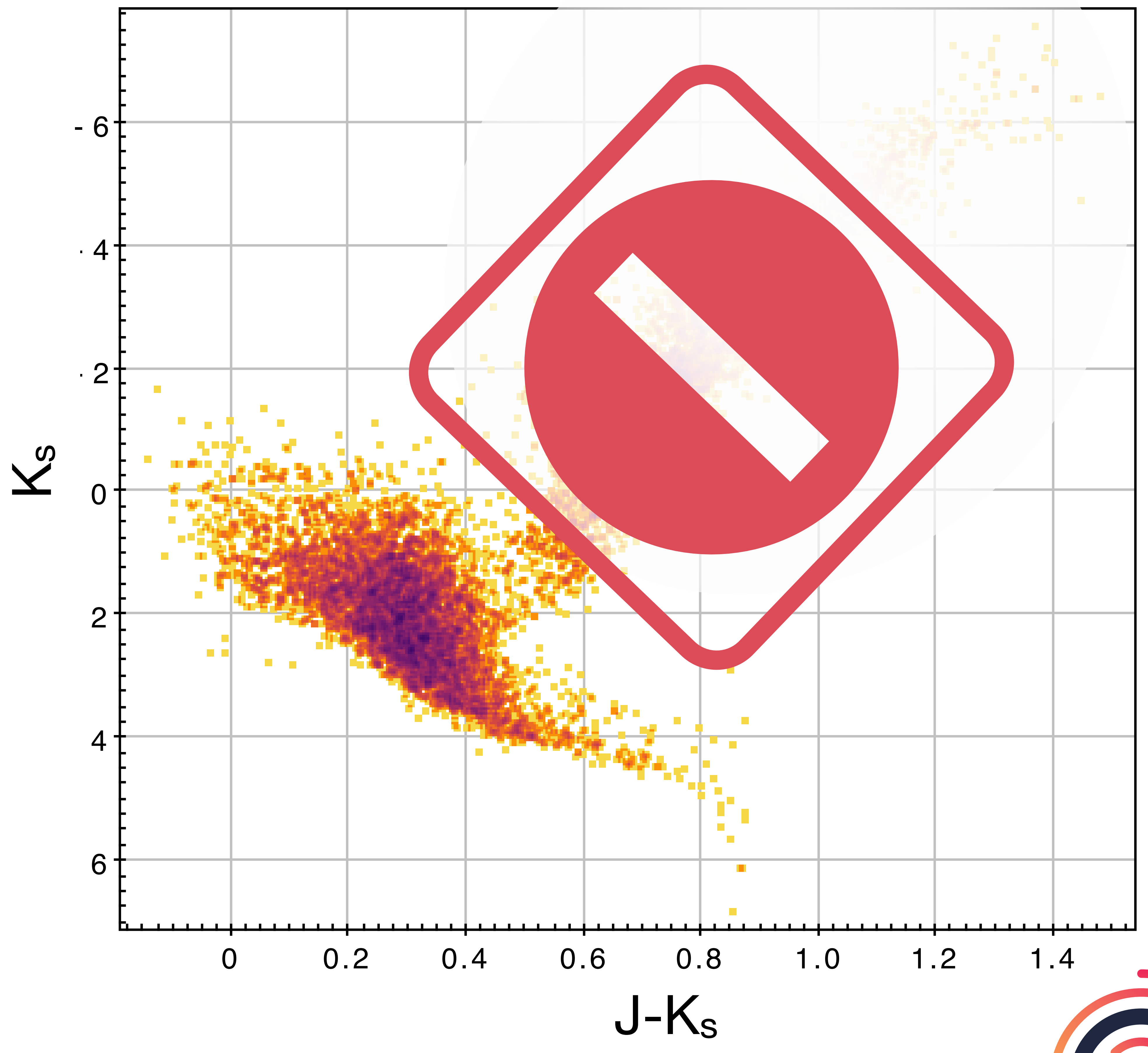
WHAT

- G-K giants
- radii up to 10 R_{sun}
- M ~ 0.8 - 4 M_{sun}
- all metallicities [-2, 0.5]

prior to CoRoT / Kepler / TESS (and Gaia):

little information on their detailed properties

TESS S-CVZ



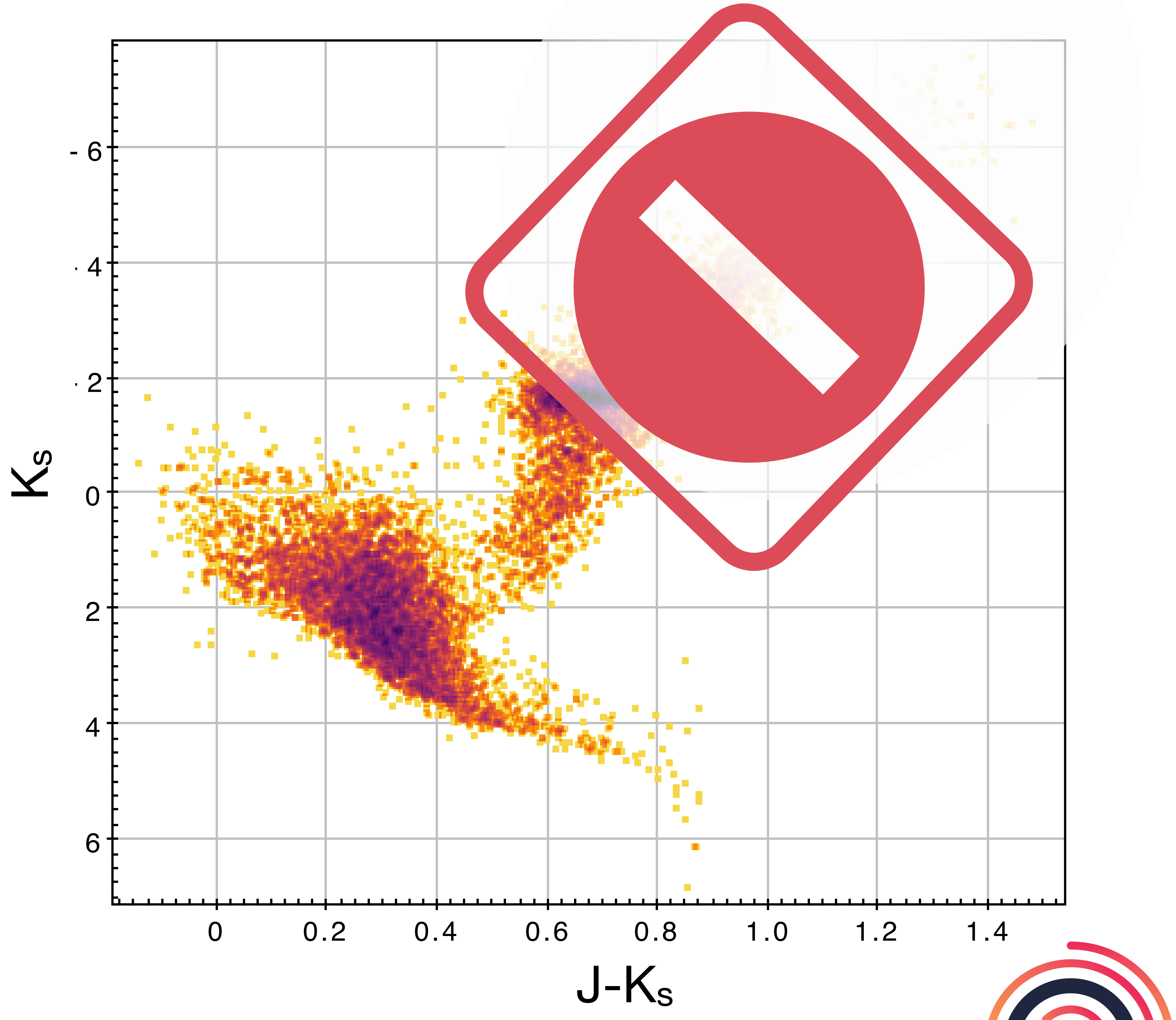
WHAT

- G-K giants
- radii up to 10 R_{sun}
- $M \sim 0.8 - 4\ M_{sun}$
- all metallicities [-2, 0.5]

prior to CoRoT / Kepler / TESS (and Gaia):

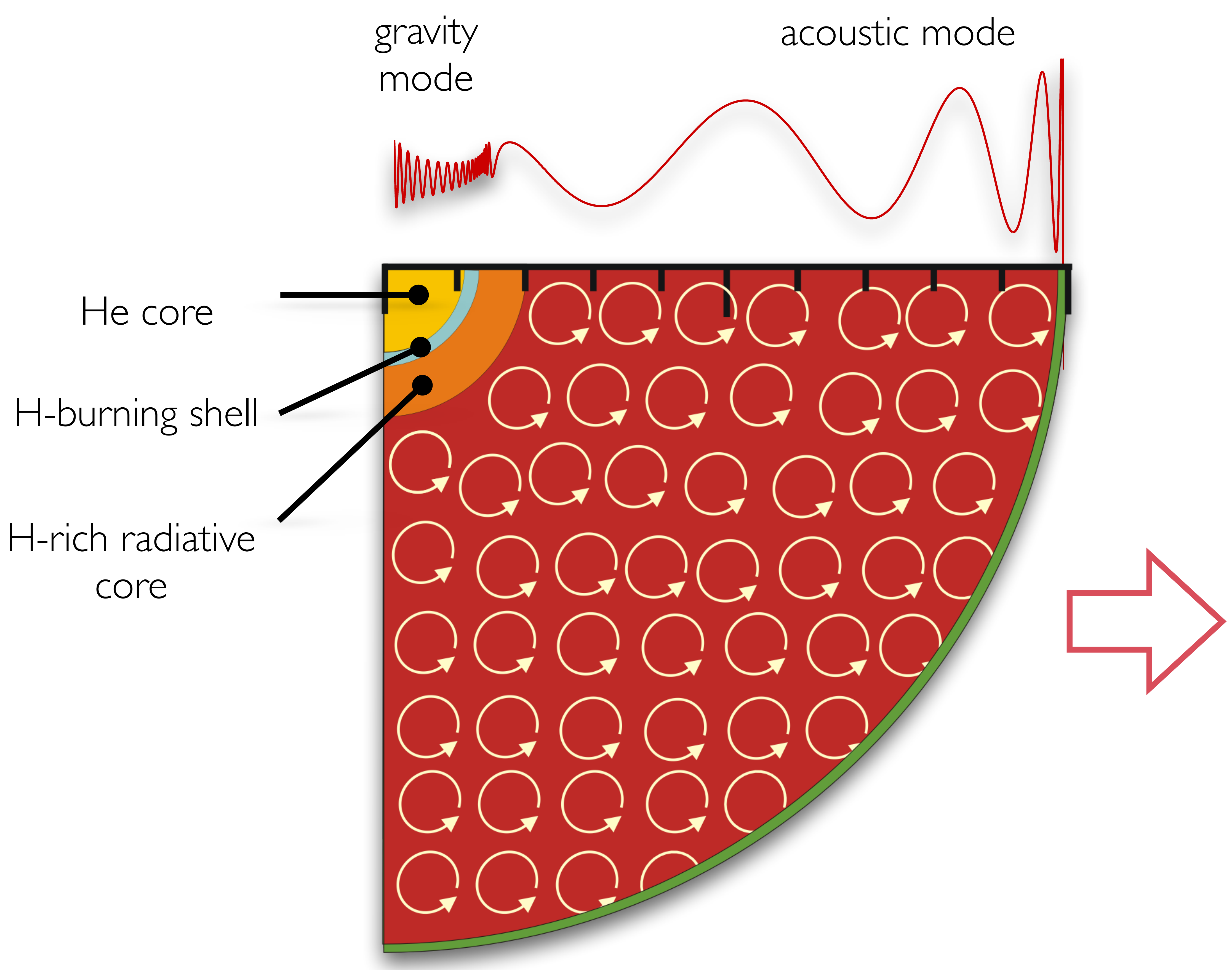
little information on their detailed properties

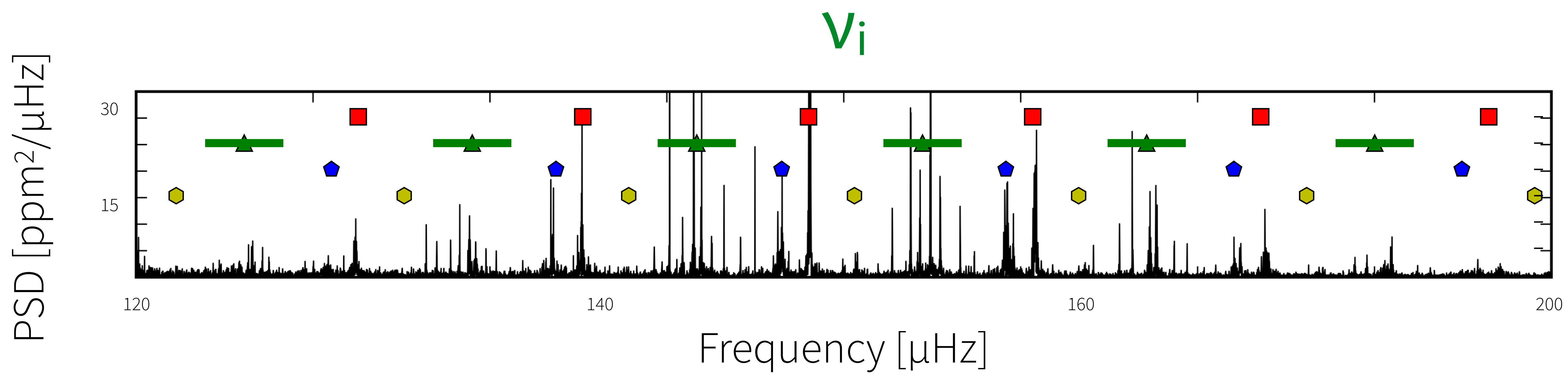
TESS S-CVZ



WHAT

- + asteroseismology





- transport of angular momentum
  talk by Charlotte Gehan later today
- constraints on internal mixing
- precise and accurate global parameters

WHY

- planets around G-K giants

improved stellar properties ⇨ improved planetary parameters

e.g. Campante et al. 2019, in press

TESS ASTEROSEISMOLOGY OF THE KNOWN RED-GIANT HOST STARS HD 212771 AND HD 203949

eters as input. We discuss the evolutionary state of HD 203949 in depth and note the large discrepancy between its asteroseismic mass ($M_* = 1.23 \pm 0.15\,\mathrm{M}_\odot$ if on the red-giant branch or $M_* = 1.00 \pm 0.16\,\mathrm{M}_\odot$ if in the clump) and the mass quoted in the discovery paper ($M_* = 2.1 \pm 0.1\,\mathrm{M}_\odot$), implying a change $> 30\,\%$ in the planet's mass. Assuming HD 203949 to be in the clump, we investigate the planet's

WHY

- planets around G-K giants
  - improved stellar properties ⇨ improved planetary parameters
  - evolution of planetary systems — *e.g. Veras et al. 2016*
  - occurrence rates of planets around stars M> 1.5 M_{sun} — *e.g. Johnson et al. , Campante et al. North et al.*

WHY

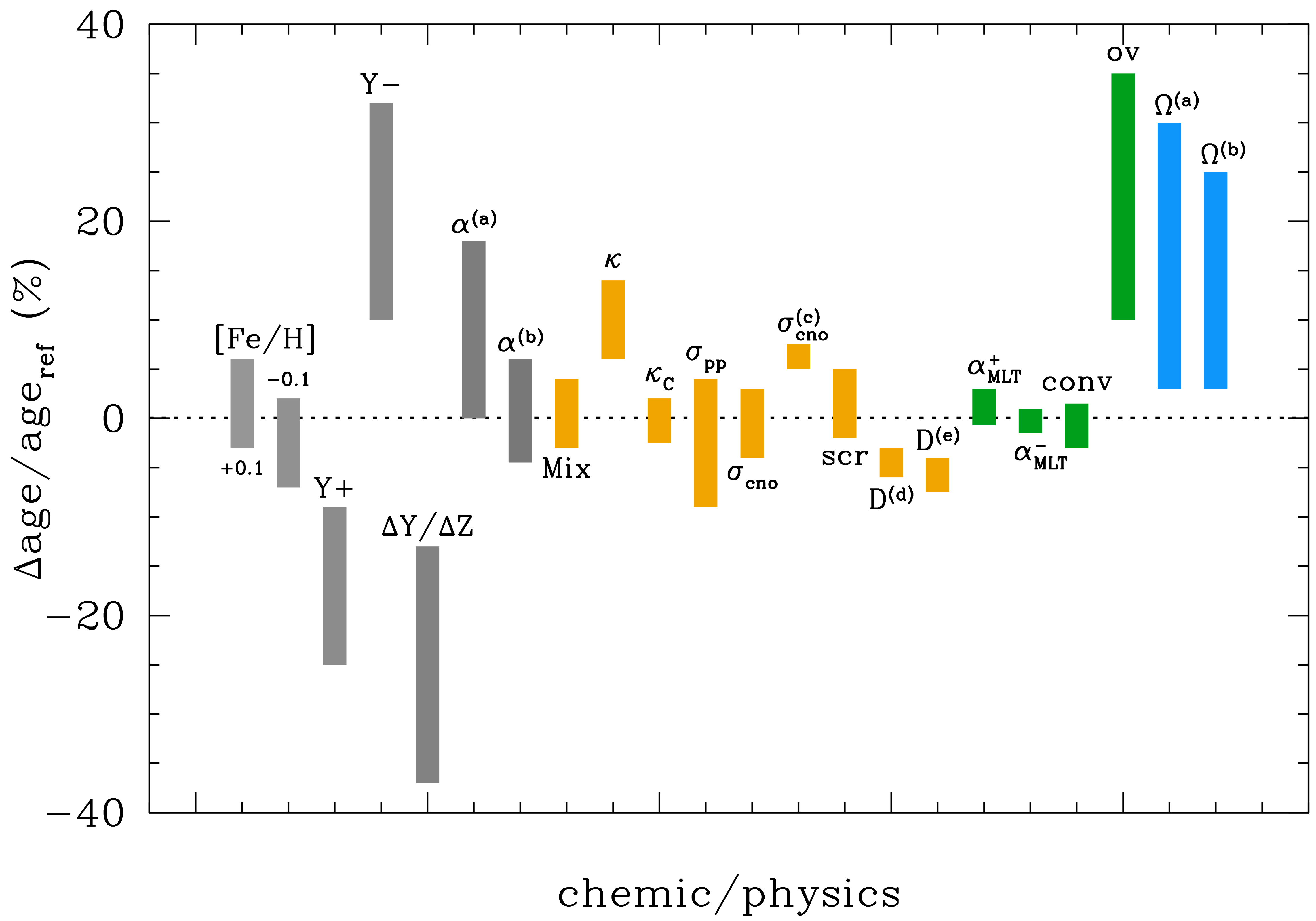
- planets around G-K giants
  - improved stellar properties ⇨ improved planetary parameters
  - evolution of planetary systems *e.g. Veras et al. 2016*
  - occurrence rates of planets around stars $M > 1.5\ M_{sun}$ *e.g. Johnson et al. , Campante et al. North et al.*
- population studies *talk by Cristina Chiappini later today*

WHY

- planets around G-K giants
  - improved stellar properties ⇨ improved planetary parameters
  - evolution of planetary systems — *e.g. Veras et al. 2016*
  - occurrence rates of planets around stars M> 1.5 M_{sun} — *e.g. Johnson et al. , Campante et al. North et al.*
- population studies — *talk by Cristina Chiappini later today*
- to constrain stellar physics which is relevant to inferring ages of MS stars

"calibrators"

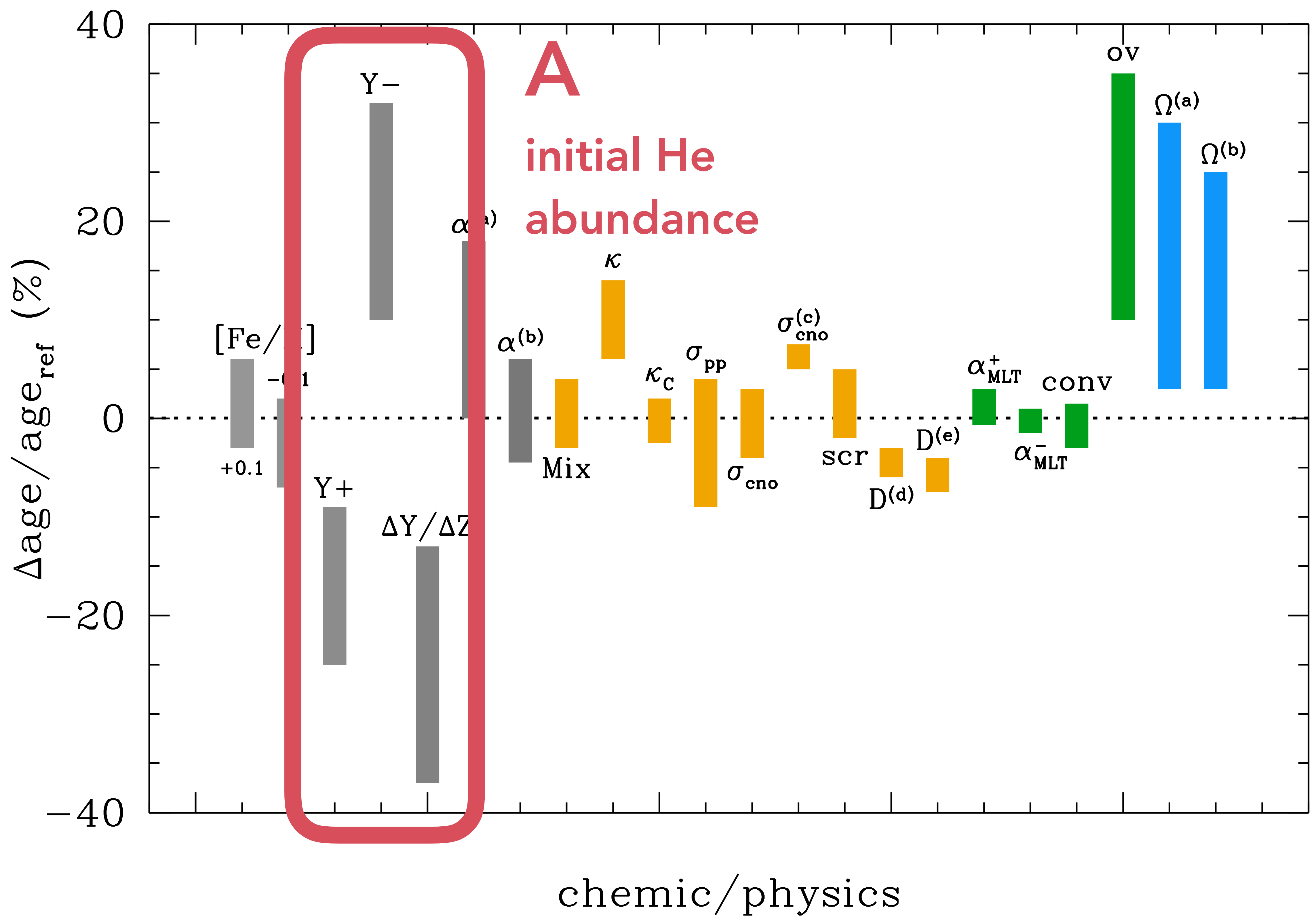
- age uncertainties of MS stars are typically fractional uncertainties of the total MS lifetime
- at the MS turnoff systematic uncertainties on age are dominated by:



Lebreton, Goupil & Montalban 2014

- age uncertainties of MS stars are typically fractional uncertainties of the total MS lifetime

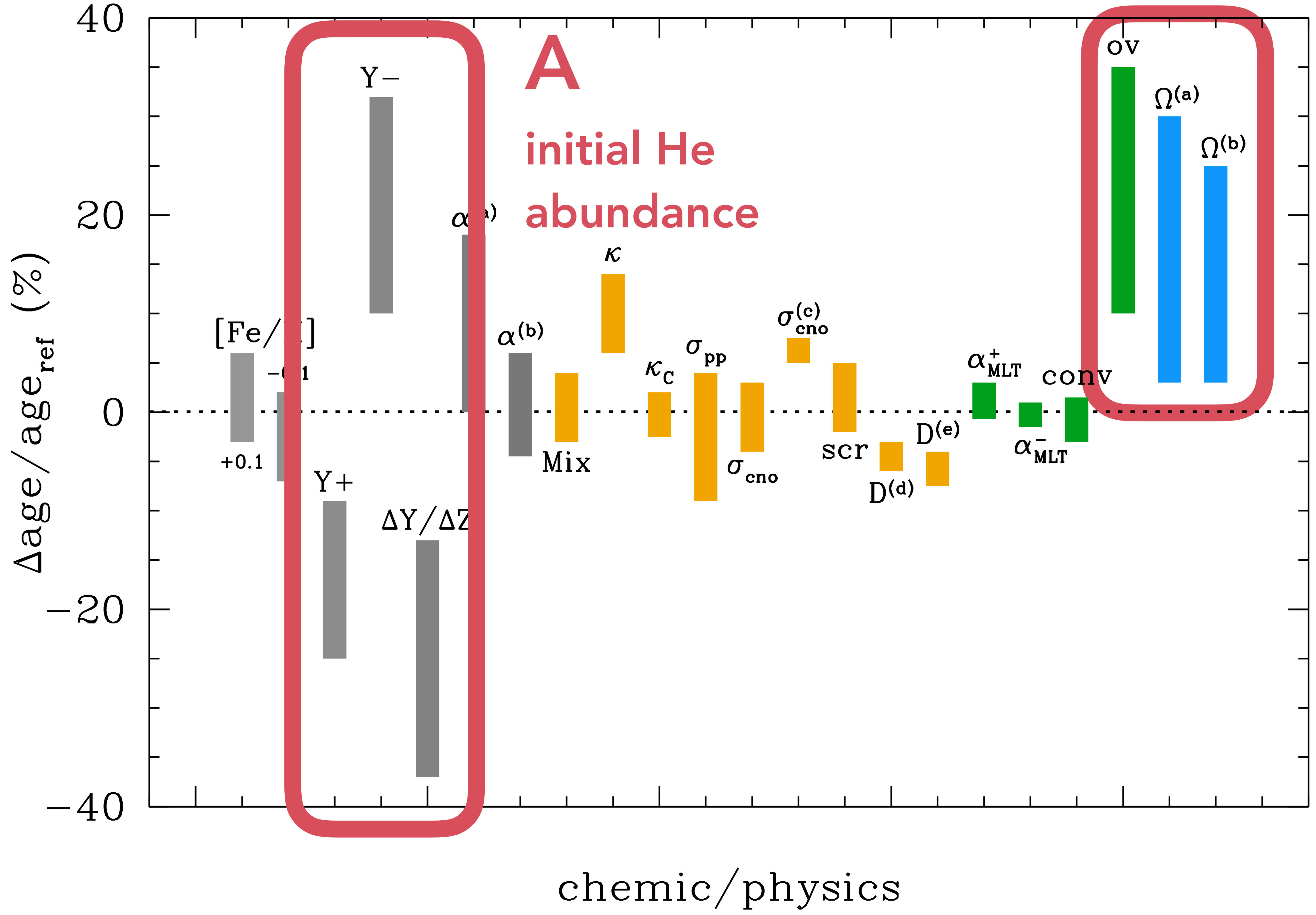
- at the MS turnoff systematic uncertainties on age are dominated by:



Lebreton, Goupil & Montalban 2014

- age uncertainties of MS stars are typically fractional uncertainties of the total MS lifetime

- at the MS turnoff systematic uncertainties on age are dominated by:



A initial He abundance

B mass of the He core, hence near-core mixing

Lebreton, Goupil & Montalban 2014

WHY

e.g. A and B cannot be inferred from Sun-like pulsators alone:

A • Y_{SURF} difficult to determine with seismology and affected by diffusion + rotation (e.g. Verma et al. 2019)

we can map $Y=Y(Z)$

B • limited inference on core overshooting because of low sensitivity of acoustic modes, and stars with convective cores being too hot

we can map $OV_{core}=OV_{core}(M,Z)$

WHY

e.g. A and B cannot be inferred from Sun-like pulsators alone:

A • Y_{SURF} difficult to determine with seismology and affected by diffusion + rotation (e.g. Verma et al. 2019)

we can map $Y=Y(Z)$

B • limited inference on core overshooting because of low sensitivity of acoustic modes, and stars with convective cores being too hot

we can map $OV_{core}=OV_{core}(M,Z)$

⇩

this is possible looking at low-luminosity giants / subgiants, red-clump and secondary clump stars

WHY

e.g. A and B cannot be inferred from Sun-like pulsators alone:

A • Y_{SURF} difficult to determine with seismology and affected by diffusion + rotation (e.g. Verma et al. 2019)

we can map Y=Y(Z)

B • limited inference on core overshooting because of low sensitivity of acoustic modes, and stars with convective cores being too hot

we can map $OV_{core}=OV_{core}(M,Z)$

⇩

this is possible looking at low-luminosity giants / subgiants, red-clump and secondary clump stars

more examples + numbers in:
"WP127 seismic constraints from ageing stars; from seismic goals to quantitative needs"

WHY

⚠ *Kepler* / TESS have observed / are observing G-K giants (intentionally)

PLATO will live in a landscape enriched by results from CoRoT/Kepler/K2/TESS

WHY

Kepler / TESS have observed / are observing G-K giants (intentionally)

PLATO will live in a landscape enriched by results from CoRoT/Kepler/K2/TESS

however:

- *Kepler* target selection based on CMD cuts + estimates of R (pre Gaia)
- *Kepler* limited exploration of [Fe/H], mass distribution dominated by 1.2-1.4 M_{sun}
- K2, TESS: limited duration of the observations

HOW

- WP127 happy to help / provide resources to aid the selection

HOW

- WP127 happy to help / provide resources to aid the selection

  a lot of progress since CoRoT and Kepler, we can be smart about how we select stars, ensuring we cover relevant mass / metallicity bins

  - Gaia
  - spectroscopic characterisation of targets (e.g. synergies with 4MOST)
  - "low-resolution"/ survey asteroseismology from TESS

⇨ PIC

HOW

- WP127 happy to help / provide resources to aid the selection
    - iterate with core science to define in detail the needs (e.g. σ_{age}) and parameter range (M, [Fe/H])
    - needs for red giant seismology: long-cadence light curves (no short-cadence data, no imagette)

HOW

- WP127 happy to help / provide resources to aid the selection
    - iterate with core science to define in detail the needs (e.g. σ_{age}) and parameter range (M, [Fe/H])
    - needs for red giant seismology: long-cadence light curves (no short-cadence data, no imagette)

define suitable&affordable telemetry cost / number of targets

SUMMARY

science with solar-like oscillating G-K giants

- field is mature ⇨ optimise the scientific return/number of targets

SUMMARY

science with solar-like oscillating G-K giants

- field is mature ⇨ optimise the scientific return/number of targets

- PLATO can go beyond Kepler / K2 / TESS
  and use G-K giants as calibrators for MS stars

  + for the same "price"

    - exoplanets around evolved stars
    - stellar population studies

SUMMARY

science with solar-like oscillating G-K giants

- field is mature ⇨ optimise the scientific return/number of targets

- PLATO can go beyond Kepler / K2 / TESS
  and use G-K giants as calibrators for MS stars

  + for the same "price"

    - exoplanets around evolved stars
    - stellar population studies

⇨

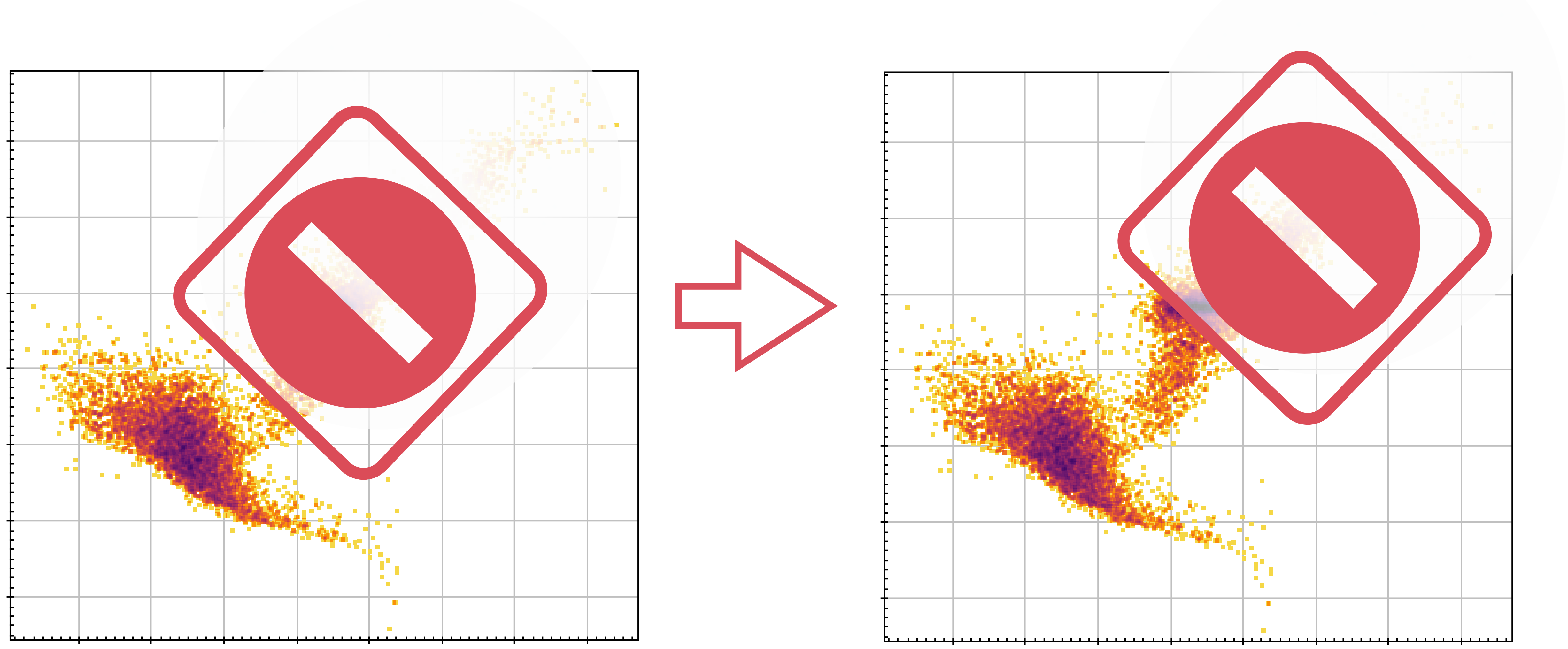
high scientific return

no interference with high-priority targets

direct benefit to core science

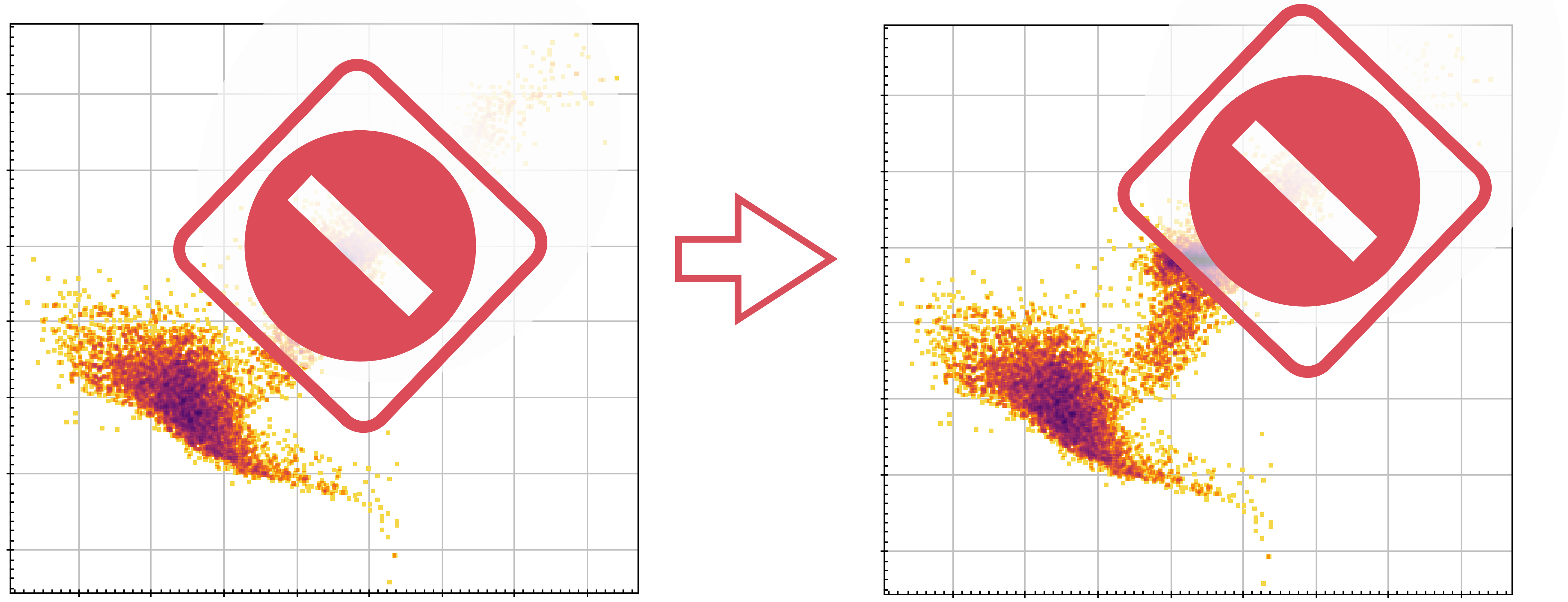
SUMMARY

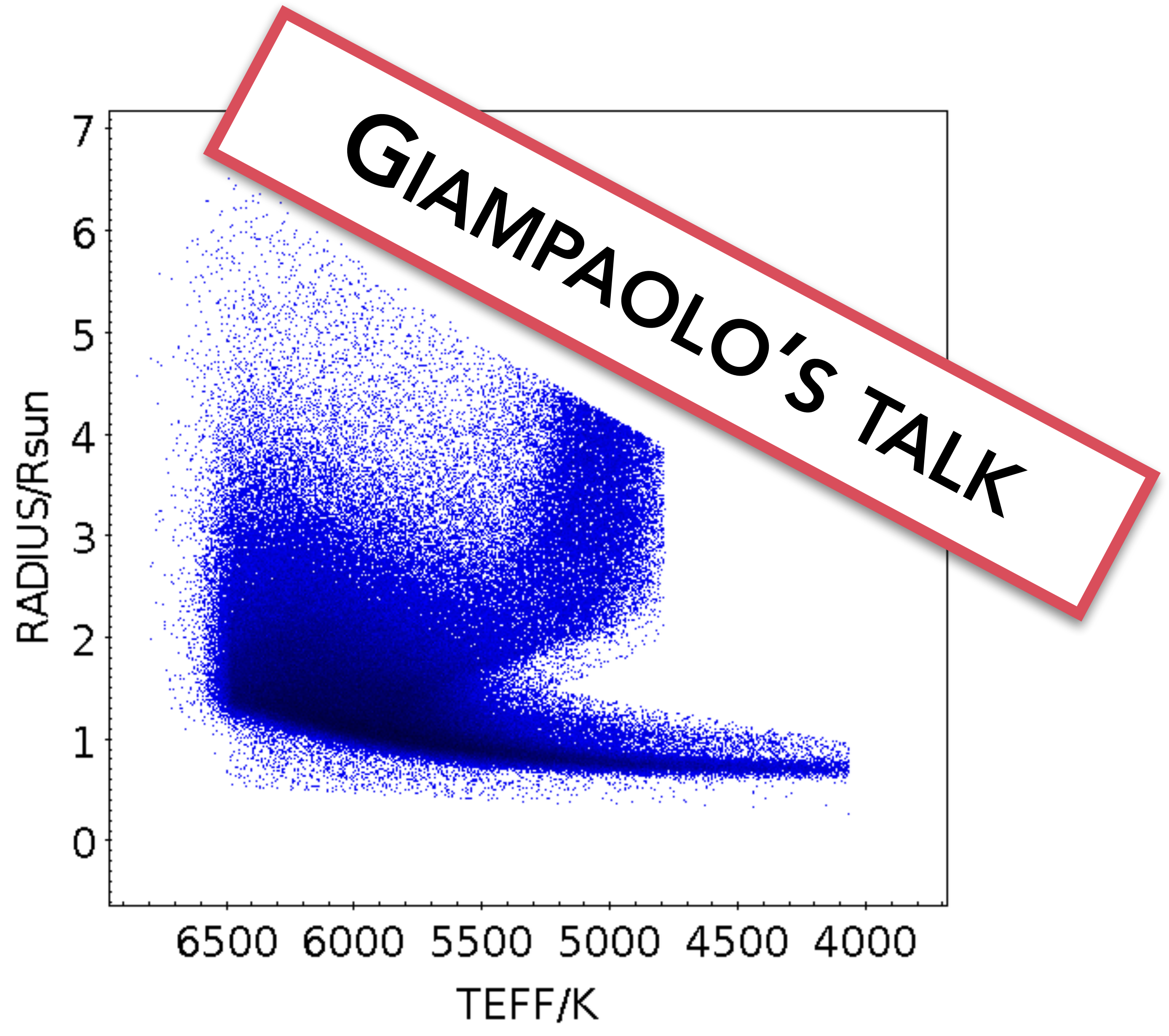
add to S5 a carefully selected sample of G-K giants?



SUMMARY

add to S5 a carefully selected sample of G-K giants?





… almost there!