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Ministero dell'Università e della Ricerca
Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA
ICSC Centro Nazionale di Ricerca in HPC, Big Data and Quantum Computing

Progress report on the use of old stellar tracers to constrain the early formation of the Galactic spheroid

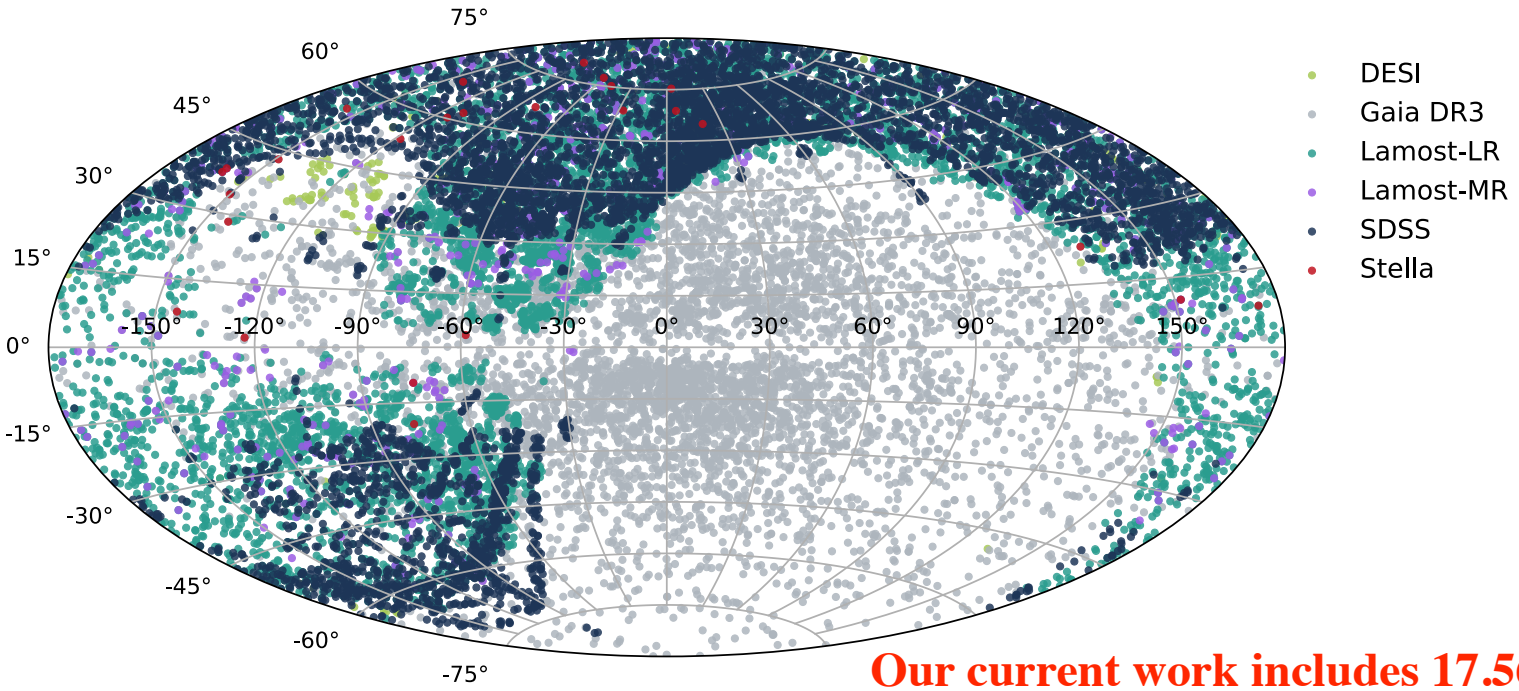
K. Baeza-Villagra, G. Bono

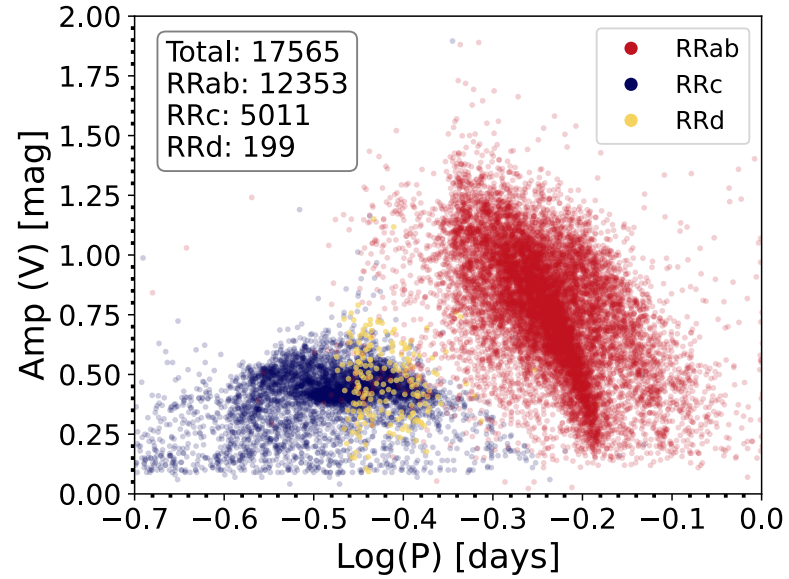
Spoke 3 III Technical Workshop, Perugia 26-29 Maggio, 2025

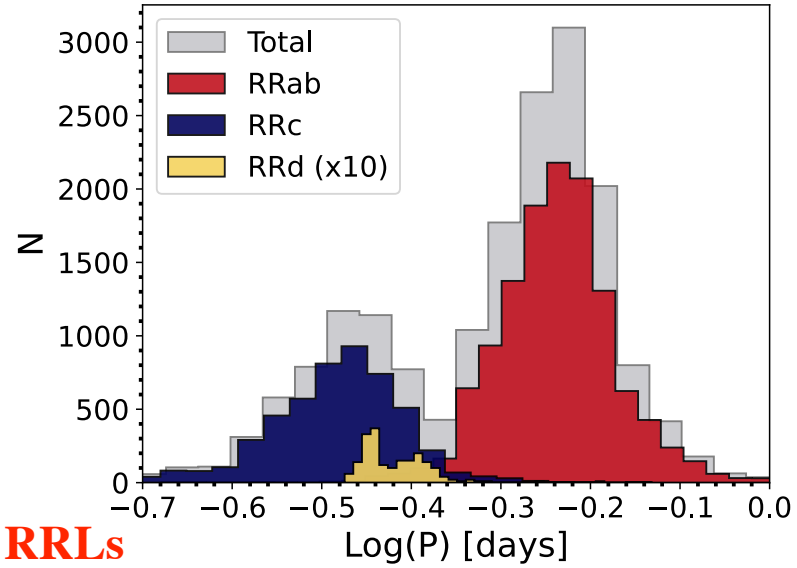
Scientific Rationale

Project Main Goal:

Provide the largest spectroscopic catalog of RR Lyrae stars (RRLs). These stars are solid tracers to investigate the early formation history of the Galactic spheroid and for performing chemical tagging analyses.







Our current work includes 17.565 RRLs

Technical Objectives, Methodologies and Solutions

→ **Estimation of Gamma-velocity using radial velocity curve templates.**

- **STELLA Robotic Observatory**
- **Mercator Telescope - HERMES spectrograph**
- The Dark Energy Spectroscopic Instrument (DESI)
- LAMOST dr8 v2 - MR
- GAIA dr3
- Sloan Digital Sky Survey (SDSS dr18)
- LAMOST dr8 v2 - LR

→ **Application of the Delta-S method to obtain metallicity estimates for RR Lyrae stars from low-resolution spectra.**

Technical Objectives, Methodologies and Solutions

→ **On the basis of individual distances, gamma-velocities, proper motions and coordinates (Gaia) we can constrain the dynamical properties of these stars and their orbits (MW potential).**

The chemo-dynamical properties of old stellar tracers allow us to trace in space and in time the assembling history of the Milly Way in its early stages.

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Our current work includes 17565 RRLs → **~ 69000 spectra**

Technical Objectives, Methodologies and Solutions

RV templates

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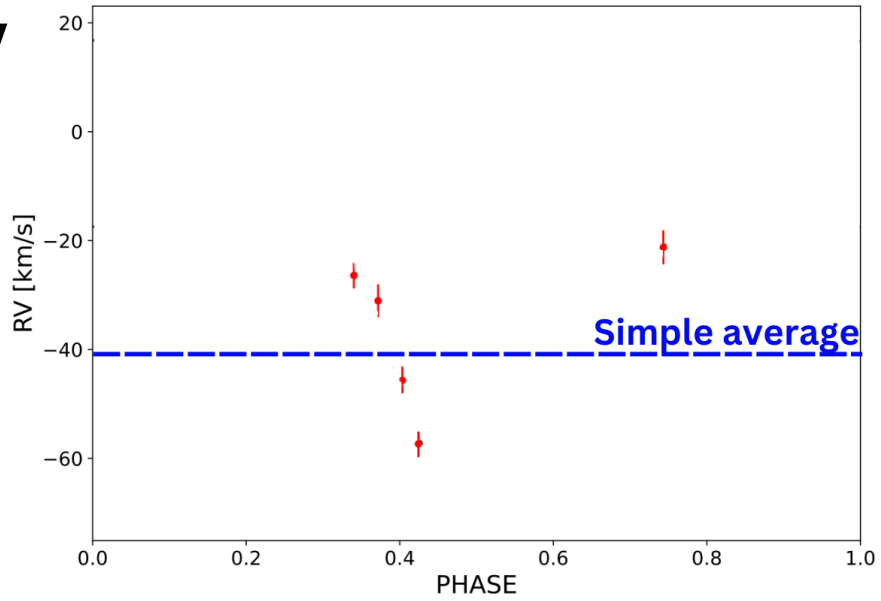
Gamma-Velocity (Vγ)

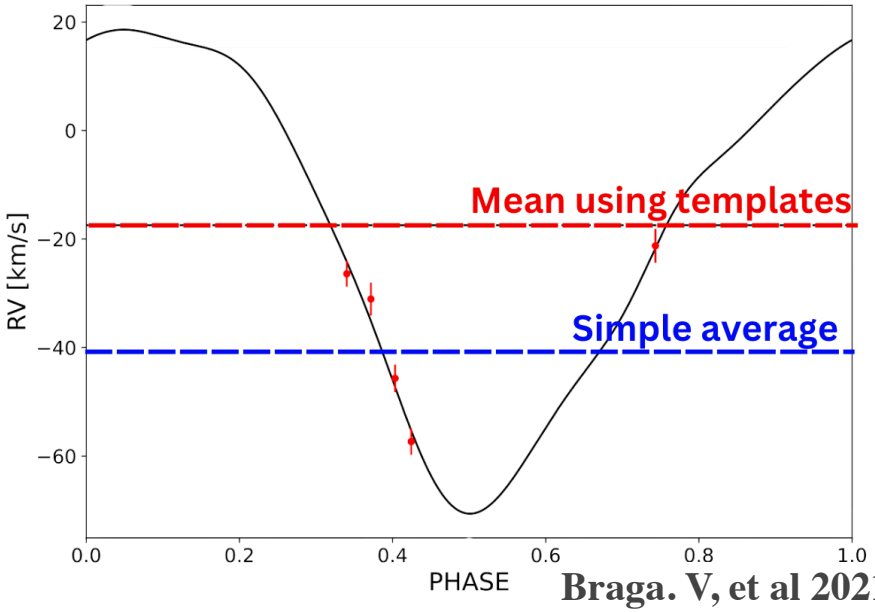
Classical aproach

Simple average



This work

RV templates (more than 3 spectra)



Braga. V, et al 2021

Technical Objectives, Methodologies and Solutions

1) Software development

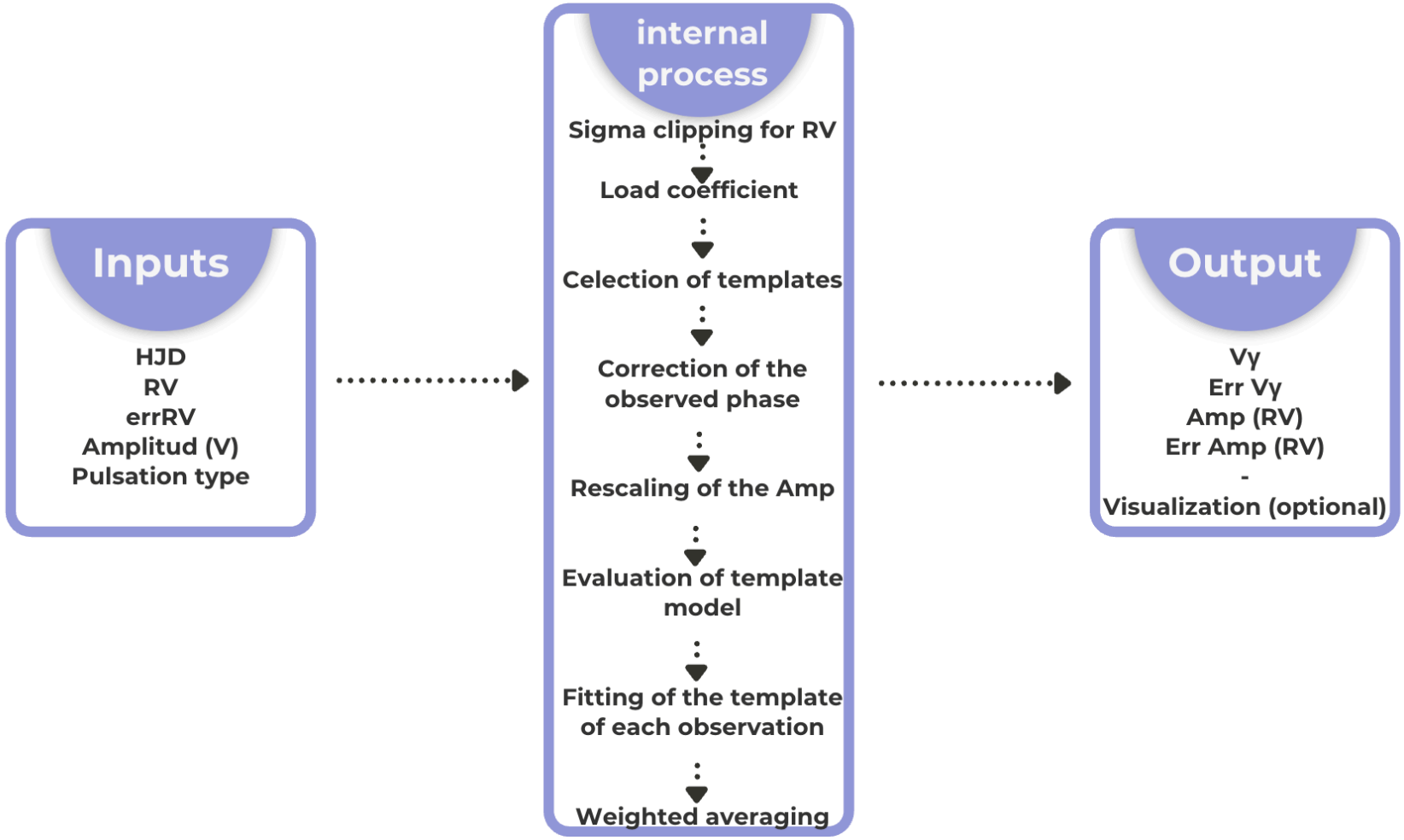
Status: complete

2) Testing the code

Status: complete

3) Validation of results

Status: complete



Technical Objectives, Methodologies and Solutions

ΔS method

↓

Metallicities

The **equivalent widths of the Ca II K and three of the Balmer series** features can also be associated with the **metallicity of RRLs**

↓

The low-resolution measurements are sufficient to provide metallicity estimates !

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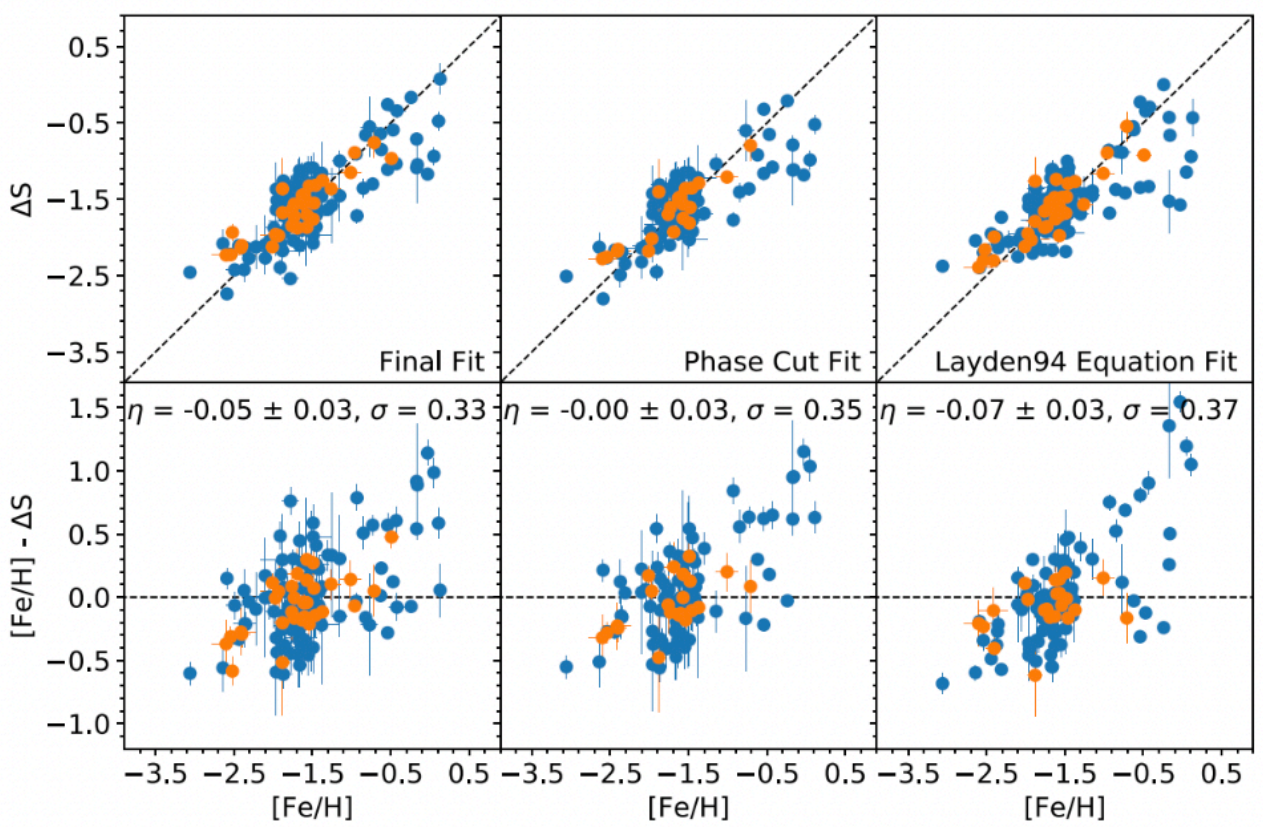
$$[F_e/H]_{\Delta S} = c_0 + c_1 K + c_2 H_\delta + c_3 H_\gamma + c_4 H_\beta$$



Crestani et al, 2021

Technical Objectives, Methodologies and Solutions

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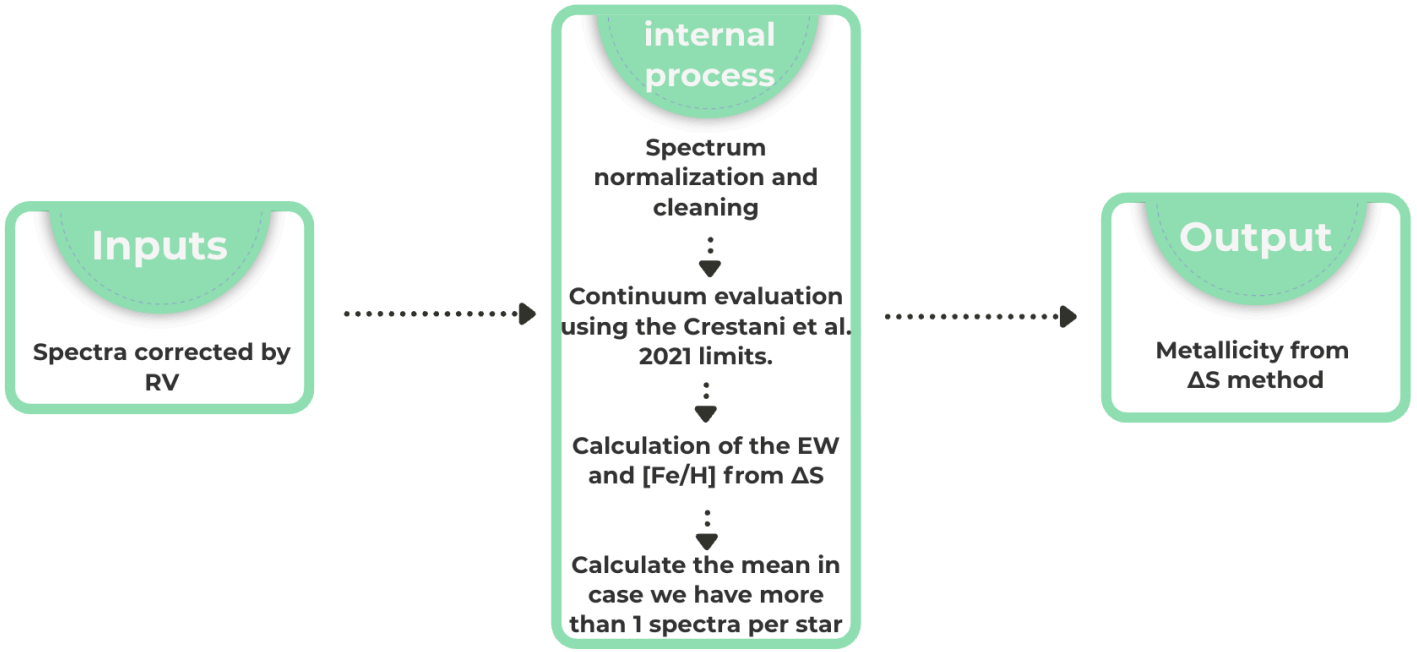
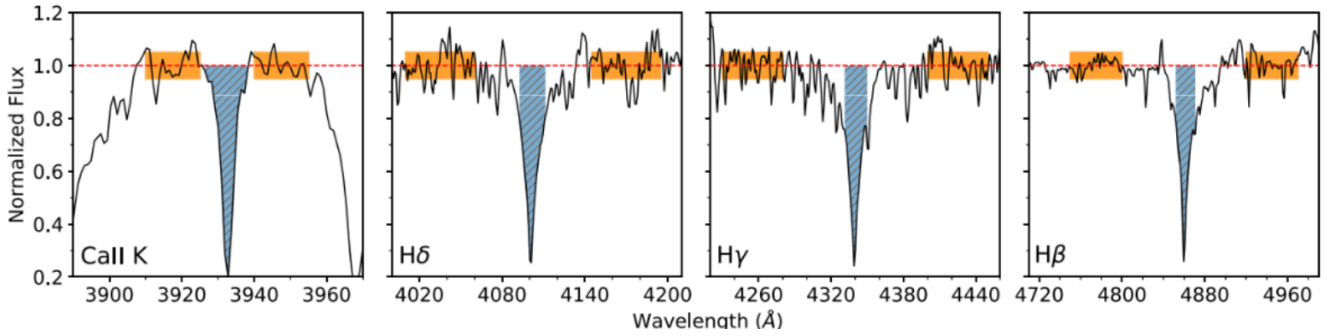


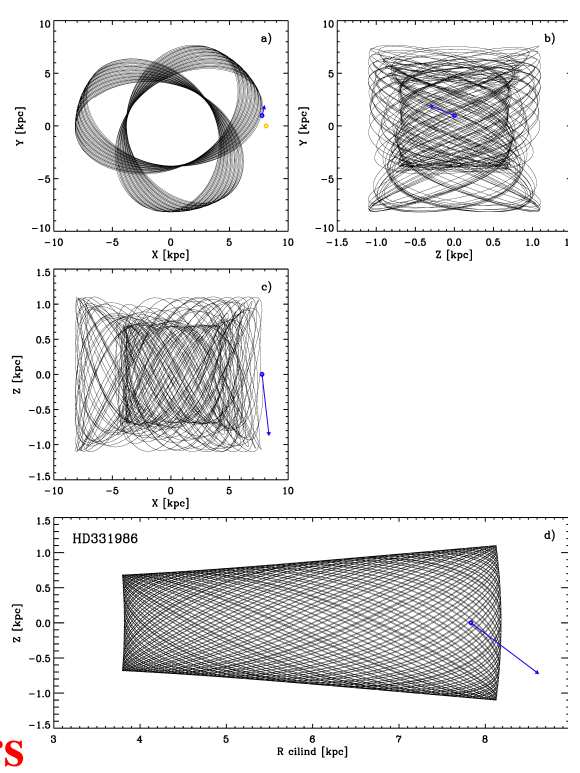


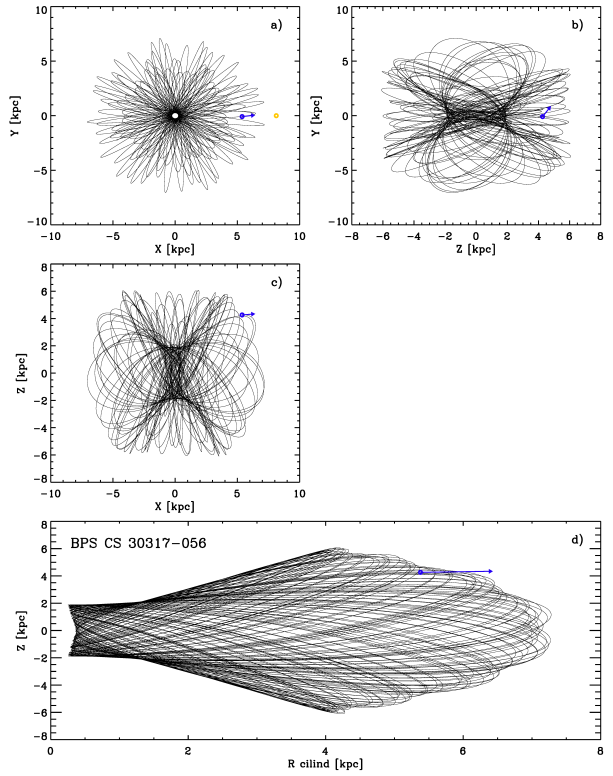
Code available in :

Crestani et al, 2021

Technical Objectives, Methodologies and Solutions

- RRL kinematics based on MW-potential (Bovy 2015)
- To estimate the errors the six input parameters (RV, distances, PM[ra,dec], position[ra,dec]) are randomly changed assuming Gaussian distributions.
- 10,000 points randomly distributed to trace orbital variations (Price-Whelan 2018)





To run these simulations are required several tens of hours on a :

AS-2015CS-TNR Supermicro CloudDCA
AMD EPYC 9754 Processor (128-cores/256-threads), 512 GB ram

Work in progress …

V. D'Orazi et al 2024

Technical Objectives, Methodologies and Solutions

6D parameters

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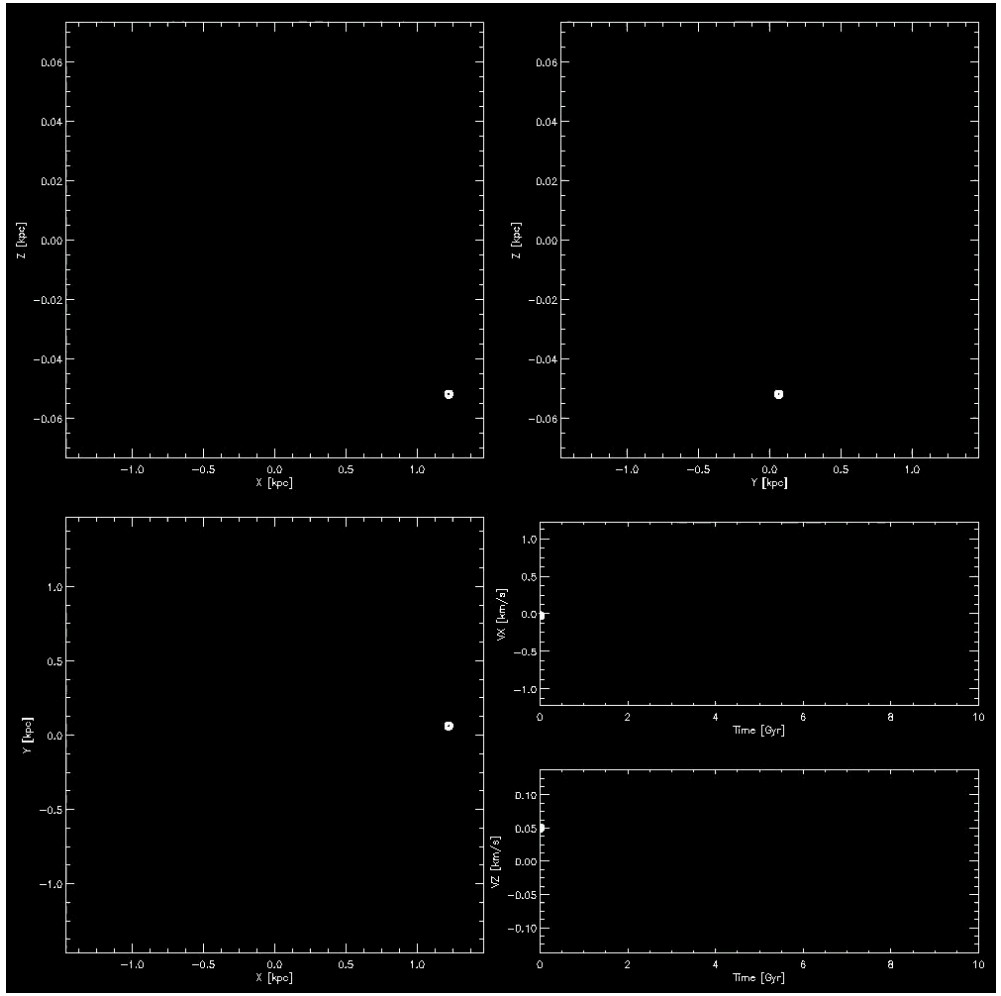
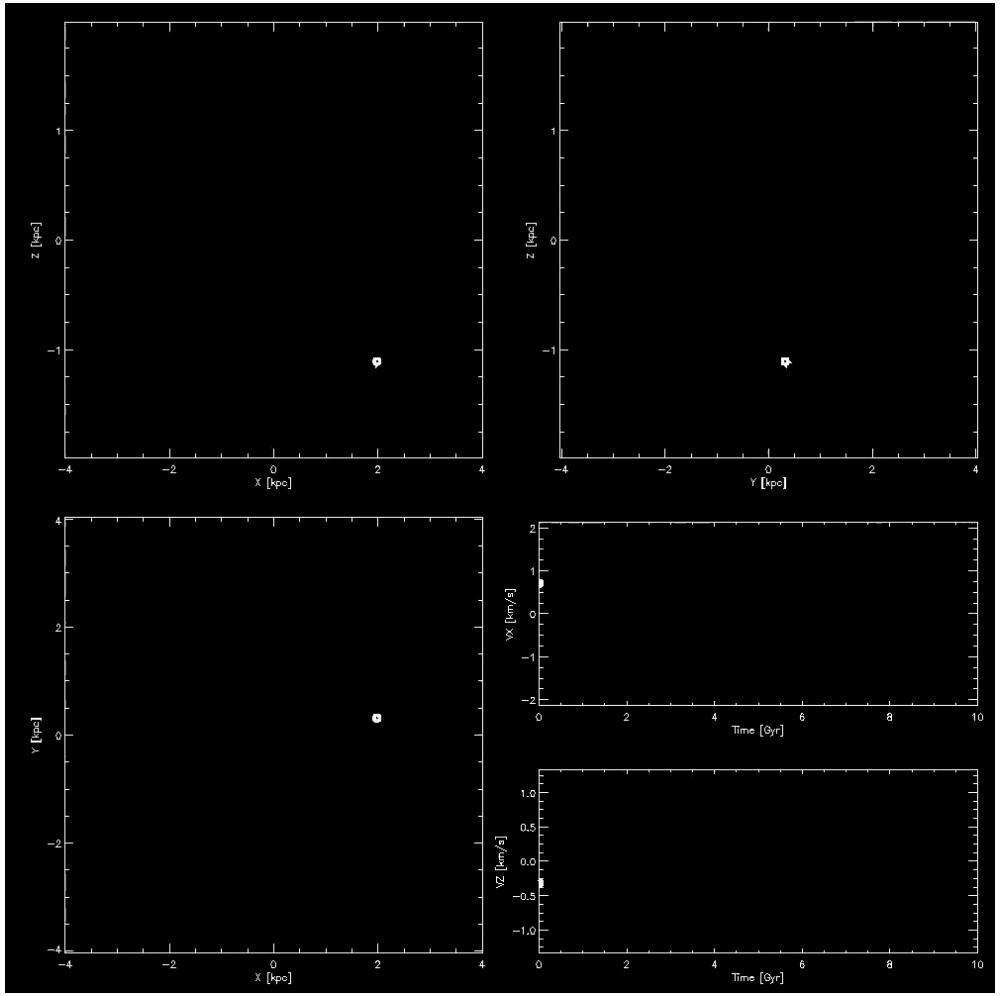
Dynamical properties





Technical Objectives, Methodologies and Solutions

1) Software development

Status: complete

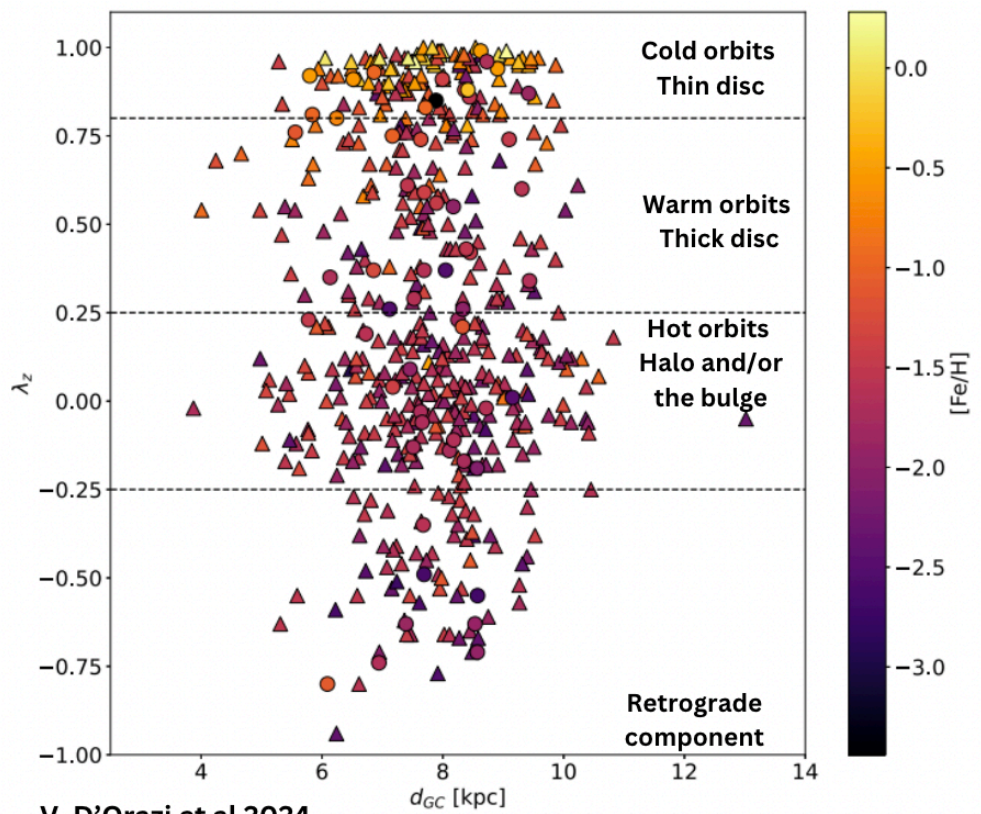
2) Testing the code

Status: complete

3) Validation of results

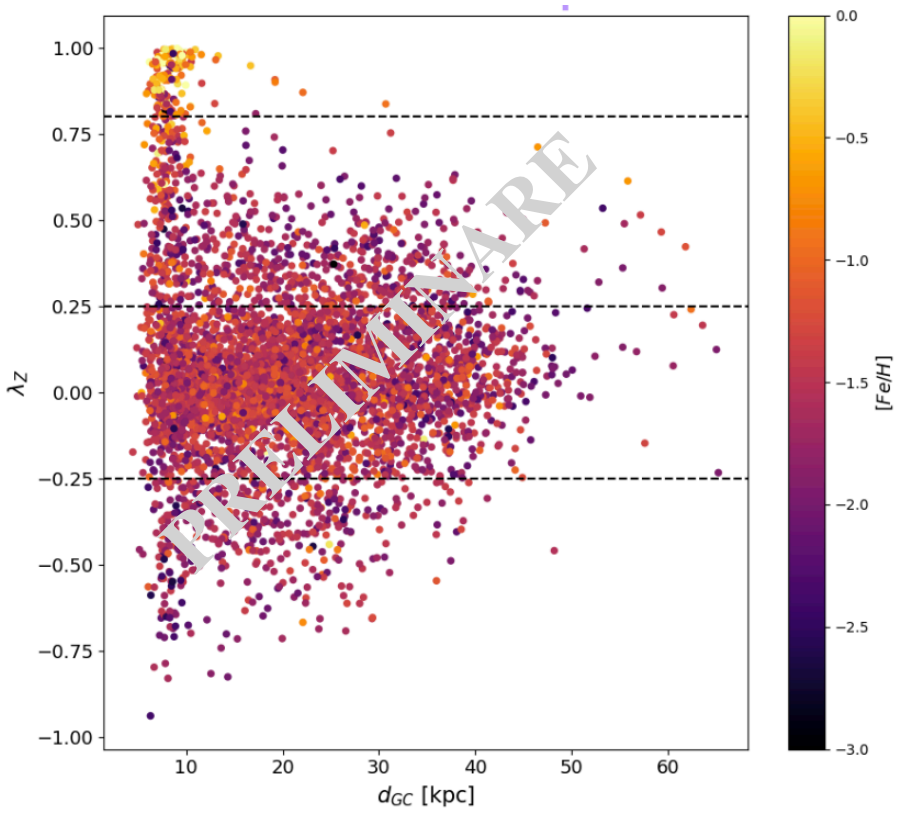
Status: incomplete

Full sample of 535 RRLs



V. D'Orazi et al 2024

Subsample of 6516 RRLs



Main Results

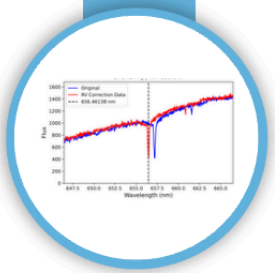
- Main Results Achived

01

SPECTROSCOPIC CATALOG SELECTION

We assembled the largest spectroscopic dataset of field RRLs (17.565) measurements collected with ground-based (LAMOST, SDSS, DESI, Mercator, Stella) and space (Gaia) spectrographs.

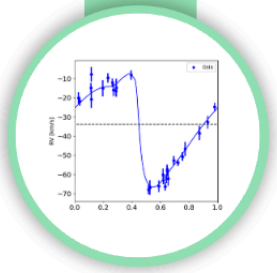
02



RADIAL VELOCITY MEASUREMENTS

We measured radial velocity separately for Balmer, calcium and metallic lines using individual spectra.

03

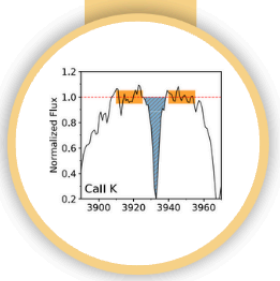


FIT OF THE RADIAL VELOCITY CURVES

We used the radial velocity curve (RVC) templates provided by Braga et al. (2021), which are based on three groups of metallic lines and four Balmer lines.

- free-amp templates
- fixed-amp templates
- average

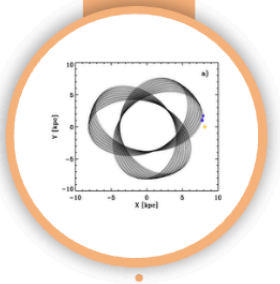
04



METALLICITIES

We use the Delta-S method–ratio between the equivalent width of the Ca K line and of the Balmer line(s) to obtain metallicities from low resolution spectra.

05

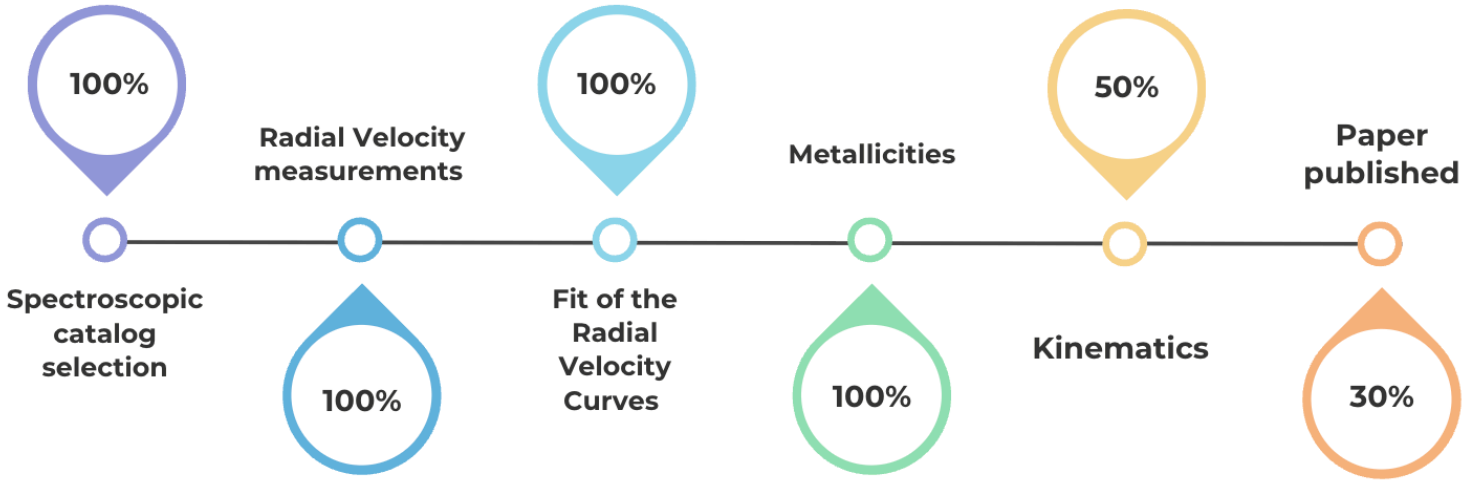


KINEMATICS

We are currently calculating RRL kinematics based on the MW potential (Bovy 2015).

Main Results

- Percentage of completion? Degree of advancement?



- Are the results in line with timescale, milestones and KPIs identifyed?

Status: on time and progressing according to plan.

Main Results

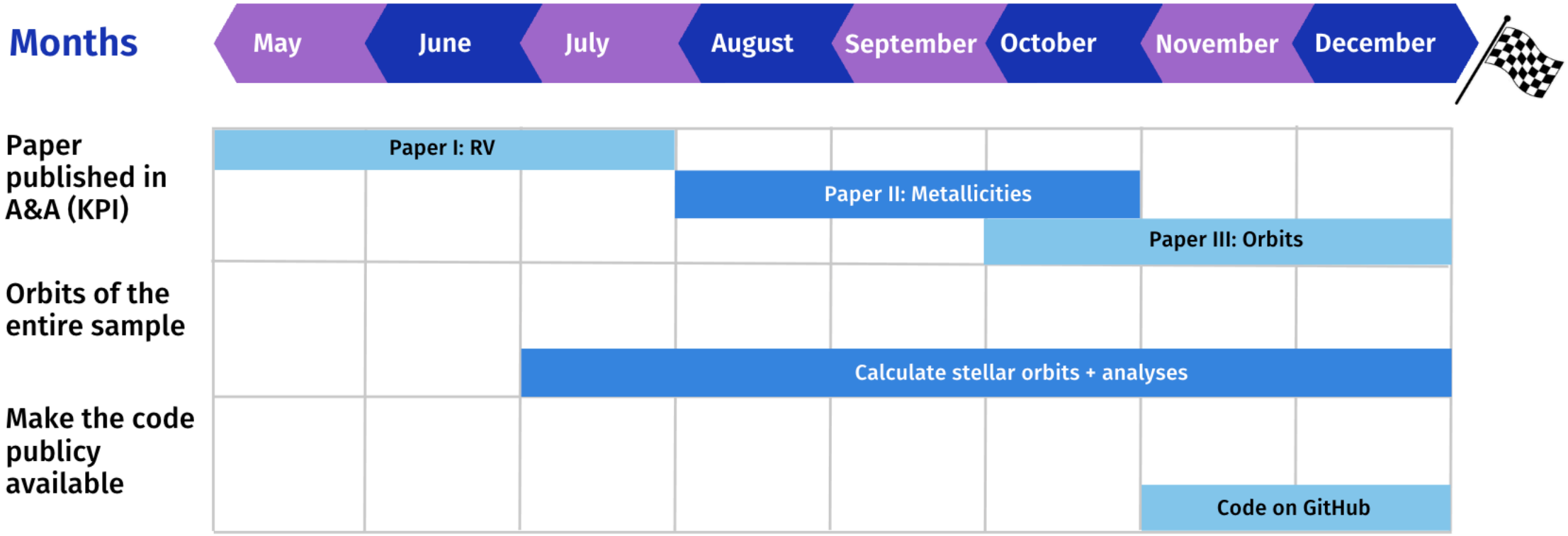
- Could we complete the project by December 2025?

We can say that it is most likely that we will be able to finish in December, but it will depend to a great extent on the publication of the papers.

- What are the key bottlenecks or critical issues preventing timely completion?

Actually, all the codes have been tested, so they will not be a problem.
We think what could cause delays is the analysis of the data, since they must make physical sense and also must be compared with values in the literature, so this part where it is discussed, is usually slower.

Final Steps


Months
May
June
July
August
September
October
November
December
Paper published in A&A (KPI)
Paper I: RV
Paper II: Metallicities
Paper III: Orbits
Orbits of the entire sample
Calculate stellar orbits + analyses
Make the code publicy available
Code on GitHub

Thank for your attention!

Contact:

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