How to (not) reduce and analyze MUSE data

Felipe Gran M.
Ph.D. student PUC/MAS, Chile

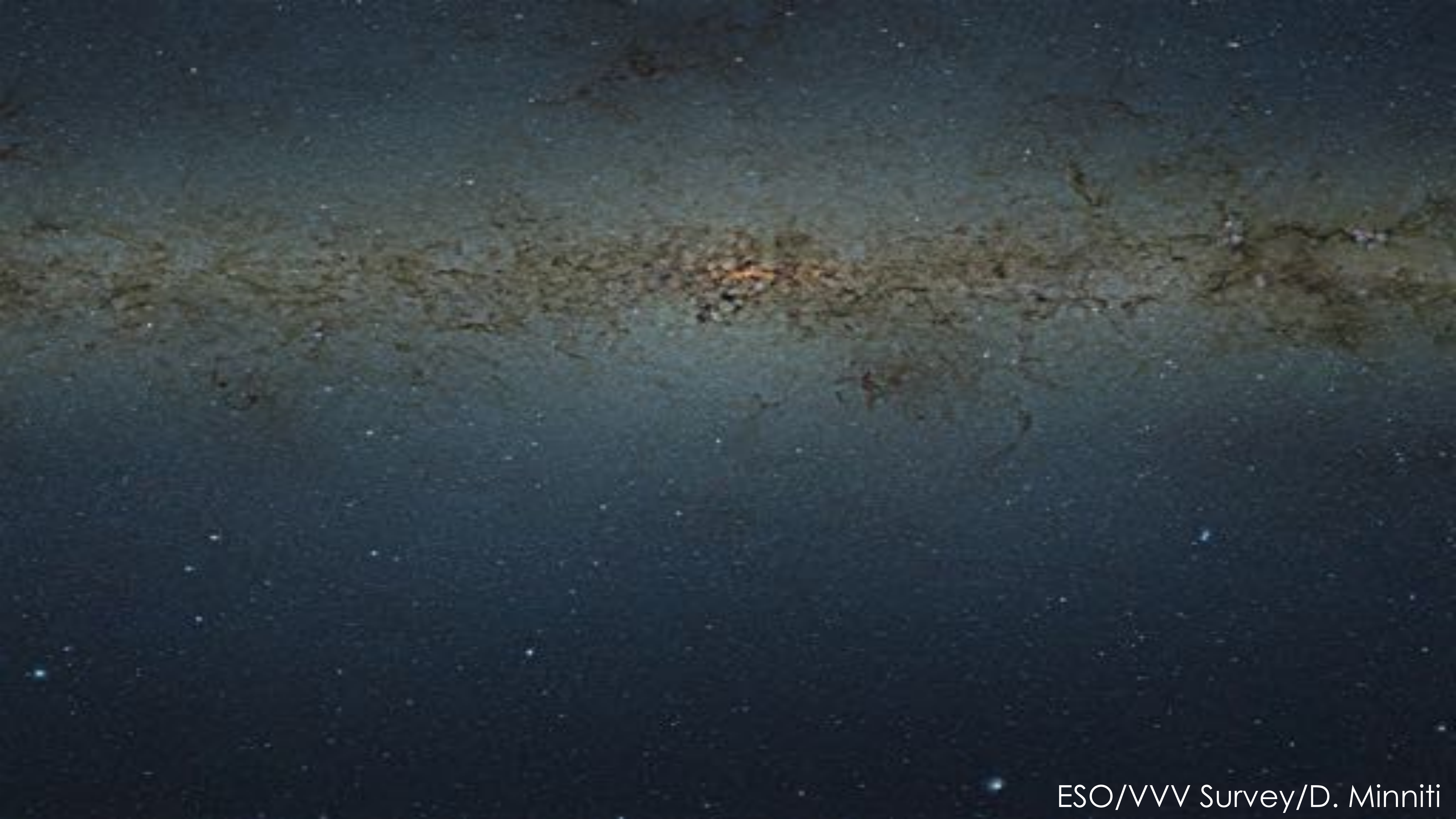
Survey Science Coffee @ ESO HQ
25.03.2019

~~How to (not) reduce and analyze MUSE data~~
Why am I here and what did I do for the last 3 months?

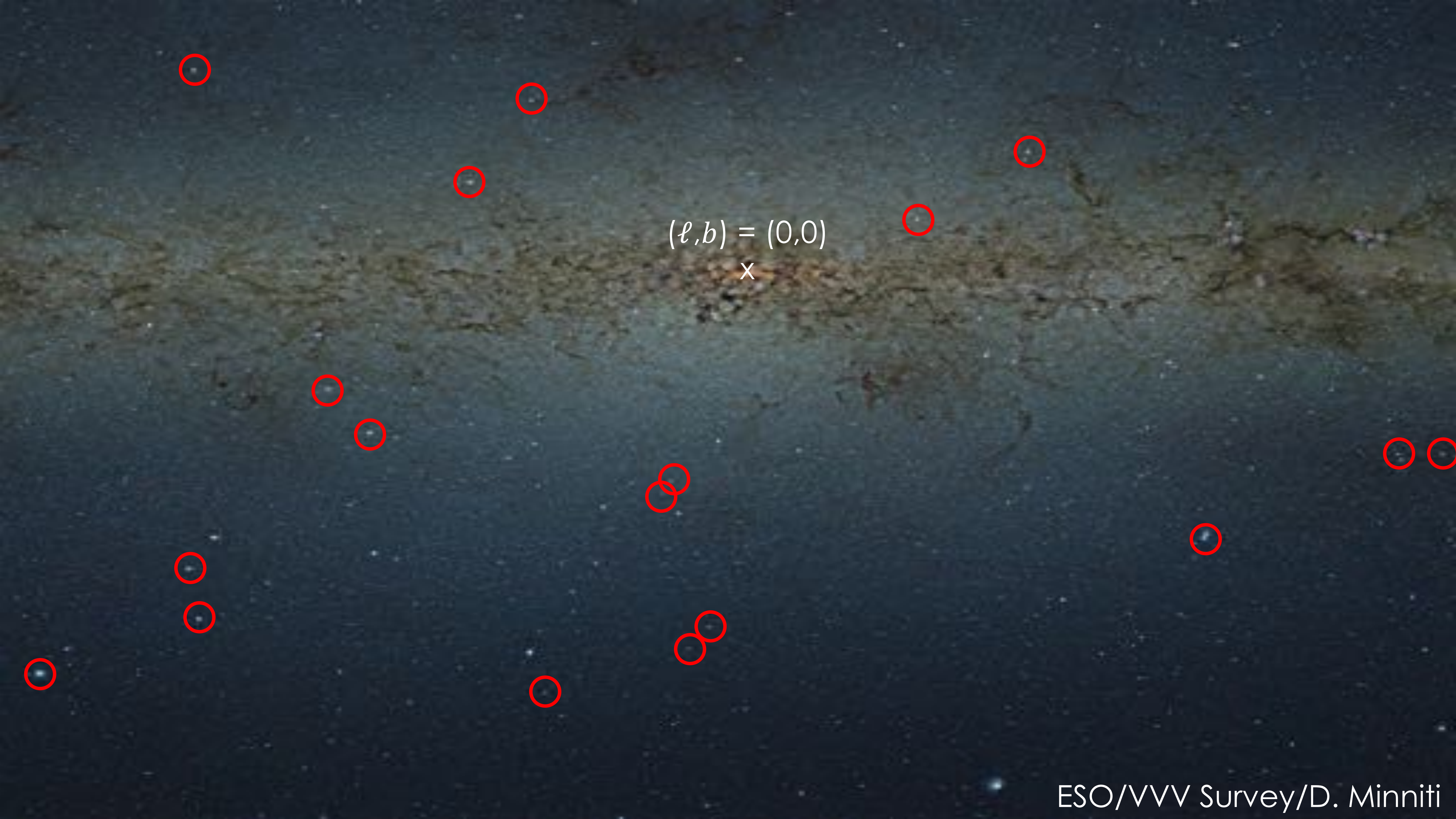
Felipe Gran M. + constant feedback and help of E. Valenti

Presentation available at **fegran.github.io/SSC.pdf**

Code available at **github.com/fegran/GoMUSEvPSFex**



ESO/VVV Survey/D. Minniti

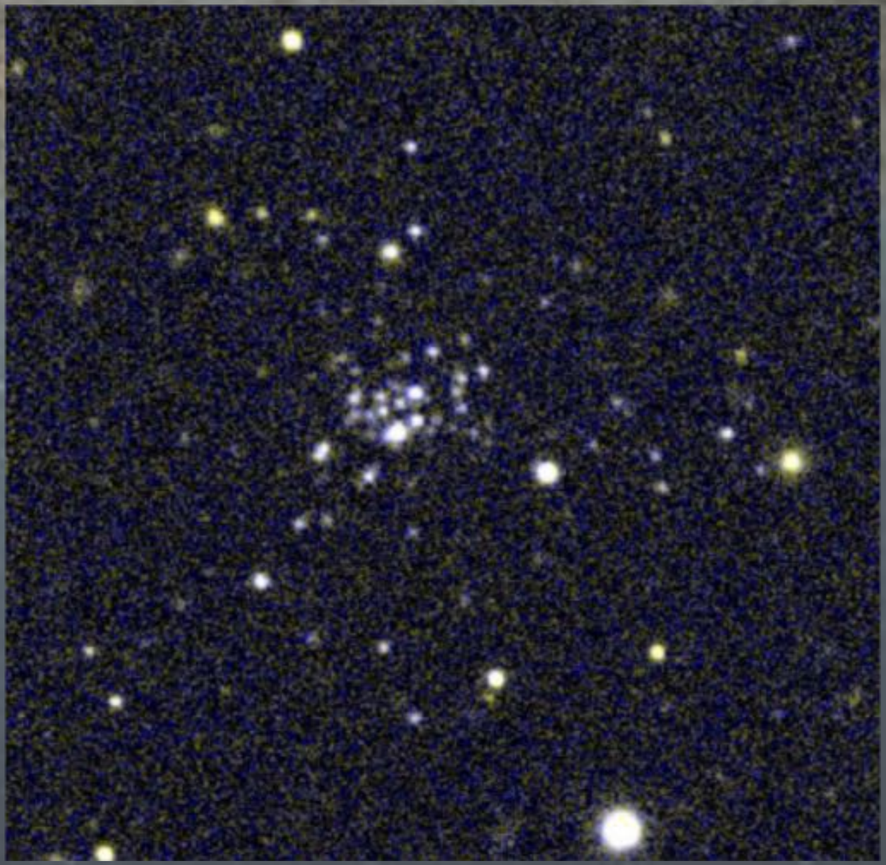


(ℓ,b) = (0,0)
x
ESO/VVV Survey/D. Minniti

Context: searching for new globular clusters

Thanks to the **wide-area** photometric surveys, the number of globular clusters has risen exponentially in the last decades.

- ★ SDSS
- ★ 2MASS
- ★ VST-ATLAS
- ★ Pan-STARS
- ★ DES
- ★ Gaia



Torrealba et al. 2018

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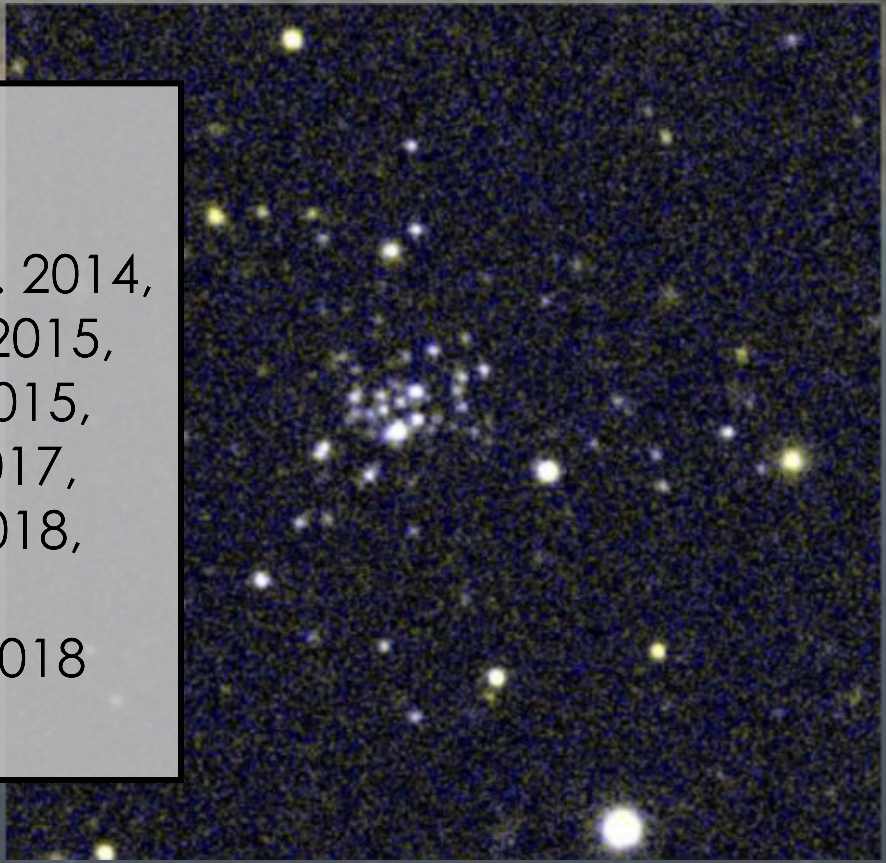
Muñoz et al. 2012, Ortolani et al. 2012, Belokurov et al. 2014,
Laevens et al. 2014, Weisz et al. 2014, Bechtol et al. 2015,
Kim & Jergen 2015, Kim et al. 2015, Laevens et al. 2015,
Luque et al. 2016, Kim et al. 2016, Koposov et al. 2017,
Laevens et al. 2017, Luque et al. 2017, Bica et al. 2018,
Camargo et al. 2018a, Camargo et al. 2018b,
Luque et al. 2018, Ryu & Lee 2018, Torreaba et al. 2018

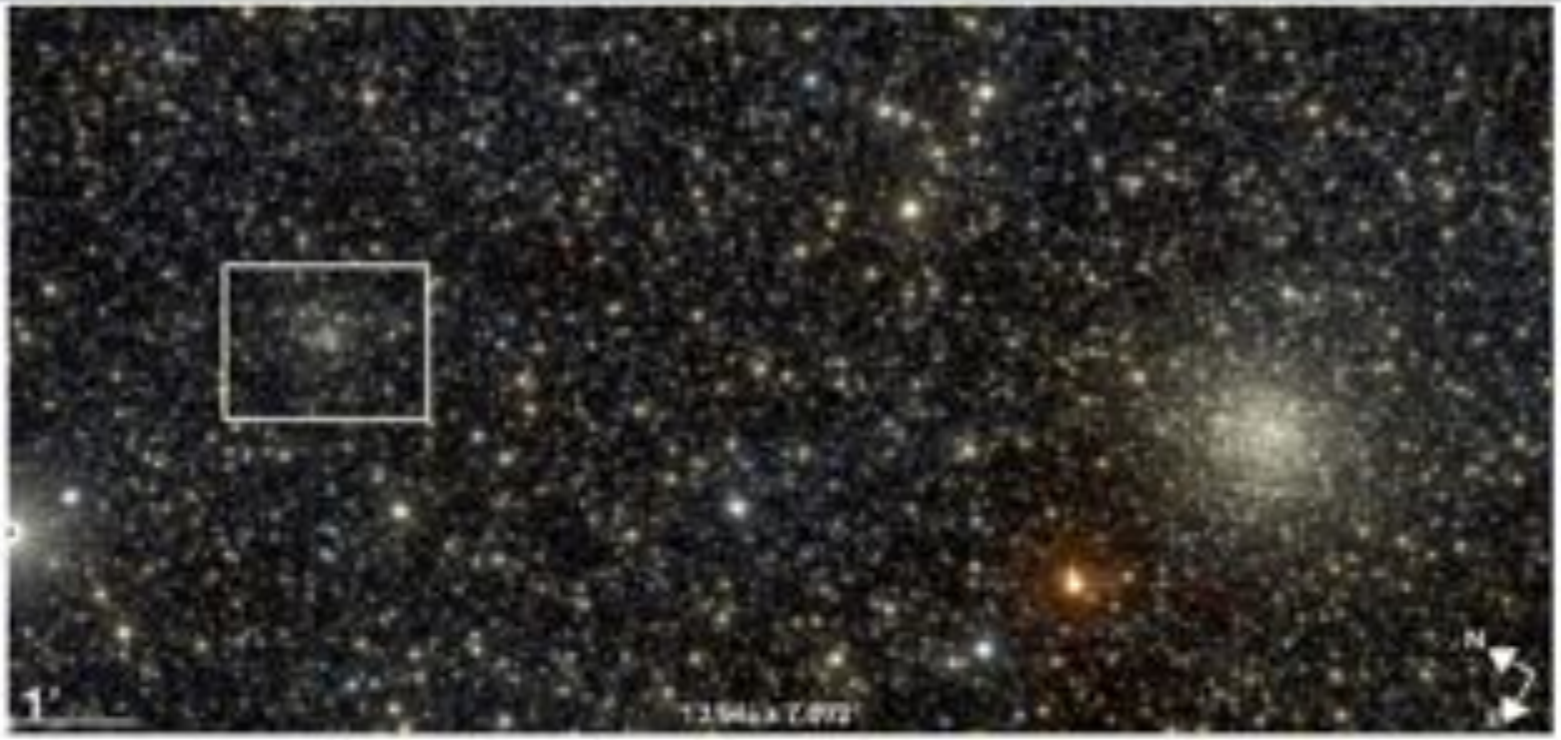


Torrealba et al. 2018

Context: searching for new globular clusters

Only a **minor fraction** of the the newly discovered clusters was located towards the Galactic plane or bulge.

- ★ **2MASS**: Hurt+2000
- ★ **Glimpse**: Kobulnicky+2005
- ★ **VVV**: Minniti+2011, Moni Bodin+2011, Minniti+2017a,2017b, 2017c, Camargo+2018
- ★ **Gaia**: Torrealba+2018, Cantat-Gaudin+2018
- ★ **DECaPS**: Barba+2019



Minniti et al. 2011

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New VVV Survey Globular Cluster Candidates in the Milky Way Bulge*

Dante Minniti[1,2,3], Douglas Geisler[4], Javier Alonso-García[2,5], Tali Palma[6],

Juan Carlos Bea

Rodrigo Contrera

Published 2017 N

The Astrophysical J

Minniti+2017a: 22 new GC candidates

New Metal-poor Globular Clusters in the Galactic Bulge: The Elephant Graveyard*

Dante Minniti[1,2,3]

Rodrigo Contreras

Roberto K. Saito[7]

Published 2017 Nove

Research Notes of th

Minniti+2017b : 38 new GC candidates

The Elephant Graveyard: 24 New Globular Cluster Candidates in the Galactic Bulge*

Dante Minniti[1,2,3], Javier Alonso-García[2,4], and Joyce Pullen[2]

Published 2017 December 29 •

Research Notes of the AAS, Volume 1, Number 1

Minniti+2017c : 24 new GC candidates

Context: follow-up of the new GC candidates

On the ESO **P101**, ~20 hours were approved to follow up 18 of these new GC candidates.

P101.D-0363(A):
"Spectroscopic confirmation of new globular clusters in the Milky Way bulge"

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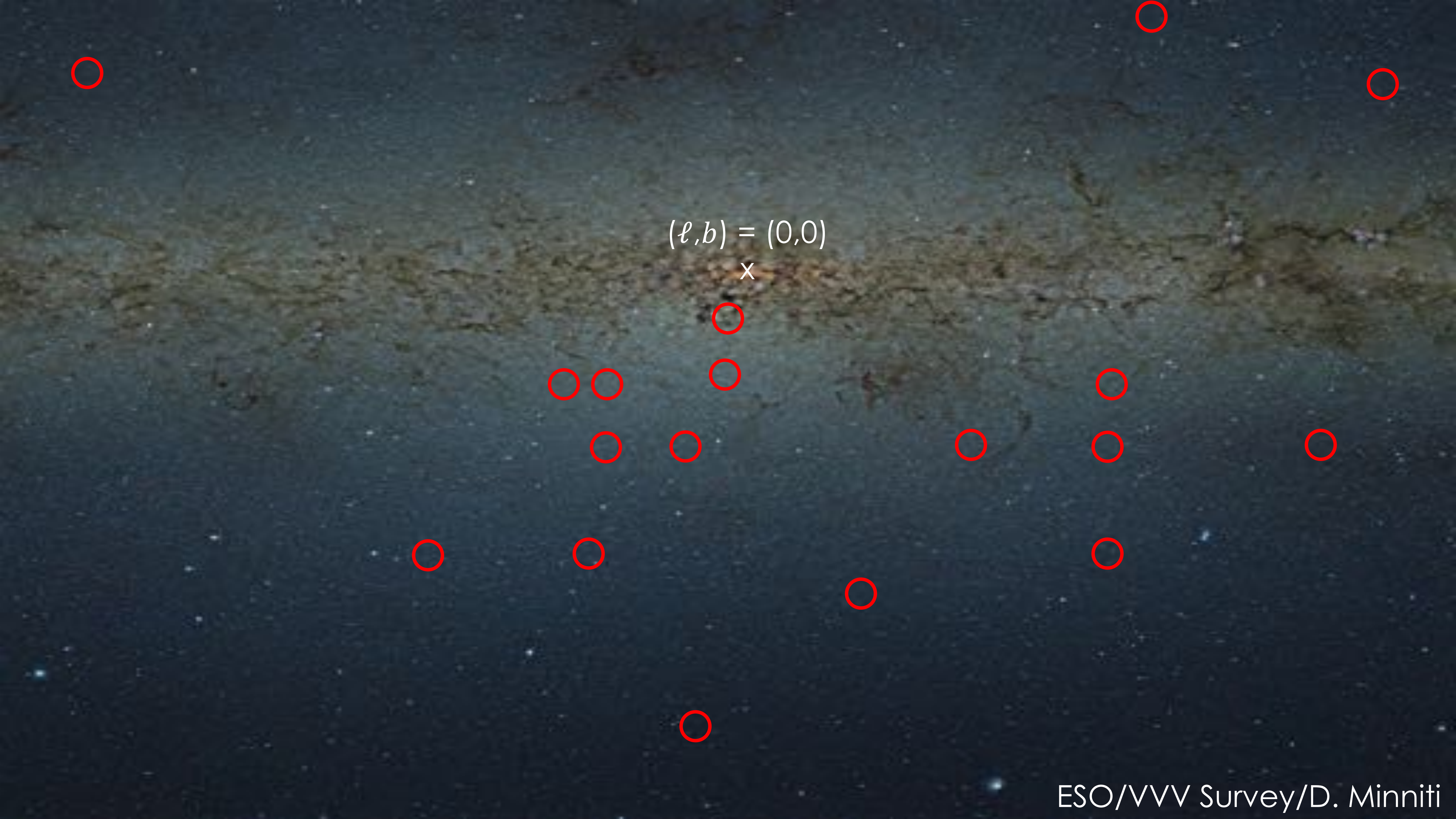
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ESO/VVV Survey/D. Minniti

Technical motivation: “short term student”

★ Learn how to **reduce** MUSE datacubes

★ Perform a careful spectra extraction by using **PSF-fitting** algorithm

★ Deriving stars **kinematics** and **metallicity** through cross-correlation technique and equivalent width determination

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- Deriving stars **kinematics** and **metallicity** through cross-correlation technique and equivalent width determination
  - Beginner's Guide to Python:

```
from specutils.fitting import fit_generic_continuum

from PyAstronomy.pyasl import crosscorrRV as CC
from specutils.analysis import equivalent_width

from joblib import Parallel, delayed
from specutils import Spectrum1D
```

Combined results: GoMUSEvPSFex

MUSE PSF photometry via PSFex

Edit

Manage topics

24 commits | 1 branch | 0 releases | 1 contributor | MIT

Branch: master ▾ | New pull request | Create new file | Upload files | Find File | Clone or download ▾

fegran FG … Latest commit e8c94b4 4 days ago

default_files	FG	4 days ago
.gitattributes	Initial commit	
.gitignore	Initial commit	
GoMUSEvPSFex.html	FG	
GoMUSEvPSFex.ipynb	FG	
GoMUSEvPSFex.py	FG	
LICENSE	Initial commit	
README.md	FG	

README.md

GoMUSE vPSFex

This repository contains scripts to perform PSF photometry on MUSE slices. Heavi

Intended usage

Here you can find an example of the usage: Jupyter Notebook.

The execution of the program occurs in a working folder, that at the beginning contains:

```
default files for Sextractor/PSFex
Raw datacube
Field of View images (White,V,R,I)
GoMUSEvPSFex.py
```

The python programme (**GoMUSEvPSFex.py**) can be divided in two major branches: "User parameters" and "Main features". The last branch also is divided into three major phases that the first two can be operated separately:

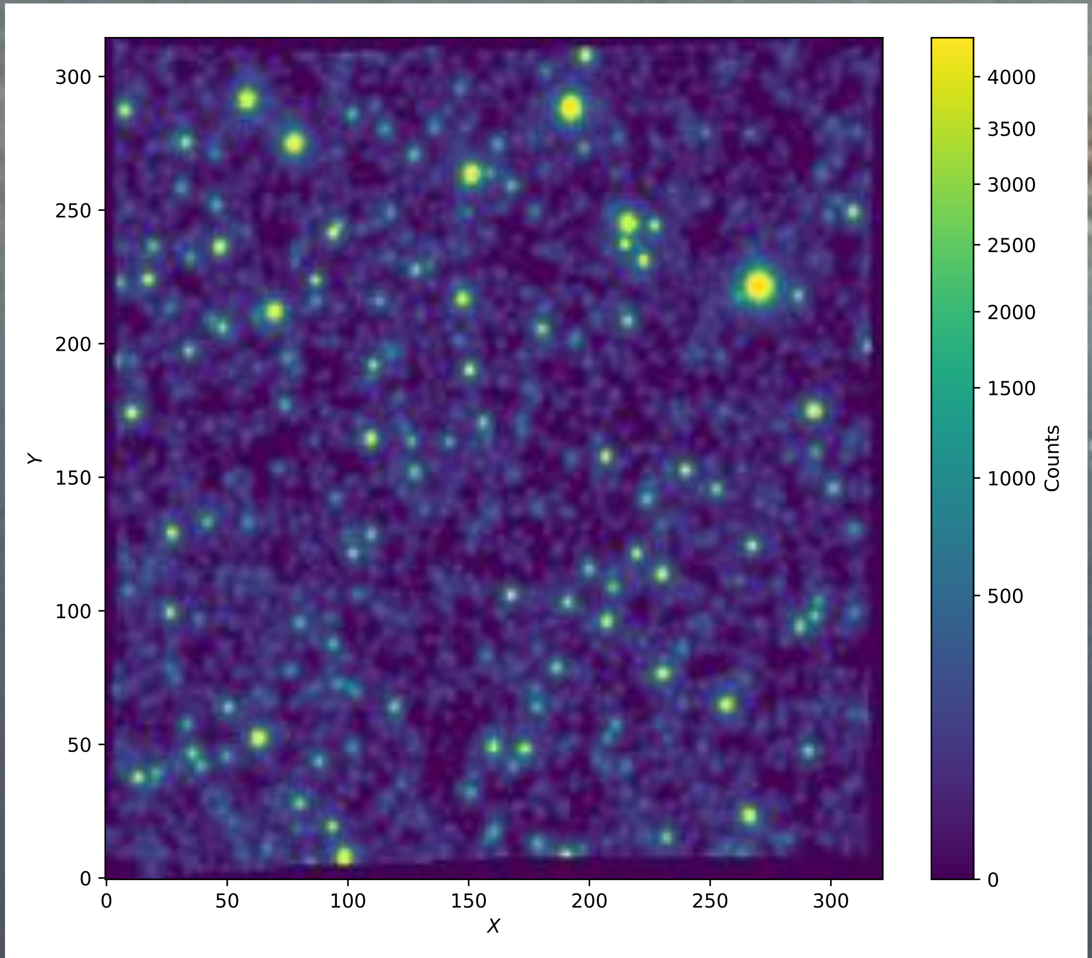
- Phase 1: Perform PSF photometry on VRI FoV images and create the catalogs.
- Phase 2: Separate slices using MissFITS to prepare to **Phase 3**.
- Phase 3: **After Phase 2**, iterate over all the MUSE slices and perform PSF photometry creating individual catalogs.

After a successful run of the script, there will be three (VRI) catalogs on **cmds_output/** and catalogs for each slice on **slice_catalogs/**. Each catalog will contain a unique star ID, (X,Y) and (RA,Dec) coordinates, magnitudes/fluxes for the CMD/slices and three diagnostic quantities (flags,fwhm, and SNR).

github.com/fegran/GoMUSEvPSFex

Combined results: GoMUSEvPSFex

CL37 $(\ell, b \simeq 0.5°, -3°)$ $N_{stars} = 518$



Basic stats:

- 18 MUSE datacubes
- Mean $N_{stars} = 460$
- Max $N_{stars} = 614$ (CL07)
- Total $N_{stars} = 7370$
- Total $N_{slices} = 66960$

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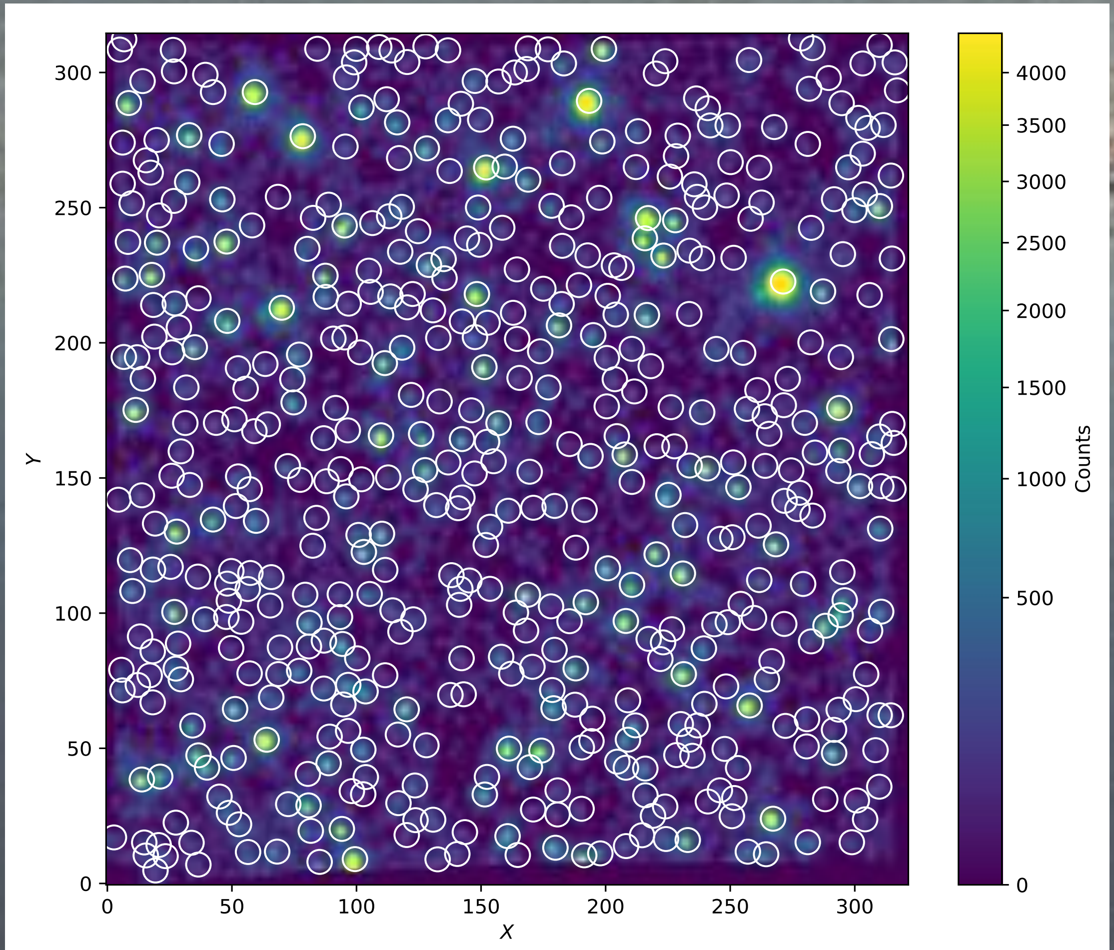

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      of 3721 | elapsed: 49.6min finished
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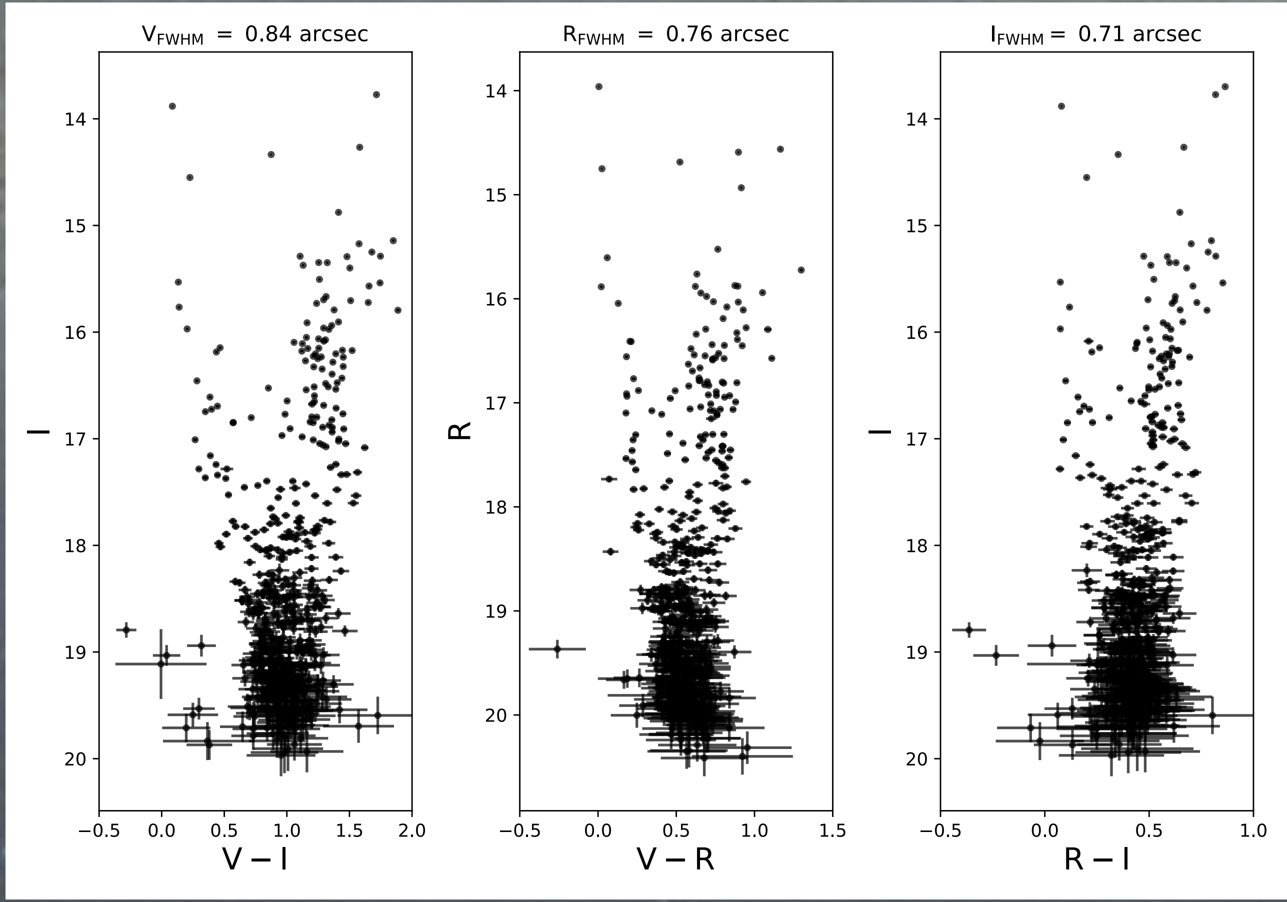

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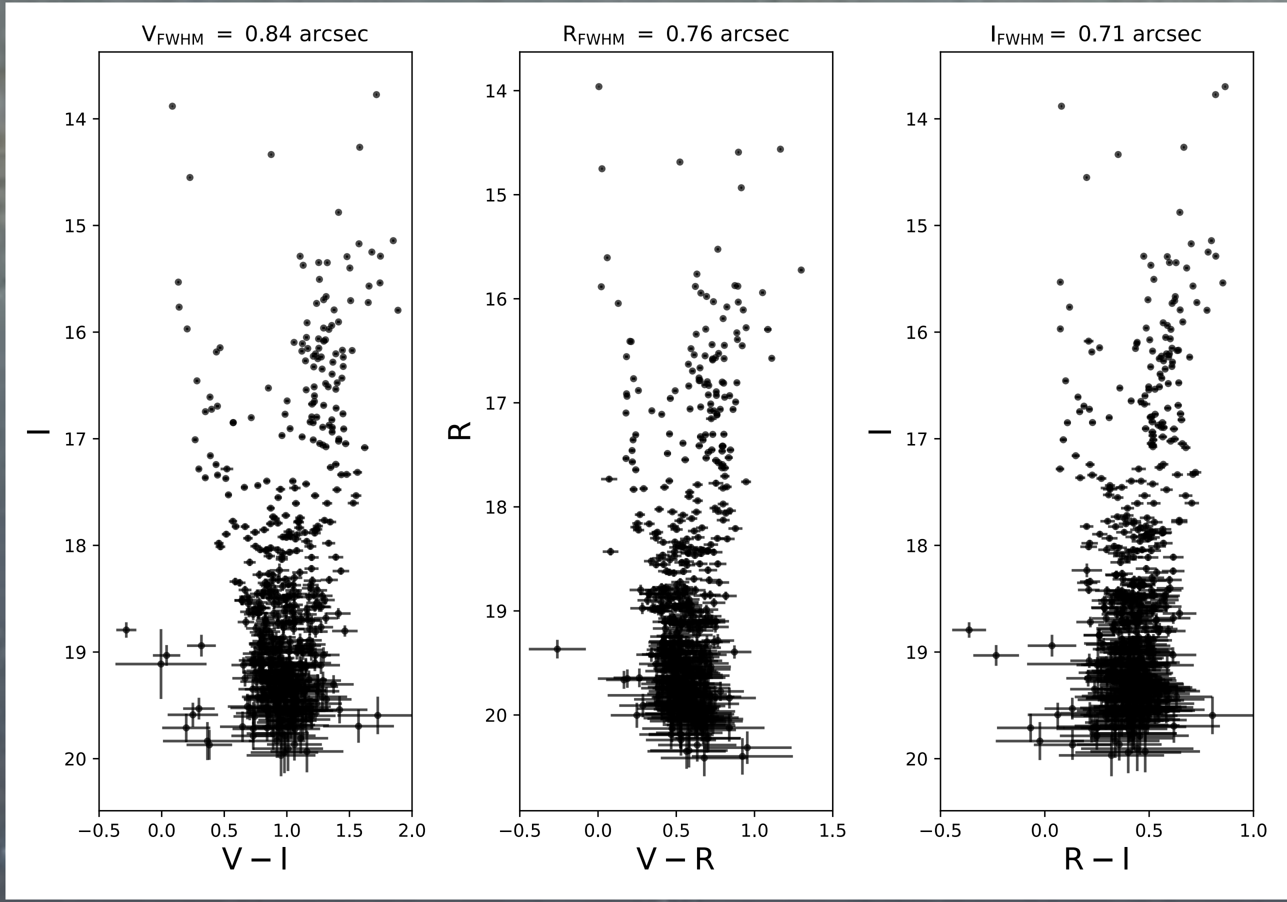

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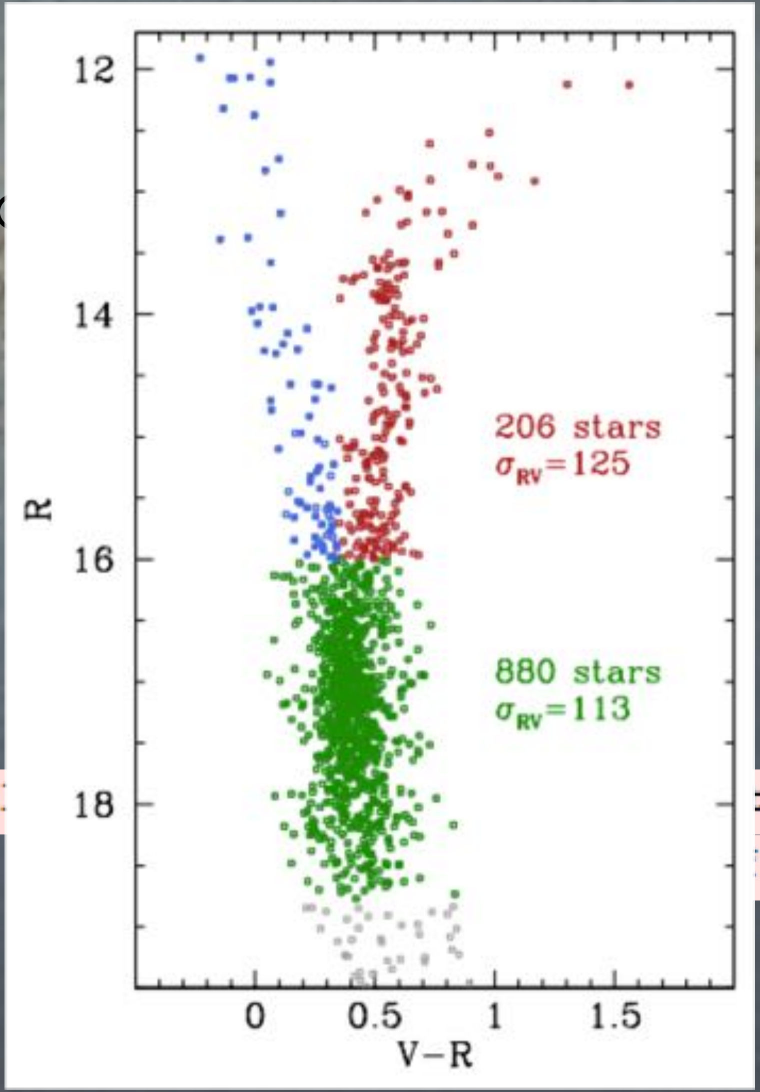

Valenti et al. 2018

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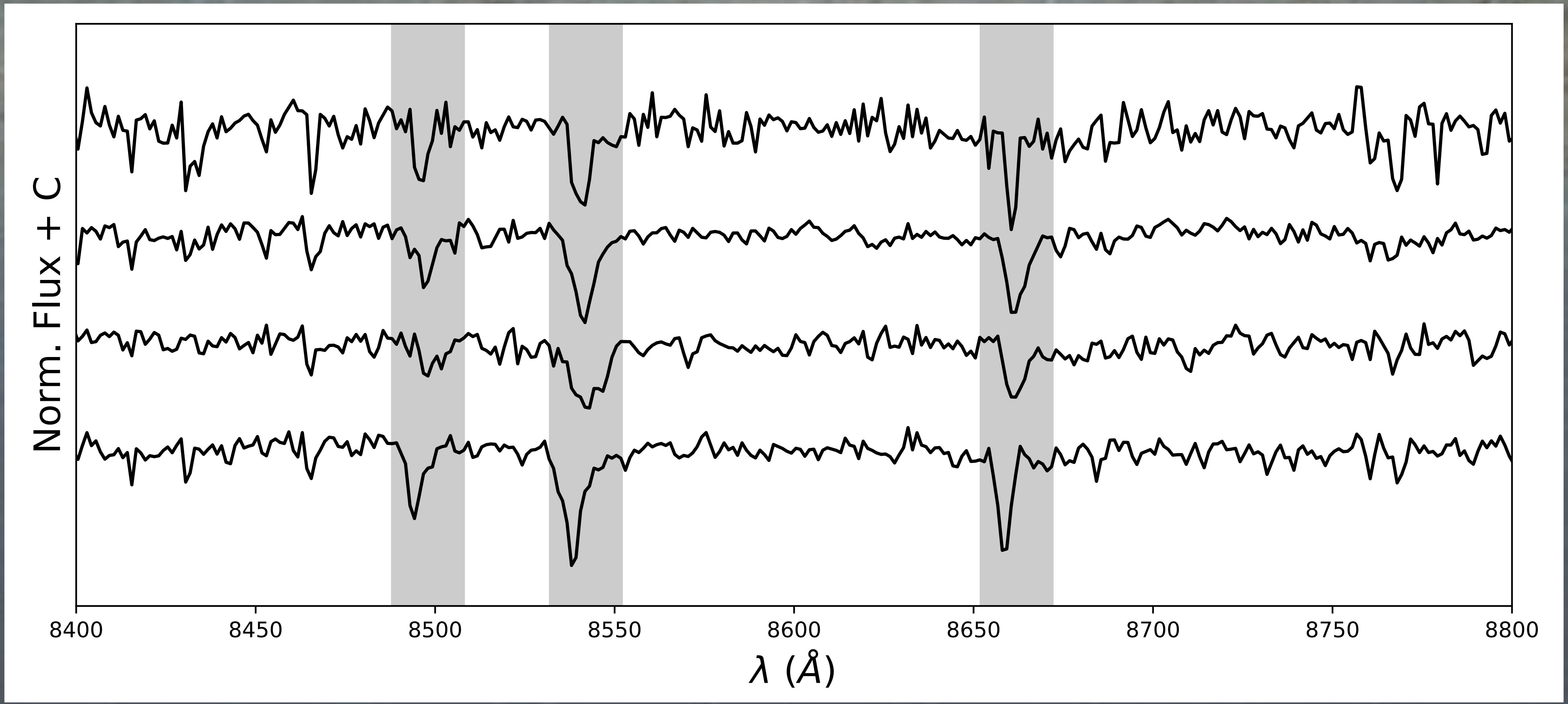

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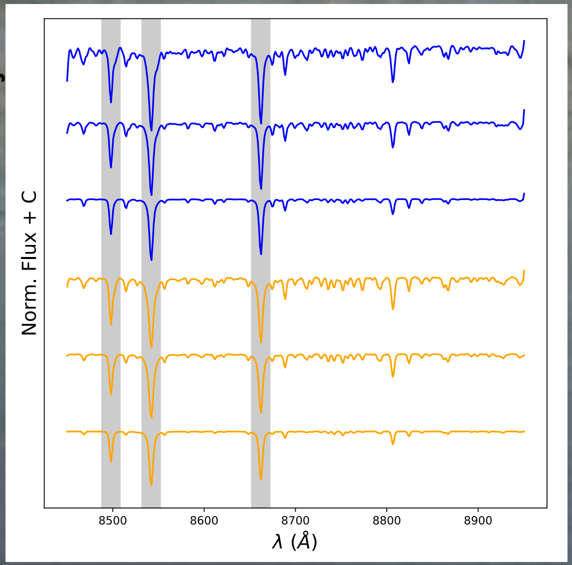
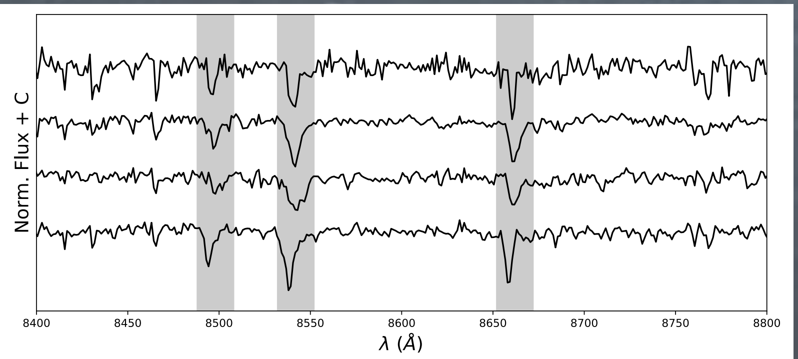
Thanks to Álvaro Rojas





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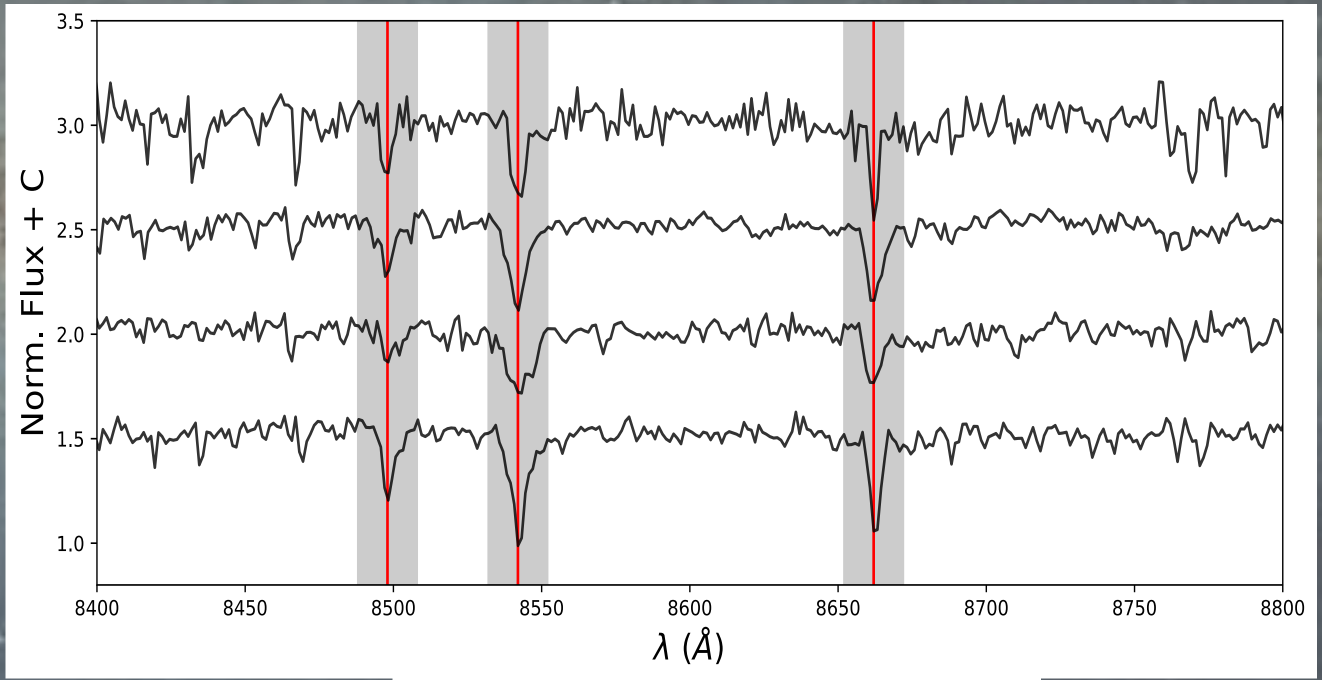
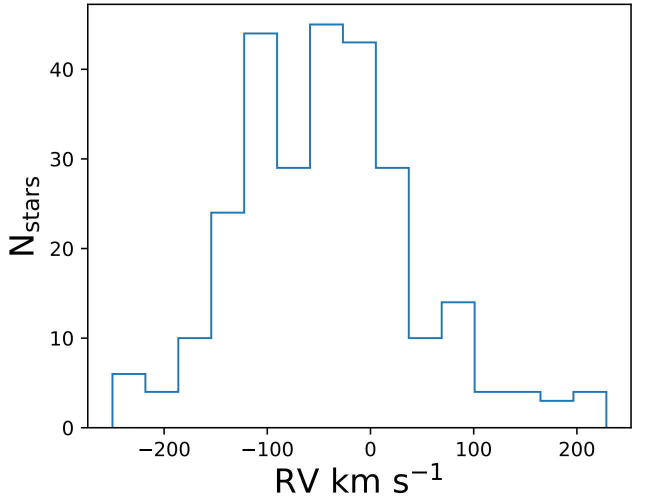
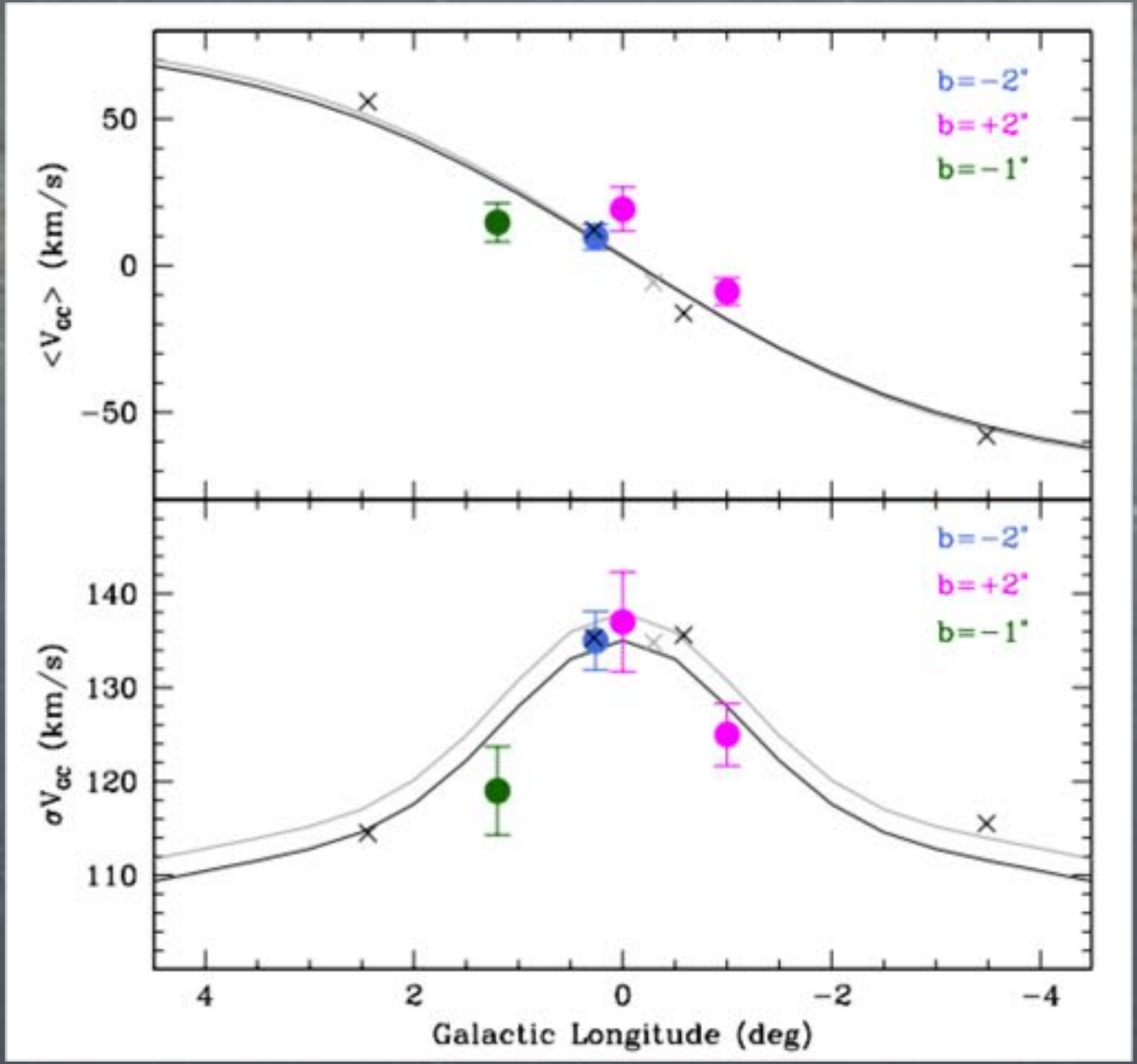
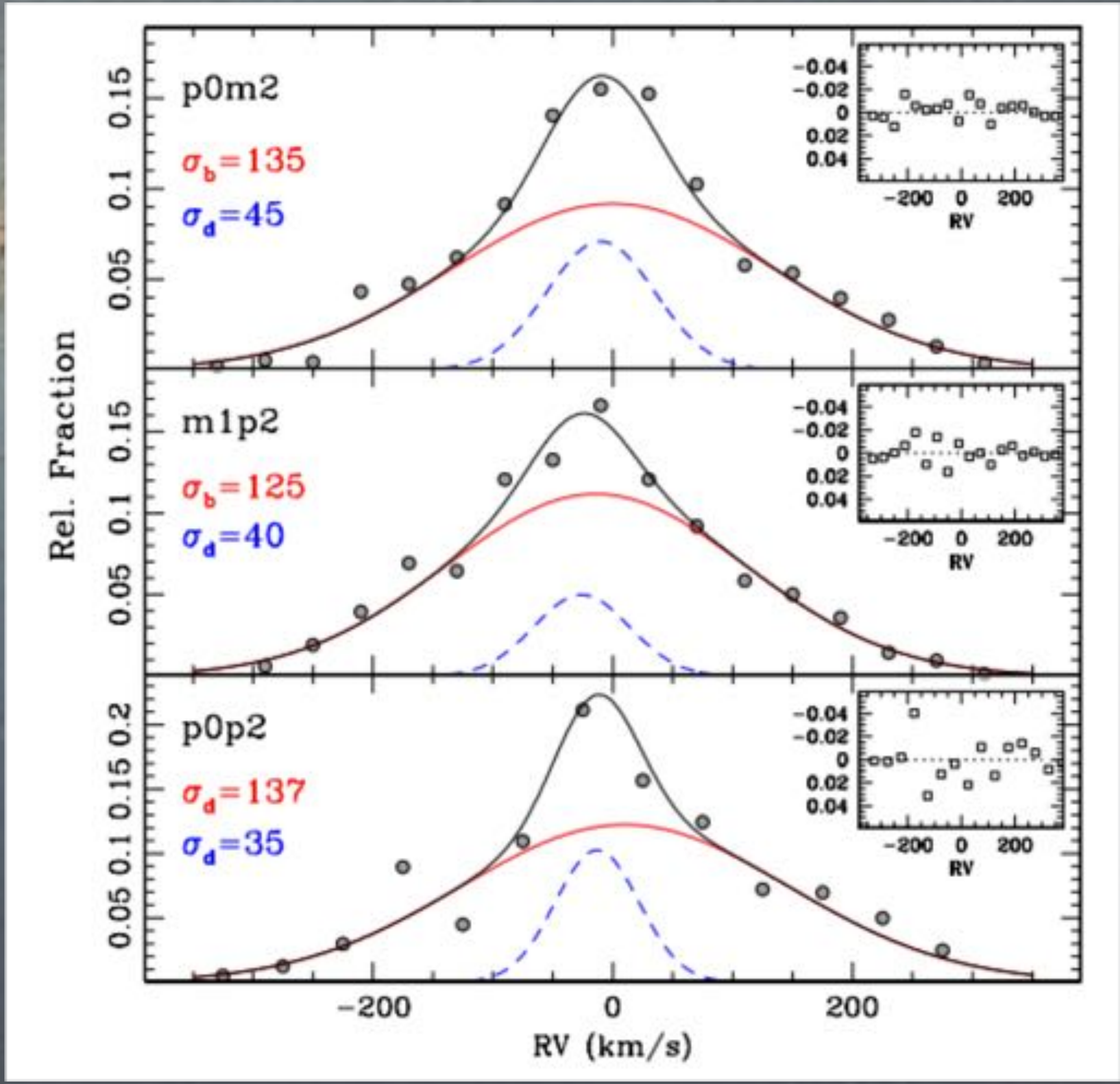




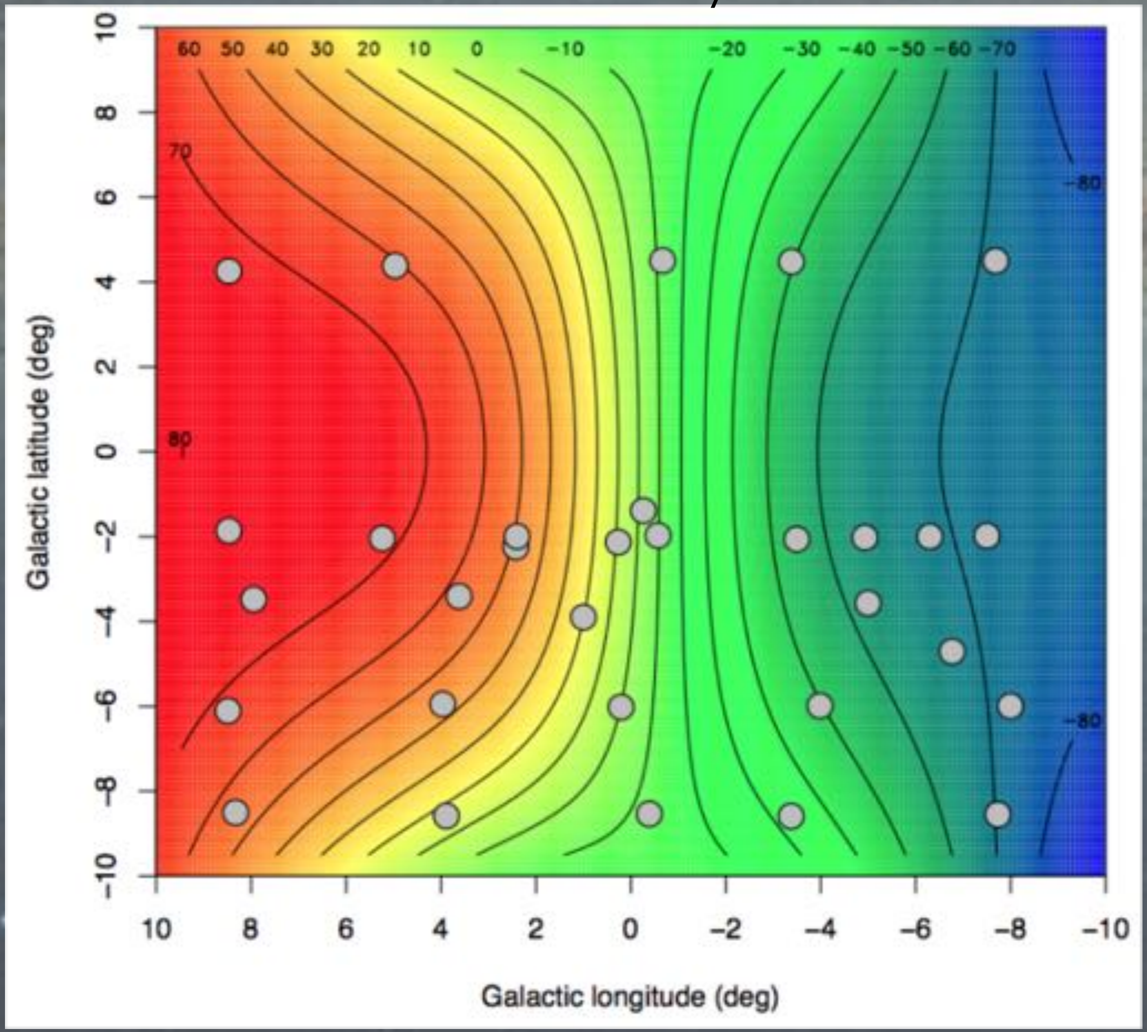
Expected goals: Valenti et al.2018



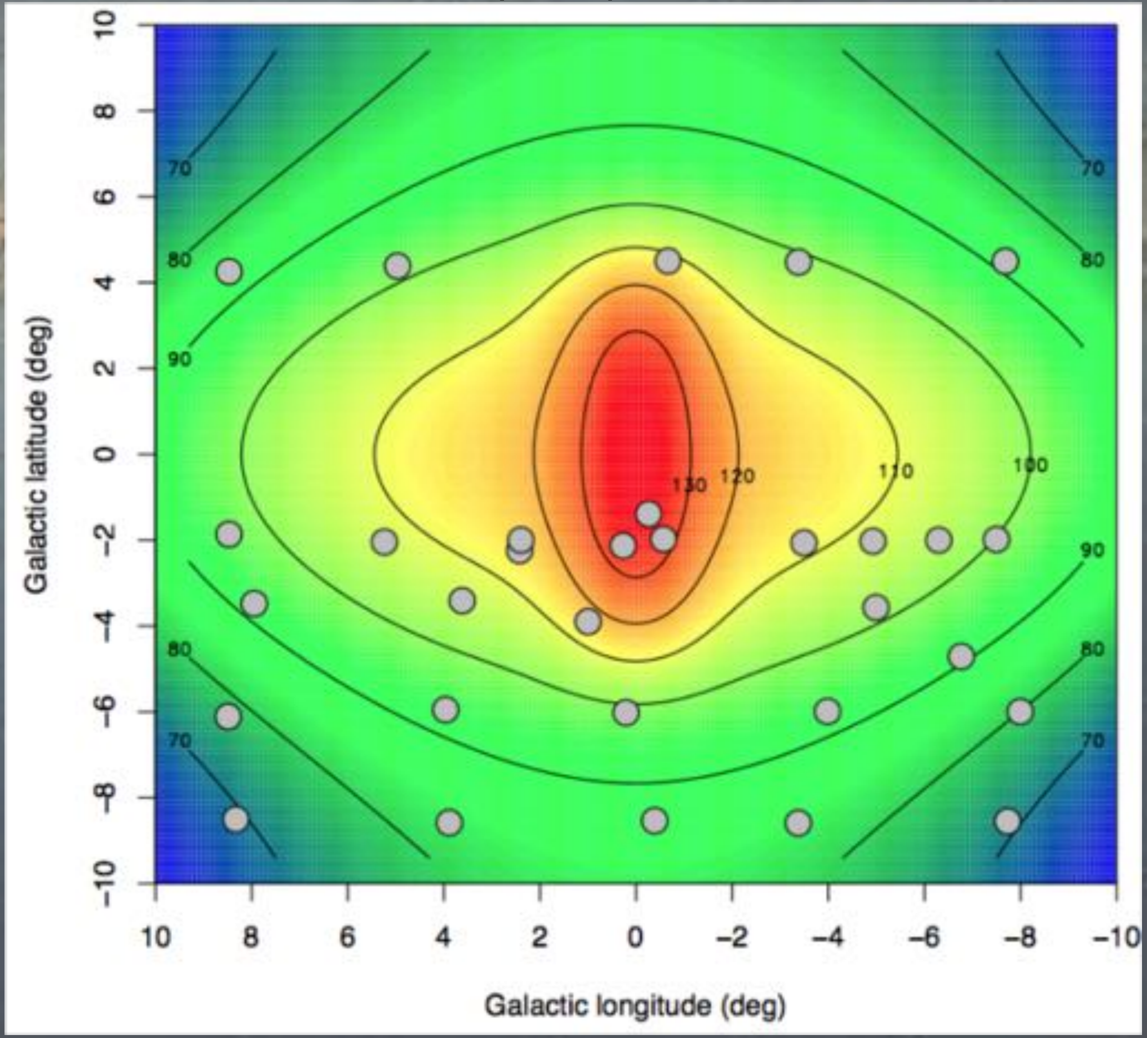


Expected goals: Zoccali et al. 2014

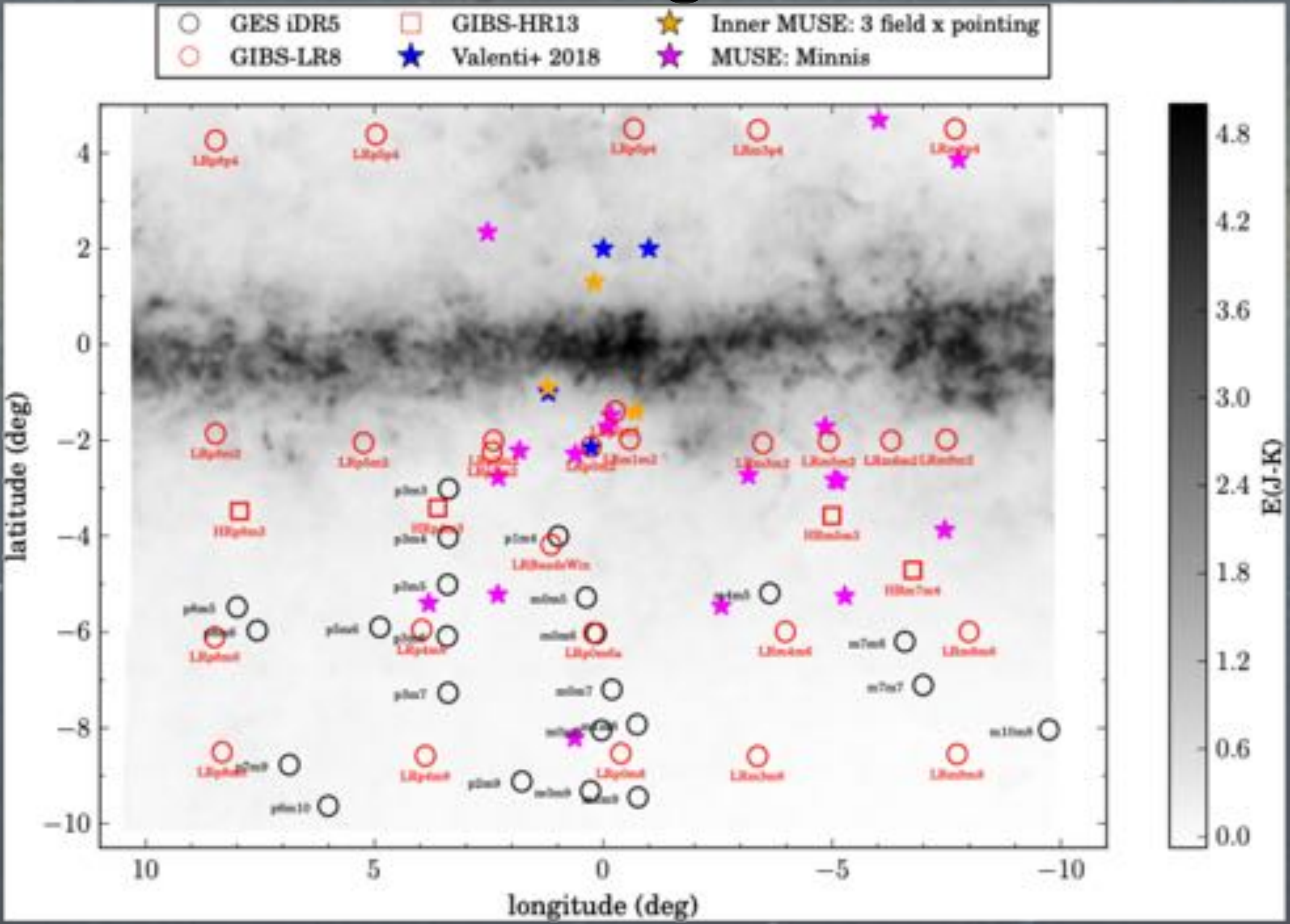
Mean radial velocity surface



Radial velocity dispersion surface

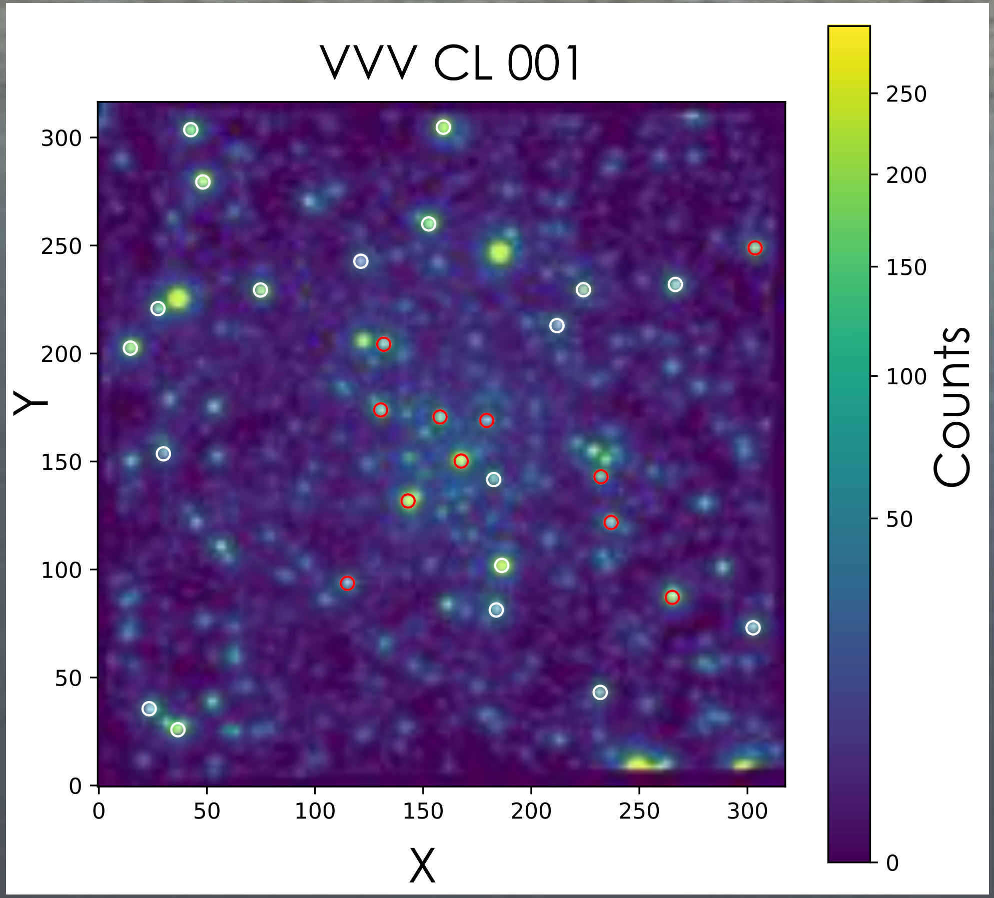


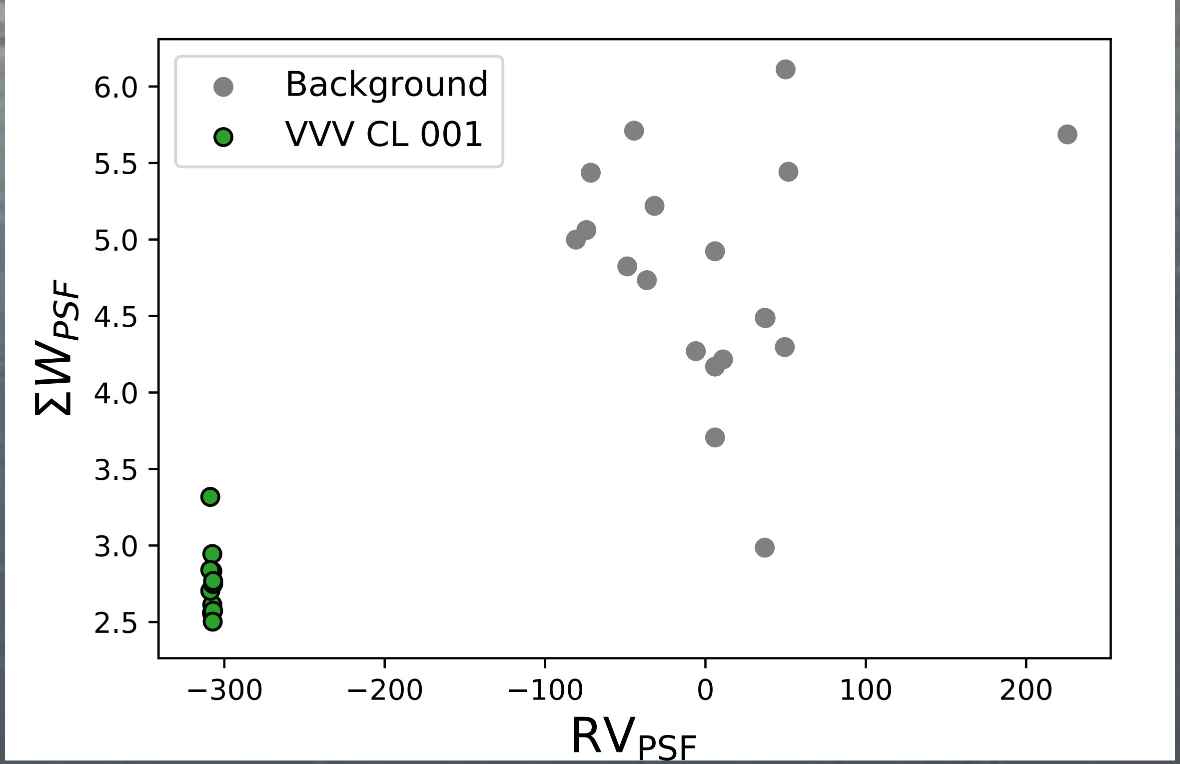
Real goals:


GES iDR5
GIBS-HR13
Inner MUSE: 3 field x pointing
GIBS-LR8
Valenti+ 2018
MUSE: Minnis
latitude (deg)
longitude (deg)
E(J-K)
4.8
4.2
3.6
3.0
2.4
1.8
1.2
0.6
0.0
4
2
0
−2
−4
−6
−8
−10
10
5
0
−5
−10

Future work: “No time to finish it”

★ Finish the analysis for the remaining fields:
derive RV and calculate CaT equivalent widths.





Future work: “No time to finish it”

★ Finish the analysis for the remaining fields:
derive RV and calculate CaT equivalent widths.

★ Cross-match the final catalog (RA,Dec,V,R,I,RV,EW) with
Gaia DR2+VVV to obtain 5D phase space information.

```
for catalog, tile in zip(data, tiles):

    stilts1 = 'java -jar stilts.jar cdsskymatch cdstable=I/345/gaia2 find=best radius=1 in=%s ' %catalog
    stilts2 = 'ifmt=ascii ra=ra dec=dec out=../tiles/VVV_GaiaDR2_%s.csv ofmt=csv' %tile

    print('Actual tile %s' %tile, end='\r')

    os.system('%s %s' %(stilts1, stilts2))
```

Future work: “No time to finish it”

★ Finish the analysis for the remaining fields:
derive RV and calculate CaT equivalent widths.

★ Cross-match the final catalog (RA,Dec,V,R,I,RV,EW) with
Gaia DR2+VVV to obtain full 6D phase space information.

★ Carefuly correct some of the spectra:
PSF model not converge or bad measurement.

Thank you for your attention!

fegran.github.io   fegran@uc.cl   @fegranm