Stellar models in Roman filters

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WINGS SIT + Filters Working Group

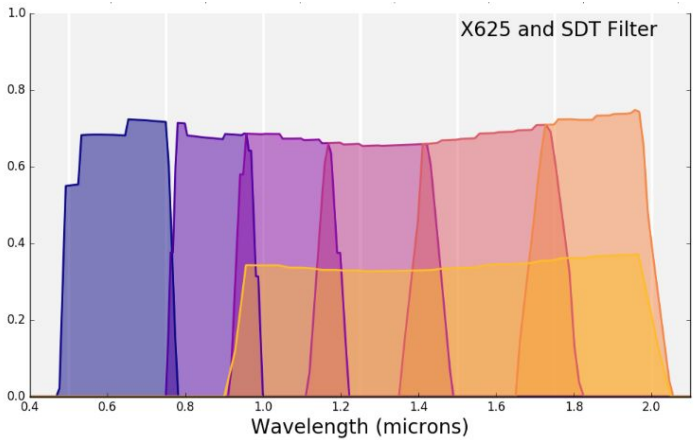
\+ PARSEC-COLIBRI stellar modeling team

A large database of stellar models in Roman filters

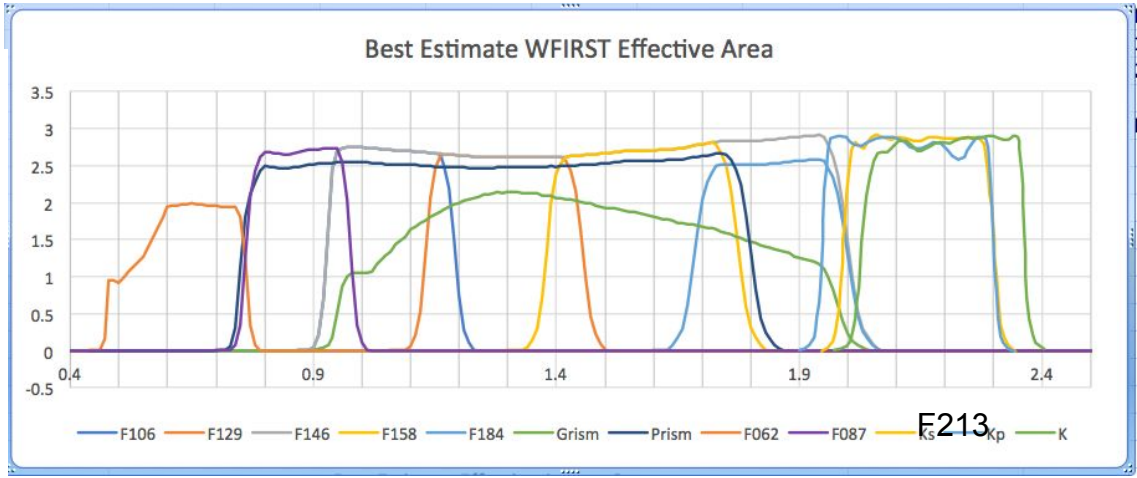
- Useful to simulate photometry of nearby fields and distant galaxies (e.g. in WINGS)
- Fairly complete in evolutionary stages (see Martha's talk)
- Expanded to simulate "unusual" stars (dust-enshrouded, alpha enhanced, fast rotators, variability...)

Filters

- We started in 2017 with '**notional**' and then '**proposed**' sets of filters
- All previous sets still available (but hidden from users)



- Present set of filters: '**Roman2021**' :
- F062 F087 F106 F129 F146 F158 F184 F213 SNprism Grism_1stOrder Grism_0thOrder



Computing bolometric corrections

Girardi+02: starting from definition of apparent magnitude in a photon-counting device

$$m_{S\lambda} = -2.5 \log \left(\frac{\int_{\lambda_1}^{\lambda_2} f_\lambda S_\lambda \mathrm{d}\lambda}{\int_{\lambda_1}^{\lambda_2} f_\lambda^0 S_\lambda \mathrm{d}\lambda} \right) + m_{S\lambda}^0 \quad ,$$

How many photons we count w.r.t. a reference flux (from Vega).

And after introducing absolute magnitudes, the Sun, and extinction, we get a general expression for Bolometric Corrections:

$$BC_{S\lambda} = M_{\mathrm{bol},\odot} - 2.5 \log \left[4\pi (10\,\mathrm{pc})^2 F_{\mathrm{bol}} / L_\odot \right] + 2.5 \log \left(\frac{\int_{\lambda_1}^{\lambda_2} \lambda F_\lambda \, 10^{-0.4 A_\lambda} S_\lambda \mathrm{d}\lambda}{\int_{\lambda_1}^{\lambda_2} \lambda f_\lambda^0 S_\lambda \mathrm{d}\lambda} \right) - m_{S\lambda}^0$$

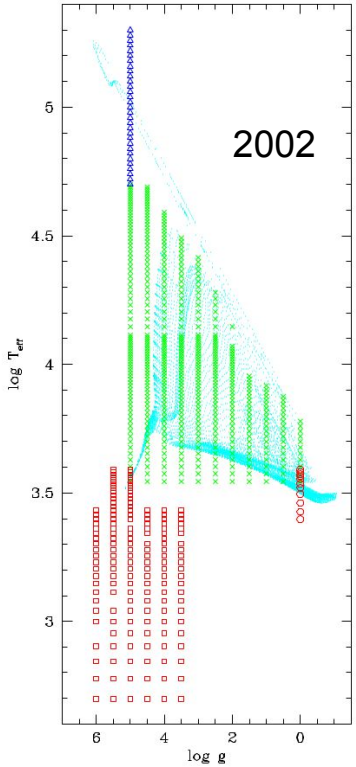
*A function **only** of spectral shape + filter transmission curve*

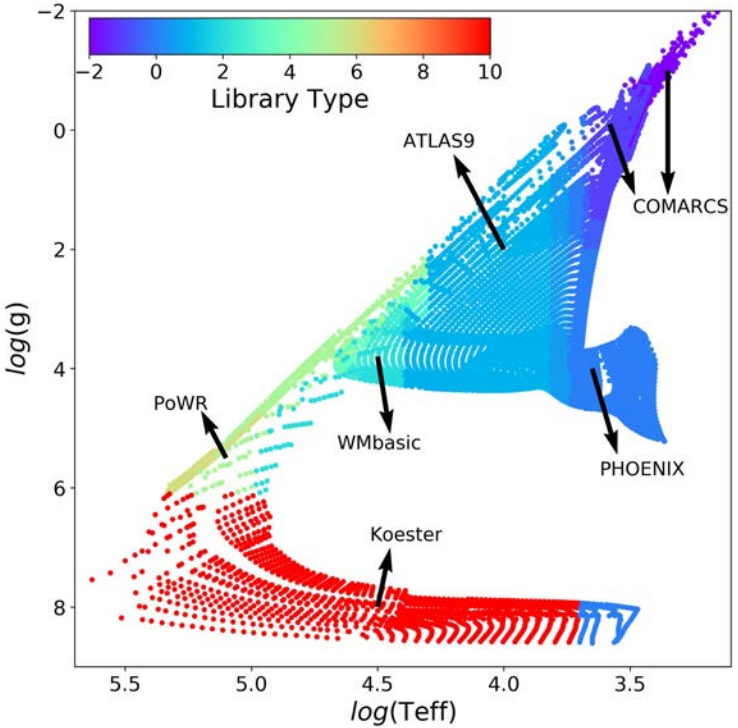
$$M_\lambda = M_{\mathrm{bol}} - \mathrm{BC}(X_i, \log g, \log T_{\mathrm{eff}}),$$

How brighter are stars at 10 pc w.r.t Vega.

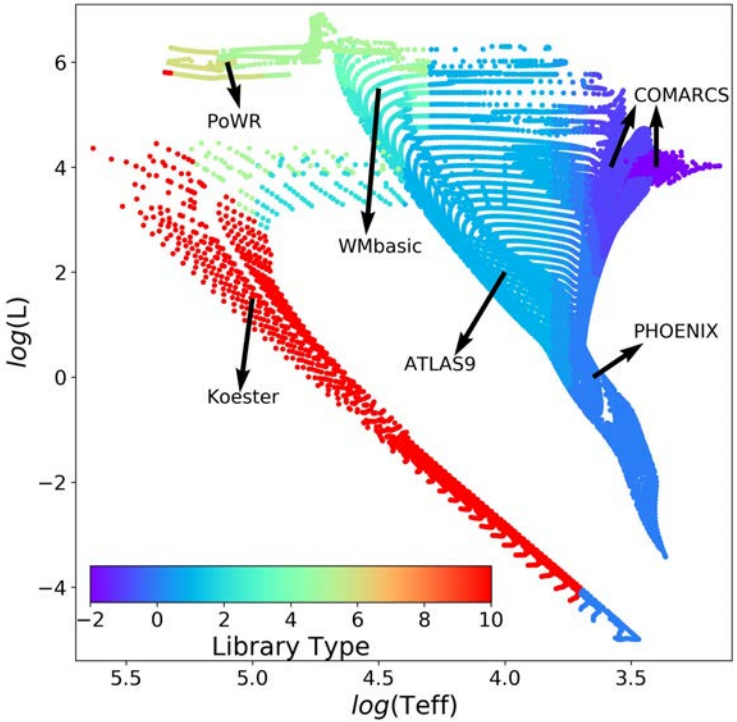
Spectral library

Large grid of F_lambda in logg X Teff X [Fe/H]





YBC (Chen+19)



Spectral library

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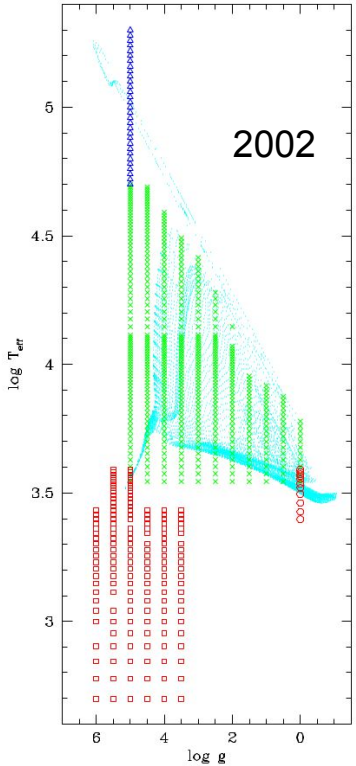

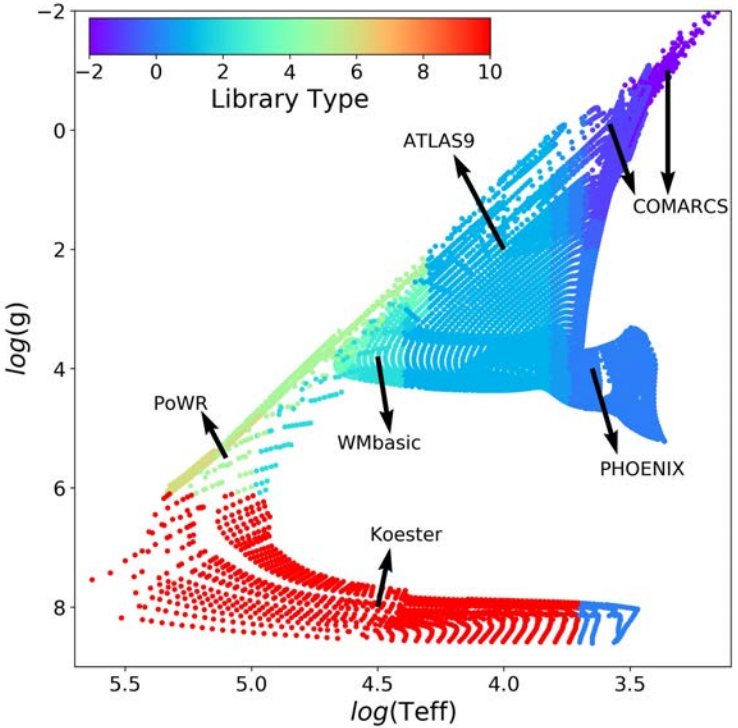

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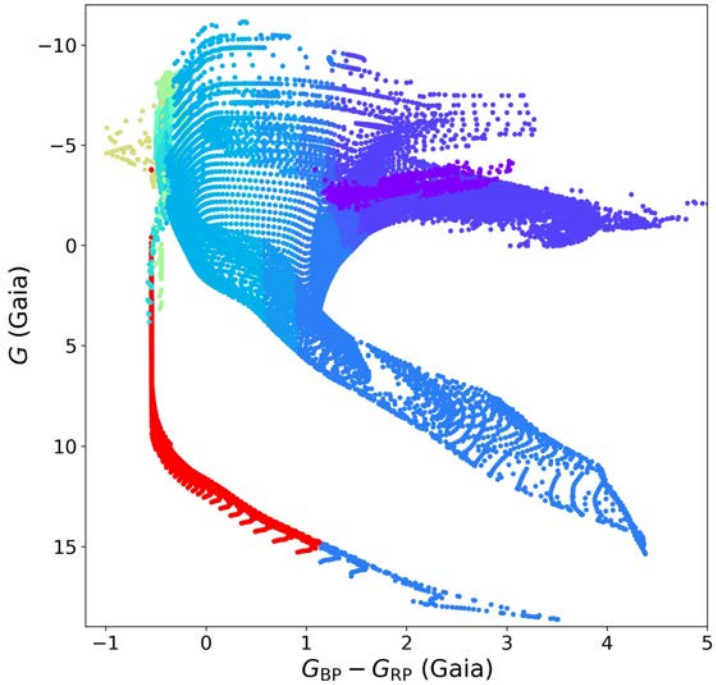


Extinction

Extinction is applied star-by-star, using O'Donnell+Cardelli's extinction curve with Rv=3.1

In practice, compute large tables of extinction coefficients, then interpolate:

$$A_\lambda/A_V = \frac{BC_{S_\lambda}(A_V) - BC_{S_\lambda}(0)}{A_V}.$$

- **Extinction coefficients** vary with Teff and with Av itself
- In Roman, variation is quite modest, *but for F062 filter*
- Variation is important in many other cases (e.g. Gaia G band, GALEX UV filters,...)

# Teff	logg	Av	A(F062)/Av	A(F158)/Av	A(Gaia_G)/Av
3500	0.00	1.0	0.802	0.194	0.686
3500	4.50	1.0	0.798	0.194	0.700
6000	4.50	1.0	0.858	0.198	0.858
15000	4.50	1.0	0.895	0.200	0.992
3500	0.00	10.0	0.761	0.191	0.598
3500	4.50	10.0	0.762	0.192	0.603
6000	4.50	10.0	0.718	0.196	0.693
15000	4.50	10.0	0.739	0.197	0.763

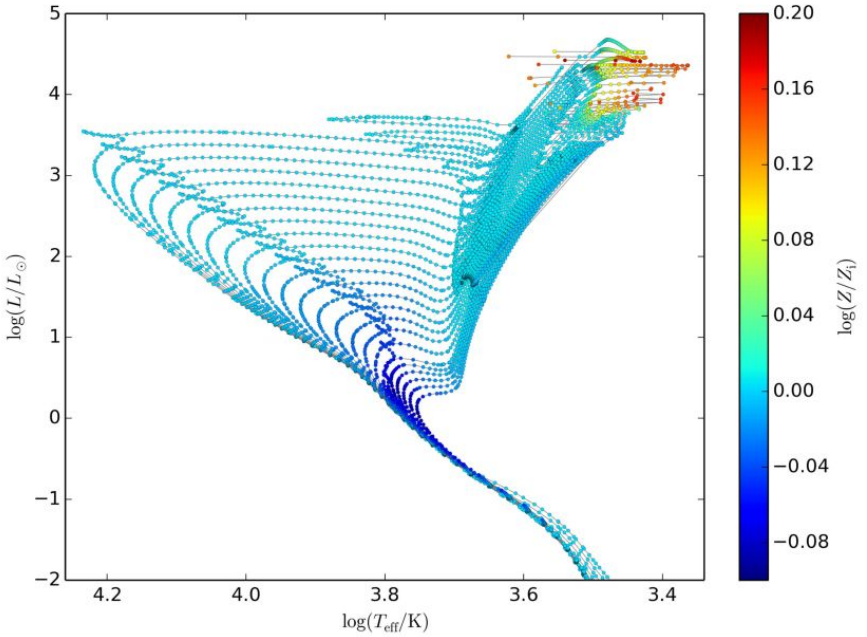
The PARSEC-COLIBRI database

BCs are primarily to complement **PARSEC-COLIBRI isochrones** -- but can be applied to any set of models:

- Masses between 0.1 and 350 Msun
- Metallicities between -2.3 and +0.4 dex
- C and N-rich models for TP-AGB stars -- with circumstellar dust and numbers calibrated on data! (Pastorelli+19+20)

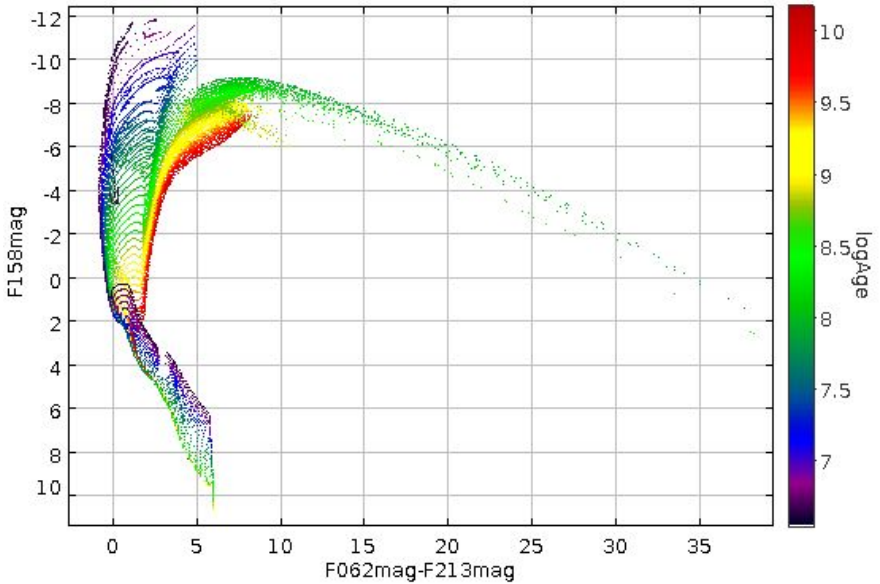
Some extensions not completely released, or not organized enough:

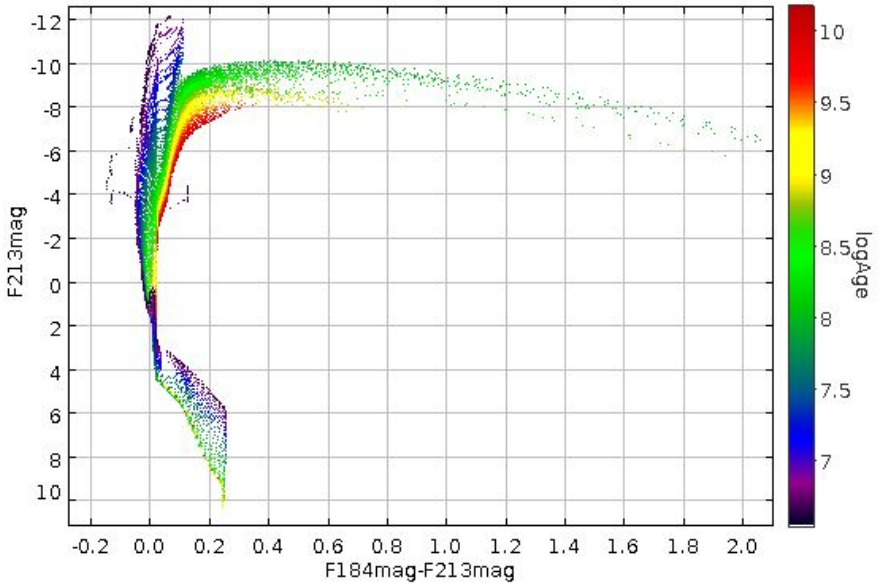
- White dwarfs, interacting binaries (Dal Tio+21)
- Fast-rotating stars (Costa+19ab, Girardi+20,Thanh+21)



Marigo+17

Isochrones in Roman system (Vegamag)

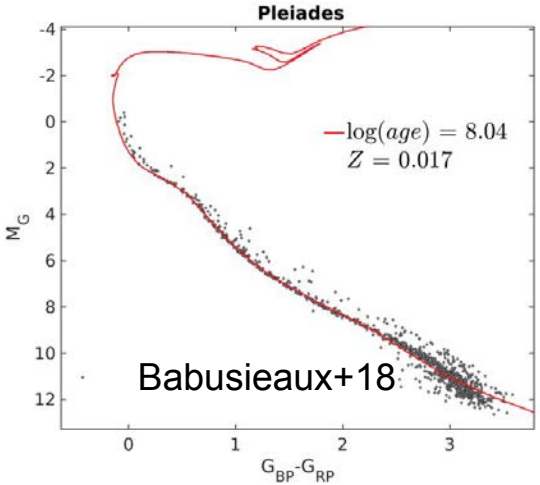




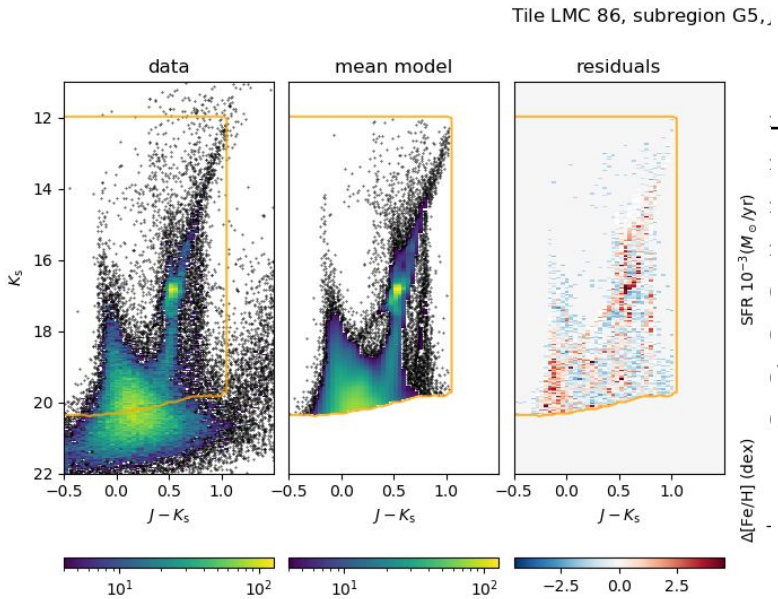
Easily retrievable from http://stev.oapd.inaf.it/cmd

The PARSEC-COLIBRI database

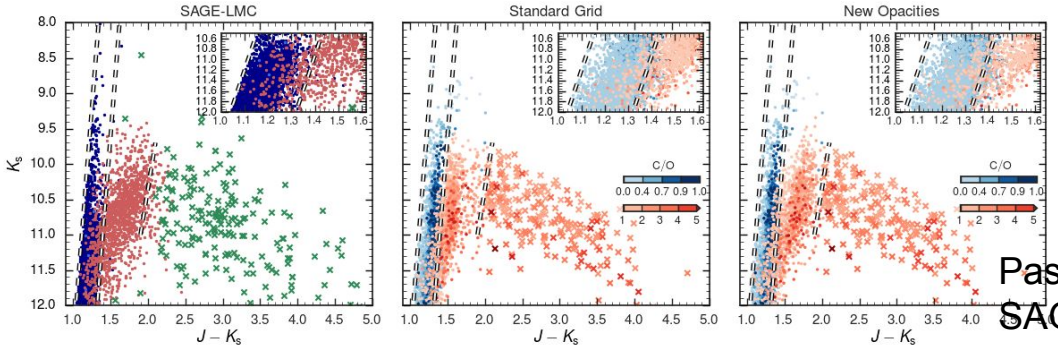
Isochrones (and their predicted star counts) being constantly tested/improved with multiband data of LG galaxies



Babusieaux+18



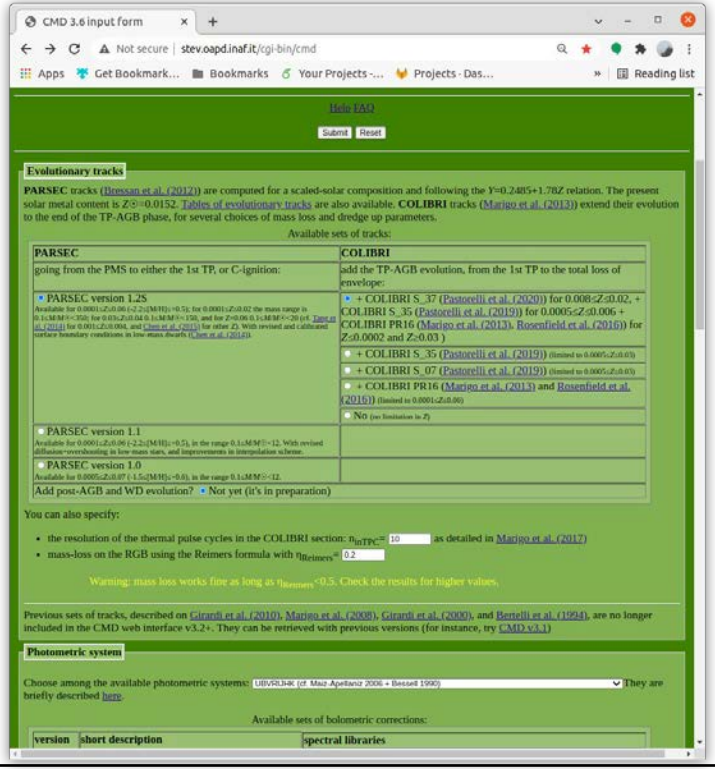
Mazzi+21
VISTA LMC data



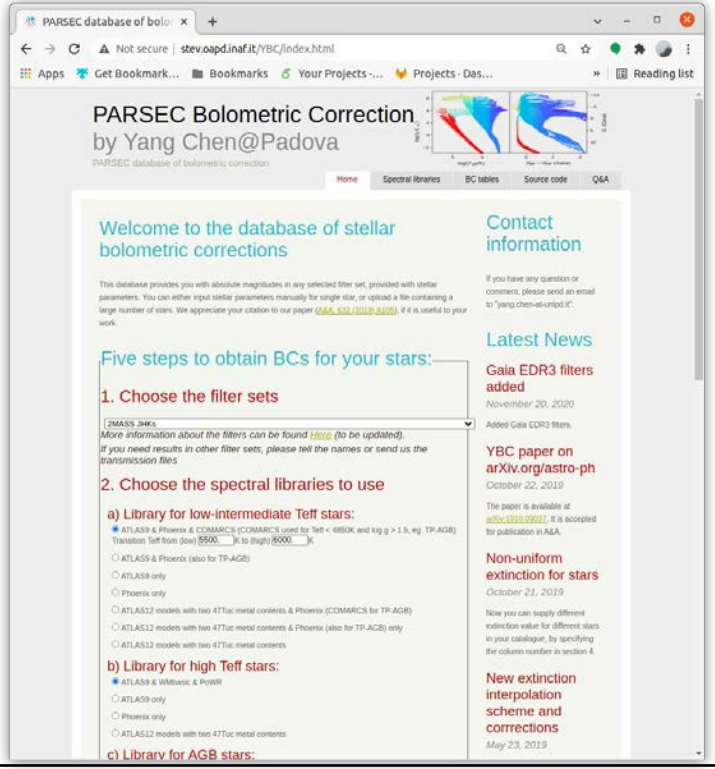
Pastorelli+20
SAGE LMC

Web interfaces

http://stev.oapd.inaf.it/cmd - isochrones in >40 systems

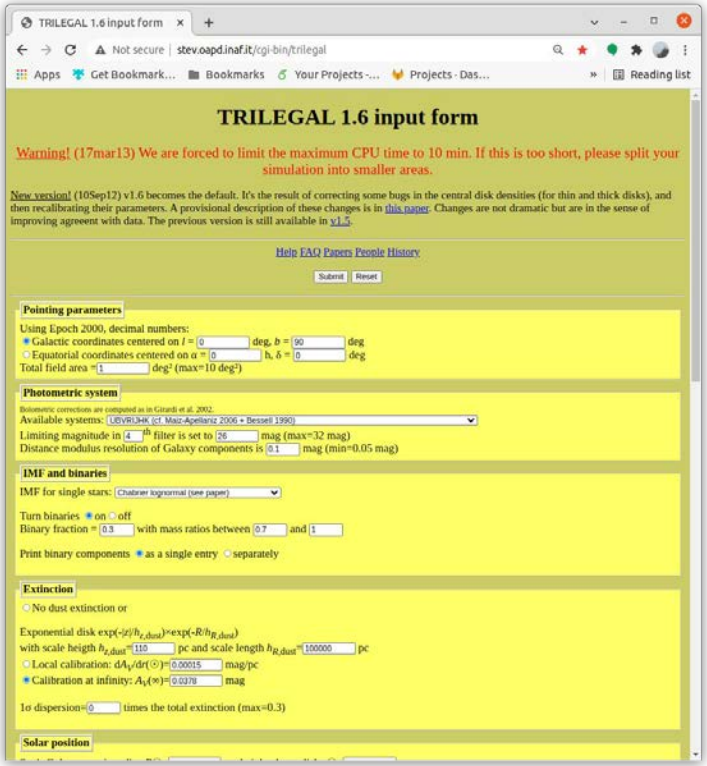


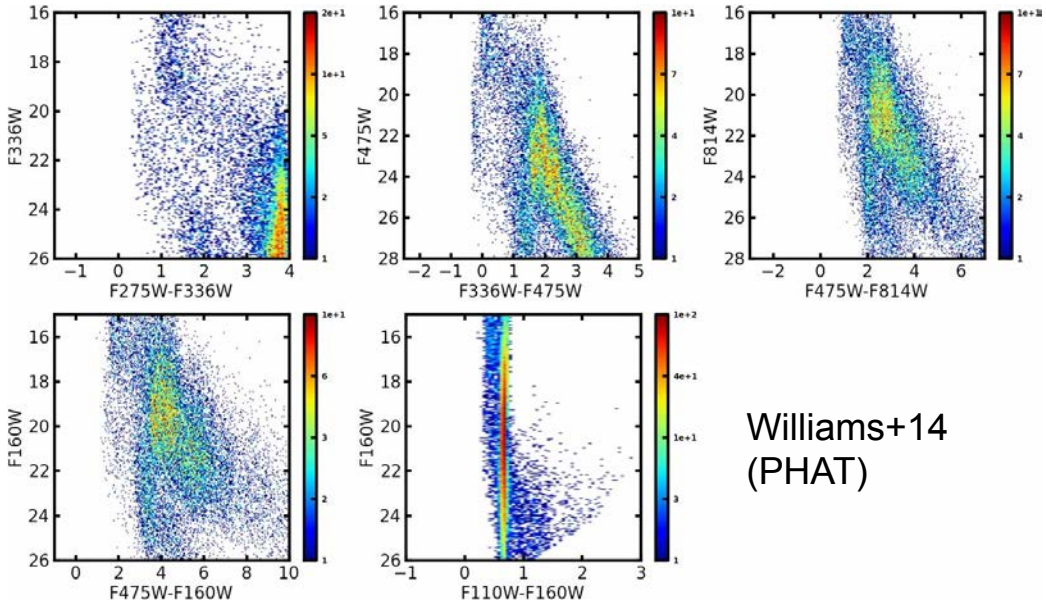
http://stev.oapd.inaf.it/YBC - BC tables



TRILEGAL model for MW foreground

http://stev.oapd.inaf.it/trilegal - expected MW population



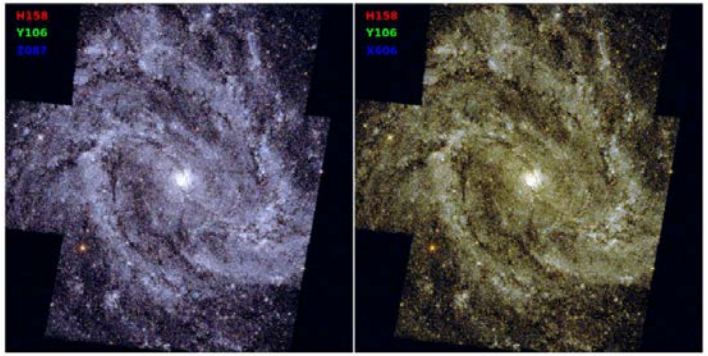


Williams+14 (PHAT)

Summary

Tools to model stars in Roman filters + any other photometric system

- BCs and isochrones are publicly available
- Used by WINGS to simulate nearby galaxies with STIPS
- Implemented in MATCH -- CMD-fitting software to derive SFHs



Quality depends on adopted spectral libraries -- but we are keeping the best ones!

Ongoing extensions: Non-scaled solar composition, dusty AGBs, rapidly-rotating stars, LPV light curves, limb darkening for transits, etc...