Calibration of new surface brightness colour relations

Romina Ibañez Bustos, Denis Mourard, Nicolas Nardetto,
the *ISSP team* (https://lagrange.oca.eu/fr/team-erc-issp) and
co-I from the *SPICA Science Team* (https://lagrange.oca.eu/fr/spica-team)

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Why perform a new calibration of the SBC relation?

CHARA/SPICA ISSP Project

S01: Exoplanet host stars

S02 & **S03:** Asteroseismic stars

S04: Surface brightness - color relation (SBCR)

S05: Limb darkening

S06: Binaries

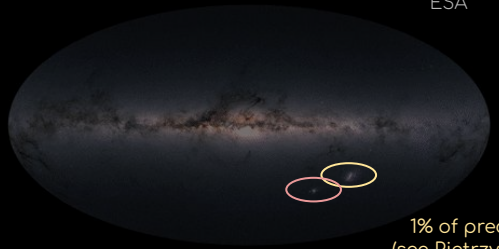
S07: Rotation

S08: Winds & environments

Why perform a new calibration of the SBC relation?

CHARA/SPICA ISSP Project S04: Surface brightness - color relation (SBCR)

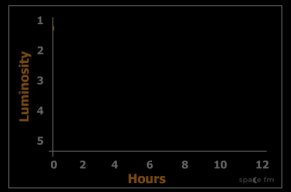
Image credit:
ESA



1% of precision for the LMC
(see Pietrzynski et al. 2013, 2019).

2% of precision for the SMC
(see Graczyk et al. 2020).

Image credit:
SPACE



See Nardetto et al. 2023.

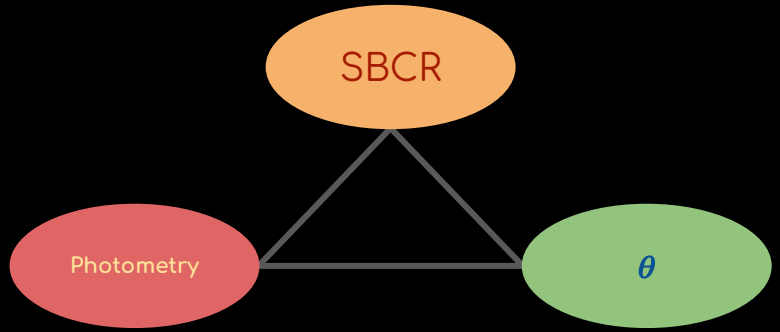
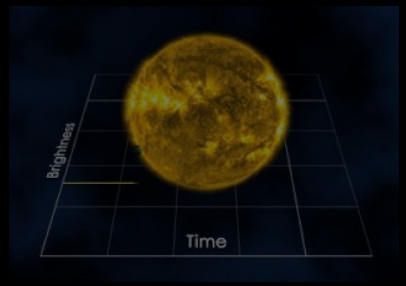


Image credit:
NASA - TESS



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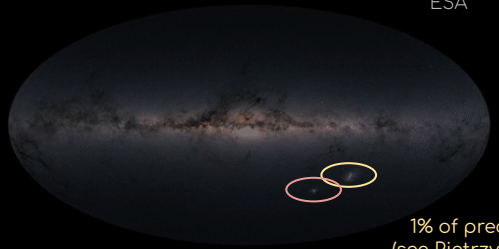

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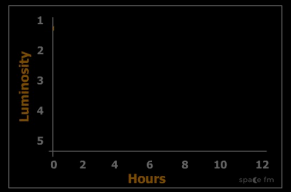

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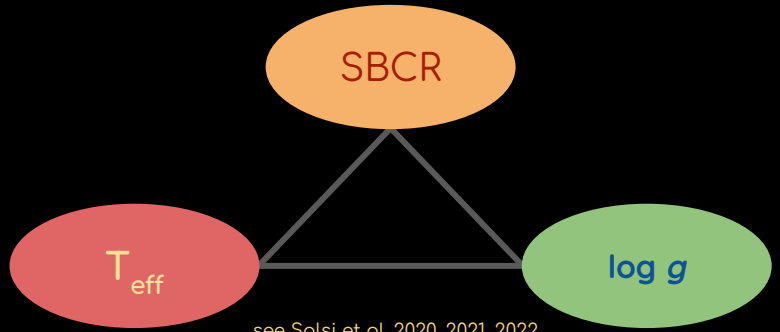
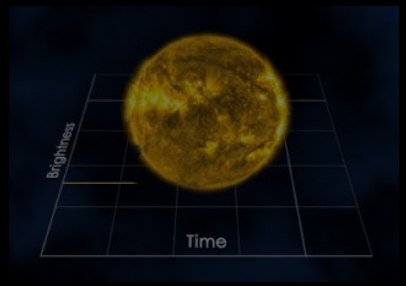


see Salsi et al. 2020, 2021, 2022.

Image credit:
NASA - TESS



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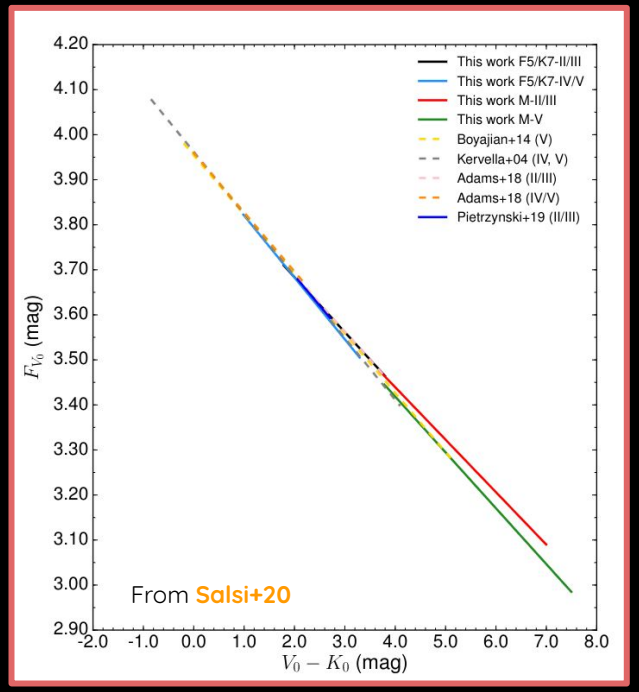
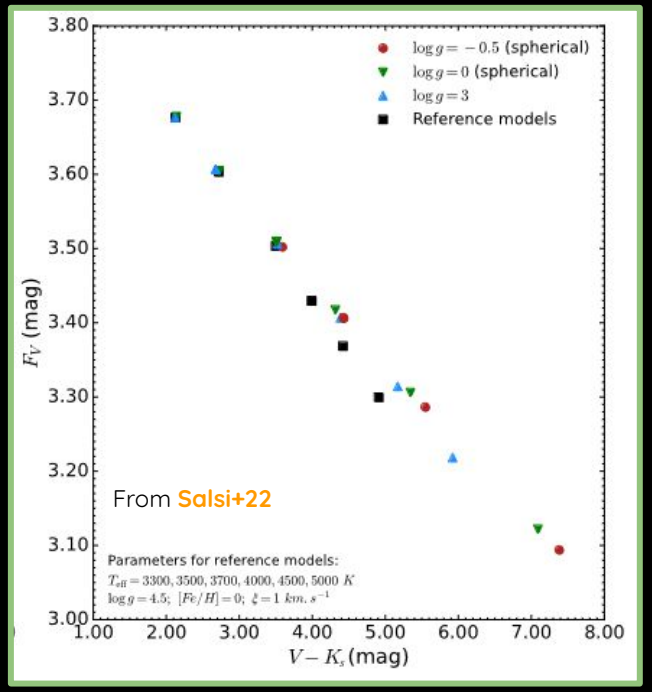
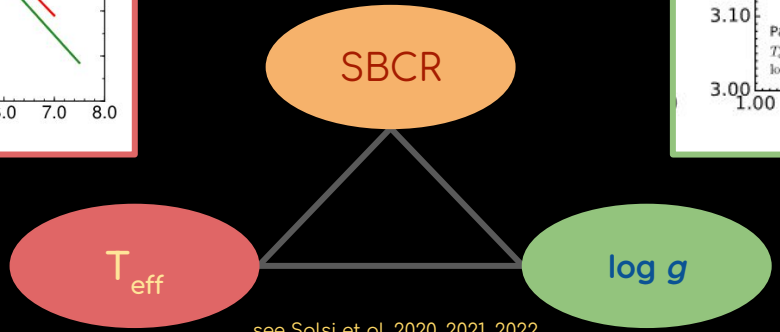
Why perform a new calibration of the SBC relation?







see Salsi et al. 2020, 2021, 2022.

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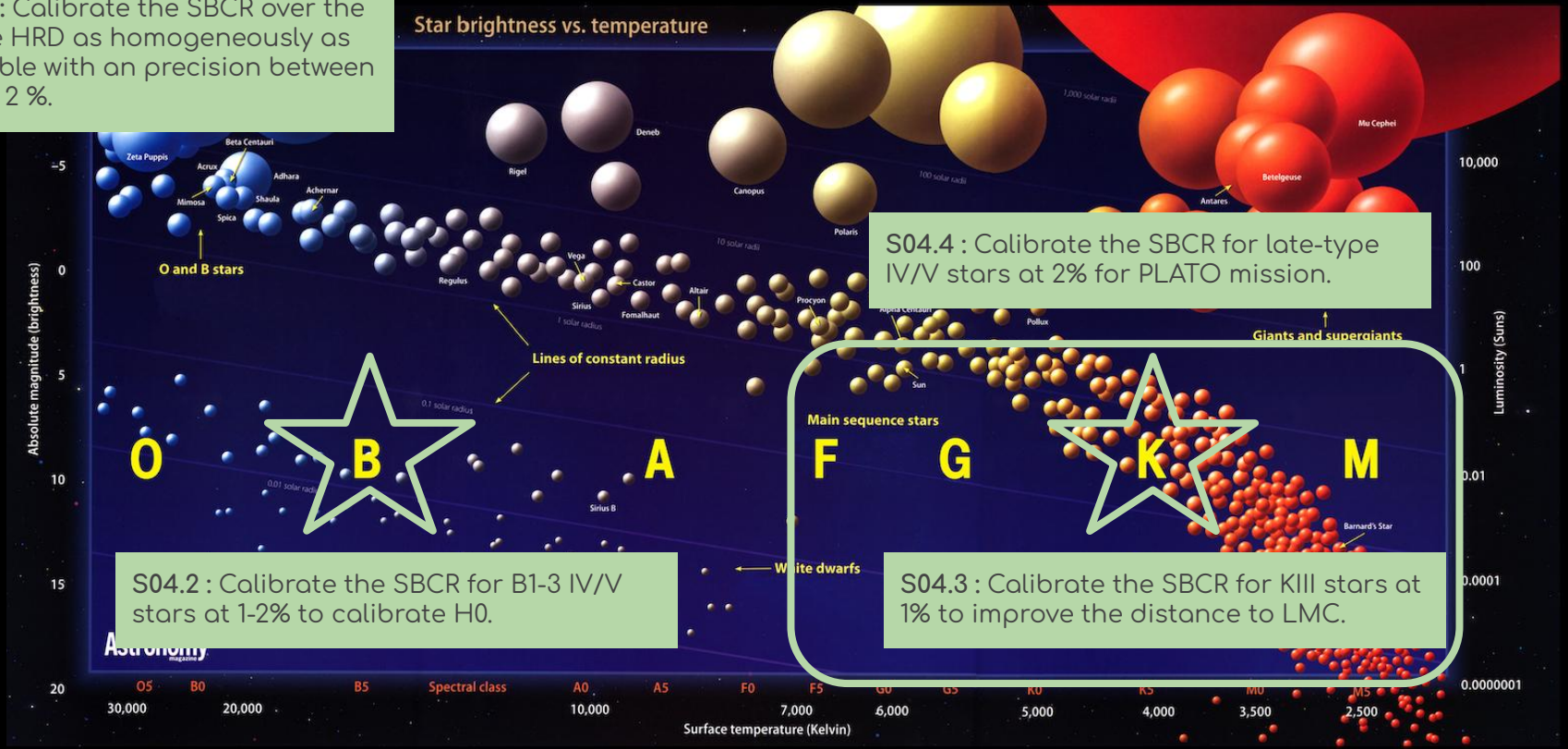
Main goals...

S04.1 : Calibrate the SBCR over the whole HRD as homogeneously as possible with an precision between 1 and 2 %.



S04.4 : Calibrate the SBCR for late-type IV/V stars at 2% for PLATO mission.

S04.2 : Calibrate the SBCR for B1-3 IV/V stars at 1-2% to calibrate H0.

S04.3 : Calibrate the SBCR for KIII stars at 1% to improve the distance to LMC.

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The sample...

Following the ideas and concepts from Salsi et al. (2020, 2021)...

stars with very low activity level over all the HRD

JSDC: flag = 0

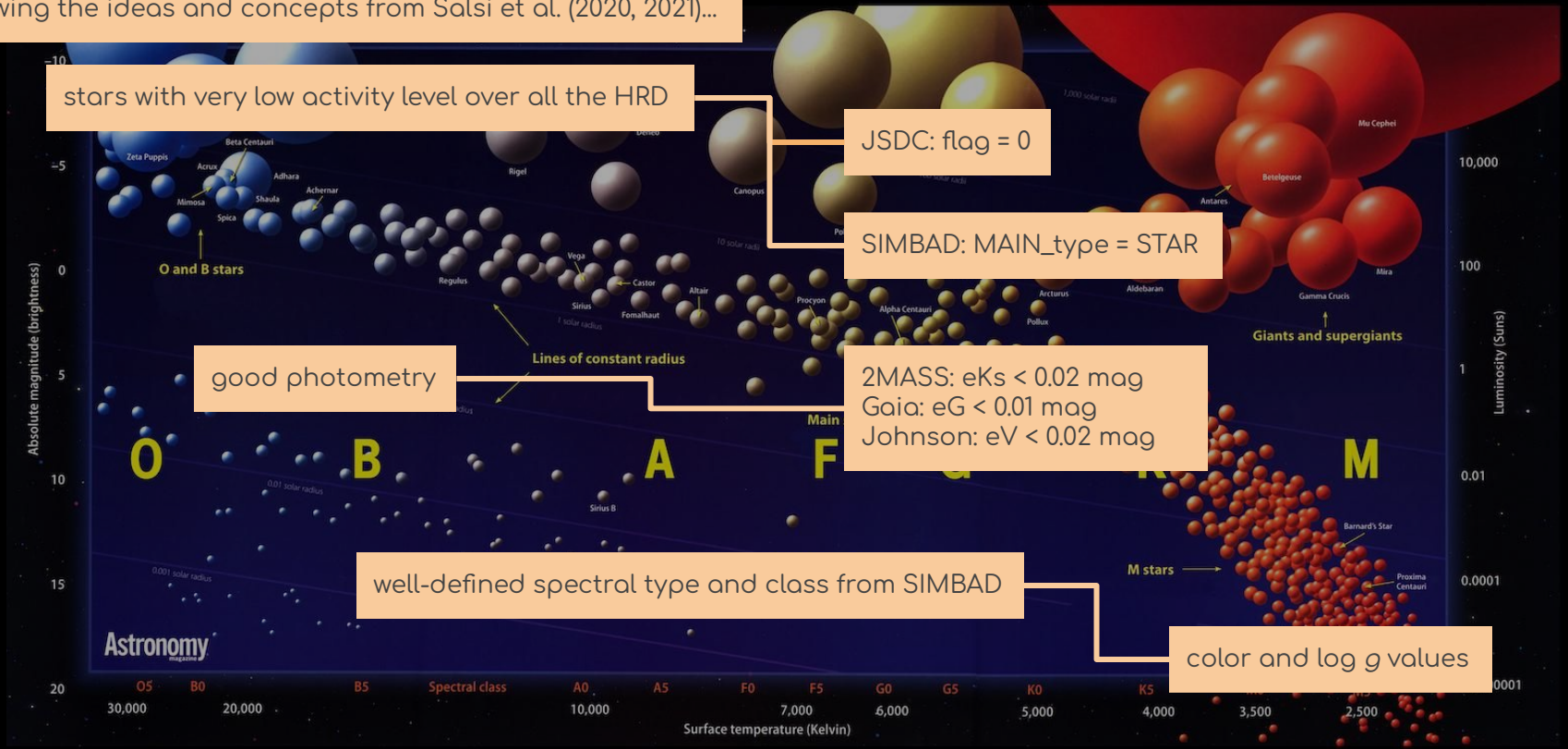
SIMBAD: MAIN_type = STAR

good photometry

2MASS: eKs < 0.02 mag
Gaia: eG < 0.01 mag
Johnson: eV < 0.02 mag

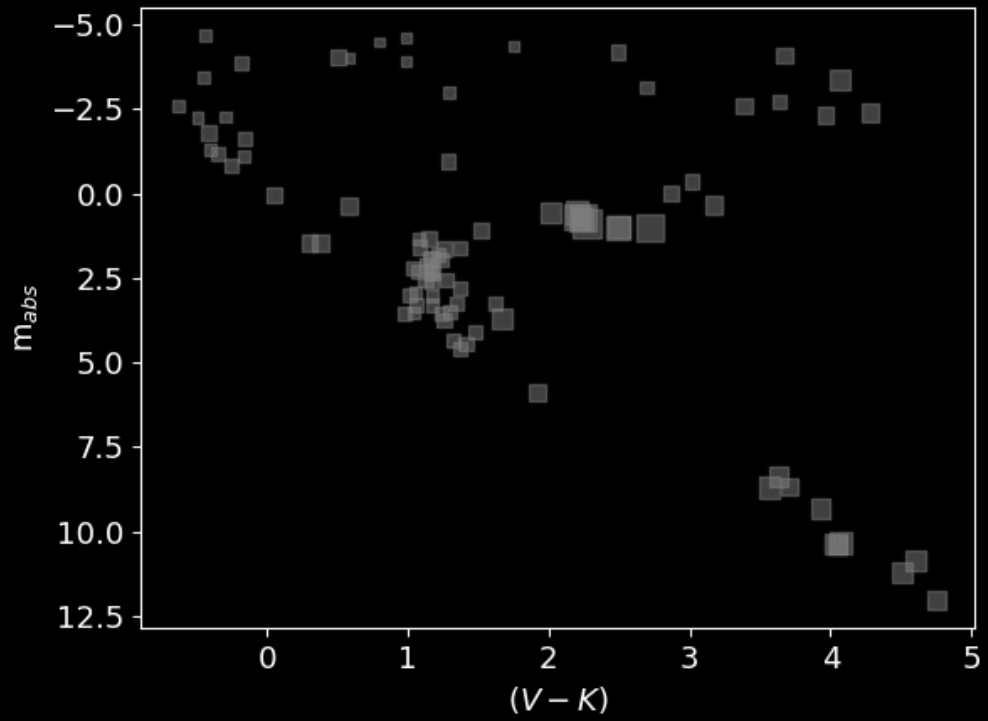
well-defined spectral type and class from SIMBAD

color and log *g* values



The sample...

868 stars with *SpT* = [B0 - M3] and *SpC* = [V, IV, >III]



P0

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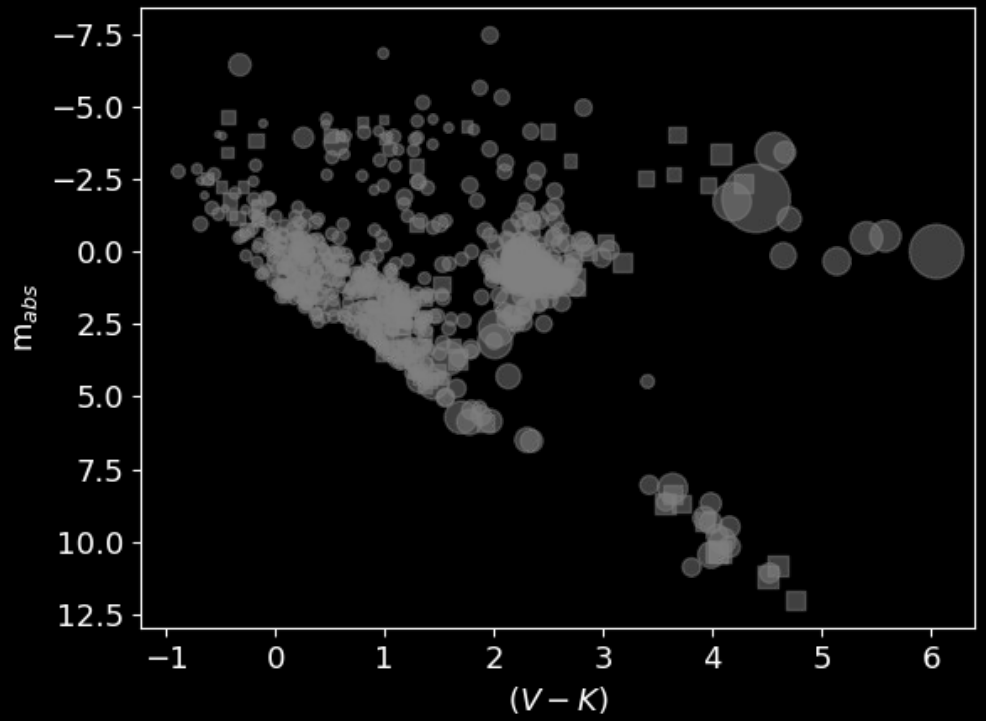

P0

P1

The sample...

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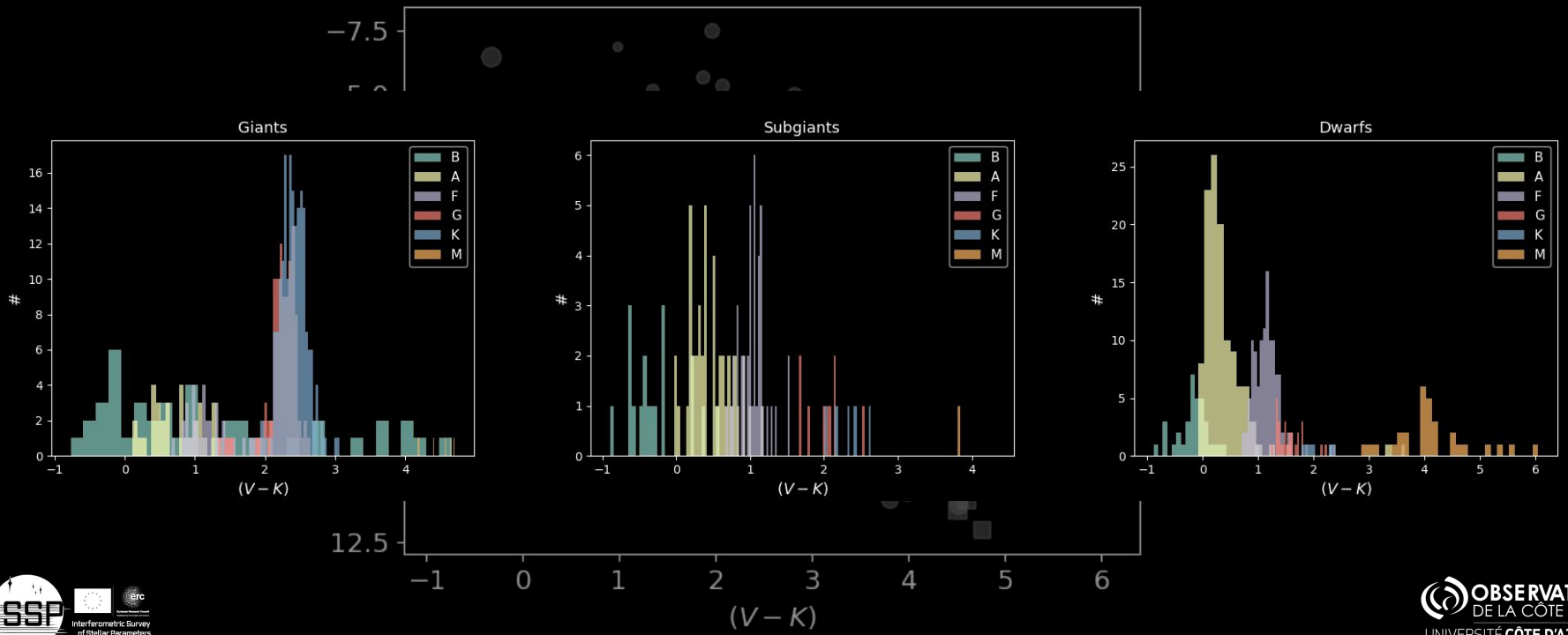
324 stars to be observed in the next semesters



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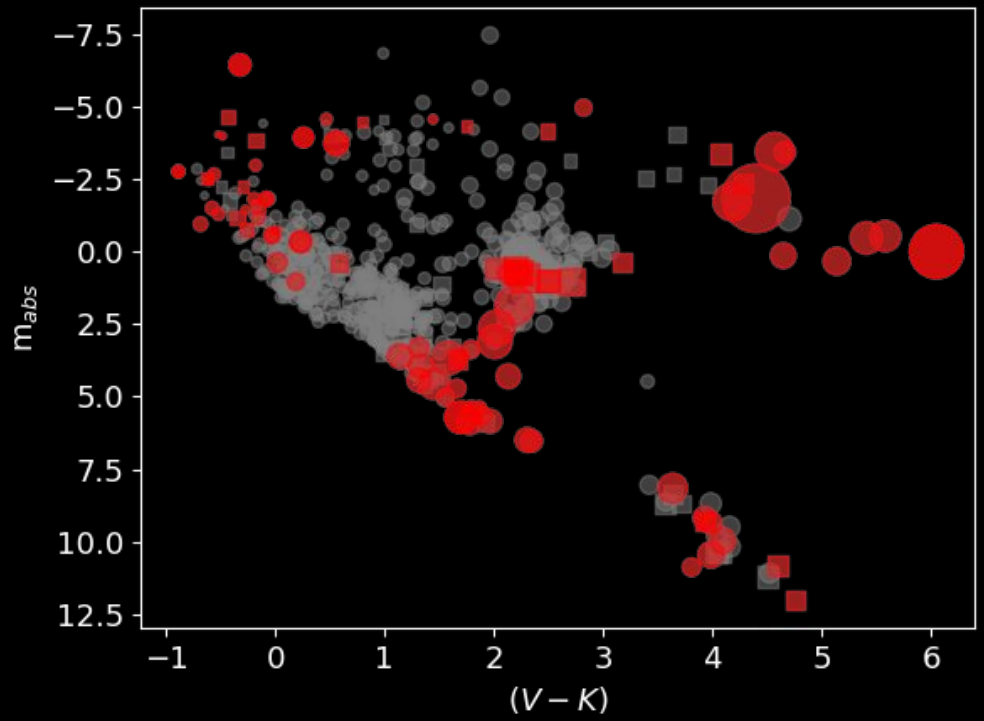

P0

P1

eKs > 0.02; eG > 0.01

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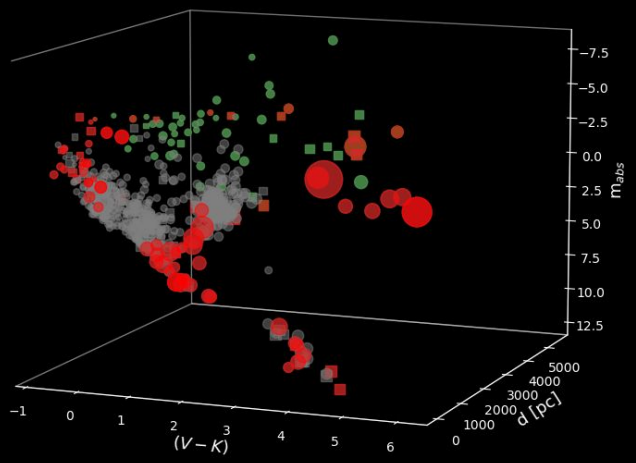

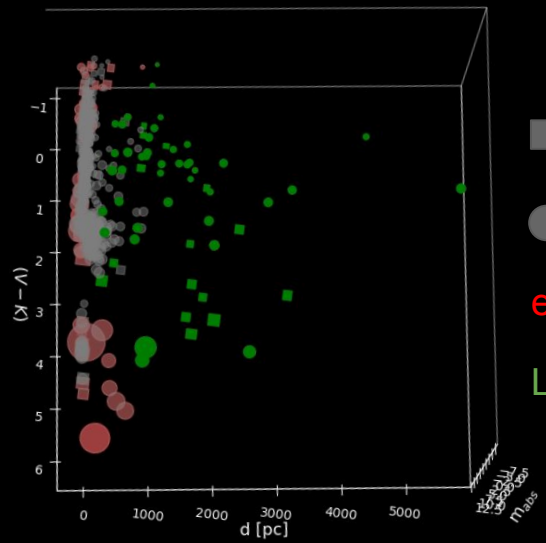

P0

P1

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Limitation in d

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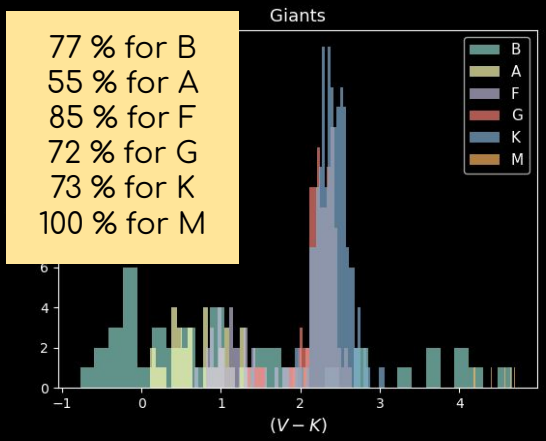
How to proceed?

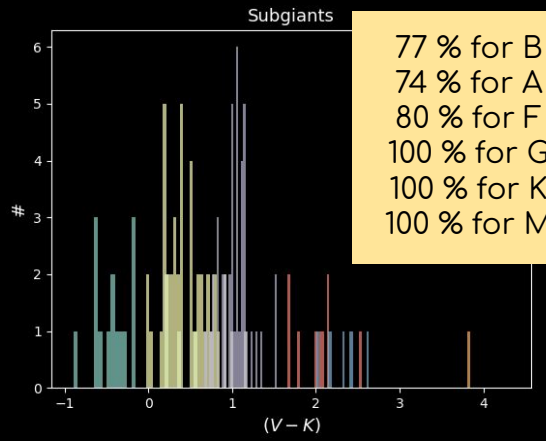
868 stars with *SpT* = [B0 - M3] and *SpC* = [V, IV, >III]

324 stars to be observed in the next semesters

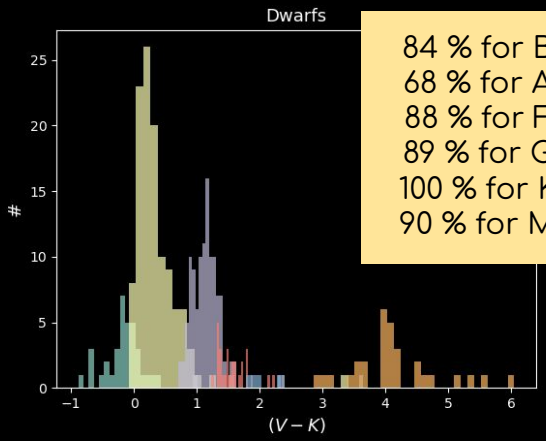
At least 1 spectrum...

77 % for B
55 % for A
85 % for F
72 % for G
73 % for K
100 % for M





77 % for B
74 % for A
80 % for F
100 % for G
100 % for K
100 % for M



84 % for B
68 % for A
88 % for F
89 % for G
100 % for K
90 % for M

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324 stars to be observed in the next semesters

At least 1 spectrum...

target_main_id	HARPS	HARPS_SNR	FEROS	FEROS_SNR	SOPHIE_SNR	ELODIE	ELODIE_SNR
* tet Leo	46	[61.9, 177.1021739130435, 294.3]	10	[45.4, 70.02, 85	[21.7839, 252.64102571428572, 375.]	15	[42.2, 211.77999999999994, 489.]
HD 175726	144	[35.6, 172.25833333333333, 399.1]	14	[104.7, 141.3, 1	[14.2645, 128.03236176470588, 182.]	1	[121.8, 121.8, 121.8]
* 14 Eri	18	[10.1, 139.34444444444443, 424.2]	1	[314.1, 314.1, 3	[43.9422, 121.16357272727272, 172.]	0	0
HD 112974	0	[0, 0, 0]	0	[0, 0, 0]	[28.9376, 47.78242424242424, 74.38]	0	0
HD 115810	0	[0, 0, 0]	0	[0, 0, 0]	[14.333, 133.9949606060606, 214.53]	0	0
* 35 Vul	0	[0, 0, 0]	10	[185.6, 235.630	[106.723, 257.6153870967742, 364.8]	0	0
HD 130396	36	[76.9, 134.46388888888887, 189.8]	53	[69.1, 192.8622	[44.9363, 53.20540000000001, 100.3]	1	[74.5, 74.5, 74.5]
HD 173740	0	[0, 0, 0]	0	[0, 0, 0]	[42.8365, 69.73016666666668, 95.34]	2	[21.5, 63.2, 104.9]
HD 169925	0	[0, 0, 0]	0	[0, 0, 0]	[6.21494, 52.33227724137932, 82.33]	4	[20.8, 71.32499999999999, 100.6]
* iot Per	0	[0, 0, 0]	0	[0, 0, 0]	[224.16, 306.385928571428856, 367.9]	1	[184.7, 184.7, 184.7]
* b03 Cyg	0	[0, 0, 0]	0	[0, 0, 0]	[186.162, 248.44044000000002, 285.]	11	[94.6, 186.7909090909091, 323.9]
* 107 Psc	0	[0, 0, 0]	4	[81.3, 102.7250	[4.0942, 26.013507727272724, 99.37]	10	[36.3, 106.84, 186.3]
* zet Per	0	[0, 0, 0]	0	[0, 0, 0]	[191.088, 532.8485555555557, 743.6]	14	[82.6, 200.56428571428572, 378.]
* eps Mon B	410	[0.8, 202.00292682926832, 262.3]	2	[95.5, 98.15, 10	[44.777, 58.8459294117647, 90.992]	1	[318.8, 318.8, 318.8]
* 54 Psc	1	[90.9, 90.9, 90.9]	0	[0, 0, 0]	[72.1409, 209.89986875, 294.882]	3	[52.7, 97.63333333333333, 136.1]
HD 37510	84	[5.1, 327.94999999999993, 604.9]	38	[2.9, 123.94736	[3.77868, 62.499791428571143, 103.0]	0	0
HD 28343	13	[20.6, 57.130769230769225, 158.8]	11	[6.0, 28.863636	[50.799, 97.35816153846153, 126.58]	8	[42.6, 61.5375, 135.2]
* tau Cet	9341	[0.1, 235.25783106733755, 586.6]	578	[2.8, 201.61141	[263.874, 280.18424999999996, 331.]	2	[10.3, 43.449999999999996, 76.6]
HD 28620	0	[0, 0, 0]	0	[0, 0, 0]	[45.523, 93.41914444444444, 122.40]	0	0
HD 43947	1	[105.9, 105.9, 105.9]	7	[61.0, 107.5, 37	[93.3335, 190.07861111111112, 265.]	14	[47.7, 91.57142857142857, 139.0]
* 21 Lyn	0	[0, 0, 0]	0	[0, 0, 0]	[22.2766, 305.97962222222225, 393.]	6	[134.3, 274.75, 437.0]
HD 187637	0	[0, 0, 0]	0	[0, 0, 0]	[39.023, 51.806511111111112, 71.772]	0	0
HD 199305	0	[0, 0, 0]	0	[0, 0, 0]	[52.7645, 93.35434444444445, 113.9]	5	[60.2, 71.32000000000001, 81.3]
HD 216899	140	[21.3, 58.97428571428571, 96.3]	5	[31.3, 42.38, 52	[44.9792, 109.62473333333332, 147.]	6	[30.0, 52.76666666666666, 65.9]
HD 72660	92	[10.6, 81.875, 241.8]	8	[1.6, 90.6875, 3	[89.7129, 148.56827142857145, 184.]	5	[65.5, 186.98, 299.9]
HD 76349	0	[0, 0, 0]	0	[0, 0, 0]	[36.7705, 50.81534285714286, 79.72]	0	0
* b Vir	96	[38.2, 90.40729166666667, 185.4]	0	[0, 0, 0]	[52.2236, 169.81861666666668, 288.]	2	[51.9, 141.2, 230.5]
* psi Ser	164	[49.8, 137.30243902439022, 303.5]	69	[5.2, 141.36956	[32.2117, 64.98586666666668, 132.2]	4	[54.8, 138.975, 179.3]
HD 16160	325	[6.9, 134.84, 366.1]	6	[26.0, 100.1833	[3.80857, 134.544474, 247.278]	2	[92.6, 111.85, 131.1]
HD 84768	0	[0, 0, 0]	2	[52.2, 74.0, 95.	[55.8549, 63.169275, 74.0672]	3	[68.3, 107.0, 130.5]
HD 119850	35	[10.1, 63.58285714285716, 107.7]	51	[9.9, 116.86470	[52.6081, 65.914225, 83.0376]	3	[21.2, 62.466666666666666, 119.6]
HD 19850	79	[19.3, 177.86708860759492, 289.7]	1	[188.9, 188.9, 188.9]	[52.6081, 65.914225, 83.0376]	3	[21.2, 62.466666666666666, 119.6]
HD 90594	6	[141.3, 166.71666666666667, 235.3]	7	[13.2, 89.84285714285714, 338.4]	[41.5908, 58.14165, 68.0976]	1	[52.9, 52.9, 52.9]
HD 28780	0	[0, 0, 0]	0	[0, 0, 0]	[264.178, 293.0743333333333, 331.3]	0	0

Instrument	Resolution $\lambda/\Delta\lambda$	Wavelength coverage (nm)
HARPS	115 000	378 - 691
FEROS	48 000	350 - 920
UVES	80 000 - 110 000	300 - 1100
XSHOOTER	4000 - 17 000	300 - 2500
ESPRESSO	70 000 - 140 000 - 190 000	380 - 788
CRIRES	46 000 - 92 000	950 - 5300
SOPHIE	40 000 - 75 000	387 - 694
ELODIE	42 000	385 - 680

SNR = [min, mean, max]

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How to proceed?

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324 stars to be observed in the next semesters

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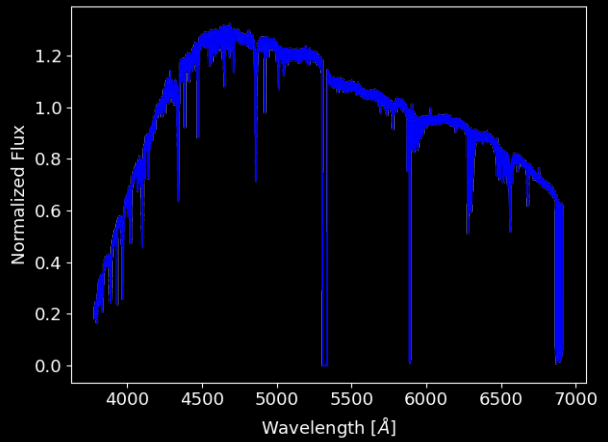
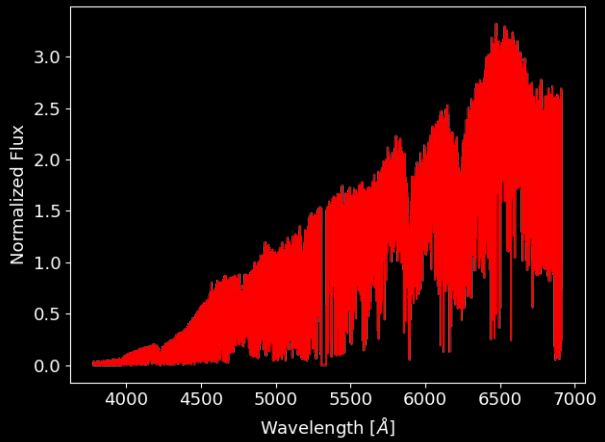
* ome Sco
SpT: B1V



HD 225213
SpT: M2V



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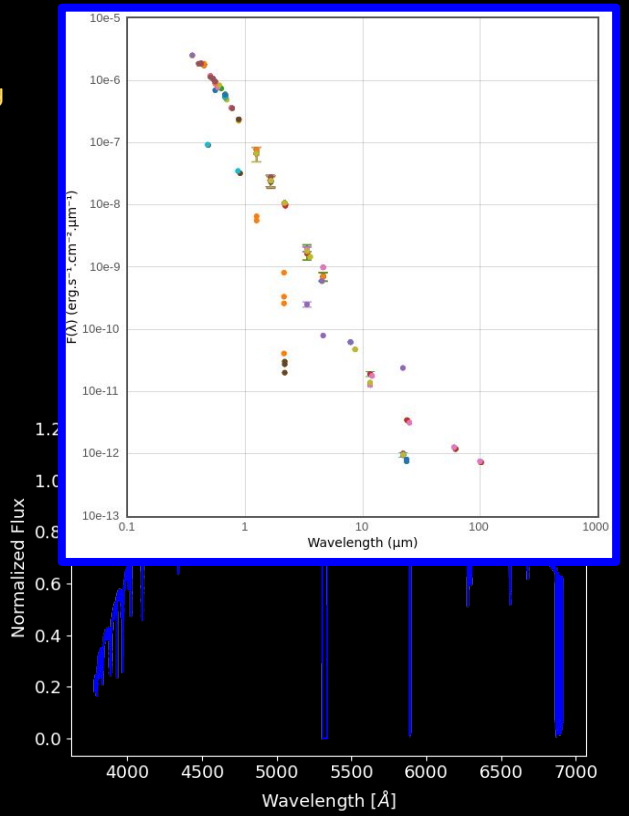
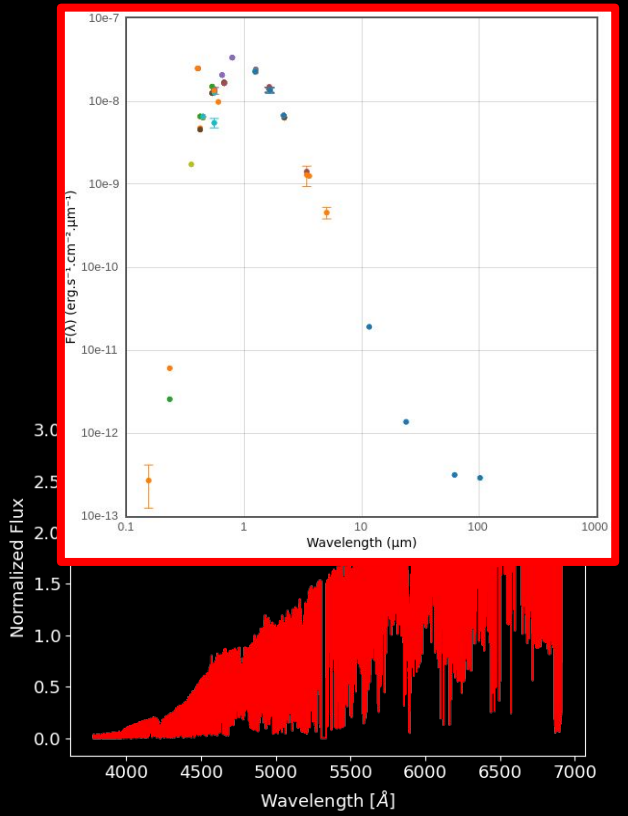
Photometry extracted from VizieR

* ome Sco
SpT: B1V





HD 225213
SpT: M2V

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How to follow the execution of the programme?

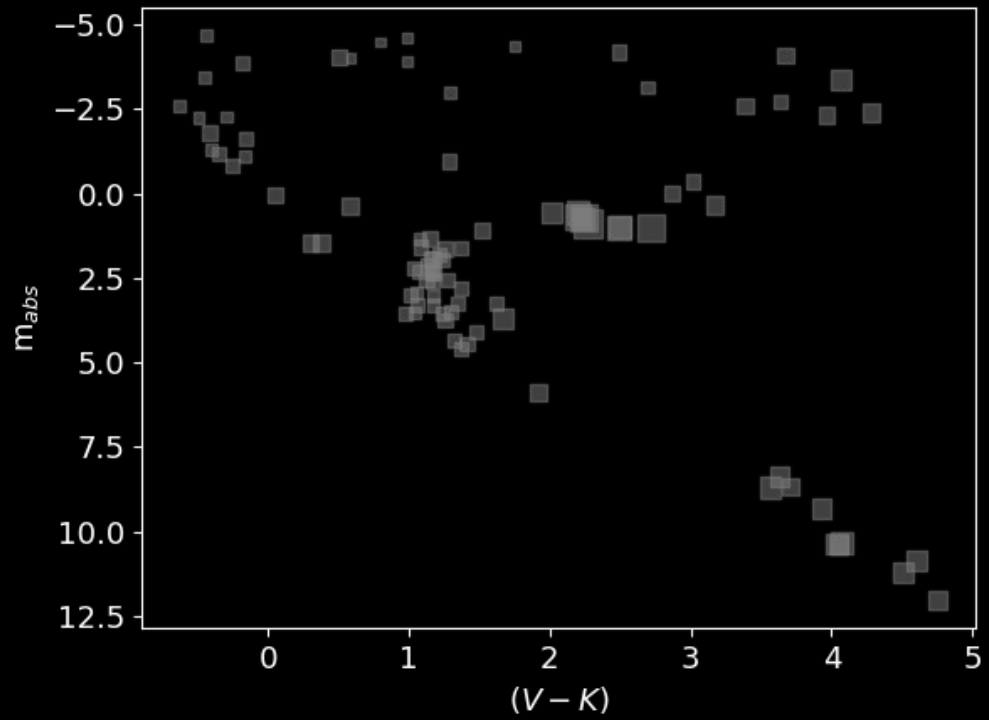
INTERFEROMETRY: θ

$F_V = 4.2207 - 0.1\, m_{V0} - 0.5 \log \theta$

$F_V = \alpha + \beta\,(V - K)$

SBCR calibration:
- For late-type stars based on JMDC and CHARA/VEGA; difference of SBCR between type and classes (Salsi+19).
- For early-type stars based on CHARA/VEGA (Challouf+14, Salsi+21).
- Theoretical study (Salsi+22).

324 stars to be observed in the next semesters



"324" ISSP S04 stars

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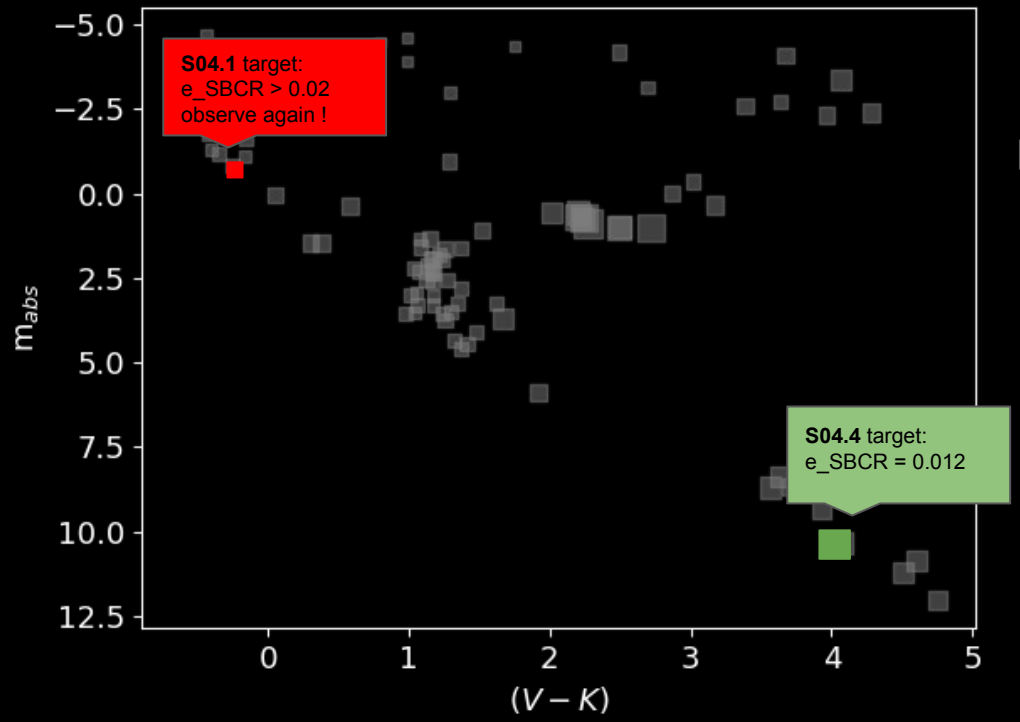
How to follow the execution of the programme?

324 stars to be observed in the next semesters



“324” ISSP S04 stars

ISSP Interferometric Survey of Stellar Parameters

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How to follow the execution of the programme?

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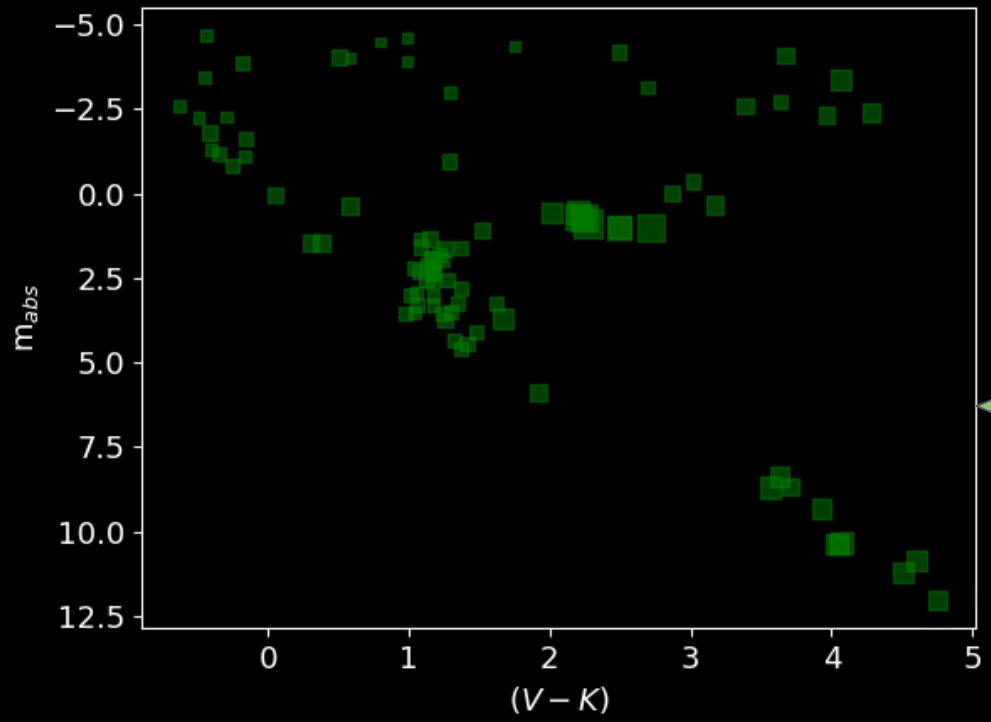

“324” ISSP S04 stars

It’s done !
Ready to publish.

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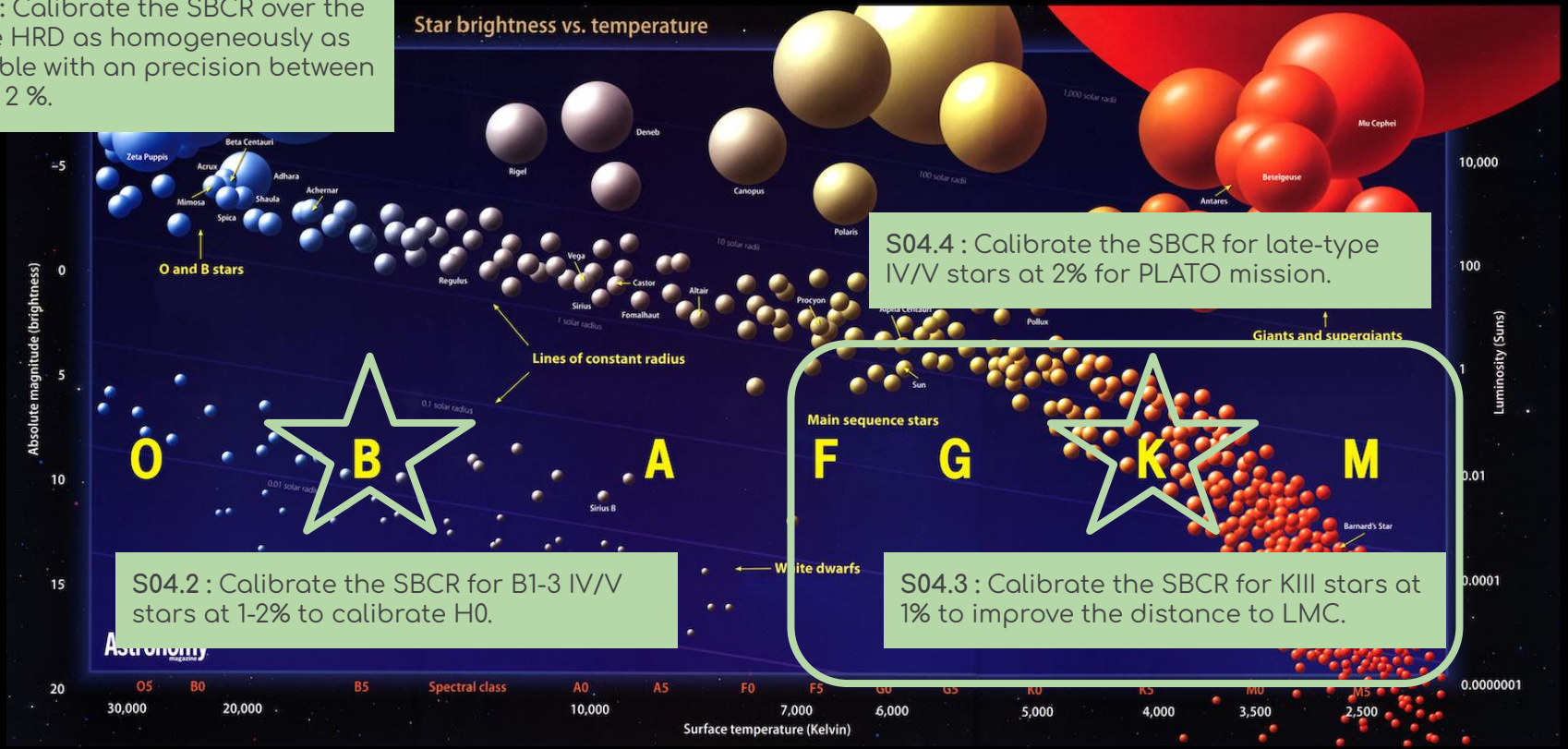
Publications of the results

S04.1 : Calibrate the SBCR over the whole HRD as homogeneously as possible with an precision between 1 and 2 %.



S04.4 : Calibrate the SBCR for late-type IV/V stars at 2% for PLATO mission.

S04.2 : Calibrate the SBCR for B1-3 IV/V stars at 1-2% to calibrate H0.

S04.3 : Calibrate the SBCR for KIII stars at 1% to improve the distance to LMC.

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