OPEN AND GLOBULAR CLUSTERS

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OPEN CLUSTERS science case

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OPEN CLUSTERS science case

Core science cases

1- Formation of open clusters
2- Disruption of open clusters
3- Open cluster as tracers of the MW disc and its chemical evolution
4- Star formation and early stellar evolution
5- Stellar evolution

For all : HR required, R=20000

OPEN CLUSTERS science case

Core science cases

1- Formation of open clusters

Dynamical properties (RV + UVW) as function of age, metallicity, position

Two SF regions : Great Cygnus Rift, Per OB1 with 20+ clusters

2- Disruption of open clusters

3- Open cluster as tracers of the MW disc and its chemical evolution

4- Star formation and early stellar evolution

5- Stellar evolution

OPEN CLUSTERS science case

Core science cases

1- Formation of open clusters

2- Disruption of open clusters

Large sample, different age and Rgc to probe dependencies

Uses same clusters of goals 3, 4

3- Open cluster as tracers of the MW disc and its chemical evolution

4- Star formation and early stellar evolution

5- Stellar evolution

OPEN CLUSTERS science case

Core science cases

1- Formation of open clusters

2- Disruption of open clusters

3- Open cluster as tracers of the MW disc and its chemical evolution

Large sample of clusters at all Rgc, at all [Fe/H], with age>100 Myr

Derive [Fe/H], detailed abundances, combine with homogeneous distances and ages

4- Star formation and early stellar evolution

5- Stellar evolution

OPEN CLUSTERS science case

Core science cases

1- Formation of open clusters

2- Disruption of open clusters

3- Open cluster as tracers of the MW disc and its chemical evolution

4- Star formation and early stellar evolution

Clusters with age < 500 Myr, cool stars to measure [Fe/H], Li, mass accretion rate, chromospheric activity

(see FRASCA)

5- Stellar evolution

OPEN CLUSTERS science case

Core science cases

1- Formation of open clusters

2- Disruption of open clusters

3- Open cluster as tracers of the MW disc and its chemical evolution

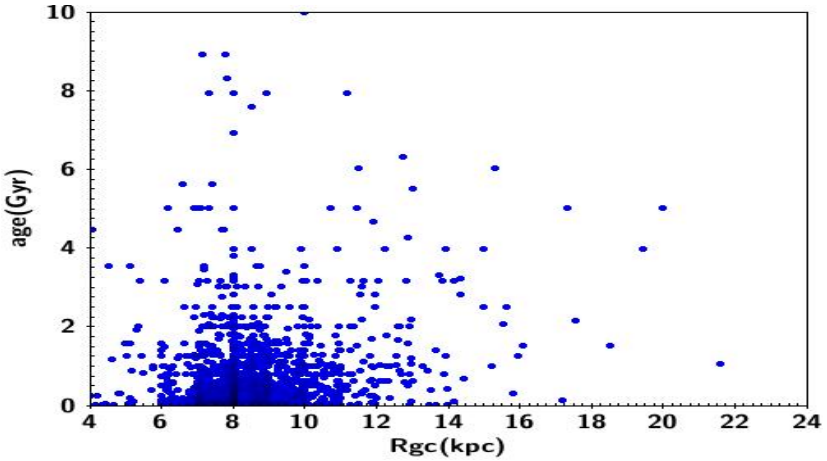
4- Star formation and early stellar evolution

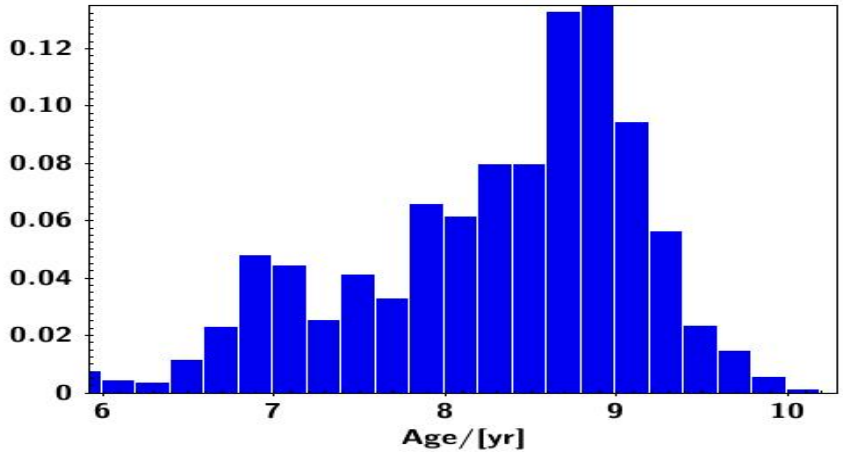
5- Stellar evolution

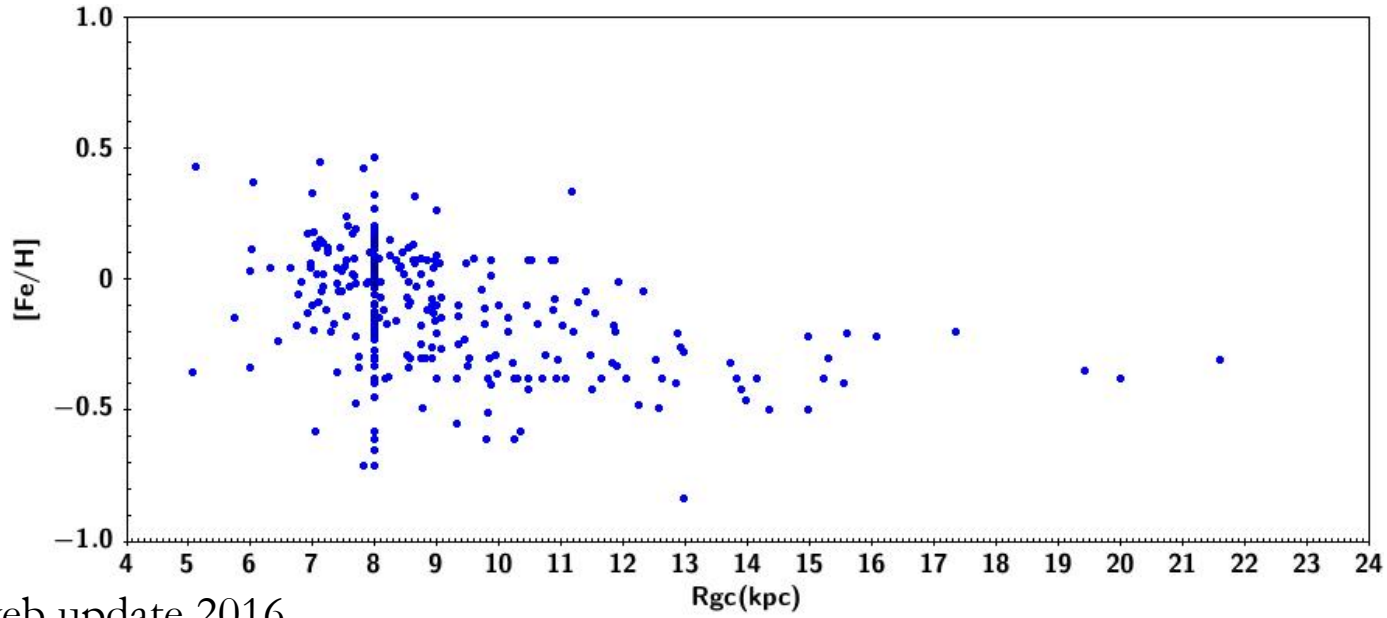
Test stellar evolution models with clusters.

Same target list of goals 3 & 4

OCs and the MW disc

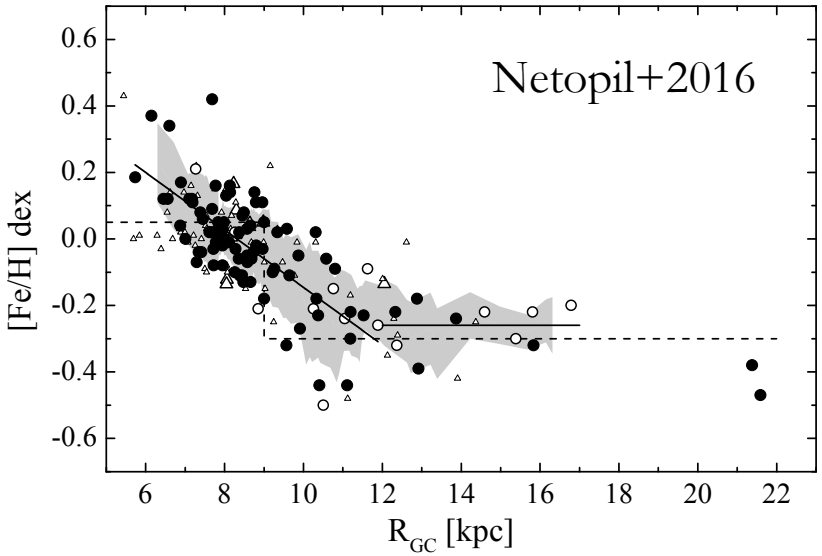


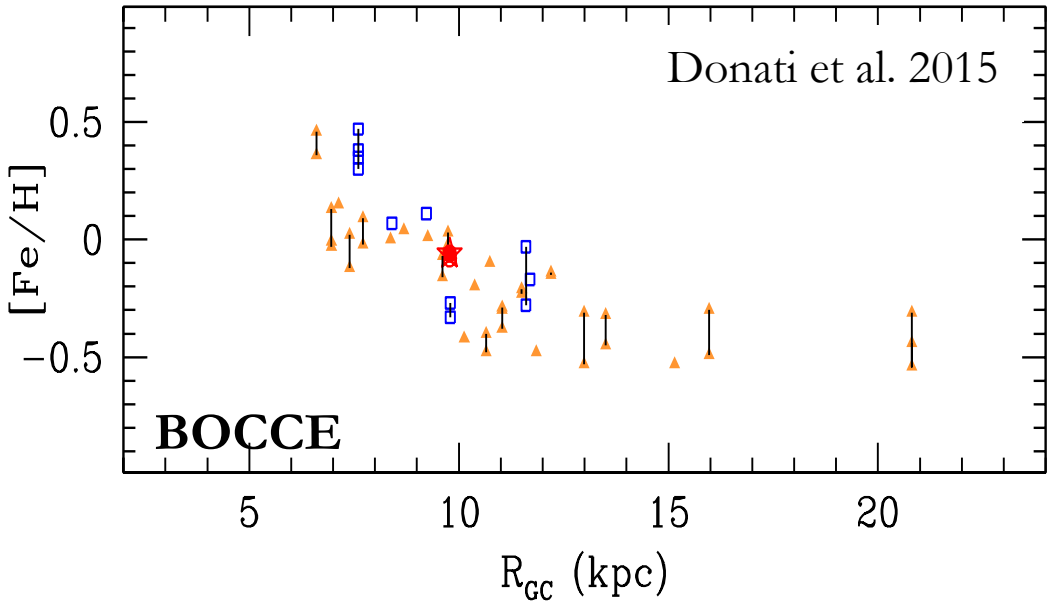


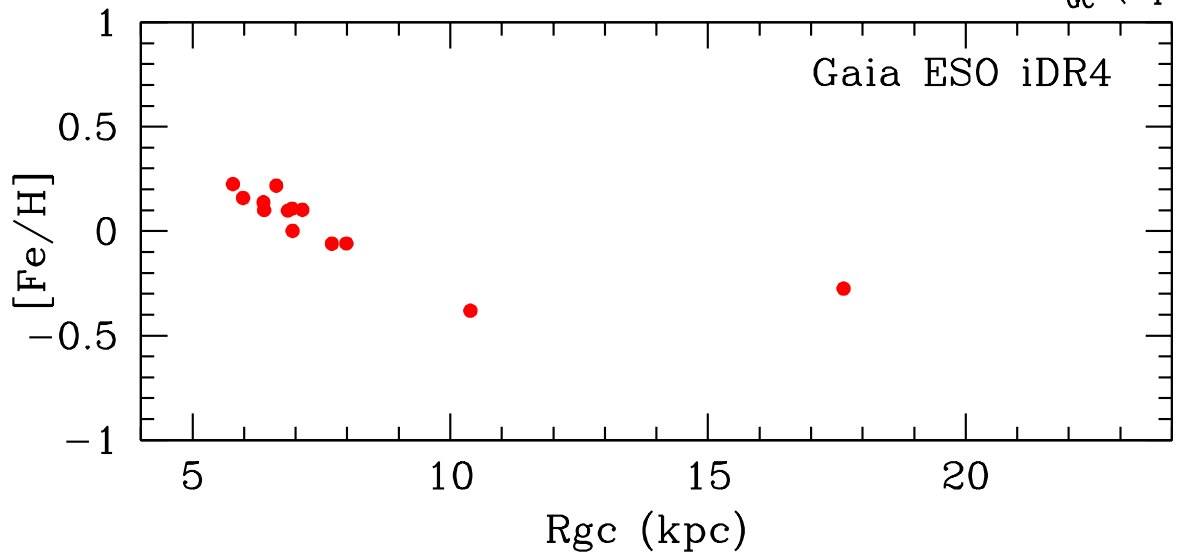


Dias+2002, web update 2016

OCs and the MW disc







OCs and the MW disc

- Age ≥ 3-500 Myr
  - ➔ red clump
- Observe cluster central region & external
- Sample also in |Z|
- Sample as far as Vlim permits
- >10 stars (small) & some×100 (large ang. size)
- Include all possible very old (some Gyr)
- Sample anticentre

Synergy with field disc survey – TBD

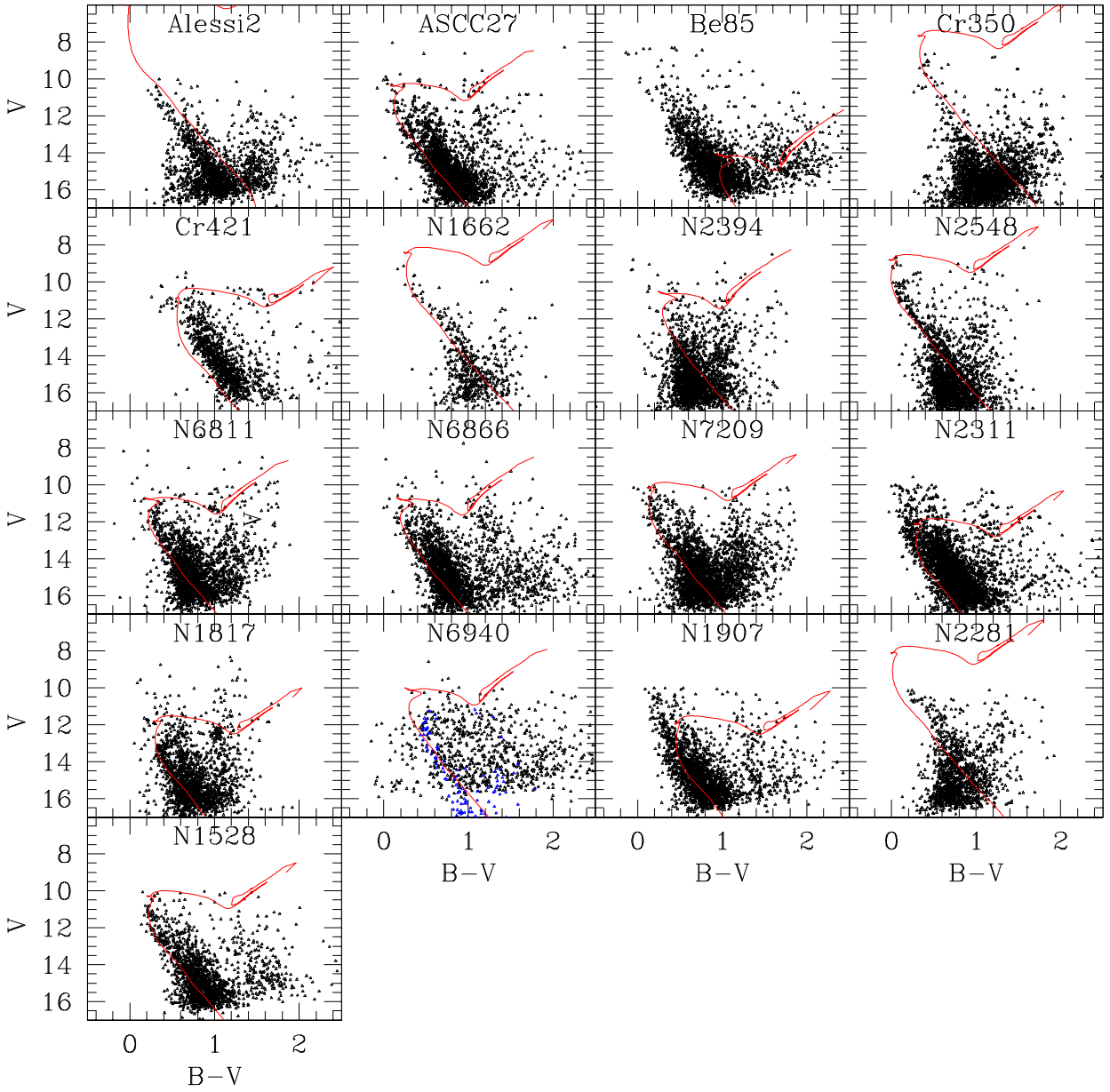
➔ include also small clusters

OCs and the MW disc

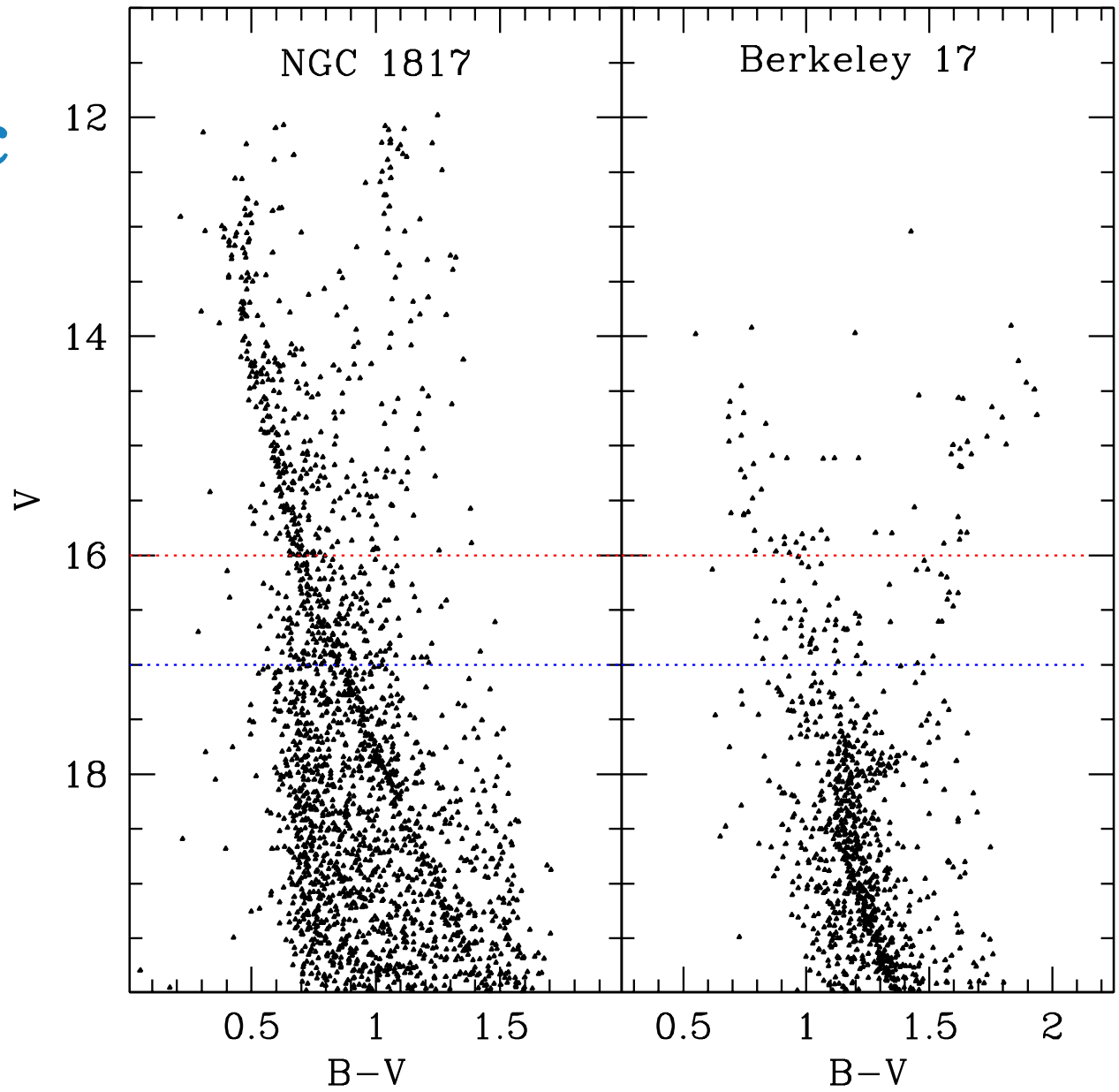
Preliminary selection of
- a- clusters
- b- target stars

Simulation of fibre allocation

Positions, photometry, membership updated with Gaia DR2

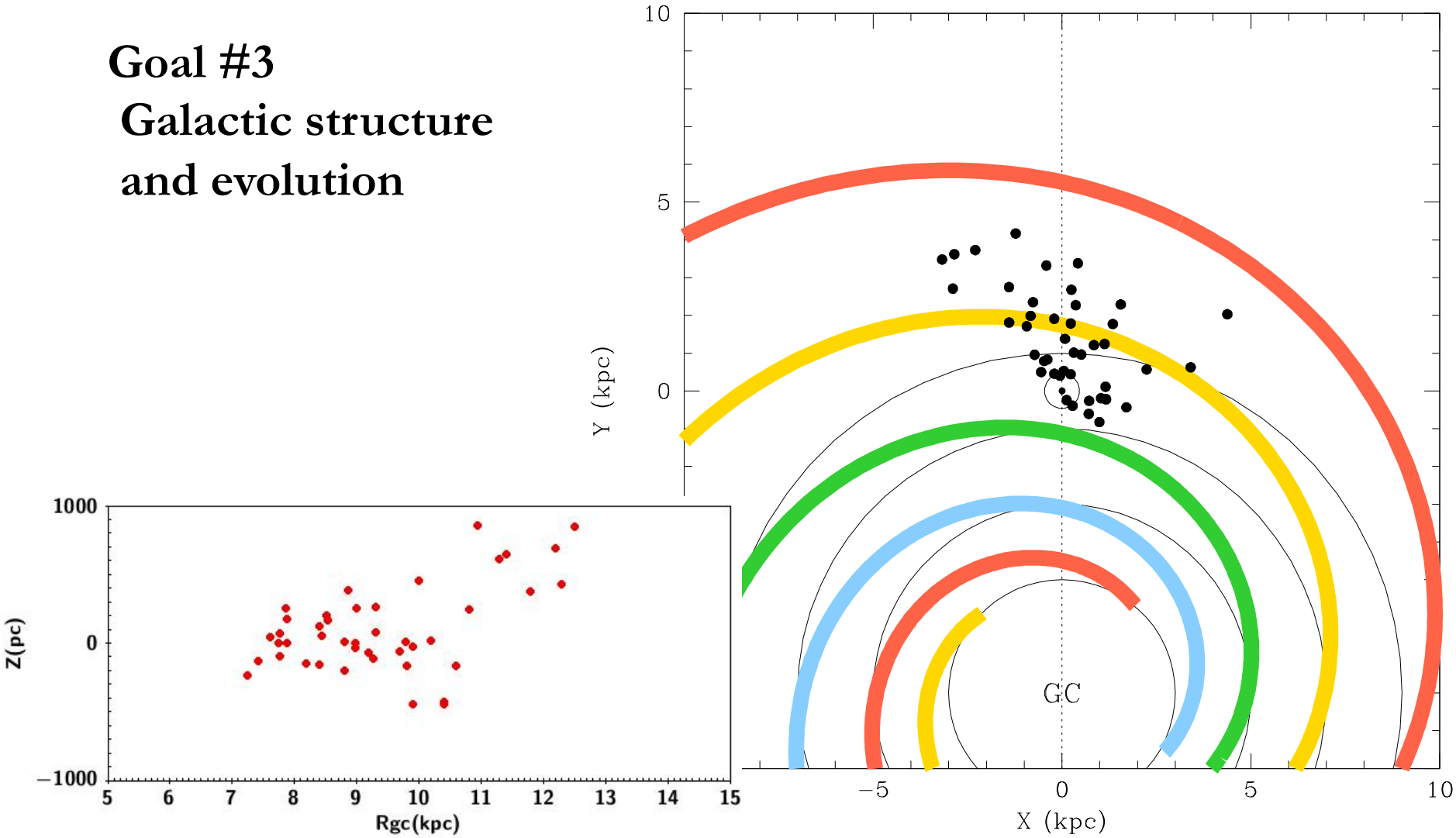


OCs and the MW disc

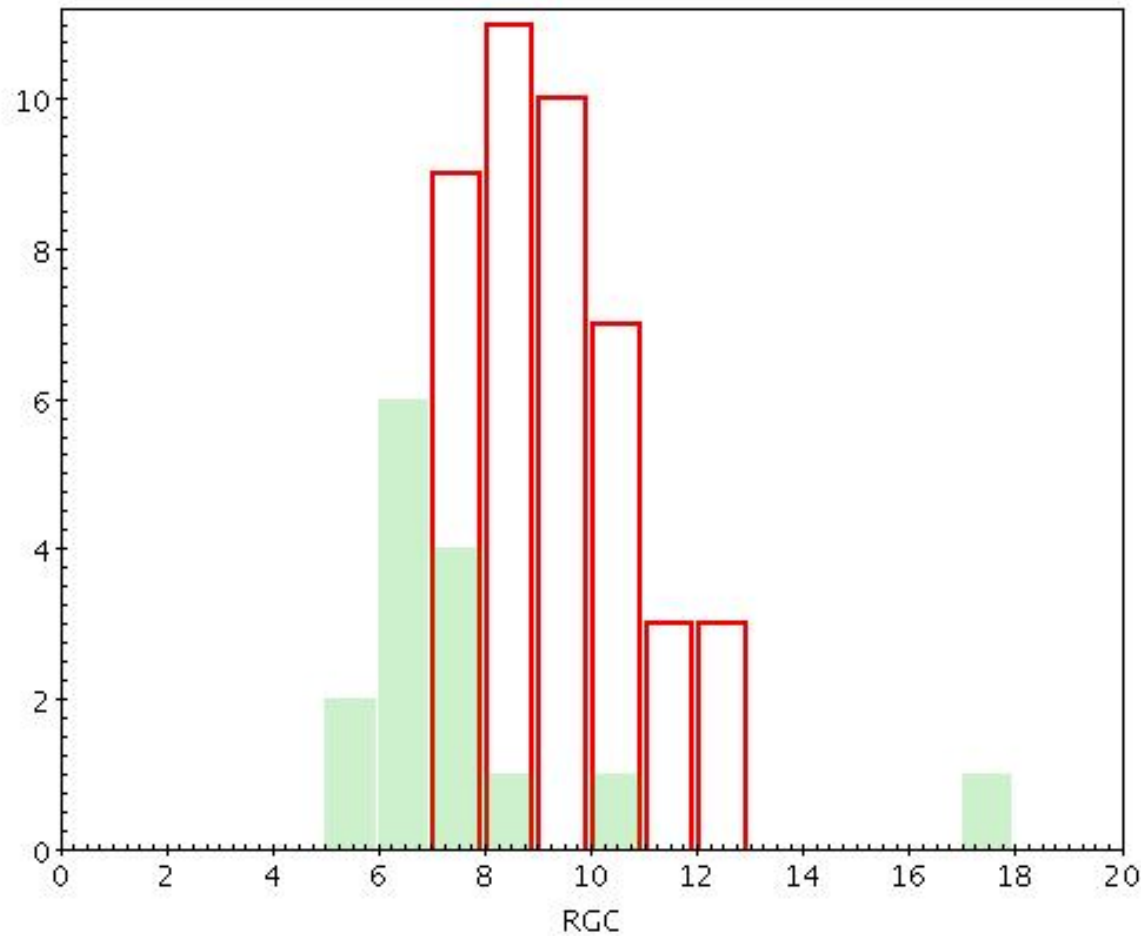


OCs and the MW disc

Goal #3
Galactic structure and evolution

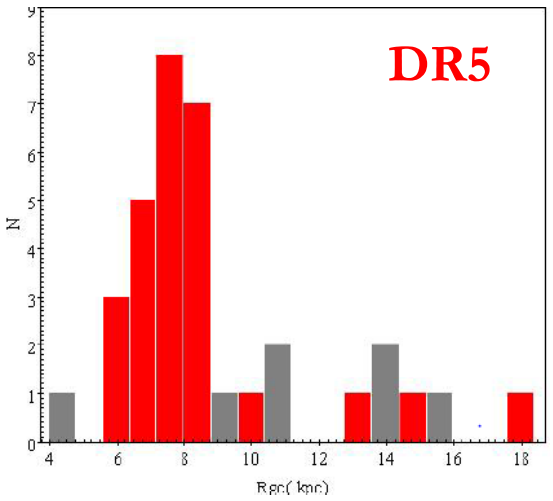


Other surveys - complementarity



Proposed v1.0 WEAVE (goal #3)

Gaia-ESO iDR4

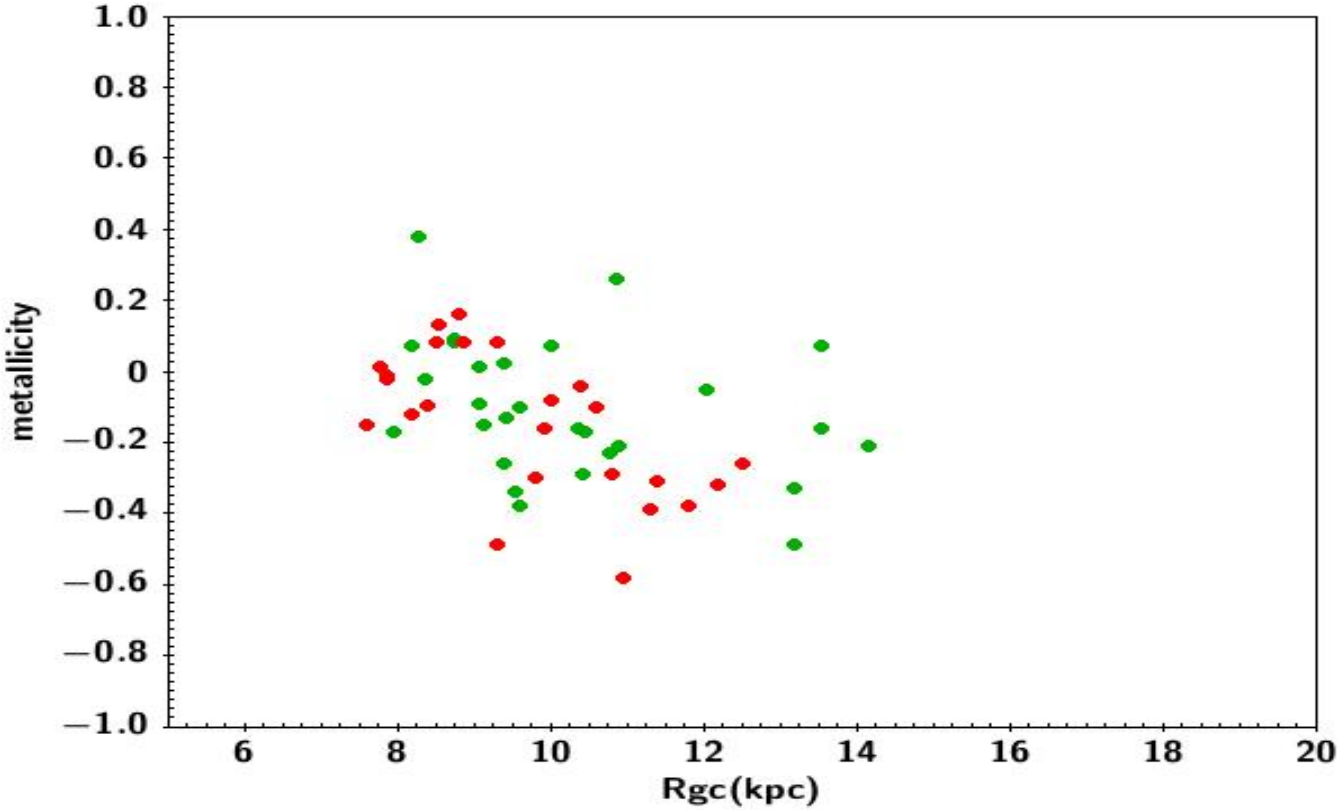


courtesy S. Randich

Other surveys - complementarity

APOGEE- OCCAM
(only giants,
only few stars/cl
no Li
no n-capture?)

WEAVE
Goal #3
(giants/dwarfs
10-100 stars/cl)



Target clusters selection

For each goal : selected list of clusters

- **Essential set**
- **Optimal set**
- **Ideal set**

plus calibrators

WL regions : blue arm: 473 - 545 nm

red arm: 595 - 685 nm

Exposure times : 3x1hr : SNR>70 in red arm

Target clusters selection

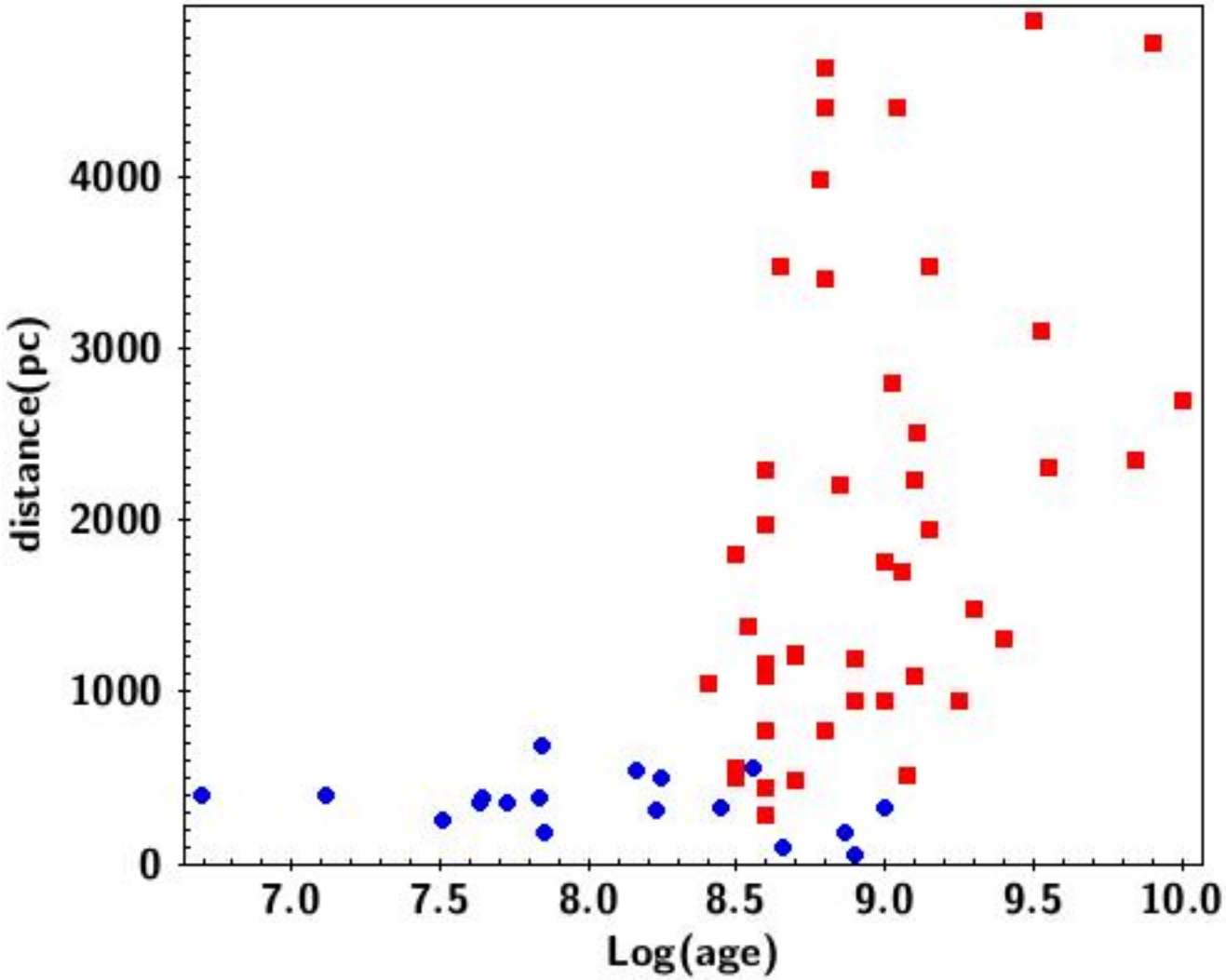
Goals

#3

Gal. Structure

#4

early cl. evol.



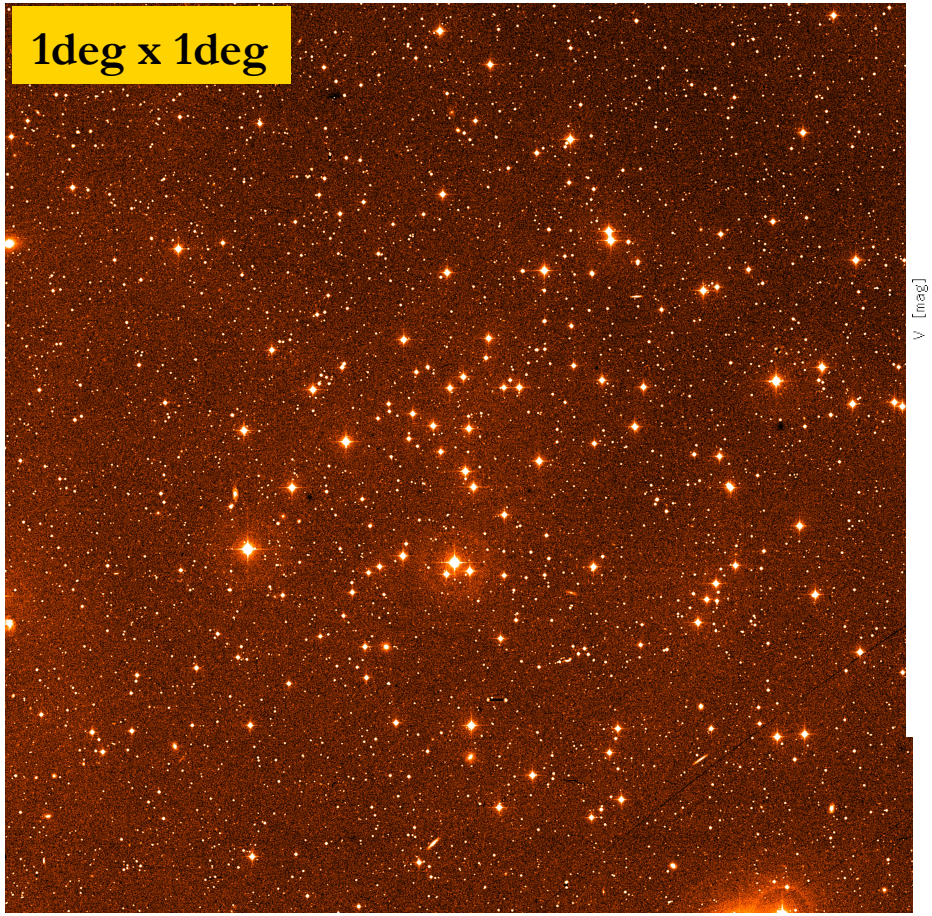
Target stars allocation

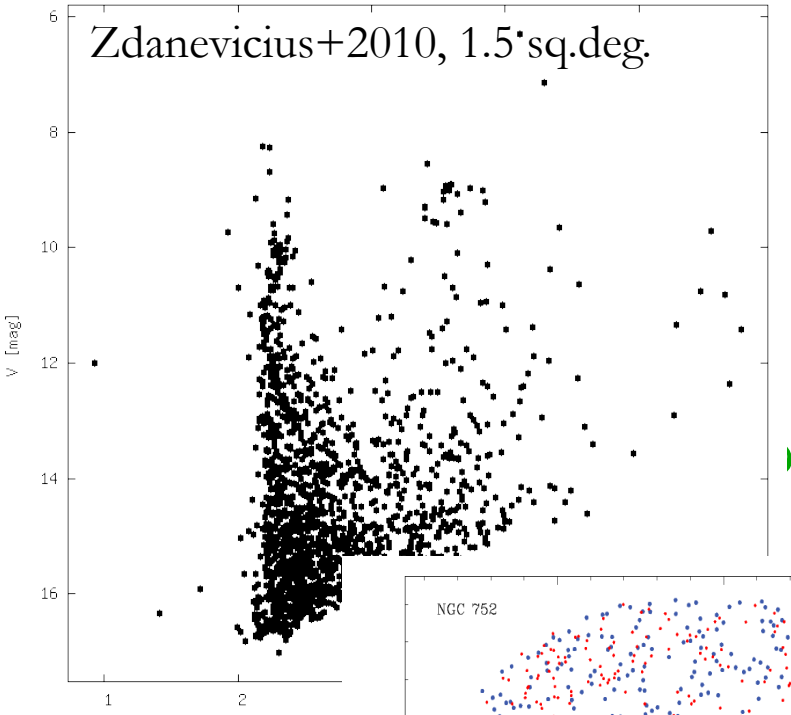
- **Young & very young (nearby)**
- **Old(er) & sparse**
- **Old & concentrated**

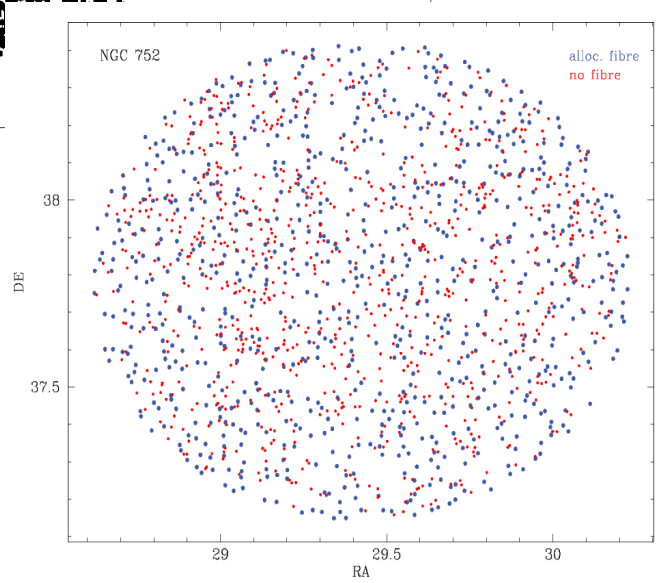
- **More than 1 cluster in 1 WEAVE field**
  (studied multiplicity of selected clusters)

Used e.g. 2MASS, APASS (**WEAVE will have Gaia**)
Run *configure* v1.0
Checked fibre allocation effectiveness

Target stars allocation : easy case







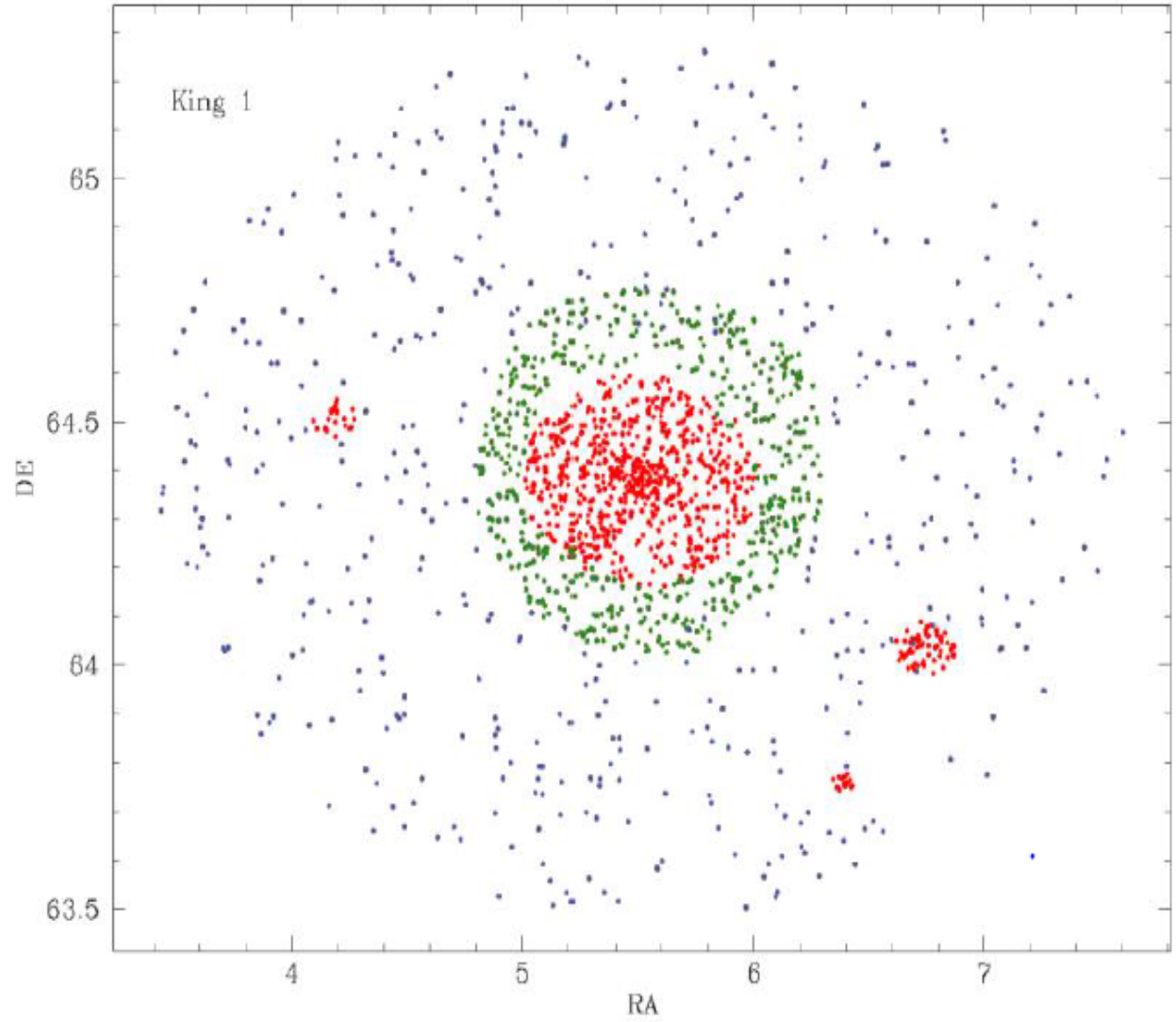
NGC 752 (D~500 pc ; age = 1 Gyr)

Target stars allocation : difficult case

King 1
(D=1900 pc,
age=2 Gyr)

✚

Majaess 8
(unstudied)
FSR 0496
(1 kpc, 1 Gyr)
FSR 0494
(5 kpc, 2 Gyr)



Calibrating clusters

SURVEY calibrators (Gaia Benchmark stars, Kepler/CoRoT fields, a few open and globular clusters) – TBD

Intra-survey :

well studied OCs
range of metallicity
range of distances/ages (giants vs dwarfs)

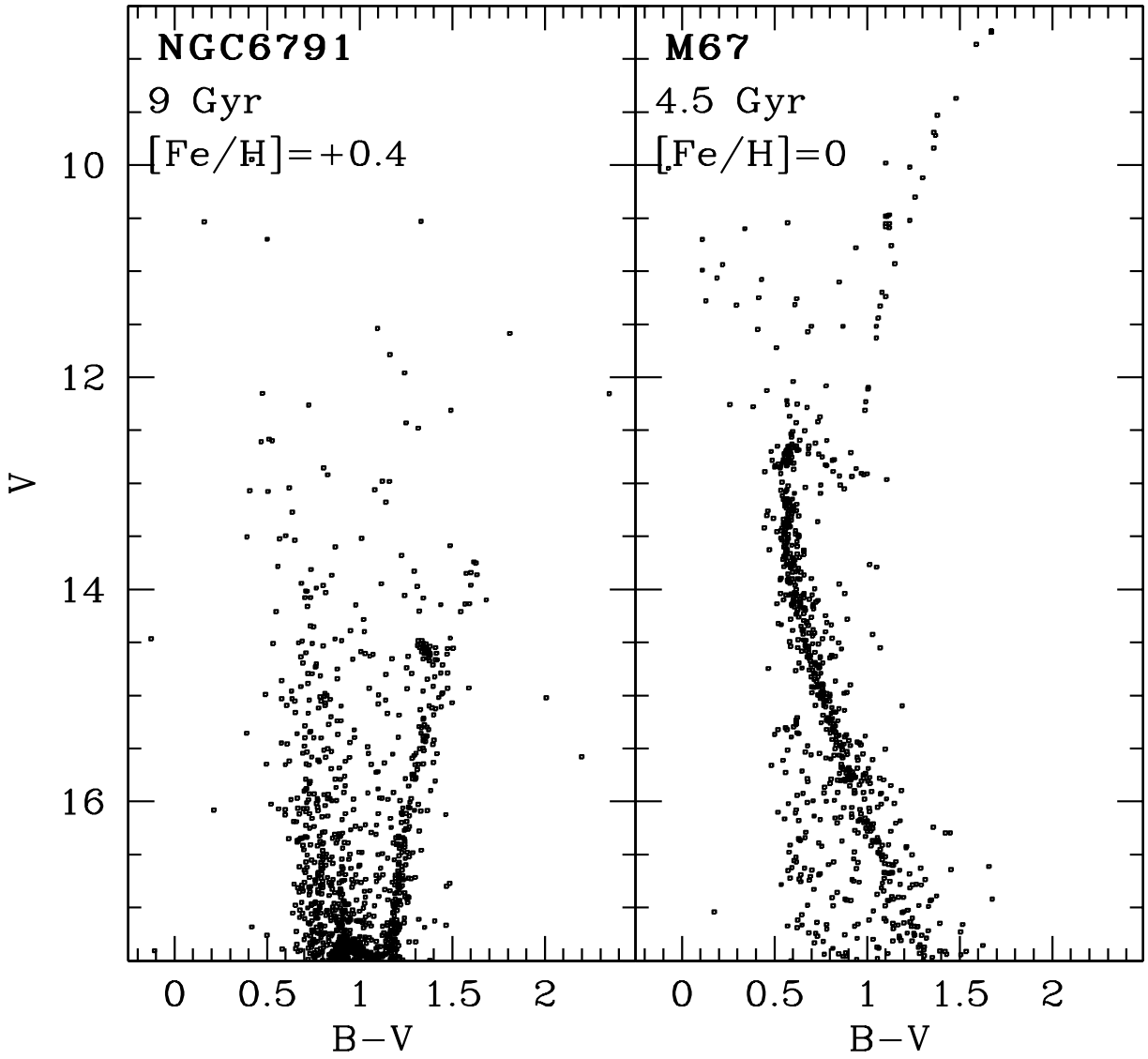
Test of parameters :

Kepler, K-2 clusters (log g)

Inter-surveys :

APOGEE
Gaia-ESO

Calibrating clusters



NGC 6791 :
Kepler, APOGEE
most metal-rich
M67 :
APOGEE, Gaia-ESO
Sun-like

Data products

- **Defined by Advanced Processing System (APS) :**

  RV, atmospheric parameters, metallicity

  + Si, Ca, V, Fe, Ni (only FGK stars)

- **Independent pipeline for young stars:**

  Li, chromospheric activity indices

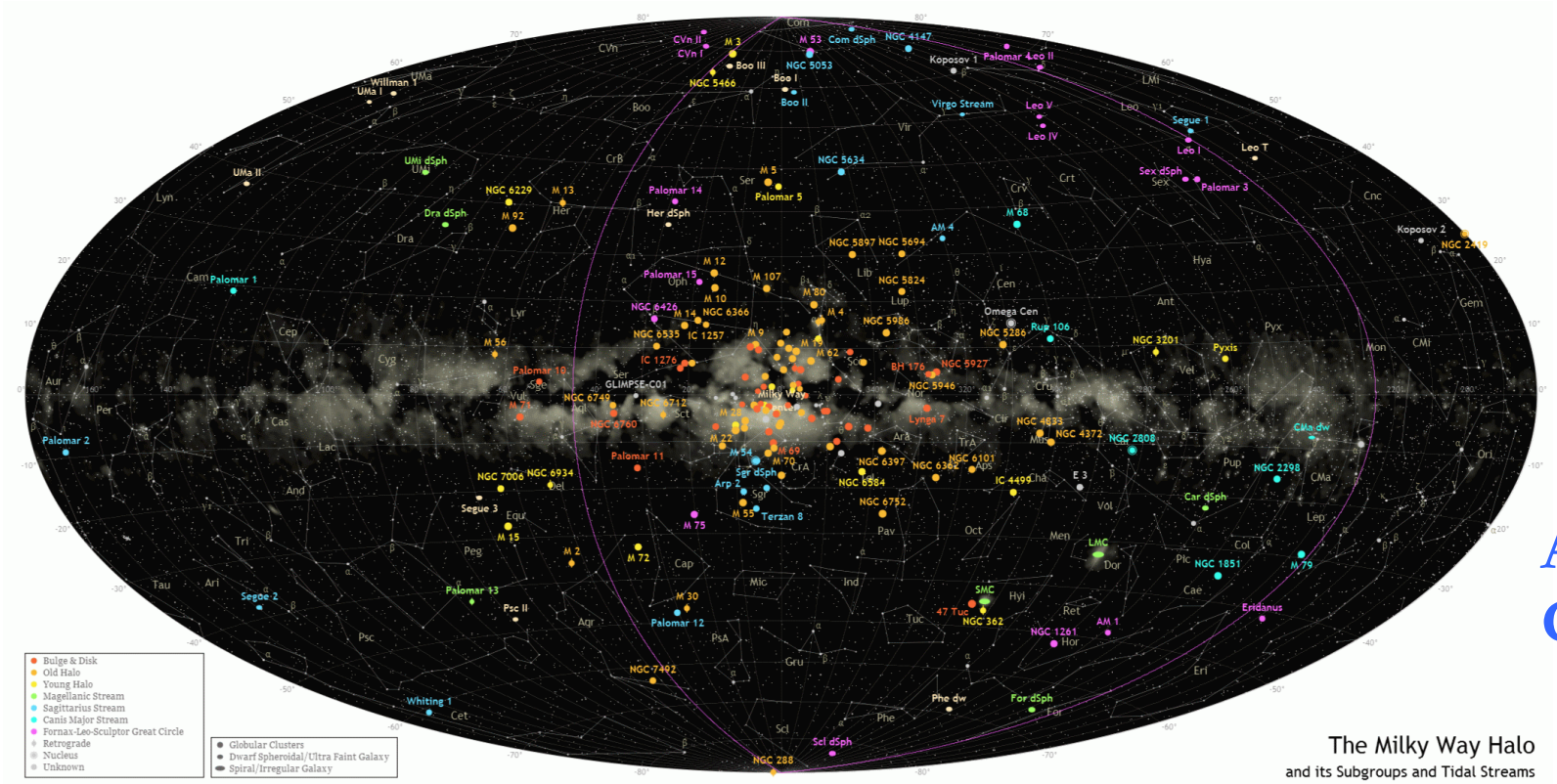
- **Desirable :**

  Li, C, α (O, Ca, Mg, Si, Ti), Fe-peak (Ni, Cr, Co, Ni), odd-Z (Na, Al), neutron-capture (s: Zr, Y, Sr, Ba, La,Nd; r: Eu, Sm)

  APS ? contribution ?

GLOBULAR CLUSTERS science case

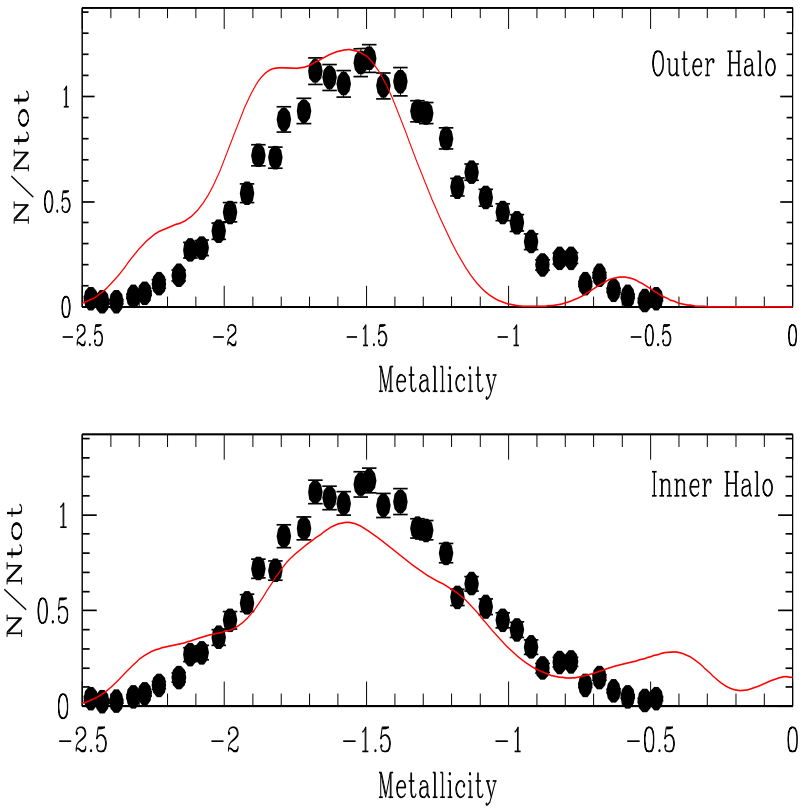
- Important ”per se” (oldest, metal-poorest stellar clusters)
- Test of stellar evolution models & astrophysical processes
- Connection with the halo



About 160 GCs in MW

Chemistry: GC ≈ halo field stars ?

Metallicity

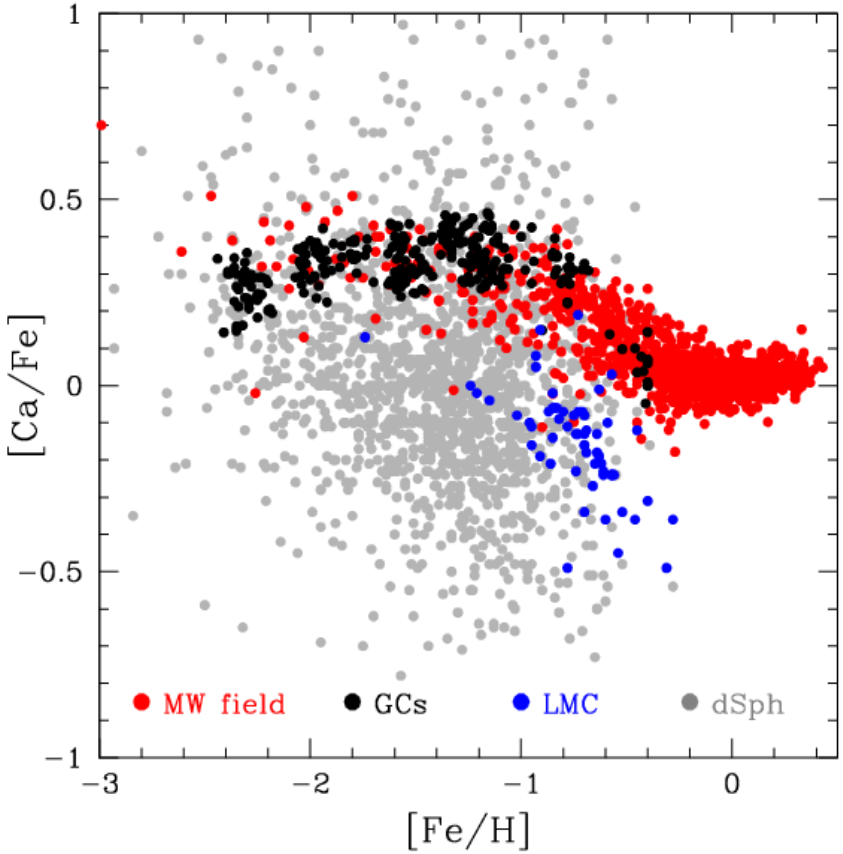


● field halo stars

— GCs

(Gratton+2012, Ivezic+2007)

α-elements

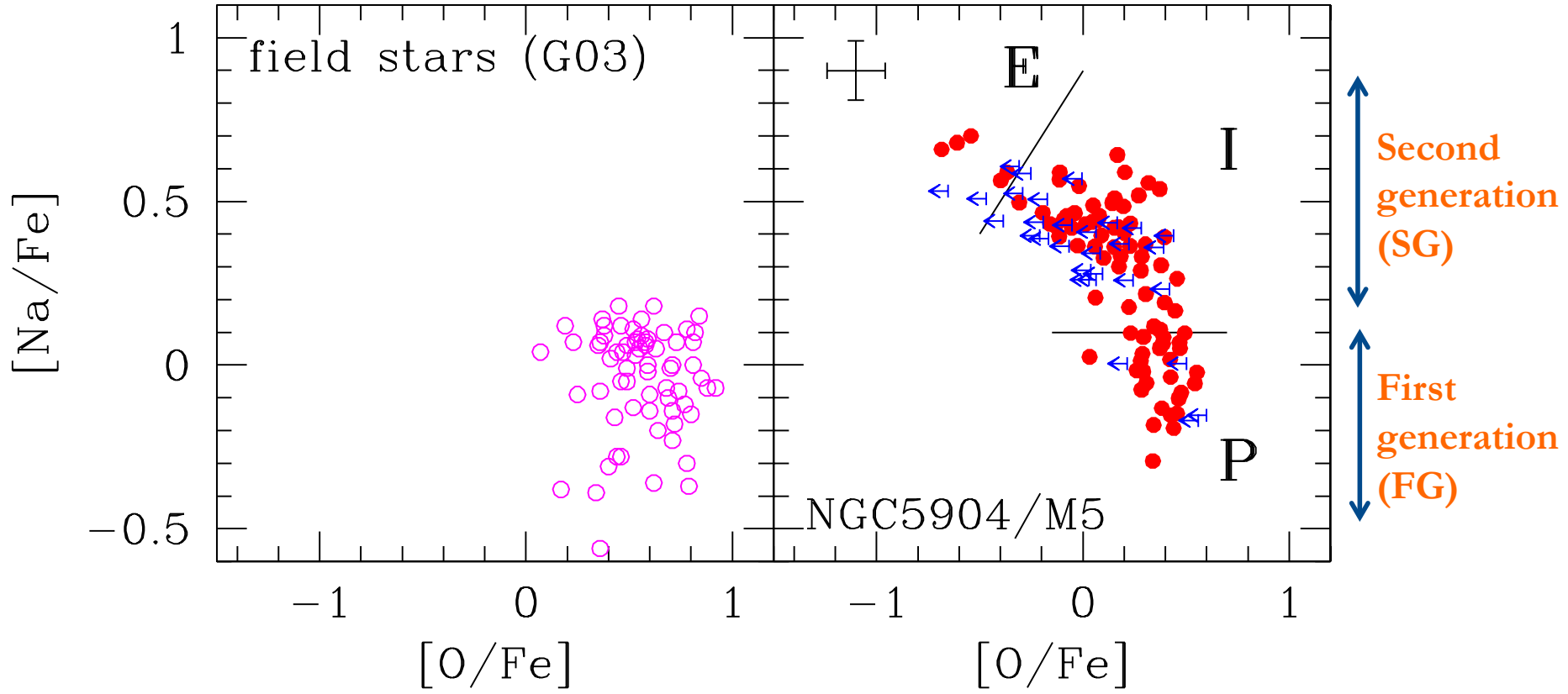


(Adibekyan+2012, Chen 2000, Gratton+2003, Jonsell +2005, Pompeia+2008, Carretta+2010, Kirby+2011)

O & Na : GCs ≠ field

nothing peculiar

O,Na anticorrelation

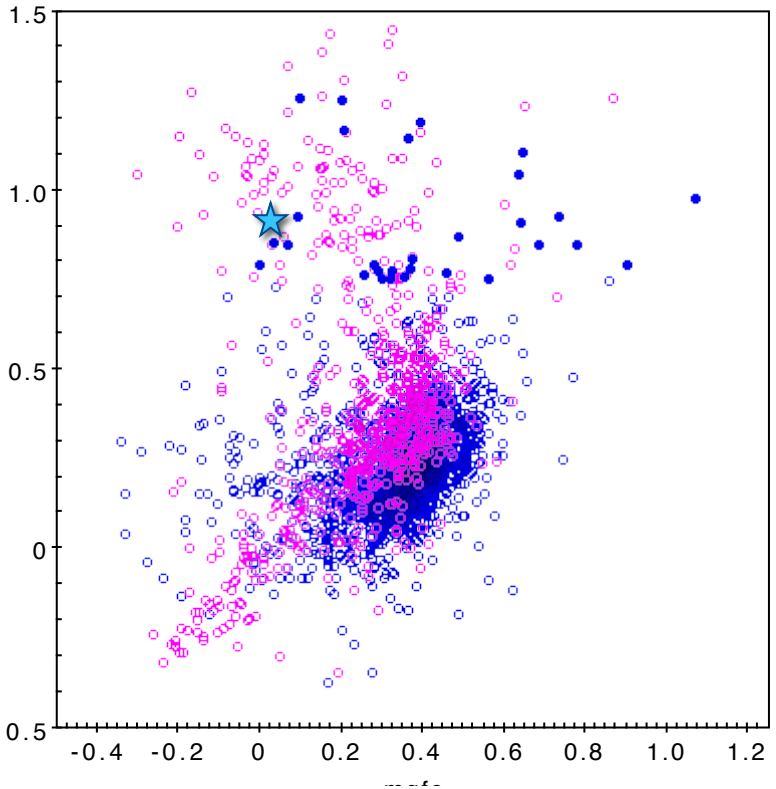


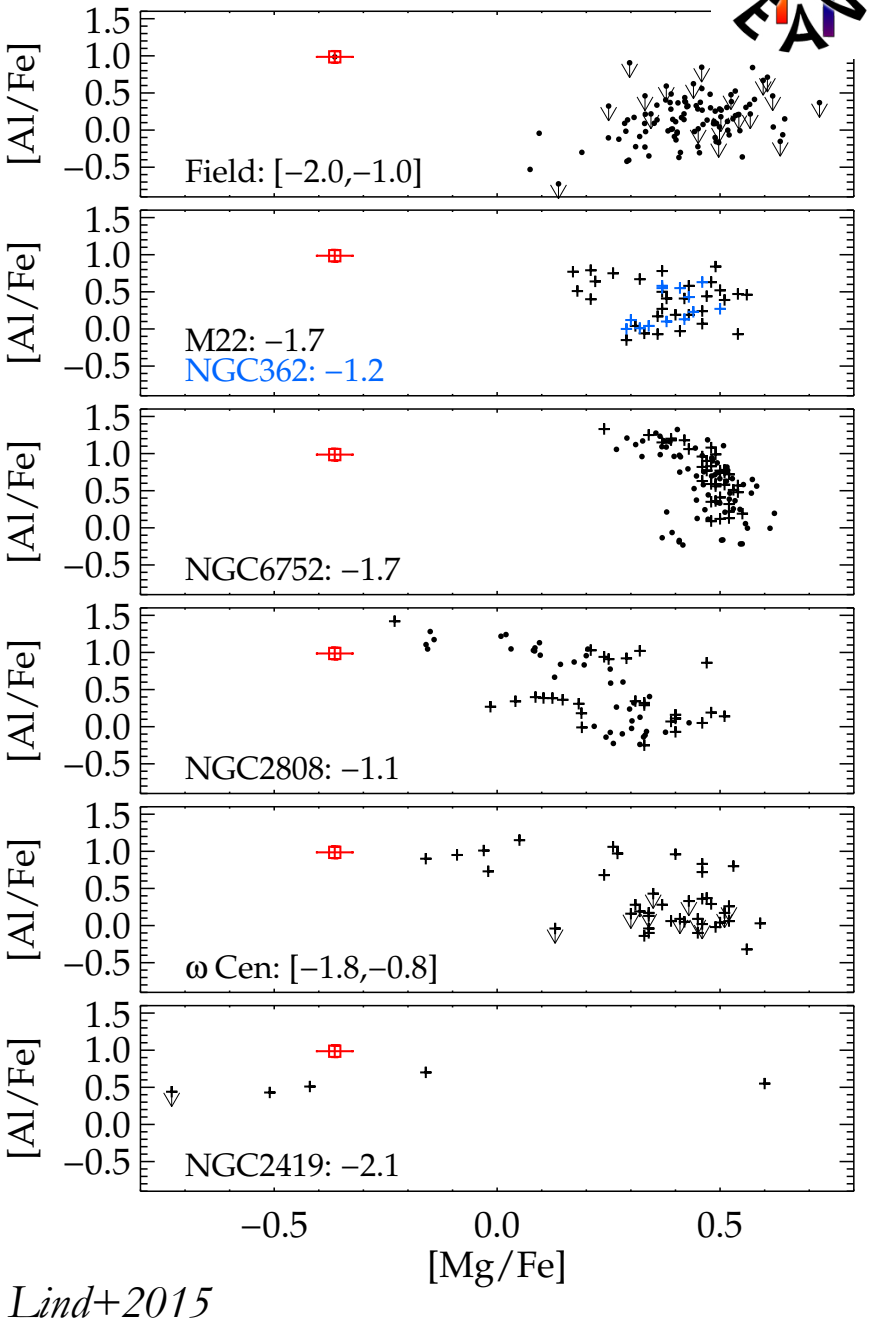
Gratton et al. 2003

Carretta et al. 2009a,b

Use WEAVE GCs for comparison with candidate escapees …

Gaia-ESO

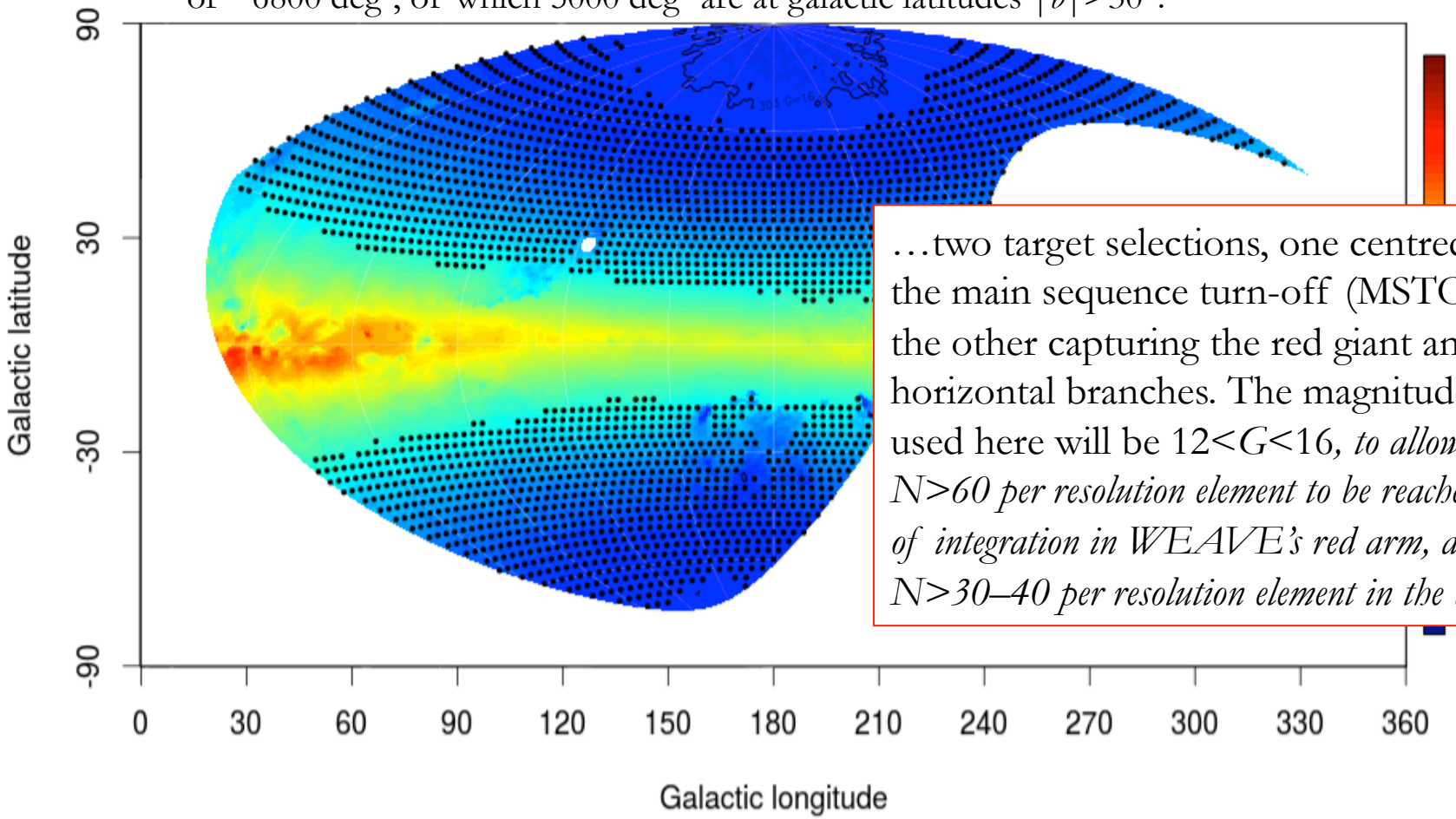




Lind+2015

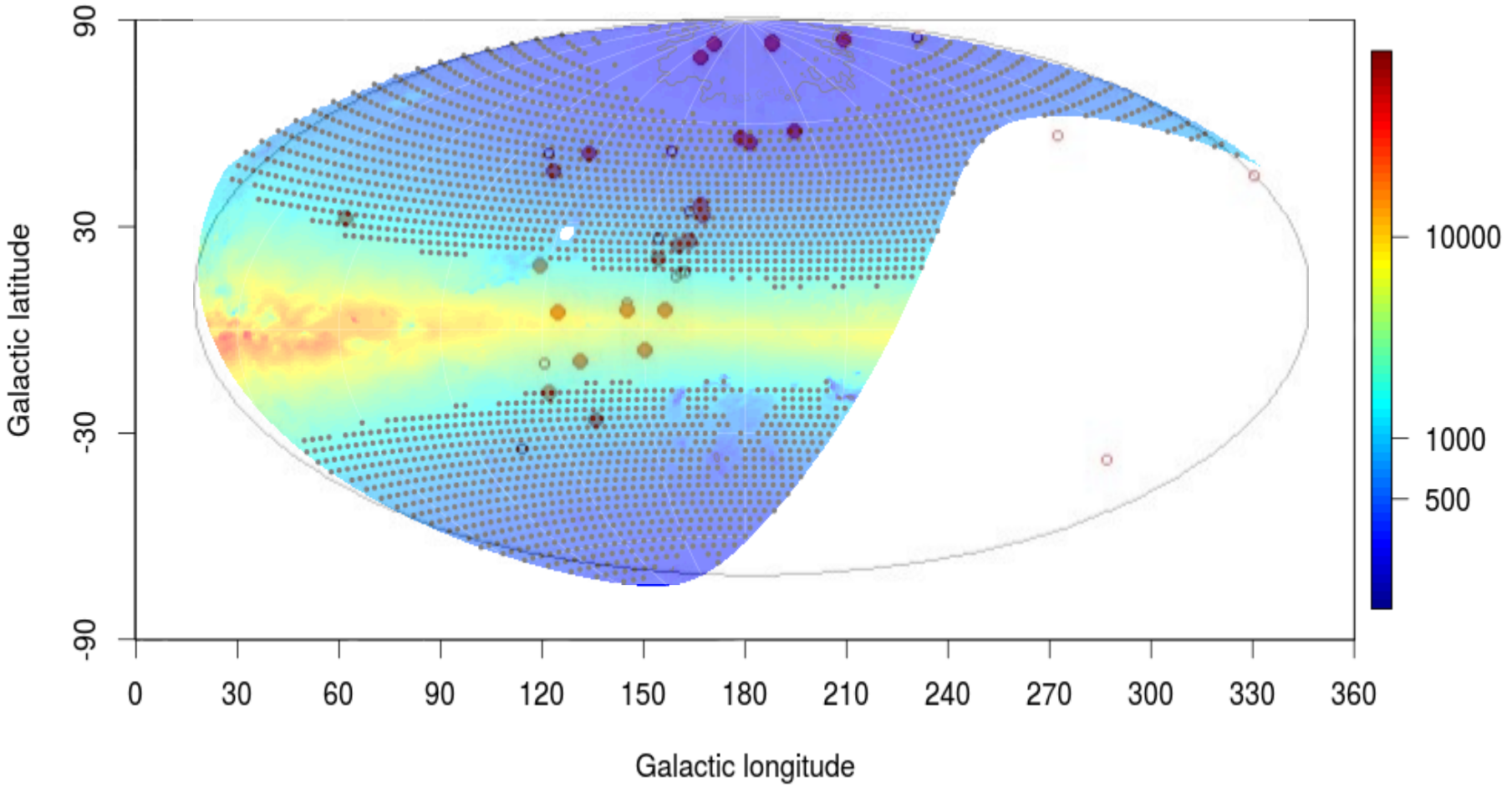
HR chemodynamical survey

Figure 3-12: Possible area coverage strategy for the HR chemo-dynamical survey. Each black dot is a WEAVE tile, making a total footprint of ~2300 WEAVE fields or ~6800 deg^2, of which 5000 deg^2 are at galactic latitudes $|b|>30°$.

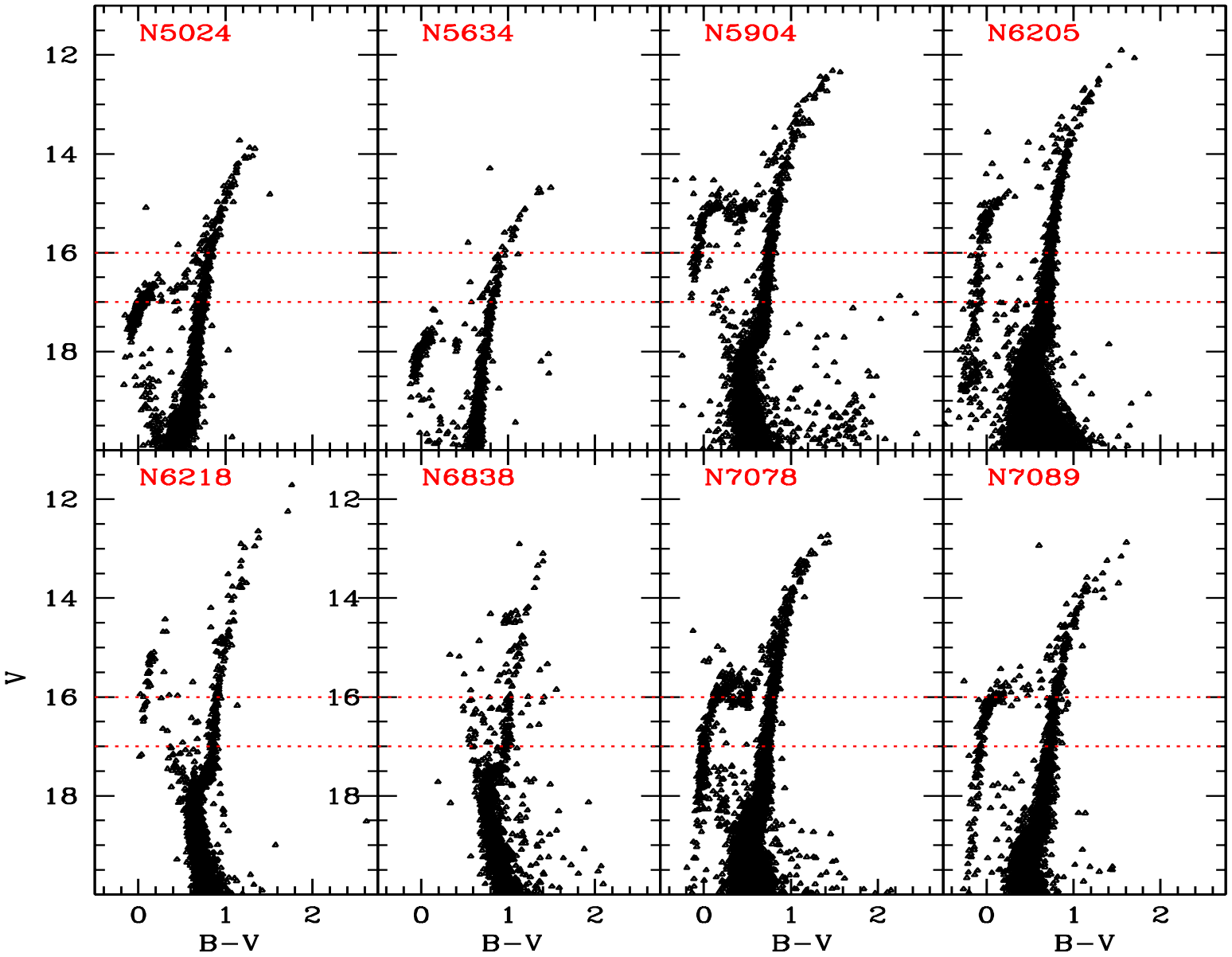


…two target selections, one centred on the main sequence turn-off (MSTO), and the other capturing the red giant and horizontal branches. The magnitude range used here will be $12<G<16$, *to allow S/N>60 per resolution element to be reached in 2h of integration in WEAVE's red arm, and S/N>30–40 per resolution element in the blue.*

HR chemodynamical survey + GCs



GCs & WEAVE



blue arm:
404 - 465 nm
or
473 - 545 nm
plus
red arm:
595 - 685 nm

LR: 5000
HR: 20000

NAME	Mess.	Rsun	E(B-V)	V_HB	(m-M)v	M_Vt	c	r_t	r_h	l	b
NGC6838	M71	4.0	0.25	14.48	13.8	-5.61	1.15	8.899	1.67	56.75	-4.56
NGC6218	M12	4.8	0.19	14.6	14.01	-7.31	1.34	17.28	1.77	15.72	26.31
NGC6254	M10	4.4	0.28	14.65	14.08	-7.48	1.38	18.47	1.95	15.14	23.08
NGC6205	M13	7.1	0.02	14.9	14.33	-8.55	1.53	21.01	1.69	59.01	40.91
NGC5904	M5	7.5	0.03	15.07	14.46	-8.81	1.73	23.63	1.77	3.86	46.8
NGC6341	M92	8.3	0.02	15.1	14.65	-8.21	1.68	12.44	1.02	68.34	34.86
NGC5272	M3	10.2	0.01	15.64	15.07	-8.88	1.89	28.72	2.31	42.22	78.71
NGC6366	-	3.5	0.71	15.65	14.94	-5.74	0.74	11.93	2.92	18.41	16.04
NGC6535	-	6.8	0.34	15.75	15.22	-4.75	1.33	7.697	0.85	27.18	10.44
NGC7078	M15	10.4	0.1	15.83	15.39	-9.19	2.29	27.3	1.0	65.01	-27.31
NGC7089	M2	11.5	0.06	16.05	15.5	-9.03	1.59	12.45	1.06	53.37	-35.77
NGC6779	M56	9.4	0.26	16.18	15.68	-7.41	1.38	10.55	1.1	62.66	8.34
NGC6712	-	6.9	0.45	16.25	15.6	-7.5	1.05	8.527	1.33	25.35	-4.32
PAL1	-	11.1	0.15	16.4	15.7	-2.52	2.57	3.715	0.46	130.06	19.03
NGC5466	-	16.0	0.0	16.52	16.02	-6.98	1.04	15.68	2.3	42.15	73.59
NGC5053	-	17.4	0.01	16.69	16.23	-6.76	0.74	11.43	2.61	335.7	78.95
NGC5024	M53	17.9	0.02	16.81	16.32	-8.71	1.72	18.37	1.31	332.96	79.76
NGC6934	-	15.6	0.1	16.86	16.28	-7.45	1.53	7.455	0.69	52.1	-18.89
NGC4147	-	19.3	0.02	17.02	16.49	-6.17	1.83	6.085	0.48	252.85	77.19
NGC6402	M14	9.3	0.6	17.3	16.69	-9.1	0.99	7.72	1.3	21.32	14.81
NGC6760	-	7.4	0.77	17.46	16.72	-7.84	1.65	15.19	1.27	36.11	-3.92
PAL11	-	13.4	0.35	17.46	16.72	-6.92	0.57	4.421	1.46	31.81	-15.57
PAL5	-	23.2	0.03	17.51	16.92	-5.17	0.52	7.583	2.73	0.85	45.86
NGC5634	-	25.2	0.05	17.68	17.16	-7.69	2.07	10.57	0.86	342.21	49.26

APOGEE GES? FLAMES
GES FLAMES
APOGEE GES? FLAMES
APOGEE
APOGEE
APOGEE
APOGEE GES FLAMES
APOGEE GES
APOGEE
APOGEE GES?

& calibrators

WHAT NEXT ?

- Refine strategy for observations
- Refine cluster selection
- Time allocated to clusters ?
- Define man-power
- Define tasks
- SV plans
- Early science candidate projects