Resolved Stellar Populations: open clusters and MW field

MA2 @ OAS BOLOGNA
17-18 DECEMBER 2018

INAF
ISTITUTO NAZIONALE DI ASTROFISICA
OSSERVATORIO DI ASTROFISICA E SCIENZA DELLO SPAZIO DI BOLOGNA

Who is who in …

… open clusters & field stars @ OAS

Michele Bellazzini
Angela Bragaglia
Eugenio Carretta
Emanuele Dalessandro
Xiaoting Fu
Livia Origlia
Donatella Romano
Monica Tosi


Michele Bellazzini


Angela Bragaglia


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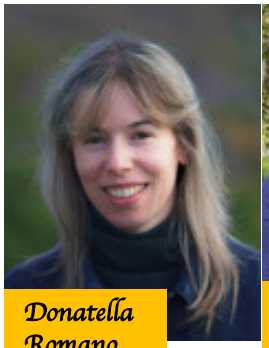
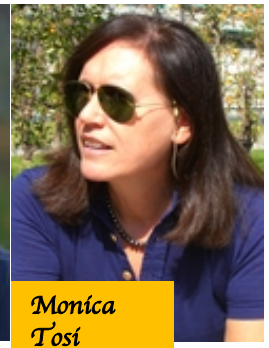
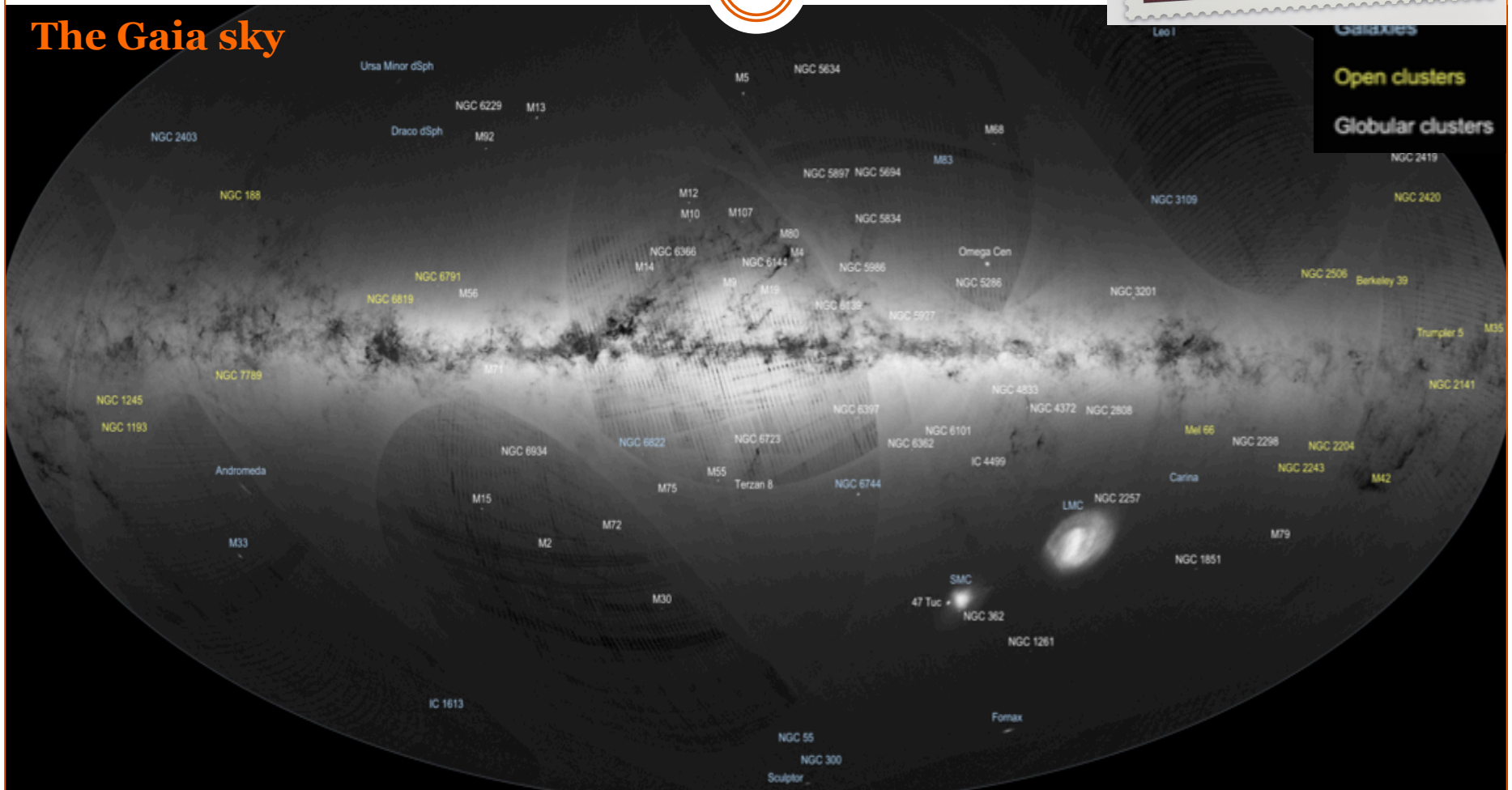
Livia Origlia


Donatella Romano


Monica Tosi

Gaia: the MW (& beyond)

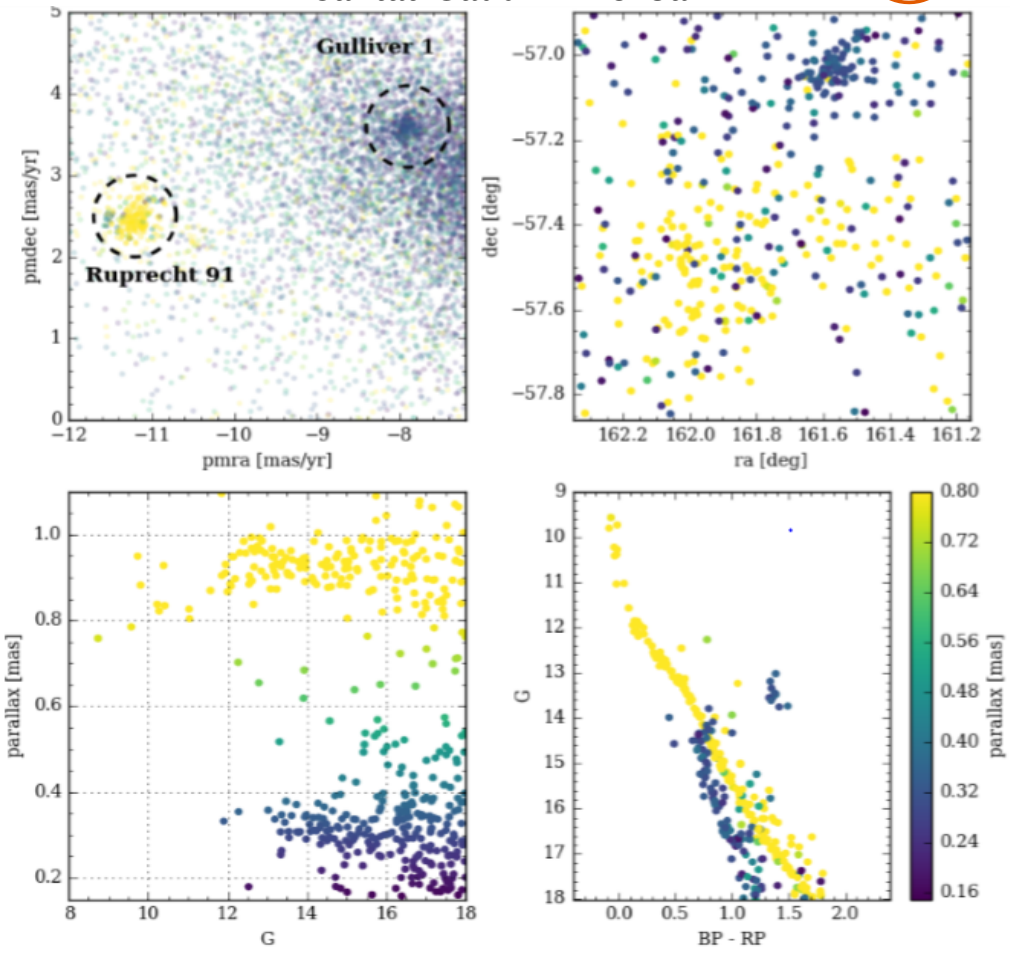
The Gaia sky



M. Bellazzini, A. Bragaglia, C. Cacciari, G. Clementini, P. Montegriffo, T. Muraveva & DPAC

Gaia: news on open clusters

Cantat-Gaudin+ 2018a

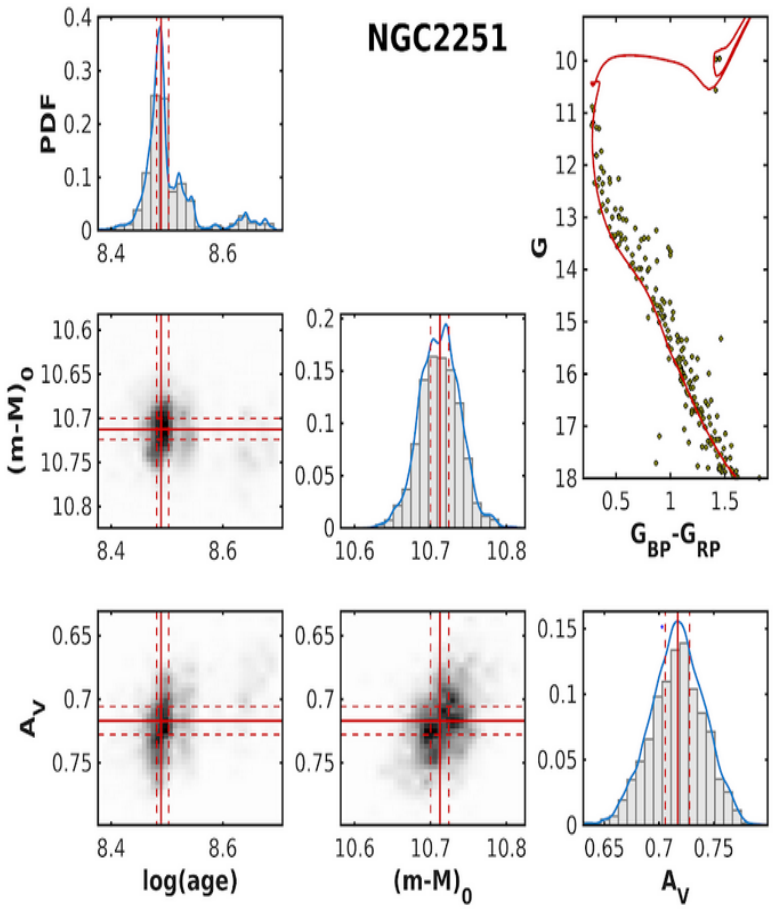


- Confirm / disprove candidate clusters & find new (130+)
- Revised census for 1200+ OCs based on Gaia DR2 (see Cantat-Gaudin+ 2018a) : 60 new OCs (32 with $D_{\odot} < 2$ kpc) … are we really complete inside 2 kpc ? …
- More new OCs by Koposov + 2017 (2) ; Castro-Ginard+ 2018 (31) ; Cantat-Gaudin+ 2018b (41) ; etc

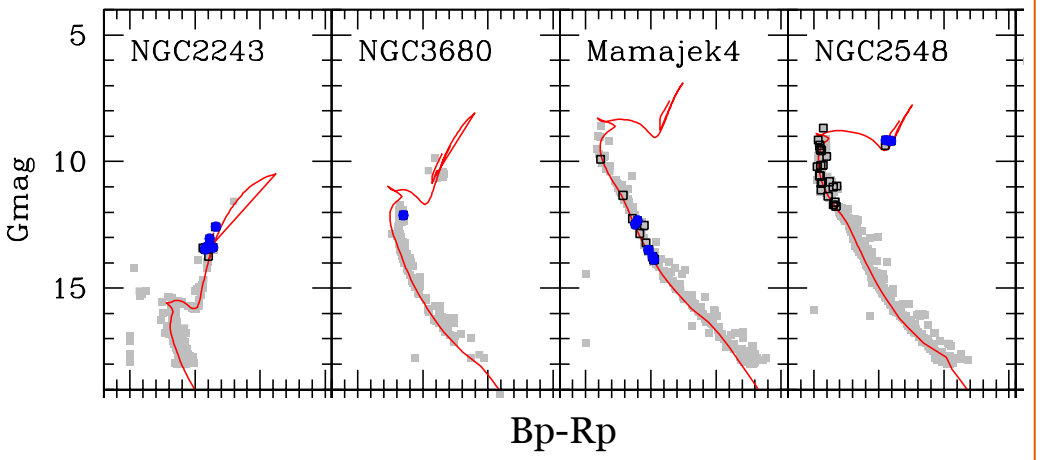
new OC : Gulliver 1, seen close to Ruprecht 91

A. Bragaglia & DPAC Gaia

Gaia: news on open clusters



- Homogenous revision of ages, metallicities (and abundances)
- Combining Gaia, stellar models, spectroscopic surveys



Bossini, Vallenari, Bragaglia+2018: Bayesian age determination (BASE9) for 270 OCs

Carrera, Bragaglia+2018: mining APOGEE and GALAH for hidden OC stars

Gaia-ESO Survey

Gaia	Gaia-ESO

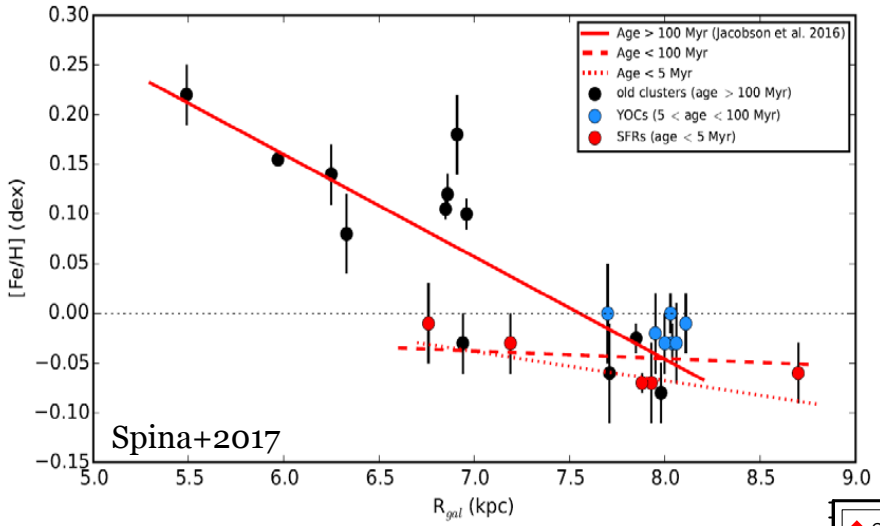
2-D → 3-D → 5-D → 6-D → 12+ D

Position	Parallax	Proper motions	Spectrum	Astrophysical parameters
Ultra-precision, over years	Distance	Transverse velocities	Radial velocity + chemistry	Ages, histories, astrophysics

300+ nights (2012-2017), ESO-VLT + FLAMES, PIs Randich & Gilmore, **400+ co-Is**, **115000 stars** (**80 open clusters**), final release Spring 2019, 80+ Gaia-ESO Consortium refereed papers (& counting)

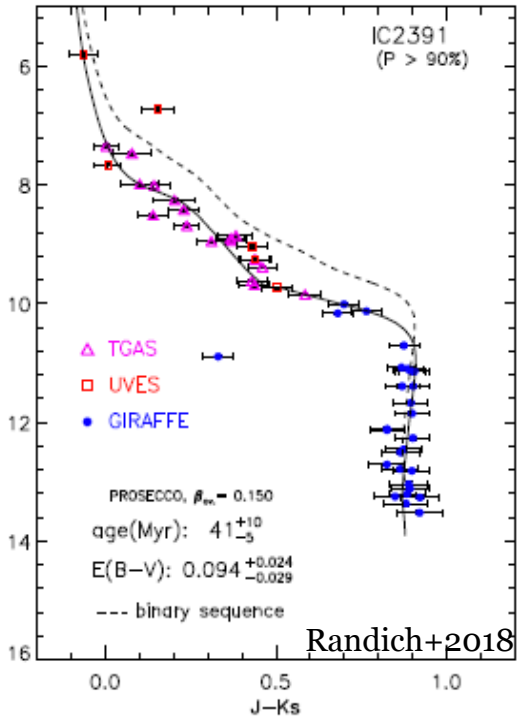
OAS: *A.Bragaglia, M.Bellazzini, F.Calura, G.Fiorentino, X.Fu, D.Romano, M.Tosi*

Gaia-ESO: ask the OCs



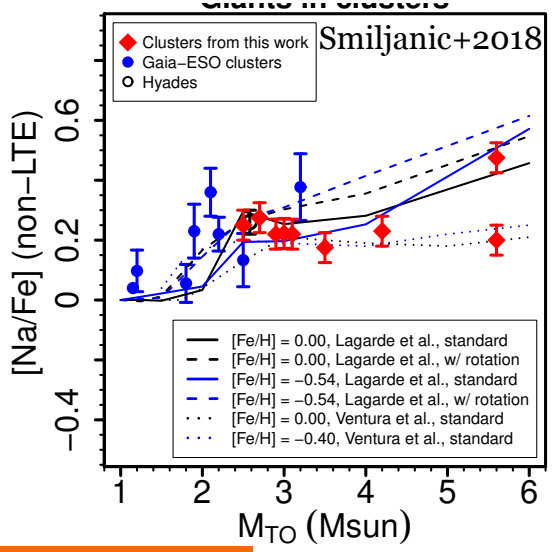
How well can we assign ages?

➔ *Gaia+Gaia-ESO +stellar models (done TGAS, in progress DR2)*



What is the distribution of metallicity in the MW disc? How does it change with time ?

➔ *Gaia-ESO + age + distance (80 OCs end-of-survey)*



Do stellar model include all / the right mixing mechanisms?

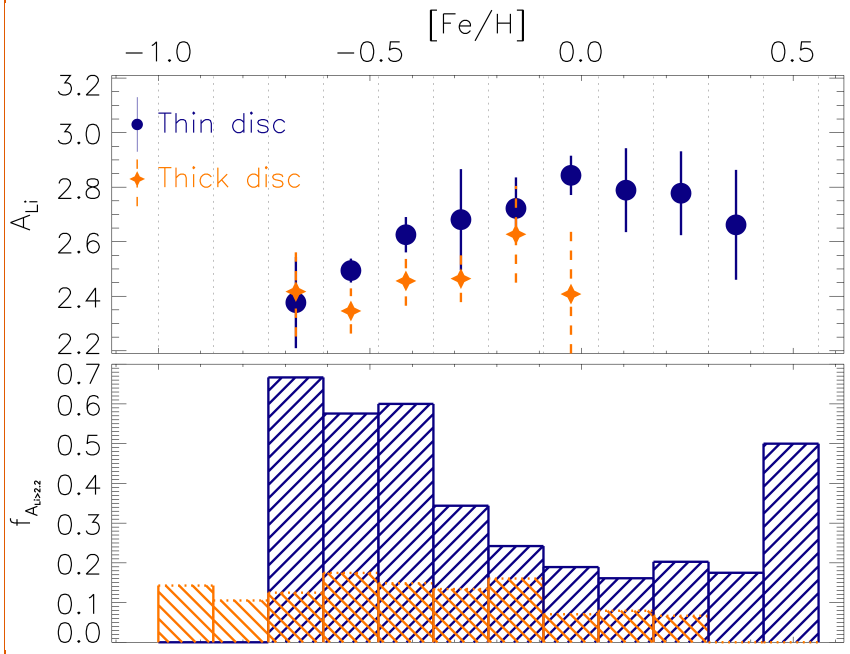
➔ *Na in giants (& C,N) (GES+follow-up)*

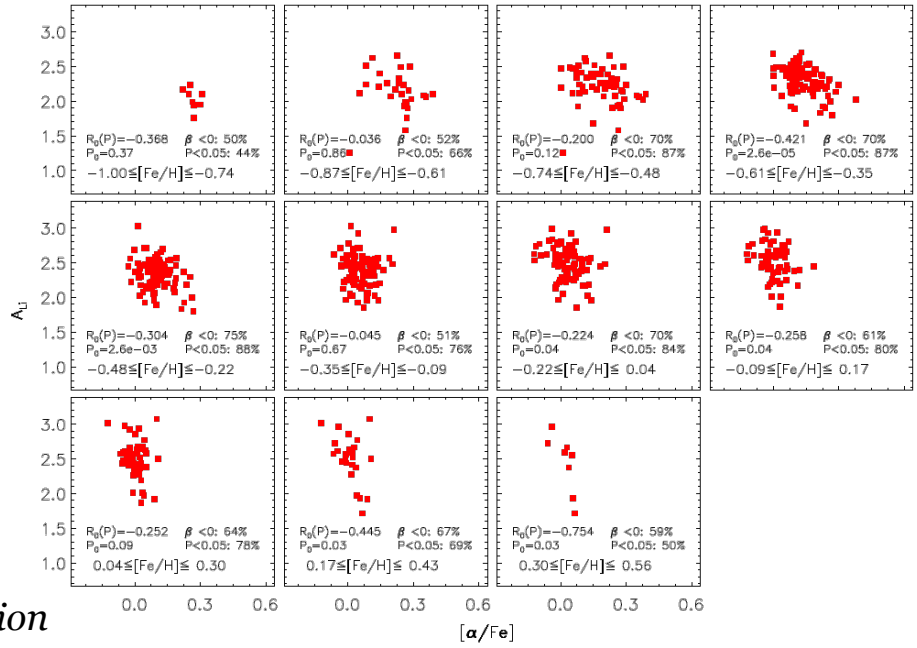
NB about half of GES papers on open cluster science

Gaia-ESO on lithium

MW lithium enrichment history

- Thin disc: stronger and higher overall level of Li enrichment than the thick disc
- Li decline at super-solar metallicity
- Li-[α/Fe] anti-correlation (c-c SNe contribution is negligible)
- Li-[s-process elements] correlation (AGB stars mainly contributed to thin disc enrichment)

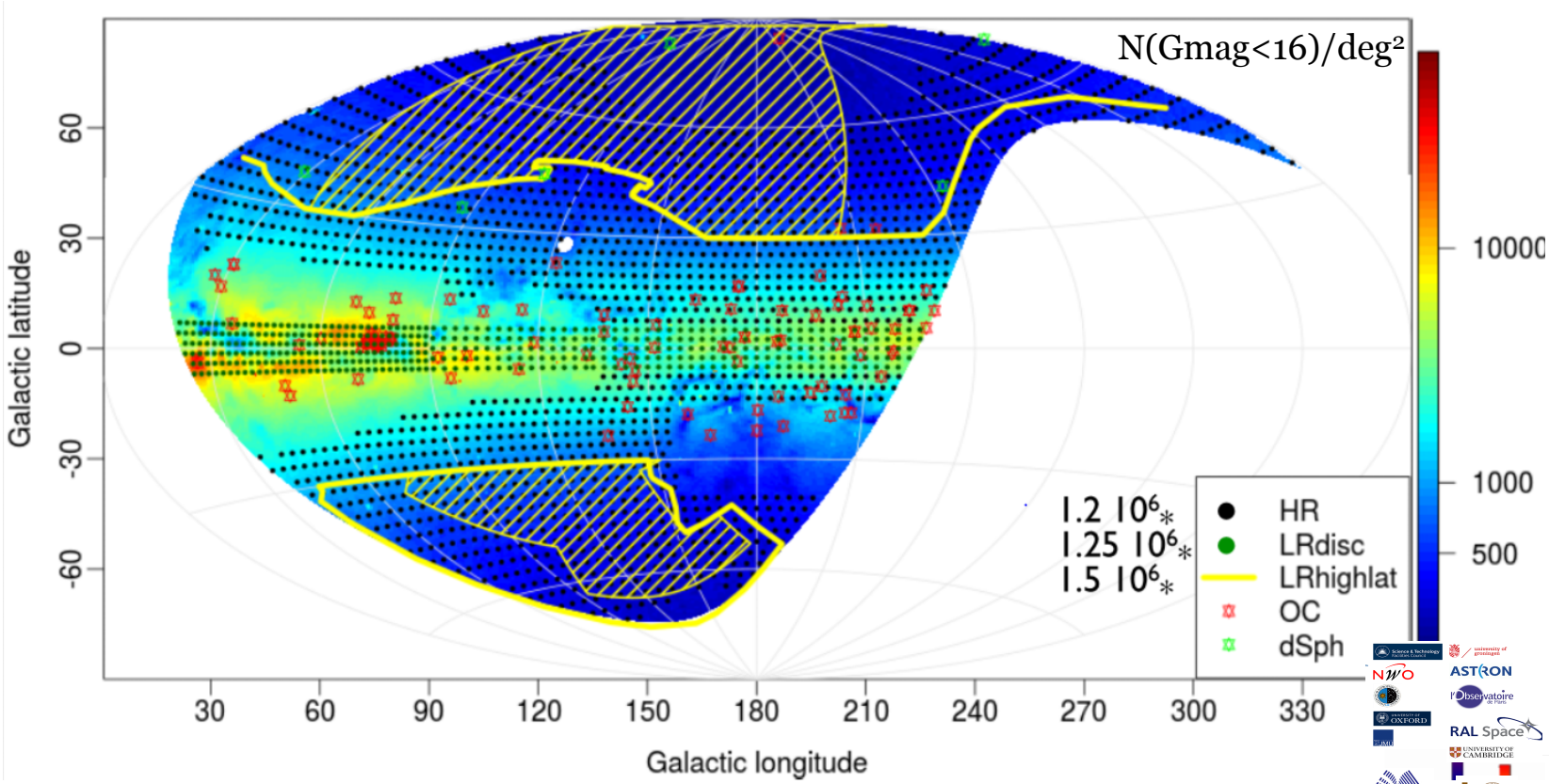




X. Fu, D. Romano, A. Bragaglia & GES Collaboration

WEAVE: next generation

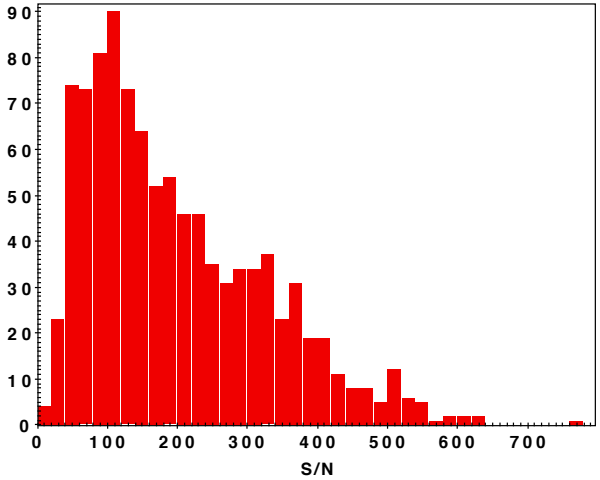
- A few million stars to unravel the MW history
- Targets “Gaia-quality”
- WHT, FoV 2 deg, 950+ fibers
- starts 2020, 5 yr

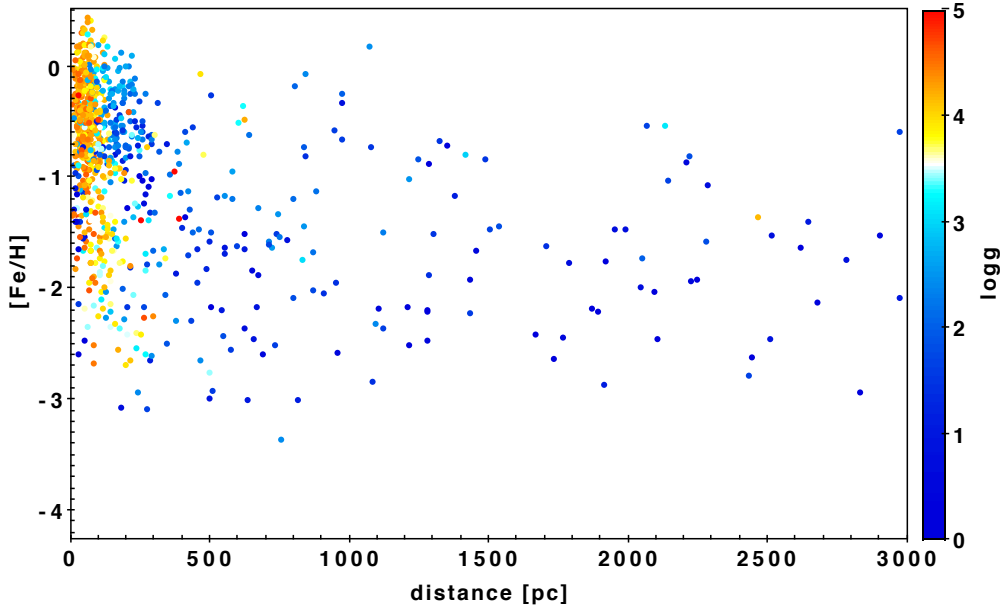


A.Bragaglia, M. Bellazzini, A. Sollima & WEAVE Consortium

AGV = Another Gaia Venture

- Define a **golden sample** of local stars belonging to thin/thick disc and halo
- Within **Gaia** highest precision sphere (PLX, PMs ➔distance, space motions, etc)
- Study accreted / dissipative components
- Derive spectroscopic parameters and detailed chemical abundances
  ➔ high-res, high SNR spectra of ~1000 stars with FIES, McDonald
  + UVES, HARPS, FEROS, SOPHIE, HIRES (archive) : ~ 1000 hr / 100+ n



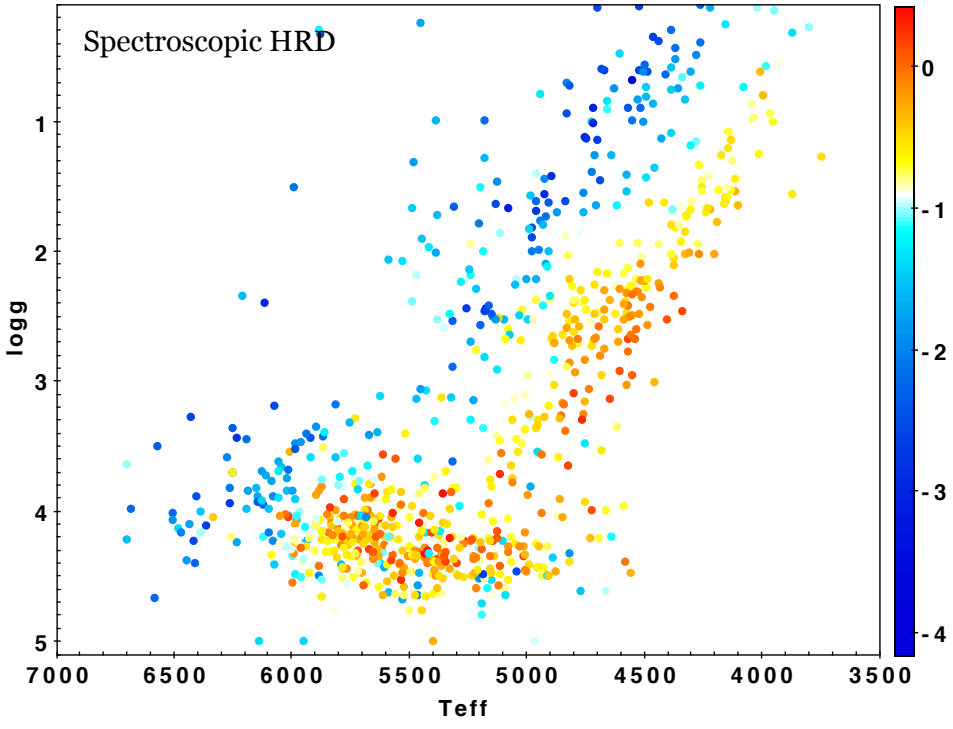


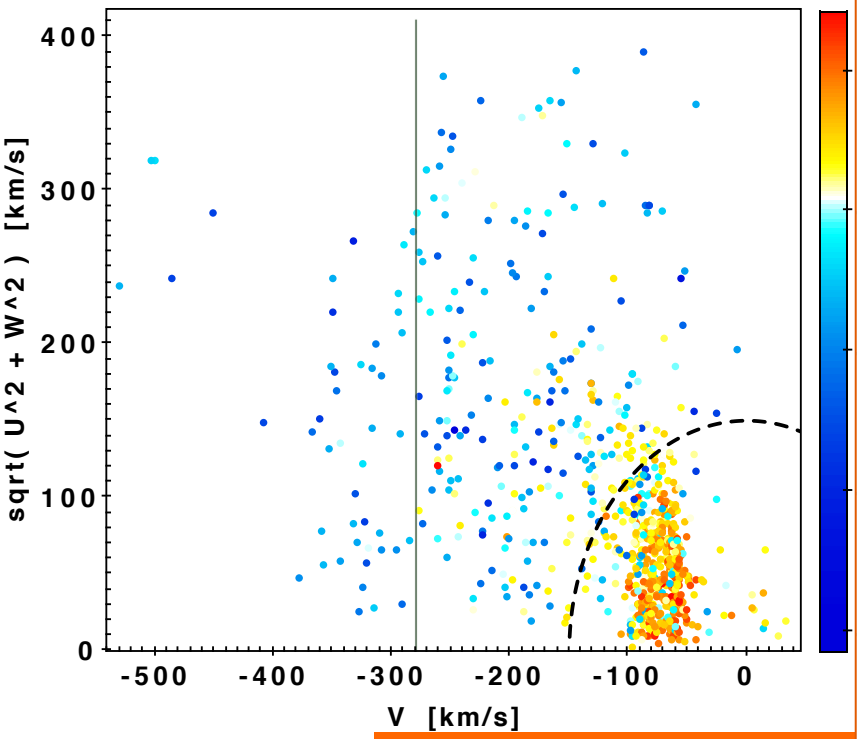
E. Carretta (PI), A.Bragaglia,, D. Romano (OAS)
R.G. Gratton, V. D'Orazi, S. Lucatello (OAPD)
C. Sneden, M. Adamow (Uni. Texas)

AGV = Another Gaia Venture

Work in progress :

- "all" elements from Be to Pb – from all nucleosynthetic sites
- Comparison with state-of-the art chemical evolution models
- Chemo-dynamics of accreted / dissipative components
- Side benefit: calibration sample for WEAVE (test all elements by pipeline/CDPs)



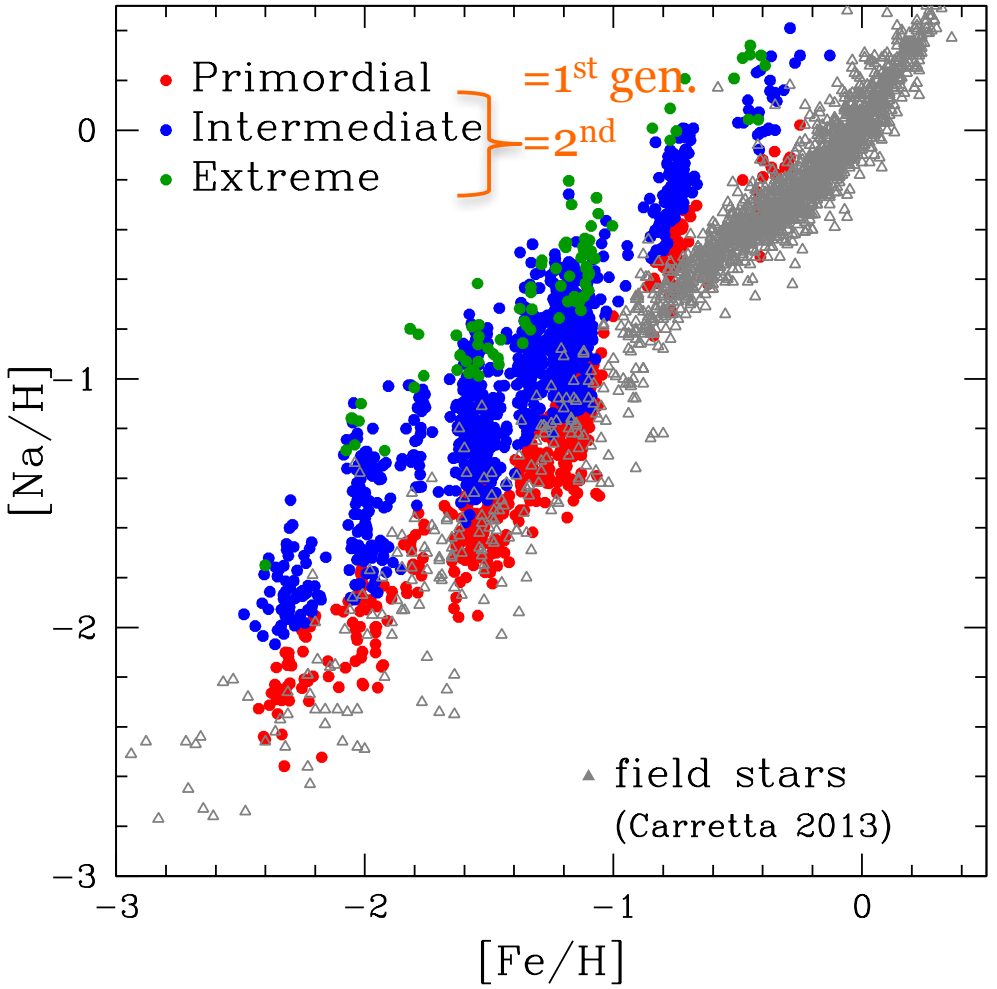


AGV = Another Gaia Venture

Connection with GCs:

20-30 stars with composition of 2nd generation in GCs are expected
(high Na, N, Al + low O, C, Mg)

➔ formation of Galactic halo
➔ link (proto-)GC / MW field



SPA - Stellar Population Astrophysics

the detailed, age-resolved chemistry of the Milky Way disk

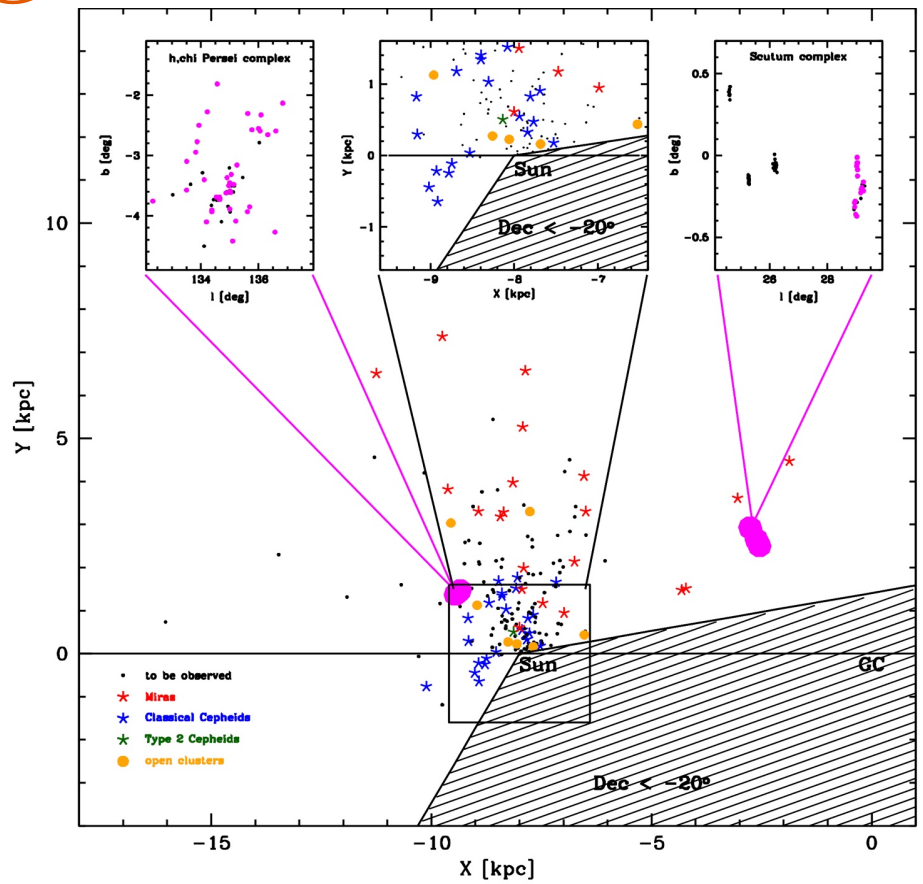
THE LARGE PROGRAM @ TNG

- **80 nights (**18 already executed) / 3 yrs
- **GIARPS** (GIANO-B+HARPS-N) **spectra**
- **500+ stars in the MW disk & clusters** with different ages and R_{GC}'s

First **high resolution, multi-element chemical maps** of the **Solar neighborhood, Scutum-arm & Persei complexes** and of the **inner+outer disk**

➔ radial/azimuthal gradients, age-chemistry relations, cosmic scatter and other inhomogeneities

➔ critical tests of **stellar evolution** & **stellar physics**



PI L.Origlia, WP Resp. G.Bono, *A.Bragaglia, E.Dalessandro*

Co-Is : G. Andreuzzi, V. Braga, T. Cantat-Gaudin, *E. Carretta*, G. Casali, S. Cassisi, G. Catanzaro, G. Cescutti, R. daSilva, V. D'Orazi, C. Fanelli, *G. Fiorentino*, A. Frasca, *X. Fu*, L. Inno, A. Lanzafame, S. Lucatello, L. Magrini, M. Marconi, A. Mucciarelli, E. Oliva, M. Rainer, *D. Romano*, N. Sanna, O.Straniero, *M.Tosi*, A.Vallenari

Co-Is from foreign Institutes: K.Fukue, N.Kobayashi, B.Lemasle, N.Matsunaga, M.Monelli

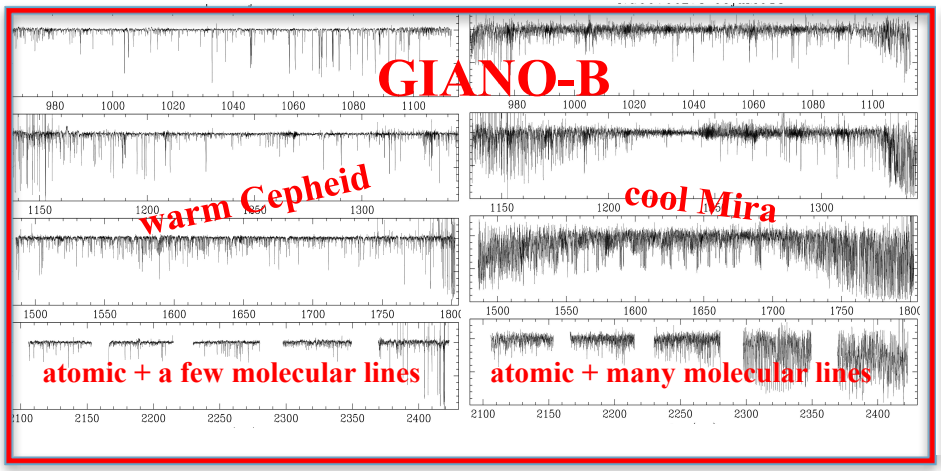
SPA - Stellar Population Astrophysics

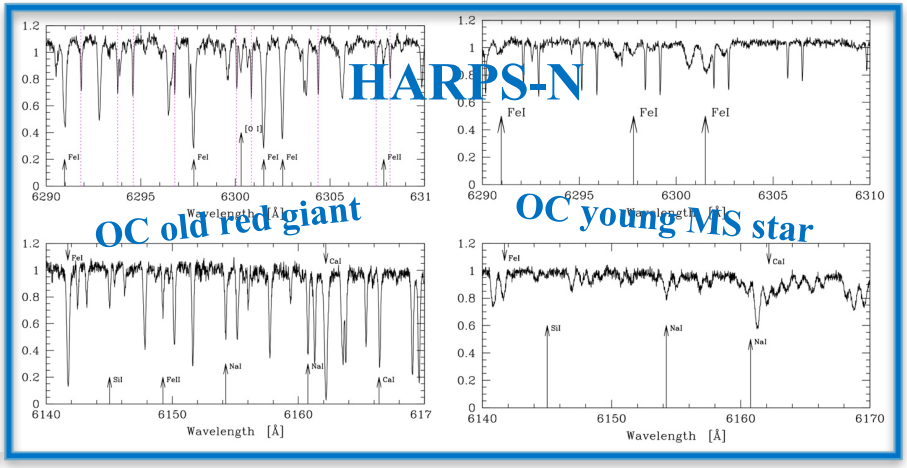
the detailed, age-resolved chemistry of the Milky Way disk

TARGETS:

- red/reddened stars: **Mira & type 2 Cepheid variables, RSGs in the Scutum complex**
  too faint in the visual to be observed with HARPS-N ➔ only near-IR **GIANO-B** spectra
  - exploring a new space of parameters in high resolution stellar spectroscopy
  - tracing gas inflows and SF in the Scutum complex triggered by interactions between the spiral arm and the central bar

- stars in **open clusters** and in the **h+χ *Persei* complex** and **Classical Cepheids**
  ➔ bright enough both in the visual and in the near IR to be observed with **GIARPS**
  - tracing chemistry of multi-age stellar populations, cluster formation and testing stellar models





SPA & more: OSTTA open clusters

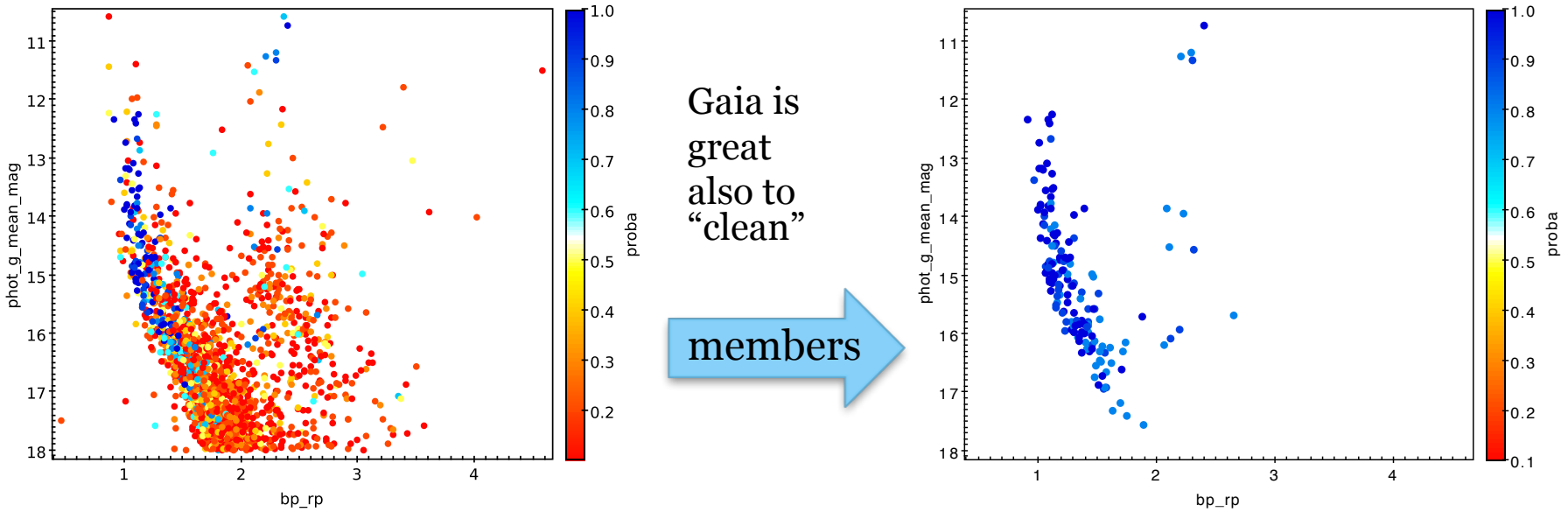
In addition to SPA : *One Star to Tag Them All* project (@NOT, proposed @ESO)

Why ? Presently we know (at least) metallicity of only ~10% of known OCs

➔ problems to derive their age, bad coverage of disc properties

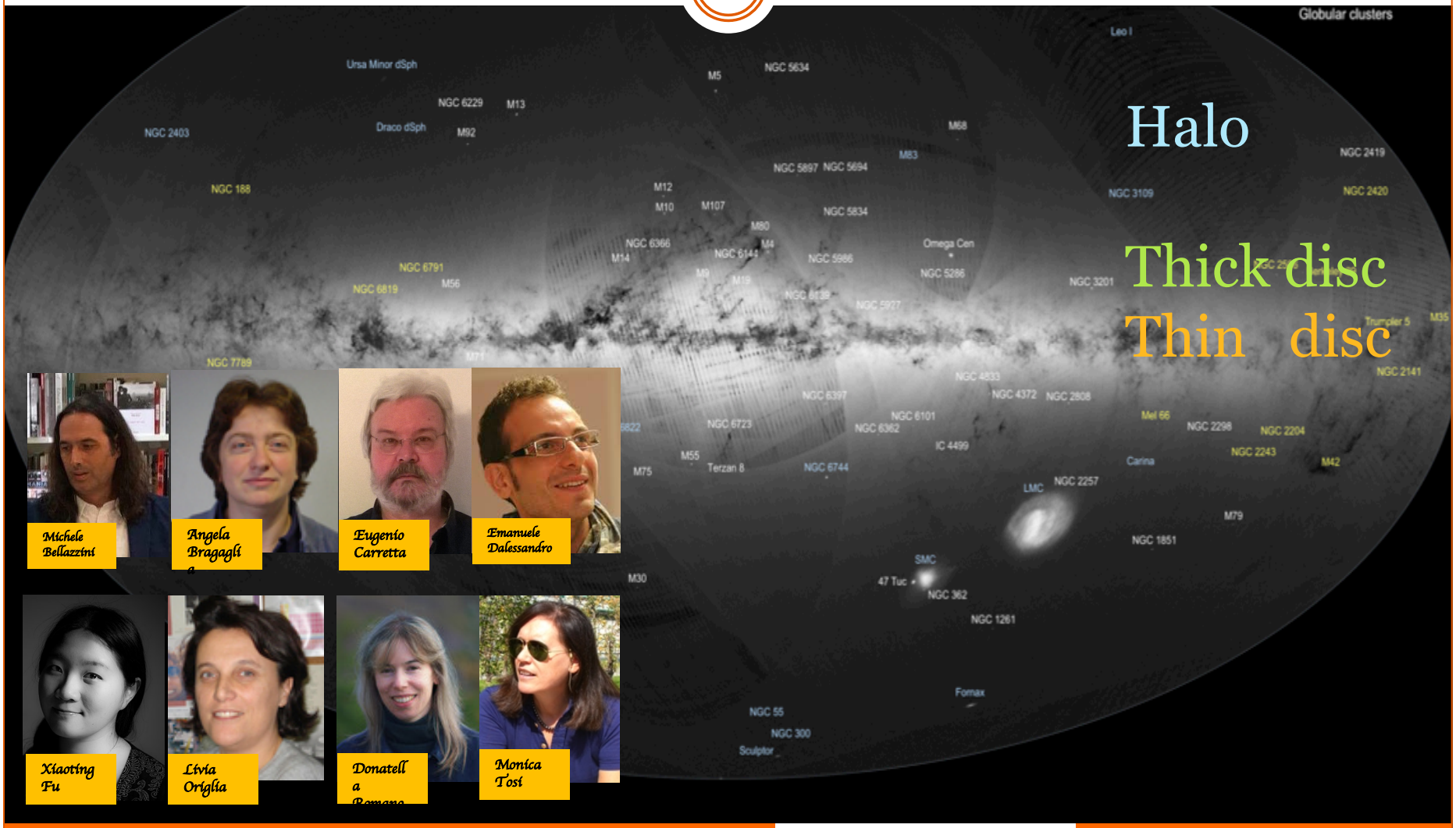
➔ add metallicity, detailed chemistry for as many OCs as possible

CMD in Gaia bands G, Bp, Rp colored by membership probability based on 5-d Gaia solution



A. Bragaglia (PI), E. Carretta, X. Fu & INAF-PD, INAF-CT, INAF-AA & Barcelona U. & Bordeaux U.

Chemo-dynamical tomography of the MW



Good & bad

The SCIENTIFIC present and future are good :
we leave in a "golden age" : Gaia, large surveys (Gaia-ESO, WEAVE, LSST…), modern instruments, modern computing and modeling

HOWEVER

- We are too few to fully exploit all this plenty (staff, PhD, Postdoc needed)
  - ➔ Our community needs to grow in number (& in coordination)
  - ➔ New positions for stellar populations (at large)

- We are not fully geared-up (staff, but in part also PhD & post-doc)
  - ➔ We need to invest in "big data", "astrostatistics" and the like
    (e.g. INAF could fund PhD positions –as INFN, IIT, CINECA, Golinelli- https://www.unibo.it/it/didattica/dottorati/2017-2018/data-science-and-computation)

- We need (stable) financial support
  - ➔ PRIN INAF, MIUR, PREMIALI, international fundings
  - ➔ support to surveys, LPs