Milky Way Stellar populations: Gaia, WEAVE, LSST

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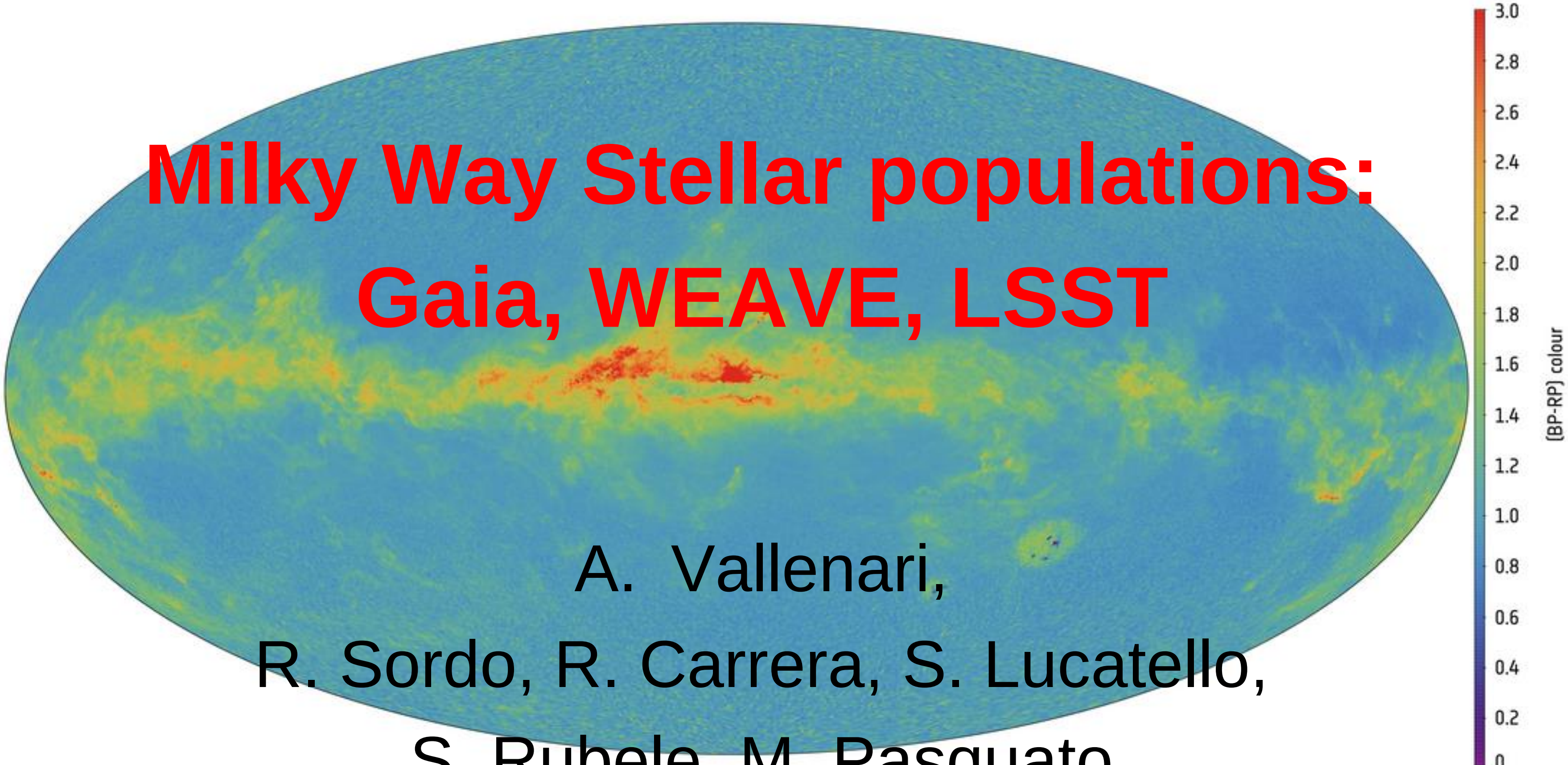

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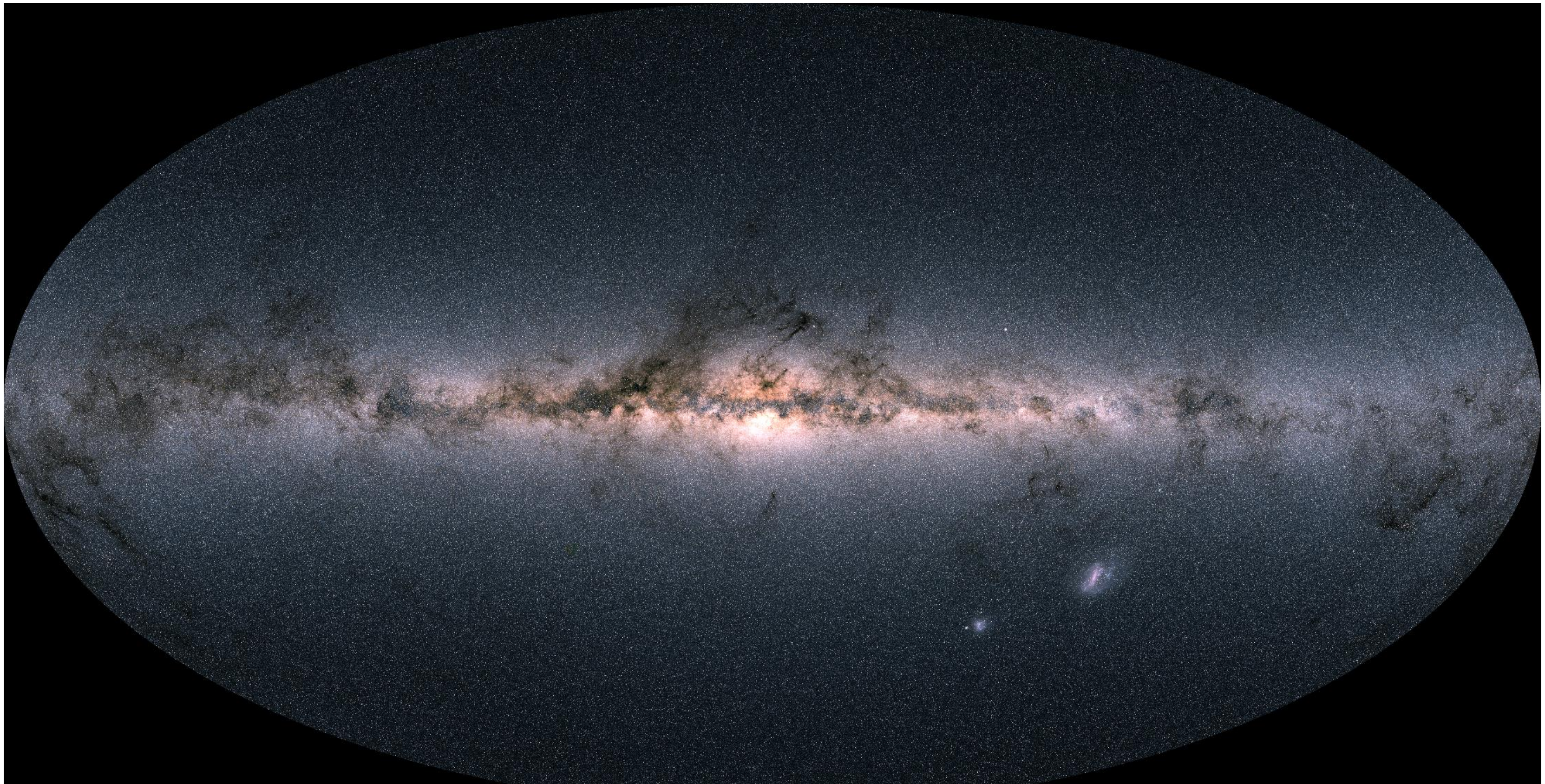
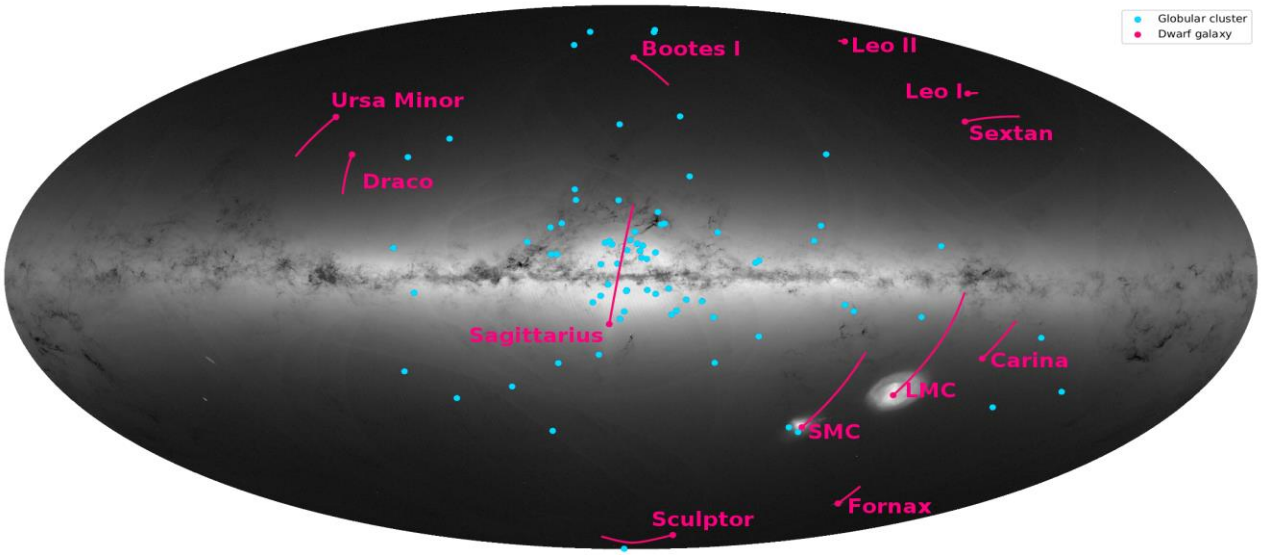
The Big Questions

- How was the Milky Way assembled and how did it evolve?
- the formation of the sub-galactic structures in the Milky Way
  - Chemo-dynamical evolution of the sub-galactic structures
  - the formation and chemo-dynamical evolution of stellar clusters
  - the star formation history in the MW

Observables: parallax, velocities, M, L, Teff, log g, [Fe/H], [X/Fe], age,....

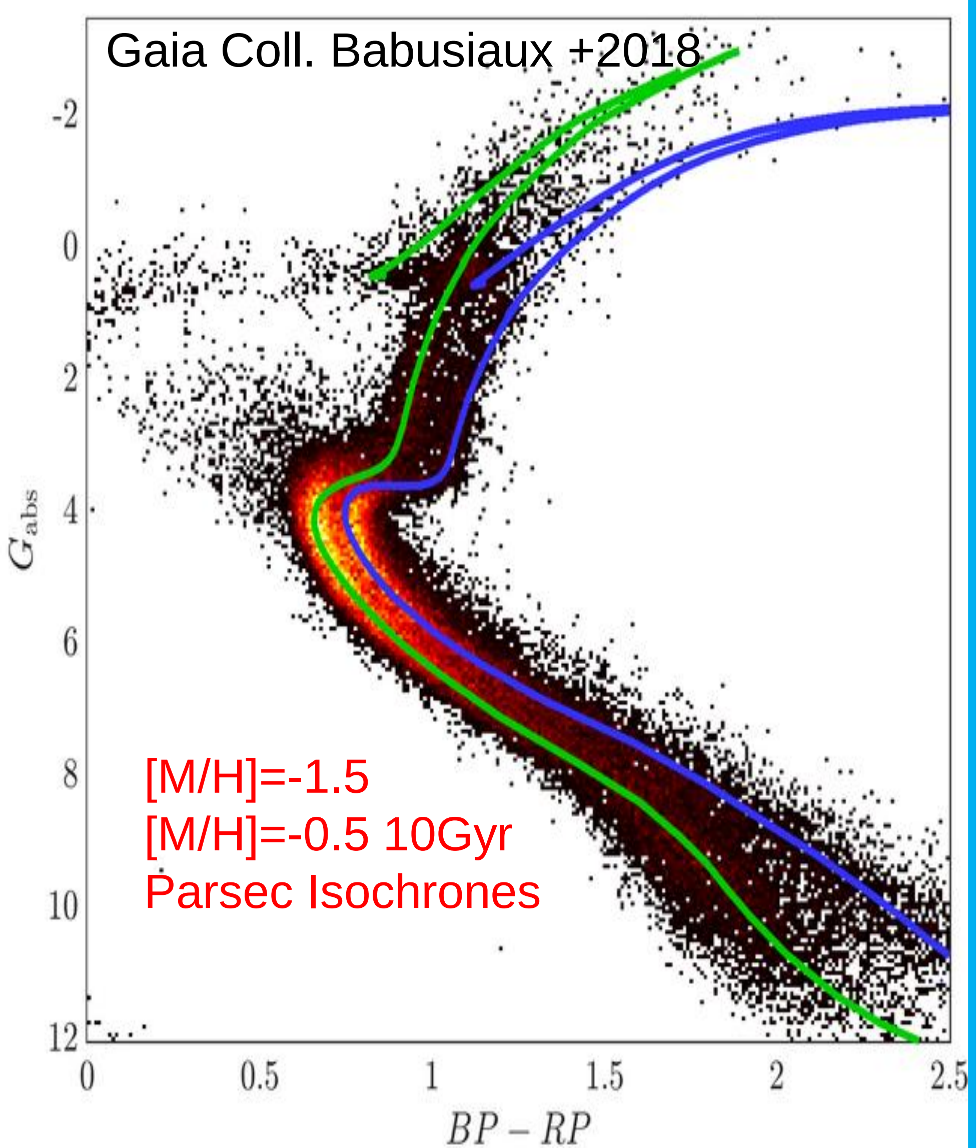


Gaia



- Brown, Vallenari et al 2018: 1600 papers from mid-2018
- Management (Deputy Chair), Validation, Simulations
- Next to come:
  - **2020 (E)DR3** –astrometry + photometry
  - 2021 DR3 –Vrad, classification, variables, minor planets, binaries, Mean Spectra
  - 2024 (?) DR4
  - **2028 (?) final Data Release**
- Overall gain in precision: factors 1.2 (DR3) and 1.7 (DR4) with respect to DR2
- proper motions improve by factors 1.9 and 4.5 with respect to DR2
- improvements by factors 2.3 in overall precision and 12.7 in proper motions for 10 year mission with respect to DR2 + gain in accuracy

Gaia DR2 new view of the Halo

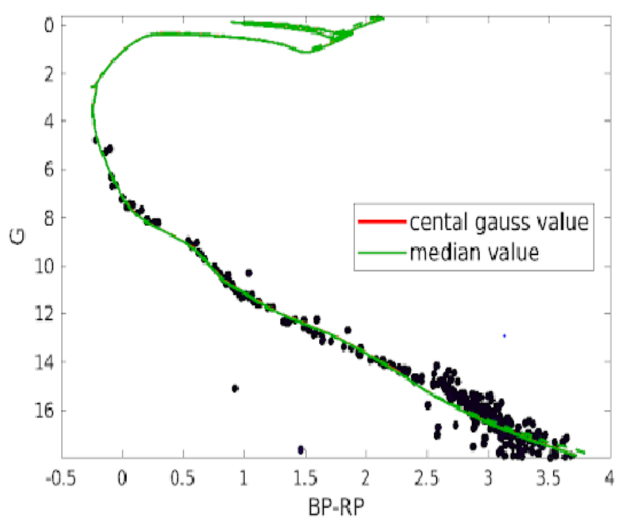


- Kinematically selected halo stars having [Fe/H] > -1 (Bonaca +2017)
- Local Halo merging history from TGAS+ RAVE (Helmi 2017, Myeong+2017
- Accretion events with DR2 found in the halo using a variety of data (Belokurov et al. 2018; Myeong et al. 2018a,b; Deason et al. 2018; Kruijssen et al 2018,Koppelman+ 2018, Lancaster+2018…)
- Haywood +2018: using Nissen &Schuster metallicity confirm that red sequence is thick disk
- Gaia Sausage/Enceladus retrograde stars are on the blue sequence(Helmi+2018)

Gaia view of OCs

- About 3000 Ocs (Kharchenko+2013, Cantat+2018, 2019,)
- Less than 10% of Ocs have high R spectroscopy(Netopil2017, Smiljanic 2018, Magrini 2017)
  - [FE/H] uncertainty : up to 0.2-0.3 dex (Friel+2010, Heiter+2014, Netopil+2016
- Distances for 1200 Ocs (Cantat-Gaudin, Jordi, Vallenari+ 2018)
  - 84% of Ocs have uncertainty <5% on parallaxes;
  - 94% of Ocs have uncertainty < 10% on parallaxes
- Radial velocities for 800 Ocs at 30% have σ<1.2km/s (Soubiran+2018) 50% based on 3 stars
- Age: 40%-50% (Netopil+2016) for the majority
- Age at 13% for 279 Ocs (Bossini, Vallenari+2019) with error budget depending from [FE/H]

Bossini, Vallenari +2019



1.2 km/s

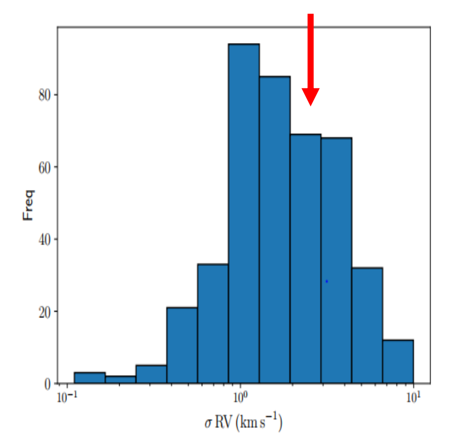


Fig. 3. Histogram of the RV standard deviation, in log scale, for the OCs with at least 3 members

Soubiran+2018

Cluster Formation: Vela OB2

The Vela OB2 association is a group of young stars (~10 Myr) located around the massive star Gamma Velorum. It was shown recently (Jeffries et al. 2014) that it is made up of not one but two overlaping groups of stars.

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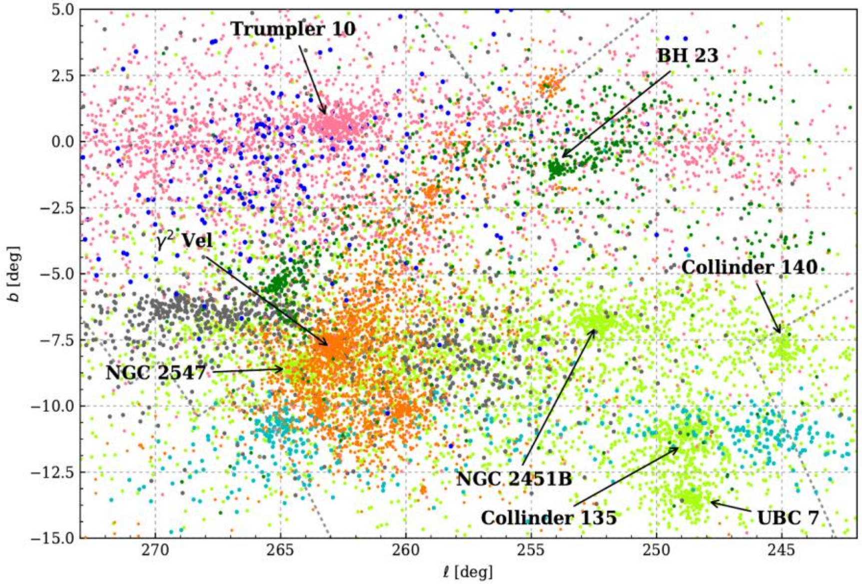
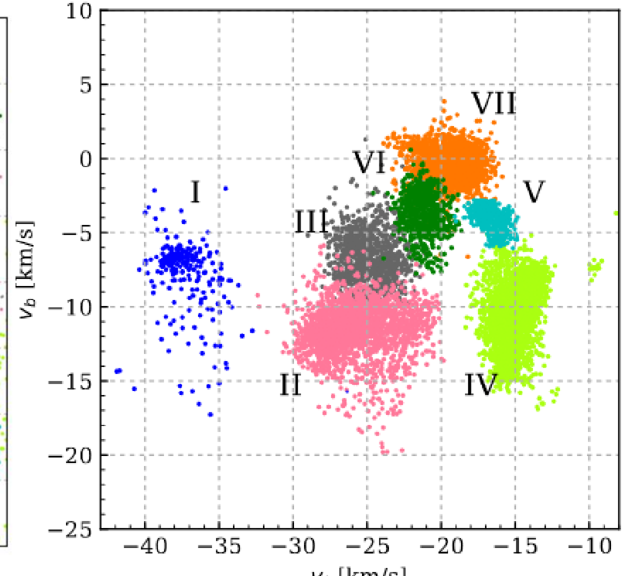
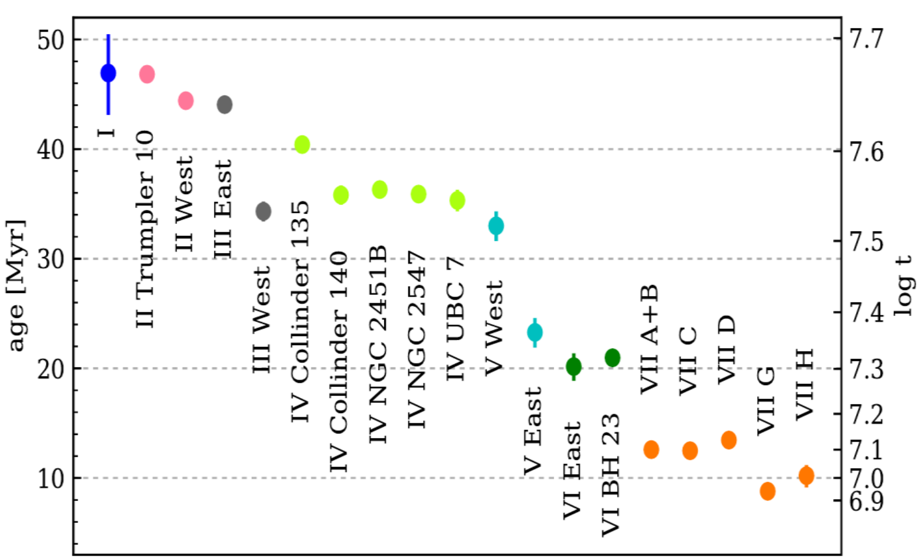
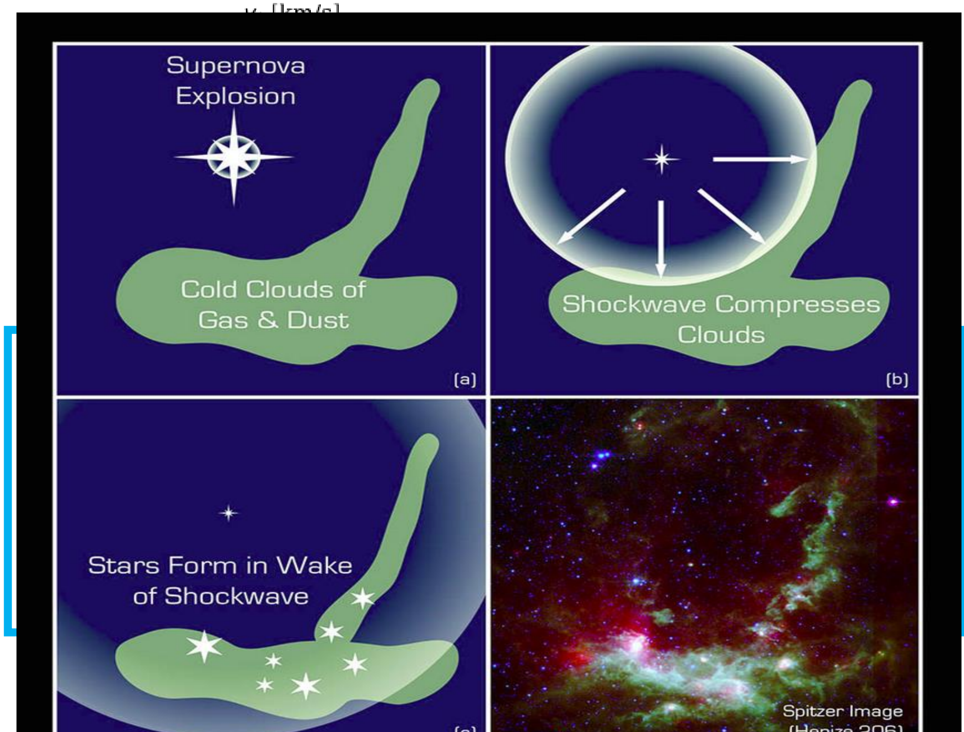
Cluster formation : Vela-Puppis



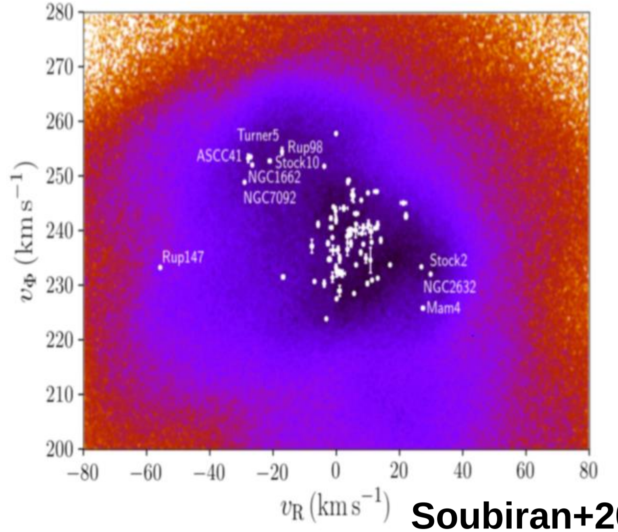


Cantat+2019



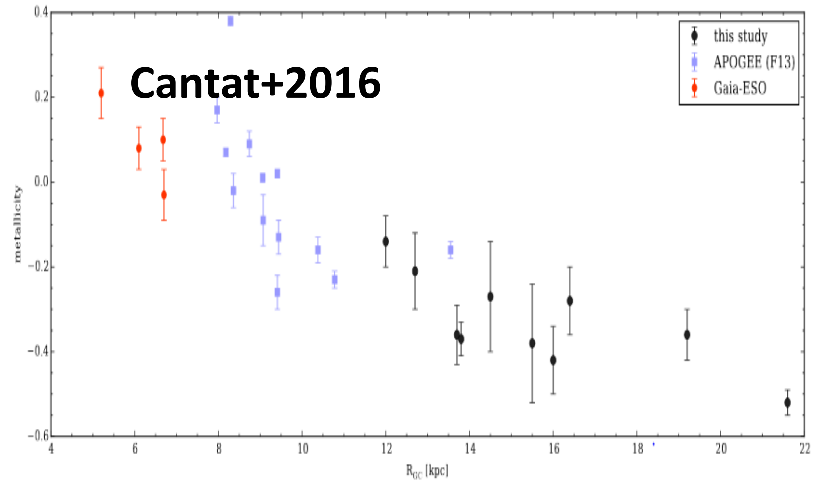


Clusters as disk tracers



Soubiran+2018

Fig. 8. Velocity distribution of nearby OCs (dist ≤ 500 pc) in (V_R, V_ϕ),



- Can we put further constraints on stellar physics to safely use stars as fossils for the Galactic formation and evolution?

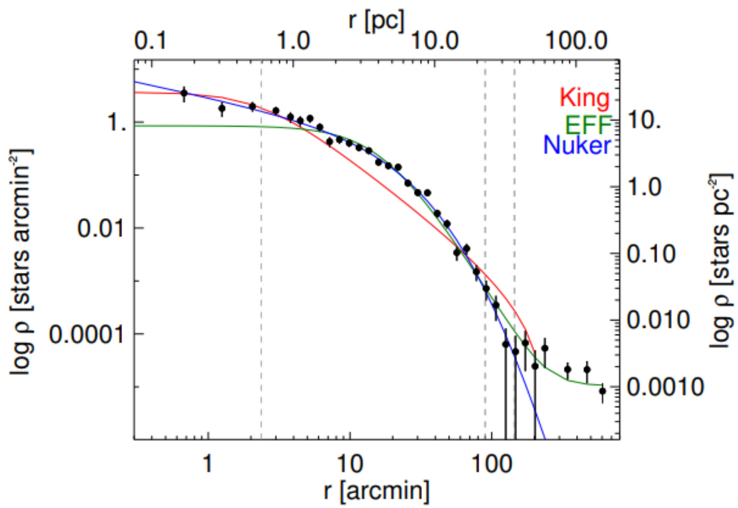
- What is the chemical evolution traced by the open clusters? (Magrini+ 2010, Jacobson+2016 Cantat+2016, Donati+2012, Bossini+2018, Carrera+2018, Carrera+2019)

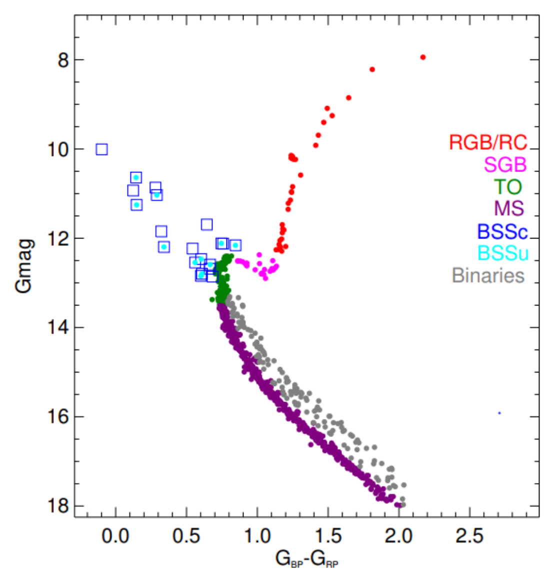
- How OCs trace the kinematics and dynamics and structure of the disks? (Soubiran+ 2018)

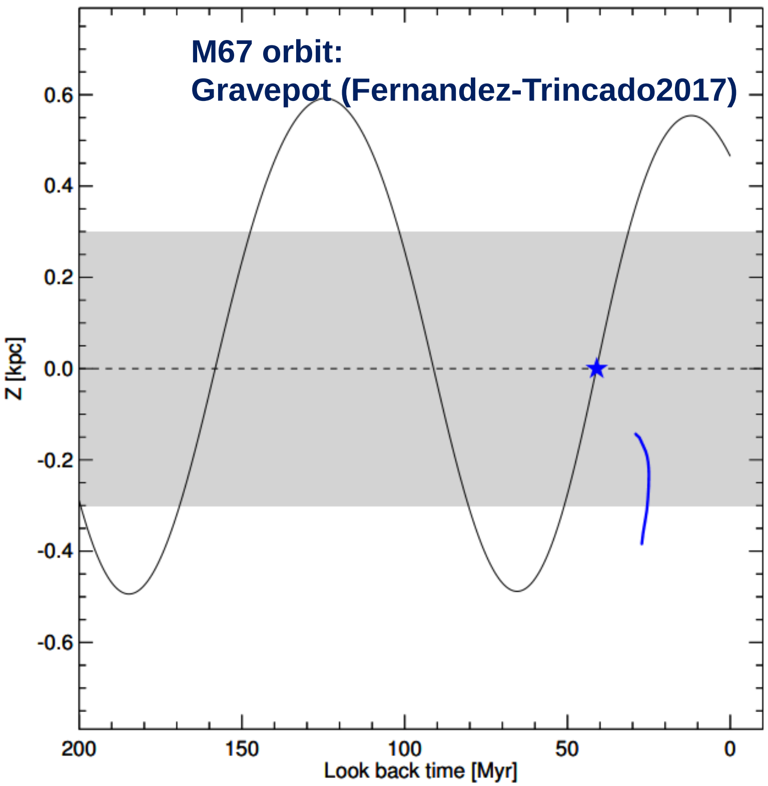
How do Ocs populate the field? M67

- M67 mass segregation(Hurley 2005)
- Current mass 2 × 10^3 Mo
- Previous determination: M67 up to 16 pc (Gao+2018)
- Membership done using UPMASK (Cantat+2018) + Clusterix (Balaguer+2017)
- Bayesian distance determination of the single stars
- M67 extends up to 200’ (50 pc) exceeding the Hill sphere
- The extra-tidal stars in M67 may originate from external perturbations such as disk shocking
- Last disk crossing 40 Myr ago

M67 , 3.6 Gyr, 860 pc-Carrera, Spera+2019







3 passages in 200 Myr
Relaxation time with no mass loss 300 Myr(Hurley 2005)
Continuously disturbed by disk shocking
Expansion of virial radius of $\delta R/R \approx \delta E/E \approx 0.3.$

M67 , 3.6 Gyr, 860 pc
blue (direction of the observer)
red (velocity-Soubiran(2018))

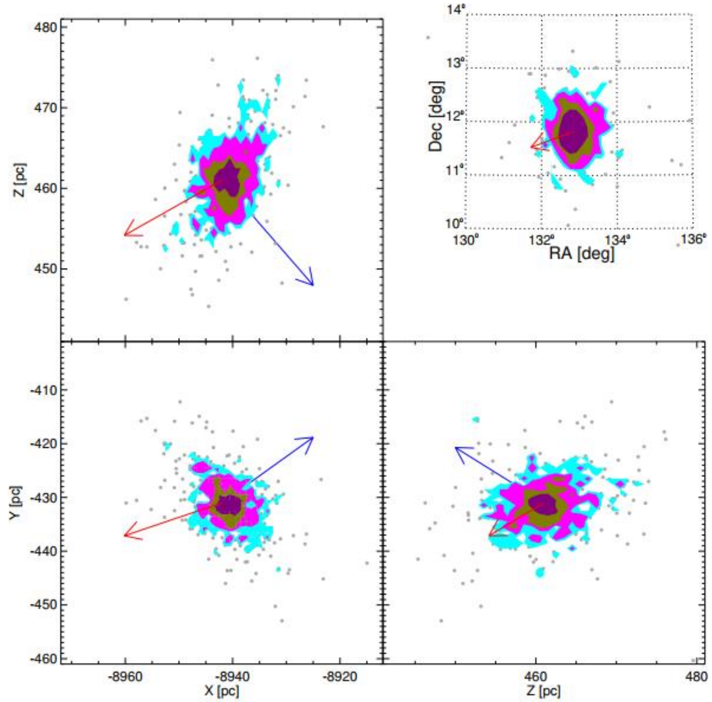
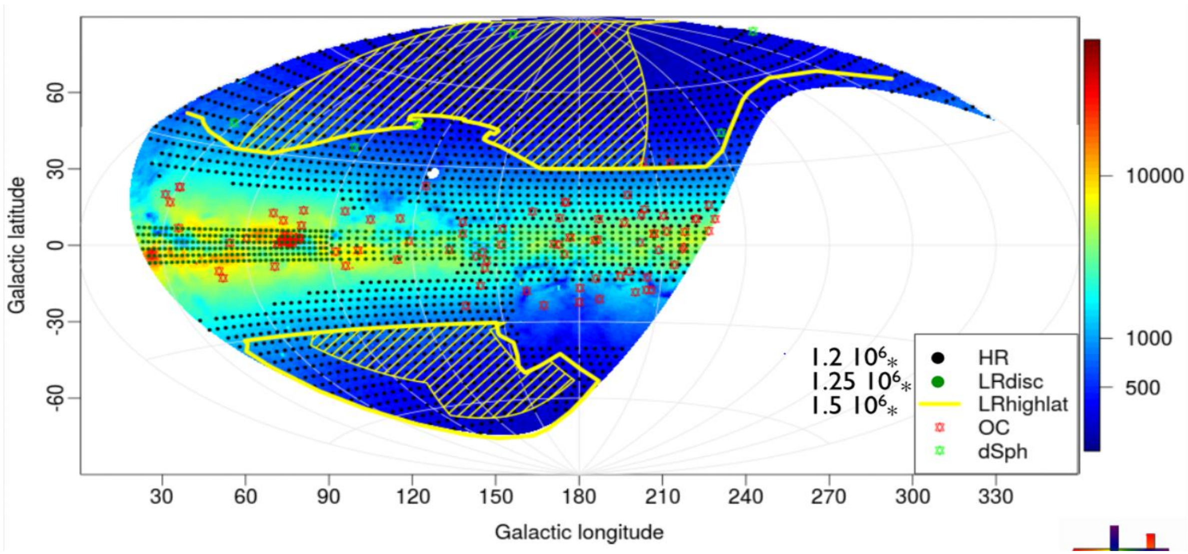
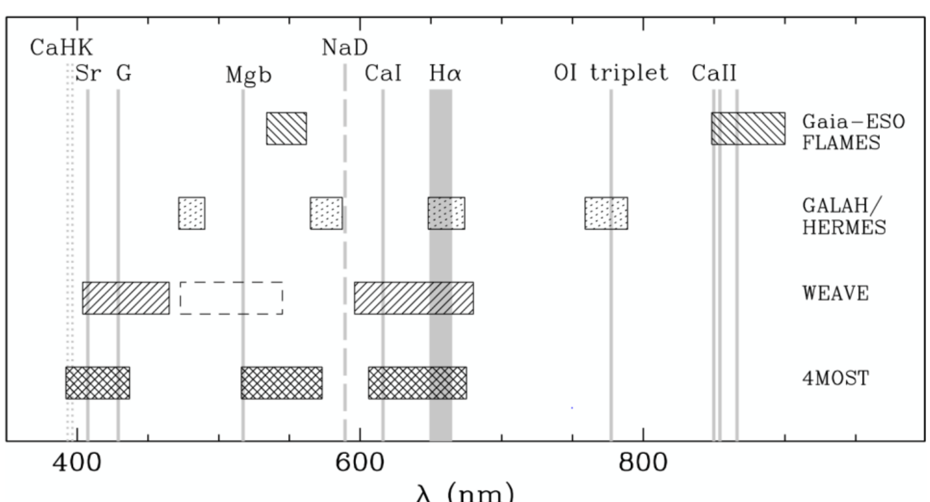


Fig. 4. Position of the M67 members in the Galactic Cartesian coordinates. Contours show different stellar densities. Red arrows are proportional to the velocities in each axis derived by Soubiran et al. (2018). Blue arrows show the direction to the observer.

WEAVE-4MOST synergie



WEAVE - GA ~3-4 million stars to unravel the MW history !



Feltzing 2018

- OCS WEAVE Survey (PI: A.Vallenari)
- About 200 targets
- Large field: Disruption of open clusters
  - chemical tagging of young clusters in the field
- OCs as tracers of the Galactic disc and of its chemical evolution
- 4MOST (2023): 1500 Ocs visible from South
- 300,000 stars G<15.5 HR
- 400,000 stars G<18 LR

→ Science case/target selection revision based on new Gaia DR2 data

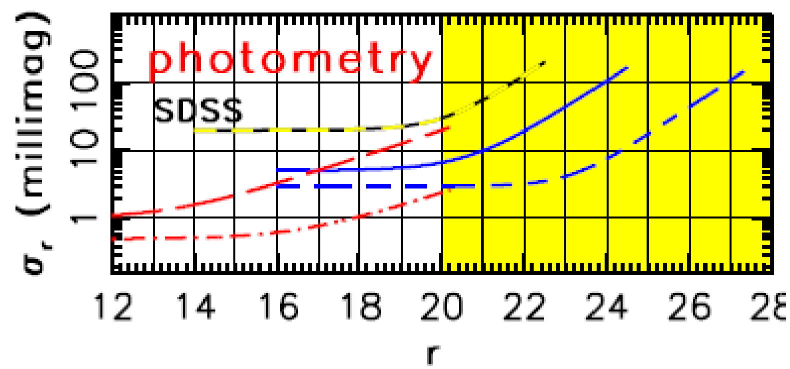
Gaia-LSST

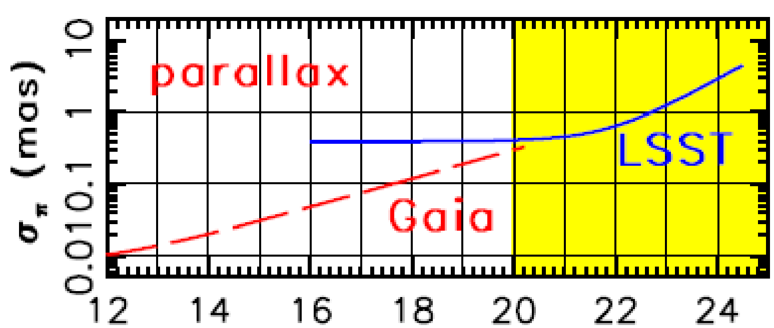
LSST Science Book: **http://ls.st/sb**

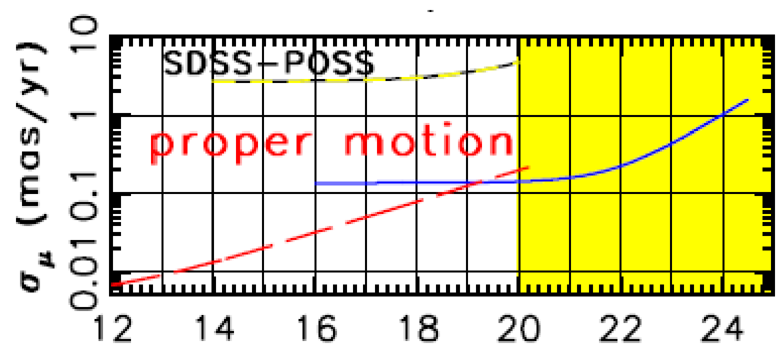
Gaia: **http://sci.esa.int/gaia**

Table 6.6: Adopted Gaia and LSST Performance

Quantity	Gaia	LSST
Sky Coverage	whole sky	half sky
Mean number of epochs	70 over 5 yrs	1000 over 10 yrs
Mean number of observations	320[a] over 5 yrs	1000[b] over 10 yrs
Wavelength Coverage	320–1050 nm	*ugrizy*
Depth per visit (5σ, r band)	20	24.5; 27.5[c]
Bright limit (r band)	6	16-17
Point Spread Function (arcsec)	0.14×0.4	0.70 FWHM
Pixel count (Gigapix)	1.0	3.2
Syst. Photometric Err. (mag)	0.001, 0.0005[d]	0.005, 0.003[e]
Syst. Parallax Err. (mas)	0.007[f]	0.40[f]
Syst. Prop. Mot. Err. (mas/yr)	0.004	0.14







- MS at turnoff Mr=4.5 detected by Gaia at 10 Kpc, by LSST at 100Kpc (24.5)
- Gaia (G=20.7, 2 Billion objects) –LSST (r=27,10 billions objects) relation
- coherent view of the Galaxy from 3 to 24 mag

Conclusions

- We are just at the beginning of the scientific exploitation of Gaia
- WEAVE, 4MOST, LSST are complements to Gaia and present and upcoming surveys with a strong legacy value