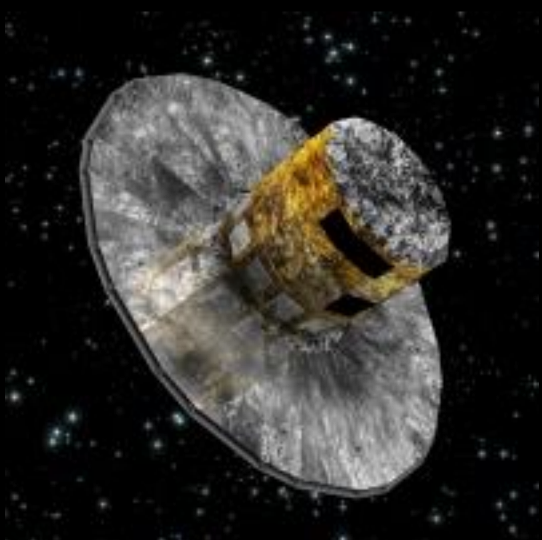
A Gaia-DR2 view of the Open Cluster population in the Milky Way



Tristan Cantat-Gaudin

Encuentros en la segunda fase: Gaia-DR2
28-30 May 2018, Barcelona

ICCUB

Universitat de Barcelona

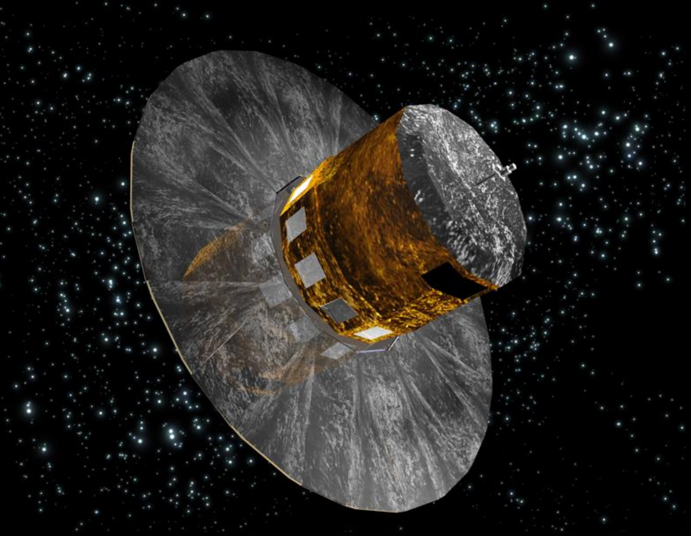

Messier 74

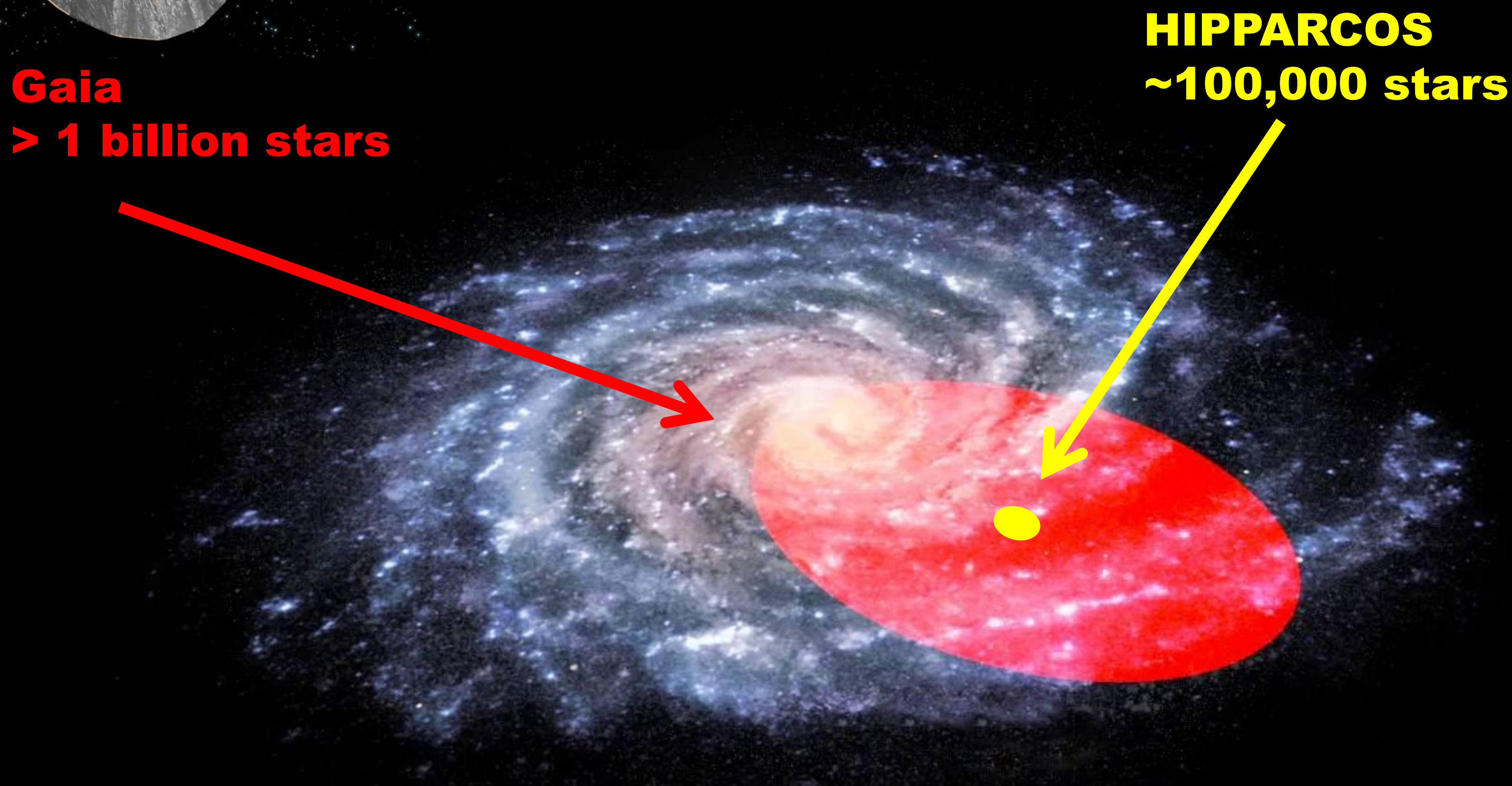

NGC 6814

Andromeda (Messier 31)


We are here.
We need tracers in order to reconstruct the shape of the Milky Way!

HIPPARCOS revolutionised our understanding of the solar neighbourhood.
Gaia will be 100 times more precise than HIPPARCOS.
It also reaches 10,000 times more sources, probing all components of the Milky Way.





(Gaia actually sees bright sources as far as the Magellanic clouds)

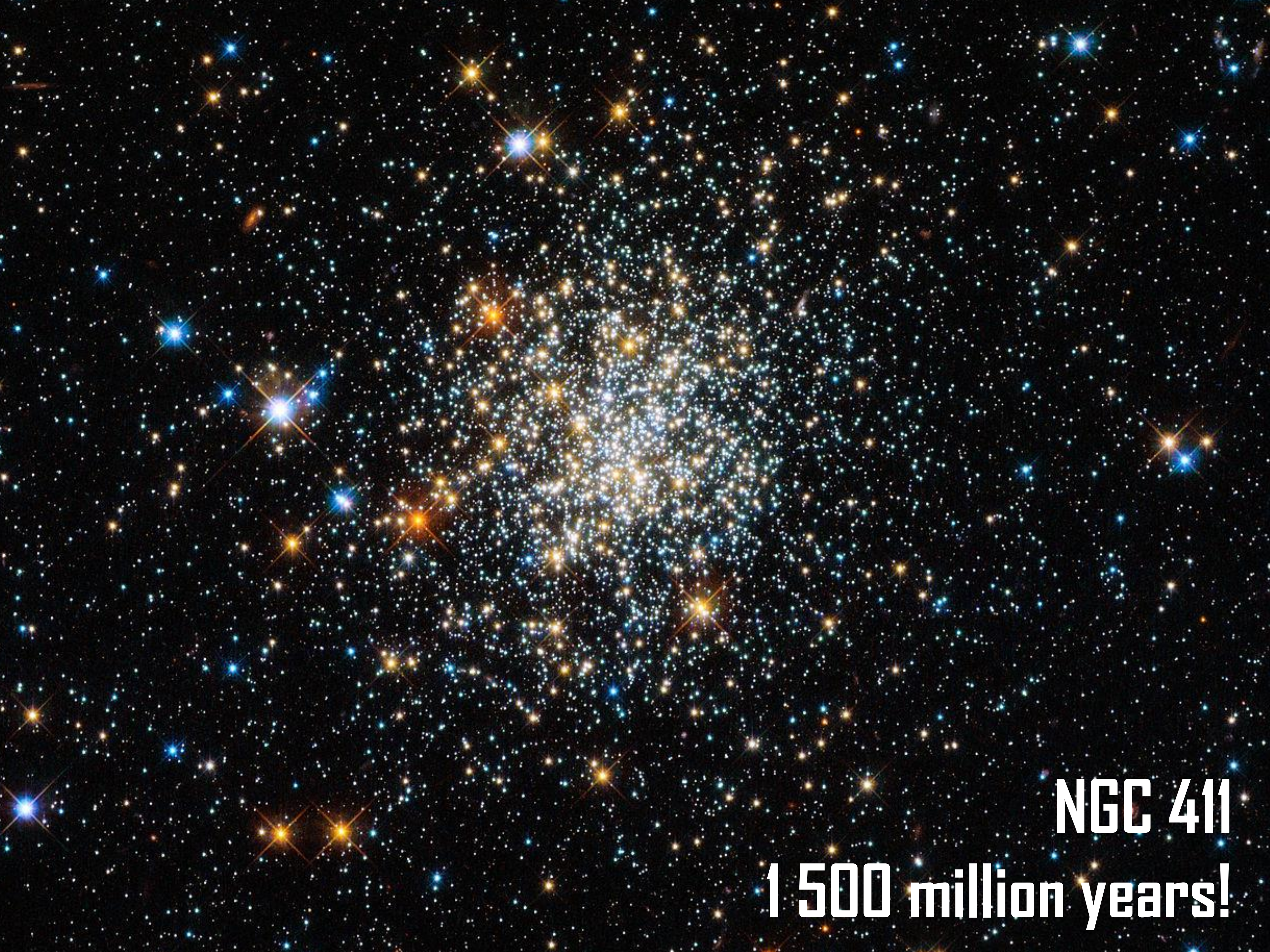
Working definition of an open cluster

Open clusters are groups of stars born together, from the same gas cloud. All stars within a cluster are the **same age**, and have the **same chemical composition**.


NGC 604
star formation


NGC 3293
8 million years


NGC 4755 (« the Jewel Box »)
16 million years


NGC 411
1 500 million years!

Working definition of an open cluster

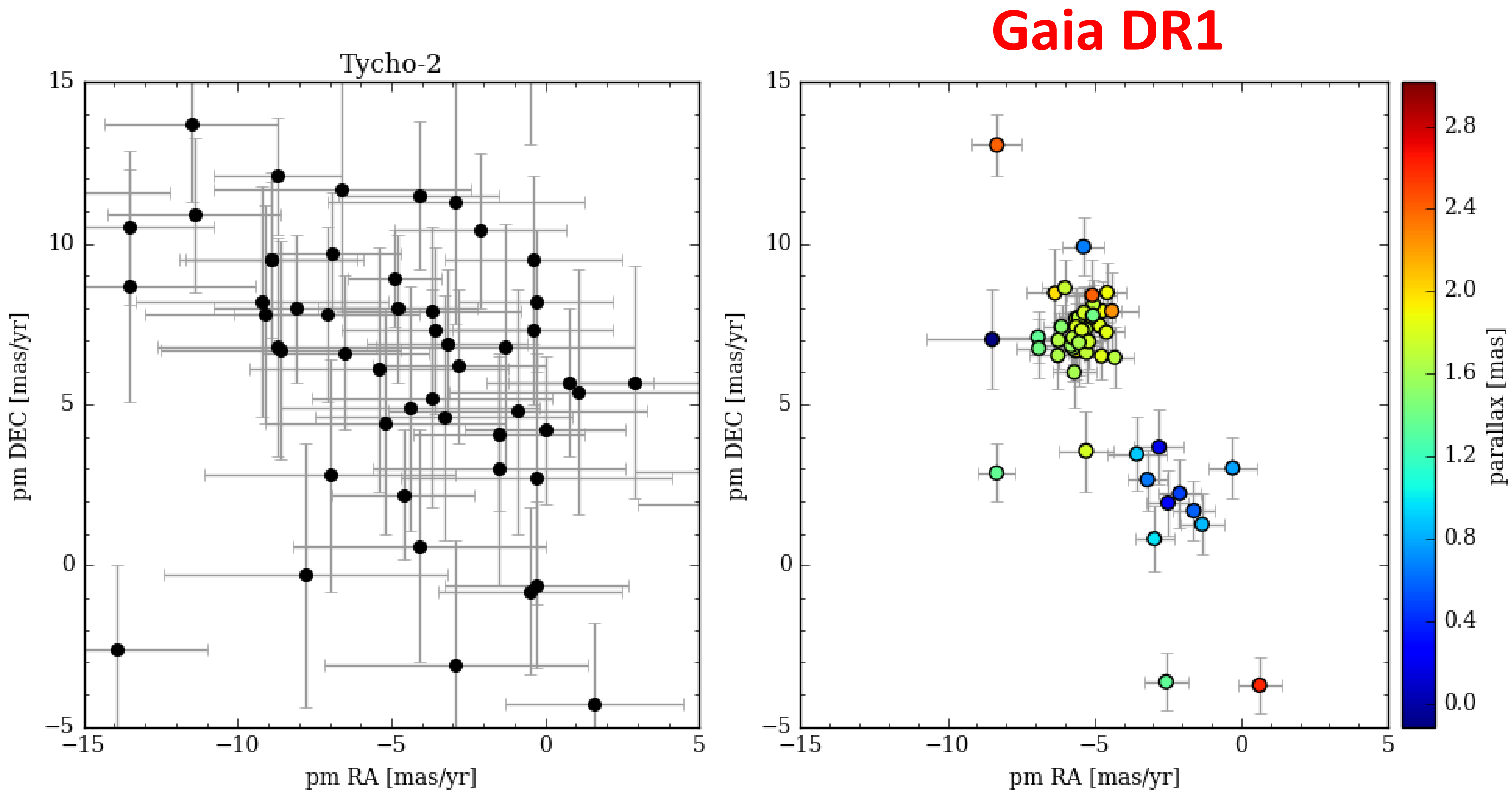
Open clusters are groups of stars born together, from the same gas cloud. All stars within a cluster are the **same age**, and have the **same chemical composition**.

Observationally: they are stars with **common proper motions** (because they travel together) and **parallaxes** (because they are all at the same distance).

Open clusters with Gaia astrometry

A jump in precision from the previous proper motion catalogues, and DR1 brought parallaxes for the brightest stars:

NGC 2527



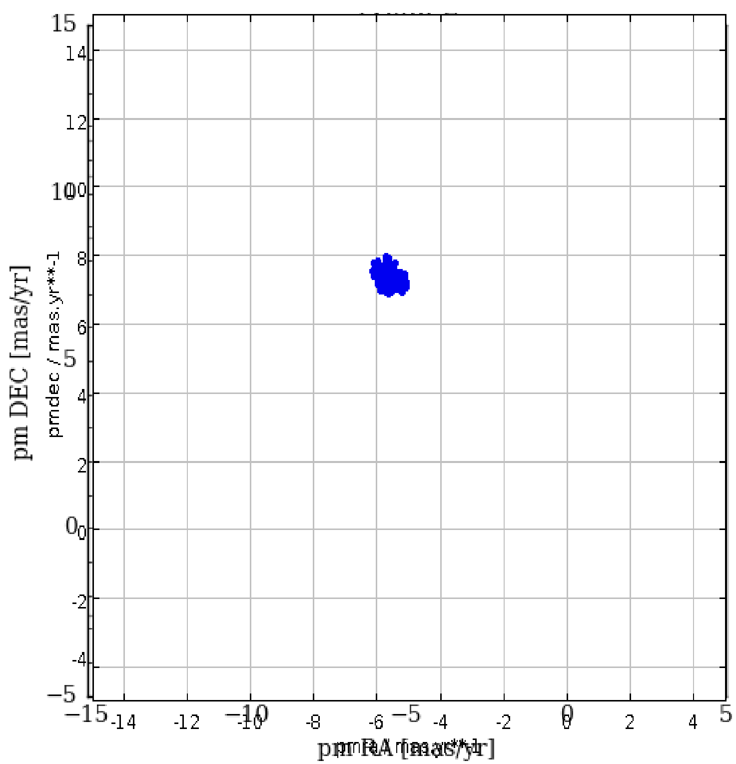
The signature of the cluster can clearly be seen as a compact group of stars with the same proper motions, and **we even have parallaxes** to estimate its distance.

Open clusters with Gaia astrometry

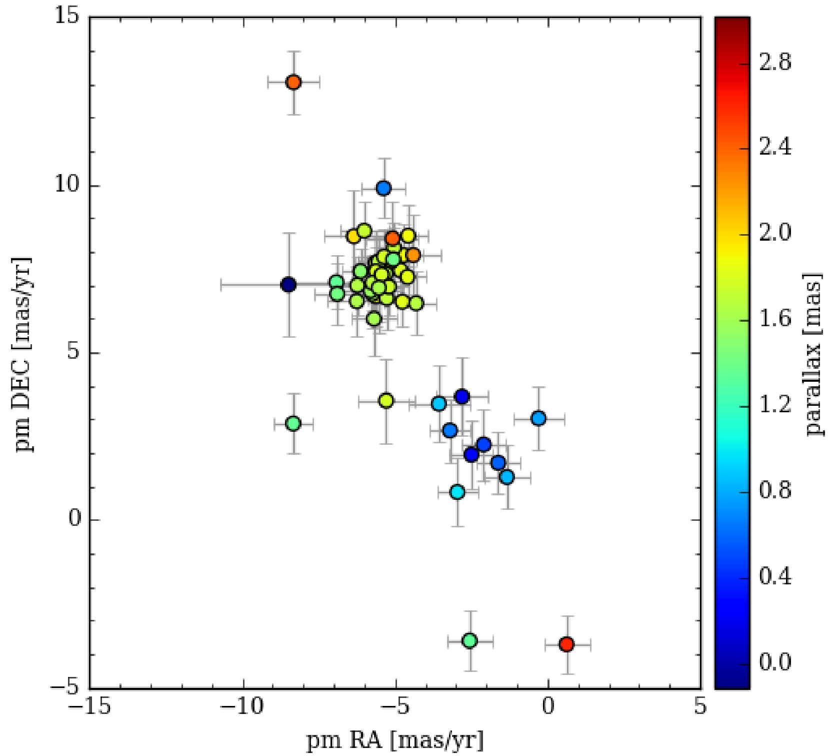
A jump in precision from the previous proper motion catalogues, and DR1 brought parallaxes for the brightest stars:

NGC 2527

Gaia DR2



Gaia DR1

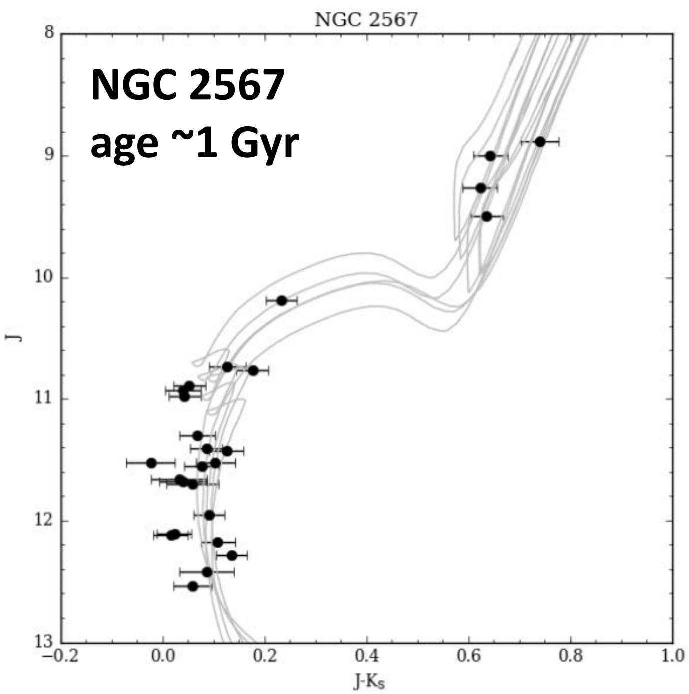


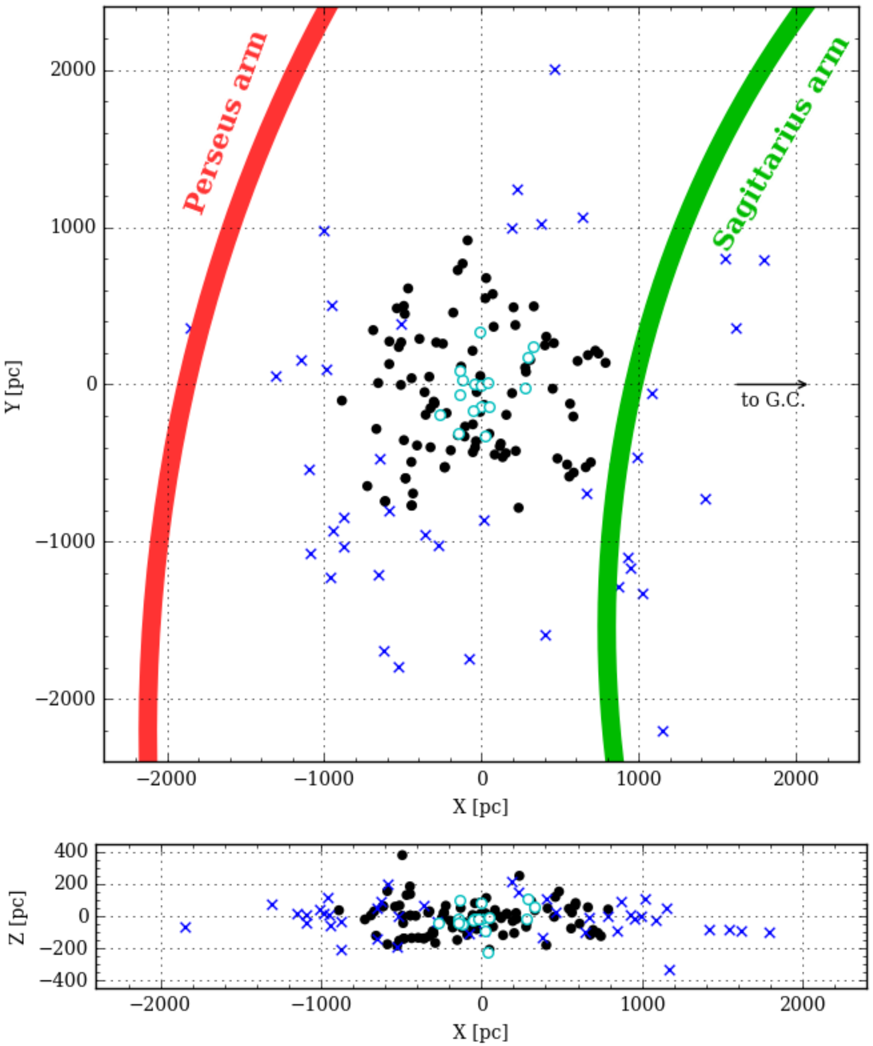
The signature of the cluster can clearly be seen as a compact group of stars with the same proper motions, and **we even have parallaxes** to estimate its distance.

Open clusters with Gaia DR1

We identified 128 open clusters from their proper motions and parallaxes in the TGAS dataset.

Selecting cluster members also allows for a better determination of cluster ages from photometry.





[Cantat-Gaudin et al. 2018a]

Open clusters with Gaia DR2

[Cantat-Gaudin et al. 2018b]

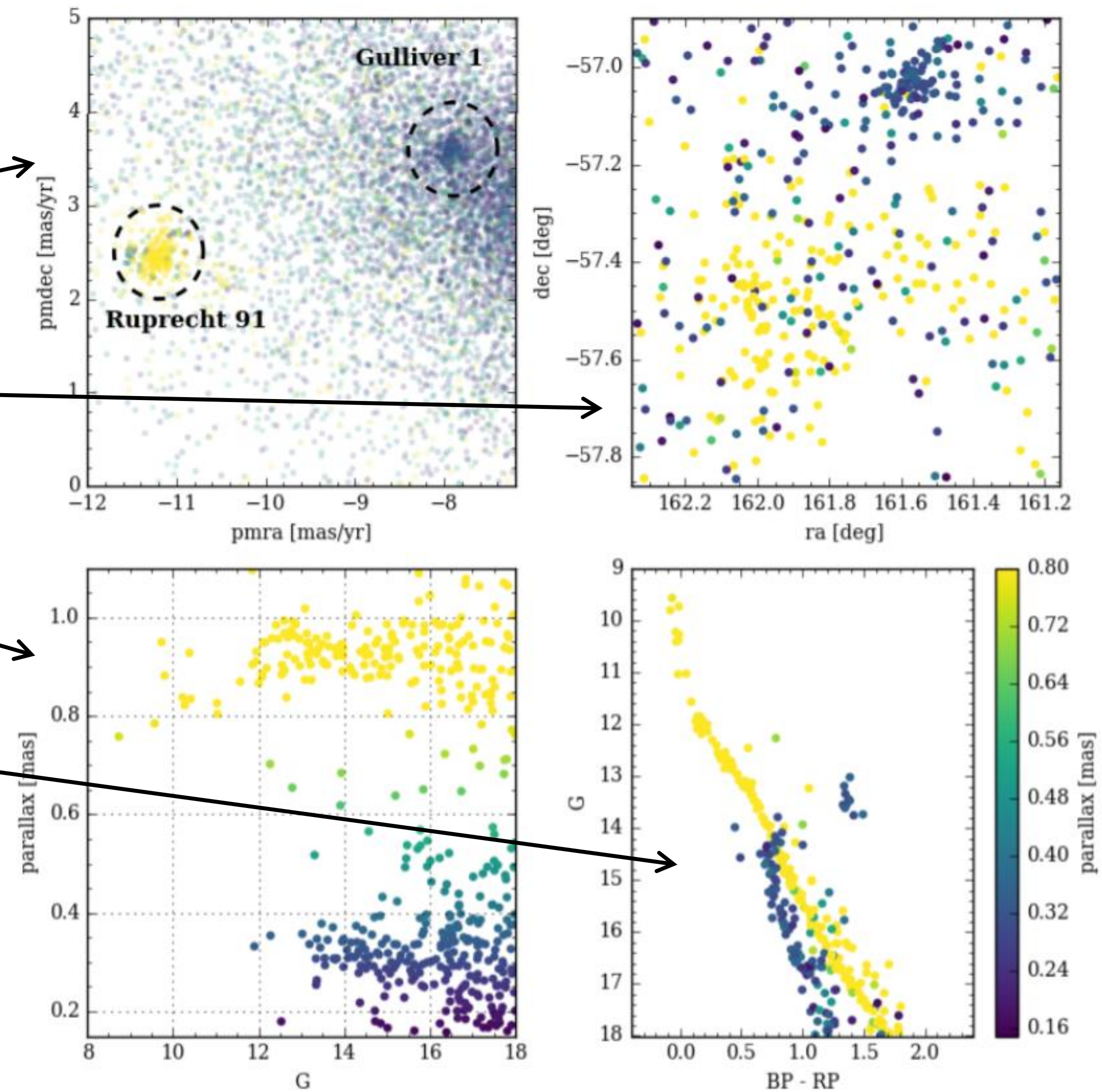
We identify OCs through:

Proper motions

Positions

Parallaxes

Photometry

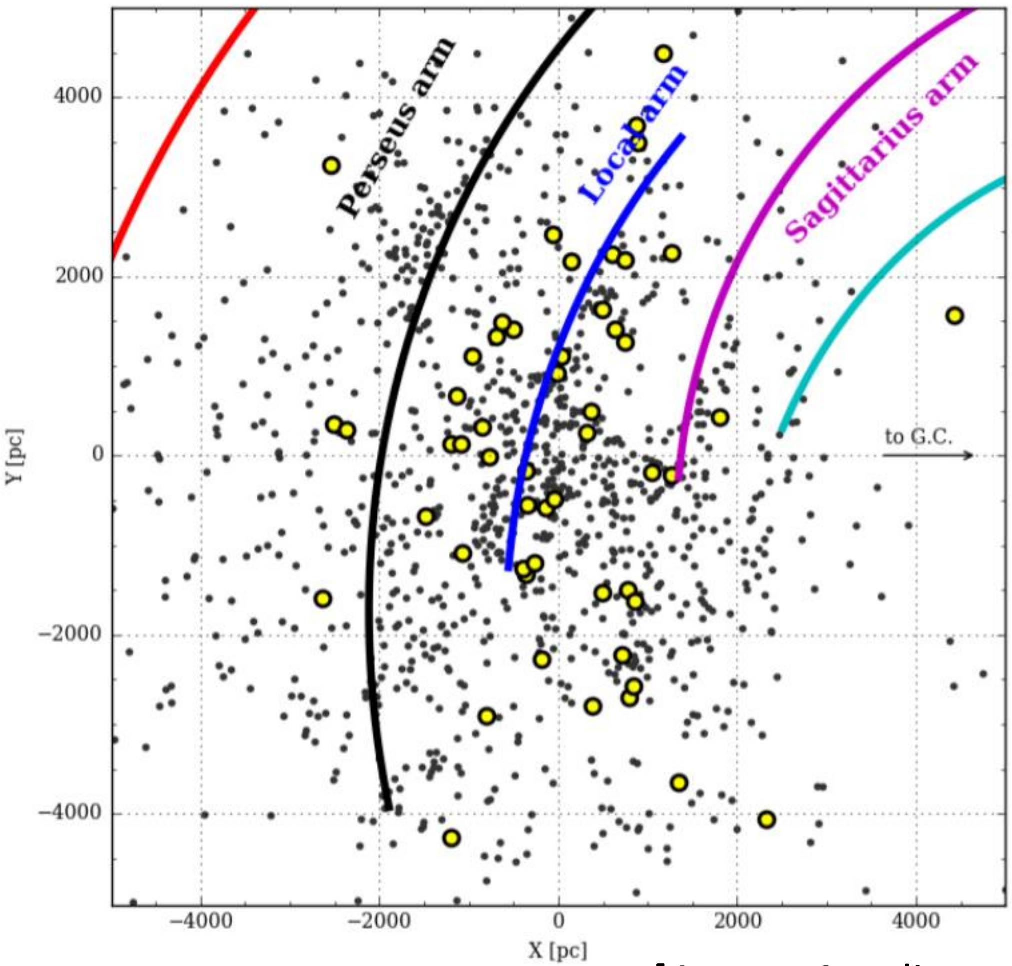


GDR2 is so good we sometimes even discovered unknown clusters « by eye » !

Open clusters with Gaia DR2

We identified over 1200 clusters (including 50 new objects!)

Obtaining distances from parallaxes through **maximum likelihood**, we can place them in 3D space.



Working with clusters I reach reasonably small fractional errors on the mean parallax. But I am still affected by local biases that cannot be corrected, only accounted for…

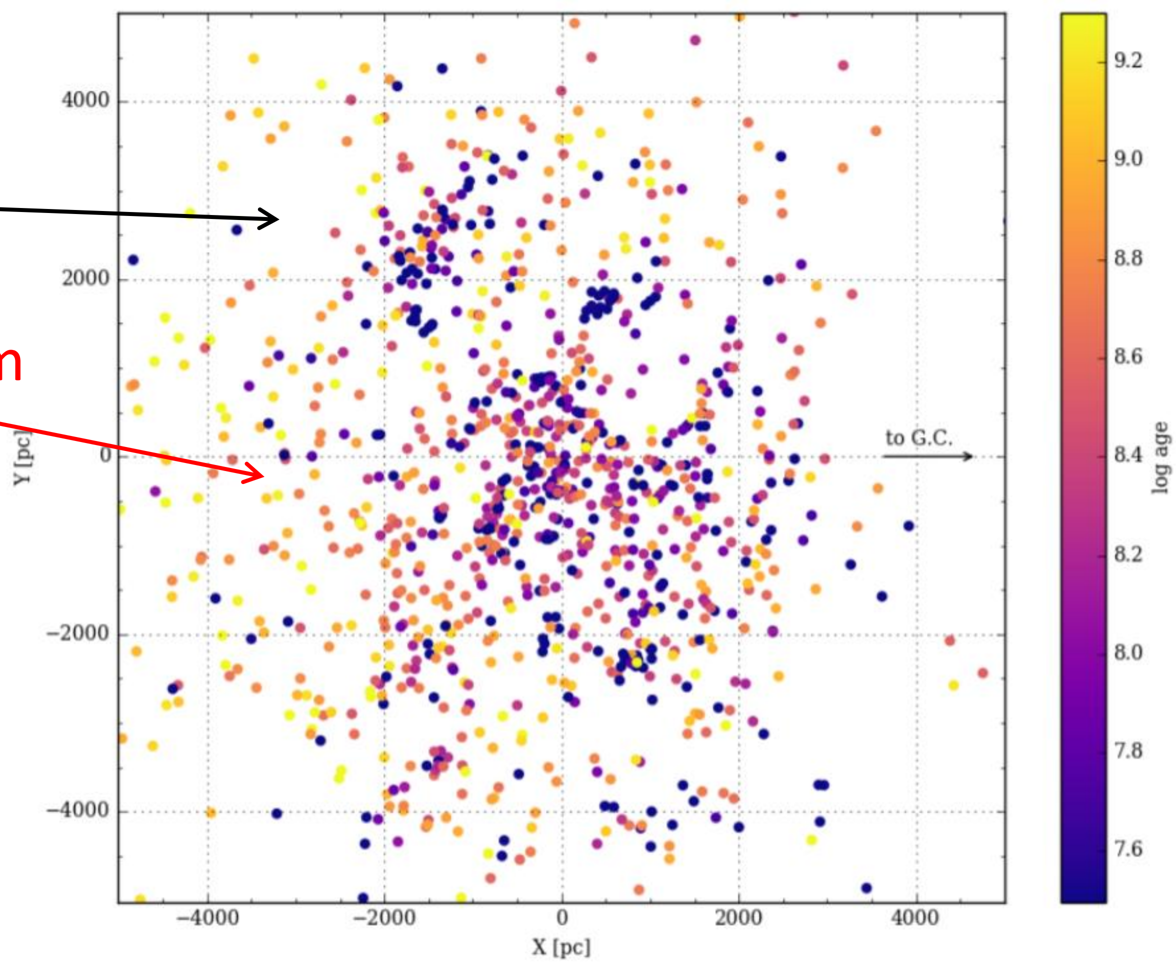
[Cantat-Gaudin et al. 2018b]

Open clusters with Gaia DR2

We identified over 1200 clusters (including 50 new objects!)

Young objects trace the spiral arms

Interrupted Perseus arm
line of sight blocked?
absence of clusters?
physical gap?



Ages taken from the literature.

[Cantat-Gaudin et al. 2018b]

Open clusters with Gaia DR2

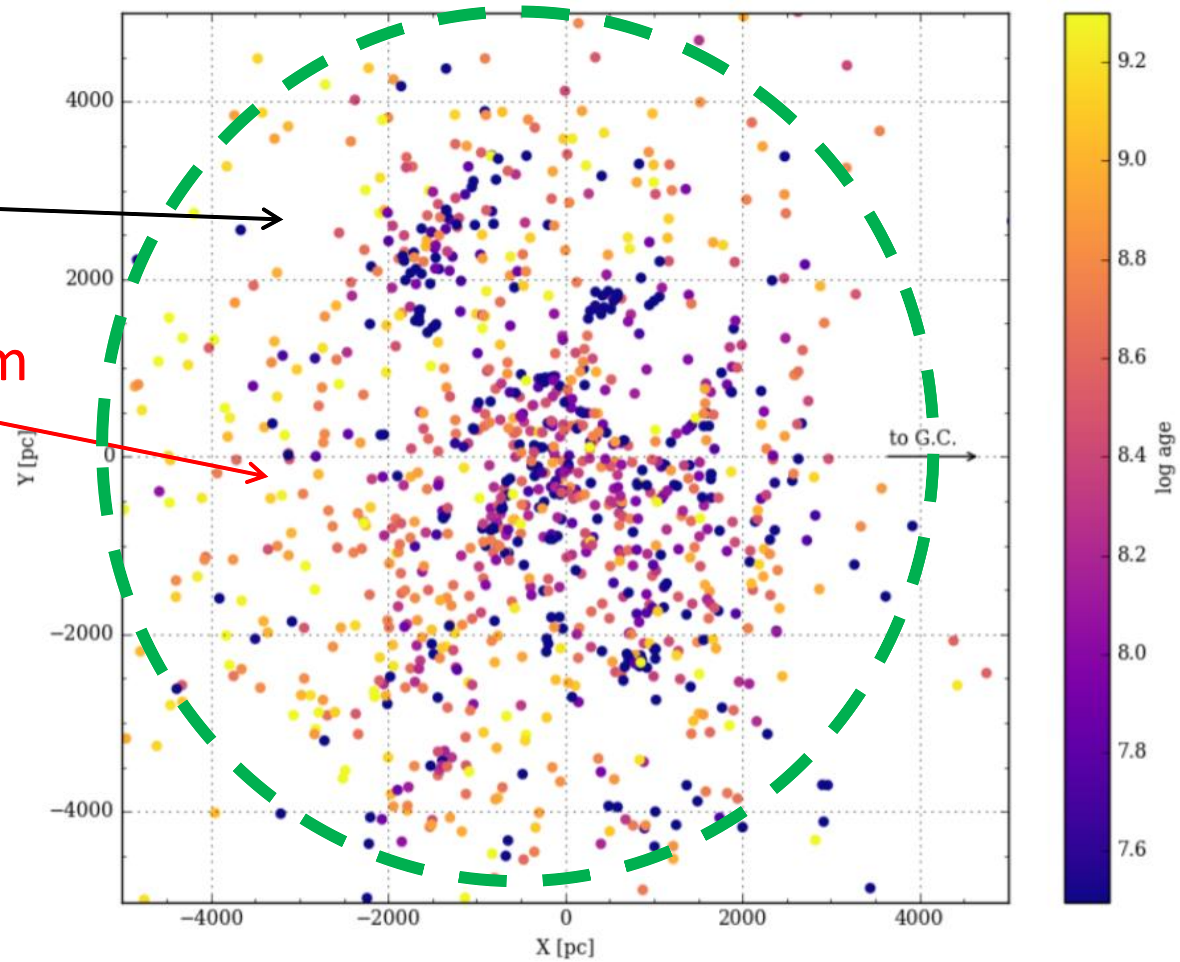
We identified over 1200 clusters (including 50 new objects!)

Young objects trace the spiral arms

Interrupted Perseus arm

Few OCs beyond 4000pc: we still need to discover them!

Ages taken from the literature.

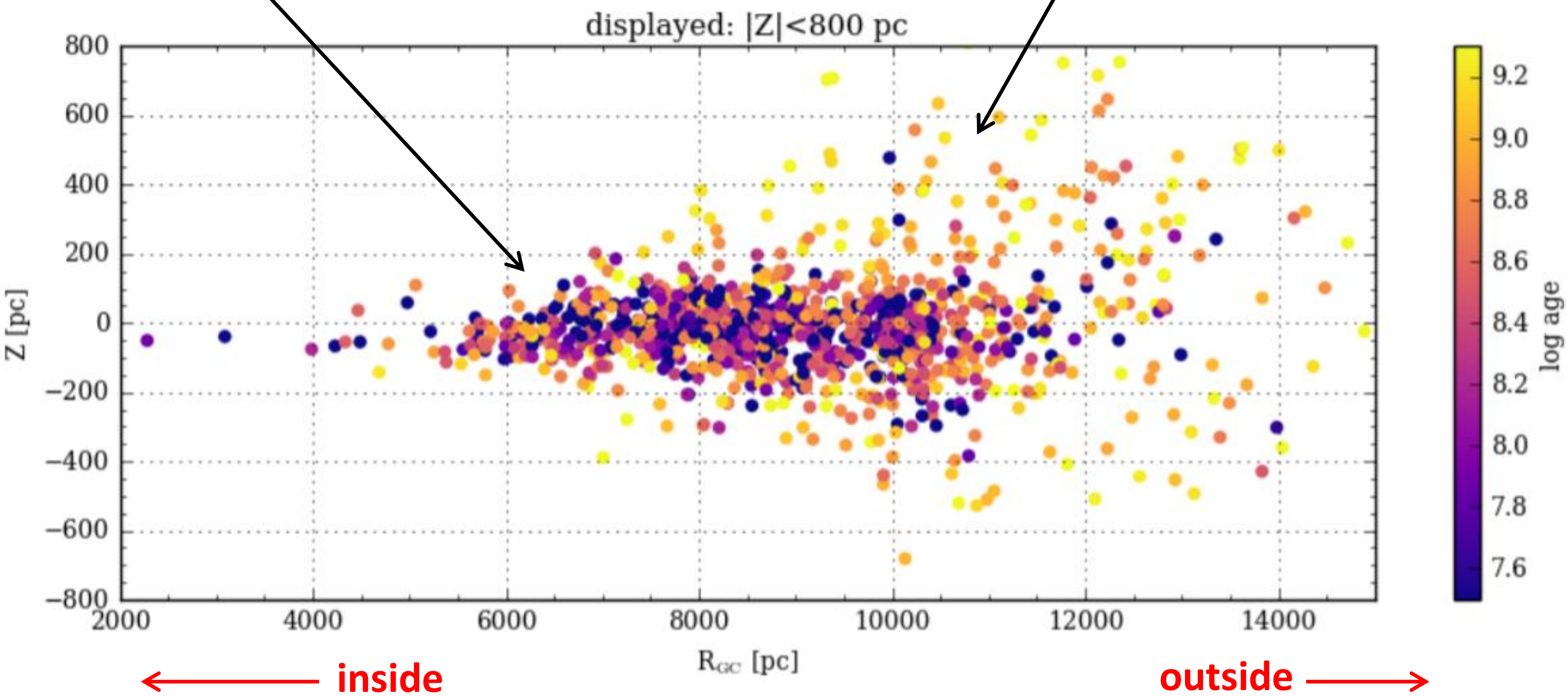


[Cantat-Gaudin et al. 2018b]

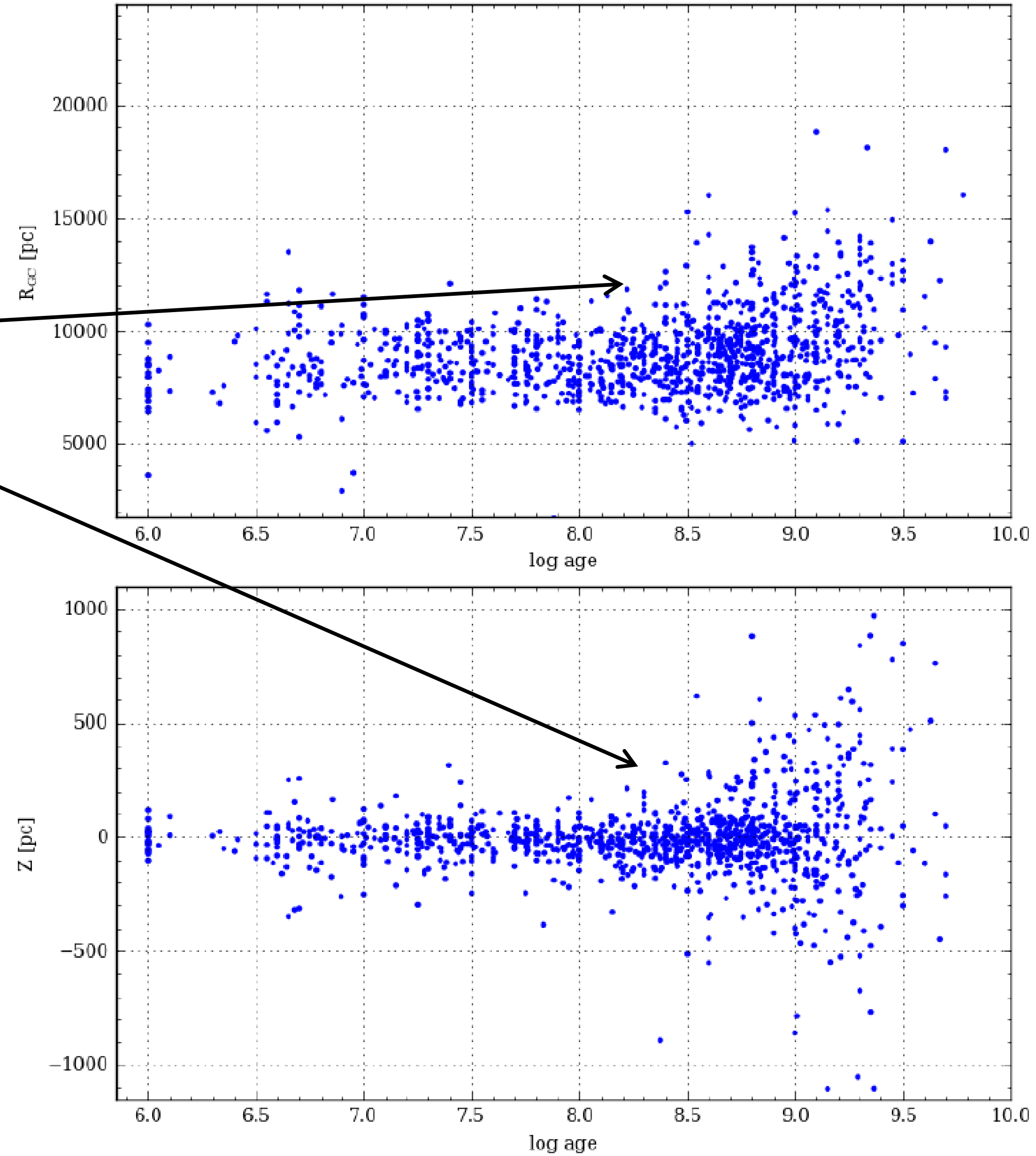
Open clusters with Gaia DR2

Young objects are close to the Galactic plane

Old clusters can be found further from the plane but not in the inner disk



log t ~ 8.5 seems to be a limit age between young and old OCs

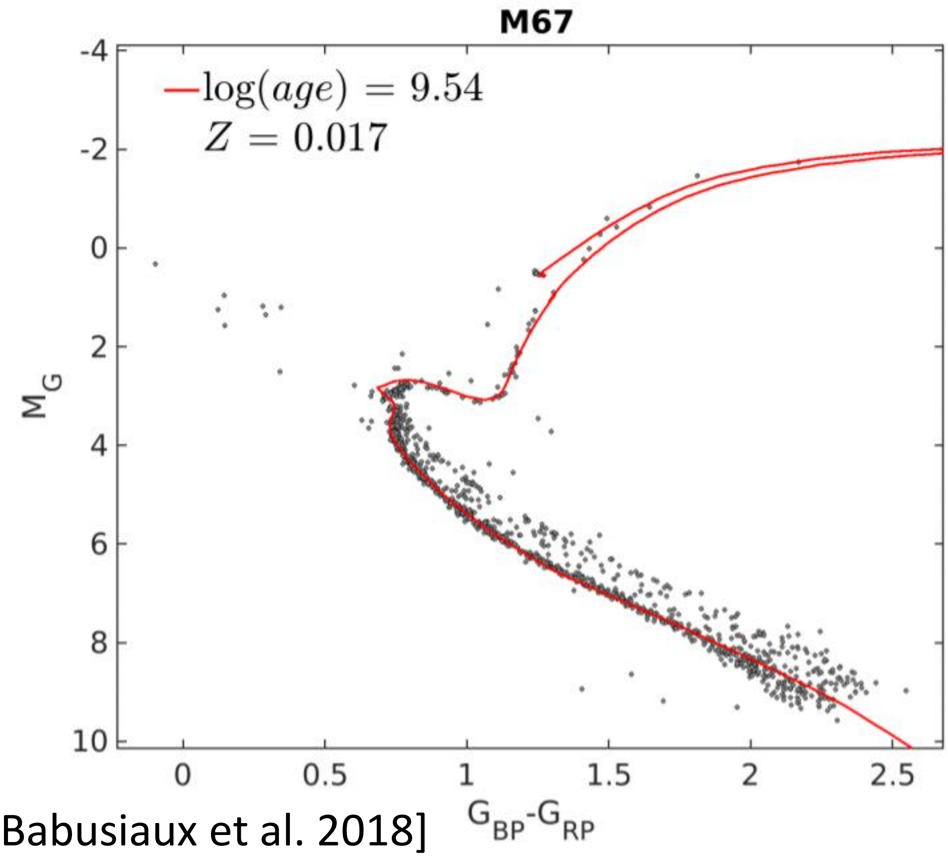


What does it tell us about the environment where clusters live?

What does it tell us about the history of the disk?

Now what?

- Homogeneously determine **ages** from GDR2 photometry. Knowing the metallicity of the cluster (from high-resolution spectroscopy) makes your age determinations even more precise.



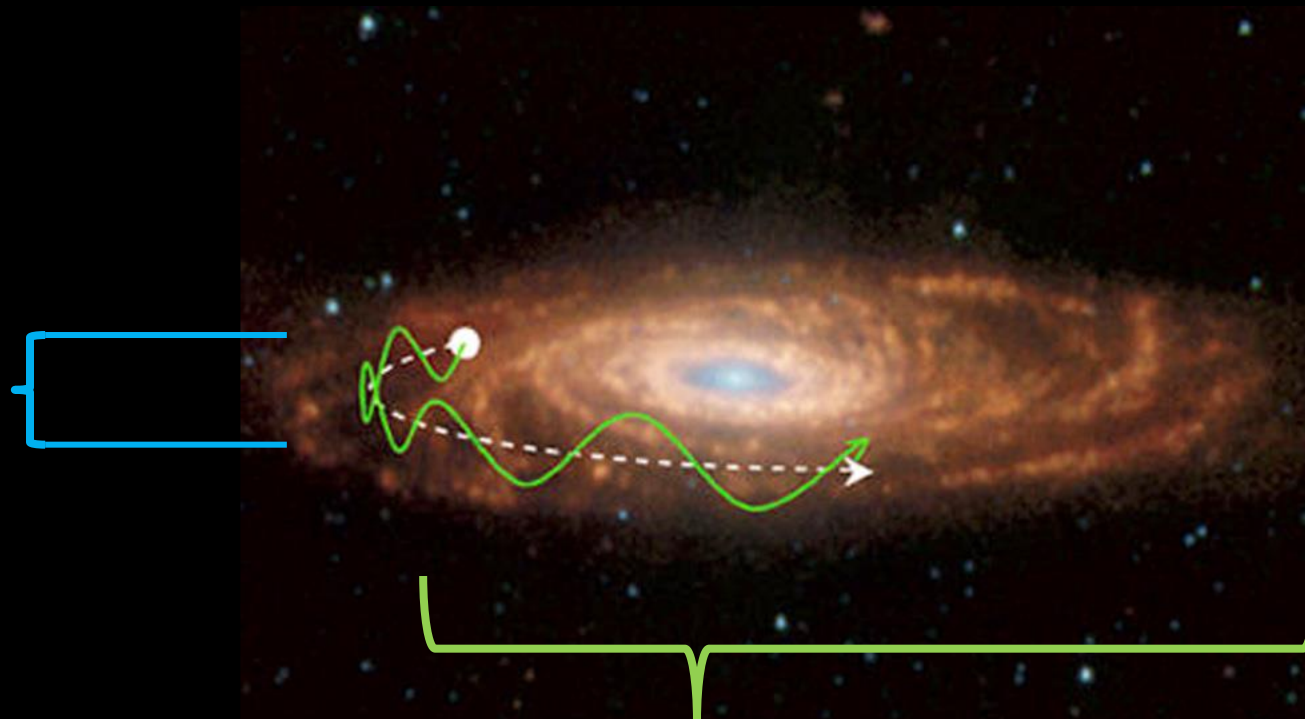
[Gaia Collaboration, C. Babusiaux et al. 2018]

Now what?

- Homogeneously determine **ages** from GDR2 photometry. Knowing the metallicity of the cluster (from high-resolution spectroscopy) makes your age determinations even more precise.

- Use GDR2 radial velocities and complementary spectroscopic data to compute **orbits**. Old and young OCs should behave differently since they are distributed differently.

If a cluster is on a perturbed orbit we can tell because of its…



To do this you need 6D information: 3D position, proper motions, and **radial velocities**.

Now what?

- Homogeneously determine **ages** from GDR2 photometry. Knowing the metallicity of the cluster (from high-resolution spectroscopy) makes your age determinations even more precise.

- Use GDR2 radial velocities and complementary spectroscopic data to compute **orbits**. Old and young OCs should behave differently since they are distributed differently.

- Use the positions and kinematics of OCs of various ages to get a better picture of the past and evolution of the Milky Way!
  Do clusters migrate a lot during their lives?
  Do the orbits of old clusters keep a fossil trace of past mergers?

Conclusion

- **Not everything can be accomplished with Gaia data alone**: ground-based observations can provide useful (or crucial) complements, in particular spectroscopy.

- Gaia data can provide useful insight to select the targets of spectroscopic surveys: **almost every aspect of cluster science can be improved with Gaia data**!