

Gaia and the large spectroscopic surveys: the New Milky Way

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The *big* question

The Milky Way



How did the Galaxy come to be like this?

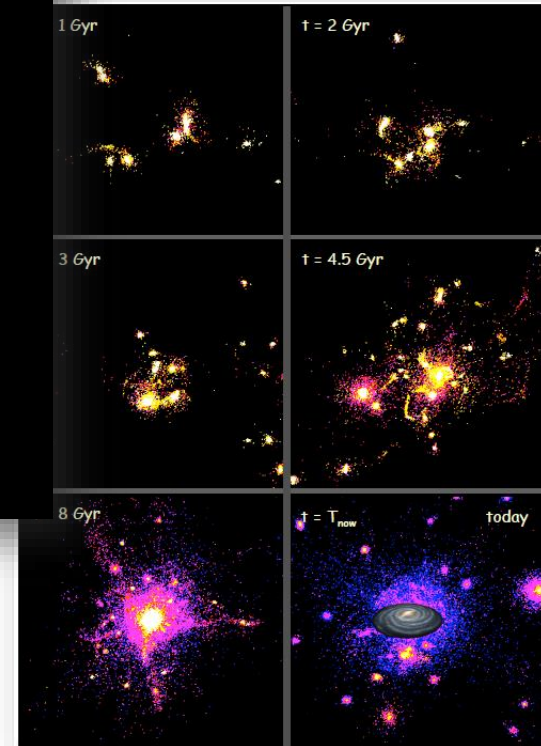
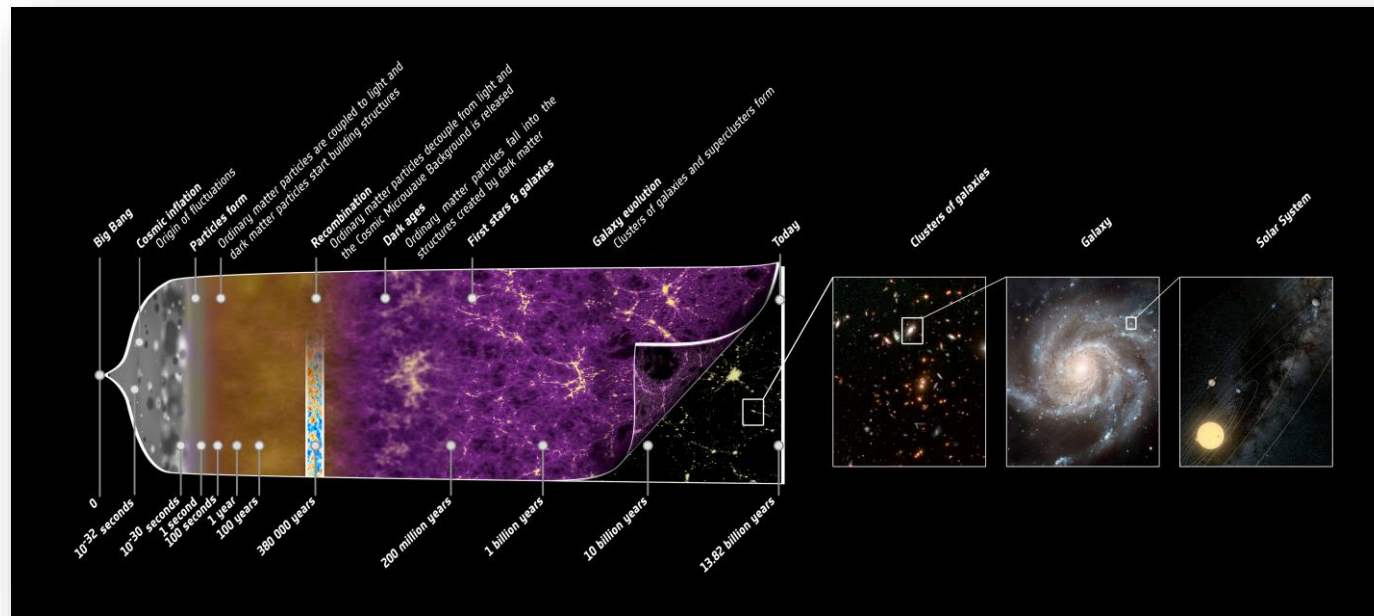
What is the structure, origin/formation epoch/mechanism and relation between the various components?

The Milky Way is a Rosetta stone



We can observe individual stars and clusters
and measure their properties

History of Cosmic structure formation



- observe distant galaxies at high redshifts, thus corresponding to various stages of their formation and evolution
- Galactic archeology

Galactic Archeology



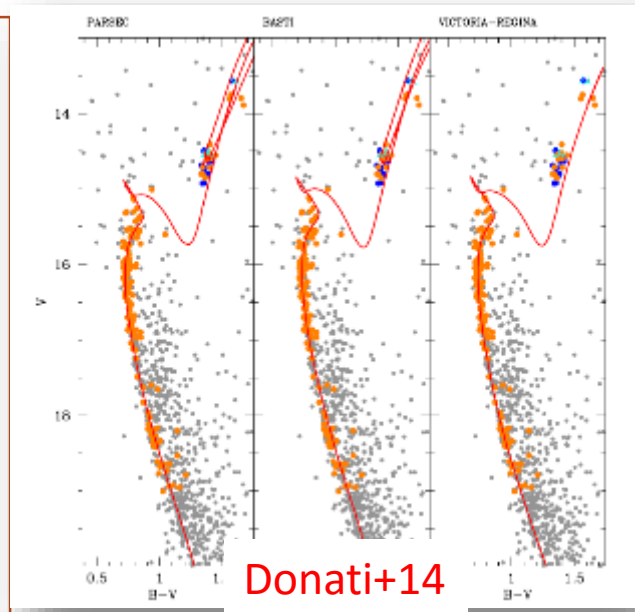
- Stars are “fossils”
 - * Motions, ages, chemical composition trace their origin
 - * Substructures pinpoint to debris from accretion events
- Studies of the Milky Way: detailed view of physical processes in galaxy evolution

What is the (ideal) set of observables?

$p(r, v, M, L, T_{\text{eff}}, \log g, [\text{Fe}/\text{H}], [\text{X}/\text{Fe}], \text{age}, \dots)$

most of these parameters are tightly correlated

- within a star: stellar physics
- among stars and clusters: star formation, IMF, SFH, SFR, stellar evolution, galaxy evolution



understanding galaxy formation and evolution

requires →

understanding star and cluster formation and stellar physics

From one to several big questions

- How do stars and clusters form and dynamically evolve to populate the MW field?
- Can we put further constraints on stellar physics to safely use stars as fossils for the Galactic formation and evolution?
- What is the shape of abundance gradients and their time evolution in the MW and Local group galaxies?
- Can we really use clusters to trace the assembly history and evolution of the main Galactic components?

Present: the Gaia-ESO Public Survey

Co-PIs: G. Gilmore and S. Randich

Consortium: 450++ Cols, 20 WGs

Aims: MW science - complement Gaia
(RV, $v \sin i$, T_{eff} , $\log(g)$, element abundances)

Instrument: FLAMES@VLT (UVES+GIRAFFE)

Observed sample: 10^5 Galactic stars in the field and in clusters (covering the parameter space, x100 stars/cluster)

Observing Nights: 340 from December 2011 to Spring 2017

Results: 82 papers, ~50 refereed ones so far, original science goals, plus unexpected results



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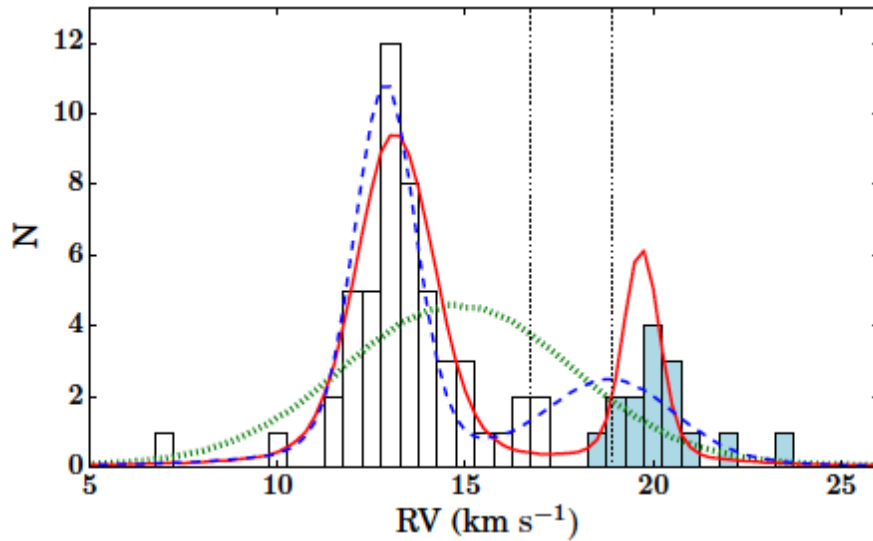


In Major INAF involvement with financial and human resources:

- 7 institutes
- 40 astronomers (staff, postdocs, PhD)
- Financial support with: premiale VLT and PRIN INAF

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Present: cluster formation and stellar physics from GES

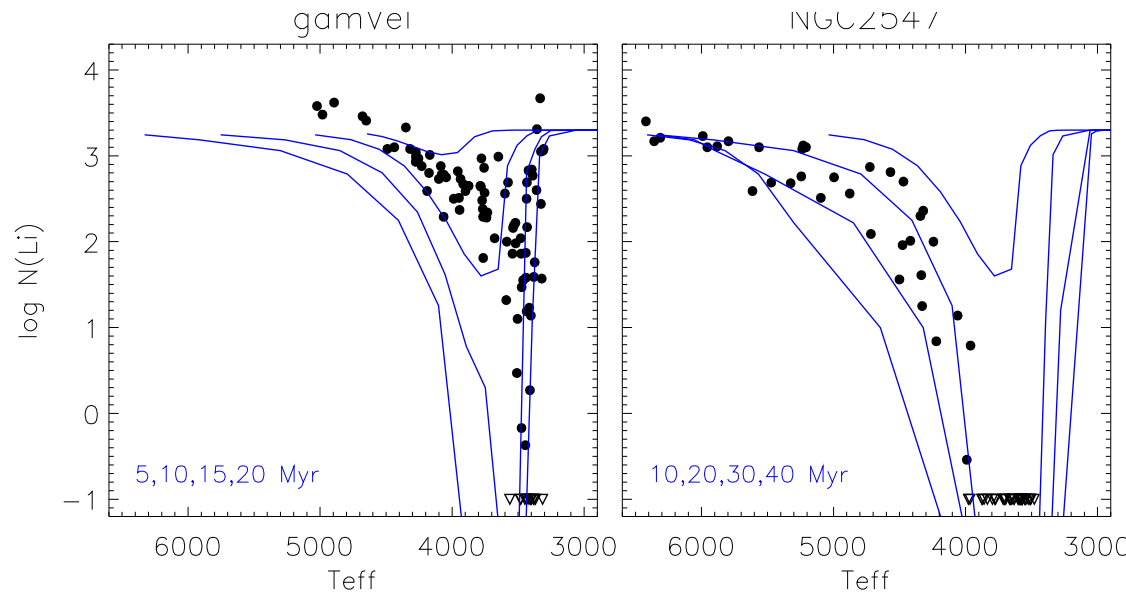


Dynamical analysis of star clusters by high precision radial velocities: new insights on cluster formation

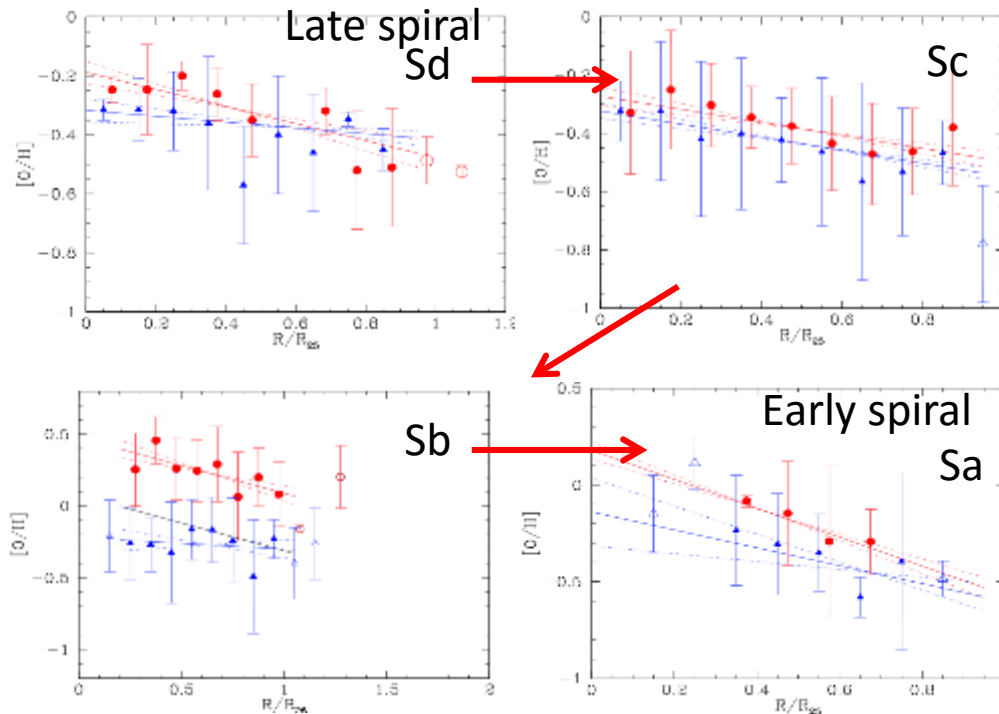
Jeffries+14, Sacco+15,
Rigliaco+15, Mapelli+15, Sacco+16

Constraints on PMS models of stellar interiors with lithium and stellar parameters: role of mag. field

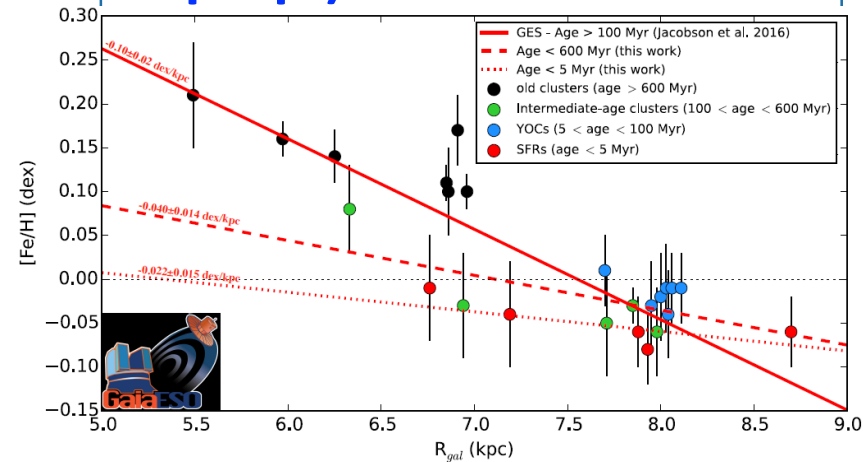
Bouvier+16, Jackson+16,
Jeffries+, Franciosini+ (in prep.)



Present: radial metallicity distributions in the MW from GES and in the external galaxies



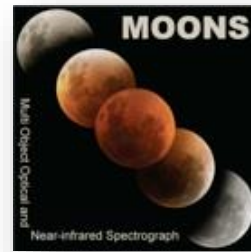
In the MW with GES open clusters (**Spina, Randich+ in prep.**):



Magrini+16: Time-evolution of the slopes of the gradients in nearby galaxies (HII regions and PNe) → function of morphological type (and environment?)

Older clusters have higher [Fe/H] than the younger ones...difficult to reconcile with 'simple' chemical evolution models!
Radial gas flows needed

The next 5 years



Gaia and the new large spectroscopic Instruments/Surveys; Completion of GES,WEAVE, 4MOST, MOONS

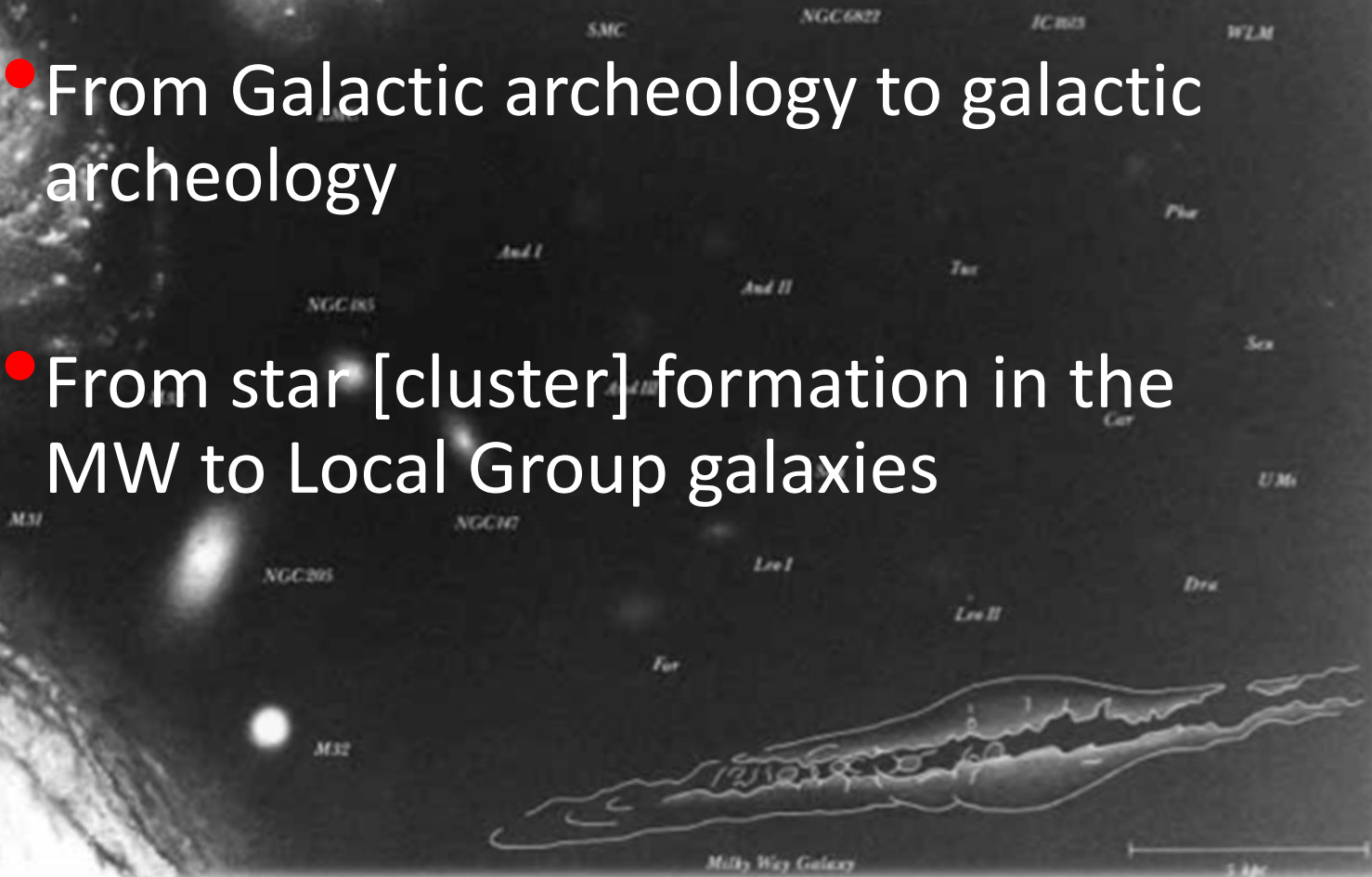
- The 6D domain for 1 billion stars! + chemistry and fundamental parameters for millions of stars – a revolution in MW science
- From the local to the Galactic scale
- A more detailed view of the inner MW and embedded clusters
- Calibration of stellar models and stellar physics
- Age scale! → Galactic and extra-galactic astrophysics



The next 10 years: The E-ELT era

Is the Milky Way really a Rosetta Stone?

- From Galactic archeology to galactic archeology
- From star [cluster] formation in the MW to Local Group galaxies



How to get there

- Gaia + Large surveys (also with E-ELT)
 - High precision, homogeneous spectroscopy
 - Massive data processing, cross-calibration, synergy with e.g. asteroseismology, and appropriate spectrum analysis
- Data mining and interpretation
 - Database and infrastructure
 - Statistical analysis and physical models
- Coordination of activities

The Gaia-ESO Survey – under the Arcetri coordination – helped creating a strong INAF community that is now collaborating effectively to address the big questions – let's keep the momentum!