A setup for Gaia-DR1:
The star formation history of our thin disc environment

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The first Gaia Data Release (Gaia-DR1, 14 September 2016) primes the pump and paves the way for a new golden age of the galactic astronomy. Gaia-DR1 will provide new parallaxes and proper motions for about two million well-behaved Tycho-2 stars placed in the solar neighborhood. This TGAS (Tycho-Gaia Astrometric Solution) catalogue is being obtained using the first year of Gaia data and Tycho positions as priors.

The aim of the work presented here has been **to evaluate the capabilities of Gaia and future on-ground spectroscopic surveys to derive the dynamical age and place of birth of the Young Local Associations (YLAs).** Test particle simulations in realistic galactic potentials and different scenarios for the accuracy on astrometric and spectroscopic data, allow us to quantify our future capabilities to trace back in time the star formation history of our thin disc environment.

YLA, what are they?

The Young Local Associations (YLA) are groups of young (mainly low-mass) stars in the solar neighborhood (r<100pc)

Groups: They share common properties when looking at the X-ray, optical spectroscopy and kinematic data

Young: spectroscopic ages between 10 – 100 Myr

Why Important? They offer us new insights into the starformationprocess in the solar neighborhood (low-density environents)

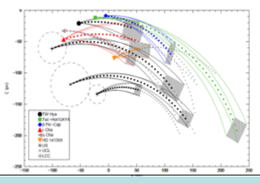
Derivation of a dynamical age for each association.
Do they match with HR ages?

Star formation in low density environments
Triggered star formation?

goals

Centers of the associations back in time
Do they have a common origin?

Linked to spiral arms shock wave?
Molecular cloud compression?



Hipparcos (1997) — N=10^5

Mag.	Number	Position [μas]	Parallax [μas]	Proper motion [μas yr^{-1}]
6–7	9381	367	501	458
7–8	23 679	497	684	608
8–9	40 729	682	939	840
9–10	27 913	936	1284	1165
10–11	8563	1403	1921	1744
11–12	2501	2125	2882	2607
≥12	630	3248	4291	4578
all	113 396	753	1033	932

TGAS-Gaia DR1 (2016)

a factor 2-10 in parallax
A factor 25-30 in proper motions

N=10^5

Michalik+ 2015

Mag.	Number	Position [μas]	Parallax [μas]	Prop. motion [μas yr^{-1}]
Subset Hipparcos				
6–7	9381	158	270	18
7–8	23 679	147	241	23
8–9	40 729	142	232	30
9–10	27 912	147	244	40
10–11	8563	164	276	60
11–12	2501	129	212	90
≥12	630	156	251	138
all (≥6)	113 395	147	244	34

Two million stars with astrometry better tan Hipparcos

N=$2{\cdot}10^6$

Michalik+ 2015

Mag.	Number[a]	Position [μas]	Parallax [μas]	Prop. motion [μas yr^{-1}]
Subset *Tycho* without Hipparcos				
6–7	411	244	399	198
7–8	8072	198	348	264
8–9	63 630	191	327	403
9–10	257 243	230	407	680
10–11	686 866	329	601	1145
11–12	993 139	379	722	1522
≥12	302 511	349	702	1615
all (≥6)	2 311 872	332	631	1259

The YLA as seen by Gaia

- Better astrometry (distances and tangential velocities)
- Detection of new members (Grand Challenge)
- Complementary on-ground RV data and chemistry

Our experiment:

	N	$< V >$	Astrometric accuracy	σ_{VR} (km/s)
Before Gaia	20	9	Hipparcos	4
DR1 TGAS-Hip	20	9	DR1-Hipp	2
DR1 TGAS-Tyc	50	11	DR1-Tycho	2
Gaia+	100	13	end-of-mission	0.5

Simulating YLA evolution

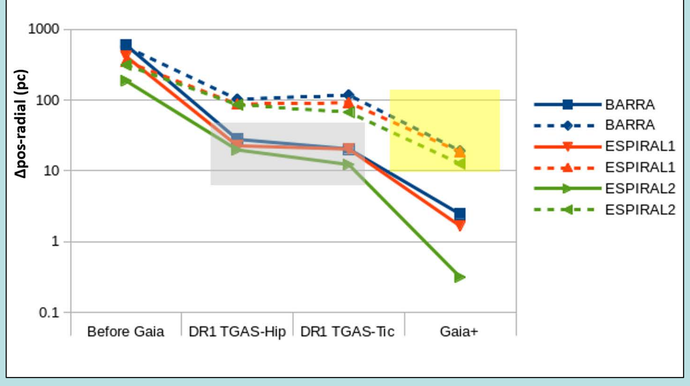
Initial conditions (Origin in 6D) → Integration forwards Δt → Heliocentric (**r,v**) at present → Gaia+ Errors → Observed (**r,v**) at present → Integration backwards -Δt → Possible origin ?

First exercise:
Can we recover the IC?
We assume the galactic potential is known (false)

Δ_{pos} Δ_{vel} $\Delta_{\sigma_{pos}}$ $\Delta_{\sigma_{vel}}$

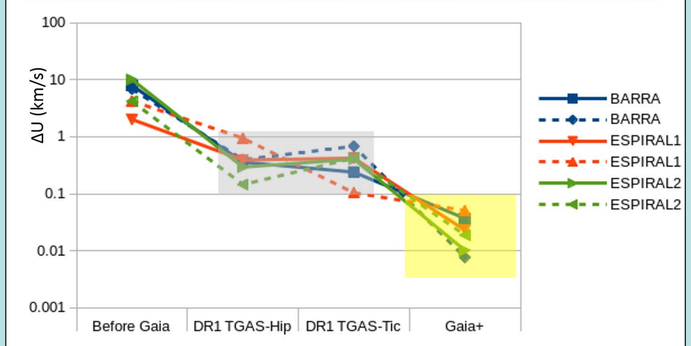
20-40 pc accuracy in the derivation of the "at birth" position (YLA 50 Myr old)

Dynamical ages shall wait for end-of-mission data (σpos< 10 pc only for Gaia+)



~1 km/s accuracy in the derivation of the at birth velocities with DR1
Star formation models can be tested

Kinematic signatures due to the potential can be checked in Gaia+



Realistic Galactic potentials and orbits back in time

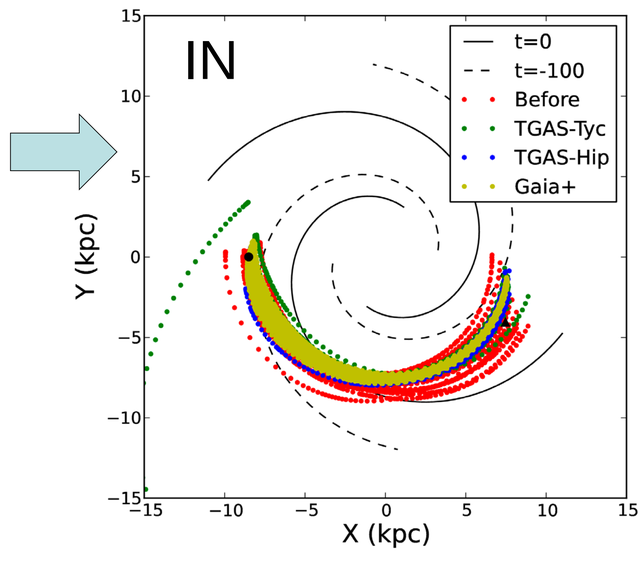
We use two Galactic potentials to perform the back in time integration:

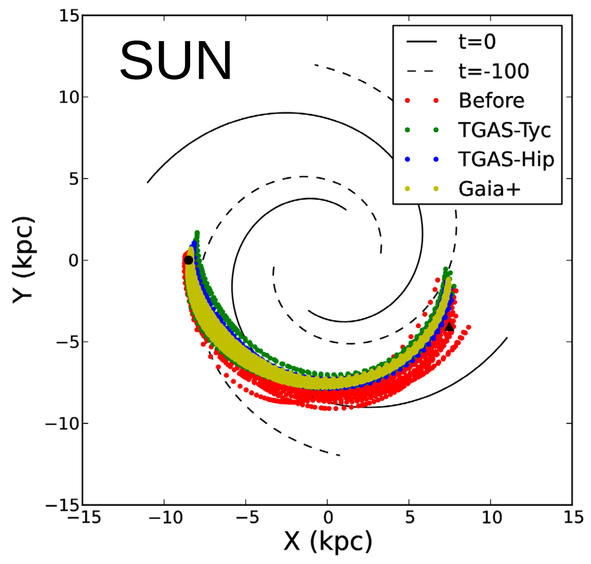
1. Bar model: As in Romero-Gómez et al (2015), axisymmetric component (A&S91) + 2 Ferrers bars (mass of $10^{10}M_\odot$ and Ω_p=50 km/s/kpc)
2. PERLAS model: As in Antoja et al (2011), Pichardo et al (2003), axisymmetric component (A&S91) + spiral arm (Amplitude 5% and we study 2 pattern speeds: Ω_p=20 and 30 km/s/kpc, PERLAS-20 and PERLAS-30, respectively)

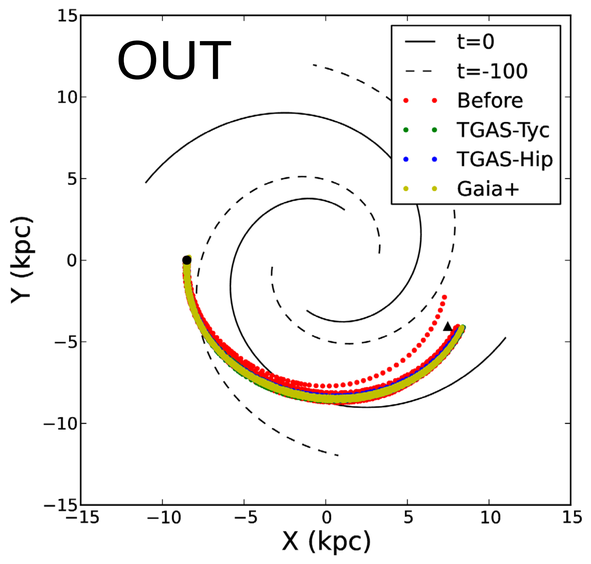
Effect of the data scenarios and type of orbits on the determination of age and place of birth

- Three different initial conditions for YLA:
  - IN: YLA born in the inner disc
  - SUN: YLA similar to TW HyA YLA
  - OUT: YLA born in the outer disc
- Two spiral loci:
  - Solid line: at present (t=0)
  - Dashed line: at birth (t=-100Myrs)
- Orbits back in time in the PERLAS-20 model in the four data scenarios

Note how "Before Gaia" the YLA never converges to a single point, while with TGAS-Tyc and TGAS-Hip the convergence is good and with Gaia+ we can determine the place of birth with good accuracy.







Challenging and exciting near future

- We will really improve the membership detection with TGAS data, detecting new members and new YLAs in the solar neighbourhood.
- Requirements: 1) we need good radial velocities (critical factor to determine dynamical age and place of birth), RAVE will be used as starting point;
  2) Available catalogues such XMM, WISE … crossmatched with TGAS will be used for the detection of young population and new members.
  3) New observing proposals are needed for chemical tagging
- Appropriate full sky clustering multivariate analysis is proposed to attach this challenging project for the evaluation of the star formation in the solar neighbourhood.