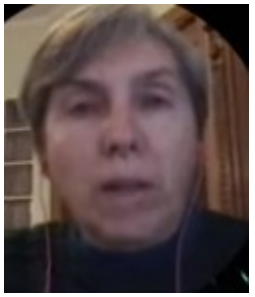
Ummi Abbas

Martin Barstow

Beatrice Bucciarelli



Jos de Bruijne

Josep Manel Carrasco

William Cooper

Nigel C. Hambly

Simon Hodgkin

The *Gaia* Catalog of Nearby Stars

Eduard Masana

Richard Smart

Daniel Michalik

Céline Reylé

Annie Robin

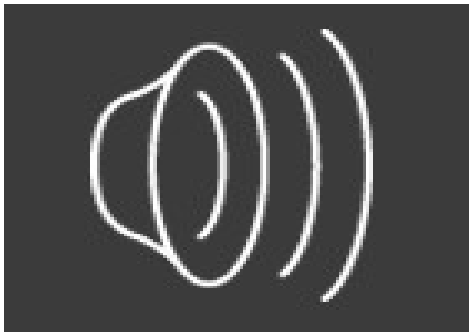
Jan Rybizki

Johannes Sahlmann

Luis Sarro

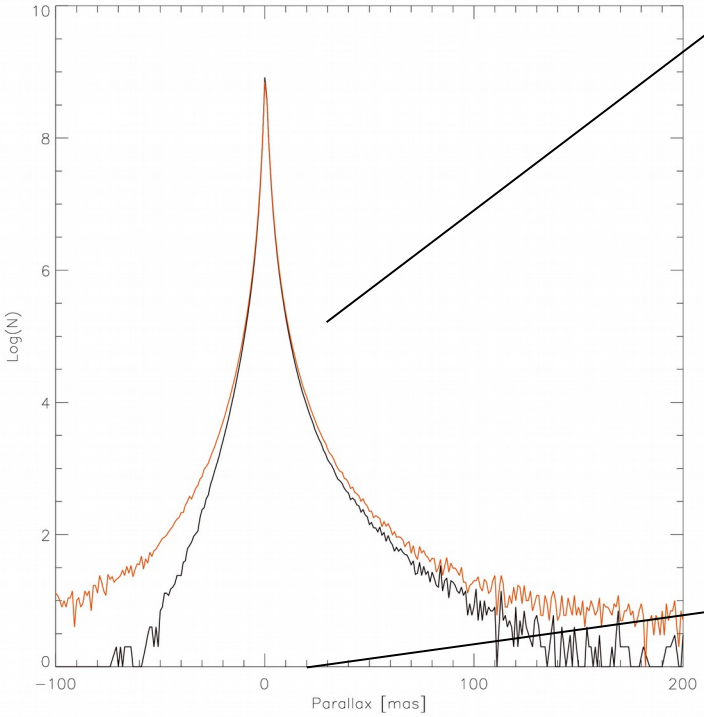
Alessandro Sozzetti

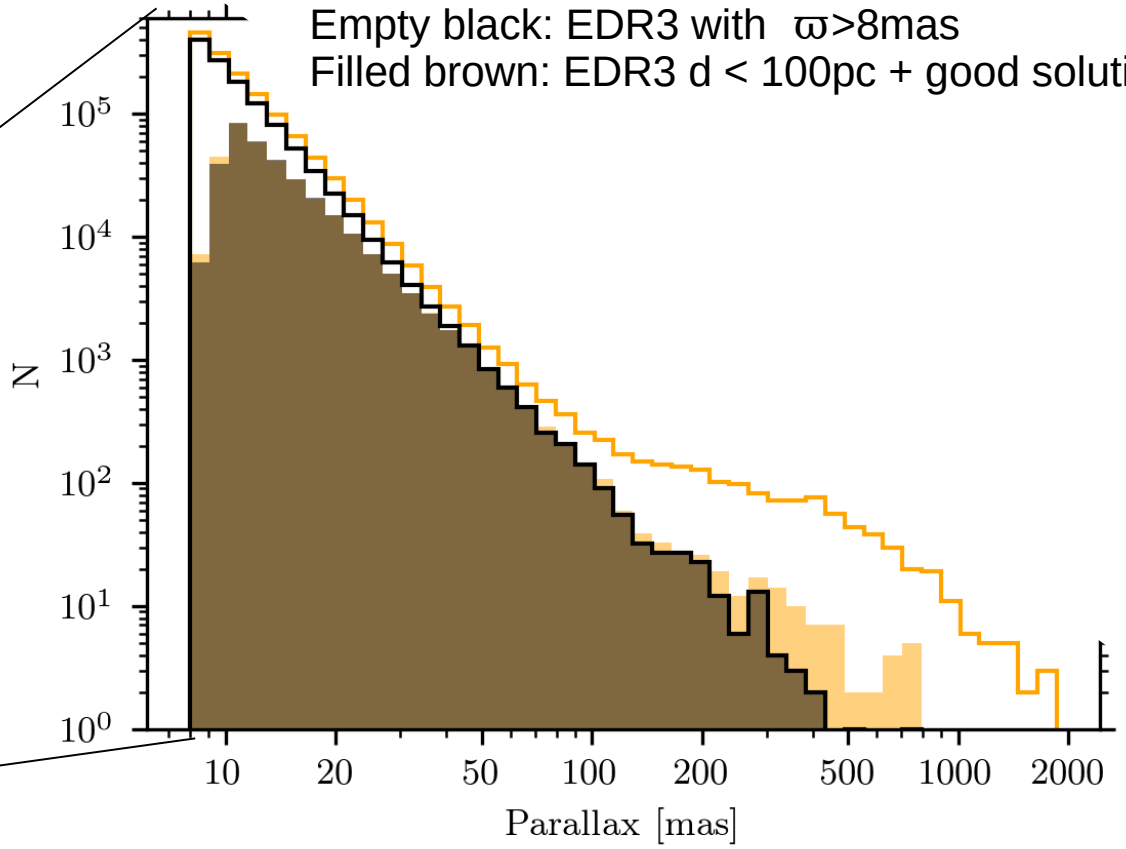
FAQ: GCNS



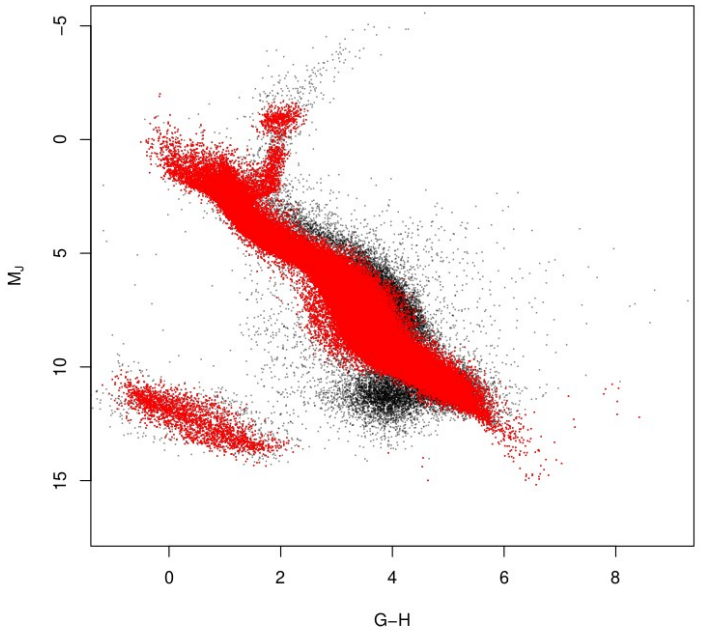
What is the GCNS?
Why is it important?
Why 100pc?
Why not before?

Empty orange: GDR2 with ϖ>8mas
Filled orange: GDR2 d < 100pc + good solution
Empty black: EDR3 with ϖ>8mas
Filled brown: EDR3 d < 100pc + good solution





HOW: Random Forest Classification

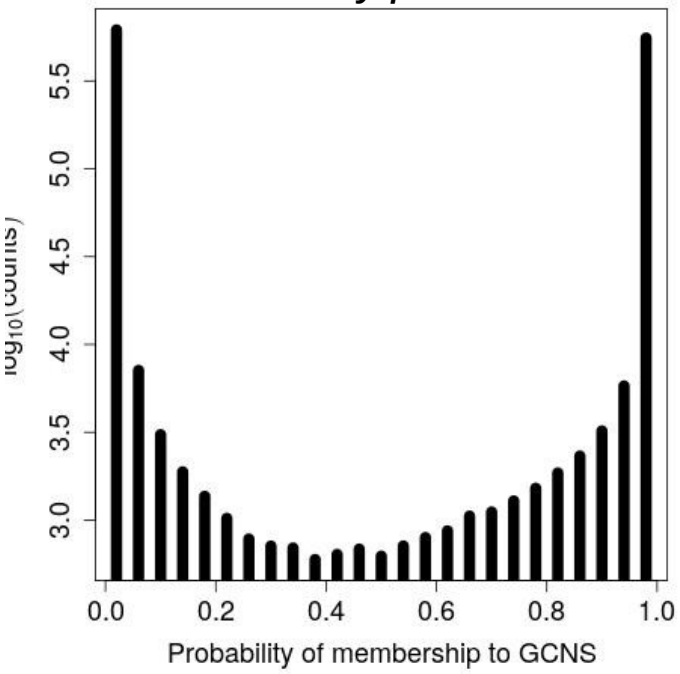


Good training set choosen from CAMD and outside plane.

Bad training set ϖ < -8 mas

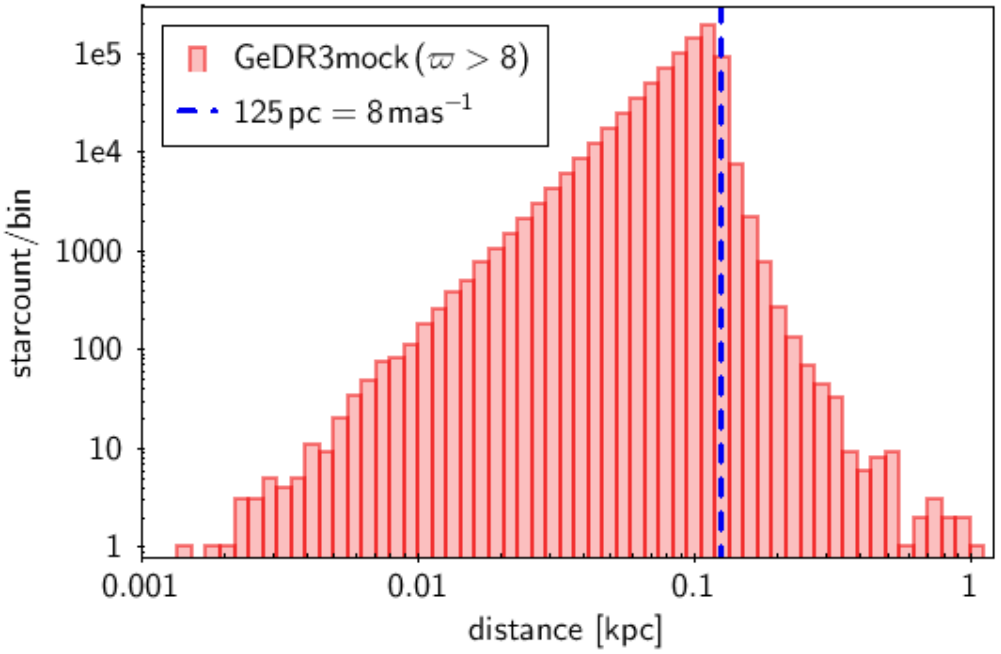
Feature name	Mean Decrease Gini index
parallax_error	33821
parallax_over_error	27713
astrometric_sigma5d_max	24035
pmra_error	20226
pmdec_error	14866
astrometric_excess_noise	12737
astrometric_params_solved	7677
ipd_gof_harmonic_amplitude	5628
ruwe	3383
visibility_periods_used	2371
pmdec	2263
pmra	2039
ipd_frac_odd_win	1566
ipd_frac_multi_peak	1006
astrometric_gof_al	801
scan_direction_strength_k2	694
parallax_pmdec_corr	522
astrometric_excess_noise_sig	413
astrometric_n_good_obs_al	394
astrometric_chi2_al	275
astrometric_n_obs_al	244
astrometric_n_obs_ac	224
dec_parallax_corr	208
astrometric_matched_transits	165
dec_pmdec_corr	157
ra_dec_corr	65
scan_direction_strength_k1	59
scan_direction_mean_k2	50
scan_direction_strength_k4	50
parallax_pmra_corr	49
ra_parallax_corr	48
ra_pmdec_corr	44
scan_direction_mean_k4	42
scan_direction_strength_k3	41
astrometric_n_bad_obs_al	38
scan_direction_mean_k3	30
ipd_gof_harmonic_phase	29
ra_pmra_corr	28
pmra_pmdec_corr	27
scan_direction_mean_k1	24
dec_pmra_corr	22

Probability of reliable Astrometry $p > 0.38$.



How: Bayesian distance estimation

Prior from mock catalog



Distance Probability Density Function use MCMC to provide percentiles. Any object with 1% probability of being within 100pc included.

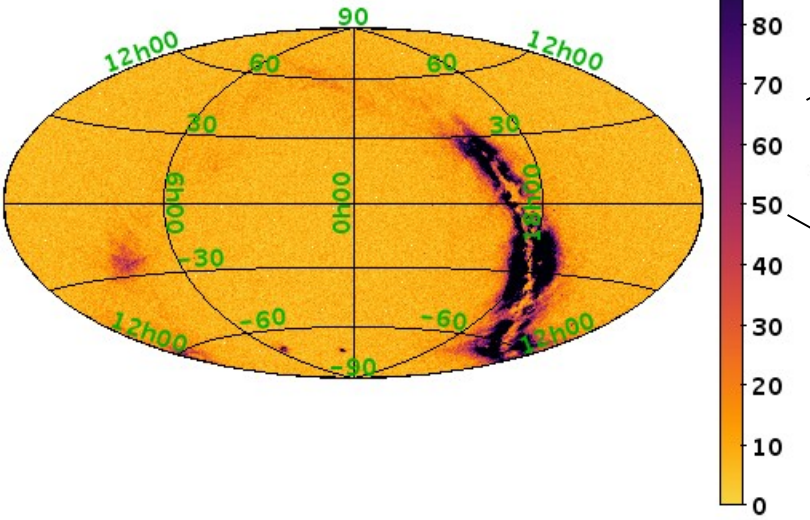
For GCNS selection:

p >= 0.38

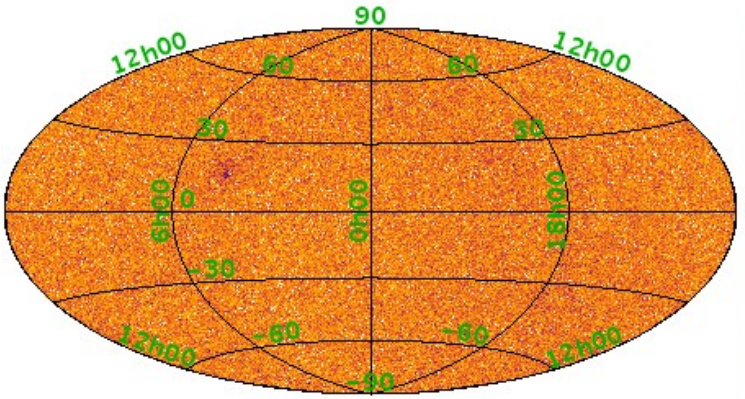
d_1 <= 0.1kpc

HOW: Sky Distribution

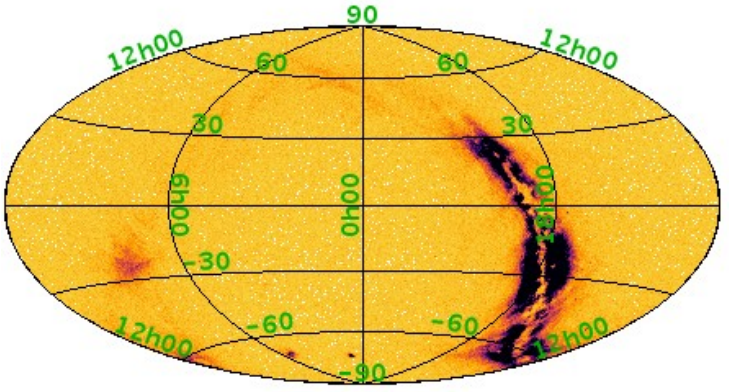
ϖ > 8mas
1211740



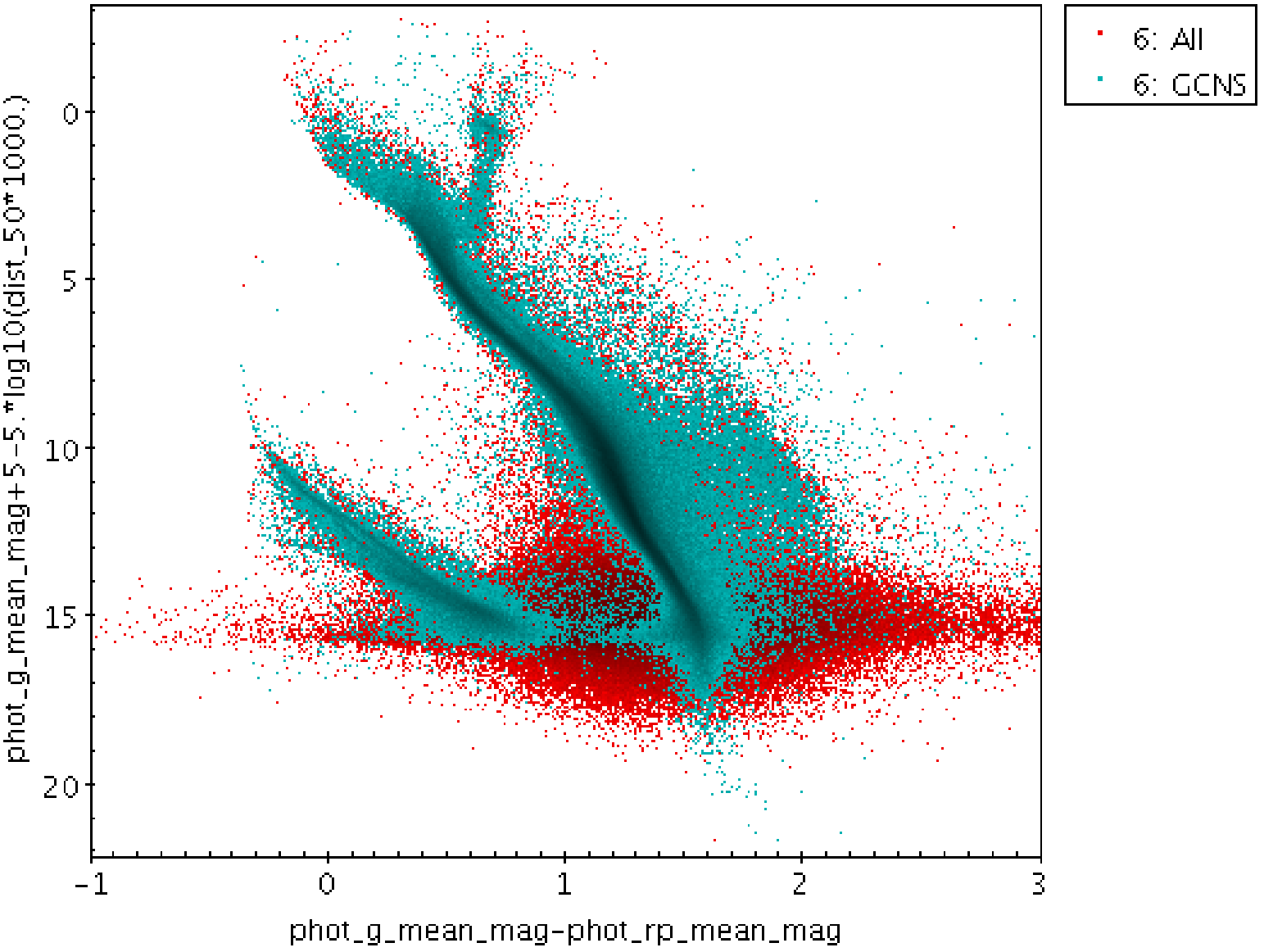
p >= 0.38 &
d_1 <= 0.1kpc
331312
GCNS



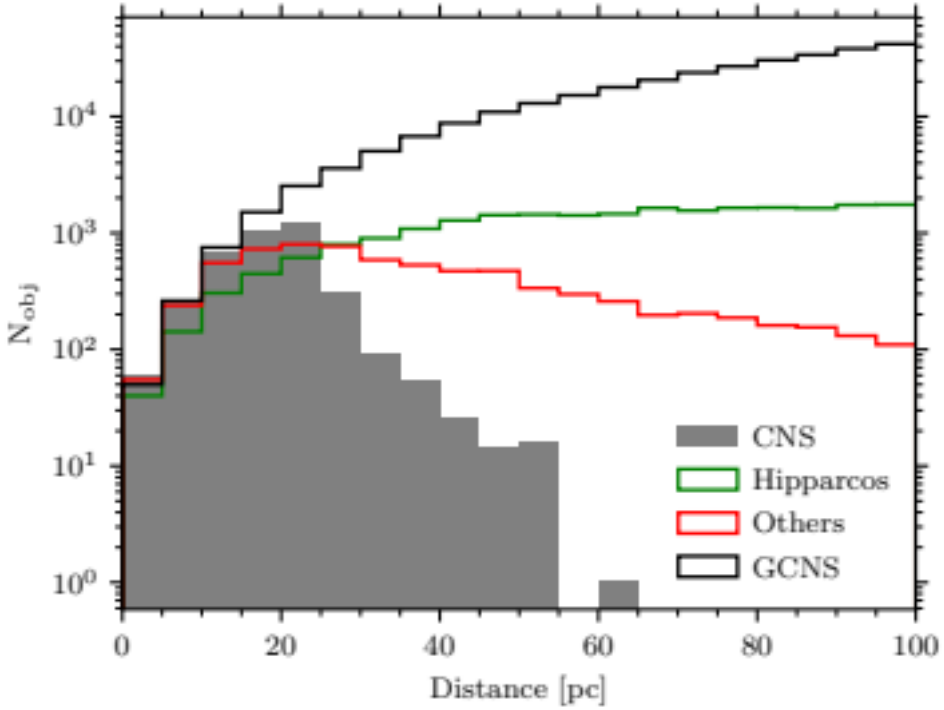
p < 0.38 or
d_1 > 0.1kpc
880428
rejected

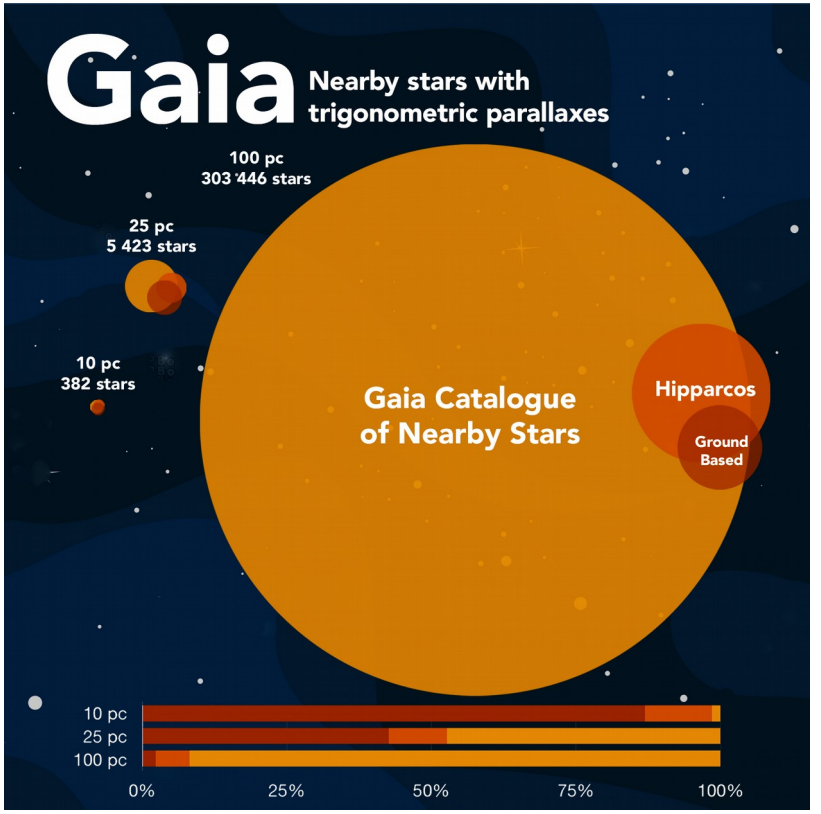


HOW: CAMD All and GCNS



Historical context





The content has increased by a factor of 2 for the 25 pc sample, and by a factor of 10 for the 100 pc sample compared to our pre-Gaia knowledge.

An examination of the 10 pc sample finds that the GCNS provides the first direct parallax of five stars in multiple systems.

Completeness

331312 GCNS entries

- 316 star in 10pc: eDR3 missing 26
  - 8% incompleteness
  - Extrapolation 1-2% incomplete
- PS1 Comparison 98% complete at 20.4
  - 50% completeness M9 @ 100pc
- Mock => 50 lost to ϖ>8mas
  - Very minor contribution
- Lost because $p < 0.38$
  - 0.1% lost positives
- Binary resolution losses, 0.6% & 15%
  - but 15% of 5% stellar binaries

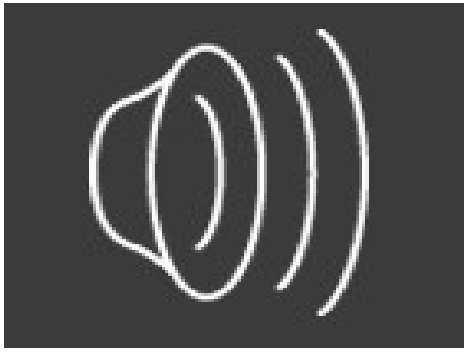
Dominated by 8%

Contamination

880428 rejected entries

- Included incorrectly, *p* large
  - 0.1% false positives (but evident)
- Outside 100pc but dist_1 < 0.1
  - 9% probability outside 100pc

Minor problem



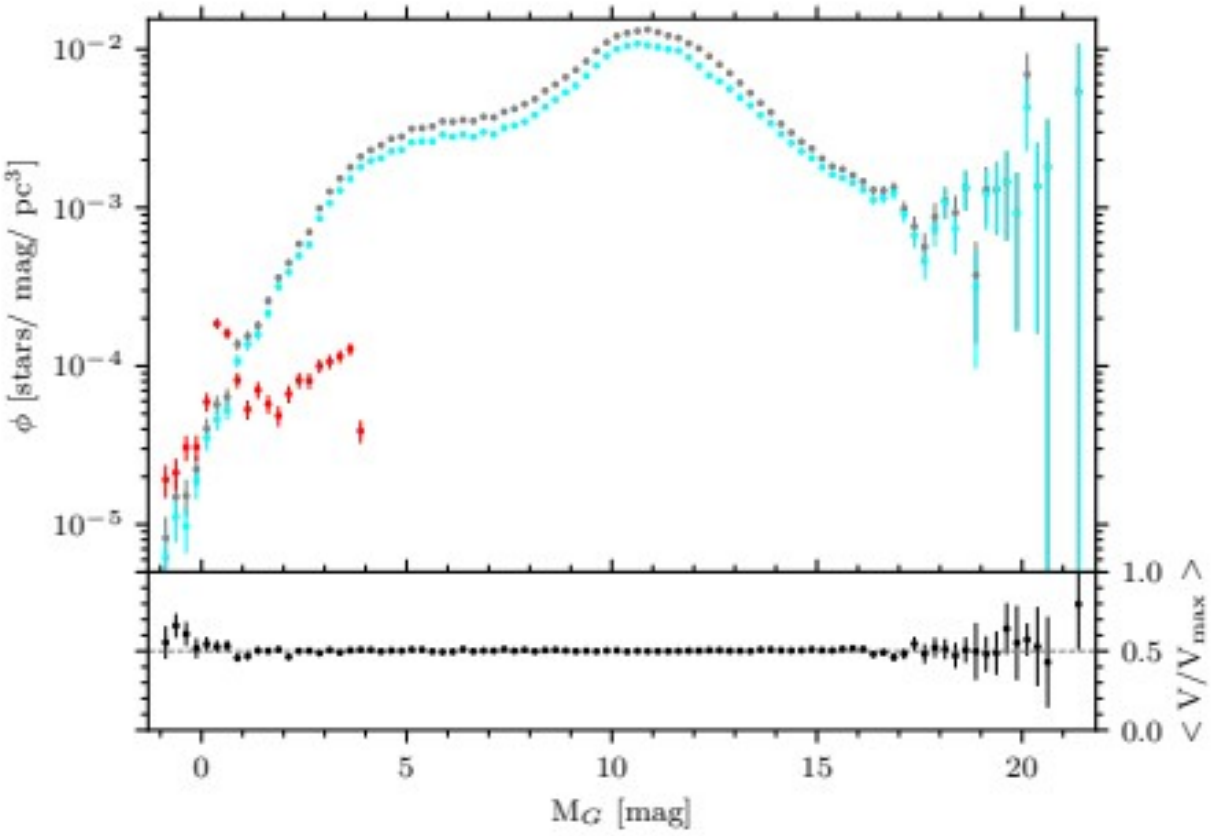
Should tailor use of catalog to goal. If a clean sample is needed use dist_50, if completeness important use dist_1 but with distance PDF. If object selection add in photometric information not used in this selection.

Exploitation: Luminosity Function.

Uses dist pdf and G for main sequence and RGB stars

GCNS Luminosity function, 0.25 bin, log scale. Grey: main sequence stars. Cyan: main sequence stars with ipd_frac_multi_peak=0. Red: giants stars.

- ρ is 0.081±0.003 */pc^3
- Stellar/substellar boundary
- Jao gap



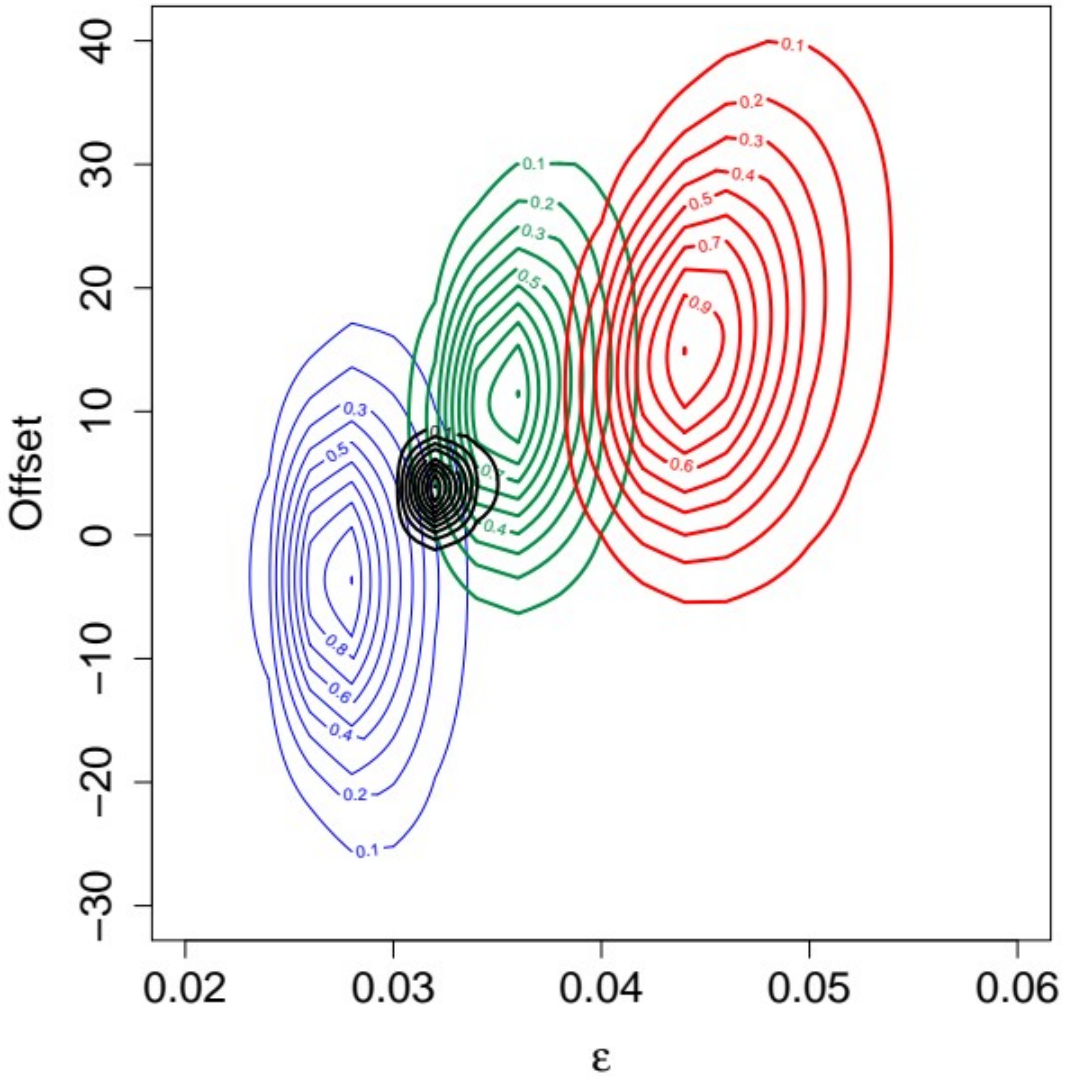
Exploitation: Vertical Stratification

Uses only b and ϖ.

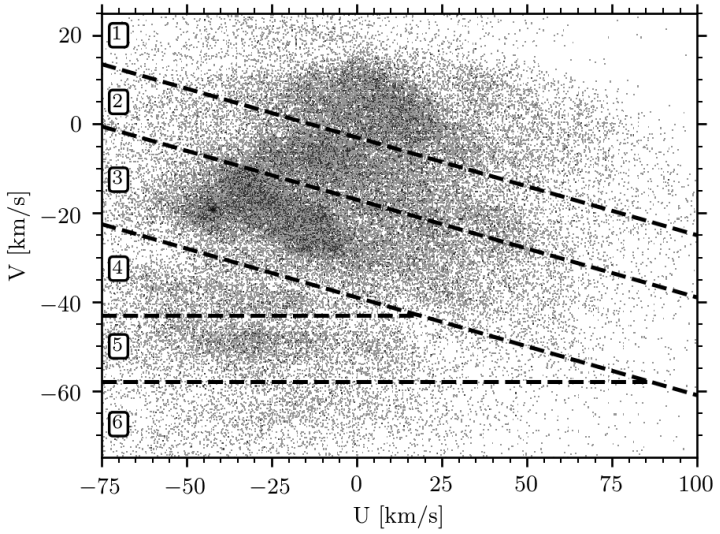
Einasto stratification law

Finds ε consistent but low solar distance above plane.

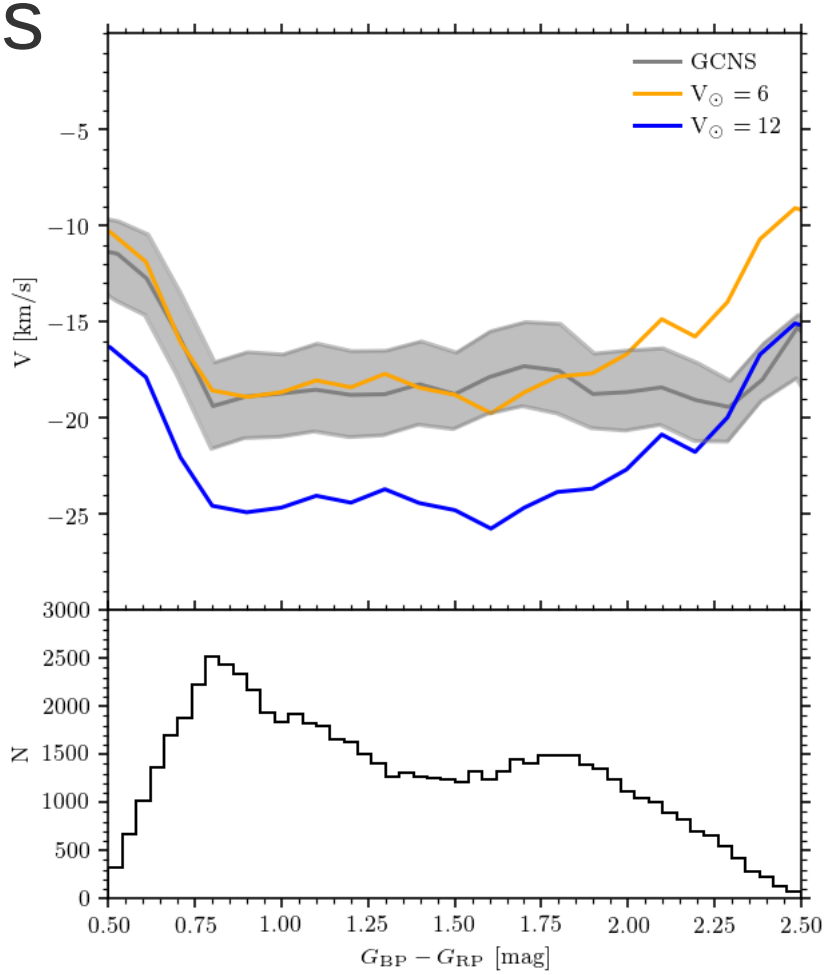
Difference of ε and *z* seen as function of age: early spectral types before the turn offpoint (blue), spectral types G and early K (green) and M-type stars(red). All objects black.



Exploitation: Local Kinematics



Structure in the UV plane



Uses dist_50, μ, G, G_{BP}, G_{RP}

- Structure in the *U, V, W* plane.
- Halo and thick disk stars
- Solar Motion quite low

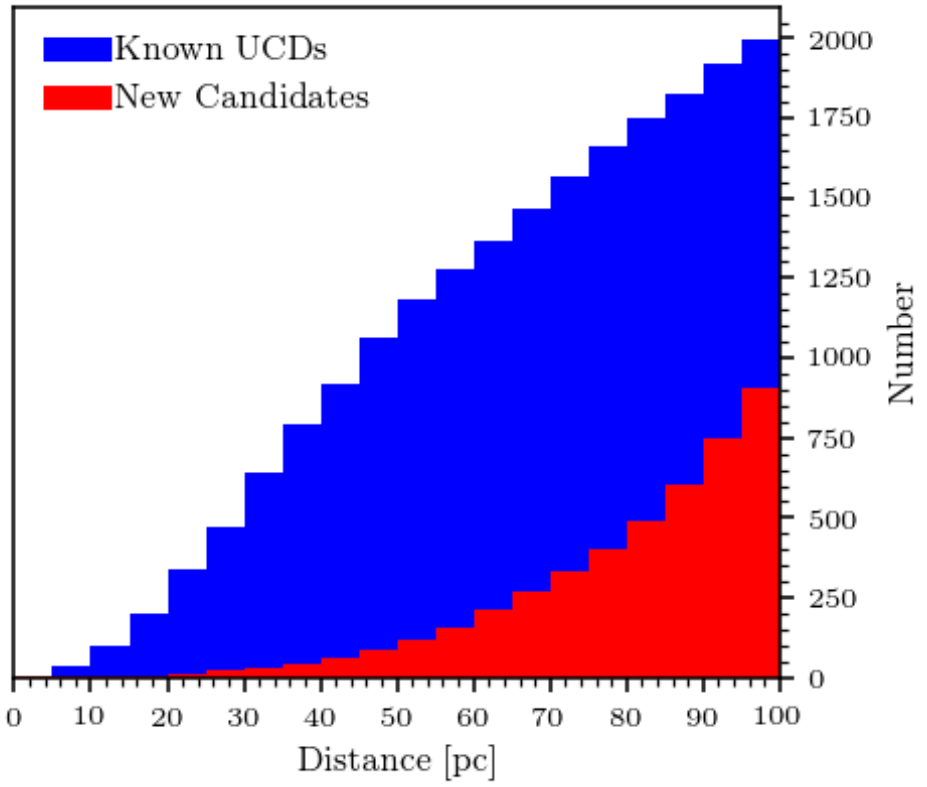
Median velocity vs G_{BP}- G_{RP} for stars with G<13, quantiles 0.45 and 0.55 in grey, median in black. Simulations with*V* of 5 (green), 7 (red), and 12 km/s (blue).

Orbits film

Exploitation: Ultra-Cool Dwarfs

- Faintest objects at Gaia limit
- Stellar/substellar boundary visible in luminosity function.
- M7 complete to 100pc

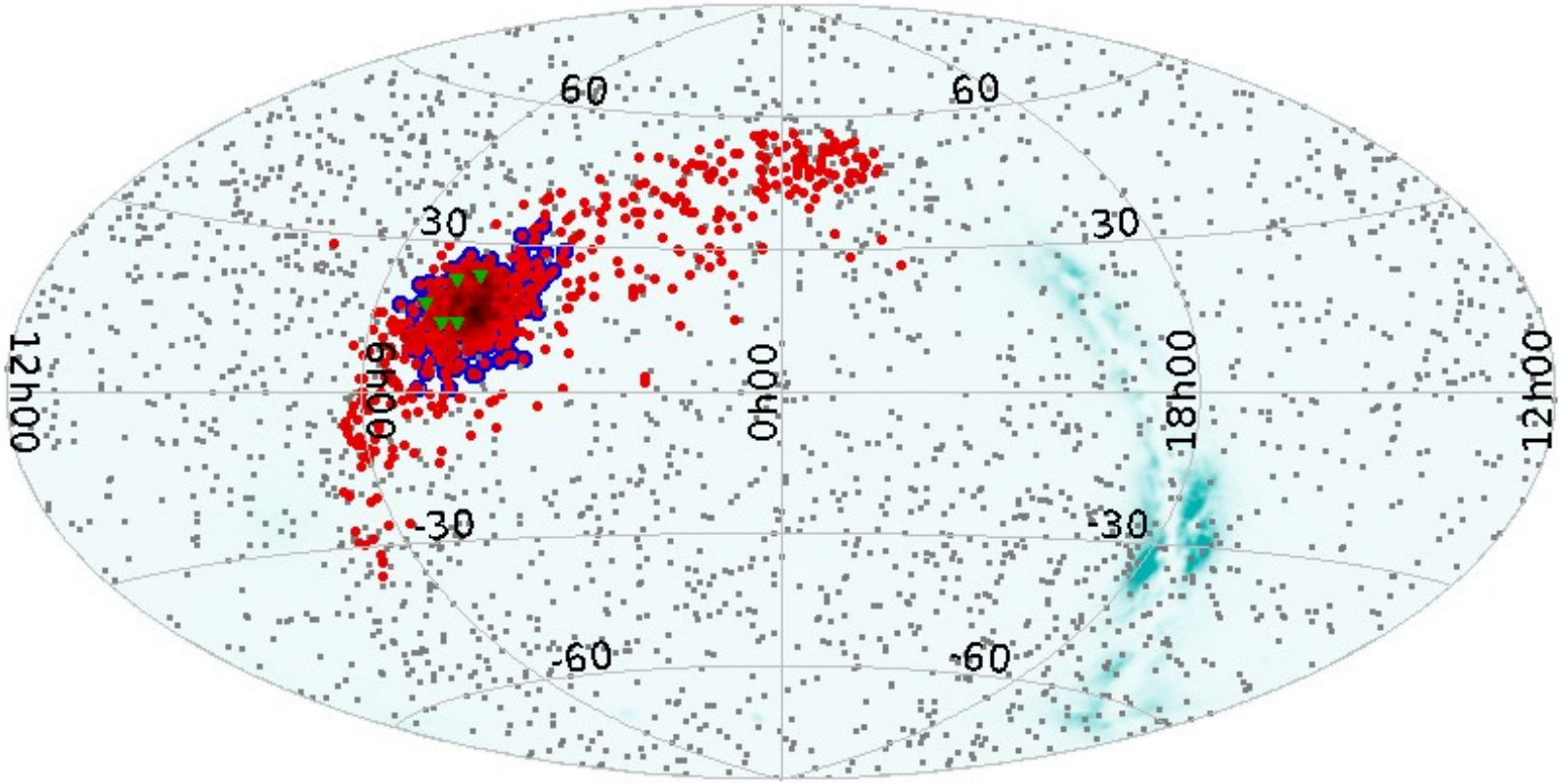
L5 complete to 30pc



Distance distribution of new UCD candidates in the GCNS (red) and known UCDs (blue).

Exploitation: Clusters

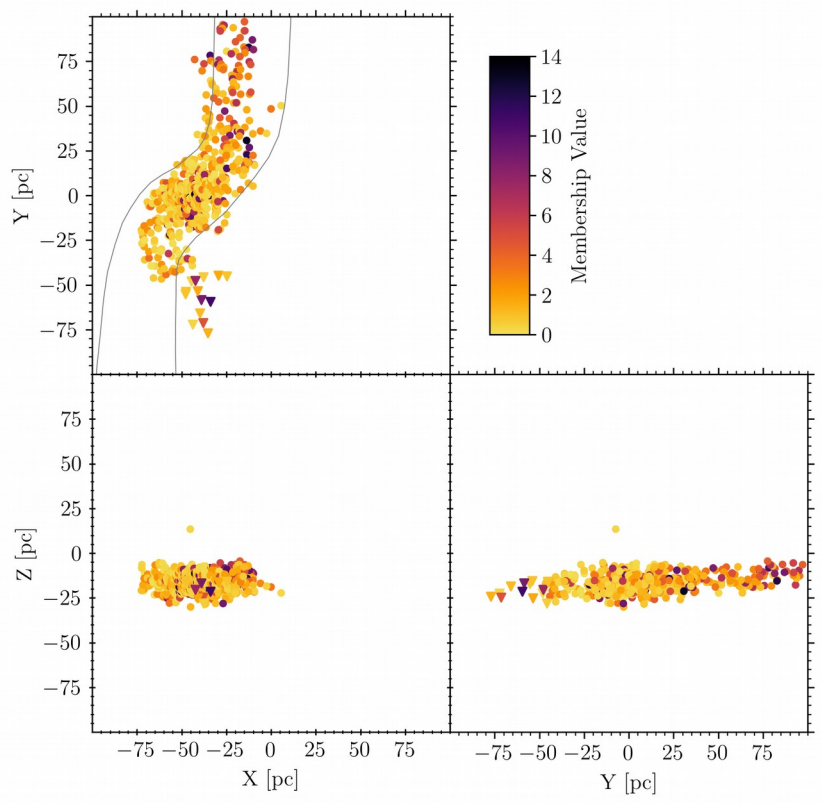
- We looked at Hyades & Coma Ber, two clusters within 100pc
- Membership selection based on kinematics and density filter
- Uses: α, δ, ϖ/dist_50, μ, V_r, astrometric uncertainties, correlations



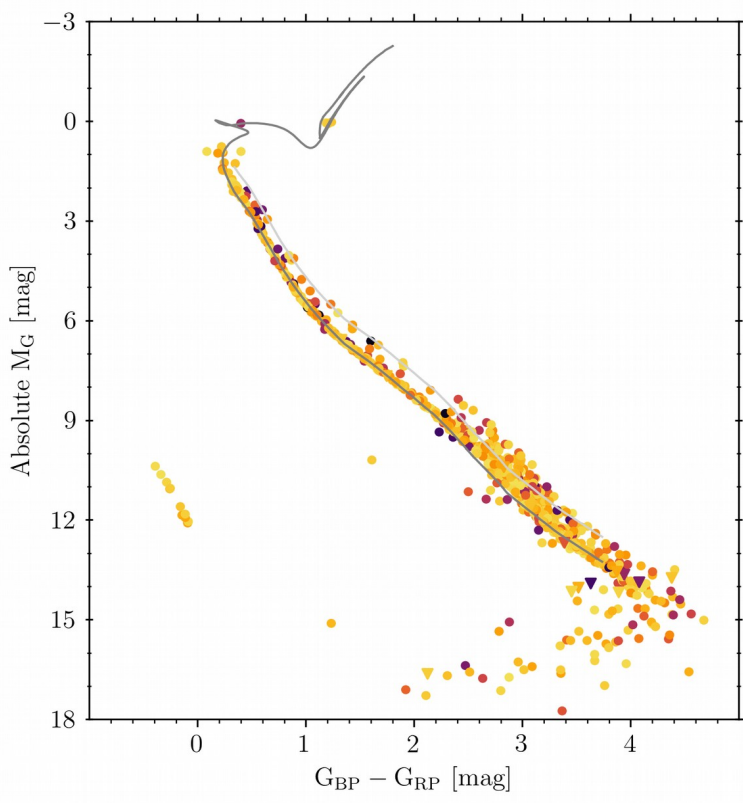
All-sky map: 920 candidate Hyades members in EDR3 (red points)

Exploitation: Clusters

- We looked at Hyades & Coma Ber, two clusters within 100pc
- Membership selection based on kinematics and density filter
- Uses: α, δ, ϖ/dist_50, μ, V_r, astrometric uncertainties, correlations



Hyades candidate members in Galactic coordinates

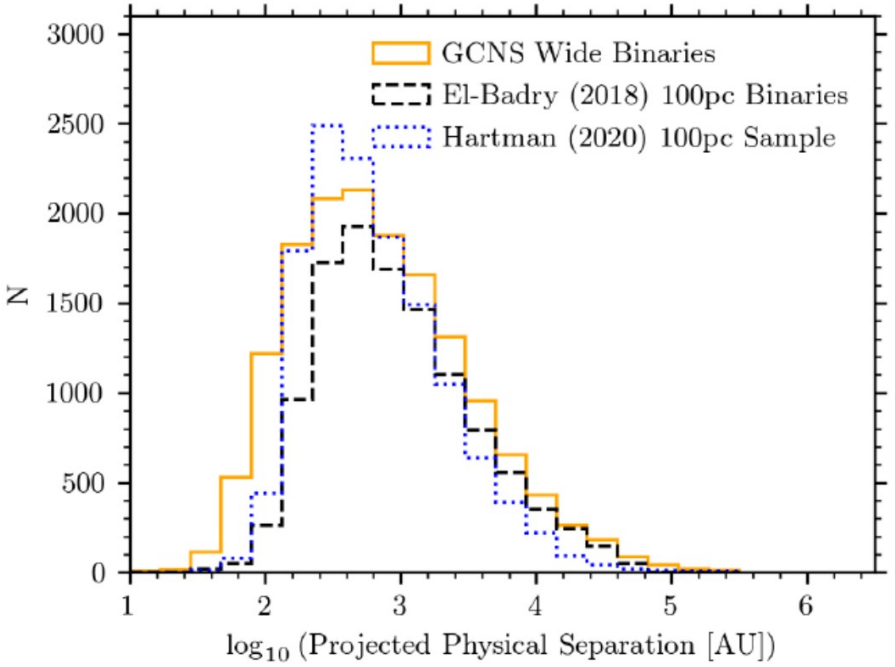


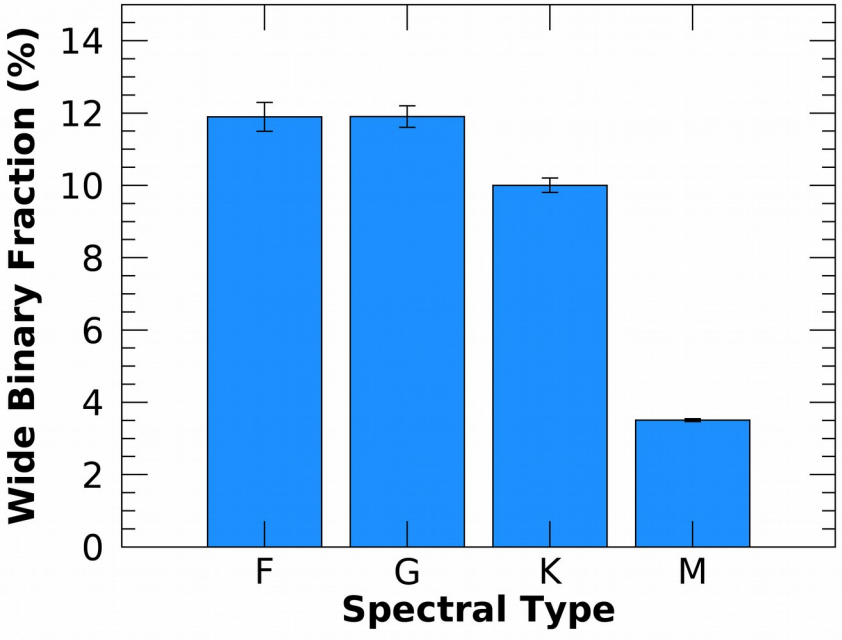
Colour-Absolute Magnitude Diagram

Exploitation: Wide Binaries

Uses ϖ, μ, G, G_{BP}, G_{RP}

- 16556 wide binary systems
- No separation bimodality
- Find f_{WB} shown in figure



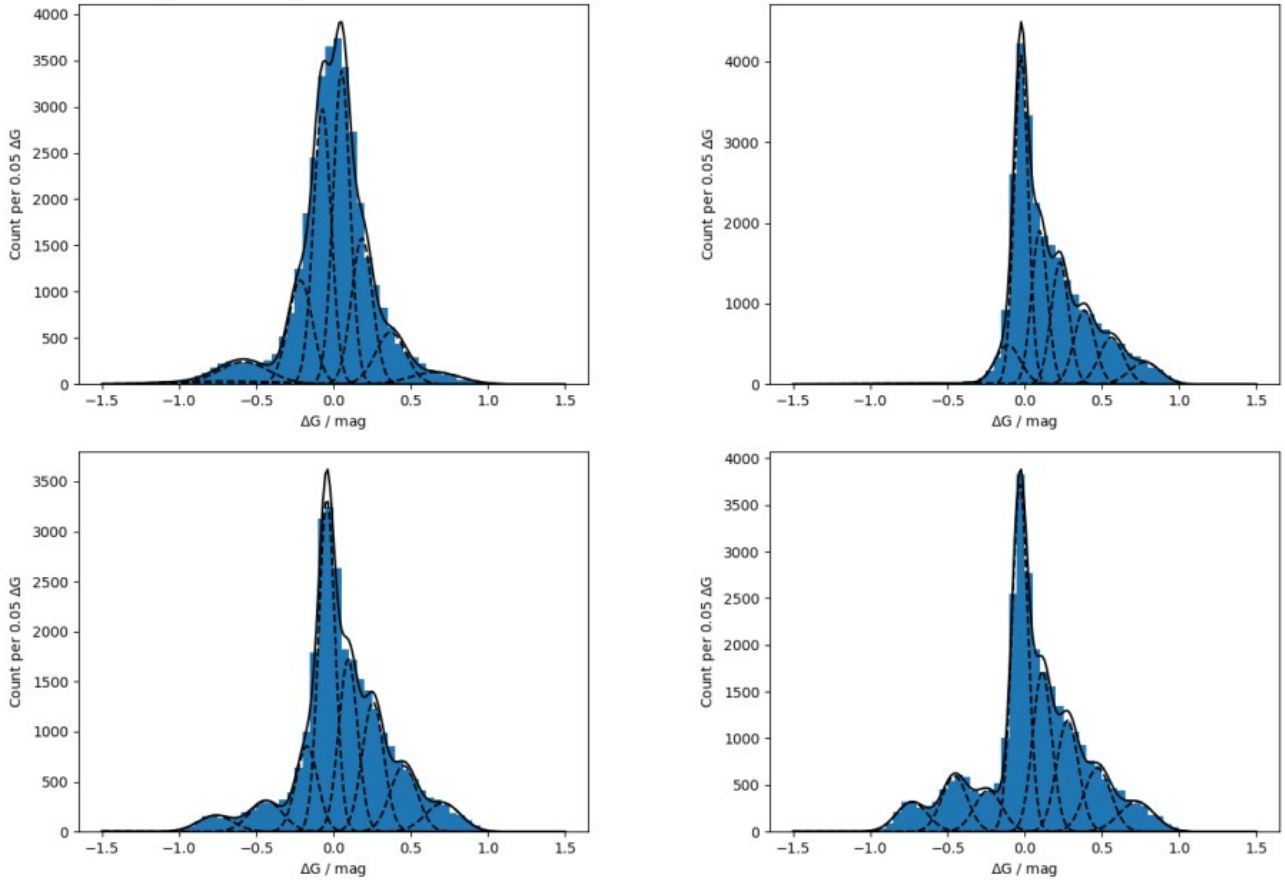


Wide binary fraction in the GCNS, error bars are binomial.

Exploitation: Unresolved Binaries

Uses dist_50, G, G_{BP}, G_{RP}

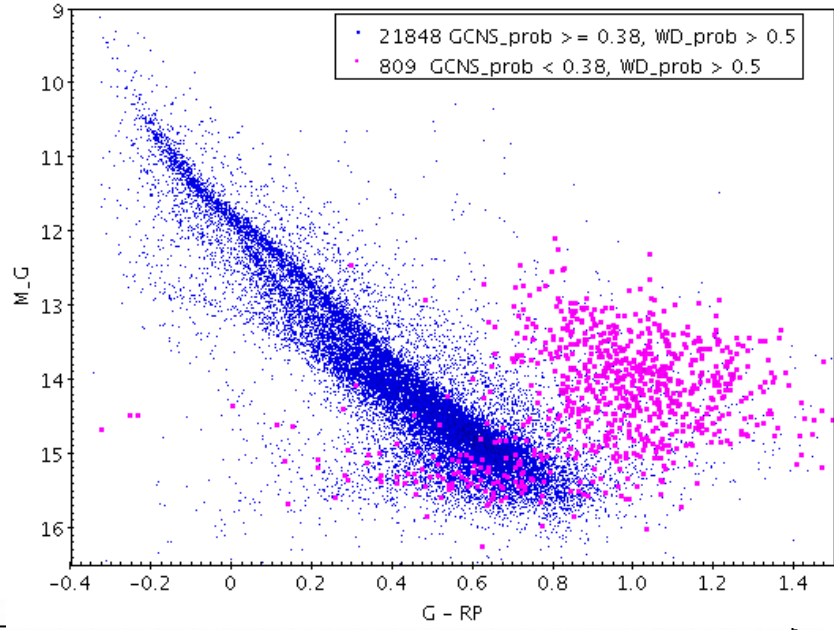
- Gaussian mixture models appropiate
- GCNS requires less binarity than indicated in Arenou (2011)
- Much can be done...



Gaussian mixture models of the distributions of star counts in bins from the main sequence. Panel 1:GCNS, 2:f_B*0.0, 3:f_B*0.5, 4:f_B where f_B from Arenou 2011.

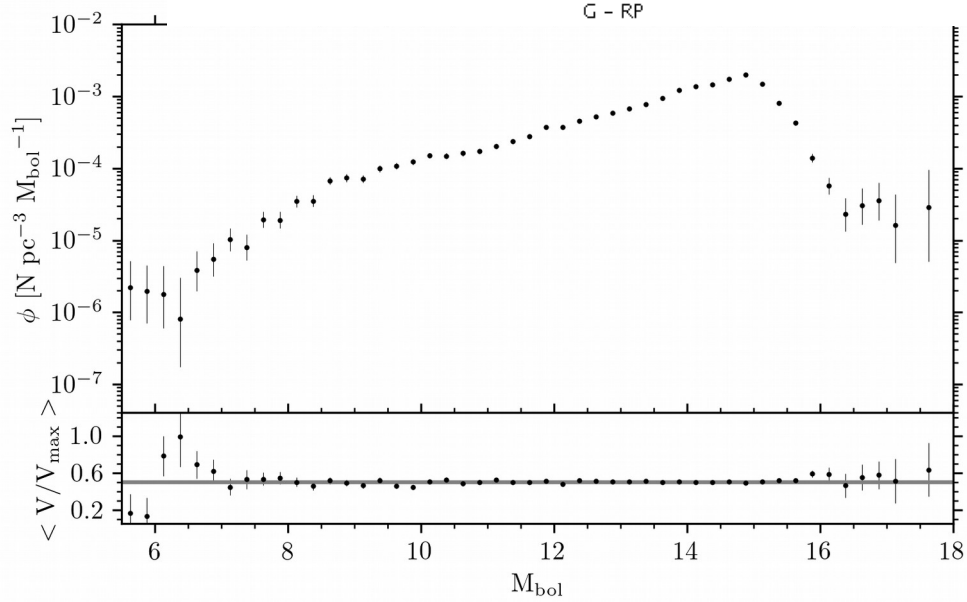
Exploitation: White Dwarfs

The WD sequence with the GCNS probability



Uses dist_50, G, G_{BP}, G_{RP}

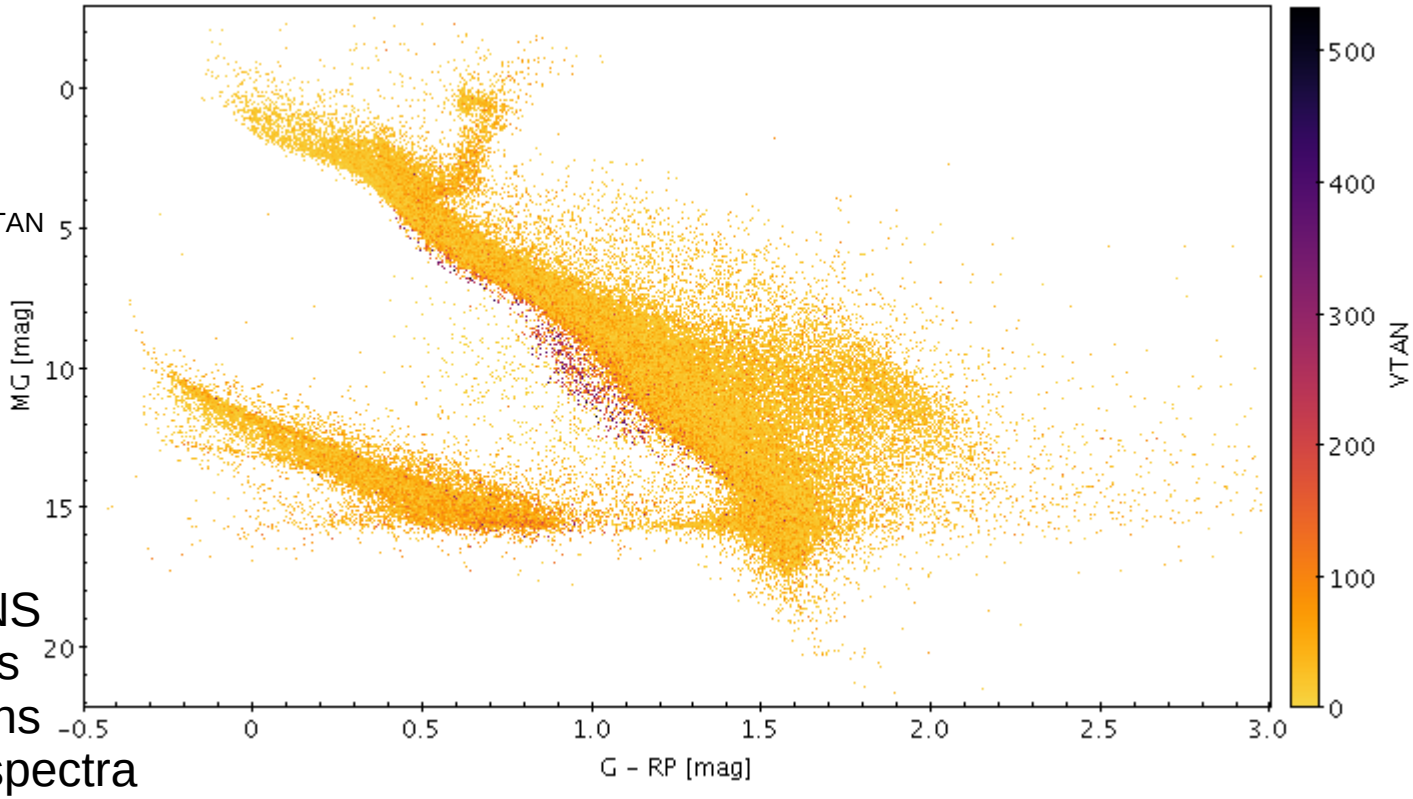
- Selected using independent Random Forest including photometry (3% difference)
- 21K WDs found in GCNS
- LF shows structure that can be modeled to recover the local historical SFR



WD LF zoom. The visible steps are probably evidence of episodic bursts of local star formation.

Future

CAMD weighted by V_{TAN}



- Needs cleaning up
- Colour outliers
- More exploitation

DR3
- RV for over 50% of GCNS
- astrophysical parameters
- some binary star solutions
- mean BP/RP and RVS spectra

DR4
- non single star solutions for most objects in GCNS
- better all round parameters

Flythru film

GCNS Extra Material

There are extra materials that showcase aspects of the GCNS hosted with ESA: https://www.cosmos.esa.int/web/gaia/edr3-questions-answers

- A video of a fly through the GCNS catalog highlighting the motions, colors and variety of the contents as well as clusters and binary systems: https://www.youtube.com/watch?v=bzQUNCleS3o
- A video of the orbits of objects in the GCNS over 500 Myr around the Galaxy: https://youtu.be/t4s50qyfFnE
- A web based interactive tool for exploring the GCNS, select special objects and see how they move: https://gruze.org/fly/
- A poster showing the bright stars and clusters within the GCNS and a poster showing the improvement Gaia has made to our knowledge of the Solar Neighbourhood: https://www.cosmos.esa.int/web/gaia/edr3-gcns
- A GCNS website: https://gucds.inaf.it/projects/gcns