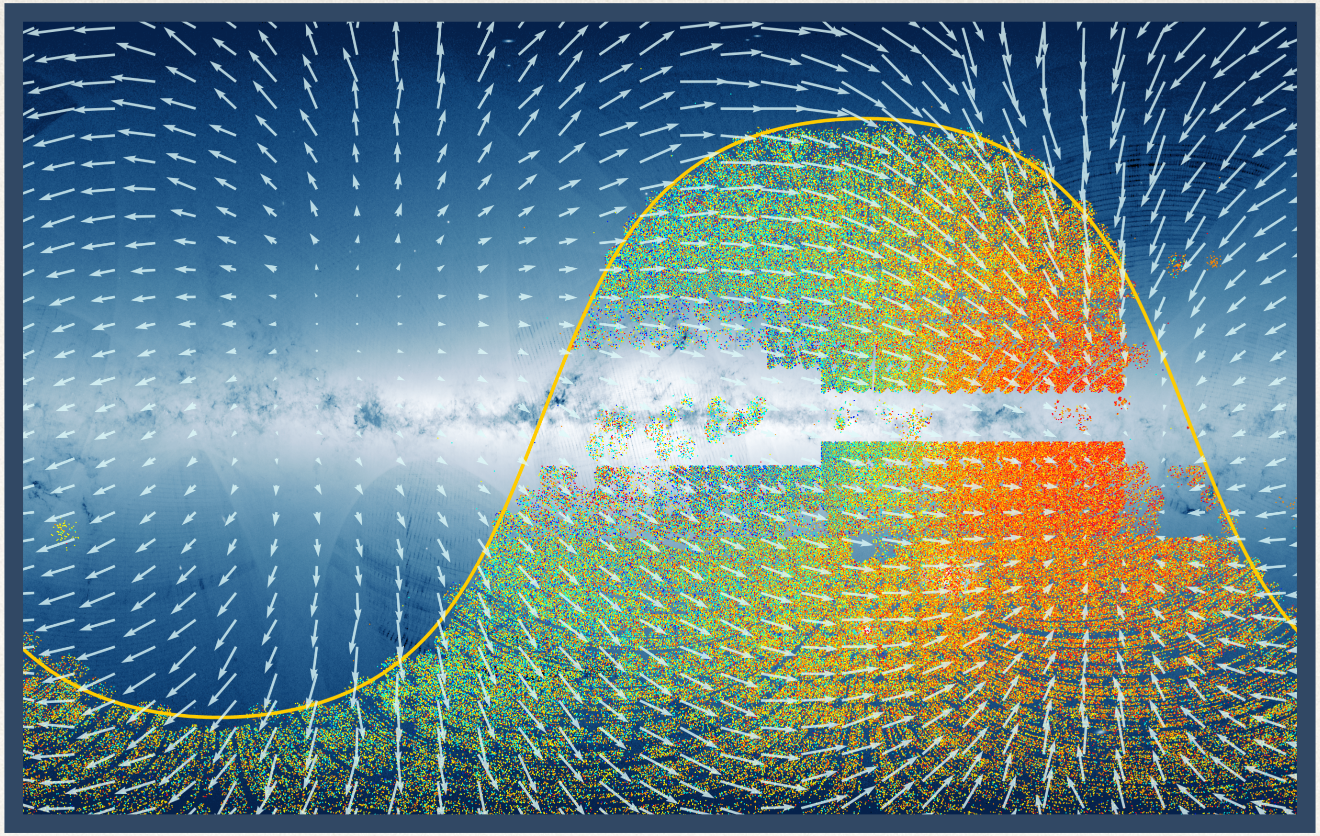
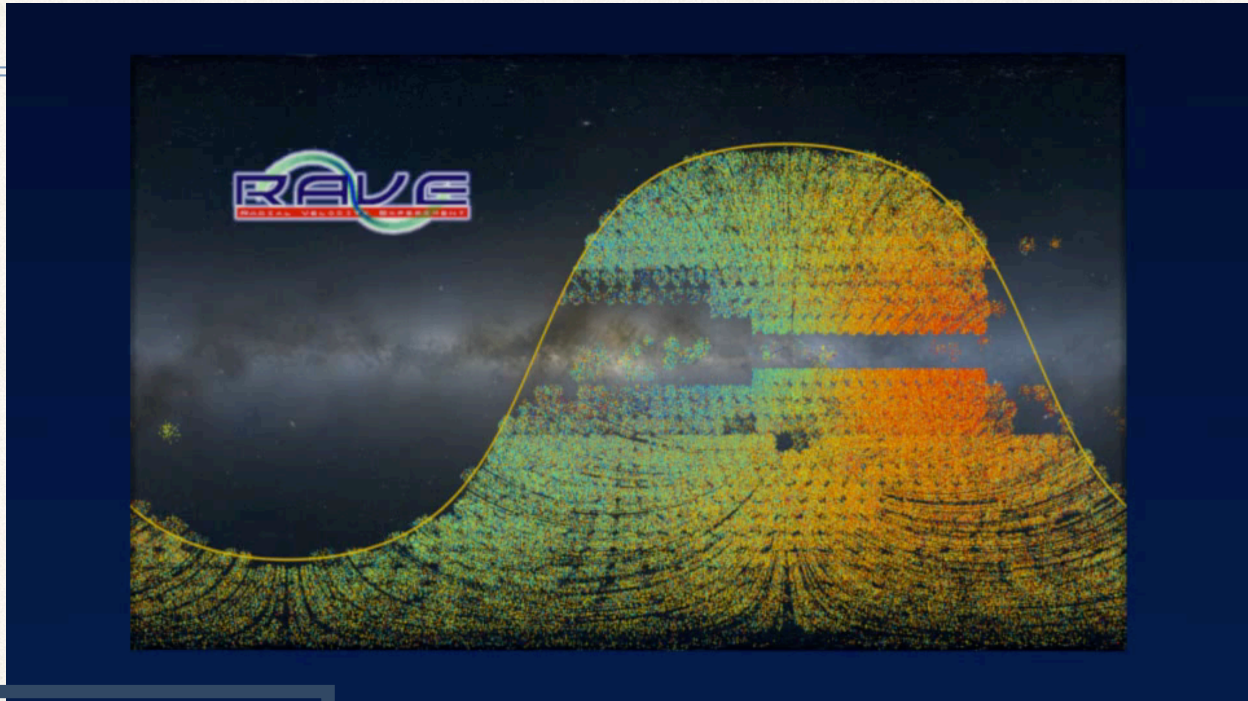


RAVE-Gaia and the impact on Galactic archeology

Andrea Kunder

Leibniz Institut für Astrophysik (AIP)

RAdial Velocity Experiment (RAVE)



520781 spectra of 457588 unique stars

Infrared flux method temperatures

Temperatures, gravities, metallicities from main pipeline

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Distances based on isochrones

Elemental abundances Mg, Al, Si, Ca, Ti, Fe, and Ni

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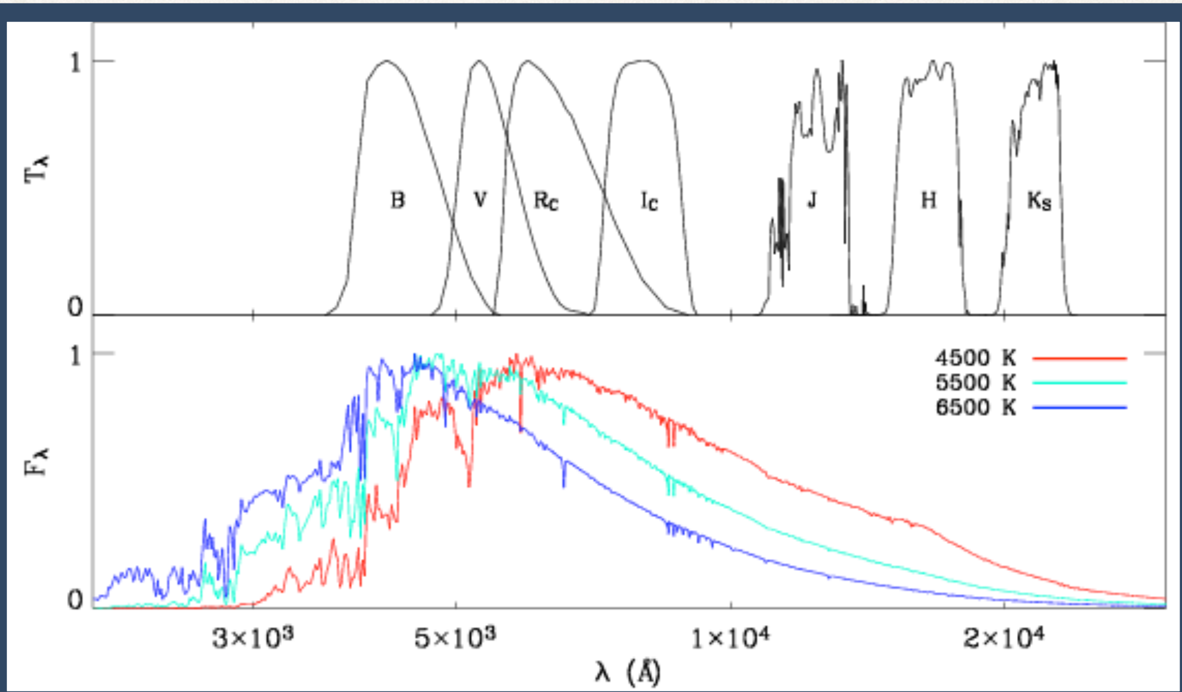

Casagrande+10

- 520781 spectra of 457588 unique stars
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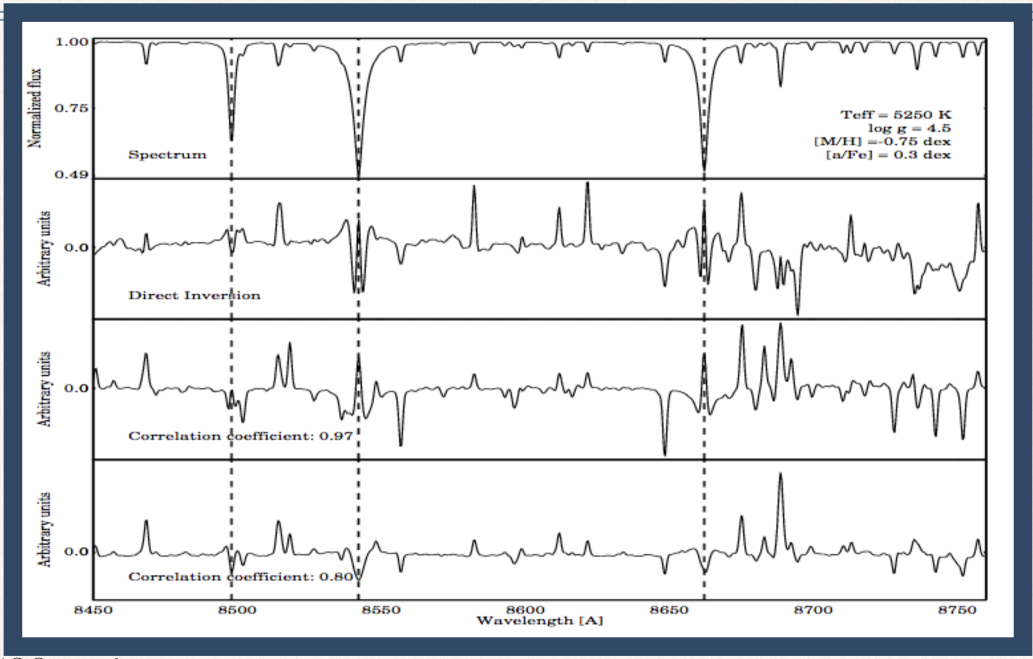

Kordopatis+11

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RAVE stellar parameters

RAVE-DR5 Best Parameters

stars with Temperatures between 4001 – 7999 K

AlgoConv = 0 → This means pipeline converged

AlgoConv = 1 stellar parameters not reliable

AlgoConv = 2 solution oscillates, mean is adopted

AlgoConv = 3 solution is extrapolation, not in learning grid

AlgoConv = 4 low SNR stars

Additional helpful constraints:

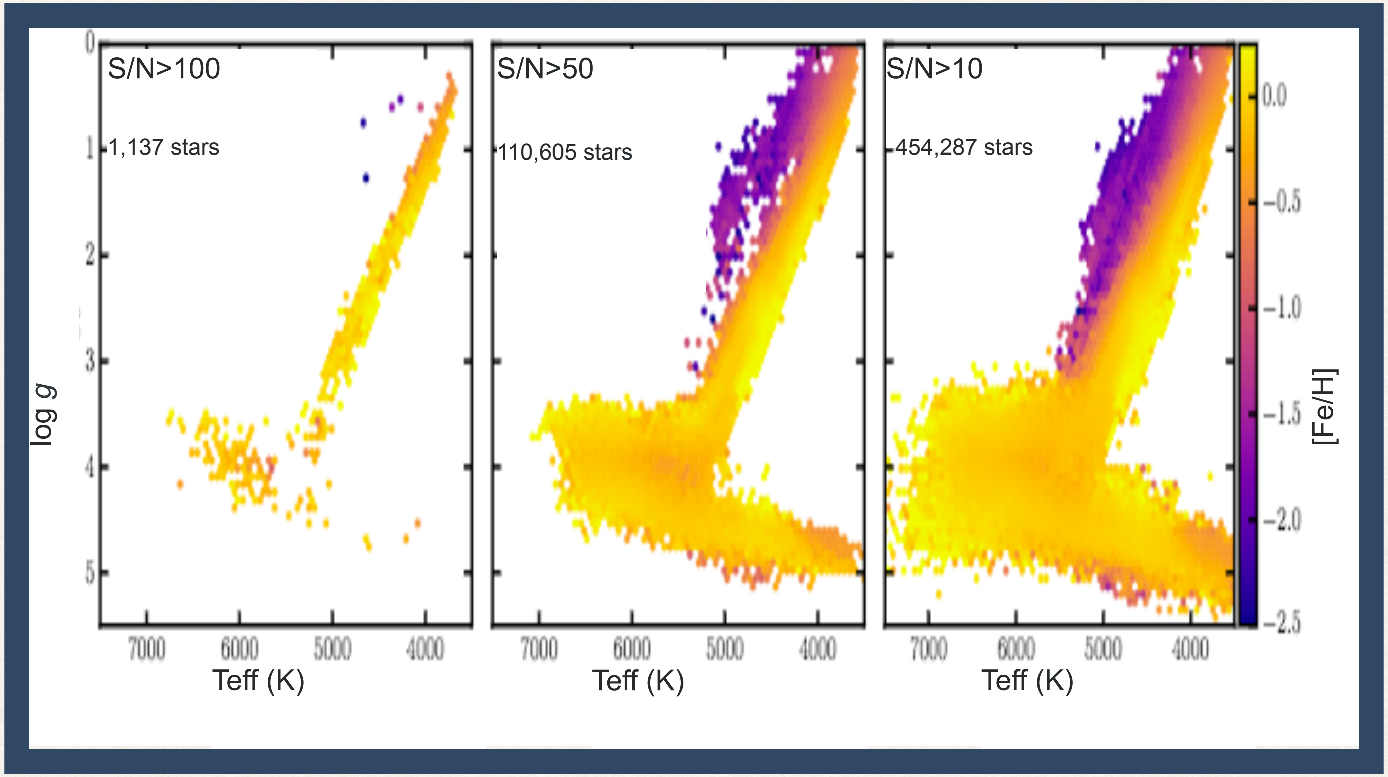
c1 = n & c2 = n & c3=n ==> morphological flags are normal

c1 = d,g,h,n,o & c2 = d,g,h,n,o,e & c3= d,g,h,n,o,e also fine to use

SNR > 40

Error in RV < 10 km/s

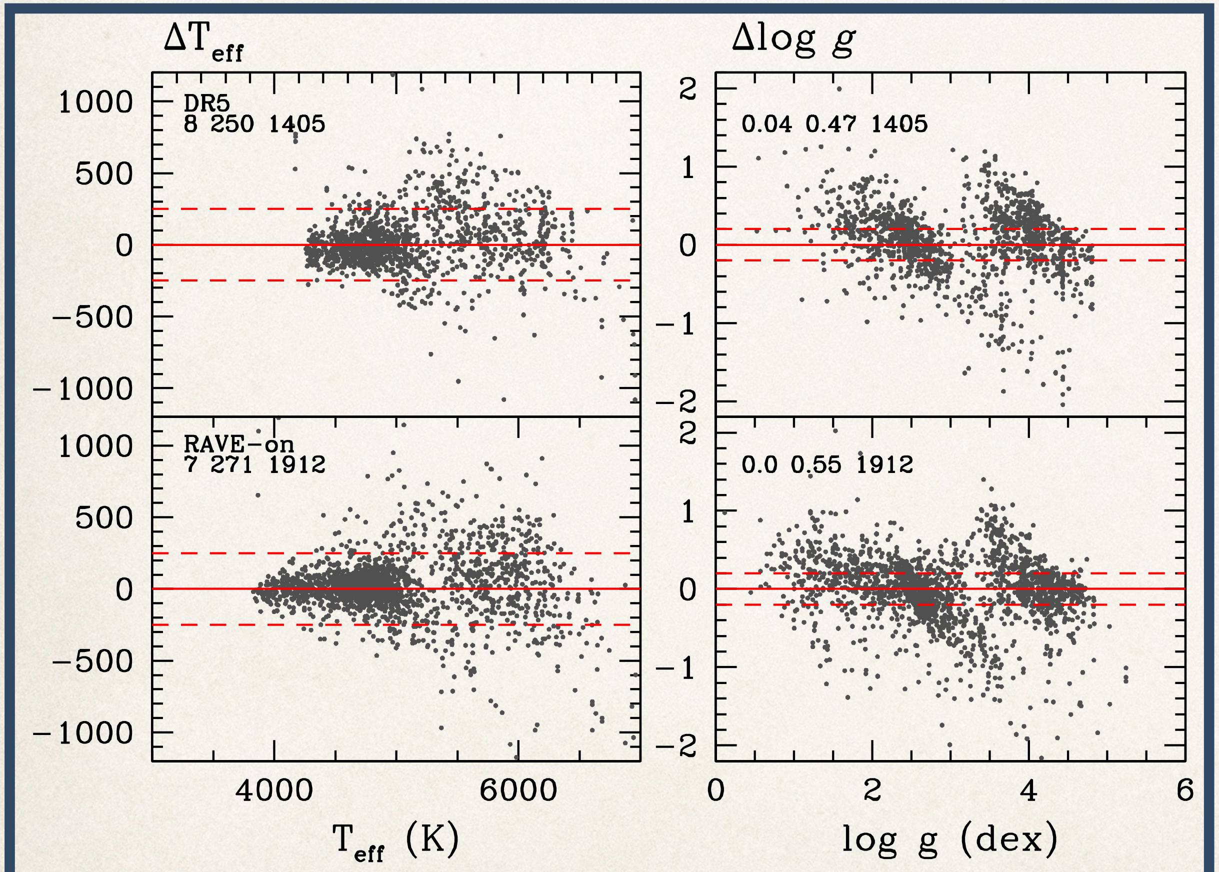
Data-driven approach (RAVE-on)



Casey+RAVE (2017)

RAVE DR5 vs RAVE-on

External Comparisons



RAVE overlap with Galah DR1, Gaia-ESO DR2, Reddy+2003, Reddy+2006, Schlaufman & Casey 2014, Trevisan+ 2011, Ramirez+ 2013, Valenti+ 2005, Bensby+ 2014, Bragaglia+2008, Carretta+2004, Takeda+2013, Funayama+2009,Pasquini +2004,Onehag+2014,Ford +2005,Johnson+10,Yang+2015

Globally, not much difference between Teff and log g parameters between RAVE-on and DR5.

RAVE DR5 vs RAVE-on

Kunder et al. 2017

External Comparisons broken up by
giants, dwarfs
hot & cold stars (Teff = 5500)
metal-rich & metal-poor (Fe/H = -0.5)
SNR

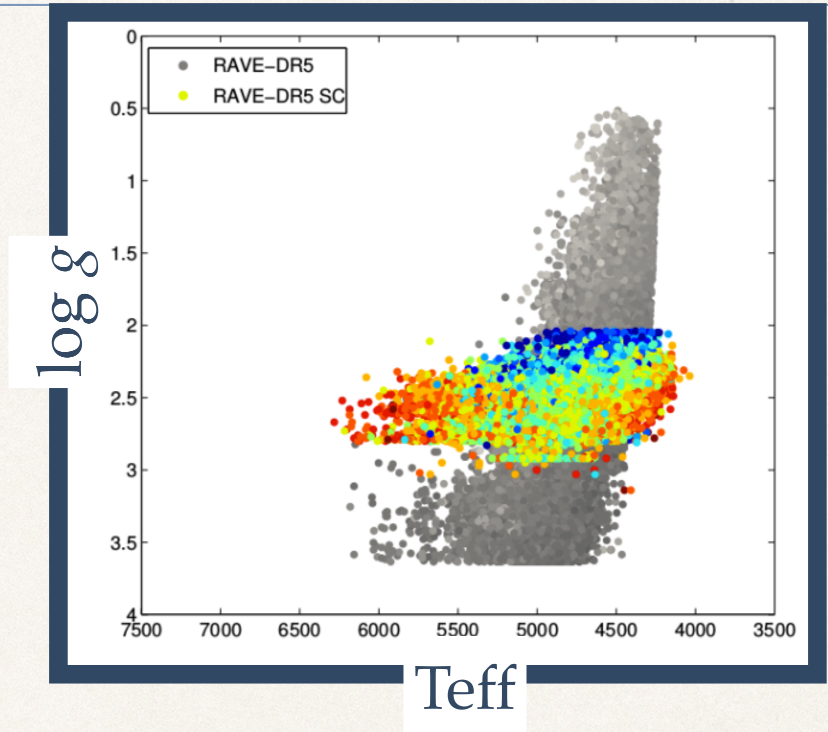
RAVE-on advantages
-- low SNR dwarf metallicities
-- high metallicity giants
-- more stars have measured stellar parameters
-- elemental abundances for high-metallicity giants

RAVE DR5 advantages
-- hot & cool metal-poor stars
-- stars with unphysical stellar parameters are flagged by AlgoConv
-- elemental abundances for both dwarfs and giants, for metal-rich and metal-poor populations

TABLE 4
ESTIMATES OF THE EXTERNAL ERRORS IN THE STELLAR PARAMETERS.

stellar type	N	$\sigma(T_{\rm eff})$	$\sigma(\log g)$	$\sigma([M/H])$	$\sigma(T_{\rm eff,IRFM})$
dwarfs ($\log g > 3.5$)					
hot, all metallicities DR5	375	442	0.39	0.41	129
hot, metal-poor DR5	38	253	0.48	0.95	258
hot, metal-rich DR5	337	453	0.38	0.95	233
cool, all metallicities DR5	332	250	0.75	0.41	187
cool, metal-poor DR5	68	303	0.87	0.61	301
cool, metal-rich DR5	264	233	0.72	0.29	146
hot, all metallicities RAVE-on	510	411	0.56	0.37	
hot, metal-poor RAVE-on	95	498	0.94	0.55	
hot, metal-rich RAVE-on	415	389	0.41	0.32	
cool, all metallicities RAVE-on	267	291	0.62	0.24	
cool, metal-poor RAVE-on	49	417	0.75	0.32	
cool, metal-rich RAVE-on	218	255	0.57	0.20	
SNR > 40					
hot, all metallicities DR5	260	210	0.29	0.16	
hot, metal-poor DR5	30	260	0.39	0.16	
hot, metal-rich DR5	230	201	0.28	0.15	
cool, all metallicities	185	202	0.50	0.17	
cool, metal-poor	48	256	0.70	0.21	
cool, metal-rich	137	164	0.41	0.13	
hot, all metallicities RAVE-on	314	273	0.34	0.21	
hot, metal-poor RAVE-on	55	354	0.61	0.36	
hot, metal-rich RAVE-on	259	253	0.24	0.16	
cool, all metallicities RAVE-on	187	250	0.54	0.17	
cool, metal-poor RAVE-on	35	303	0.65	0.21	
cool, metal-rich RAVE-on	152	237	0.49	0.15	
Giants ($\log g < 3.5$)					
all, all metallicities DR5	1294	156	0.48	0.17	110
hot DR5	28	240	0.45	0.30	261
cool, metal-poor DR5	260	211	0.58	0.20	93
cool, metal-rich DR5	1006	125	0.46	0.15	96
all, all metallicities RAVE-on	1318	140	0.41	0.20	
hot RAVE-on	5	270	0.62	0.27	
cool, metal-poor RAVE-on	293	195	0.55	0.27	
cool, metal-rich RAVE-on	1020	110	0.36	0.17	
SNR > 40					
hot DR5	22	189	0.46	0.24	
cool, metal-poor DR5	225	210	0.58	0.20	
cool, metal-rich DR5	843	113	0.44	0.13	
hot RAVE-on	3	120	0.28	0.23	
cool, metal-poor RAVE-on	248	159	0.52	0.23	
cool, metal-rich RAVE-on	810	88	0.33	0.15	
Giants (asteroseismically calibrated sample)	N_*	$\sigma(T_{\rm eff,IRFM})$	$\sigma(\log g_*)$	$\sigma([Fe/H]_c)$	
all, all metallicities	332	169	0.37	0.21	
hot	11	640	0.39	0.28	
cool, metal-poor	180	161	0.40	0.23	
cool, metal-rich	835	107	0.29	0.15	
SNR > 40					
hot	5	471	0.42	0.15	
cool, metal-poor	154	170	0.38	0.21	
cool, metal-rich	701	95	0.28	0.12	

RAdial Velocity Experiment (RAVE)



Valentini+17

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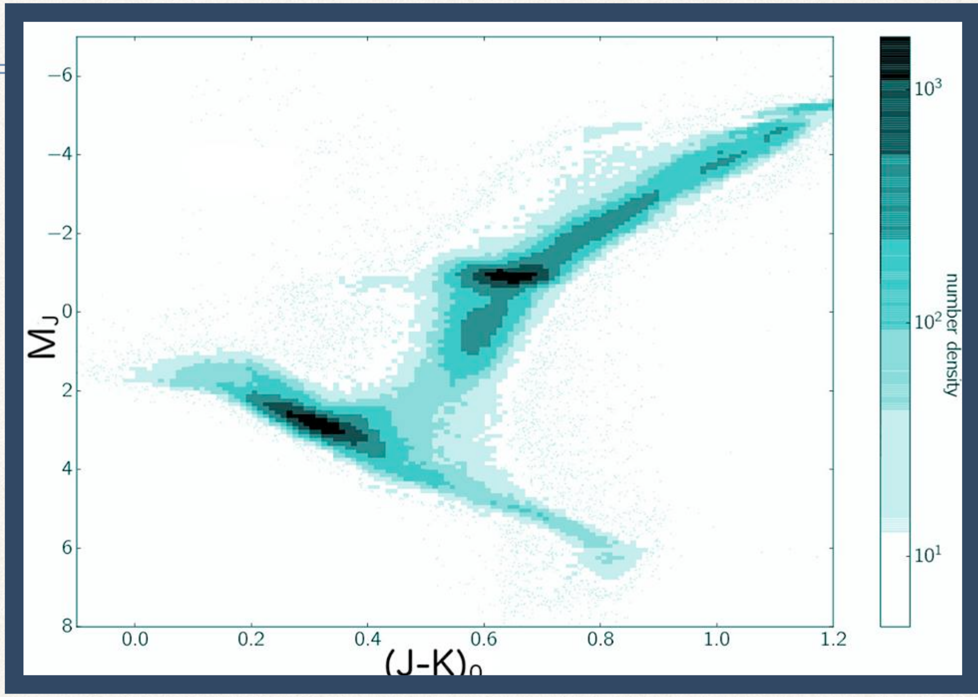

McMillan+17

Kunder+17

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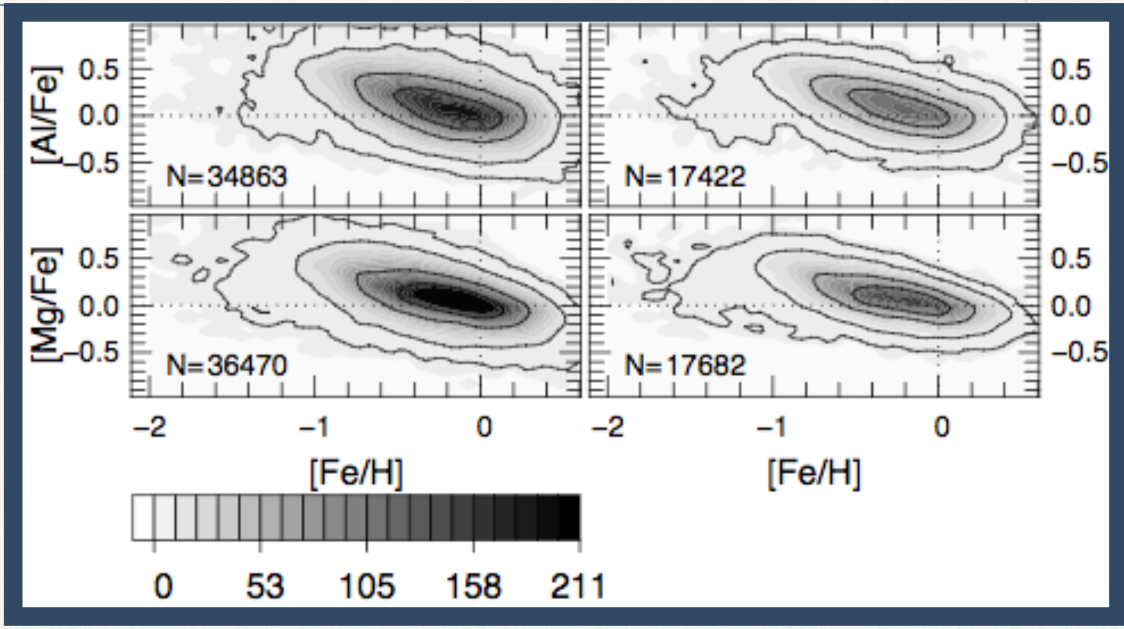

Boeche+11

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Elemental abundances Mg, Al, Si, Ca, Ti, Fe, and Ni

RAVE vs Gaia

identical wavelength range

R~7 500

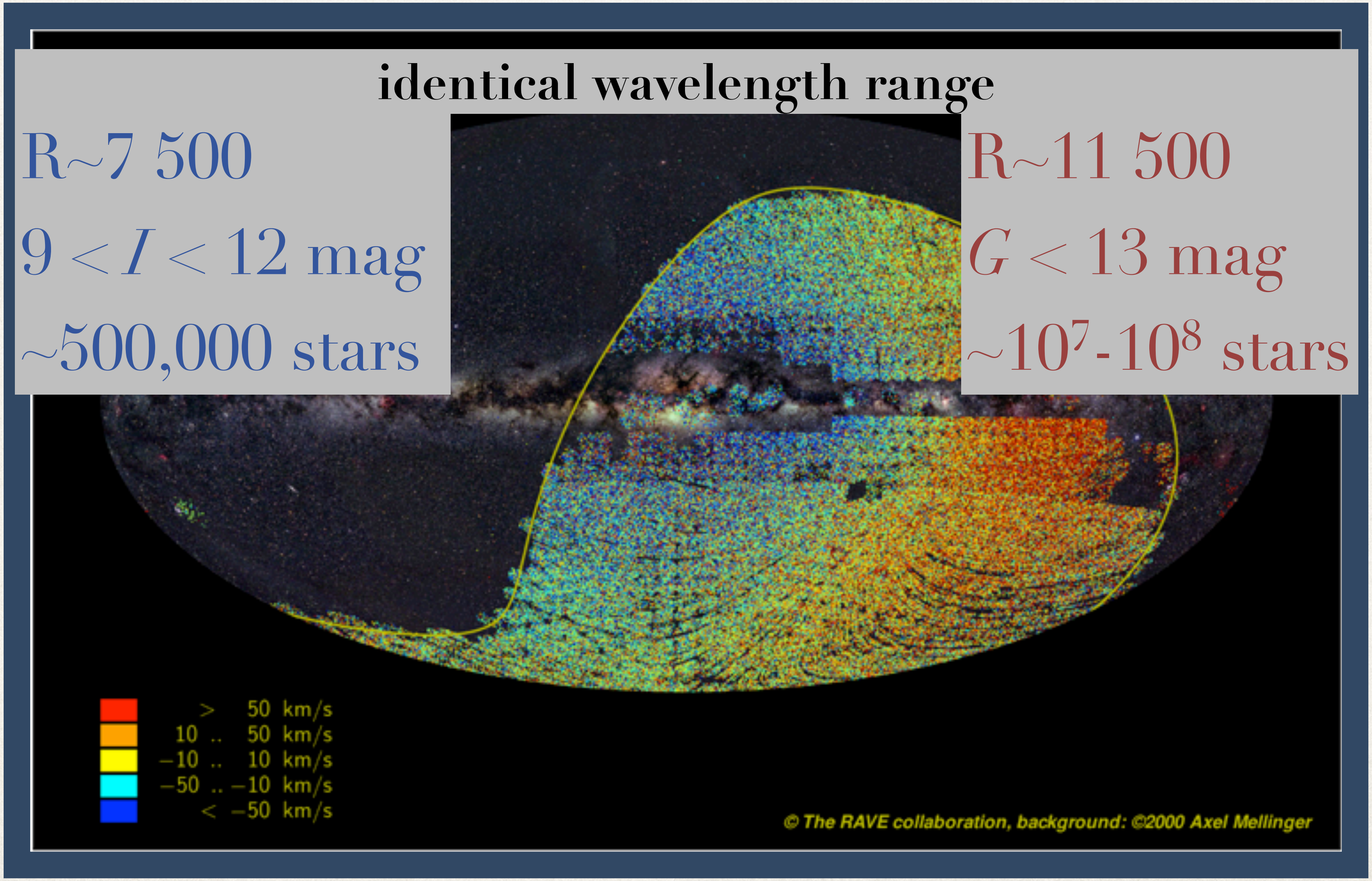
$9 < I < 12$ mag

~500,000 stars

R~11 500

$G < 13$ mag

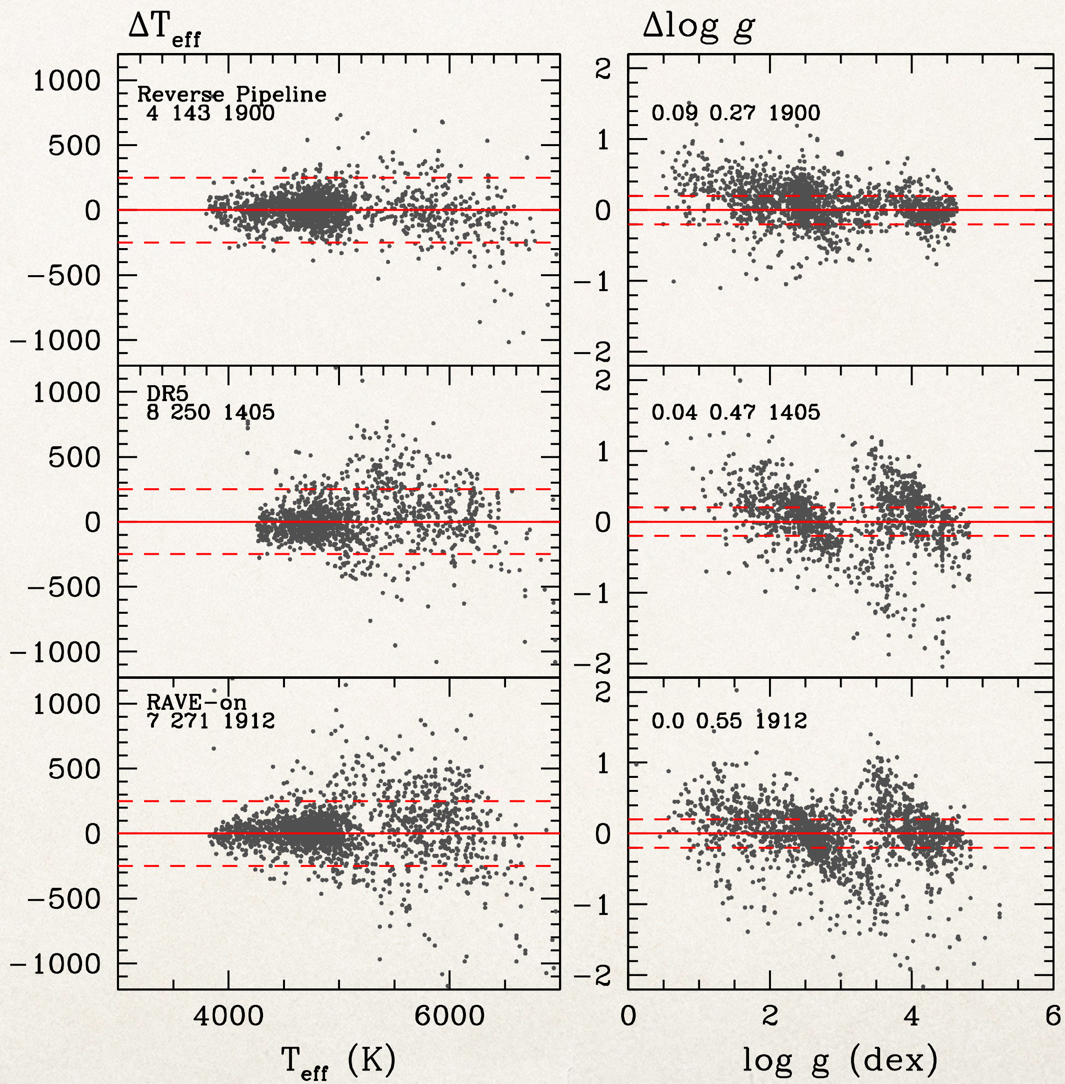
~10^7-10^8 stars



RAVE-TGAS overlap

Spectroscopic Survey	Number TGAS stars
RAVE DR5	215,600
LAMOST DR2	124,300
GALAH DR1	8,500
APOGEE DR13	21,700

TGAS to break degeneracies



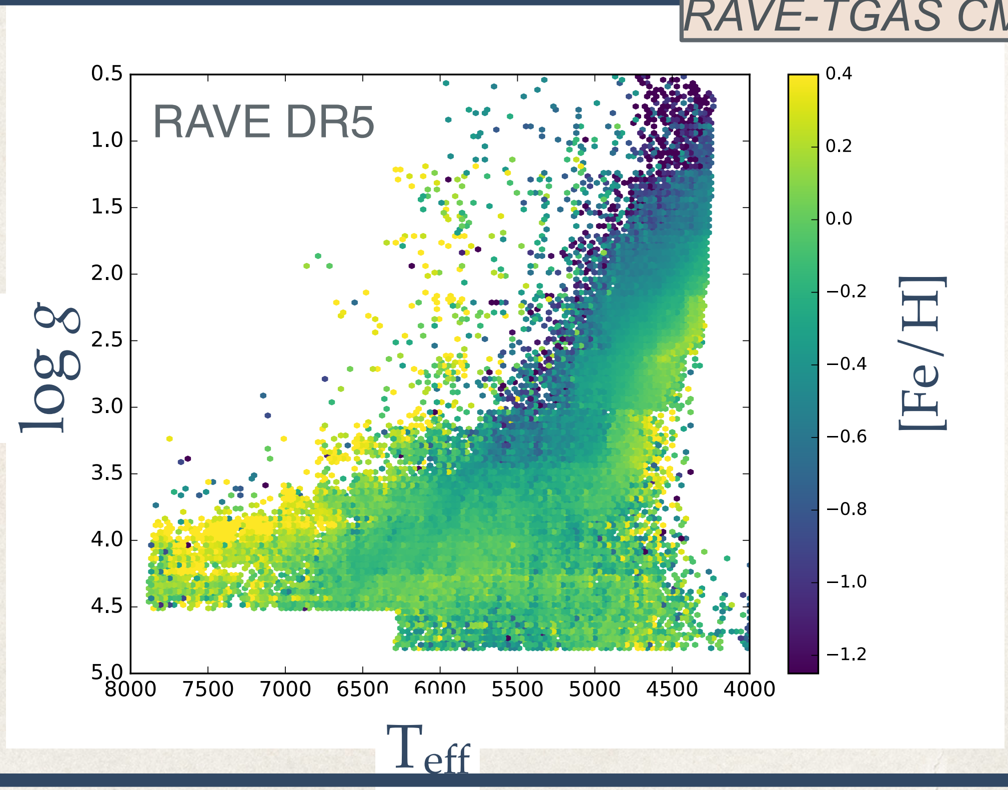
RAVE-TGAS overlap

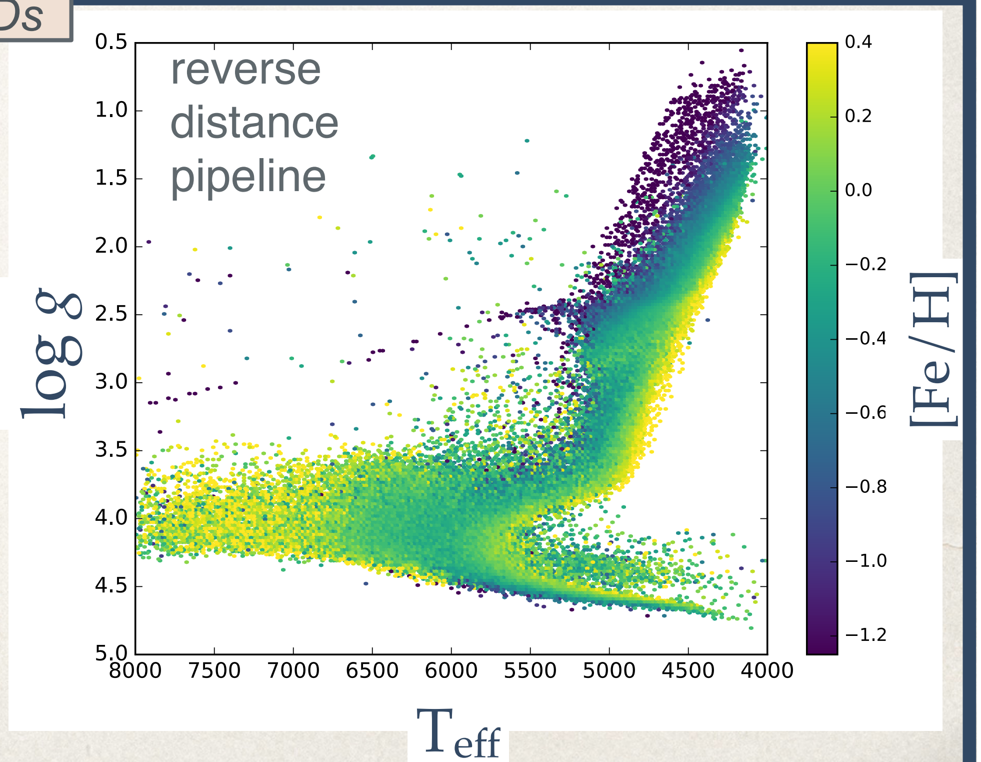
Spectroscopic Survey	Number TGAS stars
RAVE DR5	215,600
LAMOST DR2	124,300
GALAH DR1	8,500
APOGEE DR13	21,700

SNR > 20
158,703 stars

SNR > 20
158,703 stars

RAVE-TGAS CMDs





RAVE-TGAS overlap

Spectroscopic Survey	Number TGAS stars
RAVE DR5	215,600
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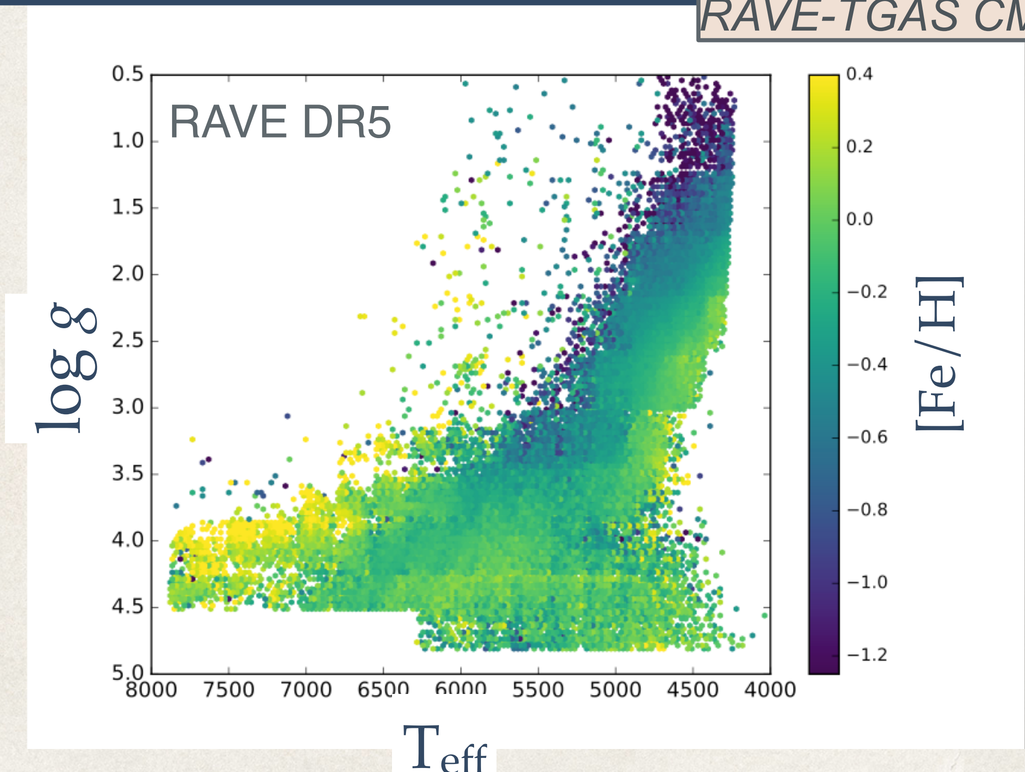
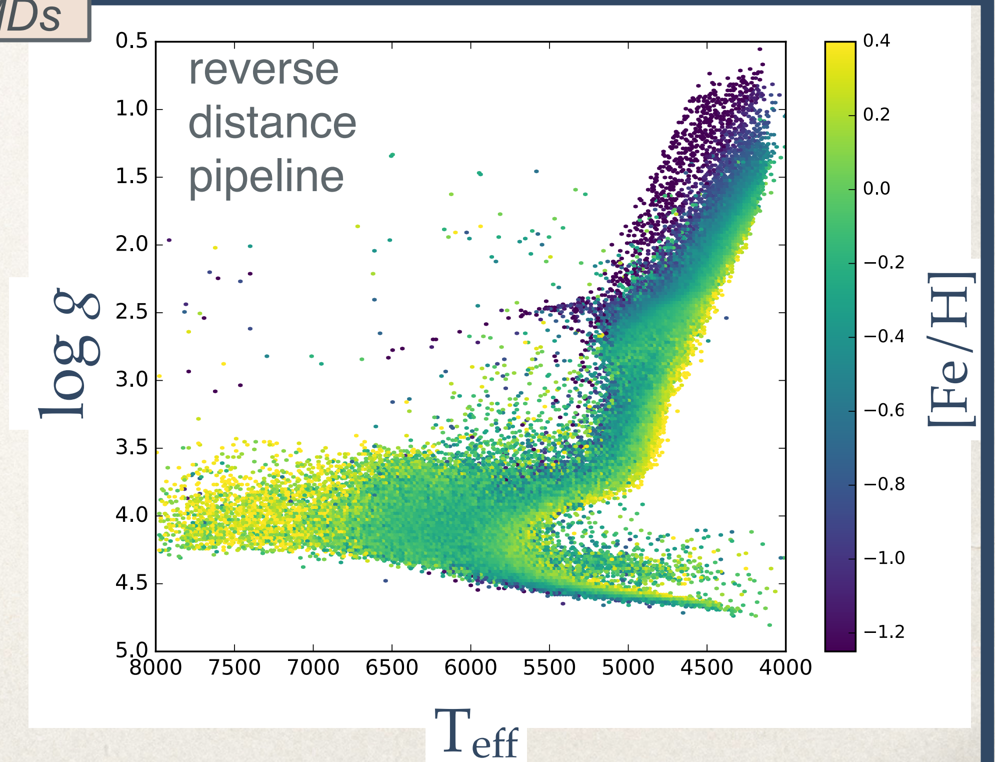
GALAH DR1	8,500
APOGEE DR13	21,700

SNR > 40
131,258 stars

SNR > 40
131,258 stars

RAVE-TGAS CMDs





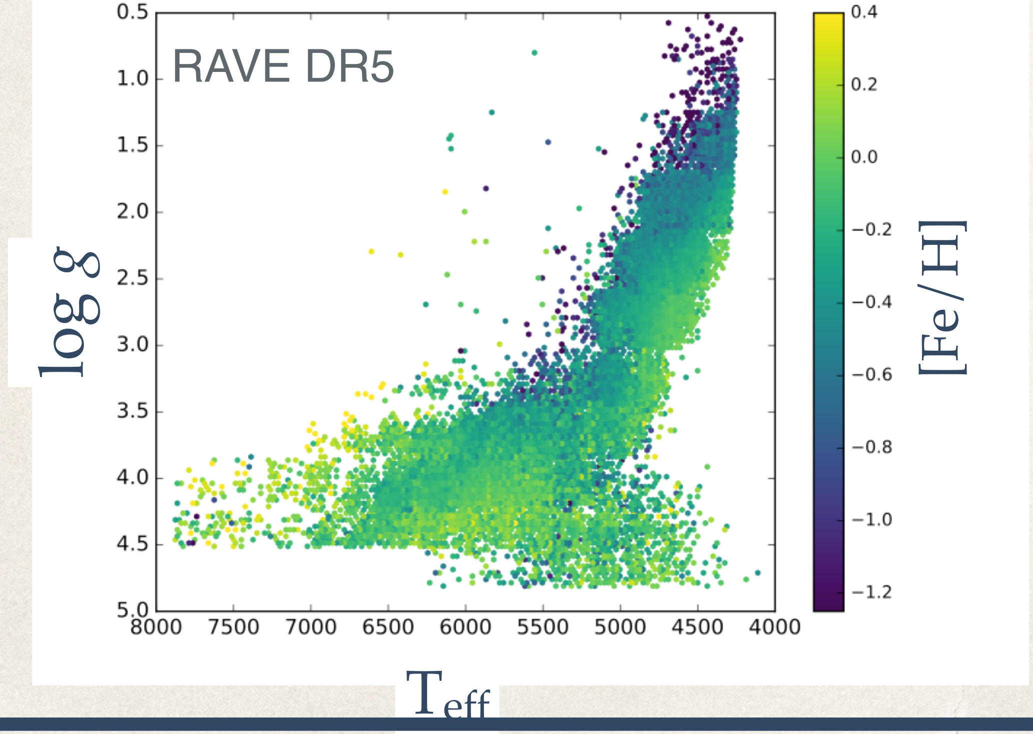
RAVE-TGAS overlap

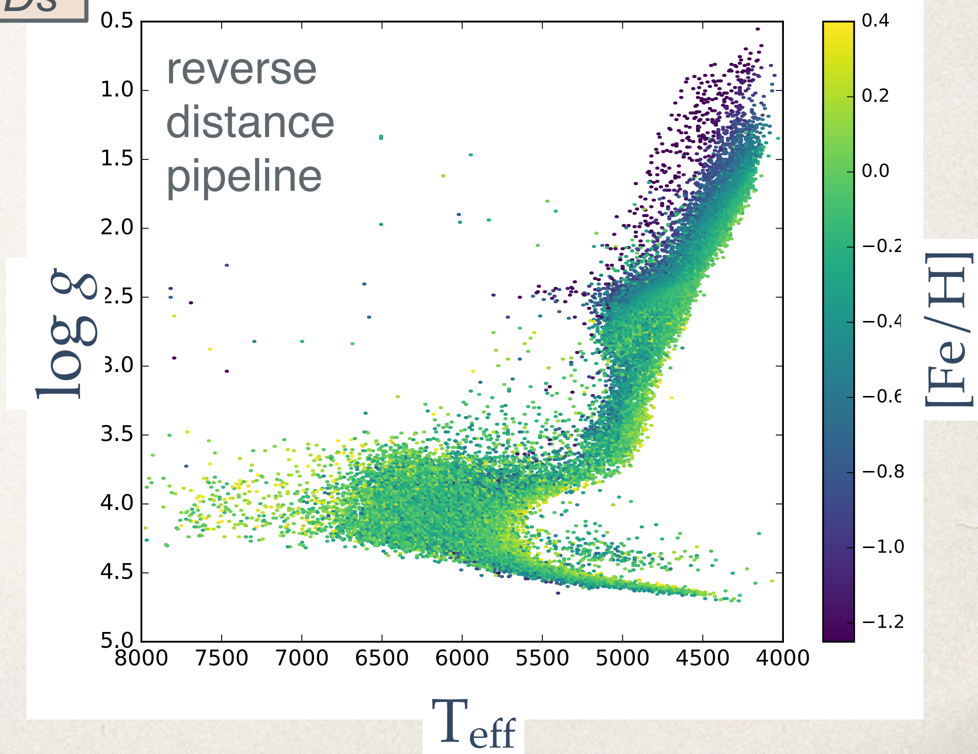
Spectroscopic Survey	Number TGAS stars
RAVE DR5	215,600
LAMOST DR2	124,300
GALAH DR1	8,500
APOGEE DR13	21,700

SNR > 70
42,545 stars

SNR > 70
42,545 stars

RAVE-TGAS CMDs





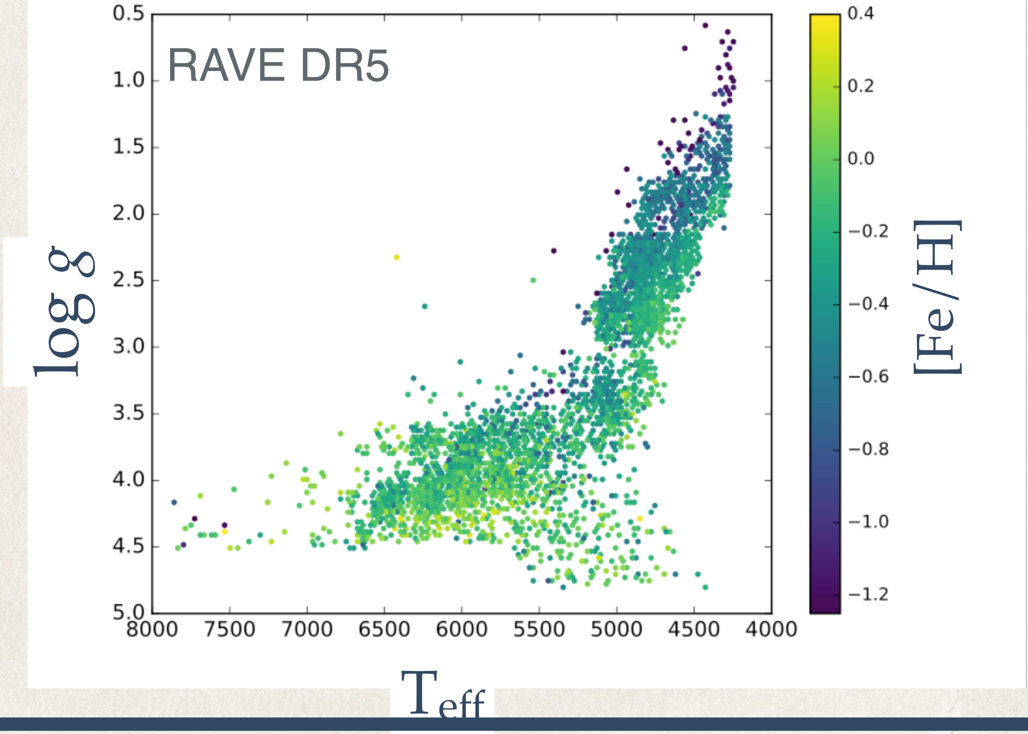
RAVE-TGAS overlap

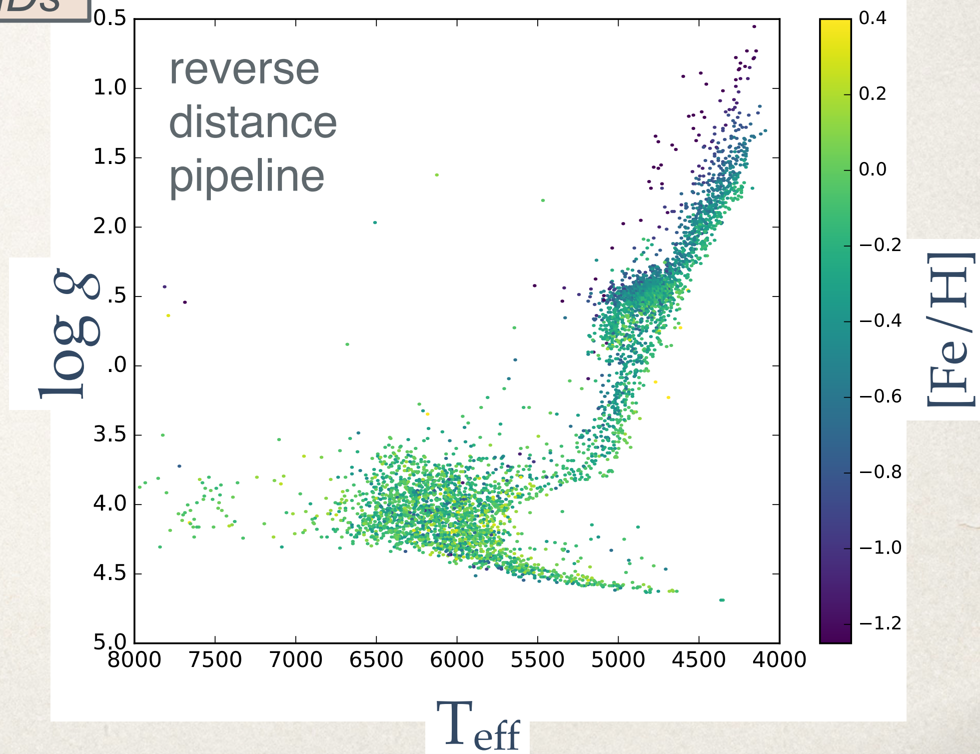
Spectroscopic Survey	Number TGAS stars
RAVE DR5	215,600
LAMOST DR2	124,300
GALAH DR1	8,500
APOGEE DR13	21,700

SNR > 100
5,111 stars

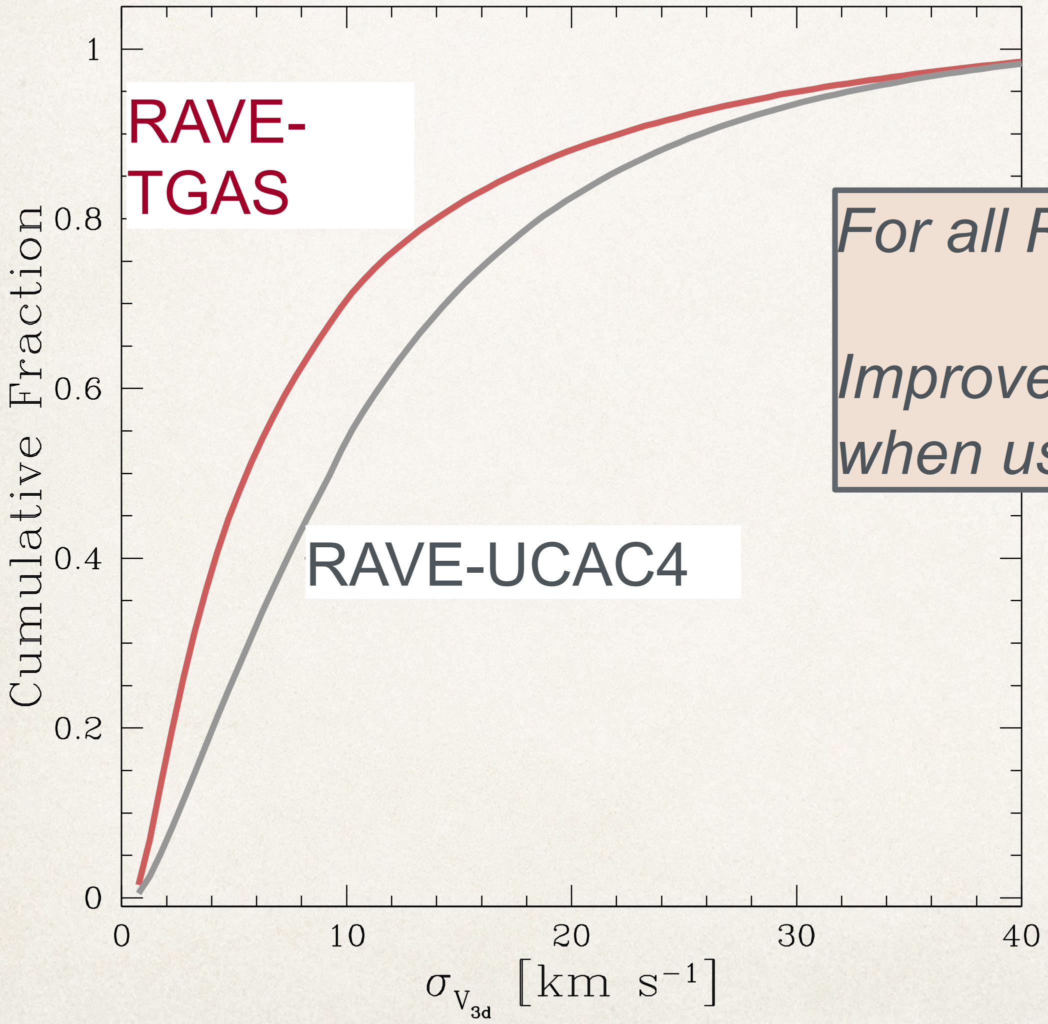
SNR > 100
5,111 stars

RAVE-TGAS CMDs





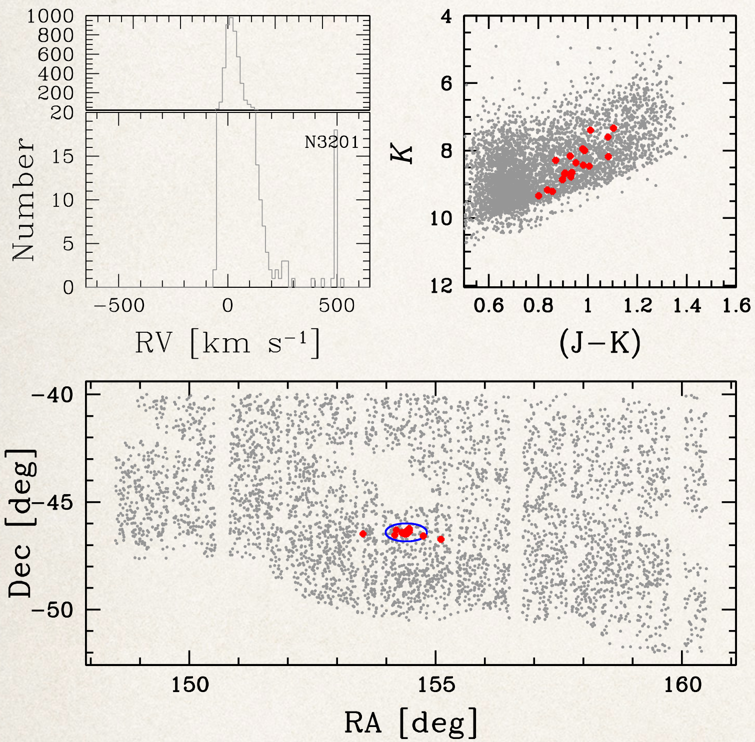
RAVE-TGAS overlap

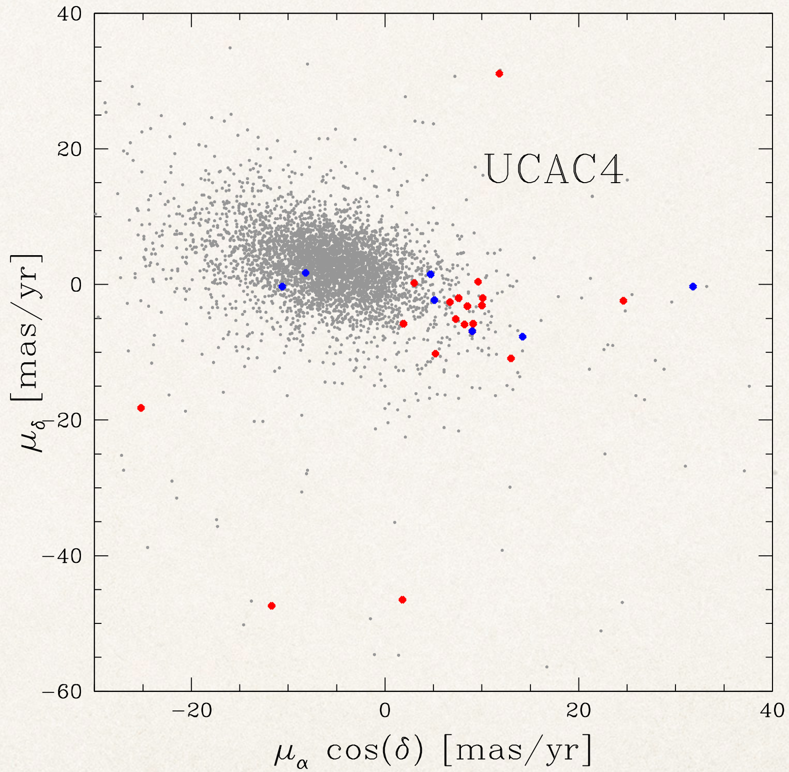


For all RAVE-TGAS stars

Improved 3D space velocities when using TGAS astrometry

NGC 3201 - pre-Gaia

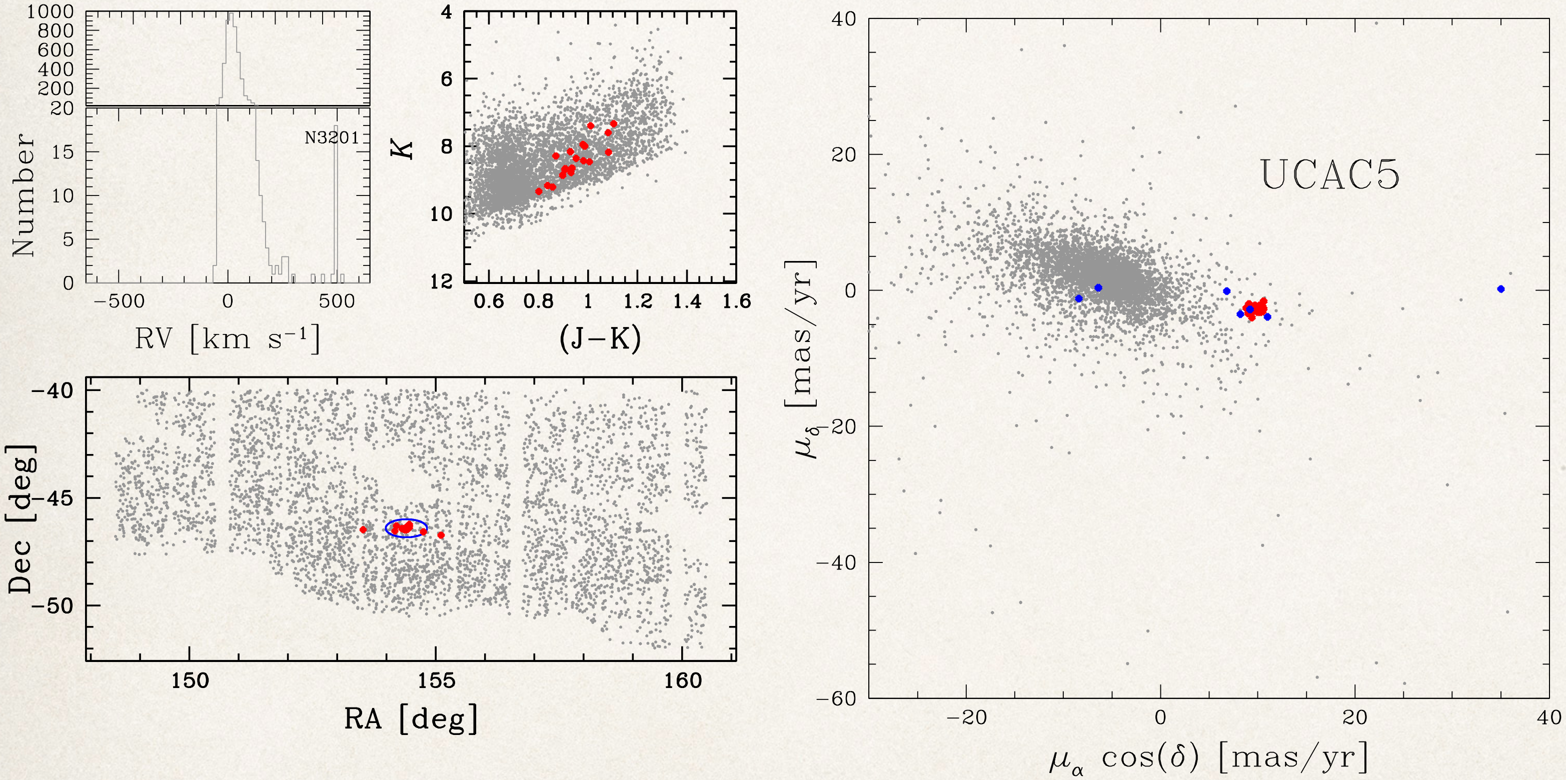




Kunder+14
NGC 3201 stars
+ extra-tidal stars

Anguiano+16
NGC 3201 stream stars

NGC 3201 - post-Gaia



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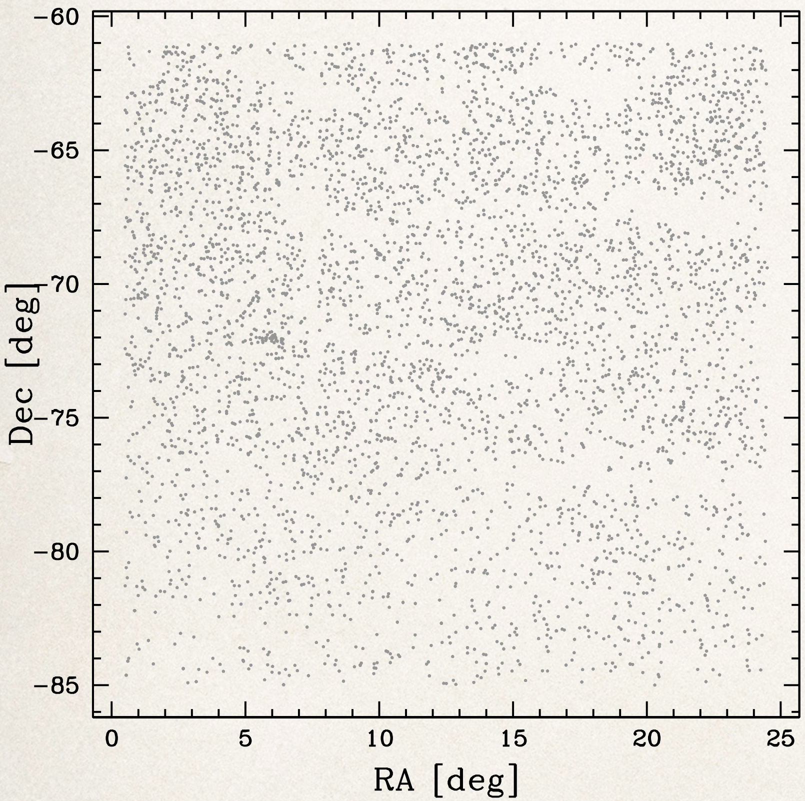
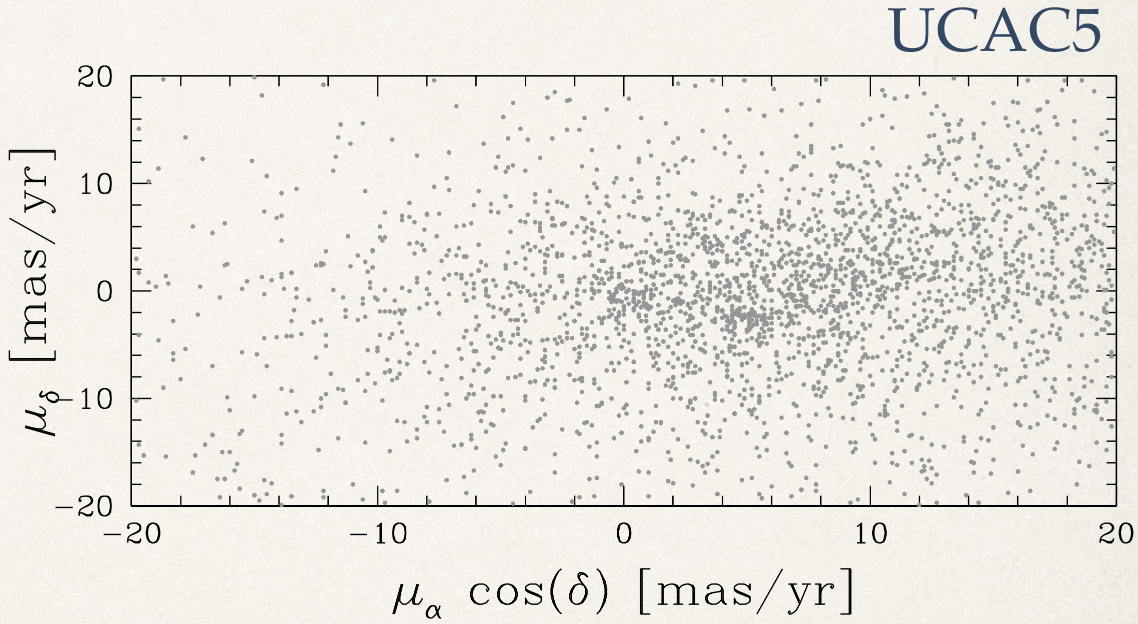
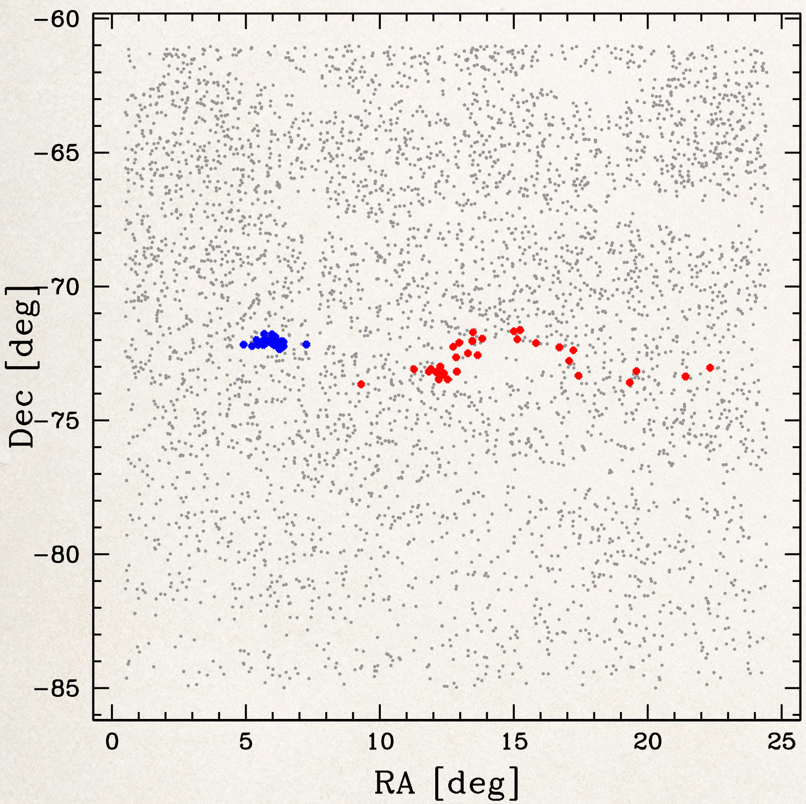
Anguiano+16
NGC 3201 stream stars

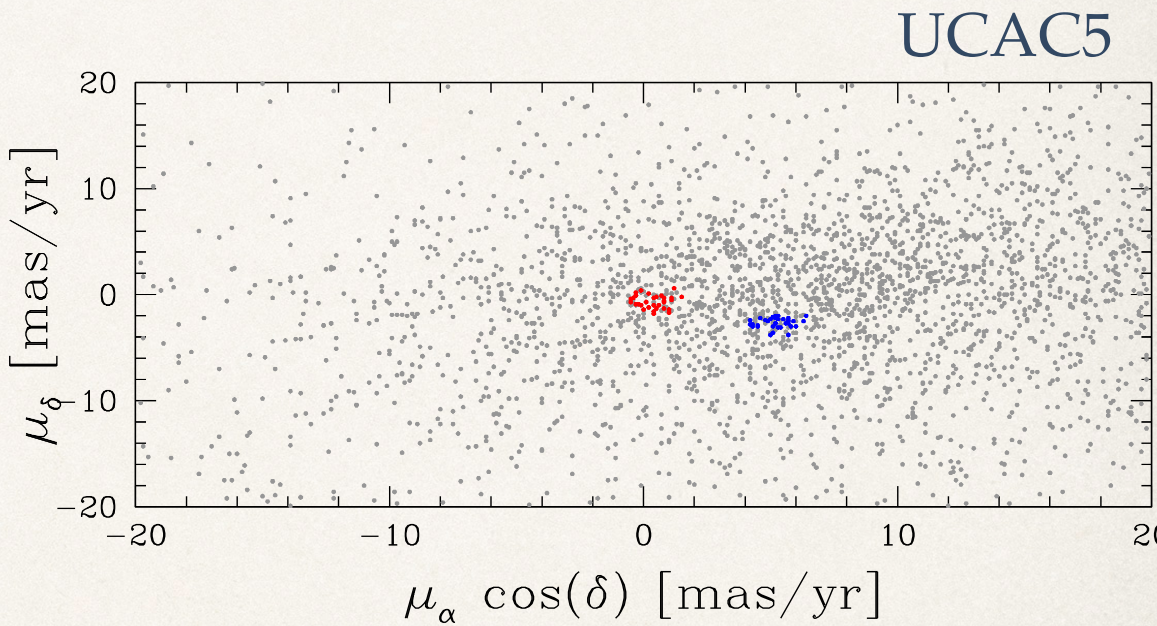
RAVE + UCAC5 proper motions



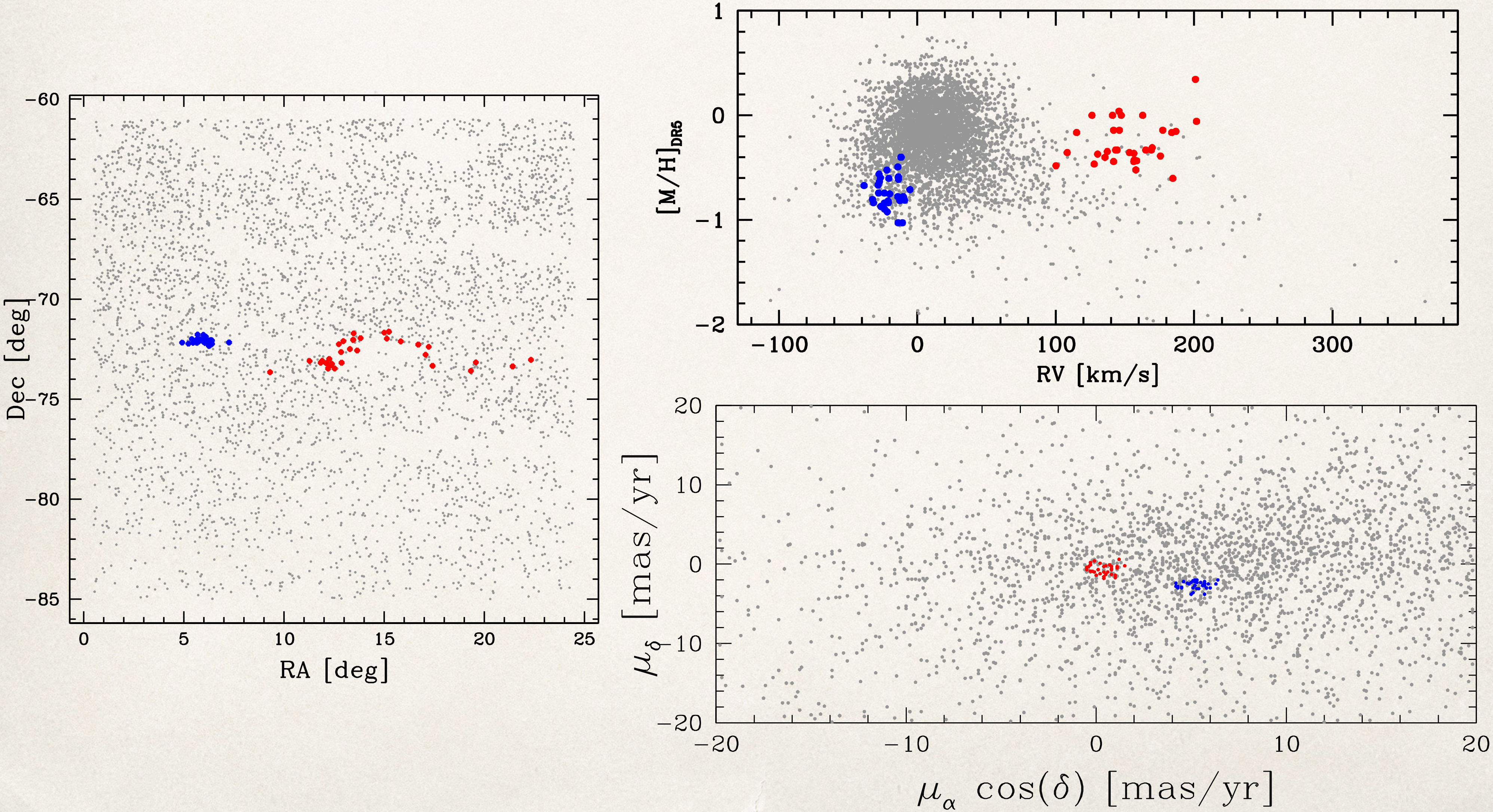


RAVE + UCAC5 proper motions

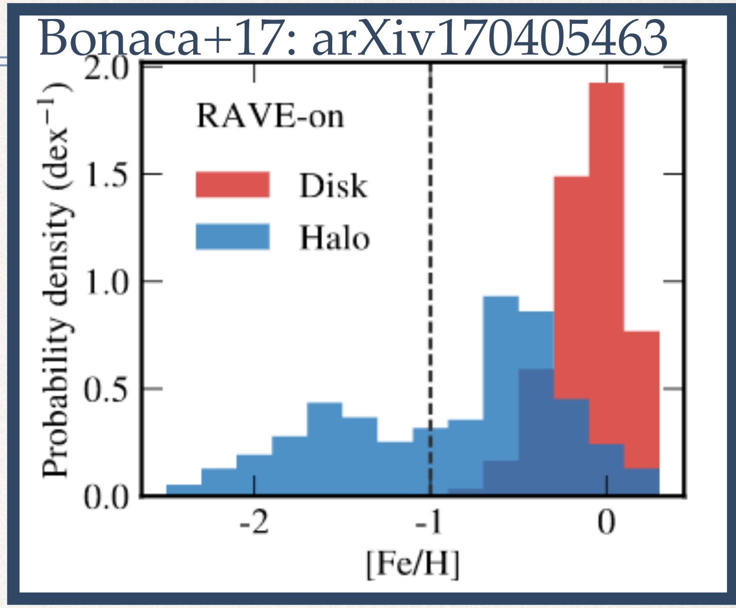


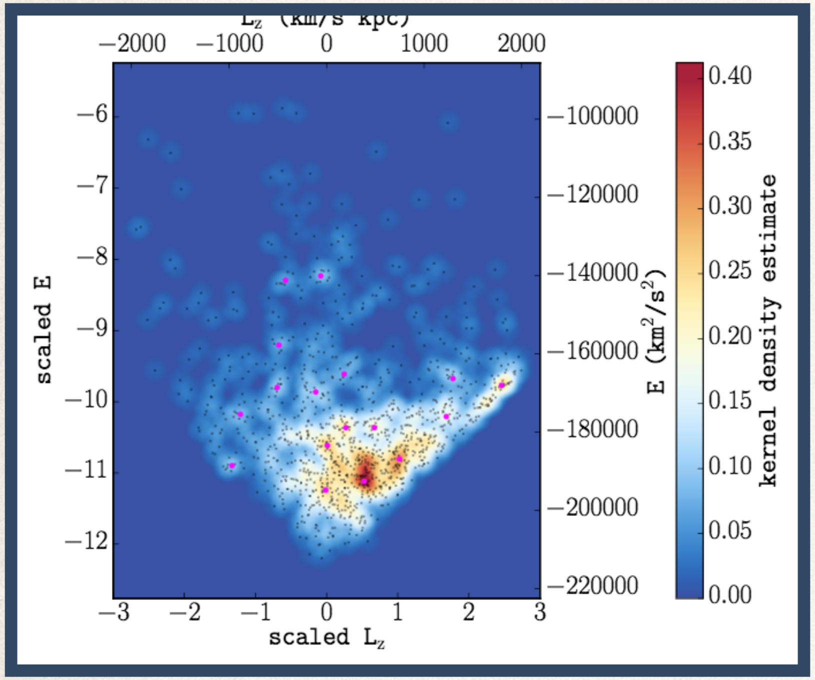


47 Tuc + SMC

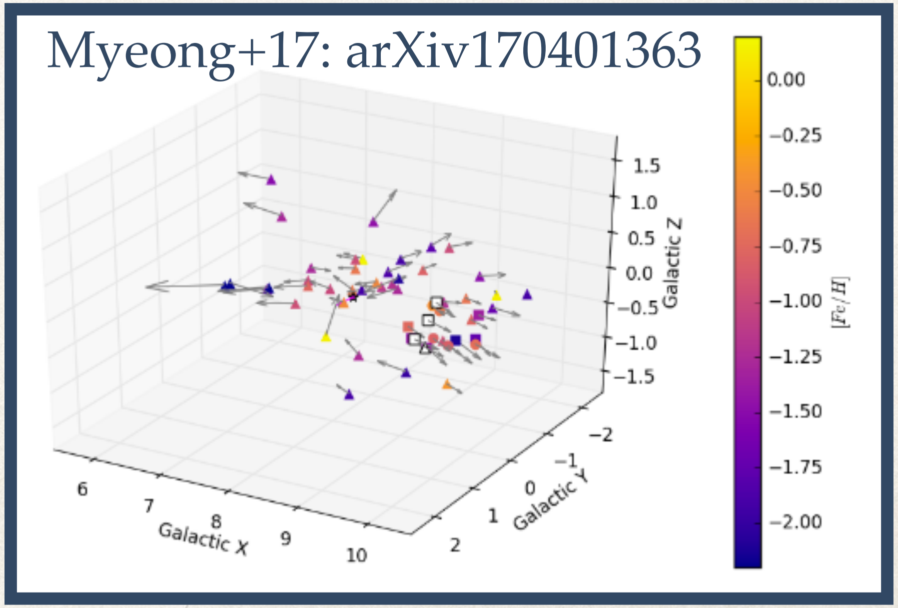


RAVE-Gaia orbits



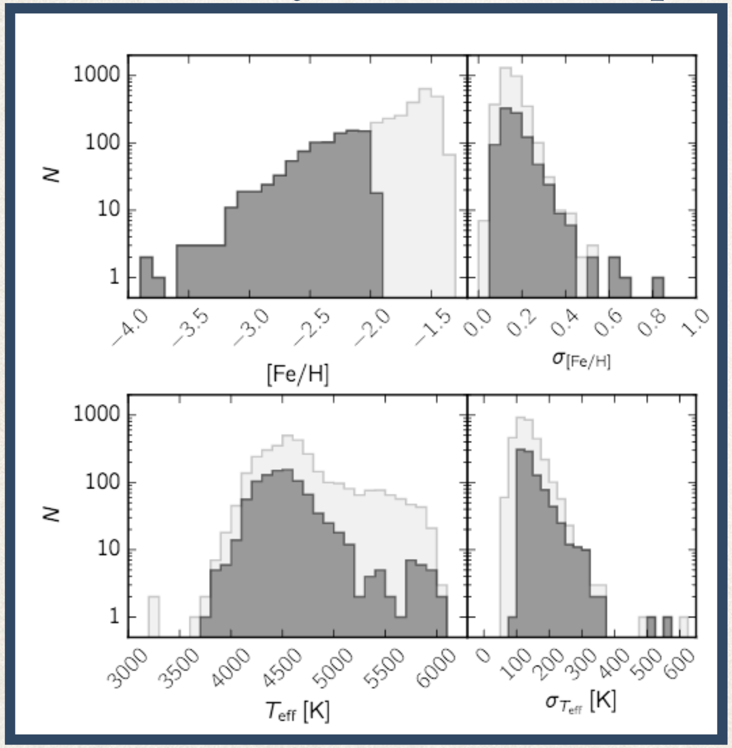


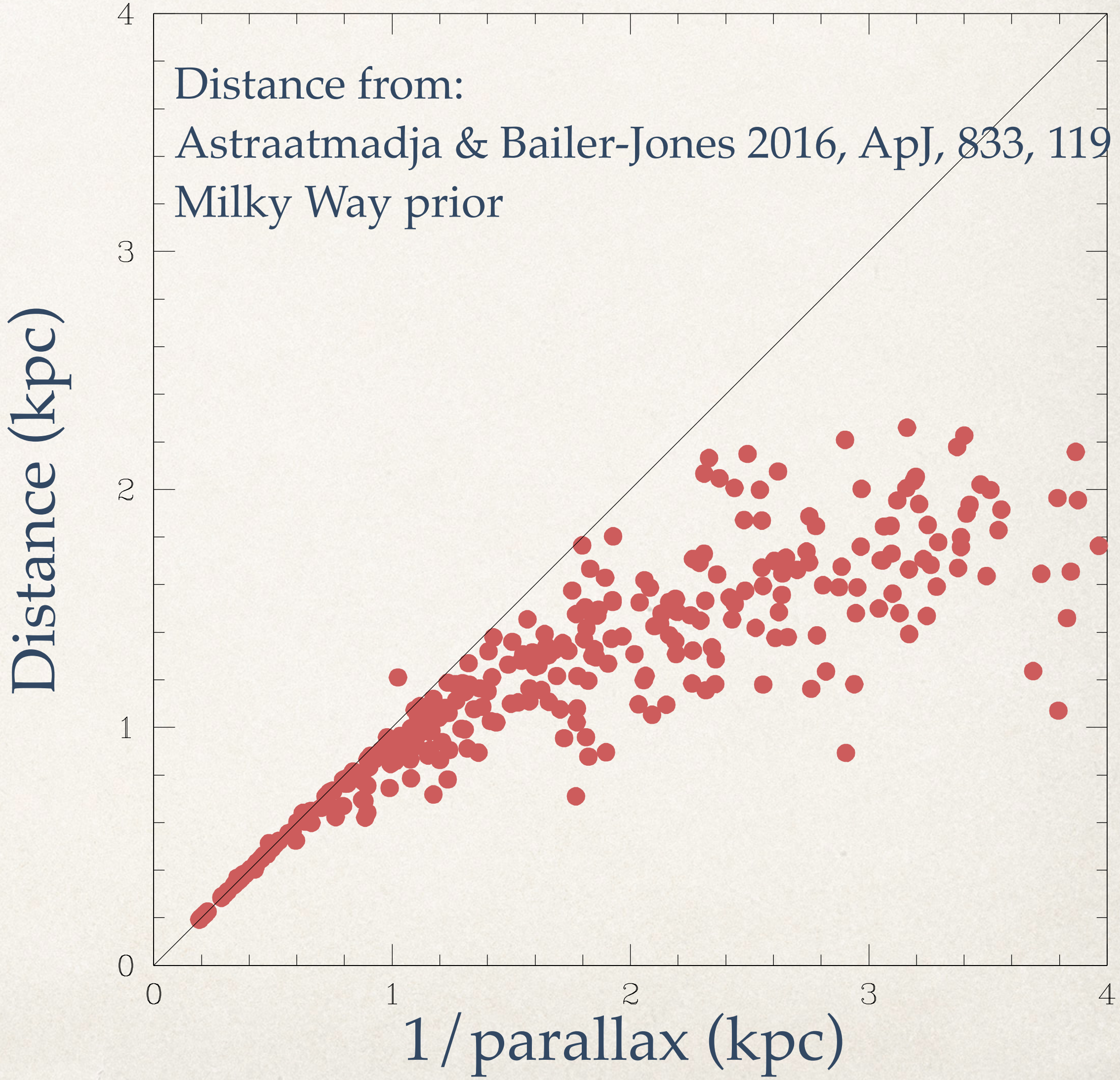
Helmi et al. 2017, A&A, 598, 58



RAVE-Gaia orbits

Matijevic+RAVE 2017: arXiv:1704.05695
877 stars with [Fe/H] < -2.0 dex
43 with [Fe/H] < -3.0 dex
σ[Fe/H] ~ 0.2 dex
kinematically unbiased sample

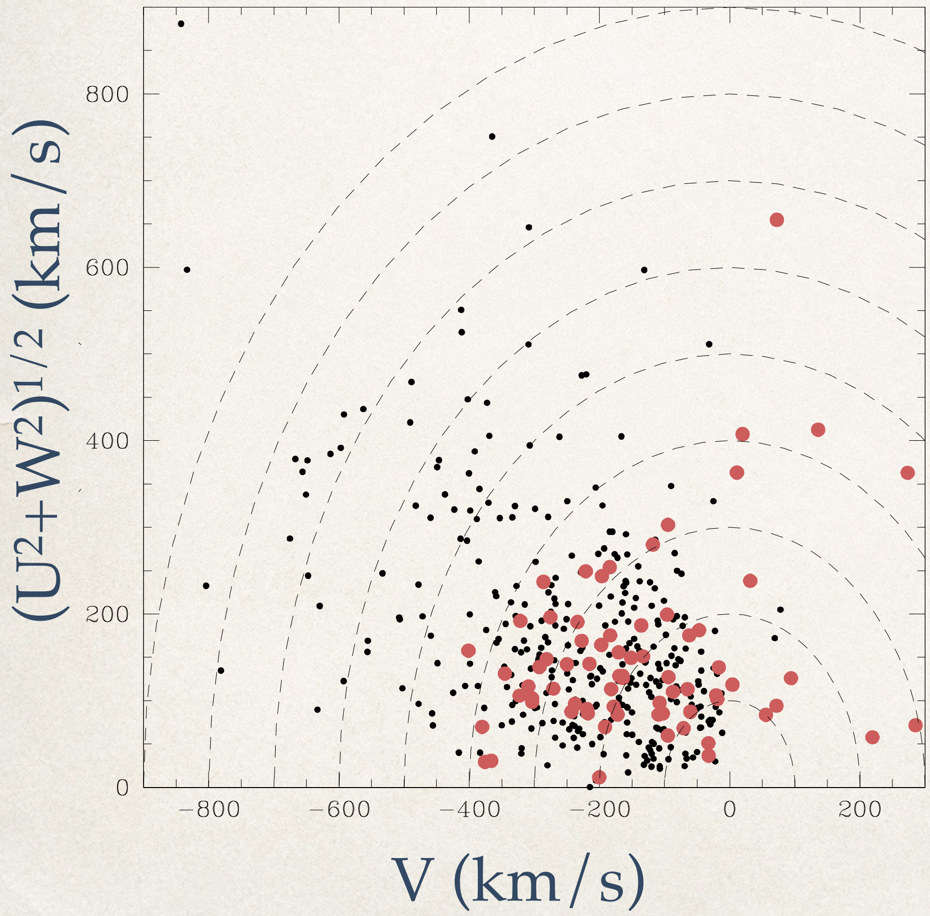


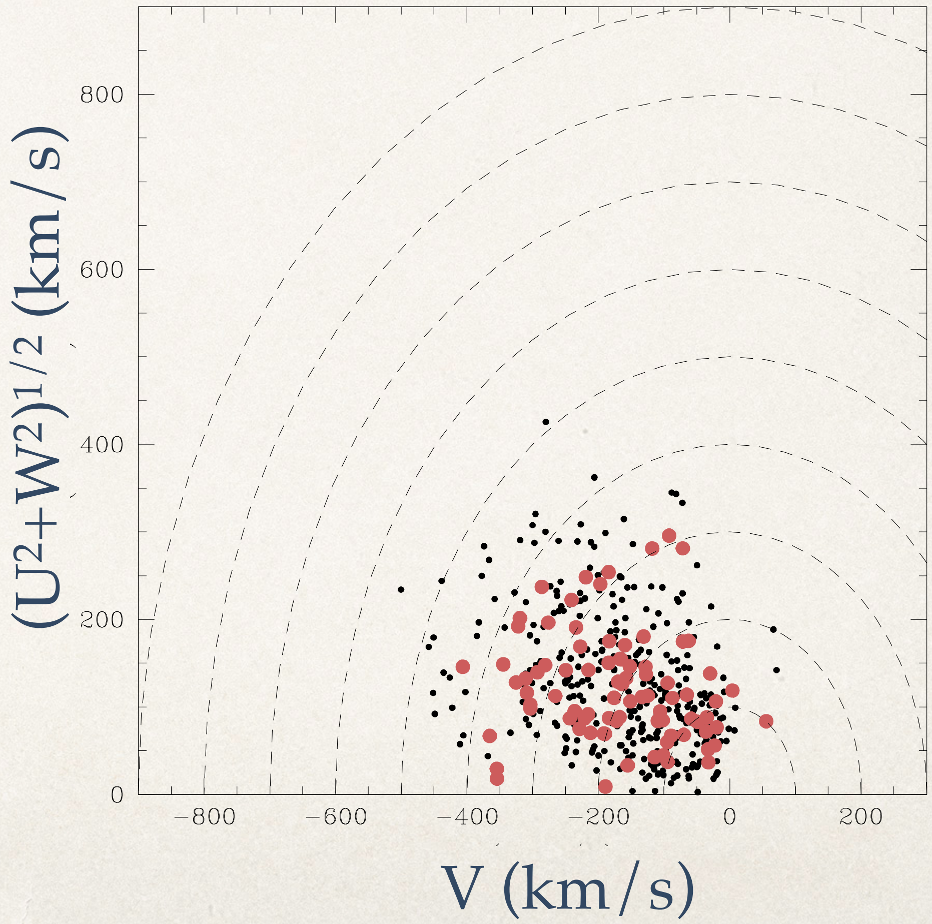


Toomre Diagram metal-poor stars

435 RAVE-TGAS stars with [Fe/H] < -2.0 dex (from Matijevic+17)

85 RAVE-TGAS with $\sigma_\varpi/\varpi < 0.25$





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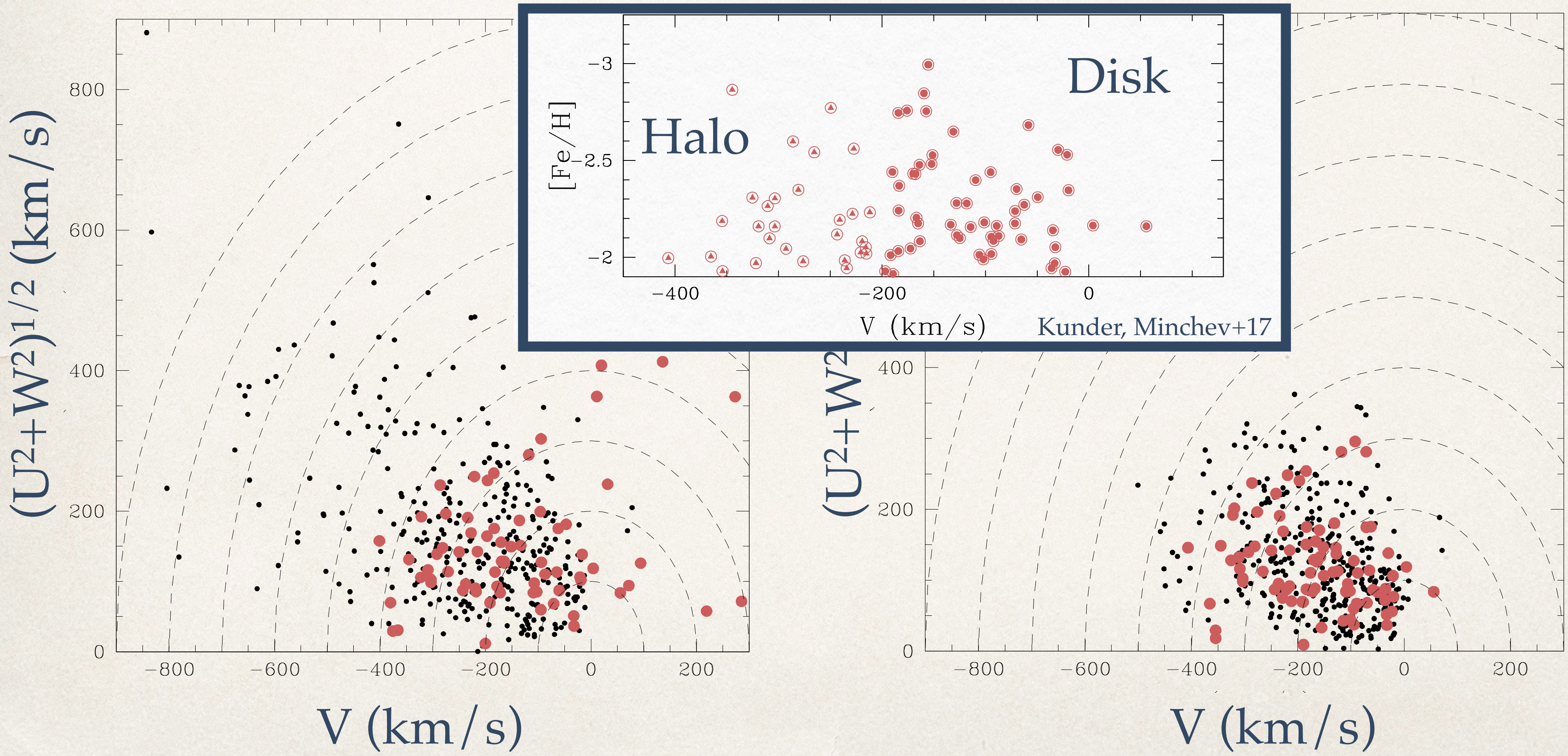
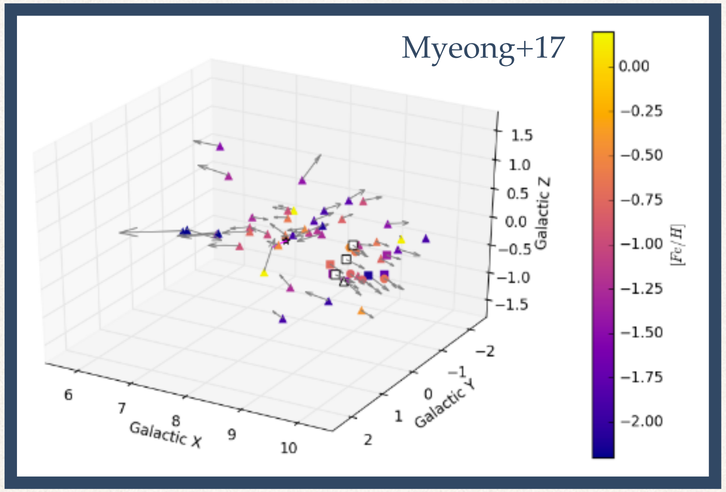
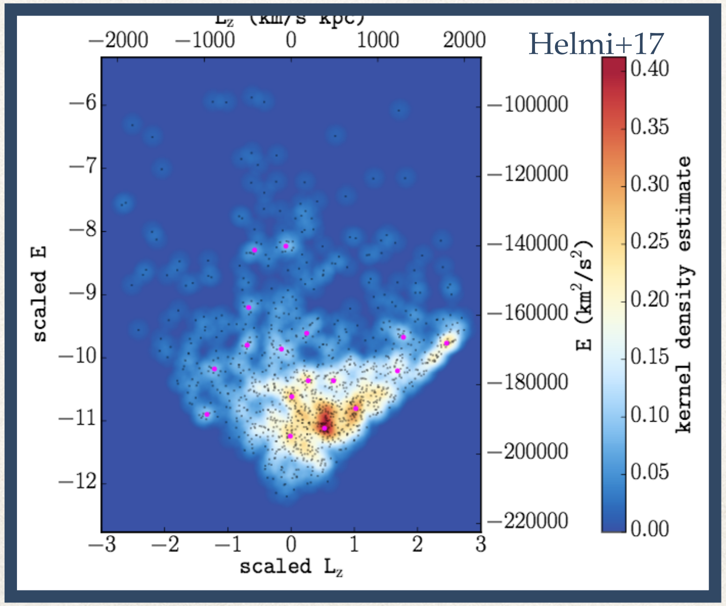
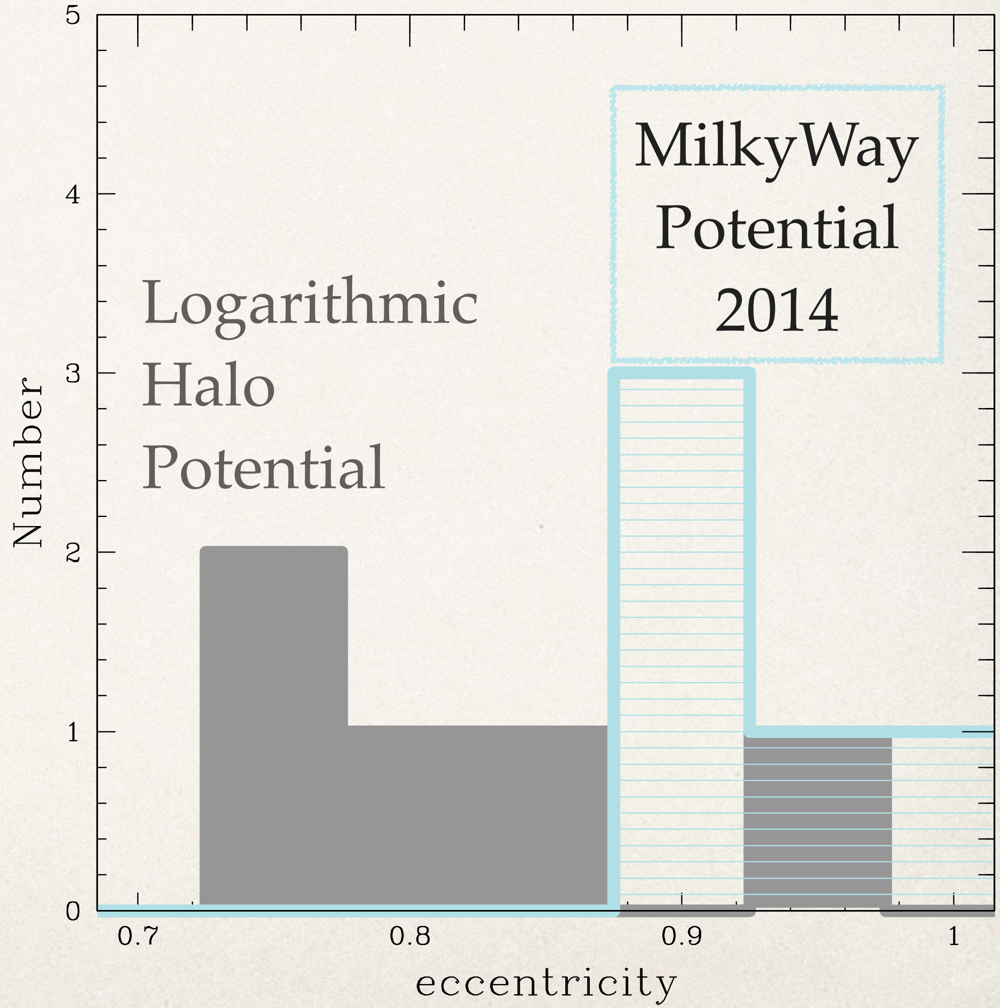


RAVE-Gaia constrain Galactic potential

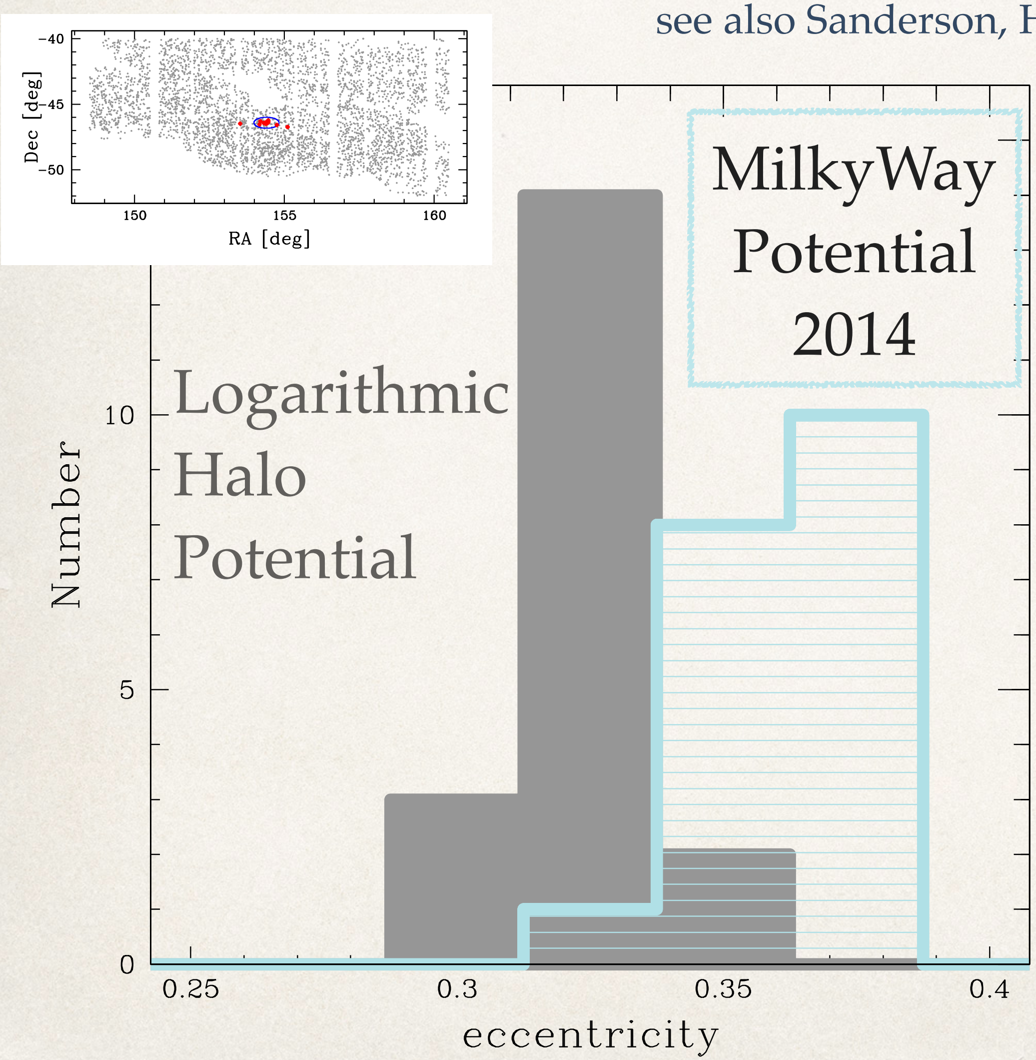


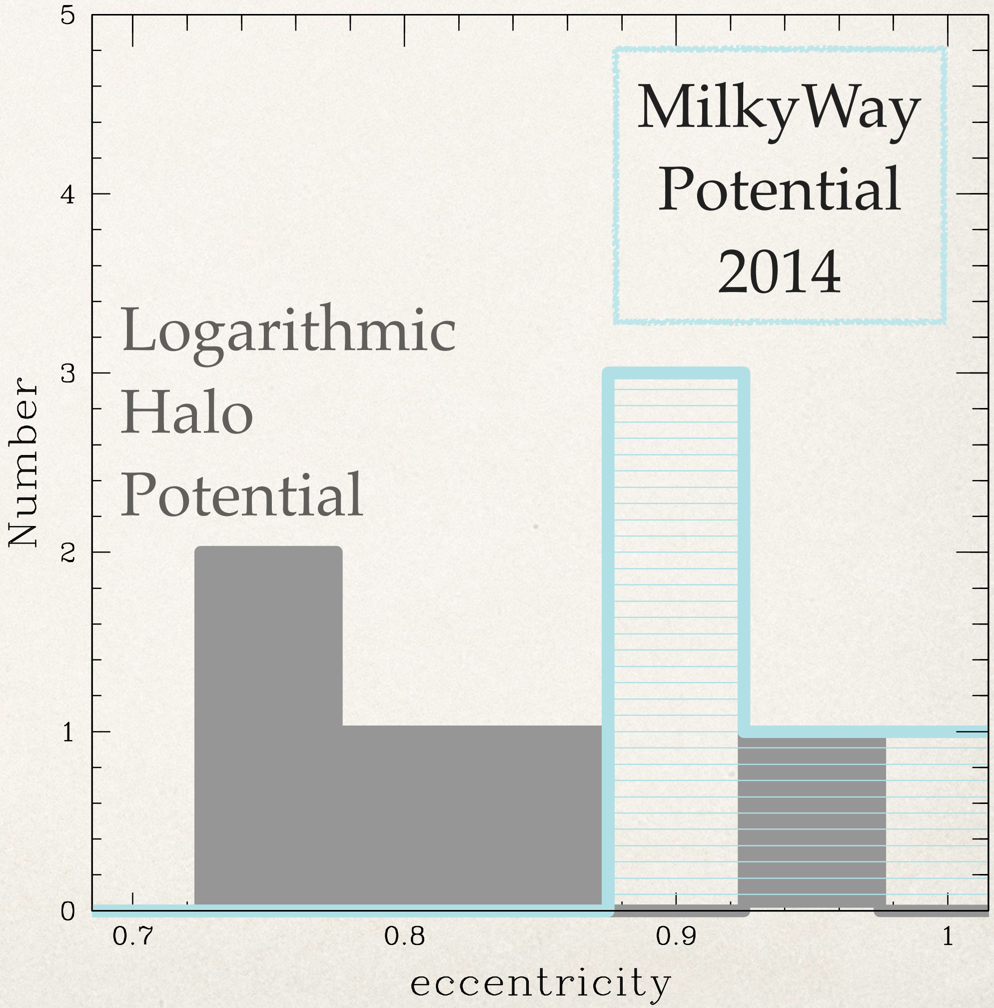




RAVE-Gaia constrain Galactic potential

see also Sanderson, Helmi & Hogg (2015)





Conclusions

RAVE-Gaia impacts Galactic archeology

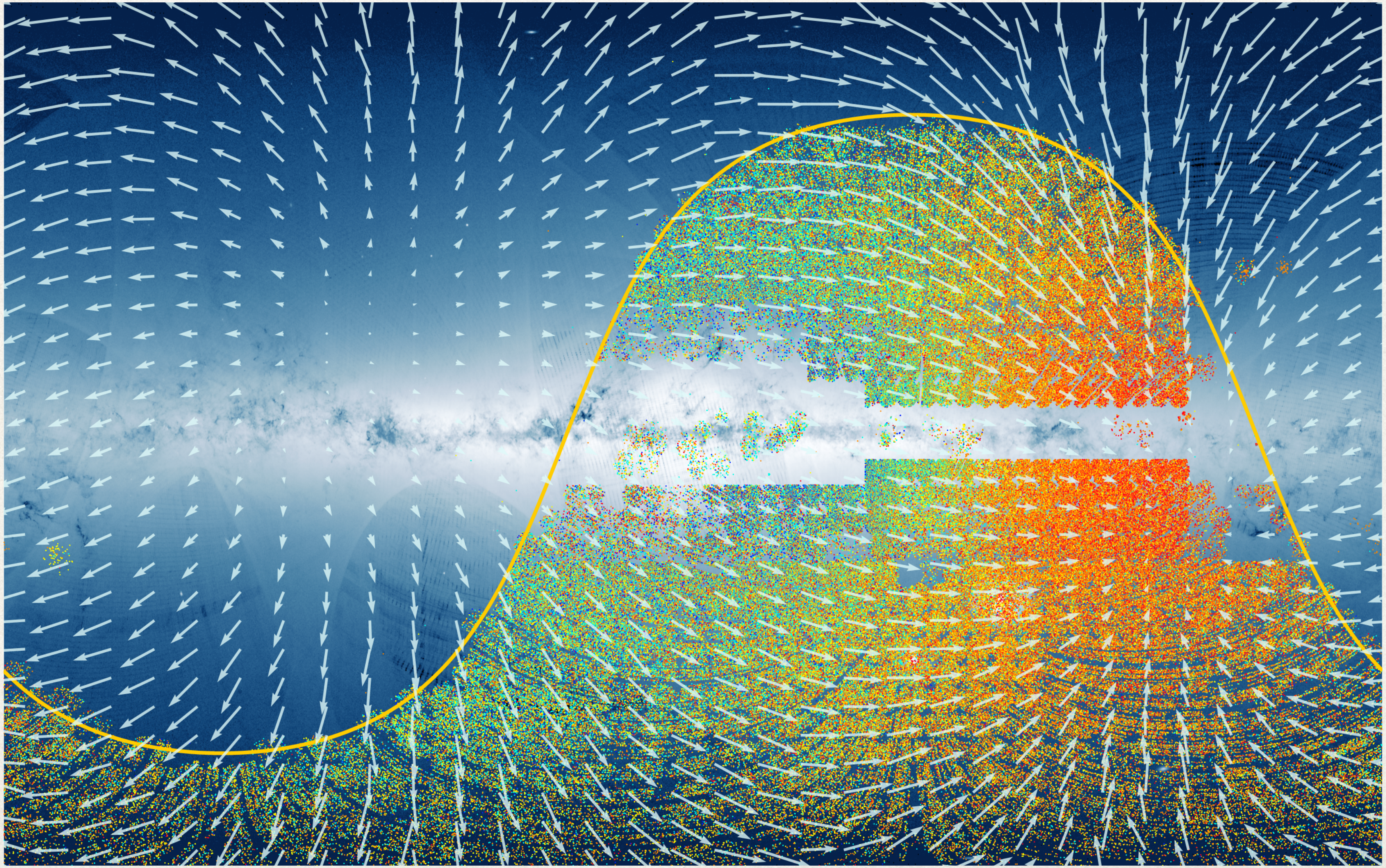
sharper view of the Galaxy

- proper motion space
- orbits
- break degeneracies for determining spectral parameters

constrain Galactic potential

RAVE DR5 + TGAS

Credits: Maarten Breddels, Kristin Riebe, RAVE team
Visualisation tool: vaex
Data: Gaia GDR1, TGAS, full catalogue and RAVE DR5



Metal-poor stars in disk