UNIVERSITY OF LEICESTER

Celebrating 100 years of change

Multiple stellar systems in Gaia DR3

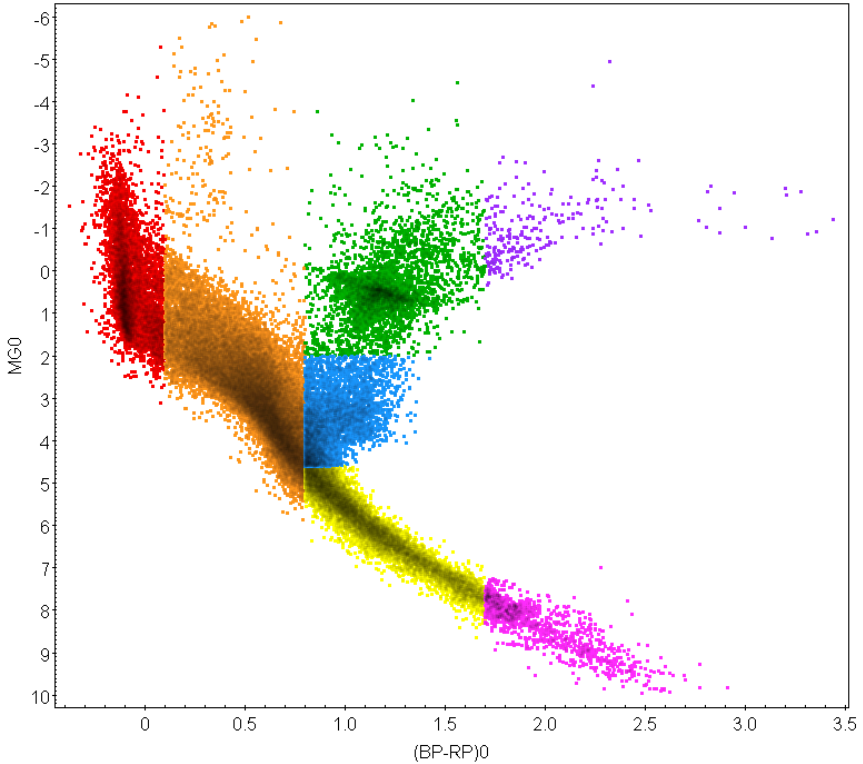
Martin Barstow – co-author of…

Gaia Collaboration, Arenou, F., et al., 2022, including the many members of Gaia DPAC

Introduction

- Binary catalogues and their contents
  - Selection criteria, selection effects
  - Completeness
- Coverage of the H-R diagram
- Example highlights
  - EL CVns
  - Ultracool dwarfs
  - Compact Objects
  - Substellar objects

(Arenou et el., arXiv:2206.05595)



J. Santos Torres (Universitat de Barcelona), 2020

- O-B red
- A-F orange
- G-K yellow
- M pink

- Subgiant blue
- Giant green/purple

What is in Gaia DR3

- Headline - ~800,000 binary star solutions
  - Orbital elements or trend parameters
- Astrometric, spectroscopic, eclipsing binaries and combinations thereof
  - Physical parameters – masses, radii

- Context:
  - ~2,300 visual binaries (ORB6)
  - ~2,400 spectroscopic binaries (SB9)

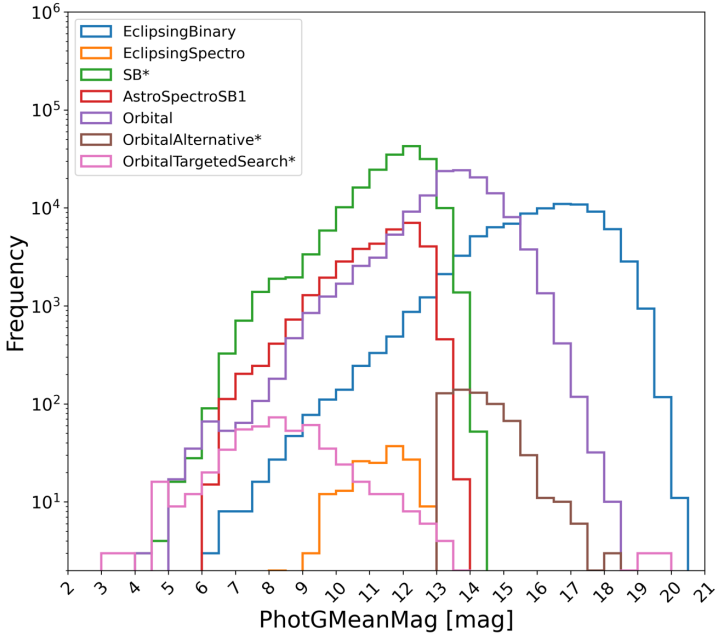
NSS catalogues

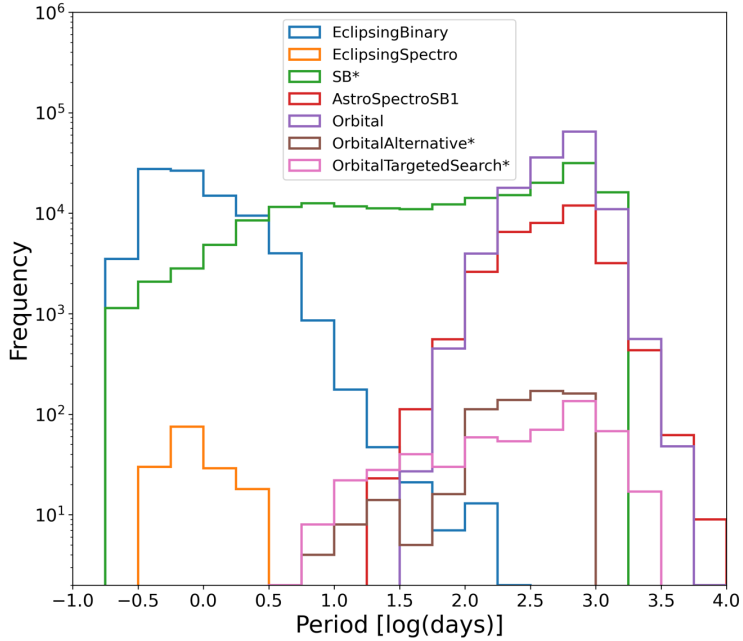
Table	nss_solution_type	Solutions	Description
nss_acceleration_astro	Acceleration7	246 947	Second derivatives of position (acceleration)
	Acceleration9	91 268	Third derivatives of position (jerk)
nss_two_body_orbit	Orbital	134 598	Orbital astrometric solutions
	OrbitalAlternative*	629	Orbital astrometric, alternative solutions
	OrbitalTargetedSearch*	533	Orbital astrometric, supplementary external input list
	AstroSpectroSB1	33 467	Combined orbital astrometric + spectroscopic solutions
	SB1 or SB2	186 905	Orbital spectroscopic solutions
	EclipsingSpectro	155	Combined orbital spectroscopic + eclipsing solutions
	EclipsingBinary	86 918	Orbits of eclipsing binaries
nss_non_linear_spectro	FirstDegreeTrendSB1	24 083	First order derivatives of the radial velocity
	SecondDegreeTrendSB1	32 725	Second order derivatives of the radial velocity
nss_vim_fl	VIMF	870	Variable-induced movers fixed

Selection criteria

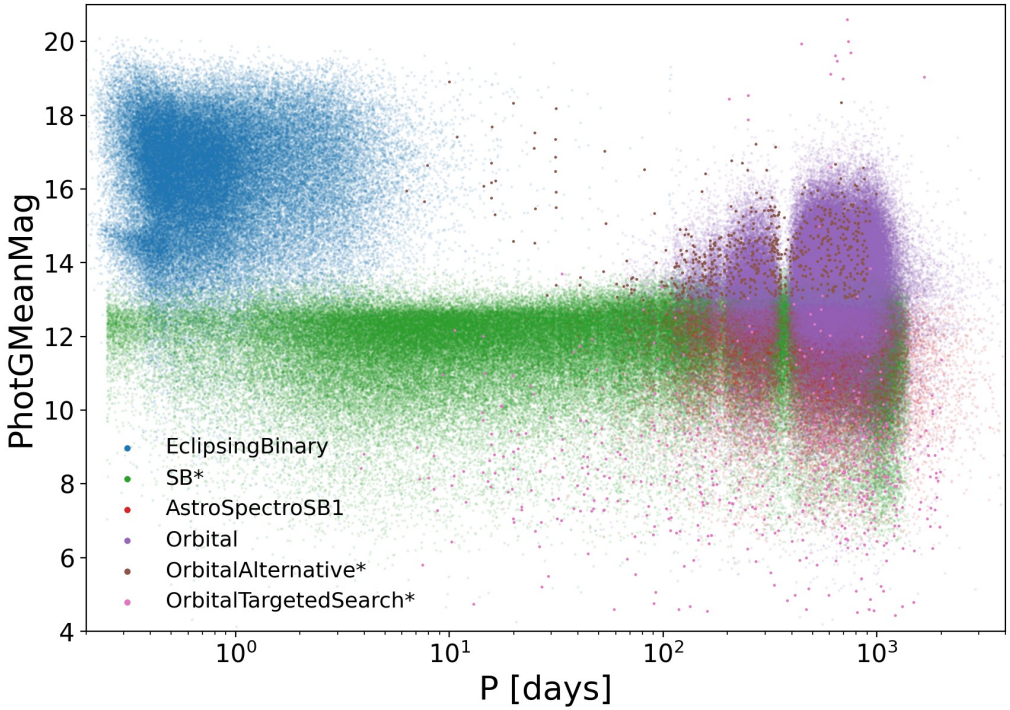
- Bad goodness of fit in upstream results
  - Either astrometric or spectroscopic
  - Or detected as eclipsing
  - + OrbitalTargetedSearch
- Astrometric – limited to most significant (ruwe > 1.4, G < 19)
  - Rejection of larger periods, partially resolved, visibility periods > 11
- Spectroscopic – transits > 10, 3875 < T_{eff} < 8125K, GOF > 4
- Eclipsing – described in Mowlavi at al. (2022), Siopis (2022)
- Further cleaning of spurious solutions

NSS Catalogues

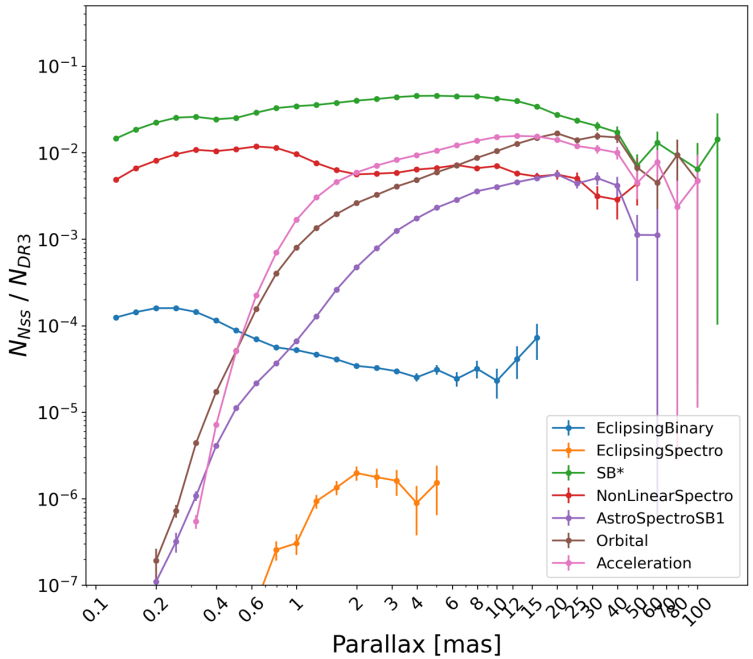


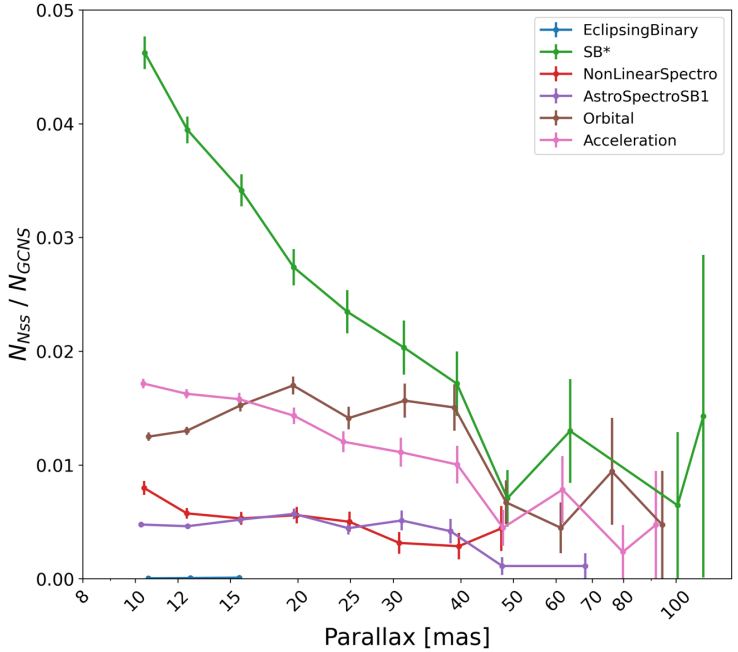


Period sensitivity

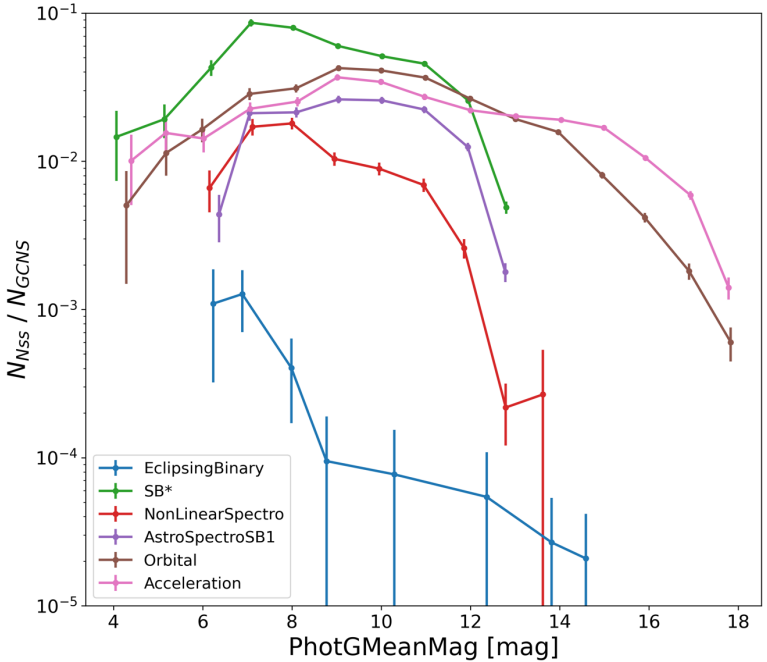


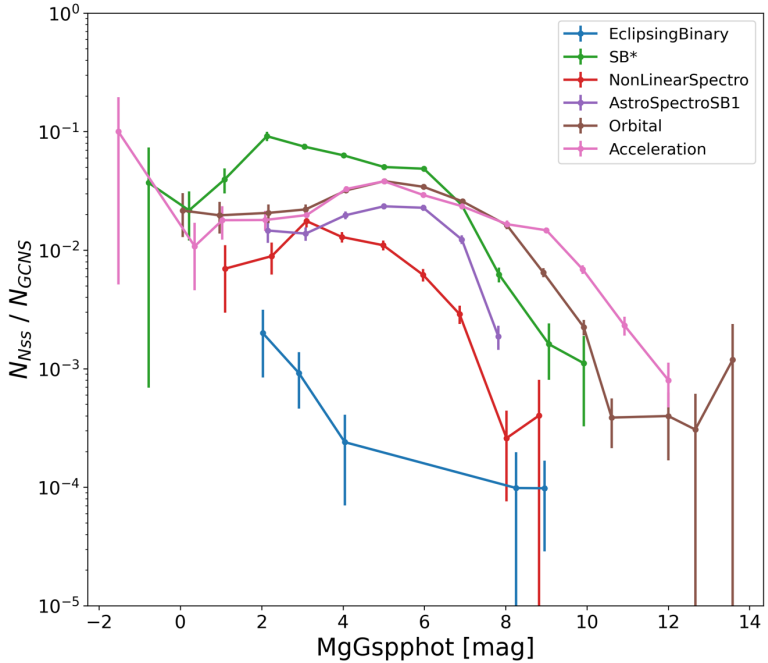
Completeness… its complex



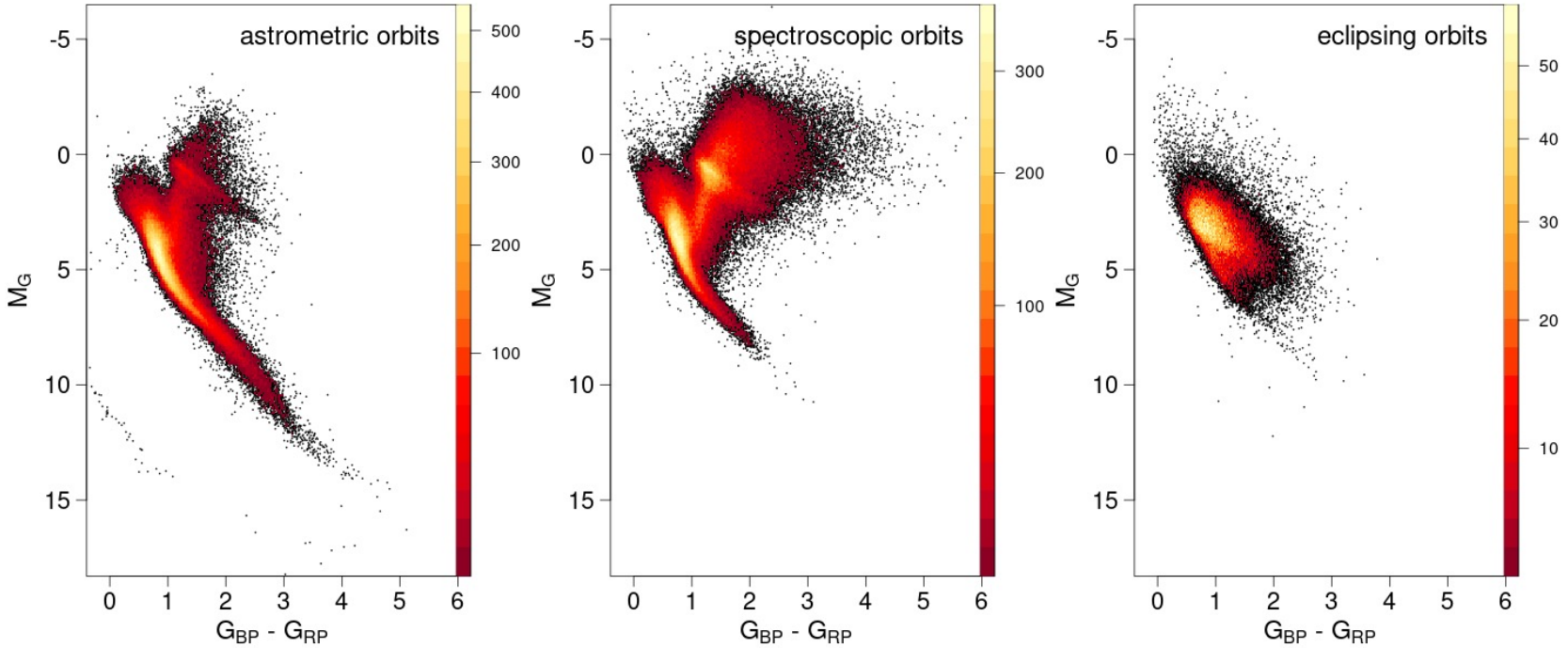


Completeness… its complex



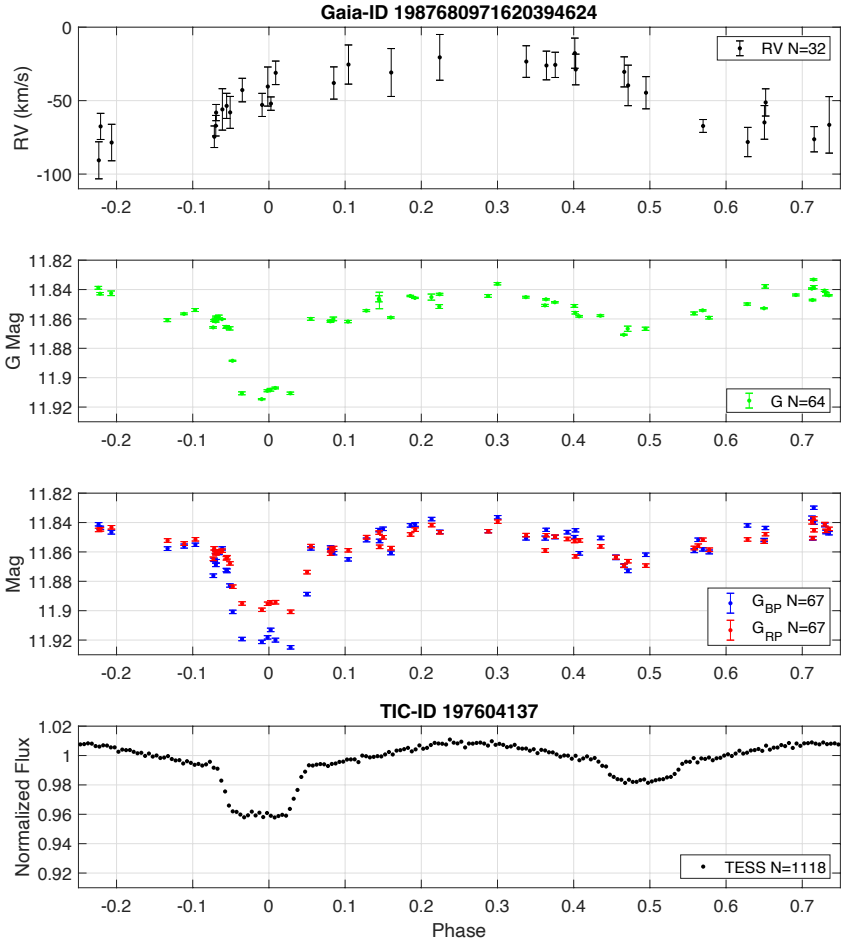


Coverage of the H-R diagram (π s/n > 5)

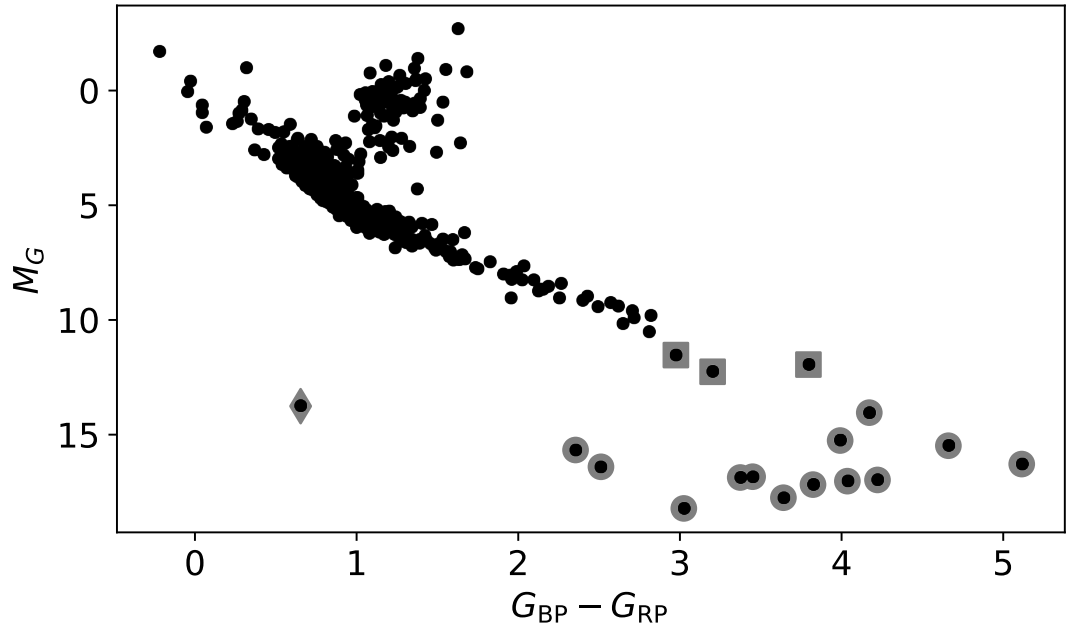


UNIVERSITY OF LEICESTER

EL CVn systems

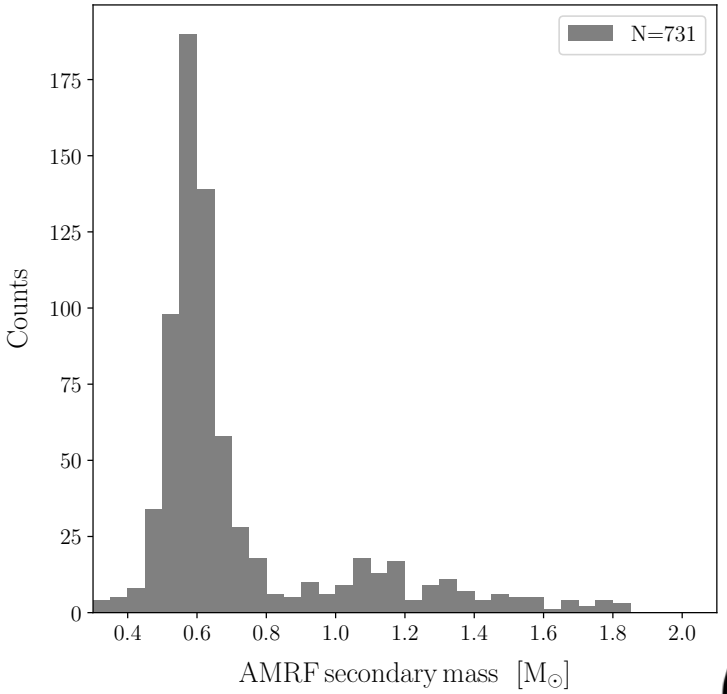


Ultracool dwarfs

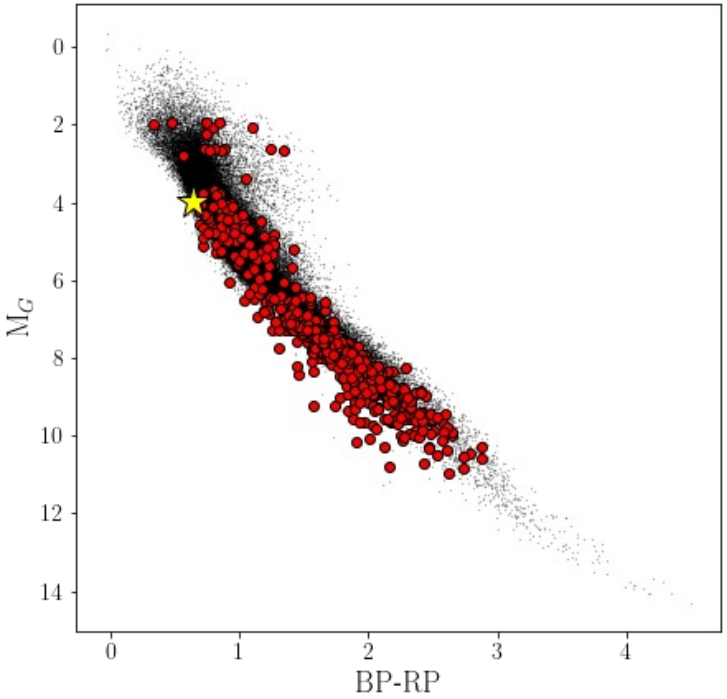


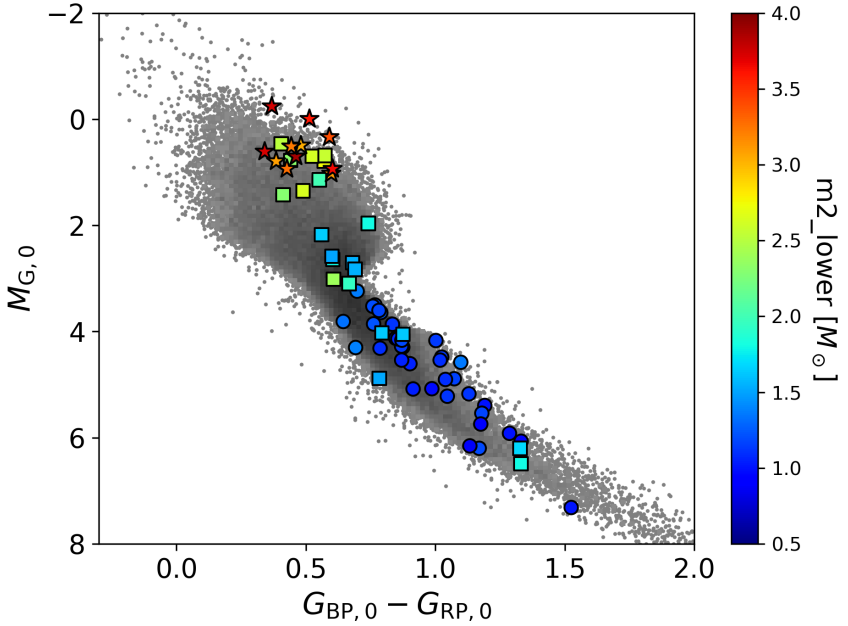
Compact objects

- Range of possible solutions – which systems may contain WDs, NSs or BHs?
- SB1 – hidden companion
- Eclipsing
- Orbital
- SB2 – only as a 3rd component



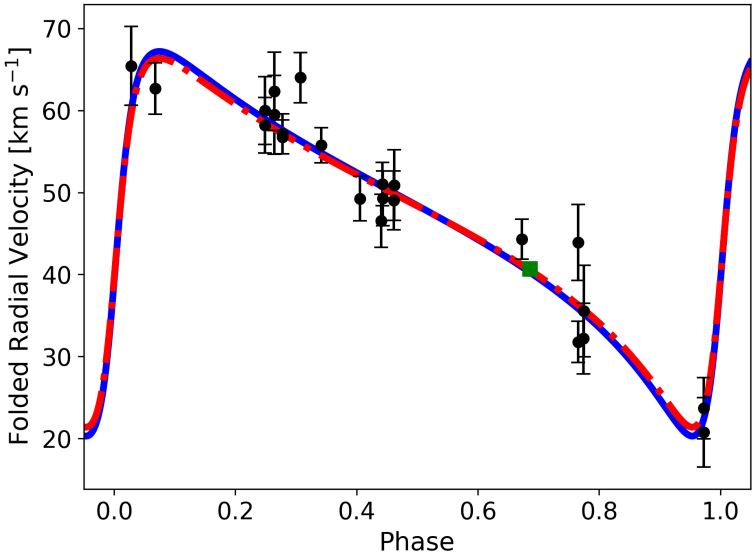
Compact objects

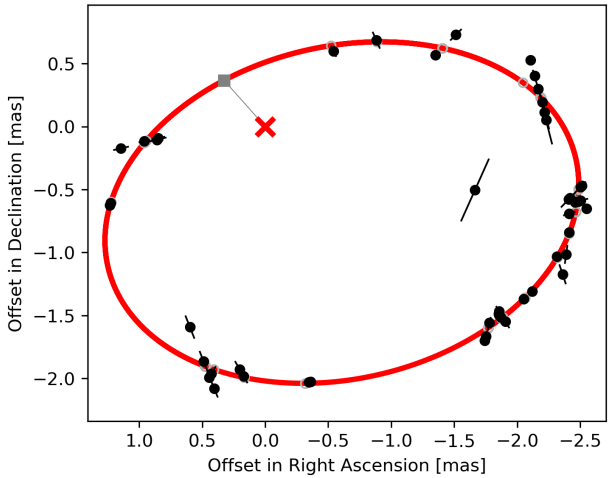




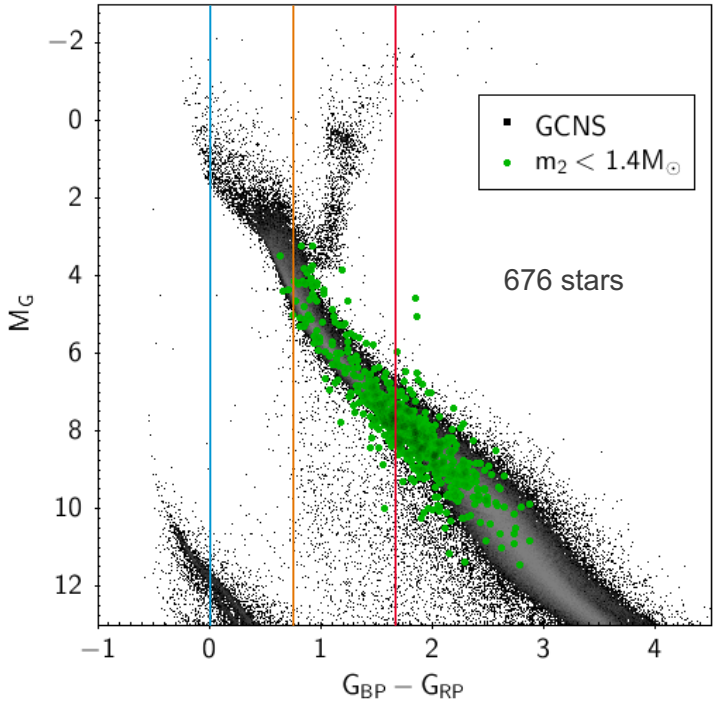
Example – Gaia 5136025521527939072

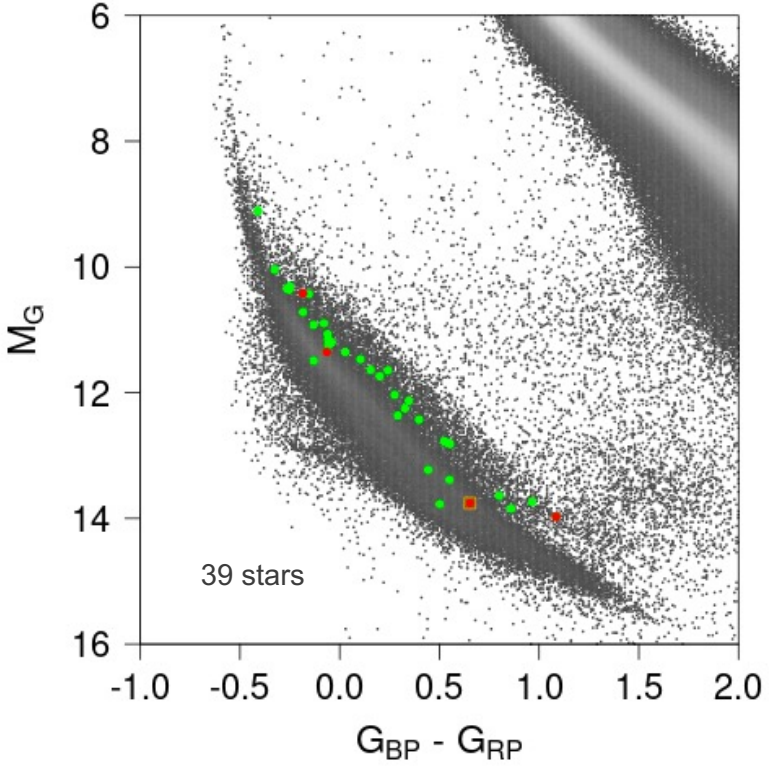
P = 536d, m_1 = 1.2 $M_\odot$, m_2 = 1.5 $M_\odot$



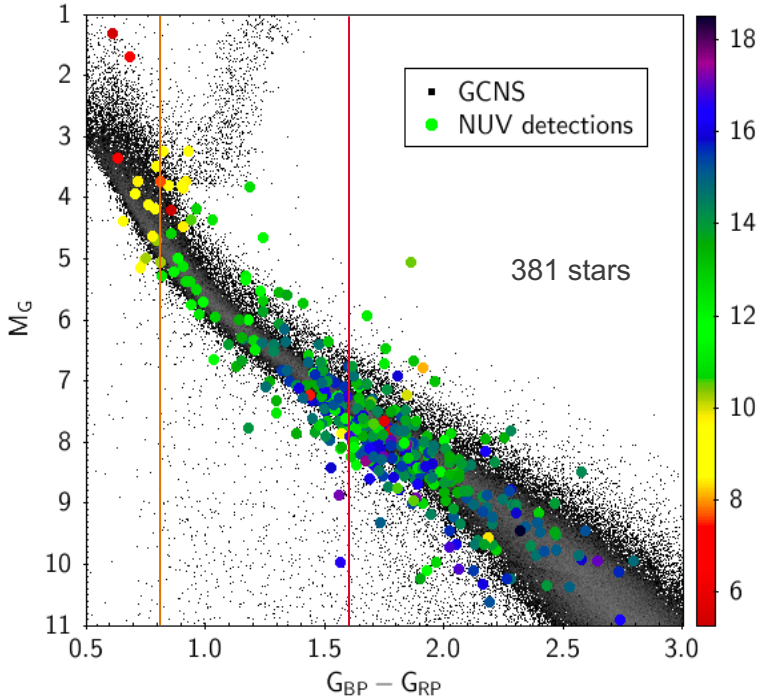


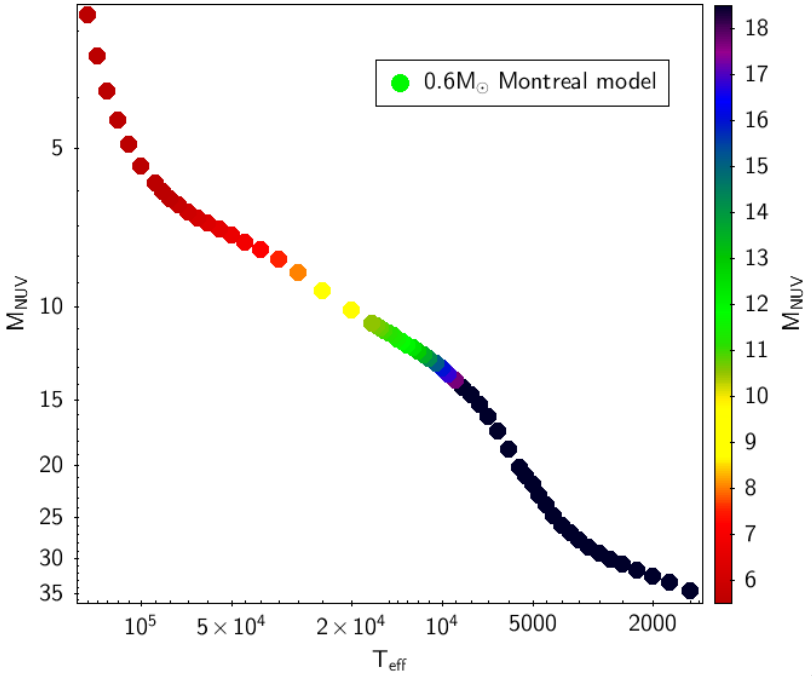
White Dwarfs



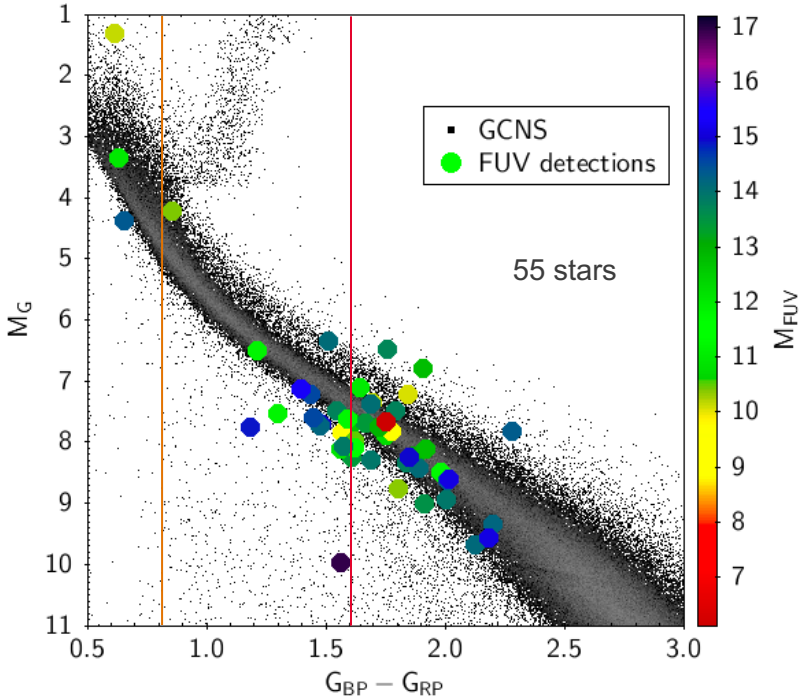


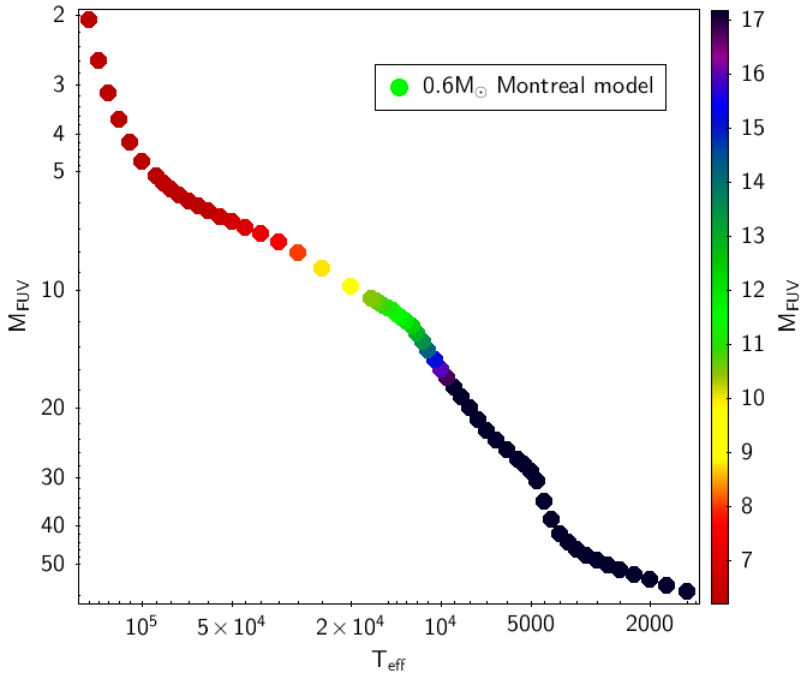
Use of Galex data



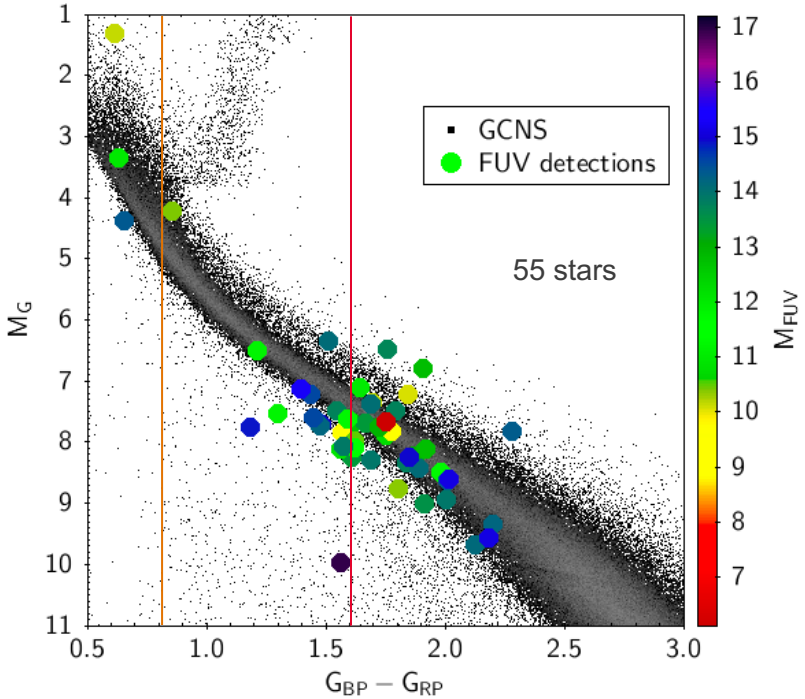


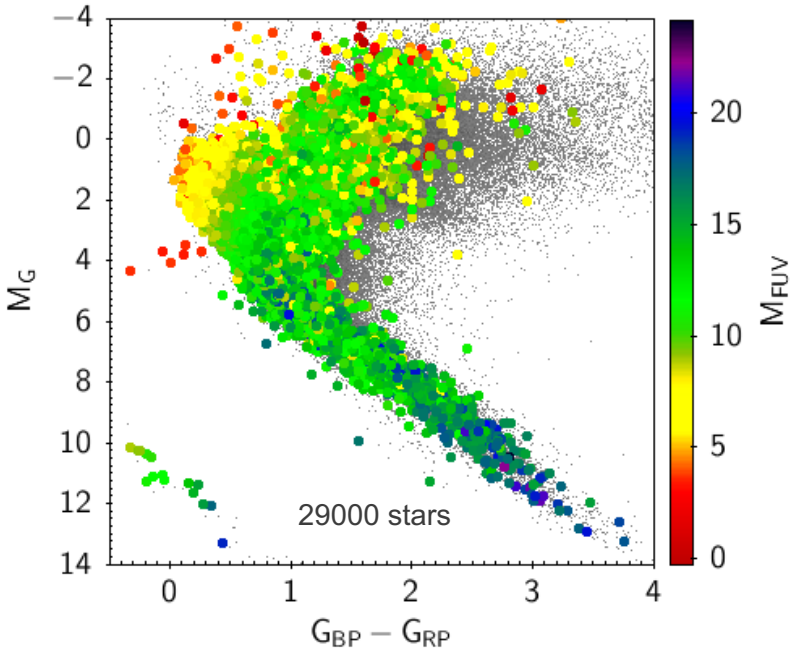
Use of Galex data



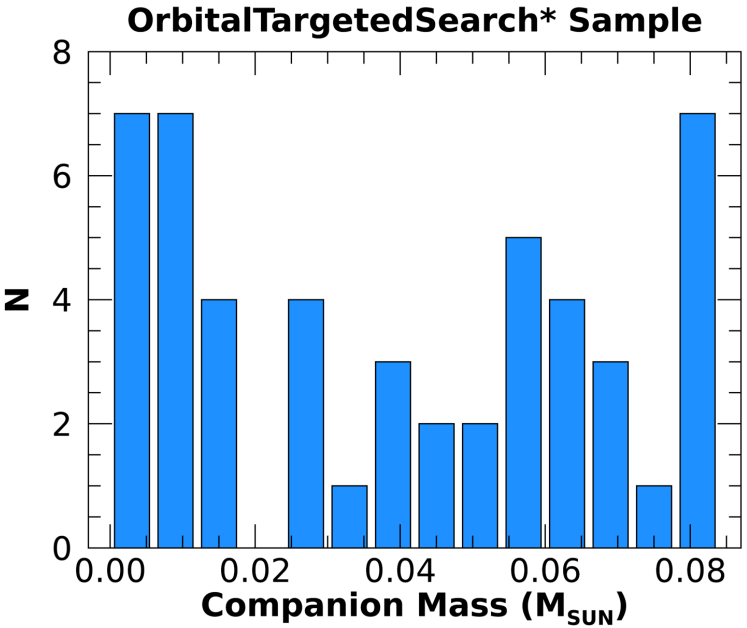


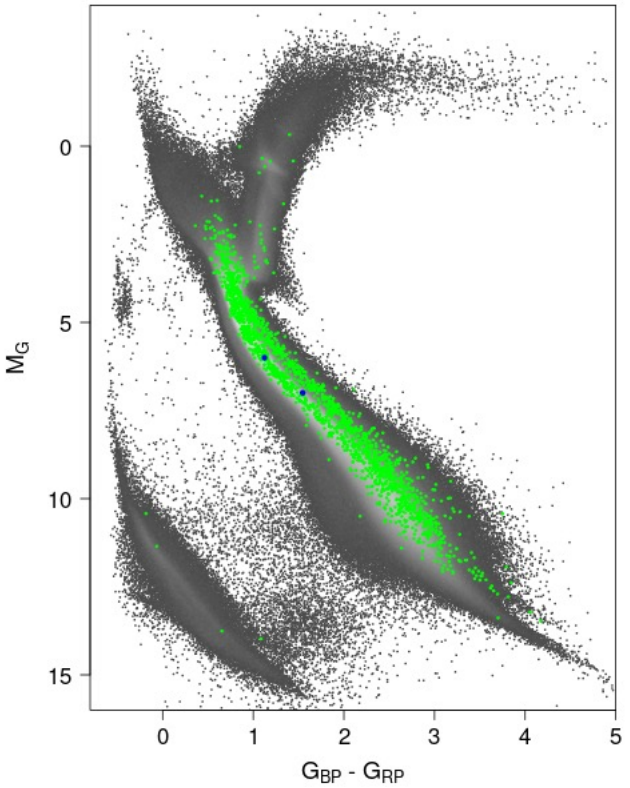
Use of Galex data



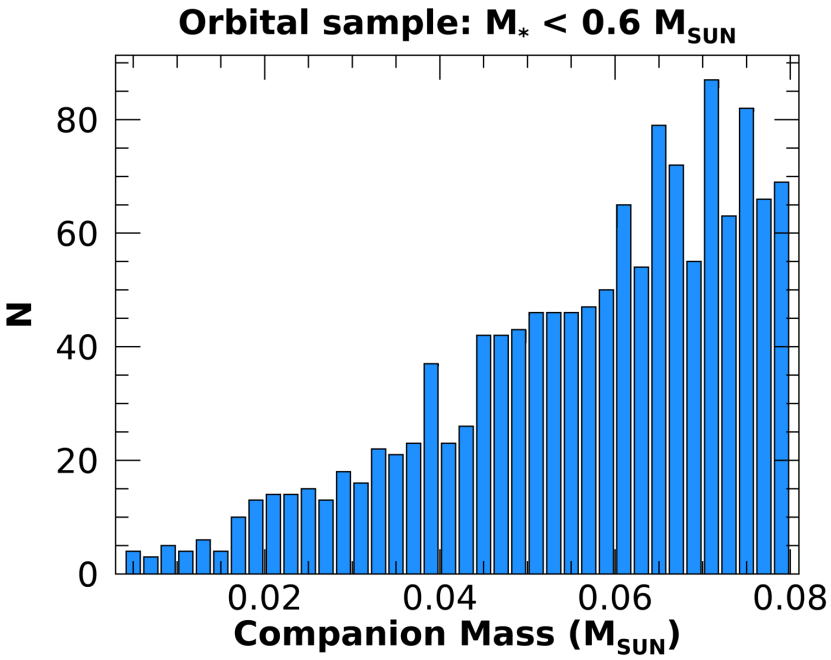


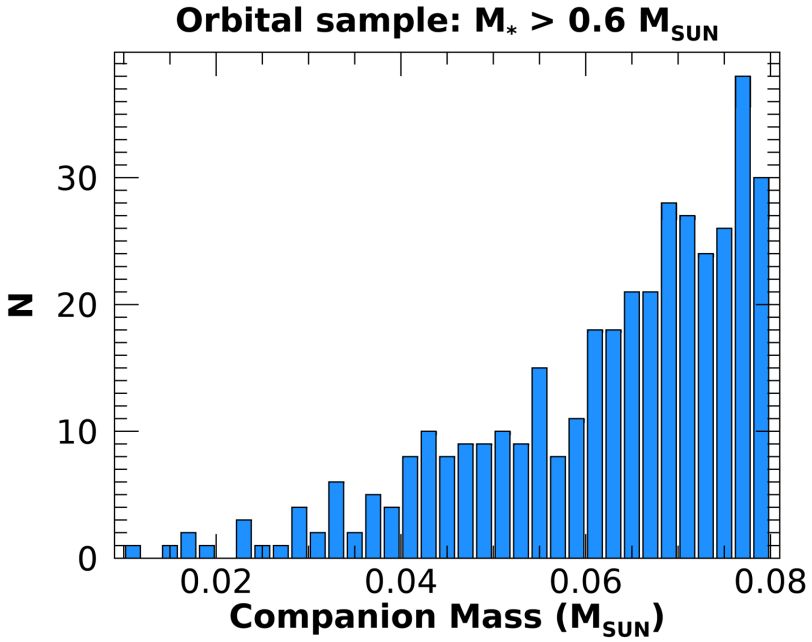
Substellar objects





Substellar objects





Conclusions

- Gaia DR3 is an enormous resource for binary stars
- Important measurements of physical parameters
- Allows search for benchmark systems
- Significant numbers of, until now, rare objects
  - Compact object companions
  - Ultracool dwarfs
  - Exoplanets
- DR3 is just the start…. DR4 to come