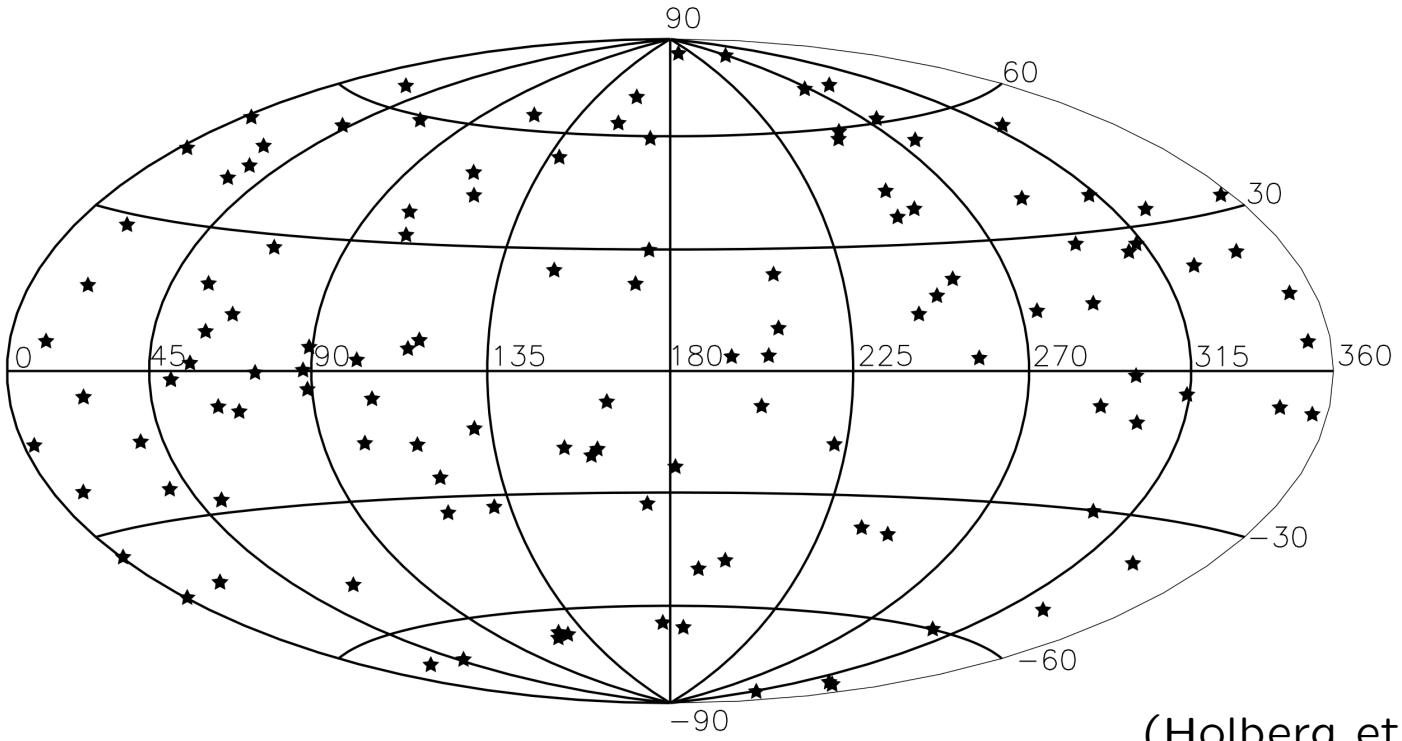
White dwarfs with Gaia & 4MOST



(Holberg et al. 2008)

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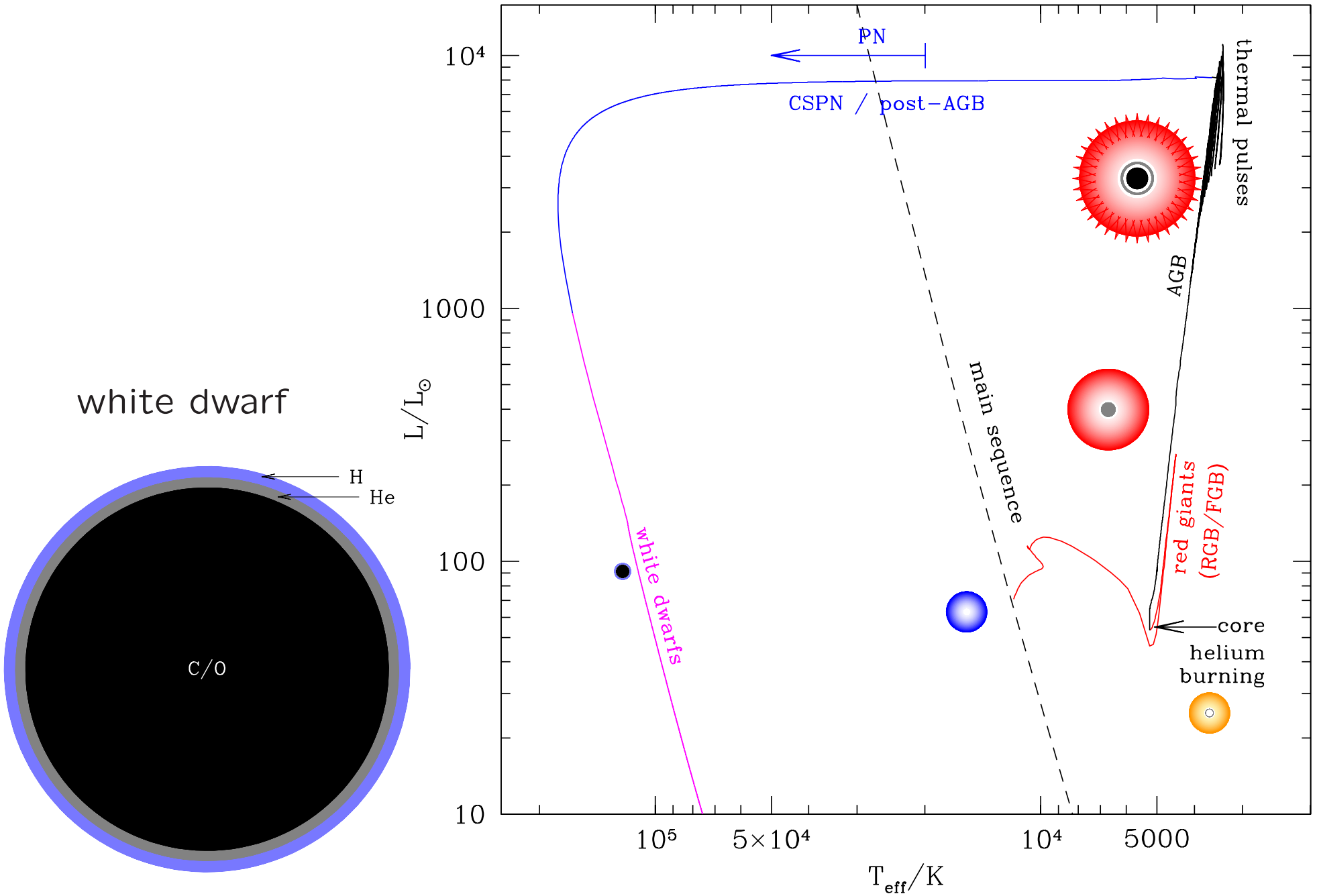
Structure

1. Present status
   What do we know, what don't we.

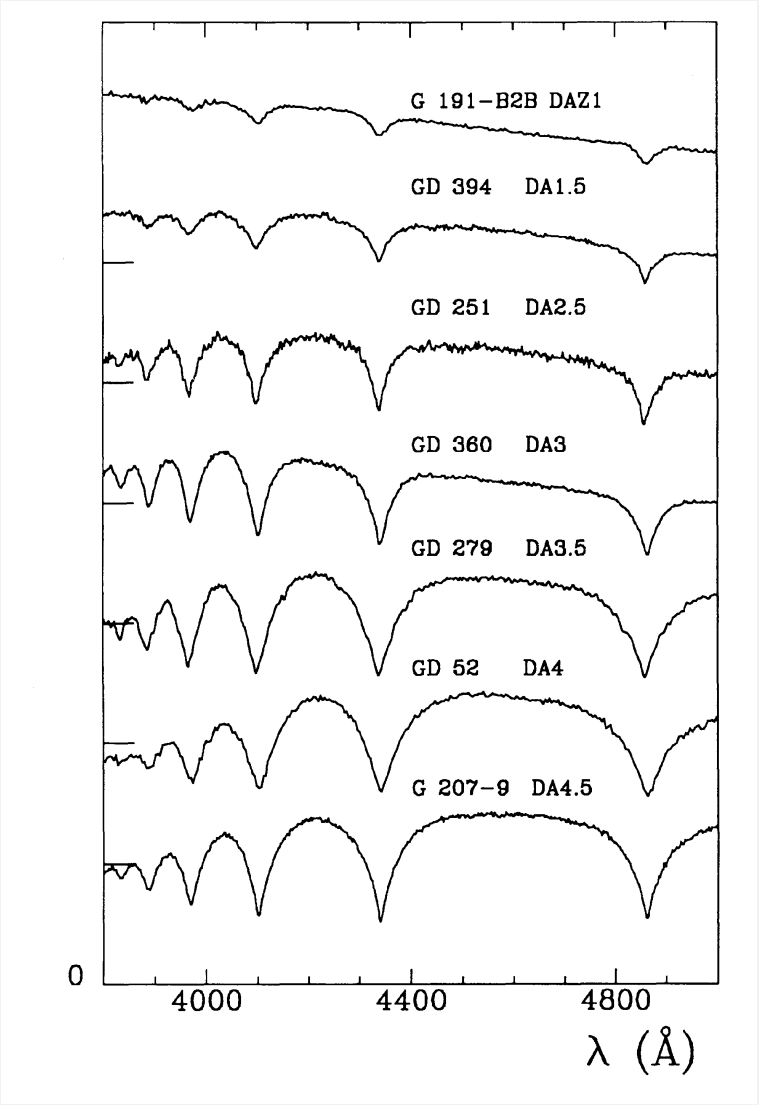
2. What to expect from Gaia?

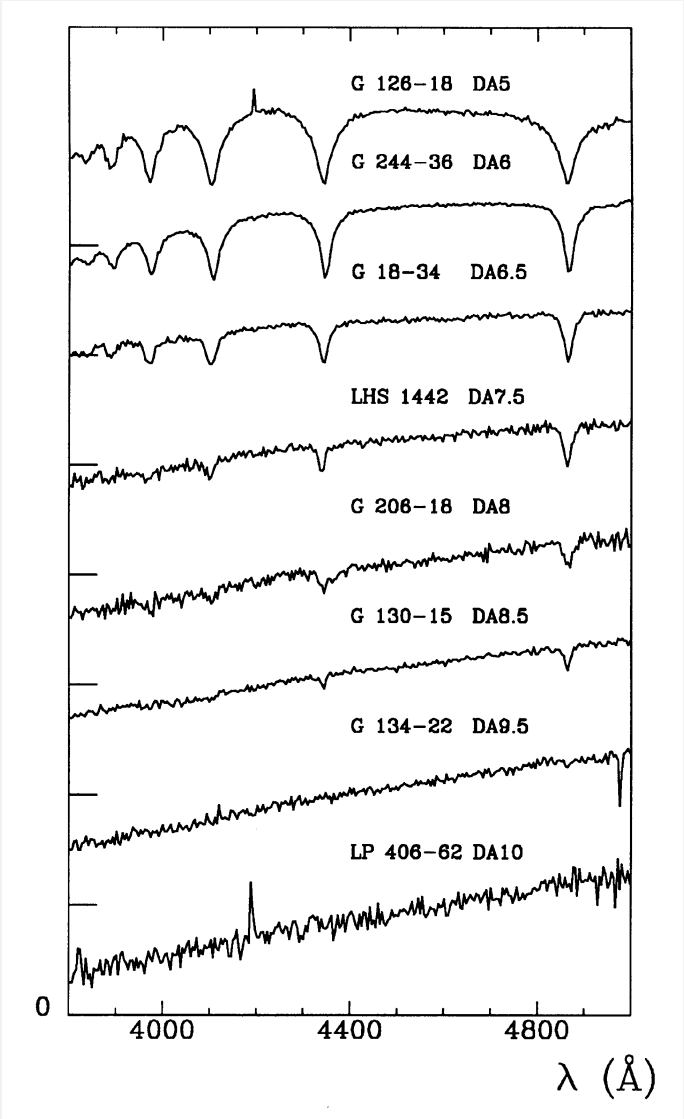
3. Questions to address with 4MOST

4. Some numbers


white dwarf
H
He
C/O
PN
CSPN / post-AGB
thermal pulses
AGB
main sequence
red giants
(RGB/FGB)
core
helium
burning
white dwarfs
10^4
1000
100
10
$L/L_\odot$
10^5
5×10^4
10^4
5000
T_{eff}/K

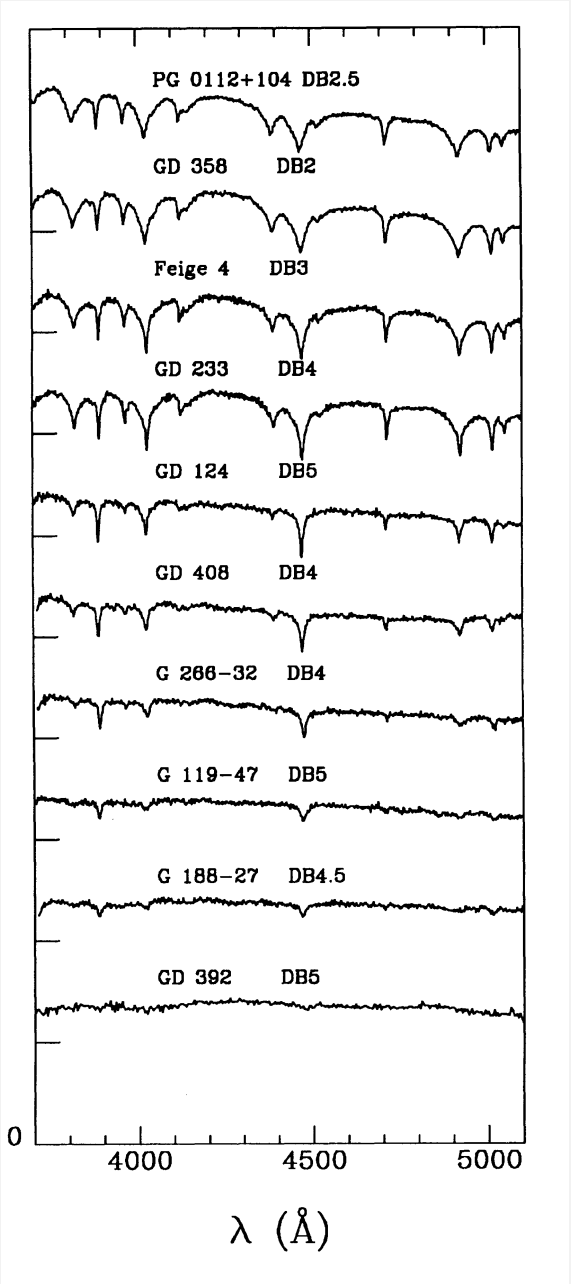
DA white dwarfs (H-rich)



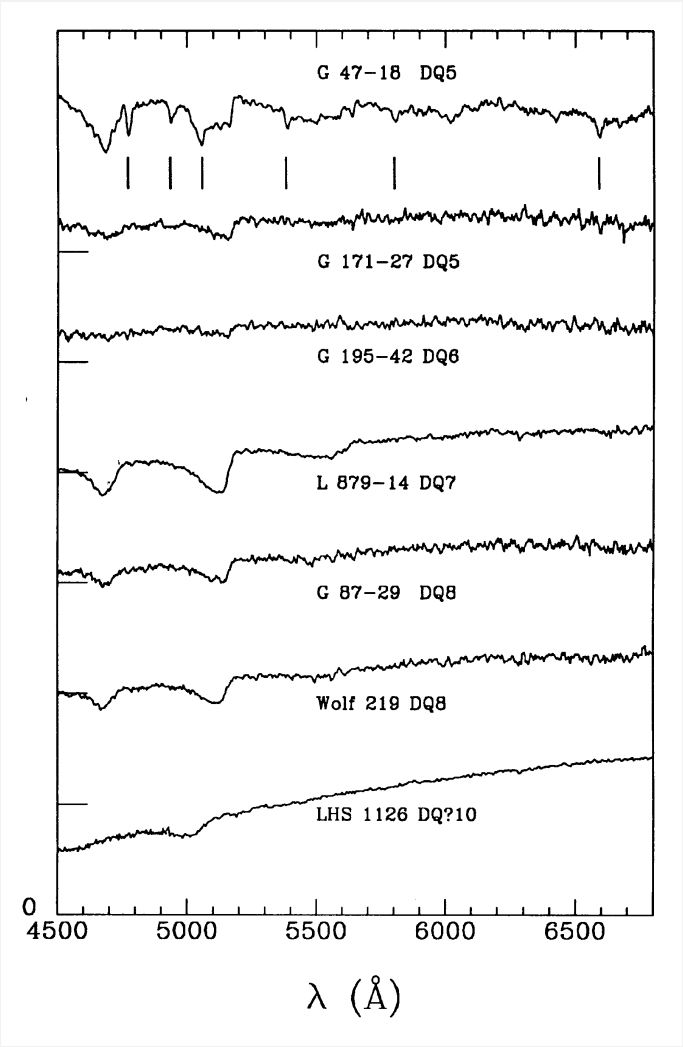


Wesemael et al. (1993)

Zoo of non-DA white dwarfs (H-poor)

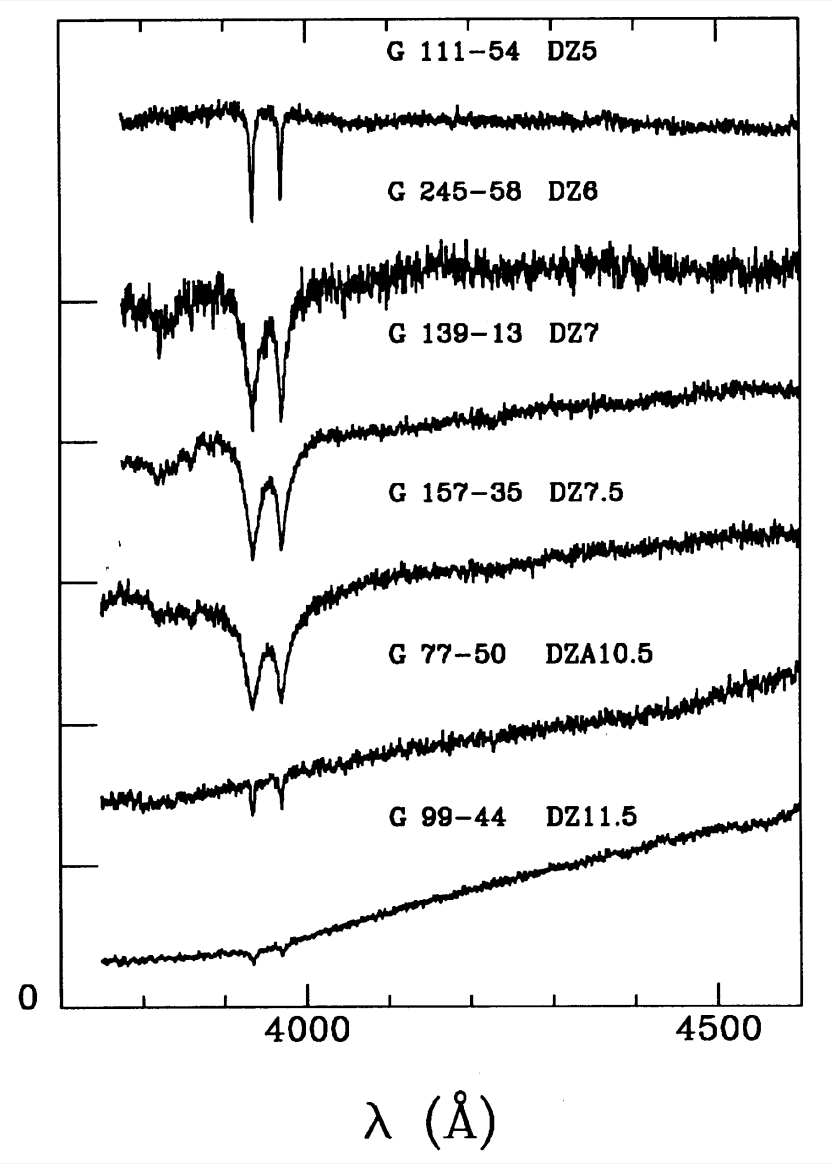


DB

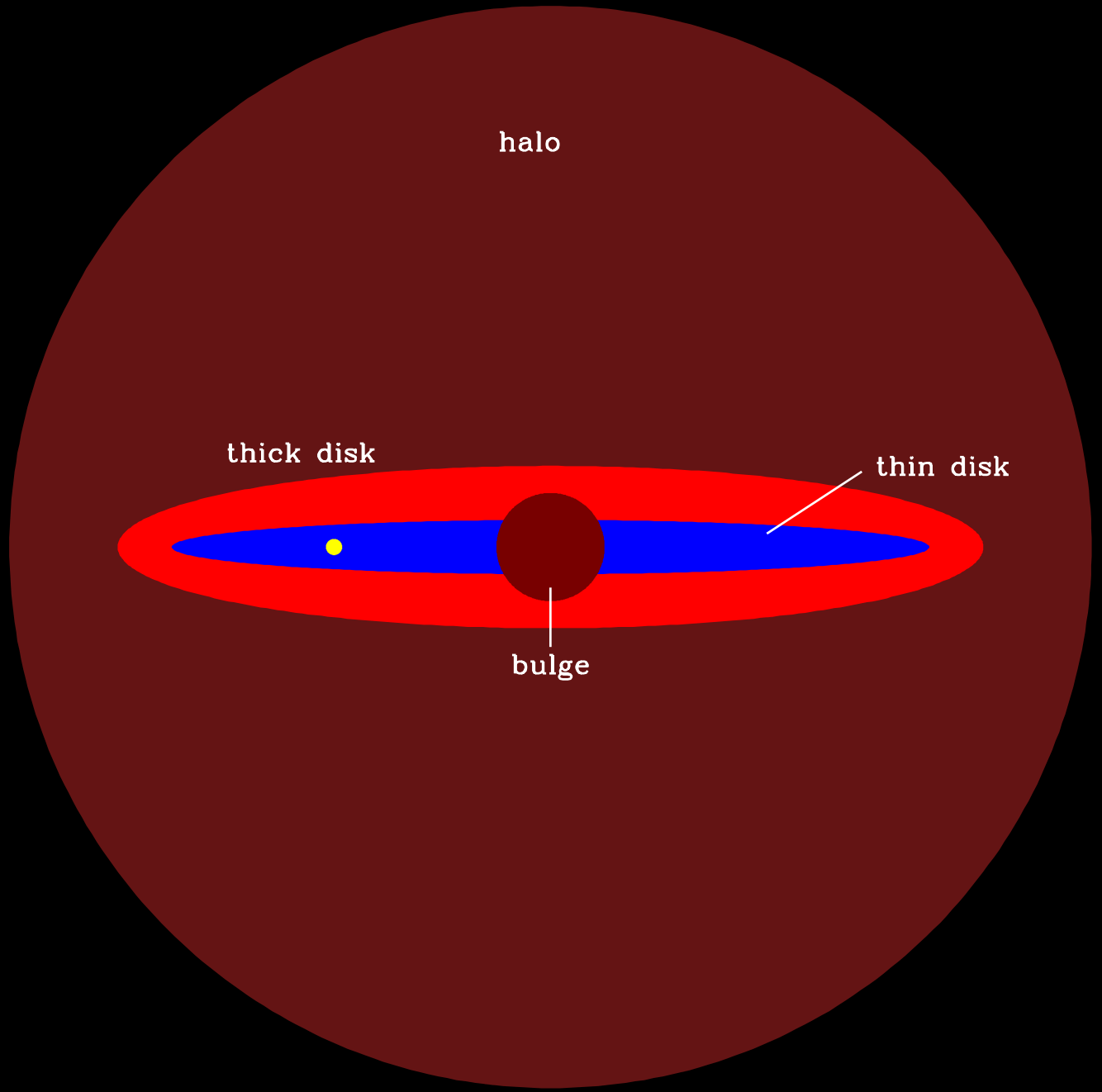


DQ

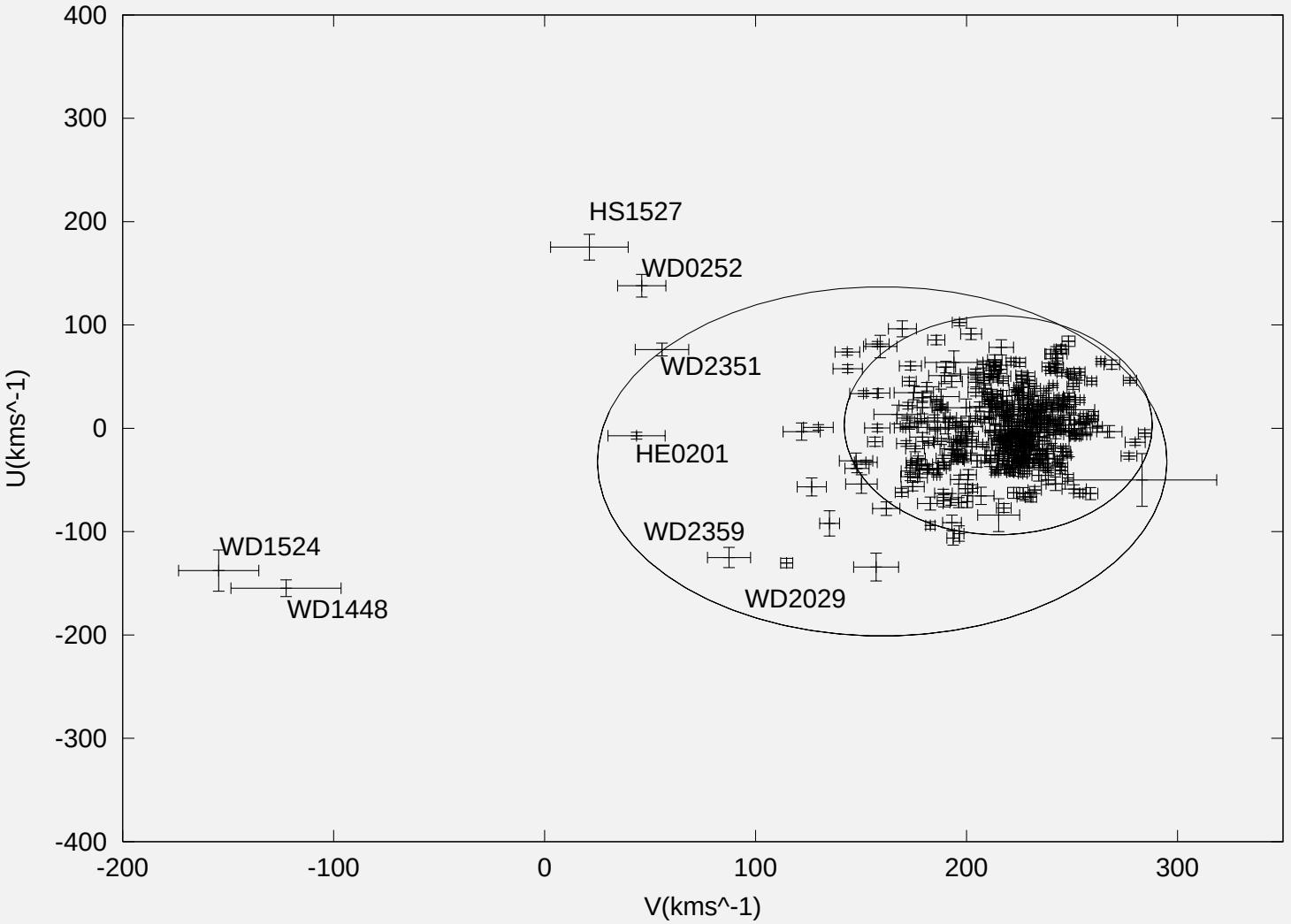
DZ, DAZ, DBZ white dwarfs (Ca lines)



Recent focus of interest, because metal lines at least sometimes caused by pollution from **debris discs** of former **planet systems**.


halo
thick disk
thin disk
bulge

$U - V$ diagram for white dwarfs



Pauli et al. (2006) based on SPY RVs and spectroscopic distances

Results

Pauli et al. (2006): total of 398 WDs classified

thin disk	368	92%
thick disk	23	6%
halo	7	2%

Results for **brightness limited** limited SPY sample ($V < 16.5$)

Remaining steps:

- correction for contamination
- conversion to **volume limited** sample
- extrapolation to Galactic population

Volume limited sample

		ρ [pc^{-3}]
thin disk	59%	2.9×10^{-3}
thick disk	35%	1.7×10^{-3}
halo	6%	2.7×10^{-4}

Extrapolation to the whole Galaxy

	N [10^9]	
thin disk	2.0	17%
thick disk	3.9	34%
halo	5.6	49%

Current status

- Currently 14235 WDs included in the McCook & Sion catalogue (17/8/2012).
- Local sample complete up to 13 pc at max.
- HIPPARCOS parallaxes only for 20 WDs.
- Mass-radius relation only poorly constrained.
- Current sample mared by incompleteness and poorly understood selection effects
- Estimates of halo and thick disc populations suffer from small number statistics.

Some open questions

Spectral evolution: Change of ratio DA/non-DA along cooling sequence, DQ: dredge up of carbon from core.
Linked questions: structure of WDs, last stages of AGB evolution, diffusion and convection in WD envelopes

Ultracool WDs: (3000–4000 K): lack of gravity/distance information makes it very difficult to distinguish young-ish low mass WDs (products of binary evolution) from very old halo/thick disc WDs
Linked questions: constraints on binary evolution, IMF in the early Galaxy

Statistics of DAZ/DBZ/DZ: guide fossil for previous planet systems
Linked questions: metallicity dependence of planet formation via population membership

Mass–radius relation: : Linked questions: structure of WDs – thin (H or He) layers vs. thick layers

Gaia's contribution

- Low res SED 4000–10000 Å
- parallaxes, accuracy 25μas ($G = 15$) to 300μas ($G = 20$)
- proper motions
- high res spectra around IR Ca triplet

What can be done:

- Identification of $G = 20$ WDs possible out to $\approx$1 kpc.
- Rough parameter estimates
- Spectral classification only for DAs with strongest lines
- High res region featureless in the vast majority of WDs $\Rightarrow$ no RVs.
- Accurate proper motions and distances allow statistical approach to halo and thick disc populations, but ambiguities still remain.

4MOST follow-up

Science questions which can be addressed with a medium res, S/N $\geq$ 10 survey

- Spectral typing; unbiased testing of spectral evolution along cooling sequence
- **Much improved** stellar parameters
- Testing of the mass-radius relation including layer thickness
- Detection of binaries with two similar WD components via discrepancy between spectroscopic distance and Gaia distance
  - Cleaning up mass distributions etc.
  - Selecting potentially interesting binaries for follow-up
- Selection of DZ/DAZ/DBZ with strong lines

4MOST follow-up

Science questions which can be addressed with a higher S/N and/or higher resolution survey

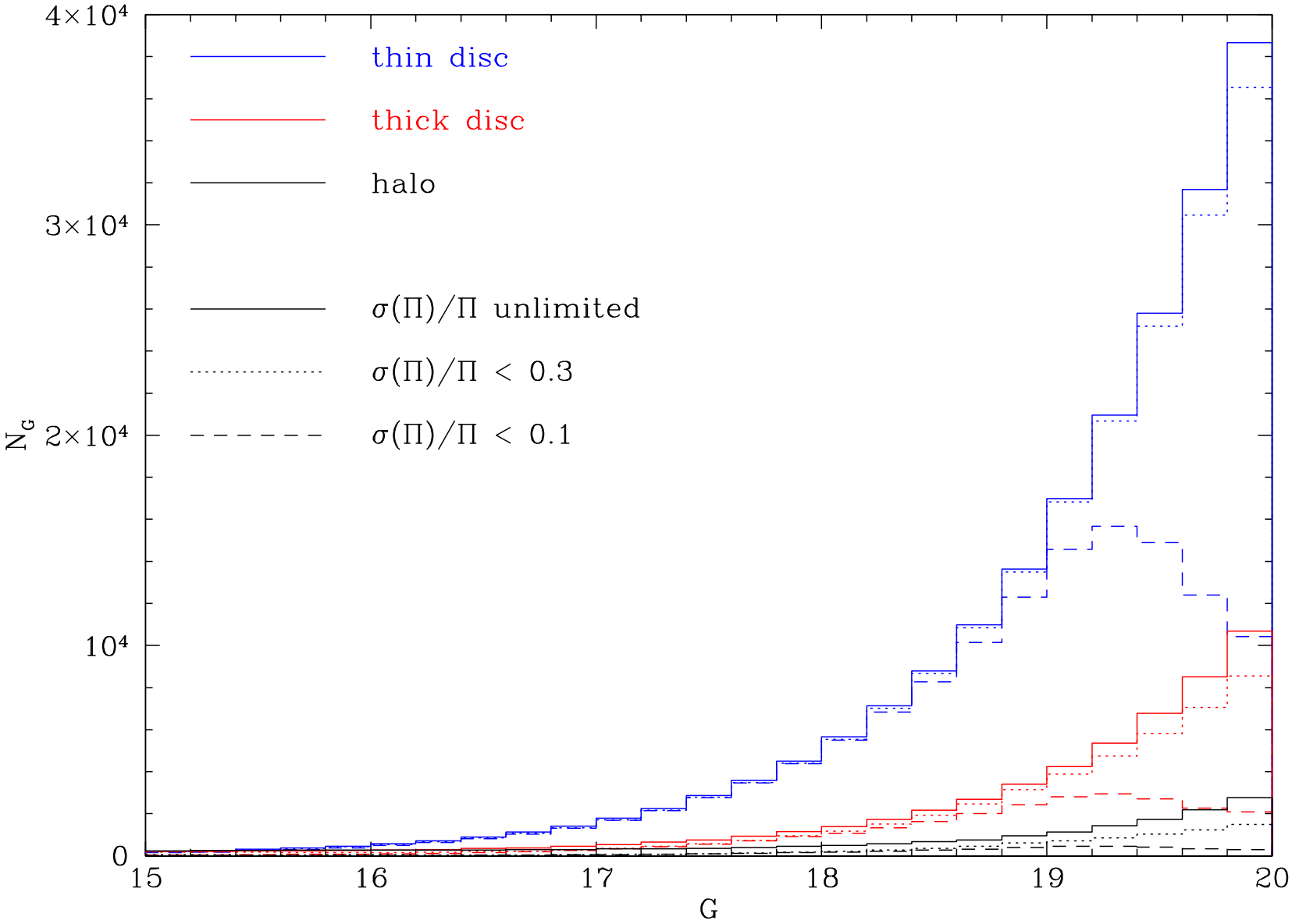
- Refinement of spectral classification (mixed types, hydrogen in cool objects)
- Measurement of radial velocities
  - Reliable classification of thin disc, thick disc and halo membership $\Rightarrow$ space densities, early IMF
  - Identification of binary candidates if more than one epoch or follow-up of WDs with extreme velocities
- Much more systematic selection of DZ/DAZ/DBZ white dwarfs $\Rightarrow$ Hunt for remnants of planet systems in all three Galactic populations.

The Gaia WD sample

Simulations calibrated with the SPY sample (Napiwotzki 2009; Carrasco et al. A&A submitted):

	all	$\frac{\sigma(\Pi)}{\Pi} < 0.3$	$\frac{\sigma(\Pi)}{\Pi} < 0.1$
thin disk	202 861	197 154	132 172
thick disk	56 628	47 945	26 970
halo	19 950	10 102	4 906
total	279 440	255 203	164 048

The Gaia WD sample



Summary

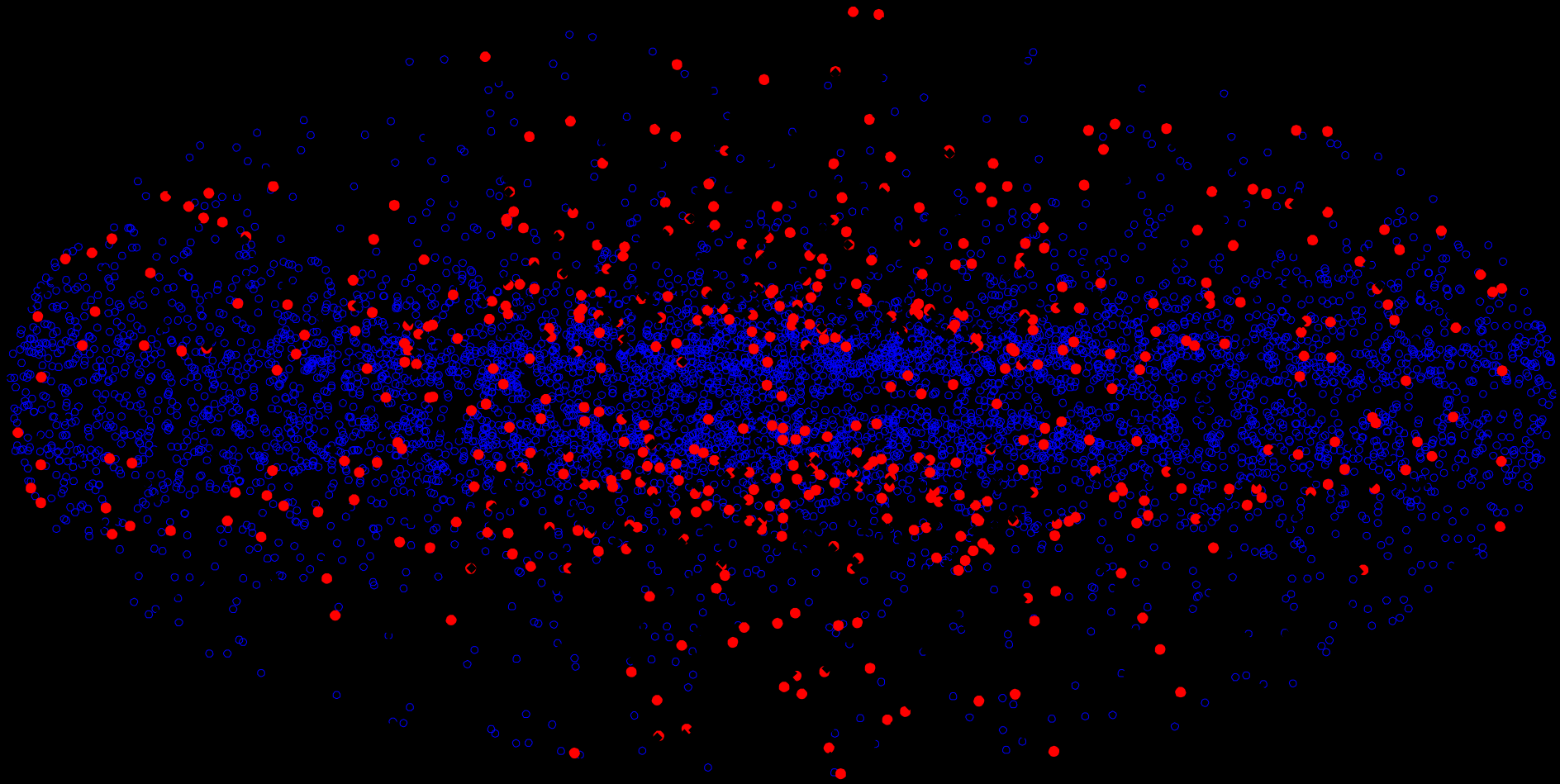
Gaia survey

- will increase the number of known WDs by a factor > 10 and it will increase the number of WDs with accurate parallaxes by a factor $>$ 1000!
- will produce a much improved local sample. Improved understanding of the Galactic WD populations, but limitations.

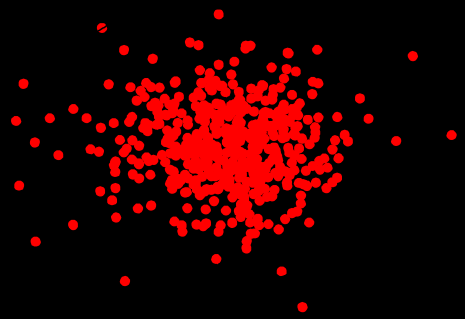
4MOST survey

- will yield spectral classifications and improved stellar parameters and will allow to understand spectral evolution.
- will make detection of binaries for cleaning up or follow-up possible.
- will allow systematic hunt for potential remnants of planet systems.
- allow to determine the contributions of the Galactic WD populations.

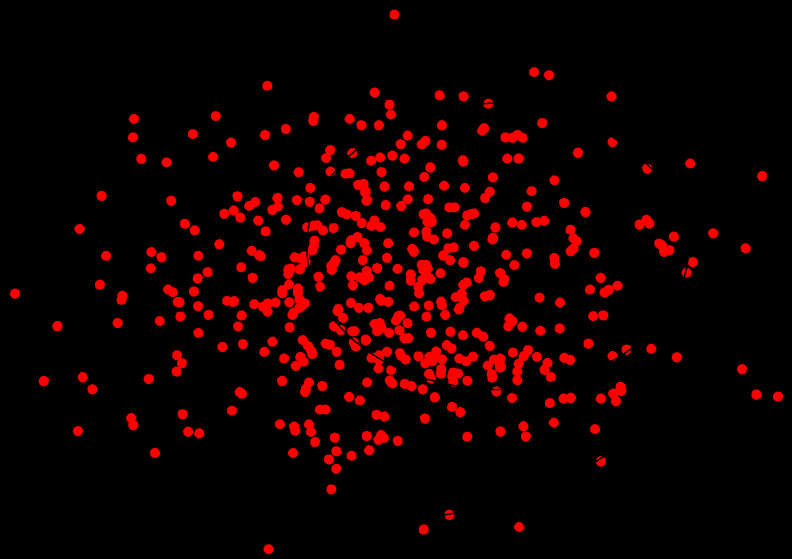
Simulated population of post-AGB stars



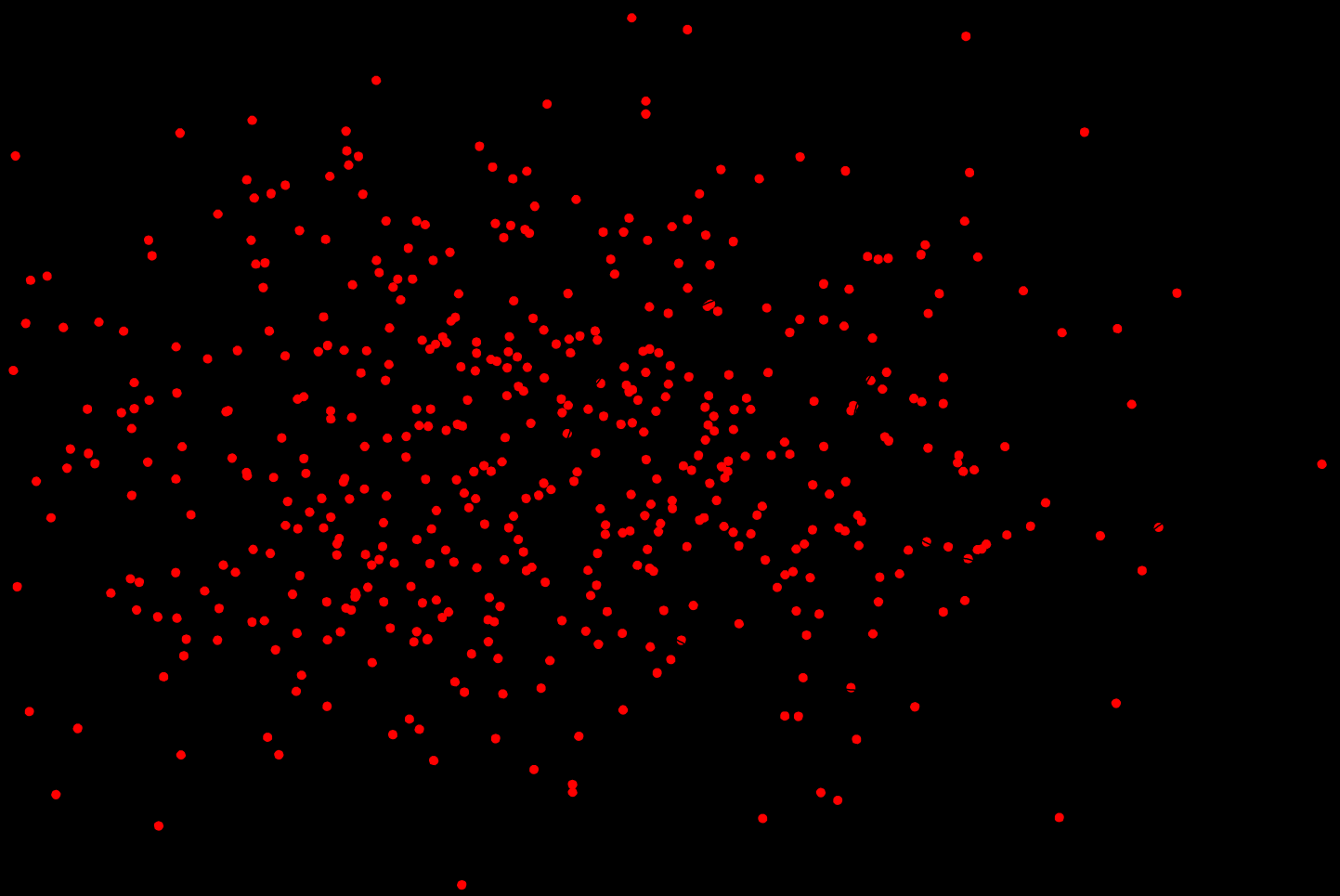
Simulated thin disk WDs in $U - V$ plane



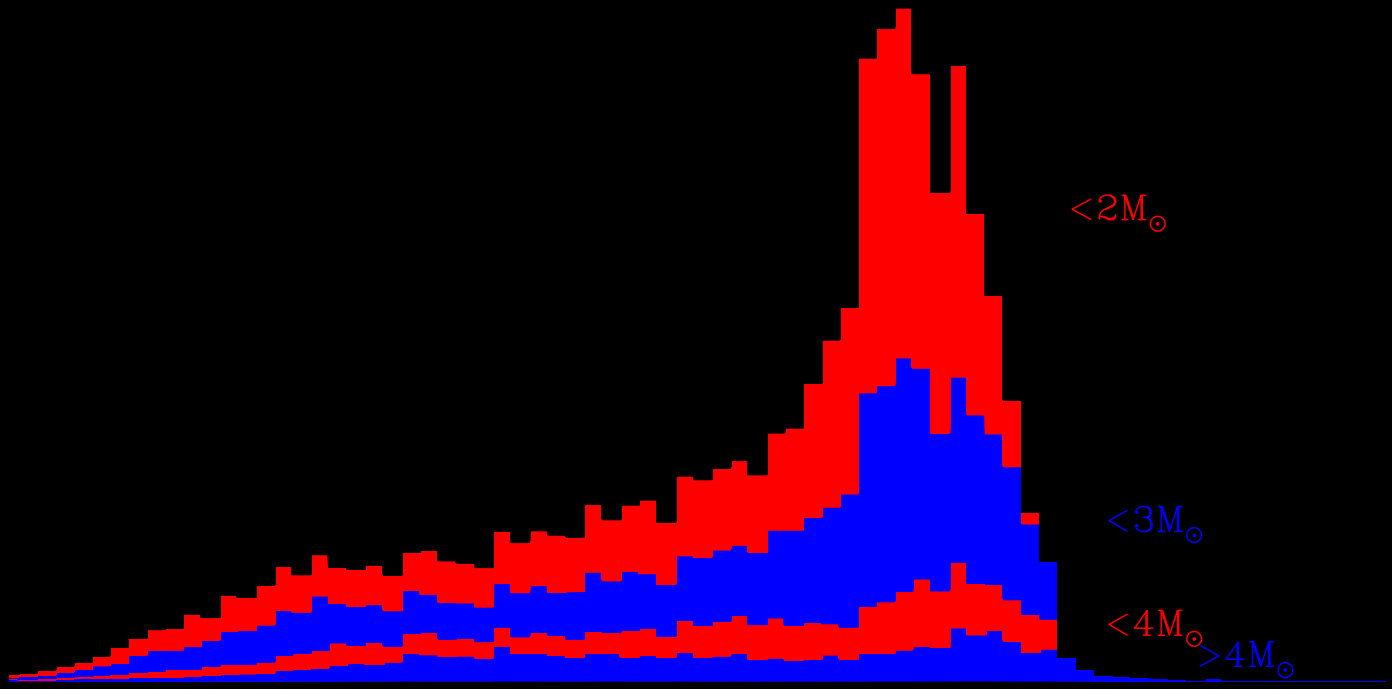
Simulated thick disk WDs in $U - V$ plane



Simulated halo WDs in $U - V$ plane



Luminosity function – thin disc



Luminosity function – halo