Cool WDs in the WTS survey

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OUTLINE

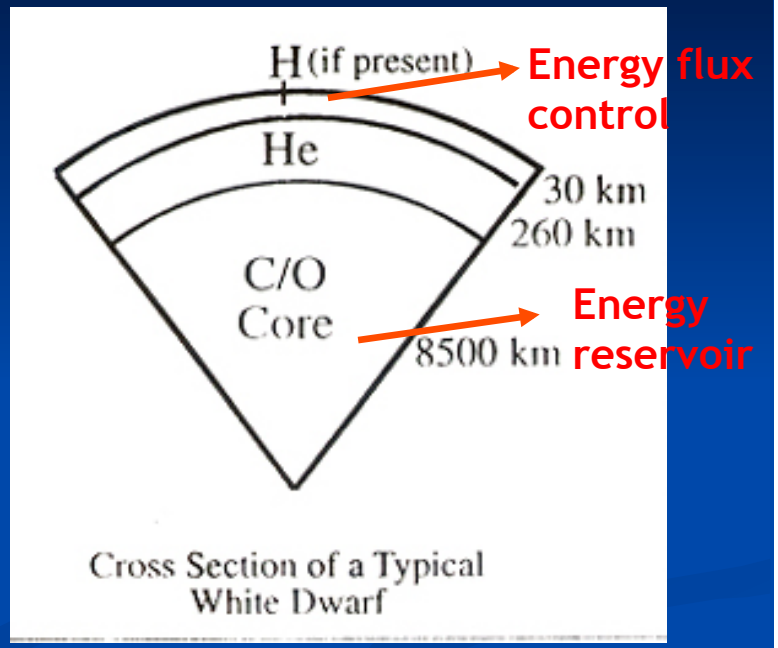
- Introduction
- WFCAM Transit Survey (WTS)
- Cool WDs identification
- Summary

White dwarfs

- evolutionary end-product of most stars when finishing their main sequence lifetime ($M<8\text{-}12\ M_{\odot}$)

-WD evolution is driven by a simple cooling process, duration ~ age of the Galaxy, so they are useful objects to probe the structure and evolution of the Galaxy

White dwarf structure



Cool white dwarfs **(T_{eff}<5000 K)** provide information:

- Halo white dwarf population: only few members known so far…
- Initial mass function (distribution of stellar masses at birth)
- Age of the Galaxy from the cut-off in the luminosity function
- DA/non-DA WD ratio in the cool domain not well stablished yet
- Information about Hydrogen opacities (still need to be improved at low T_{eff})

Cool WDs

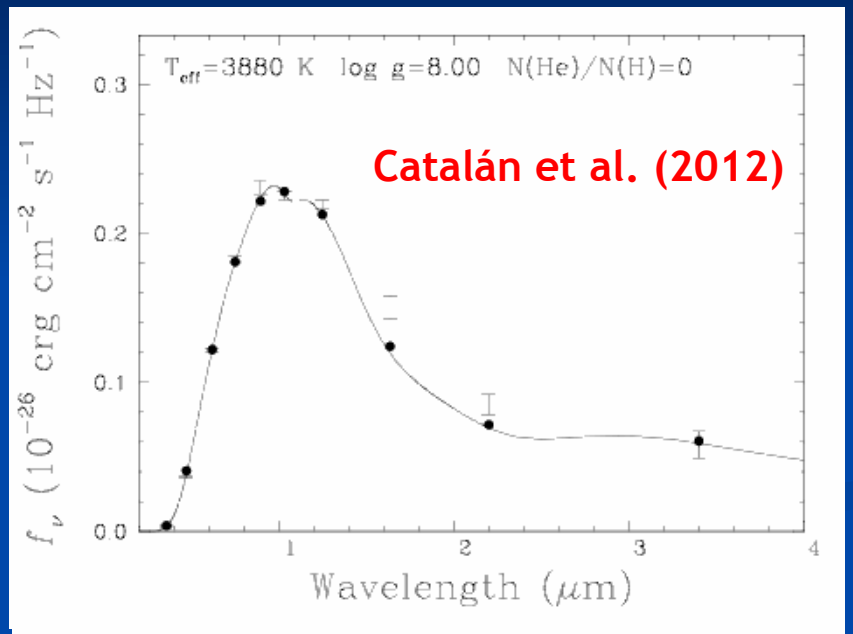
Few have been detected so far in SDSS (Kilic et al. 2010a,b, but it is too shallow g,r ~22)

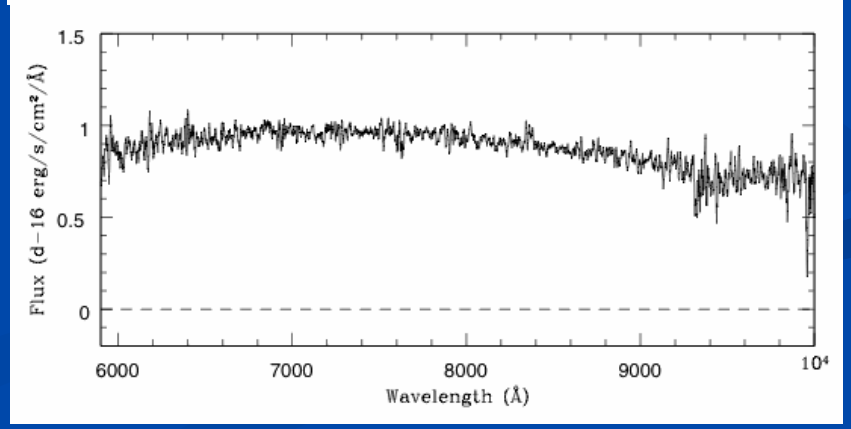
But, some of these ultra-cool WDs (T_{eff}<4000K) are low-mass products of binary evolution, thus not representative for the oldest WDs (log g<7.5)

And in UKIDSS: Lodieu et al. (2009), Leggett et al. (2011)

Only 4 H pure ultracool WDs found so far: Kilic et al. 2012 & Catalán et al. (2012)

LSRJ0745+2627: brightest H-pure ultracool WD found using Leigh Smith μ catalogue





WTS (WFCAM Transit Survey)

- **WFCAM at UKIRT telescope (Mauna Kea) + zyJHK filters**

Main aim:

detection of planetary companions to low-mass stars (transit method)

PI: D. Pinfield, Co-PI: S. Hodgkin

Take over the time span of five years many repeat observations in NIR bands

(from 2007 until 2012)

6 sq degrees of total sky coverage: 4 fields

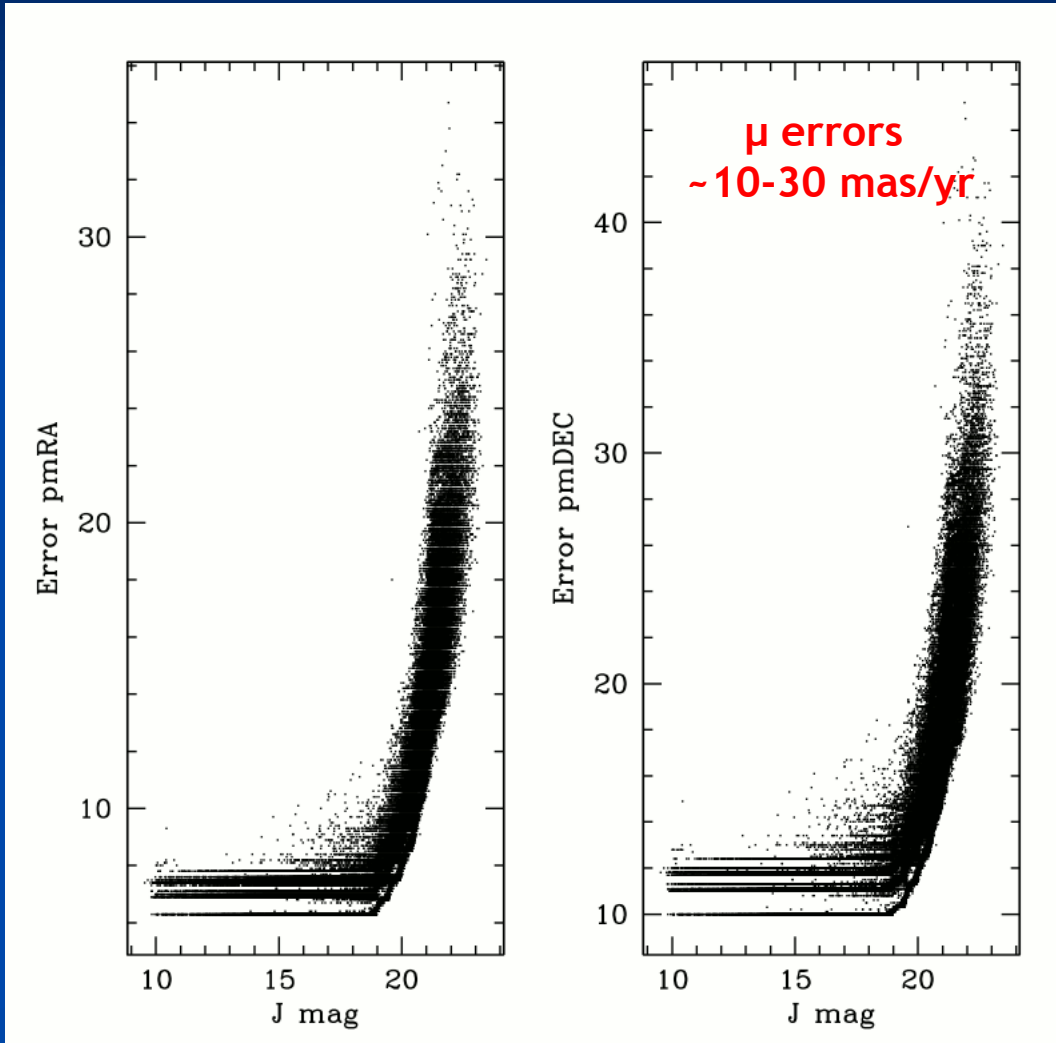
50% of the WTS observations are completed and reduced so far

Deep images in J band:

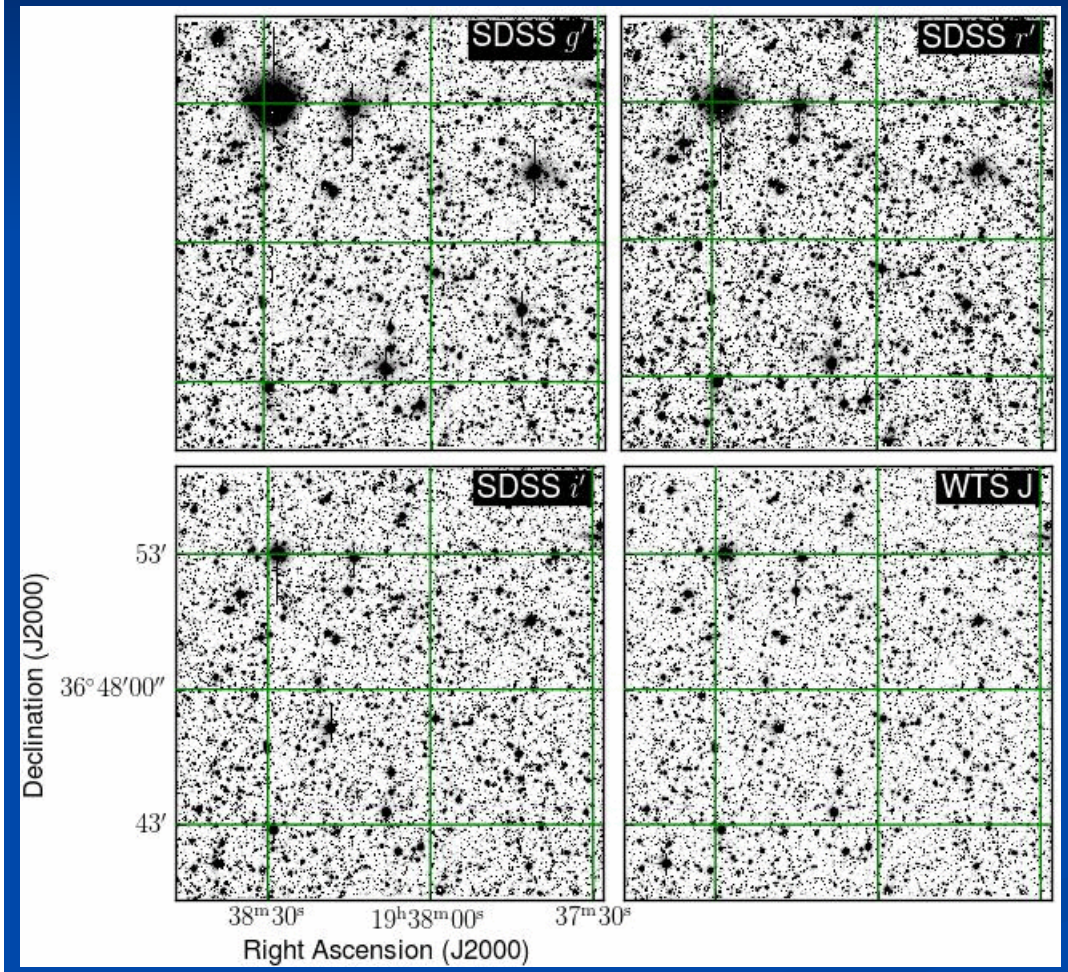
25 h in J band, increase the depth by stacking images (Simon Hodgkin at IoA), for 19h field so far

Proper motion

- J band stacked images: 40 images, seeing < 1.2 arcsec, airmass < 1.5 and zeropoint > 22.8. The depth reached in this way is J = 23 mag (5σ).
- We pick the first image (first epoch) as a reference, and then follow each detected star through all the other images. (Chi sq. minimization, ΔJ=0.5 mag)
- 2007-2009 images included
- μ accuracy may still improve by including last stacked images (2010-2012)



WTS fields optical broadband photometry



- Optical broadband photometry:

SDSS g',r',i'

obtaining depth of 25 mag (S/N=5)

-3.5m telescope + LAICA at CAHA (20 nights awarded)

-INT + WFC at la Palma (6 nights awarded, bad weather)

-100% of 19h, 17h fields covered

- 50% 3h, 7h fields covered (last december)

WTS fields optical broadband photometry

- Reduction:

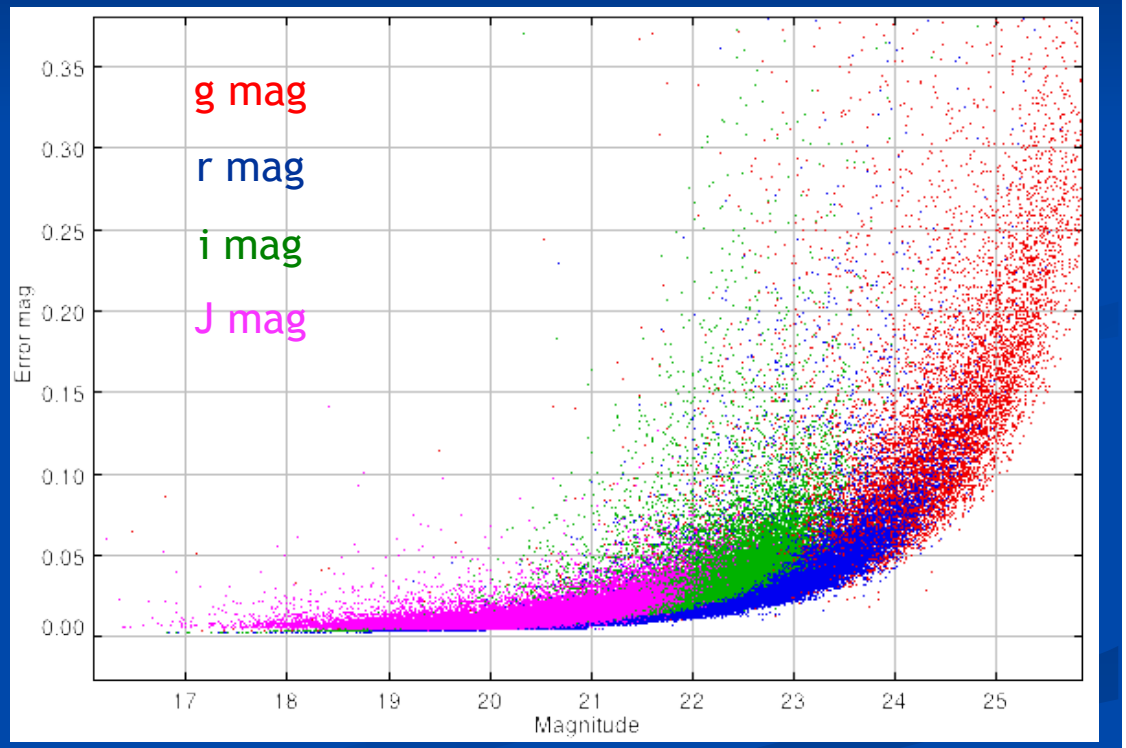
- Adapted Alhambra survey pipeline

(astrometry calibration, image combination with Swarp, zeropoint)

- Photometric calibration using IRAF tasks (using standard fields)

- Aperture correction

- Finally, cross-matching with J band catalogue using stilts (5 arcsec)



WD population in the WTS fields

- **Napiwotzki (2008)**

- based on the model of Galactic structure by Robin et al. (2003)

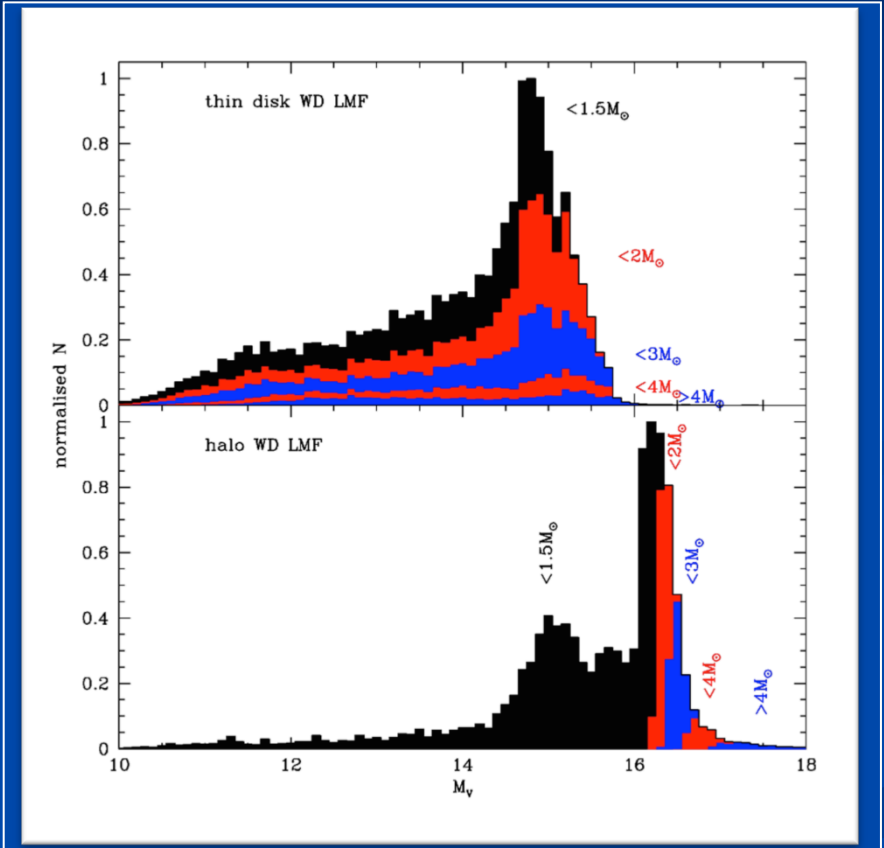
- population identification based on the results of the kinematic study of Pauli et al. (2006)

- calibrated with the local sample (Holberg et al. 2008)

- checked against the proper motion selected sample of cool WDs by Oppenheimer et al. (2001)

- more than 1500 WDs with μ>10mas/yr will be detected in the WTS fields (standard IMF)

- 100 cool WDs with Mv>15 mag (T_{eff} < 5000 K) most of them thick disc and halo members



Simulated WD luminosity distribution

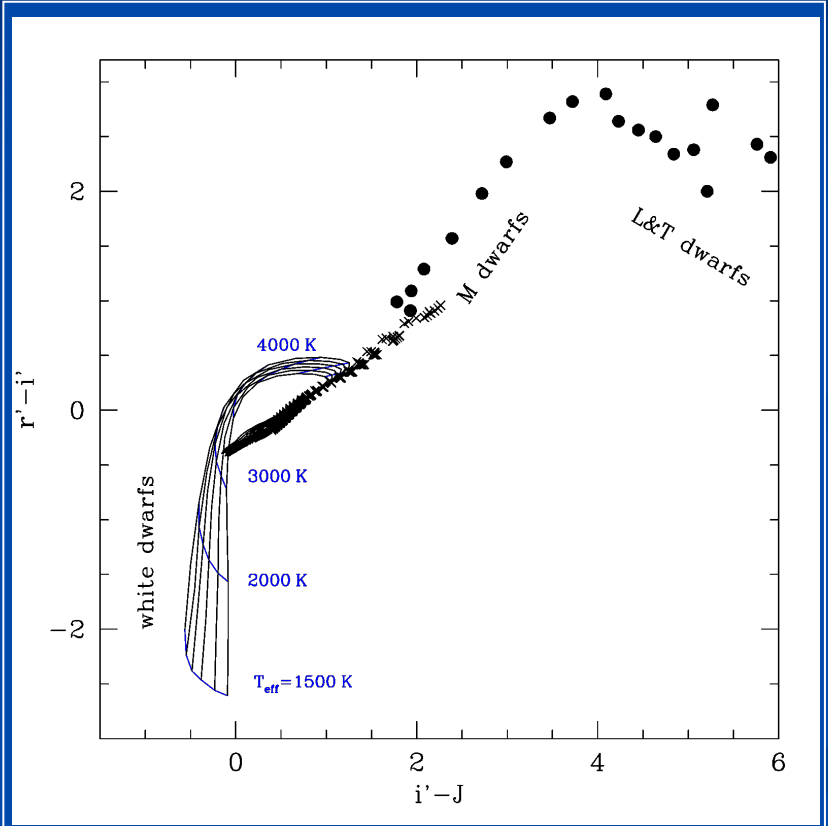
Cool WDs

Cool WDs have SEDs very different from other types of cool objects

- **H-rich WDs**: show flux depression in the IR due to H molecule absorption
- **He-rich WDs**: become very red with T_{eff}

Synthetic magnitudes from:

http://www.astro.umontreal.ca/~bergeron/
Holberg & Bergeron (2006)
Kowalski & Saumon (2006)
Tremblay et al. (2011)
Bergeron et al. (2011)



Colour-colour diagram r-i vs i-J

Cool WDs

Cool WDs have SEDs very different from other types of cool objects

- **H-rich WDs**: show flux depression in the IR due to H molecule absorption
- **He-rich WDs**: become very red with T_{eff}

Selection criteria:

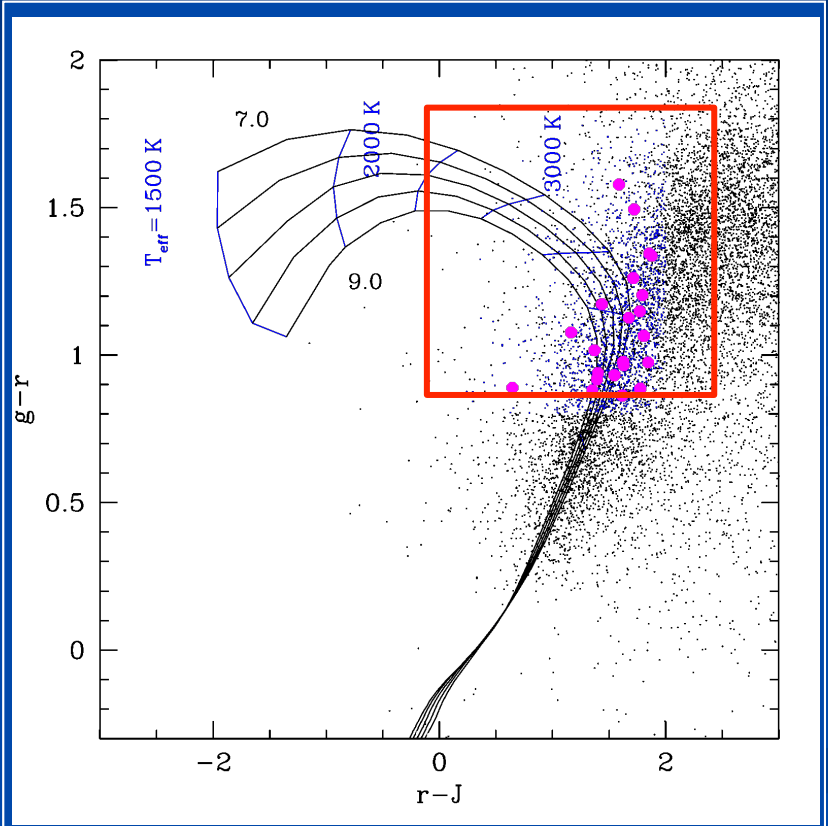
0.2 < g-r < 1.8
-0.6 < r-i < 0.6

g-i < 1.8

0.2 < i-J <1.4

J >14 μ>100 mas/yr

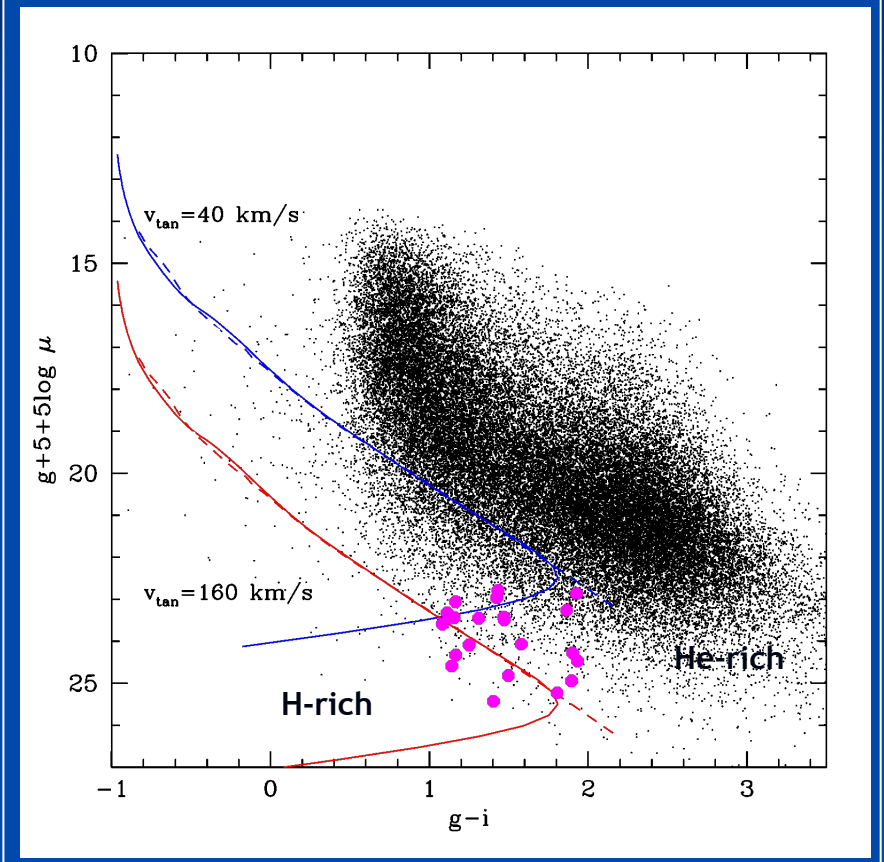
19h field



Colour-colour diagram

Updated Holberg & Bergeron (2006)

Reduced proper motion diagram



Reduced proper motion diagram
Holberg & Bergeron (2006) models

To identify the membership of the WDs to a given population we use the rpm diagram:

$$H_g = g + 5 \log \mu + 5$$

Selection criteria:

μ>100 mas/yr

H_g > 22.5

We identified:

6 WD candidates with μ>150 mas/yr

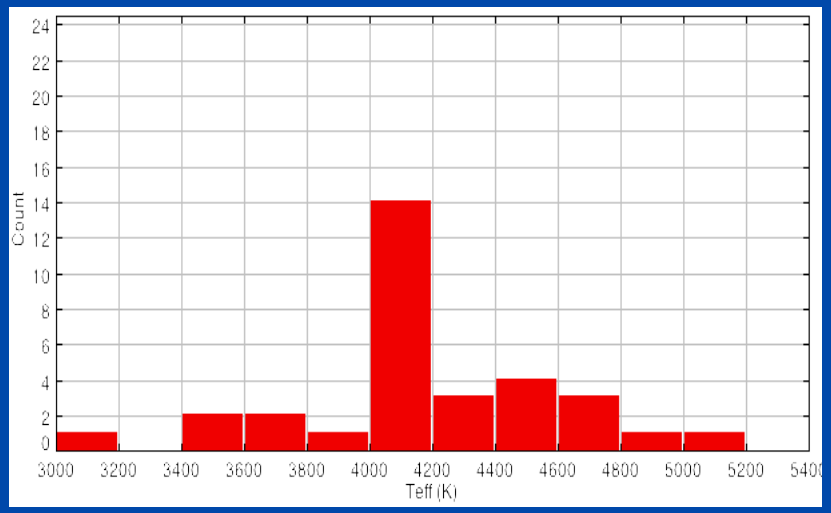
27 WD candidates with μ>100 mas/yr

In preparation: **Catalán et al.(2012b)**

Effective temperature and composition

Fit of griJ to synthetic magnitudes based on Levenberg-Marquardt method to minimize χ^2 assuming two possible compositions H-pure (DA) and He-pure (DB)

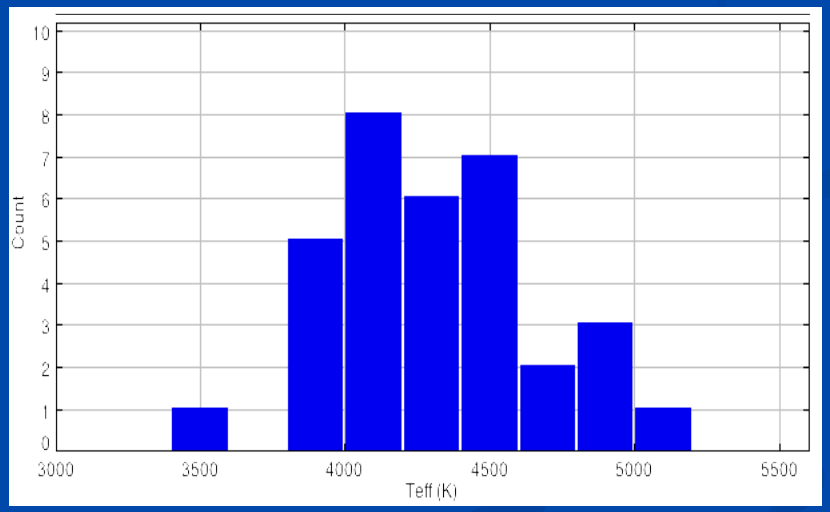
DA: 1500-140000K, log g=7.0-9.5



T_{eff} Histogram, H-pure composition

fixed log g=8.0

DB: 3500-40000K, log g=7.0-9.0

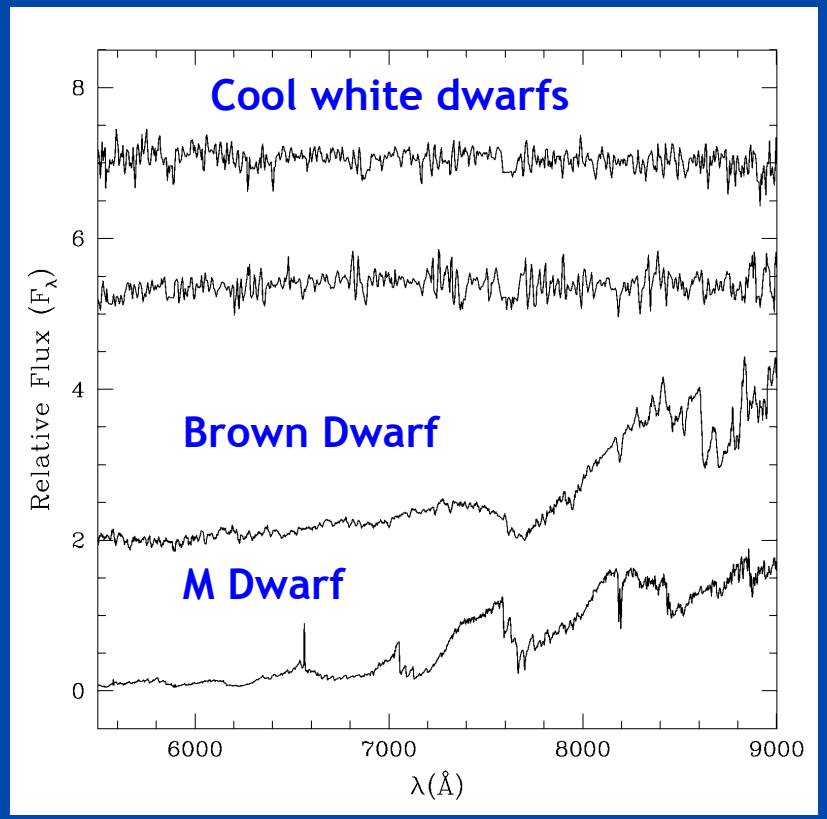


T_{eff} Histogram, He-pure composition

fixed log g=8.0

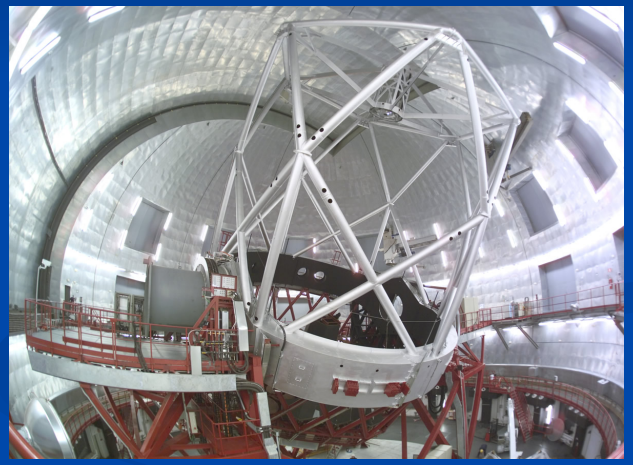
Spectroscopic follow-up

4 of the cool WD candidates confirmed at GTC + OSIRIS R500R in July 2011



Spectra obtained at the GTC (S/N = 15)

Gran Telescopio Canarias
GTC (La Palma Observatory)



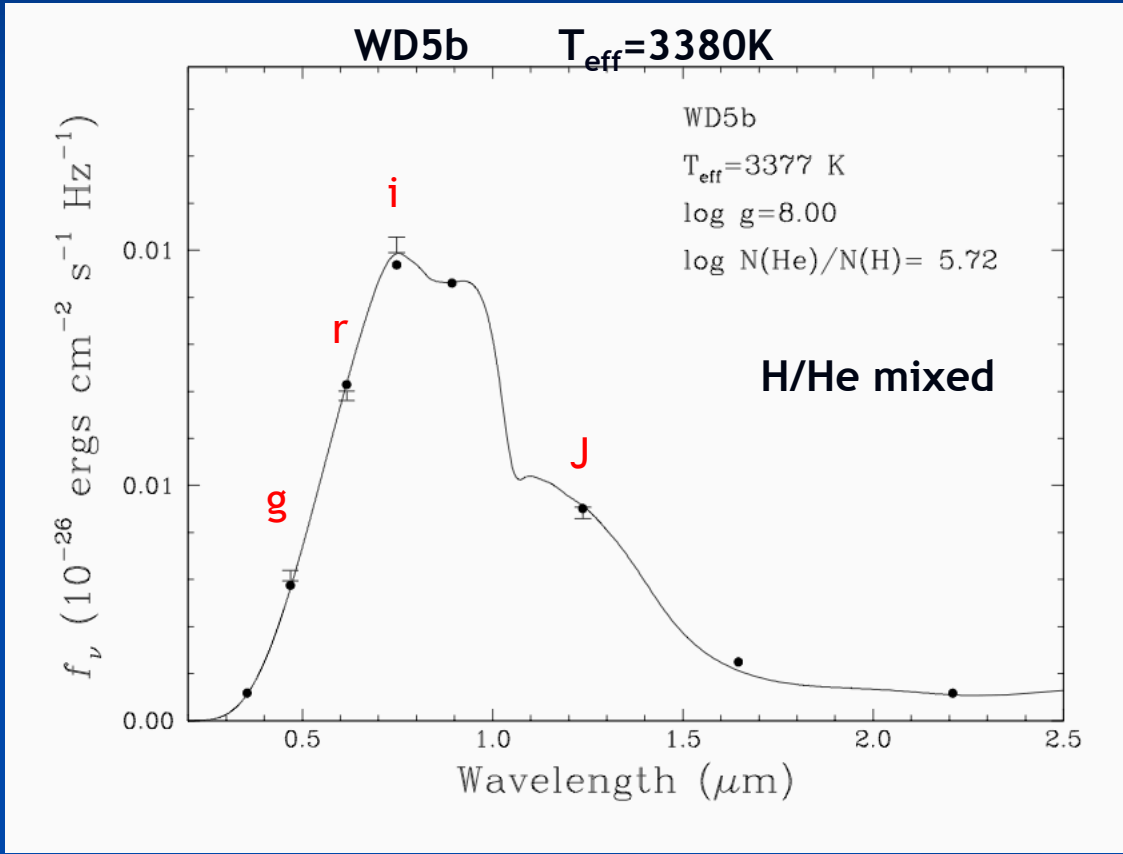
Featureless spectra

Cool WD confirmation

More observing time needed to confirm the other candidates

Effective temperature and composition

Fit of griJ to synthetic magnitudes (Holberg & Bergeron, 2006, Kowalski & Saumon, 2006, Tremblay et al. 2011, Bergeron et al. 2011) http://www.astro.umontreal.ca/~bergeron/



Fits by P.-E. Tremblay

Effective temperature and composition

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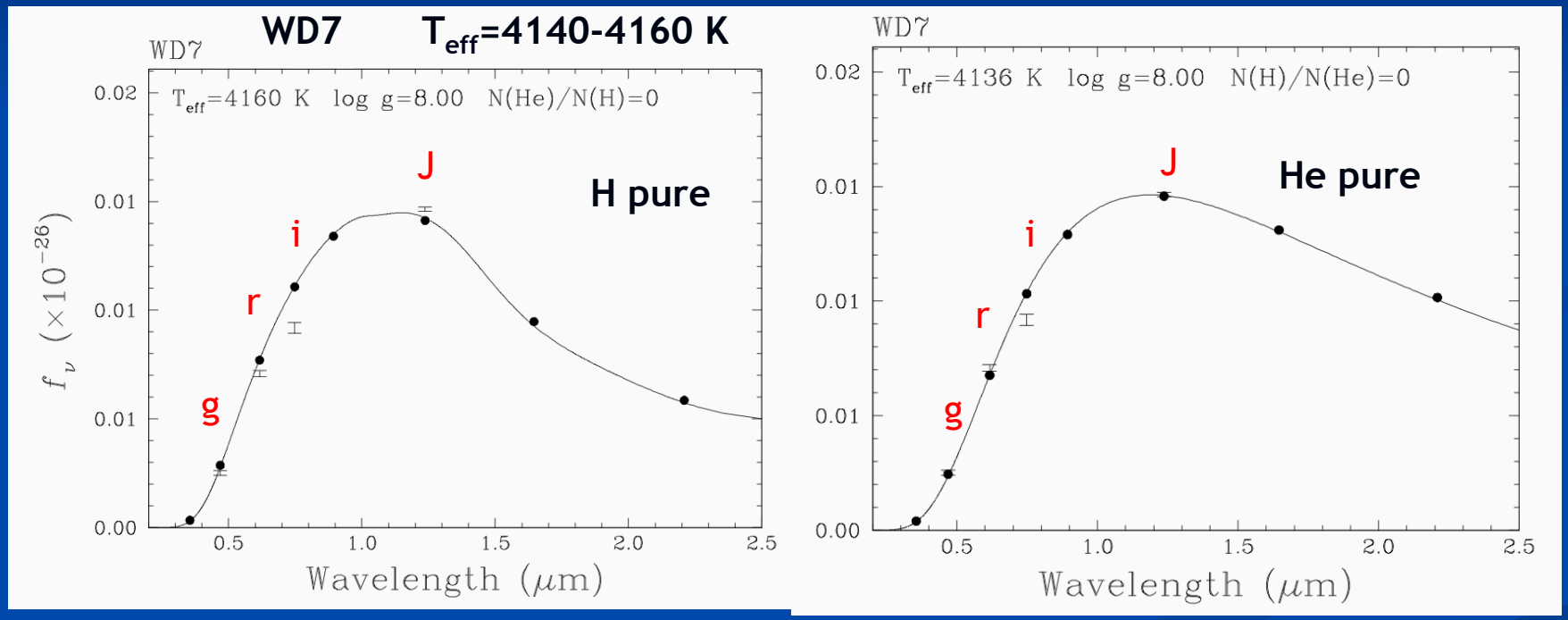

We obtained time at Gemini North to get H band magnitudes to distinguish between H/He rich compositions

Summary

WTS data can be used to detect new cool WDs, 4 cool WDs spectroscopically confirmed so far, next steps:

- complete the optical imaging and analysis of the four WTS fields

  we will be in a position of ruling out or confirming IMFs
- Continue with spectroscopic follow-up of the coolest WD candidates

Other surveys: Alhambra Survey (8 sq deg, 20 medium-bands optical + JHK, lim. mag = 25)

Other research lines:

- Hydrogen opacities are rather uncertain at low T_{eff}:

  - test WD model atmospheres, brown dwarfs atmospheres
- Improve the initial-final mass relationship of pop. II WDs using the cool WDs detected