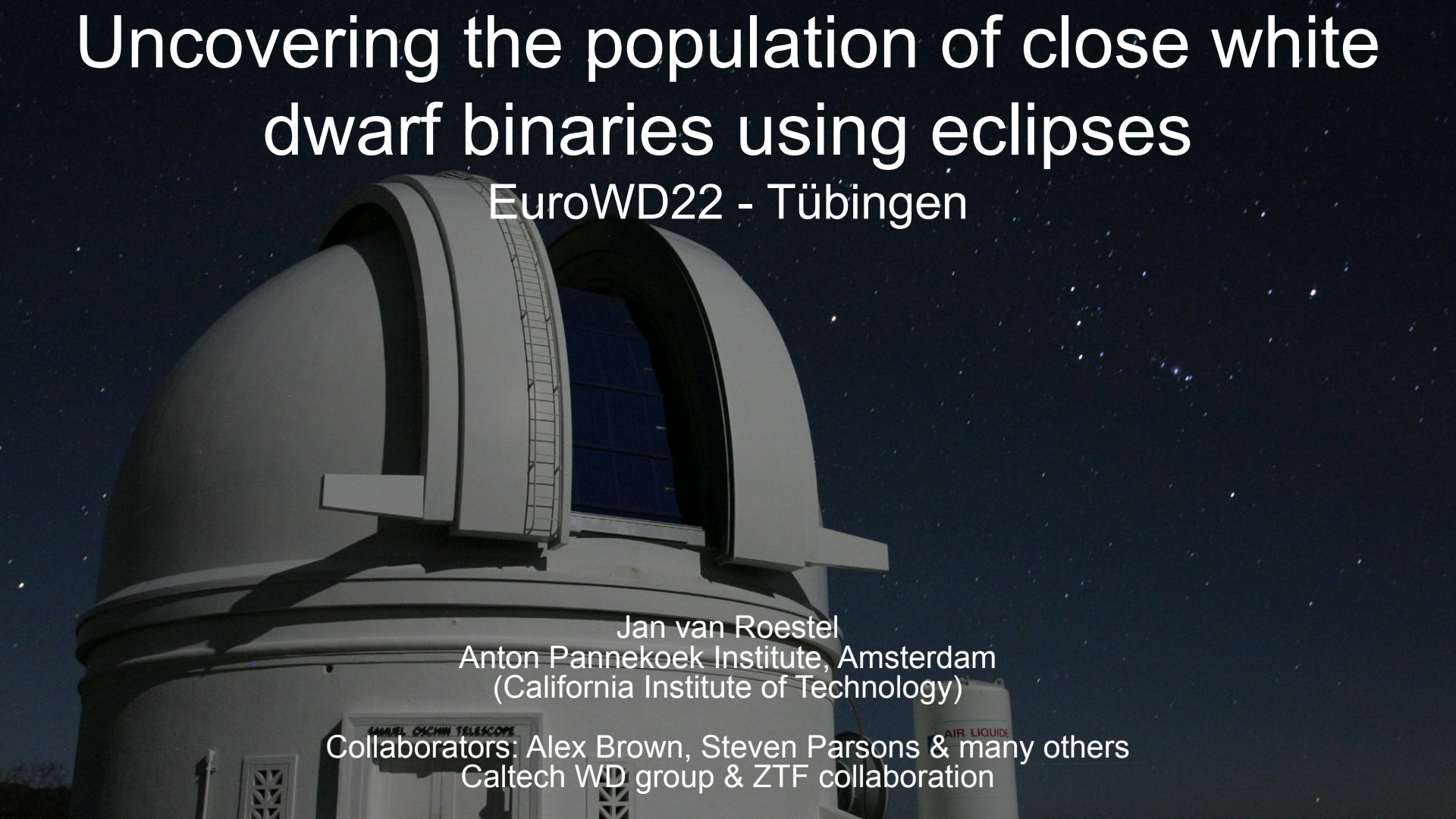
Uncovering the population of close white dwarf binaries using eclipses

EuroWD22 - Tübingen



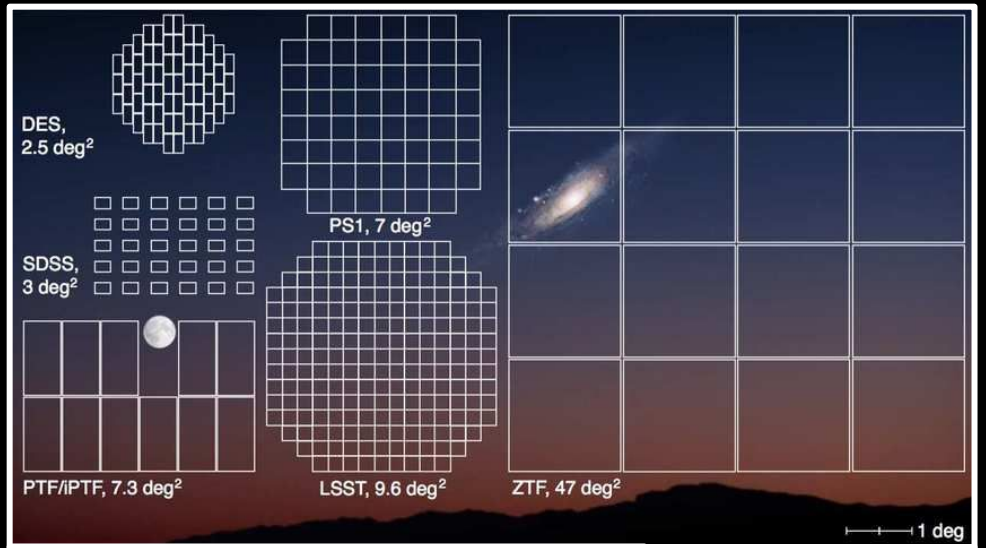
Jan van Roestel
Anton Pannekoek Institute, Amsterdam
(California Institute of Technology)

Collaborators: Alex Brown, Steven Parsons & many others
Caltech WD group & ZTF collaboration

Zwicky Transient Facility

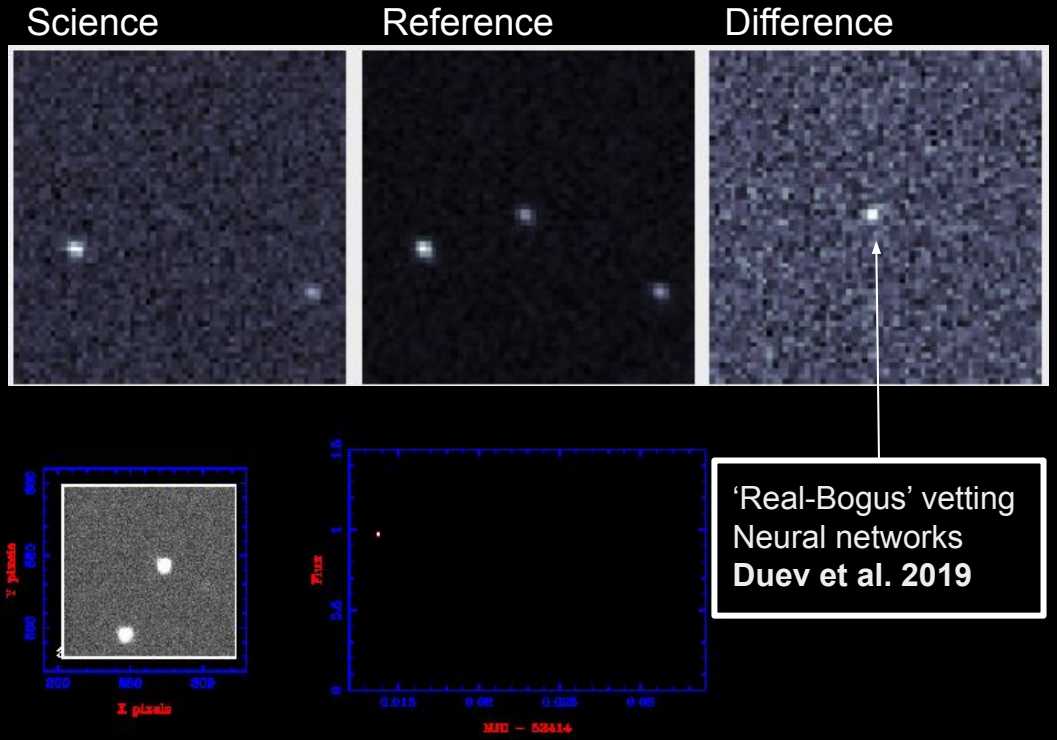
“Celestial cinematography”

- **1.2m** telescope
- **47** square degrees
- 1.01 arcsec/pixel
- ***gri*** ~ 20.5 AB-mag limit
- ~600 median epochs



~2 Billion objects with lightcurves!

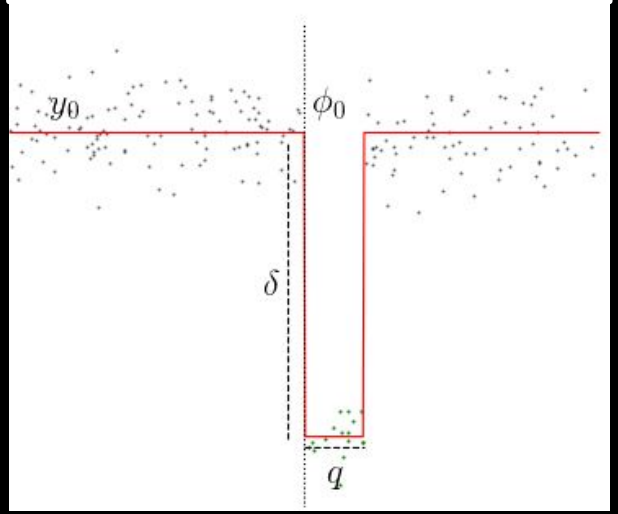
Finding eclipsing white dwarfs in the ZTF data



‘Real-Bogus’ vetting
Neural networks
Duev et al. 2019

Credit: ULTRACAM team

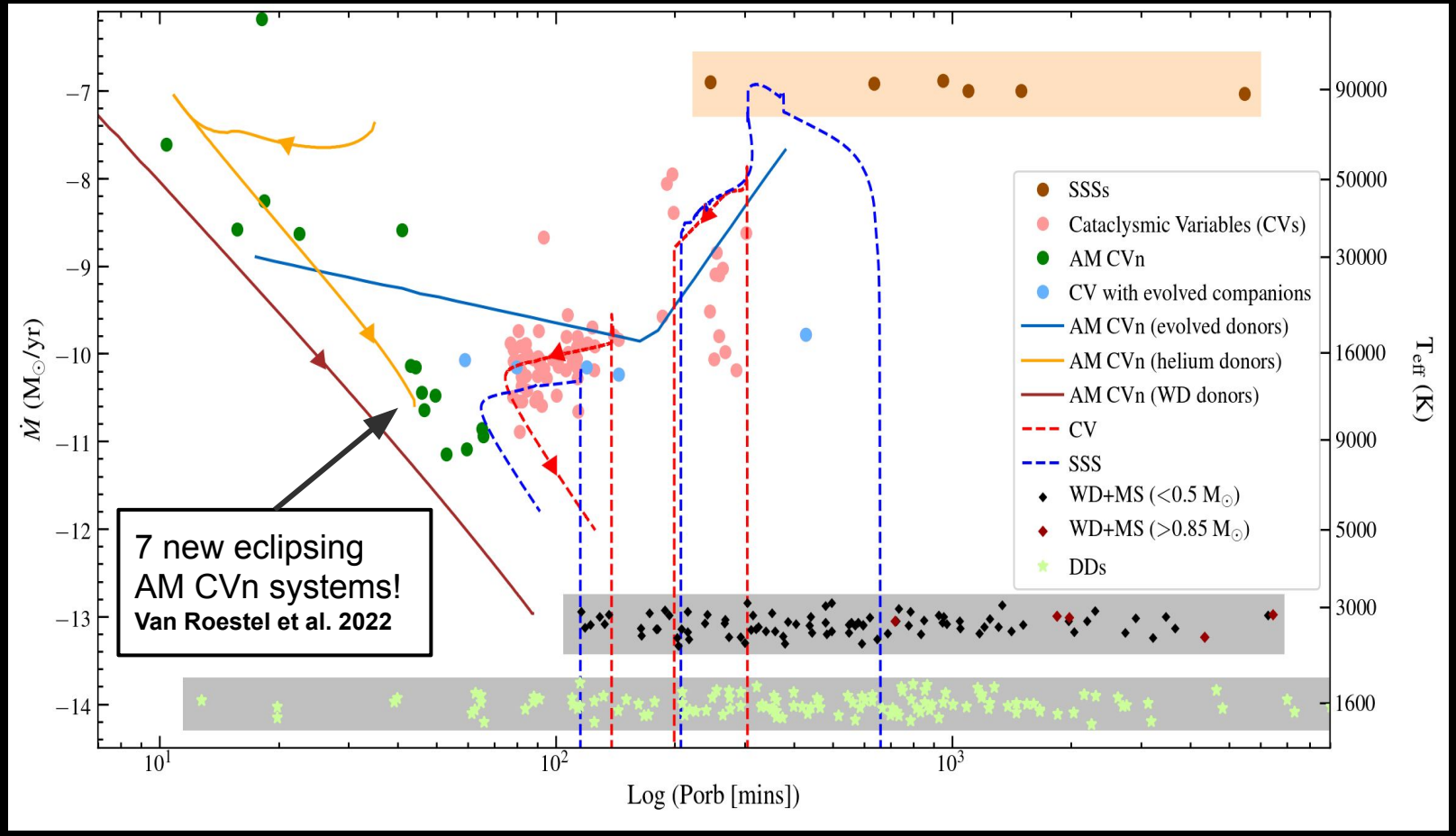
Boxed-least-squares period finding
Kovacs 2002,
GPU implementation: J. Hoffman



Eclipse searches:

- Parsons et al. 2016
- Burdge et al. 2020/21
- Keller et al. 2021
- Kosakowski et al. 2022

Short period white dwarf binary stars



Toloza et al. 2019

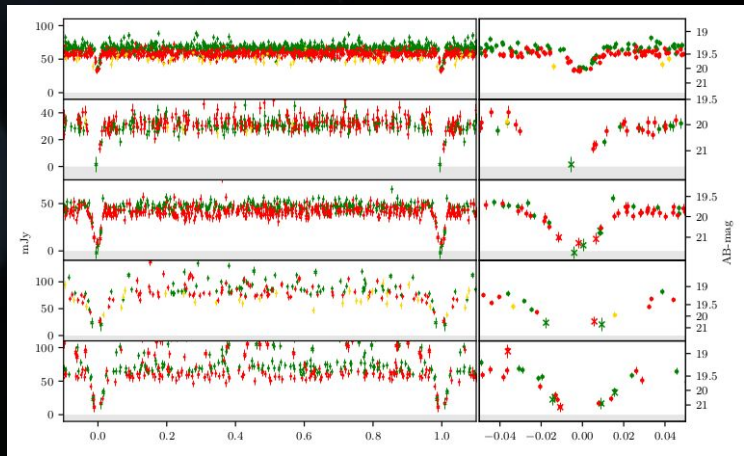
Eclipsing AM CVn binary stars

Van Roestel et al. 2022:

- 5 new eclipsing AM CVn systems
- Periods 35-62 minutes

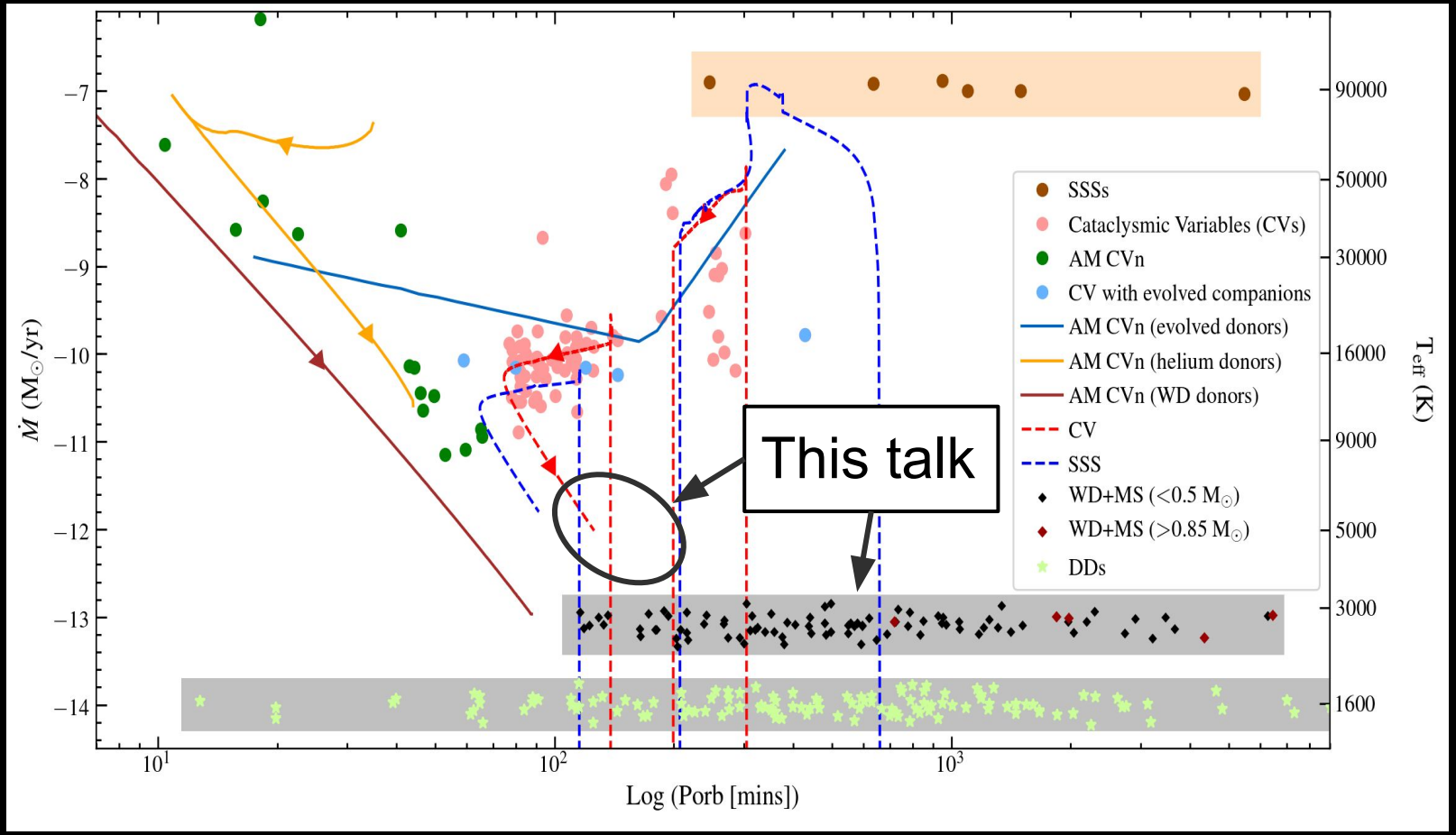
Conclusions:

- No hidden population
- $M_{WD} \sim 0.82\ M_{\odot}$
- Donor types; inconclusive

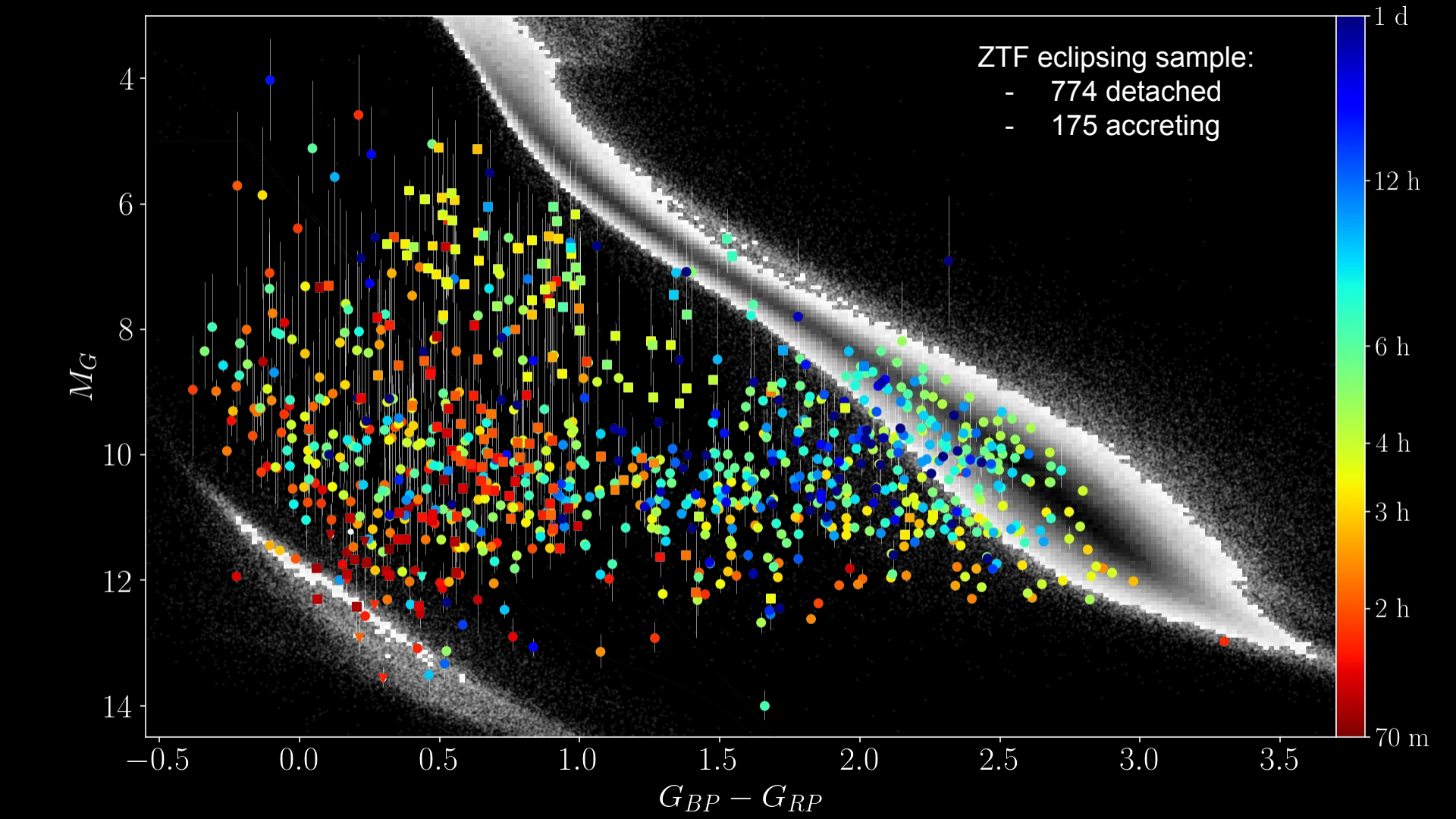


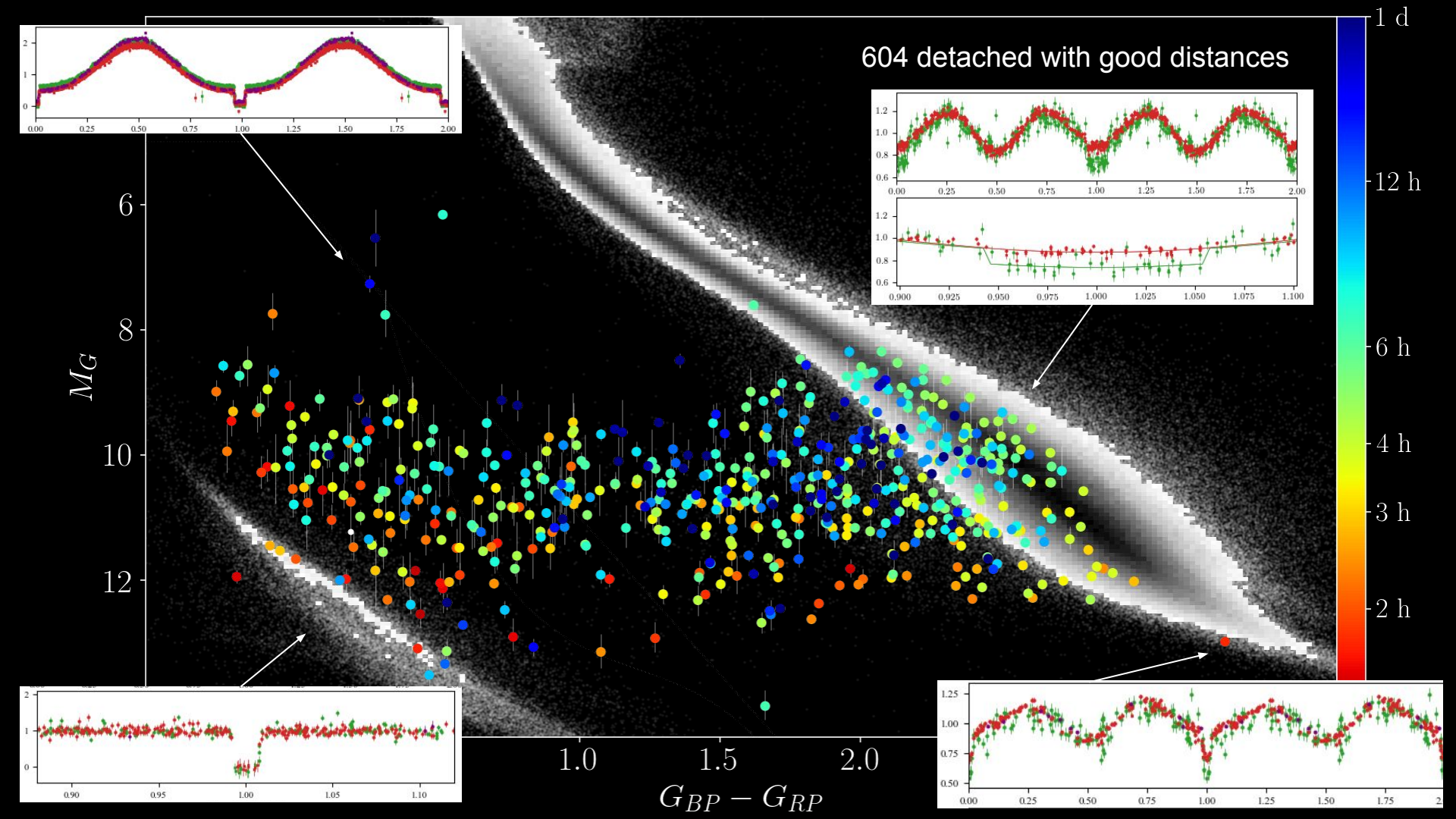
Learn more at:
“AM CVn 4.5” workshop
August 30th

Short period white dwarf binary stars

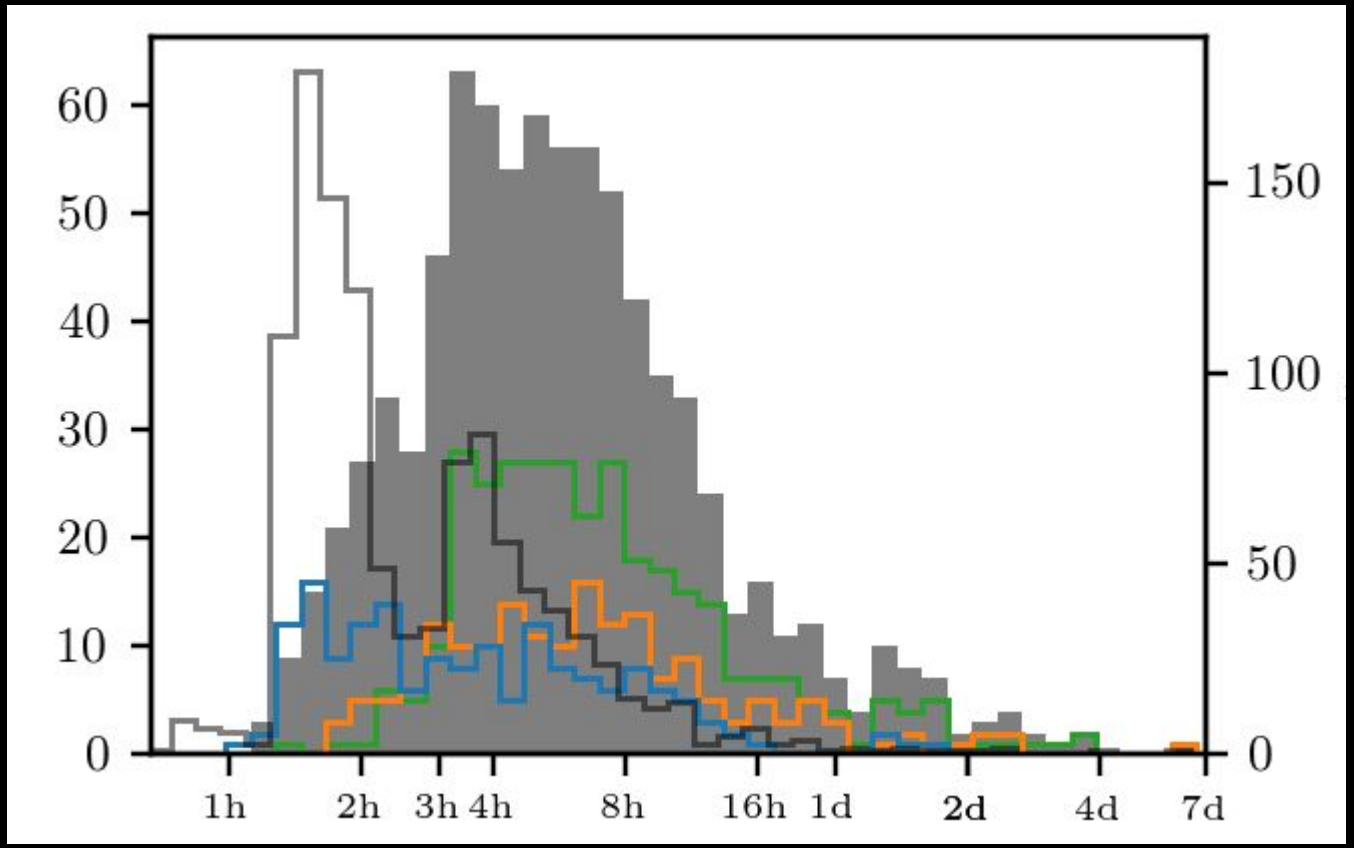


Toloza et al. 2019


ZTF eclipsing sample:
- 774 detached
- 175 accreting
M_G
$G_{BP} - G_{RP}$
4
6
8
10
12
14
−0.5
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
1 d
12 h
6 h
4 h
3 h
2 h
70 m


604 detached with good distances
1 d
12 h
6 h
4 h
3 h
2 h
M_G
6
8
10
12
1.0
1.5
2.0
$G_{BP} - G_{RP}$

Preliminary result: the observed period distribution

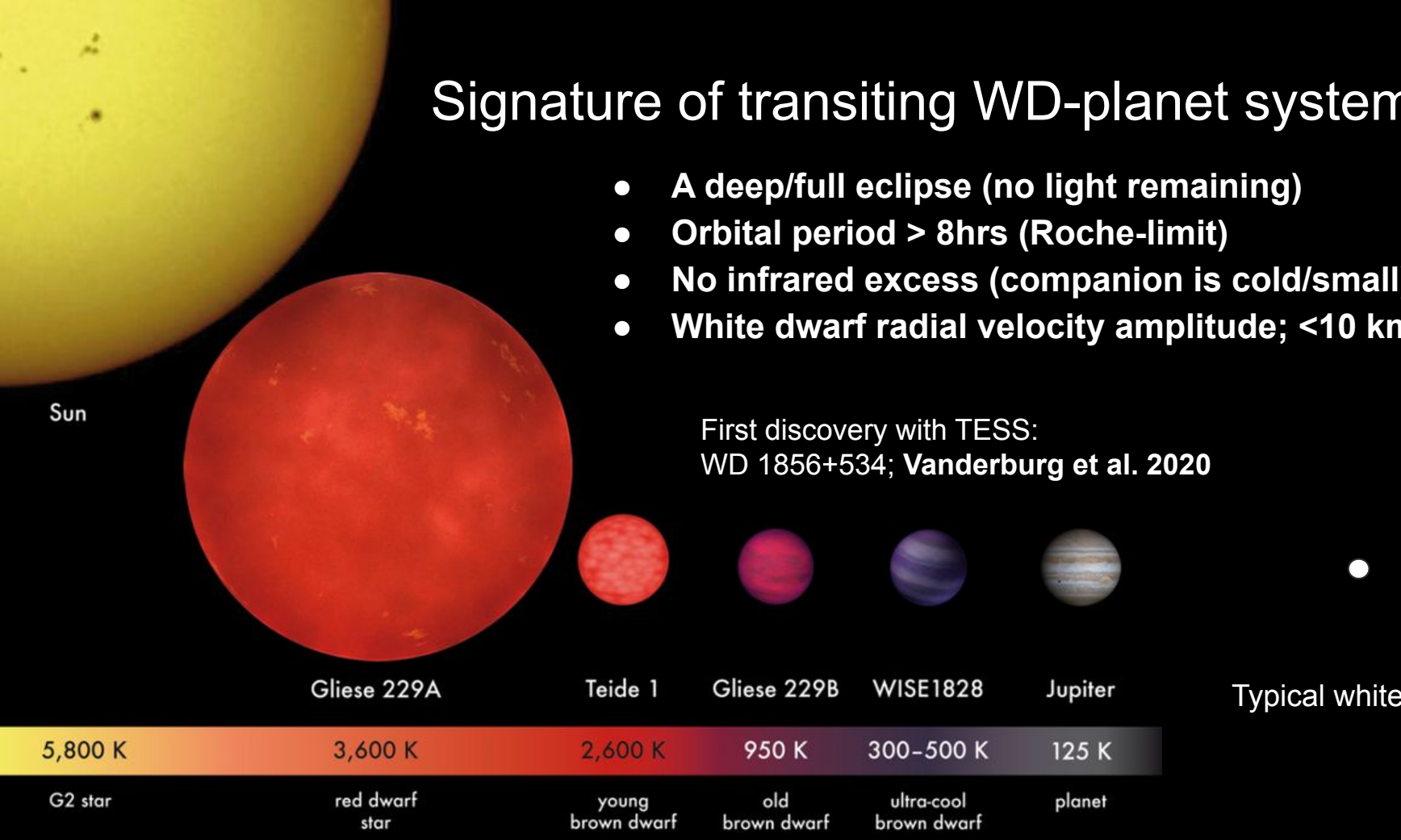


- Period peak: ~6hrs
- No period ‘spike’ ?
  (Davis et al. 2008, Zorotovic et al. 2016)

Signature of transiting WD-planet systems:

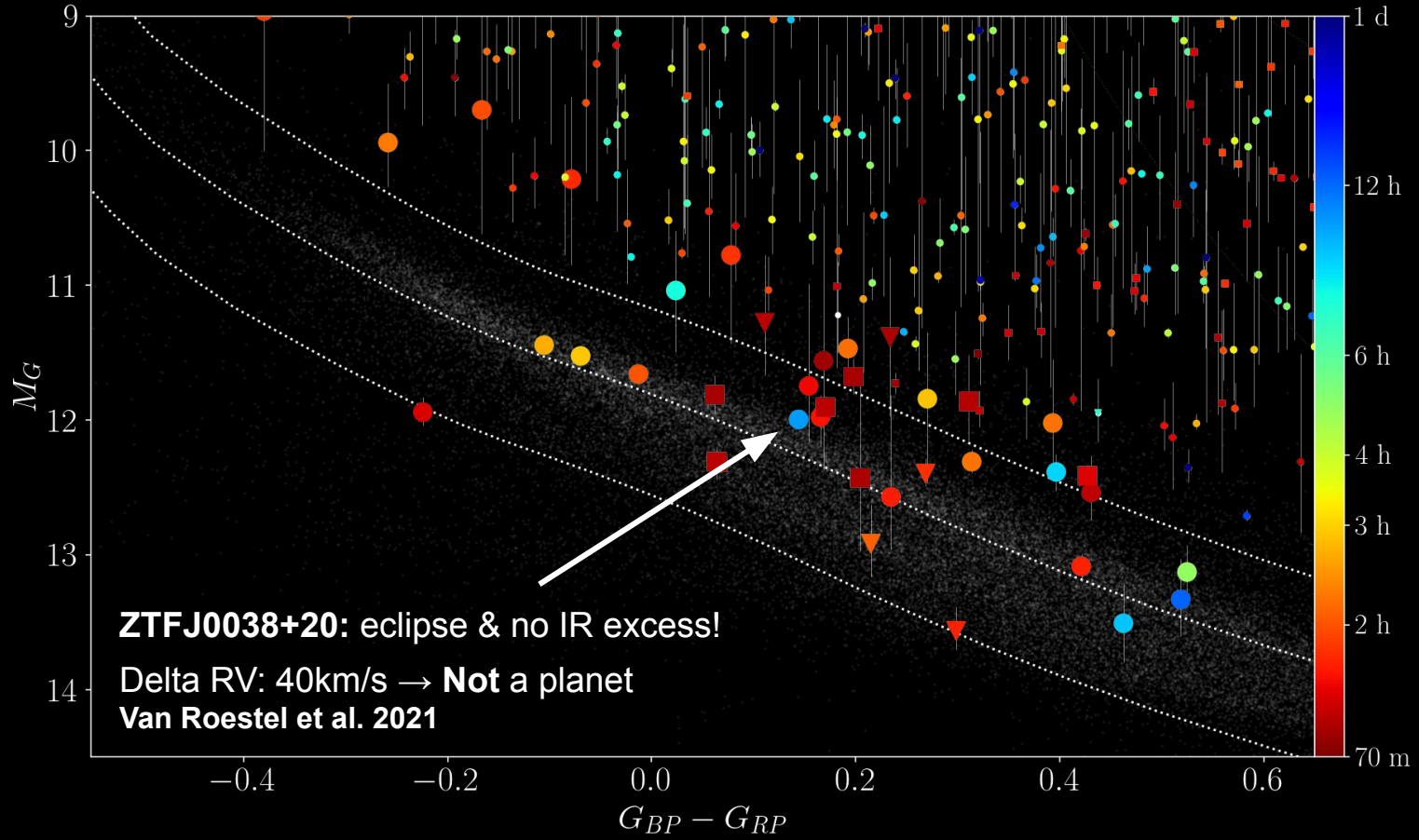
- **A deep/full eclipse (no light remaining)**
- **Orbital period > 8hrs (Roche-limit)**
- **No infrared excess (companion is cold/small)**
- **White dwarf radial velocity amplitude; <10 km/s**

First discovery with TESS:
WD 1856+534; **Vanderburg et al. 2020**

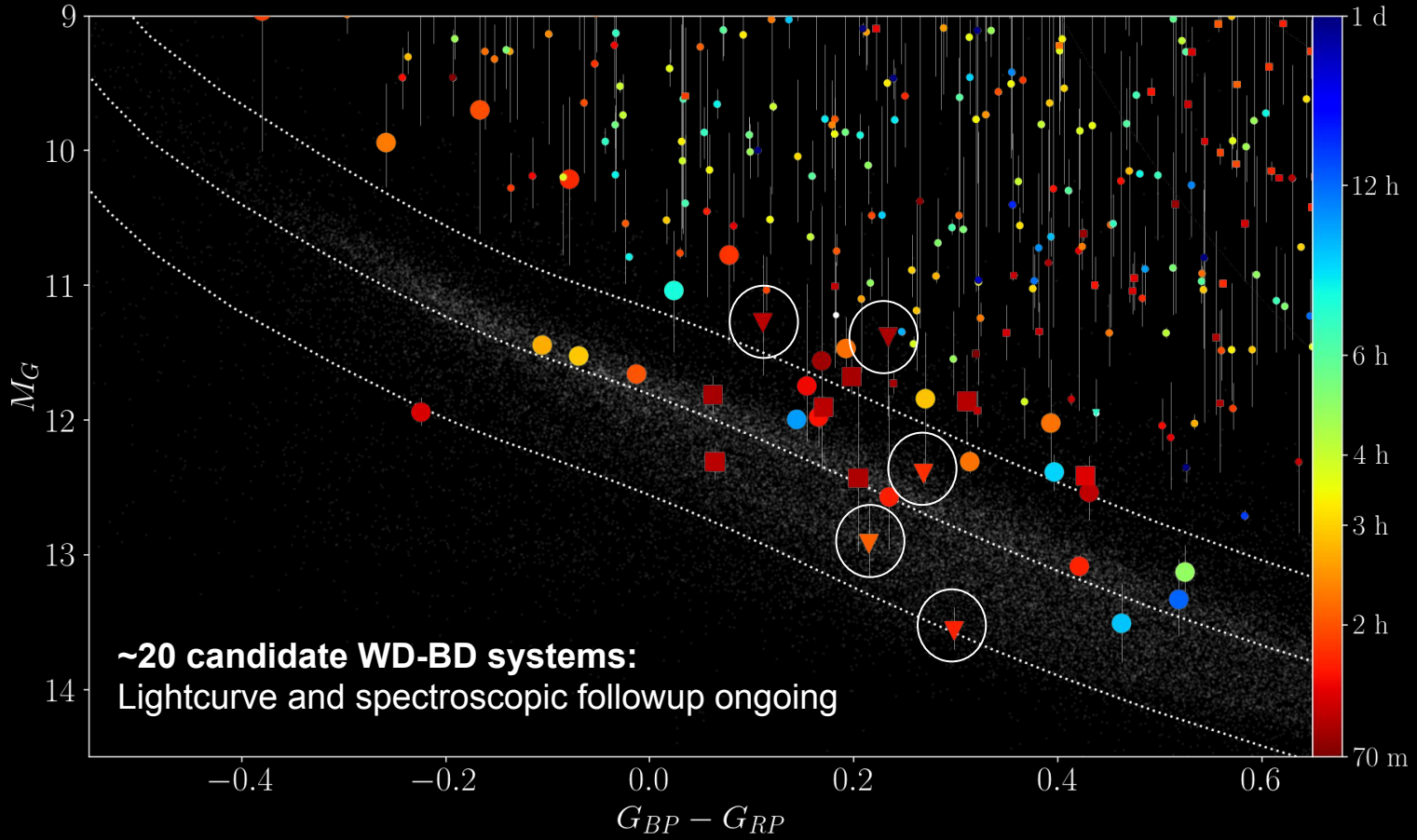


Typical white dwarf

White dwarfs with dark companions



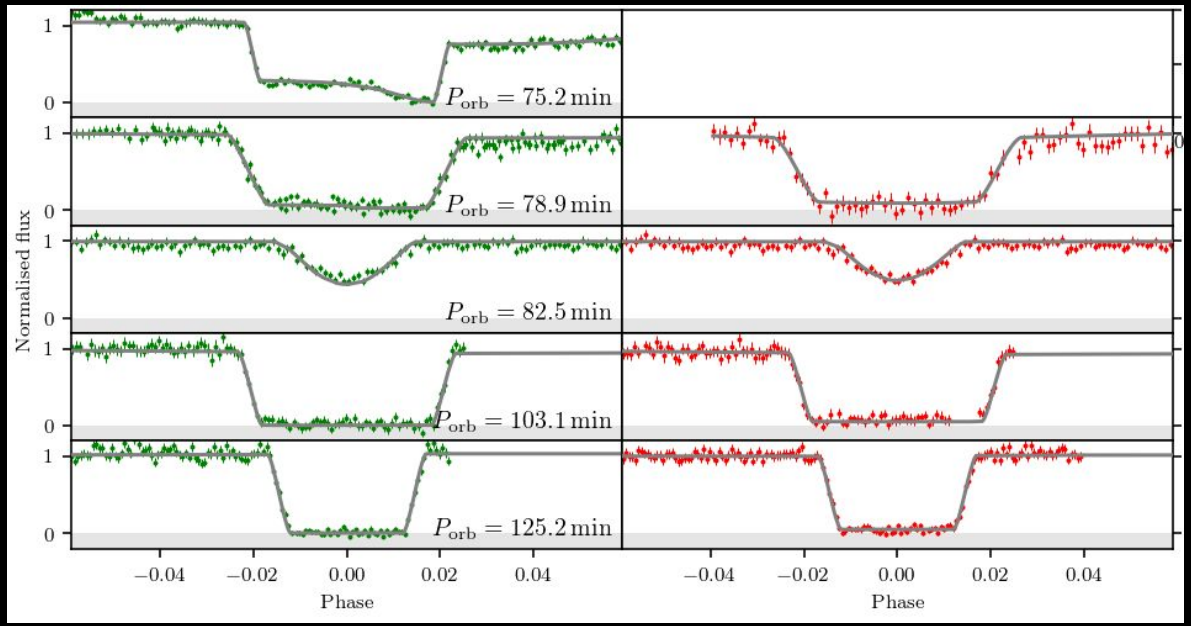
White dwarfs with dark companions

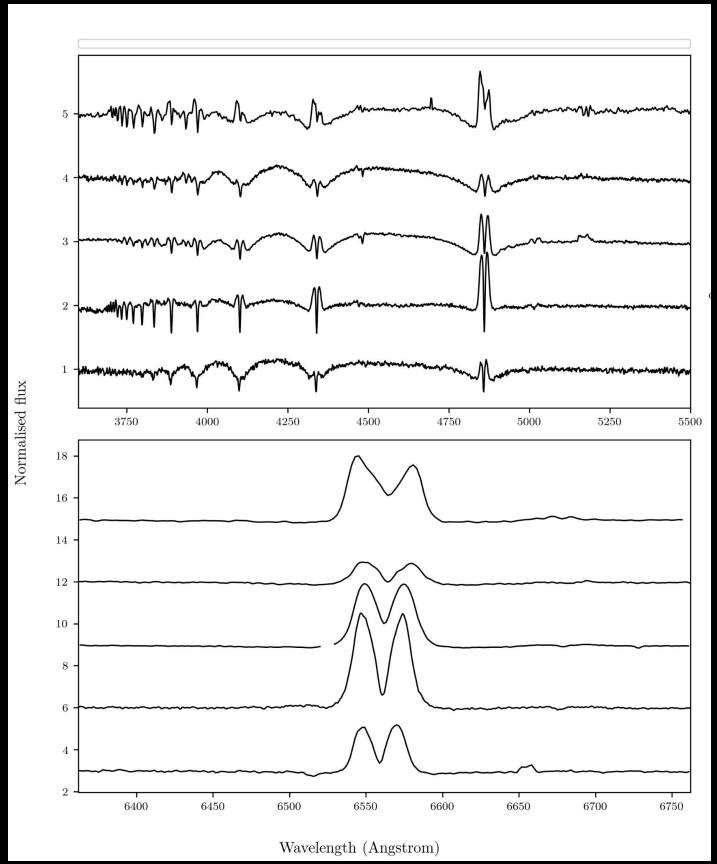


The missing period-bouncers?

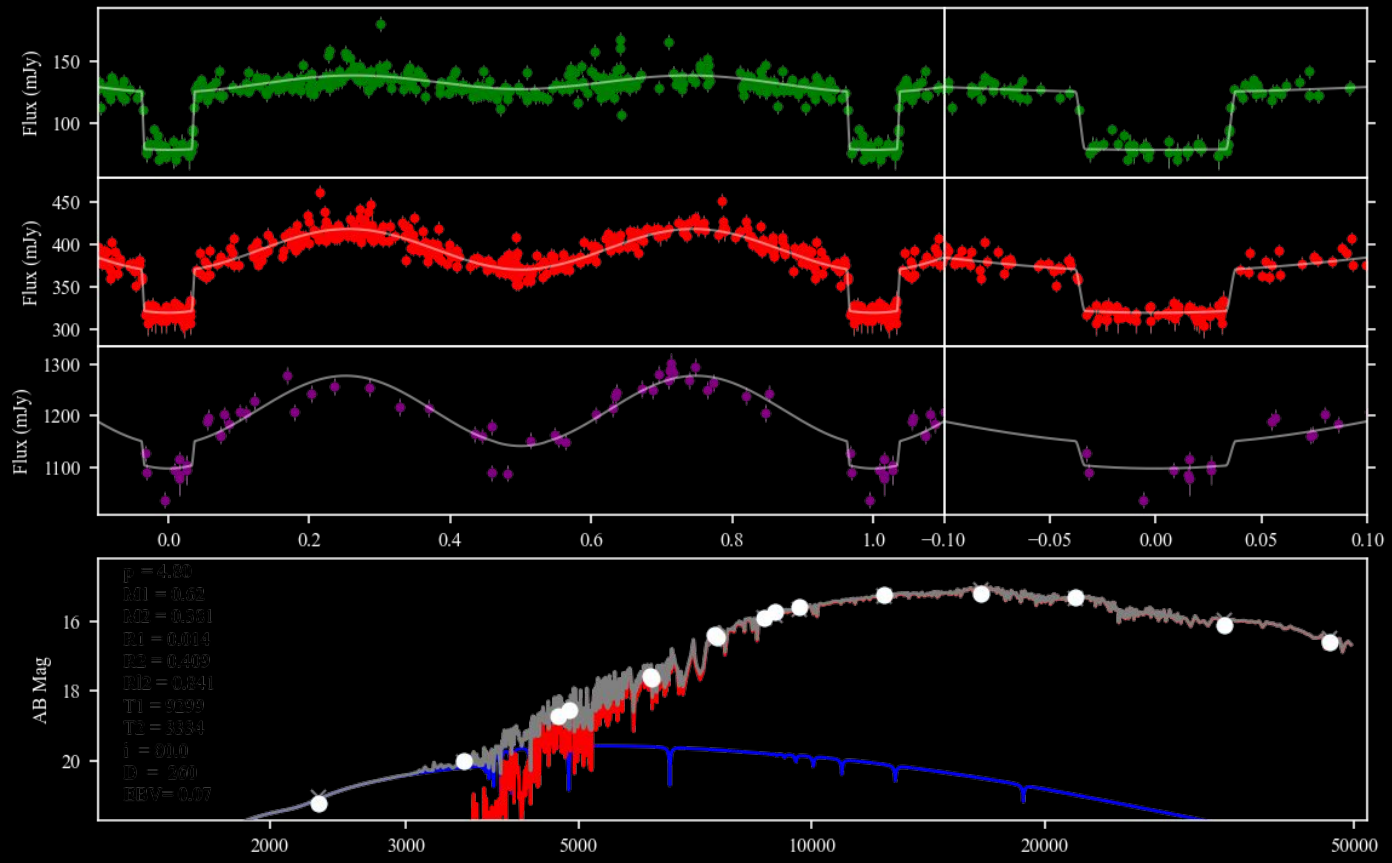
- Deep eclipses → secondary is cold
- Double peaked emission → Accretion disk
- No outbursts/flickering
- 10-20% of overall CV space-density

Period bouncer:
McAllister et al. 2017
Pala et al. 2018
Neustroev et al. 2018





Work-in-progress: fitting ZTF lightcurves & SED for all objects



Fit all data:

- $ZTF_{g,r,i}$
- Gaia plx
- SED
- E_{BV}

Parameter ‘guesstimate’:

- M_1, M_2
- R_1, R_2
- T_1, T_2
- Inclination
- Distance
- E_{BV}

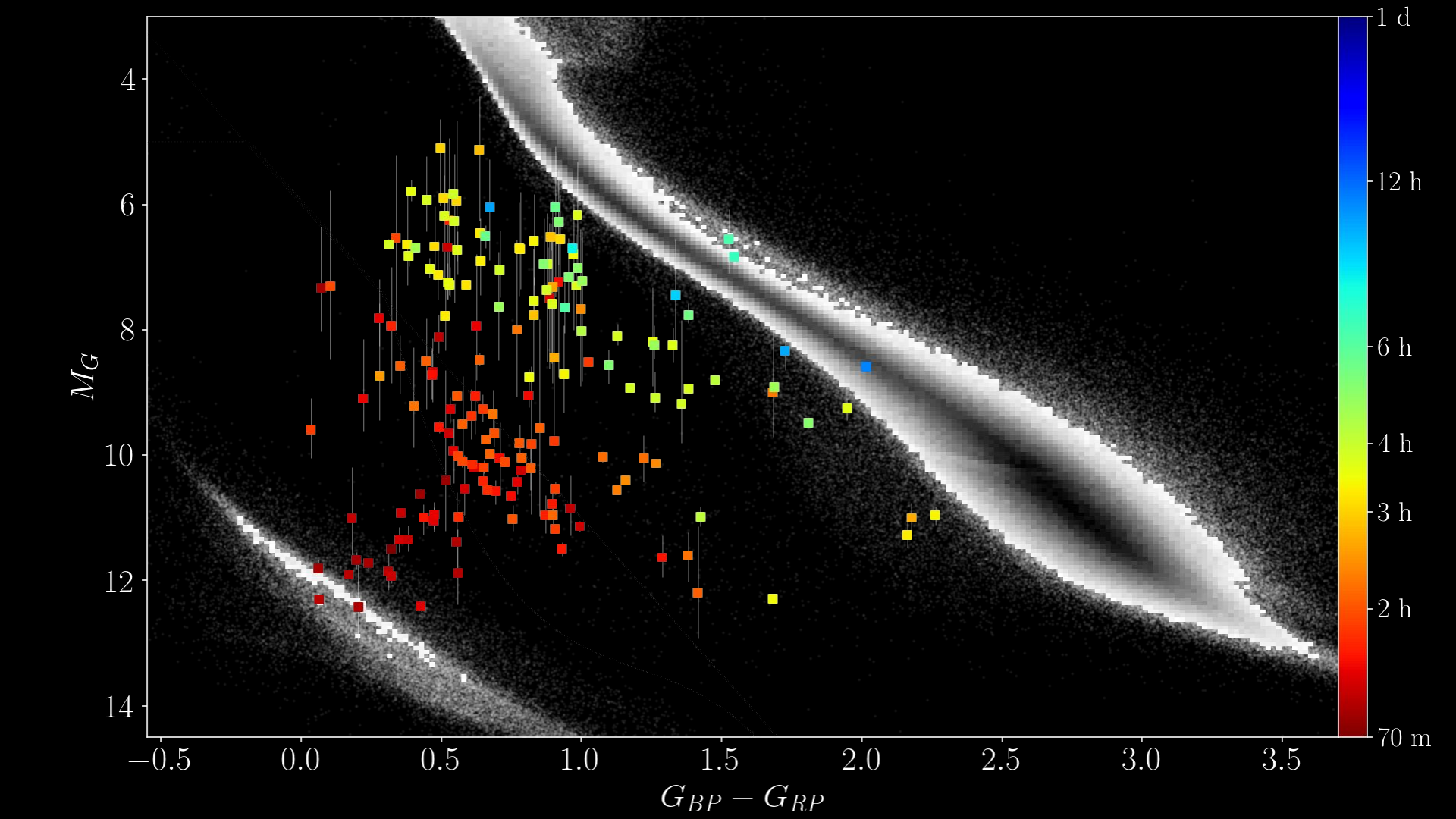
Summary

Eclipsing white dwarf population:

- Found 774 eclipsing WD-MS/BD eclipsing binaries
- No ‘period-spike’ in the period distribution
- Work-in-progress: model fitting on all data

White dwarfs with dark companions:

- 7 eclipsing AM CVn systems
- No short-period transiting Jupiter-mass objects (yet)
- Found: 5 eclipsing period bouncers


4
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$G_{BP} - G_{RP}$
1 d
12 h
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3 h
2 h
70 m

WD ZTFJ0038+20: ZTF white dwarf – giant planet candidate

deep eclipses ✓; no IR excess ✓; Period: 10 hrs ✓; Radial velocity ✗