Pan-Planets

A Search for Transiting Planets Around Cool stars

J. Koppenhoefer, Th. Henning and the Pan-PlanetS Team

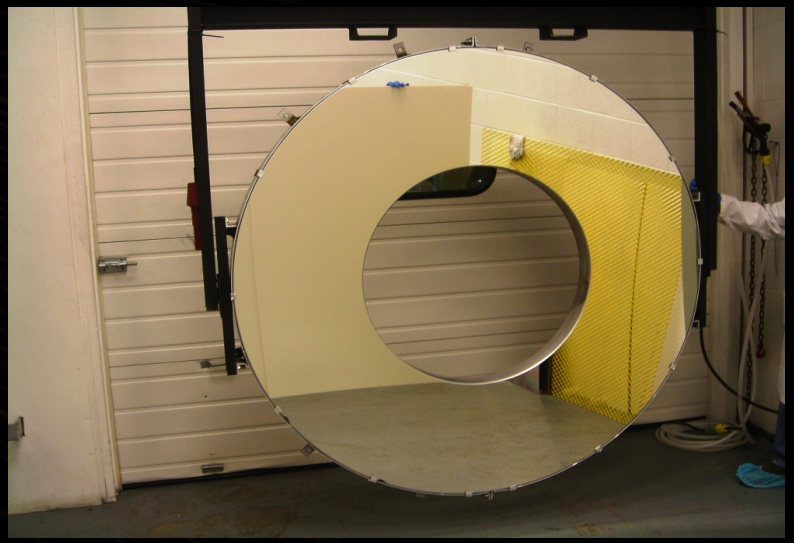
Pan-STARRS 1:

1.8m prototype telescope

operated on Haleakala/Hawaii

consortium of few hundred astronomers with a wide range of scientific goals

Site characteristics:
~35% bad weather
~15% downtime (prototype)
DIMM seeing: 0.8” FWHM



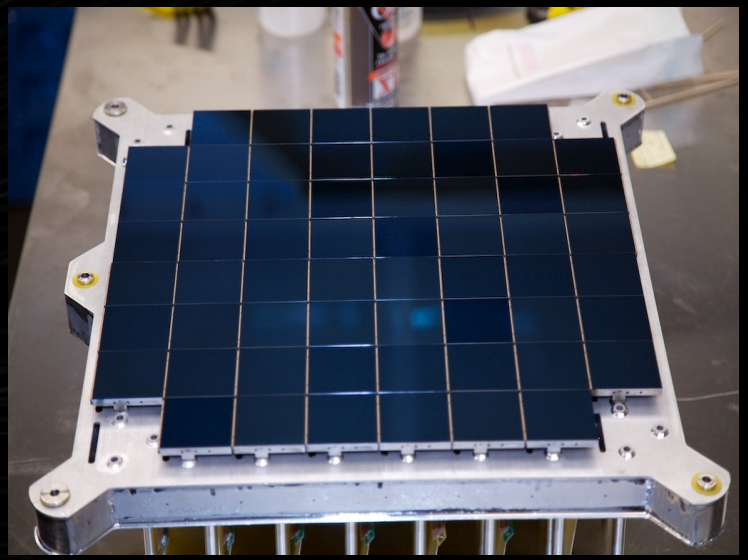
Pan-STARRS 1:

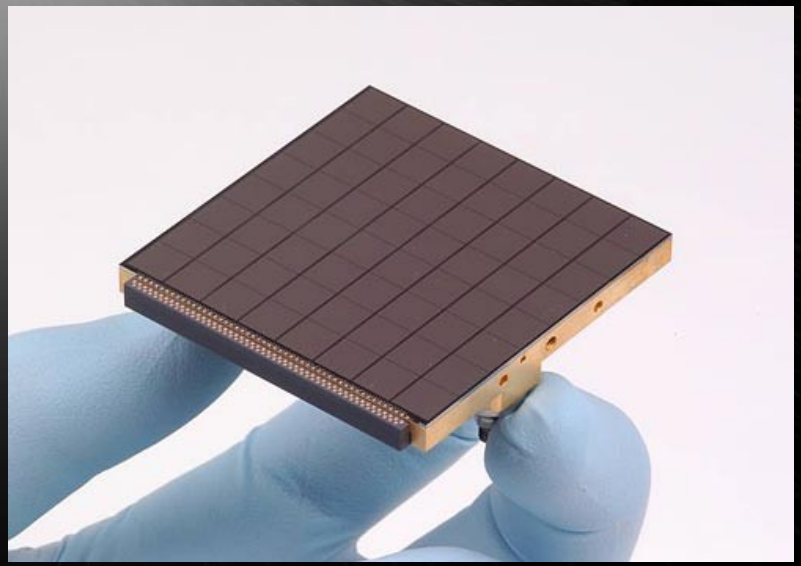
7 sq. deg FOV

60 devices, 8x8 cells each

=> 3840 CCDs

1.4 giga pixel (0.248”/pixel)





fast read-out (~12s)

~7e^- read-out noise

high QE at longer wavelengths

image quality: ~1.1” FWHM

Pan-Planets:

Survey duration: May 2010 – October 2012

4% of total PS1 observing time: 180 hours

13.5 <= i' <= 18 mag

~1h per night

7 slightly overlapping fields (~40 sq. deg.)

30s exposures => cycle rate ~5min

~16.000 exposures => 80 TByte raw data

~4 mio light curves with a few thousand data points

(Koppenhoefer et al. 2009)

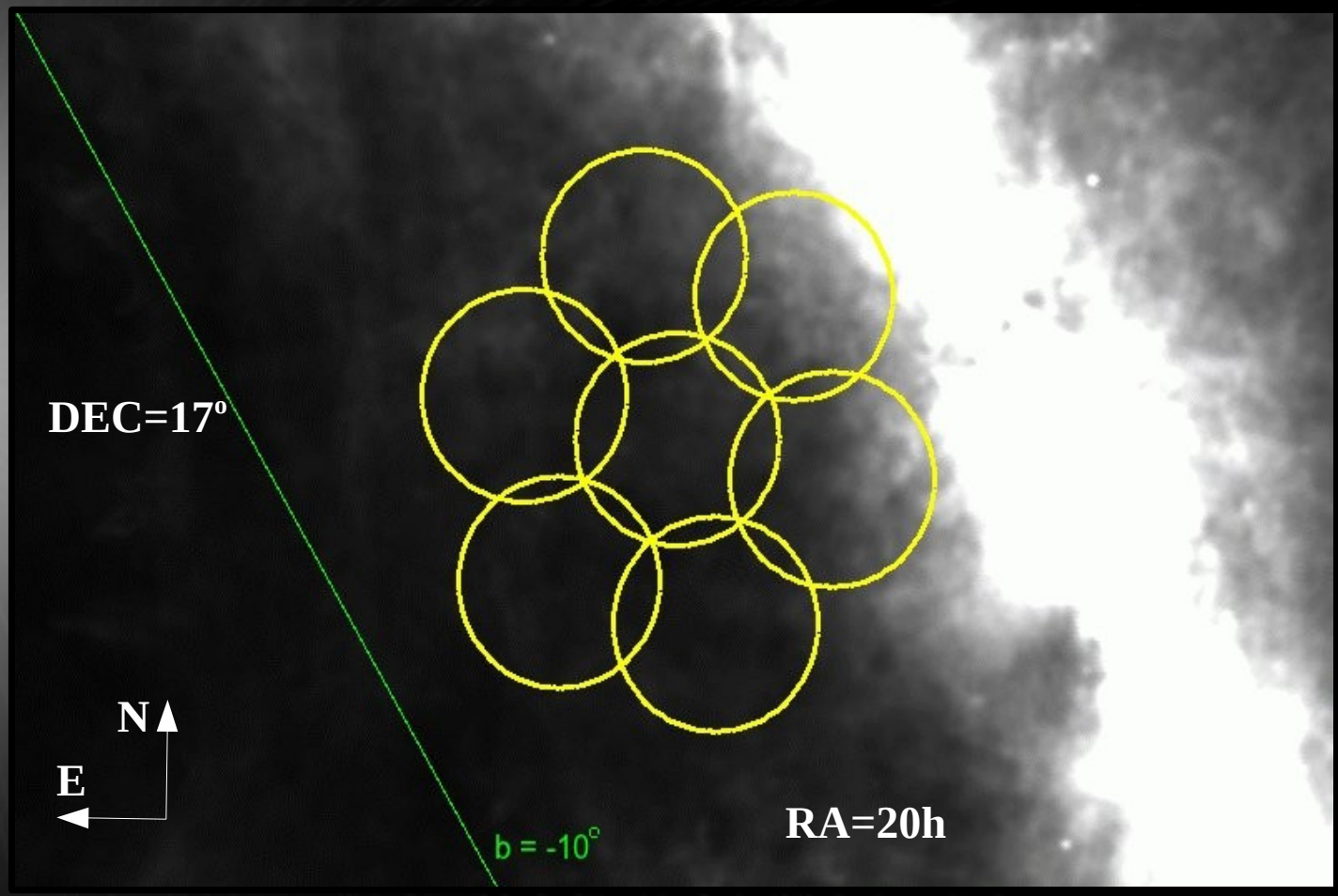
Follow-up strategy:

Photometric: Calar Alto 1.23m, Wendelstein 2m

Spectroscopic: HET, Keck

Pan-Planets:

Survey duration: May 2010 – October 2012



Photometric: Calar Alto 1.23m, Wendelstein 2m
Spectroscopic: HET, Keck

Pan-Planets:

Survey duration: May 2010 – October 2012

4% of total PS1 observing time: ~170 hours

13.5 <= i' <= 18

~1h per night

7 slightly overlapping fields (~40 sq. deg.)

30s exposures => cycle rate ~5min

~16.000 exposures => 80 Tbyte raw data

~4 mio light curves with a few thousand data points

(Koppenhoefer et al. 2009)

Follow-up strategy:

Photometric: Calar Alto 1.23m, Wendelstein 2m

Spectroscopic: HET, Keck

Pan-Planets:

Why do another OGLE-type survey?

- faint objects are difficult to follow-up

- Kepler is dominating the field

Interesting niches exist:

- Jupiter-size planets around M-dwarfs

- planets around White dwarfs

M-Dwarfs:

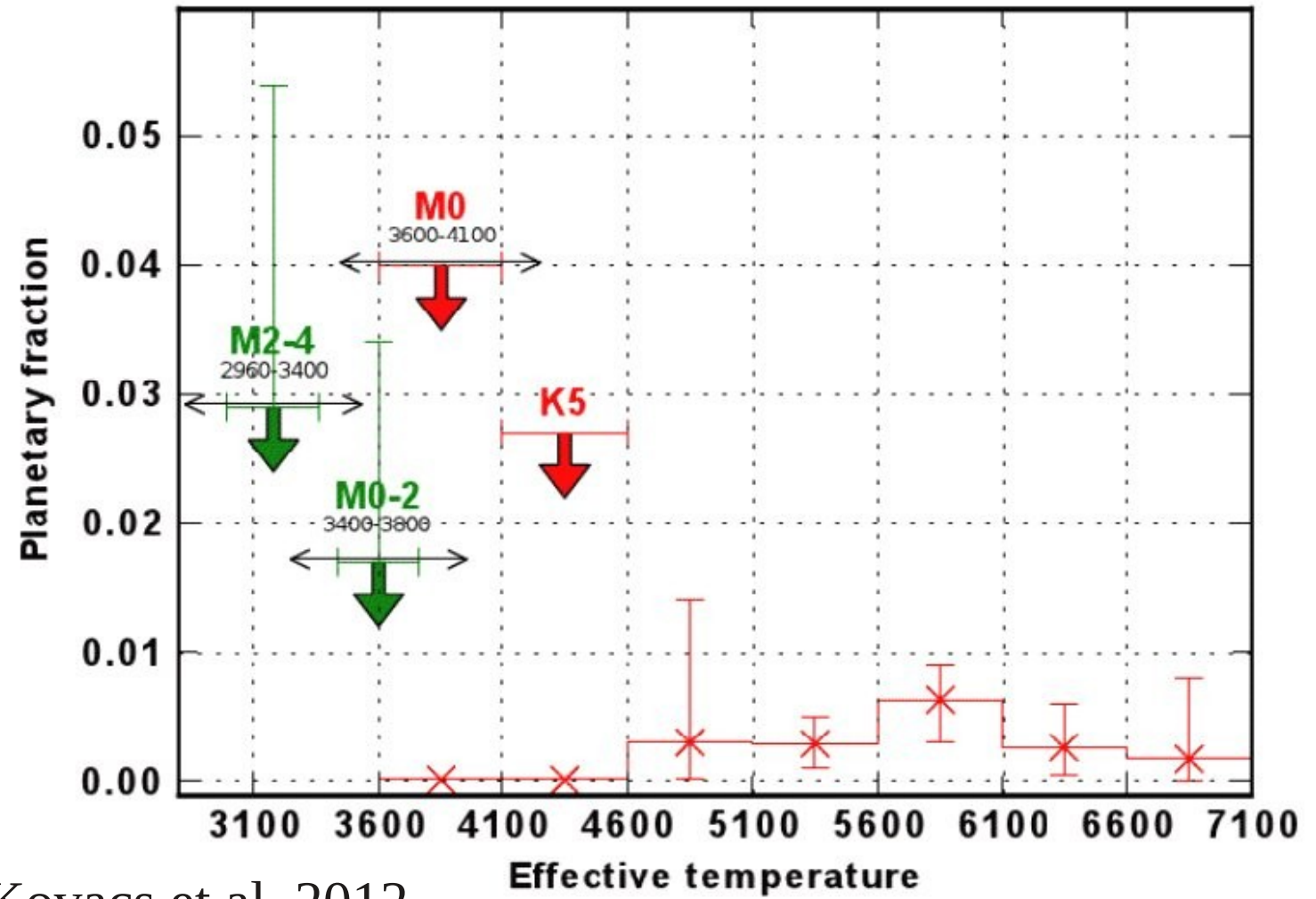
- short period Jupiter-sized planets are expected to be less common around M-dwarfs
- fraction poorly known (RV, RoPACS, Kepler)

  => with Pan-Planets we increase the sample size by an order of magnitude

- theorists predict a large population of low-mass Planets (Ida&Lin 2005), Kennedy&Kenyon 2008)
- smaller stellar radius → deeper transits

  => Pan-Planets is sensitive to Neptune-sized planets

M-Dwarfs (→ RoPACS):



Kovacs et al. 2012

M-Dwarfs:

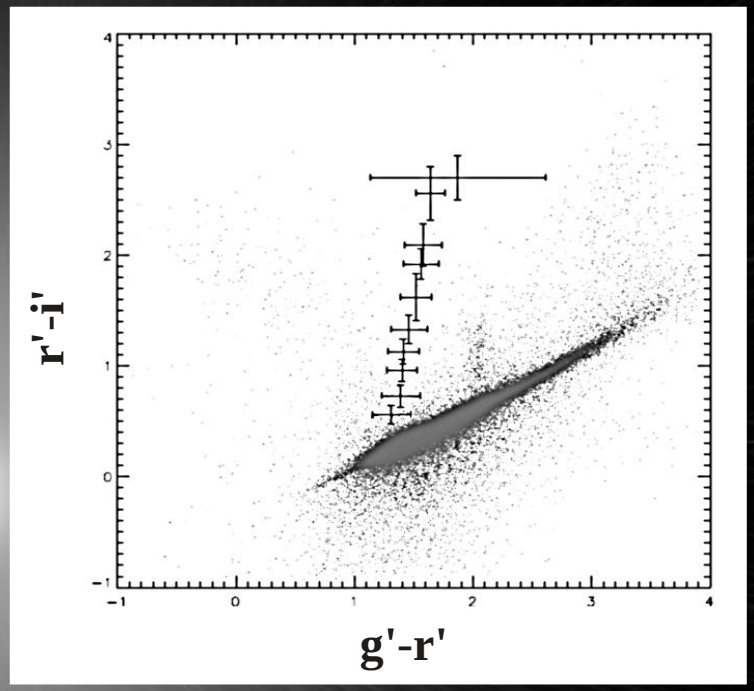
- short period Jupiter-sized planets are expected to be less common around M-dwarfs
- only upper limits known (RV, RoPACS, Kepler)

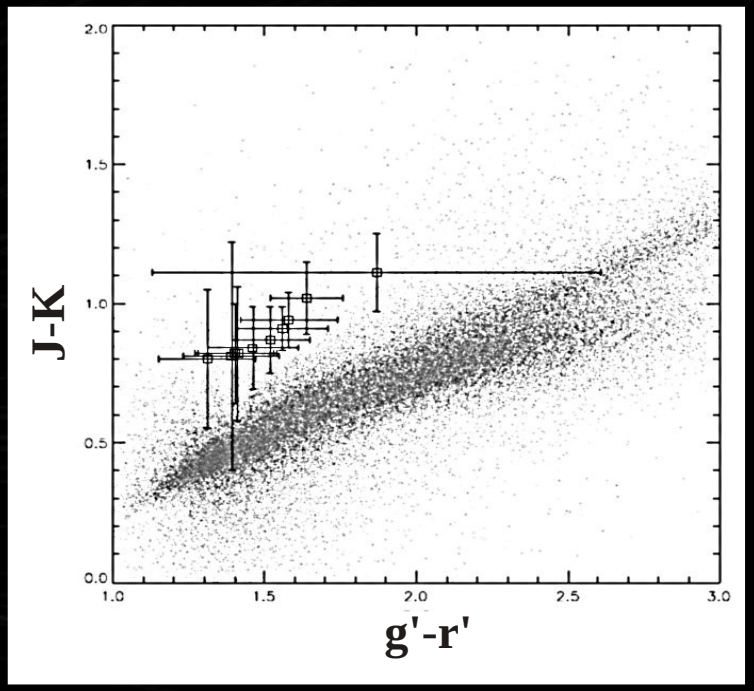
  => with Pan-Planets we increase the sample size by an order of magnitude

- theorists predict a large population of low-mass Planets (Ida&Lin 2005, Kennedy&Kenyon 2008)
- smaller stellar radius → deeper transits

  => Pan-Planets is sensitive to Neptune-sized planets

M-Dwarf Selection:





- based on multi-color information (grizyJHK)
- combined Pan-STARRS with 2MASS NIR photometry
- M-dwarf colors from West et al. 2011
- >50.000 late M-dwarfs with i'<18 mag in 40 sq.deg.
- include proper motion in the future

Planets around White Dwarfs:

- WDs have about Earth-size

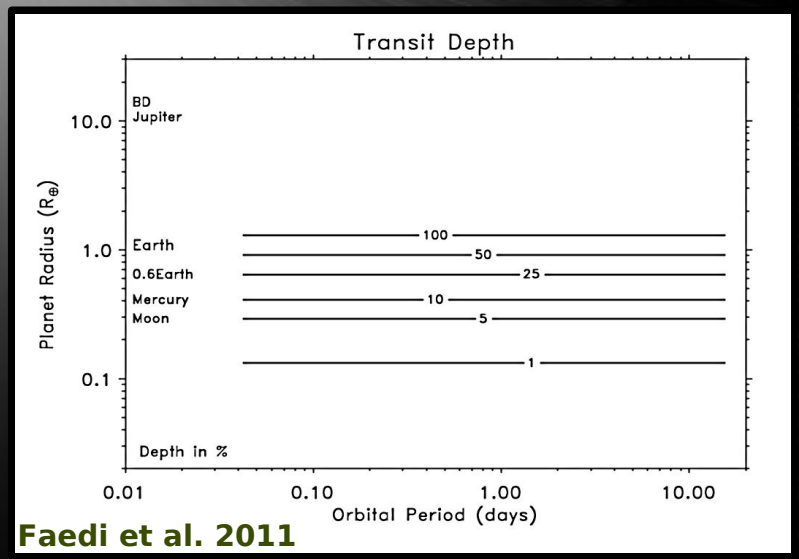
  → deep / total eclipses

- short transits (few minutes)

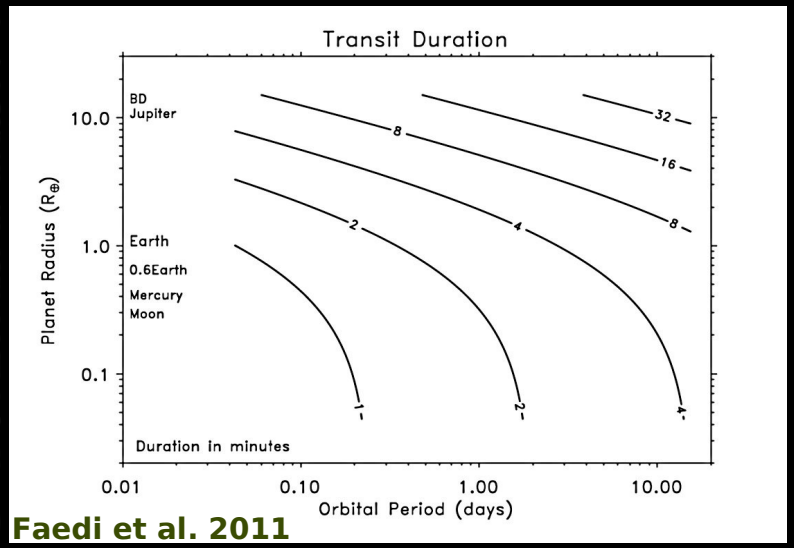
- low transit probability

  → large sample size required

~5000 White dwarfs i'<=18 mag in 40 sq. deg.



Faedi et al. 2011



Faedi et al. 2011

Data Processing & Analysis:

Reduced images provided by Pan-STARRS pipeline

↓

Munich Difference Imaging Analysis Pipeline (MDIA)
(Koppenhoefer et al. 2011)

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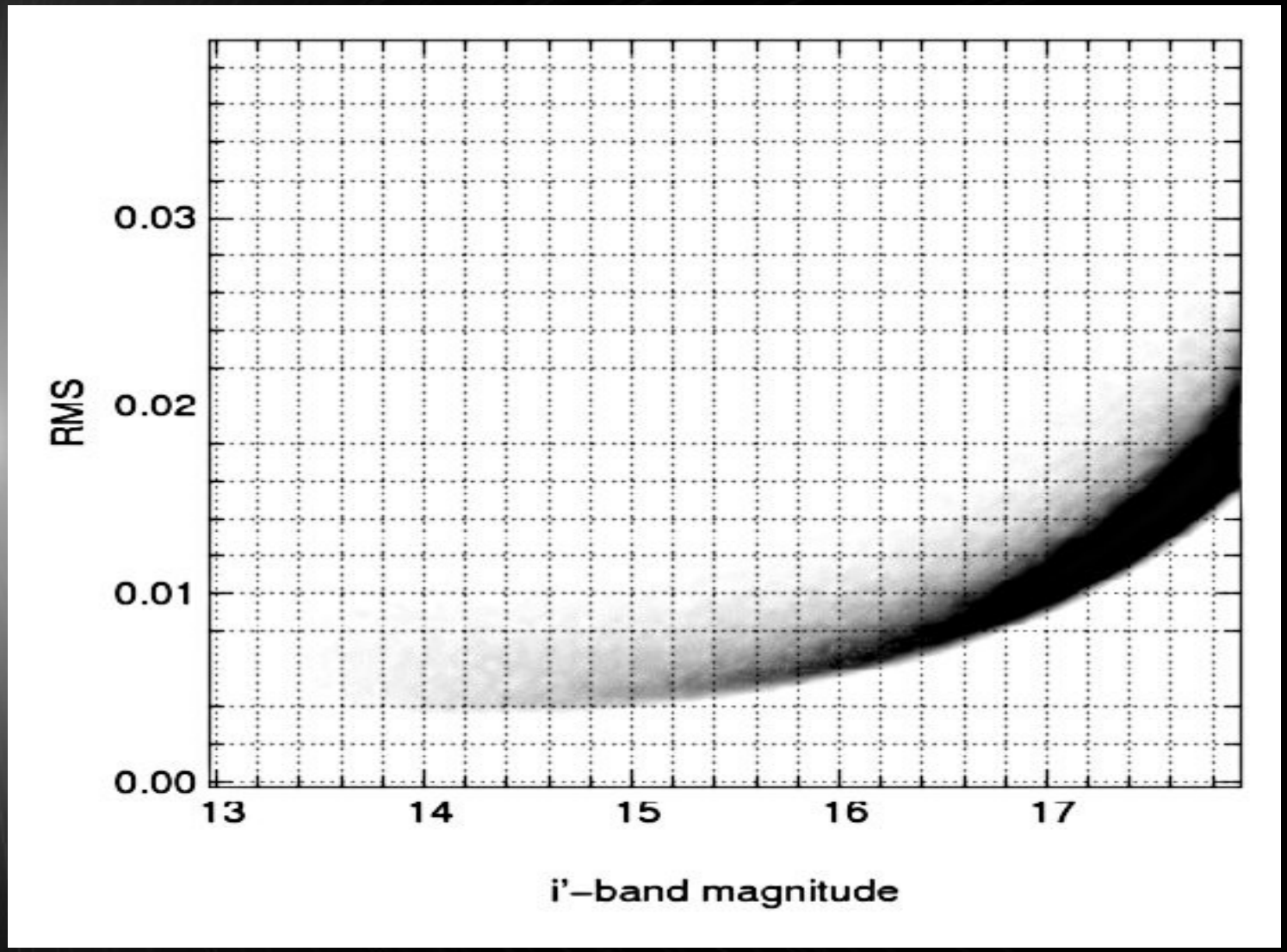
Light Curve Analysis:

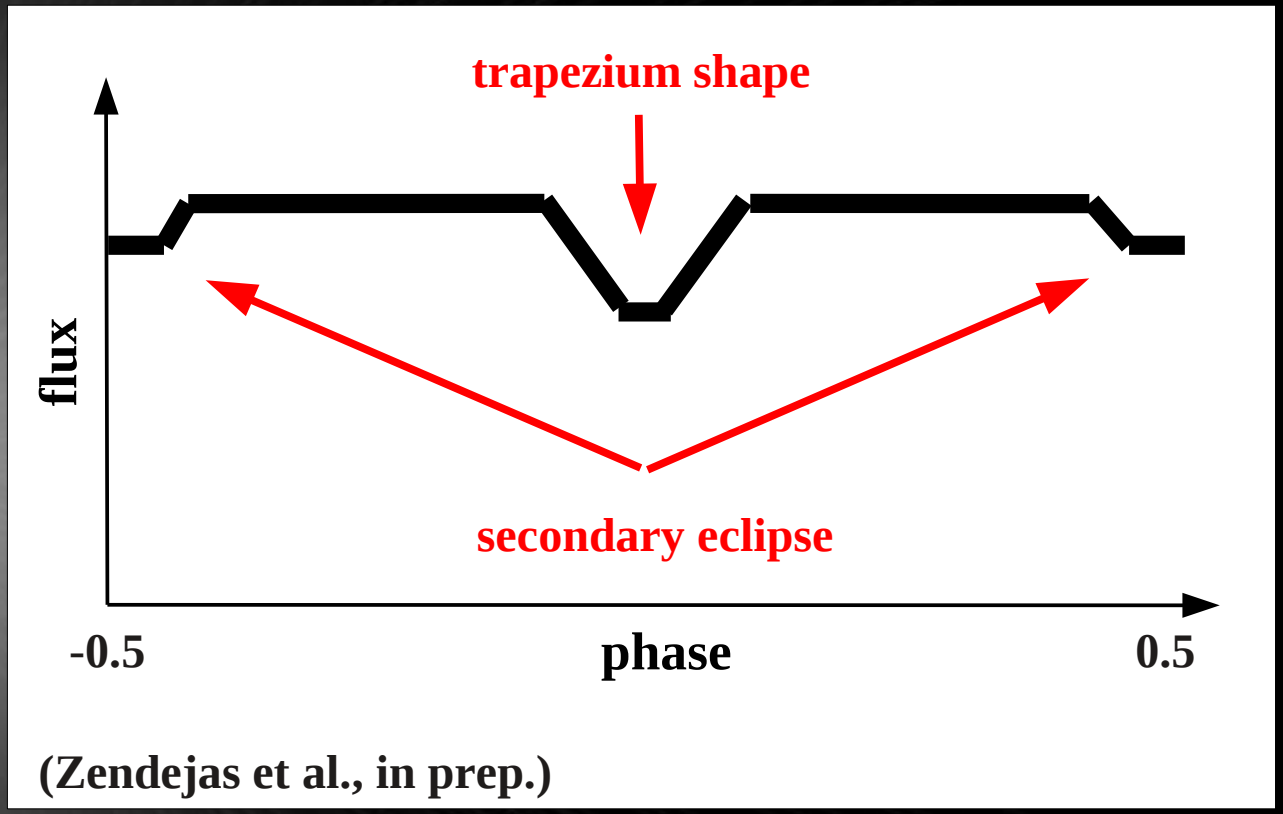
removal of systematic effects, detection of periodic signals and candidate selection

Photometric Precision:



~ 4-5 mmag precision at the bright end limited by detector systematics

Detection Algorithm:



(Zendejas et al., in prep.)

- efficient to detect eclipsing binaries
- better estimate for eclipse depth
- useful to exclude binaries in the planet candidate selection process

Status & First Results:

- data processing ongoing

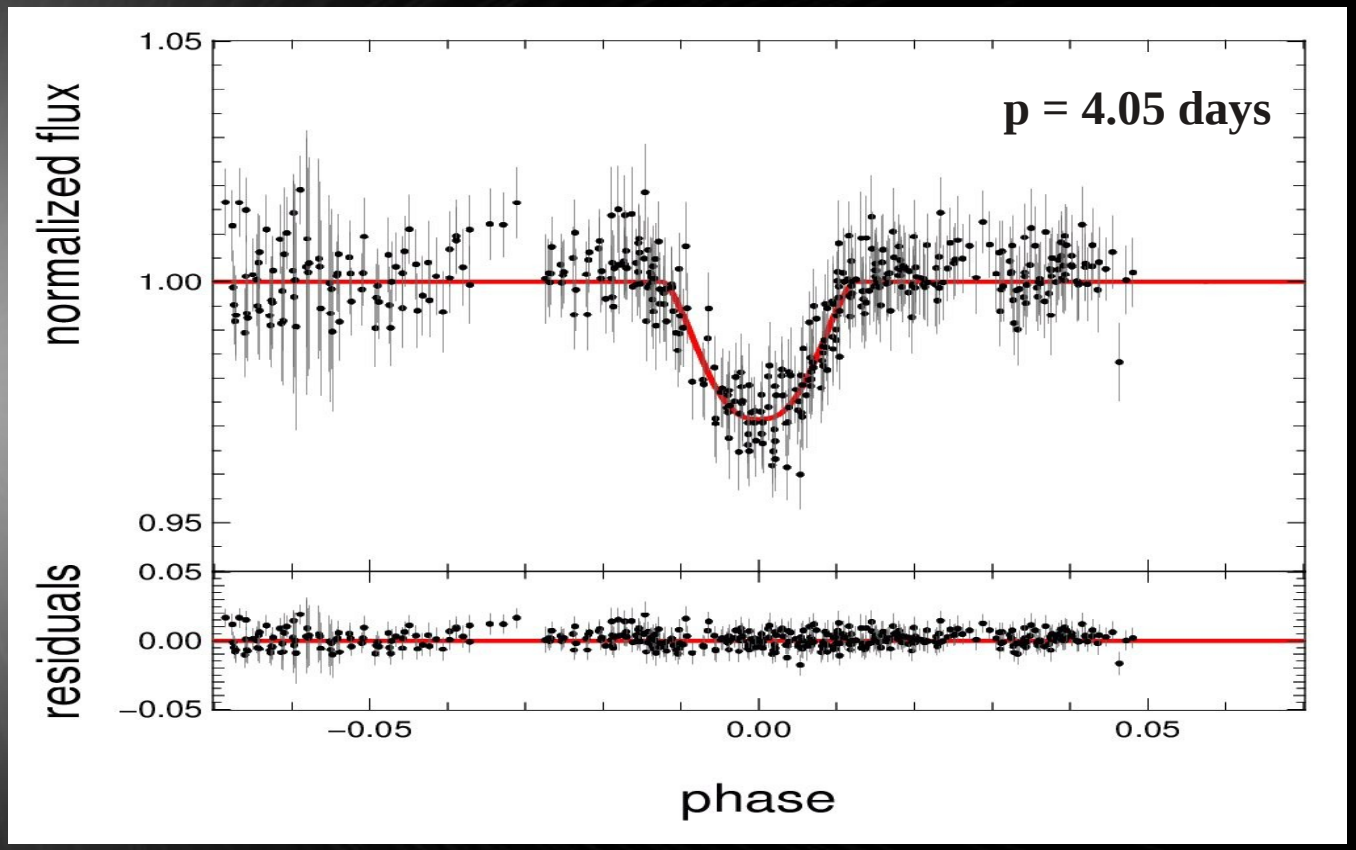
- 1 1/2 fields completed (only 2010+2011 data)

- mainly limited by computation time

- 6 M-dwarf planet candidates are being followed-up @ Calar Alto + HET

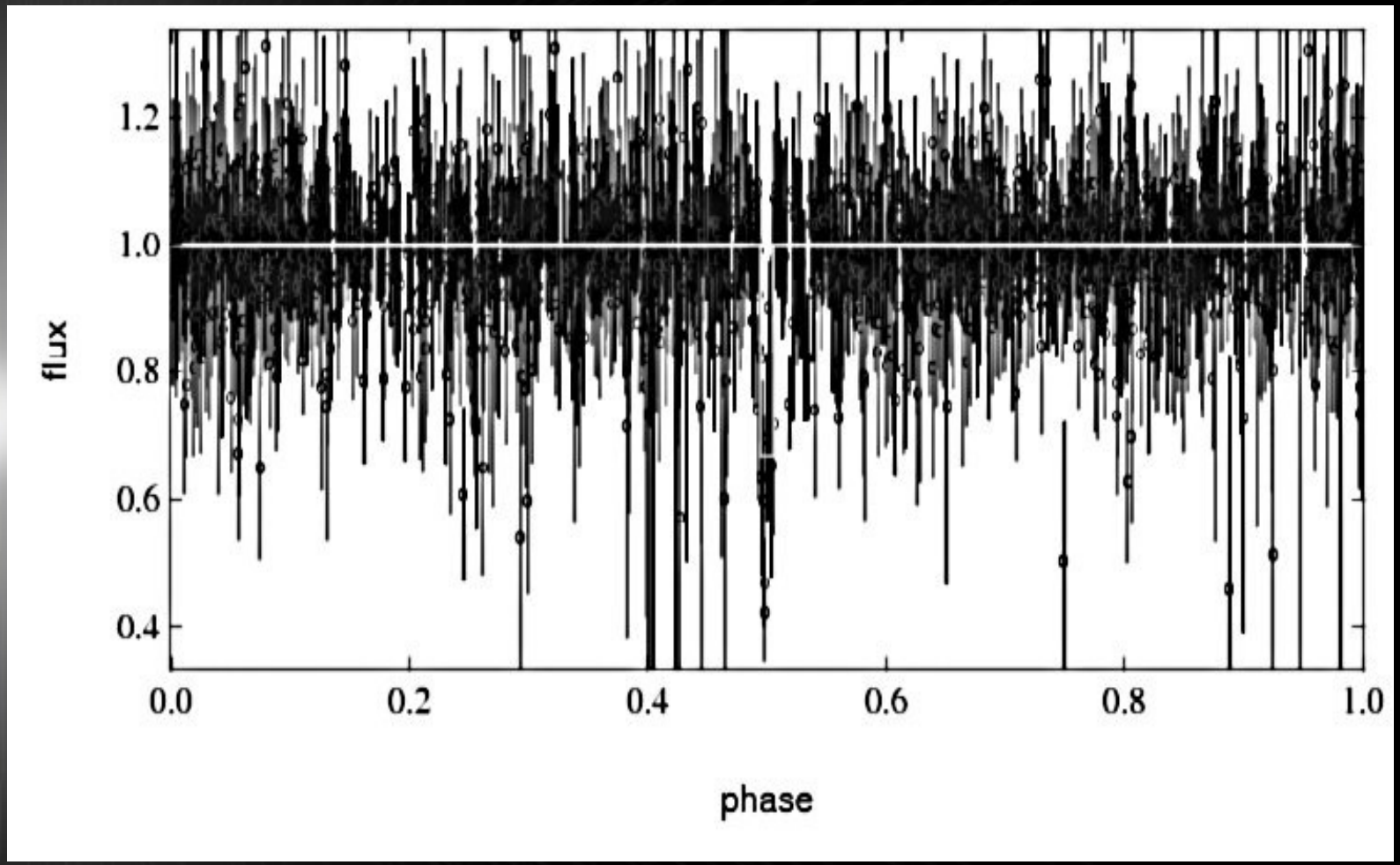
- few candidate White dwarf companions

Status & First Results:



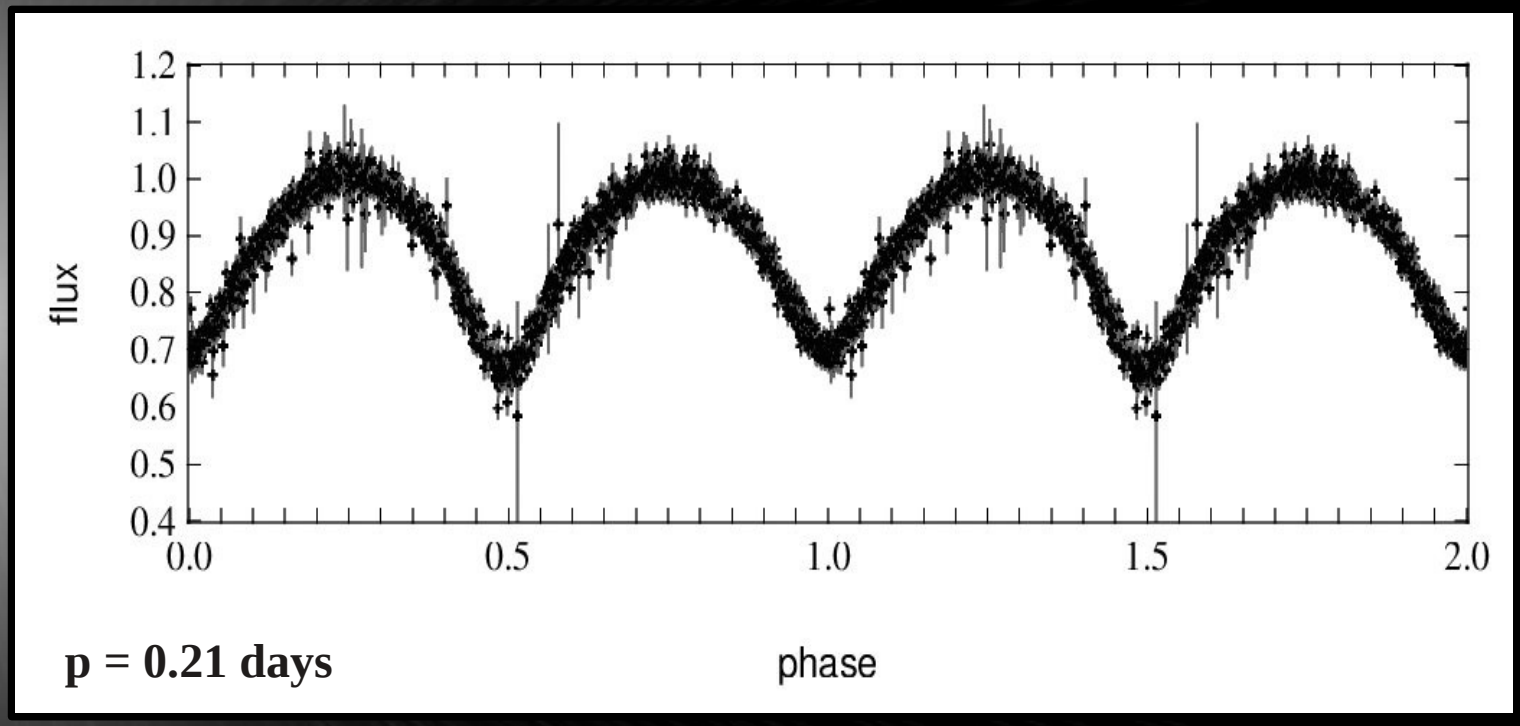
~1.7 R_{Jup} candidate orbiting a 15th mag G-dwarf

Status & First Results:



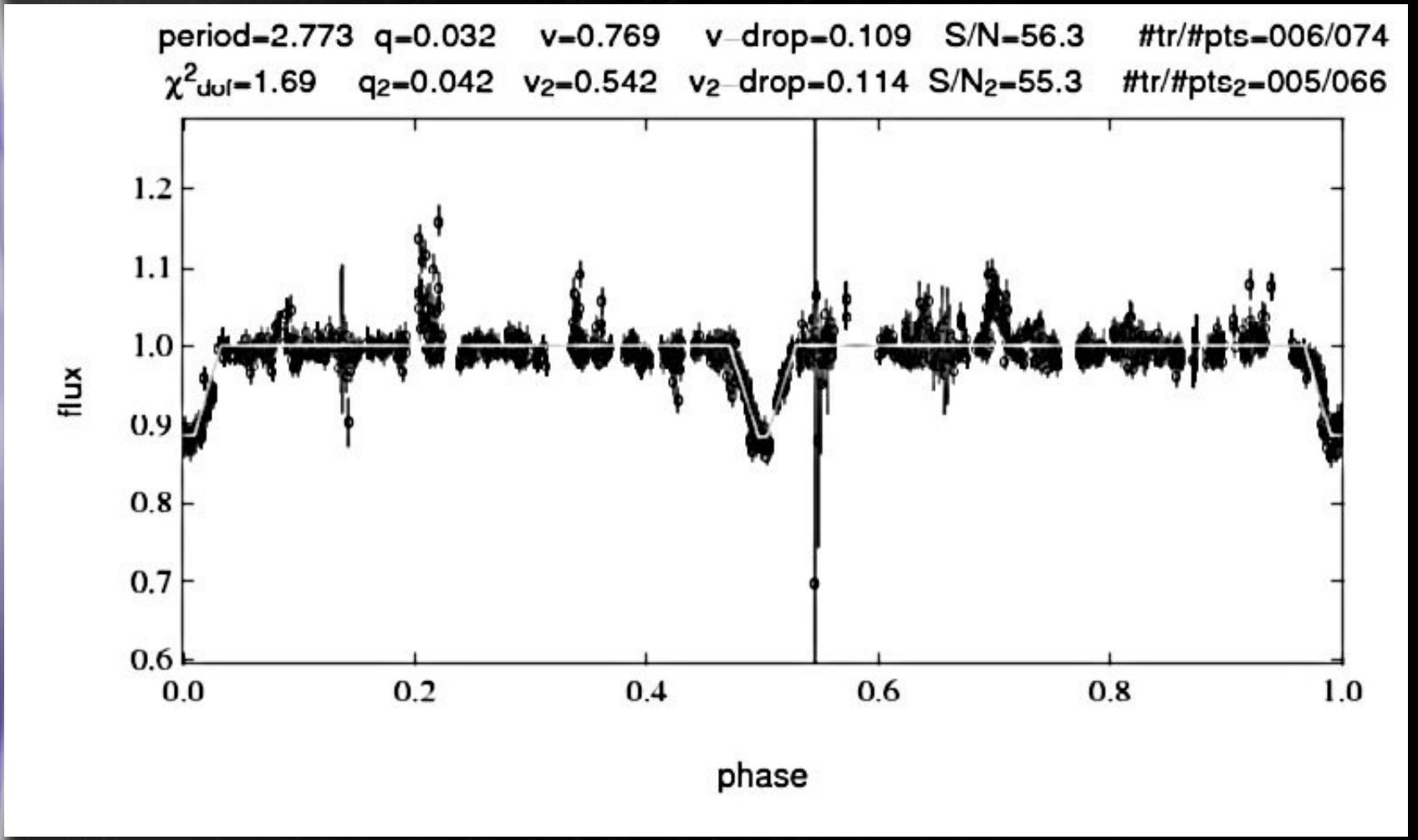
White dwarf planet candidate, p ~ 0.3d, transit ~ 4min

Status & First Results:



ultra-short period binary

Status & First Results:



M-dwarf/M-dwarf binary candidate

Summary:

Pan-Planets is an large aperture wide field survey for transiting extra-solar planets

the large sample size will allow us to derive the frequency of Jupiter-sized planets around M-dwarfs

the survey is sensitive to planets down to Neptune-size (around M-dwarfs) and Earth-size (around White dwarfs)

additional science projects include studies of eclipsing binaries, flare stars, M-dwarf variability, etc.

Thank you,
for your attention!