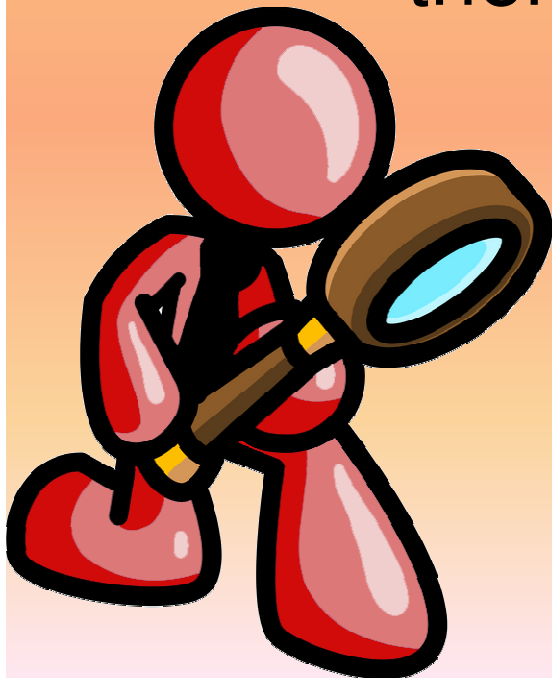


# An independent planet search in the *Kepler* data

Or:

“There is nothing new under the Sun” – but then,  
there are so many other suns...

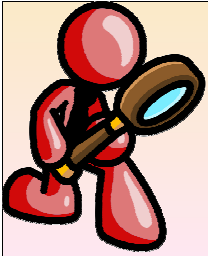


Aviv Ofir

and:

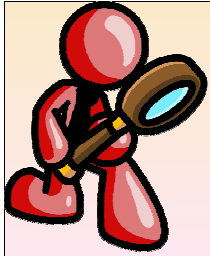
Stefan Dreizler, Guillem Anglada  
Göttingen University





# Outlook

- Why independent searches should be done
- Our search: the SARS pipeline
- Validation example: KOI 1843
- Conclusions

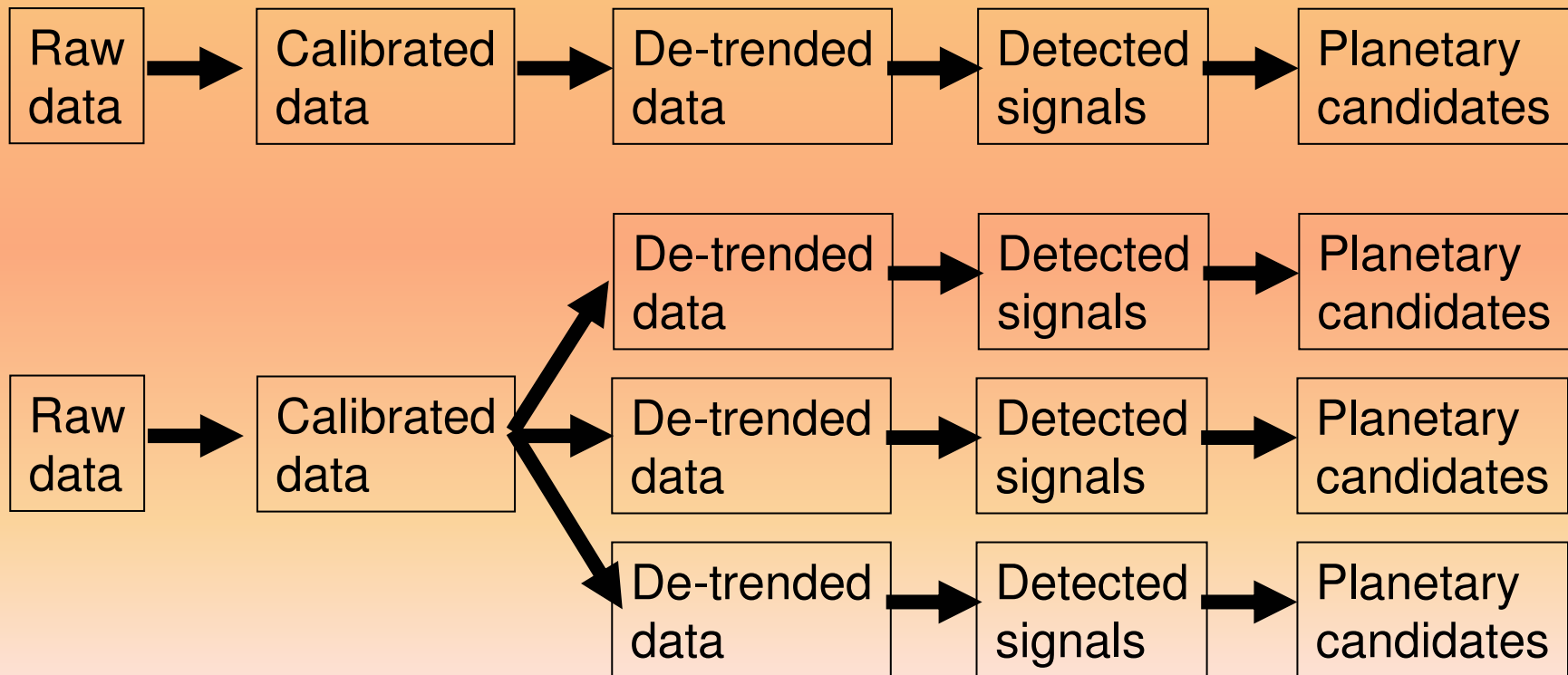


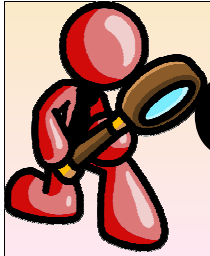
# Why independent searches should be done



Flow of data:

- Kepler:

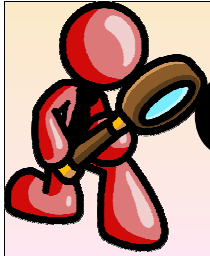




# Our search: the SARS pipeline Description

- Main points:
  - Segmented smooth
  - SARS detrending
  - Signal search using BLS
  - New signal tests (e.g. “half-half”, long-term filter)
  - Multi-planet fit:  $P^2 \propto a^3$ .
- SARS:
  - **S**imultaneous **A**dditive and **R**elative **S**ysrem. Does what it names says.  
Born in CoRoT, applied to Kepler unchanged, significant optimization for Kepler possible.



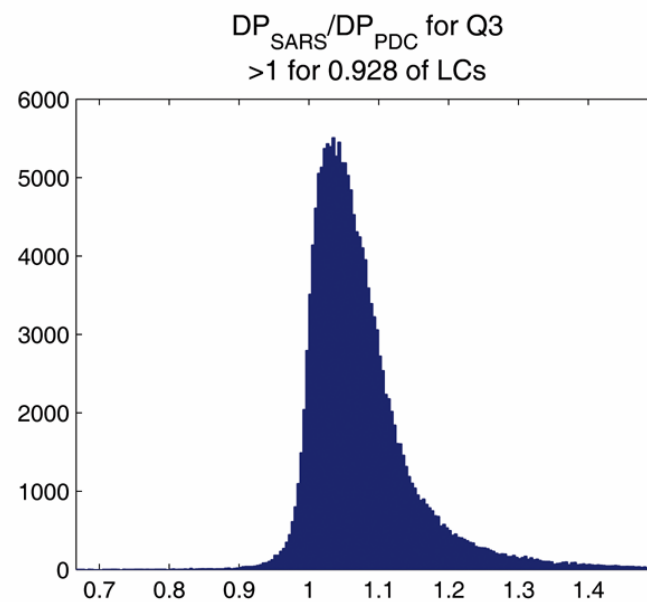
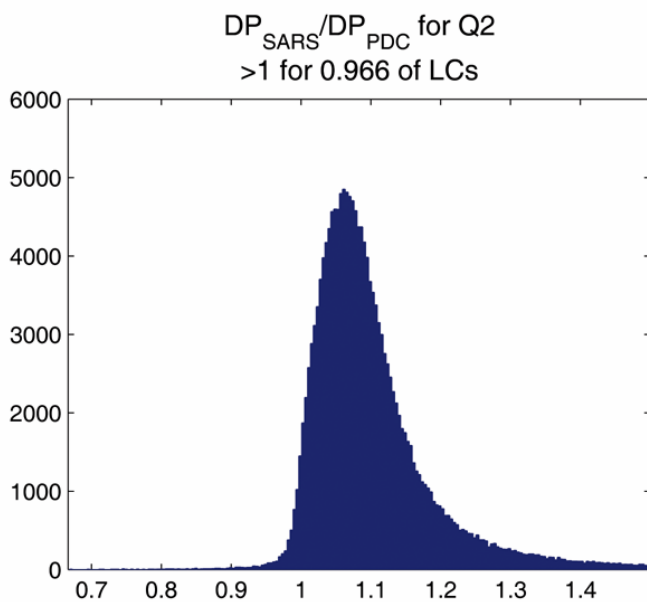
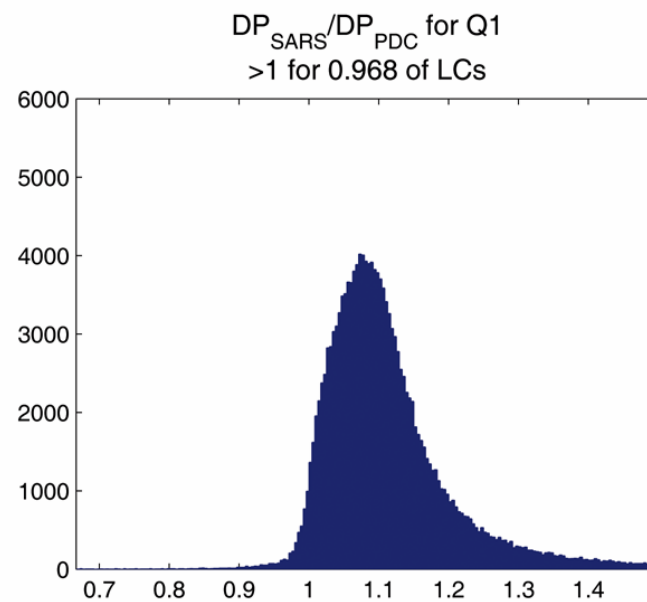
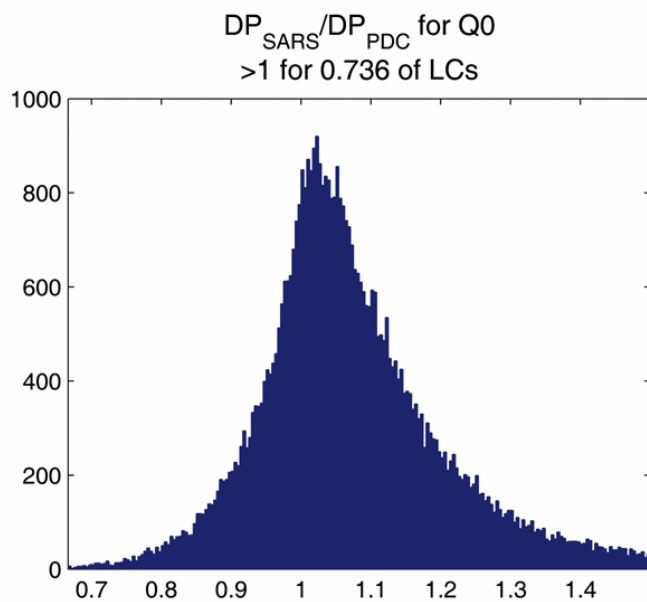


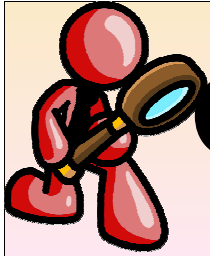
# Our search: the SARS pipeline

## Results



- SARS-processed all Q0-Q6 data
  - Cleaning statistics: Detection Power= $\sqrt{N}/\sigma$

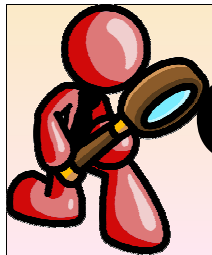




# Our search: the SARS pipeline

## Results

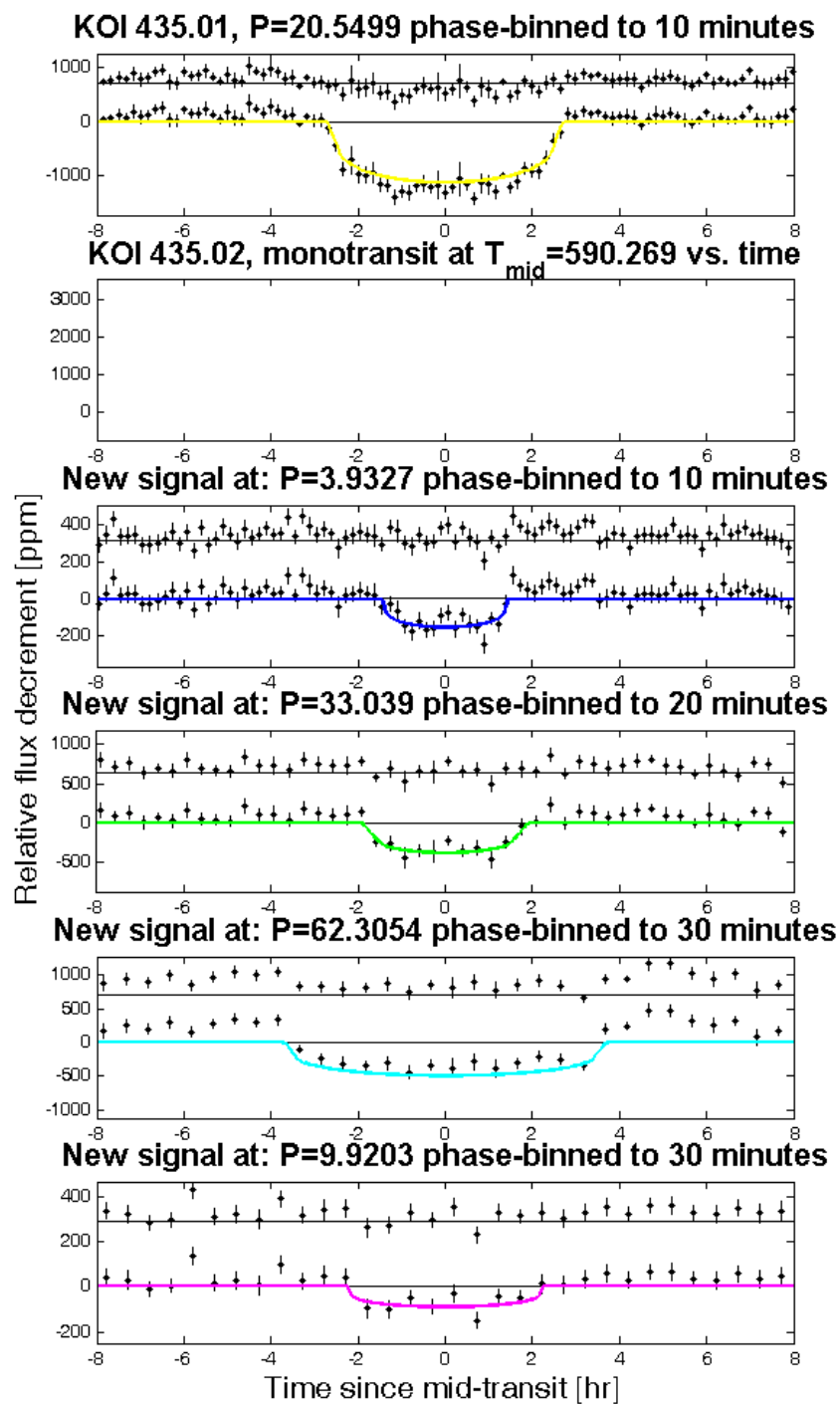
- SARS-processed all Q0-Q6 data
  - Cleaning statistics:  $\text{Detection Power} = \sqrt{N}/\sigma$
- BLS-searched KOIs ONLY (<1% of the data):
  - 84 new signals detected in 64 systems. Notable:
    - All, by definition, in multiple systems.
    - KOI 435: only the second 6-candidate systems

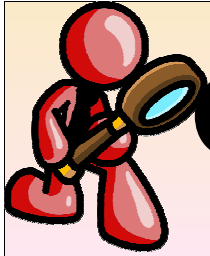


# Our search: the Results

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Planet Formation and Ev



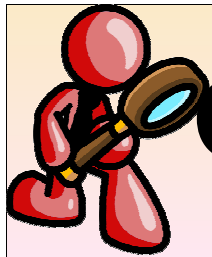


# Our search: the SARS pipeline

## Results



- SARS-processed all Q0-Q6 data
  - Cleaning statistics:  $\text{Detection Power} = \sqrt{N}/\sigma$
- BLS-searched KOIs ONLY (<1% of the data):
  - 84 new signals detected in 64 systems. Notable:
    - All, by definition, in multiple systems.
    - KOI 435: only the second 6-candidate systems
    - KOI 277: 6:7 period commensurability, anti-correlated TTVs, (=Kepler-36)
    - KOIs 719 and 1574: small candidates in the HZ
    - KOI 1843
    - Reject 11 KOIs as EBs using photometry alone



# Our search: the SARS pipeline

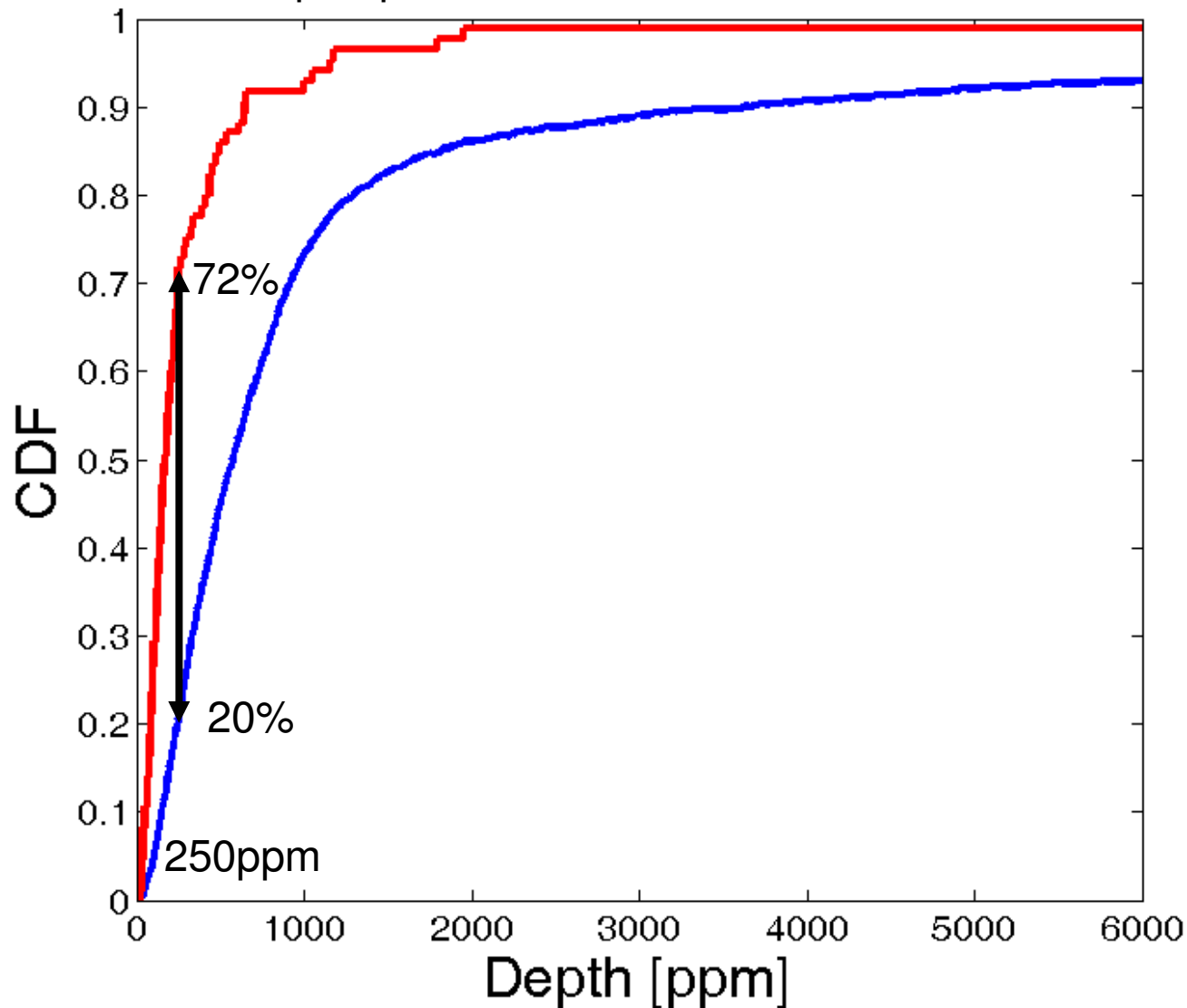


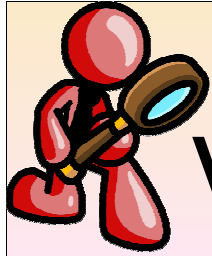
## Results

- SARS-p
  - Cleanin
- BLS-search
  - 84 new
    - All, by
    - KOI 4
    - 6-can
    - KOI 2
    - (=Kep
    - KOIs
    - KOI 1
    - Rejec

Depth of

Blue: Kepler planet candidates. Red: new candidates



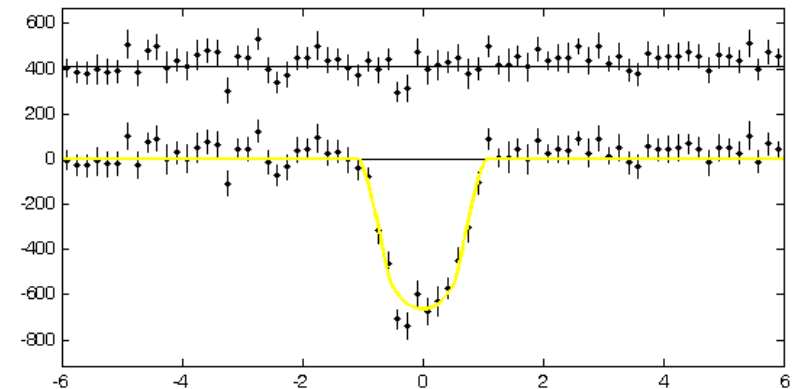


# Validation example: KOI 1843

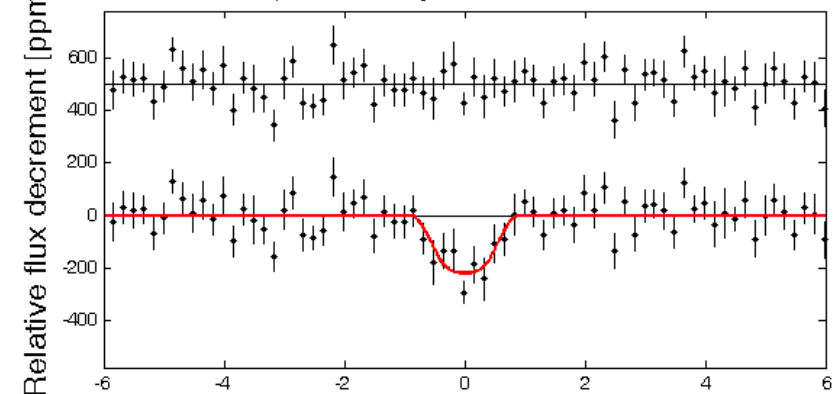


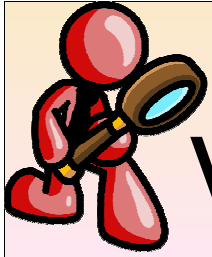
- Batalha *et al.* (2012):
- $R_* = 0.52 R_{\text{Sun}}$  (KIC), so:
- $R_{1843.01} = 1.35 R_{\text{Earth}}$
- $R_{1843.02} = 0.84 R_{\text{Earth}}$

KOI 1843.01,  $P=4.1945$  phase-binned to 10 minutes



KOI 1843.02,  $P=6.356$  phase-binned to 10 minutes



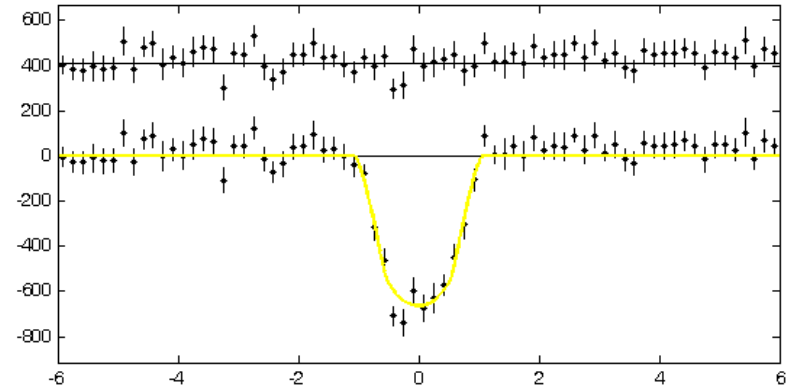


# Validation exam

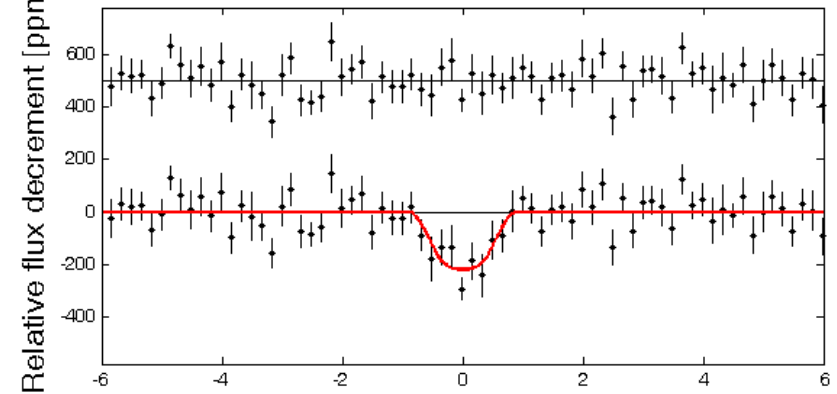
- Batalha *et al.* (2012):
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- $R_{1843.01} = 1.35 R_{\text{Earth}}$
- $R_{1843.02} = 0.84 R_{\text{Earth}}$
- Third signal:
  - $P_3 = 4.25 \text{ hr}$  (!)
  - $R_3 = 0.61 R_{\text{Earth}}$

Planet Formation and

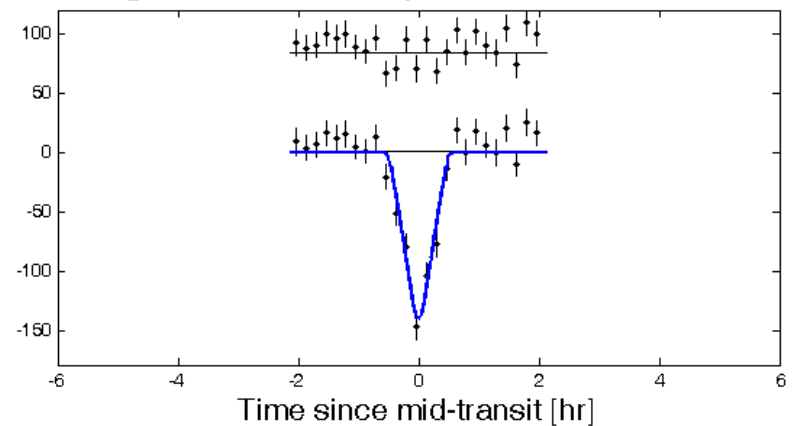
KOI 1843.01,  $P=4.1945$  phase-binned to 10 minutes



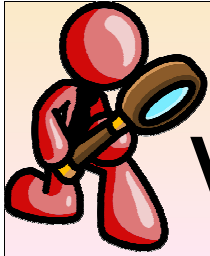
KOI 1843.02,  $P=6.356$  phase-binned to 10 minutes



New signal at:  $P=0.17689$  phase-binned to 10 minutes





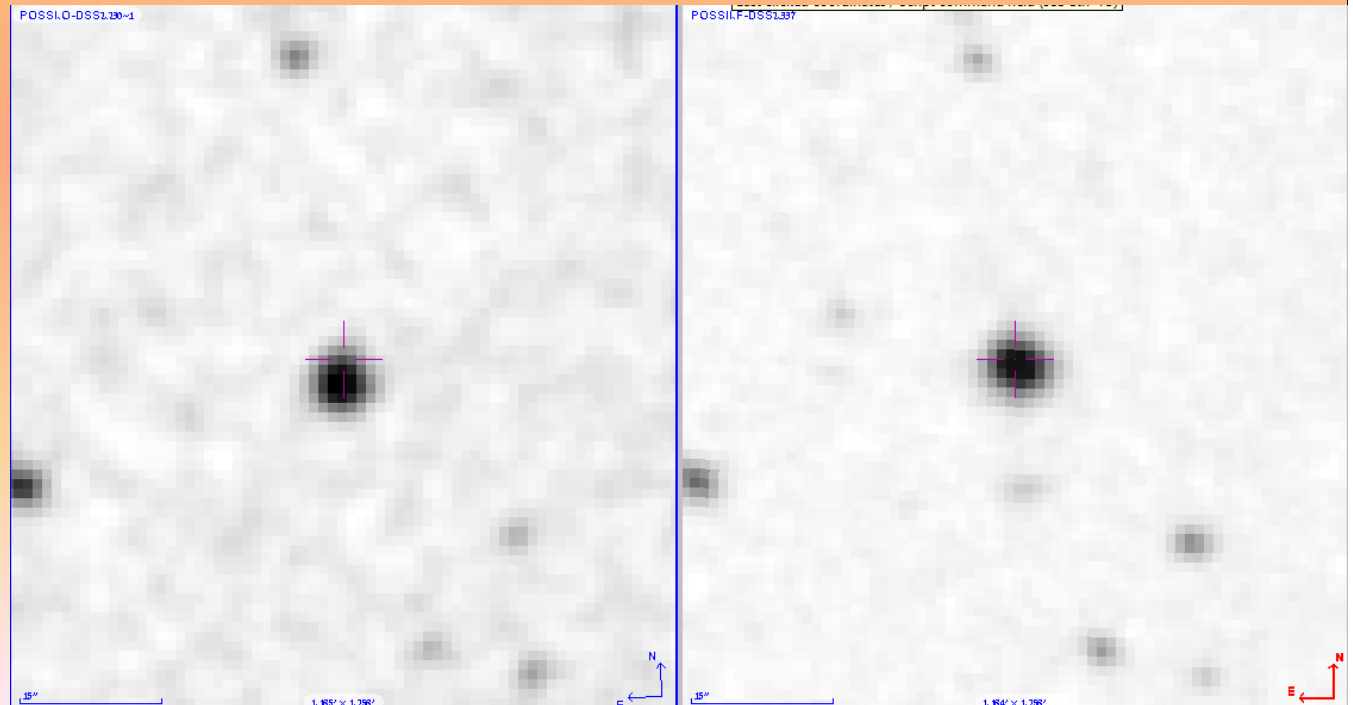


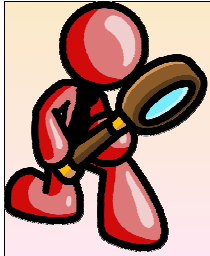
# Validation example: KOI 1843



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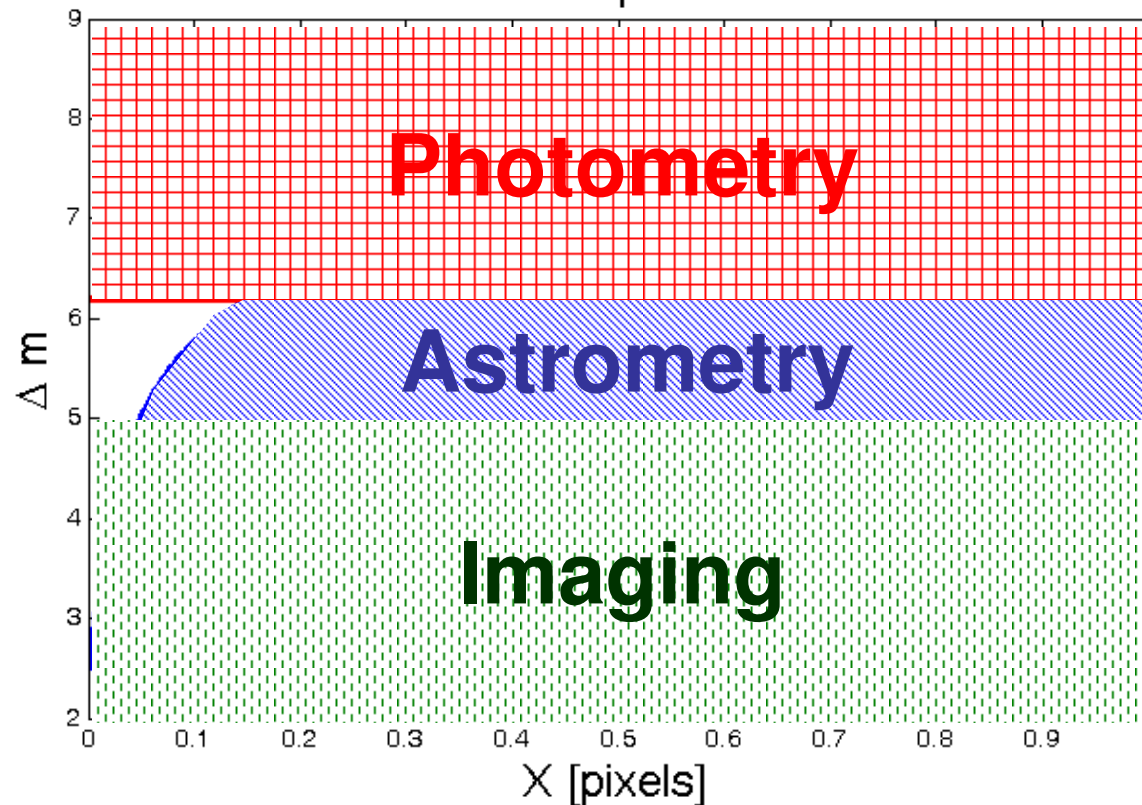
- Third signal:
  - $P_3 = 4.25 \text{ hr}$  (!)
  - $R_3 = 0.61 R_{\text{Earth}}$
- Nearby, high PM  
M dwarf

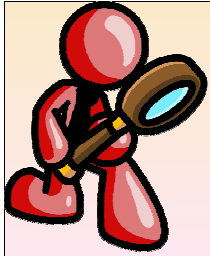




# KOI 1843

Signal 1 - Blue: astrometry, Red: photometry, Green: imaging/pm  
True depth: 0.2

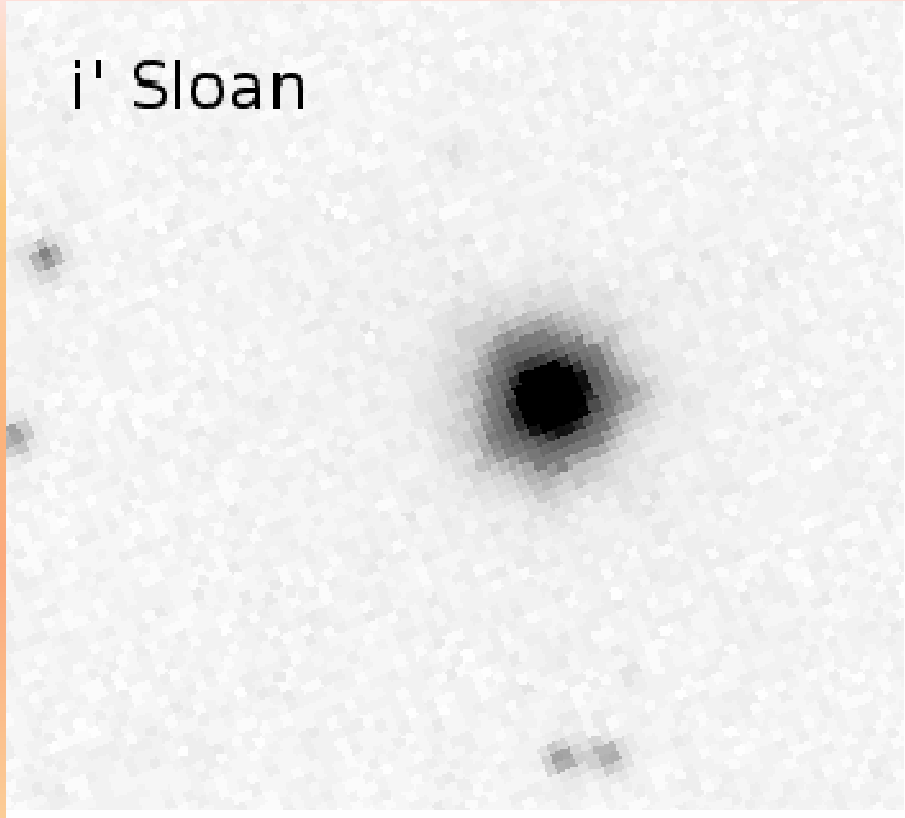




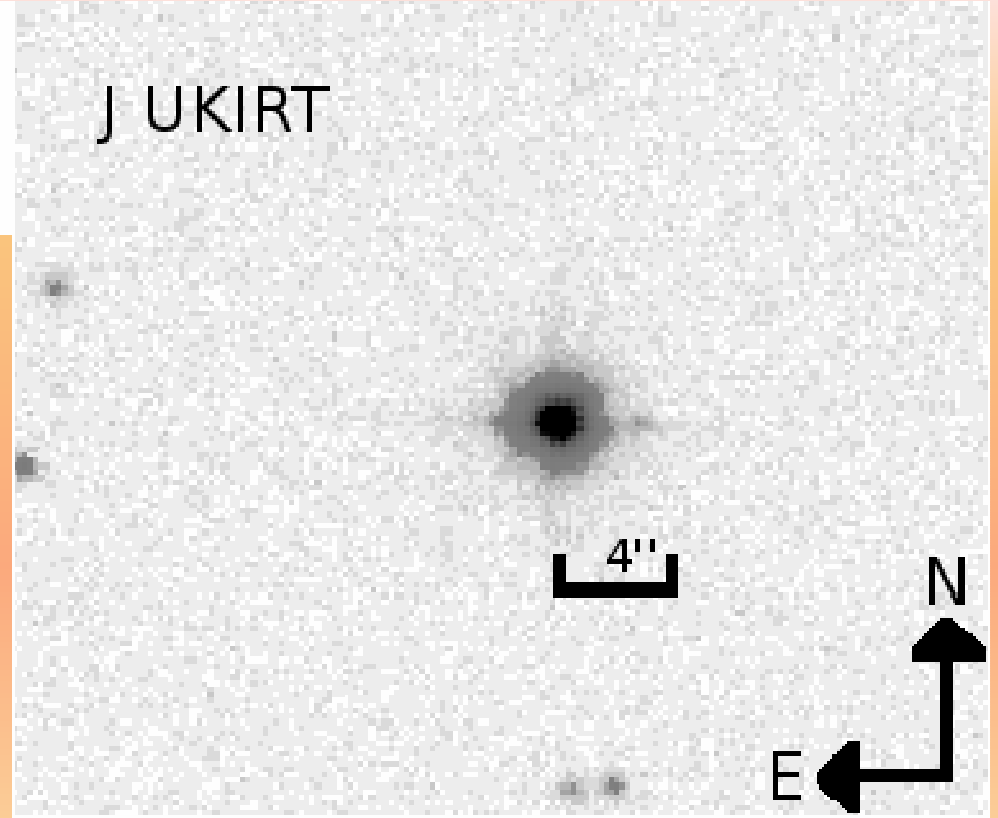
# KOI 1843

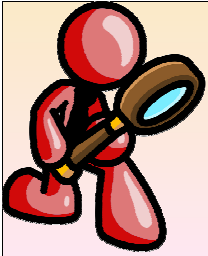


i' Sloan



J UKIRT





# Conclusions

- We applied a *different* pipeline
  - Different sensitivities and biases: candidates order
  - Compares well with PDC-MAP
  - Detected a number of interesting objects.
  - Work on a validation scheme in progress.
- Project with several parts: to be continued.  
Despite the success of the Kepler mission, parallel analysis by multiple teams is required.

# Thank You.

