

# TraMoS: Transit Monitoring in the South

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## Outline

# Transit Timing Variations

# TraMoS Project

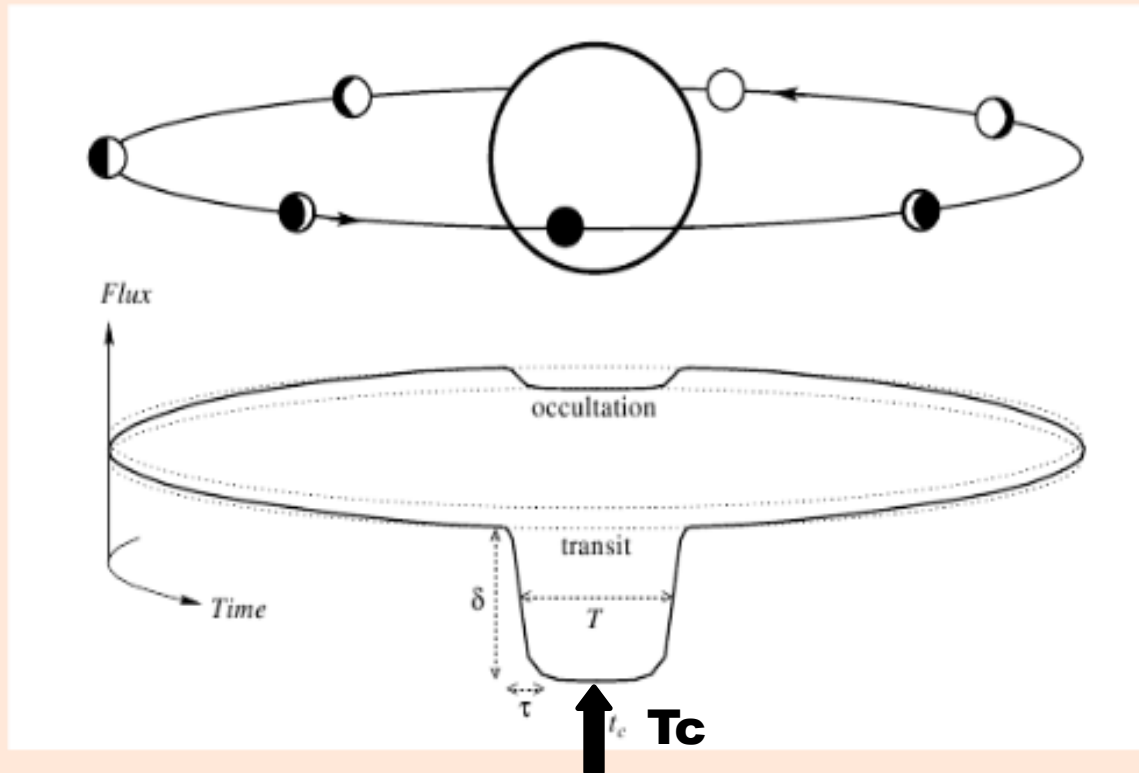
- Observations
- Data Analysis
- Results

# Conclusions

# Transit Timing Variations

- Gravitational Perturbations induced by the presence of unseen orbital companions in the system produce variations in the orbital elements of the transiting body.

→ Variations in the orbital Period



# Transit Timing Variations (TTVs)

A technique sensitive to detect objects down to  
Earth-mass regime

(Miralda-Escude et al. 2002, Agol et al. 2005, Holman & Murray 2005)

TTVs can have amplitudes of several minutes  
(fully detectables)

especially when perturber is in orbital resonances

# TTVs Today

- Now is an intensively used technique:
  - Kepler + CoRot

- Several recent results → Kepler

- Several TTVs Candidates by ground-based observations but no conclusive results (yet)

Kepler-9 (2010)

Kepler-11 (2011)

Kepler-16 (2011)

Kepler-18 (2011)

Kepler-19 (2011)

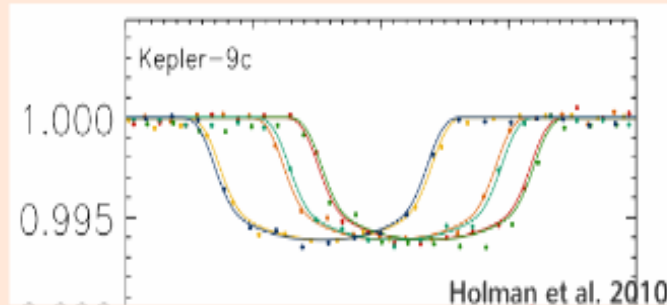
Kepler-23...Kepler-33  
(26 planets)

(2012)

# TraMoS: Transit Monitoring in the South

## GOALS

- Refine physical parameters of the transiting exoplanets
- Perform a homogeneous monitoring of transiting exoplanets
- Search for (short/long-term) variations in the light curve parameters:



Mid-Time  
Transit Duration  
Transit Depth

via high cadence photometric observations (15 - 50 seconds)

(First Transit Monitoring Project of the Southern Hemisphere)

# TraMoS: Observations

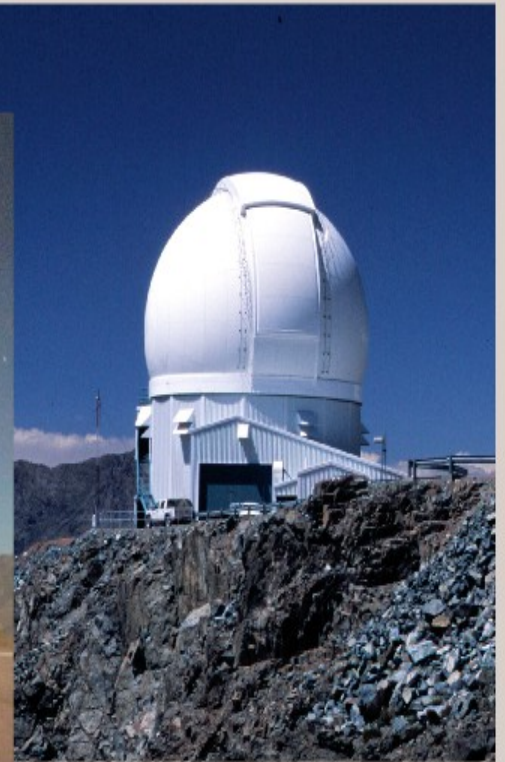
1m - SMARTS: Y4KCam

Gemini: GMOS-South

SOAR: SOI

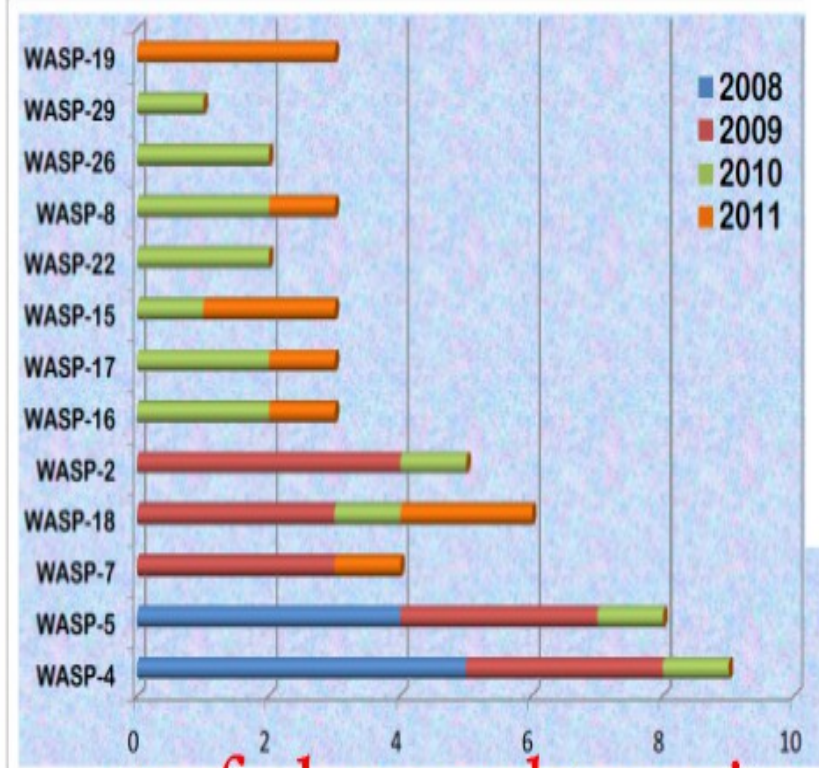
VLT: FORS1/2

+ 0.6m telescopes (remote observing)



# More than 70 transits have been observed for more than 20 systems

Planet	Date	Telescope	Planet	Date	Telescope
OGLE-TR-111b	2008-04-26	VLT	OGLE-TR-113b	2008-12-19	Gemini-S
	2008-04-30	VLT		2008-12-29	Gemini-S
	2008-05-04	VLT		2009-01-21	Gemini-S
	2008-05-12	VLT		2009-02-20	Gemini-S
	2008-05-20	VLT		2009-02-23	Gemini-S
OGLE-TR-132b	2009-12-25	Gemini-S	OGLE2-TR-L9	2009-12-18	Gemini-S
	2010-01-16	Gemini-S		2009-12-28	Gemini-S
	2010-01-21	Gemini-S	OGLE-TR-10	2009-09-06	Gemini-S
	2010-02-12	Gemini-S			
	2010-03-16	Gemini-S			
OGLE-TR-56b	2009-04-28	Gemini-S	GJ 1214b	2010-04-28	SOAR



# of observed transits



I. OGLE-TR-111b

**Hoyer et al. 2011**

III. WASP-4b

**Hoyer et al. 2012  
(Submitted)**



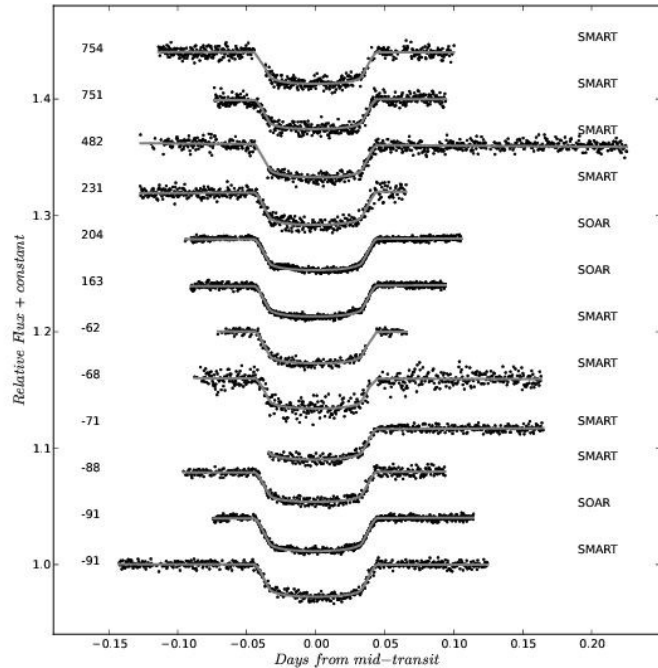
Results

II. WASP-5b

**Hoyer et al. 2012**

**Follow-up of 3 Hot Jupiters**

# WASP-4b



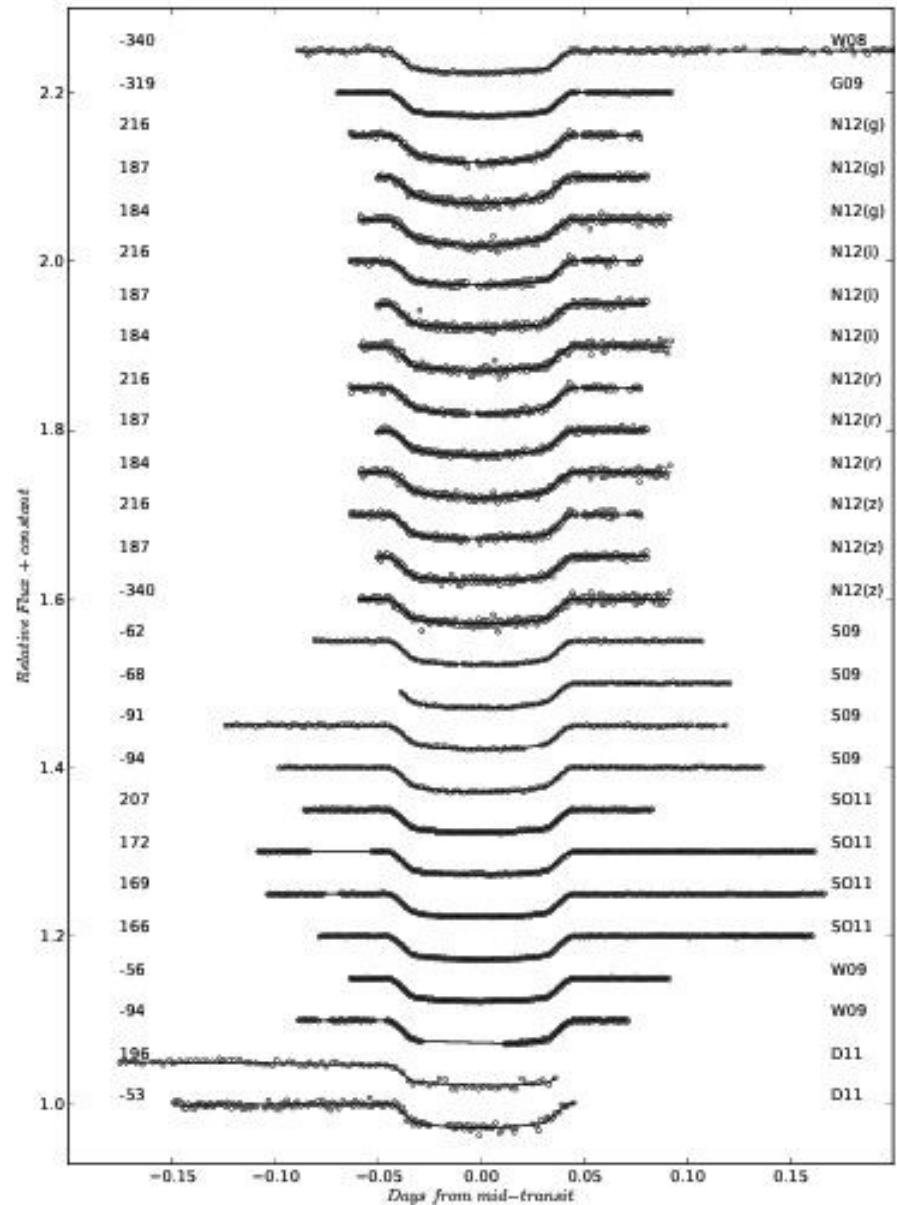
Discovered 2007

Radius: 1.36 R<sub>Jup</sub>

Mass: 1.12 M<sub>Jup</sub>

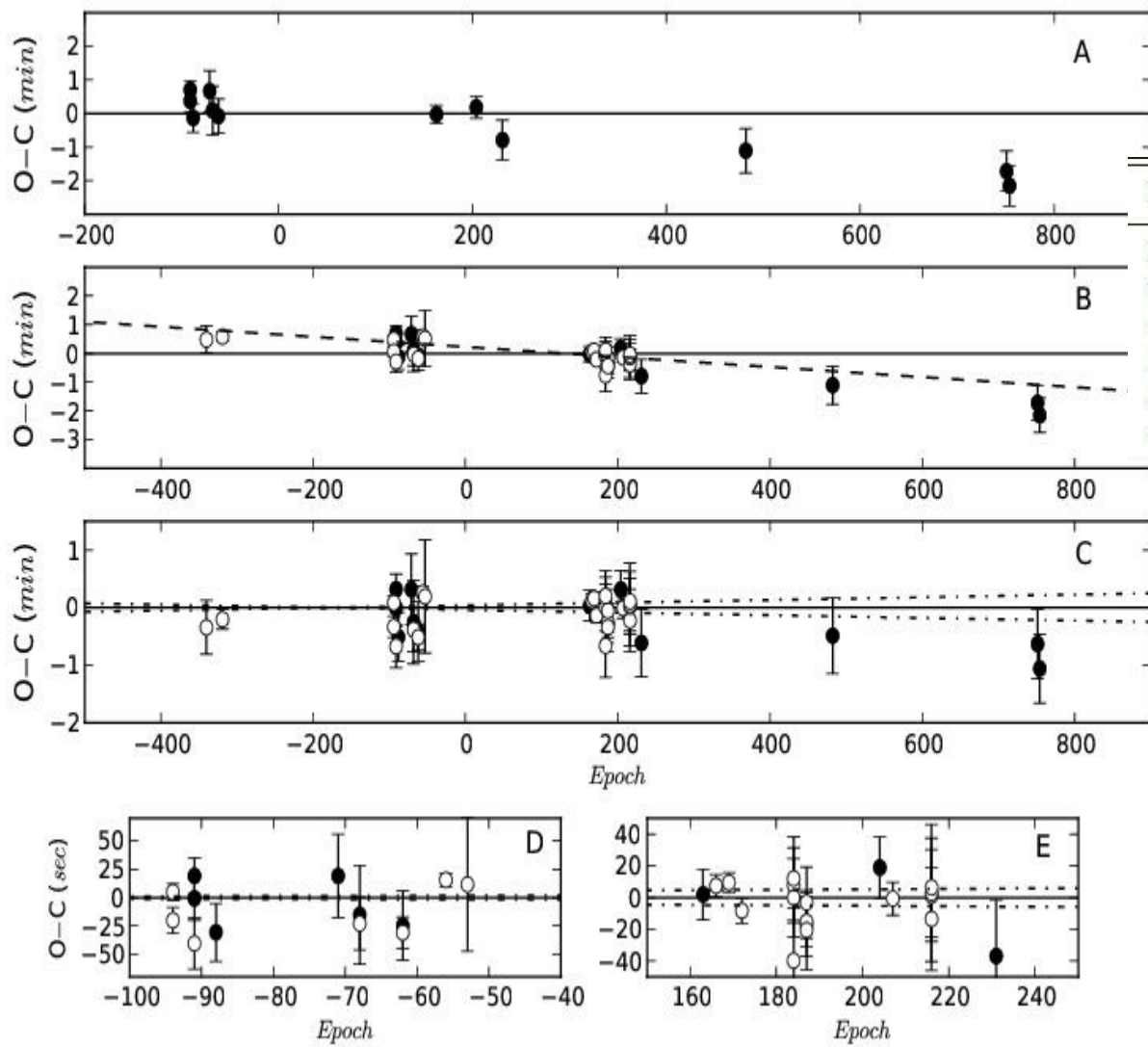
Period: 1.338 days

G8V, V = 12.6 mag , R<sub>star</sub>=1.15 R<sub>sun</sub>



**Analysis using 12+26 light curves**

# WASP-4b

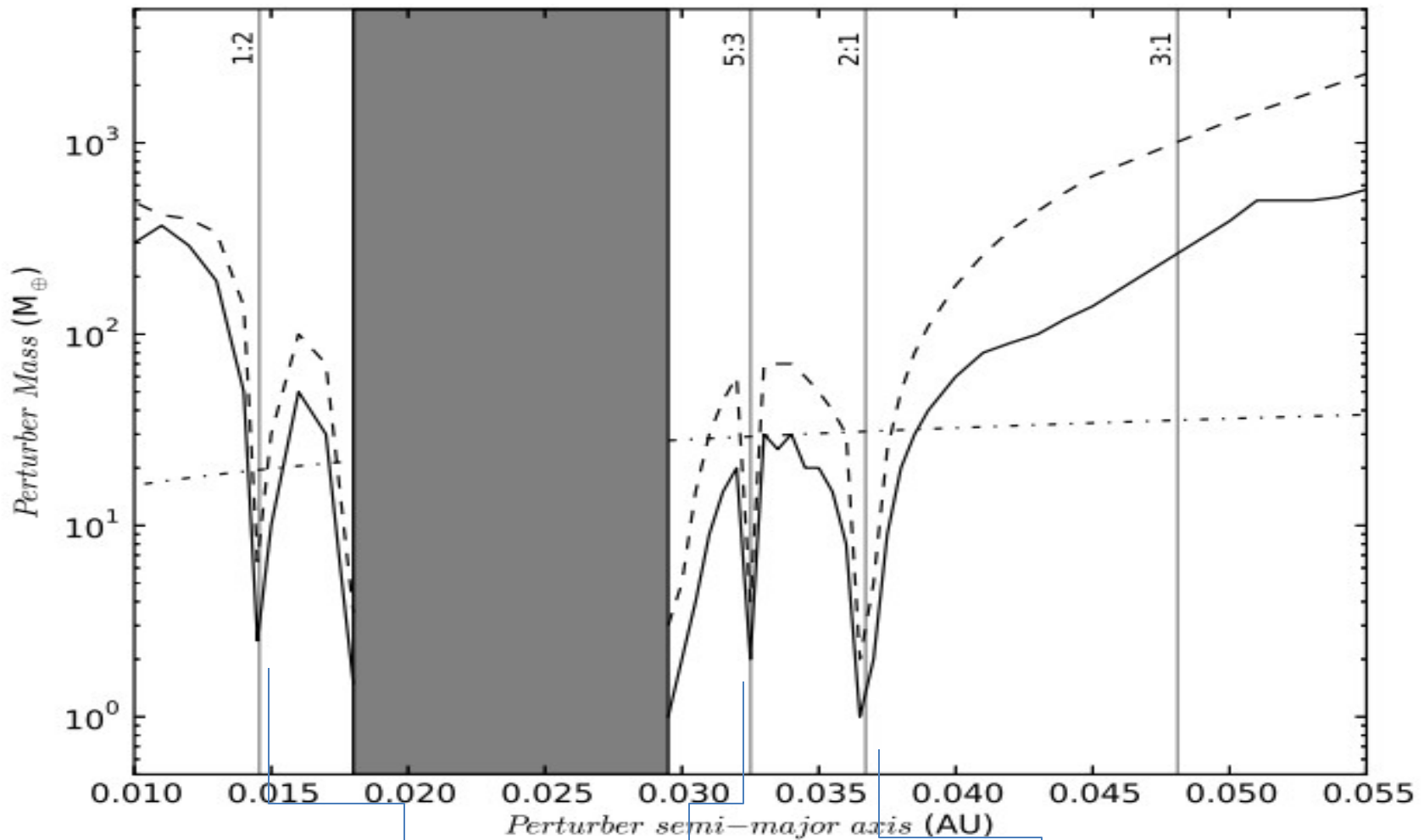


Parameter	Derived Value	error
P (days)	1.33823204	$\pm 0.00000016$
$T_0$ (BJD)	2454823.591923	$\pm 0.000028$
$i$ (deg)	88.52	$+0.39, -0.26$
$R_p/R_s$	0.15445	$\pm 0.00025$
$a/R_s$	5.463	$+0.025, -0.020$
$e$	$0^a$	

**TTV RMS of  
20 seconds  
over 4 years**

Hoyer et al. 2012b (Submitted)

# WASP-4b Limits to perturber mass












2.5

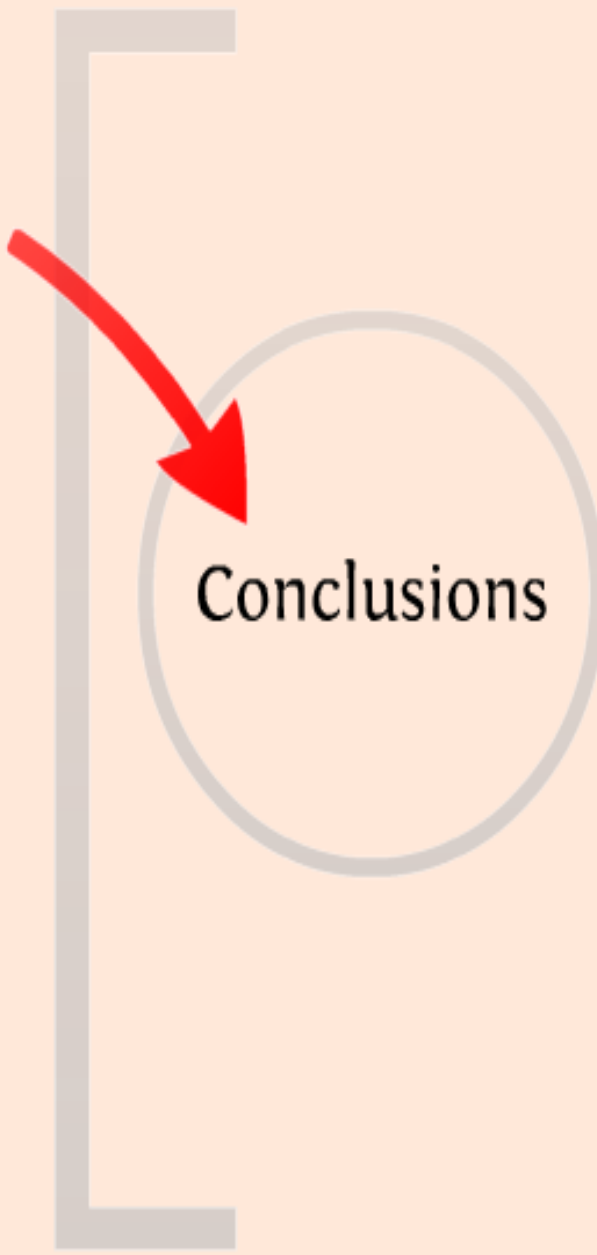
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# TraMoS

## First Results:

	OGLE-TR-111b	WASP-5b	WASP-4b
Refined Parameters			
TTVs			
Perturber Mass Limits			
Other Studies			Spots
Status	Published	Published	Submitted



## Conclusions

- **TTVs** is a powerful technique to detect companions down to the Earth-Mass regime.
- **TTVs** can determine the architecture of exoplanetary transiting systems
- We have conducted a **monitoring program** of transiting extrasolar planets which led to a long-term project: **TraMoS**.
- More than **70 transits** have been observed (+ observations during 2012)
- The first TraMoS results have been **published/submitted**
  - **No companions for Hot-Jupiters**

**Thanks !**