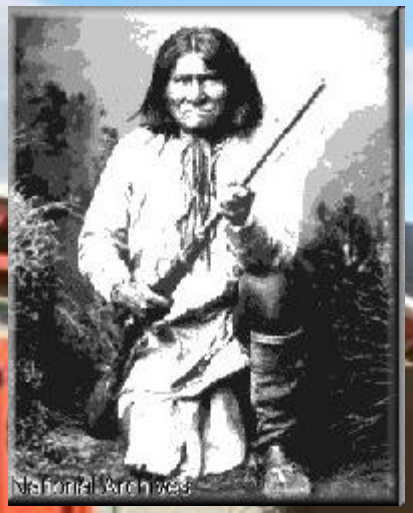
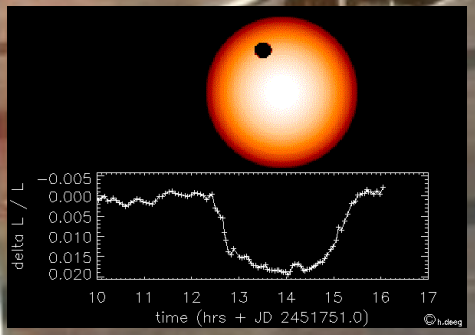


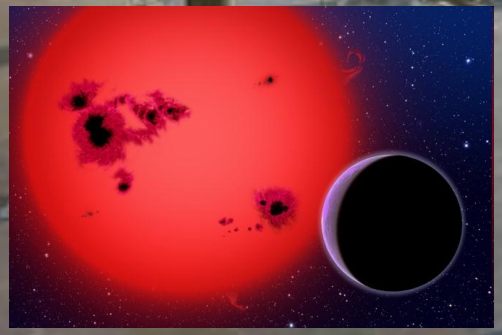
APACHE

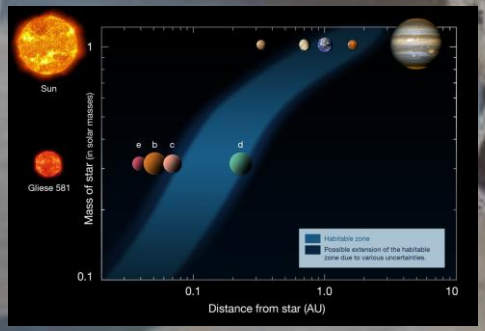
"While living I want to live well."

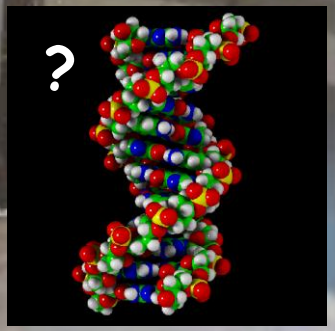
A. Sozzetti (INAF-OATo)

On behalf of the APACHE Team









Transiting Planets: A Treasure Trove

- **Learn about the history of planet migration through Rossiter-McLaughlin effect measurements**
- **Learn about the architecture of multiple systems**
- **Learn about the physical structure and composition of exoplanets**
- **Learn about the structure, chemistry, and dynamics of atmospheres**

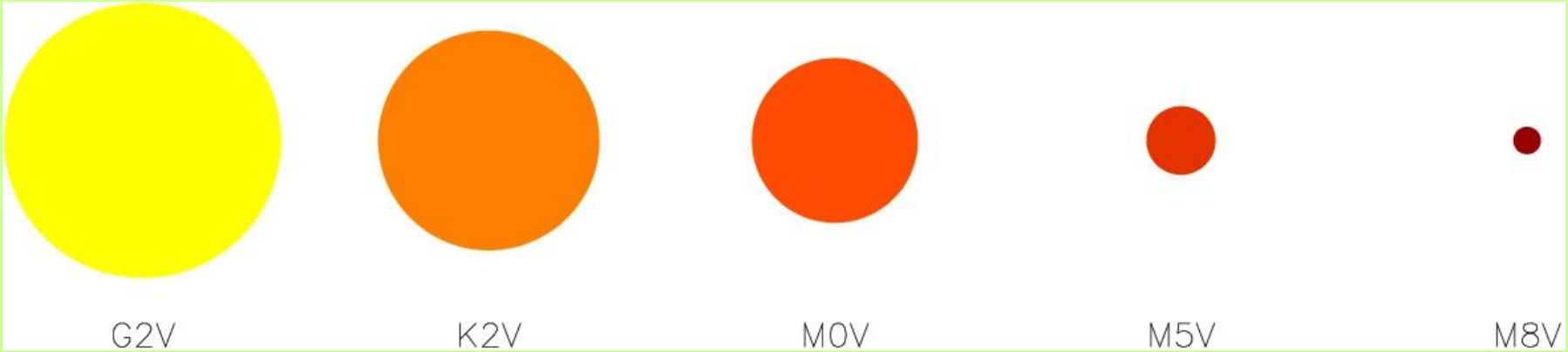
Ground-based Searches for Transiting Exoplanets

Survey	Location	Apert.(mm)	CCD	FOV (deg^2)	Range(mag)	Scale(")	Since	Nr. stars	Filters
OGLE[a]	Las Campanas	1300	8K×8K	0.34		0.26	1992	$> 10^6$	UBVRI
APT[b]	Australia	500	2K×2K	6	9.4	10-15	1995		B,V,R,I
Vulcan[c]	Lick Obs.	120	4K×4K	49	< 13		1999	6000	V, R
STARE[d] (TrES)	Tenerife	99	2K×2K	32		10.8	1999	>24000	B,V,R
ASAS-3[e]	Las Campanas	2×71, 250, 50	$2\times2K\times2K$	64, 4.8, 936			2002		V,I
SuperWasp[f]	S. Africa, La Palma	2×8×111	2K×2K	16×61	<13	13.7	2002	$> 100K$	
BEST[g]	OHP	195	$2K\times2K$	9.6	10-14	5.5	2002	100K	clear
XO[h]	Haleakla	2×110	1K×1K	51.84	12	25.4	2003	$> 100K/year$	400-700 nm
WHAT[i]	Wise Obs.	110	2K×2K	67.24	10-14	14	2004	15000	I
HATNet[j]	Hawaii, FLWO	6×110	2K×2K	67	I<14	14	2003	96K	I
VulcanSouth[k]	Antarctic	200	4K×4K				2004-2005		600-700nm
SLEUTH[l](TrES)	Palomar	100	2K×2K	36	< 14		2003	10000	r',g,i,z
PSST[m](TrES)	Arizona	100	2K×2K	36	10-13	10	2004	4000-12000	B,V,R, VR
BEST II[n]	Armazones	250	$4K\times4K$	2.8^o	10-16	1.5	2007	100K	clear
TEST[p]	Tautenburg	300	$4K\times4K$	4.8	10-15	2	2007	50000	(UBVI)R
ASTEP-South[q]	Antarctic	100	$4K\times4K$				2008		
MEarth[r]	FLWO	2×400	$2K\times2K$	0.18	< 9	0.75	2008	4131	
PANSTARRS[s]	Haleakla	4×1800	1.4bil pix.	49	<24	0.3	ongoing	6000/night	g,r,i,y
VISTA-ROPACS[t]	Paranal	4000	$8K\times8K$			0.339	ongoing		Z,Y,J,H,K_s
ASTEP	Antarctic	400					2010		
PASS[u]	Antarctic	all sky		5.5-10.5				250K	
ICE-T[v]	Antarctic	2×600		65			2012	1.3M	yes
OmegaTrans[w]	Paranal	2600	16K×16K	1	13.5-17.5	0.26		200K	R

Sozzetti et al. 2010

A) Deep, small-field surveys of faint (F-G-K) stars
B) Shallow, large-field surveys of bright (F-G-K) stars
C) New strategies for M dwarf transit searches

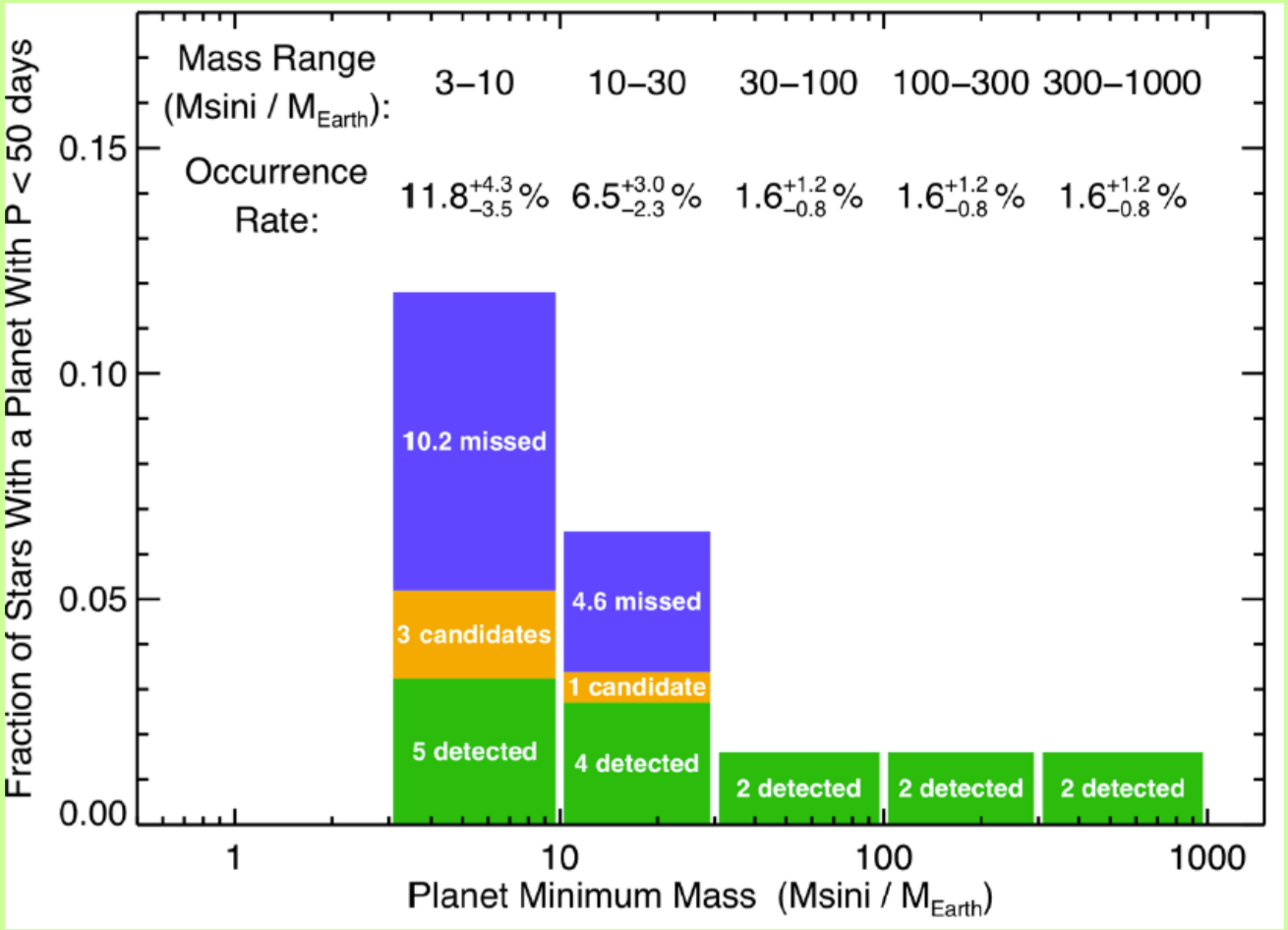
The Small Star Opportunity



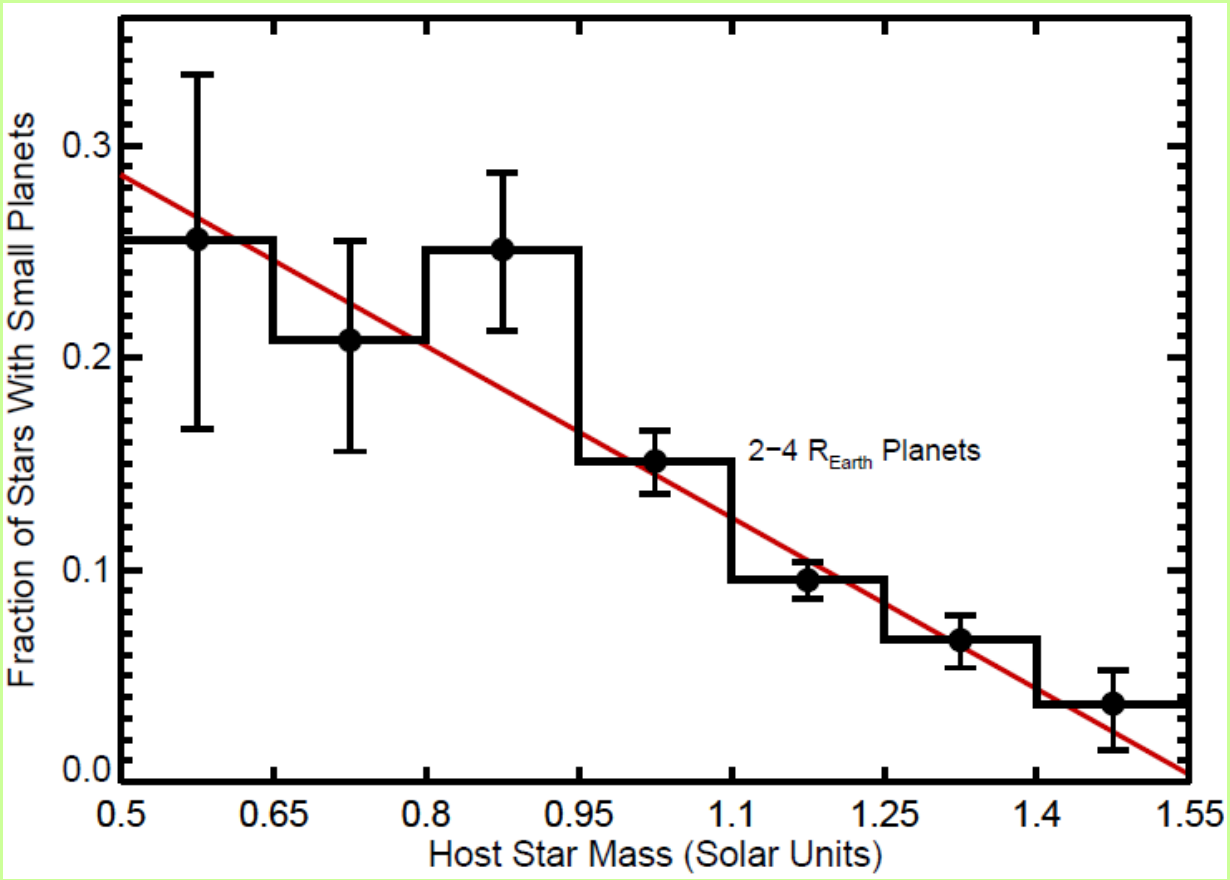
Consider a 7-M_{Earth} 2-R_{Earth} habitable zone planet:

- ✓ Transits are deeper *Sun: 0.03% M5V: 0.5%*
- ✓ Transits are more frequent *Sun: 365 days M5V: 15 days*
- ✓ Transits are more likely *Sun: 0.5% M5V: 1.6%*
- ✓ Greater Doppler Wobble *Sun: 1.3 m/s M5V: 10 m/s*
- ✓ Better contrast ratio *Sun: 0.0004 M5V: 0.05*

Low-Mass, Short-Period Planets Are Common…



…Especially Around M Dwarfs!



Occurrence rate of Neptunes and Super Earths: 34% (Bonfils et al. 2011)

However, the Star Must Cooperate…

- M dwarfs are intrinsically faint
- Low-mass stars can be fast rotators
- M dwarfs can be very active

Significant impact on a variety of techniques in terms of:

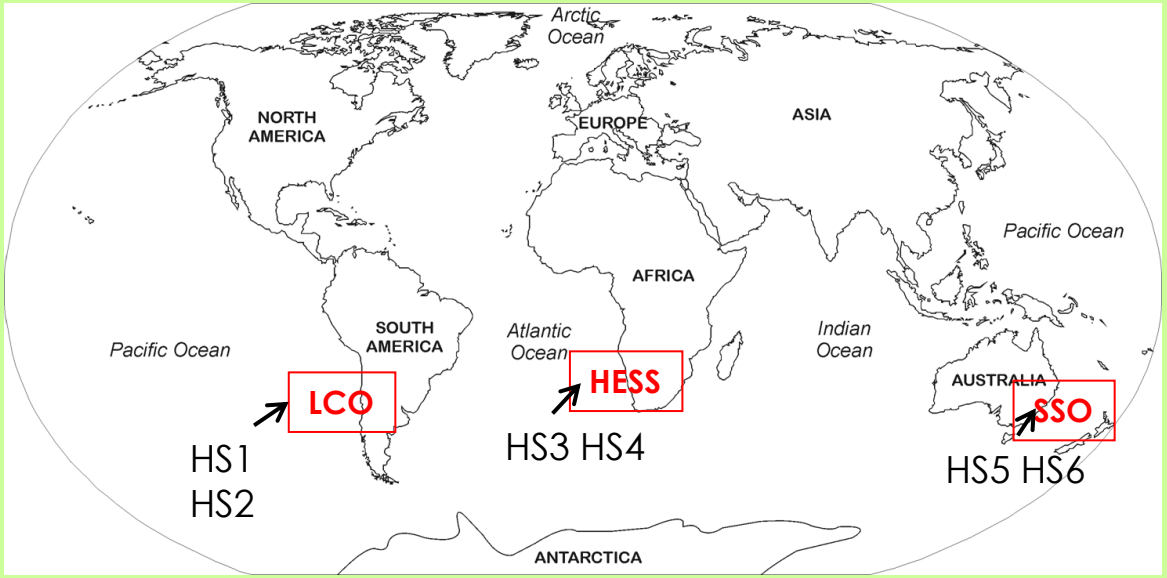
A) sample sizes
B) detectability thresholds
C) prospects for follow-up, confirmation and characterization

We've already heard about many well-designed experiments…

…So Why APACHE?

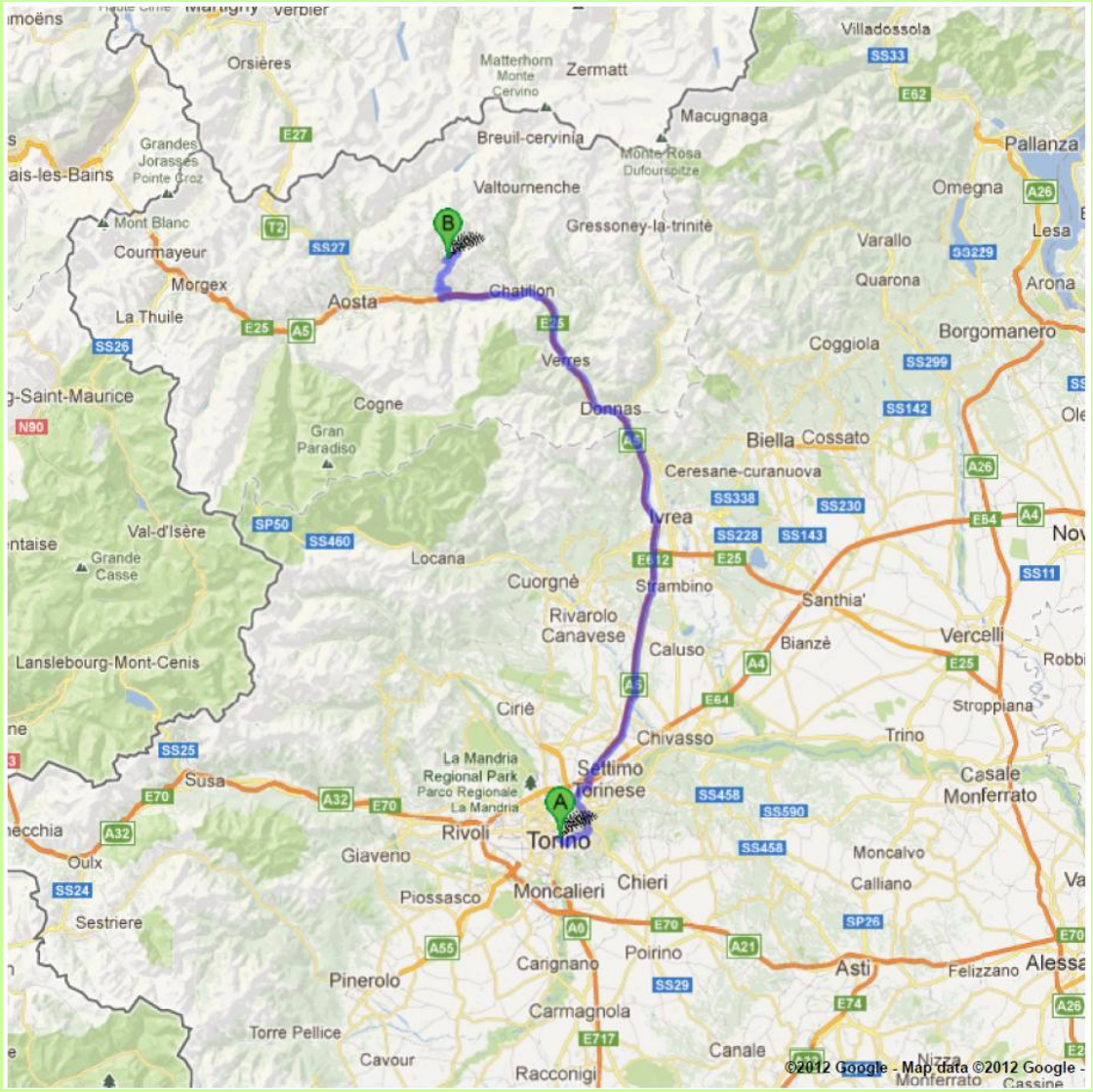
Isn't this just the 27th Transit Survey on the market?

GASPAR Travels a lot…



Our UK and Geneva Friends Not Much Less!

APACHE: The (Quasi) Zero-km Transit Survey!



The OAVdA Site

The Astronomical Observatory of the Autonomous Region of the Aosta Valley

The APACHE Team

- **INAF-OATo:** L. Lanteri, M. Lattanzi (Project Manager), R. Smart, A. Sozzetti (Project Scientist)

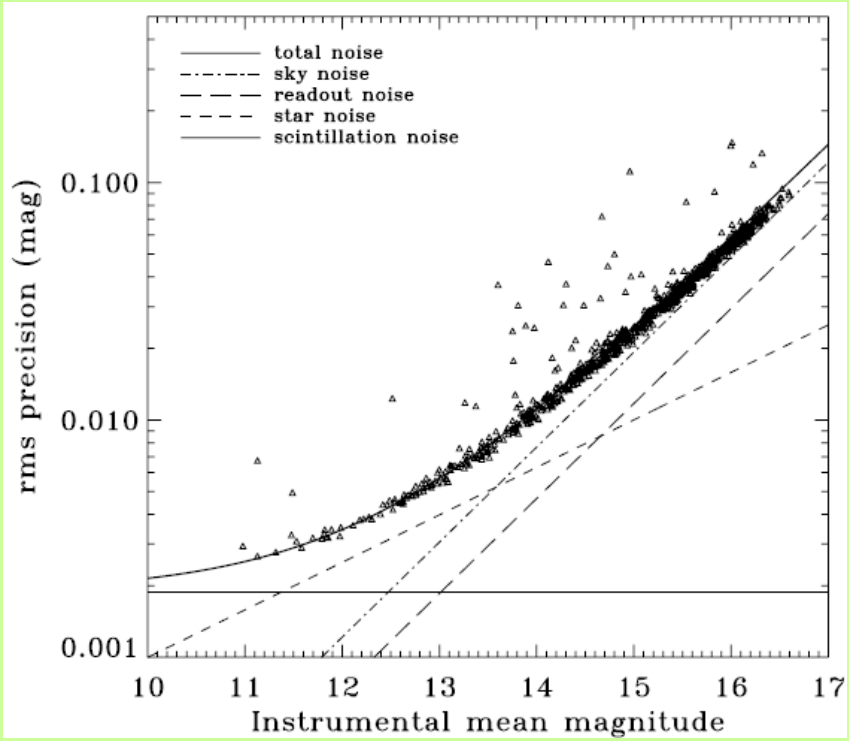
- **OAVdA:** A. Bernagozzi, E. Bertolini (Project Manager), P. Calcidese, A. Carbognani, D. Cenadelli, J.M. Christille, M. Damasso, P. Giacobbe

Site Characterization

Damasso et al. 2010

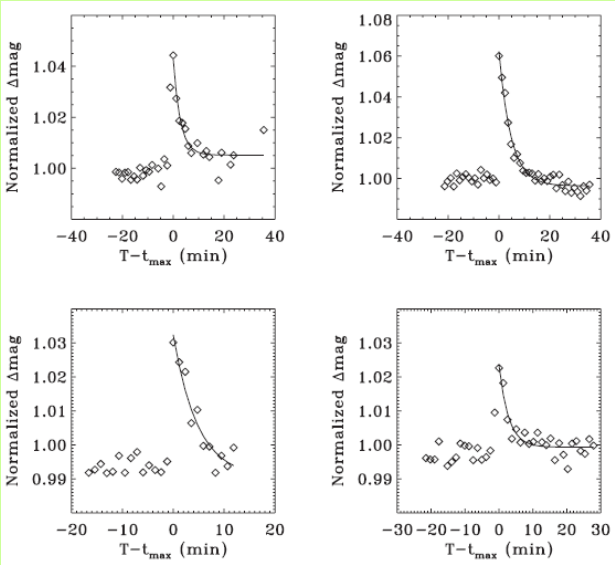
Median seeing: 1.7”

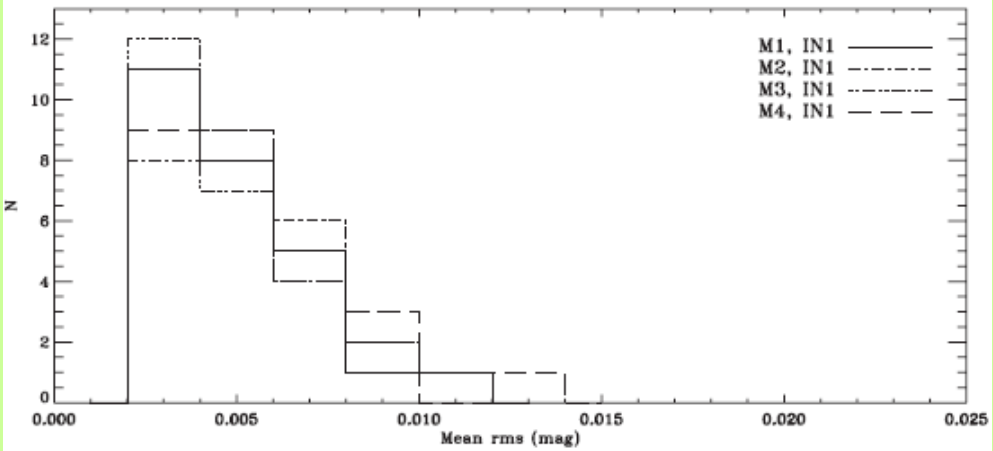
Fraction of usable nights: 57%



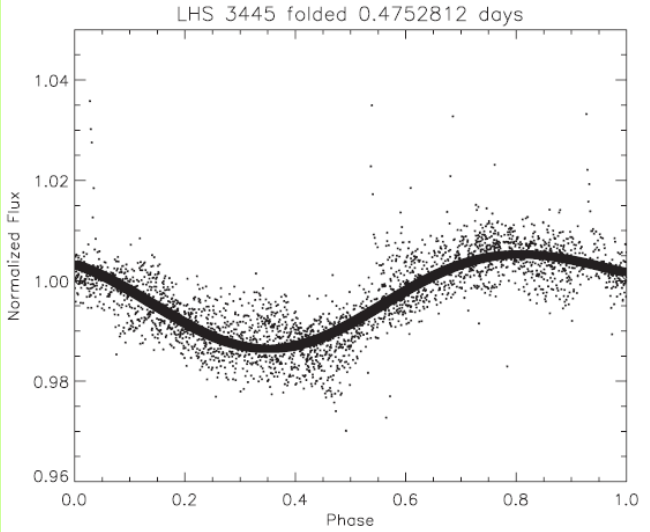
Median precision at *R*=13: ~ 6 mmag

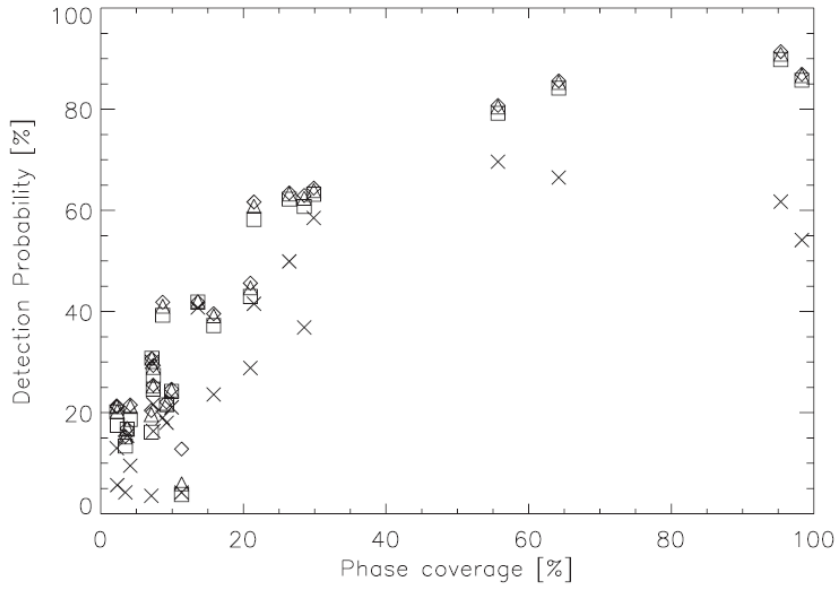
Pilot Study



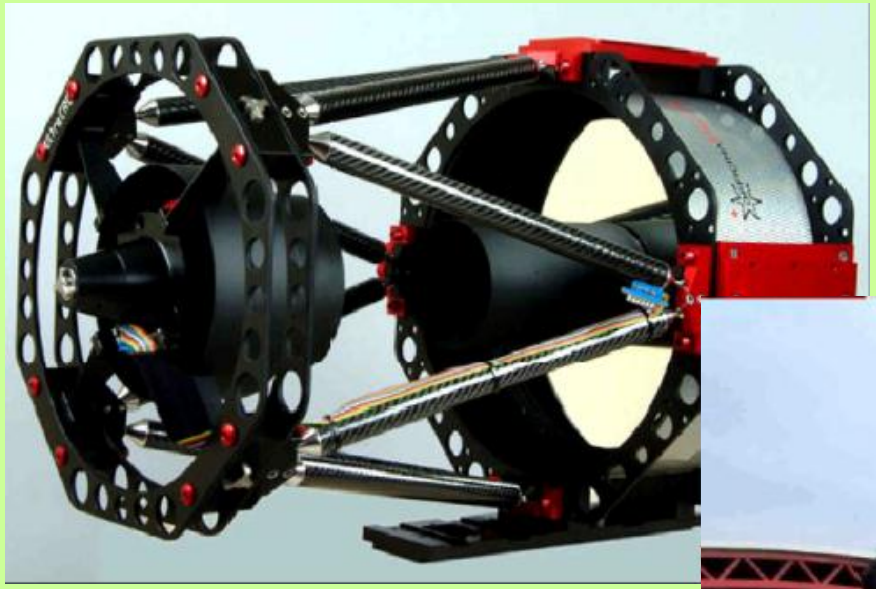


Giacobbe et al. 2012





The APACHEs



Telescope:
RC Pro 400 LT f/8.4
Weight: 42 kg
Optical set glass: LK7 for LT model

Mount:
GM 2000 - QCI, 10 Micron

CCD:
Fli PROLINE KAF-1001°
Array Size: 1024 x 1024
Pixel size: 24 µm
Pixel scale 1.5 arcsec/pixel
Field: 26.3' X 26.3'

Survey Operations

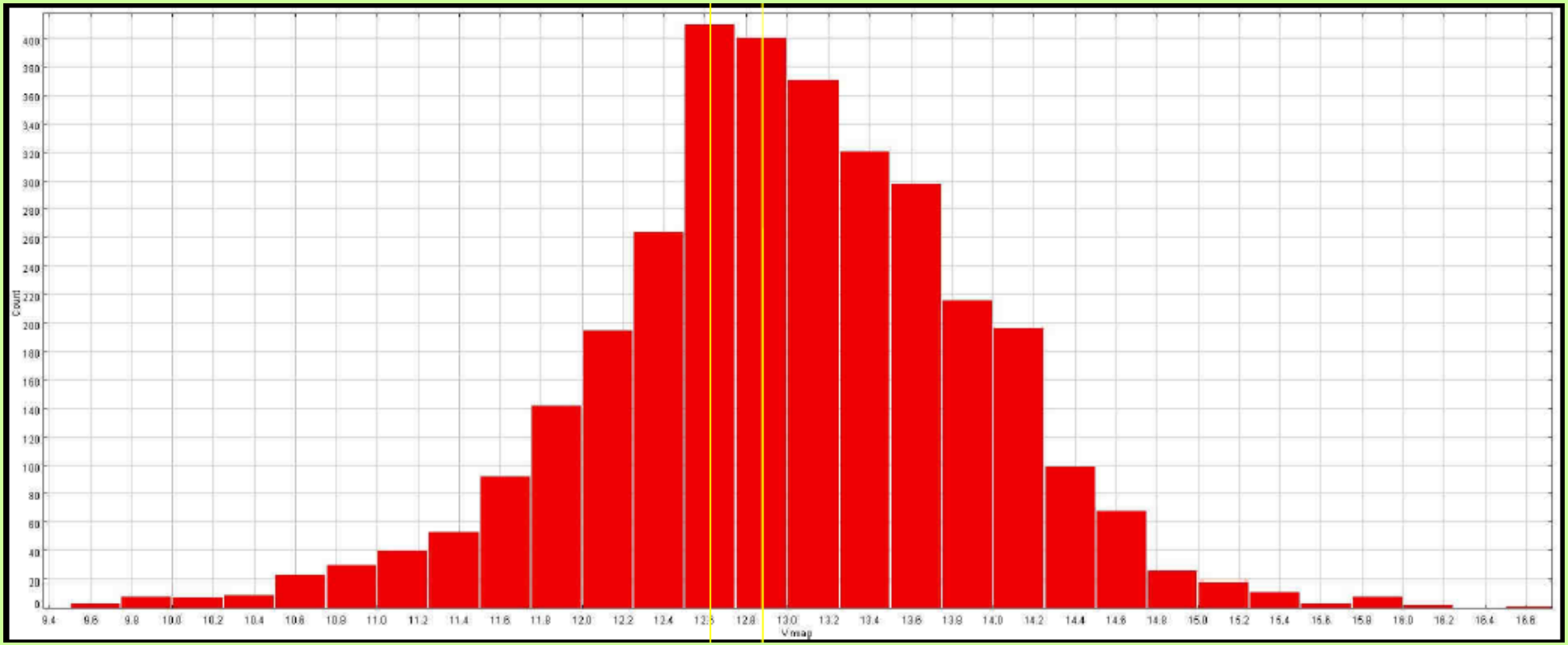
- **RTS2** is the choice for the operations control software architecture, including scheduler, pre-processing and database

- Well-tested **TEEPEE** pipeline on site. Independent reduction with **Robin** (Lanteri 1999). Real-time differential photometry pipeline **TSE** under development

See J-M Christille's poster!

APACHE Input Catalogue

- ~3000 Northern M0-M5 dwarfs from Lepine & Gaidos (2011)
- Good visibility, no bright stars in the FoV, not too sparse fields
- Cross-checks with some 20 catalogues to weed out binaries, active stars, fast rotators
- Support reconnaissance spectroscopy ongoing (Asiago Red Dwarf Survey)
- Number of Gaia transits helps to set priorities
- Highest priority targets are observed in conjunction with HARPS-N as part of the GAPS Large Program (PI A. Sozzetti)

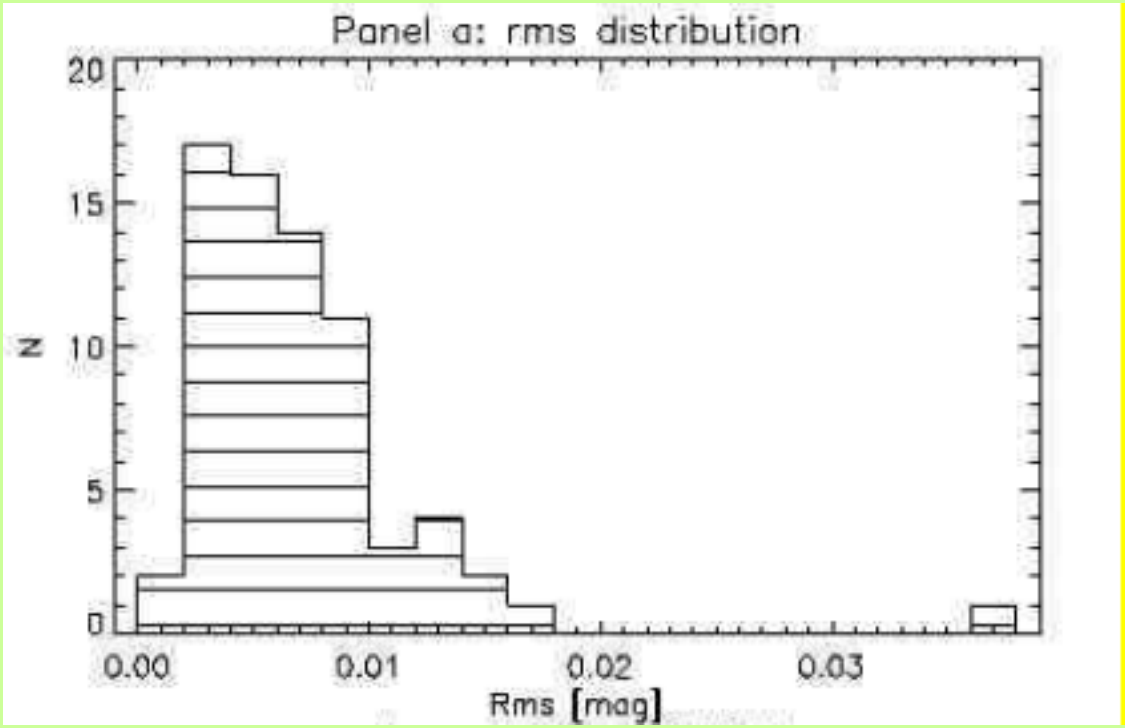


Targets are typically bright (mean V~14), potentially good for follow-up

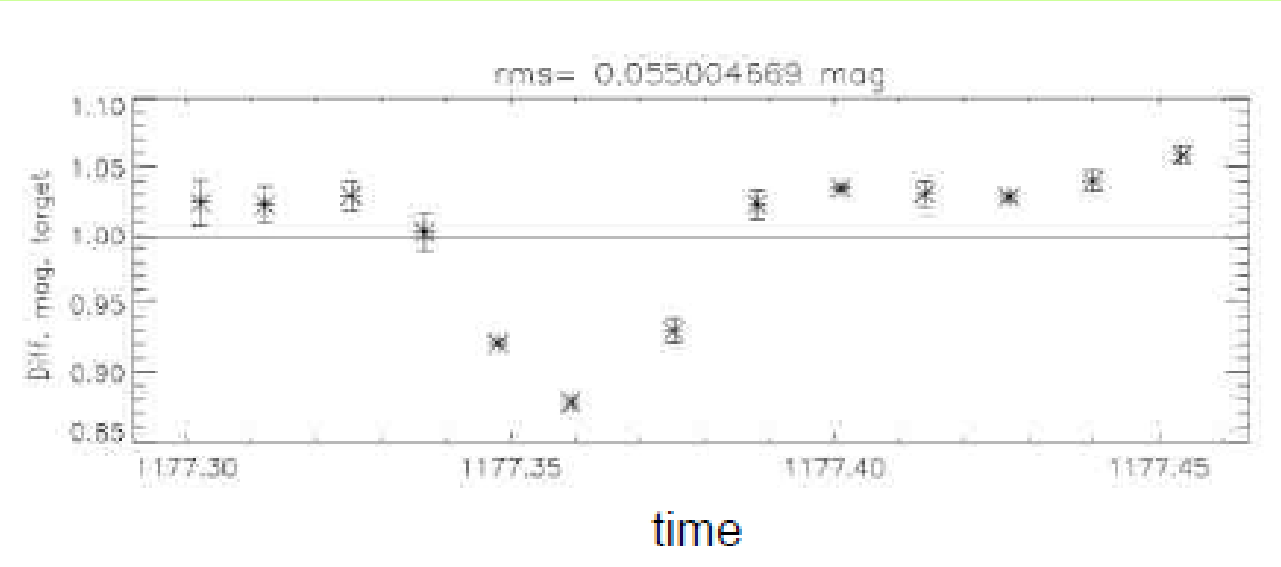
First Results

- **Survey ongoing since 4 months**
- **To-date, ~100 fields monitored**
- **Typically, a dozen fields per telescope each night**
- **We achieve routinely**

  5-6 mmag precision

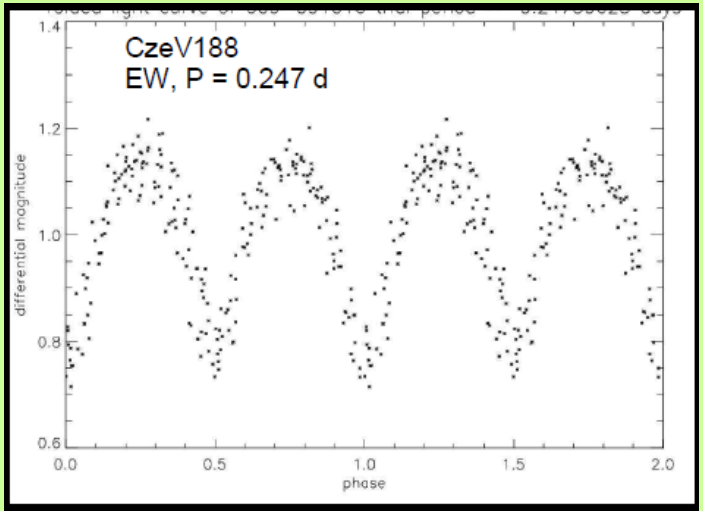


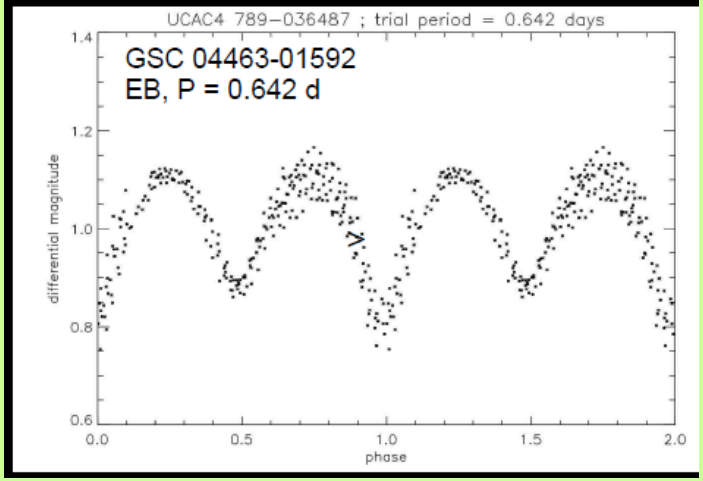
A Target Showing a Transit!

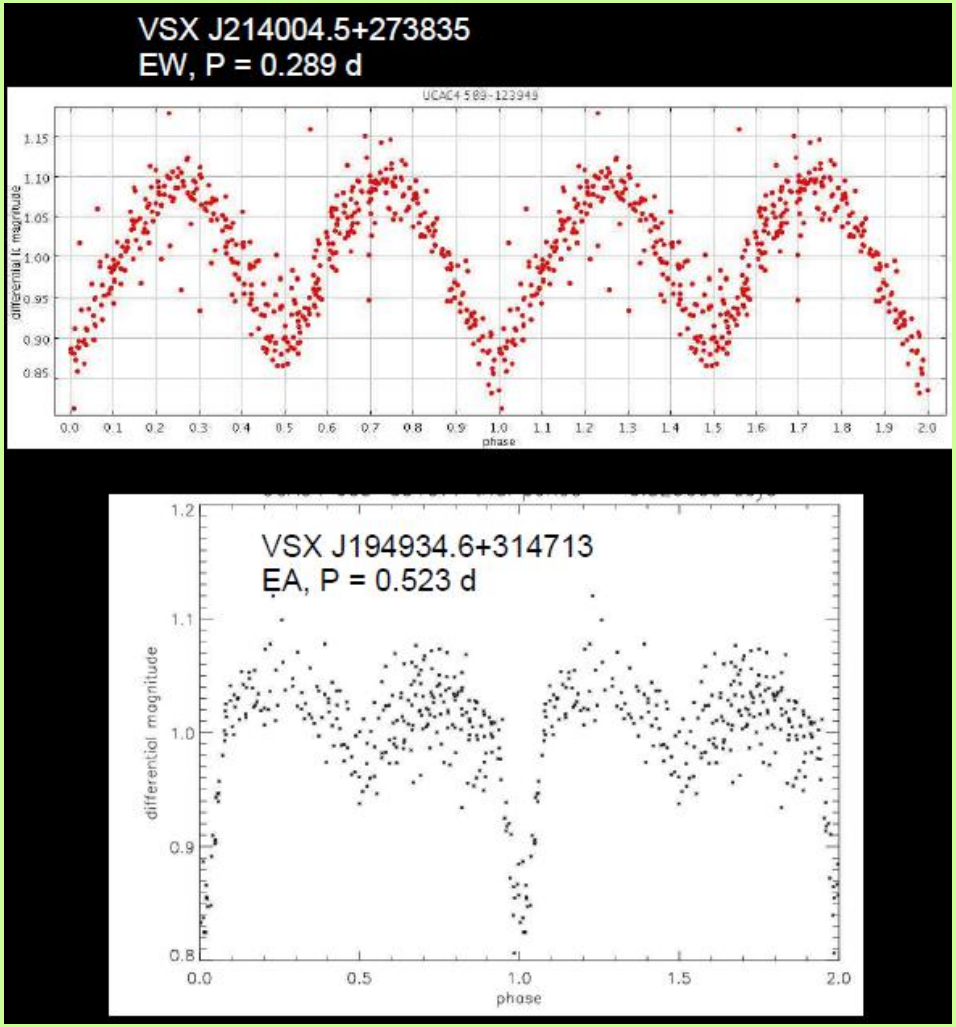


Well, simply our first eclipsing M dwarf binary…

The Usual Bunch of Field Variables







Follow us on the Web!