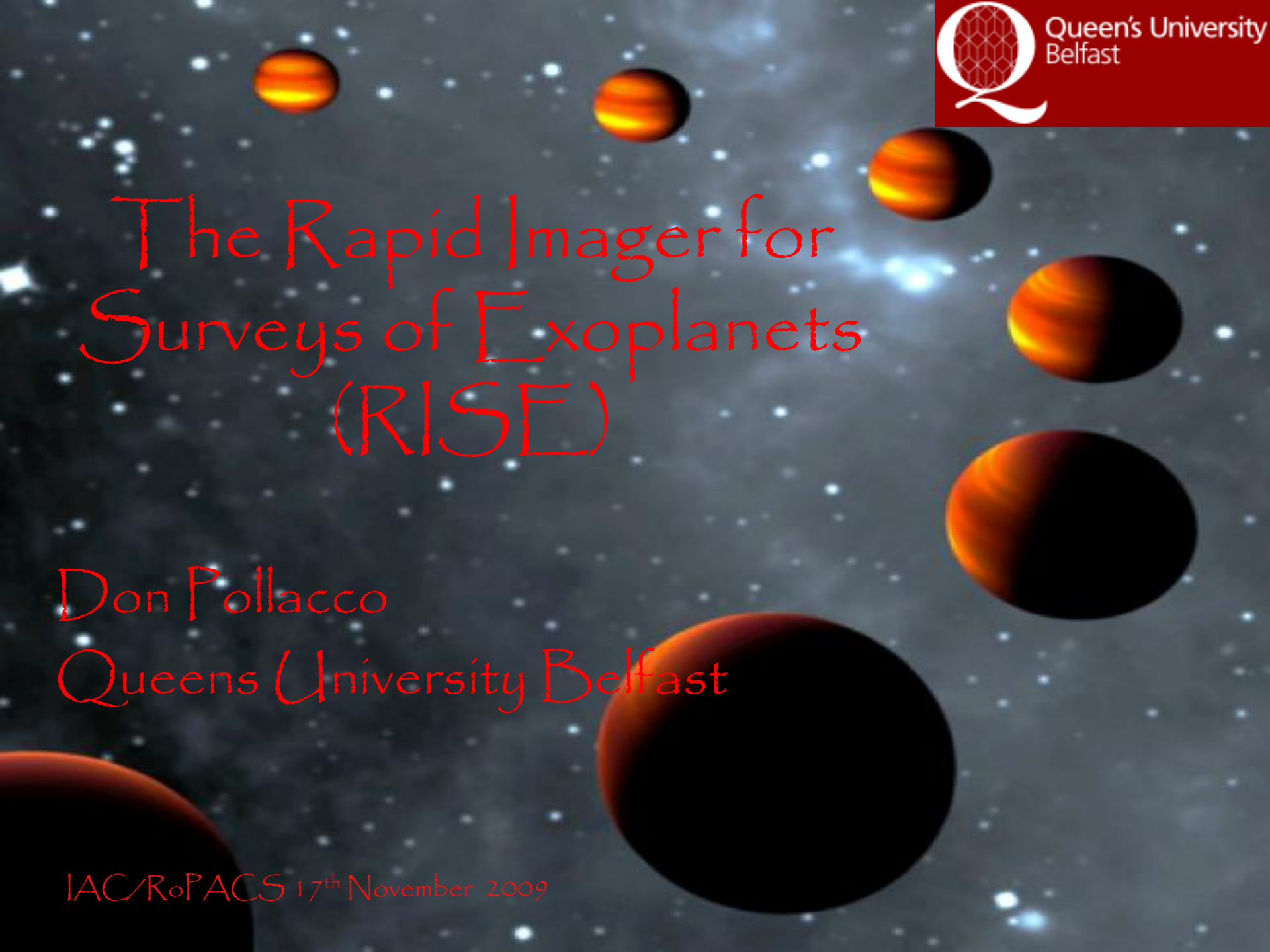
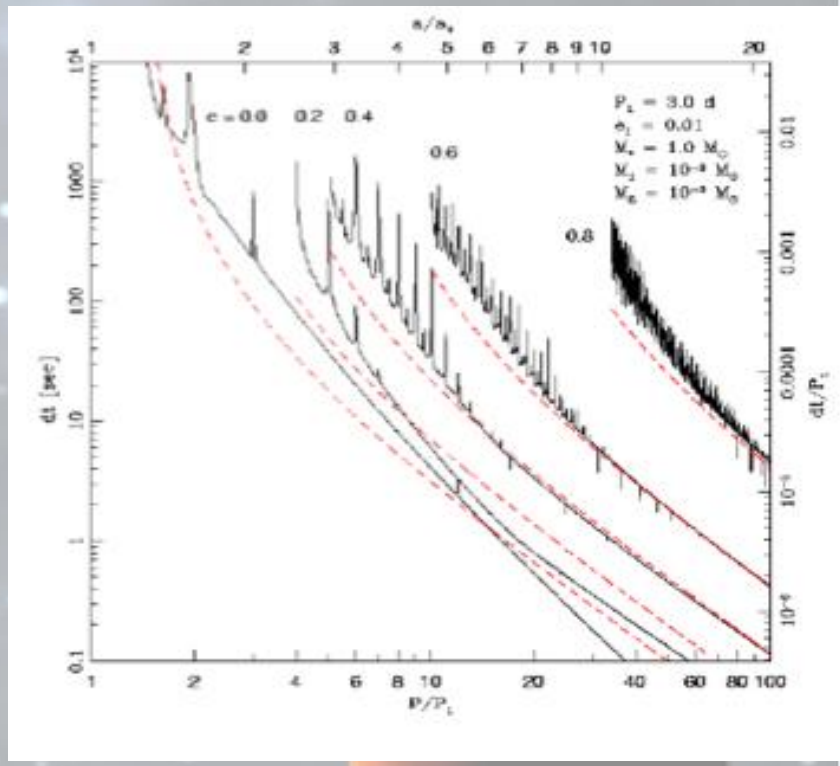

Queen's University
Belfast
The Rapid Imager for Surveys of Exoplanets (RISE)
Don Pollacco
Queens University Belfast
IAC/RoPACS 17th November 2009

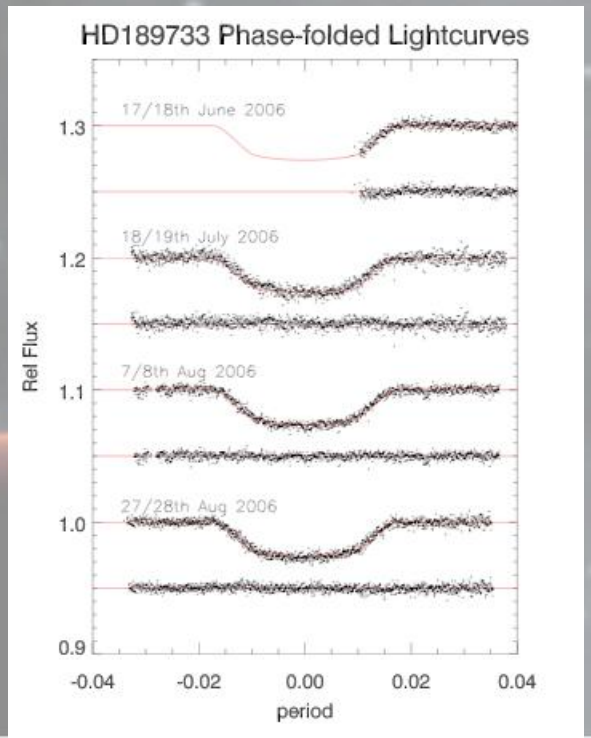
Outline

- Scientific Motivation – TTV
- High precision photometry
- The Liverpool Telescope
- RISE
- TTV and other science results
- The future

A short cut to Earth mass objects?

Holman and Murray (2005) – TTV from Jupiter mass companion in >1 yr orbit or hot Earth (P~40-50d) detectable.

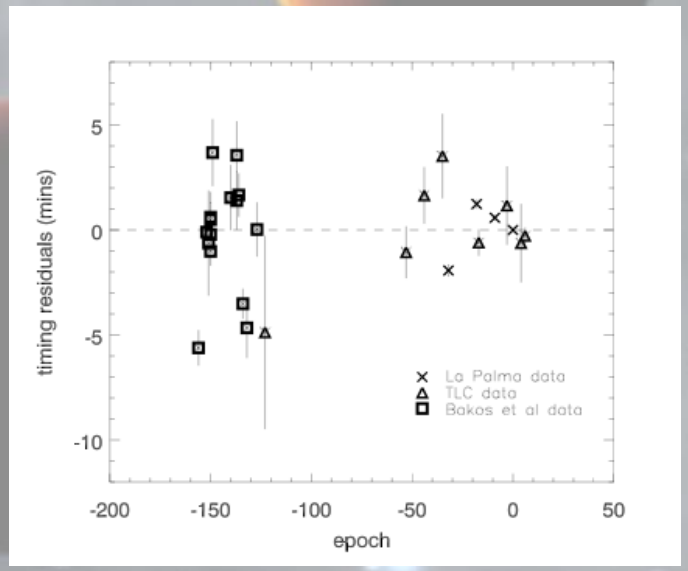




First attempt

NOT/LT/WHT, Δt ~ 5-15 sec

MCMC fitting

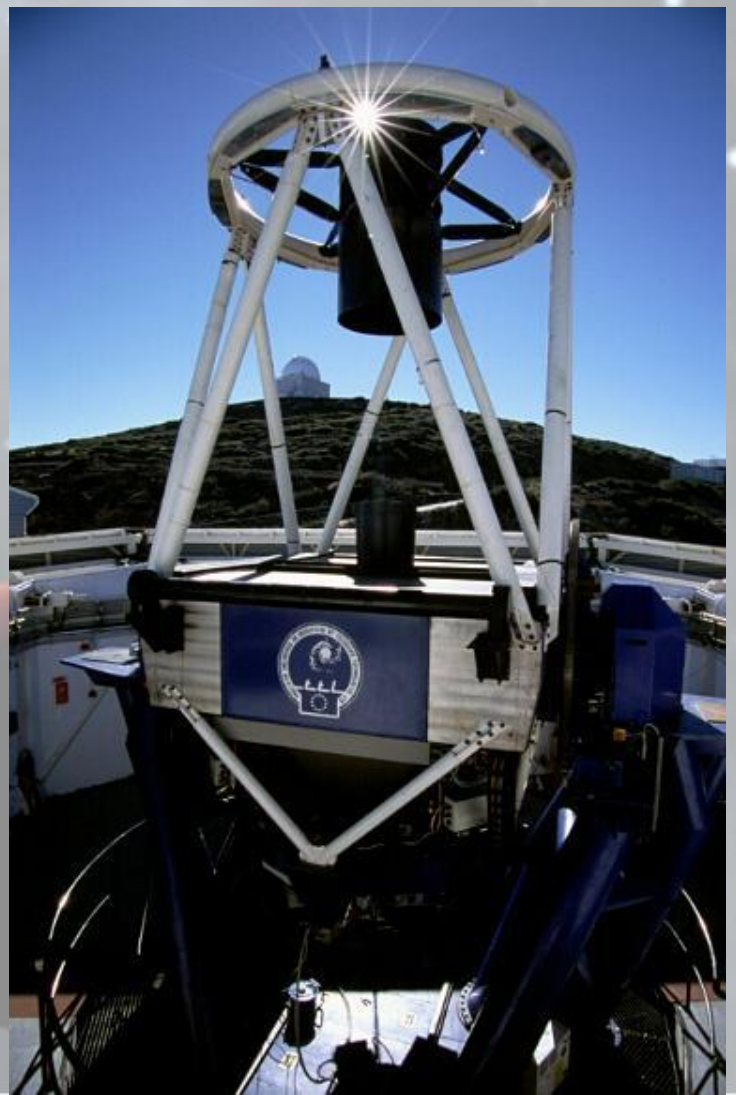


How to do high precision photometry

- Sort the Telescope!
- Doughnuts....

- If you take flats think about what you doing
- Autoguiding
- Systematic noise sources (filter wheels, temp changes, colour terms etc)

Liverpool Telescope



2.0m RC optics, alt-az mount.
Full robotic control

Optimized for ESP photometric work

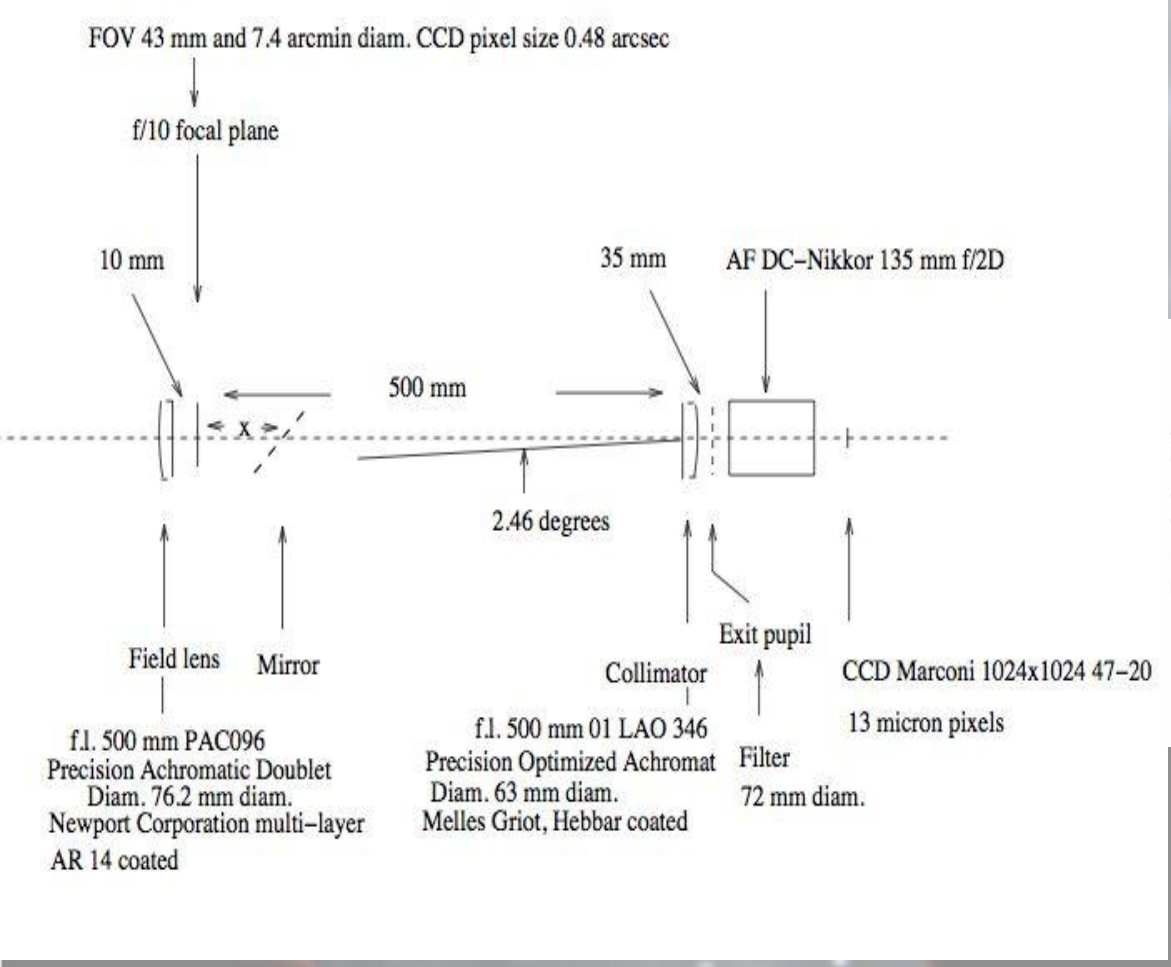
RISE at the LT : why we built it

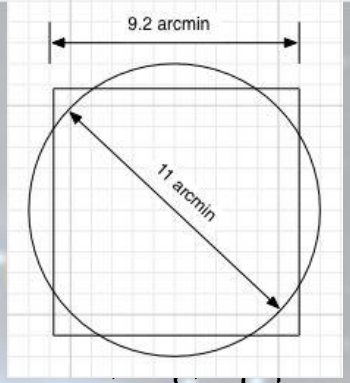
RISE: Optical – John Meaburn, Mechanical – JMU, Software + Construction – QUB

Wide-field, focal reducer for the LT. Uses a frame transfer e2v sensor.

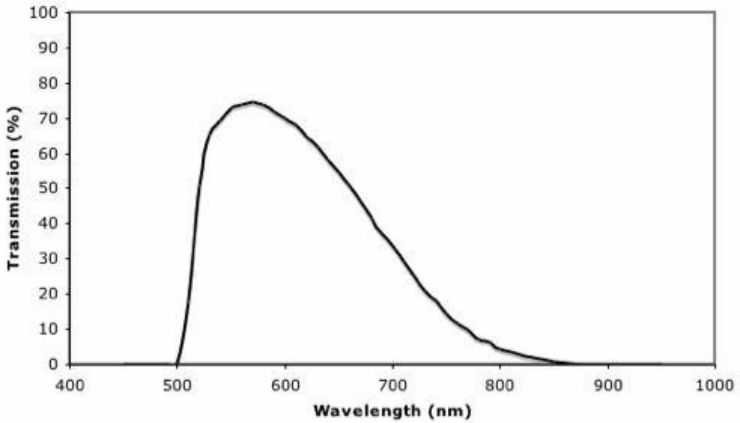
Designed for "rapid" continuous photometry of bright stars with plenty of comparison objects

RISE Characteristics





9.2 arcmin field 0.54"/pixel. Usually used binned 2x2

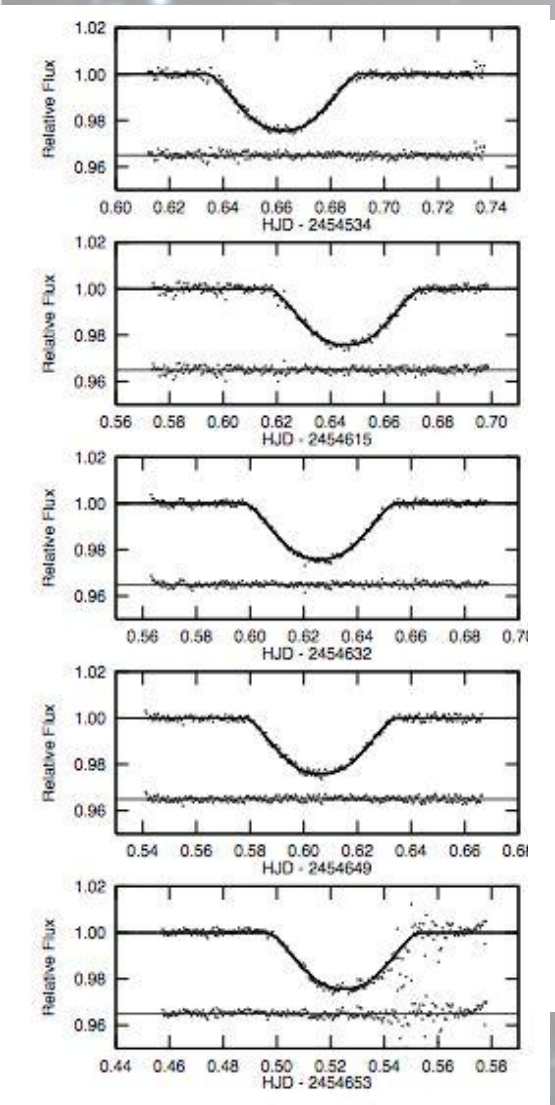


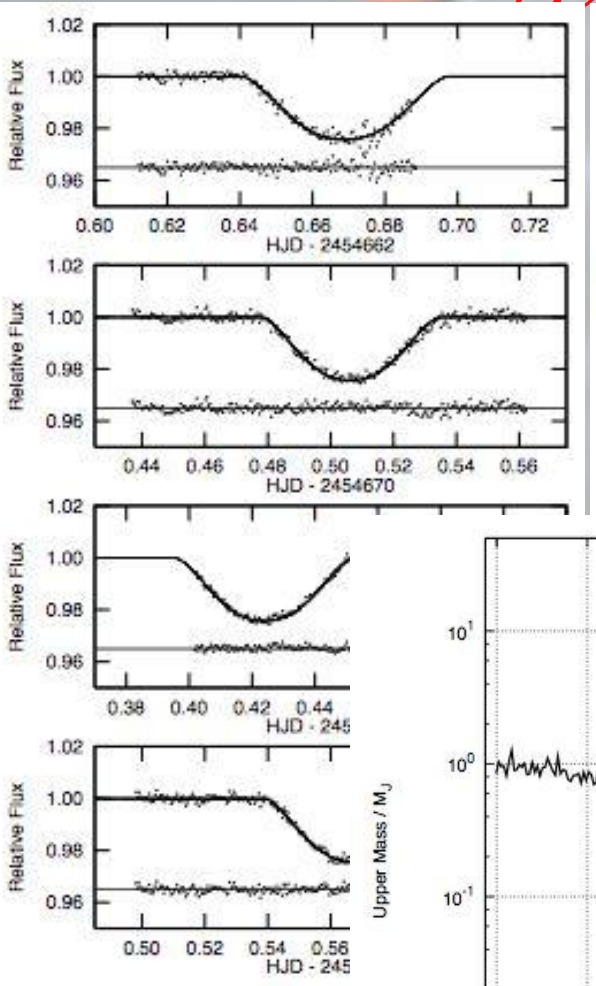
CCD: gain 2.3 e/adu, 10 e ron. Fixed V+R filter

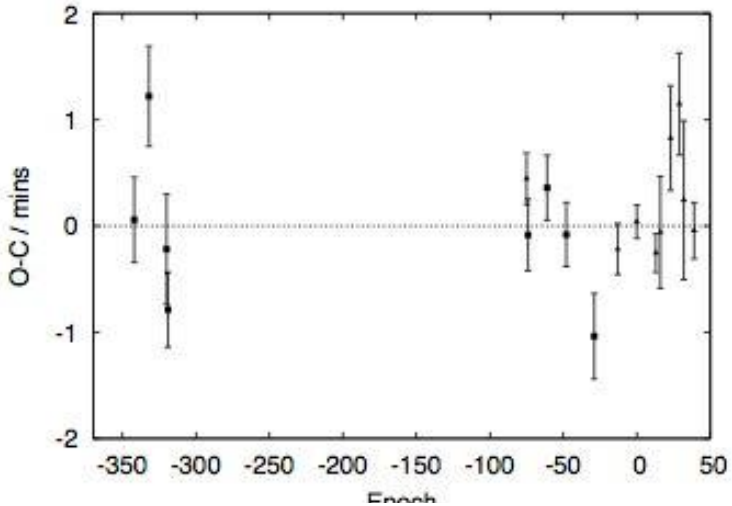
Optical layout matched to LT

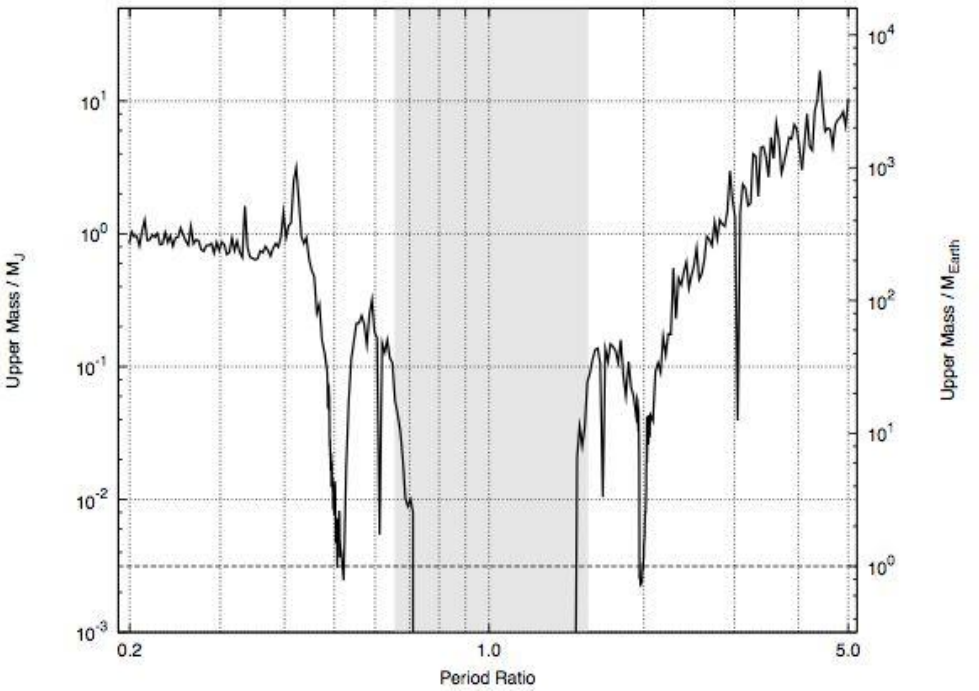
Minimum exposure 0.8s, no readout time

TTV observations of TrES-3b









Gibson et al 2009a

.... and HAT-P-5

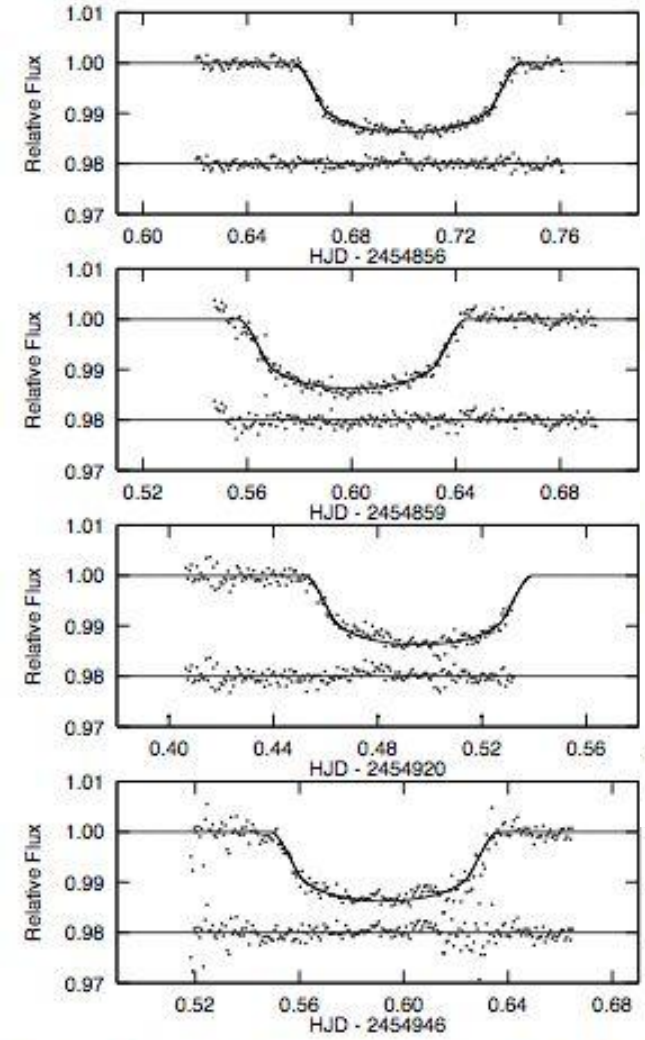


Figure 1. RISE light curves of HAT-P-3 taken from 2009 January 24 to 2009 April 24 in 1 minute bins. Their best fit models are over-plotted and the residuals from the best fit are shown offset

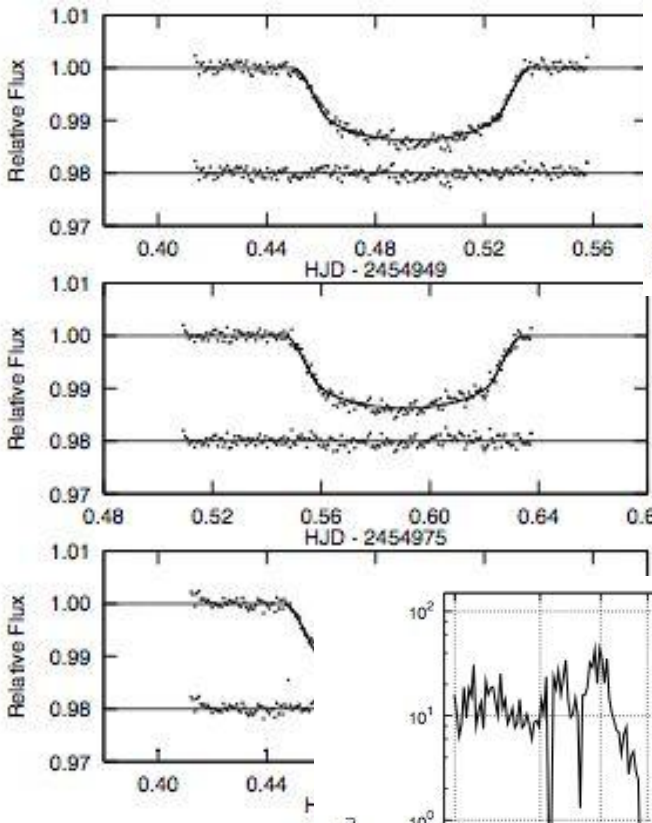


Figure 2. Same as Figure 1, f
April 27 to 2009 May 26.

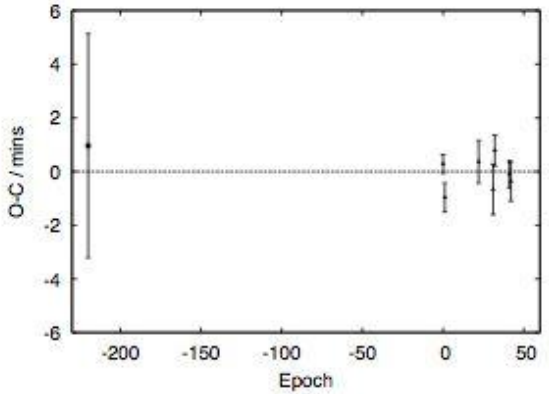
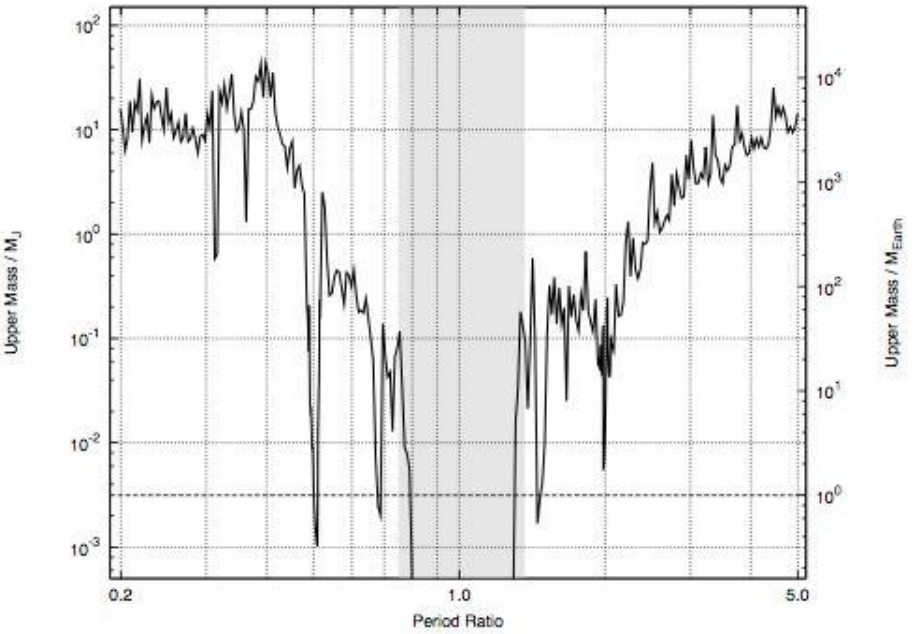


Figure 4. Timing residuals of the RISE transits (triangles) and the discovery epoch from T07 (square) using the updated ephemeris.

Gibson et al 2009b

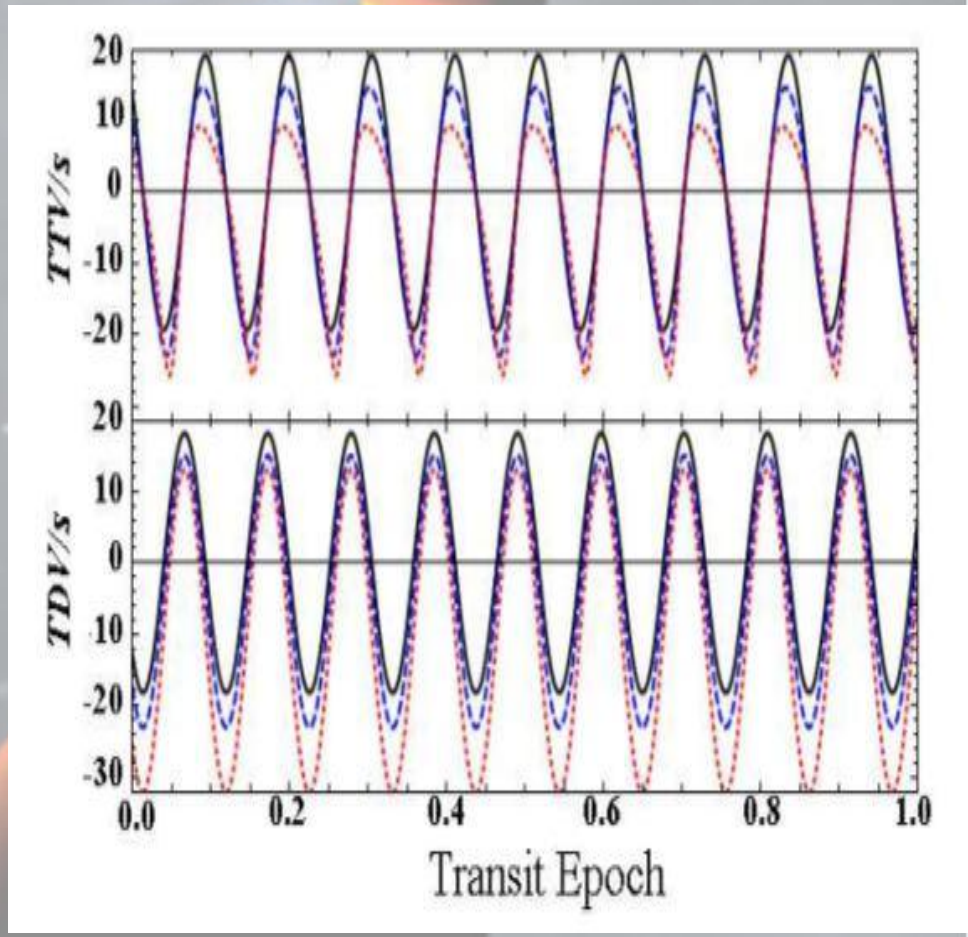


Transit Duration Variations

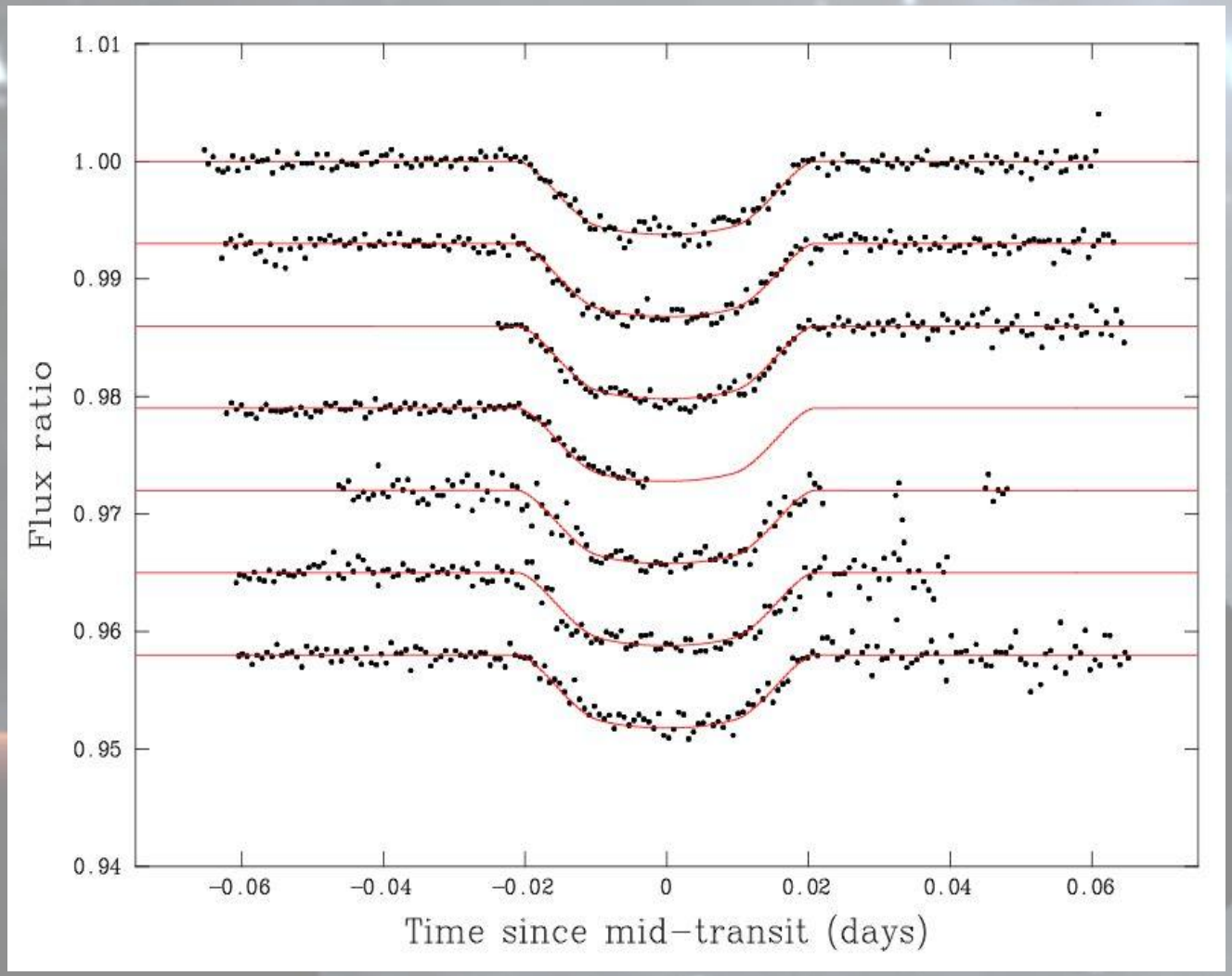
Kipping 2009
Consider an Exo-moon:

- Planet/moon orbit barycentre => oscillatory motion for planet in velocity and position during exo-moon orbit => TTV in usual way but also change in transit duration

- Consider geometry: TTV + TDV out of phase by 90 deg => powerful diagnostic.



LT/RISE observations of GJ436



Fossey, Kipping etc
Feb-june 2009

ΔTTV ~ 14.1s

ΔTDV ~13.5s

Extremely challenging but significant and just do-able with RISE (first 4 lc's have errors of 15sec).

Using RISE in RoPACS

In general the RoPACS targets will be relatively faint at about R~15, however, exposures of 30-60 sec will still deliver photometry at the millimag level => superearths (early M dwarfs). Several things will be important:

1) Calibration files obtained specifically for the night of observations (this isnt normally the case!).
2) Reasonably accurate ephemeris – very important to get 30-45 minutes of pre- and post-transit photometry.
3) Useful number of comparison stars (preferably of the same colour).

Conclusion: best use of LT is for publication quality lc's and not really for filtering mimics

Current RISE ESP Proposals/Projects

1) SuperWASP planet discovery light curves (7 published papers 2008-9)

2) TTV continuation with WASP-12b (2 published papers in 2009)

3) TDV/TTV GJ436 continuation (Fossey/Kipping etc)

4) HAT-P-13 – first double planet – predicted TTV ~20sec, can be used to derive inclination of non eclipsing object with great accuracy.

5) WYFCAM Transit Survey M-dwarf candidates (Pinfield/Hodgkin etc)

6) ESP host star rotation periods

RISE 2!

Greek 2.3m Aristarchos Telescope.

Original idea from John Meaburn – Collaboration of original partners – Need a JMU science collaborator interested in ESP observational science.

Slightly improved copy of LT/RISE. MoU gives 3n/month for 3yr, more possible

Conclusions

The LT has been optimized for obtaining this kind of photometry

RISE is commissioned and is taking (generally) extremely high quality data of ESP targets

RISE/LT on RoPACS targets would be able to deliver publication quality lc for objects as small as SuperEarths (early M dwarfs).