Fast photometry at the Thai 2.4m telescope

Andrea Richichi (NARIT) & Collaborators

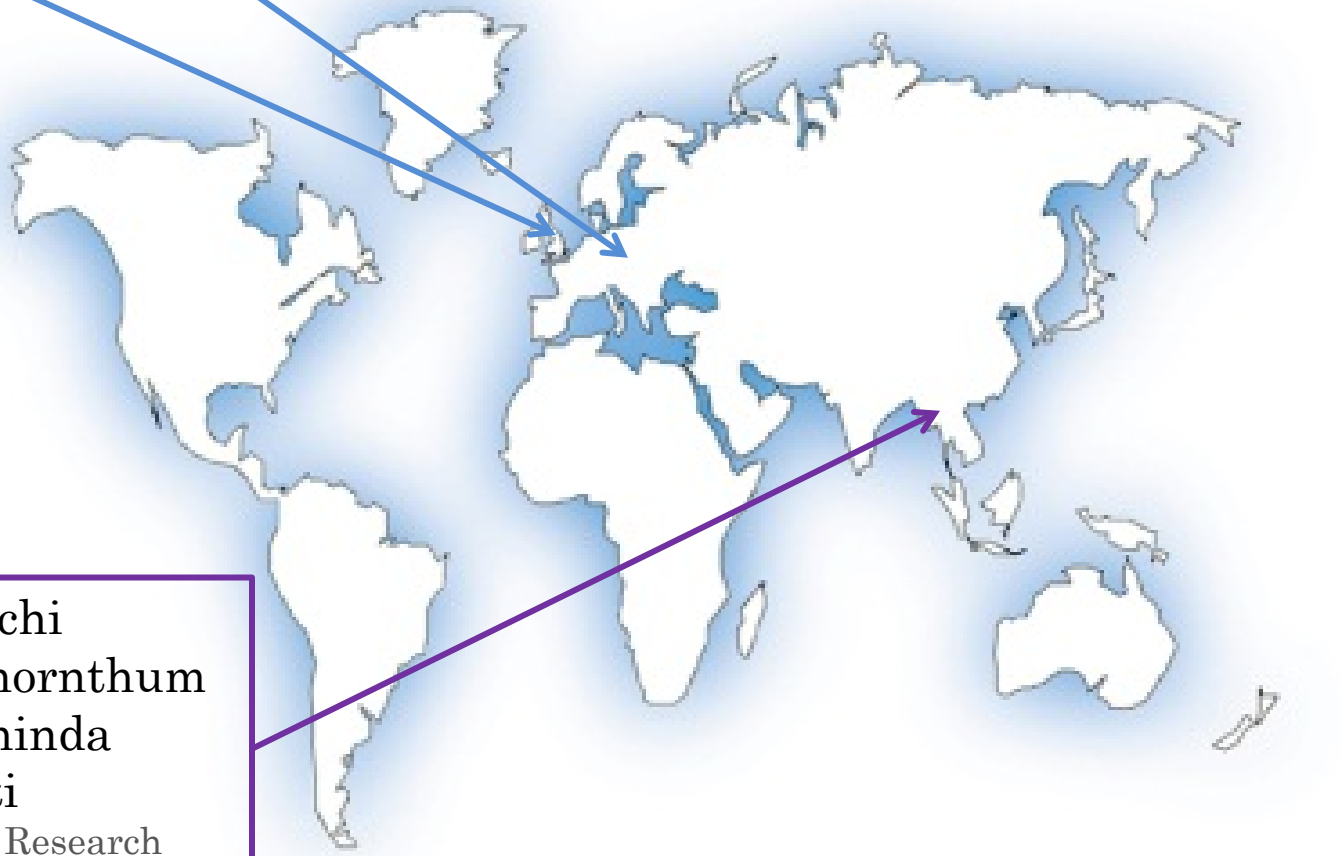
NCU, Taiwan, 15 October, 2013

9th East Asian Meeting on Astronomy

Collaborators

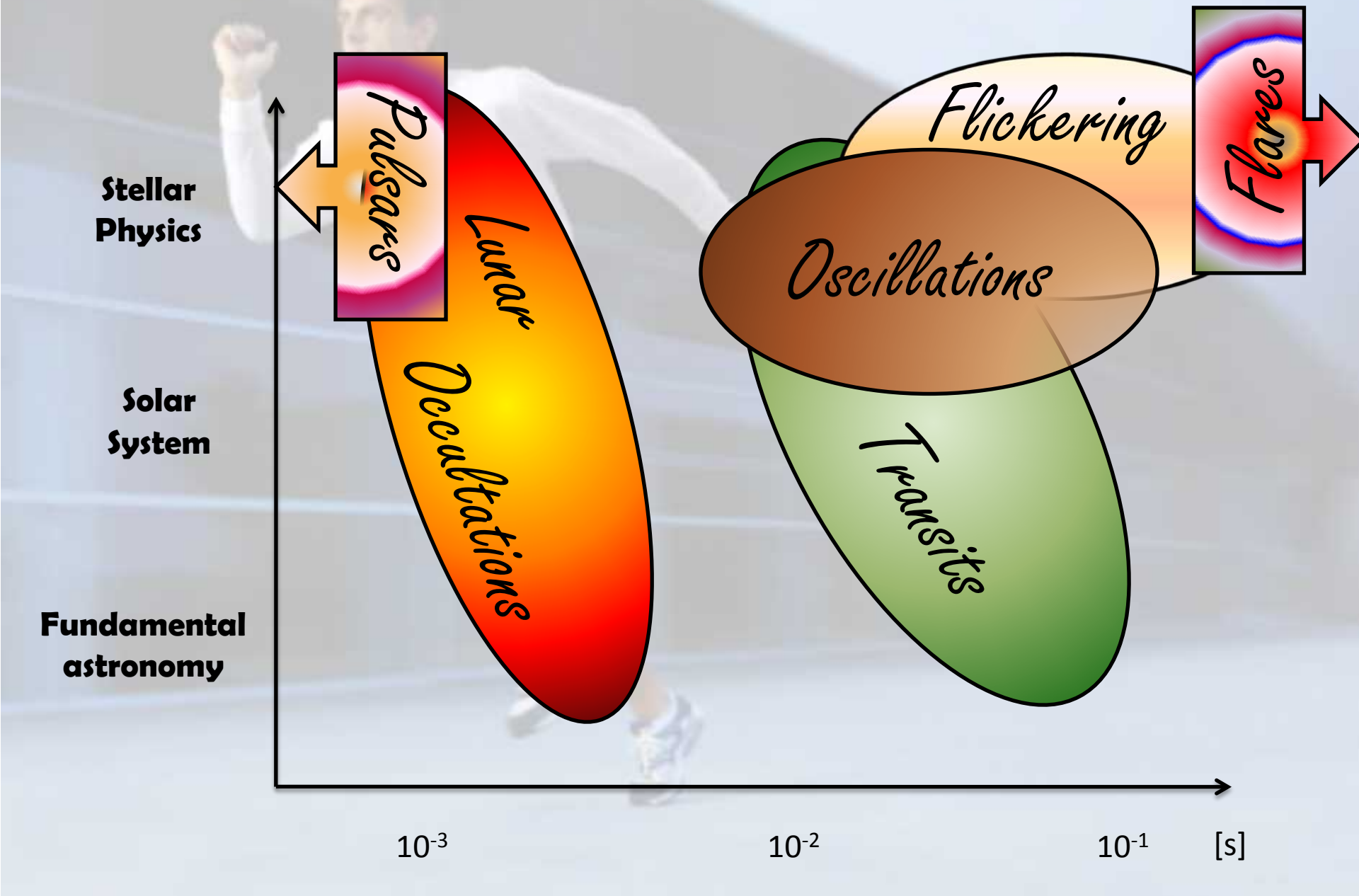
Agnieszka Słowikowska
Univ. of Zielona Góra, Poland

Vik Dhillon
Univ. of Sheffield



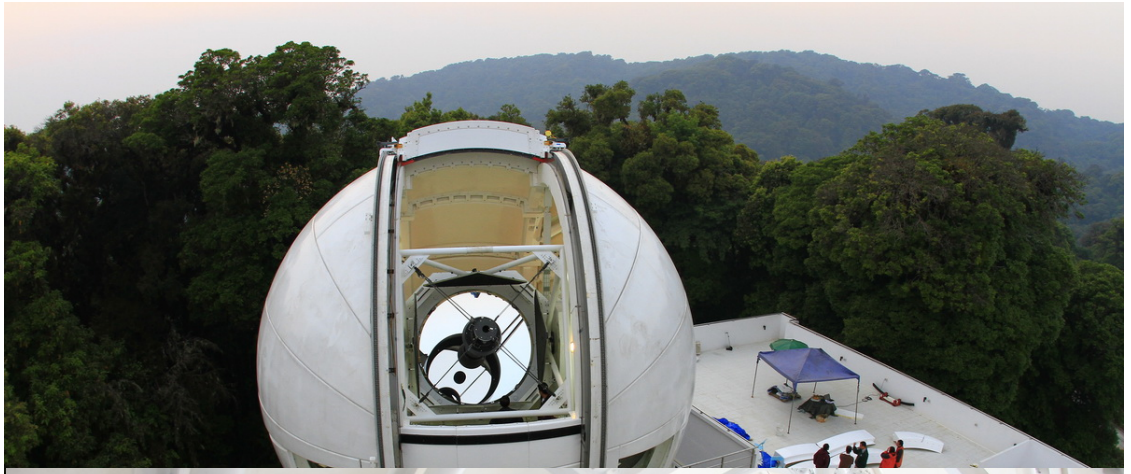
Andrea Richichi
Boonrucksar Soonthornthum
Saran Poshyachinda
Puji Irawati
National Astronomical Research Institute of Thailand

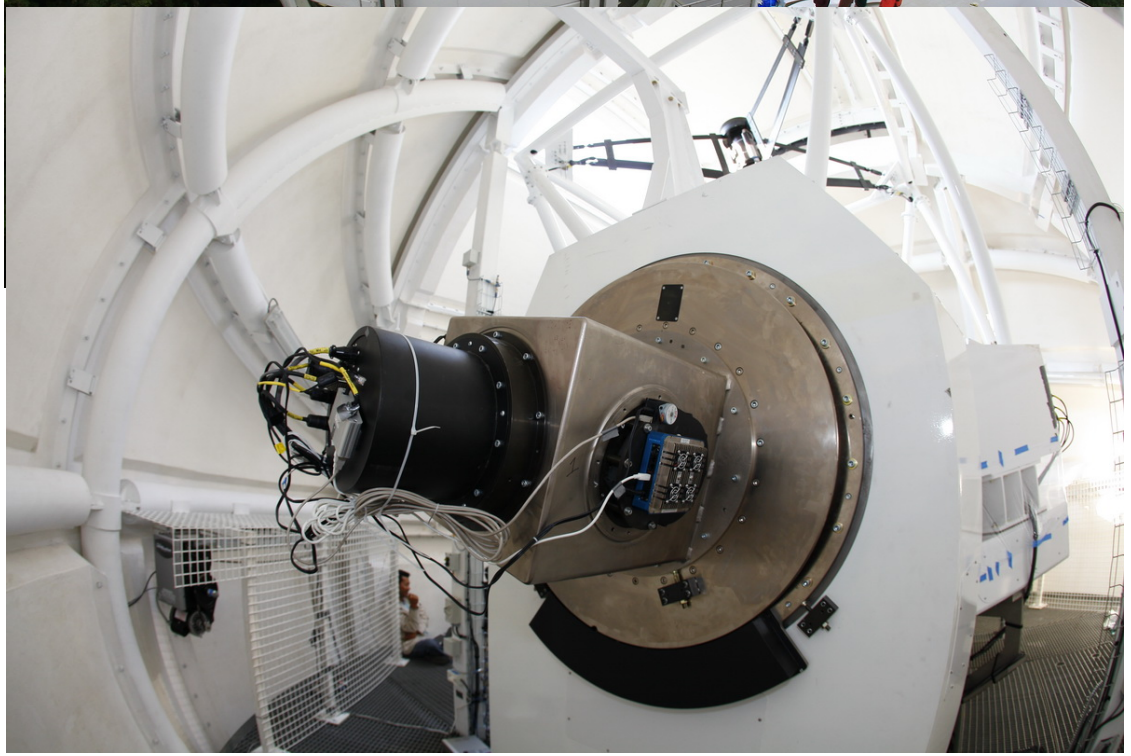
Timing Considerations



Thai National Telescope (TNT)

- 2.4m alt-az Ritchey-Chretien, f/10
- Two Nasmyth foci
- Nasmyth 1 with derotator, 4 ports, autoguider, fiber feeds
- imagers and spectrographs, visitor instruments
- Erected 2012, Inaugurated 2013
- First official season (Cycle 1) to start in November 2013, Call for Proposals, TAC





Also operated by NARIT:

- 0.5m f/6.5 (planning 0.7m)
- 60cm PROMPT8 robotic telescope at Cerro Tololo (incl. polarimeter)

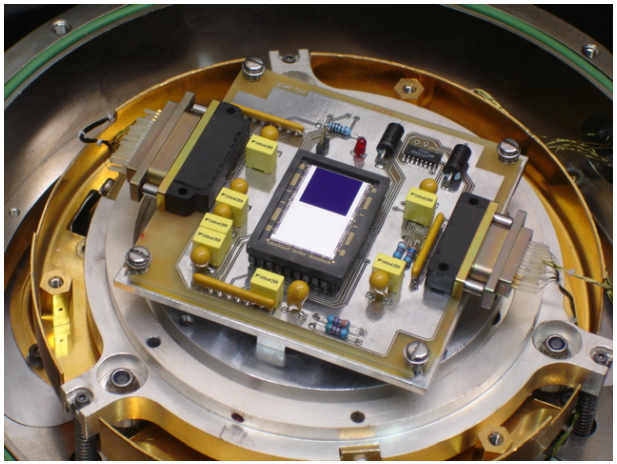
High-Time Resolution Instrumentation at TNT

CCDs

- Apogee U9000 with drift-scan
- ANDOR iKon-L936 in subwindow mode
- up to 2ms, with limitations in time coverage

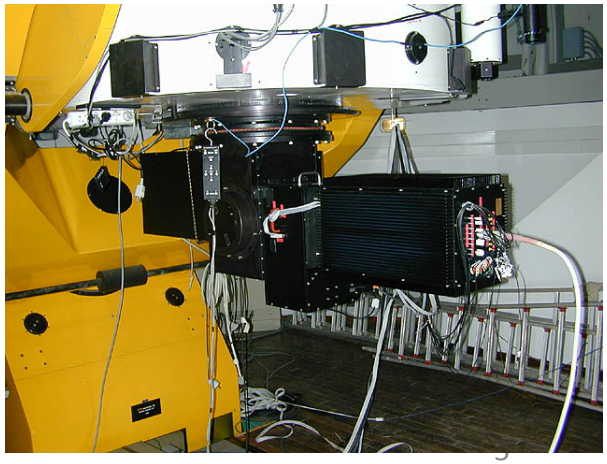
ULTRASPEC

- EMCCD, avalanche mode, frame transfer
- LN_2 cooled
- 1kx1k, 7.7 x 7.7 arcmin
- switchable gain
- 0.005s in subframes



OPTIMA (*TBC*)

- 12 APDs, fiber-fed
- photometry, polarimetry
- 10^{-6} s resolution
- accurate GPS timing
- plans for Cycle 2 visitor instrument at TNT



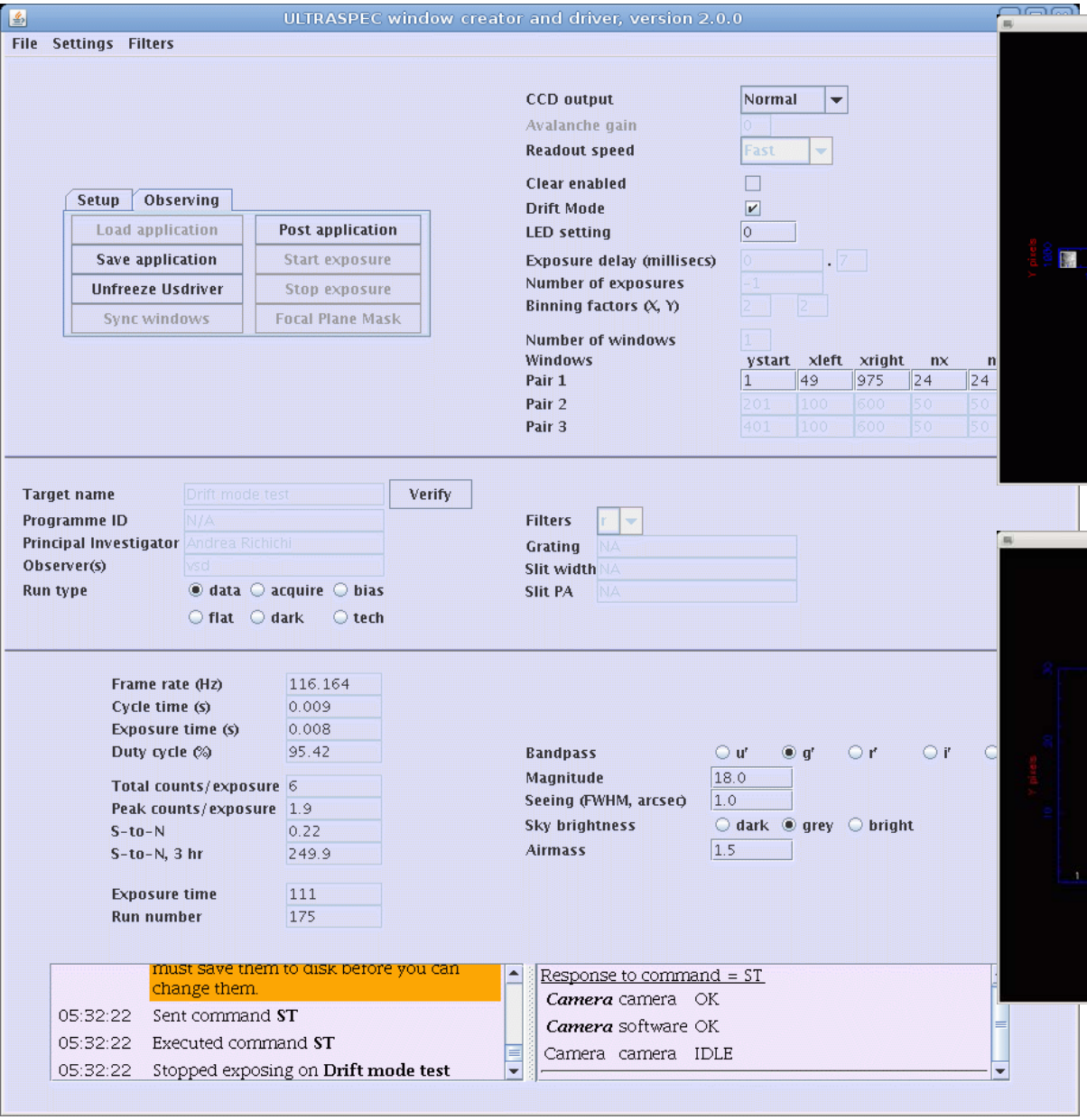
ULTRASPEC @ TNT

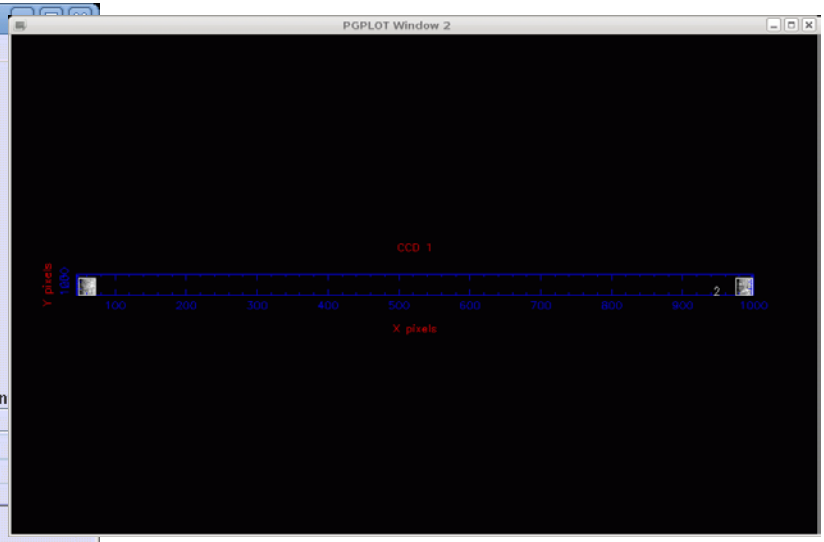
Built by Sheffield/Warwick/UKATC

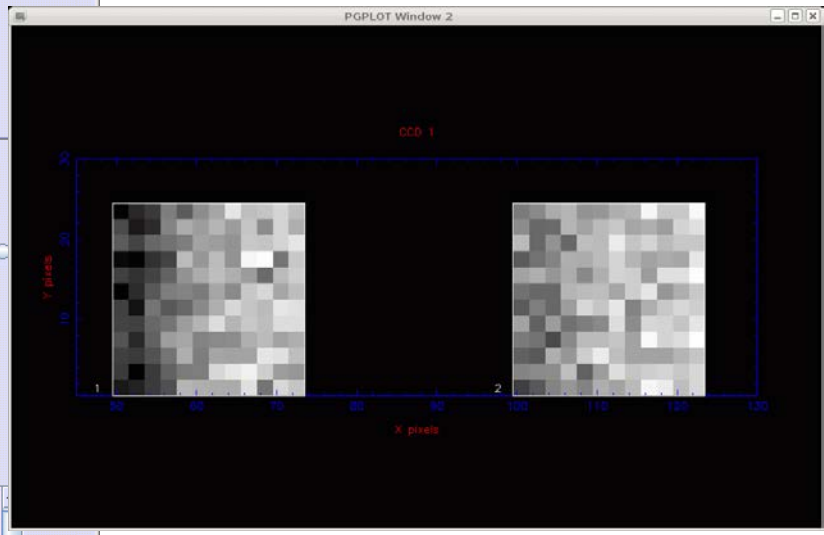
PI: Vik Dhillon, Univ of Sheffield

- Frame-transfer EMCCD
- Previously used on ESO3.6m and NTT
- MoU signed with NARIT in 2012
- New Optics (0.45”/pixel, 7.7’ FOV)
- 2 filter wheels, wide options
- At TNT: g’=24 in 30 min @ SNR=10 (TBC)
- Subframe readouts up to 400+ Hz
- Compact objects (isolated and in binaries), transients/survey follow-up
- Installation Aug 2013
- Commissioning Nov 2013
- 22 nights GTO in Cycle 1

ULTRASPEC GUI





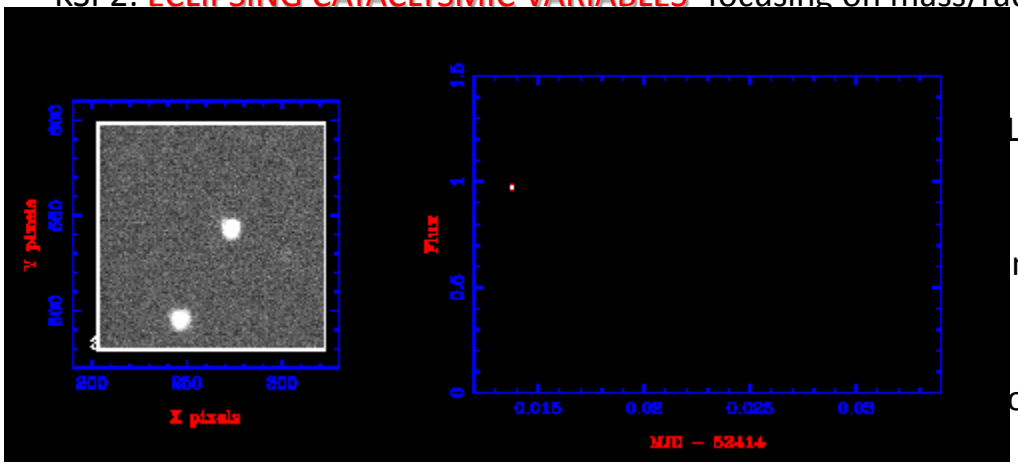


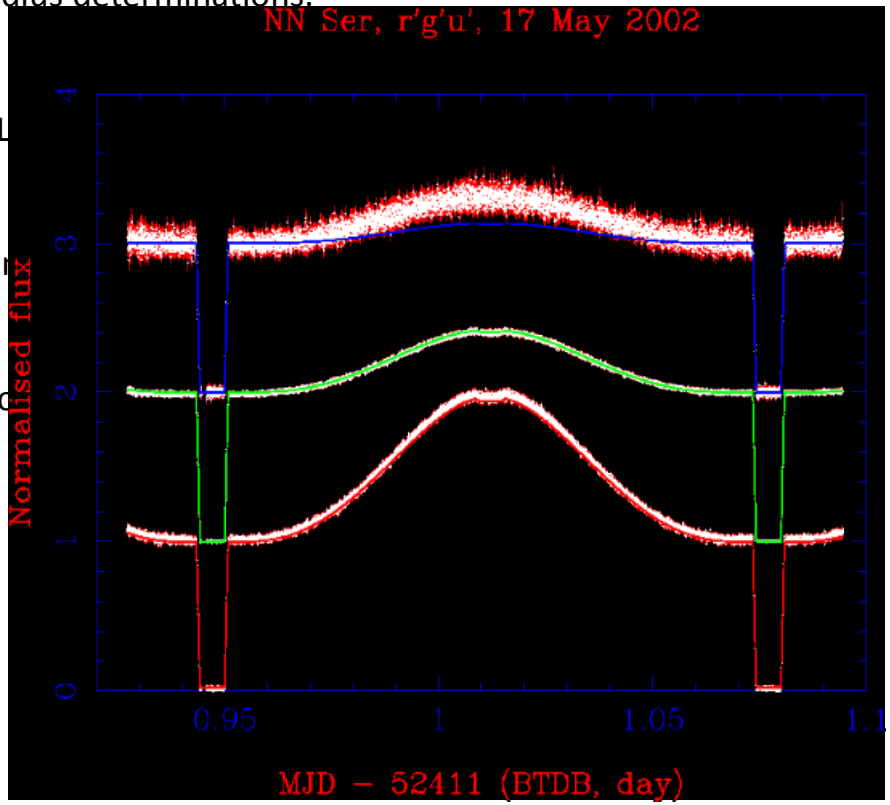
ULTRASPEC Science

KSP1: PULSARS -both isolated (i.e. AXPs, SGRs, RRATs, XDINS, radio pulsars, Fermi pulsars) and in binaries (e.g. MSPs).
Leader: Dhillon (Sheffield)

- NN Ser: an eclipsing WD+RD detached binary (ULTRACAM)

KSP2: ECLIPSING CATACLYSMIC VARIABLES -focusing on mass/radius determinations.





Brinkworth et al. (2006)
Later detections of planet(s) (Chen 2009, Parsons 2009, Qian 2009)

KSP6: AM CVN STARS
Leader: Steeghs (Warwick)

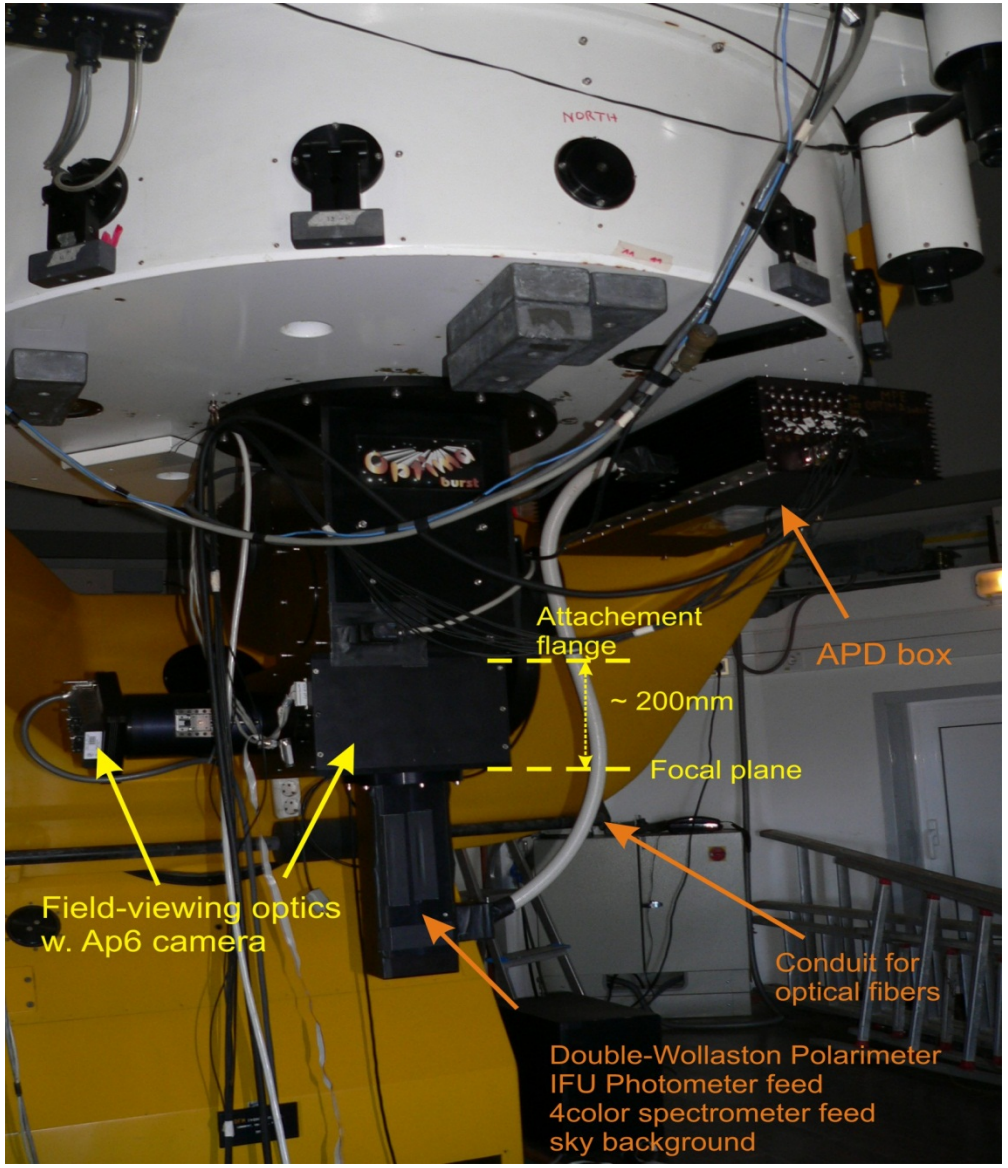
KSP7: GAMMA-RAY BURSTS
Leader: Levan (Warwick)

KSP8: OCCULTATIONS AND TRANSITS
Leader: Richichi (NARIT)

Optical Timing Analyzer (OPTIMA)

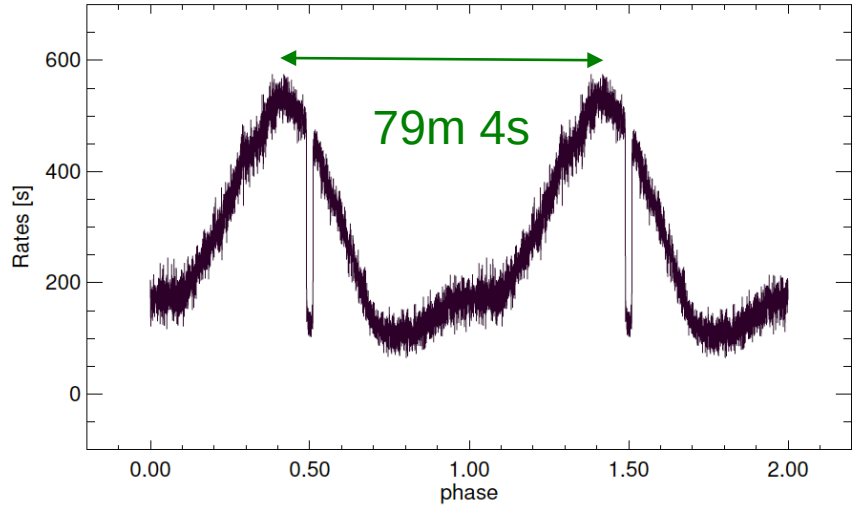
Gottfried Kanbach & Arne Rau
Max-Planck-Institut für
Extraterrestrische Physik, Germany
Agnieszka Słowikowska
University of Zielona Góra, Poland

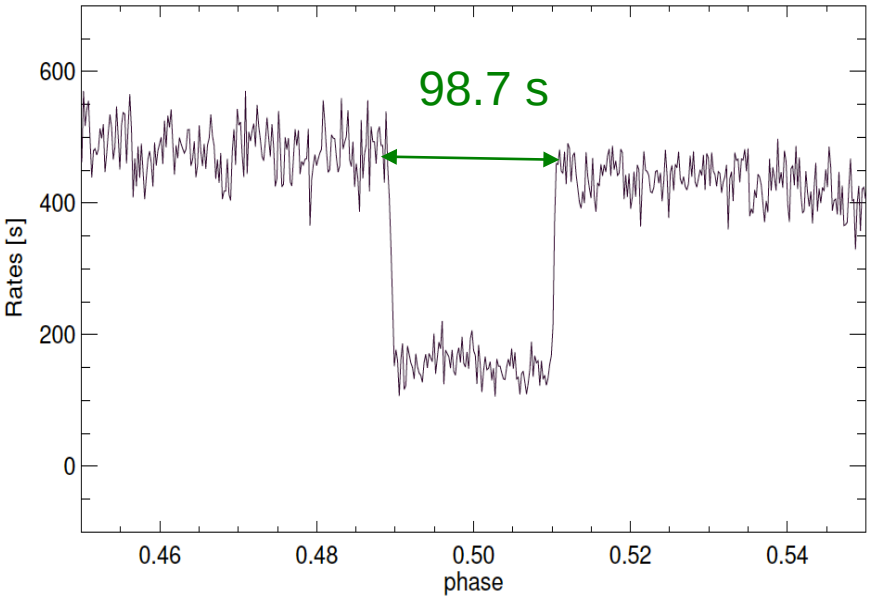
- Photon counting APD detectors, λλ=450-900 nm
- seeing-matched fibers with background subtraction
- Estimated m_v=20 in 1 s at TNT
- Polarimetric mode
- μs resolution, 5ns timing relative to GPS
- fast variable sources: pulsars, magnetars, cataclysmic variables, X-ray binaries, flare stars
- Possible deployment at TNT in Nov 2014 (Crab)



OPTIMA at the 1.3m telescope in Skinakas (Crete, Greece)

OPTIMA: the polar CV RXS J1845+4831





The extremely short orbital period of 79m 04s and eclipse duration of 98.7s show this system to be in an extreme state of binary evolution

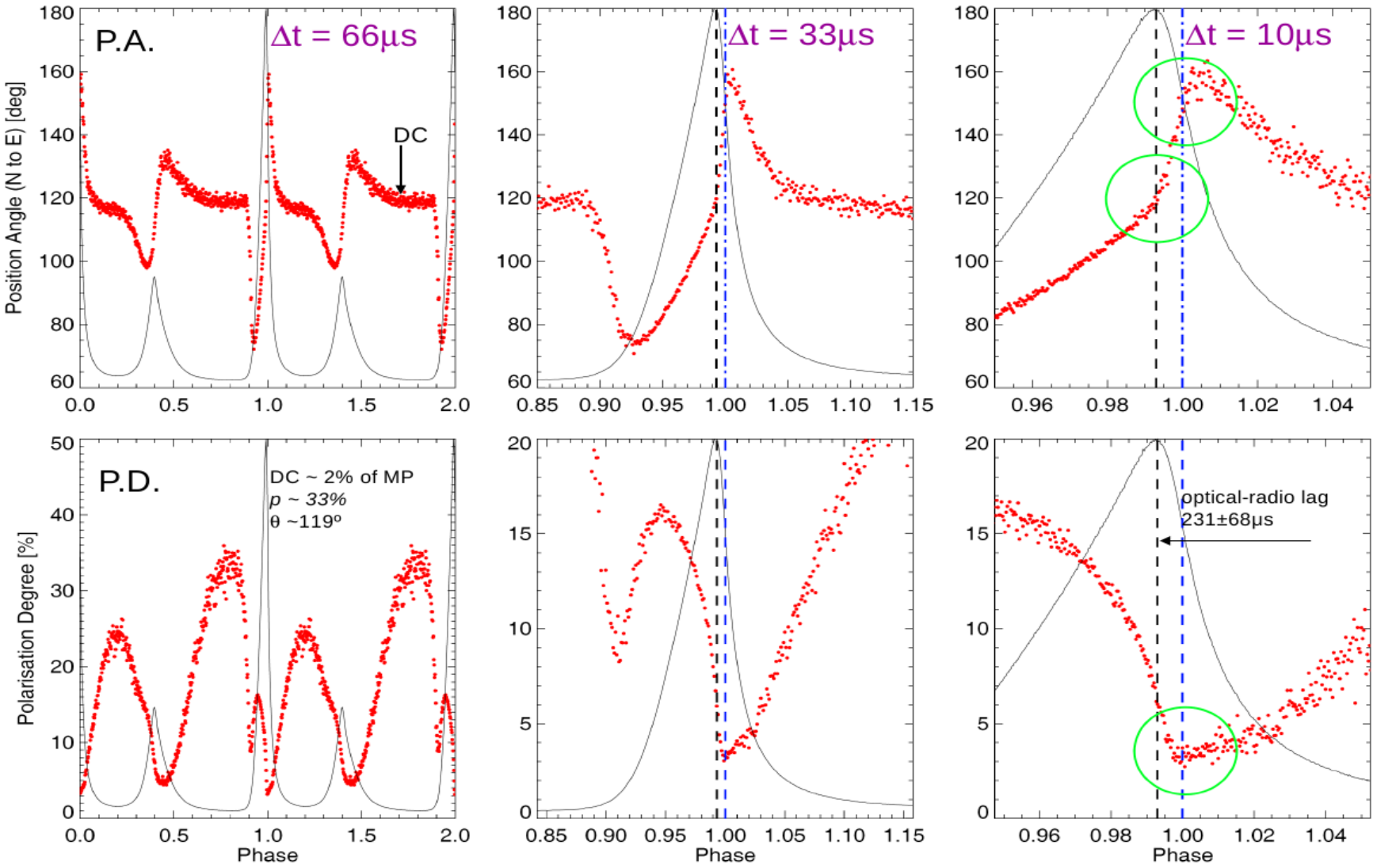
Sharp ingress/egress and flat bottom (i.e. no change in brightness)

Overall minimum of lightcurve (m ~ 20) is deeper than eclipse:

- There must several components of emission:
- The bright spot (small and well defined)
- An accretion disk or stream
- the irradiated secondary

(Rau et al in preparation, 2013)

The Crab pulsar: time-resolved polarization



Słowikowska et al. 2009, 2013

HTR projects at TNT in Cycle 1

Nov 5-13, 2013: **ULTRASPEC** on-sky commissioning and first GTO science
Total of 22 nights GTO, including Jan and Mar 2014

(preliminary Open Time allocation, TBC)
39 full and **13 partial** nights dedicated to ULTRASPEC, most requested instrument
Pulsations, Exoplanet Transits, Lunar Occultations, Trans-Neptunian Occultations, Times of
Minima in Compact Binaries, Flickeri

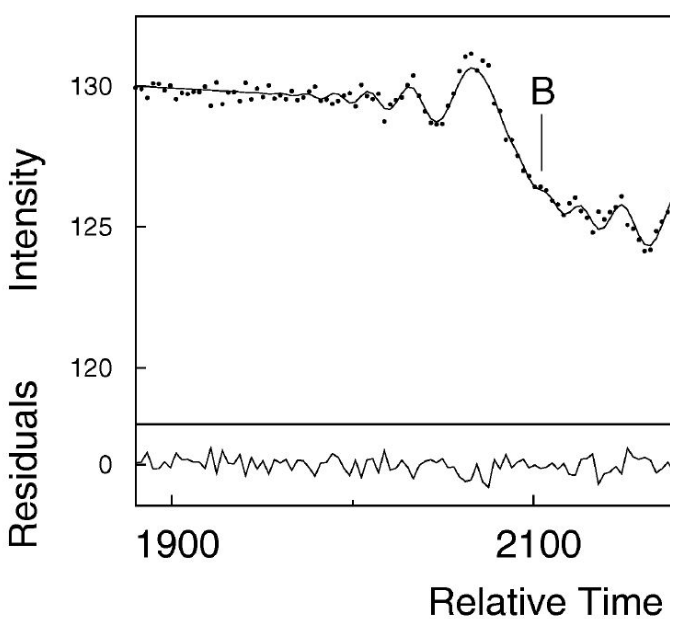
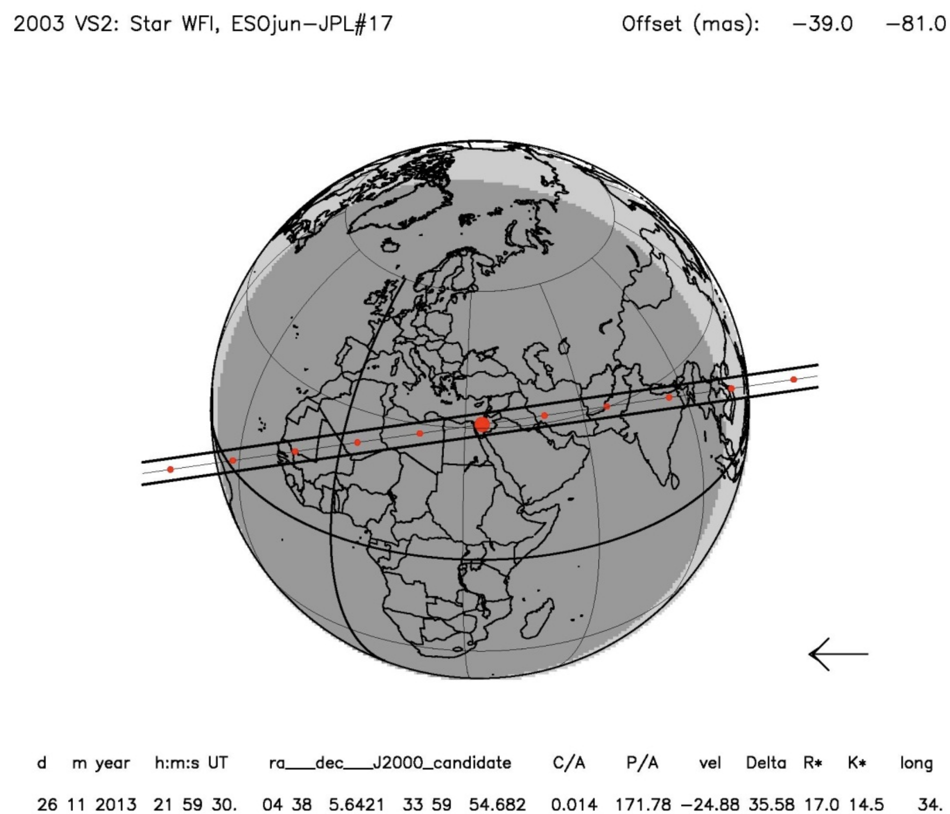


Figure 3. Occultation light curve (dots) and best fit
newly detected pre-main-sequence binary. The tim
of the two components are marked. The lower pan

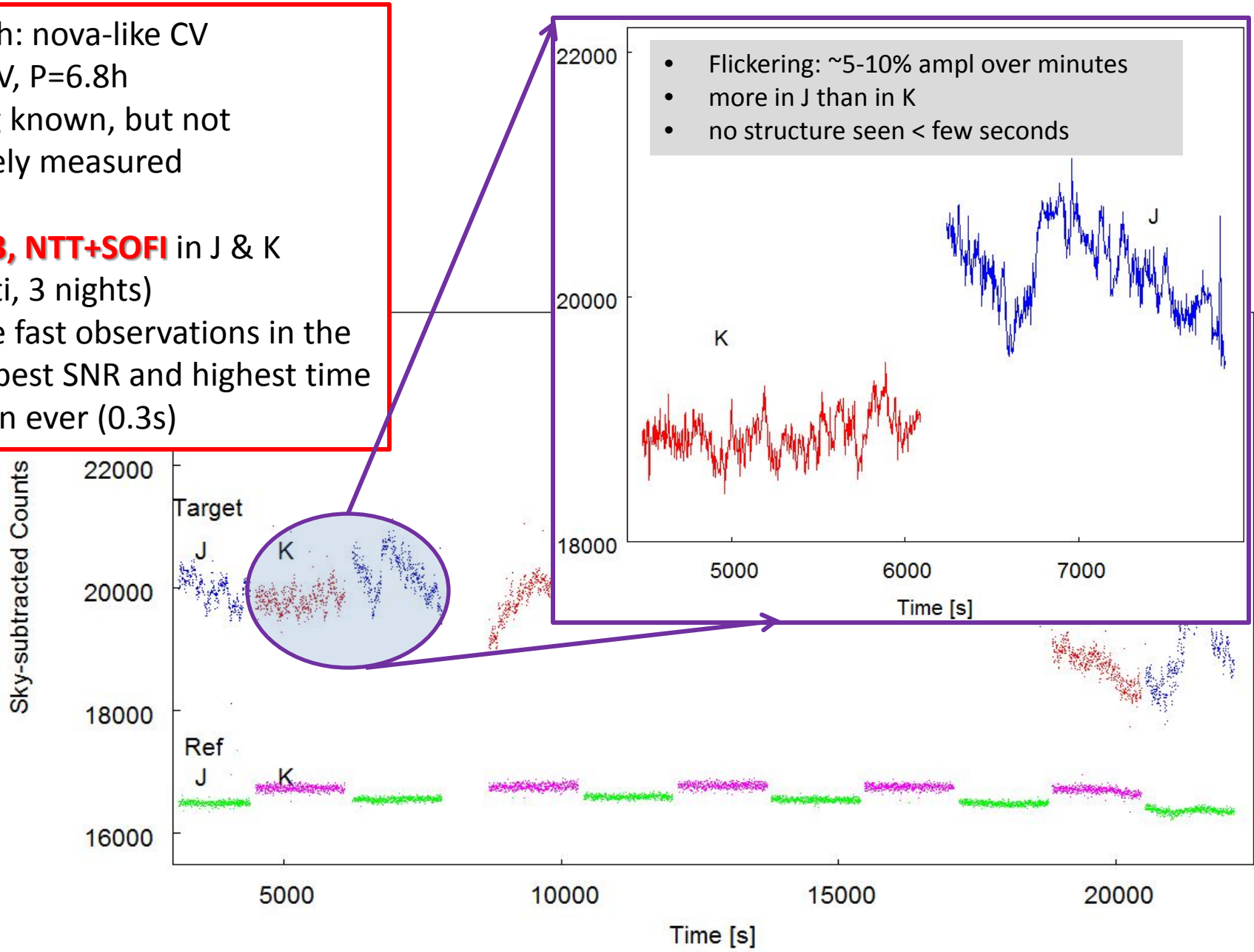
The occultation of a R=16.5 mag star by the TNO 2003-VS2, predicted to be visible from Doi Inthanon on November 26, 2013.



Flickering in CVs

V426 Oph: nova-like CV
WD + K3V, P=6.8h
flickering known, but not extensively measured

July 2013, NTT+SOFI in J & K
(P. Irawati, 3 nights)
First time fast observations in the near-IR, best SNR and highest time resolution ever (0.3s)



Concluding Remarks

- The Thai 2.4m telescope is ideally equipped to pursue high-time resolution observations
- Short events (few seconds) can be sampled up to 2ms using specialized modes on commercial CCDs
- The state-of-the-art ULTRASPEC instrument can be used for fast imaging on fields from 7'x7' to 4"x4" with speeds up to 4ms
- Cycle1 observations about to start, restricted to Thai and MoU institutes (shared-risk basis)
- Cycle 2 plans include more science nights in an open call
- Addition of OPTIMA as a visitor instrument for resolutions up to μs
- emphasis on collaborative networks for transients and transits
- complement the 2.4m by adding observational opportunities at other sites co-funded by NARIT

Extra Slides

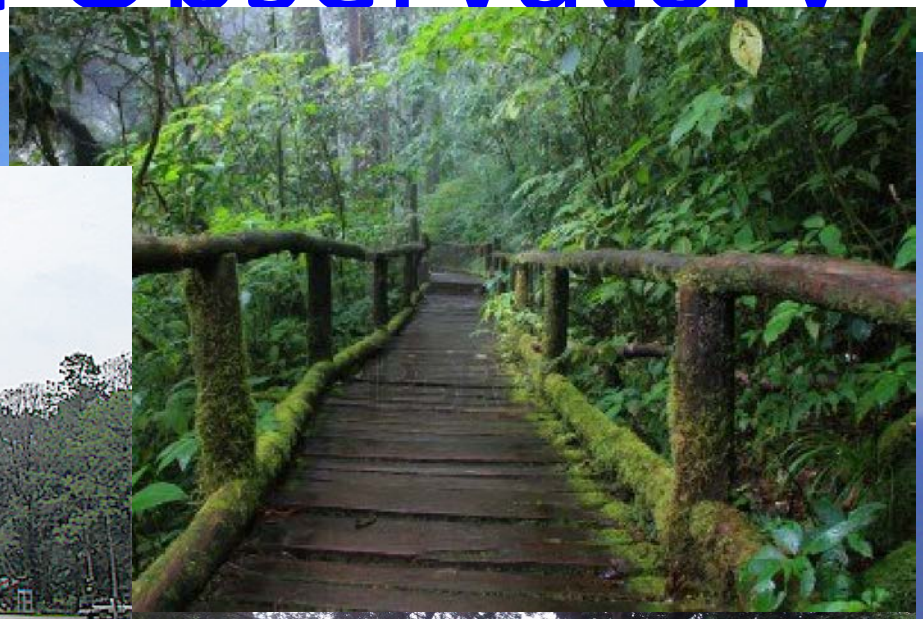
NARIT and the TNO

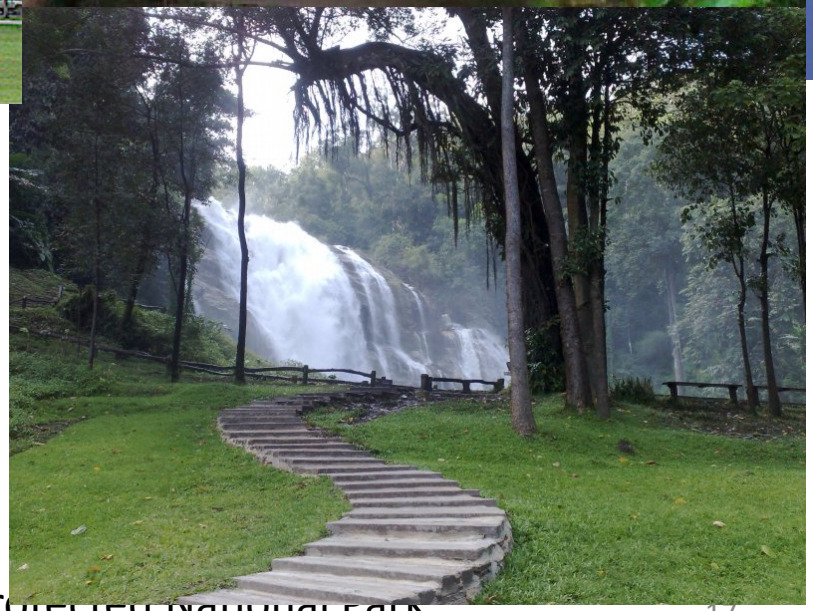
- National Astronomical Research Institute of Thailand
- Public Organization (Min. of Science and Technology)
- 100+ staff, of which ~10 Thai and international researchers and postdocs
- stellar and extragalactic astrophysics, cosmology, optical and radio, theory and observations

NARIT Mission:

- develop human resources and technology
- leading astronomical center in SE Asia
- establish international collaborations (SEEAN)
- additional strategic directions: Antarctica, Radio Astronomy, Climate

Thai National Observatory





Doi Inthanon at 2,457 m above mean sea level

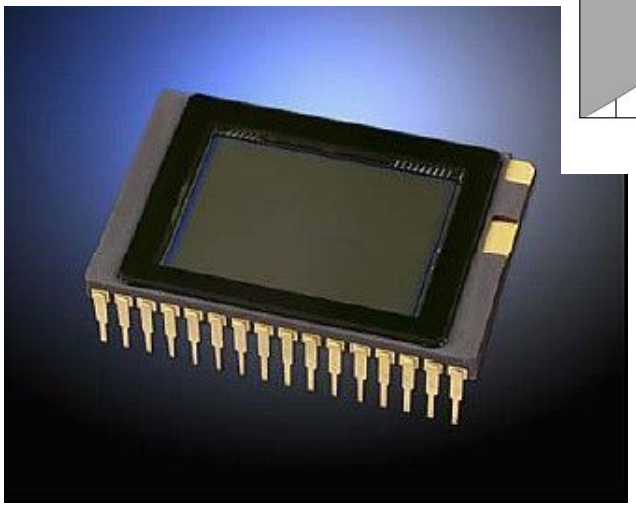
Latitude : 18 deg 34’ 21” N
Longitude : 98 deg 29’ 7” E

Observing window : October to May
Average seeing : ~1 arcsec
Typical temperatures : +5^{o}C to +15^{o}C
Mostly above the local inversion layer, located in a protected National Park

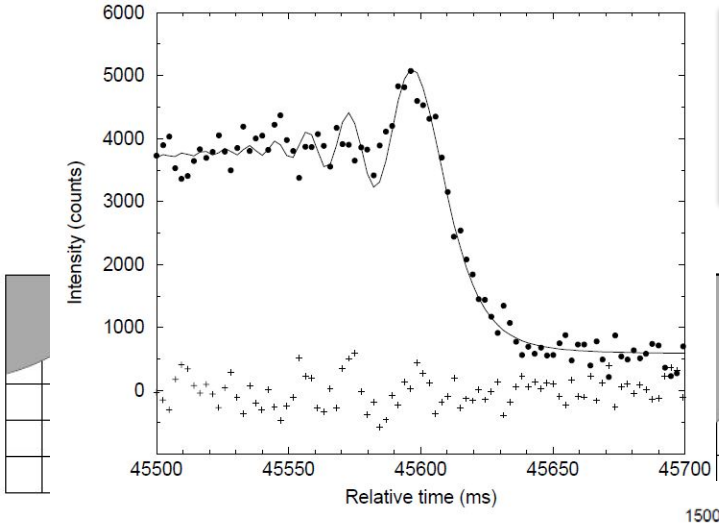
Drift-Scanning CCDs

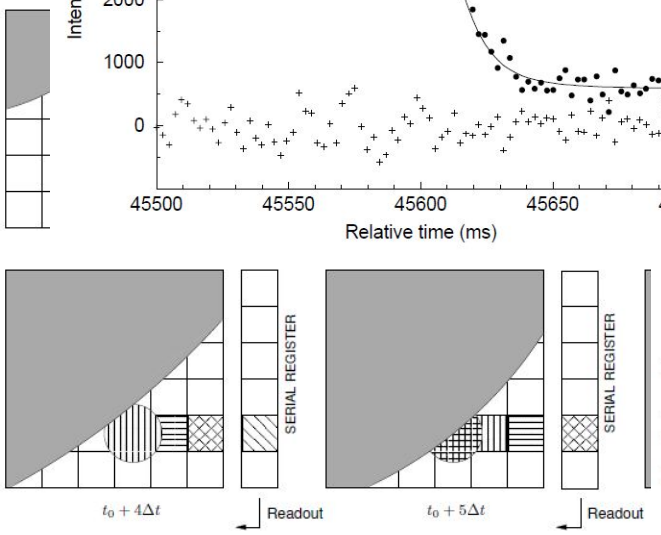
- affordable
- ms Time Resolution
- choice of pixel (low background noise)

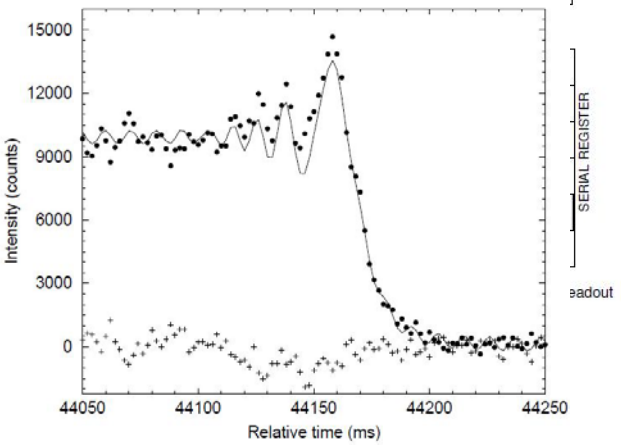
- need correct pixel scale
- limited time range

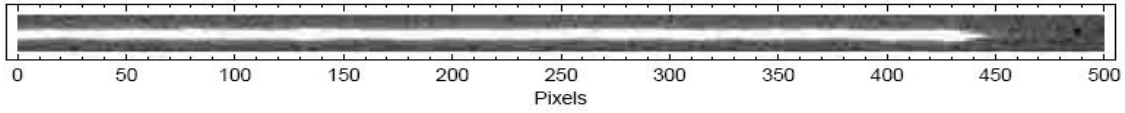


TNO 2.4m has Apogee 9000 with 2ms time resolution









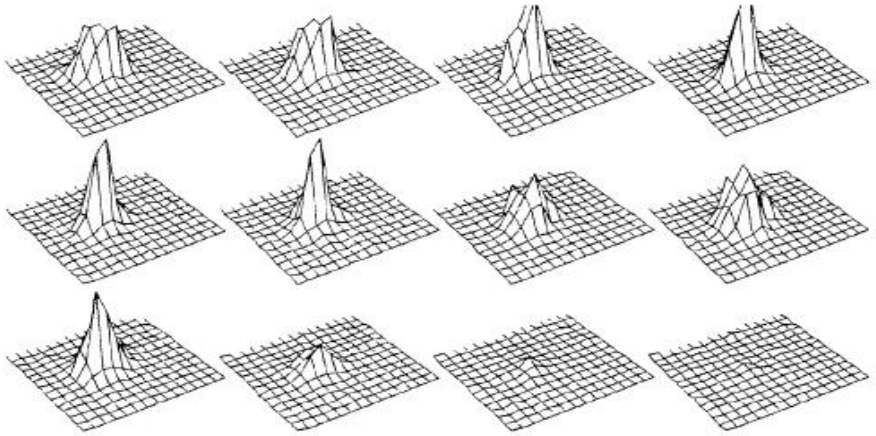
Fors et al (2001)

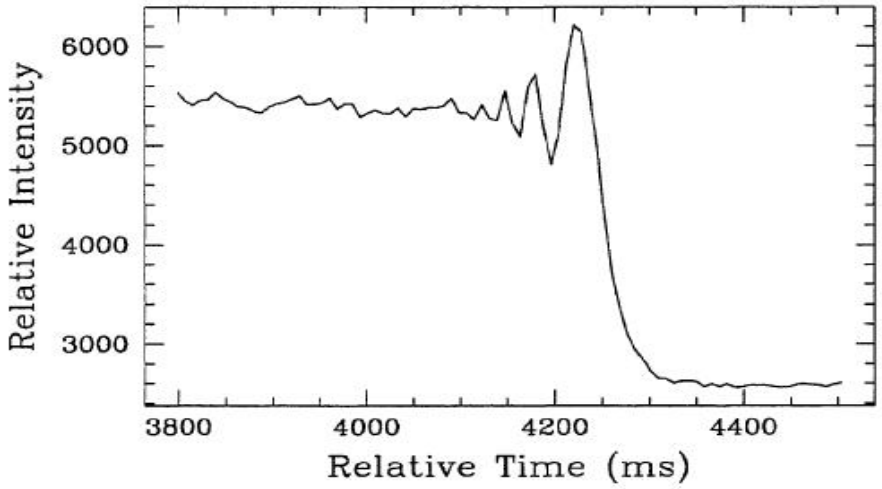
Subwindows

- ms Time Resolution
- gapless
- long time range

- ~~expensive~~
- ~~sophisticated ROE~~

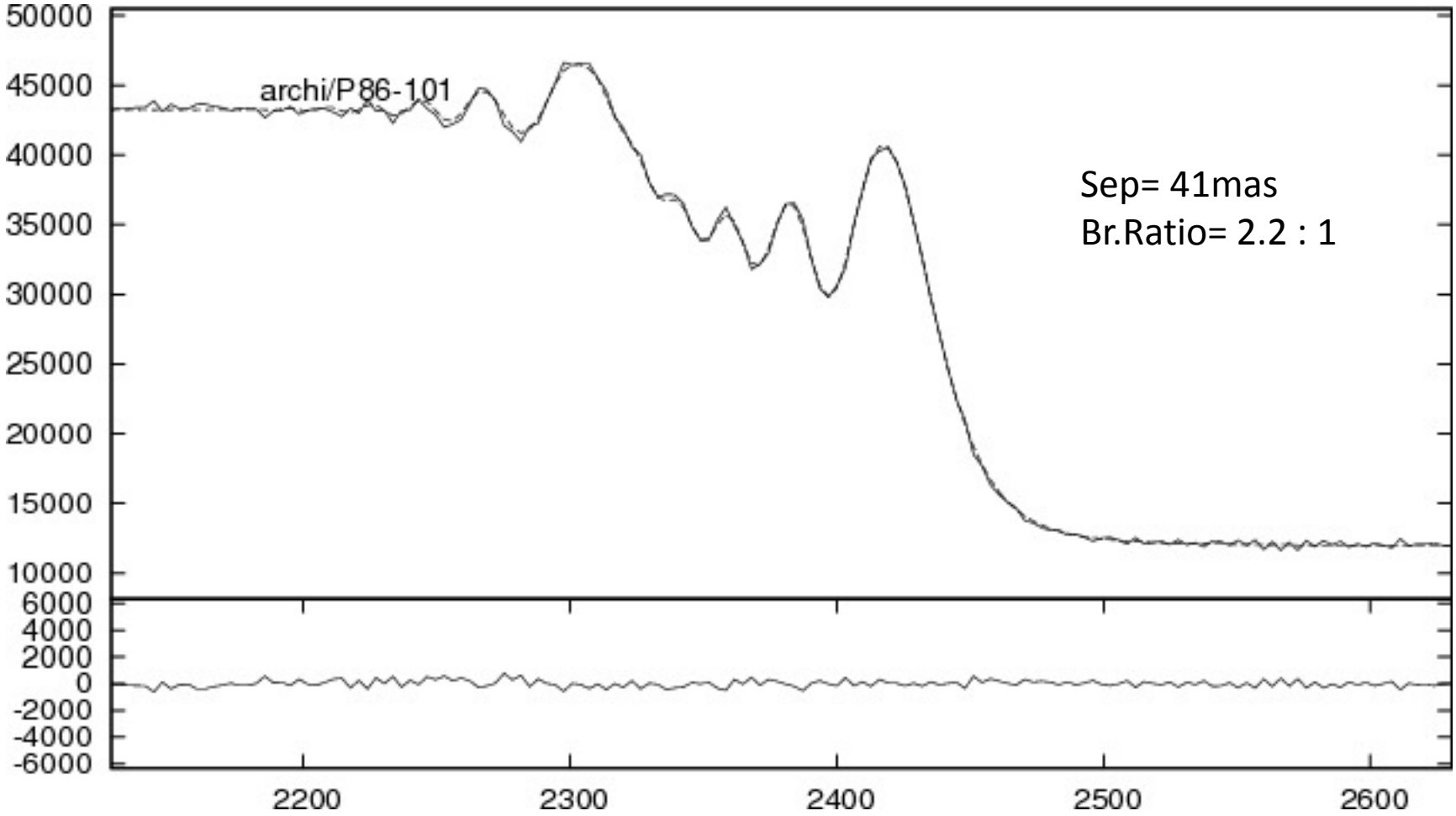
Now also implemented on CCDs





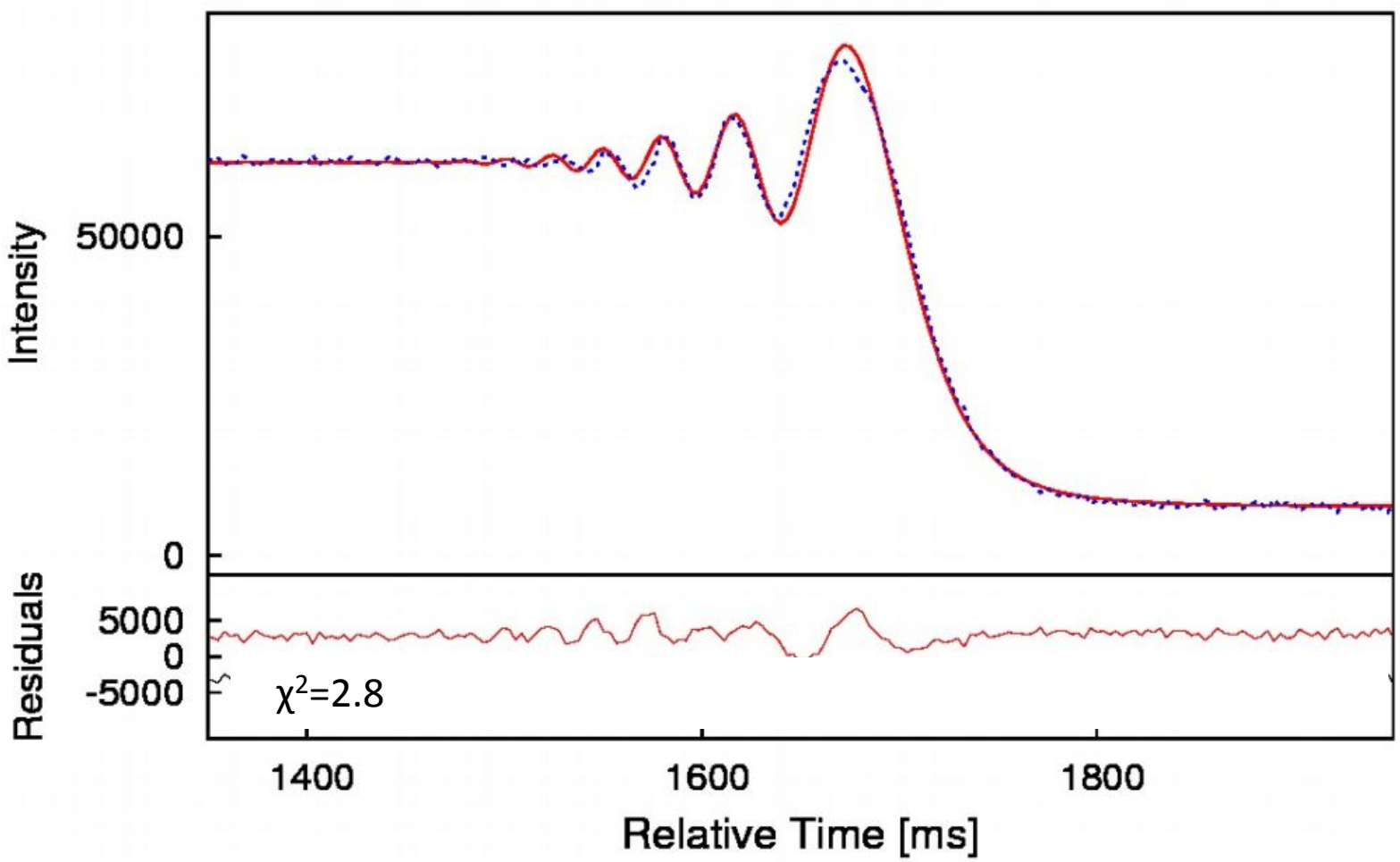
ARNICA (Richichi et al 1996)

Example of a binary star (easy)



Example of a binary star (harder)

2MASS17073892-2554521, K=5.21



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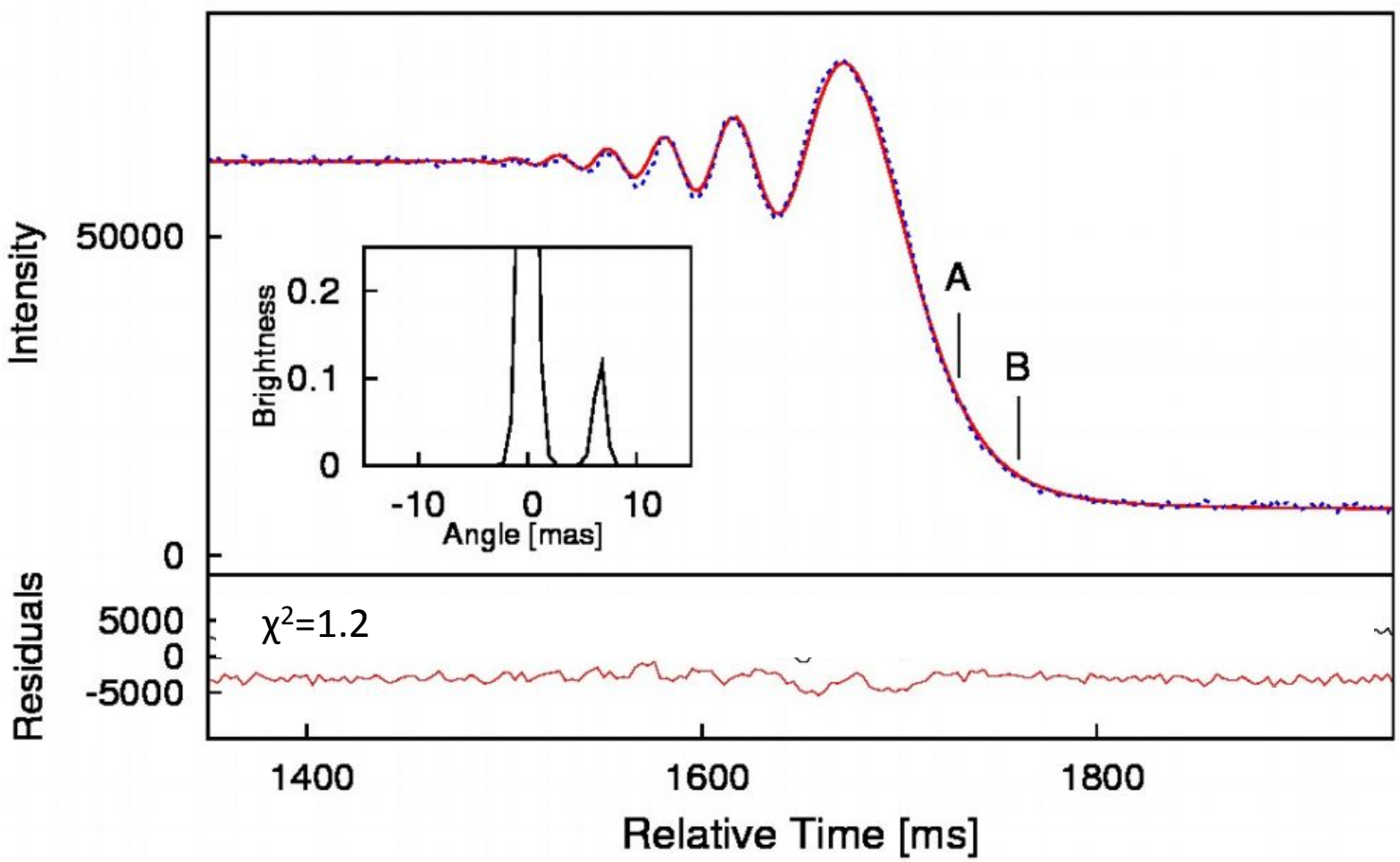
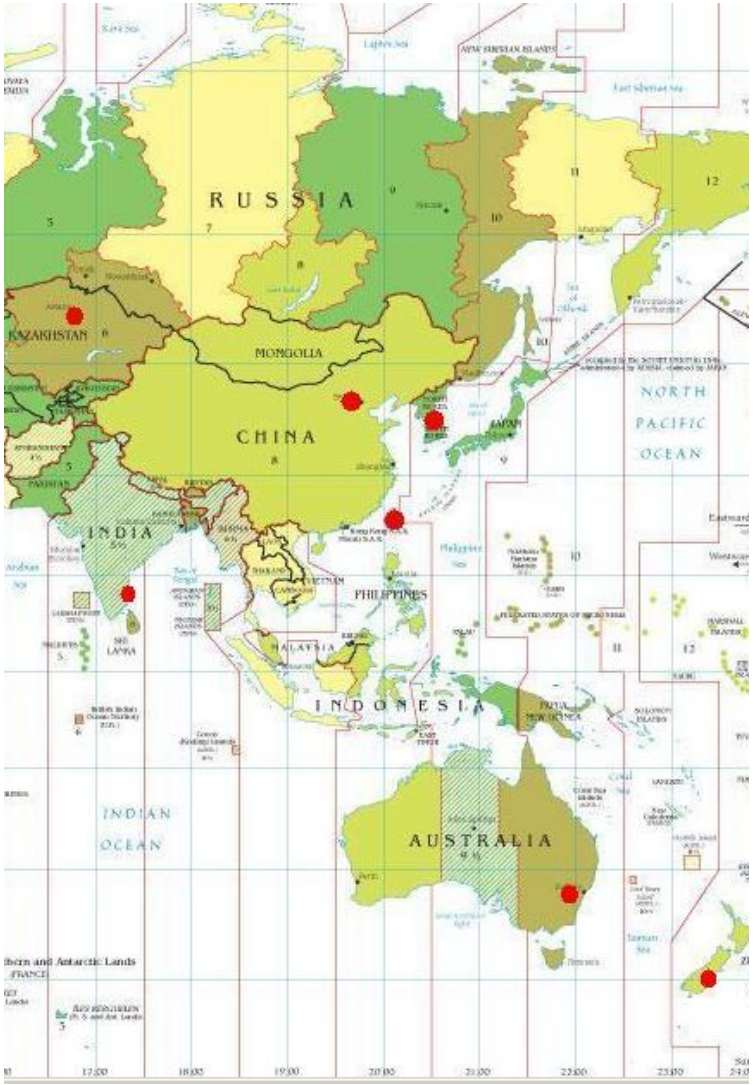
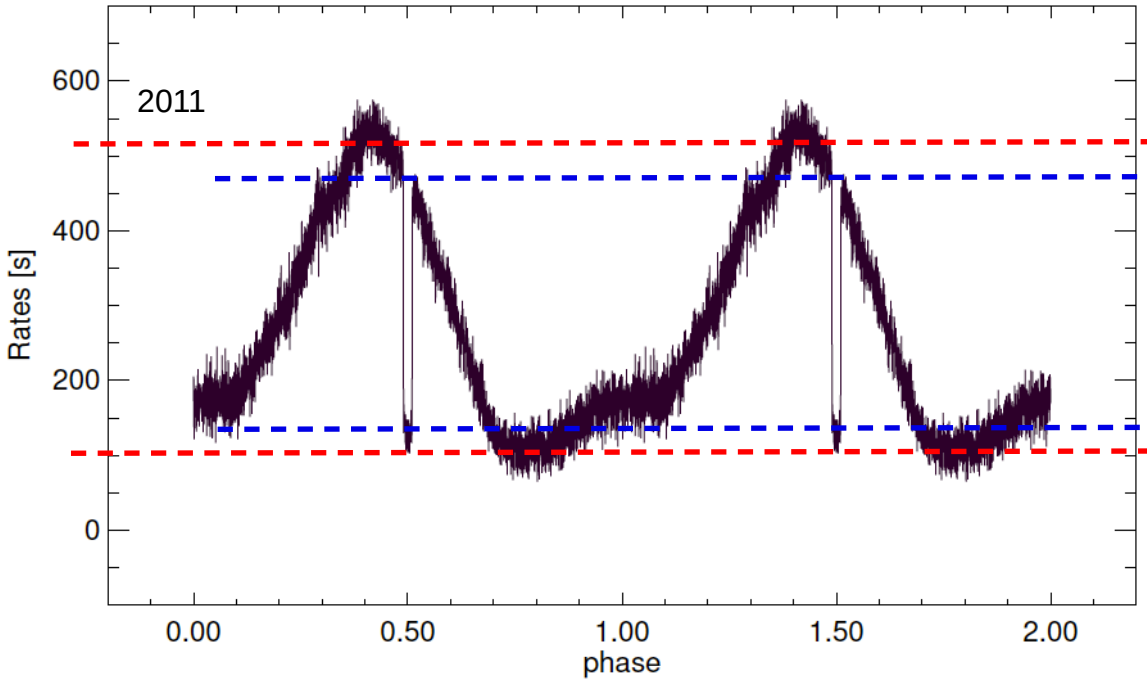


Networking Considerations

WET, SONG, ...



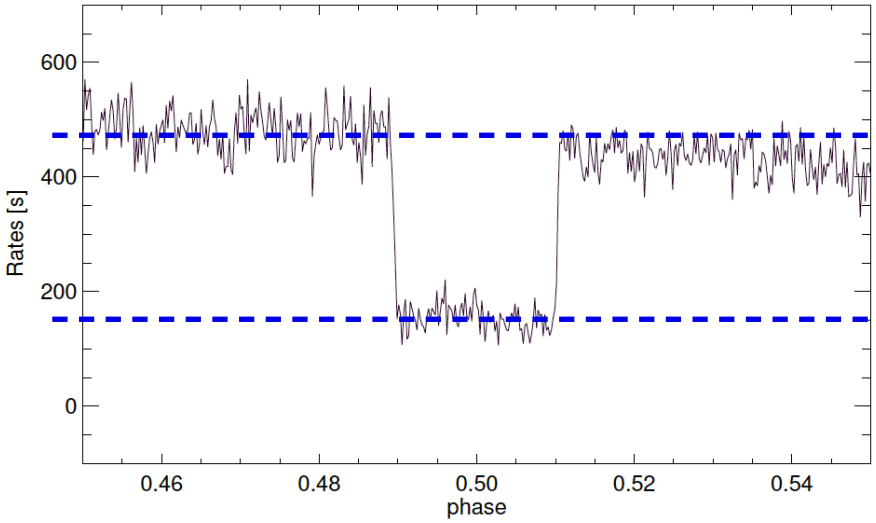


m ~ 18.1

~ 18.3

~ 19.5

m ~ 20.0



~ 18.3

~ 19.5

RXS J1845+4831 Summary:

Aligning all eclipses measured in 2011 and 2012,
we find an eclipse (ingress) ephemeris of
Porb = 0.054907167(2) d corresponding to 79 min 03.97923 (17) s
with HJD0(UTC)=2455733.301427.

The eclipse duration is 98.7s.
Sharp ingress/egress and flat bottom (i.e. no change in brightness)

Overall minimum of lightcurve (m ~ 20) is deeper than eclipse

→There must several components of emission
→- the bright spot (small and well defined
→- an accretion disk or stream
→- the irradiated secondary
→
(ref. to Horne et al., 1994)