The Puoko-nui Photometers

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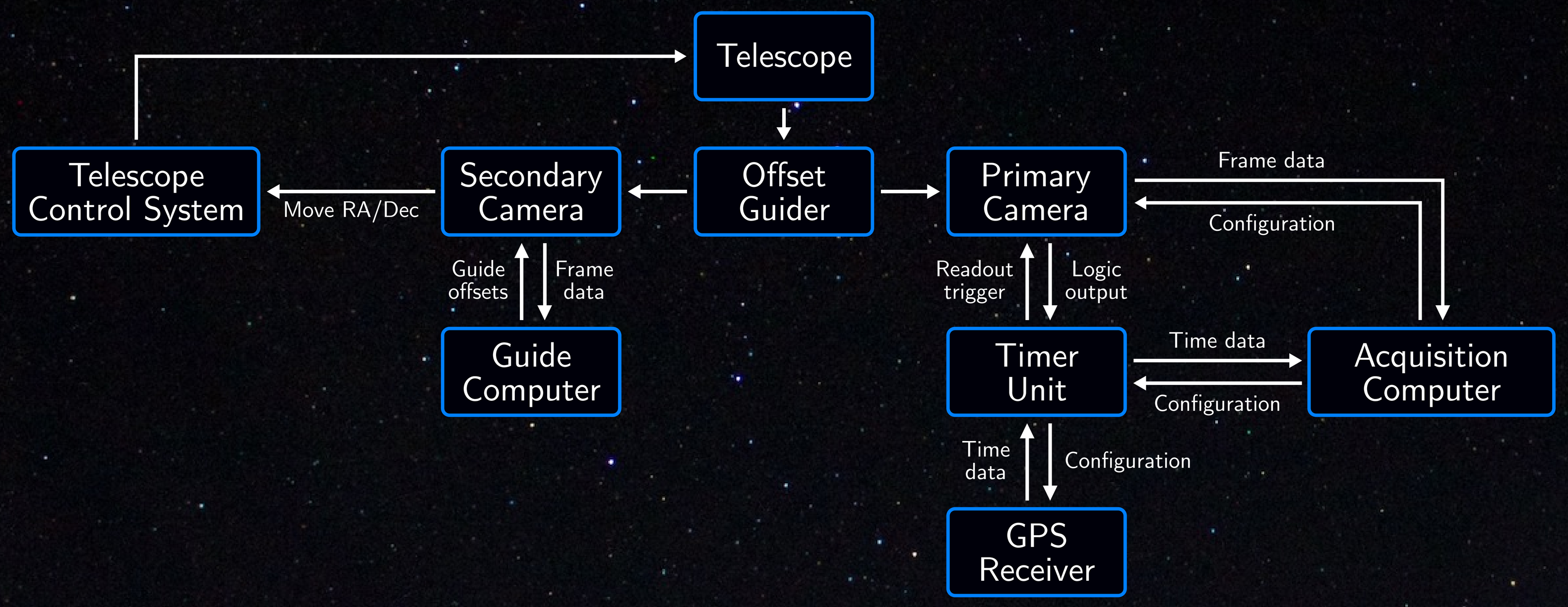
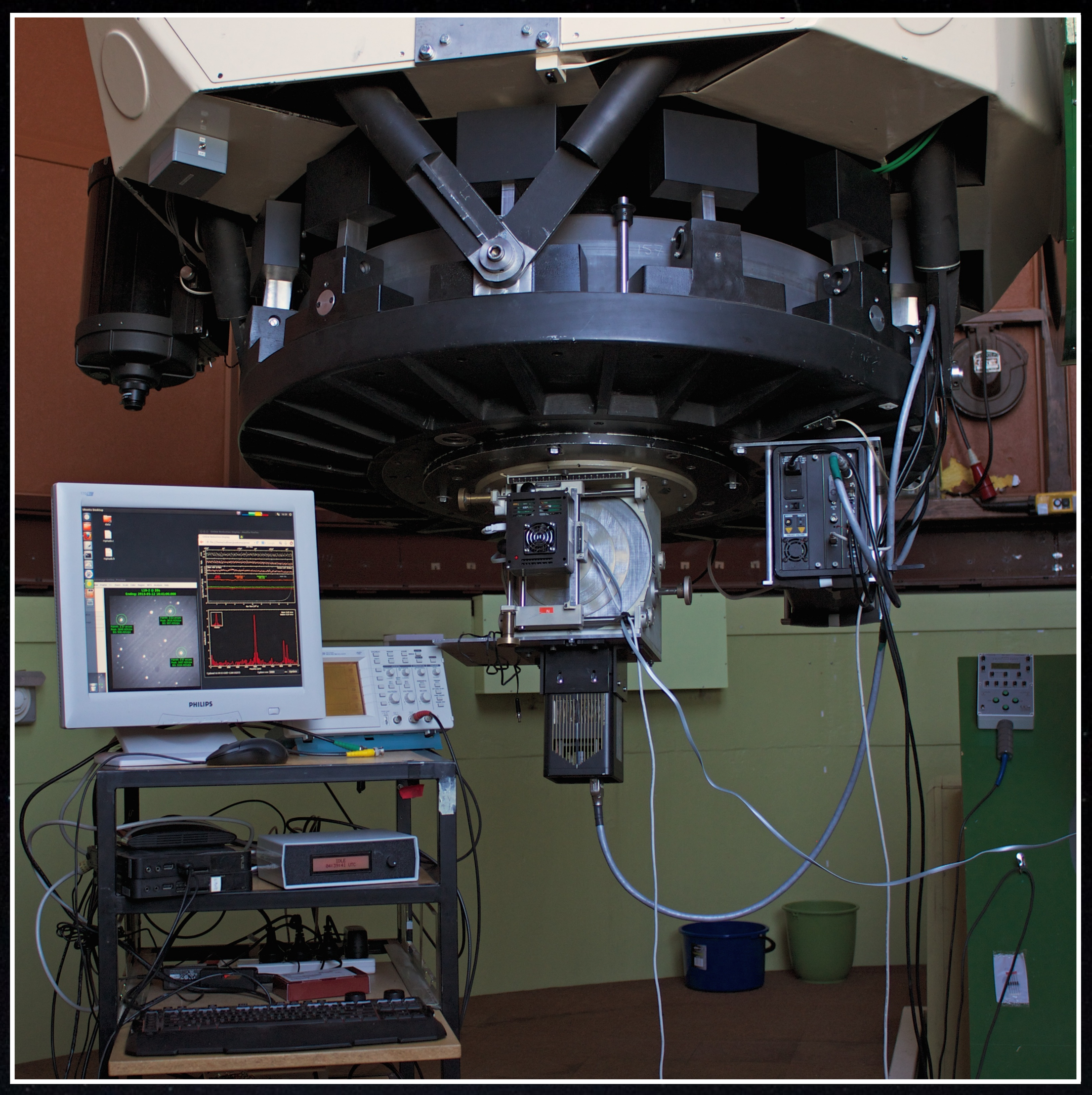
Victoria University of Wellington
Te Whare Wānanga o te Ūpoko o te Ika a Māui

We have developed a portable high-speed photometric system that has been designed to efficiently undertake high time precision fast photometry of objects with variability timescales between tens of milliseconds and tens of minutes.

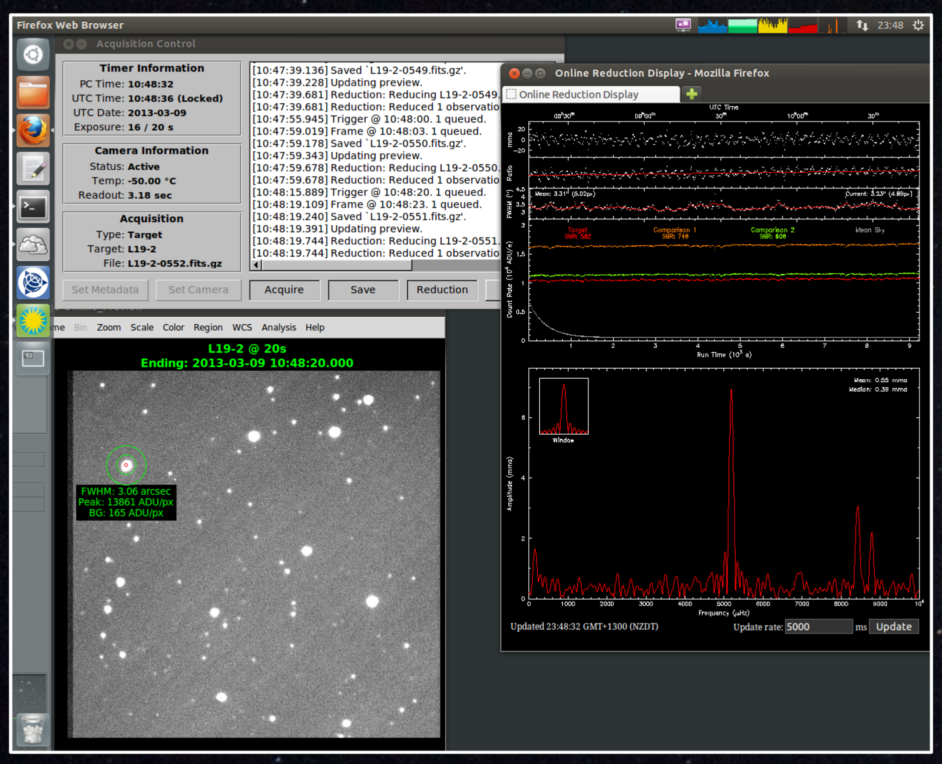
Two instruments have been created using this design: Puoko-nui South is based in Wellington, NZ, and is used primarily with the 1 m telescope at Mt. John University Observatory (MJUO) in the South Island of NZ. Puoko-nui North is based at the University of Texas at Austin, and has been used with the 2.1 m telescope at McDonald Observatory in west Texas and the 0.6 m robotic telescope at Meyer Observatory (PJMO) in central Texas.



A block diagram illustrating the main components of Puoko-nui South. Puoko-nui North mounts the primary camera directly on the telescope, and does not include the offset guider or secondary camera.



Puoko-nui South mounted on the 1 m telescope at Mt. John University Observatory, Lake Tekapo, NZ. The 1 m dome is also pictured in the poster background.



The Puoko-nui acquisition environment provides a simple acquisition interface and comprehensive real-time analysis.

The key components of the system are:
(1) an externally triggered commercial frame-transfer CCD,
(2) a custom GPS-derived time source, and
(3) flexible software for both instrument control and online analysis/display.

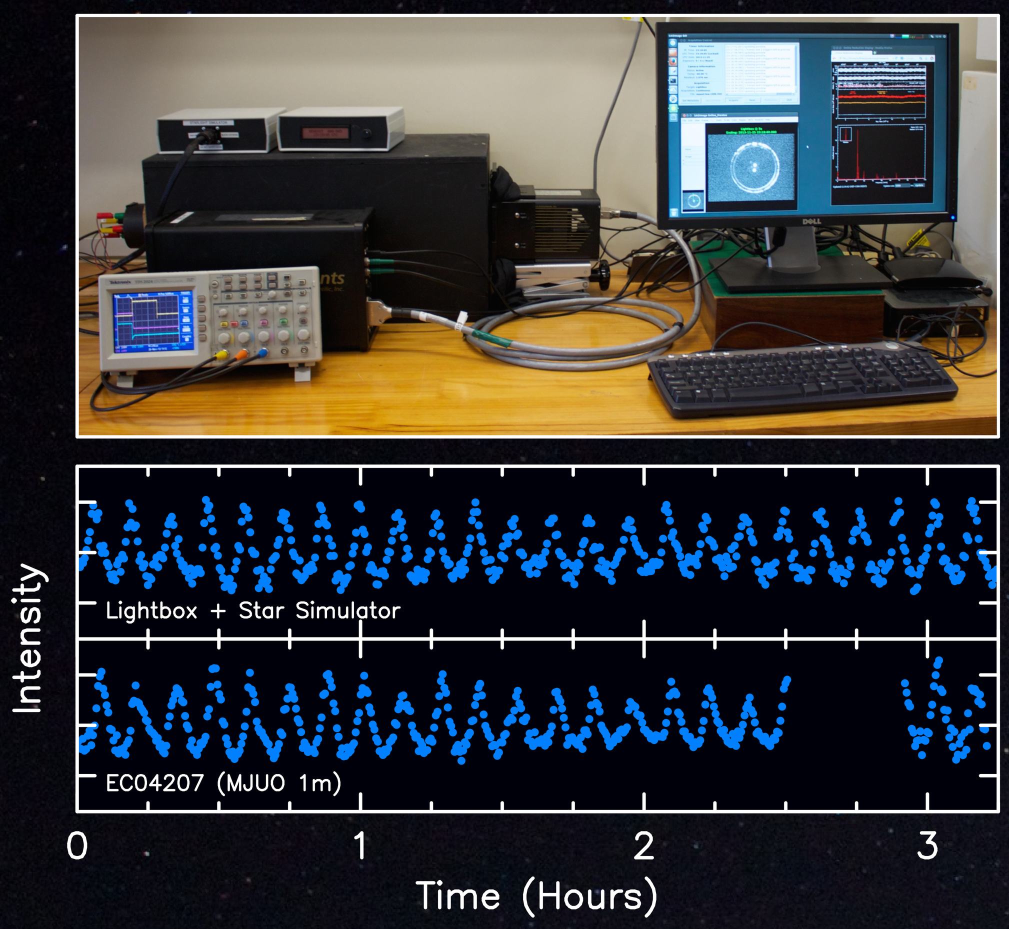
Both instruments use back-illuminated 1k $\times$ 1k frame-transfer camera systems produced by Princeton Instruments. Frame Transfer CCDs allow the readout procedure to occur in parallel with the next exposure, which reduces the readout "deadtime" to a few ms. The CCD in Puoko-nui North includes an Electron Multiplication readout mode, which enables very fast readout rates with low readout noise.

Accurate exposure timing is provided by a microcontroller-based timing unit that interfaces with a GPS receiver, the CCD camera, and the acquisition computer. Two timing modes are supported:
(1) a high-resolution mode (1 ms resolution, µs precision) for exposures $\leq$ 60 s.
(2) a low-resolution mode (1 s resolution, ms precision) for exposures $>$ 60 s.

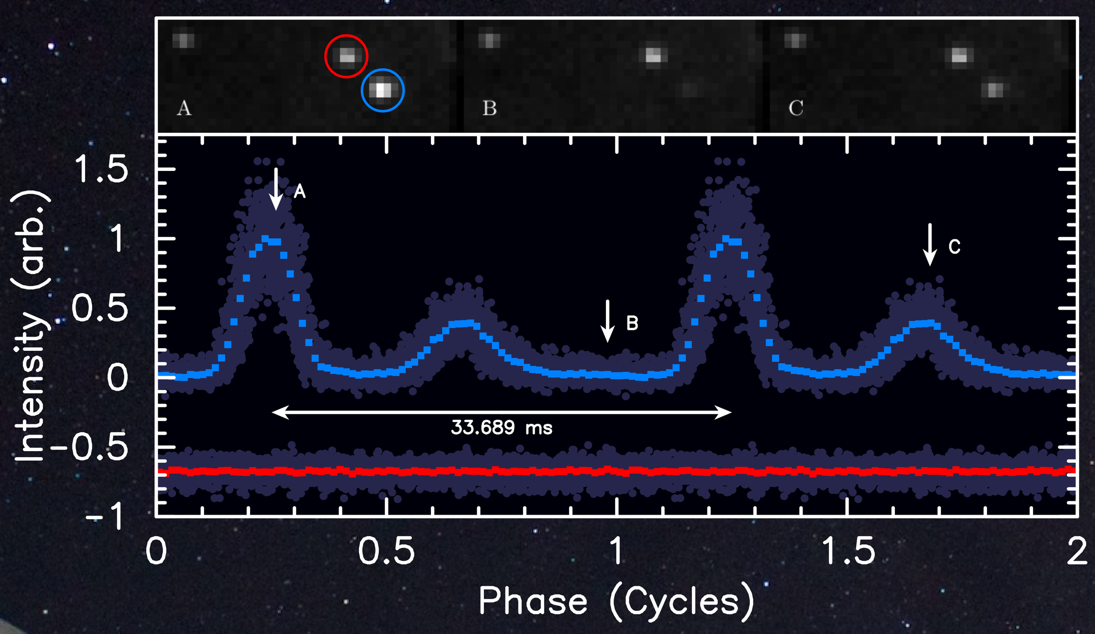
The Puoko-nui acquisition system includes real-time analysis and display software (`tsreduce`). This software performs aperture photometry on the incoming data and displays the evolving lightcurves together with a Fourier transform of the target star lightcurve. The online analysis can output image centroid coordinates to an external program for telescope auto-guiding via the science frames.

Puoko-nui South includes a separate auto-guiding system employing a dedicated a secondary camera on a 2D slide mechanism. This arrangement can access a much larger field of view than the main camera, which increases the chances of finding a suitable guide star in the often sparse WD fields.

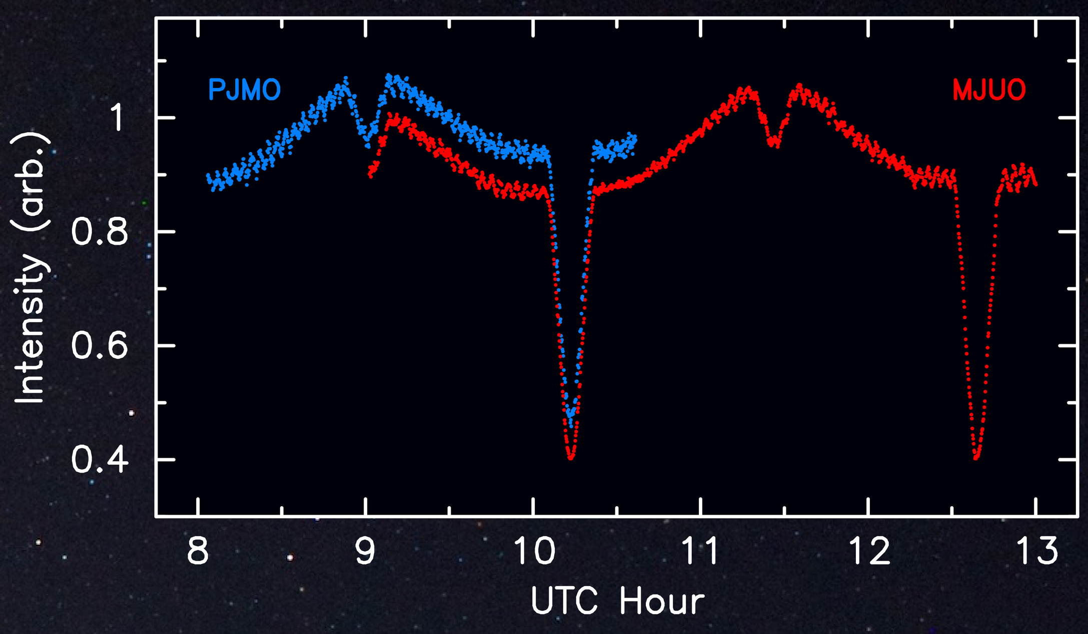
See **Chote et al. 2014, MNRAS, 440, 1490** for more details on the Puoko-nui systems.



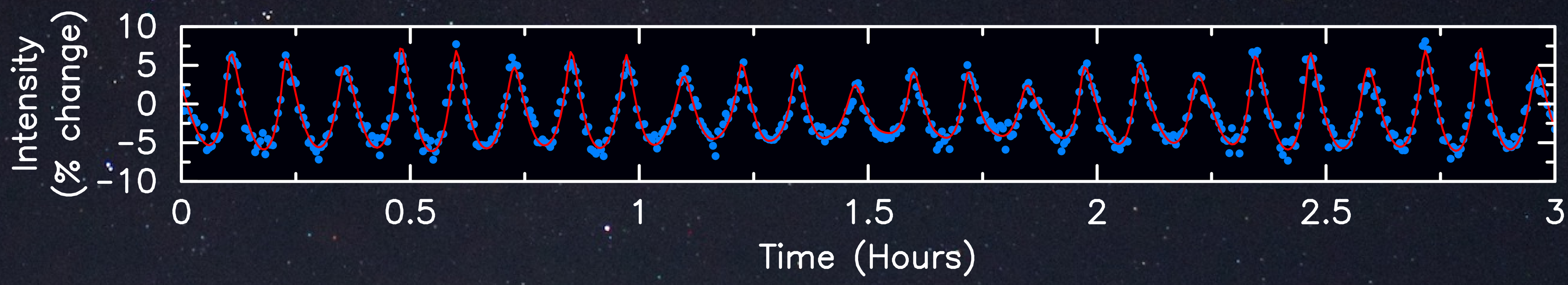
We have developed an instrumentation test system using LEDs in a lightbox, driven by a configurable microcontroller unit. This provides great flexibility in generating test intensity profiles, including realistic simulations of pulsating white dwarfs.



Puoko-nui North can acquire scientifically useful frames at rates of up to 200 Hz. Observations of the Crab pulsar using the 2.1 m telescope at McDonald observatory clearly reveal the characteristic pulsar intensity profile.



Concurrent observations of PG 1336−015 were acquired using Puoko-nui North and South with telescopes at PJMO and MJUO respectively. The target features a pulsating sdB star in a close binary eclipsing configuration.



Observations of the pulsating helium atmosphere white dwarf EC 04207-4748 acquired using Puoko-nui South with the 1 m telescope at MJUO were used to constrain the sub-surface convection zone timescale τ_0 for this object. More information is available in **Chote et al. 2013, MNRAS, 431, 520**.

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