How citizen scientists, schools, amateur astronomers can help discover exoplanets using digital cameras

Project **PANOPTES**

Panoptic **A**stronomical **N**etworked **OP**tical observatory for **T**ransiting **E**xoplanets **S**urvey

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Exoplanet transit: An easier way to detect a planet

If the planet passes in front of its star, we see the star dimming slightly

PANOPTES goals

Discovering transiting exoplanets requires monitoring large parts of the sky for long periods of time

Amateur astronomers, citizen scientists are very good at this, and schools can participate with student team projects

BUT:

- Cost must be small to get strong community participation
- Technical challenges: hardware, software
- Requires coordination (data must be combined between many observers)

→ project PANOpTES is aimed at solving these 3 problems to enable a world-wide network of low-cost imaging units for exoplanet transit discoveries

→ PANOpTES is aimed at enabling collaboration between citizen scientists, amateur astronomers, schools and “real”

Enabling technologies

Digital cameras are relatively cheap and high quality

~20 Mpix
<3e- readout noise
Outstanding cosmetic quality
Fast readout (<<`1sec)
Robust construction
Low dark current (<< sky background)

…. for a few $100s

Using many digital cameras + lenses is the most cost-effective way to cover large parts of the sky with good sensitivity
(Few $1000s per square degree square meter of etendue)

Phase 1 (completed)

GOALS:

Demonstrate low-cost reliable hardware solution

→ prototype system has been running for 2 yrs

Demonstrate that high precision photometry can be achieved with low-cost digital cameras

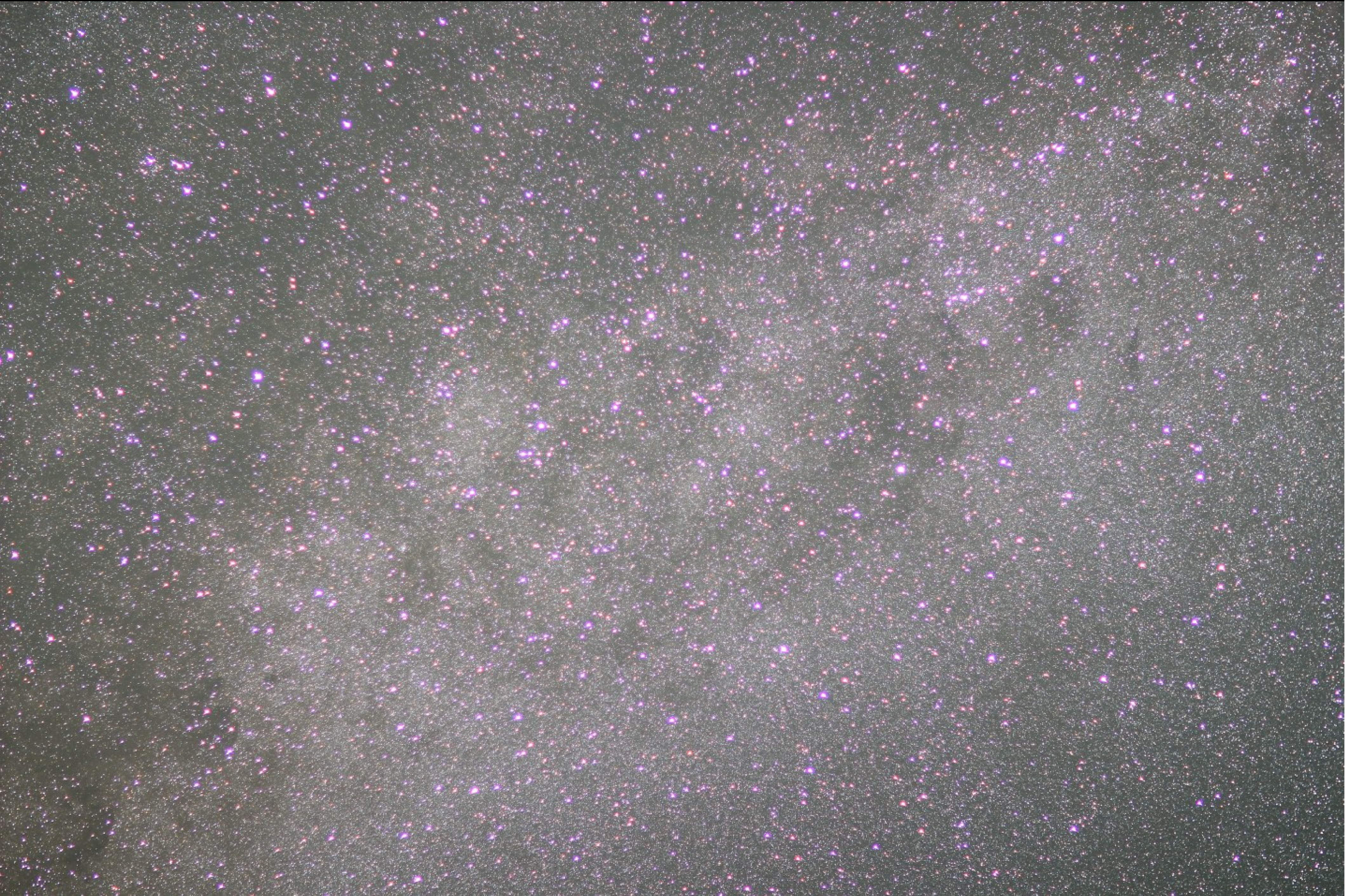
Color camera have complex pixel / star interaction

→ demonstrated % level photometry in 1mn exposure with a single camera

→ demonstrated that a single camera can detect a single transit

PANOPTES prototype unit at Mauna Loa observatory

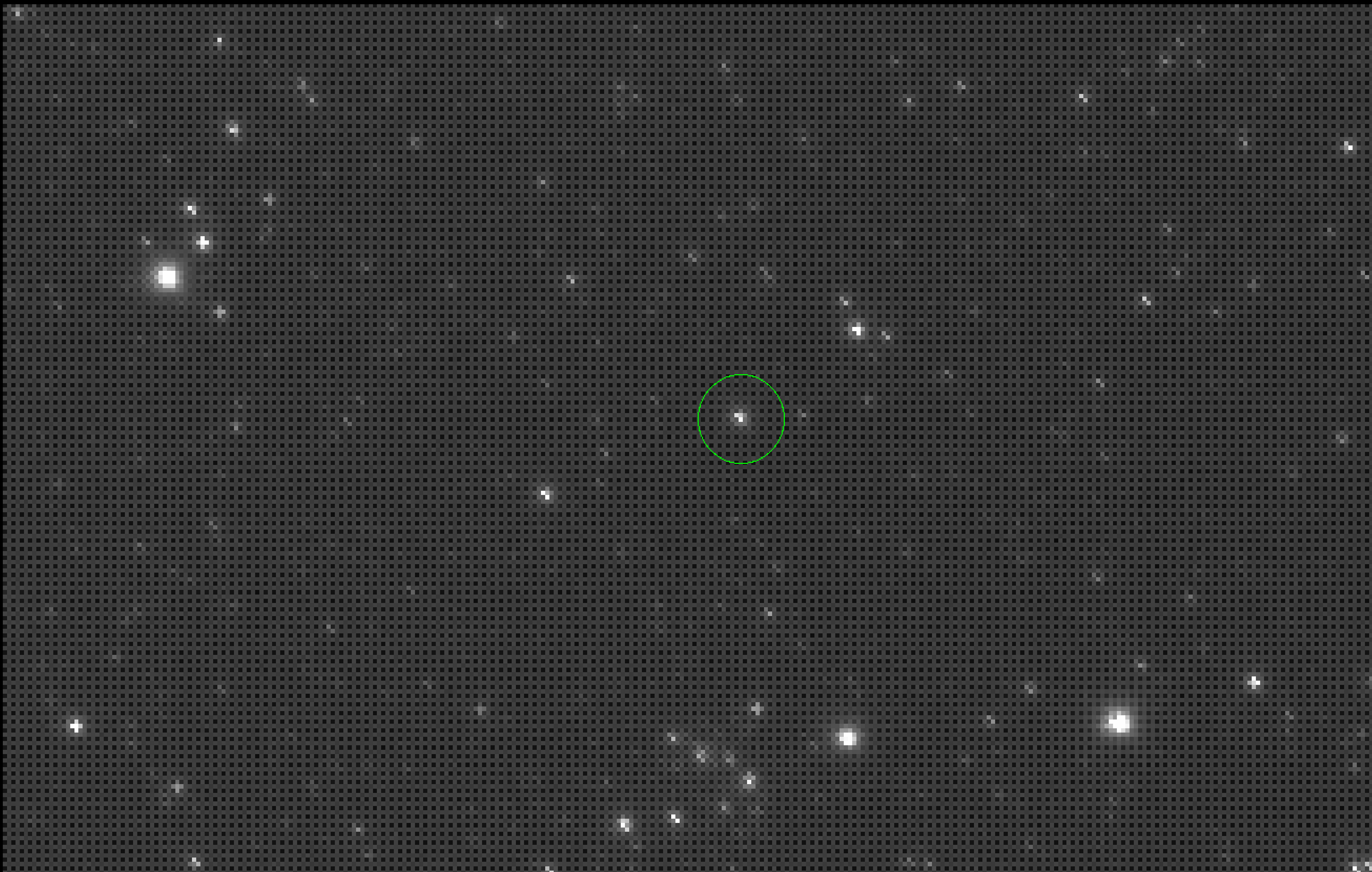
Example image (Cygnus field): >100,000 stars in a single image



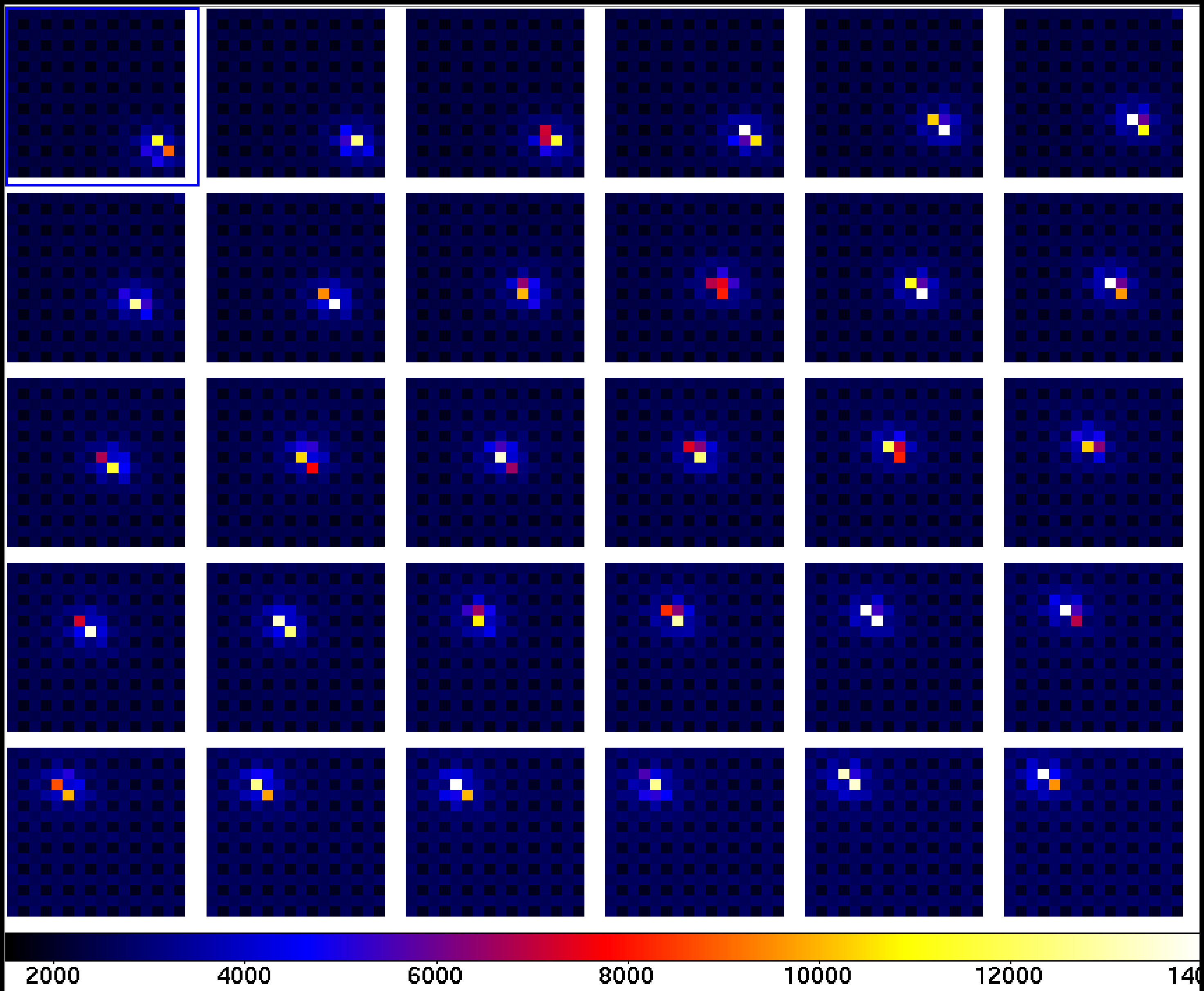
Example image – 315 sec exposure, ISO 100 (March 1, 2011)

Lower left corner of previous image

Test on star HD54743 (V=9.35)
1 mn cadence

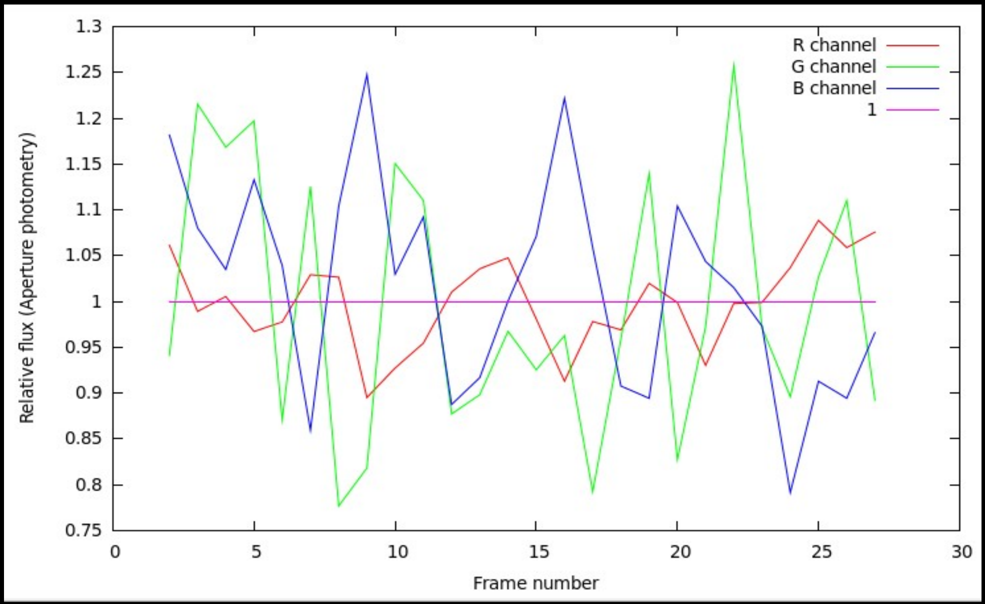


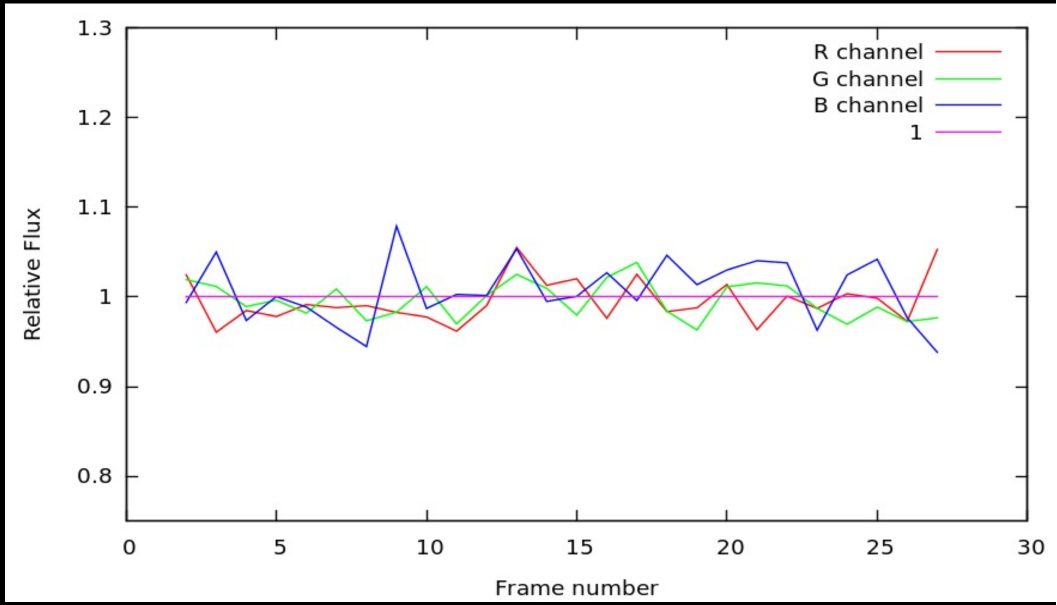
Test on star HD54743 (V=9.35)
1 mn cadence



Test on star HD54743 (V=9.35)
1 mn cadence

Error term	R channel	G channel	B channel	Notes
Atmospheric Scintillation	0.3%	0.3%	0.3%	
Photon Noise	2.79%	1.00%	2.24%	mV=9.35, includes background contribution (bright time, r=40arcsec mask)
Readout Noise	0.40%	0.23%	0.71%	
Flat field error	0.5%	0.4%	0.5%	Error term irrelevant with good tracking
Total (expected)	2.88%	1.14%	2.42%	
Achieved	**2.48%**	**2.04%**	**3.51%**	





Next steps

Build more units, deploy them around the globe for 24hr coverage

Partner with schools, amateur astronomers, and existing exoplanet transit surveys

Set up data storage and processing hub