The Evryscope and extrasolar planets

Octavi Fors[1]

Nicholas Law[2],
Jeffrey Ratzloff[3,6], Daniel del Ser[4],
Philip Wulfken[5], Dustin Kavanaugh[6]

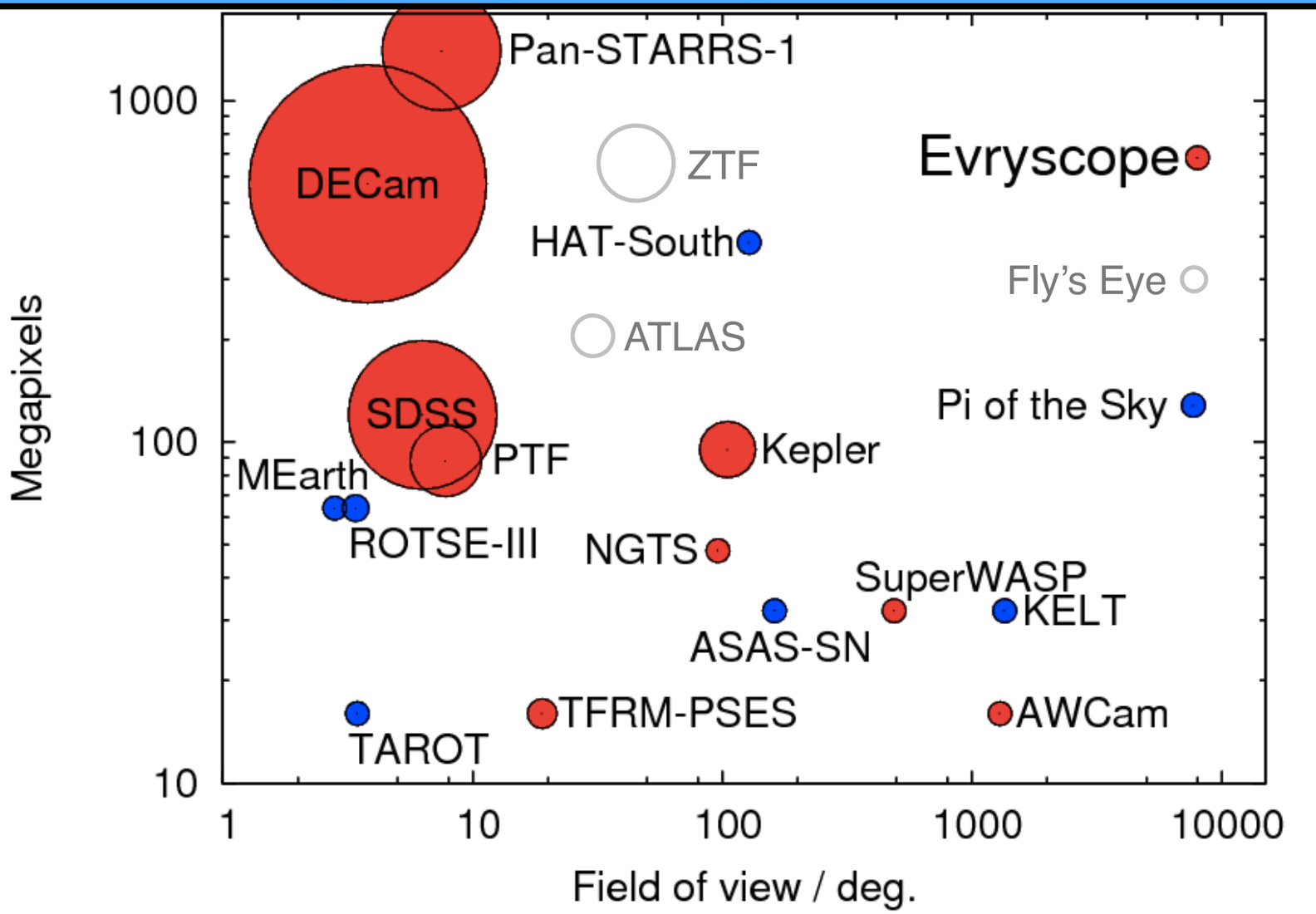
University of North Carolina, Chapel Hill

[1]: Software lead ; [2]: P.I. ; [3]: Mechanical ; [4]: Software ;
[5]: Optical ; [6]: Simulations

http://evryscope.astro.unc.edu/

AST-1407589

The Evryscope: why build it?



Points are sized by telescope aperture. Red and blue points are single- and multiple-site surveys, respectively. Grey point are projected but not-yet on-sky surveys.

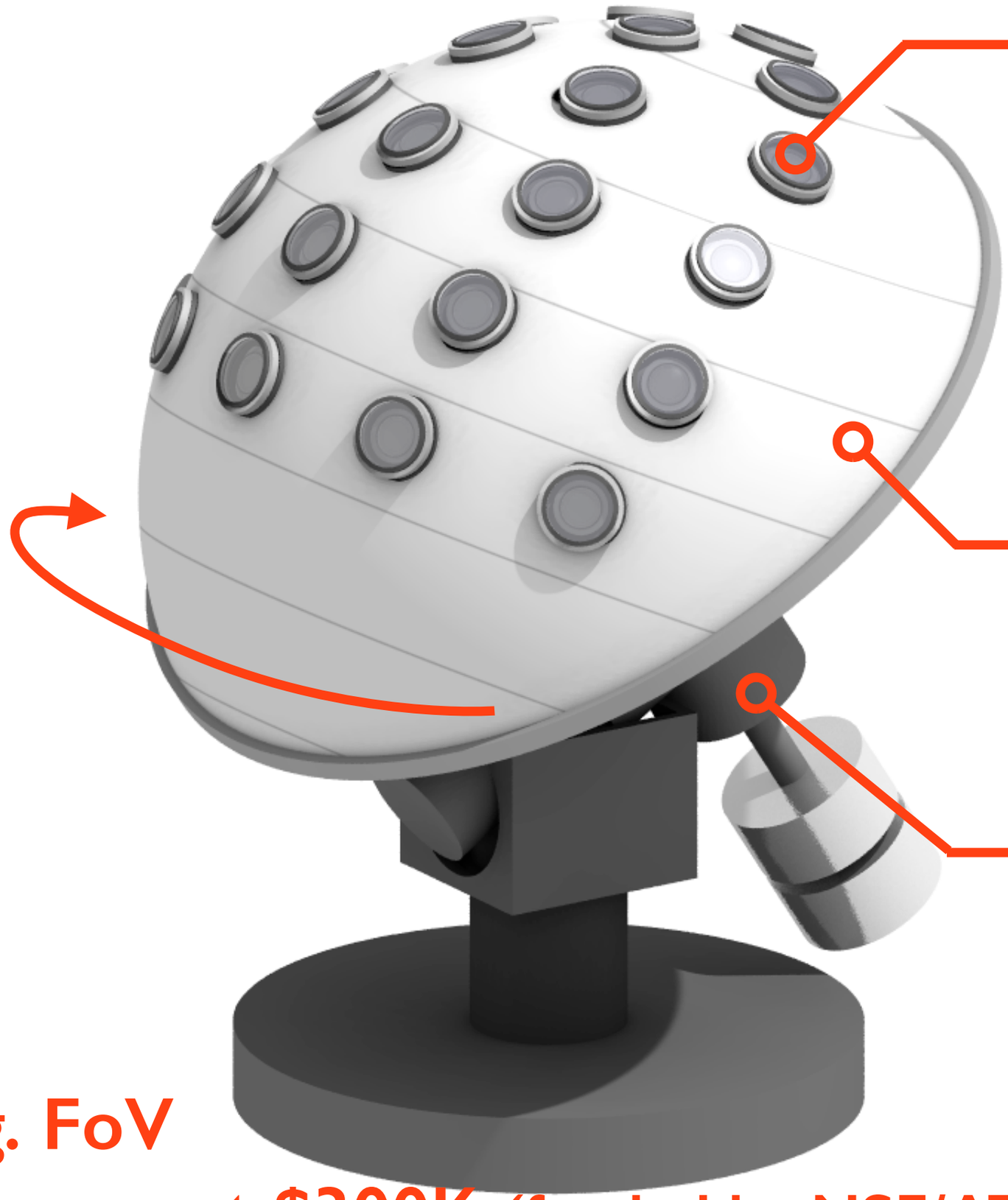
-Most of surveys (transiting exoplanets and others) cover the sky by tile & revisit strategy in a **few-days**. So they **are not sensitive** to ~hrs/mins timescale events.

-Evryscope opens a new parameter space among operating sky surveys: it adds an order of magnitude in **FoV** and **high data cadence (2mins)**.

Key capability: long-term, high-cadence monitoring of millions of targets simultaneously.

-A lot of people can benefit!

The Evryscope: Concept



691 MPix

8,000 sq.deg. FoV

Total hardware cost $300K (funded by NSF/ATI 2014)

The Evryscope: why build it? (II)

Key projects summary with Evryscope:

Transiting exoplanets

- Asteroid-sized planets around white dwarfs
- Confirmation of long-period TESS single-transit detections
- Habitable zone of M-dwarfs
- The nearest & brightest stars

Nearby microlensing events

- 2-minute cadence even before detection

Eclipse/transit timing & measurement

- Exoplanet detection
- Mass-radius relation measurement

Young & active stars

- Comprehensive measurement of stellar activity
- All stars g<16, every 2 minutes, 100-degree declination range

Young Nearby Supernovae

- Monitor the objects before they go off
- Shock breakout & pre-outbursts

Gamma Ray Bursts

- Optical observations of GRBs before gamma-ray detection
- Orphan afterglows across the sky

Exotic transients

- Post-facto localization of gravitational wave counterparts, millisecond radio transients, ...

The Evryscope: deployment

When: deployed May 2015 (4 months ahead of schedule).

Where: CTIO.

Status:

- as today it has already collected ~250,000 29MPx images (~15TB of raw data).

- fully robotic: system health, weather status monitoring & observations scheduling.

- wind-shake, tracking & image quality within requirements.

- reduction pipeline is providing astrometrically and photometrically-calibrated images.

The Evryscope: specifications

FoV: 8,000 sq.deg.

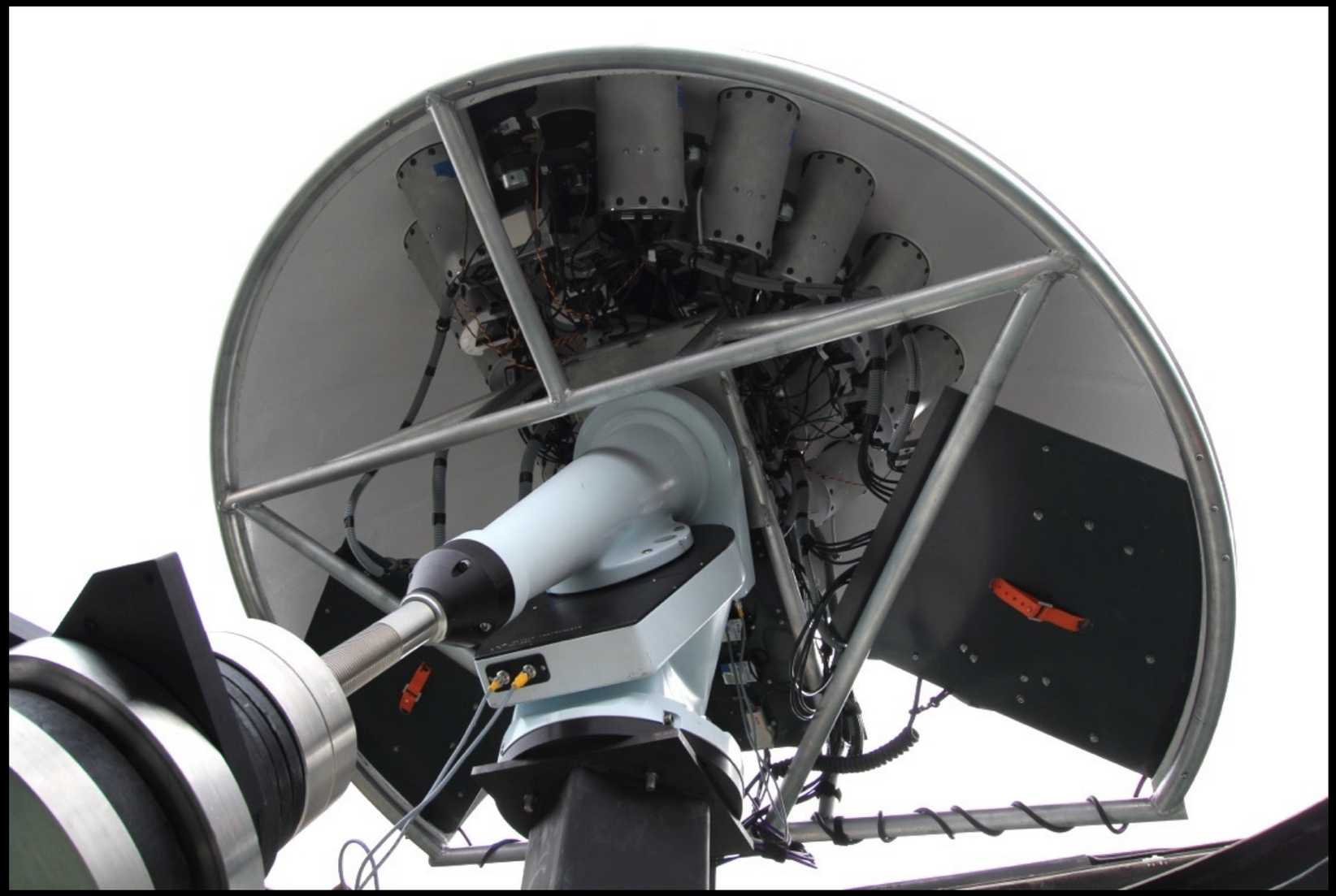
Direct imaging:

g_{lim}~16 every **2 minutes**

g_{lim}~18 every hour

Precision photometry:

3 mmag on all g=12 stars
every 16 minutes

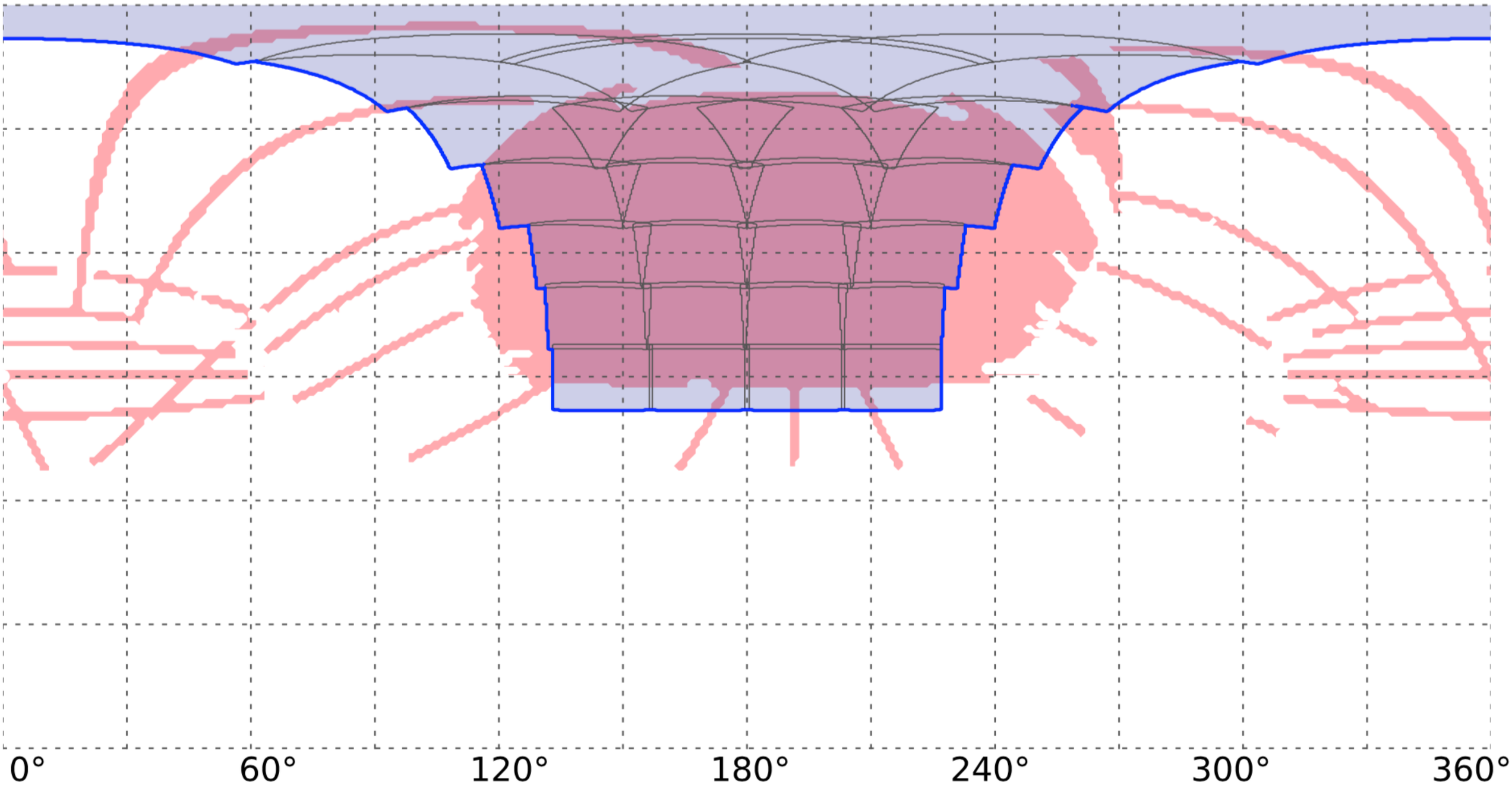


Data rates: 97% survey efficiency (4sec dead time).

104 MBit/sec continuous raw data streaming.

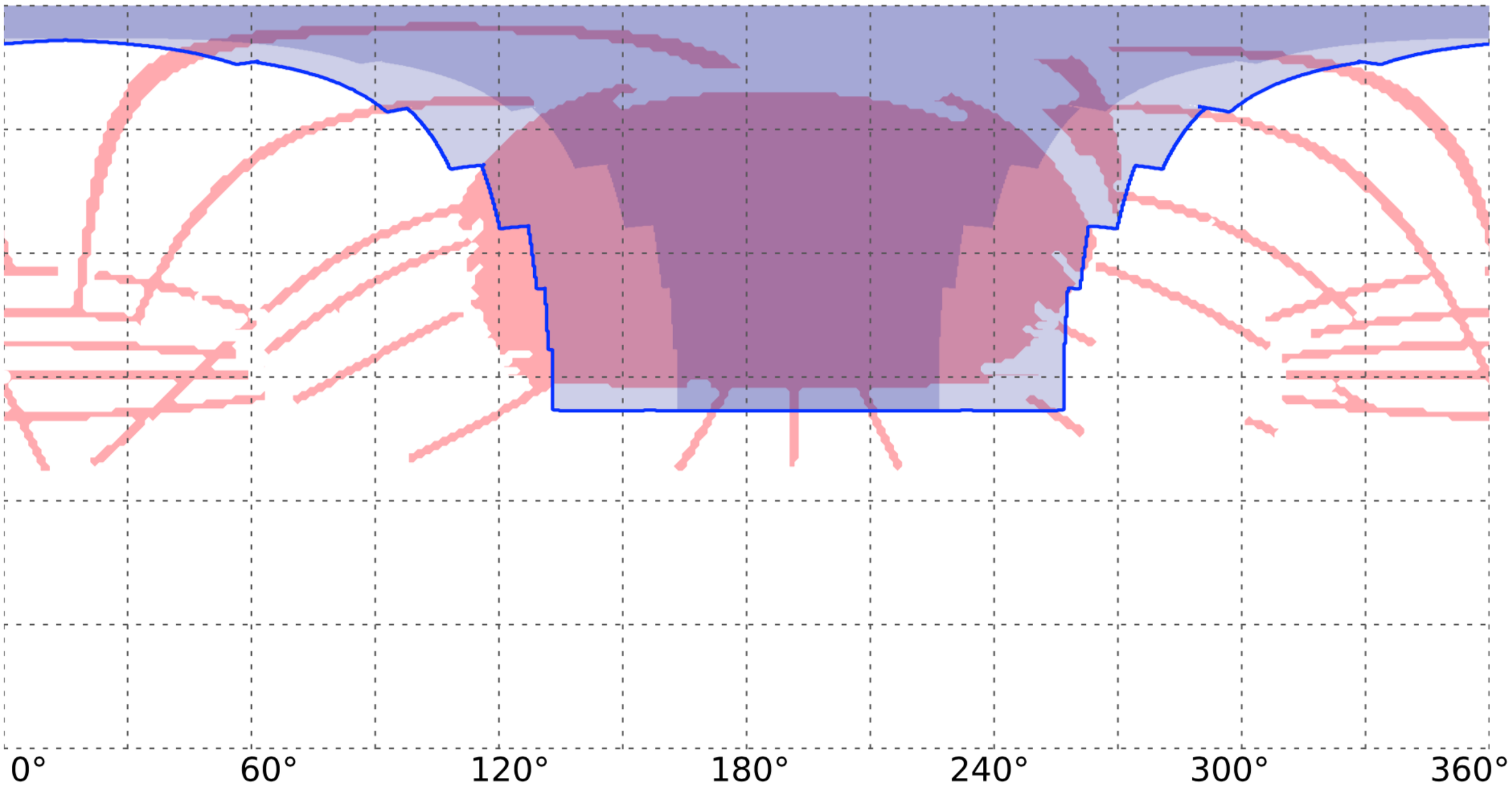
35,000 photometric measurements/yr for **20 million** stars (~100TB/yr).

The Evryscope: specifications (II)



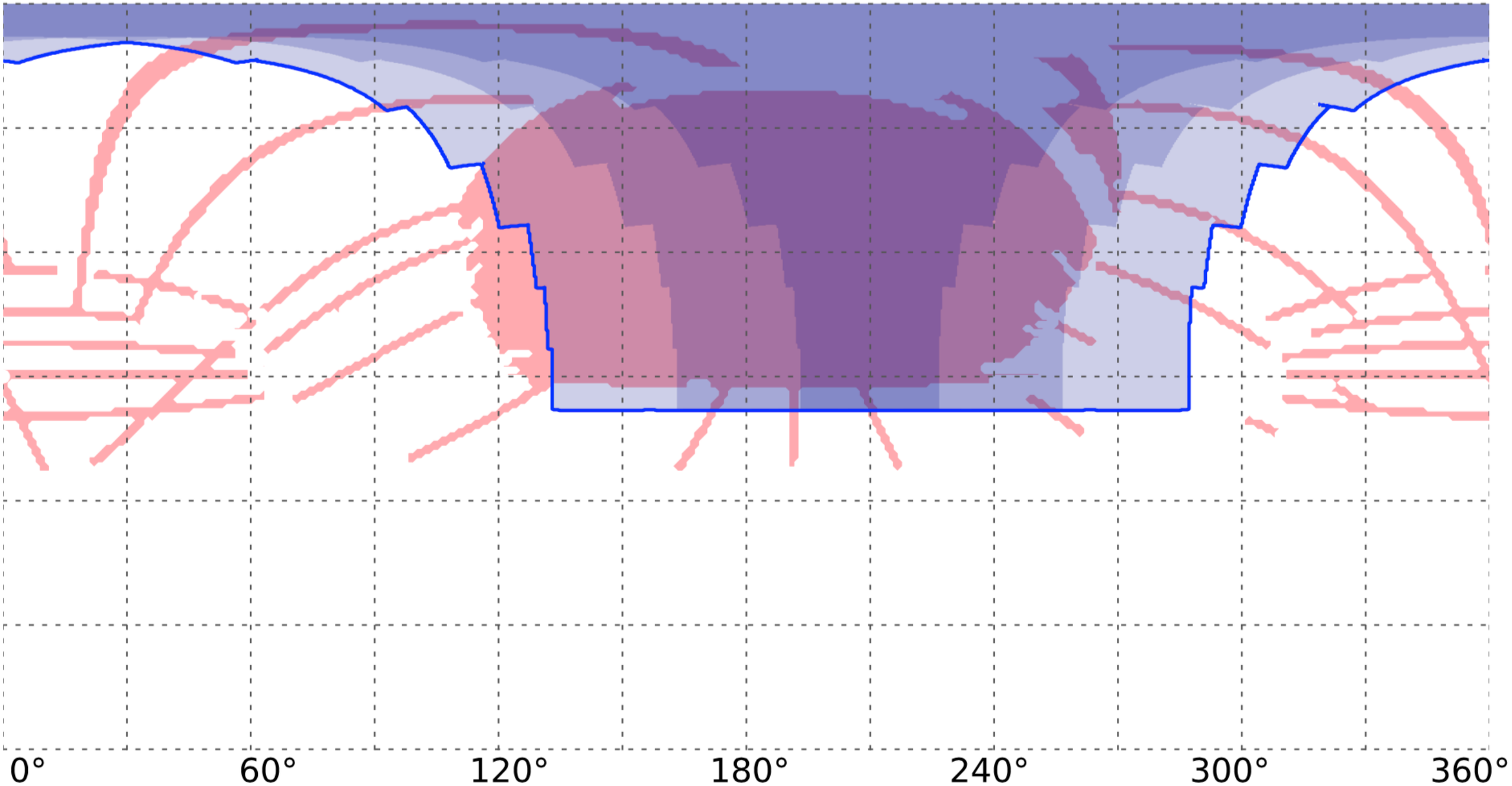
8,000 sq. degrees instantaneous FoV vs. SDSS DR7 FoV

The Evryscope: specifications (II)



Ratchet back HA every 2hrs.

The Evryscope: specifications (II)



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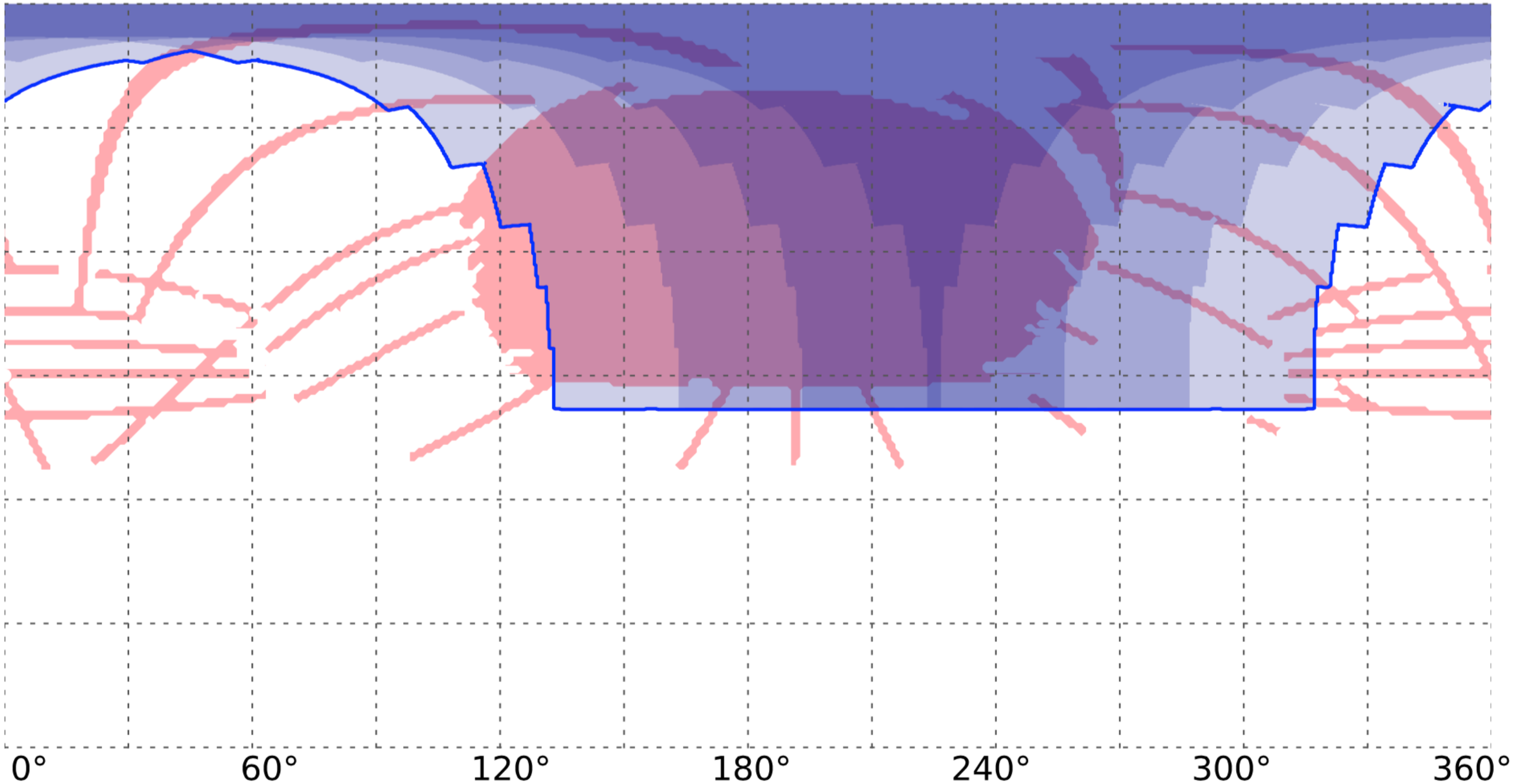

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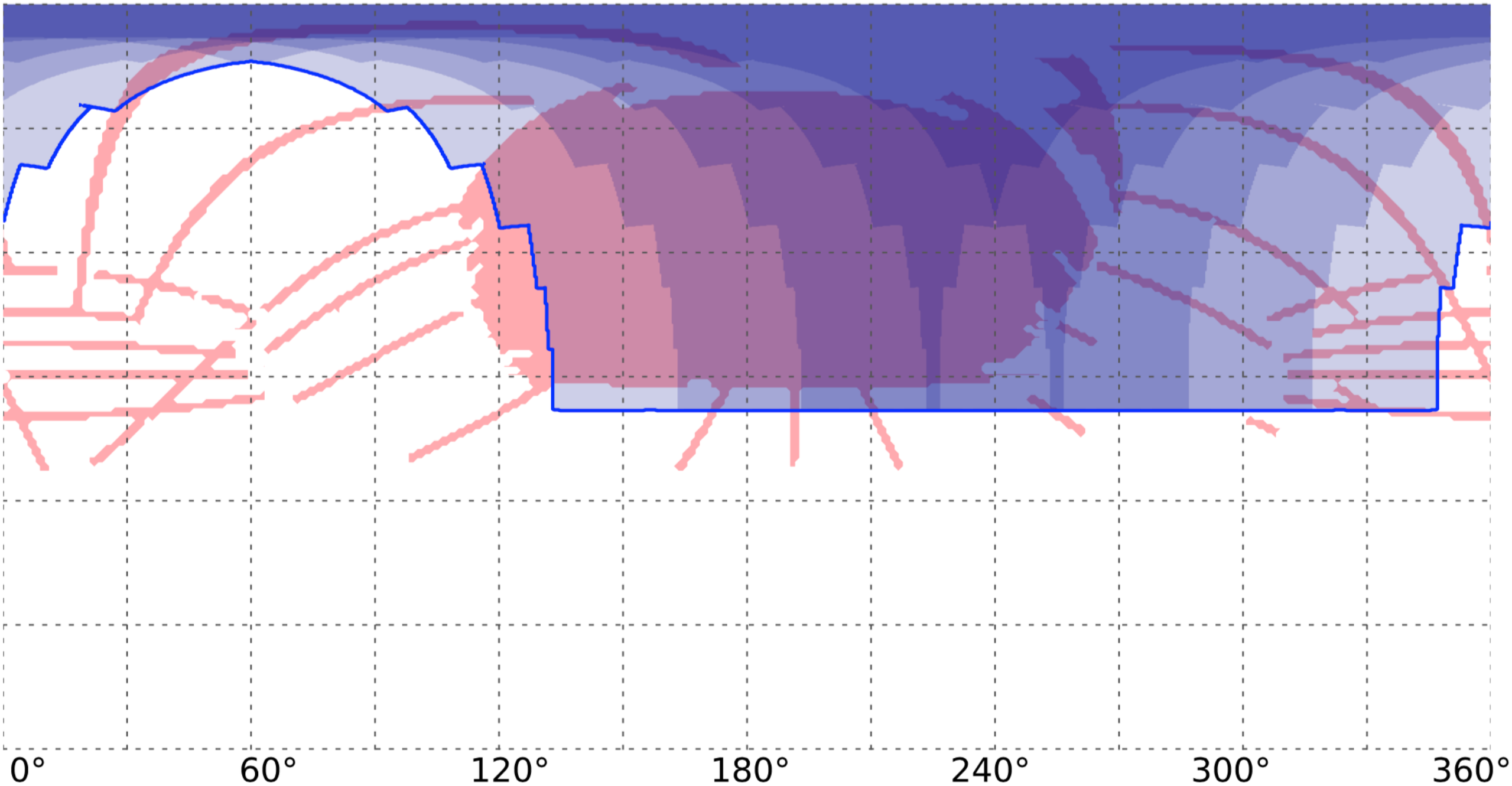
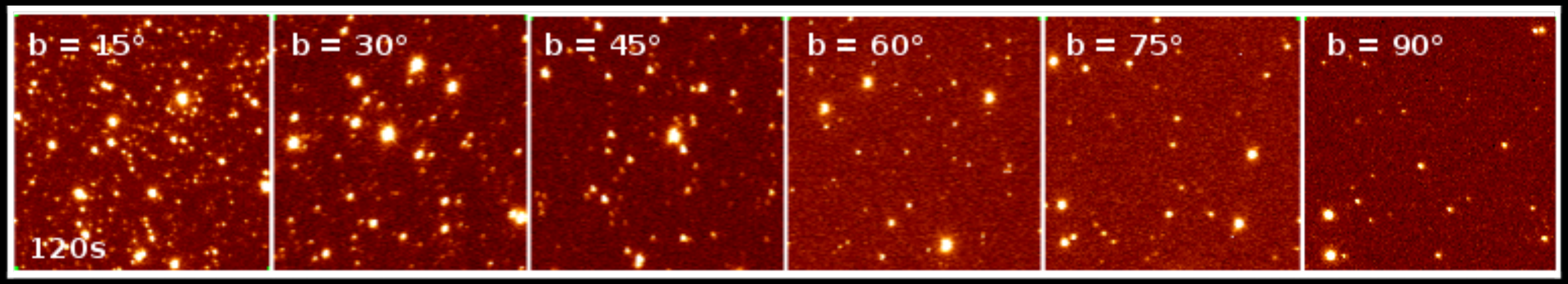
The Evryscope: specifications (II)



~40% of the entire sky is covered in ~6.5h at 2 minutes cadence

The Evryscope: specifications (III)



90% of stars b>15° in 120s exposures with **uncrowded photometry**

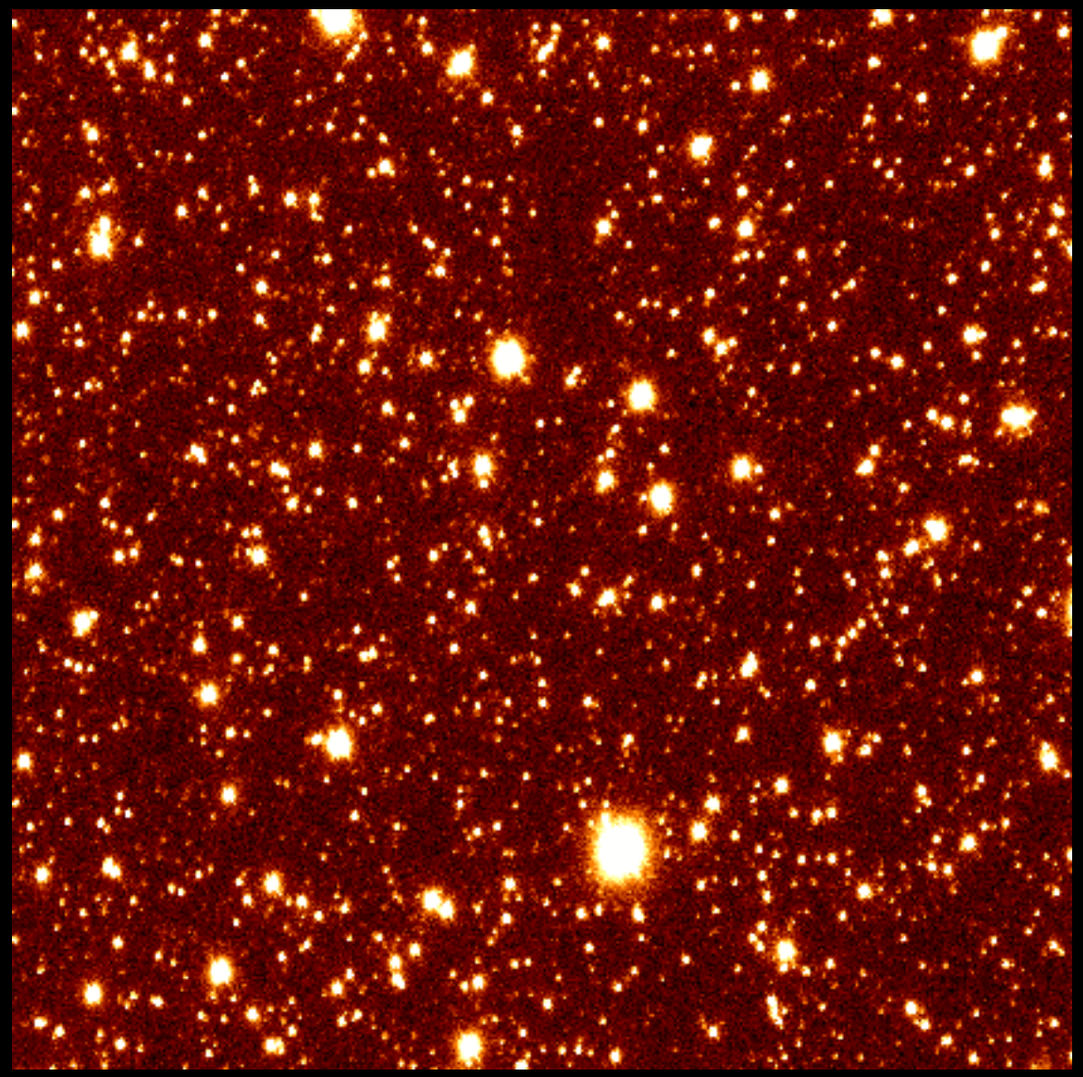
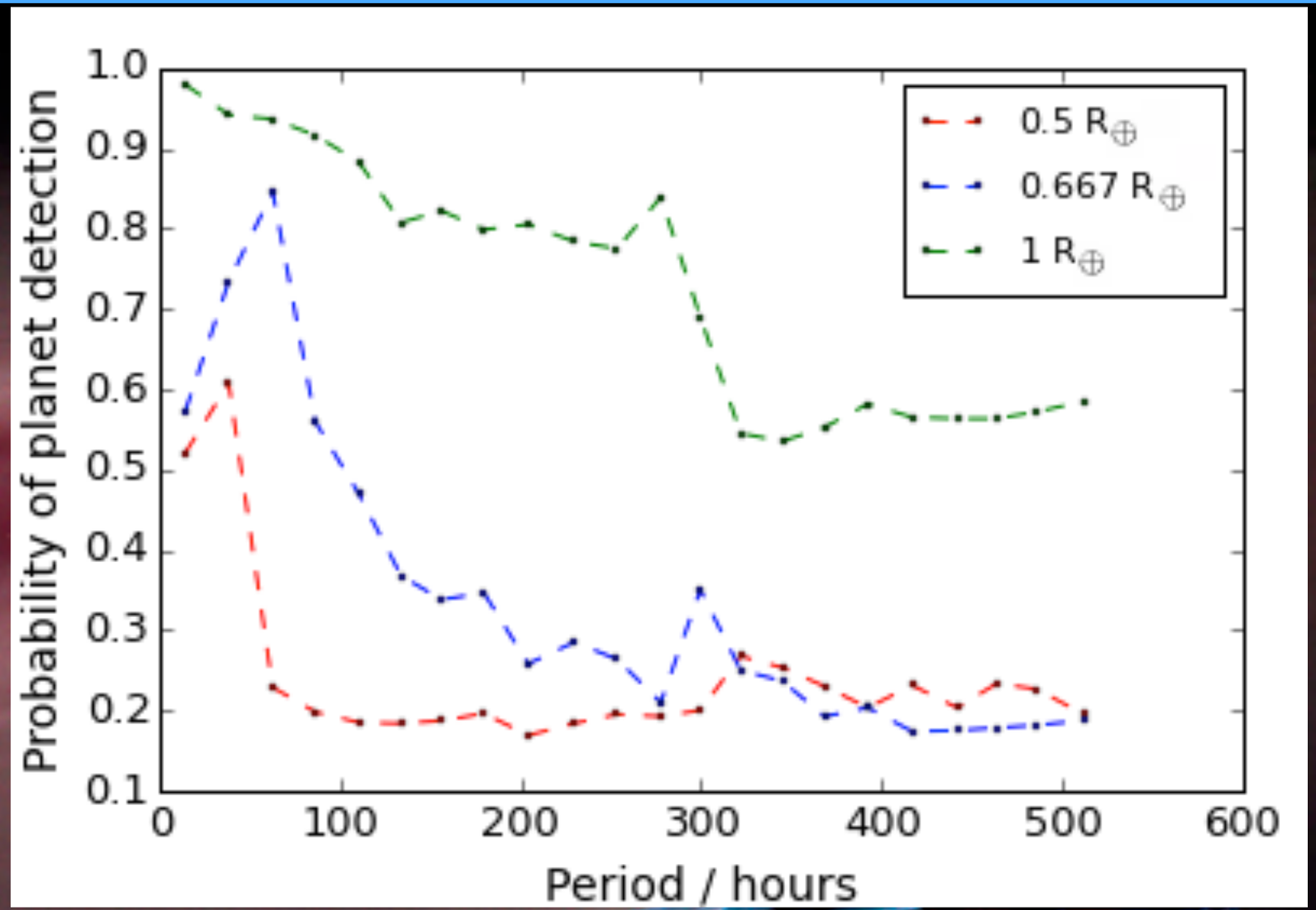


Image quality: 1:1 zoom cutout of a single Evryscope exposure taken under typical sky conditions at CTIO. This image makes up about 0.03% of the Evryscope FoV.

First large-scale survey for habitable planets transiting White Dwarfs

- Planetary system evolution during red giant phase is a topic of active research.

- a few **100+** WDs with <10% precision and **~1000+** g<16 WDs each night are observed with **2mins cadence**.



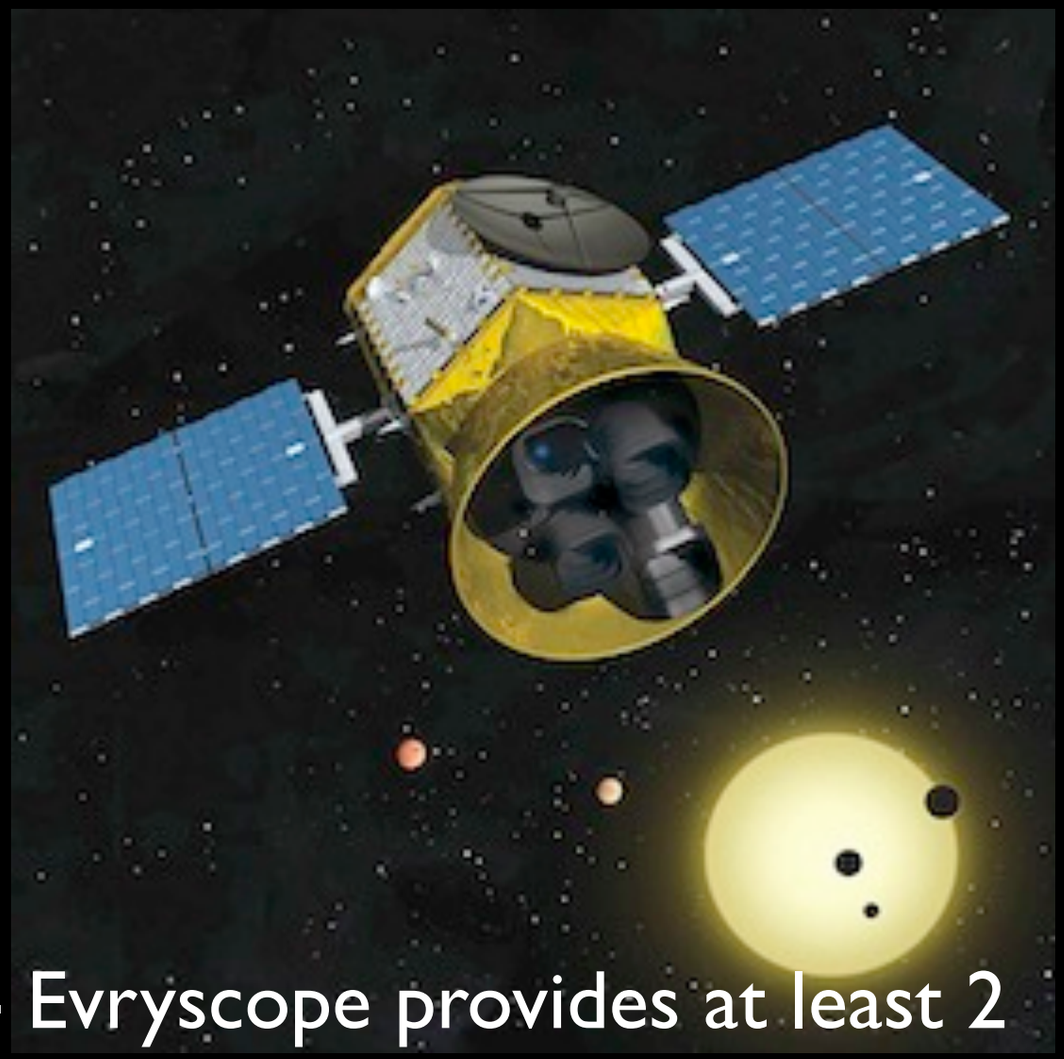
The probability of detecting a transiting rocky planet around a white dwarf in **one month of Evryscope data**, based on detailed **simulations** of our detection efficiency, detection algorithms and correlated noise.

- >Ceres-size objects could be detectable (+dust clouds etc.).

- even a null result for the transiting WD exoplanets would constrain the habitable planet fraction at the 30% level (Agol 2011).

Mark Garlick

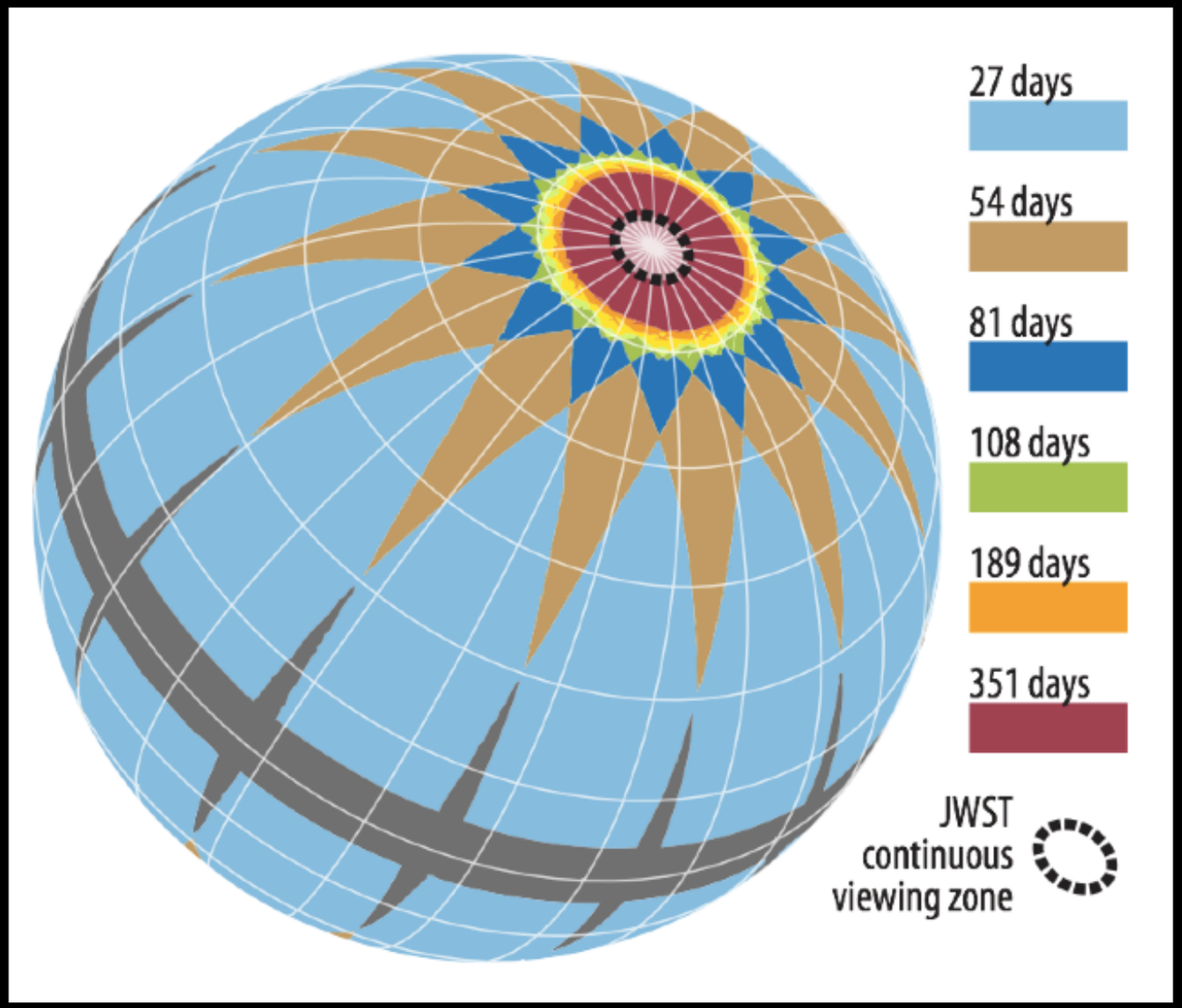
TESS-Evryscope Synergies



- Four 10.5cm lenses
- 2300 sq. deg. FOV, 21”/pixel
- ~200,000 nearby, bright stars (m_I = 4-13)

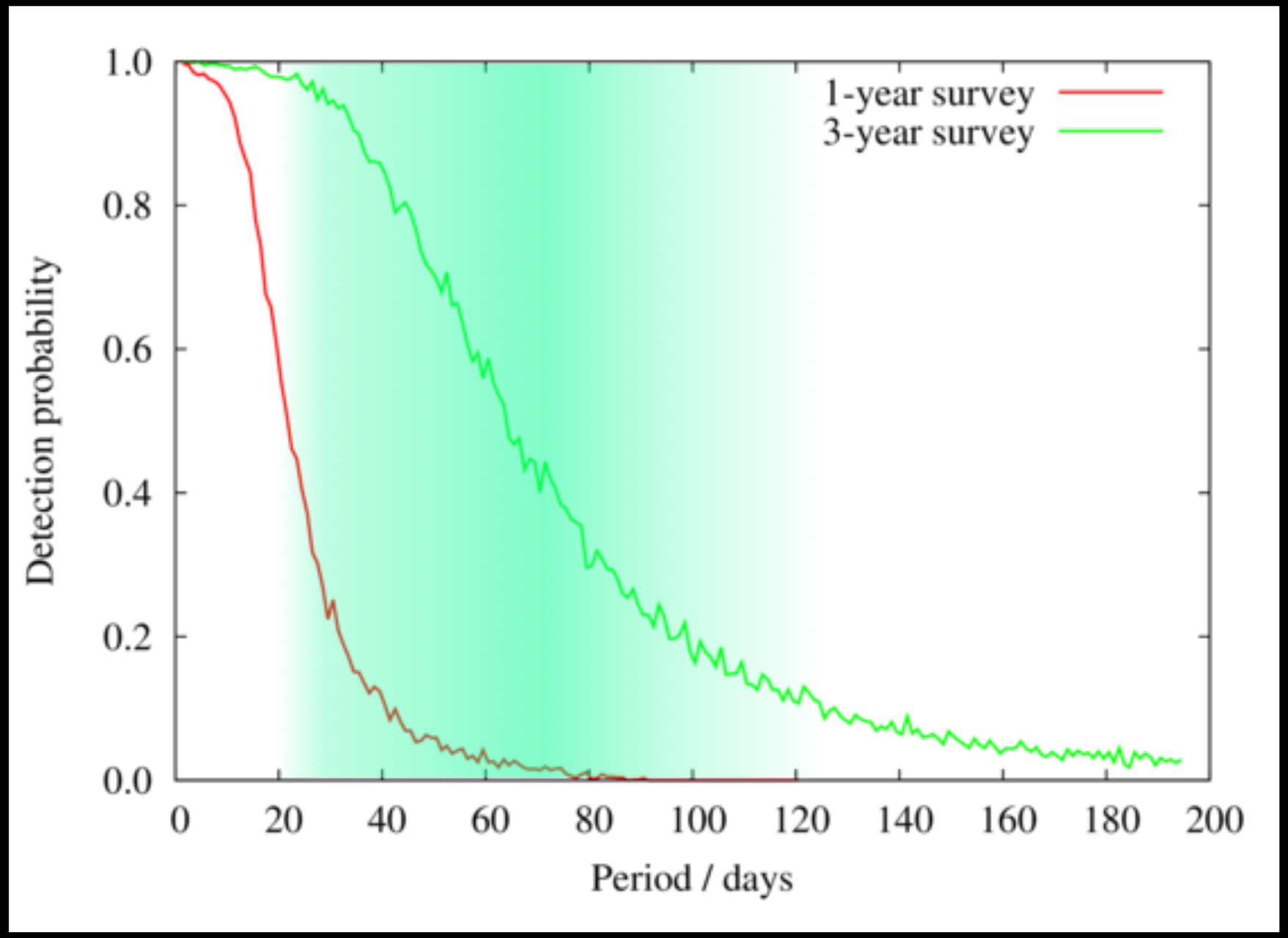
- Evryscope provides at least 2 years of target **pre-imaging for TESS host characterization**

- Observes fields for **>20 times longer than TESS** => greatly increases TESS long-period giant return



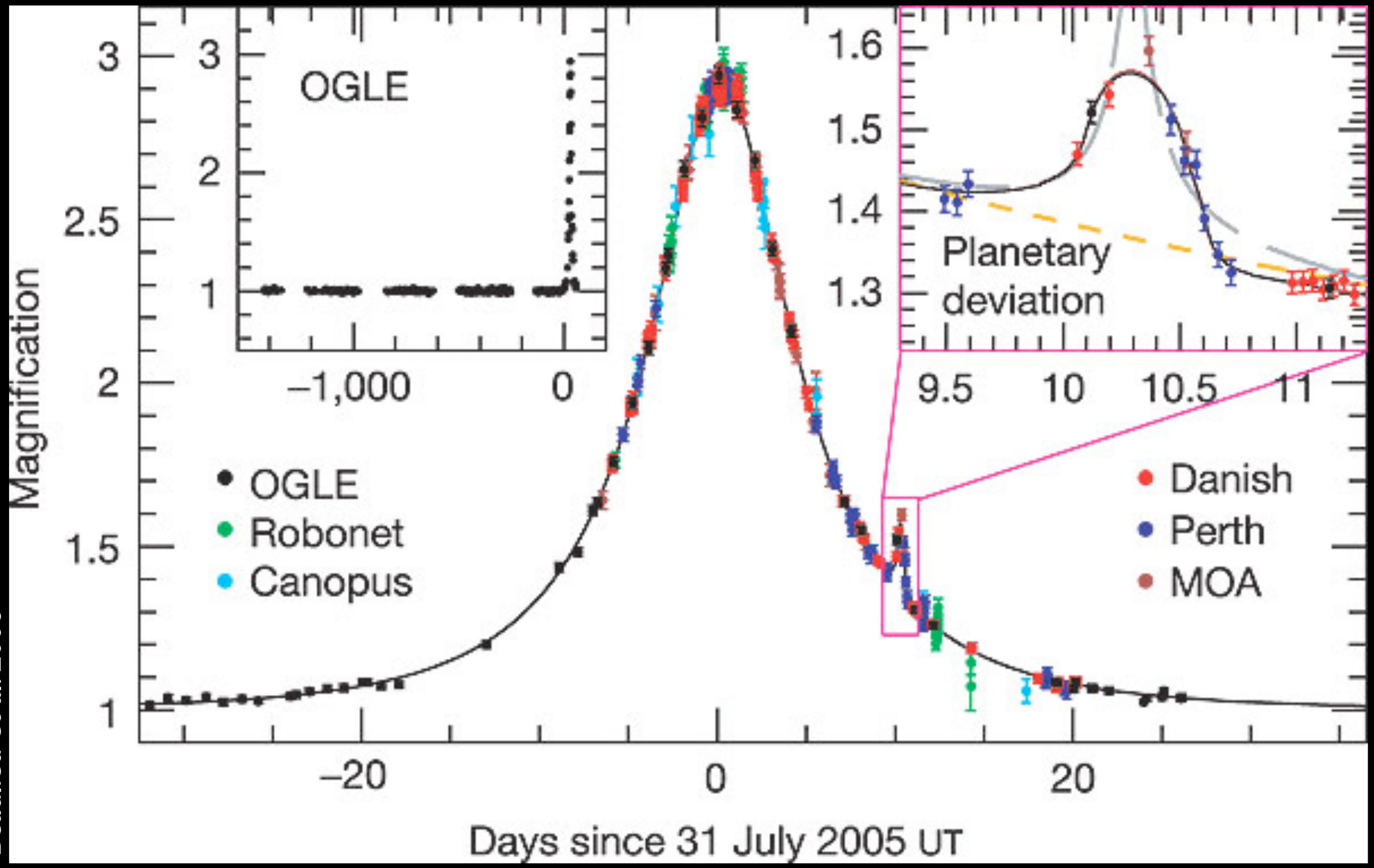
Nearby M-dwarfs transits

- ~5,000 M-dwarfs bright & small enough to find few-Earth-radii planets.
- **5-10 few-Earth-radii rocky planets** likely detectable based on simulations.
- >30,000 M-dwarfs searchable for giant planets.



The probability of detecting a transiting rocky planet around an M-dwarf in **1 and 3 years** of Evryscope data, based on detailed simulations of our detection efficiency, detection algorithms and correlated noise.

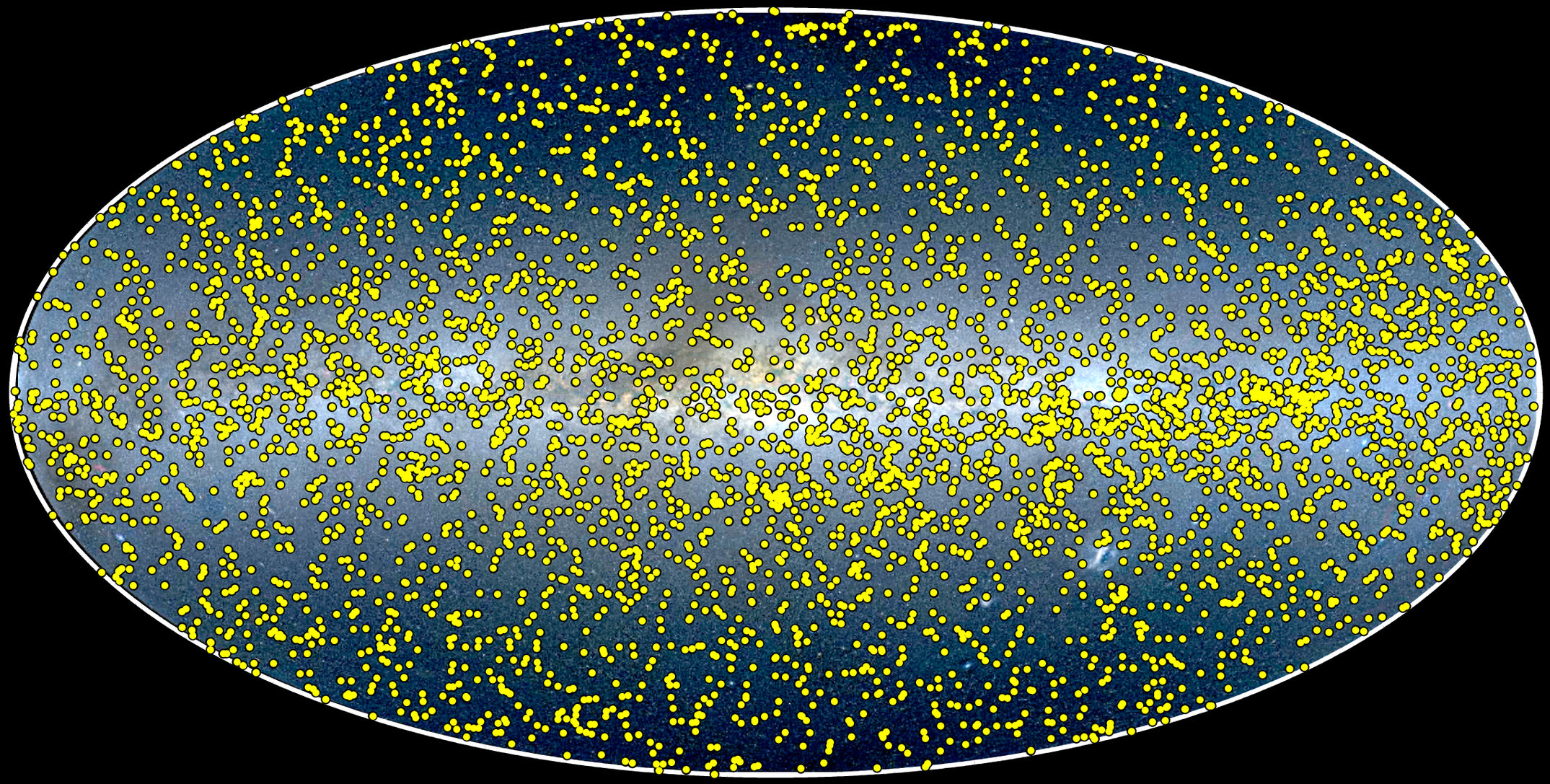
All-sky survey of rare microlensing events of nearby stars



Beaulieu et al. 2006

Rocky planet in 2.6AU orbit around M-dwarf (m_I=14.2)

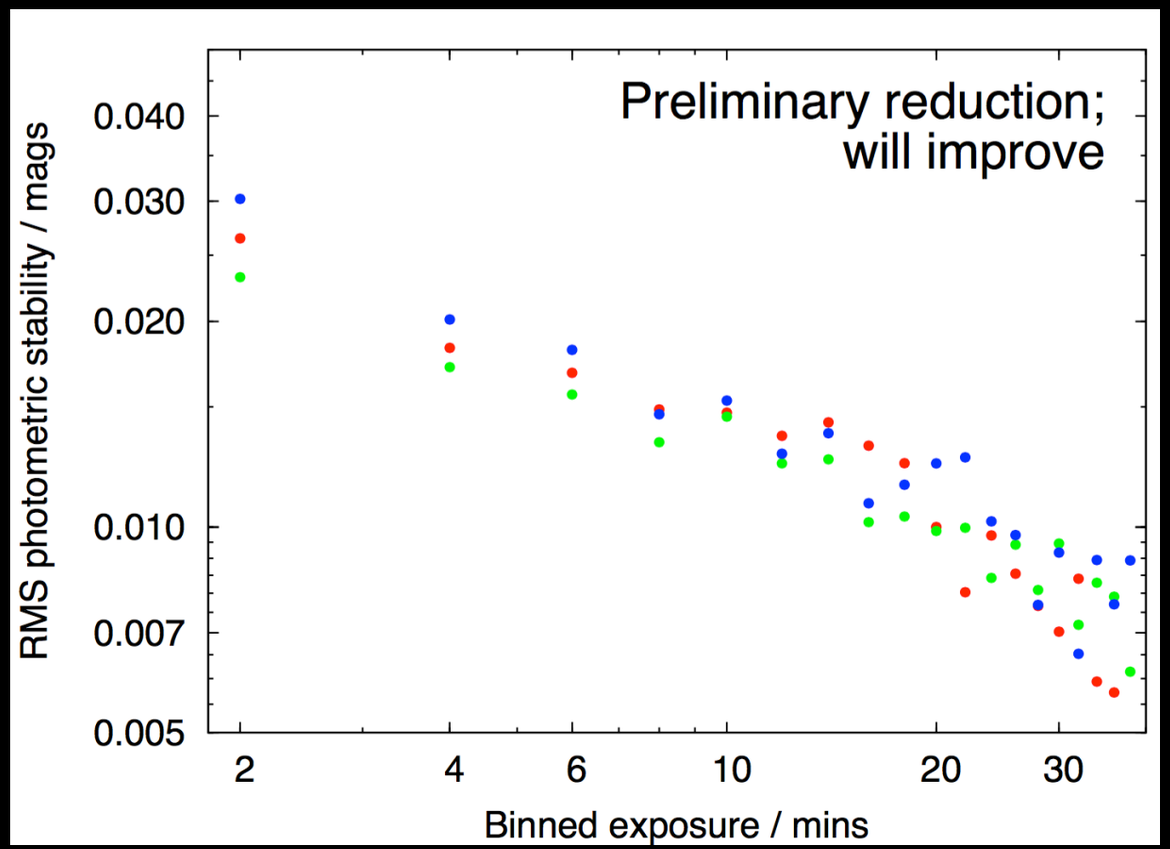
Bright, nearby stars



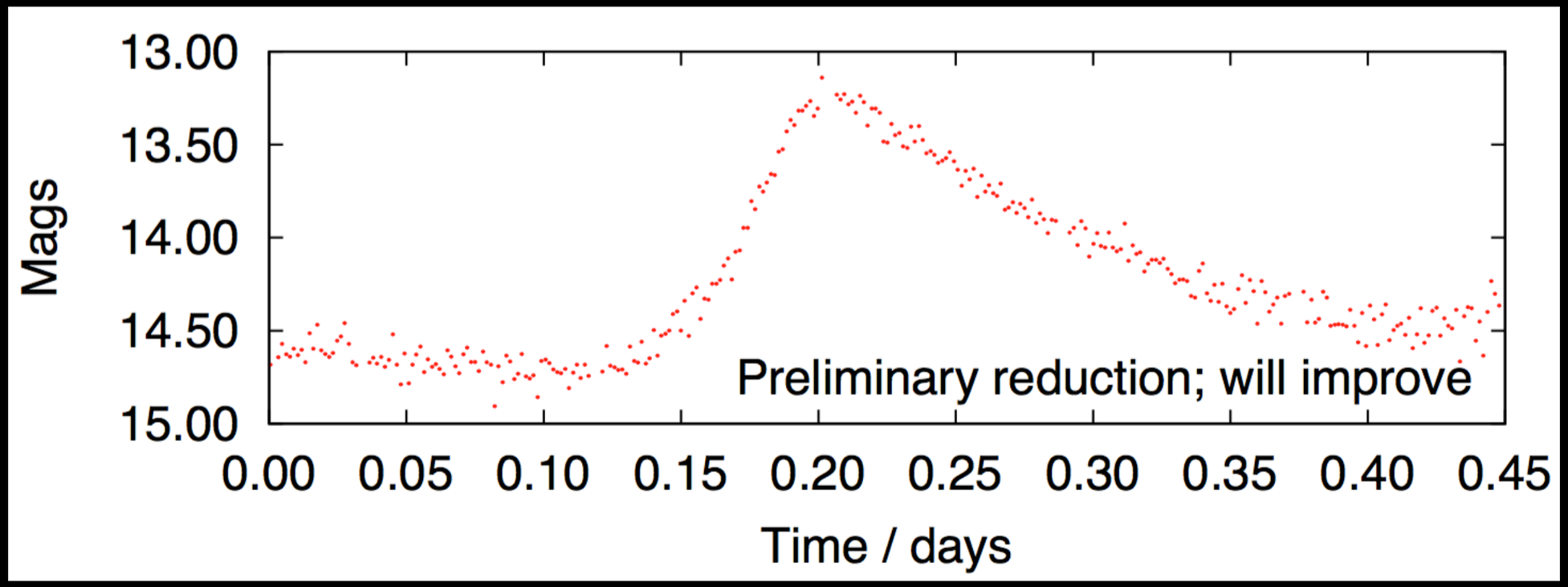
In 2 years Evryscope will perform a short-time exposures survey, which will be sensitive to long-term planets in the very bright end.

This survey will monitor 70,000 stars g<10 for increasing planets around very bright stars, which will be amenable to follow up atmospheric characterization.

Preliminary results



Photometric performance achieved by the Evryscope for 3 different nights for stars which are bright enough to be limited by scintillation and systematics. The photometric performance improves as expected for low levels of systematic noise.



Light curve of the RR-Lyr V*RS Oct imaged by the Evryscope during a single night sampled at 2mins, from our preliminary data analysis.

Thank you.

Questions?

Interested in collaborating?

nmlaw@unc.edu ; ofors@unc.edu