The Evryscope: the first full-sky gigapixel-scale telescope

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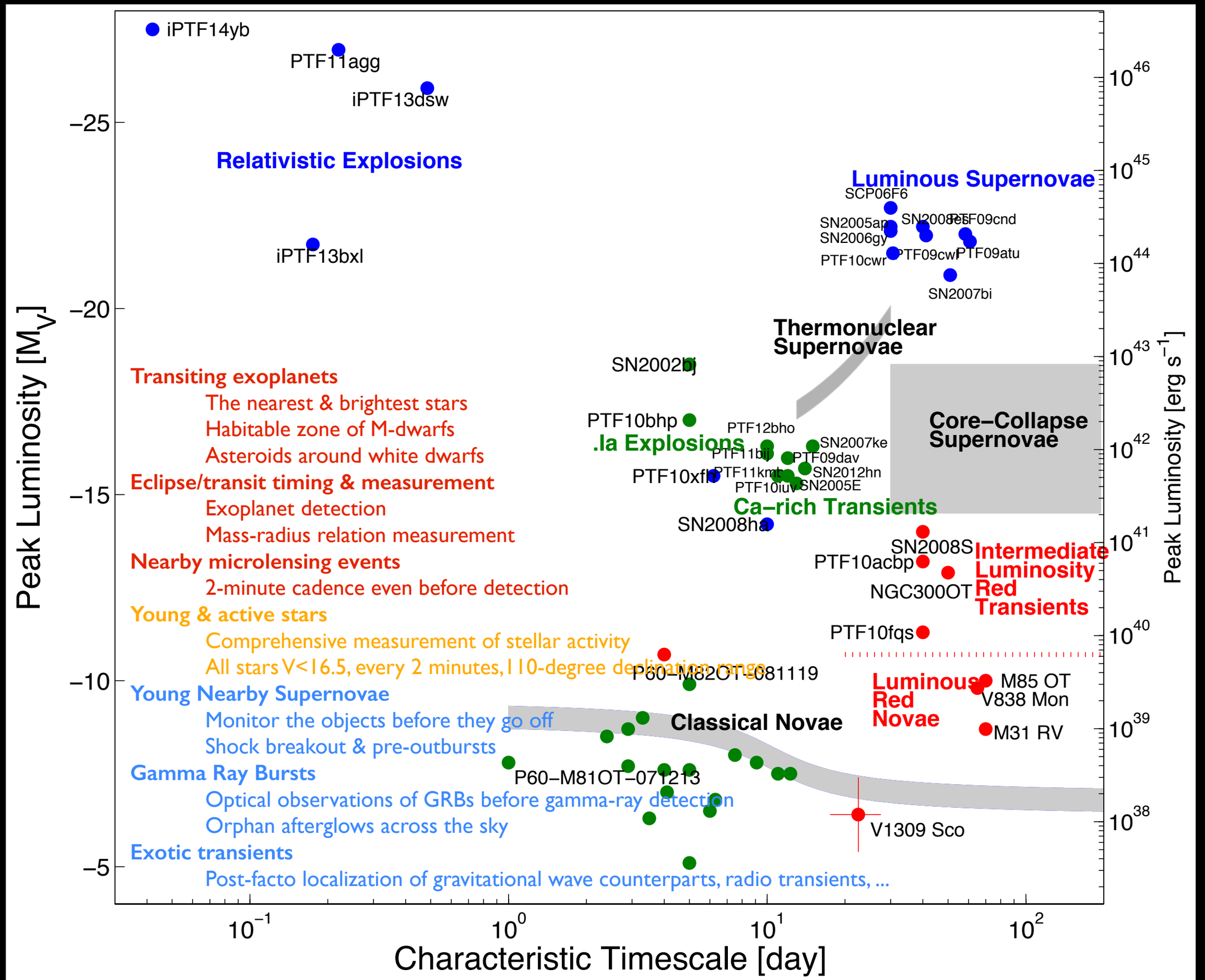
AST-1407589
AST-1555175

Optical transient timescales

Mansi Kasliwal



The Evryscope ("wide-seer")

691 MPix

8,000 sq. deg. FOV

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

"Bug-eyed"
- Popular Mechanics

"Looks more like an architectural folly than a telescope"
- Science

"Like an upside-down colander repurposed into a Star Trek prop"
- Science News

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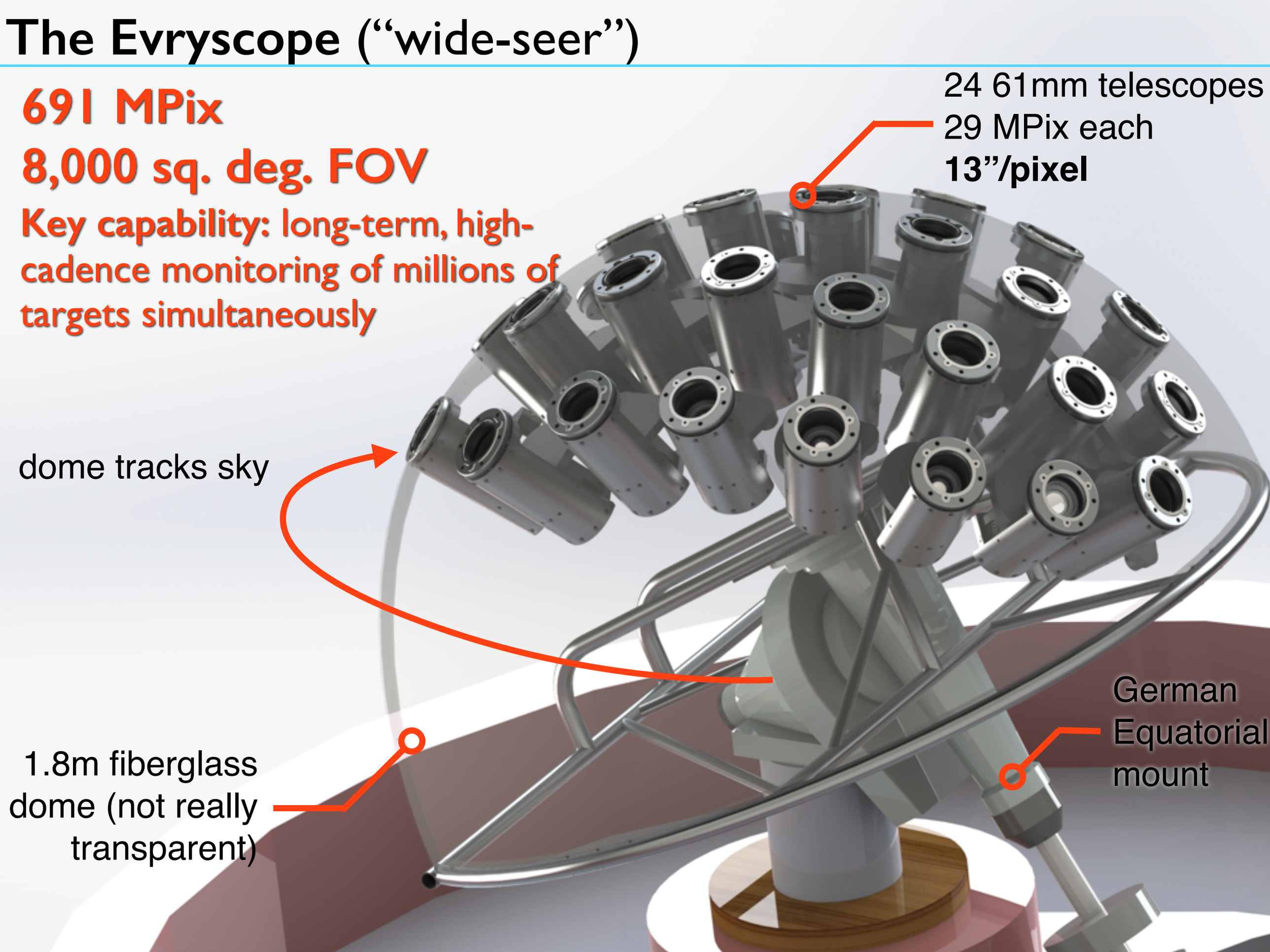
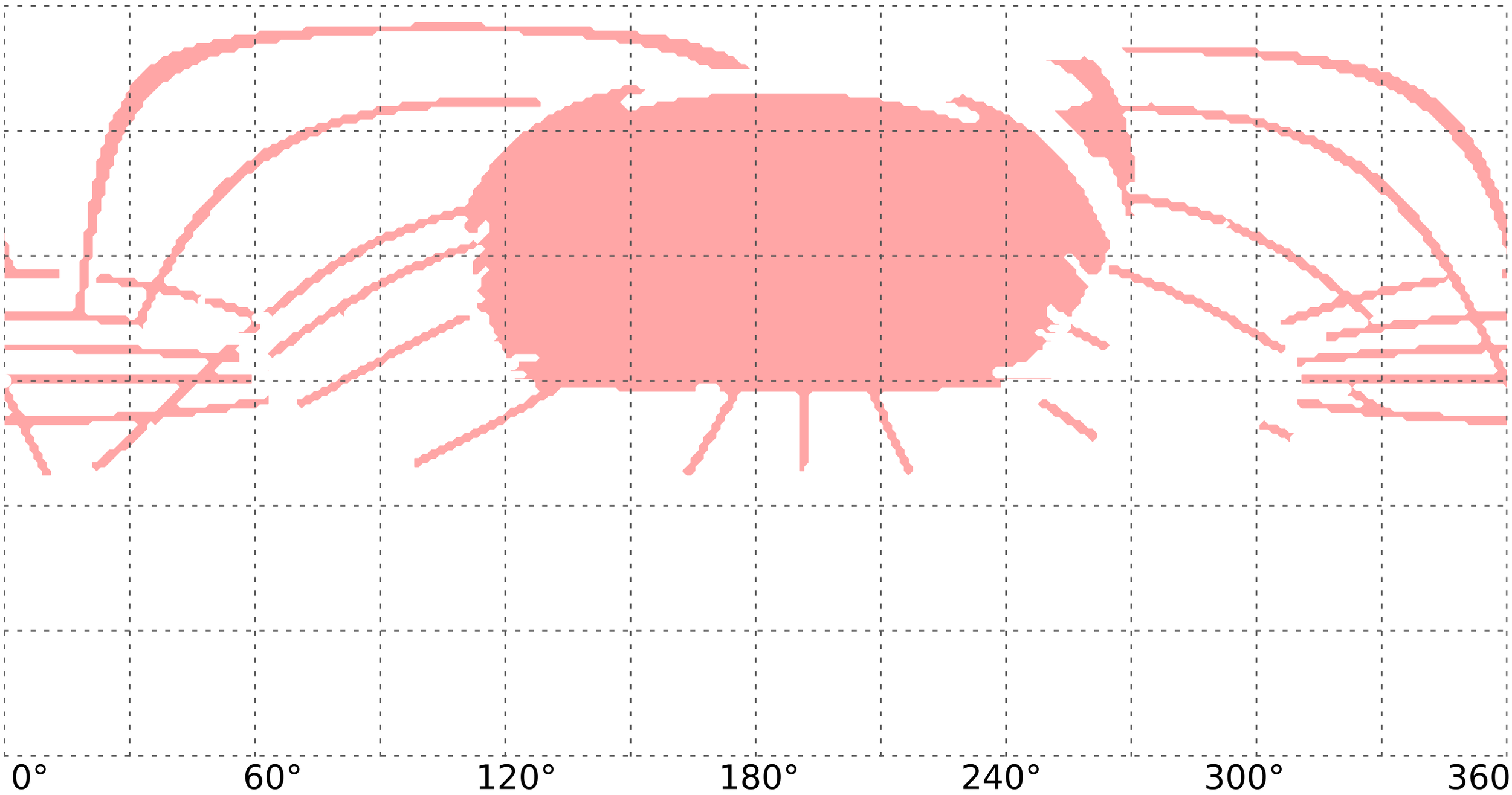


Northern Evryscope sky coverage



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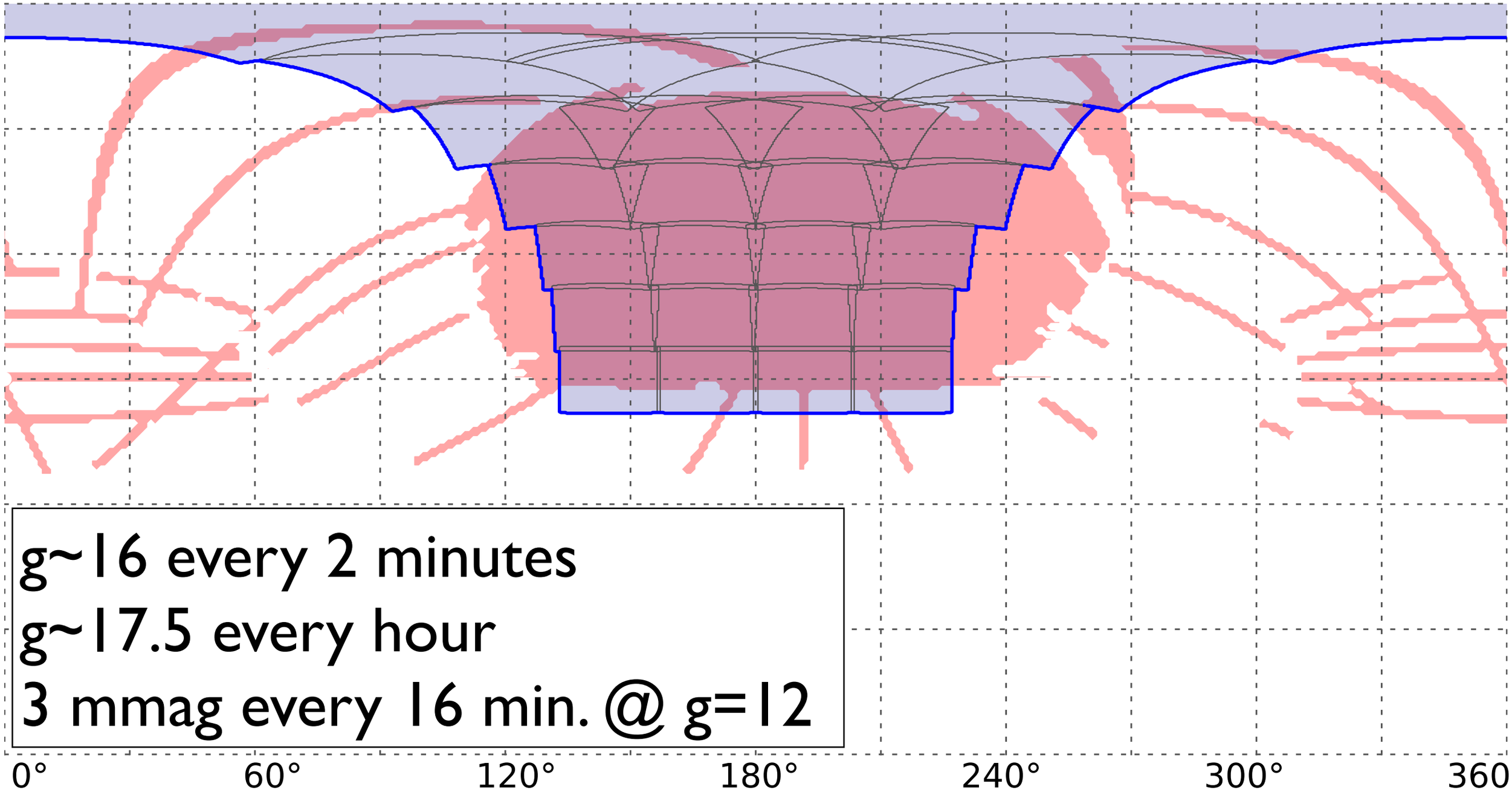

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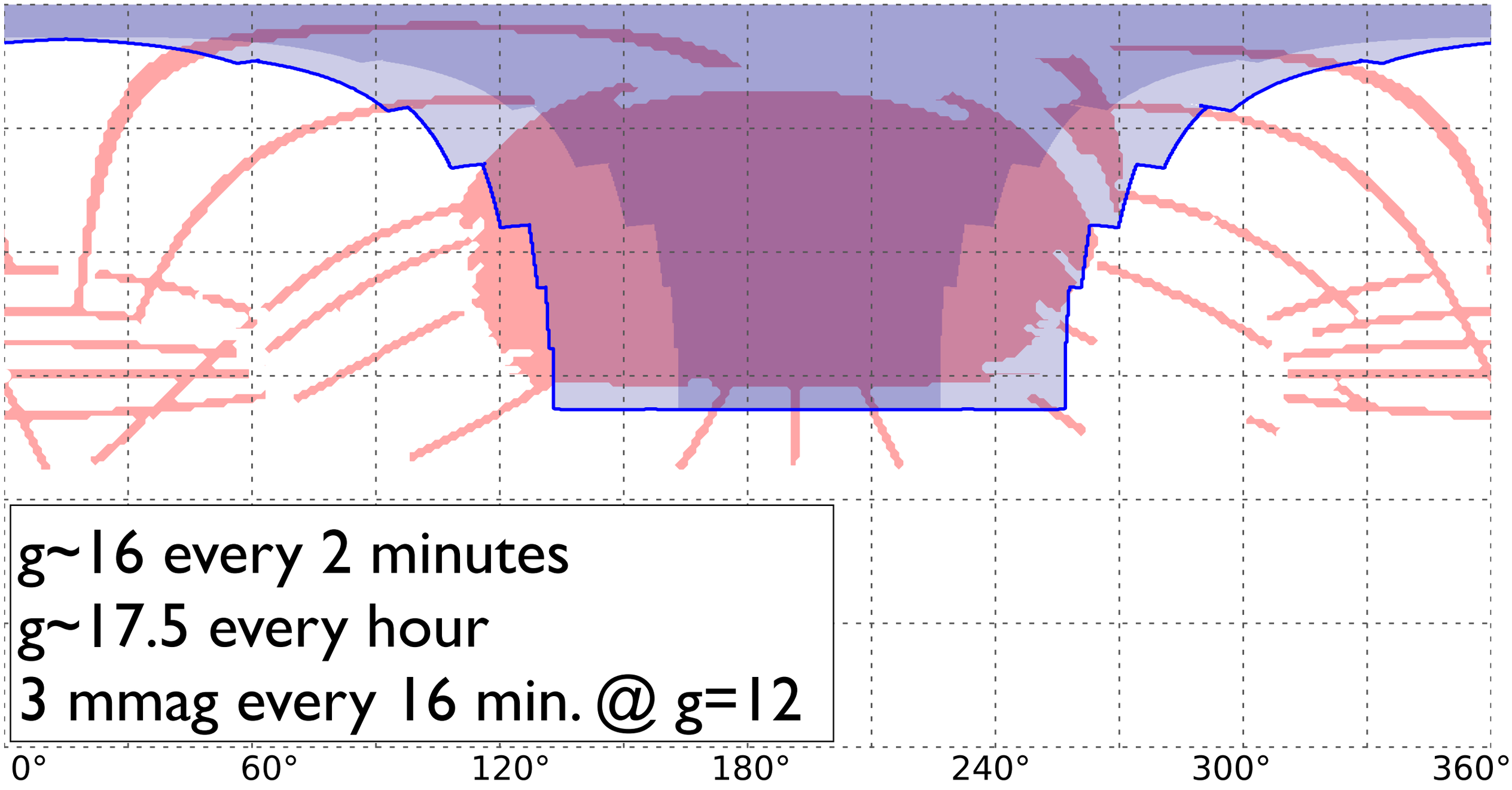
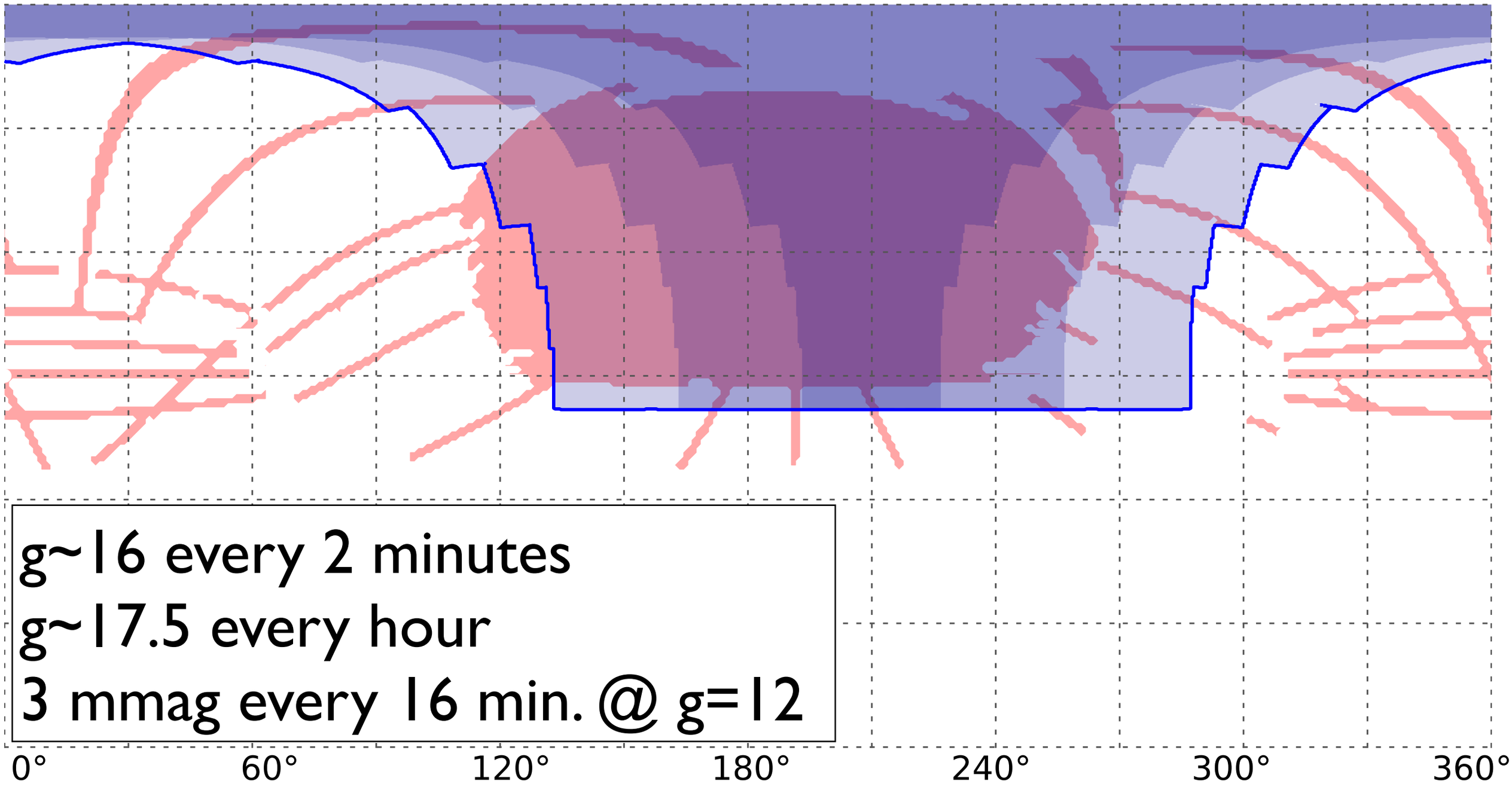


Evryscope sky coverage (flipped to North)



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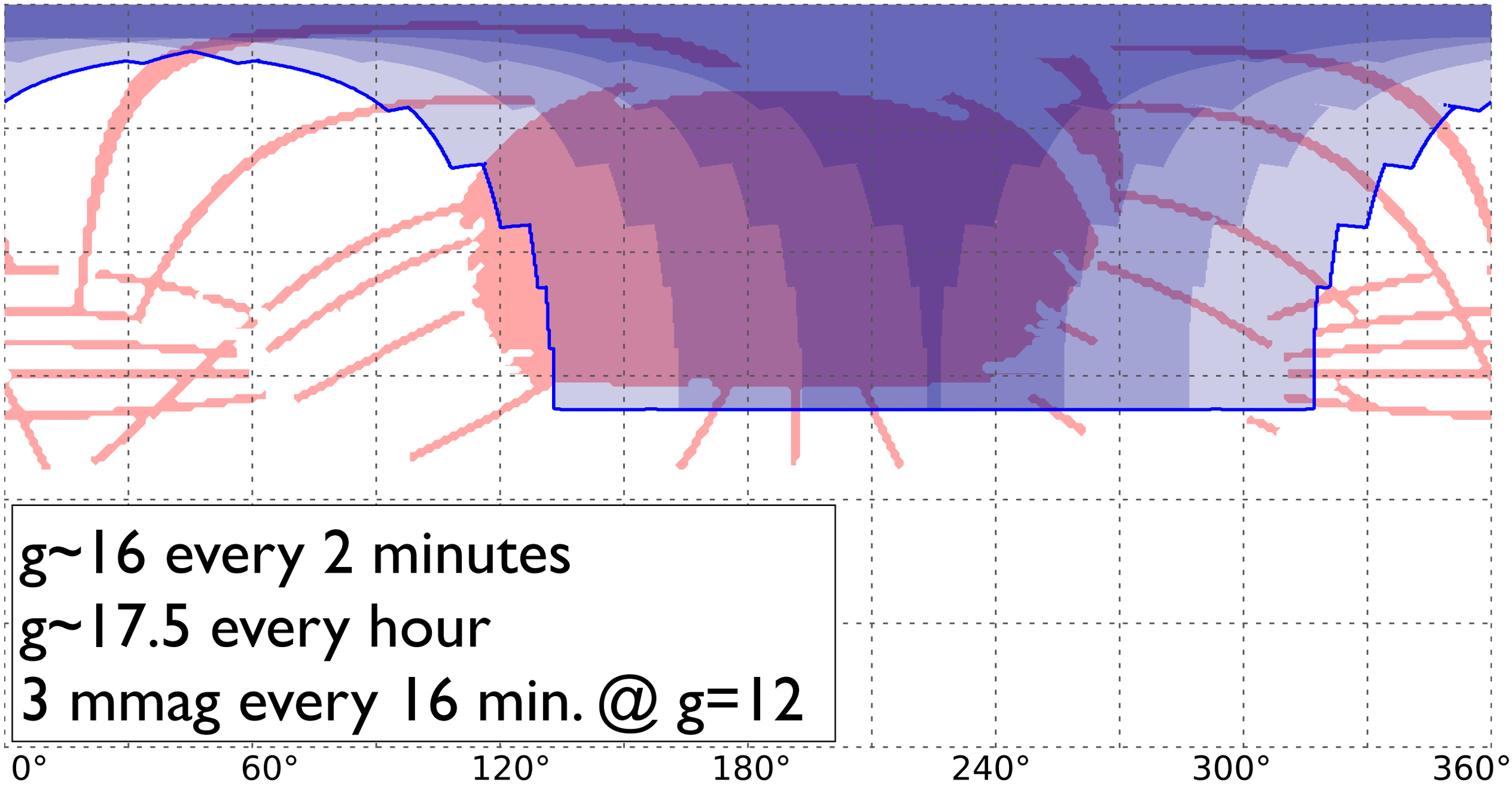

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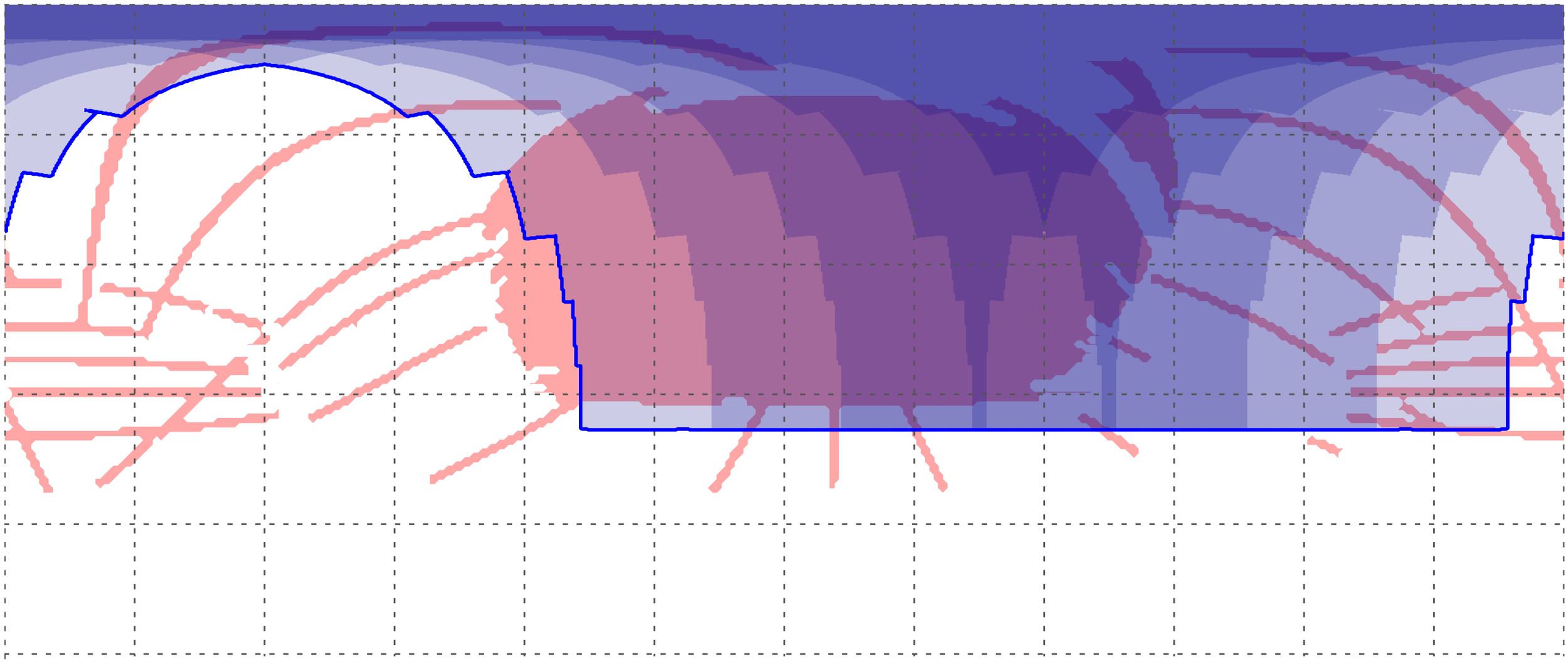


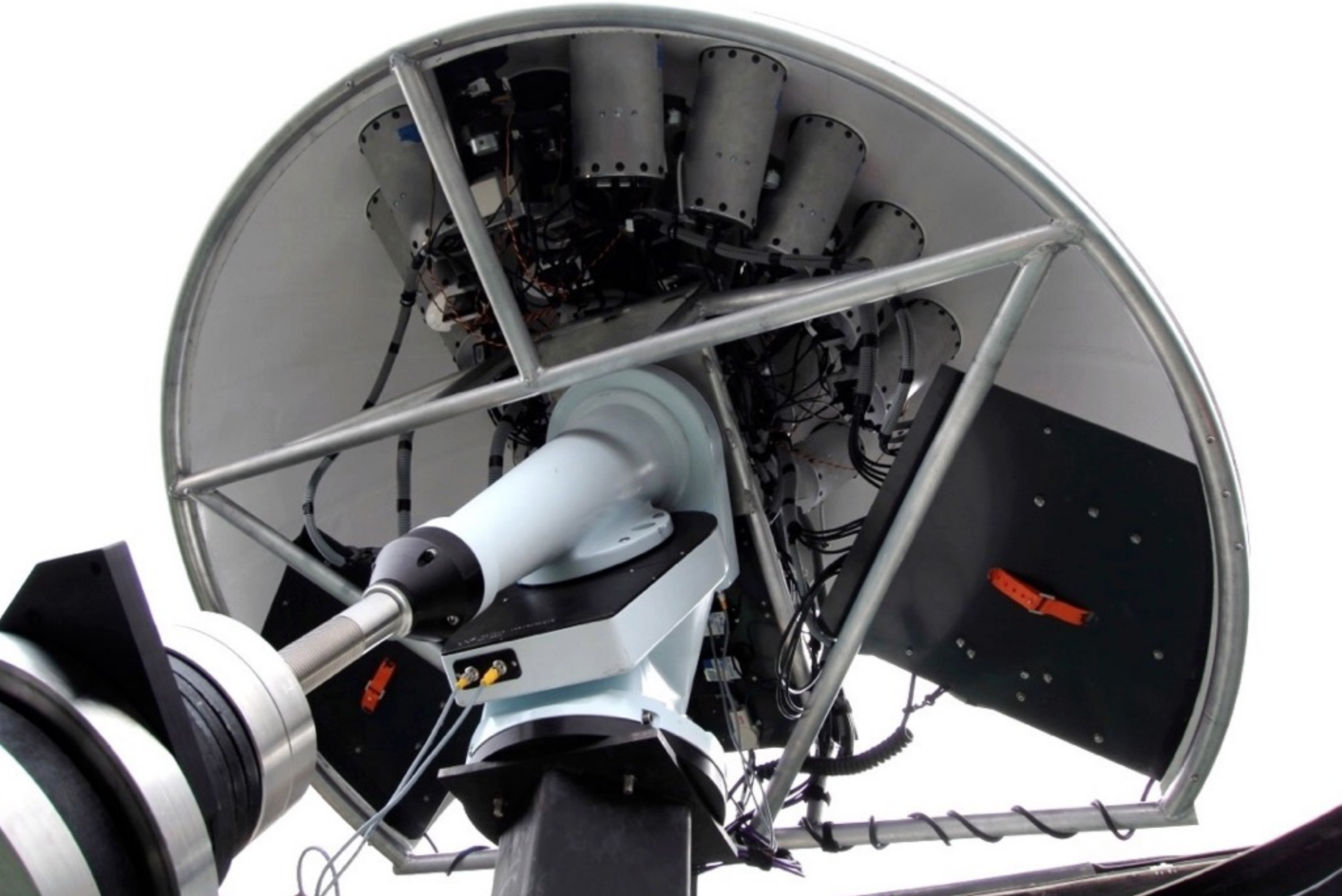
Every year:

20-35k observations of essentially all objects brighter than 16th magnitude

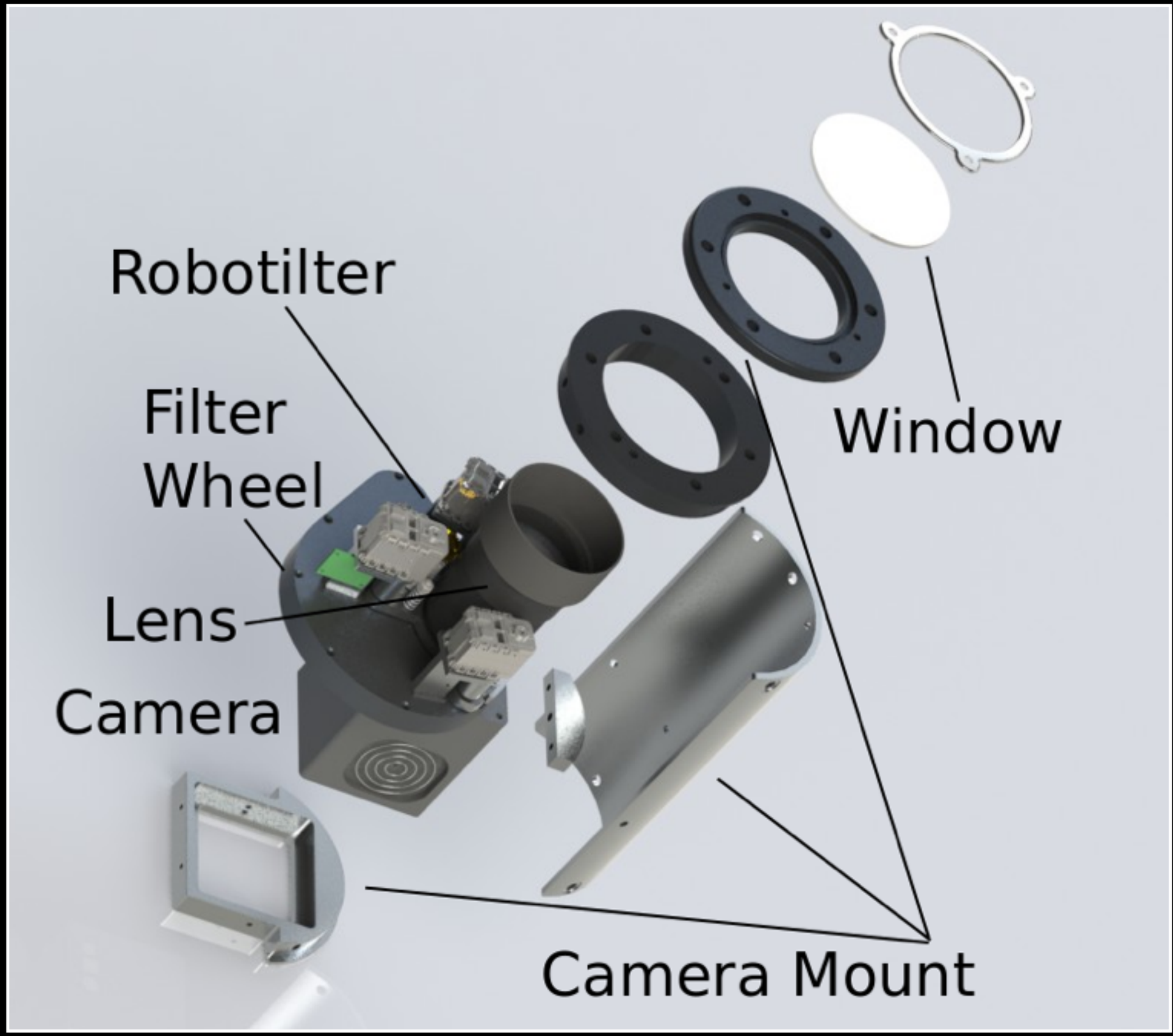
Evryscope @ CTIO

Thanks NSF/ATI & NSF/CAREER!
Funded July 2014
Deployed May 2015

Evryscope @ CTIO

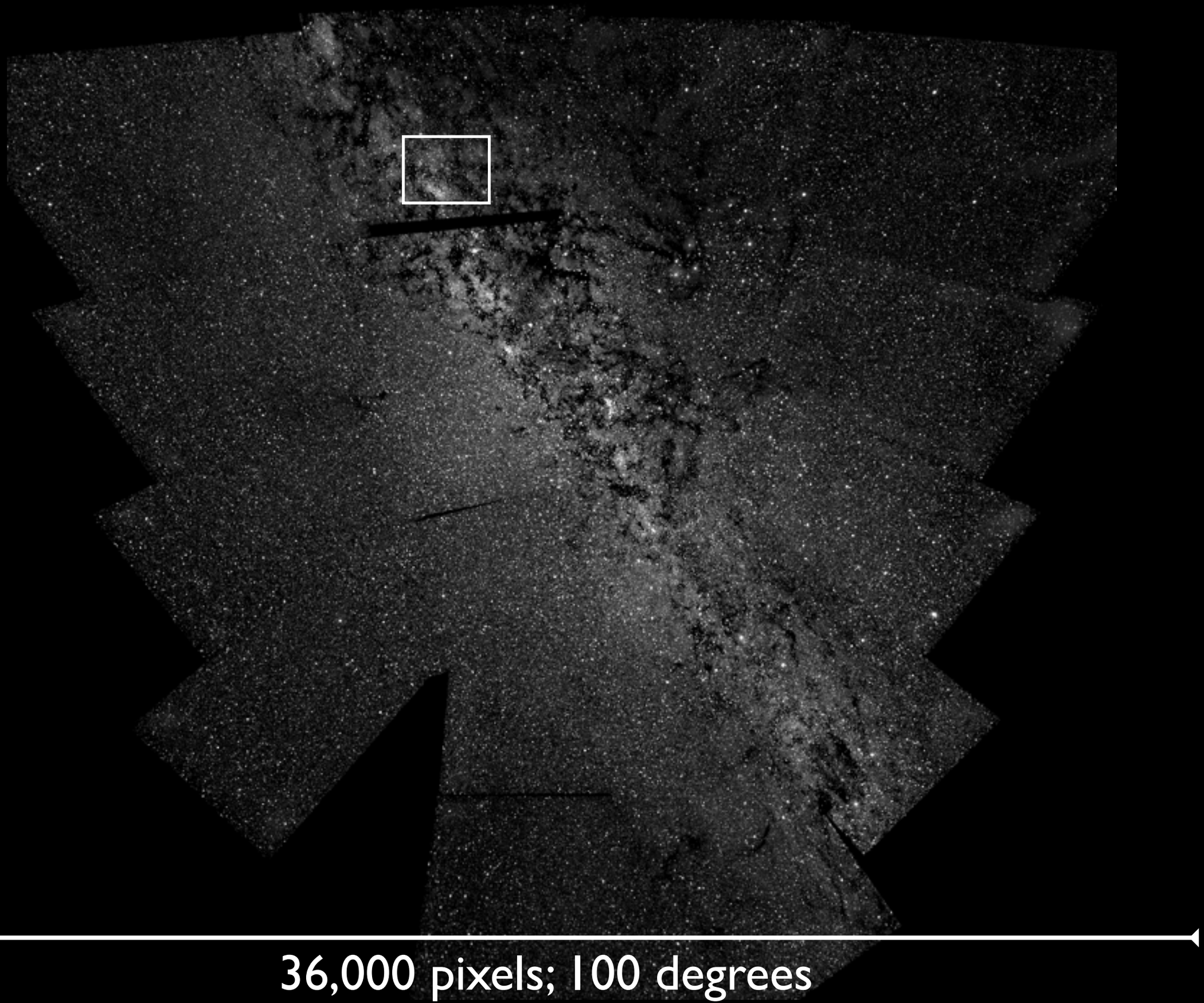


Evryscope Camera Assembly



See Jeff Ratzloff's talk (Monday) & paper 9908-32

One Evryscope Image

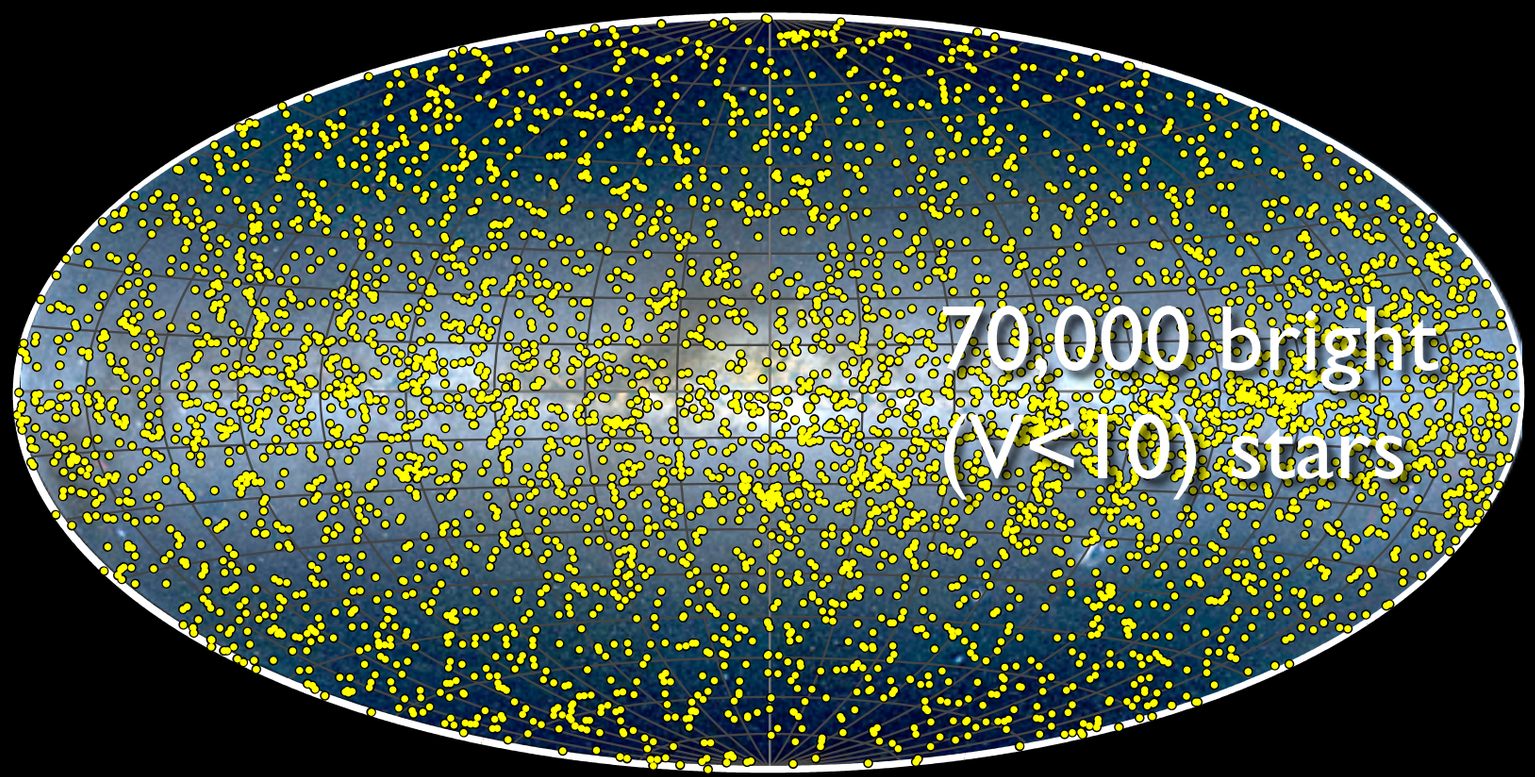


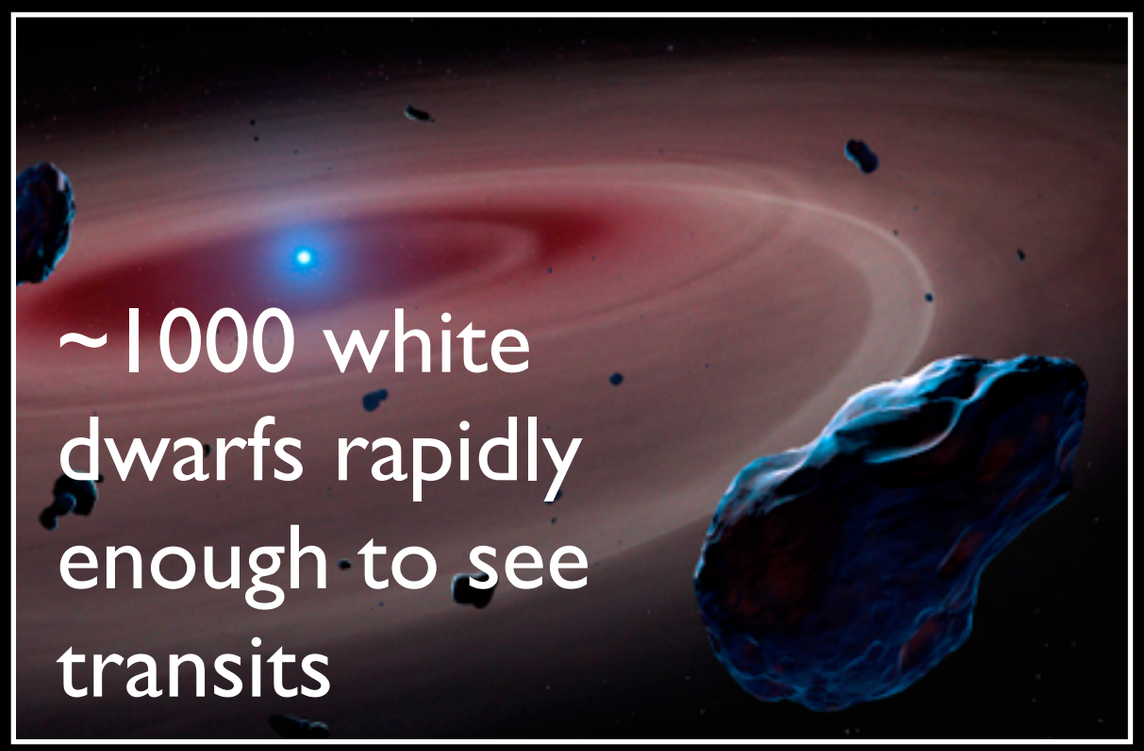
36,000 pixels; 100 degrees

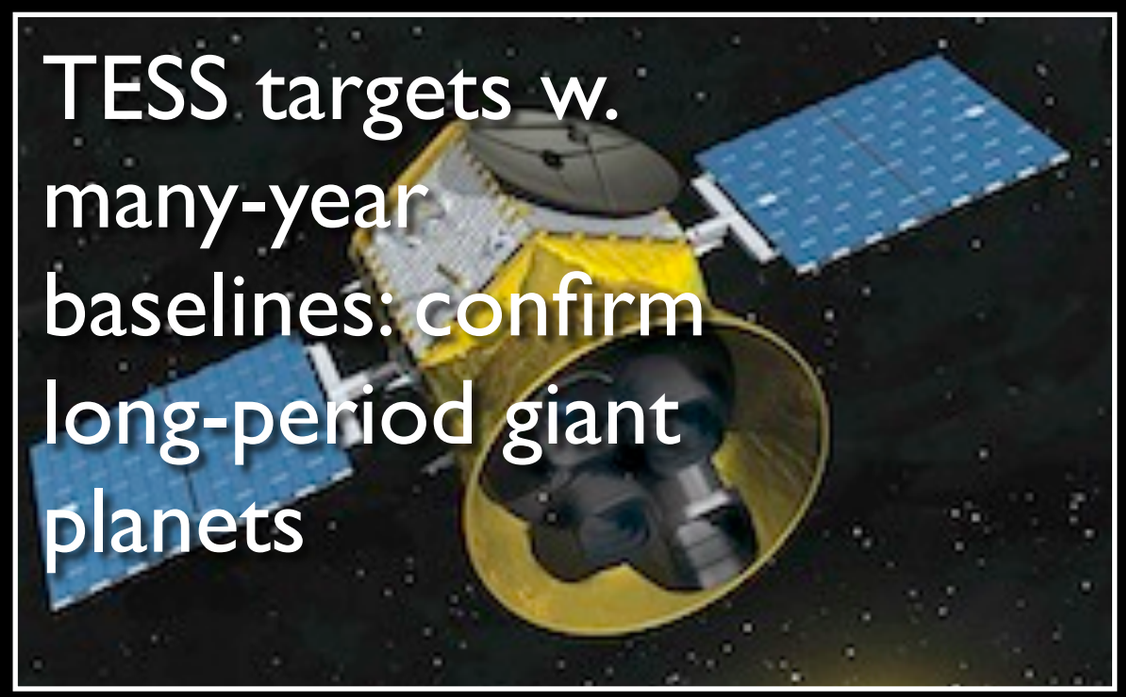
1% of Evryscope field of view

Key capability: long-term, high-cadence monitoring of rare all-sky targets

>30,000 M-dwarfs w. habitable-zone Jupiter sensitivity

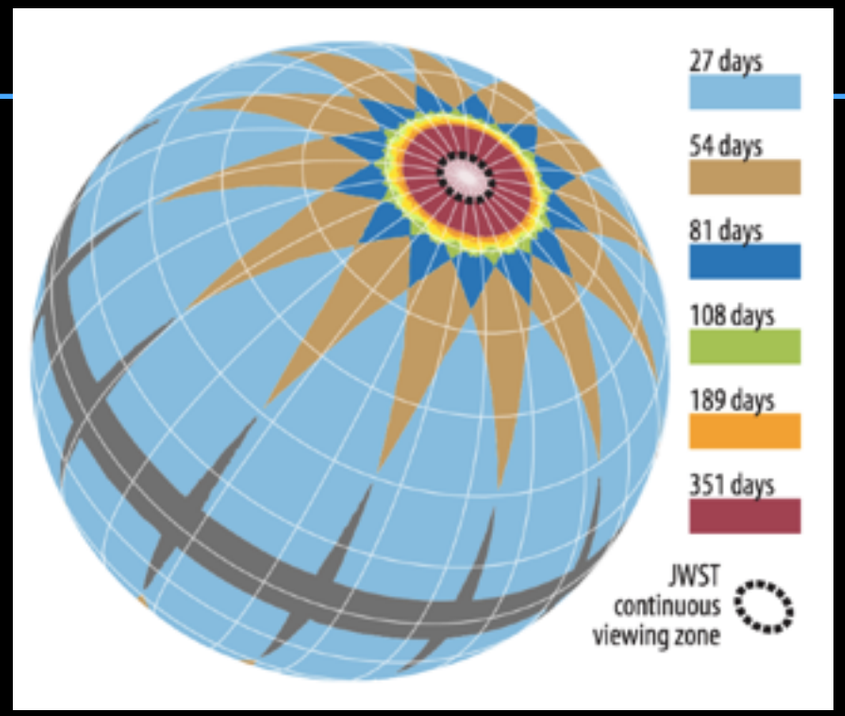






TESS Synergies

- Evryscope has slightly smaller aperture, 2X finer pixel sampling
- Will provide simultaneous multi-color imaging of TESS fields
- Long term observations: ~50 times longer than TESS

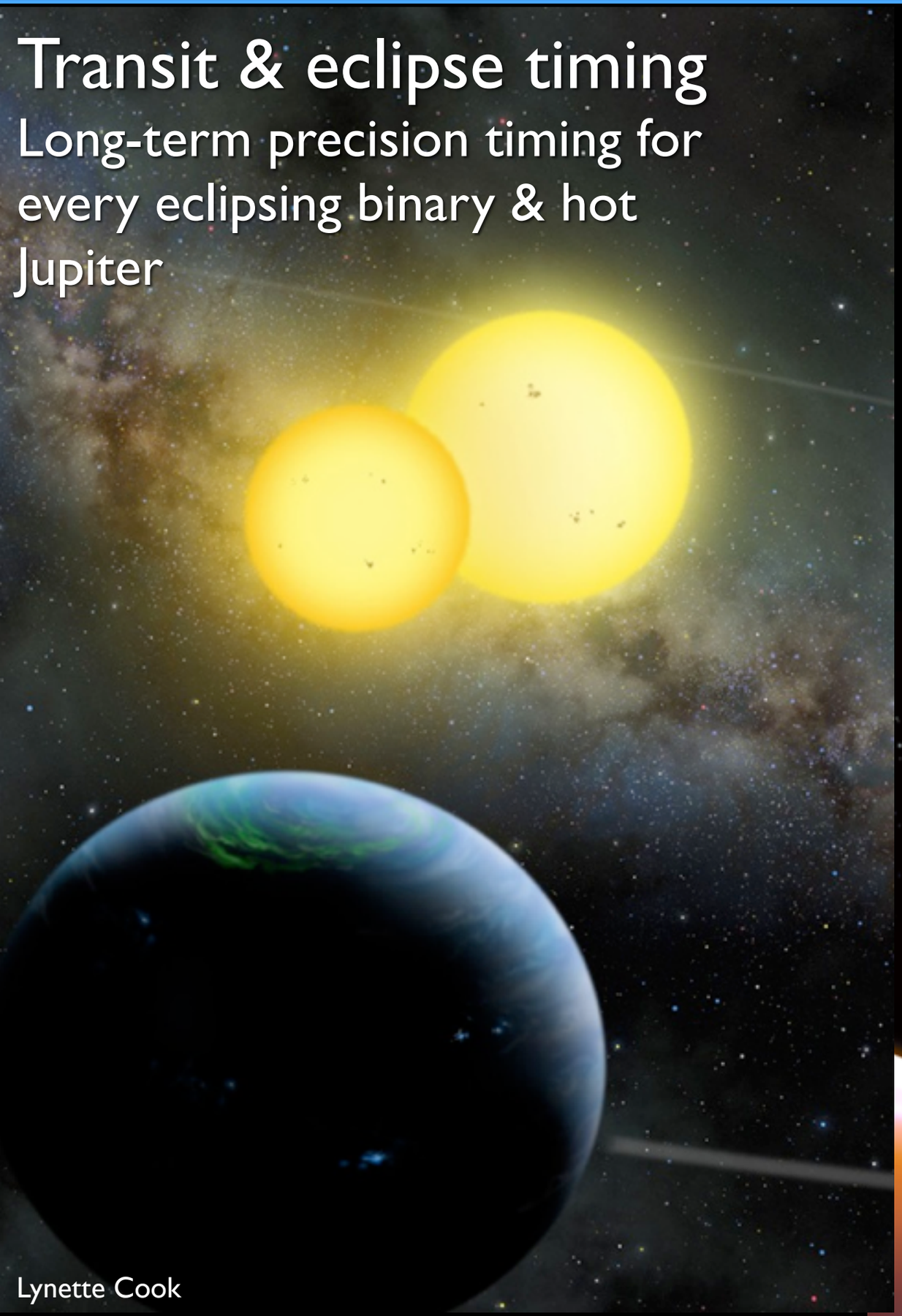


	Evryscope	TESS
Aperture	61mm	105mm
Pixel sampling	13”/pix	21”/pix
FoV	8000 sq. deg.	2300 sq. deg.
Cadence	2 mins	30 mins (faster for selected targets)
Survey length	5 years	27 days (most of sky)
Filter	Blue	Red

Other planet-detection methods & stellar astrophysics

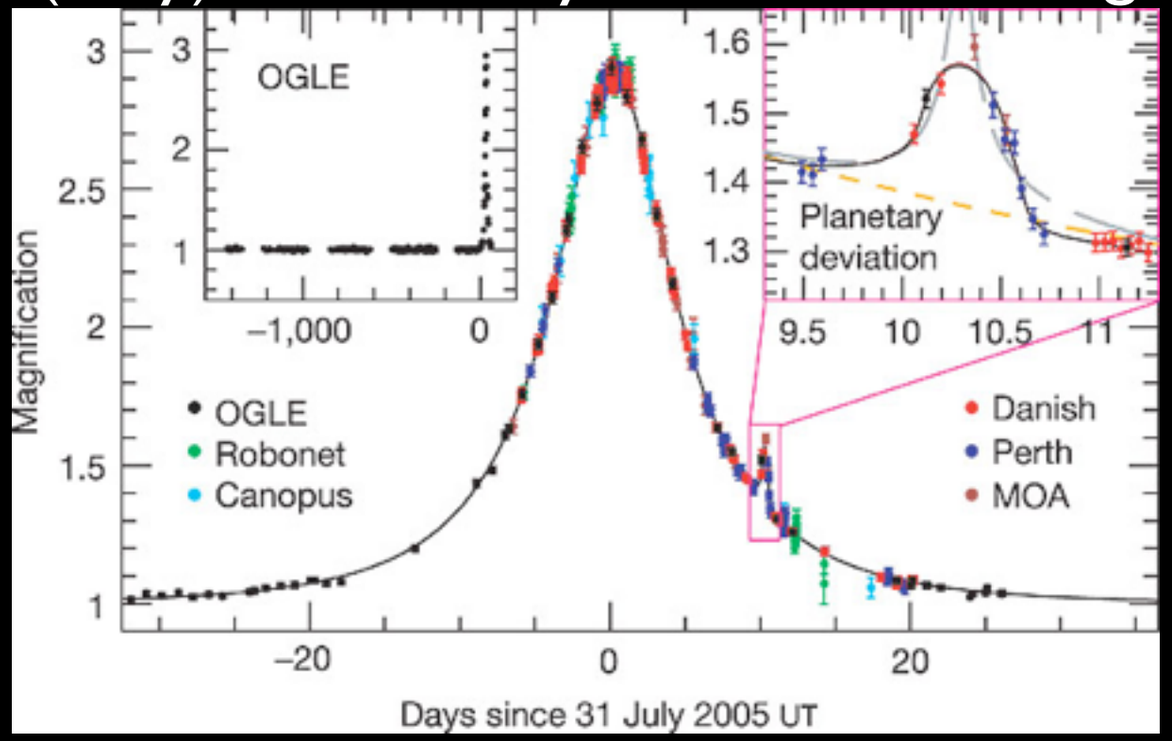
Transit & eclipse timing

Long-term precision timing for every eclipsing binary & hot Jupiter



Lynette Cook

(very) rare nearby-star microlensing

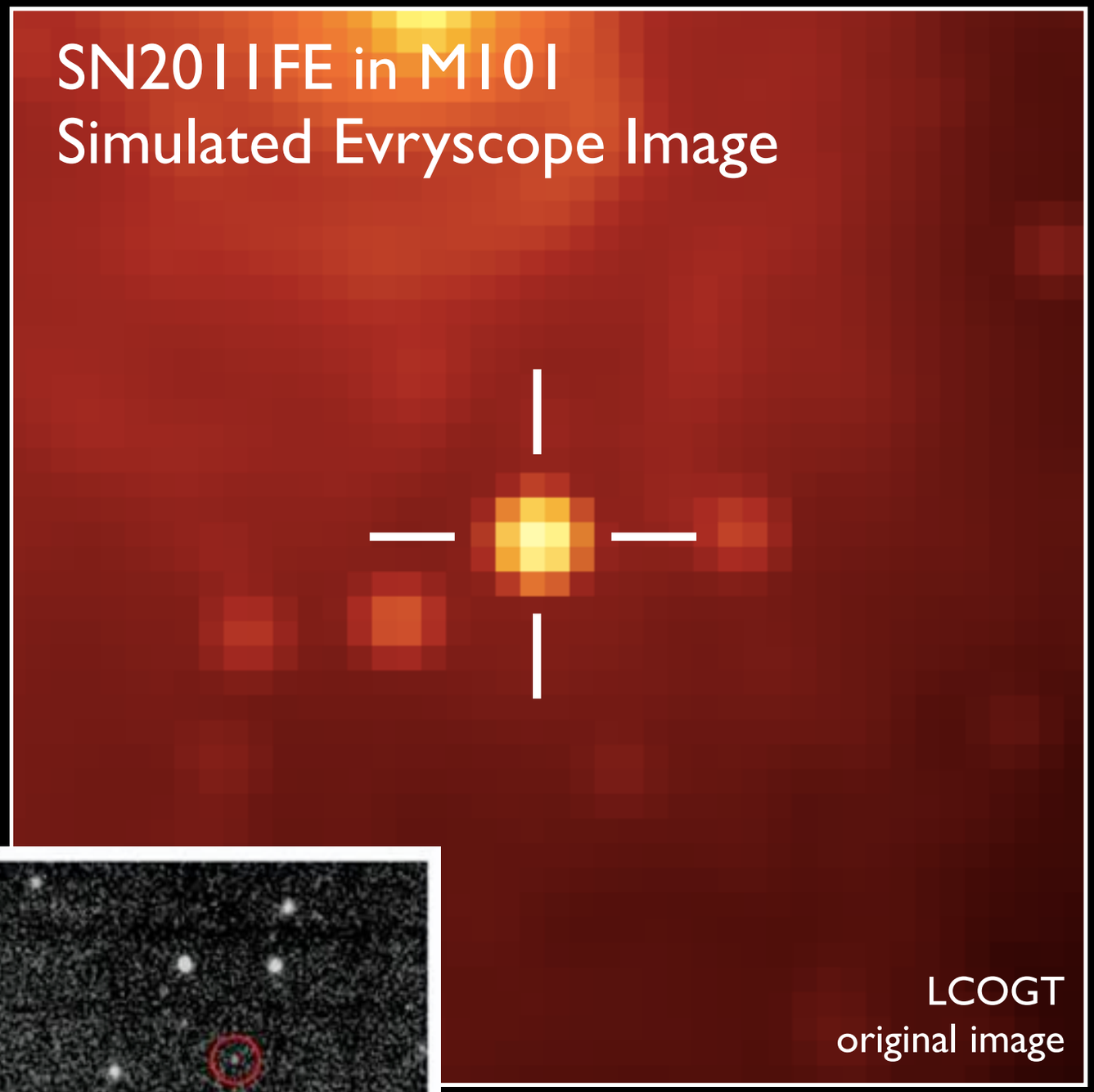


Beaulieu et al. 2005

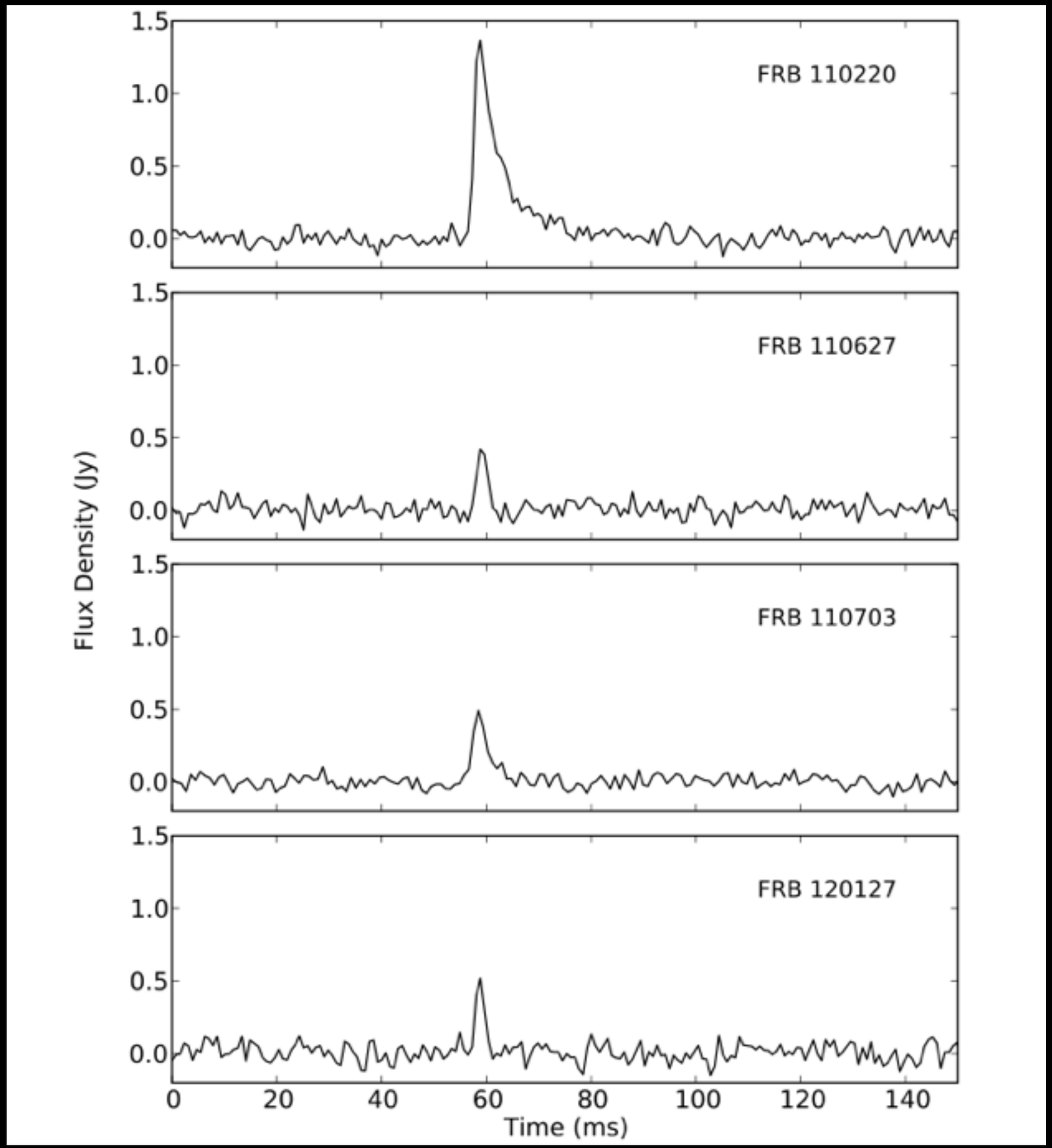
+ stellar variability, young stars, compact objects, accretion events...

Nearby supernovae, bright GRBs, and GW counterparts

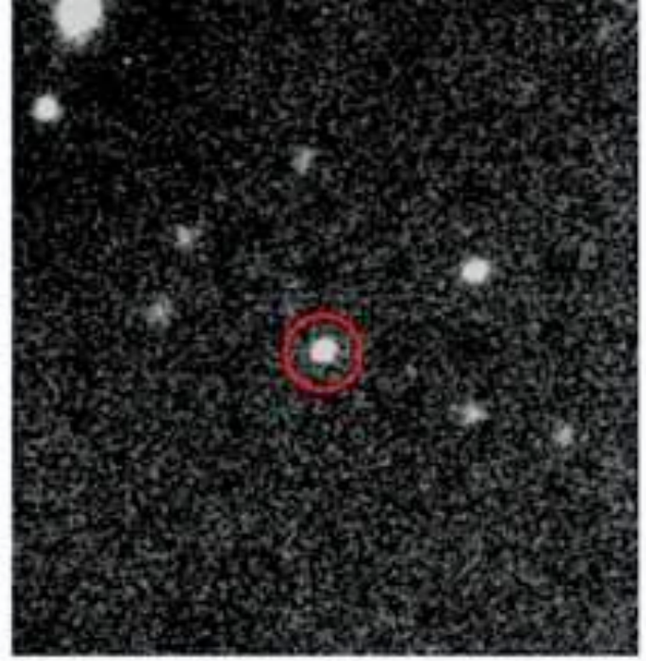
- High-cadence imaging *without needing pointing*
- Probe shock-breakout regime of nearby supernovae; prompt emission from GRBs
- Search for *pre-explosion* outbursts (probing mass loss in final stages of massive star evolution)

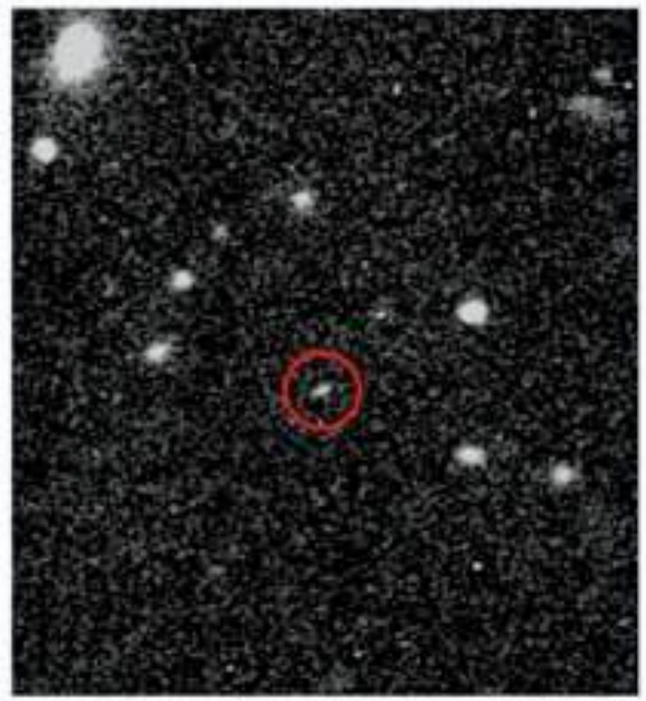


The Unknown

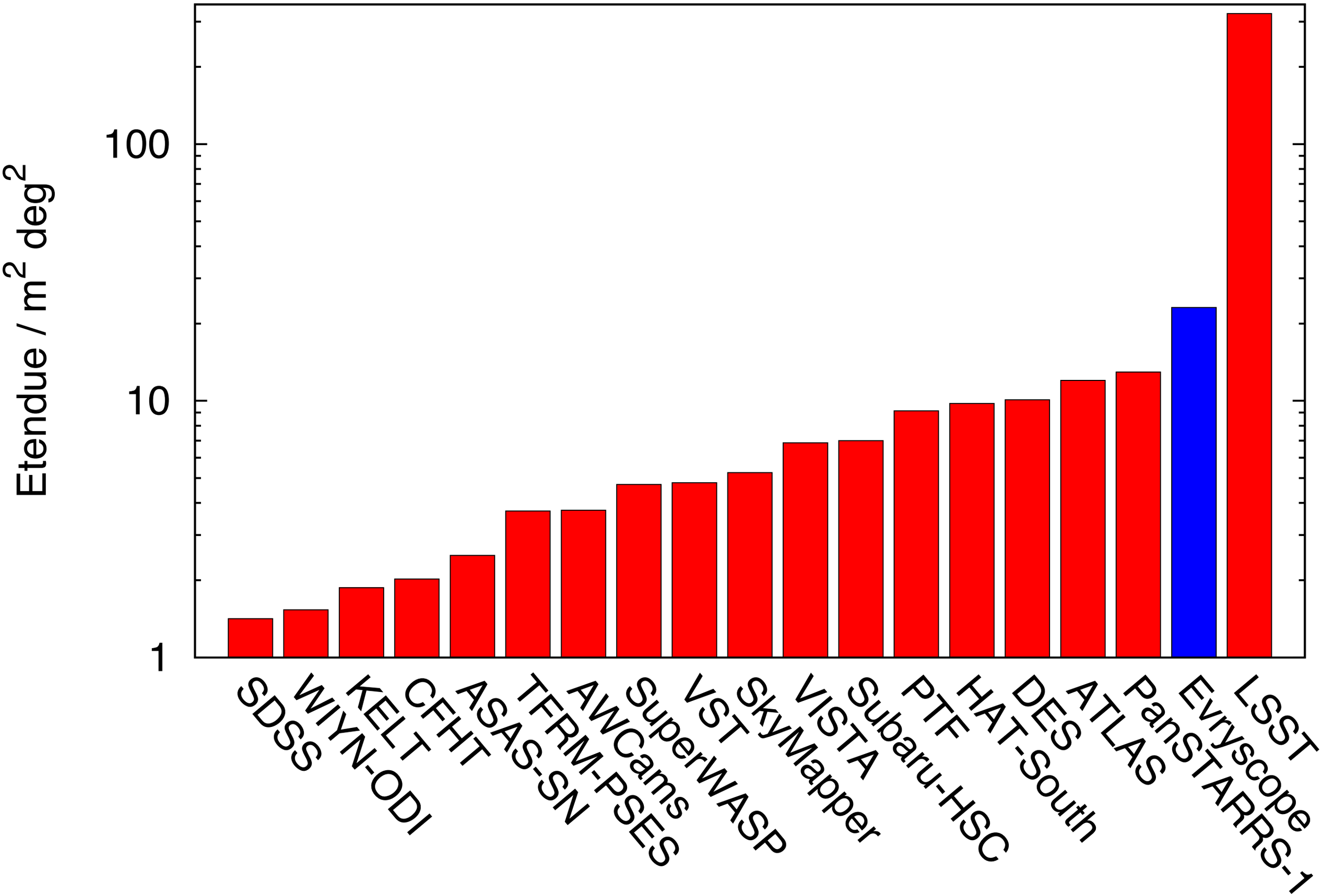


Thornton et al. 2013

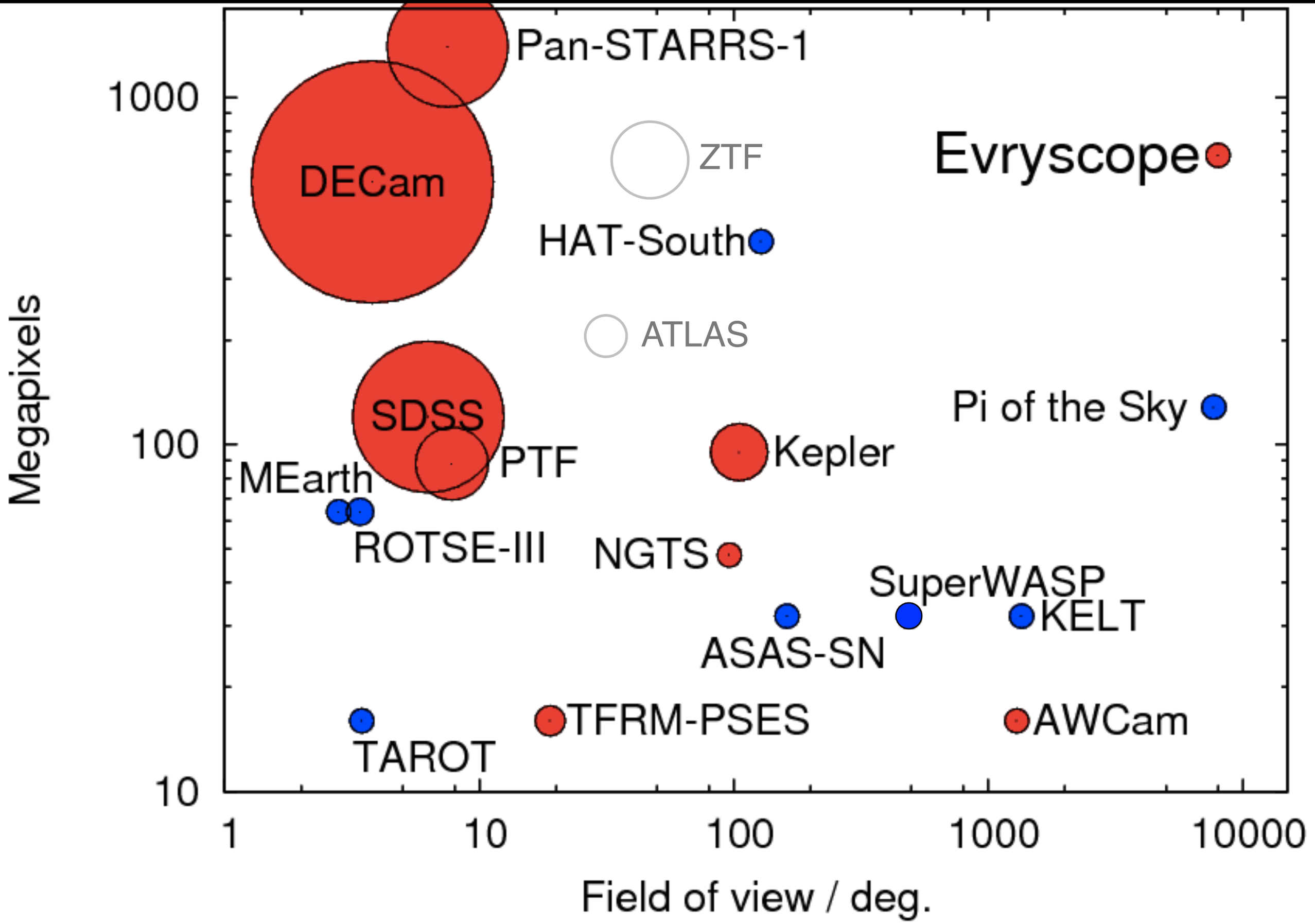




Current survey etendues



Survey parameter space



Observing the entire sky every three nights

LSST (6.7m eff.)
for 30 seconds
every 3 nights
0.03% duty cycle

Evryscope (61mm)
for 3 nights
every 3 nights
97% duty cycle

Observing the entire sky every three nights

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every 3 nights
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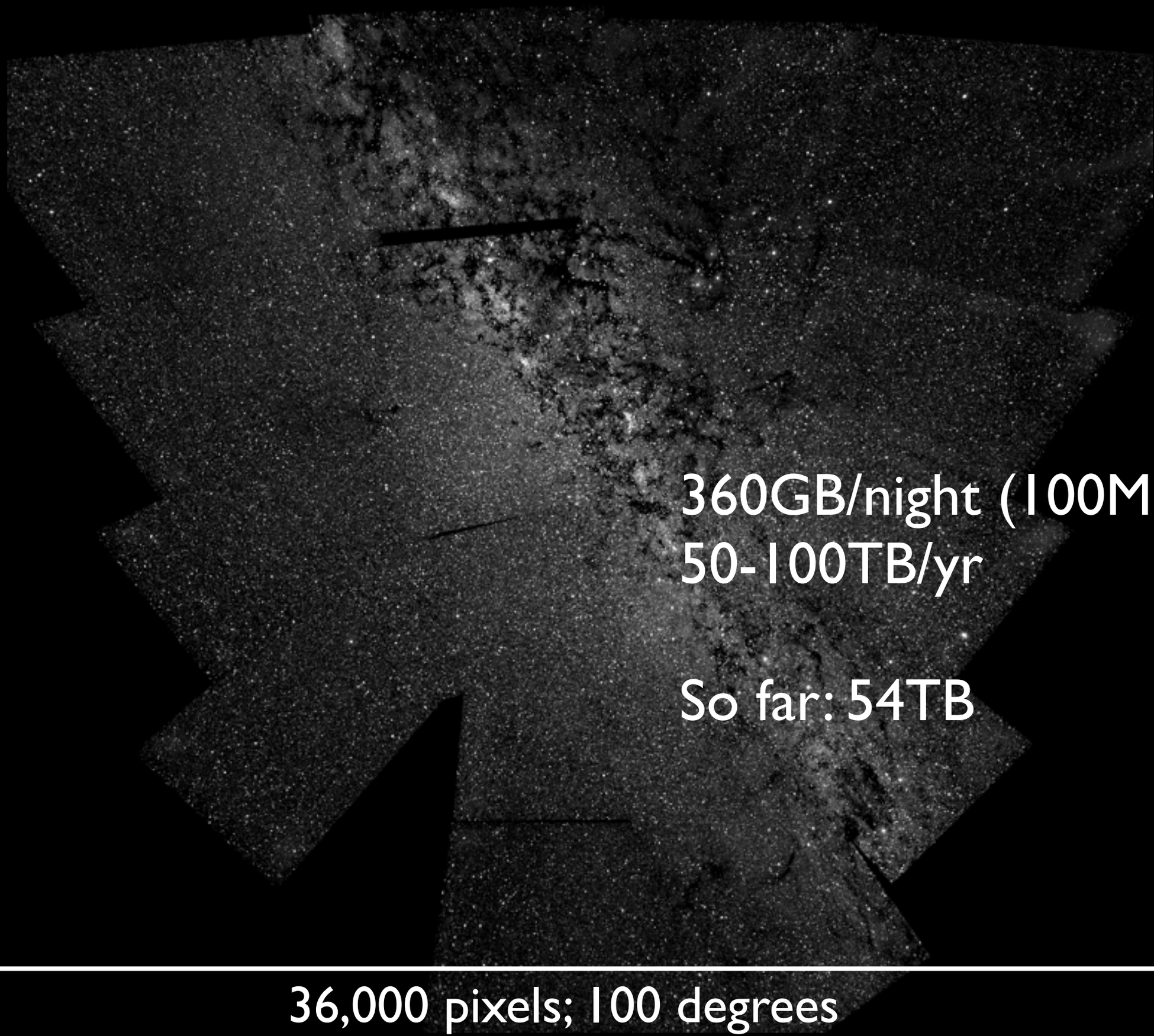
Evryscope (61mm)
for 3 nights
every 3 nights
97% duty cycle

In three nights, Evryscope total photon collection is comparable to LSST's, everywhere on the sky

Data challenges



360GB/night (100Mb/sec)
50-100TB/yr

So far: 54TB

36,000 pixels; 100 degrees

Evryscope Pipeline

1. Evryscope

~0.8Gb/2min

2. CCD calibration

- Pixel non-linearity
- Masterdark substraction & Masterflat division
- Image masking

Telescope pointing coordinates

3. Astrometric reduction

- `Astrometry.net`
- WCS TAN-SIP to TAN-TPV conversion
- `SExtractor` positions & photometry
- Testing astrometric reduction

4. Light curves

Single-night light curve computation

- Source association
- Differential photometry from a subset of reference stars whose RMS is minimum
- Magnitude residuals fitting to a (x,y) polynomial
- Light curve detrending (`SysRem`, `TFA`)

Multi-night light curves

- Signature detection
- Phase folding (`Lomb-Scargle`)

Database

Store images, light curves, and catalogs

100 Tb NAS running `PostgreSQL`

Astronomers

SCIENCE with collaborators!

Deliverables

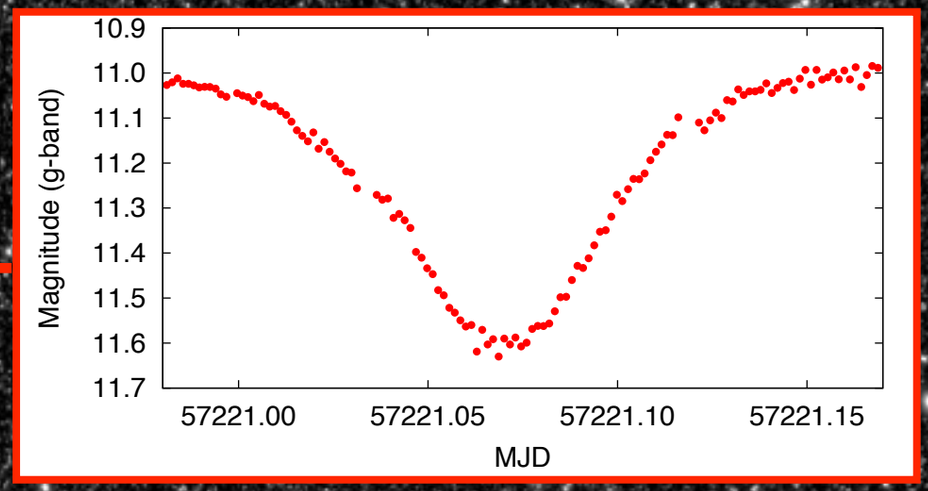
WCS Image cutouts around a target and time range

Multi-night light curves

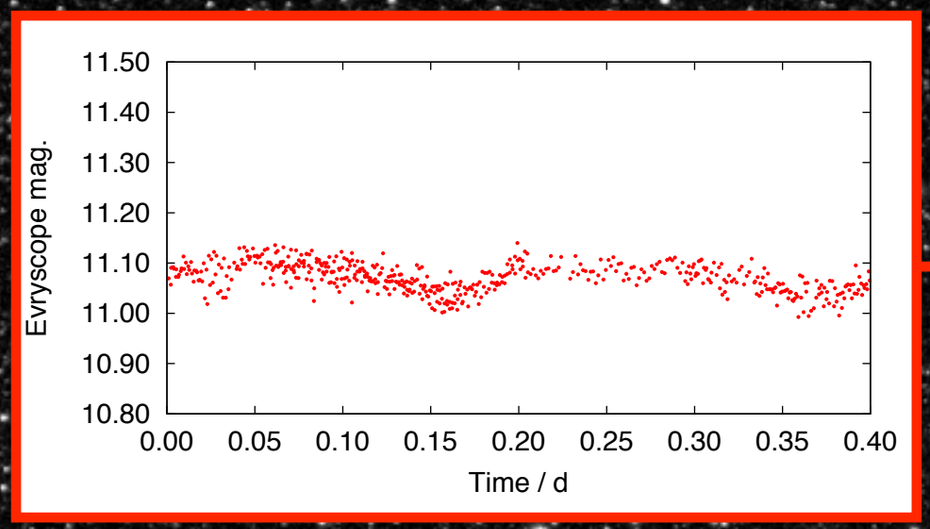
Targets

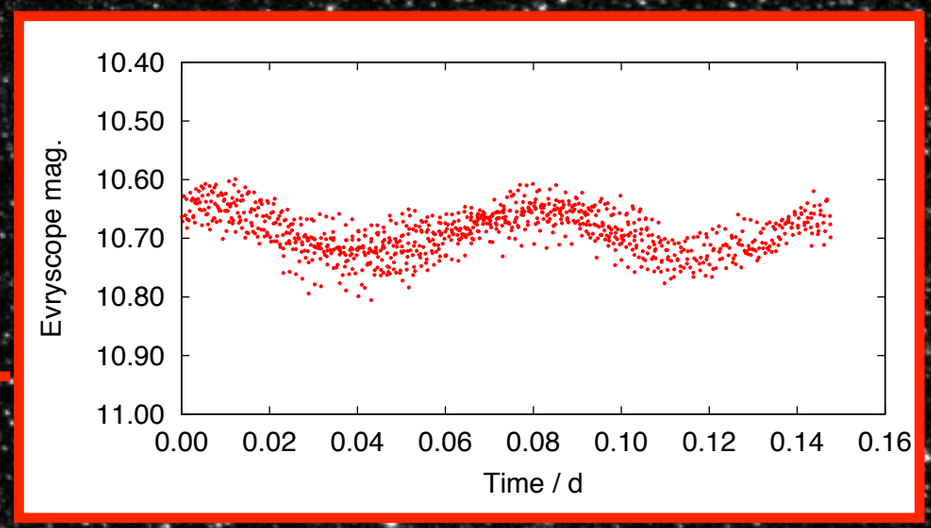
Catalogs of targets to monitor

Pipeline output



Pipeline output





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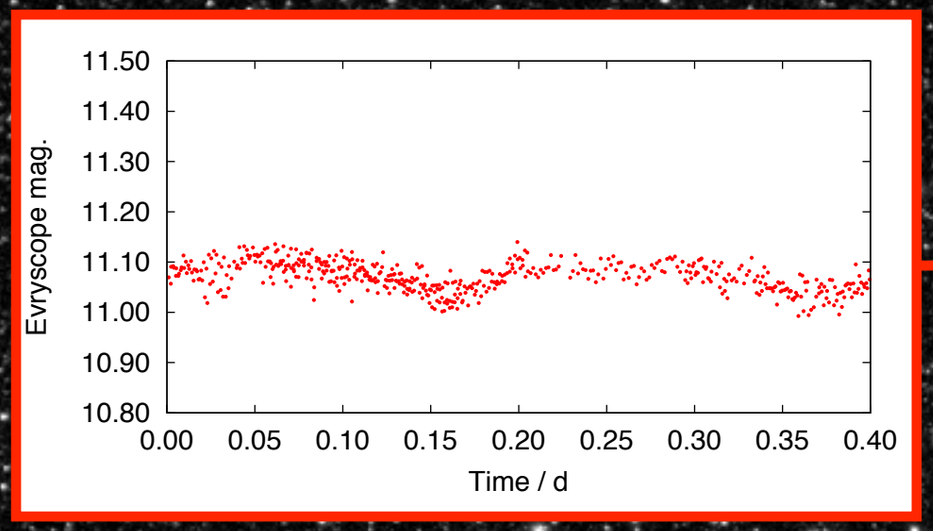
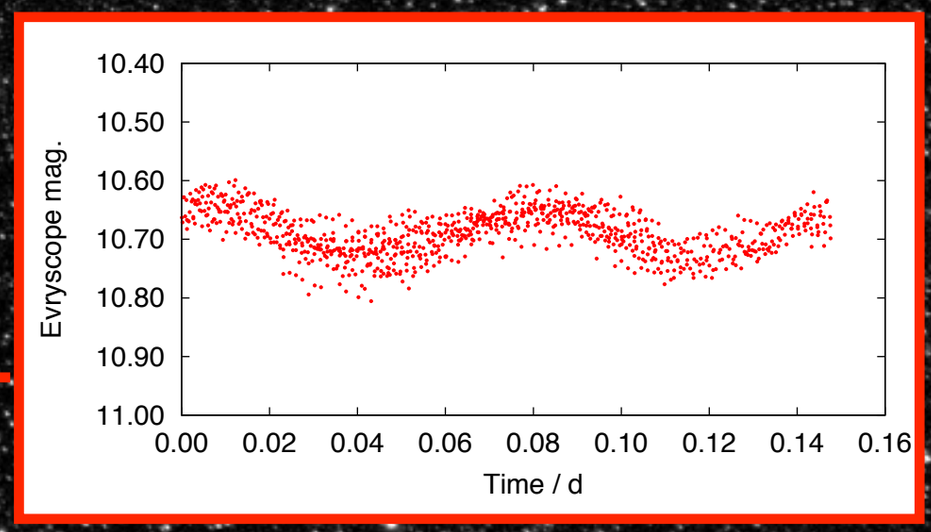


Routine: few-% photometric accuracy
(scintillation limited)



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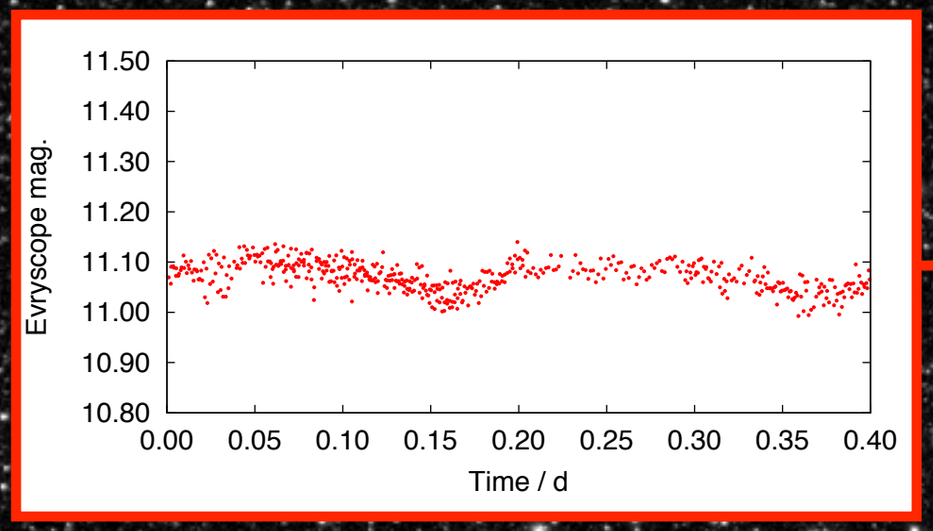
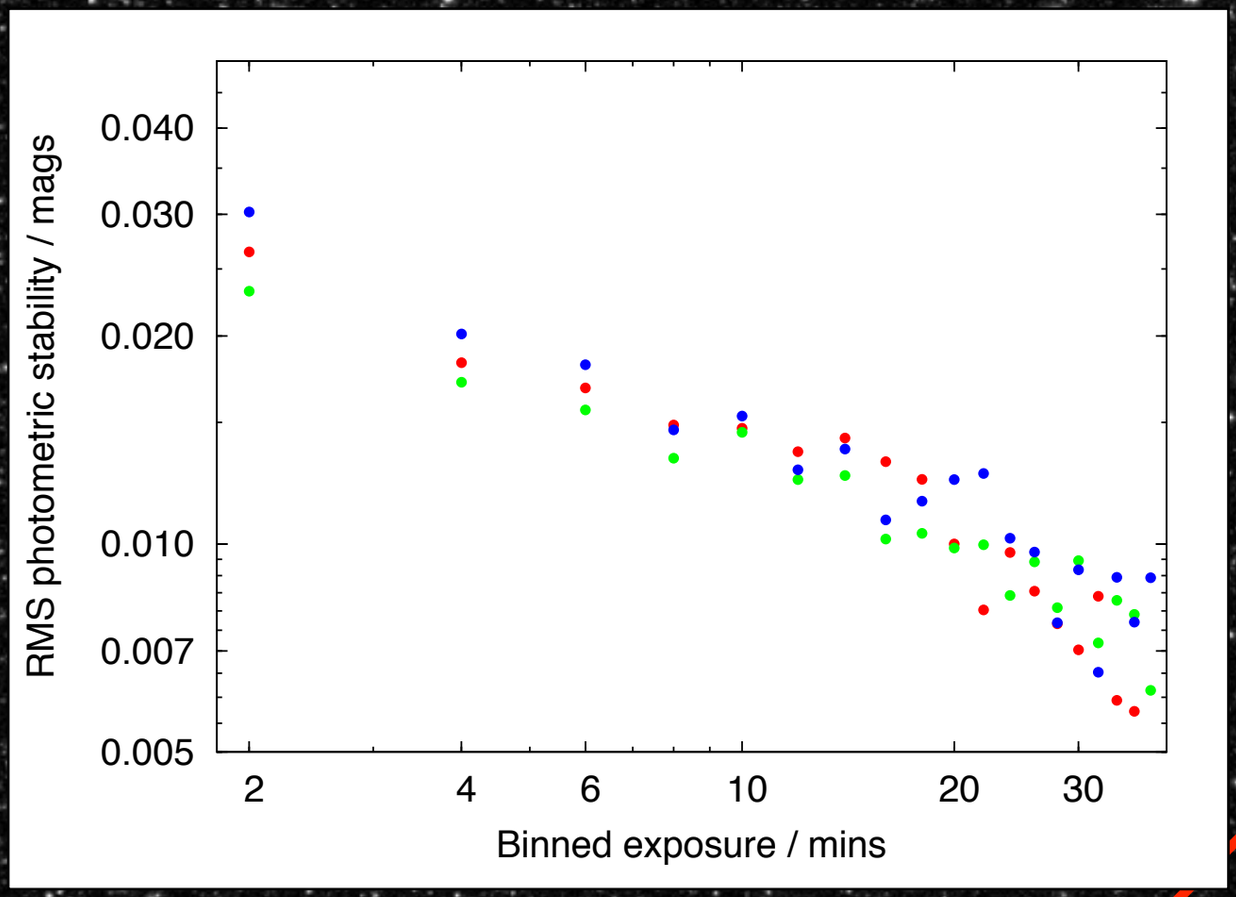
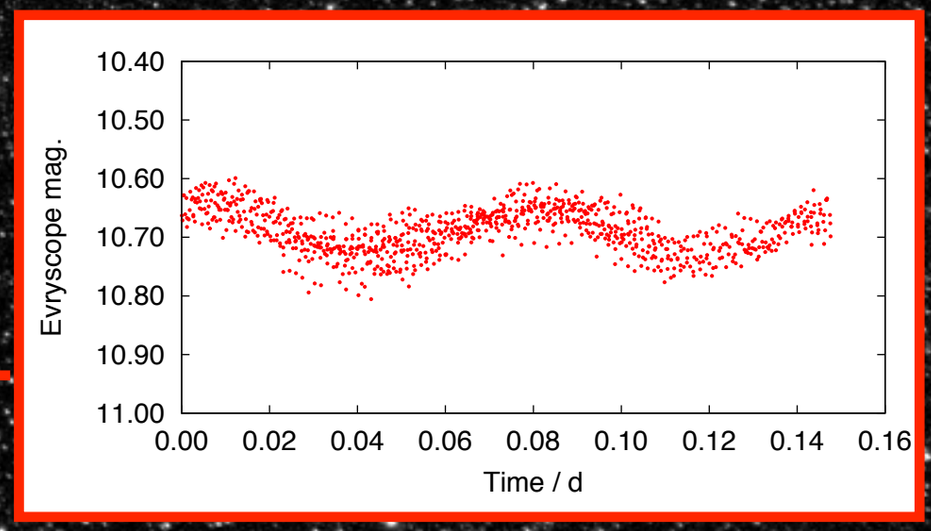


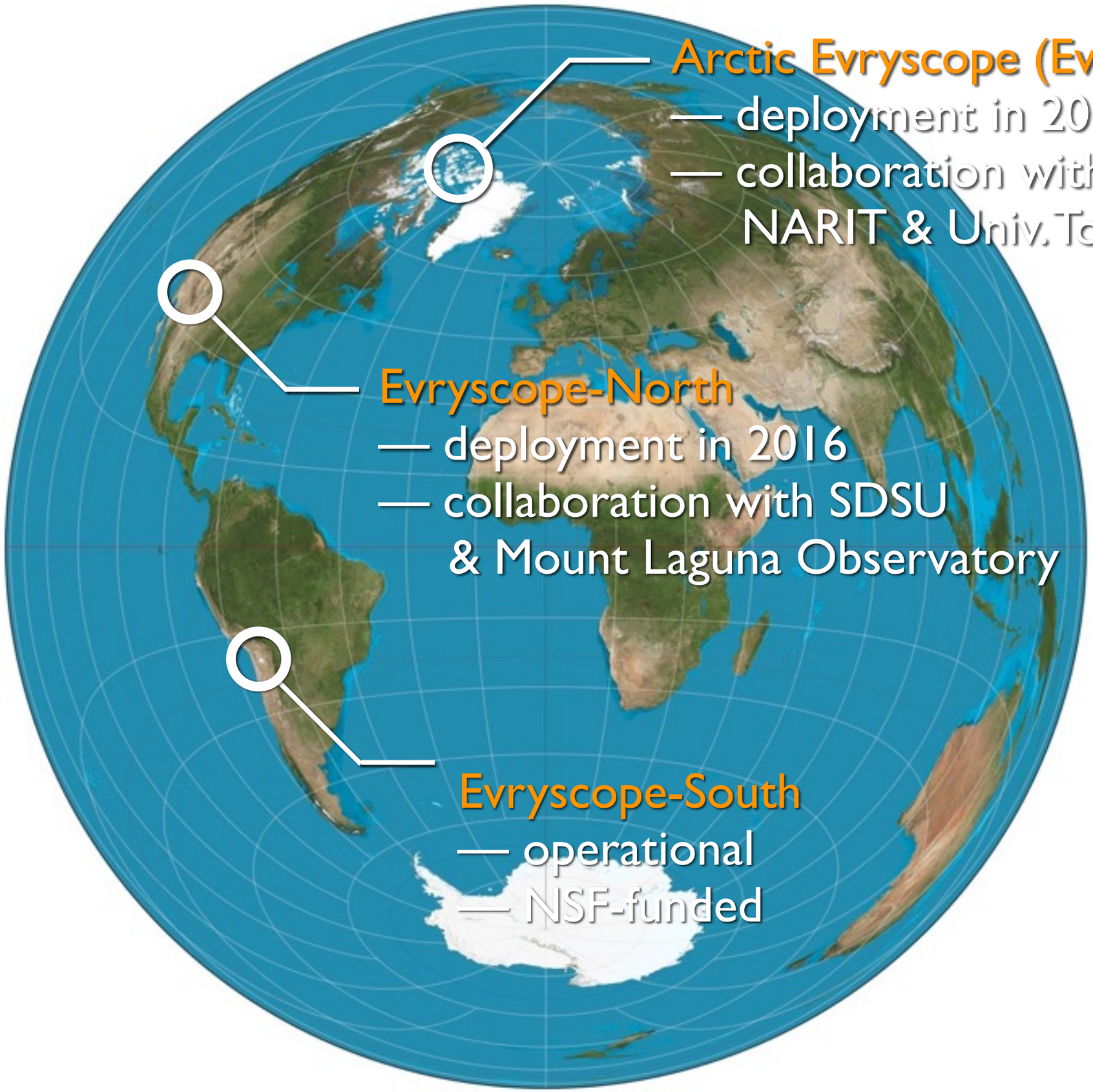
Current: few-% photometric accuracy (scintillation limited)



Binning improves performance to 5-7 mmag level (currently)



Evryscope Global Network



The Evryscope -- interested in collaborators!

http://evryscope.astro.unc.edu

Transiting exoplanets

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

Eclipse/transit timing & measurement

- Exoplanet detection
- Mass-radius relation measurement

Nearby microlensing events

- 2-minute cadence even before detection

Young & active stars

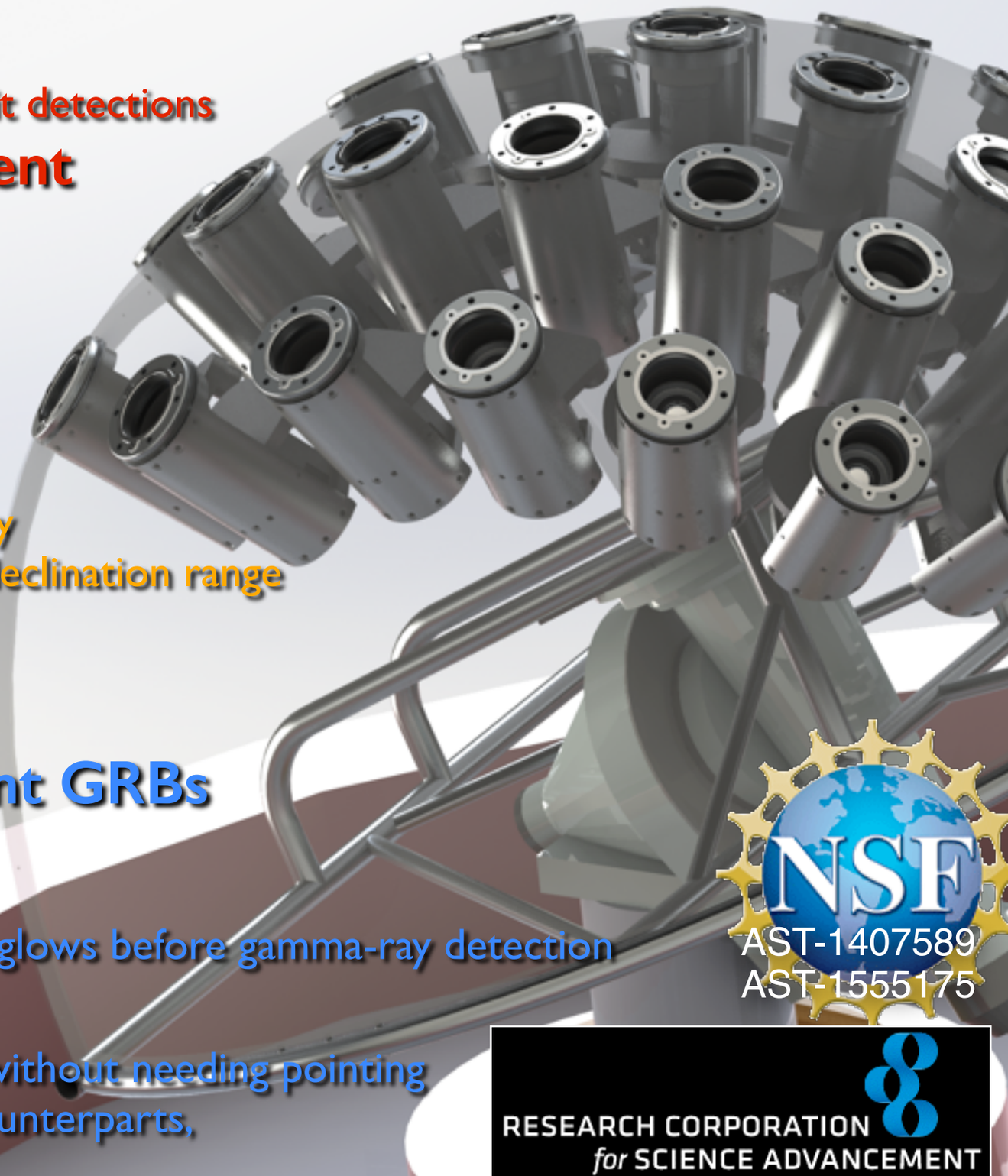
- Comprehensive measurement of stellar activity
- All stars g<16.5, every 2 minutes, 100-degree declination range
- Eclipsing binary discovery
- Compact object accretion
- White dwarf pulsations

Young Nearby Supernovae & distant GRBs

- Monitor the objects before they go off
- Shock breakout & pre-outbursts
- Optical observations of GRBs & orphan afterglows before gamma-ray detection

Exotic transients

- Visible-light counterparts to rapid transients, without needing pointing
- Post-facto localization of gravitational wave counterparts,



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