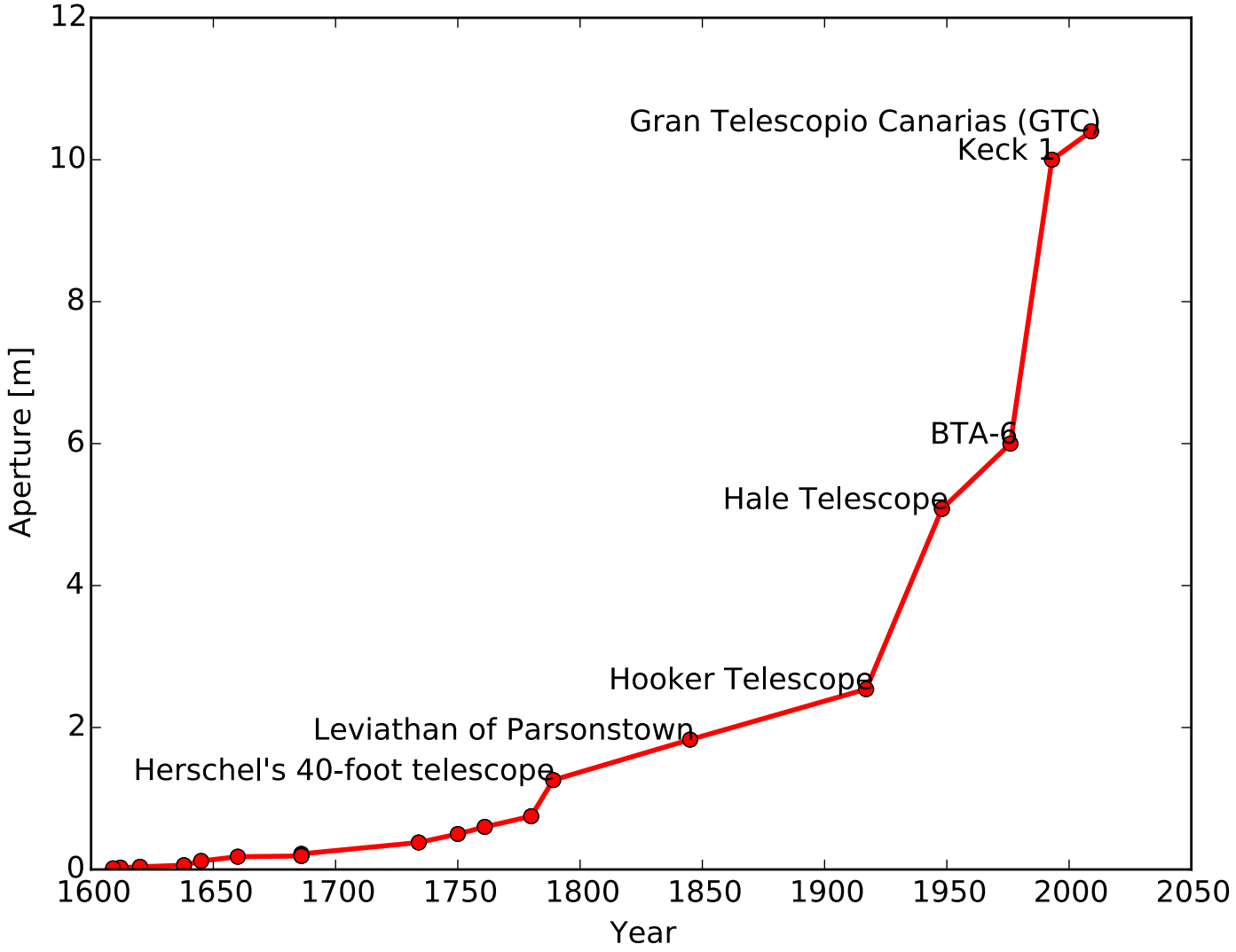
Big capabilities of small robotic telescopes

Robo-AO, ZTF, SEDM

Nadia Blagorodnova
On behalf of Robo-AO, ZTF and SEDM teams
25th July 2016

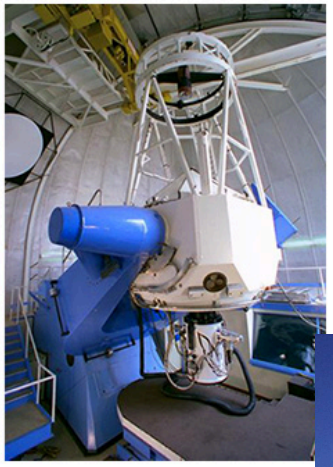
We live in the era of (very) large telescopes!



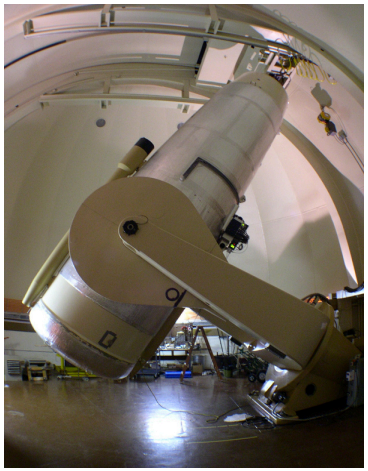
Why small robotic telescopes?

- Available!
  - Large number of small telescopes
  - No oversubscription
- Specialized -> affordable!
  - Robotic operations needs little manpower
  - Data reduction pipelines deliver end-quality data
- Replicable

Big capabilities of small telescopes



Robo-AO
Kitt Peak 2.1m

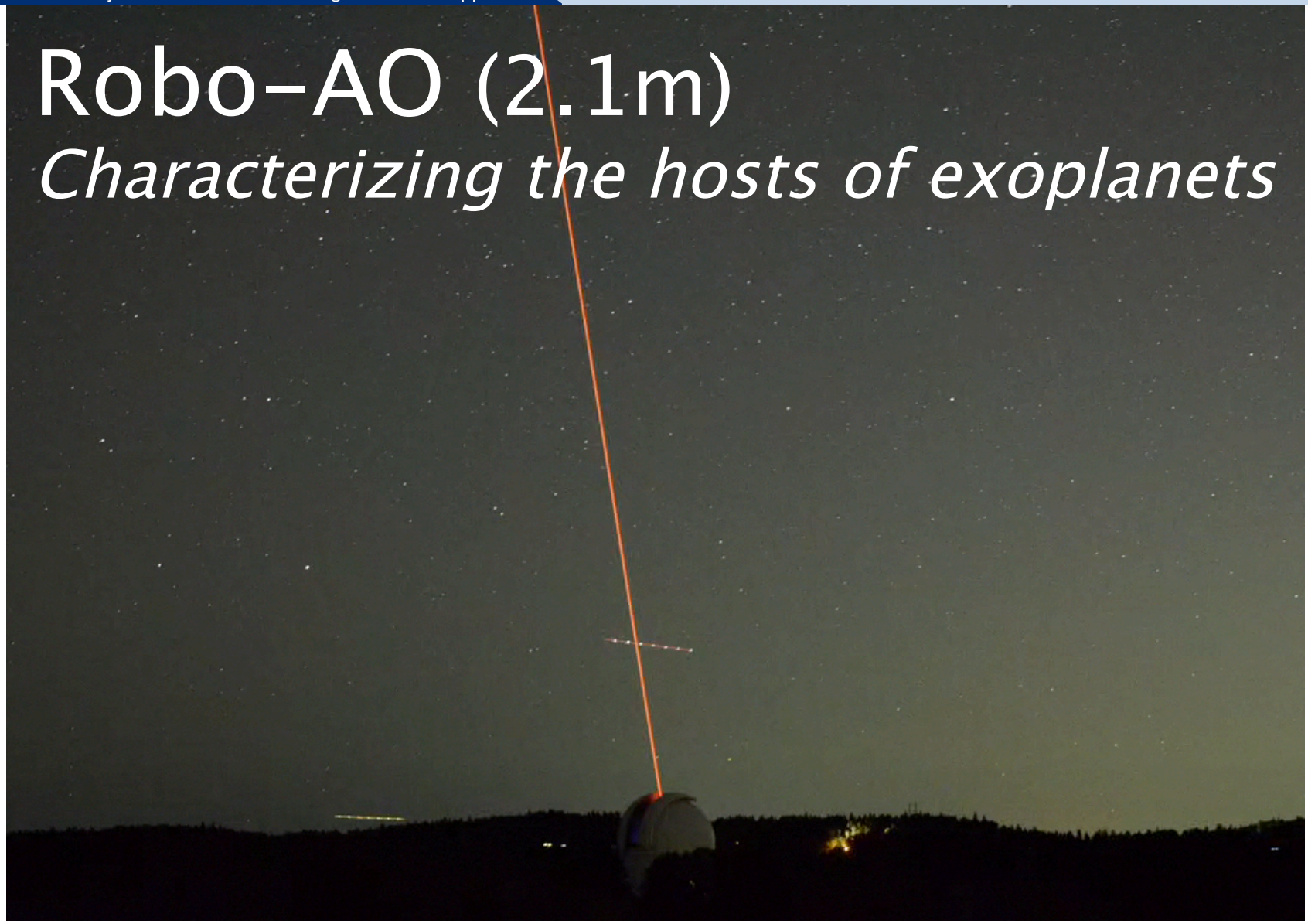


ZTF
Palomar P48
(1.2m)

SEDM
Palomar P60
(1.5m)

Robo-AO (2.1m)

Characterizing the hosts of exoplanets



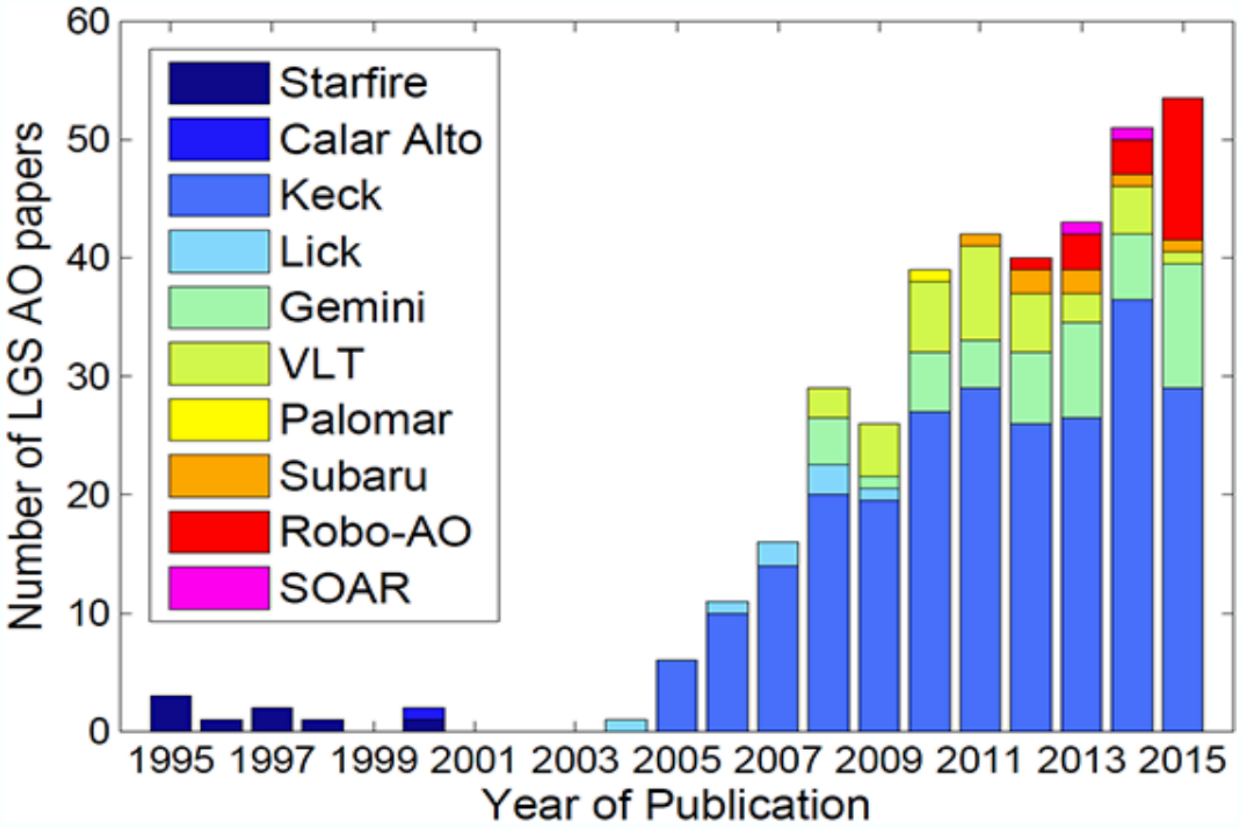
Robo-AO Operations at Palomar

- Three years of robotic scientific operations on Palomar 60”
- Most efficient AO system in the world
  - About 21 observations per hour
    - Record of 247 observations in one night
  - 18,000+ total robotic observations in ~150 nights
  - ~80 second average overhead time between science observations
    - ~20 seconds to set up AO system, plus automated LGS acquisition
  - Automatic data reduction pipeline
- 25 total science publications (more in submission)
  - 12 publications in 2015
  - More on the way…

Initial Kitt Peak Operations

- Installed **Robo-AO** in November 2015
  - Regular operations started in January 2016
  - Over 15,000 science observations before monsoon shutdown
- Not initially robotic
  - Telescope control system old, requires manual operation
  - Operating in manual-ish mode
- Telescope automation
  - Summer 2016 implementation
  - Several months of testing and improvement
  - Expect ~30% increase in efficiency

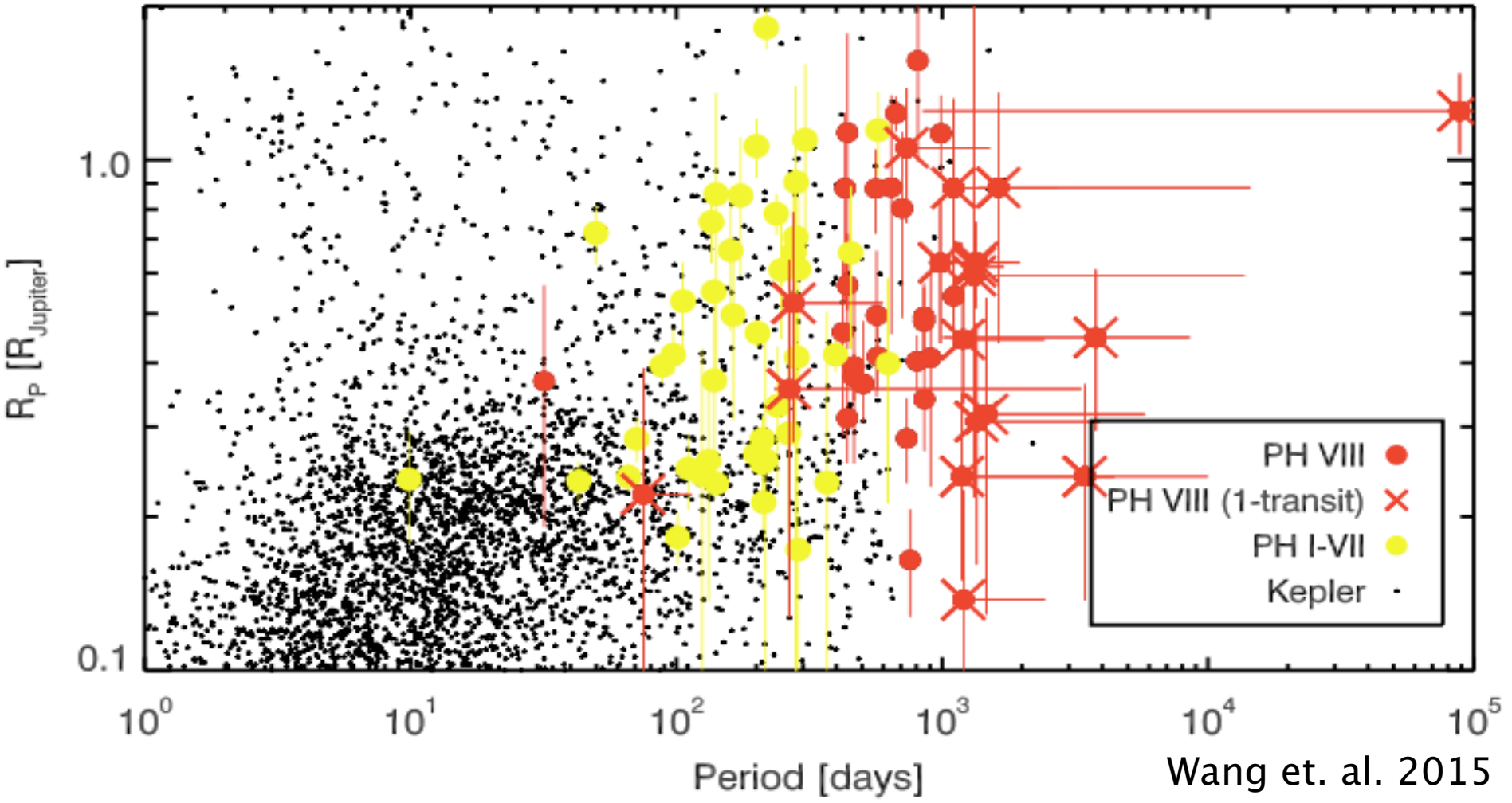
Robo-AO Science Publications



Adapted from P. Wizinowich

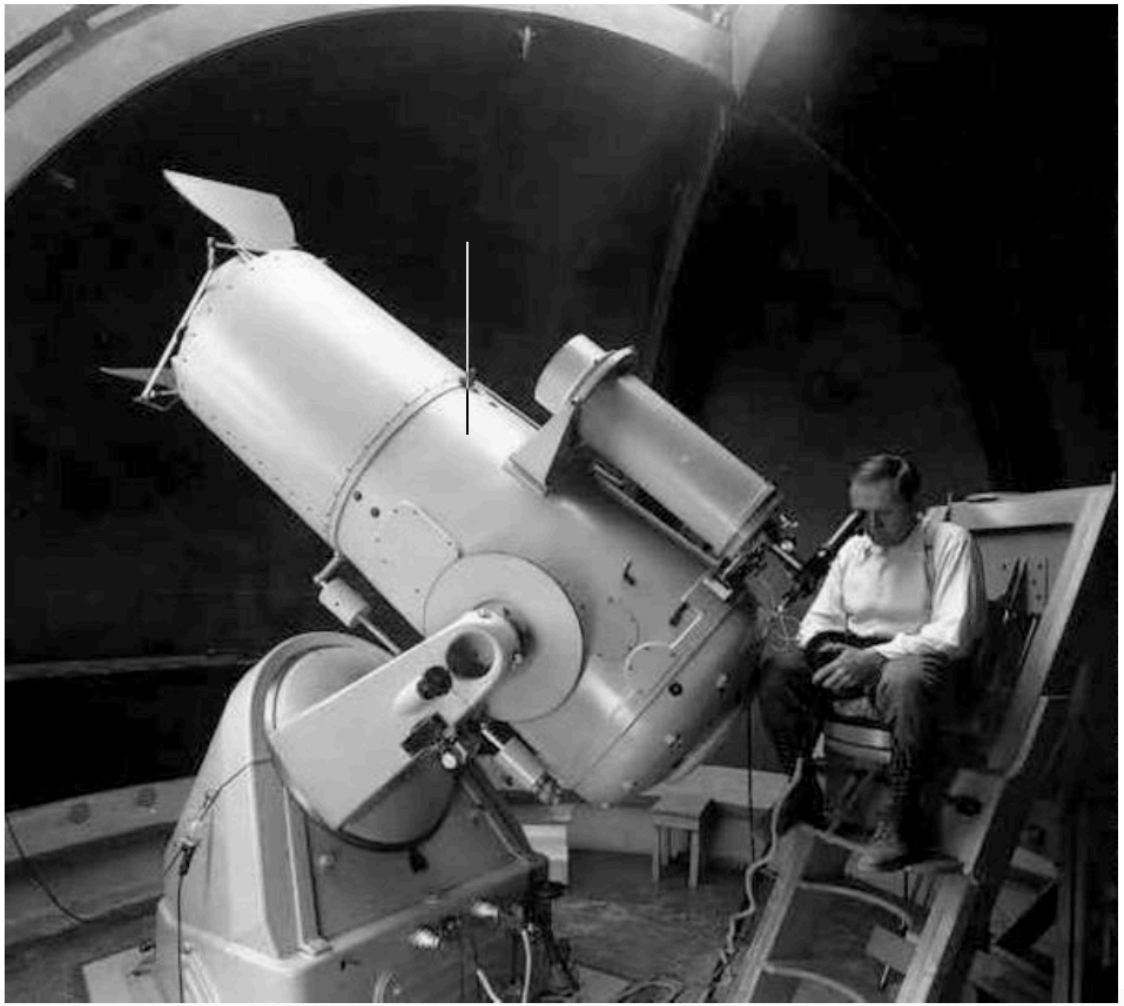
- Largest high-resolution survey papers
- Comparatively small amount of observing time

Example science case



Wang et. al. 2015

Zwicky Transient Facility (1.2m)

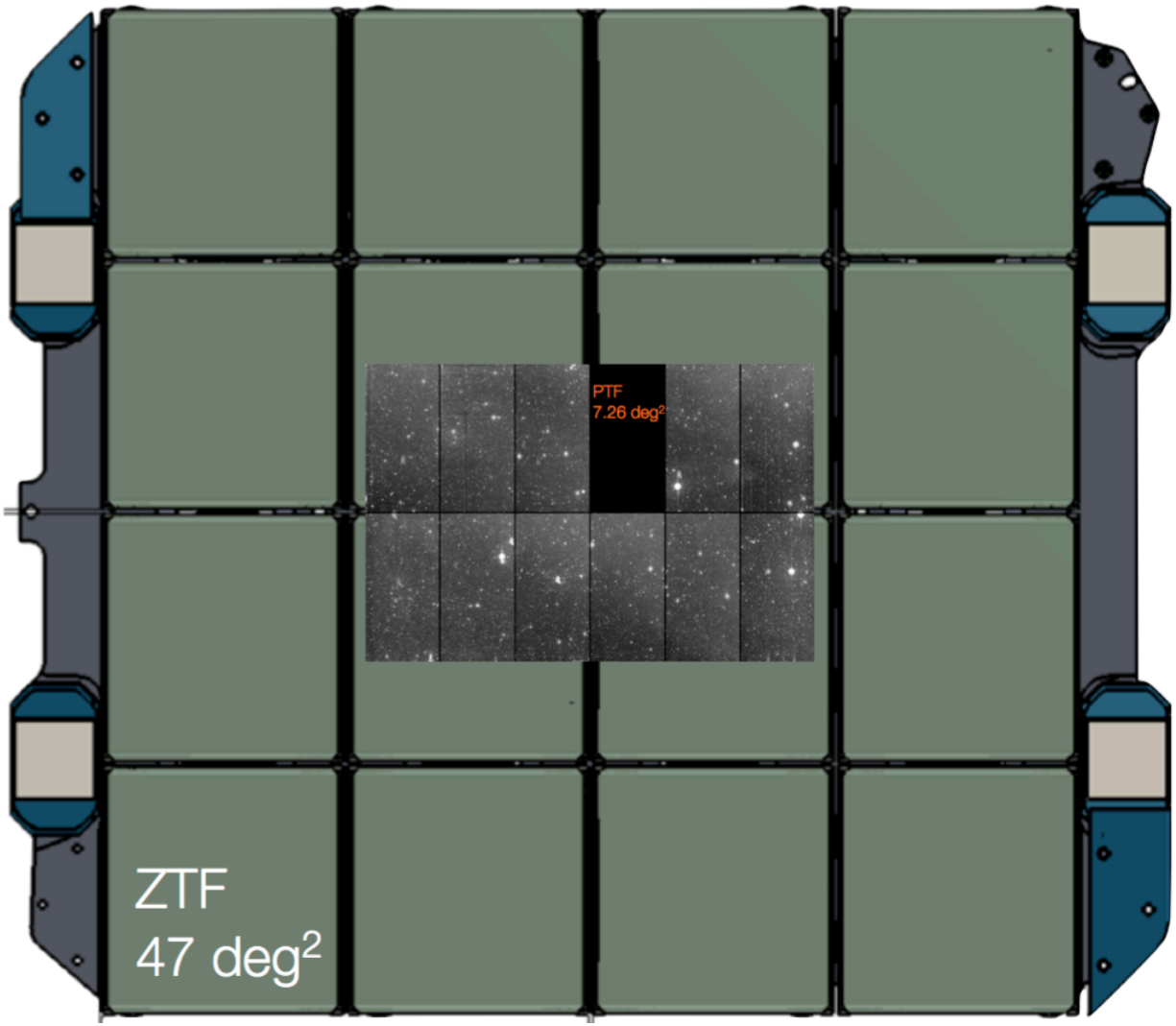


ZTF science goals

- Early observations of young SNe.
  - Test progenitor physics
- (Sub)relativistic explosions and rare transients.
- Detection of GW EM counterparts
- Variability catalogues with exquisite cadence.
- Search for Near Earth Asteroids.

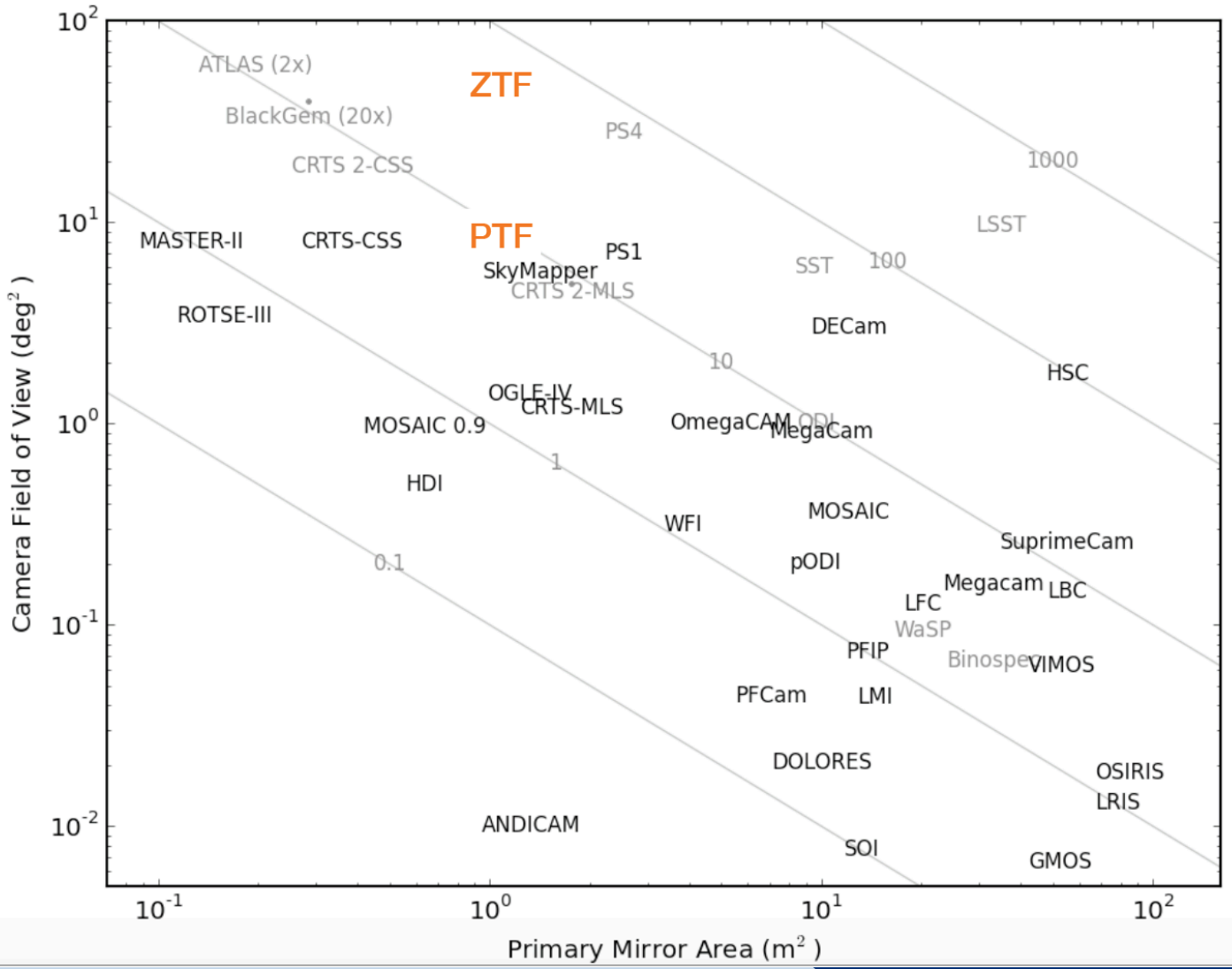
Big capabilities of small telescopes

A new camera will fill the P48 focal plane.



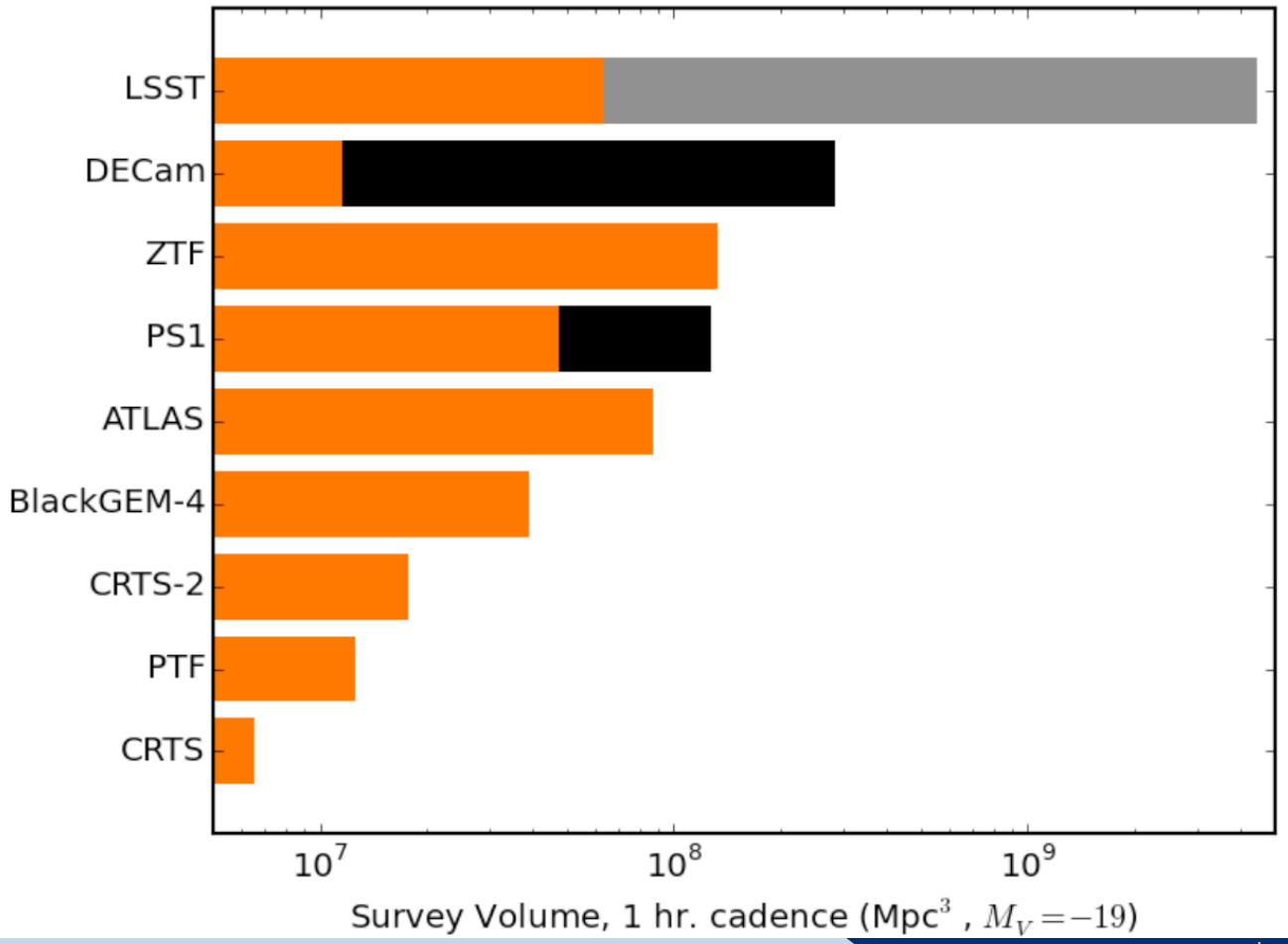
Big capabilities of small telescopes

ZTF will have the largest field of any meter-class camera.



Big capabilities of small telescopes

ZTF will have world-leading speed in finding spectroscopically-accessible transients.



ZTF will perform two general purpose surveys for the US community.

Northern Sky Survey

Analogous to LSST Wide-Fast-Deep

3-day average cadence on visible sky

systematic samples of AGN, supernovae, SLSNe, TDE, halo RR Lyr...

Galactic Plane Survey

300 visits/year ($\delta > -30^\circ$, $|b| < 7^\circ$; $\Delta l = 240^\circ$)

large-scale gyrochronology, young star outbursts, M-dwarf flares, rare and exotic variables and binaries...

combine to ~50% of the collaboration time

MSIP funding provides access to PTF, iPTF, & ZTF data.

already: PTF data for selected high-cadence fields

M81, the Beehive Cluster, Orion, Kepler, Stripe 82, Cass A
see http://www.ptf.caltech.edu/page/data_access

2015: Release of complete PTF archive

2016: Initial release of iPTF data

2017: ZTF first light, commissioning, and reference building

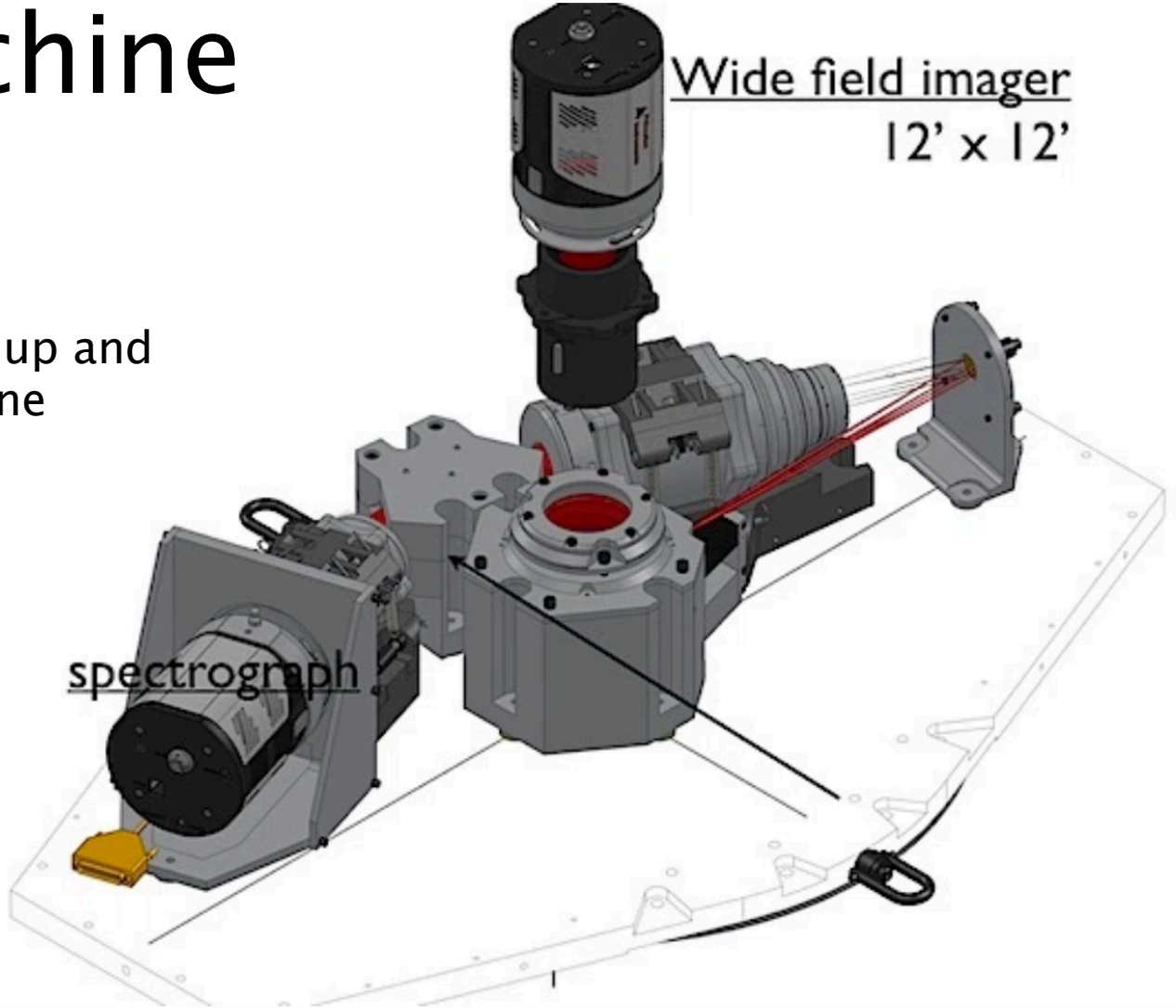
2018: First ZTF data release; public transient alerts begin

2019: Public alerts of transient candidates & cutouts begin

2020: End of MSIP-funded survey; final data releases

SED Machine (1.5m)

Photometric follow-up and classification machine



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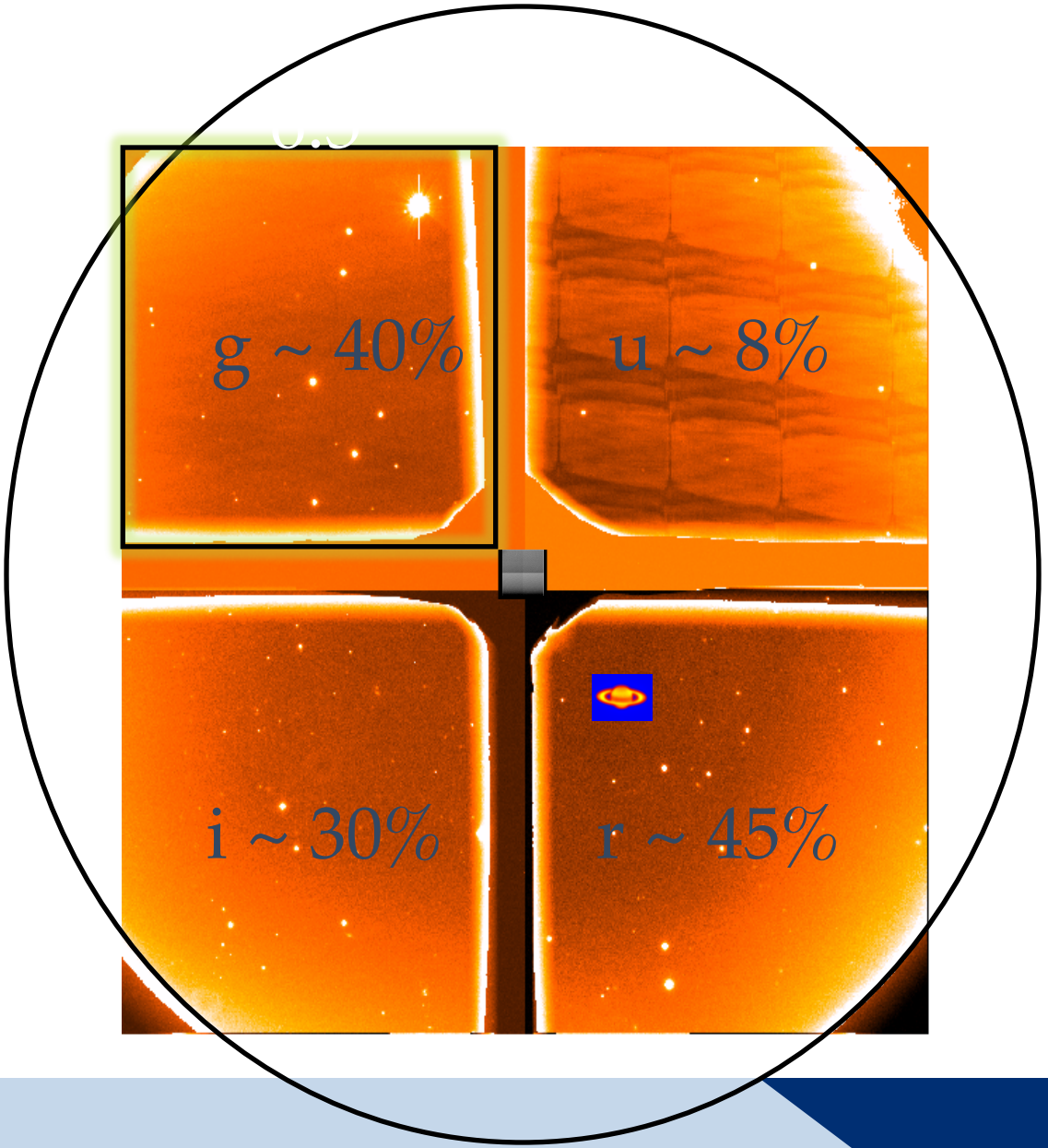

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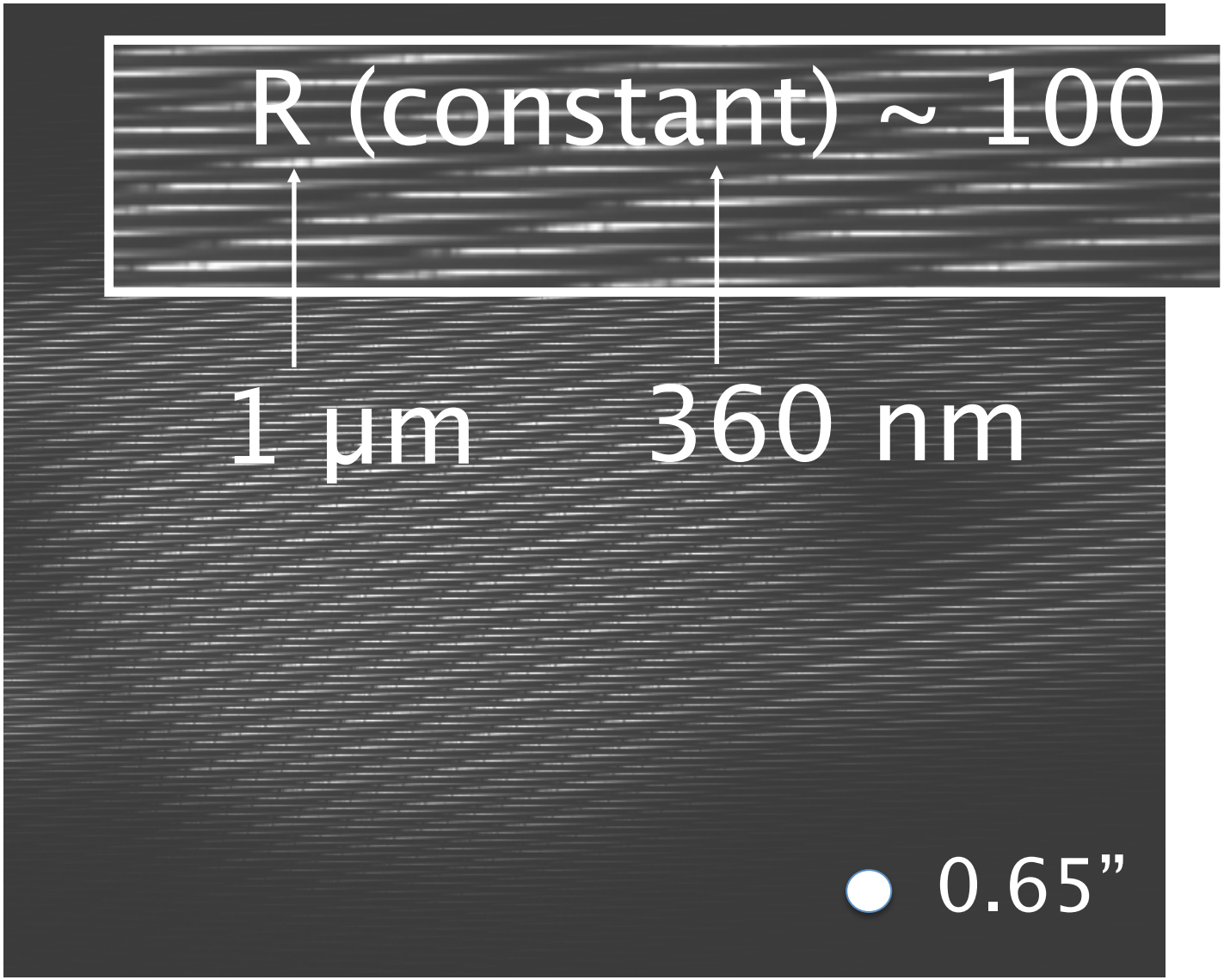
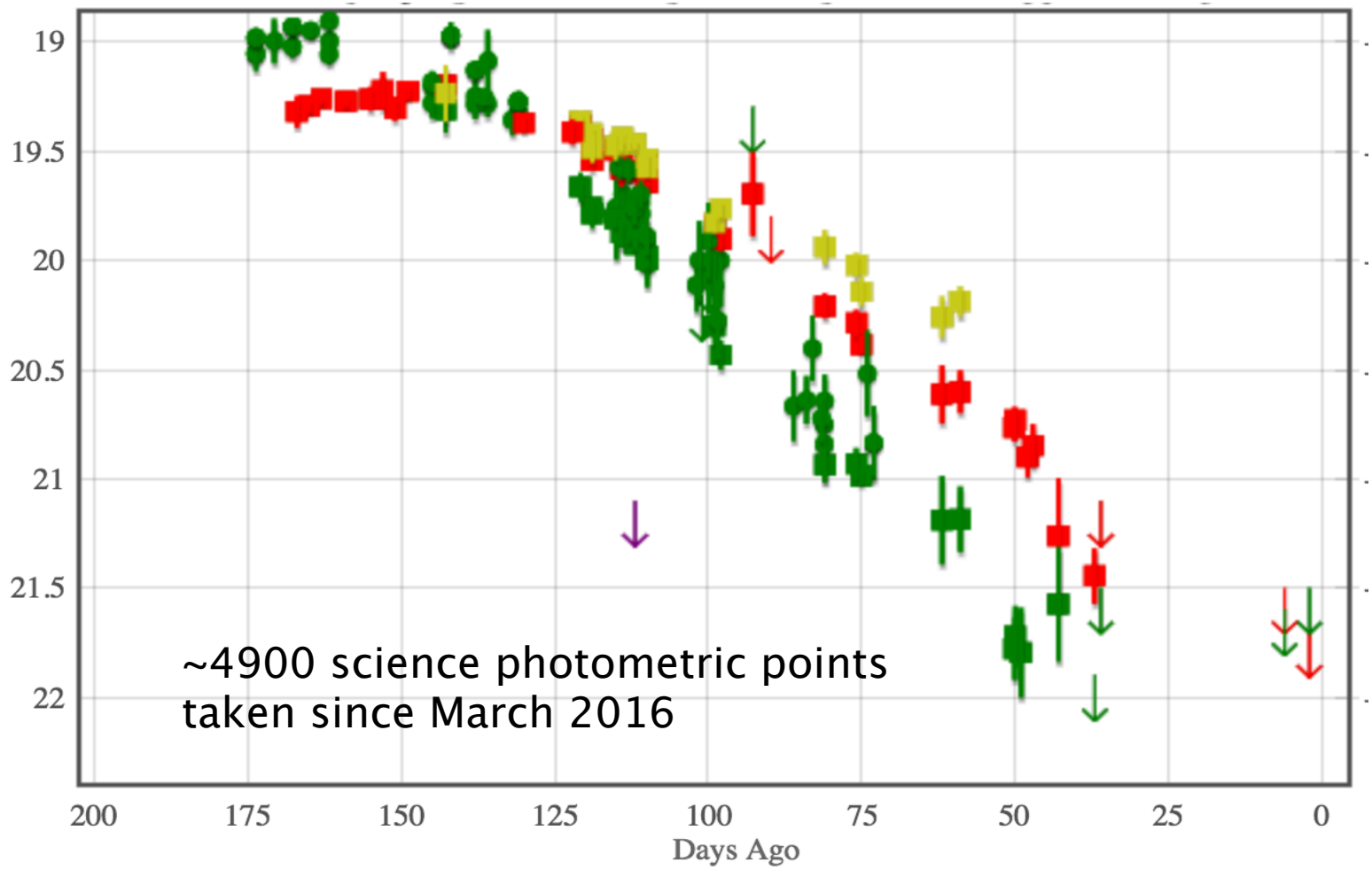


Photometric follow-up



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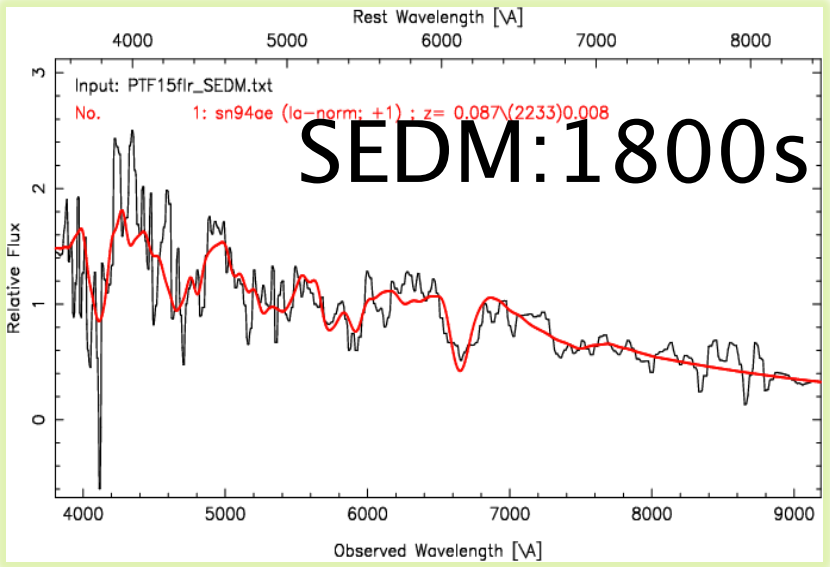
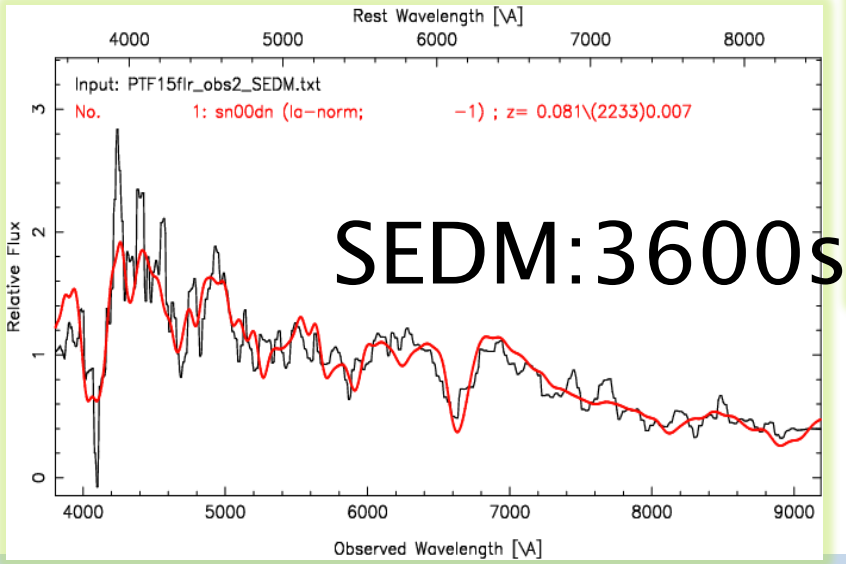
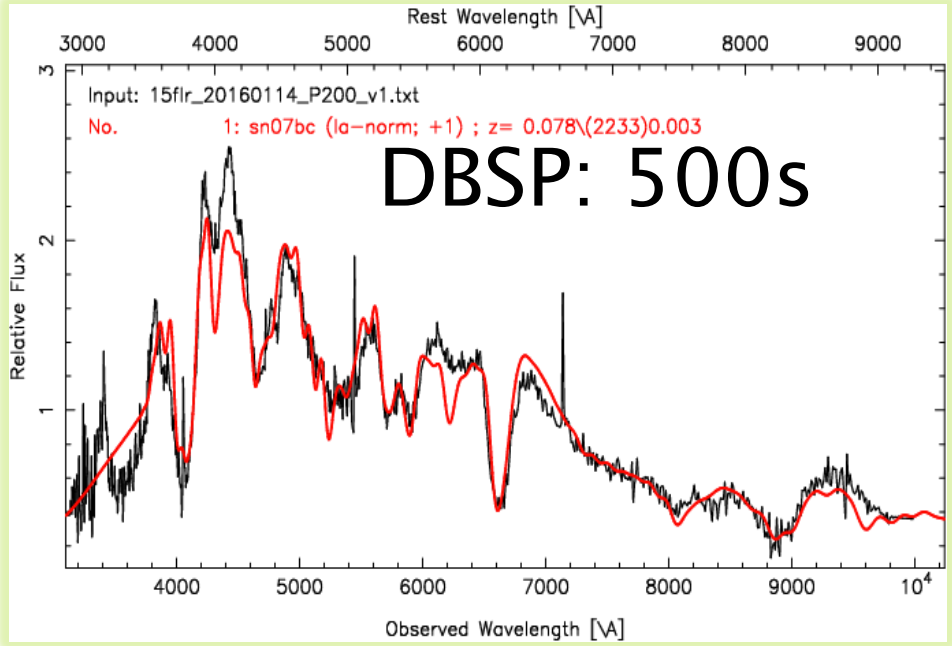


SEDM:1800s



SEDM:3600s

Classification (19mag)



DBSP: 500s

~150 science spectra taken since March 2016

SEDM Operations

- Regular operations on P60 since March 2016
- Fully robotic operations since April 2016.
  - Automatic photometry reduction pipeline
  - (Almost) automatic IFU reduction pipeline
- Applications:
  - Photometry: follow-up of PTF transients and asteroids
  - Spectra: transient classification, galaxy redshifts, SSO, CV systems…
- Commissioning end summer 2016.

Conclusions

- GROWTH counts with powerful purpose-specific instruments.
- Small specialized telescopes are key for big projects.
- Robotic operations cut down on manpower and increase efficiency.
- Opportunity to replicate an army of small specialized telescopes (at low cost).


Thank you!