The Swope Supernova Survey and its first Type Ia supernova data release

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Collaborators: Ryan Foley, Charlie Kilpatrick, Armin Rest, David Jones, Tony Piro, Justin Roberts-Pierel, Matt Siebert, Dave Coulter, Giorgios Dimitriadis, Barry Madore, Maria Drout, Mark Phillips, Eric Hsiao, Chris Burns, and many

The Swope Supernova Survey (SSS)

PI: Anthony Piro. CoIs include CRB.

1-m Henrietta Swope Telescope at Las Campanas Observatory

Image: Cedric Foellmi

SSS GOALS

✦ Southern Hemisphere supernova imaging follow-up survey

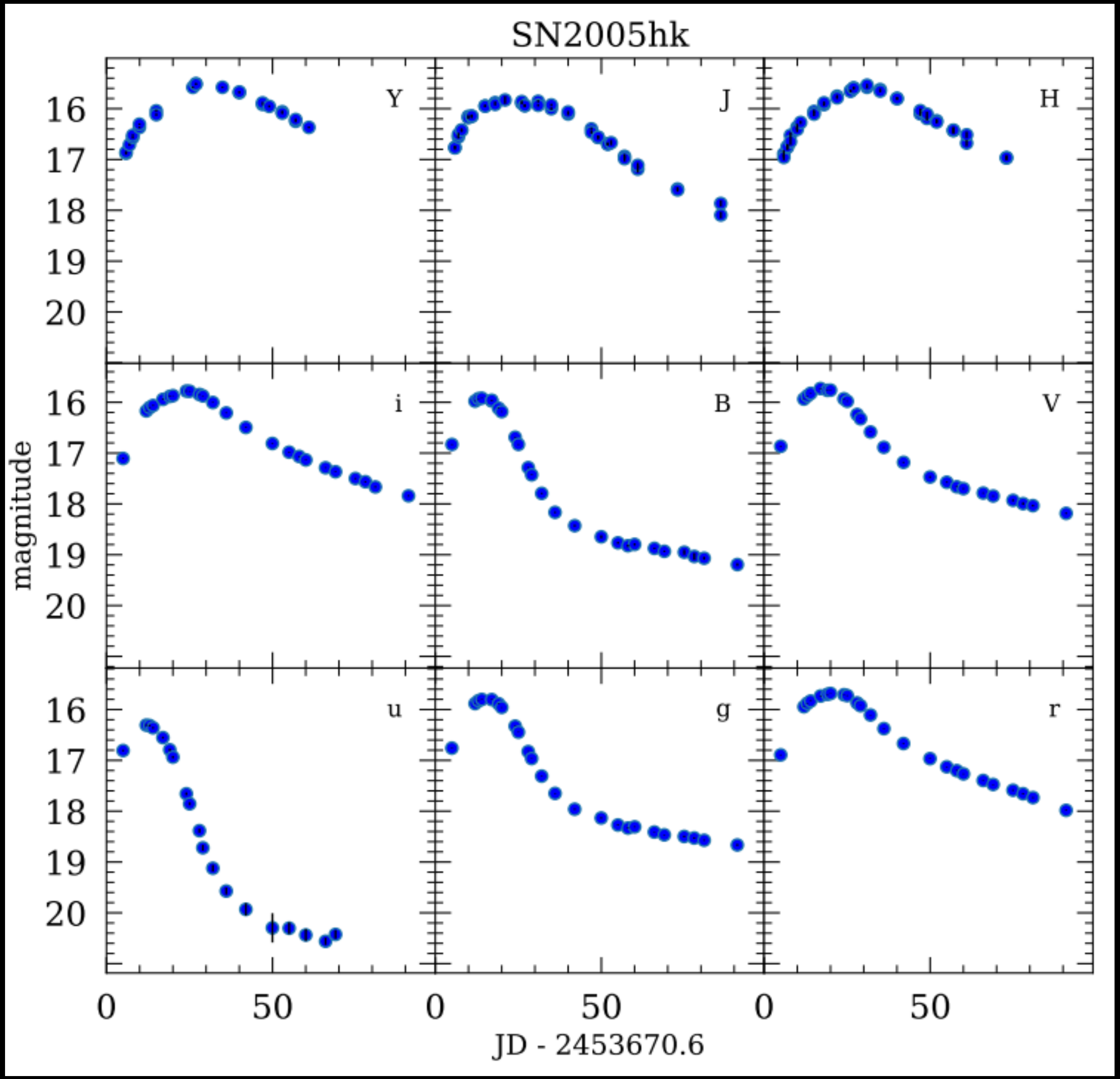
1. SN Ia cosmology program (my main focus)
   - HST Dust follow-up (P.I. Foley)
   - HST UV follow-up (P.I. Siebert)
2. SNe Ia explosions and progenitor systems
3. Observe young transients to constrain physical properties
4. Exotic, interesting events (IIn, TDE, SLSN, Iax…)

- Sub-surveys
  - Gravitational wave discovery/follow-up
  - K2/TESS follow-up

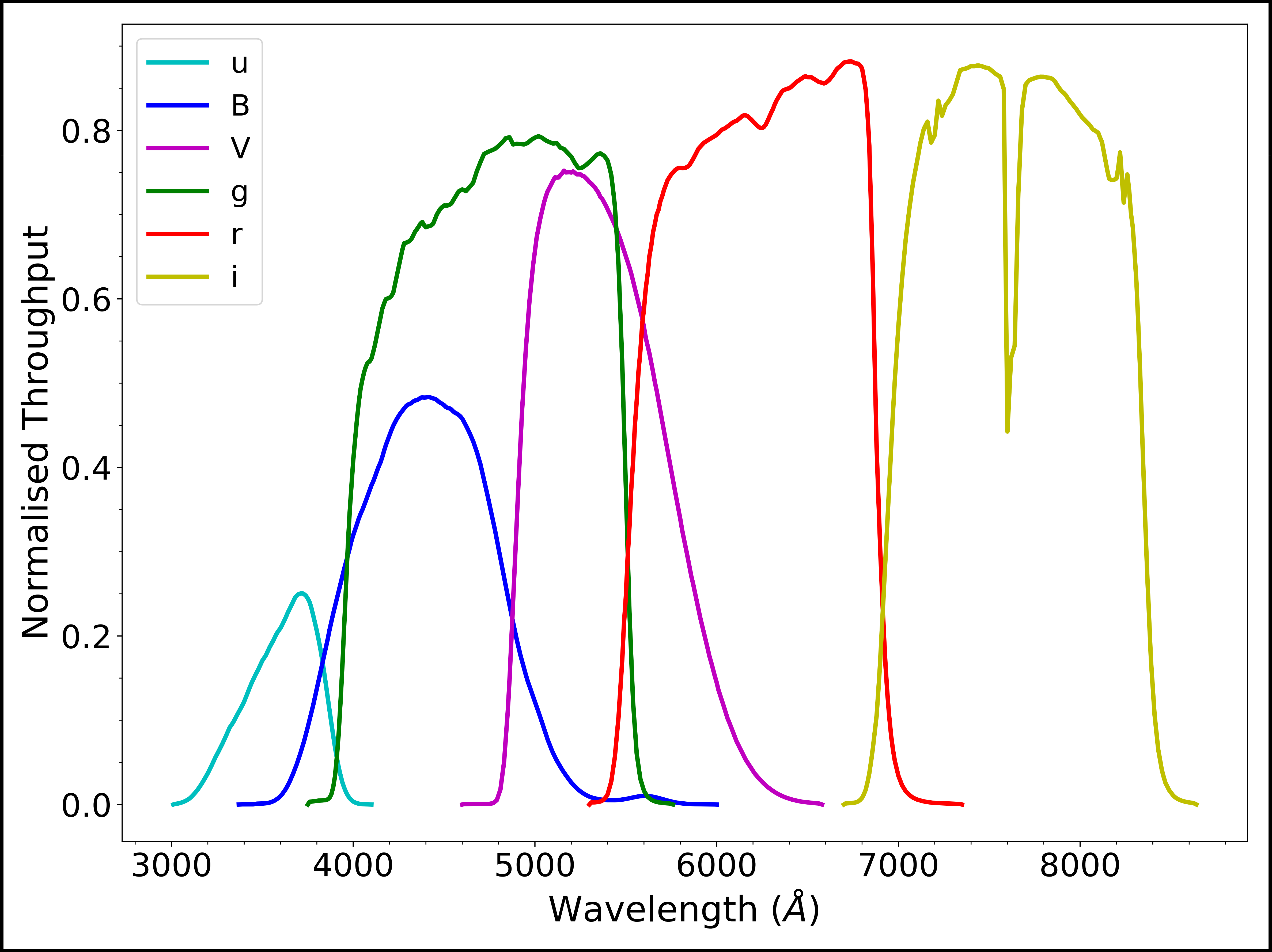
ITS PREDECESSOR: CARNEGIE SUPERNOVA PROJECT (CSP)

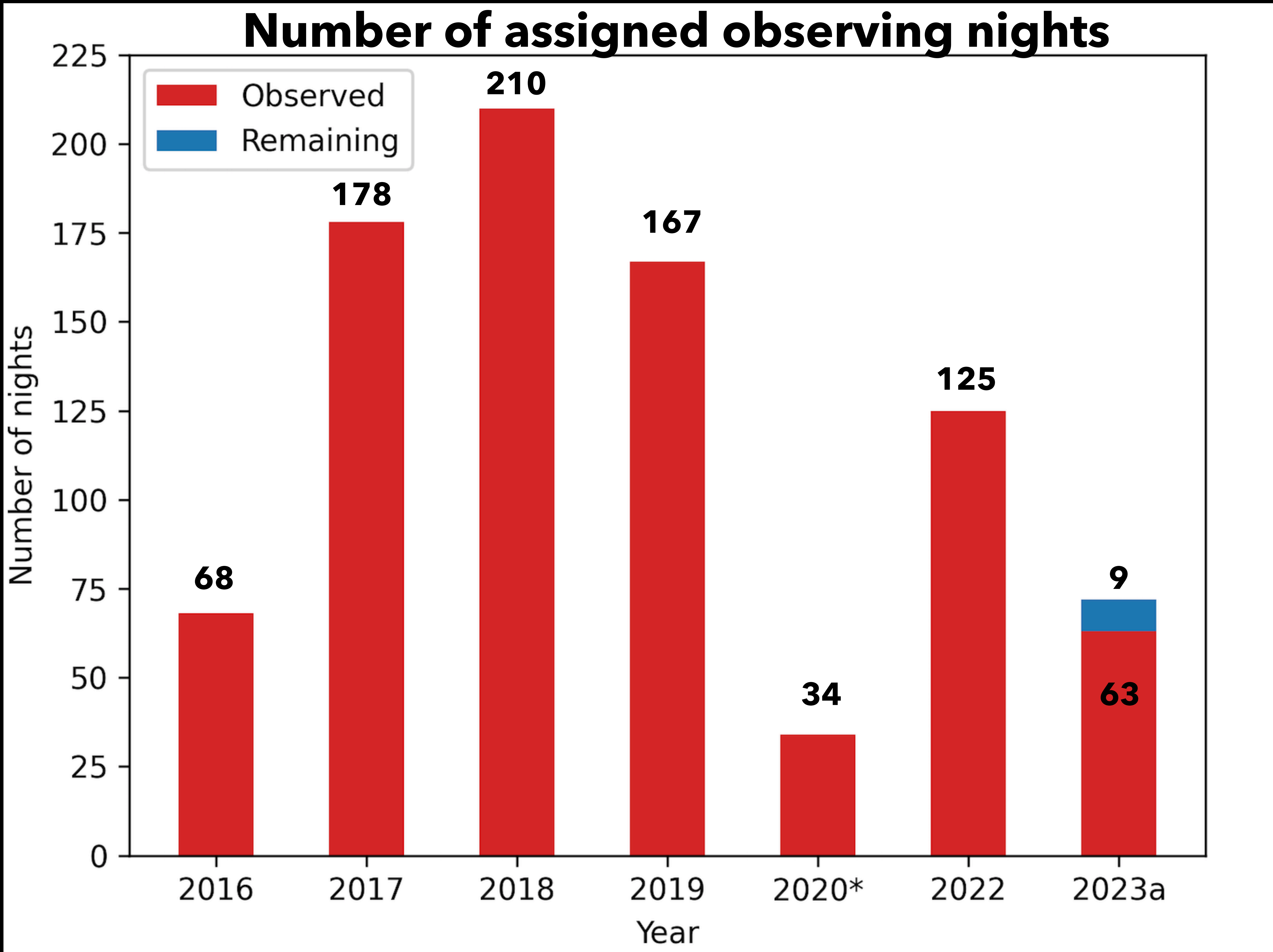
Hamuy+06; Contreras+10, Krisciunas+17; Burns+18; Phillips+19, and many others

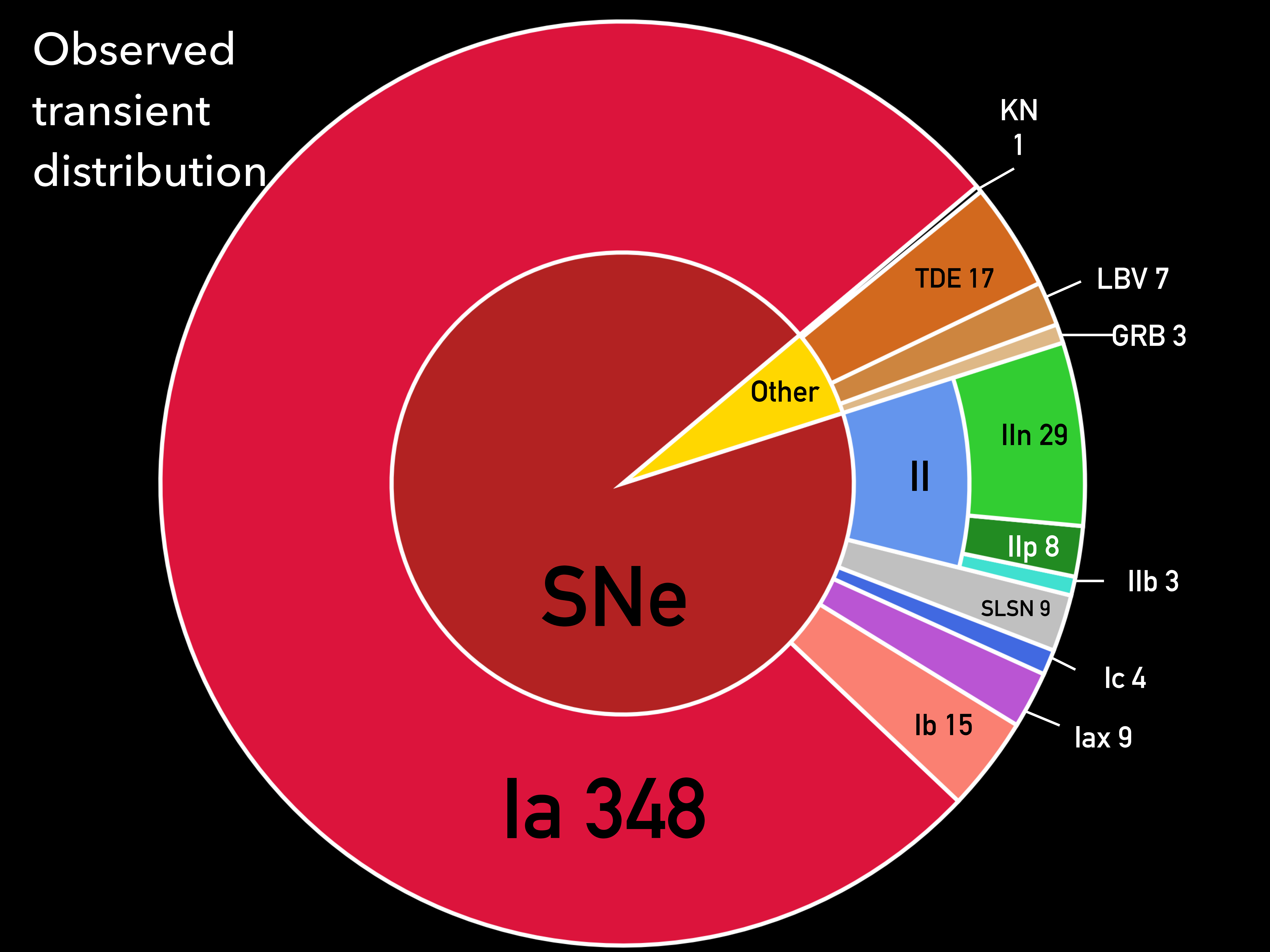
- 2004-2009 & 2011-2015 (CSP-II)
- ugriBV and YJH
- 134 SN Ia (214 in CSP II)
  - ★ 89 SN Ia for cosmo analysis (125 in CSP-II)
- Targeted selection (CSP-II mostly untargeted)



SIX OPTICAL BANDS

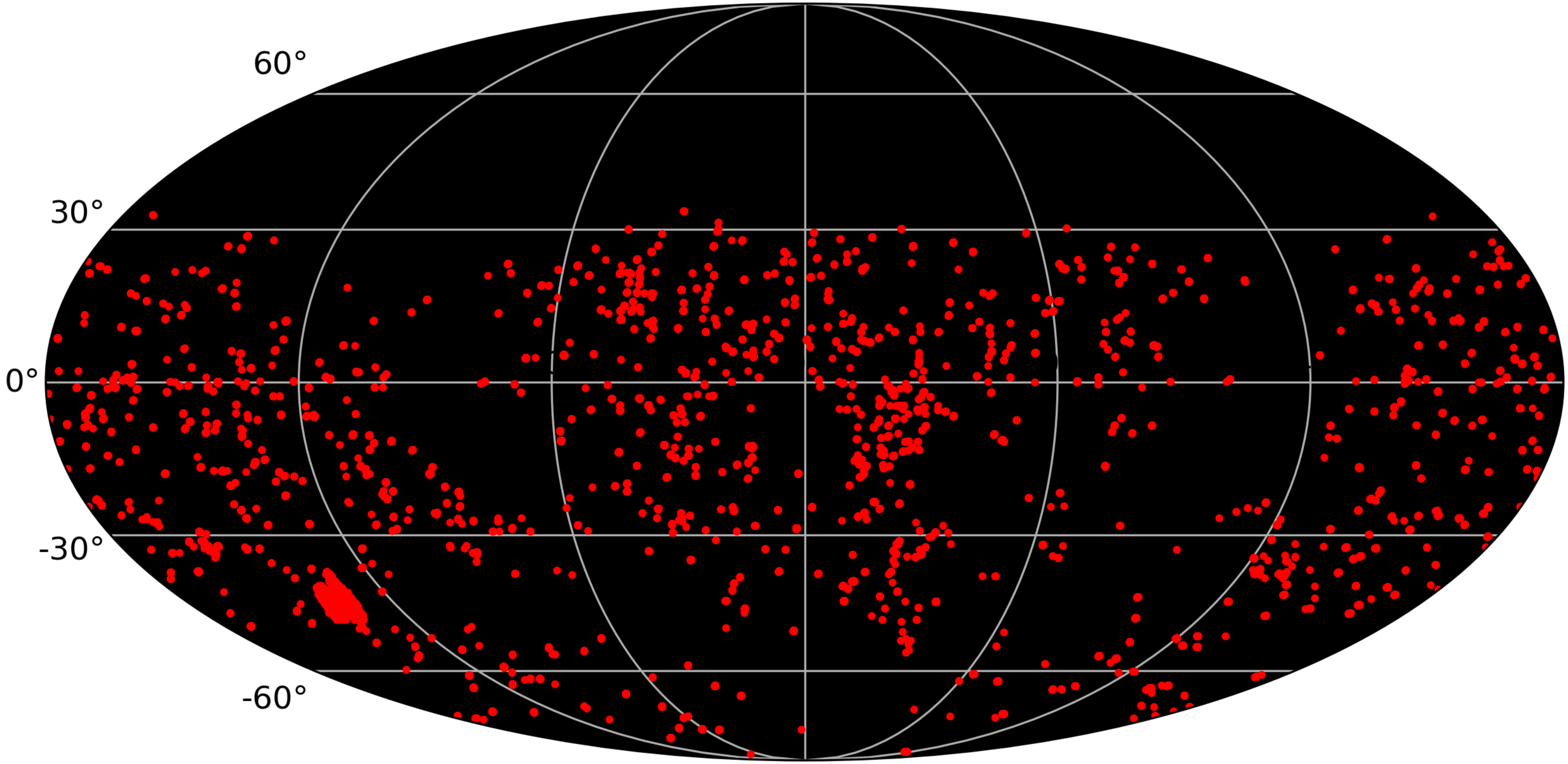



Number of assigned observing nights
Observed
Remaining
Number of nights
225
200
175
150
125
100
75
50
25
0
68
178
210
167
34
125
9
63
2016
2017
2018
2019
2020*
2022
2023a
Year



Observed
transient
distribution
KN
1
TDE 17
LBV 7
GRB 3
Other
IIn 29
II
IIp 8
IIb 3
SLSN 9
SNe
Ic 4
Iax 9
Ib 15
Ia 348

TARGET SKY-LOCALIZATION



SSS PUBLISHED PAPERS (36) (some others in progress)

Type Ia Supernovae (8)

1. X-ray limits on the progenitor system of the SN Ia 2017ejb (Kilpatrick+18)
2. Photometric and Spectroscopic Properties of Type Ia Supernova 2018oh with Early Excess Emission from the Kepler 2 Observations (Li+19)
3. K2 Observations of SN 2018oh Reveal a Two-component Rising Light Curve for a Type Ia Supernova (Dimitriadis+19)
4. Nebular Spectroscopy of Kepler's Brightest Supernova (Dimitriadis+19)
5. SN 2013aa and SN 2017cbv: Two Sibling Type Ia Supernovae in the Spiral Galaxy NGC 5643 (Burns+20)
6. SN 2019muj - a well-observed Type Iax supernova that bridges the luminosity gap of the class (Barna+21)
7. SN 2018agk: A Prototypical Type Ia Supernova with a Smooth Power-law Rise in Kepler (K2) (Wang+21)
8. Flight of the Bumblebee: the Early Excess Flux of Type Ia Supernova 2023bee revealed by TESS, Swift and YSE observations (Wang+23)

Gravitational Waves (9)

9. Multi-messenger Observations of a Binary Neutron Star Merger (Abbott+17)
10. The Unprecedented Properties of the First Electromagnetic Counterpart to a Gravitational-wave Source (Siebert+17)
11. The Old Host-galaxy Environment of SSS17a, the First Electromagnetic Counterpart to a Gravitational-wave Source (Pan+17)
12. A Neutron Star Binary Merger Model for GW170817/GRB 170817A/SSS17a (Murguía-Berthier+17)
13. A gravitational-wave standard siren measurement of the Hubble constant (Abbott+17)
14. Swope Supernova Survey 2017a (SSS17a), the optical counterpart to a gravitational wave source (Coulter+17)
15. Light curves of the neutron star merger GW170817/SSS17a: Implications for r-process nucleosynthesis (Drout+17)
16. Electromagnetic evidence that SSS17a is the result of a binary neutron star merger (Kilpatrick+17)
17. The Gravity Collective: A Search for the Electromagnetic Counterpart to the Neutron Star-Black Hole Merger GW190814 (Kilpatrick+21)

Other transients (19)

18. The Early Detection and Follow-up of the Highly Obscured SN II 2016ija/DLT16am (Tartaglia+18)
19. The tidal disruption event AT2017eqx: spectroscopic evolution from hydrogen rich to poor suggests an atmosphere and outflow (Nicholl+19)
20. To TDE or not to TDE: the luminous transient ASASSN-18jd with TDE-like and AGN-like qualities (Neustadt+20)
21. Ca hnk: The Calcium-rich Transient Supernova 2016hnk from a Helium Shell Detonation of a Sub-Chandrasekhar White Dwarf (Jacobson-Galán+20)
22. The Rise and Fall of ASASSN-18pg: Following a TDE from Early to Late Times (Holoien+20)
23. SN 2019ehk: A Double-peaked Ca-rich Transient with Luminous X-Ray Emission and Shock-ionized Spectral Features (Jacobson-Galán+20)
24. Double-peaked Balmer Emission Indicating Prompt Accretion Disk Formation in an X-Ray Faint Tidal Disruption Event (Hung+20)
25. Discovery and follow-up of ASASSN-19dj: an X-ray and UV luminous TDE in an extreme post-starburst galaxy (Hinkle+21)
26. A cool and inflated progenitor candidate for the Type Ib supernova 2019yvr at 2.6 yr before explosion (Kilpatrick+21)
27. Discovery of a Fast Iron Low-ionization Outflow in the Early Evolution of the Nearby Tidal Disruption Event AT 2019qiz (Hung+21)
28. AT 2019qyl in NGC 300: Internal Collisions in the Early Outflow from a Very Fast Nova in a Symbiotic Binary (Jencson+21)
29. SN2017jgh: a high-cadence complete shock cooling light curve of a SN IIb with the Kepler telescope (Armstrong+21)
30. Updated Photometry of the Yellow Supergiant Progenitor and Late-time Observations of the Type IIb Supernova 2016gkg (Kilpatrick+22)
31. An Early-time Optical and Ultraviolet Excess in the Type-Ic SN 2020oi (Gagliano+22)
32. Forbidden hugs in pandemic times. IV. Panchromatic evolution of three LRN (Pastorello+22)
33. The Optical Light Curve of GRB 221009A: the Afterglow and Emerging SN (Fulton+23)
34. Late-time HST observations of AT2018cow I: Further Constraints on the Fading Prompt Emission and Thermal Properties 50-60 days post-explosion (Chen+23)
35. Late-time HST observations of AT2018cow II: Evolution of a UV-Bright Underlying Source 2-4 years post-explosion (Chen+23)
36. The Type II-P SN 2019mhm and Constraints on its Progenitor System (Vázquez+23)

SNE IA TARGET SELECTION

1. Mostly untargeted (from discovery, all-sky surveys: ASASSN, ATLAS, YSE, ZTF,…)

2. $0.015 < z < 0.085$, but also if $z < 0.01$ (potential Cepheid calibrators)

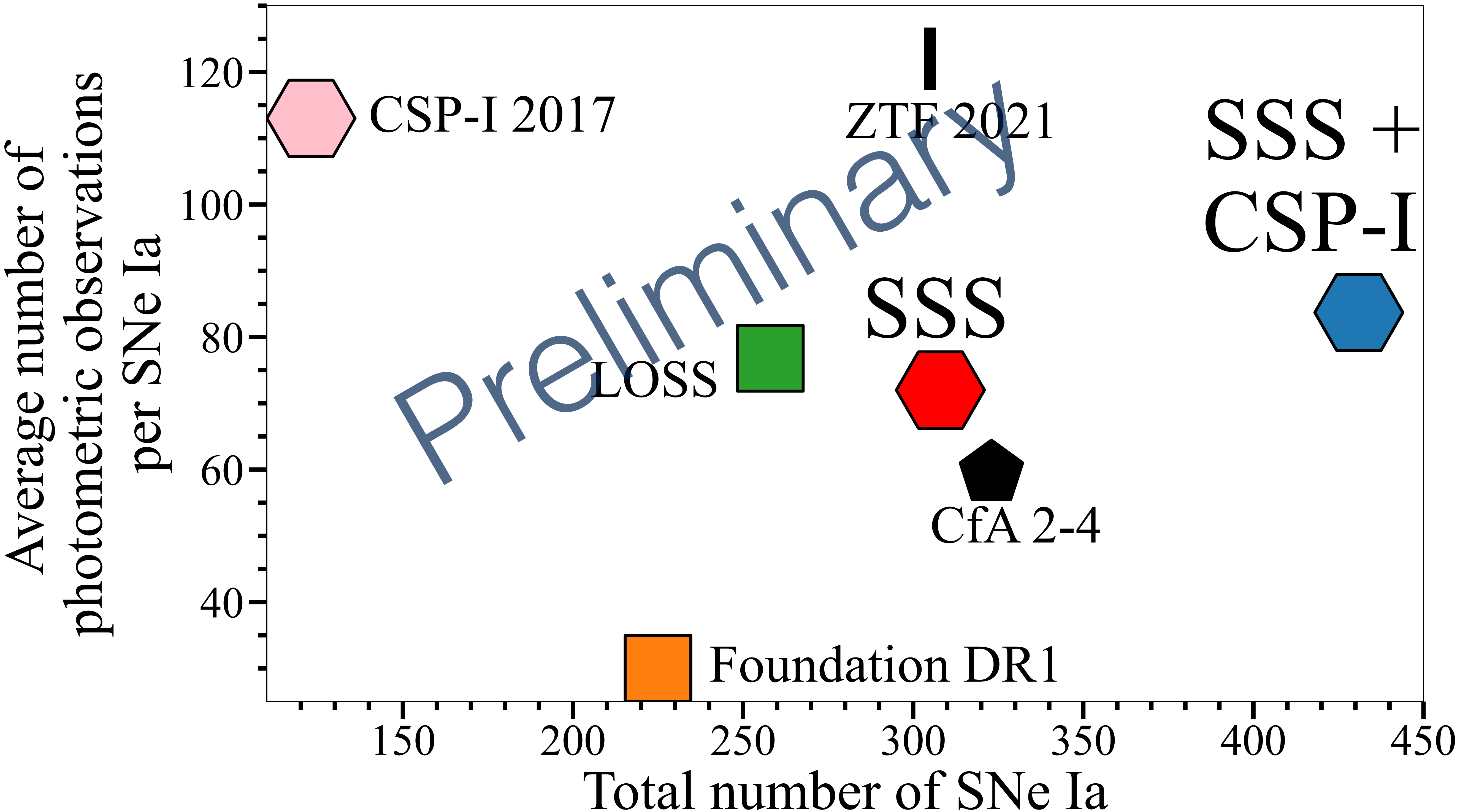
3. Low Milky Way reddening

4. Observable until 45 days after max

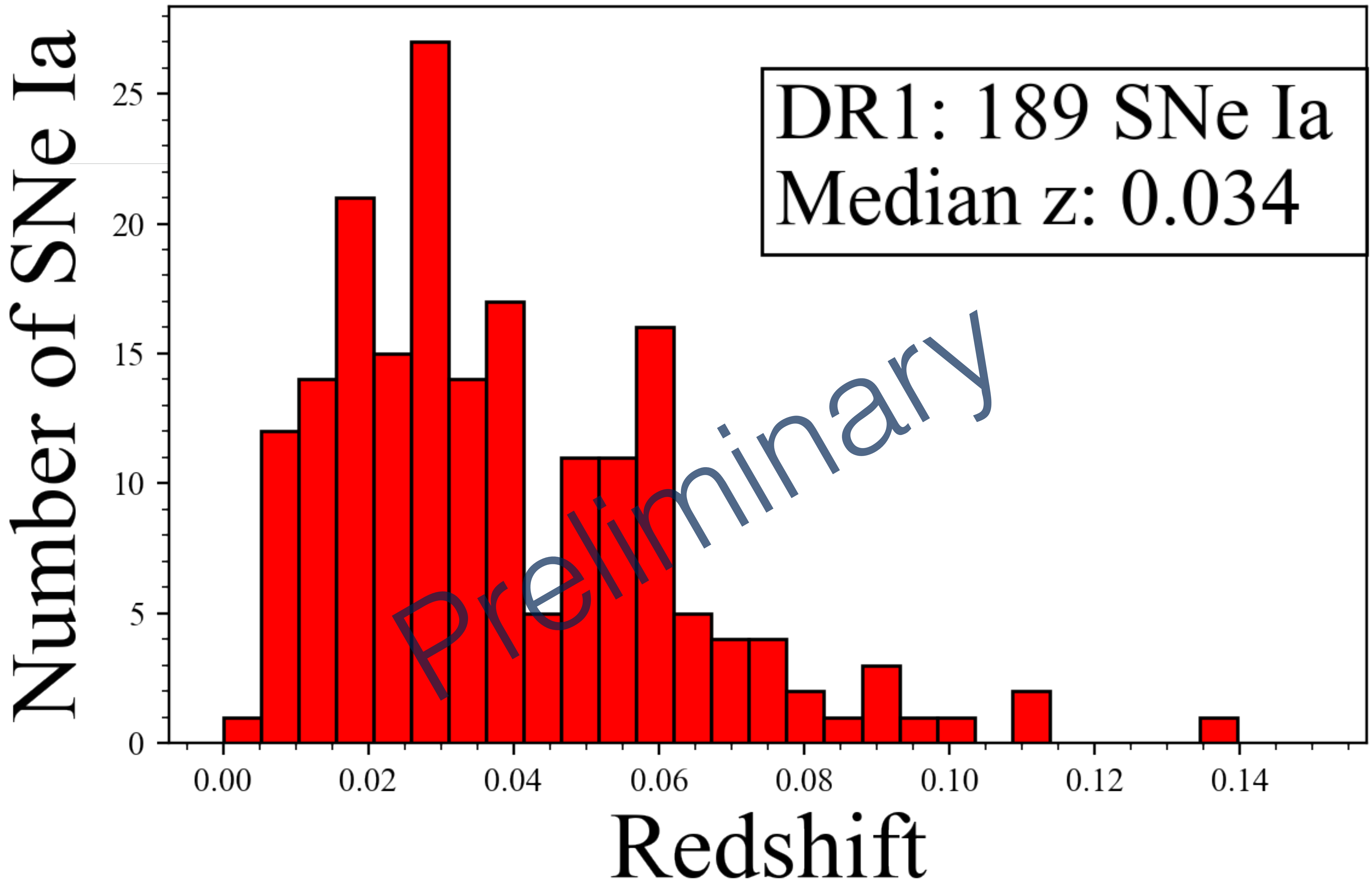
5. Confirmed Ia before max

SN IA CADENCE + follow-up spectra and host-galaxy spectra

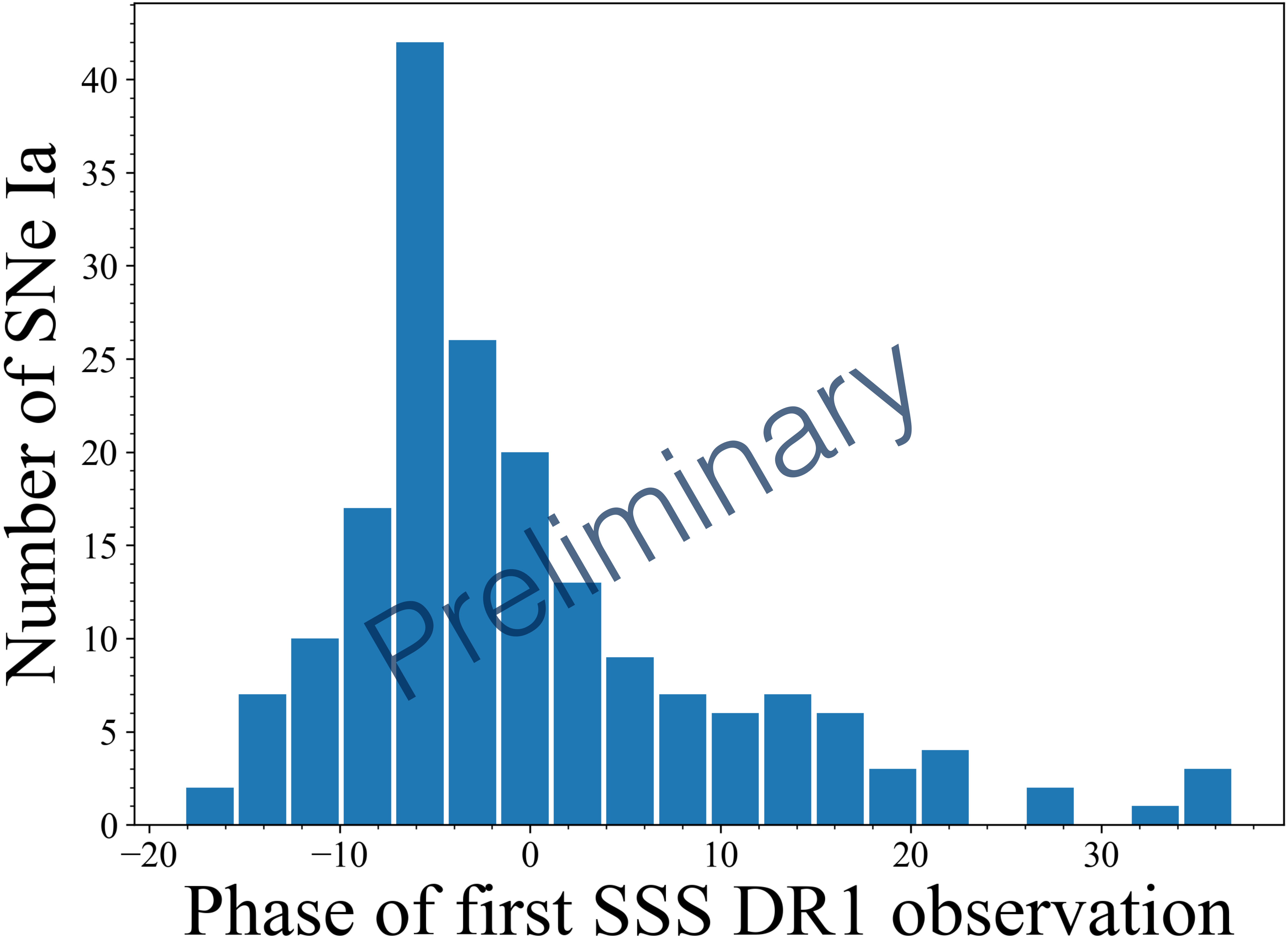
Phase	Cadence
pre-max	nightly
max to +20	3
+20 to +40	4
+40 to +45/50	7



Preliminary
CSP-I 2017
ZTF 2021
SSS +
CSP-I
SSS
LOSS
CfA 2-4
Foundation DR1
120
100
80
60
40
150
200
250
300
350
400
450
Total number of SNe Ia
Average number of photometric observations per SNe Ia



DR1: 189 SNe Ia
Median z: 0.034
Preliminary
Number of SNe Ia
0
5
10
15
20
25
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
Redshift



Number of SNe Ia
40
35
30
25
20
15
10
5
0
−20
−10
0
10
20
30
Phase of first SSS DR1 observation
Preliminary

SOME PRETTY PICTURES

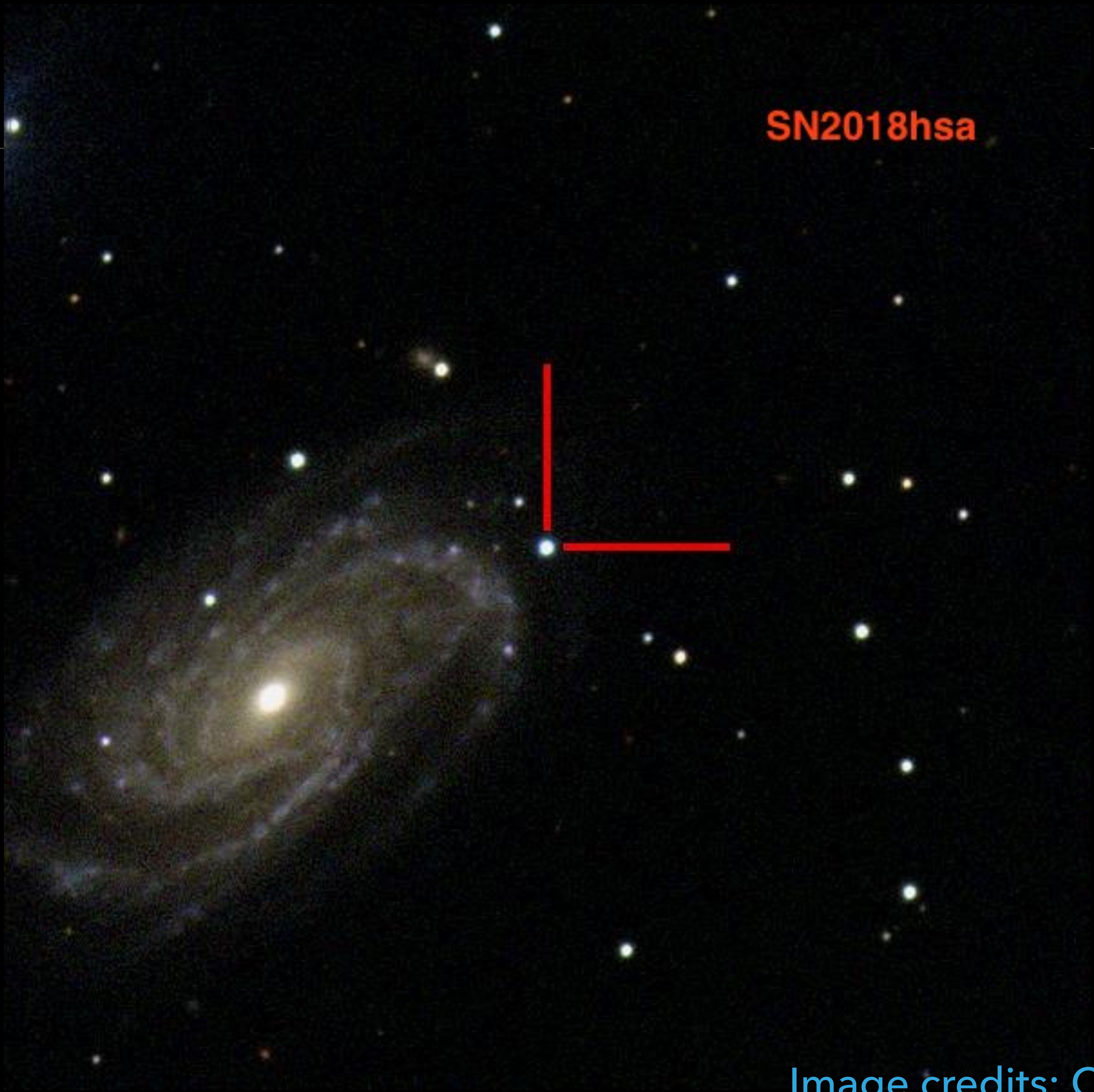


Image credits: C. Kilpatrick

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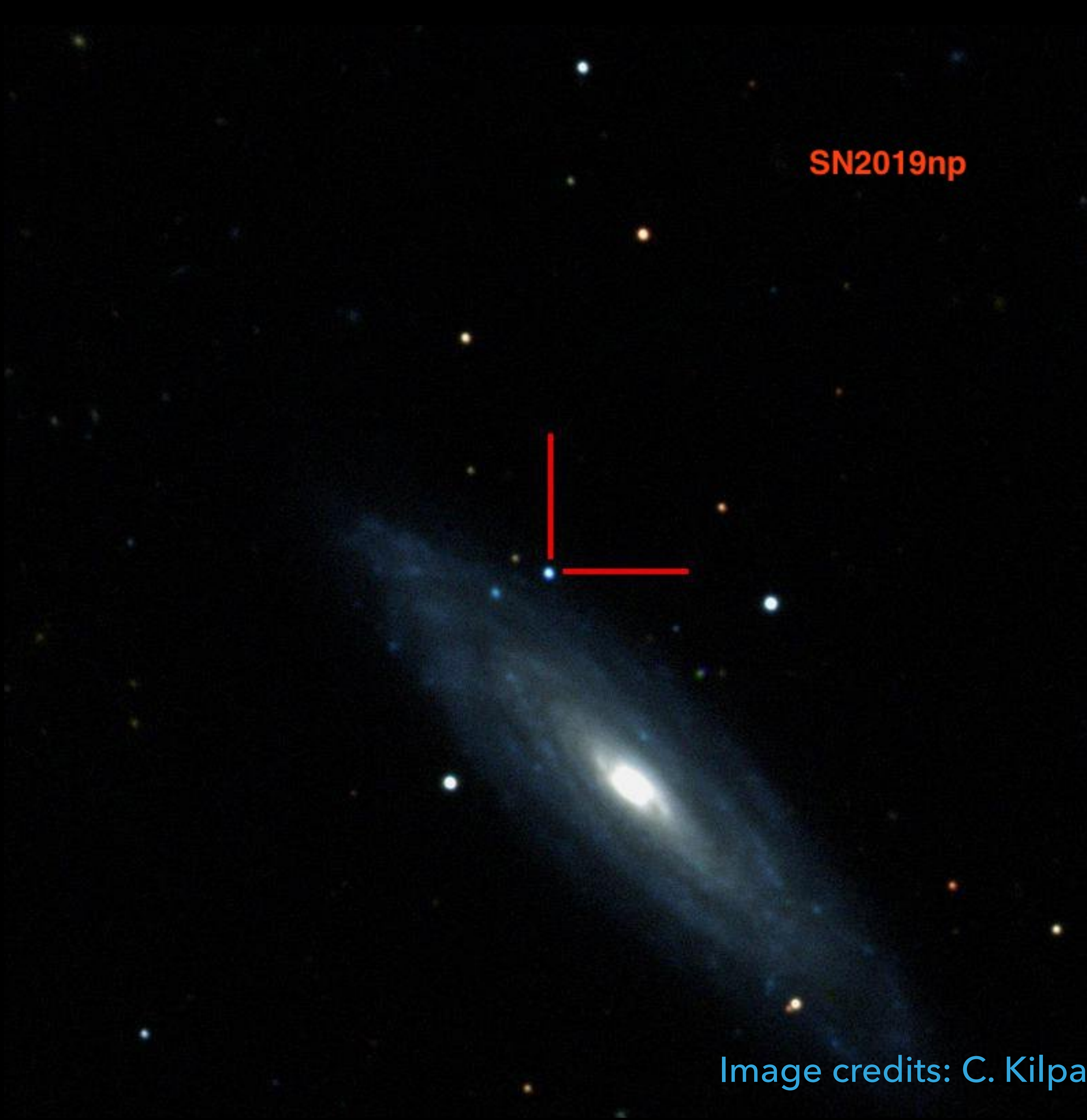


Image credits: C. Kilpatrick

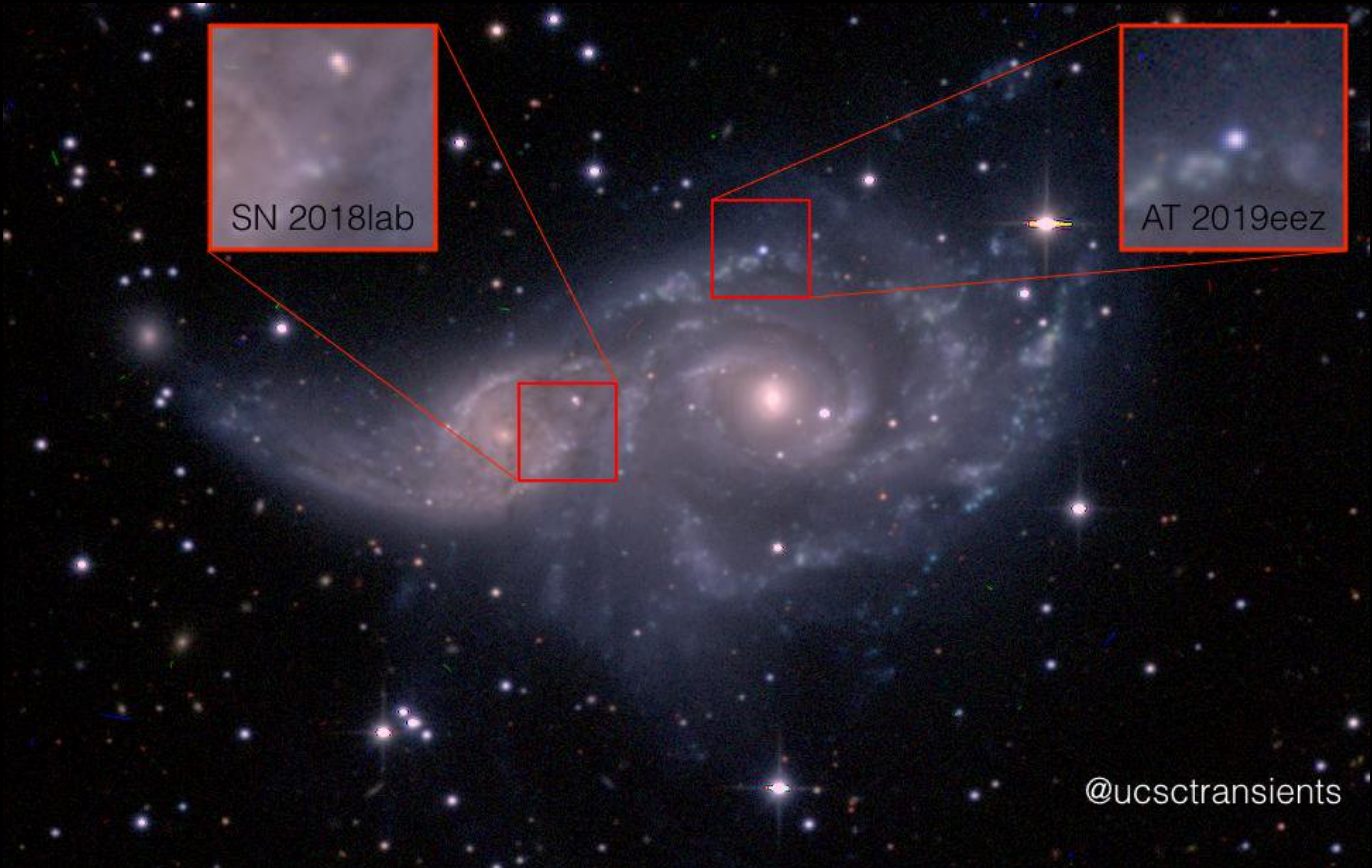
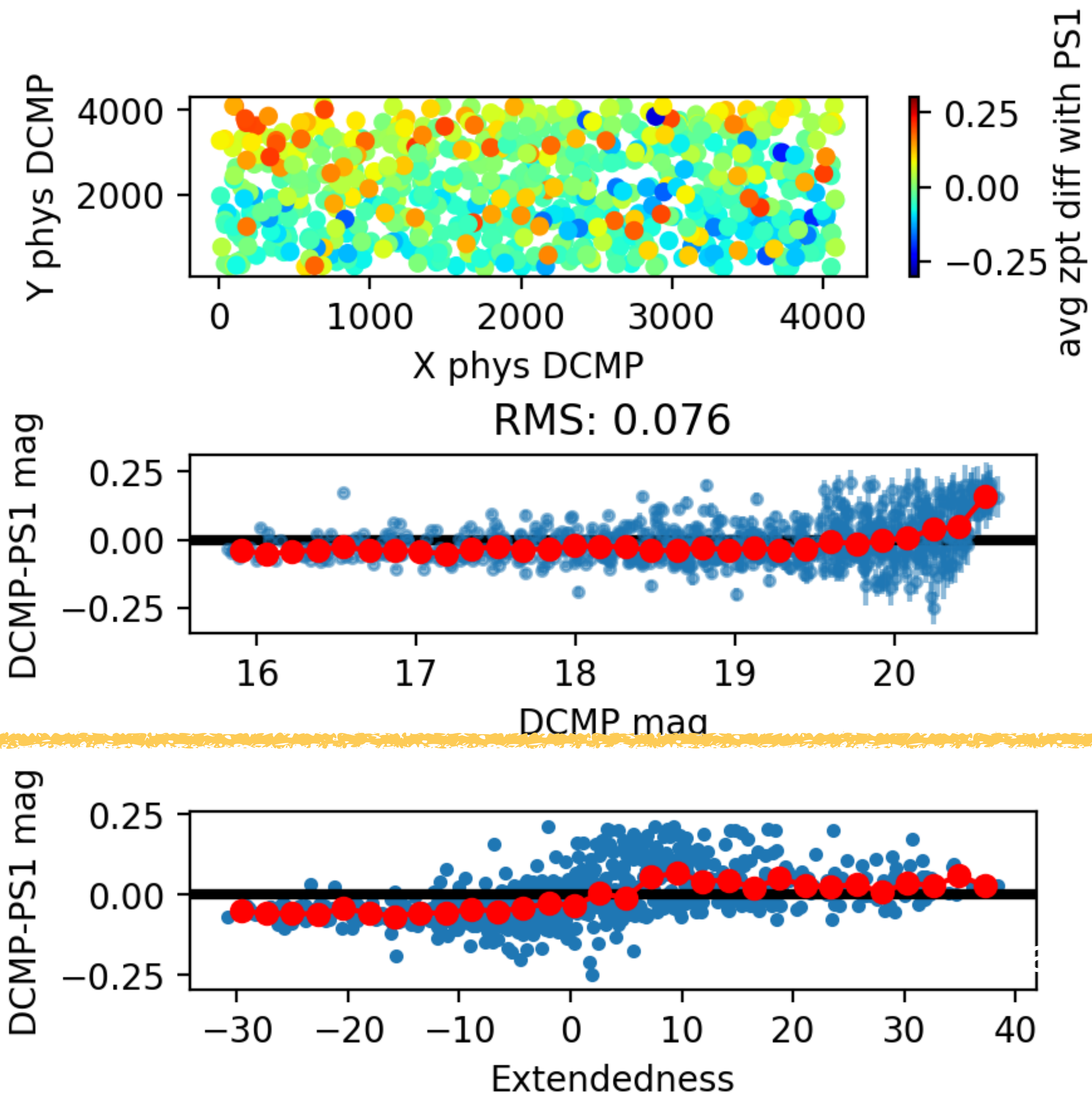


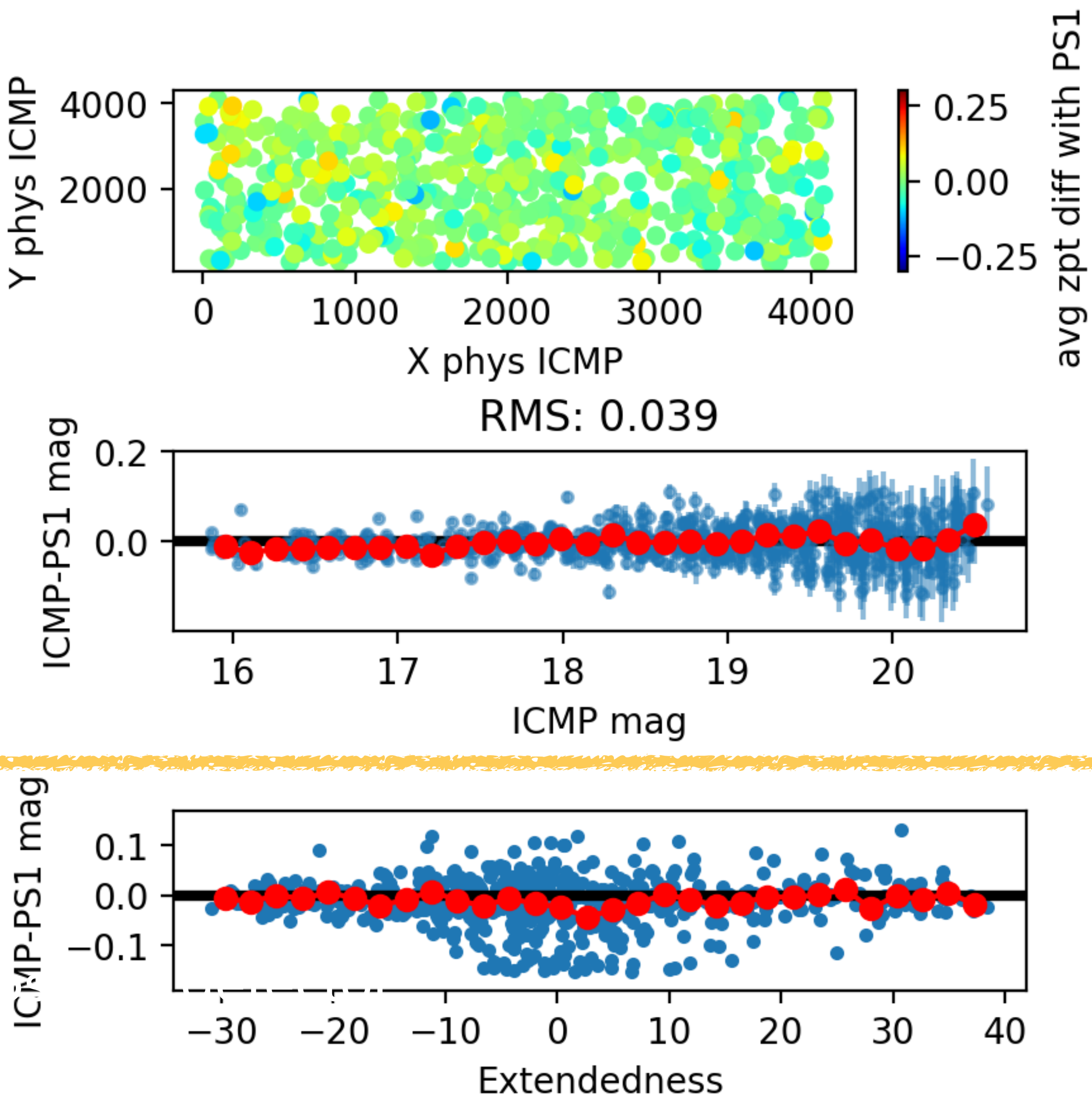
Image credits: C. Kilpatrick

IMPROVING THE PHOTOMETRY

DOPHOT

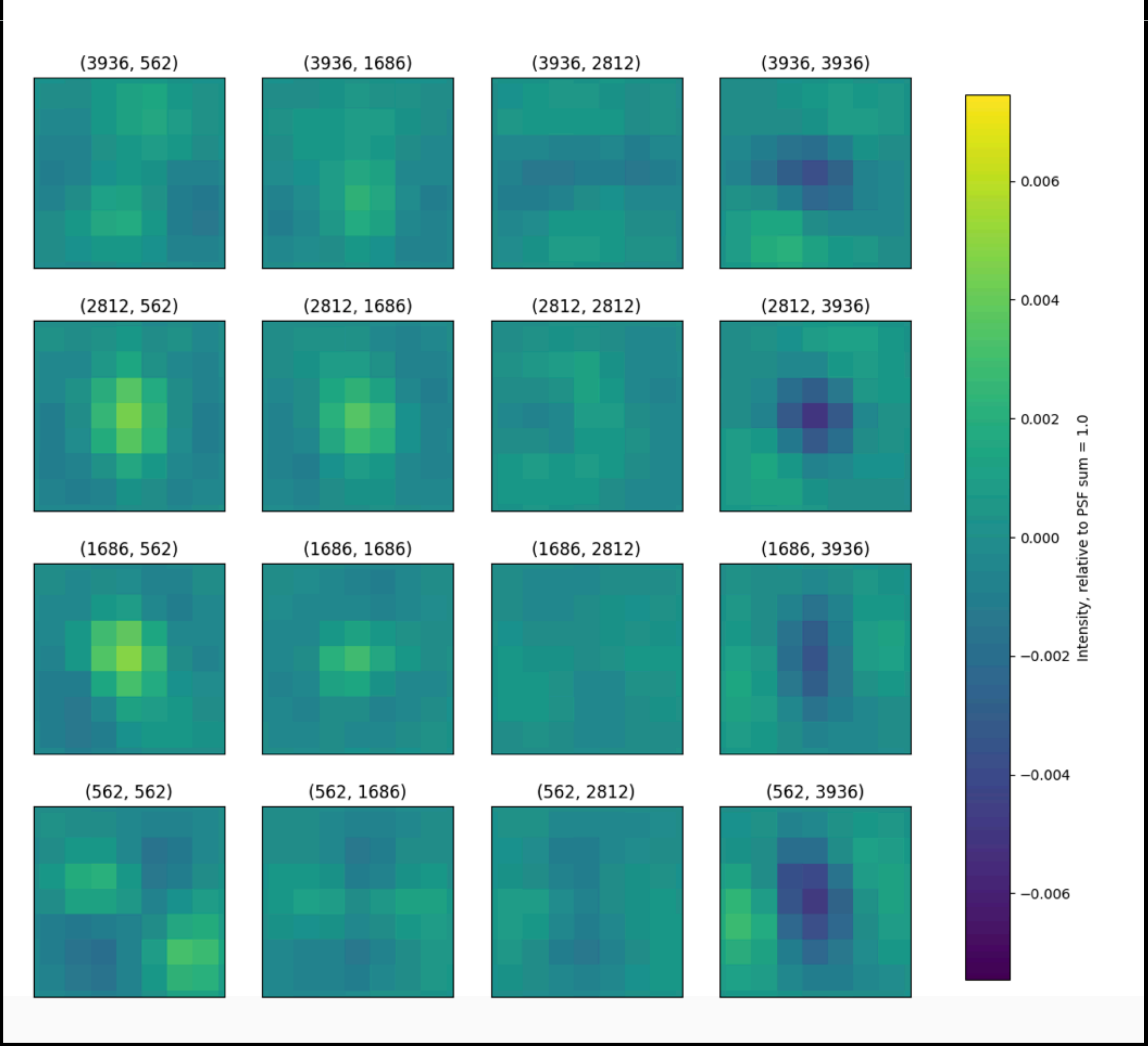


Aperture Photometry



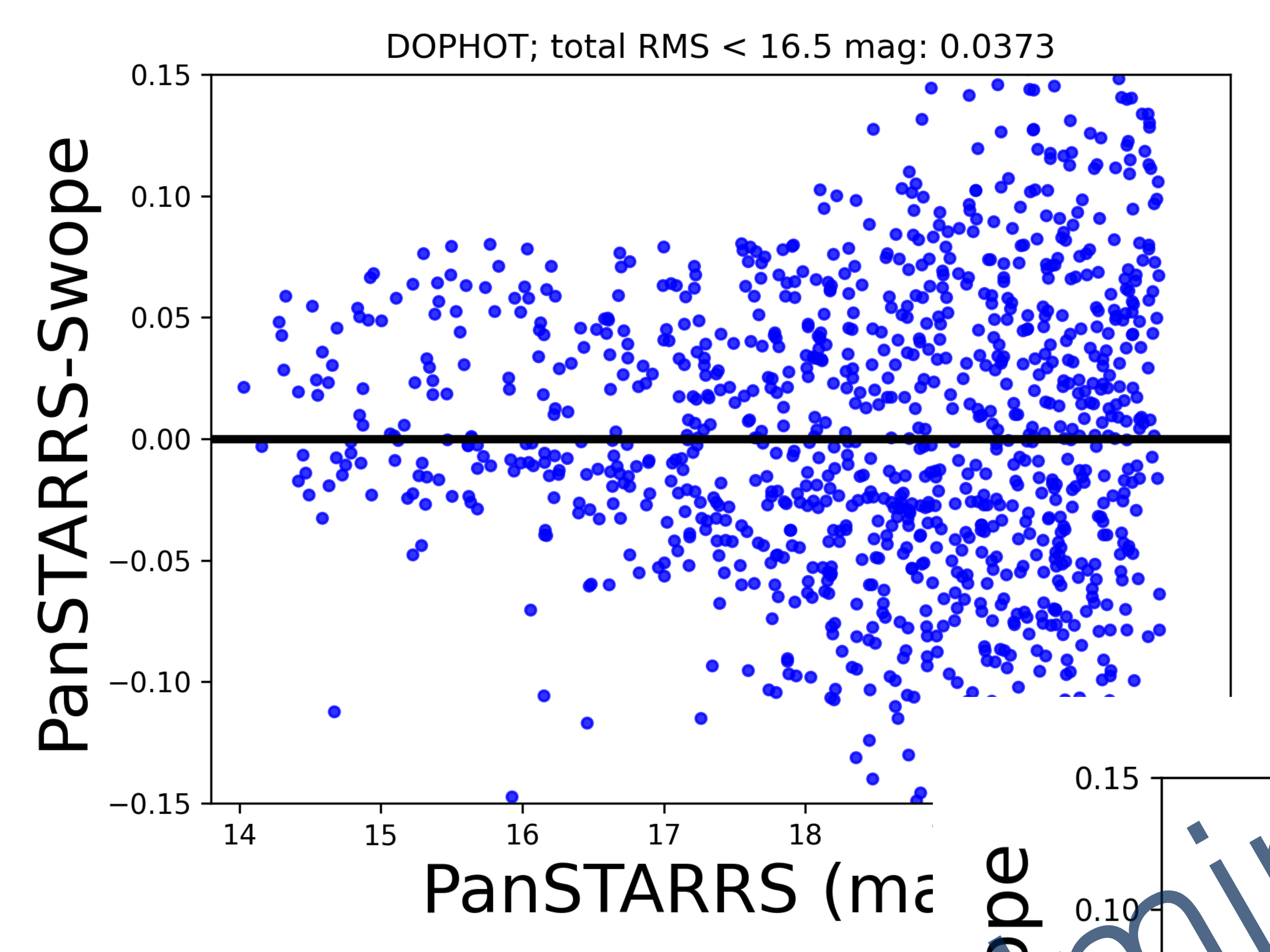
NEW PHOTOMETRY METHOD: APPLYING A SPATIALLY-VARYING PSF

- Use astropy's photutils gridded effective PSF models
- Working closely with Justin Roberts-Pierel and Armin Rest (STScI)

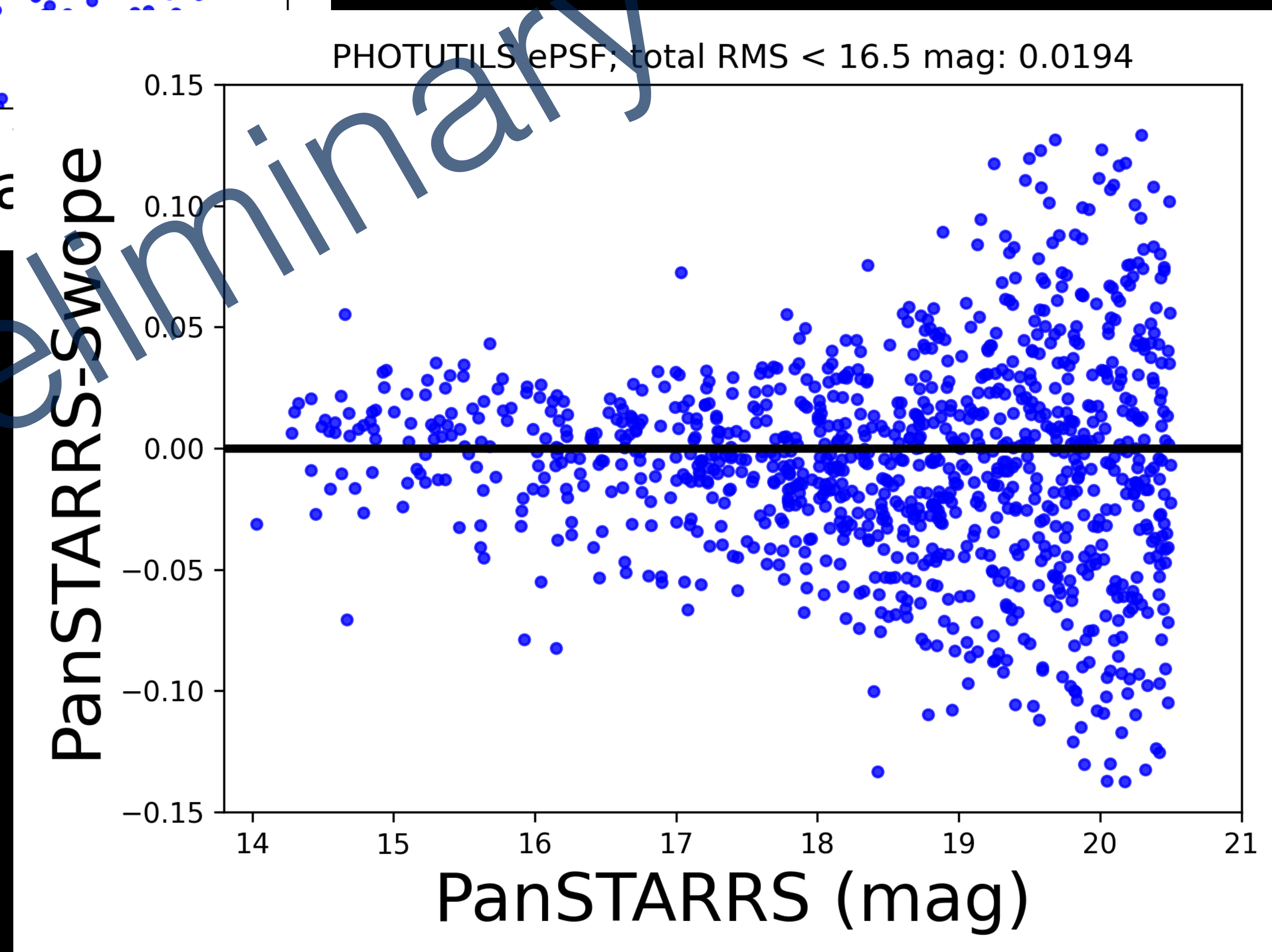


Difference from the mean ePSF

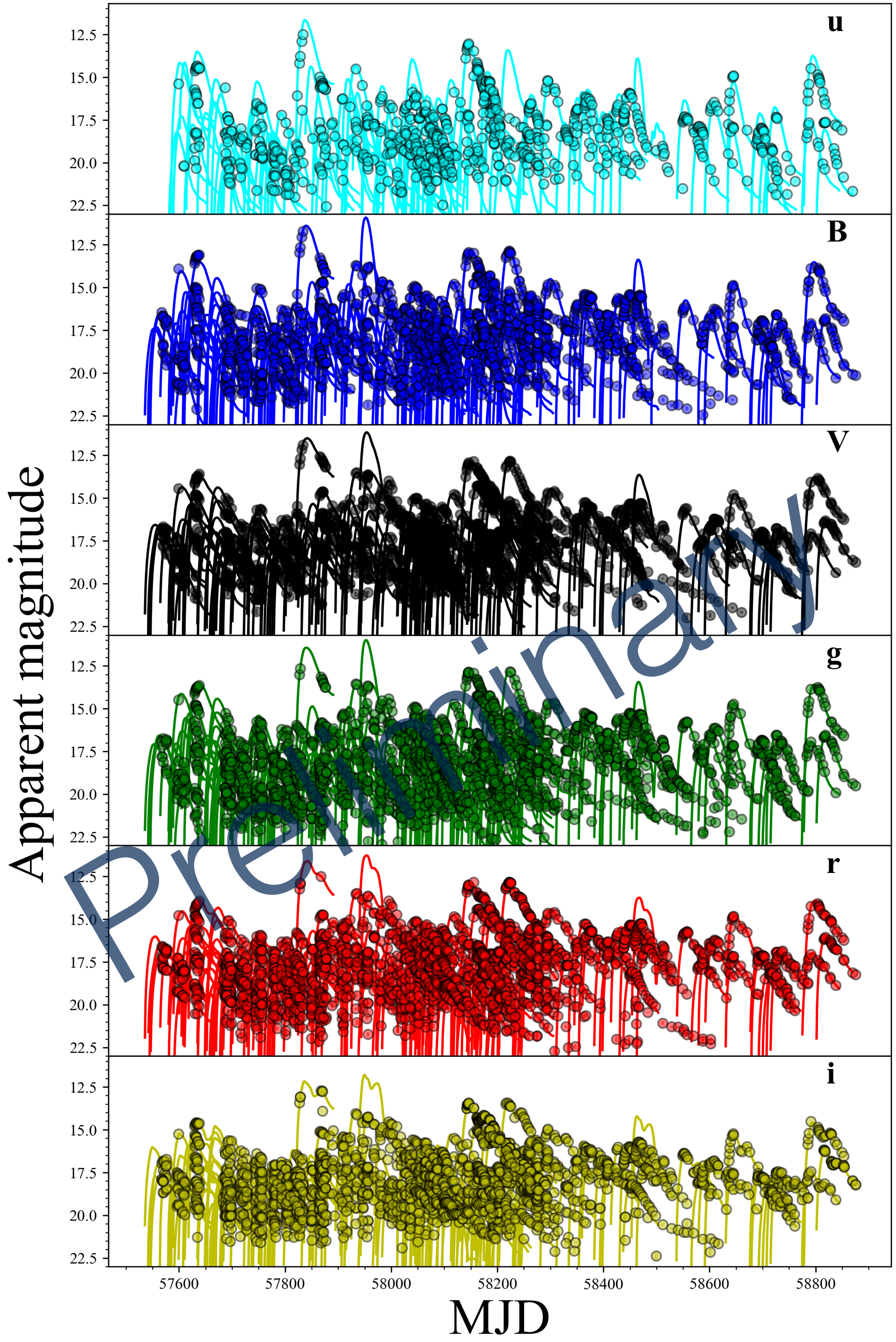
-> deviation across the detector



Improvement!



SSS DR1 light curves

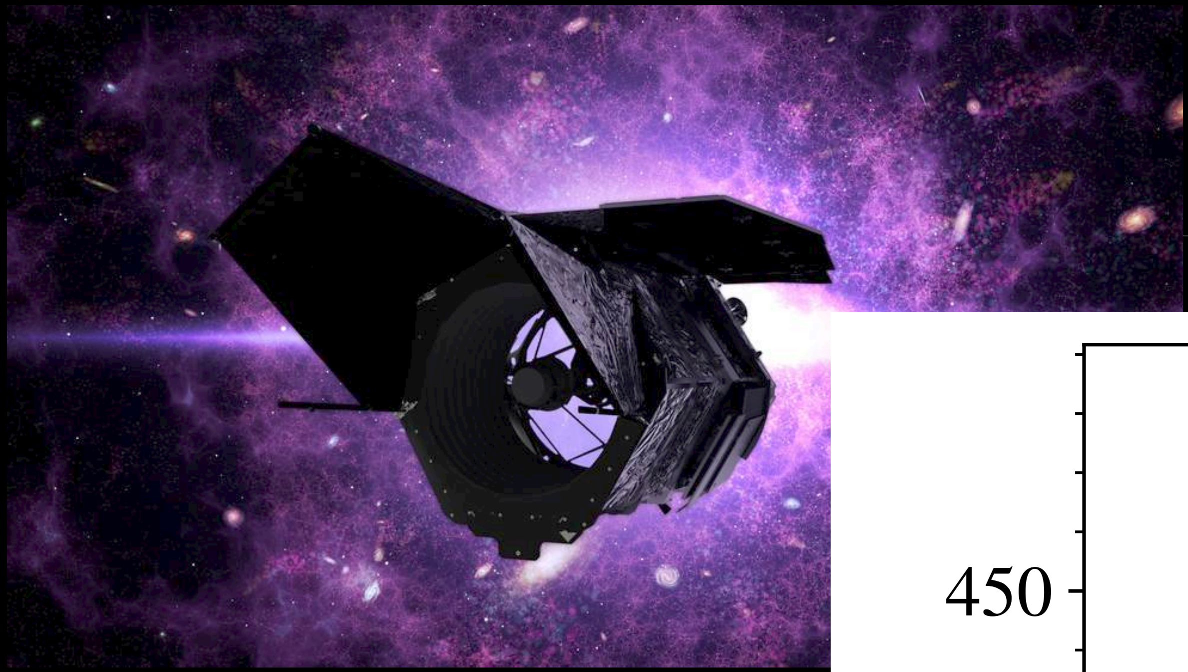


SSS UNIQUENESS/ADVANTAGES

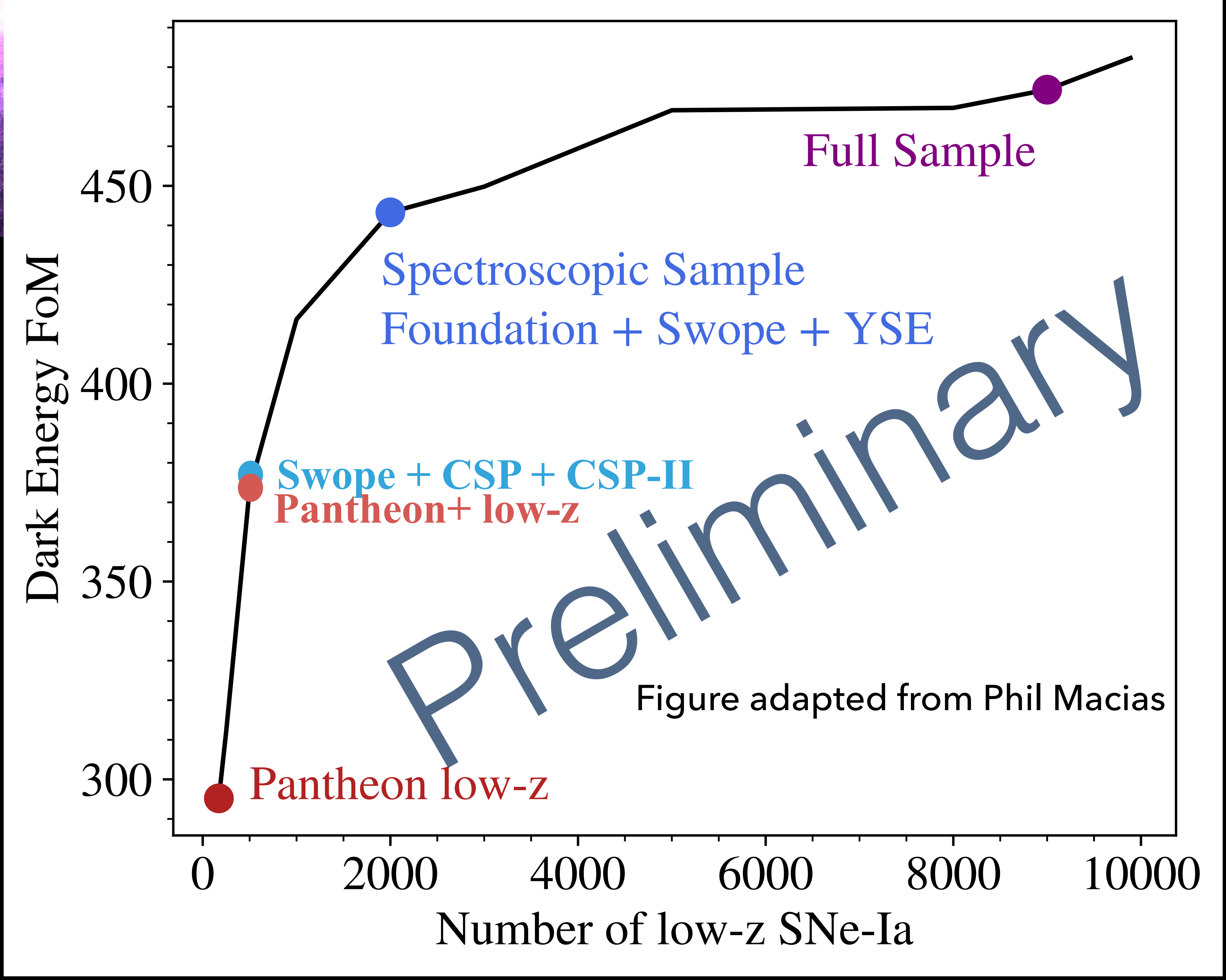
- 6 filters, large wavelength range, high cadence — Better distance measurements
- Untargeted sources (similar to high-z surveys) — Better bias corrections
- 300 SNe Ia, ~400 with CSP, ~ 600 CSP-II — Better calibration
- Lots of u-band + spectral data — Better SN modeling
- New potential Cepheid/TRGB calibrators — Better H_0 statistics
- Lots of host-galaxy spectra, at SN location and nucleus

    - Better understanding of local environment
    - Spectroscopic redshift measurements of faint galaxies

75% OF ROMAN SPACE TELESCOPE'S 800 LOW-Z REQUIREMENT



Along CSP-I and CSP-II data



FIRST SWOPE SUPERNOVA SURVEY SNIA DATA RELEASE COMING THIS SUMMER!

- ~200 low-redshift type Ia supernovae in 6 optical bands
- High cadence, host + SN spectra
- ~150 more in DR2
- Will combine with CSP and CSP II to have 600 low-redshift SN Ia in the same system
- 75% of Roman's Space Telescope low-redshift requirement

Thank you!