SweetSpot Survey: Overview and Early Results

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New Advances in NIR SN Ia Science

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UNIVERSITY OF PITTSBURGH

PITTPACC

Thanks to my collaborators:

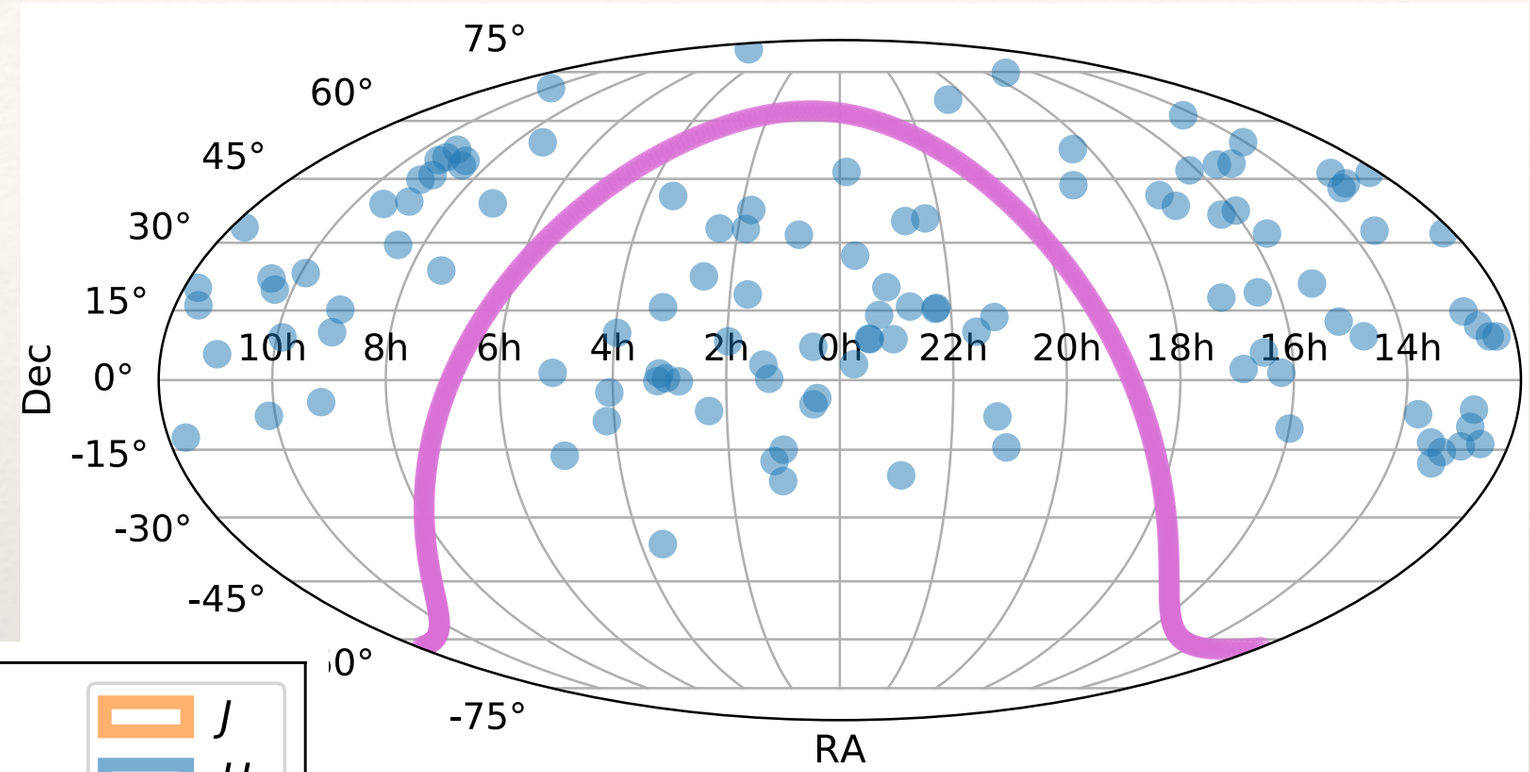
Michael Wood-Vasey, Anja Weyant, Lori Allen, Lluis Galbany, Peter Garnavich, Saurabh Jha, Dick Joyce, Tom Matheson, Peter Milne, Jessica Kroboth,

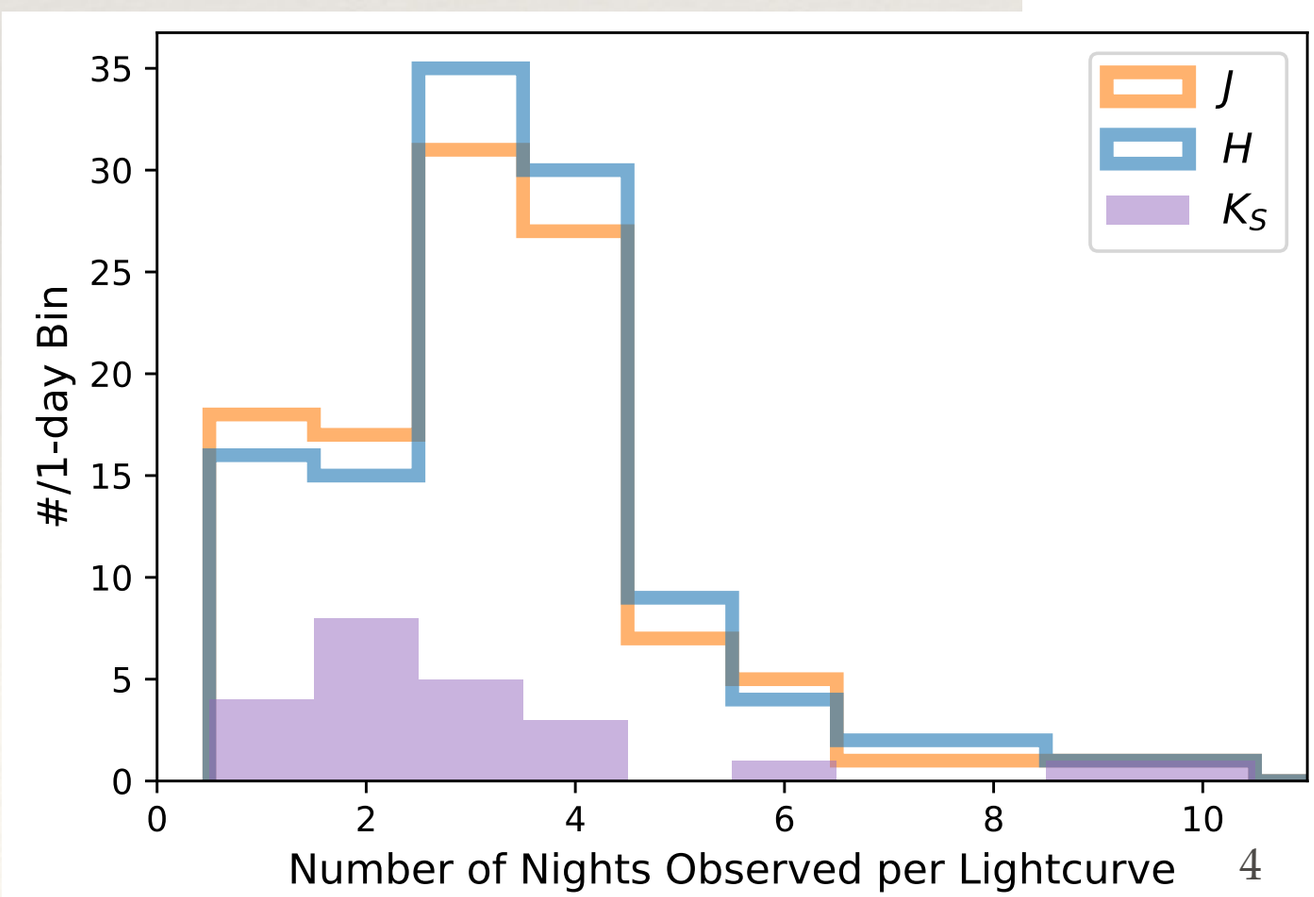
SweetSpot: 3-year NOAO Survey on WIYN 3.5 m

- Extend NIR Hubble diagram to z~0.08
- Quantify how standard SN Ia are in the NIR, particularly H-band
- Improve understanding of colors of SNeIa
- Provide a standard well-calibrated rest frame reference for future higher redshift surveys.
- Test correlations between NIR SNeIa and host galaxy properties

115 NIR Supernovae Observed

- 88.5 nights
- 114 SNeIa
- 1 SN Ibn

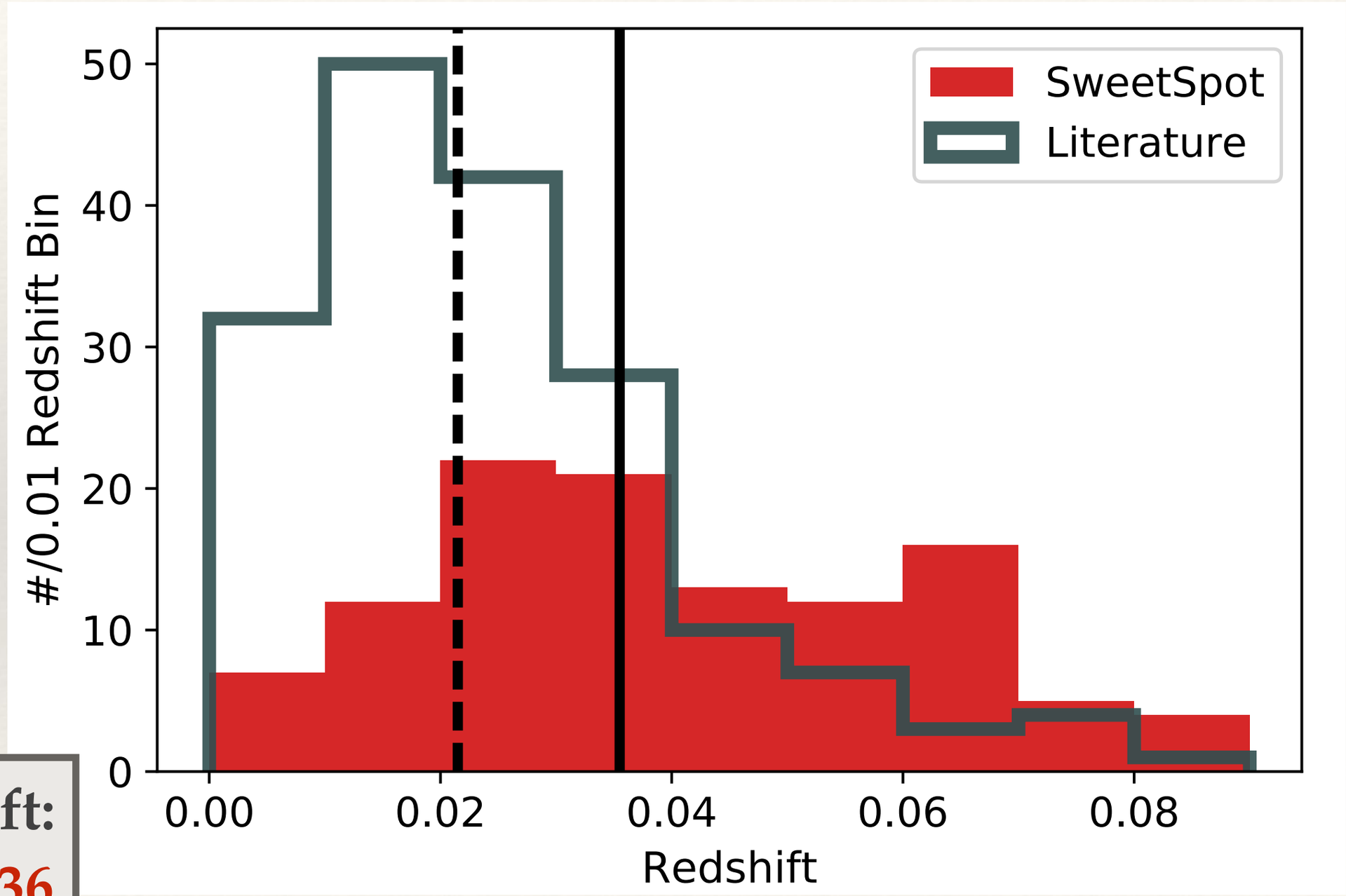




Median # LC pts:

J : 3, H : 3, Ks : 2

Redshift Distribution



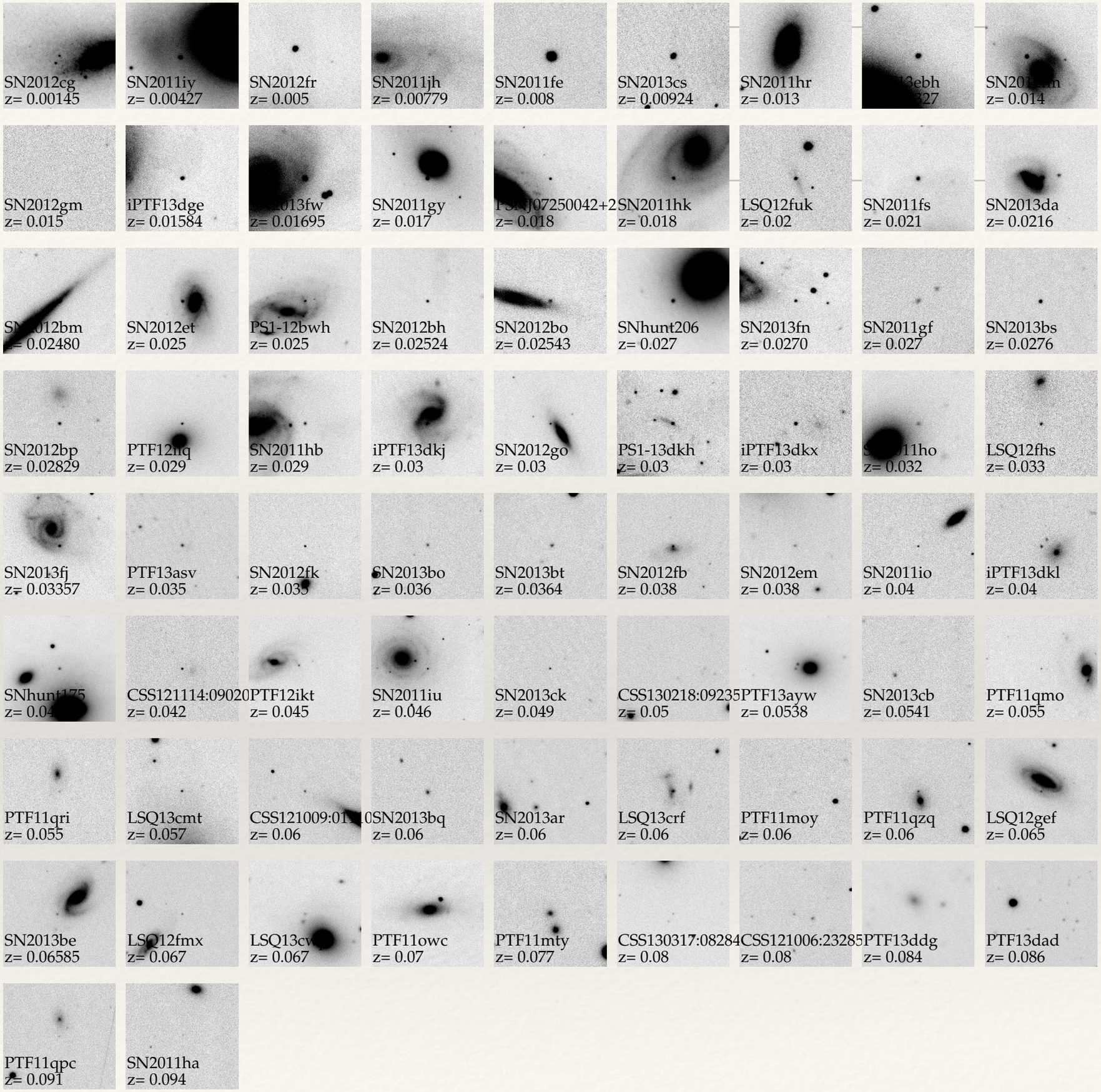
Median redshift:

SweetSpot: 0.036

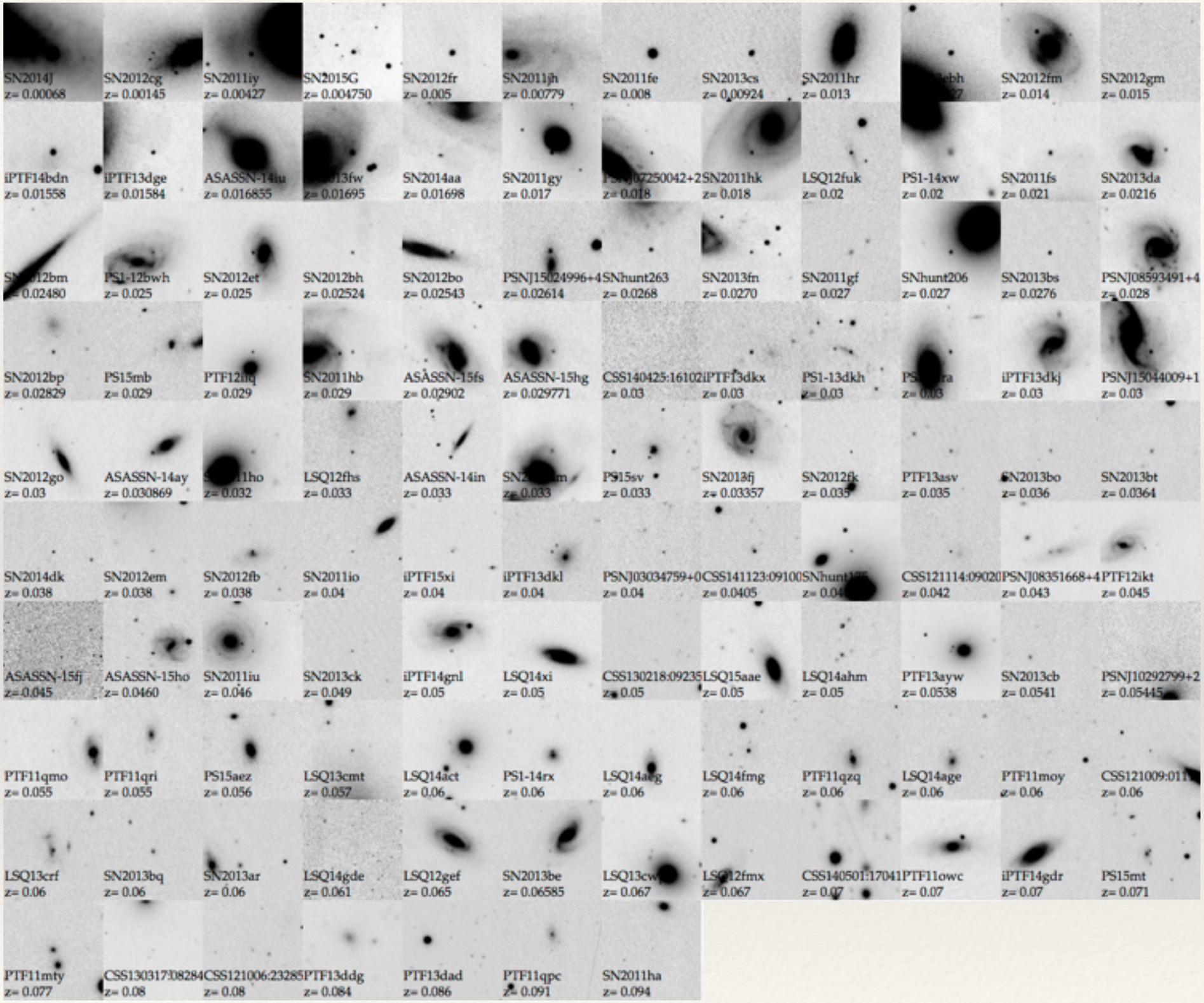
Literature: 0.021

DR1

- Calibrated Images of 74 SNeIa, including SNe from pilot
- 63 SNe observed within 20 days of B-band maximum
- 10 before B-band maximum
- 33 light curves



Weyant et al (2018, AJ accepted)



DR2

- Calibrated Images of 114 SNeIa, including SNe from pilot+DR1
- Host Galaxy subtraction using LSST data reduction pipeline

Status of Survey

- **Pilot** released in Weyant et al (2014), ApJ, 784, 105
- **Data Release 1** Accepted to AJ, arXiv: 1703.02402
  - 74 SNeIa with 33 lightcurves
- **Data Release 2** is planned for 2018
  - 114 SNeIa with light curves including host galaxy subtractions
- **Data Release 3** is planned for ~2019
  - Improved calibration and host galaxy template subtractions
  - Optical light curves from SuperLOTIS
- **Science papers**: Host galaxy correlations planned for 2018 (first results in 2017)
  - Color study with optical LC, Hubble diagram and properties, bulk flow (with CSP for Southern hemisphere), high redshift connections

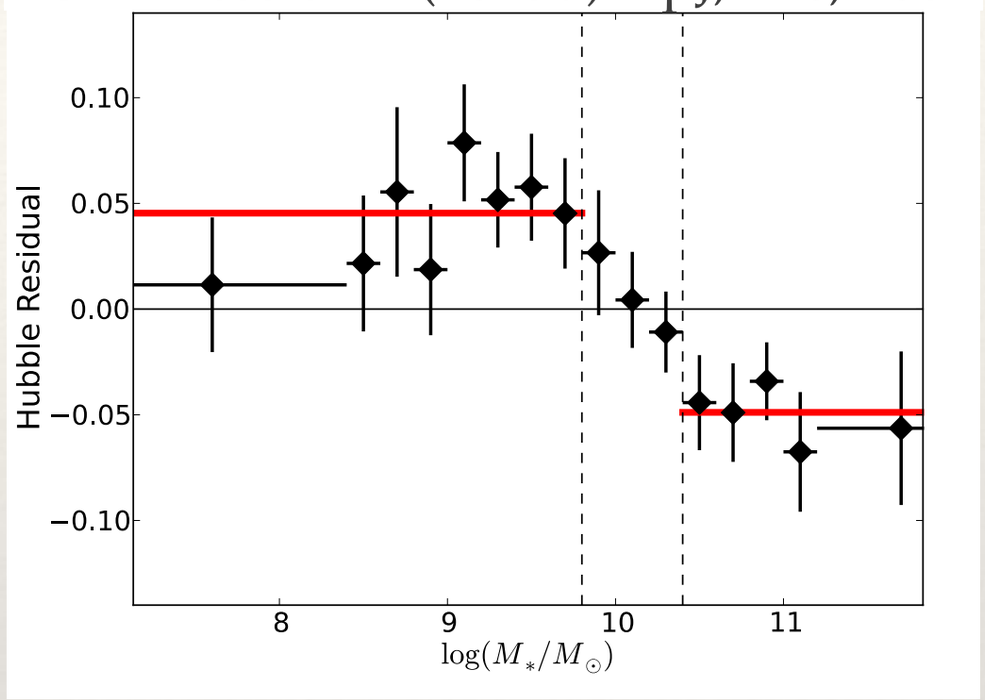
NIR SNeIa with Optical LCs

- SuperLOTIS — Robotic telescope on Kitt Peak run by Peter Milne
  - 60 optical light curves for SweetSpot SNeIa
  - Goal to use them for T_Bmax, but will also be used for color studies and other science
- Open Supernova Catalog:
  - 105 SNeIa on OSC with optical light curves that have NIR light curves in literature
- SuperLOTIS data can be sparse because it was not dedicated to our survey or have light curves that miss the B-band peak. There's not guarantee of having a corresponding optical SN on OSC.
  - Best choice: Use a CSP model of getting both NIR and optical LCs

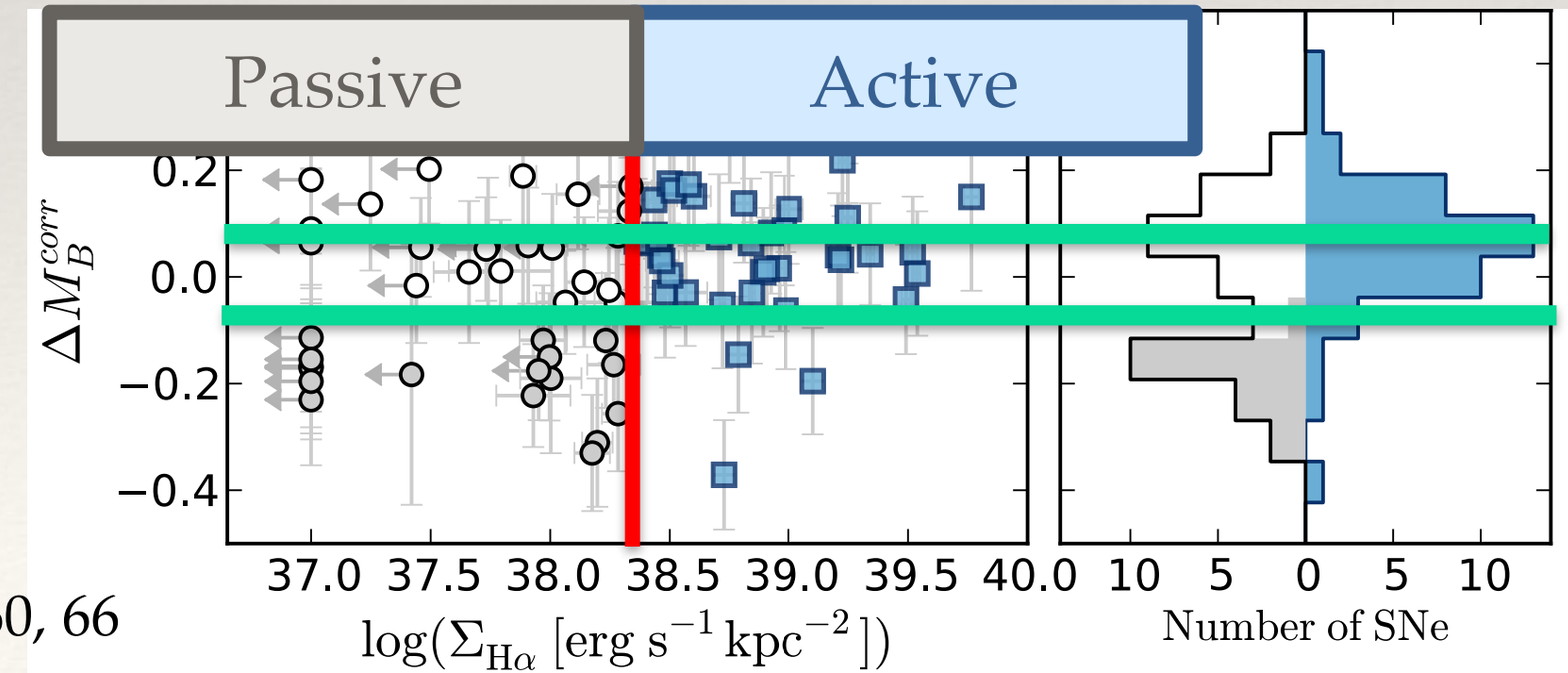
Results: Host Galaxy Correlations

- In optical there are correlations see with different host galaxy properties. 2 largest are
  - Mass
  - Local Star formation rate

Childress et al (2013b) ApJ, 770, 108

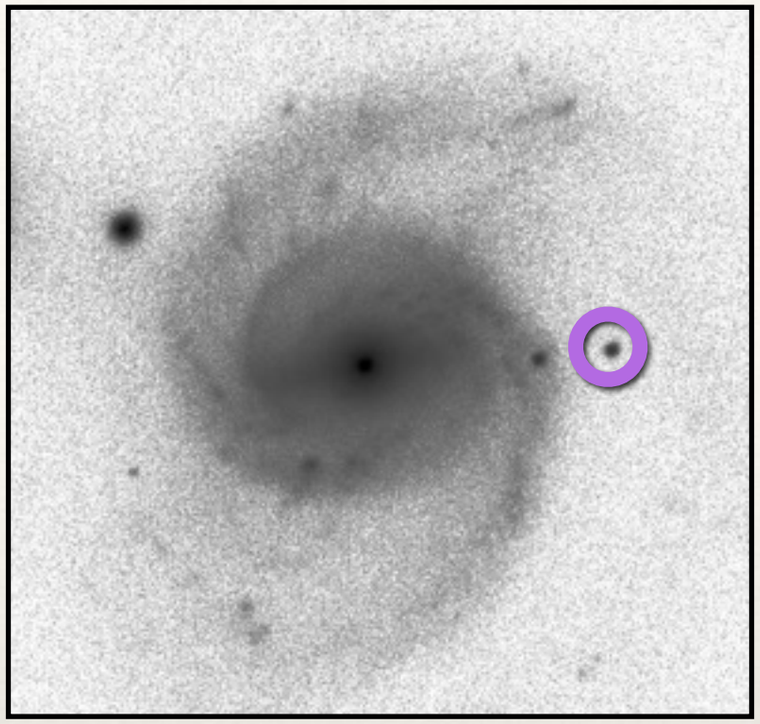


Does this exist in the NIR?

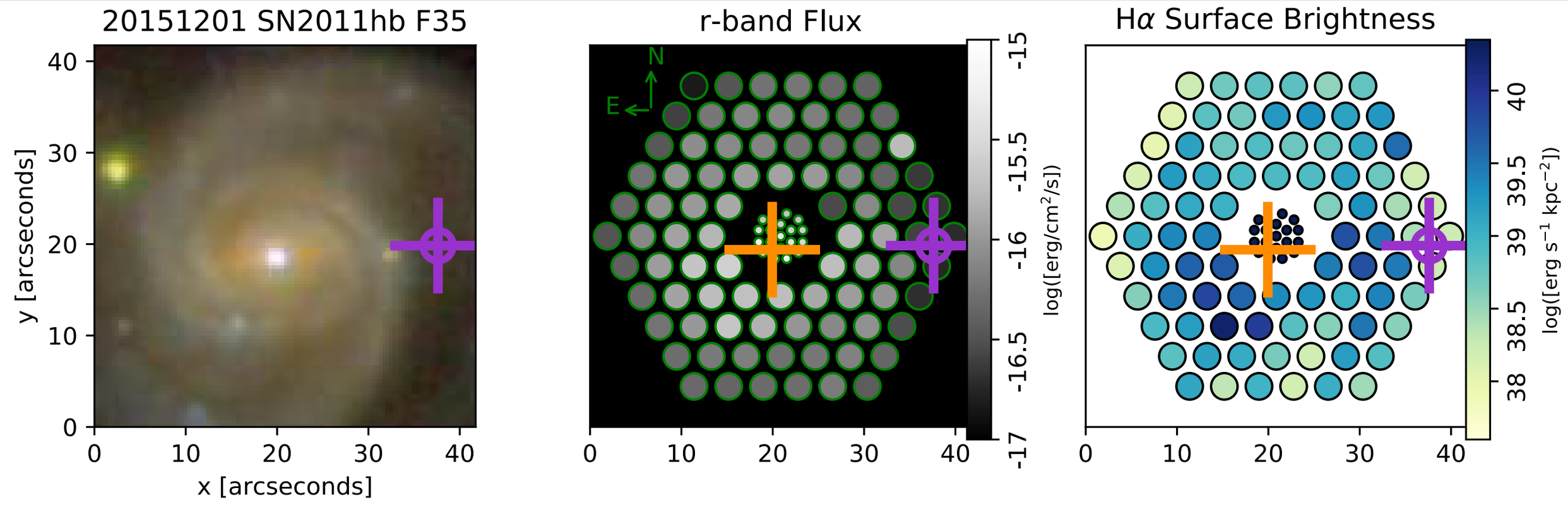


Rigault et al (2013) A&A, 560, 66

IFU Spectra of 32 SweetSpot Host Galaxies using HexPak



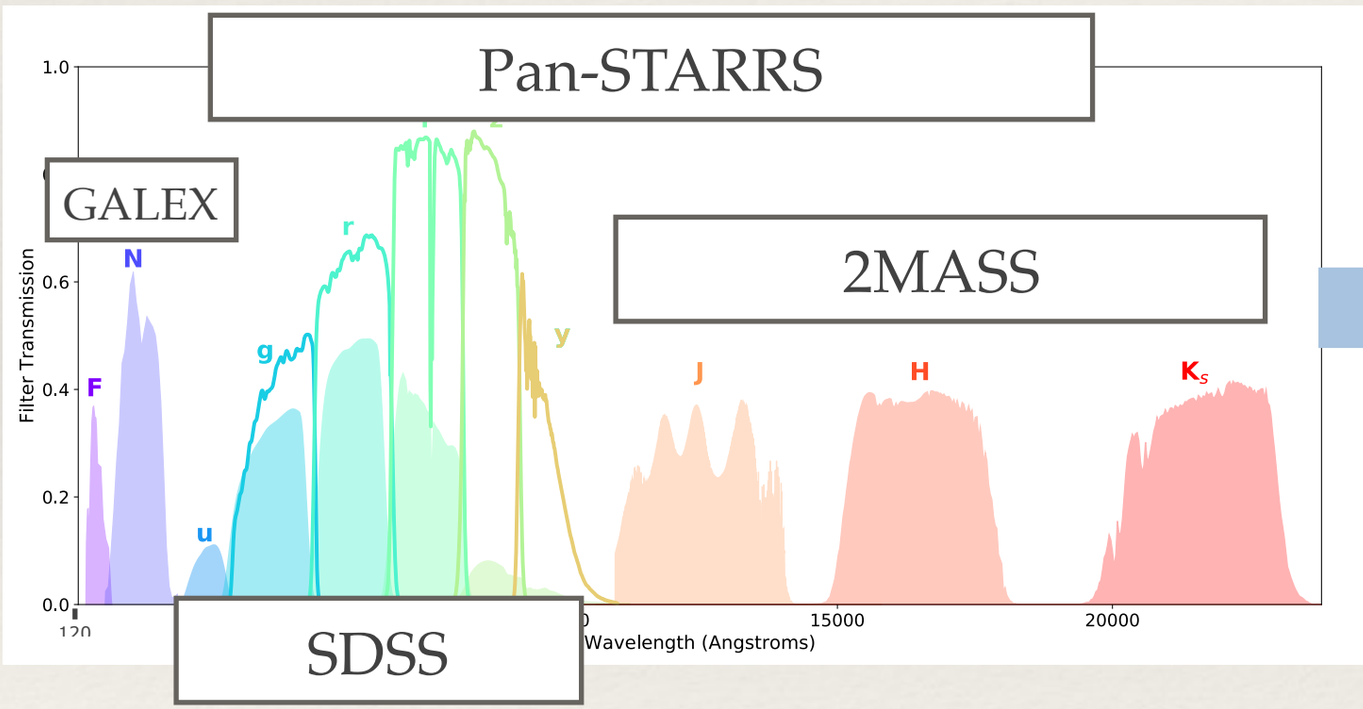
More IFU data from:
AMUSING (95),
PISCO (34),
MaNGA (~3)



Data reductions in Ponder (2017)

Host Galaxy Information

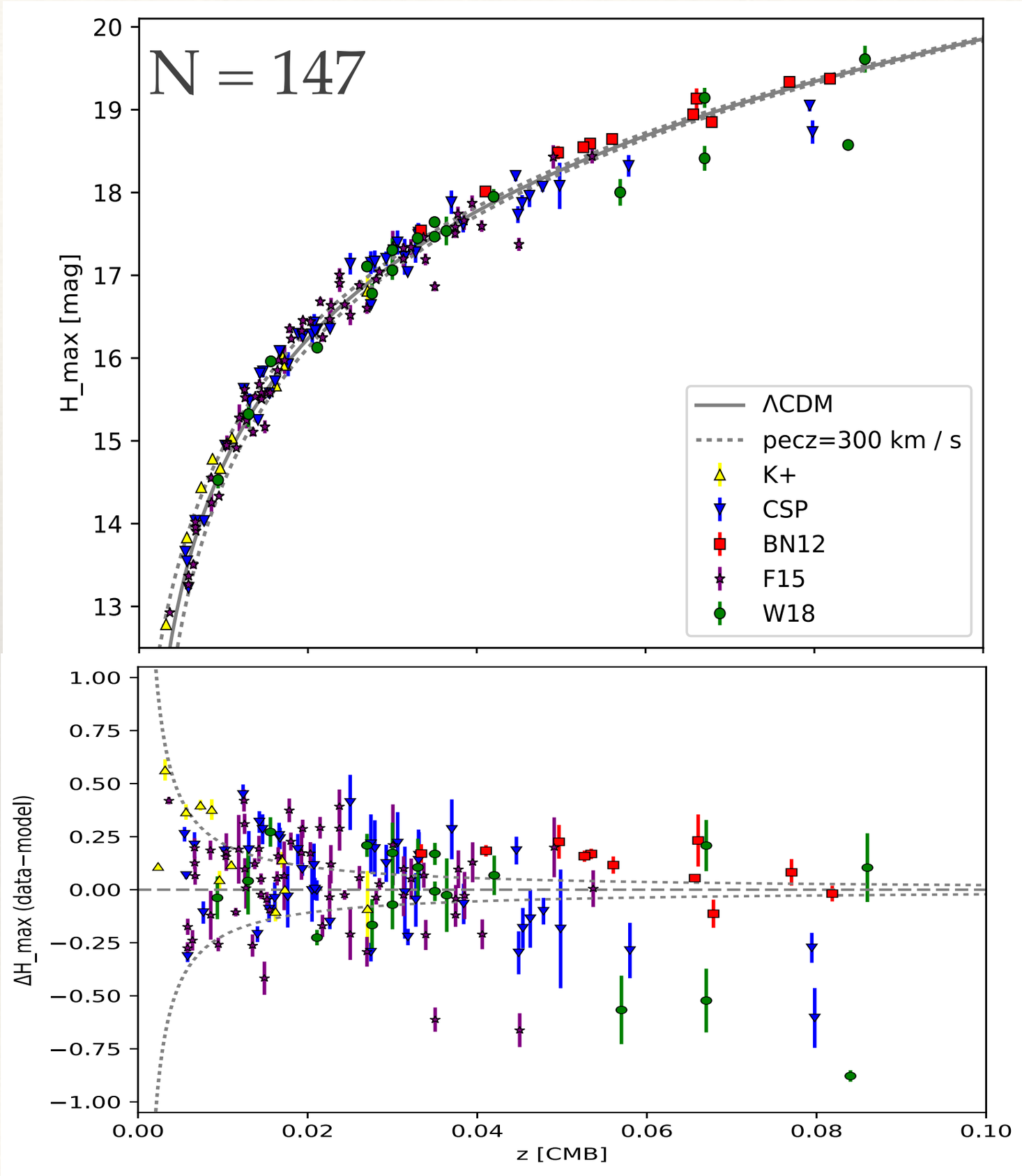
Collected Catalog data spanning different wavelengths.



`kcorrect`

- Galaxy K-corrections
- Fits spectral templates
- Templates give physical properties such as **mass**

H-band Hubble Diagram and Residuals



SNeIa

K+ : 11

CSP: 45

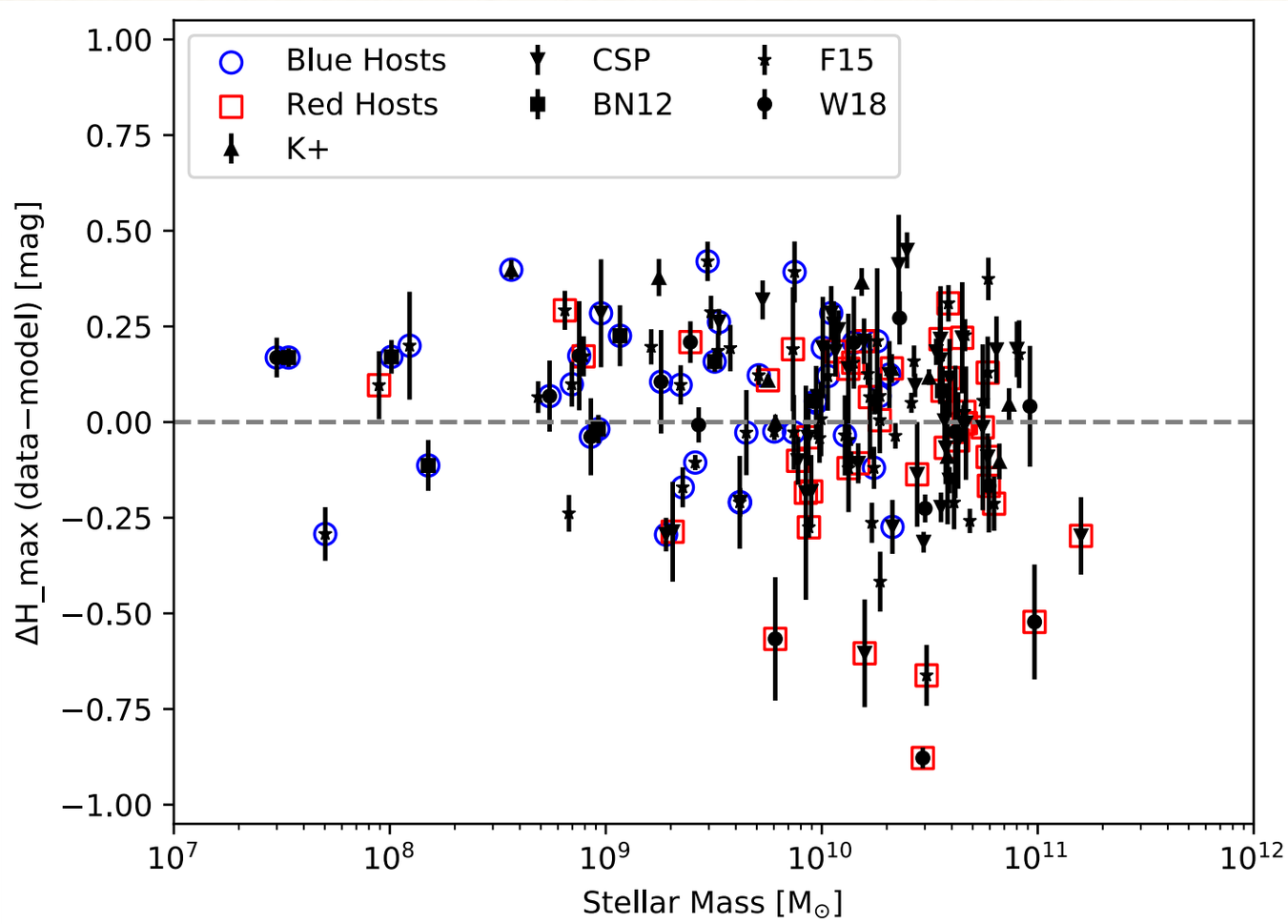
BN12: 11

F15: 62

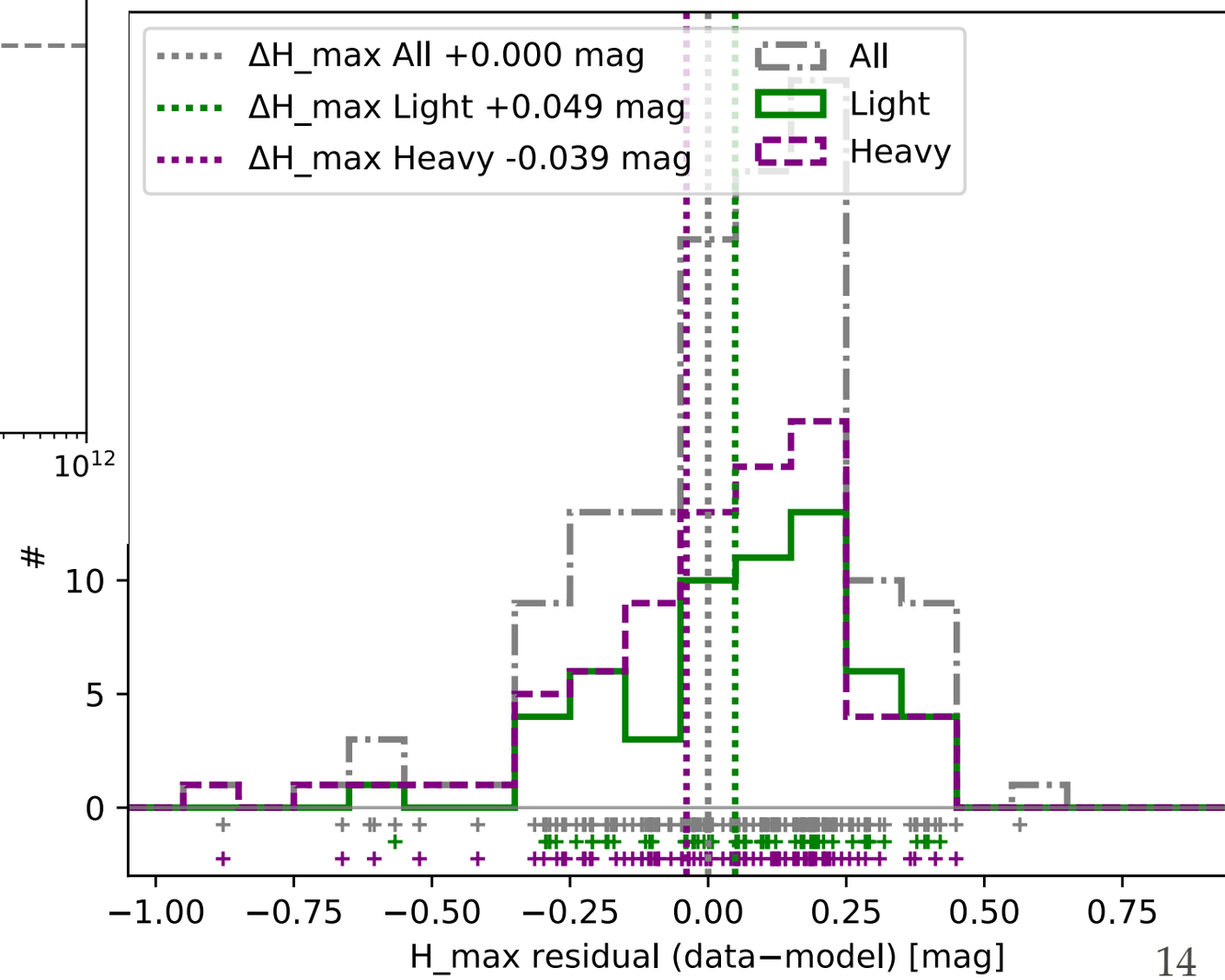
W18: 18

Ponder (2017), Ponder et al (in prep)

Host Galaxy Mass v NIR residual

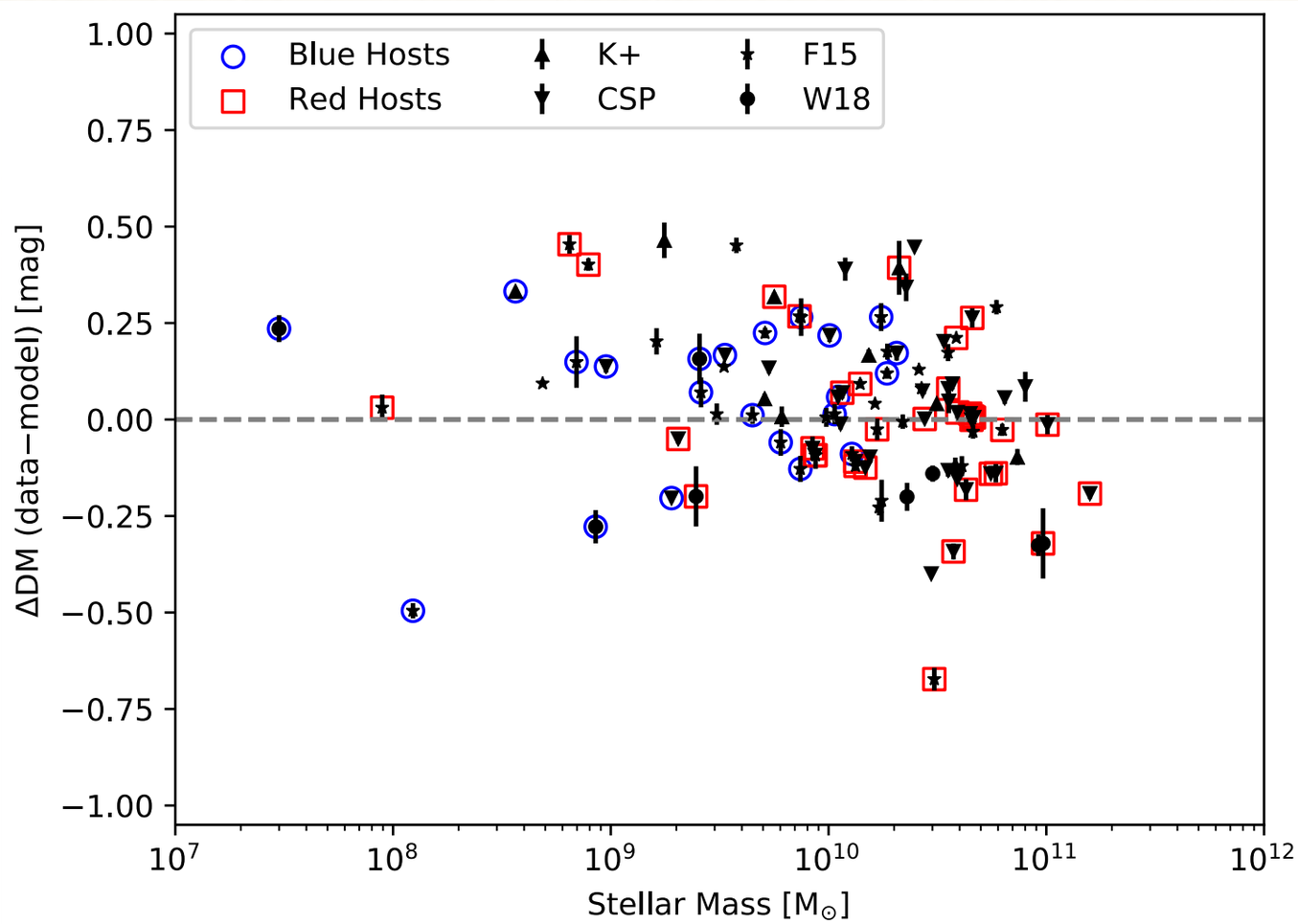


N= 136

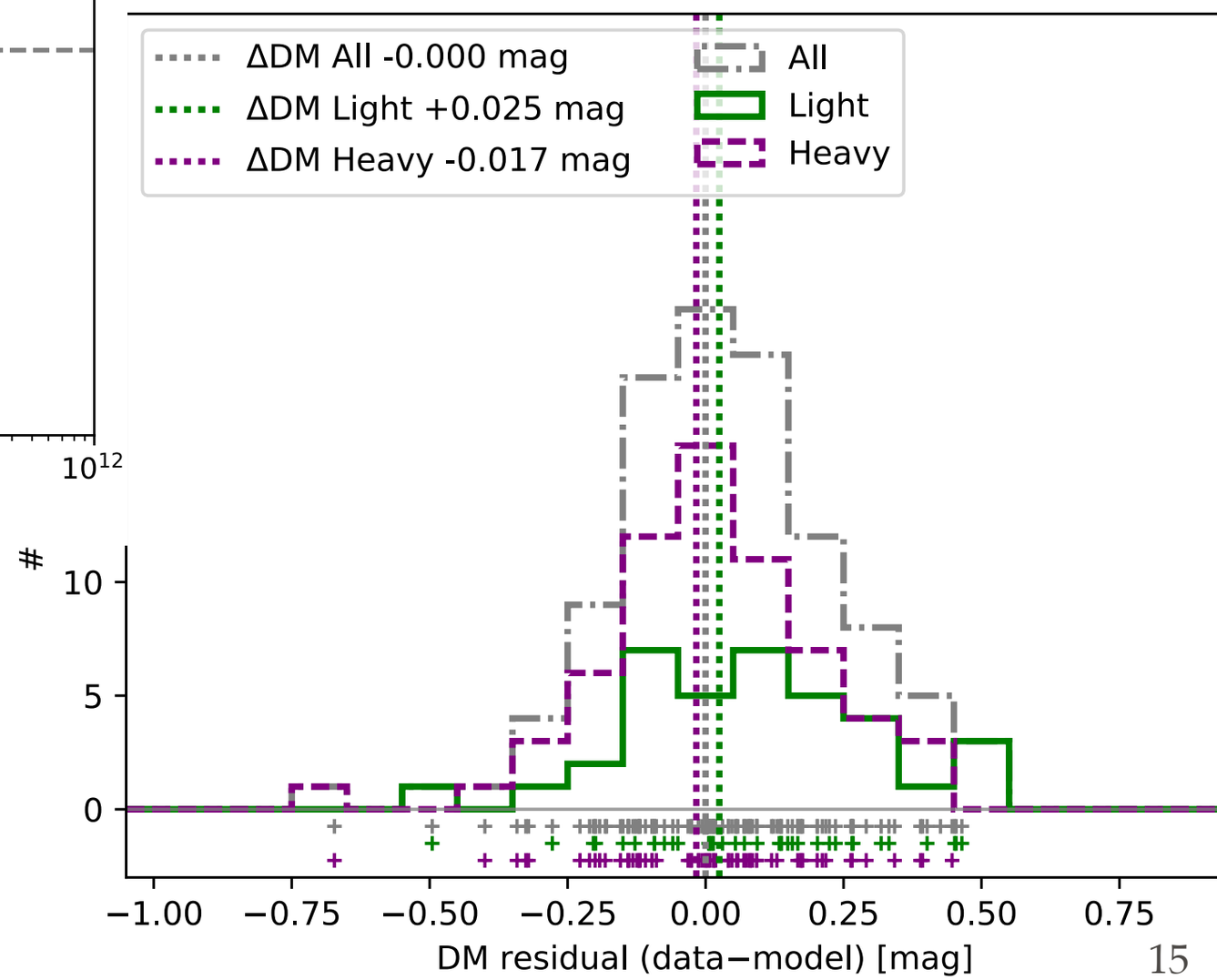


Significance of mean:
Light ~1.8σ
Heavy ~ 1.4σ

Host Galaxy Mass v Optical residual

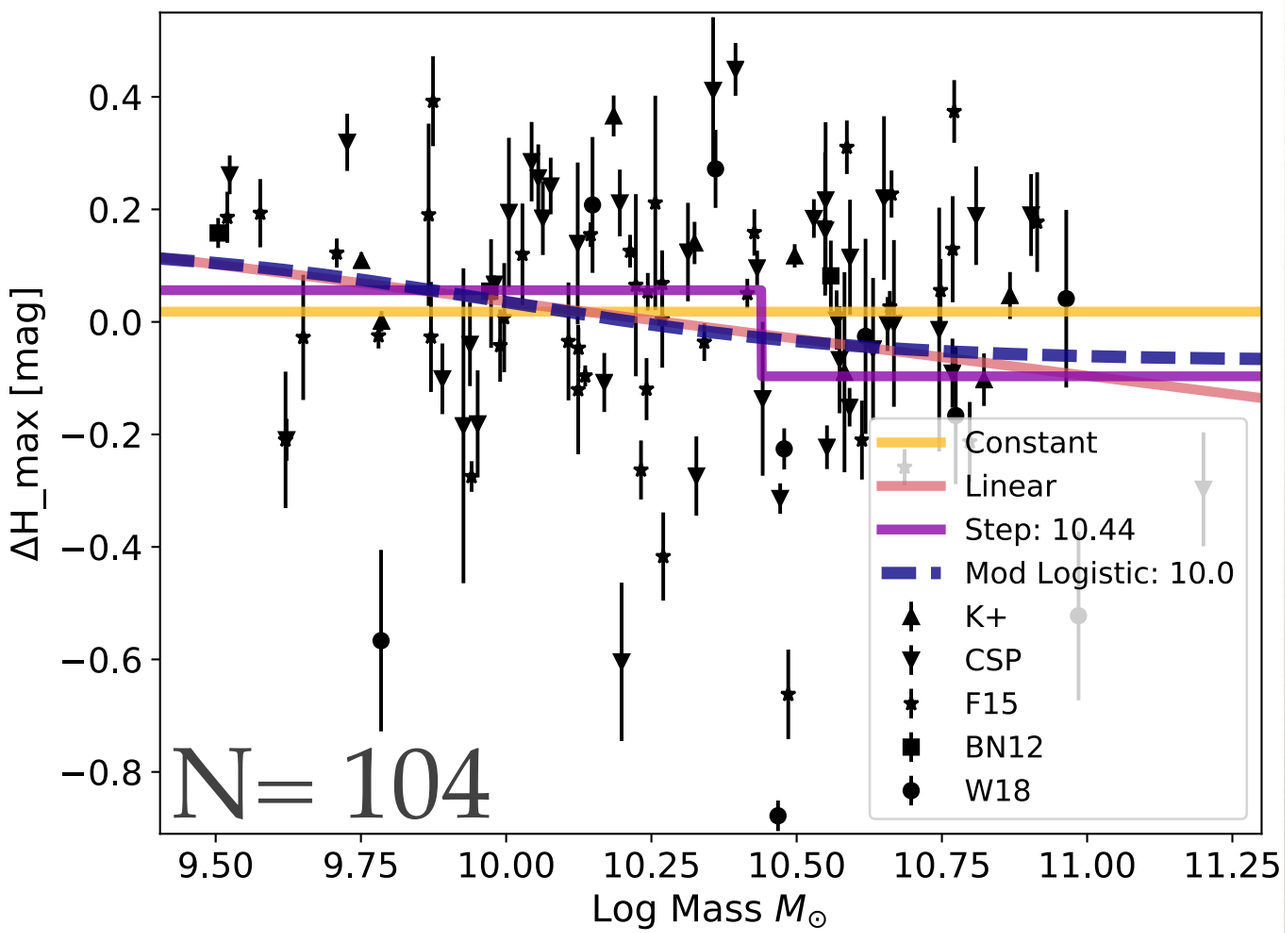


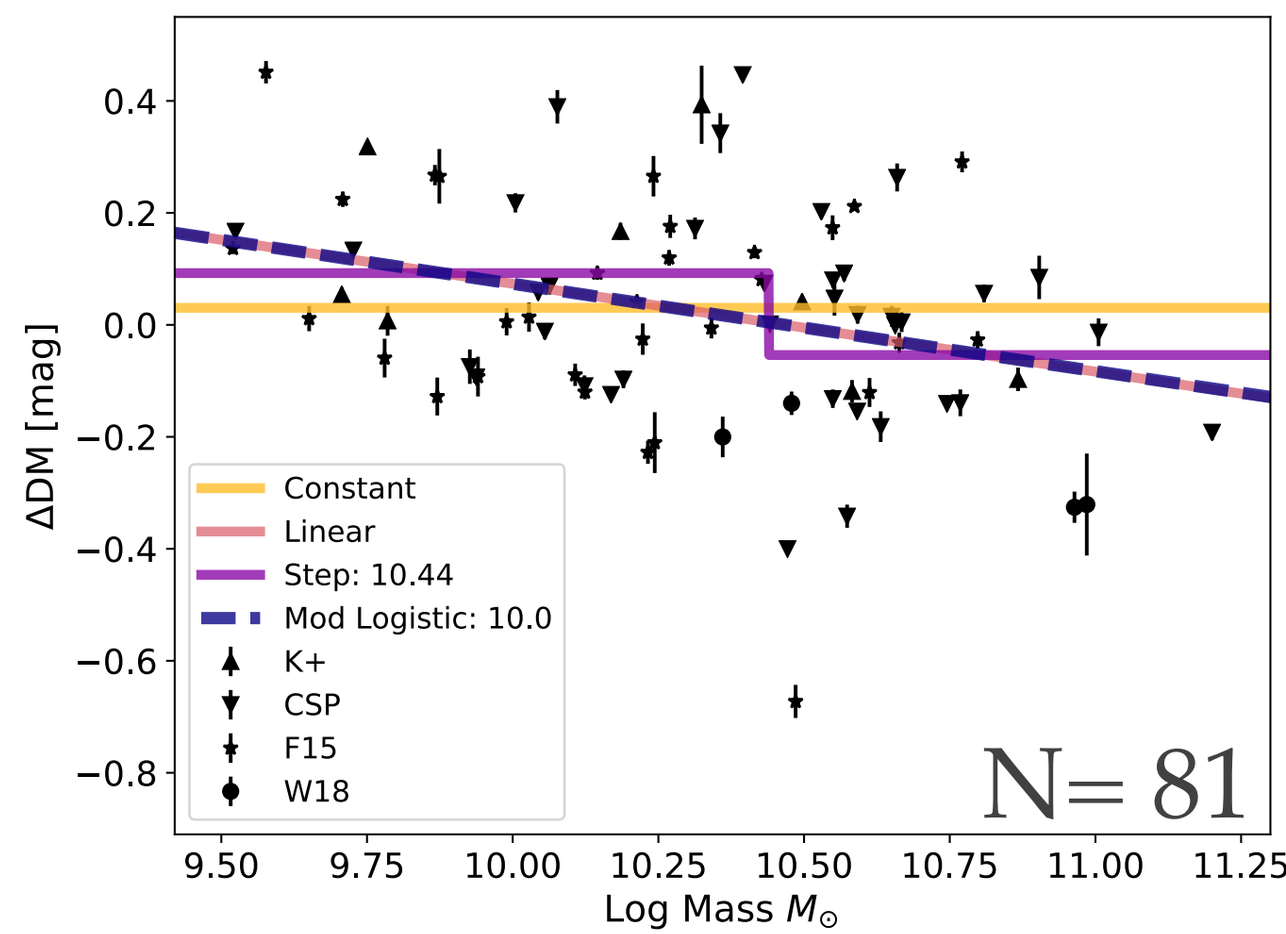
N= 100



Significance of mean:
Light ~ 0.7σ
Heavy ~ 0.7σ

Fitting Models to Residual v Mass





H-band

Step size: 0.15 ± 0.04 mag

Step @ 10 logM: 0.06 ± 0.04 mag

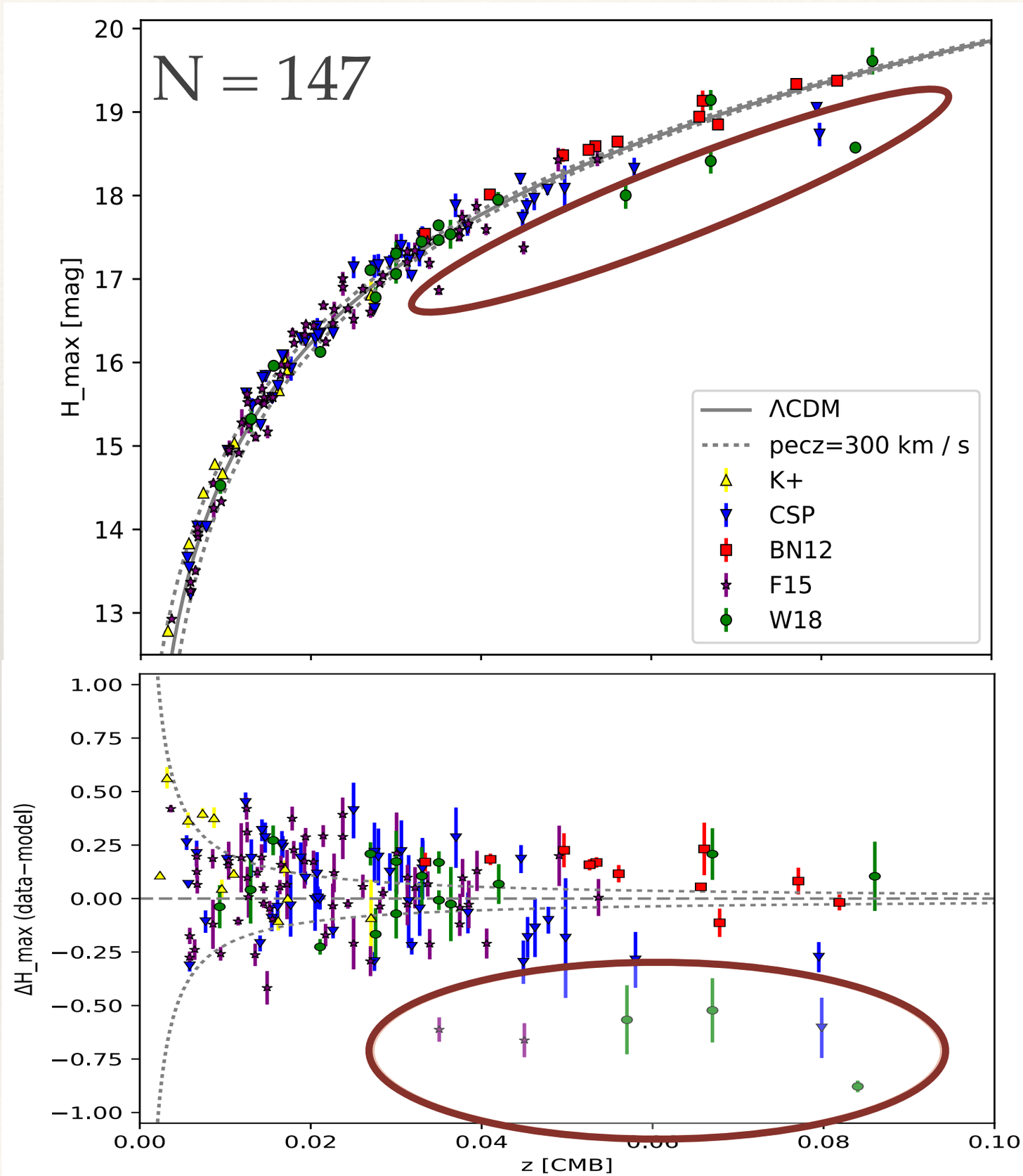
Information Criteria: Prefer/ strongly prefer constant

Optical/Distance Modulus

Step Size: 0.15 ± 0.04 mag

Step @ 10 logM: 0.13 ± 0.04 mag

Information Criteria: Strongly prefer step



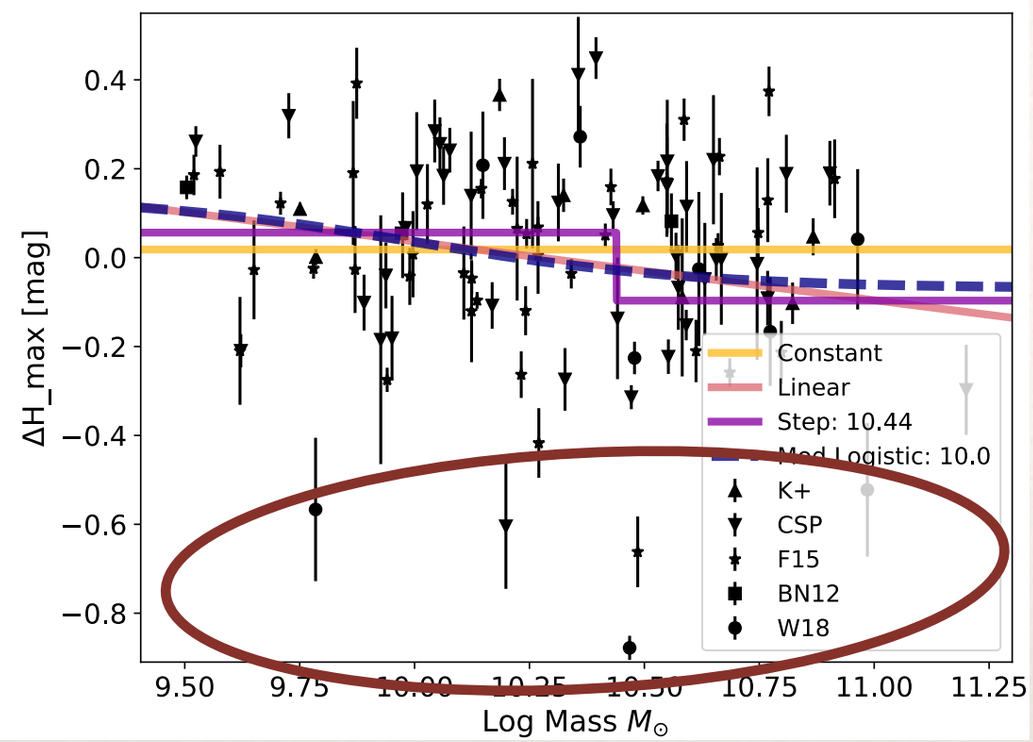
Outlier Population?

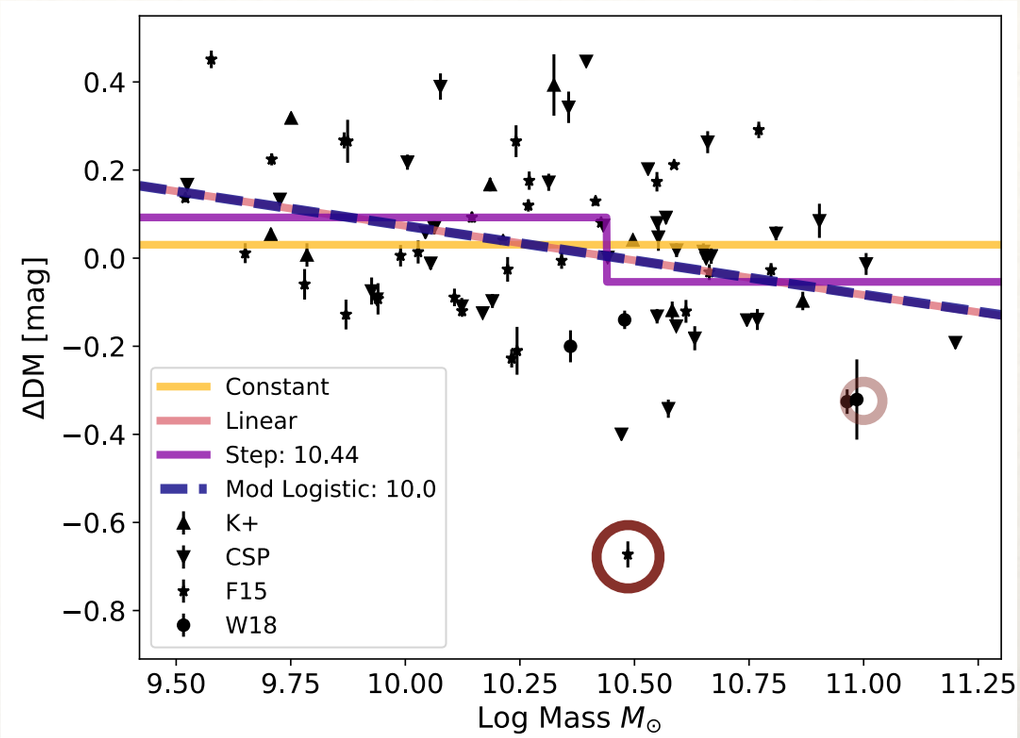
- Smooth Hubble flow
- **Massive** : >10^{10} solar masses
  - except 1 with bright star on galaxy
- **Red** : $0.6 < g\text{-}r < 0.8$
- **Bright** : > - 21 r-band mag

“Outlier” SNeIa

- LSQ13cmt - W18
- LSQ13cwp -W18 — compare to CSP, in a lens system
- PTF13ddg - W18
- 2005eu - F15/CfA
- 2009lf - F15/CfA
- ~~2007hx - CSP~~ Confirmed poor data

Fitting Models to Residual v Mass





H-band

Step Size: 0.15 ± 0.04 mag

Step @ 10 LogM: 0.06 ± 0.04 mag

Information Criteria: Prefer/strongly prefer constant

Without Outlier Pop:

Step Size: 0.08 ± 0.03 mag

Step @ 10 LogM: 0.02 ± 0.03 mag

Information Criteria: Strongly Prefer constant

Optical/Distance Modulus

Step Size: 0.15 ± 0.04 mag

Step @ 10 LogM: 0.13 ± 0.05 mag

Information Criteria: Strongly prefer step

Without Outlier Pop:

Step Size: 0.14 ± 0.04 mag

Step @ 10 LogM: 0.12 ± 0.05 mag

Information criteria: Strongly prefer step

Summary

- SweetSpot will contribute 114 SNeIa to NIR dataset.
- Full data set of photometric light curves in **2018** with final release in 2019.
- Early results show a correlation between host gal mass and NIR residual that is ~consistent with the correlation in the optical
  - At least some significance stems from outlier population
  - Information criteria suggest that a step function is not the optimal way to characterize NIR versus host gal. mass correlation
- We will examine local host galaxy correlations through local H-alpha and SFR measurements.

Want more information?

- **SweetSpot pilot: Weyant et al (2014)**
  - arXiv: https://arxiv.org/abs/1310.2259
- **SweeSpot Dr1: Weyant et al (2018)**
  - arXiv: https://arxiv.org/abs/1703.02402
- **Host galaxy correlations with NIR residuals: Ponder (2017)**
  - Chapter 4: http://d-scholarship.pitt.edu/32578/
- **HexPak data reductions: Ponder (2017)**
  - Chapter 3: http://d-scholarship.pitt.edu/32578/
- **SweetSpot webpage:** https://mwvgroup.github.io/SweetSpot/