Cosmology with ULTRASAT

3nd ULTRASAT Science Workshop, July 13 2023

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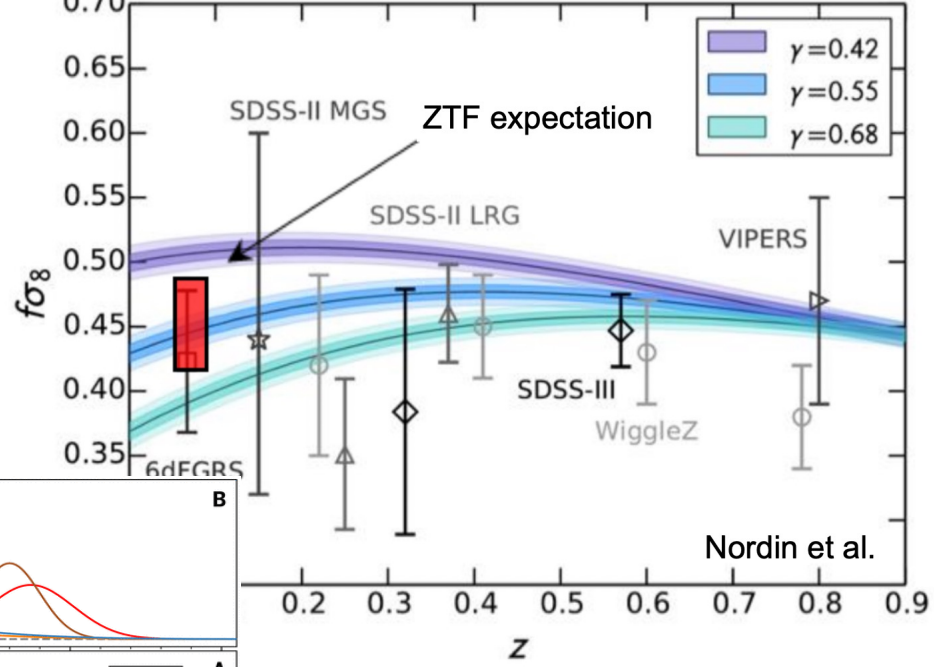
WG members: Ely Kovetz, Marek Kowalski, Sarah Libanore, Jakob Nordin, Steven Worm

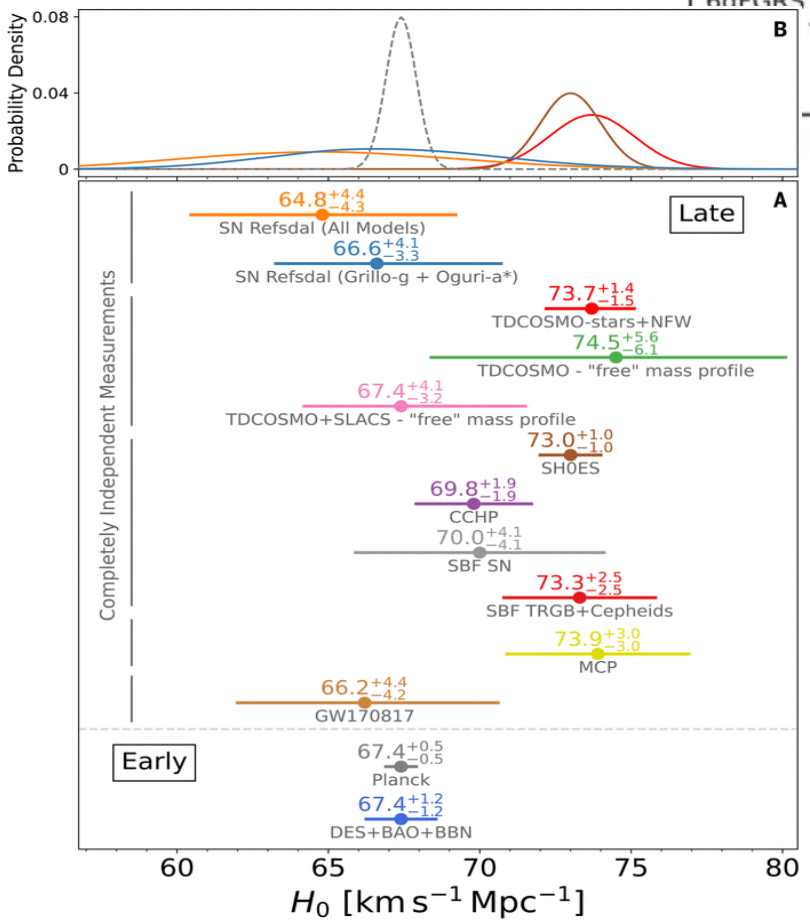
HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

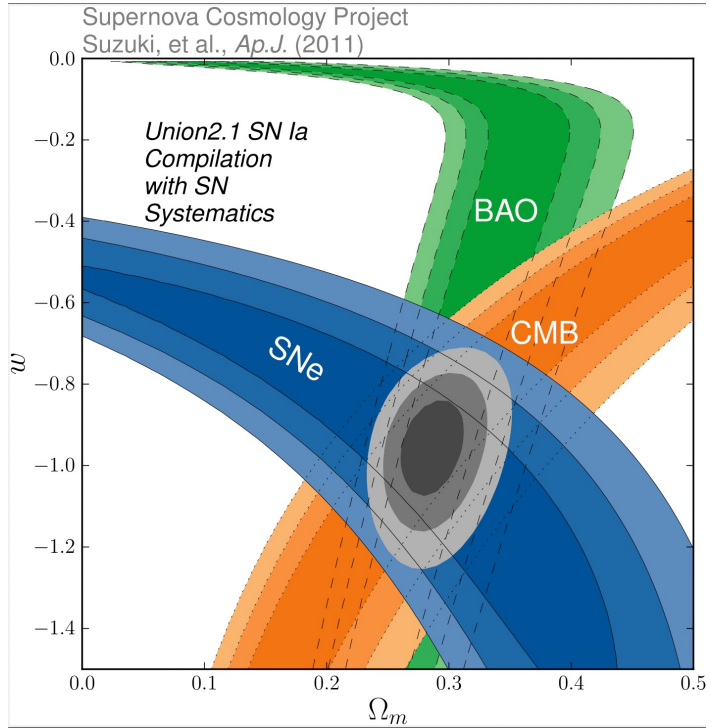
DESY.

SN Ia Cosmology

- SNe remain a key method to probe dark energy up to z~2.
- Uncertainties dominated by systematics, require to understand host, dust and progenitor dependence.
- Nearby SNeIa important, as they are well observable. Several applications for cosmology of nearby SNeIa, e.g. Hubble constant or sigma8, but also dark energy.

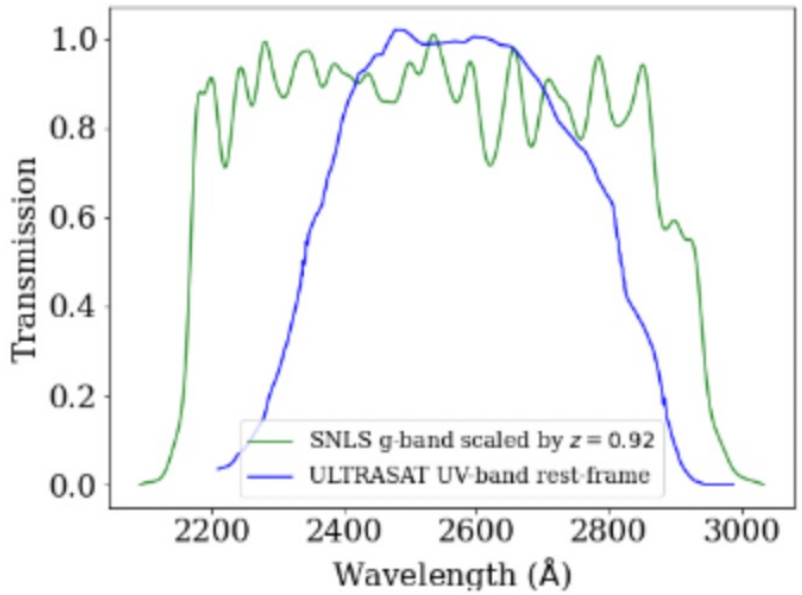


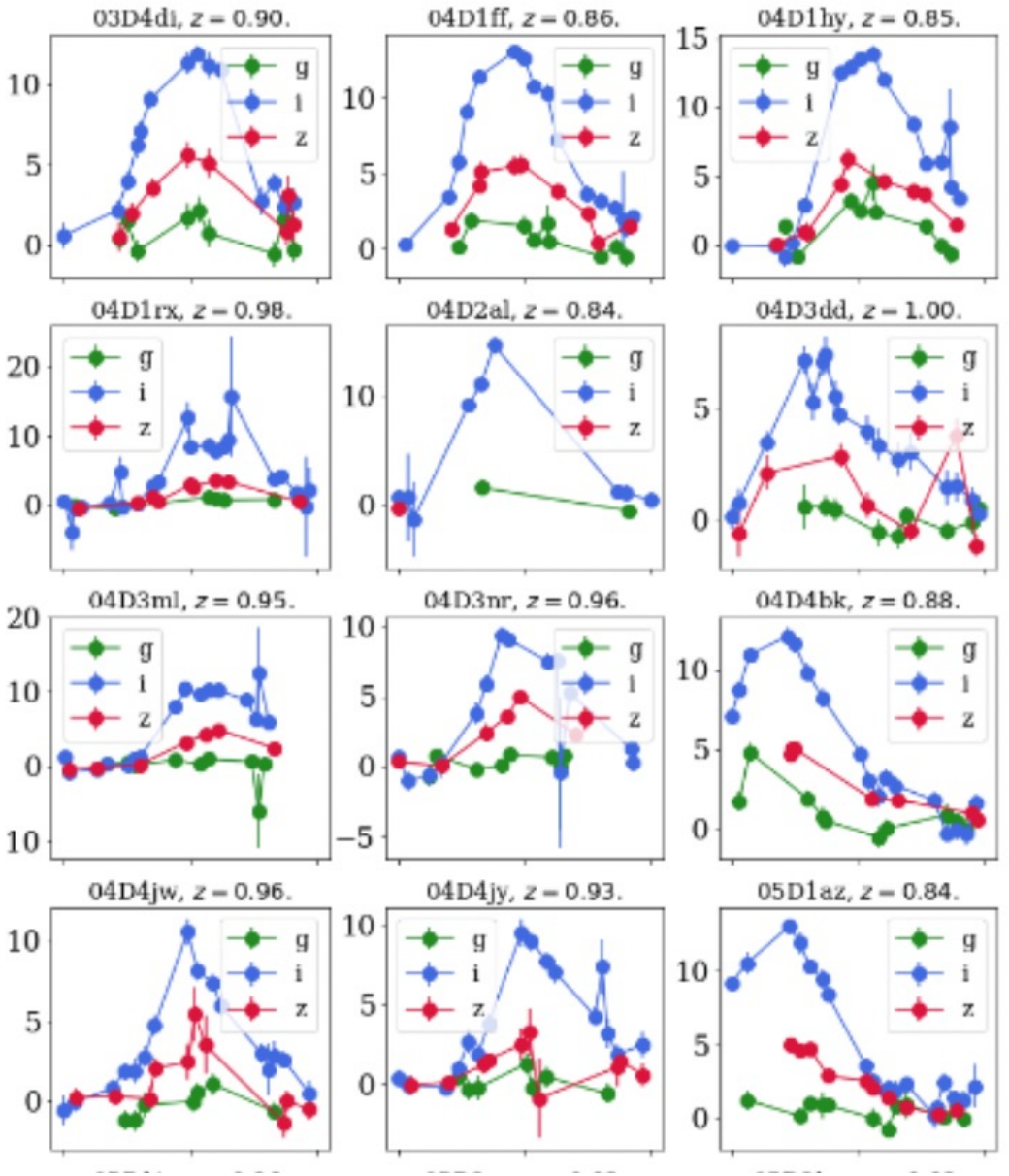




Connecting low-z to high-z

SNela show up in the UV

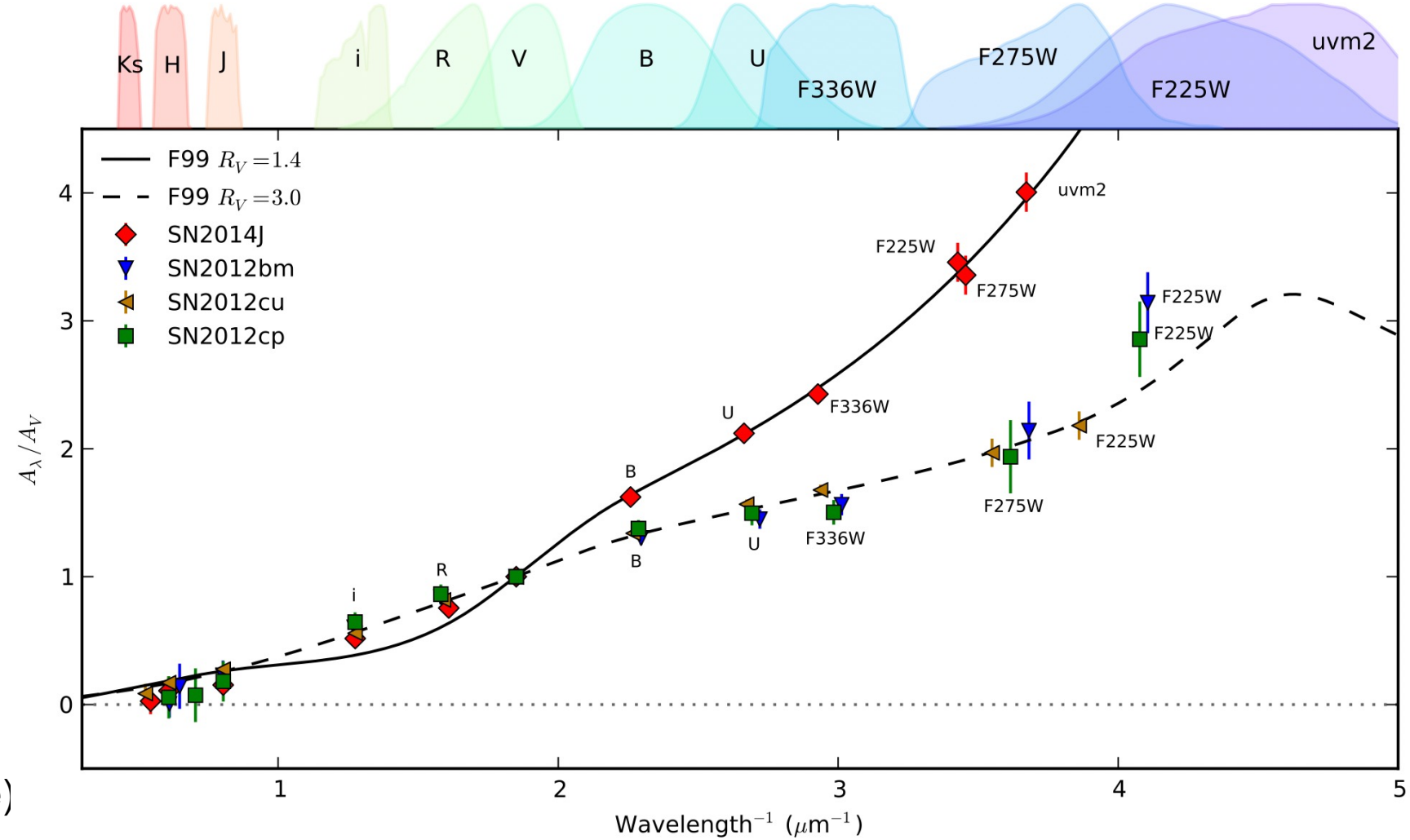




Study of SNLS high-redshift SNela: 17 of 46 (z~0.8-1) SNela have at least one detection in the UV. For a survey area of 8000 deg^2, the rate will be ≥ 300 (2400) SNela per year up to a redshift of 0.1 (0.2).
(Alice Townsend, PhD student @ HU)

SN Ia and Dust

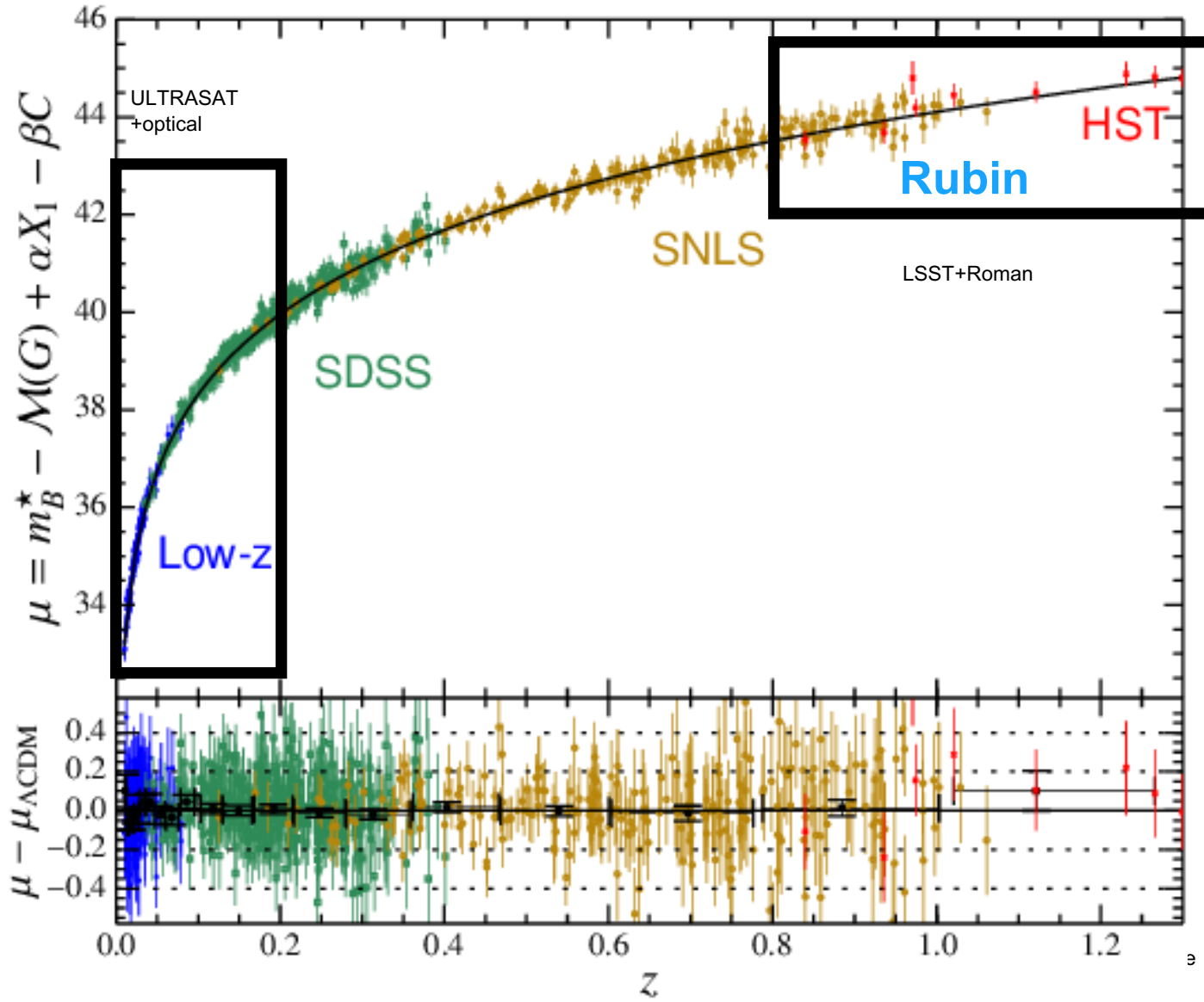
- SNeIa are standizable to 12% flux using standard techniques.
- Up to 30% improvements possible for more complete SNeIa measurements.
- Dust and progenitor system uncertainties somewhat degenerate.
- ULTRASAT can provide very valuable UV data for large number of SNe (slow cadence)

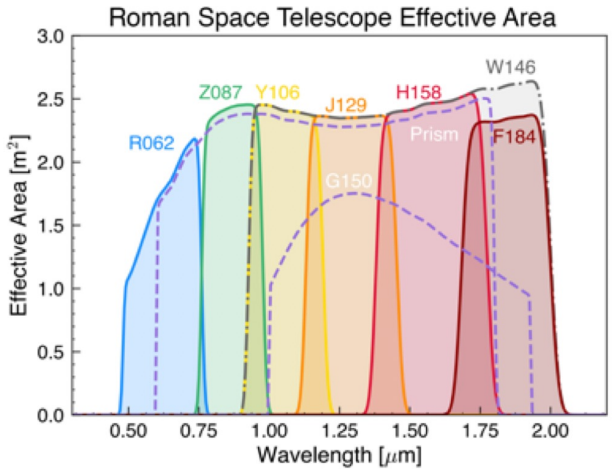


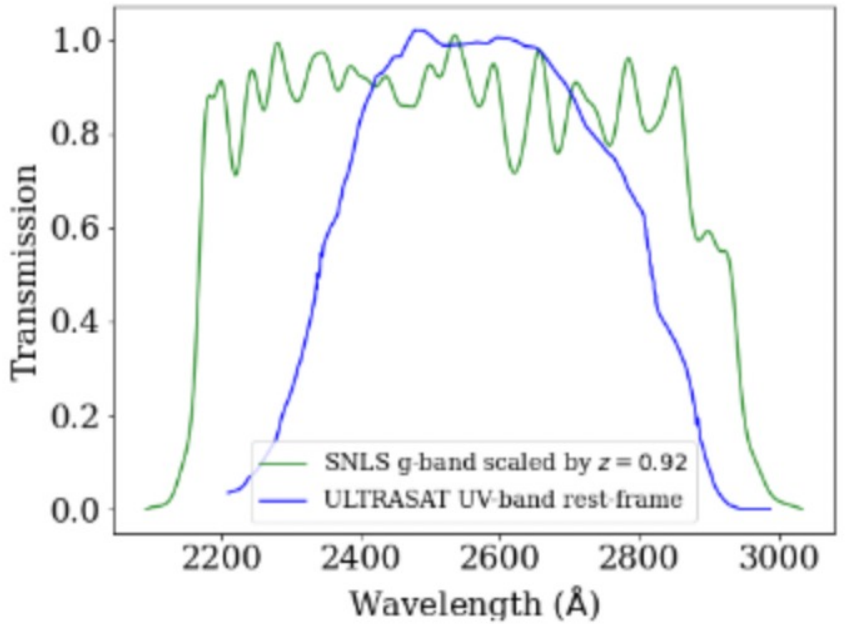
Photometric precision in the UV relaxed roughly by factor A_UV=2-3.5

Connecting low-z to high-z

ULTRASAT can empower the rest-frame UV band, available for

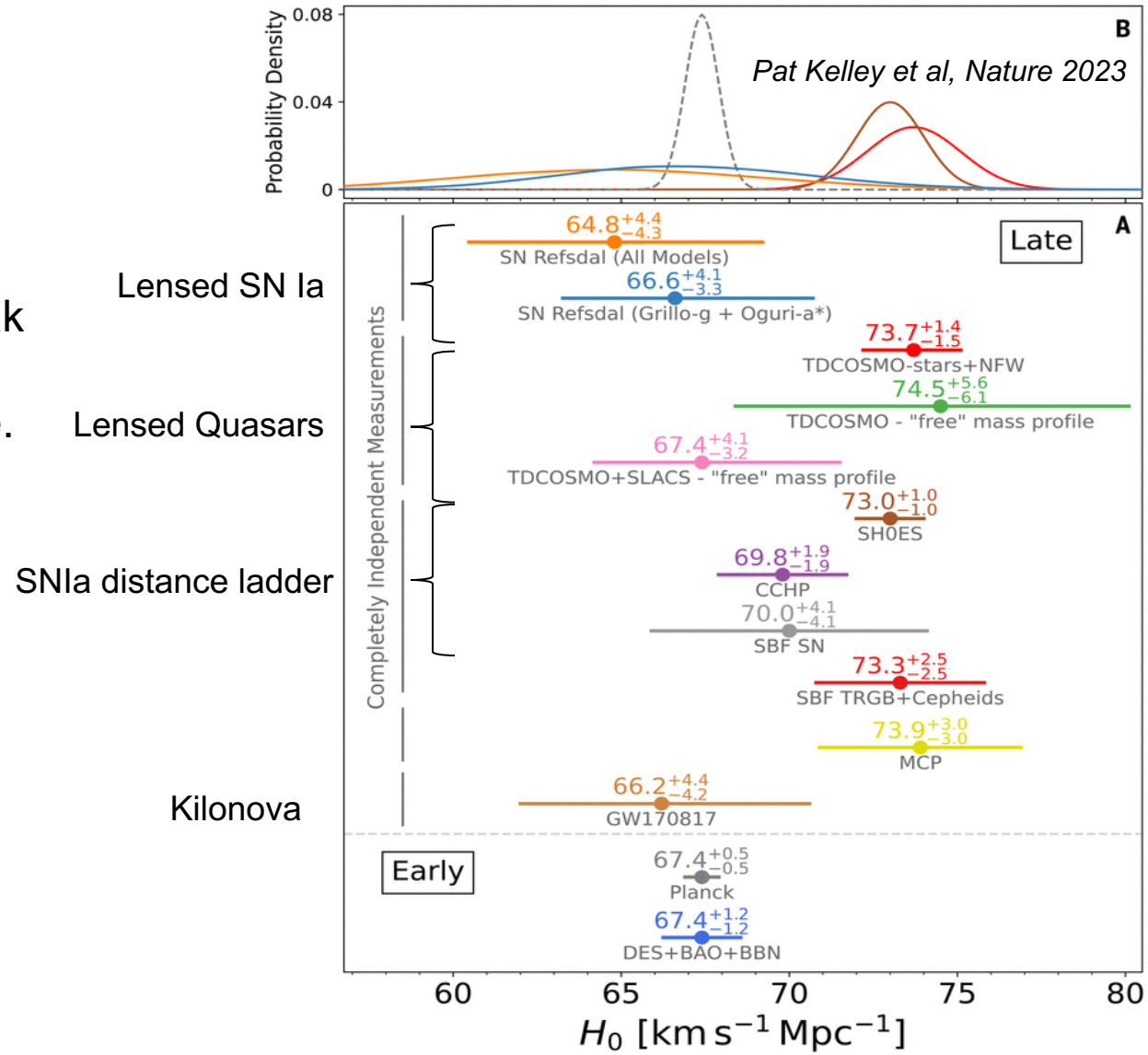






Hubble Constant from lensed SNe & Kilonovae

- Lensed SNe: different light path allows to translate time delay to Hubble constant
  - Not unique to ULTRASAT
  - But transients in the UV shorter (eg. Shock break out), hence these could lead to the best constraints. Uncertain/small rates pose an issue.
- Kilonovae with redshift and GW observations standard sirens
  - Large ULTRASAT sample
  - UV could break degeneracy between angle and distance, and hence improve the measurement.
  - More work required!



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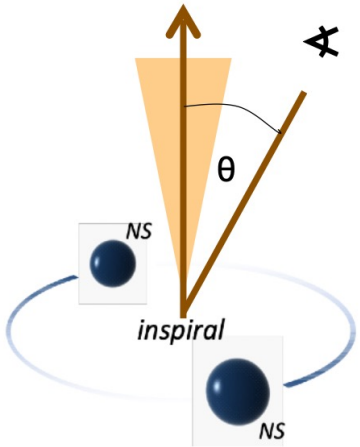

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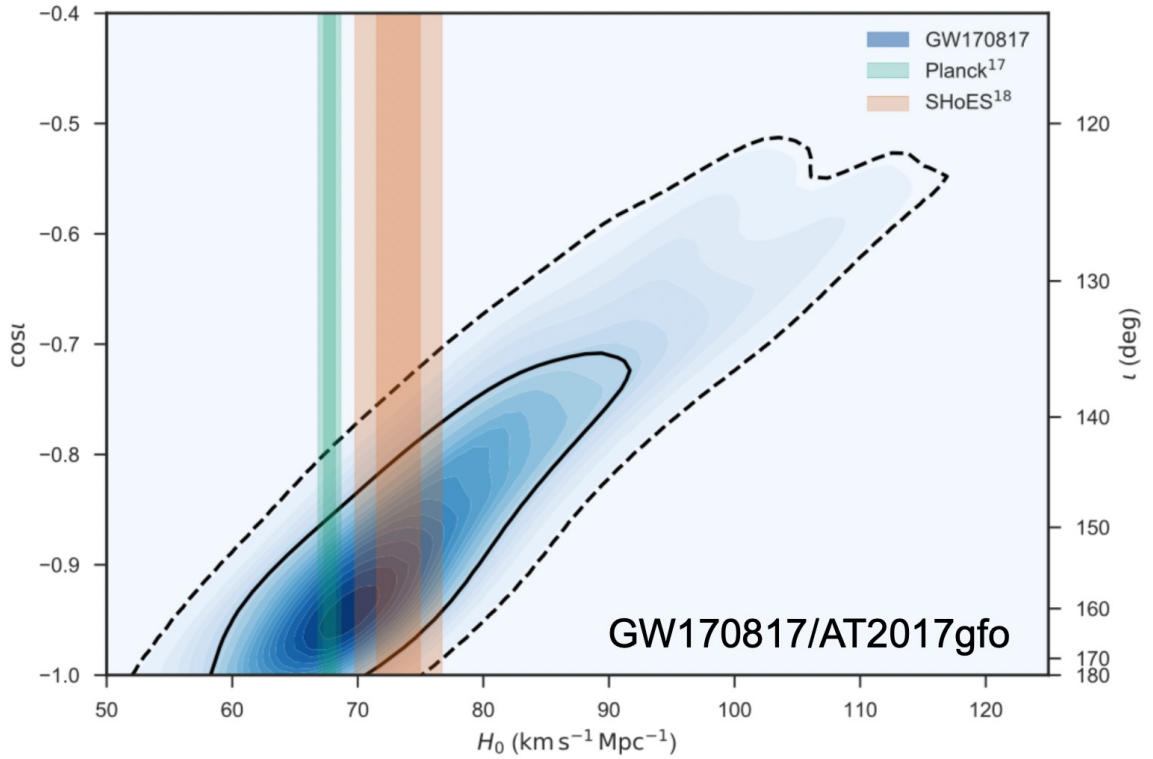


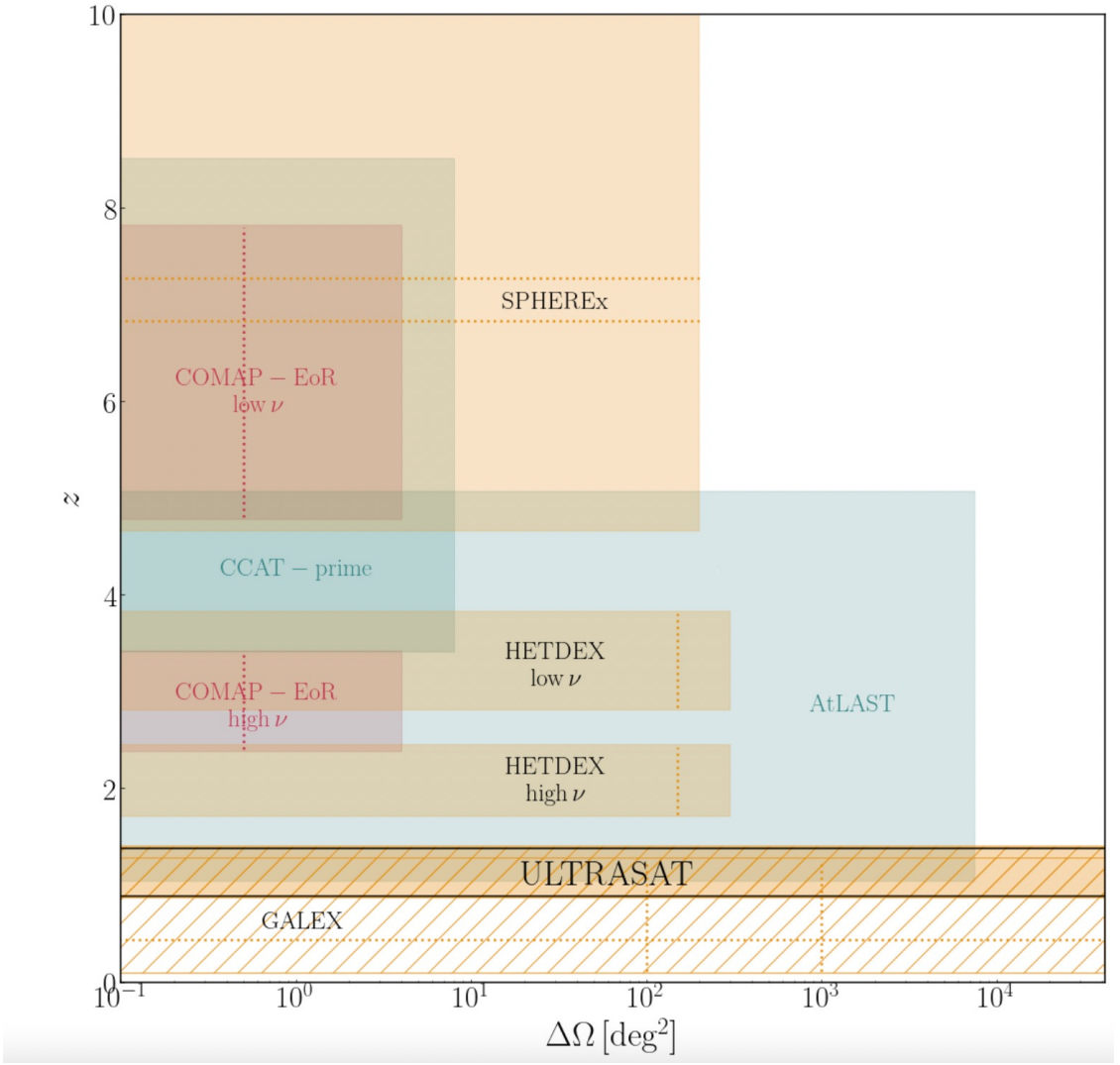
Nature 551 (2017) no.7678, 85-88

Cosmology with Lyman-Alpha intensity maps

Structure formation

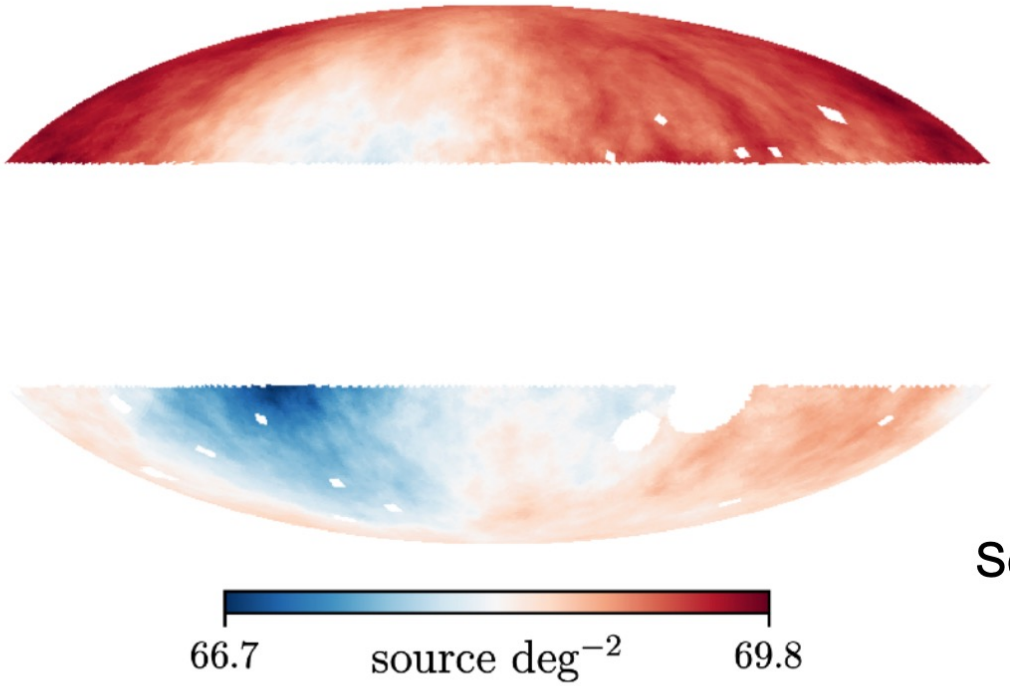
Idea by Ely Kovetz & Sarah Libanore: Lyalpha @ 0.8 <z<1.3 falls into ULTRASAT band

See next talk!

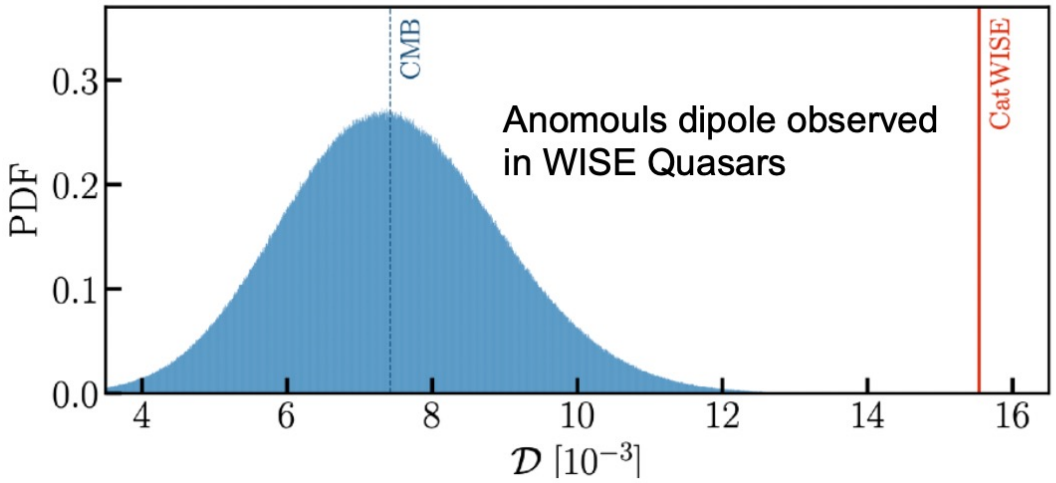


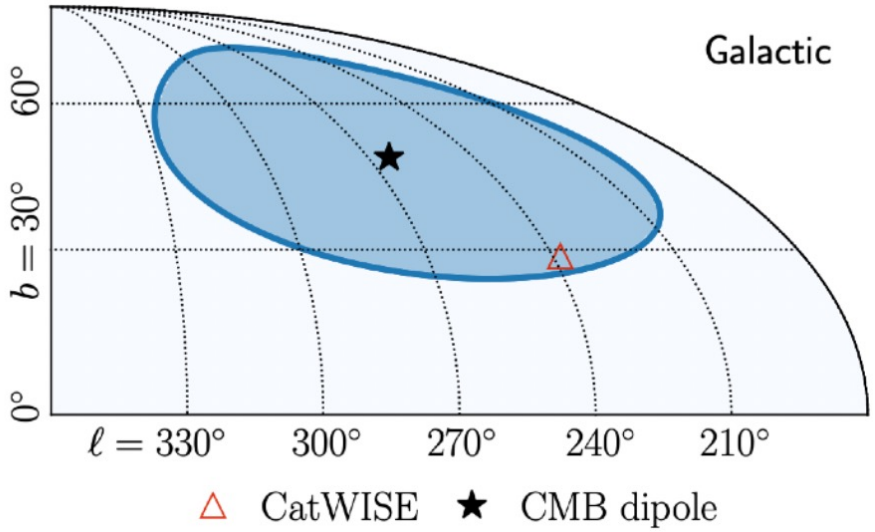
Cosmology with Galaxies

ULTRASAT will produce a UV data point for a large number of galaxies, which should be useful for improving photo-z and characterizing dust, EBL, etc. Even number counts could be interesting, see WISE Quasar study (Secrest et al., 2021).



Smoothed Quasar number counts



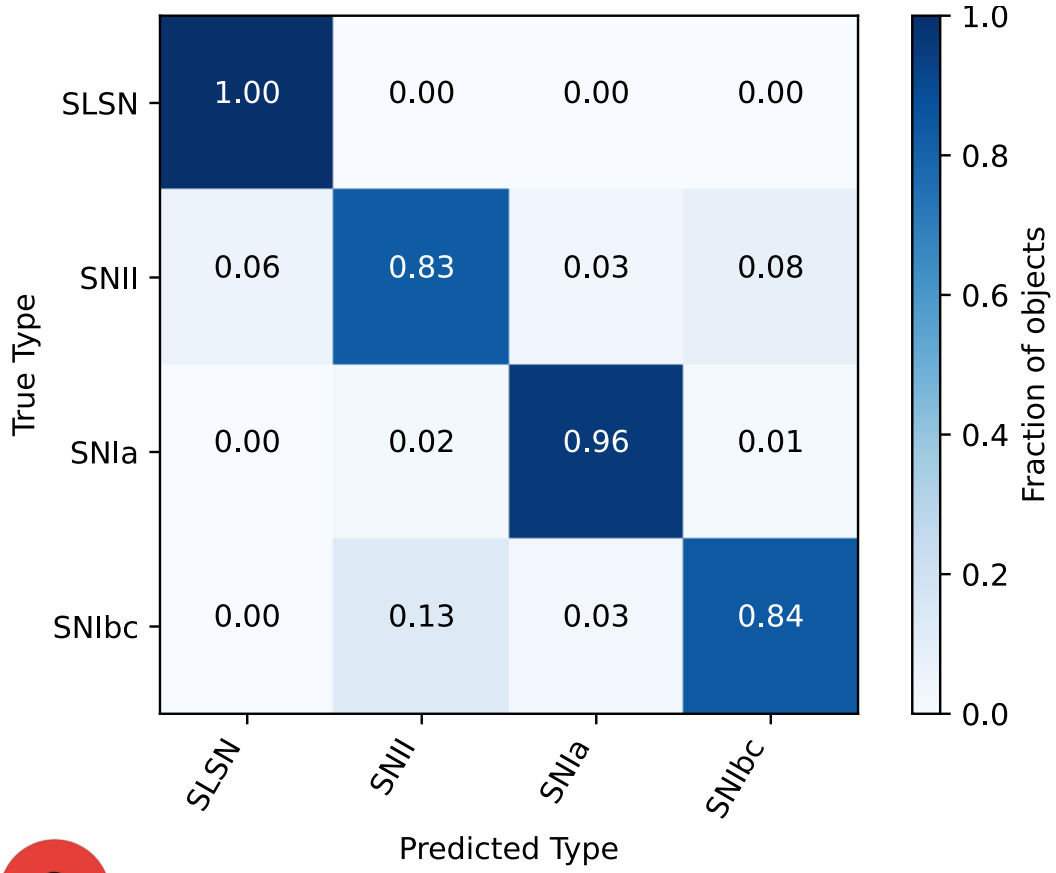


Secrest et al., 2021

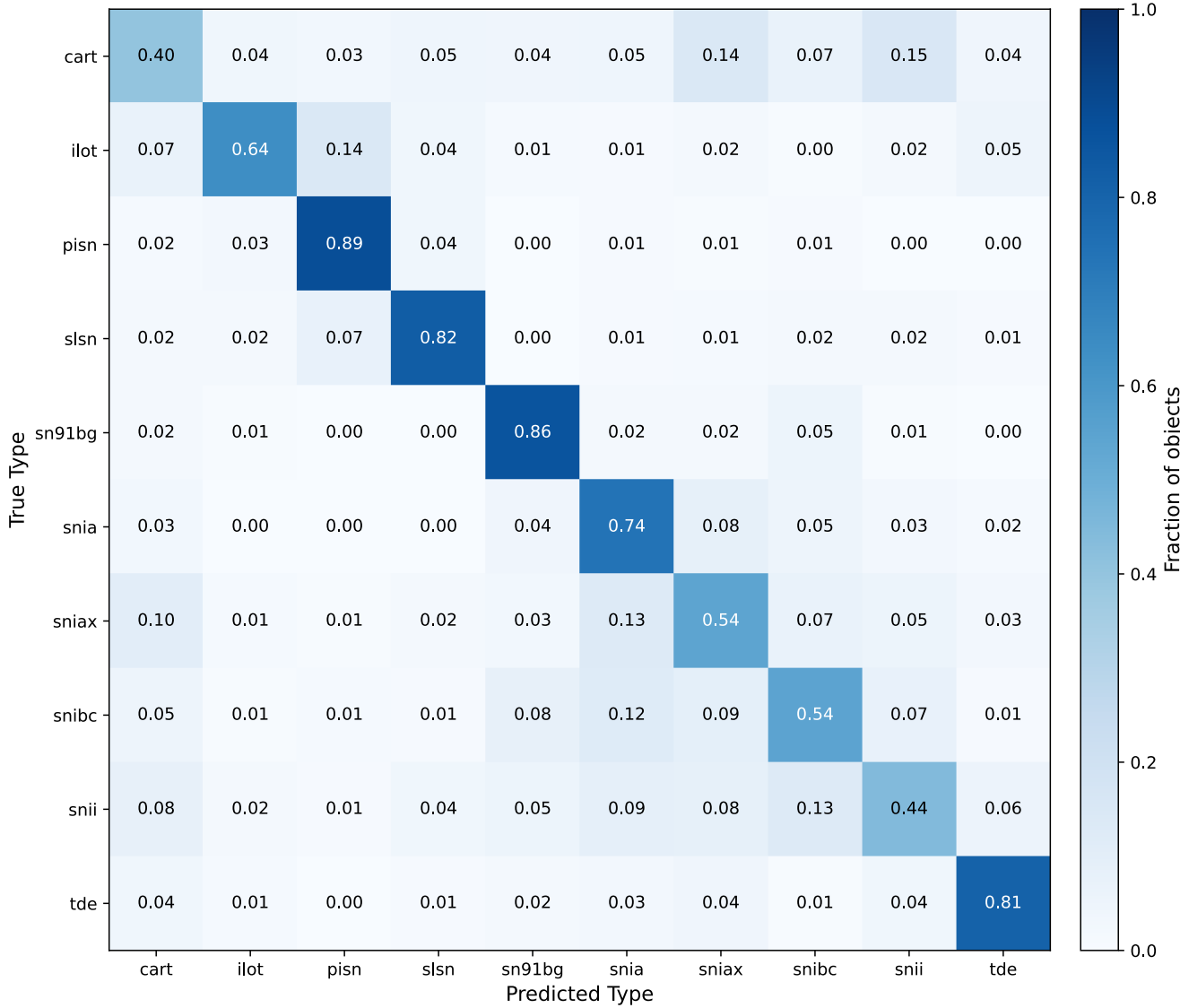
Requirement: Flux calibration < 1% across the sky

Preparation Activities: analyzing ZTF and simulated LSST data

- ZTF photometric classification (Alice Townsend et al, PhD @ HU)



- LSST Elastic classification challenge (Jakob Nordin et al, HU)



AMPEL broker & analysis realtime framework
@ DESY supporting ZTF, LSST, ULTRASAT,…

Some requirements

- gri - photometry over 8000 sq deg with 3-4 day cadence or for about 2000 SNeIa per year up to a redshift ~0.,15 (mag~21)
- We'd also need redshifts of 1000-2000 hosts (z<0.2) (work with DESI and 4MOST?)
- Galaxy catalogs, including photo-zs, to help transient searches.

Conclusions

- Cosmology is not primary goal of ULTRASAT...
- ... but extra UV data will be very useful for a large number of cosmological studies
- Requires coordination with other Ultrasat WGs and surveys, e.g. LSST
- Future work: optimize survey and determine requirements for a most useful data set
- **Let me know if you have ideas and want to join the effort!**