Supernovae: from current surveys to the future with Rubin

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An Extraordinary Journey Into The Transient Sky

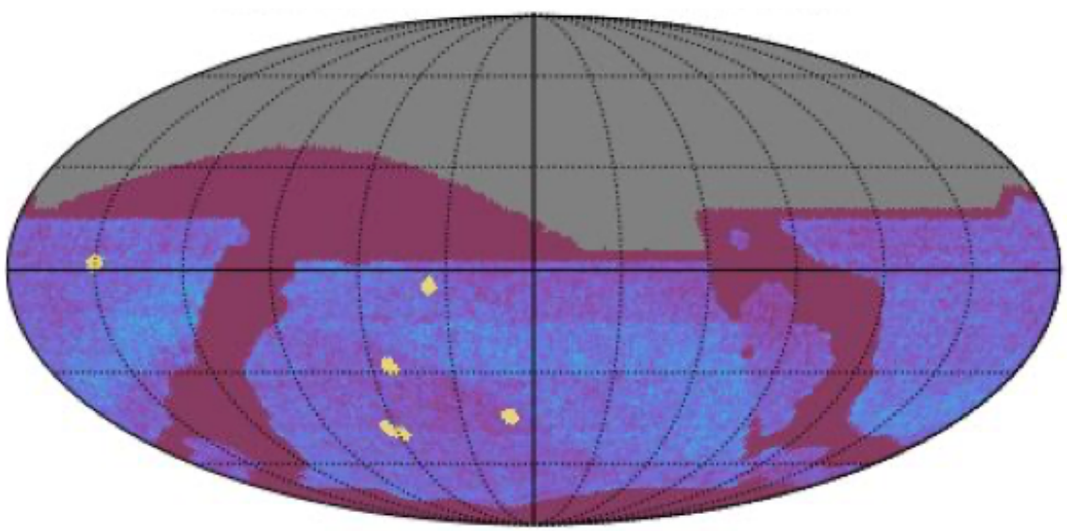
Australian Government

Australian Research Council

SWINBURNE UNIVERSITY OF TECHNOLOGY

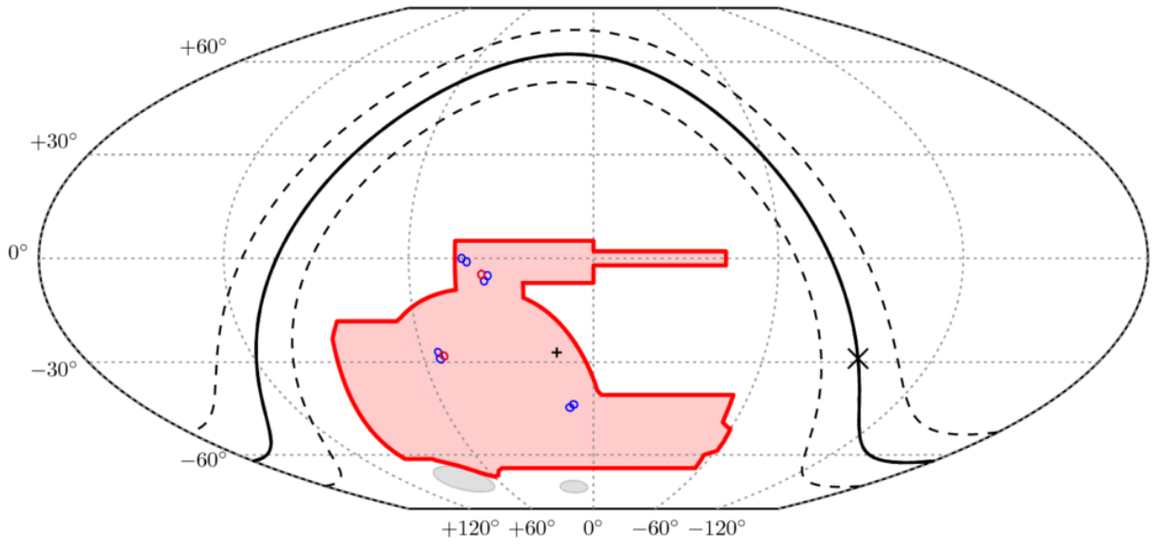
LSST

- 10 years
- WFD + 5 Deep drilling fields
- $m_r \approx 24.7$ mag



Supernova survey

- 5 years
- 10 Deep drilling fields
  - $m \approx 23.5$-24.5 mag



LSST

>1 million SN Ia

Supernova survey

>2.000 high-quality SN Ia

LSST

>1 million SN Ia

billions of detected objects

30.000 live transients (TiDES)

Frohmaier et al. 2025 (previous talk!)

Supernova survey

>2.000 high-quality SN Ia

30.000 SN candidates

425 spectroscopically SN Ia

Smith, D'Andrea, Sullivan, AM et al. 2018

LSST

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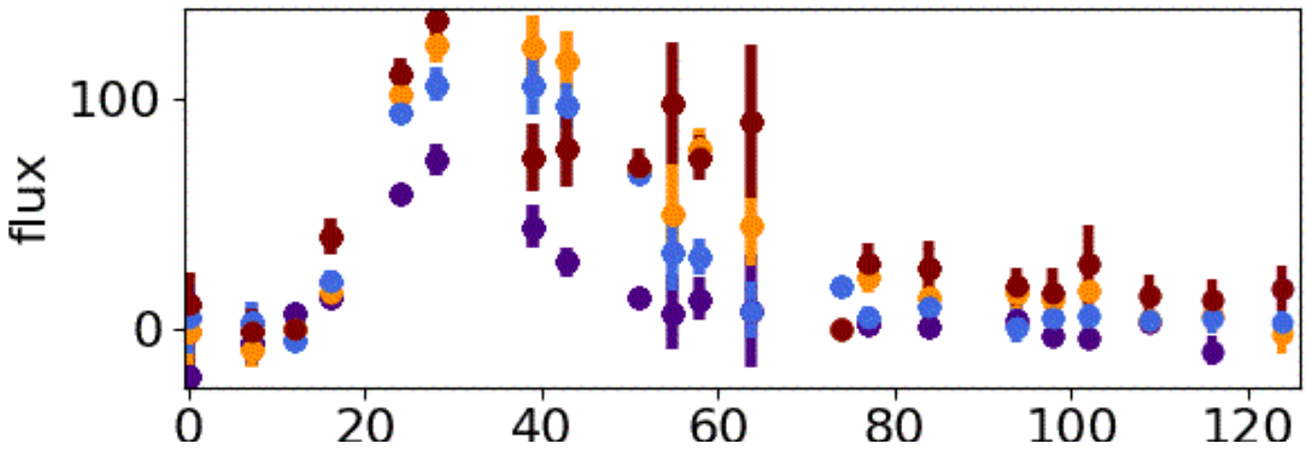
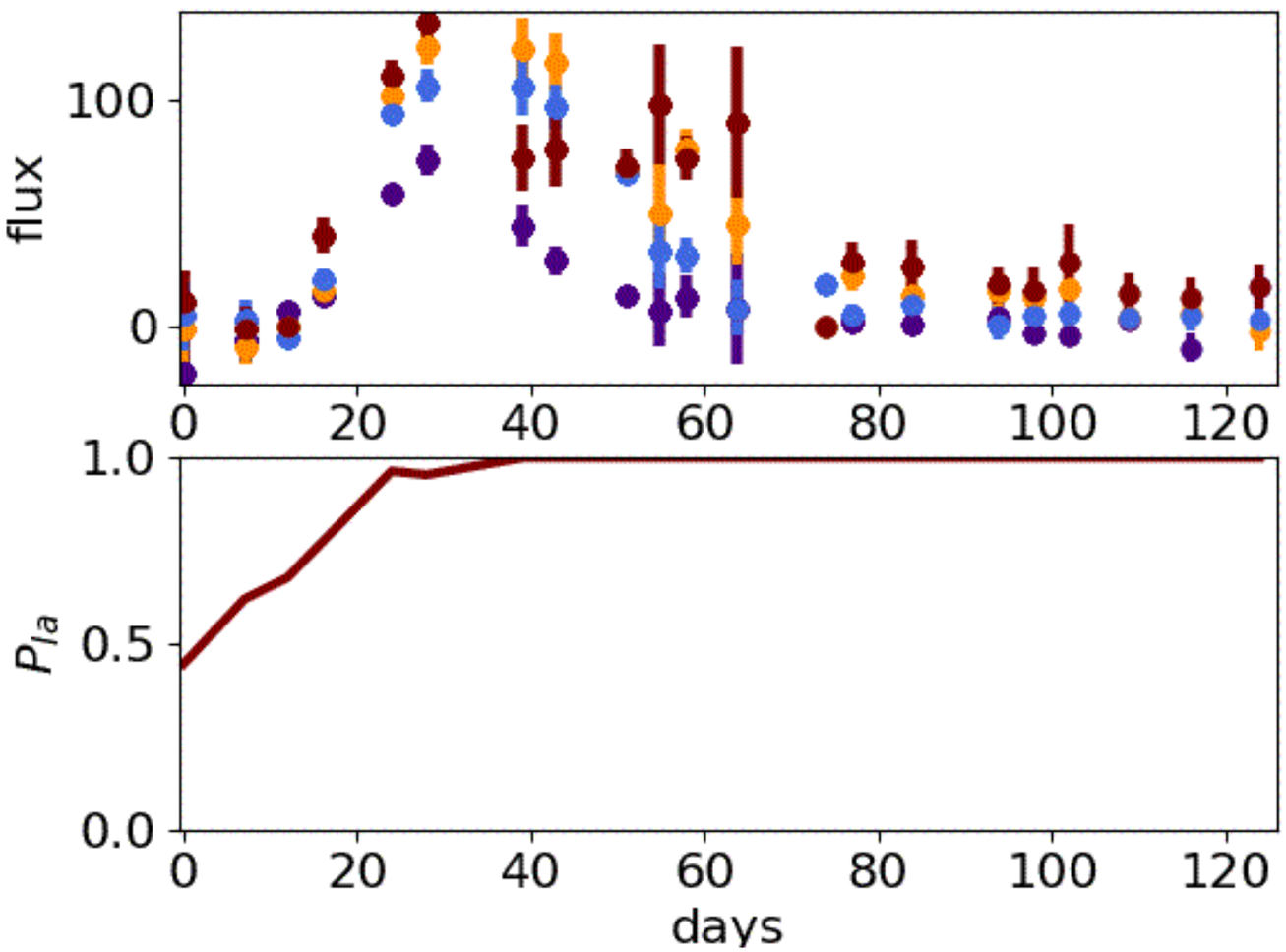
How can we maximise SN Ia science?

Photometric classification



Photometric classification



SuperNNova

Möller+ 2020, 2022b

Deep Learning photometric classification

Recurrent and Bayesian Neural Networks

Trained with large simulations

Normal Ia, Peculiar Ia and CC SNe

DES 5-year SNIa

Light-curves

+

Host-galaxy redshifts

+

SuperNNova

Accuracy >98%

Vincenzi, Sullivan, Möller et al. 2022

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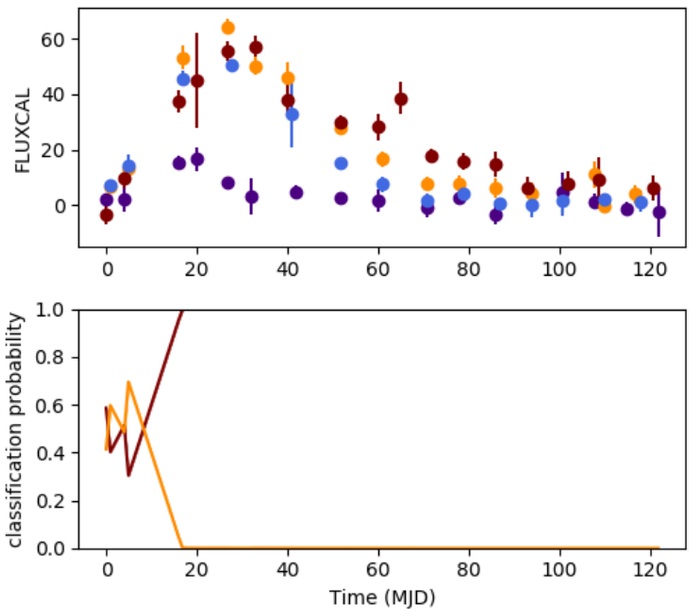
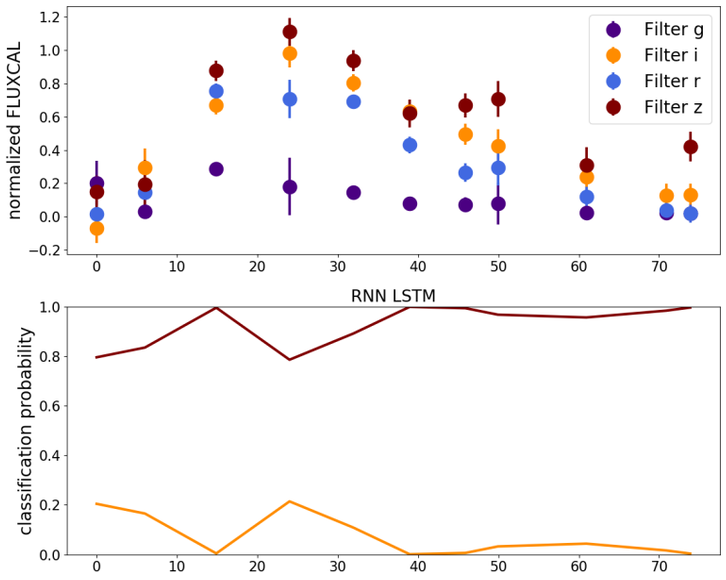
SuperNNova

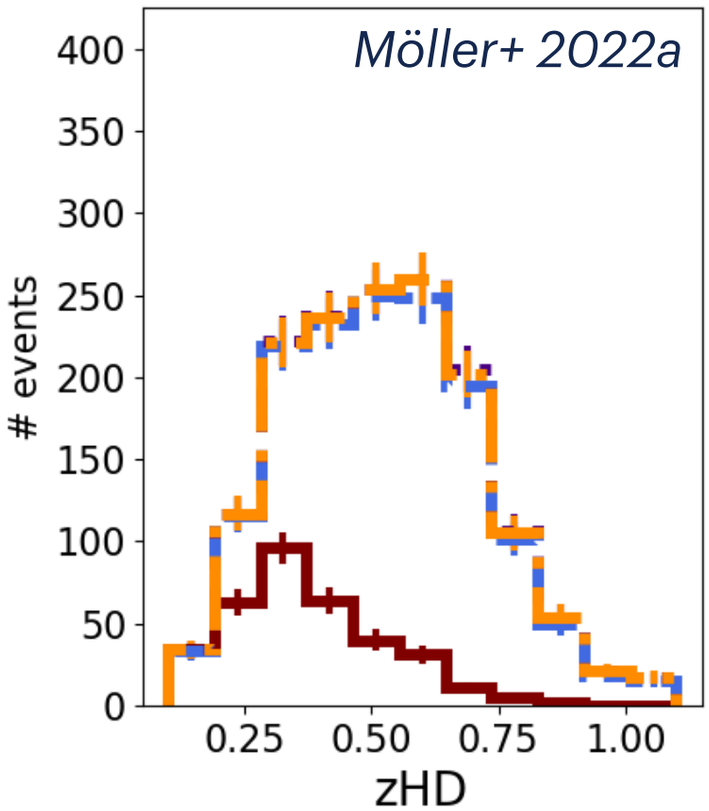




1484 SNe Ia

Möller+2022a

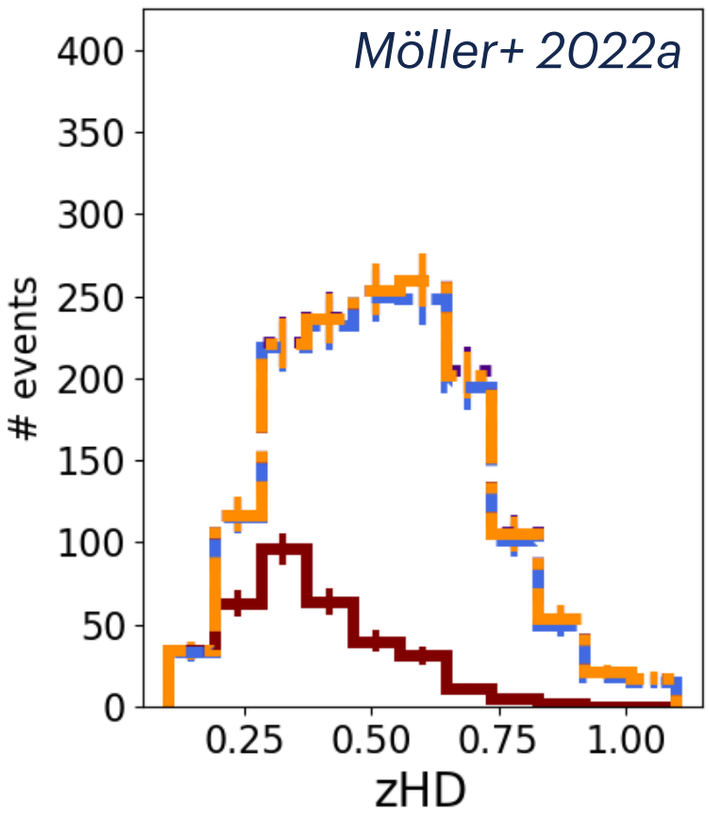
DES 5-year SNIa



Spectroscopic SNe Ia

Photometric SNe Ia

DES 5-year SNIa



Spectroscopic SNe Ia

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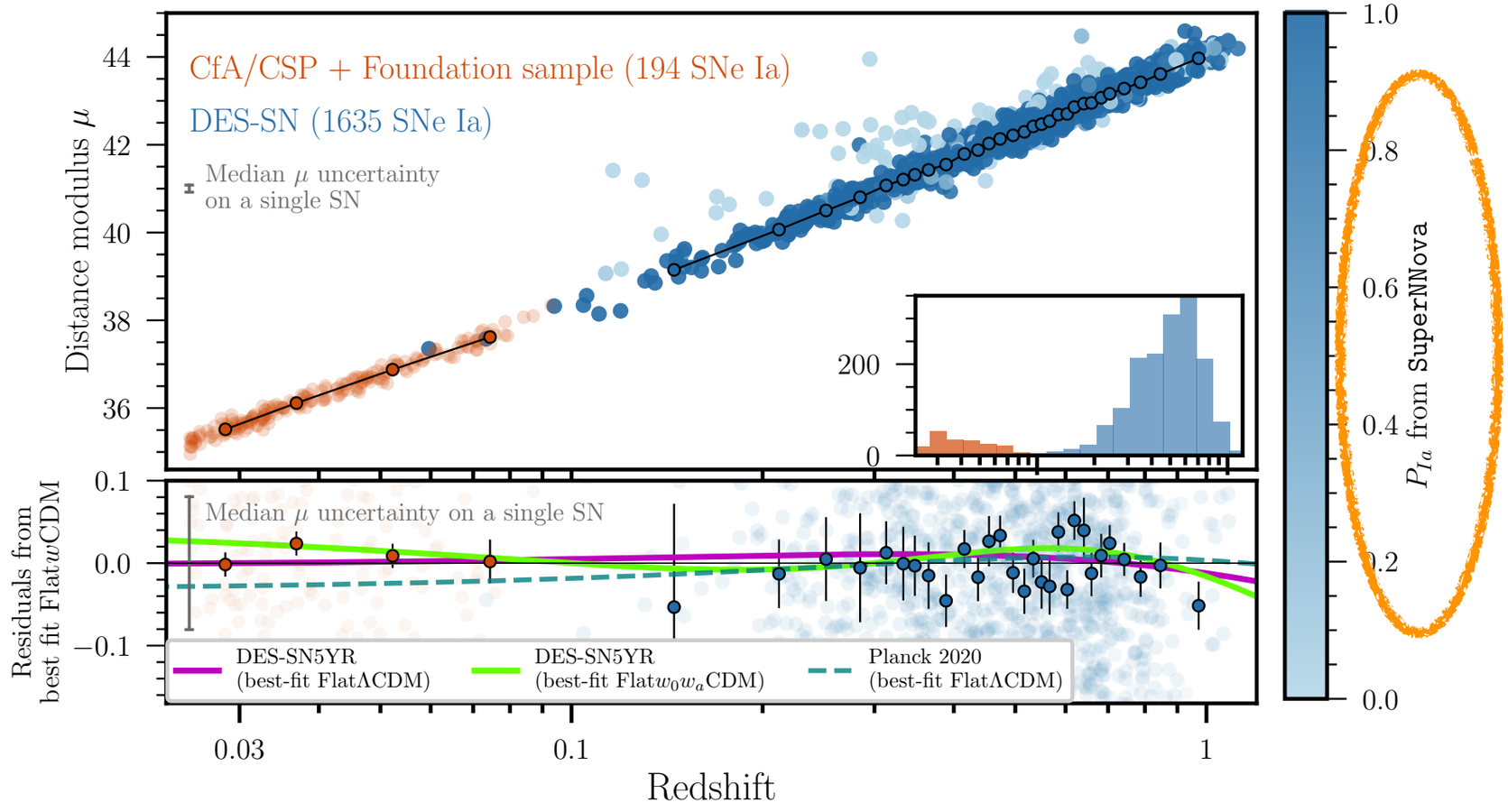

DES Collaboration 2024

Largest high-z SN Ia sample from a single survey for cosmology

Towards a complete SNIa sample

Light-curves

+

~~Host-galaxy redshifts~~

+

SuperNNova

Accuracy >97%

Möller+2024

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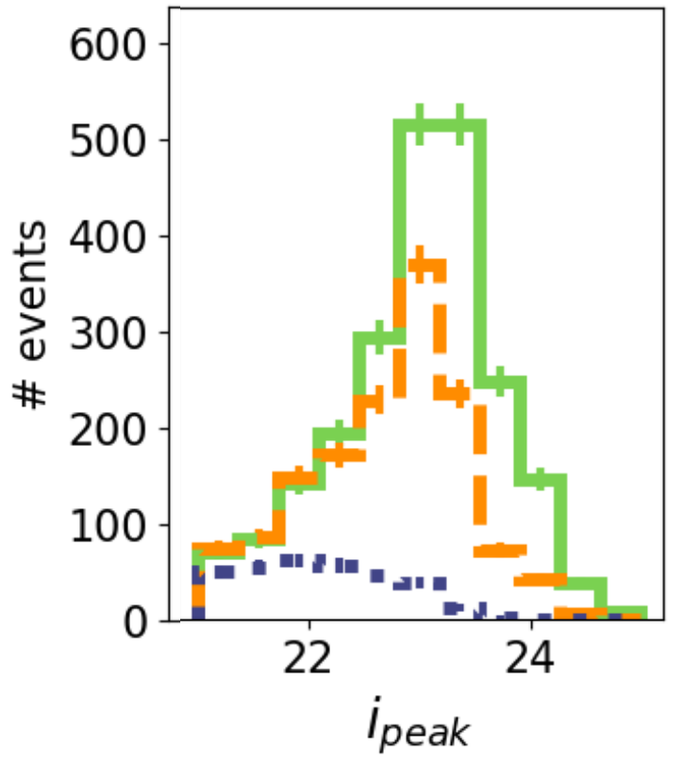


Photo class SNphoto z
(almost complete sample!)

Photo Ia host specz
(DES cosmology)

Spec Ia

2298 SNe Ia

(Expected well sampled ~2360) *Möller+2024*

Towards a complete SNIa sample

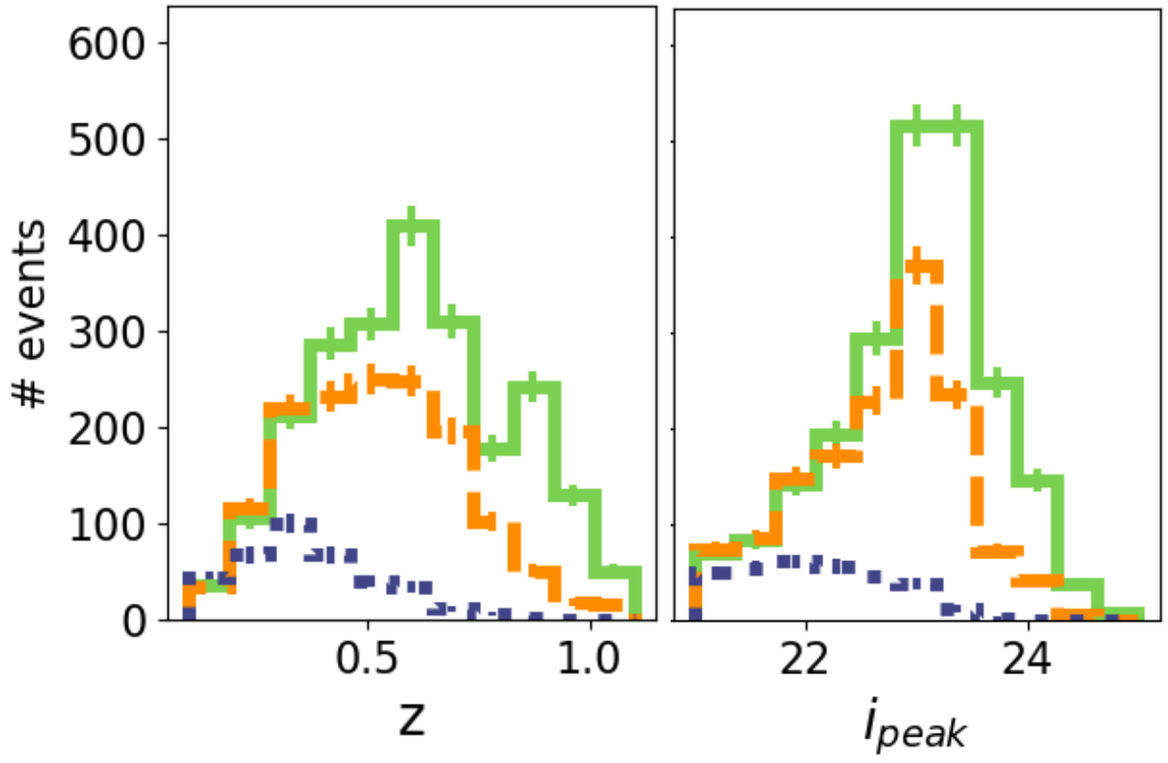
Light-curves

+

~~Host-galaxy redshifts~~

+

SuperNNova



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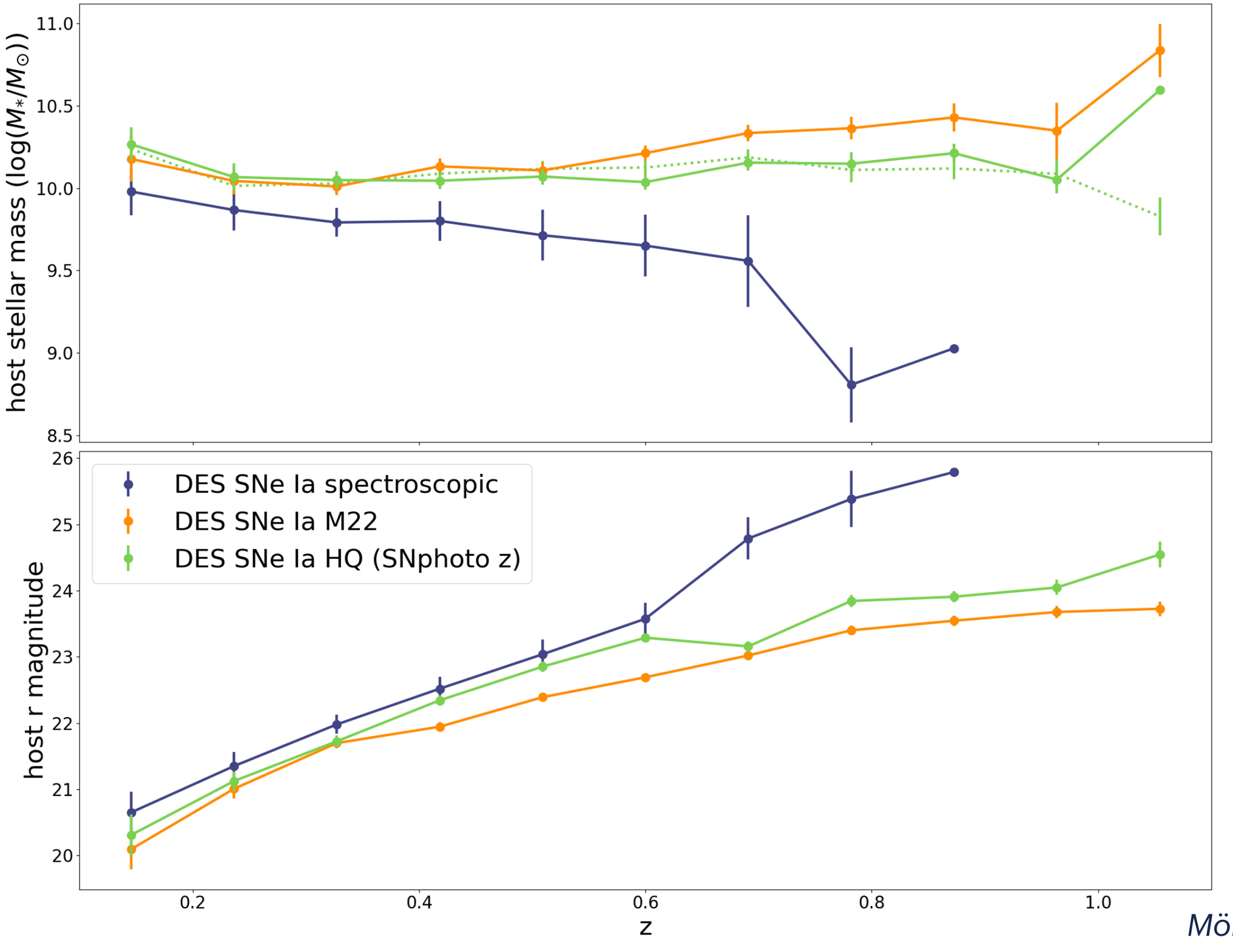
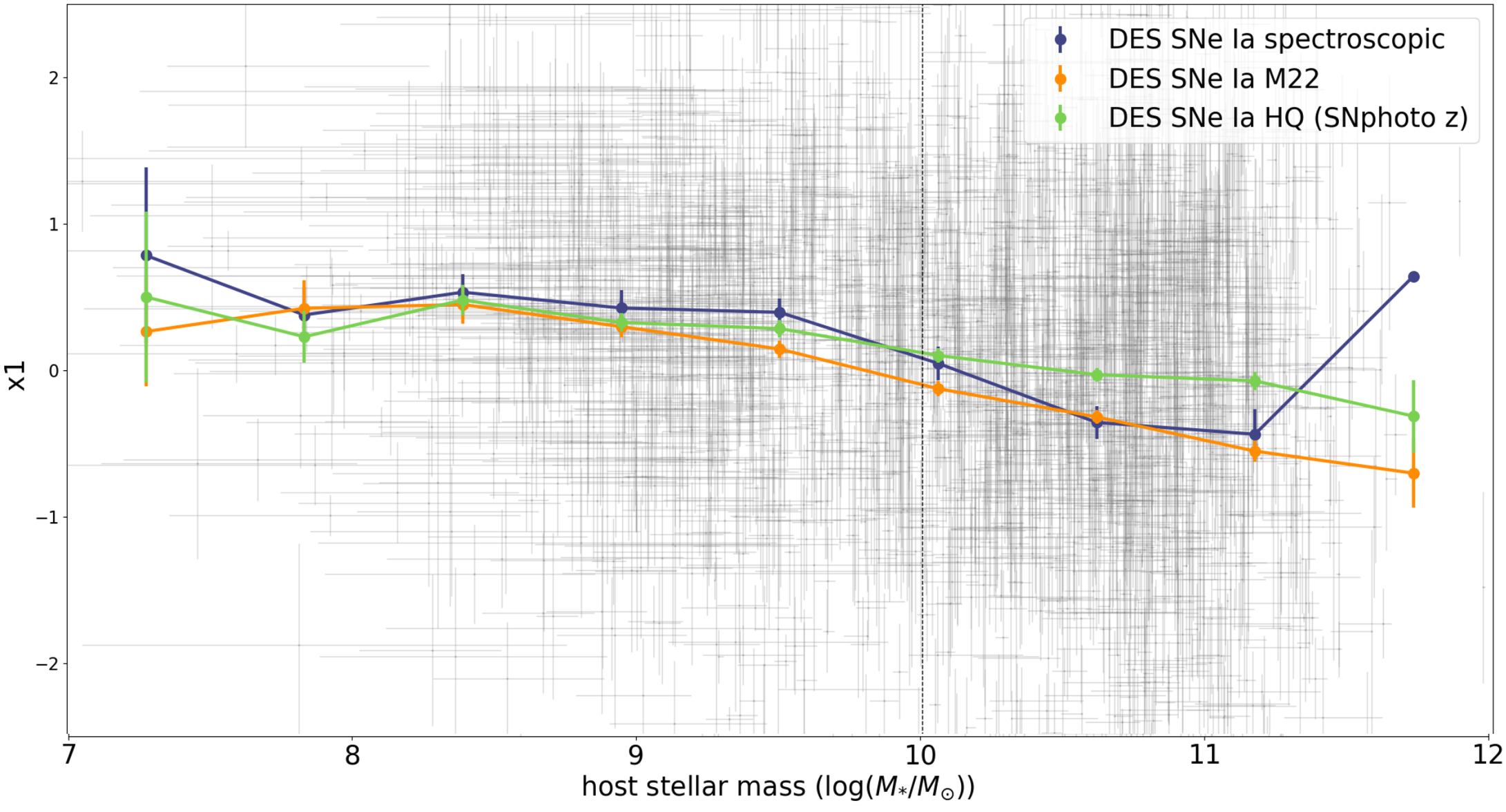
Möller+2024

Towards a complete SNIa sample



Möller+2024

Towards a complete SNIa sample



Also see Ed Charleton talk yesterday on using this sample for rates!

Möller+2024

Photometric classification for spectroscopic follow-up

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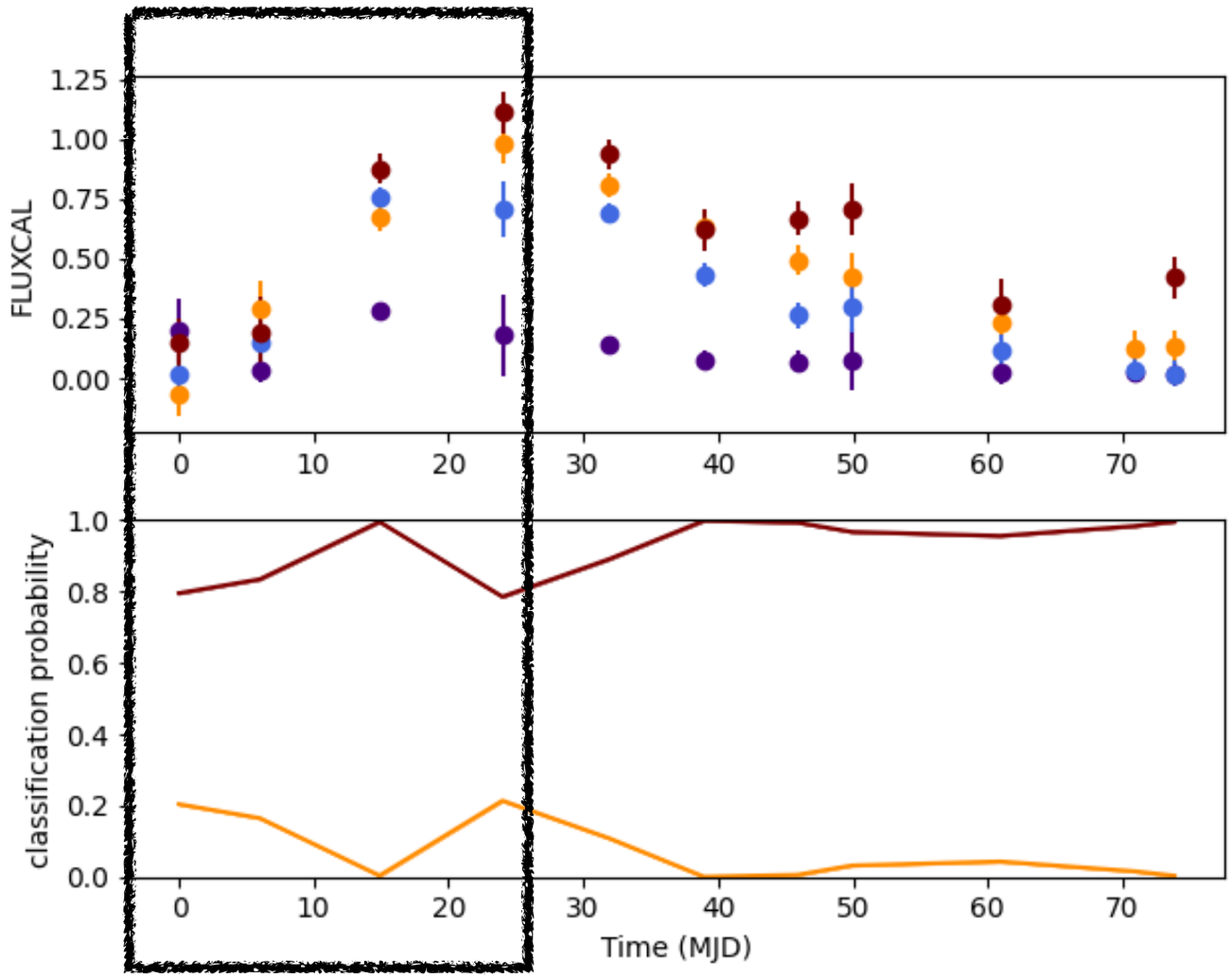
Early SNe Ia follow-up



accuracy	efficiency	purity
90.4 ± 0.1	91.5 ± 0.2	89.4 ± 0.2

Möller+ 2024

Photometric classification for spectroscopic follow-up

Early SNe Ia follow-up

	Total	SNe Ia		Non Ias	AGN candidates
		Spec	Photo		
Early light-curves	3250	336	776	120	230
SNN P_{Ia}>0.5	1288	294	687	4	18

Also see Emille Ishida's talk this morning on other early SNe Ia classifiers in Fink!

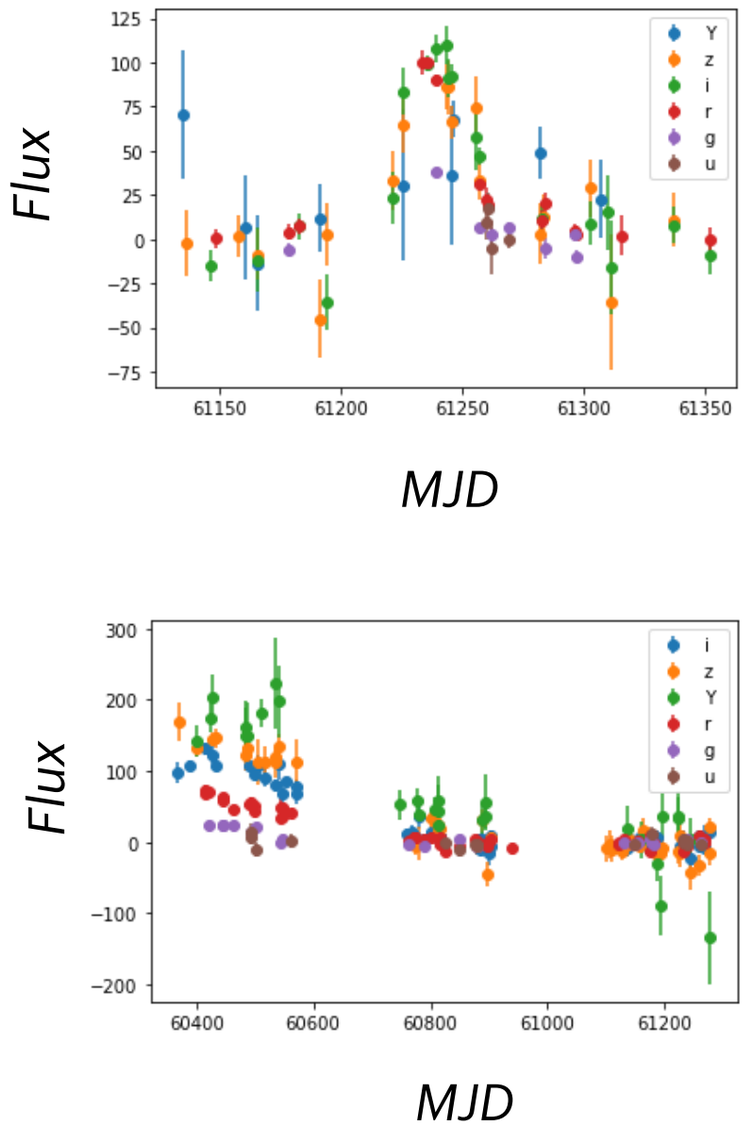
Möller+ 2024

Towards Rubin

ELAsTiCC: LSST-like simulations

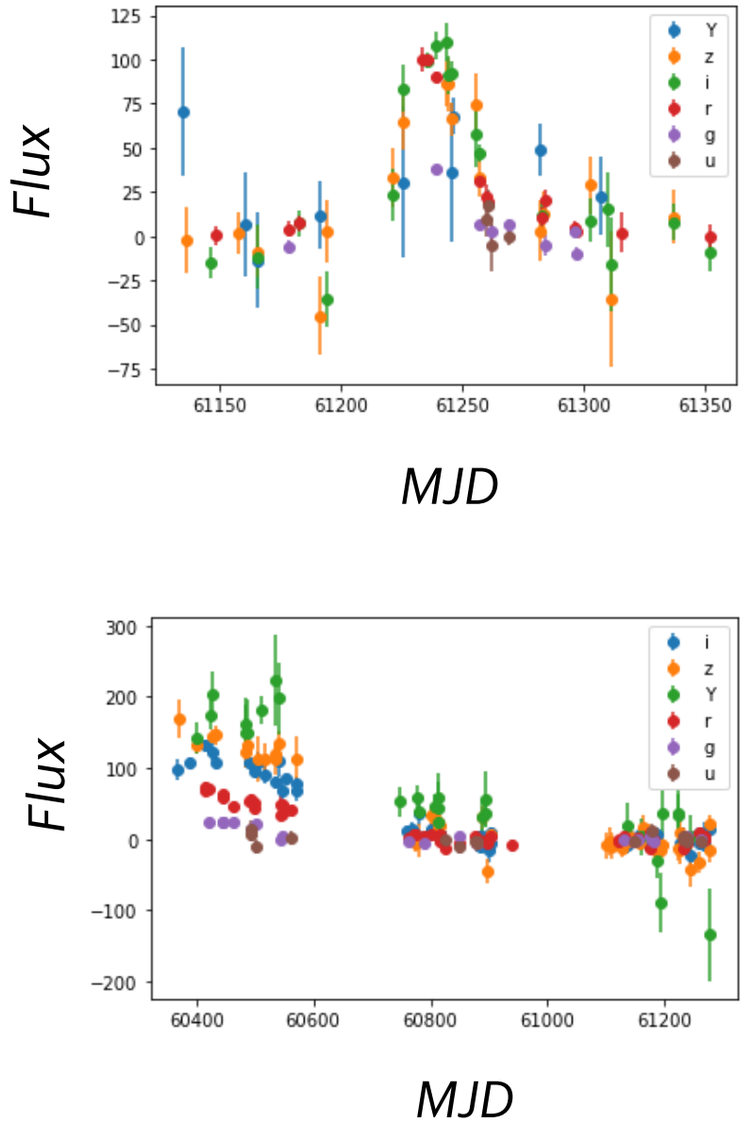
Towards Rubin

ELAsTiCC: LSST-like simulations



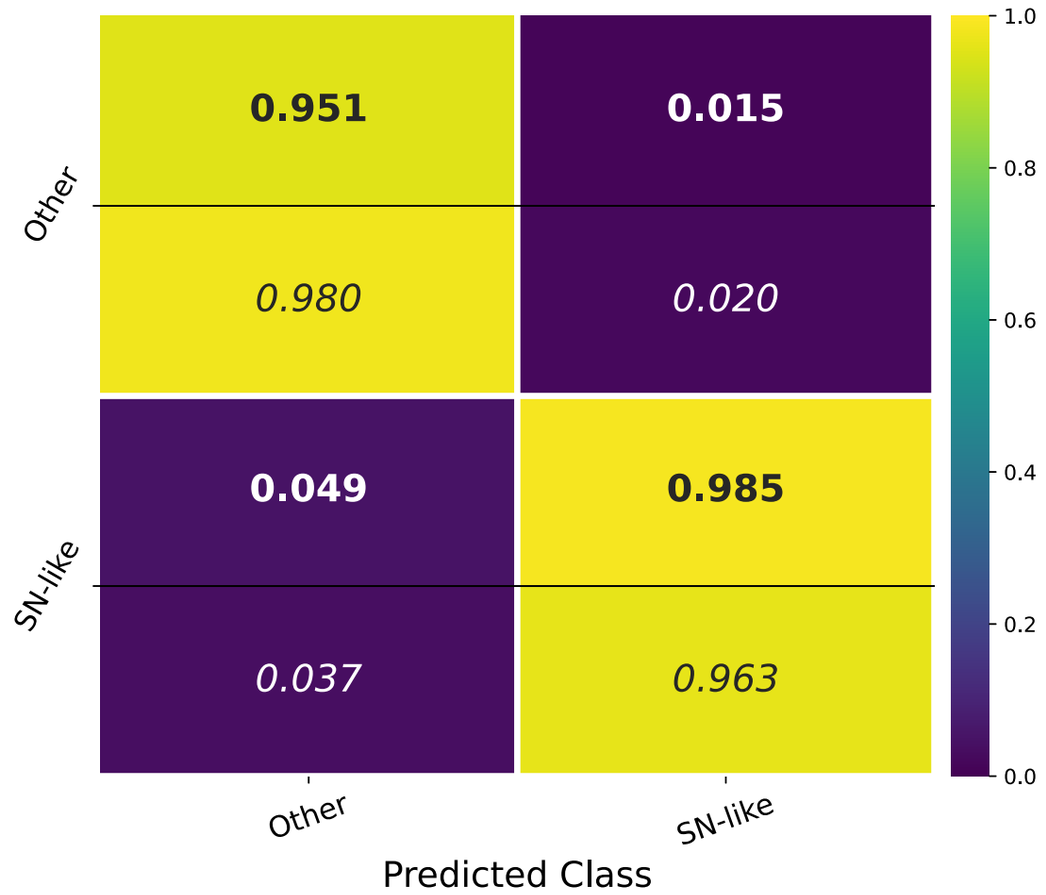
Towards Rubin

ELAsTiCC: LSST-like simulations



Precision

Recall



Fraga et al. incl AM 2024

Summary

Dark Energy Survey:

- First SN Ia photometric classification for precision cosmology
- Photometric classification for ~complete SN Ia sample!

In the Rubin era, photometric classification allows:

- To harness most SNe Ia
- Early SN Ia identification

Fink broker will select SN Ia in Rubin with SuperNNova

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