

Photometric Supernova Classification in the Roman Era

Helen Qu (University of Pennsylvania)

Exploring the Transient Universe with the Nancy Grace Roman Space Telescope, 2/8/2022

Why photometric classification?



Why photometric classification?

Type Ia Supernova (SN Ia)
Cosmology

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Core Collapse (CC)
Astrophysics

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- pure SN Ia sample
- can classify SN events after they happen

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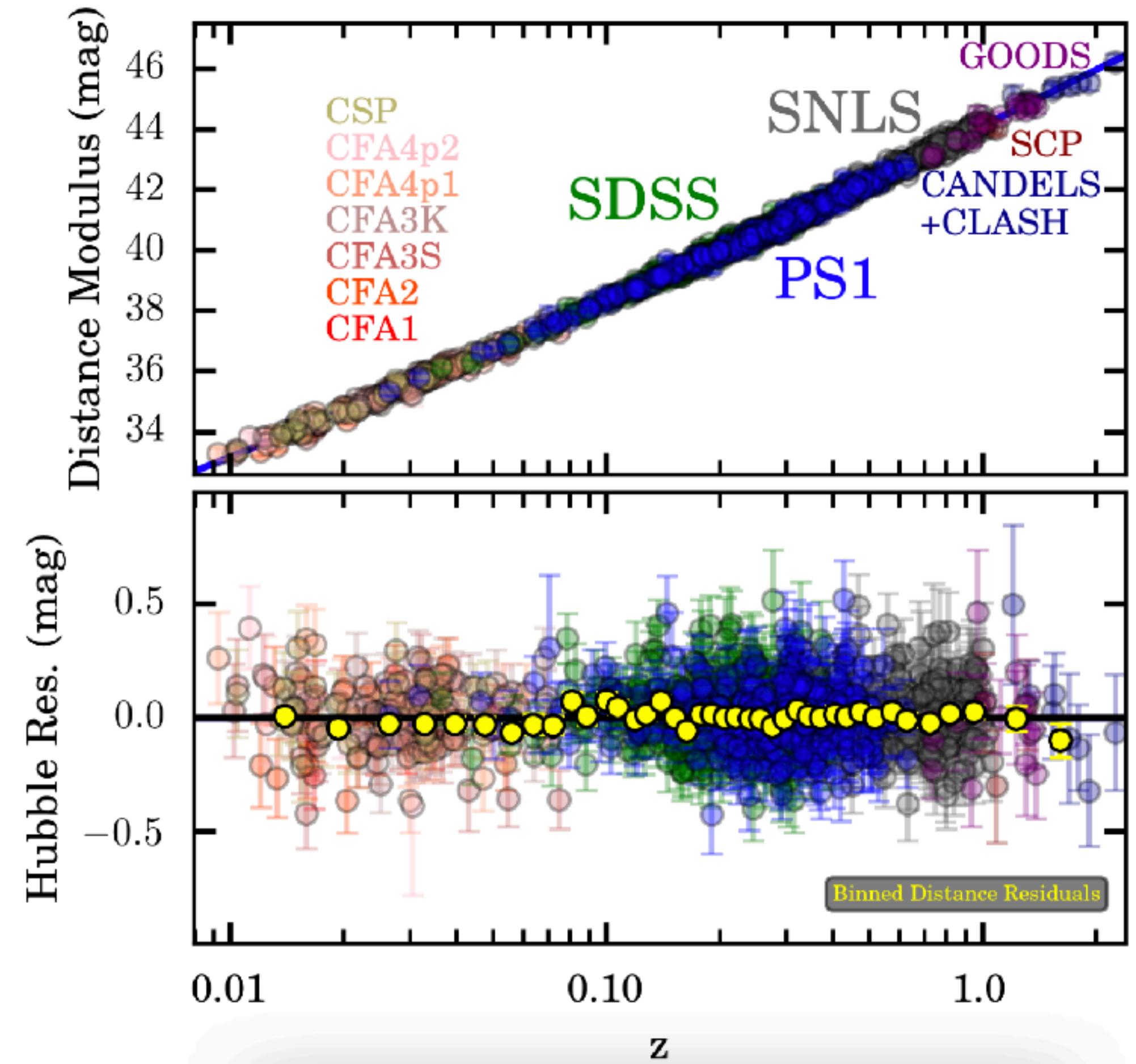
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Core Collapse (CC) Astrophysics

- classify by SN type
- classify as early as possible

SN Ia Cosmology

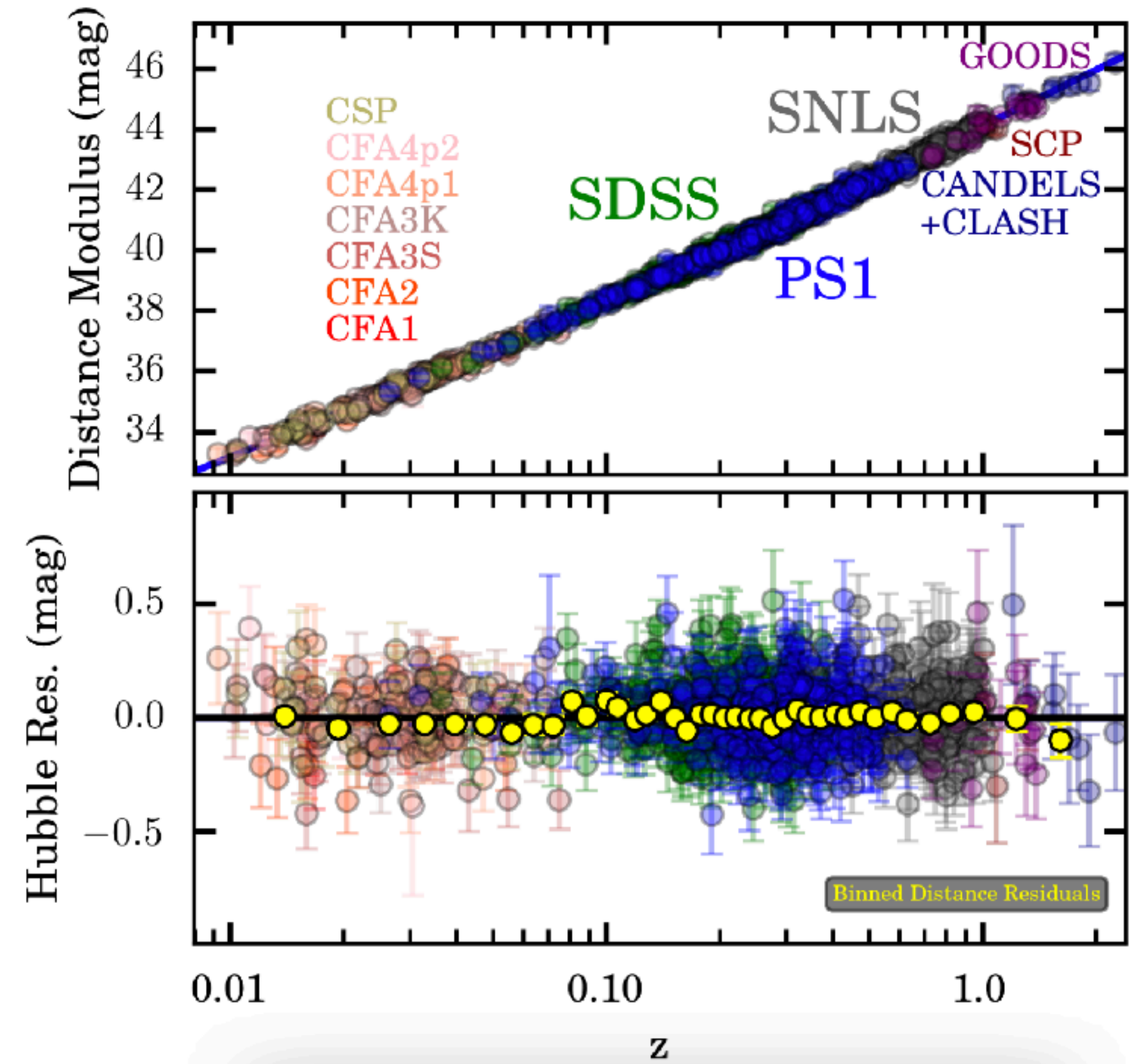
- SNe Ia are:
 - **highly luminous:** observable out to $z \sim 1 - 2$
 - **standardizable candles:** brightness \rightarrow distance



Scolnic et al., 2018

SN Ia Cosmology

- SNe Ia are:
 - **highly luminous:** observable out to $z \sim 1 - 2$
 - **standardizable candles:** brightness \rightarrow distance
- **Input:** Redshift z , luminosity distance d_L
- **Output:** cosmological parameters ($\Omega_m, \Omega_\Lambda, w$)



Scolnic et al., 2018

Core Collapse Astrophysics

- Better understanding of progenitor physics of different SN types

Core Collapse Astrophysics

- Better understanding of progenitor physics of different SN types
- Early SN type information → more opportunities for follow-up observation

What's different about our approach?

Template Matching

- low computational requirements
- lower accuracy
- ex. pSNID

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SCONE

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SCONE

(**S**upernova **C**lassification with a **C**onvolutional **N**eural **N**etwork)

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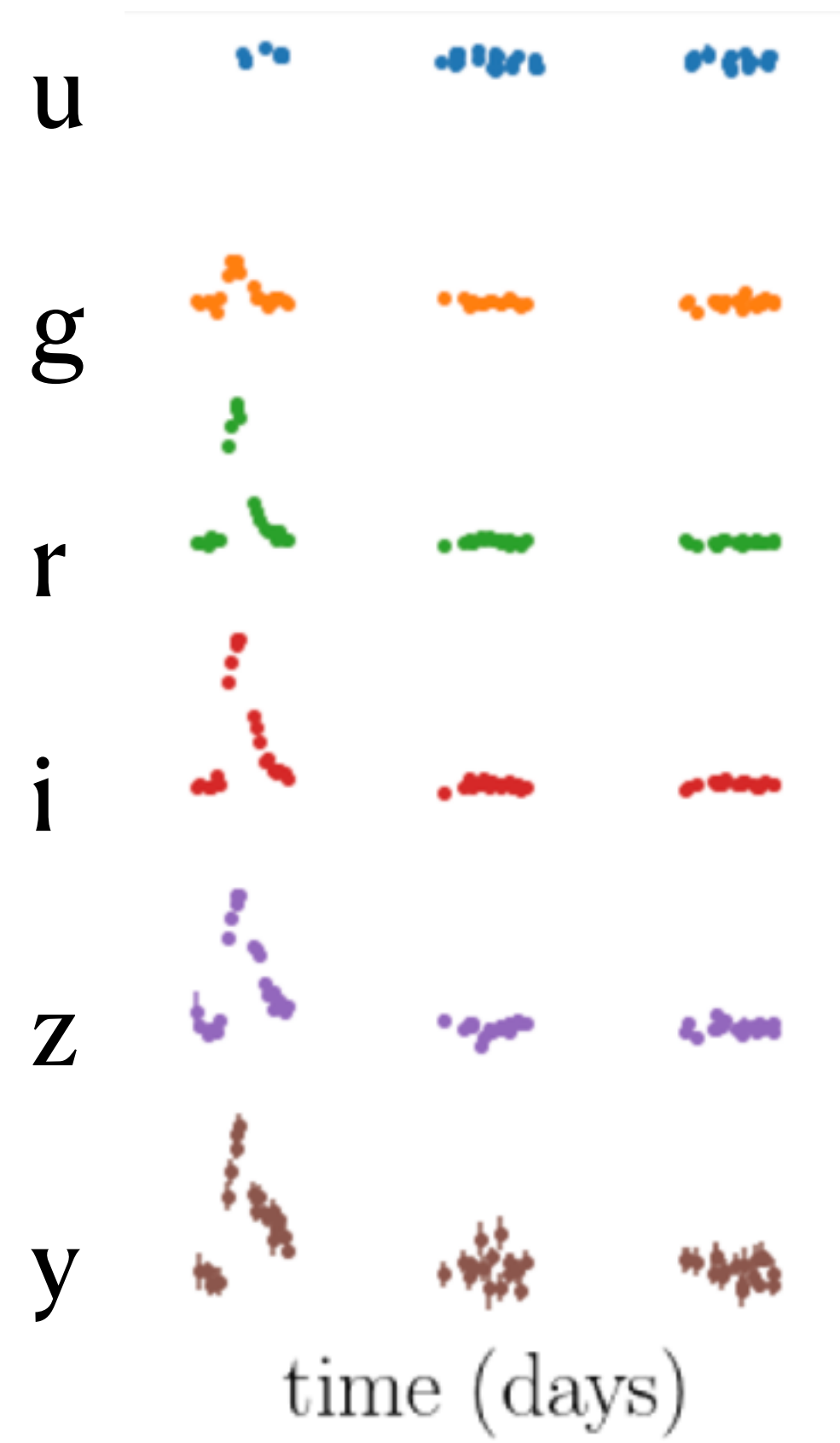
SCONE

(**S**upernova **C**lassification with a **C**onvolutional **N**eural **N**etwork)

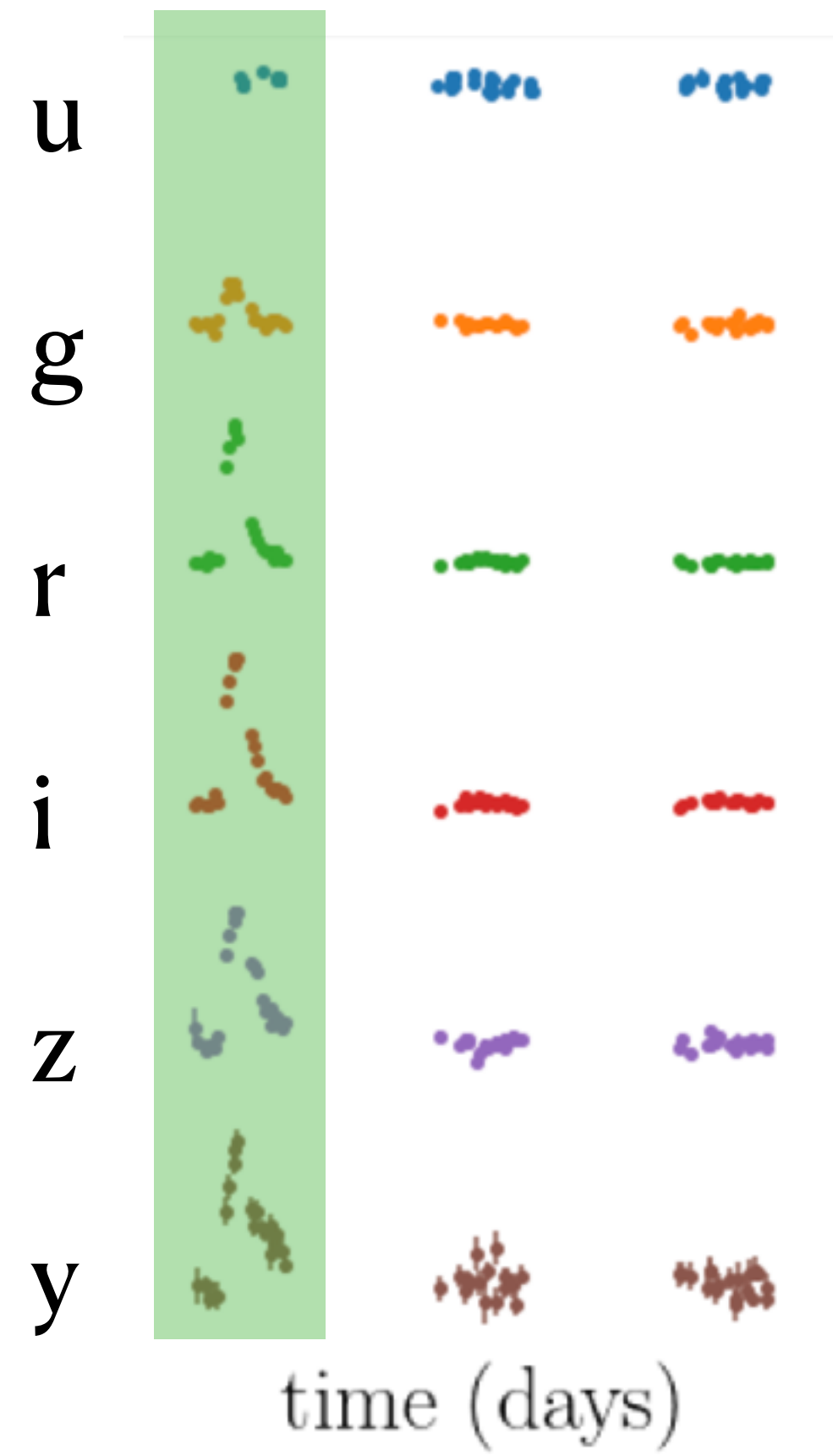


image recognition

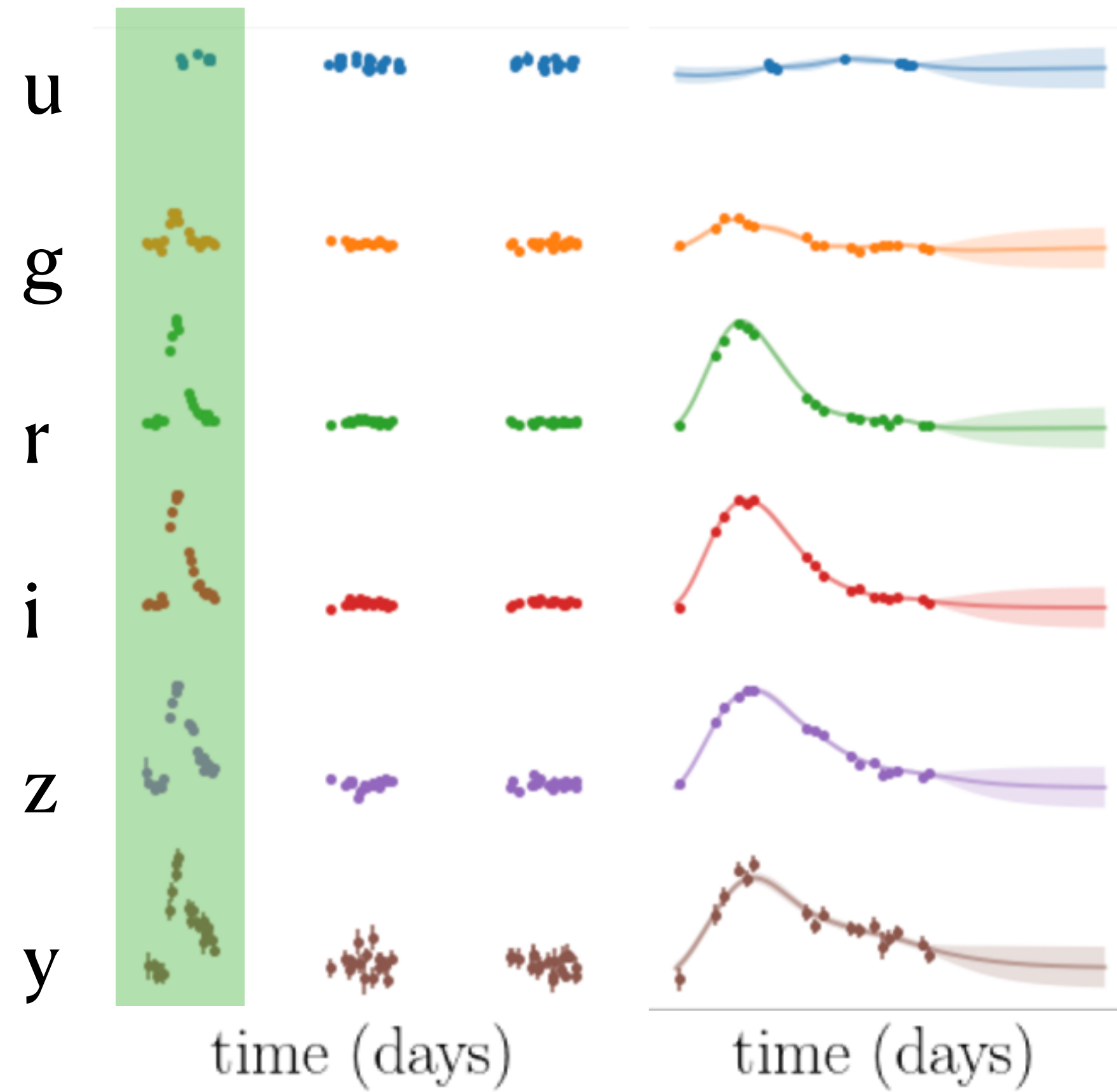
SN Photometry \rightarrow Images



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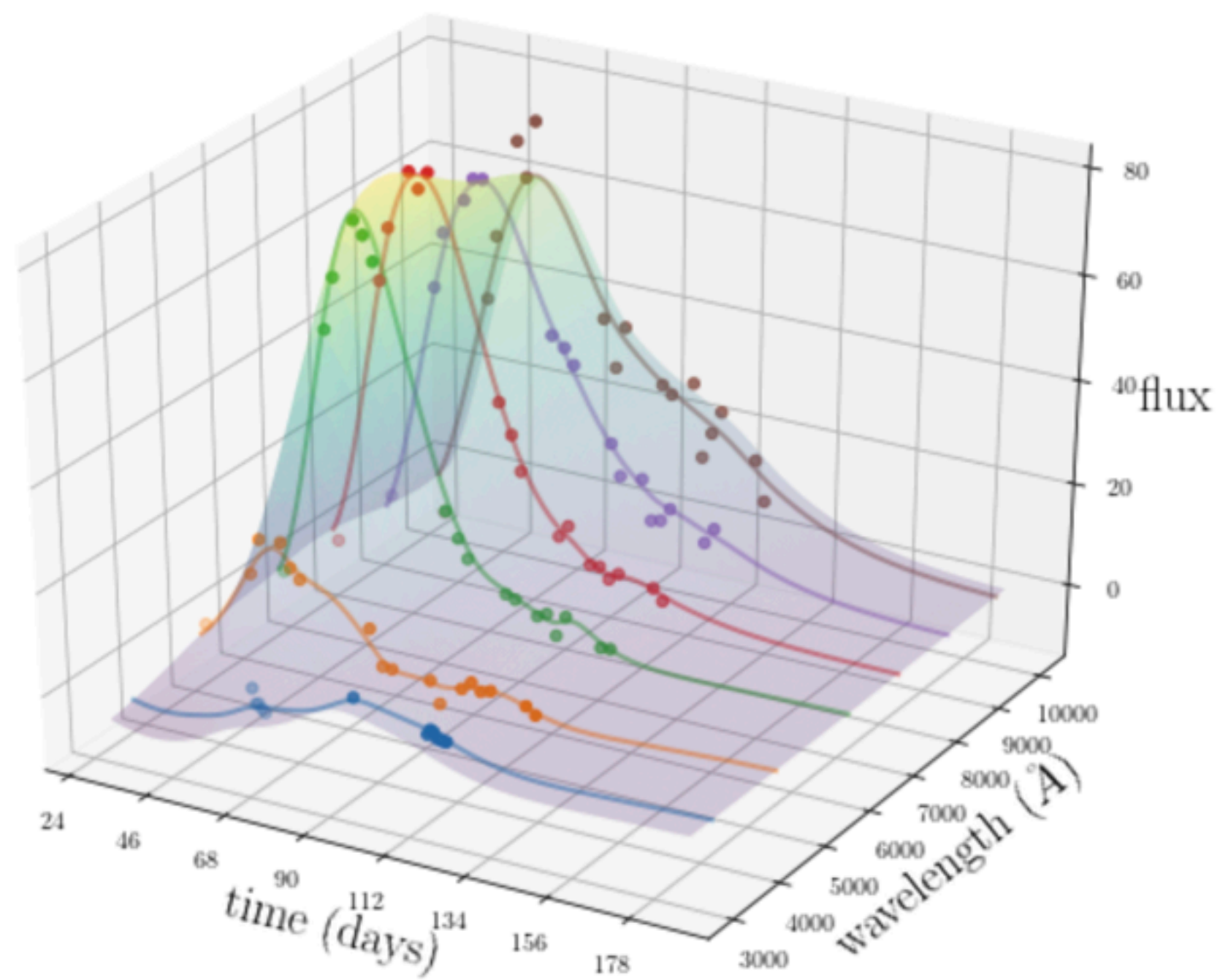
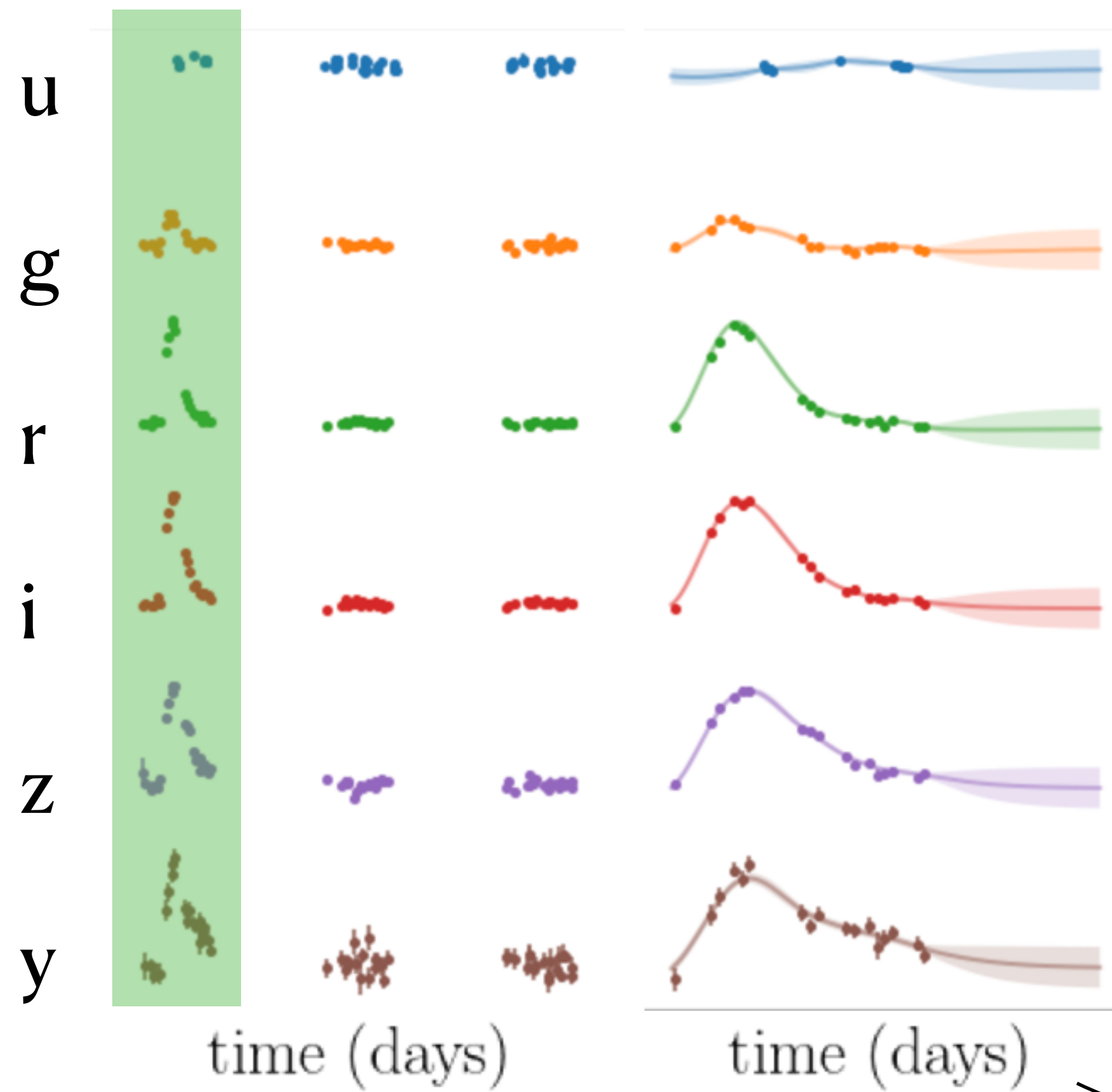


SN Photometry \rightarrow Images



Gaussian process (time)

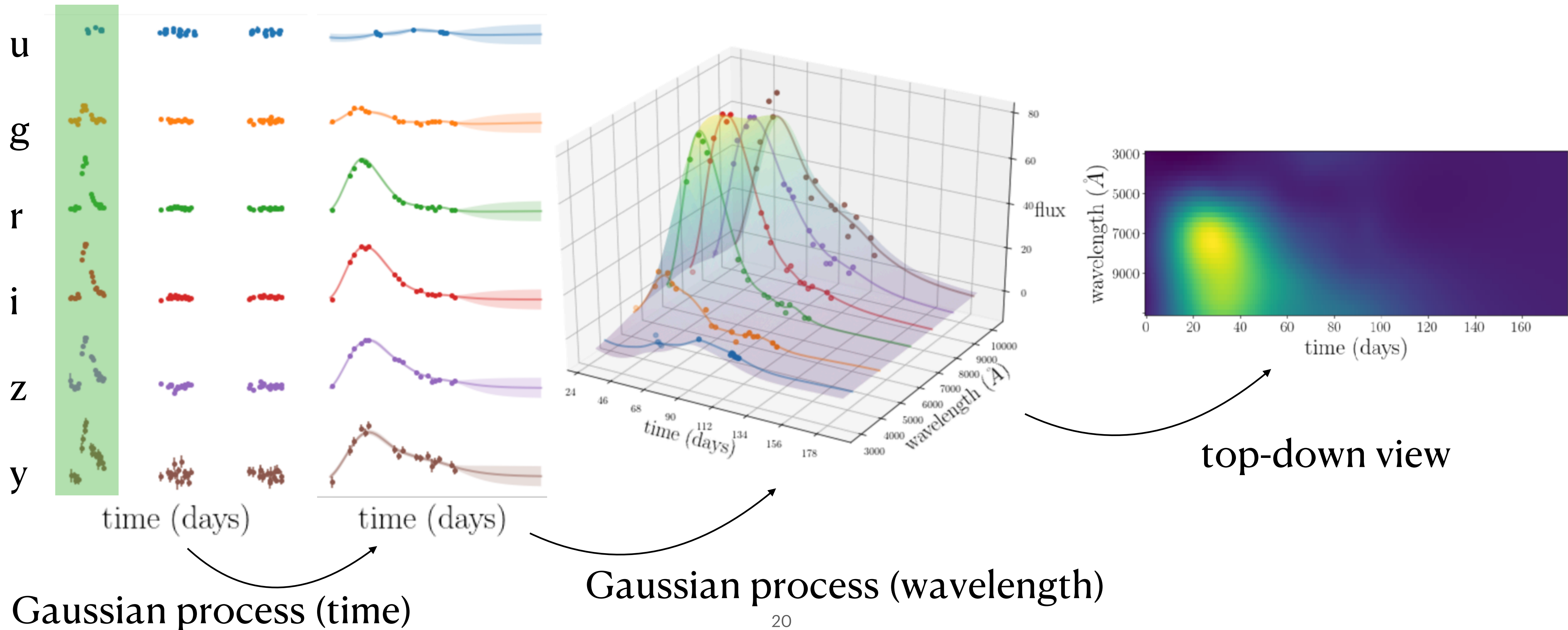
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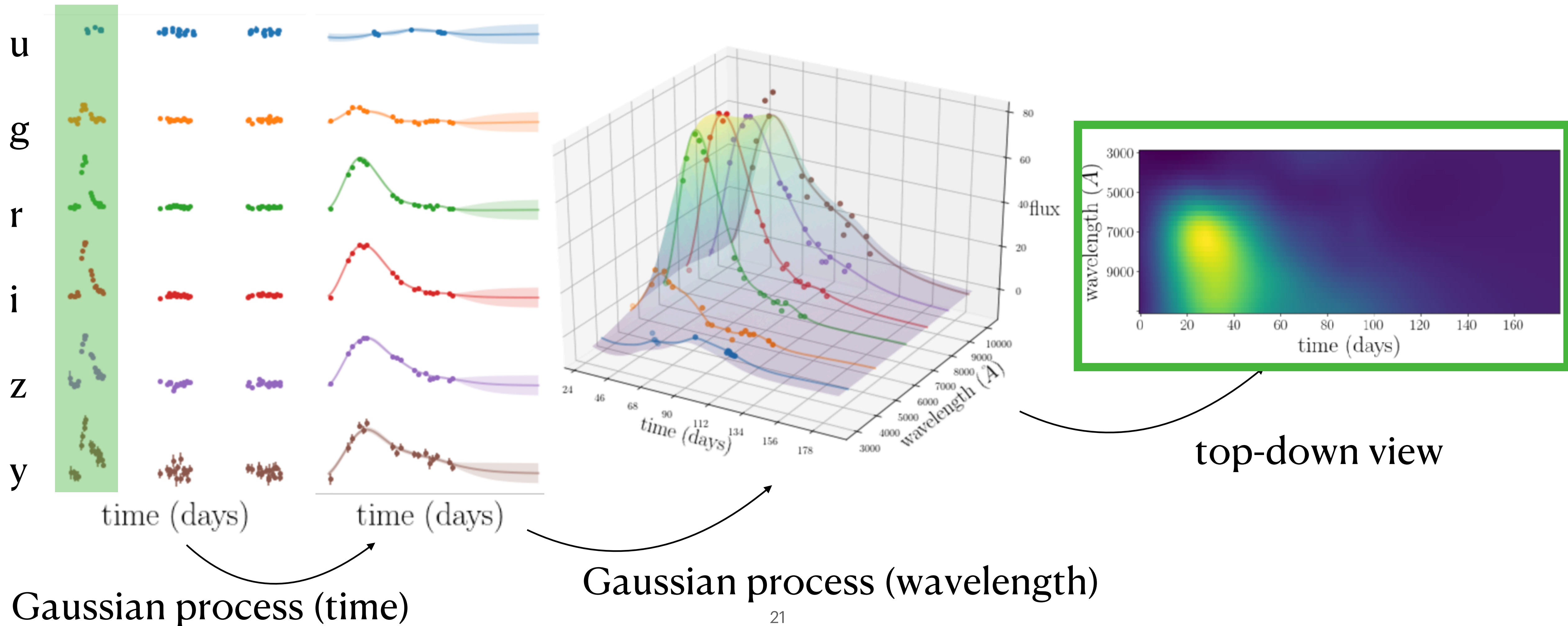
Gaussian process (time)

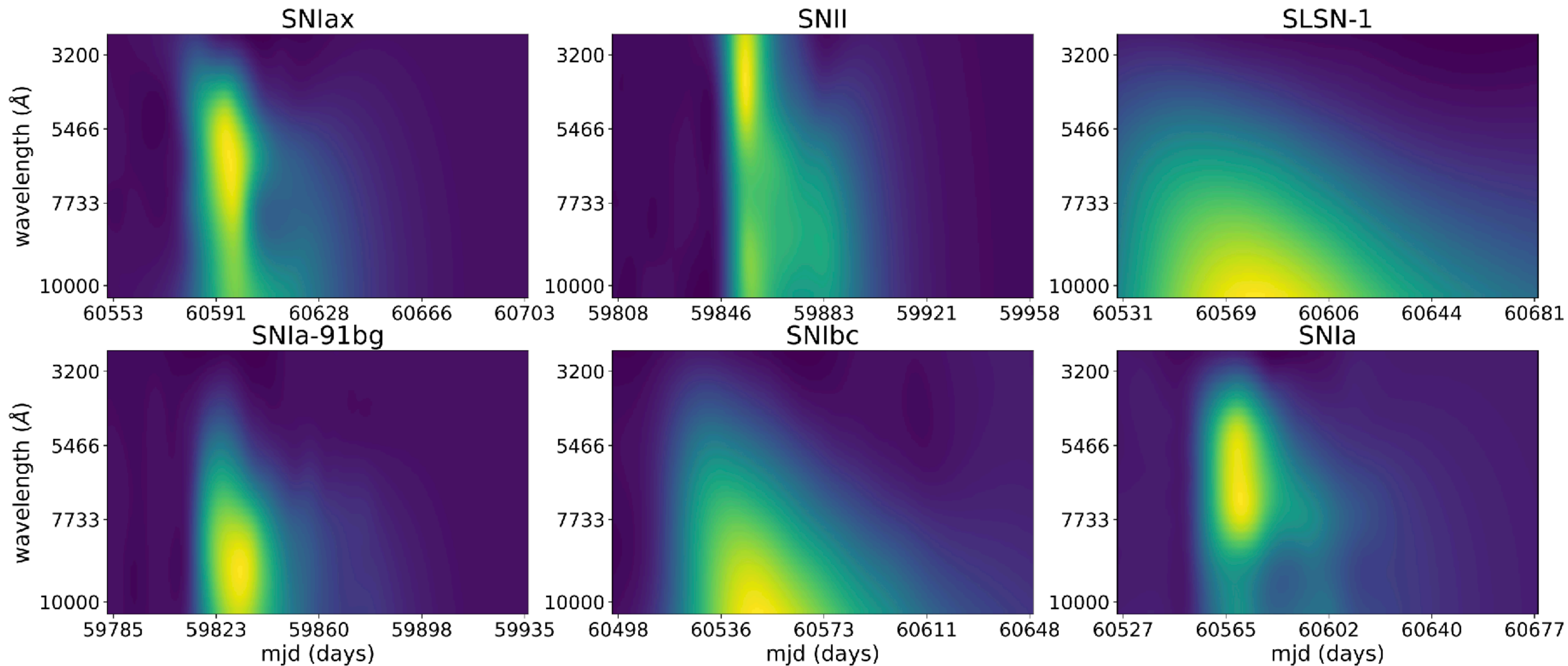
Gaussian process (wavelength)

SN Photometry \rightarrow Images



SN Photometry \rightarrow Images





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Cosmology*

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*Core Collapse (CC)
Astrophysics*

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SN Ia Cosmology

SN Ia vs. non-Ia Classification

Actual Type	SN Ia	0.9978 ± 0.002	0.0022 ± 0.002
	non-Ia	0.0033 ± 0.0033	0.9967 ± 0.0033
		SN Ia	non-Ia
		Predicted Type	

- accuracy without redshift:
99.73 %

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- caveat: these results are from simulated SNe datasets; **real data is always messier!**

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Cosmology

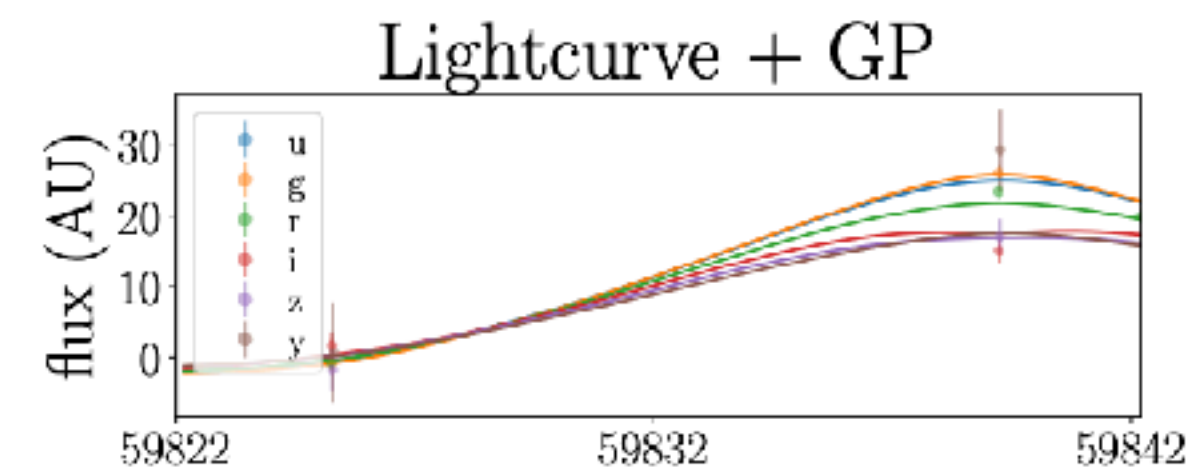
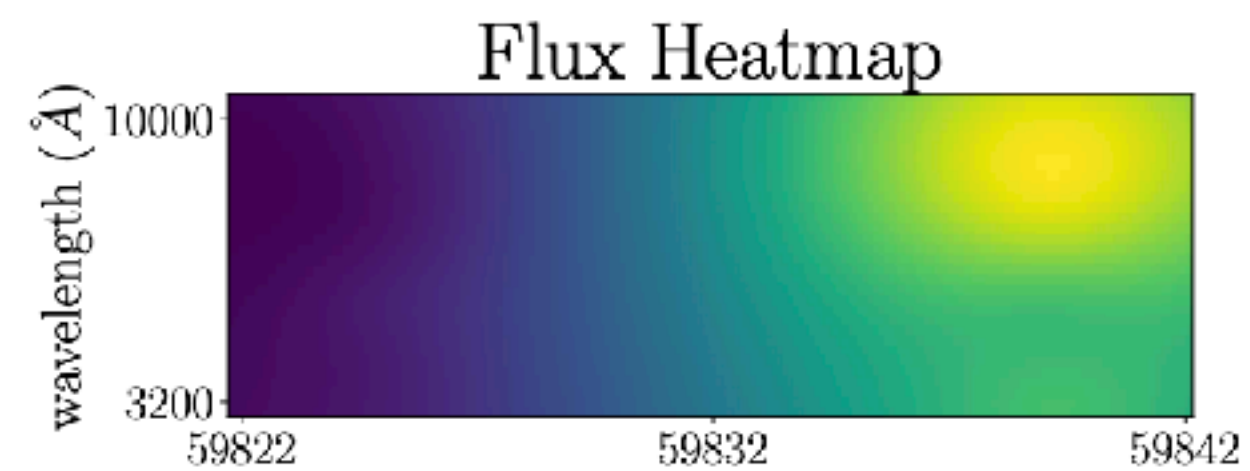
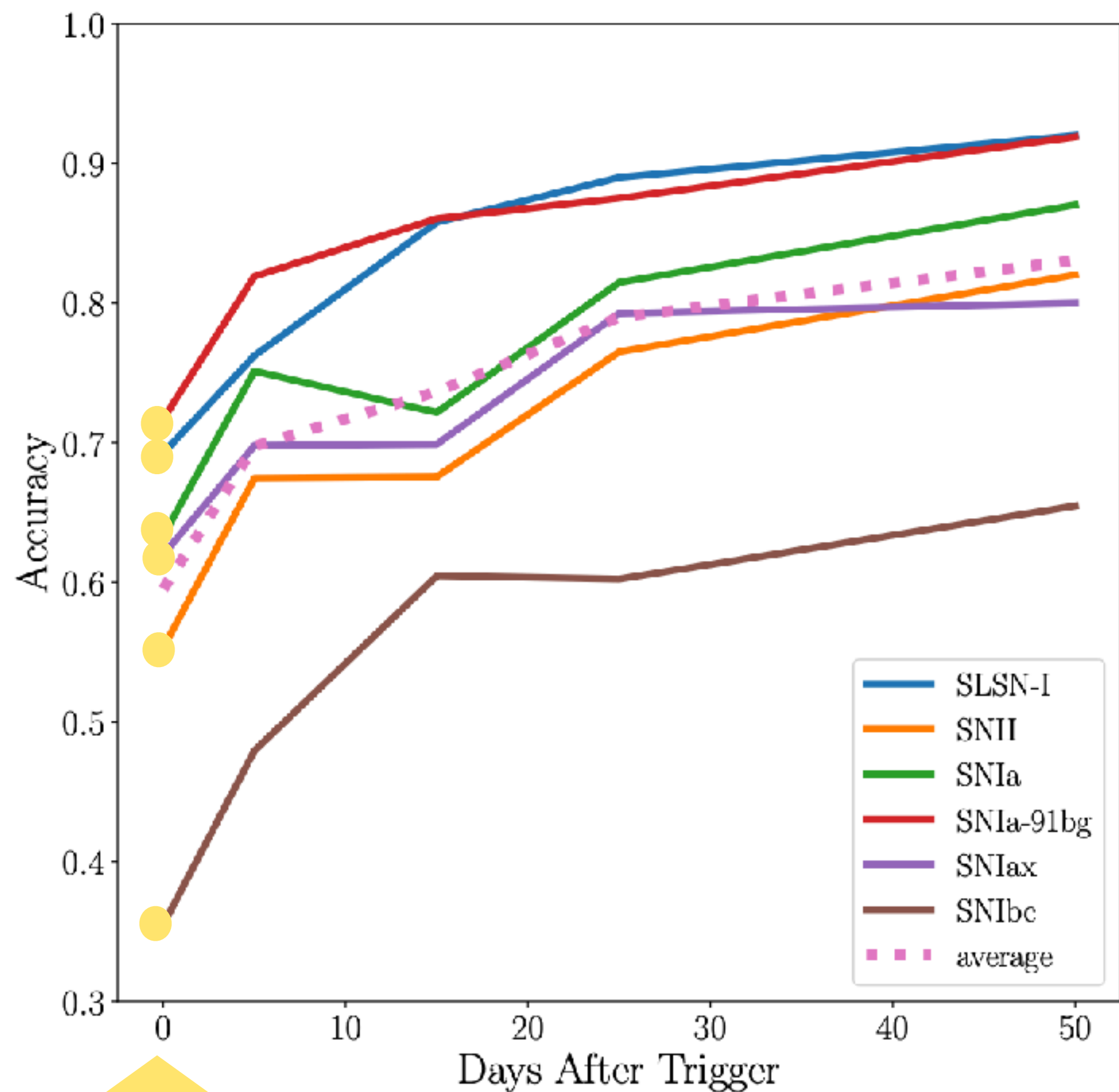
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Core Collapse Astrophysics

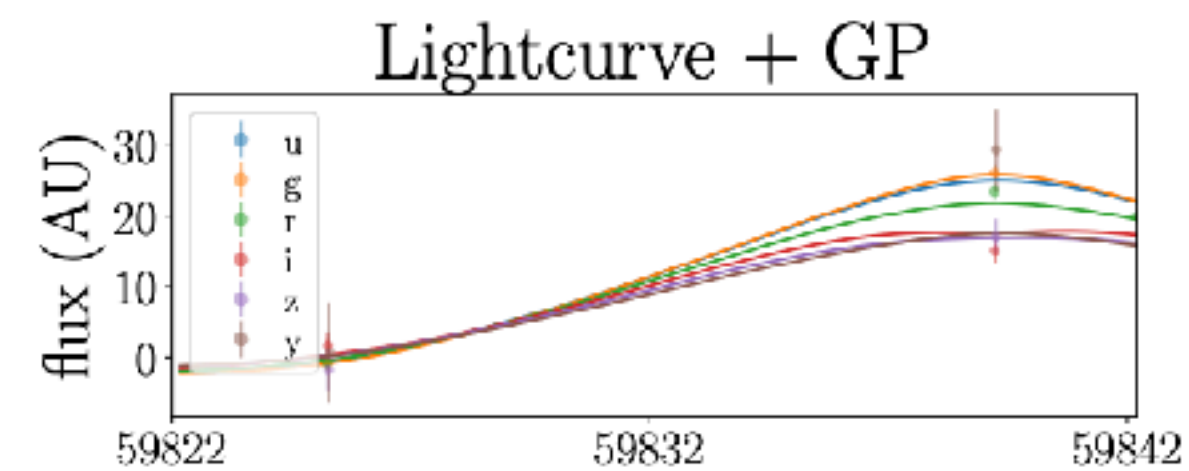
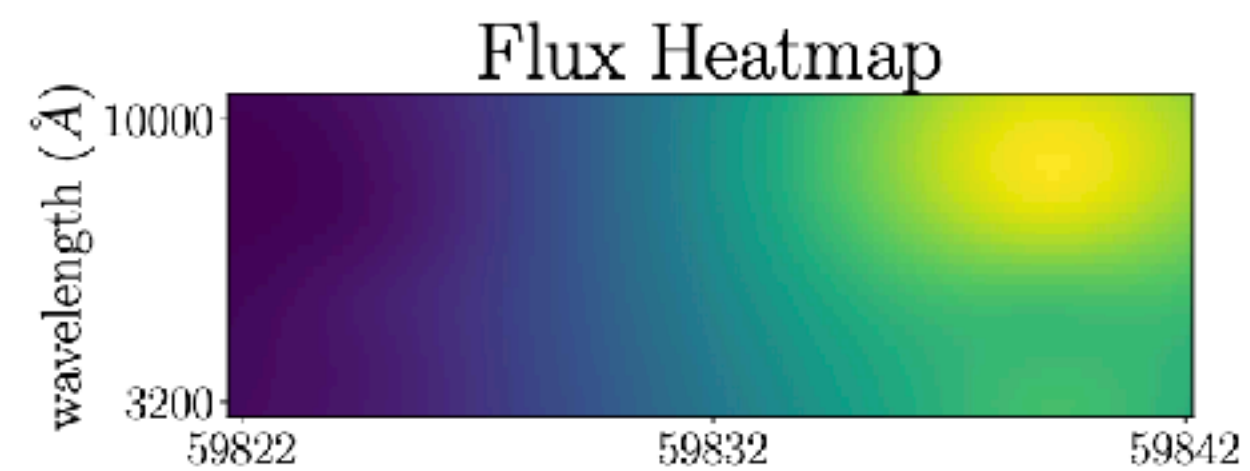
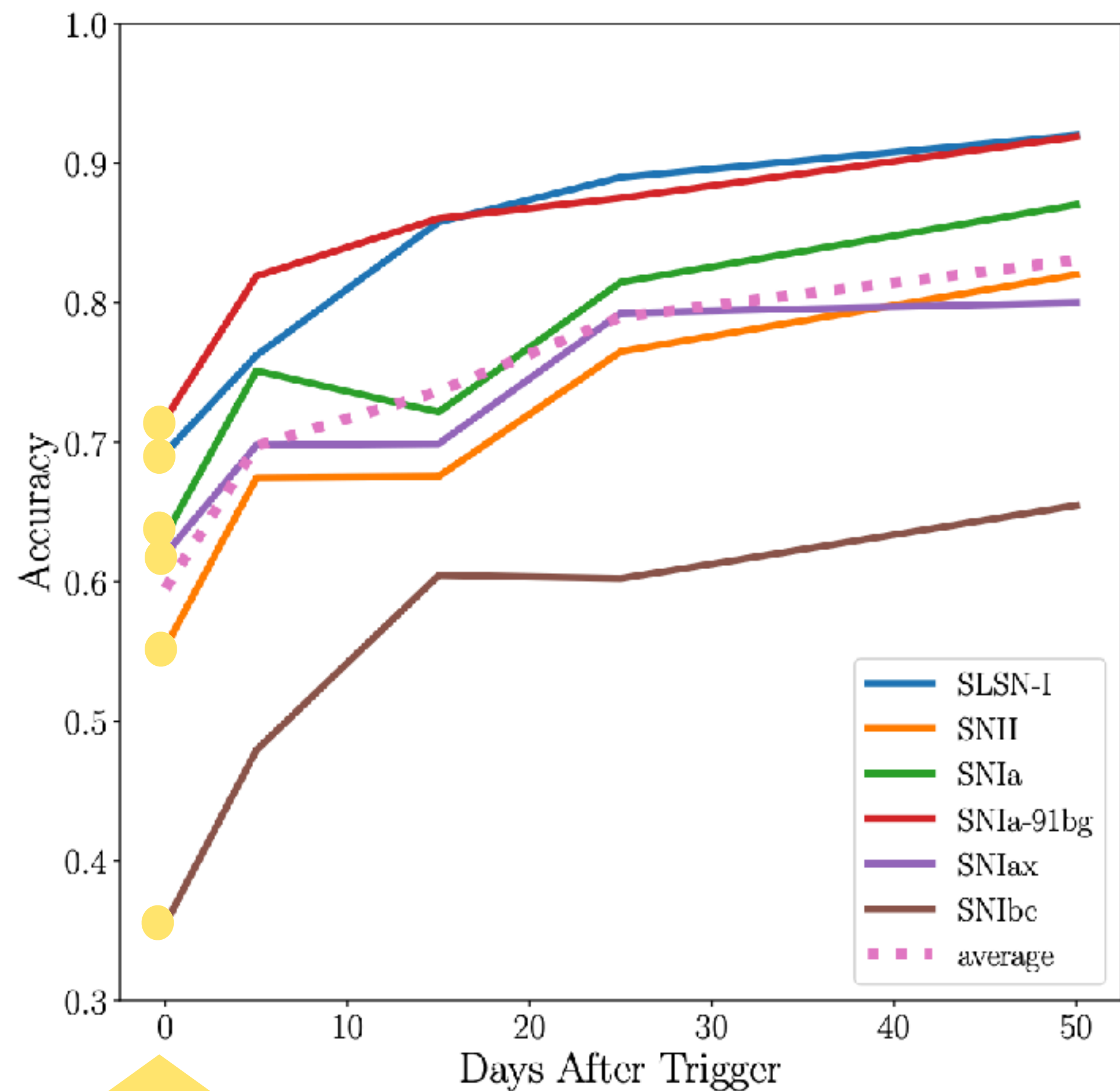
Early-time SN typing



0 days
after trigger*

Core Collapse Astrophysics

Early-time SN typing

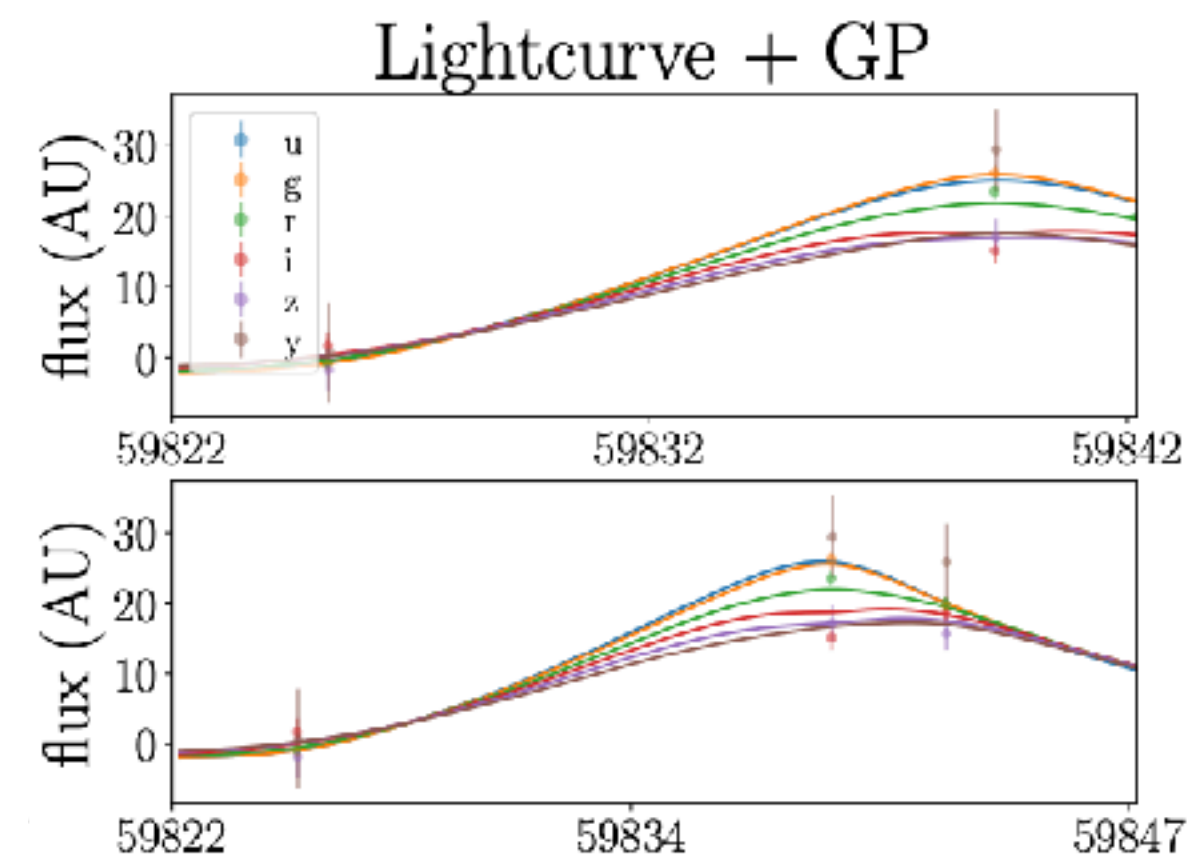
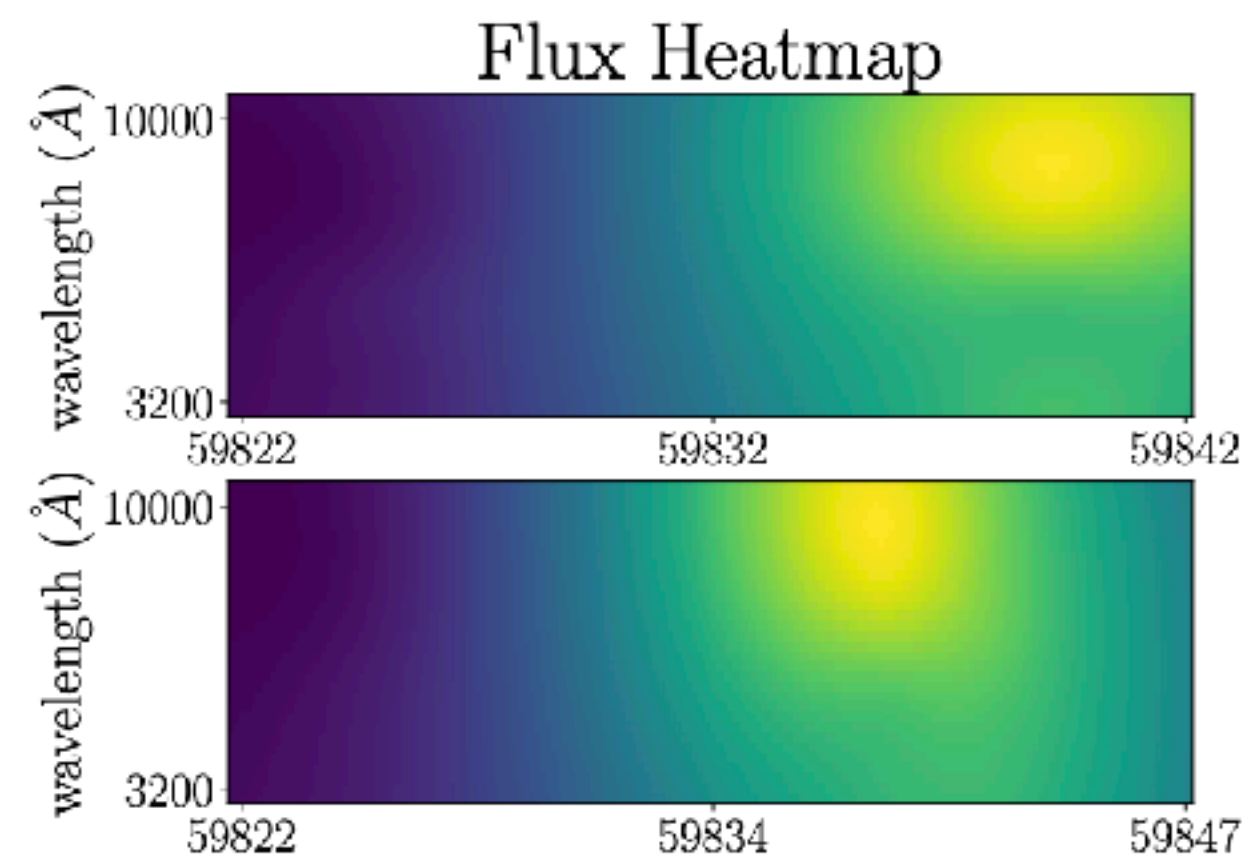
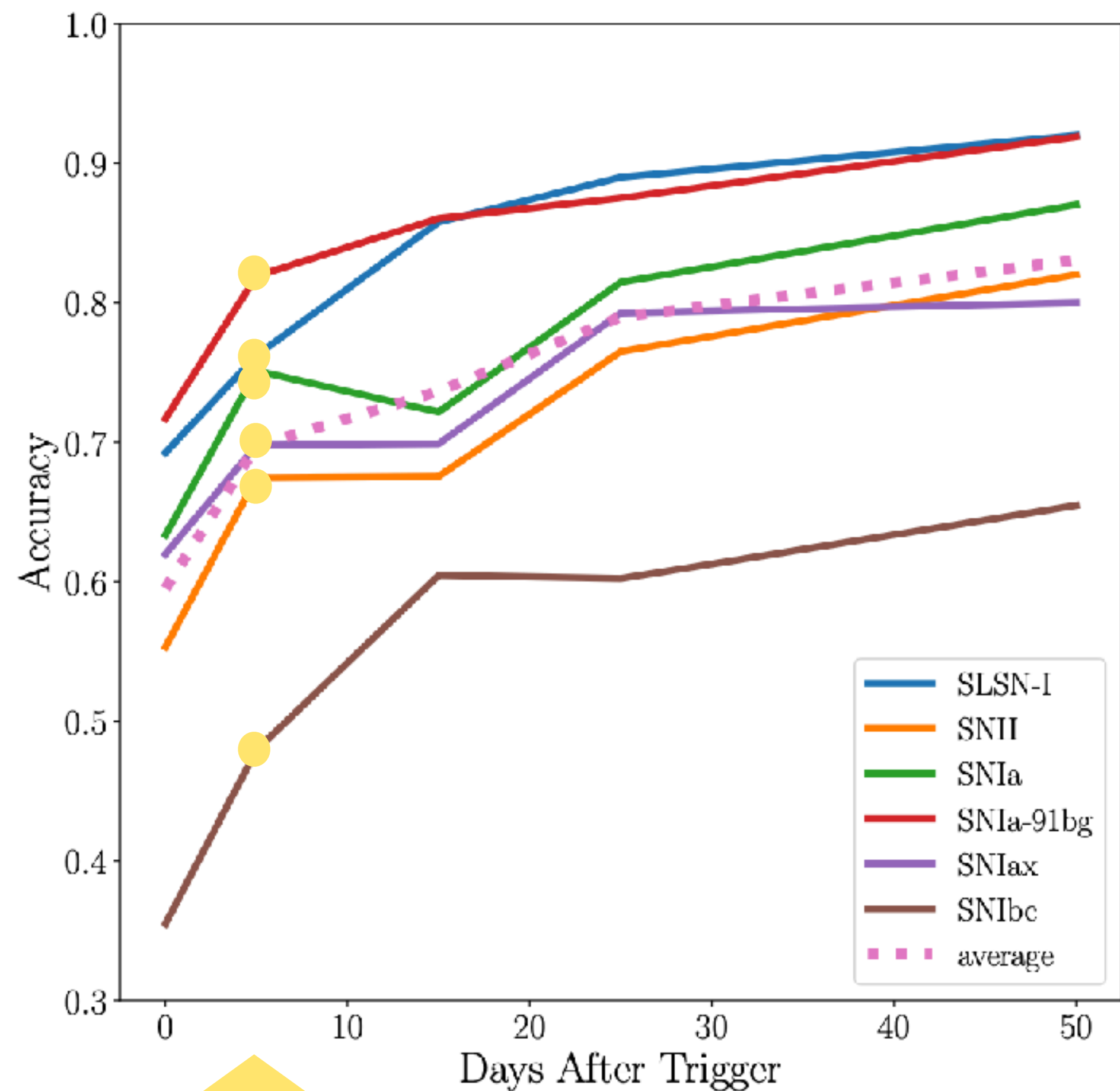


0 days
after trigger*

* trigger = second SNR>5 detection on a different night than the first SNR>5 detection

Core Collapse Astrophysics

Early-time SN typing

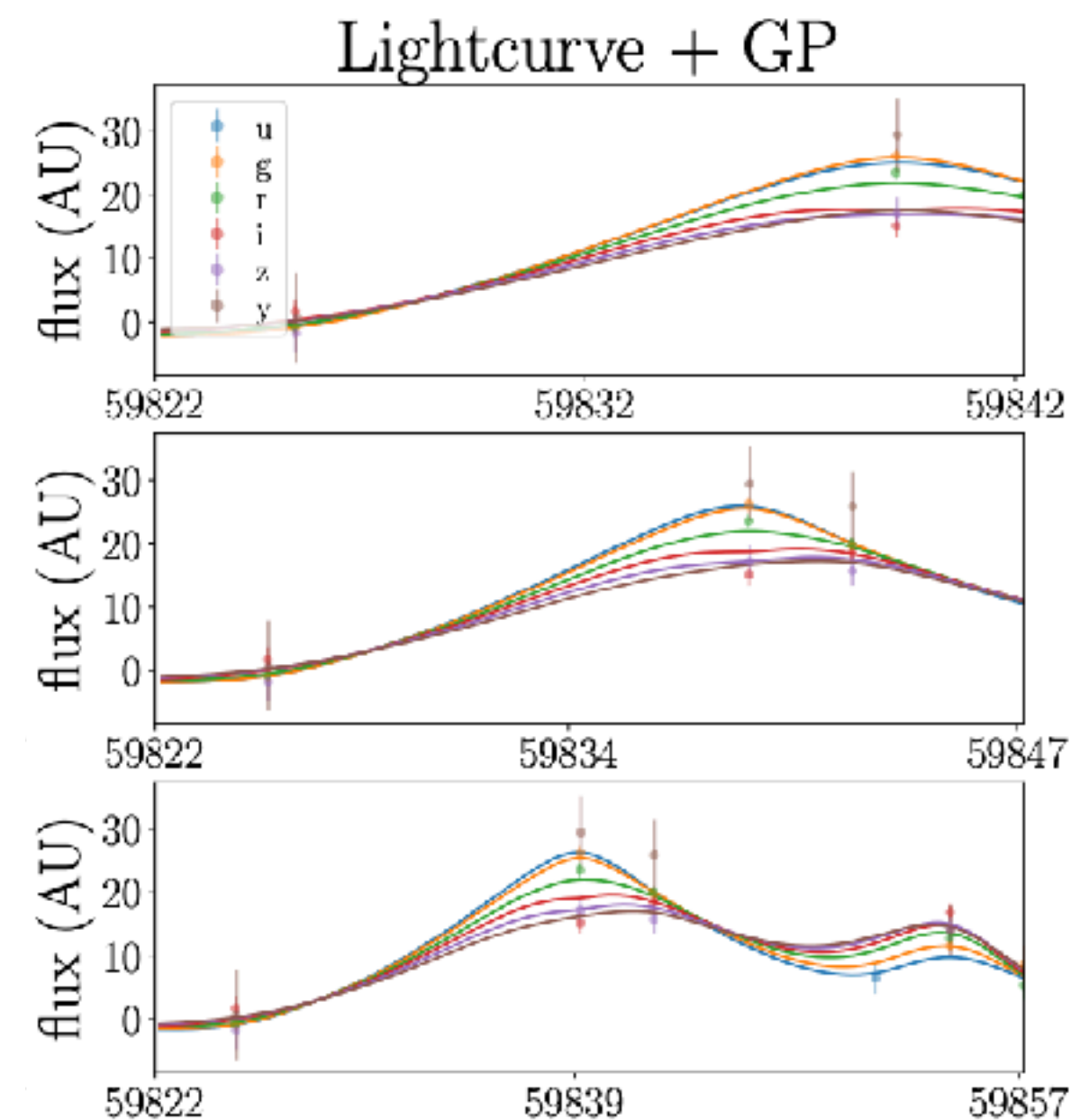
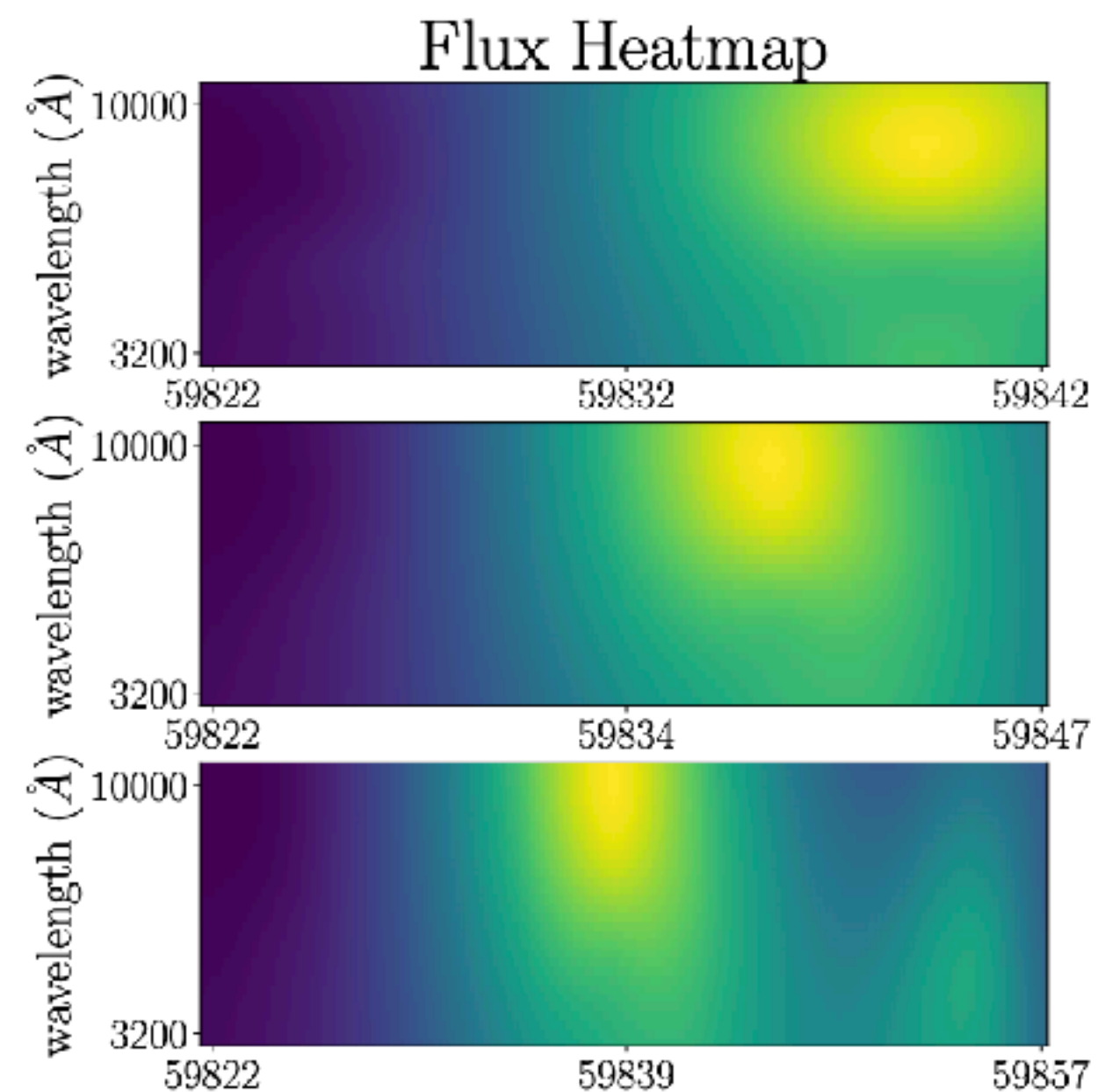
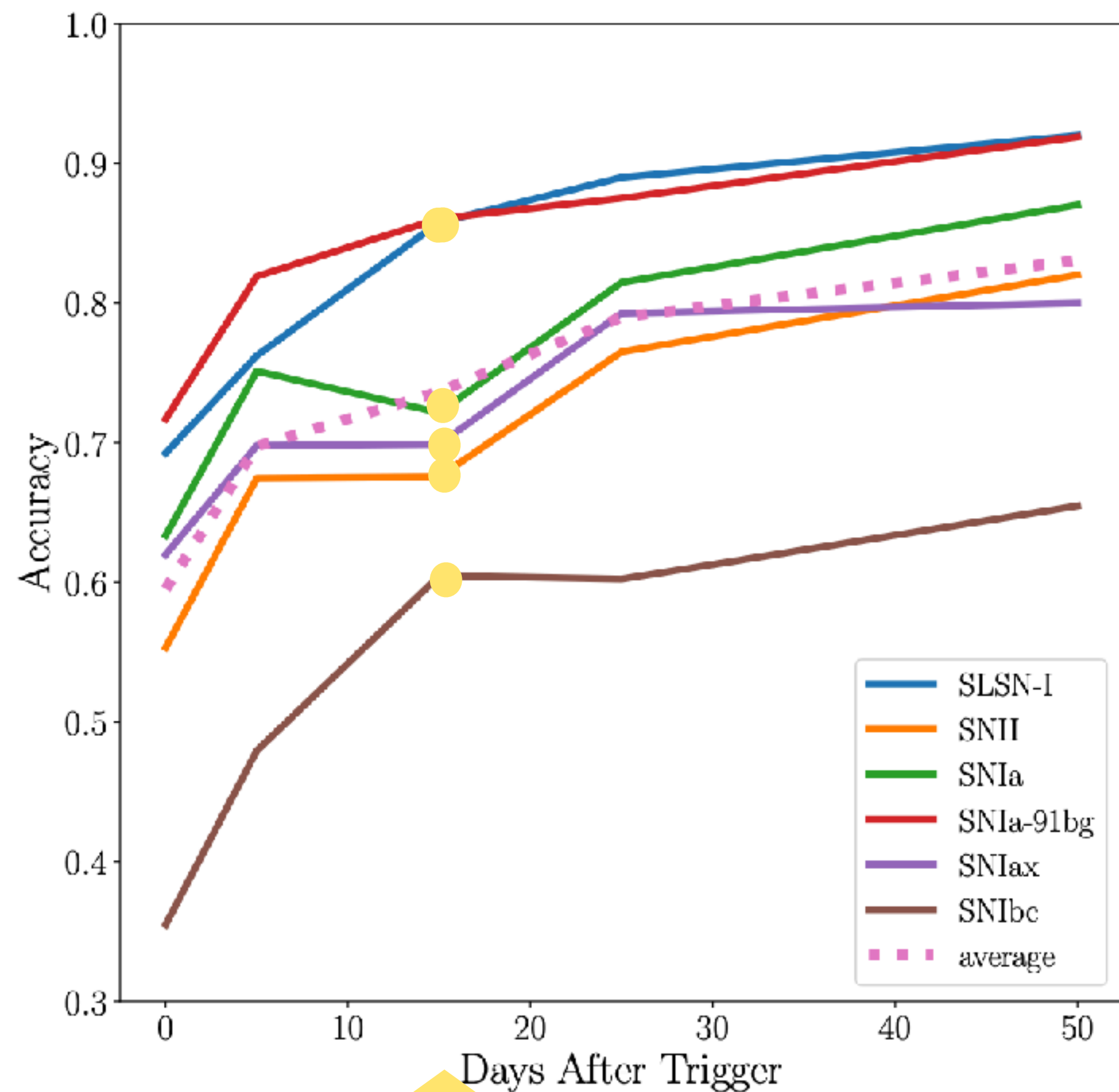


0 days
after trigger

5 days
after trigger

Core Collapse Astrophysics

Early-time SN typing



0 days
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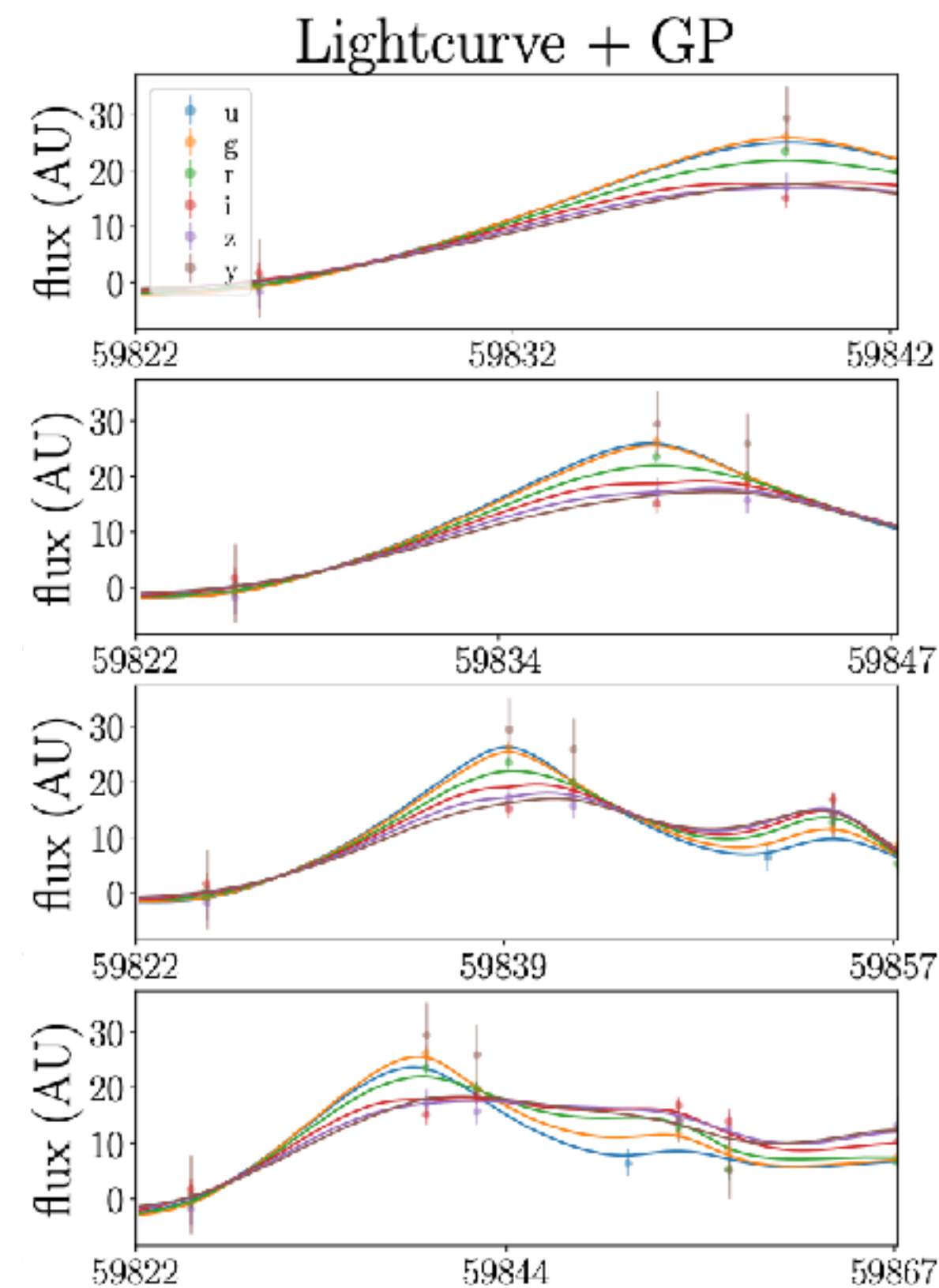
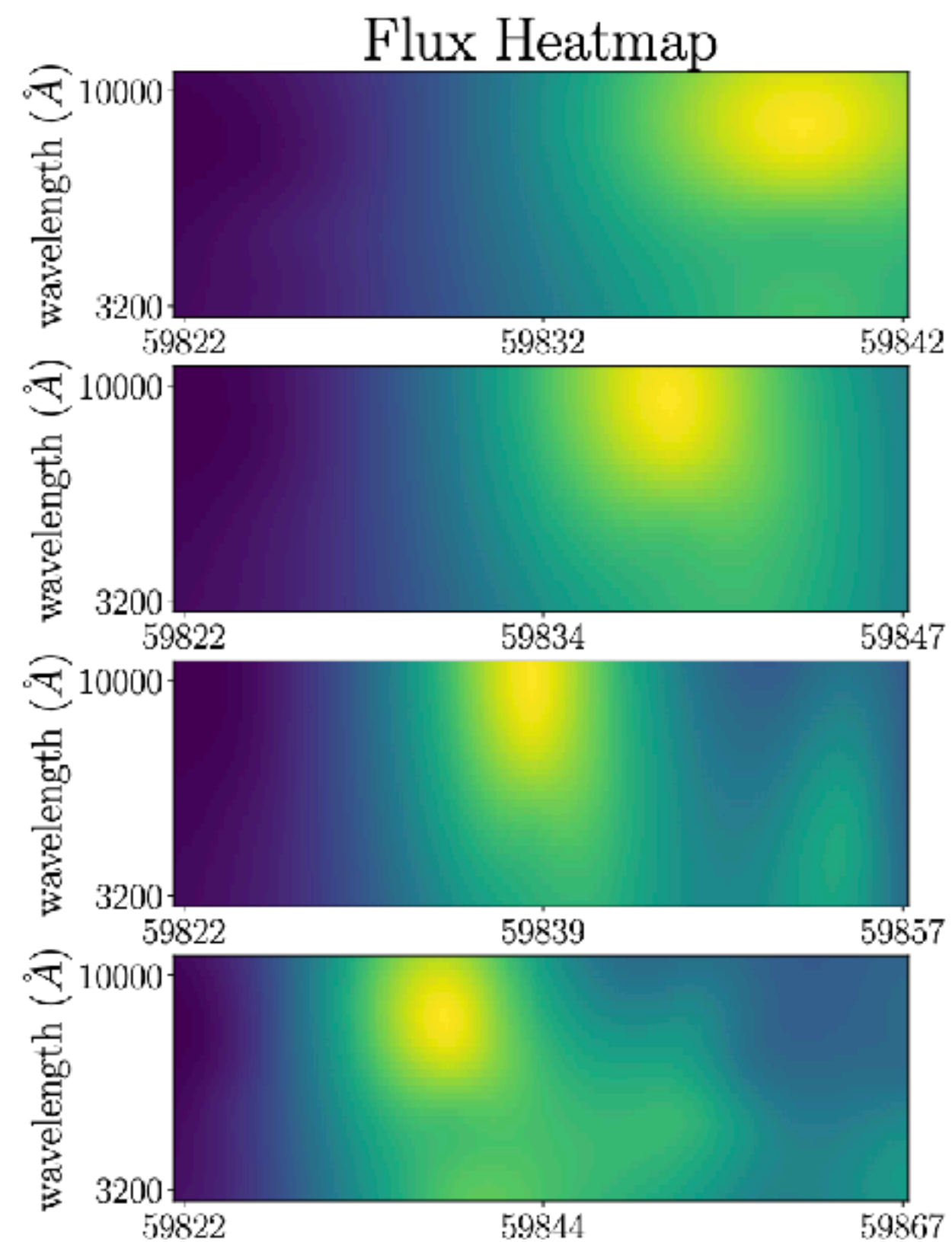
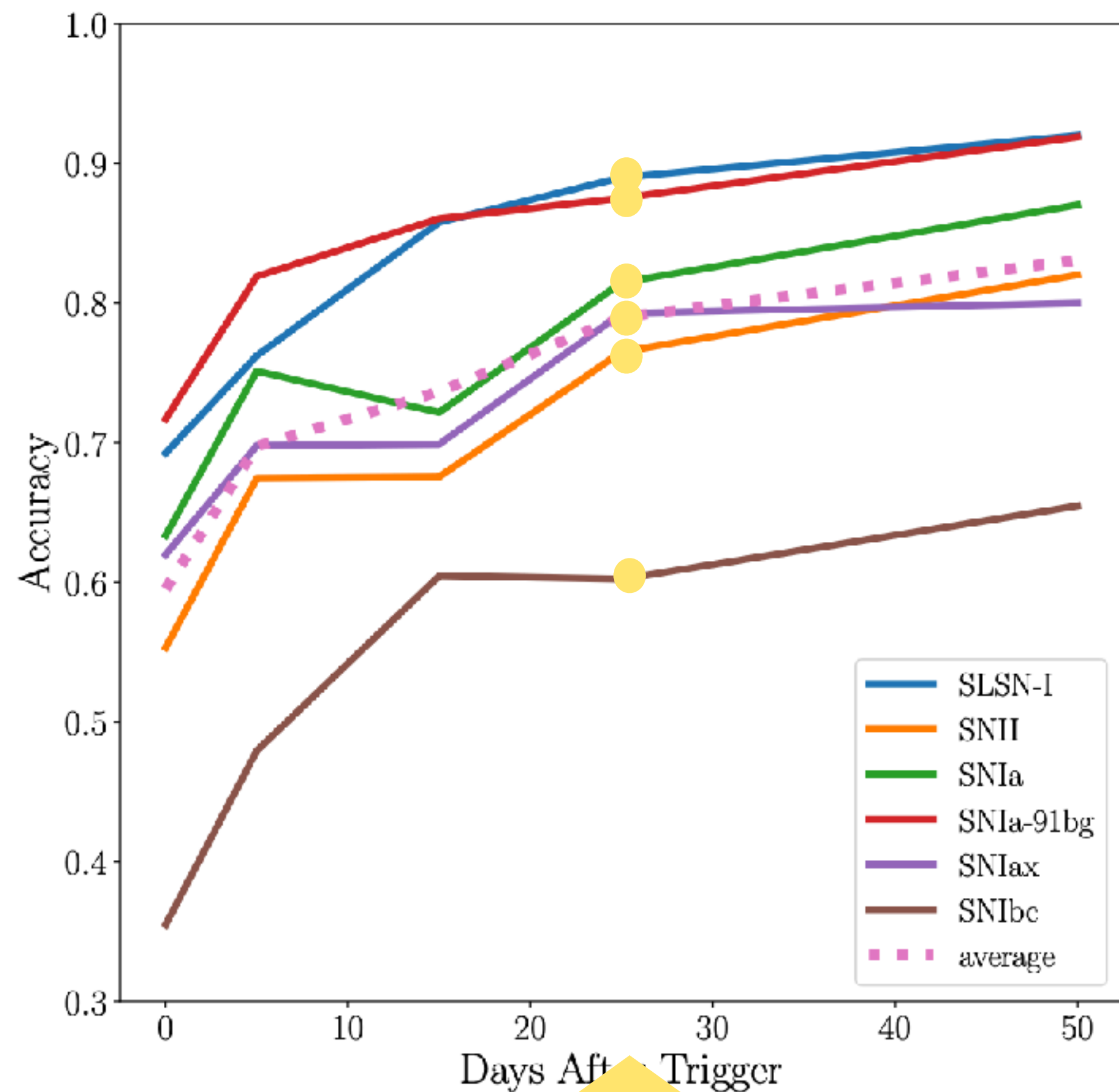
5 days
after trigger

15 days
after trigger



Core Collapse Astrophysics

Early-time SN typing



0 days
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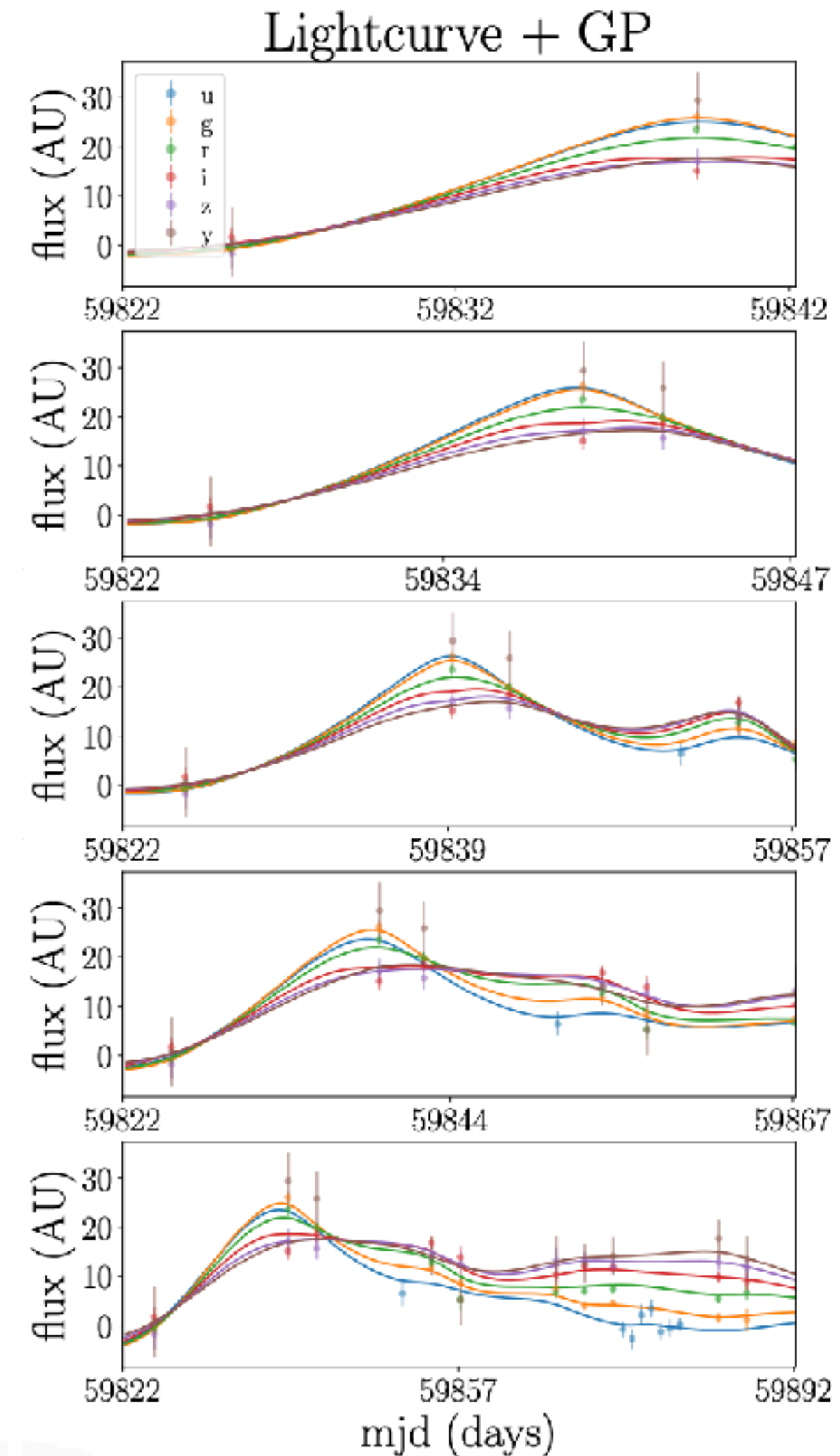
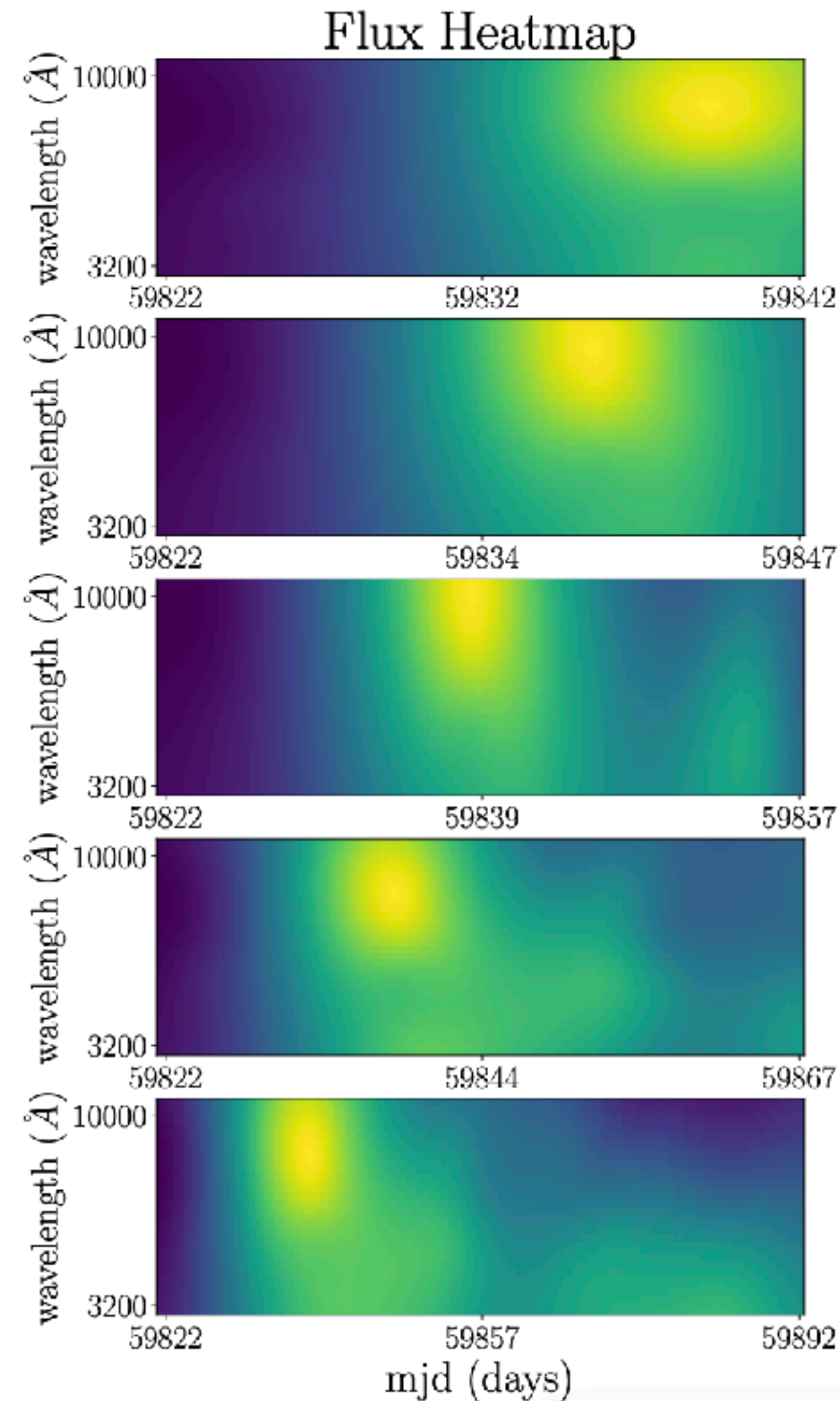
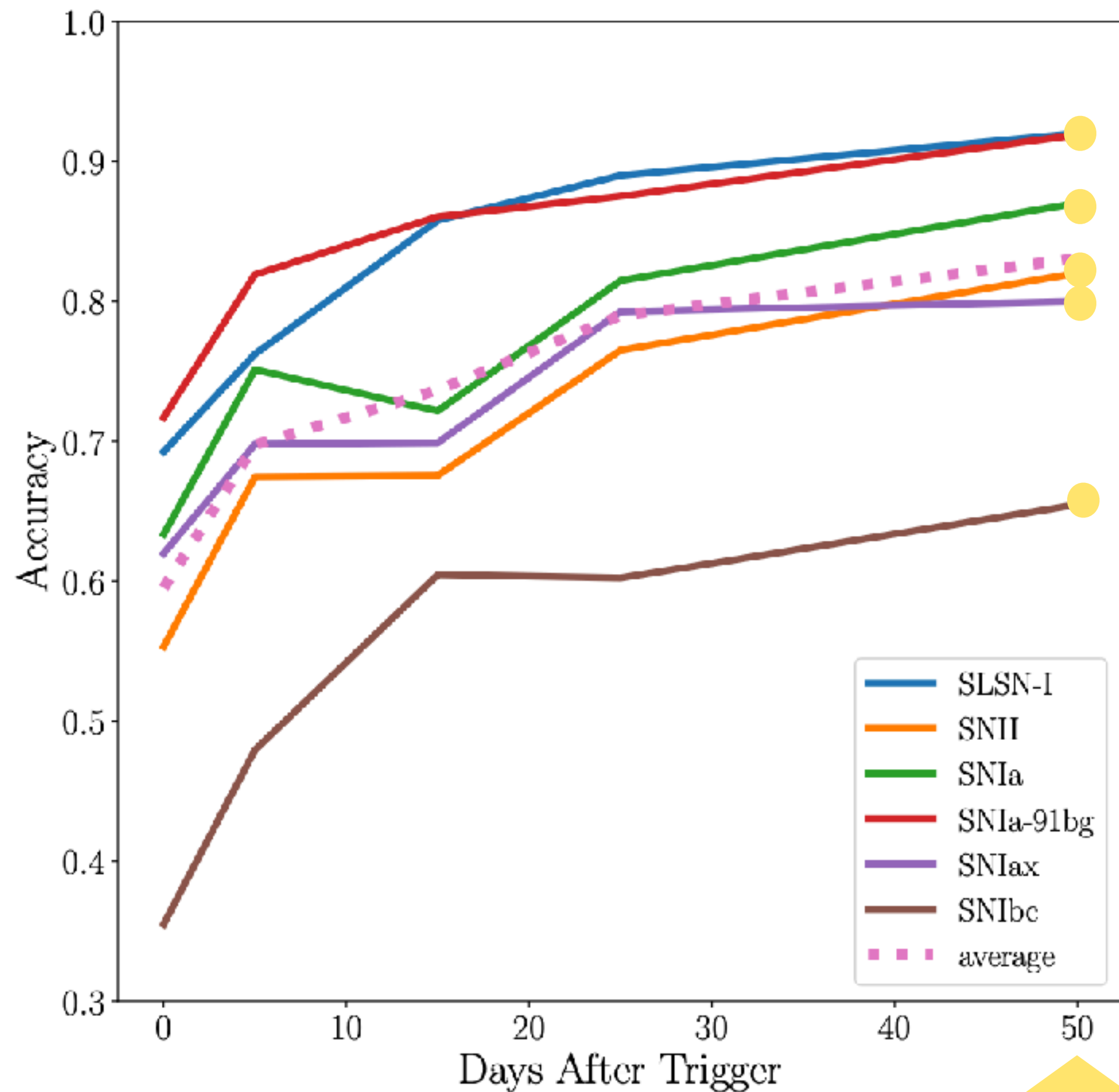
5 days
after trigger

15 days
after trigger

25 days
after trigger

Core Collapse Astrophysics

Early-time SN typing



0 days
after trigger

5 days
after trigger

15 days
after trigger

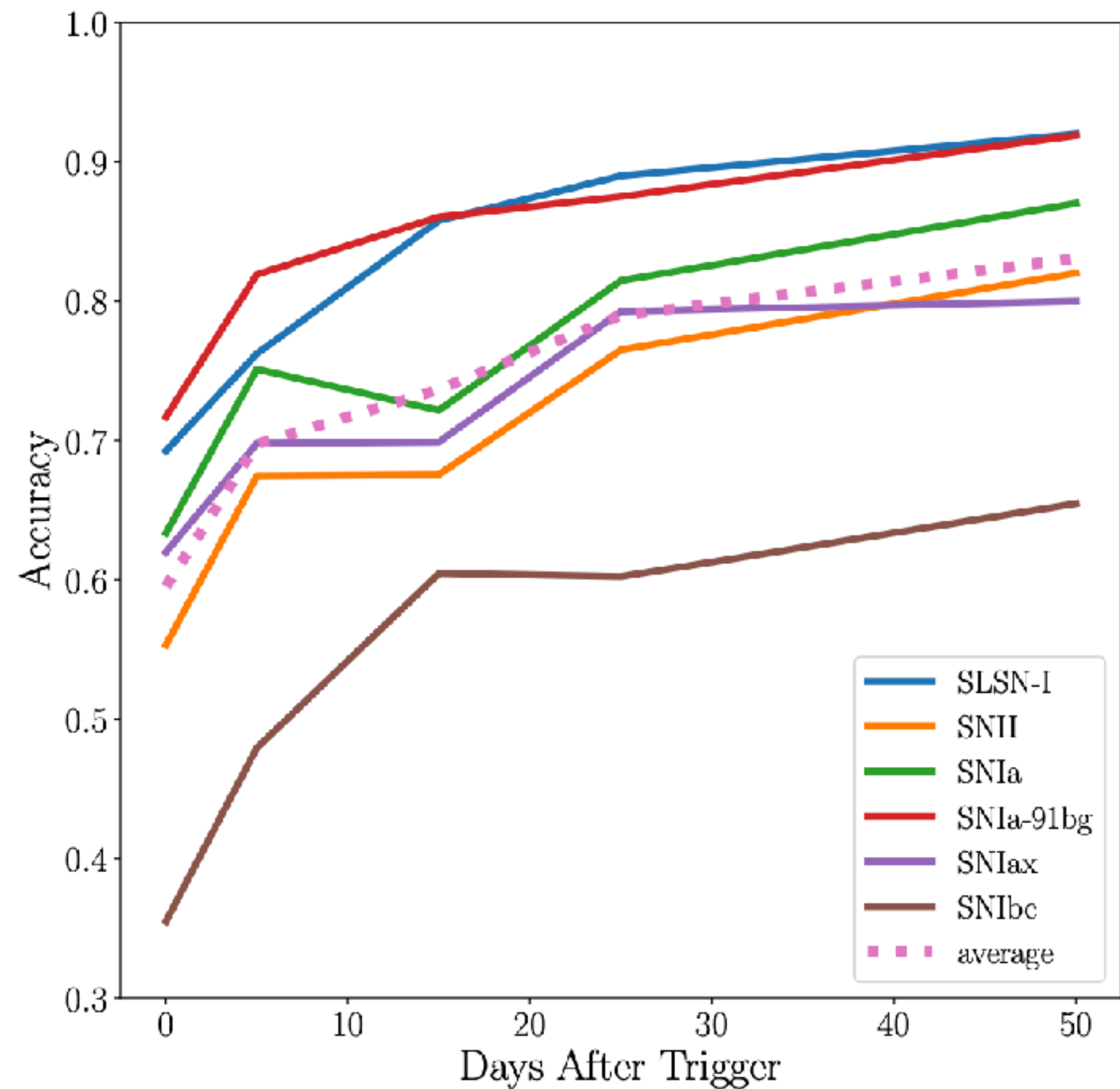
25 days
after trigger

50 days
after trigger

Core Collapse Astrophysics

Early-time SN typing

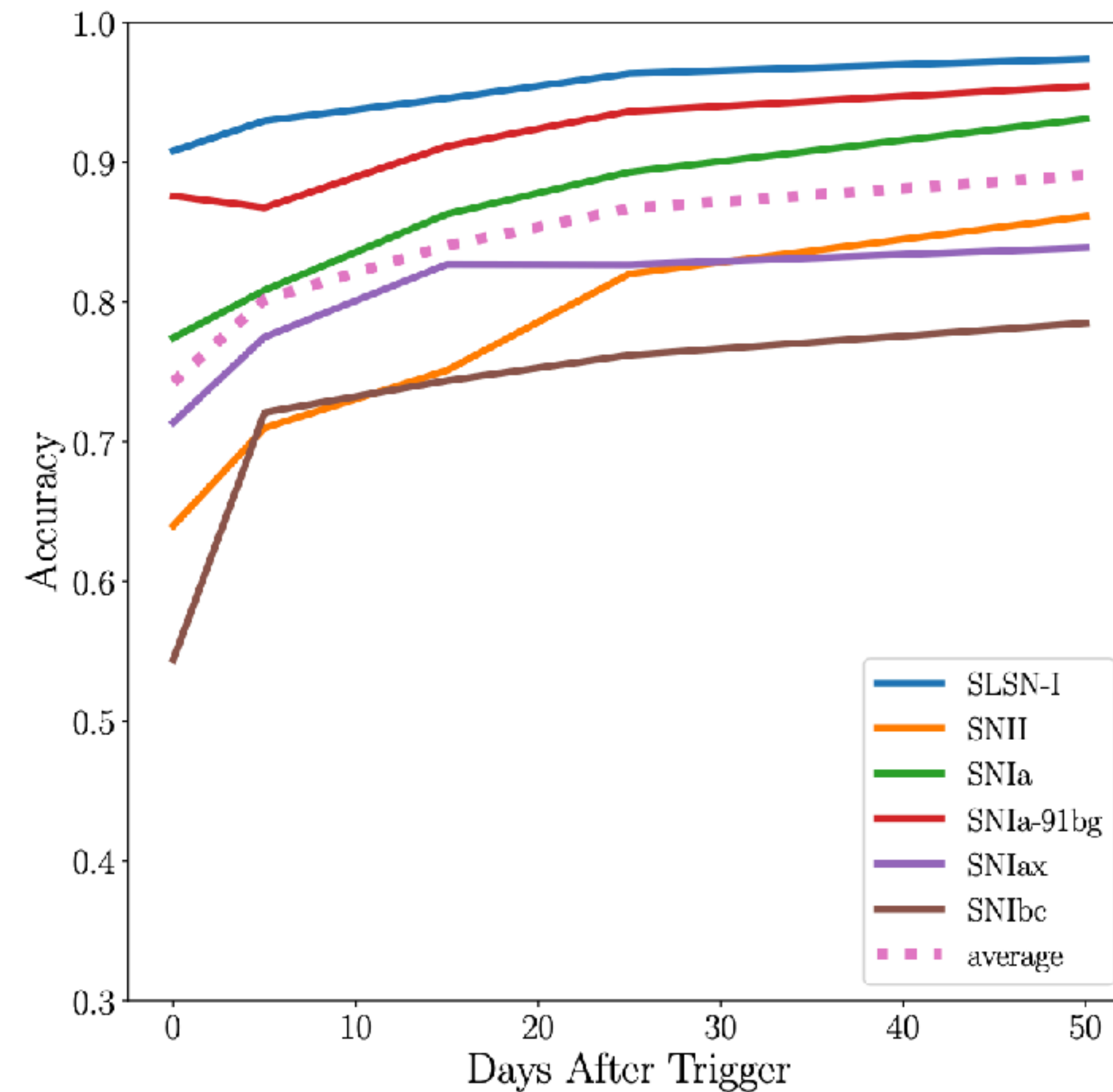
no redshift



+ redshift
information



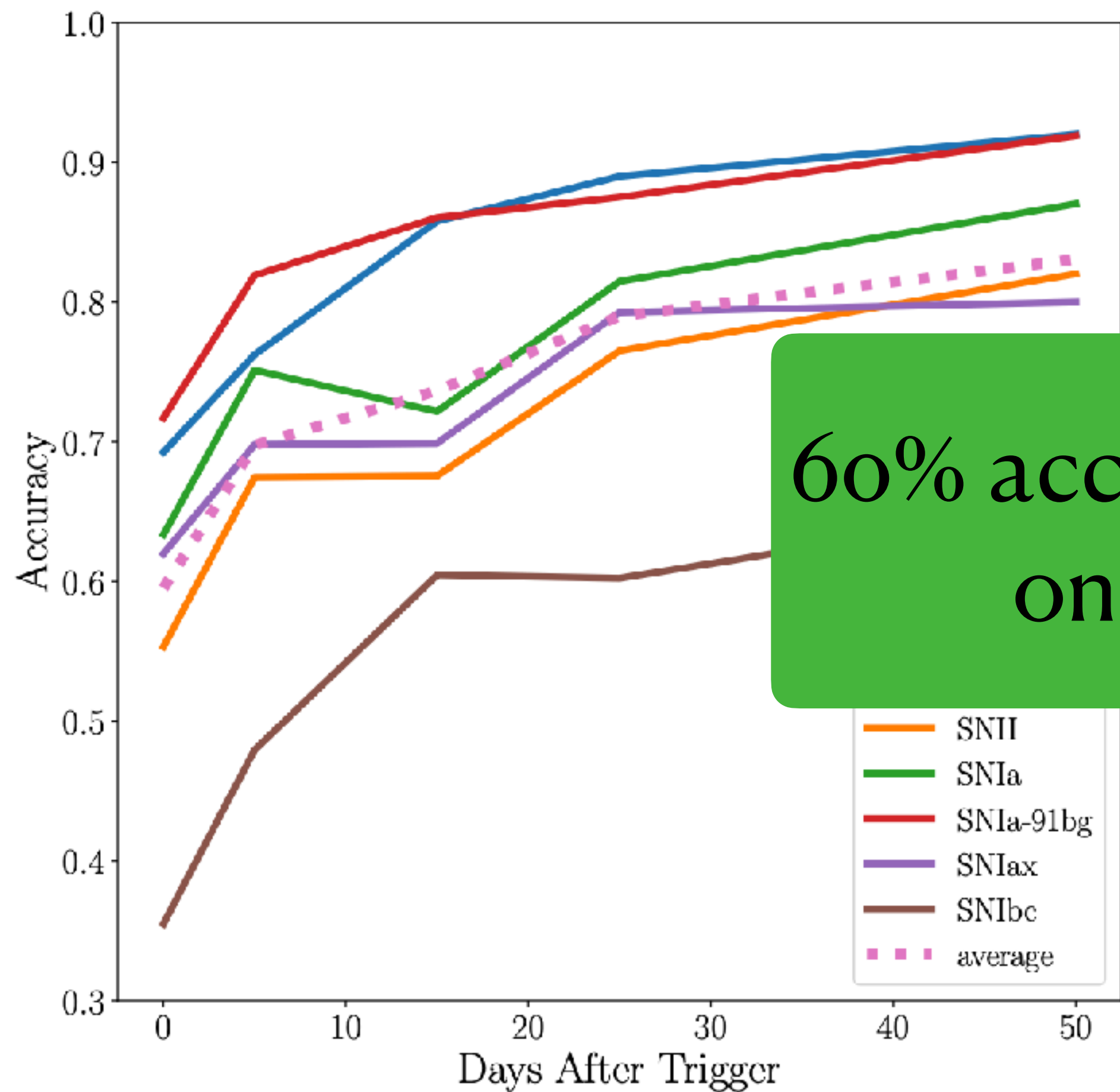
with redshift



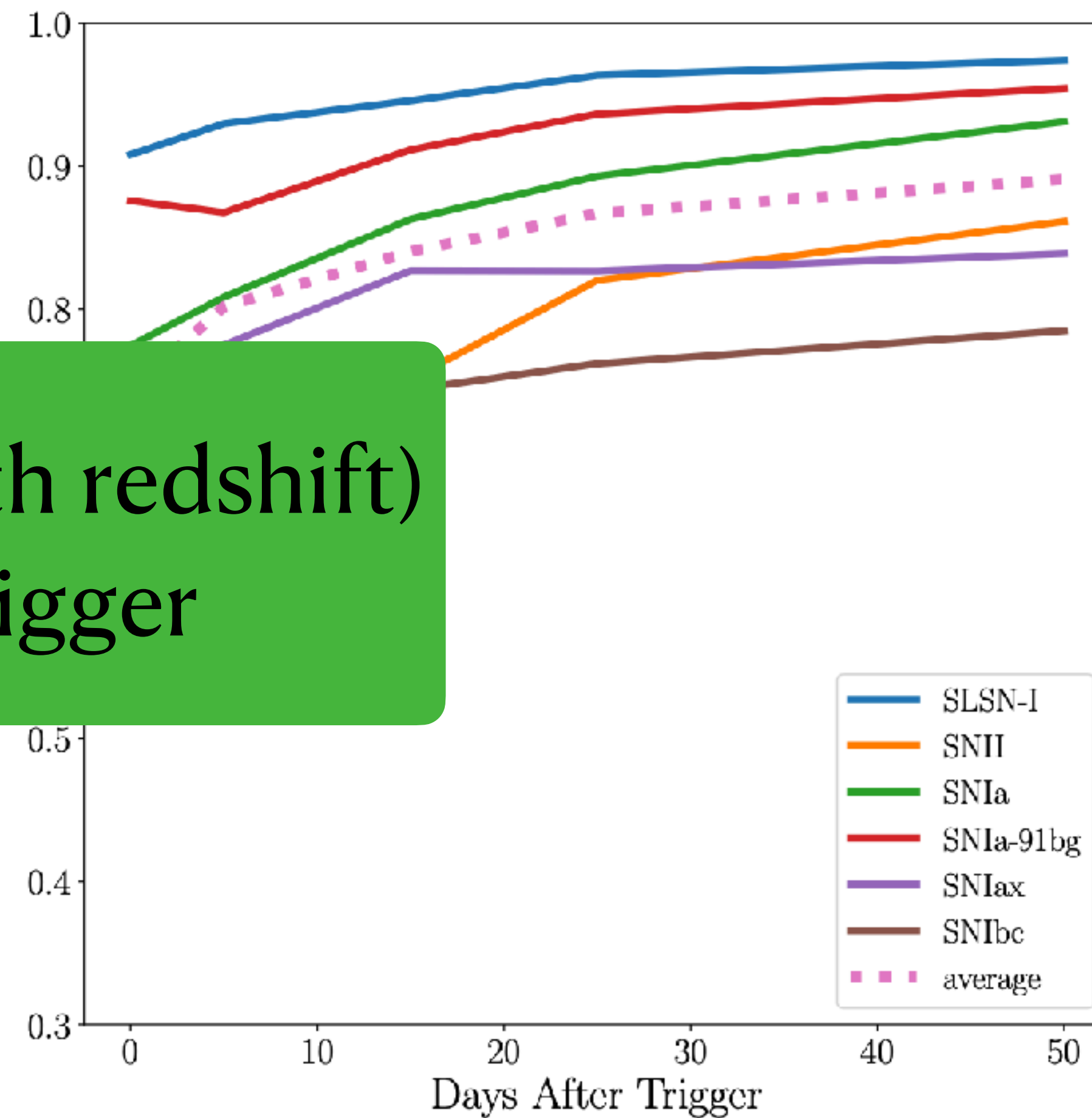
Core Collapse Astrophysics

Early-time SN typing

no redshift



with redshift

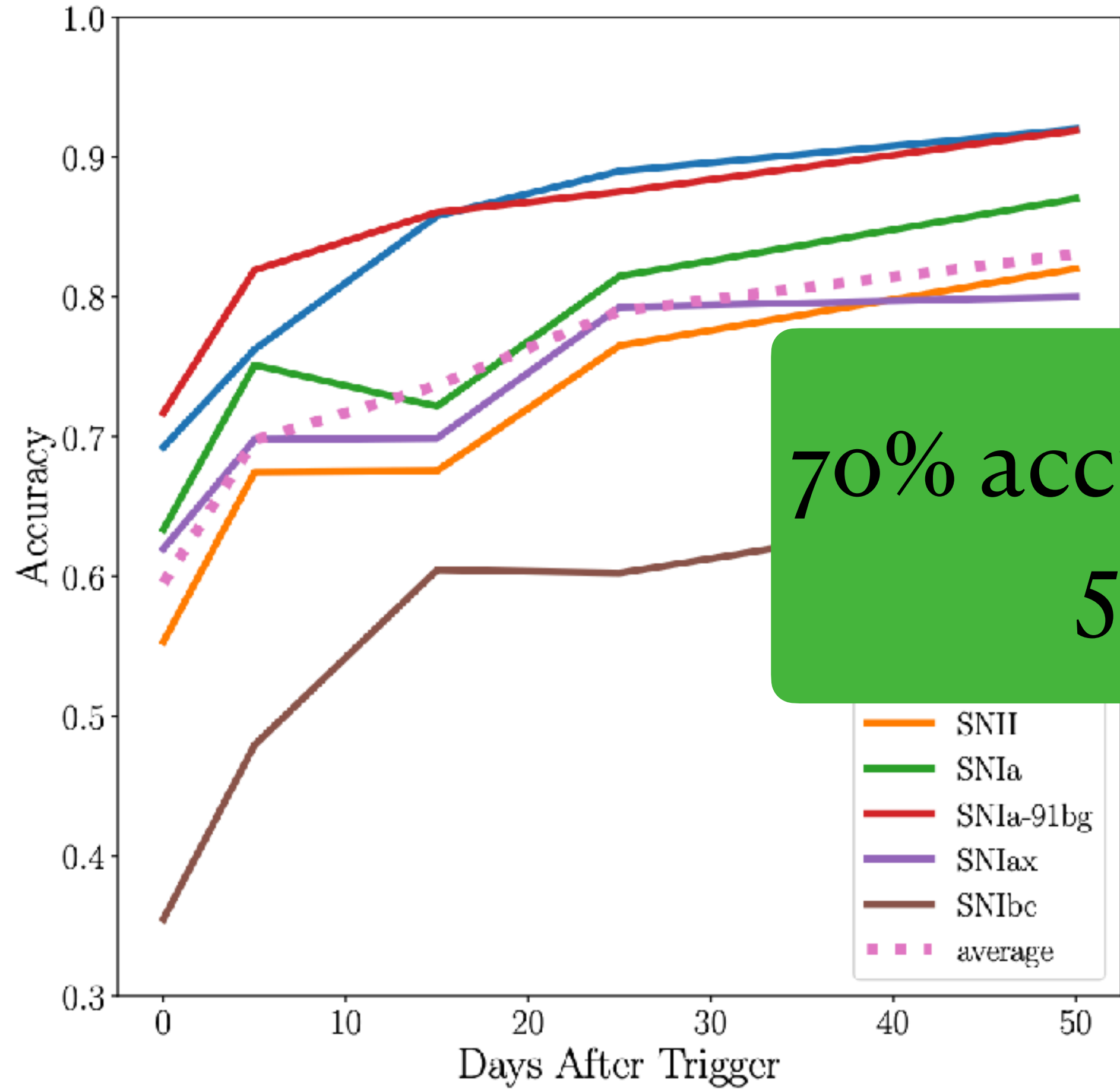


60% accuracy (75% with redshift)
on the night of trigger

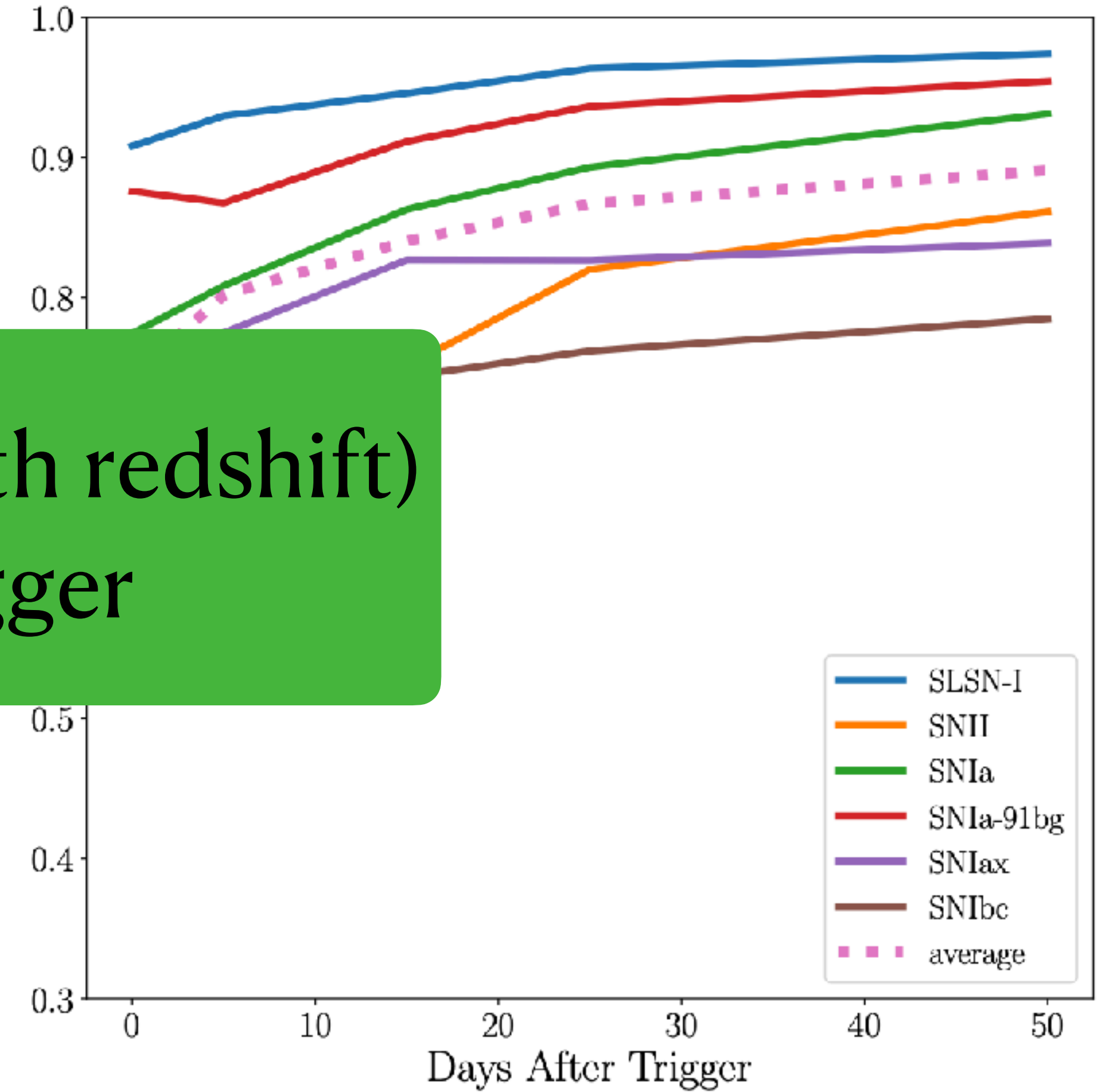
Core Collapse Astrophysics

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no redshift



with redshift

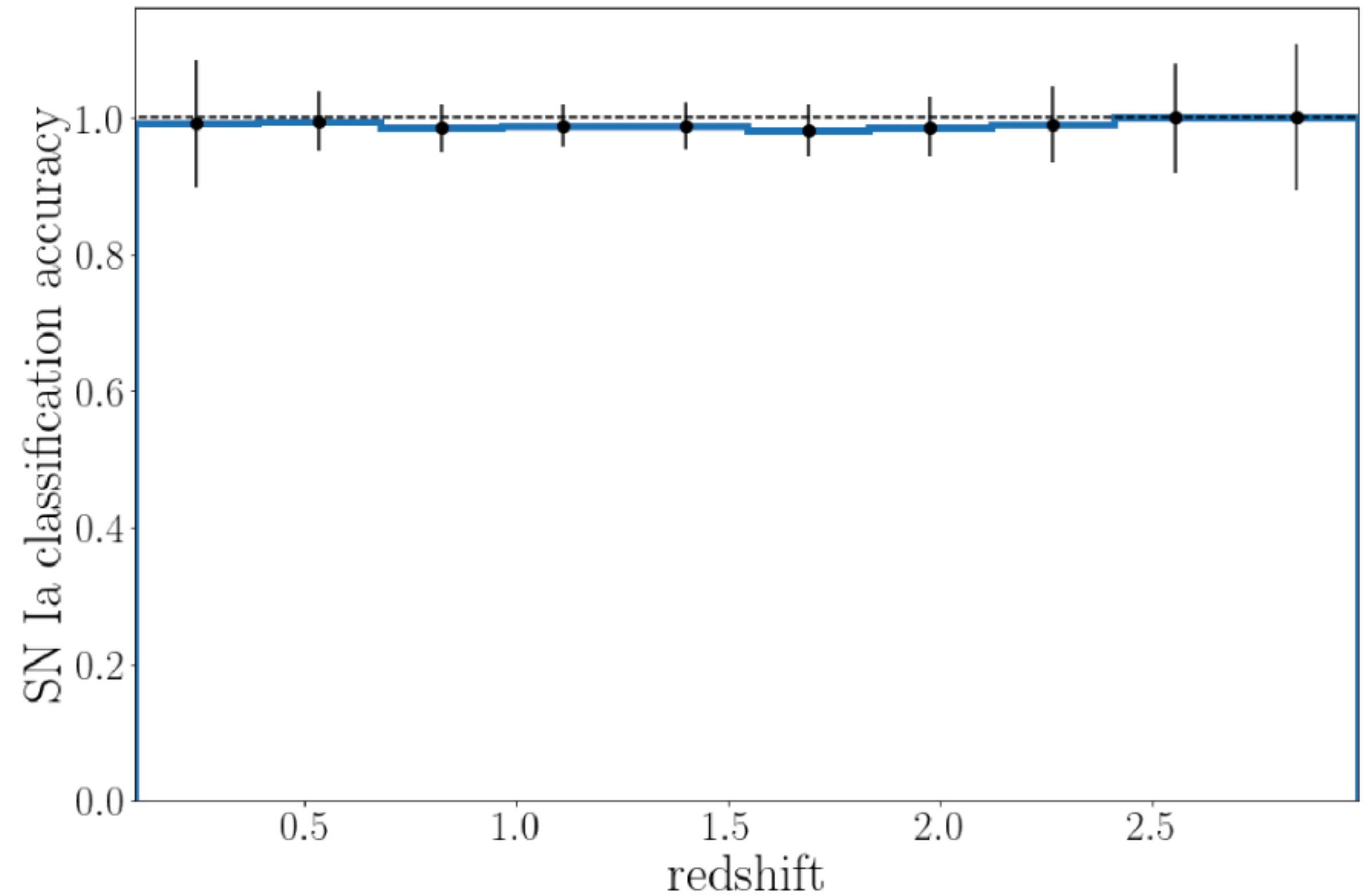


70% accuracy (80% with redshift)
5 days after trigger

Roman SNIa Classification

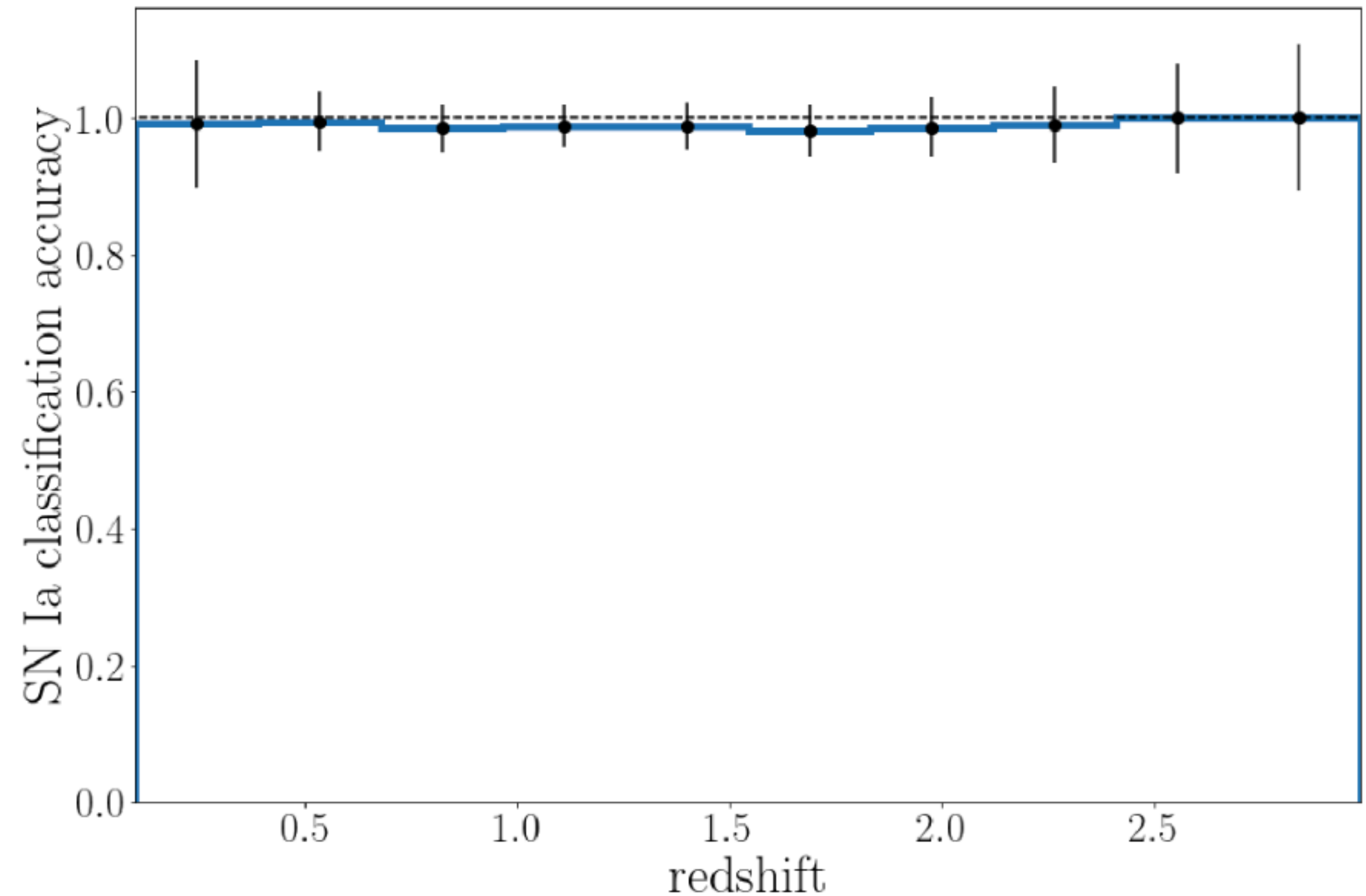
Roman SNIa Classification

- Simulated Roman shallow + deep photometry



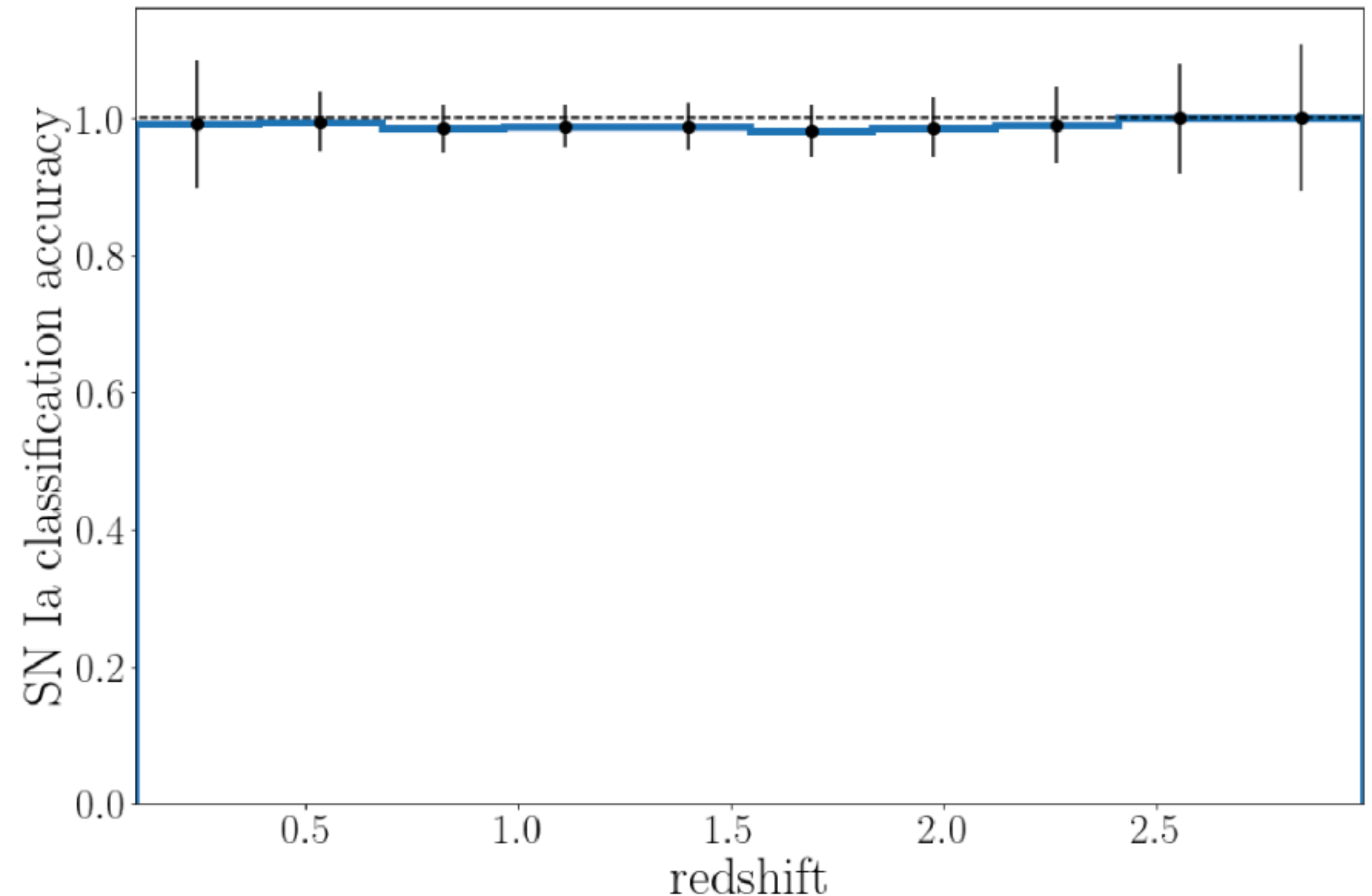
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- Simulated Roman shallow + deep photometry
- Contaminants: realistic mixture of peculiar SNIa and core collapse SNe



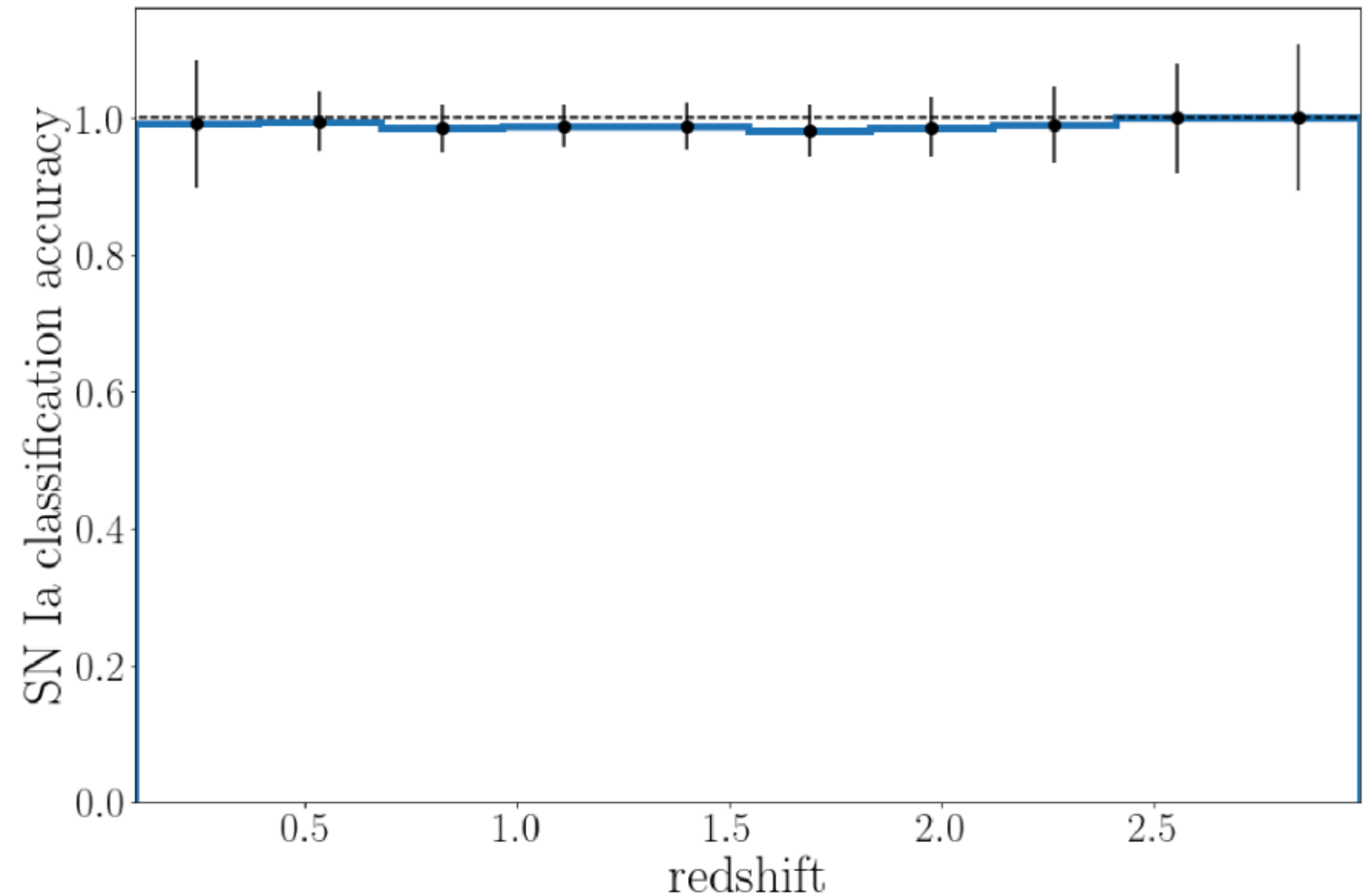
Roman SNIa Classification

- Simulated Roman shallow + deep photometry
- Contaminants: realistic mixture of peculiar SNIa and core collapse SNe
- 98.8 % average SN Ia classification efficiency, 0.8 % core-collapse contamination



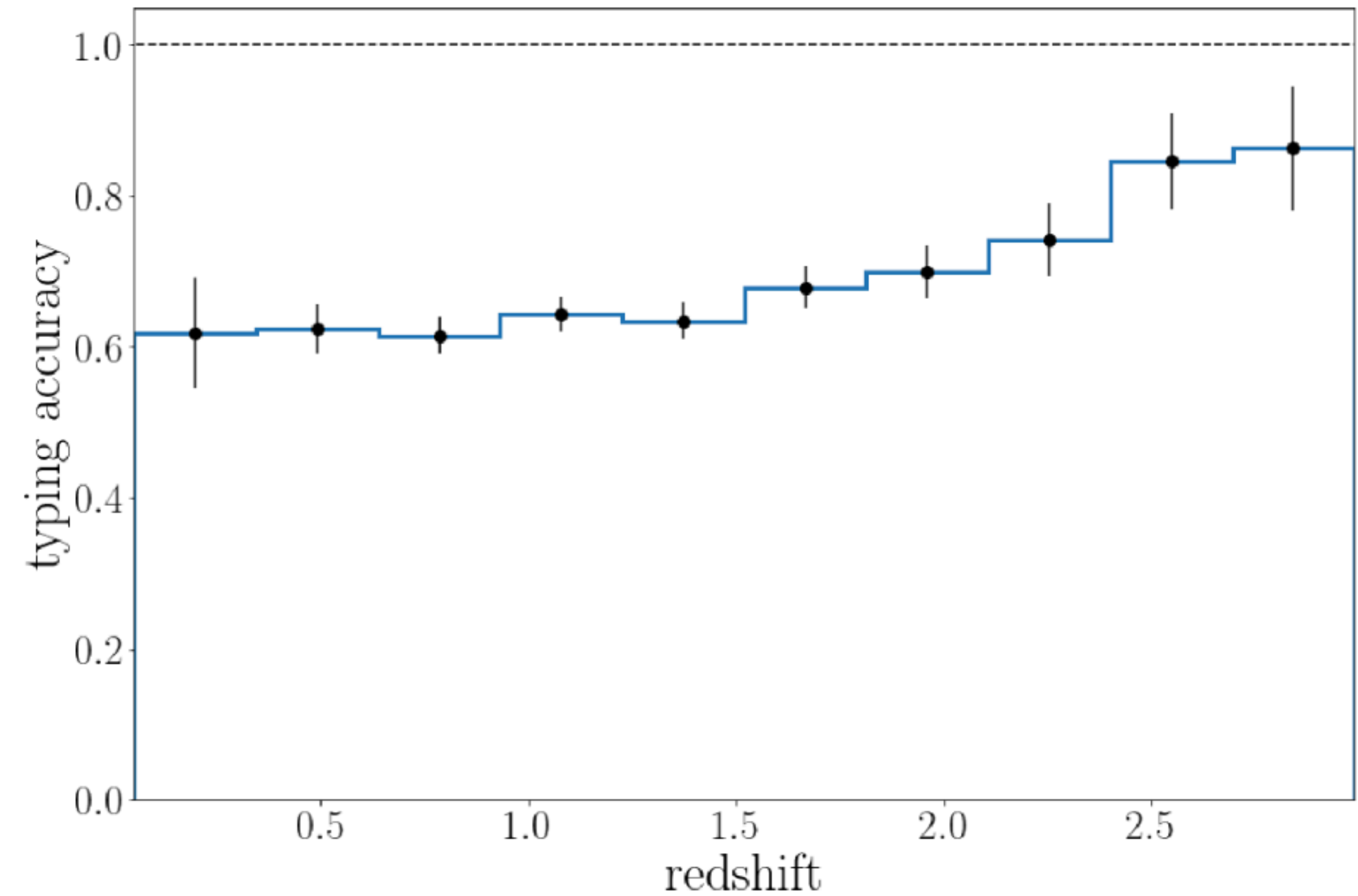
Roman SNIa Classification

- Simulated Roman shallow + deep photometry
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- 98.8 % average SN Ia classification efficiency, 0.8 % core-collapse contamination
- Caveat: results on simulations may not translate exactly to real data



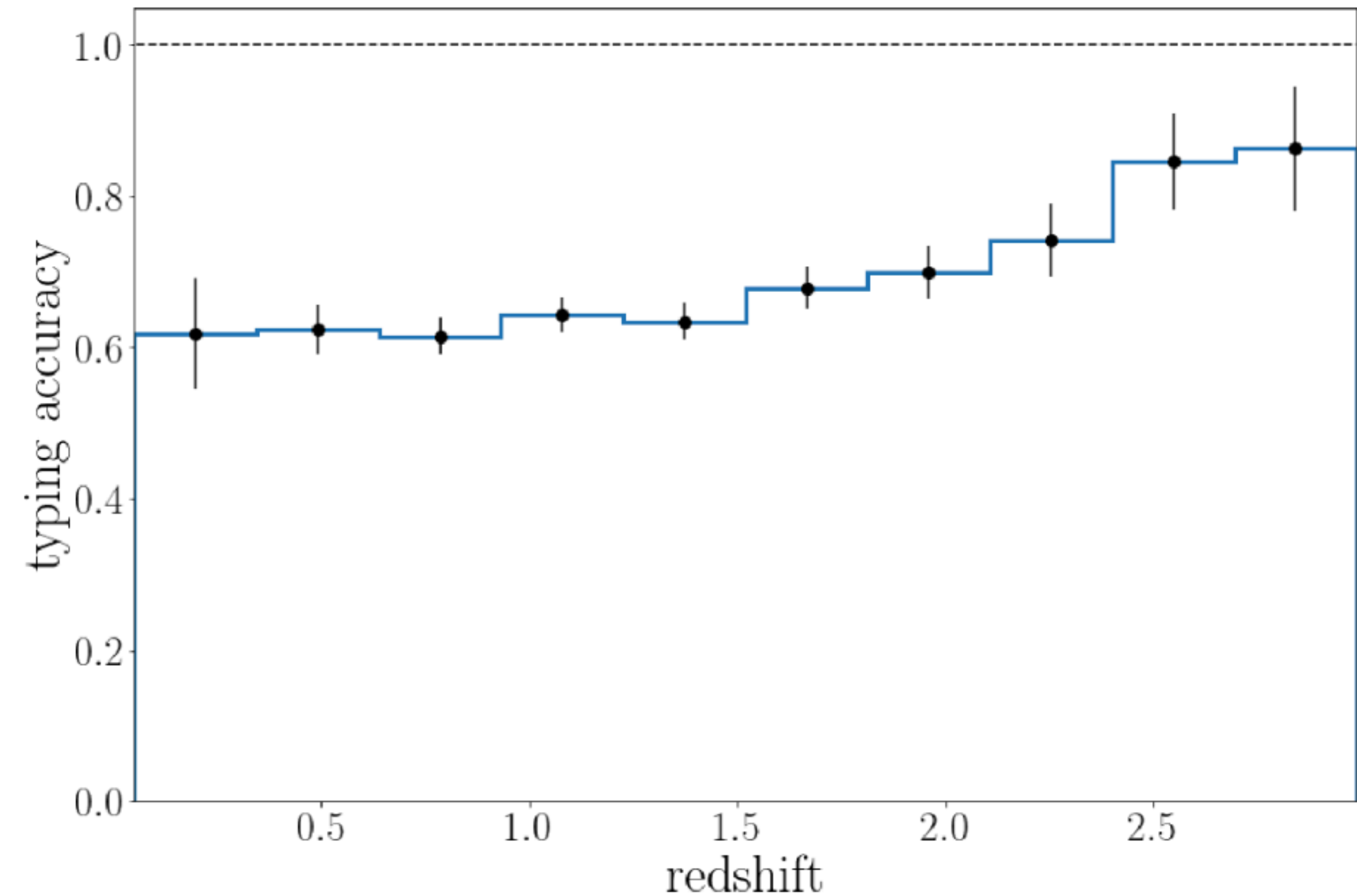
Early-Time Roman SN Classification

- Photometric typing of 6 SN types up to 5 days after trigger



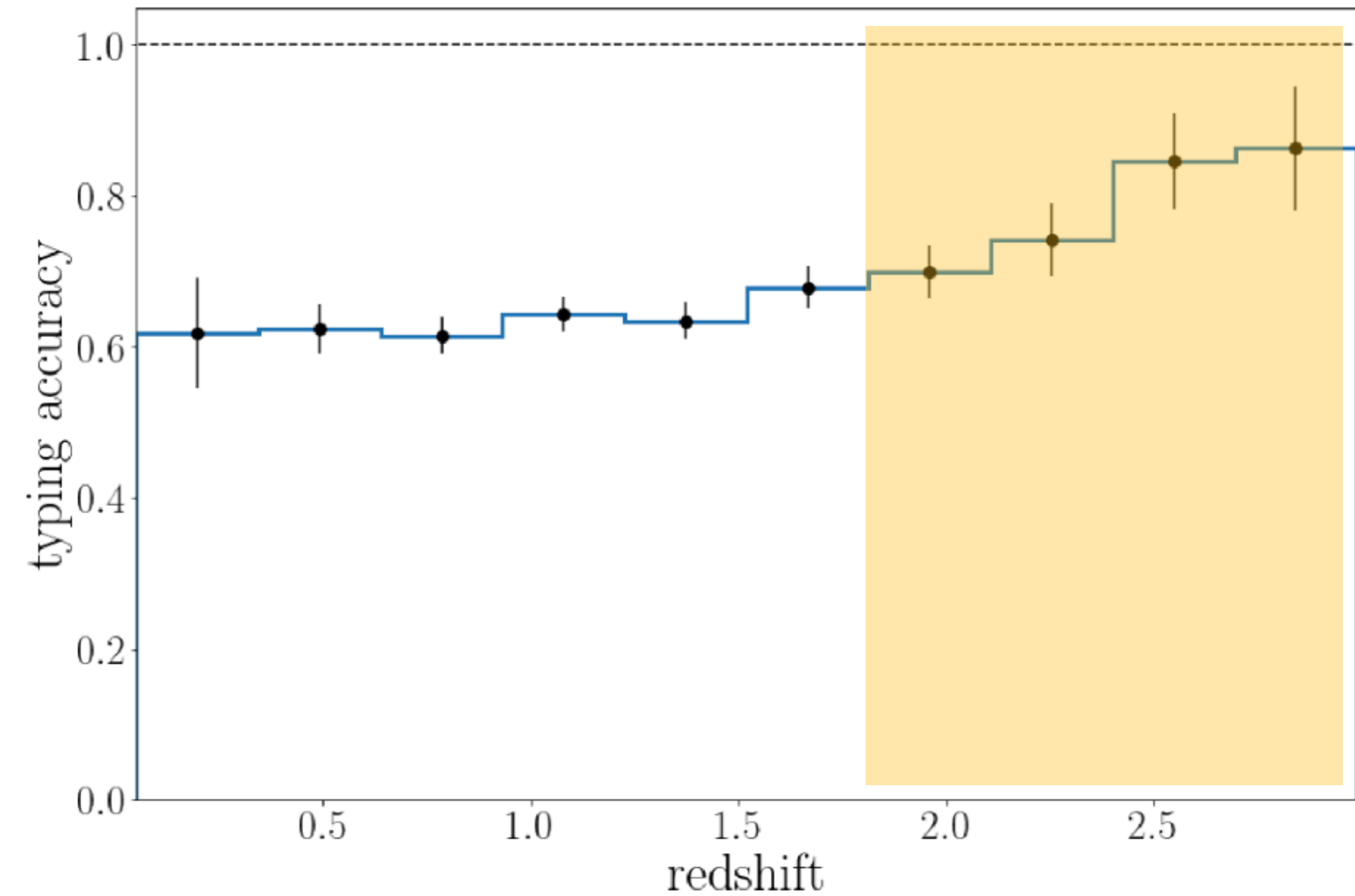
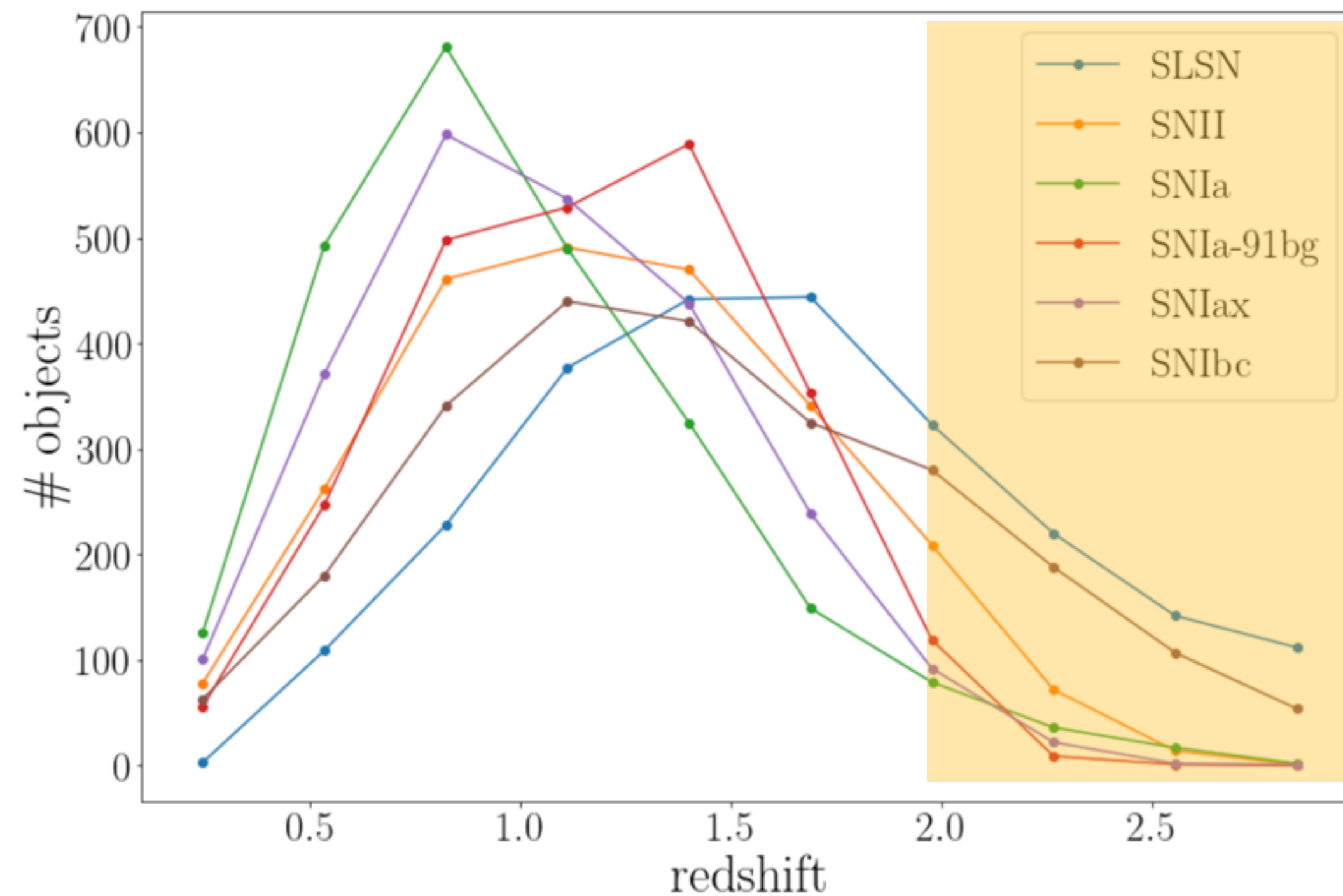
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Summary

SCONE: image recognition-based classifier that's quick to train

*Type Ia Supernova (SN Ia)
Cosmology*

>**98%** accuracy on LSST and Roman simulations

Qu et al., AJ, 2021

*Core Collapse (CC)
Astrophysics*

5 days after trigger:

- **80%** 6-way typing accuracy
- **70%** without redshift

Qu et al., AJ, 2022