Spectro-photometric templates of Core Collapse Supernovae

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On behalf of: Rob Firth, Natasha Karpenka,
Charlotte Angus, Mark Sullivan

Why core collapse templates?

Transients in LSST - Science goals

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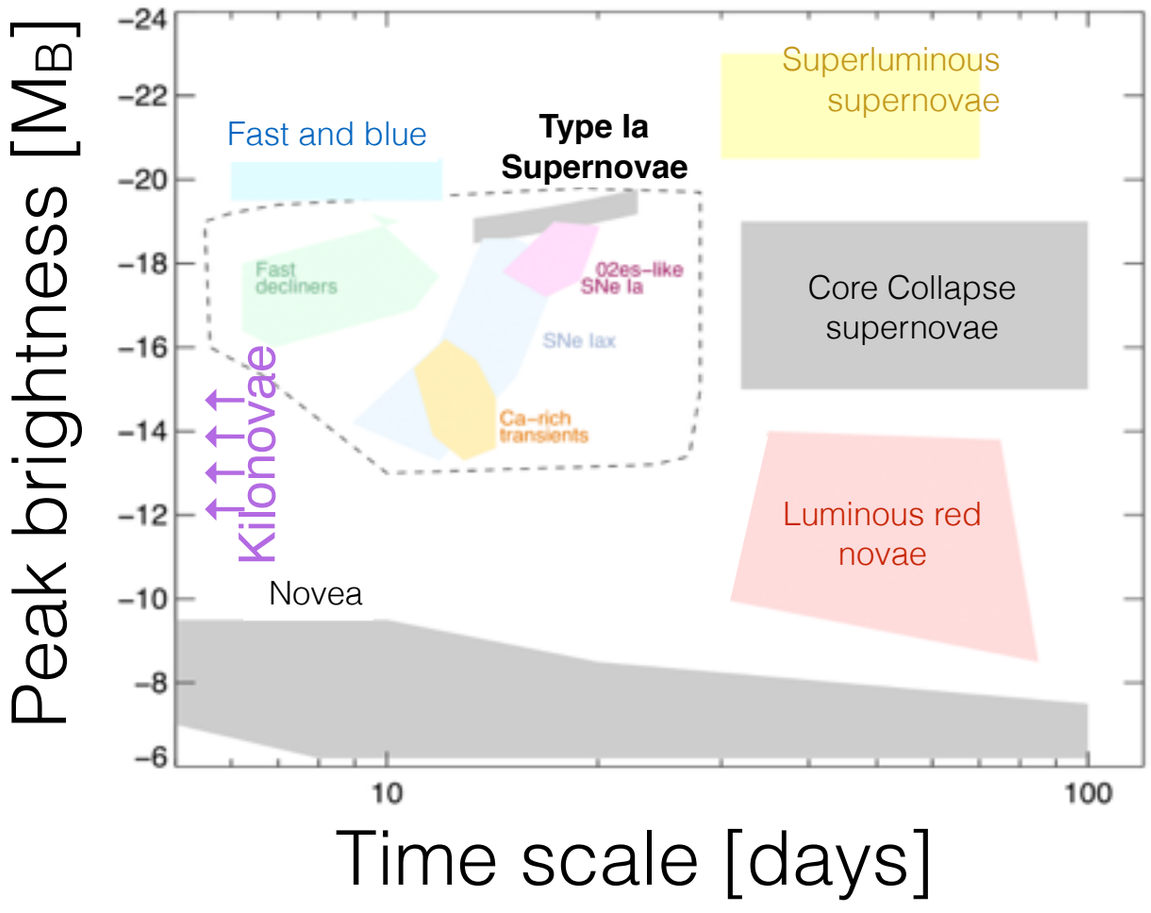
Transients Astrophysics and discovery



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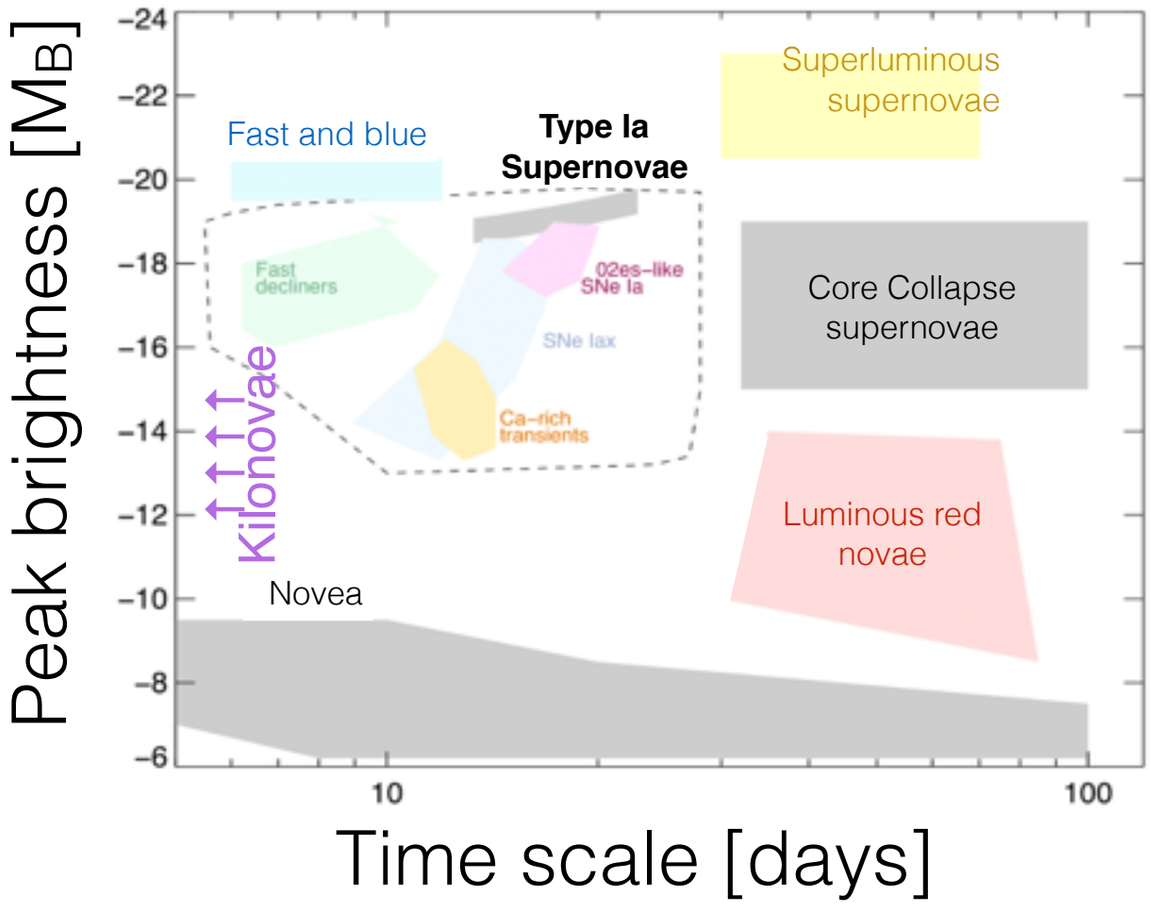

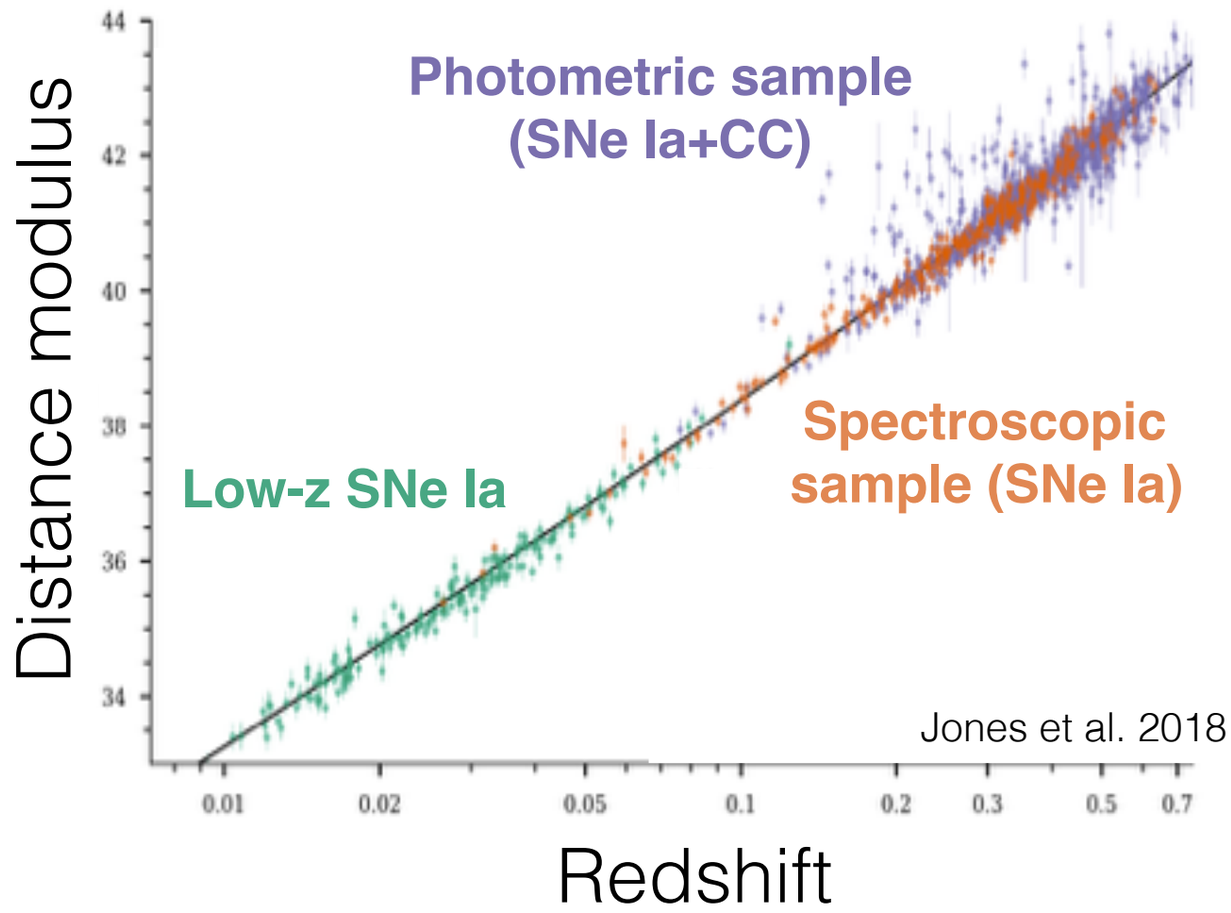

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Challenges

Why core collapse templates?

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Transients Astrophysics and discovery	Type Ia Supernovae Cosmology

Challenges

Identify interesting/new transients	Best strategy for spectroscopic follow-up

10^6 transient alerts per night…

What's the best strategy to find what we want?

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Identify interesting/new transients

Best strategy for spectroscopic follow-up

Identify Type Ia Supernovae

Control/model systematics (e.g. contamination)

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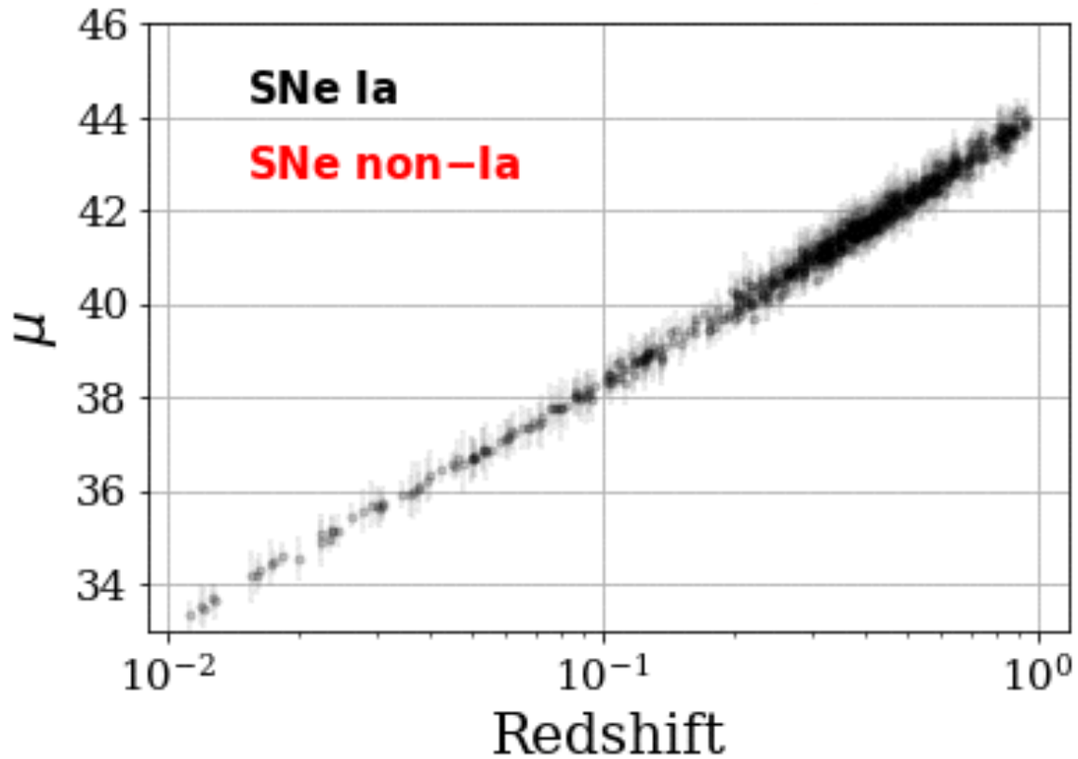
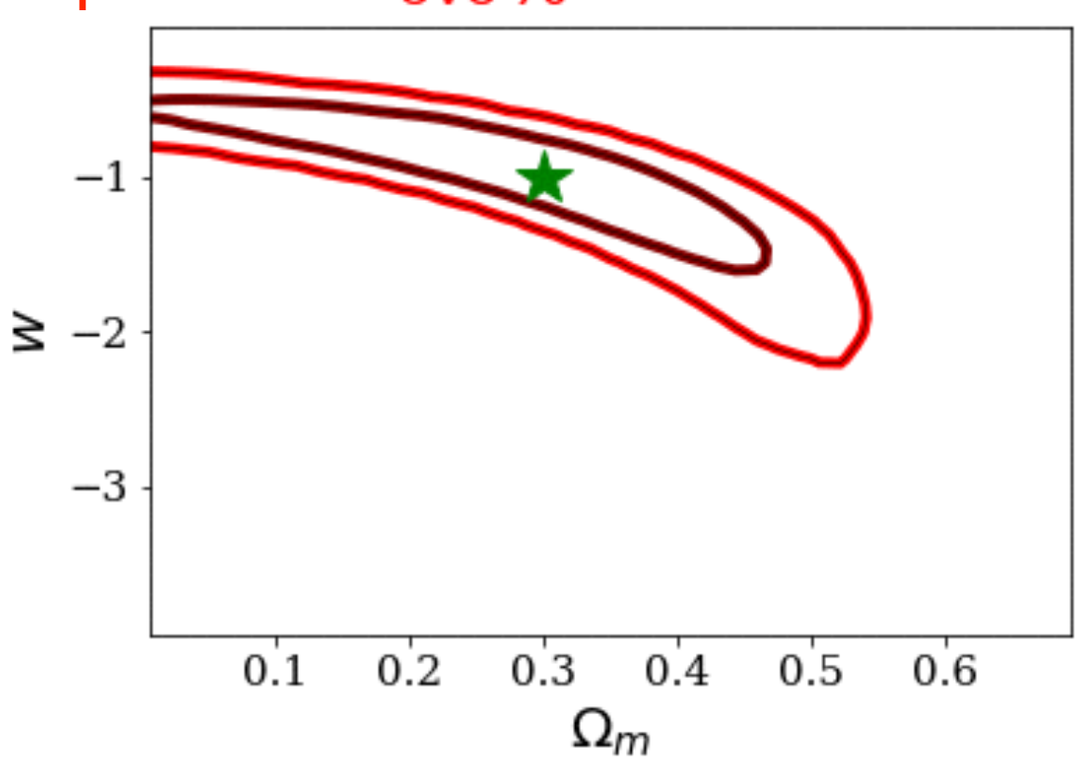
Challenges

Identify interesting/new transients	Best strategy for spectroscopic follow-up	Identify Type Ia Supernovae	Control/model systematics (e.g. contamination)

Contamination from Core Collapse SNe: 0.0%





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“Work in progress” solutions…

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Develop algorithms for photometric classification

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Realistic simulations of SNe of multiple types

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Realistic simulations of SNe of multiple types

LSST UK: Phase A

The general “recipe”

Realistic simulations of SNe of multiple types

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Realistic simulations of SNe of multiple types

SNe Ia

➔ Template

➔ Rate

➔ Intrinsic properties
(σ_{int}, stretch, color…)

The general "recipe"

Realistic simulations of SNe of multiple types

SNe Ia	➔ Template ➔ Rate ➔ Intrinsic properties (σ_{int}, stretch, color…)
SNe CC (SNe II, SNe IIb, SNe IIn, SNe Ib, SNe Ic/Ic-BL)	➔ Templates ➔ Rates ➔ Intrinsic properties (Luminosity function)

The general "recipe"

Realistic simulations of SNe of multiple types

SNe Ia

➔ Template

➔ Rate

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(σ_{int}, stretch, color…)

SNe CC

(SNe II, SNe IIb, SNe IIn, SNe Ib, SNe Ic/Ic-BL)

➔ Templates

➔ Rates

➔ Intrinsic properties
(Luminosity function)

70 well observed Core Collapse SNe

⇨

70 new Templates
(SNe II, SNe IIb, SNe IIn, SNe Ib, SNe Ic/Ic-BL)

Core Collapse templates

70 well observed
Core Collapse SNe

Modjaz et al. 2014, Bianco et al. 2014,
Hicken et al. 2017, Taddia et al. 2013…

70 new Templates
(SNe II, SNe IIb, SNe IIn,
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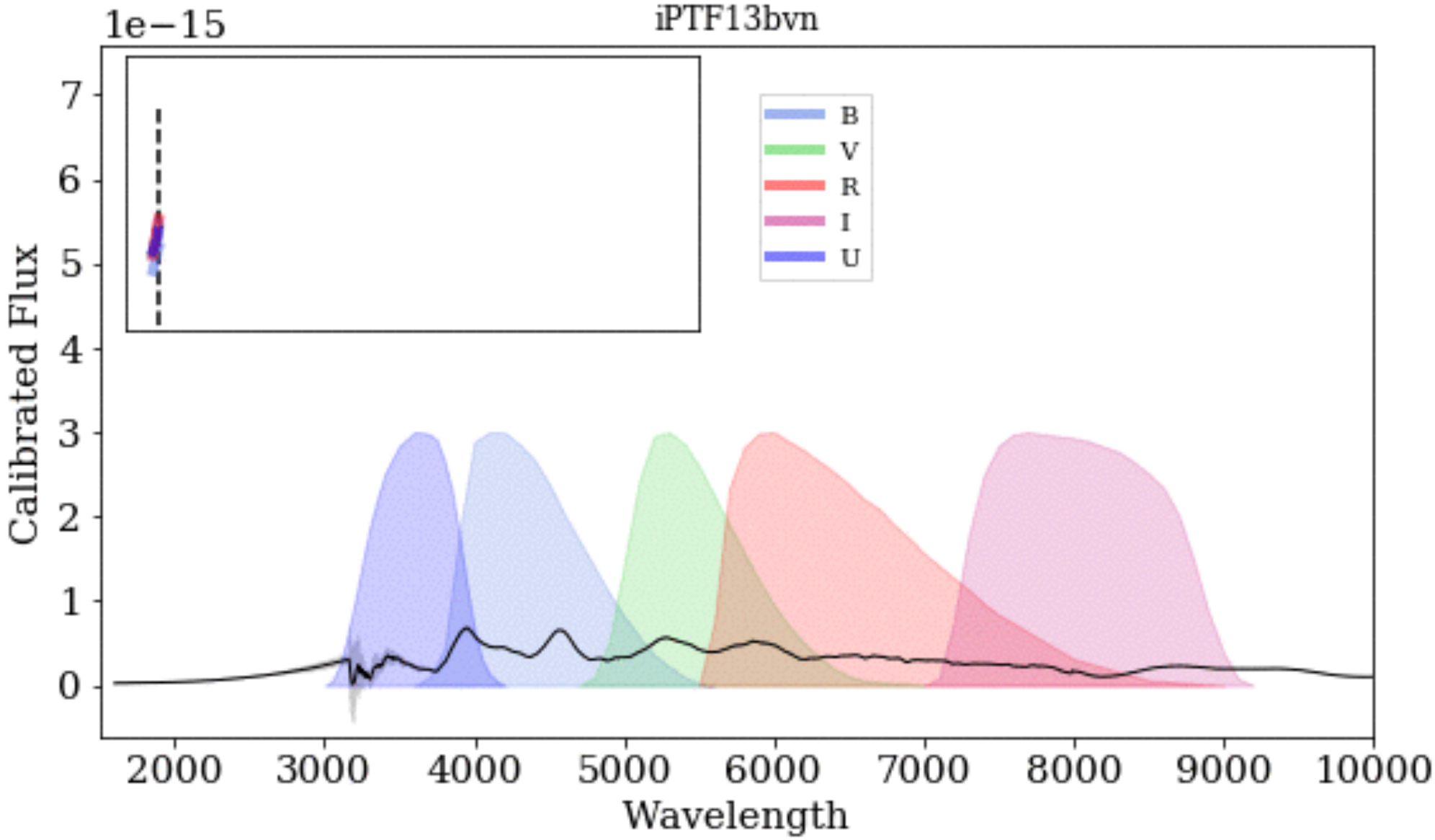
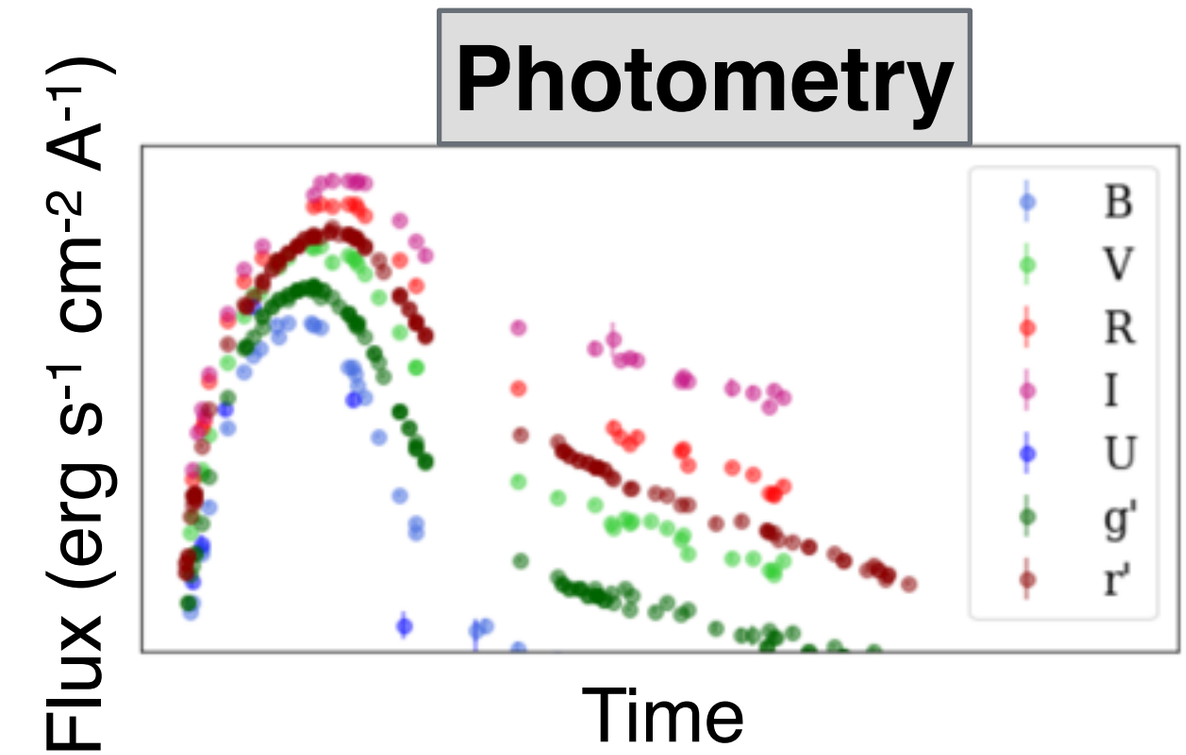


Templates: method



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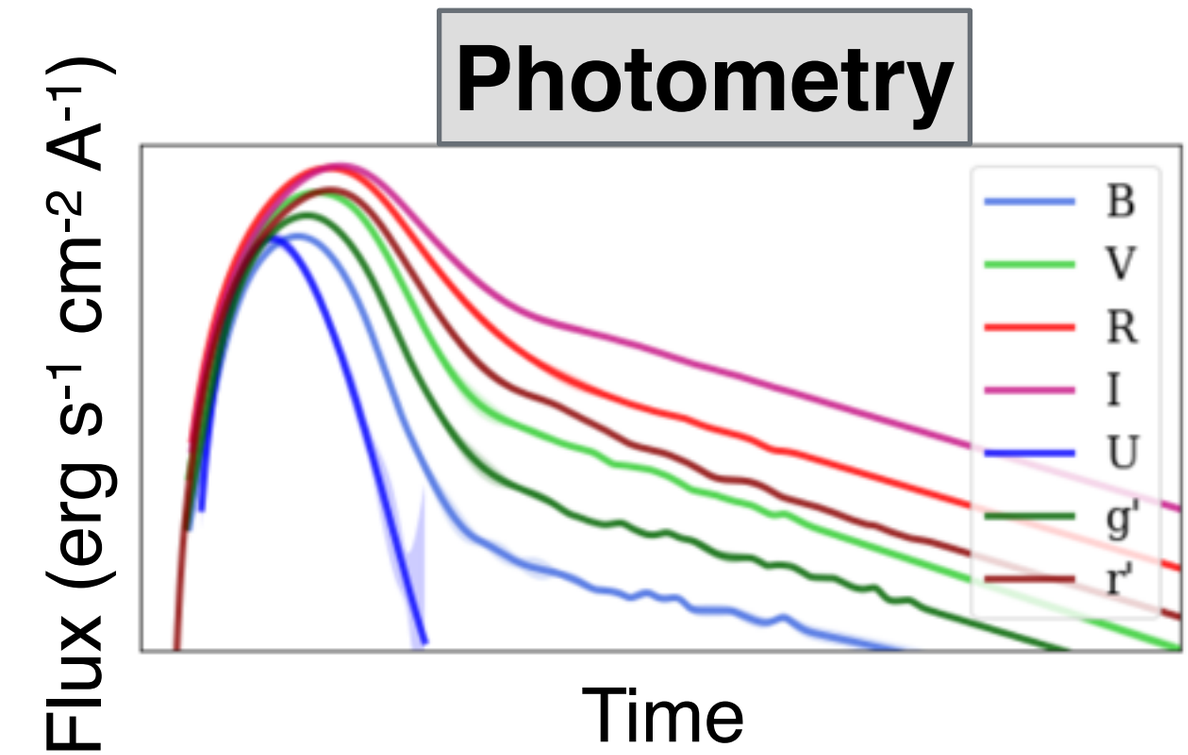
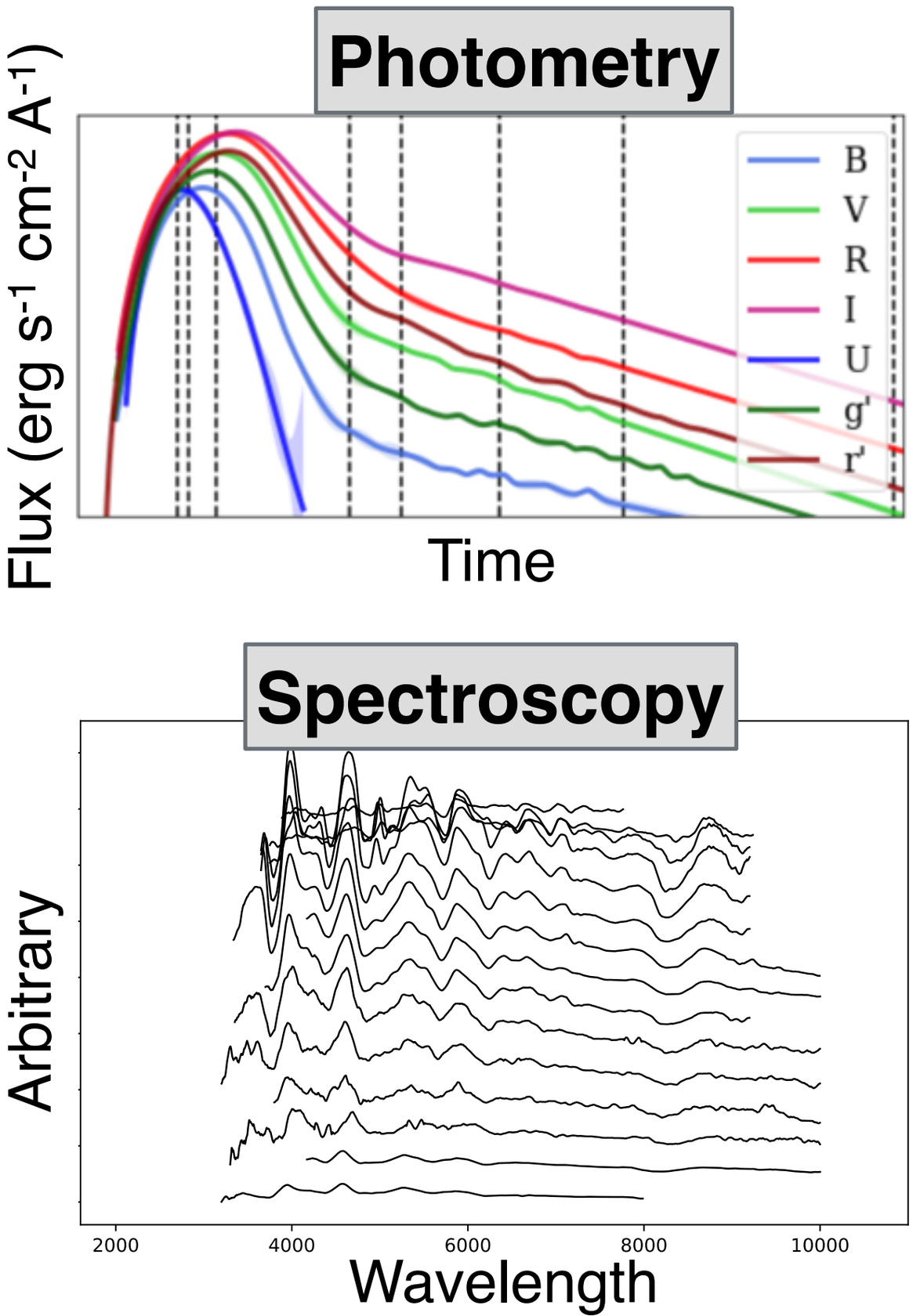


No functional form assumed,

➔ Gaussian processes

Templates: method



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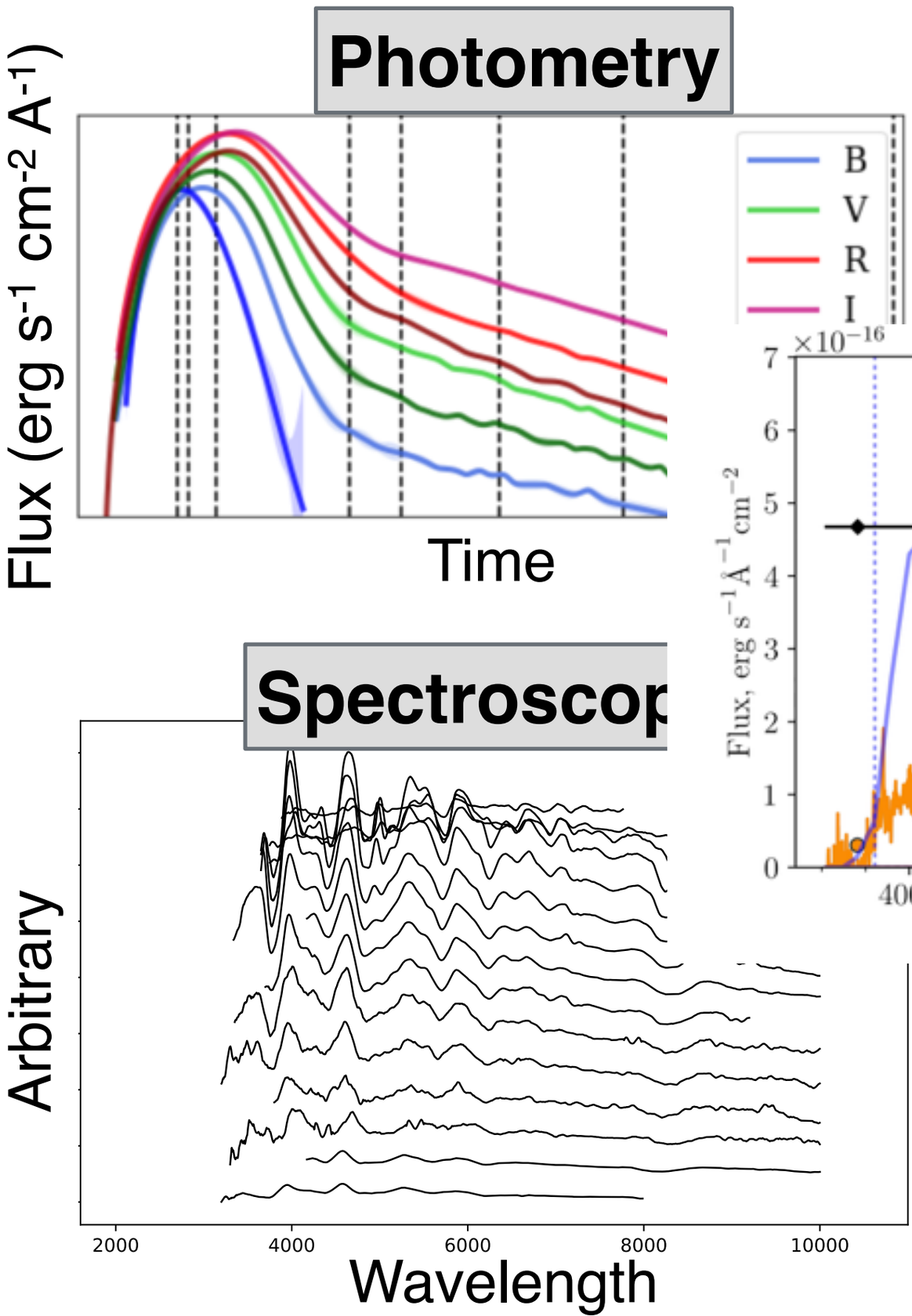
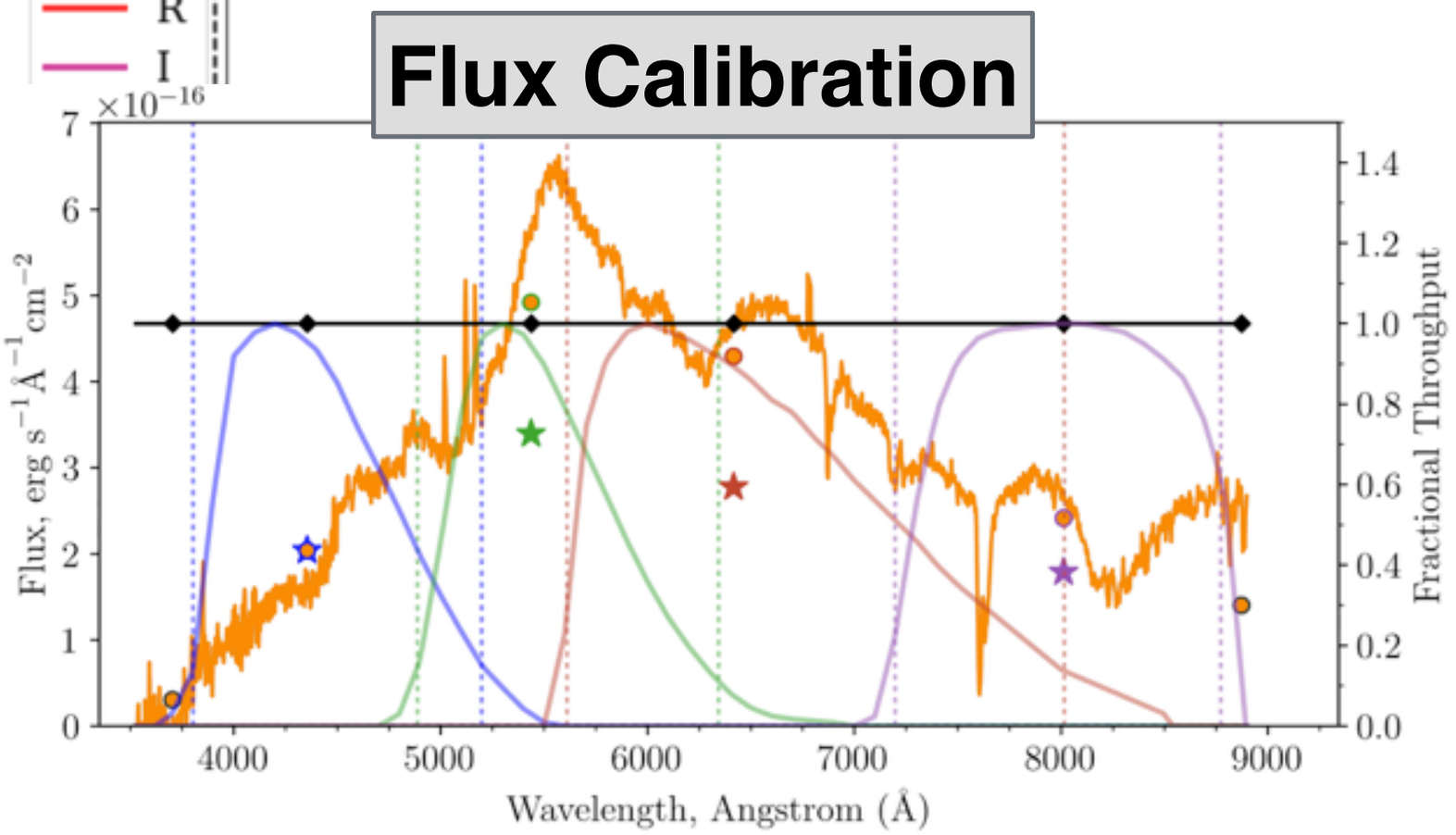
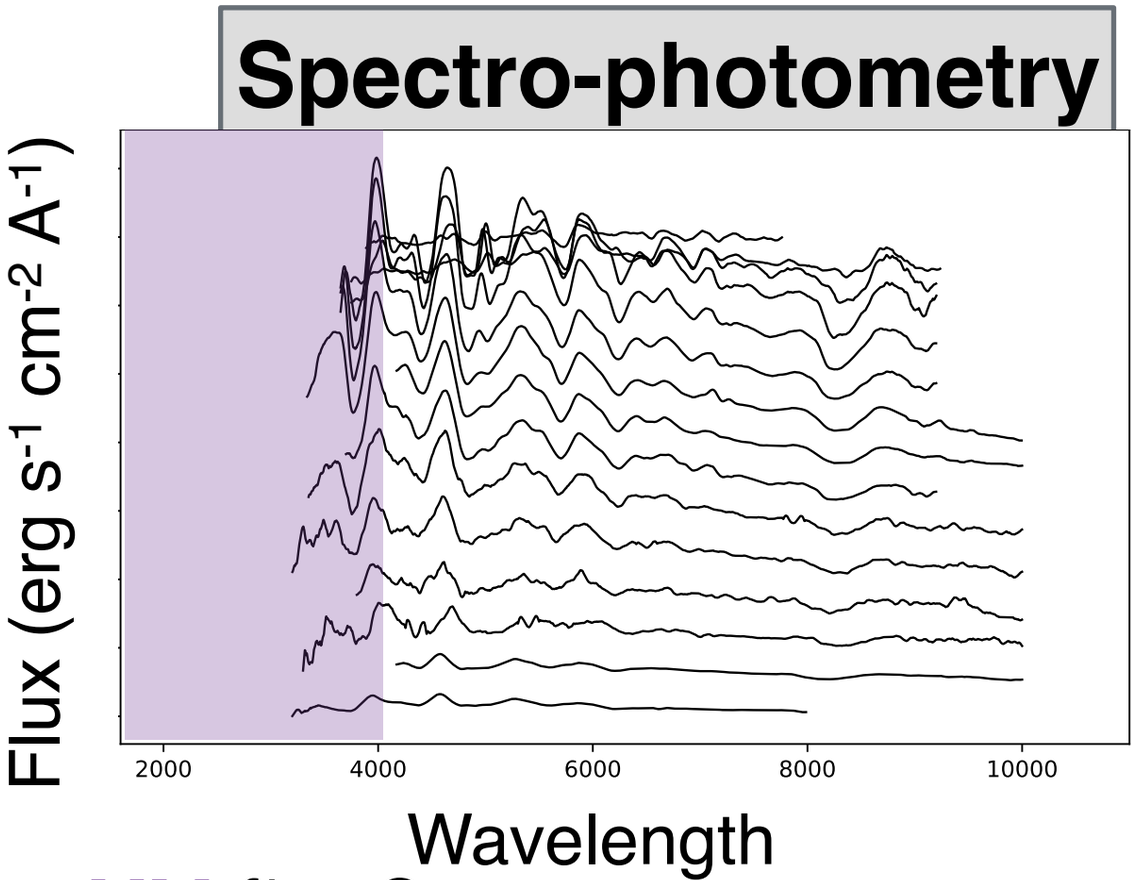


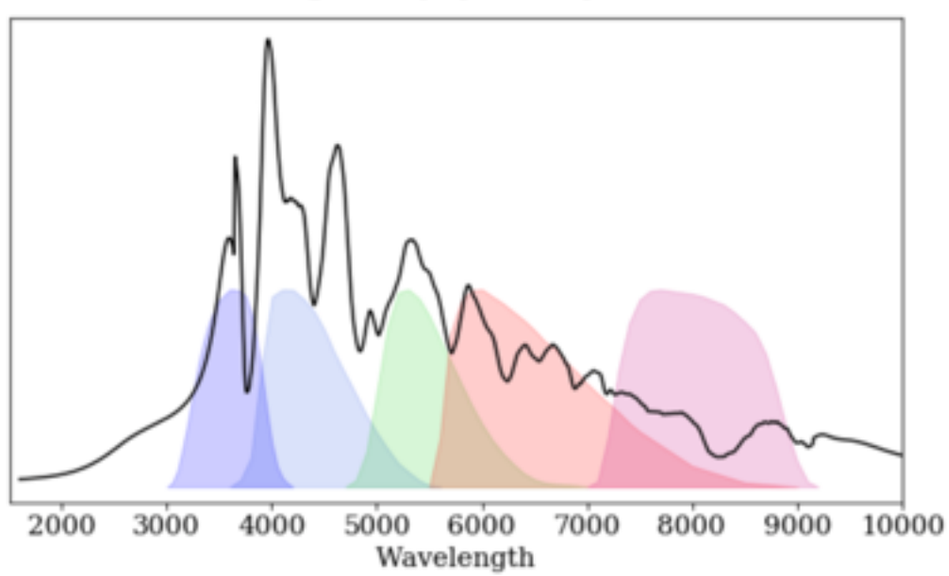


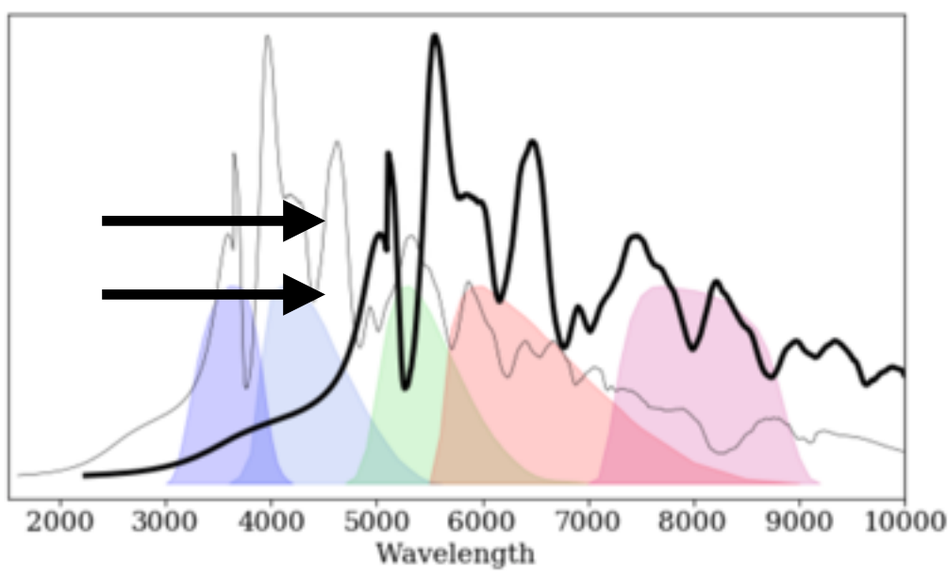
Credit: Rob Firth

Templates: method



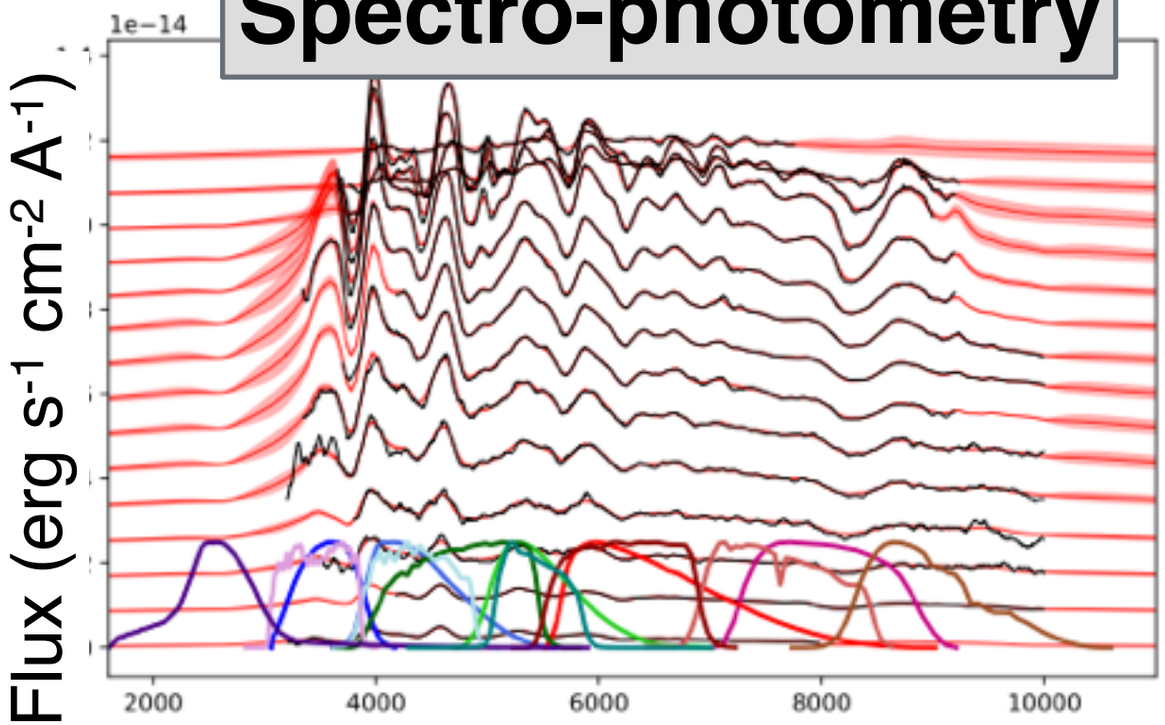
UV flux?





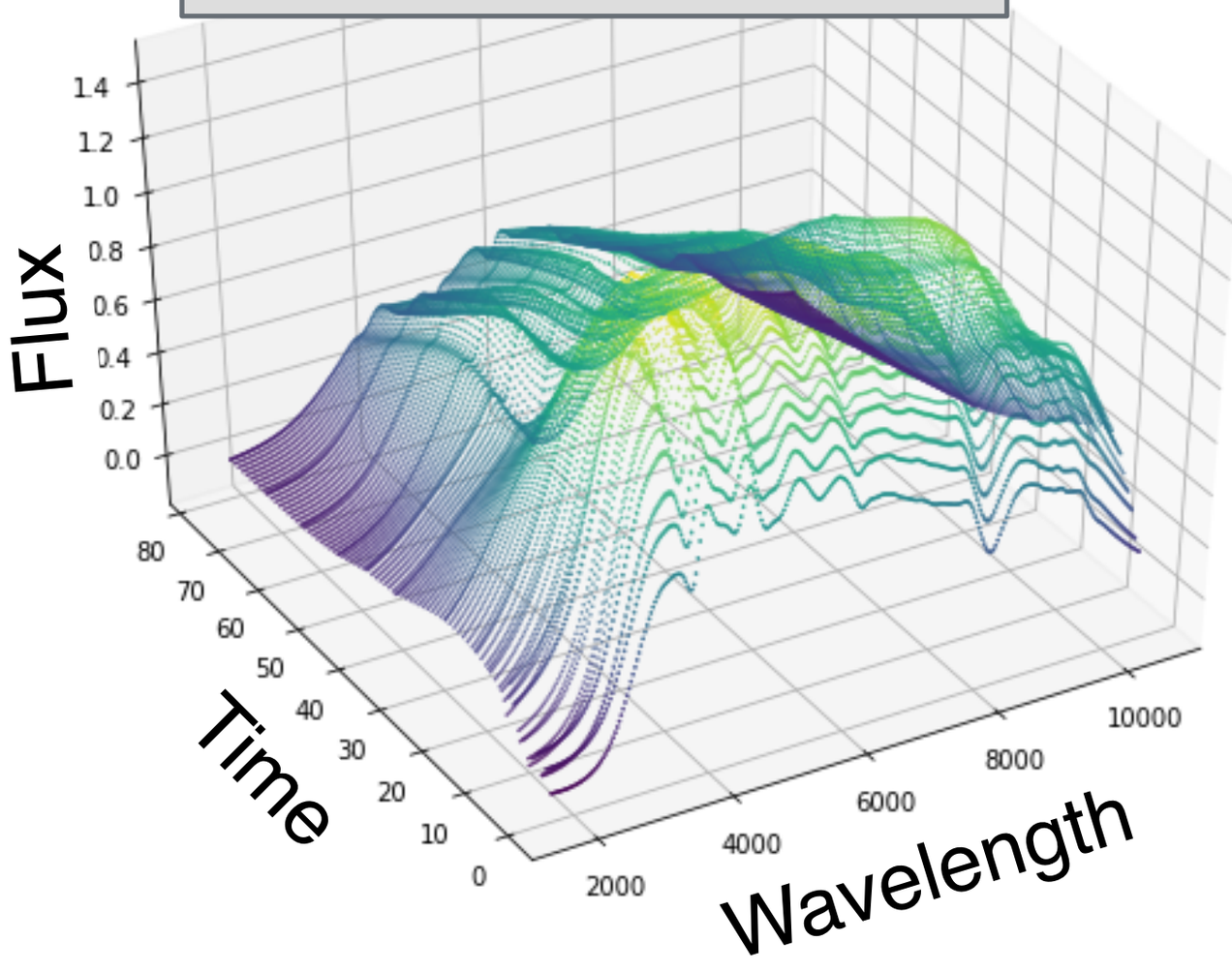
Templates: method

Spectro-photometry



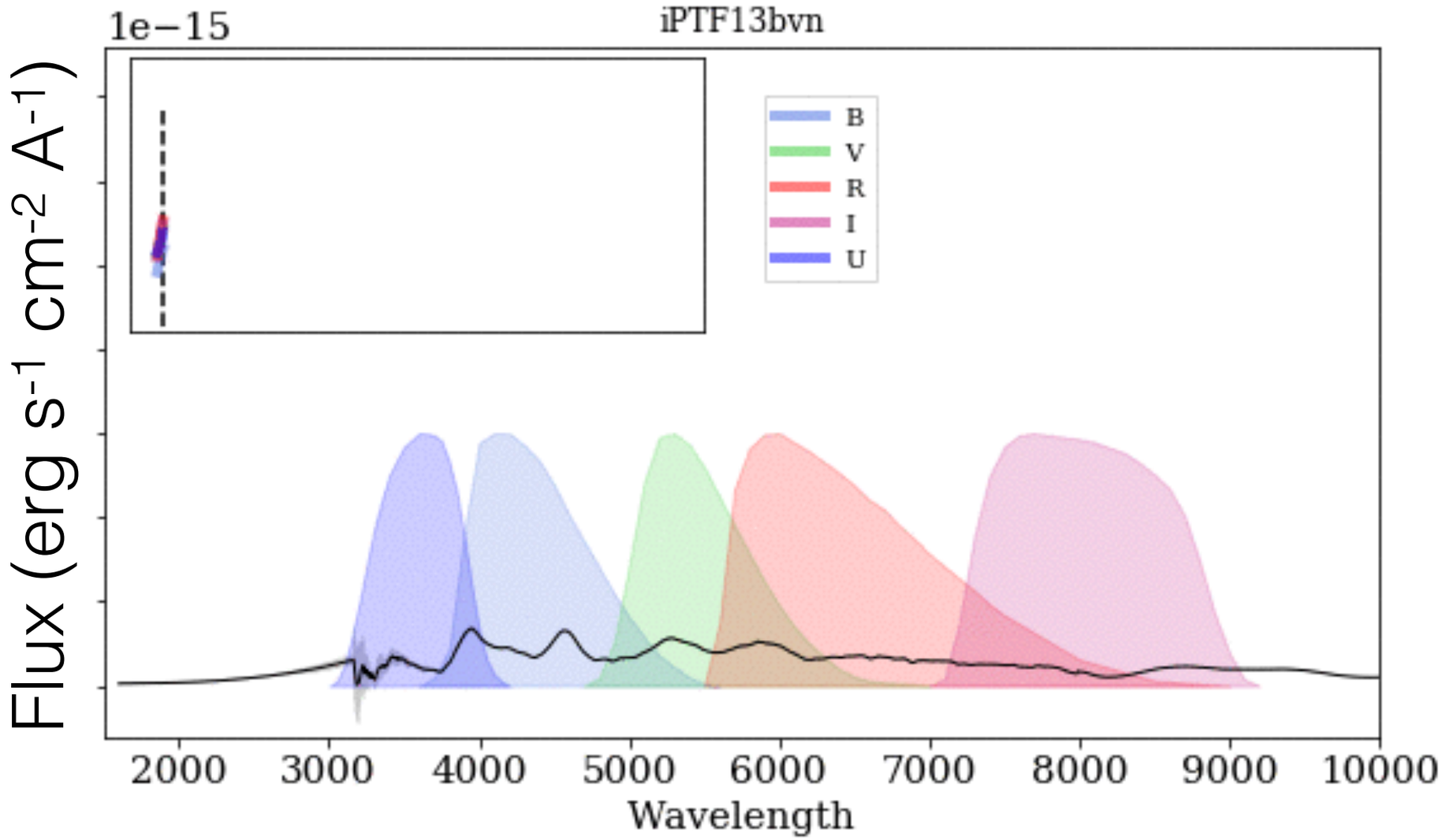
UV broad-band photometry

2D Gaussian Processes



Templates: method

Time series of Spectro-photometry



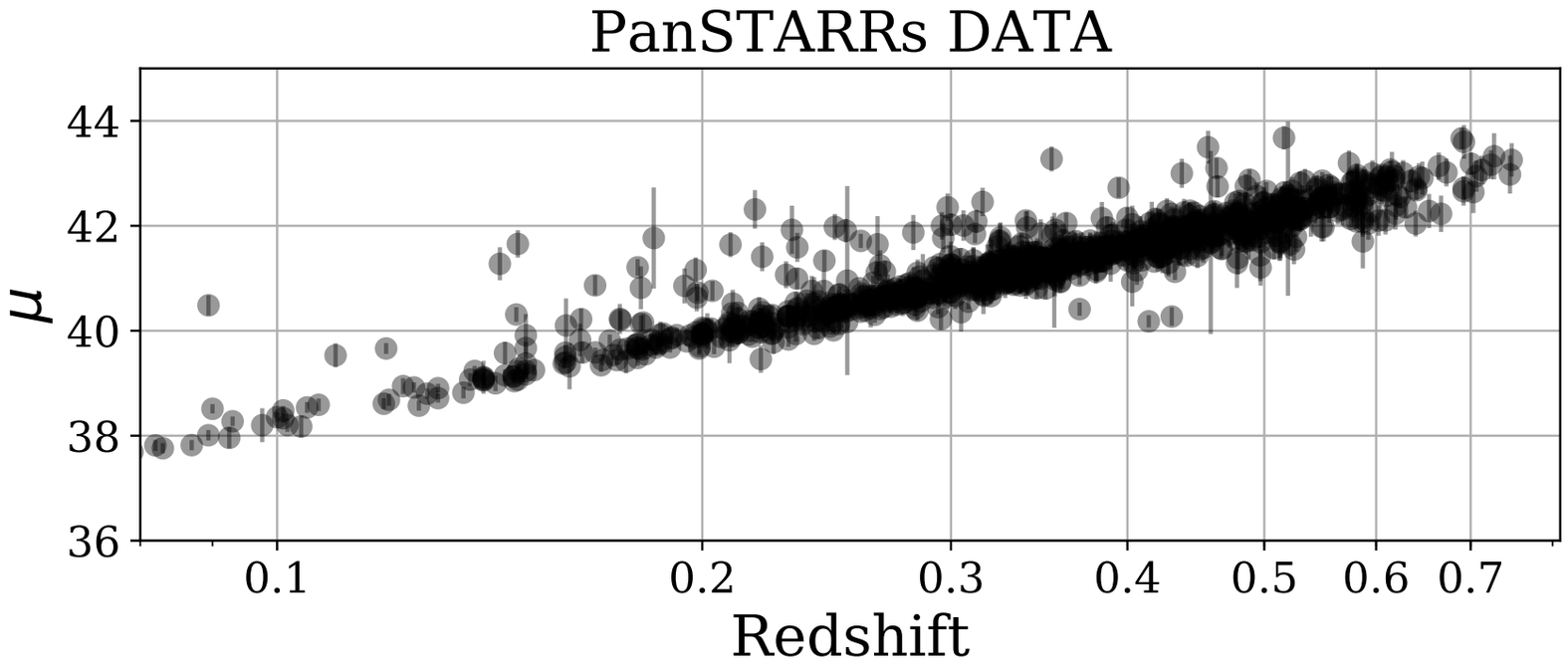
Previous core collapse models	**New core collapse models**
Kessler et al. 2010	Vincenzi et al. in prep
➔ One “average” spectral evolution template	➔ Photometric and spectroscopic **diversity, New SNe** easy to add!
➔ Poor UV extension	➔ **UV extension** for simulations at high redshift
➔ NO dust corrections	➔ **Dust** corrected: any dust model can be applied

The general "recipe"

Realistic simulations of SNe of multiple types

SNe Ia	➔ Template ➔ Rate ➔ Intrinsic properties (σ_{int}, stretch, color…)
SNe CC (SNe II, SNe IIb, SNe IIn, SNe Ib, SNe Ic/Ic-BL)	➔ Templates (Vincenzi et al. in prep.) ➔ Rates ➔ Intrinsic properties (Luminosity function)
Dust	➔ Dust model ➔ Dust distribution

Simulations vs published photometric surveys



Pan-STARRS

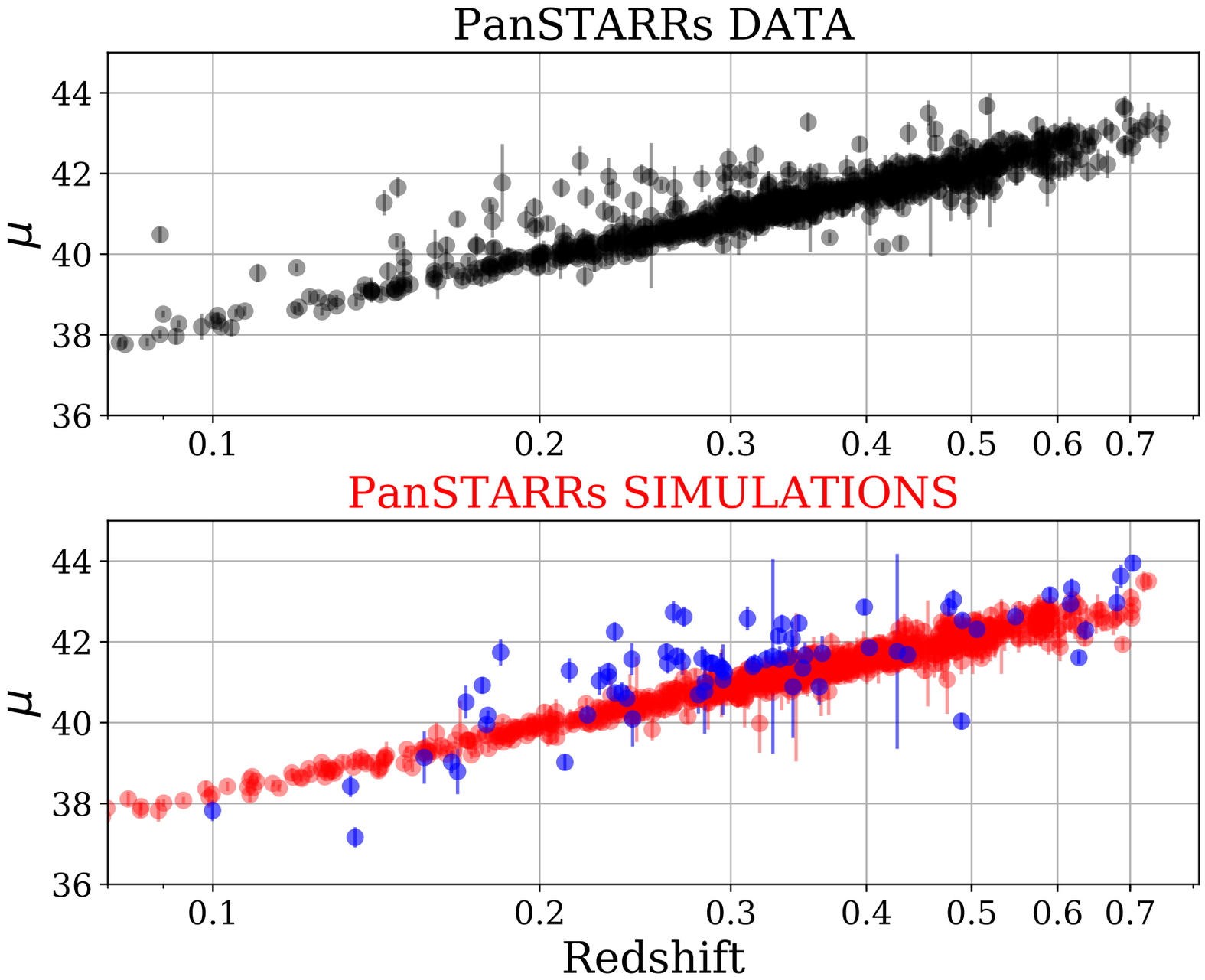
Photometric sample:

~**1100 SNe**

redshift **0.01-0.8**

Jones et al. 2017,2018

Simulations vs published photometric surveys



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Simulated SNe Ia
Simulated CC SNe

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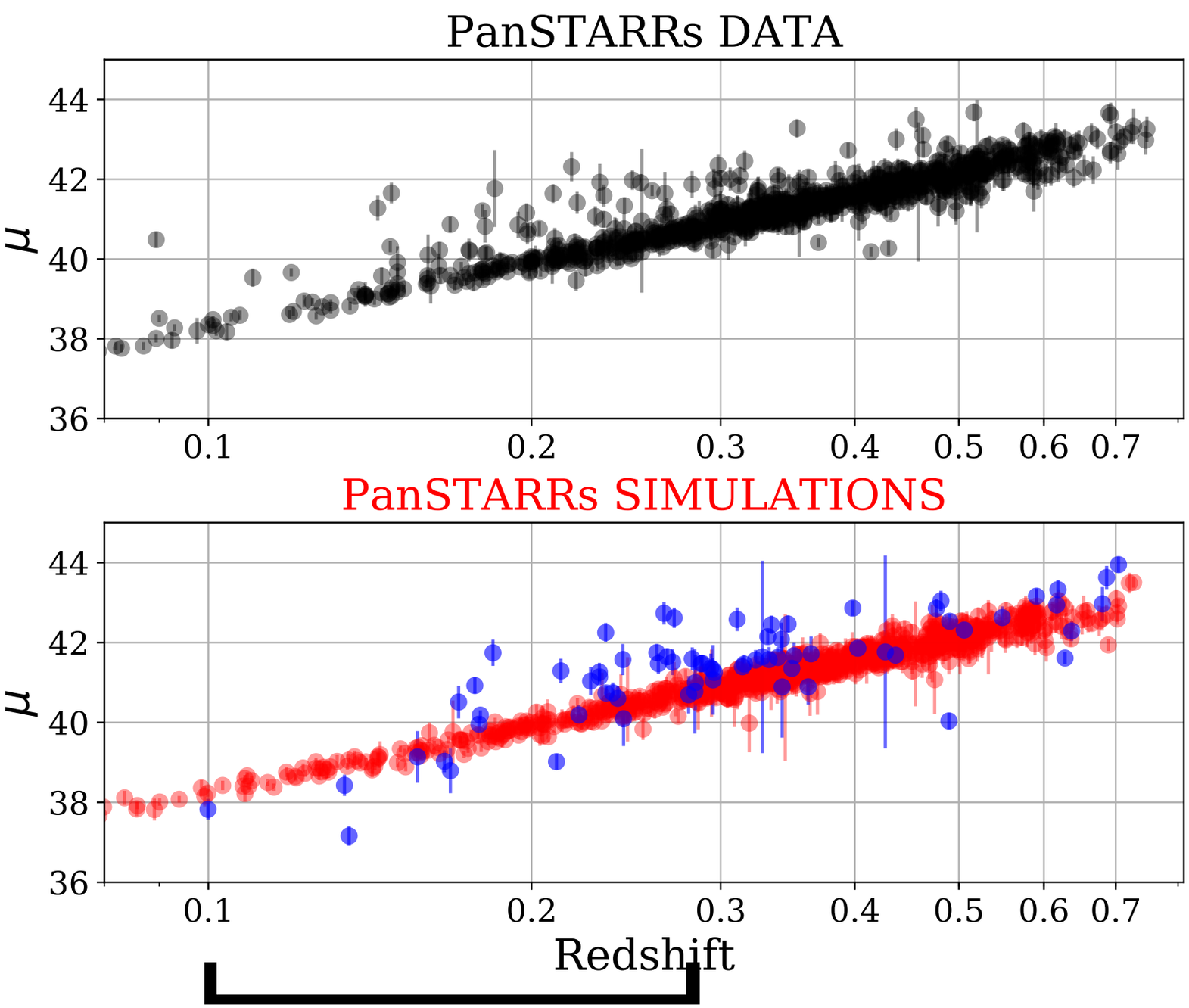

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At low redshift it is difficult to reproduce the CC "tail"

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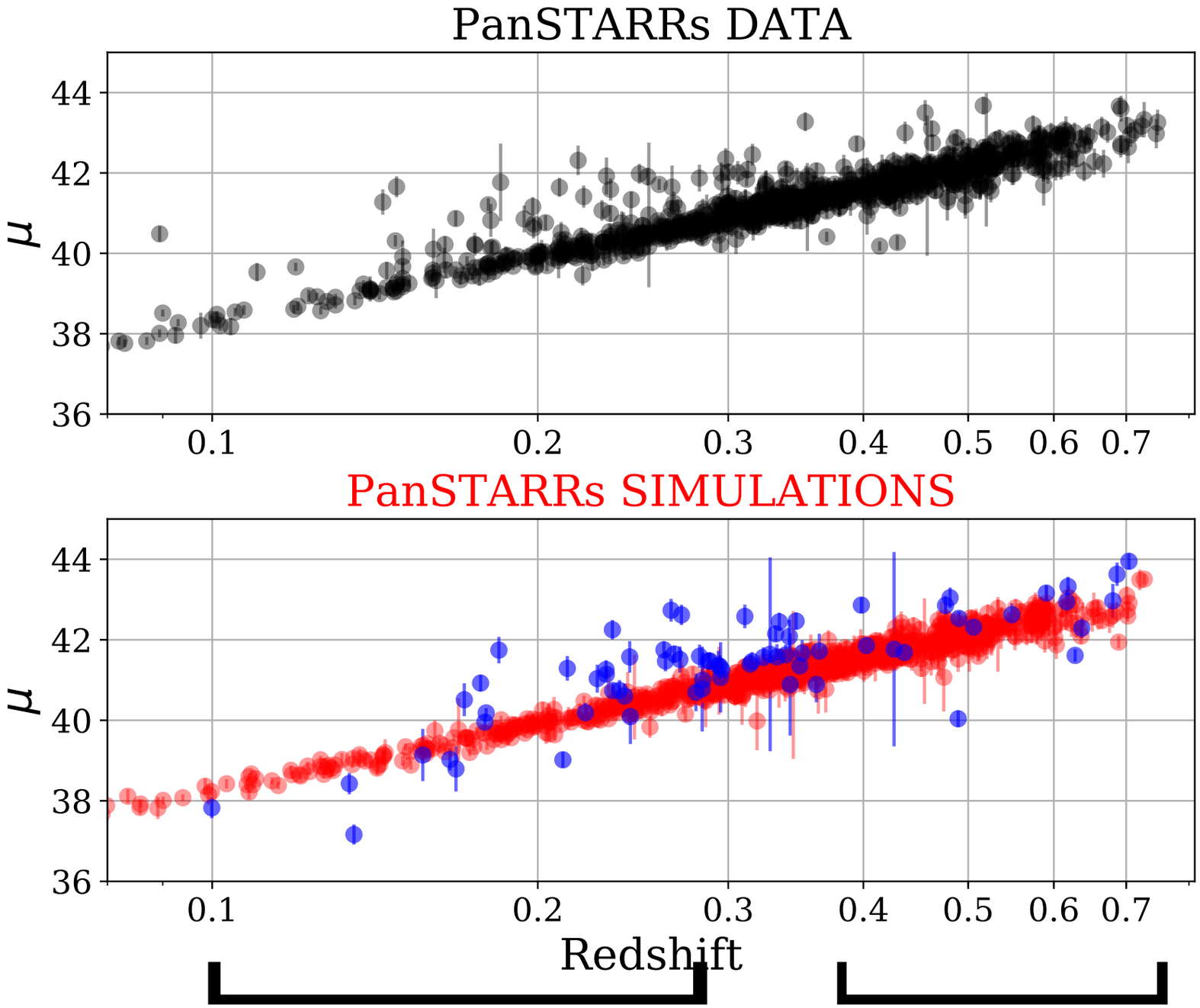

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Simulated SNe Ia
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~7% contamination!

More than **twice** the contamination predicted with previous templates.

Future work

Comparison **Simulations** vs **Data:**
➔ Close comparison simulations to available photometric surveys (SDSS, PanSTARRS, DES)

Photometric classification:
➔ Training samples for photometric classifiers: to fully exploit ML and deep learning algorithms we need to build large training samples

➔ Testing samples: provide benchmark samples for testing performances of ML algorithms

In collaboration with **LSST DESC SN WG**, **Rutherford Appleton Laboratory**

Understand contamination for cosmology:
➔ Predict systematic uncertainties due to CC contamination in future photometric surveys like LSST