University of Southampton Supernova Group

UNIVERSITY OF Southampton

# PISCOLA: Python for Interactive Supernova Cosmology Light-curve Analysis

Cosmic Explosions 2019

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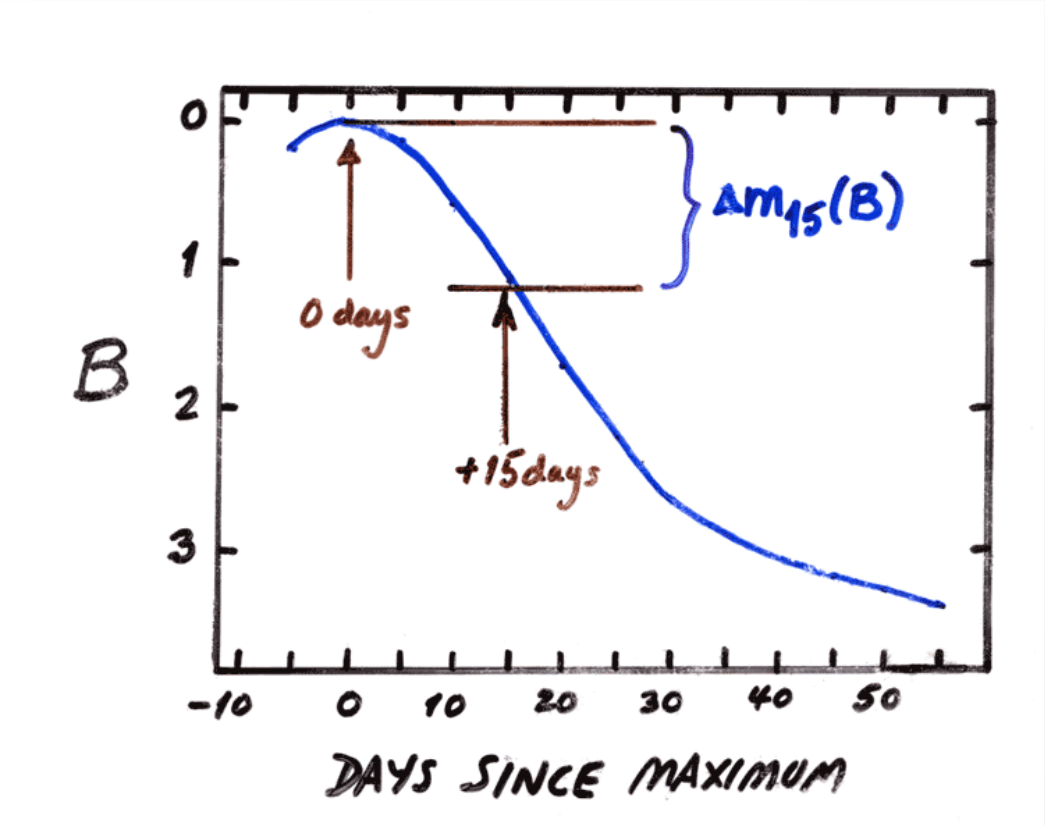
DARK ENERGY SURVEY

# Type Ia Supernovae

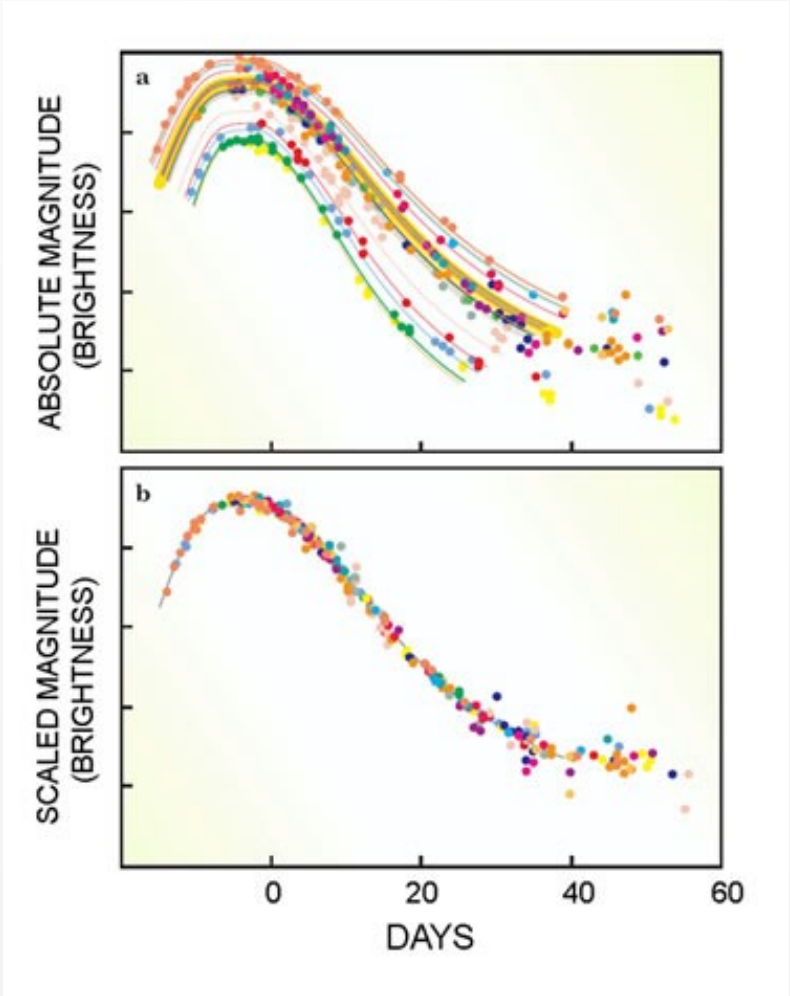
- Produced by White Dwarves (WD) in binary systems
- Lack of Hydrogen in the spectra at peak
- Mean $M_B^{max} \sim -19$ mag ($L_{SN} \sim 10^9$-$10^{10}\ L_\odot$)
- “Low” peak absolute magnitude dispersion
- Standardisable candles

SN 1994D
(HST image)

# SNe Ia as standardisable candles

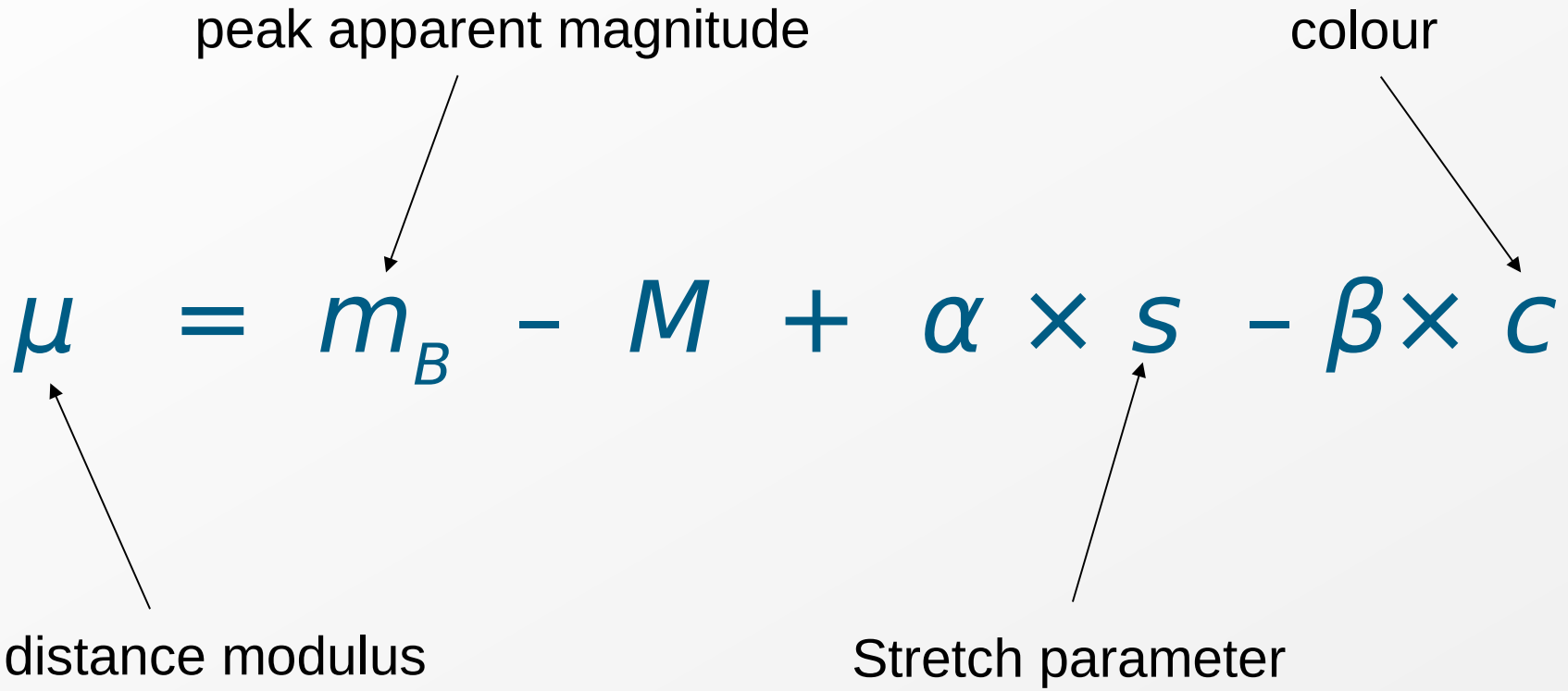



Phillips (1993)

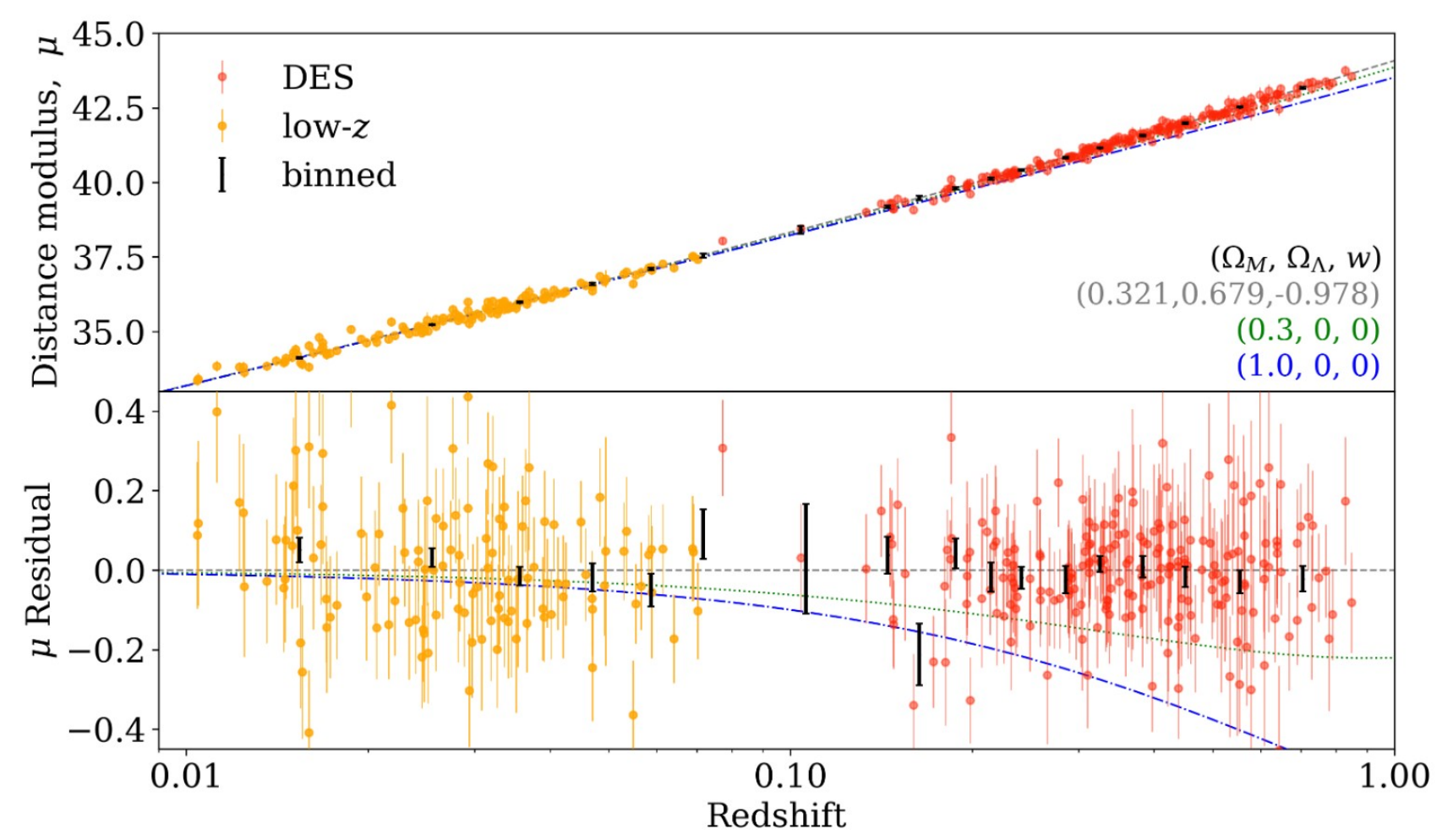



Kim et al. (1997)

# Standardising SNe Ia



# SNe Ia Cosmology




**Dark Energy Survey (DES) Sample**

Abbott et al. (2018)

# The future of SNe Ia Cosmology

Decrease statistical uncertainty

↓

Wide Field Surveys
(ZTF, LSST, etc.)

Improve standardisation

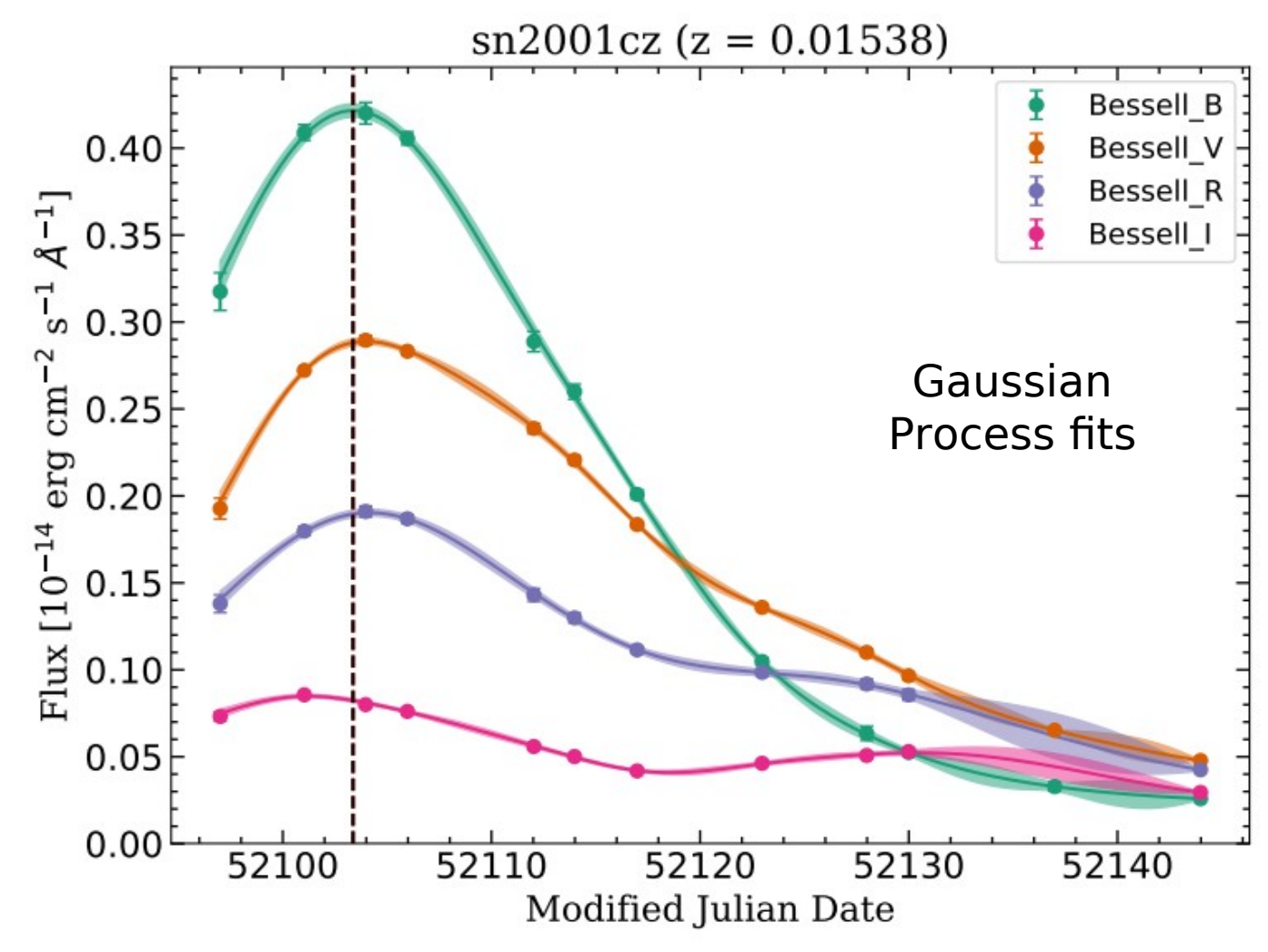
↓

**?**

# PISCOLA: Python for Interactive Supernova Cosmology Light-curve Analysis

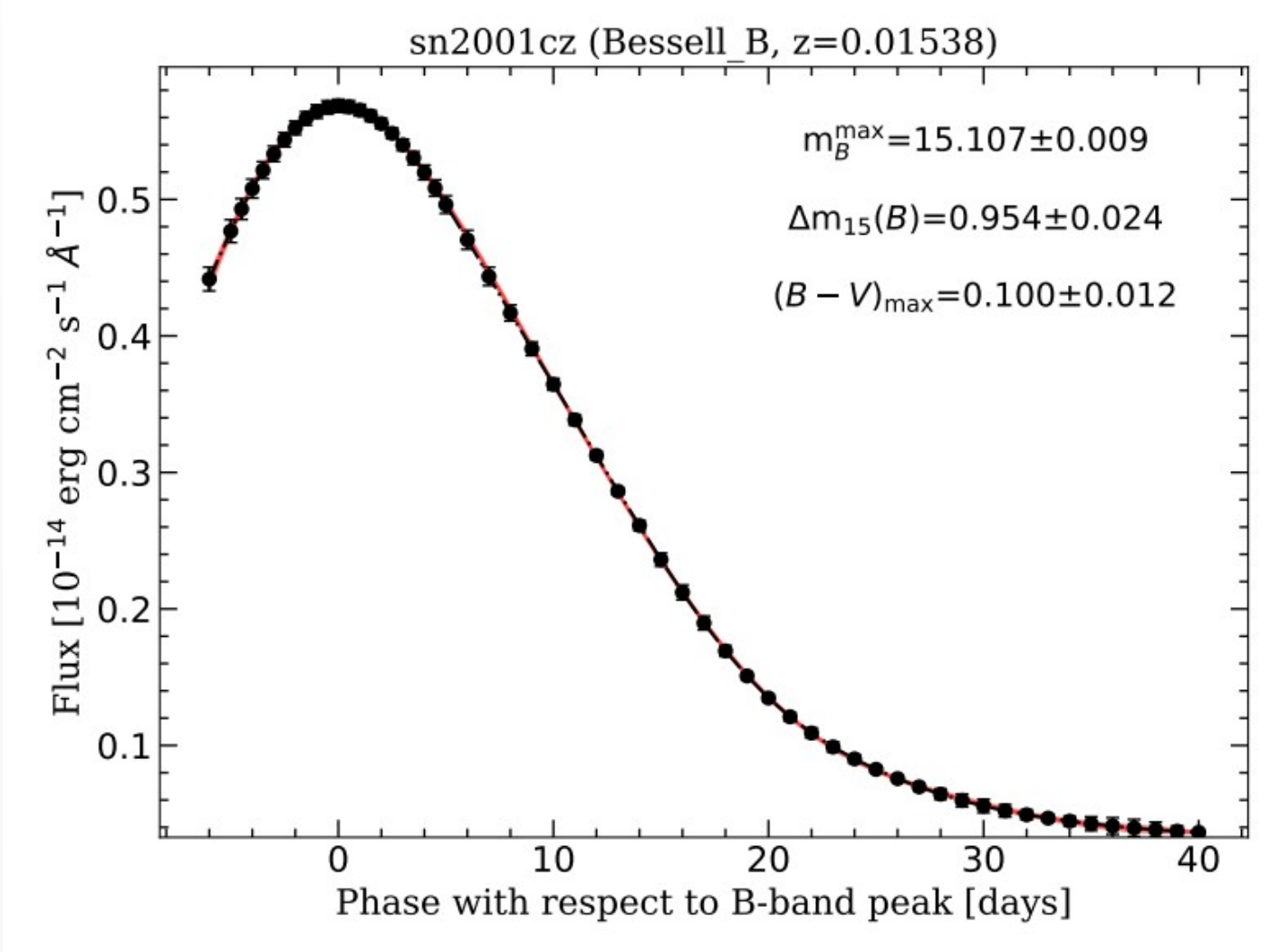
- Data driven
- Works with any band
- Written in Python v3
- Flexible and easy to use
- Good for exploration

# Light-Curves Fits



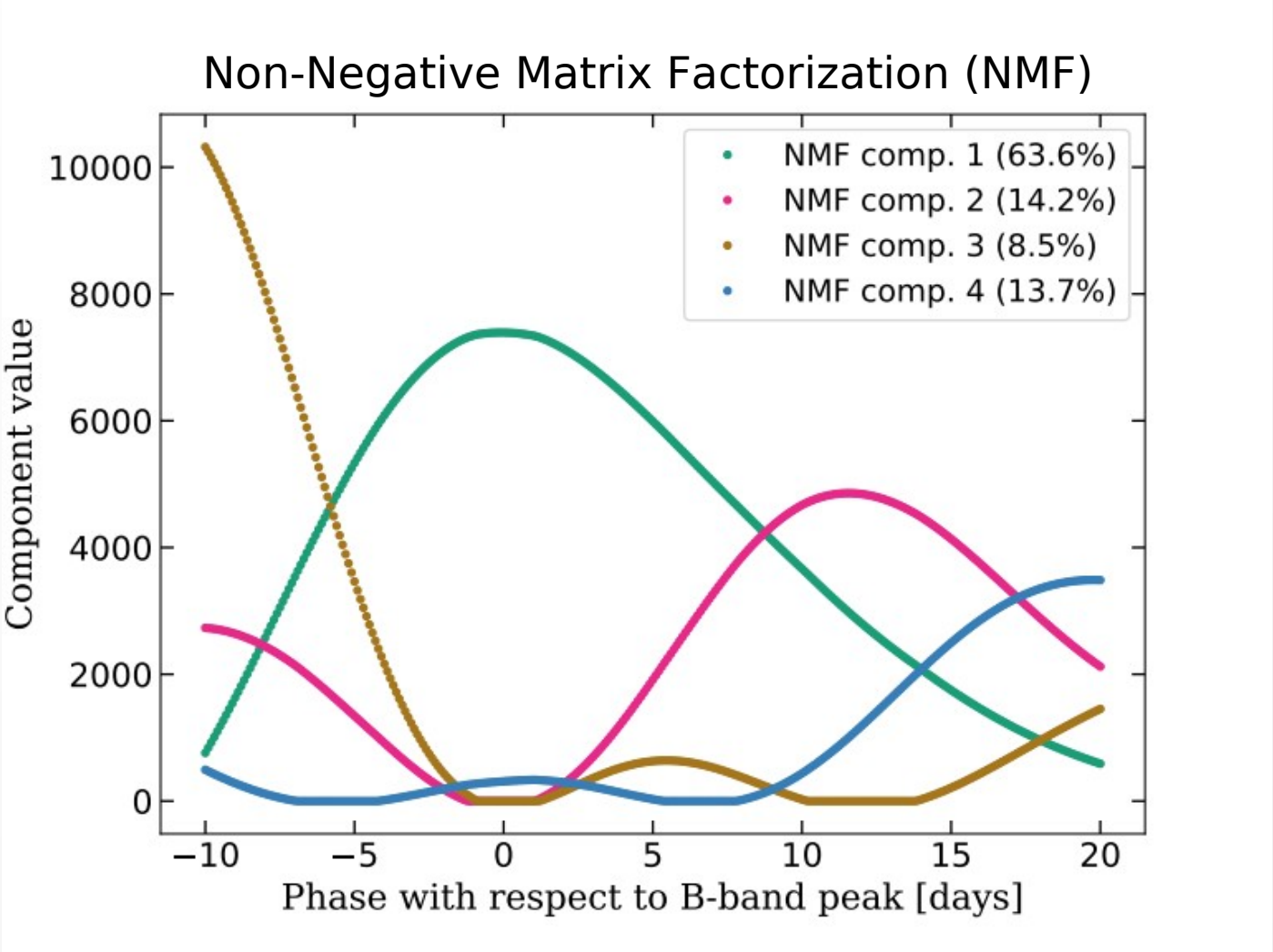

Müller et al. (in prep.)

# B-band Reconstruction

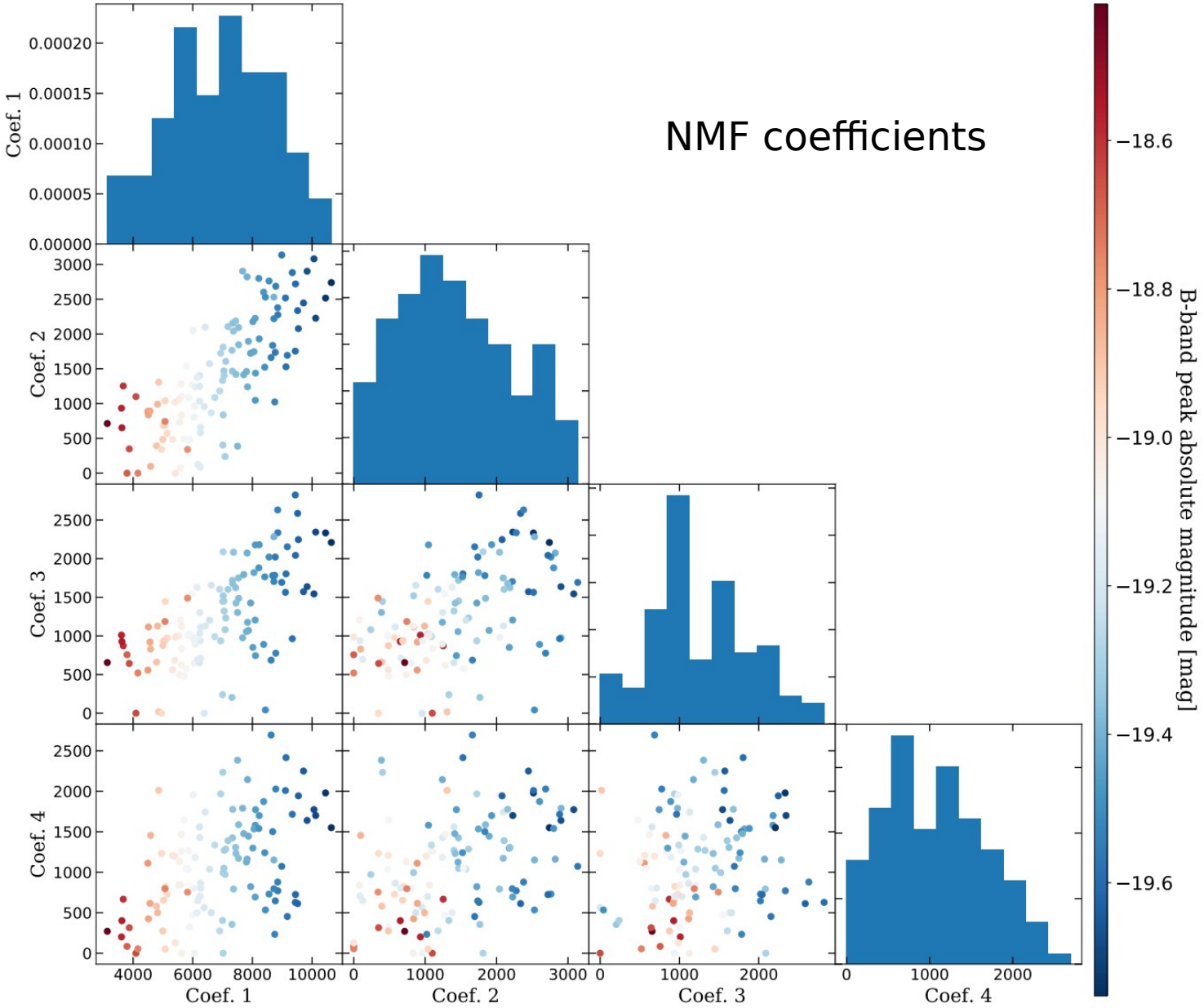



Müller et al. (in prep.)

# Light-Curves Decomposition




Müller et al. (in prep.)




Müller et al. (in prep.)

# Summary

- The persistent presence of intrinsic dispersion after standardisation indicate latent unmodeled processes

- Gaussian Process proves to have several advantages over template driven fits

- With PISCOLA and NMF-like techniques we are going to have further understanding of the physics SNe Ia explosions, improving their standardision as well

- PISCOLA is open source: github.com/temuller

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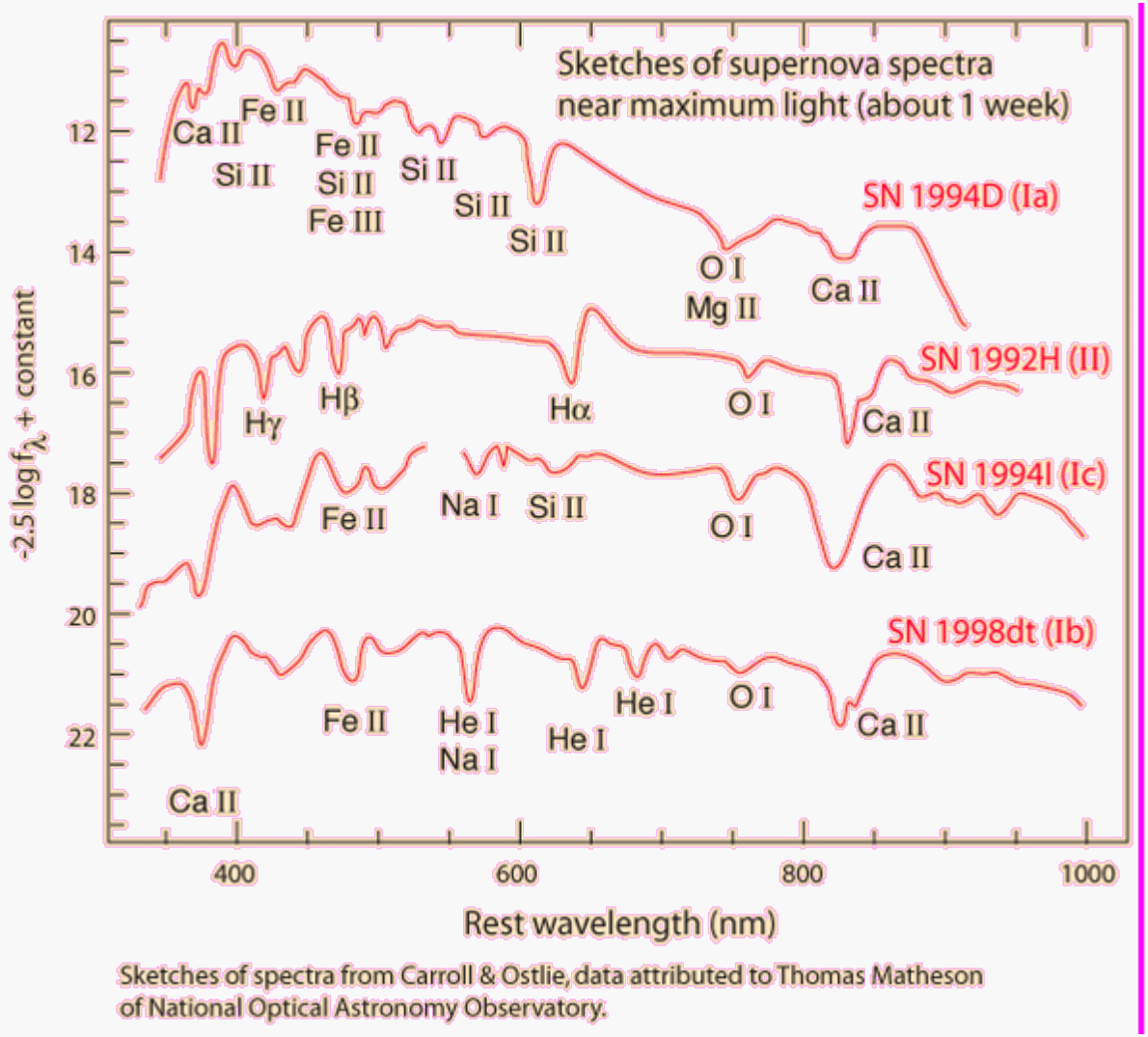
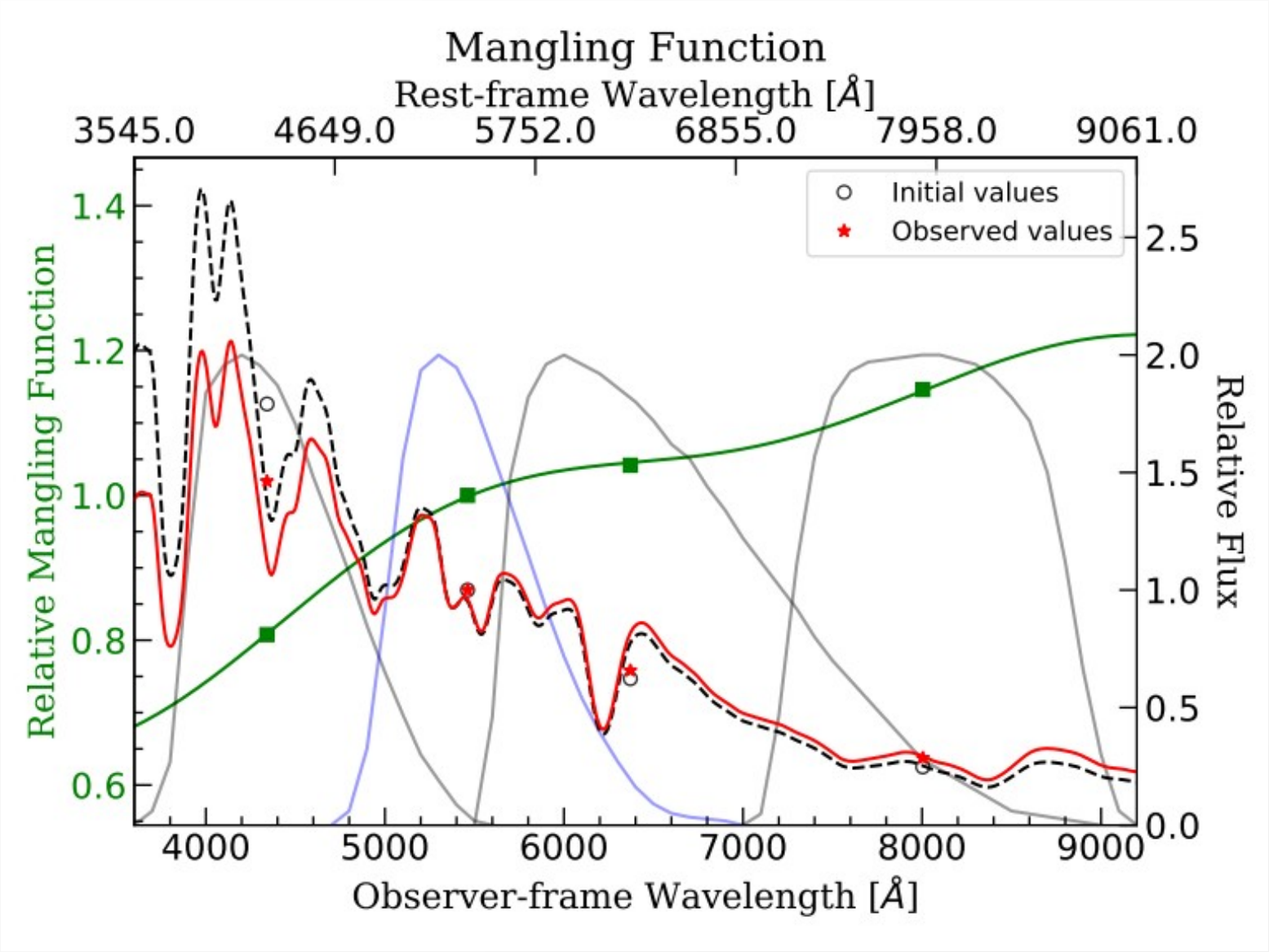
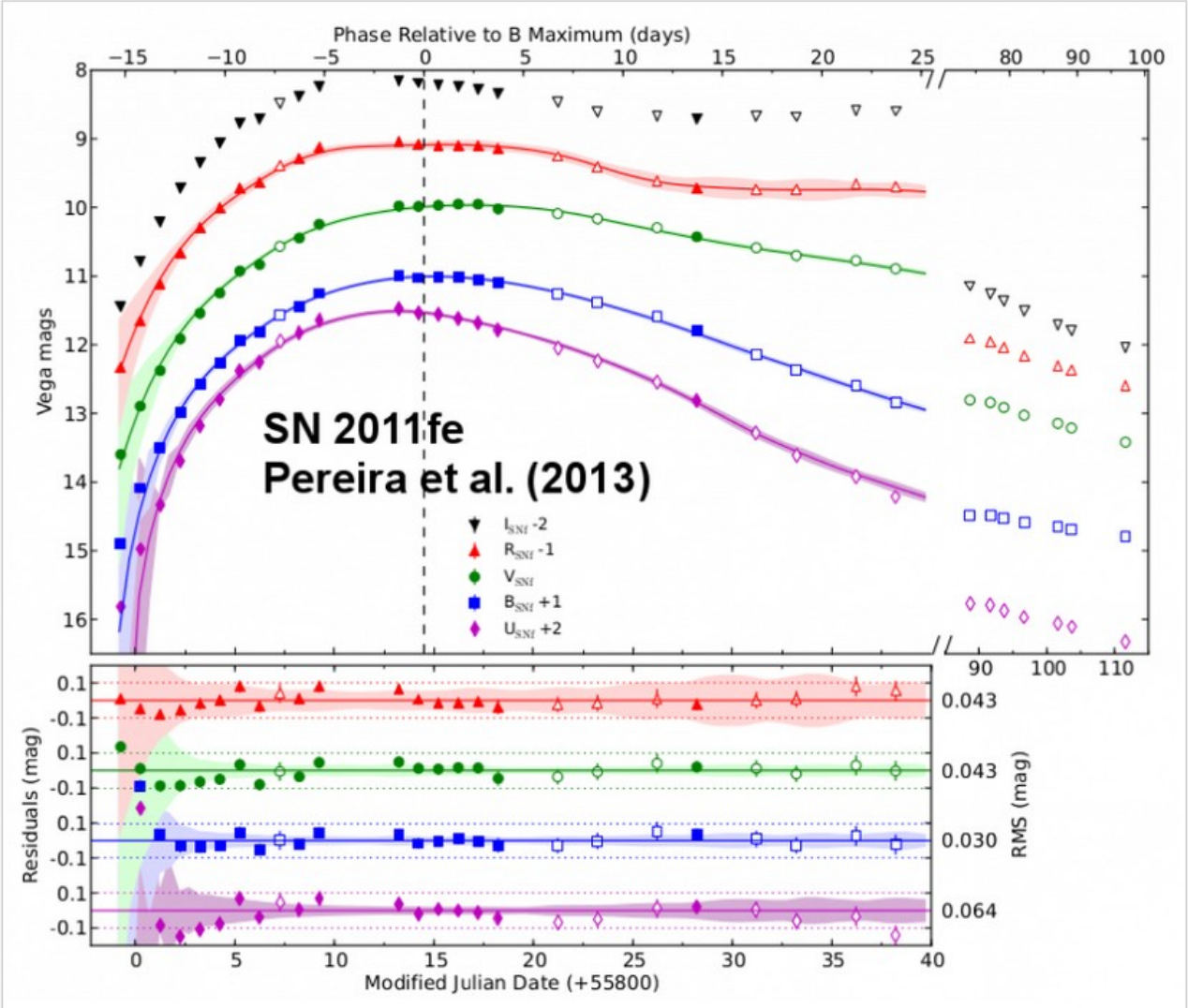
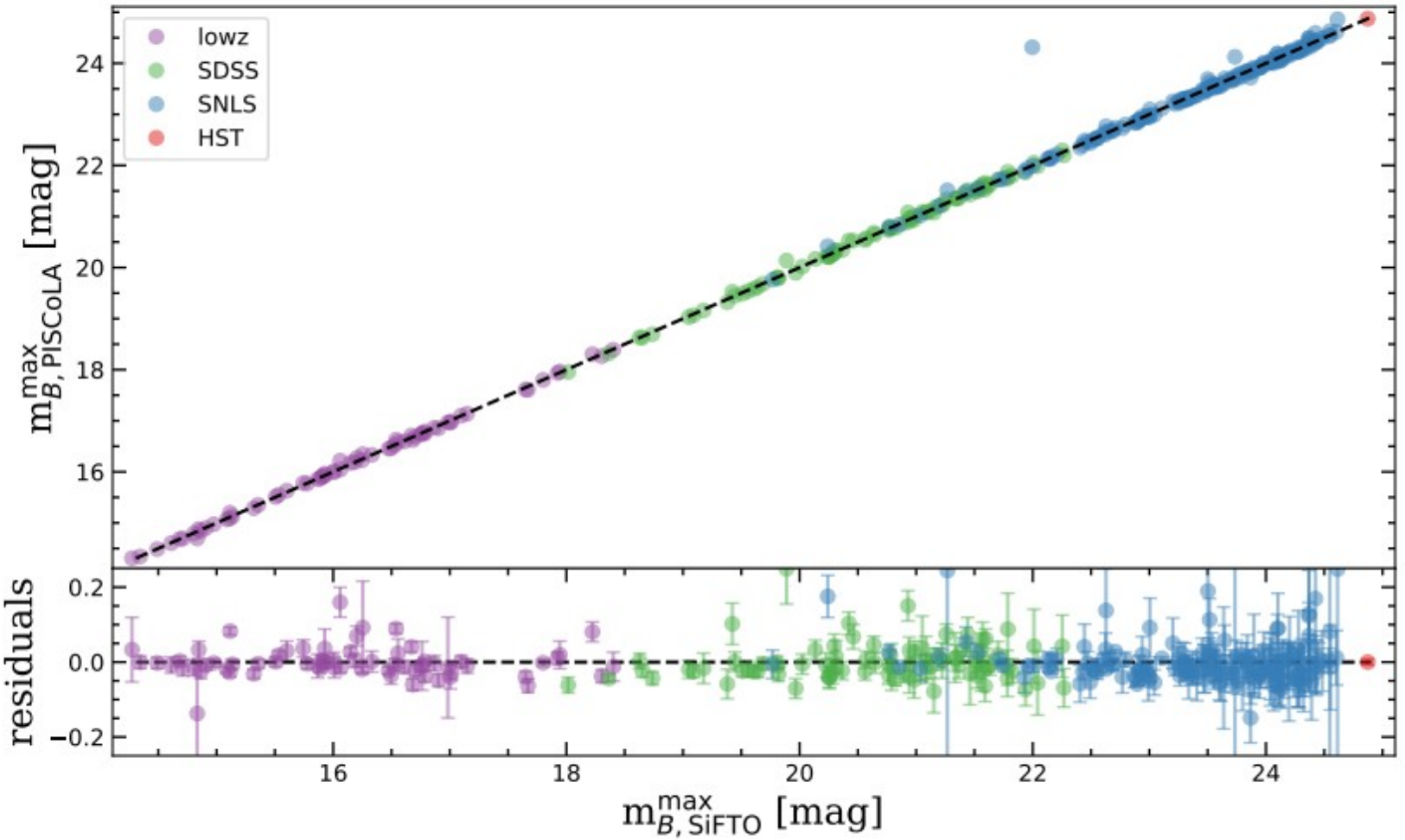


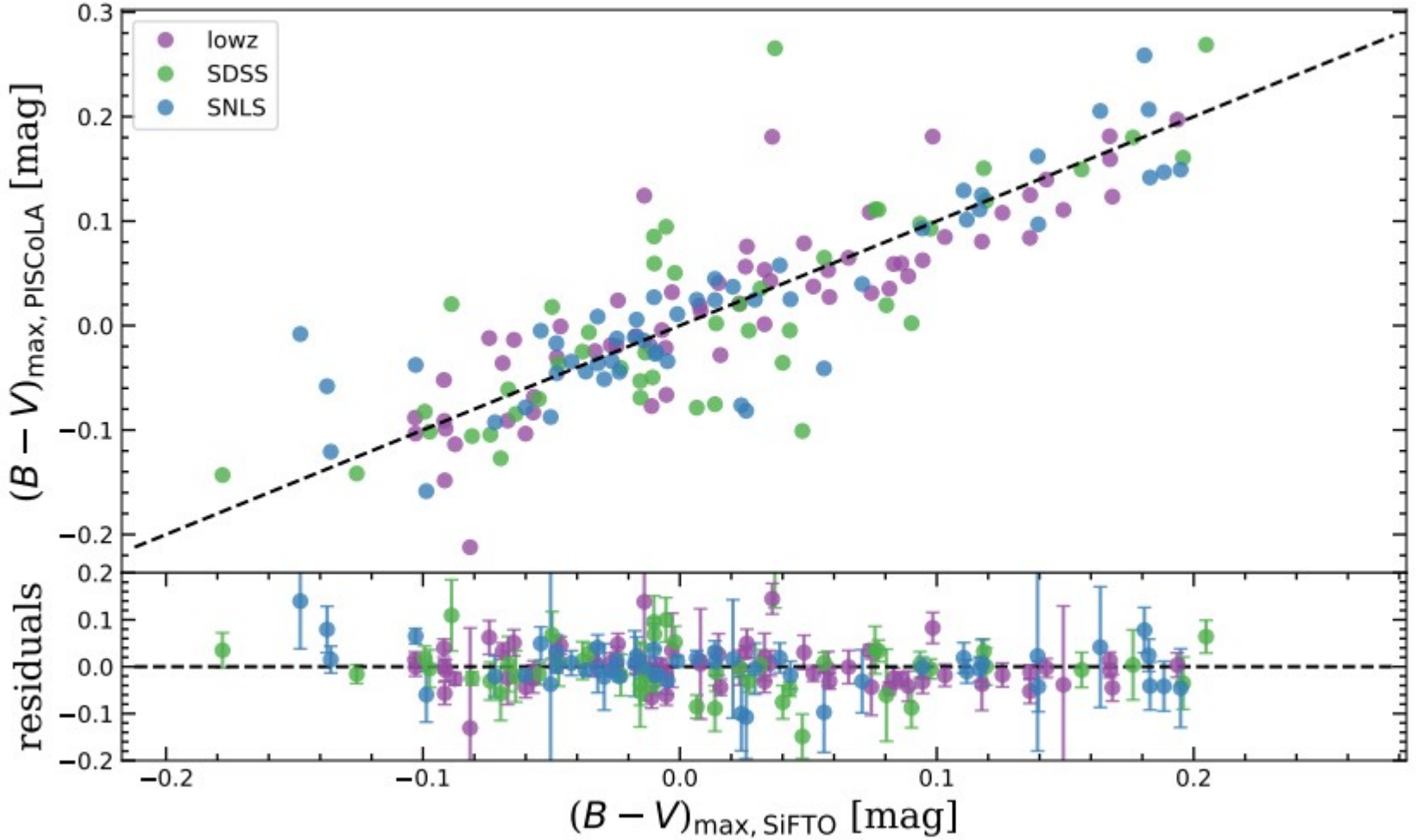

Sketches of spectra from Carroll & Ostlie, data attributed to Thomas Matheson of National Optical Astronomy Observatory.


Mangling Function
Rest-frame Wavelength [Å]
3545.0
4649.0
5752.0
6855.0
7958.0
9061.0
Initial values
Observed values
Relative Mangling Function
1.4
1.2
1.0
0.8
0.6
Relative Flux
2.5
2.0
1.5
1.0
0.5
0.0
4000
5000
6000
7000
8000
9000
Observer-frame Wavelength [Å]

sn2011fe2.png



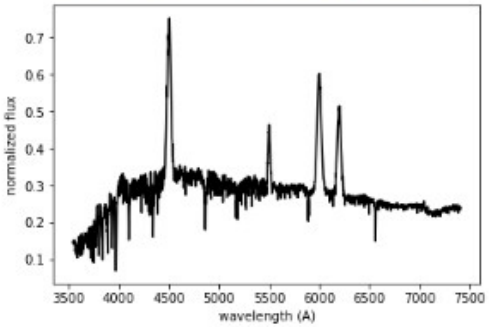

lowz
SDSS
SNLS
HST
$m^{max}_{B,\,PISCoLA}$ [mag]
residuals
$m^{max}_{B,\,SiFTO}$ [mag]
16
18
20
22
24
0.2
0.0
−0.2


lowz
SDSS
SNLS
$(B-V)_{\mathrm{max,\,PISCoLA}}$ [mag]
residuals
$(B-V)_{\mathrm{max,\,SiFTO}}$ [mag]
0.3
0.2
0.1
0.0
−0.1
−0.2
−0.2
−0.1
0.0
0.1
0.2

# Principle Component Analysis (PCA)

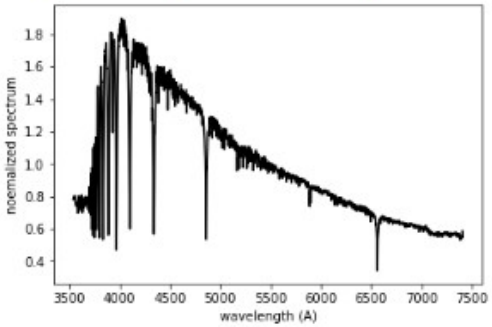
The principle components **may** represent the true **building blocks** of the objects in our dataset.

**observed object**



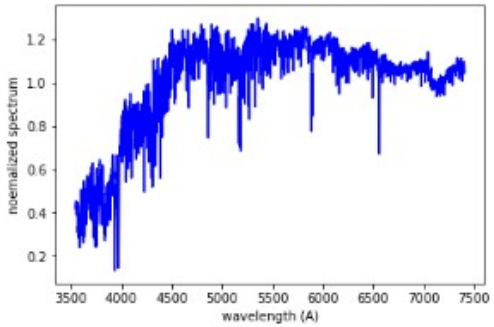

**= A ***

**principle comp. 1**



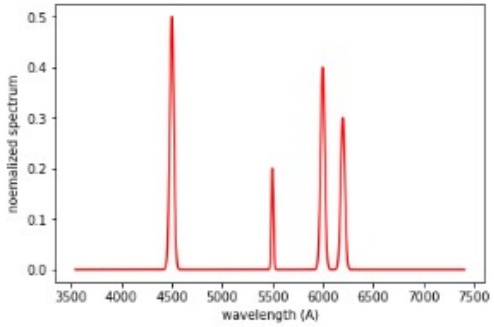

**+ B ***

**principle comp. 2**




**+ C ***

**principle comp. 3**




Slide Credit: Dalya Baron (Tel Aviv University)