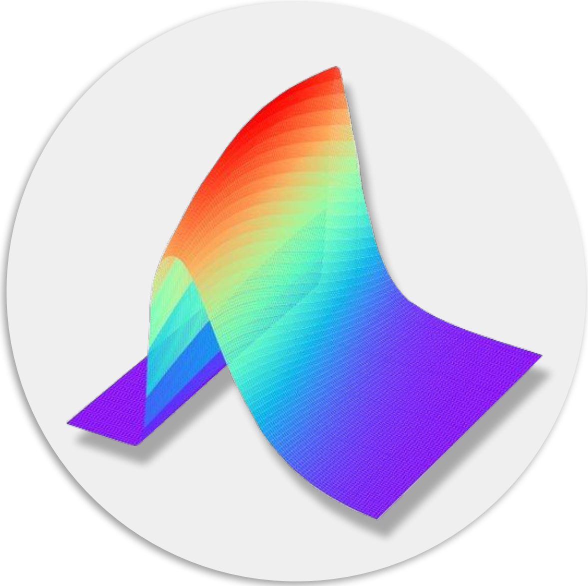
RAINBOW

Light curve fitter



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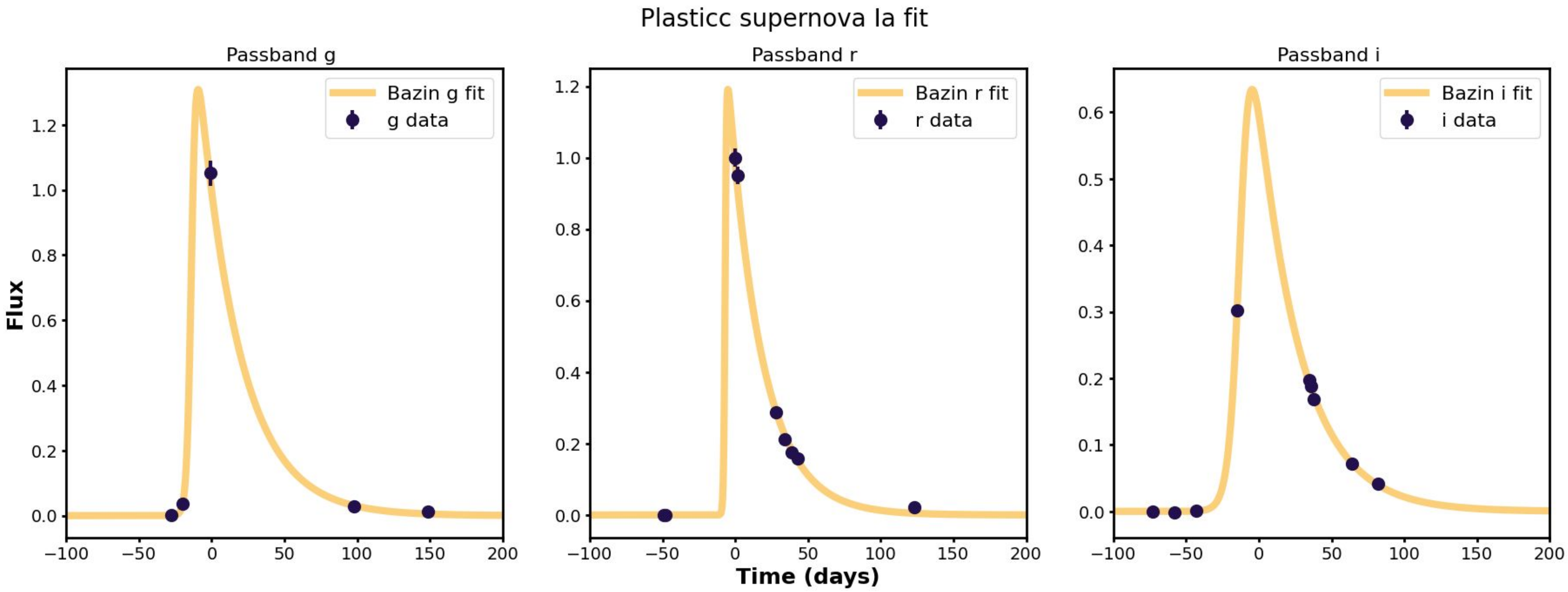
Transient feature extraction : Bazin

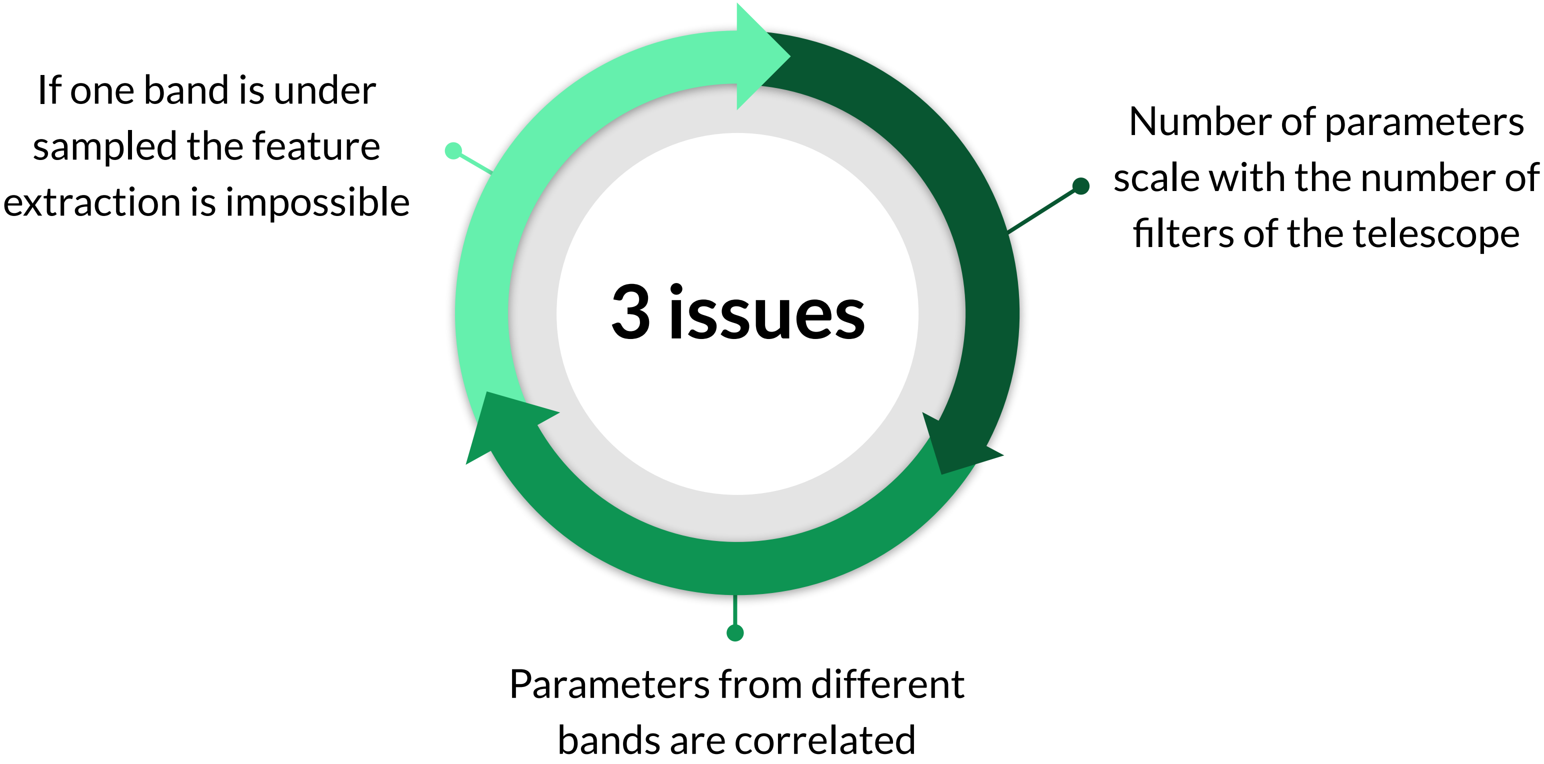
$$F_\nu(t) = A \times \frac{e^{\frac{-(t-t_0)}{t_{fall}}}}{1 + e^{\frac{t-t_0}{t_{rise}}}}$$



A	t0	tr	tf

A	t0	tr	tf

A	t0	tr	tf


3 issues
If one band is under sampled the feature extraction is impossible
Number of parameters scale with the number of filters of the telescope
Parameters from different bands are correlated

$$F_\nu(t,\nu) = \frac{\pi}{\sigma_{SB}} \times \frac{B_\nu(T,\nu)}{T(t)^4} \times F_{bol}(t)$$

Theoretical solution (assuming that the object is a black body)

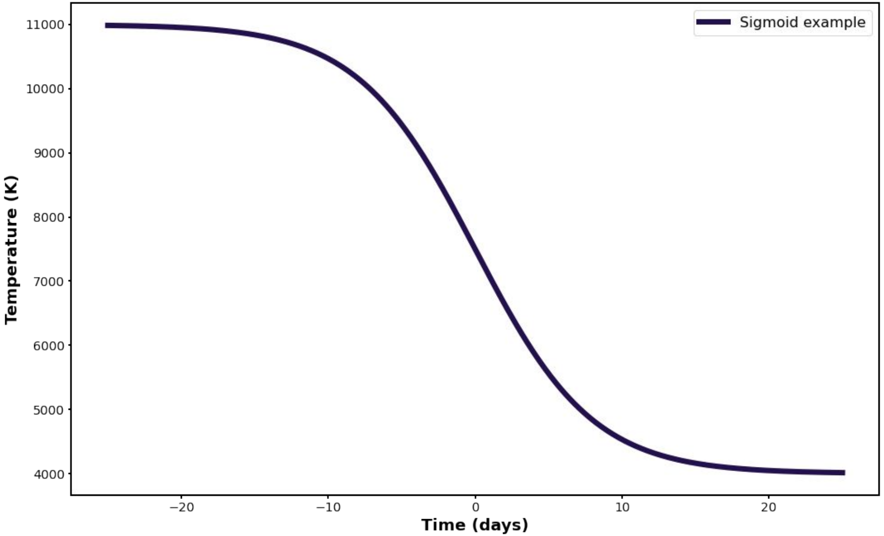
$$F_\nu(t,\nu) = \frac{\pi}{\sigma_{SB}} \times \frac{B_\nu(T,\nu)}{T(t)^4} \times F_{bol}(t)$$

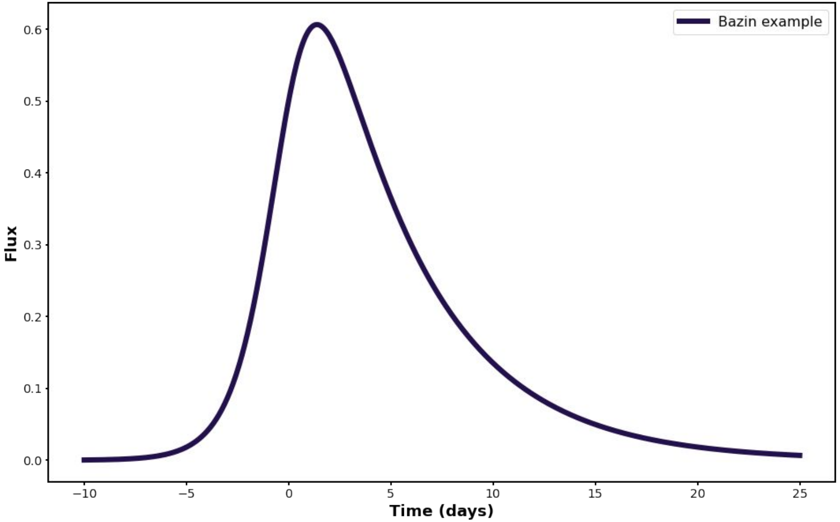
Sigmoid

$$T(t) = T_{min} + \frac{T_{var}}{1 + e^{\frac{t-t0}{k_{sig}}}}$$

Bazin

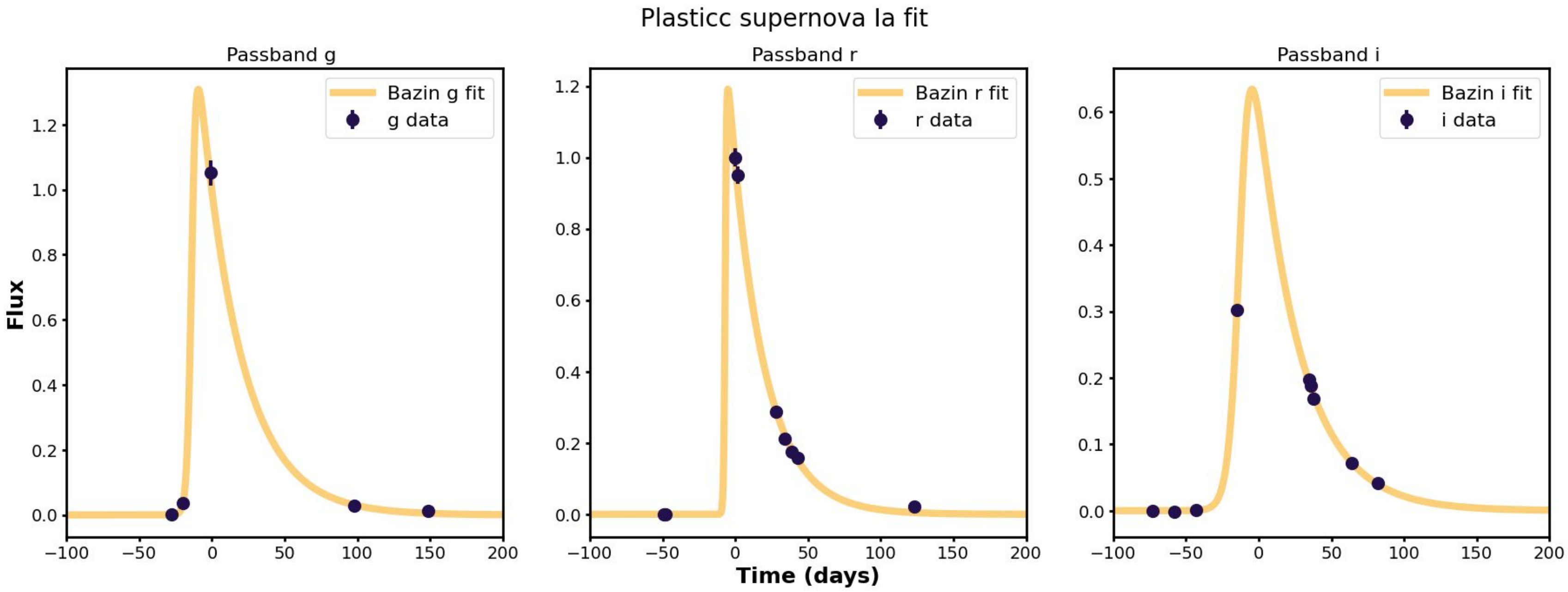
$$F_{bol}(t) = A \times \frac{e^{\frac{-(t-t_0)}{t_{fall}}}}{1 + e^{\frac{t-t_0}{t_{rise}}}}$$





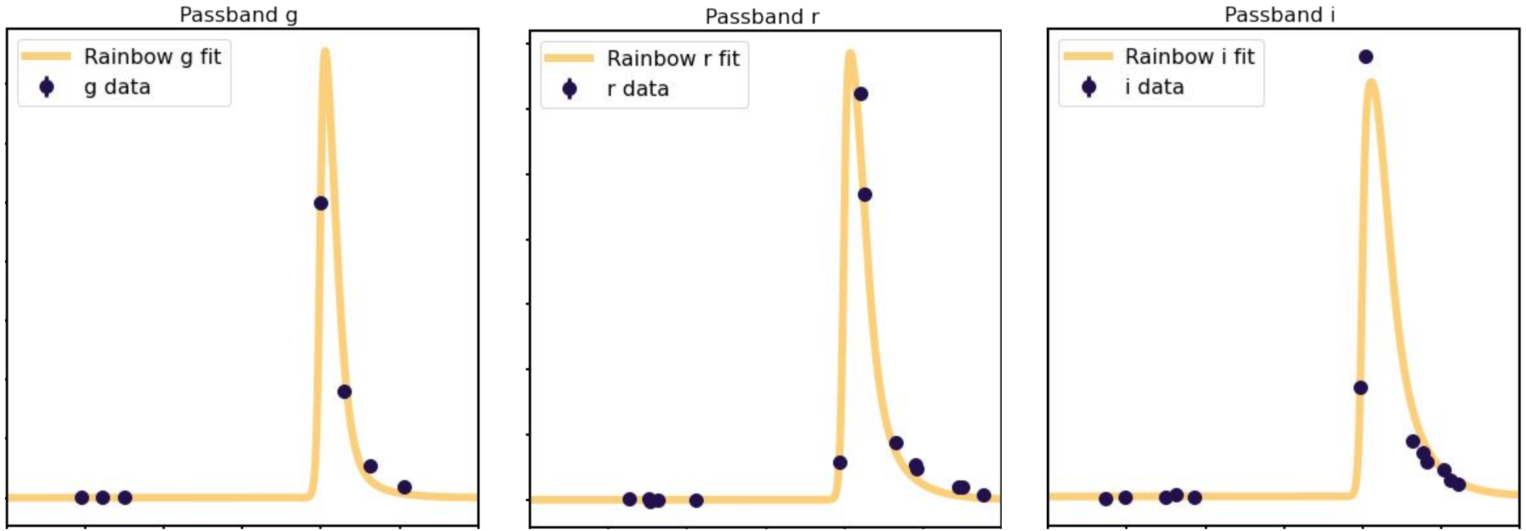
We require 7 data points !

Fit examples

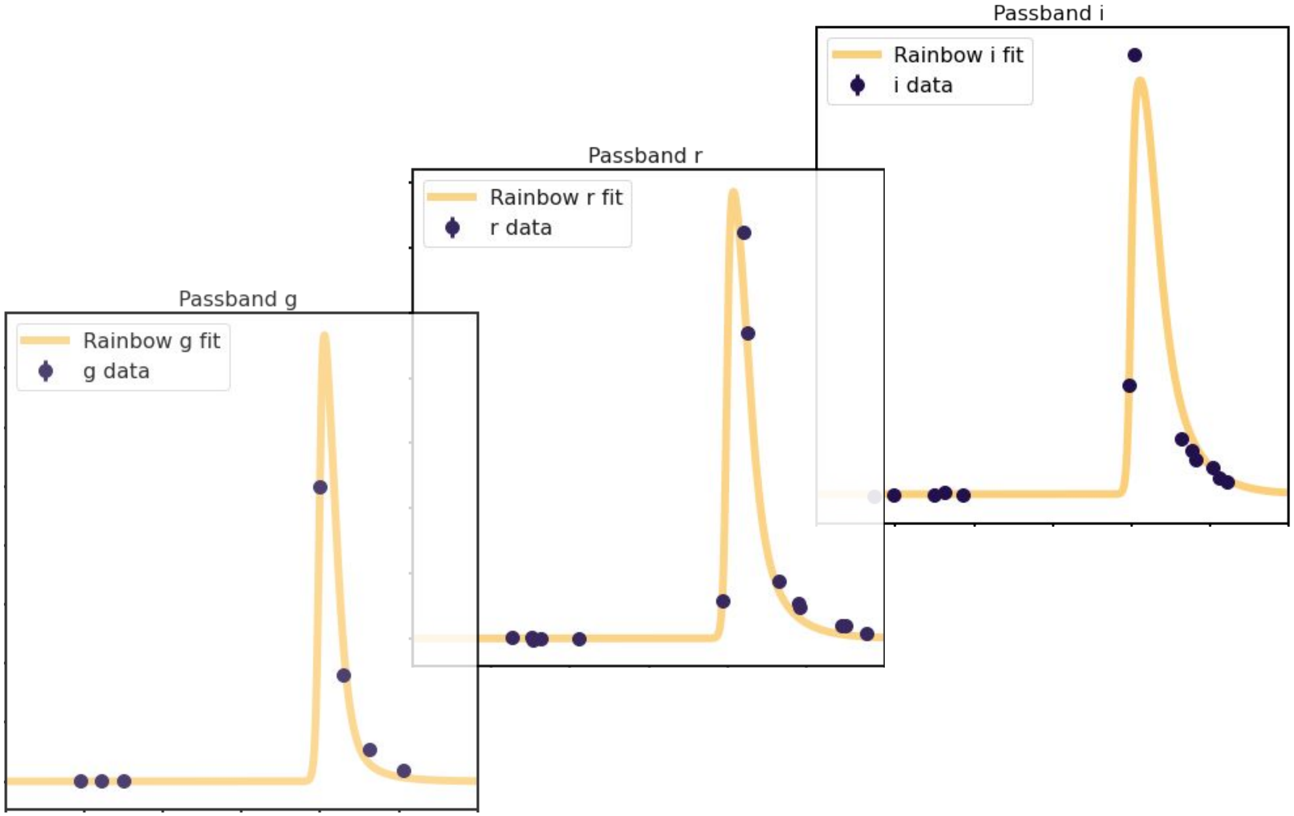


A	**t0**	**tr**	**tf**	**Tvar**	**Tmin**	**ksig**

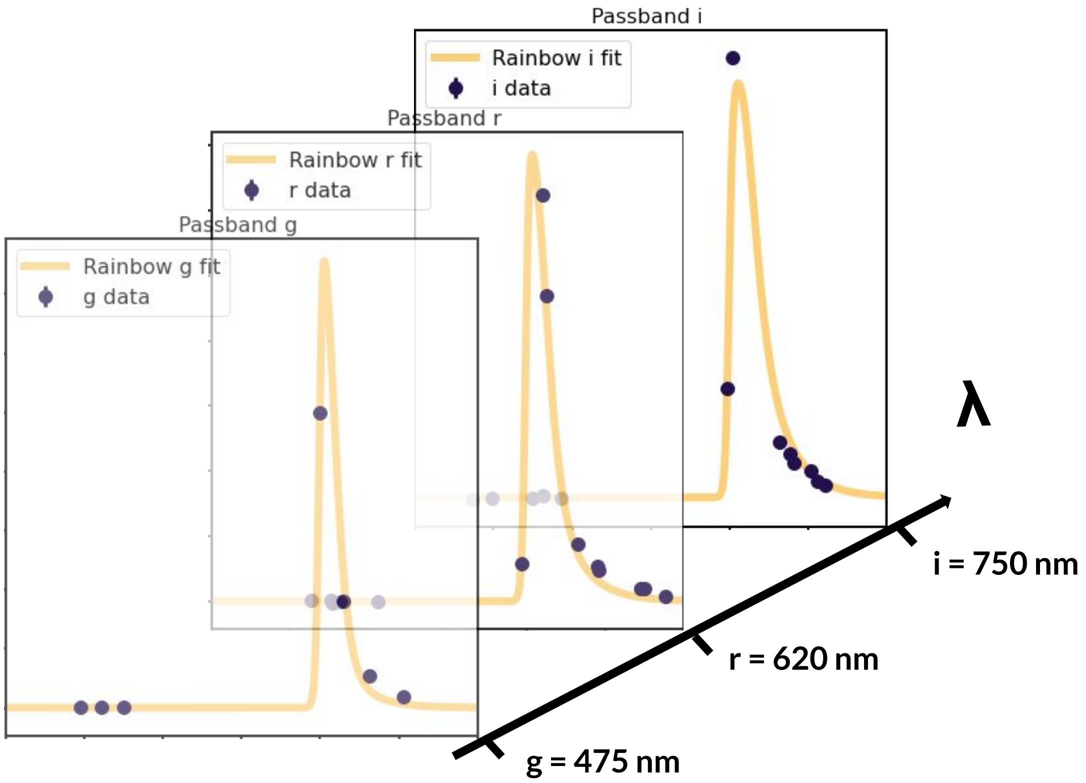
3D way to visualise



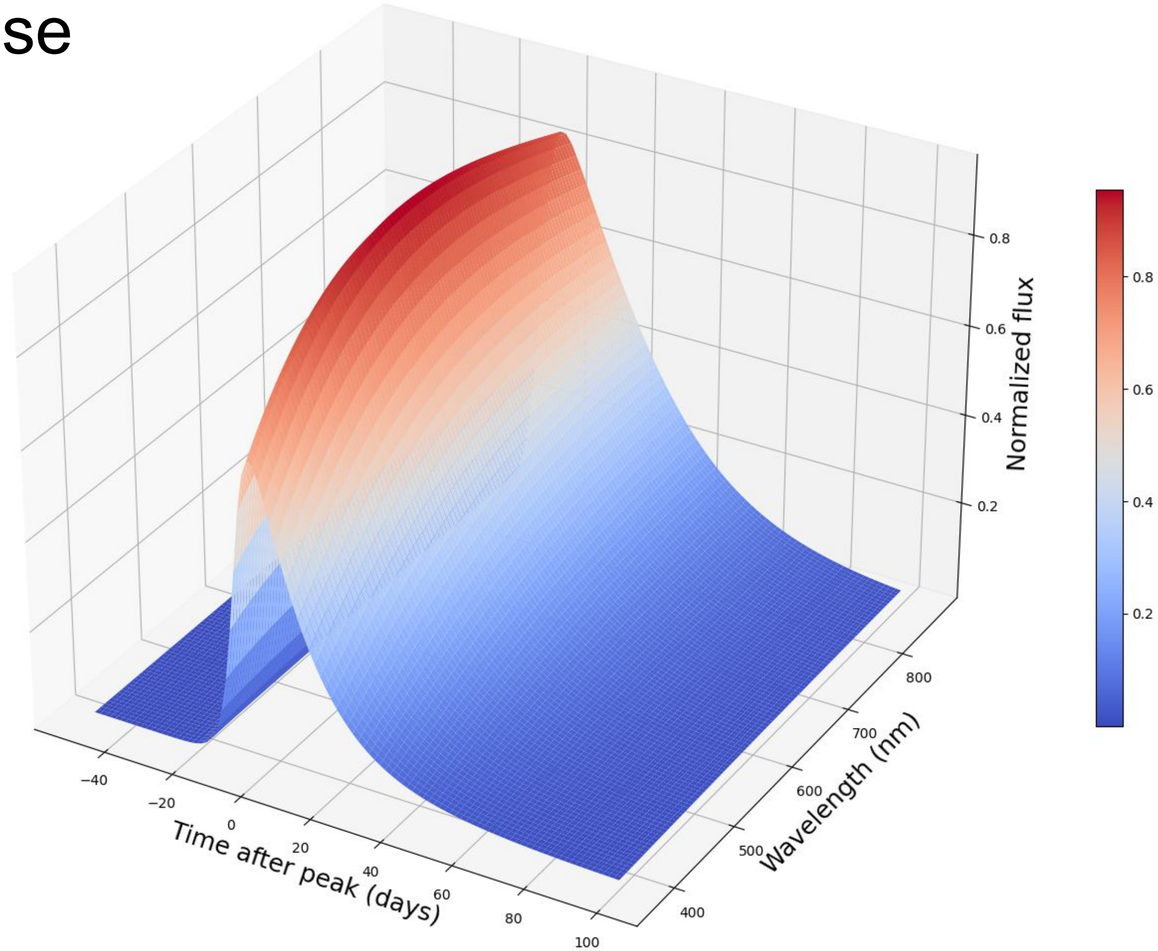
3D way to visualise



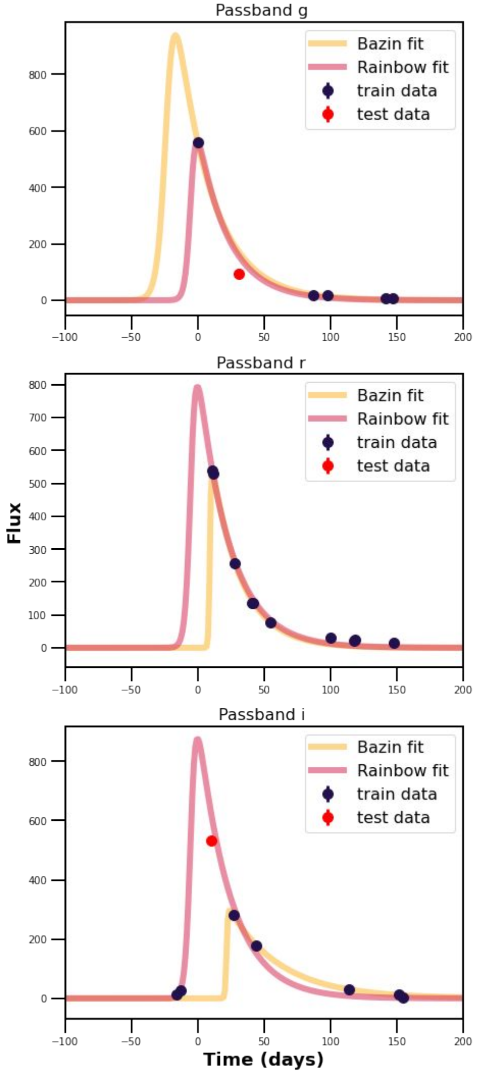
3D way to visualise



3D way to visualise



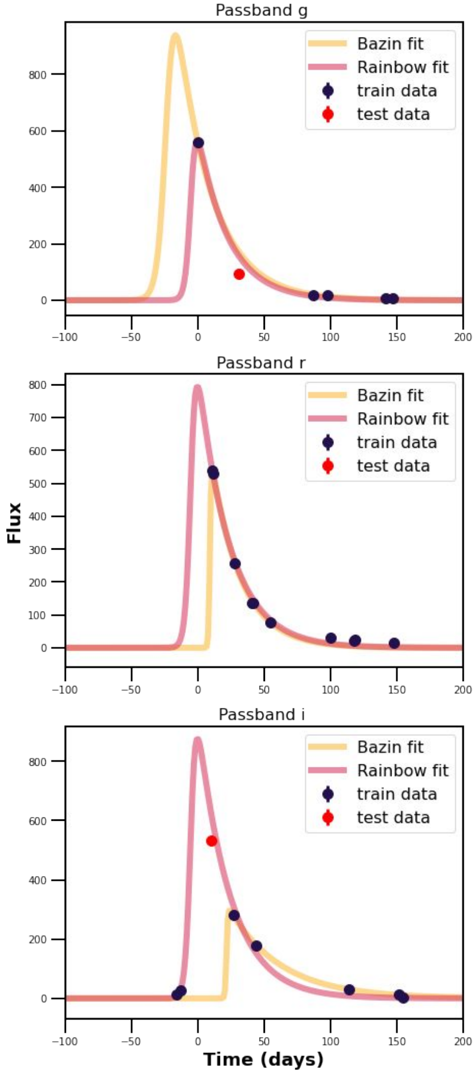
Goodness of fit : points removed



Goodness of fit : points removed

1000 SNIa

	Bazin	Rainbow
Mean RMSE	0.29	0.15
Median RMSE	0.1	0.064



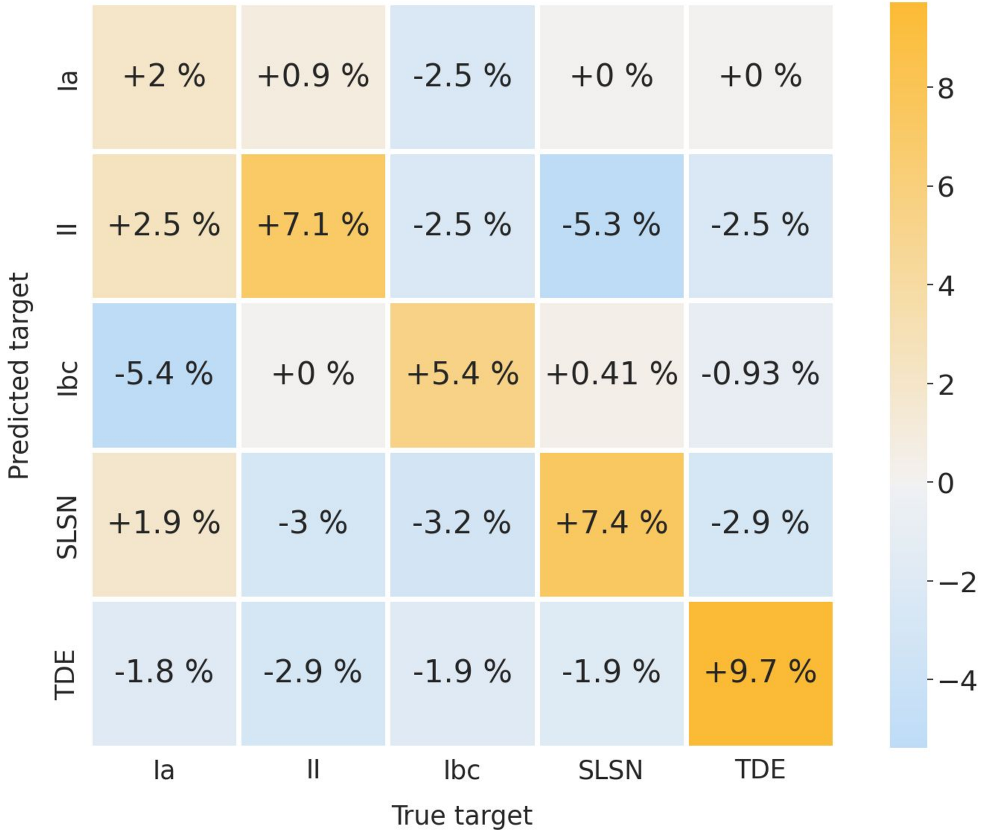
Classification multiclass

300 of each type

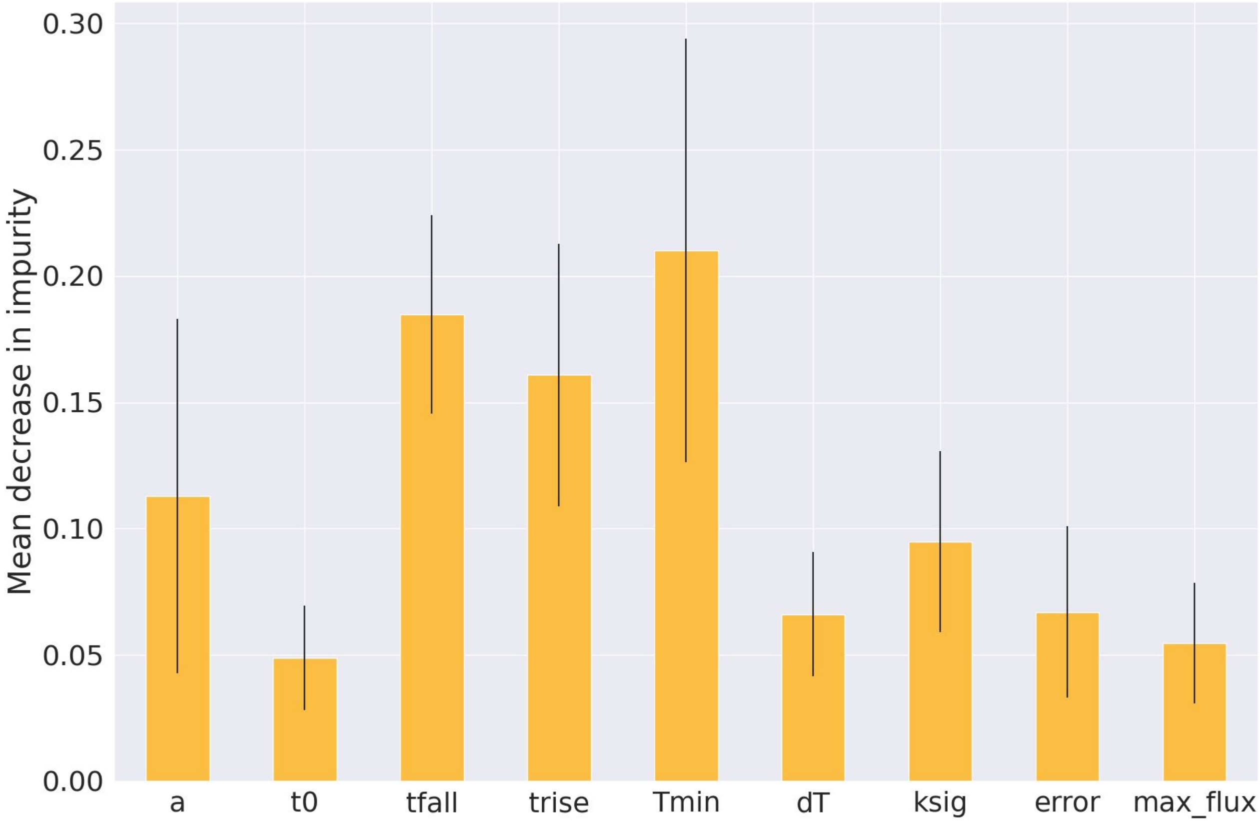
50/50 train test

Random Forest

RAINBOW - Bazin



Classification multiclass



Conclusion

→ RAINBOW offers a very dense description of objects in multiple passbands

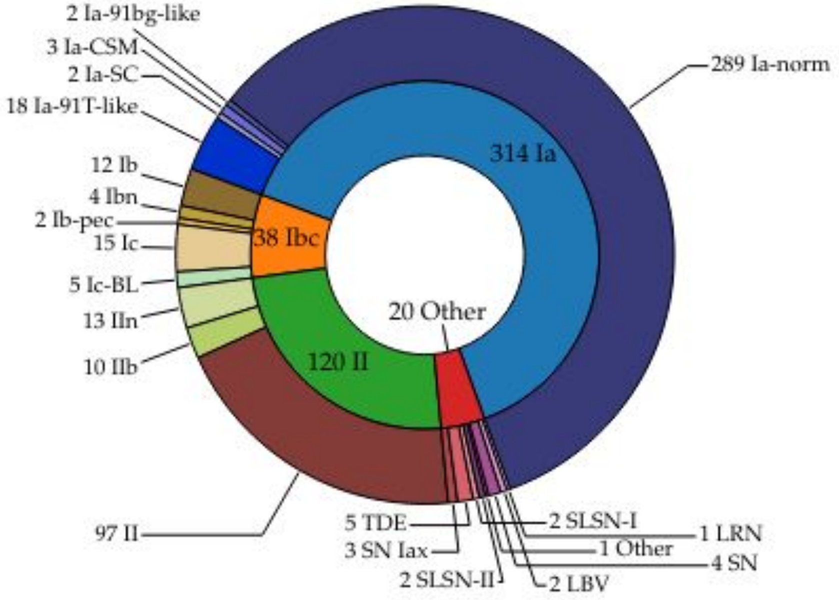
→ Analysis show that it performs better than the standard method

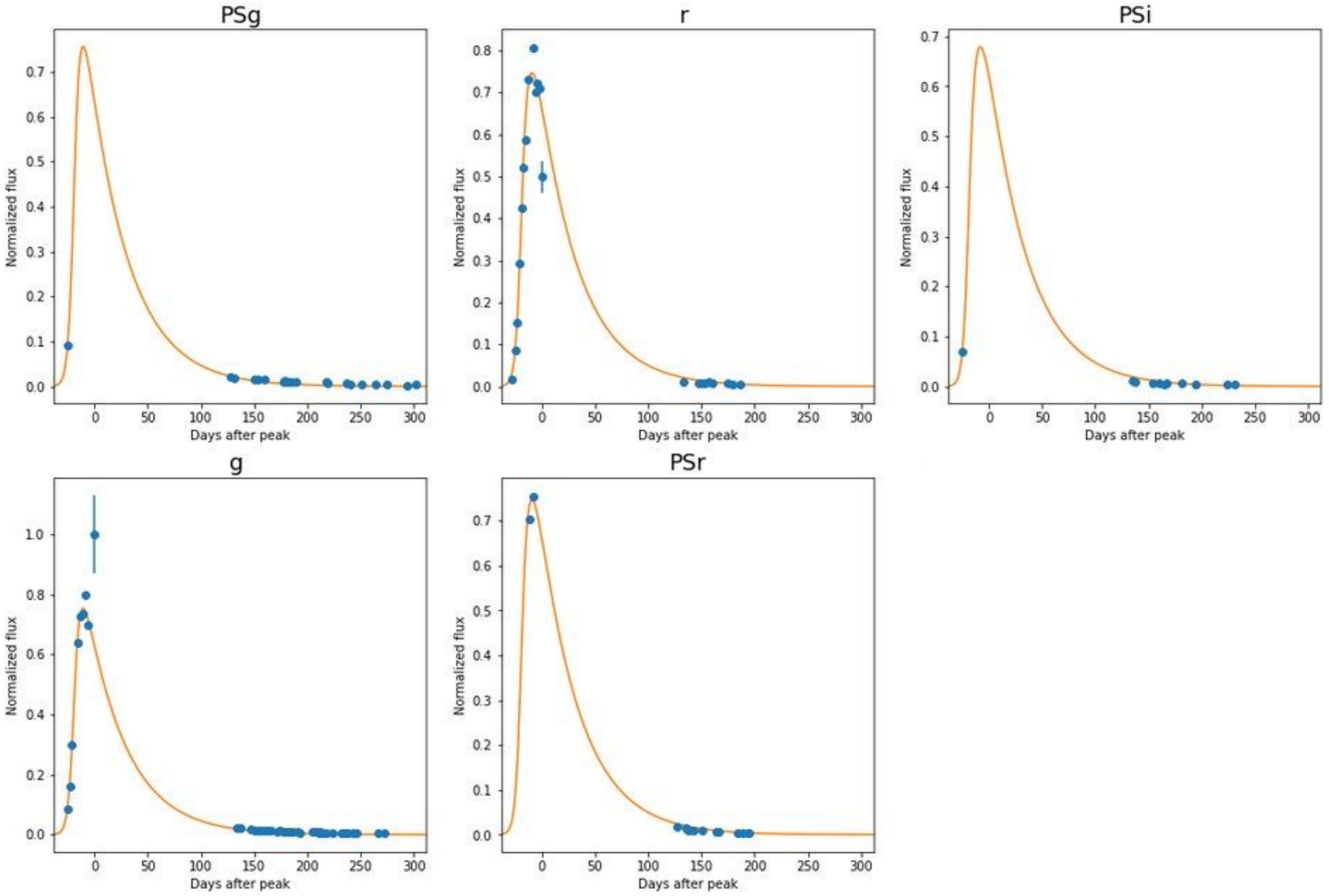
→ Paper is almost out !

YSE database : good application

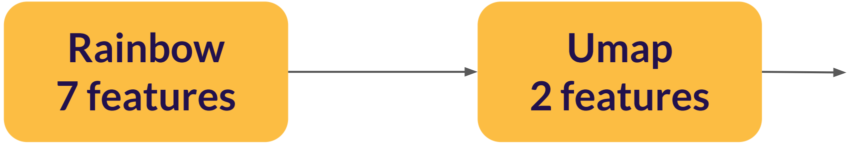
ZTF
g and r

PANSTARR
g, r and i




PSg
r
PSi
g
PSr
Normalized flux
Days after peak

Umap on rainbow features



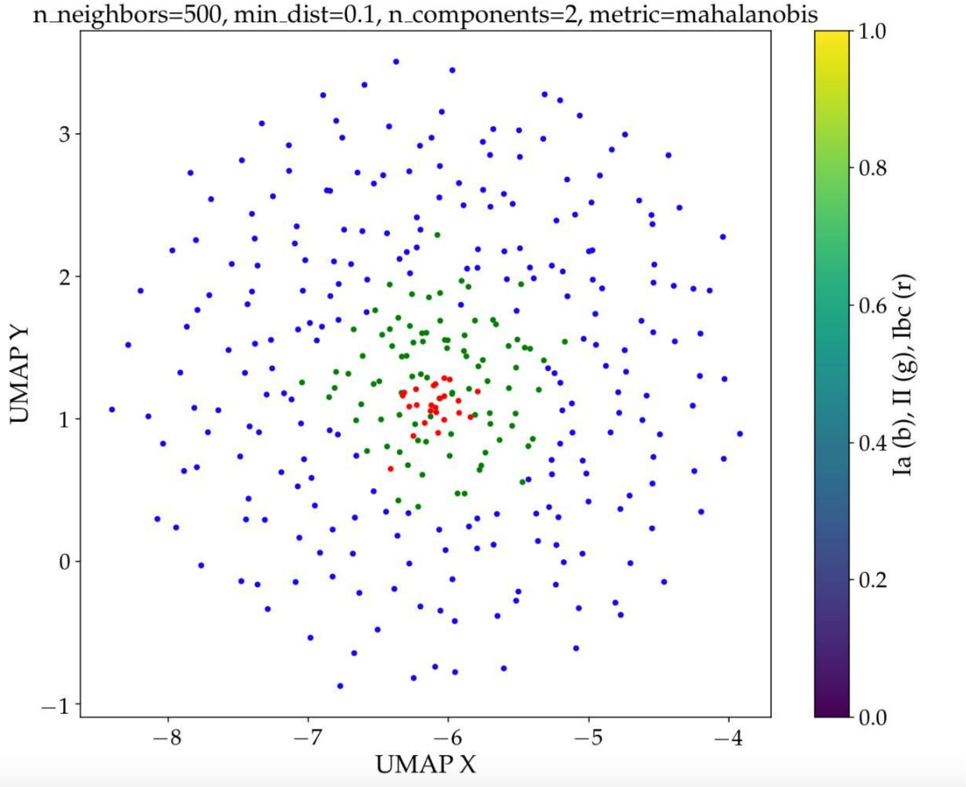
Umap on rainbow features

Rainbow
7 features

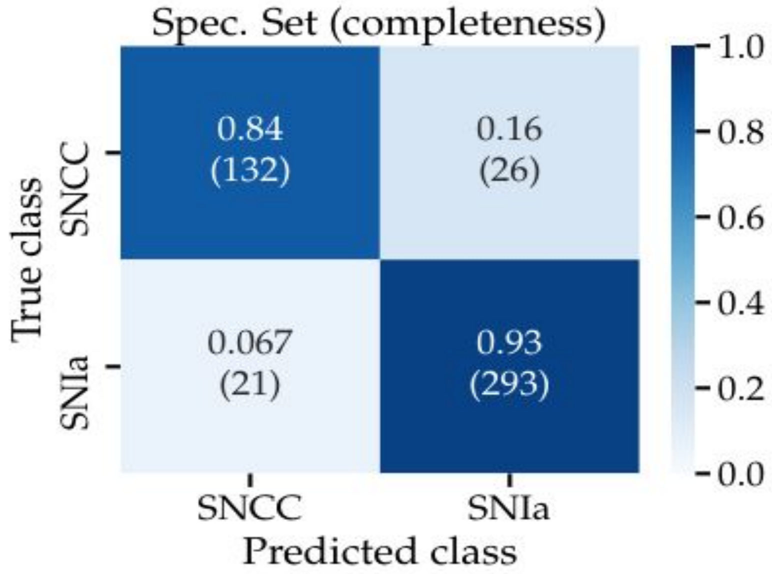
→

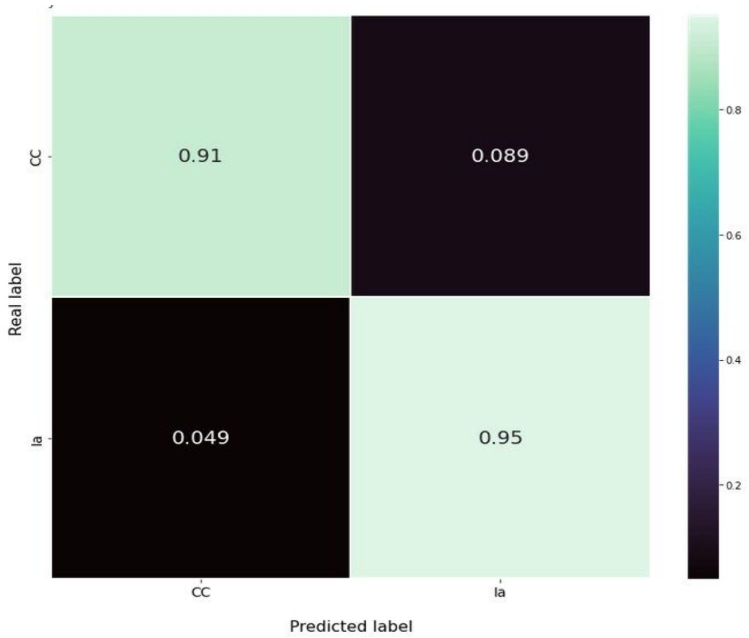
Umap
2 features

→



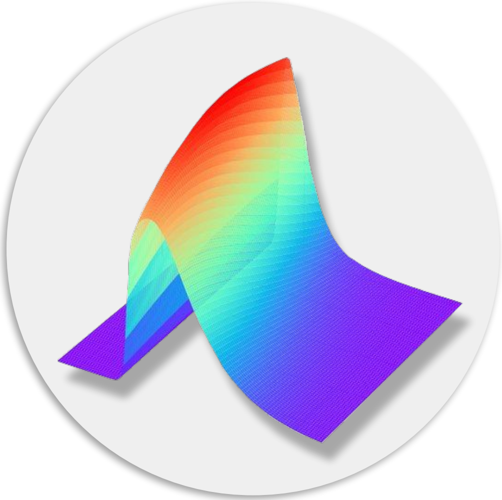
Improved classification score from YSE paper !





https://arxiv.org/abs/2211.07128

RAINBOW

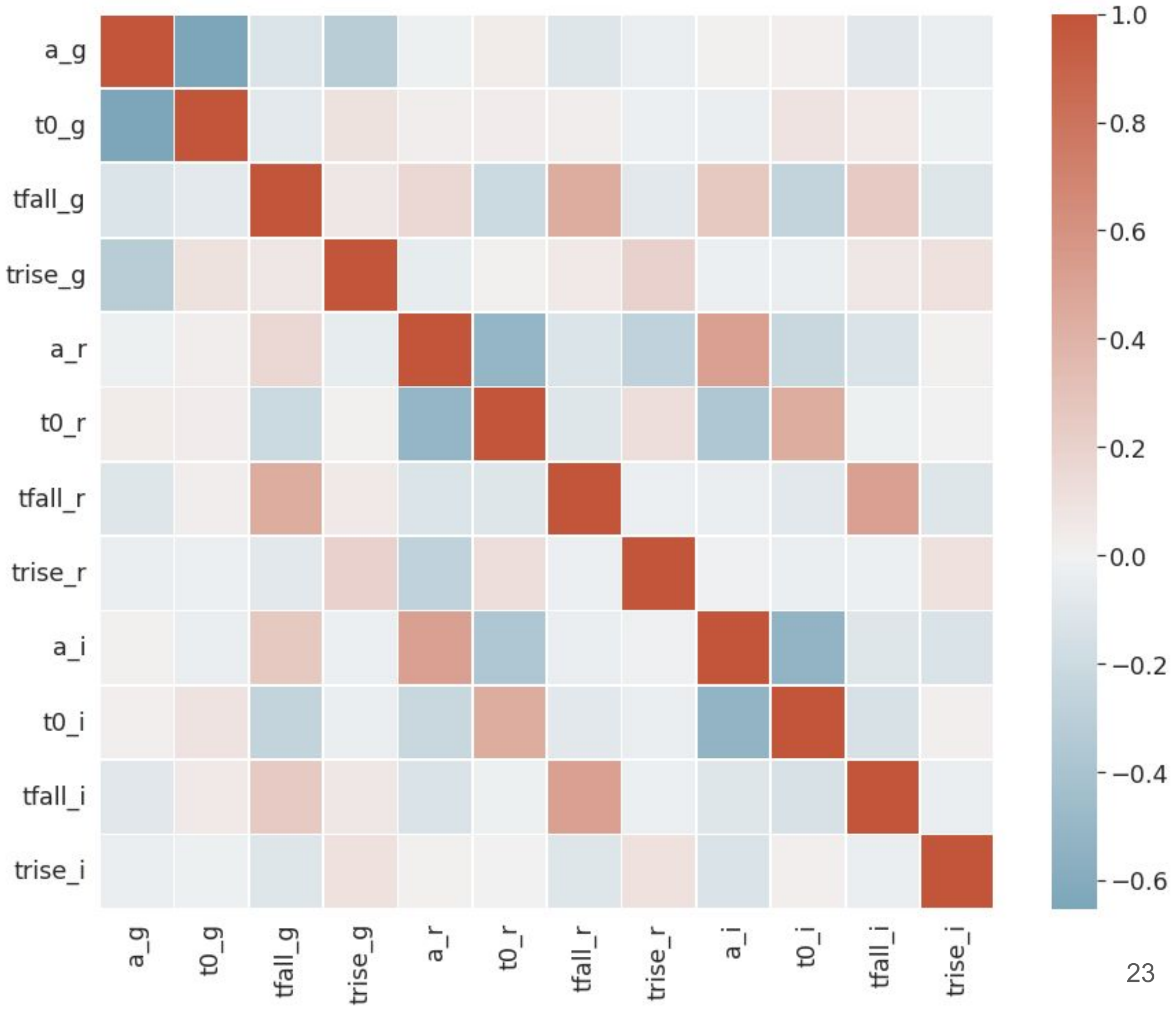


Realistic **A**nalytical **I**nterpolation of super**N**ovae
Bridging **O**ptical **W**avelengths

Correlation problem

1000 SNIa

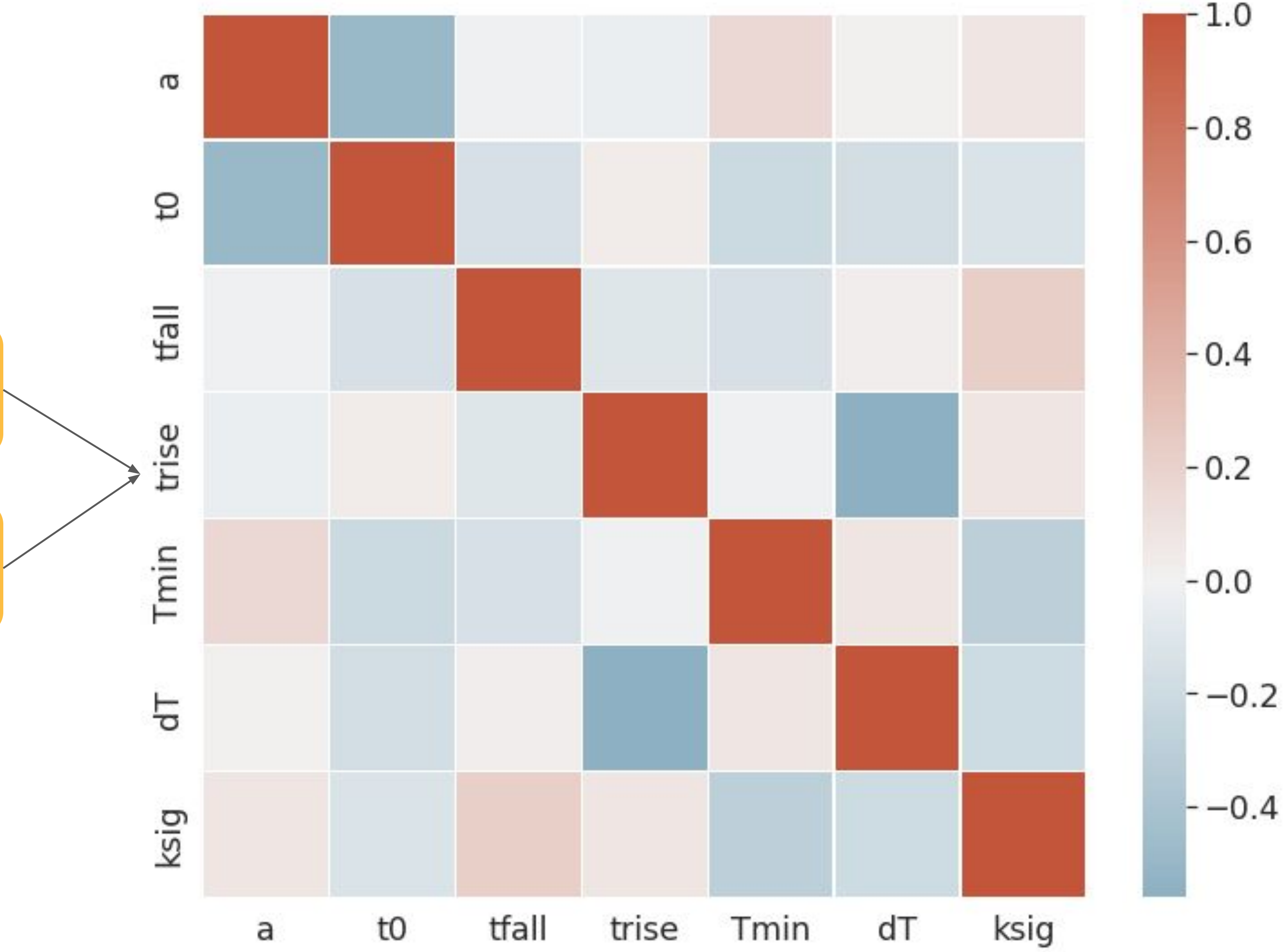
1000 SNII



Correlation

1000 SNIa

1000 SNII



Solution

Blackbody hypothesis

$$F_\nu(\nu) = \int B_\nu(\nu) d\Omega = \pi B_\nu(\nu)$$

Stefan Boltzmann law

$$F_{bol} = \sigma_{SB} \times T^4$$

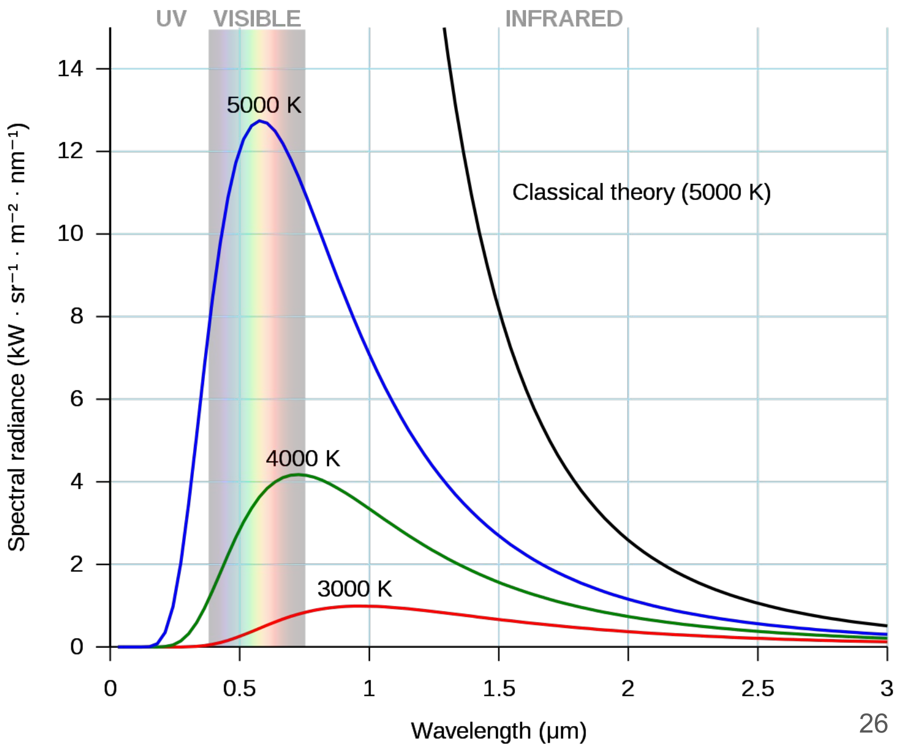
Therefore :

$$\frac{F_\nu^{obs}(\nu)}{F_{bol}^{obs}} = \frac{F_\nu(\nu)}{F_{bol}} = \frac{\pi B_\nu(\nu)}{\sigma_{SB} \times T^4}$$

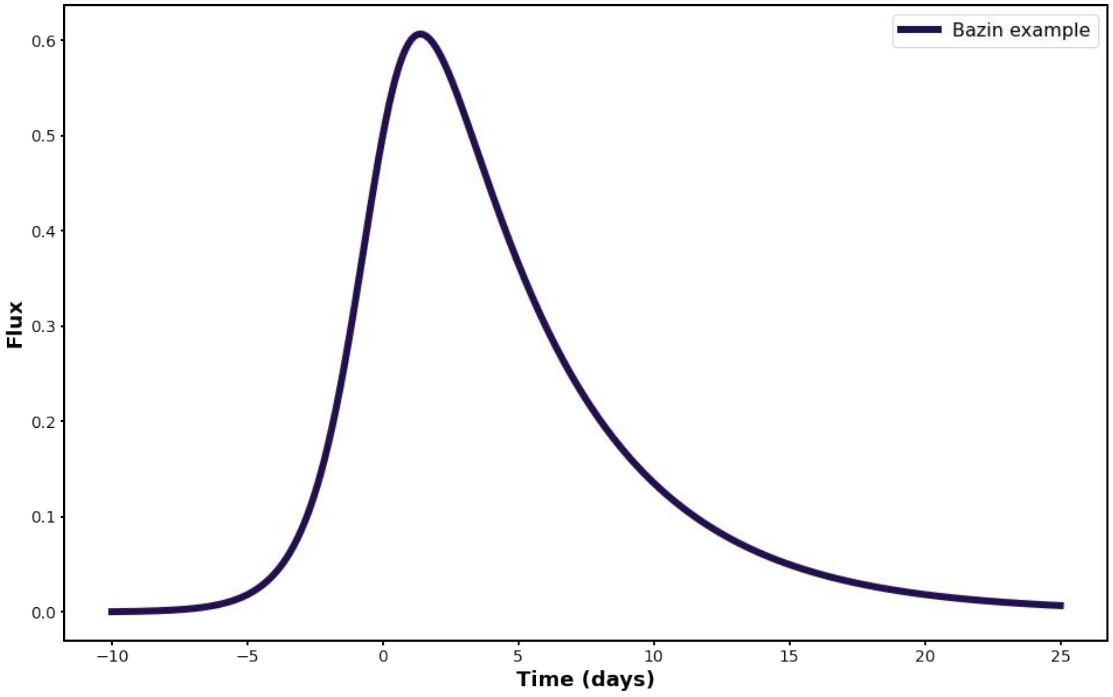
$$F_\nu(t,\nu) = \frac{\pi}{\sigma_{SB}} \times \frac{B_\nu(T,\nu)}{T(t)^4} \times F_{bol}(t)$$

Planck's law

$$B_\nu(\nu,T) = \frac{2h\nu^3}{c^2} \times \frac{1}{exp(\frac{h\nu}{k_B T}) - 1}$$



$$F_\nu(t,\nu) = \frac{\pi}{\sigma_{SB}} \times \frac{B_\nu(T,\nu)}{T(t)^4} \times \boxed{F_{bol}(t)}$$



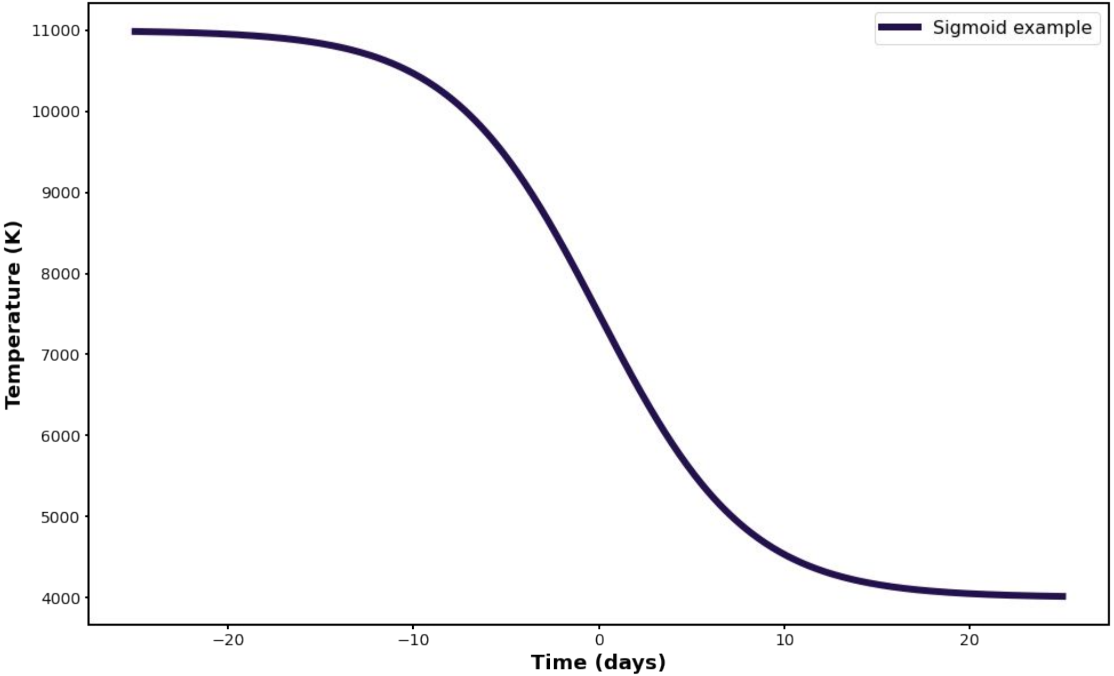
$$F_{bol}(t) = A \times \frac{e^{\frac{-(t-t_0)}{t_{fall}}}}{1+e^{\frac{t-t_0}{t_{rise}}}}$$

Bazin function : **4** parameters

(here we assume that the baseline is 0)

A = 1
t0 = 0
tfall = 5
trise = -1

$$F_\nu(t,\nu) = \frac{\pi}{\sigma_{SB}} \times \frac{B_\nu(T,\nu)}{T(t)^4} \times F_{bol}(t)$$



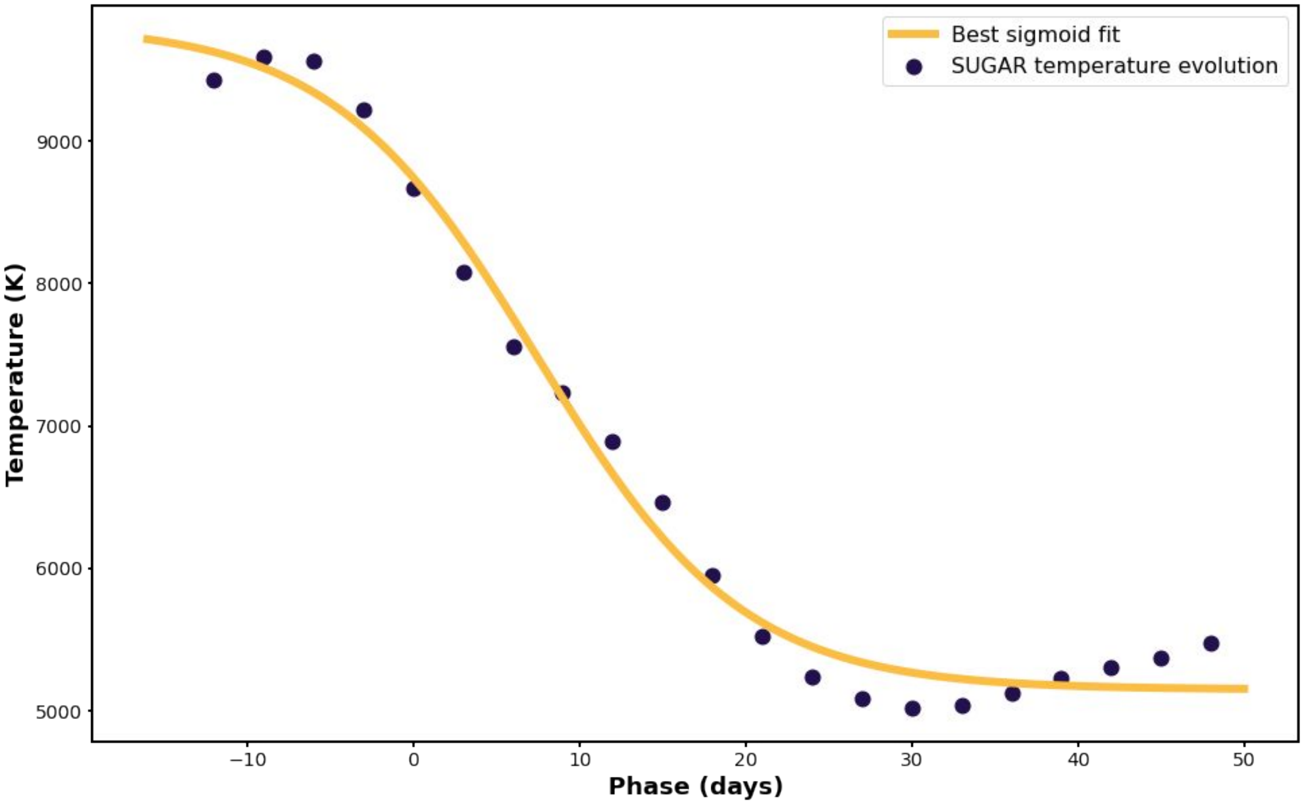
$$T(t) = T_{min} + \frac{T_{var}}{1 + e^{\frac{t-t0}{k_{sig}}}}$$

Sigmoid function : **3** parameters

(t0 is common with Bazin)

Tmin = 4000
Tvar = 7000
ksig = 4
(**t0** = 0)

Why sigmoid ?



Best sigmoid fit
SUGAR temperature evolution
Temperature (K)
9000
8000
7000
6000
5000
Phase (days)
−10
0
10
20
30
40
50