Kilonova detection in Fink

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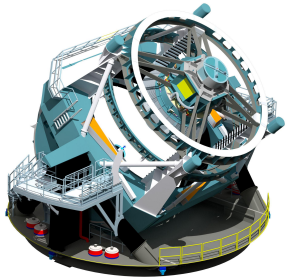
LSST France, 29th Nov, 2022

Fink

every ~30 seconds down to mag ~24



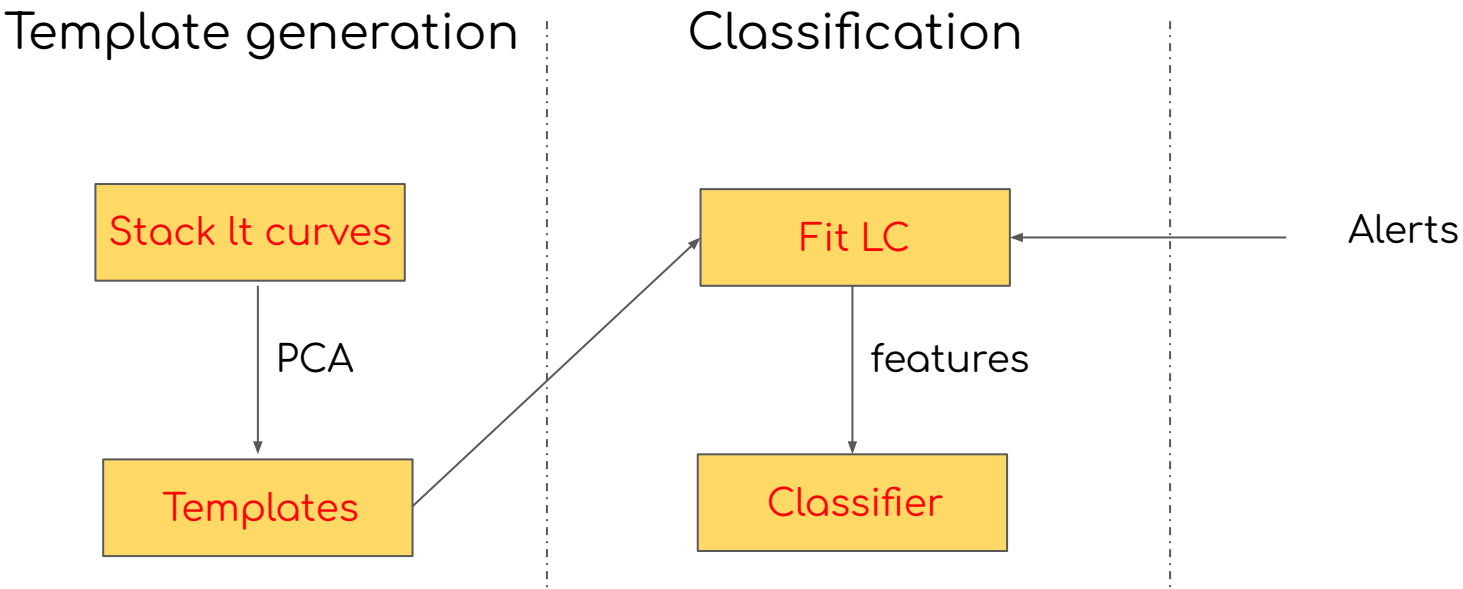
10 million alerts per night…

BROKER

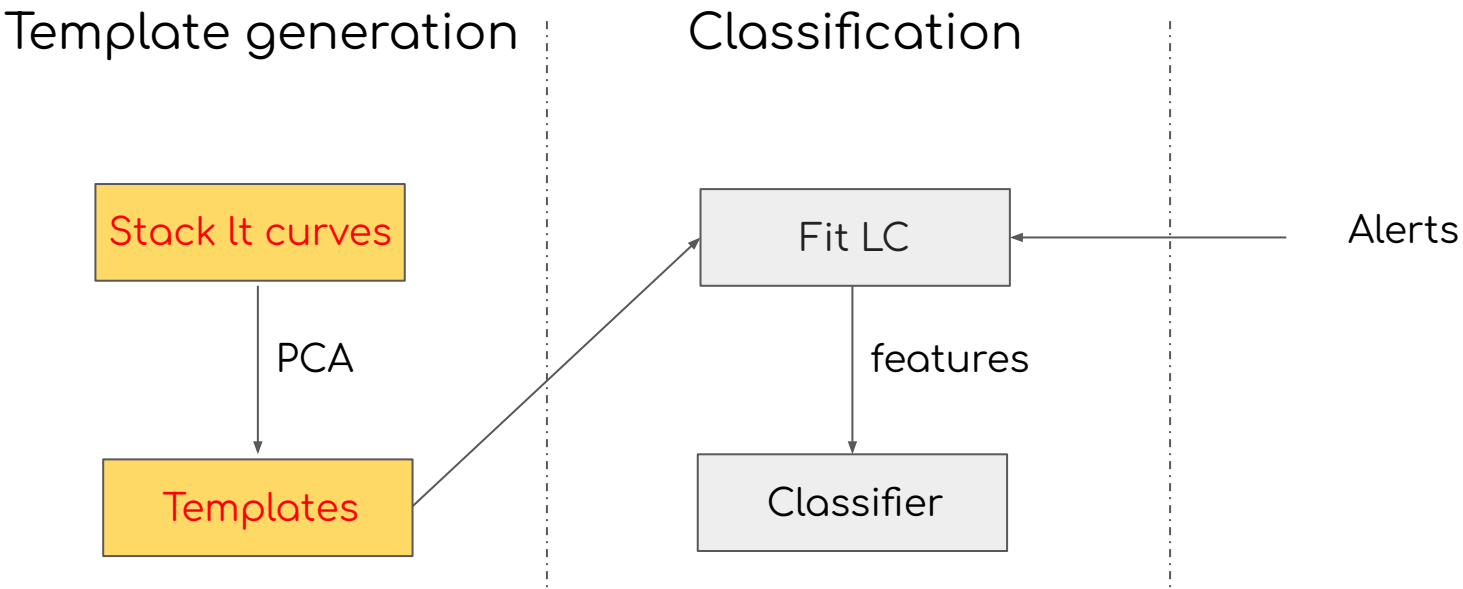
Machine learning
Catalog association
Streams join

We would like the interesting ones ...

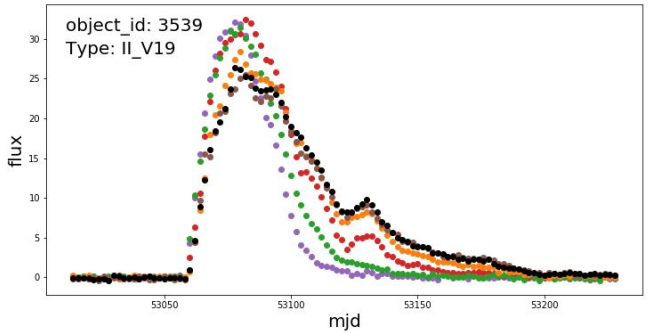
KN module for Fink

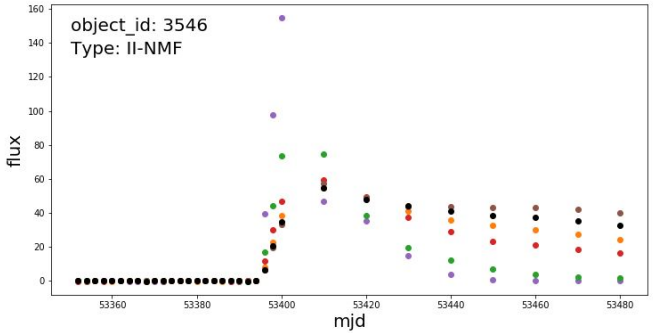


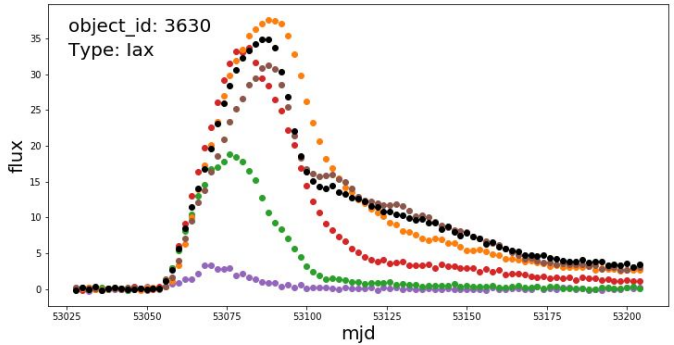
KN module for Fink



Generating PCs: Dataset (RESSPECT 'perfect' simulations)





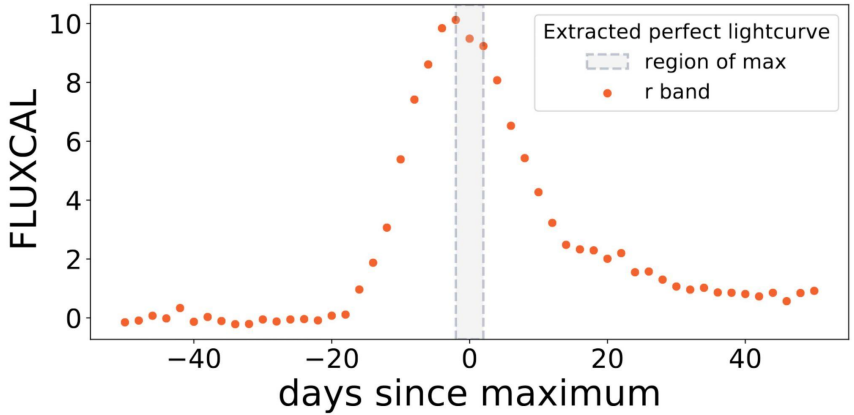


'Perfect' simulations:

- Different types of transient events
- Readings every 2 days
- No missing data points

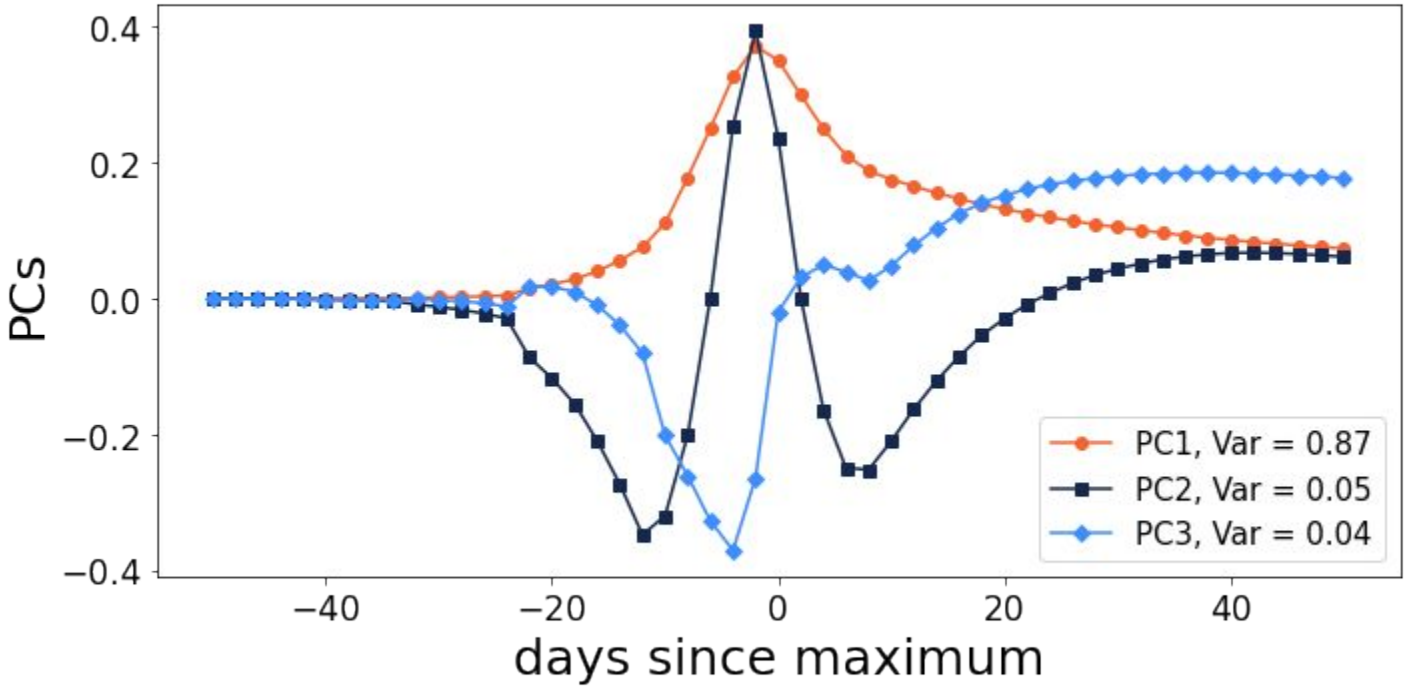
Generating PCs: Anchoring the data

- Events: 1000 KN events + 1000 non-KN events
- Filter only ‘g’ and ‘r’ bands of LSST
- Extract 100 days of data in such a way that Amplitude is placed at day 50.



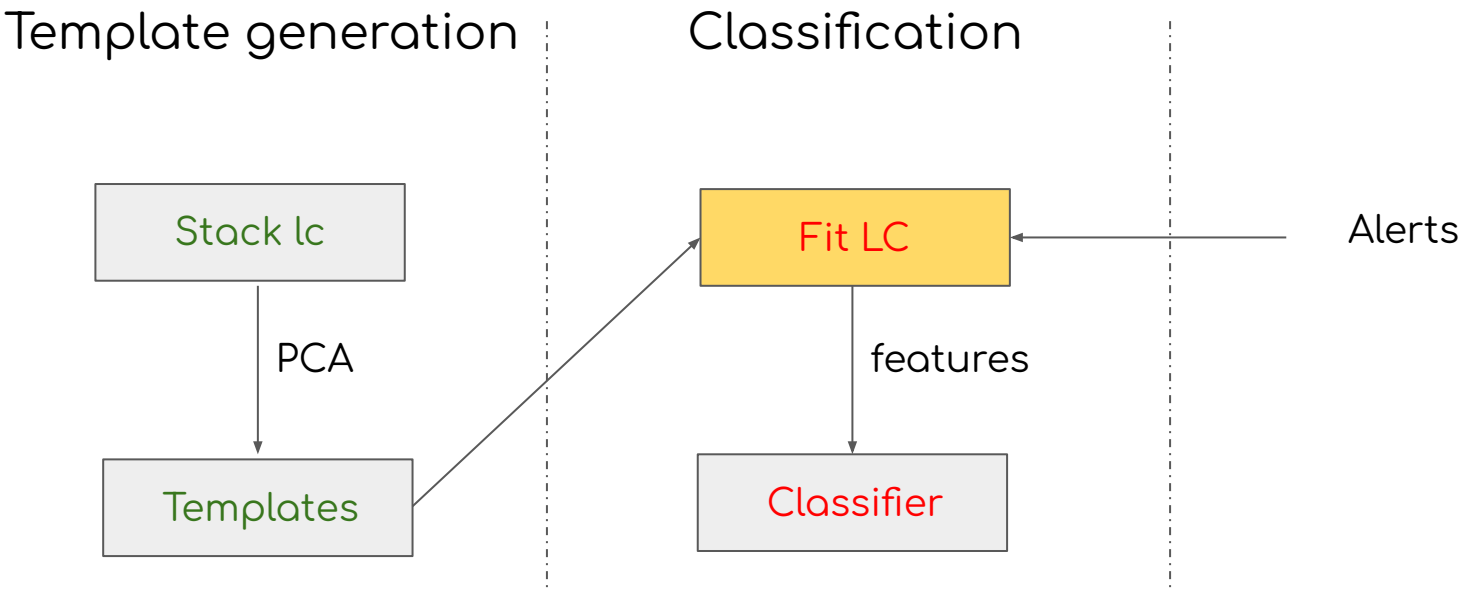
Dataset: RESSPECT sims

Generated templates



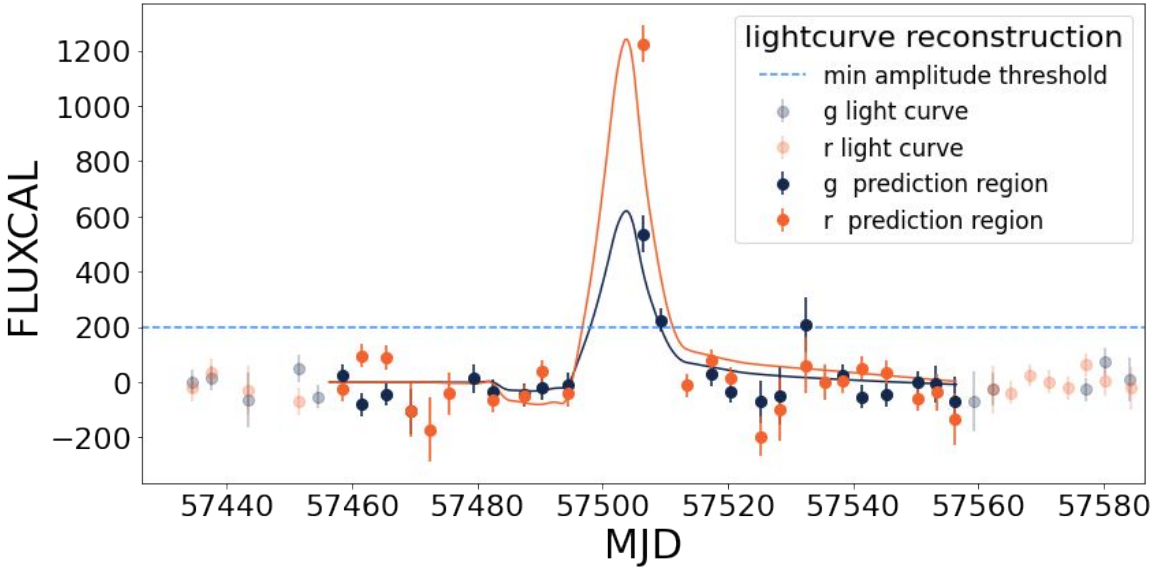
Next we will represent light curves as a linear combination of these 3 curves

Flowchart



Now we will represent light curves as a linear combination of the templates

Fitting the curve: ZTF Simulations



For each band:

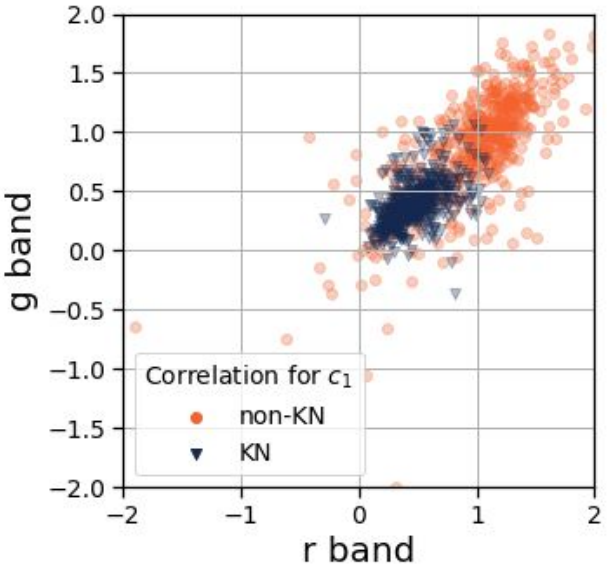
Make fit only if max flux is above a threshold (>200)

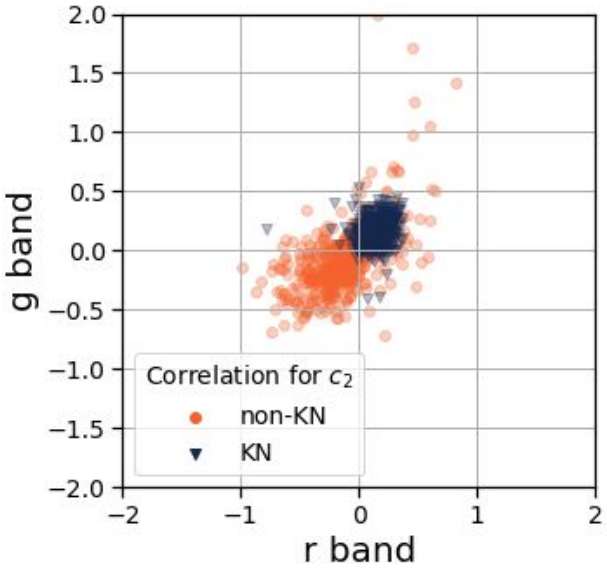
Anchor the data with day 50 of the prediction region as highest flux.

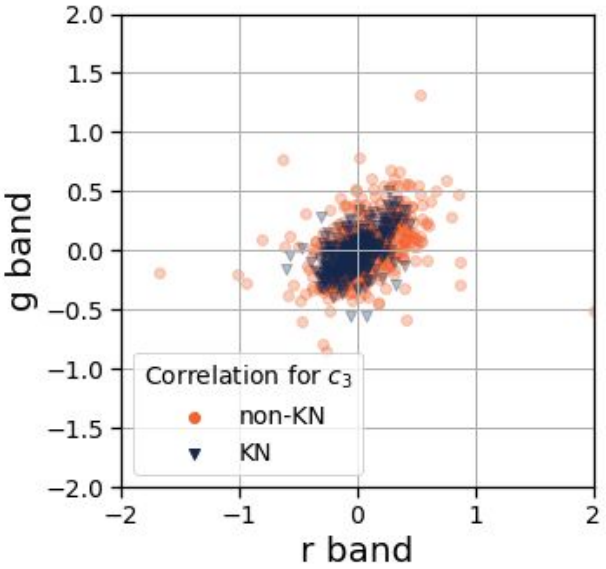
Optimize values of PC coefficients to obtain the fit.

$$loss = \sum_{i}^{N} \frac{(l_{p,i} - l_i)^2}{\sigma_i^2} + \left[\sum_{k=1}^{3} c_k^2 - c_1^2 H(c_1)\right] \frac{f_{\max}^2}{\sigma_{f_{\max}}^2}$$

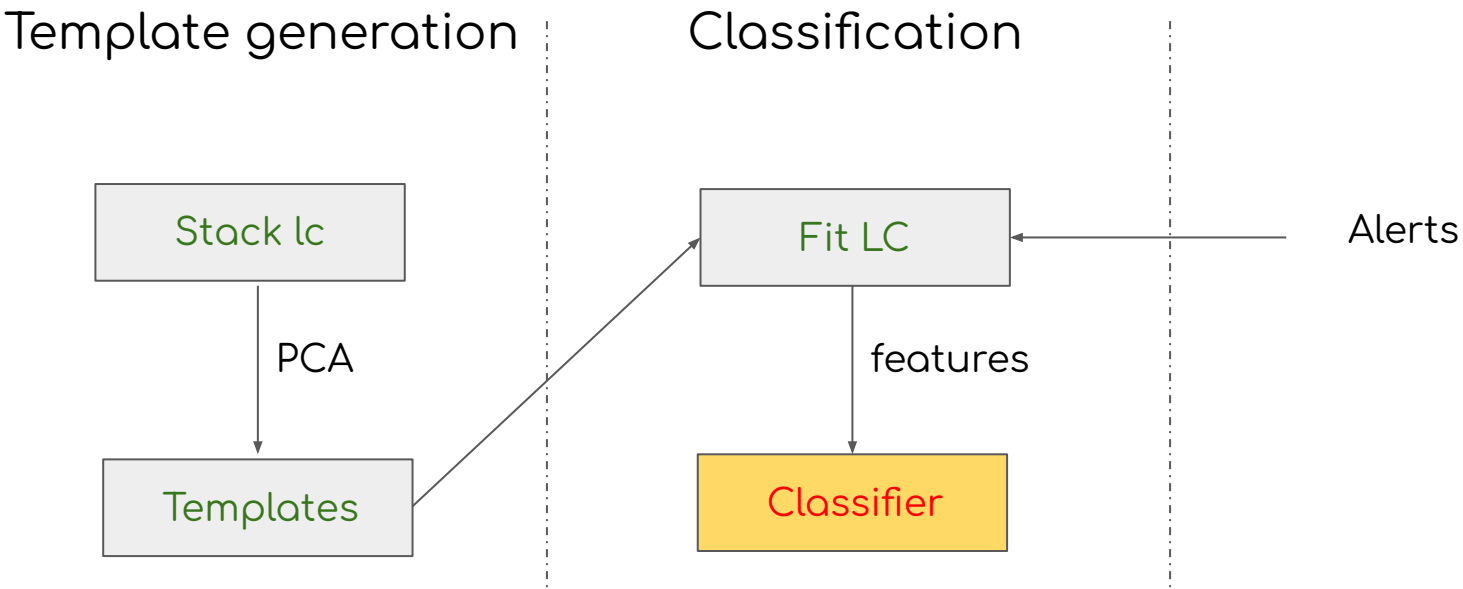
Correlation plots







Flowchart



Now we will represent light curves as a linear combination of the templates

Classification (Random Forest)

Features: fit coefficients, max flux, fit residual

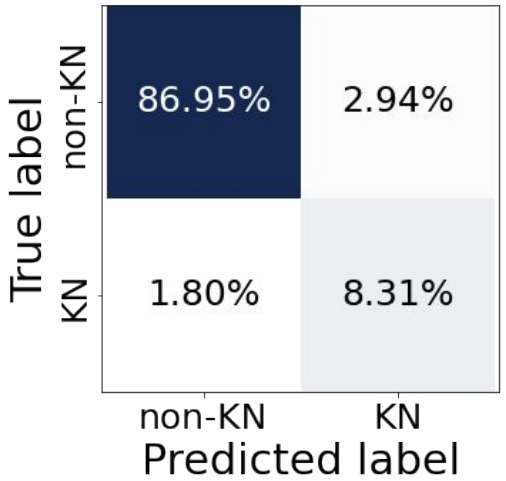
Train dataset:

total number of events: 22280
total number of KN: 3280
total number of non KN: 19000

Test dataset:

total number of events: 18715
total number of KN: 1892
total number of non KN: 16823

results

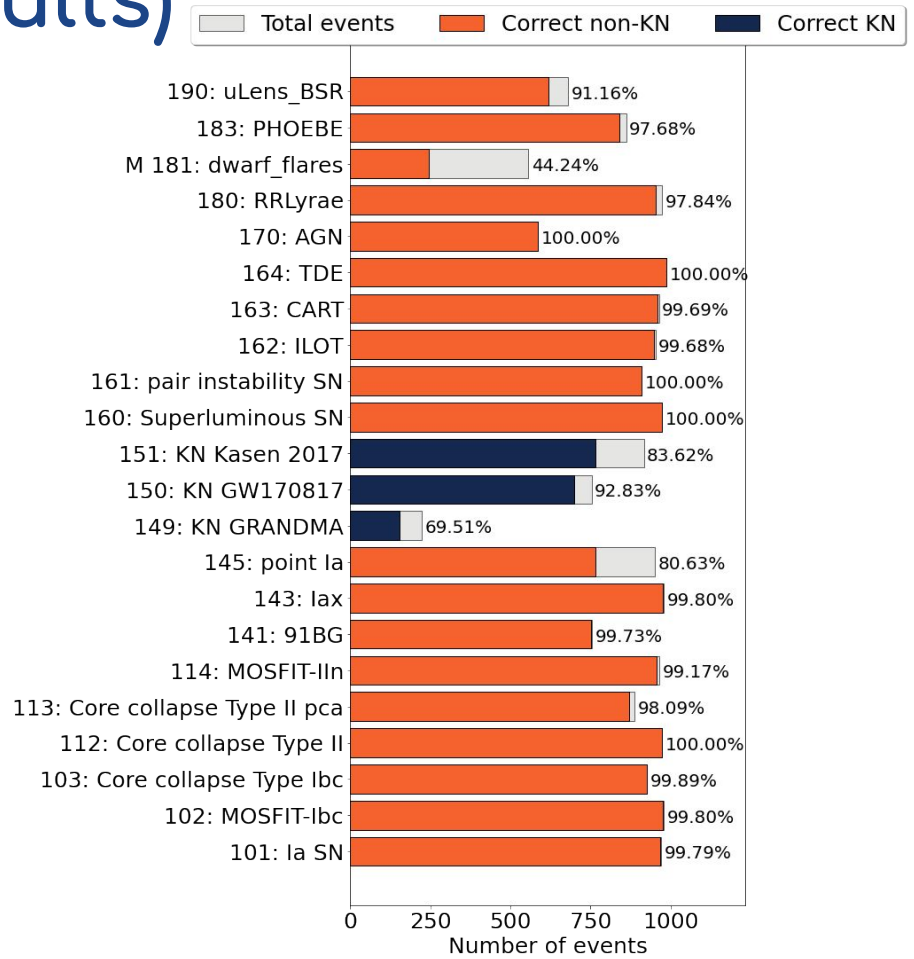


True Positive : 1555
False Positive : 550
True negative : 16273
False negative : 337

Classification (Results)

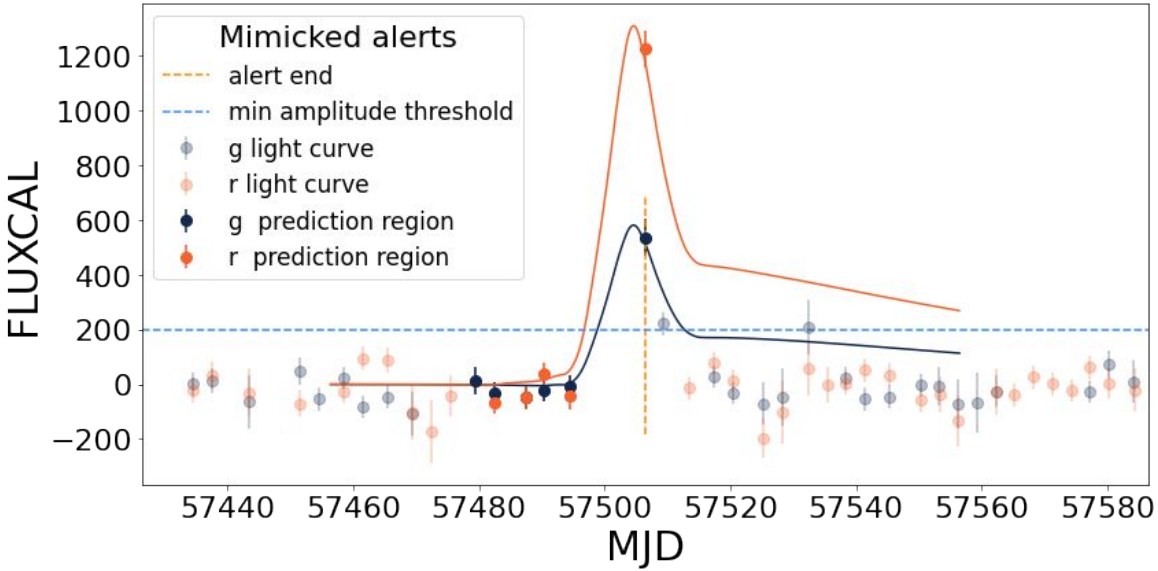
Test Dataset

total number of events: 18715
total number of KN: 1892
total number of non KN: 16823



What about alerts?

Mimic alerts



Pick a point with flux>200

Use only 30 days of data before this date

Classification (Random Forest)

Features: fit coefficients, max flux, fit residual

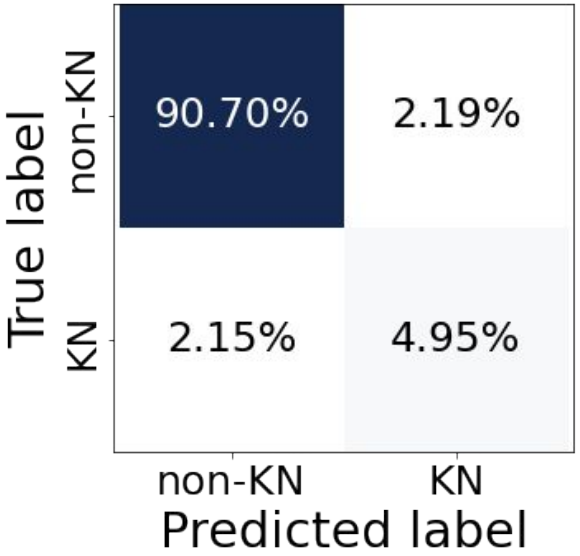
Train dataset:

total number of events: 22280
total number of KN: 3280
total number of non KN: 19000

Test statistics:

total number of events: 13125
total number of KN: 932
total number of non KN: 12193

results

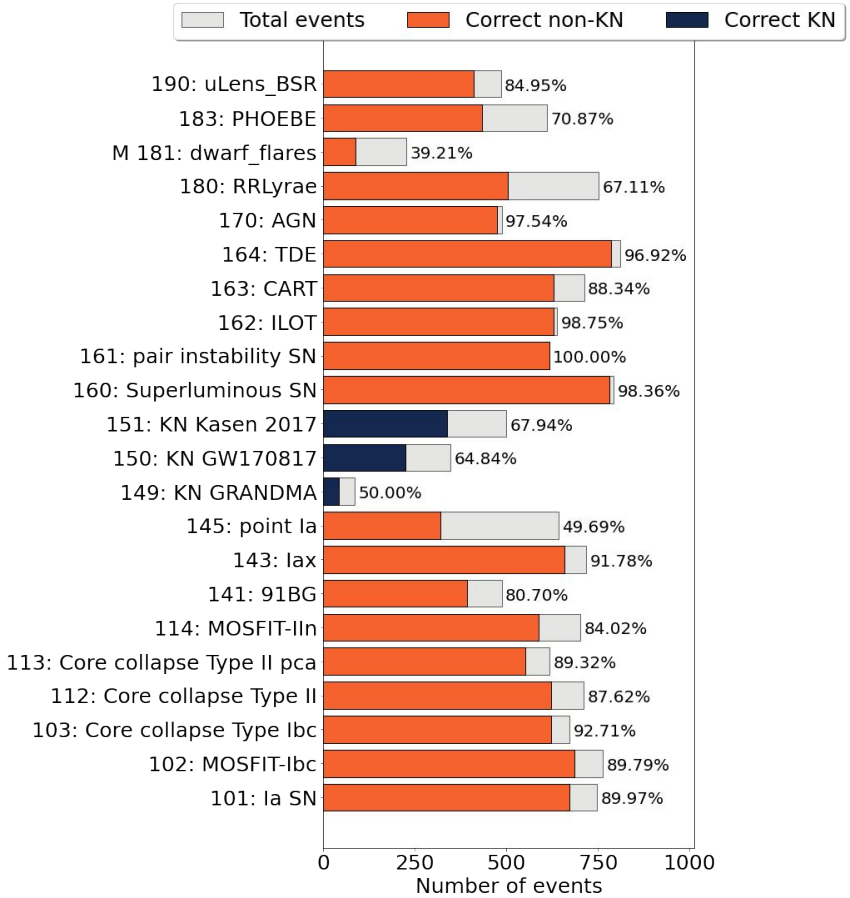


True Positive : 650
False Positive : 288
True negative : 11905
False negative : 282

Classification results

Test dataset:

total number of events: 13125
total number of KN: 932
total number of non KN: 12193



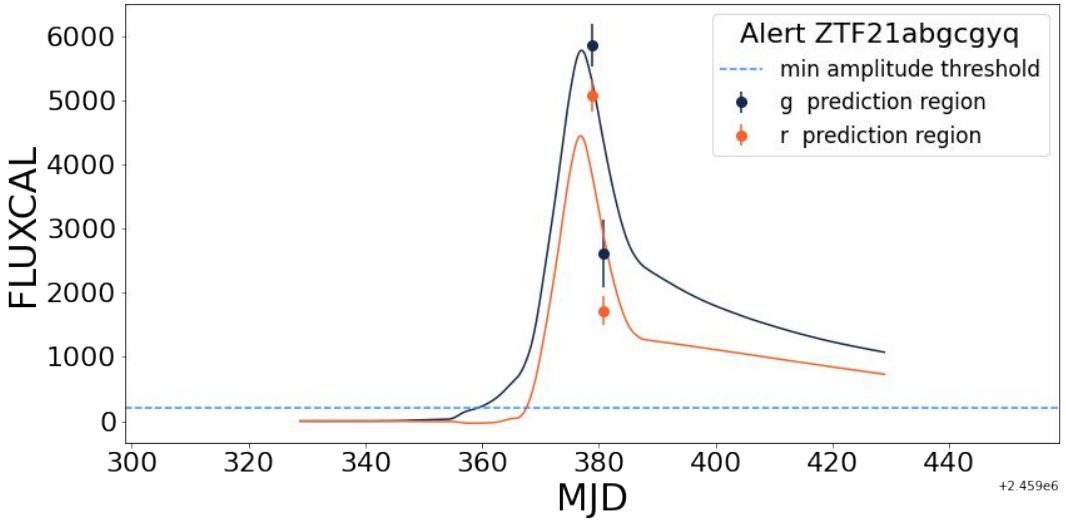
Results on ZTF Alert stream

Number of alerts: 75,925,464

Number of nights: 524

Number of alerts classified as KN: 1996

(1251 Unique objects)



Example KN-candidate classification by the module

https://fink-portal.org/ ZTF21abgcgyq

alert ID 1626368700115015000

Summary

- Built KN detection module to analyze alerts in real time.
  (among one of the classifiers used by GRANDMA collaboration for follow-up)
- Requirement:
  At least 2 points in a band with max_flux > 200
- Impurities mostly come from other “fast”-transients
- Code: https://github.com/b-biswas/kndetect
- Paper on arXiv:2210.17433!

Thank you!