NOMAI: A real-time photometric classifier for superluminous supernovae identification

Fink general meeting

Etienne Russeil

Superluminous supernovae (SLSNe)

- Core collapse supernovae with M<-20
- Wide variety of behaviour
- < 500 known SLSNe
- LSST: 10^4 SLSN per year (Villar+2018)

Mostly ZTF

Credit: Palomar Observatory/Caltech

Searching for SLSNe in the ZTF stream

Already multiple classifiers

Searching for SLSNe in the ZTF stream

Already multiple classifiers

Now Fink also has one !

NOMAI: A real-time photometric classifier for superluminous supernovae identification

A science module for the Fink broker

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ABSTRACT

Superluminous supernovae (SLSNe) are one of the most luminous stellar explosions known, yet they remain poorly understood. Because they are intrinsically rare, efficiently identifying them in the large alert streams produced by modern time-domain surveys is essential for building larger observational samples and enabling spectroscopic follow-up. We present NOMAI, a machine learning classifier designed to identify SLSN candidates directly from photometric alerts in the ZTF stream, using light curves accumulated over at least 30 days. It does not require any spectroscopic redshift and is running in real time within the Fink broker. ZTF light curves are transformed into a set of physically motivated features derived primarily from model-fitting procedures using SALT2 and Rainbow, a blackbody-based multi-band fitting framework. These features are used to train an XGBoost classifier on a curated dataset of labeled ZTF sources constructed using literature samples of SLSNe, along with TNS and internal ZTF labeled sources. The final training dataset contains 5280 unique sources, including 225 spectroscopically classified SLSNe. On the training sample, the classifier reaches 66% completeness and 58% purity. Deployed within the Fink broker, NOMAI has been running continuously since 18/12/2025 on the ZTF alert stream and publicly reports SLSN candidates every night by automatically posting them to dedicated communication channels. Based on this, we also report the first two-month as an evaluation period, where the classifier successfully recovered 22 of the 24 active SLSNe reported on the Transient Name Server. The achieved performances, particularly the high completeness in real-time operations, demonstrate that the classifier provides a valuable tool for experts to efficiently scan the alert stream and identify promising candidates. In the near future, NOMAI is intended to be adapted to operate on the Legacy Survey of Space and Time conducted by the Vera C. Rubin Observatory, which is expected to uncover an unprecedented number of transients, making machine learning based photometric classification essential.

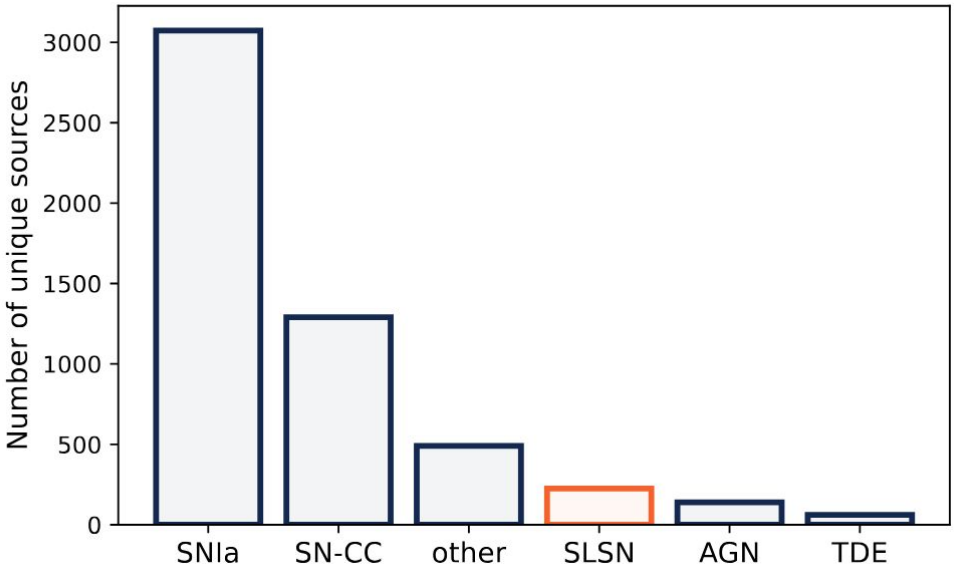
Key words. supernovae: general, methods: data analysis, techniques: photometric, surveys, astronomical databases: miscellaneous, methods: numerical

The training sample (spectroscopic labels)

Private ZTF labels

- **SLSNe from sample papers**

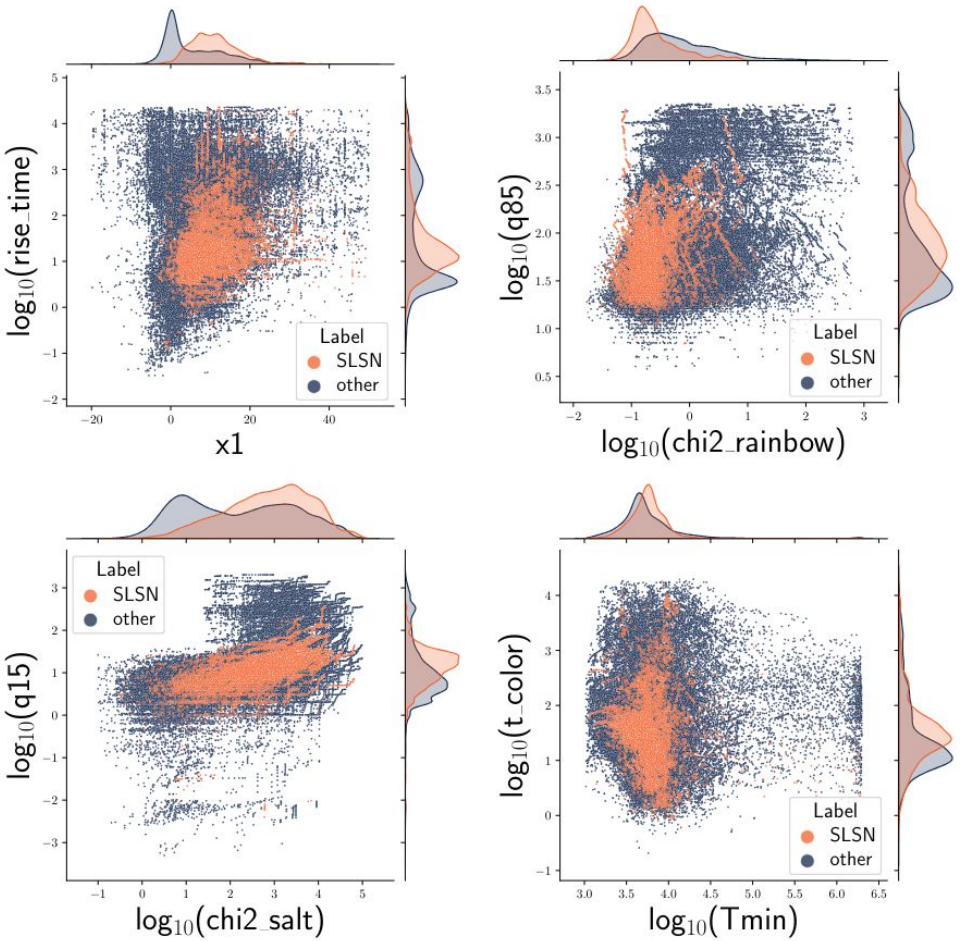
  Gomez et al. (2024) & Pessi, P. J. et al. (2025)
- **Every available TNS labels**
- **Reclassify all missed SLSNe**



Feature extraction

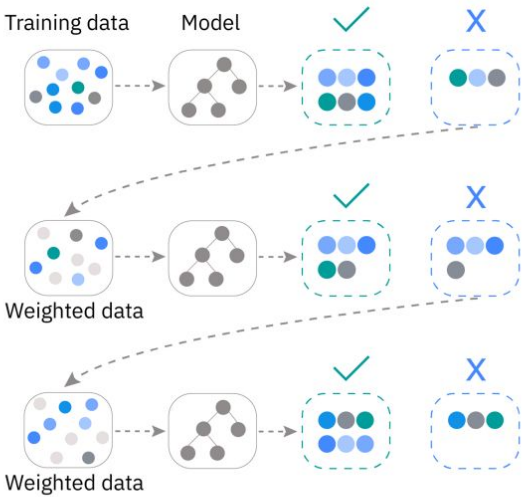
27 features per light curve

- SALT2 features
- Rainbow features *Russeil et al. 2024*
- Statistical features
- Distnr
- No redshift !



Machine learning method

XGBoost classifier

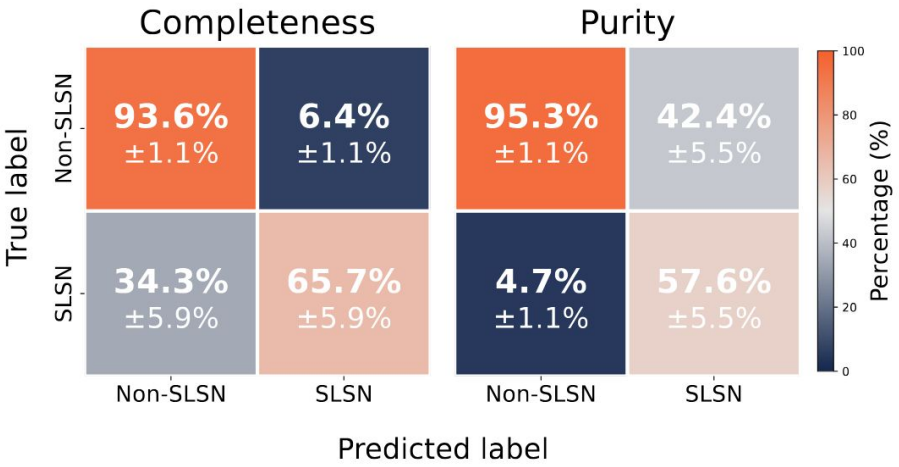


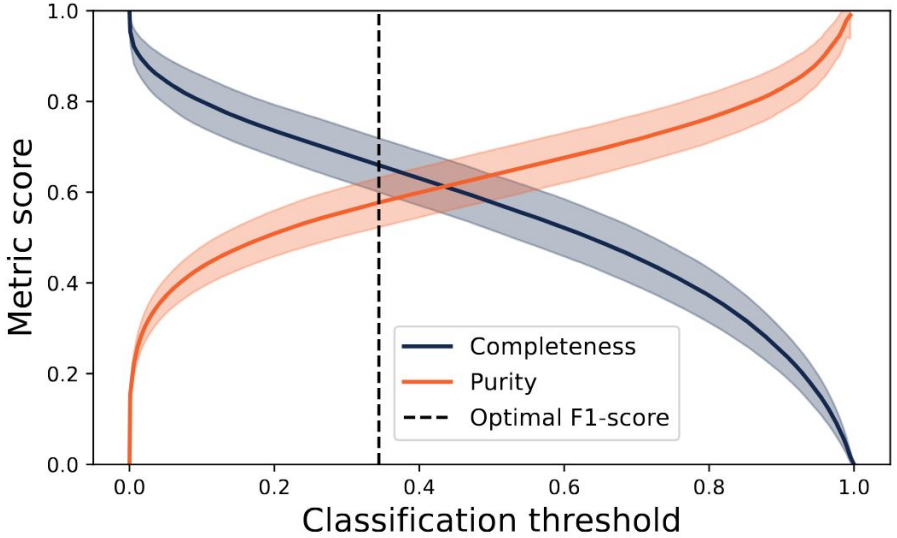
Hyperparameter optimization

[max_depth]
[learning_rate]
[max_delta_step]
[reg_lambda]
[reg_alpha]
1000 random sets

https://www.ibm.com/fr-fr/think/topics/xgboost

Training results





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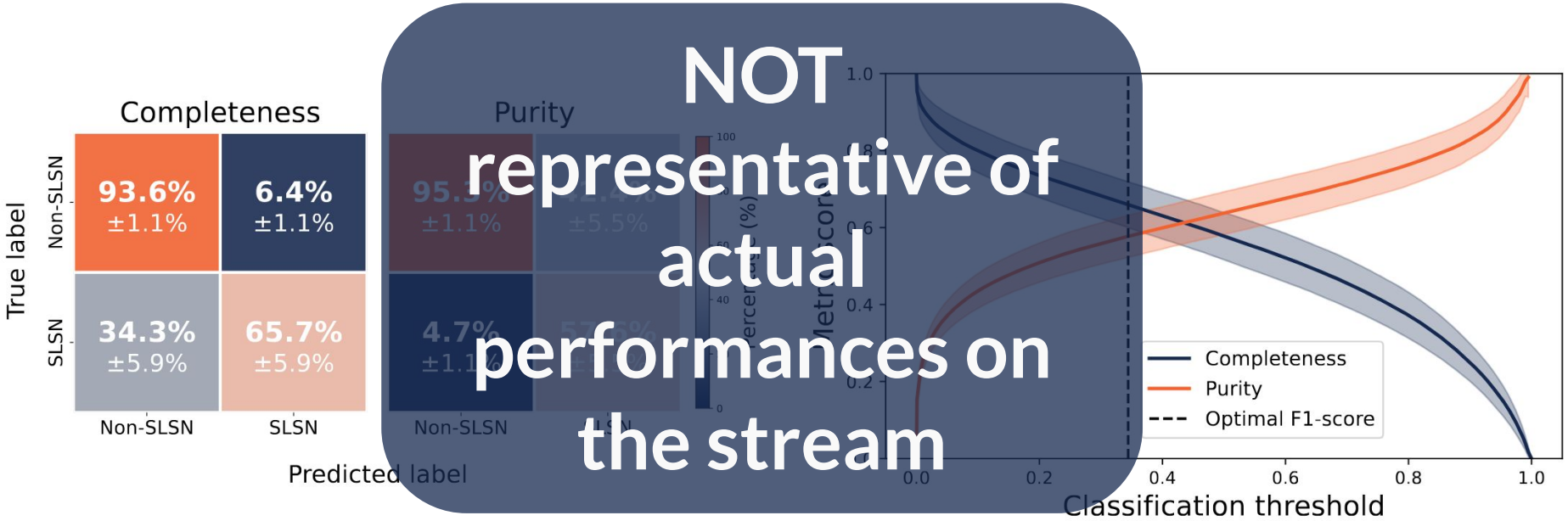


NOT representative of actual performances on the stream

🤖 SLSN SLACK BOT 🤖

Has been running live for several months now

slsn-bot APPLI 21 h 20

Mardi 3 mars

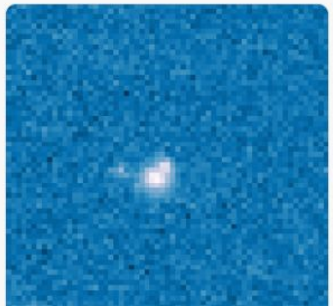
Number of candidates for the night 20260303: 4 (4 unique objects).

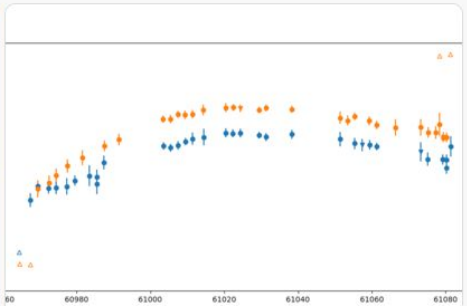
	objectId	slsn_score
0	ZTF25abxjtkv	0.961665
1	ZTF25abuovxv	0.768442
2	ZTF24ablzlmw	0.642631
3	ZTF26aabpbkj	0.434377

21 h 21 ==========

TNS classification: SN IIn
Fink: https://ztf.fink-portal.org/ZTF25abxjtkv
Fritz: ZTF25abxjtkv
Score: 0.962
E(B-V) = 0.048
SDSS photo-z = 0.084 +- 0.017
Peak M = -19.93 (-20.36 < M < -19.41)

2 fichiers | Tout télécharger





What results after 2 months ?

From 18/12/25 to 18/02/25

Purity

Completeness

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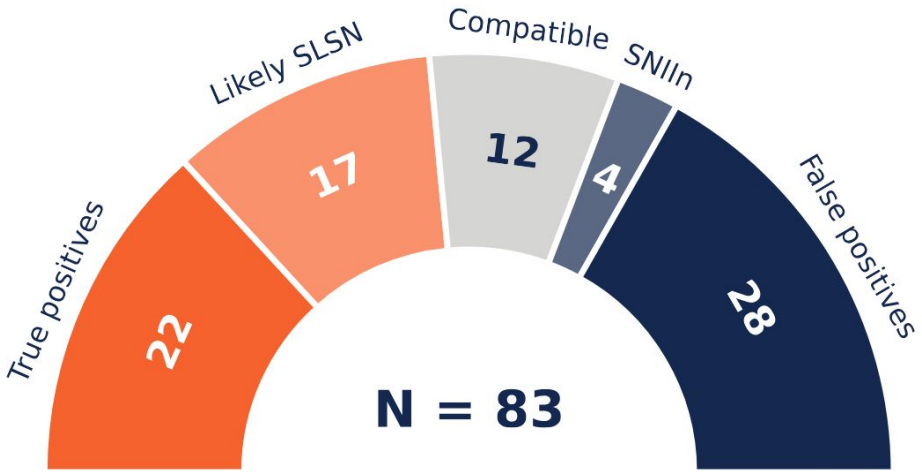

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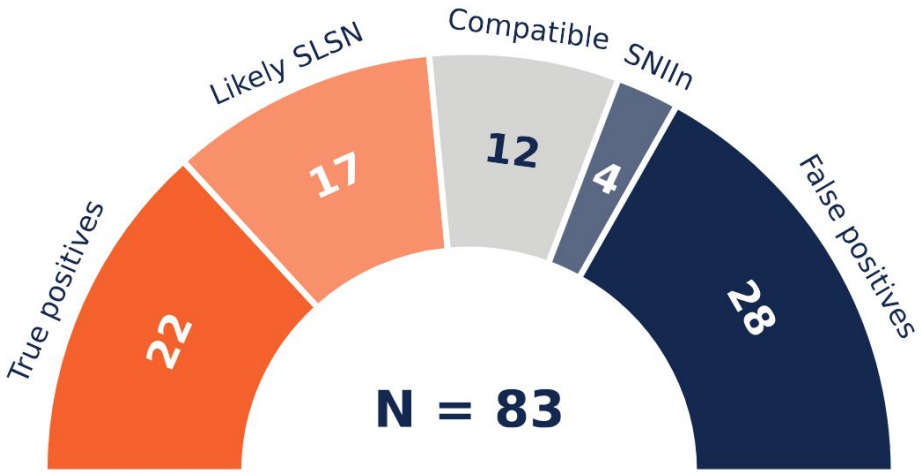


Completeness

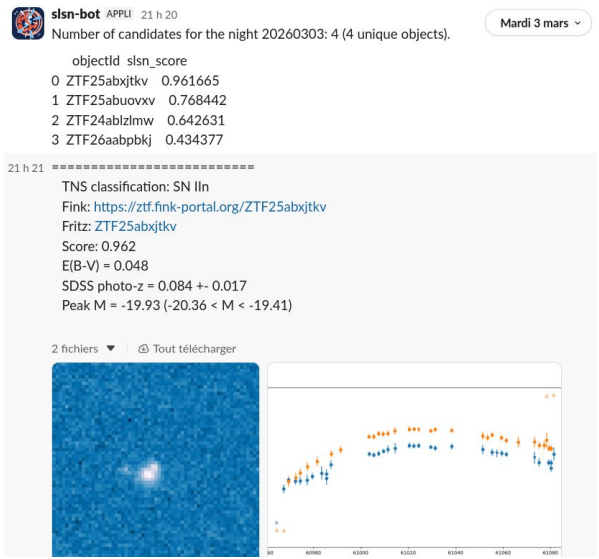
22 / 24 = 92 %

Not bad!

(But of course impossible to know the true value)

How to access NOMAI's predicitons ?

Slack bot (slsn-bot)

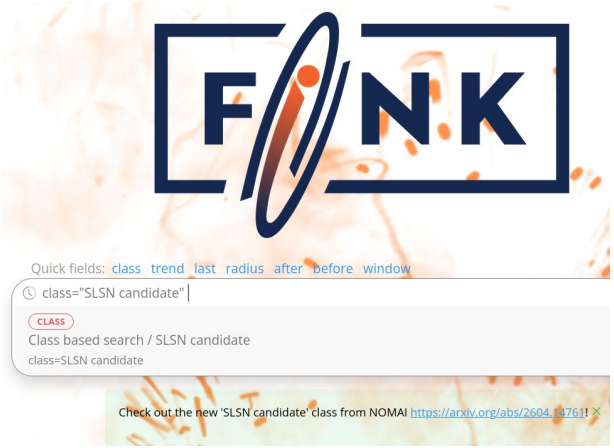


Fink data transfer

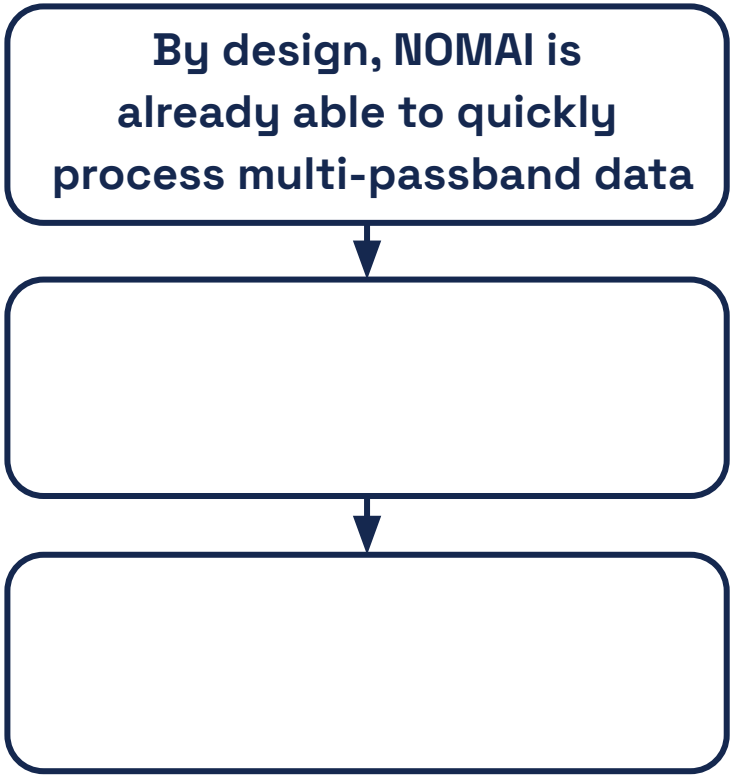
With a query using the alert value:

slsn_score > 0.35

Fink class



NOMAI for LSST ?



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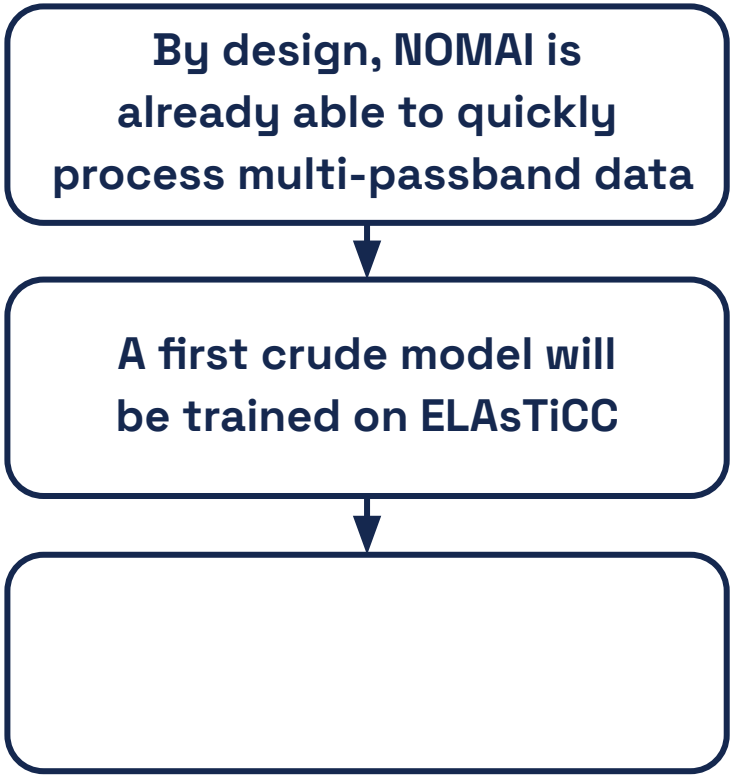

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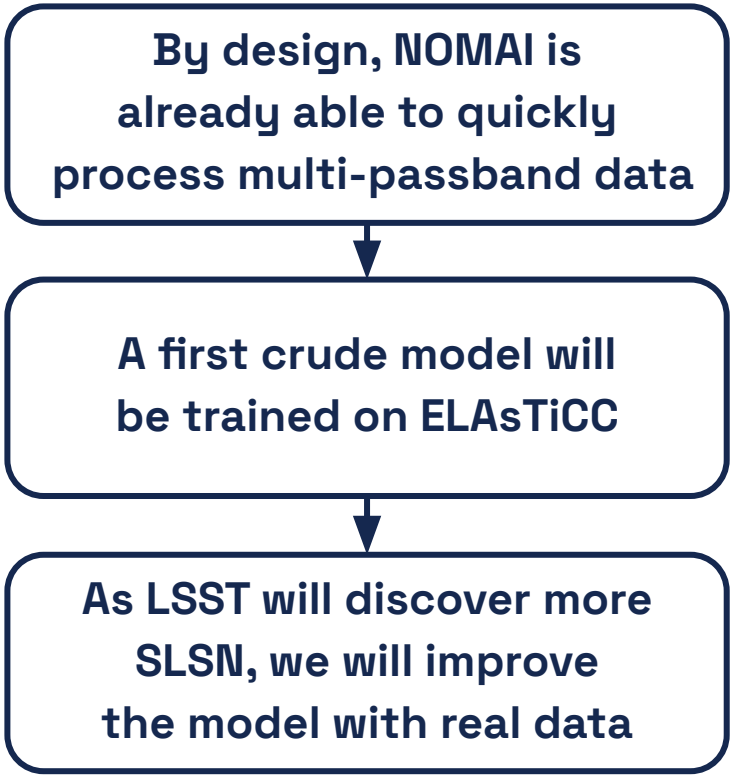


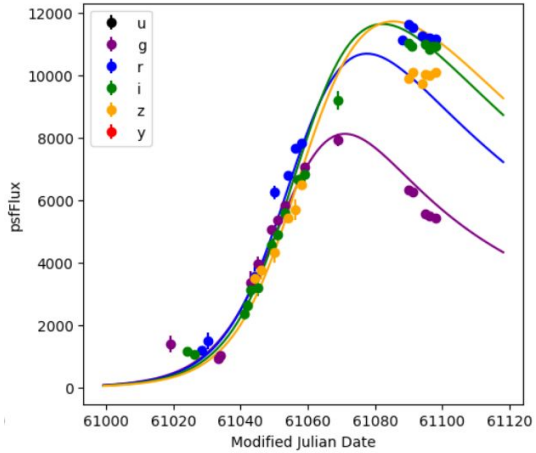
WORK IN PROGRESS

NOMAI for LSST ?

By design, NOMAI is already able to quickly process multi-passband data

A first crude model will be trained on ELAsTiCC

As LSST will discover more SLSN, we will improve the model with real data



Blackbody model

BUT ...

Rainbow might not be enough for LSST

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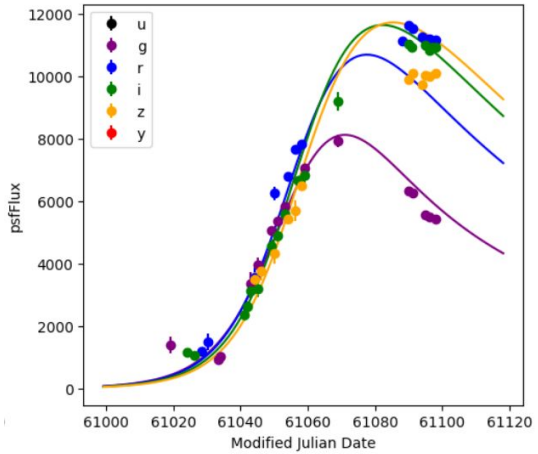
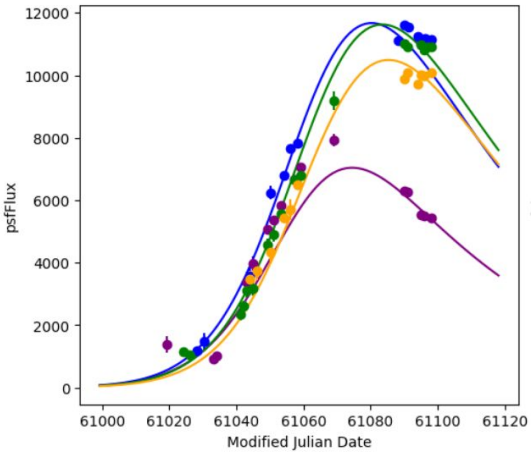
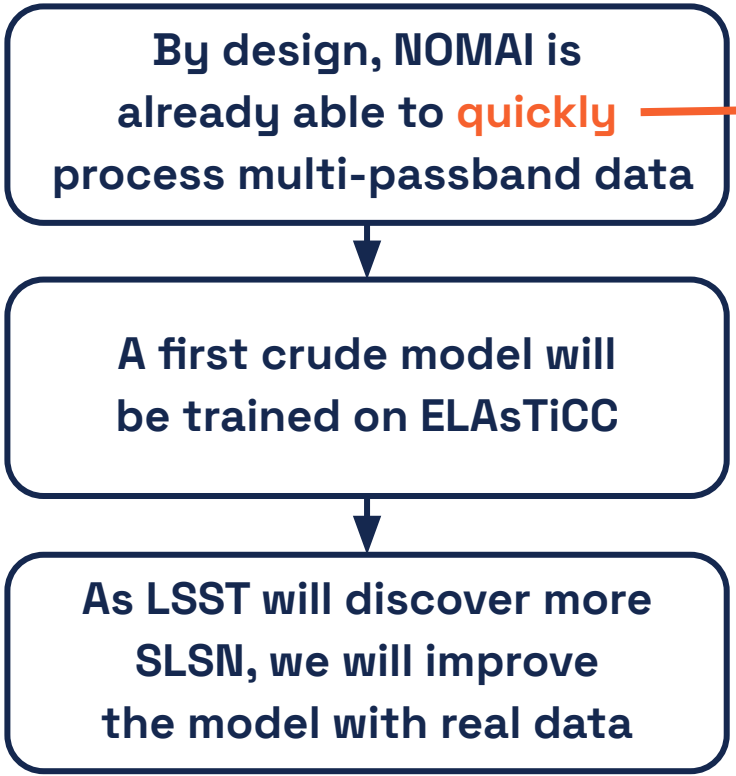


Blackbody model



UV extincted Blackbody model

NOMAI for LSST ?



YES BUT ...

Not fast enough for LSST.

An optimized version of Rainbow is being developed in Rust

Takeaway mesages

SLSNe were rare, but are becoming abundant

NOMAI is built to miss as few candidates as possible

Ready for today, evolving for tomorrow

OUTER WILDS