# Selecting LSST Transients for Spectroscopic Follow-up with an Active Learning Loop


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The key to understanding the physics of powerful, explosive transient time-domain phenomena is spectroscopic data. Spectroscopy reveals the transient class, redshift, and also provides insight into the progenitor systems and physics of these explosions. LSST will increase the rate of discovery and the total number of observed transients by over two orders of magnitude from ongoing surveys. Currently, roughly 8% of transients discovered are followed spectroscopically; this fraction will fall to under 0.1% with LSST. The community desperately needs a method to determine which transients merit precious spectroscopic follow-up time.

## Recommendation System for Spectroscopic Follow-up (RESSPECT):

- An active learning pipeline that recommends transients for spectroscopic follow-up based on machine learning categorization uncertainty
- Objects with uncertain classification have spectra taken to determine their true label
- Once the label is confirmed, the object is replaced in the training set to improve the algorithm going forward
- RESSPECT is trained to catch transient events (eg. supernovae, kilonovae) early. The spectra is ideally taken at peak luminosity to minimize exposure time
- The pipeline is designed to work on as few as five observed points in four different broad-band filters ([g,r,i,z])

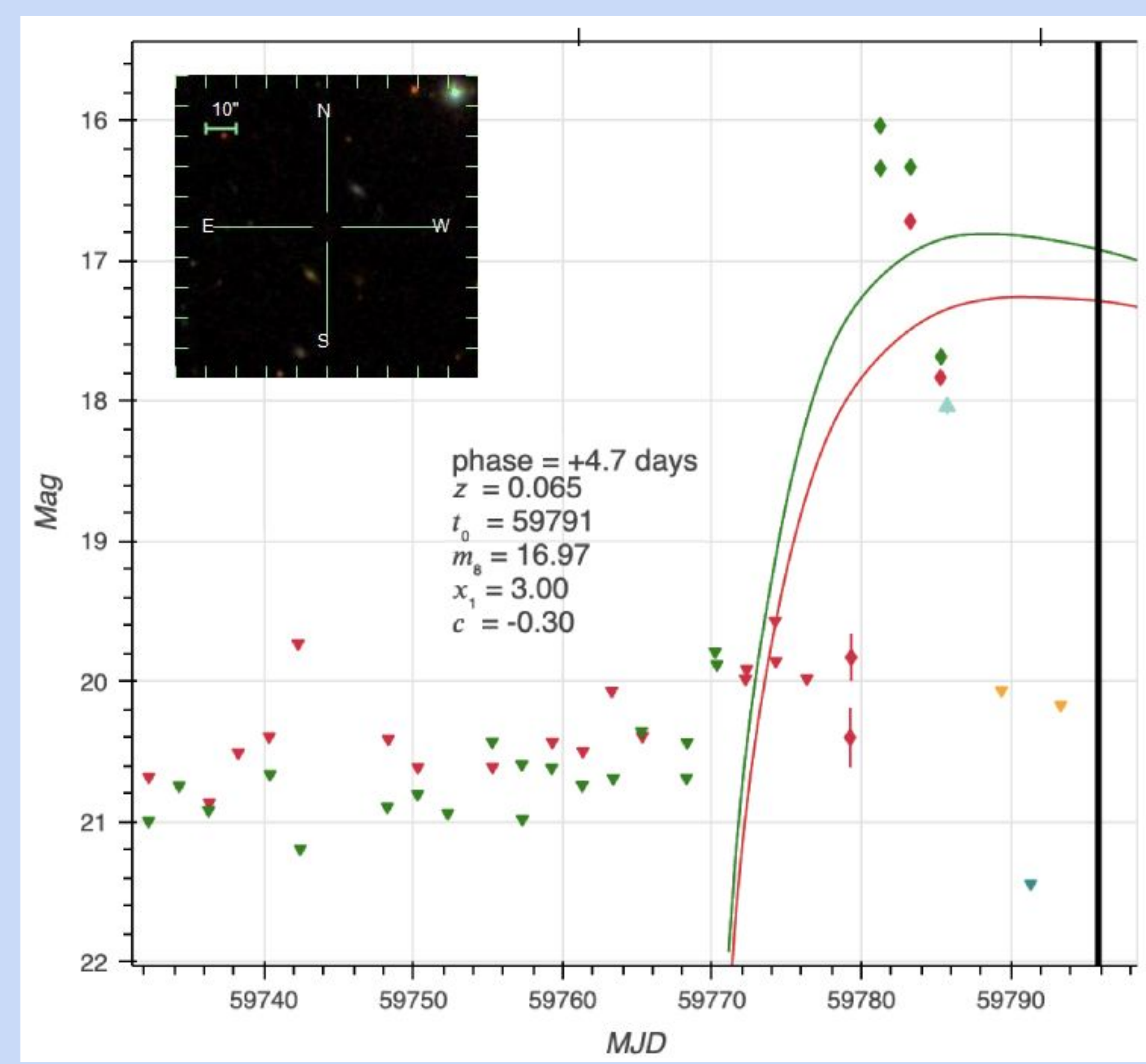


Fig 1: 2022pnf photometry with poor SALT fit and an uncertain classification. This is the kind of object we want spectra of.

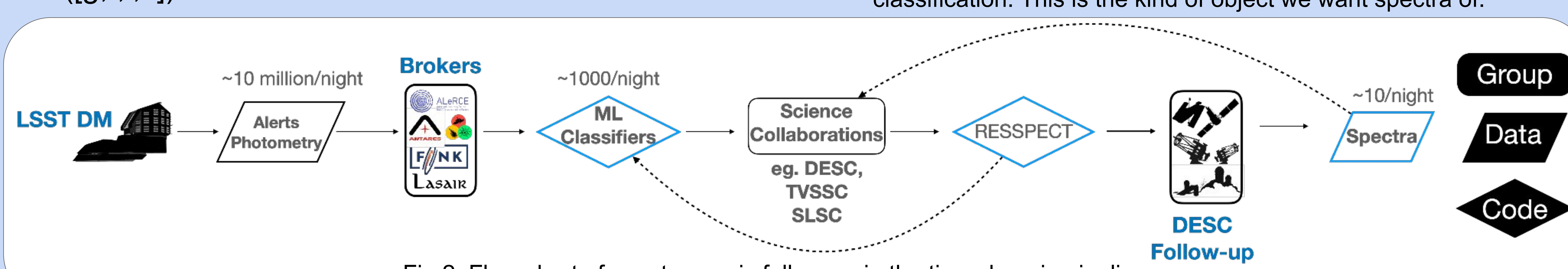


Fig 2: Flow chart of spectroscopic follow-up in the time-domain pipeline.

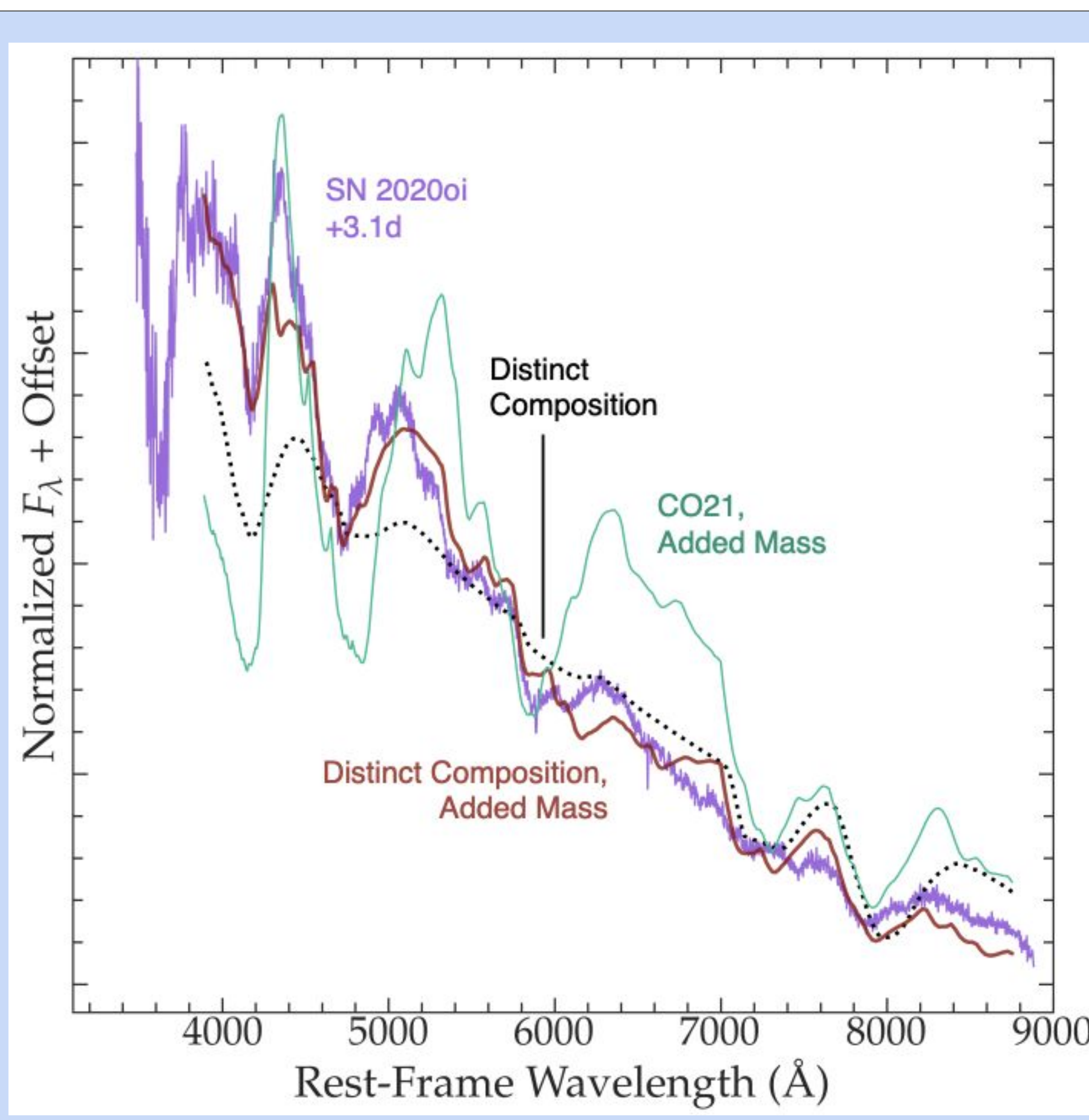


Fig 3: Spectra of SN 2020oi taken during a rare early-time bump in its photometry. Composition model for full explosion does not fit, and must be enriched by lighter elements, suggesting the supernova exploded into surrounding material stripped from the star pre-explosion. [5]

## Simulate end to end analysis with RESSPECT

- Deploy pipeline to NERSC
- Ingest classified ELAsTiCC objects from LSST brokers
  - The Extended LSST Astronomical Time-Series Classification Challenge - simulated data challenge to connect LSST brokers and science collaborations (Tuesday 3:30 parallel session)
- Select objects with uncertain classification
- Create synthetic transient spectroscopy with SNANA
- Model telescope (4MOST) efficiencies
- Use TOM Toolkit (https://lco.global/tomtoolkit/) to mock follow-up observations
- Store and classify obtained spectra at NERSC
- Test RESSPECT active learning system, and update brokers

## Future Work:

- Apply pipeline to real-time surveys such as Young Supernova Experiment, Zwicky Transient Facility
- Working with other collaborations (eg. Dark Energy Spectroscopic Instrument)

### References:


[1] E. E. O. Ishida, *Optimizing spectroscopic follow-up strategies for supernova photometric classification with active learning*, 2019

[2] D. O. Jones, *The Young Supernova Experiment: Survey Goals, Overview, and Operations*, 2021

[3] M. L. Graham, *LSST Alerts: Key Numbers*, DMTN-102, 2020

[4] Željko Ivezić, *LSST: from Science Drivers to Reference Design and Anticipated Data Products*, 2008

[5] Alexander Gagliano, An *Early-Time Optical and Ultraviolet Excess in the type-Ic SN 2020oi*, 2021



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