Bright Transient Survey II
&
SEDM Spectral Classifier

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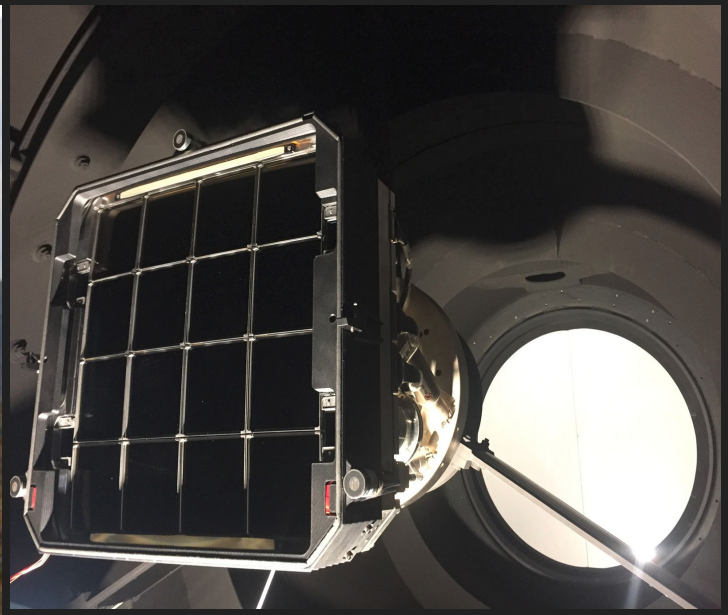
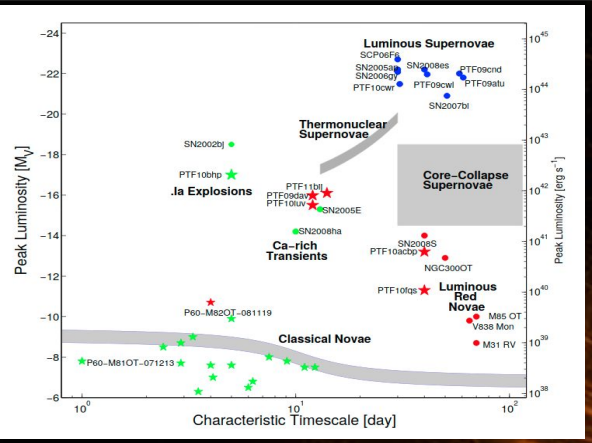
The Zwicky Transient Facility (or Utility)



Ultra low resolution spectrograph (R ~ 100) : SEDM

Low to medium resolution (R ~ 1000 to 10000) : DBSP



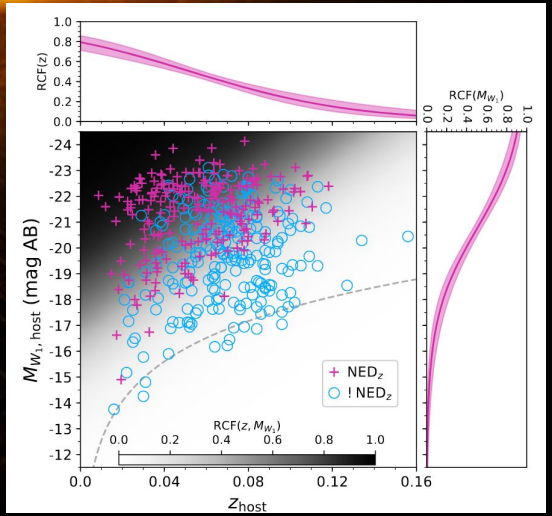
Explore transient phase space *(Kasliwal Thesis 2011)*

What do we want to know?

Estimate rates for known transients

Estimate rate limits for rare transients

Estimate redshift completeness factor *(Kulkarni 2018)*



Catch some fast transients (with 2d cadence)!

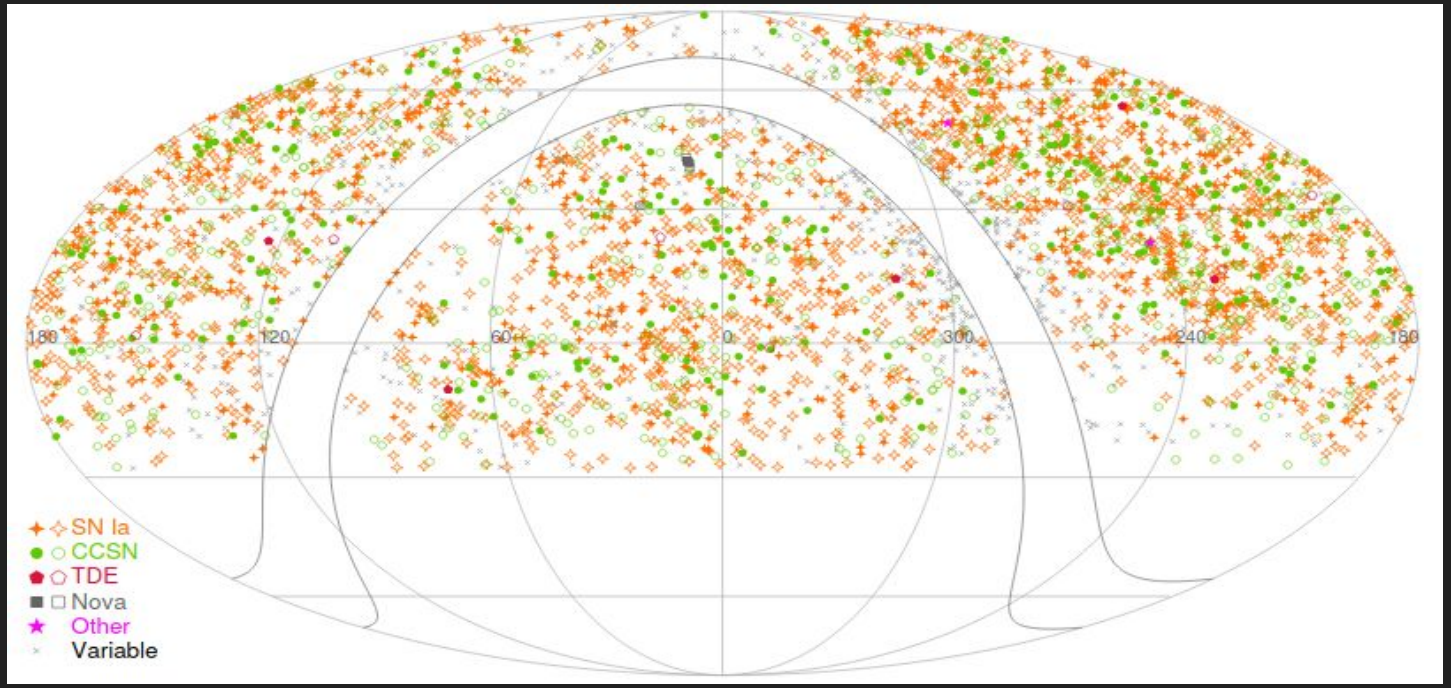
Sibling Supernovae

Ultra long supernovae

AND much more!

BTS : An unbiased view of transient night sky!

- ★ Untargeted and flux limited (m < 19)
- ★ No strong variables (like CV, AGN) or moving objects
- ★ Spectroscopically complete (m < 18.5)



How does BTS work?

ZTF Alert stream (~10^6 alerts)

BTS Filter
> Real (Deep learning real-bogus classifier)
> Not moving
> Mag limit (m < 19)
> Not close to bright star
> Not in galactic plane
> No long term history

Filtered candidates (~50)

Human Scanner

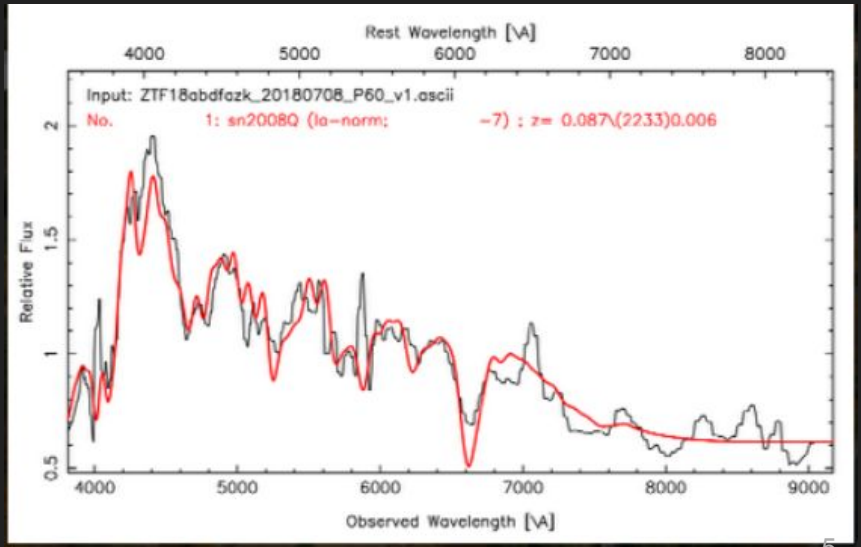
Candidates sent to TNS as 'AT' (~10)

Follow-up assignment
> First to SEDM
> Reassign to P200/Keck if ambiguous & fading
>Supported with LT-SPRAT, APO-DIS and ALFOSC-NOT

Spectra obtained (~5/night)

Human classifier (with some help from SNID, Superfit, Gelato, DASH)

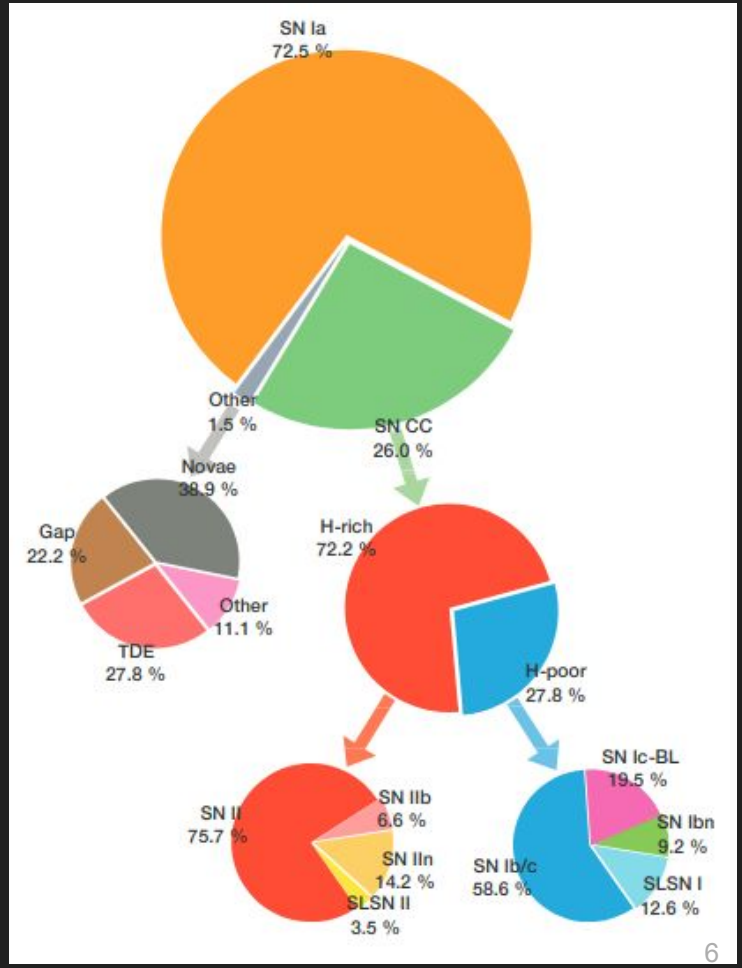
Successful classifications sent to TNS (~3/day)



BTS on TNS (Since May 2018)

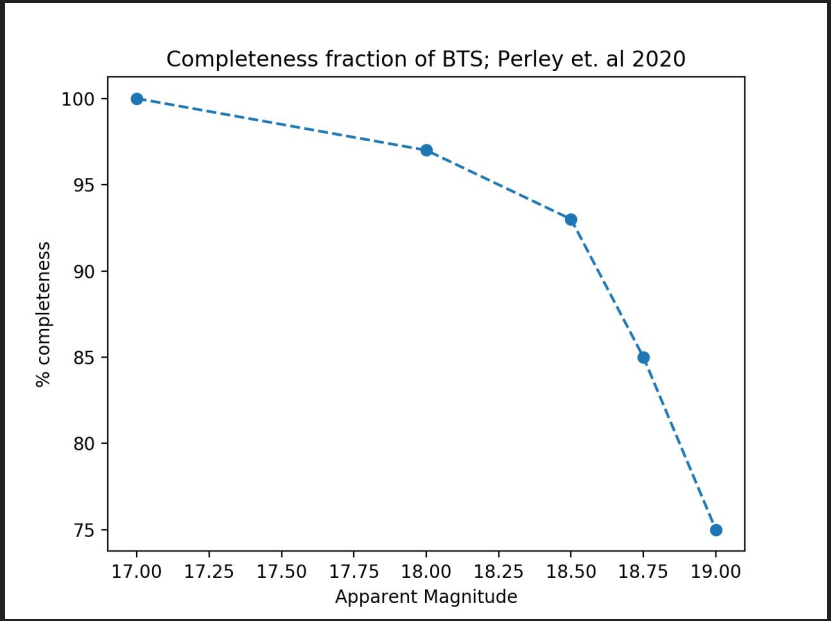
★ Total by ZTF on TNS
- **3286** by ZTF, **1699** by other groups

★ SEDM averages 8 ZTF spectra per night
- Leading in TNS classifications
  - **47%** of total, **3.1x** more than next classifier
- **1674** primary, **2032** total (Supporting + Non-SN)
- More than 5000 spectra on GROWTH Marshal (over 3000 sources have at least one SEDM spectrum)



BTS Phase I results

- ★ 93% complete for m < 18.5 (Perley 2020)
- ★ More than 3000 classified transients
- ★ Preliminary results on
  - Timescale-Luminosity phase space
  - CC SNe rate measurements
  - Host galaxy properties
  - Redshift completeness of local galaxy catalogs



BTS Phase II aim :

100% completeness to 18.5 mag with 2 day cadence

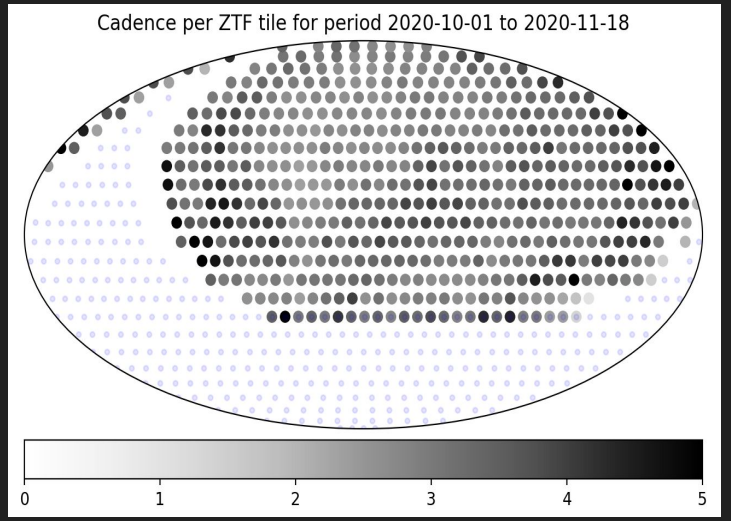
2-Day Cadence MSIP Survey Performance (2020-10-01 to 2020-10-18)

Area covered in 2 days on average

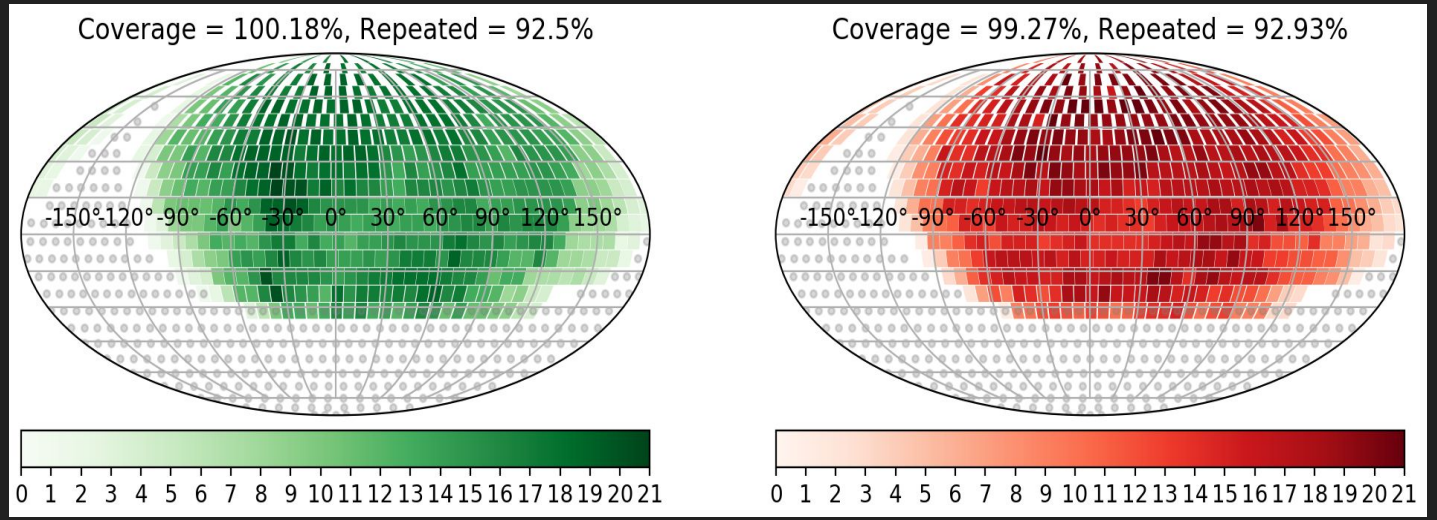
15615 (g) sq. deg

15821 (r) sq. deg

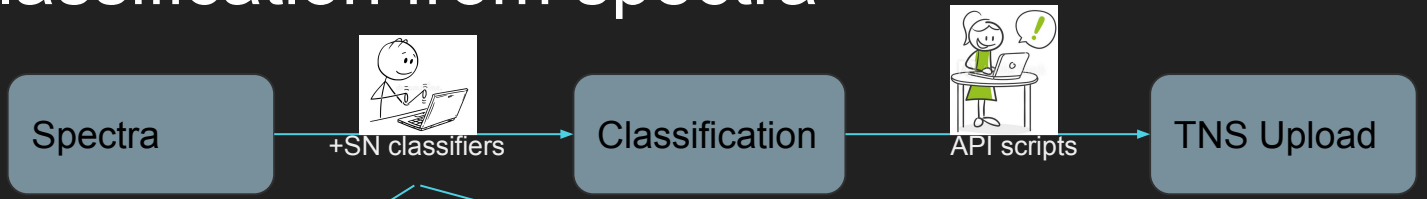
(~70% of visible)



Cumulative coverage maps in g and r bands



Classification from spectra



Reclassification before spectroscopic sample release

>2000 spectra! (Zooniverse)

Template cross-correlation based

E.g. : SNID, Superfit
Pros : Secure redshift and age output, host galaxy templates
Cons : 'Type attractor' for low SNR spectra, slow

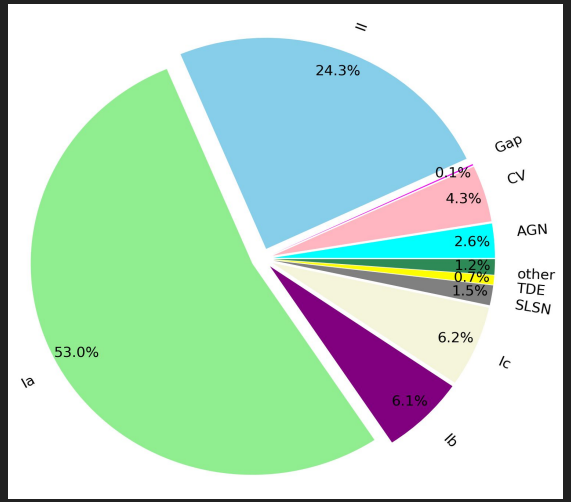
Machine learning based

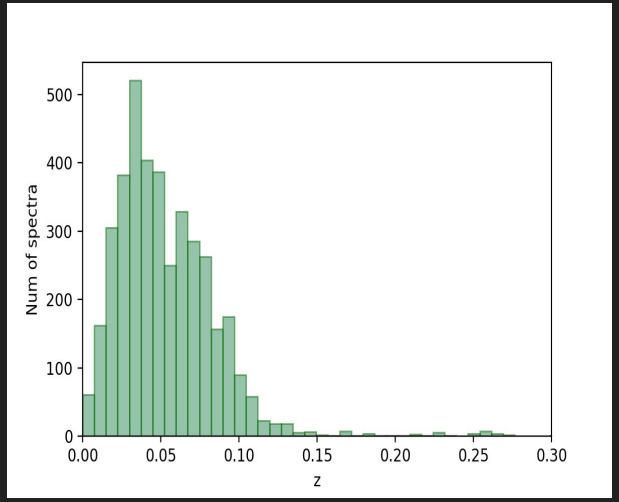
E.g. : DASH
Pros : Fast, balanced training set (data augmentation), high training accuracy
Cons : Sensitive to training sample, < 50% accurate for SEDM spectra

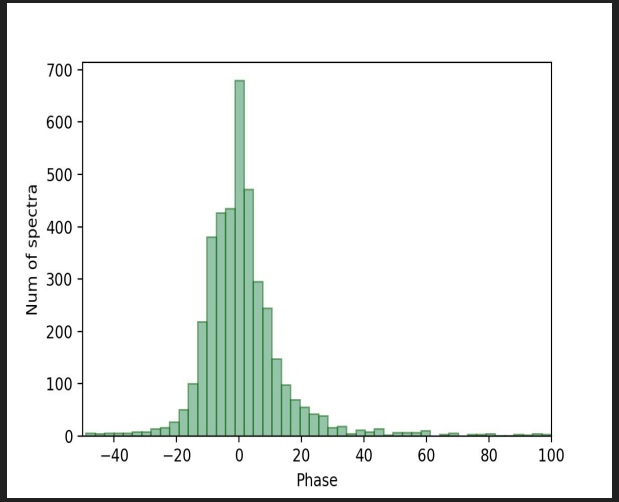
Multiple human classifiers => Inconsistencies + Time consuming

Not robust enough for automation!!

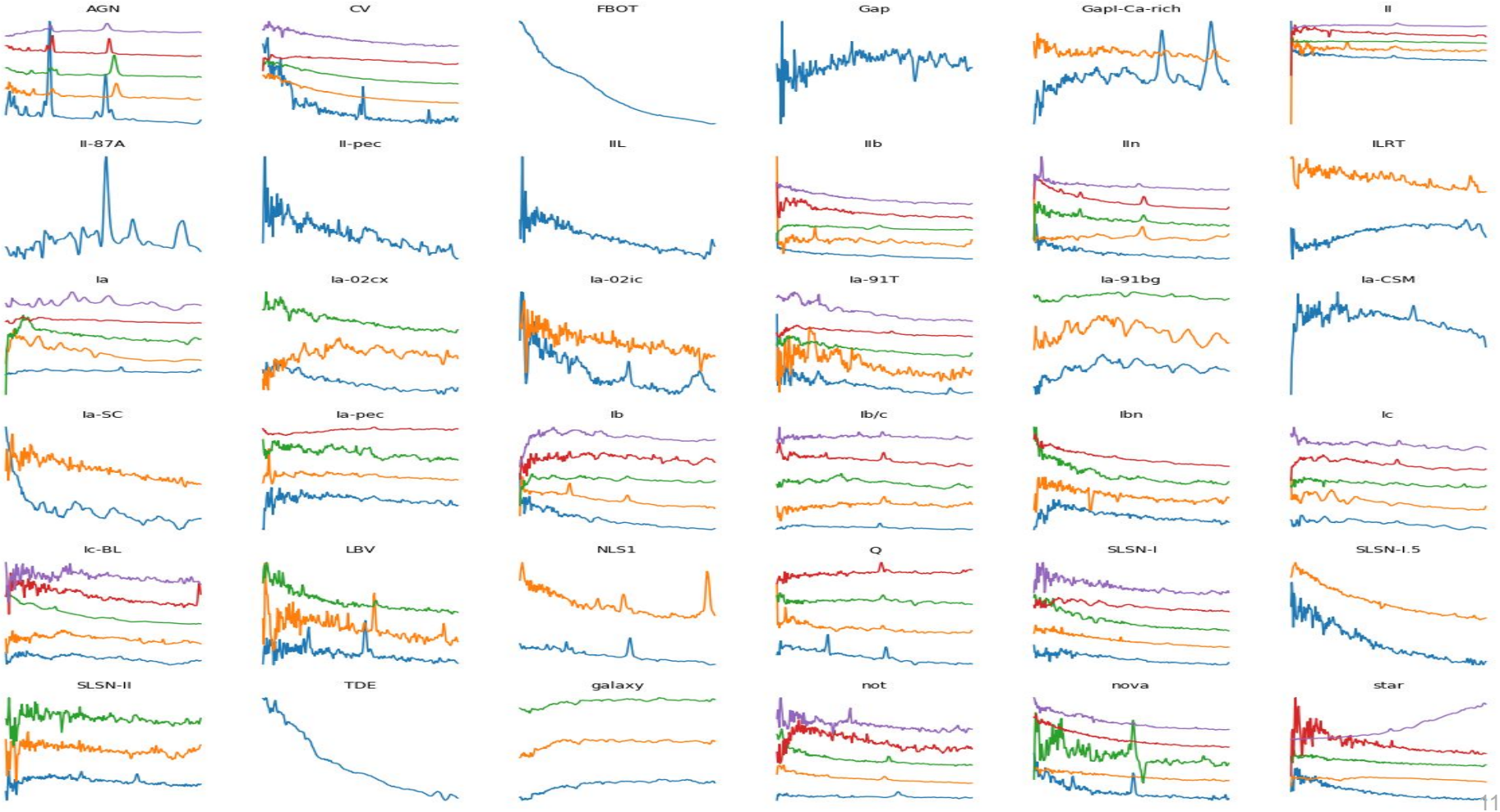
SEDM Spectral Classifier : Design Goals



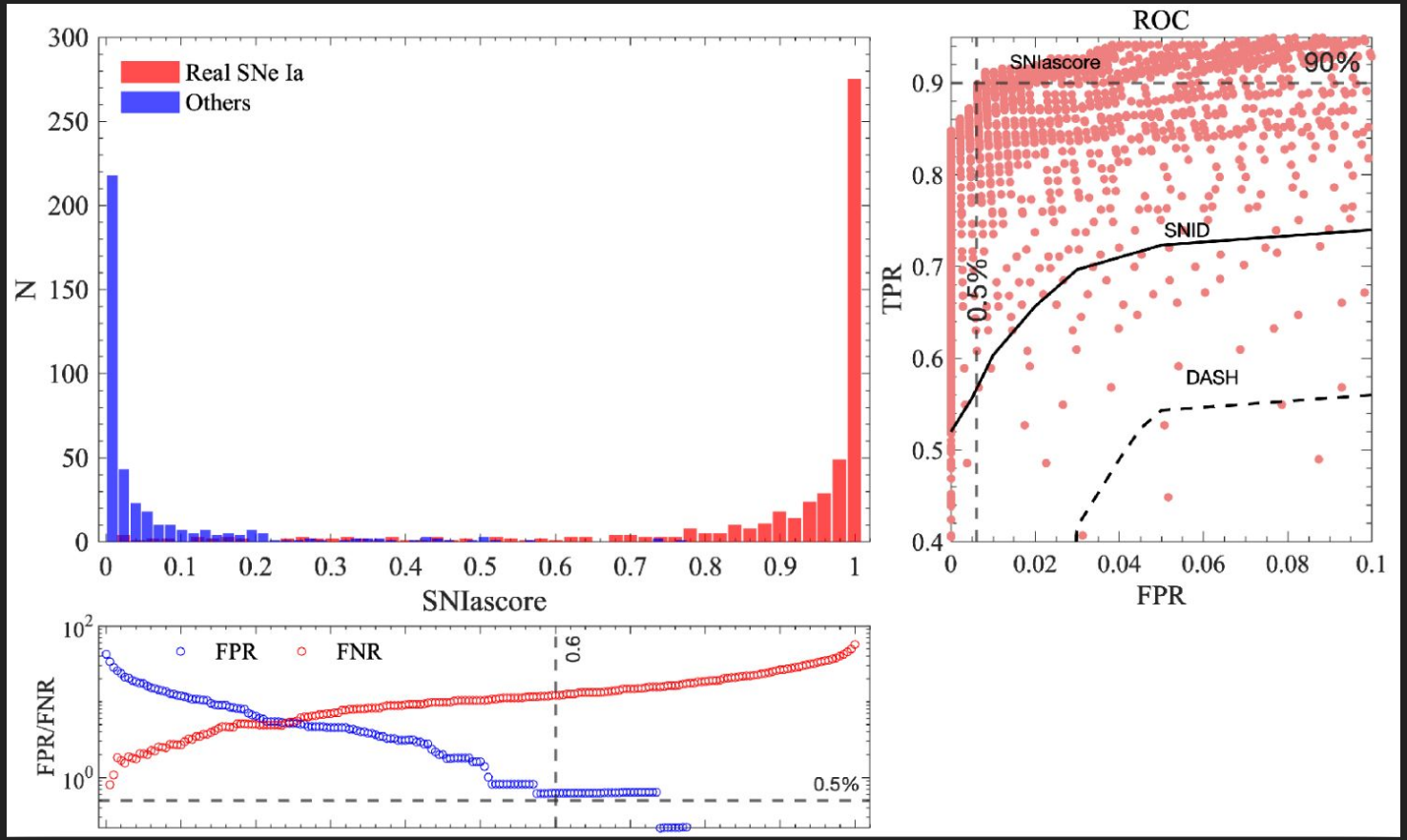




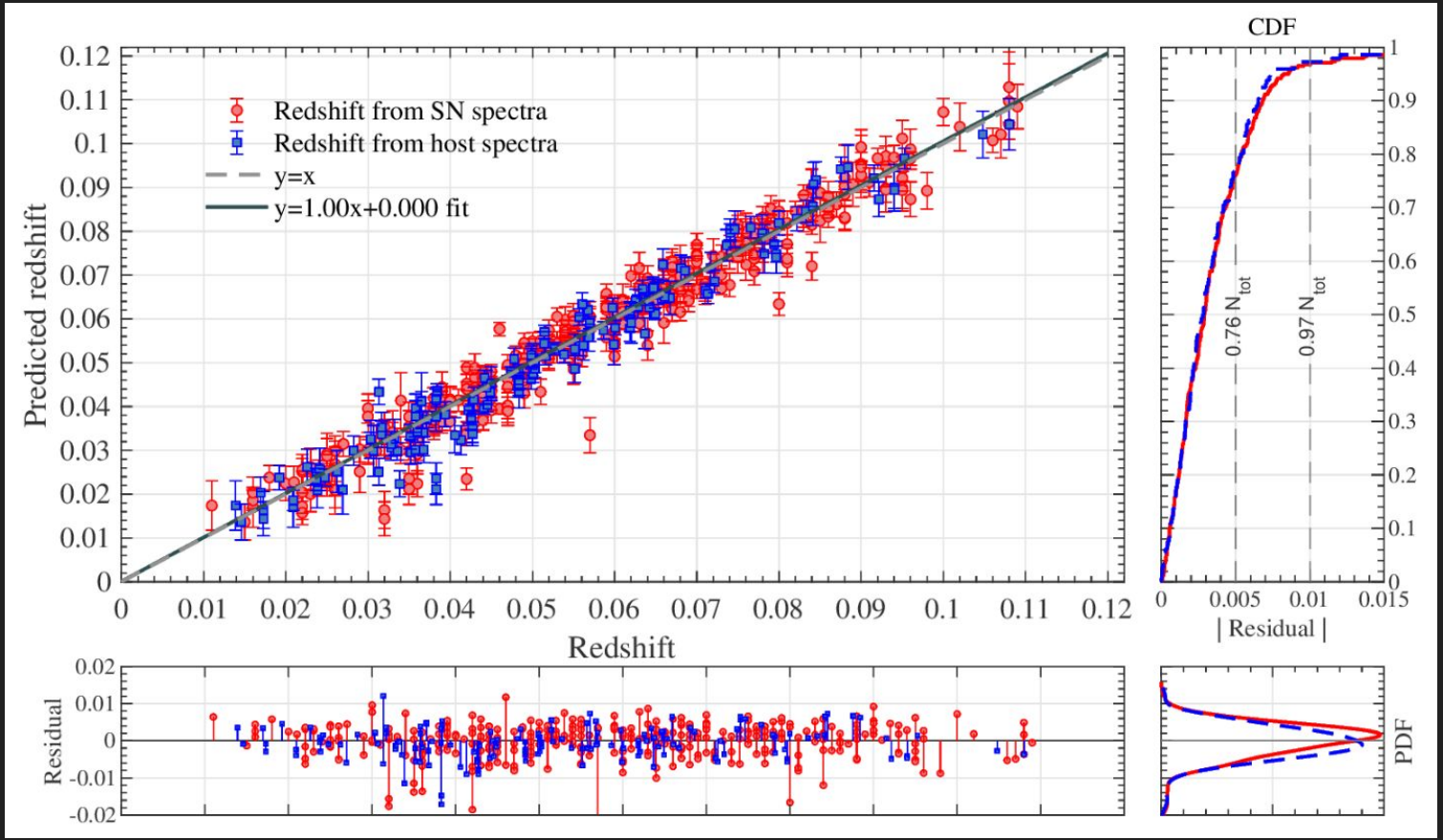
- ★ Good accuracy, low false positive rate
- ★ Differentiate as many types as possible
- ★ Reliably classifies majority of data set
- ★ Can estimate redshift and phase
- ★ Easy to re-train with larger sample
- ★ Easy to use interface


AGN
CV
FBOT
Gap
Gap!-Ca-rich
II
II-87A
II-pec
IIL
IIb
IIn
ILRT
Ia
Ia-02cx
Ia-02ic
Ia-91T
Ia-91bg
Ia-CSM
Ia-SC
Ia-pec
Ib
Ib/c
Ibn
Ic
Ic-BL
LBV
NLS1
Q
SLSN-I
SLSN-I.5
SLSN-II
TDE
galaxy
not
nova
star

SNIascore : Deep Learning classifier for Type Ia

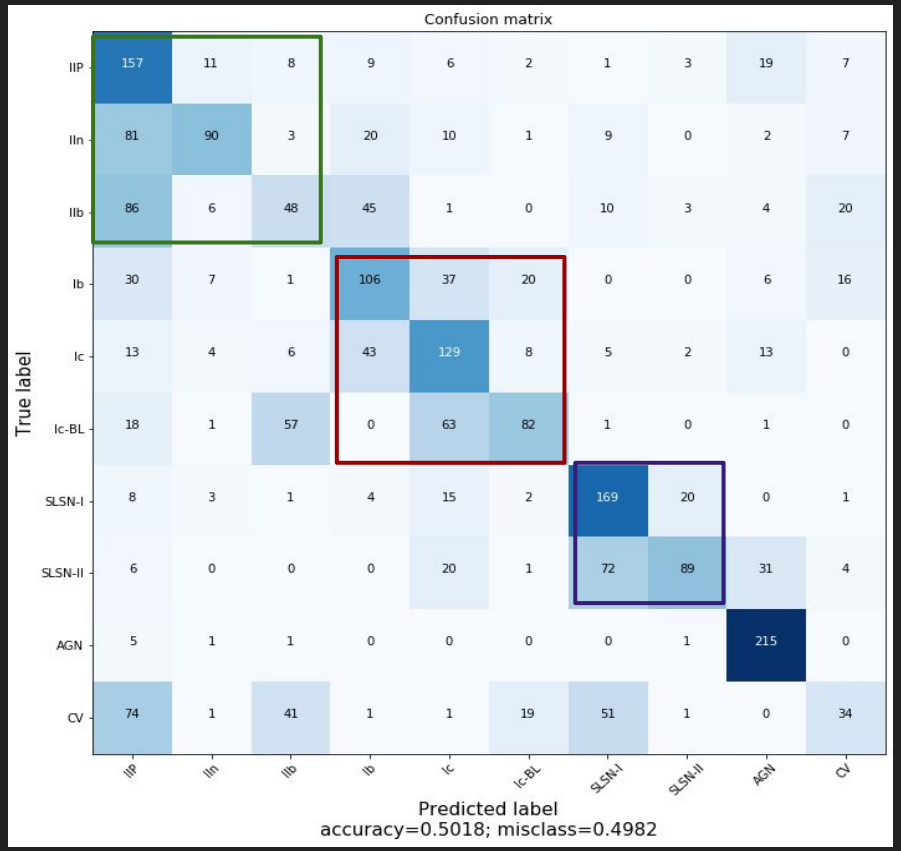


SNIascore : Redshift regression

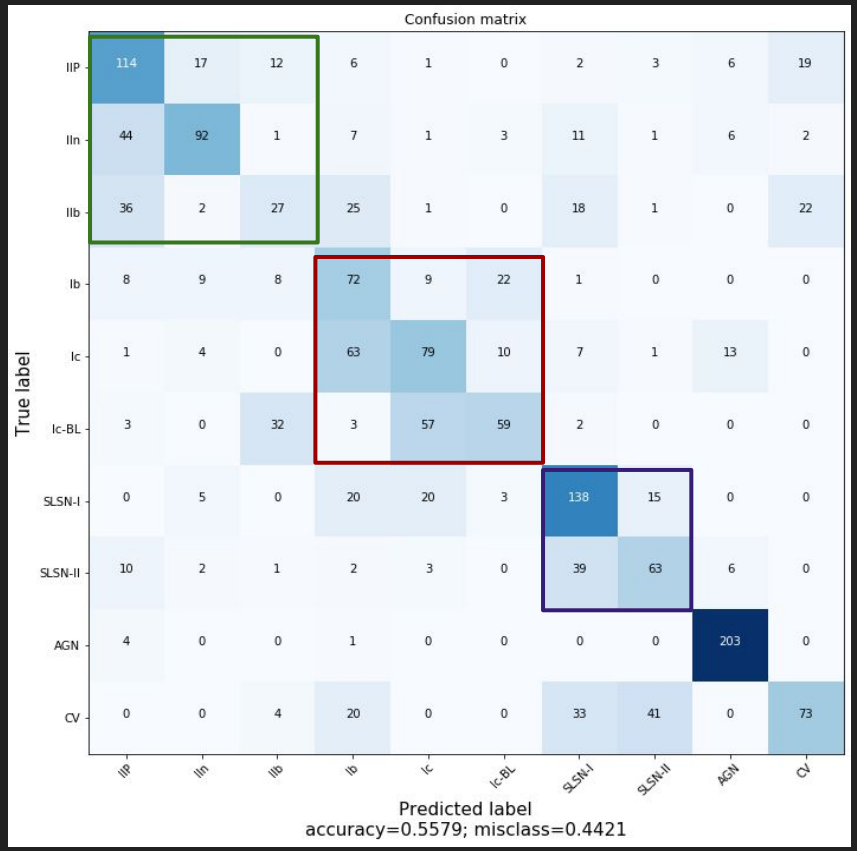


Multi-class Deep Learning

Multi-class model



Parallel binary classifiers (0.9 probability cutoff)



SEDM Spectral Classifier : Future Work

- ★ Hierarchical models
  - SN vs CV vs AGN
  - Type Ia vs Core-collapse, H-rich vs H-poor
  - Sub-classes of above
- ★ Add lightcurve history information in training
- ★ Add redshift and phase regression for multiclass
- ★ Deploy in real-time with other classifiers for SEDM automated classification

Questions?