Exploration of rapidly evolving transients with the Subaru/HSC transient survey

Seiji Toshikage, Masaomi Tanaka, Ichiro Takahashi (Tohoku Univ),
Naoki Yasuda, Nao Suzuki(Kavli IPMU) Tominaga Nozomu, Takashi J. Moriya(NAOJ) and HSC transient working group

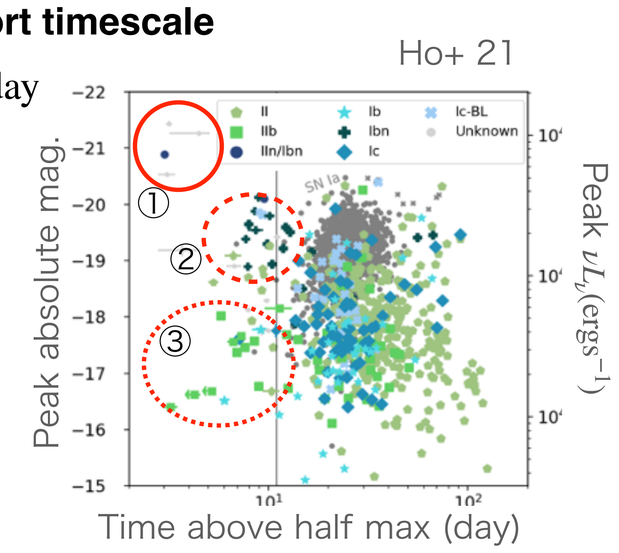
Summary

- A number of Supernovae and peculiar transients (SuperLuminous, rapidly evolving, etc.) are discovered by recent transient surveys
  - a method for transients classification without spectroscopic data is needed
- Subaru/Hyper Suprime-Cam survey discovered 1824 Supernovae in the COSMOS field
- We developed a machine learning multiclass classifier for type Ia, Ibc, II supernovae and rapidly evolving transients
- New rapidly evolving transients were identified at redshift z = 0.70 - 1.0
- Event rate of rapidly evolving transients is estimated ~ 2% of Core-Collapse Supernovae
  - type Ibn supernovae ~ 0.4% of CCSNe → ≥2% of He star experience eruptive mass loss before the explosion

Rapidly evolving transients (RETs)

- **optical transients with a short timescale**
  - time above half max $\leq$ 10day
  - unsolved mechanism
- **Subdominant types of RETs**
  - ① AT2018cow like
  - ② Type Ibn (CSM)
  - ③ Type IIb (SCE)

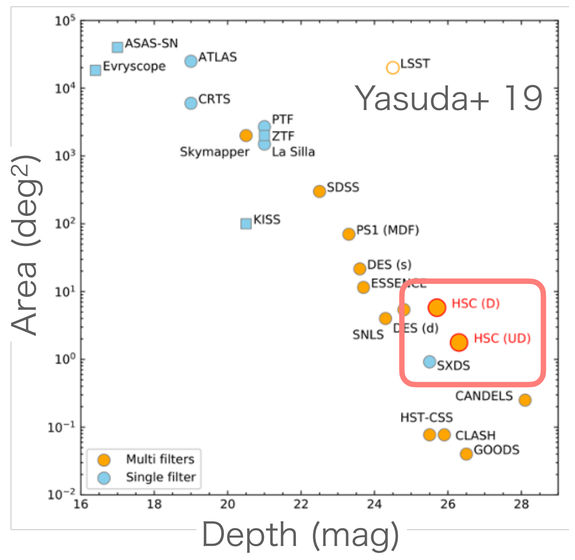
  by Ho et al. 2021



Subaru/HSC transient survey

- The Hyper Suprime-Cam-SSP transient survey program
  - 2016.11 - 2017.04
  - COSMOS UD/D field
    1.77/ 5.78 deg^2
  - g, r, i, z band

- 1824 Supernovae
  spec-z 759 objects
  photo z 957 objects
  No redshift 108 objects



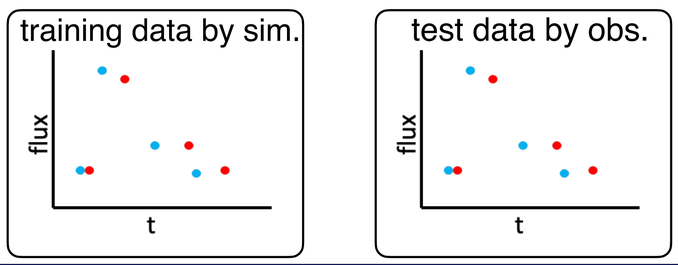
Method - Classification of rapidly evolving transients -

① Datasets

training data set by simulation

Ia	SALT2 model template
Ibc・II	observational template
RETs	Arnett82 semi-analytic model

test data set by observation
COSMOS UD 879 SNe



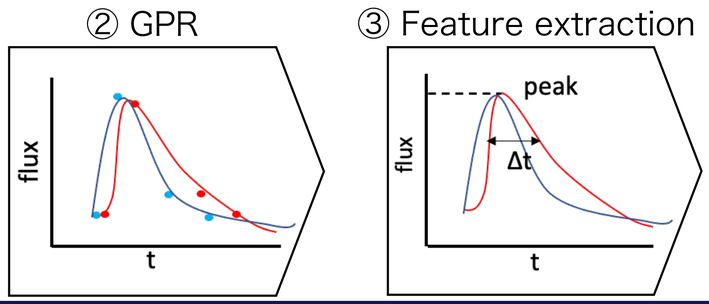
② Gaussian Process Regression (GPR)

connect sparse data with smooth curves

③ Feature extraction

60 features per one object
e.g. peak flux
decline time from peak to half

② GPR ③ Feature extraction



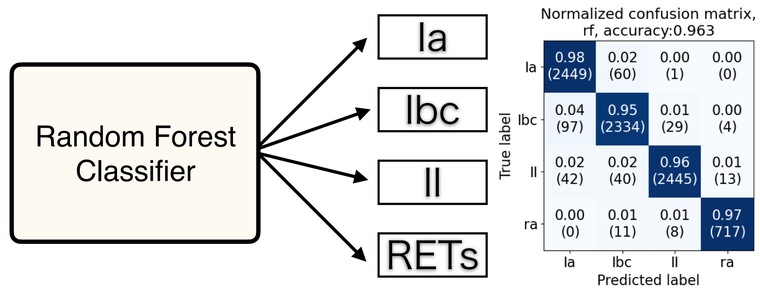
④ classification by machine learning

Random Forest (supervised learning)
- Validation with simulation data

  Accuracy 0.96(all) 0.97 (RETs)

- classification of real data

  66/879 objects classified as RETs

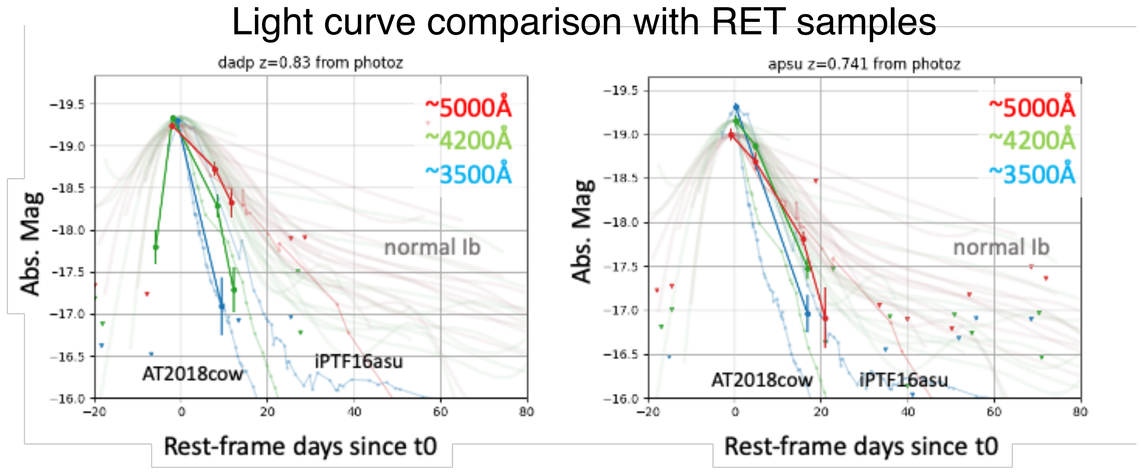


Results - New rapidly evolving transients

66 RET candidates by machine Learning
↓ selection by the light curve

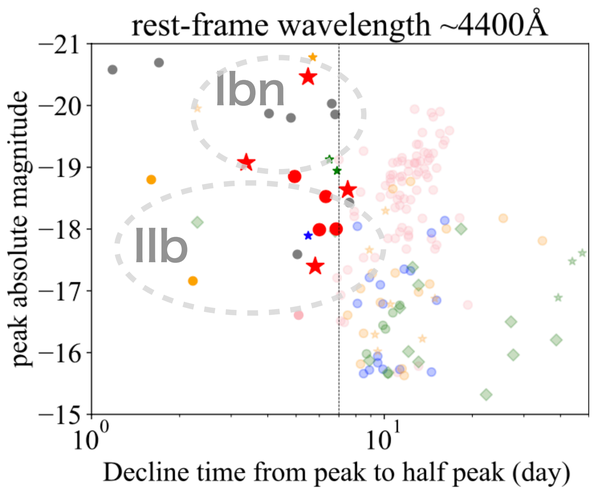
9 RETs identified （4 objects reported by Tampo+ 20）

Light curve comparison with RET samples



Discussion - phase diagram and event rate

Estimation of event rate with HSC RETs



$$r = \Sigma_i^N \frac{(1+z_i)}{\epsilon T_i V_{max,i}} \simeq 6000\ \mathrm{yr}^{-1}\ \mathrm{Gpc}^{-3}$$

~ 2% of Core-Collapse Supernovae

Ibn $\simeq 1150\ \mathrm{yr}^{-1}\ \mathrm{Gpc}^{-3}$
$\simeq$ 0.4% of CCSNe

Ib $\simeq$ 20% of CCSNe Shivers et al. 2017
→ 2% of He star eruptive mass loss