Identifying Pair Instability SuperNovae (PISNe) inside Fink data

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Super Luminous SuperNovae (SLSN)

Different causes [1] :

→ Circumstellar interaction

→ Magnetar driven supernovae

→ Large 56 Ni production

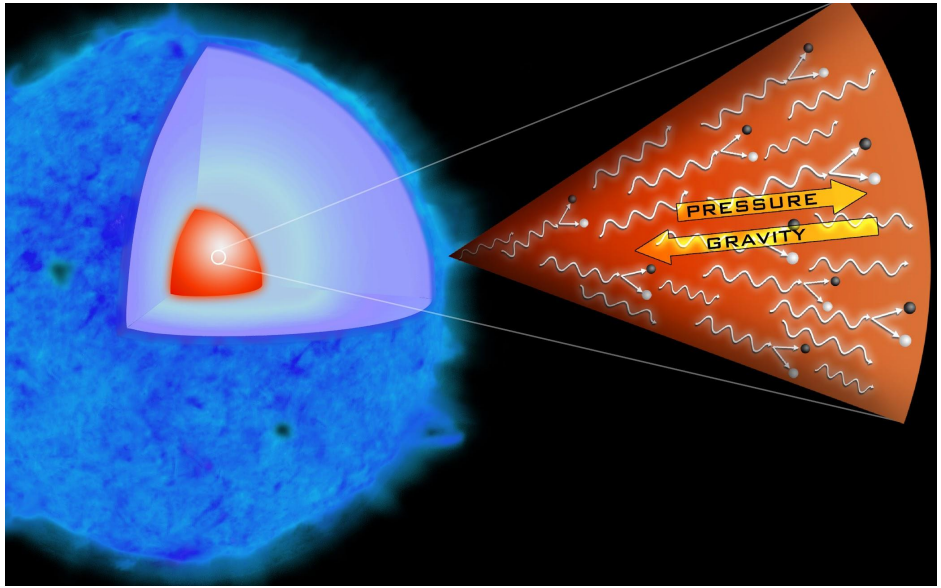
Pair Instability SuperNova (PISN) [2]:

→ From 130 $M_{\odot}$ to 260 $M_{\odot}$

→ Low metallicity stars

→ Population III

→ Triggered by electron/positron pair production

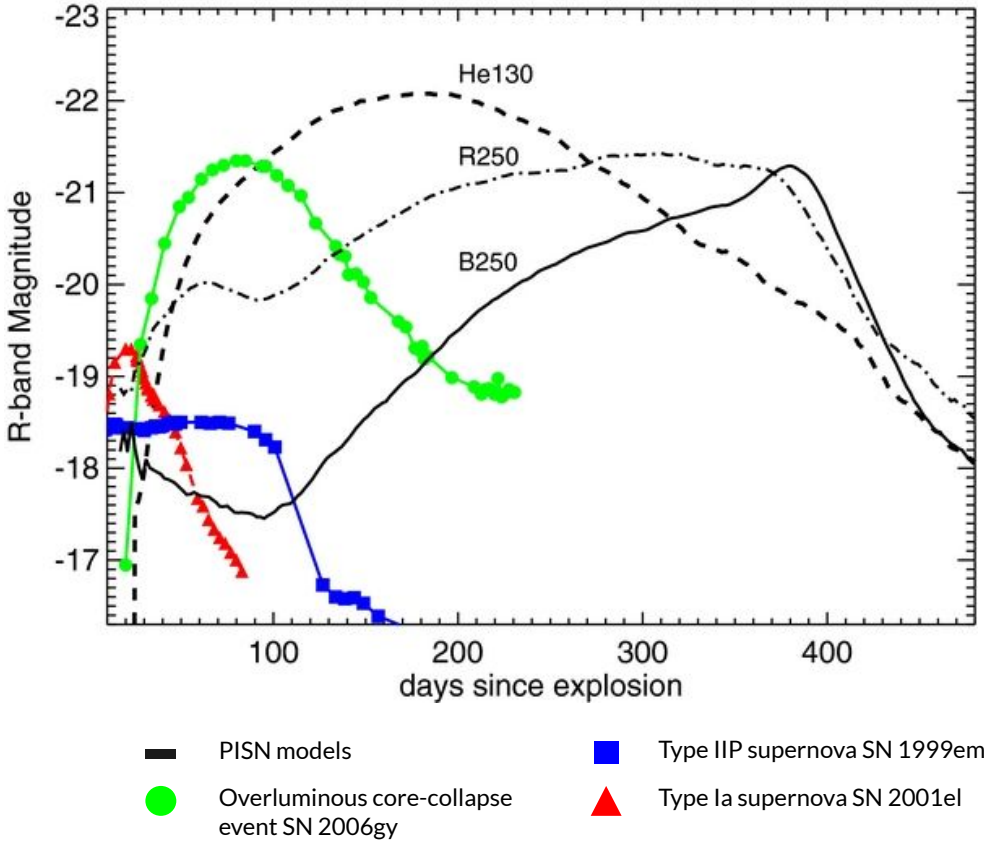


https://en.wikipedia.org/wiki/Pair-instability_supernova

[1] The most luminous supernovae
[2] How Massive Single Stars End their Life

Properties of Pair Instability SuperNovae

- Still hypothetical
- Very bright : up to absolute M ~ -22
- Long events : > 1 year

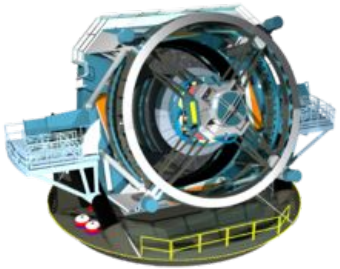


Pair instability supernovae: light curves, spectra, and shock breakout

Where to find them ?

In first generation of stars

- Almost exclusively hydrogen and helium
- Very high redshift
- Very faint objects
- Need m > 23 limiting observed magnitude [2]
- We need LSST

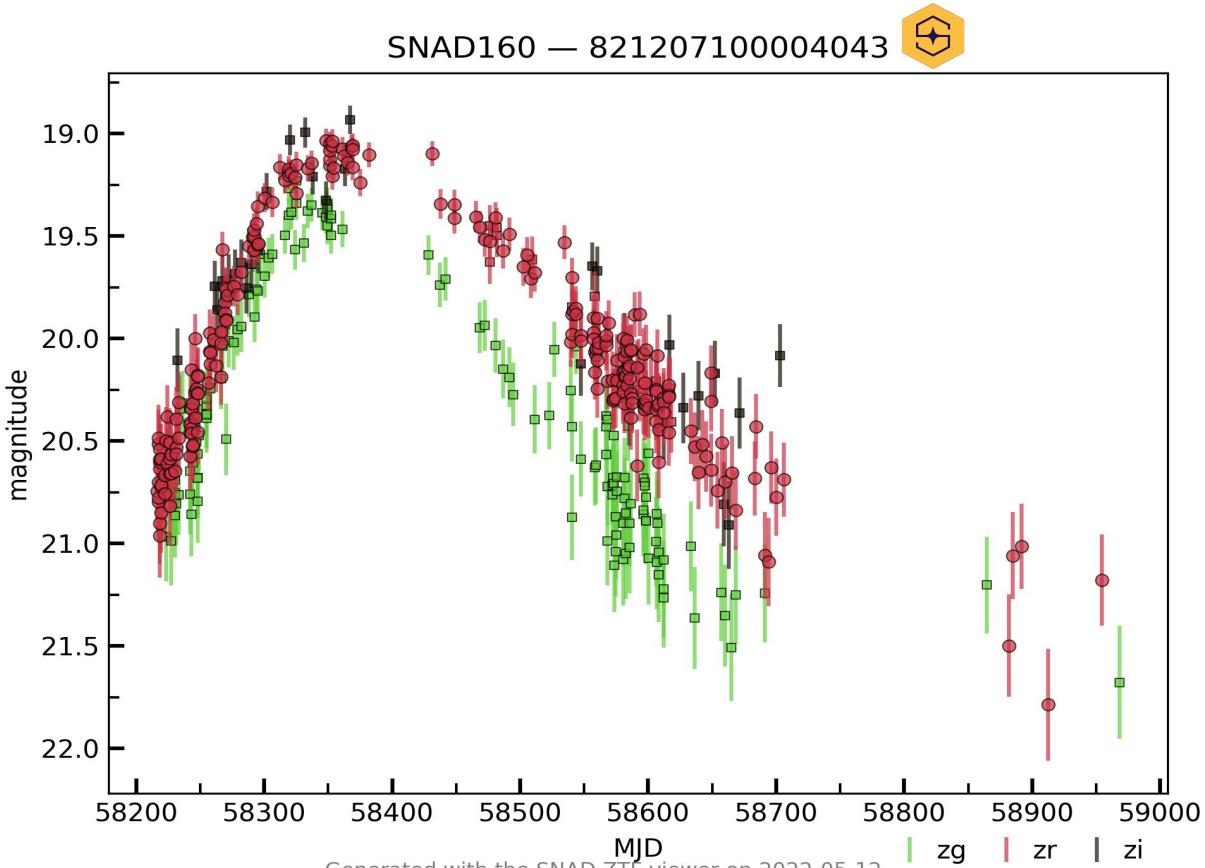


In low metallicity pockets

- Much closer/younger stars [1]
- Lower redshift
- Visible by ZTF (?)

[1] Pair-Instability Supernovae in the Local Universe
[2] Euclid: Discovering pair-instability supernovae with the Deep Survey⋆

For example :

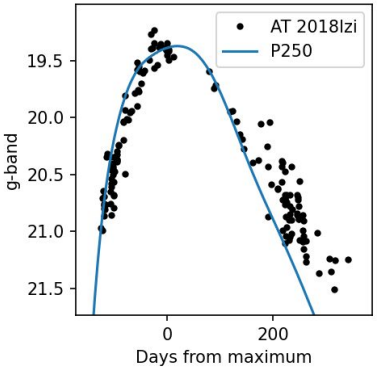


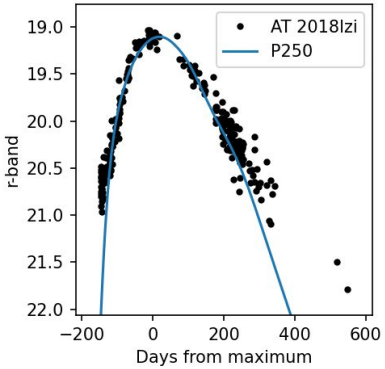
https://ztf.snad.space/dr8/view/821207100004043

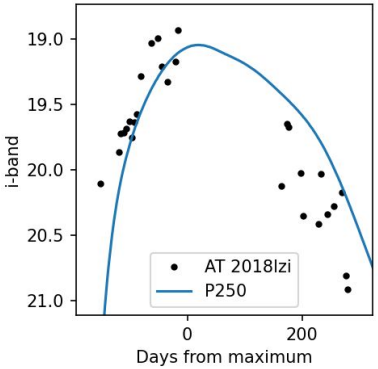
Generated with the SNAD ZTF viewer on 2022-05-12

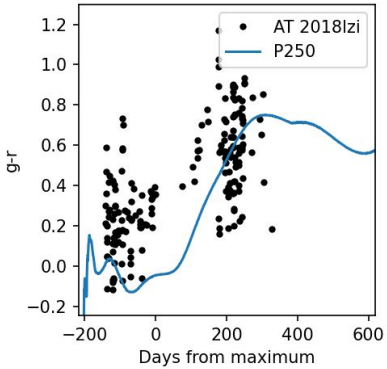
Comparison to PISN models

- Done using STELLA [1] : radiation hydrodynamics code
- Reasonable match : 250 $M_{\odot}$ and ~0.25 redshift
- Already faded









MJDmax(g) = 58349.79
obs mag(g) = 19.371
model mag(g) = -21.547
DistMod(g) = 40.917
z(g) = 0.288

MJDmax(r) = 58363.07
obs mag(r) = 19.104
model mag(r) = -21.505
DistMod(r) = 40.609
z(r) = 0.254

MJDmax(i) = 58383.38
obs mag(i) = 19.045
model mag(i) = -21.817
DistMod(i) = 40.862
z(i) = 0.281

Model by Alexandra Kozyreva
Fit by Stéphane Blondin

[1] Theoretical light curves for deflagration models of type Ia supernova

Find more using Fink

Apply filters

Remove known objects :

- Alerts with galactic objects from SIMBAD.

- Alerts with MPC counterparts

- Objects with spectroscopic classification in TNS

Smart cuts to remove :

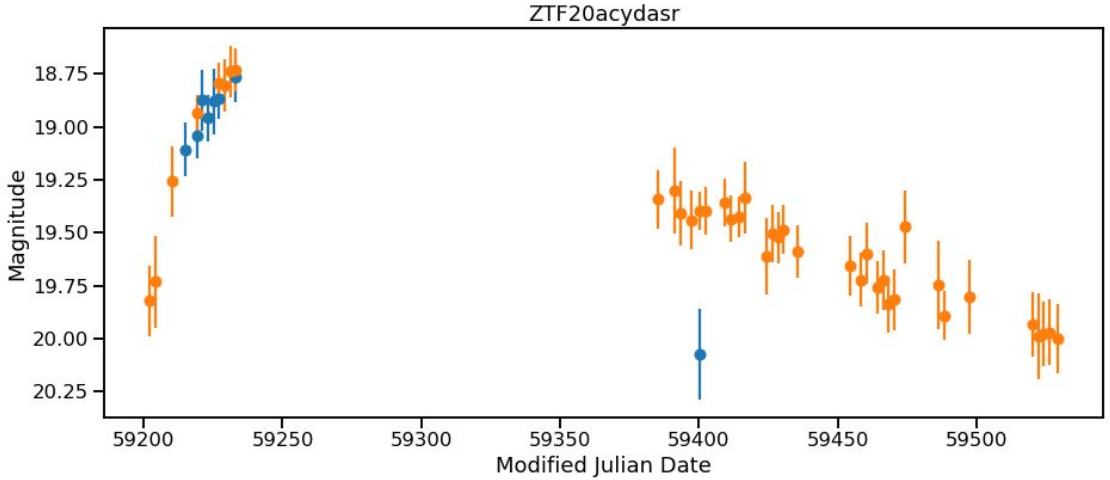
- Alerts inside galactic plane (|b| > 20 degrees)

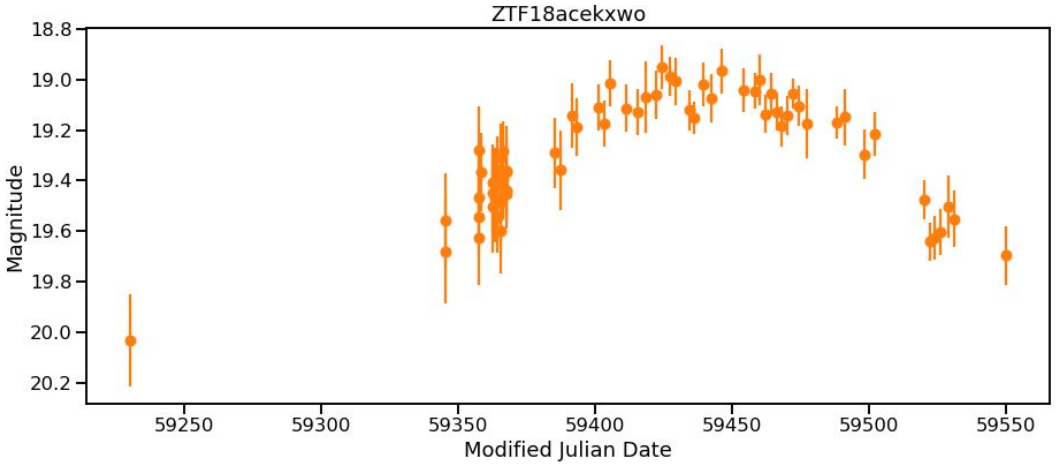
- Objects with less than 20 measurements

- Objects with less than 100d of variation

New candidates

From 76 million to ~ 200 objects

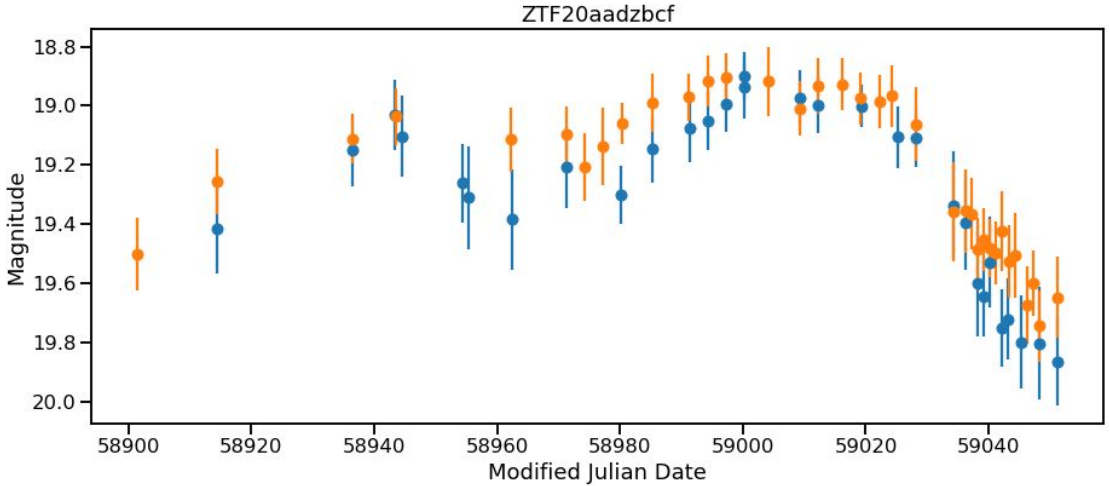


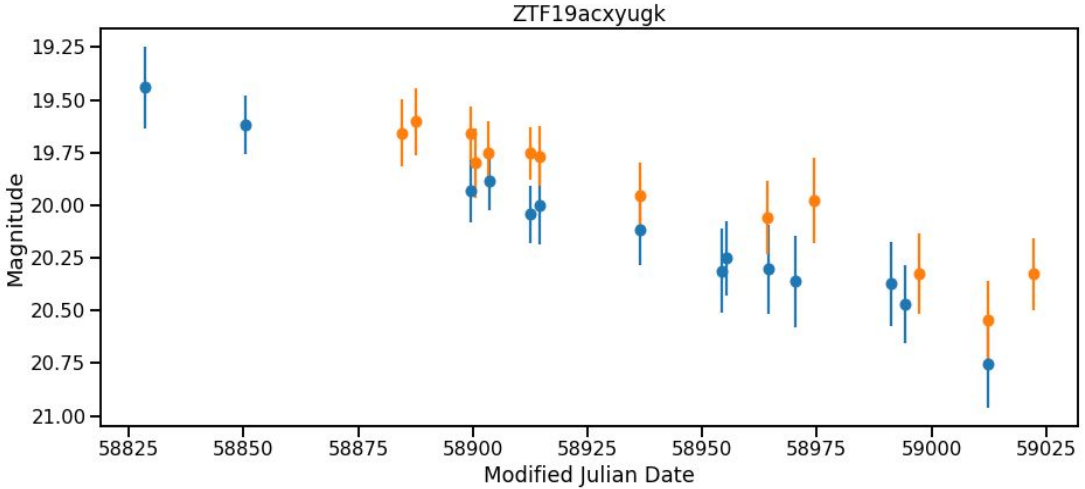


g band

r band

New candidates





g band

r band

Goal of the project

- **Best case :** Find a rising PISN candidate and take a spectrum

- **We can :** Build a catalog of realistic PISN candidates

- **In any case :** Be prepared for LSST with a robust method to isolate objects that look like PISN

Thank you for your attention

Find more using Fink

Apply cuts and remove :

- Alerts with galactic objects from SIMBAD.

- Alerts inside galactic plane (|b| > 20 degrees)

- Alerts with MPC counterparts

- Alerts whose distance to nearest source in reference image PSF-catalog is below 2 arcseconds.

- Objects with less than 20 measurements

- Objects with less than 100d of variation

- Objects with spectroscopic classification in TNS