

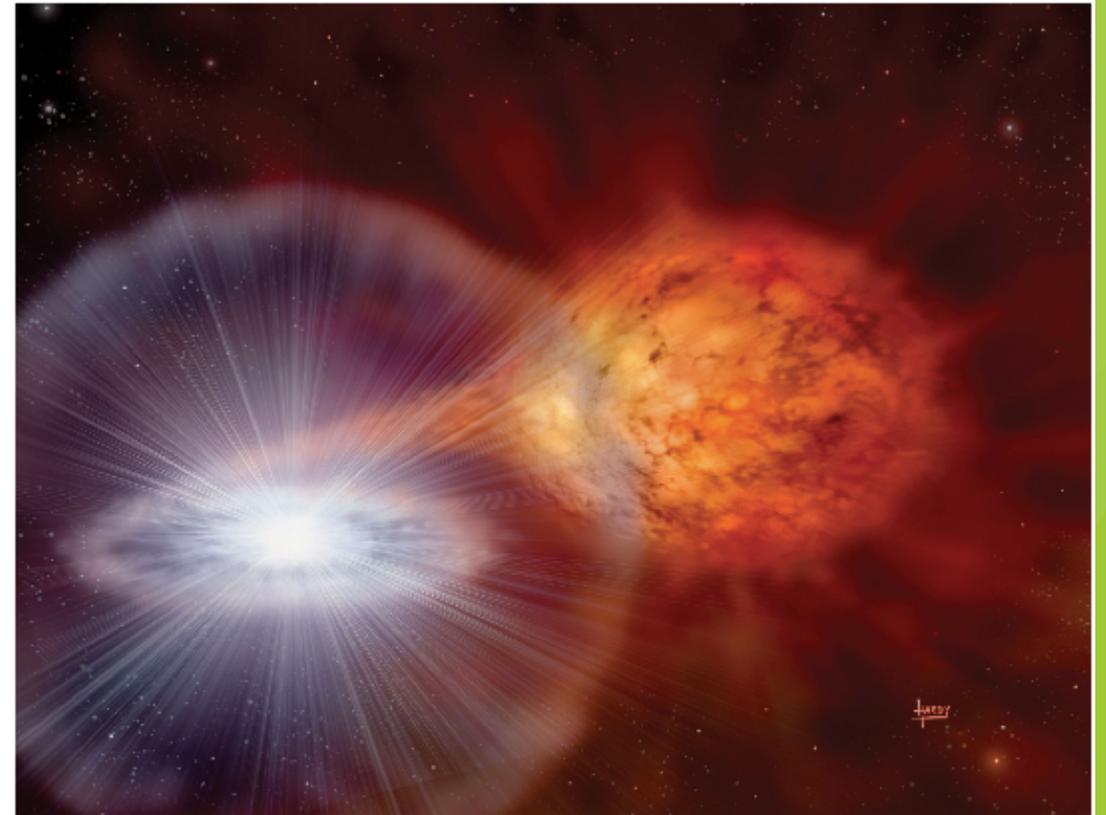
The Search for Kilonova

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Mentor Scientists: Marcelle Soares-Santos, Huan Lin

Supernova

- ▶ A supernova occurs in a binary star system.
- ▶ A dense star (white dwarf) accretes the companion star
- ▶ After the white dwarf has accumulated a critical mass, the star is now hot enough to undergo rapid nuclear fusion.
- ▶ Since the critical mass has little variance, the amount of light given off is roughly always the same.
- ▶ SN are used as standard candles.

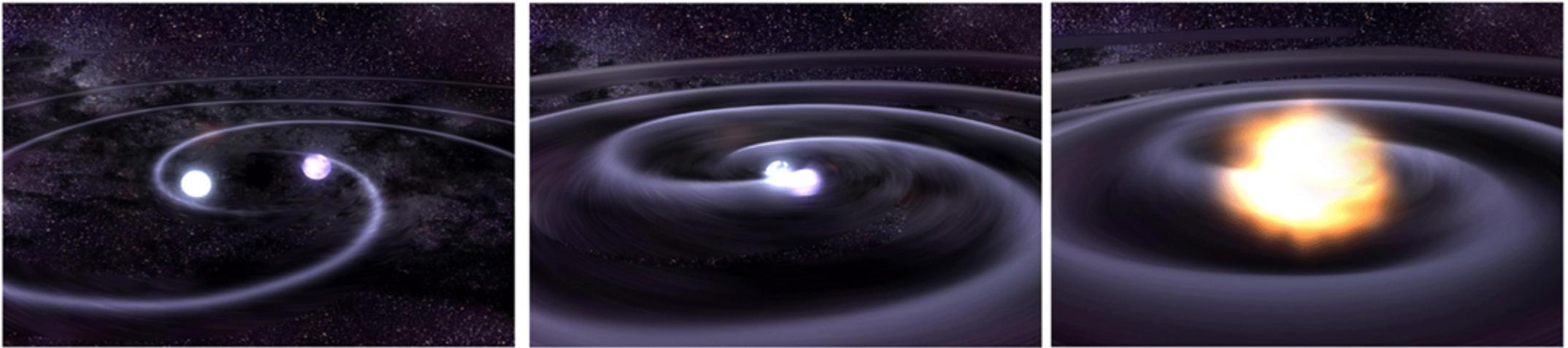


Artist's rendition of a white dwarf accumulating mass from a nearby companion star. This type of progenitor system would be considered singly-degenerate.

Image courtesy of David A. Hardy, © David A. Hardy/www.astroart.org.

Kilonova

- ▶ A Kilonova (KN) is the electromagnetic radiation emitted from the merger of two massive objects such as a black hole and neutron star or two neutron stars.
- ▶ They are very similar to Supernova but not as bright.
- ▶ They last less than 3 weeks which is pretty short compared to a Supernova
- ▶ They are most visible in the near-infrared spectrum.



Why Study Them?

- ▶ Other than the fact that we are having fun exploring the universe?
- ▶ Another result of these binary collisions is a gravitational wave.
- ▶ Gravitational waves were theorized and have been indirectly detected, but never directly.
- ▶ Kilonova detection can be used in tandem with GW detectors currently being developed.
 - ▶ They will allow for a comparison between the speed of gravity and the speed of light.
 - ▶ They will give a more precise location as to where the GW came from.

Ligo Observatory near
Richland, Washington
sincedutch.wordpress.com



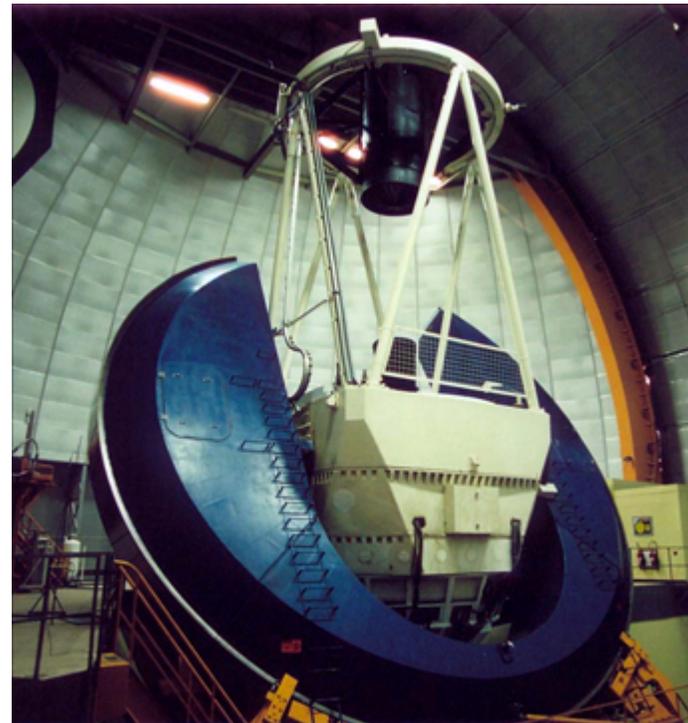
Ligo Observatory in
Livingston, Louisiana
www.ligo.caltech.edu

My Project

- ▶ I am using Dark Energy Survey (DES) data in order to look for these objects.
- ▶ The DES team “throws away” these types of objects because Kilonova (KN) are too dim to be considered Supernovae.
- ▶ I am sorting through “junk”. Writing code in python to sort through this data in order to produce possible candidates for KN.



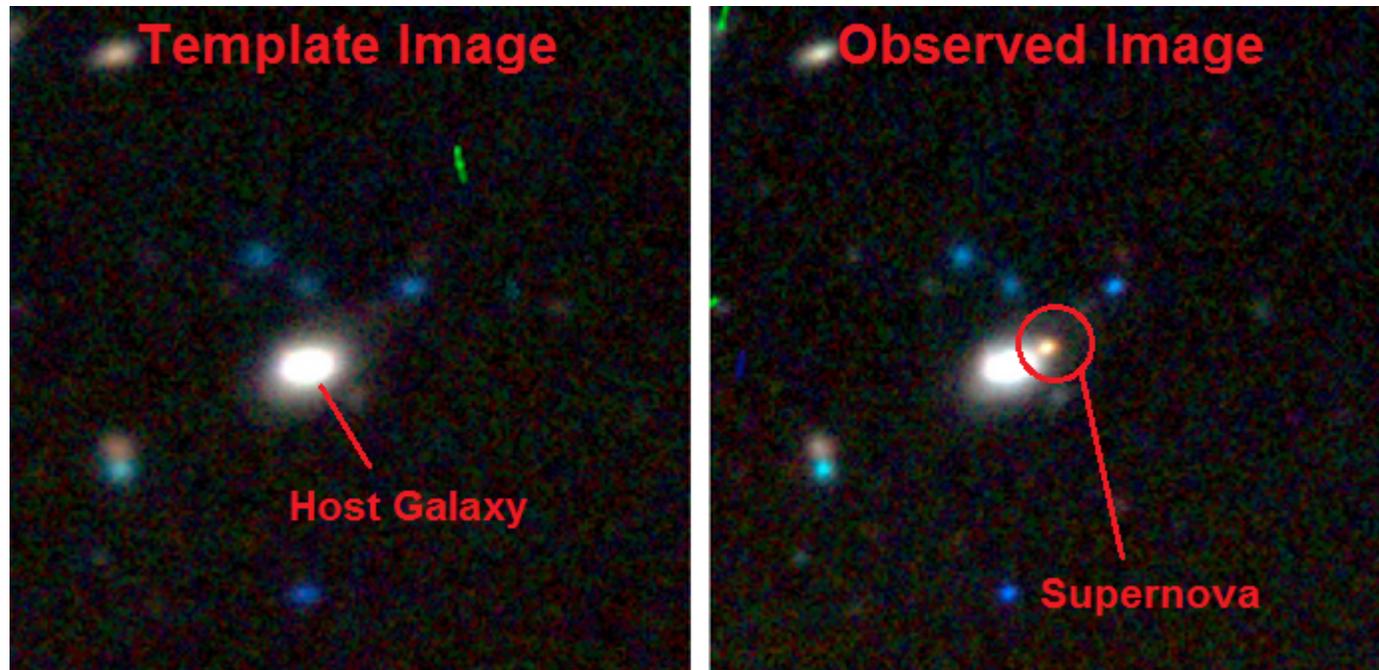
darkenergydetectives.org



www.fnal.gov

DES image subtraction

- ▶ A template image of the sky is made.
- ▶ The template image is subtracted from an observed image
- ▶ The resulting brightness is called the flux
- ▶ Many images are taken over the season through different filters
- ▶ A significant flux over a long duration means some event is happening

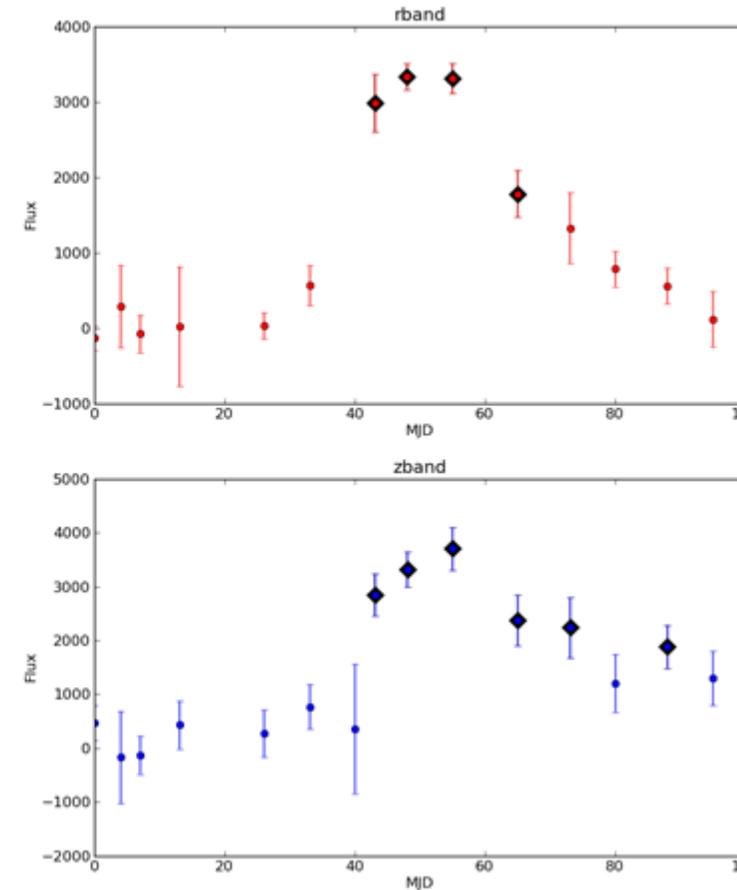
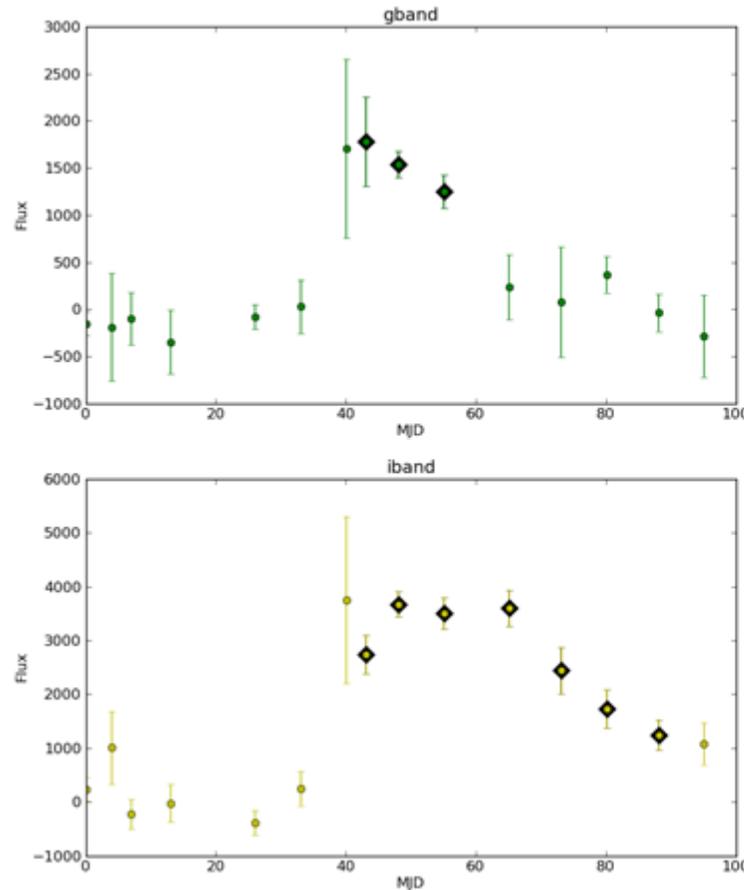


Criteria of Selection

- ▶ Make a Signal to Noise cut.
- ▶ It had to occur at least 3 times in r band.
- ▶ The duration had to be less than 22 days.
- ▶ The data was fit with a function generated by theorists.

$$f(t) = \frac{c \left(\frac{t}{t_0} \right)^b}{1 + e^{\left(\frac{t-t_0}{t_c} \right)}}$$

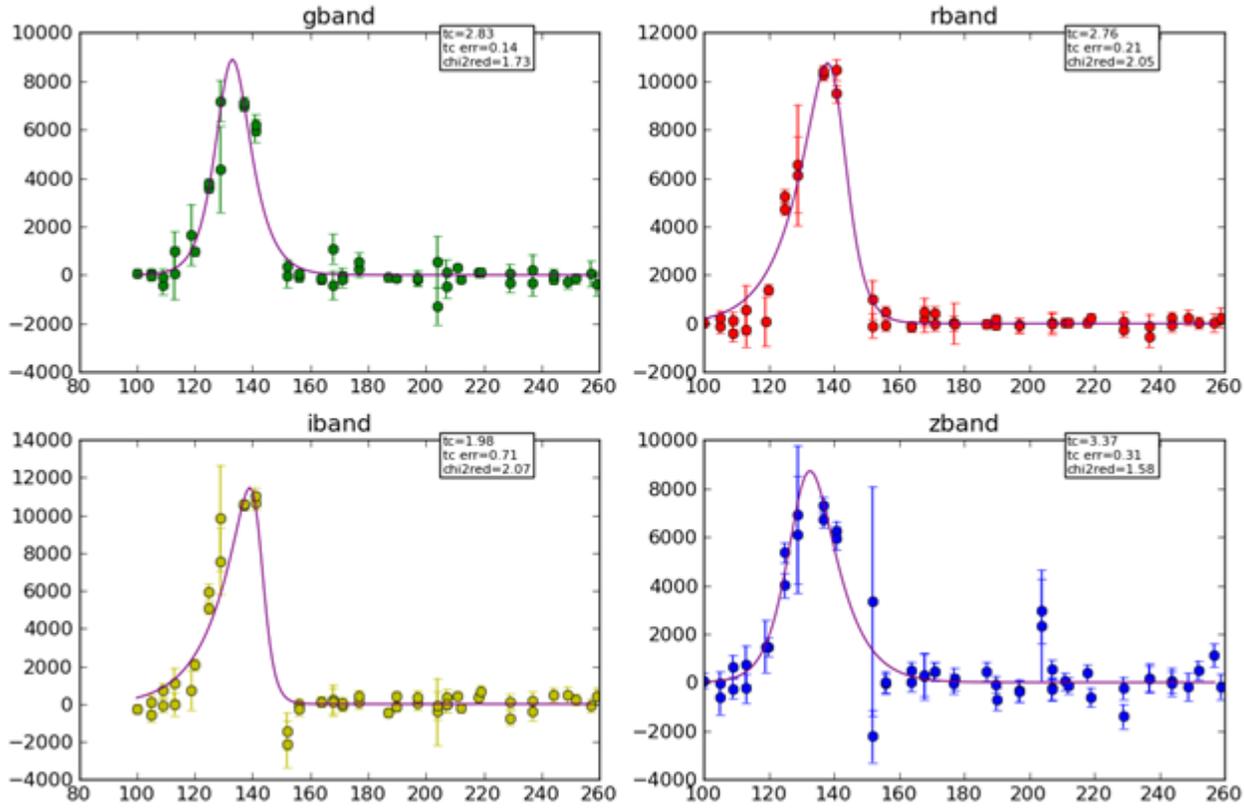
- ▶ Where:
 - ▶ c = normalization parameter
 - ▶ b = rise rate
 - ▶ t_c = fall off rate
 - ▶ t_0 = approx. peak position



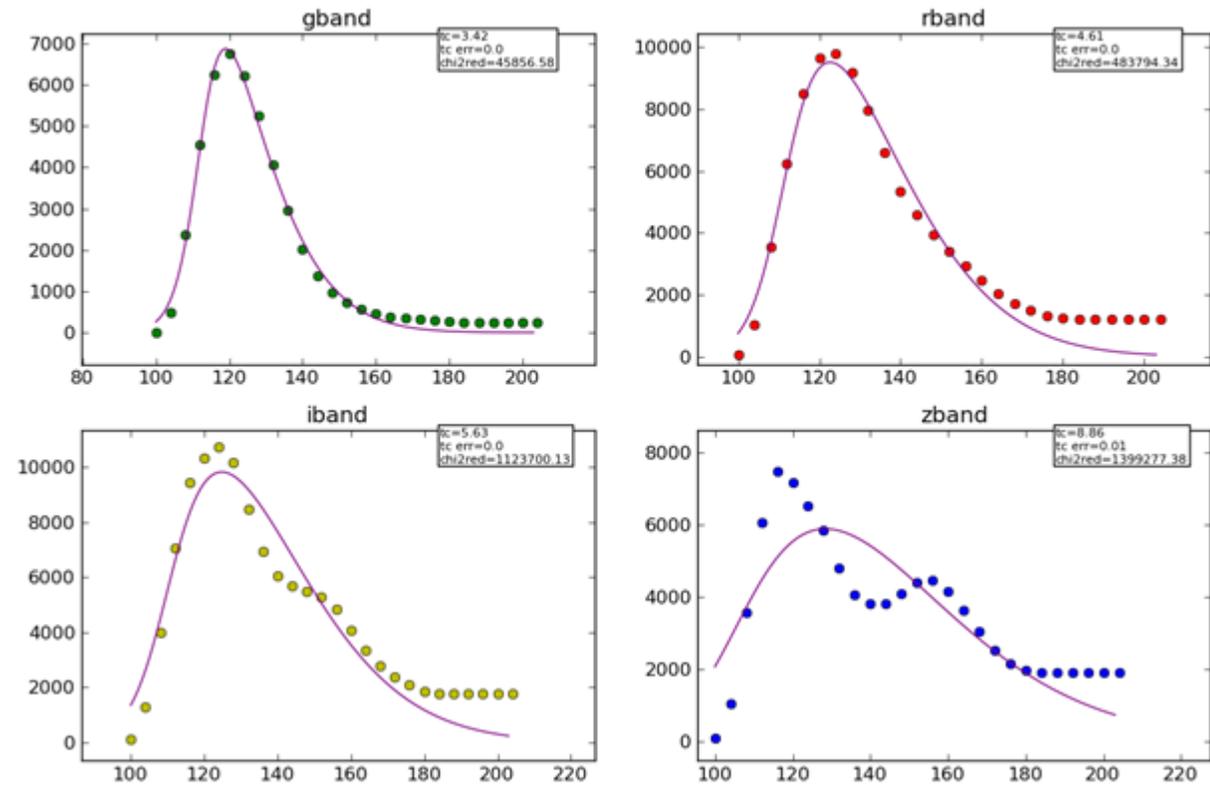
The black diamonds represent points above the signal to noise threshold.

Example Light Curve

flux vs. MJD, canID=1143426

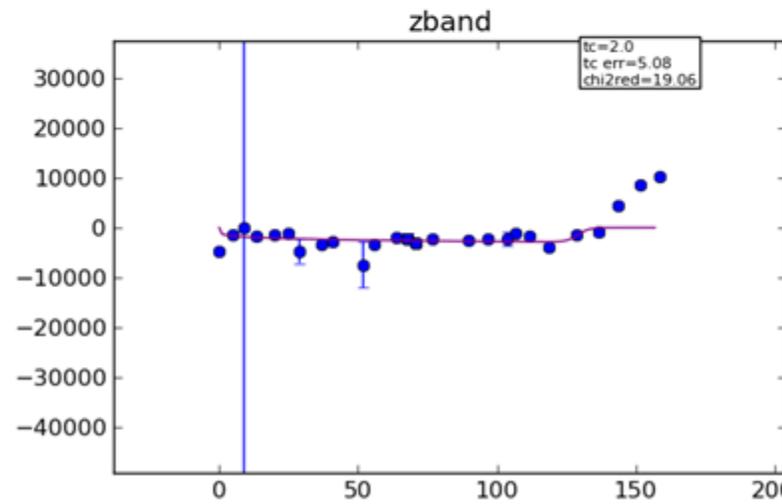
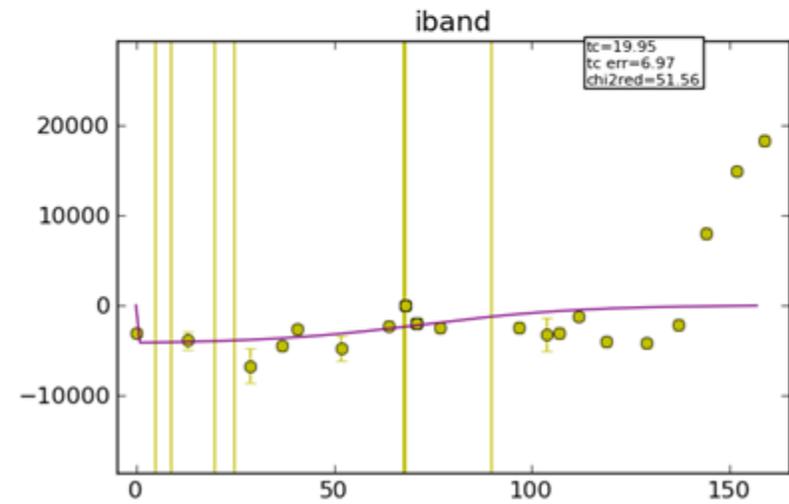
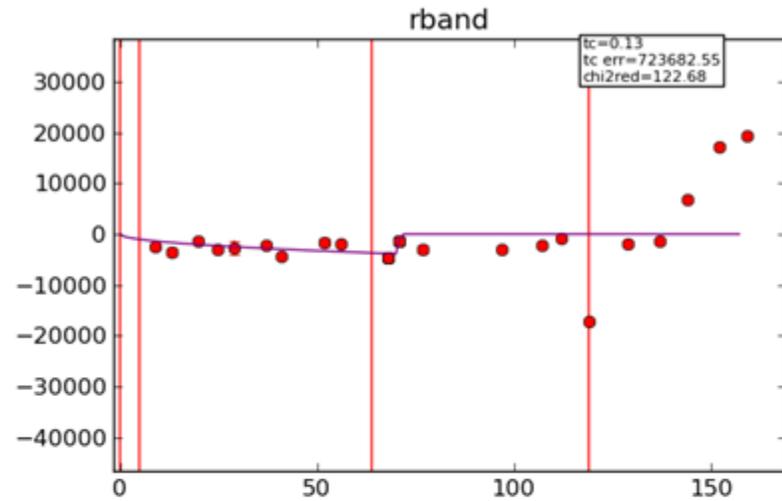
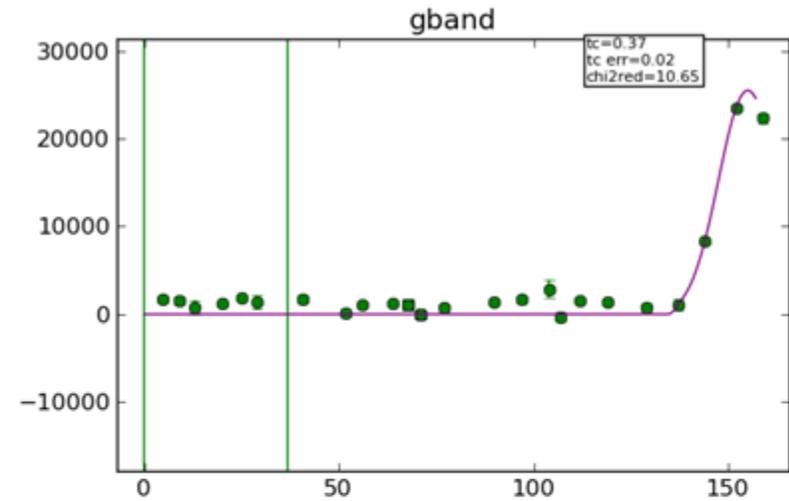


flux vs. MJD, canID=153158



A Possible Candidate

flux vs. MJD, canID=621453



Filter	Object ID	Search	Template	Subtracted
g	11813330			
i	11818593			
r	11817896			
z	11832058			

Results

- ▶ In the end, the code obtained 2 real objects from 1 of 10 fields.
- ▶ These objects were too bright to be considered Kilonova.
- ▶ Light curve fitting needs a little work.
- ▶ Developed a method which can be easily and quickly applied to a DES field to search for Kilonova.

Bringing back to the Classroom

- ▶ A better understanding of the day-to-day life of a physicist.
- ▶ A better understanding and appreciation of how science is performed at a laboratory.
- ▶ Improved my programming skills (possible incorporation into classwork)
- ▶ Learned more about astronomy and astrophysics.
- ▶ Collaboration involved with physics.

Thanks

- ▶ FermiLab
- ▶ TRAC program (Harry Cheung and Bjoern Penning)
- ▶ Marcelle Soares-Santos
- ▶ Huan Lin