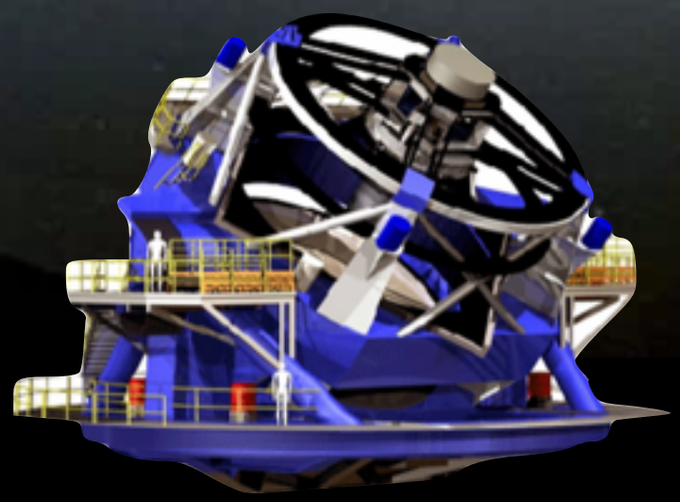
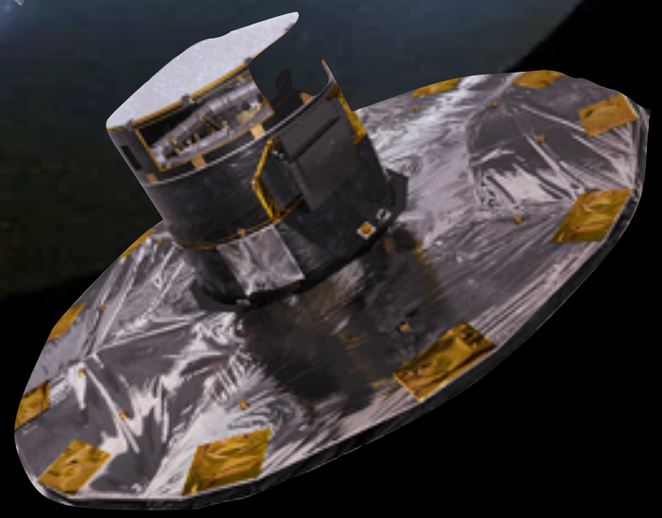
TRANSIENT SKY IN THE BIG DATA ERA



ŁUKASZ WYRZYKOWSKI ***(pron: Woocash Vizhikovsky)***

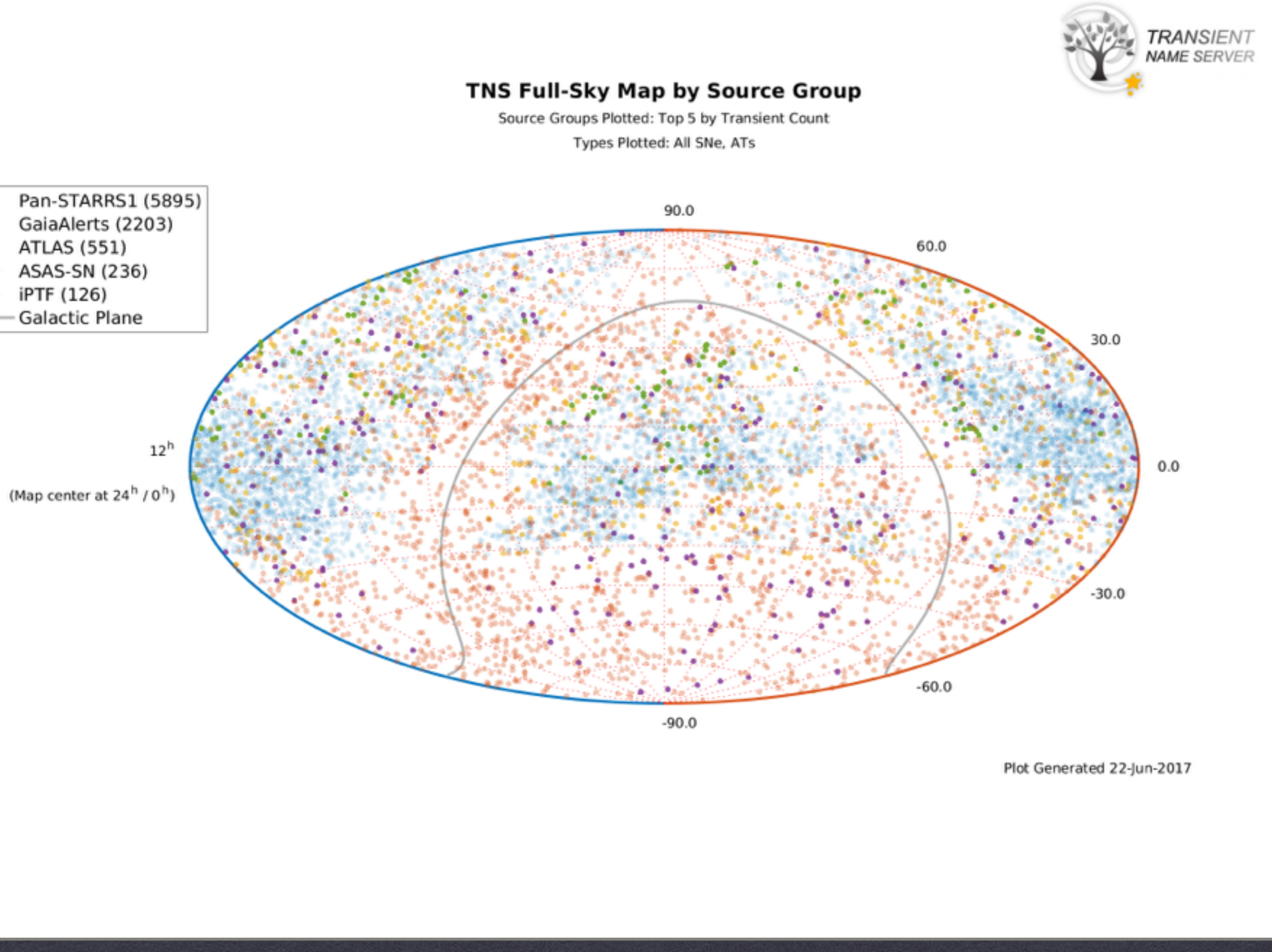
WARSAW UNIVERSITY OBSERVATORY

with:

S.Hodgkin, M.Gromadzki, A.Hamanowicz, K.Rybicki, J.Klencki, Z.Kostrzewa-Rutkowska,, OGLE and Gaia Teams.

EWASS 2017, Prague
S14-Astroinformatics

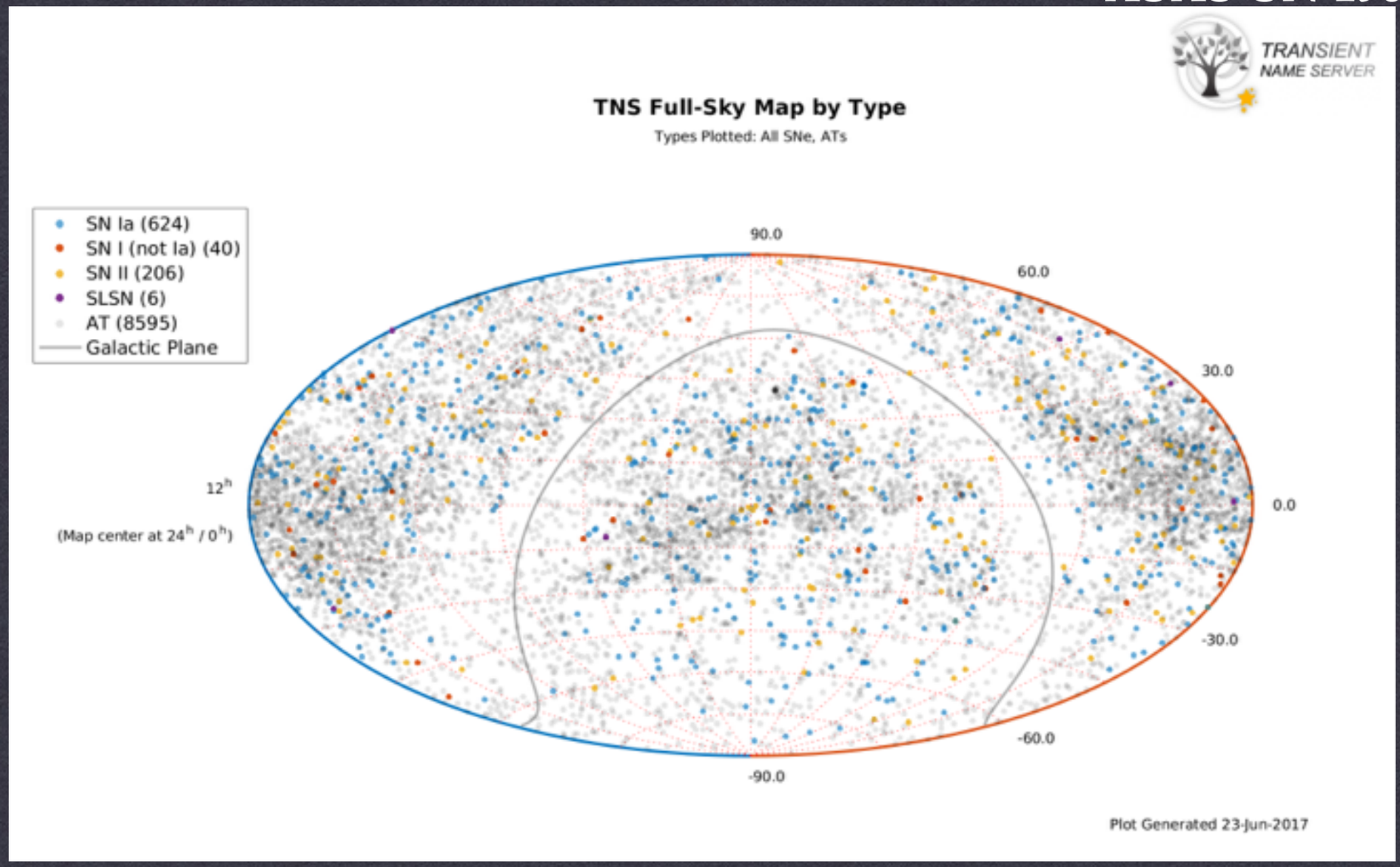
TRANSIENT SKY



STATS

TNS since Jan 1, 2016
Reported : 9547
classified : 879 <10%

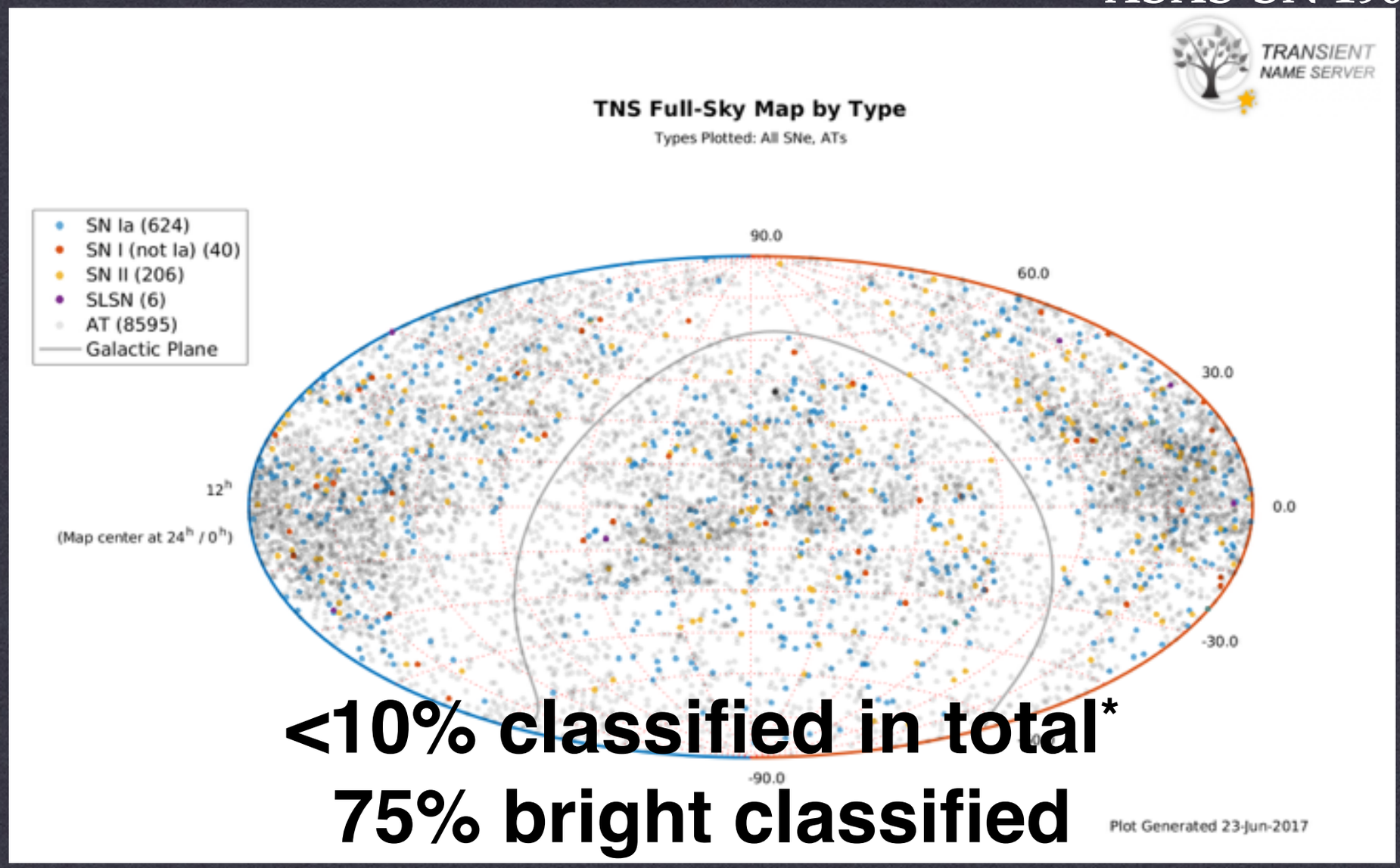
ratio classified:
Pan-STARRS1 136/5908
GaiaAlerts 116/2224
ATLAS 143/574
ASAS-SN 190/254



STATS

TNS since Jan 1, 2016
Reported : 9547
classified : 879 <10%

ratio classified:
Pan-STARRS1 136/5908
GaiaAlerts 116/2224
ATLAS 143/574
ASAS-SN 190/254



<10% classified in total*
75% bright classified

* not all classifications reported to TNS yet

GO BRIGHT?

bright is good:

- easy to detect
- easy to follow-up for long time until late epochs
- studies of detailed aspects of explosions

GO BRIGHT?

bright is good:

- easy to detect
- easy to follow-up for long time until late epochs
- studies of detailed aspects of explosions

should we go bright only?

No!

GO BRIGHT?

bright is good:

- easy to detect
- easy to follow-up for long time until late epochs
- studies of detailed aspects of explosions

should we go bright only?

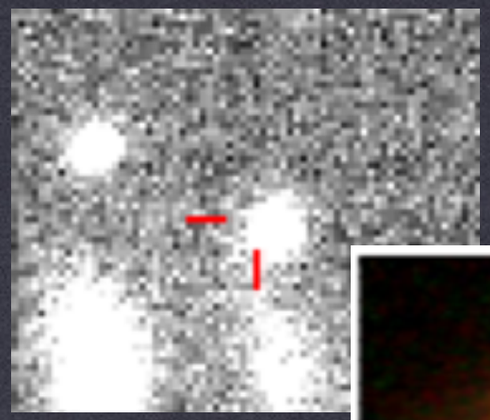
No!

GO FAINT!

- many interesting transients are faint!
- distant SN Ia - Dark Energy and cosmology
- lensed supernovae - Dark Matter distribution
- SN impostors - SN physics
- faint and fast - new rare explosions
- the unknown!

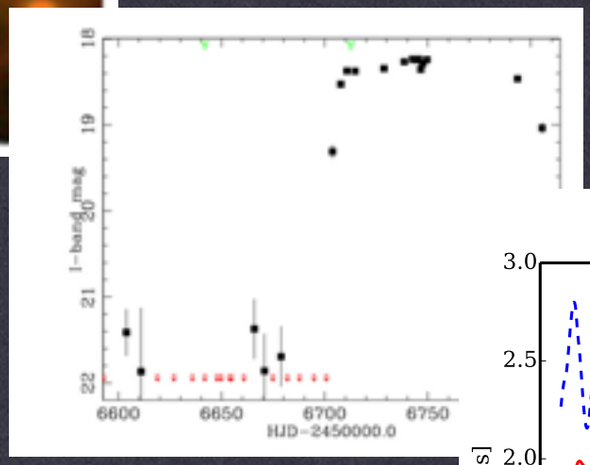
PRE-CLASSIFICATION

pixel level

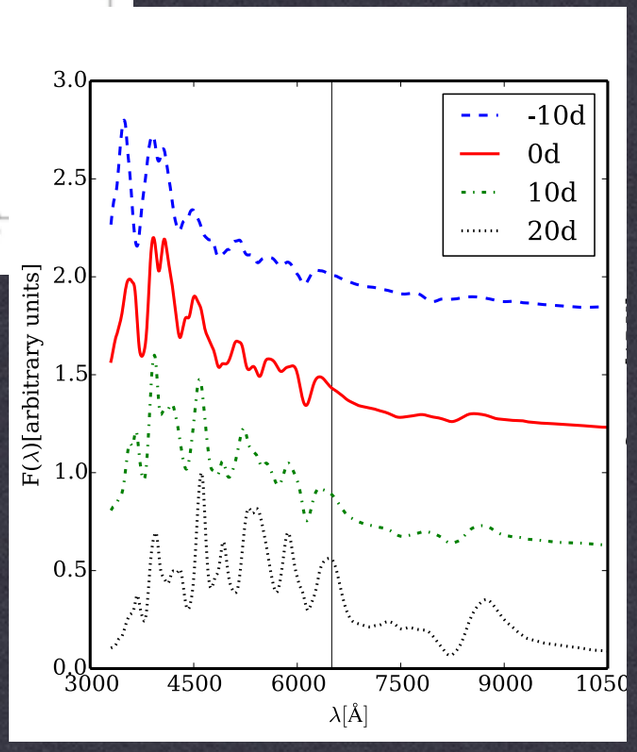


context level

light curve level



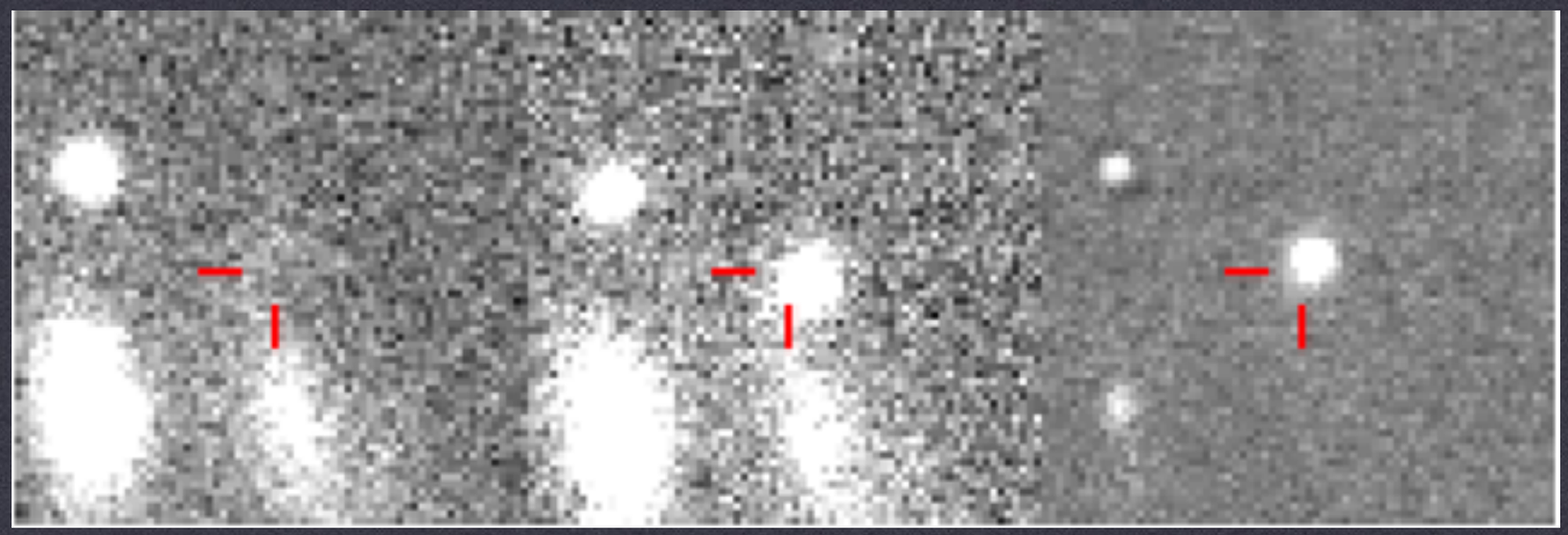
spectrum level

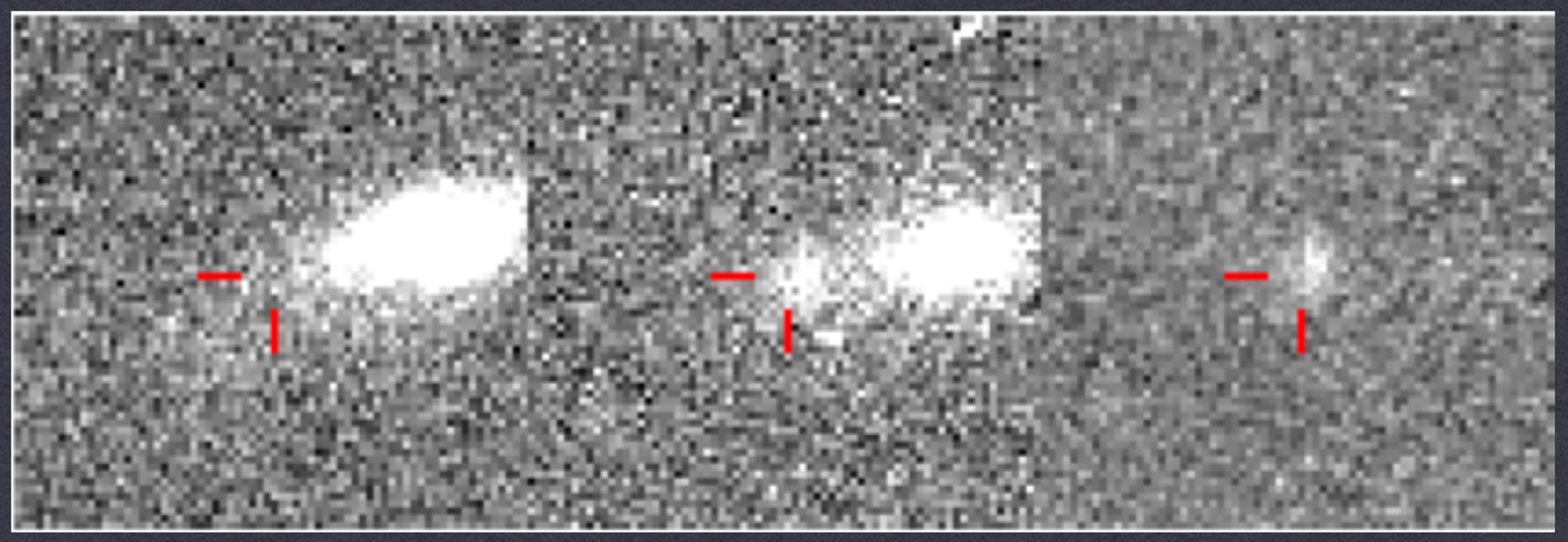


PIXELS

easy examples

reference image current image difference image

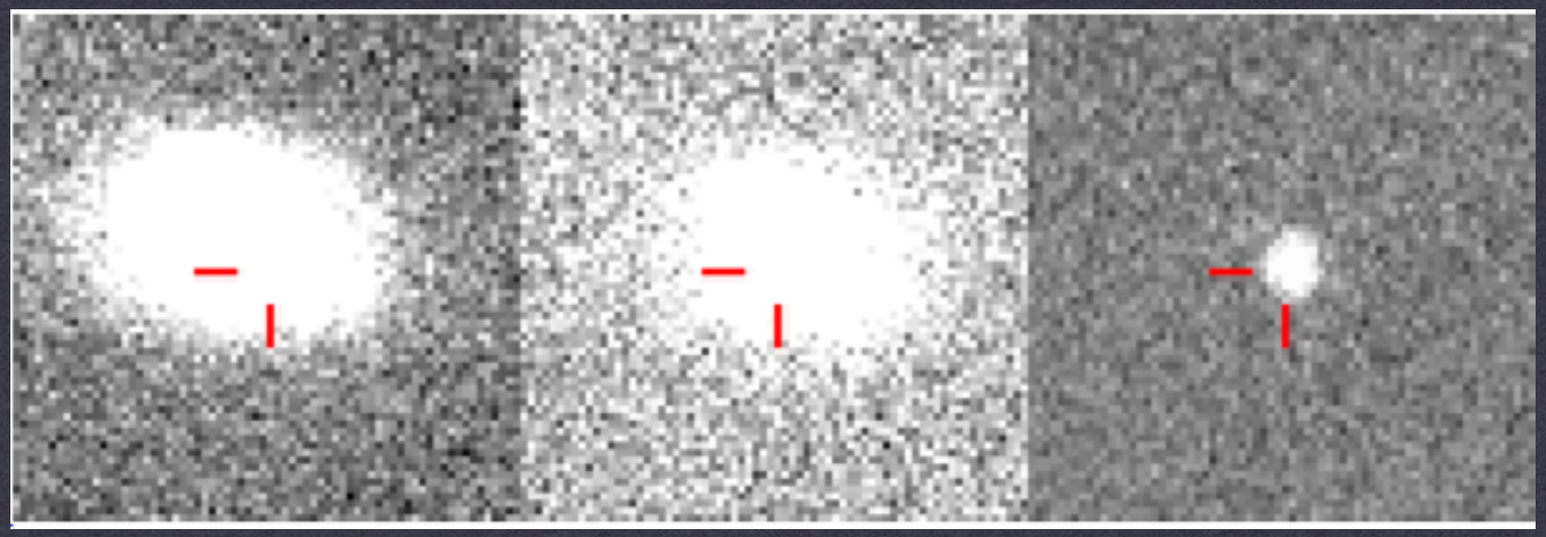


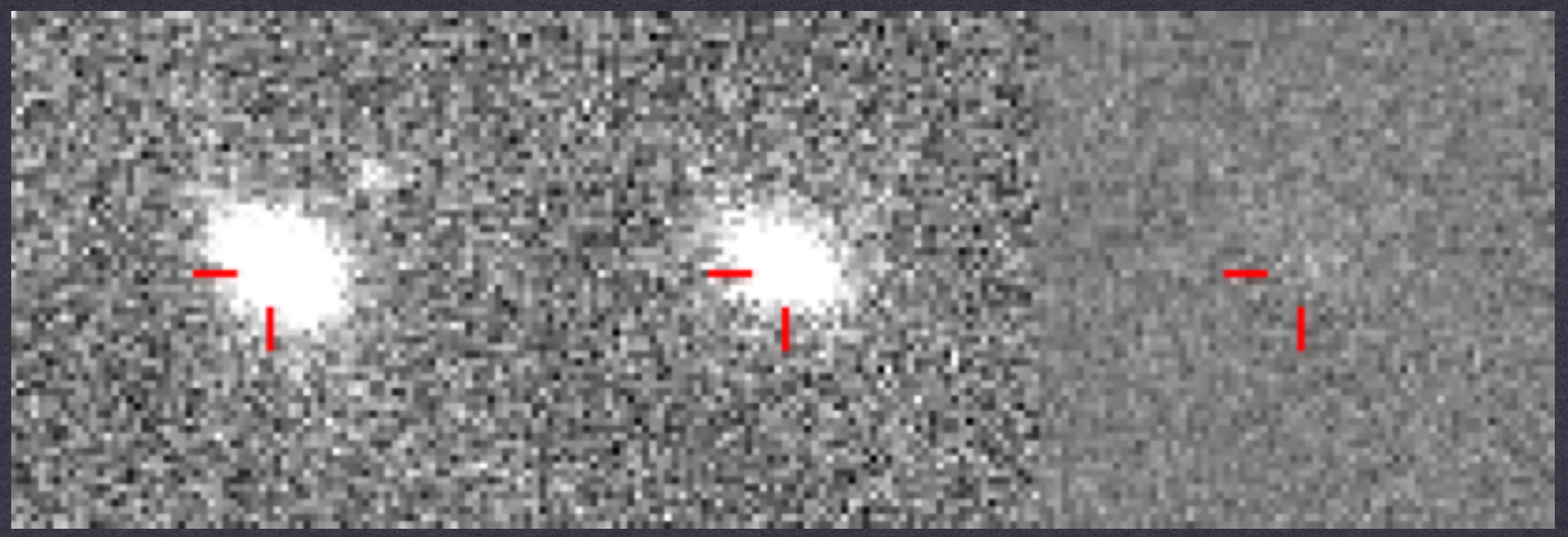


PIXELS

hard examples

reference image current image difference image



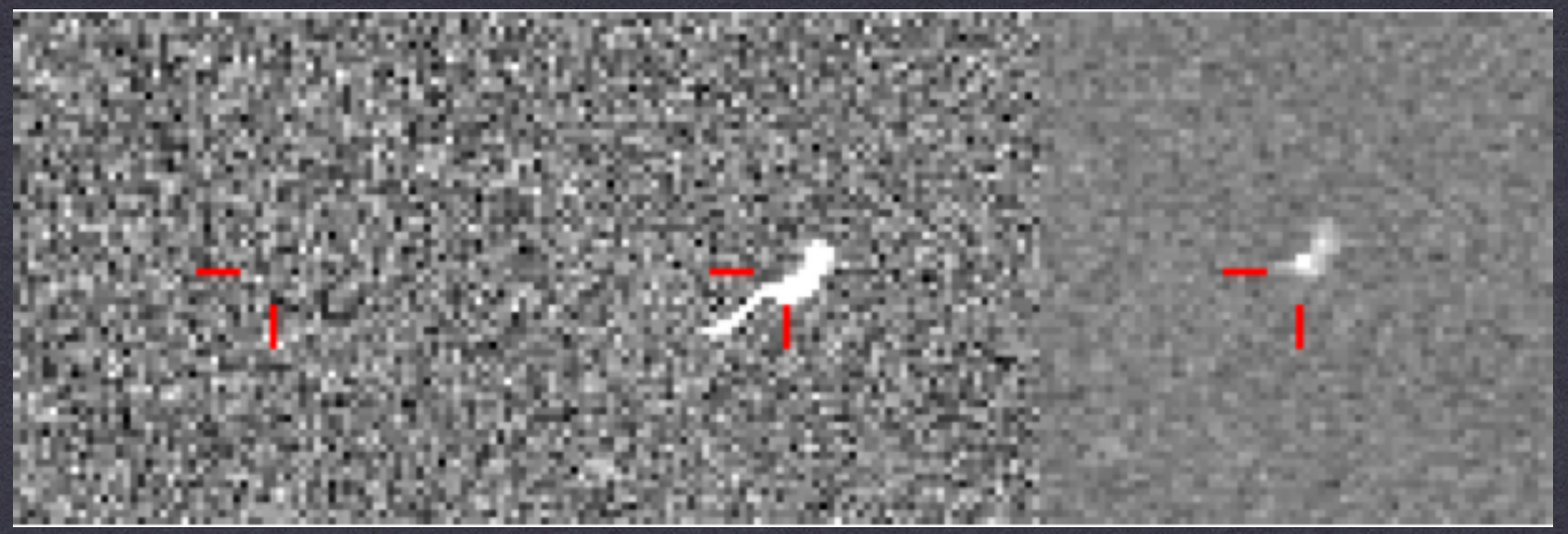


TDE

PIXELS

bogus examples

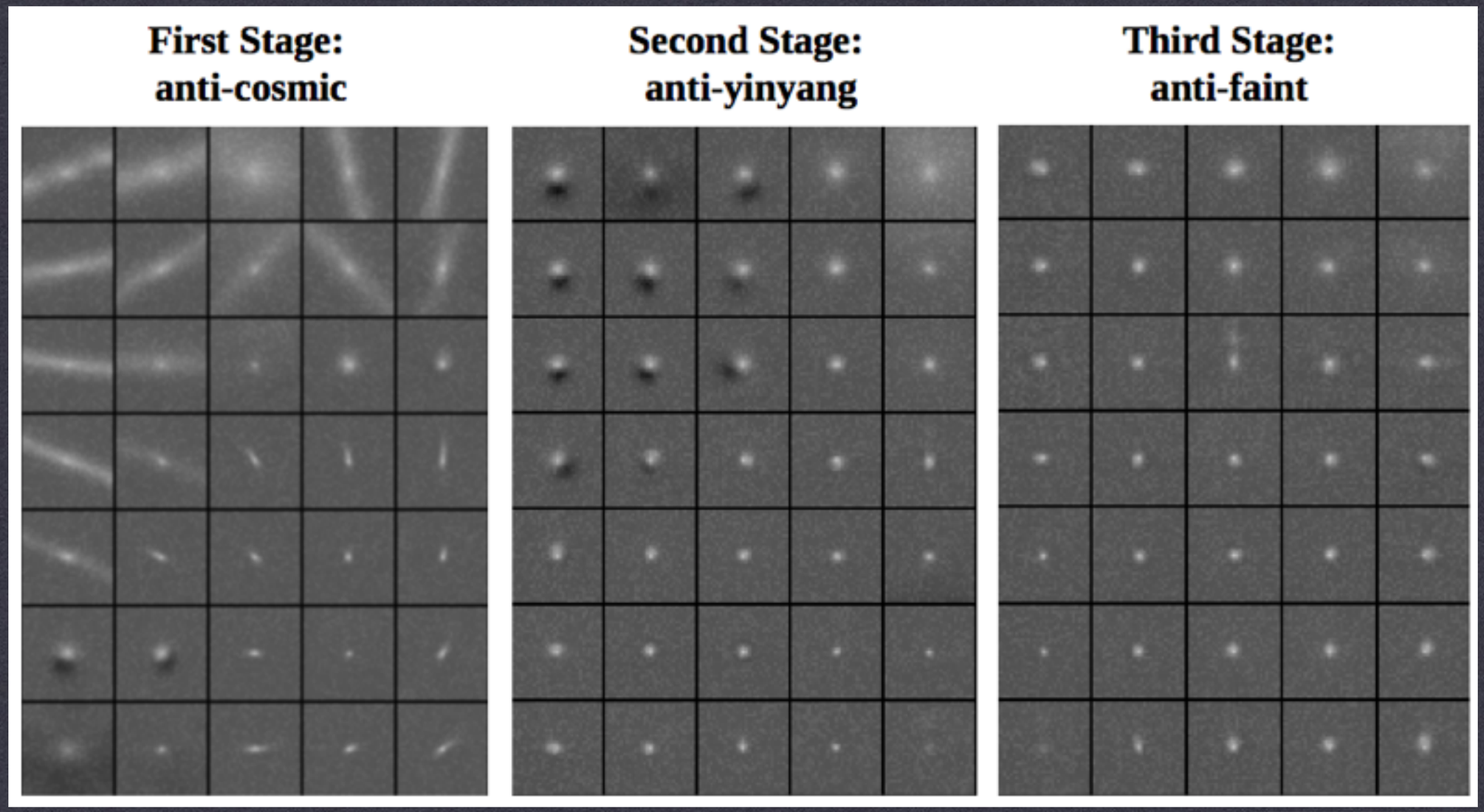
reference image current image difference image



PIXELS

real-bogus classification

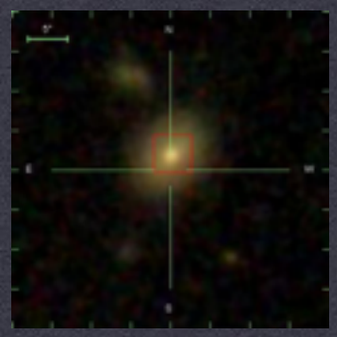
- Self-Organizing Maps on difference images
- single image used only - allows rapid detections of transients!
- 3% false positive rate

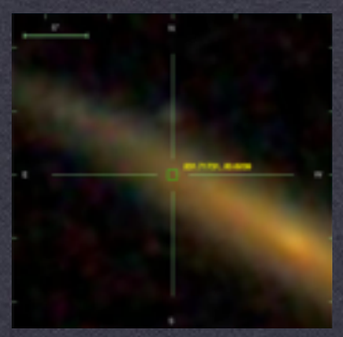


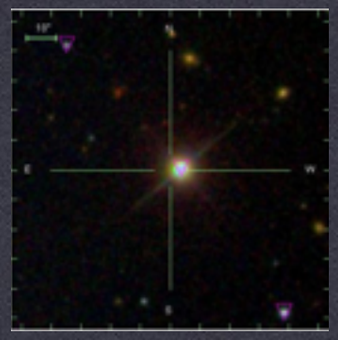
Klencki et al. 2016

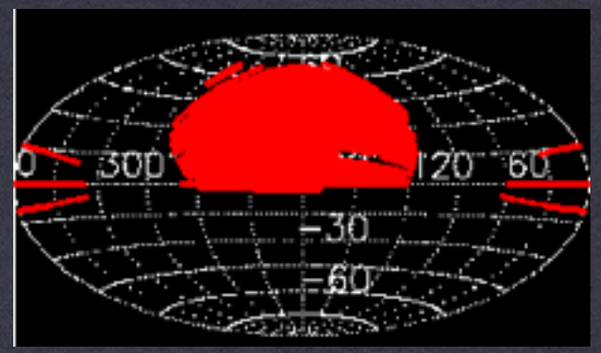
CONTEXT

- wealth of archives with imaging and catalogues
- problem: missing data (e.g., SDSS imaging only in the North)
- Decision Trees, Fuzzy SVM



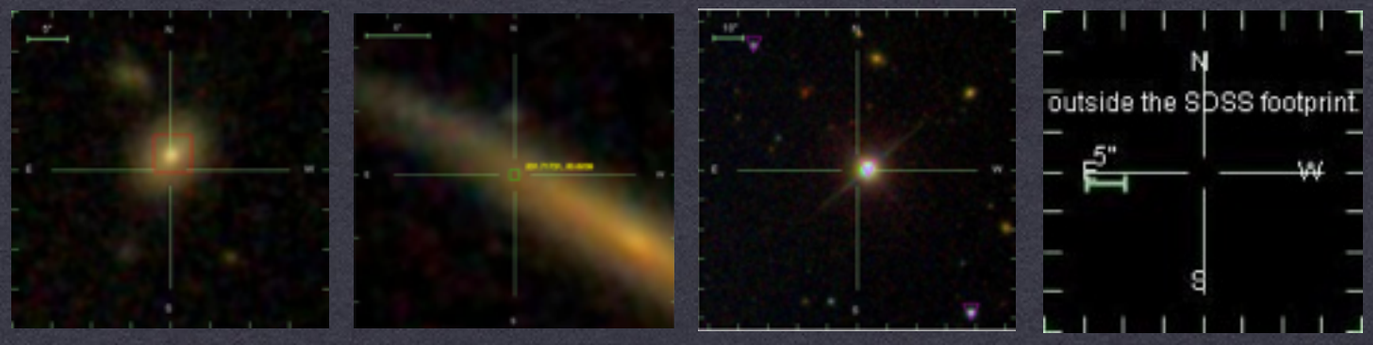


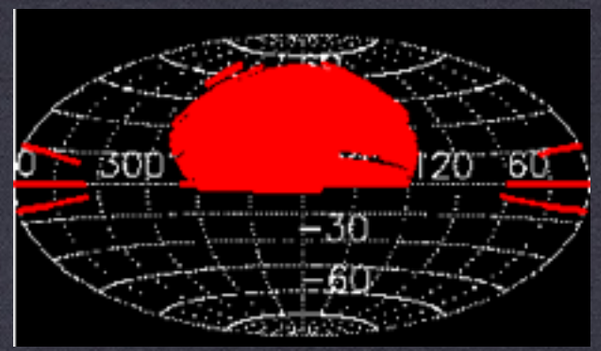


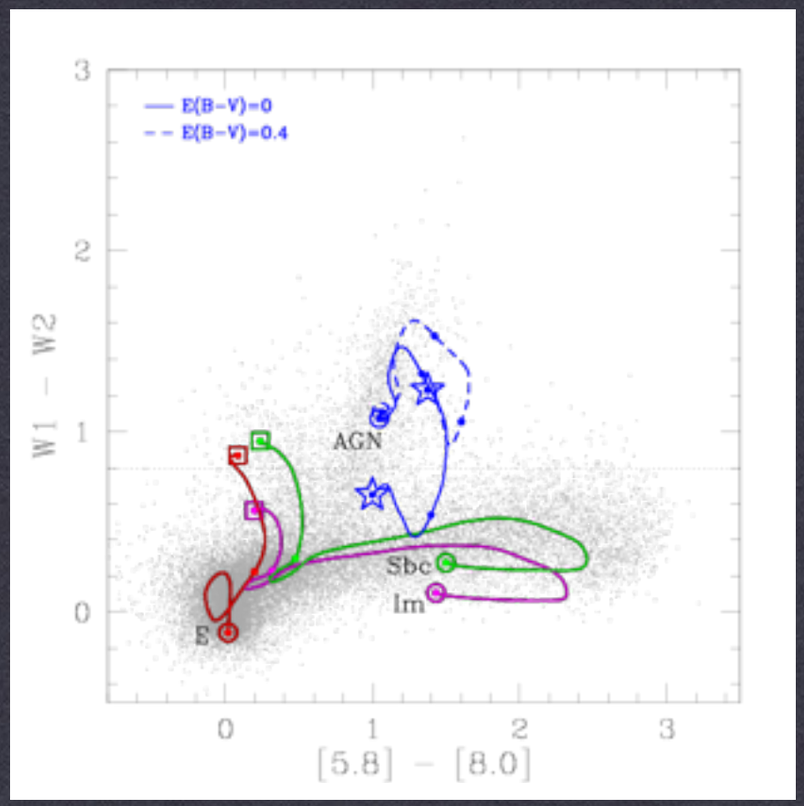


CONTEXT

- wealth of archives with imaging and catalogues
- problem: missing data (e.g., SDSS imaging only in the North)
- Decision Trees, Fuzzy SVM

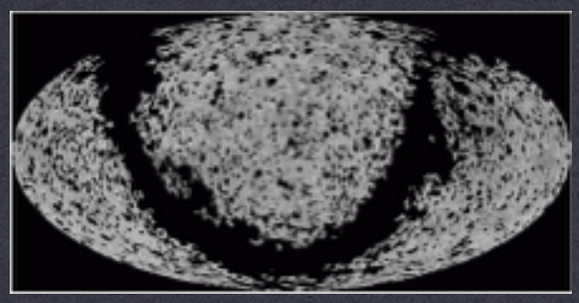






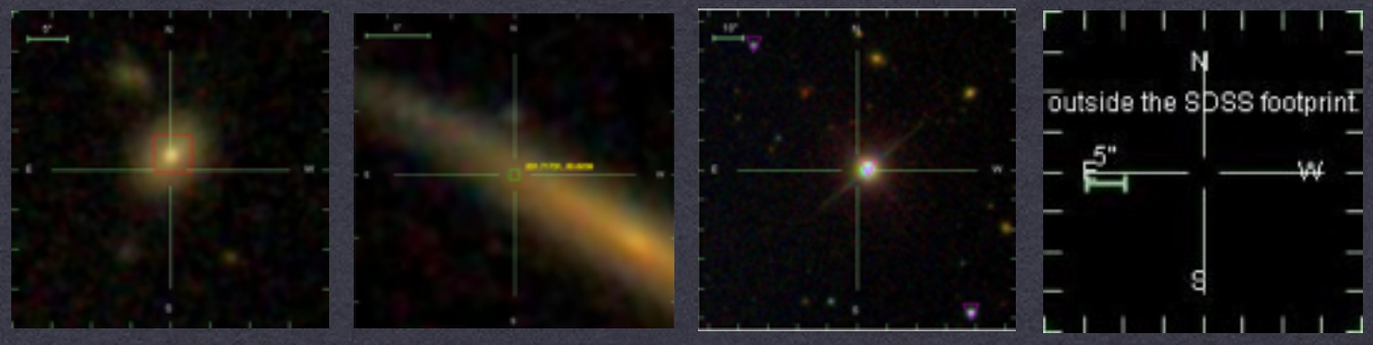
Assef+2013

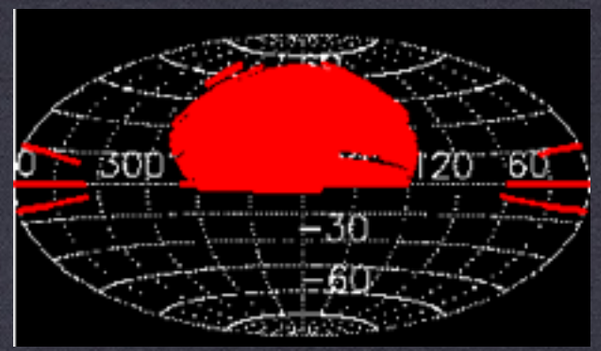
multi-wavelength surveys:
Rosat (X)
GALEX (UV)
Wise (IR)
2MASS (NIR)
large fraction of the sky!

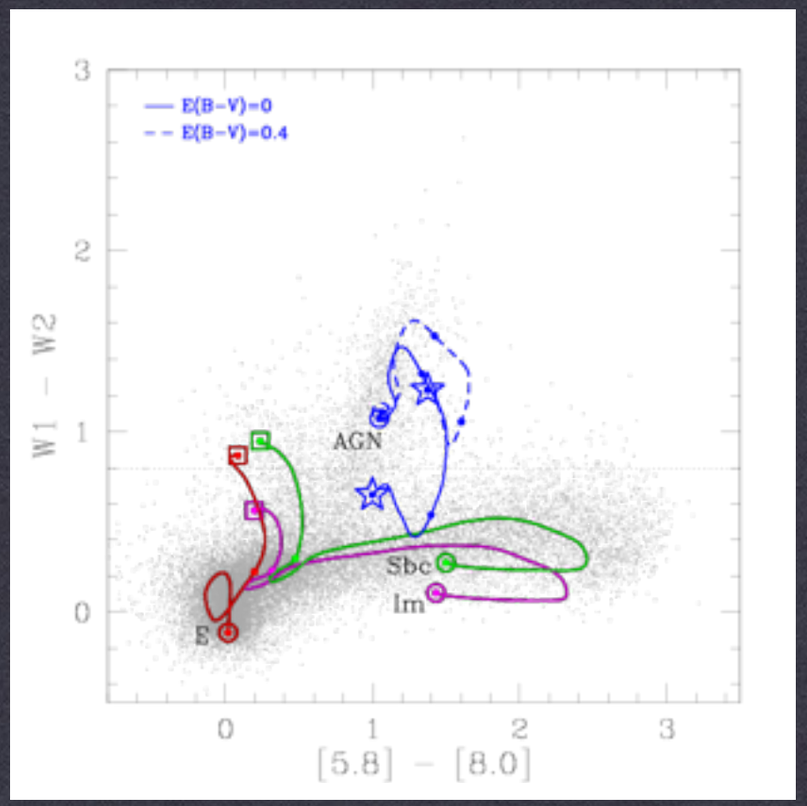


CONTEXT

- wealth of archives with imaging and catalogues
- problem: missing data (e.g., SDSS imaging only in the North)
- Decision Trees, Fuzzy SVM

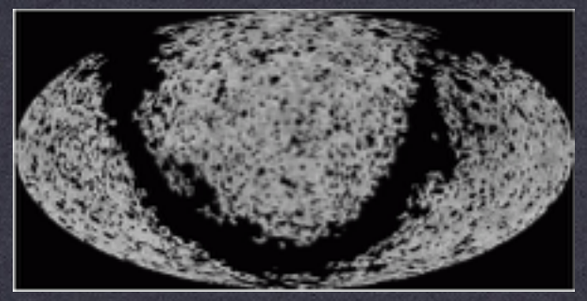




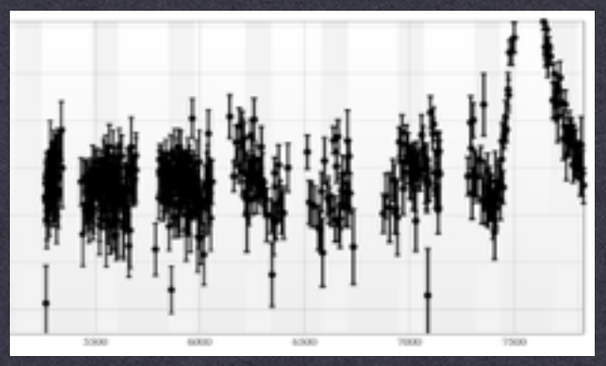


Assef+2013

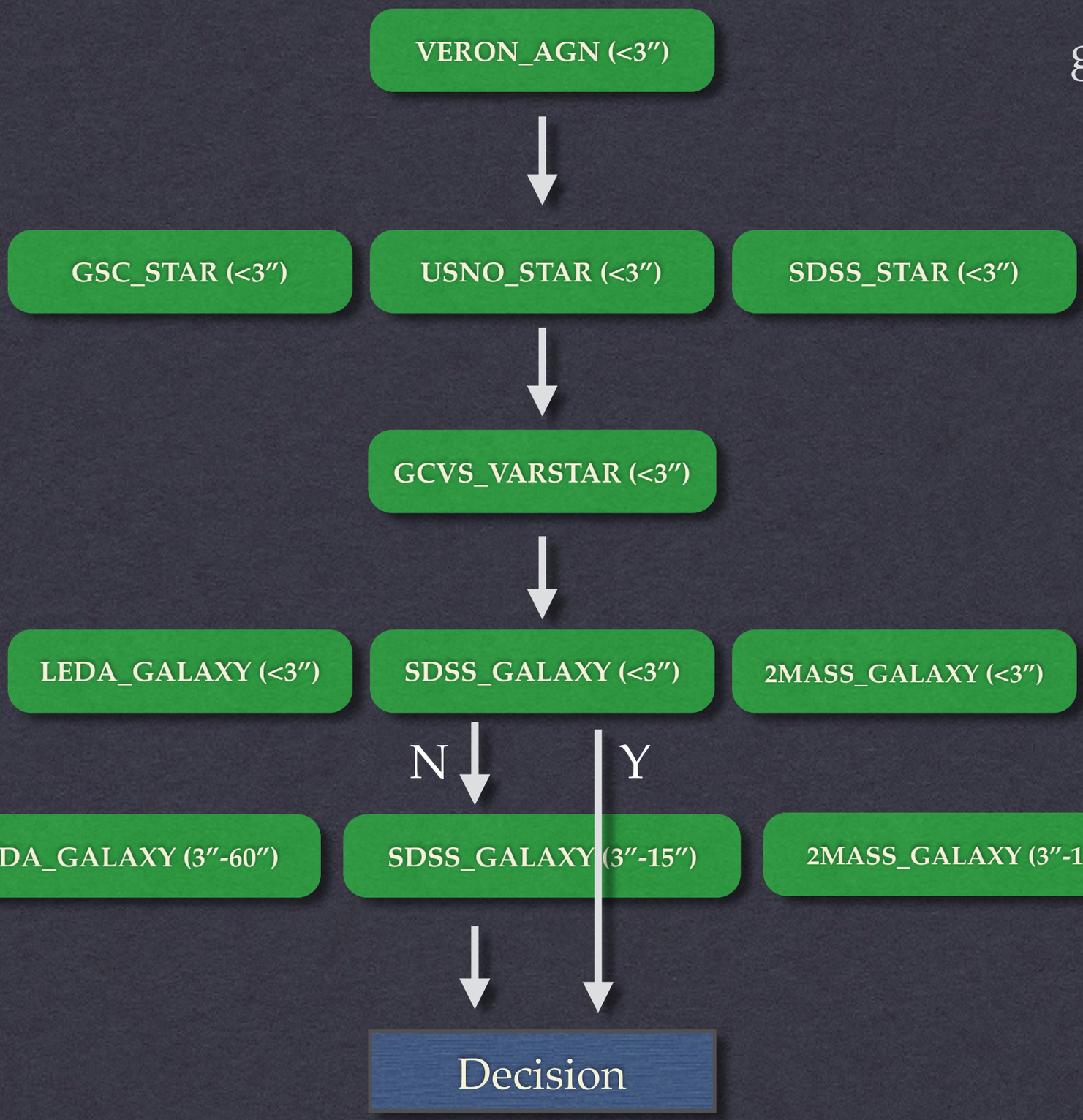
multi-wavelength surveys:
Rosat (X)
GALEX (UV)
Wise (IR)
2MASS (NIR)
large fraction of the sky!



large flare missed in a known AGN z=0.324



CONTEXT



good match to known AGN?

star very nearby?

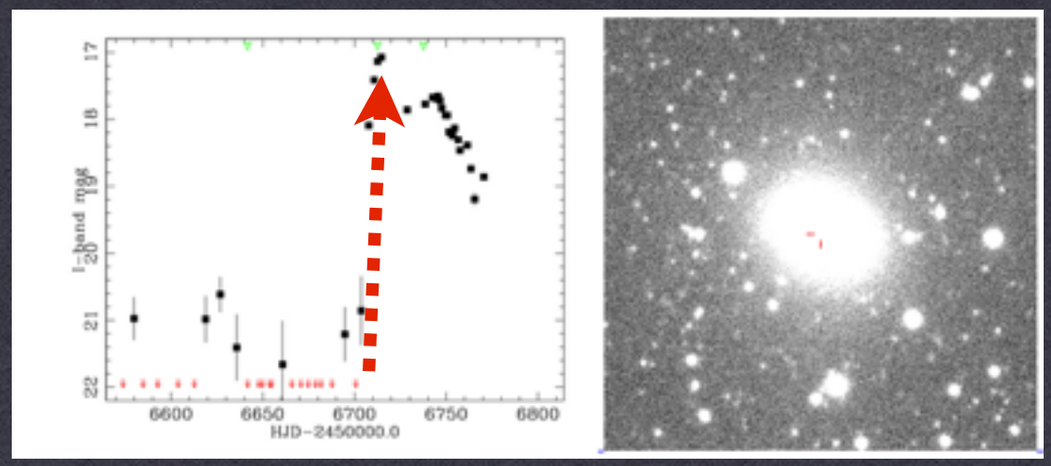
known variable star?

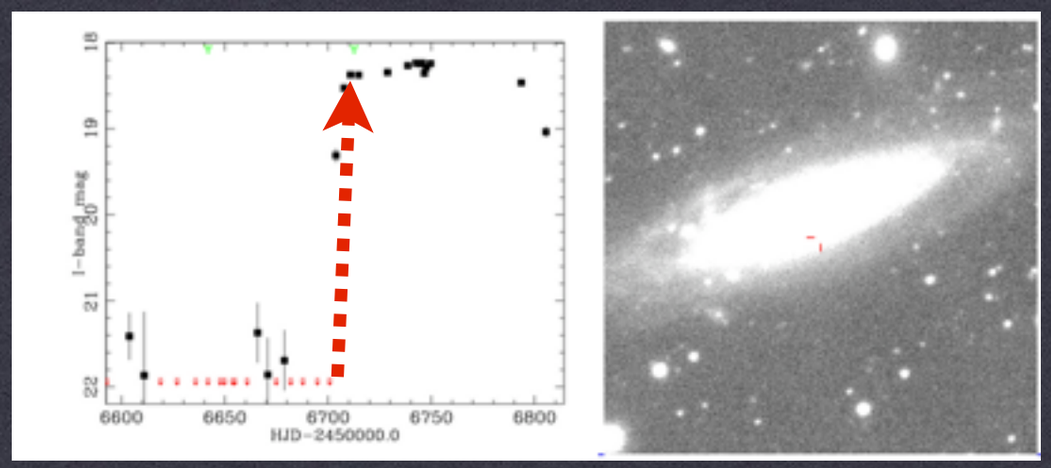
very close to galaxy core?

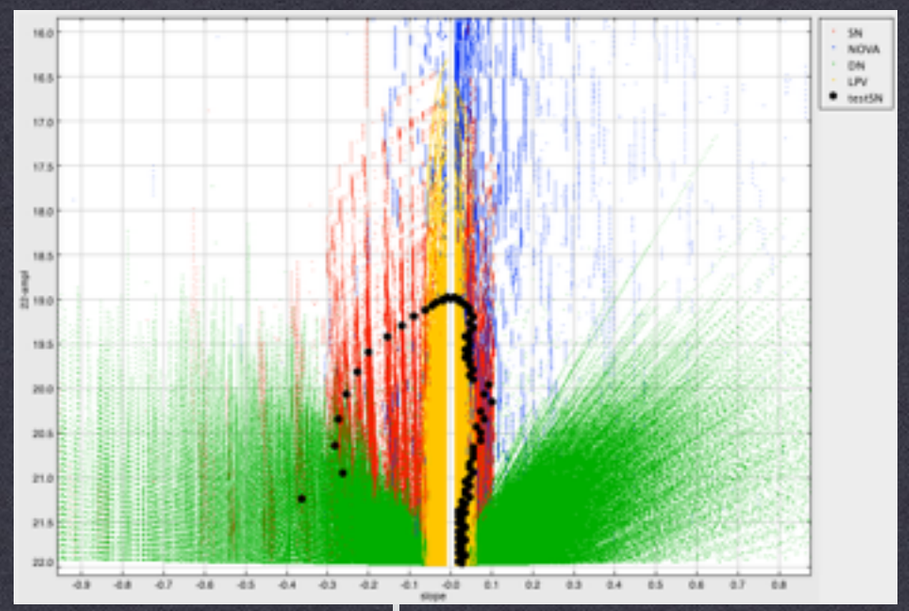
galaxy nearby?

LIGHT CURVE

- simple parameters:
  - last non-detection
  - rising slope
  - max magnitude
- training set: 90 spectroscopically classified supernovae
- classifier: Random Forest
- correct answers: 84%







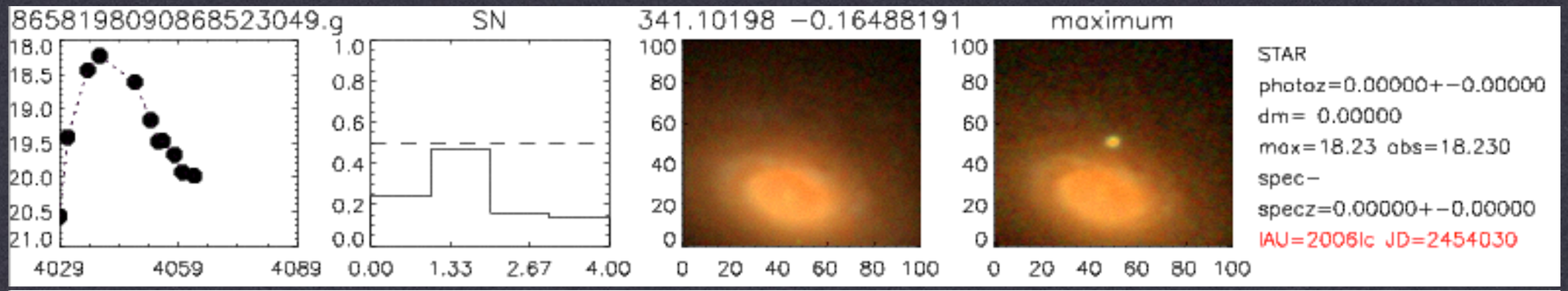
SN Ia *Novae* *LPVar*

SN II *DN*

Wyrzykowski et al. 2014

LIGHT CURVE

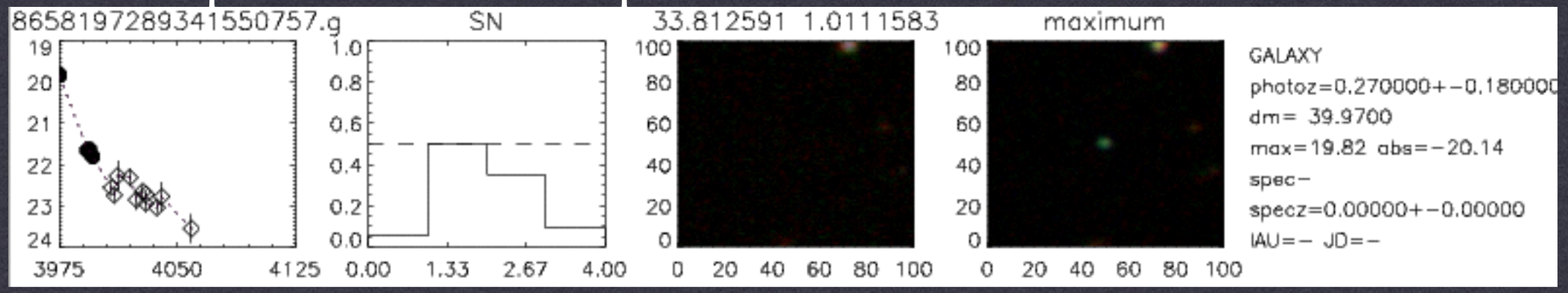
test on Stripe 82

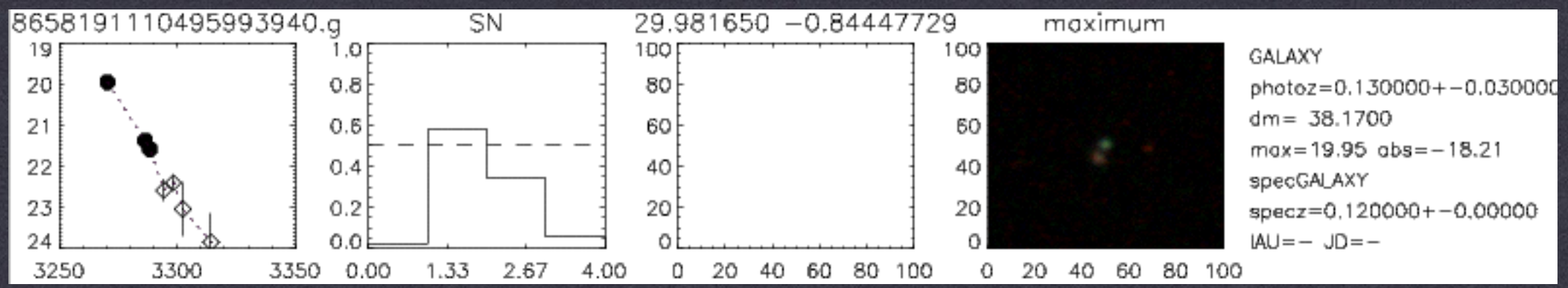


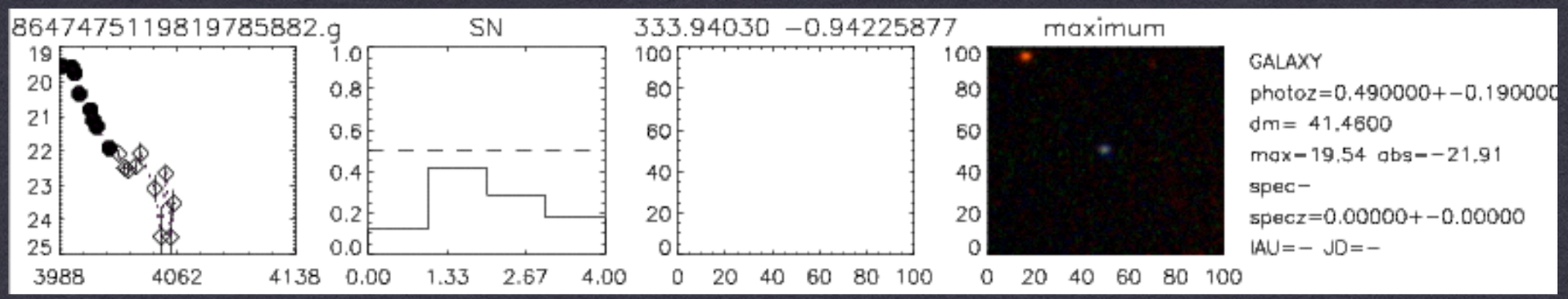
Classifier does not know about the galaxy!

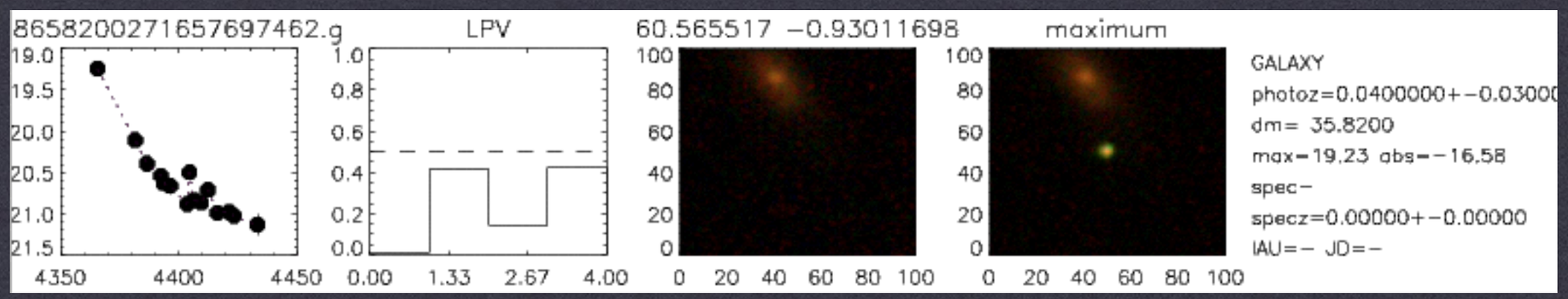
LIGHT CURVE

new supernovae in Stripe 82



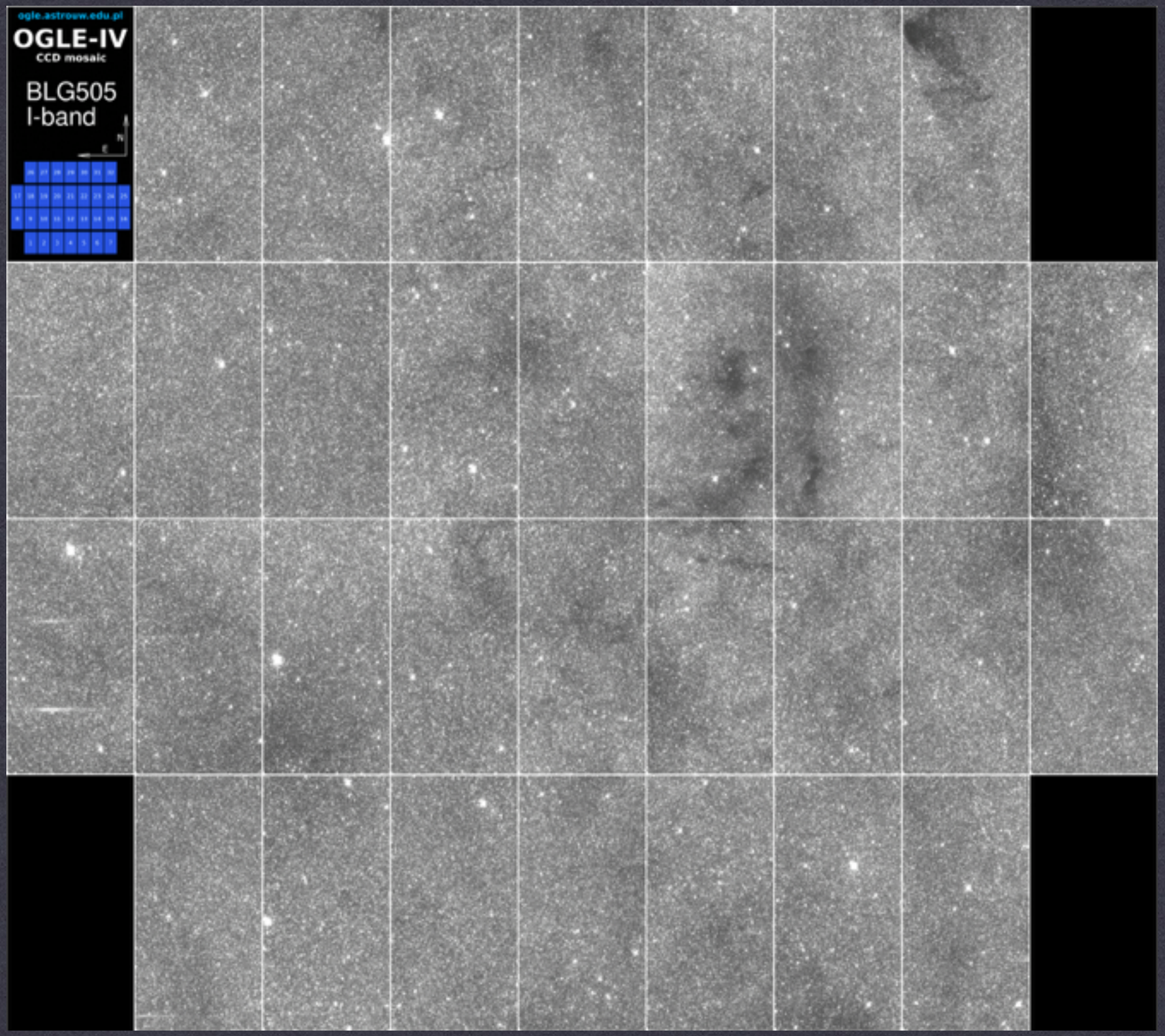






overlooked super-luminous supernova found: Z.Kostrzewa-Rutkowska+2013

LIGHT CURVE - MICROLENSING

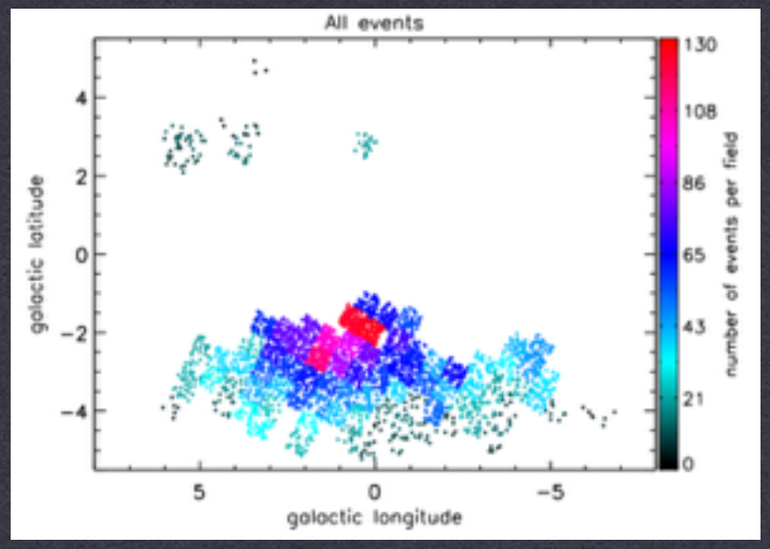


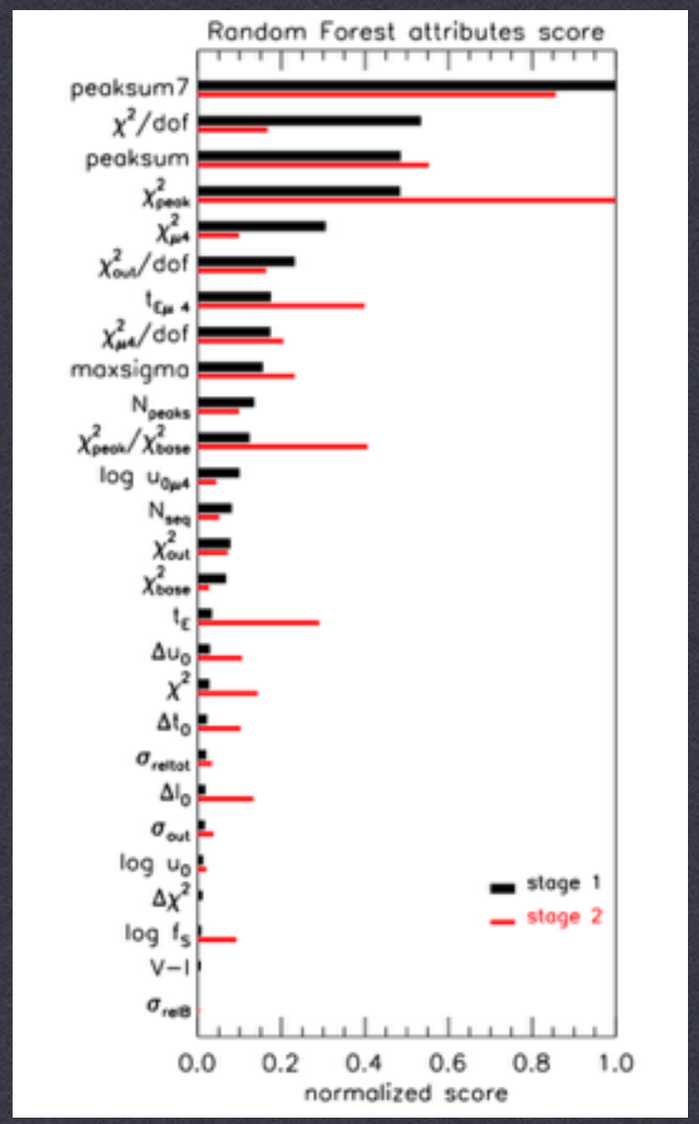
5 million objects per frame and ~1 star is brighter due to microlensing

LIGHT CURVE - MICROLENSING

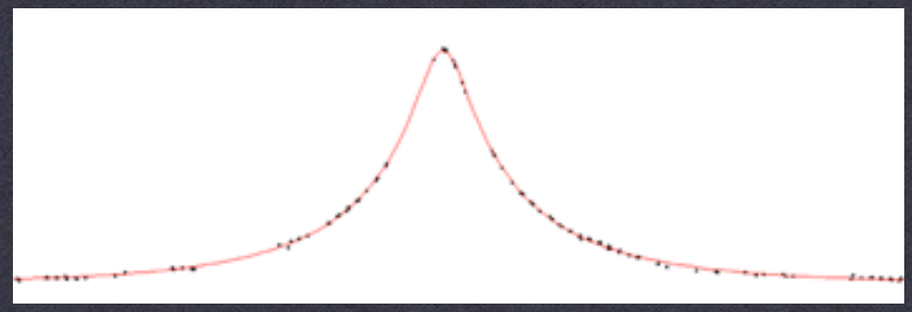
Supervised classification on 150 million light curves
Random Forest with 26 attributes

3500 standard events

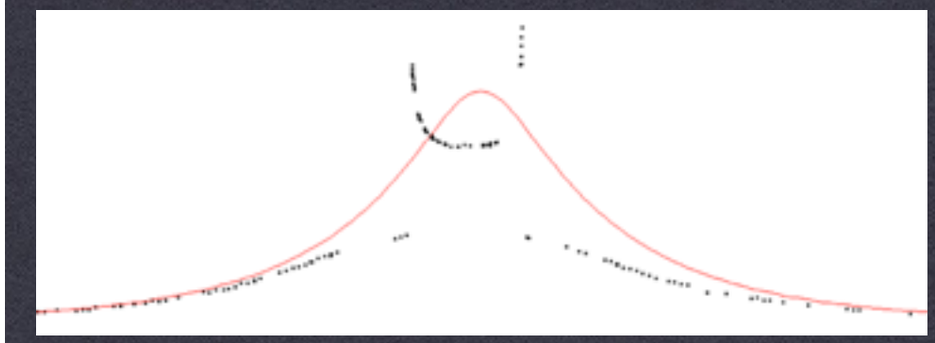




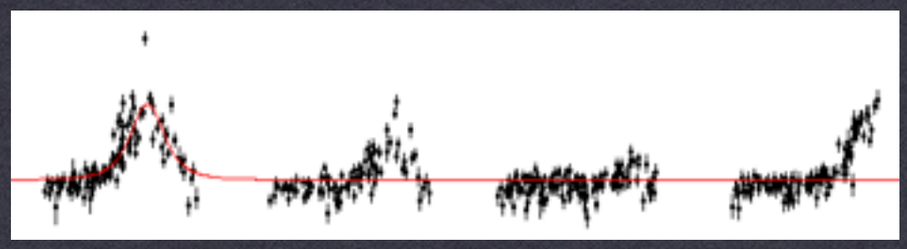
class ULENS



class EXOTIC



class OTHER



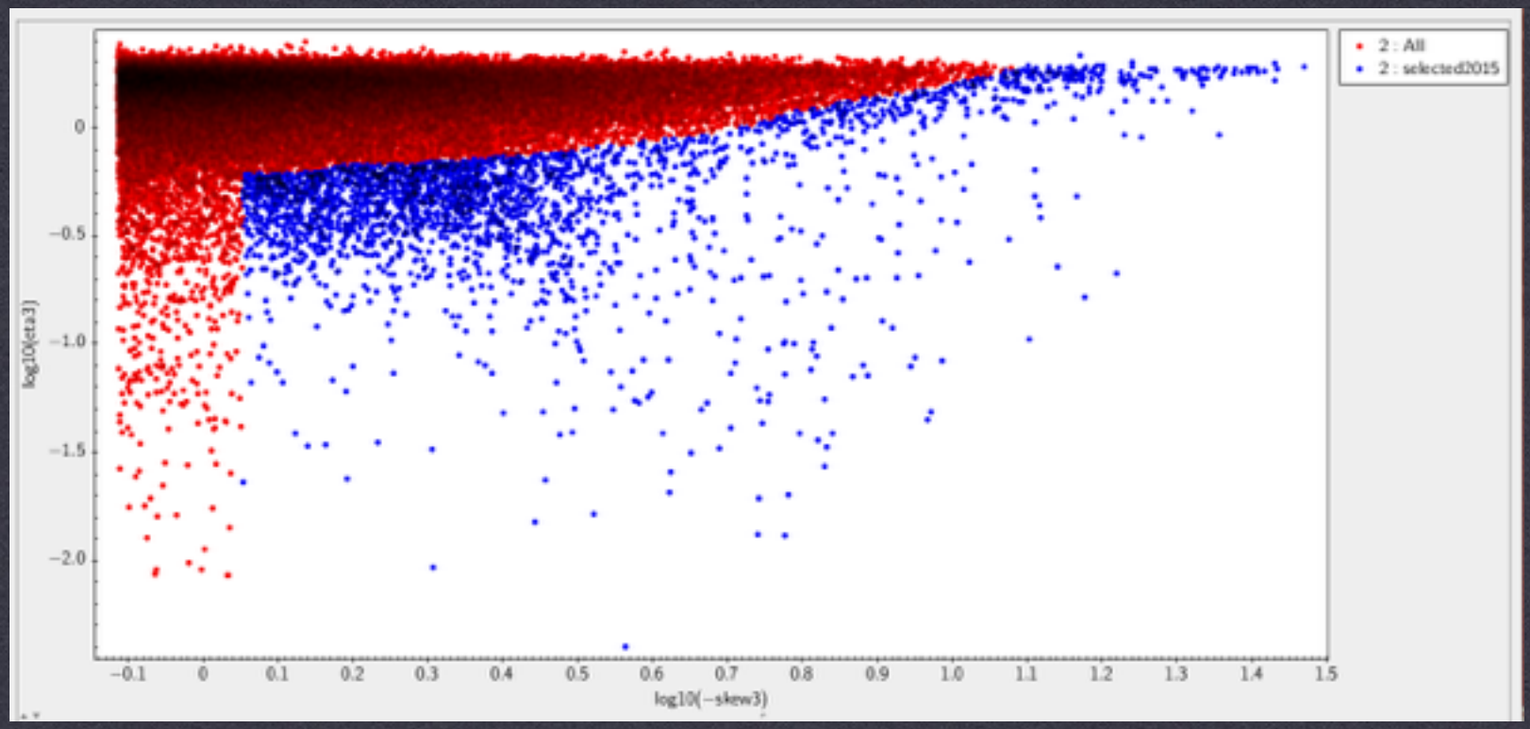
Wyrzykowski+2015

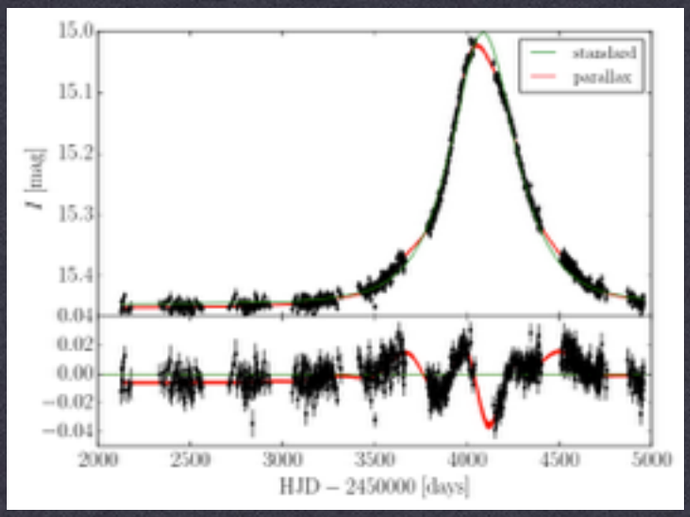
LIGHT CURVE - MICROLENSING

Hunt for black hole lenses - very long events

Pre-filtering for transients: **skewness-vonNeumann**

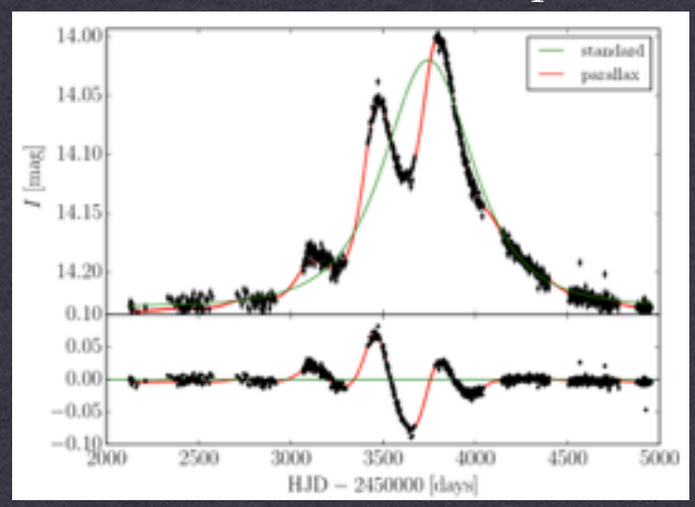
Random Forest to pick assymetric light curves





99.9% BH candidate

$M=6.9\ M_o$ $D=1.9$ kpc



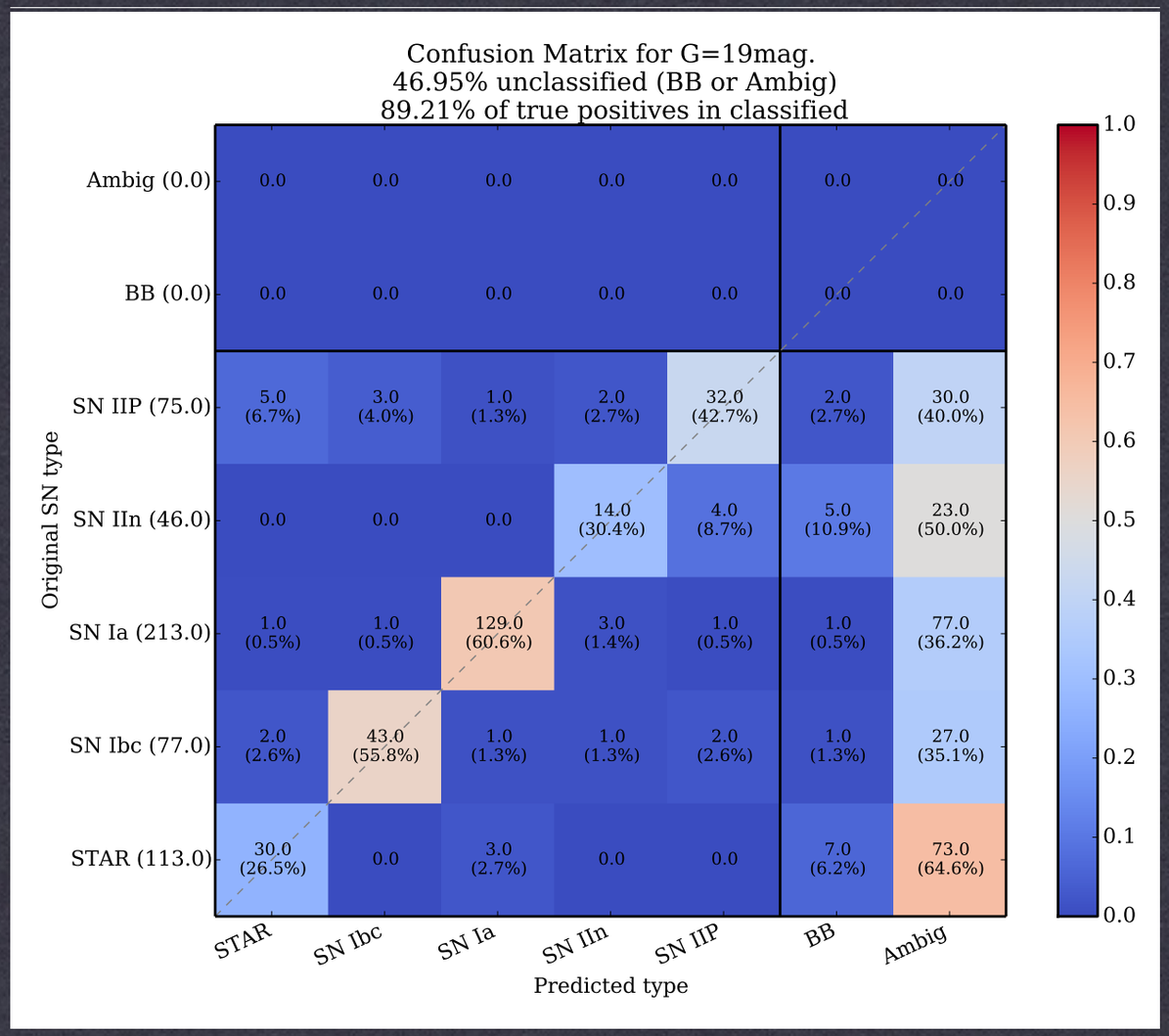
nearby WD/NS/MS candidate

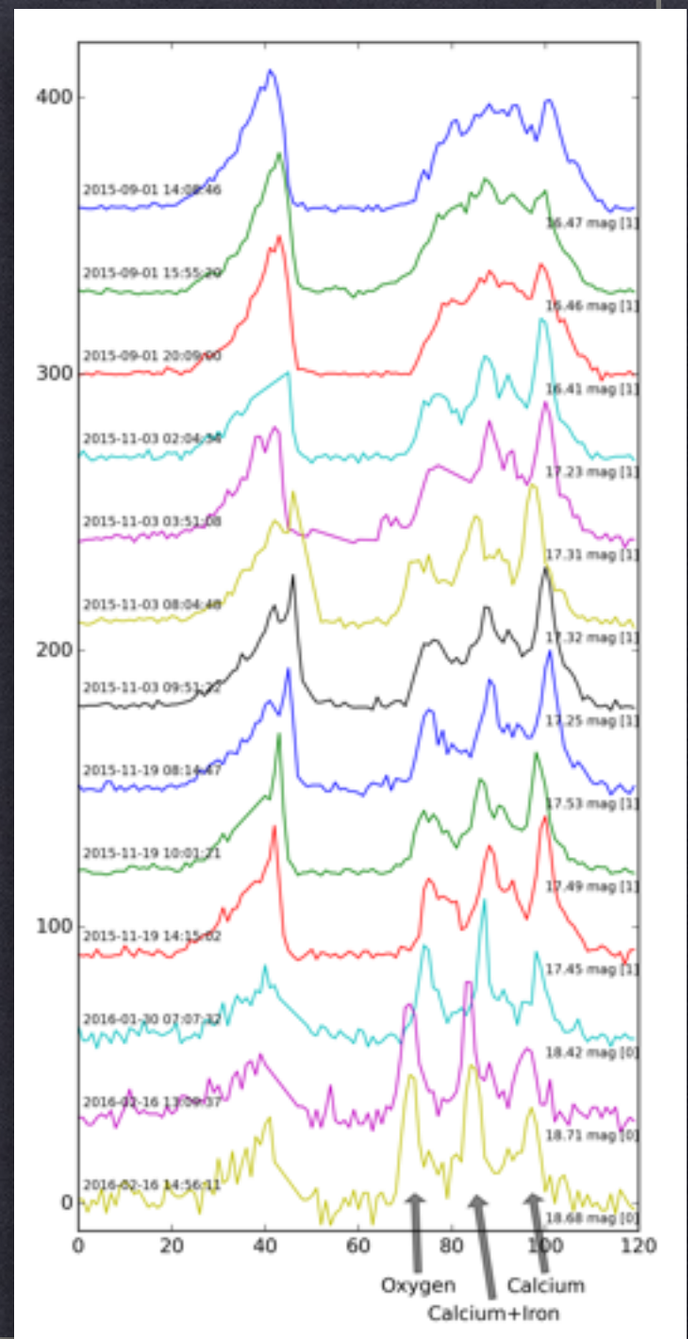
$M=\sim 1.3\ M_o$ $D=\sim 0.6$ kpc

Wyrzykowski+2016

SPECTRA (LOW RESOLUTION)

Gaia delivers low-res (R<100) spectra for ALL OBSERVATIONS
powerful to recognise SN Ia, SN II, CV, stars
training on thousands of known transients spectra in high-res





Blagorodnova+2014

also SED machine, Blagorodnova+2017 in prep.

SUMMARY

- to exploit science with transients we NEED Machine Learning NOW!

- individual solutions and ideas exist:
  - pixel level
  - context level (archives)
  - light curve level
  - spectra level

- is there a need for a clever, self-adjusting, unified and ultimate classification tool for generic application for transients?