G184098 / GW150914

Pipeline for Transient Identification

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Strategy Outline

- Two complementary approaches have been developed:
  - Transient identification by photometric analysis of sources identified in the fields (SRPGW)
  - Transient identification by image analysis (SUDARE)

- There are pros and cons for both techniques (useful redundancy).
  - Analysis by source extraction is typically more rapid and possibly less affected by image defect.
  - Analysis by image subtraction does not suffer from crowding and is more general.

Gravitown server
(OA-Roma)

CPU: 24 core @ 2.4 GH
RAM: 256 GB
16 + 4 TB disk (raid 0 + 1)

analysis tools

MariaDB

Reference catalogues
IGSL v3 (custom, 1.22 G_{obj})
GSC-2.3, TMASS, UCAC4, ...
Objects catalogues
Tools
query, X-match, export, ...

Images archive
Ref. catalogues
Extracted cats
Products

Website
(wordpress)
Public info
Images & Products
Blog
References

GraWITA
computational resources

Cloud
(owncloud)
Products
Previews
Biblio
Misce

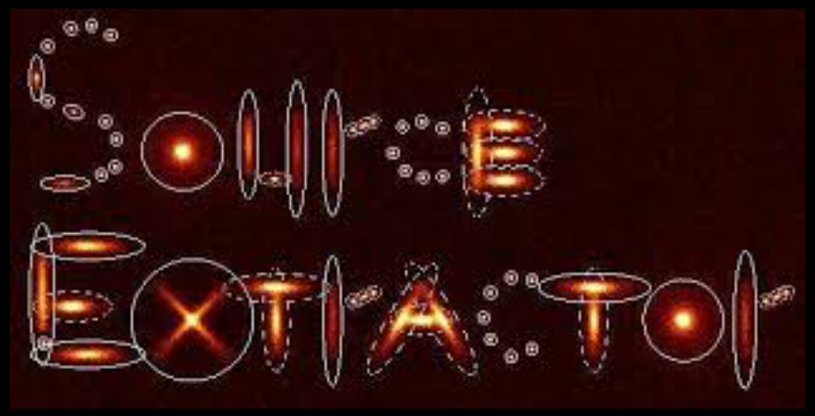
Google
Drive (proposals)
Group emails
Forms
Misce

+ other stuff

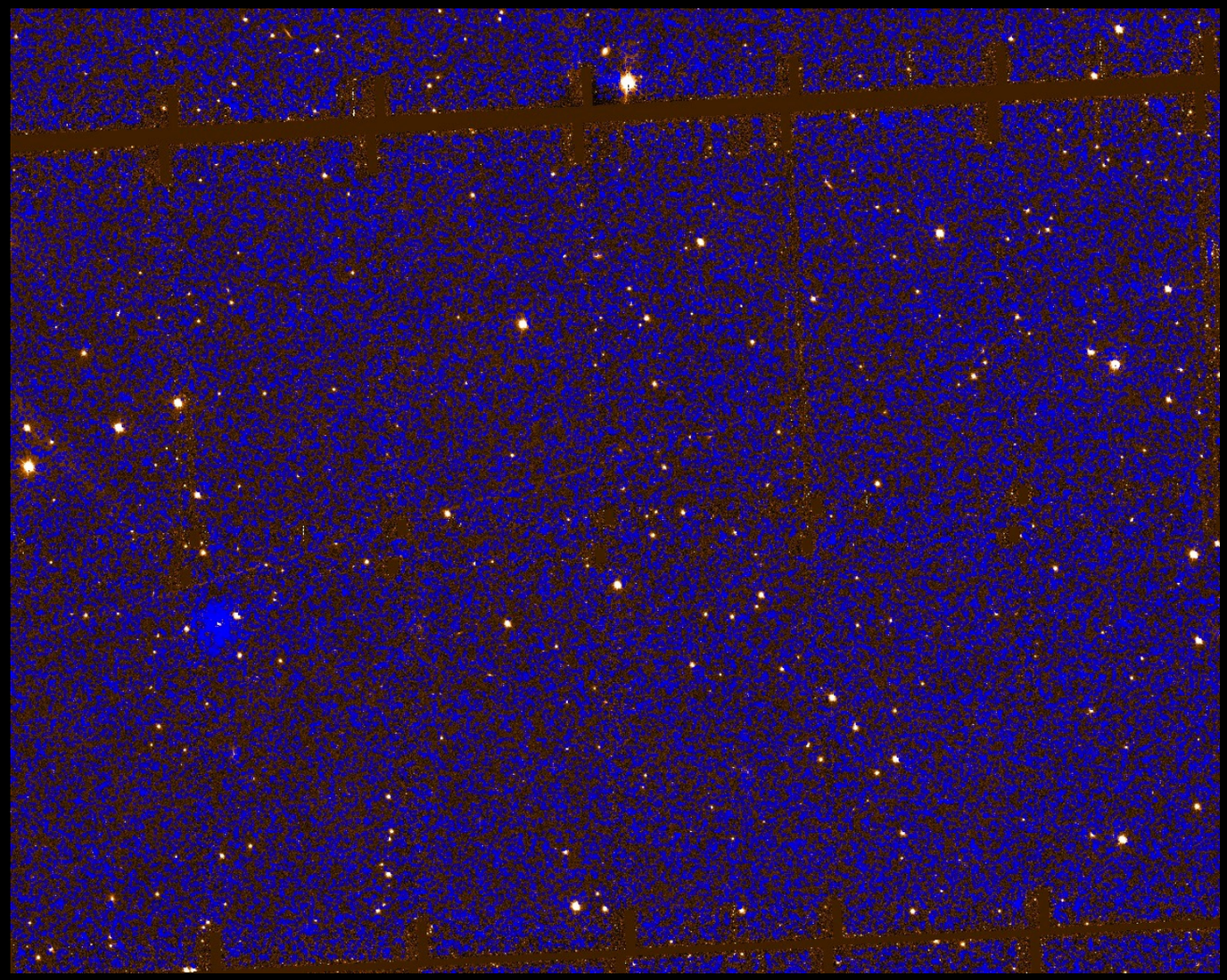
WG7

Strategy Outline

- Source extraction, source list cleaning by means of morphological parameters.
  - Here the SExtractor algorithm is used, mainly for its rapidity. More alternatives are possible.

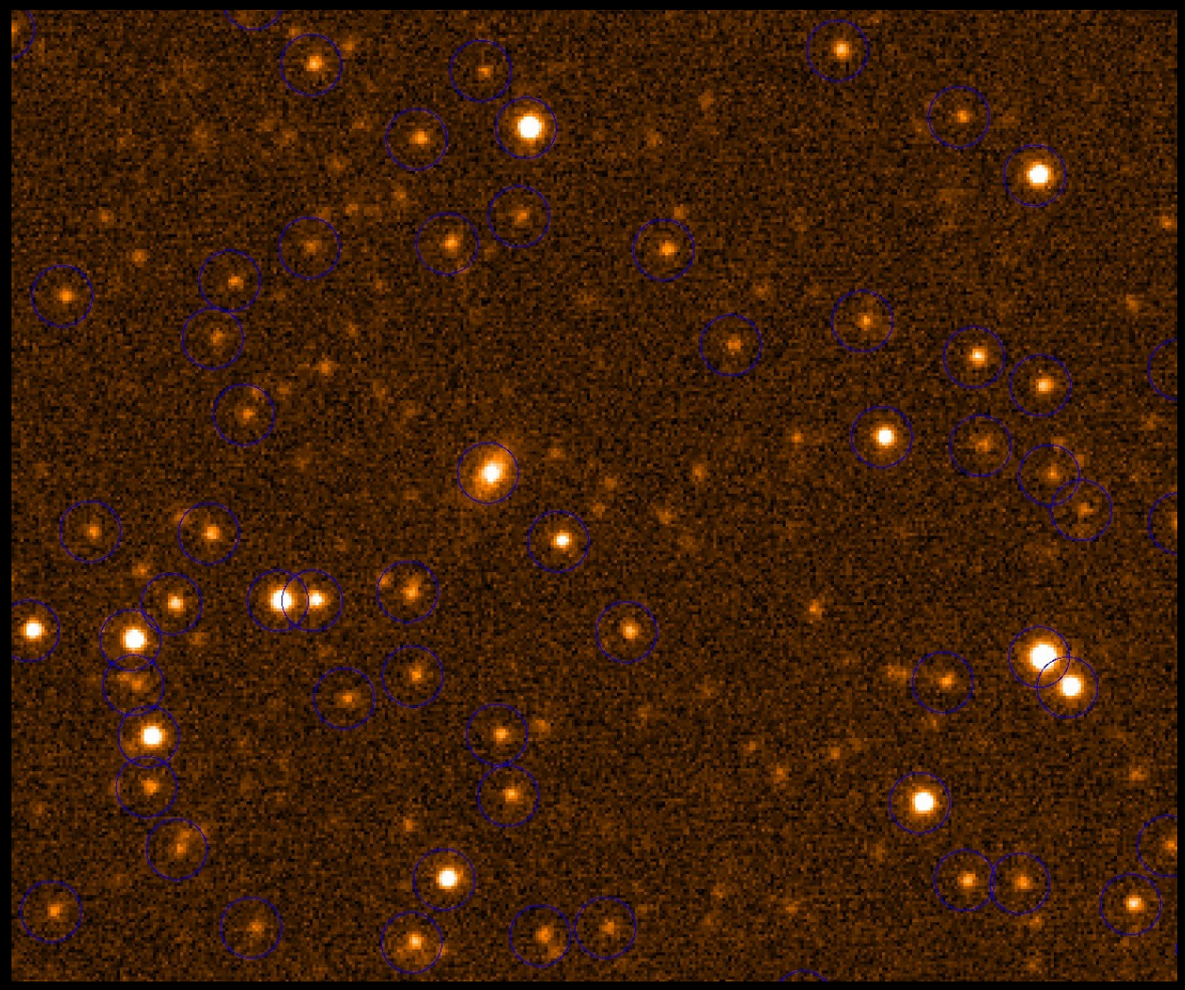


P50: ~150K sources cleaned by the exposure map



Strategy Outline

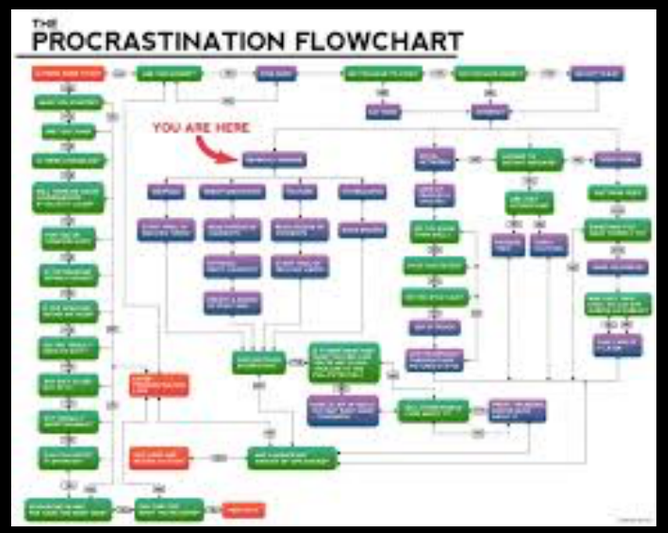
- Sources are ranked basing on weight map information, nearby bright objects, etc.
    - The idea here is to select a subset of sources to derive global statistics.



- Database feeding for epochs, seeing, etc.
- Aperture photometry and magnitude normalization.
    - Here the popular DAOPHOT algorithm is used. It is not the most rapid, but it is definitely the most reliable.

Strategy Outline

- Cross-match with the Initial GAIA catalogue and the SIMBAD database.
    - Just sources NOT present in the IGAIA catalogue are saved, unless they are listed in SIMBAD.



- Selection of variable sources at a given magnitude dependent threshold.
    - This is a sort of adaptive selection. Magnitude differences for each pair of the available epochs is computed [N*(N-1)], objects are binned (~1000 objects/bin), and basic sigma-clipped statistics are derived. Then objects more variable than the chosen limit are selected.

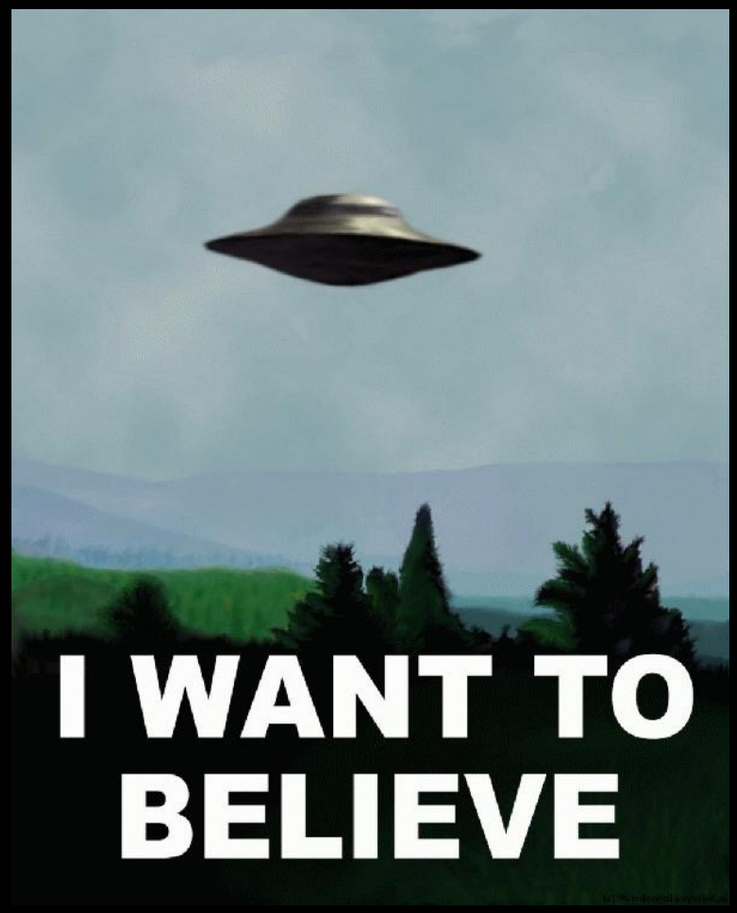
Strategy Outline

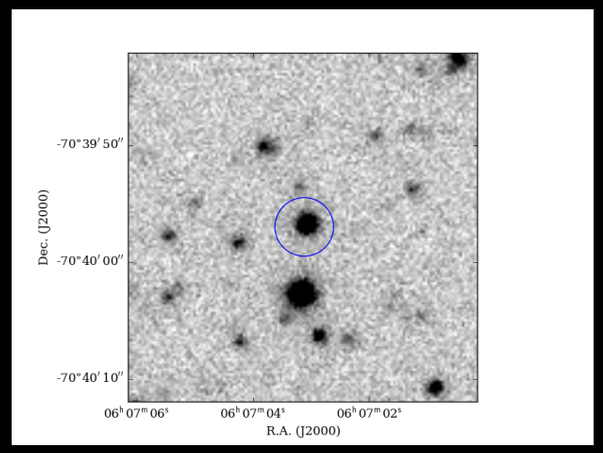
- Cross-match of the remaining list with minor planet catalogues.
  - Minor problem for G184098, quite an important issue for low Ecliptic latitude fields.

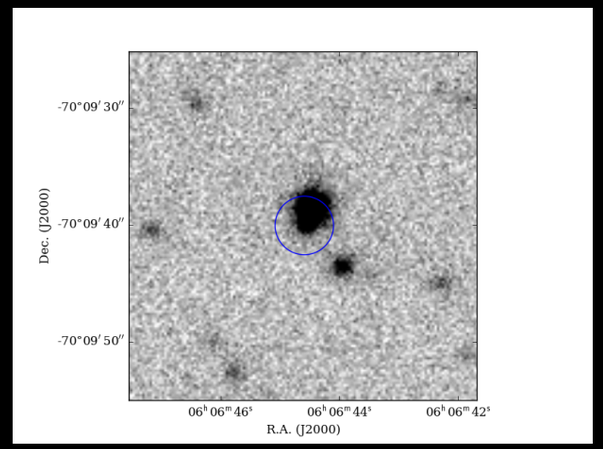
- PSF photometry, stamp generation, score evaluation.
  - PSF photometry again computed applying the DAOPHOT algorithm only to the interested object, i.e. no mass PSF fitting.
  - The score is a function returning an evaluation of the interest of the selected candidate basing upon e.g. variability intensity, brightness, presence or not of bright close companions, etc.

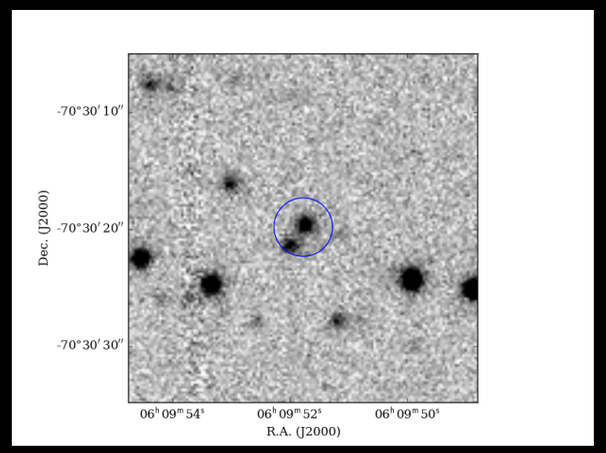
Strategy Outline

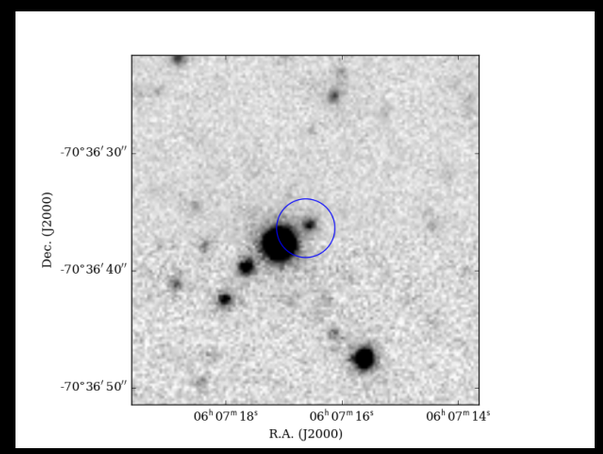
- V i s u a l selection!











- Full PSF photometry of the few selected “interesting” candidates.
  - This time ROMAFOT is used!

Table 5.1: ROMAFOT commands

Command	Description
ADAPT/ROMAFOT	Adapt trial values to a new image frame
ADDSTAR/ROMAFOT	Add pre-selected subarrays to the original image frame
ANALYSE/ROMAFOT	Select objects or analyses the results of the fit procedure
CHECK/ROMAFOT	Estimate number and accuracy of artificial objects recovered
CBASE/ROMAFOT	Create the base-line for transformation of frame coordinates
CTRANS/ROMAFOT	Execute transformation of coordinates on intermediate table
DIAPHRAGM/ROMAFOT	Perform aperture photometry
EXAMINE/ROMAFOT	Examine quality of the fitted objects; flags them if needed
FCLEAN/ROMAFOT	Select subarrays containing artificial objects
FIND/ROMAFOT	Select objects from ROMAFOT frame using the image display
FIT/ROMAFOT	Determine characteristics of objects by non-linear fitting
GROUP/ROMAFOT	Perform an automatic grouping of objects
MFIT/ROMAFOT	Fit the PSF using the integral of the PSF (for undersampled data)
MODEL/ROMAFOT	Determine subpixel values to be used for the integral of the PSF
REGISTER/ROMAFOT	Compute absolute parameters and stores results in final table
RESIDUAL/ROMAFOT	Compute difference between original and reconstructed image
SEARCH/ROMAFOT	Perform actual search of object above certain threshold
SELECT/ROMAFOT	Select objects or stores parameters in intermediate table
SKY/ROMAFOT	Determine intensity histogram and background in selected areas

Search by template subtraction

GW.py flowchart

INPUT:
reduce images

from VSTtube

prepare input

create mask for bad pixels and saturated star

image difference

PSF match: **hotpants** (ISIS)
and image difference

candidate search

search image and rank sources
(positive/negative search)

catalog merging

create merged catalog of sources detected in different epochs and pointings

visual inspection

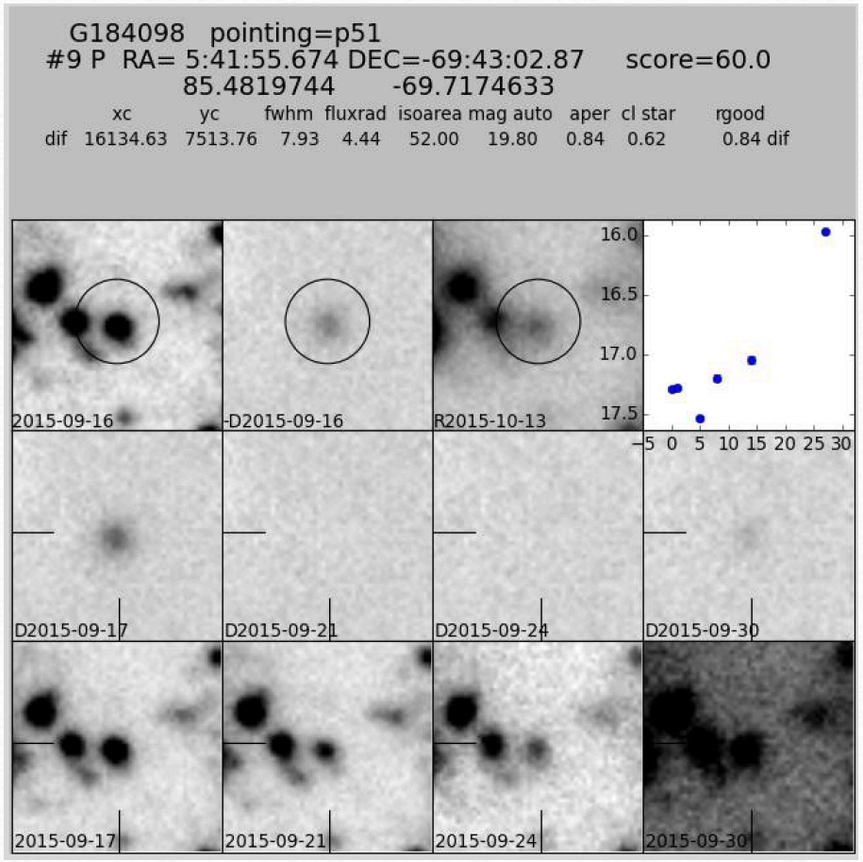
display and record stamps for selected object

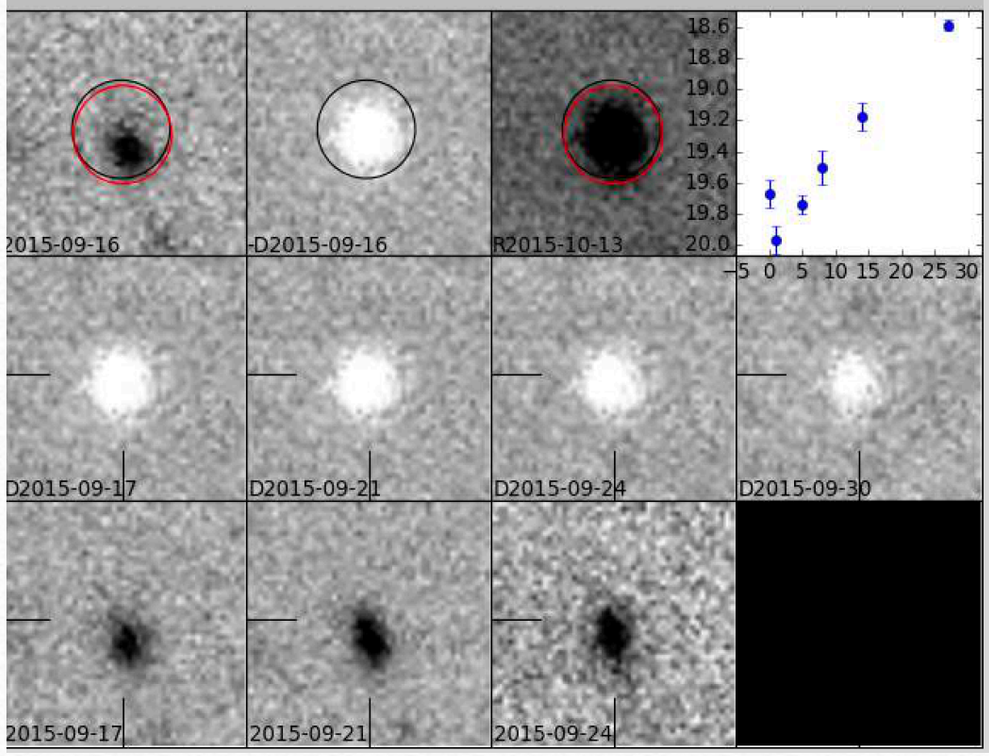
Unsupervised candidate selection

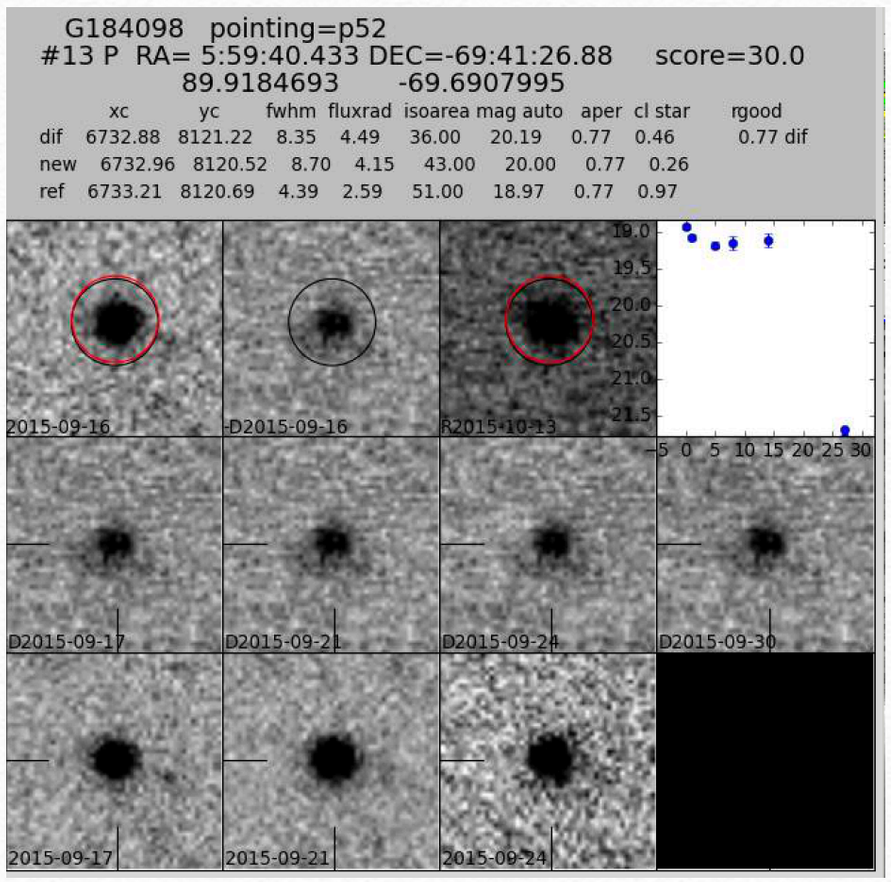
GOAL: reduce the number of candidate visual inspection by 2 order of mag (1000 ->10)

Using a simple ranking approach
Calibrated by artificial star experiments

[rank] ---------- version 0.1
CONDITIONS:
low isoarea ISOAREA_IMAGE_1<2*fwhm, -30
low isoarea ISOAREA_IMAGE_1<4*fwhm -30
FWHM too high FWHM_IMAGE_1/fwhm>1.5 -30
FWHM too high FWHM_IMAGE_1/fwhm>2.0 -30
low FLUXRADIUS FLUX_RADIUS_1/(fwhm/1.6)<0.65 -60
high FLUXRADIUS FLUX_RADIUS_1/(fwhm/1.6)>1.3 -60
low classstar CLASS_STAR_1<0.4 -30
low class star CLASS_STAR_1<0.03 -30
near faint galaxy (CLASS_STAR<0.3)&(MAG_AUTO>18) +30
near bright stars (CLASS_STAR>0.37&(MAG_AUTO>16) -30
good pixels (positive/negative<0.80) -30
good pixels (positive/negative<0.60) -30





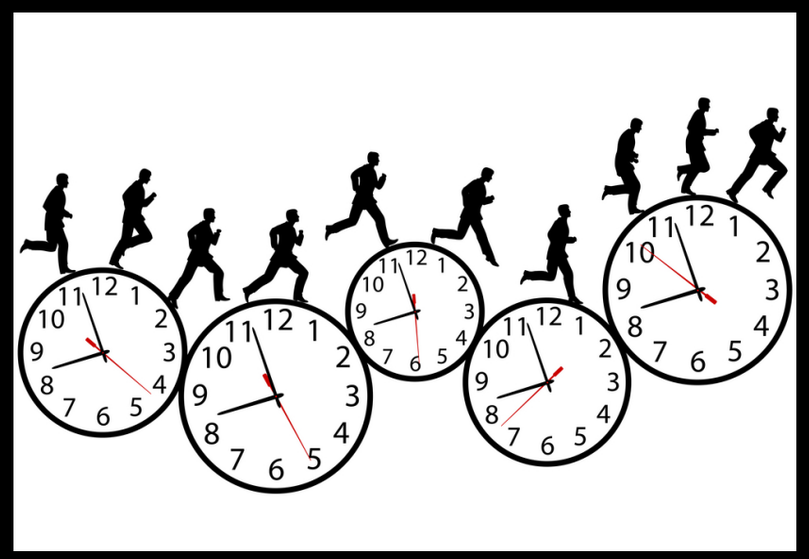


A few examples...

Some figures…

- Typically, in a VST frame we have from ~10k to 500k sources.
  - Magellanic Cloud fields of course are the most demanding for this kind of analysis.

- Running time depends on the input list size and the number of epochs. Typically from ~a few minutes to several hours/pointing for the source extraction technique. About 1.5 hour/ pointing for the image subtraction, roughly independently of the crowding.



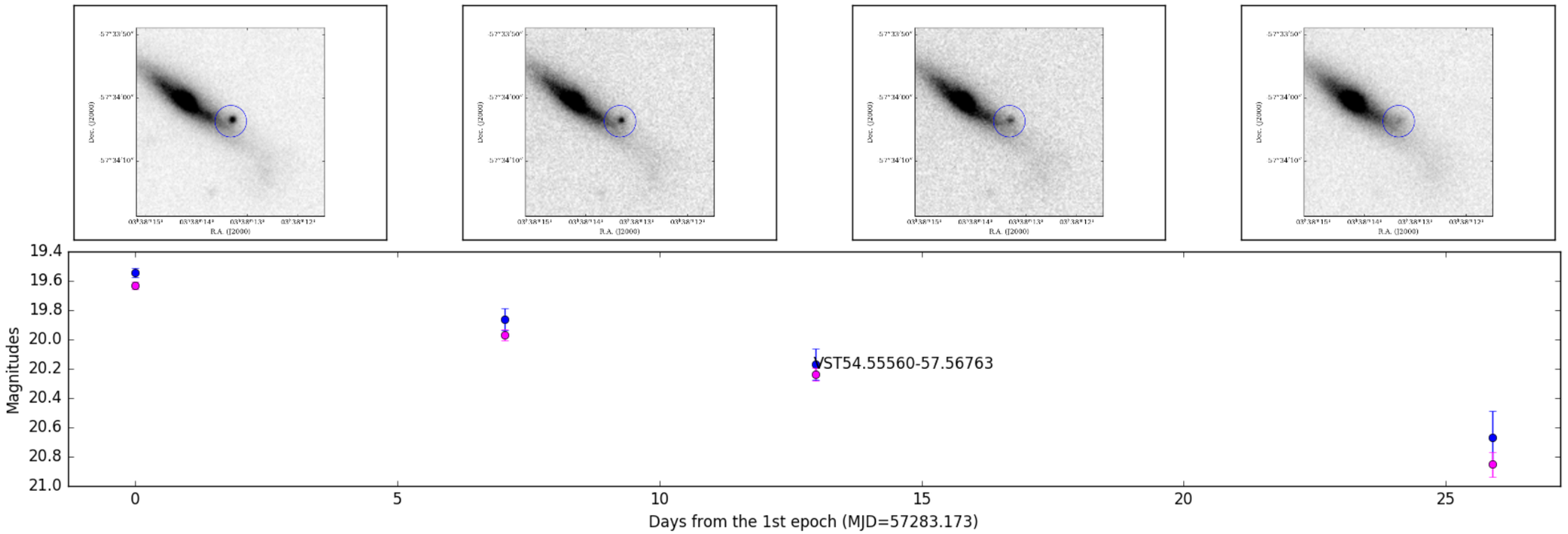
Some figures…

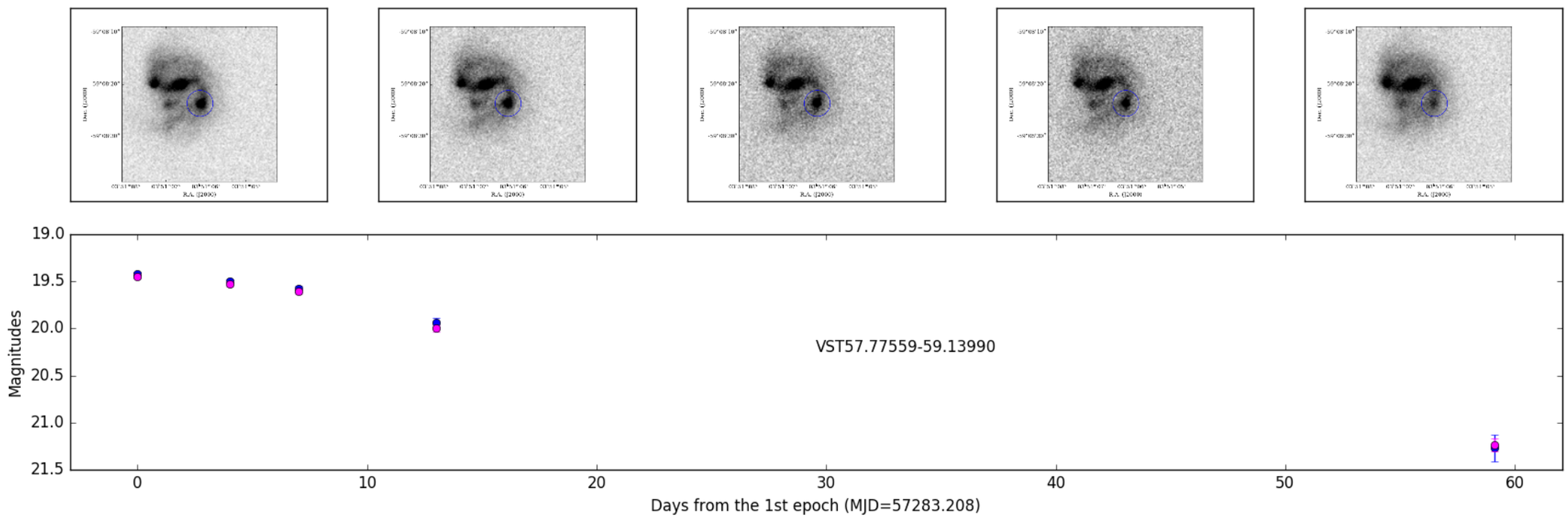
- With both pipelines we end up with ~100 objects of interest, and from them ~10 would be target of a specific follow-up.

- A large fraction of the candidates (of course) are in common. However, weaknesses and strengths of the two techniques tend to compensate.

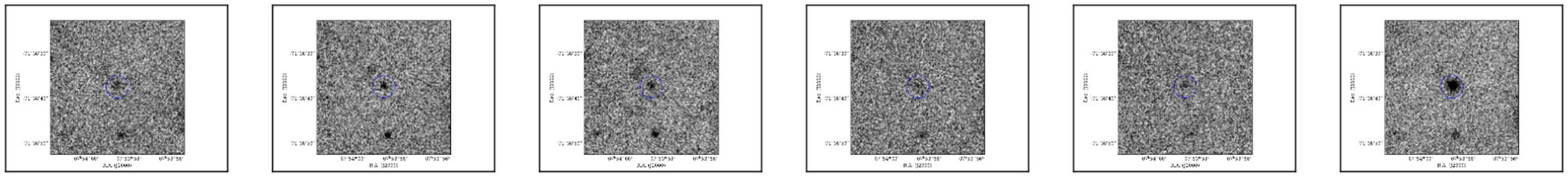
- Redundant approach is useful, if not mandatory.

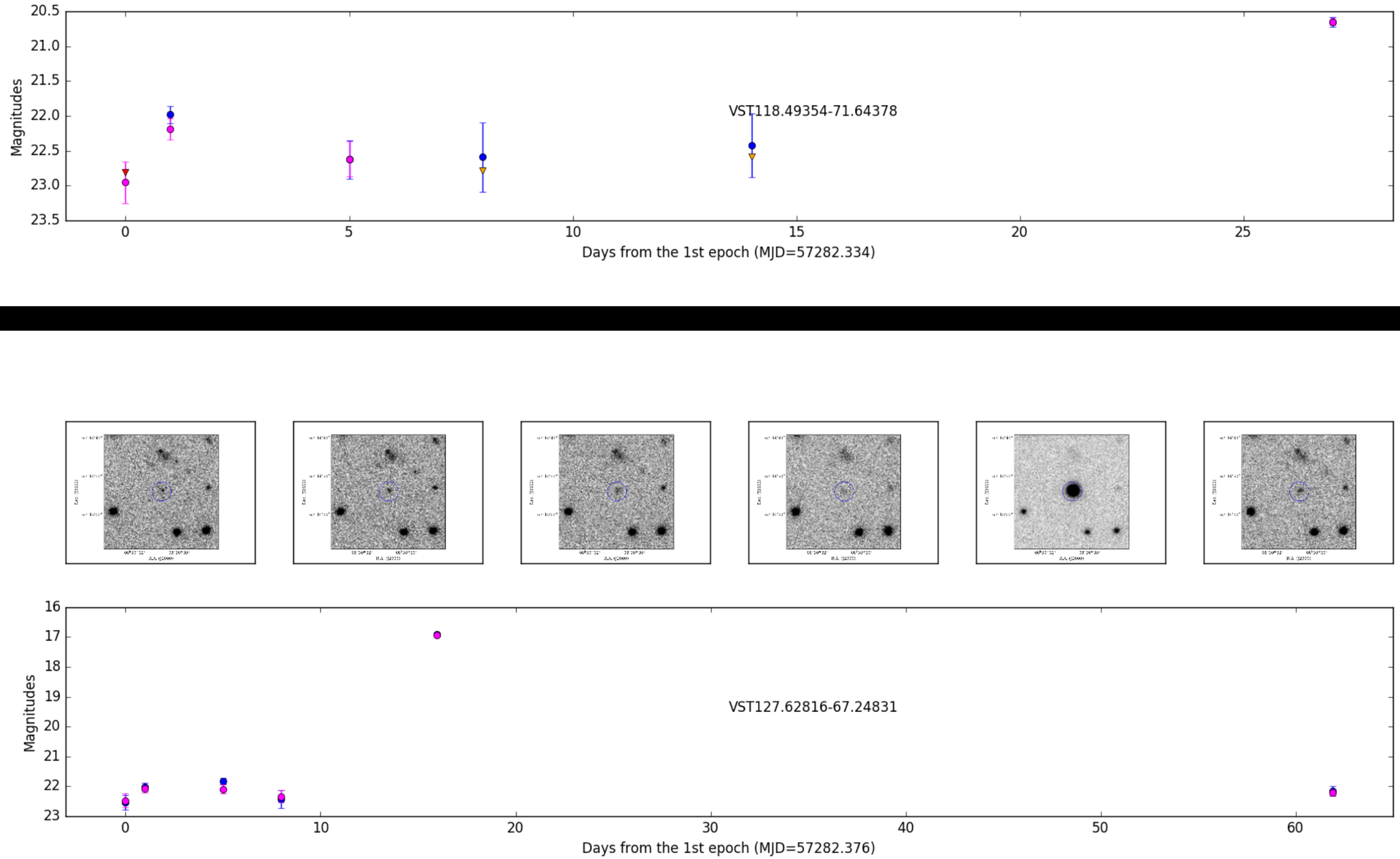
SNae?


Magnitudes
Days from the 1st epoch (MJD=57283.173)
VST54.55560-57.56763


Magnitudes
Days from the 1st epoch (MJD=57283.208)
VST57.77559-59.13990

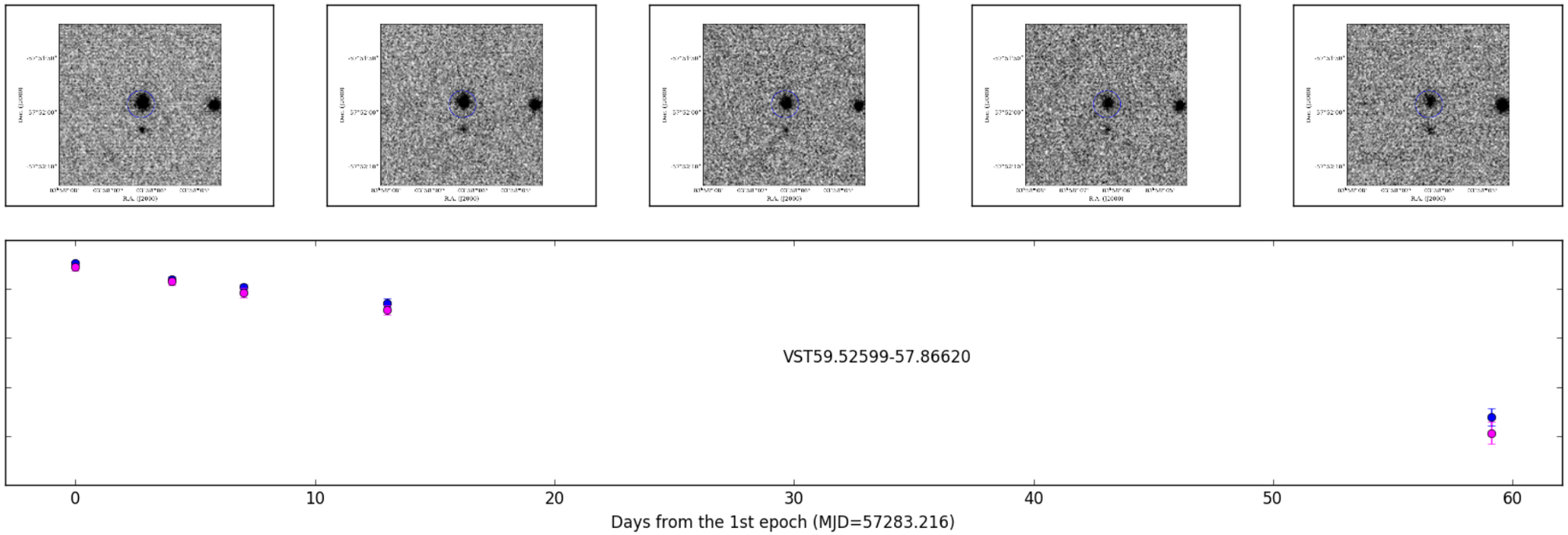
Novae?

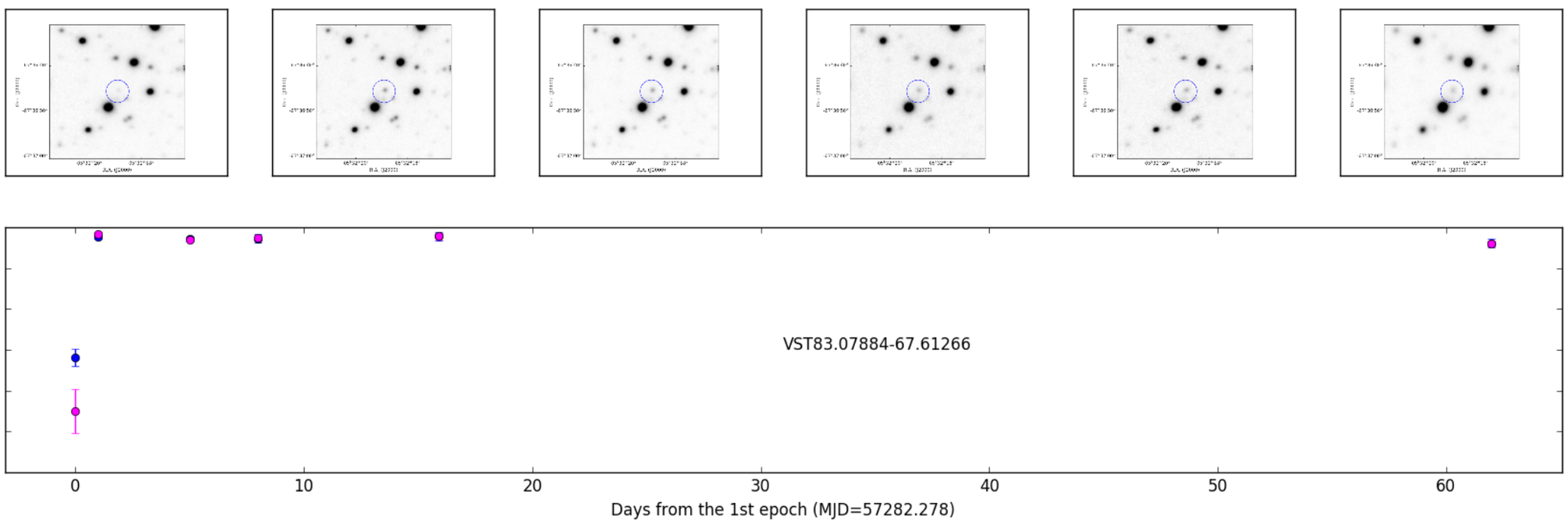



VST118.49354-71.64378
Magnitudes
Days from the 1st epoch (MJD=57282.334)

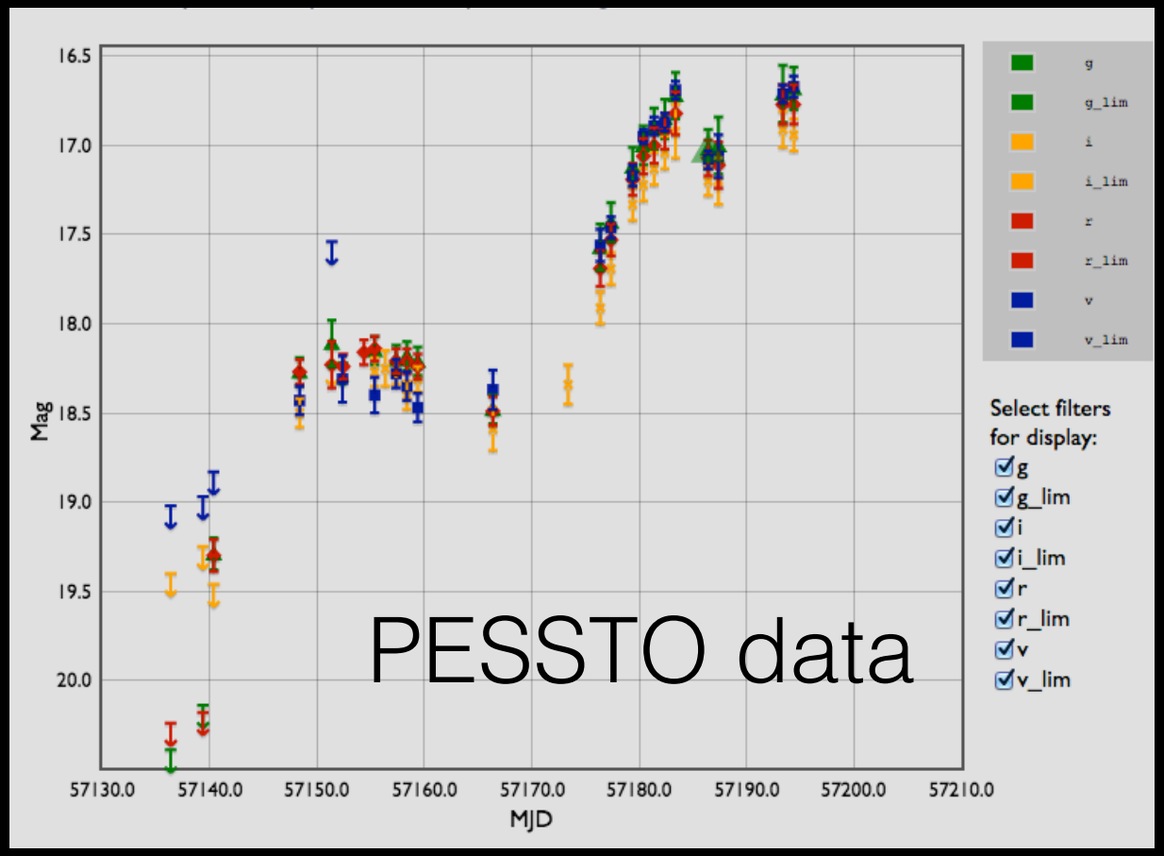
VST127.62816-67.24831
Magnitudes
Days from the 1st epoch (MJD=57282.376)

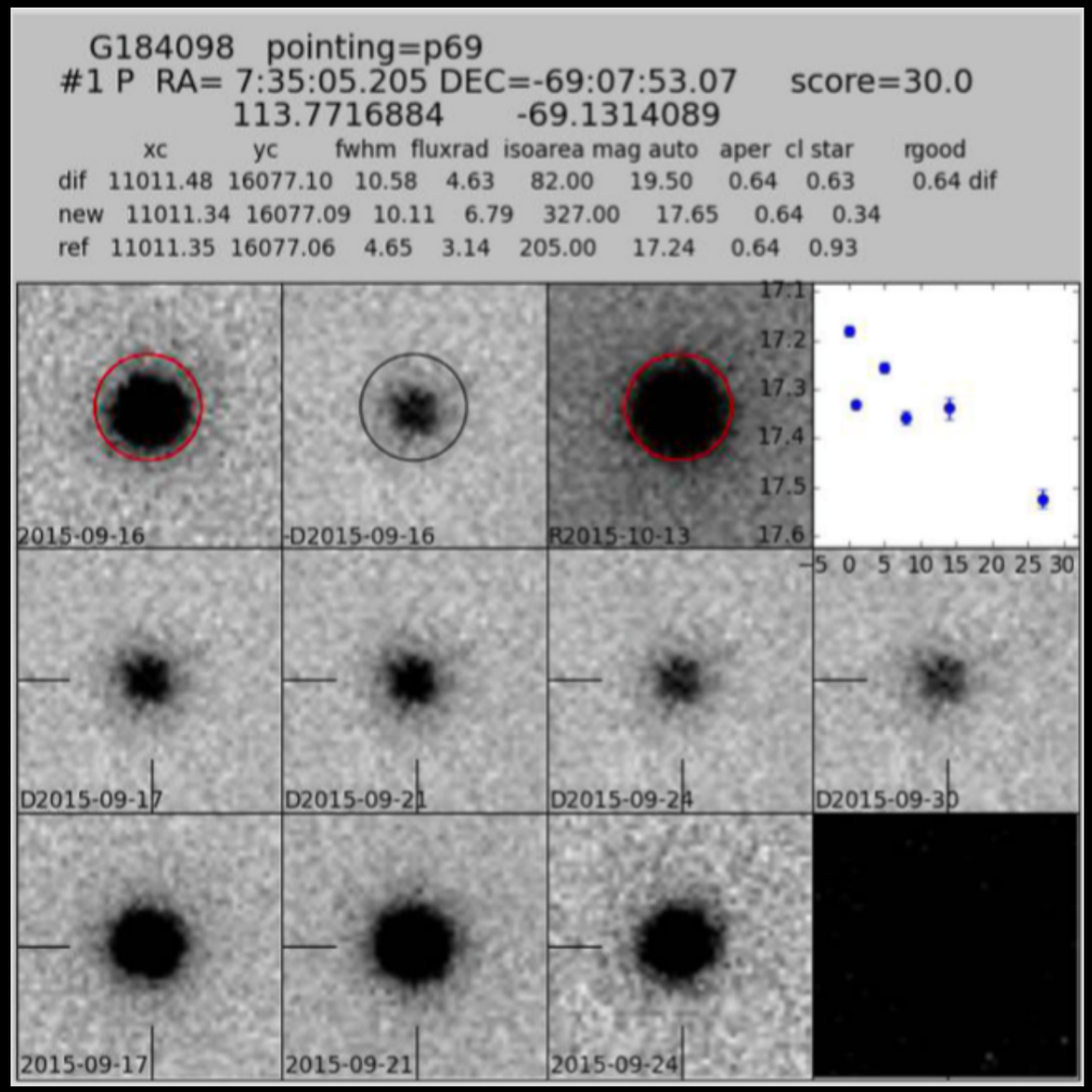
Decaying or brightening sources...

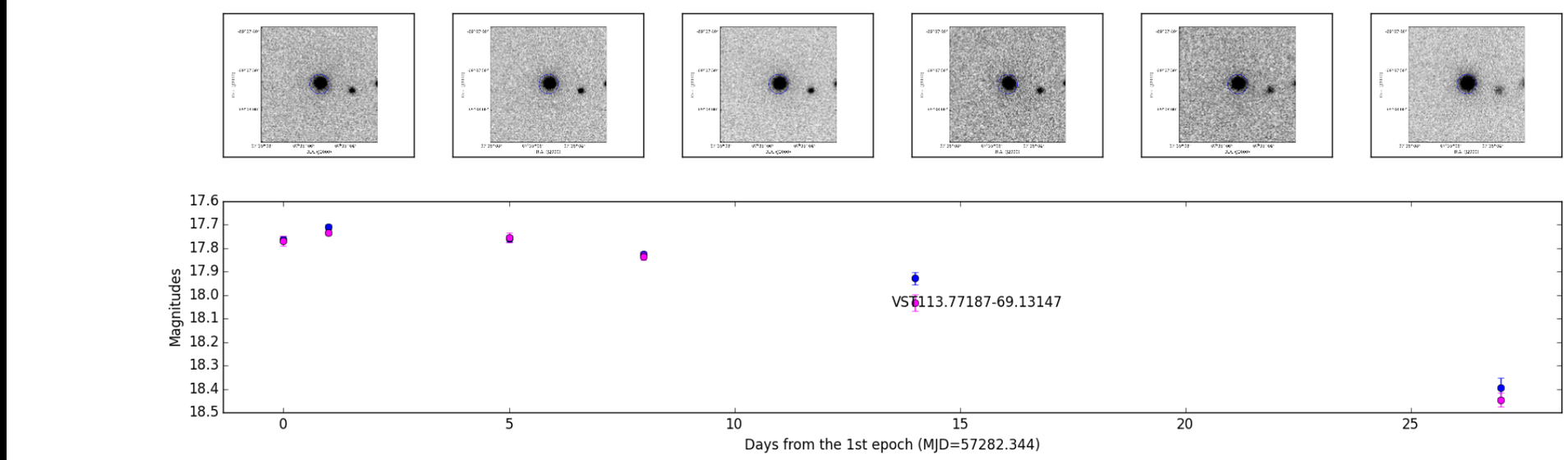




An independent re-discovery
SN 2015J (type IIn)







WARNING

Do not mention *Star Trek* or any *Star Trek*-related subject matter around this individual. Doing so may result in lengthy, mind-numbing conversations involving the history, origins and details of the Starship *Enterprise*, *Star Trek* episodes and movies, *Star Trek* characters, technology, themes, and philosophies.
Thank you for your cooperation.