ALeRCE
Automatic Learning for the
Rapid Classification of Events

Real-time automatic host galaxy association

or

Fixing the LSST image stamps

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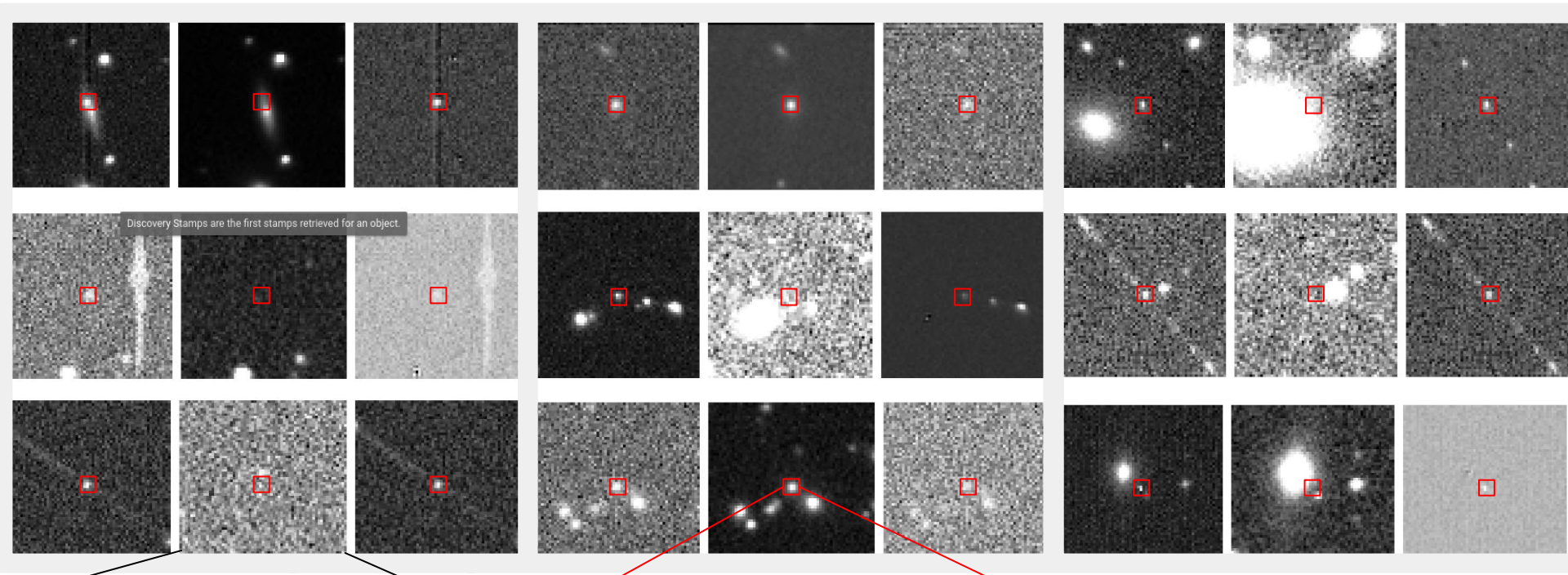
Would you trigger 8 m class follow-up on these ZTF candidates?



Automatic host association

Reliable **real-time alert classification** would benefit from **real-time host galaxy identification**.

Two main ways to identify host galaxies:

1. from a **catalogue** of galaxies around the position of an object (e.g. smallest normalized distance)

2. Identifying the host galaxy directly from the **images**, e.g., visual selection or convolutional neural network (CNN)

ALeRCE's sample of host galaxies

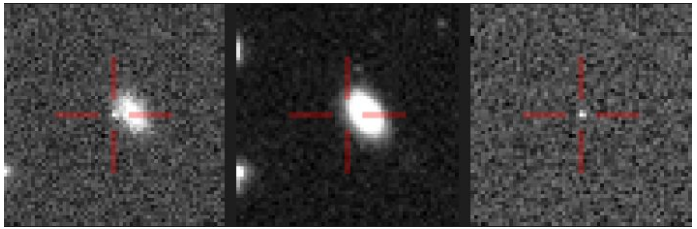
Alert ingestion: ingestion of the ZTF stream.

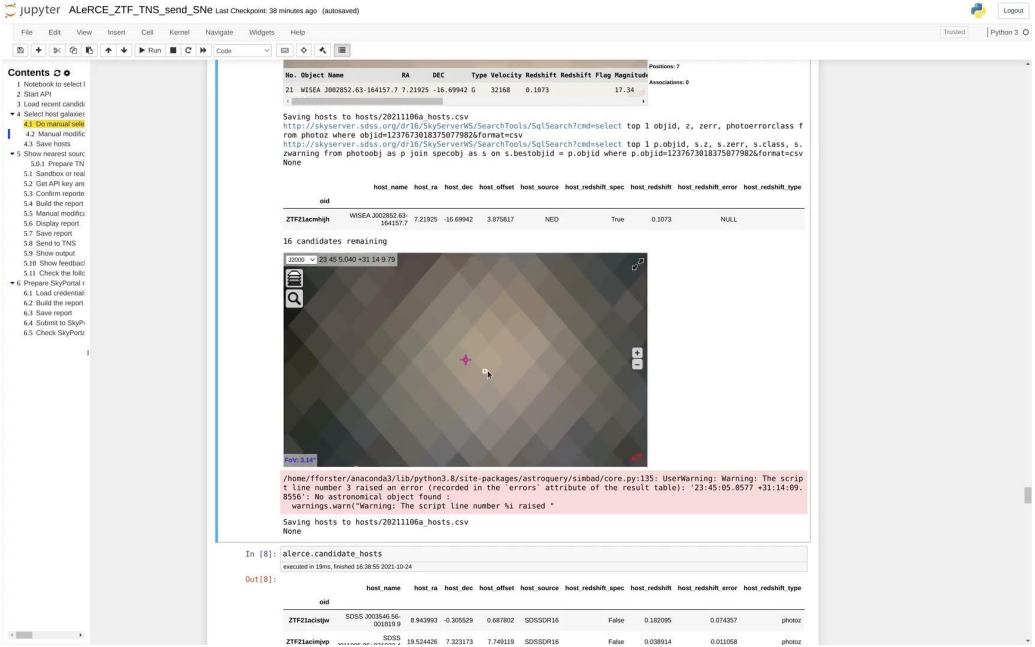
CNN classification: new objects are classified using their image stamps (SN, AGN, asteroid, variable star, or bogus.

Visual inspection: every new SN candidate is visually inspected and vetoed if necessary.

Galaxy selection: host galaxy of good SN candidates are visually selected.

More than 13 k host galaxies selected so far!





https://github.com/alercebroker/TNS_upload

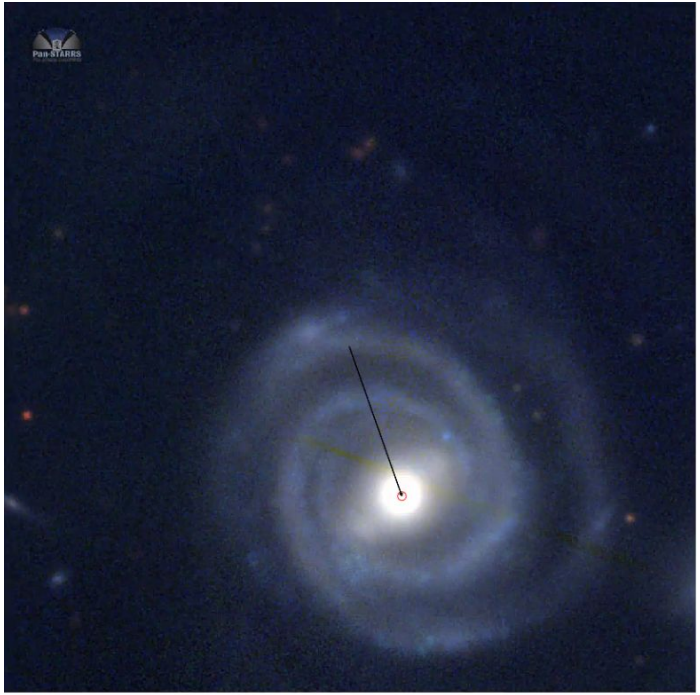
Automatic image detection

Can we **mimic human labelers**?

Training as **regression**: given an image predict a vector with the position of the host.

A **large input field of view** would be needed to account for large nearby galaxies.

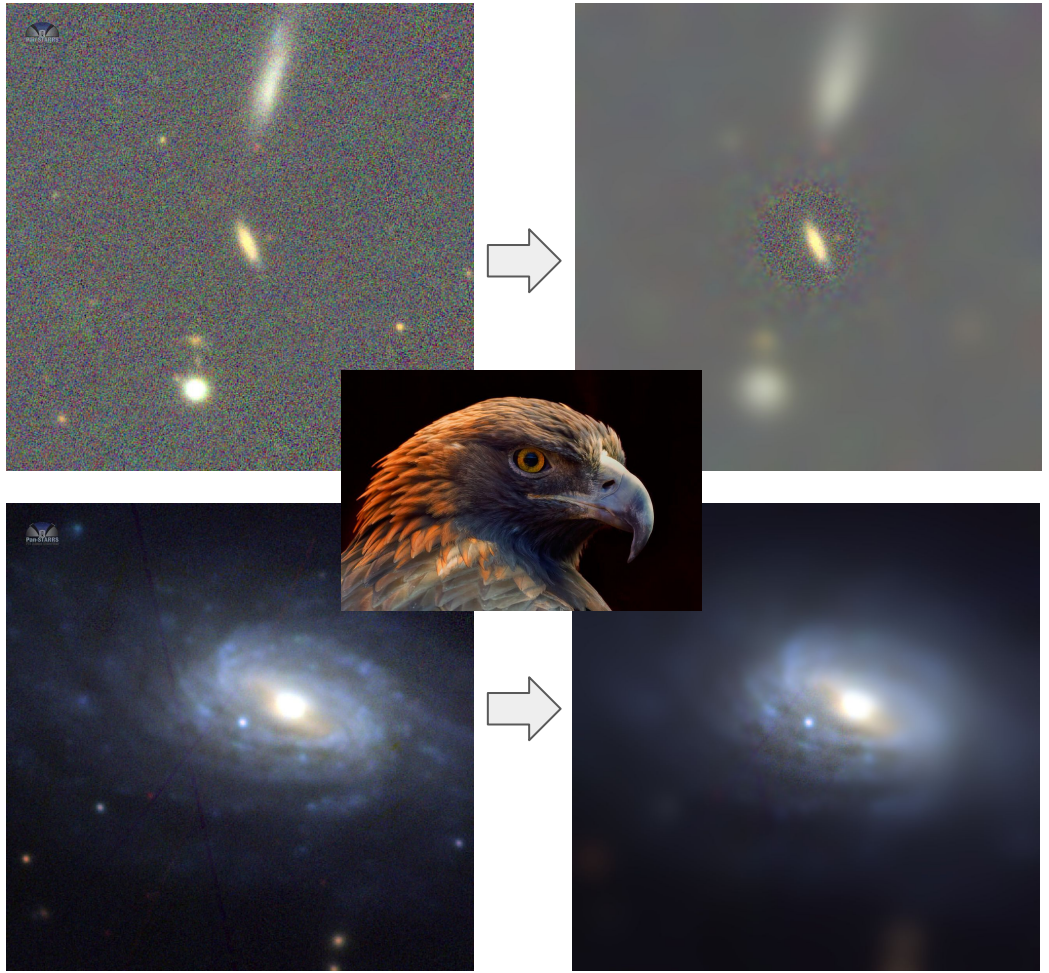
*We can solve the regression problem using **multi resolution images** centered at the alert position.*



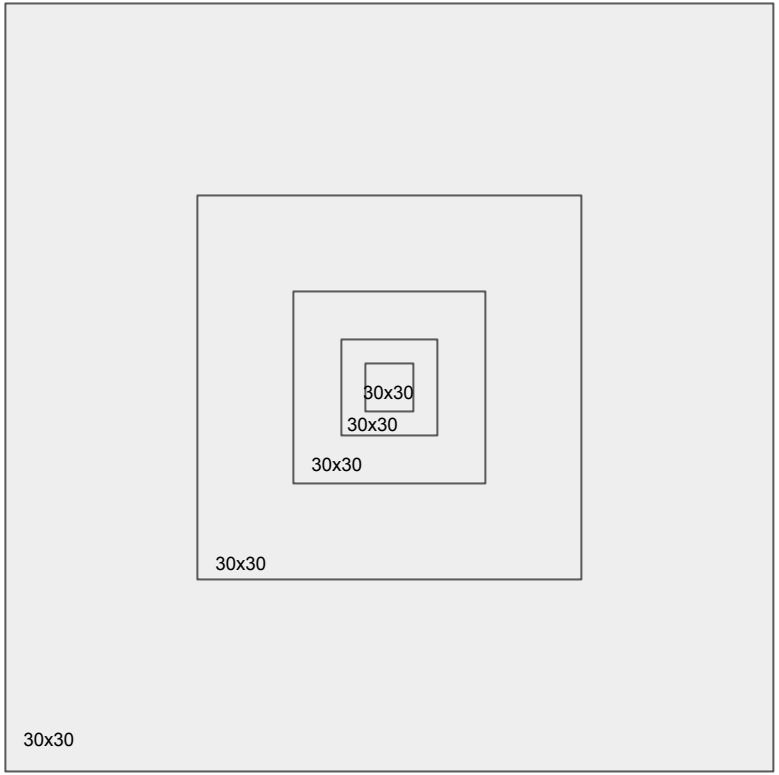
Multi resolution images

We want input images that satisfy the following requirements:

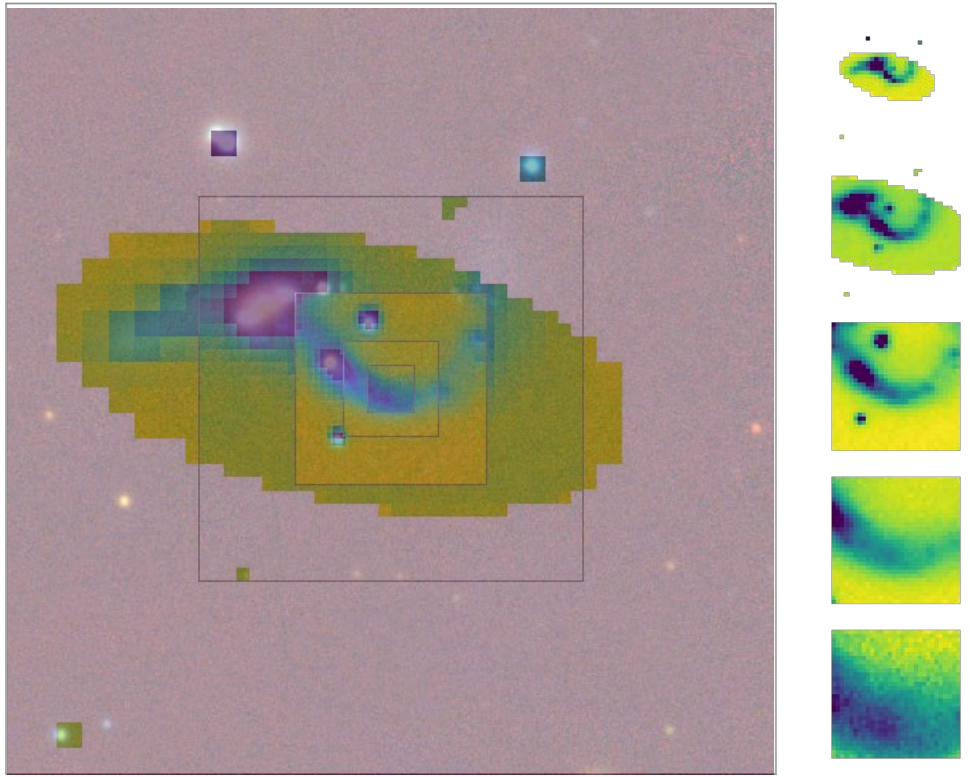
1. Span a **large area** to identify large nearby host galaxies.
2. Have **good central resolution** to identify small host galaxies.
3. Are **lightweight** to be acquired and streamed rapidly.



Multi resolution images (starting from 120”x120”=480x480=2,304,000 pixels)



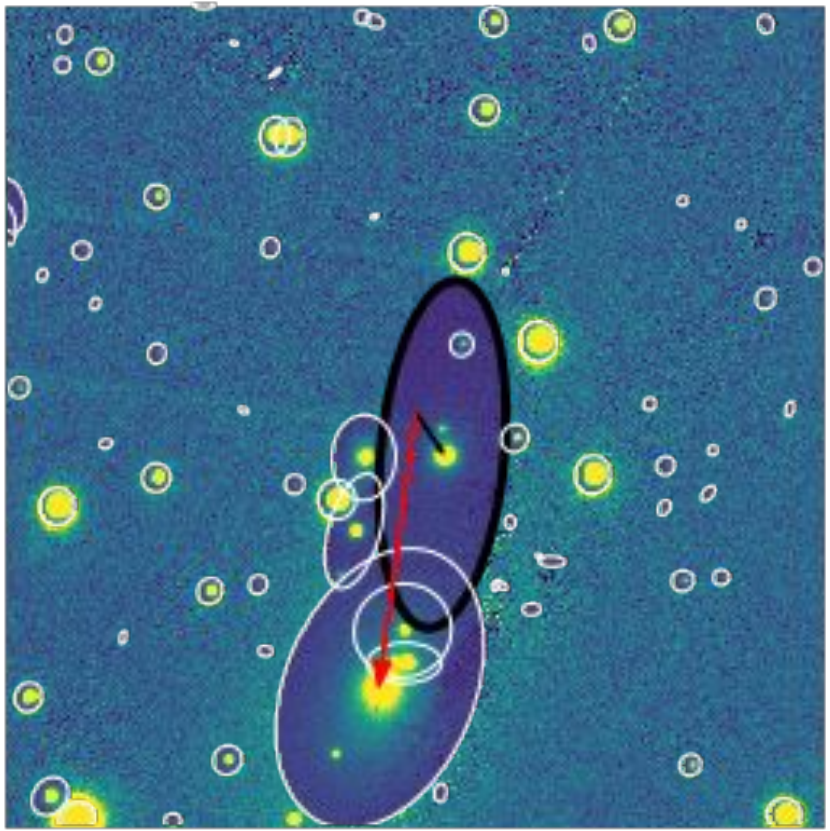
5 levels (5x30x30=4,500 pixels=2.0%)



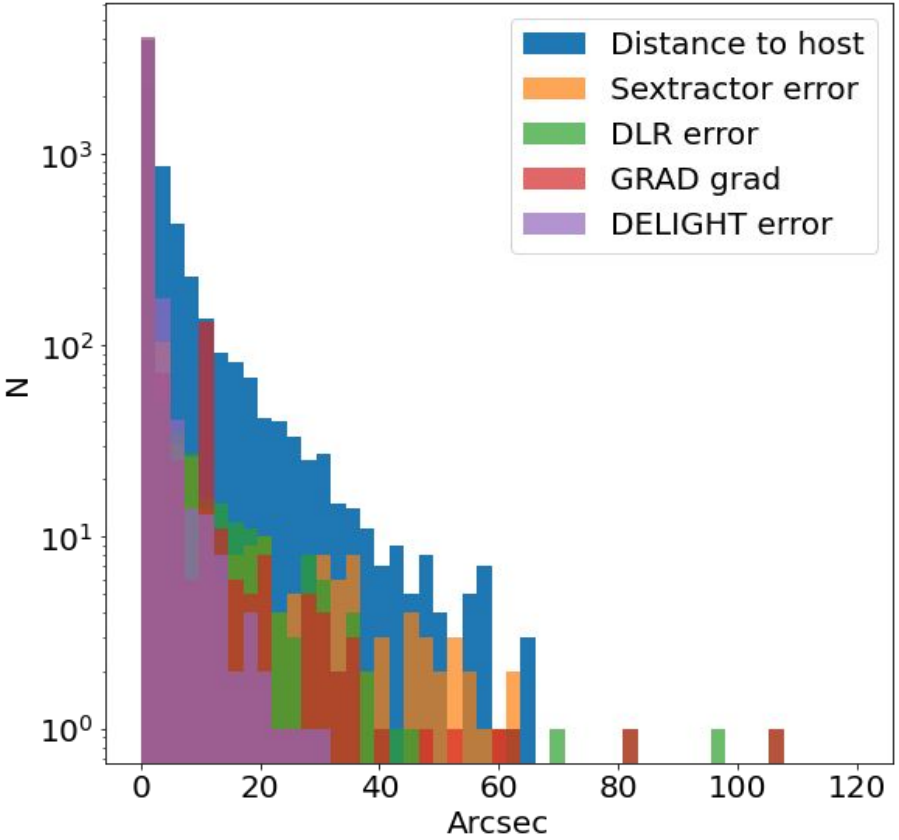
Host association methods

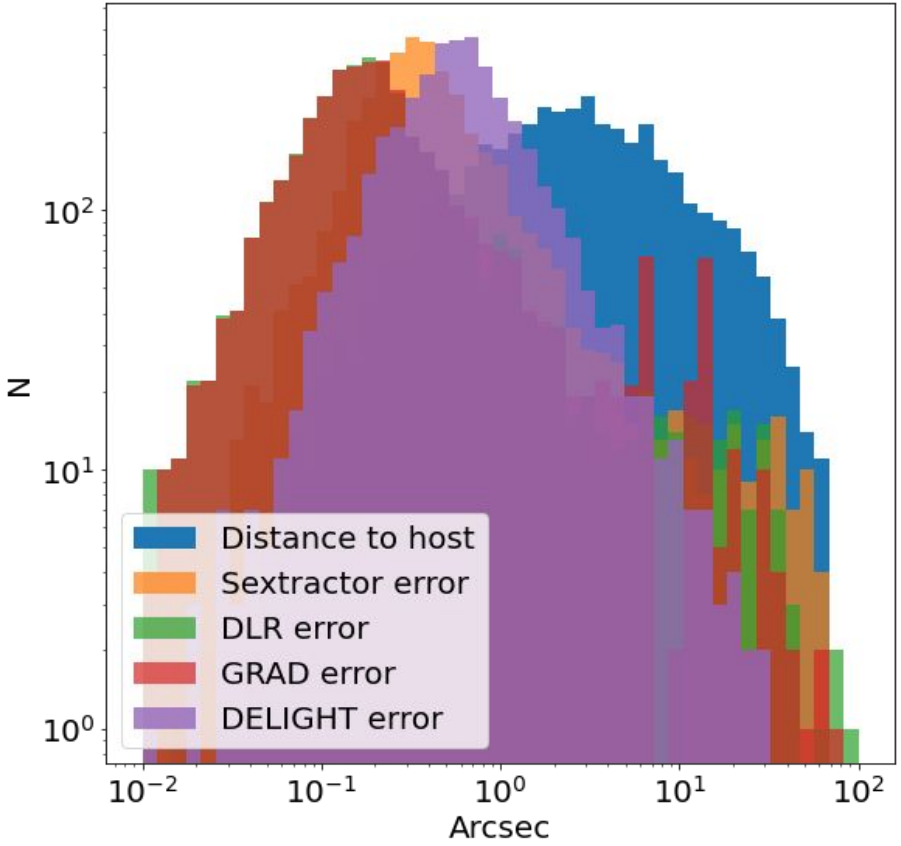
Compare different methods:

1. **True position**: visually selected host (from NED, Simbad or SDSS DR16).
2. **Sextractor predicted**: closest normalized distance using Sextractor ellipses.
3. **Directional light radius (DLR, Gupta+2016)**: closest normalized distance using source moments.
4. **Gradient ascent (Grad, Gagliano+21)**: start from source and ascend light profile.
5. **DELIGHT (Deep Learning Galaxy Host, this work)**: CNN prediction based on multi resolution image.



Distance error





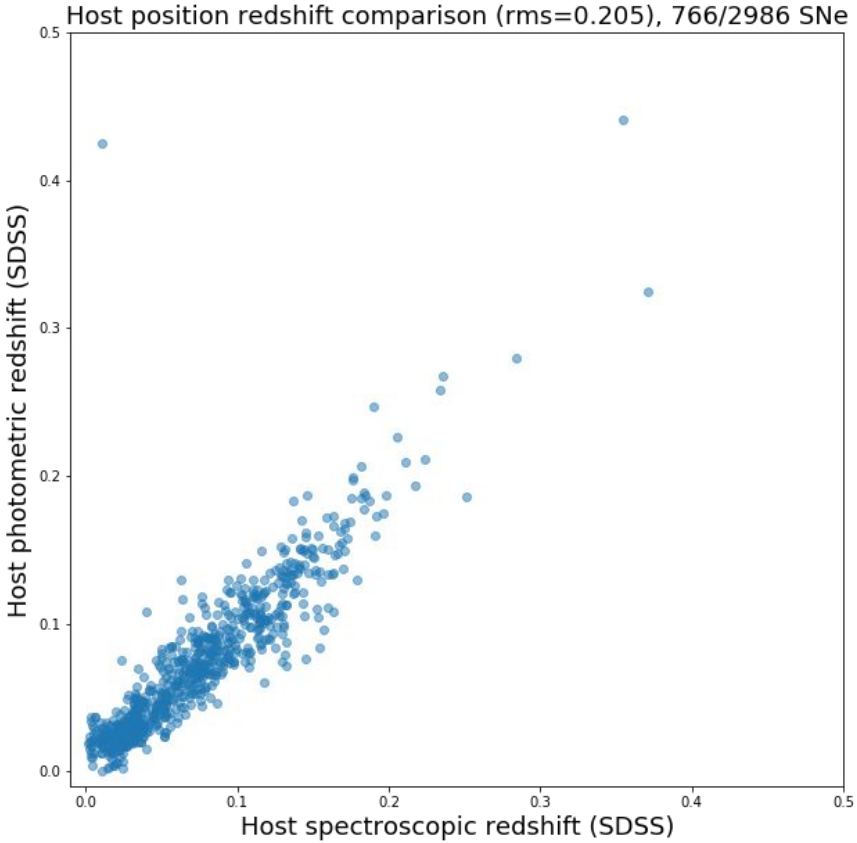
What is the redshift error?

Host galaxy properties can help with **fast classification**, in particular the **redshift**.

What are the sources of error in the redshift?

e(z_tran) = e(host_phot) + e(host_id)

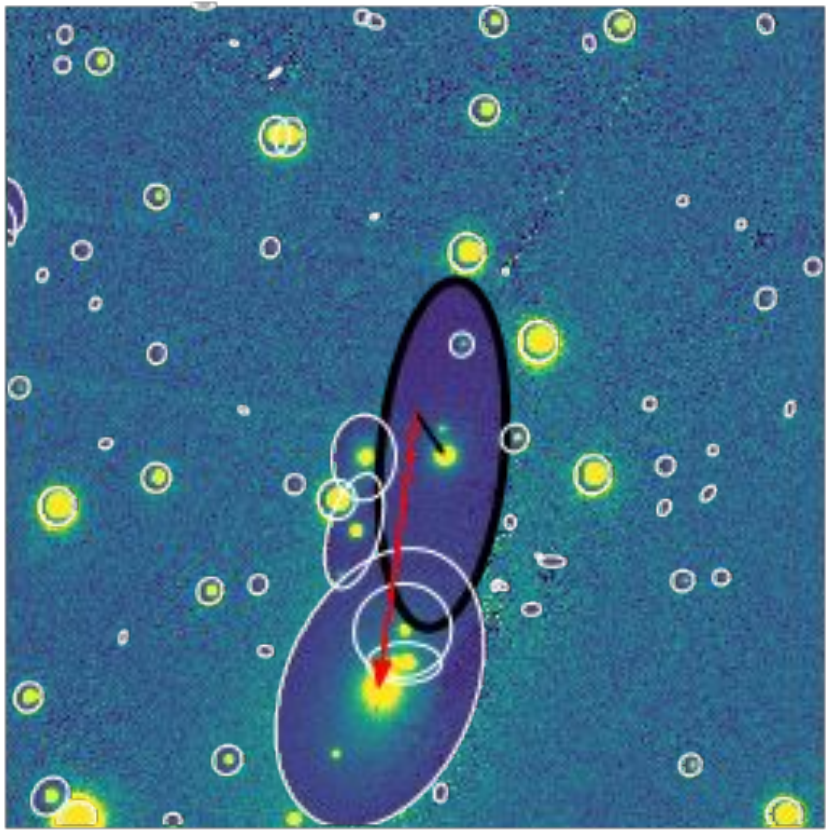
Can we estimate the distribution of the 2nd random variable?



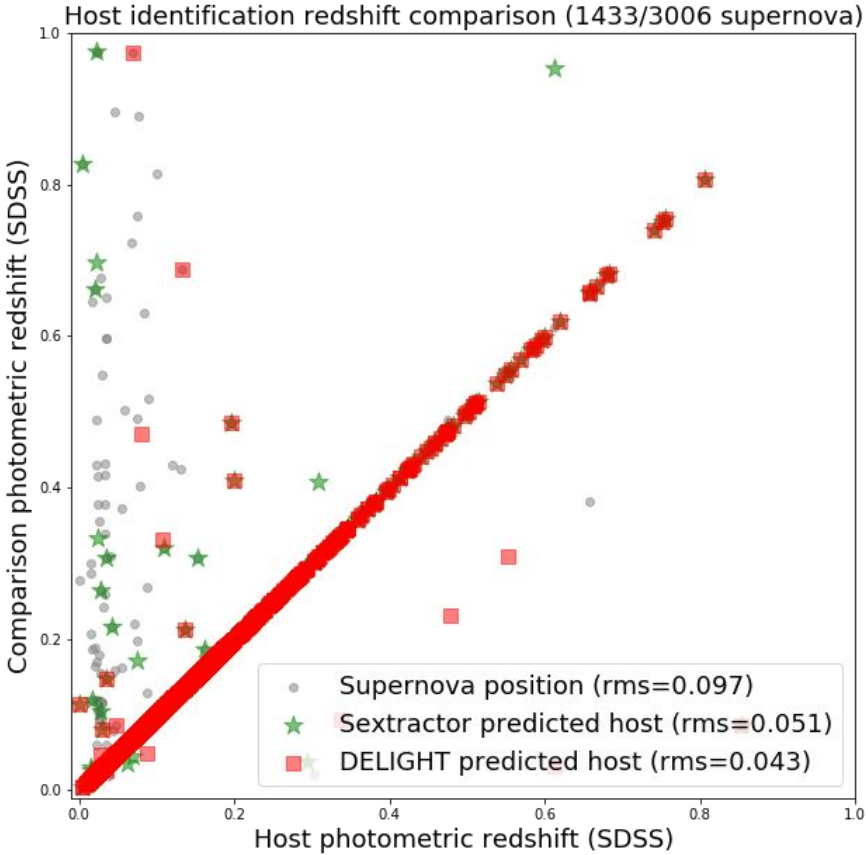
Redshift determination

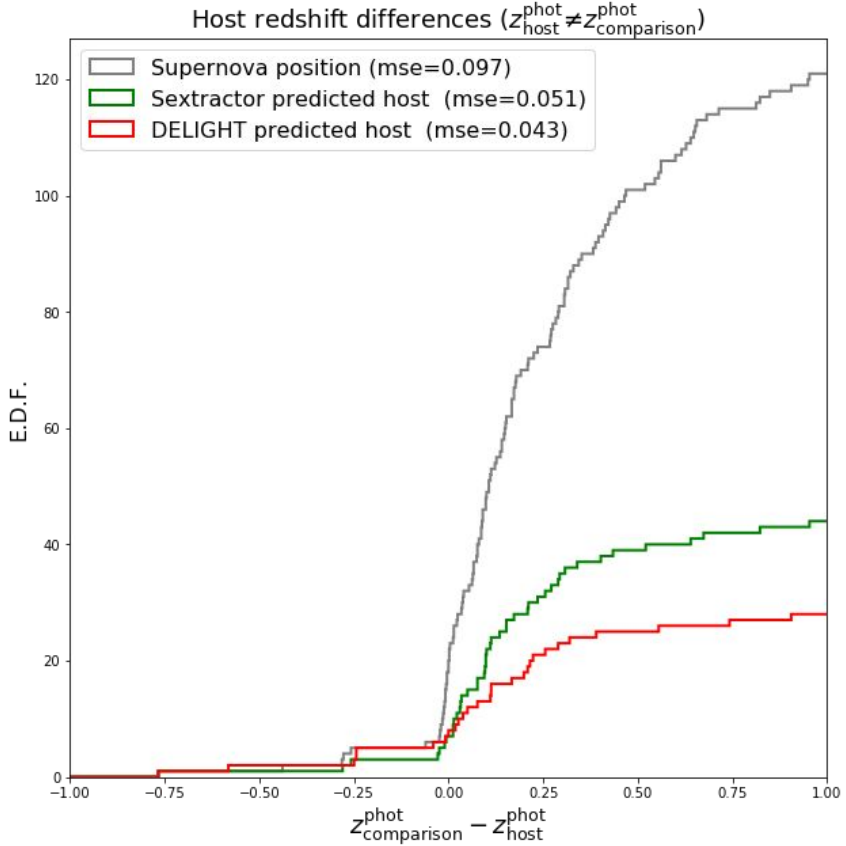
Compare different methods:

1. **True redshift**: source in SDSS nearest to visually selected host position
2. **Supernova position**: source in SDSS nearest to SN position.
3. **Sextractor predicted**: source in SDSS nearest to closest normalized distance sextractor source.
4. **DELIGHT predicted**: source in SDSS nearest to CNN host prediction.

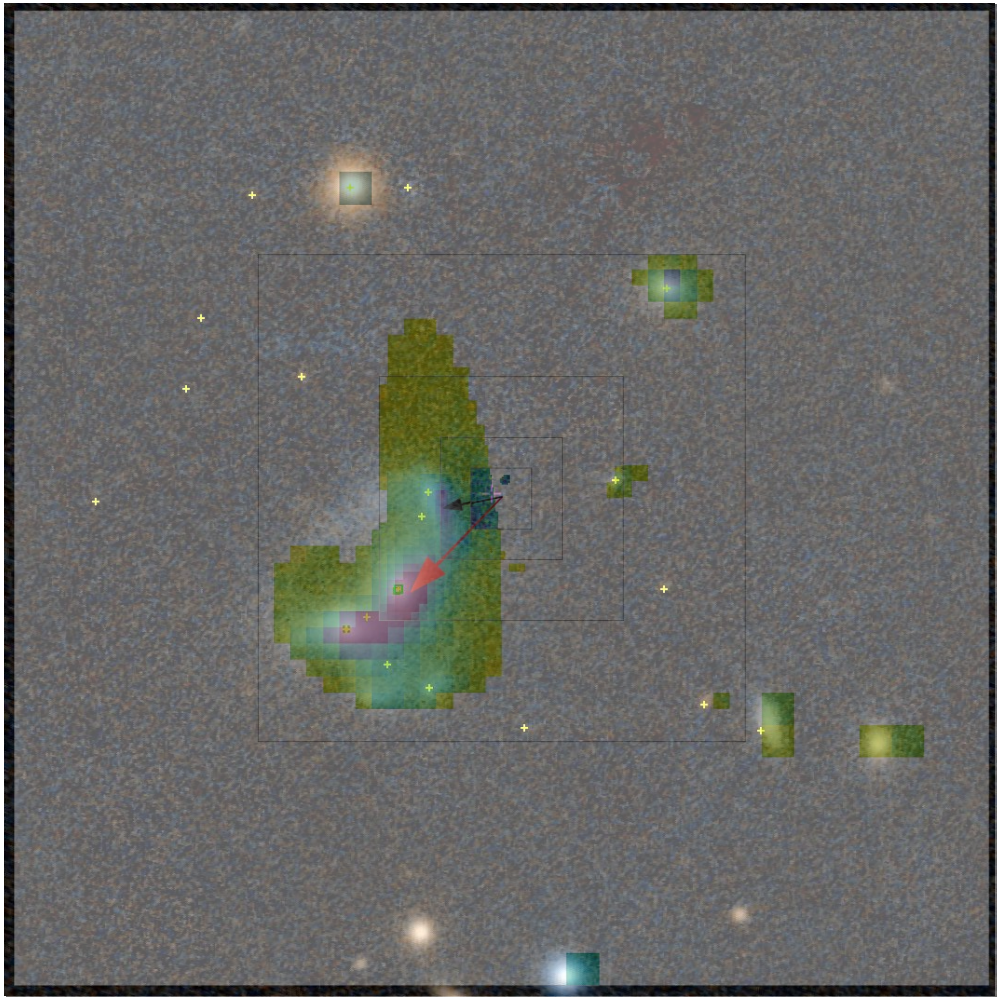


Redshift error





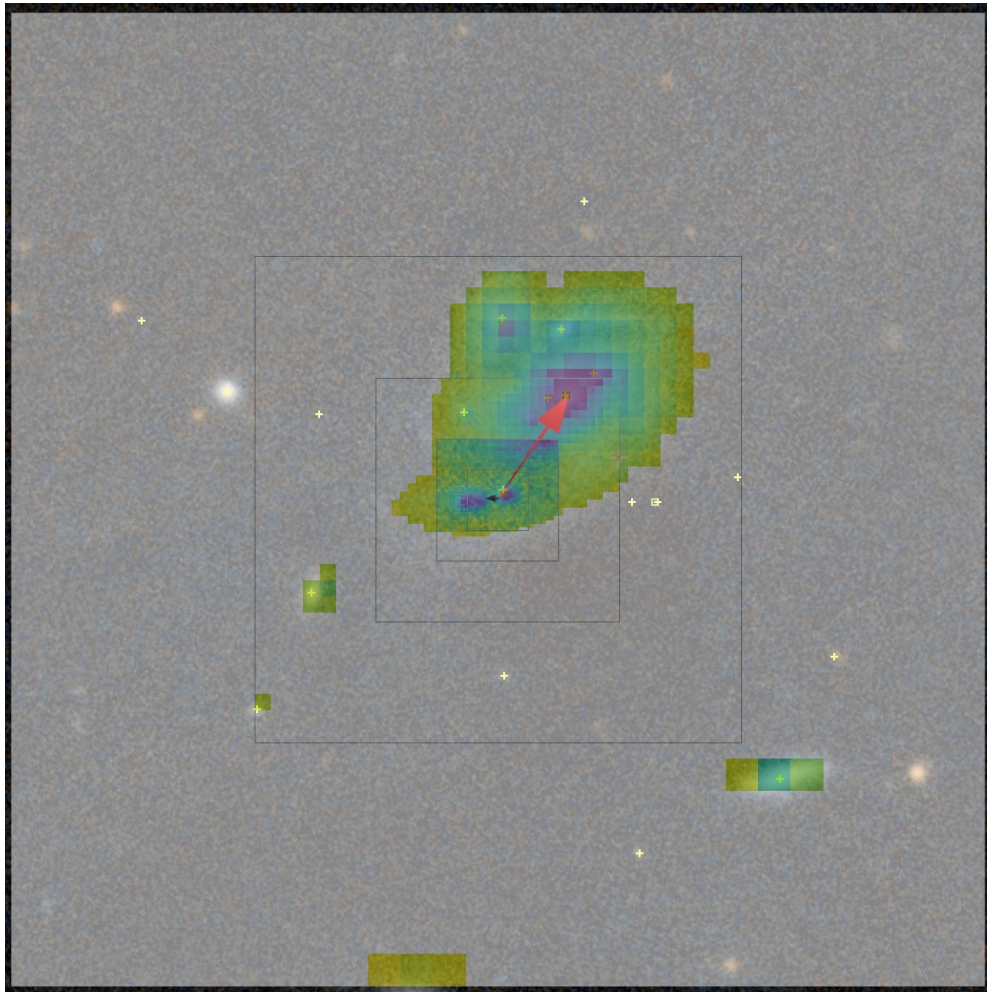
Examples



Sextractor

CNN

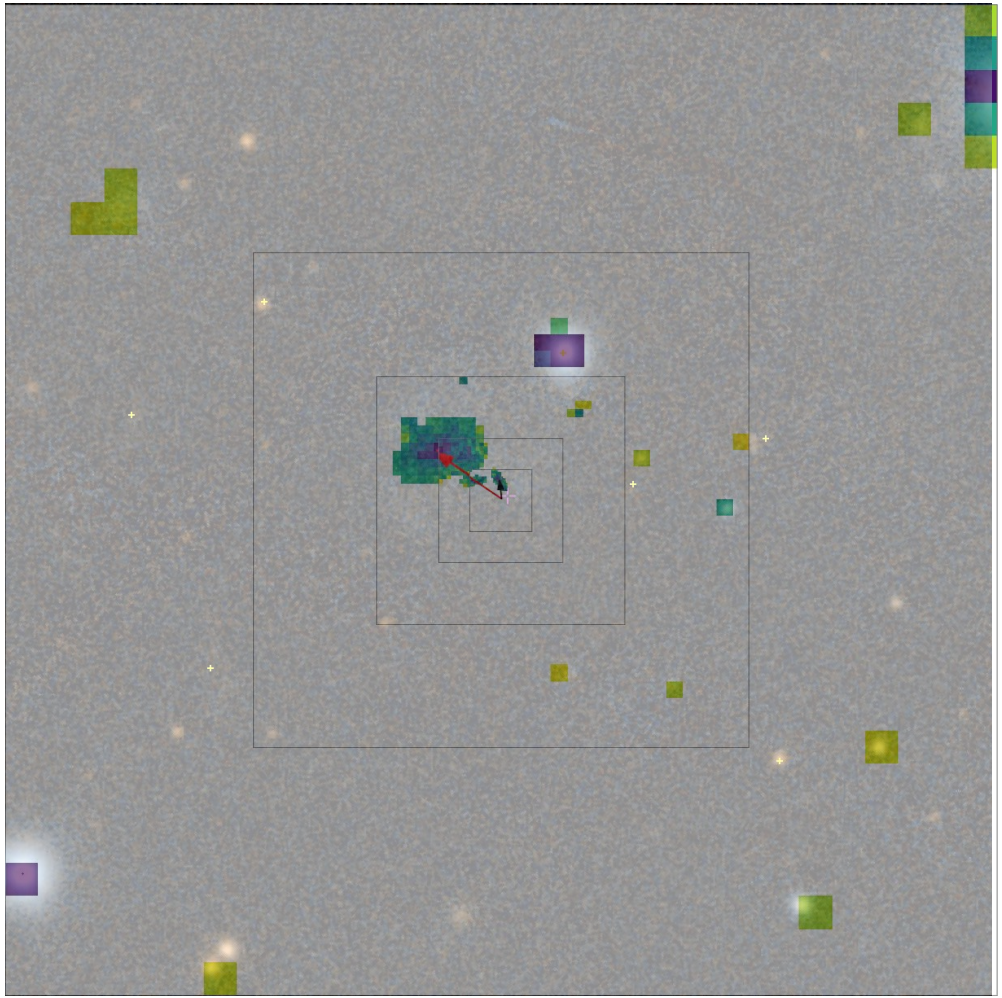
Examples



Sextractor

CNN

Examples



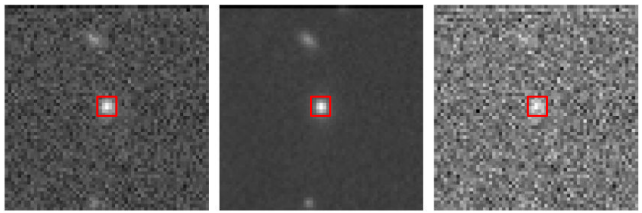
Sextractor

CNN

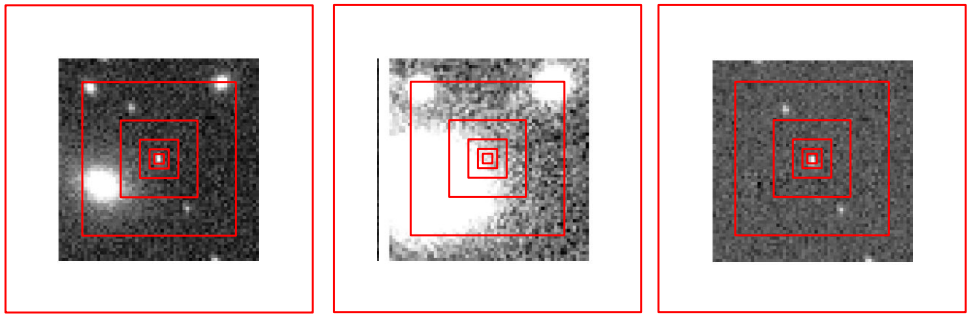
Conclusions & proposal

Multi resolution images are an efficient way of storing information. They allow for **very fast**, lightweight, and reliable **host galaxy association** using CNNs, but also for fast and reliable **alert classification** (c.f. ALeRCE stamp classifier, Carrasco-Davis+21).

LSST alert stamps are too small. We propose to represent LSST alert stamps in a hierarchical way, moving from 6” pixel FoV to 3” x 2^{n-1} FoV, with n the number of levels.



Current LSST
31x31= **961 pix**
FOV=6”



Proposal
15x15 * (1 + (n-1)*3/4) pix
= **900 pix** for n=5, FOV = 48”
= **1068 pix** for n=6, FOV=96”

"The main challenges ahead of massive time-domain surveys are timely recognition of interesting transients in the torrent of imaging data, and maximizing the utility of the follow-up observations." (Tyson 2006)