Multi-scale stamps for real-time classification of alert streams

Ignacio Reyes Jainaga, Francisco Förster, Alejandra M. Muñoz Arancibia, Guillermo Cabrera-Vives, Amelia Bayo, Franz E. Bauer, Javier Arredondo, Esteban Reyes, Giuliano Pignata, A. M. Mourão, Javier Silva-Farfán, Lluís Galbany, Alex Álvarez, Nicolás Astorga, Pablo Castellanos, Pedro Gallardo, Alberto Moya, Diego Rodríguez.
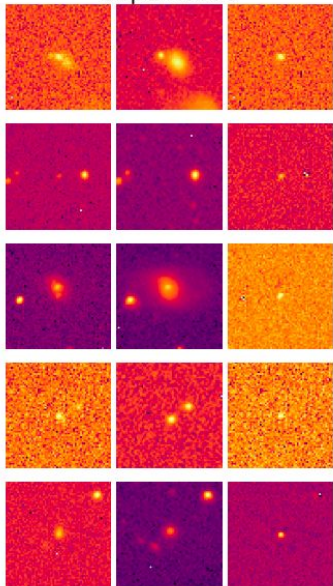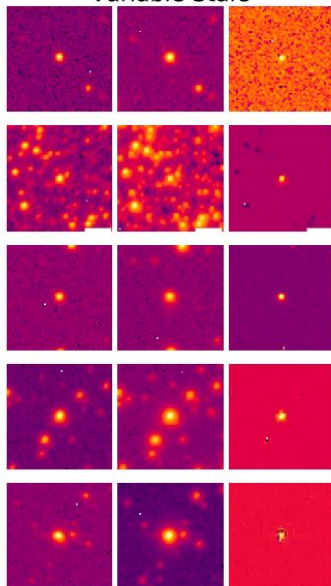
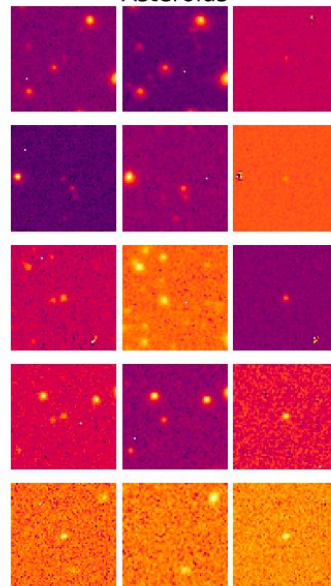# ALeRCE stamp classifier
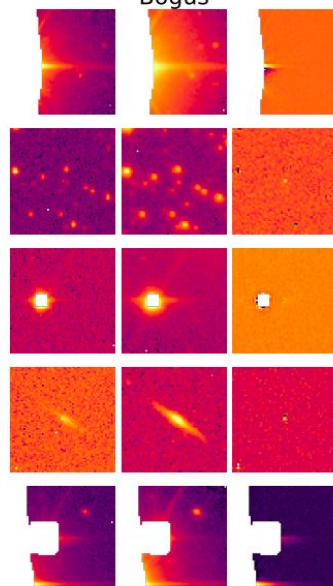

Active Galactic Nuclei · Supernovae · Variable Stars · Asteroids · Bogus
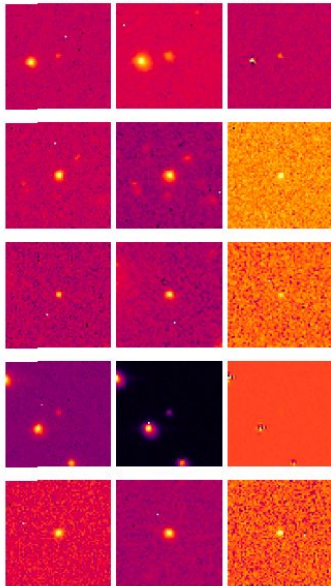
ALeRCE stamp classifier achievements

- Using this model we have reported more than 18,000 supernovae candidates in TNS.

- ALeRCE is the 3rd highest SNe reporter worldwide.

- 30% of the confirmed supernovae worldwide, discovered since 2021, have been found thanks to ALeRCE.

Automatic stamp classification can be very important for real-time science
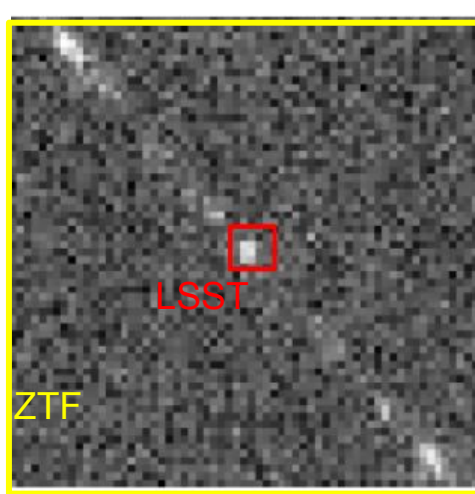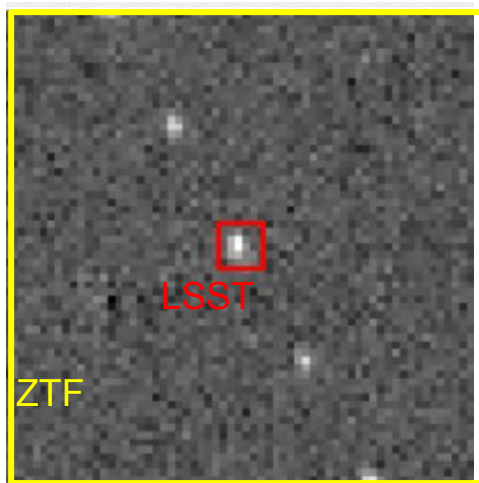
Hey! what are these things?

What will happen with Rubin?

LSST image stamps will be tiny!

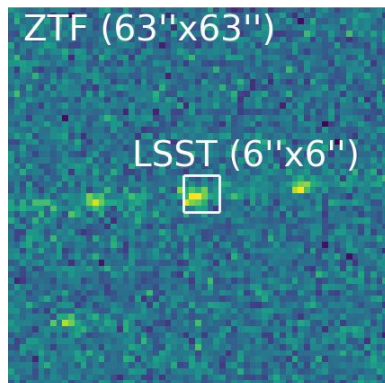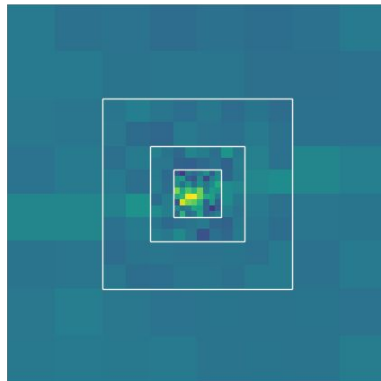# What can we do?

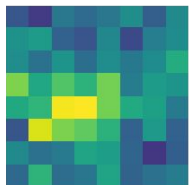Can we increase the Field of View and keep the same number of bytes?

Original stamp

ZTF (63''x63'')

LSST (6''x6'')

Multi-scale stamp (superimposed)

8'' x 8'' scale   16'' x 16'' scale   32'' x 32'' scale   63'' x 63'' scale
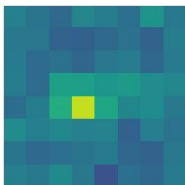
Multi-scale stamp classifier

- We did a classification experiment with the available ZTF stamps.

- Four scenarios:

  - Original "full" stamps: 63 x 63 pixels.
    63'' x 63'' field of view. **F1-score: 86.68**.

  - "Cropped" stamps: 16 x 16 pixels.
    16'' x 16'' field of view. **F1-score: 86.19**.

  - "Low resolution" stamps (subsampling).
    16 x 16 pixels, 63'' x 63'' field of view.
    F1-score: 82.69.

  - "Multi-scale" stamps. 4 scales in the configuration shown before.
    F1-score: 87.39.

Multi-scale stamp classifier

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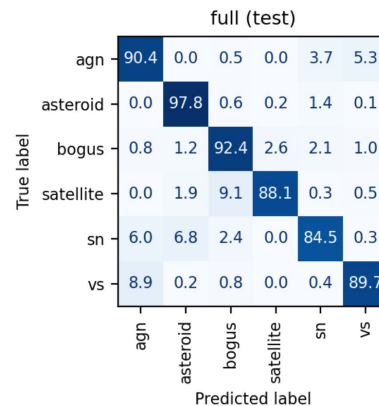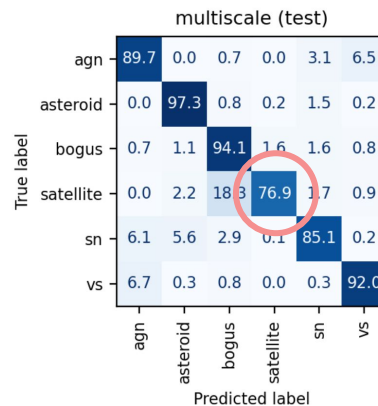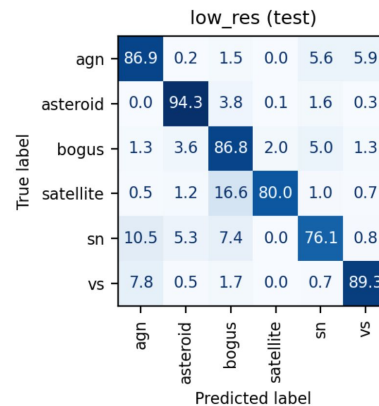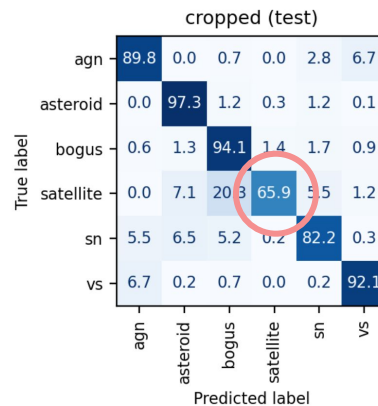- Four scenarios:

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cropped (test)

True label \ Predicted label	agn	asteroid	bogus	satellite	sn	vs
agn	89.8	0.0	0.7	0.0	2.8	6.7
asteroid	0.0	97.3	1.2	0.3	1.2	0.1
bogus	0.6	1.3	94.1	1.4	1.7	0.9
satellite	0.0	7.1	20.3	65.9	5.5	1.2
sn	5.5	6.5	5.2	0.2	82.2	0.3
vs	6.7	0.2	0.7	0.0	0.2	92.1

low_res (test)

True label \ Predicted label	agn	asteroid	bogus	satellite	sn	vs
agn	86.9	0.2	1.5	0.0	5.6	5.9
asteroid	0.0	94.3	3.8	0.1	1.6	0.3
bogus	1.3	3.6	86.8	2.0	5.0	1.3
satellite	0.5	1.2	16.6	80.0	1.0	0.7
sn	10.5	5.3	7.4	0.0	76.1	0.8
vs	7.8	0.5	1.7	0.0	0.7	89.3

multiscale (test)

True label \ Predicted label	agn	asteroid	bogus	satellite	sn	vs
agn	89.7	0.0	0.7	0.0	3.1	6.5
asteroid	0.0	97.3	0.8	0.2	1.5	0.2
bogus	0.7	1.1	94.1	1.6	1.6	0.8
satellite	0.0	2.2	18.3	76.9	1.7	0.9
sn	6.1	5.6	2.9	0.1	85.1	0.2
vs	6.7	0.3	0.8	0.0	0.3	92.0

full (test)

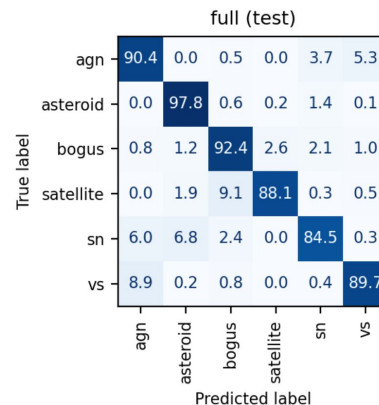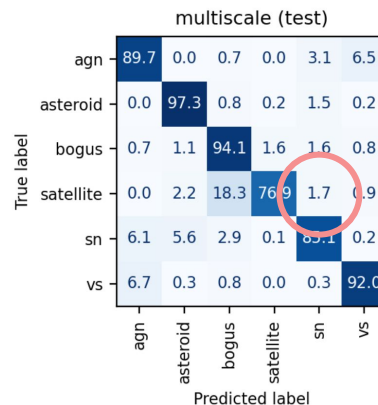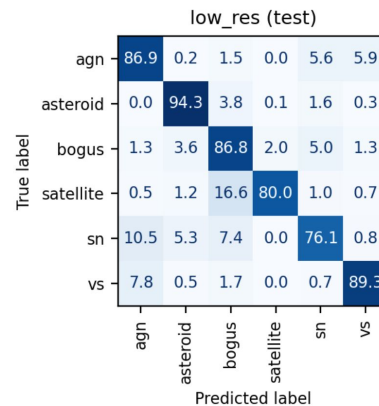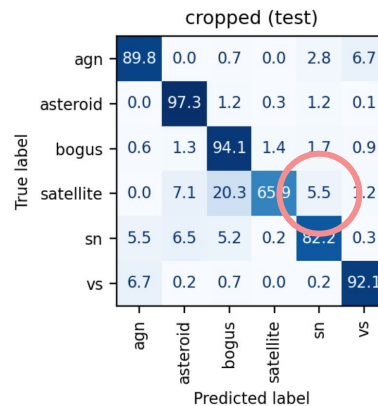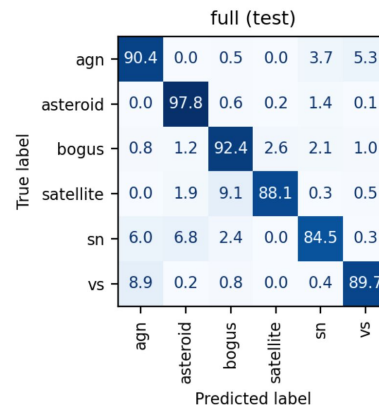| True label \ Predicted label	agn	asteroid	bogus	satellite	sn	vs
agn	90.4	0.0	0.5	0.0	3.7	5.3
asteroid	0.0	97.8	0.6	0.2	1.4	0.1
bogus	0.8	1.2	92.4	2.6	2.1	1.0
satellite	0.0	1.9	9.1	88.1	0.3	0.5
sn	6.0	6.8	2.4	0.0	84.5	0.3
vs	8.9	0.2	0.8	0.0	0.4	89.7

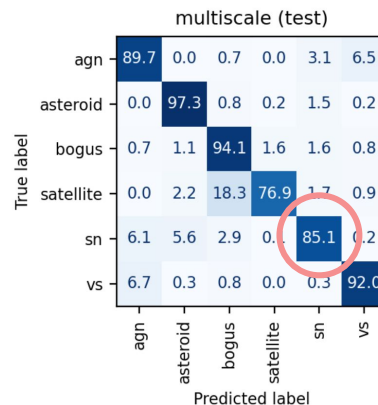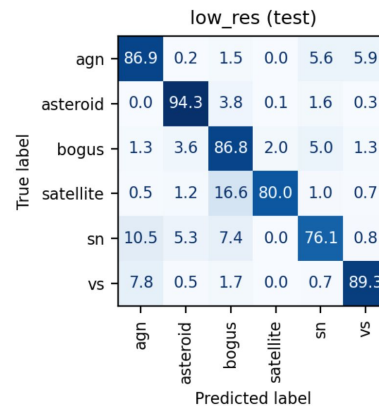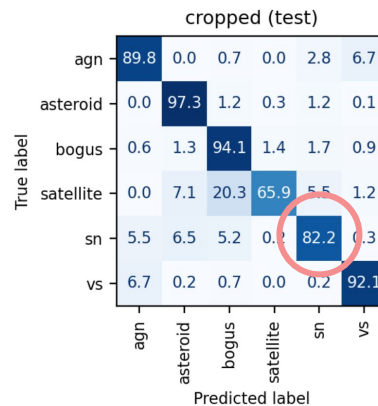# Multi-scale stamp classifier

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Confusion matrices for cropped (test), low_res (test), multiscale (test), and full (test).

Our proposal for Rubin alerts

Current specifications (DMTN-102):
Image cutouts of at least 30 x 30 pixels in size (6" x 6")

Multi-scale stamps:

- 16 x 16 pixels, with a 0".2 pixel width. FoV of 3".2 x 3".2.

- 16 x 16 pixels, with a 0".4 pixel width. FoV of 6".4 x 6".4.

- 16 x 16 pixels, with a 0".8 pixel width. FoV of 12".8 x 12".8.

- 16 x 16 pixels, with a 1".6 pixel width. FoV of 25".6 x 25".6.

Conclusions

- No other evaluated strategy was better than the multi-scale proposal (F1-score over test set).

- The current LSST specifications have stamps with a very small FoV, which could negatively impact the ability of brokers to provide a high-quality, fast transient classification.

- We advocate that LSST adopts a multi-scale stamp strategy for the real-time alert stream, and invite all Science Collaborations to discuss how this change might impact their future research.

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Unlabeled data predictions
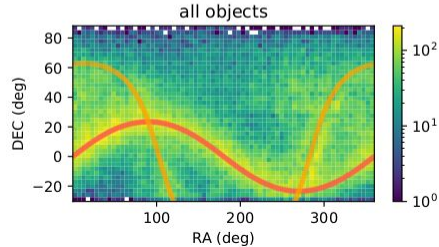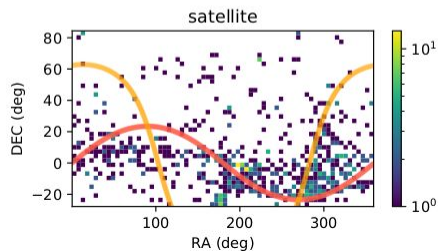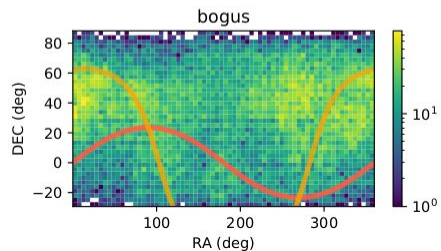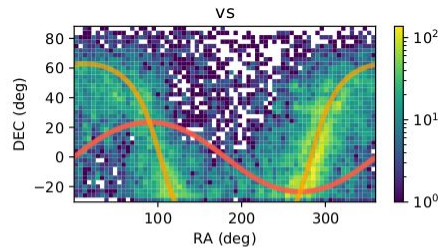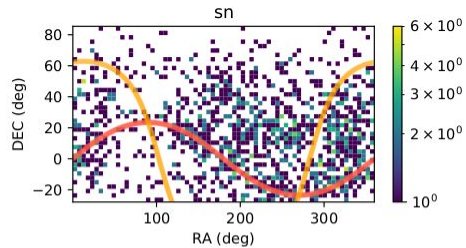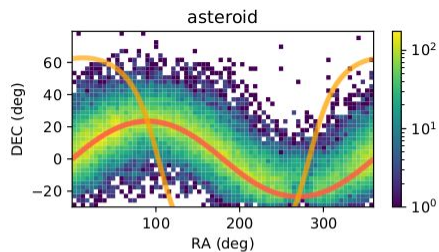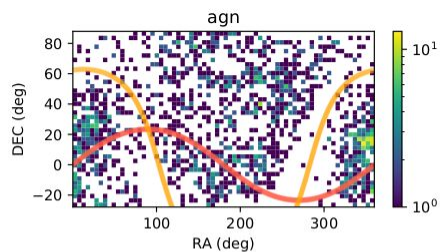
Unlabeled data predicted as satellite