

Morphological Classification of Jets in Active Galactic Nuclei

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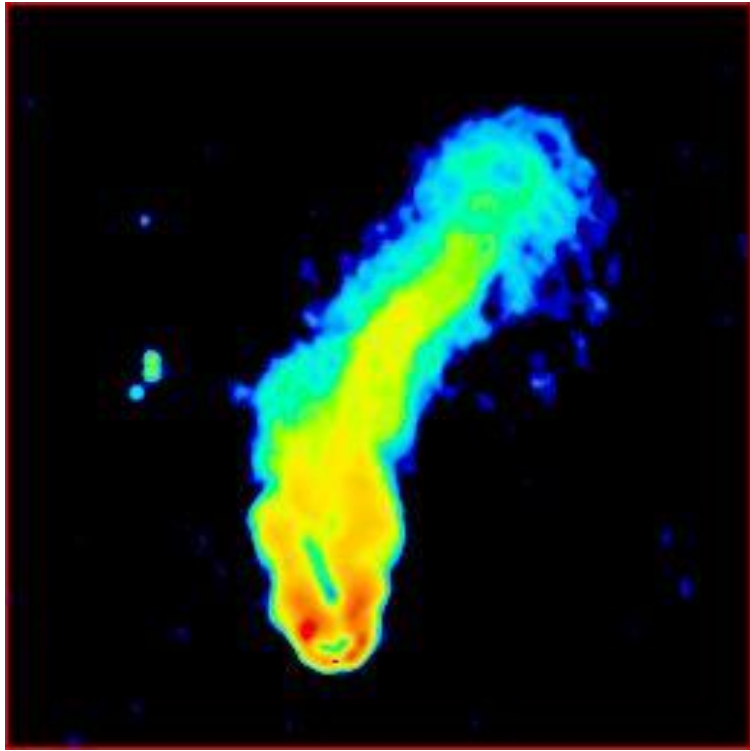
¹MIPT

²IFIS PUCV (Chile)

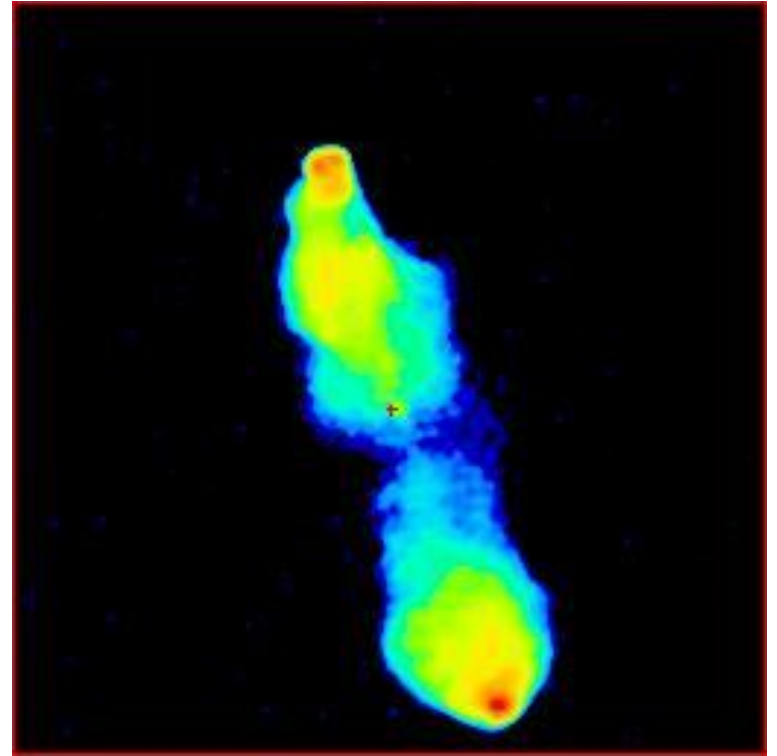
³ASC LPI RAS

October 14, 2024

Fanaroff-Riley Morphology (kpc)

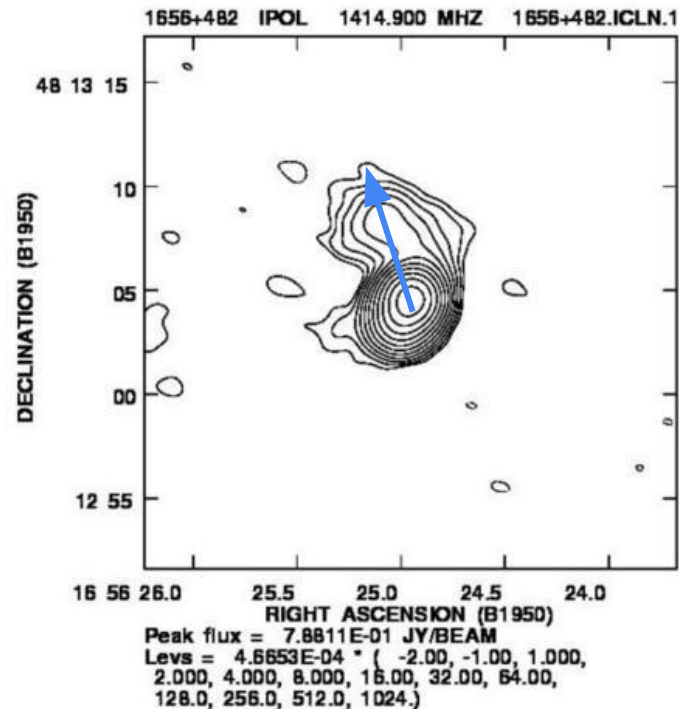
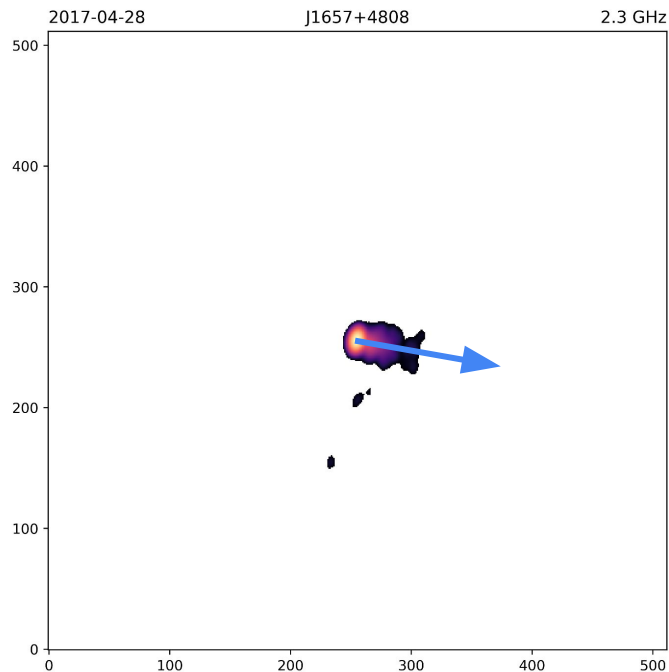


3C 83.1B, FR I, 1.4 GHz, 409 kpc



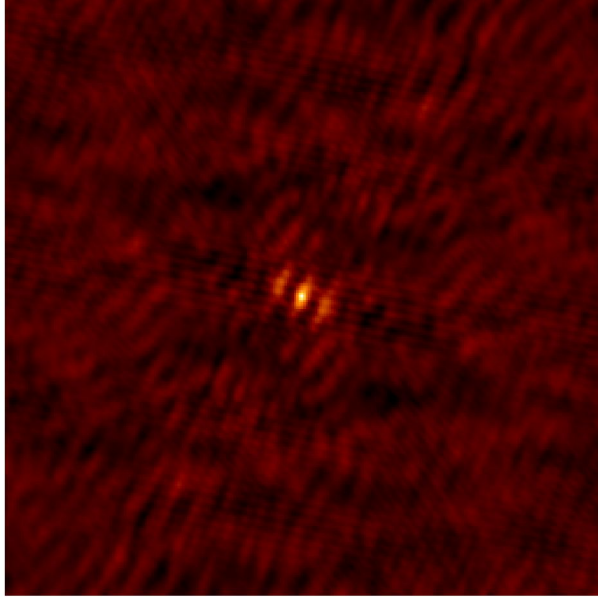
3C 173.1, FR II, 1.5 GHz, 220 kpc

AGN Morphology on Different Scales (pc & kpc)



Very-Long-Baseline-Interferometry (VLBI)

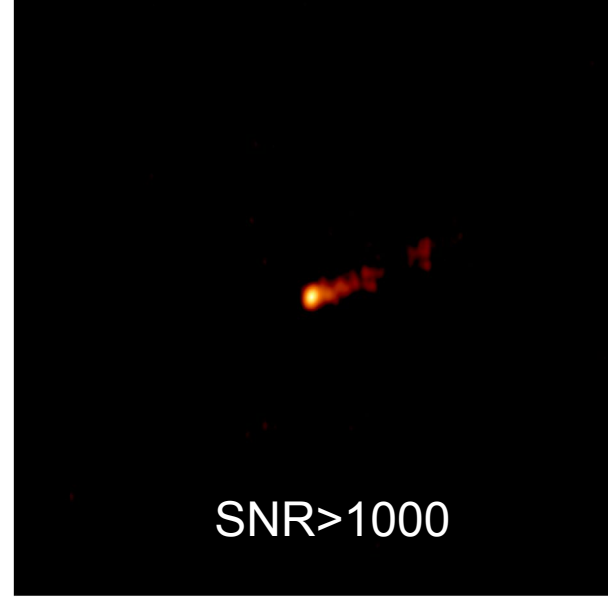
2020-09-22 J1230+1223 8.4 GHz



Raw map



2020-09-22 J1230+1223 8.6 GHz

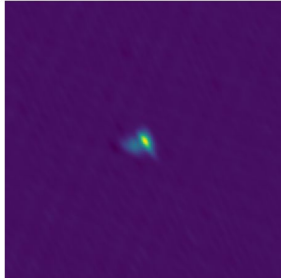


After CLEAN algorithm

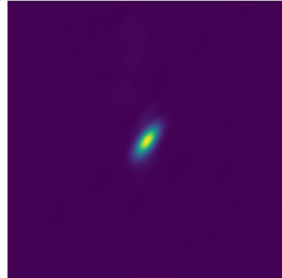
Research Motivation

- Consideration of the extended structure of observed sources for celestial coordinate systems construction (GLONASS/GPS);
- Creation of subsamples with known morphological properties;
- Search and investigation of abnormal objects.

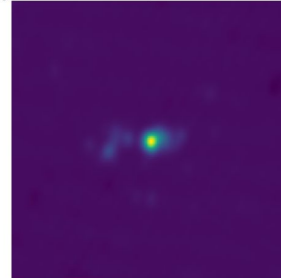
J2059+7328, 2015-09-01



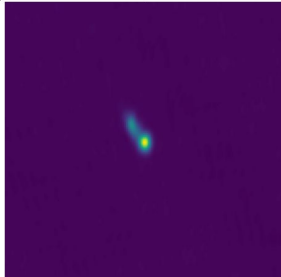
J1631+4348, 2014-01-30



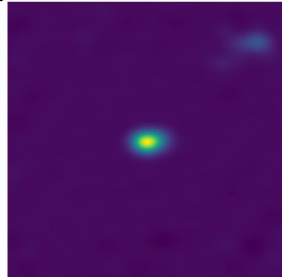
J1415+1320, 2021-03-24



J1414+1922, 2013-04-21



J0655+2306, 2021-01-29



J1305+5731, 2014-02-07

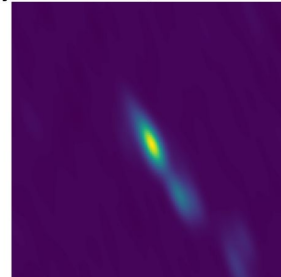
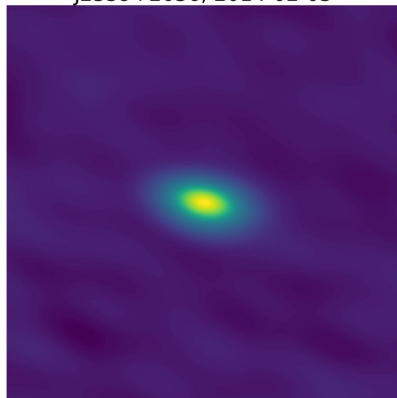


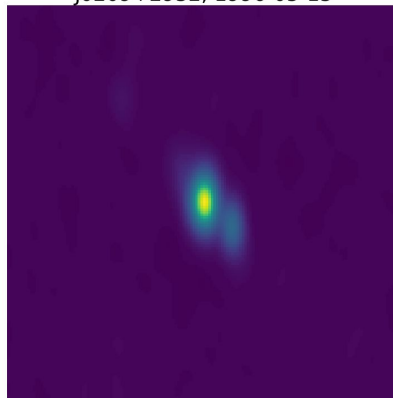
Image Classification¹ (130+ thousand)

Gaussian source

J2359+2036, 2014-02-03



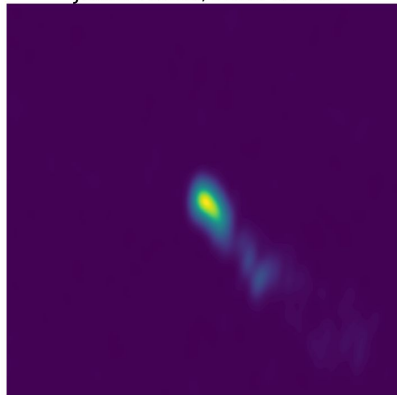
J0209+2932, 1996-05-15



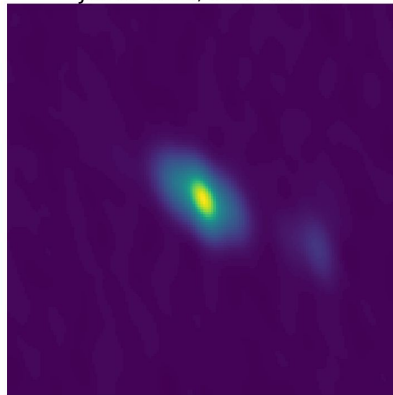
Double Gaussian sources

Single-sided jet sources

J1229+0203, 2019-01-10



J0241-0815, 2002-05-08

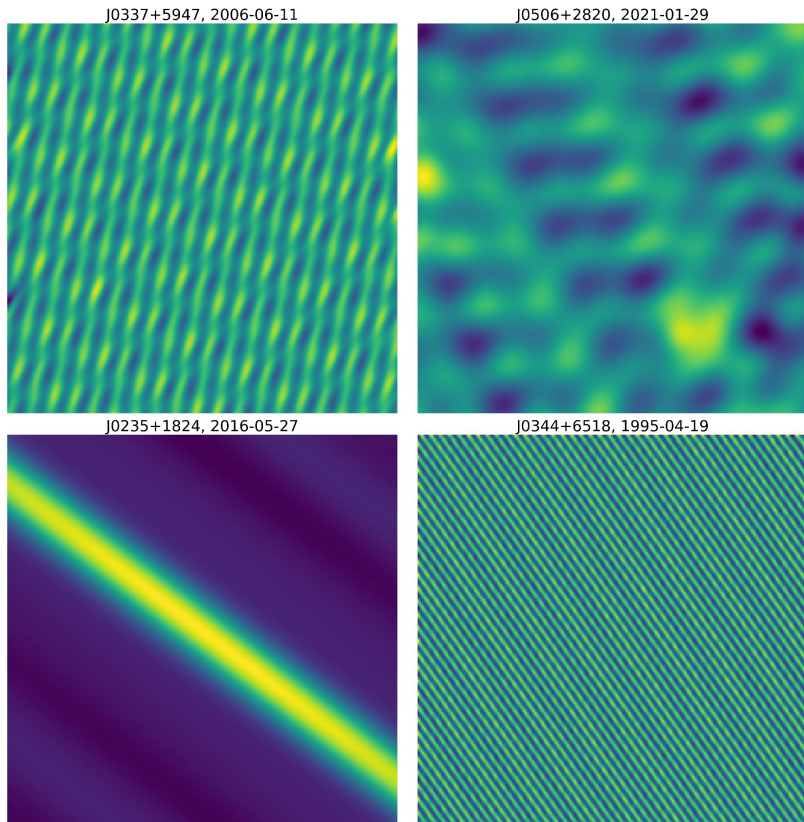


Double-sided jet sources

¹https://astrogeo.org/vlbi_images/

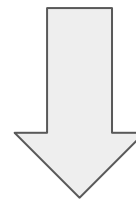
Filtration and Data Preparation

Examples of noisy images



Filtration criteria:

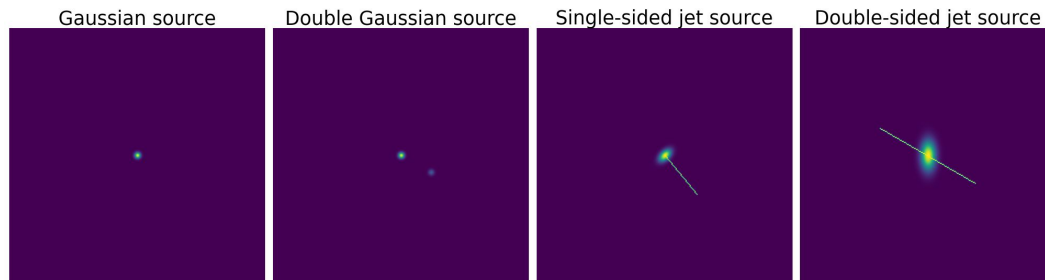
- $|C - I_{\max}| \geq 3$;
- $\text{SNR} \leq 10$.



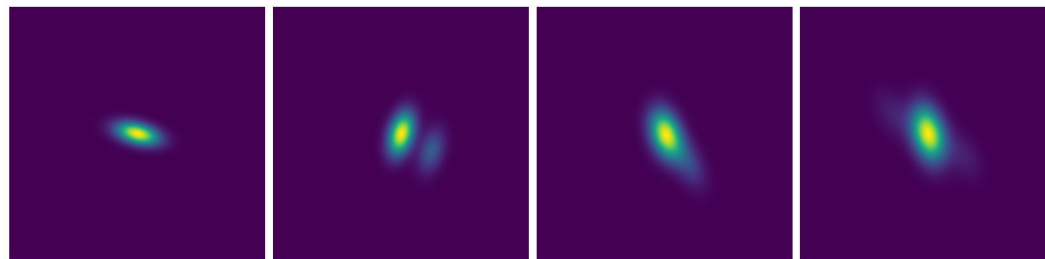
2.3% images were eliminated

Synthetic Data

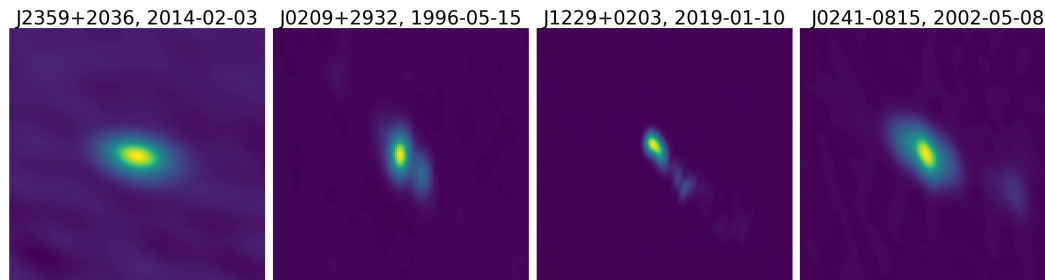
Model sources



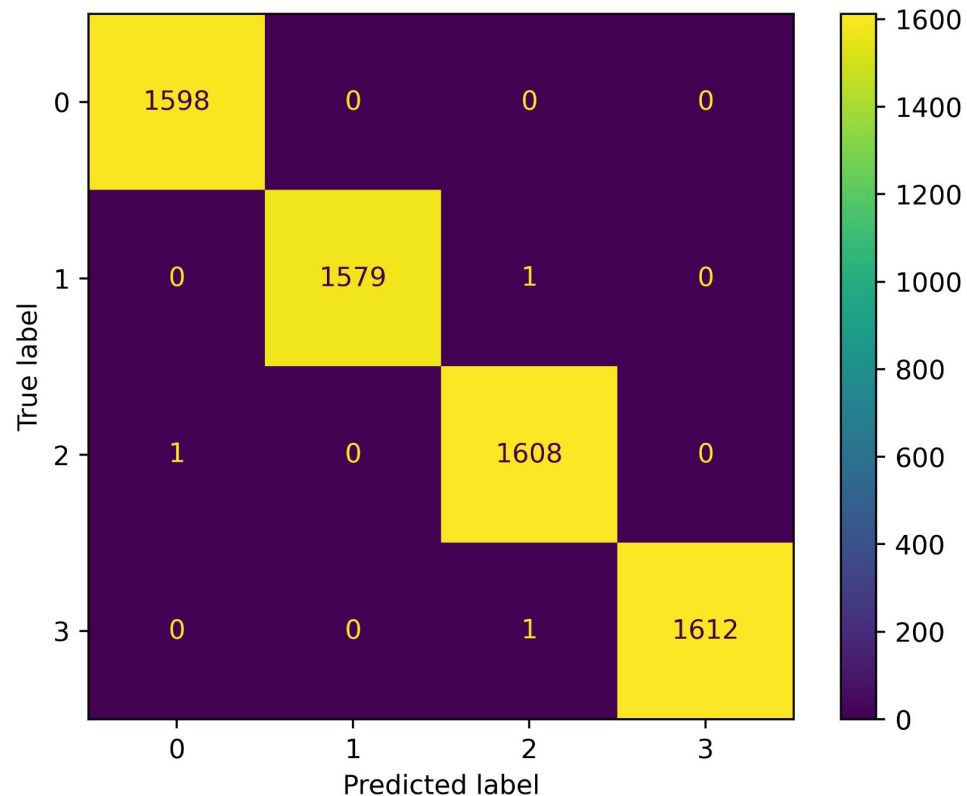
Model sources \otimes Point spread function



Real sources

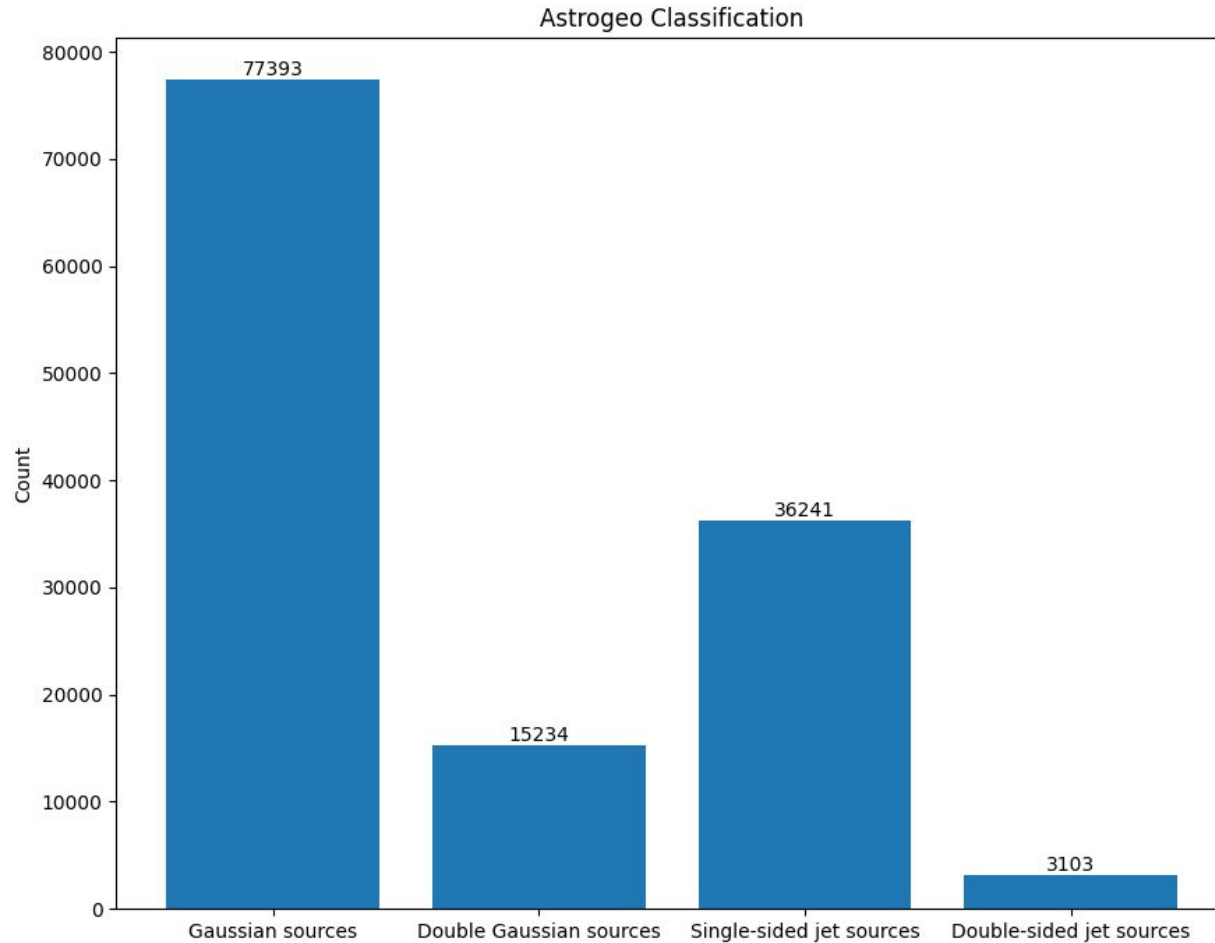


Results on Test Data

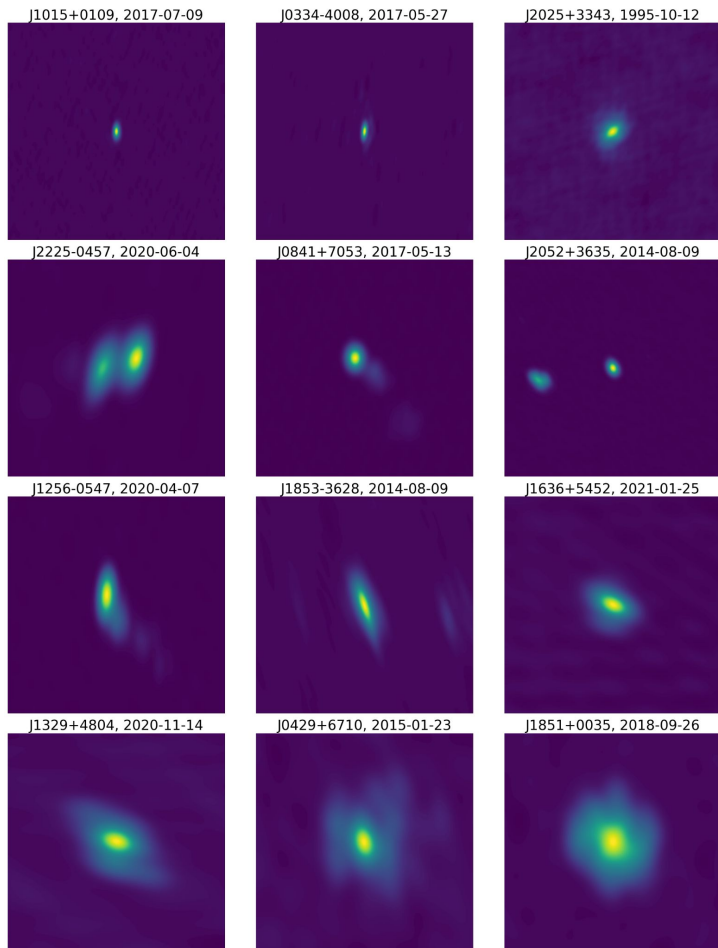


Precision: 99.95%
Recall: 99.95%
F1 Weighted Score: 99.95%

Classification Results



Model Predictions



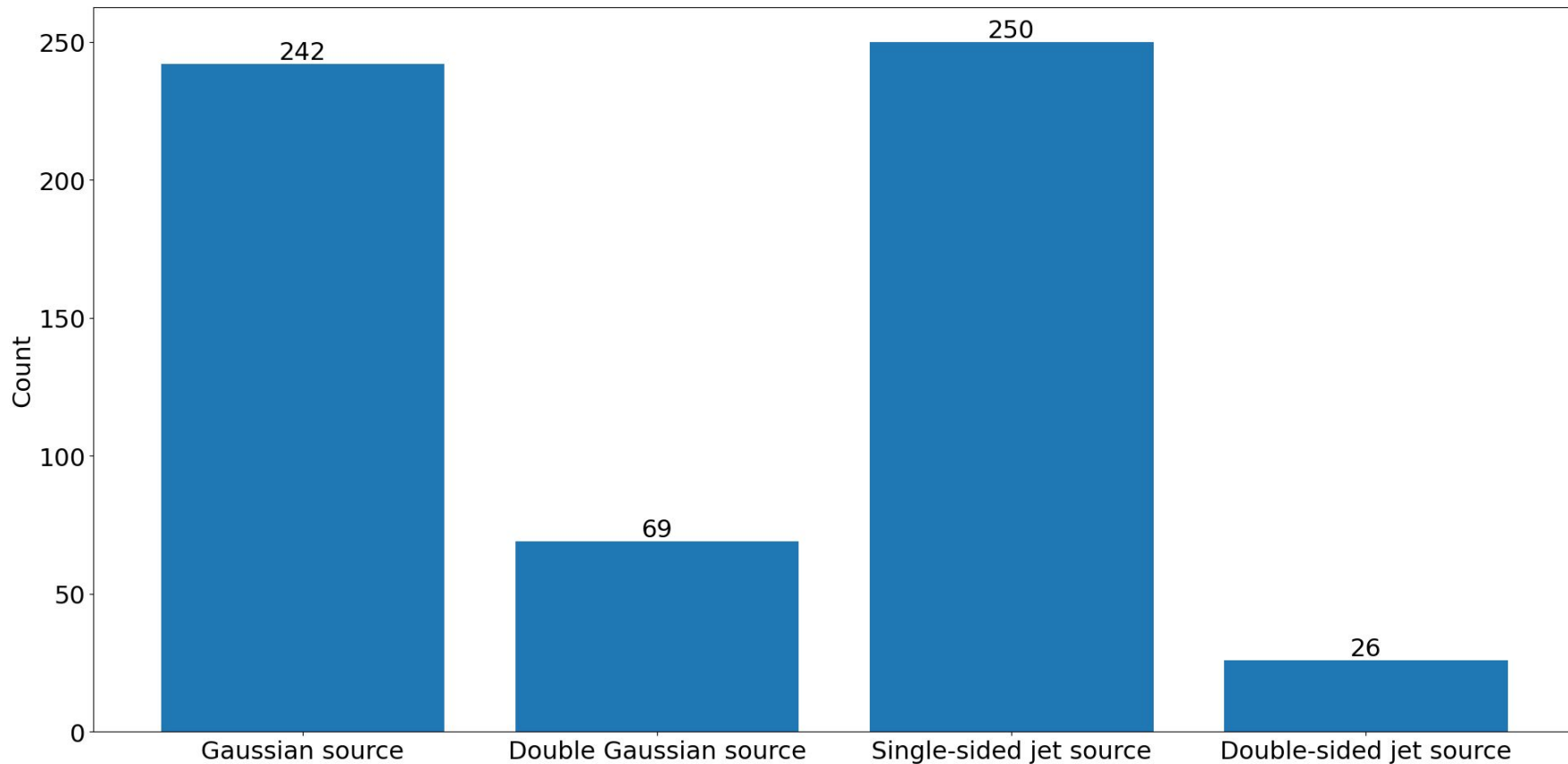
Gaussian sources

Double Gaussian sources

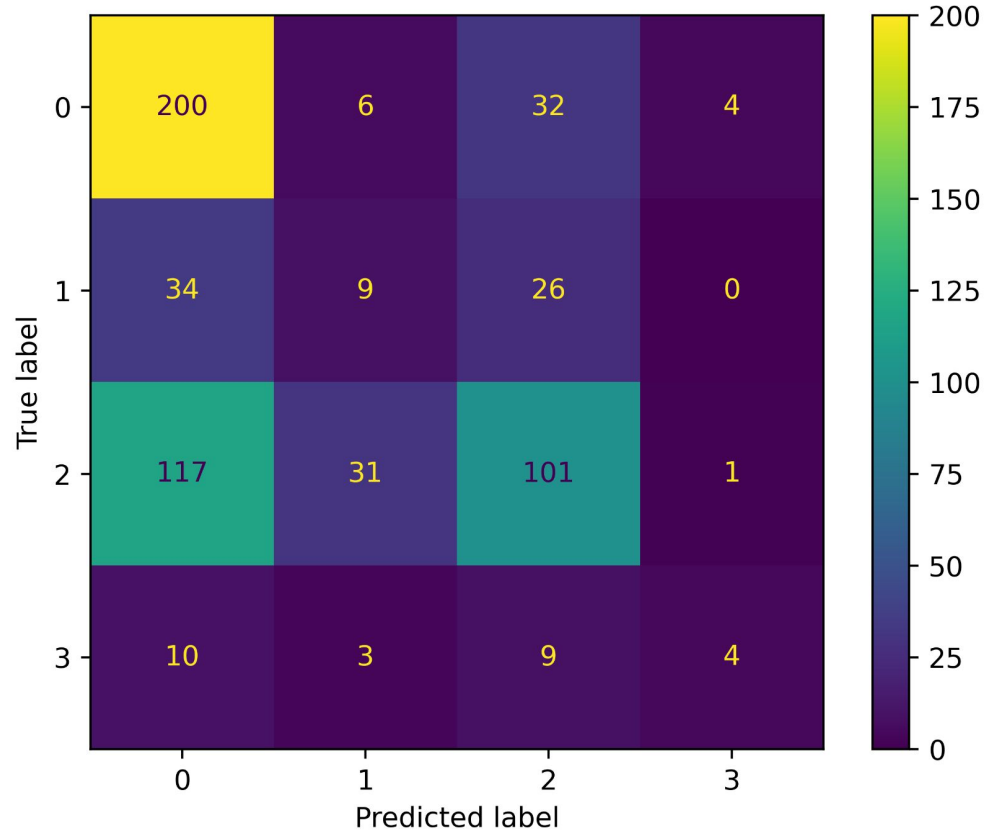
Single-sided jet sources

Double-sided jet sources

Manual Image Labelling



Quantifying the Quality of Classification



Precision: 44.58%

Recall: 37.87%

F1 Weighted Score: 50.74%

Results

- More than 130 thousand Astrogeo images were processed and cleaned;
- 2 SQL tables with meta parameters of files were filled in;
- A dataset of synthetic images was generated;
- A CNN model was developed and trained to classify images of jets in AGNs;
- Morphological classification of real sources was obtained;
- A web interface for image labelling was developed.

Future Plans

- Improvement of the quality of image classification;
- Investigation of other machine learning algorithms;
- Development of a search tool for jets with similar morphology.
- Use of the Blandford-Königl analytical model;
- Prediction of morphological classes at pc and kpc scales;

Bibliography

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