Potentials of AutoML solving astronomical problems

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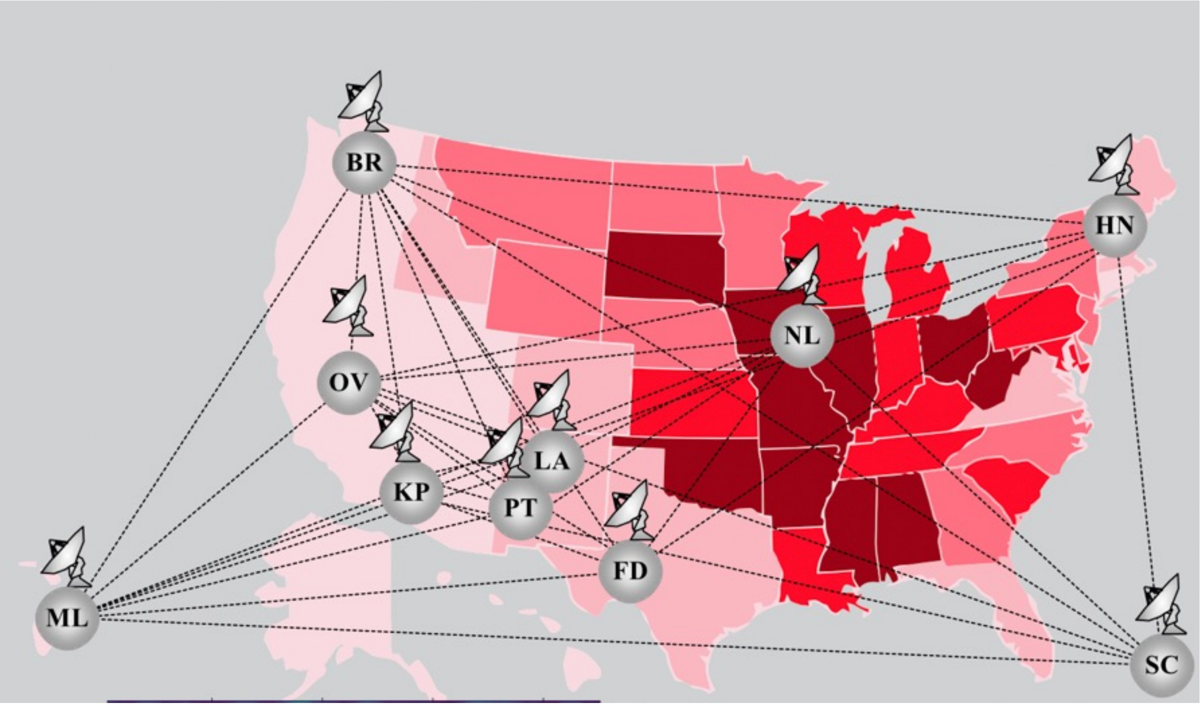
Introduction

- Observed at 1.4 GHz by VLBA
- Aim: inspecting a large sample of mJy radio sources at mas resolution.
- pre-selected from the Faint Images of the Radio Sky at 20cm (FIRST) survey by VLA (Very Long Array)



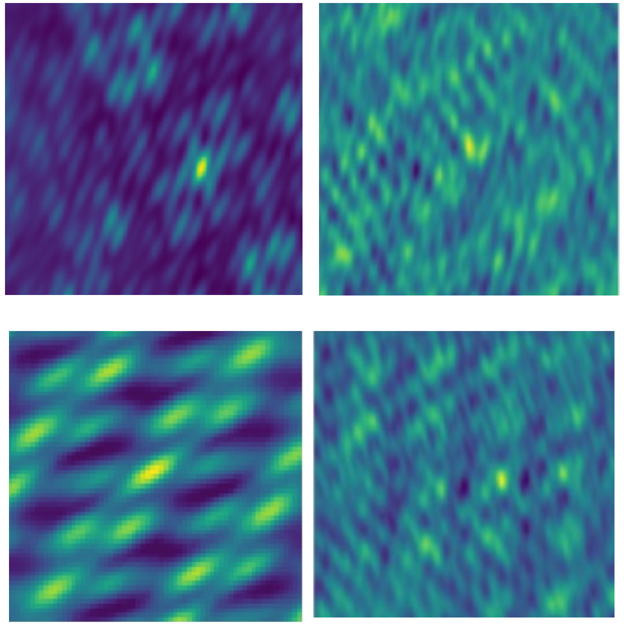
Very Long Baseline Array(VLBA)

Source Detection and Characterization (DECORAS)

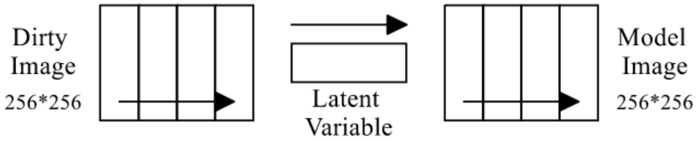
Dirty beam deconvolution

Is there a source?
Where is it ?
How big it is ?
How bright it is?

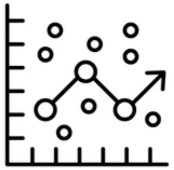
Collected Images of the Sky



Generating Simulated data

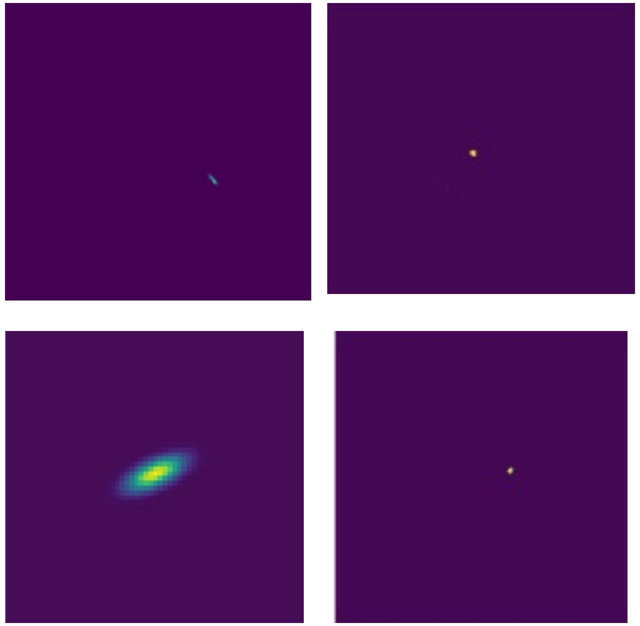


Deep Learning



Regression

Visualization Techniques

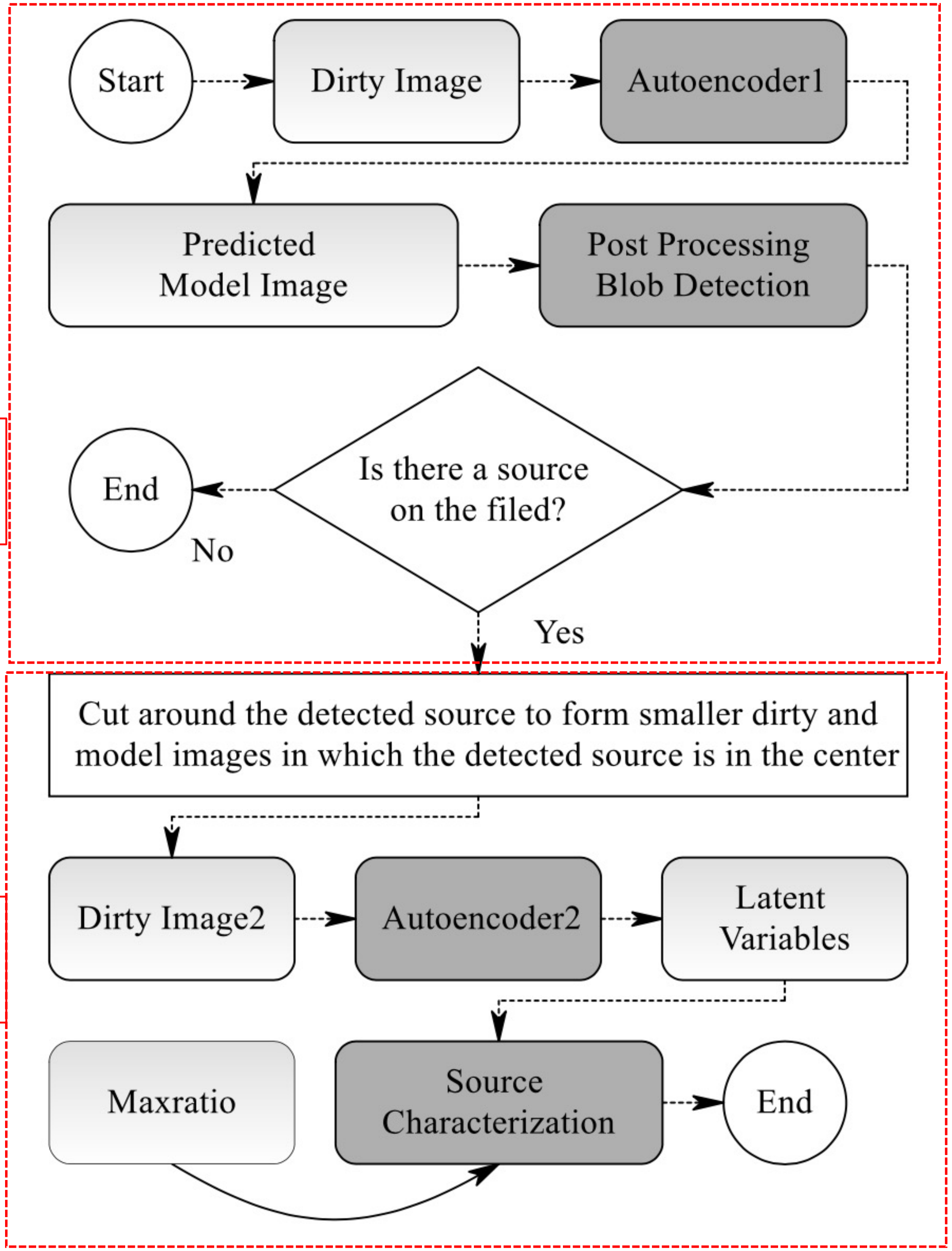


doi: https://doi.org/10.1093/mnras/stab3519

DECORAS Flowchart

Source Detection

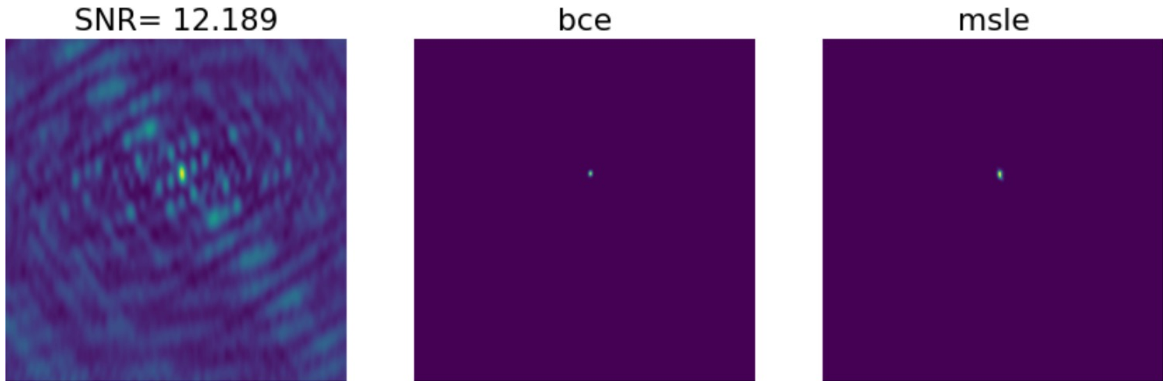
Source Characterization



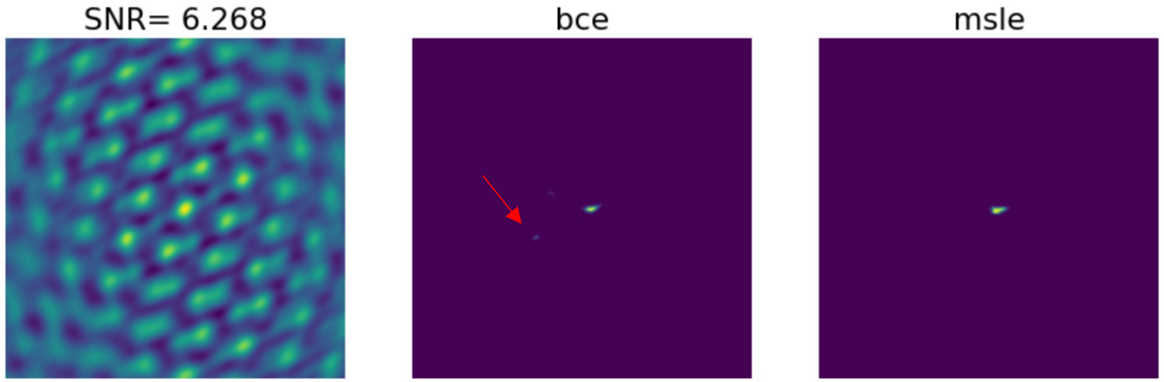
Loss Functions

- Binary Cross Entropy (BCE)
- Mean Squared Logarithmic Error (MSLE)

Good Example



Problematic case

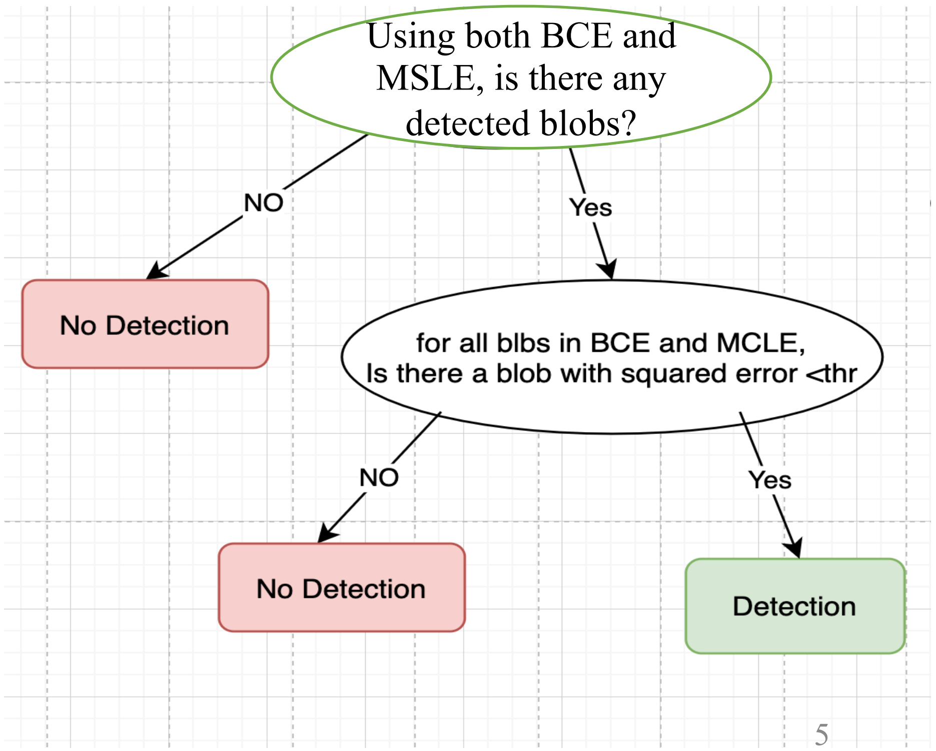


Evaluation Metrics

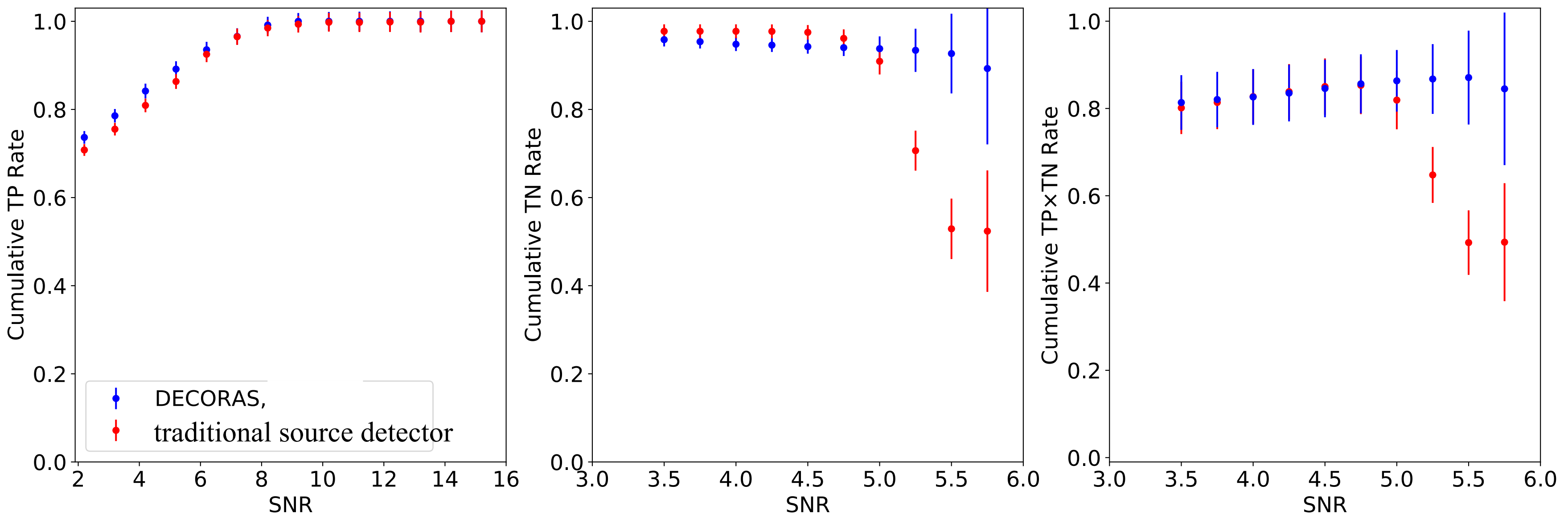
$$TP\ rate = \frac{TP}{TP + FN}$$

$$TN\ rate = \frac{TN}{TN + FP}$$

DECORAS Source Detection Strategy

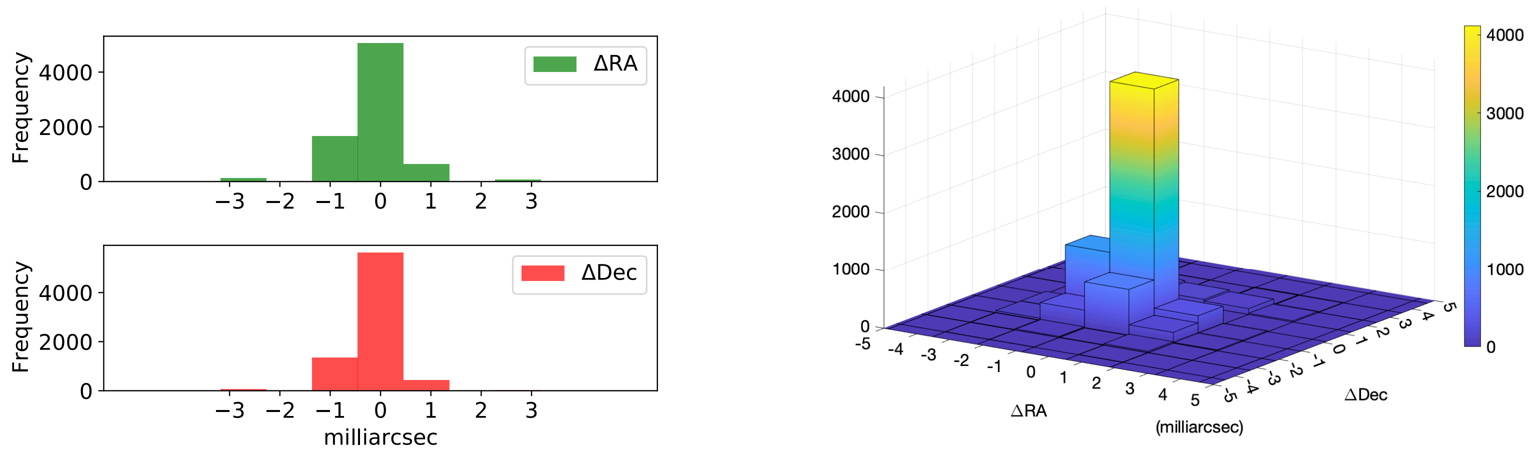


DECORAS on dirty images
vs
traditional source detector on clean images (down to 3 σ)



Recovering source Position within 0.61 ± 0.69 mas

VLBA beam size: 16 × 6 mas^2



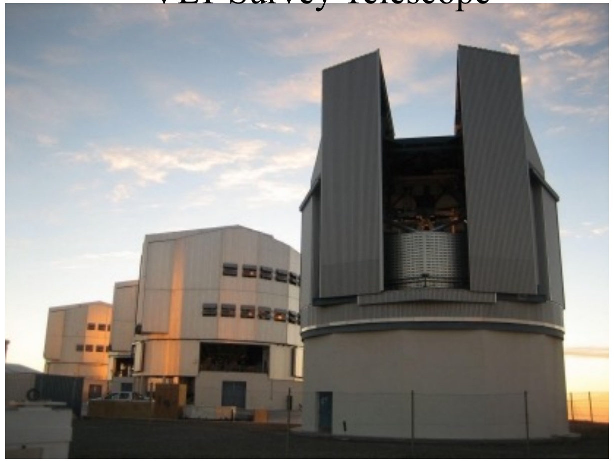
Generalizing DECORAS to other appliocations using AutoML

- Generating multiple datasets:
  - Recovering surface brighhtness distribution: LOFAR data

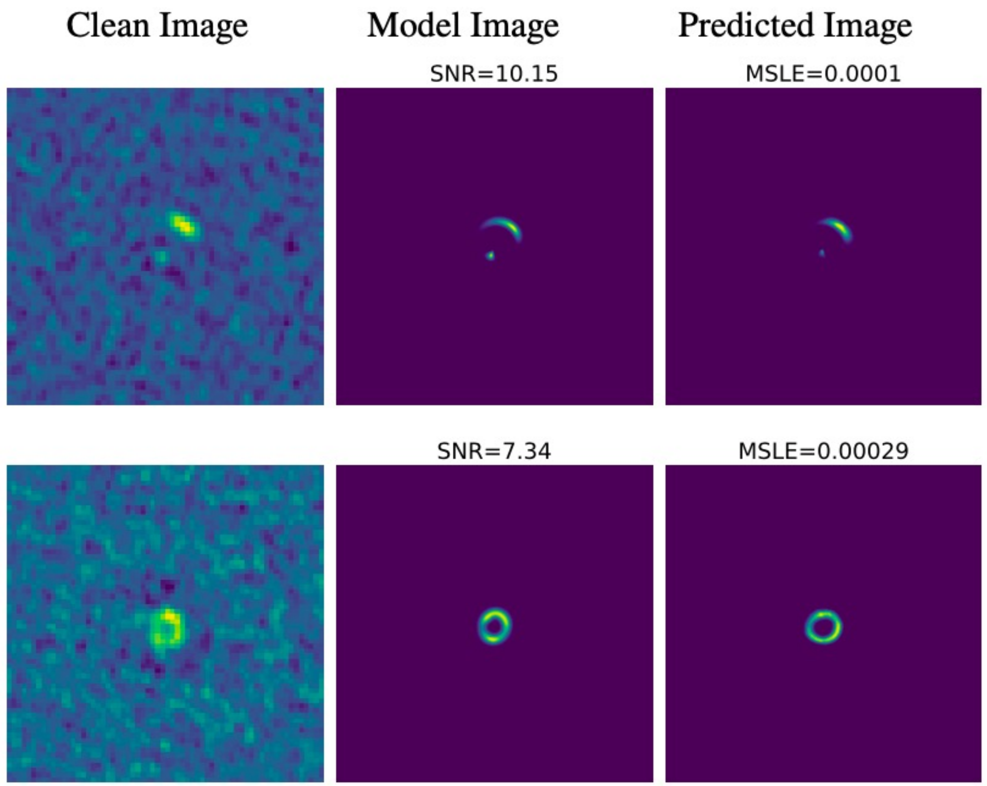
LOFAR Telescope

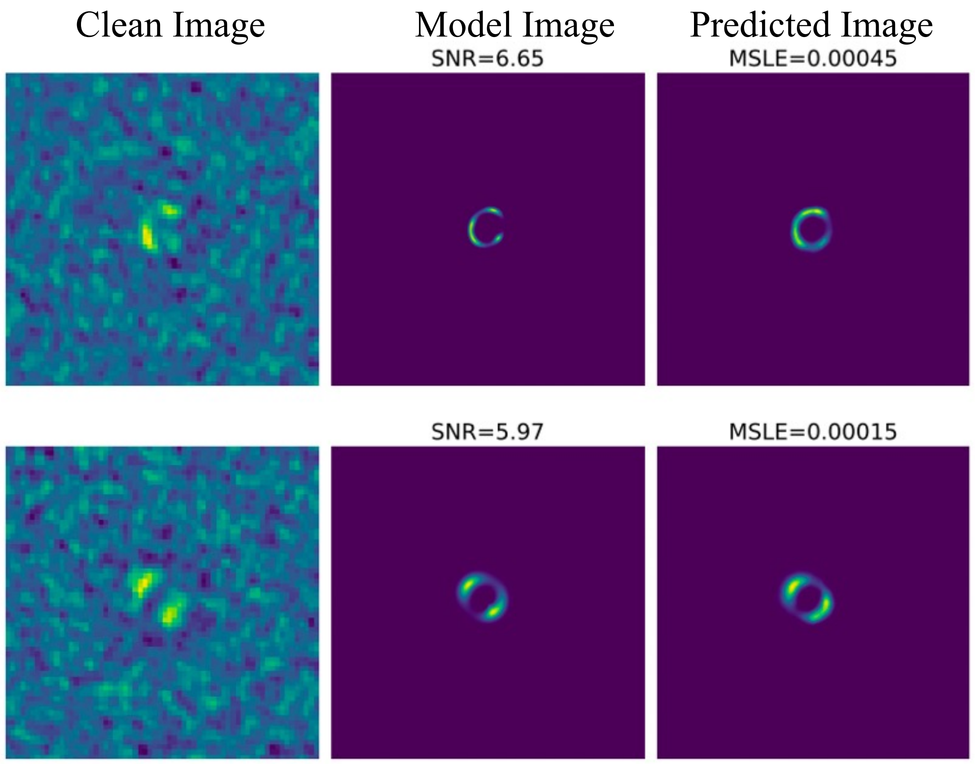
  - Debelending two source emissions: VLT Survey data

VLT Survey Telescope

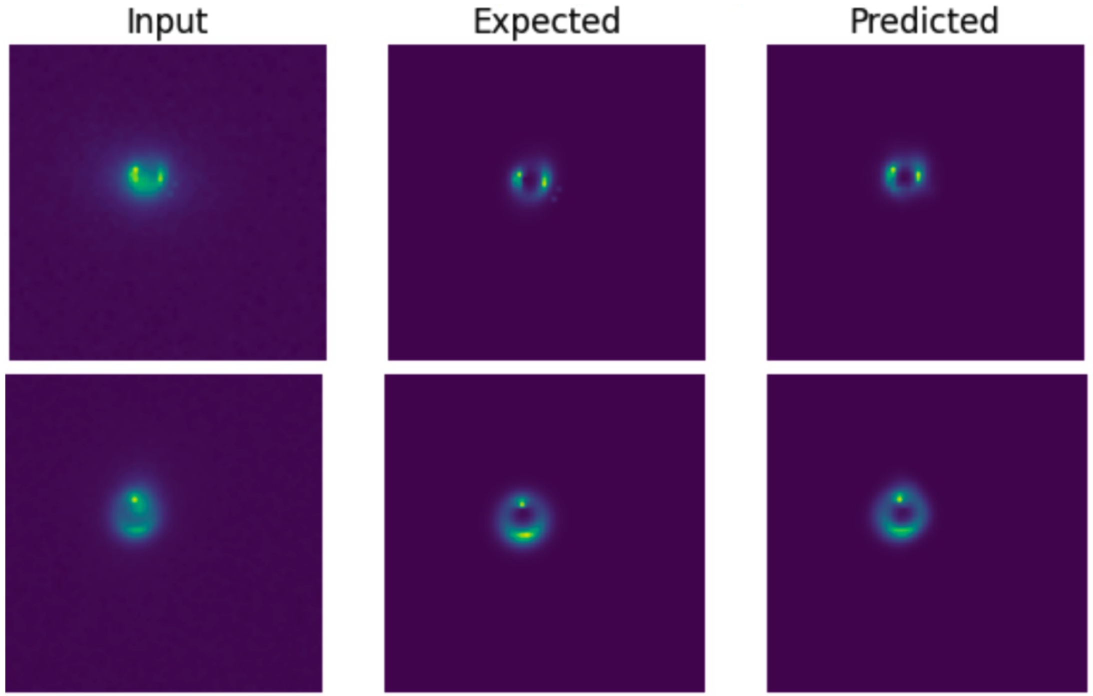


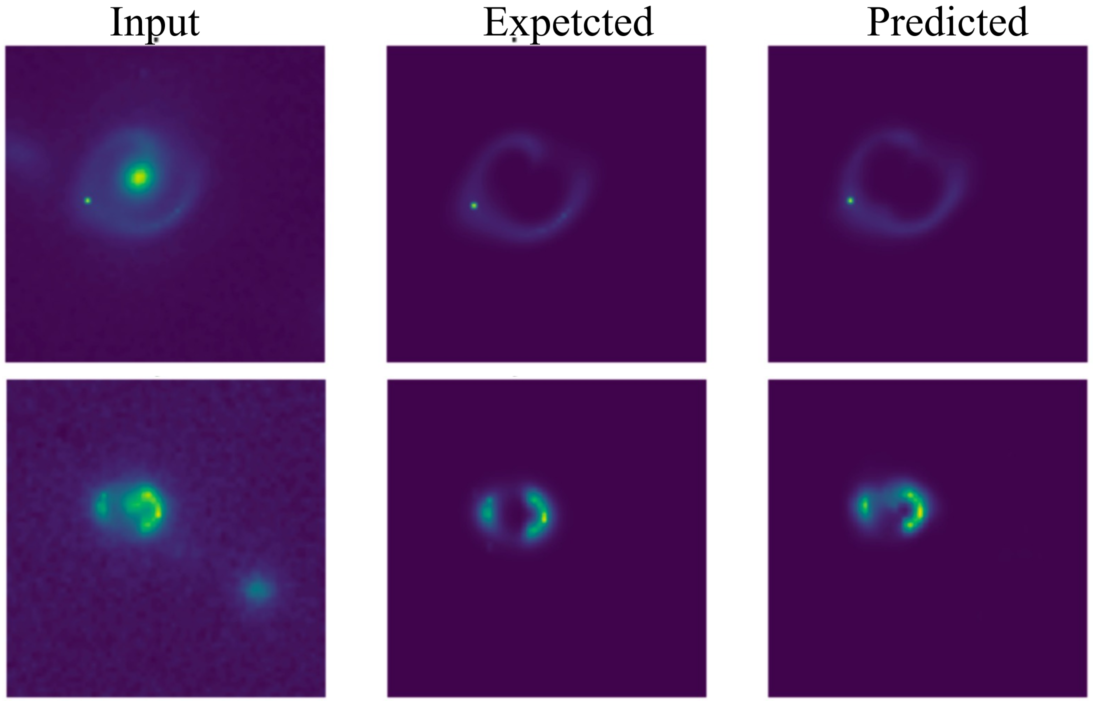
Recovering surface brighhtness distribution: LOFAR data





Debelending two source emissions: VLT Survey data





Final Remarks

- Machine learning has a promising future in astrophysics, if it can prove itself to the astronomers,
- Defining the problem correctly is as important as developing efficient algorithms,
- Having some knowledge on the data and its properties are essential to use AI in astronomy,
- The key to develop practical solutions (for real astrophysical problems) is collaboration.
- AutoML can be a potential solution to reinvent the wheel for many astronomical problems.