DEPARTMENT OF SPACE AND CLIMATE PHYSICS

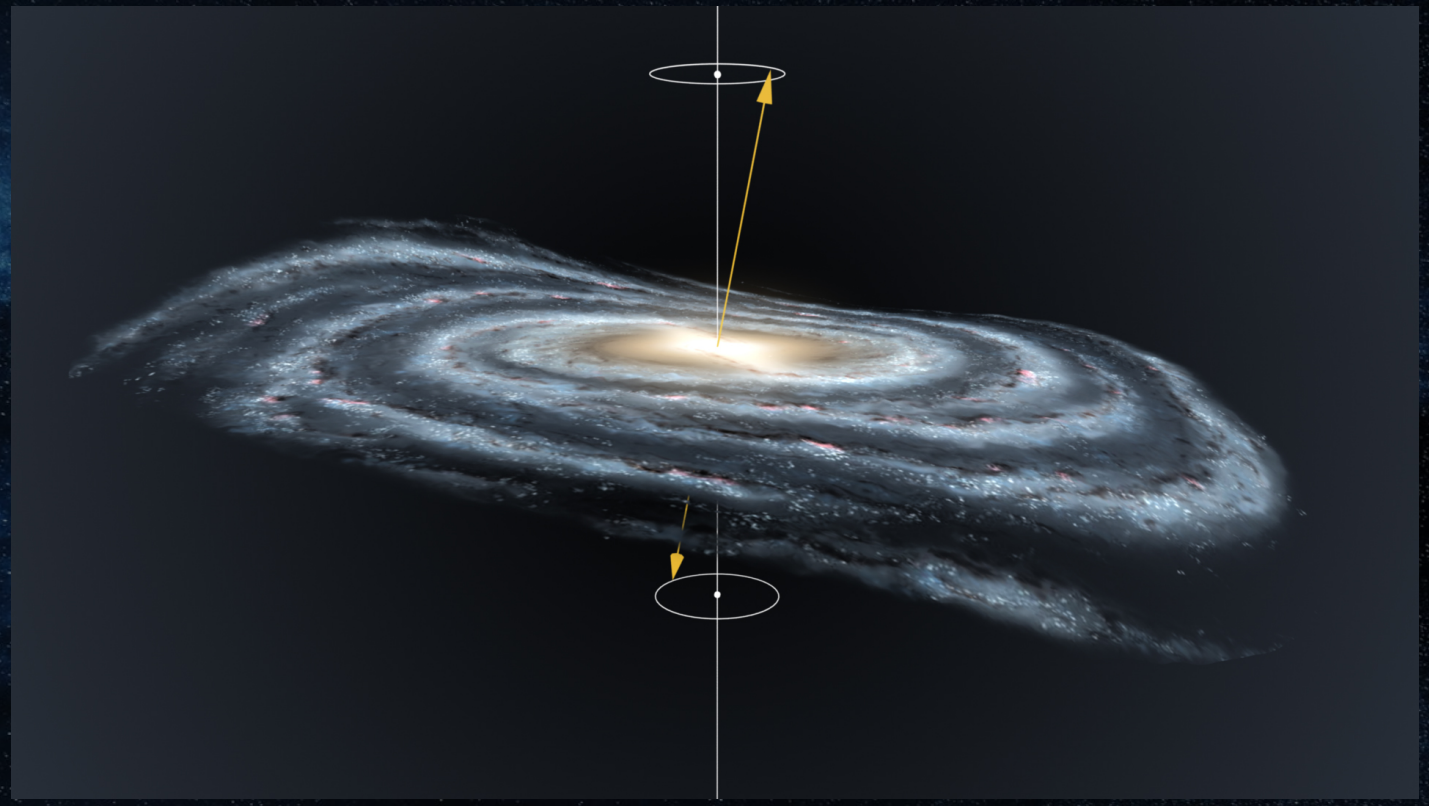
UCL

ANALYSING EDGE-ON GALAXIES WITH DEEP LEARNING

Dr. Žofia Chrobáková (MSSL, UCL)
Physics in the AI Era Conference, 24-27 September, Pisa

Collaborators: Dr. Roman Nagy (FMPI CU), Dr. Peter Butka (TUKE), Dr. Viera Krešňáková (TUKE), Juliána Gazdová (TUKE)

GALACTIC WARPS

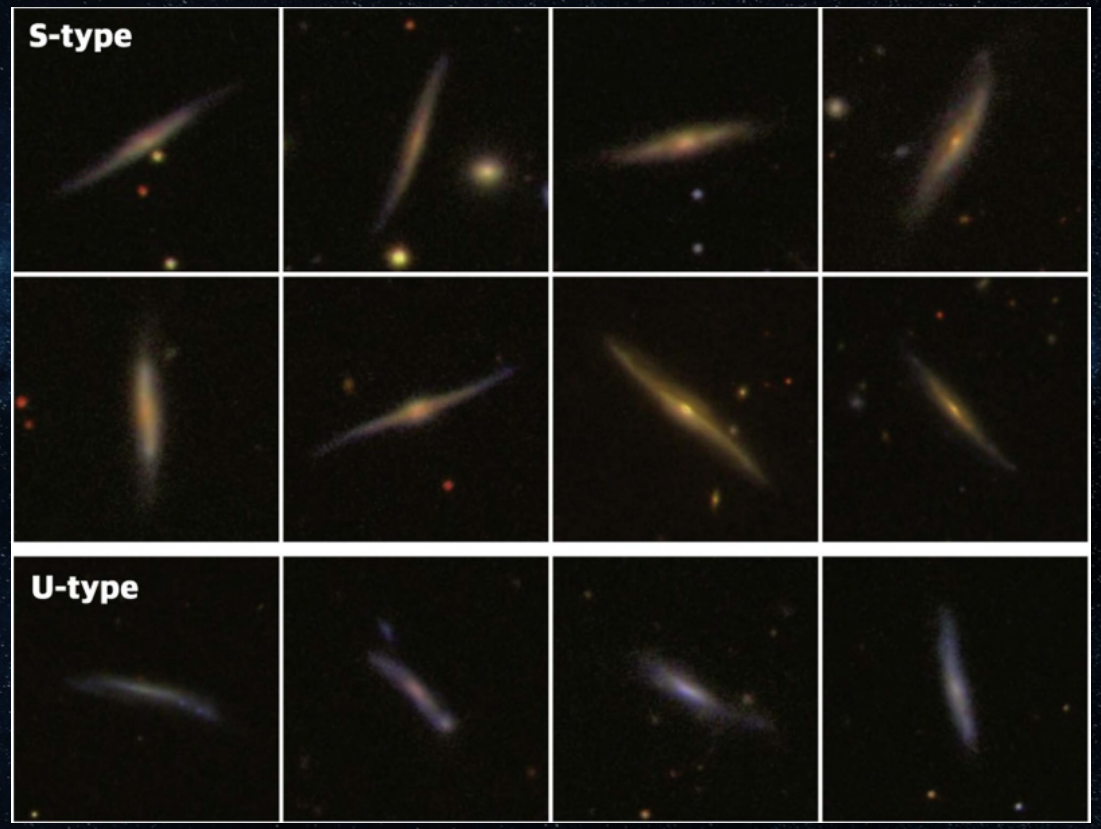


Credit: Gabriel Pérez Díaz, SMM (IAC)

GALACTIC WARPS

- About 70% of spiral galaxies have a warp
- Warps can have various shapes and sizes
- Dependence of warp on environment was observed, but nothing conclusive

EXTRAGALACTIC WARPS



Zee et al. (2022)

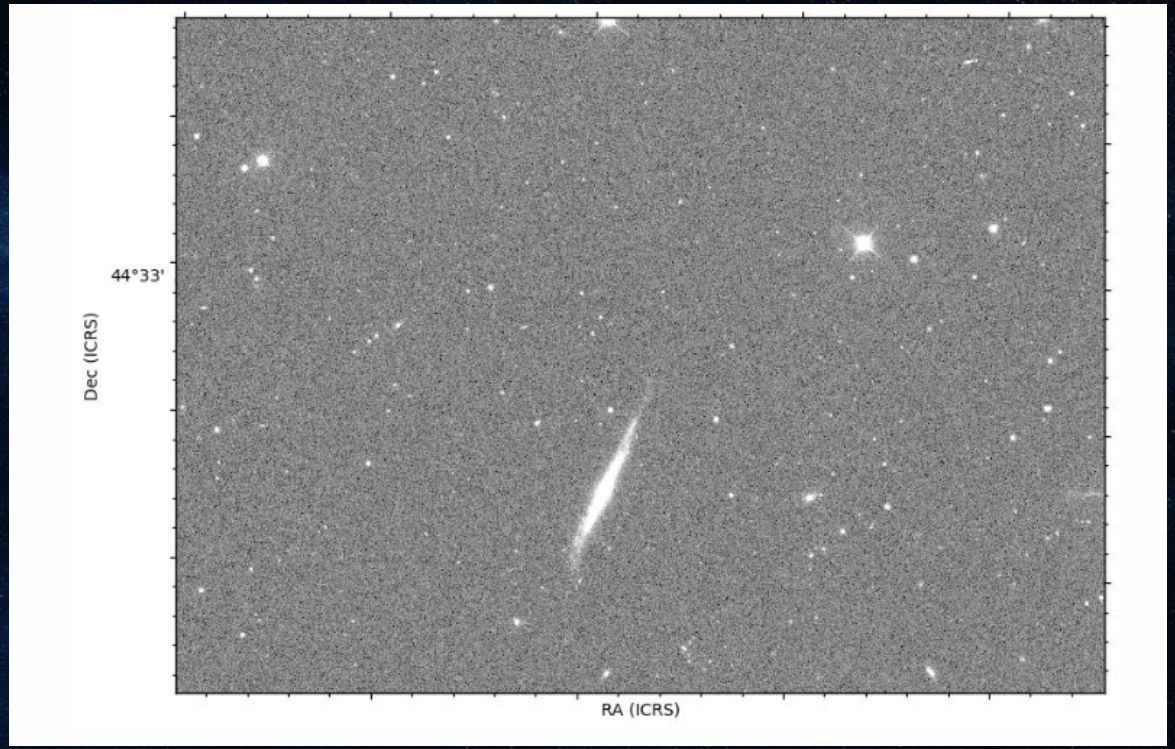
MOTIVATION

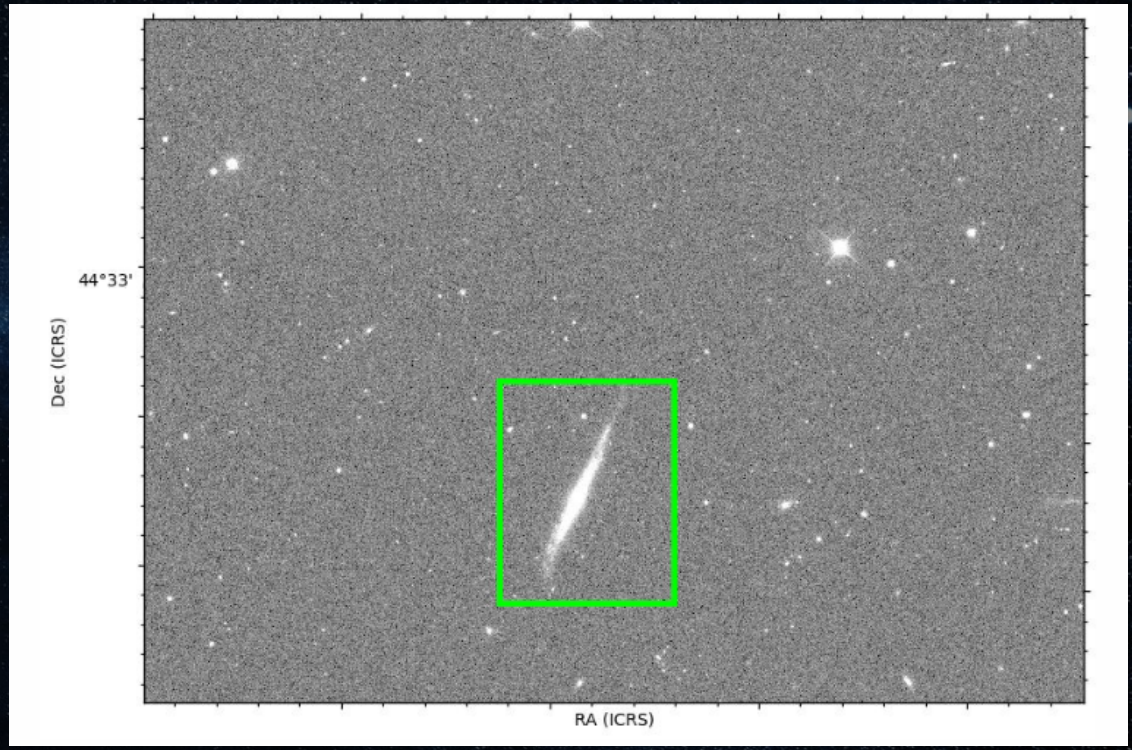
- Get a detailed statistics of warps in the universe, thanks to new surveys
- Connect the findings to the warp in the Milky Way
- Considering the amount of data, machine learning is necessary for the analysis

GALAXY ZOO

- Project at Zooniverse, where volunteers can classify galaxies
- We selected galaxies that at least ~80% of respondent classified as spiral and edge-on
- In the end we have ~15 000 galaxies, for which we download the fits from SDSS DR7
- We use YOLOv5

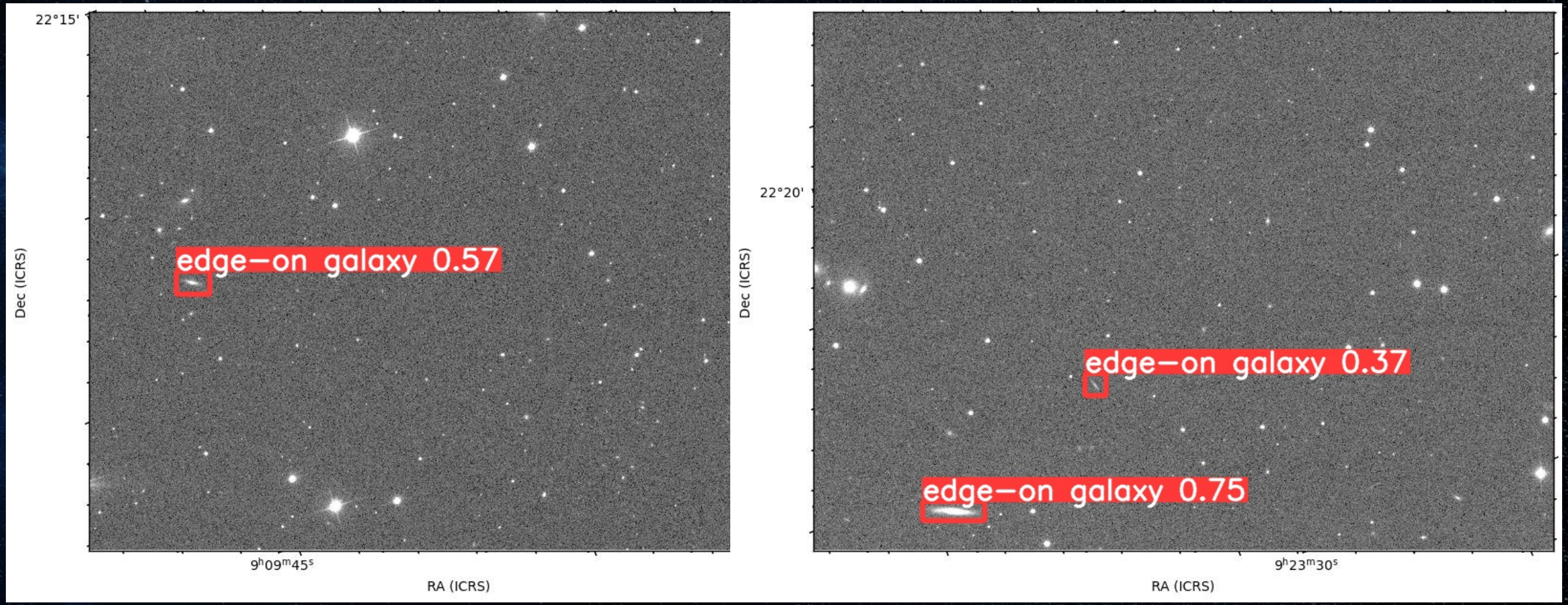
ANNOTATION





RESULTS OF THE DETECTION

RESULTS OF THE DETECTION

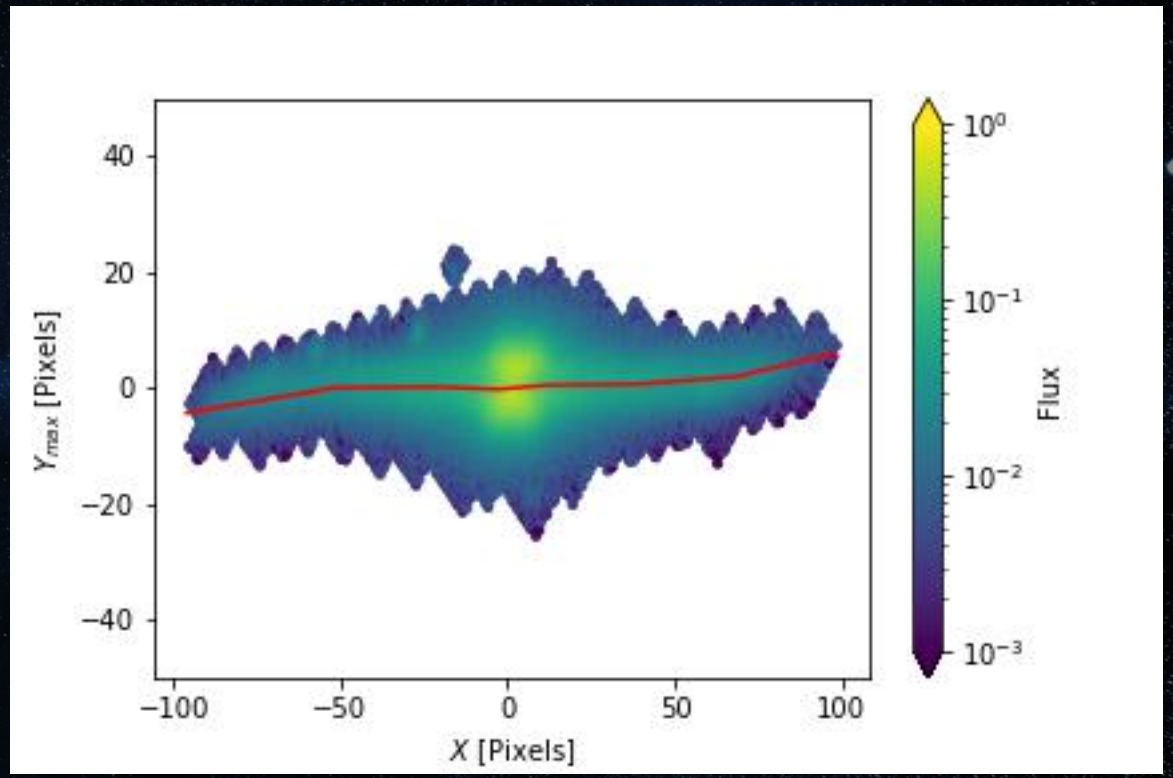


arXiv: 2406.15064

WARP CALCULATION

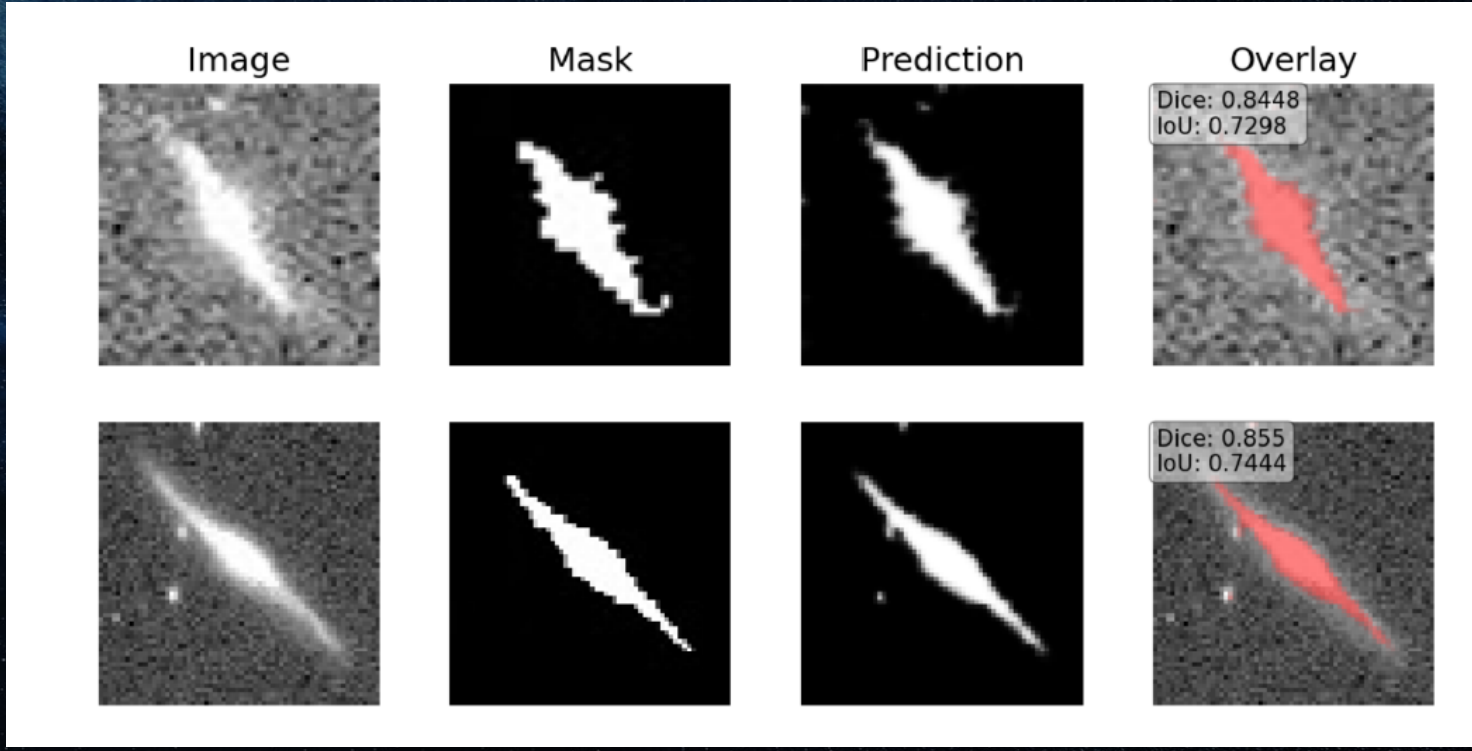
- Let's look at UGC 12253 as an example
- Vertical position of the pixel with maximum flux can be calculated as

$$y_{c,i} = \frac{\int F(x_i, y) Y \mathrm{d}y}{\int F(x_i, y) \mathrm{d}y}$$



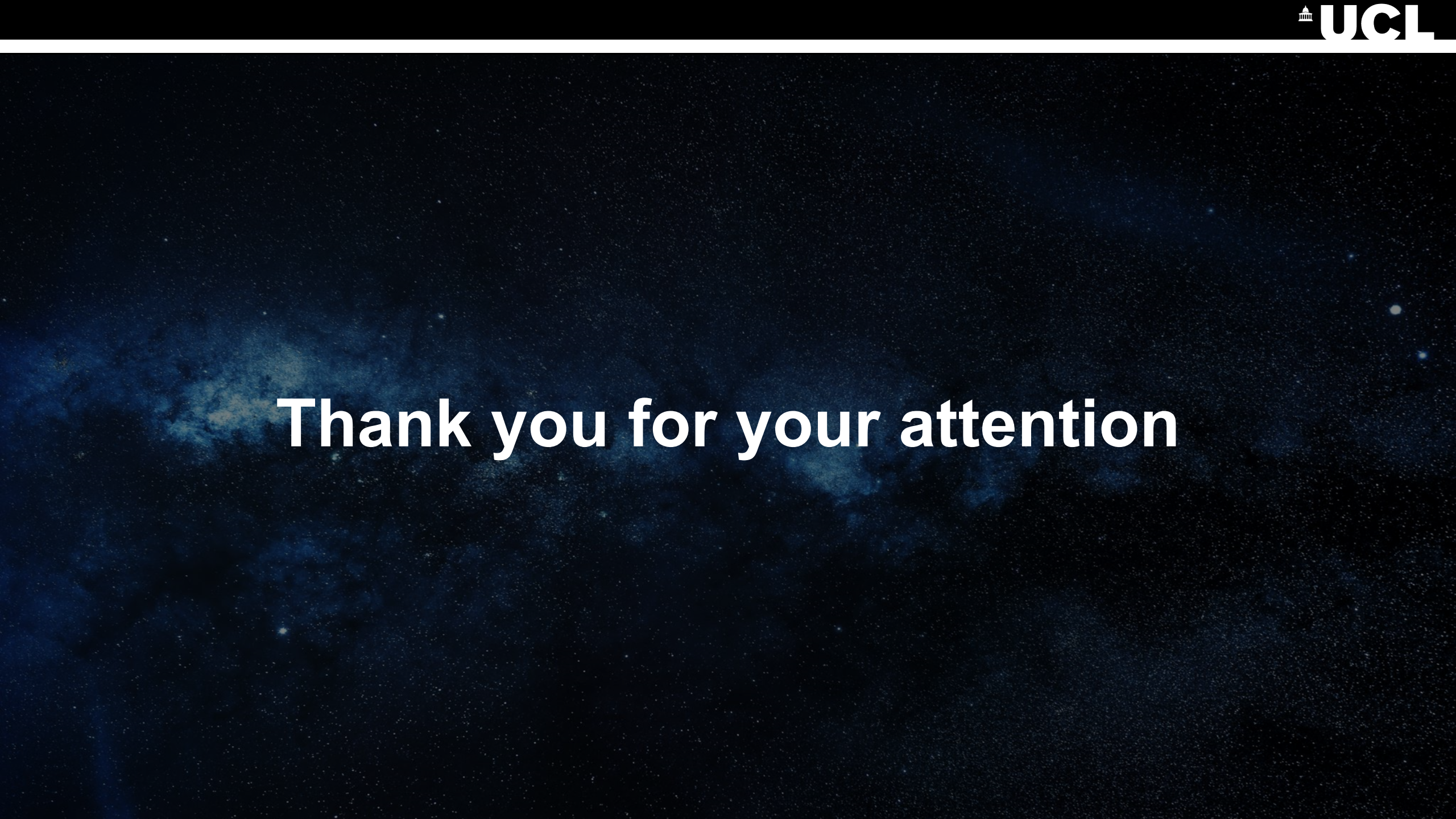
WARP CALCULATION

- Segmentation of galaxies using SCSS-Net

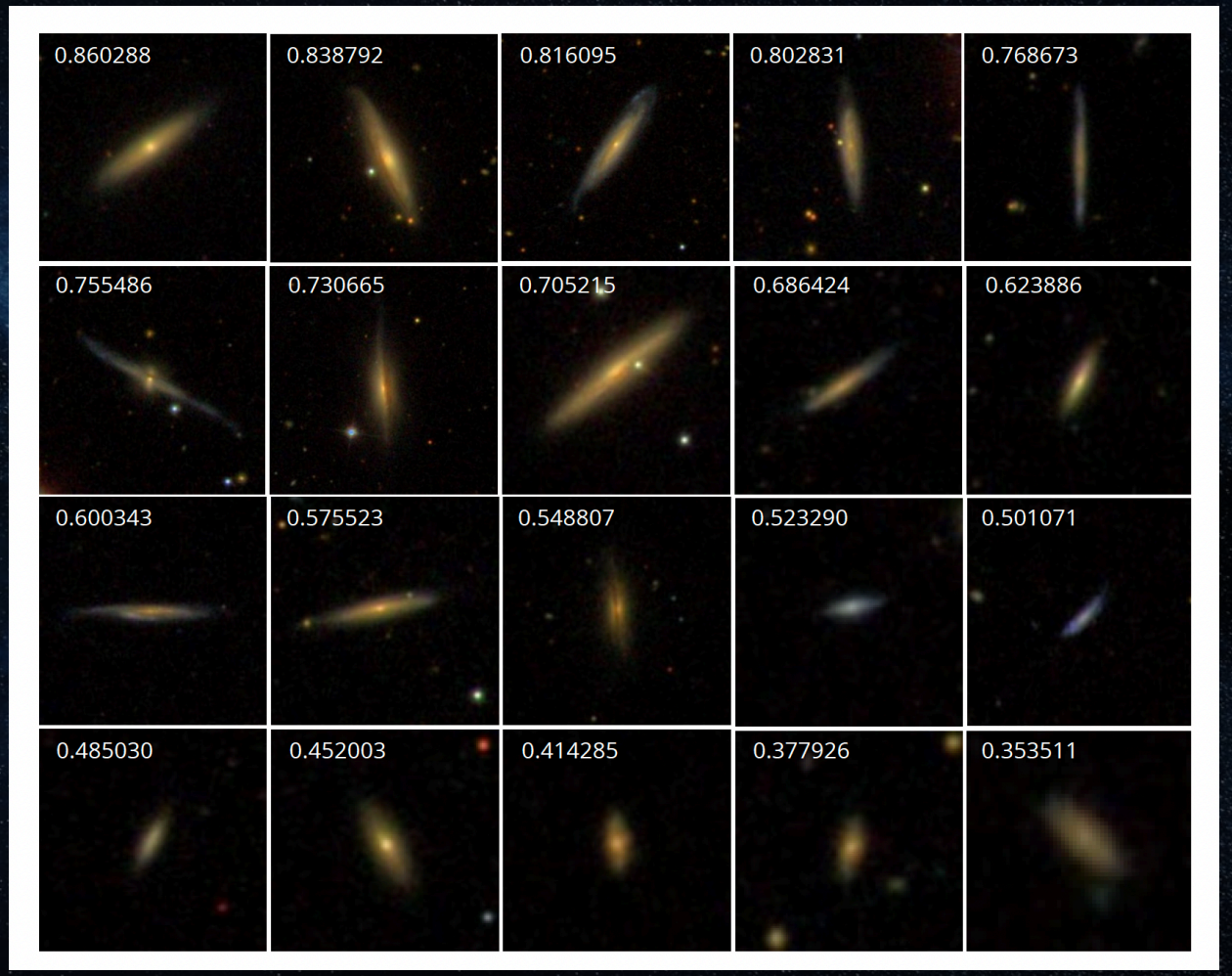


CONCLUSIONS

- We have a very well working deep learning algorithm for detection of spiral, edge-on galaxies
- More work to be done to detect warps, but preliminary results are promising
- Potential for new discoveries with upcoming data


Thank you for your attention

RESULTS OF THE DETECTION



RESULTS OF THE DETECTION

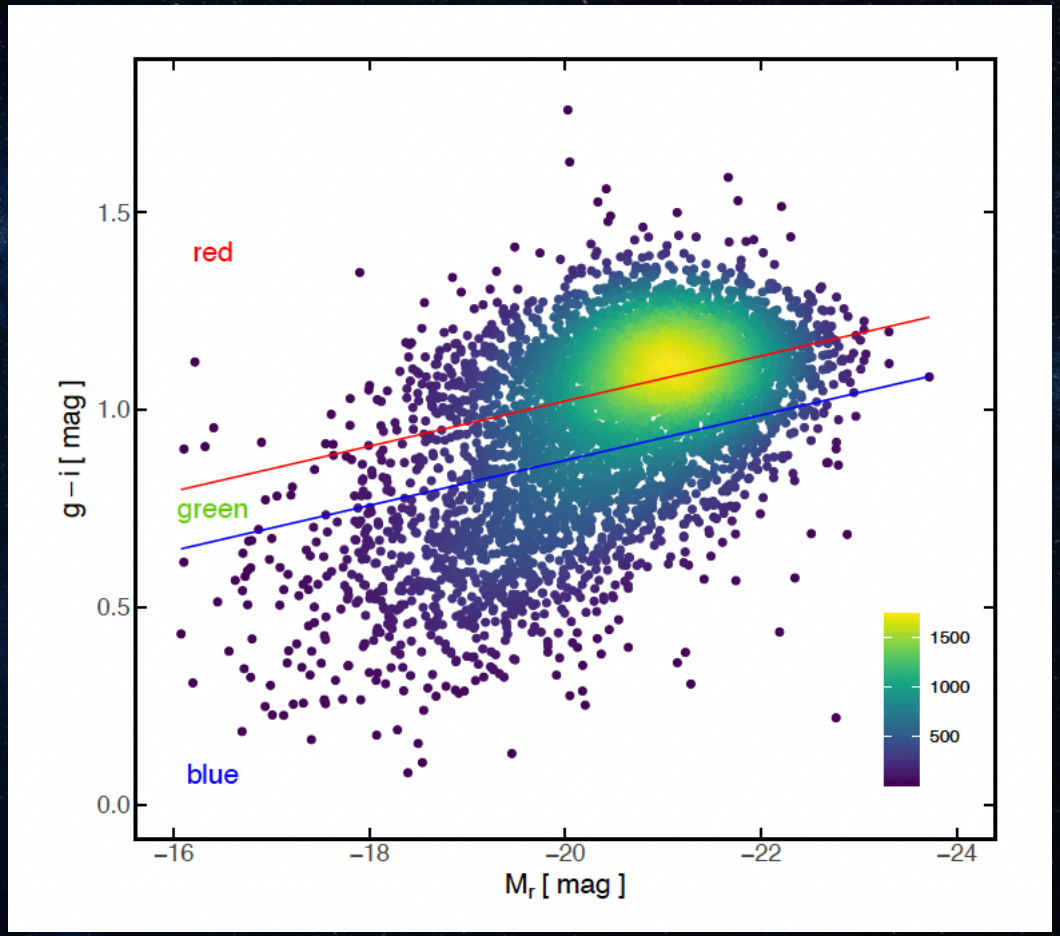
Table 1. Table with metrics calculated by YOLOv5 on testing dataset. One image may contain more than 1 instance of edge-on galaxy. Precision and Recall are calculated according to TP, FP and FN values (see Table 2).

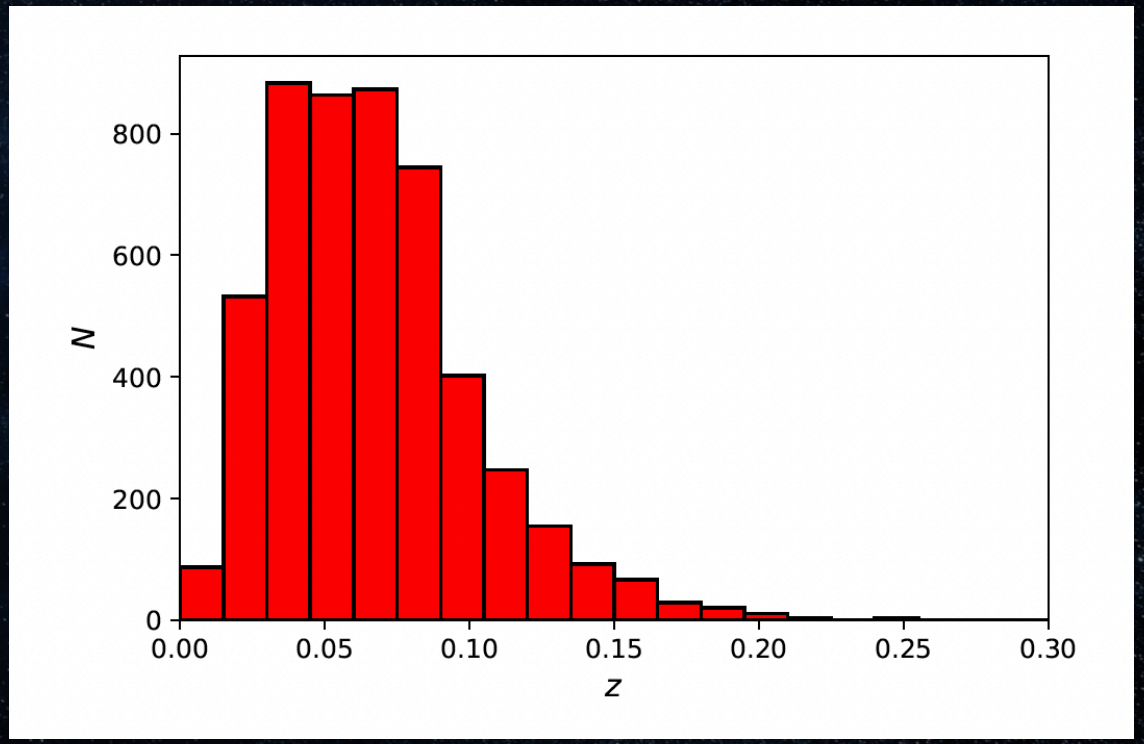
Images	Instances	Precision	Recall
1353	1892	0.80	0.94

Table 2. Summary of TPs, FPs, and FNs identified by the YOLOv5 detection model.

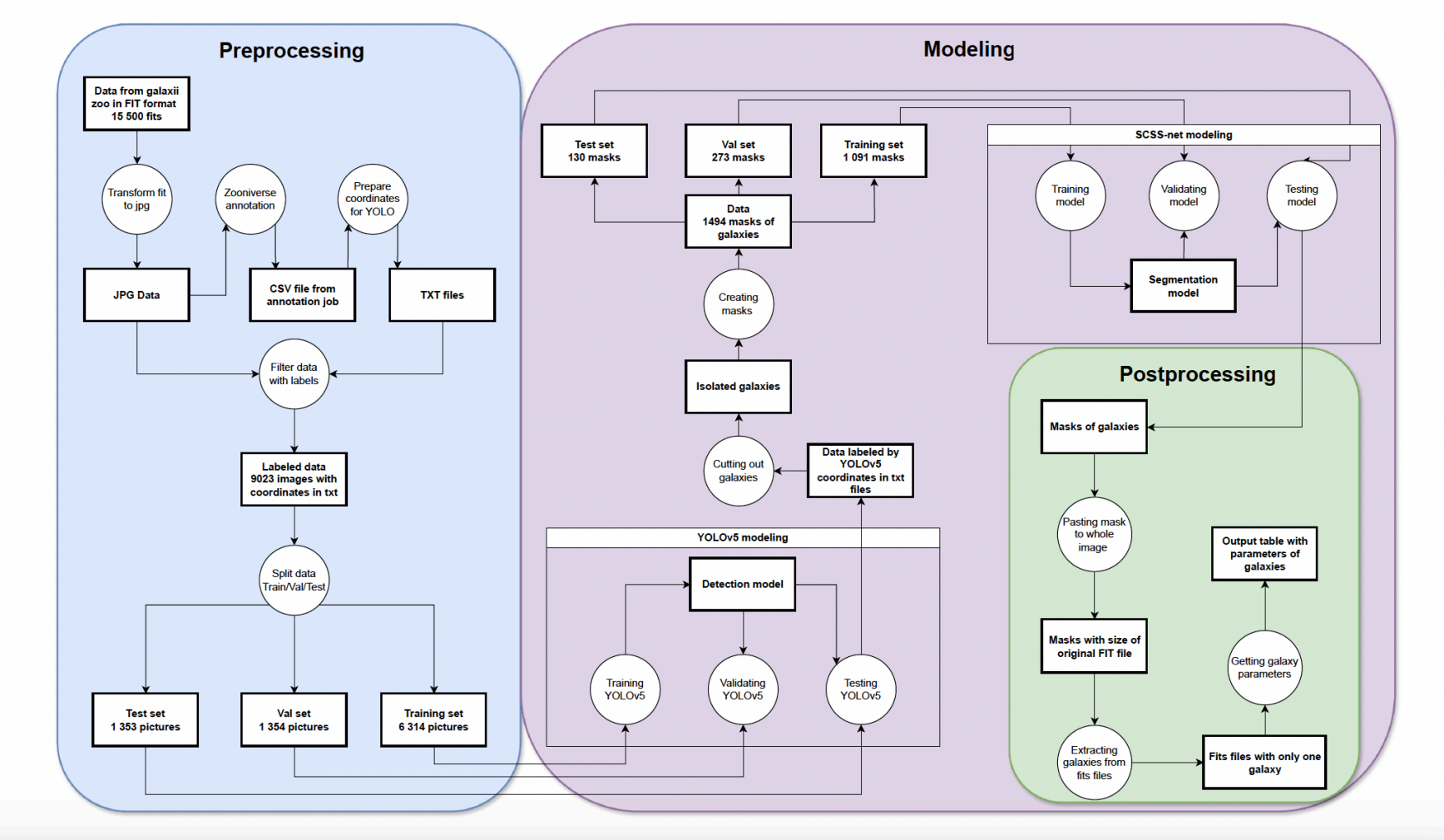
Detection case	Count
True Positives (TP)	1783
False Positives (FP)	442
False Negatives (FN)	113

RESULTS OF THE DETECTION





FLOWCHART


Preprocessing
Data from galaxii zoo in FIT format 15 500 fits
Transform fit to jpg
Zooniverse annotation
Prepare coordinates for YOLO
JPG Data
CSV file from annotation job
TXT files
Filter data with labels
Labeled data 9023 images with coordinates in txt
Split data Train/Val/Test
Test set 1 353 pictures
Val set 1 354 pictures
Training set 6 314 pictures
Modeling
Test set 130 masks
Val set 273 masks
Training set 1 091 masks
Data 1494 masks of galaxies
Creating masks
Isolated galaxies
Cutting out galaxies
Data labeled by YOLOv5 coordinates in txt files
YOLOv5 modeling
Detection model
Training YOLOv5
Validating YOLOv5
Testing YOLOv5
SCSS-net modeling
Training model
Validating model
Testing model
Segmentation model
Postprocessing
Masks of galaxies
Pasting mask to whole image
Masks with size of original FIT file
Extracting galaxies from fits files
Fits files with only one galaxy
Getting galaxy parameters
Output table with parameters of galaxies