Galaxies OBserved as Low-luminosity Identified Nebulae (GOBLIN): Catalog of 43,000 high-probability dwarf galaxy candidates in the UNIONS survey

In collaboration with: David Chemaly, Oliver Müller, Elisabeth Sola, Sébastien Fabbro, Ashley Ferreira, Alan W. McConnachie, Eugene Magnier, Michael J. Hudson, Kenneth Chambers, François Hammer, and Ruben Sanchez-Janssen

EPFL

Nick Heesters

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The Ultraviolet Near Infrared Optical Northern Survey

CFIS (u + r)

Canada-France-Hawaii-Telescope (CFHT)
Credit: Gordon W Myers

Pan-STARRS (i)

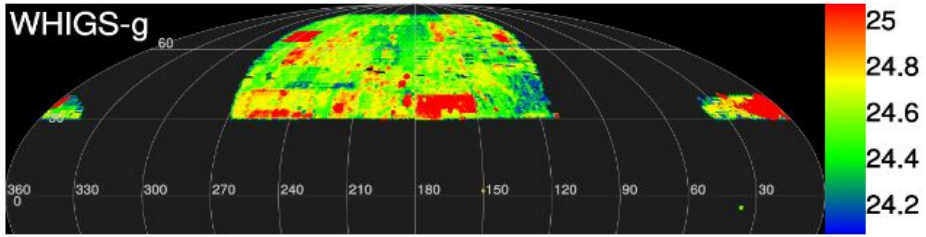
Pan-STARRS Telescopes on Haleakalā
Credit: Forest and Kim Starr

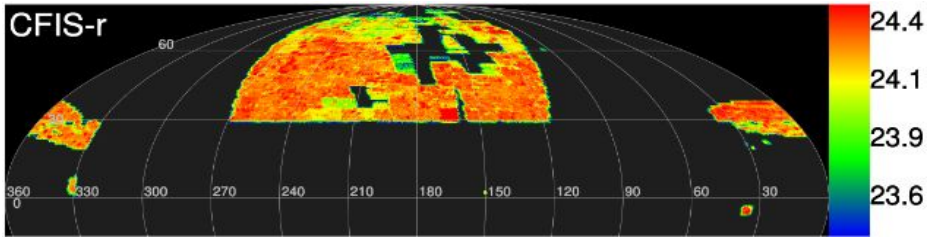
WISHES (z) **WHIGS (g)**

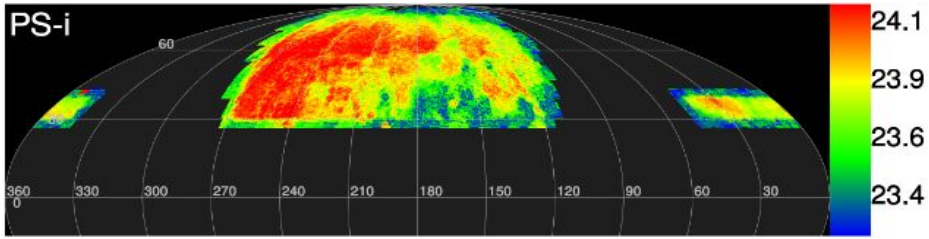
Subaru Telescope on Mauna Kea
Credit: Denys

www.skysurvey.cc

Coverage & depth





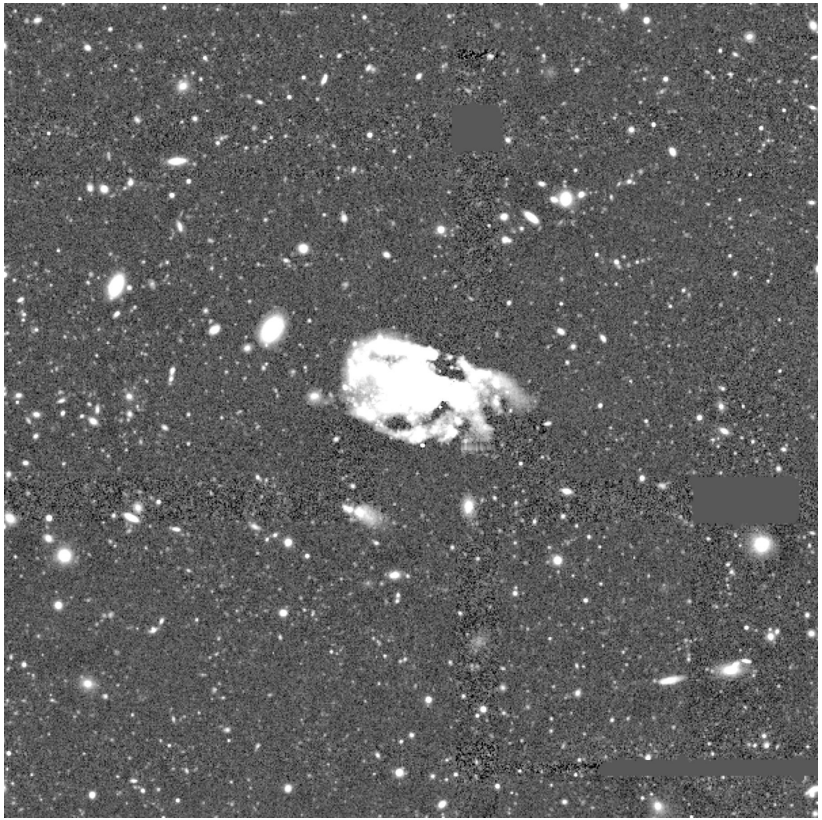


Gwyn et al. 2025, arXiv:2503.13783

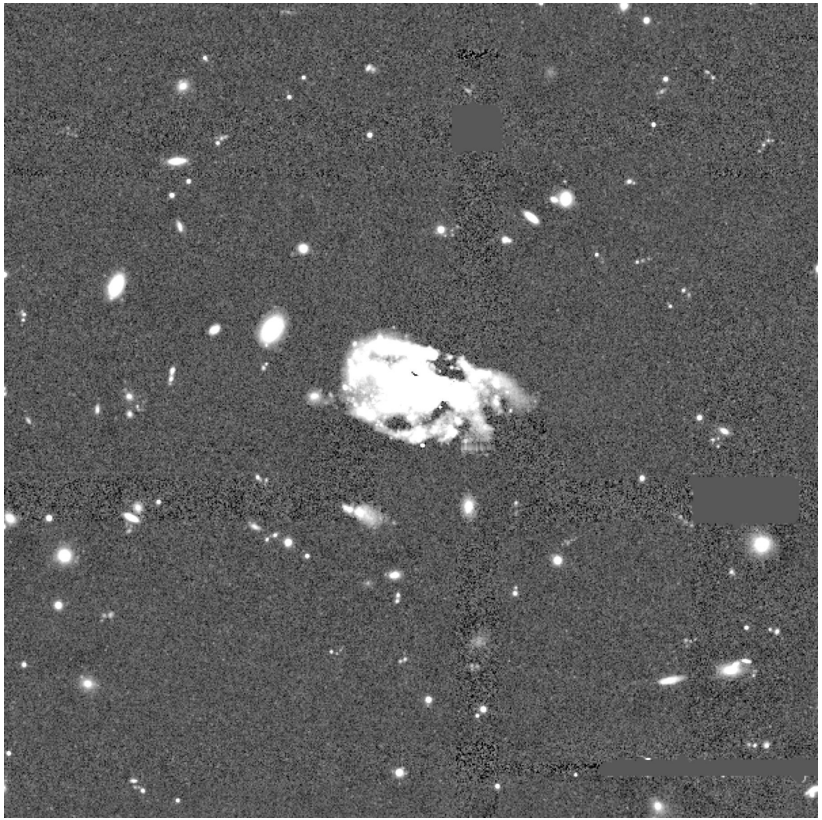
Preprocessing steps: original image

Binning (4x4 pixels)

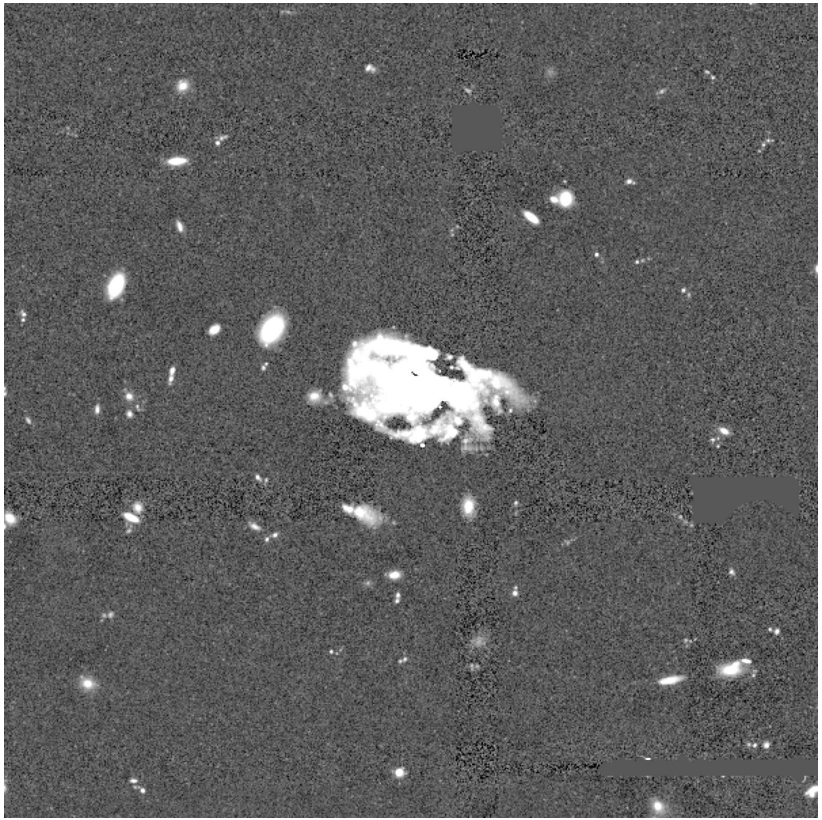
Correcting over-subtraction & masking anomalies



Masking tiny objects

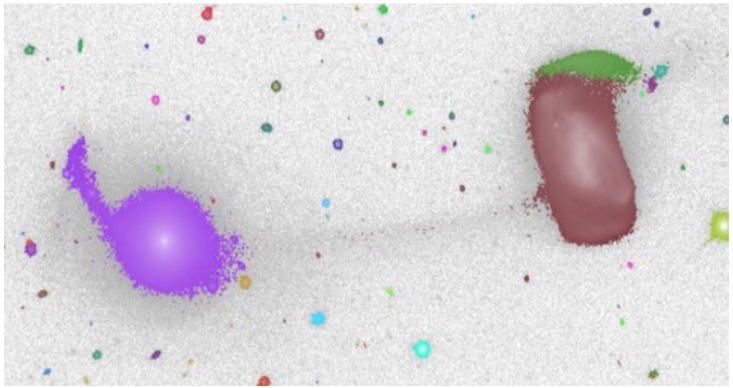


Masking Milky Way stars

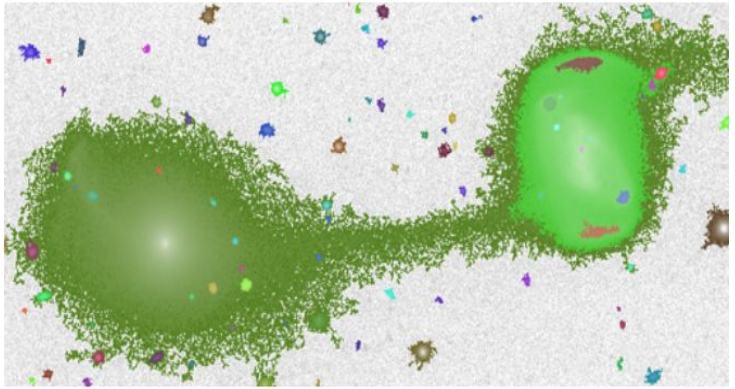


Detection using MTObjects (MTO)

- Similar to Source-Extractor but:
  - Optimized for low-surface-brightness objects
  - Non-parametric



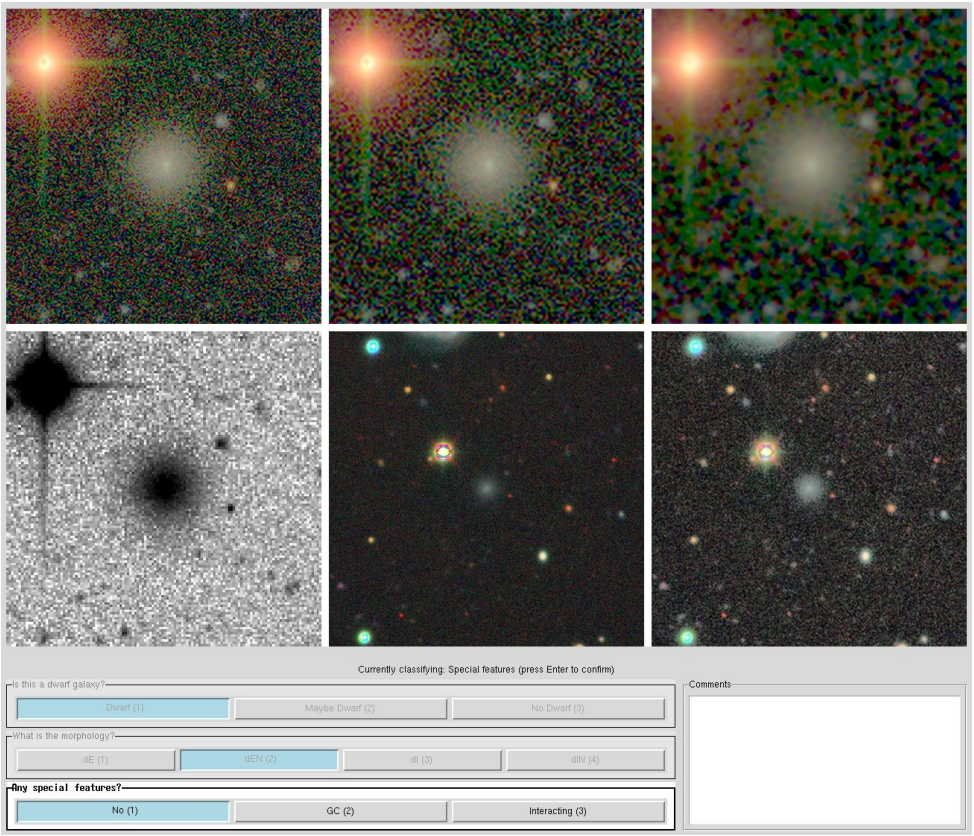
Source Extractor

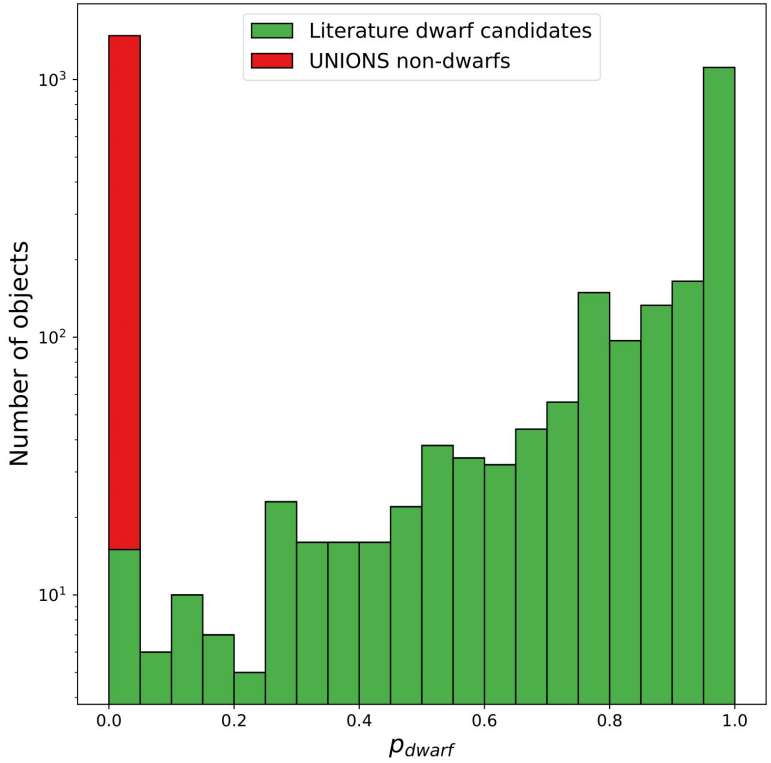


MTO

Teeninga et al. 2015, ISMM, Springer, 157–168; Teeninga et al. 2016, MMTA, 1; github.com/CarolineHaigh/mtobjects

Assigning probabilities to dwarf candidates





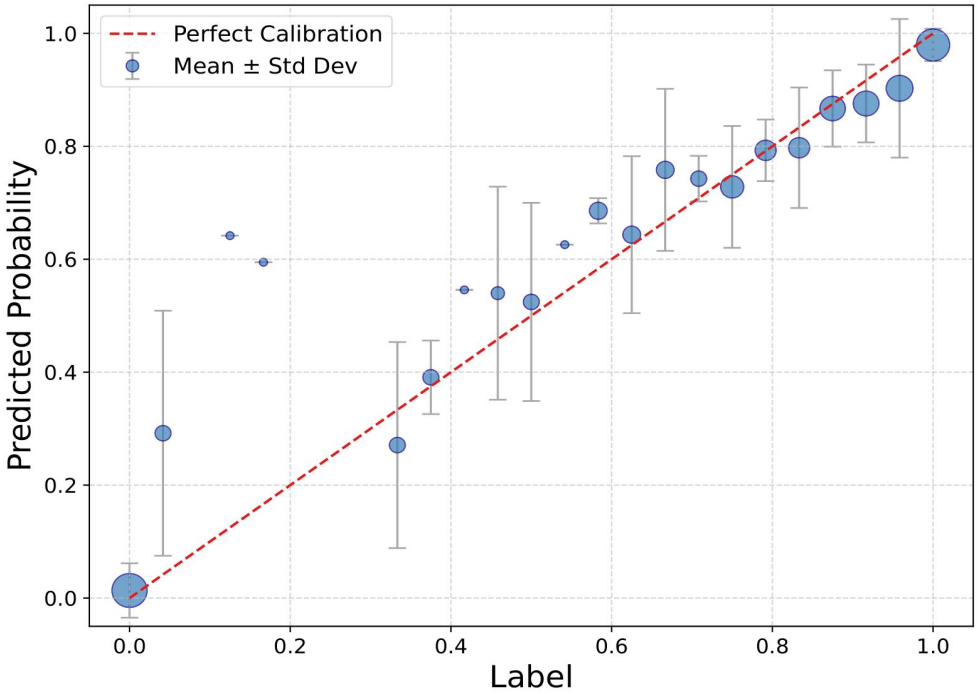
Heesters et al. 2025, A&A, Forthcoming article; arXiv:2505.18307

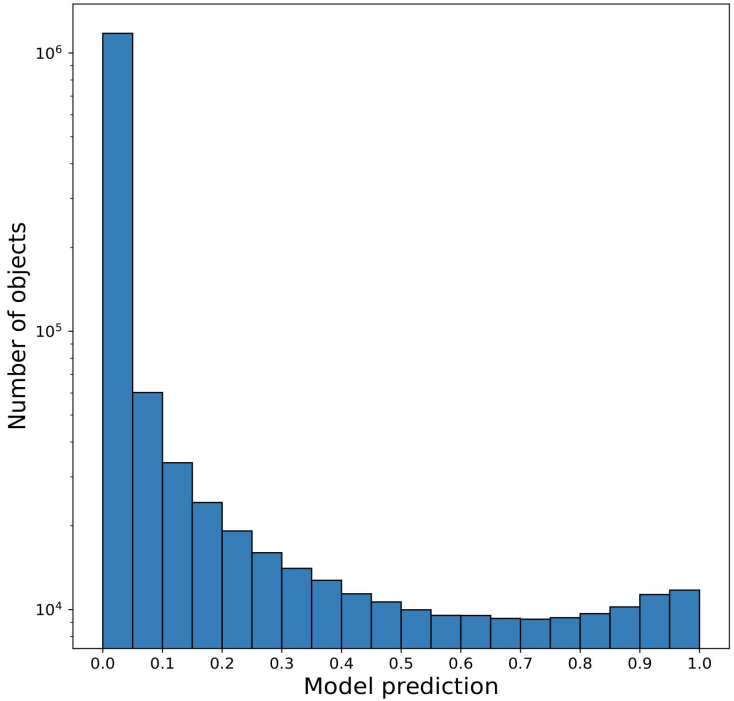
Fine-tuning Zoobot

Original Zoobot	Fine-tuning	Dwarf Classifier
• Trained on Galaxy Zoo data • Over a million labeled images • General galaxy morphology classification	• Our visual classifications • ~3,500 training examples • Soft labels (probabilities)	• Specialized for dwarf classification • Outputs probability scores

Lintott et al. 2008, MNRAS, 389, 1179; Willett et al. 2013, MNRAS, 435, 2835; Walmsley et al. 2023, JOSS, 8; github.com/mwalmsley/zoobot

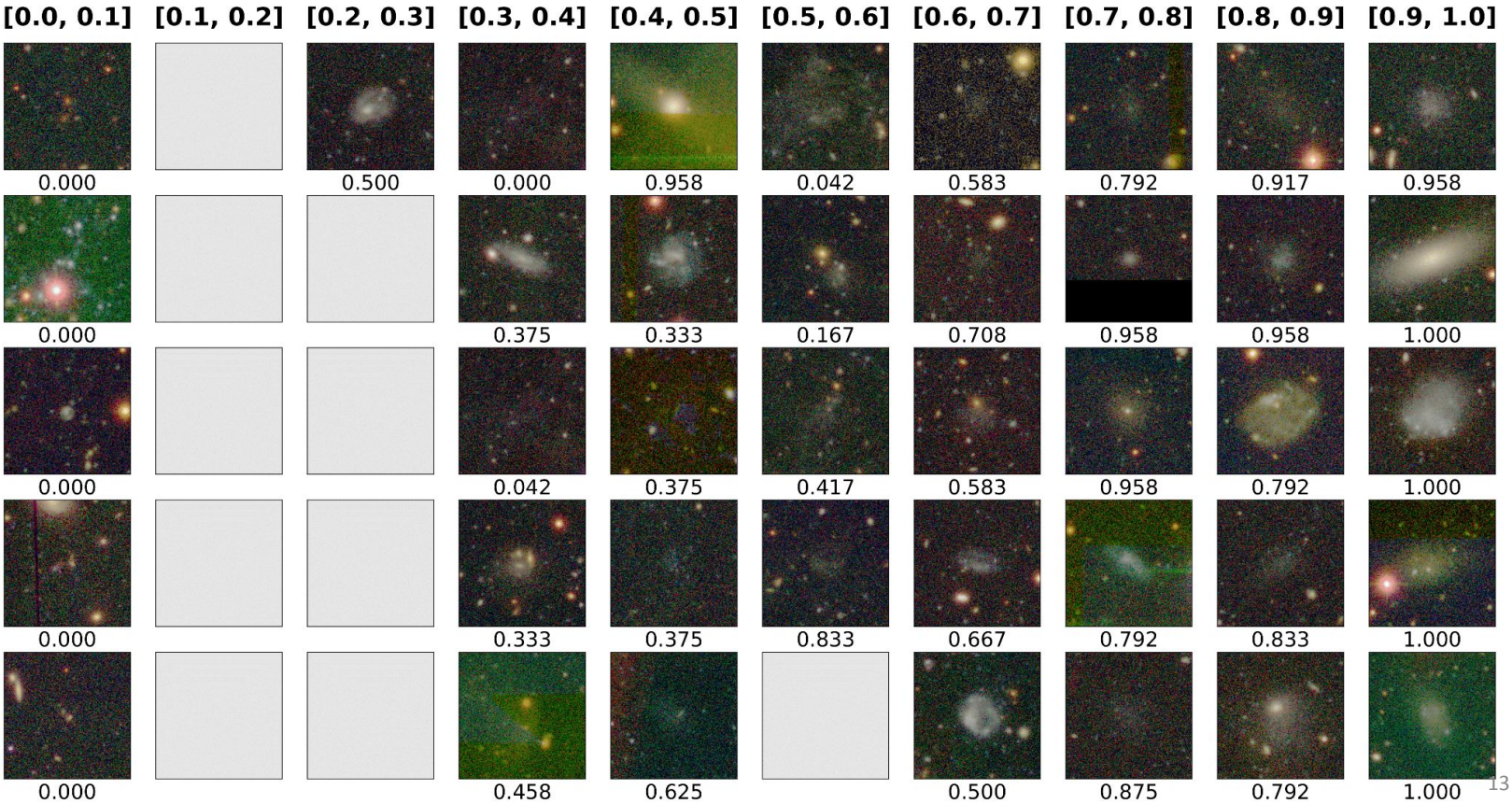
Model performance



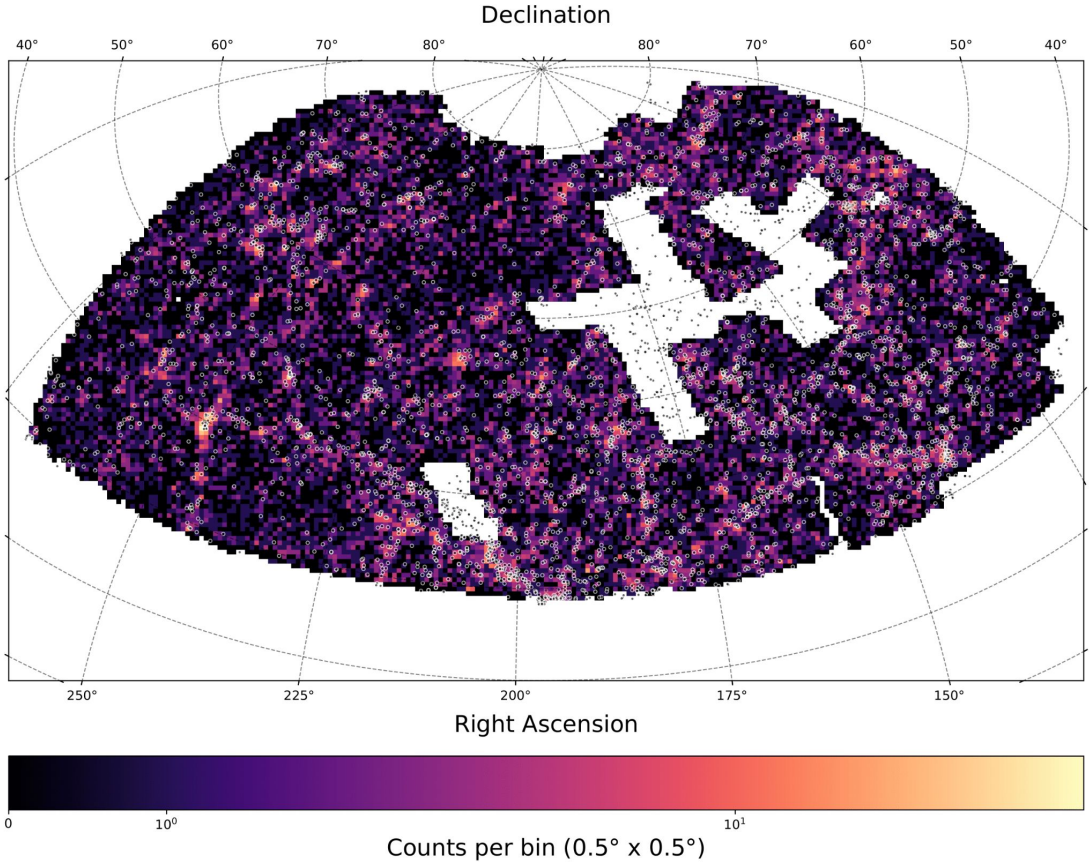


Heesters et al. 2025, A&A, Forthcoming article; arXiv:2505.18307

Example predictions



Spatial distribution of high-confidence candidates

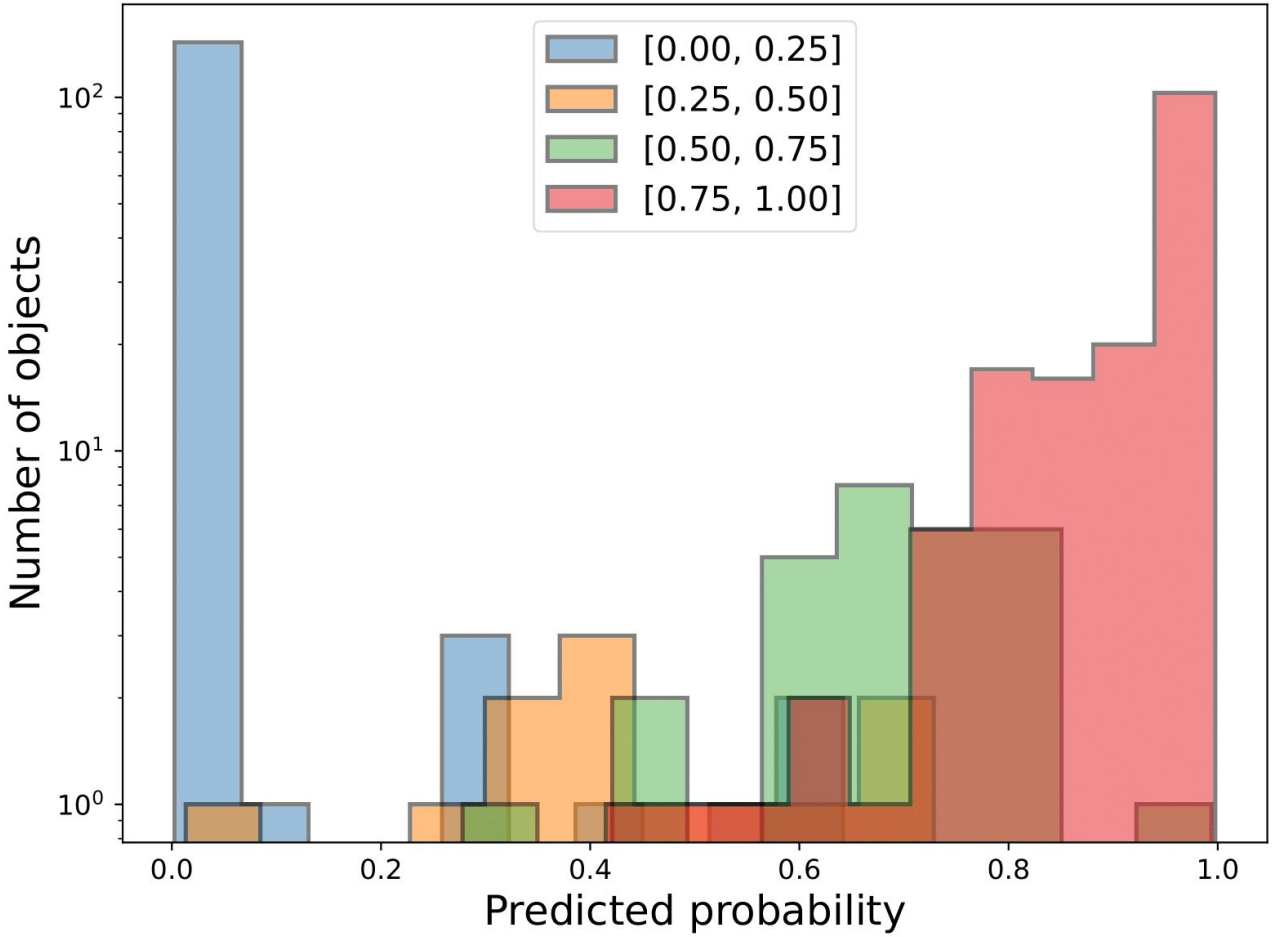


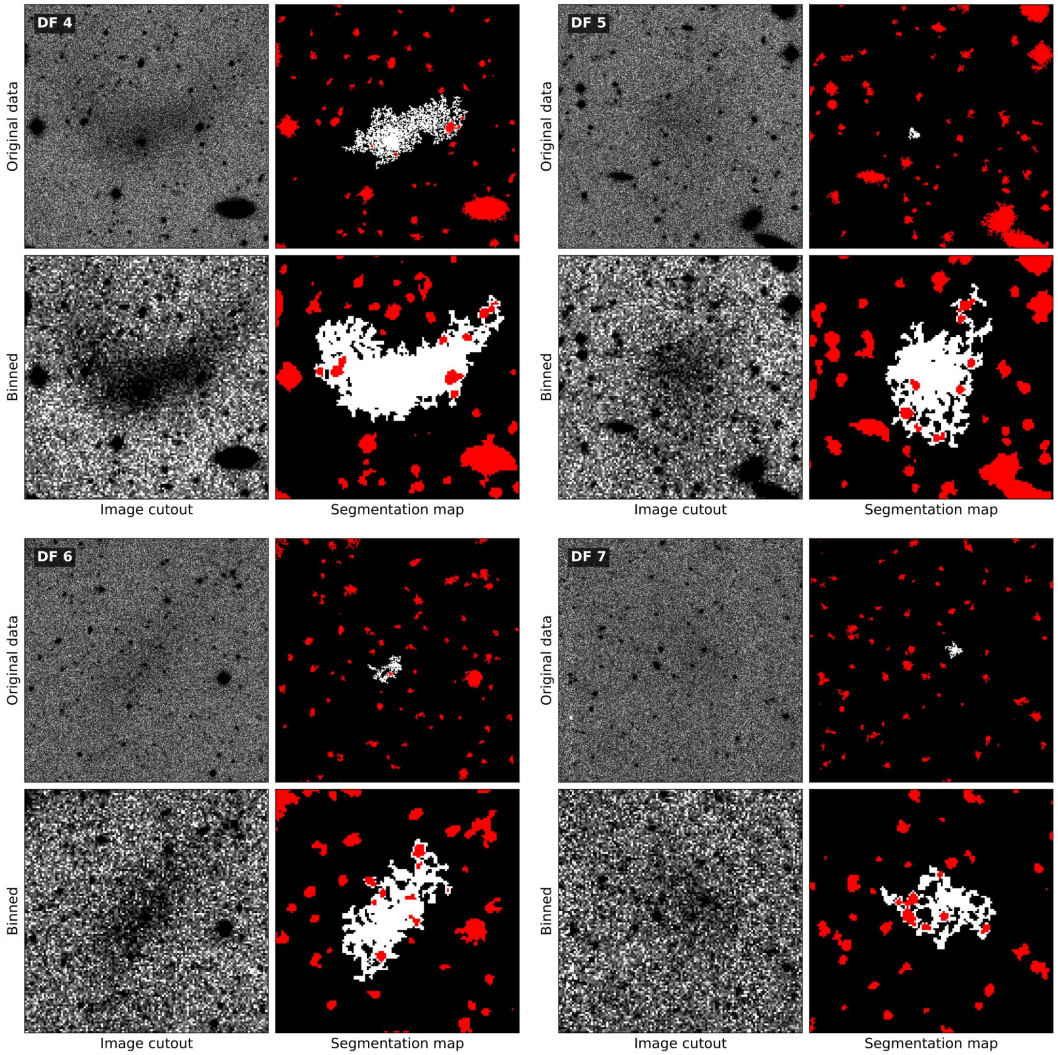
Conclusions

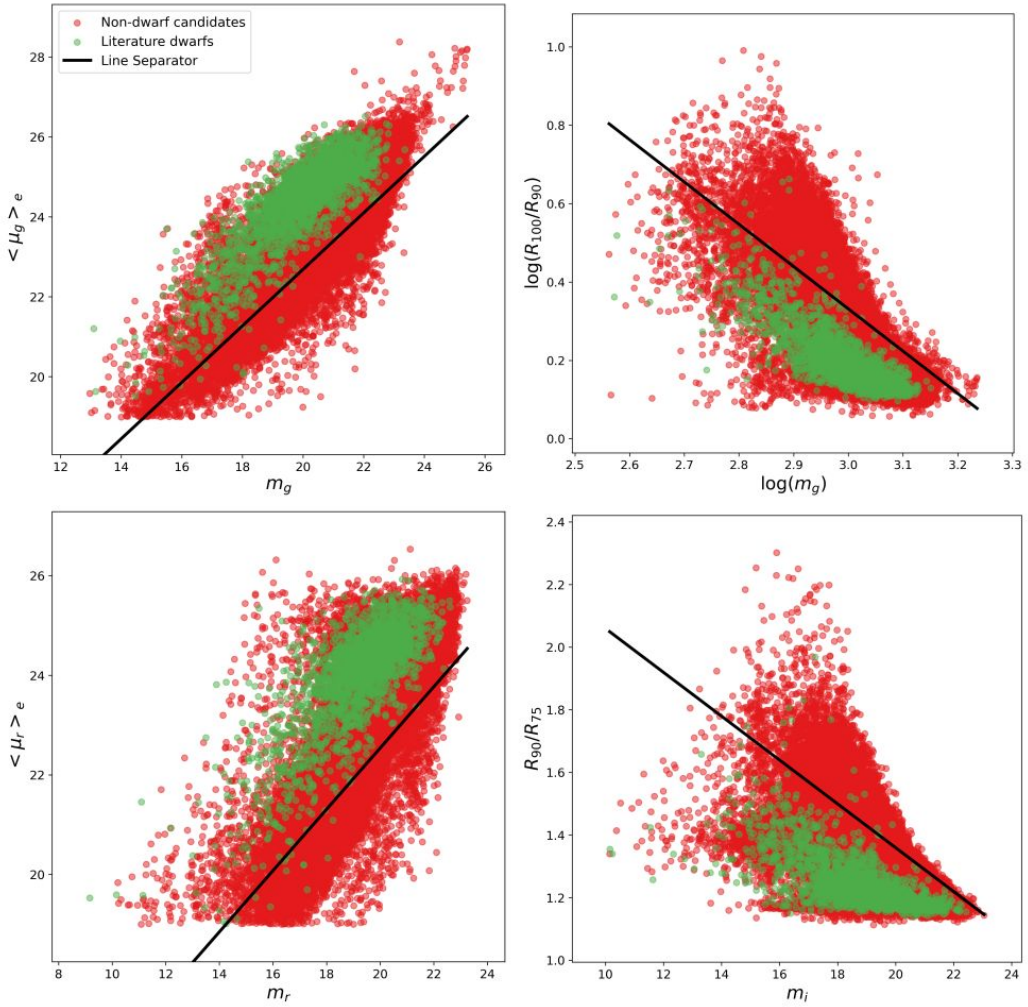
- Large-scale search for nearby dwarf galaxies in the UNIONS survey
- Used dwarf galaxy candidates from the literature to train the model
- Fine-tuned deep learning model Zoobot as a dwarf galaxy classifier
- Model returns probability of being a dwarf galaxy based on morphology
- Model predicts ~43,000 high-probability candidates ($p_{dwarf} > 0.8$)
- High-confidence candidates follow the projected distribution of massive galaxies ($\rightarrow$ likely satellites)
- Full GOBLIN catalog (~1.5 million objects with p_{dwarf}) available online (soon)

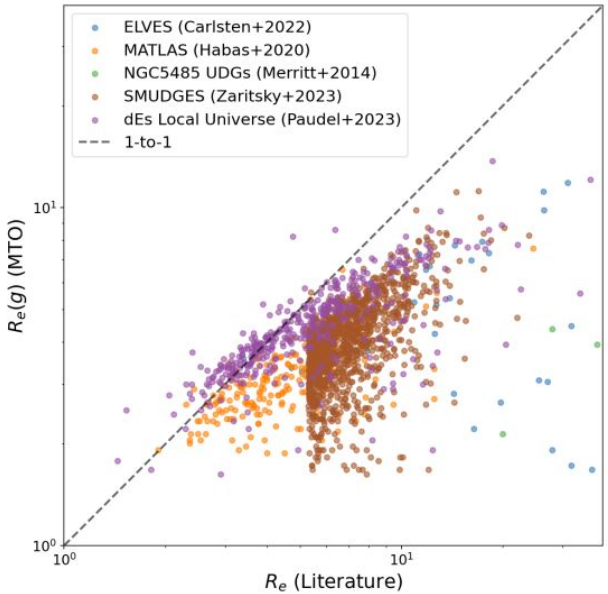
Backup

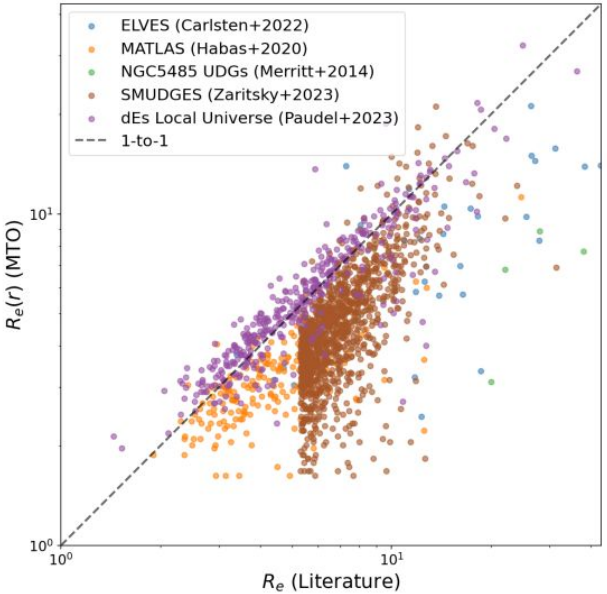
Catalog	Number of Objects	Distance (Mpc)
ELVES	49	< 12
MATLAS	315	$\sim$10 - 45
SAGA	27	25 - 40.75
SMUDGES	1212	$\lesssim 143$
NGC5485 UDGs	4	$\sim$27
dEs Local Universe	402	$\lesssim 40$

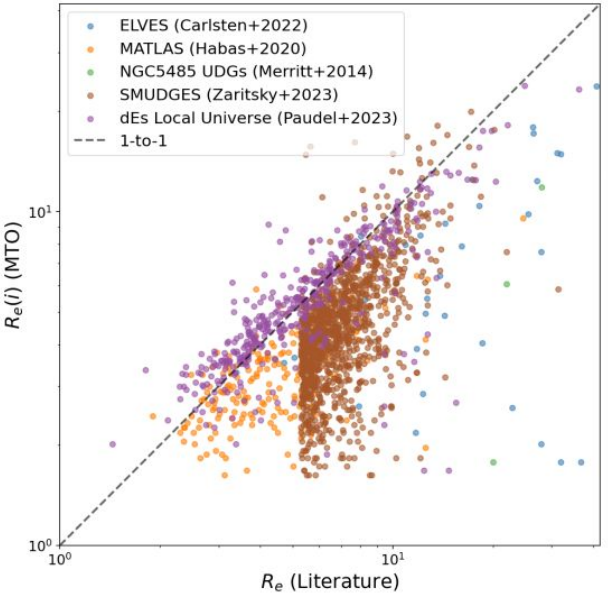

[0.00, 0.25]
[0.25, 0.50]
[0.50, 0.75]
[0.75, 1.00]
Number of objects
10^2
10^1
10^0
0.0
0.2
0.4
0.6
0.8
1.0
Predicted probability

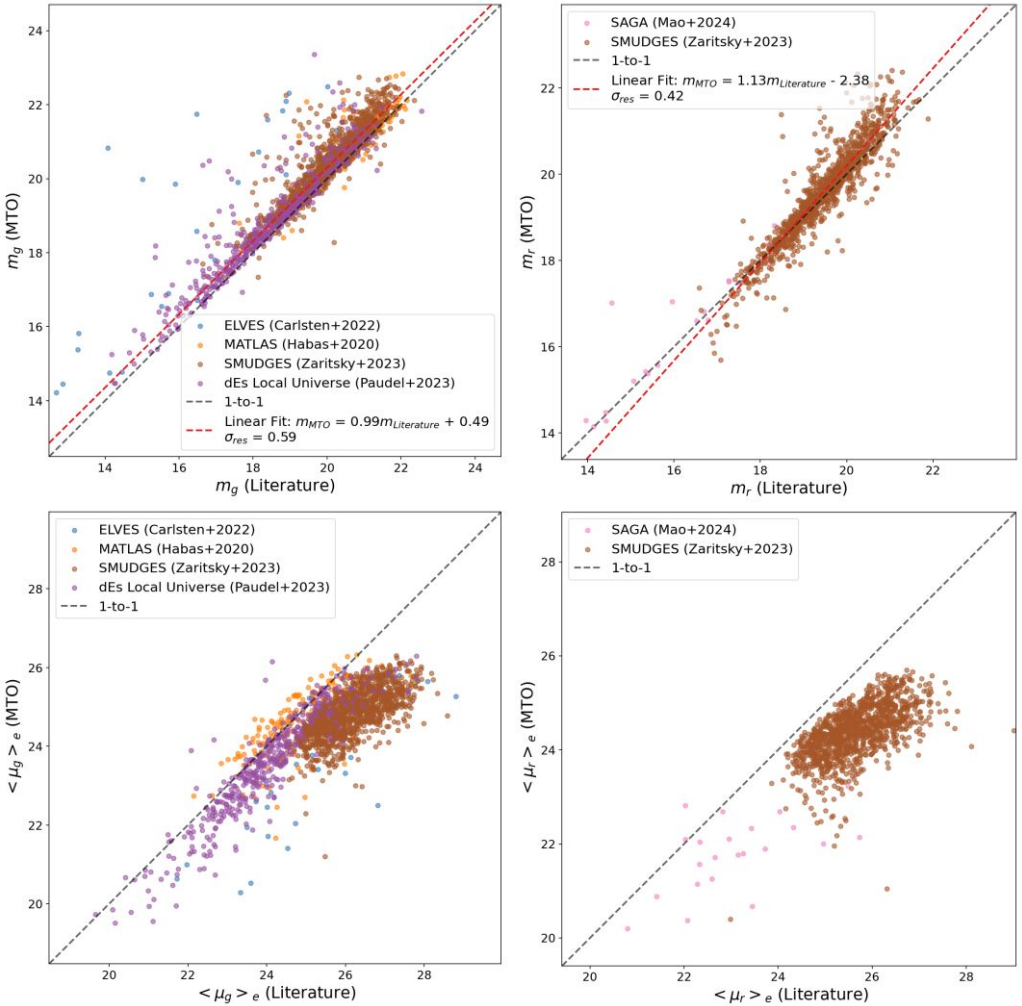

DF 4
DF 5
DF 6
DF 7
Original data
Binned
Image cutout
Segmentation map

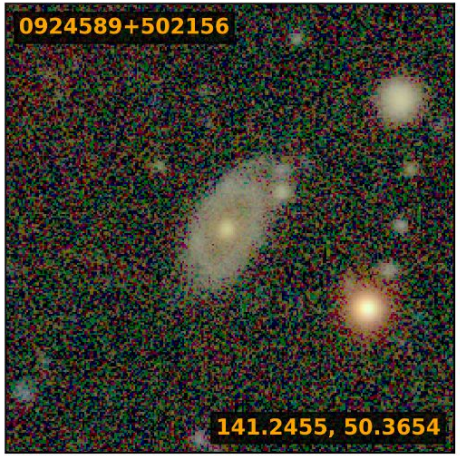

Non-dwarf candidates
Literature dwarfs
Line Separator
$< \mu_g >_e$
m_g
$\log(R_{100}/R_{90})$
$\log(m_g)$
$< \mu_r >_e$
m_r
R_{90}/R_{75}
m_i


ELVES (Carlsten+2022)
MATLAS (Habas+2020)
NGC5485 UDGs (Merritt+2014)
SMUDGES (Zaritsky+2023)
dEs Local Universe (Paudel+2023)
1-to-1
$R_e(g)$ (MTO)
R_e (Literature)
10^0
10^1

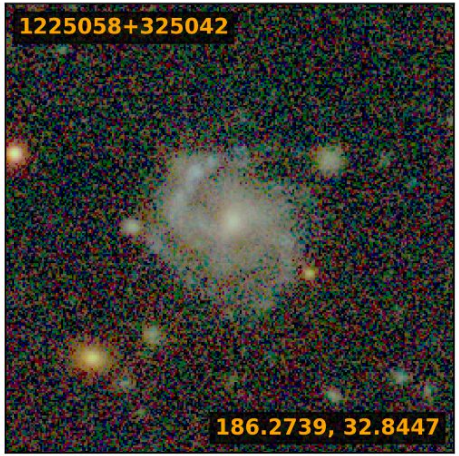

ELVES (Carlsten+2022)
MATLAS (Habas+2020)
NGC5485 UDGs (Merritt+2014)
SMUDGES (Zaritsky+2023)
dEs Local Universe (Paudel+2023)
1-to-1
$R_e(r)$ (MTO)
R_e (Literature)
10^0
10^1

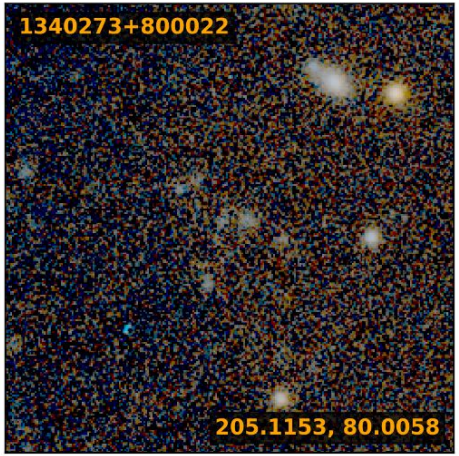

ELVES (Carlsten+2022)
MATLAS (Habas+2020)
NGC5485 UDGs (Merritt+2014)
SMUDGES (Zaritsky+2023)
dEs Local Universe (Paudel+2023)
1-to-1
$R_e(i)$ (MTO)
R_e (Literature)
10^0
10^1

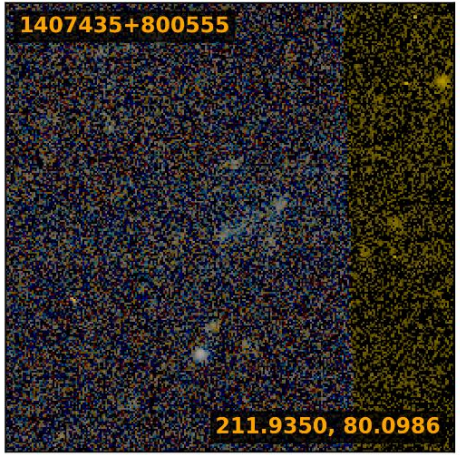

ELVES (Carlsten+2022)
MATLAS (Habas+2020)
SMUDGES (Zaritsky+2023)
dEs Local Universe (Paudel+2023)
1-to-1
Linear Fit: $m_{MTO} = 0.99m_{Literature} + 0.49$
$\sigma_{res} = 0.59$
m_g (MTO)
m_g (Literature)
SAGA (Mao+2024)
SMUDGES (Zaritsky+2023)
1-to-1
Linear Fit: $m_{MTO} = 1.13m_{Literature} - 2.38$
$\sigma_{res} = 0.42$
m_r (MTO)
m_r (Literature)
ELVES (Carlsten+2022)
MATLAS (Habas+2020)
SMUDGES (Zaritsky+2023)
dEs Local Universe (Paudel+2023)
1-to-1
$< \mu_g >_e$ (MTO)
$< \mu_g >_e$ (Literature)
SAGA (Mao+2024)
SMUDGES (Zaritsky+2023)
1-to-1
$< \mu_r >_e$ (MTO)
$< \mu_r >_e$ (Literature)

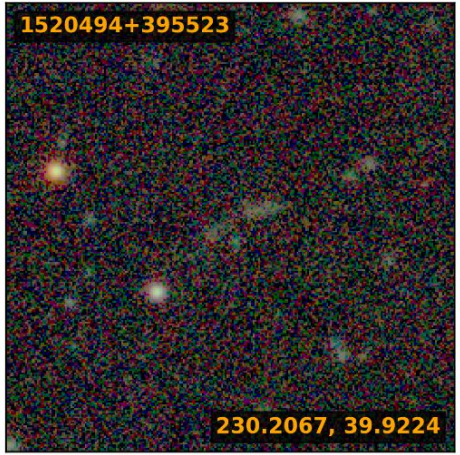

0924589+502156
141.2455, 50.3654


121853+654443
184.7173, 65.7334

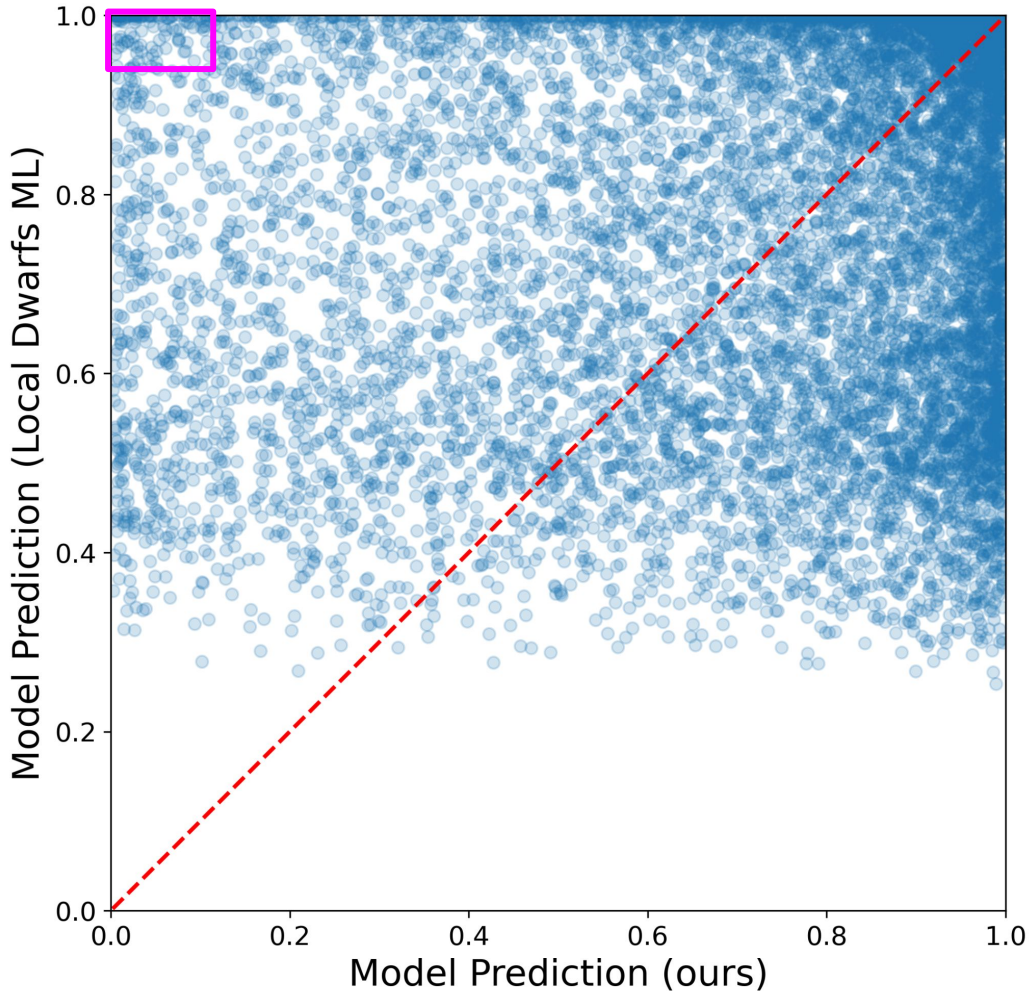

1225058+325042
186.2739, 32.8447

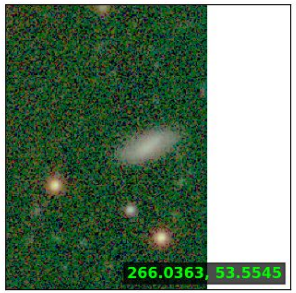

1340273+800022
205.1153, 80.0058


1407435+800555
211.9350, 80.0986


1520494+395523
230.2067, 39.9224


1810007+575451
272.5030, 57.9143


Model Prediction (Local Dwarfs ML)
Model Prediction (ours)
0.0
0.2
0.4
0.6
0.8
1.0



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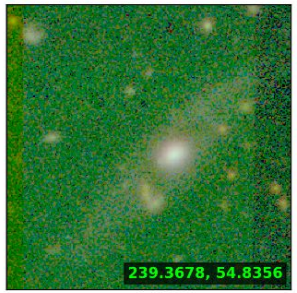

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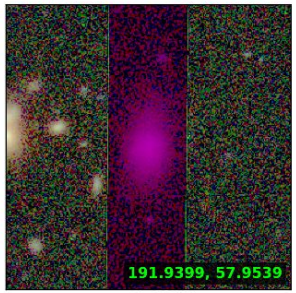

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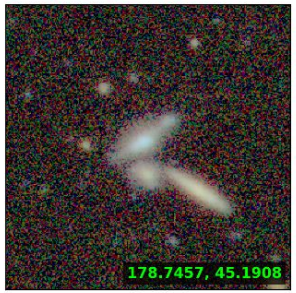
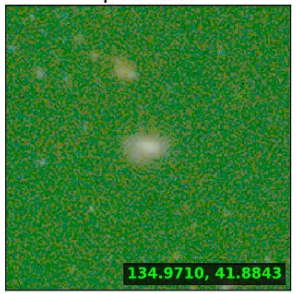


p: 0.021

p: 0.082

p: 0.028



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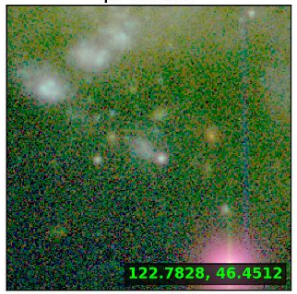

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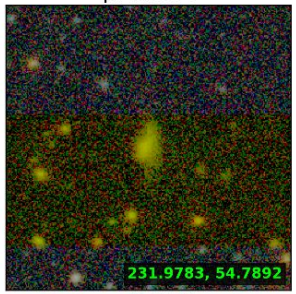
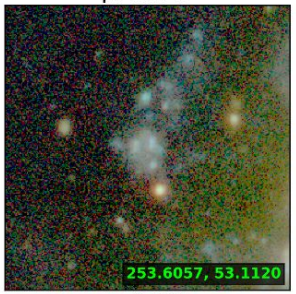


p: 0.052

p: 0.029

p: 0.011



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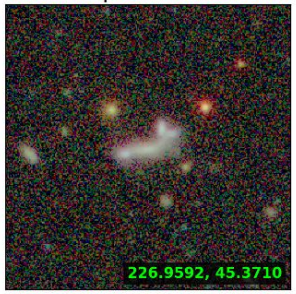

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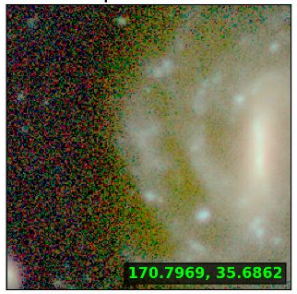
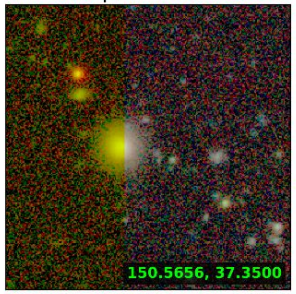


p: 0.029

p: 0.088



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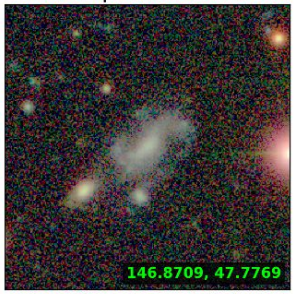

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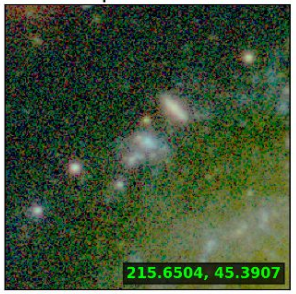
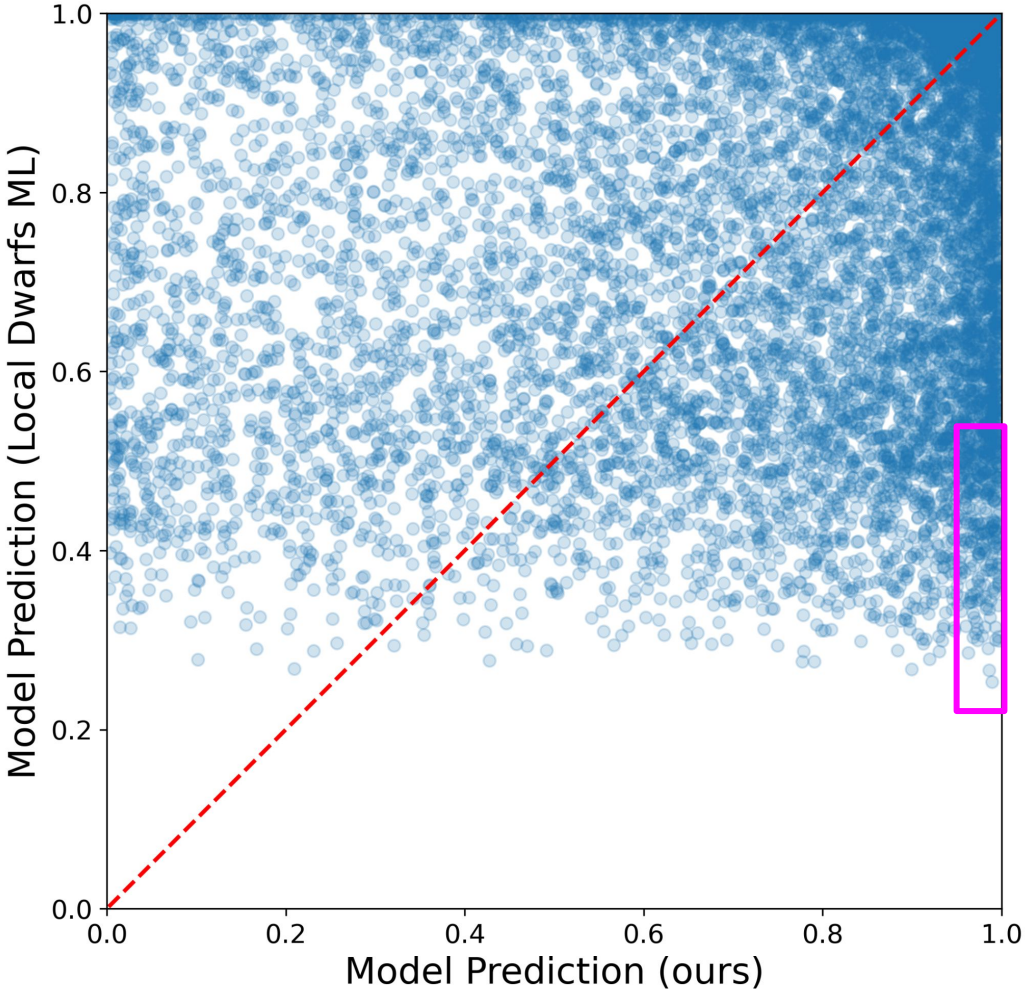
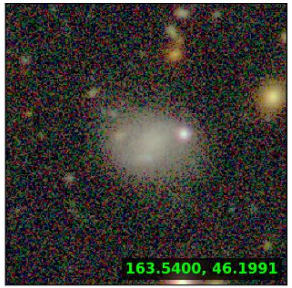


p: 0.009


1.0
0.8
0.6
0.4
0.2
0.0
Model Prediction (Local Dwarfs ML)
0.0
0.2
0.4
0.6
0.8
1.0
Model Prediction (ours)

p: 0.968

p: 0.988



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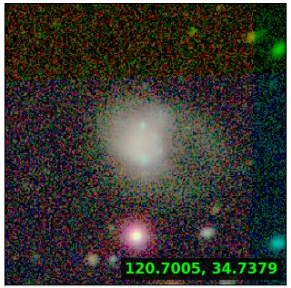
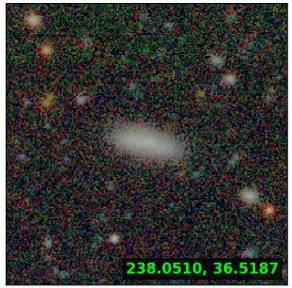
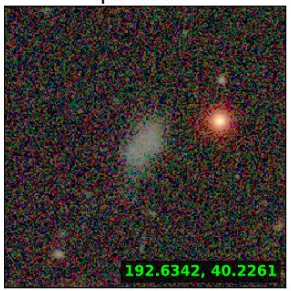


p: 0.952



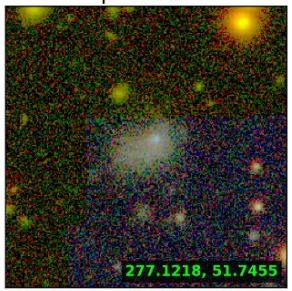
p: 0.961

p: 0.992



p: 0.975

p: 0.996



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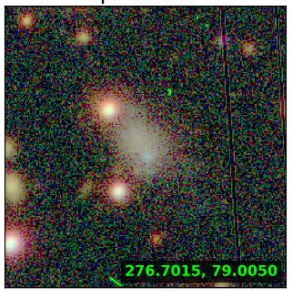

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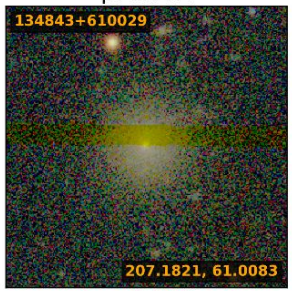

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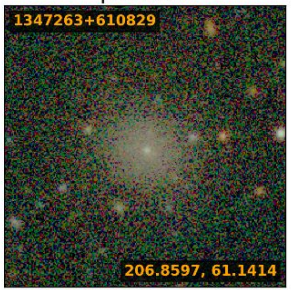

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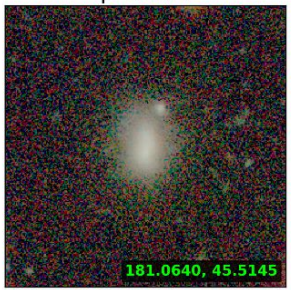

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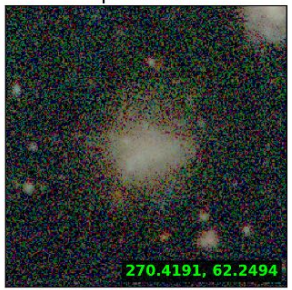

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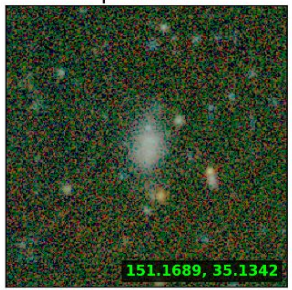
p: 0.957



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