

The Renaissance of Planetary Nebula Luminosity Function (PNLF) as Standard Candle with MUSE: Age and Metallicity Dependence

Azlizan A. Soemitro

Leibniz-Institut für Astrophysik Potsdam (UP & AIP)

in collaboration with

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Lucas Valenzuela (LMU)

Peter Weilbacher (AIP)

Robin Ciardullo (The Pennsylvania State University)

George Jacoby (NFS's NOIRLab)

Magda Arnaboldi (ESO)

Nordic-Baltic Astronomy Days 2026



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sound horizon-based (Λ CDM-dependent)

CMB (Planck)

67.4 ± 0.5 km/s/Mpc

Planck Collab. 2020 A&A 641 A6

CMB (WMAP + ACT)

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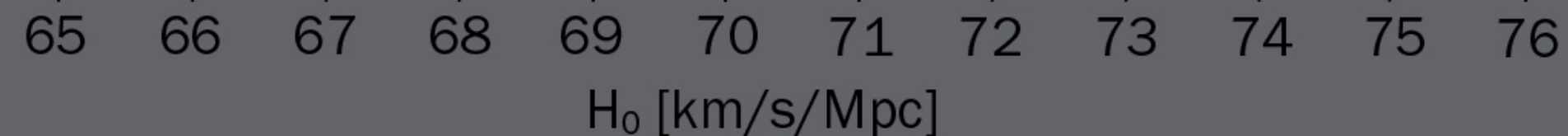
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Cepheids (CCHP/JWST)

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The Hubble Tension

Credit: V. Pouline, cerncourier.com

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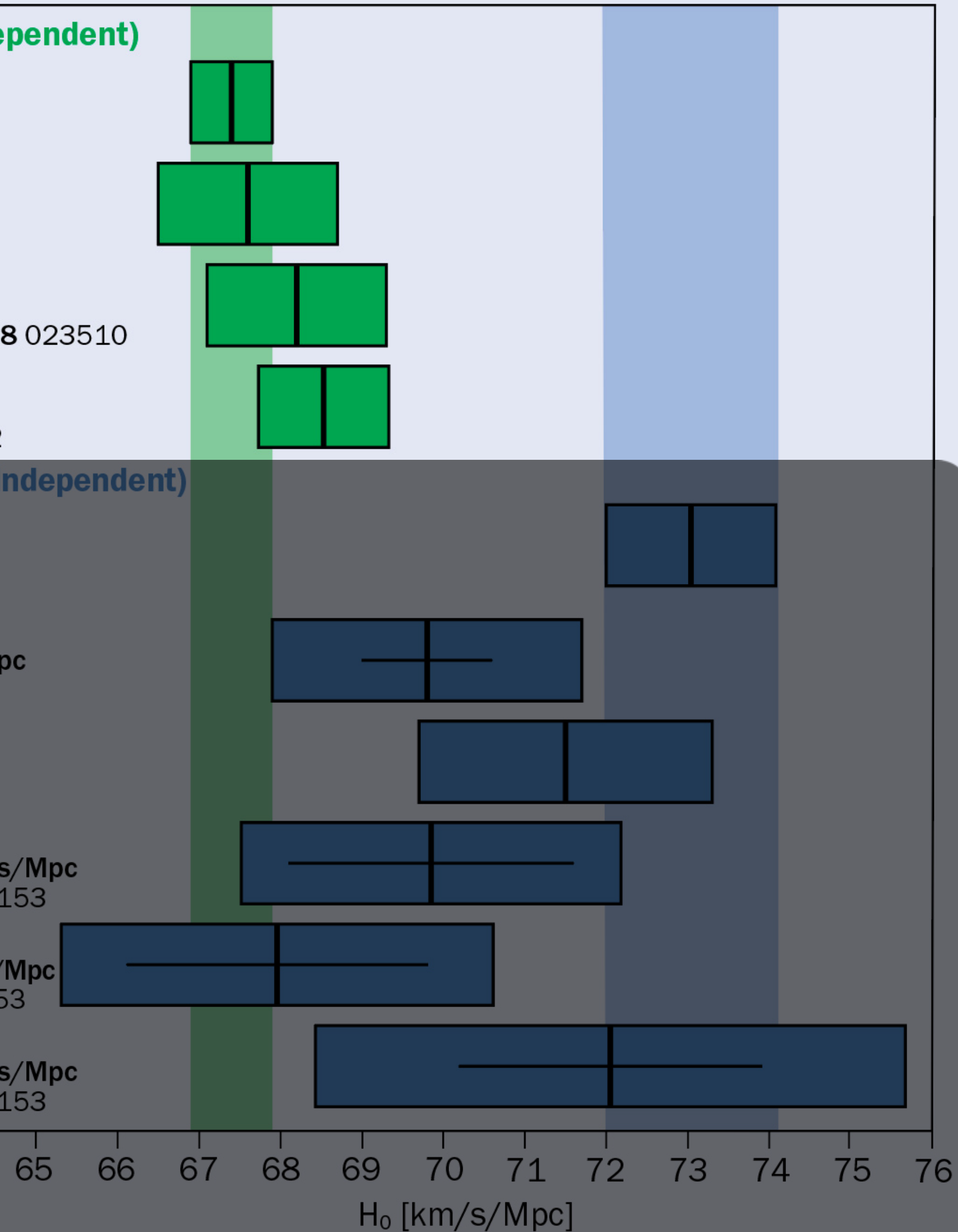
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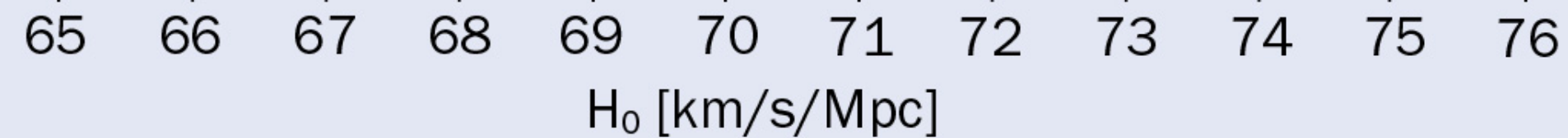
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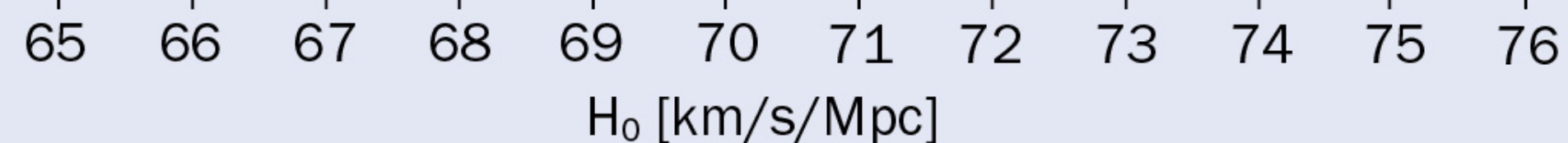
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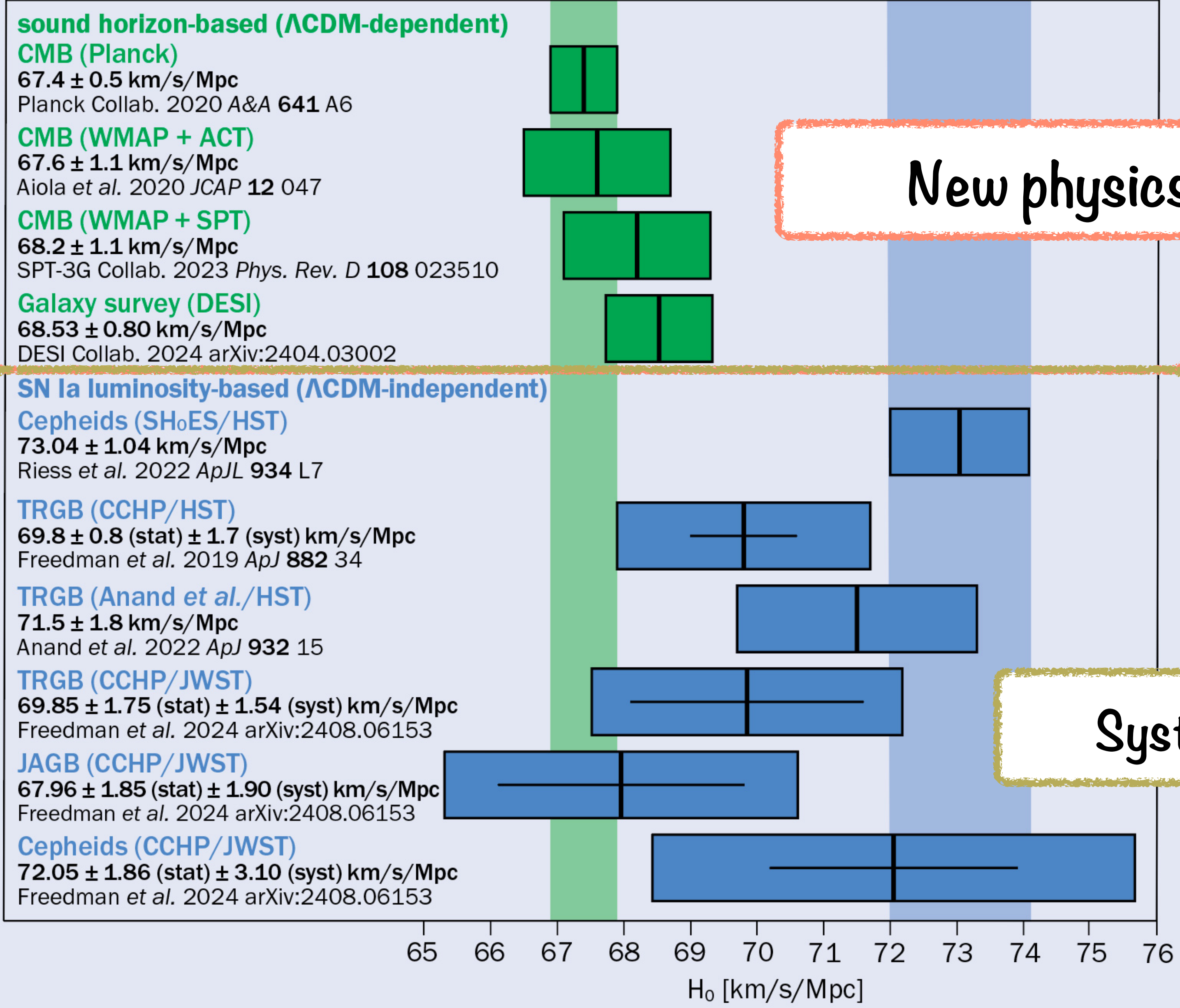
The Hubble Tension

Systematic error?

New physics?

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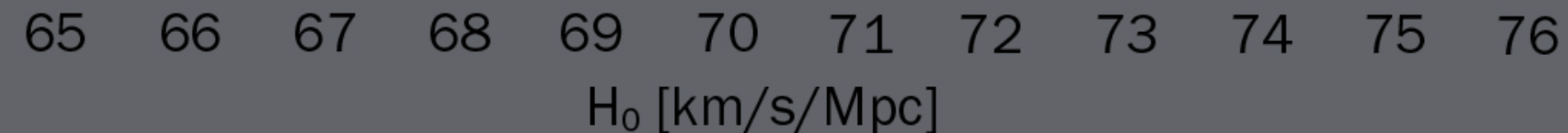
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MUSE-PNLF

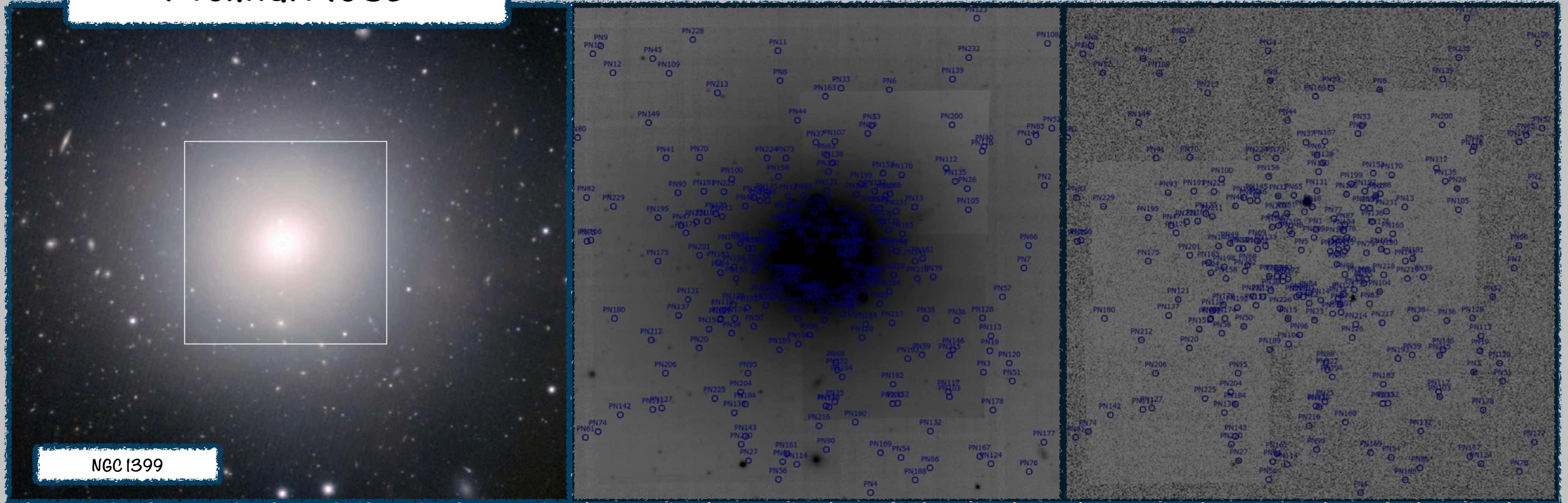


The Hubble Tension

Systematic error?

Credit: V. Pouline, cerncourier.com

Archival MUSE



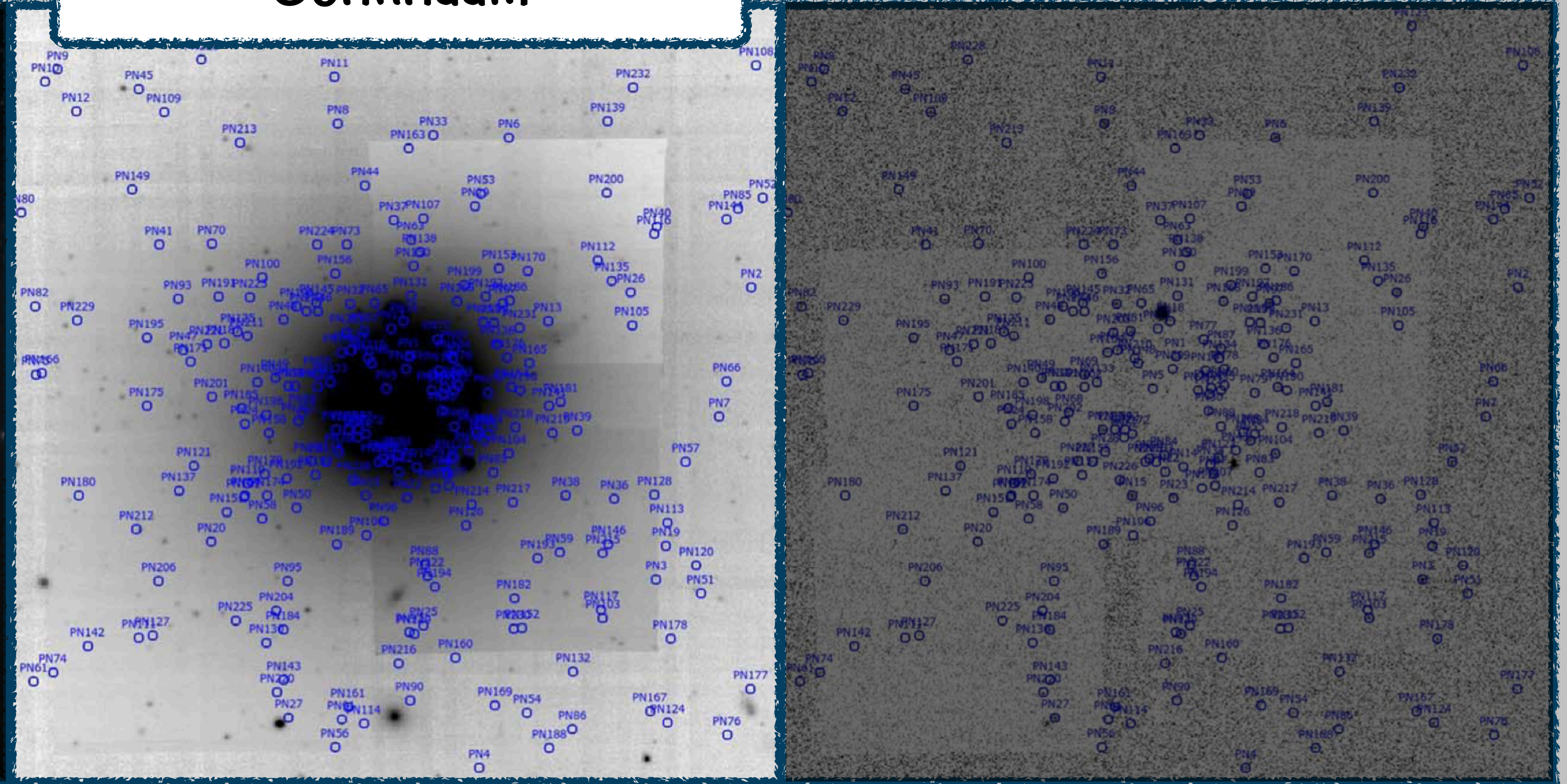
NGC 1399

Credit: Jacoby et al. (2024)

Continuum

Archival MUSE

NGC 1399



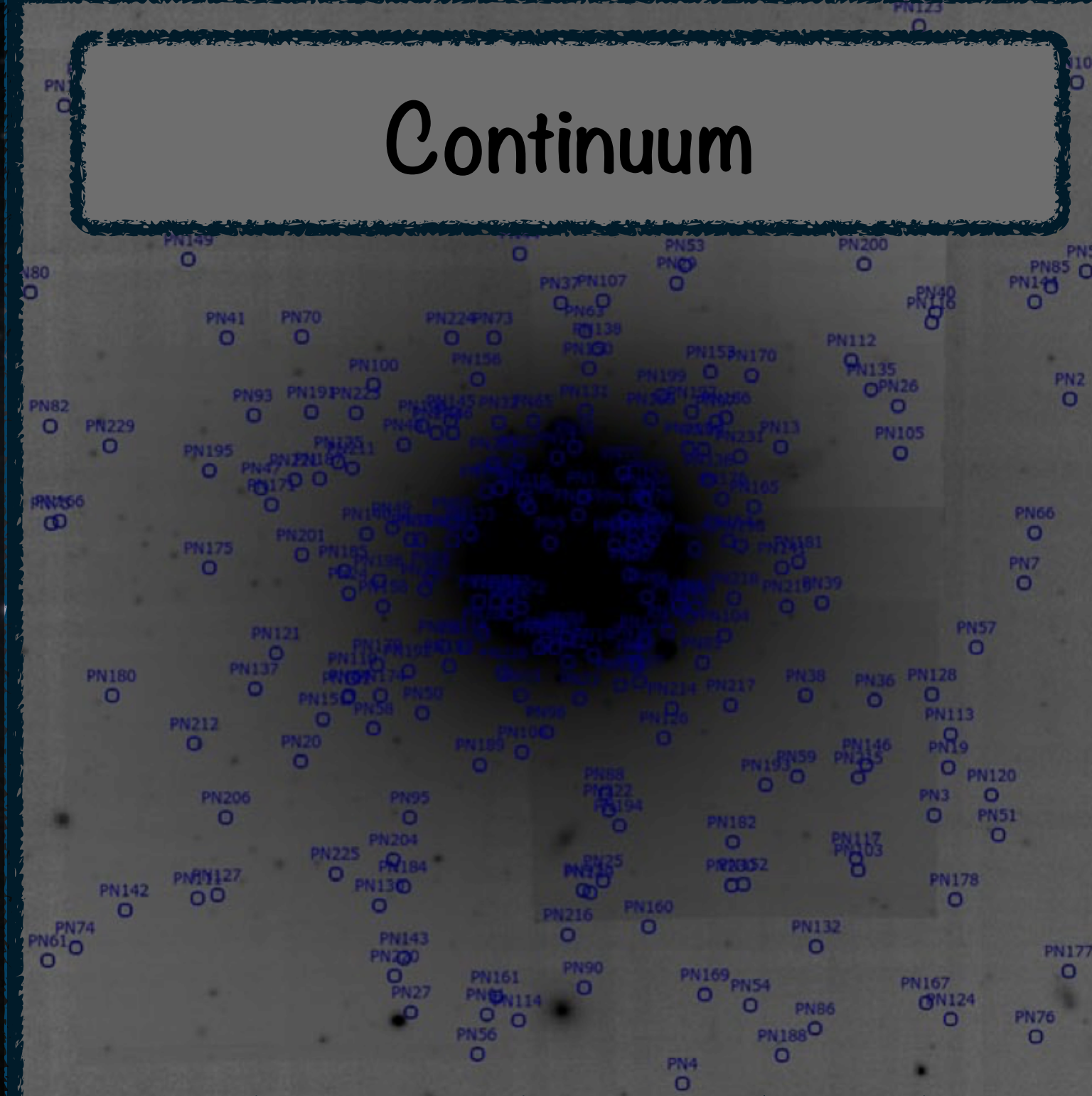
Credit: Jacoby et al. (2024)

Archival MUSE

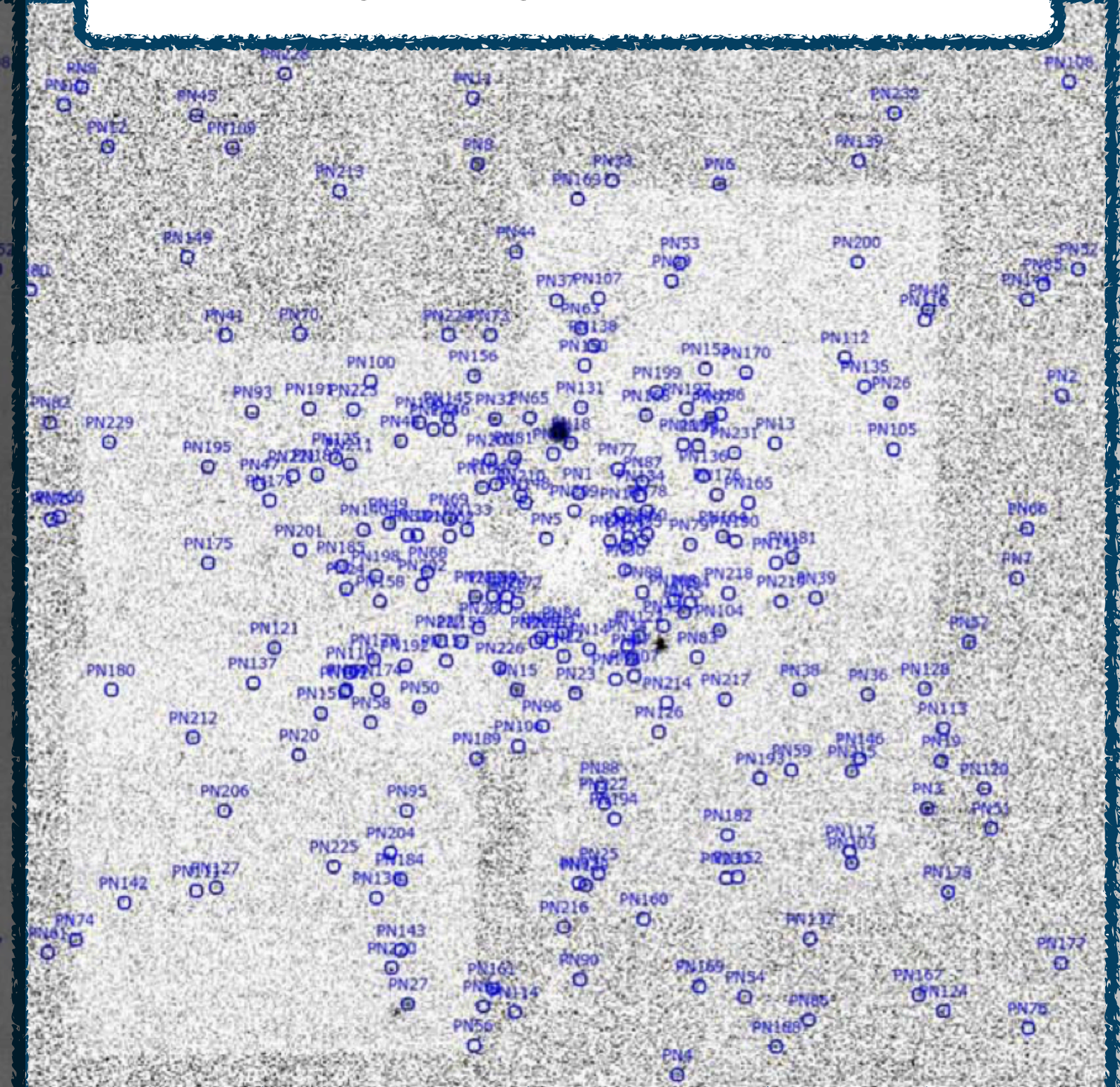


NGC 1399

Continuum



[OIII]5007



Credit: Jacoby et al. (2024)

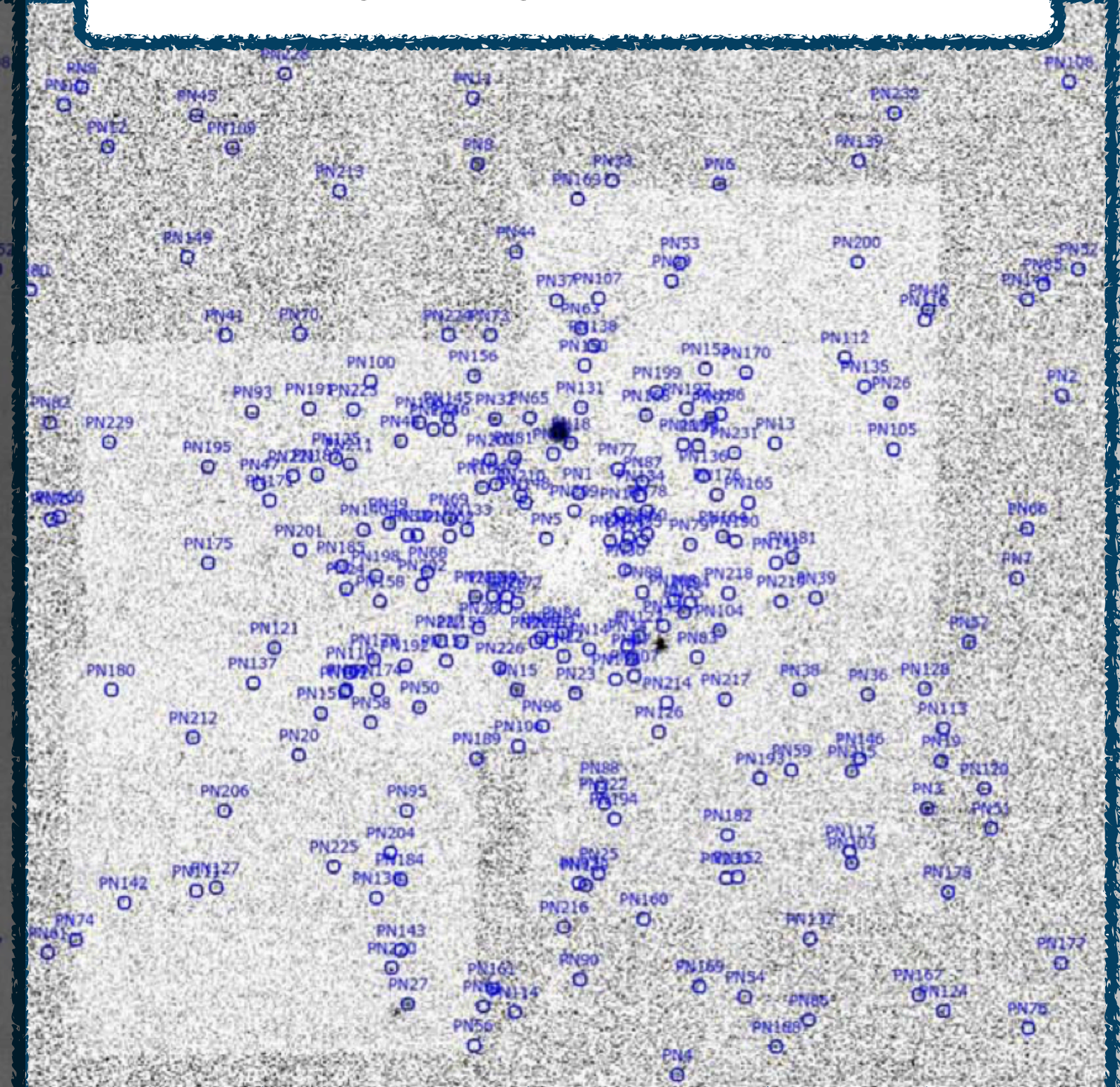
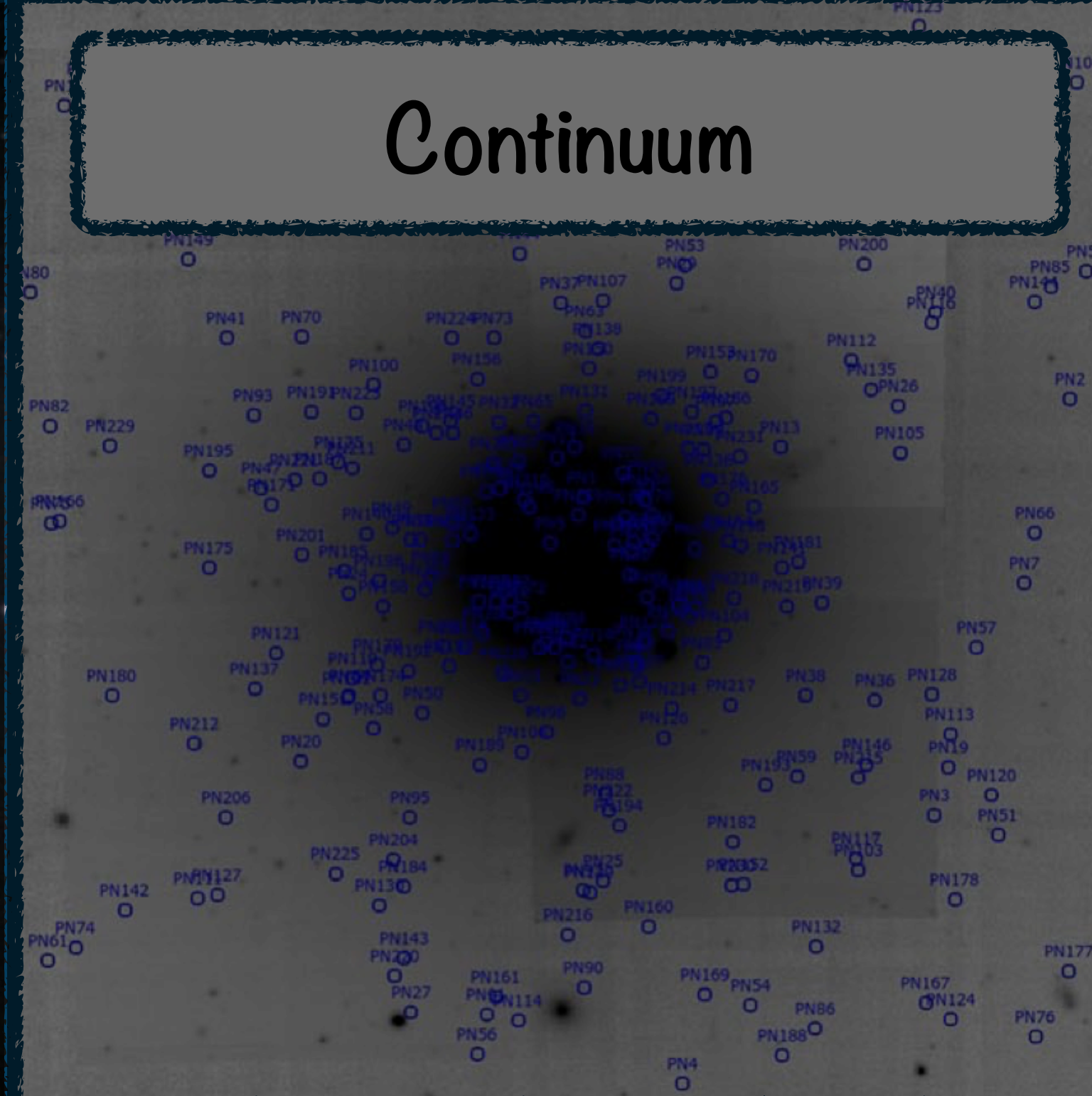
Differential emission line filter (DELF, Roth et al. 2021)

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Archival MUSE



Continuum



NGC 1399

Credit: Jacoby et al. (2024)

Archival MUSE



NGC 1399

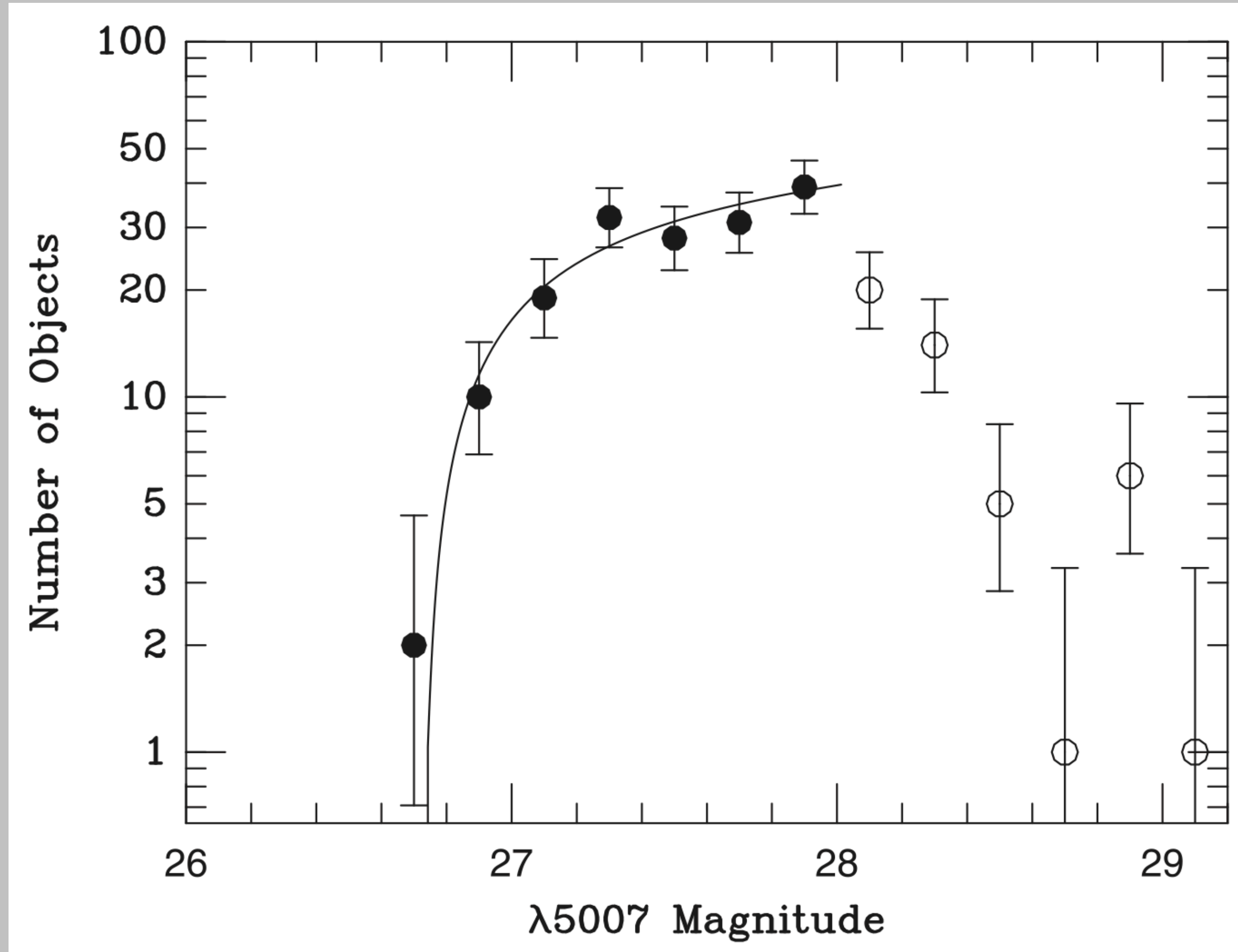
Continuum

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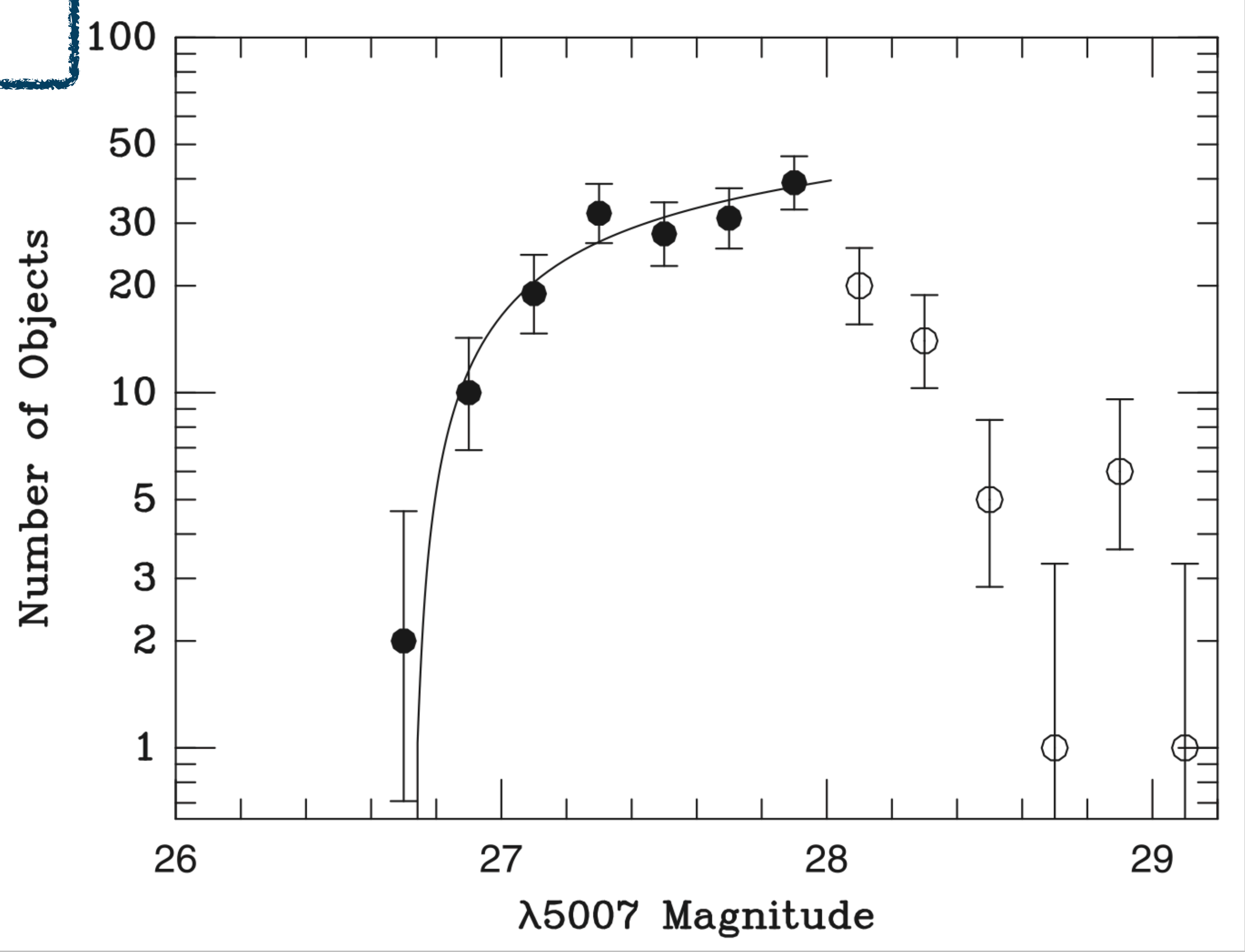
$$m_{5007} = -2.5 \log F_{5007} - 13.74 \text{ (Jacoby 1989)}$$

Credit: Jacoby et al. (2024)

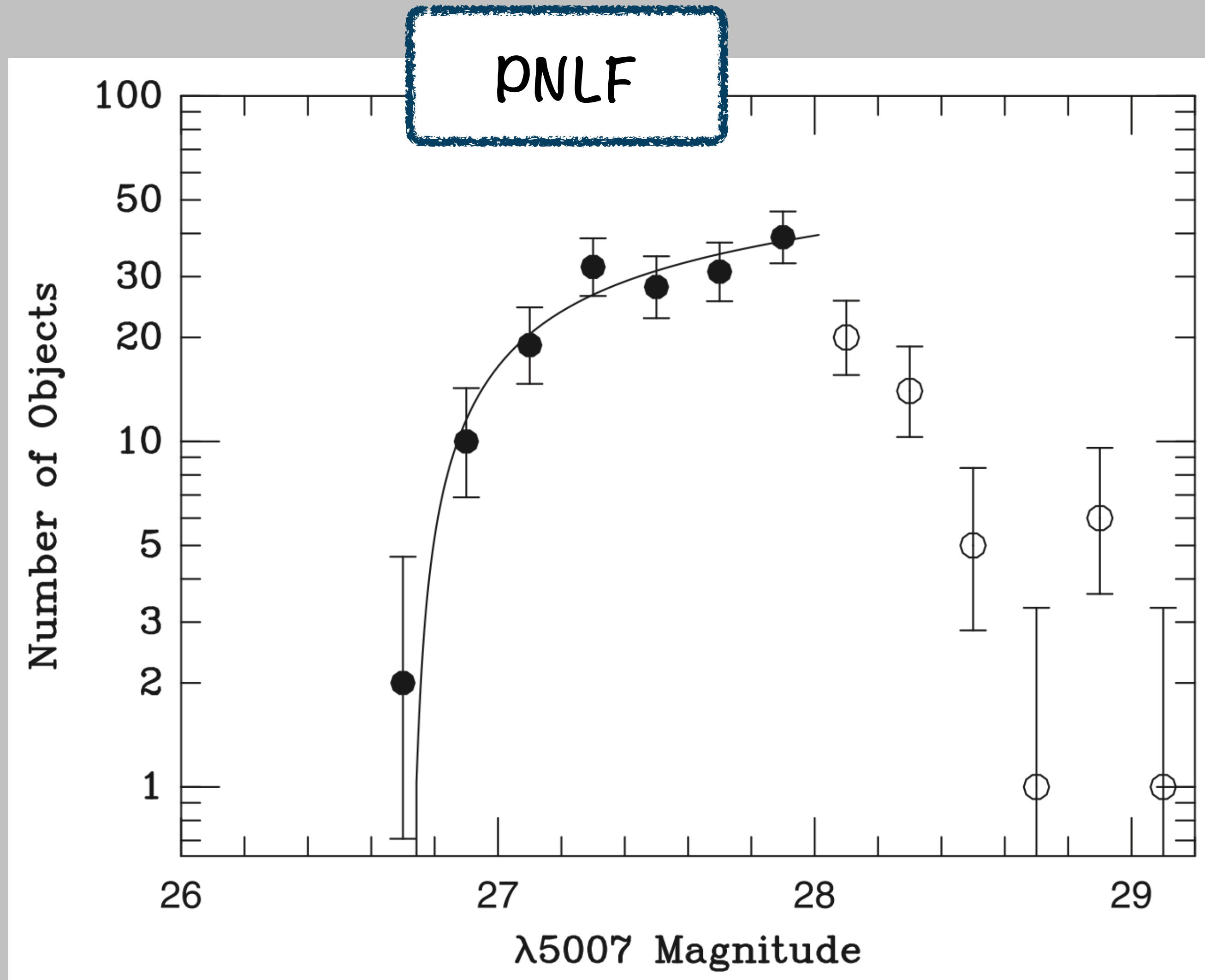


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PNFL

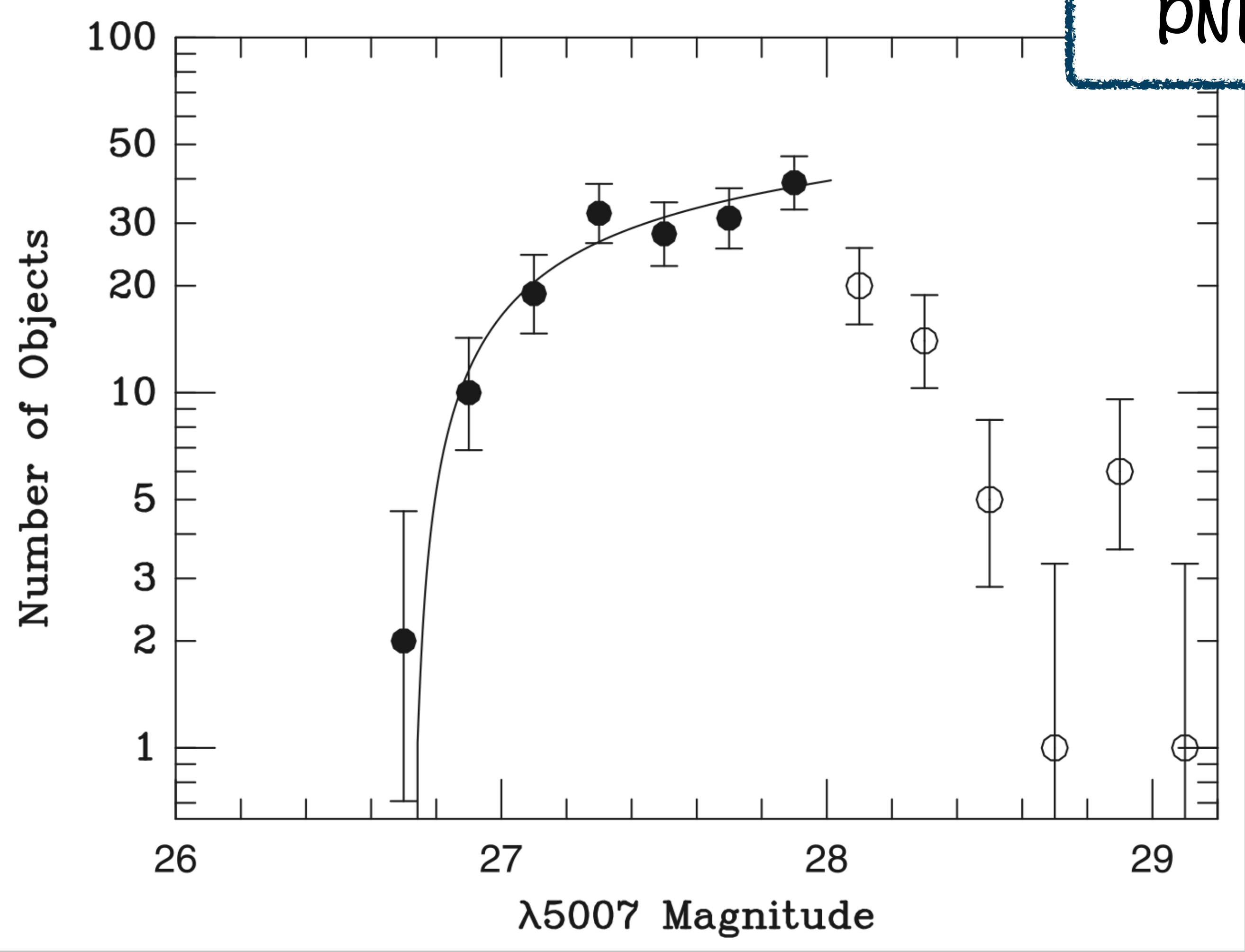


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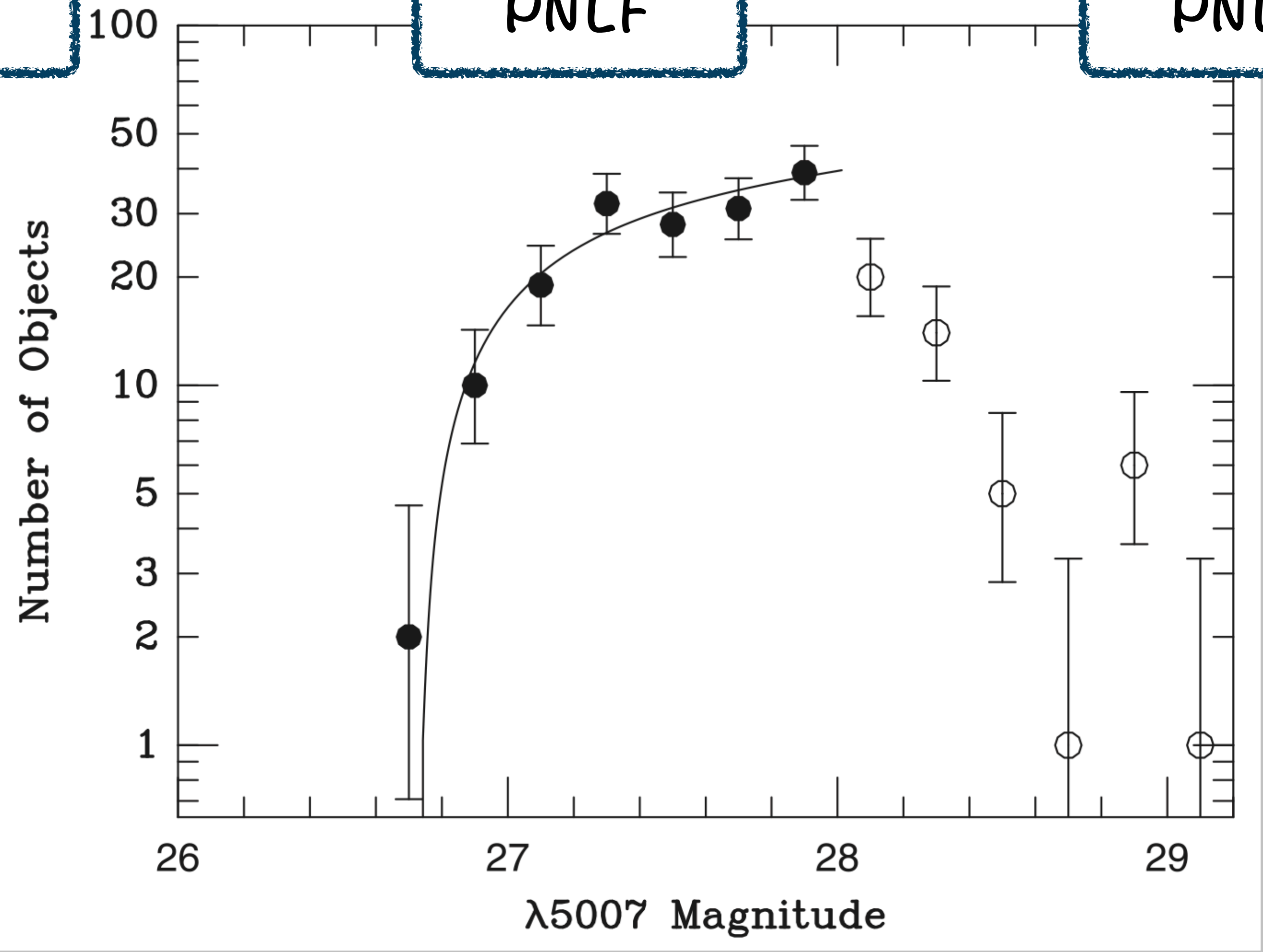


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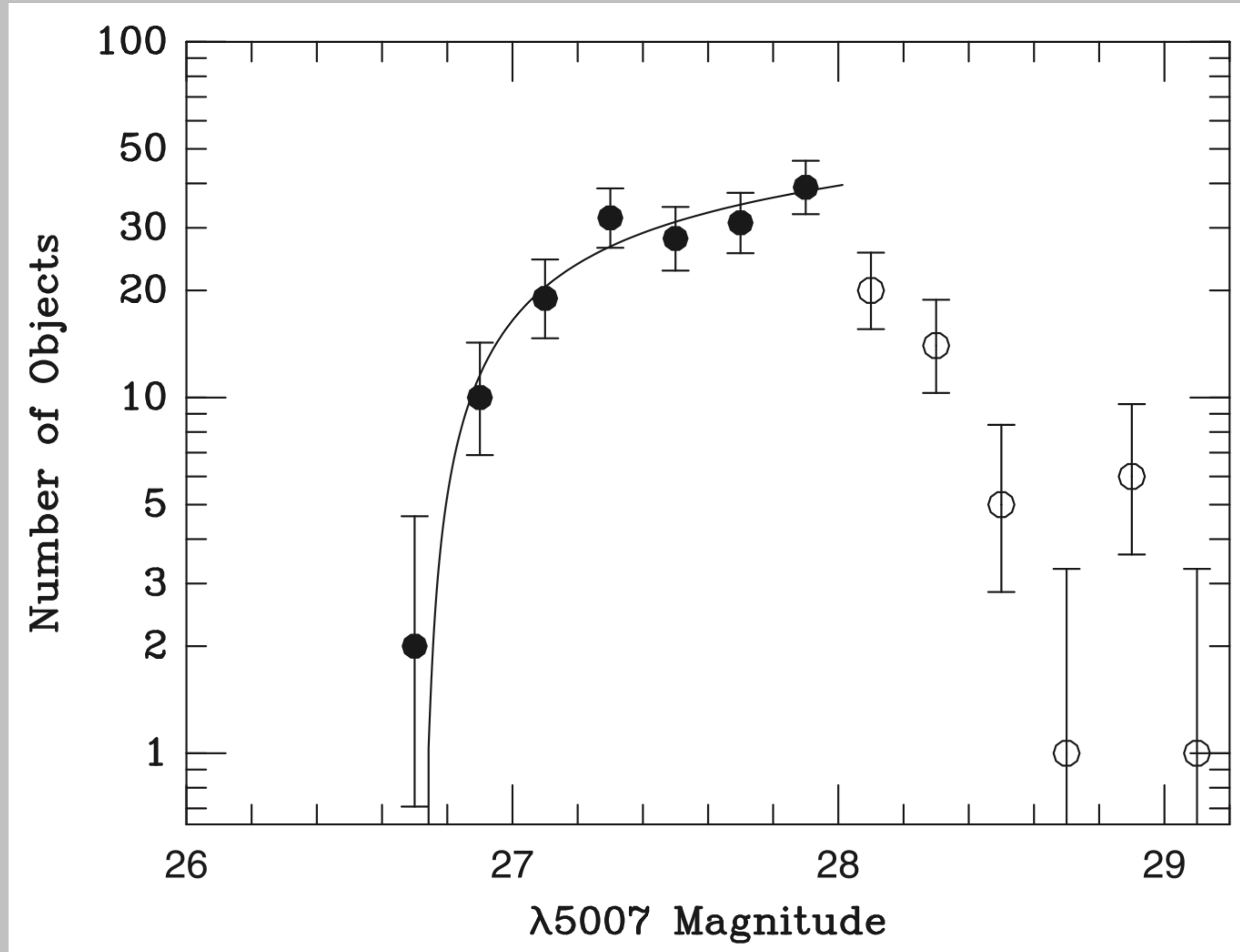
PNFL

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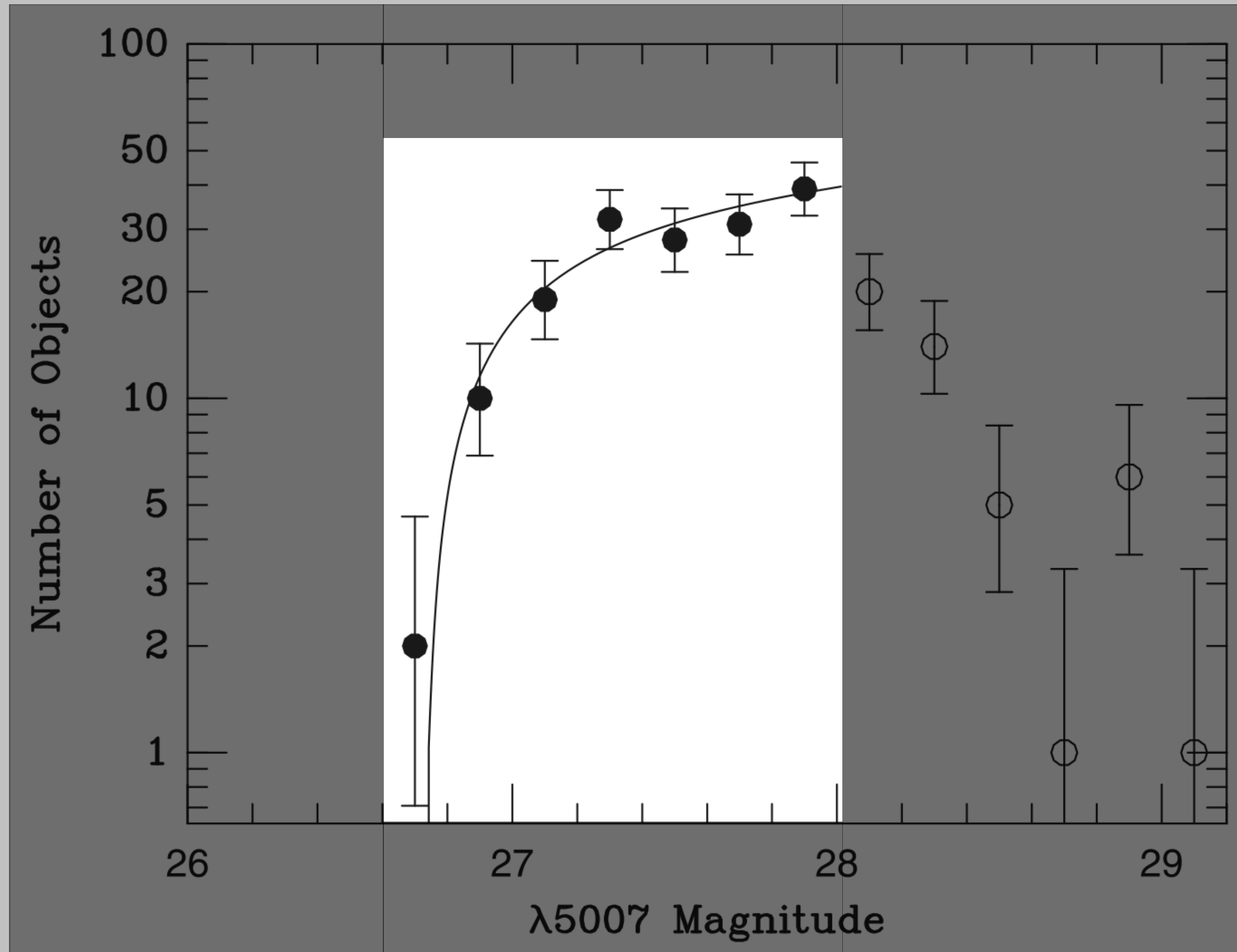
PNFL



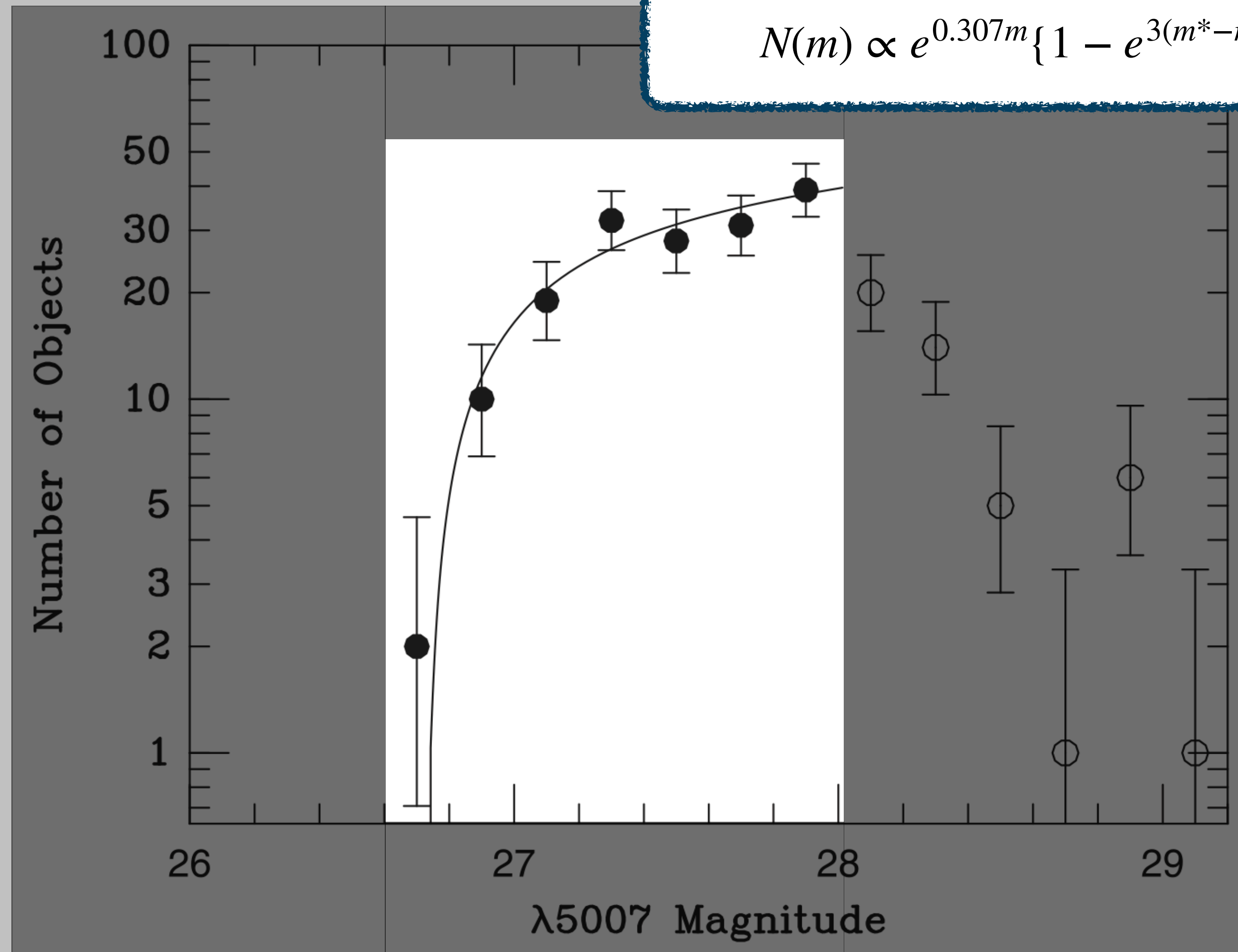
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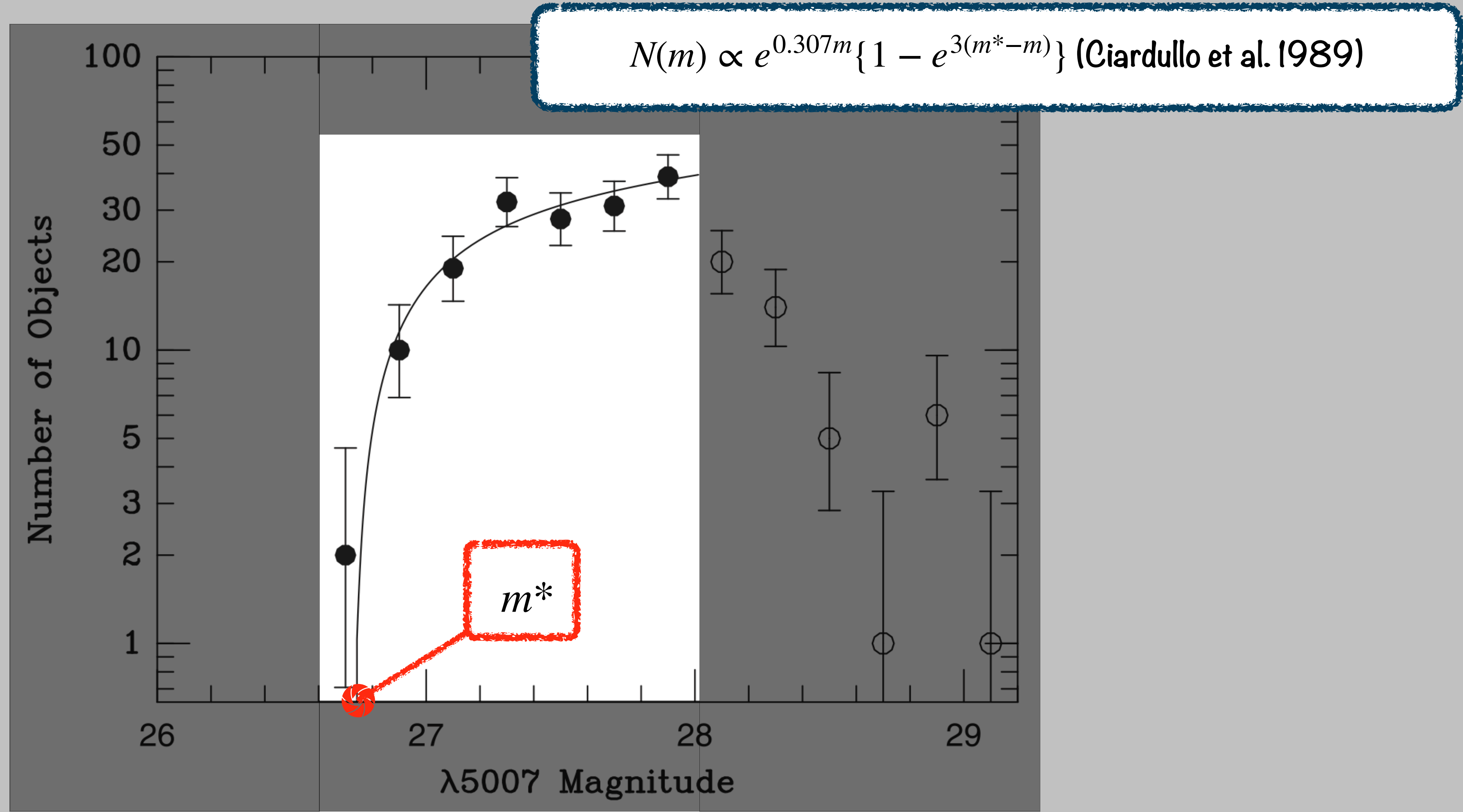
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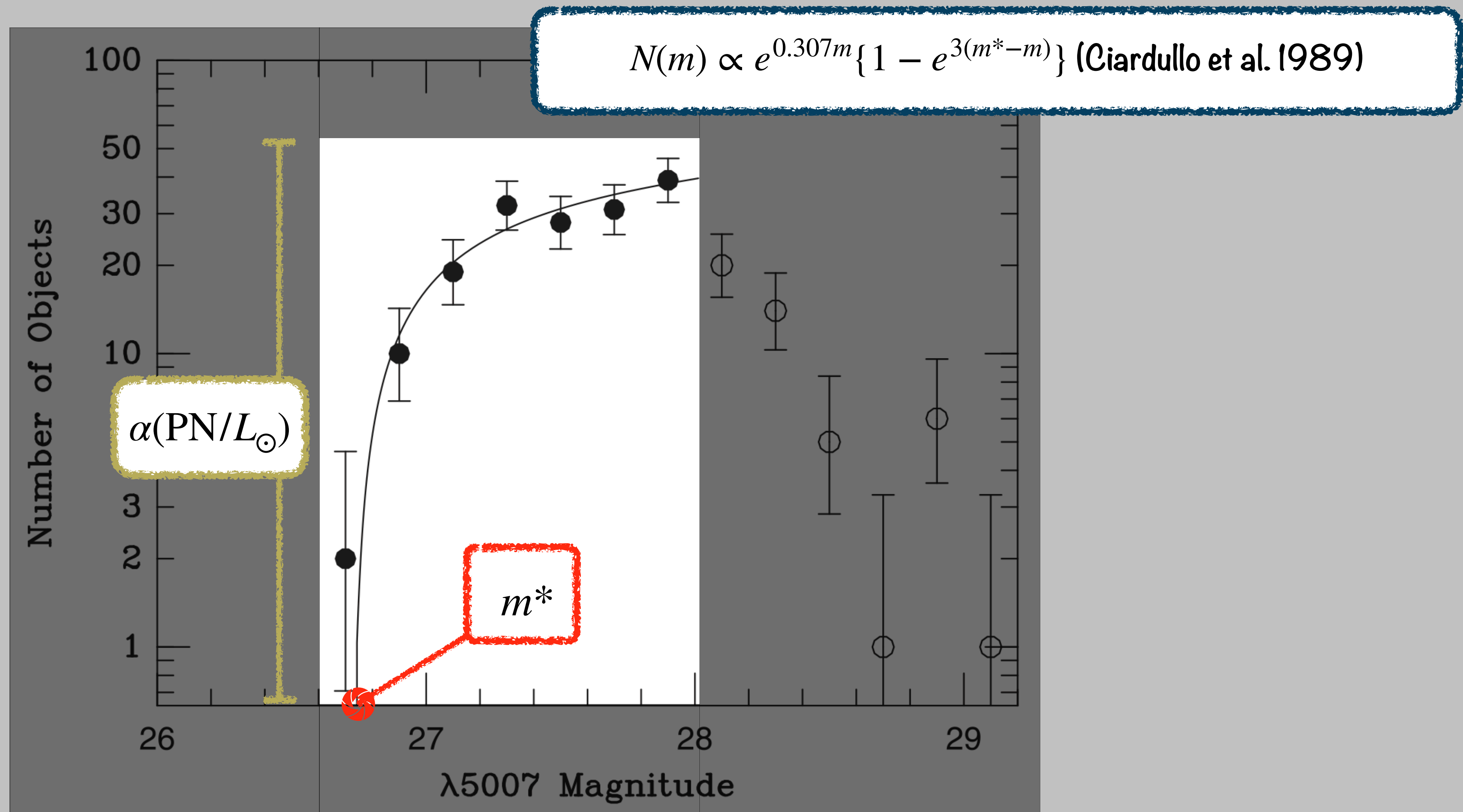
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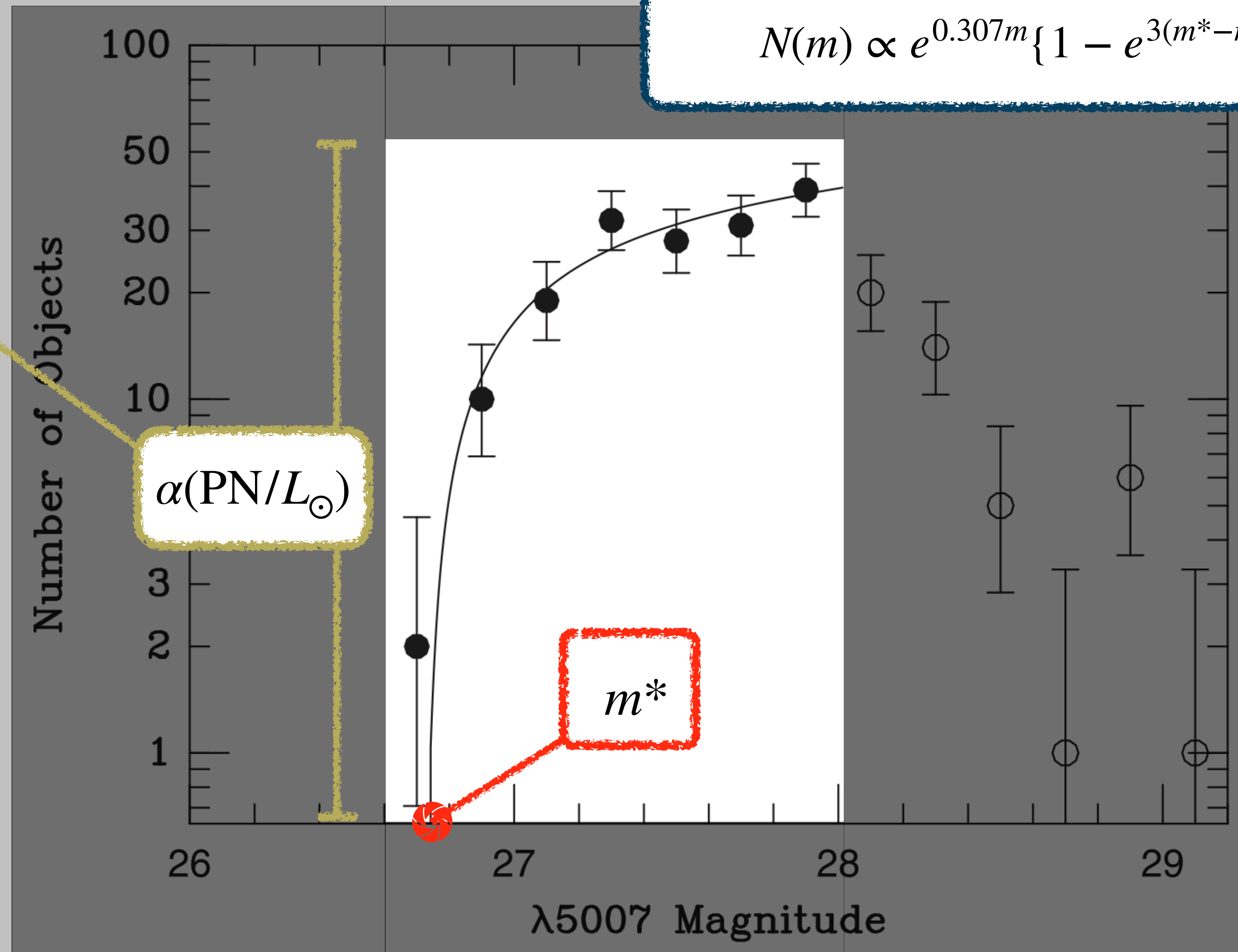
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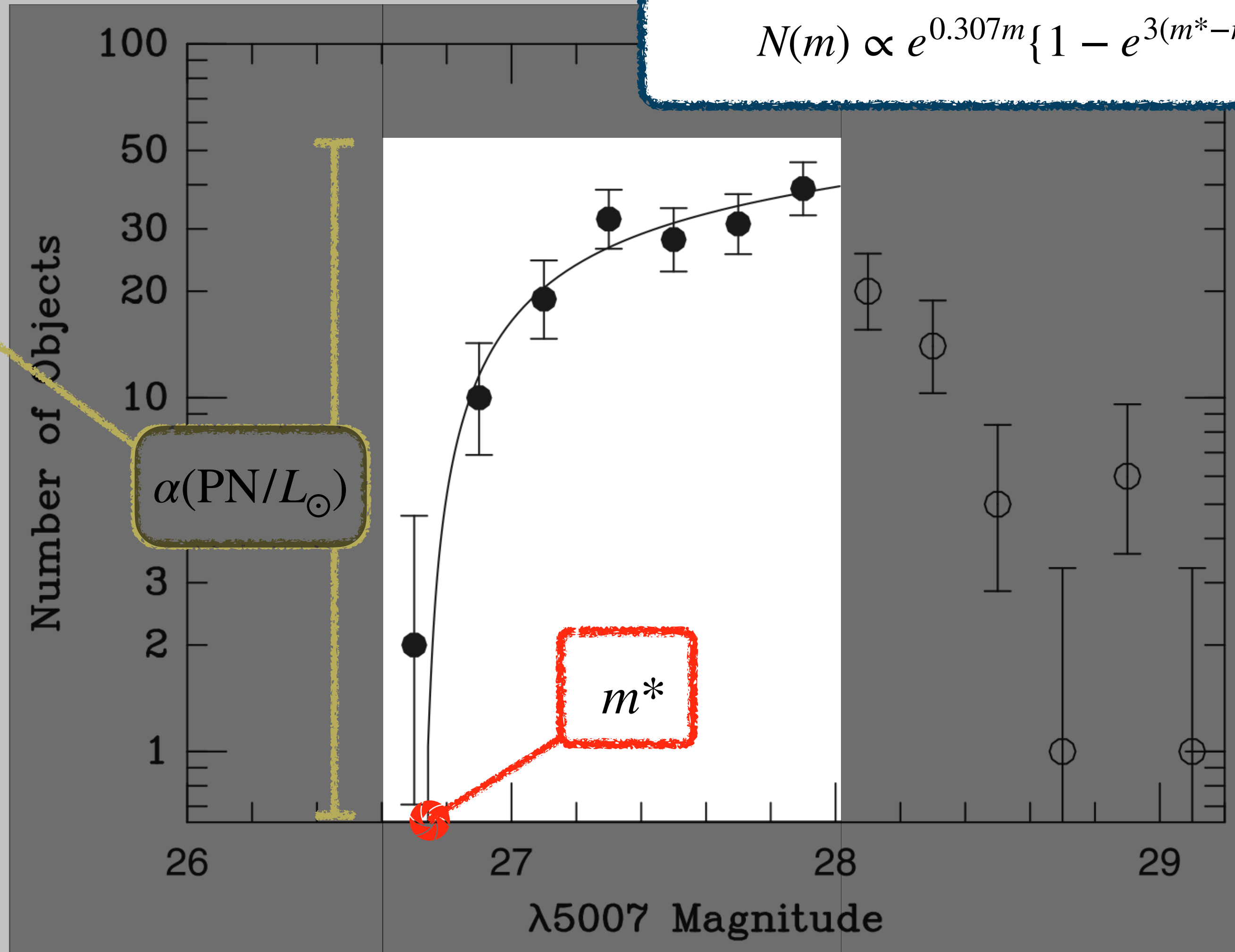
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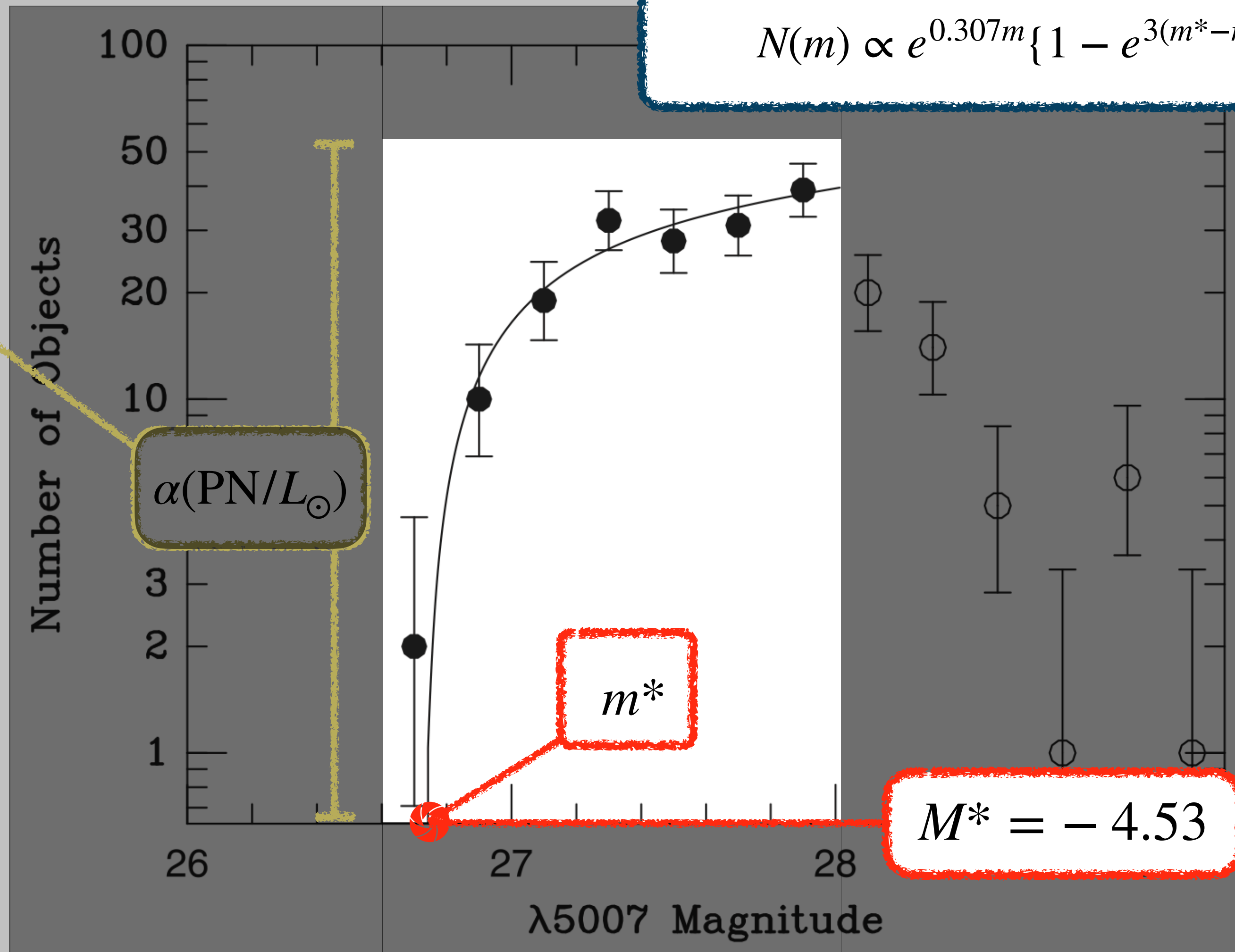
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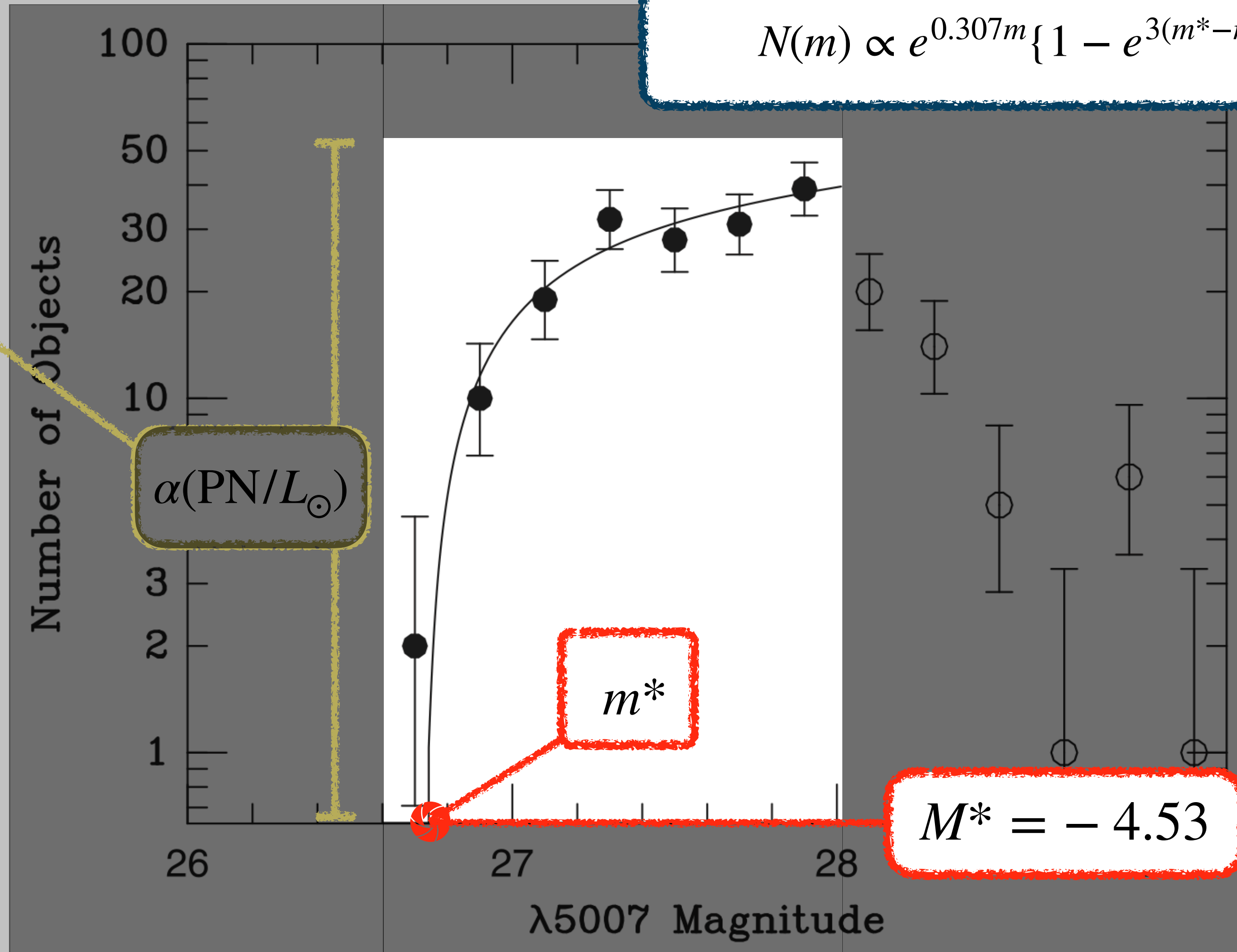
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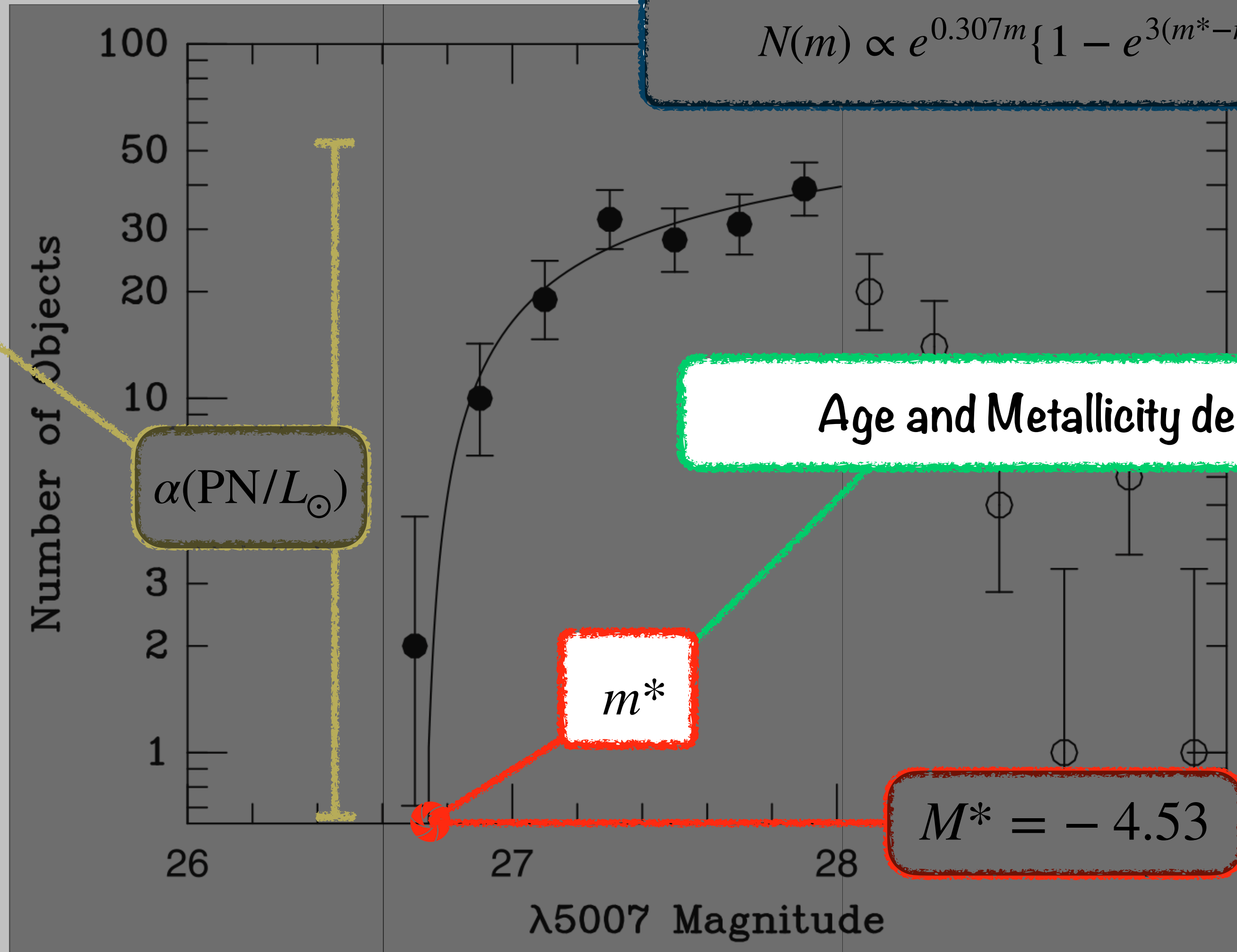


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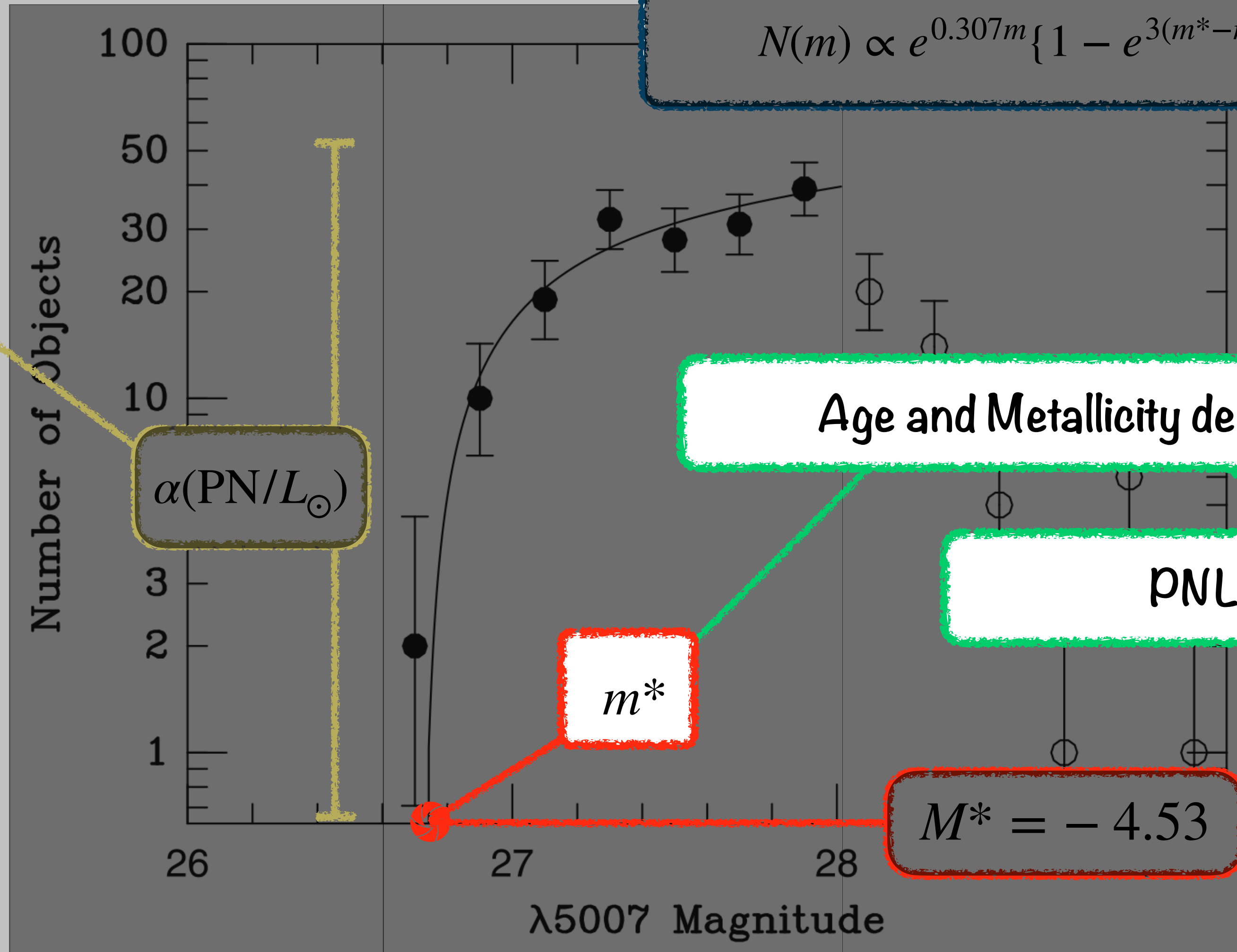
MUSE-PNLF
up to 40 Mpc

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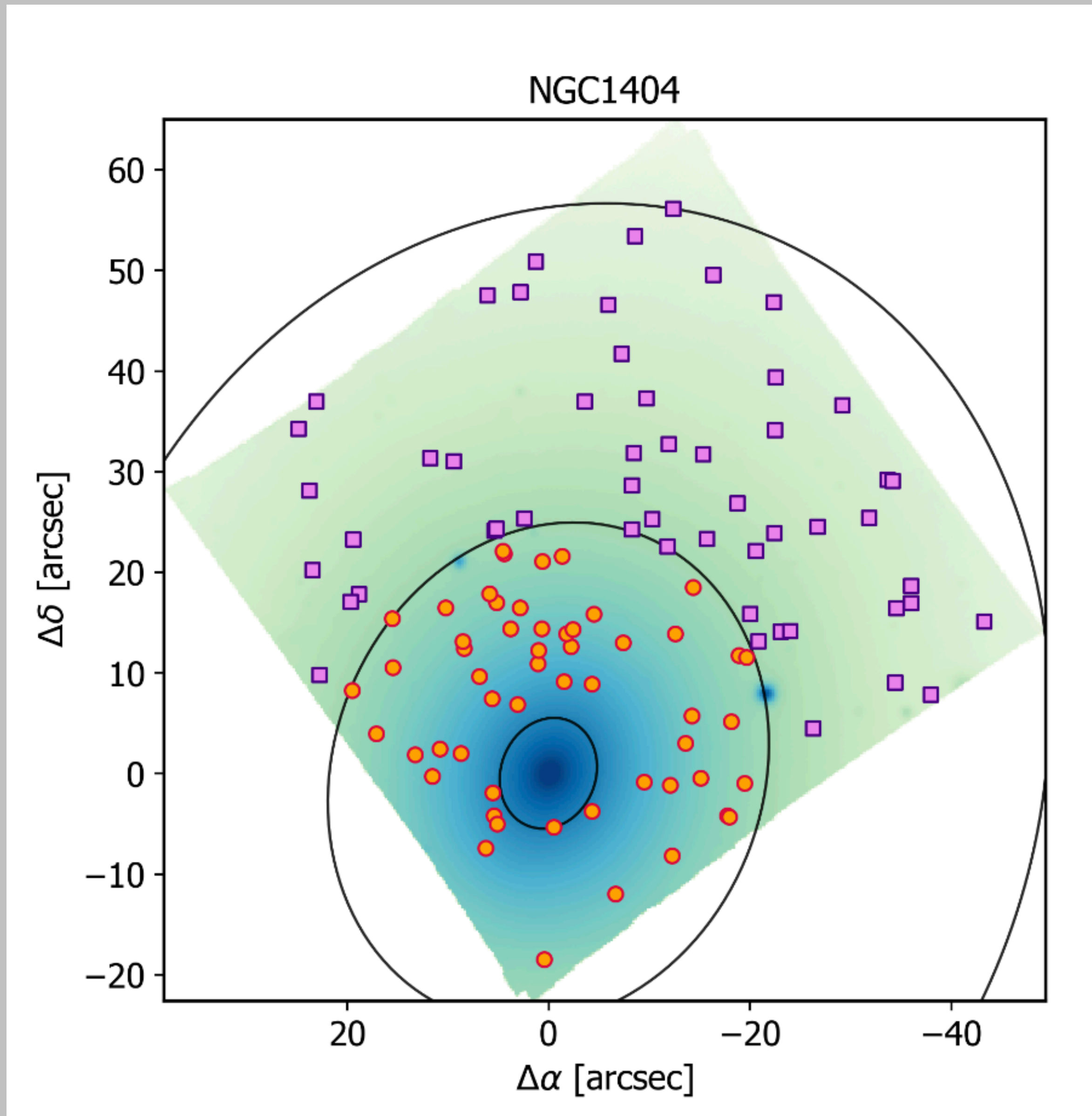


Age and Metallicity dependence?

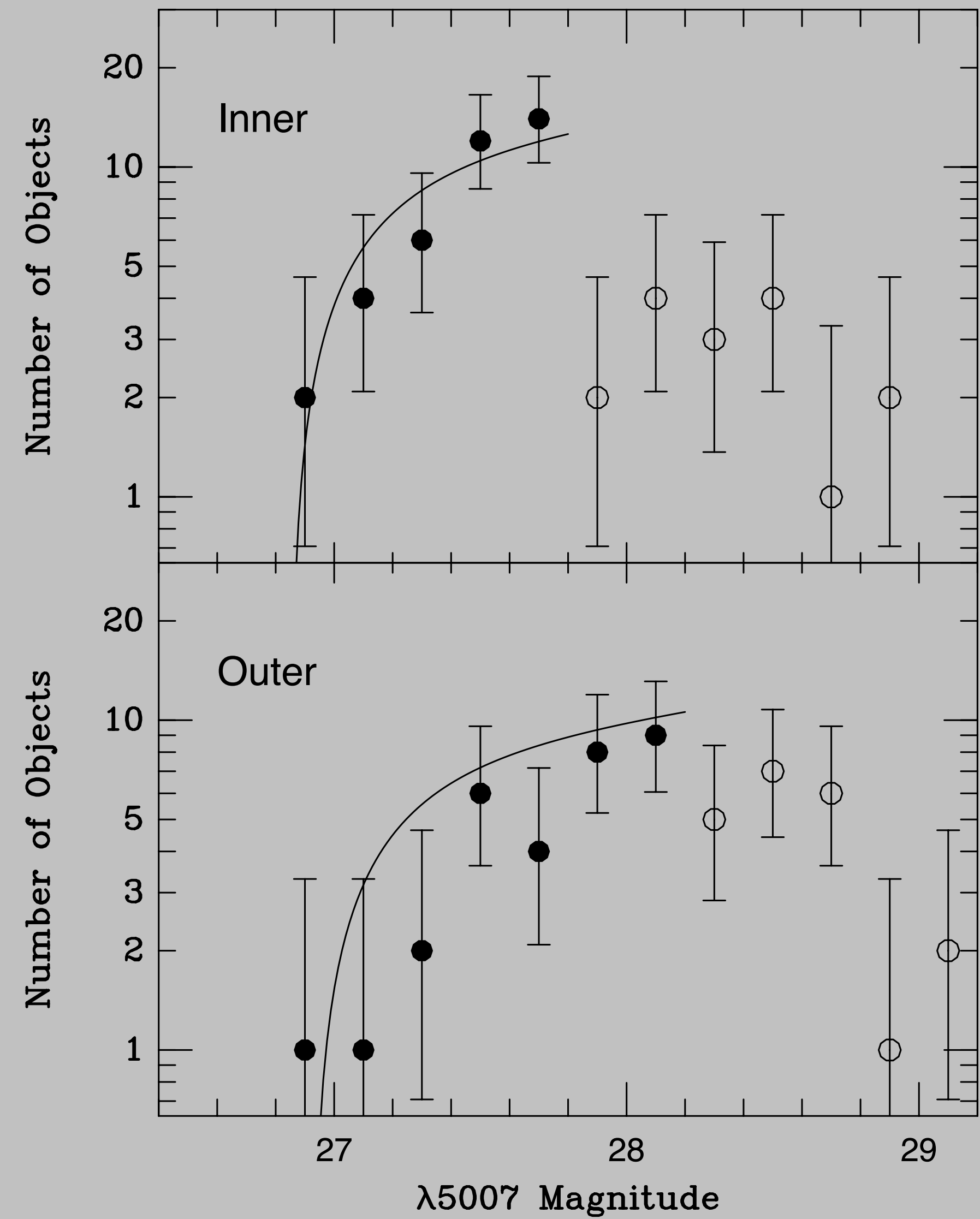
PNLF- H_0 target selection

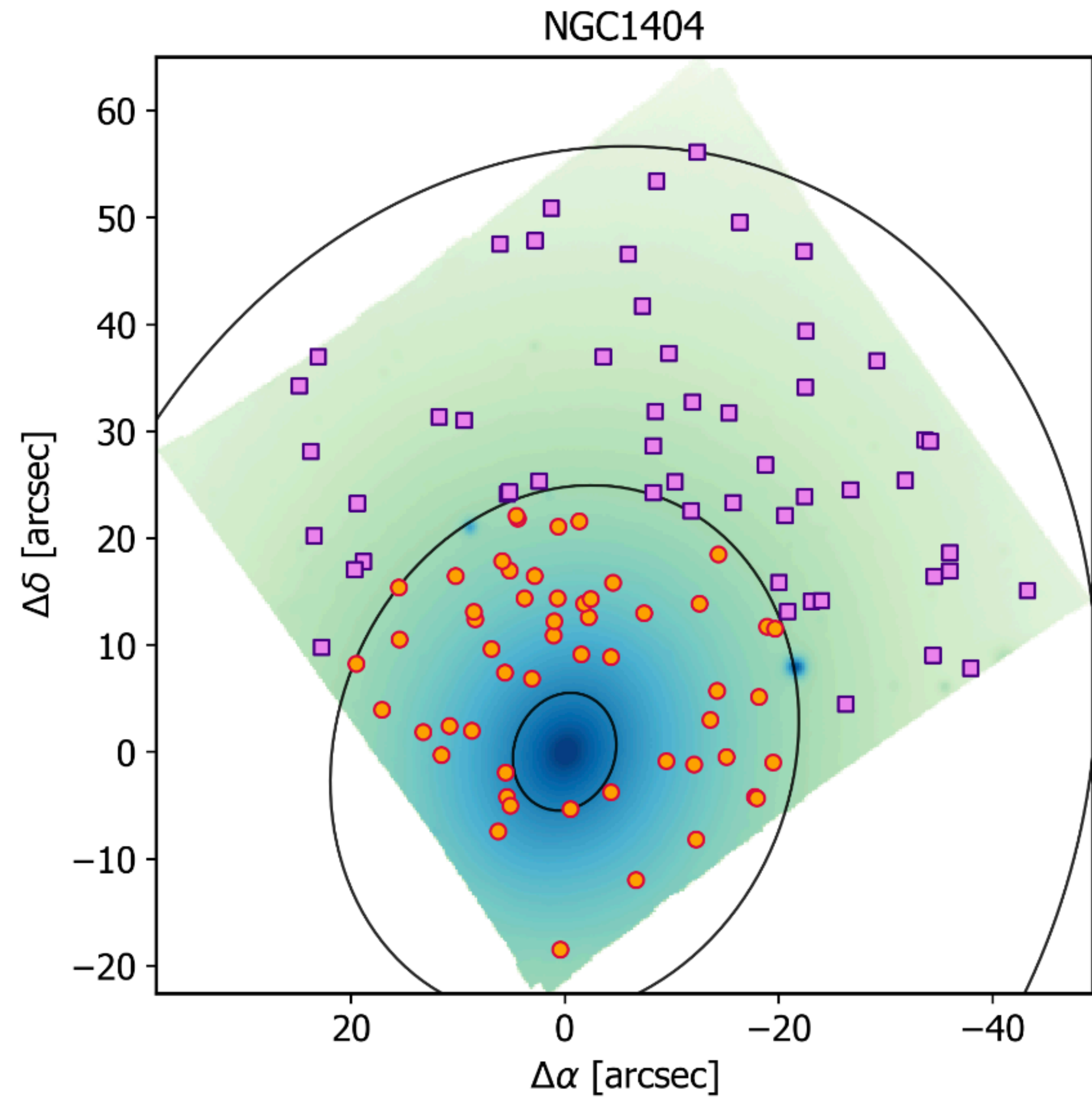
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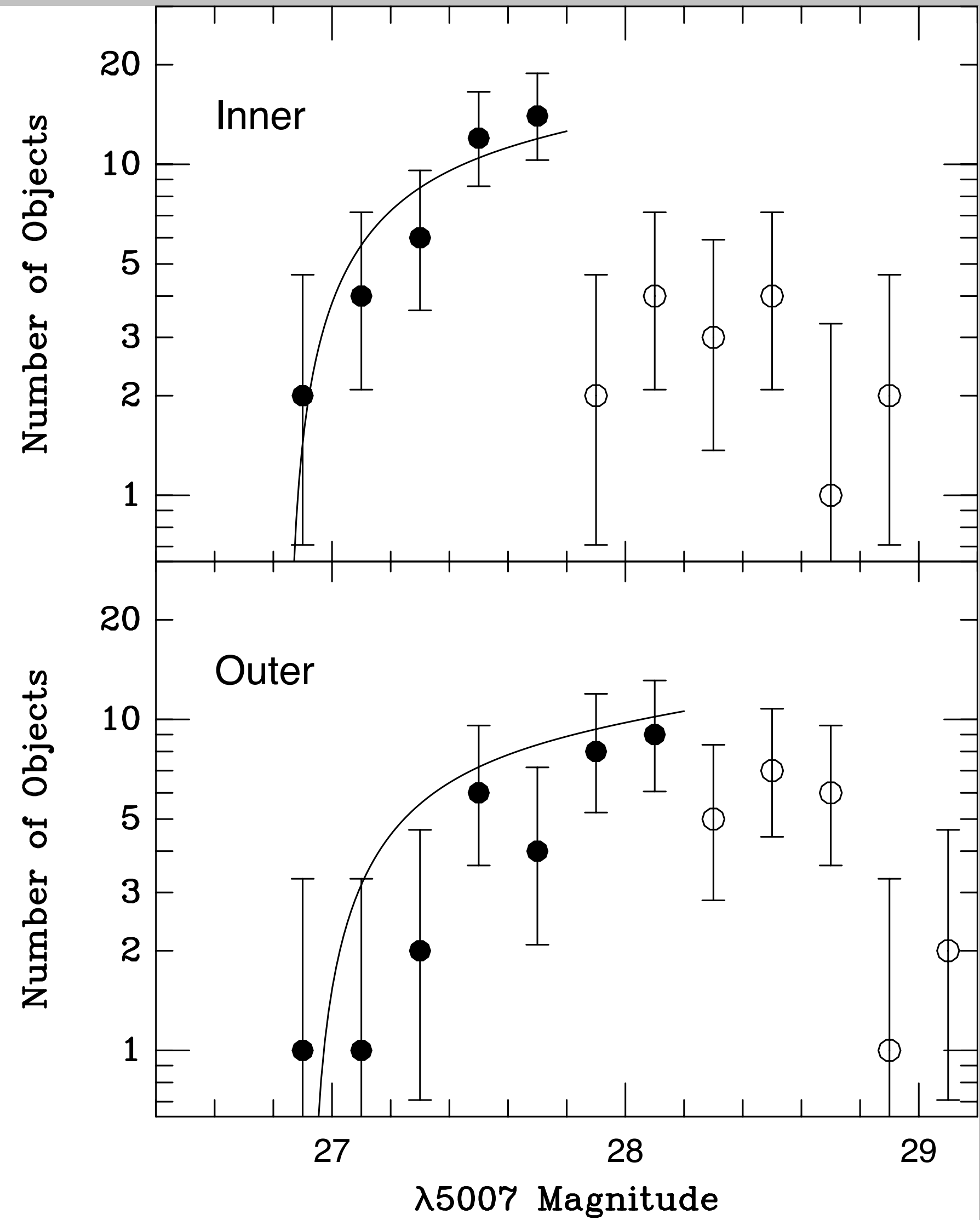


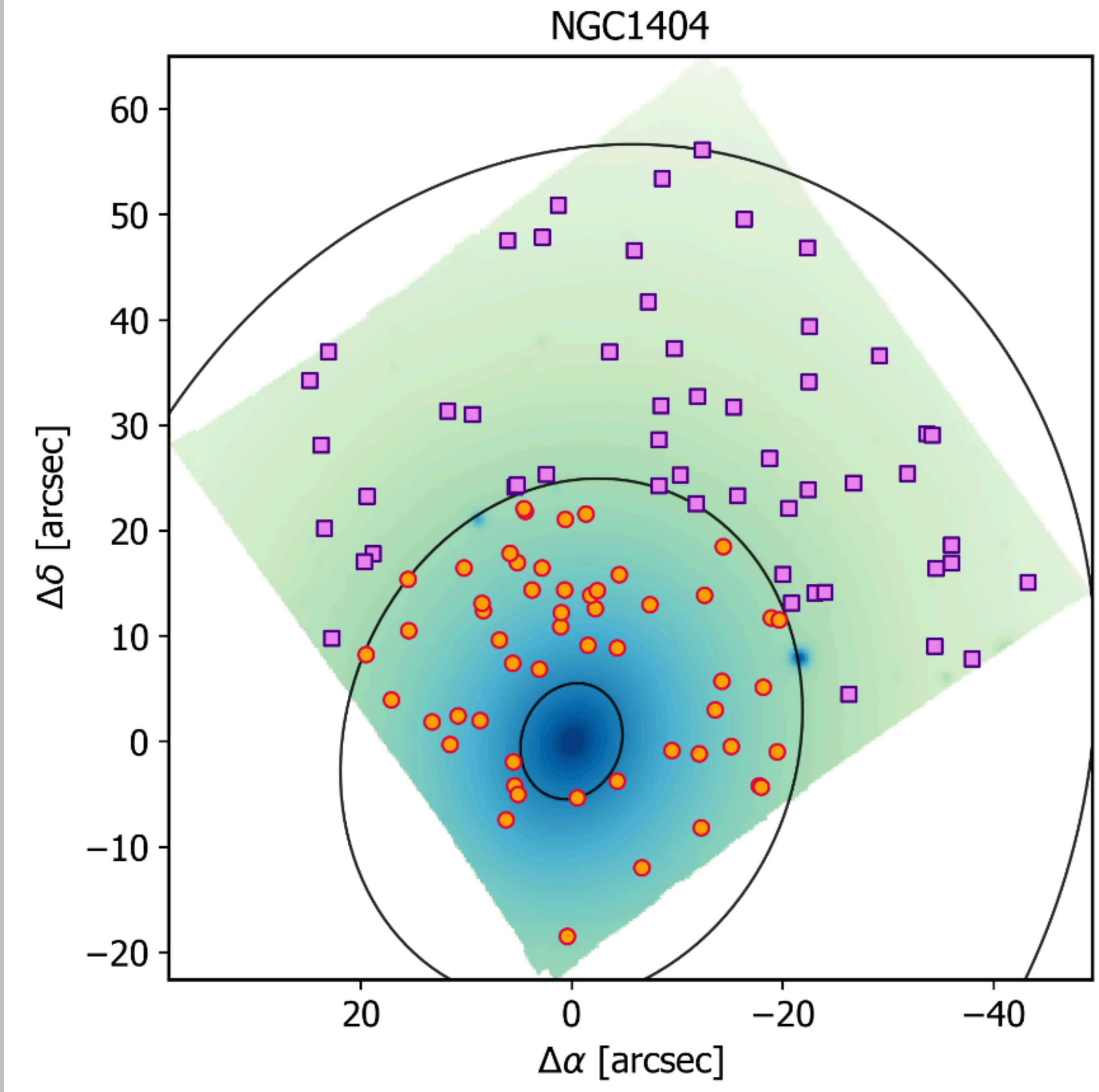
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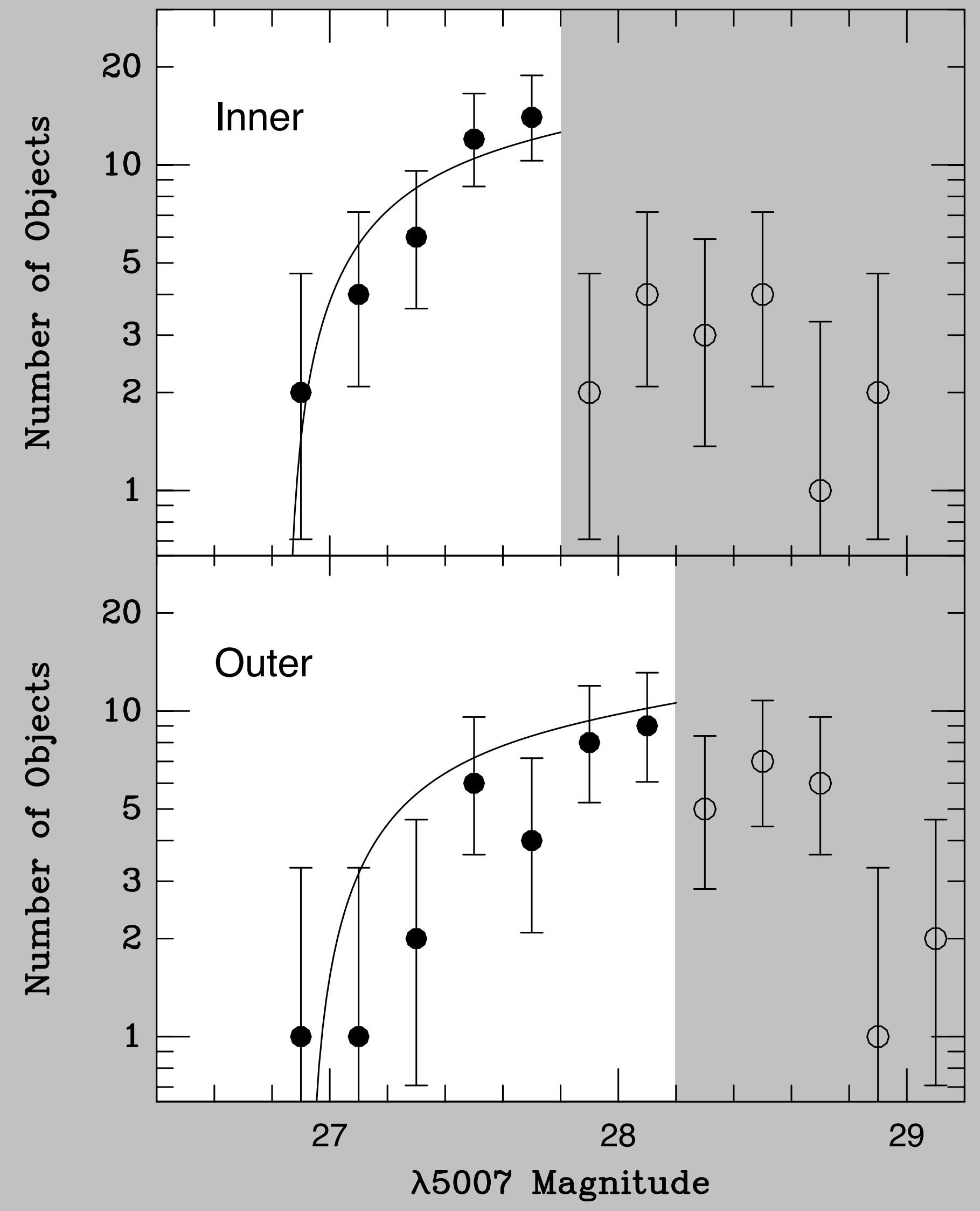


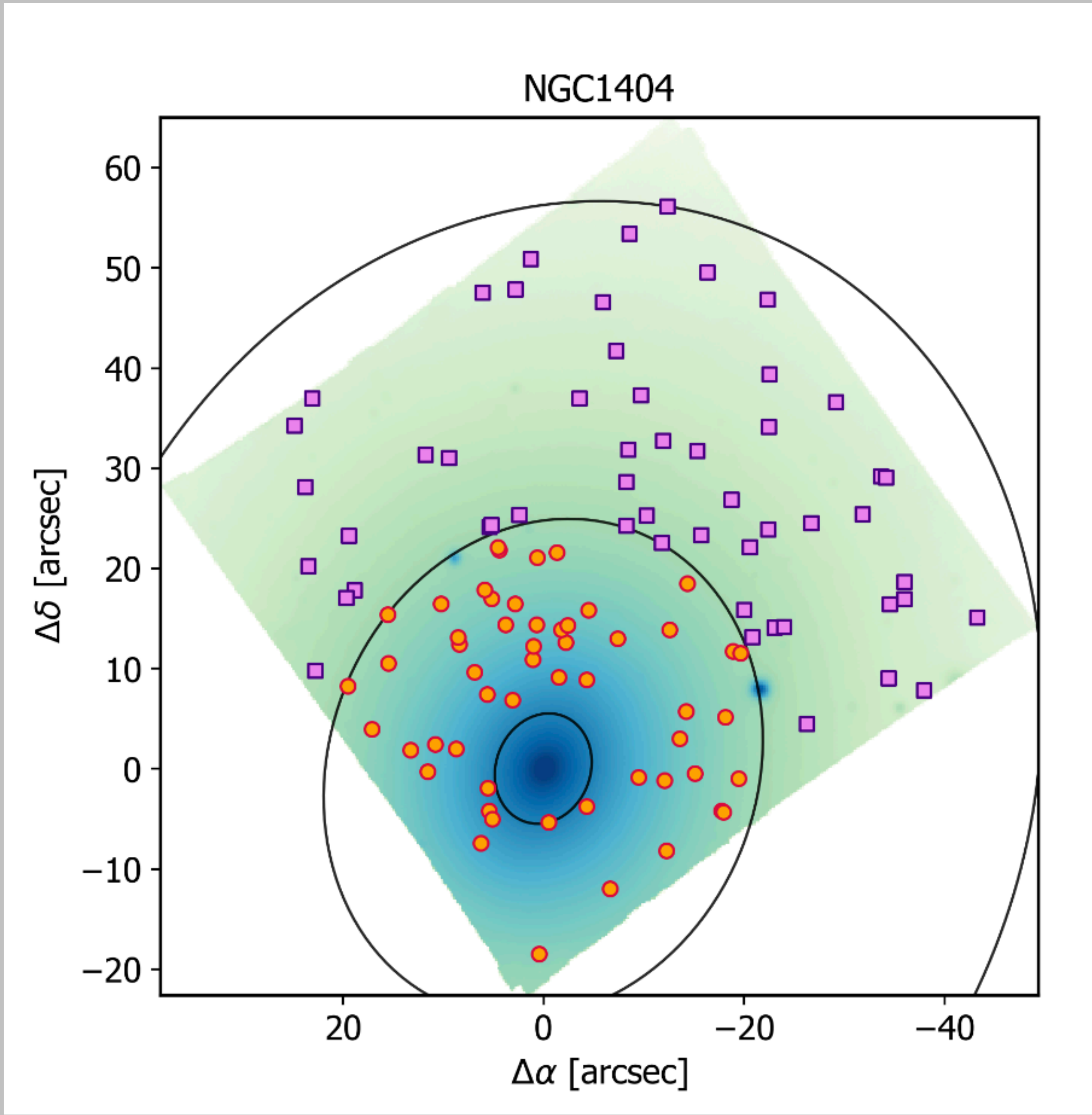
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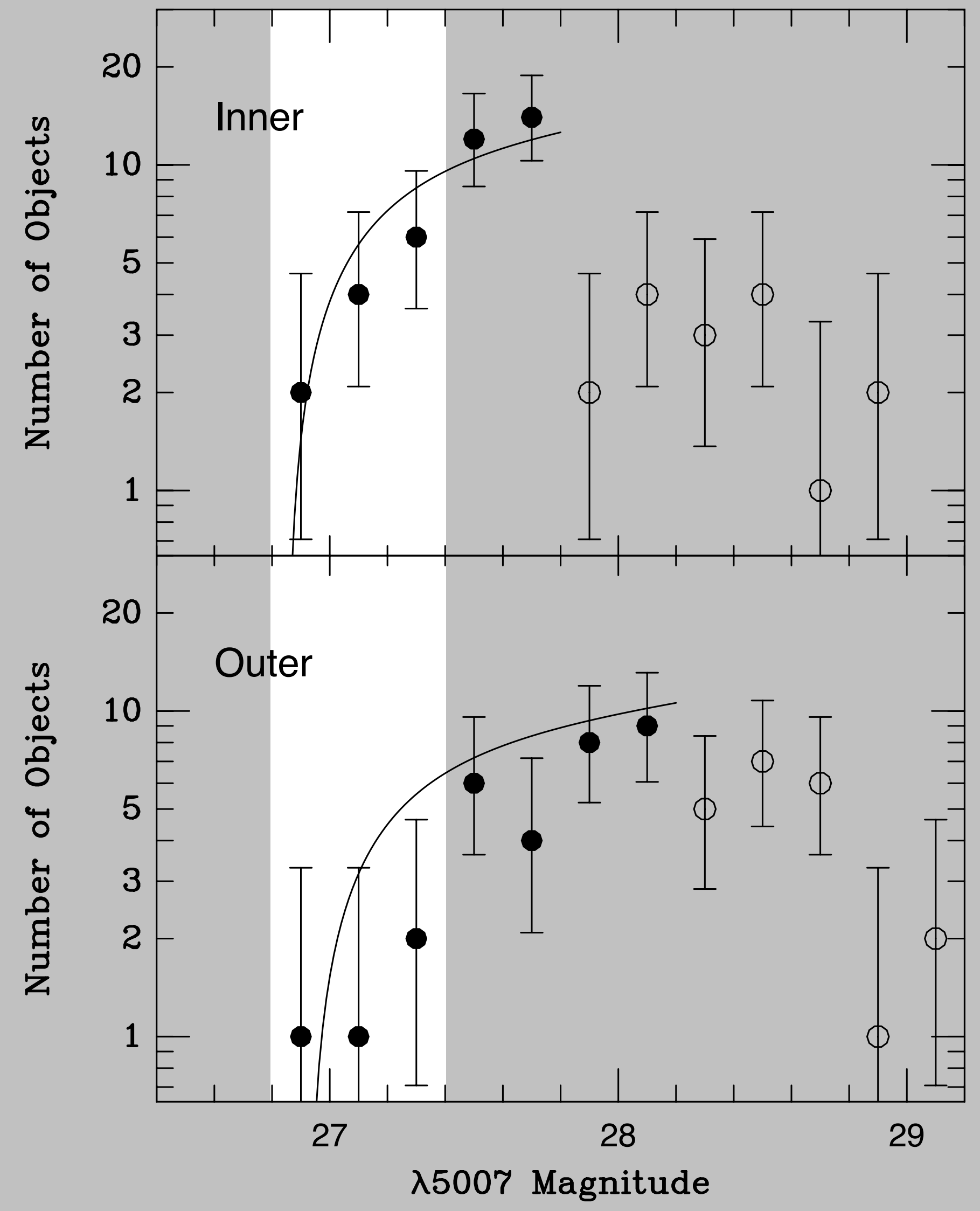


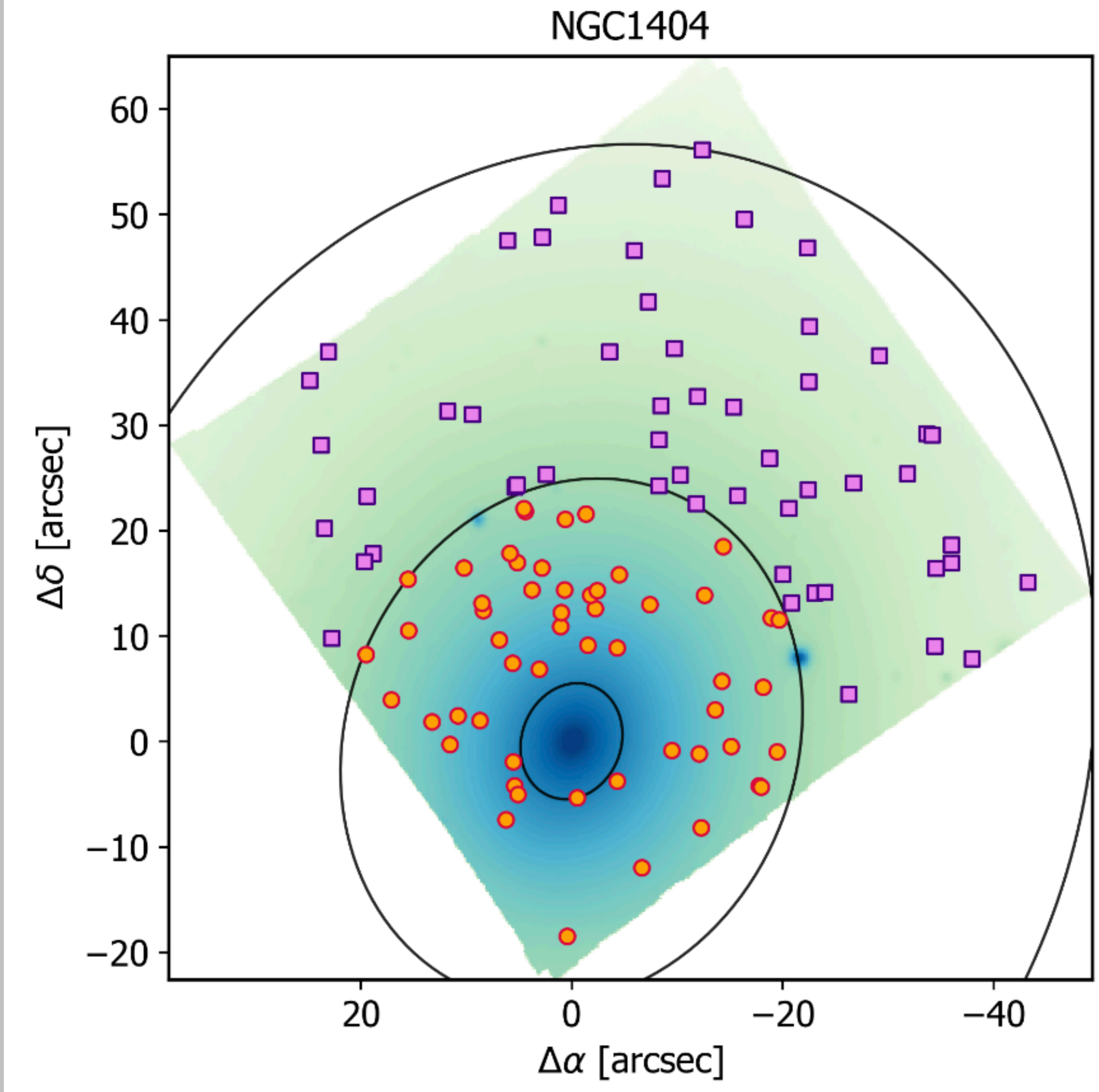
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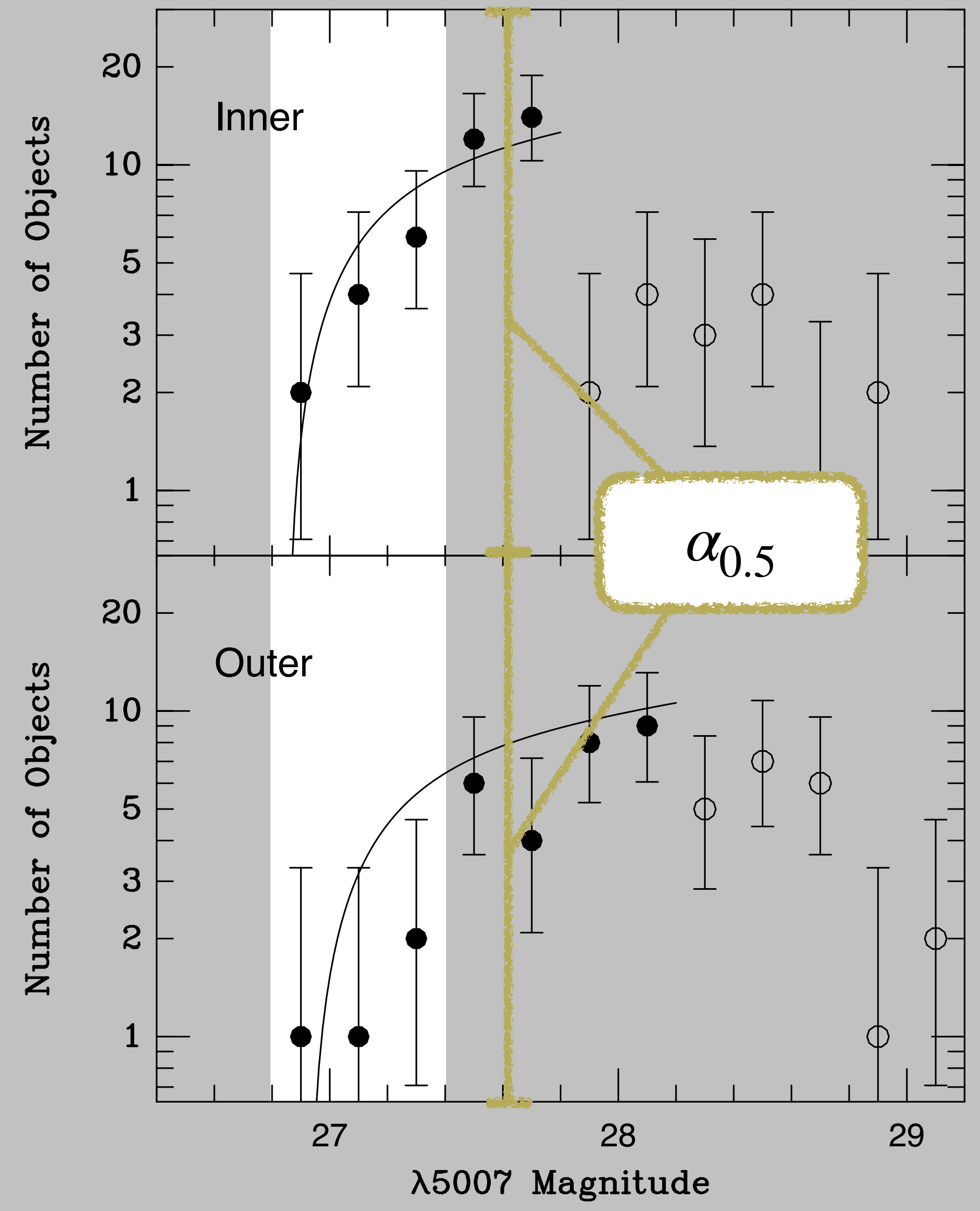


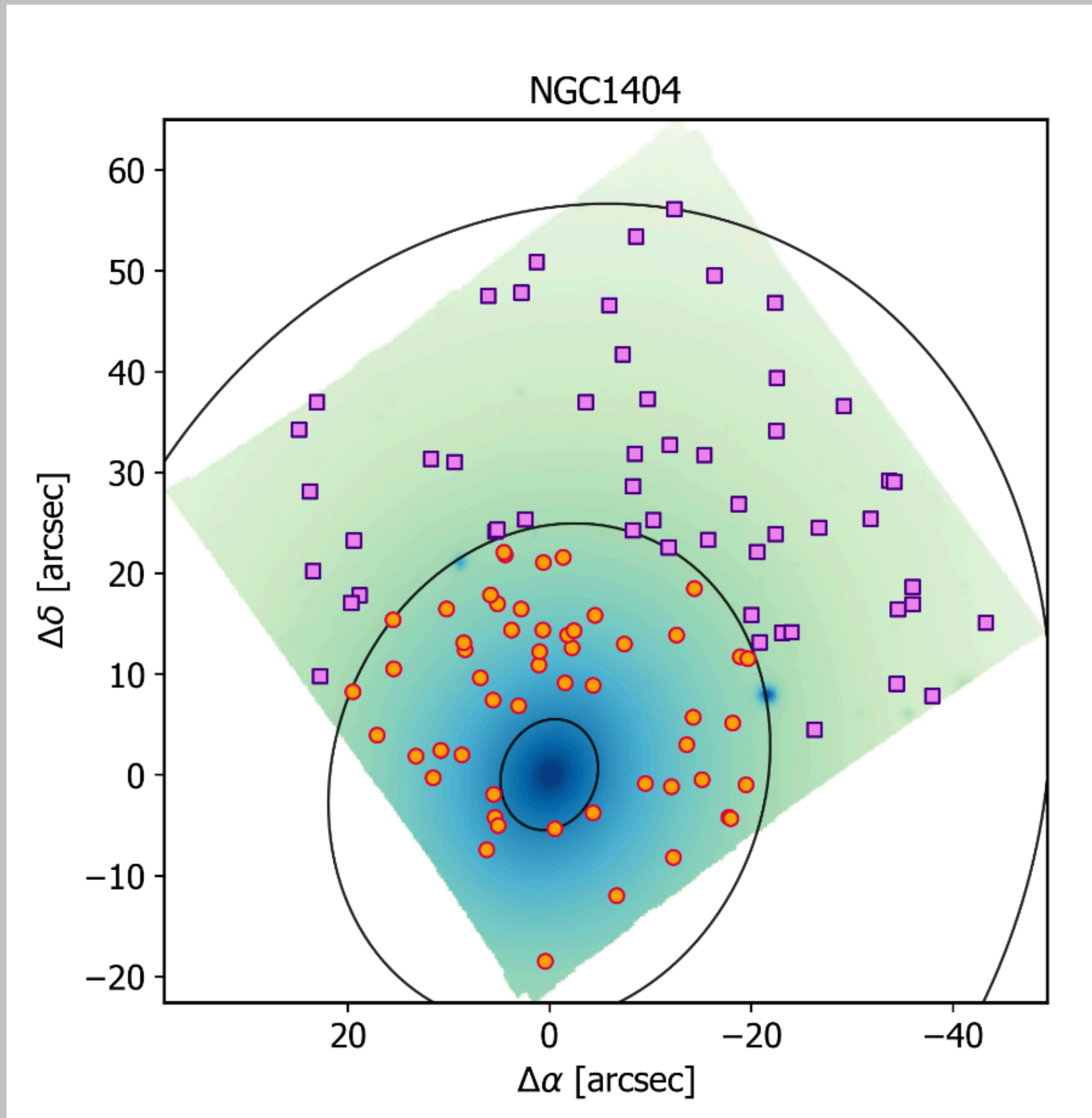
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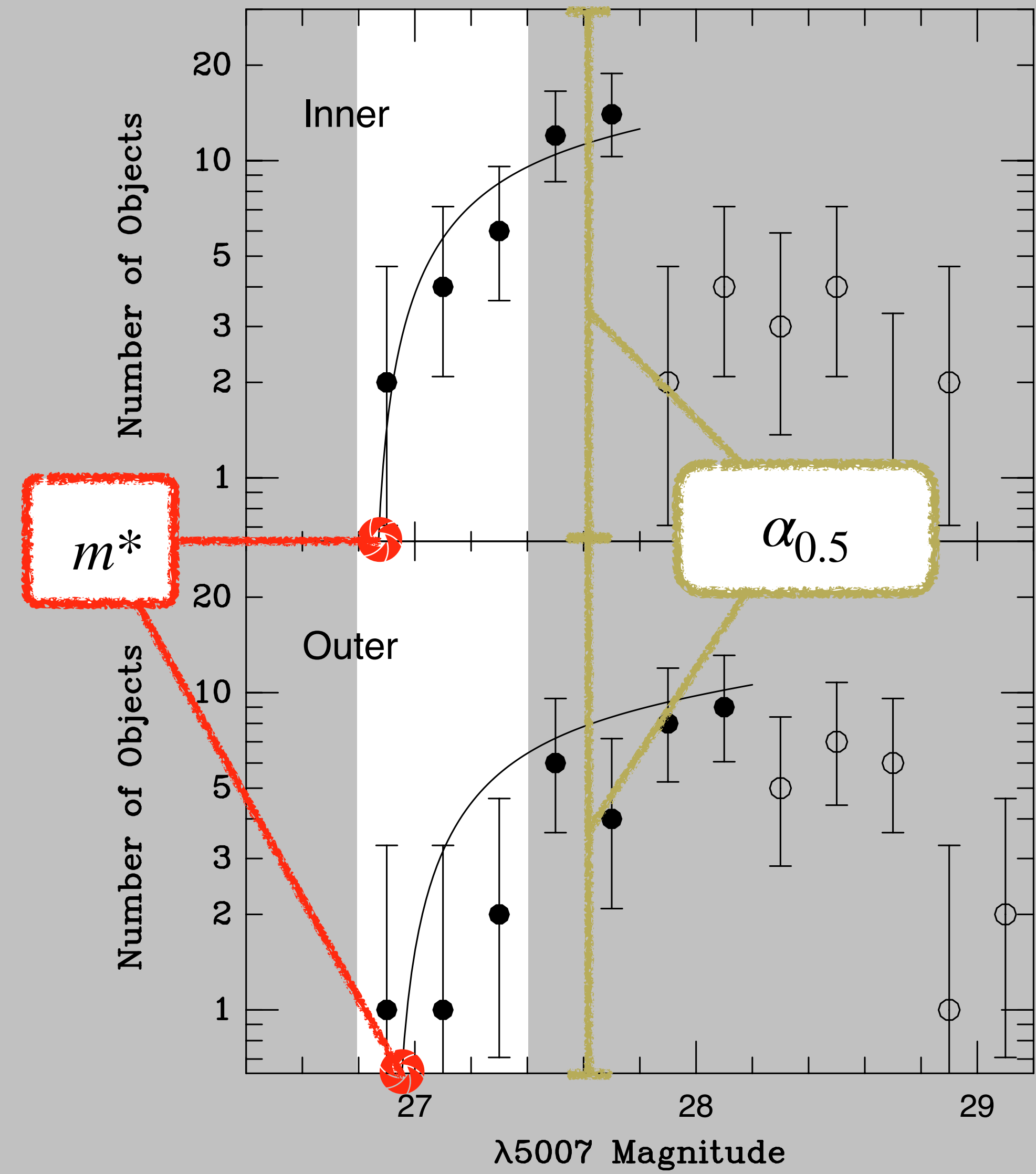


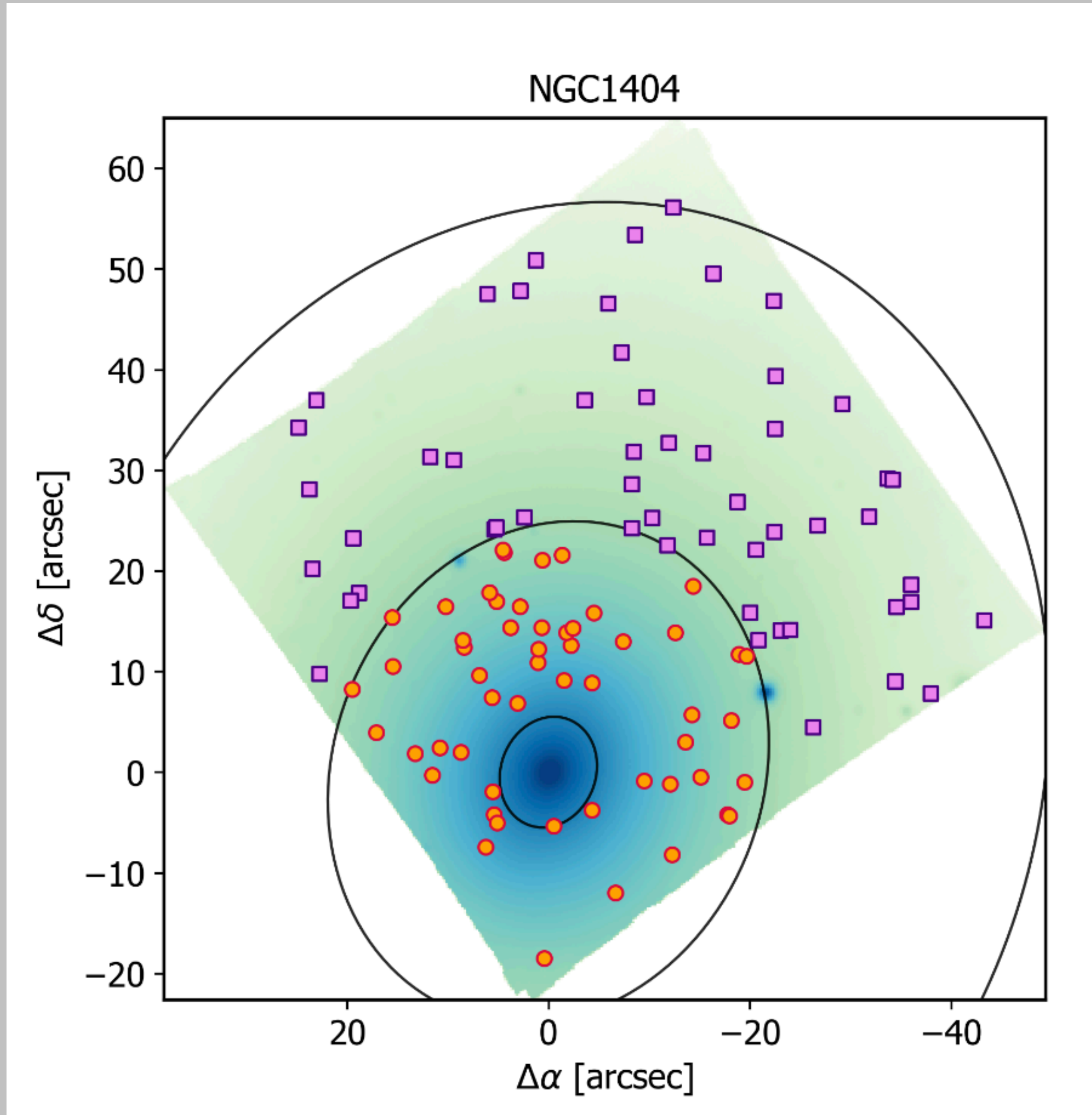
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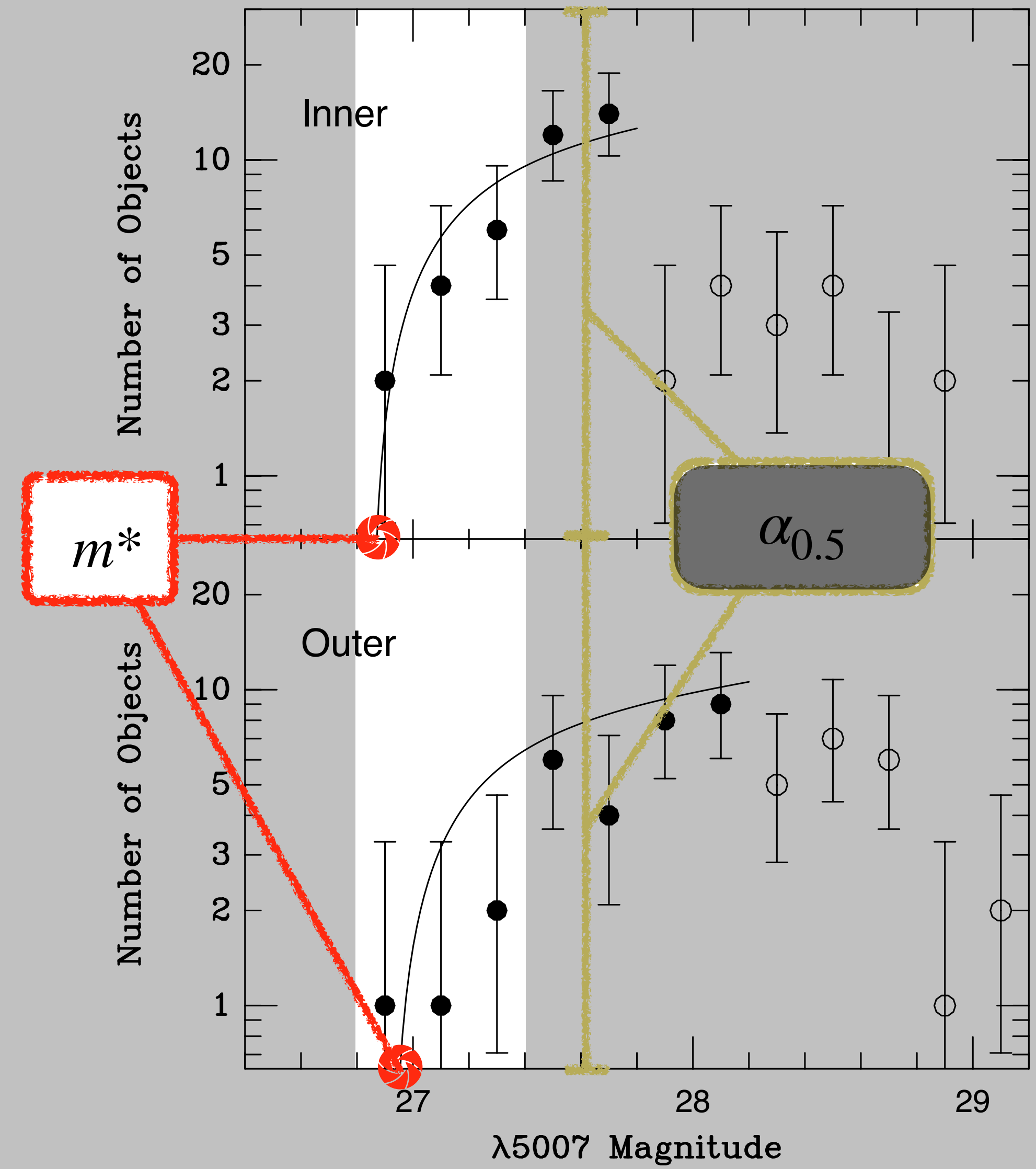


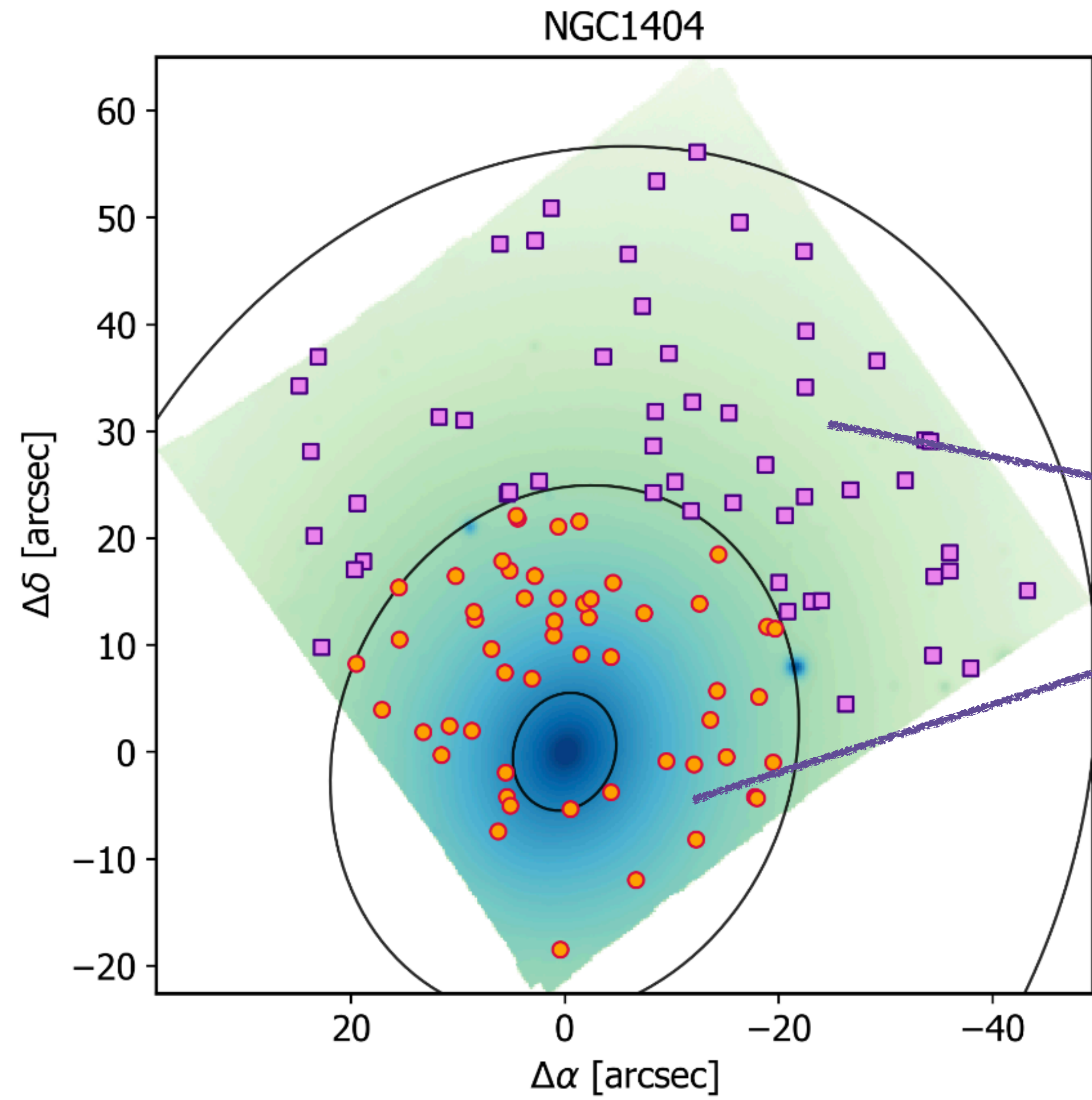
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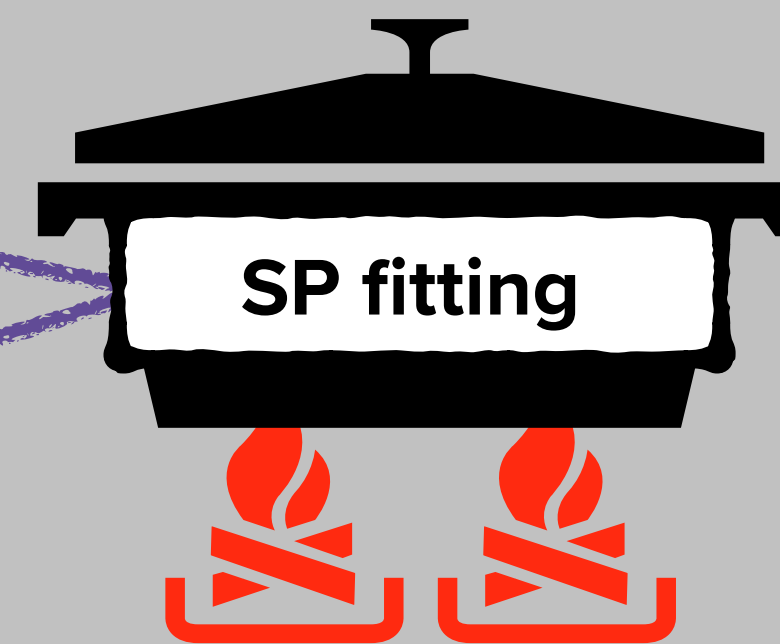


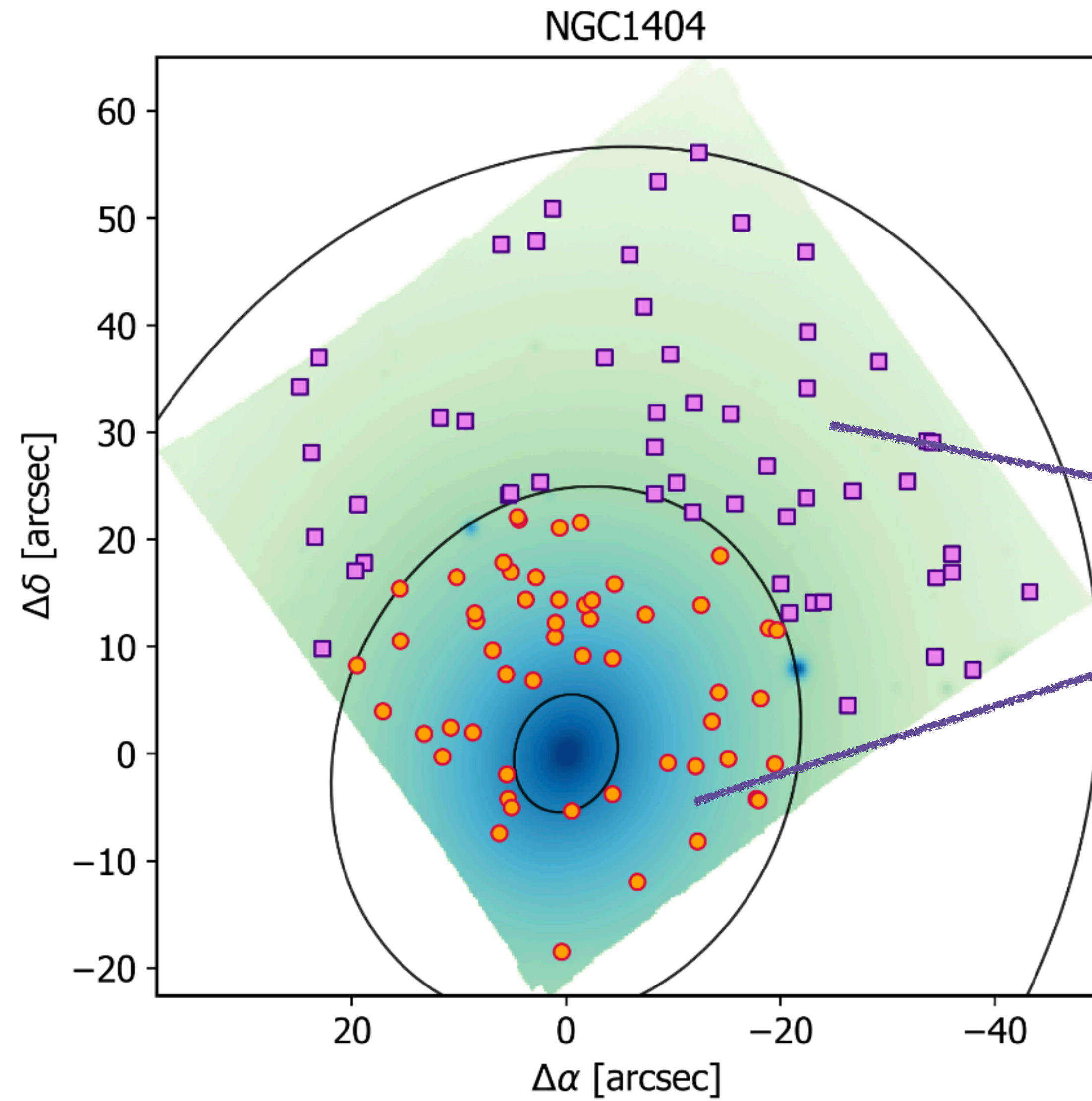
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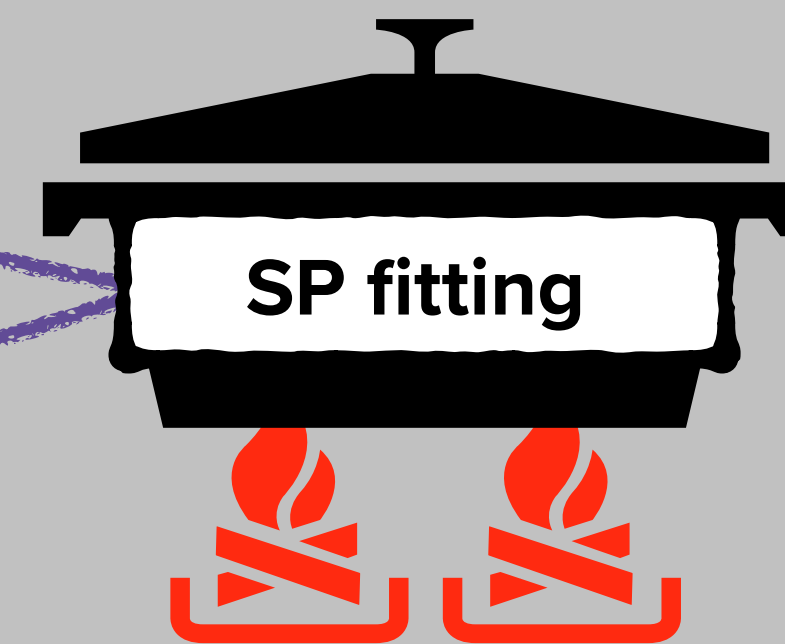


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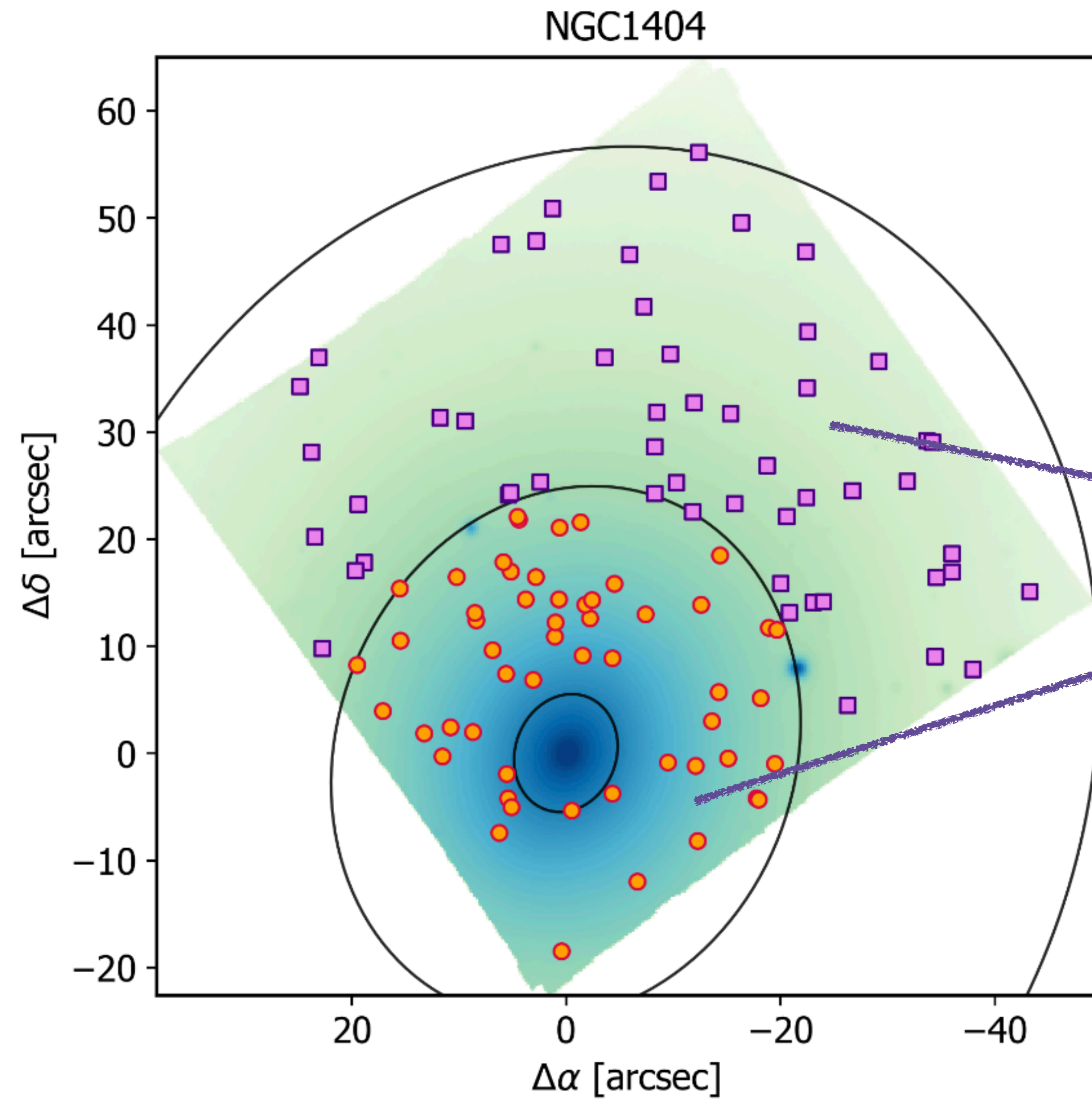




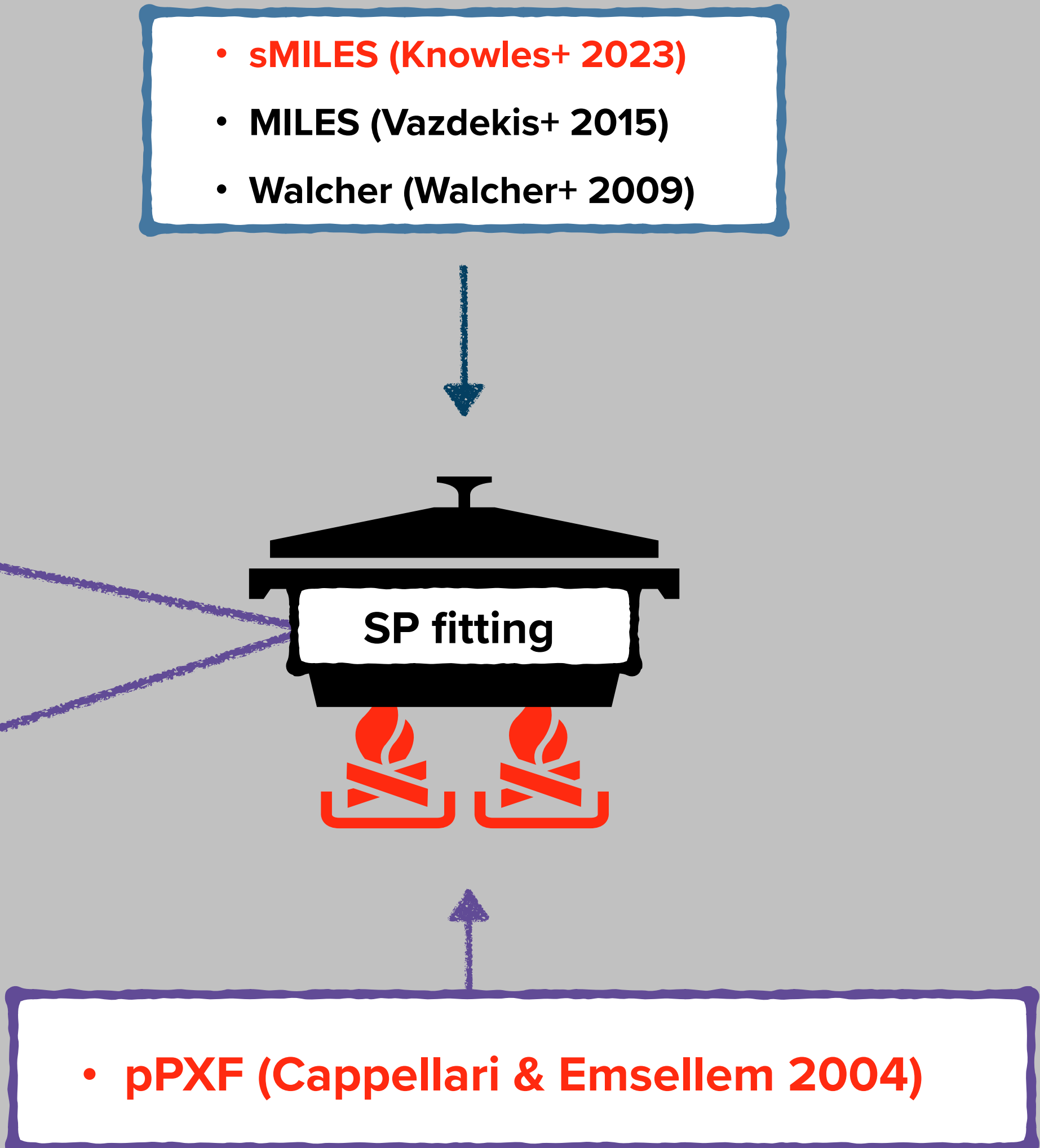
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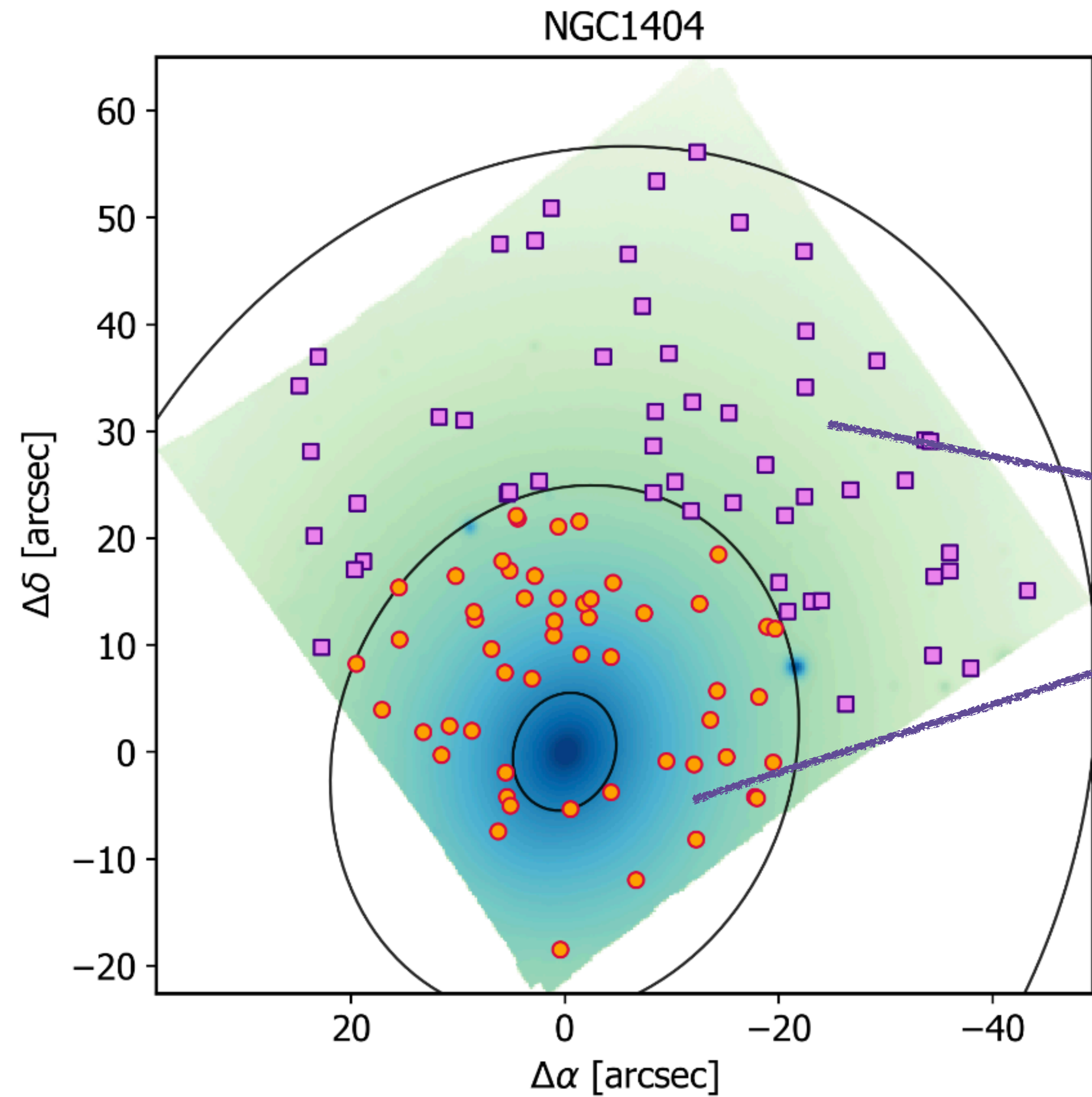


- **pPXF (Cappellari & Emsellem 2004)**

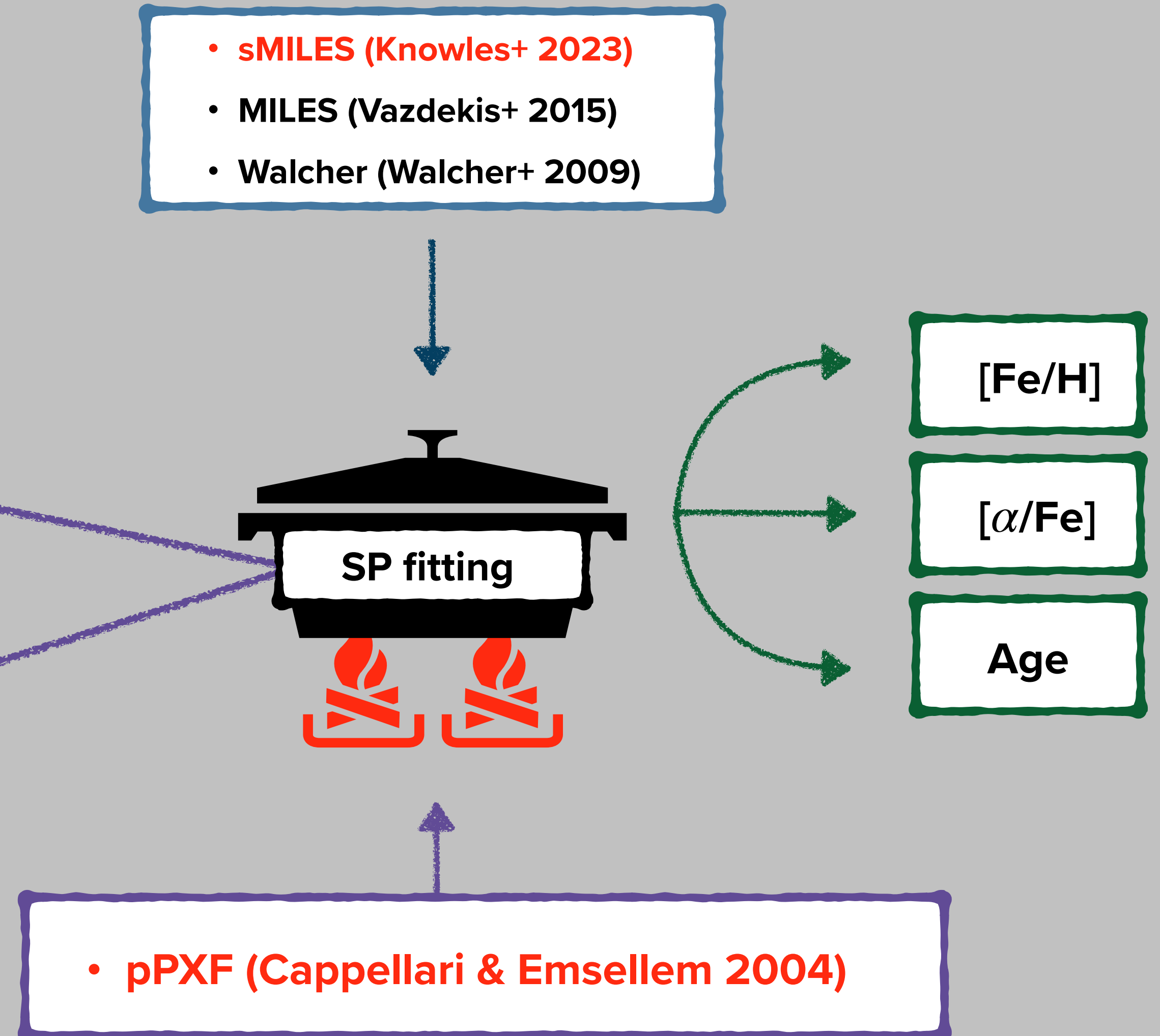


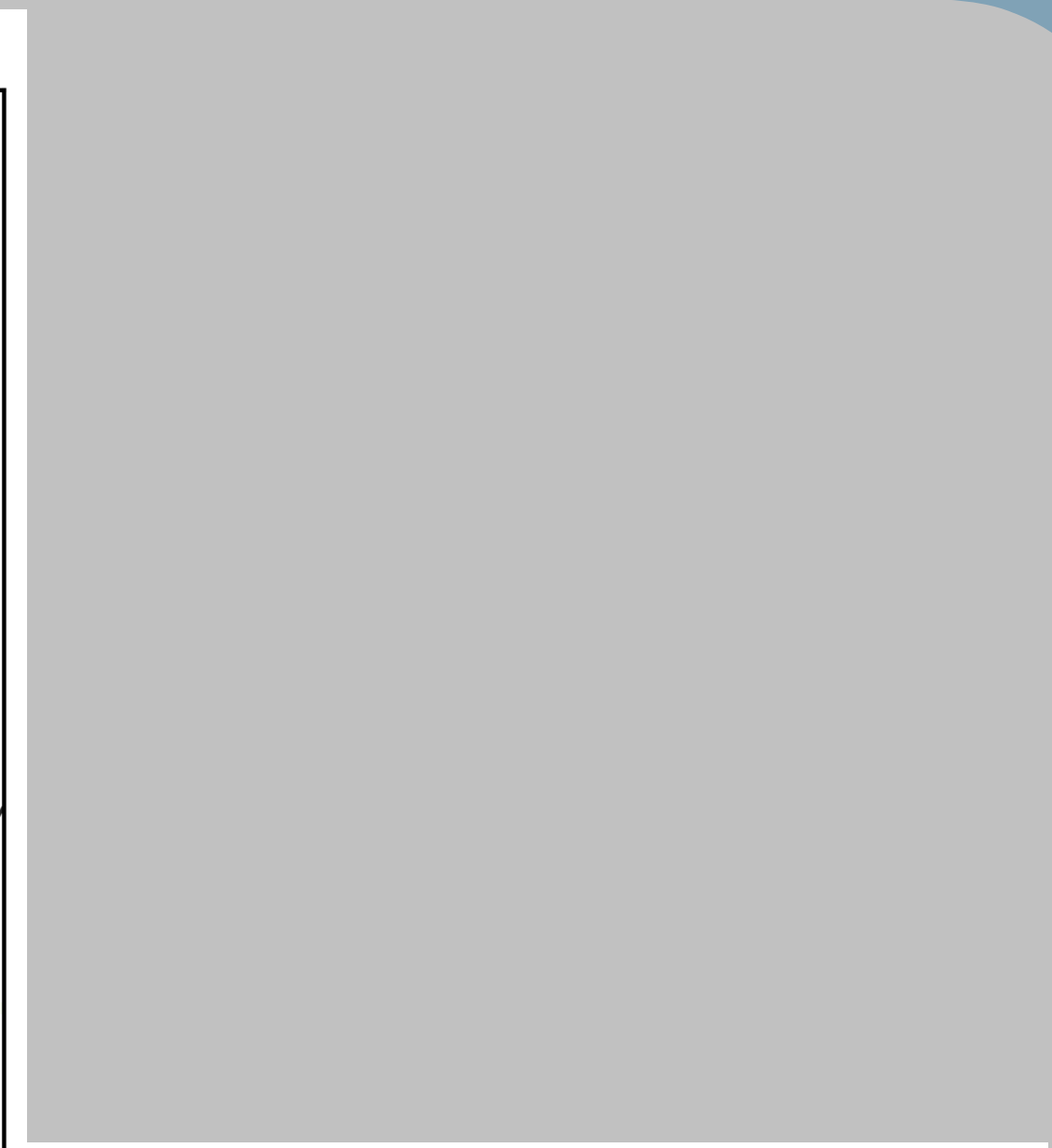
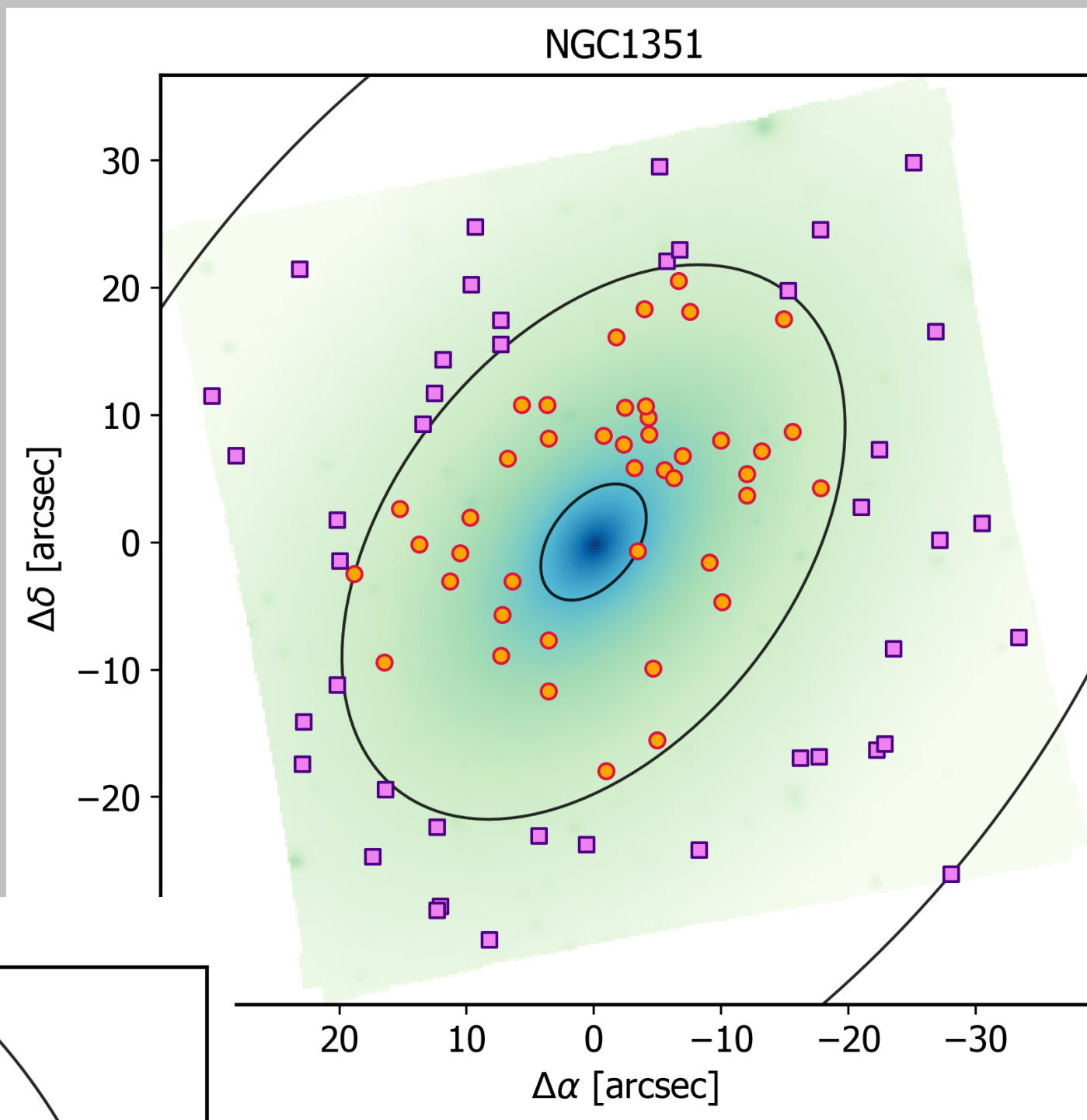
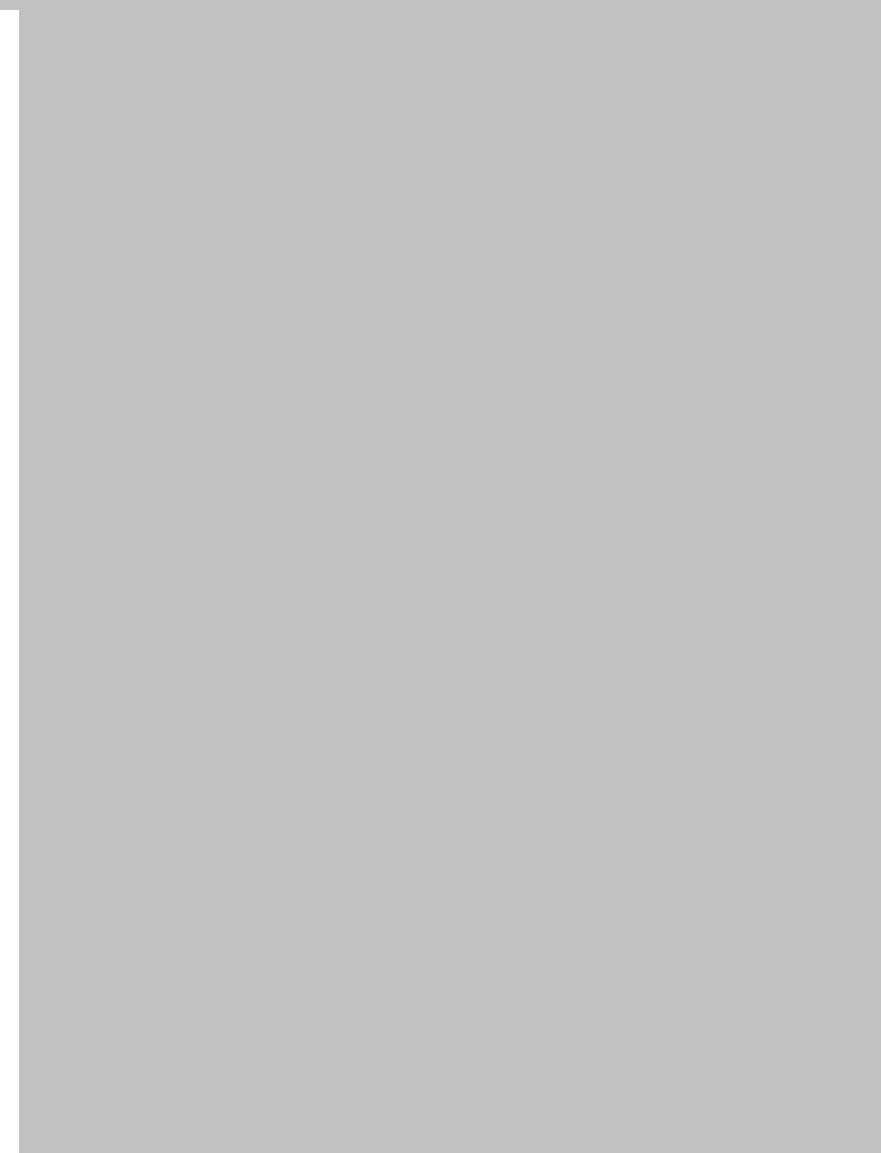
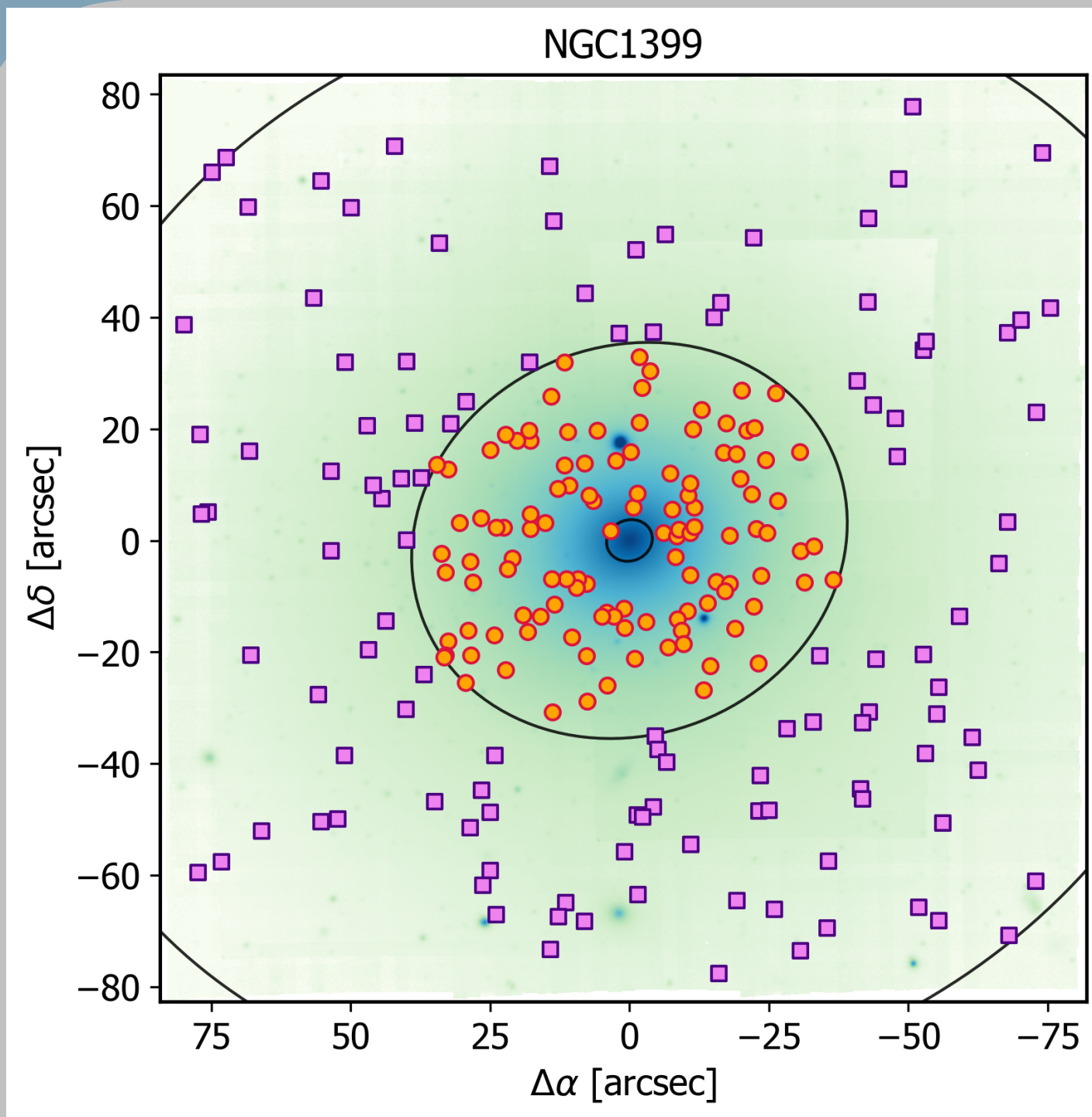
Credit: Soemitro et al. (2025)



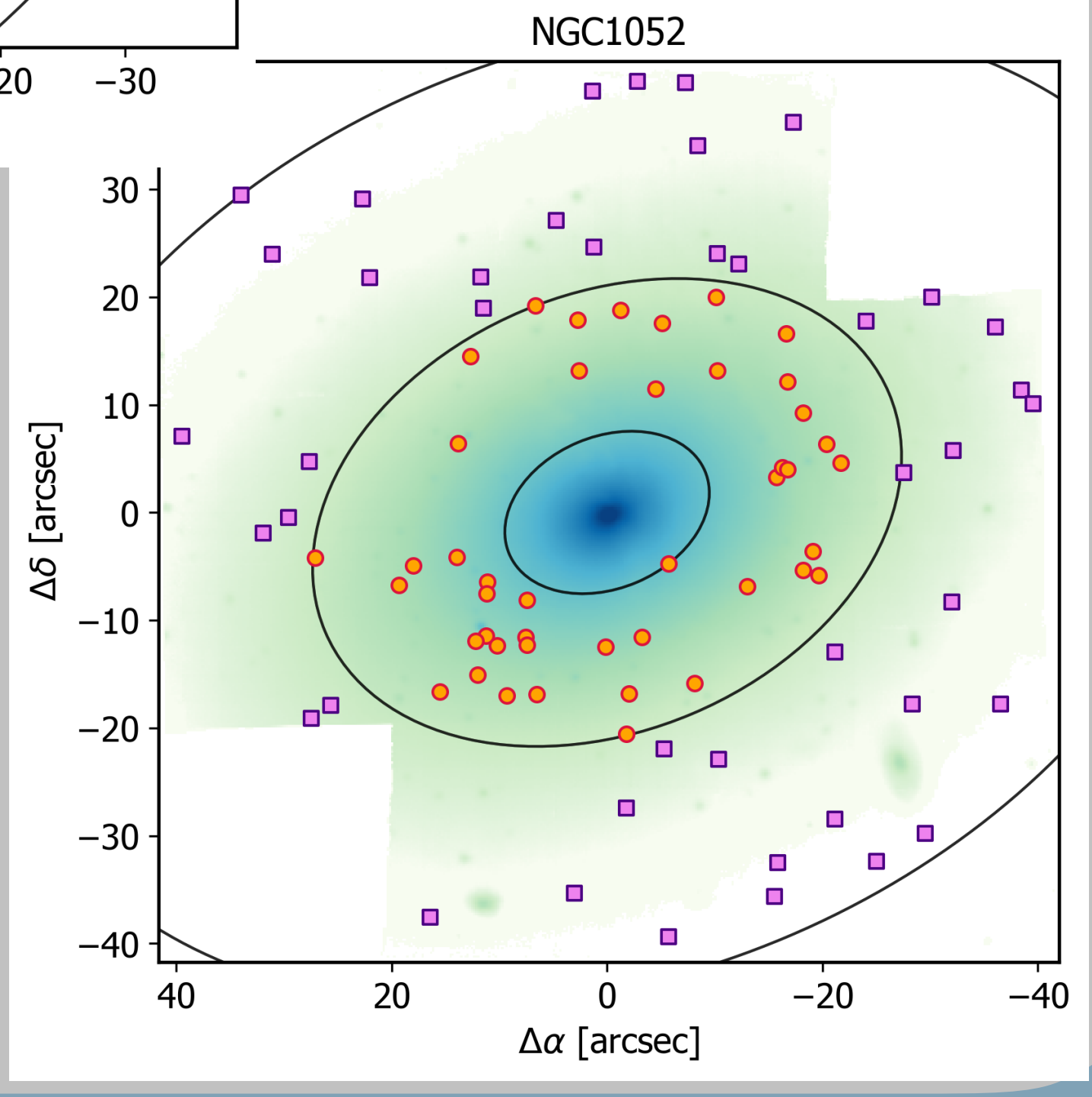
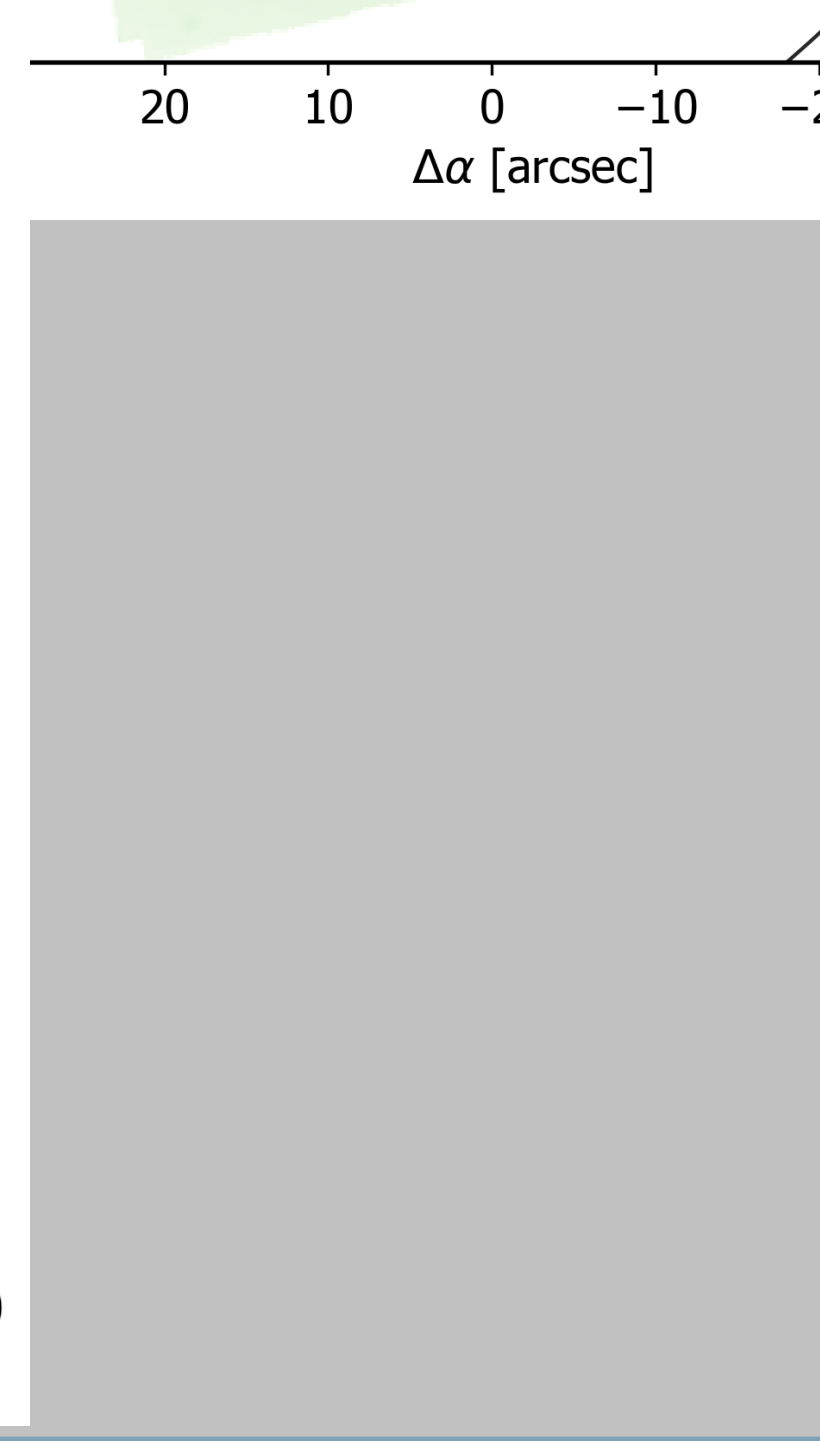
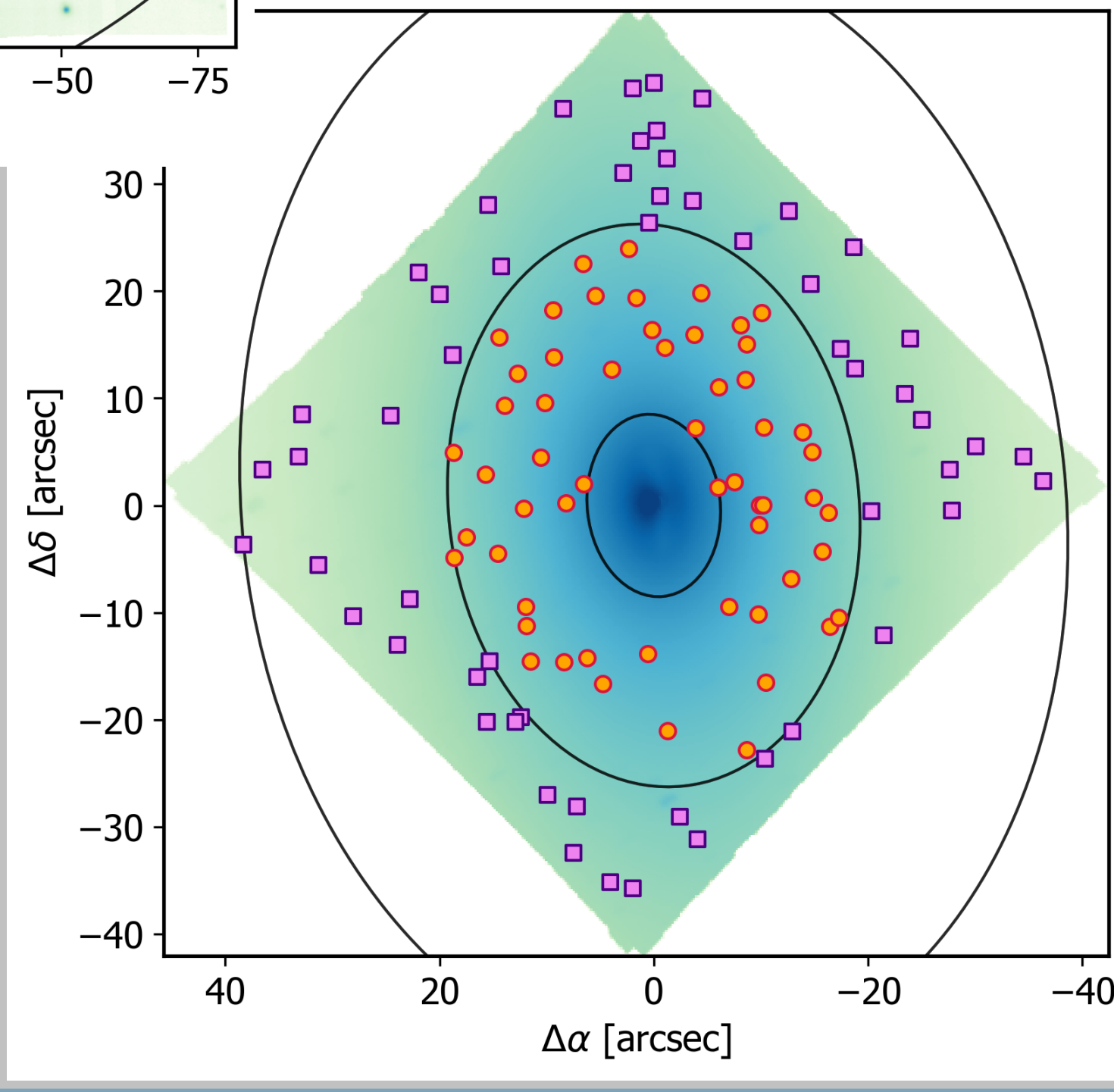


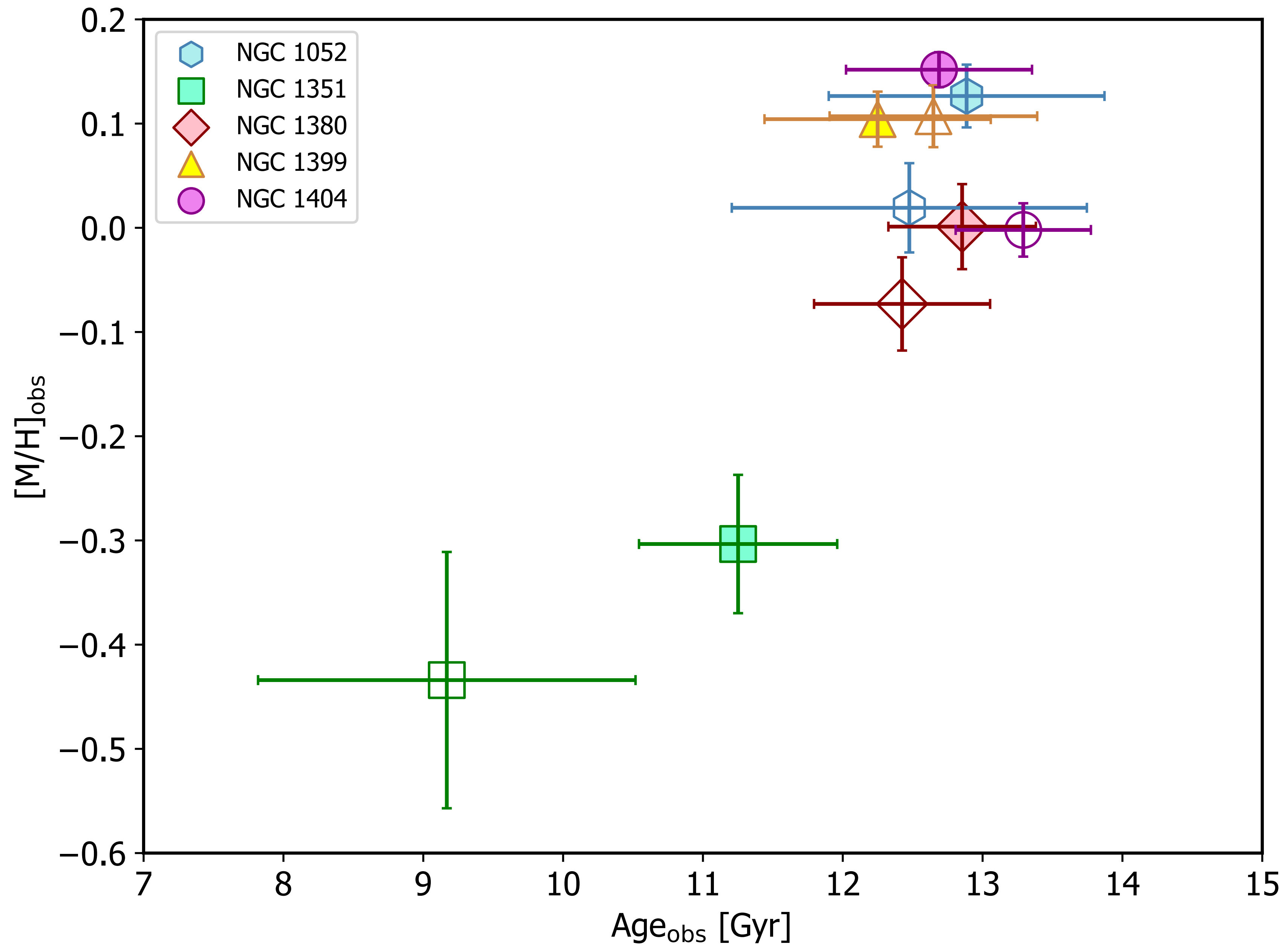
Credit: Soemitro et al. (2025)

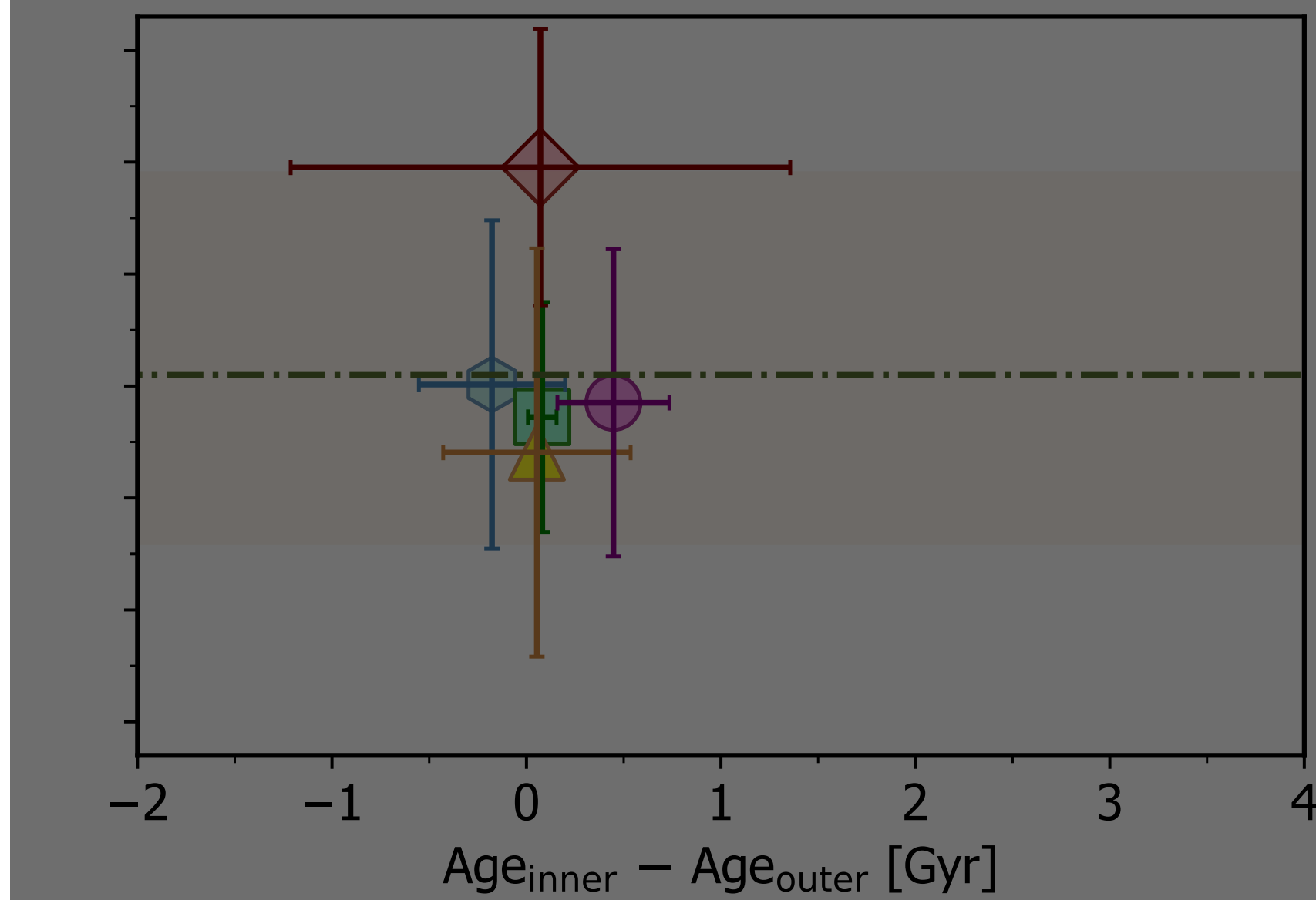
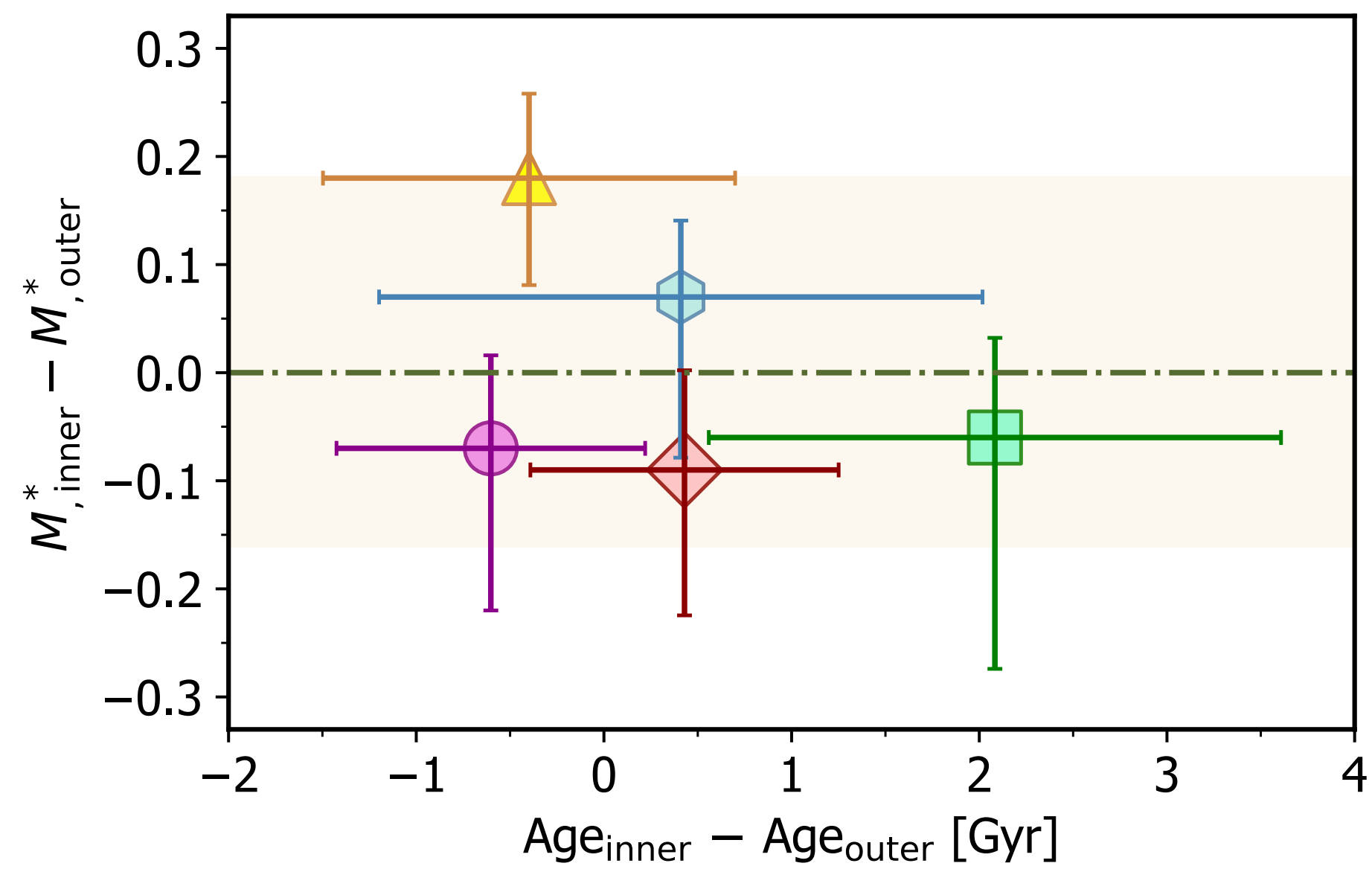
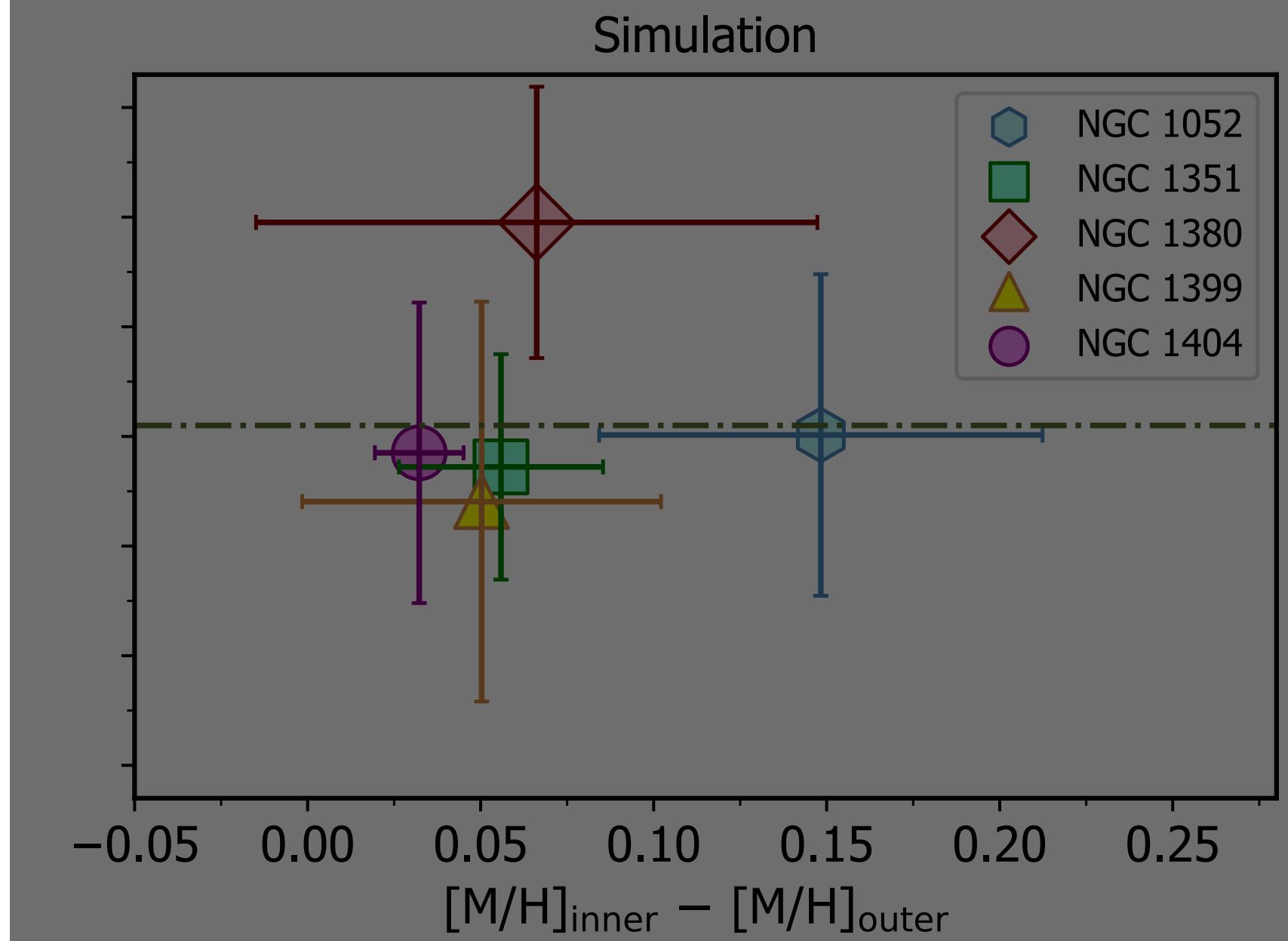
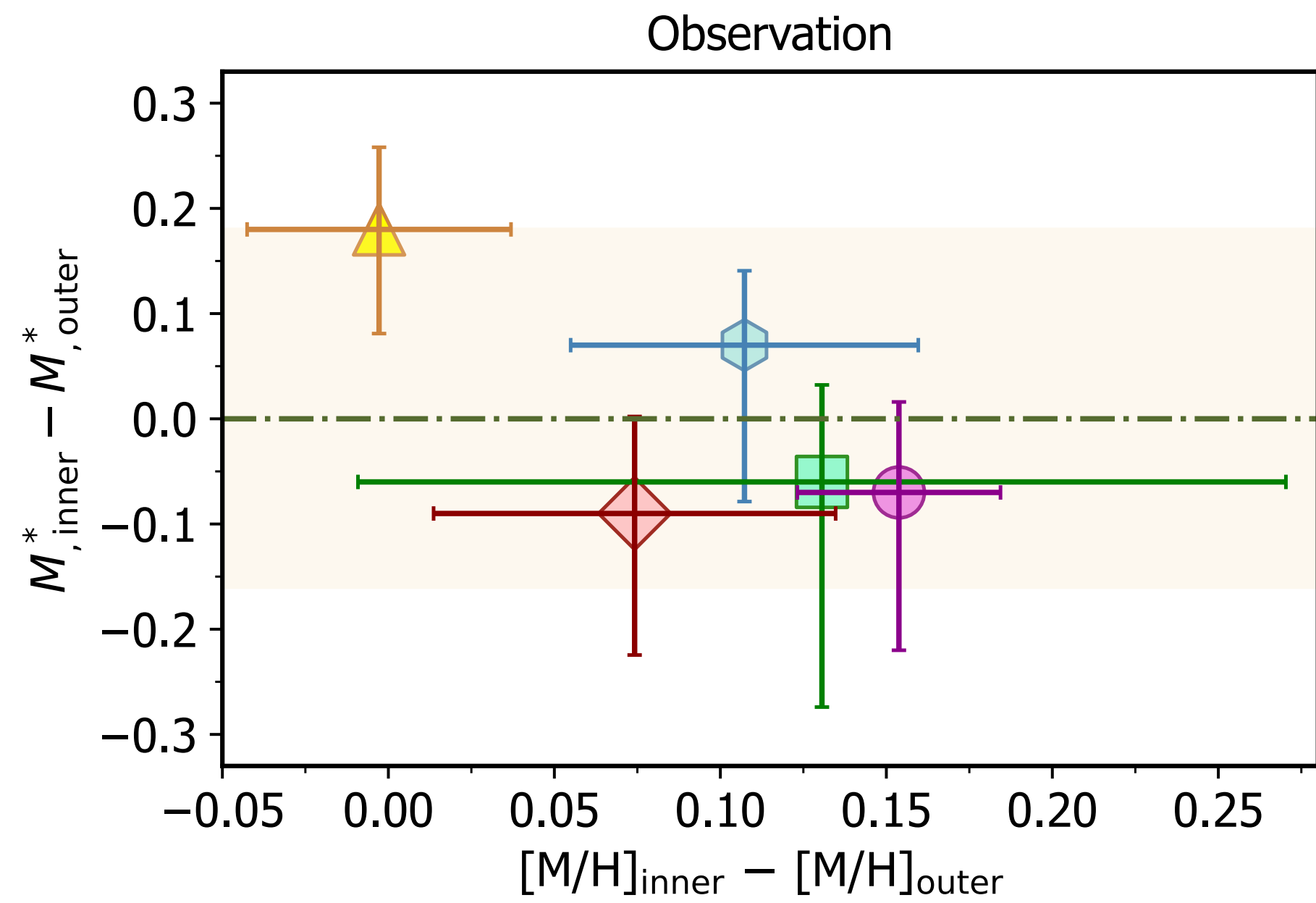




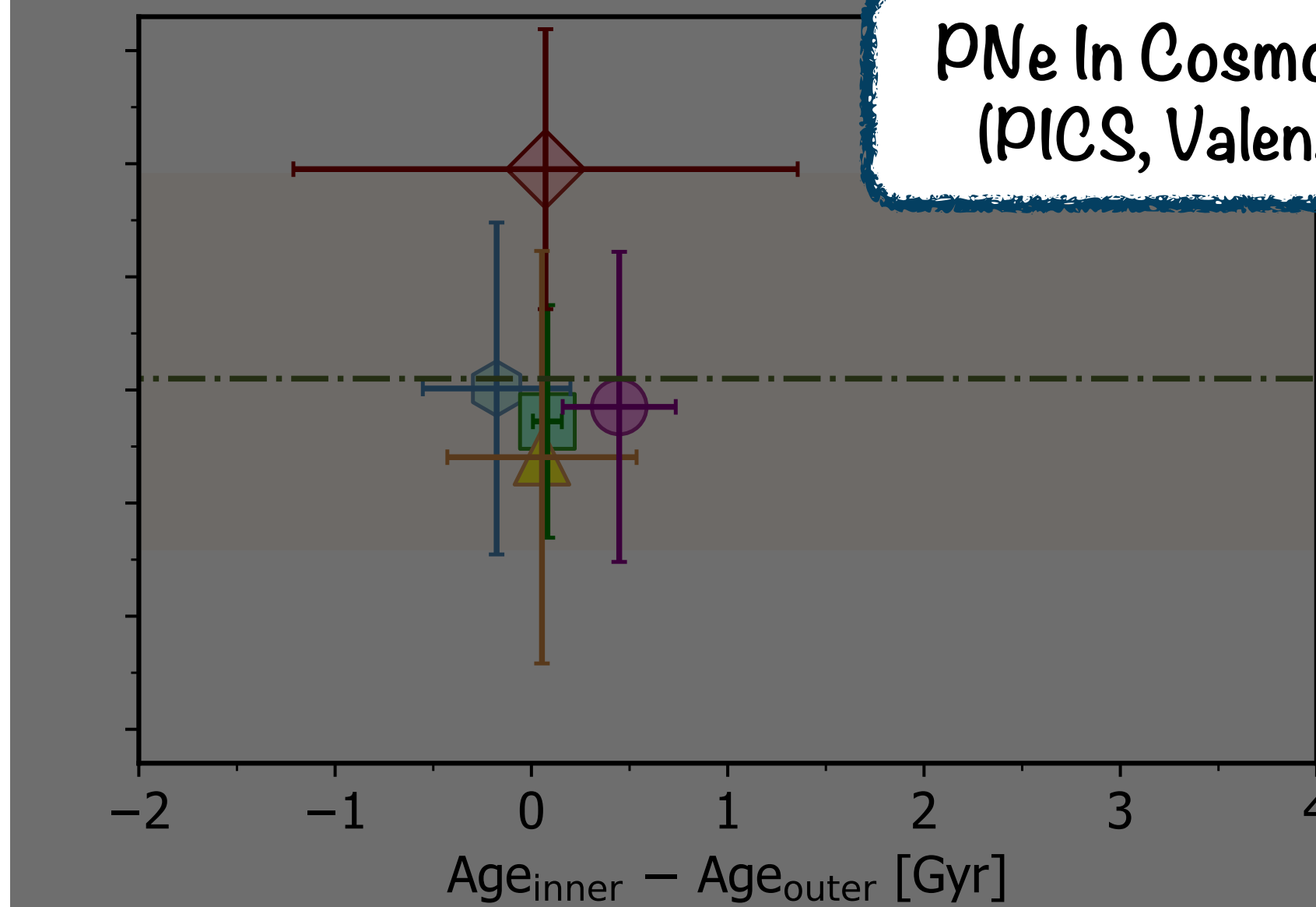
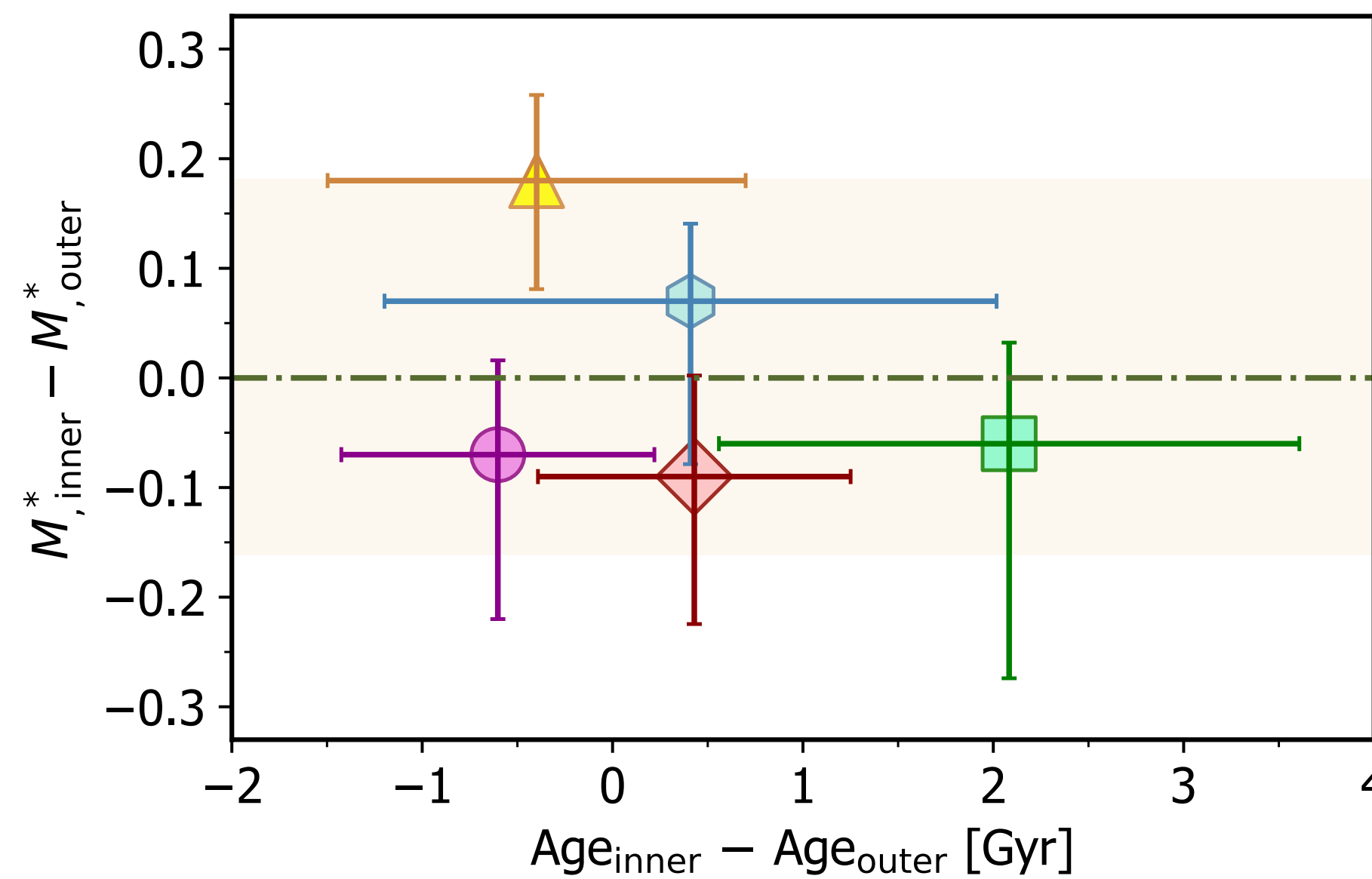
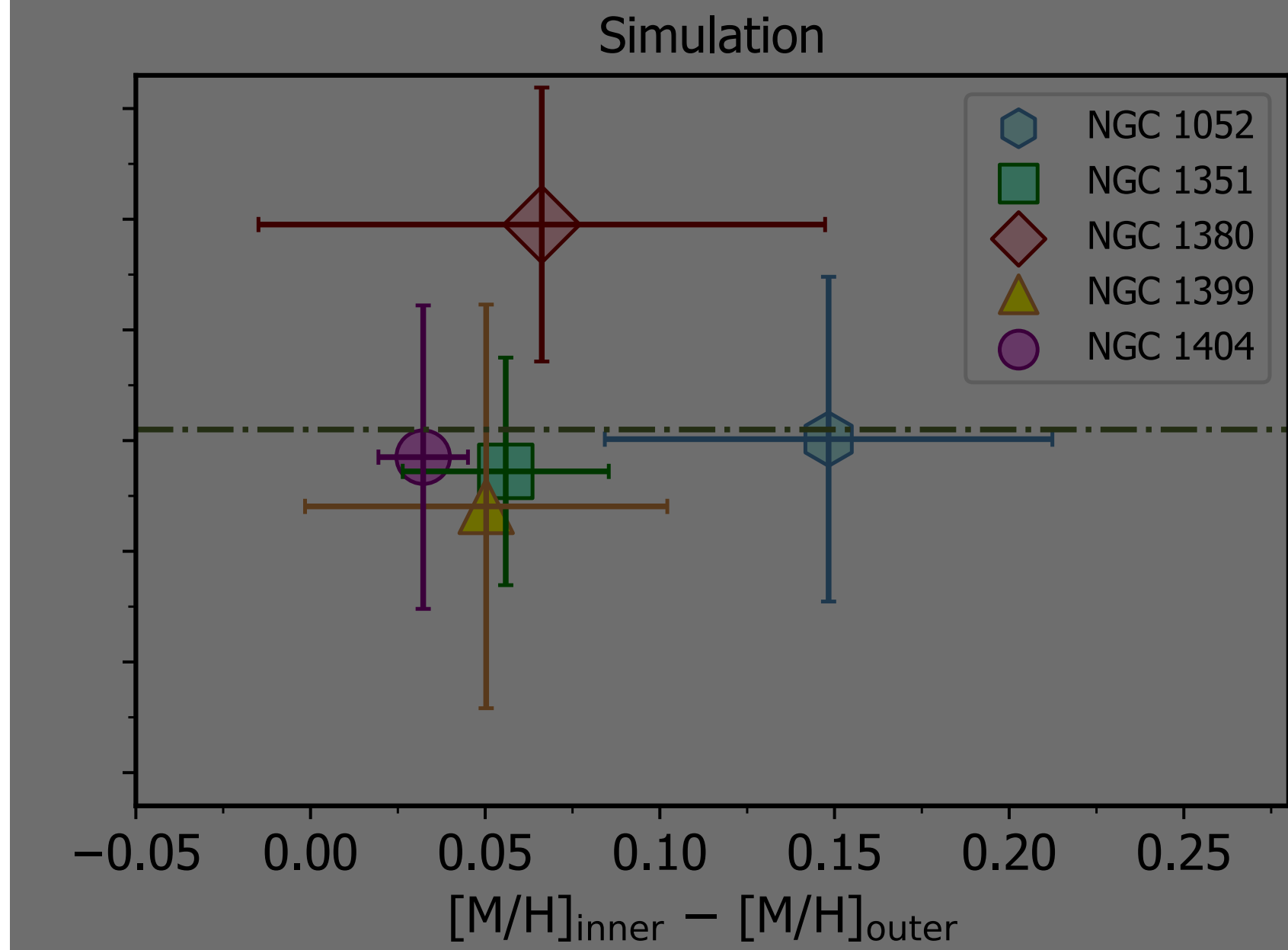
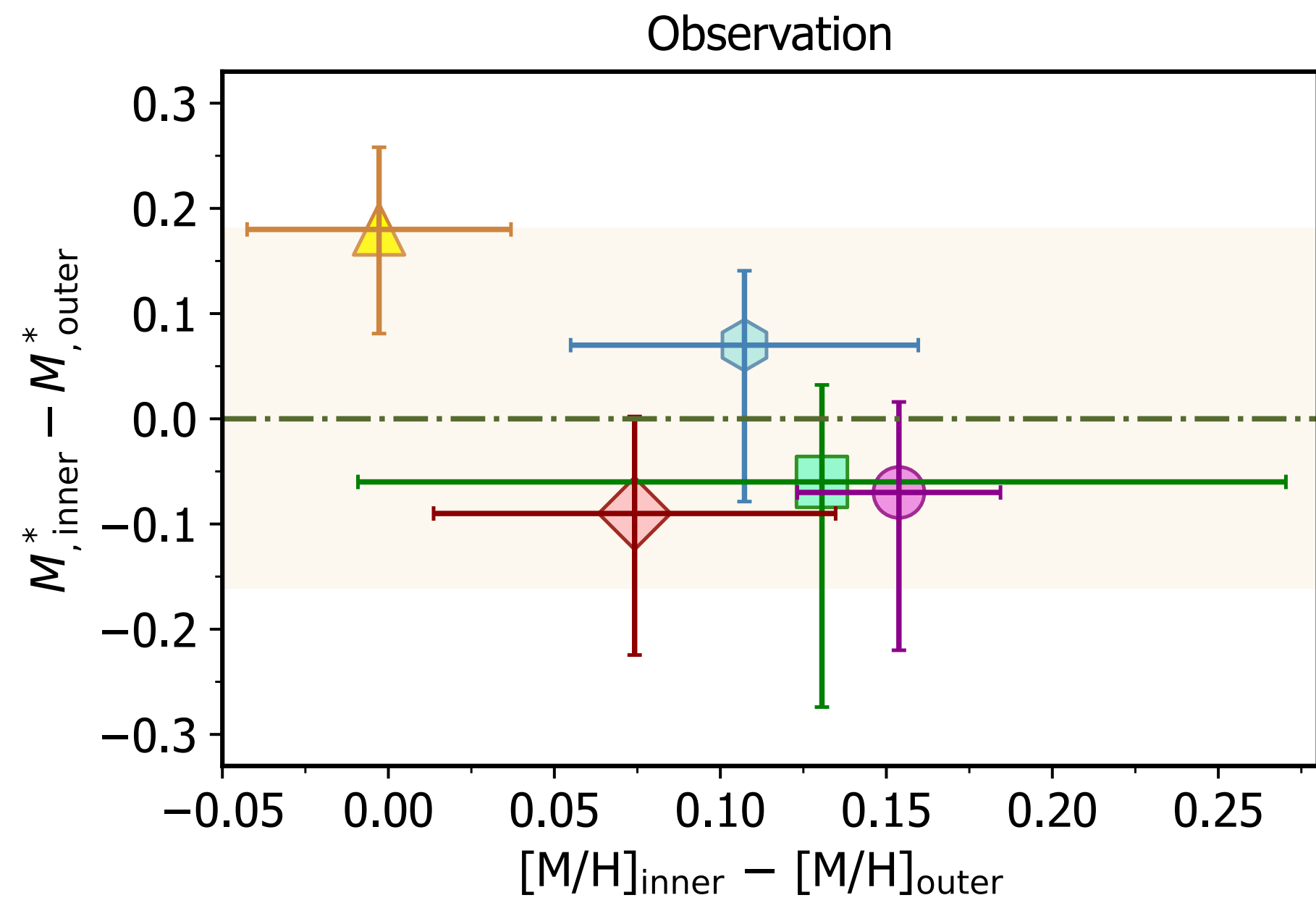
Credit: Soemitro et al. (2025)





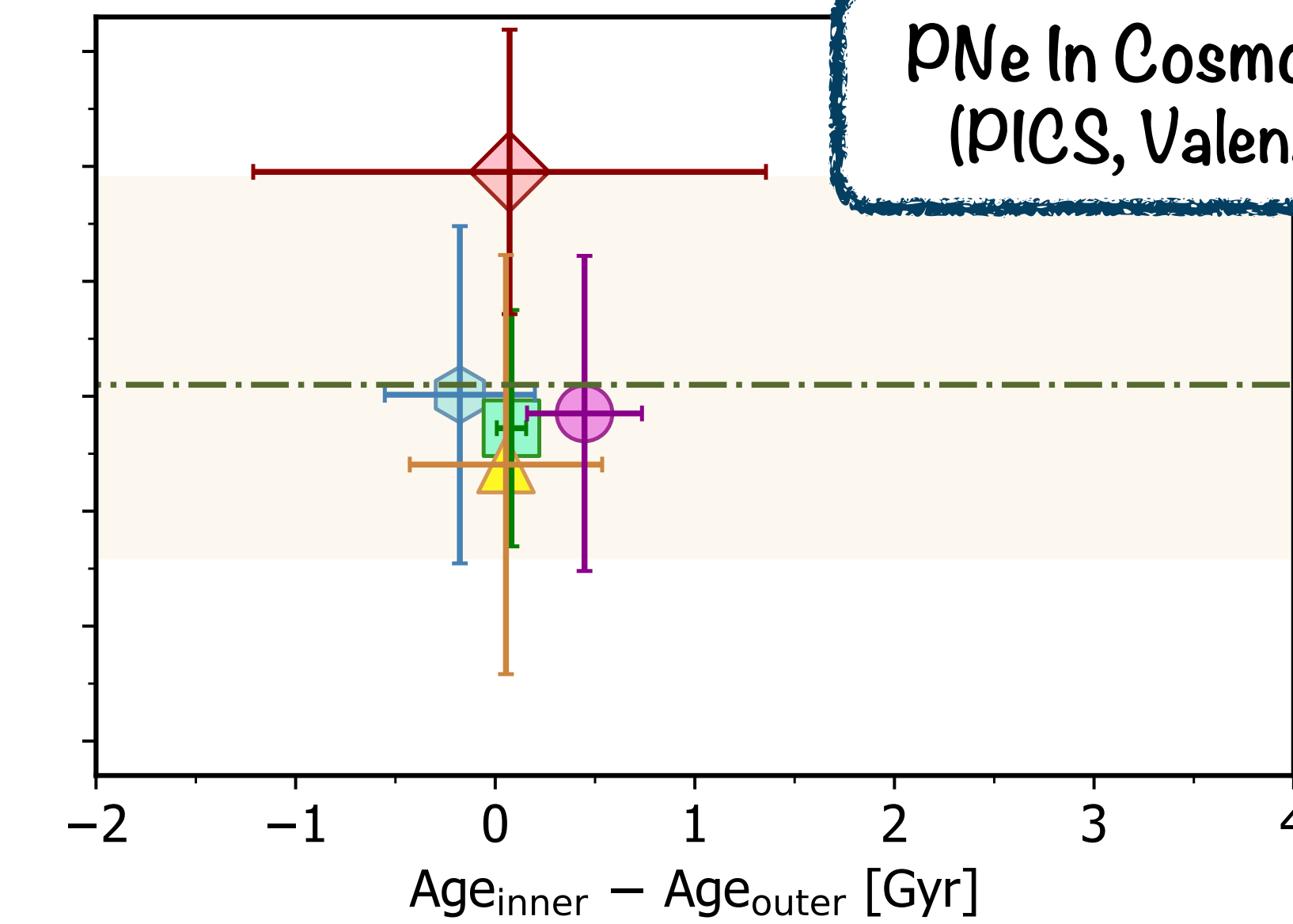
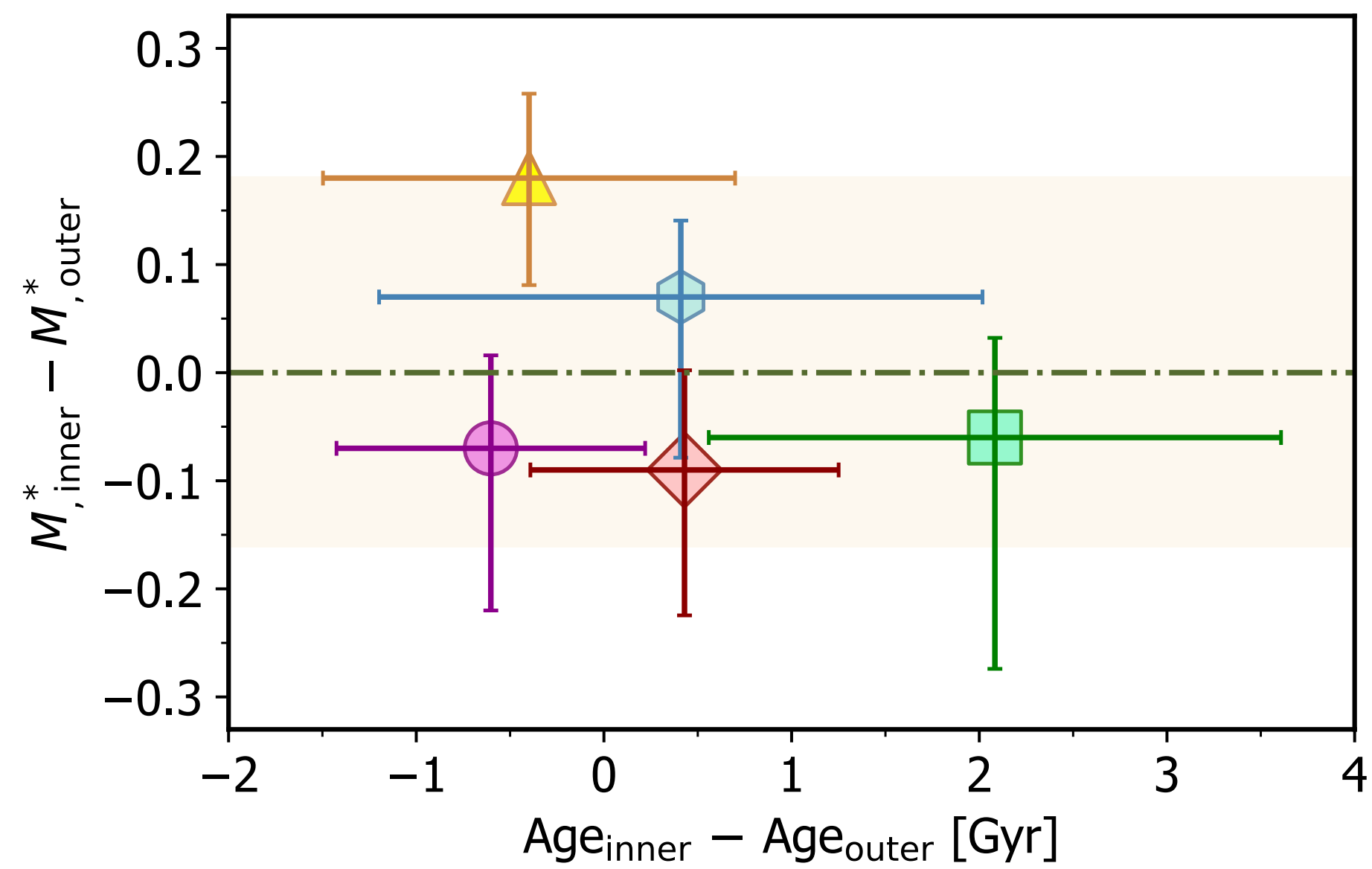
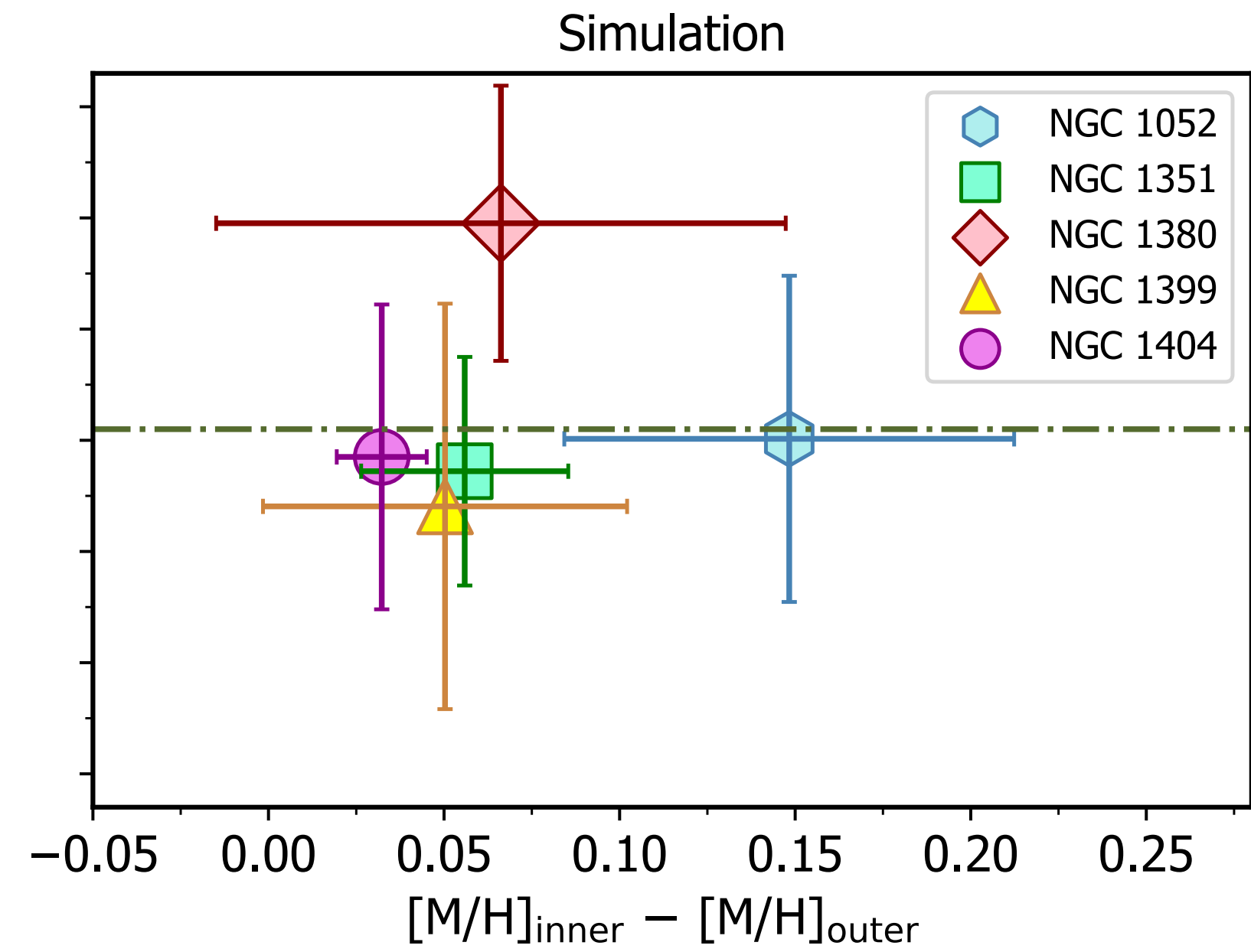
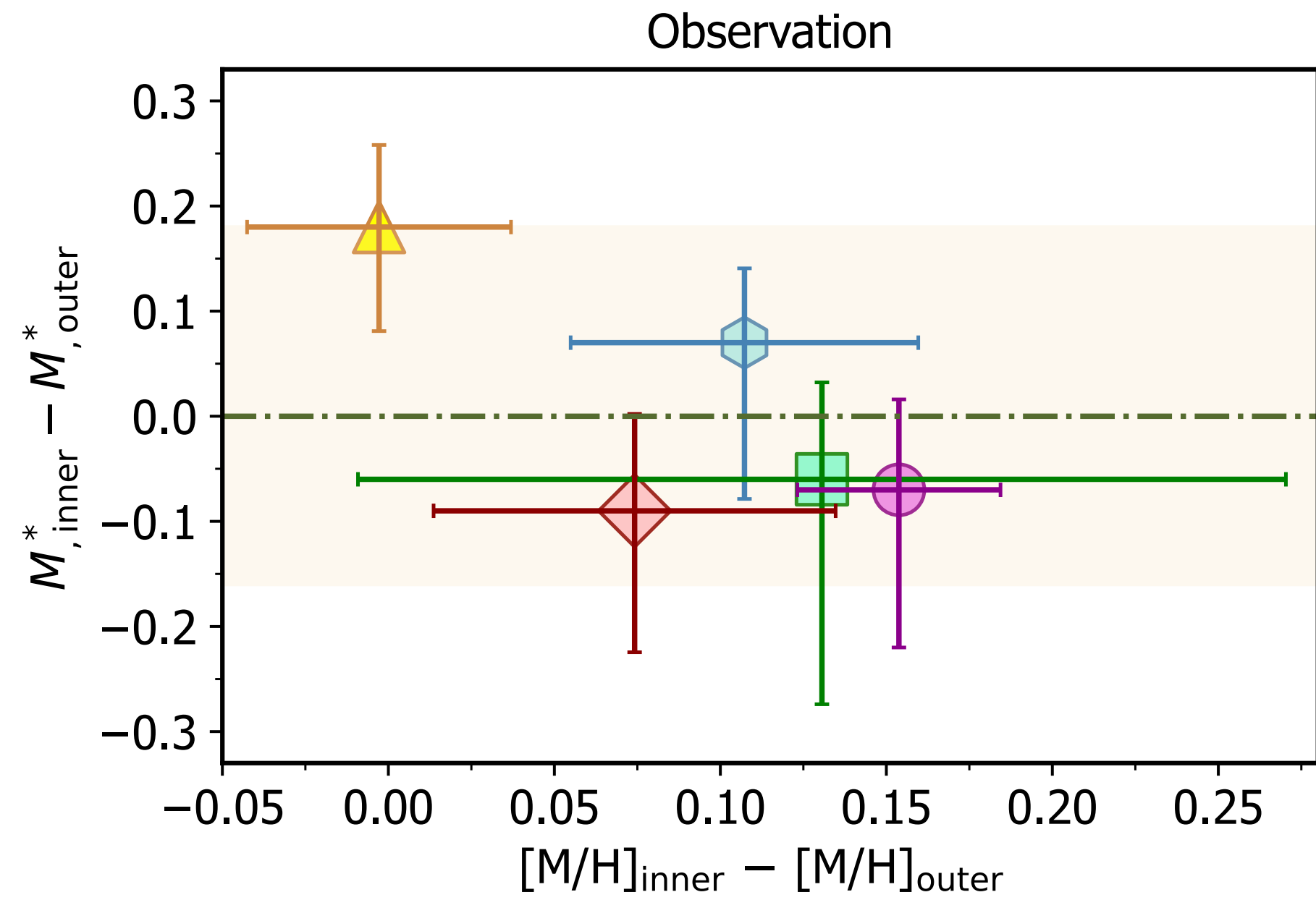


Credit: Soemitro et al. (2025)



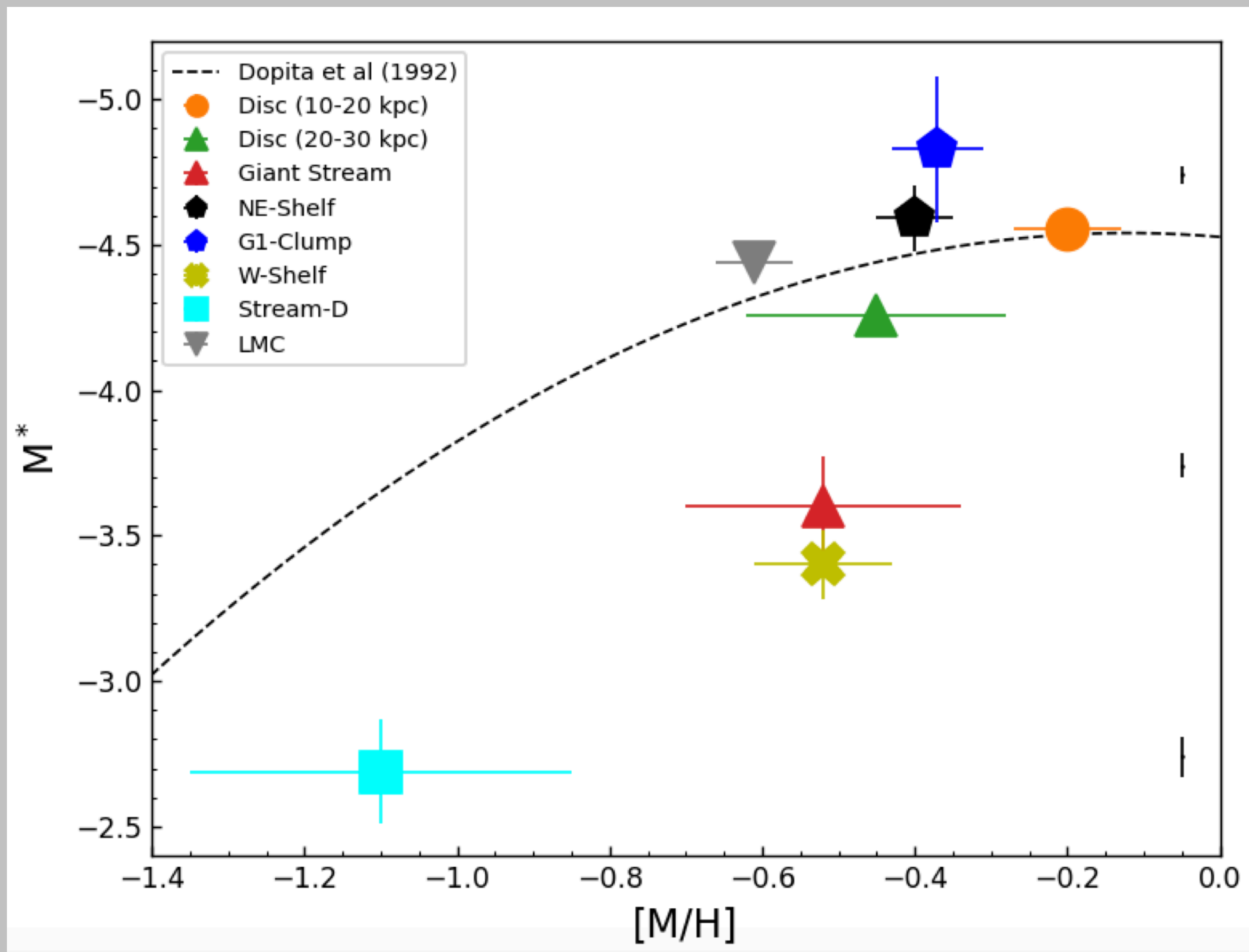
PNe In Cosmological Simulations
(PICS, Valenzuela et al. 2025)

Credit: Soemitro et al. (2025)

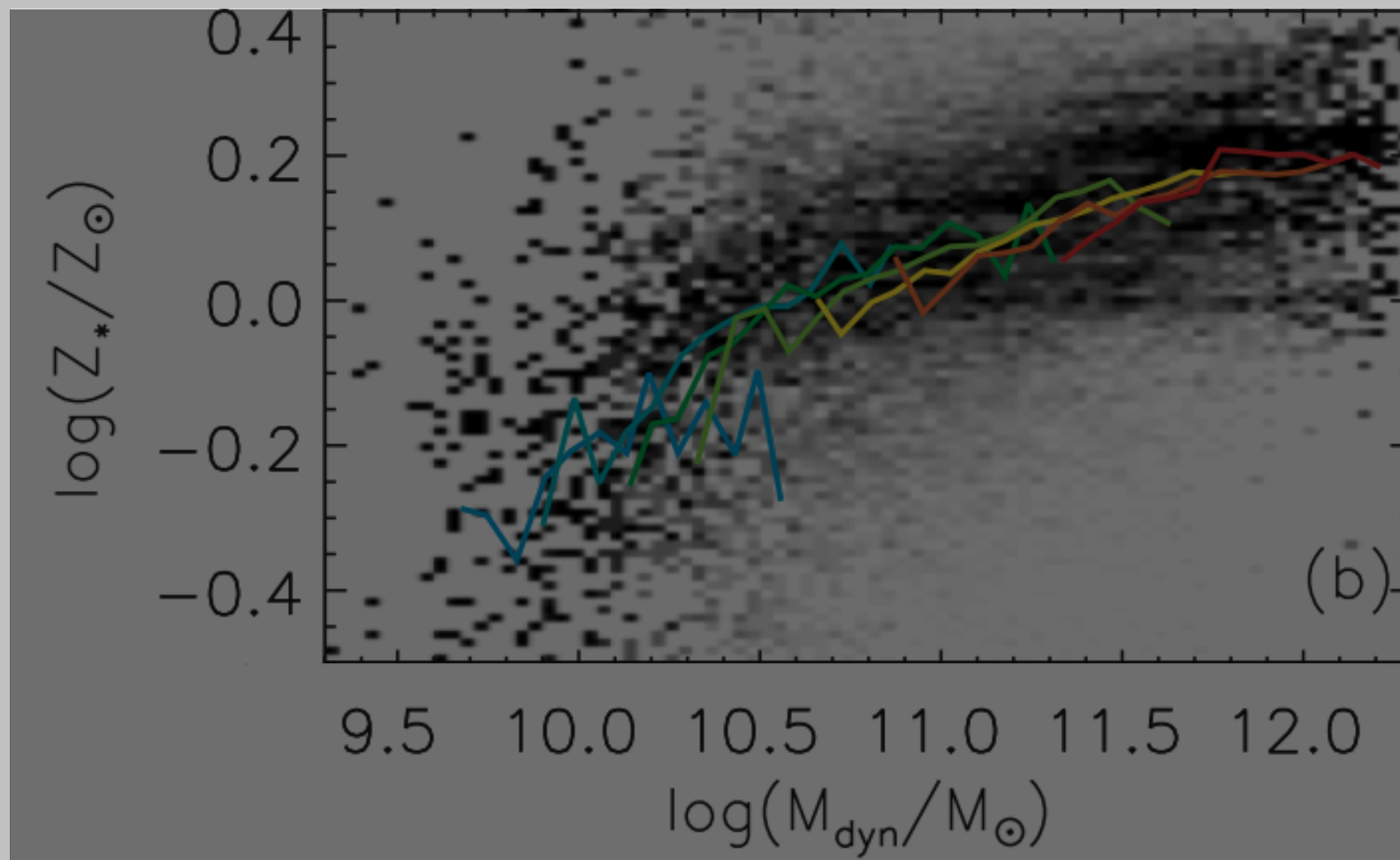


PNe In Cosmological Simulations
(PICS, Valenzuela et al. 2025)

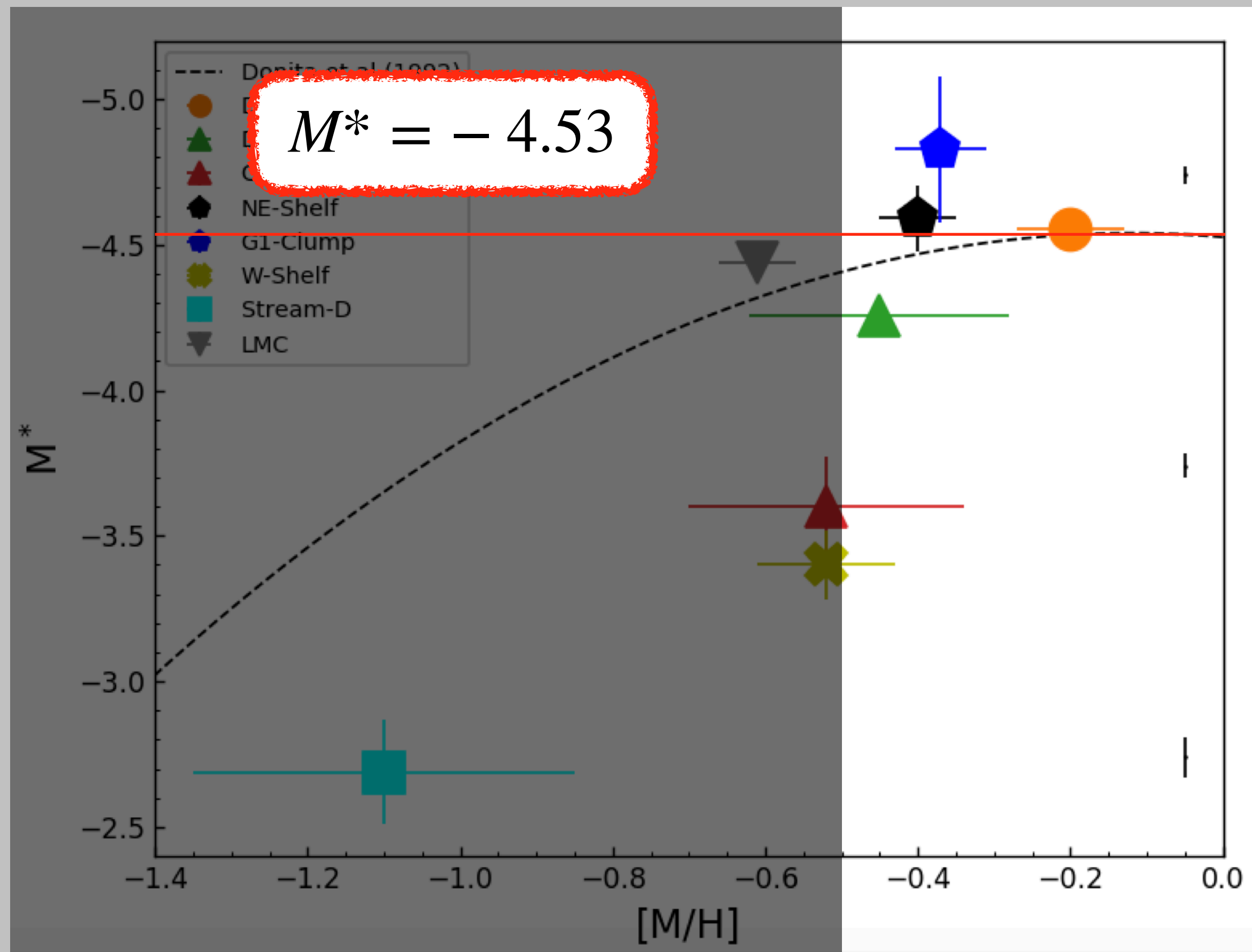
Credit: Soemitro et al. (2025)



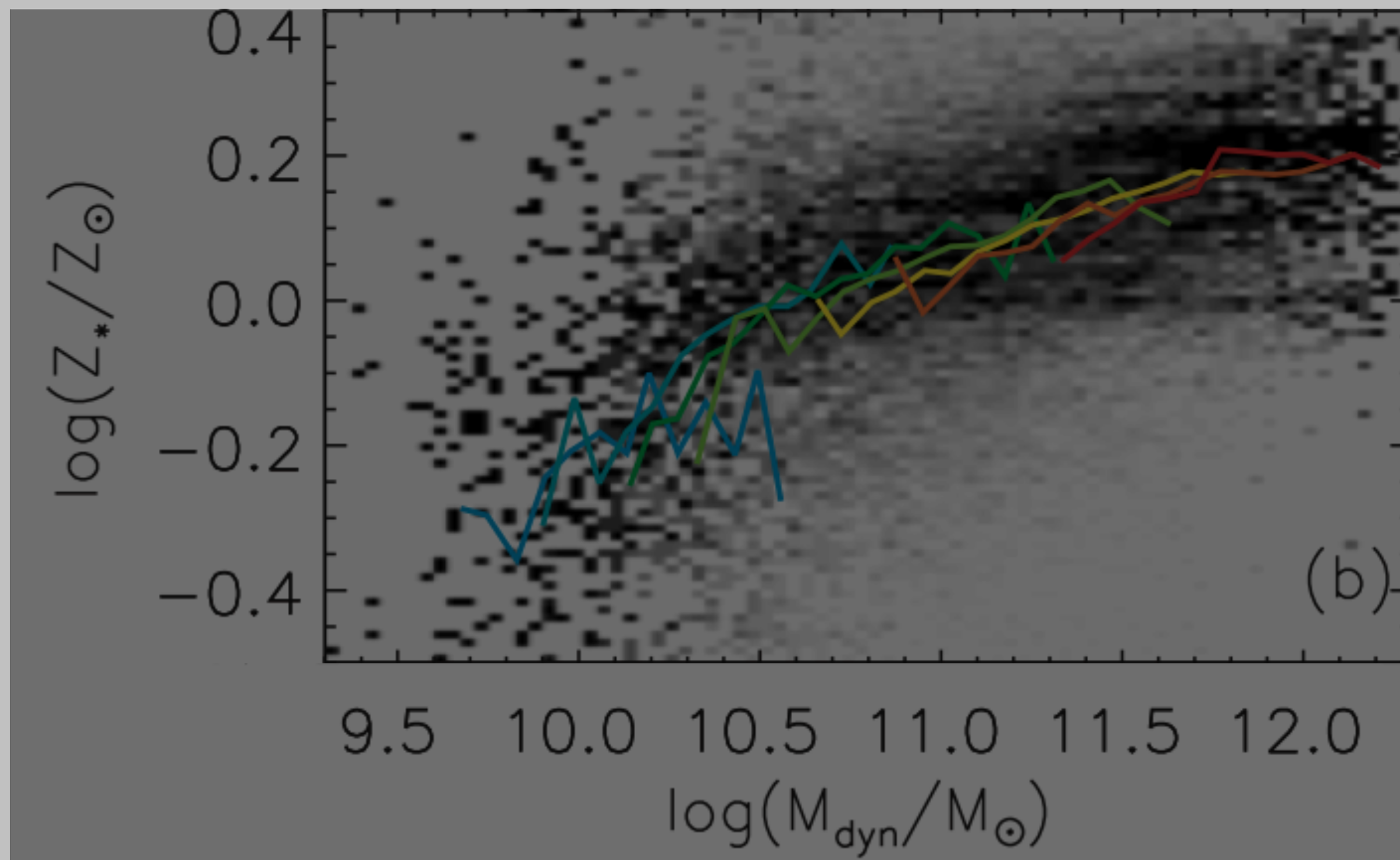
Credit: Bhattacharya et al. (2021)



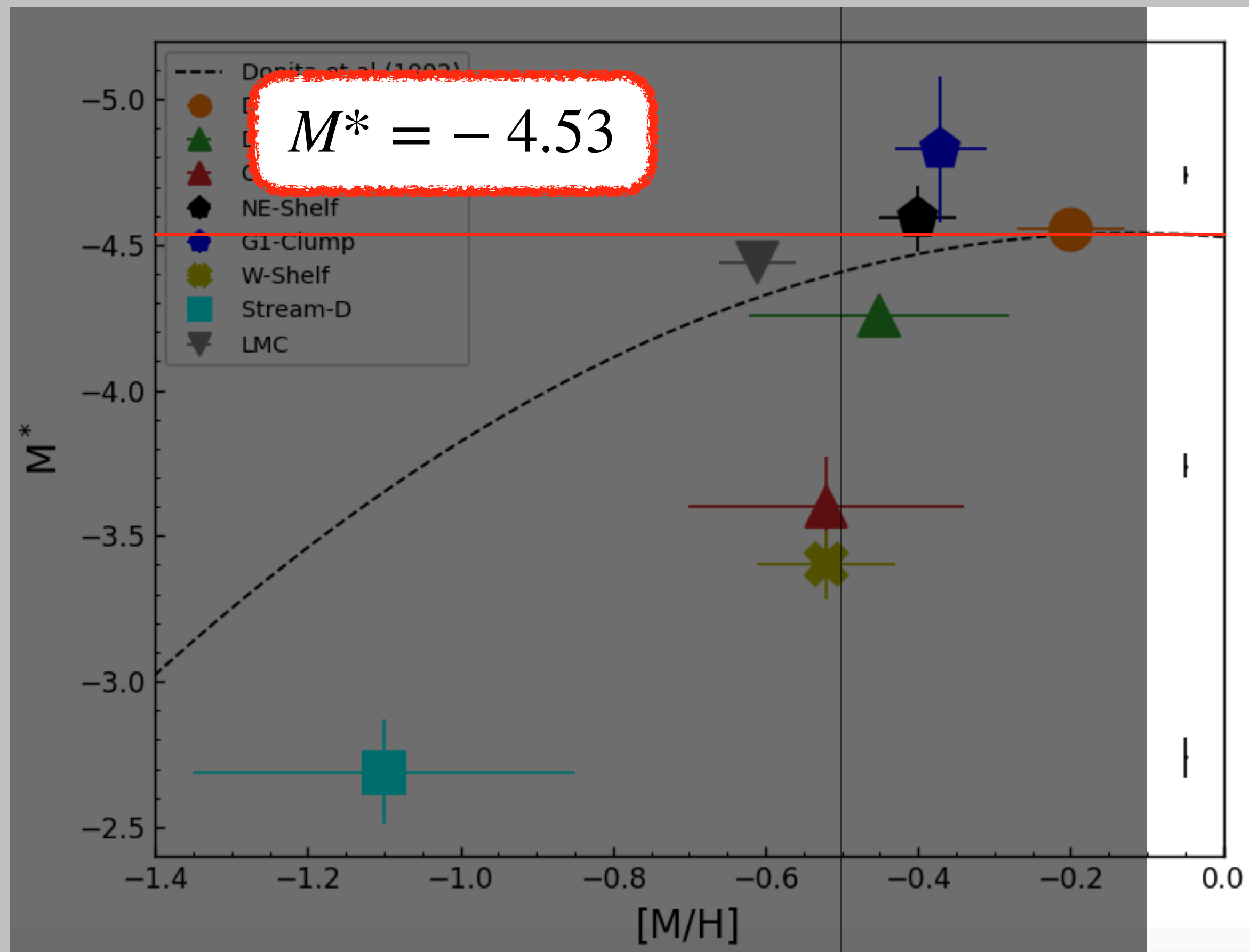
Credit: Galazzi et al. (2006)



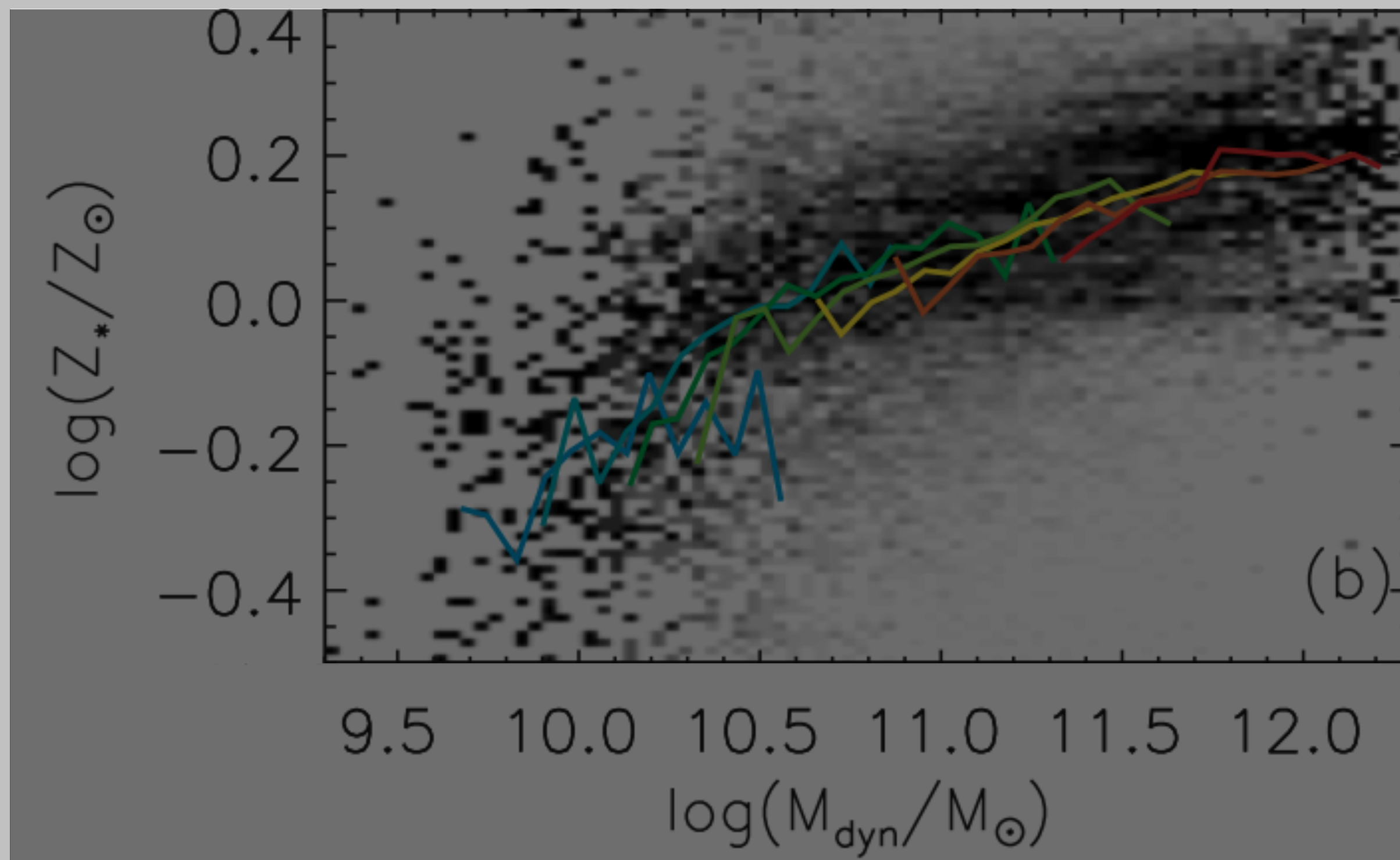
Credit: Bhattacharya et al. (2021)



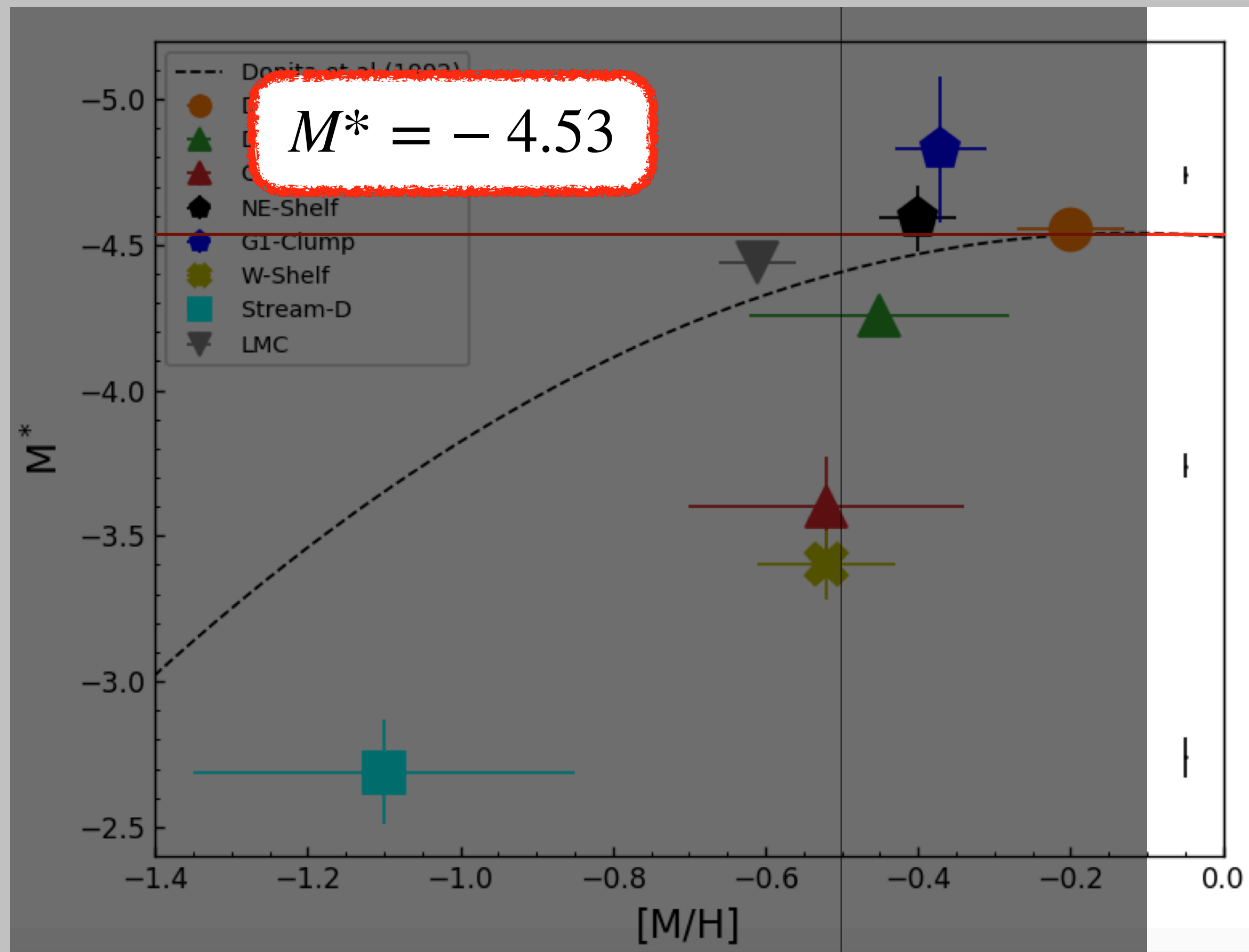
Credit: Galazzi et al. (2006)



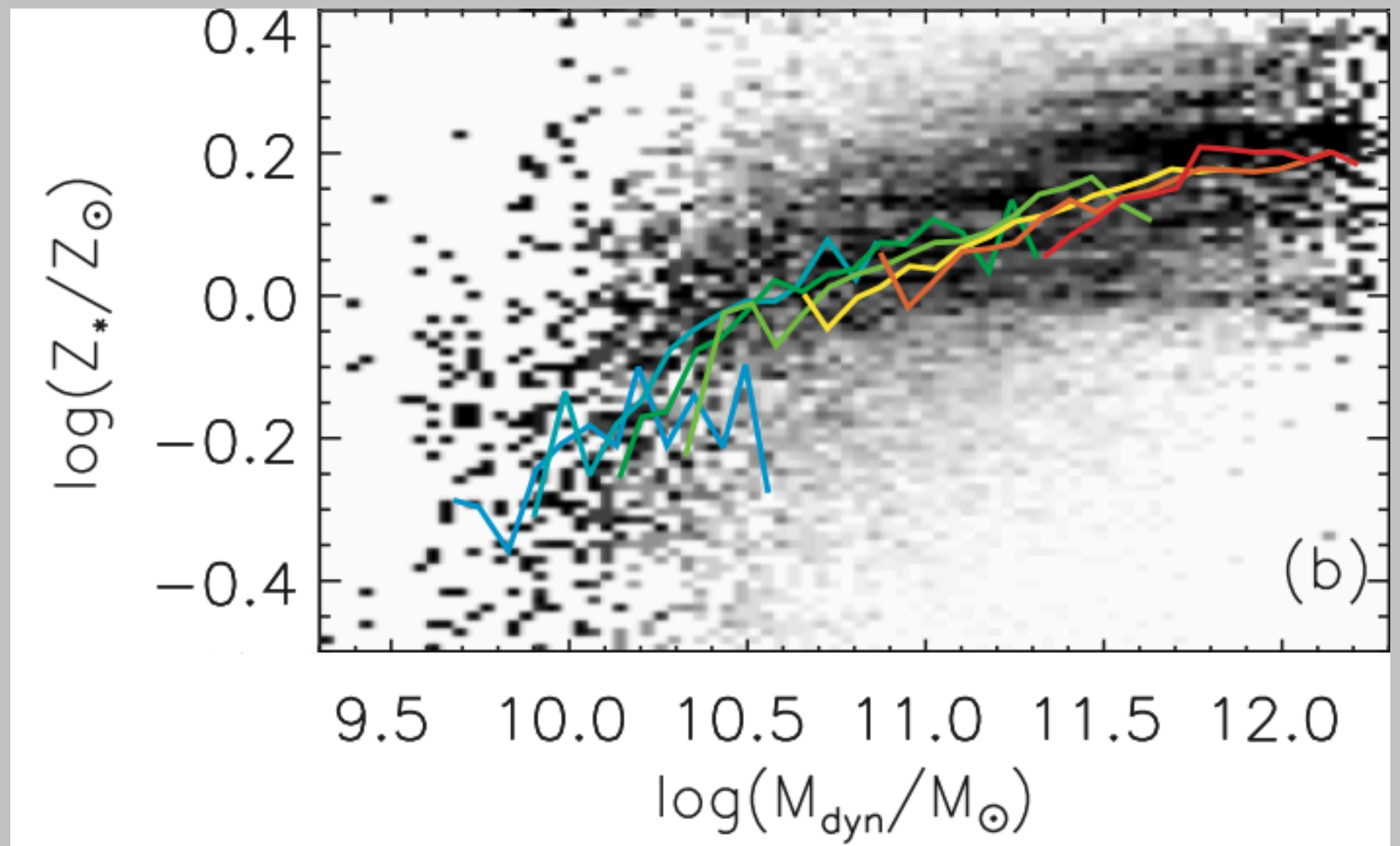
Credit: Bhattacharya et al. (2021)



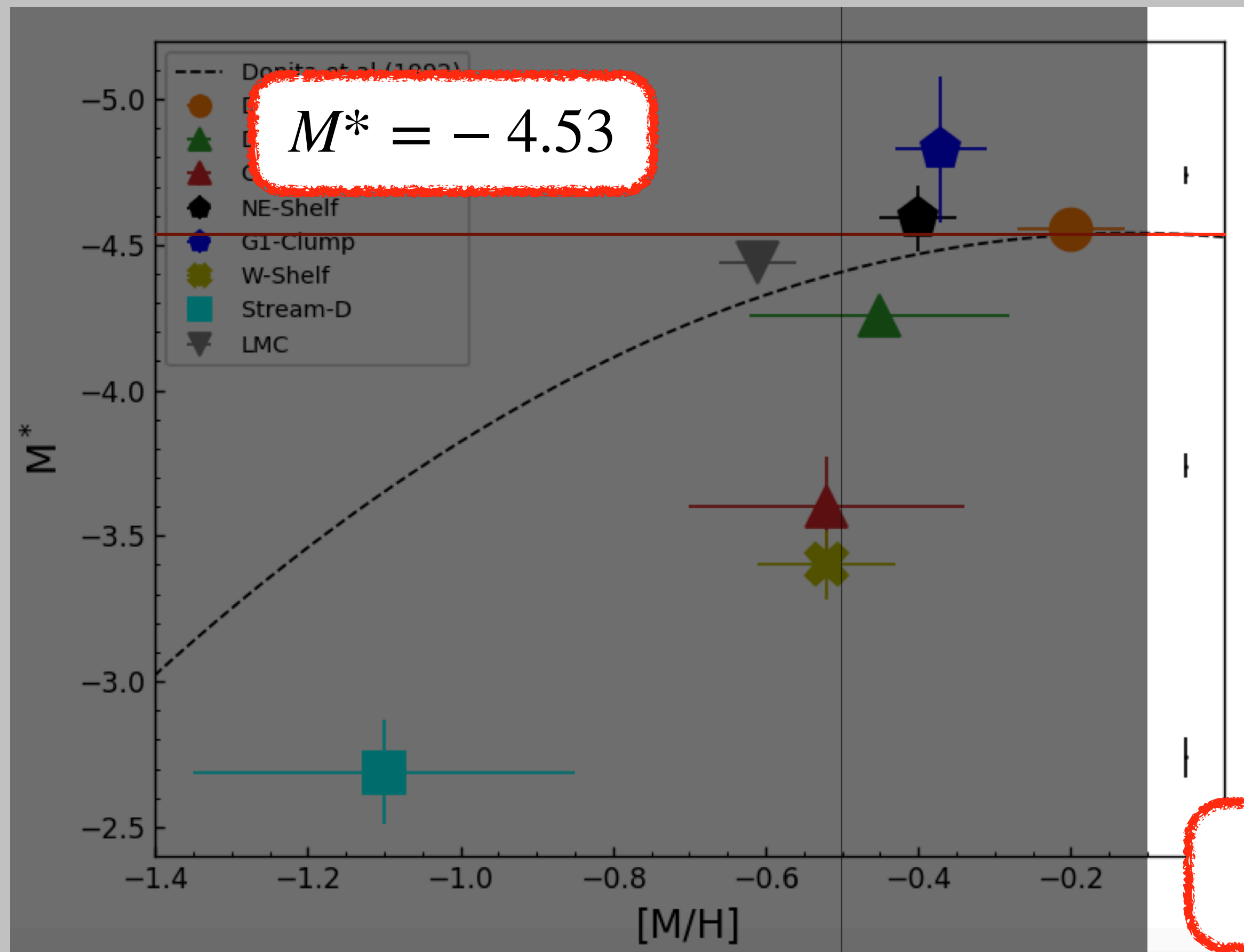
Credit: Galazzi et al. (2006)



Credit: Bhattacharya et al. (2021)

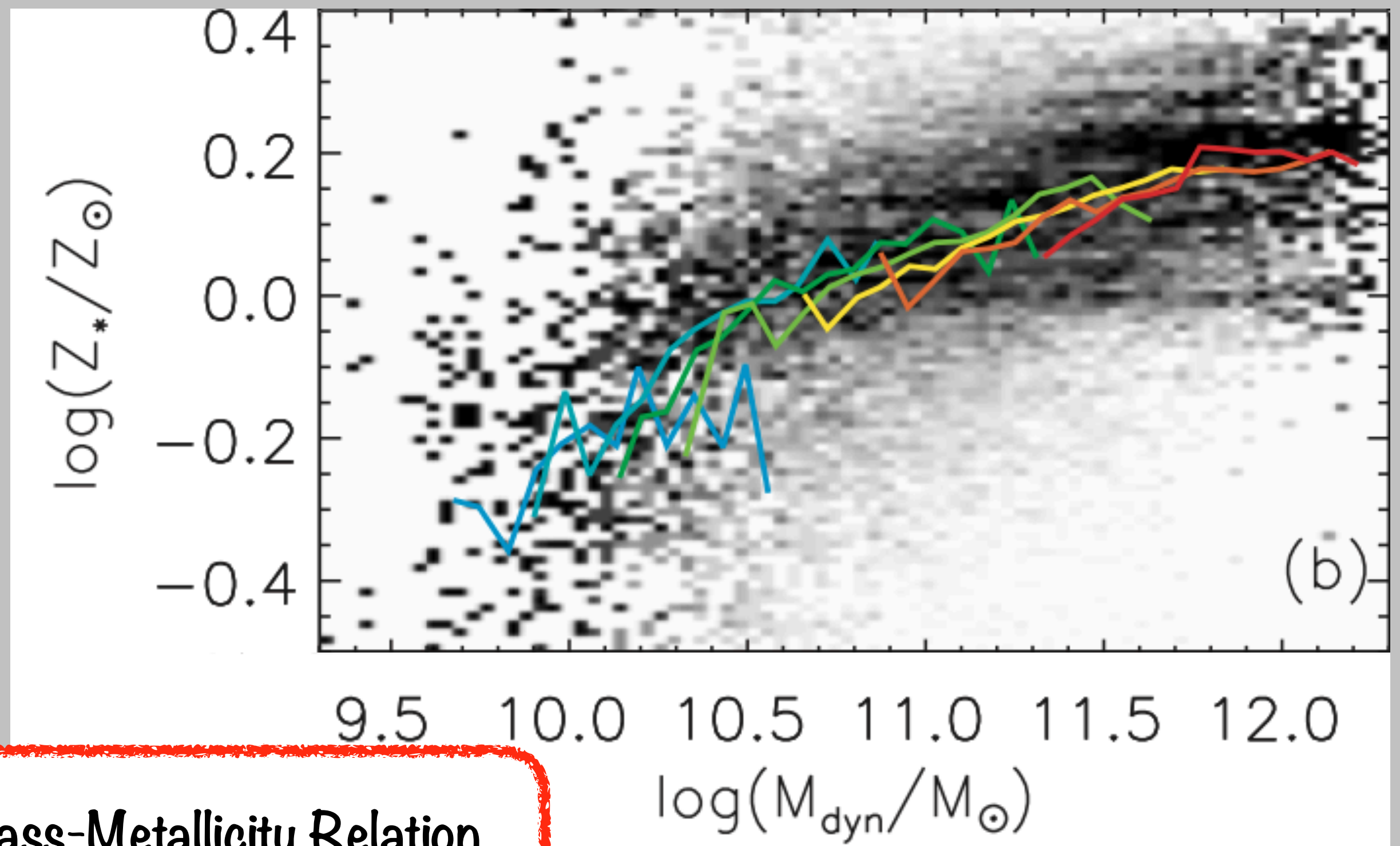


Credit: Galazzi et al. (2006)

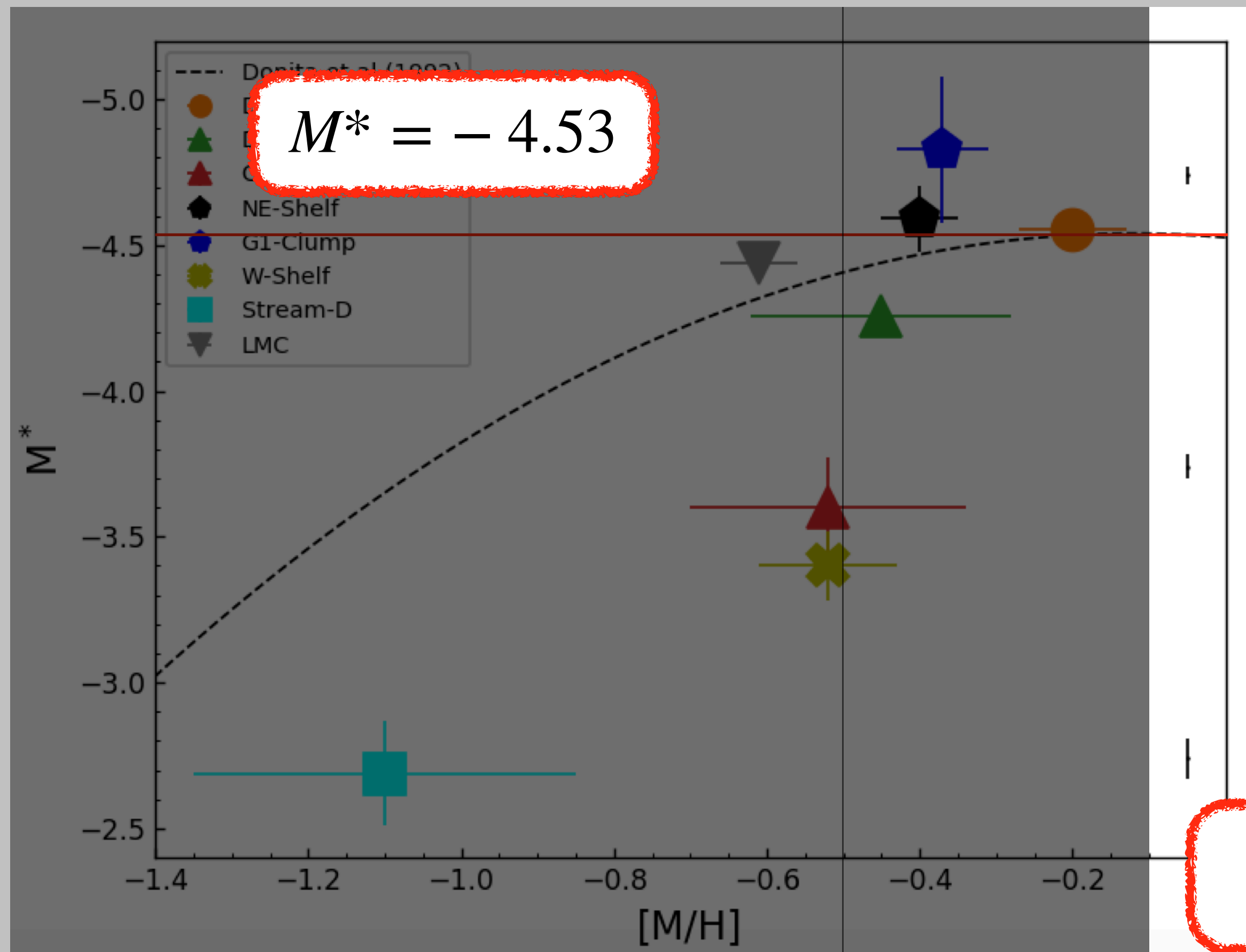


Credit: Bhattacharya et al. (2021)

Mass-Metallicity Relation

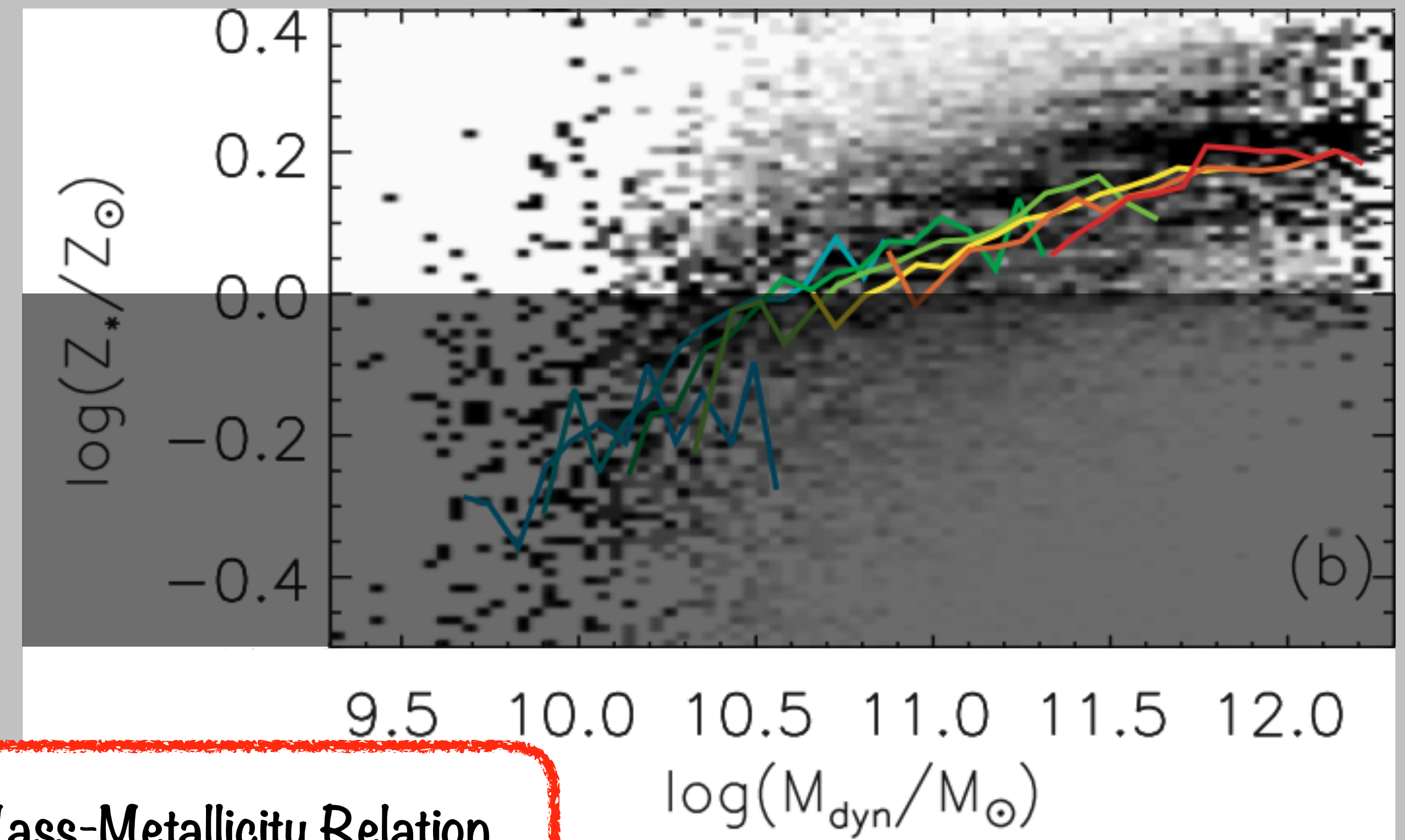


Credit: Galazzi et al. (2006)

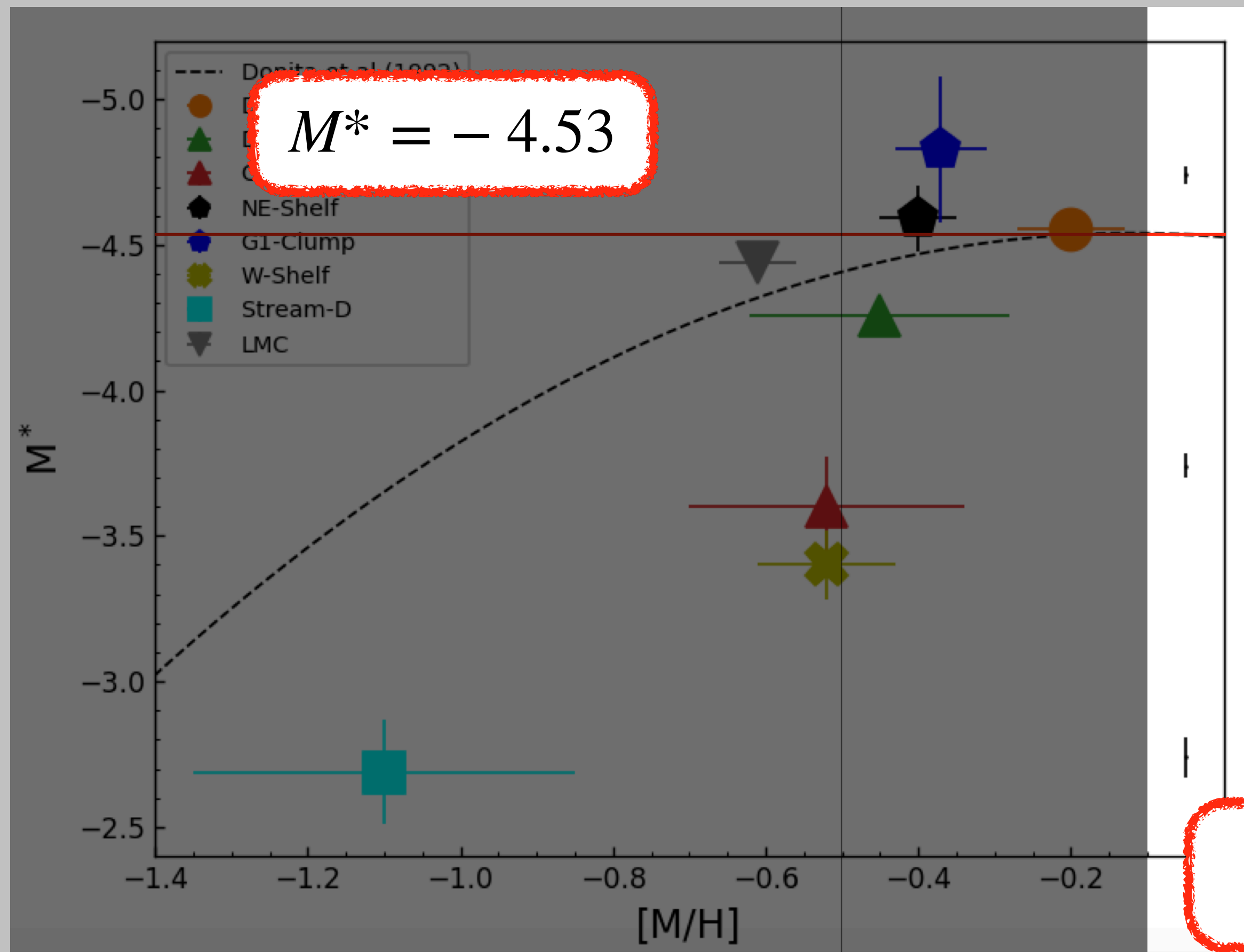


Credit: Bhattacharya et al. (2021)

Mass-Metallicity Relation

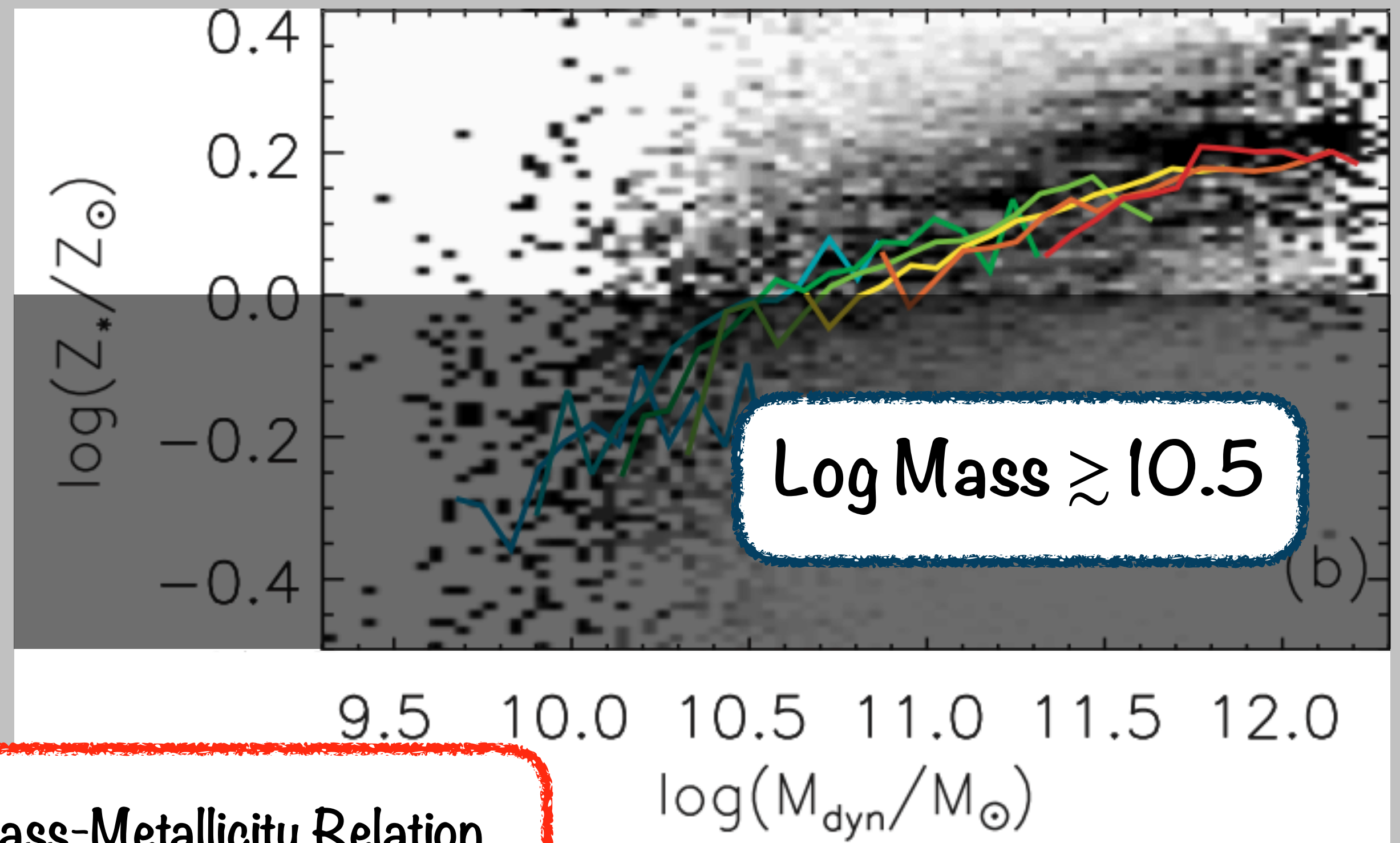


Credit: Galazzi et al. (2006)

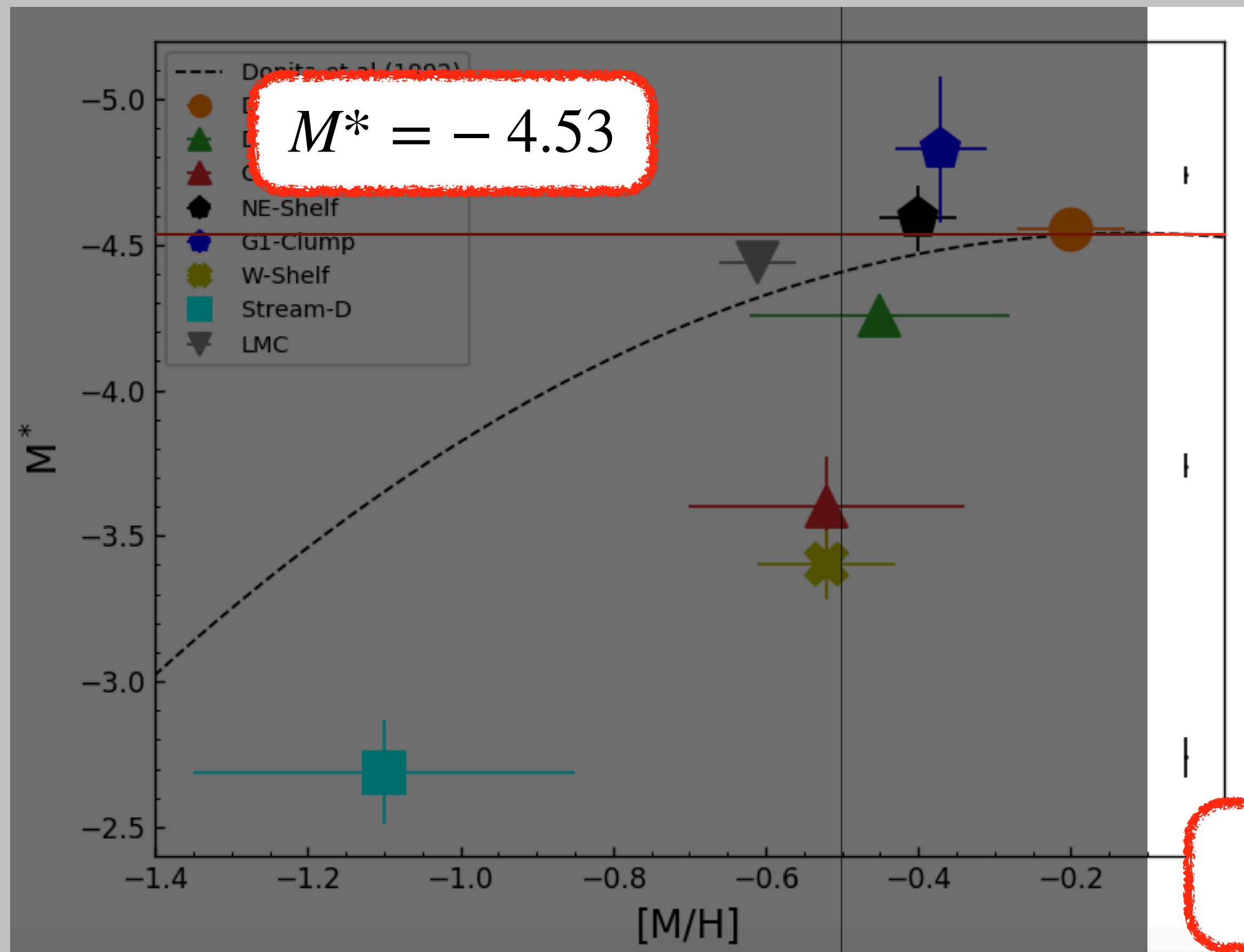


Credit: Bhattacharya et al. (2021)

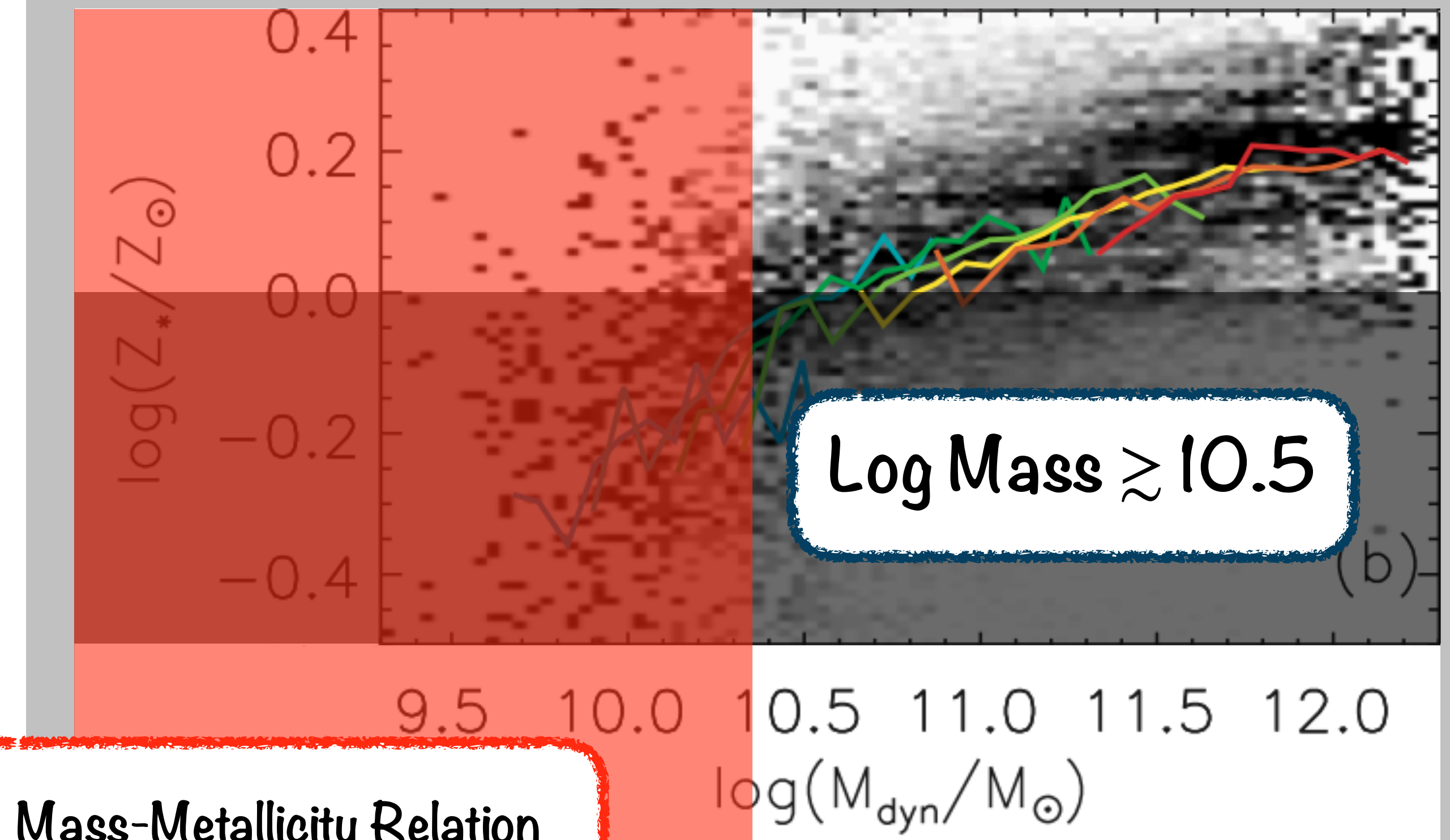
Mass-Metallicity Relation



Credit: Galazzi et al. (2006)

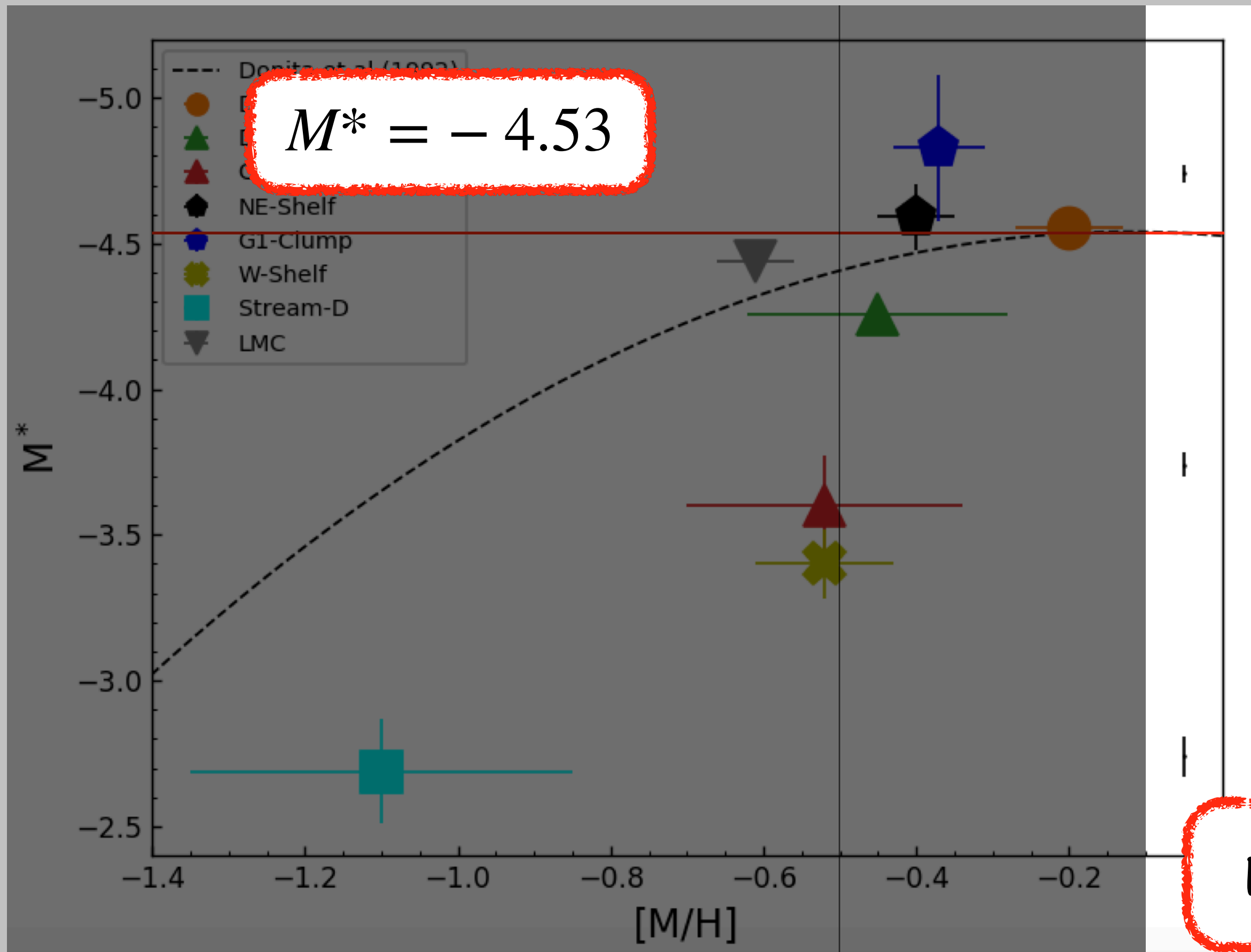


Credit: Bhattacharya et al. (2021)

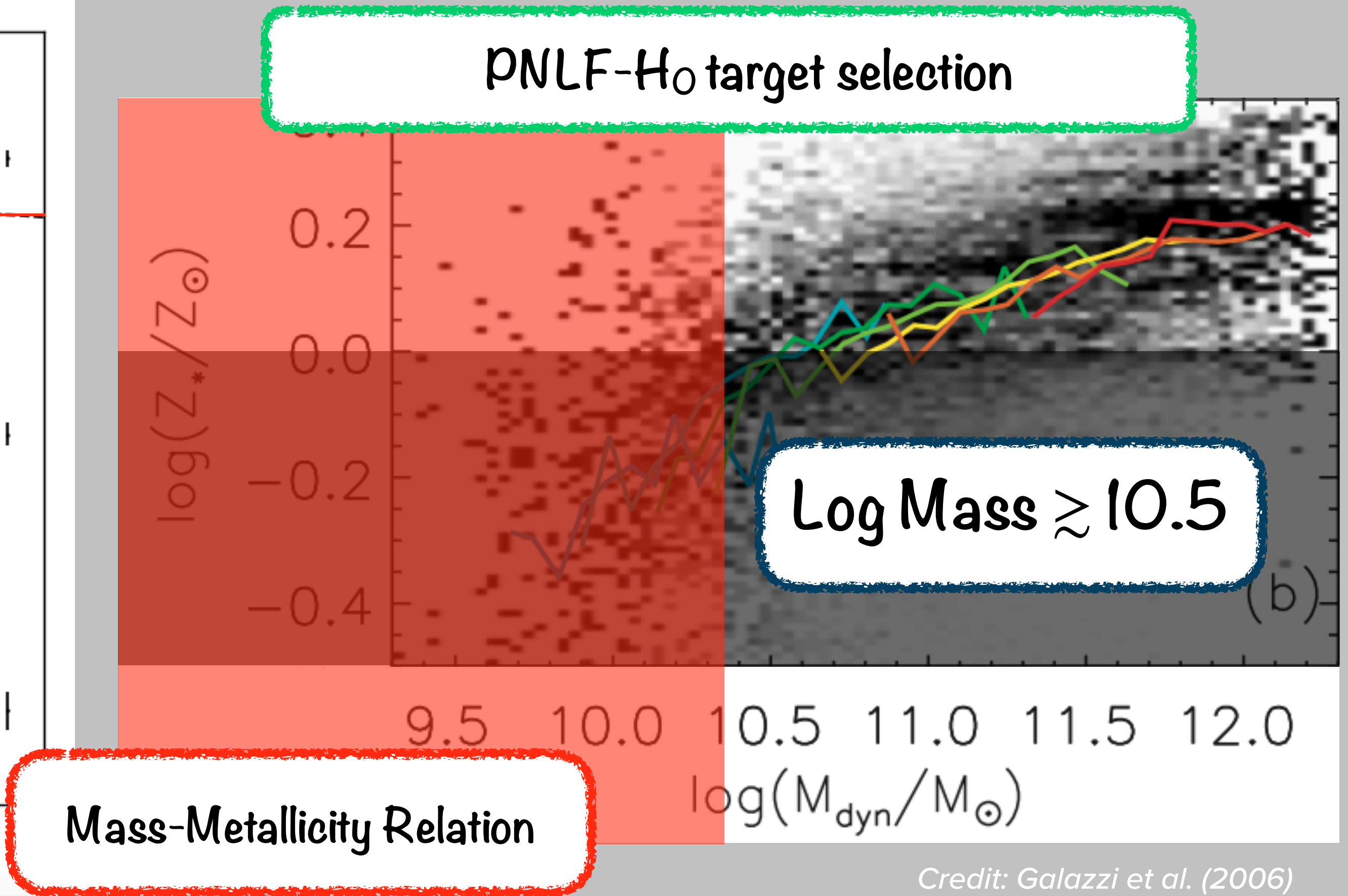


Mass-Metallicity Relation

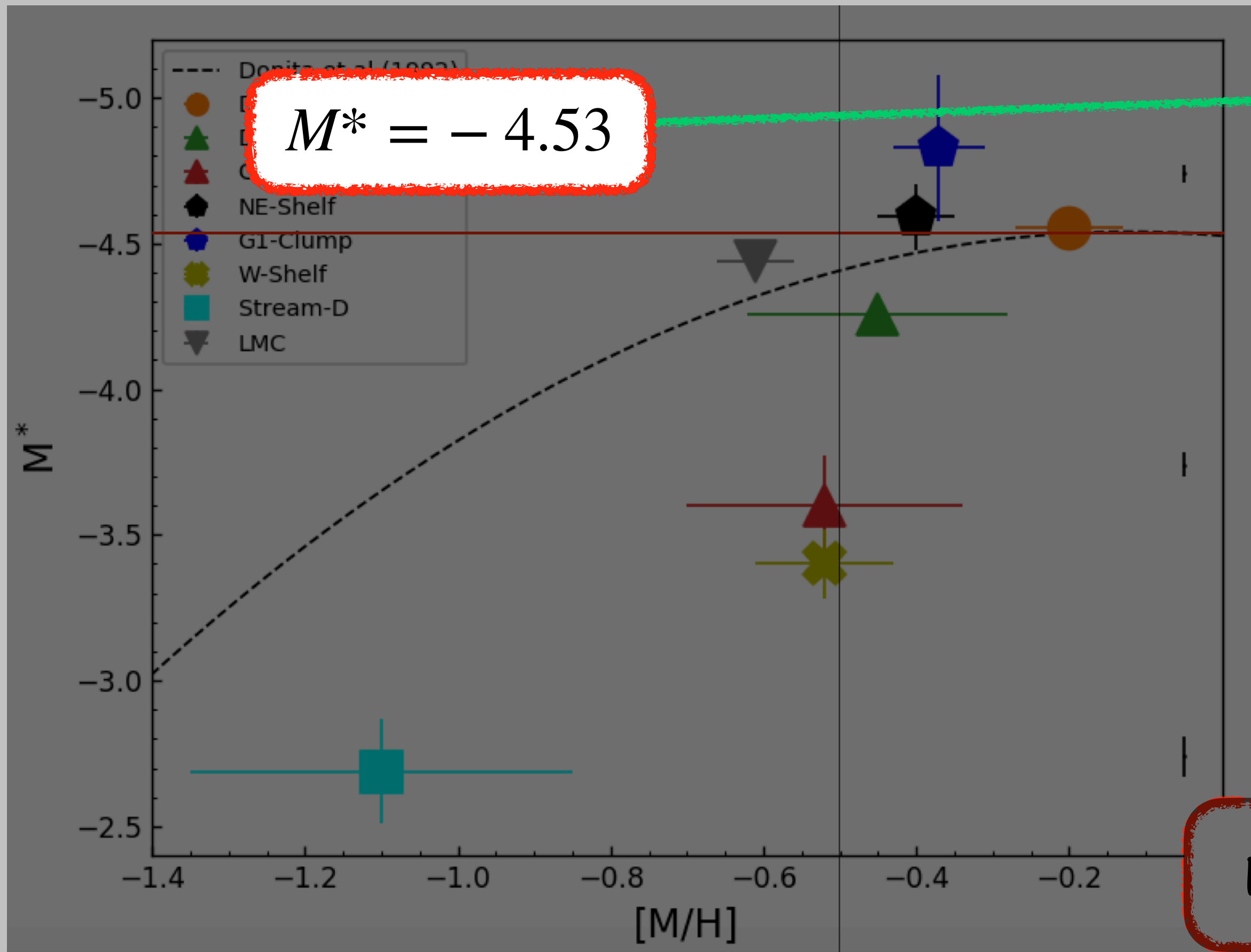
Credit: Galazzi et al. (2006)



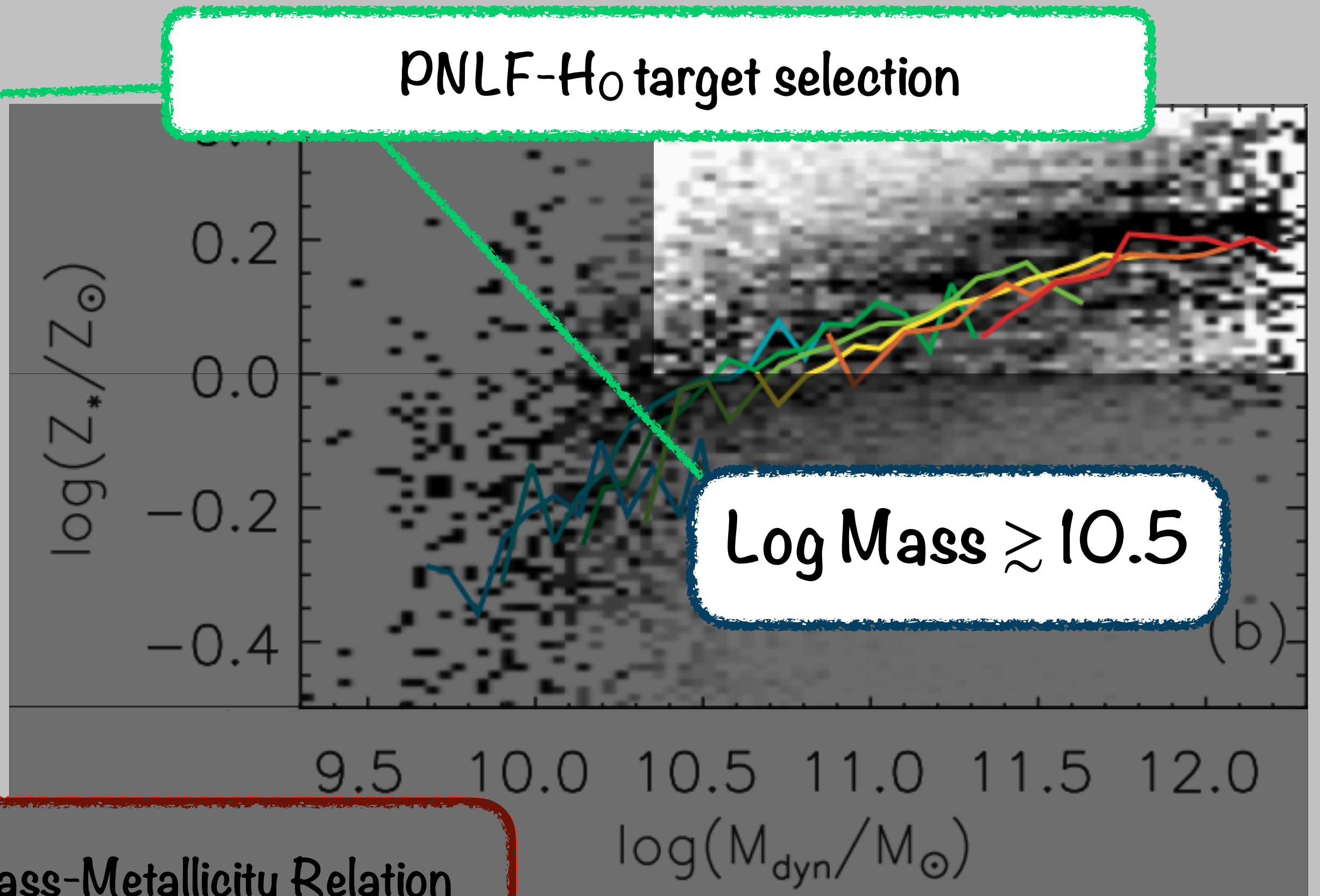
Credit: Bhattacharya et al. (2021)



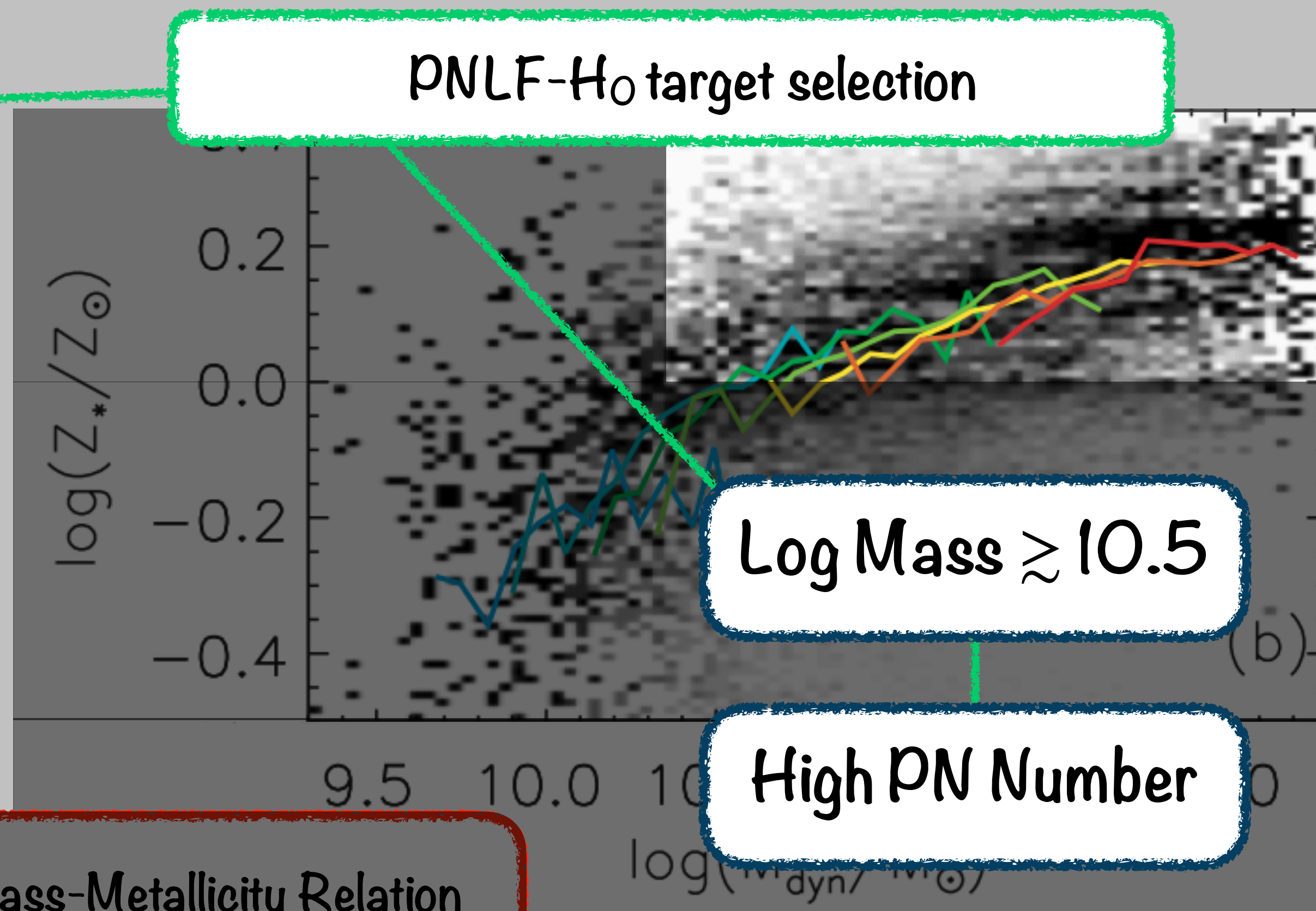
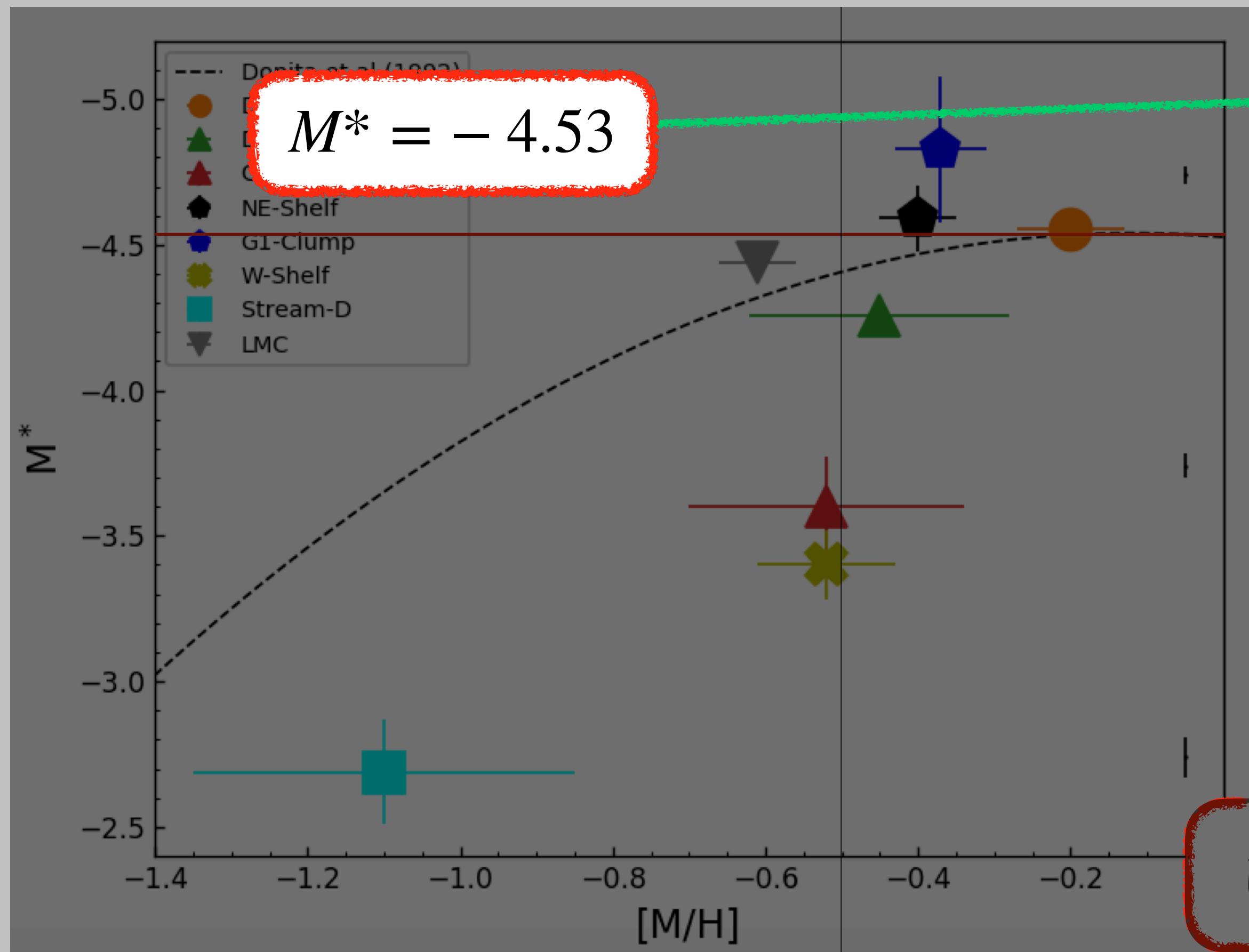
Credit: Galazzi et al. (2006)



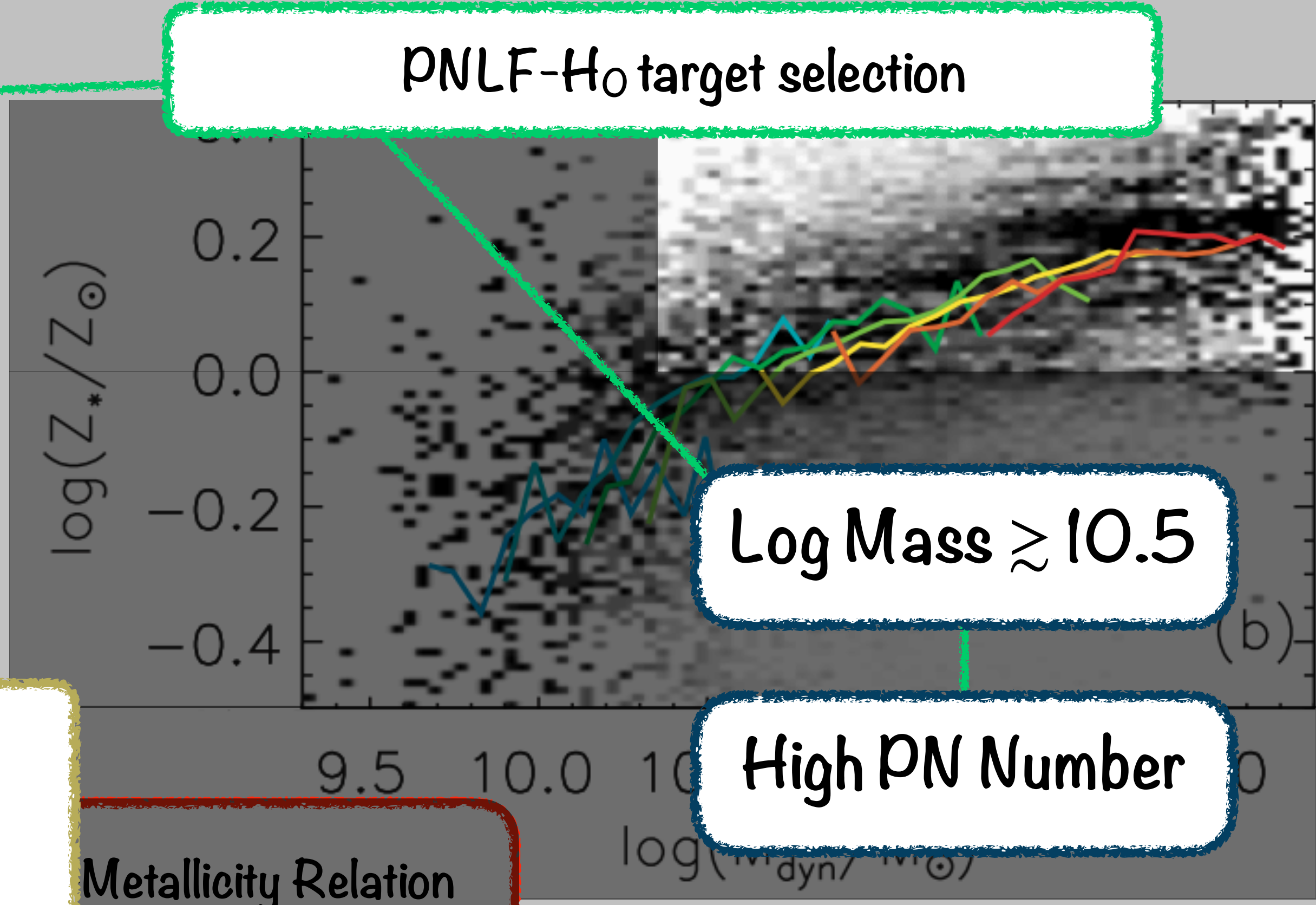
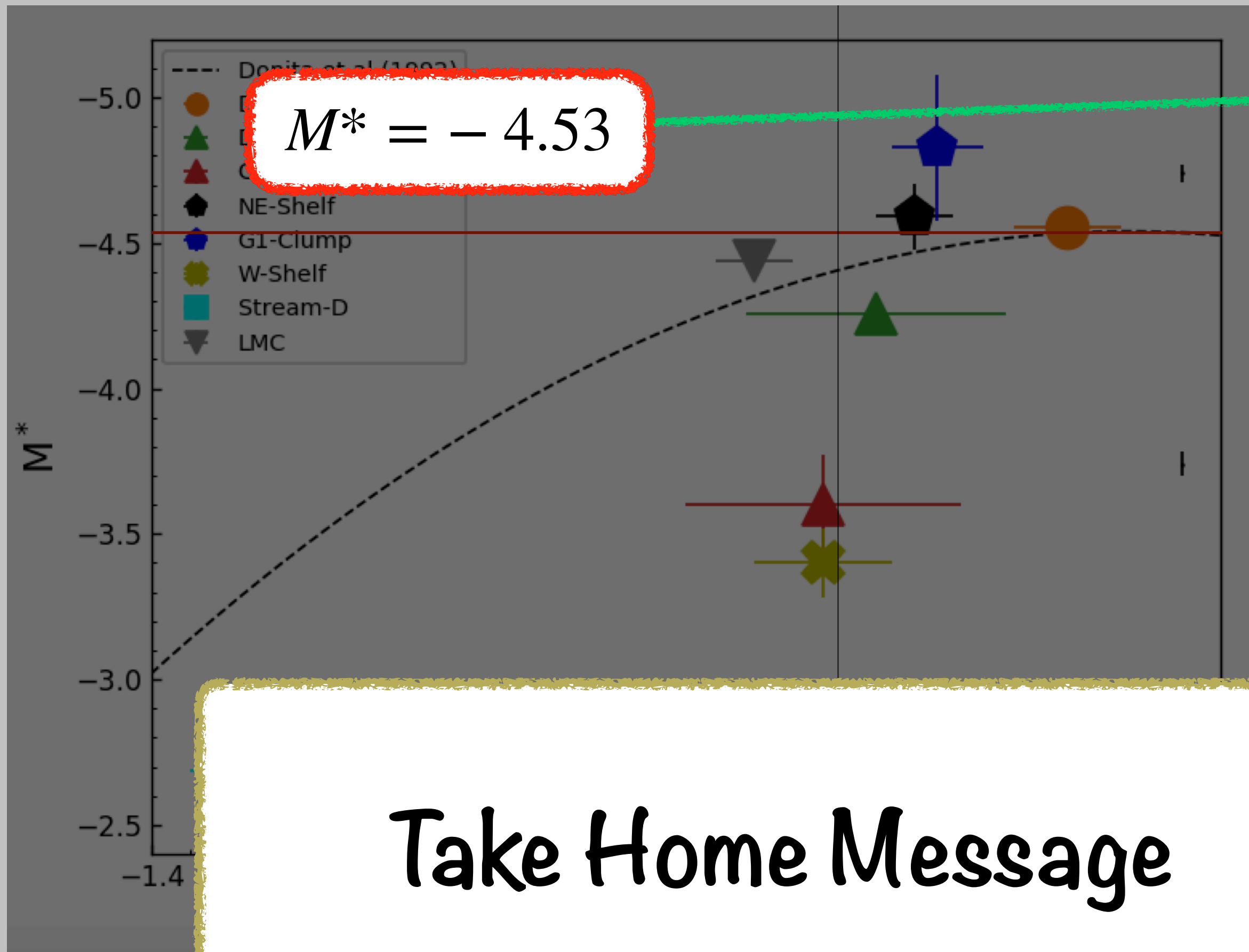
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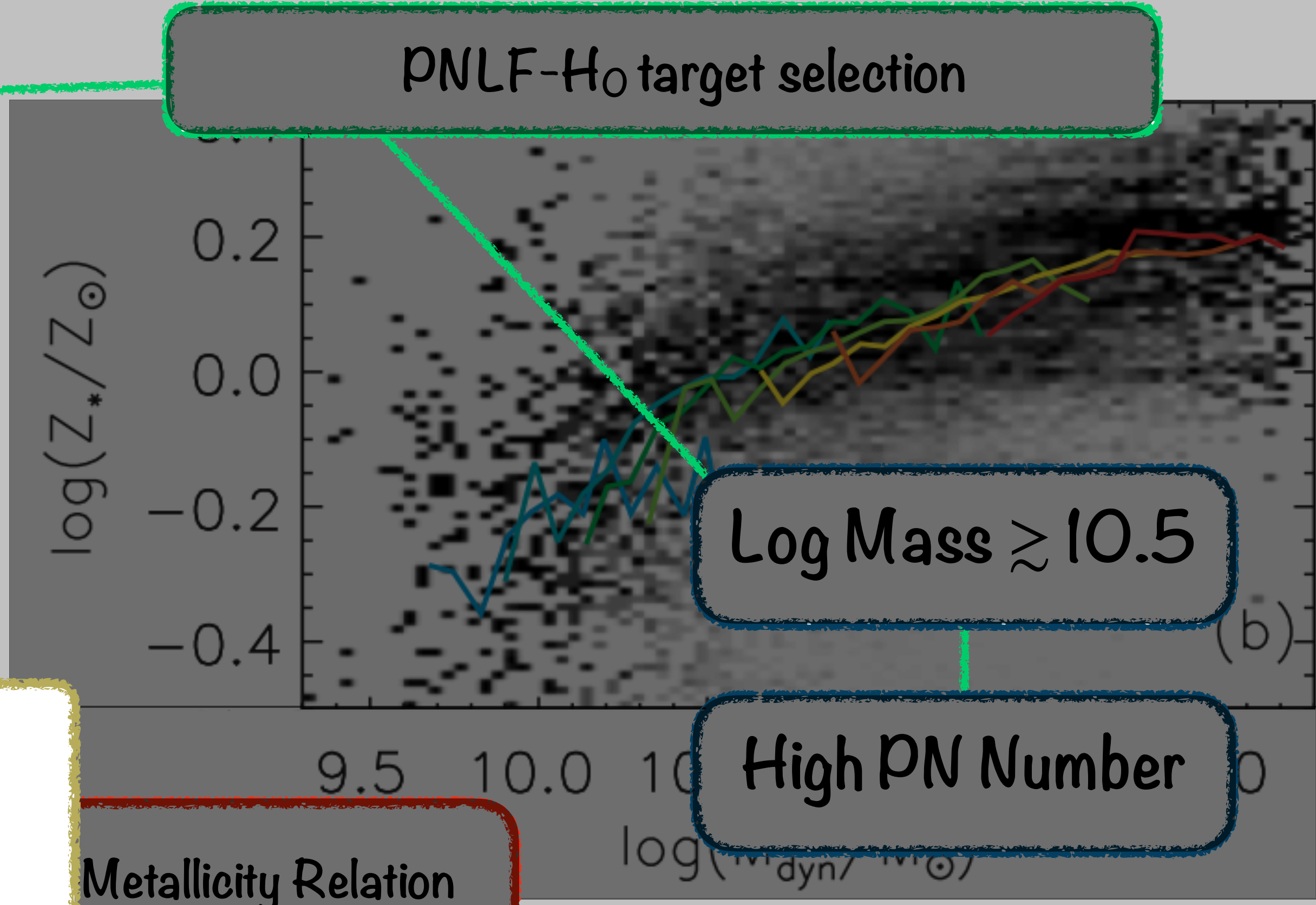
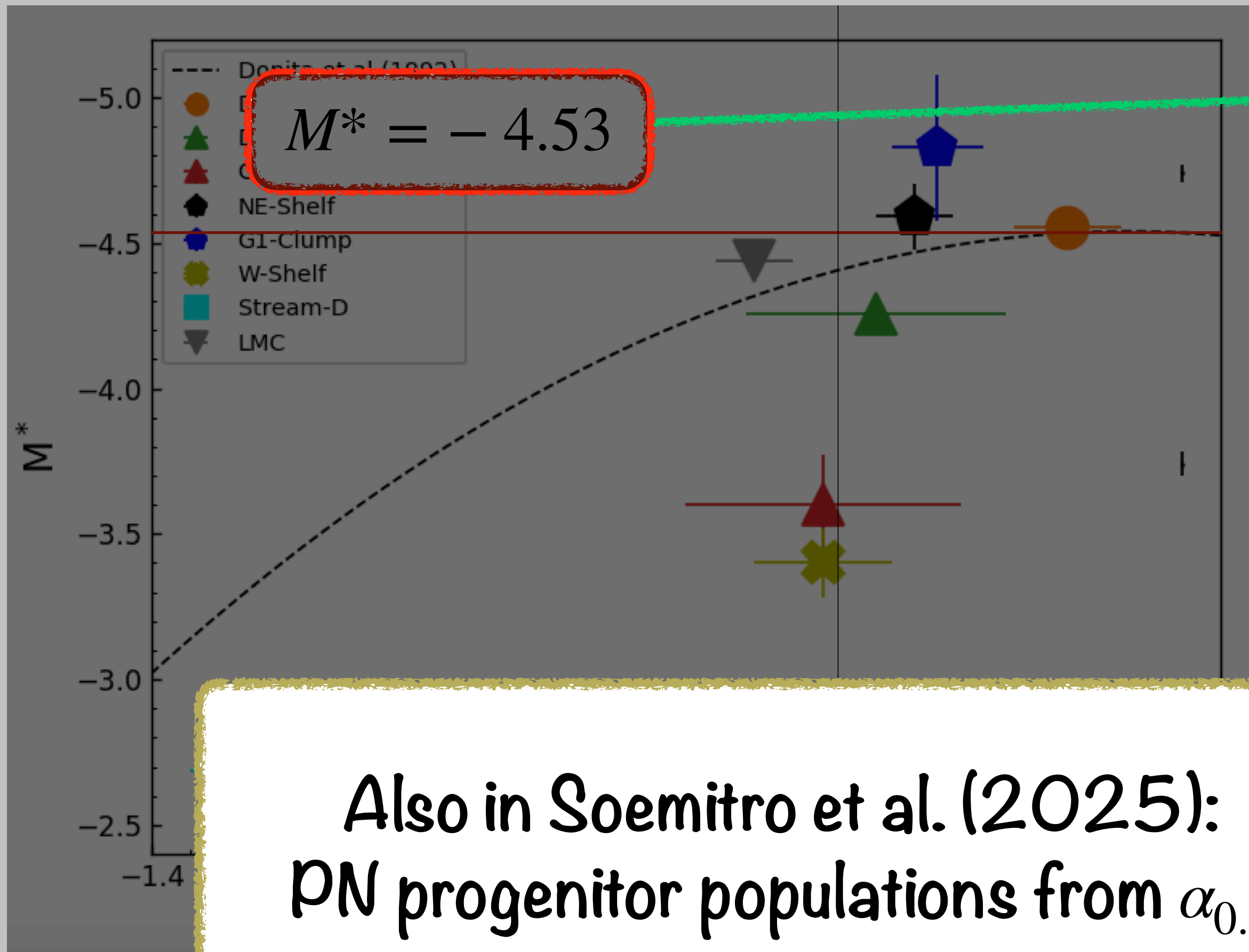
Credit: Galazzi et al. (2006)



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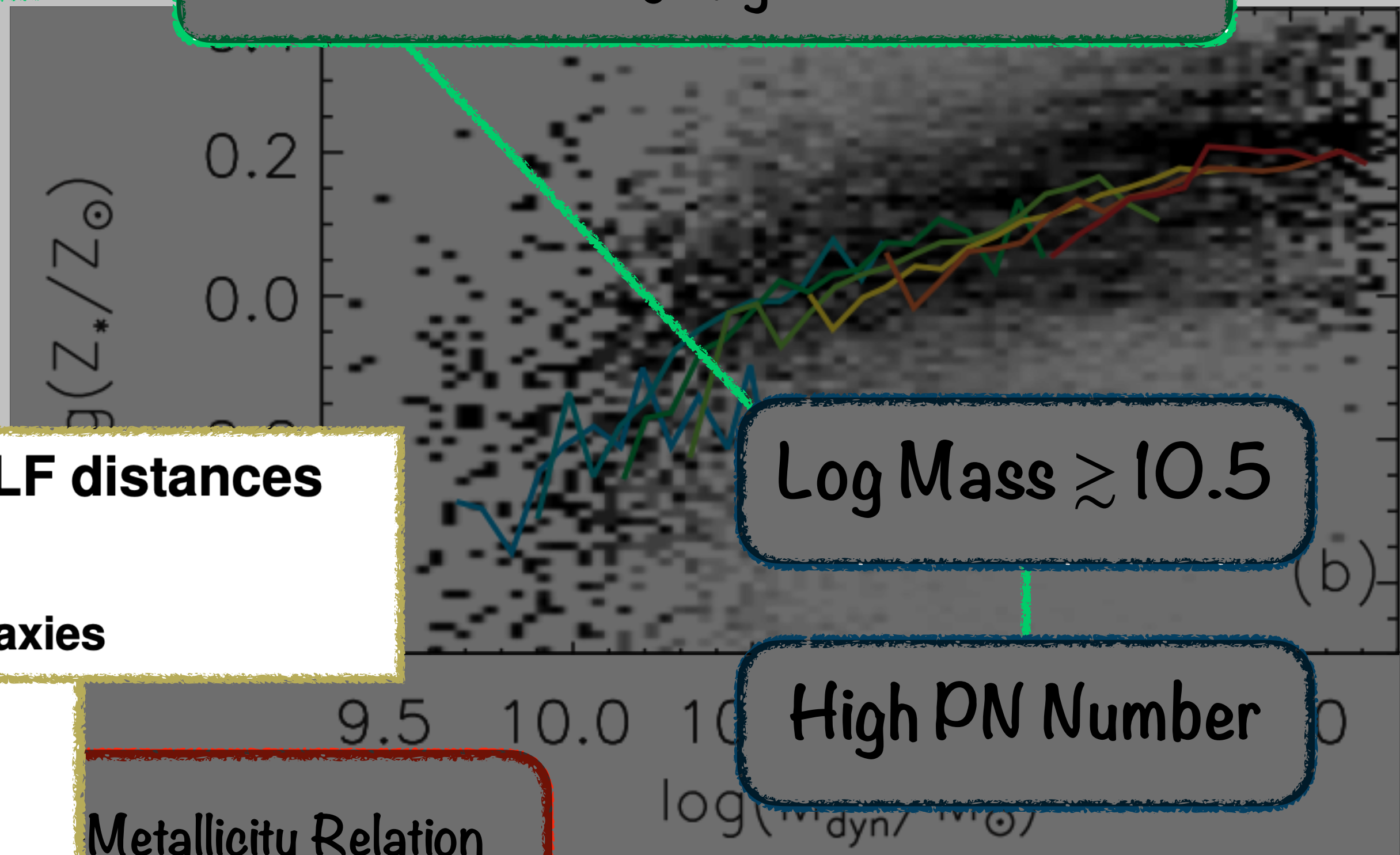
Credit: Galazzi et al. (2006)



$M^* = -4.53$

PNLF- H_0 target selection

Towards precision cosmology with improved PNLF distances using VLT-MUSE
 III. Impact of stellar populations in early-type galaxies



Log Mass $\gtrsim 10.5$

High PN Number

Metallicity Relation

Also in Soemitro et al. (2025):
 PN progenitor populations from $\alpha_{0.5}$

Credit: Galazzi et al. (2006)