

# A photometric search for Free-Floating Planet near the earth using Hyper Suprime-Cam data

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## Abstract

Free-floating planets are difficult to detect with conventional methods because they do not orbit bright host stars. In this study, we carried out a search for free-floating planet candidates near the Earth using photometric data from Hyper Suprime-Cam (HSC). Color indices were derived from magnitudes measured in multiple HSC bands, and color-magnitude diagrams and two-color diagrams were constructed. Gaia catalog information was used to estimate distances and convert apparent magnitudes into absolute magnitudes. By comparing the observational data with theoretical isochrones based on the ATMO2020 models, we selected candidates for young, low-temperature planetary-mass objects.

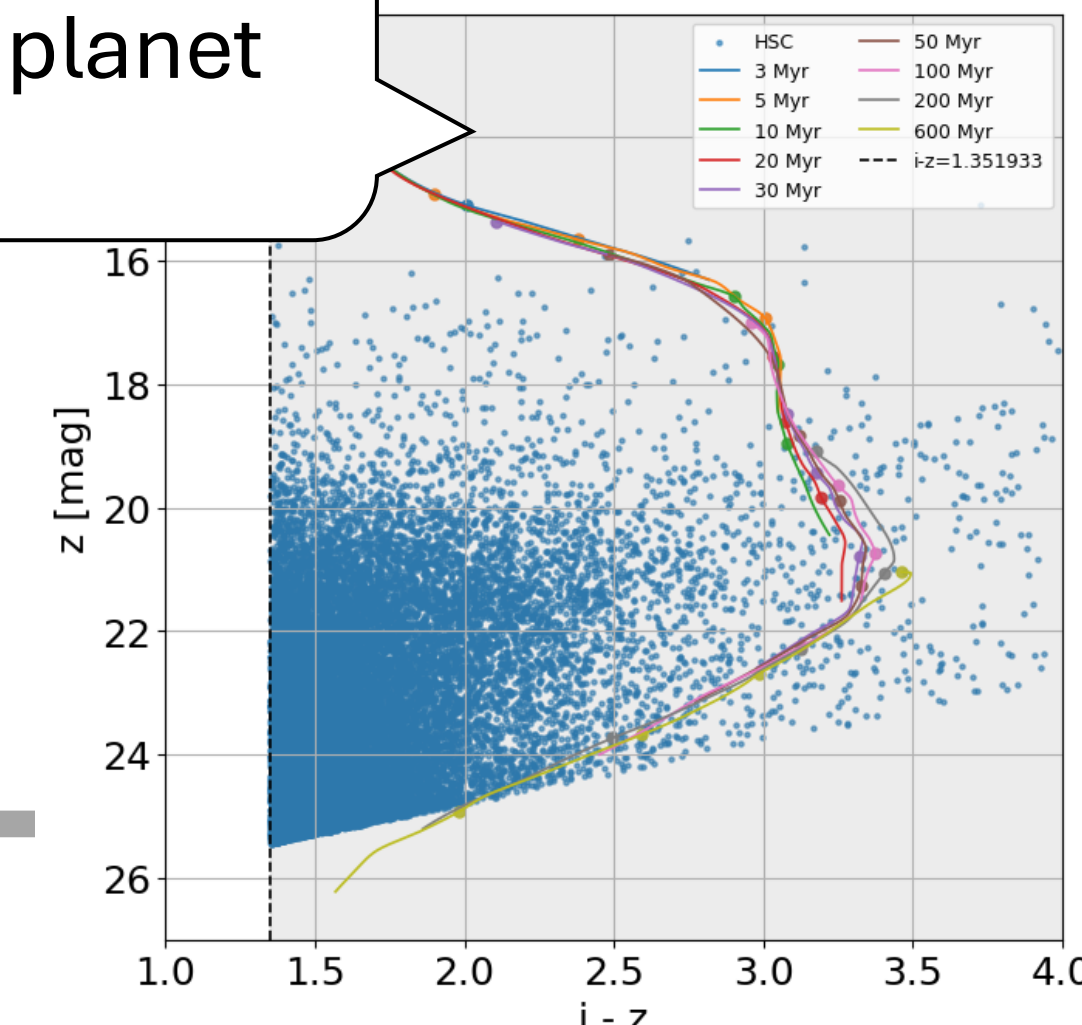
## Model<sup>[3]</sup>

- ATMO2020 models brown dwarfs and giant gas planets.
- It is used to create theoretical isochrone for different ages and masses

## HSC-SSP data

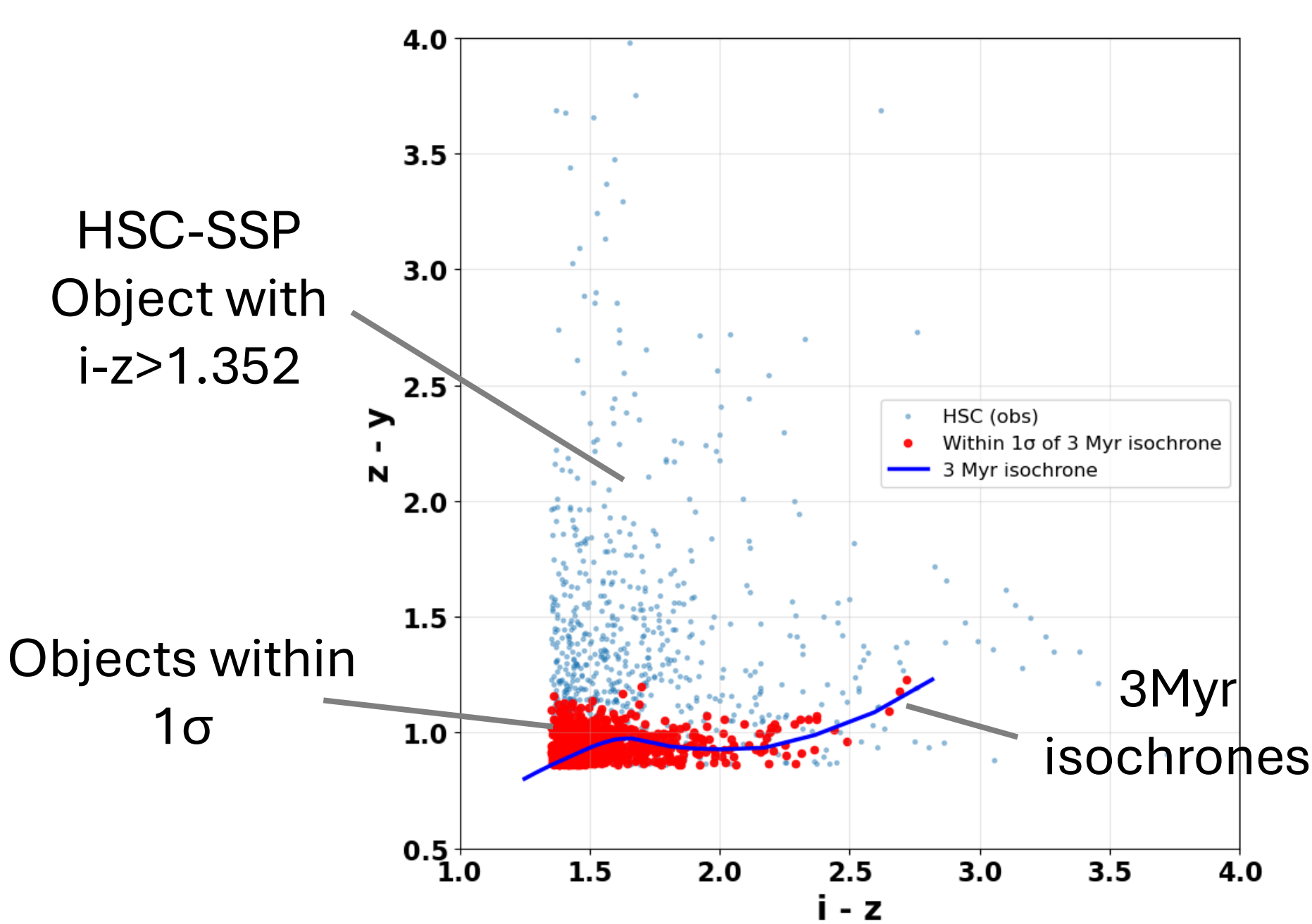
- Using HSC-SSP photometric data in the i,z and y bands.
- ATMO2020(3Myr):13Mj → i-z=1.352
- Selection: i-z>1.352

HSC sources with i-z>1.352 were used to select free floating planet candidates



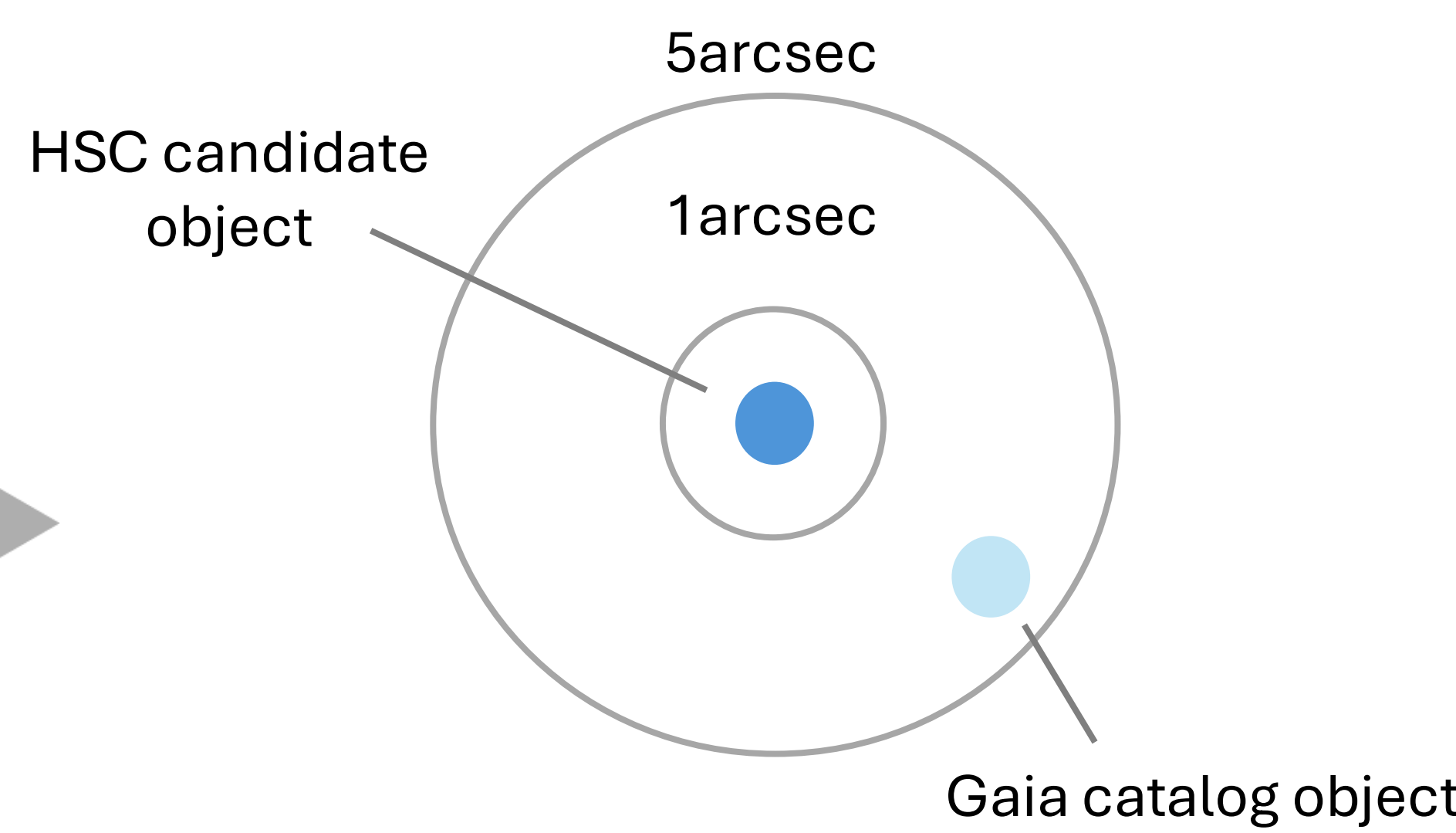
## Search Method in this study (Example for 3Myr case)

### ① Objects overlapping with 3Myr isochrones



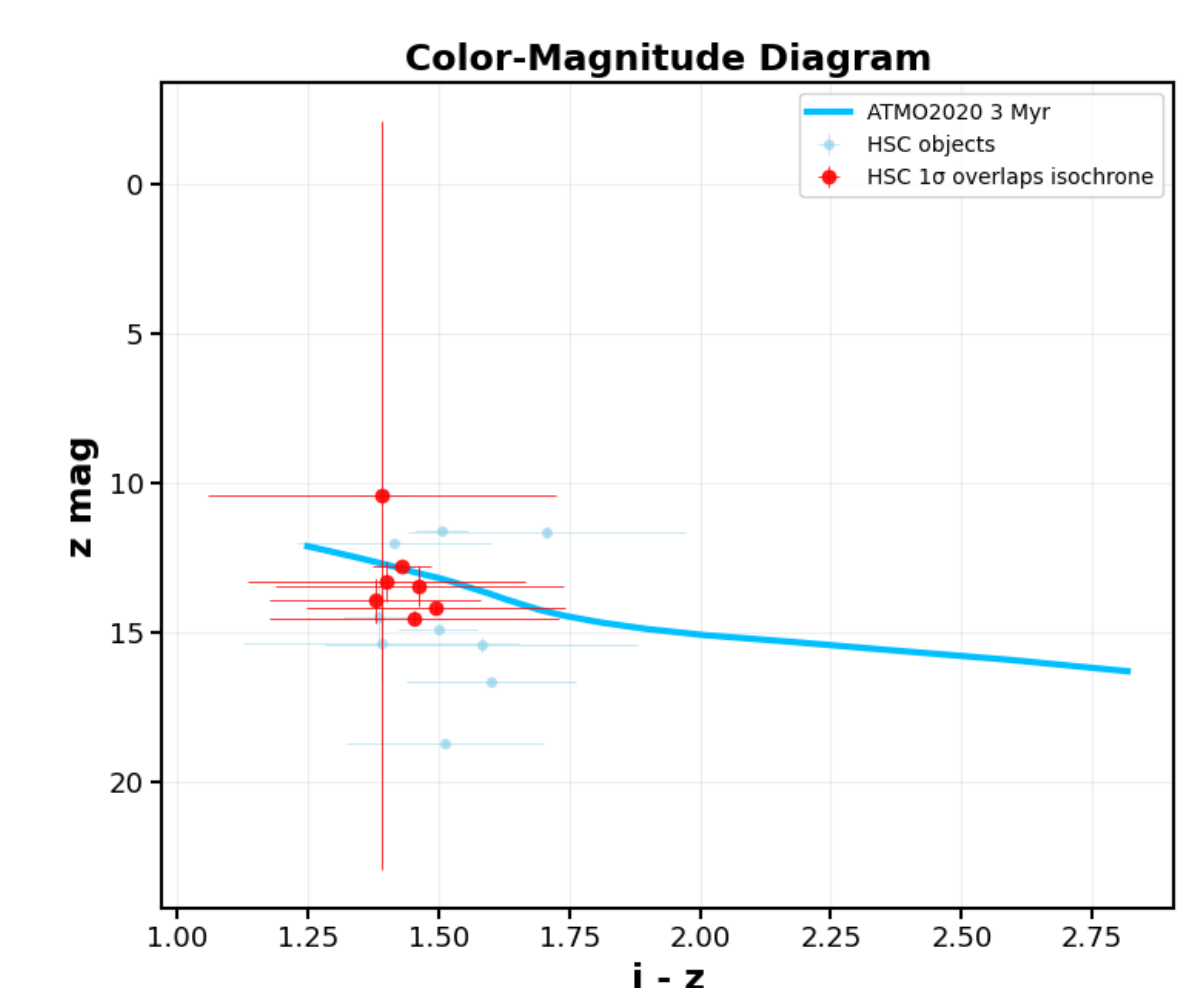
Search for candidate objects on the two-color diagram. [2][3]

### ② Cross-Match with the Gaia catalog



Gaia sources were shifted according to their proper motions → check whether they match HSC objects?

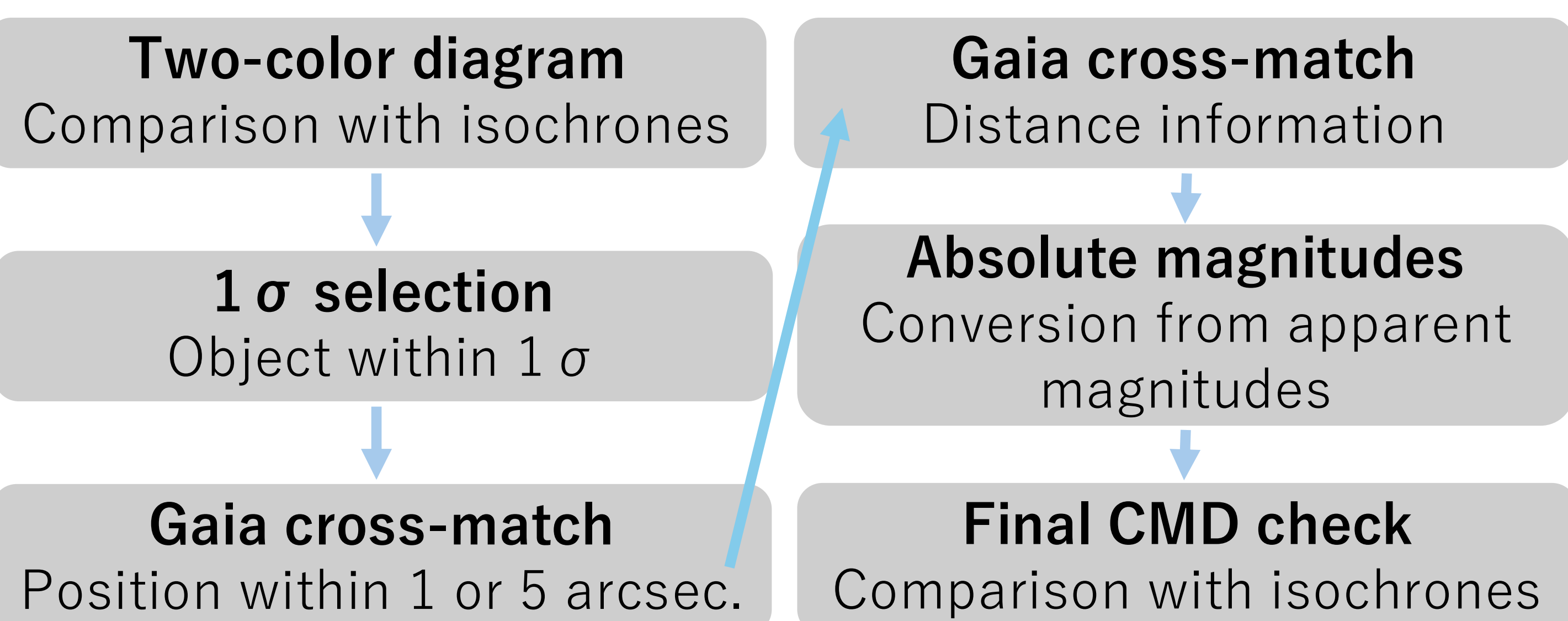
### ③ Color-Magnitude Diagram of candidate objects and theoretical isochrones



Candidates were converted to absolute magnitudes and compared with the isochrones within 1 sigma error.

## Results and Discussion

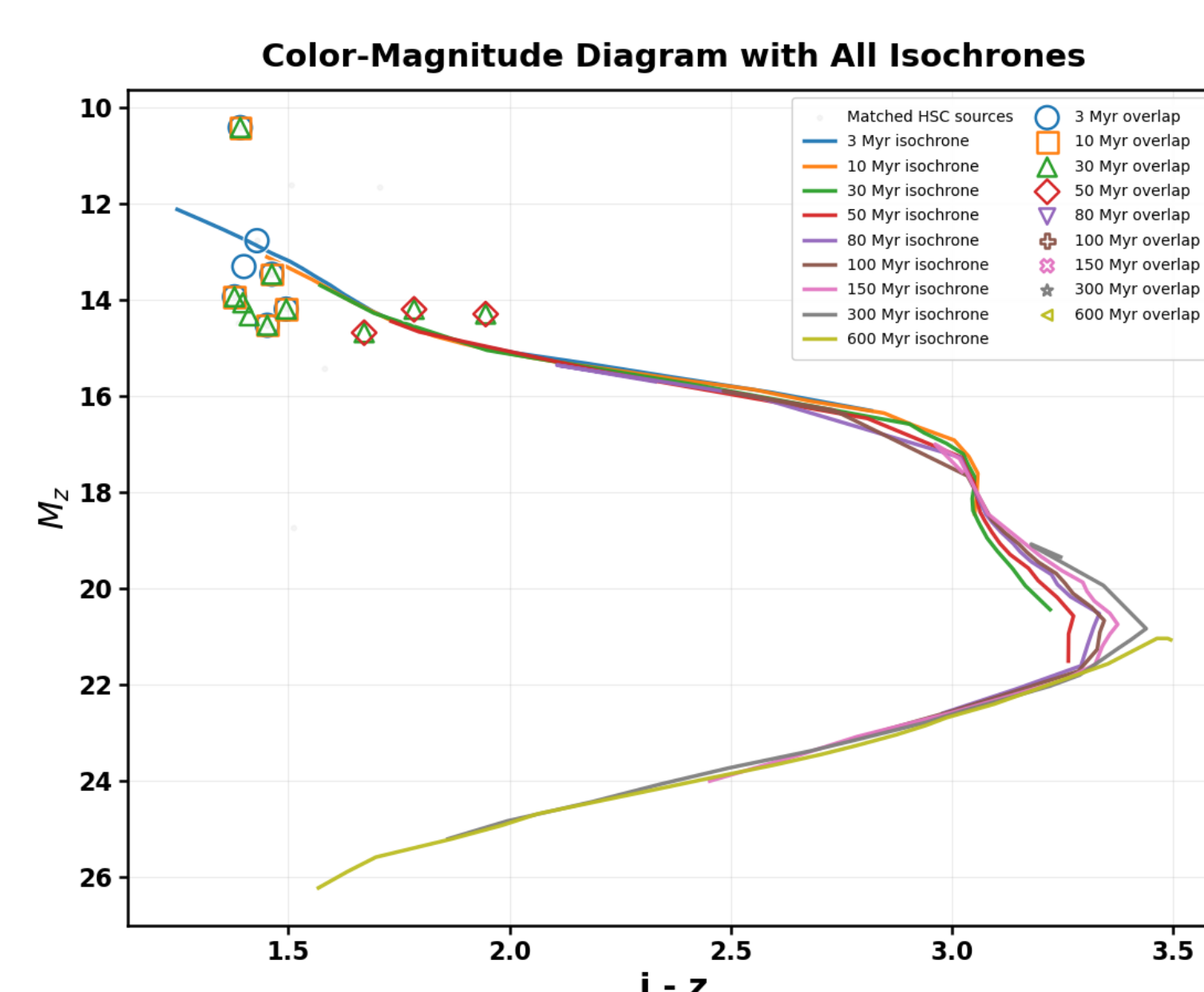
### Selection flow



### ② Cross-Matching the Gaia catalog with HSC observational data

age(Myr)	Number of Promising candidates (1arcsec)	Number of candidates (5arcsec)
3	0	20
10	0	14
30	0	27
50	0	17
80	0	5
100	0	0
150	0	0
300	0	0
600	0	38

### ③ Color-Magnitude Diagram of observational data and theoretical isochrones



age(Myr)	Number of candidates
3	7
10	5
30	10
50	3
80	0
100	0
150	0
300	0
600	0

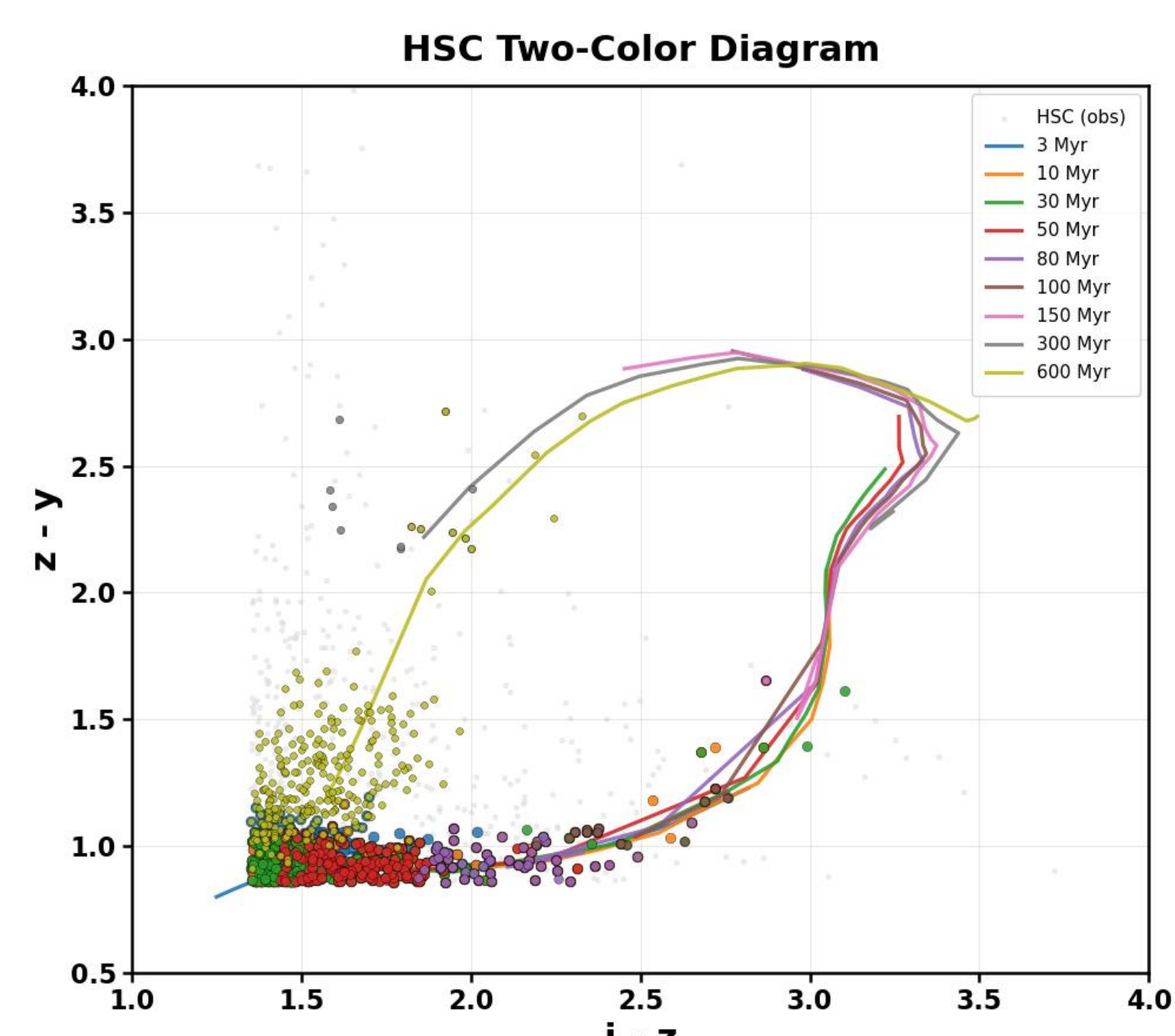
Final result

Candidates cross-matched within 5 arcsec and overlapping with the isochrones within 1 sigma errors were plotted.

## Reference

- [1] Miret-Roig et al. 'A rich population of free-floating planets in the Upper Scorpius young stellar association', Nature Astronomy, Volume 6, p. 89-97, 2021.
- [2] Bouy et al. 'Infrared Spectroscopy of free-floating planet candidates in Upper Scorpius and Ophiuchus', Astronomy & Astrophysics, Volume 664, id.A111, 14 pp, 2022.
- [3] M.W. Phillips et al. 'A new set of atmosphere and evolution models for cool T-Y brown dwarfs and giant exoplanets', Astronomy & Astrophysics, Volume 637, id.A38, 20 pp, 2020.

### ① Two-Color Diagram observational data and theoretical isochrones



age(Myr)	Number of candidates
3	671
10	565
30	412
50	212
80	55
100	14
150	1
300	13
600	267

Free-floating planet candidates overlapping with the isochrones within 1 sigma errors were identified for each age.