Characterizing High-Redshift Quasars (z>4.5) from 4MOST to LSST

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Motivation

Identifying high-redshift quasars (z > 4.5) is crucial for studying the early Universe, supermassive black hole growth, and cosmic reionization [1,2]. Most known high-redshift quasars are in the northern hemisphere, leaving the southern sky largely unexplored [3] —a critical gap for upcoming facilities like the Vera C. Rubin Observatory's LSST [4].

Purpose

We aim to create a comprehensive catalog of high-redshift quasar candidates in the southern hemisphere using multi-wavelength photometry and custom Spectral Energy Distribution (SED) fitting for spectroscopic follow-up with 4-meter Multi-Object Spectroscopic Telescope (4MOST) as part of the Chilean AGN/Galaxy Extragalactic Survey (ChANGES).

Results

Our final catalog contains 6,125 high-redshift quasar candidates (4.5 < z < 7) with detections in 6+ photometric bands, eliminating 99% of the known brown dwarf contaminants through our statistical selection criteria. Initial spectroscopic validation confirmed one quasar at z = 5.606 (J342-18) with the Next Generation Palomar Spectrograph (NGPS) at the Palomar Observatory Hale Telescope.

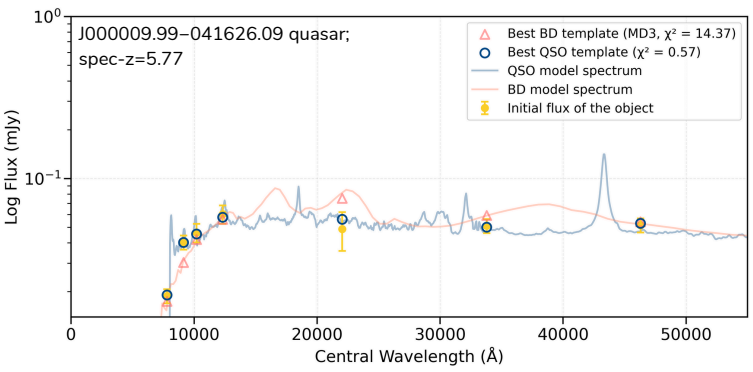


Fig. 1 Example of SED fitting for a known quasar from the F23 sample.

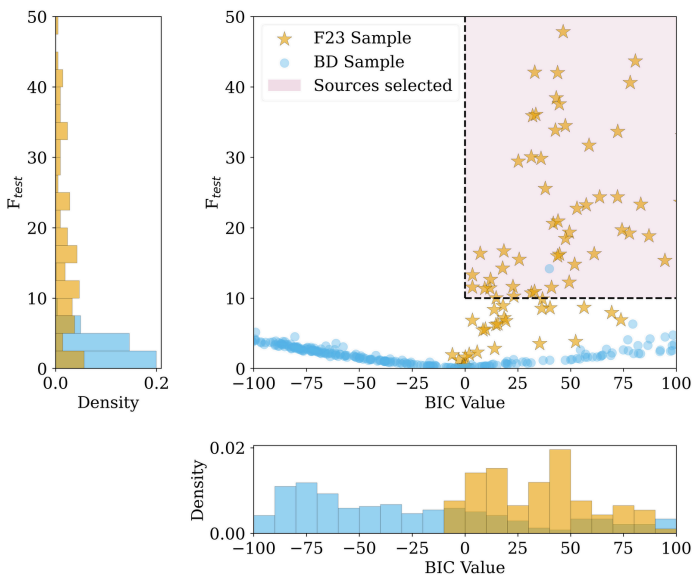


Fig. 3 The distribution of F-test and BIC values of the high-redshift quasars from the F23 sample and BD sample.

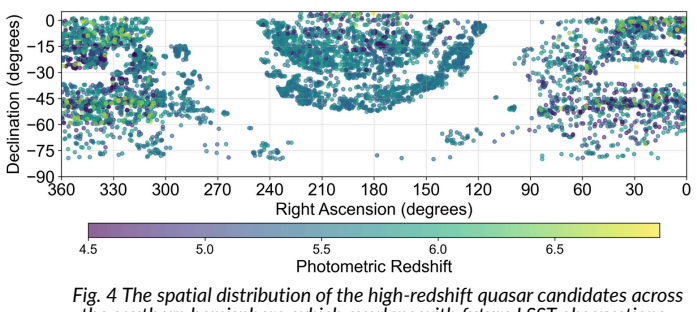
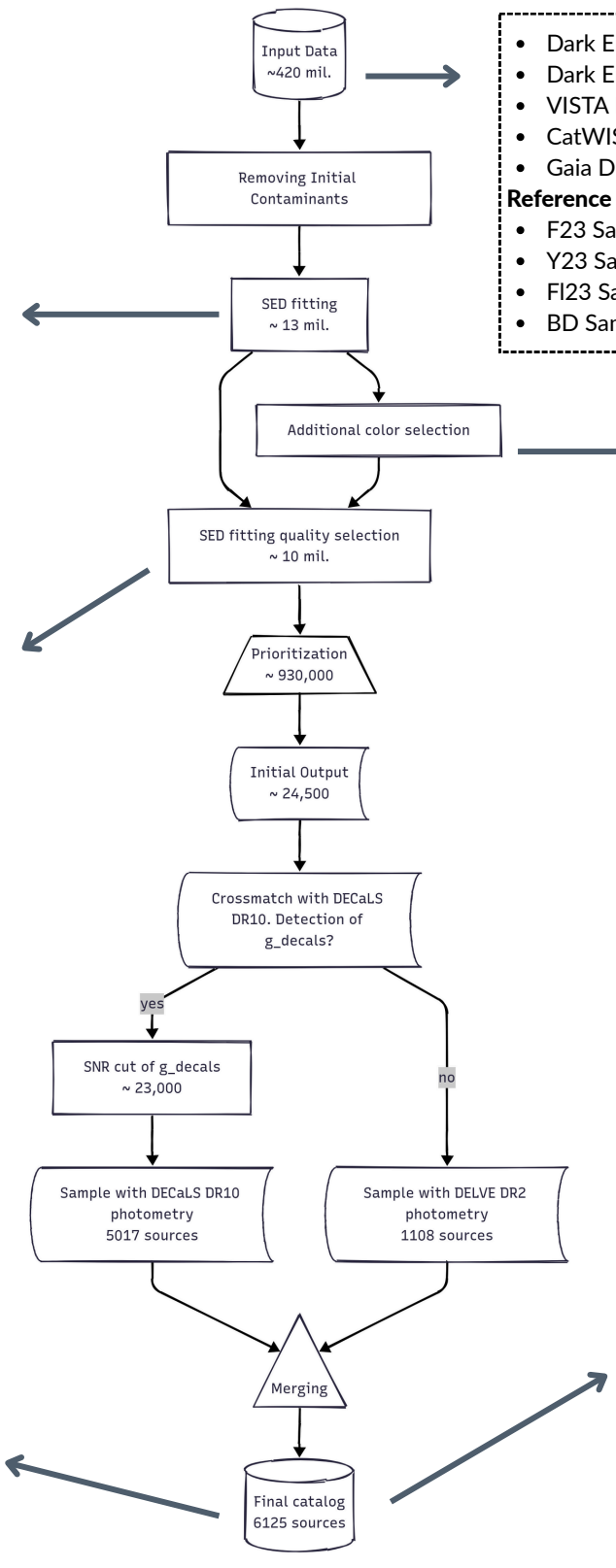


Fig. 4 The spatial distribution of the high-redshift quasar candidates across the southern hemisphere, which overlaps with future LSST observations and matches 4MOST's optimal observing range



- Dark Energy Camera Local Volume Exploration Survey (DELVE DR2) [5]
- Dark Energy Camera Legacy Survey (DECaLS DR10) [6]
- VISTA Hemisphere Survey (VHS DR5) [7,8]
- CatWISE 2020 [9]
- Gaia DR3 [10]

Reference Samples

- F23 Sample (~500 spectroscopically confirmed quasars at 5.4 < z < 7.6) [2]
- Y23 Sample (~550 spectroscopically confirmed quasars at 4.4 < z < 6.6) [11]
- Fl23 Sample (~600 spectroscopically confirmed quasars at z > 4.5) [12]
- BD Sample (~5,700 spectroscopically confirmed brown dwarfs) [13-17]

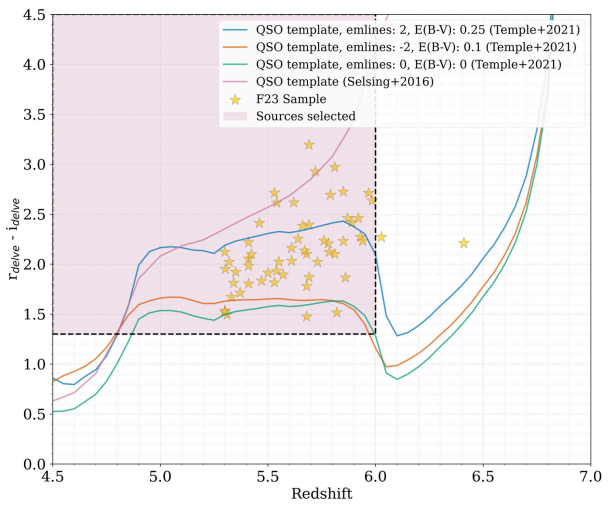


*Fig. 2 The relation between **r-i** color and the redshift for high-redshift quasars from the F23 sample, using DELVE photometry. For sources at z < 6, we selected those with **r-i > 1.3**. All sources at z > 6 are retained regardless of their color.*

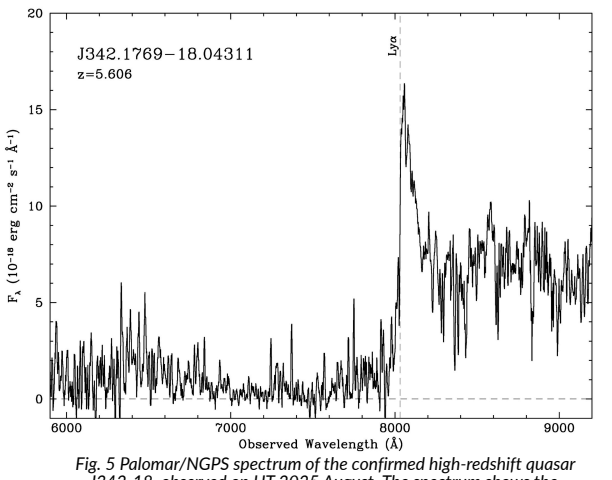


Fig. 5 Palomar/NGPS spectrum of the confirmed high-redshift quasar J342-18, observed on UT 2025 August. The spectrum shows the characteristic Lyman-α break at ~8000 Å, confirming the quasar nature of this candidate selected through our SED fitting methodology.

Conclusion

Our SED fitting methodology produced 6,125 high-redshift quasar candidates achieving 44% completeness and 1.5% reliability in test regions (−30° < Dec < 0°), ready for 4MOST spectroscopic confirmation beginning in 2026. The resulting spectroscopically confirmed sample will serve as a training set for developing photometric redshift algorithms for LSST's multi-band photometry, enabling automated classification and real-time identification of the most distant quasars for future studies

References:

[1] Bañados+2018, ApJ, 861, 2; [2] Fan+2023, A&A, 61, 373; [3] Wang+2024, ApJ, 968, 1; [4] Ivezić+2019, Apj, 873, 2; [5] Drlica-Wagner+2022, AJSS, 261, 38; [6] Dey+2019, AJ, 157, 5; [7] McMahon+2020 Msngr, 154, 35; [8] Edge+2013 Msngr, 153, 32; [9] Wright+2010 AJ, 140, 6; [10] Vallenari+2023, A&A, 674, A1; [11] Yang+2023 ApJ, 269, 27; [12] Flesch+2023, ApJS, 175; [13] West+2011, AJ; [14] Lodieu+2014, MNRAS, 569, 120; [15] Mace+2014, PhD thesis; [16] Marocco+2015, MNRAS; [17] Best+2015, APJ