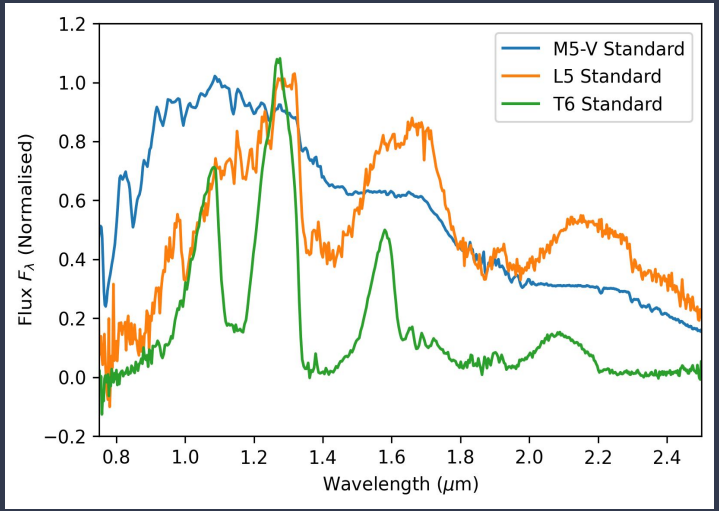
Identifying Ultra-Cool Brown Dwarfs

In the COSMOS Survey

Image credit: Nasa

Alasdair Koplick and Ewan Scopes

Brown Dwarfs and Their Importance



Brown dwarfs are:

- Unable to fuse their own hydrogen
- Spectral types M, L, T & Y
- ~4 - 80 Jupiter Masses
- ~0.5 - 1.1 Jupiter Radii

Importance of brown dwarf scale heights:

- Evolution of Milky Way
- Large contaminant population for z=6 galaxies
- ~50% of our local neighbourhood[1]

[1]: B Holwerda et al. Beyond the Local Volume I. Surface Densities of Ultracool Dwarfs in Deep HST/WFC3 Parallel Fields [2022]

This Project

The aim of this project is to identify brown dwarfs. This is challenging. Scale height estimates from 290-400 Parsecs across 11 previous papers.[2]

Compared to previous papers:

- Using a larger dataset (COSMOS)
- More filter bands
- Different identification techniques

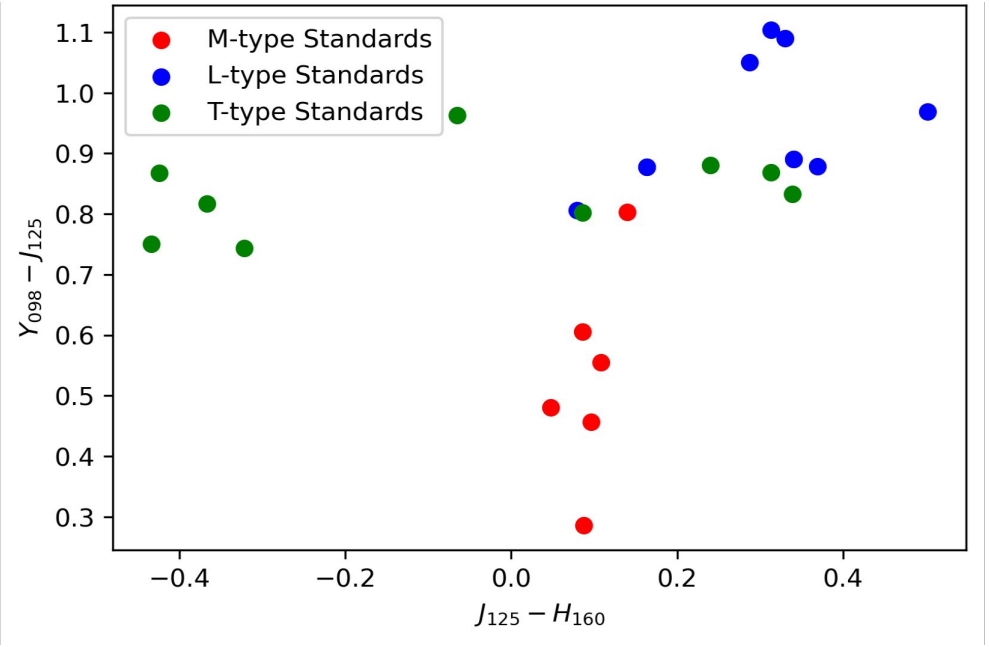
Two key parts to our process:

1. **Test suitability of various model spectra**
2. **Brown dwarf selection chain**

[2]: Holwerda et al. The Effect of Atmospheric Cooling on Vertical Velocity Dispersion and Density Distribution of Brown Dwarfs [2017]

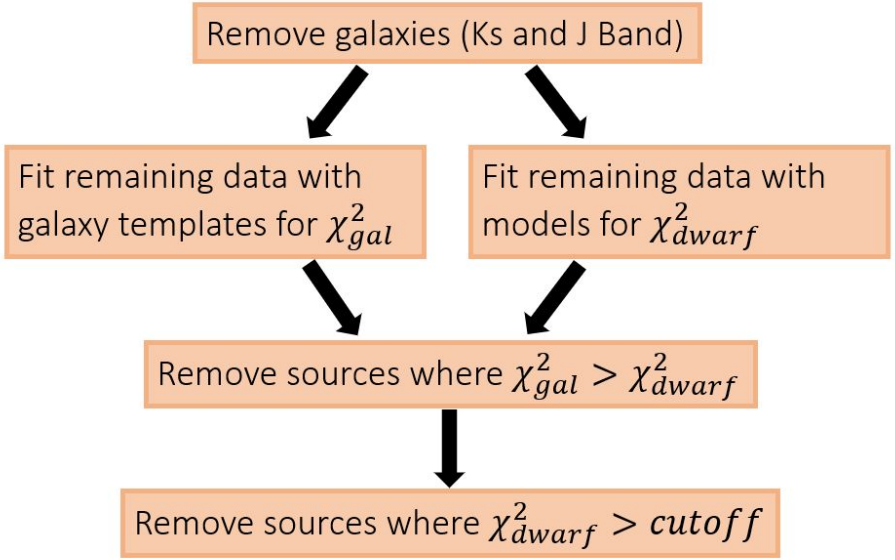
1. Model Suitability Testing

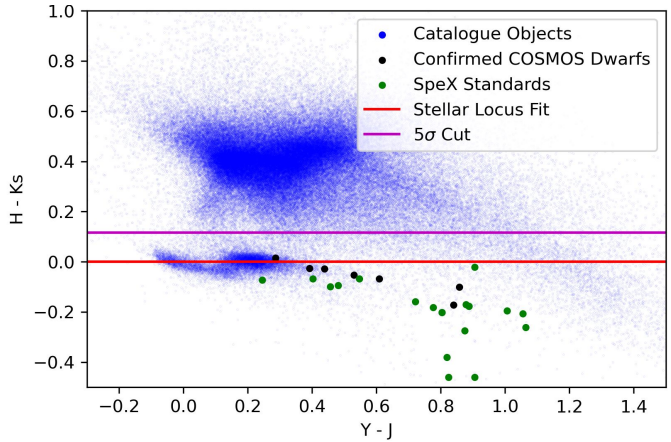
- Known set of dwarfs “Spex Standards” and “Aganze Dwarfs” tested against
- Three different model sets tested
- Plotted in colour colour space against Spex Standards
- Spectra fitted against Aganze Dwarfs



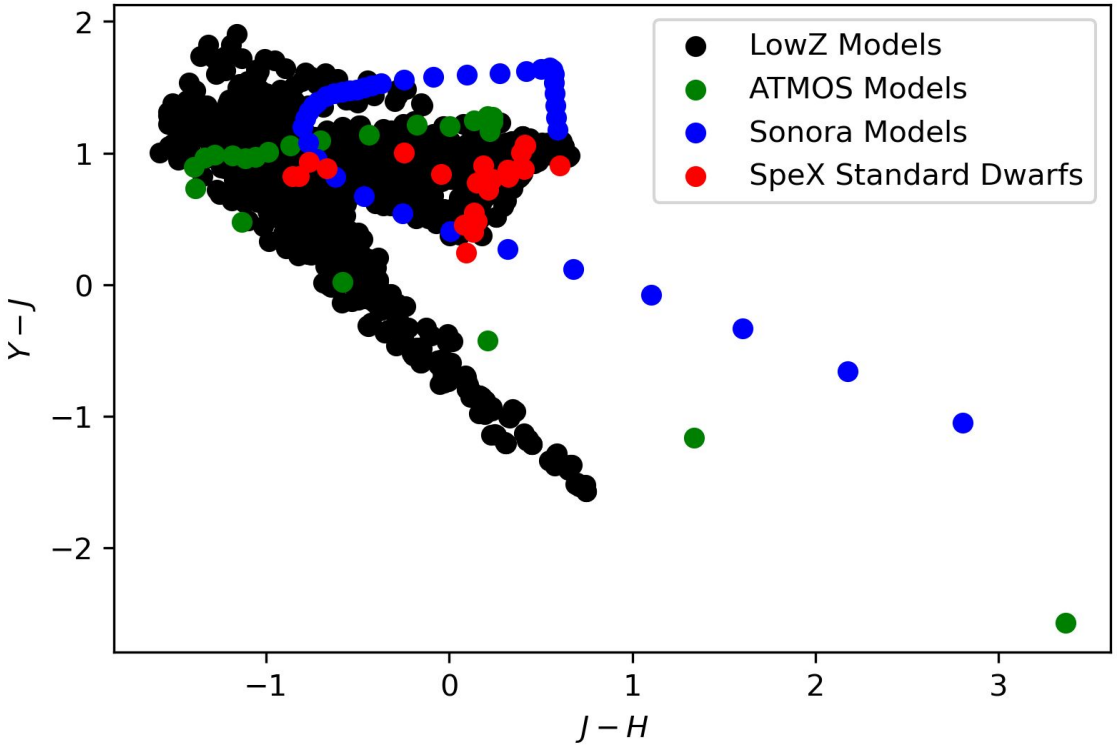
2. Brown Dwarf Selection Chain

- J band >25 magnitudes removed
- Cutoff based on largest χ^2_{dwarf} from Aganze dwarfs
- Best fitting model parameters give results for each source



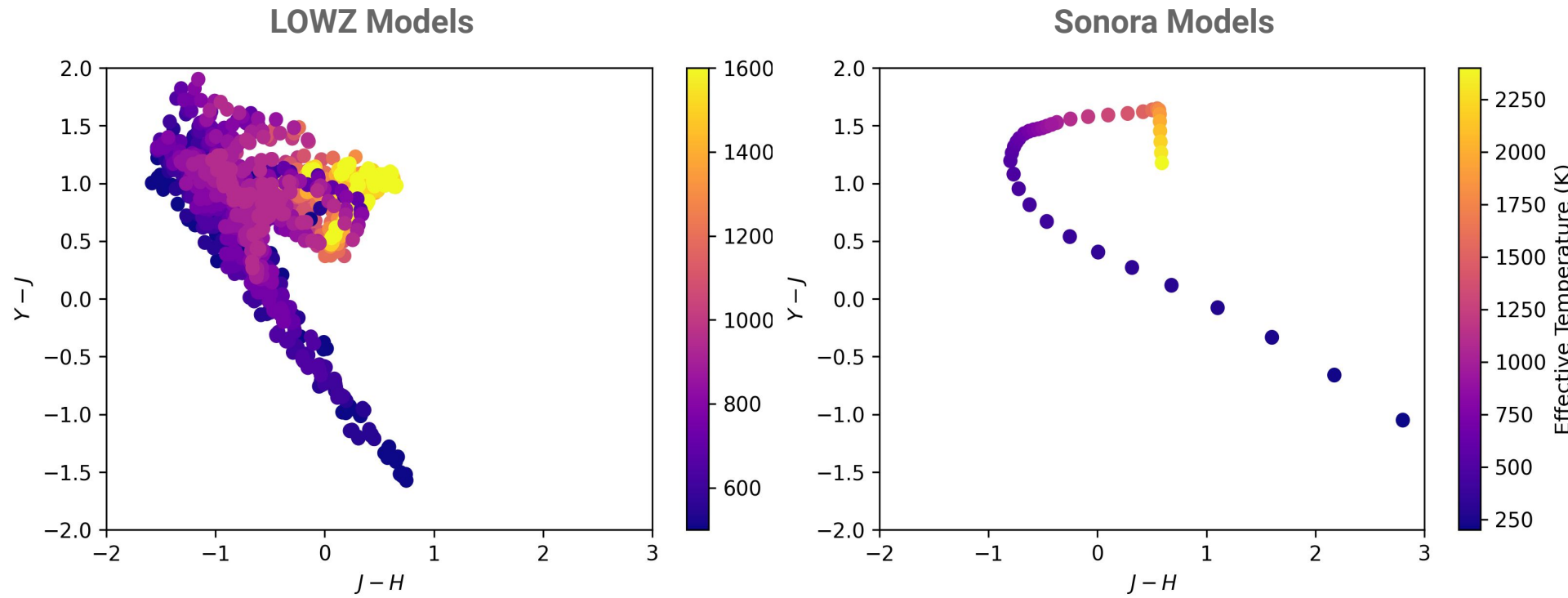


Model Results I: Suitability



- From visual inspection the ATMOS models were discarded

Model Results I: Suitability



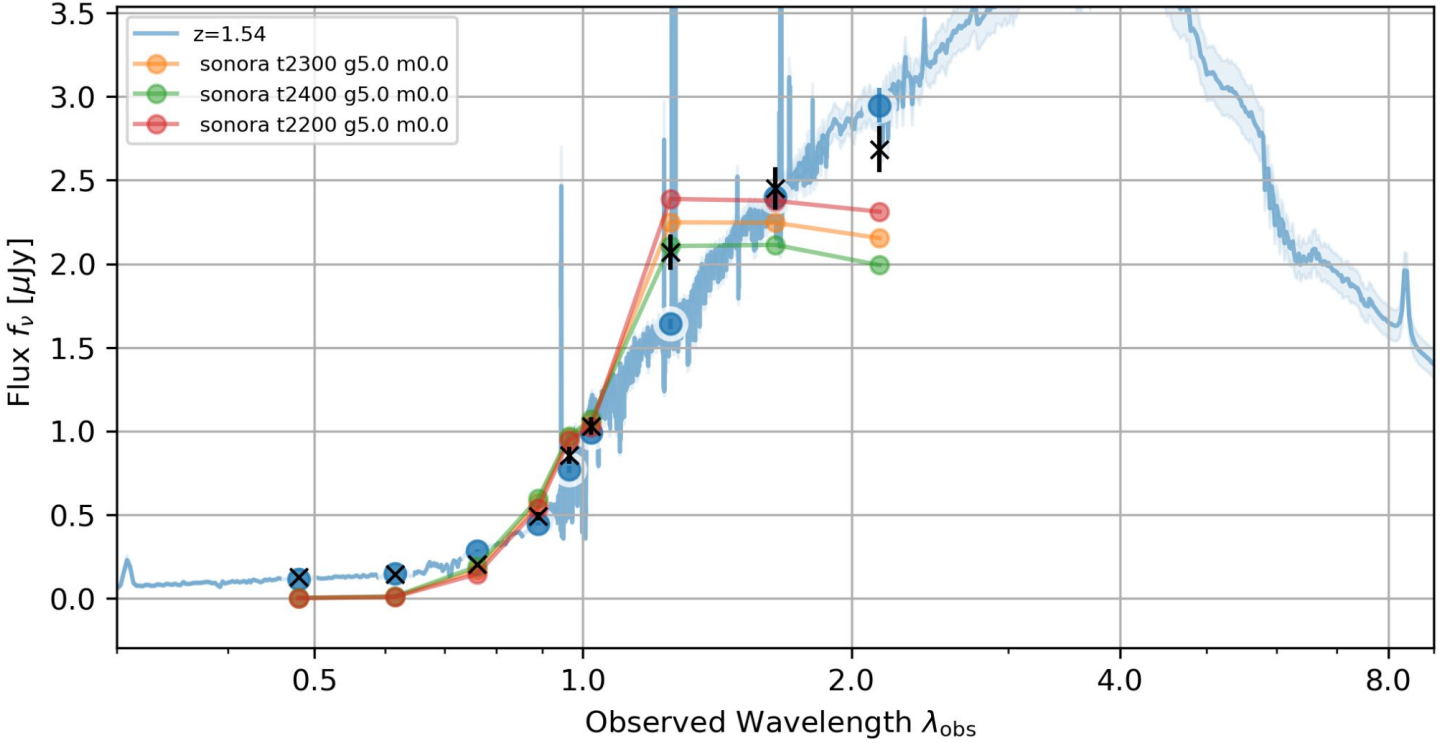
Model Results II: Disparity with Aganze Identification

Confirmed dwarfs from Aganze[3] and what we have identified them as:

Aganze ID	LowZ T_{eff} (K)	Sonora T_{eff} (K)	Fitted Redshift z	Best Fit Object (LowZ)	Best Fit Object (Sonora)
J10001957+0218224	1600	2400	5.65	Galaxy	Galaxy
J10002575+0222265	1600	2300	5.69	Brown Dwarf	Brown Dwarf
J10002739+0212135	1600	2400	0.98	Brown Dwarf	Brown Dwarf
J10003031+0227345	1600	2400	5.66	Brown Dwarf	Brown Dwarf
J10001529+0221196	950	425	1.47	Brown Dwarf	Brown Dwarf
J10002236+0219530	1600	2300	1.54	Galaxy	Galaxy
J10003503+0217012	1600	2400	1.50	Galaxy	Galaxy
J10004273+0220589	950	900	5.96	Brown Dwarf	Brown Dwarf
J10002943+0217108	1600	2400	5.60	Brown Dwarf	Brown Dwarf

[3]: C. Aganze, A. J. Burgasser, M. Malkan, C. A. Theissen, R. A. Tejada Arevalo, C.-C. Hsu, D. C. Bardalez Gagliuffi, R. E. Ryan, and B. Holwerda, Beyond the Local Volume. I. Surface Densities of Ultracool Dwarfs in Deep HST/WFC3 Parallel Fields, ApJ 924, 114 (2022)

Model Results II: Disparity with Aganze Identification



Dwarf Results: Identified Brown Dwarf List

Final identification results by type:

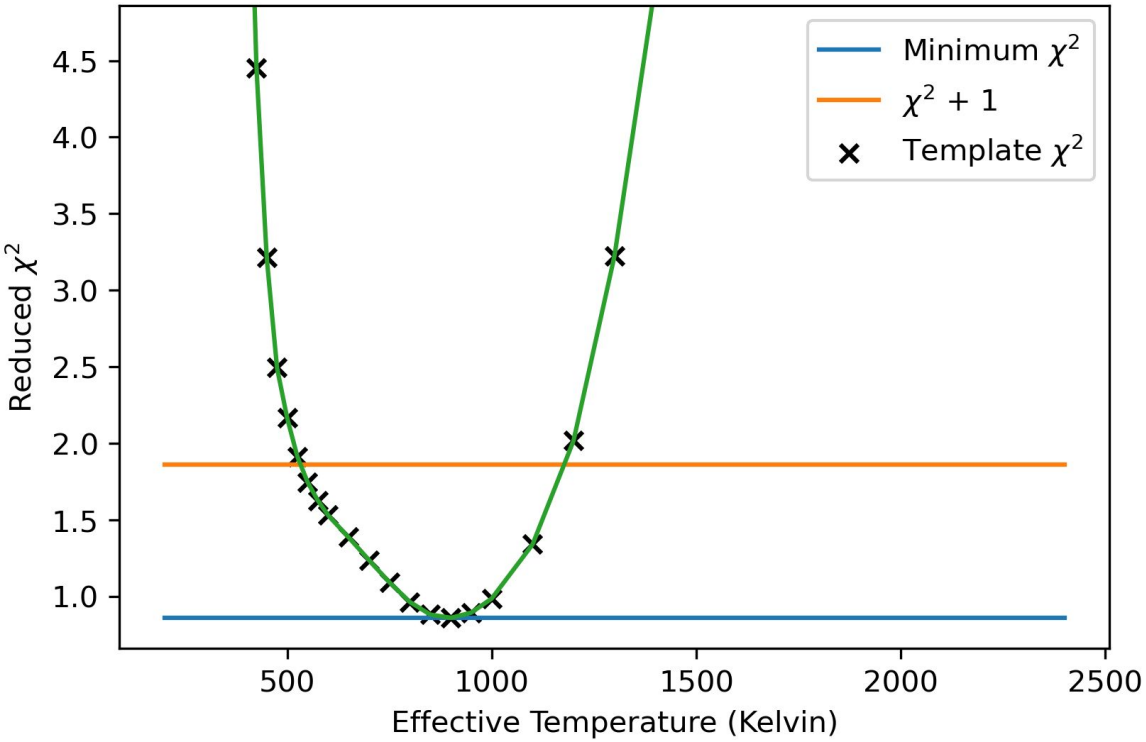
Model Sets Used	Number of Candidate Dwarfs	M-Type Dwarfs	L-Type Dwarfs	T-Type Dwarfs	Y-Type Dwarfs
Sonora and LowZ	1580 (831 LowZ, 749 Sonora)	586	549	411	34
Sonora	1776	1014	285	106	371
LowZ	1723	0	1242	481	0

Dwarf Results: Identified Brown Dwarf List

Selected range of identified dwarfs (out of 1580):

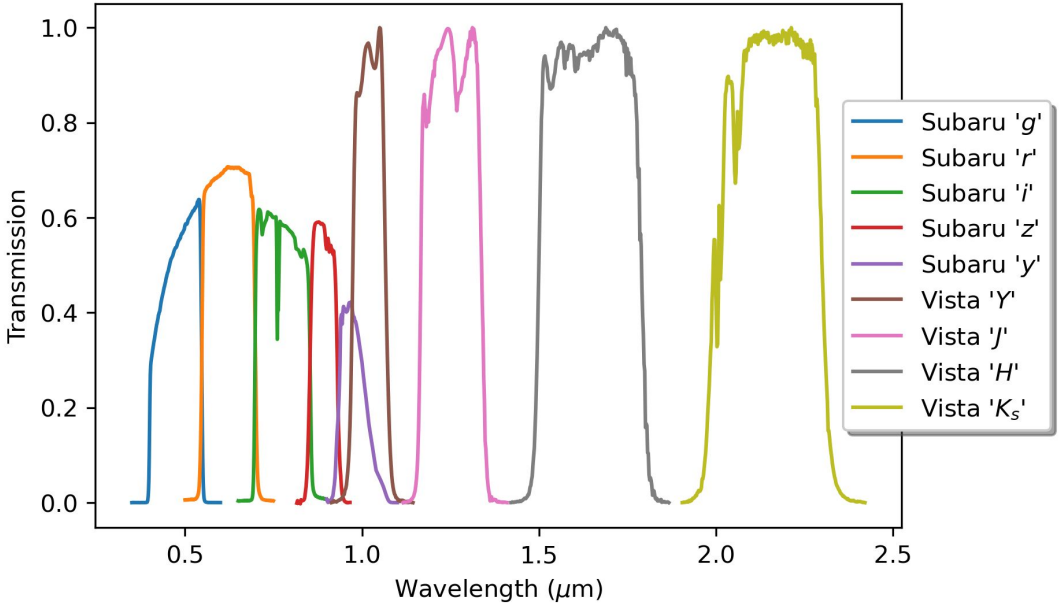
COSMOS ID	Effective Temperature T_{eff} (K)	Uncertainty $\sigma_{T_{eff}}$ (K)	Dwarf Type	Distance (kpc)
6394	2400	19	M8.5V	0.716
7236	2400	22	M8.5V	0.212
9836	1600	60	L6V	0.154
73432	2200	162	L1V	0.93
162238	1000	113	T5.5V	0.785
65231	900	174	T8V	N/A
911028	300	171	Y2V	N/A
978382	425	224	Y0V	N/A

Dwarf Results: Uncertainties



- Error increases significantly with lateness of spectral type
- Many edge cases with LOWZ supported needing higher temperature models

Dwarf Results: Further Error Contributions



- Filter band overlap contribution
- Error propagation on type and distance
- Type and distance estimates due to taking closest temperature from tables

Conclusion & Future Prospects

Thoughts on models:

- Fine tuned models are best fitting
- Combining different models most ideal approach
- Probably best used with combination of other techniques

Improvements:

- Error propagation
- Investigation of more model sets
- Inspection of confirmed dwarf sets

Next part of project: Estimate galactic scale height using the dwarfs identified