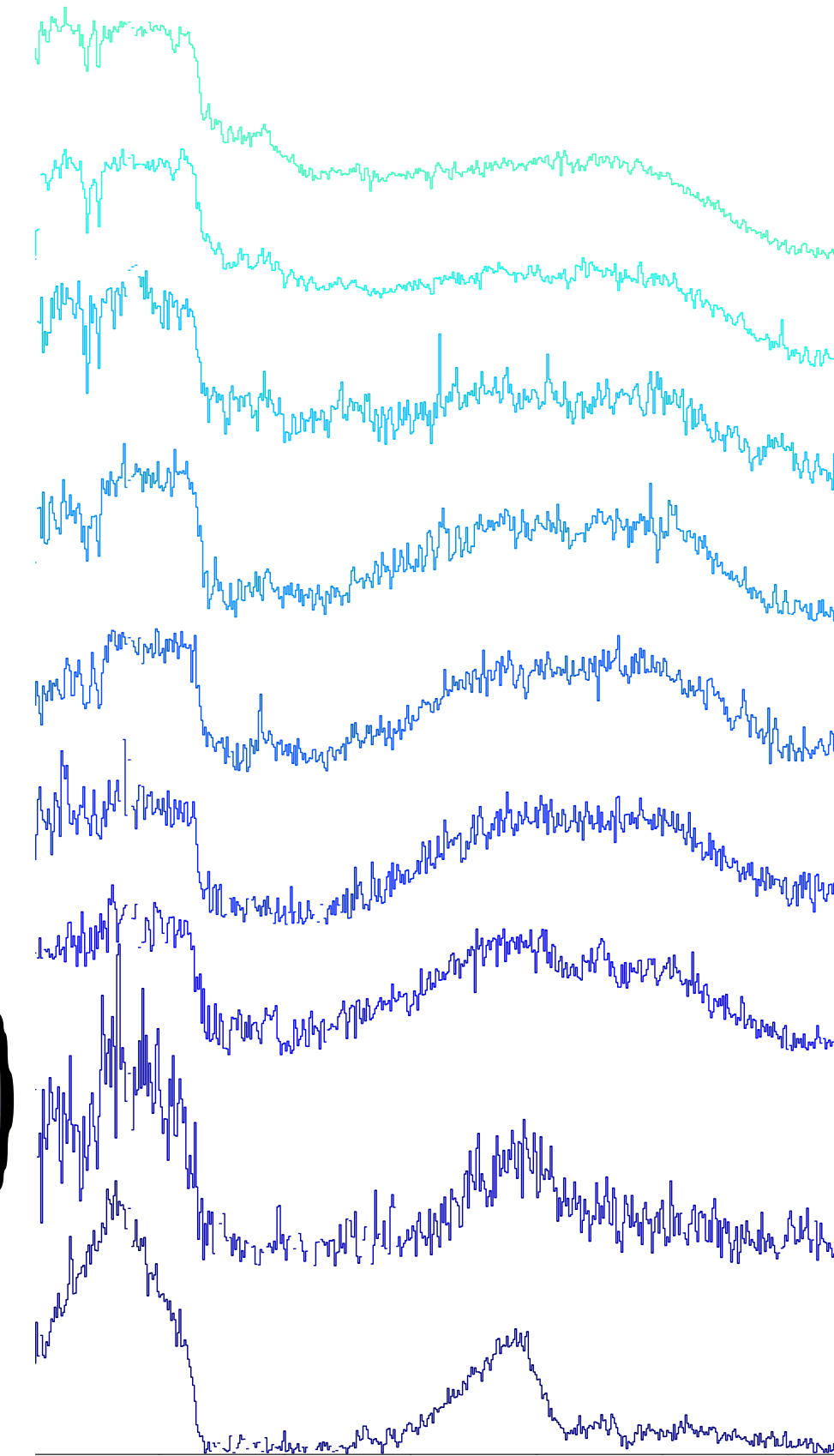# Spectroscopic search, classification and analysis of ultracool dwarfs in *Euclid* Q1 data

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ESA/Gaia/DPAC
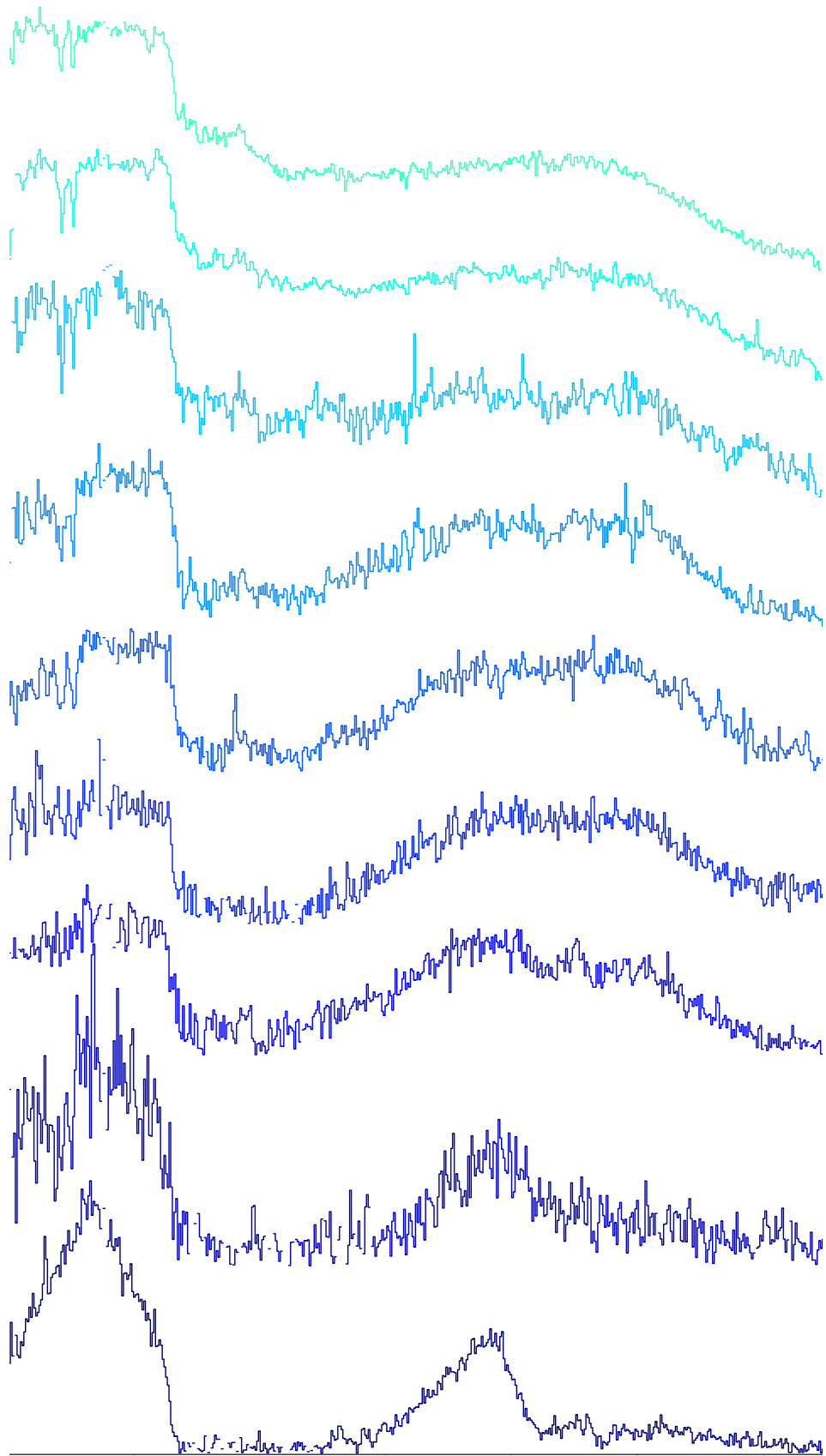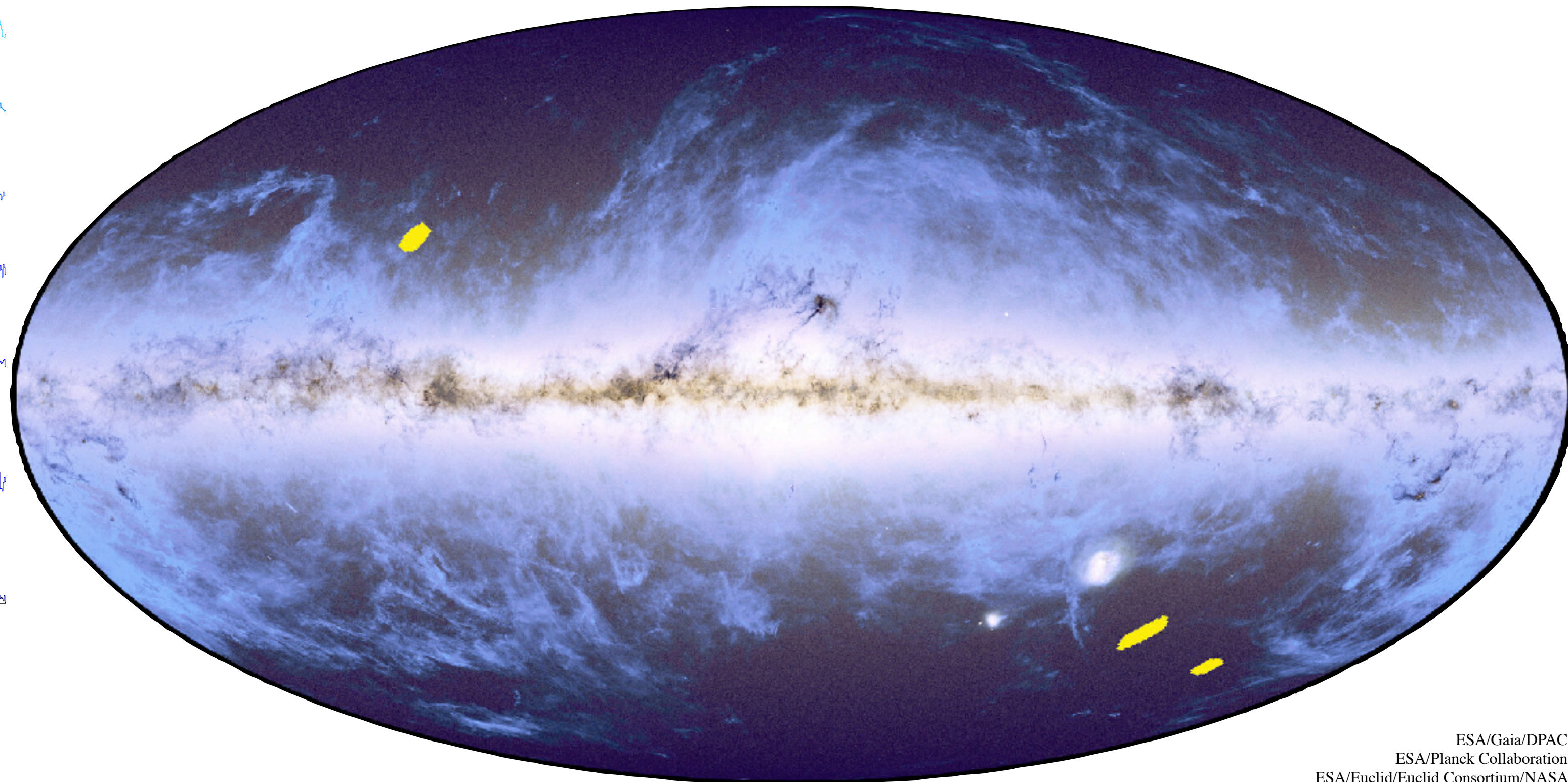ESA/Planck Collaboration
ESA/Euclid/Euclid Consortium/NASA

Spectroscopic search, classification and analysis of ultracool dwarfs in *Euclid* Q1 data

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Co-authors:

ERC Substellar project:
M. Žerjal, N. Sedighi, E. L. Martín, J.-Y. Zhang, N. Vitas, S. Tsilia, S. Muñoz Torres

Independent Legacy Science (ILS) team
P. Mas-Buitrago, V. J. S. Béjar, N. Lodieu, D. Barrado, E. Solano,
P. Cruz, R. Tata, N. Phan-Bao, A. Burgasser

Euclid space mission

- **Early Release Observations (ERO)**
    ERO-02 fields (Martín et al. 2025)

- **Wide survey** | Talk by Eduardo Martín |

- **Deep Fields**
    Q1 data (already public)
    - VIS and NIR images
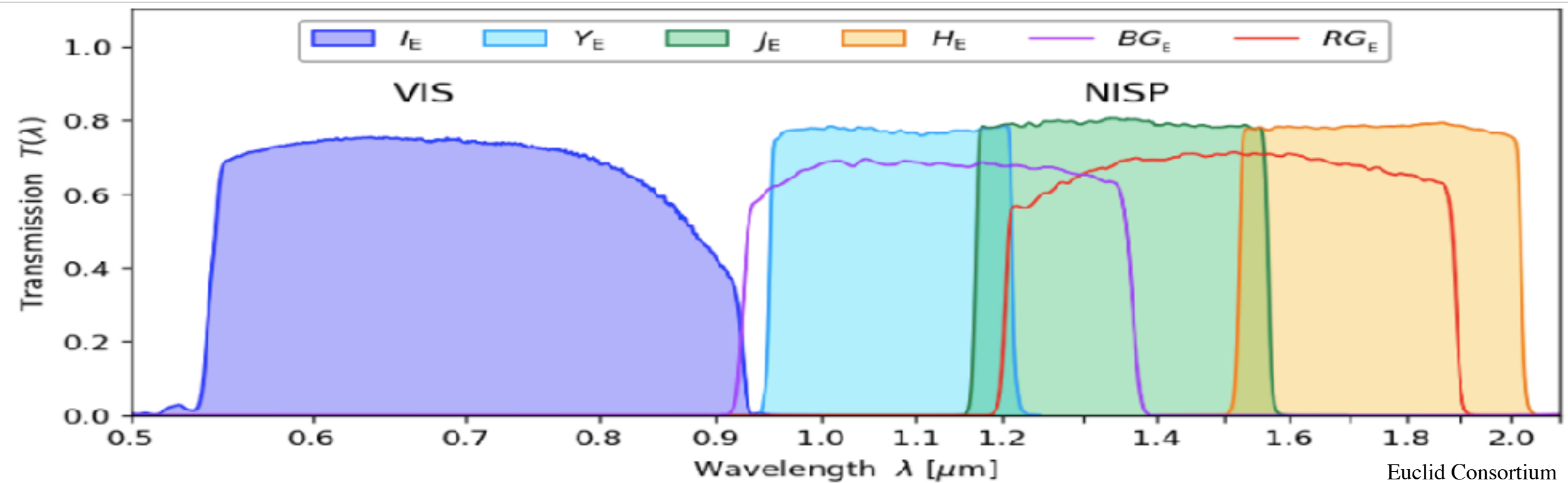   - NIR spectra (1.2-1.9μm)
        R~450
    - Catalogues
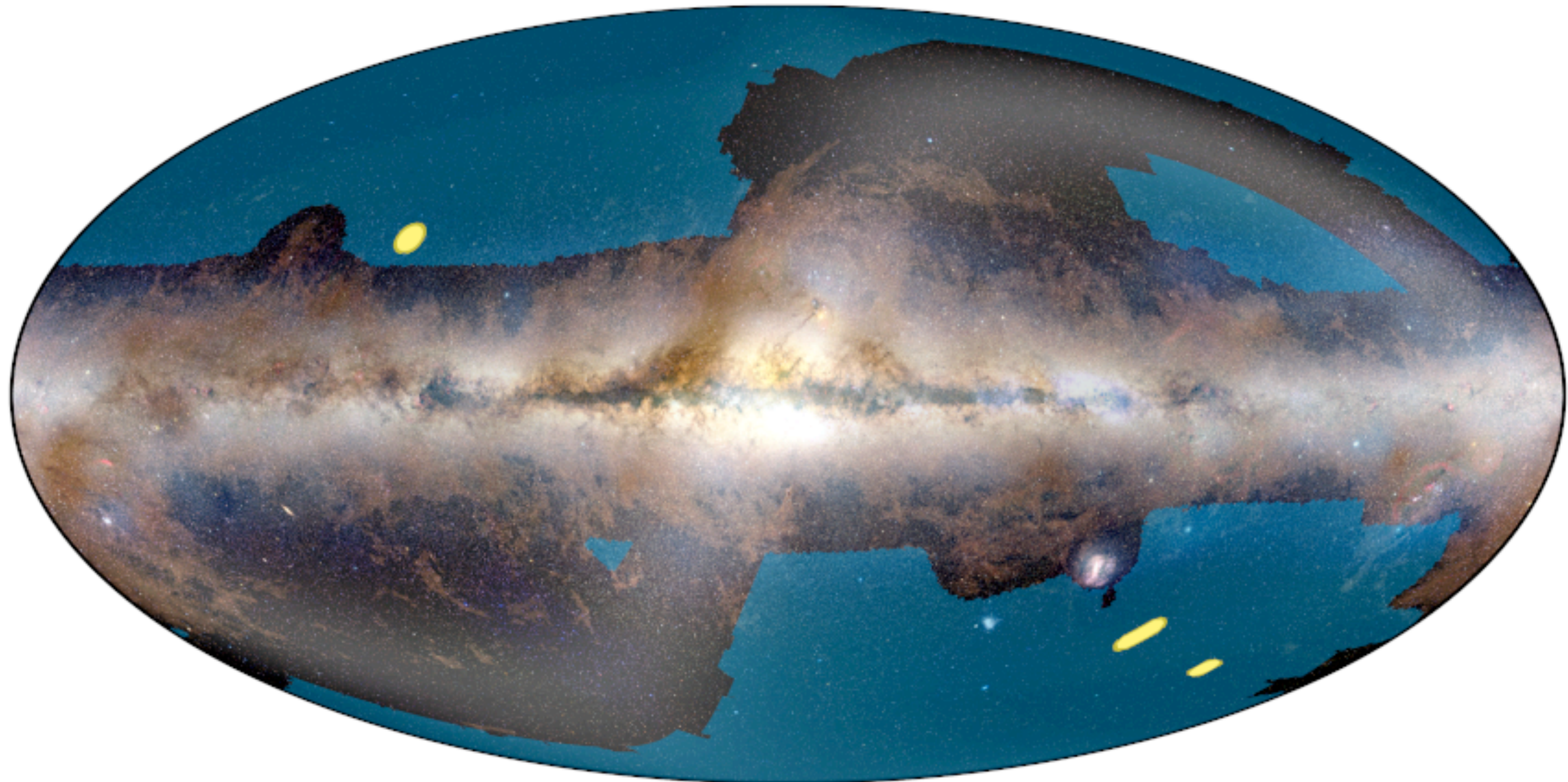
The Euclid Wide Survey and the Euclid Deep Survey
▬ Euclid Wide Survey : 13,345 deg² in 6 years, avoiding the galactic plane (stars, dust) and the ecliptic plane (zodiacal light)
▬ Euclid Deep Fields : North=20 deg² (top left), Fornax=10 deg² (bottom right), South=23 deg² [+ extended coverage]

Deep Fields	Area deg²
EDFN	20
EDFF	10
EDFS	23

Motivation

- To identify late L- and T-type dwarfs directly through the H_2O and CH_4 absorption bands.

- To confirm the UCD nature of candidates from the photometric catalogs prepared by our group.

- Test the spectral analysis of confirmed UCDs from *Euclid* data: spectral classifications, effective temperatures, H_2O, CH_4 and NH_3 spectral indices, K_I measurements.

Euclid Q1 spectra

Slitless spectroscopy in the 53 deg² total area

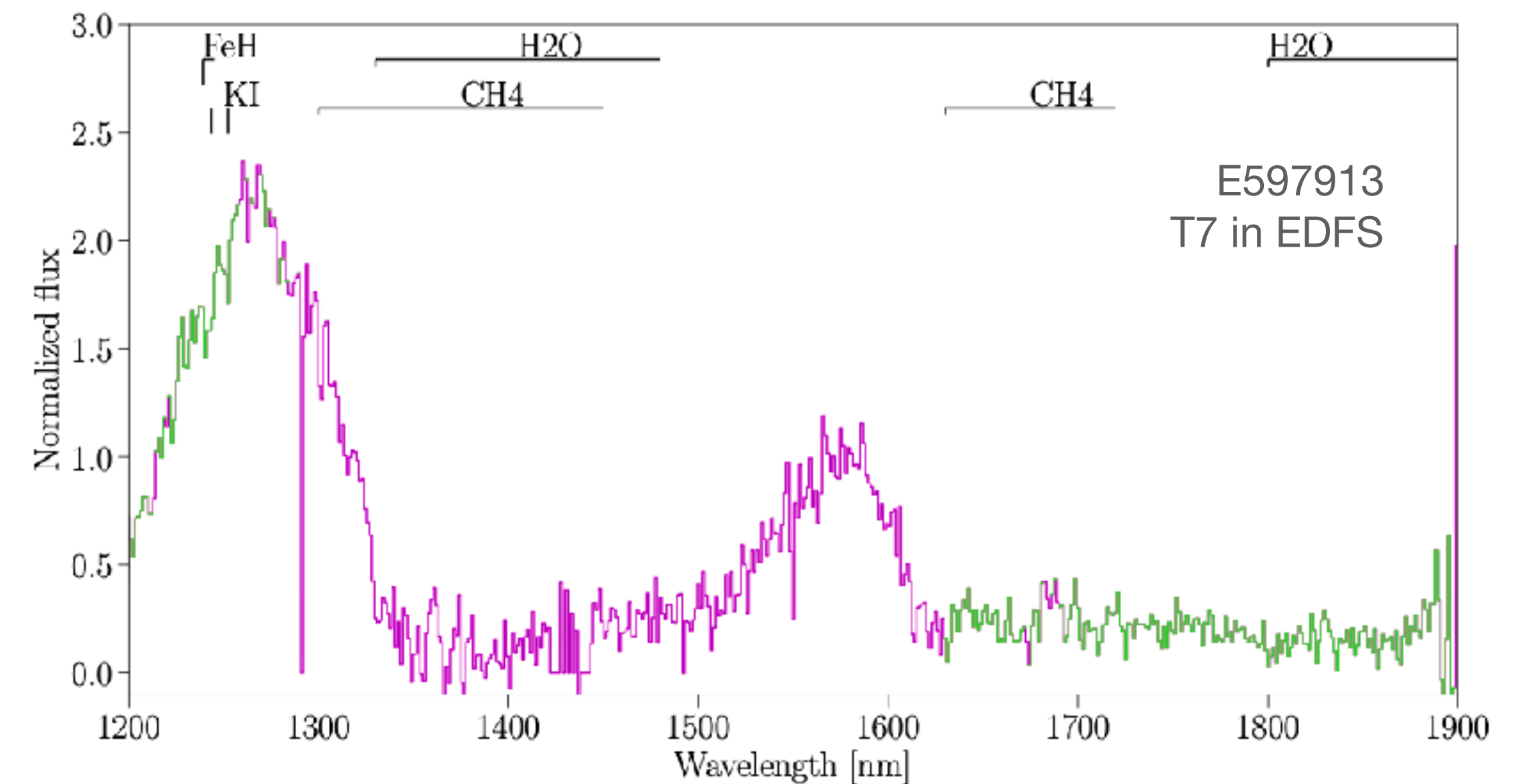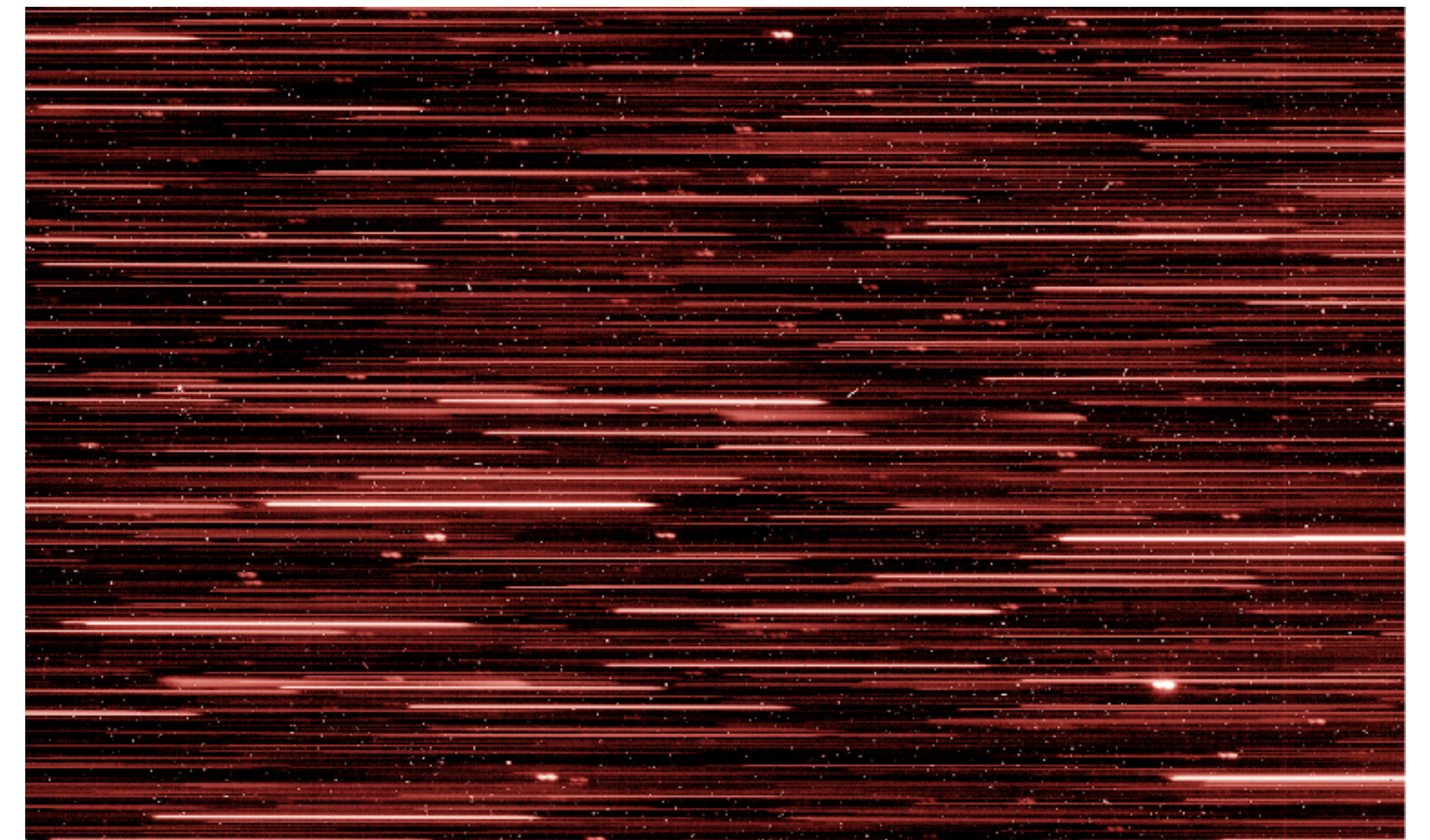4.3 million 1D spectra extracted
    Each from the coadd of spectra in 1 to 4 positions
    2 flags: `NDITH` and `QUALITY`

But: persistence, cross contamination, ghosts, cosmic rays, bad pixels…

→ plots in 2 colors:
green for `NDITH` >2 and magenta for `QUALITY`<0.7

Crossmatch with Zhang J-Y et al. 2024 compilation

510 candidates match (99%)

224 confirmed as UCDs -> **60 benchmarks**

   Spectra of objects with magnitudes $14 \leq J \leq 19$
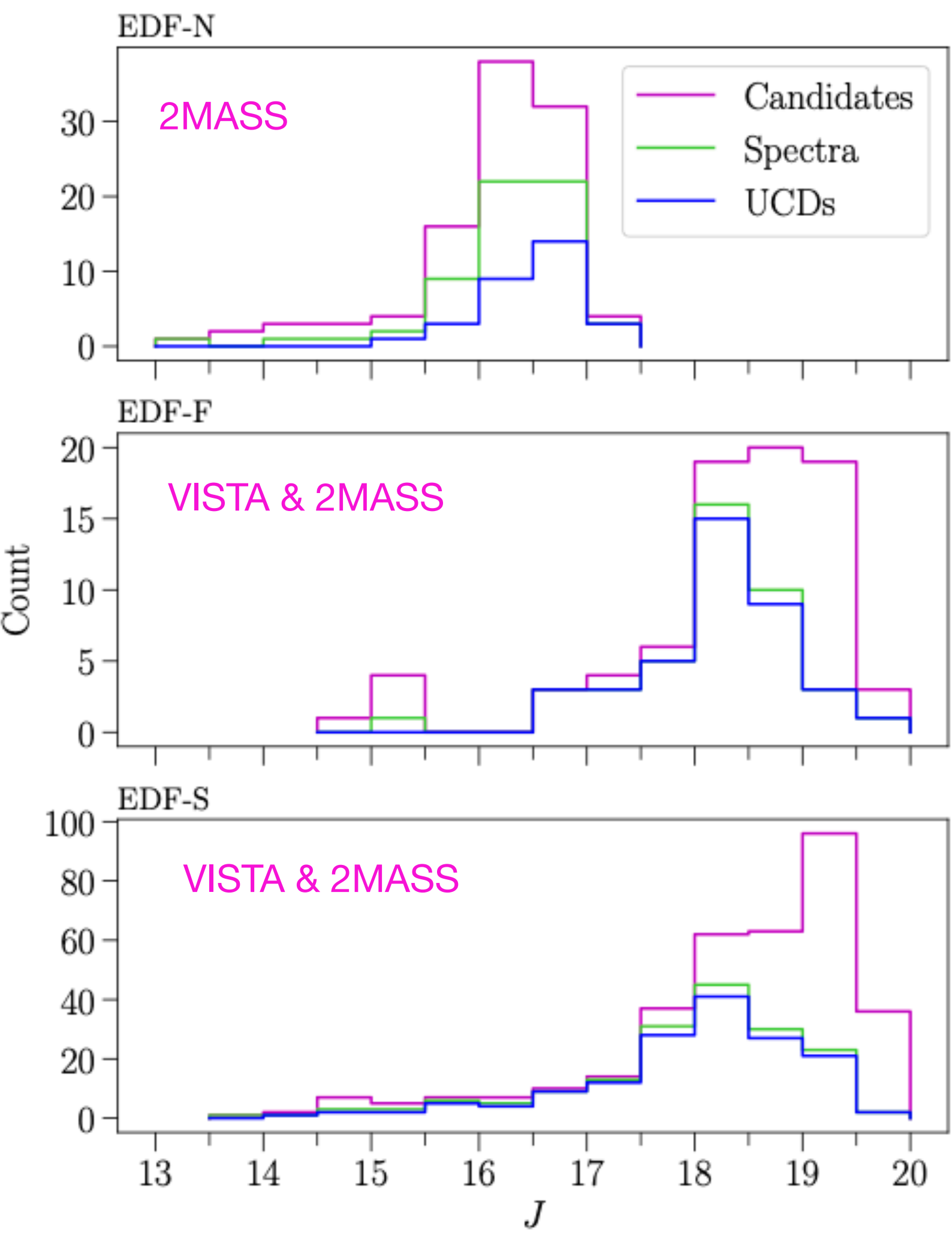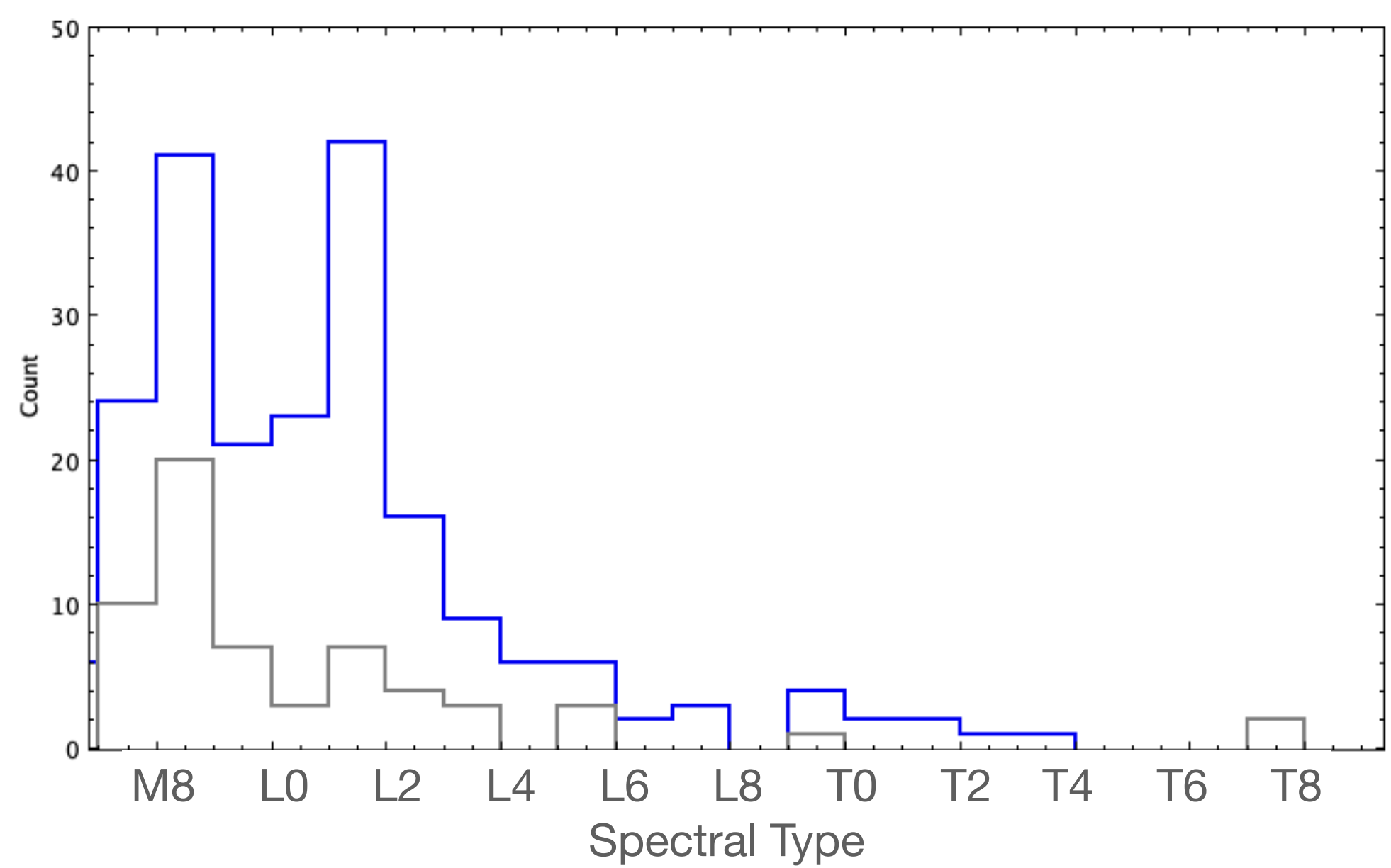
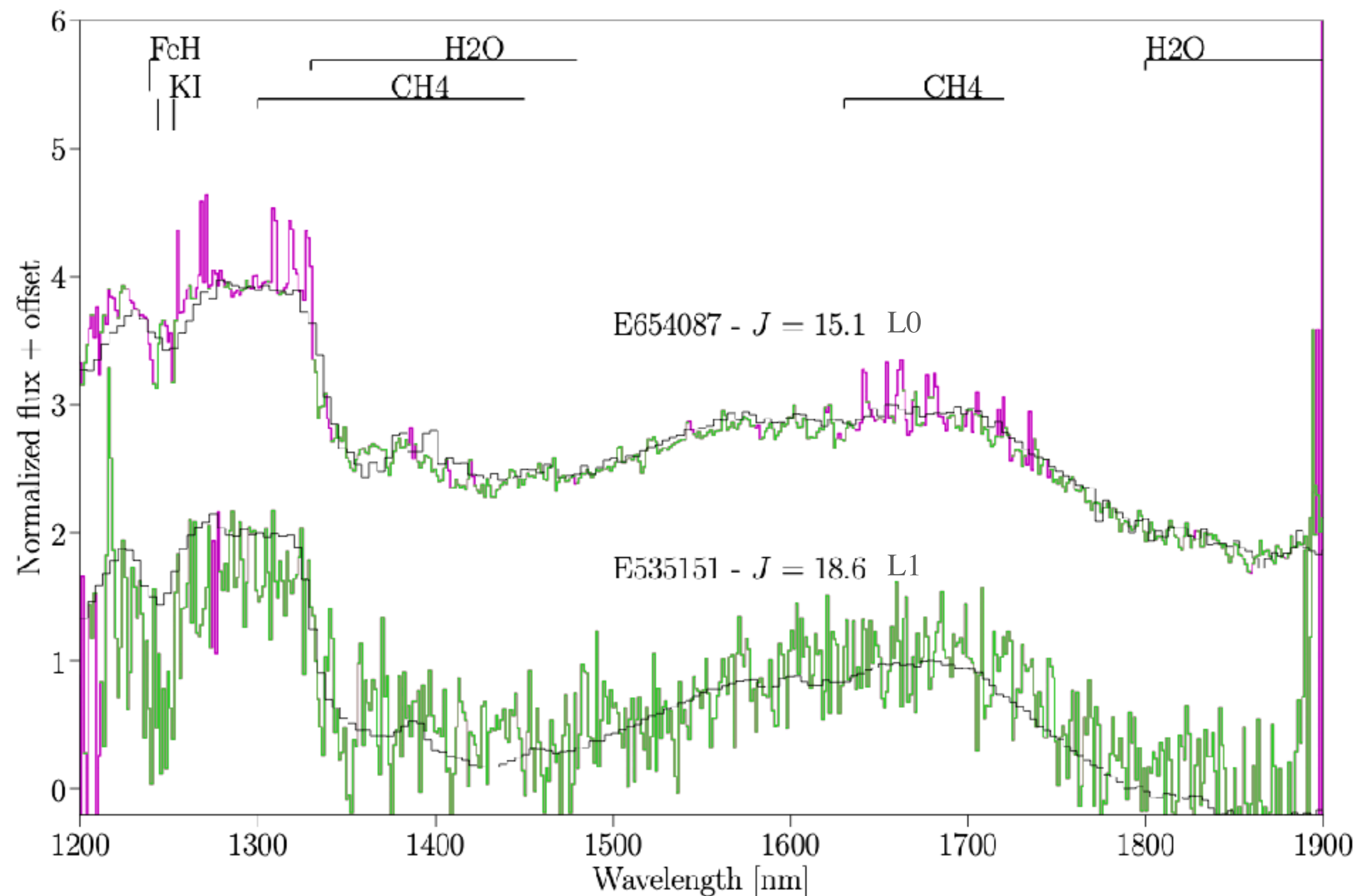   Lack of some late Ls and Ts

Crossmatch with Zhang J-Y et al. 2024 compilation

510 candidates match (99%)

224 confirmed as UCDs -> **60 benchmarks**

Spectra of objects with magnitudes $14 \leq J \leq 19$

Lack of some late Ls and Ts

Standard templates from Burgasser et al. 2006

Hist Jerry types

BD30 meeting, 1-5 September, 2025.   carlos.dominguez@iac.es

Spectral type classification

Challenge:
- Small wavelength range (1.2-1.9µm)
- Low resolution (R~450)
- Contamination
- Space data vs. ground based templates

Done by comparison to standard templates (compiled in SPLAT; Burgasser et al. 2017).
- Best by χ^2 fit or residual minimisation.
- Avoid telluric regions and artefacts filtering by `QUALITY` and `NDITH`.
- Uncertainty of ± 1 subtype. If larger, a colon is added. A "p" indicates a peculiar spectrum (different subtypes over the wavelength range).
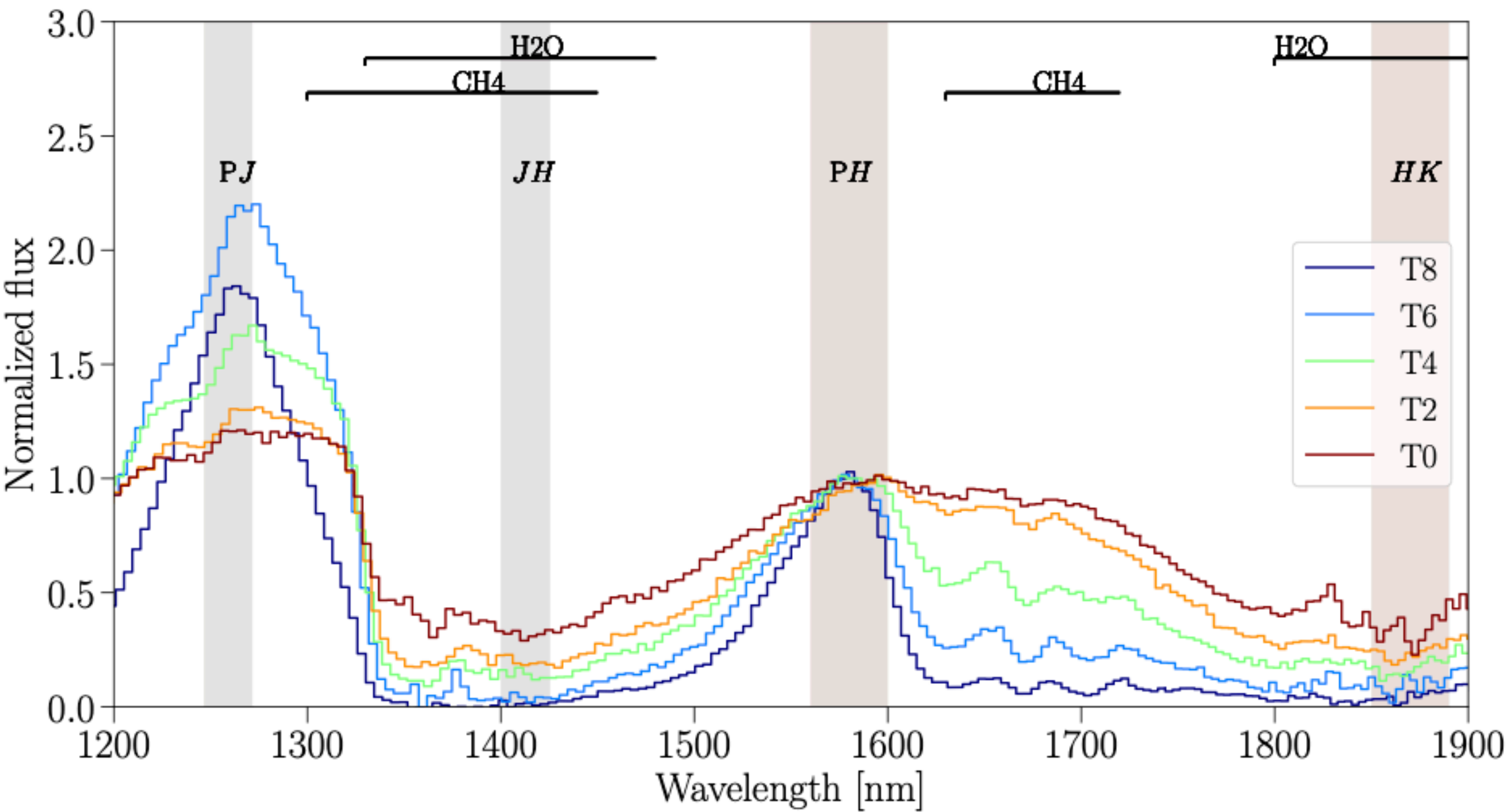
Spectroscopic search

A search for late-Ls and Ts
in Q1 spectra database.

First results:

16 objects found, from which 11 are new:

		>0.6	>0.5	>0.35
Alias	SpT	PJ-JH	PH-JH	PH-HK
E528241	T5	0.9	0.7	0.7
E265716	T4p	0.9	0.9	0.9
E523574	T4	0.9	0.8	0.8
E273062	T3p	0.9	0.8	0.6
E536416	T2:	0.8	0.8	0.8
E273015	T1:	0.8	0.8	0.8
E644720	T1:	0.7	0.6	0.6
E511520	T1:	0.8	0.8	0.9
E267056	L9:	0.7	0.7	0.5
E517518	L9	0.6	0.6	0.5
E271934	L9p	0.7	0.6	0.4

Spectral index search

Standard templates from Burgasser et al. 2006; Looper et al. 2007

Spectroscopic search

A search for late-Ls and Ts
in Q1 spectra database.

First results:

16 objects found, from which 11 are new:

Alias (Ref.)	SpT	I_E (mag)	Y_E (mag)	J_E (mag)	H_E (mag)
E528241	T5	27.6	23.6	23.2	23.6
E265716	T4p	24.4	20.5	20.1	19.8
E523574	T4	26.7	21.4	20.9	21.1
E273062	T3p	24.0	20.9	20.6	20.5
E536416	T2:	25.4	21.5	21.2	20.9
E273015	T1:	23.2	20.2	19.8	19.7
E644720	T1:	22.9	19.5	19.2	18.9
E511520	T1:	22.9	19.6	19.1	18.7
E267056	L9:	24.0	20.7	20.0	19.4
E517518	L9	23.3	19.9	19.3	18.8
E271934	L9p	23.8	20.4	19.9	19.5

$J_E \sim J + 1$

E271934 (L9p) is a **Binary**
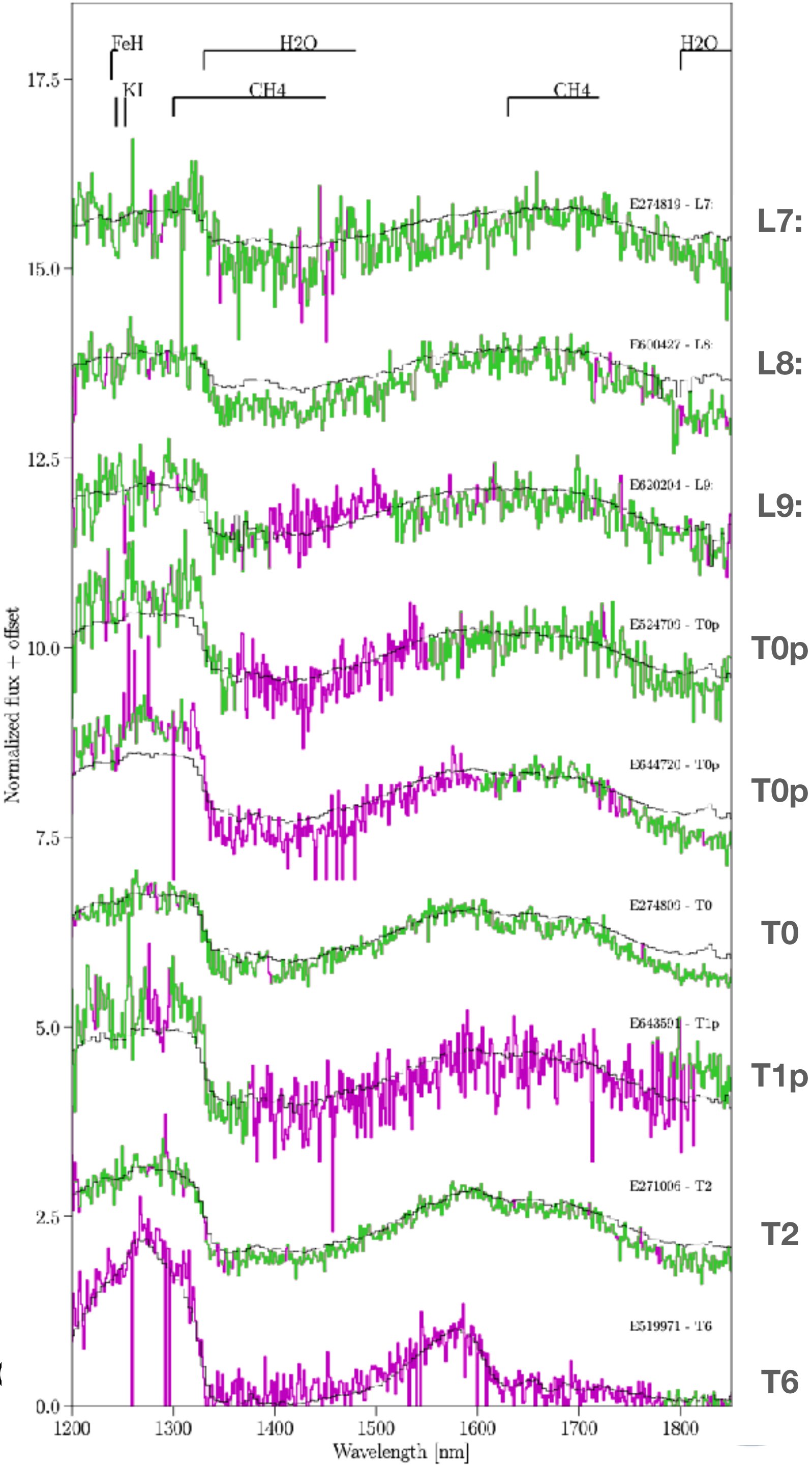Talk by Sara Muñoz Torres
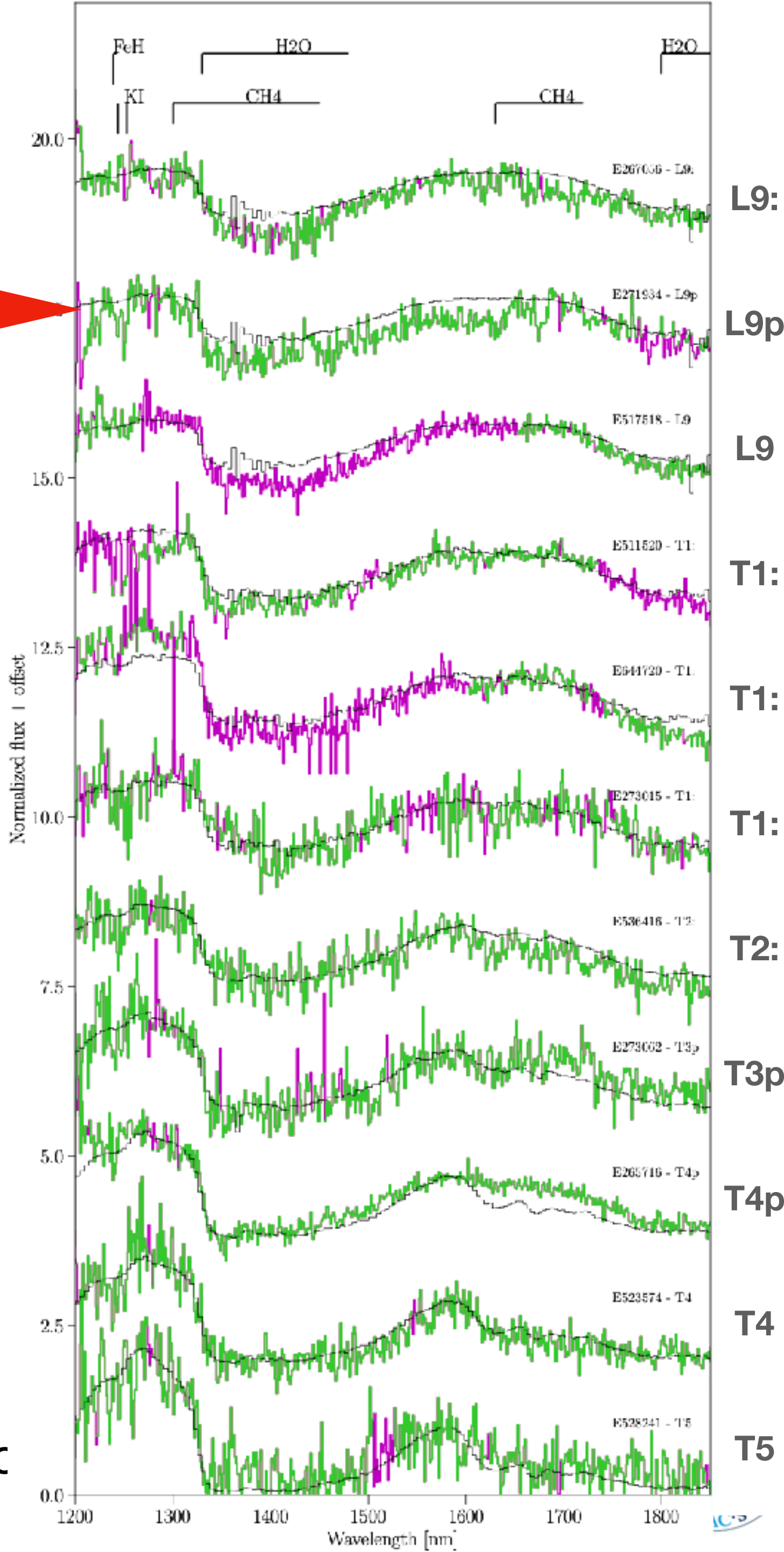
Žerjal's catalog

In this paper we classified as UCDs 111 photometric candidates, starting by the later SpT.

We later classified 272 more candidates (Žerjal et al. submitted)

Talk by Marusa Žerial

See also the talk by Anjana Mohadasan
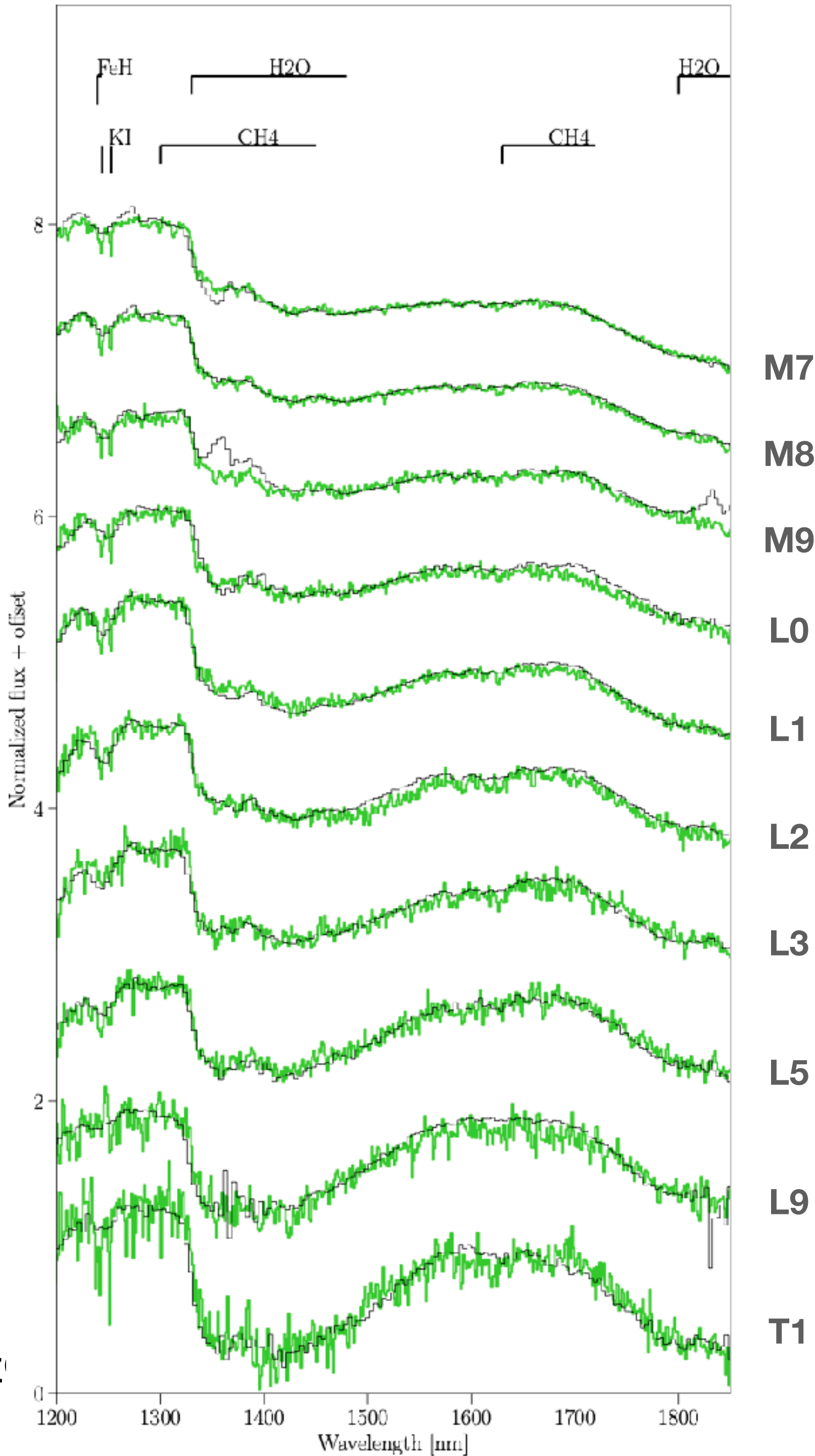
Preliminary *Euclid* UCD templates

Euclid spectra is free from telluric absorption bands

Alias	Number of spectra
EUC_T1	3
EUC_L9	4
EUC_L5	3
EUC_L3	6
EUC_L2	8
EUC_L1	14
EUC_L0	11
EUC_M9	8
EUC_M8	29
EUC_M7	13

Ongoing work
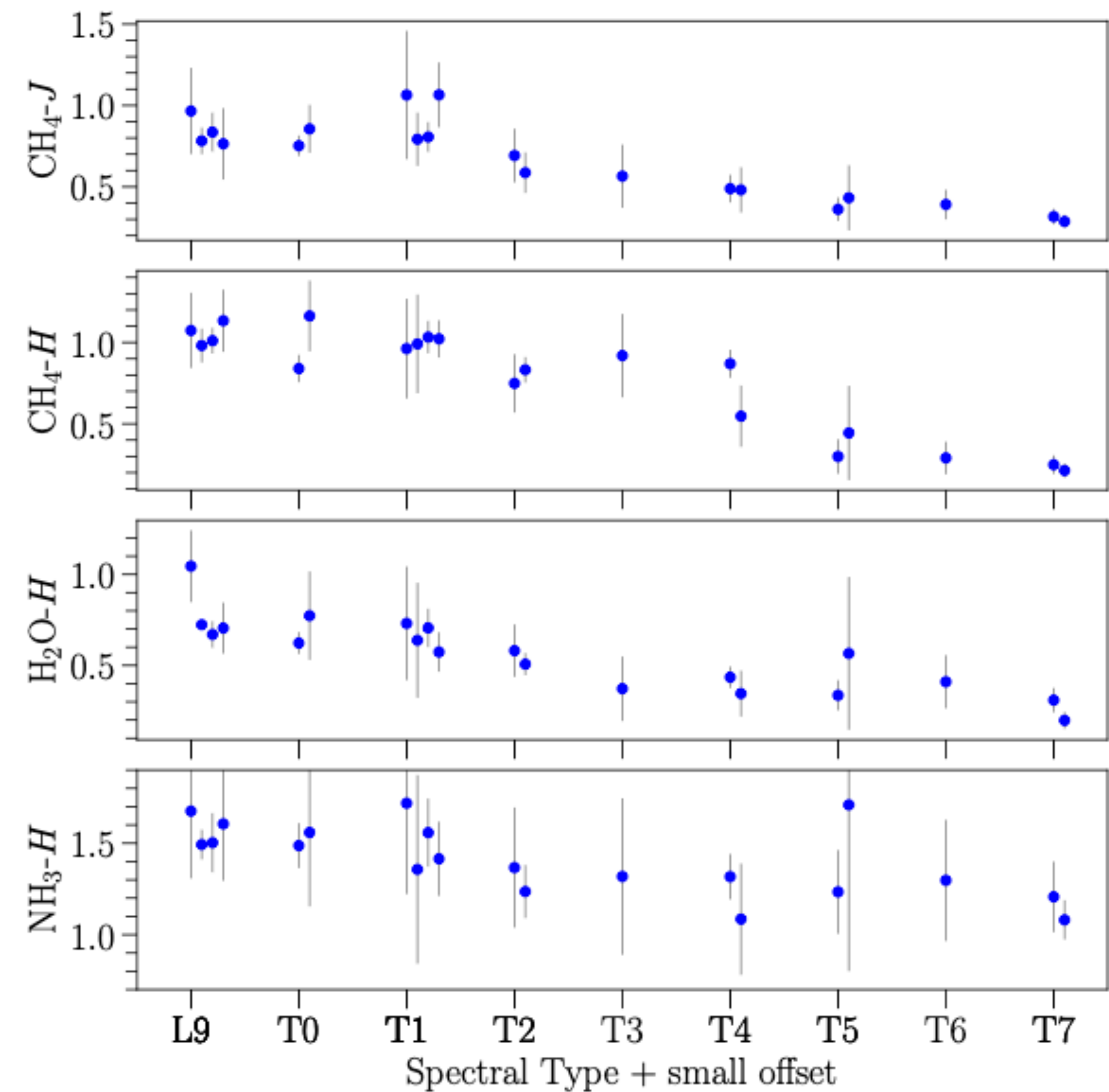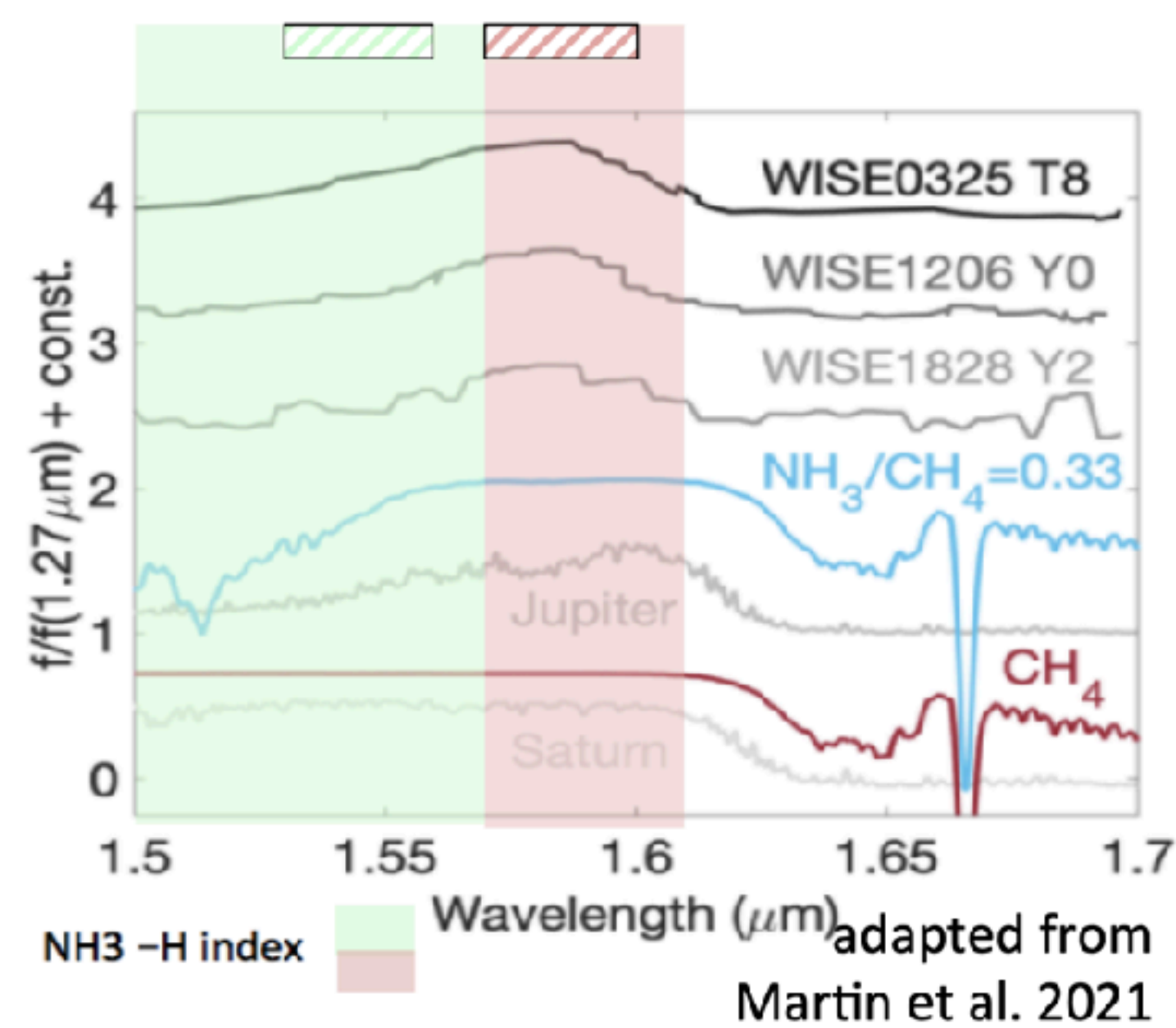
New version from 600 UCDs: all spectral types

Future data releases → larger number of spectra

NIR spectral indices

CH₄-*J* , **CH₄-*H*** , and **H₂O-*H*** defined by Burgasser et al. (2006) → Ts

NH₃-*H* redefined by Martín et al. (2021) → late Ts and Ys

NH3 –H index   adapted from Martin et al. 2021
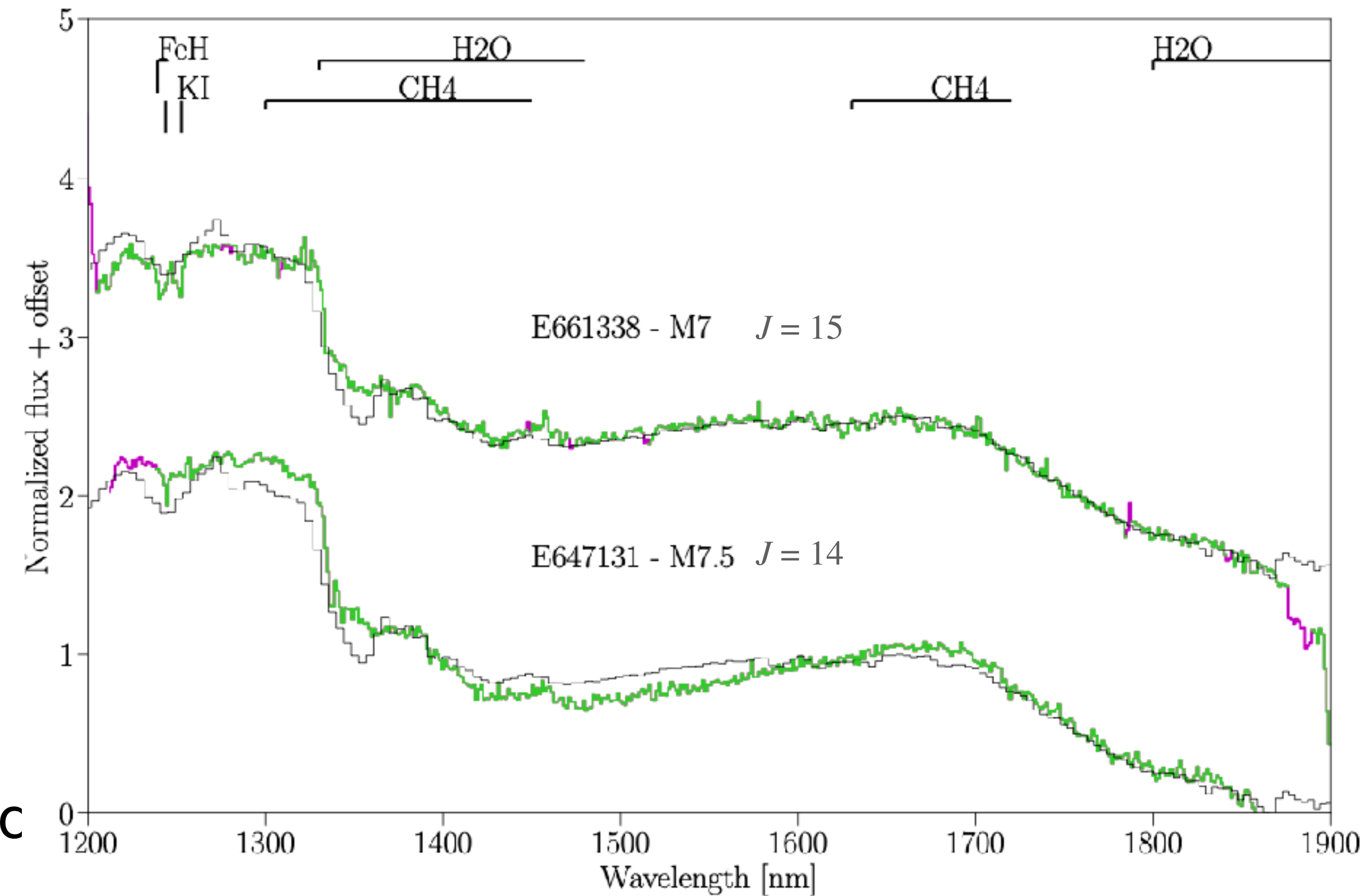
KI absorption doublet
12436 / 12526 Å

Comparison of old and young objects

E661338
from Q1 data of EDF-S

E647131
from ERO-02 fields (Martín et al. 2025), extracted
by Dominguez-Tagle et al. (in preparation)

Standard templates from Burgasser et al. 2008

KᵢI absorption doublet
12436 / 12526 Å

Pseudo equivalent width (pEW)

- Our pEW values (blue dots) with NISP (R~450) are higher, compared with those of Martin et al. (2017) (gray +) with NIRSPEC (R~2000).

- Following Malkan et al. (2002) procedure: we measured the pEWs of Martin et al.'s spectra degraded to R~450. → higher values relative to the original ones. We computed a second-order polynomial fit to the differences.

- Applied this relation to our NISP measurements (Green squares)
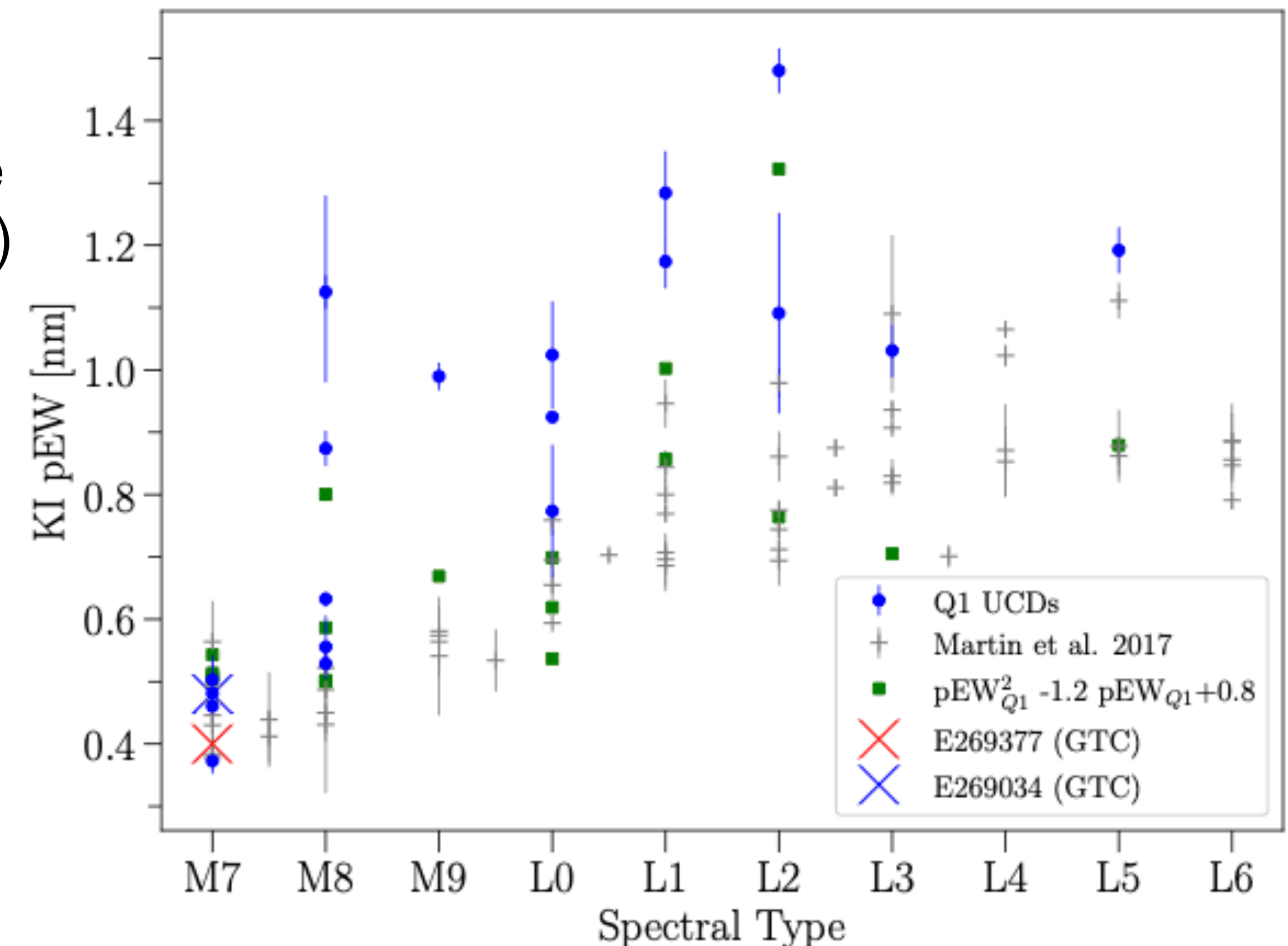
Estimation of effective temperatures

Deep transfer learning approach by Mas-Buitrago et al. (2024) trained with a synthetic grid of `Sonora Elf Owl` models (Mukherjee et al. 2024)

Table 3. Preliminary templates.

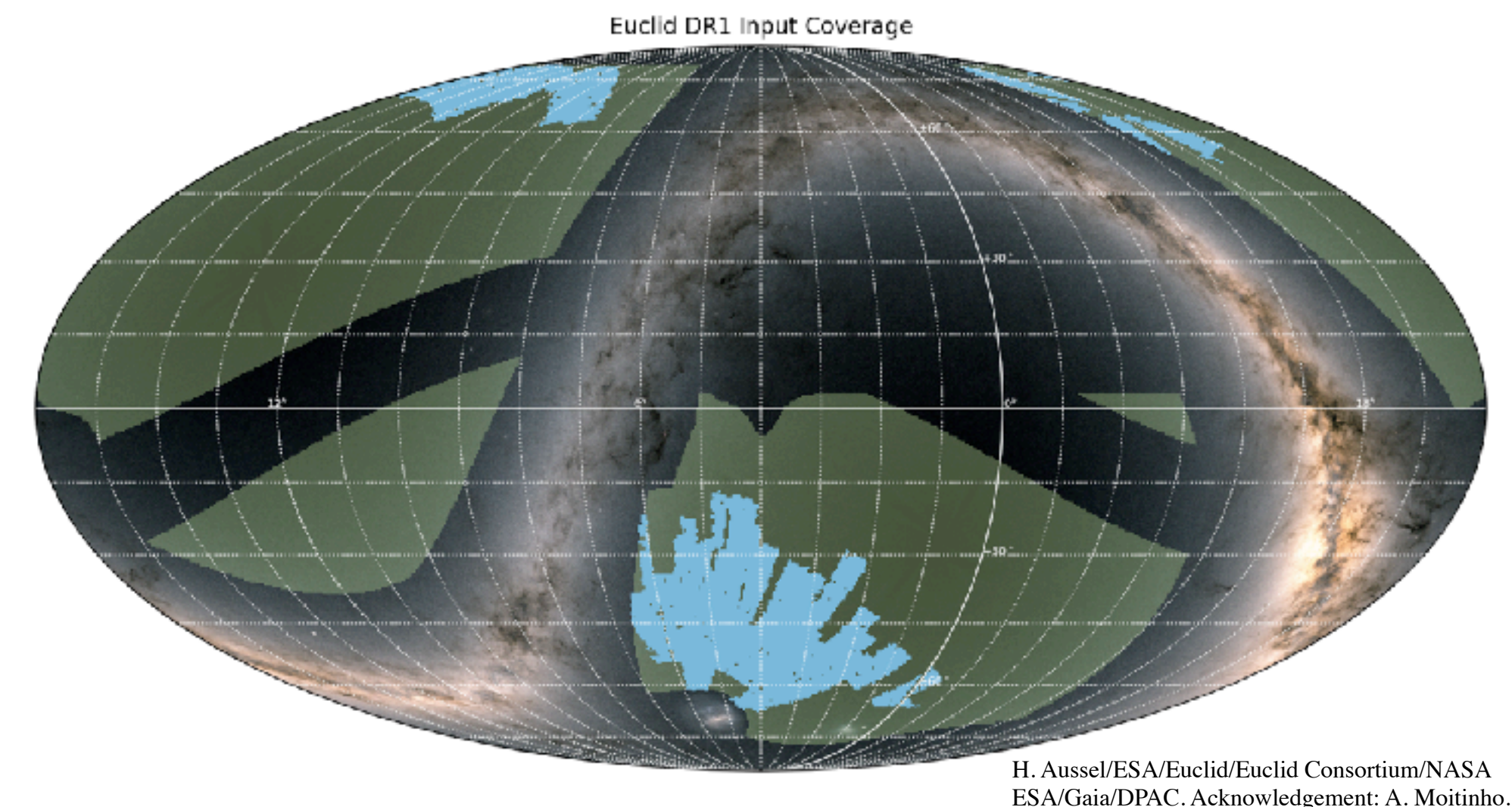| Alias	Number of spectra	$T_{\rm eff}$ (K)
EUC_T1	3	1536^{+93}_{-59}
EUC_L9	4	1453^{+61}_{-129}
EUC_L5	3	1504^{+71}_{-139}
EUC_L3	6	1705^{+54}_{-118}
EUC_L2	8	1799^{+61}_{-51}
EUC_L1	14	2031^{+140}_{-32}
EUC_L0	11	2264^{+108}_{-37}
EUC_M9	8	2264^{+123}_{-51}
EUC_M8	29	2376^{+96}_{-35}
EUC_M7	13	. . .
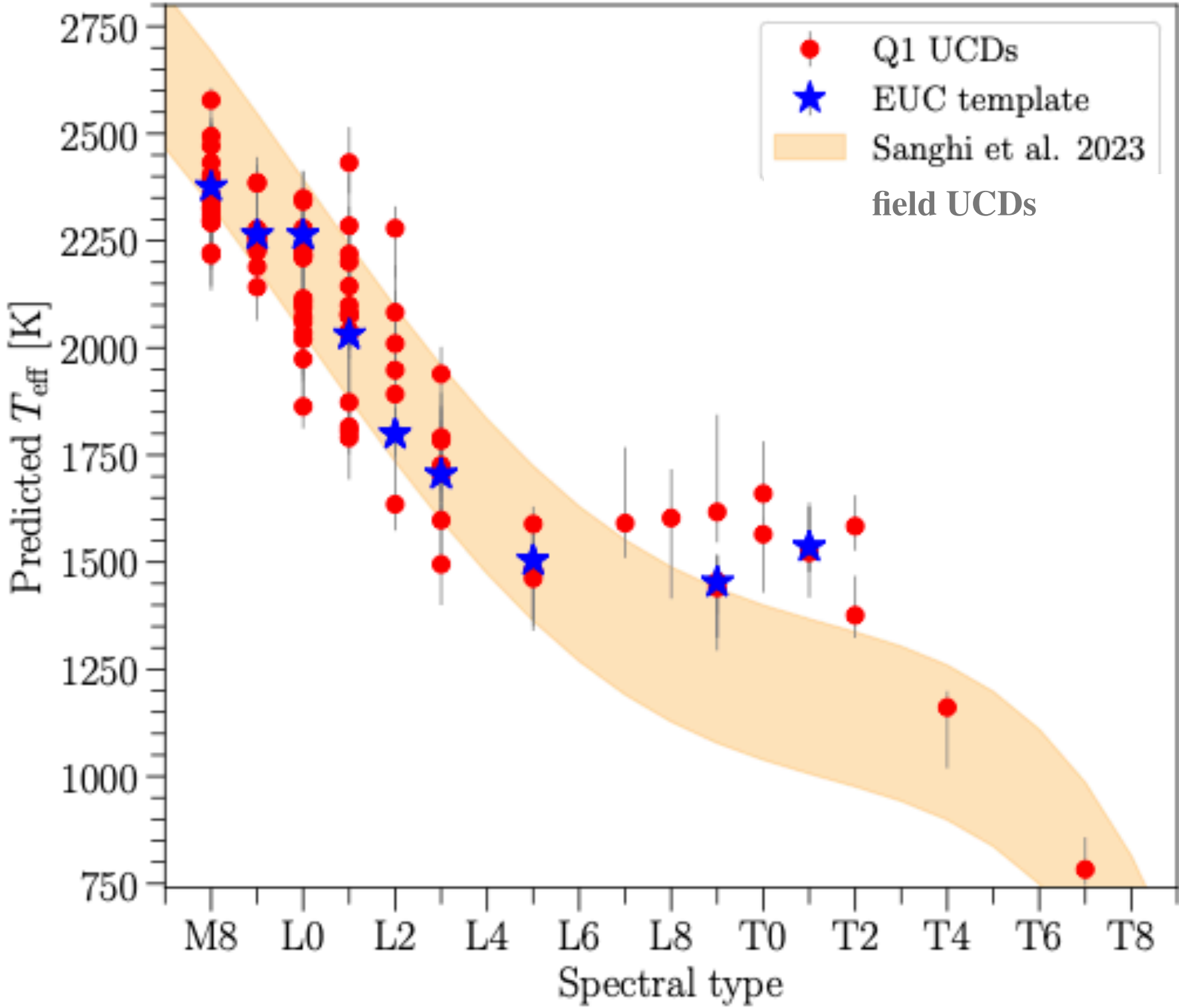
See also the talk by Nafise Sedighi

Ongoing work

- Spectra own extraction code: **Dominguez-Tagle** et al., in preparation.
- Detail analysis of peculiar objects, follow-up observations
- ERO-02 and LDN1641

Future work

- **DR1**
  - Deeper, cleaner spectra for the Deep Fields
  - NISP blue grism (9260 -13660 Å)
  - 30 times larger area for the Wide Survey

Euclid DR1 Input Coverage

H. Aussel/ESA/Euclid/Euclid Consortium/NASA
ESA/Gaia/DPAC. Acknowledgement: A. Moitinho.

Conclusions

- We identified **8 Ts and 3 late Ls** directly through the H_2O and CH_4 absorption bands.

- We classified a large number of UCDs from the candidates in Zhang and Žerjal catalogs: **more than 160 UCDs (this paper), …** *currently over 600.*

- We present **the first spectral analysis** of confirmed **UCDs from *Euclid*** data: SpT, Teff, H_2O, CH_4 and NH_3 spectral indices, K_I measurements.

- Paper **accepted** for publication in ApJ: future DOI: 10.3847/1538-4357/adf72d

- This is just a first step, more results coming soon as we continue working on Q1 data, and the new releases provided by ESA.

Talks by Marusa Žerial, Sara Muñoz Torres, Nafise Sedighi, Stella Tsilia and Anjana Mohadasan

Thank you