

## Introduction

Next-generation facilities such as the JWST will uncover the first substantial populations of young (<5 Myr) free-floating planetary-mass objects (PMOs) in nearby star-forming regions (SFRs) and clusters. These objects are expected to have spectral types (SpTs) from early-L to late-T, a regime that has been poorly explored so far.

Nearby young moving groups (NYMGs, ages 15-200 Myr) are useful laboratories as they enable NIR spectroscopy of objects in the required SpT regime. Although some of the objects studied at these ages may not be in the planetary-mass range, their effective temperature and consequently many spectral properties will be shared with younger, less massive objects. Our dataset includes objects from nearby SFRs, clusters and NYMGs.

- Construct a spectral library of late-type young objects
- Prepare quick and efficient methods for spectral typing and youth analysis of LT dwarfs

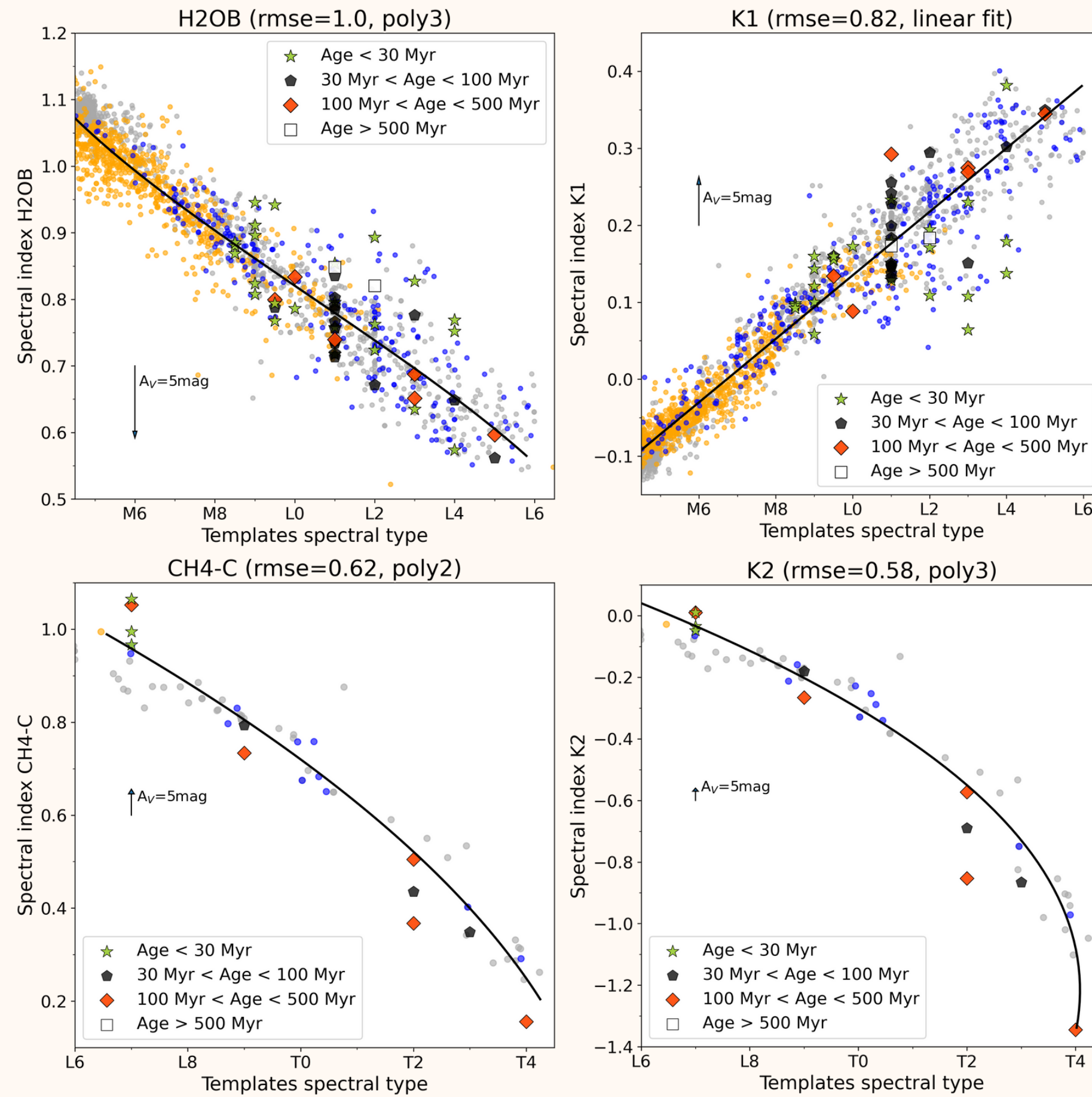
## NIR Spectral Indices

We inspected several indices from the literature, using the derived SpT and extinction from the direct comparisons with spectral templates, and selected:

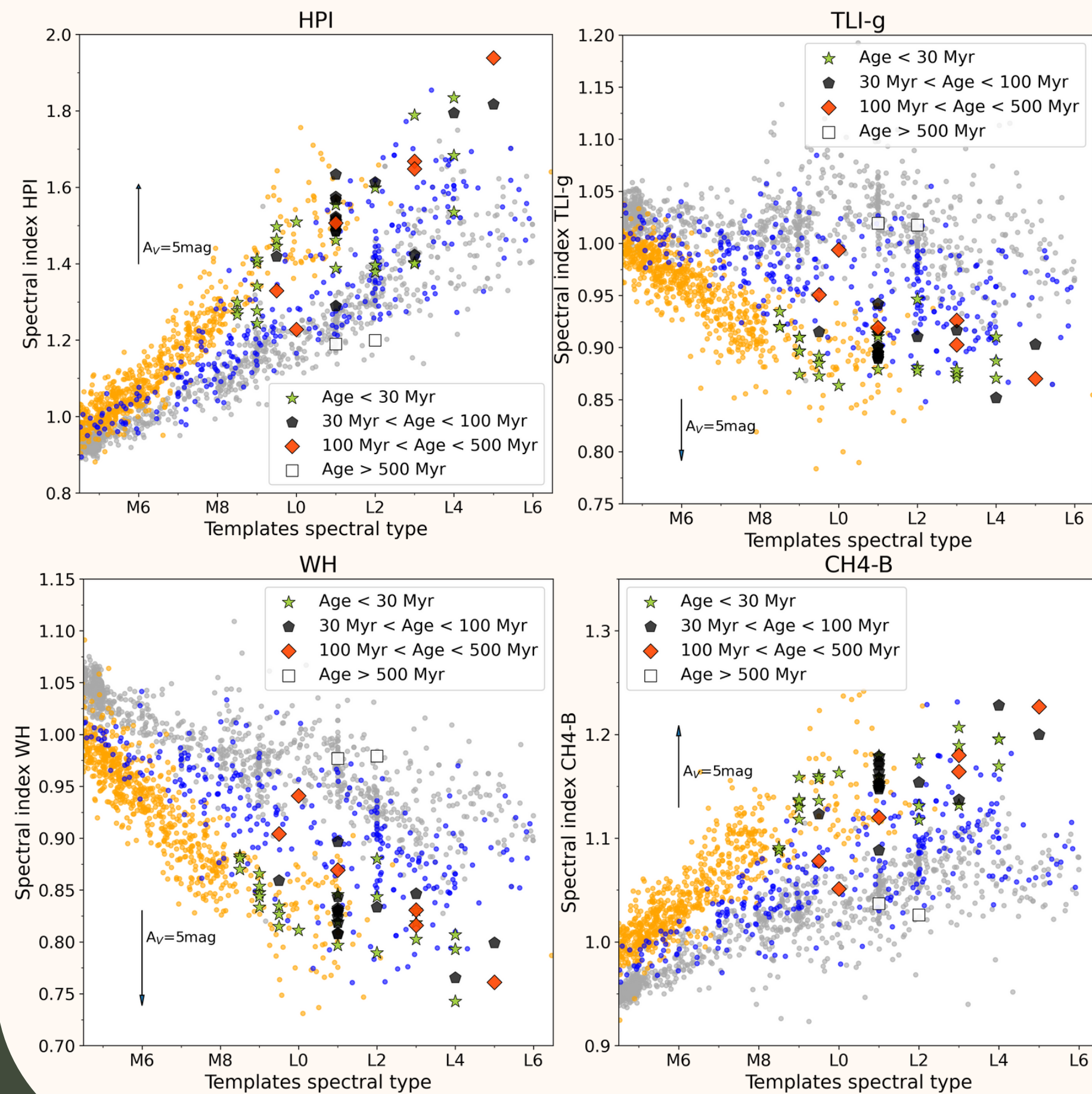
- Spectral type indices that demonstrate a good correlation with SpT and are gravity-insensitive (Figure 2)
- Gravity-sensitive spectral indices that separate well young objects from old, field objects (Figure 3)

## Spectral Type Indices

**Figure 2.** Spectral type indices: H2OB (McLean et al. 2003), K1 and K2 (Tokunaga et al. 1999), and CH4-C (Burgasser et al. 2002) versus the derived SpT from the direct comparison to spectral templates. The orange, blue, and grey dots are young, mid-gravity, and field objects from Almendros-Abad et al. (2022), respectively. The remaining symbols correspond to our dataset divided into different age groups (see legend). The solid black lines are the derived calibration curves and the black arrows represent the effect of extinction of 5 magnitudes.



## Gravity-sensitive Spectral Indices



The TLI-g index was defined by Almendros-Abad et al. (2022) using a sample of cool dwarfs with SpTs in the range M0-L3 (see Poster #144). From Figure 3, one can see that this index also performs well in the range L3-L6.

**Figure 3.** Gravity-sensitive indices: HPI (Scholz et al. 2012), TLI-g (Almendros-Abad et al. 2022), WH (Weights et al. 2009), and CH4-B (Burgasser et al. 2002) versus the derived SpT. The symbols are identical to those in Figure 2.

### References:

Almendros-Abad et al. (2022), A&A 657, A129; Burgasser et al. (2002), ApJ, 564, 421; Burgasser et al. (2006), ApJ, 637, 1067; Cushing et al. (2005), ApJ, 623, 1115; Kirkpatrick et al. (2010), ApJS, 190, 100; Luhman et al. (2017), ApJ, 153, 46; McLean et al. (2003), ApJ, 596, 561; Scholz et al. (2012), ApJ, 744, 6; Tokunaga et al. (1999), AJ, 117, 1010; Weights et al. (2009), MNRAS, 392, 817

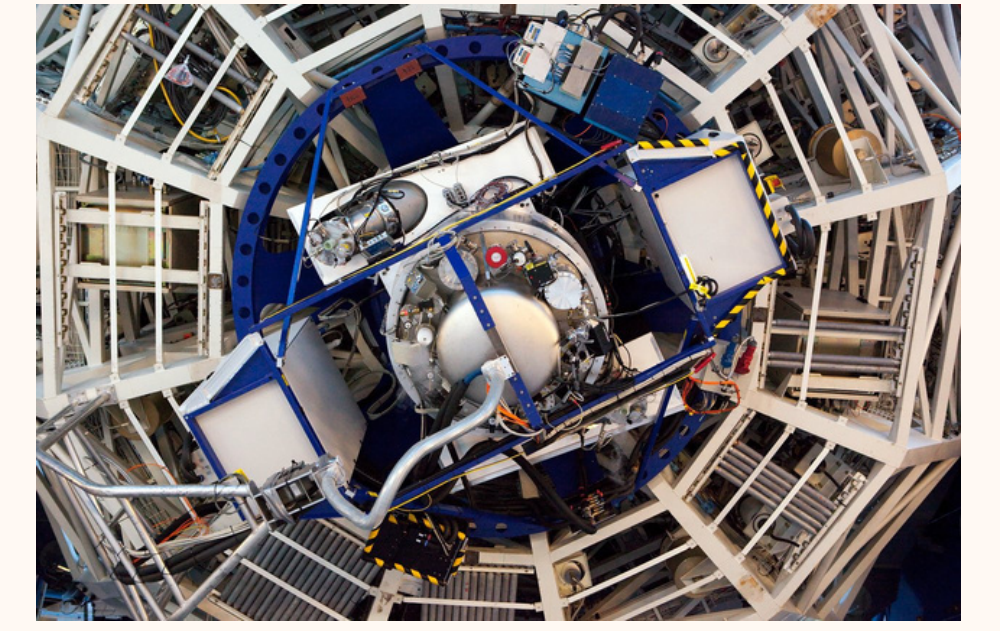
## Dataset

### Characteristics

- 60 publicly available NIR spectra from X-Shooter/VLT;
- Young brown dwarfs and PMOs in NYMGs and star-forming regions;
- Spectral types L0 - T4

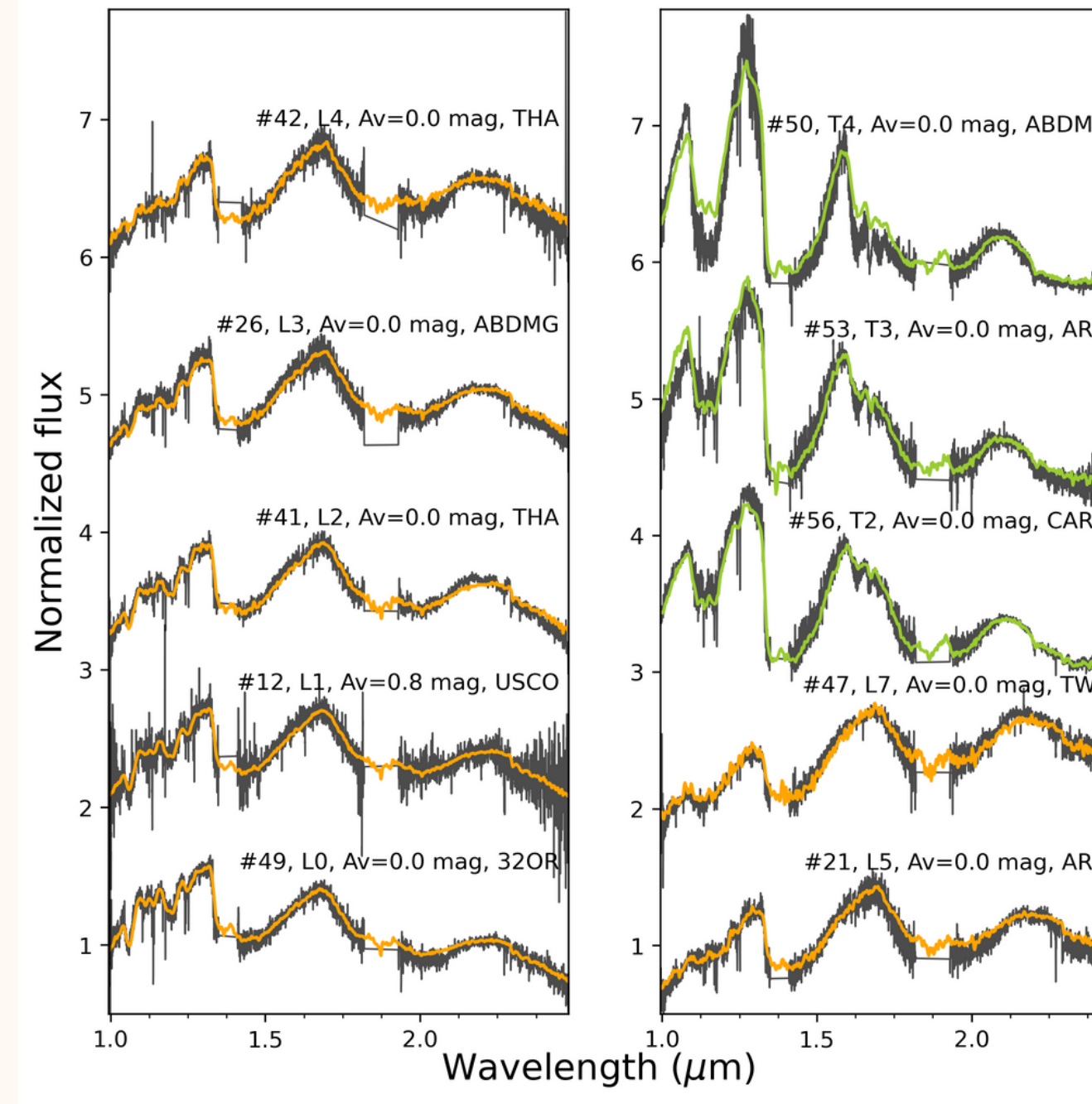
### X-Shooter

- NIR arm
  - Resolution ~ 4300 - 11 600
  - Coverage: 1.0 - 2.5  $\mu\text{m}$



Credits: ESO

## Comparison with Spectral Templates



One method for SpT derivation is by direct comparison with spectral templates (spectra of objects with well-defined SpT).

Luhman et al. (2017)  
M0 - L7 (\*)

Kirkpatrick et al. (2010)  
M0 - L9  
Burgasser et al. (2006)  
T0 - T8

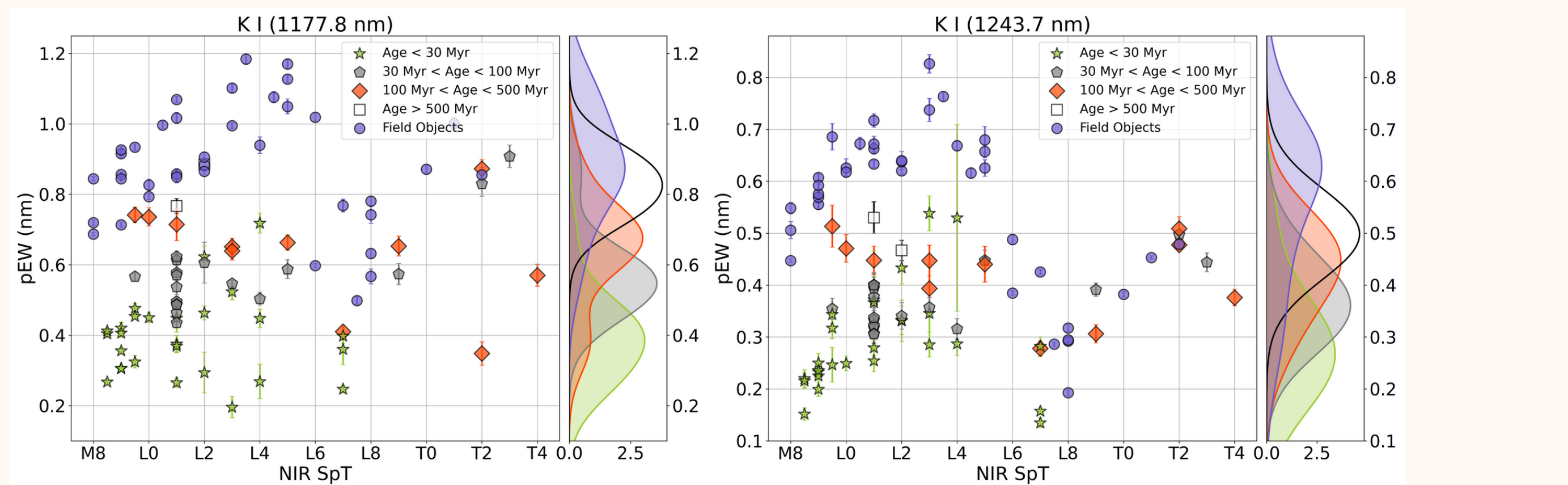
**Figure 1.** Sequence of ten spectra from our dataset (black), along with the best fitted spectral templates (young templates shown in orange and field templates in green). The corresponding ID, the derived SpT, and extinction as well as the region to which each member belong, are shown next to each spectrum.

Three fitted parameters:

- Spectral type
- Extinction: only considered for USCO, assumed  $A_v=0$  mag for NYMGs and older clusters
- Normalization wavelength

(\*) Young templates L1, L3 and L5 were obtained by linear interpolation of the original sequence.

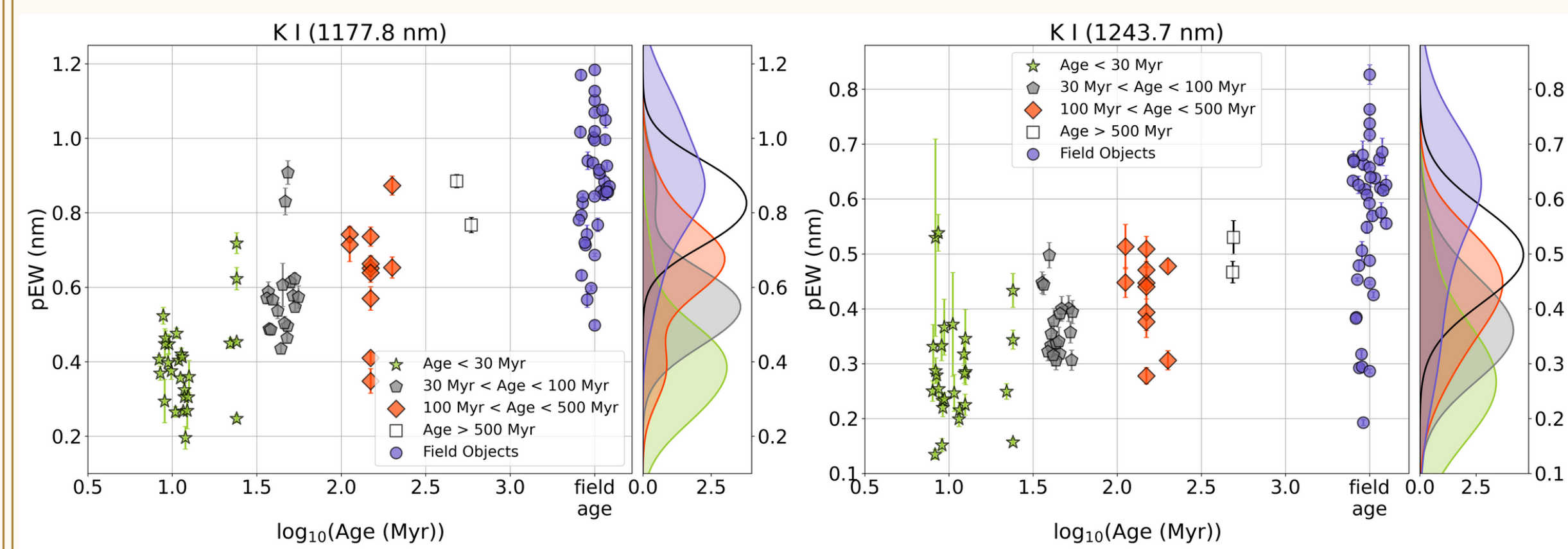
## Pseudo-equivalent Widths of Alkali Lines



**Figure 4.** Pseudo-equivalent widths of the 1177.8 nm and 1243.7 nm K I lines for our dataset (color-coded according to different age groups) and field objects from McLean et al. (2003) and Cushing et al. (2005).

The alkali lines (e.g. K I lines in the J band) are gravity-sensitive, meaning that the pseudo-equivalent widths (pEWs) of these lines correlate with surface gravity. Hence, pEWs might be useful age indicators.

We observe that younger objects (lower surface gravity) present weaker alkali lines (Figures 4 and 5).



**Figure 5.** pEWs of alkali lines as a function of age (logarithmic scale) for our dataset (color-coded according to different age groups) and field objects from McLean et al. (2003) and Cushing et al. (2005). A small random offset was added on the x-axis to objects of the same age group for clarity.