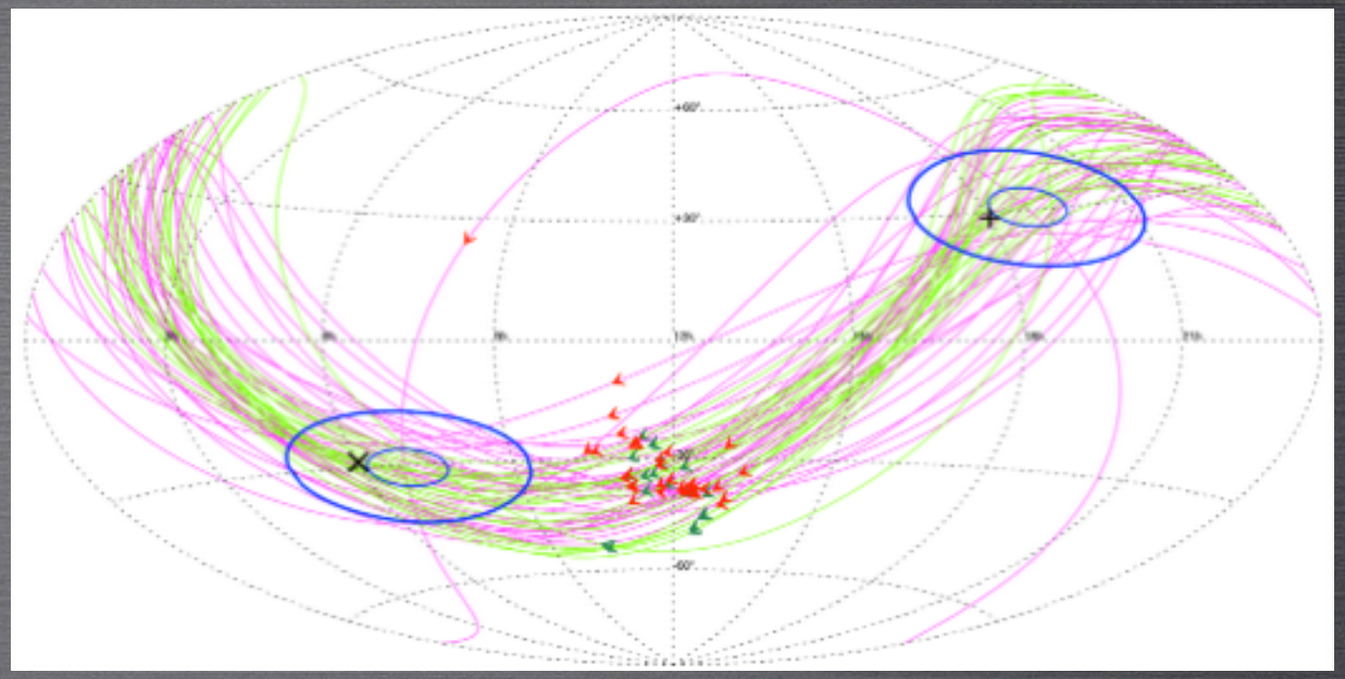
Credit ; Journey to the Stars, AMNH



The BASS Survey for Brown Dwarfs in Young Moving Groups

Brown Dwarf to Exoplanet Connection Conference
Delaware, 2014

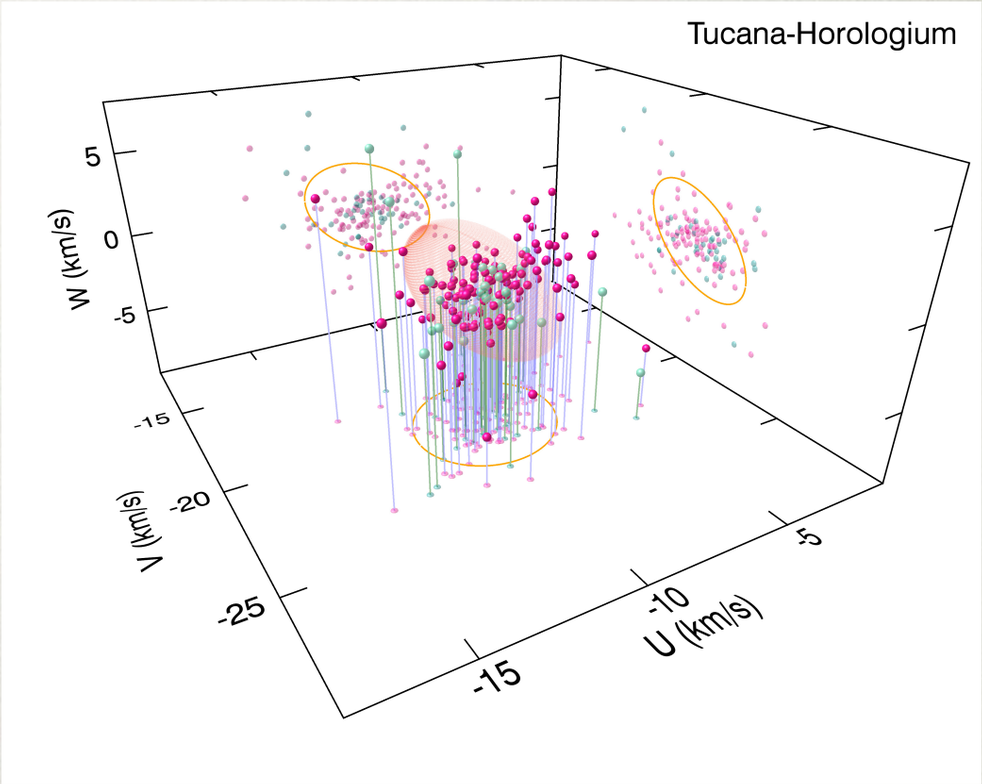
Jonathan Gagné, David Lafrenière, René Doyon, Jackie Faherty, Lison Malo, Étienne Artigau, Kelle Cruz, Adam Burgasser, Marie-Ève Naud, Loïc Albert

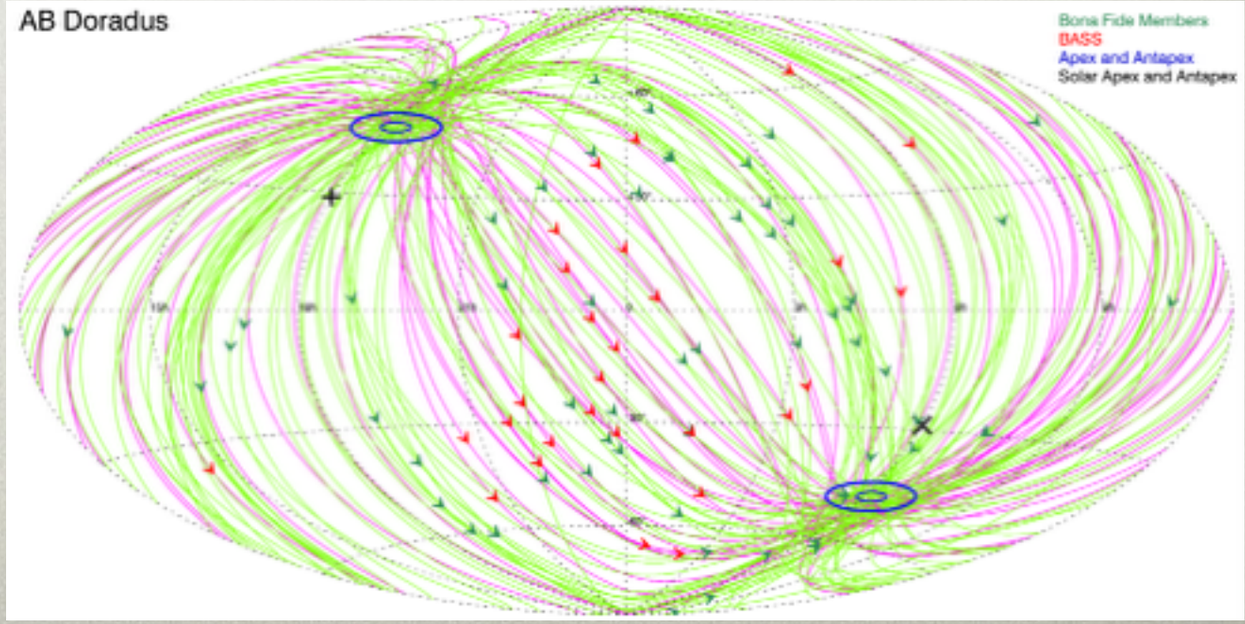
CRAQ

Université de Montréal

What is a Moving Group ?

- A group of young coeval stars (typically < 200 Myr)
- Born from the same molecular cloud
- Still share a similar galactic velocity
- Nearby = Spread-out on the sky
- Brown dwarf population is missing !



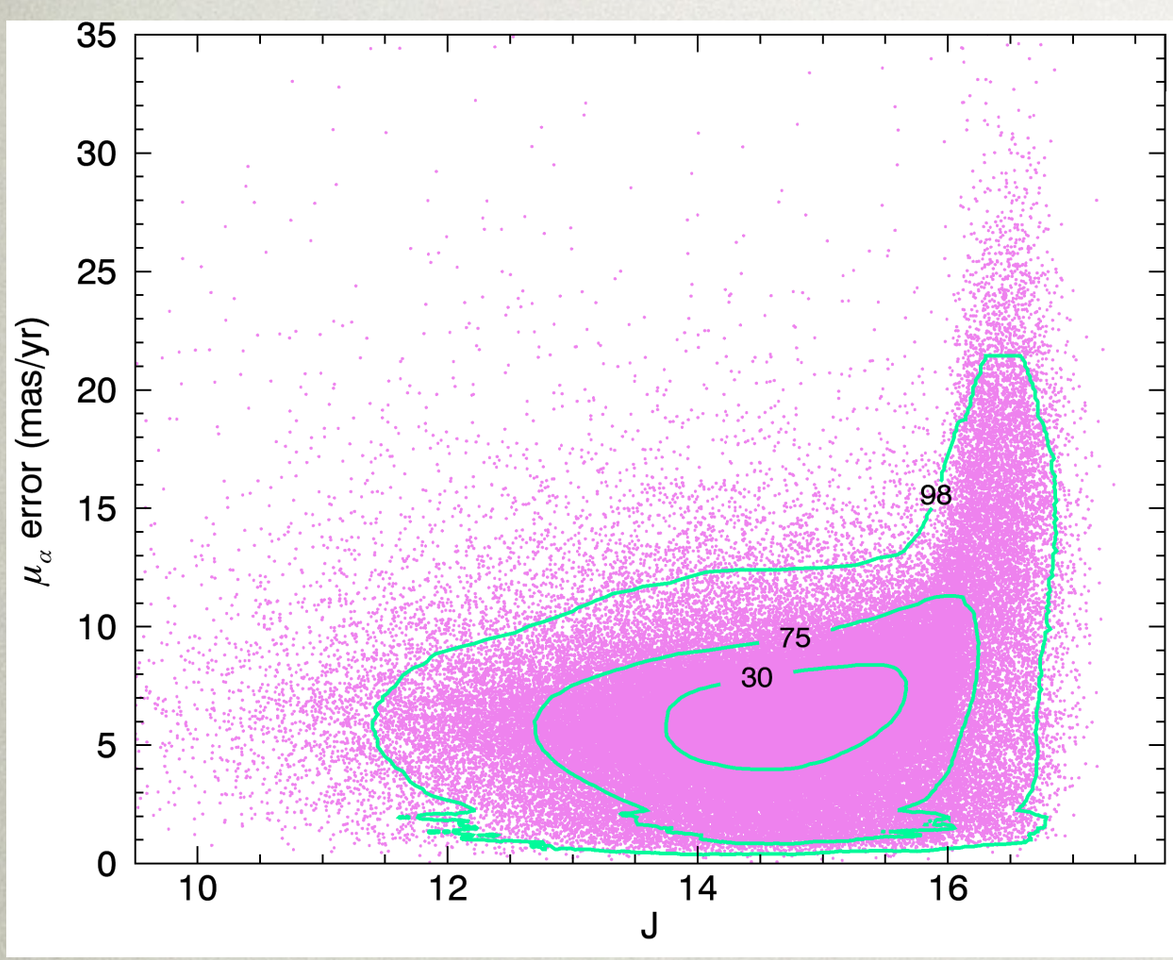


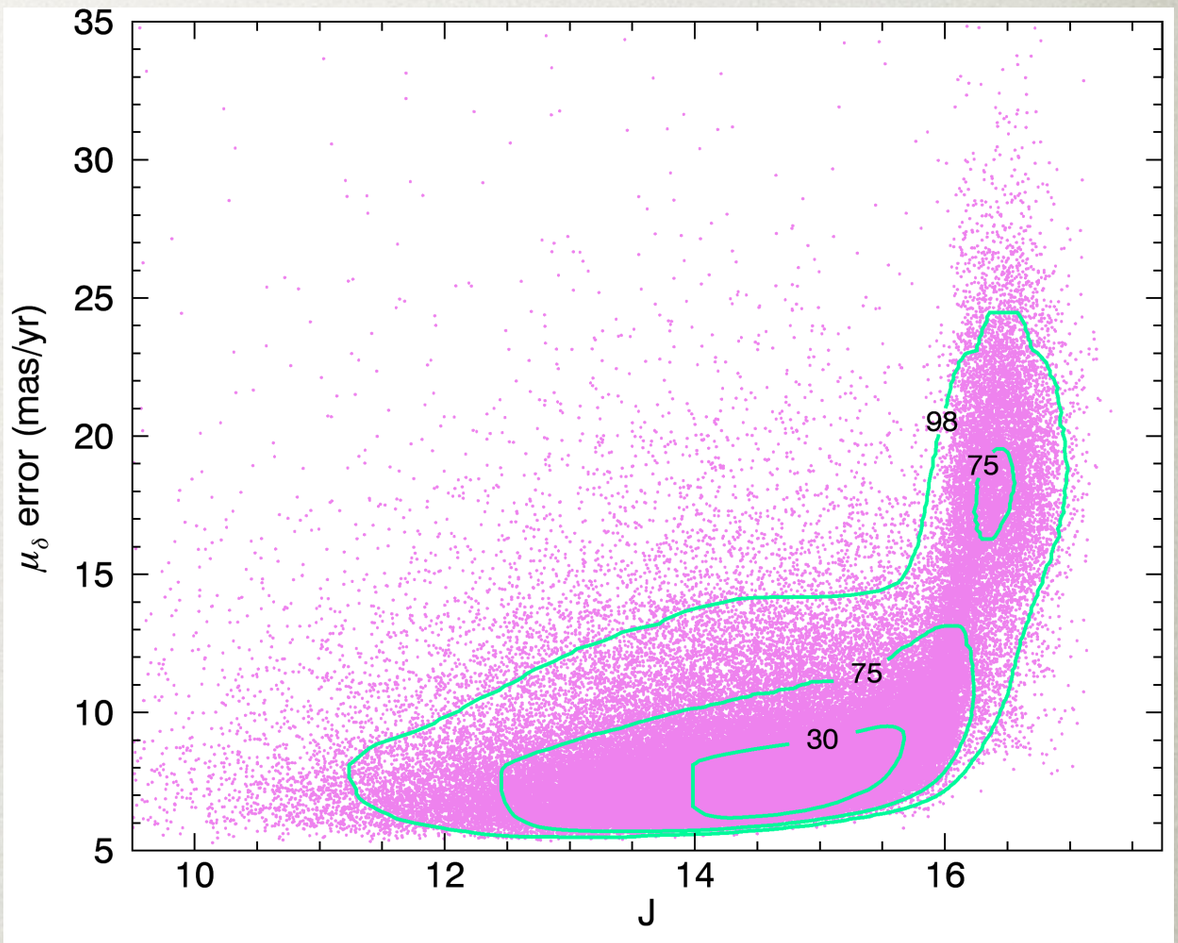
Gagné 2014d (Accepted ApJ)
arXiv 1410.4864

What is BASS ? 2/22

- BASS = Banyan All-Sky Survey
- Cross-Match of the whole *AllWISE + 2MASS*
- 100,000 potential > M5 dwarfs with PMs
- BANYAN II tool to identify candidate members of MGs
- 230 new high priority candidates
- 250 new low priority candidates

The BASS Sample 3/22



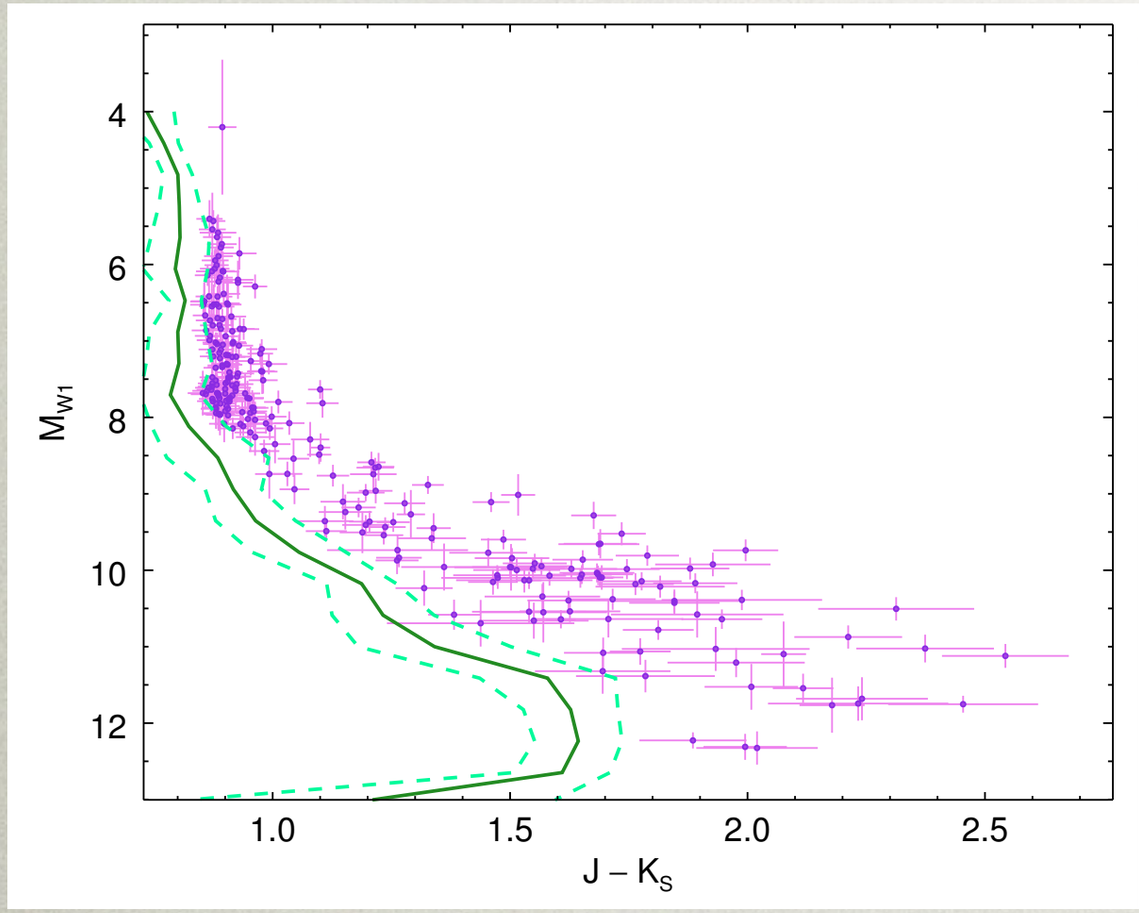


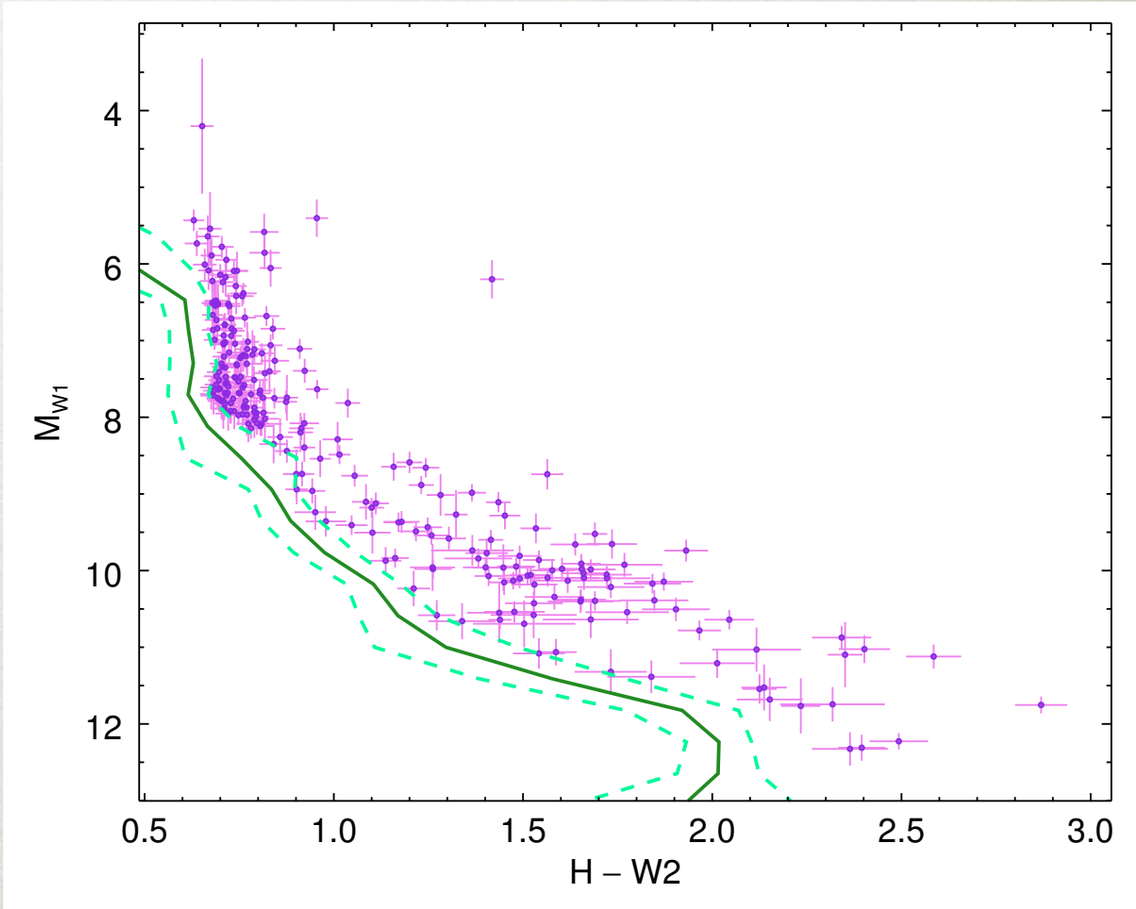
Gagné 2014d (Accepted ApJ)
arXiv 1410.4864

The 2MASS / AllWISE cross-match yields pretty good PM measurements !

Typical precision is ± 10 - 15 mas/yr

The BASS Sample 4/22

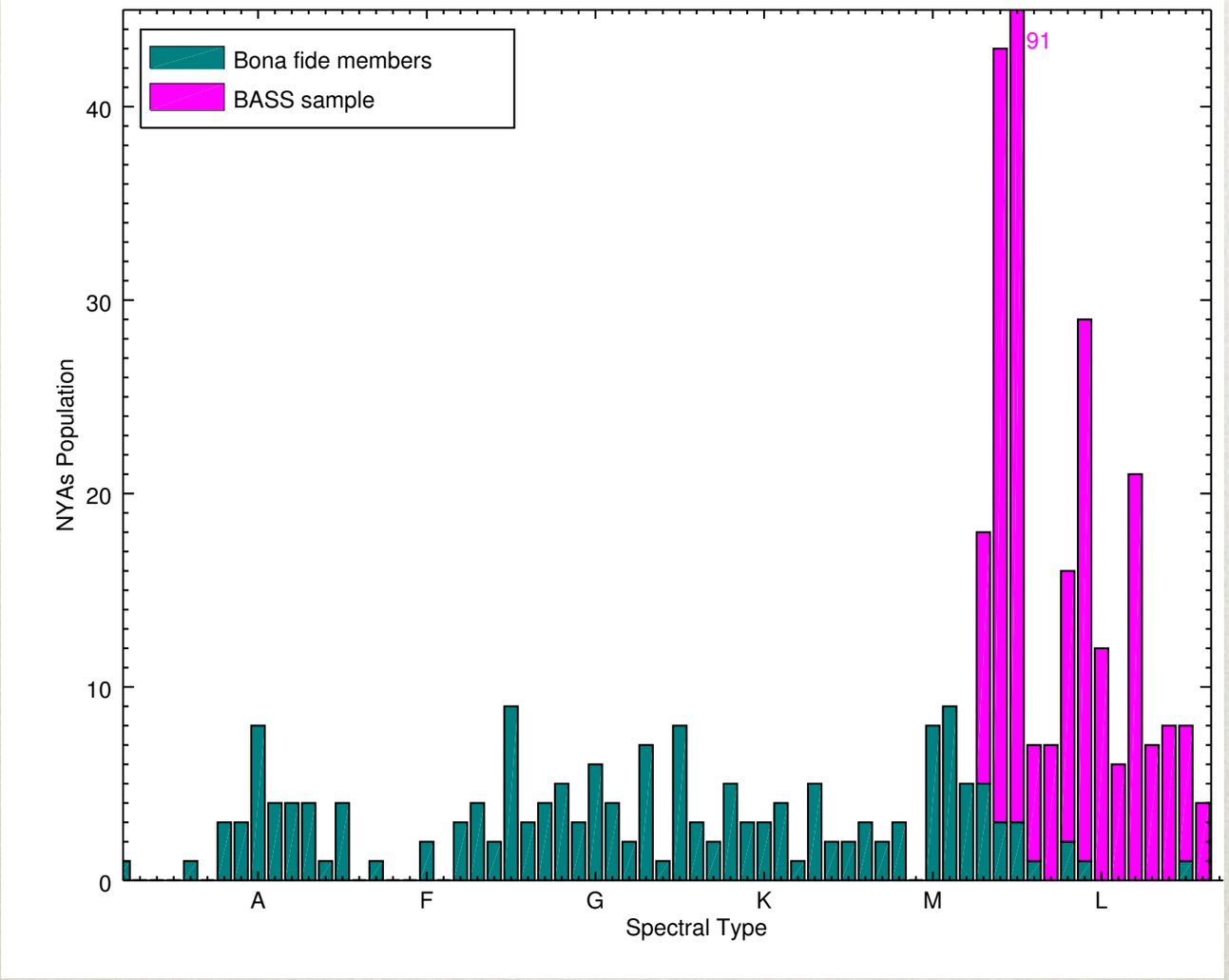




Gagné 2014d (Accepted ApJ)
arXiv 1410.4864

The Kinematic distances of BASS candidates is consistent with redder colors / larger luminosity than field dwarfs

The BASS Sample 5/22



Gagné 2014d (Accepted ApJ)
arXiv 1410.4864

Estimated Spectral Types span M5 — L6,
A largely unexplored space for MG members

Spectrocopic Follow-up

Now What ?

Several measurements are still needed to confirm membership

- Radial velocity : needs hi-resolution spectroscopy
  => big telescopes, lots of time
- Parallax : need a large temporal coverage
  => small telescopes, **lots** of time
- Signs of youth : needs low-resolution spectroscopy
  => easier !

IRTF Telescope

We thus start with low-resolution NIR spectoscopy

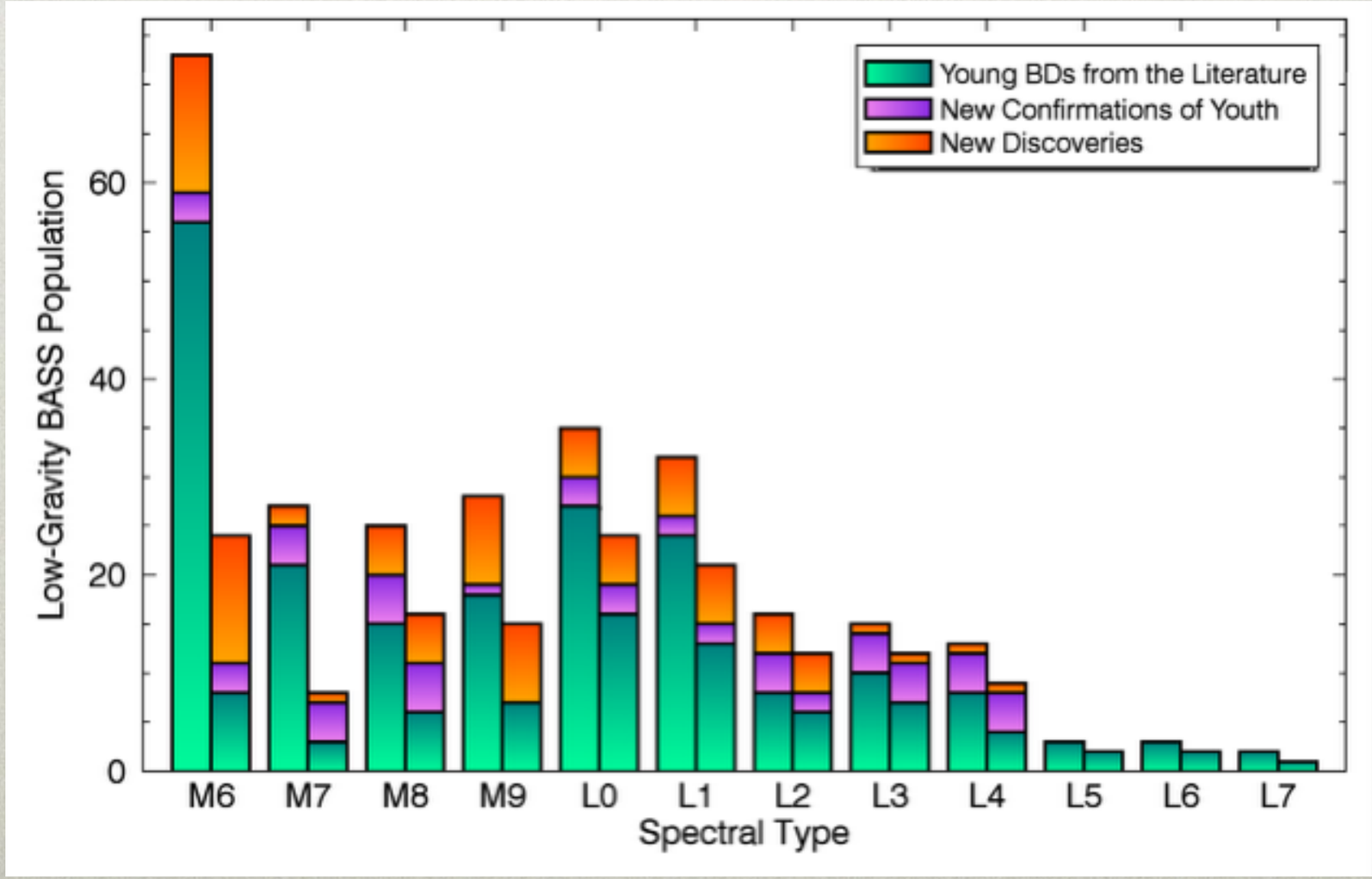
=> Identify young brown dwarfs, reject contaminants

Spectrocopic Follow-up

=> We followed more than 200, from which 100 are high-priority candidates

=> Discovered ~ 50 new M6 - L4 low-gravity dwarfs

=> Identified new signs of Low-g in ~ 30 known objects



Gagné et al., in prep.

Spectrocopic Follow-up

Young Ls are quite beautiful ;

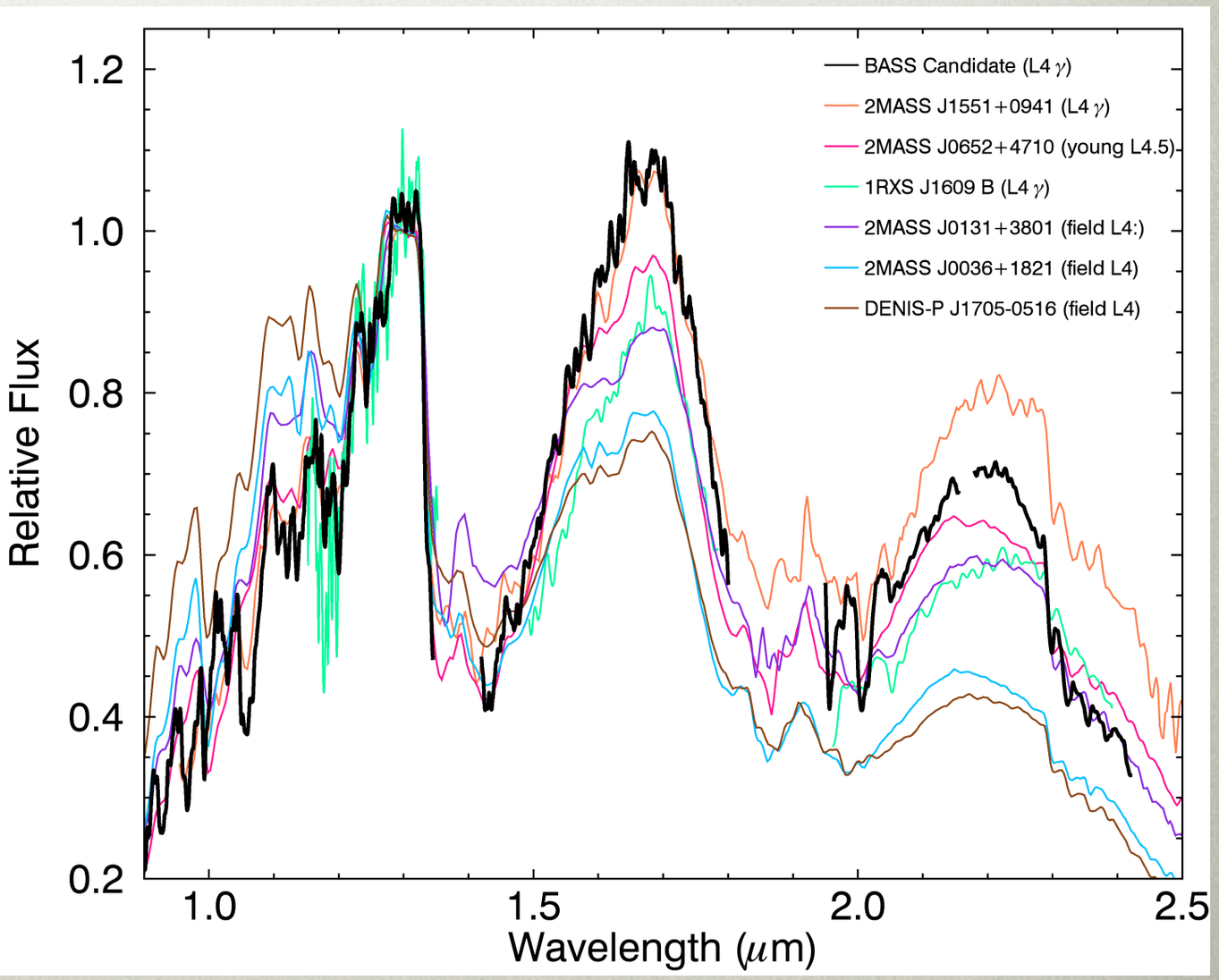
=> Triangular H-band

=> Red Slope

=> Very weak atomic lines (Na I, K I)

=> Deeper VO absorption

=> Different shape in K band



Gagné et al., in prep.

Spectrocopic Follow-up 9/22

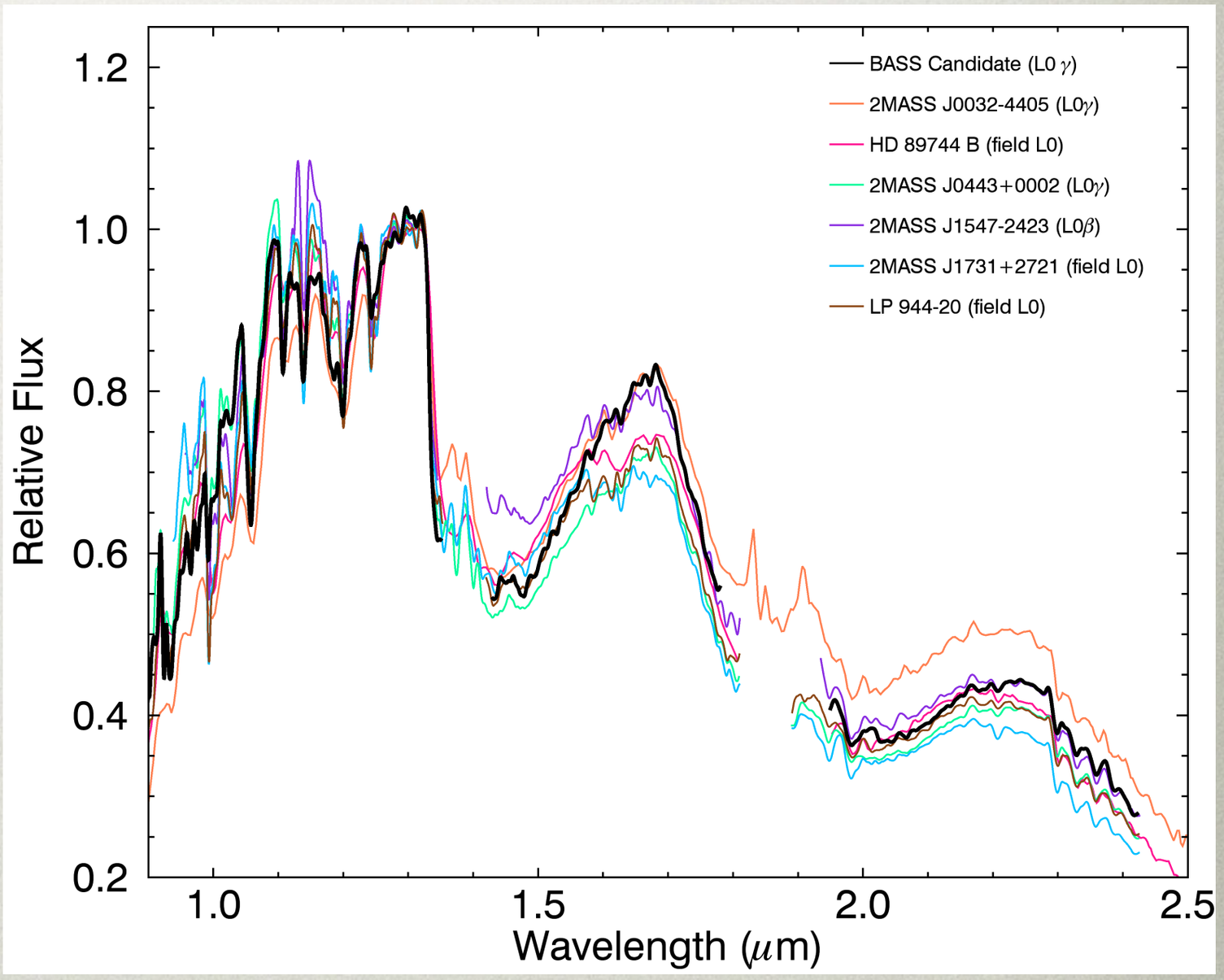
Why ?

inflated radius + smaller mass = lower G, lower P

=> Less pressure broadening

=> Thicker clouds

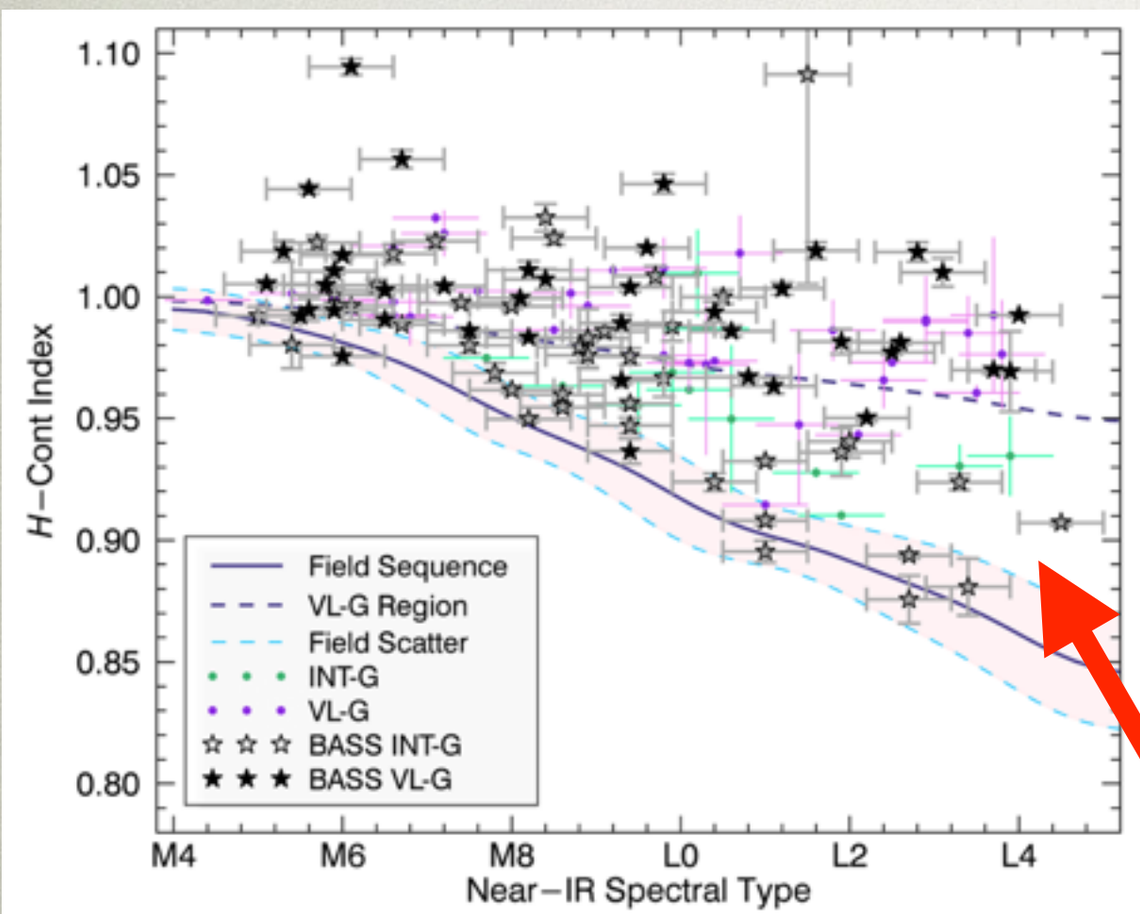
=> Less CIA of H2

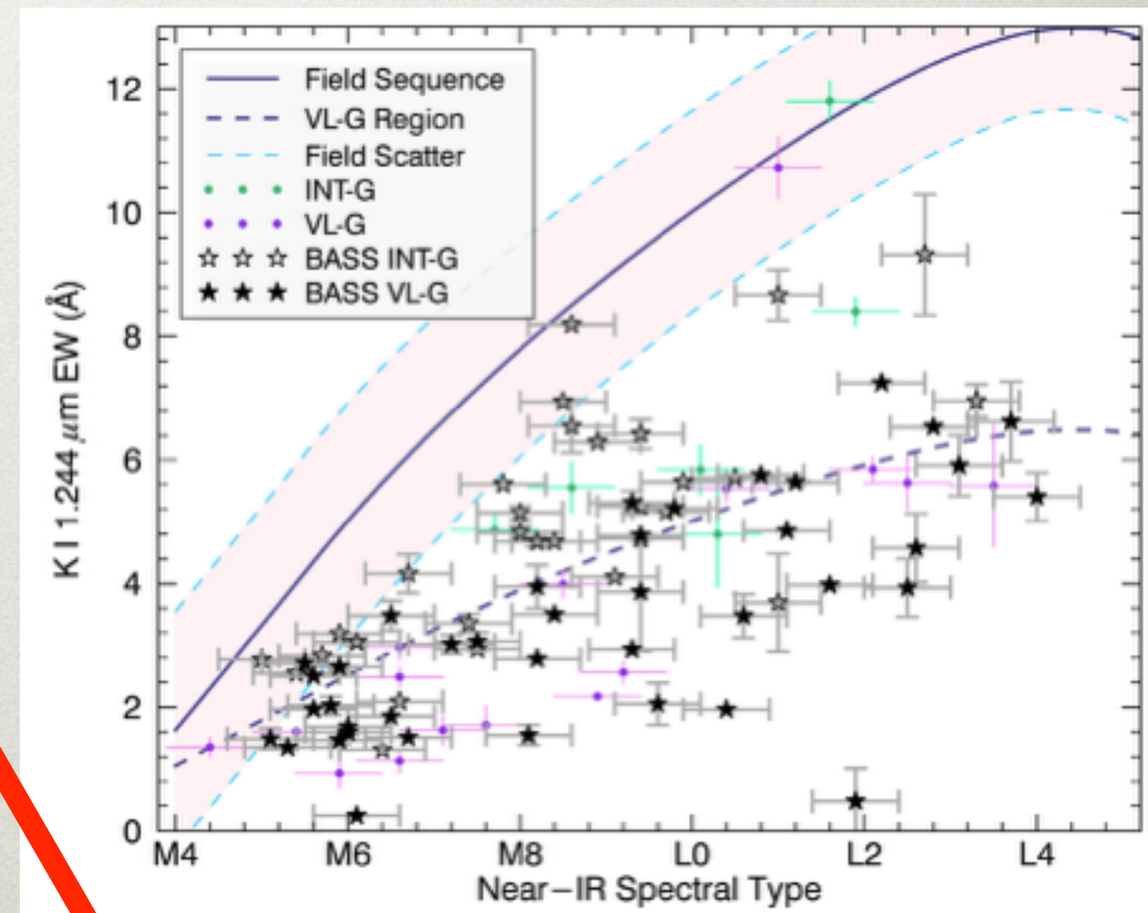


Gagné et al., in prep.

Spectrocopic Follow-up 10/22

We used the Allers & Liu (2013) + Visual comparison To assign spt + gravity class





Gagné et al., in prep.

Lots of new low-G brown dwarfs !

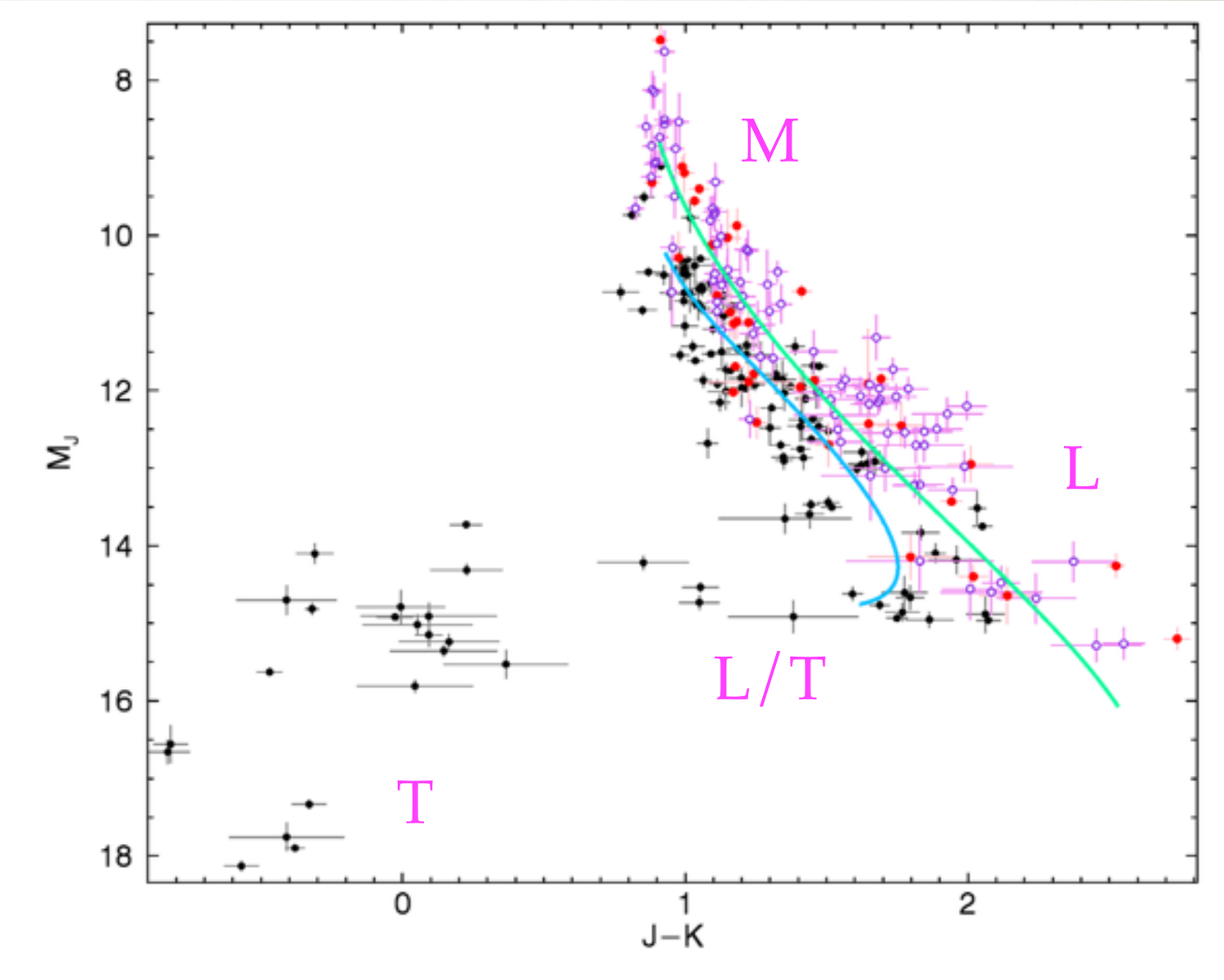
Photometric Sequences 11/22

Kinematic Distances Allow us to create Kick-Ass CMD diagrams :

=> Filled Red = Low-Gravity + PLX

=> Open Purple = Low-Gravity + Kinematic Distance

=> Black = Field



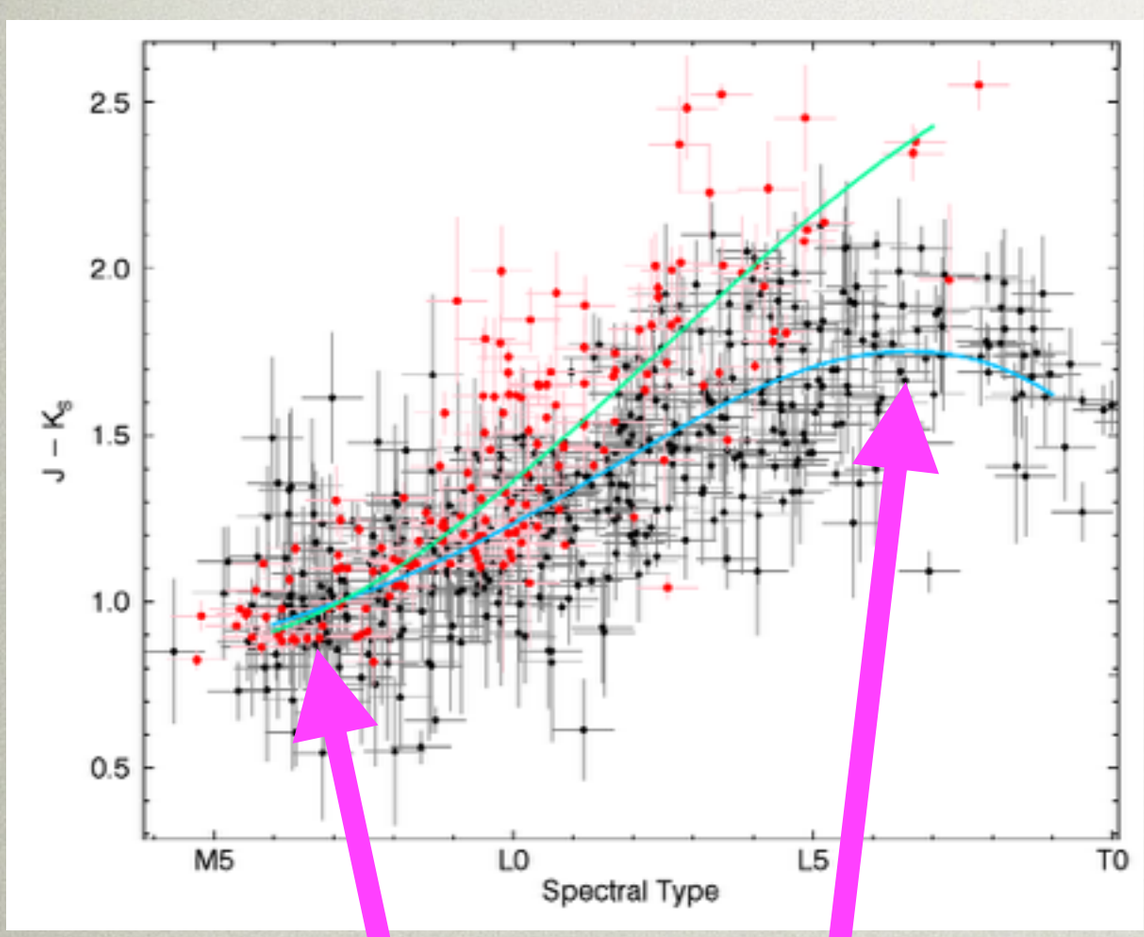
Gagné et al., in prep.

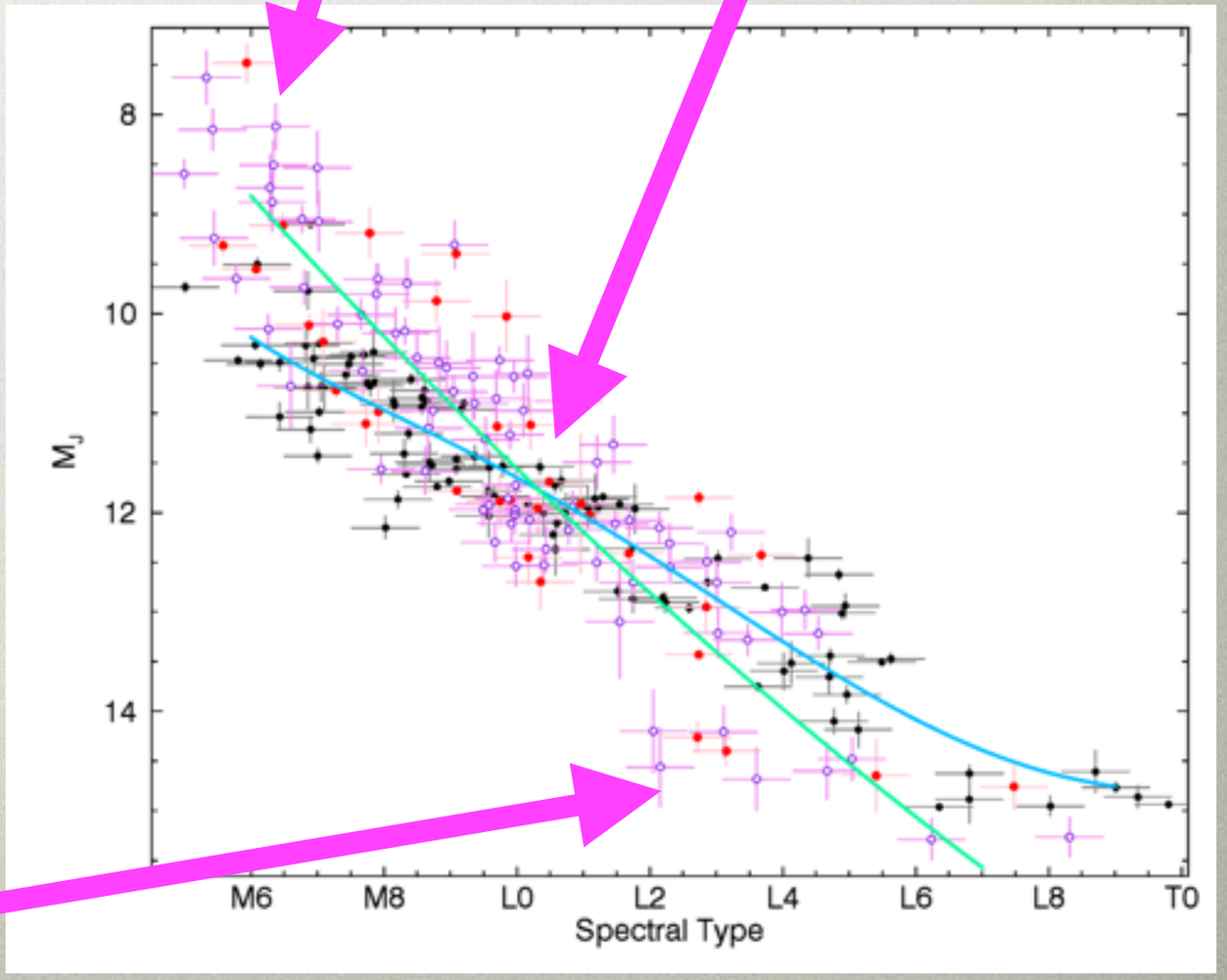
Photometric Sequences

We define new M6 - L7 empirical sequences :

Inflated radii = brighter

Clouds block the light !



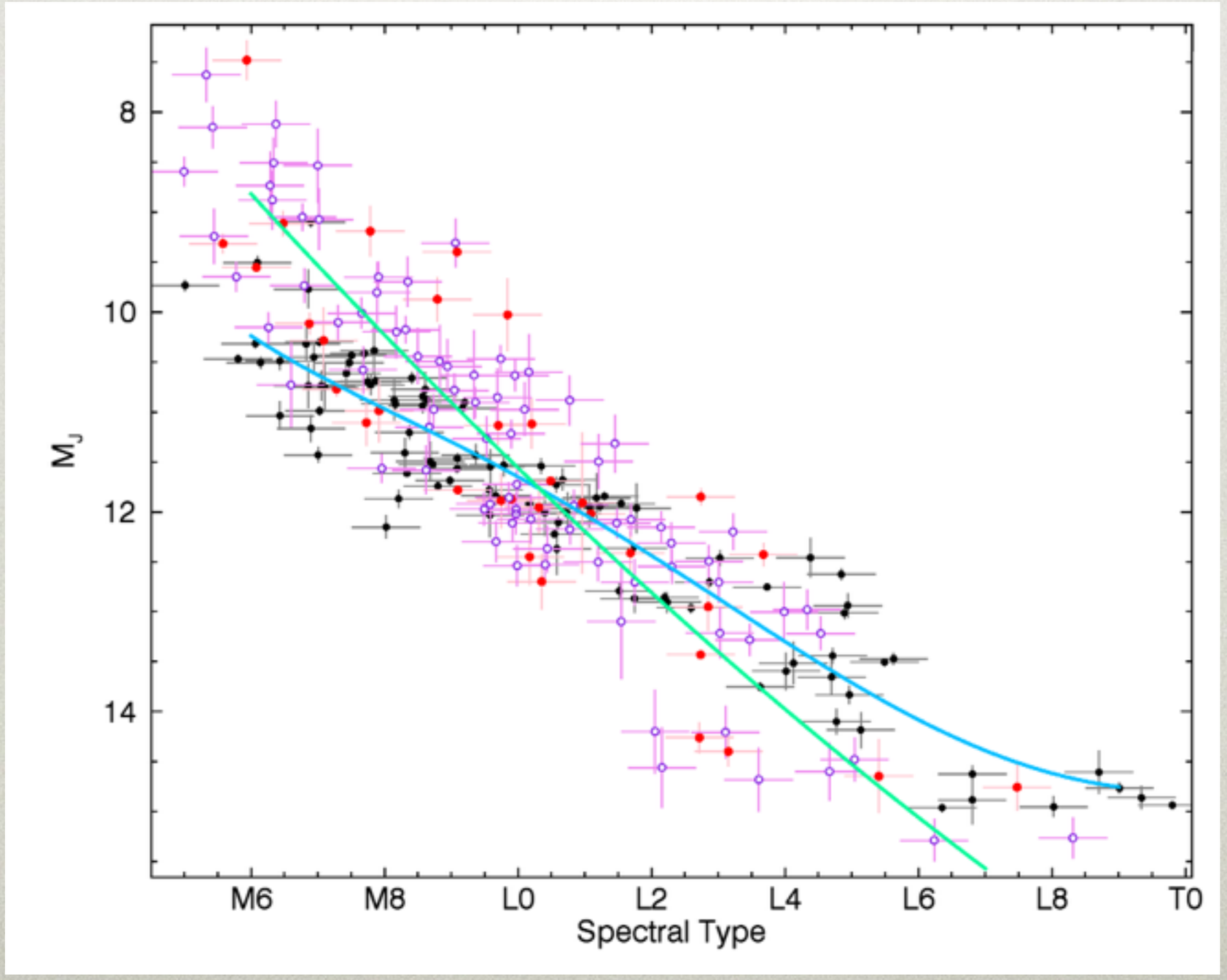


Gagné et al., in prep.

No clouds

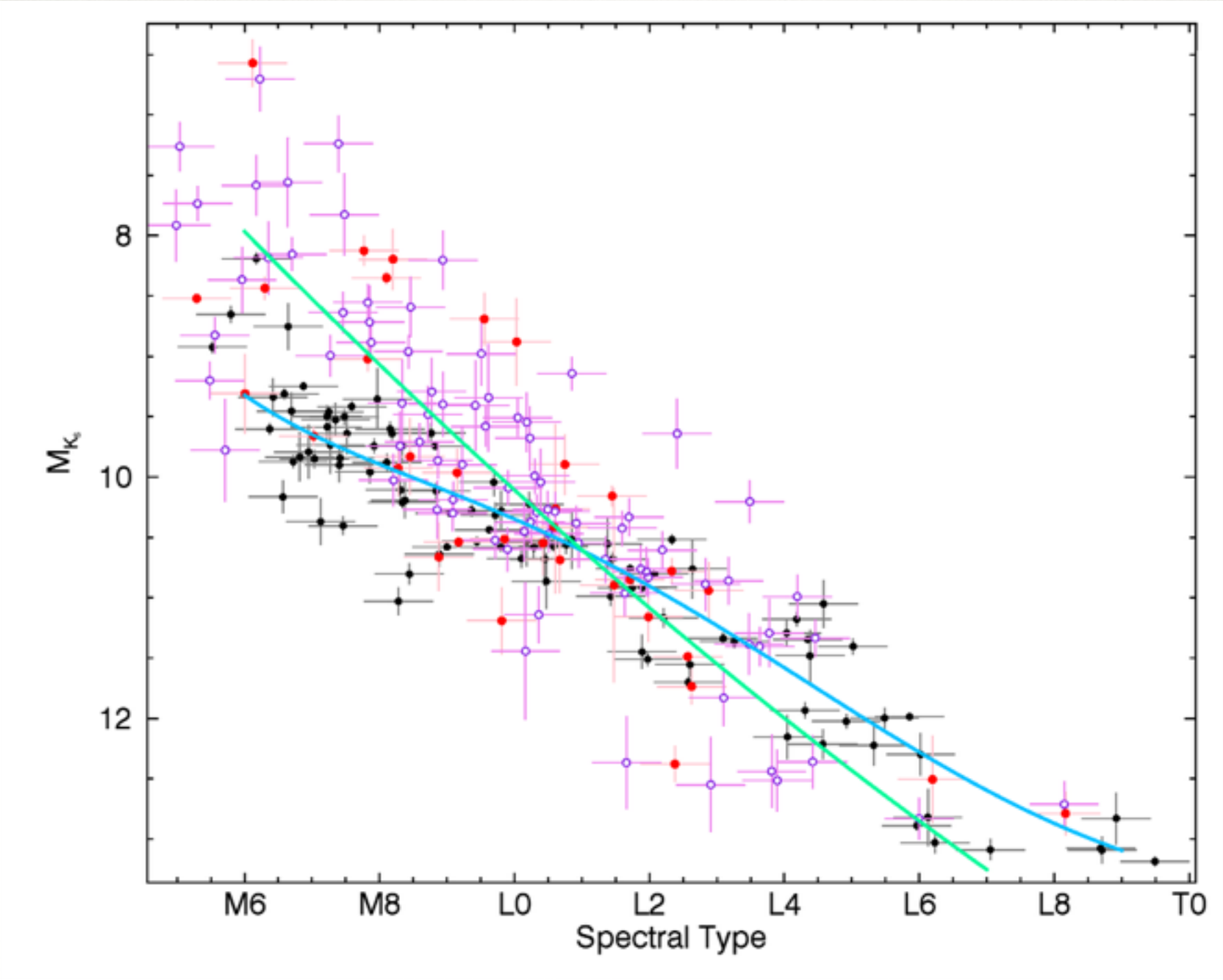
Thick clouds

Photometric Sequences



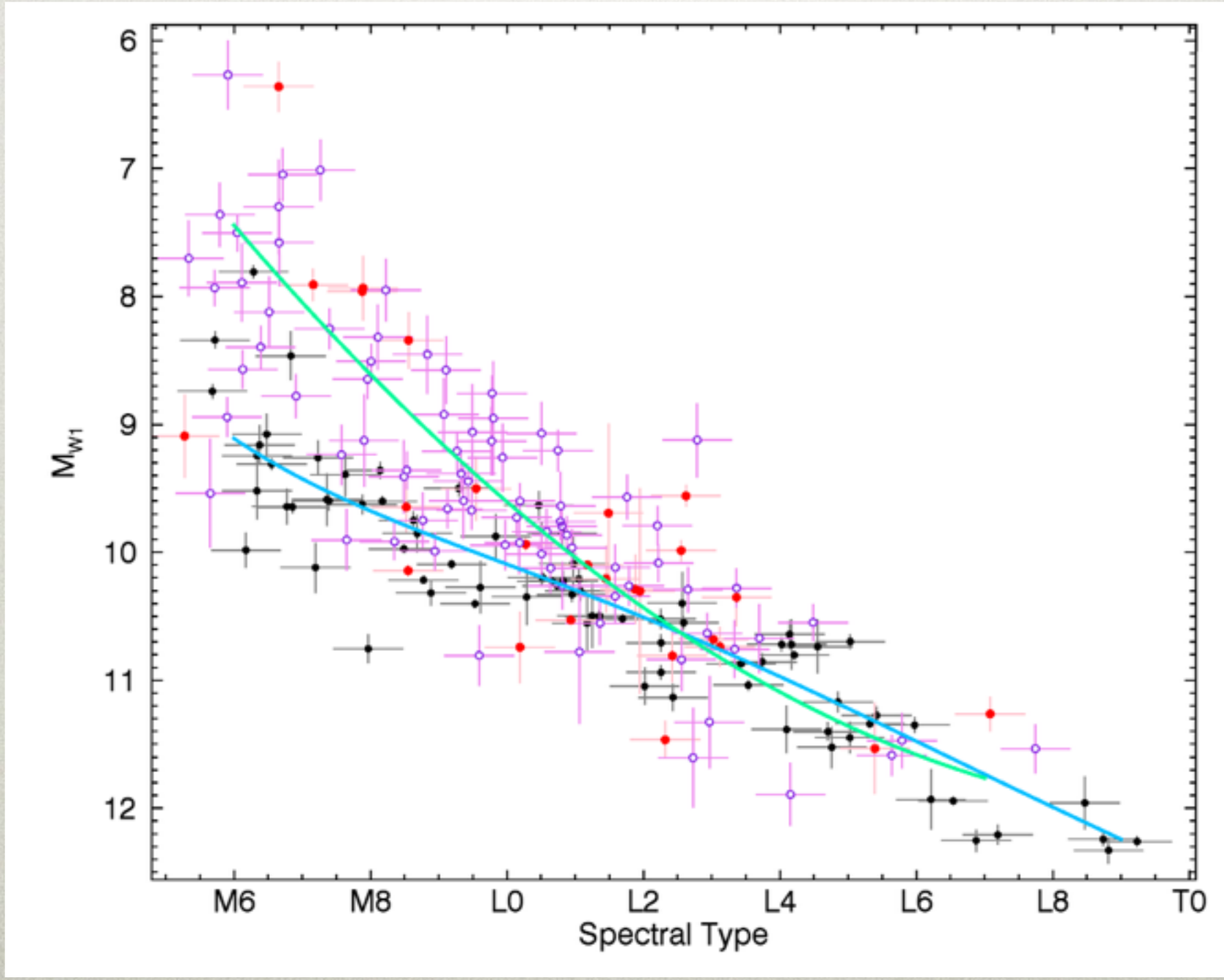
Gagné et al., in prep.

Photometric Sequences



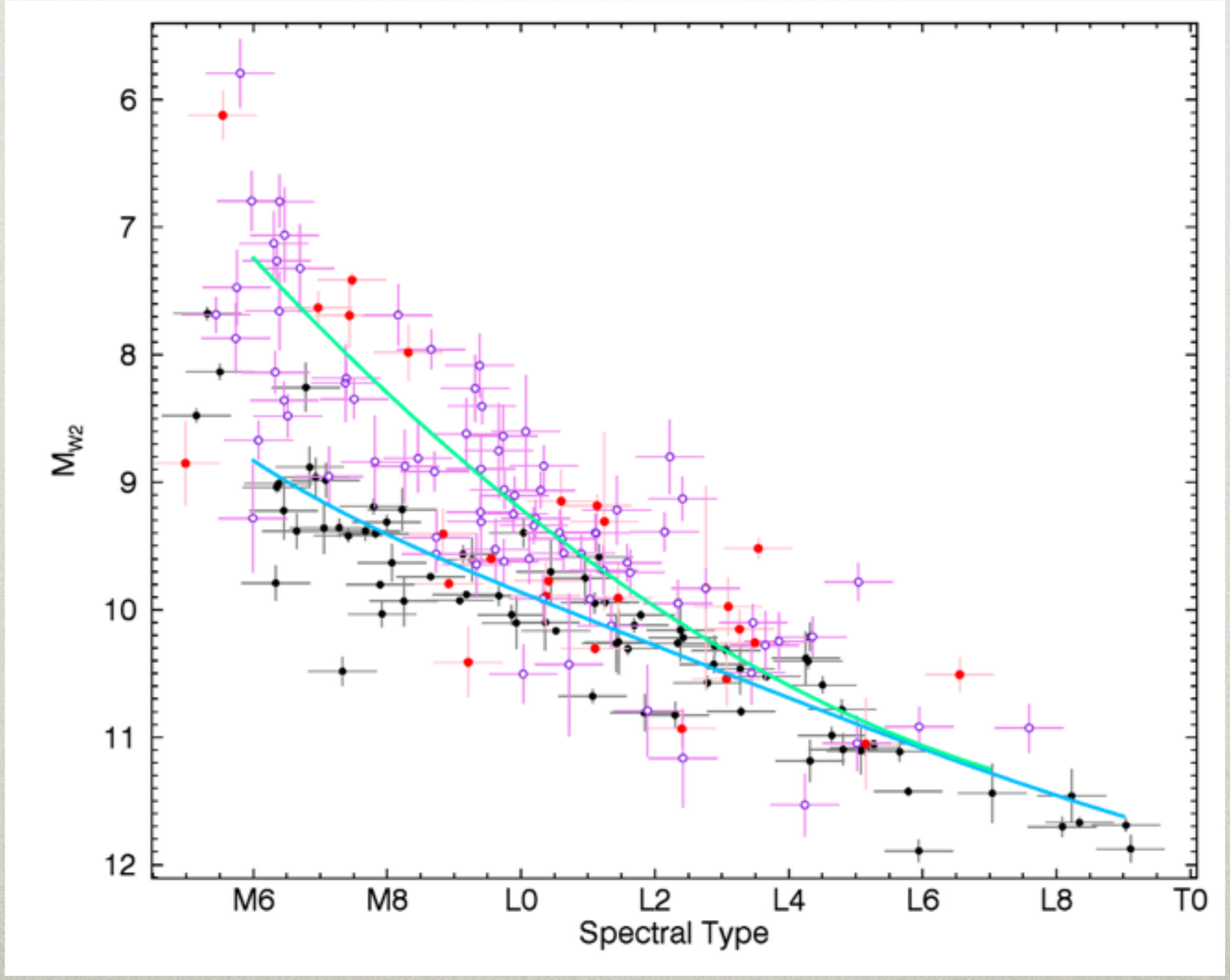
Gagné et al., in prep.

Photometric Sequences



Gagné et al., in prep.

Photometric Sequences

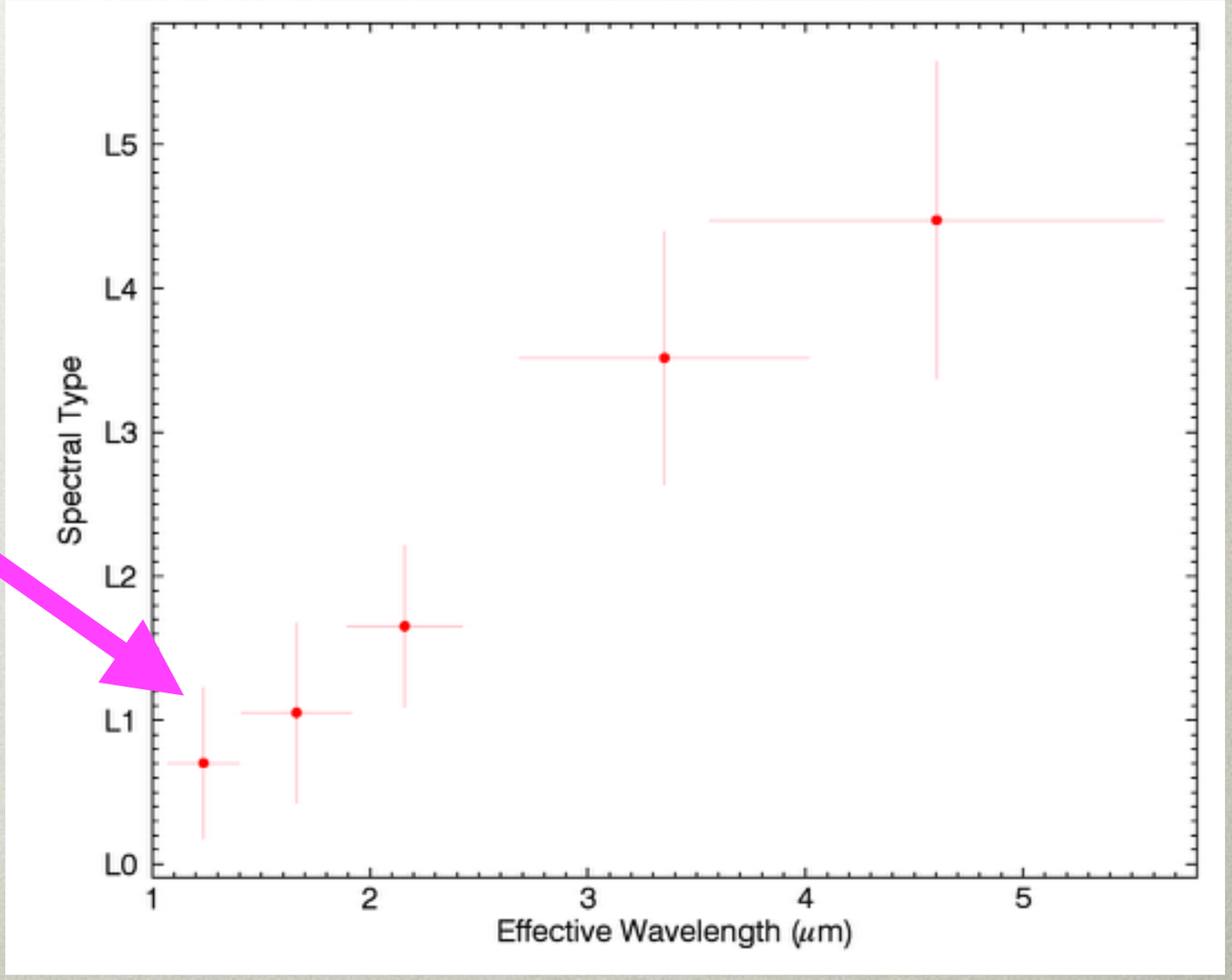


Gagné et al., in prep.

Photometric Sequences

Absolute Magnitude - Spectral Type Sequences cross
At different Spectral types in different filters !

Clouds are more opaque at ~ 1 μm



Gagné et al., in prep.

Warning : preliminary results ahead !

Physical Parameters

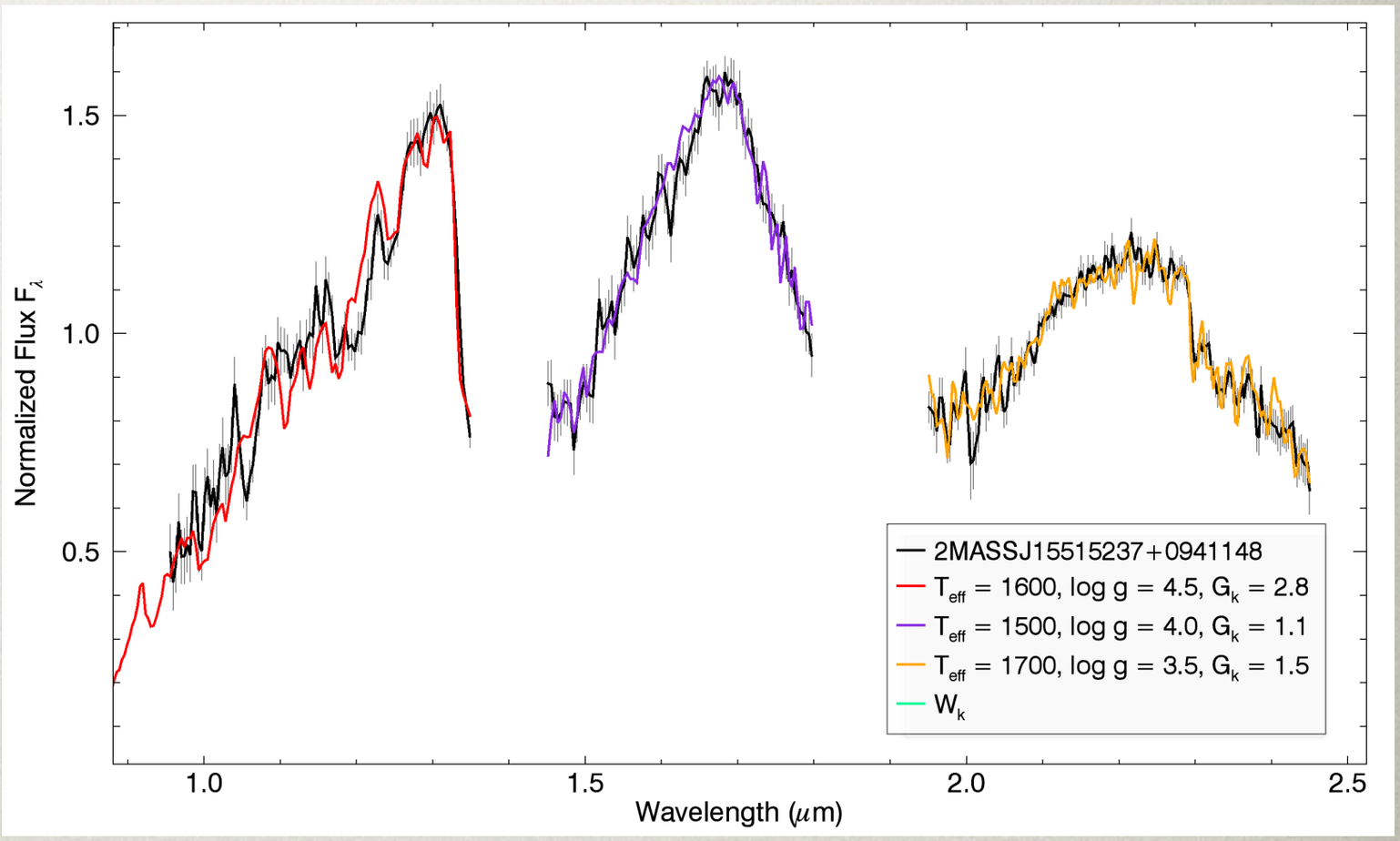
We use

CIFIST2011/BT-SETTL models +
AMES-COND Isochrones

To investigate :

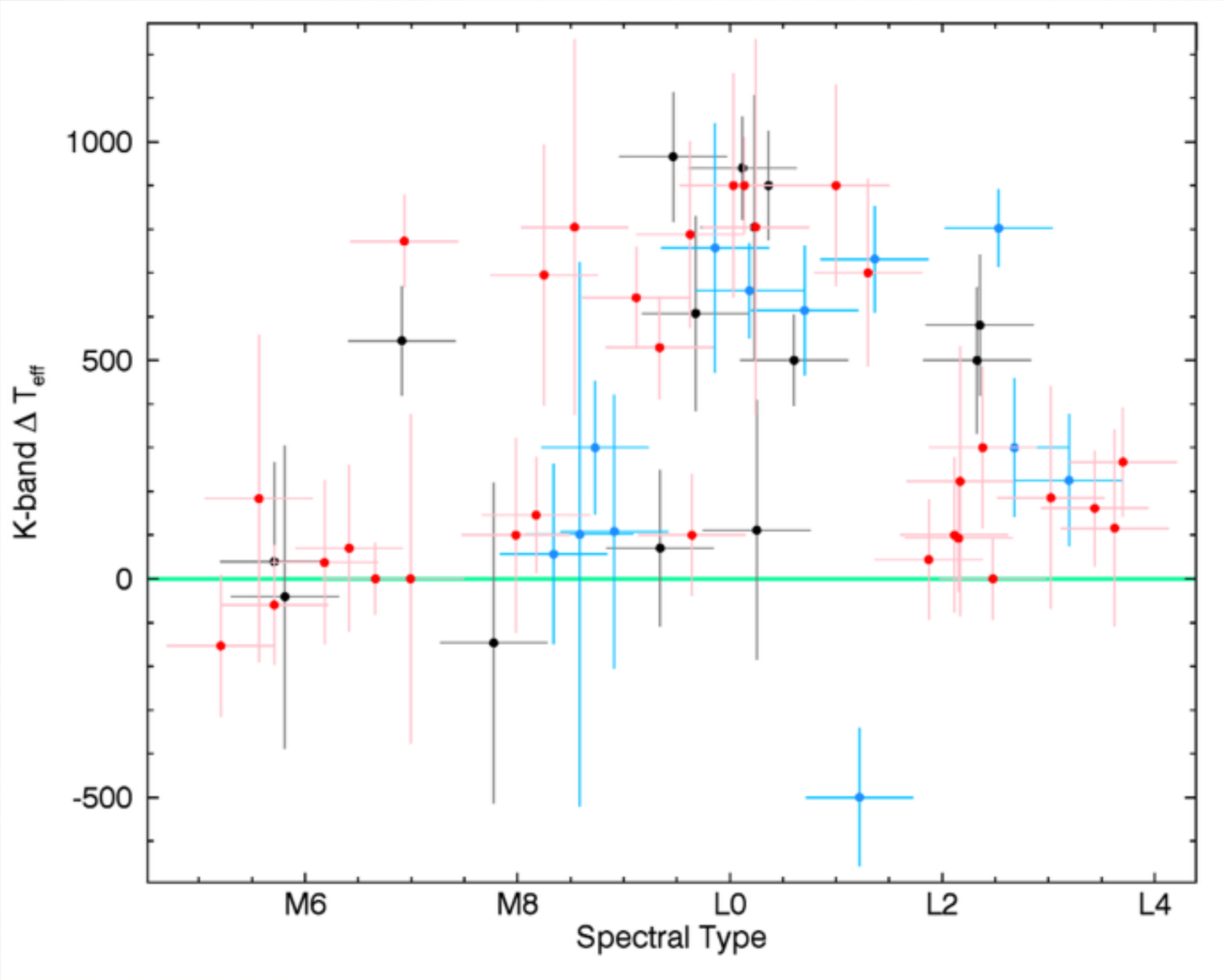
- Mass
- Temperature
- Log g

... Work in progress !



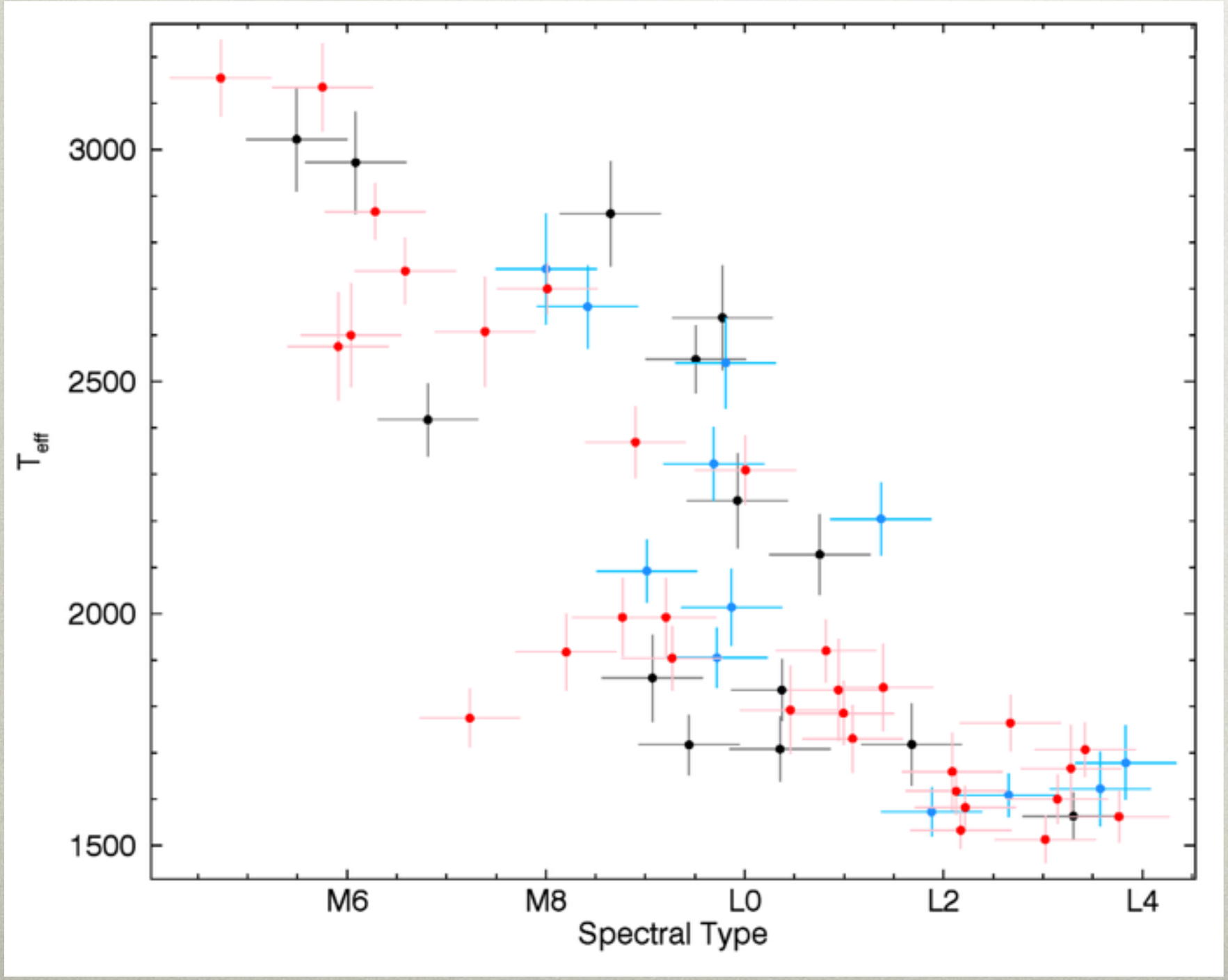
Gagné et al., in prep.

Physical Parameters



Gagné et al., in prep.

Physical Parameters



Gagné et al., in prep.

Physical Parameters 18/22

Histogram for Estimated Masses of Low-G BDs in BASS :

Why so many 13 MJup ??

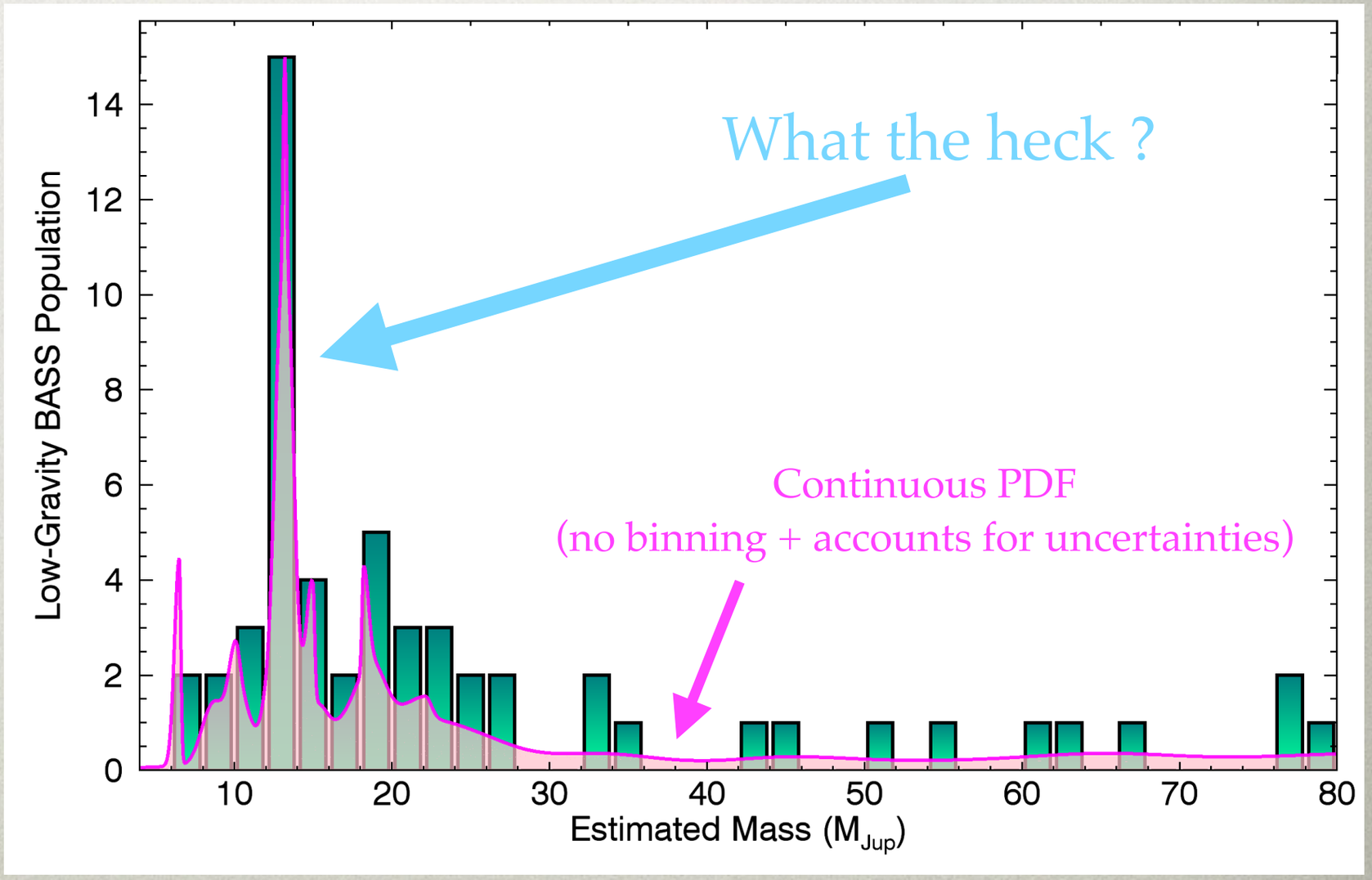
=> Selection effects unlikely

=> Is it an effect of isochrones folding on themselves ?

=> Or is there some underlying physical explanation ?

=> Floating planets ?

and other wild spectulation

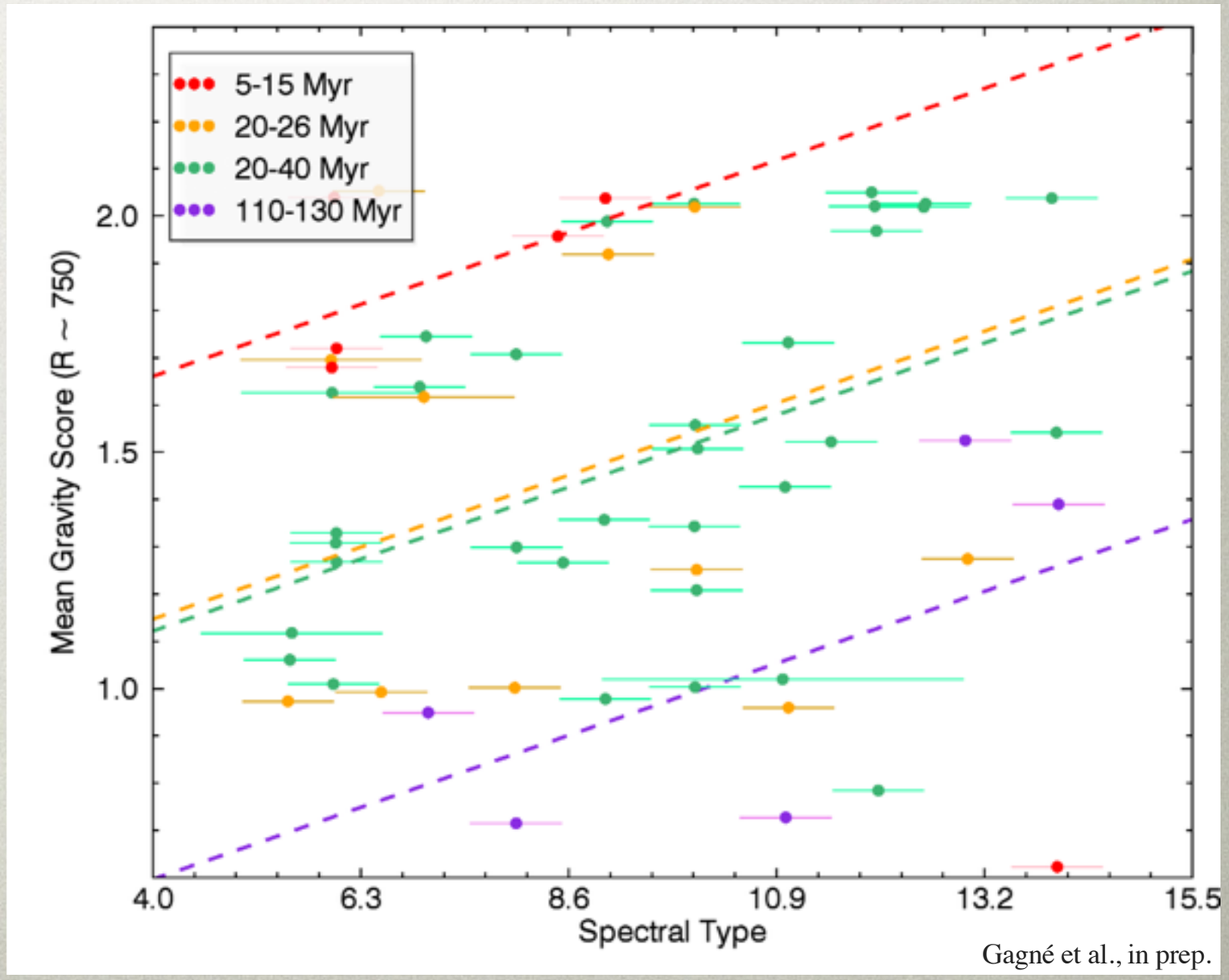


Gagné et al., in prep.

Age Calibration ? 19/22

Can we calibrate the age of BDs from their NIR spectra ?

=> Mean gravity score from Allers & Liu (2013) seems to correlate with age !

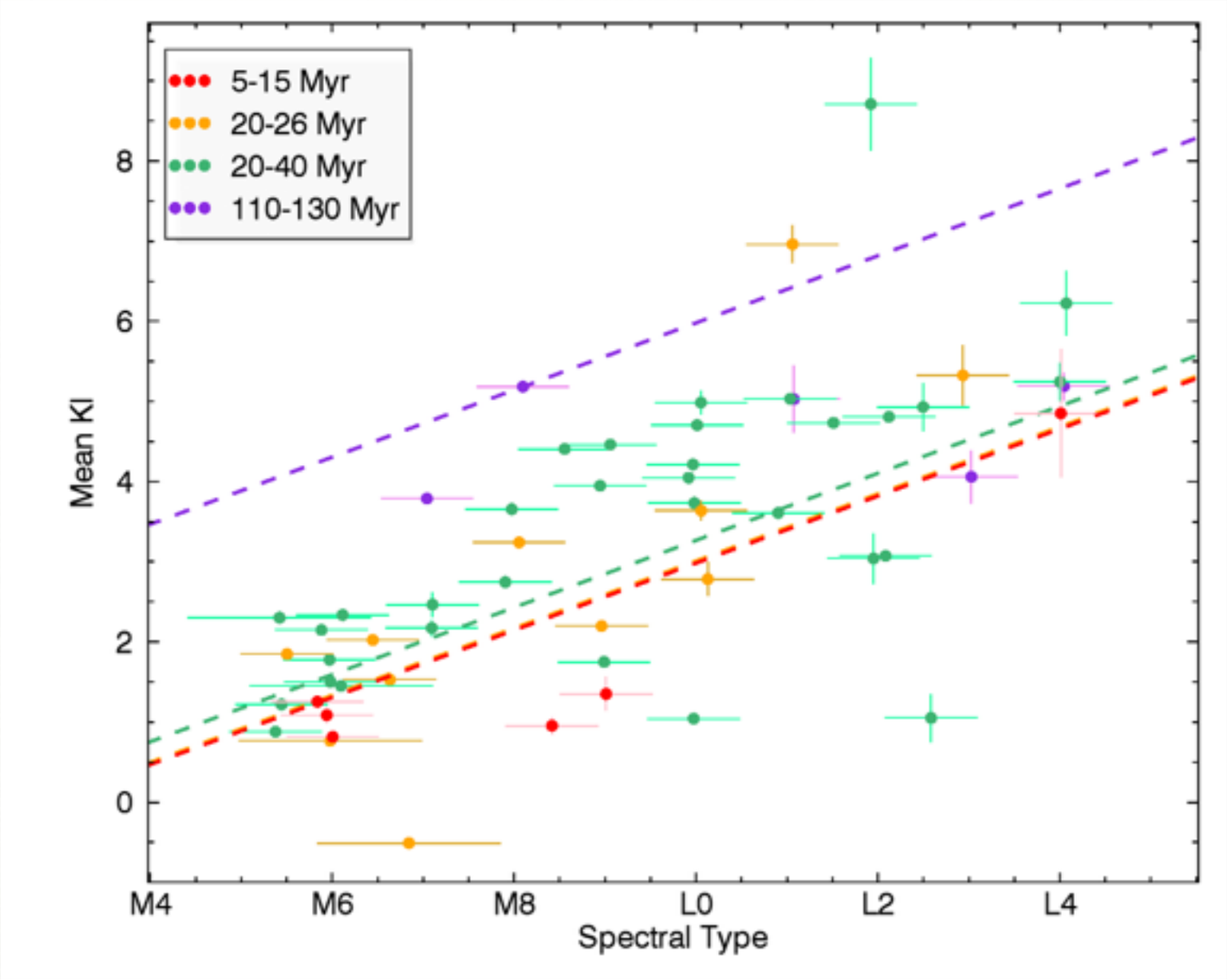


Gagné et al., in prep.

Age Calibration ? 20/22

Can we calibrate the age of BDs from their NIR spectra ?

=> So does the mean K I equivalent width

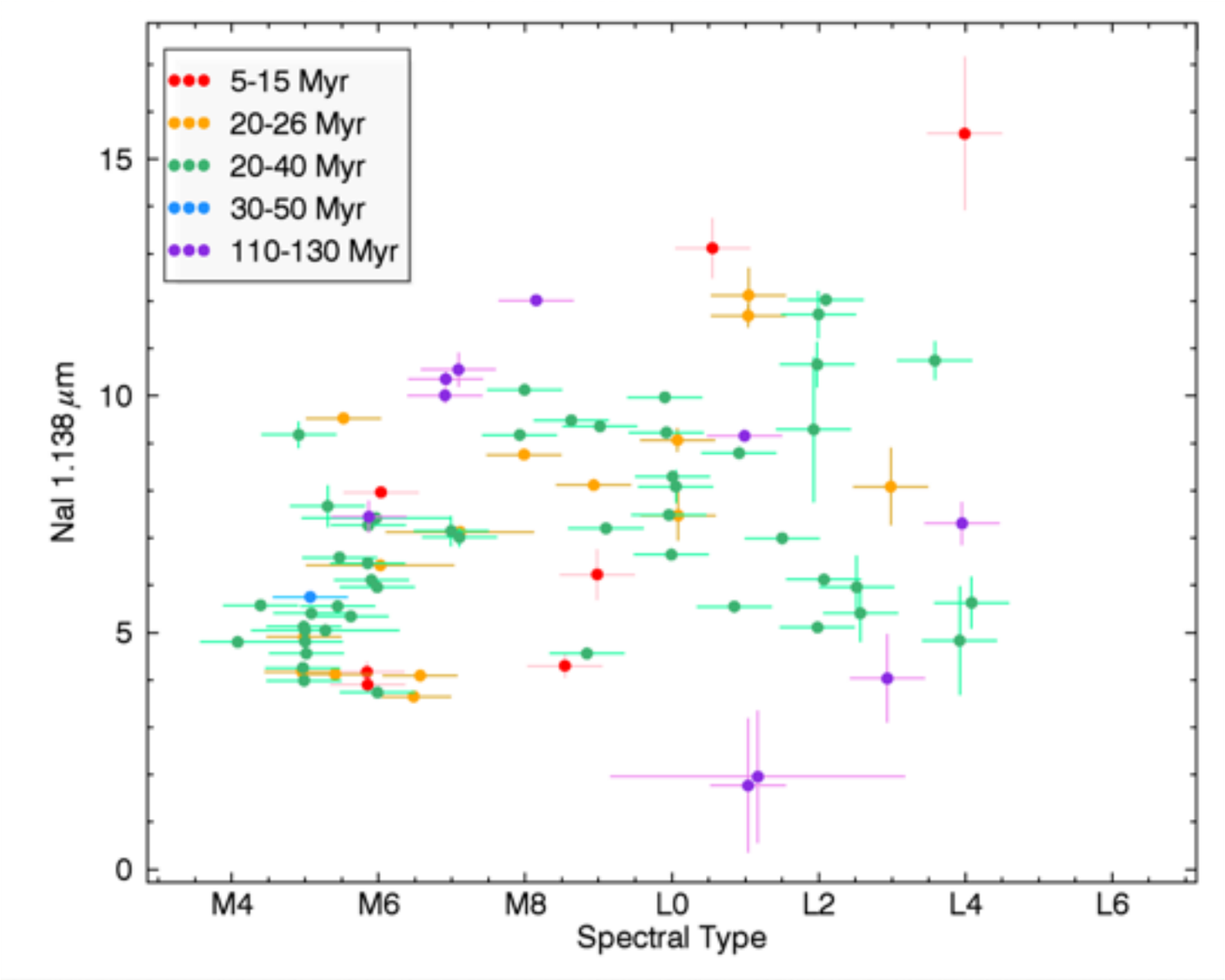


Gagné et al., in prep.

Age Calibration ? 21/22

Can we calibrate the age of BDs from their NIR spectra ?

=> Not so obvious in the case of Na I

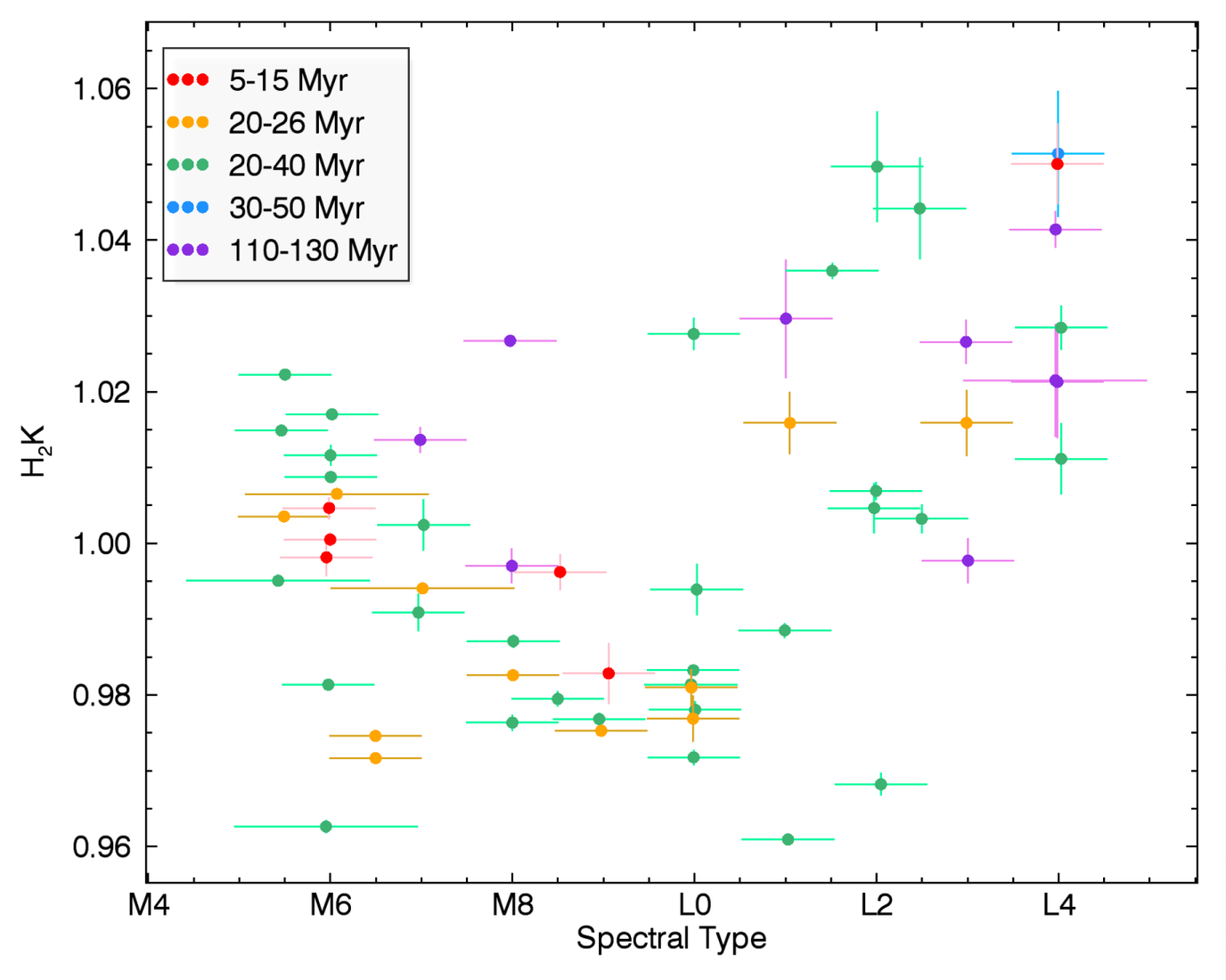


Gagné et al., in prep.

Age Calibration ? 22/22

Can we calibrate the age of BDs from their NIR spectra ?

=> Or using Canty 2013's H_2K



Gagné et al., in prep.

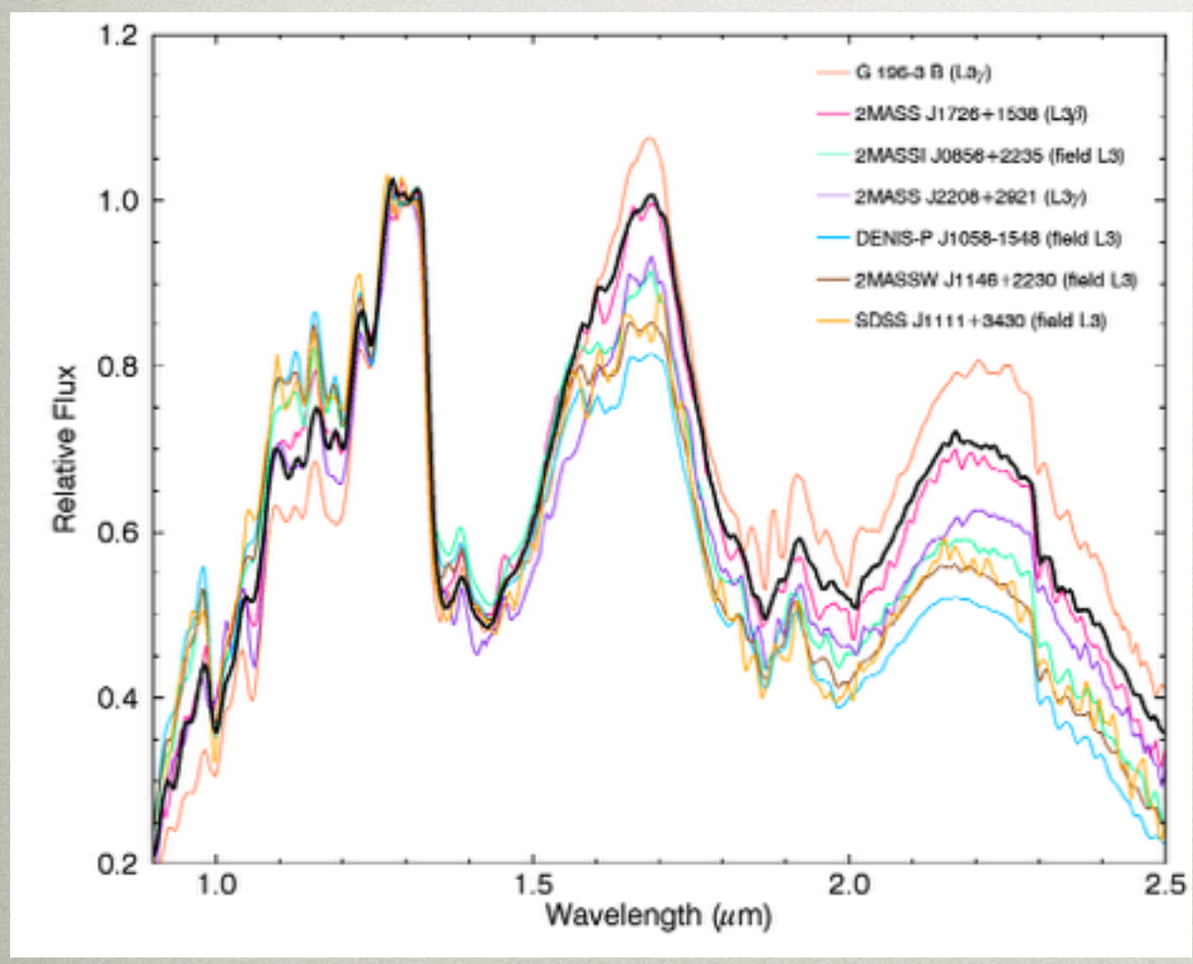
Thank You !

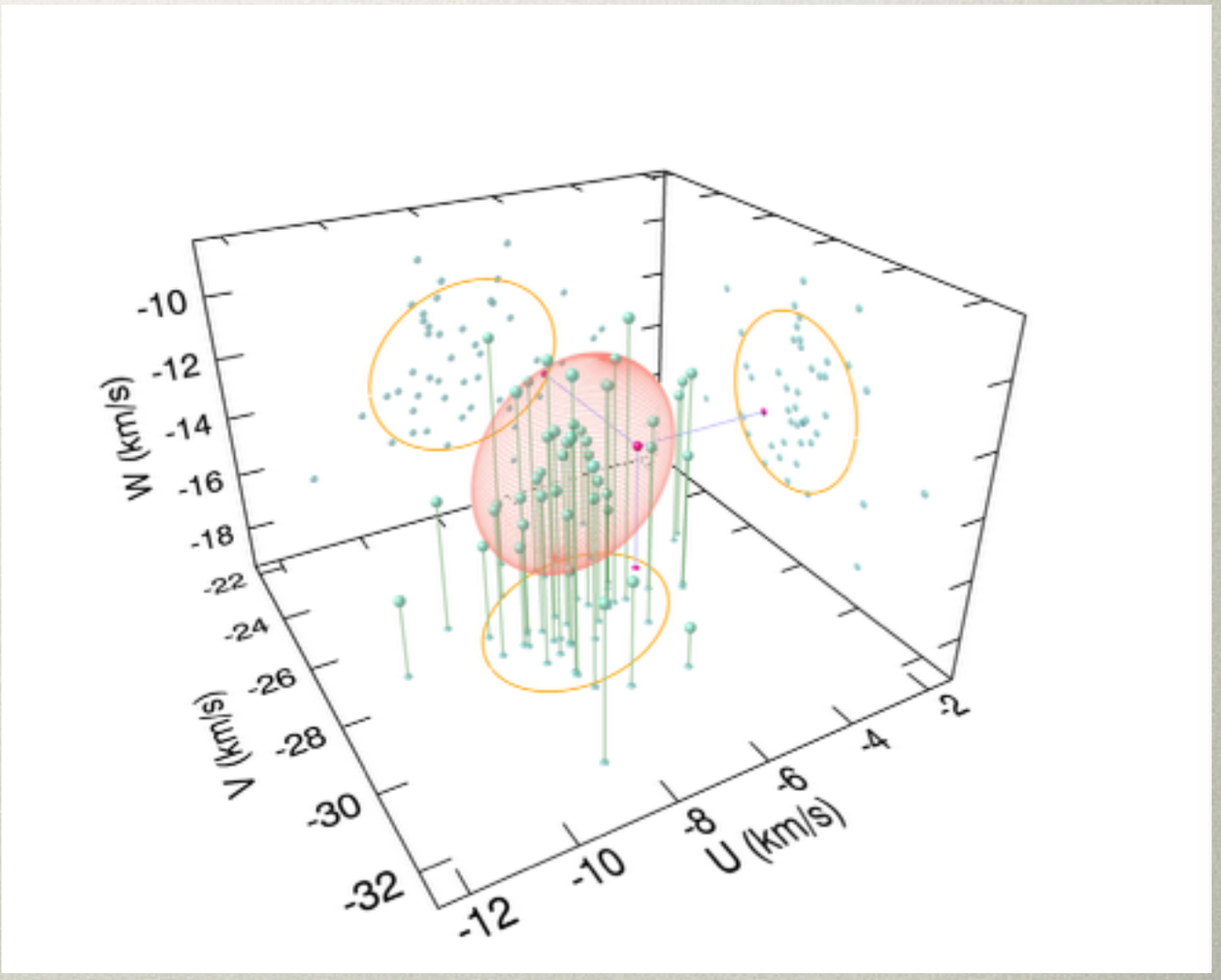
BDEXOCON, Delaware 2014

BASS Discoveries Extra 1

(1) A new low-gravity L3 bona fide member in AB Doradus !

Estimated mass : 18 M_{Jup}

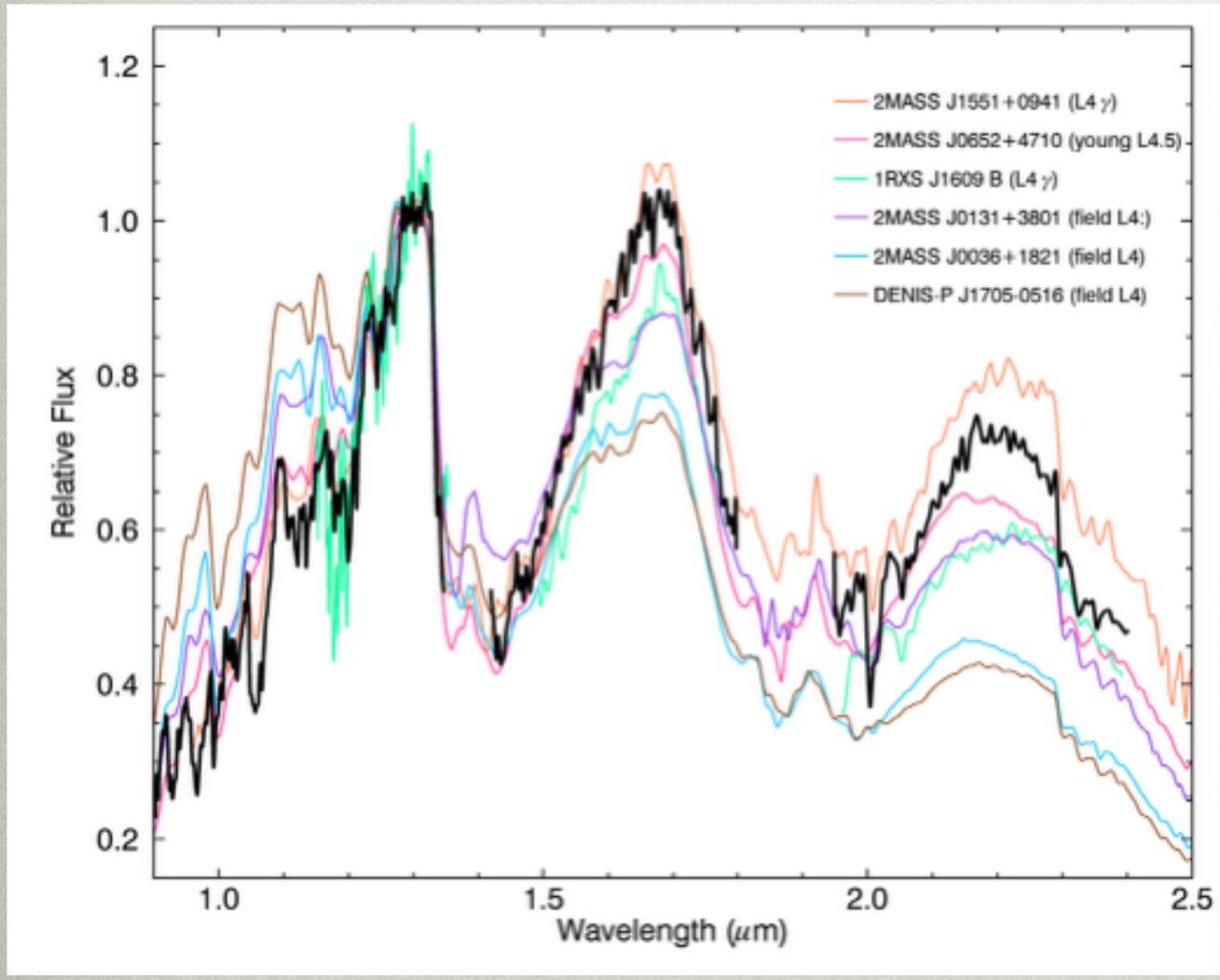




Gagné et al., in prep.

BASS Discoveries Extra 2

(2) A new low-gravity L4 planetary-mass companion to a low-gravity M6 candidate member of Tucana-Horologium



R ~ 6 000 resolved spectrum of the companion !

Estimated mass : 13 M_{Jup}

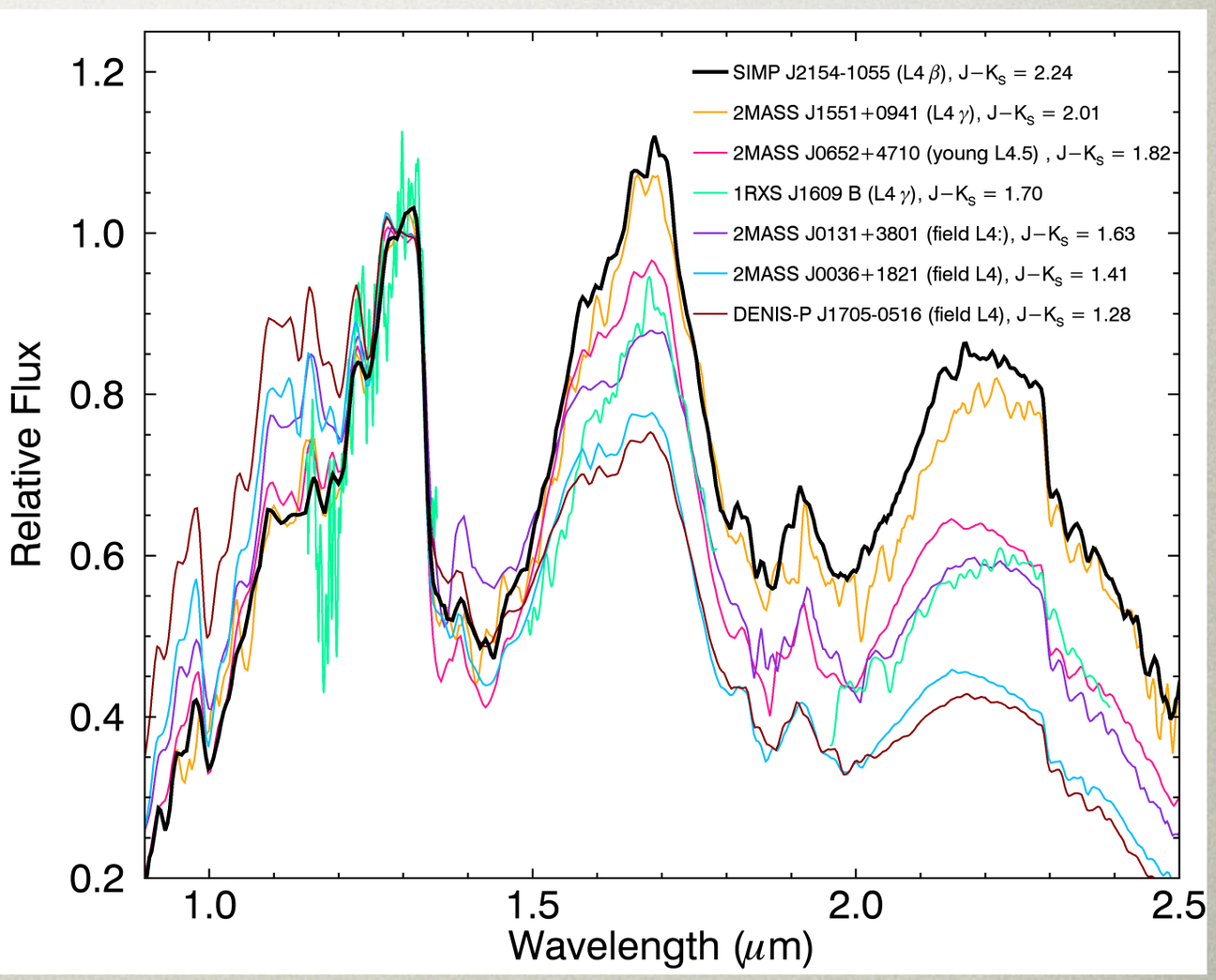
Artigau et al., in prep.

BASS Discoveries Extra 3

(3) A new low-gravity L4 candidate member of Argus

... that was accidentally discovered in the SIMP survey !

Estimated mass : 10 M_{Jup}

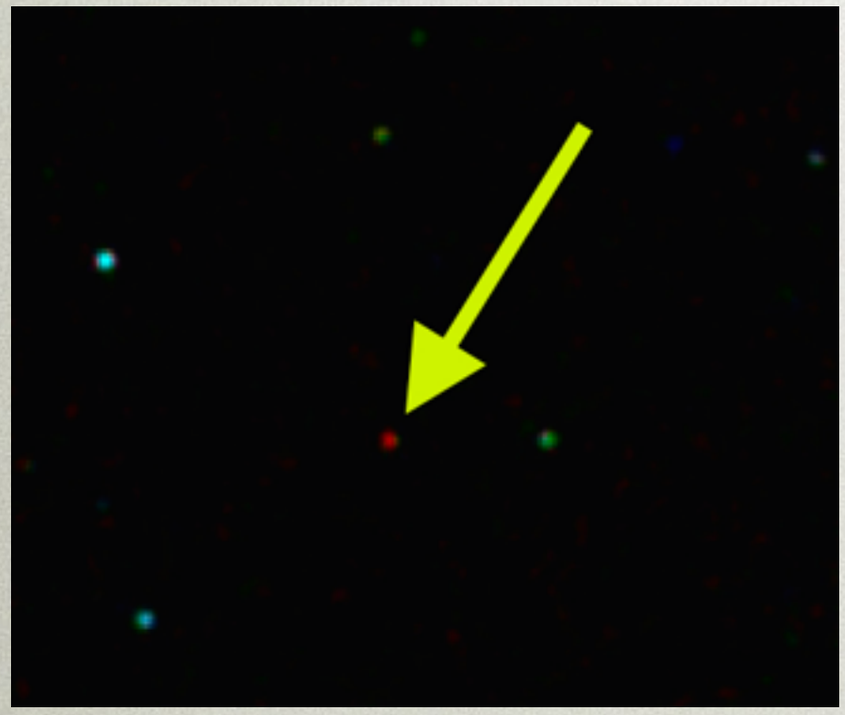


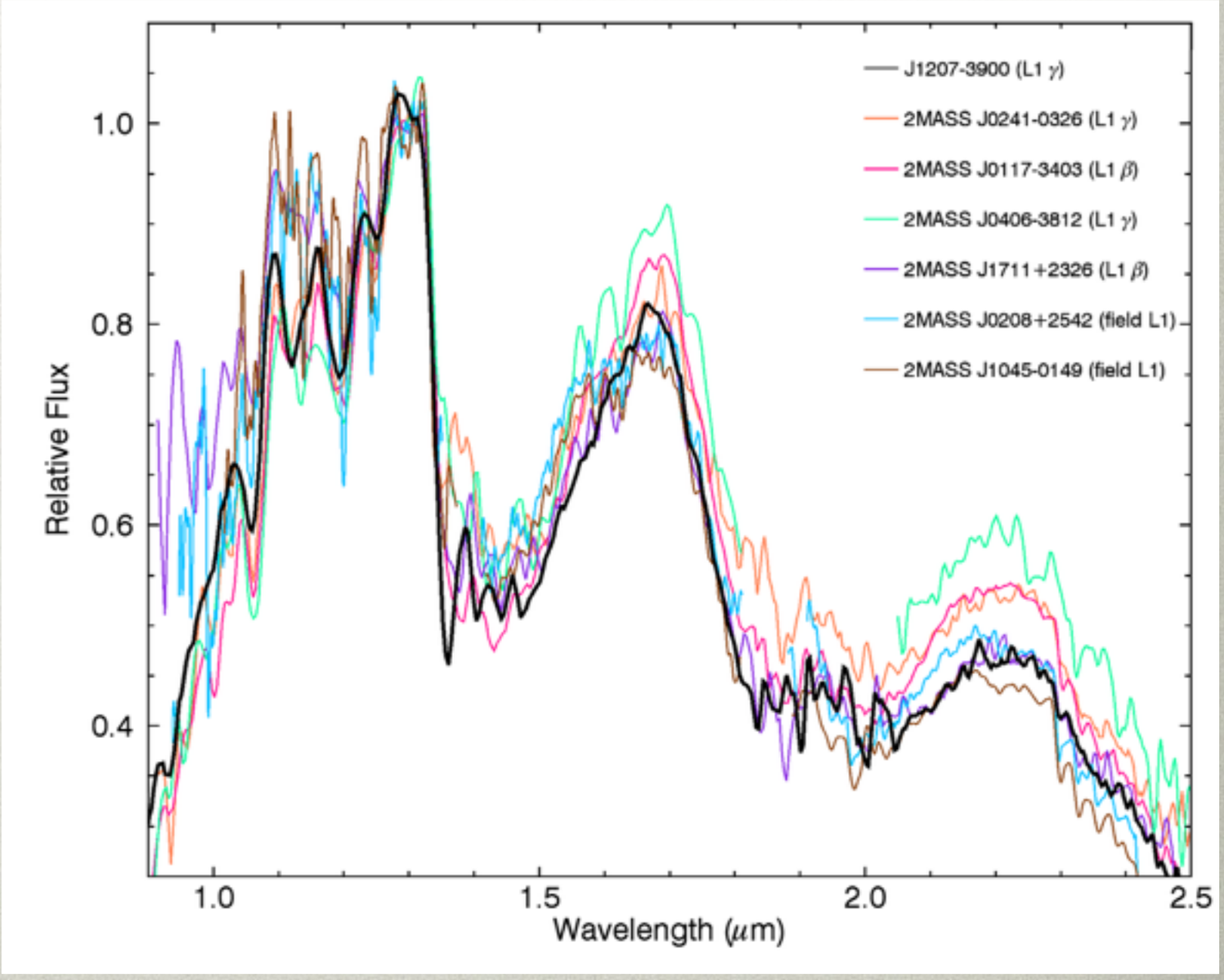
Gagné et al., 2014c
2014ApJ...792L..17G

BASS Discoveries Extra 4

(4) The first L dwarf candidate member of TW Hydrae

Estimated mass : 12 M_{Jup}

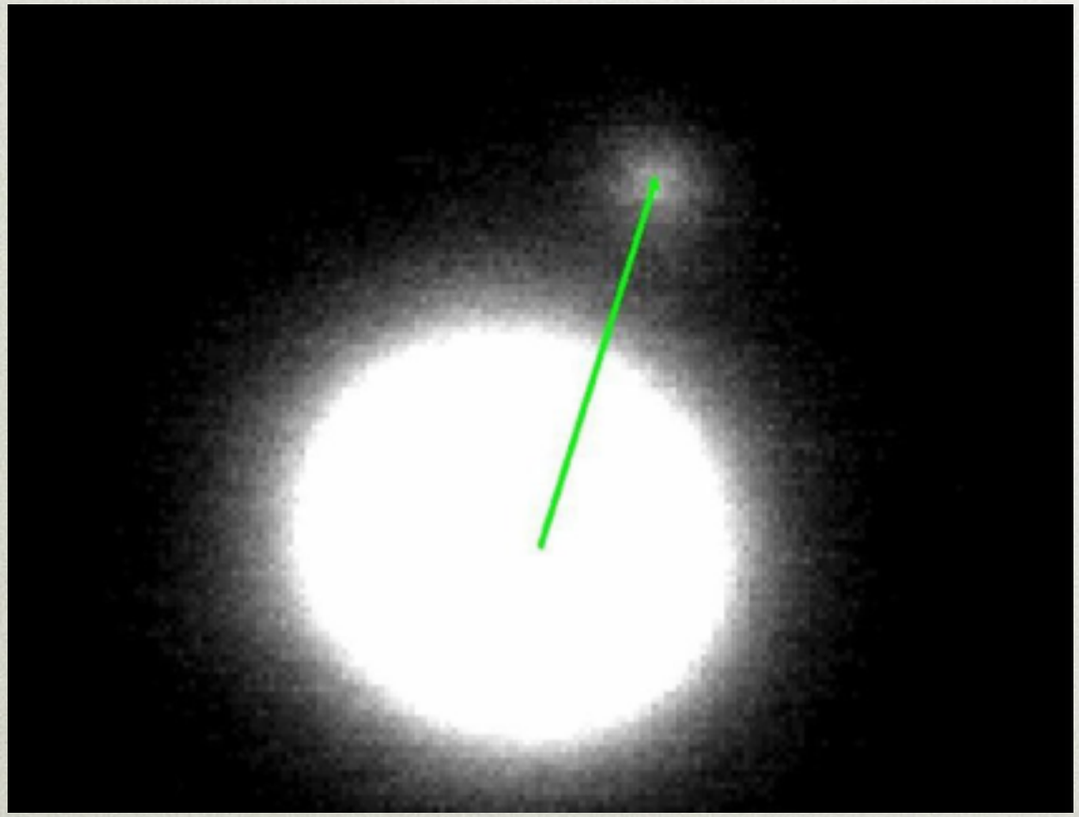




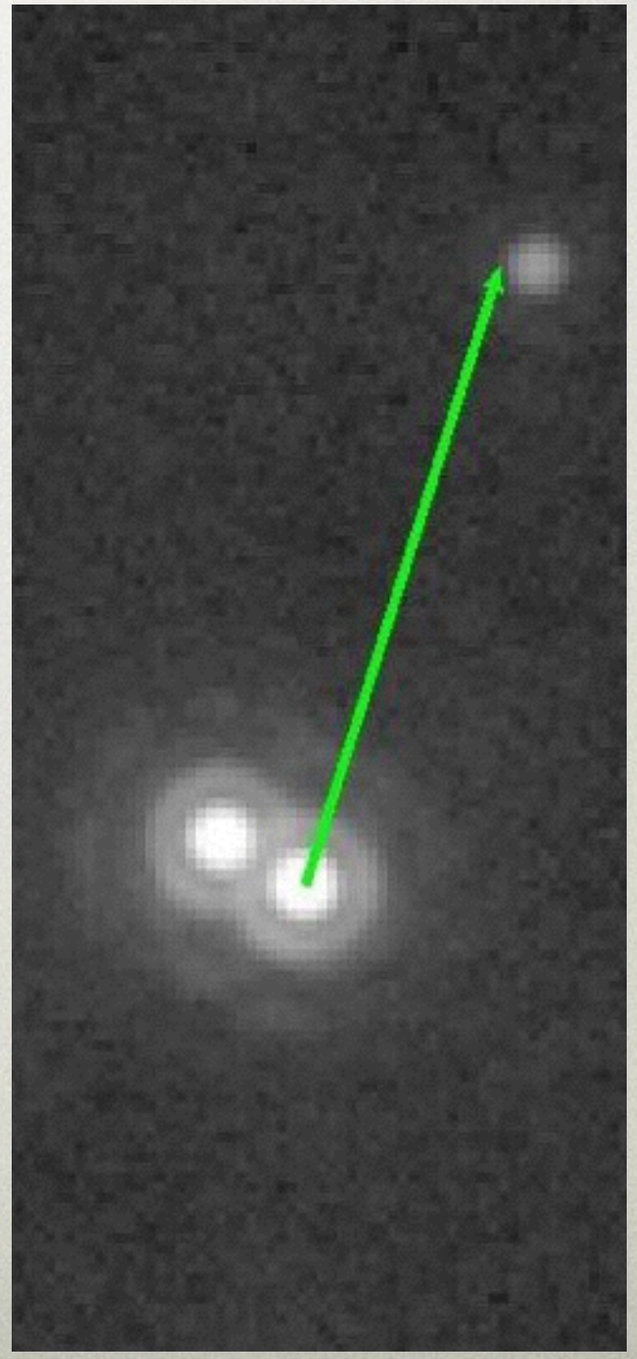
Gagné et al., 2014b
2014ApJ...785L..14G

BASS Discoveries Extra 5

(5) J0103-5515, the M5 + M5 + 12-14 MJup companion in Tucana-Horologium



Naco *H*-band

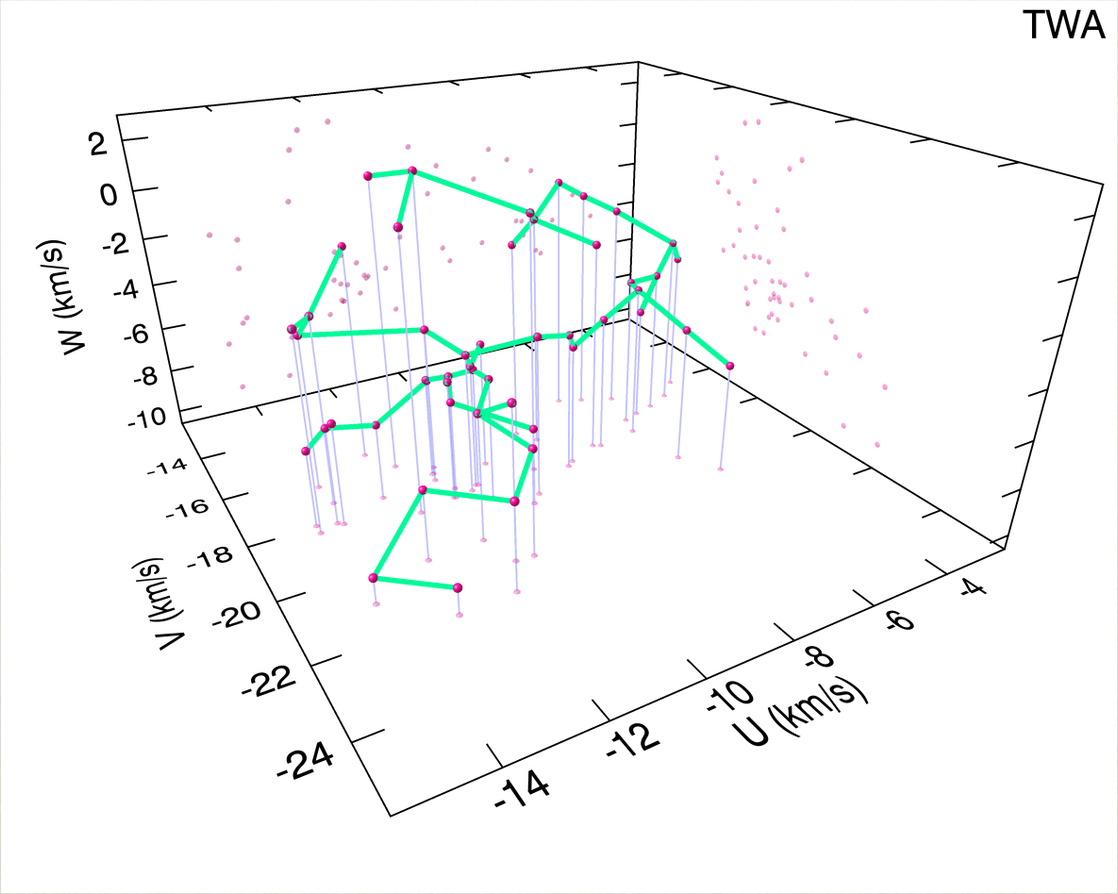


Naco *L'*-band

Delorme et al., 2013
2013A&A...553L...5D

Mass Segregation ? Extra 6

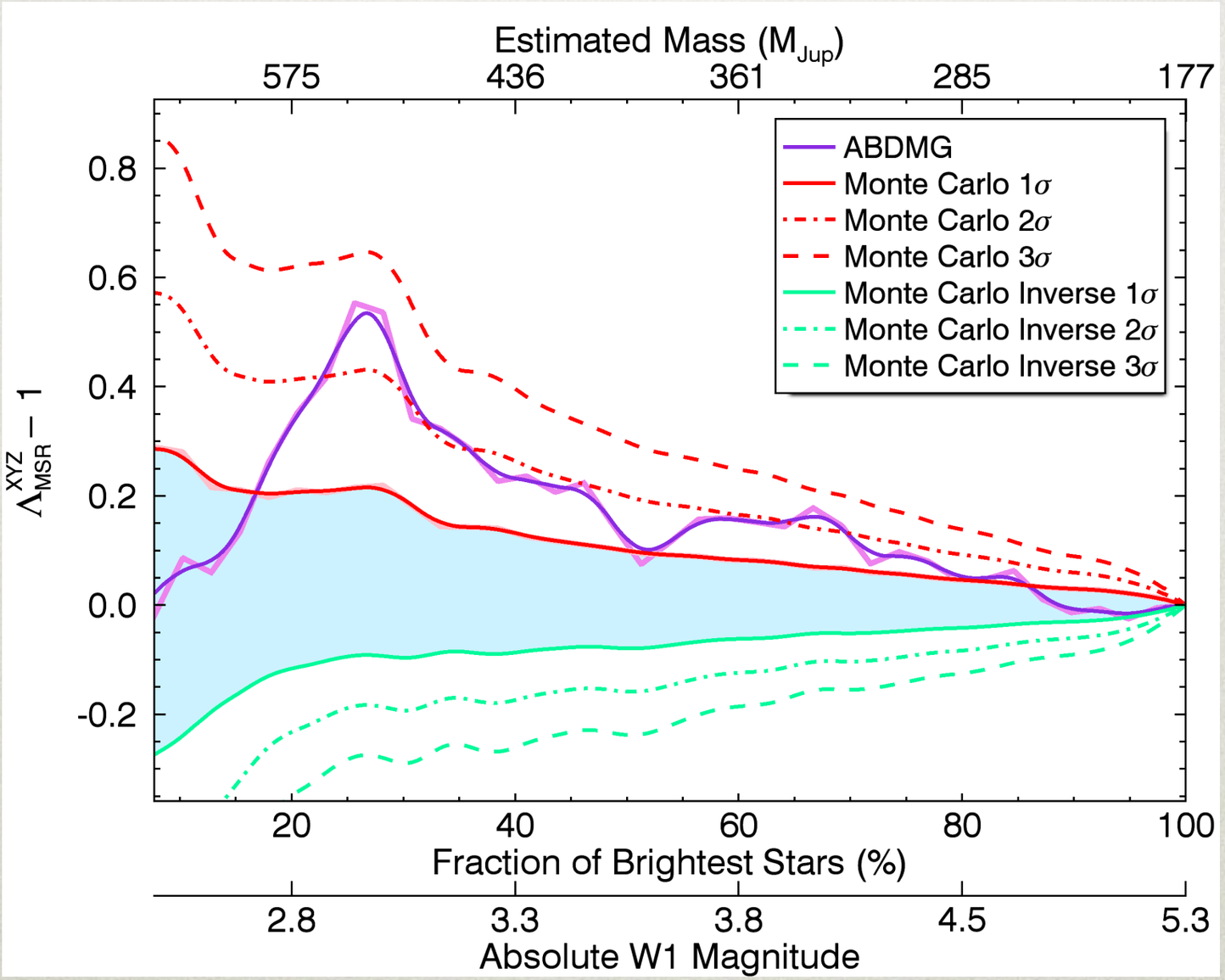
With the Method of Minimal Spanning Trees,
=> We do not need to know the center of mass <=



Gagné 2014d (Accepted ApJ)
arXiv 1410.4864

(1)Build the shortest network that connects all UVW point
(2)No Loops are Allowed
(3)Measure the total length of the Network

Mass Segregation ? Extra 7



Gagné 2014d (Accepted ApJ)
arXiv 1410.4864

(4) Build MST for N brightest members
(5) Repeat for N random members

Mass Segregation ? Extra 8

Mass Segregation is detected at ~ 2-3 sigma for :

- AB Doradus (both spatial and dynamical)
- β Pictoris (spatial only)
- Columba (dynamical only)
- Including BASS candidates increases these detections to 2 - 4 sigma + Tucana starts showing spatial + dynamical mass segregation !

=> we must measure parallax, RV and confirm youth for more substellar members to verify this

Thank You !

BDEXOCON, Delaware 2014