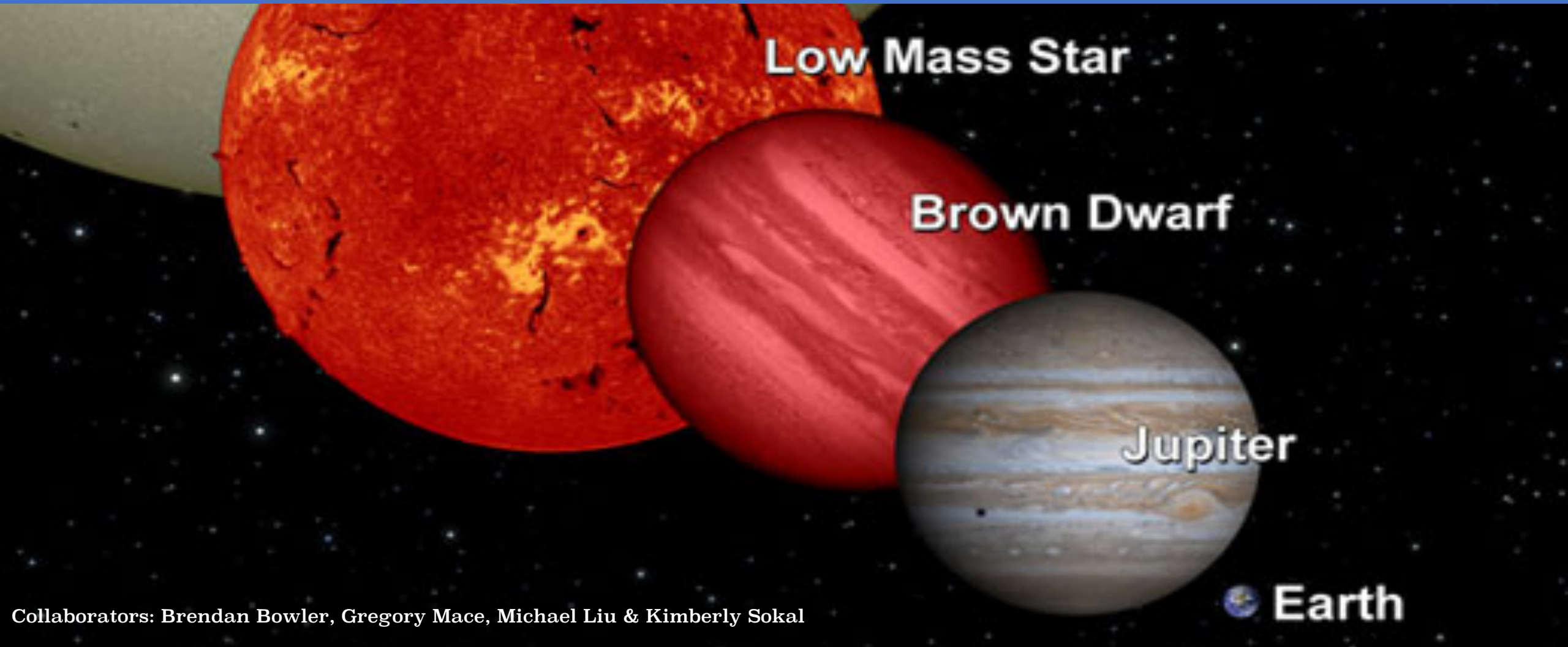


# Characterizing 2MASS J0443+3723 B:

A Young Companion at the Substellar Boundary with Potential Membership in the Beta Pictoris Moving Group



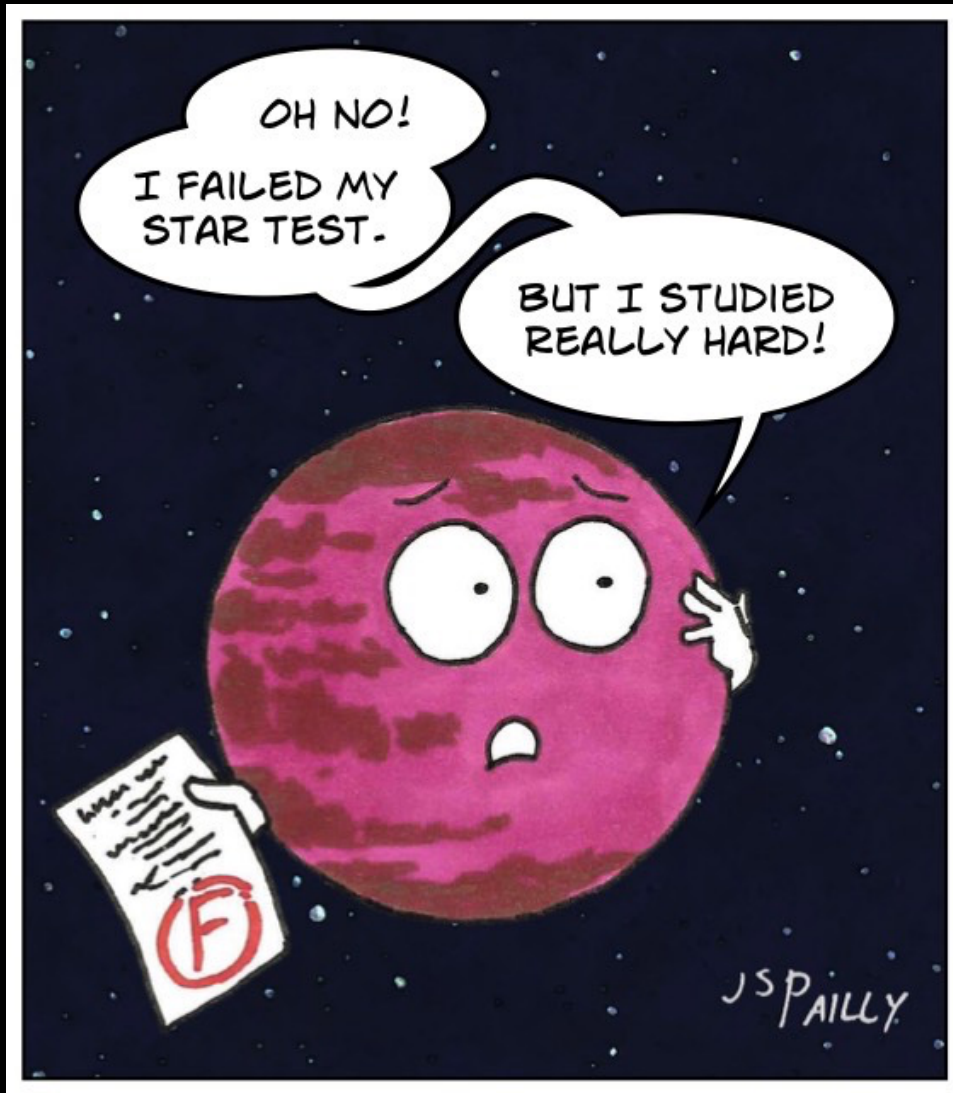
# Brown Dwarfs

$$13M_J \lesssim M_{BD} \lesssim 75M_J$$

- Insufficient mass to sustain hydrogen fusion
- Luminosity and effective temperature steadily decrease with time

“Failed Stars”

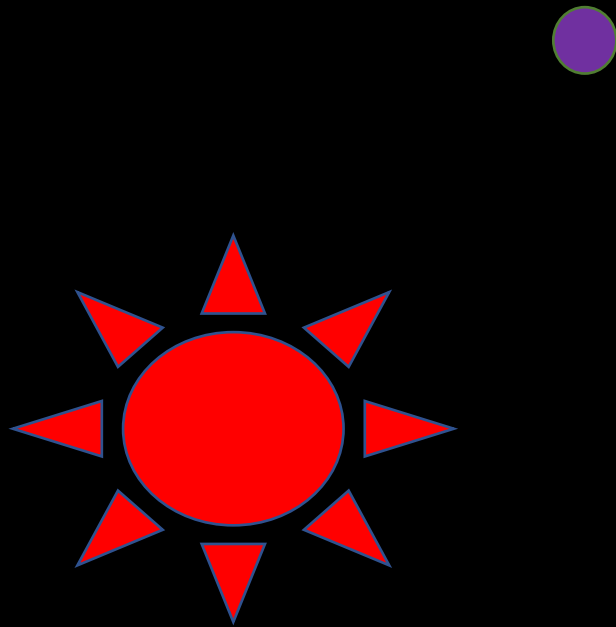
**Brown dwarfs are found in a variety of environments**



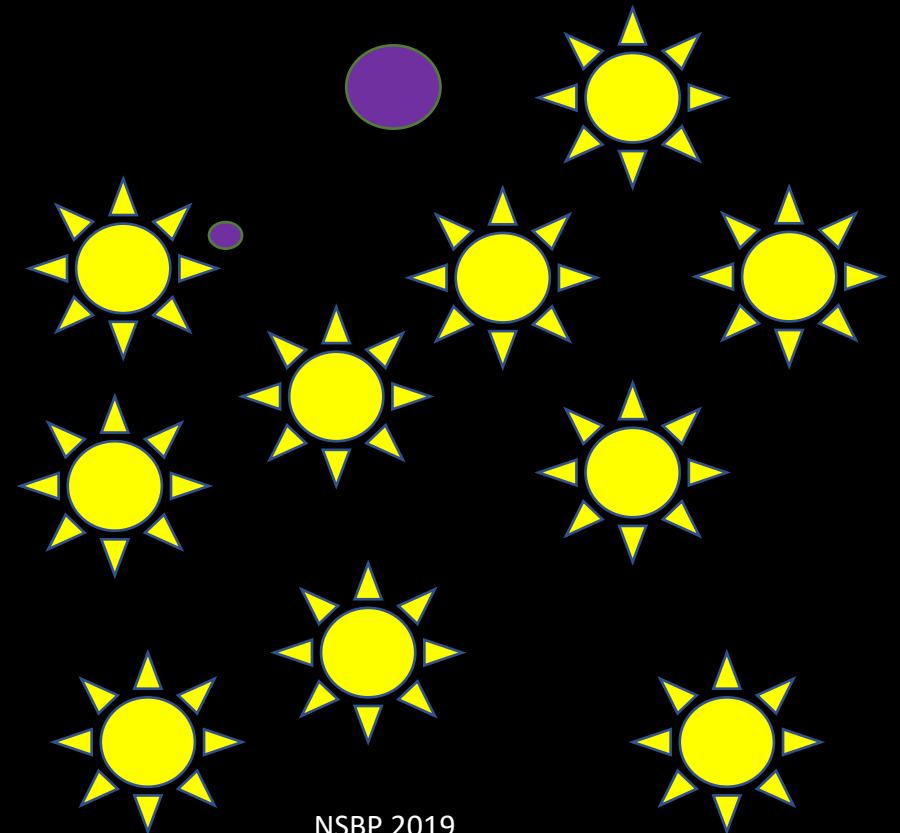
# Benchmark Brown Dwarfs

- Brown dwarfs with two fundamental parameters: age and luminosity
- Helpful for mass determination using substellar evolutionary models

## Companions



## Moving Groups



# There Are Only 5 Known Ultracool Companions in the $\beta$ Pictoris Moving Group

## Planets

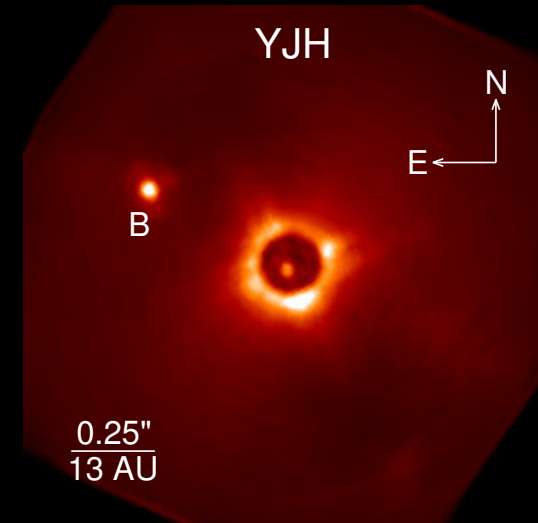
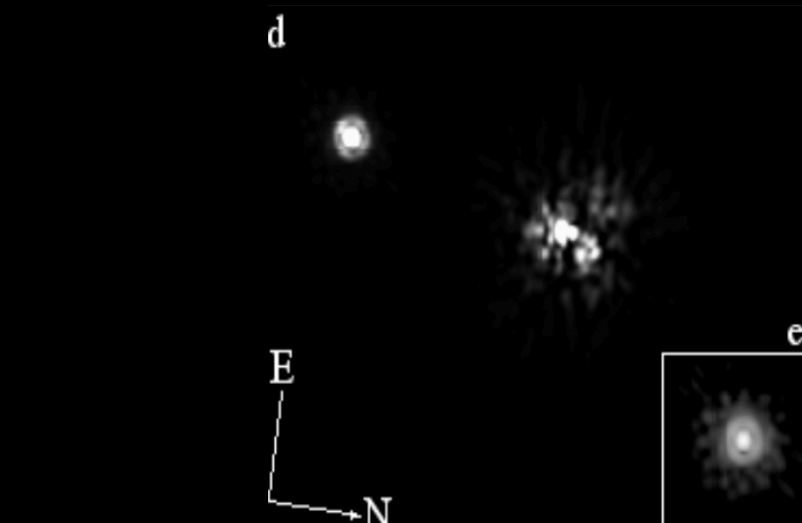
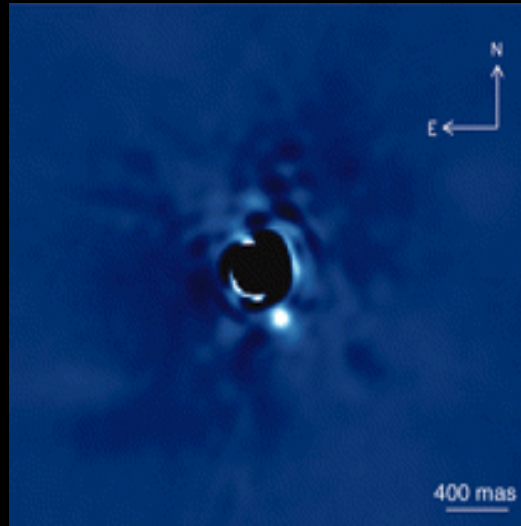
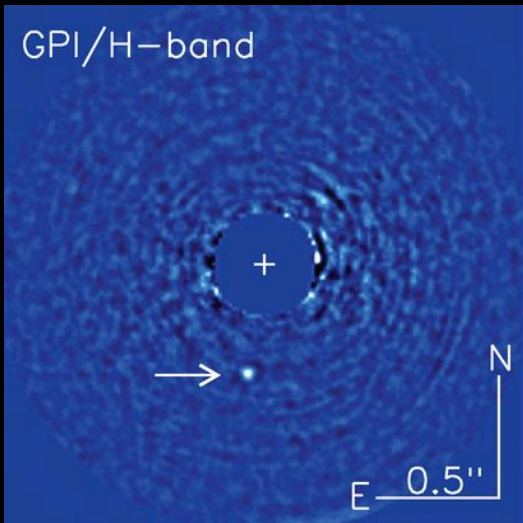
## Brown Dwarfs

Macintosh et al. 2015

Lagrange et al. 2010

Lowrance et al. 2000

Biller et al. 2010



51 Eri b

$\sim 2 M_J$

$\beta$  Pic b

$\sim 13 M_J$

HR 7329 B

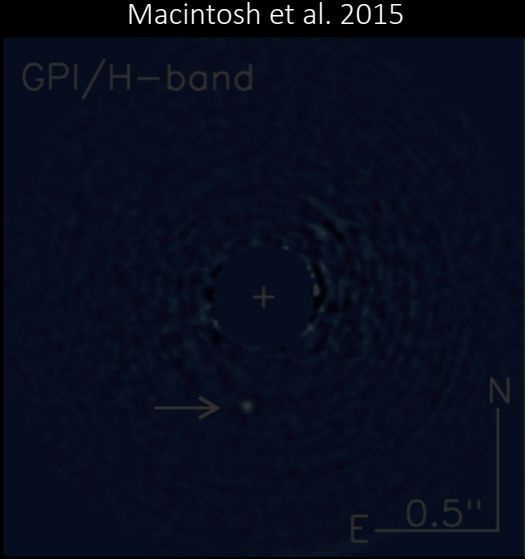
$\sim 50 M_J$

PZ Tel B

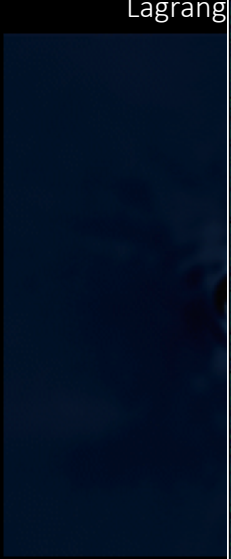
$\sim 38-72 M_J$

# There Are Only 5 Known Ultracool Companions in the $\beta$ Pictoris Moving Group

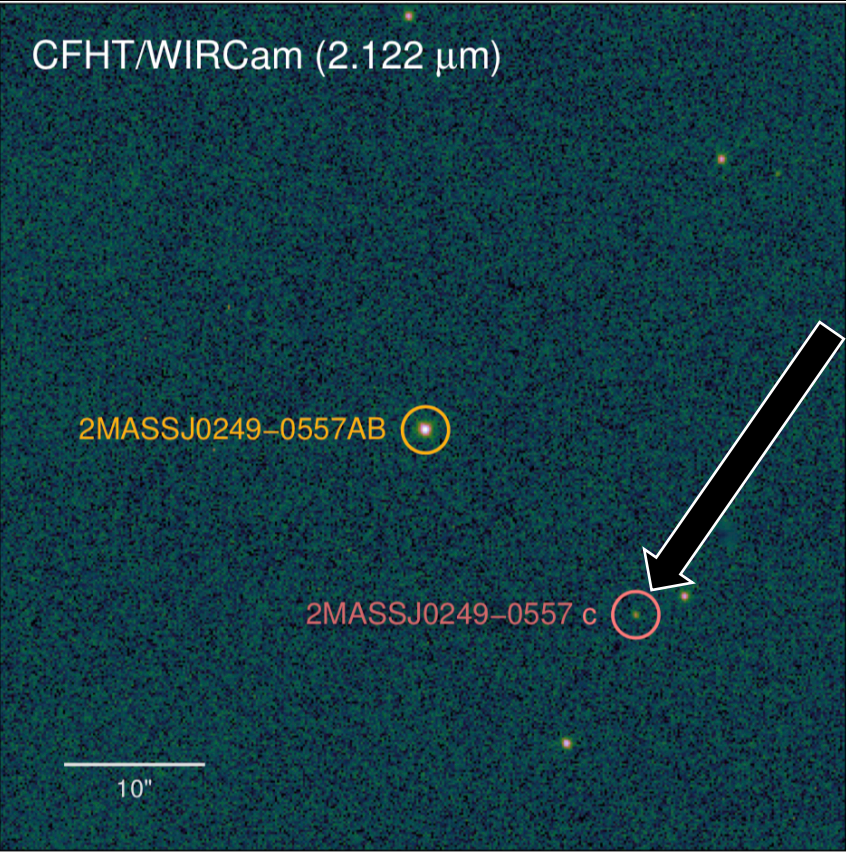
Dupuy et al. 2018



51 Eri b  
~2  $M_J$



$\beta$  Pic  
~13  $M_J$



2MASS 0249 c  
~11.6  $M_J$

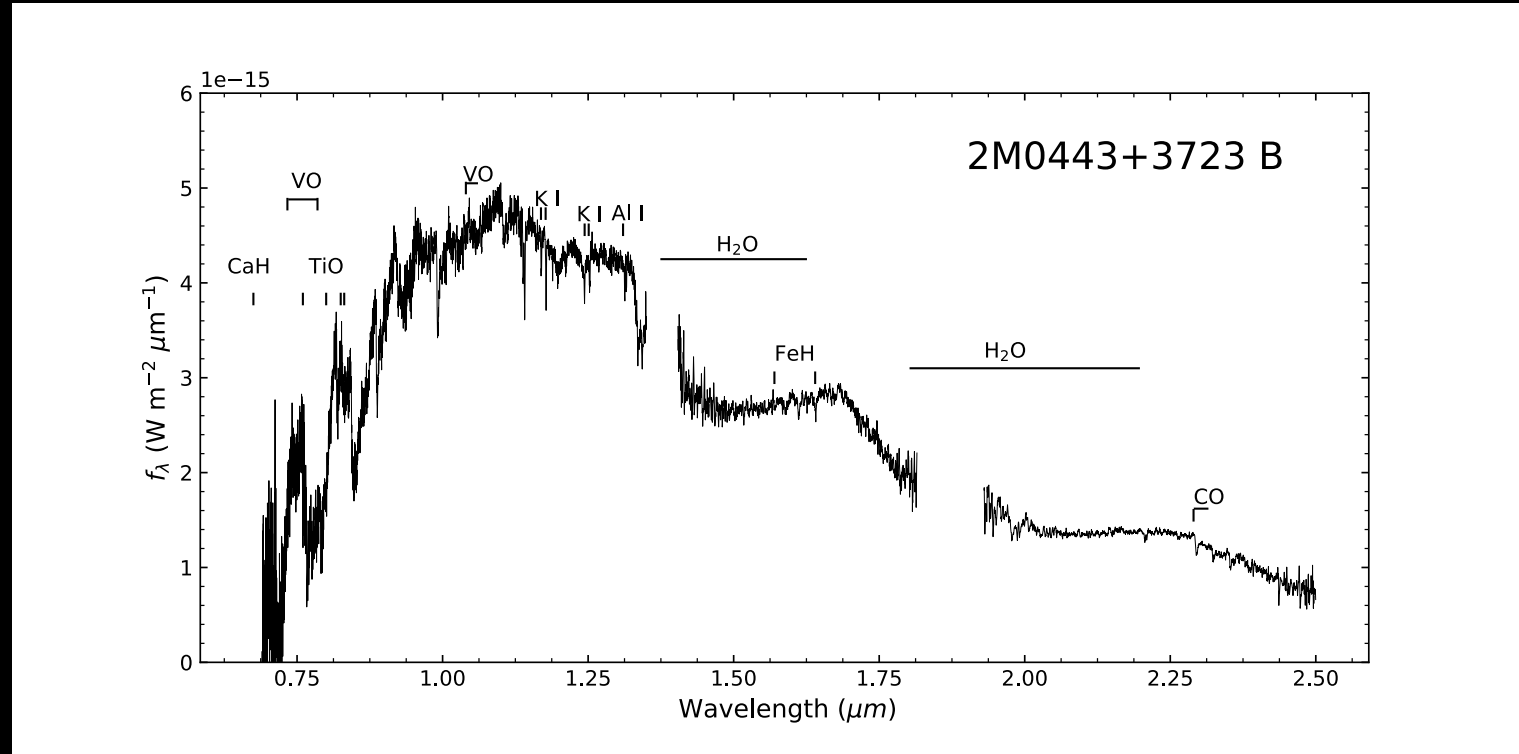
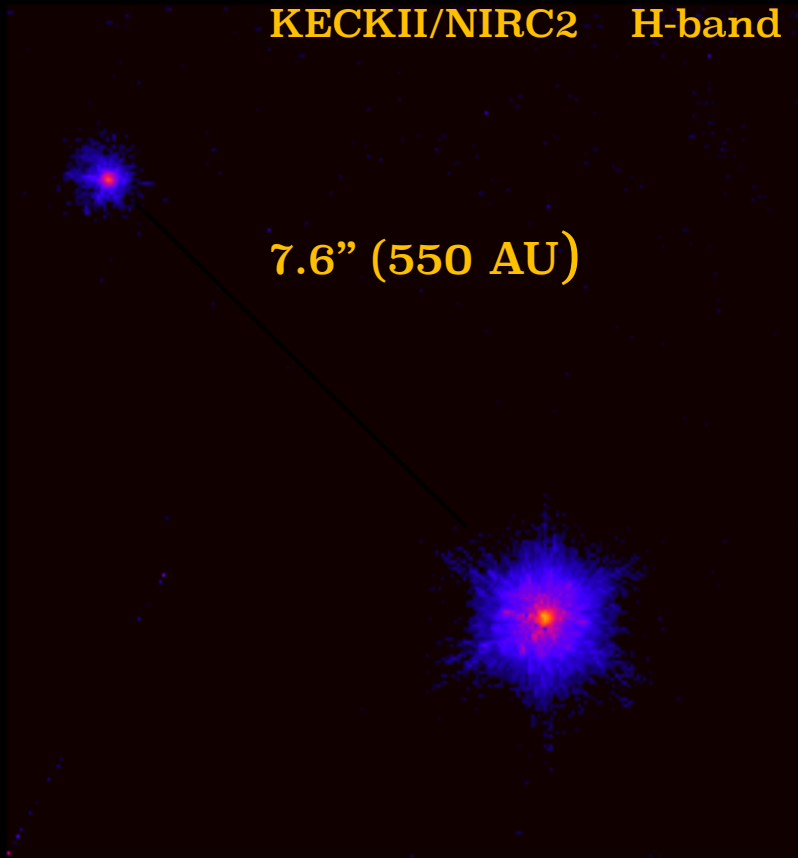


29 B  
 $M_J$



PZ Tel B  
~38-72  $M_J$

# 2M0443+3723 B



Phillips et al., in  
prep

# 2M0443 B:

an analog system to PZ Tel B

SpT

Sep(AU)

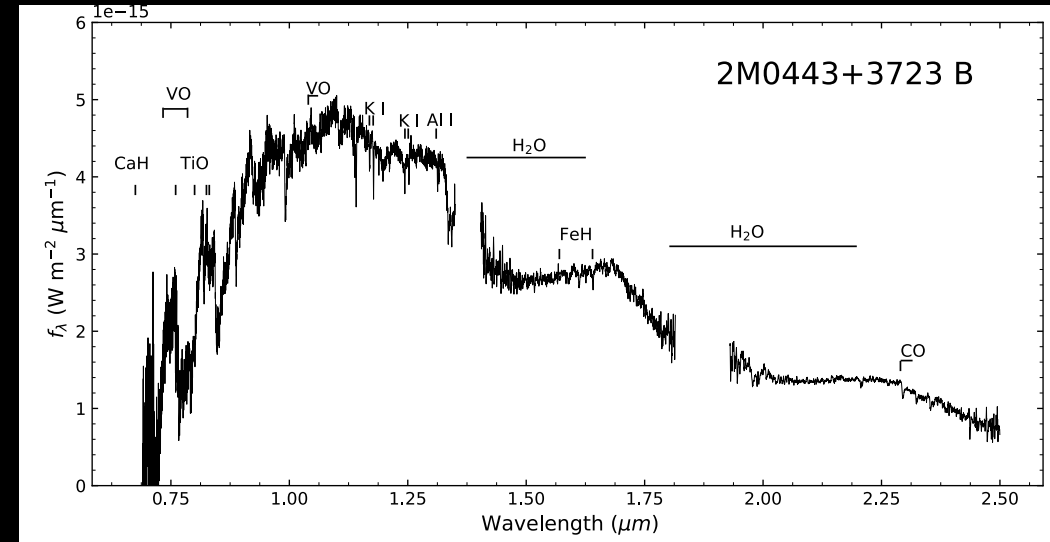
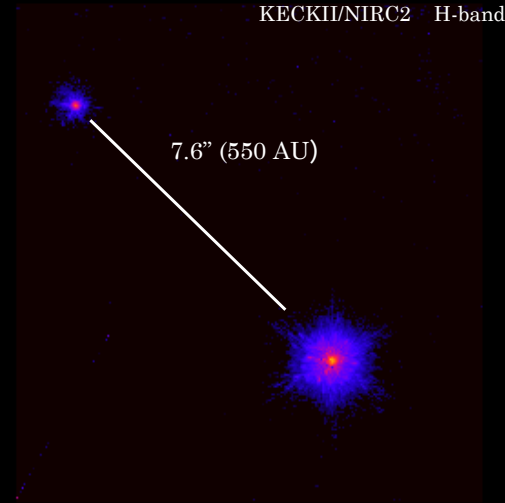
$T_{\text{eff}}(K)$

$\log g(\text{dex})$

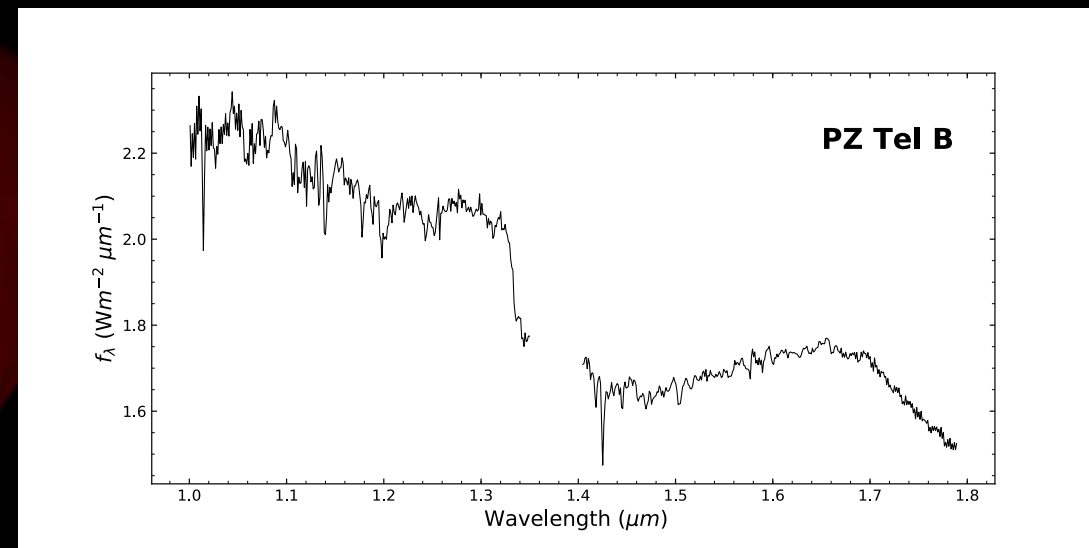
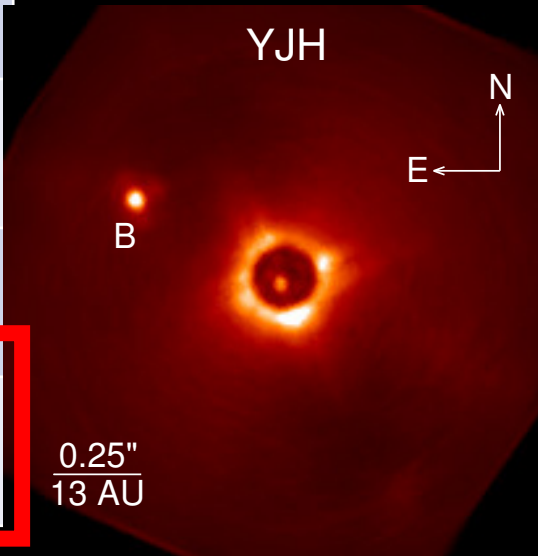
$\log\left(\frac{L}{L_{\odot}}\right)$

Mass( $M_J$ )

	2M0443 B	PZ Tel B
SpT	$M6 \pm 1$	$M7 \pm 1$
Sep(AU)	550	25
$T_{\text{eff}}(K)$	$2800 \pm 100$	$2700 \pm 100$
$\log g(\text{dex})$	4.0	$< 4.5$
$\log\left(\frac{L}{L_{\odot}}\right)$	$-2.12 \pm 0.03$	$-2.51 \pm 0.10$
Mass( $M_J$ )	$\sim 99 \pm 5$	38 – 72

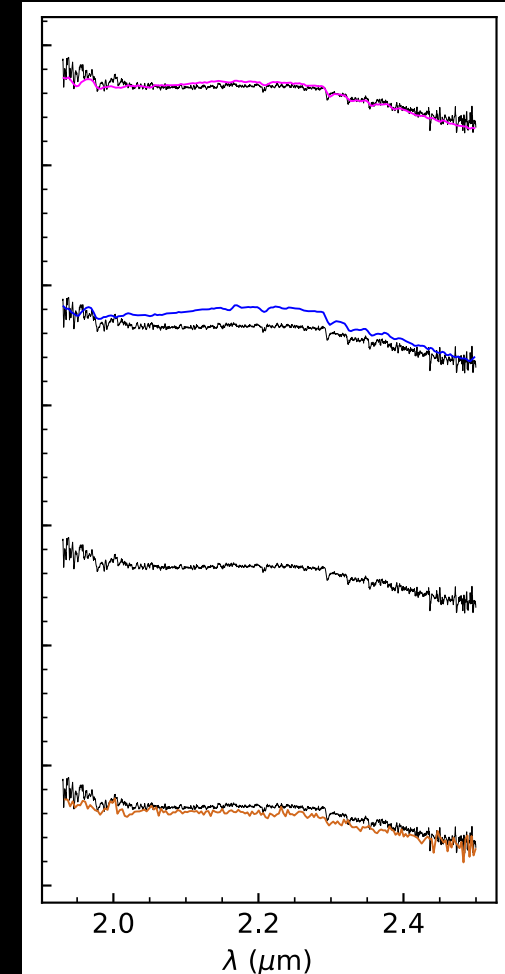
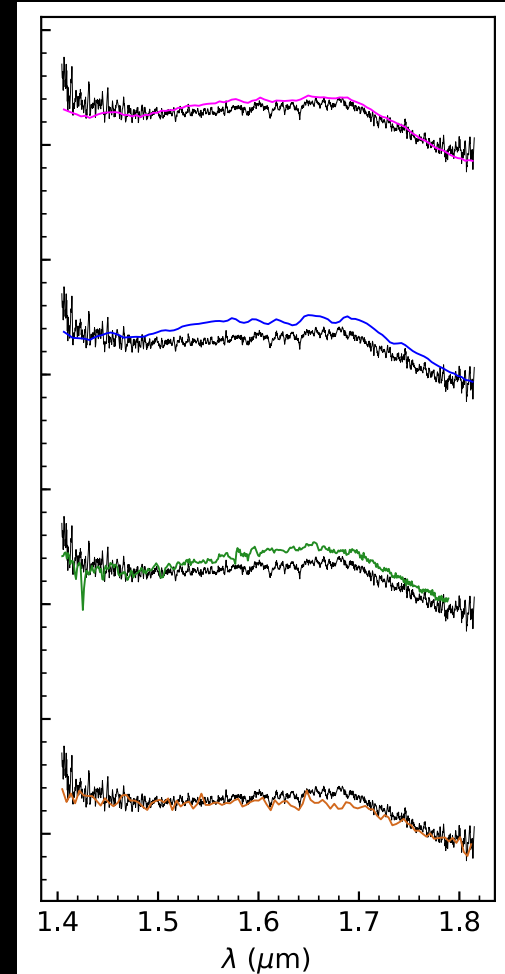
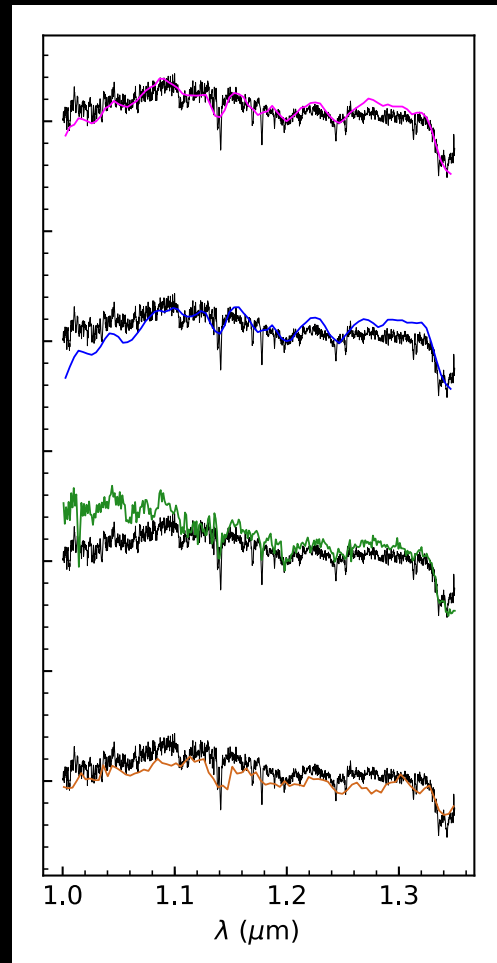
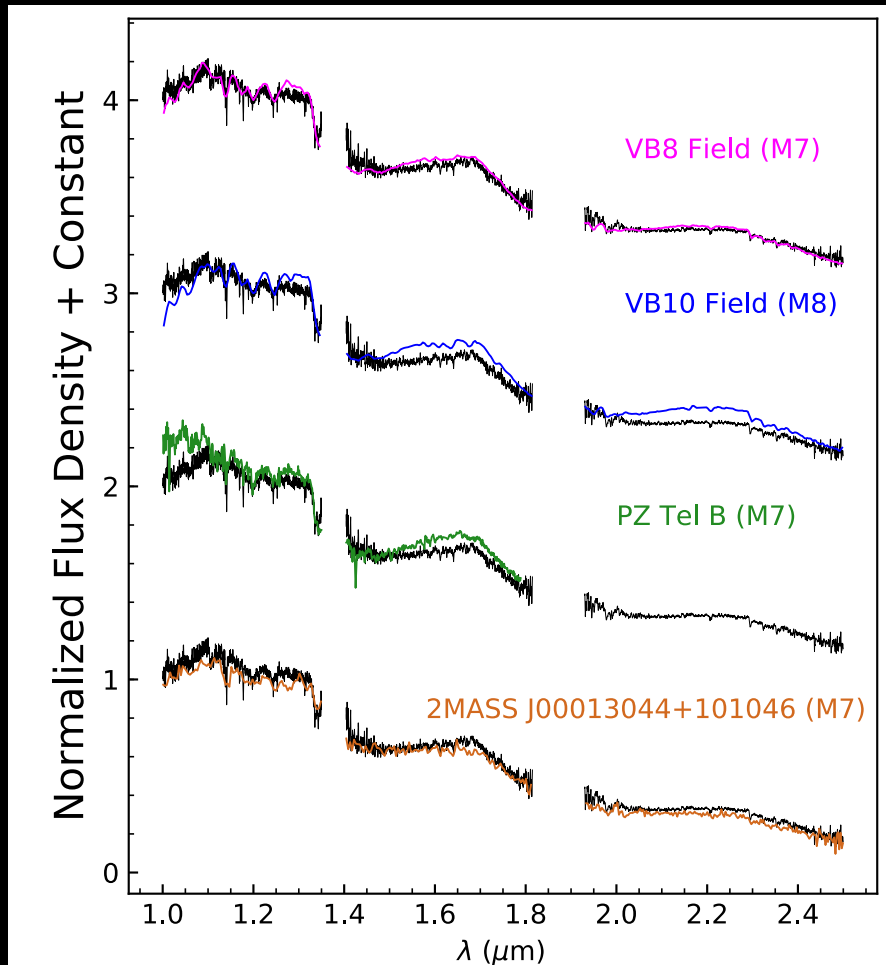


Maire et al. 2015



NSBP 2019

# 2M0443 B is Comparable to Young and Field Ultracool Dwarfs



Phillips et al., in prep



# Determining Spectral Type with Allers & Liu 2013

Allers & Liu 2013

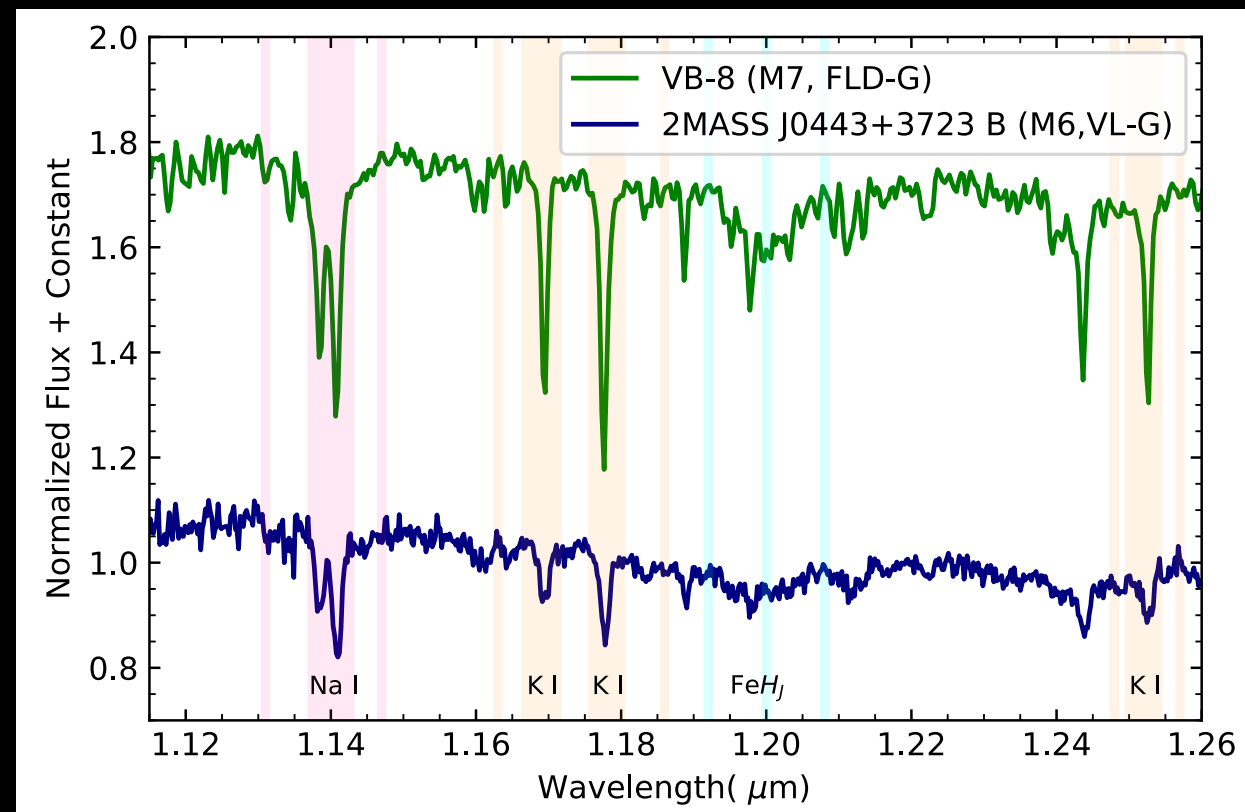
## Main Results

- M6 spectral type
- Gravity score: VL-G

## Allers & Liu 2013 Classification Scheme

- VL-G:  $\leq 30$  Myr
- INT-G: 50~200 Myr
- FLD:  $\geq 200$  Myr

Caprice Phillips



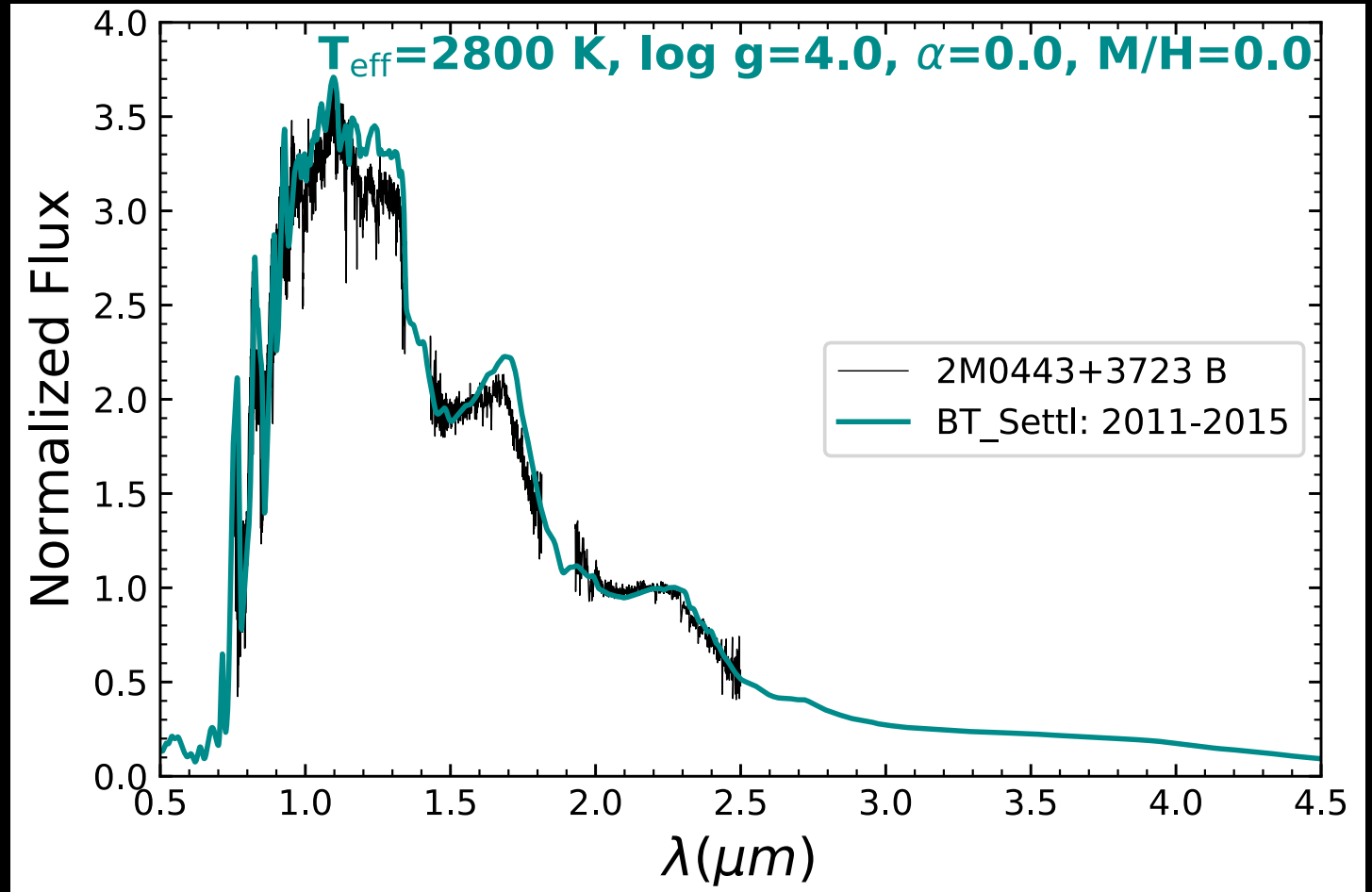
Phillips et al., in prep

**SIGNATURE OF  
YOUTH**

NSBP 2019

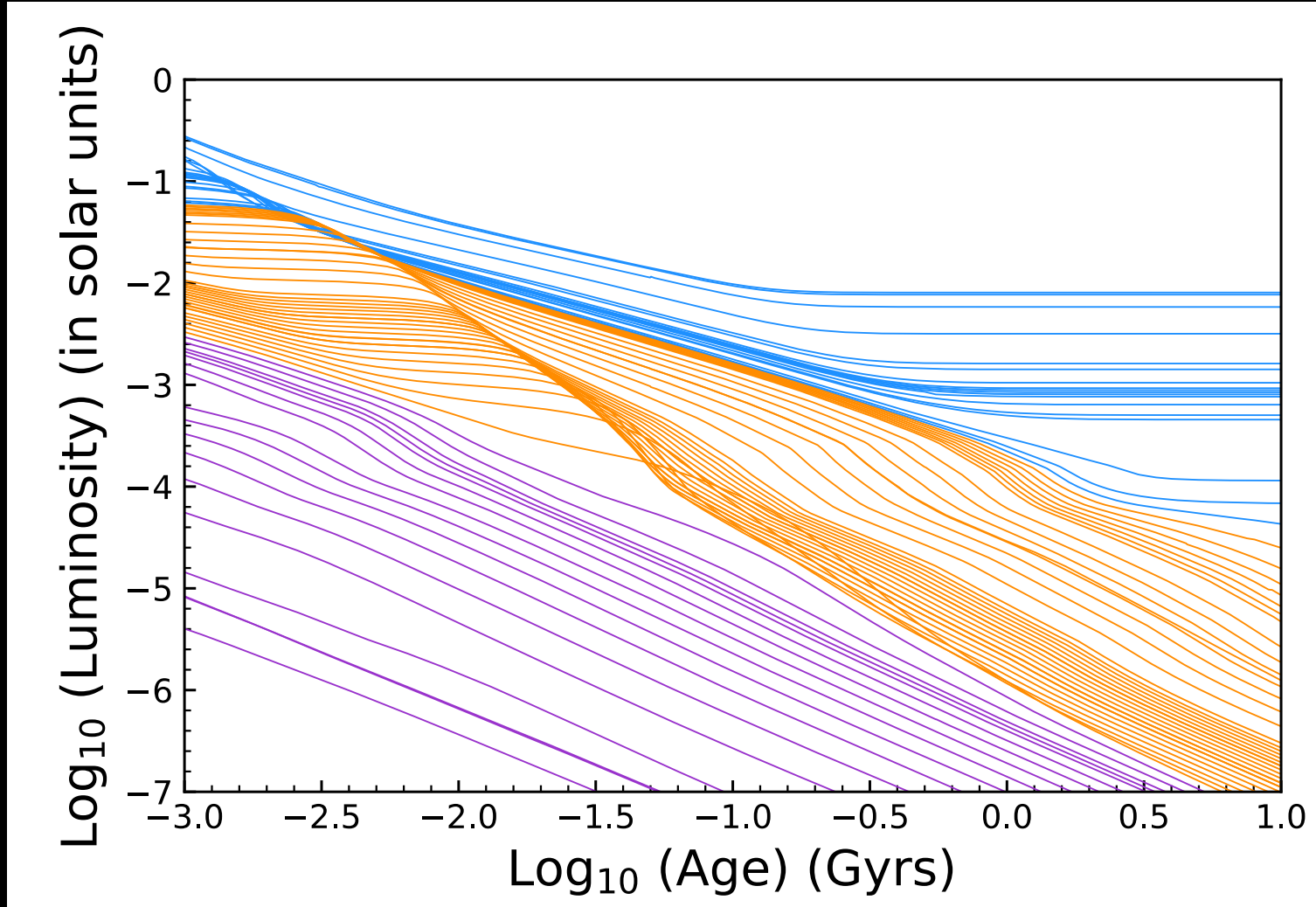
# Atmospheric Model Comparison Show $T_{\text{eff}} = 2800 \text{ K}$ and $\log g = 4.0 \text{ dex}$

**SIGNATURE OF  
YOUTH**



Phillips et al., in prep

# Age + Luminosity $\longrightarrow$ Mass



**Low  
Mass  
Stars**

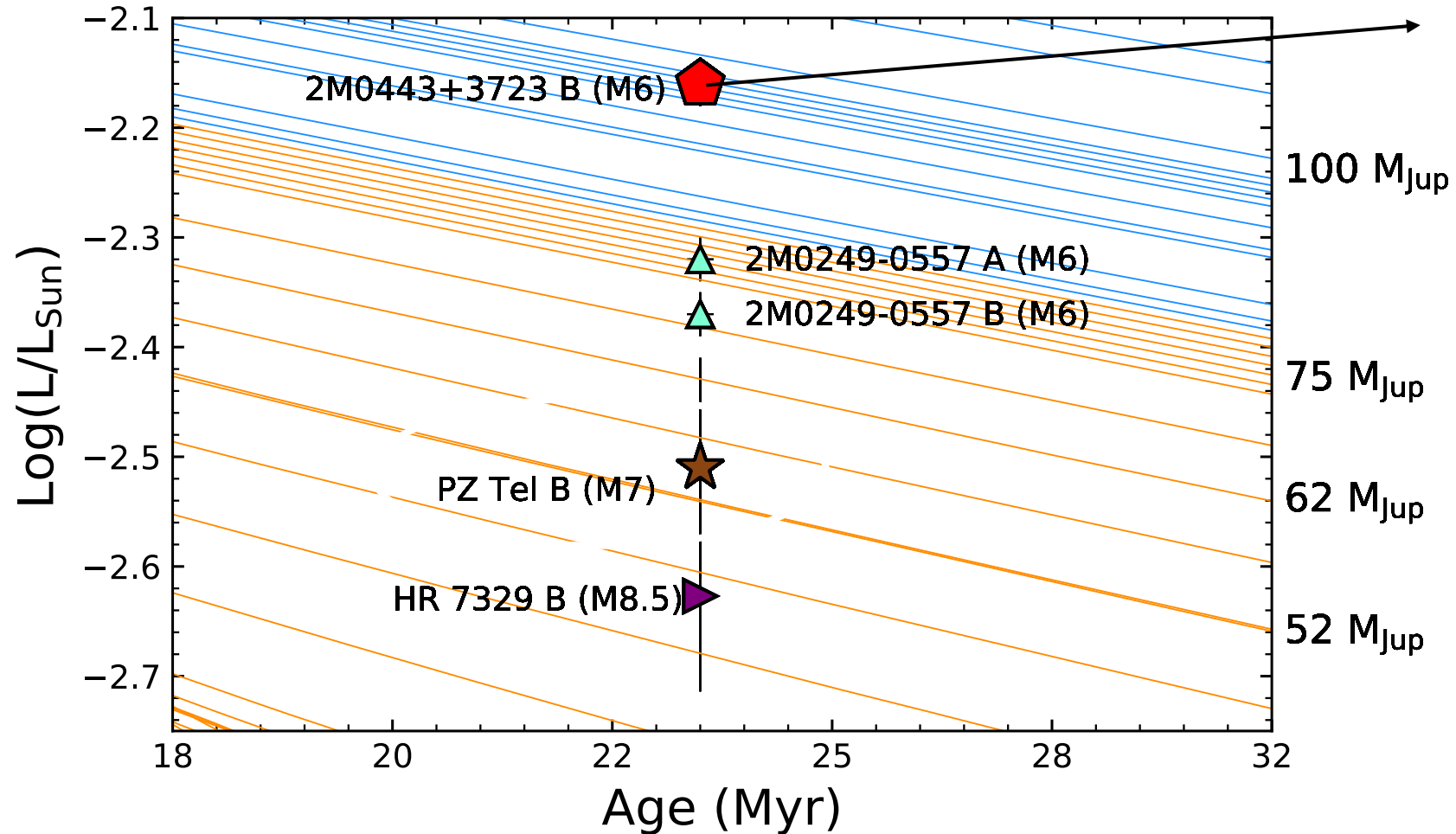
**Brown  
Dwarfs**

**Gas  
Giants**

Burrows 2001

$$13M_J \lesssim M_{BD} \lesssim 75M_J$$

# Model Dependent Mass is $> 75M_J$

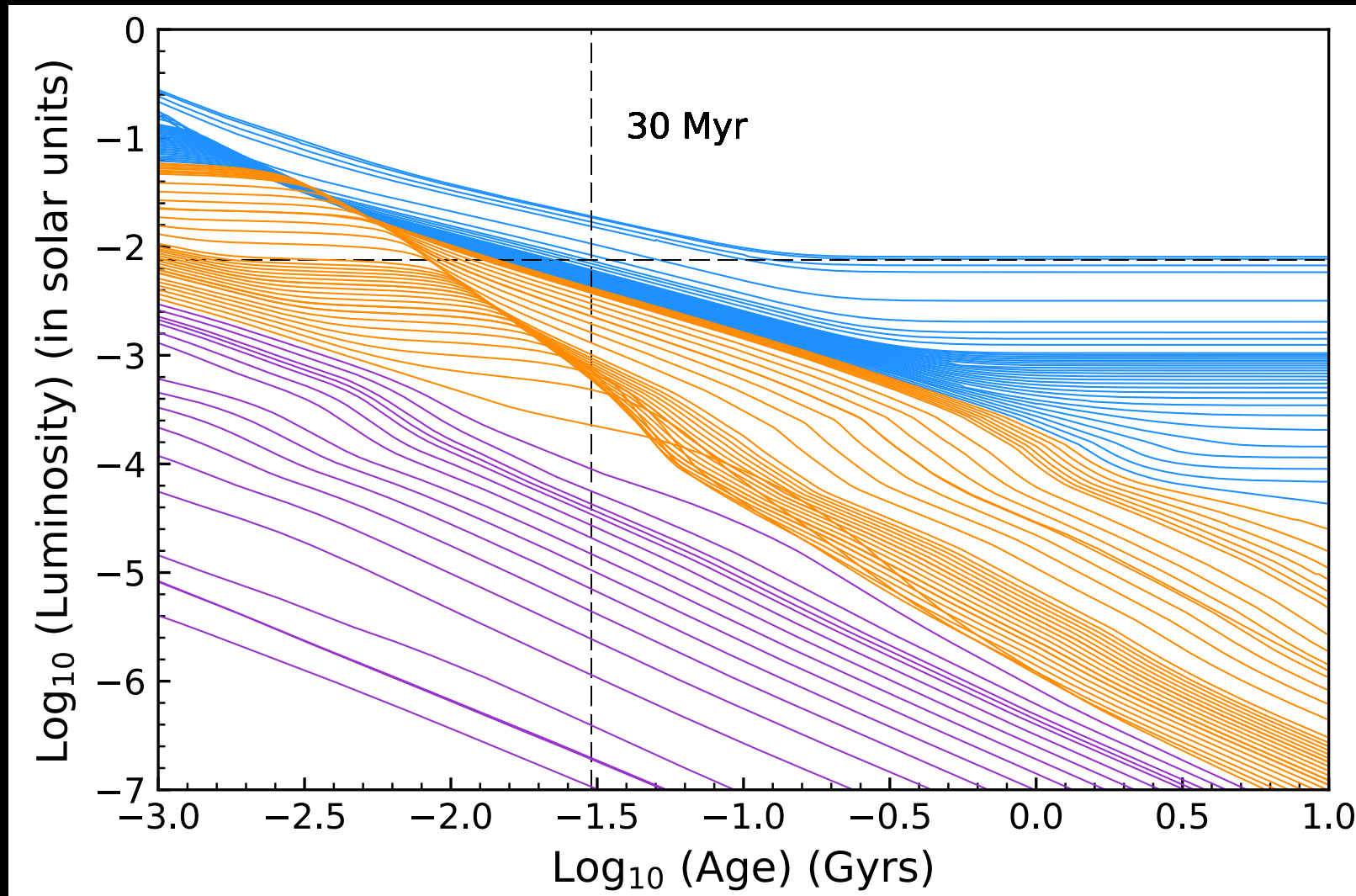


$99 \pm 5 M_J$

$$13M_J \lesssim M_{BD} \lesssim 75M_J$$

Phillips et al., in prep

# Age Changes the Inferred Mass



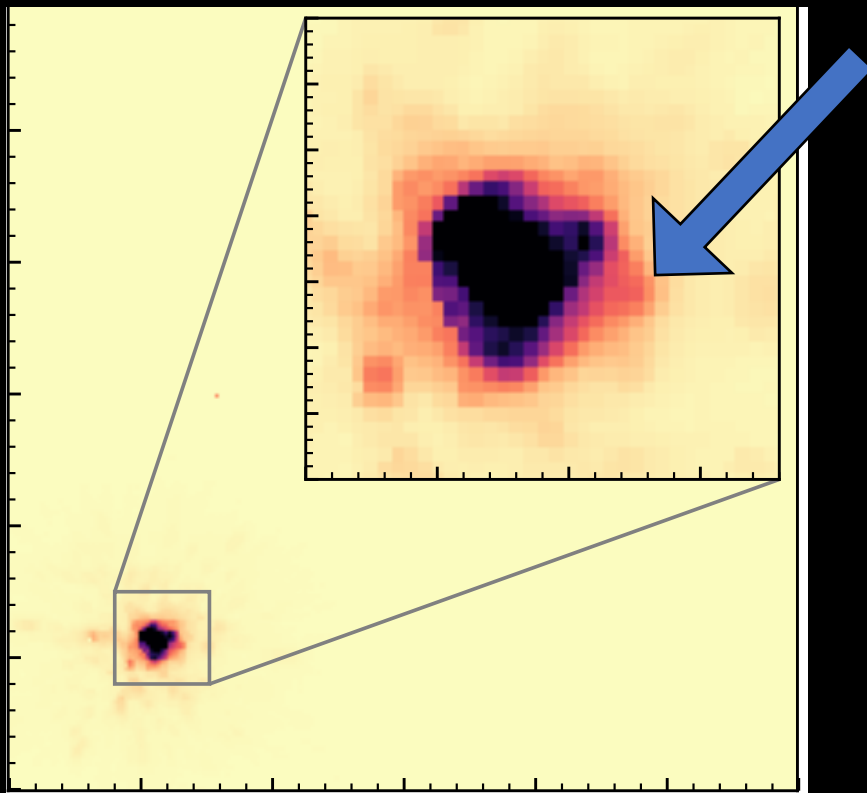
**Low Mass  
Stars**

**Brown  
Dwarfs**

**Gas  
Giants**

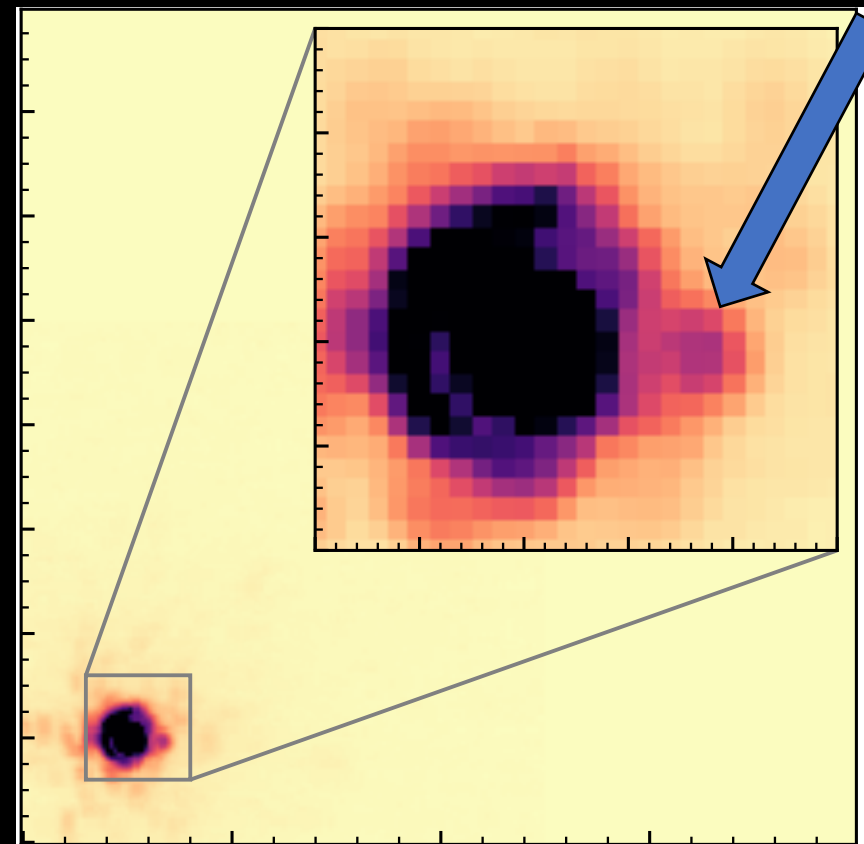
# 2M0443 B Could Be an Unresolved Binary

**HOST STAR: 2M0443 A**



Caprice Phillips

**2M0443 B**

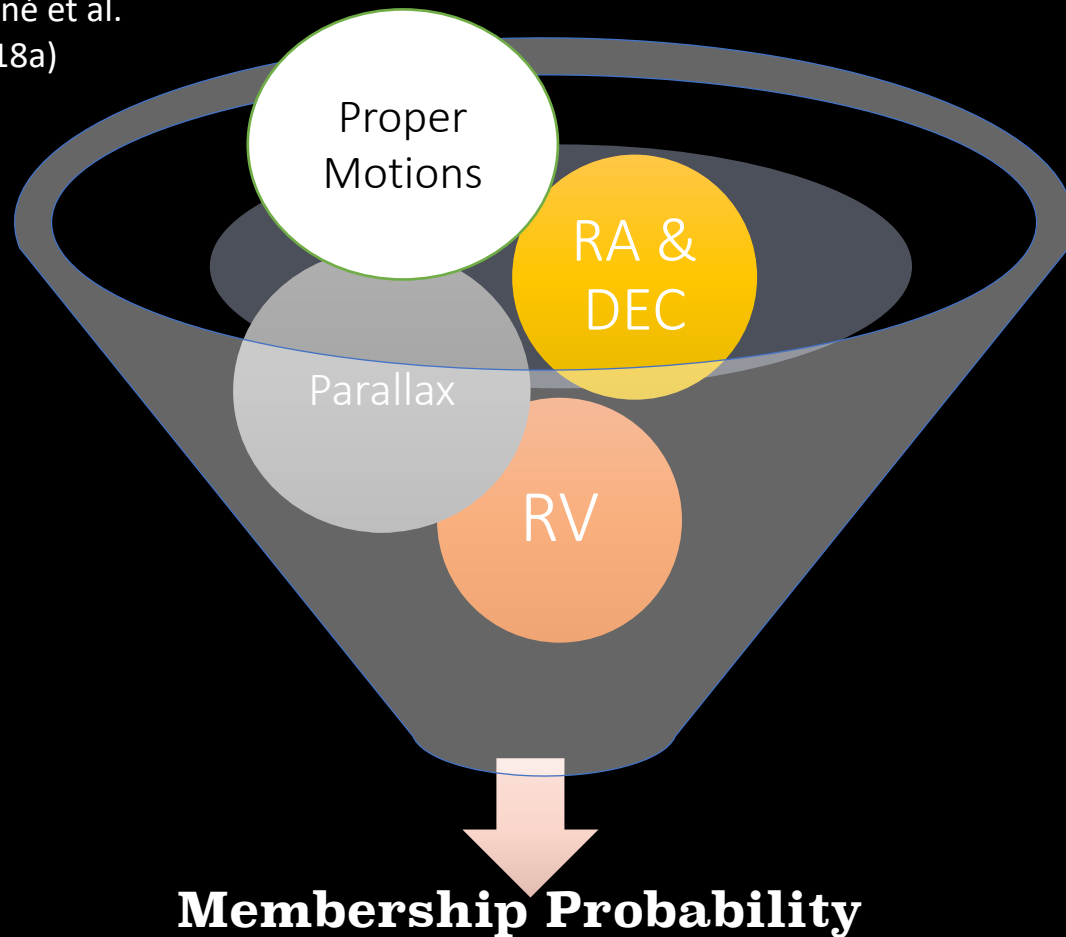


Phillips et al., in prep

NSBP 2019

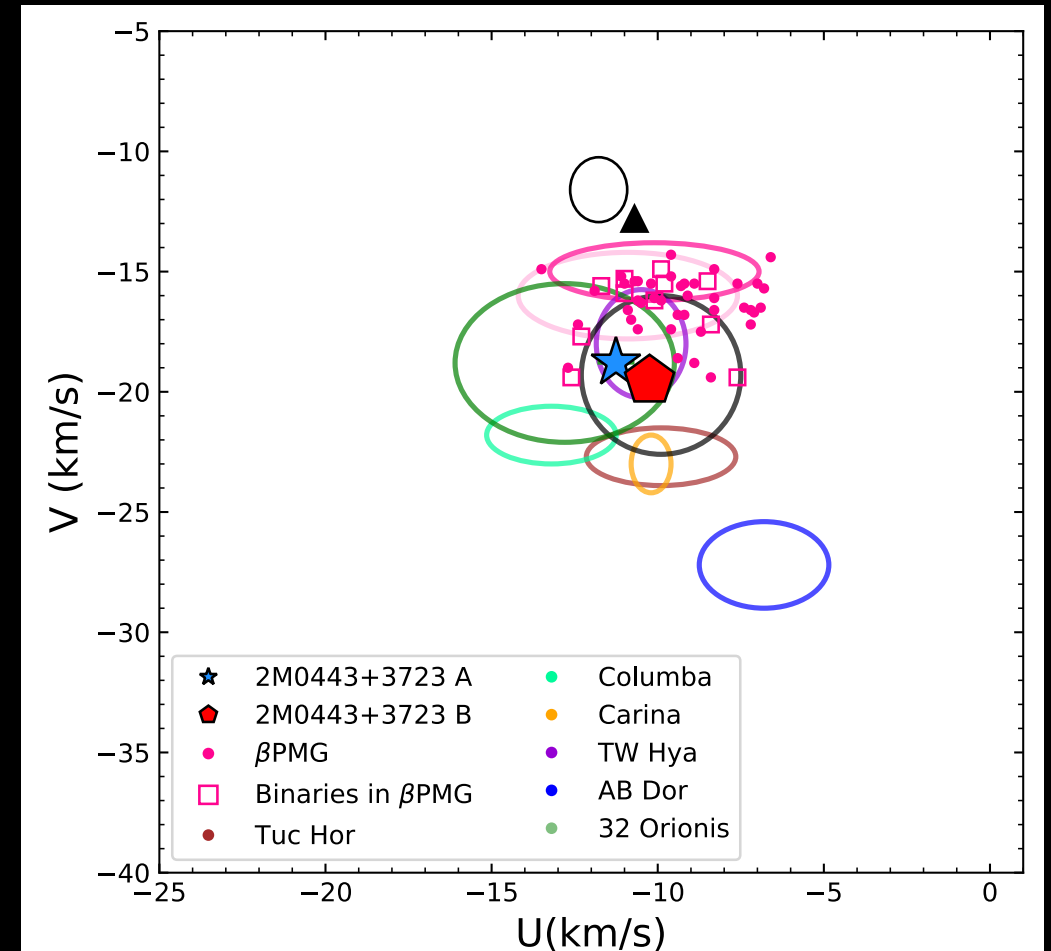
# Assessing Membership with BANYAN $\Sigma$

Gagné et al.  
(2018a)



- **2M0443 B: 0 %** for BPMG and 99.9% for field
- **2M0443 A: 0.4 %** for BPMG and 99.6 % for field

**2M0433 AB kinematics are inconsistent with nearby young moving groups**



# Conclusions

BPMG member

Young field object

Kinematic  
outlier

Indicators of  
youth  
VL-G

Single

Unresolved  
binary

$M \sim 99 \pm 5 M_J$

$M \sim 52 \pm 3 M_J$

Mass in range 30-110  $M_J$