
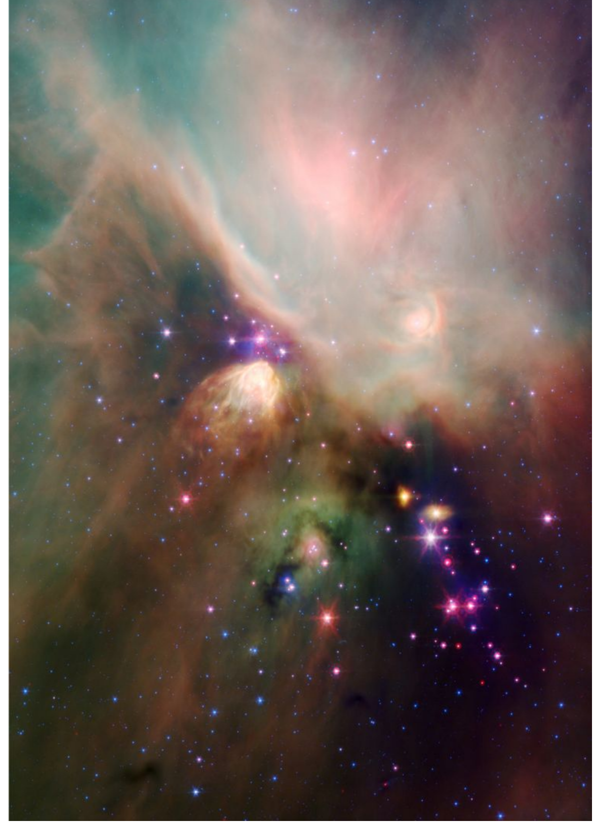

The SONYC survey:

Understanding brown dwarf formation through multi-object spectroscopy

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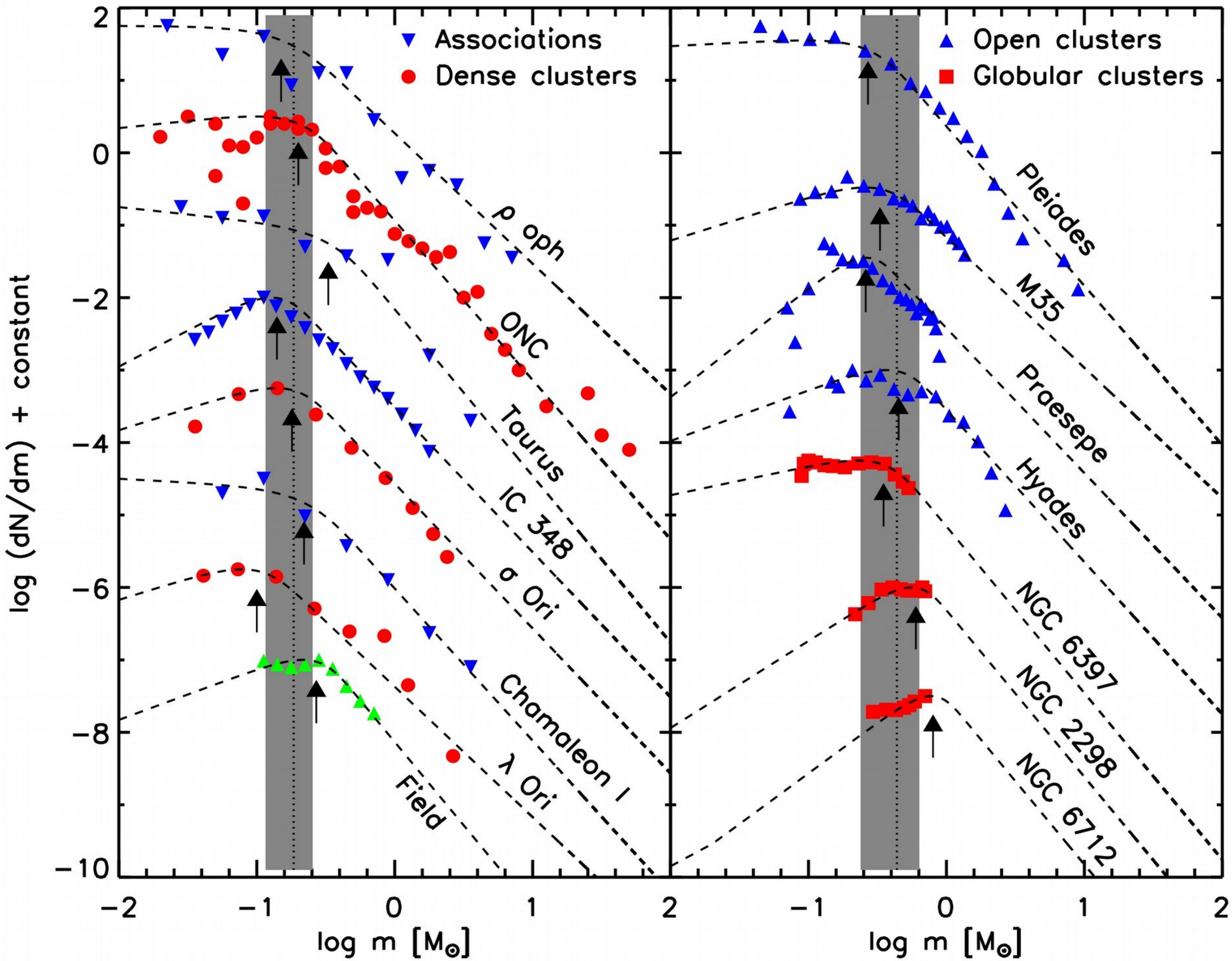
Initial mass function (IMF)

Bastian et al. (2010)



SONYC * Substellar Objects in Nearby Young Clusters

Observationally constrain the low-mass-end of the IMF in diverse star forming regions

How many of BDs are there, compared to stars?

Lower limit for star formation?

Does the environment influence the shape and the cutoff of the IMF?

How do the BDs form?

SONYC * Substellar Objects in Nearby Young Clusters

accretion

atmospheres

activity

Large samples of brown dwarfs: groundwork for characterizations of their properties

disks

dynamics

multiplicity

spatial distribution

Benchmark objects to calibrate models

Why look in star forming regions?

reliable mass functions (same distance, age, star-formation history)

(relatively) compact

substellar objects are luminous (youth)

no effects of dynamical evolution

star formation conditions directly observable

extinction: makes BDs fainter, reddens also background sources
(membership issues: spectra needed for every object)

differential reddening

uncertainties in models at young ages

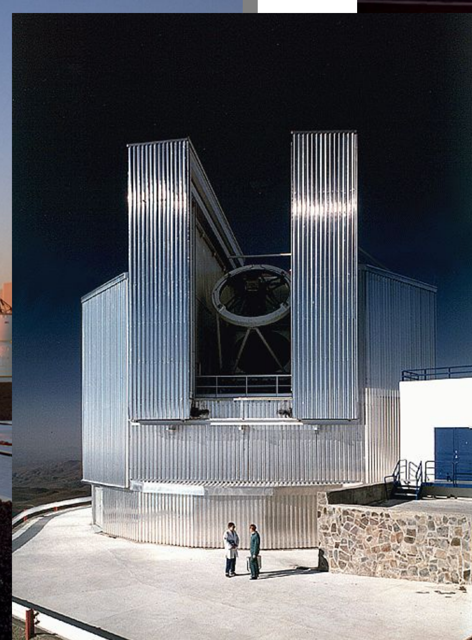
STEP 1 deep optical and near-infrared photometry

→ selection of the candidates aims to detect photosphere

Optical: SuprimeCam/Subaru, VIMOS/VLT, MOSAIC/CTIO-4m

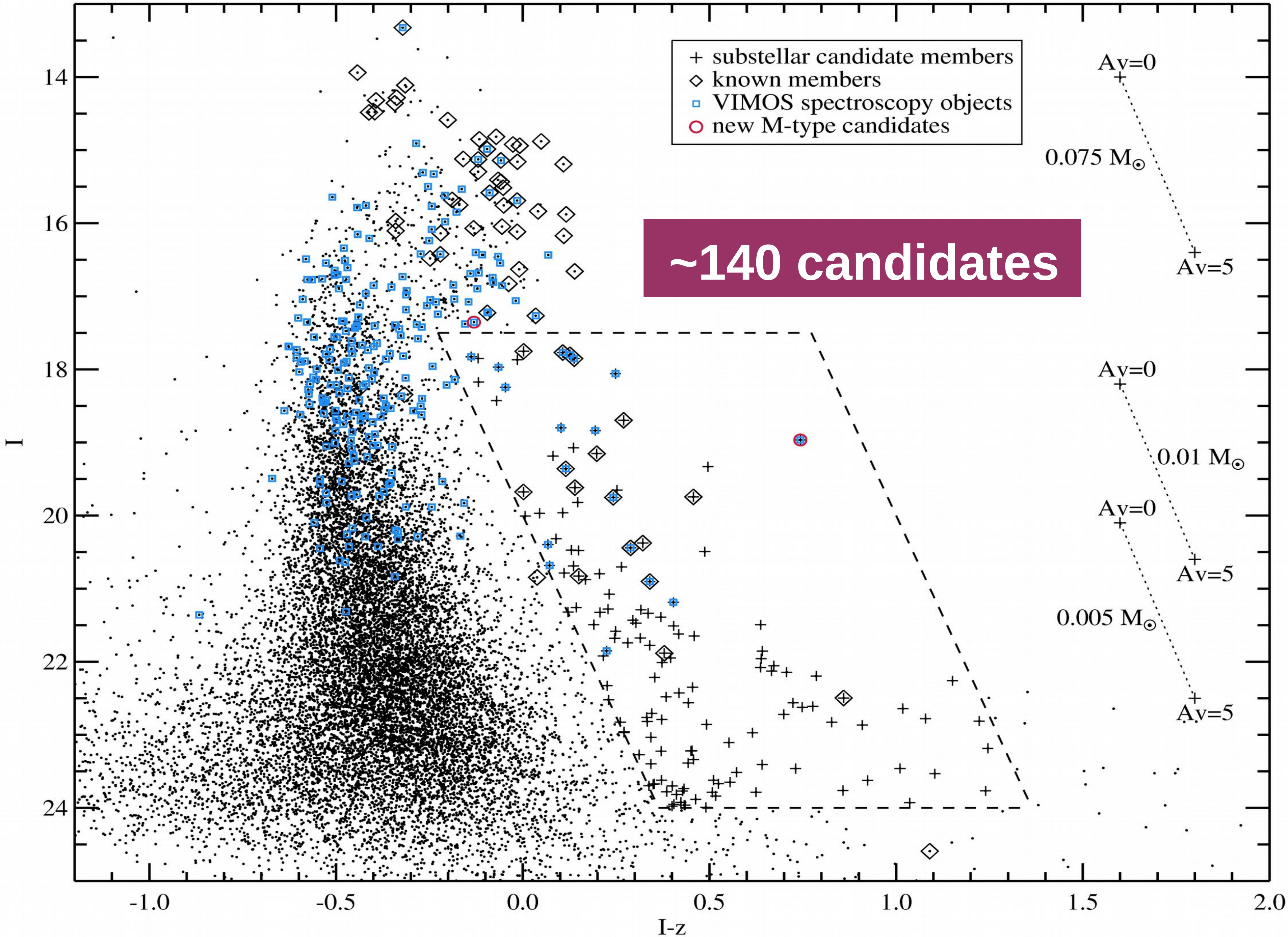
NIR: MOIRCS/Subaru, SofI/NTT, NEWFIRM/CTIO-4m

Public surveys: 2MASS, UKIDSS, Spitzer c2d



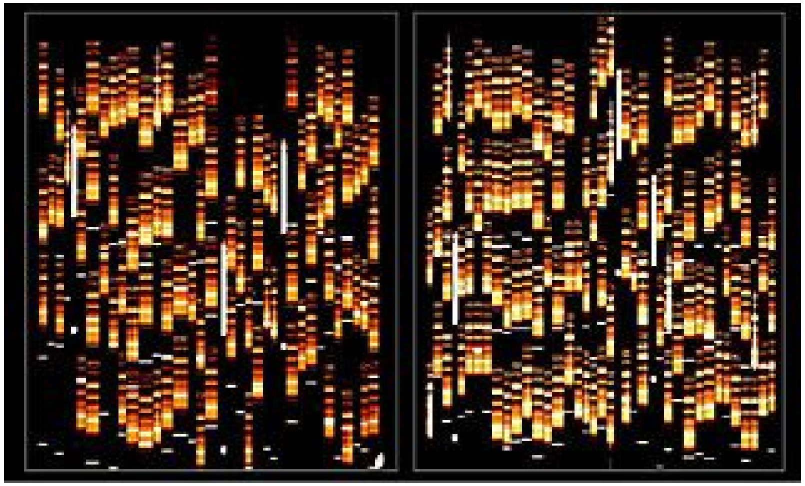
Chamaeleon-I

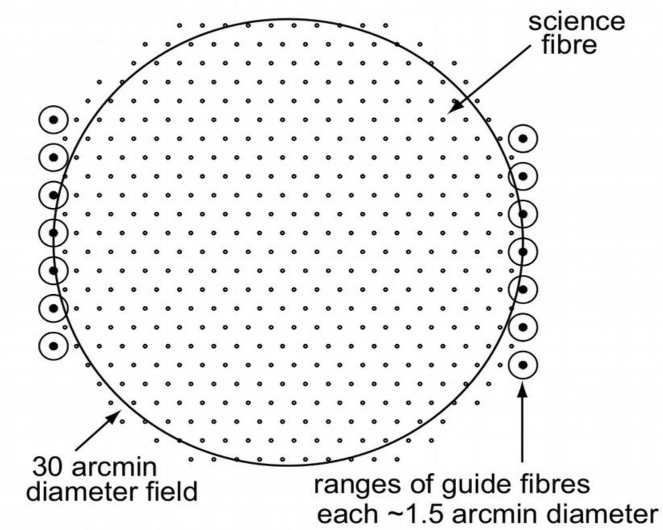
Muzic et al. (2011)



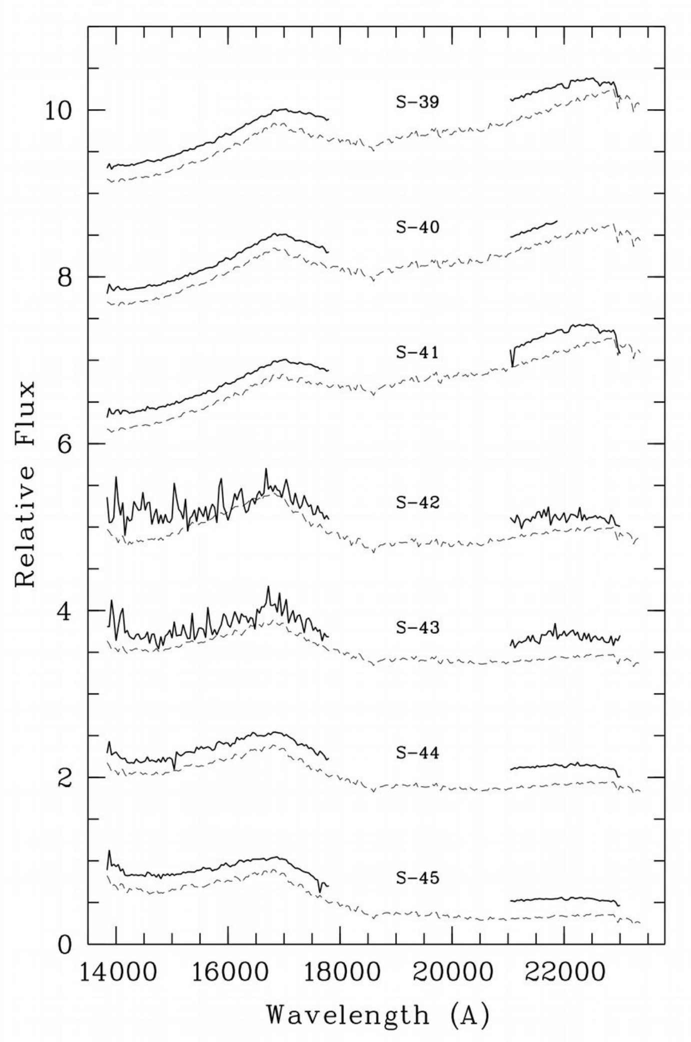
We really need spectra! A lot of them...

Instrument	Band/Resolution		FOV	
VIMOS/VLT	optical red	R$\sim$210	4 x 8' x 7'	MOS
MOIRCS/Subaru	HK	R$\sim$500	4' x 7'	MOS
FMOS/Subaru	JH	R$\sim$600	d = 30'	MOS
SINFONI/VLT	HK	R$\sim$1500	8''	IFU
SpeX/IRTF	0.8-2.5μm	R$\sim$100		slit
SofI/NTT	HK	R$\sim$600		slit

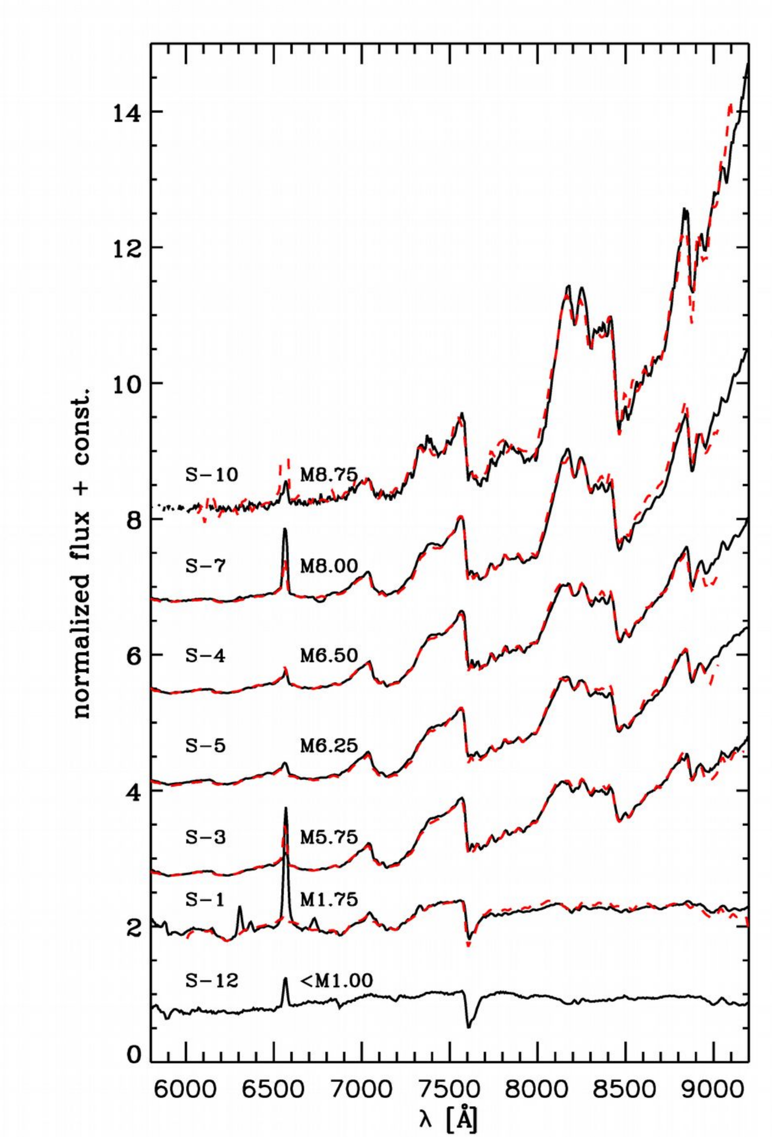




Spectral diagnostic – gravity sensitive features

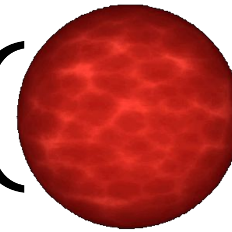


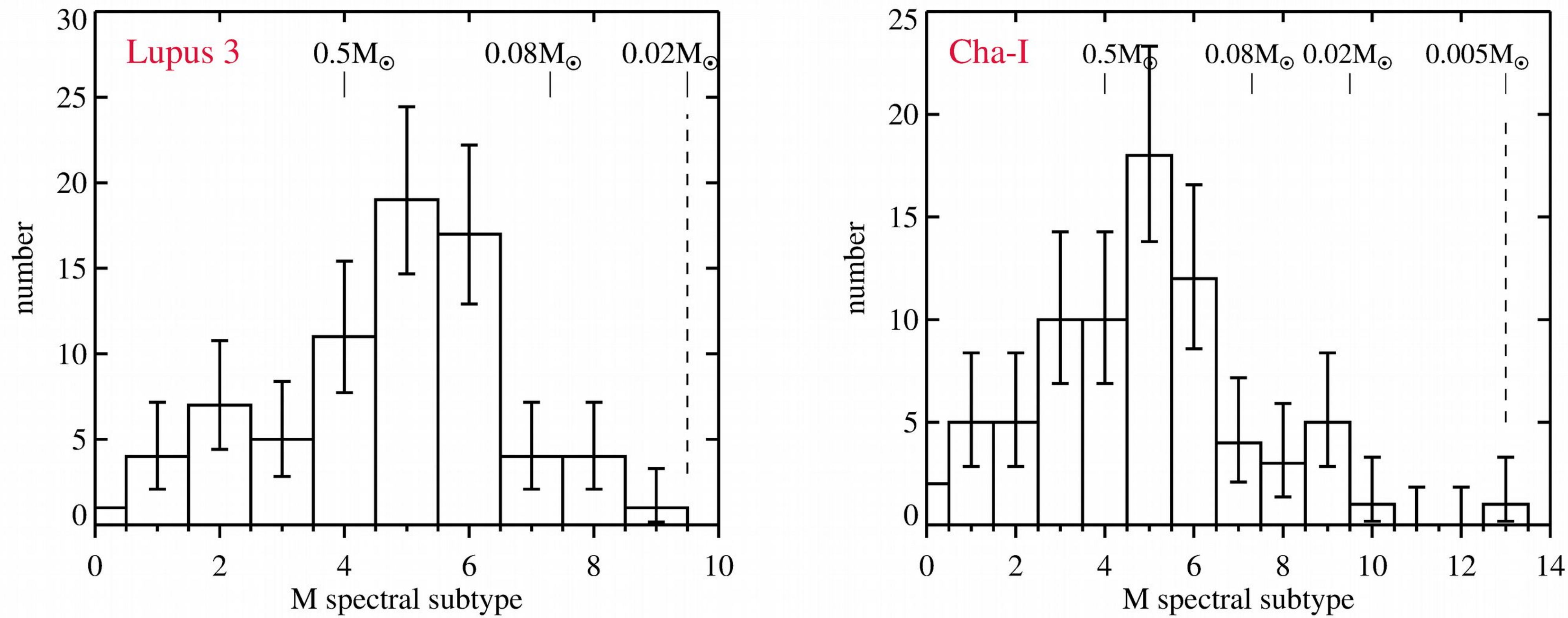
NGC 1333
Scholz et al. (2012)



Lupus 3
Muzic et al. (2014)

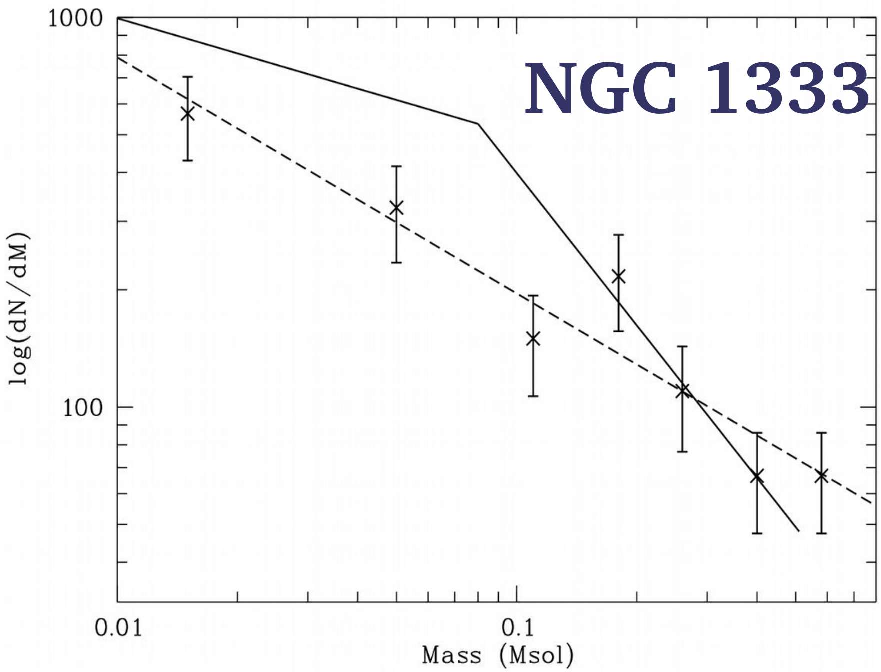
	Cha-I	ρ Oph	NGC 1333	Lupus 3	UpSco
Distance [pc]	160	125	300	200	145
Age [Myr]	~ 2	~ 1	1-3	~ 1	5-10
Survey Area [deg^2]	0.25	0.25	0.25	1.4	57
Completeness [$M_\odot$] at A_V [mag]	0.005 ≤ 5	0.003-0.03 ≤ 15	0.004-0.008 ≤ 5	0.009-0.02 ≤ 5	0.02 ≤ 5
# of subst. candidates	142 (opt)	309 (opt) 83 (Spitzer)	196 (opt) 10 (Spitzer)	409 (opt-NIR)	96 (opt-NIR)
# of spectra	34	160	160	138	30
# of confirmed VLMOs	9	19	35	9	24

N()/ N() = 2 - 5

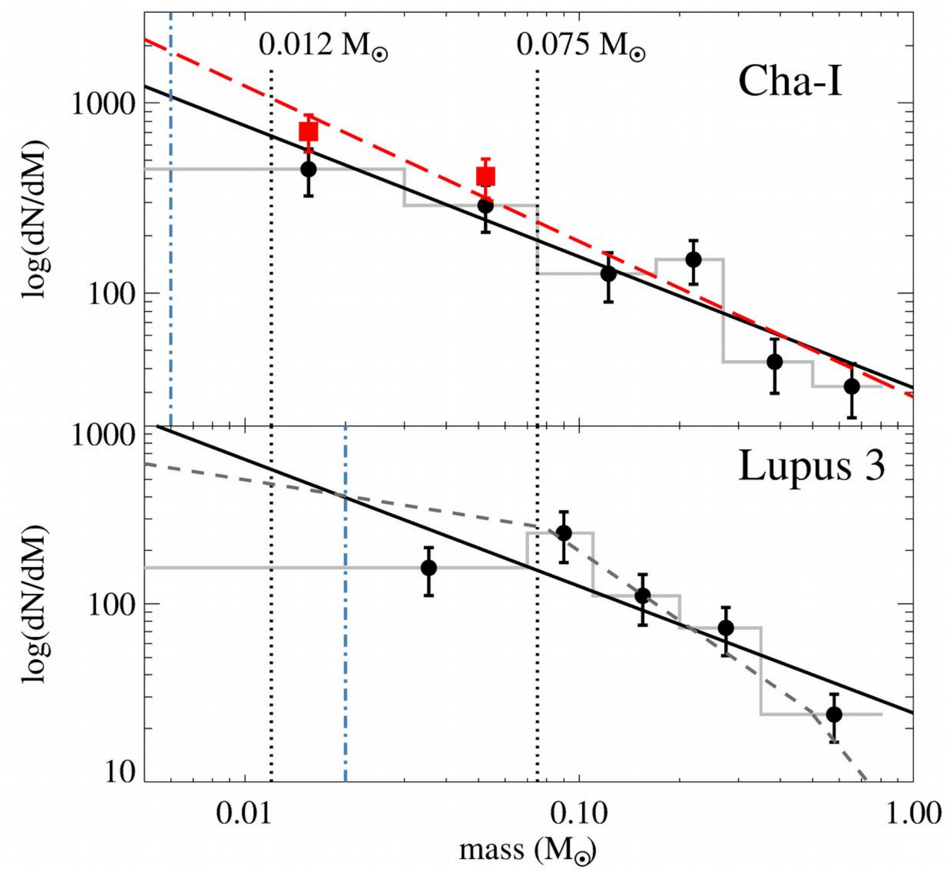


Muzic et al, 2015, subm.

IMF $dN/dM \propto M^{-\alpha}$ $\alpha \sim 0.7$



Scholz et al. (2012)

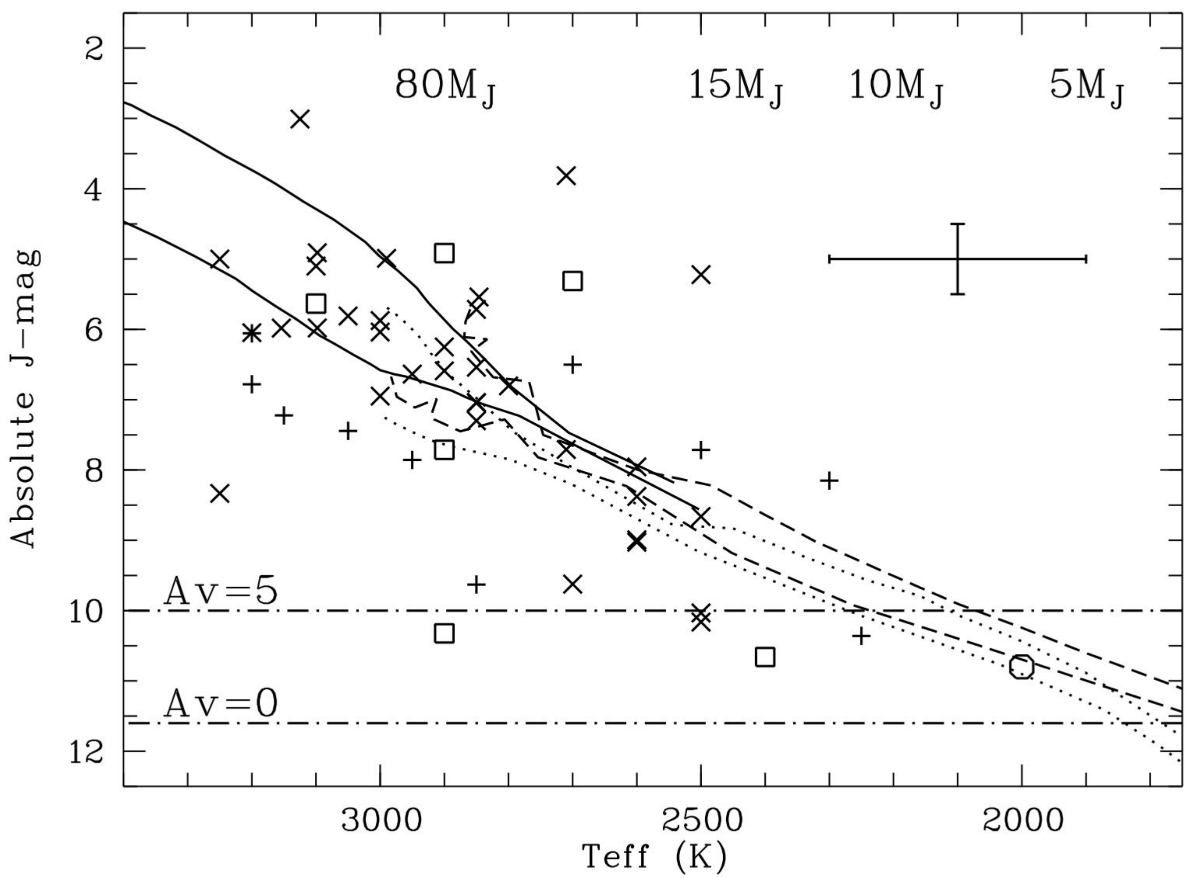


Muzic et al. , 2015, subm.

Similar α found in:

σ Ori (Peña Ramírez+ 2012), **Blanco-1** (Moraux+ 2007), **IC 348**(Alves de Oliveira+ 2013), **Up Sco** (Lodieu+2007), **α Per** (Barrado y Navascues+ 2002), ...

NGC1333 – the most comprehensive study



Scholz et al. (2012b)

3 objects in the planetary-mass domain

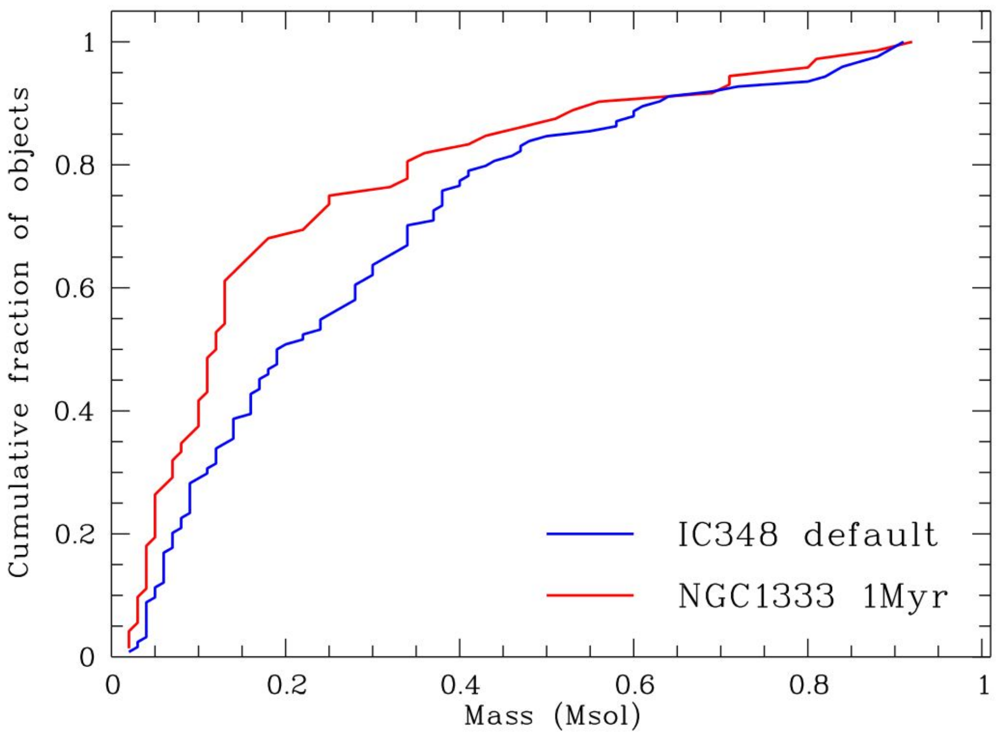
The coolest one
~ L3
T ~ 2000K
mass ~ 0.006 $M_\odot$

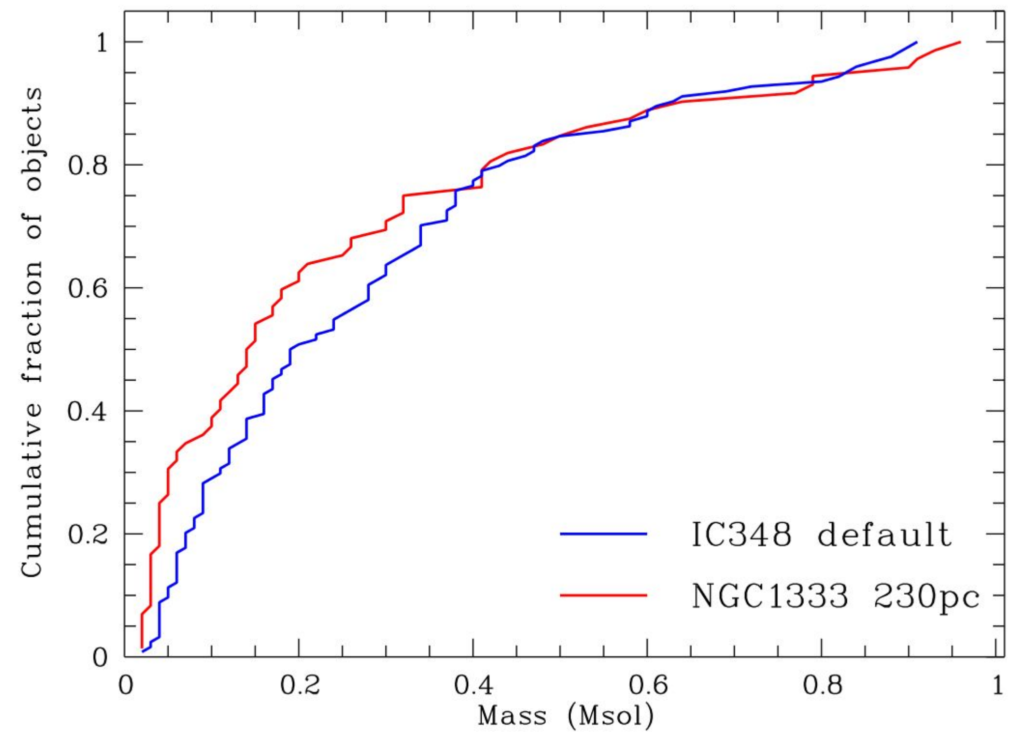
Substantial planetary-mass population can be excluded

Star/BD ratio

Effects of various assumptions -
distance, age, extinction law, isochrones

Scholz et al. (2013)





IF d (NGC1333) < d (IC348)
denser environment produces more BDs (??)

Summary

- Census of brown dwarfs fairly complete down to De-burning limit
- Free-floating objects with masses down to a few Jupiter masses exist, but their mass budget is small
- Star/BD ratio is 2 – 5, but many sources of error to be understood before comparing the numbers

Spectra & photometry available on the SONYC website

http://browndwarfs.org/sonyc.html