

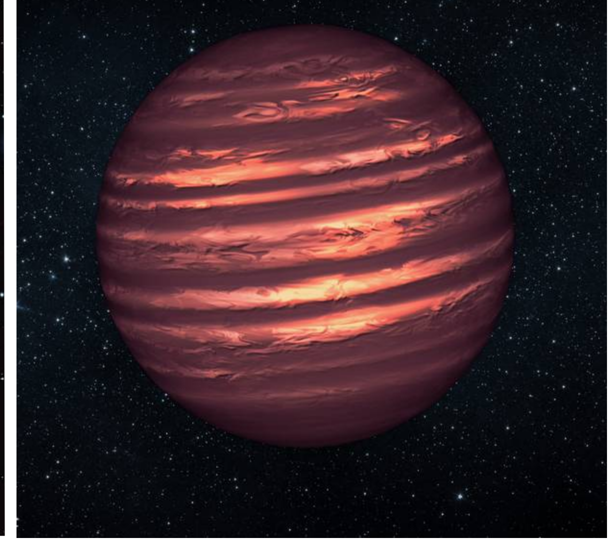


Young Brown Dwarfs:
Testing star formation across environments

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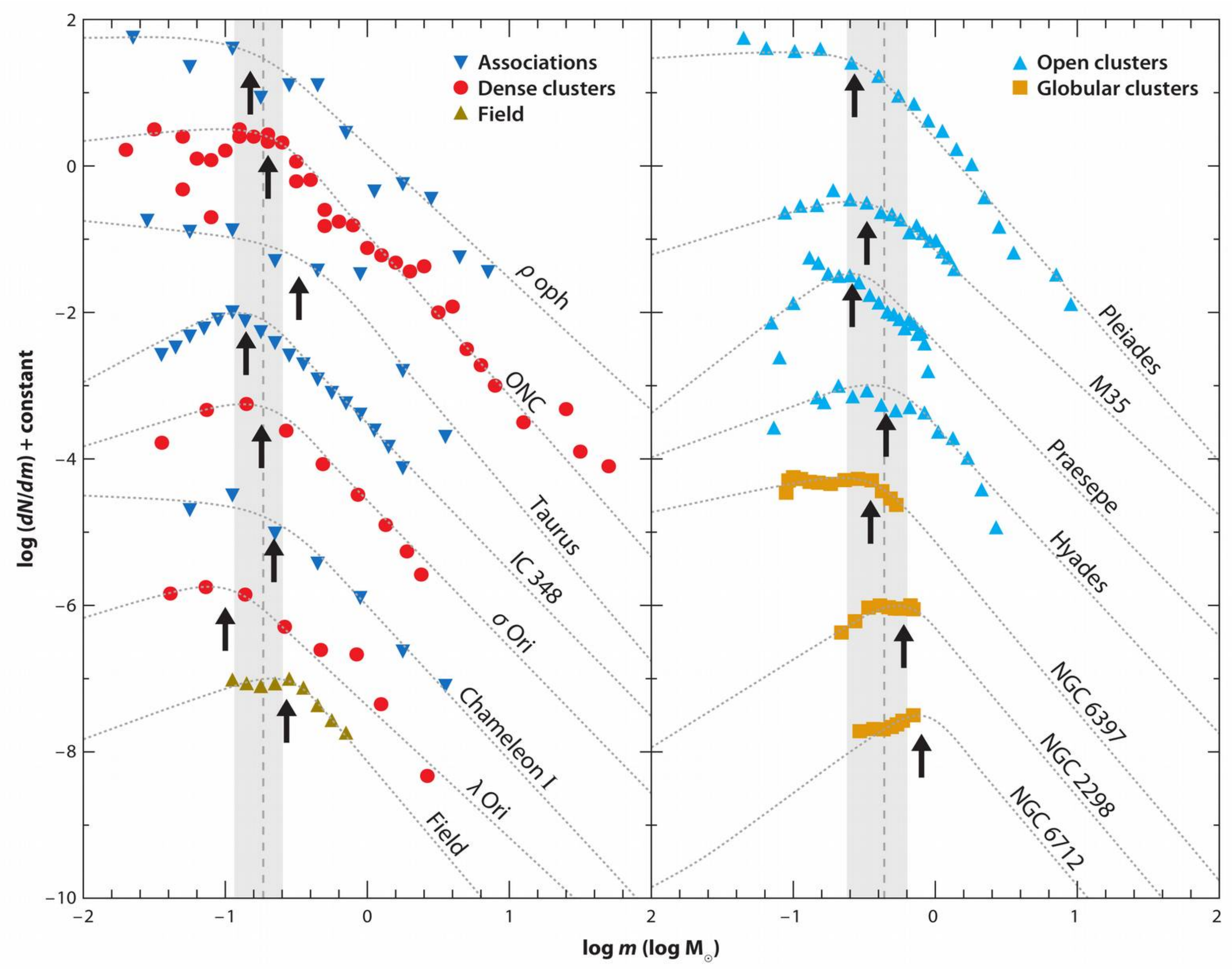
V. C. Geers (UK ATC)
R. Schoedel (IAA-CSIC), et al.

Outline

SONYC survey – brown dwarfs in nearby star forming regions

New program to look for brown dwarfs in massive young clusters – RCW 38



Bastian et al. (2010)

SONYC

Substellar Objects in Nearby Young Clusters

Two main goals:

(I) Establish the **deep** substellar IMF in various SFRs, using **consistent** methodology

(II) Provide clean samples of brown dwarfs - groundwork for characterization of their properties

SONYC Summary

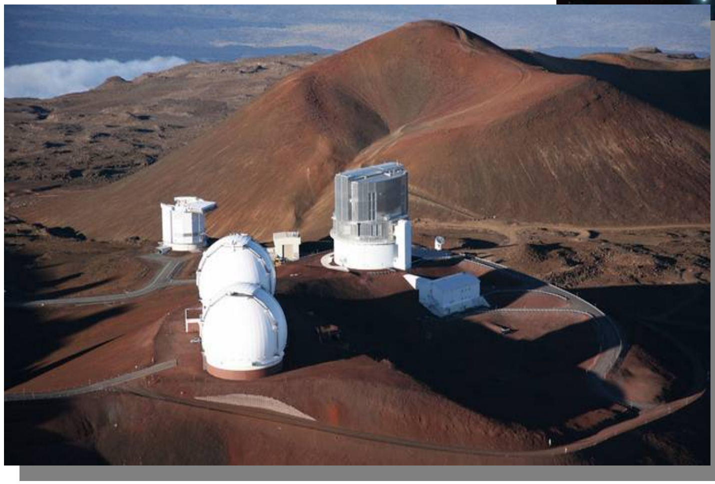
2006 – 2015 (tbc)

15 nights at 8-m telescopes

5 regions
> 700 spectra
~ 100 confirmed brown dwarfs
& very low-mass stars

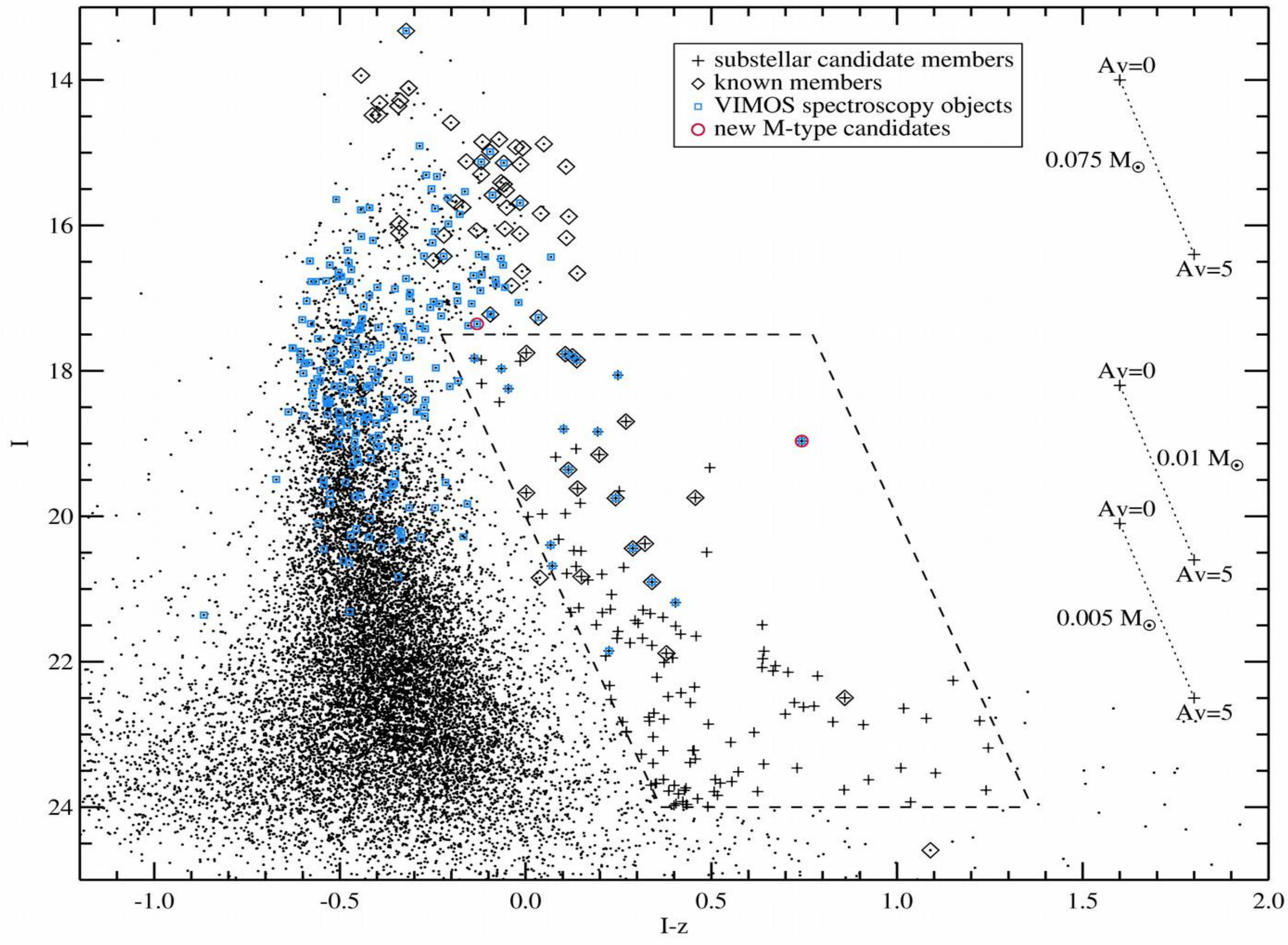
9 papers

browndwarfs.org/sonyc



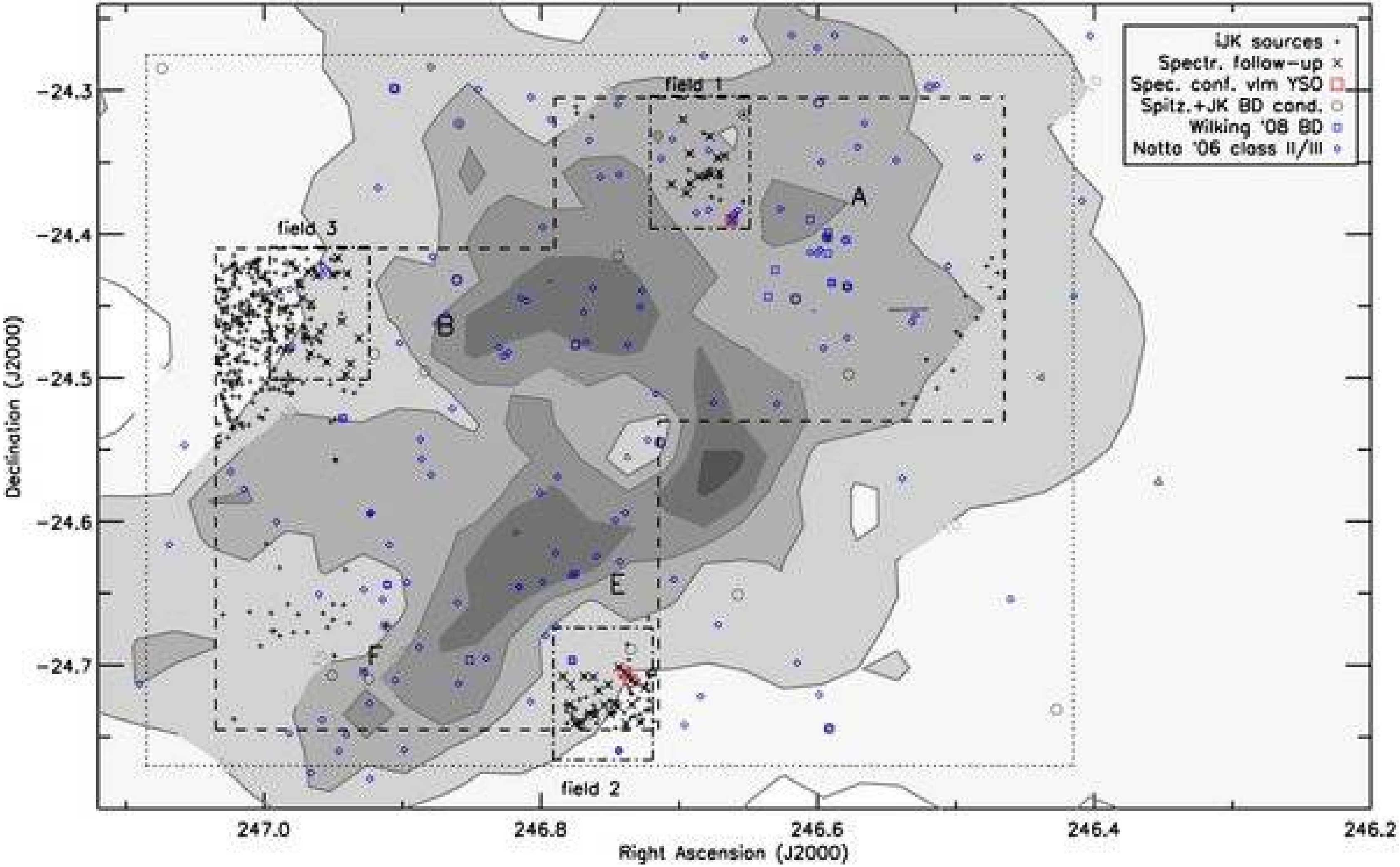
Candidate selection

Cha-I



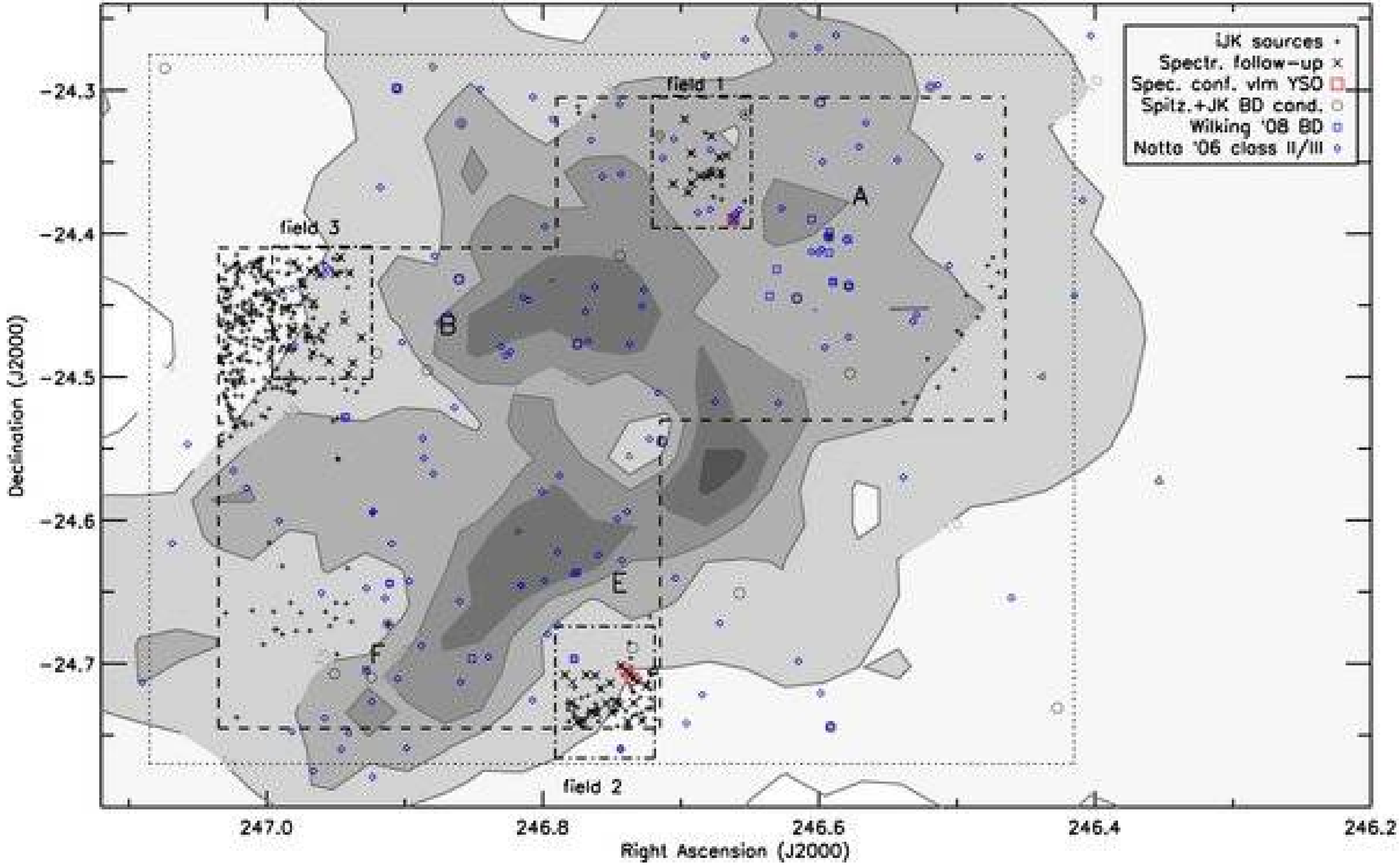
Muzic et al. (2011)

ρ-Oph



Geers et al. (2011)

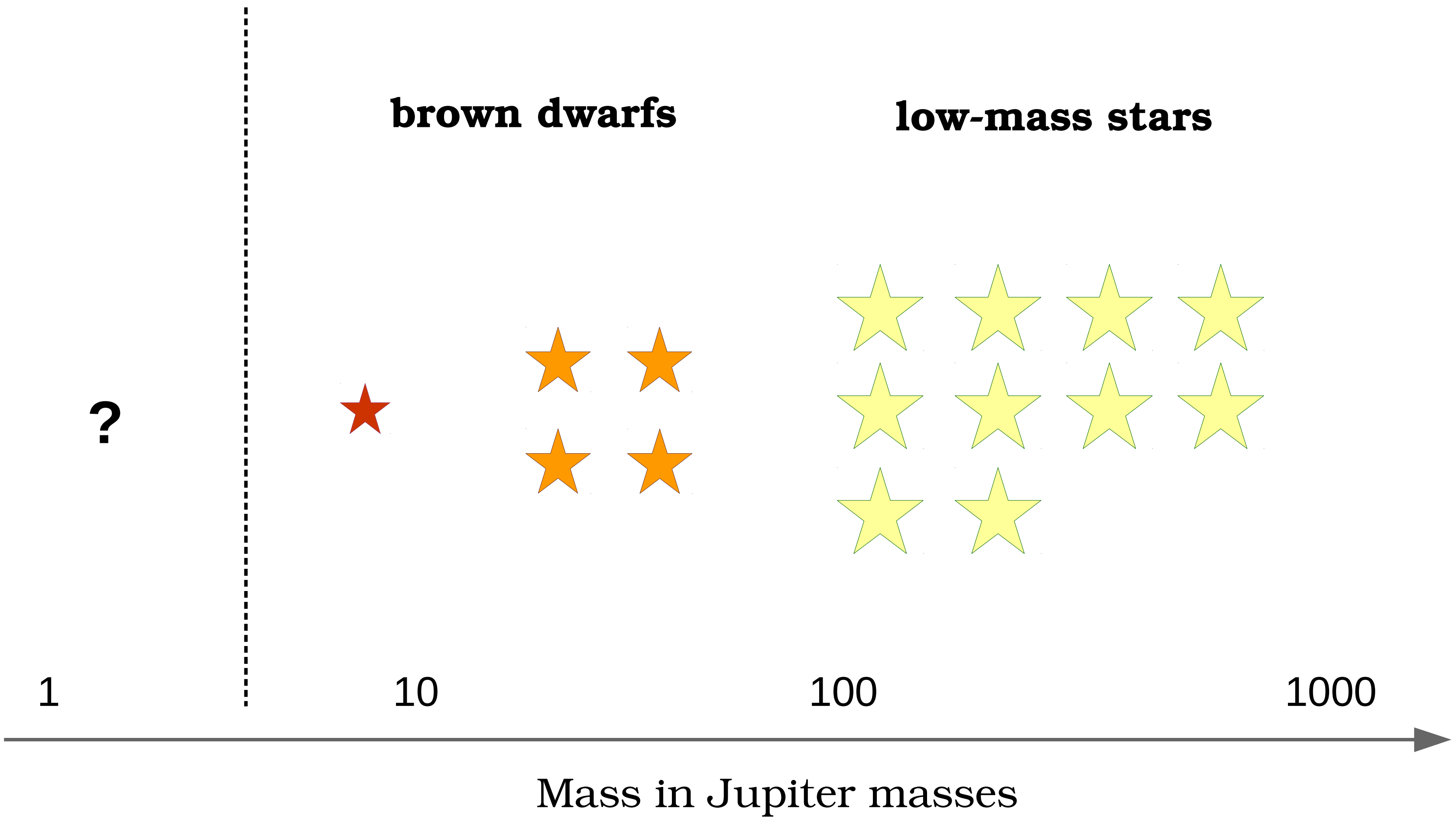
ρ-Oph



Geers et al. (2011)

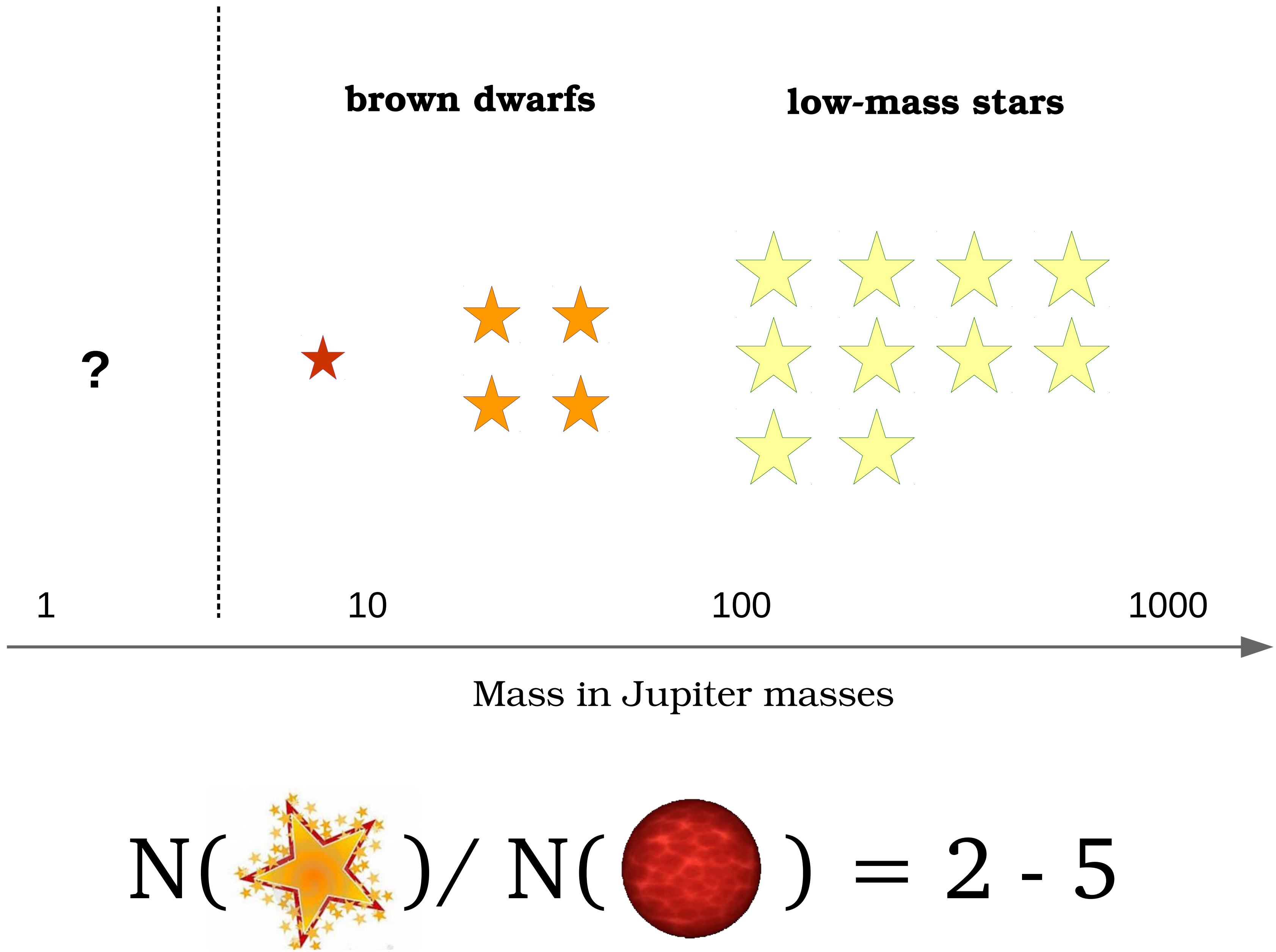
Spectroscopy is mandatory!

SONYC

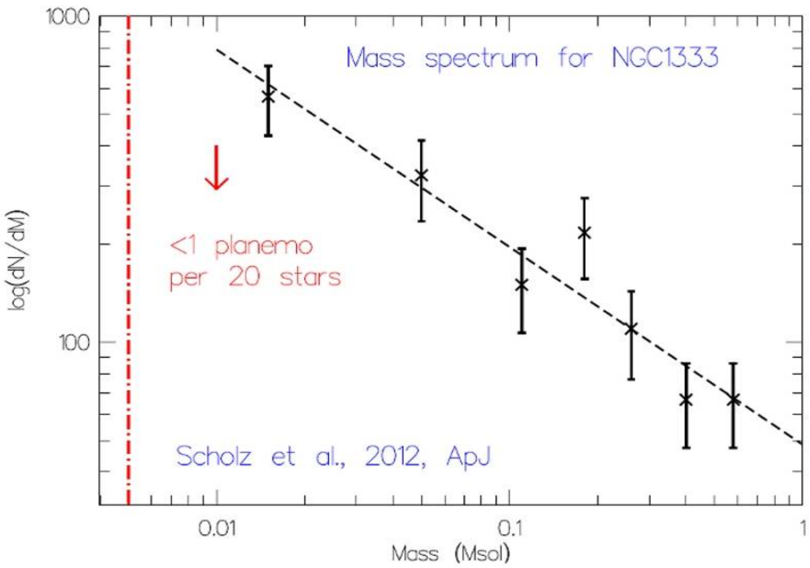


brown dwarfs
low-mass stars
?
1
10
100
1000
Mass in Jupiter masses

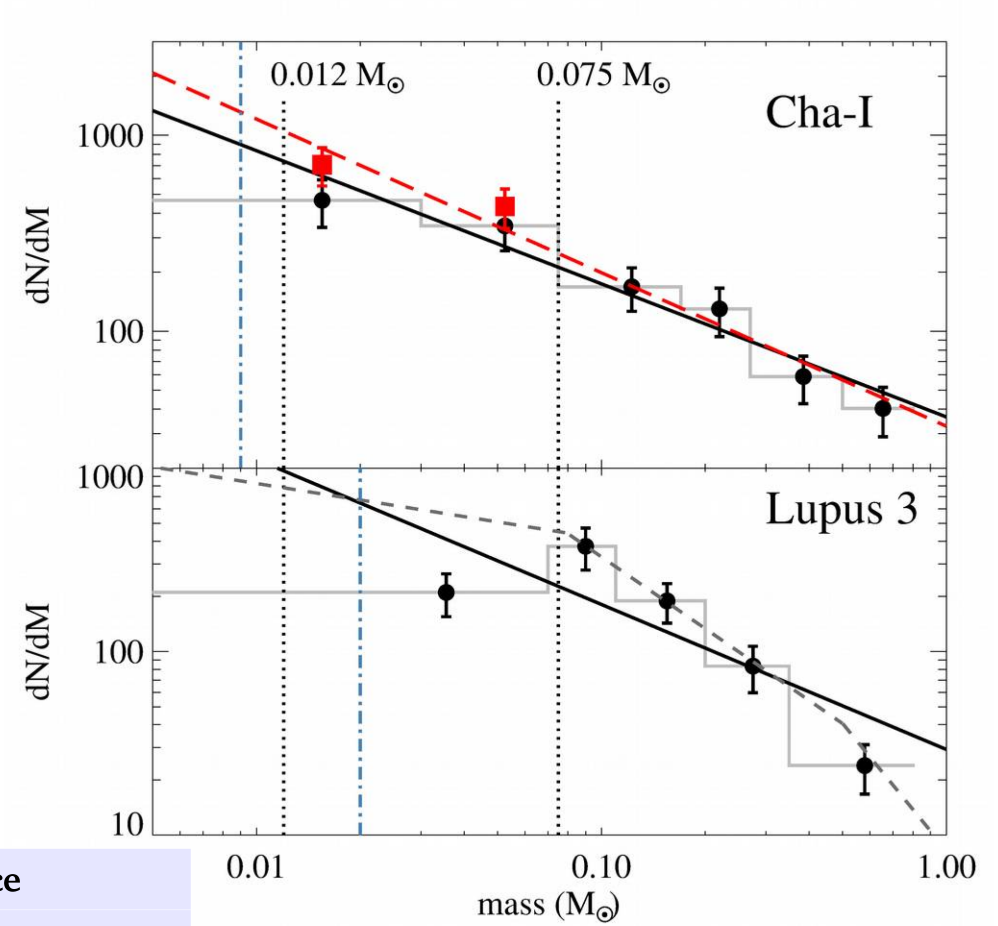
SONYC


brown dwarfs
low-mass stars
?
1
10
100
1000
Mass in Jupiter masses
N( )/ N( ) = 2 - 5

IMF $dN/dM \propto M^{-\alpha}$ $\alpha \sim 0.6 - 1.0$



Scholz et al. (2012)



Muzic et al. (2015)

	α	Mass range	Reference
σ Ori	0.6 ± 0.2	0.006 – 0.35	Peña Ramírez+2012
Upper Sco	0.45 ± 0.11	0.009 – 0.2	Lodieu+2013
Collinder 69	0.2 – 0.4	0.01 – 0.65	Bayo+2011
IC 348	0.7 ± 0.4	0.012 – 0.075	Alves de Oliveira+2013
	0.7 – 0.8	0.03 – 1.0	Scholz+2013
ρ Oph	0.7± 0.3	0.004 – 0.075	Alves de Oliveira+2013

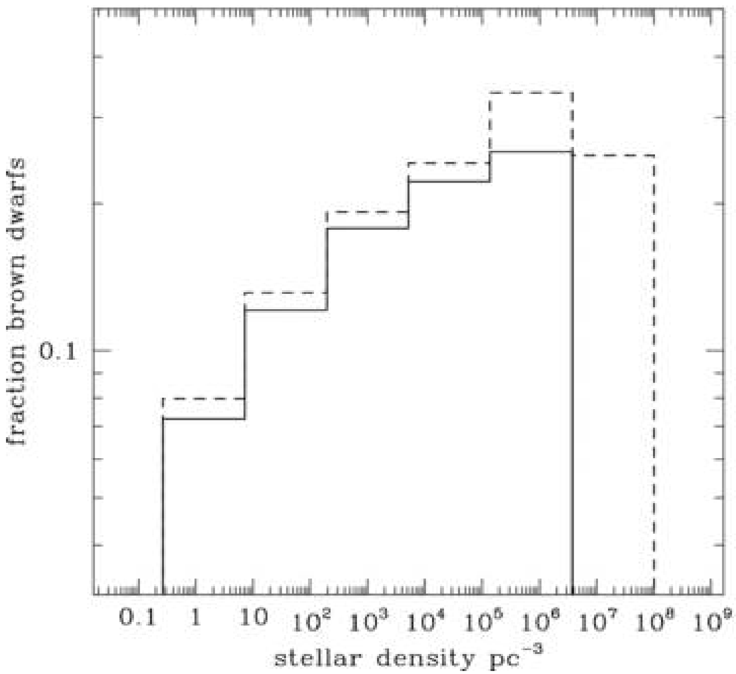
Dense cluster – more BDs?

Initial $\langle\rho\rangle \sim 10^2\ M_\odot\ pc^{-3}$ IC348

$10^3\ M_\odot\ pc^{-3}$ NGC1333 Parker & Alves de Oliveira (2017)

Dense cluster – more BDs?

Most BD formation theories predict some dependence on environment



Bonnell et al. (2008)

Density:
- any theory that requires ejection
- gas infalling on star clusters
- turbulent fragmentation framework

Presence of O stars:
- photoionization of intermediate-mass cores

(Bate 2012; Padoan & Nordlund 2002; Bonnell et al. 2008; Vorobyov et al.; Whitworth & Zinnecker 2004)

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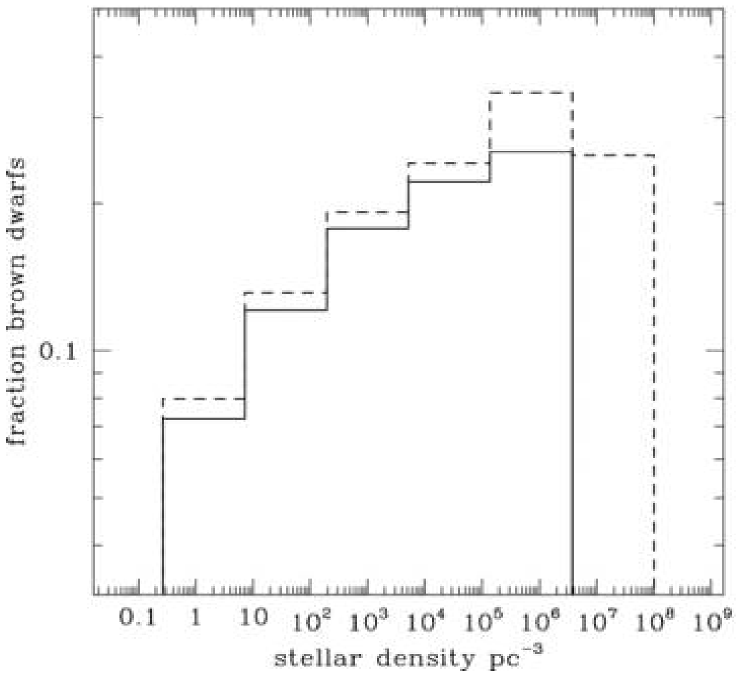

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Most of the nearby SFRs are fairly similar

Ultimate test: much denser environment, many OB stars

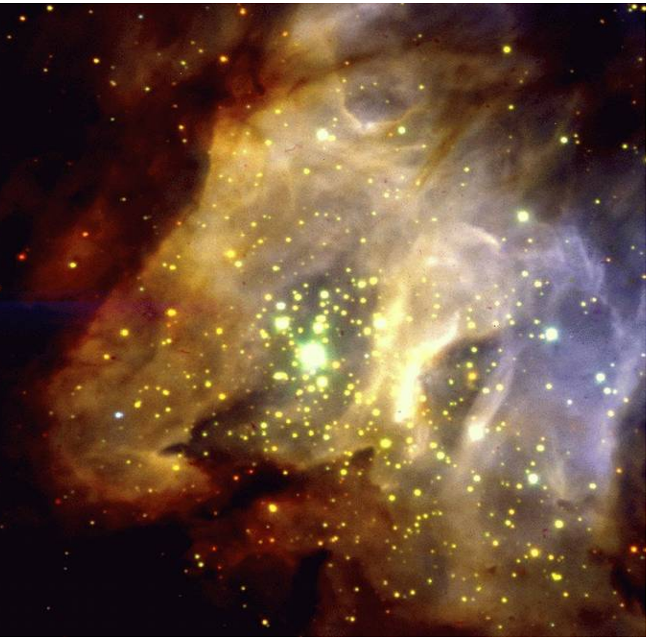
Testing the environmental differences

Massive clusters are far away!

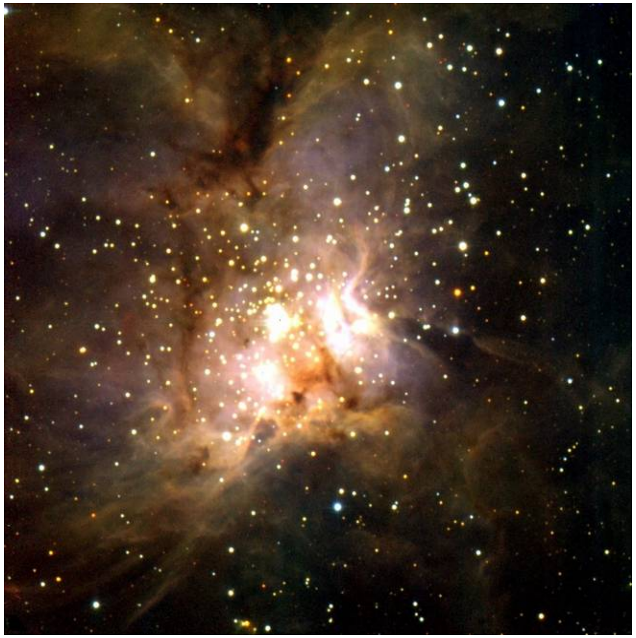
10 MJup @1 Myr, 1 kpc, Av=0-10 → H=18.9-20.8

New program to observe selected clusters with VLT and Gemini-S

RCW 38

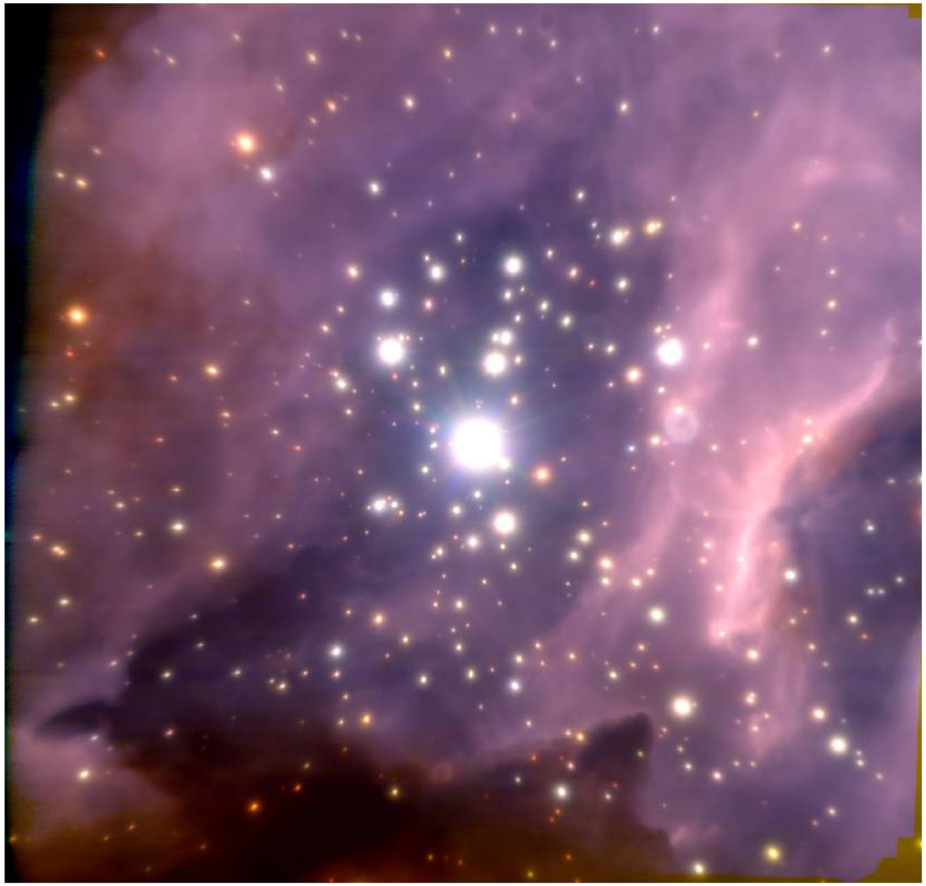


RCW 36



NGC 2244

RCW 38



AO imaging with NACO/VLT

Young: ~1 Myr

Dense: densest young cluster within 4 kpc
(MYStIX survey)

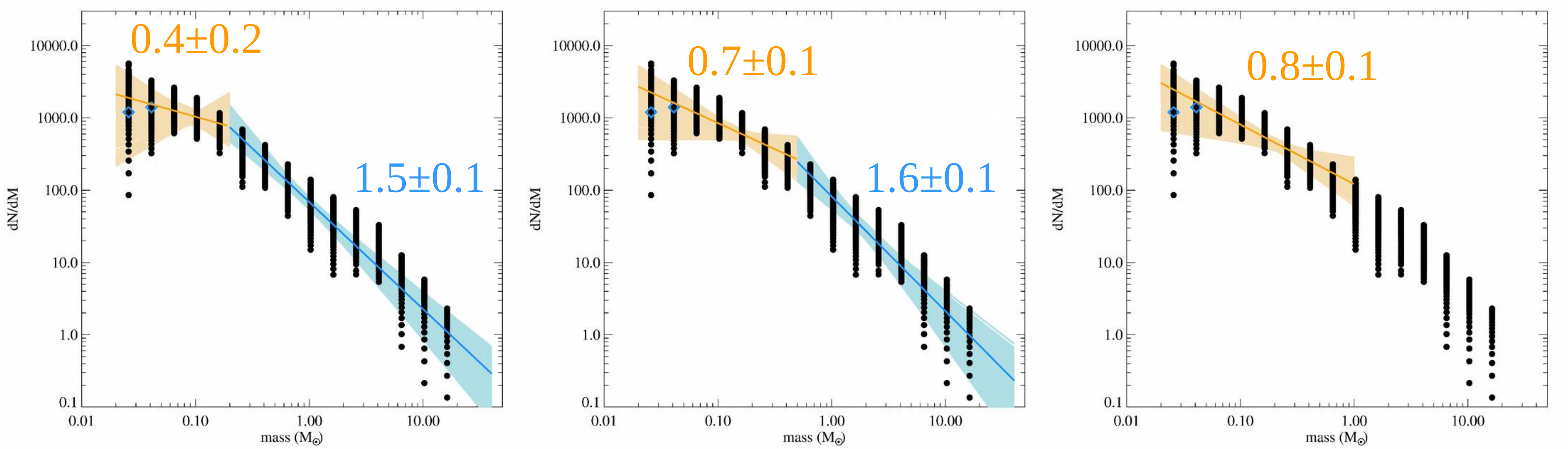
Density wrt other SFRs:

> 2	times that of	ONC
~10		NGC1333
> 25		Cha I

Rich in massive stars: 60 OB candidates
(Wolk et al. 2006, Winston et al. 2011)

RCW 38

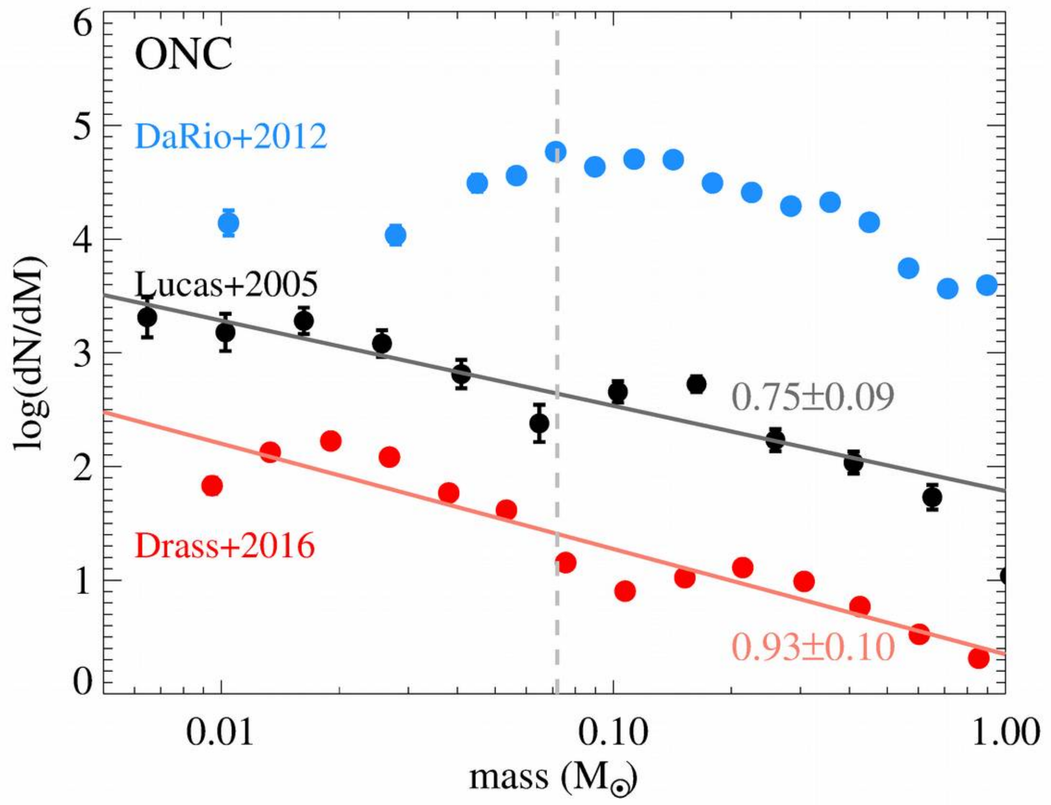
Muzic et al. (2017, submited)



N()/ N() = 2.0 ± 0.6

No evidence for significant environmental differences

The (complicated) case of the ONC



Low-mass content is mass segregated (Andersen et al. 2011)

Older (4-5 Myr) population in front (Alves & Bouy 2012; Bouy et al. 2014)

Not all the surveys use spectroscopy

Conclusions

- Census of substellar objects in young clusters mostly complete down to the D-burning limit, in selected regions even down to ~5 MJup

- For every brown dwarf, there are 2 - 5 stars

- First results in massive young cluster RCW 38: no evidence for environmental differences

- Future:
  Gaia: distances
  JWST: 1-2 MJup objects in NGC 1333 (spectroscopy) and
  RCW 38 (imaging)