Exploring "Rogue Planets" with JWST

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A Few Basic Questions about the Origin(s) of Stars, Brown Dwarfs and Planets

How common are brown dwarfs relative to stars?

Does the low-mass IMF vary with environment?

How far down in mass does the stellar IMF extend?

Is there a large population of 'rogue planets'?

Do the lowest-mass free-floating objects form 'like stars' or 'like planets'?

SONYC = Substellar Objects in Nearby Young Clusters

~15 nights on 8m telescopes

5 regions, ~50 confirmed objects

12th paper in preparation, extending to a massive star forming region

browndwarfs.org/sonyc

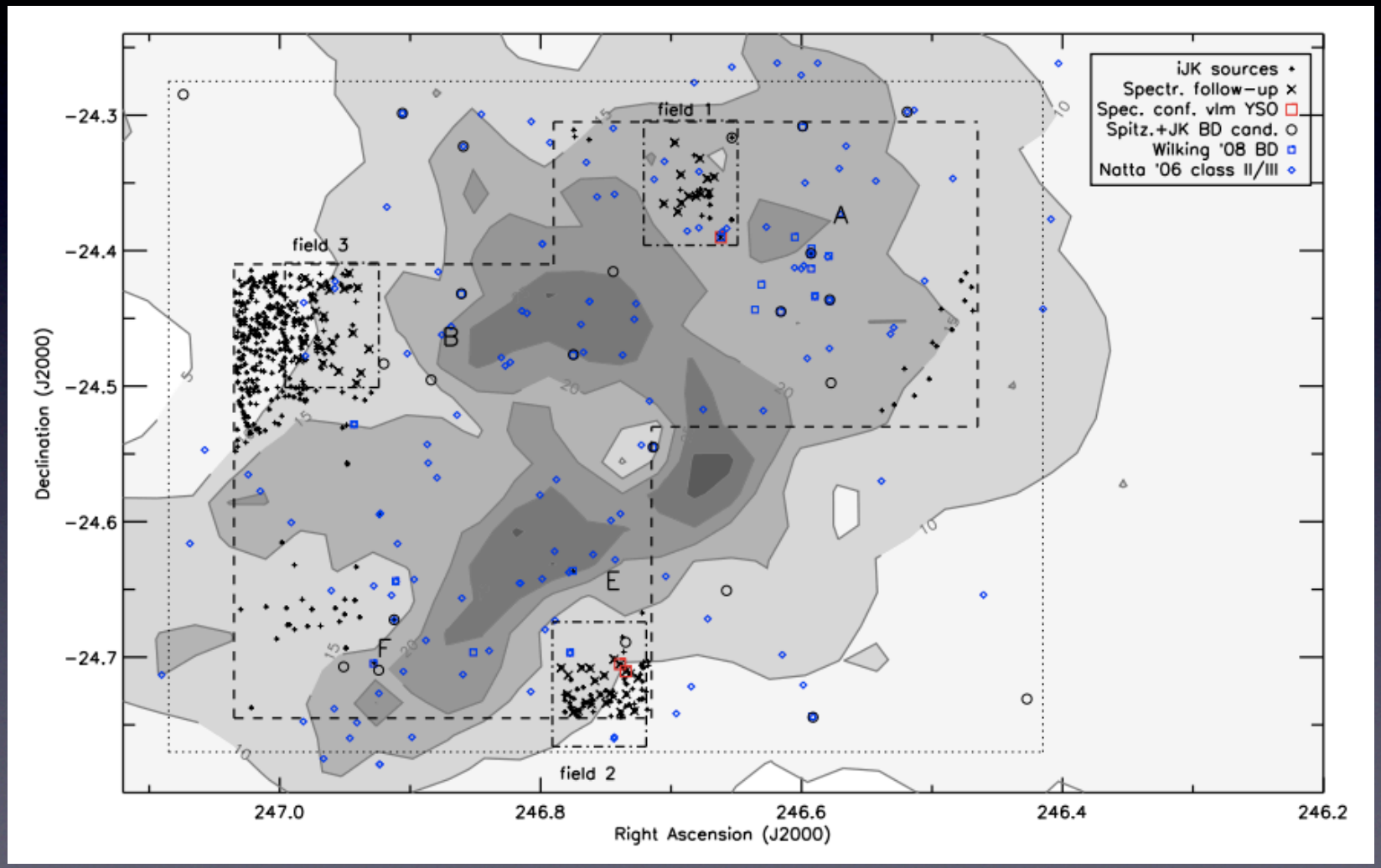
How deep can we go?

For nearest star forming regions (d=150pc, Av=5):

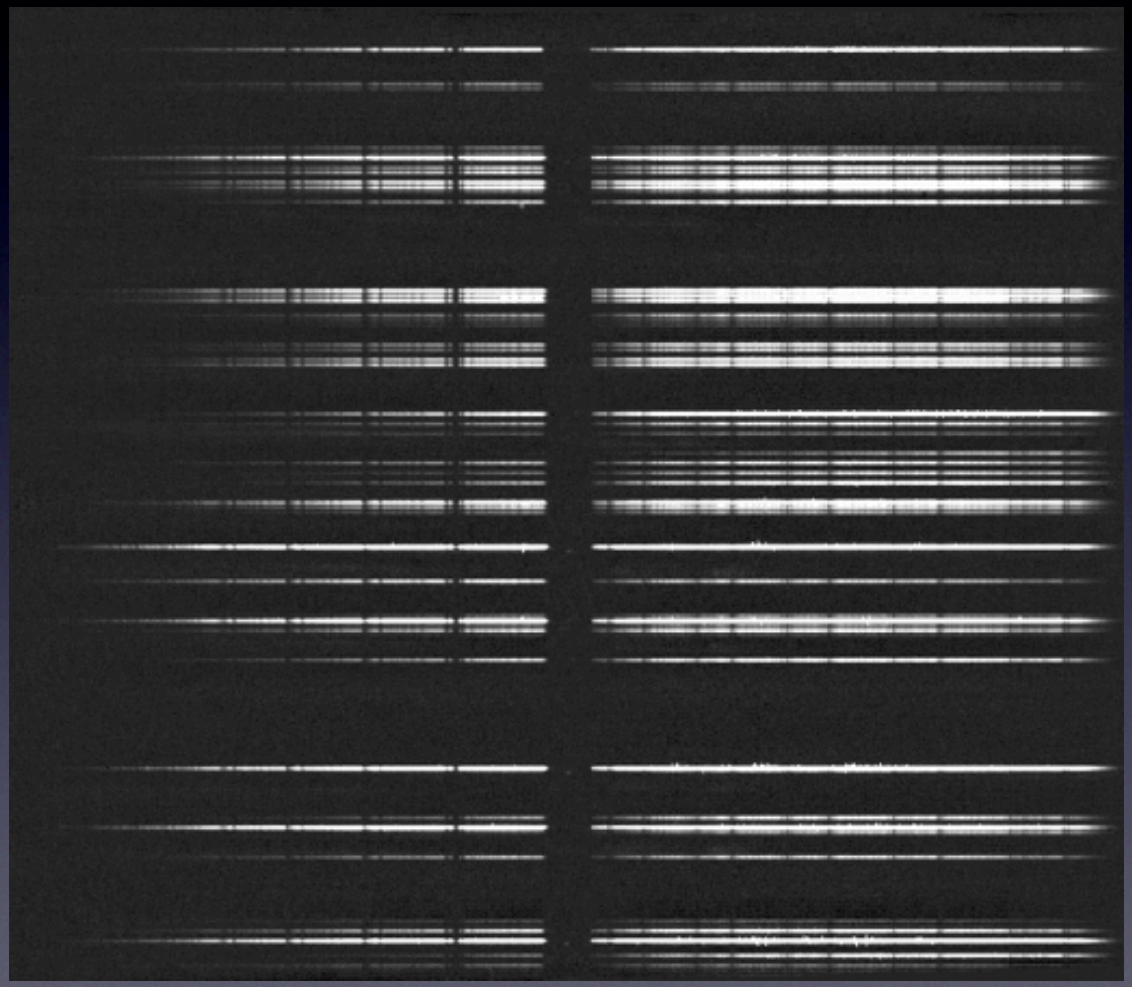
5 Jupiter masses means J=18, K=17

→ about the limit for spectroscopy for 8-m class telescopes

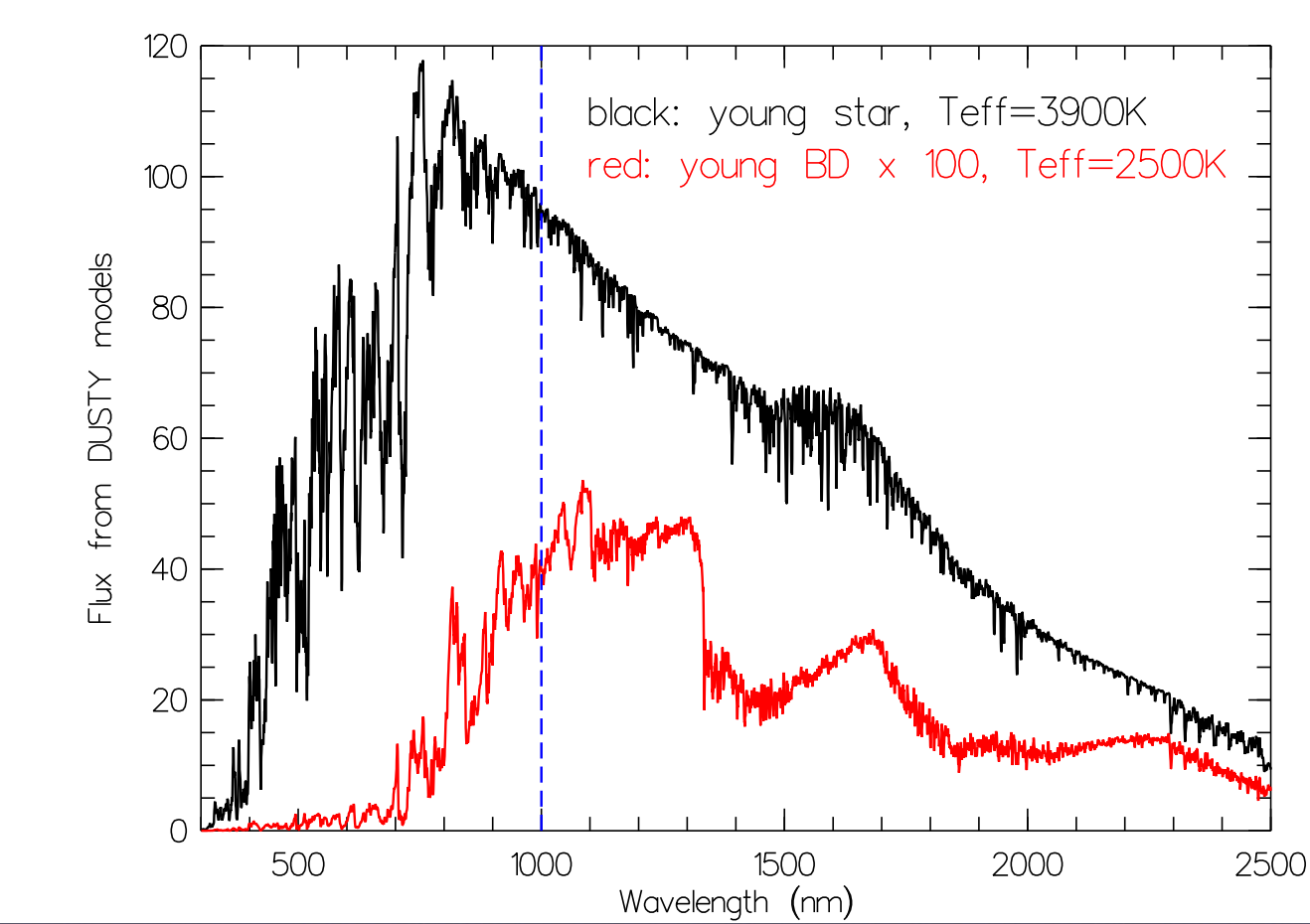
Needle in haystack

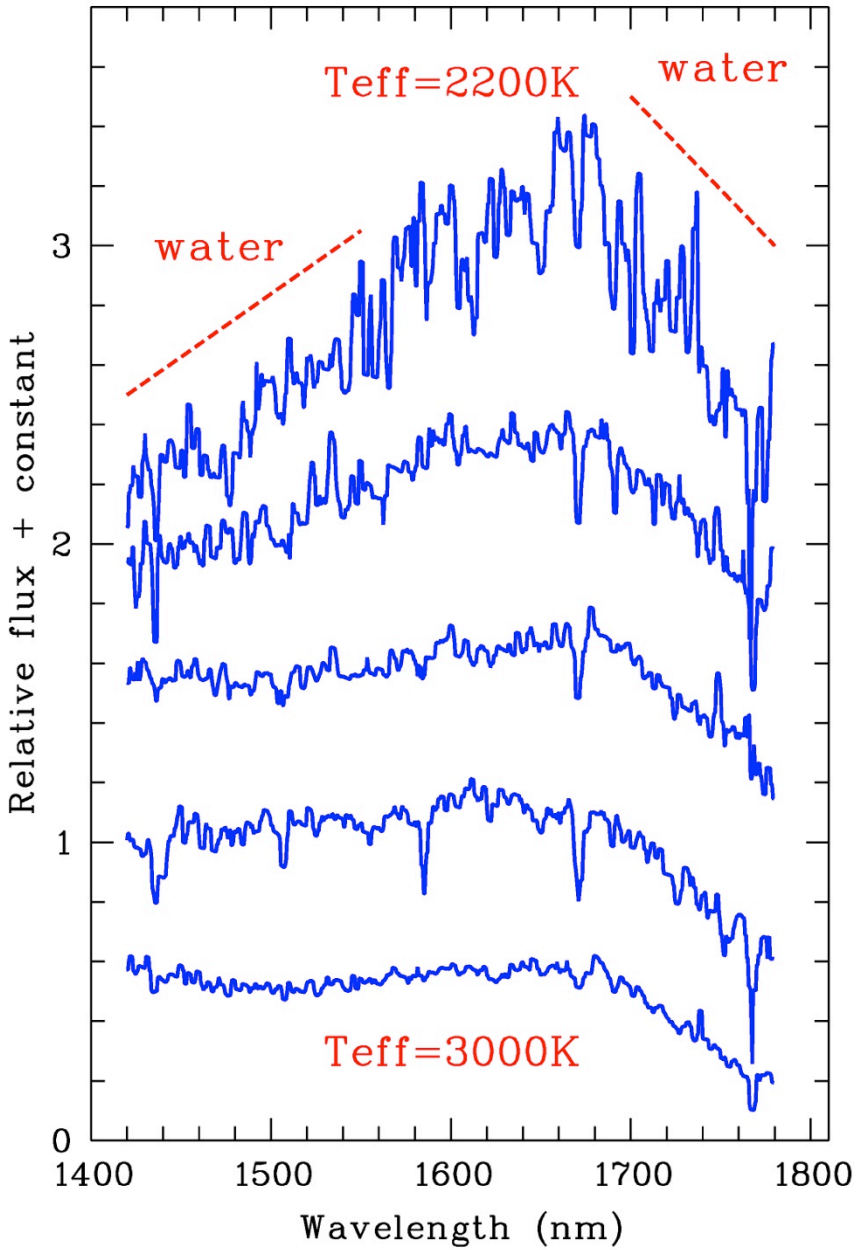


Spectroscopy mandatory



Stars vs. brown dwarfs





planetary-mass object ($6M_{Jupiter}$)

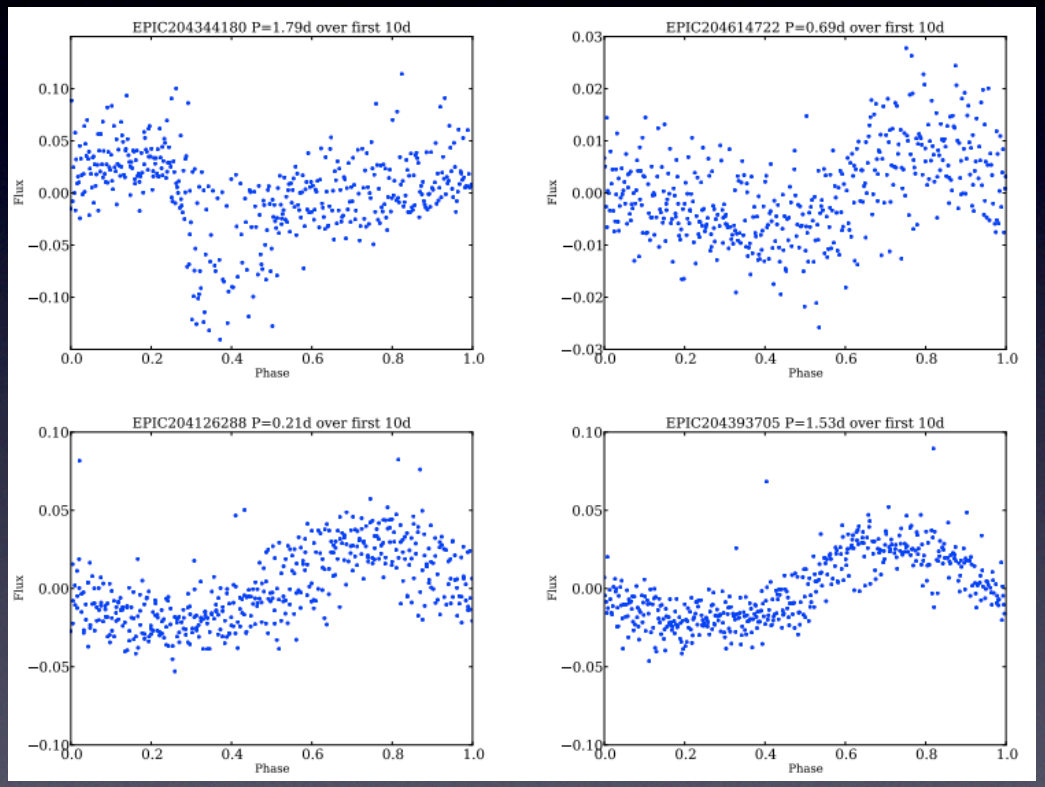
brown dwarfs

substellar boundary

Scholz et al. (2012)

Disks with ALMA

Rotation with K2

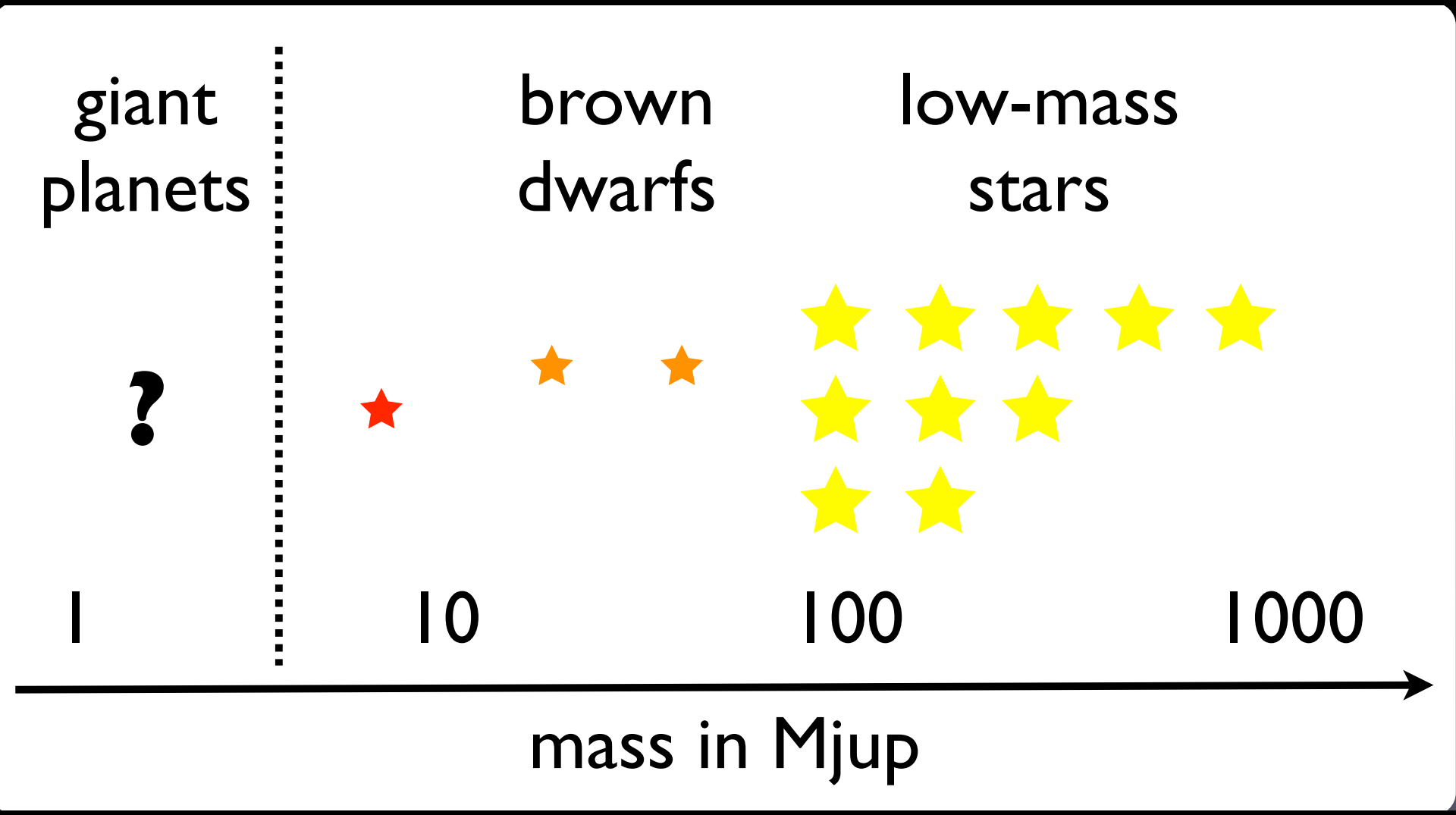


angular momentum conservation:

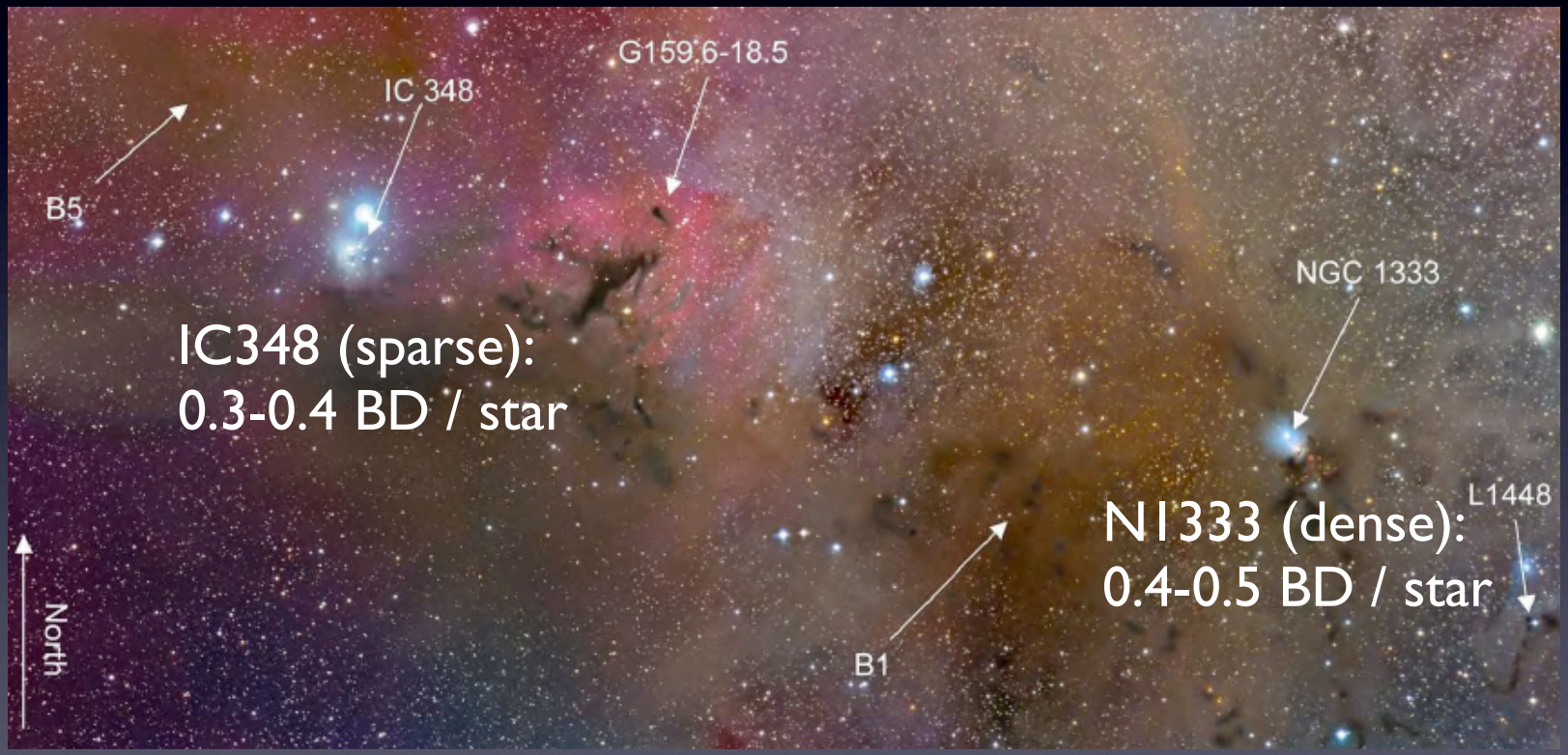
no disk-locking in brown dwarfs

Scholz, Kostov, Jayawardhana, Muzic 2015

Abundance of Brown Dwarfs

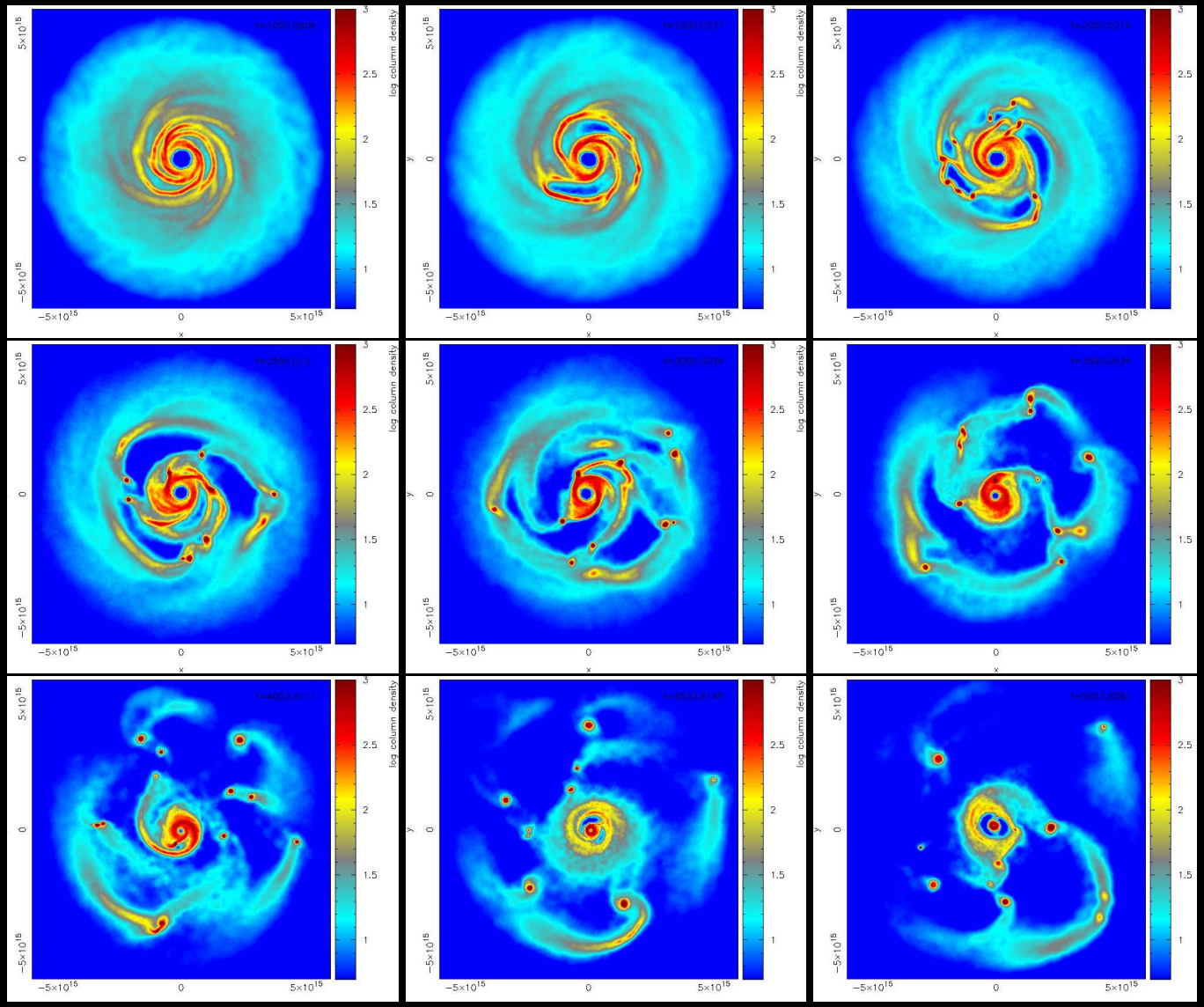


Dense cluster = more BDs?



Scholz et al. 2013

Ejection from protostellar disks?

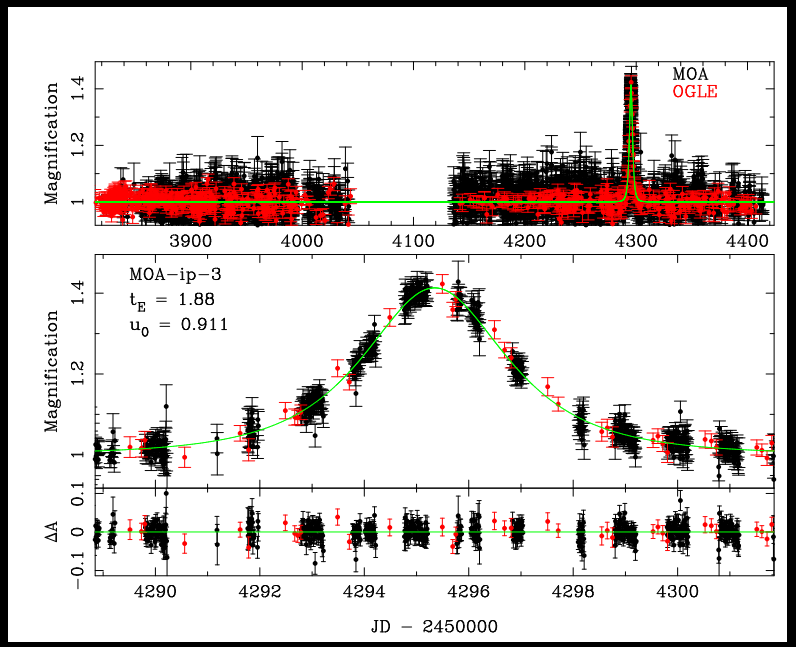


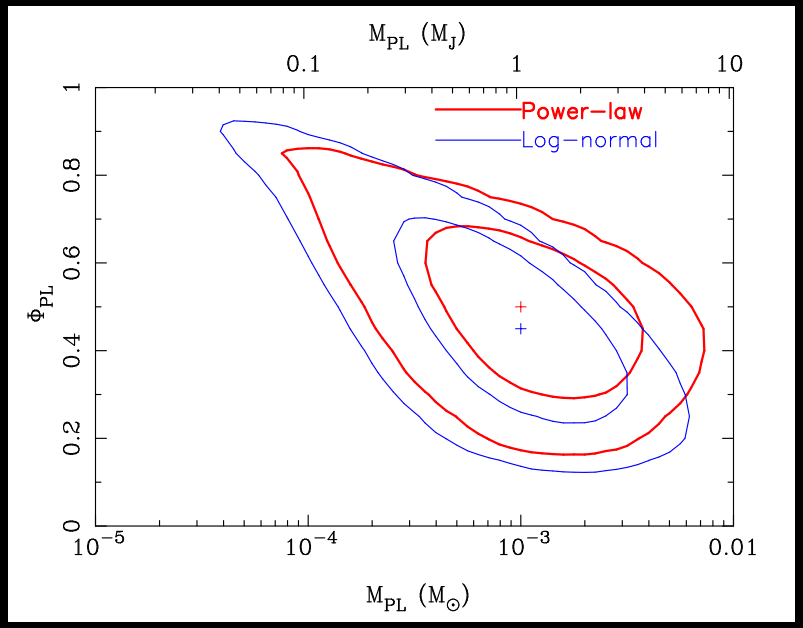
Stamatellos et al. (2007)

A population of "rogue planets" from microlensing?

"…we report the discovery of a population of unbound or distant Jupiter-mass objects, which are almost twice (1.8+1.7) as common as main-sequence stars… An abrupt change in the mass function at about a Jupiter mass favours the idea that their formation process is different from that of stars and brown dwarfs. They may have formed in proto-planetary disks and subsequently scattered into unbound or very distant orbits."

Sumi et al. (2011)





WFSS mode on NIRISS/JWST

Input: Young L4 object, spectrum from Allers & Liu (2013); re-normalized in K -band

Filter F200W: 1.7 - 2.2 microns
S/N values at 2 microns

Exposure time	S/N @	K (mag)	S/N @	K (mag)
2 x 245s	10	20.3	30	19.0
10 x 245 s	10	21.3	30	20.0
24 x 245 s (1e4s)	10	21.8	30	20.5

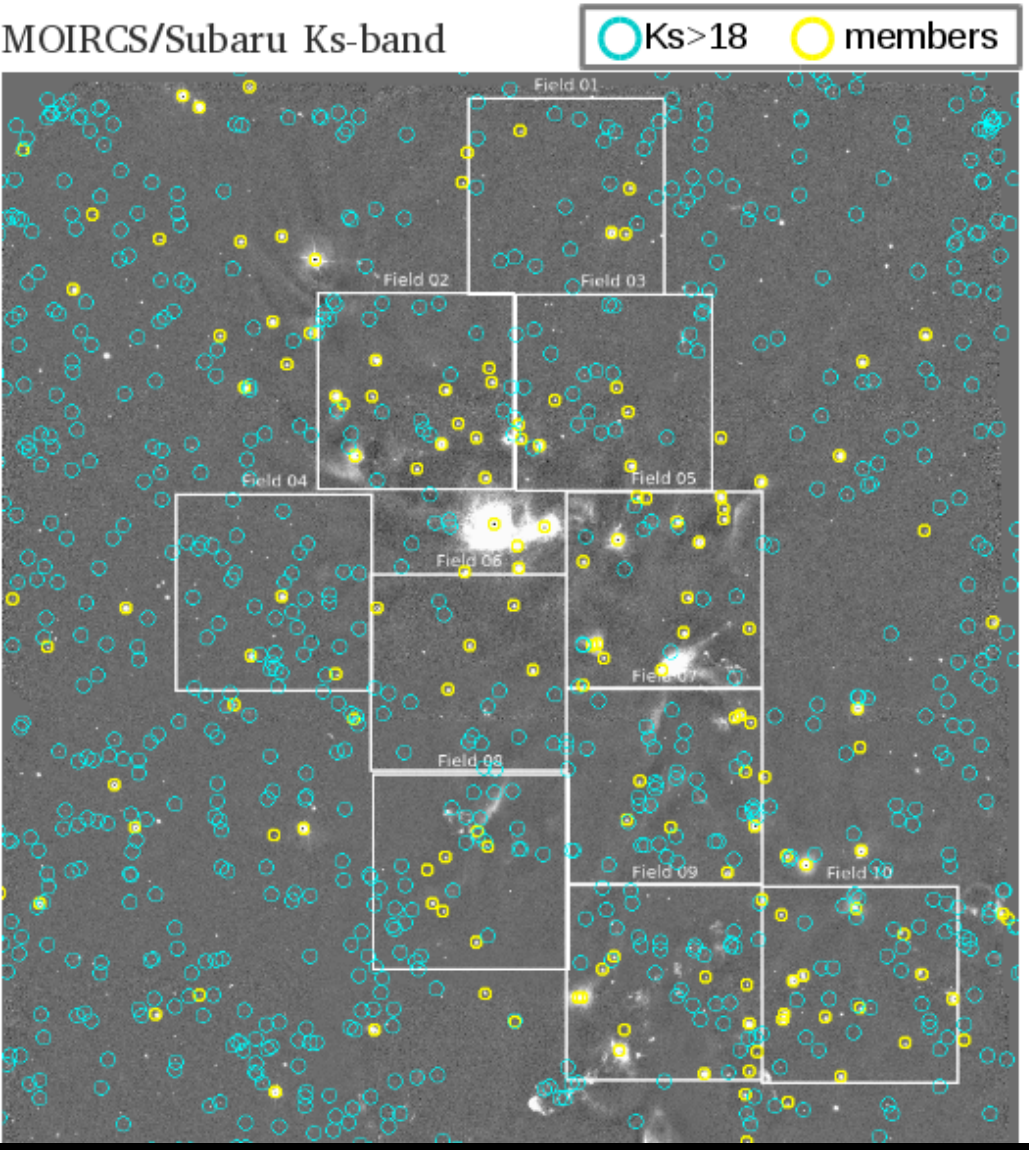
Filter F150W: 1.3 - 1.7 microns
S/N values at 1.6 microns

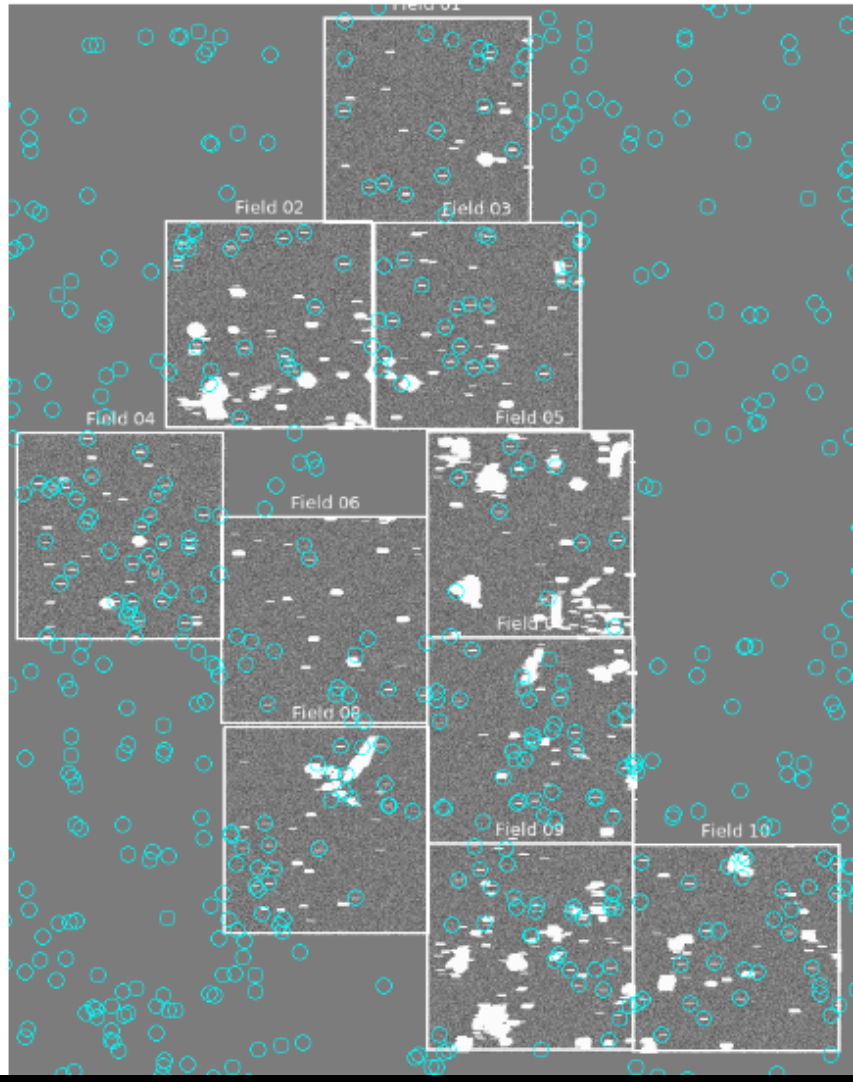
Exposure time	S/N @	K (mag)	S/N @	K (mag)
2 x 245s	10	20.5	30	19.5
10 x 245 s	10	21.5	30	20.5
24 x 245 s (1e4s)	10	22.0	30	21.0

NGC1333 planemos

BT-Settl model output for d=300 pc and Av=0

Mass	J	H	Ks
0.015 MSun	16.1	15.6	15.2
0.005 MSun	18.3	17.6	17.0
0.001 MSun	22.4	21.4	21.2





NIRISS simulation by Kora Muzic, using Grizli tool by Gabriel Brammer

WFSS mode on NIRISS/JWST

Details of the simulation

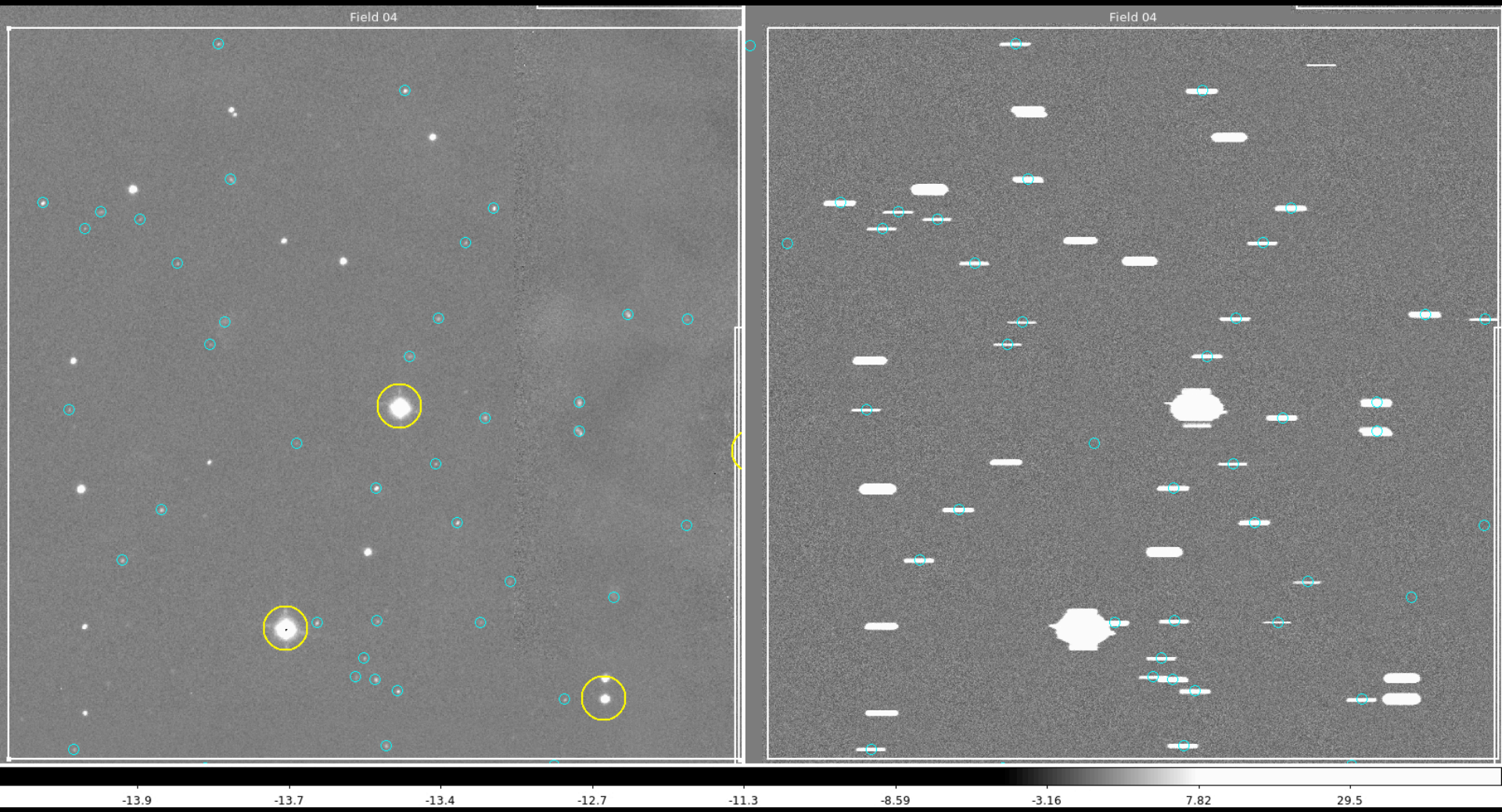
Performed with the Grizli tool, by Gabriel Brammer (STScI)
https://github.com/gbrammer/grizli

Filters: F150W and F220W
Exposure times: 1700s for F150W; 2500s for F200W (time to reach H=22 at S/N=10)

Total exposure time per field:
F150W: 1700 s + 10 min overhead = 38 min
F200W: 2500 s + 10 min overhead = 42 min

80 min per field, times 10 fields + 30 min slewing overhead = **13.8 hours**

NIRISS simulation by Kora Muzic, using Grizli tool by Gabriel Brammer



NIRISS simulation by Kora Muzic, using Grizli tool by Gabriel Brammer

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