DENSITY DEPENDENCE OF THE UPPER-MASS IMF - THE CASE OF ORION A

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Stellar Initial Mass Function

- Stellar initial mass function (IMF): mass distribution of a population of stars when they were initially formed
- High mass end: Salpeter slope $\xi(M) = \xi_0 M^{-2.35}$.
- Theoretical importance: test of star formation theories
- Observational importance: estimates of total stellar mass, SFR, feedback of an unresolved population all depend on the assumed IMF

Motivation

Question: Is the Upper-mass IMF universal?

- Hypothesis:
  high mass stars are less frequent in low density regions
  ... and perhaps less frequent in low mass clusters
  (e.g. Weidner, Kroupa & Bonnell 2010)

- Test: Compare the ratio of high-mass stars to low-mass stars in a low-density region to
  (1) theoretical IMFs
  (2) a high-density environment

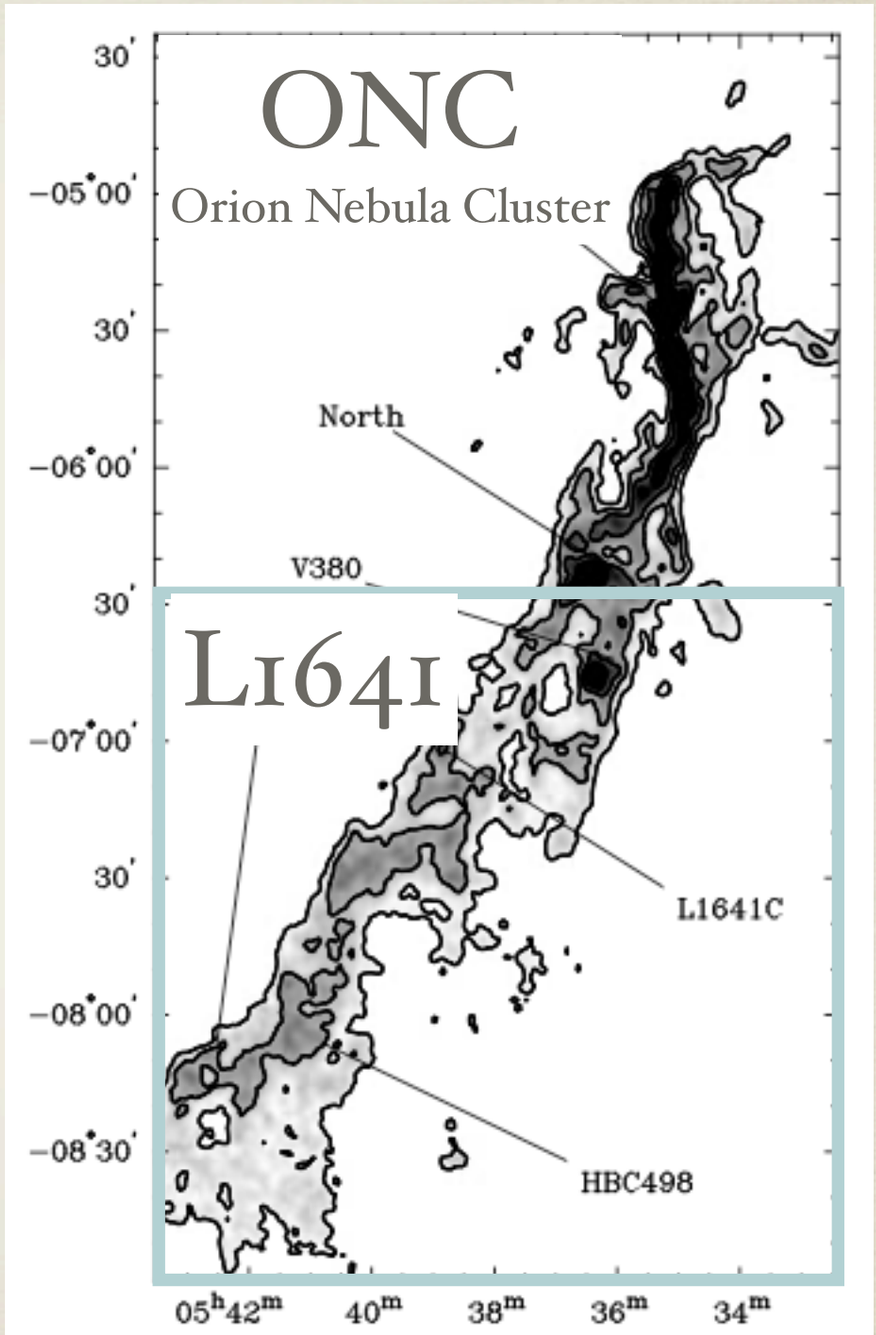
Challenge

- Need a young region to know the environmental density
- Need large number of stars (N ~1000) to test the upper-mass IMF
- Need a massive low-density region to compare to high-density regions
- Large area: Foreground/background contamination
  => Need spectroscopic survey to confirm members

Does the IMF depend on Density?

ONC	vs	L1641
cluster		distributed

- ONC: ~1500 stars
  2 O+ 7 early B stars
  well-populated IMF
- L1641: > 500 stars
  earliest star is B4
- Same distance, age
  => direct comparison
- Goal: Characterize YSOs in L1641



Orion A cloud in ^{13}CO

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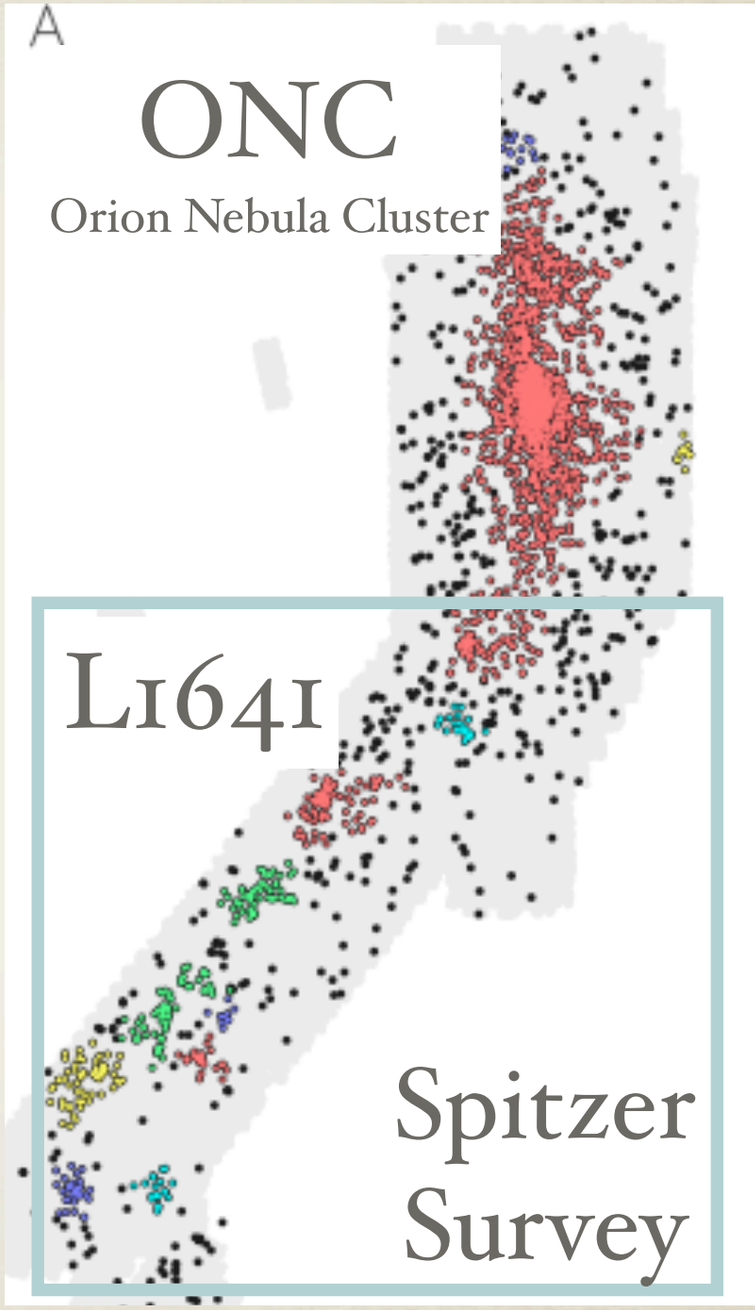
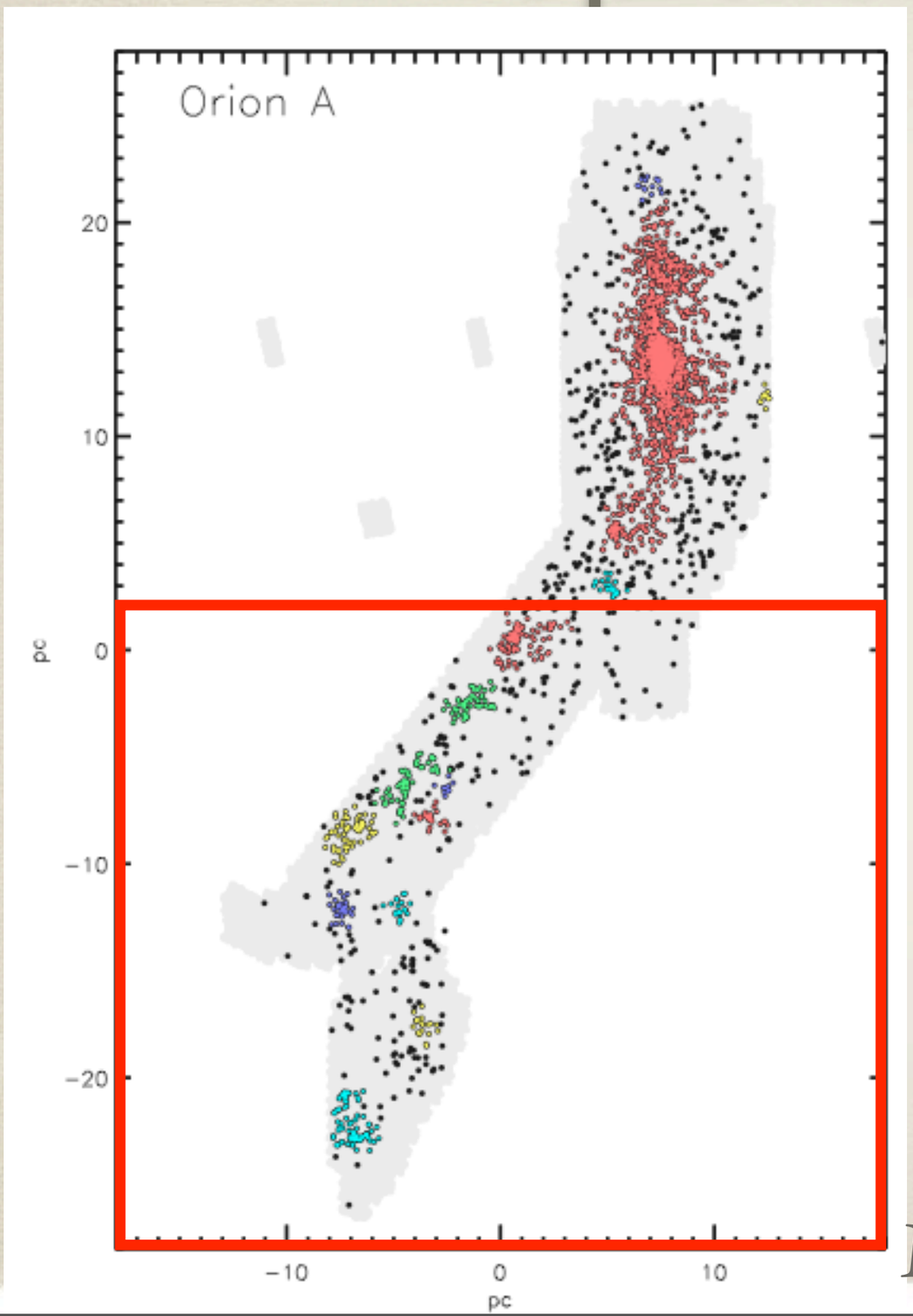


Gutermuth 2012

Spitzer Survey



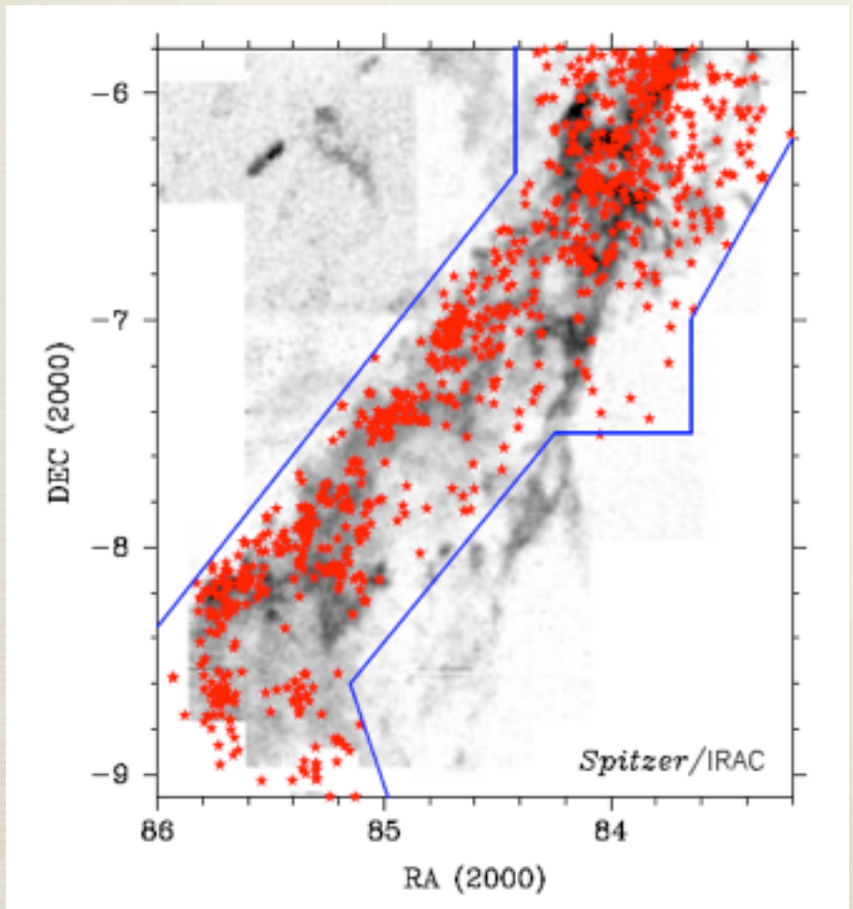
- ~500 objects in L1641 with IR excess: protostars/dusty envelopes and stars with disks
- No YSOs without IR excess, ~50% of the population
  => need to identify them on the optical CMD
- For statistics, want as large a sample as possible

Megeath et al (2012)

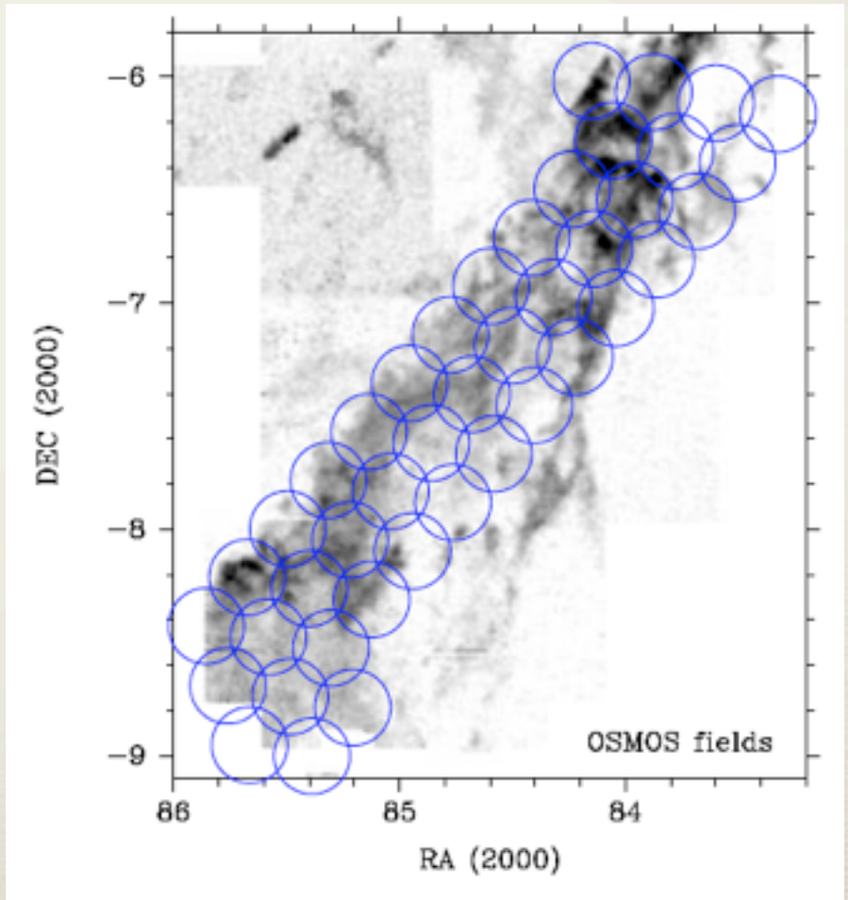
Sample

- IR-excess stars: Spitzer IR survey from Megeath et al. 2012

- Non-IR-excess stars:
  V, V-I photometry to find non-excess stars
  Confirm with optical multi-object spectroscopy (Magellan/IMACS, MMT/Hectospec)



Spitzer/IRAC field



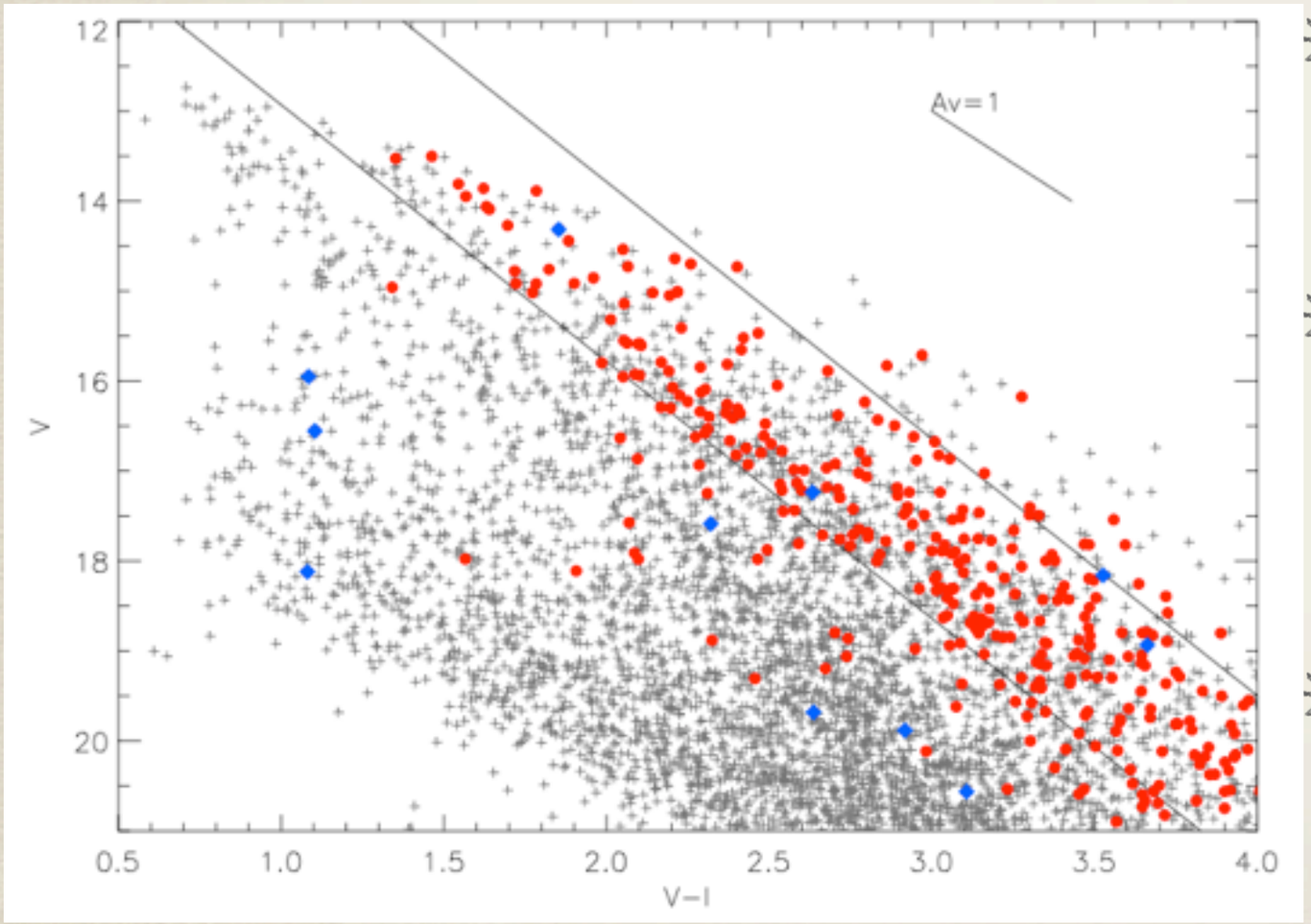
Optical Photometry field

Observational results

● : objects w/ disks

◆ : protostars

\+ : non-IR excess



V vs. V-I CMD

- ~2000 targets selected for spectroscopy
- confirmed membership & obtained spectral types and extinction
- class II/class III ratio ~ 1

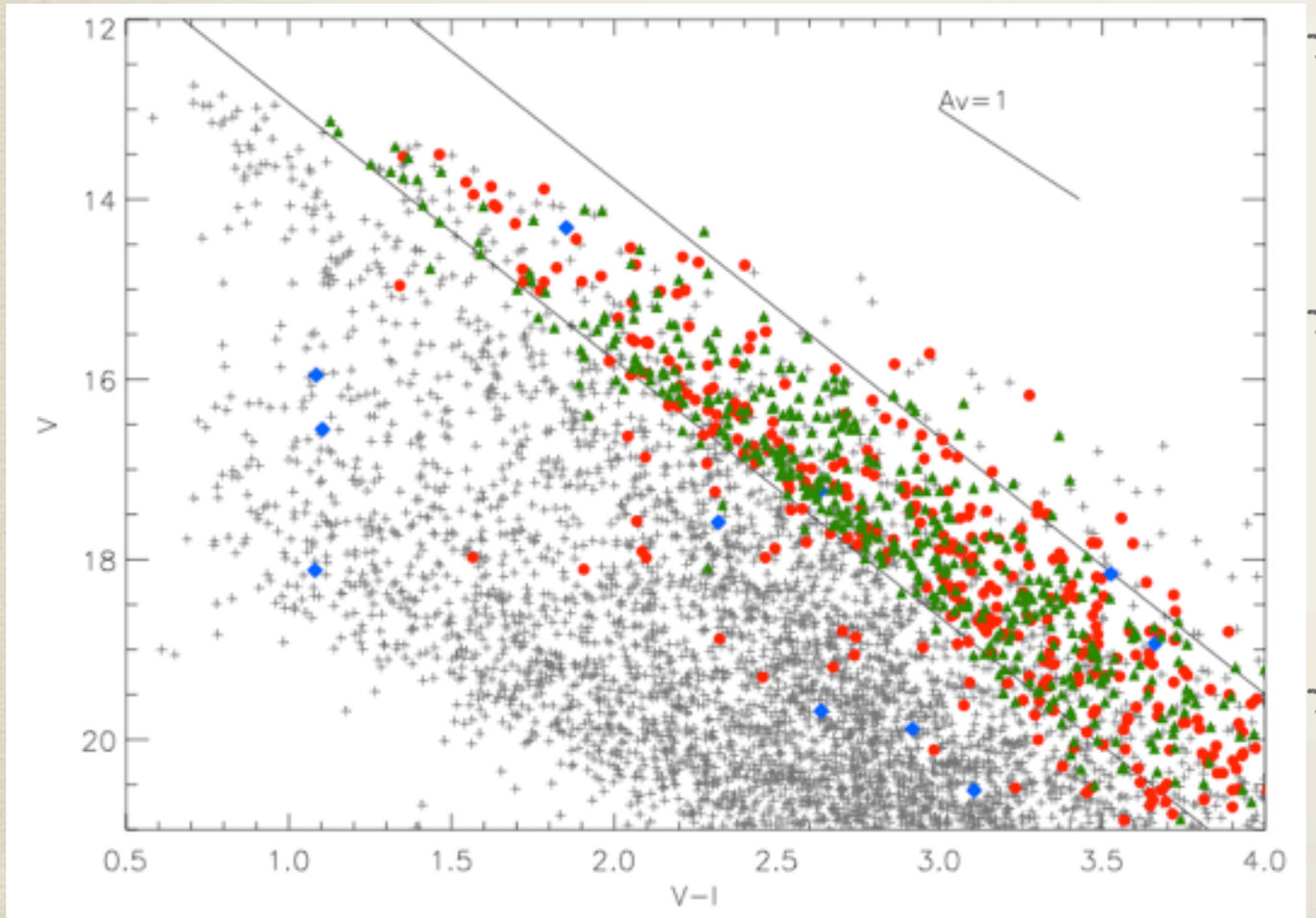
Observational results

: objects w/ disks

: protostars

: non-IR excess

: class III



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Intermediate Mass Stars

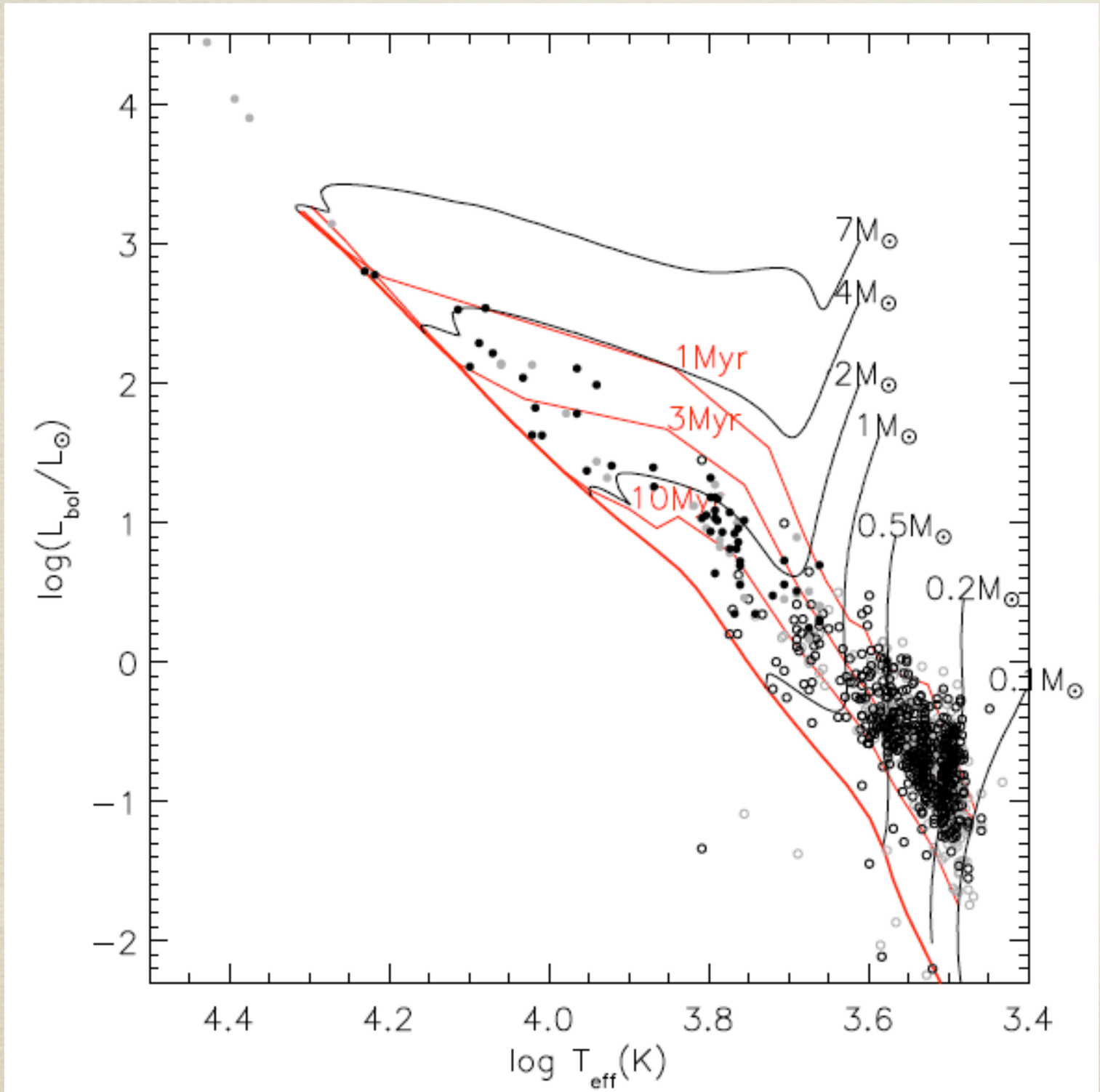
- Improve sample:
  optical photometry and spectra of late B to G stars
  missing from the low-mass sample (too bright)

- Main source of contamination:
  foreground F & G dwarfs, indistinguishable in CMD
  and low-res spectra => Kinematics needed

- Proper motion from UCAC to minimize contamination

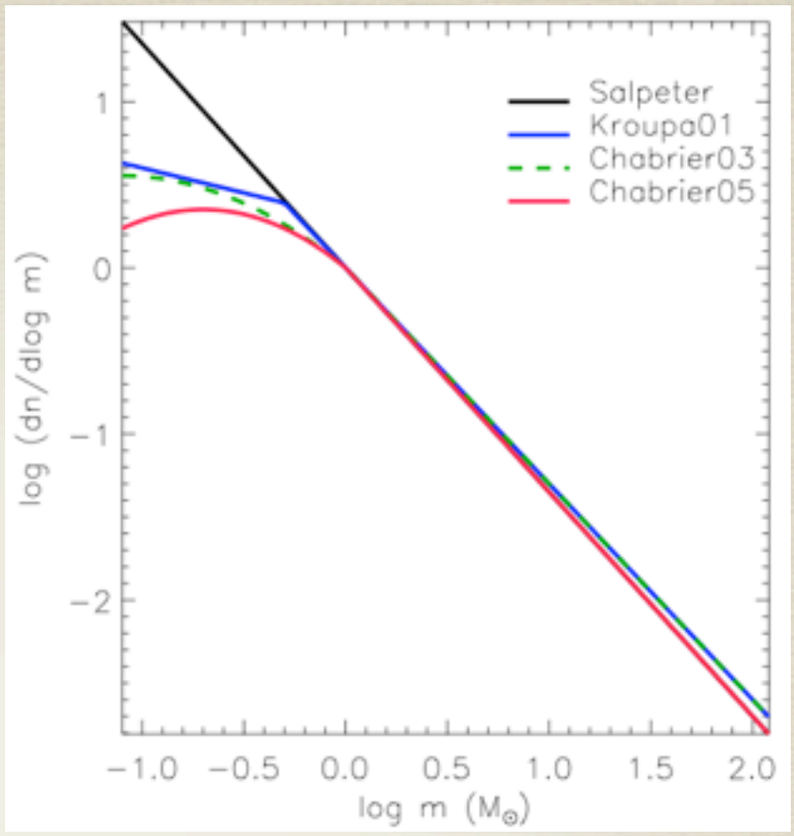
- Radial velocity => Magellan/MIKE spectroscopy
  20% of F & G stars observed (4 out of 20) are members

HR diagram



- Age ~ 3-4 Myrs
- Lack of O & early B star is not a result of evolution

Results
-Theoretic IMF



* Earliest star in L1641 is B4
* Spectroscopic Members ~500
  (total population ~1000)
* Test: ratio of N (O-B4) : N (> B4)
* Using ONLY the spectroscopic members,
  P (no stars earlier than B4) ~ 0.0018 (Chabrier 2005 IMF)
  P = 0.014 (Kroupa 2001 IMF)
* By using only the spectroscopic members, we underestimate the significance of the result.

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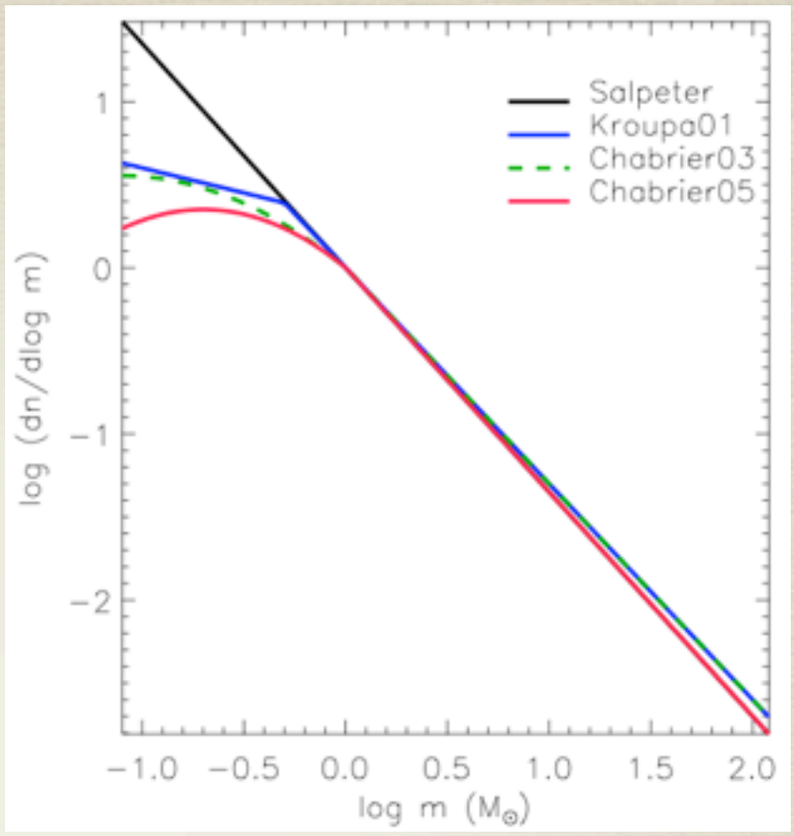

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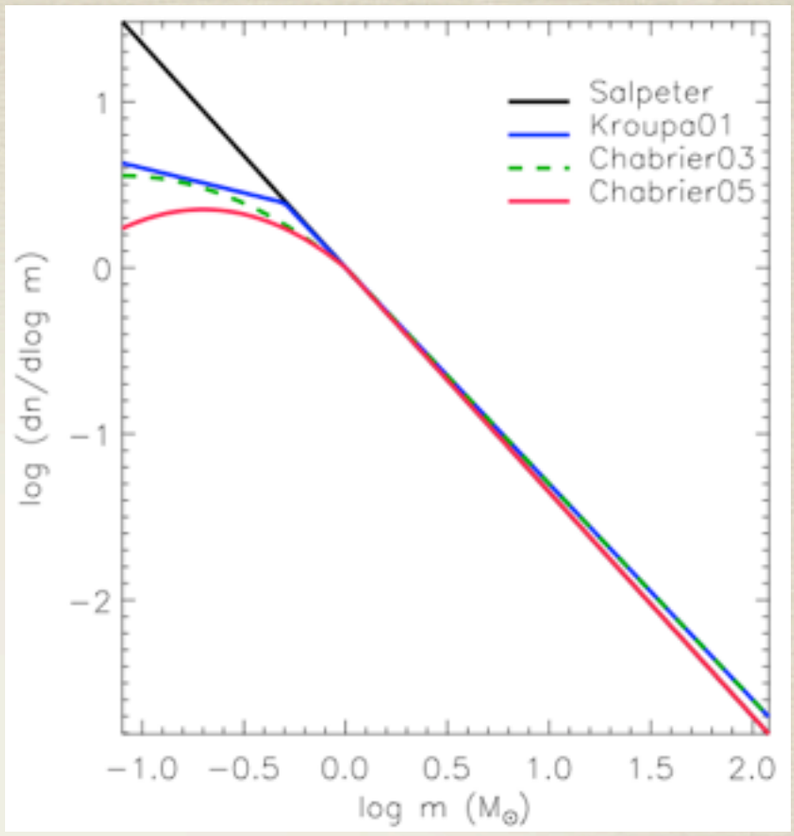

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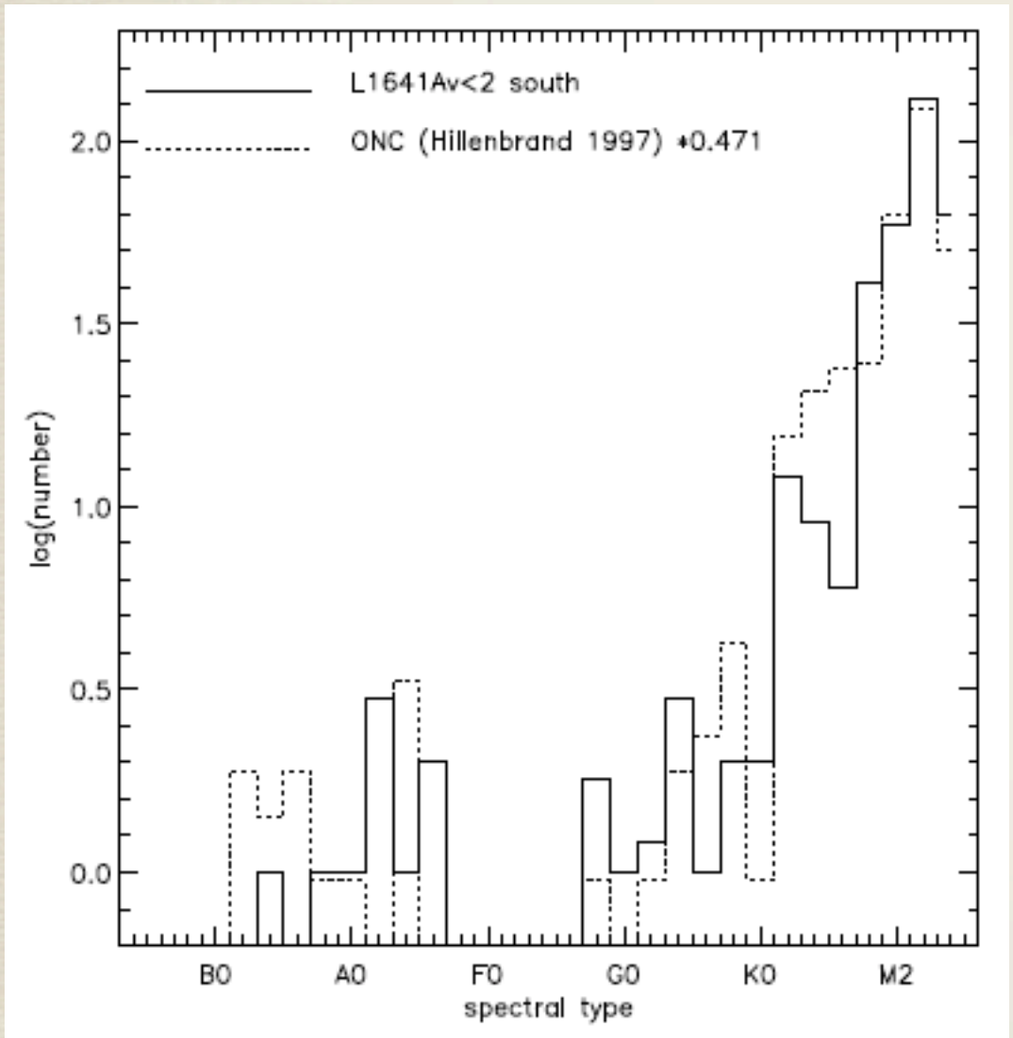
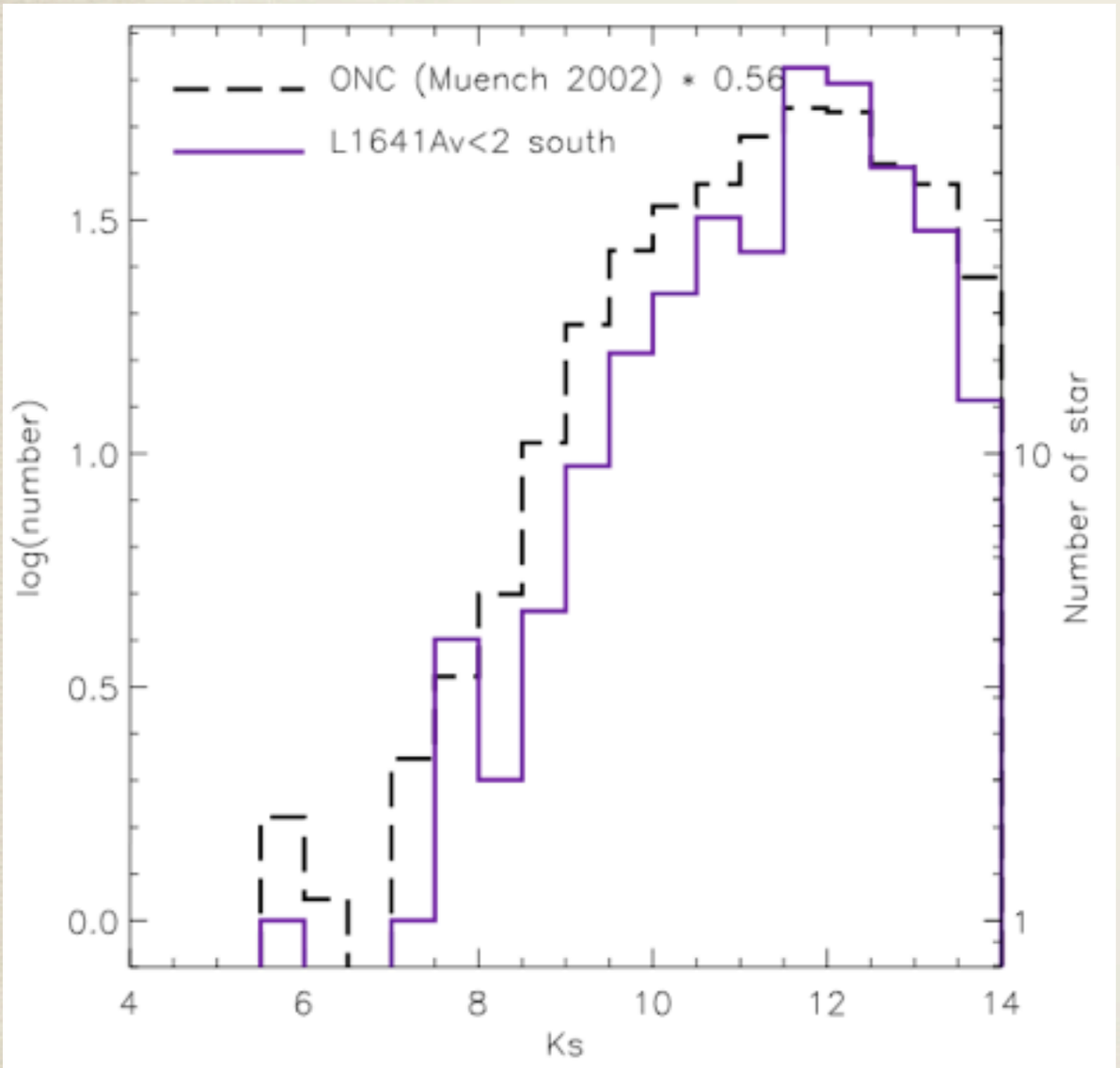
Comparison with ONC - Spectral Type distribution



- Av < 2 sample for both
  ~440 stars in ONC
  ~220 in L1641)
- Test ratio of N (O-B4) : N (> B4)
  (incomplete only in low-mass bin)
- "Fisher's exact test": P=0.085
- Difference not very significant; importance of sample size

Comparison with ONC-K Luminosity Function



- Spectroscopically-confirmed L1641 sample
- Muench et al. 2002 (5' x 5' field centered on Trapezium)
- Test ratio of N(K<9): N(12>K>9)
- Fisher's test: P=0.024
- Conservative

Summary

- Photometric and spectroscopic surveys of a low-density region L1641 south of the ONC
- L1641 has a population size ~ 1000, but earliest star is B4
- Unlikely (P~0.01) that the upper-mass IMF is the same as Kroupa (2001) or Chabrier (2005)
- Spectral type distribution inconclusive
- Bright end KLF different from that of the ONC, P=0.024 (conservative)
- High-mass stars are less frequent in low-density regions => density dependent upper-mass IMF