Extreme Variables in Star Forming Regions

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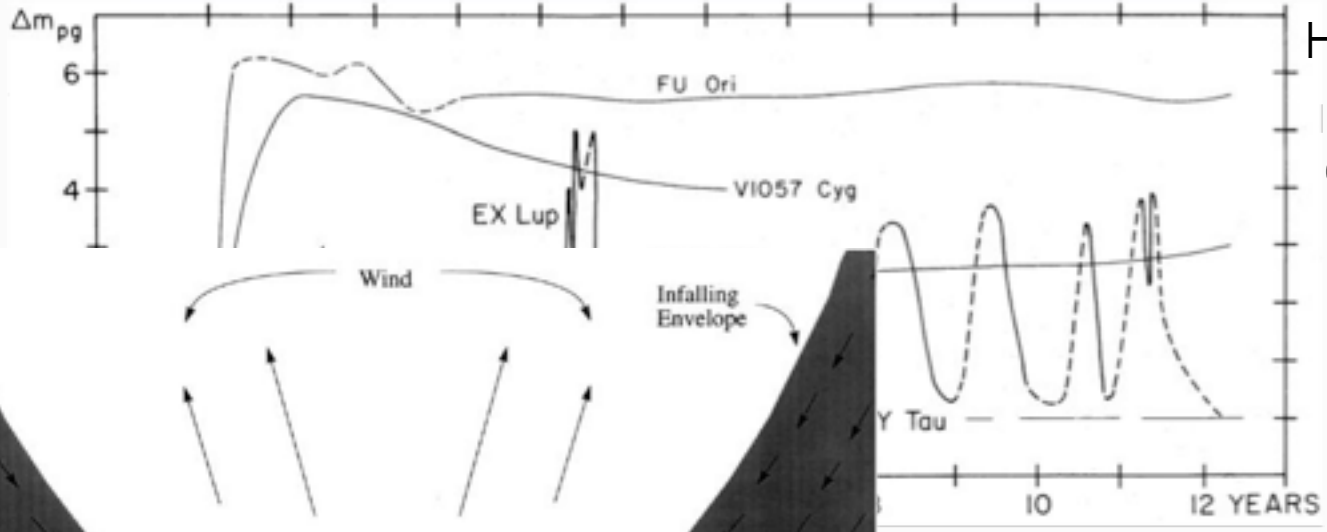
Eruptive Pre-Main Sequence (PMS) Variables



Herbig (1977)

ght to
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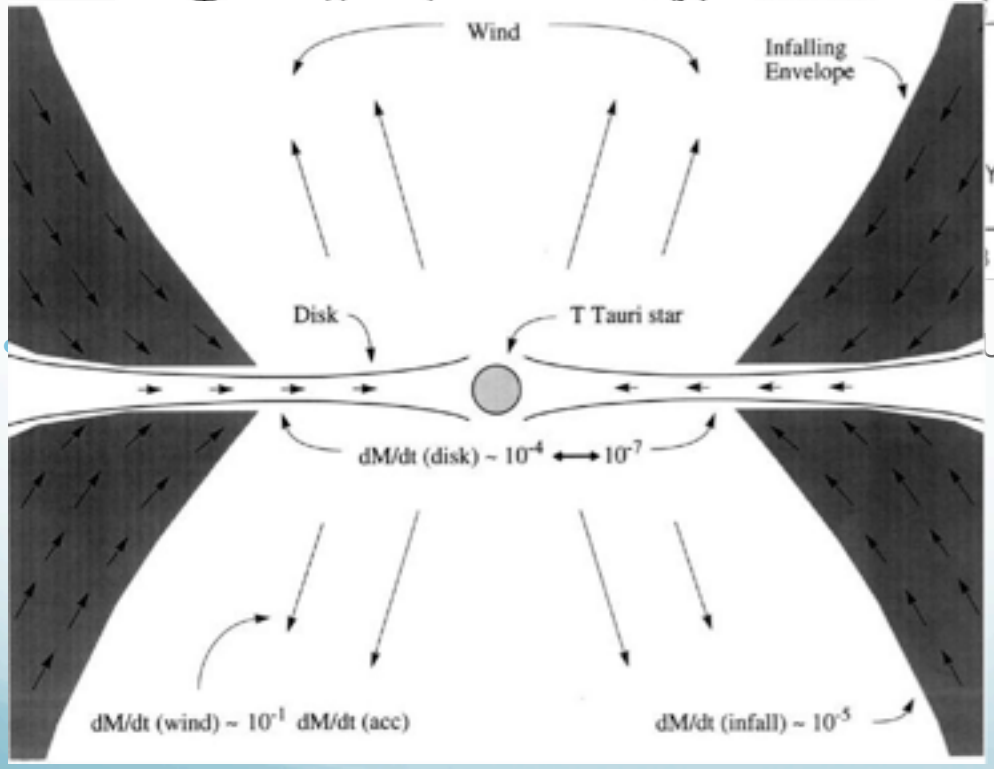


Hartmann & Kenyon (1996)

U Orionis (FUORs)

- ΔV=5-6 mag. Slow decline (~100 yrs)
- Broad absorption, blueshifted Balmer lines in the optical. Spectral types of late F to G supergiants
- NIR spectra with H_2O and CO absorption. Best matched with K-M supergiant atmospheres.
- Associated to molecular outflows and reflection nebulae. (See Hartmann & Kenyon 1996)

Eruptive Pre-Main Sequence (PMS) Variables

- Both classes defined at optical wavelengths. This tends to exclude younger protostars.
- Optically invisible PMS stars have shown infrared variability and share spectral characteristics with FUORs, i.e OO Ser, [CTF93]216-2, AR 6B and PP 13S (Hodapp et al 1996, Caratti o Garatti et al 2011, Aspin & Reipurth 2003, Aspin & Sandell 2001).
- Aspin & Greene (2010) find a number of Class I FUOR-like objects
- **V1647 Ori** (Fedele et al. 2007), **OO Ser** (Kospal et al. 2007) and **[CTF93]216-2** (Caratti o Garatti et al 2011) show characteristics of both FUORs and EXORs (Spectrum, Outburst Duration)
  - EXORs and FUORs part of a continuum of outburst events (Gibb et al. 2006, Fedele et al. 2007)

Importance of FUORs

- FUOR outbursts are thought to be common among PMS stars
- Would help to explain observed scatter in HR diagrams of low-mass PMS clusters. (Baraffe et al 2009).
  - Solve the so called “Luminosity problem” (Kenyon et al. 1990, Caratti o Garatti et al 2012)
- Stellar and sub-stellar masses derived until now are likely to be wrong!!!
- Goal of the project: Determine how common are FUORs
  - Use of UKIDSS GPS and VVV (GLIMPSE,WISE,IPHAS,etc)

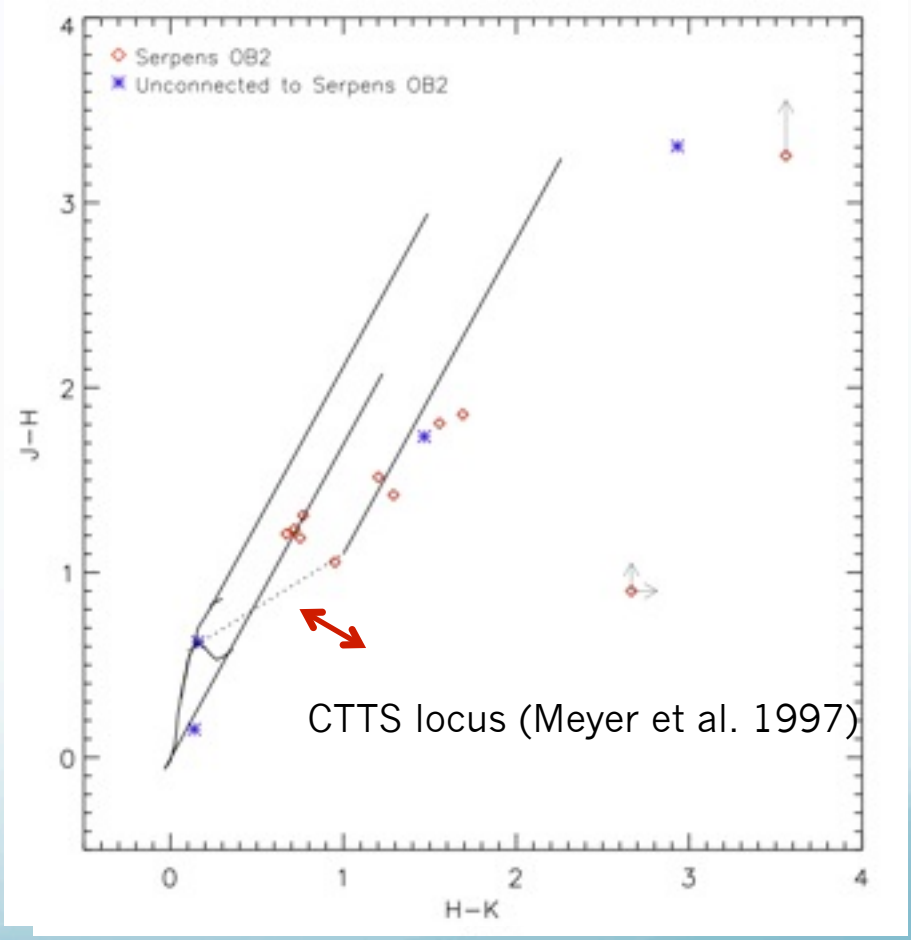
Candidate Selection

- Search for candidates in 2 epoch variability data from GPS data release DR5
  - MergedClass=-1
  - K_1(2)ppErrBits < 256
  - K_1(2)Ell < 0.3
  - ΔK>1
  - K<16 mag in at least one epoch
  - Coordshift < 0.5 arcsec

  - Removing false positives left us with 17 candidates with ΔK up to 3.75 mag

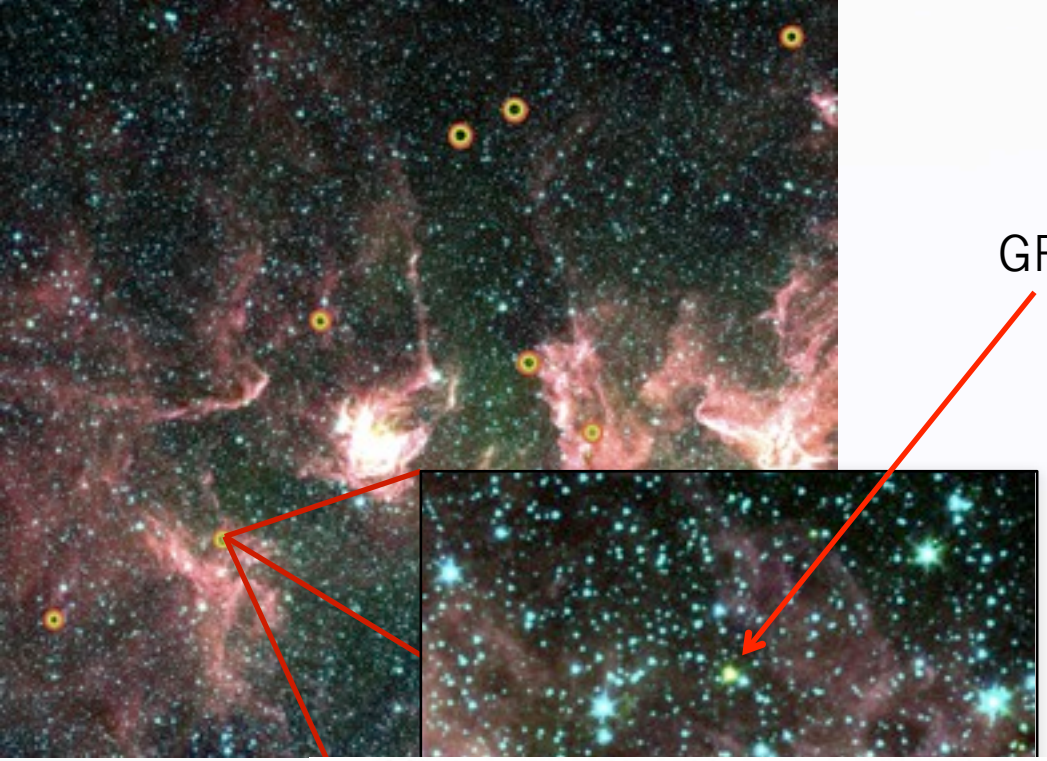
Properties

- Extremely red in CMD
- NIR excess in colour-colour diagrams
- 11 of 17 candidates within 1 deg^2 of Serpens OB2 association
- NIR photometry and spectroscopy with ISAAC.



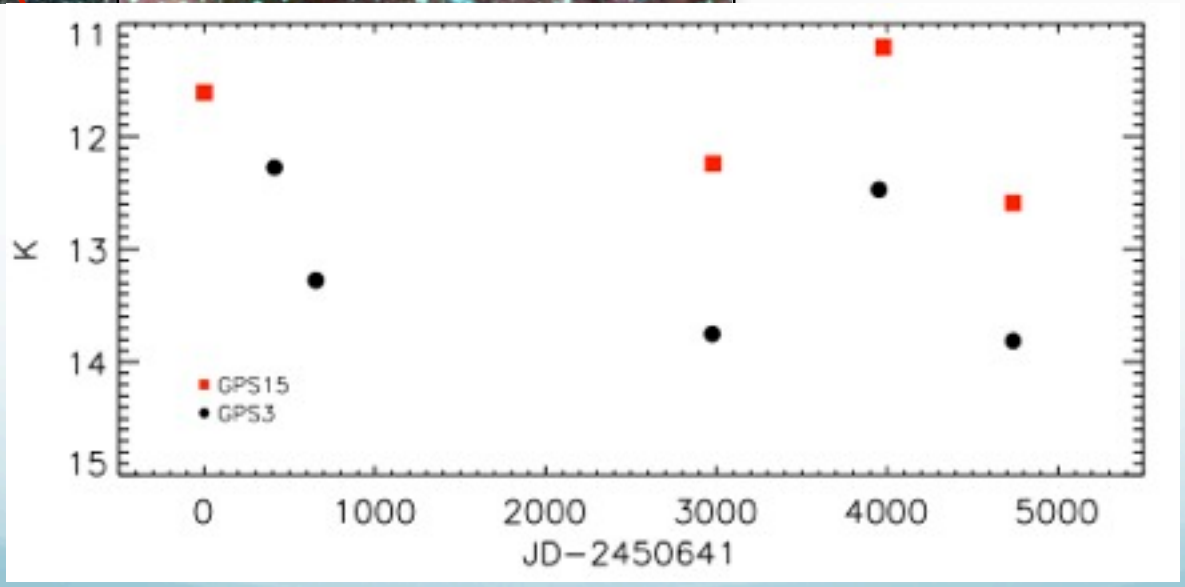
RESULTS

Serpens OB2 (blue -3.6 μm, green -4.5 μm, red -8.0 μm)

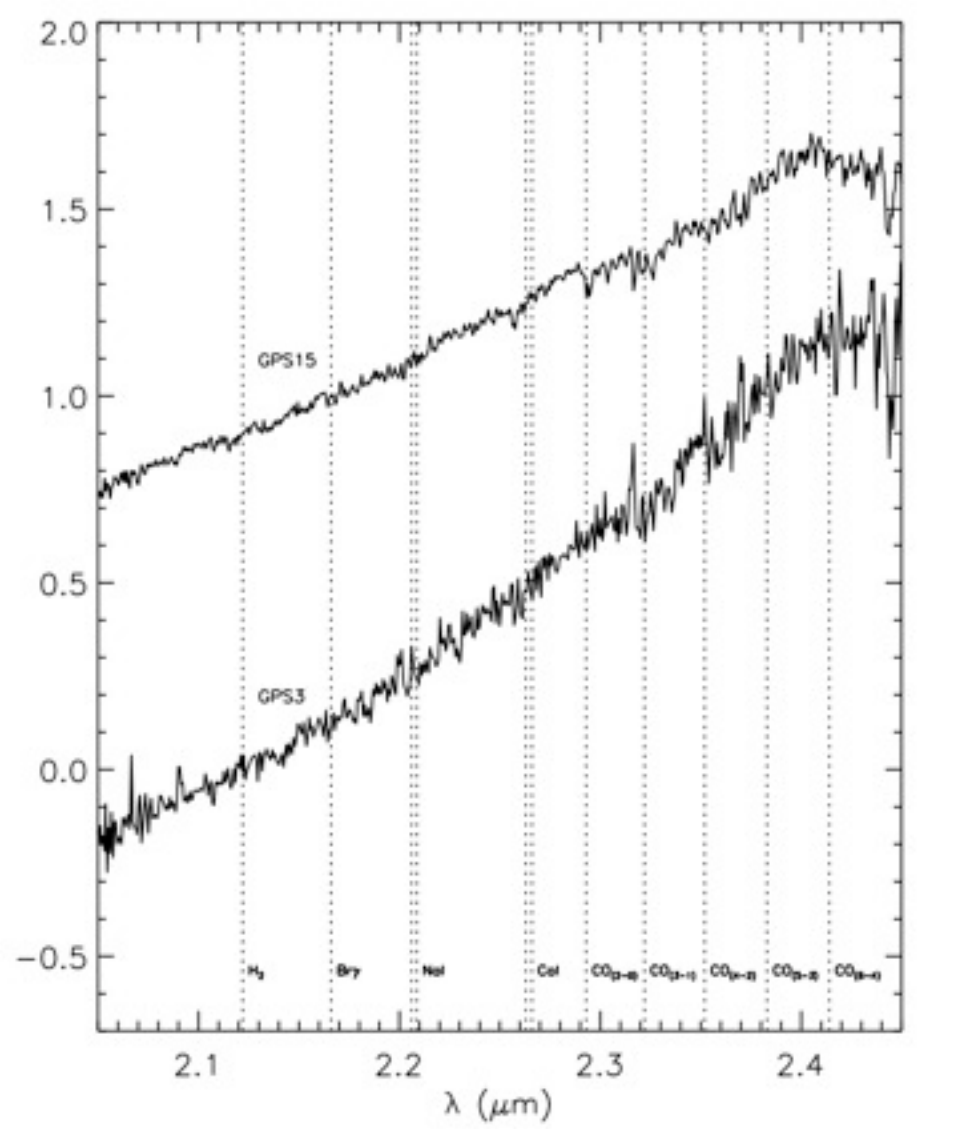


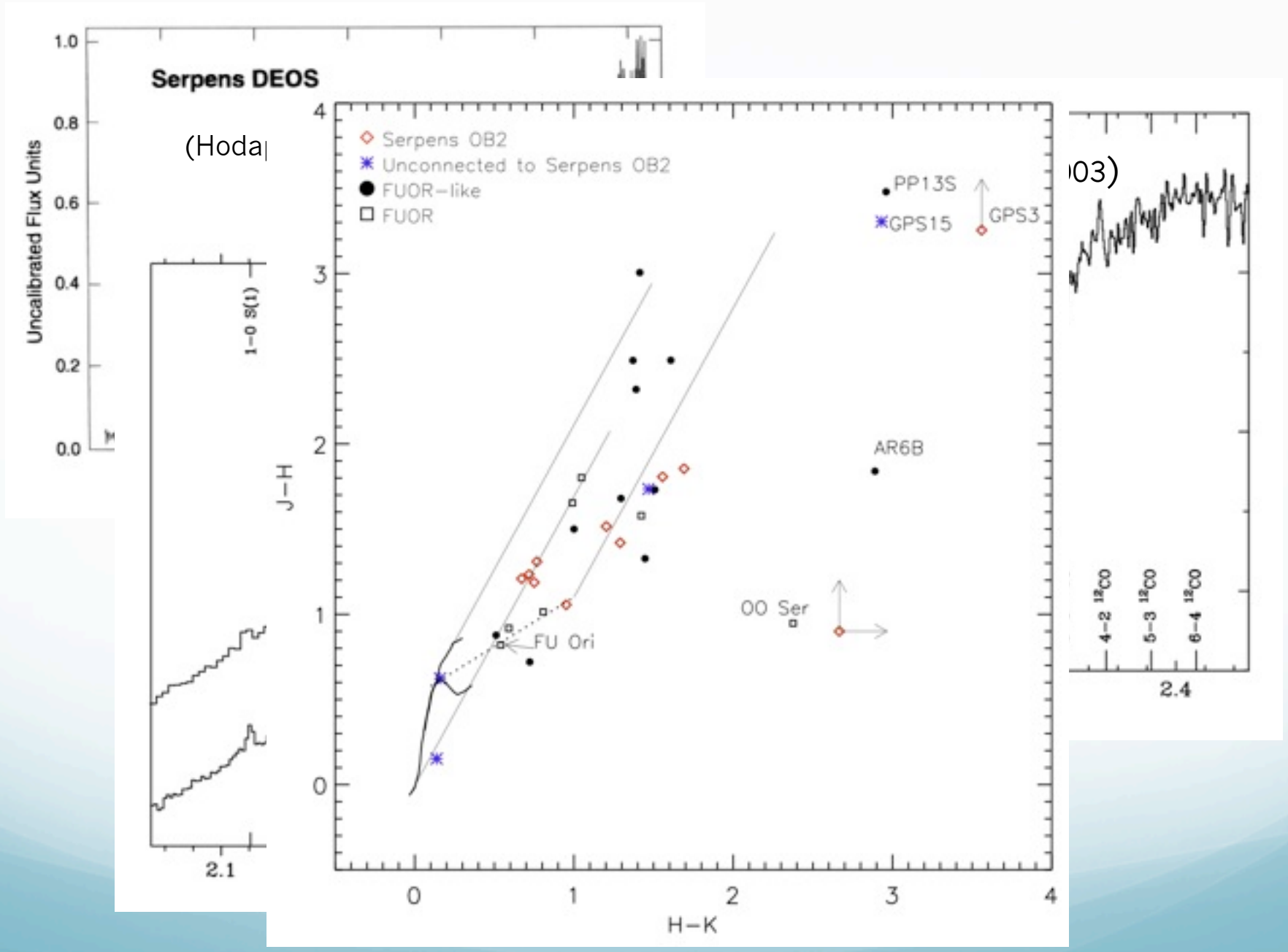
GPS15 however, not associated with a star forming region

GPS3 Corresponds to one of the reddest objects in our sample, along with GPS15



- GPS15 and GPS3 correspond to very red objects. Show similarities to embedded sources classified as FUORs

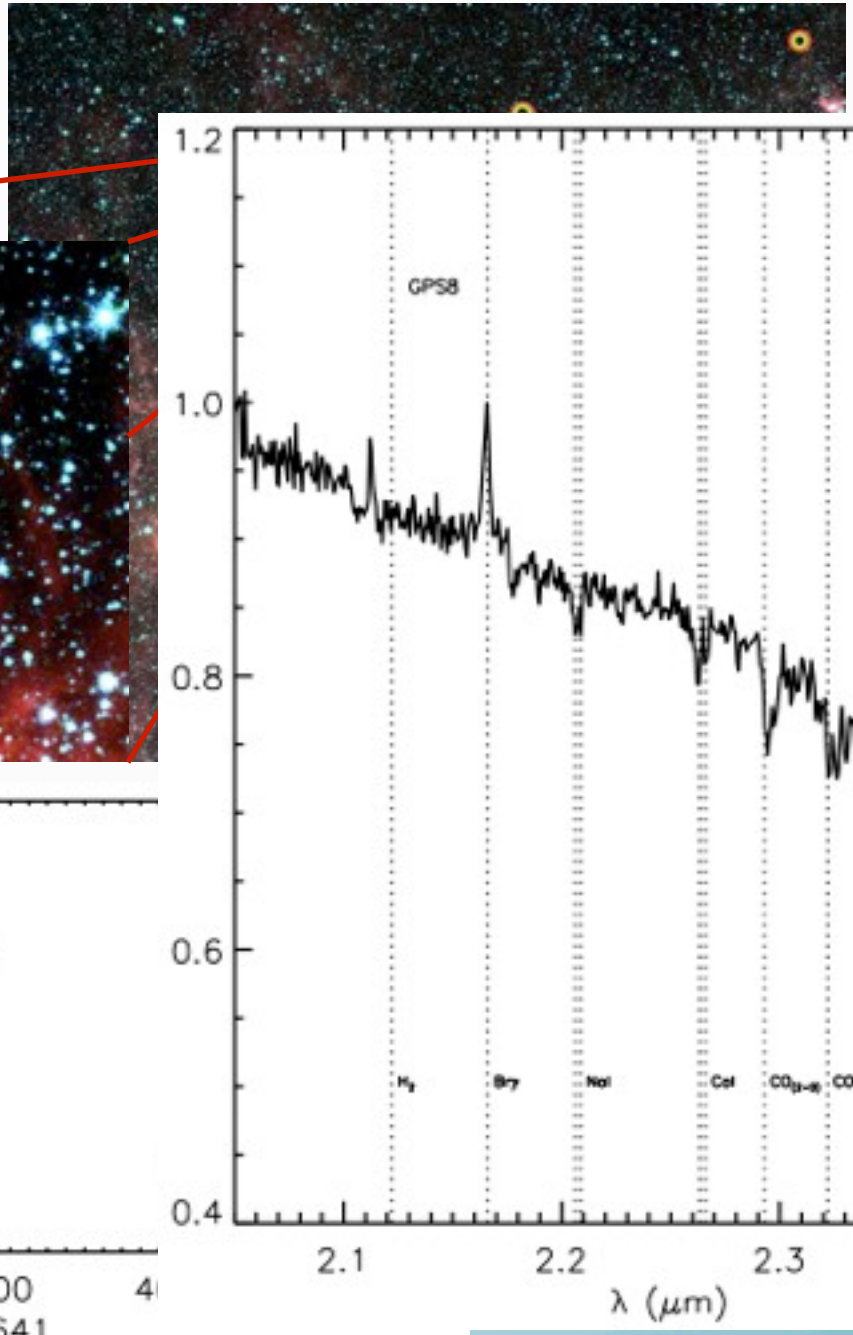


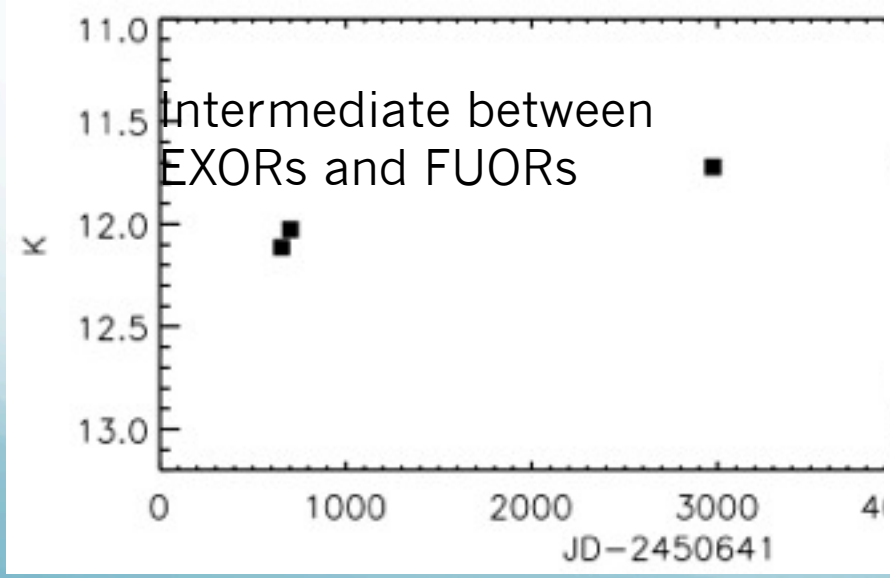

Serpens DEOS
(Hoda
03)
Uncalibrated Flux Units
1.0
0.8
0.6
0.4
0.2
0.0
1-0 S(1)
2.1
Serpens OB2
Unconnected to Serpens OB2
FUOR-like
FUOR
PP13S
GPS15
GPS3
AR6B
OO Ser
FU Ori
J-H
H-K
0
1
2
3
4
4-2 12CO
5-3 12CO
6-4 12CO
2.4

Everything points to deeply embedded Class I FUOR/EXOR classification

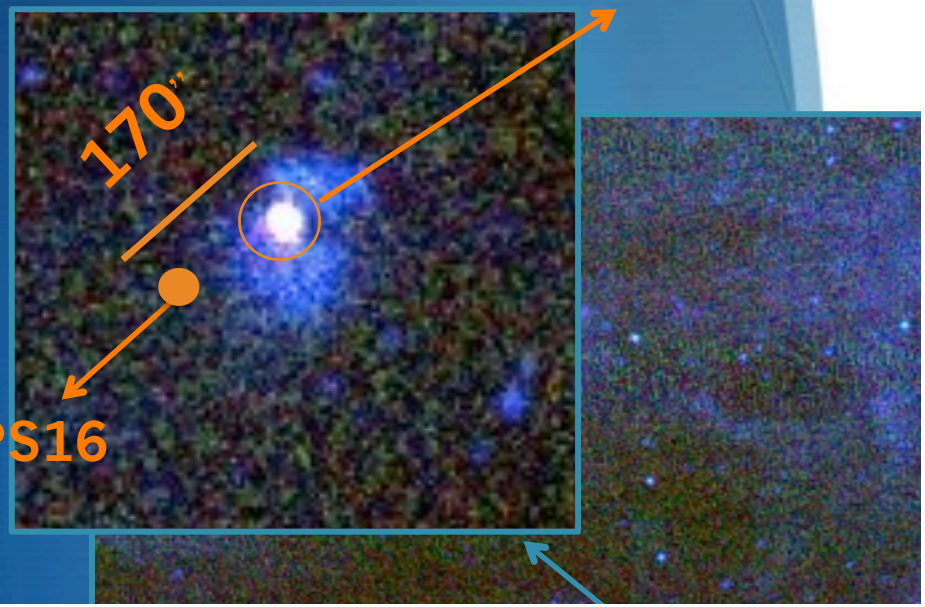
FIRE Spectroscopy

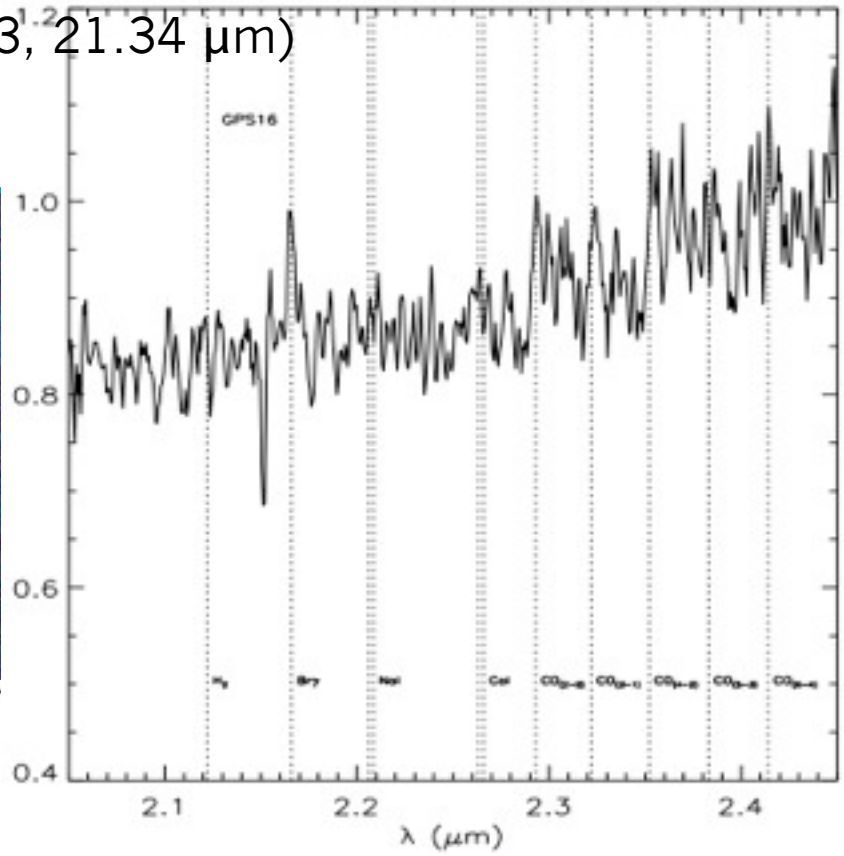
GPS8

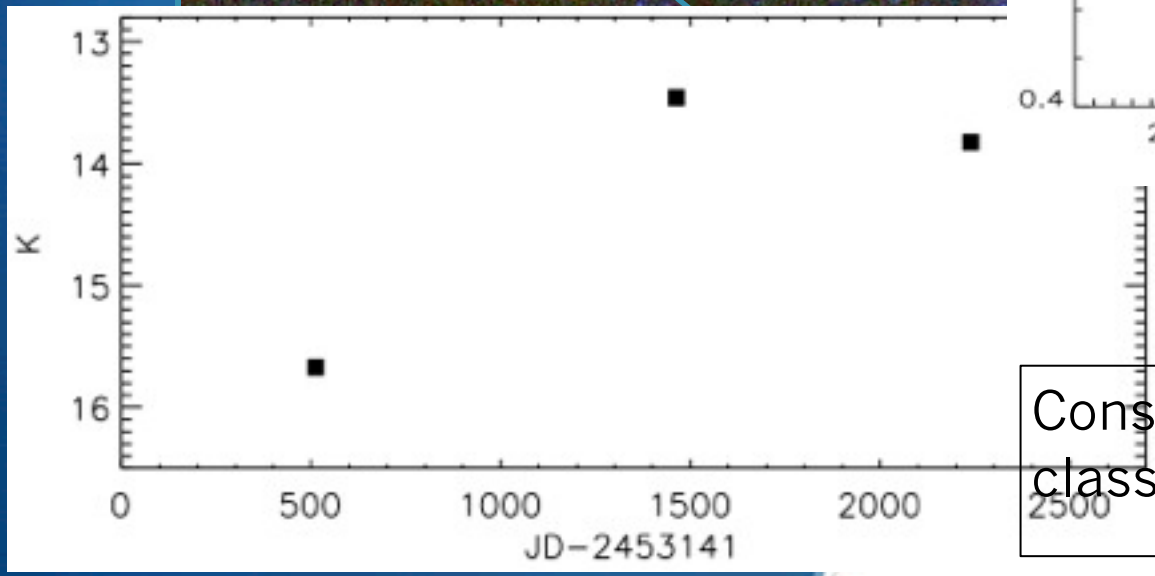

GPS8
1.2
1.0
0.8
0.6
0.4
2.1
2.2
2.3
2.4
λ (μm)


Intermediate between
EXORs and FUORs
11.0
11.5
12.0
12.5
13.0
K
0
1000
2000
3000
JD−2450641

MSX6C false color image (8.28, 12.13, 21.34 μm)



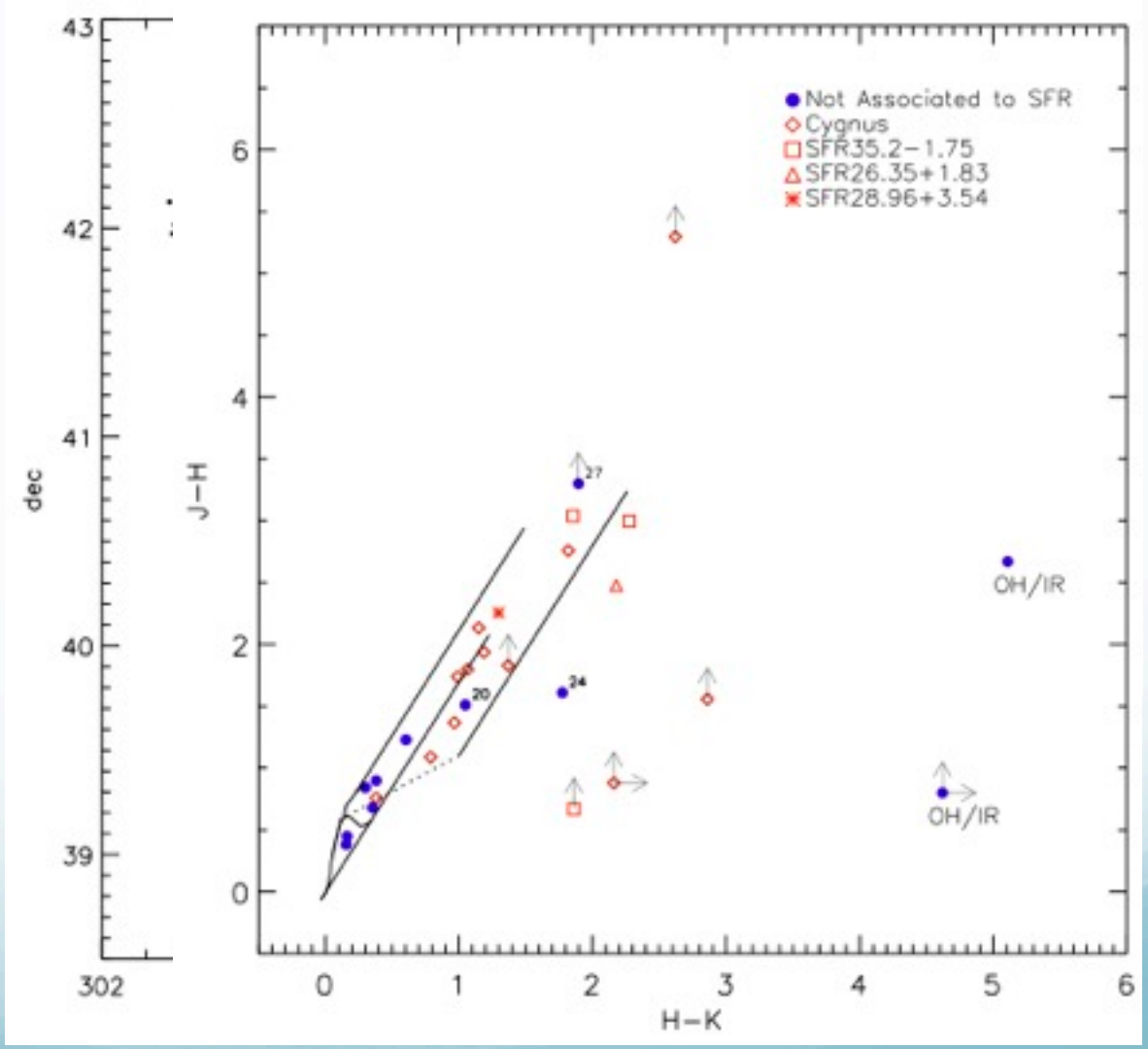




Consistent with an EXOR classification.

DR7 Candidate selection

- 3365 stars selected
- 28 candidates
- 12 in a ~6ºx3º area in Cygnus
- 5 within 300 arcsec of SFRs from Avedisova (2002).
- 66% of our sample located at SFRs



Thank you