The GPS/GLIMPSE 360 search for red objects

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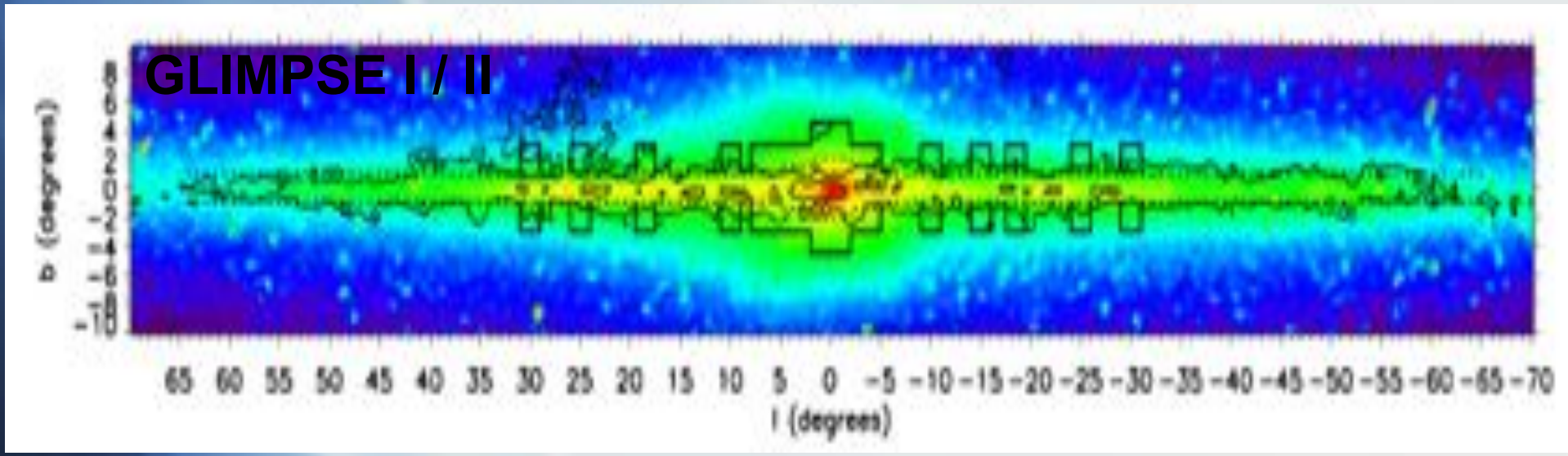
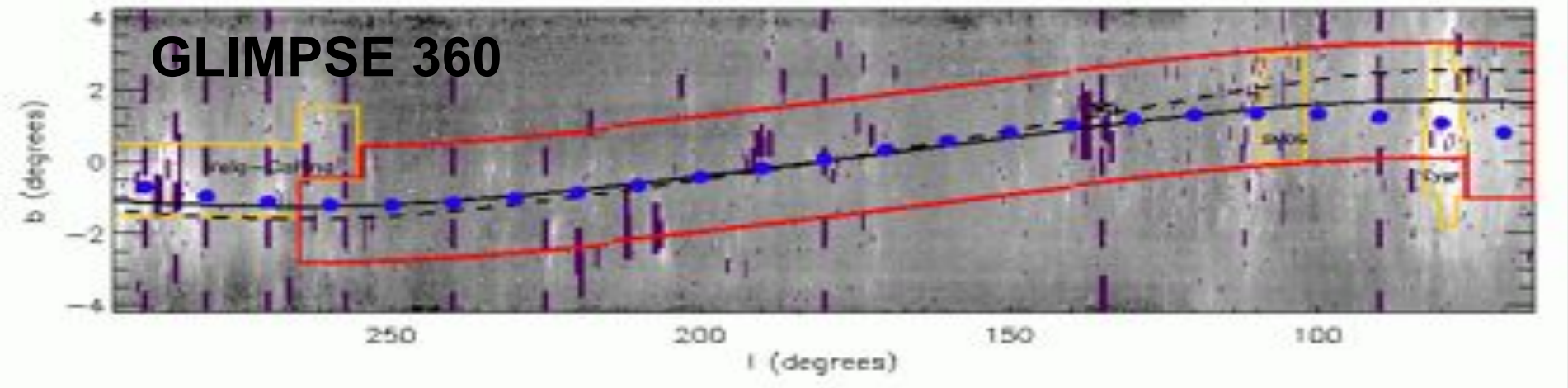
UHerts

GLIMPSE I/II Surveys



- GLIMPSE I (|l|=10-65deg, |b|<1.5deg)
- GLIMPSE II (|l|<10deg , |b|<1.5deg)
- All IRAC bands (3.6, 4.5, 5.8, 8mu), follow-up 24 & 70mu MIPSGAL I/II surveys
- vertical extensions for GLIMPSE 3D (|b|<3.1deg)

GLIMPSE 360 Survey

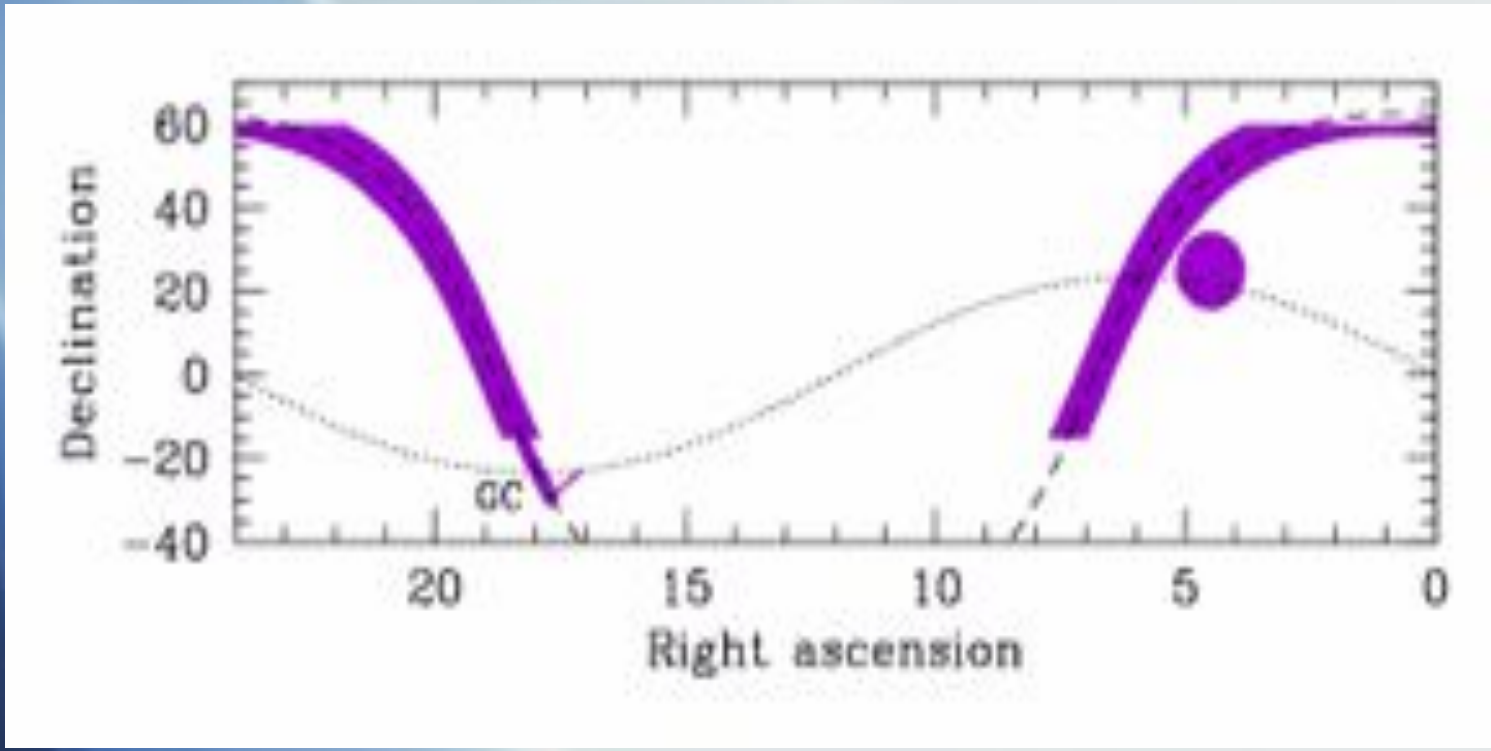


- **GLIMPSE 360 (65 < *l* < 102 and 109 < *l* < 265 , |b|<3.1deg)**
- **IRAC 3.6 & 4.5mu only**
- **deeper and brighter than GLIMPSE I/II**

Table 1. Sensitivity Limits in mJy (magnitudes in parentheses)

Project	3.6 μm Lower	3.6 μm Upper	4.5 μm Lower	4.5 μm Upper
GLIMPSE360[a]	0.015 (18.2)	1100 (6.0)	0.021 (17.3)	1100 (5.5)
WISE[b]	0.06 (16.8)	110 (8.6)	0.10 (15.6)	60 (8.6)
GLIMPSE	0.20 (15.4)	440 (7.0)	0.20 (14.9)	450 (6.5)

UKIDSS GPS Survey



- Mapping Galactic plane covering ~1800 sq. deg in JHK to a depth J=20.0, H=19.1, K=19.0
- 15<l<107 and 142<l<230 deg, |b|<5deg.

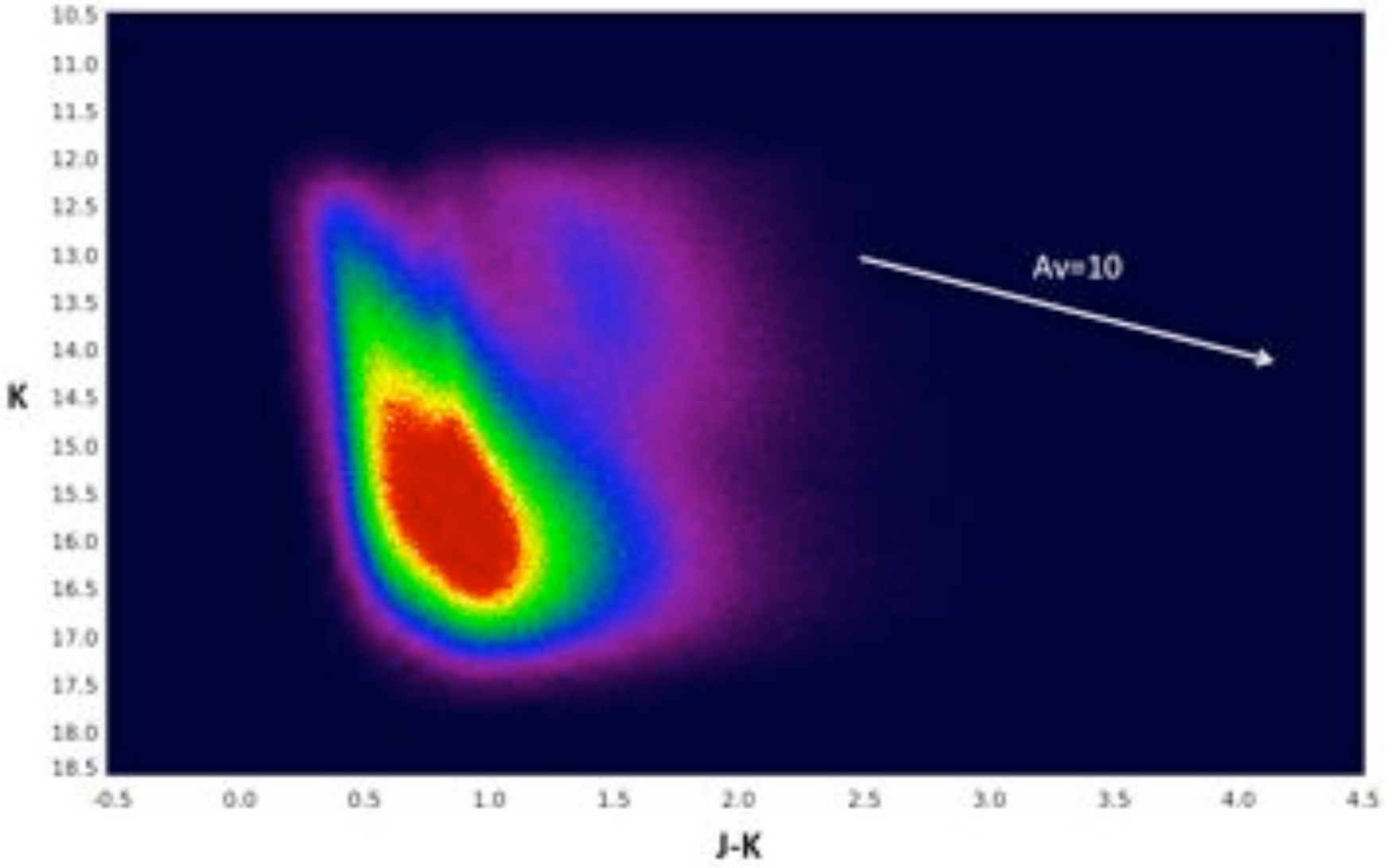
GLIMPSE 360+GPS

- GLIMPSE 360 depth well-matched to GPS near-IR **survey depth** (K=17.8, H=18.6, J=19.5)
- GPS covers a substantial portion of the GLIMPSE 360 region (**65 < *l* < 102 and 141 < *l* < 230**)
- To create a **catalog of red sources** (YSOs, evolved stars (AGBs), PNe, T dwarfs), study star formation in the Outer Galaxy

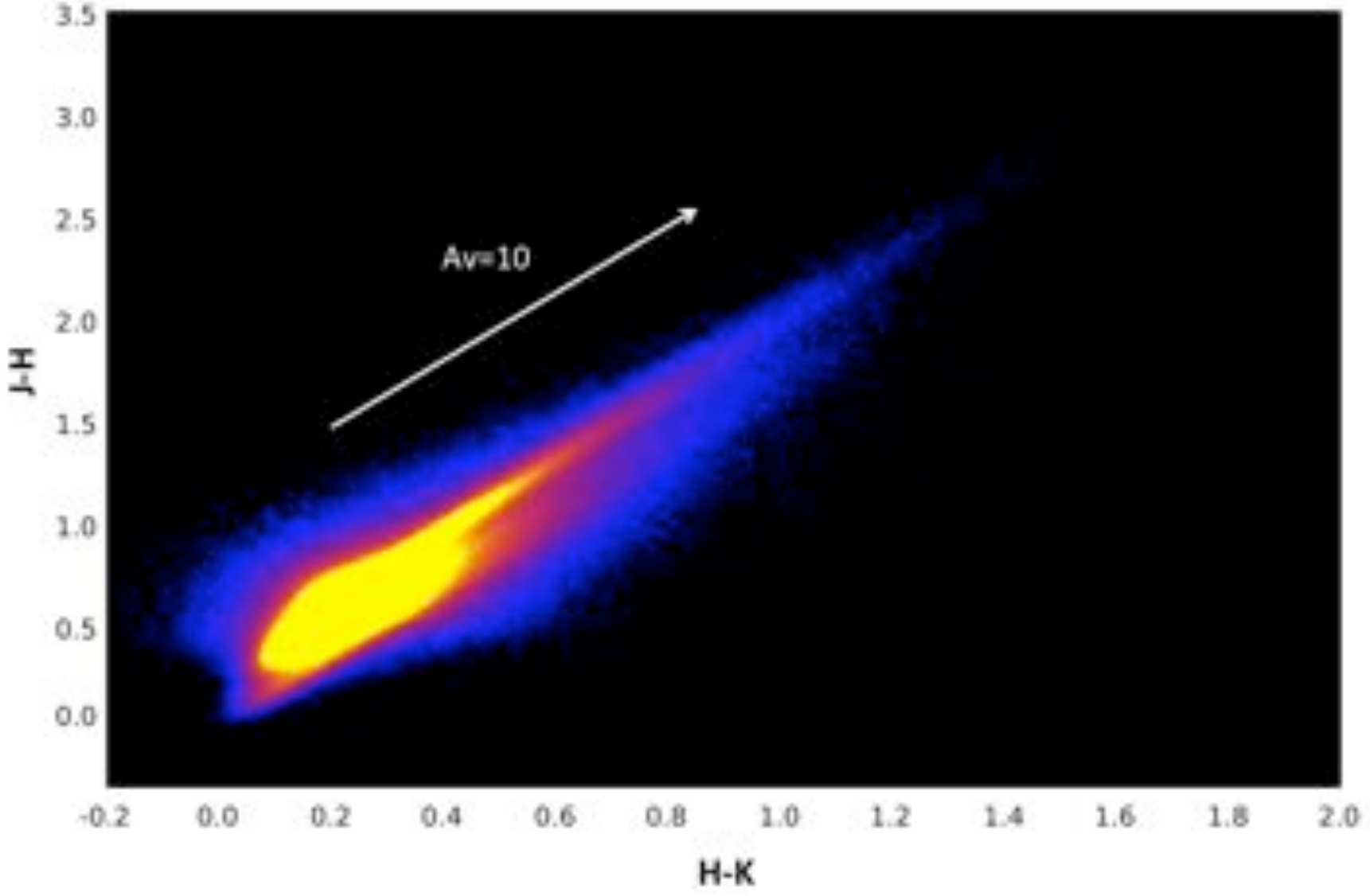
Matched Catalog Filters

- Remove close stellar pairs: csf=0 (**no source within 3"**)
- mergedClass=0, Ell<0.3, pstar>0.99: minimum value for a source to be **classified as a star**, not a probable star or a galaxy, remove extended or unresolved stellar pairs
- ppErrbits<256: remove sources with less reliable photometry due to **deblending or bad pixels**
- For **reliable photometry**: selected sources with fractional flux errors below 15%
- Remove spurious detections: selected sources detected at least **twice at 3.6 and 4.5mu**
- Merged catalog consists of **3,037,470 sources**

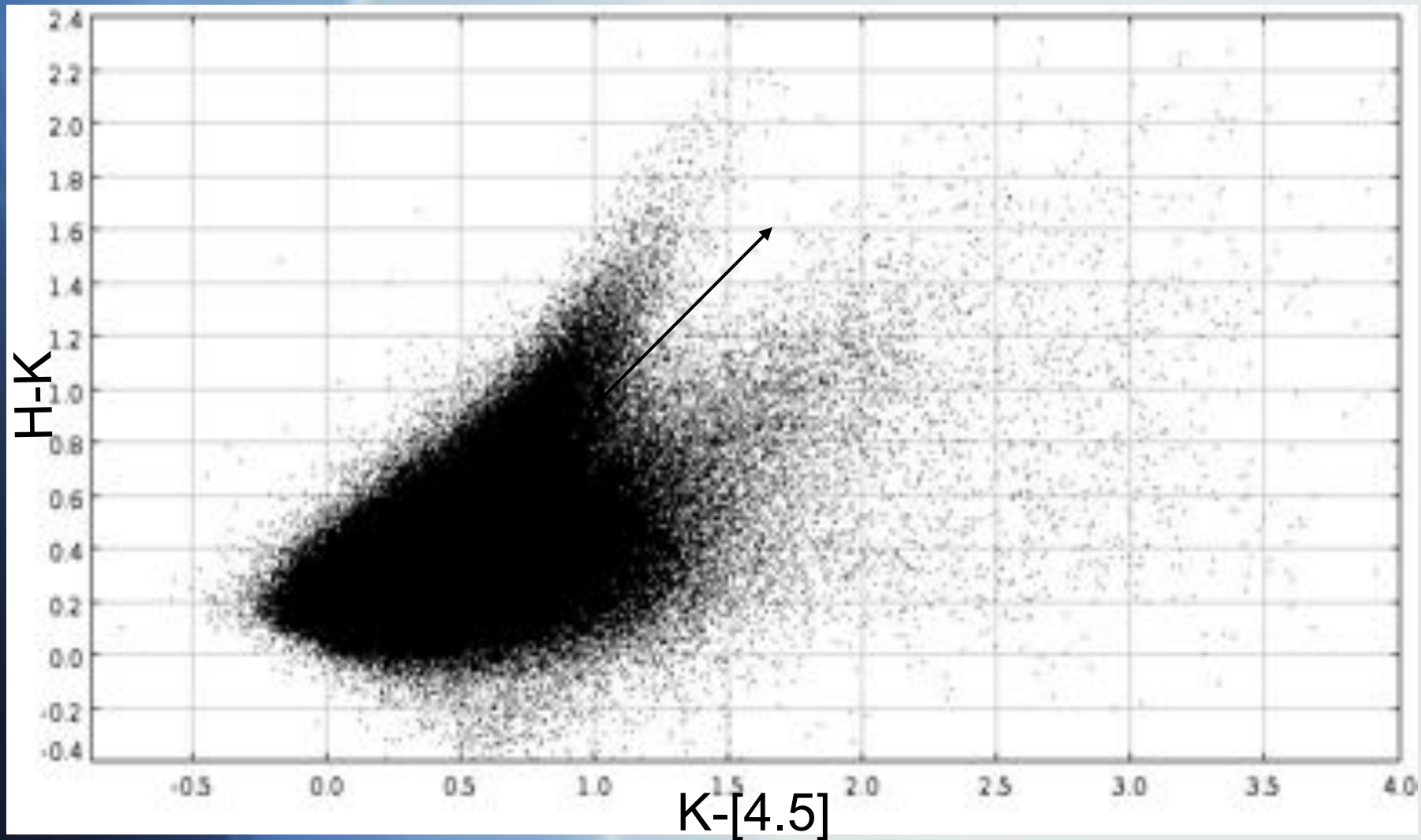
Matched Catalog



Matched Catalog



Matched Catalog



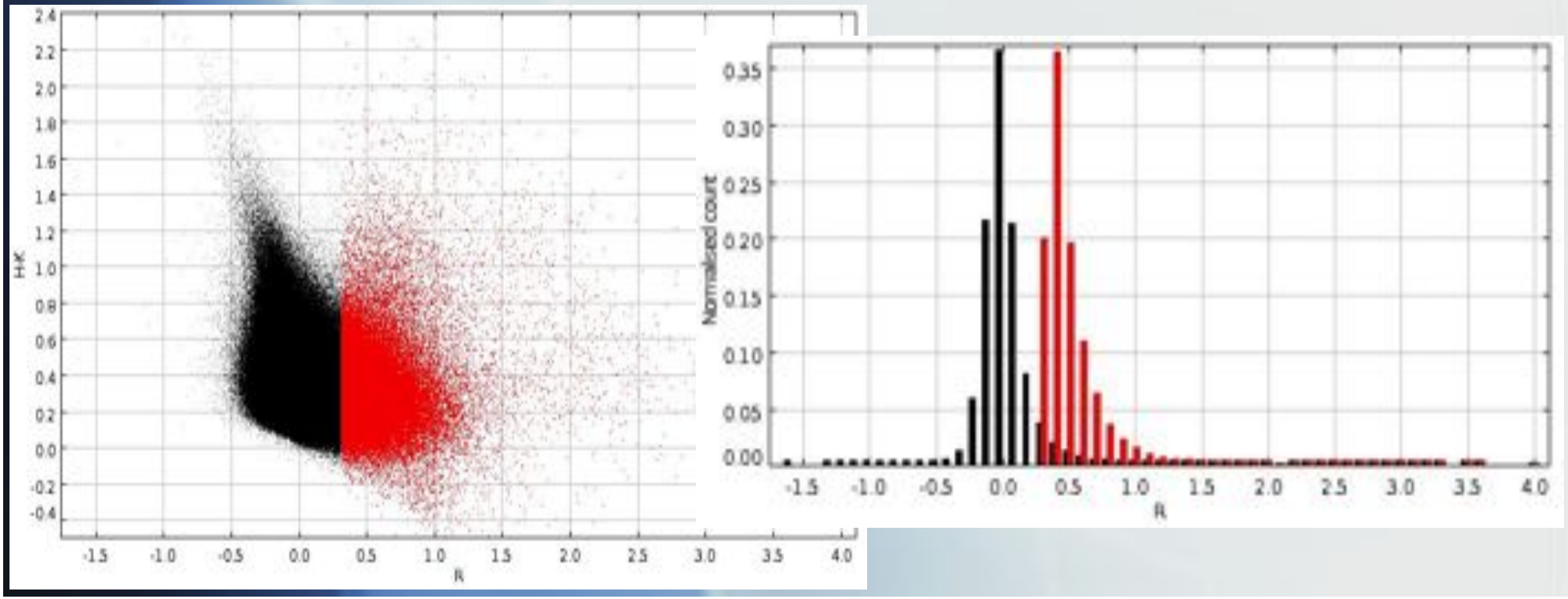
- H-K vs K-[4.5] provides the best distinction between **extincted and 'red' sources**

Red Catalog Selection

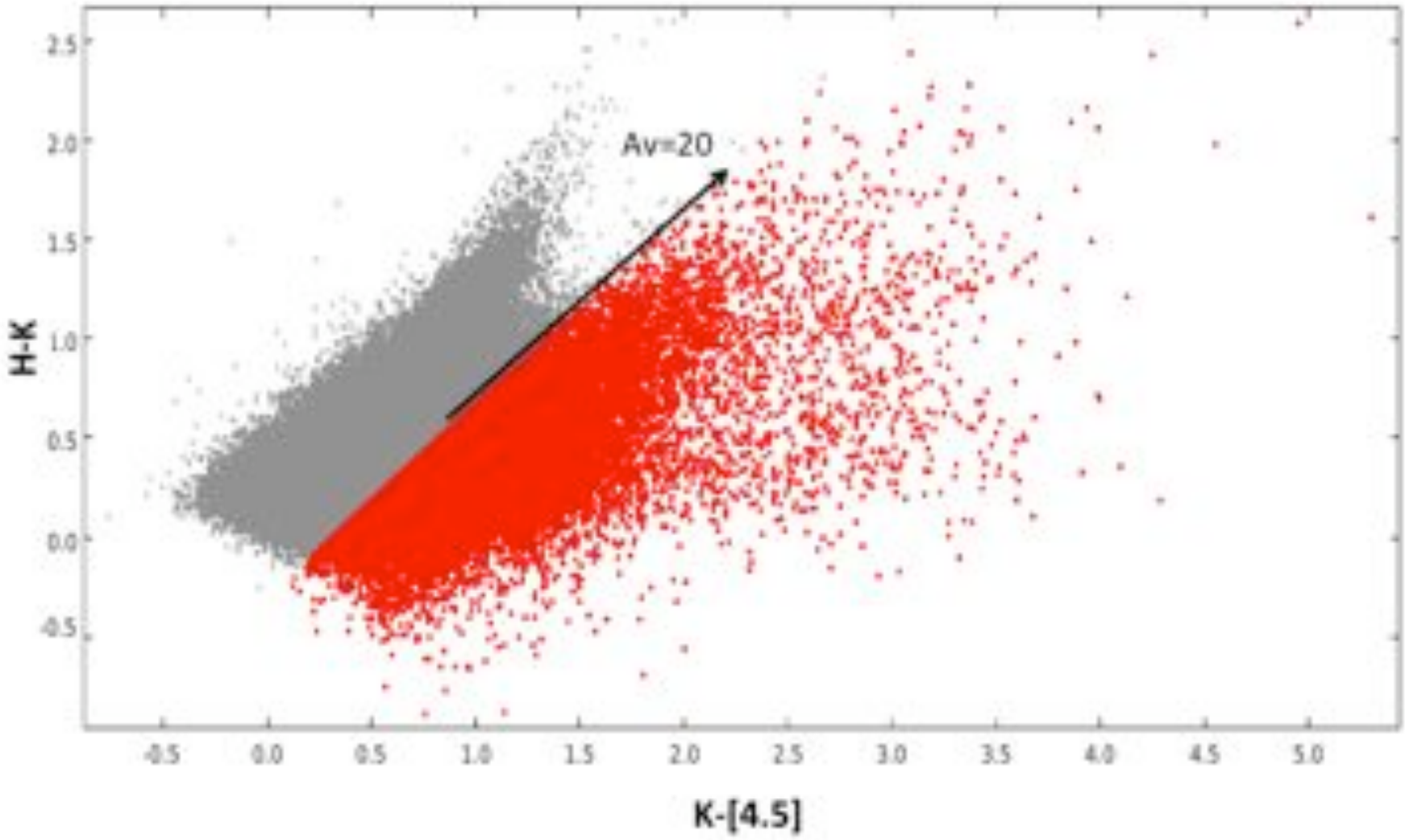
- Calculated the color index R:

$R = (K-[4.5]) - [E(K-[4.5])/E(H-K)] * (H-K)$

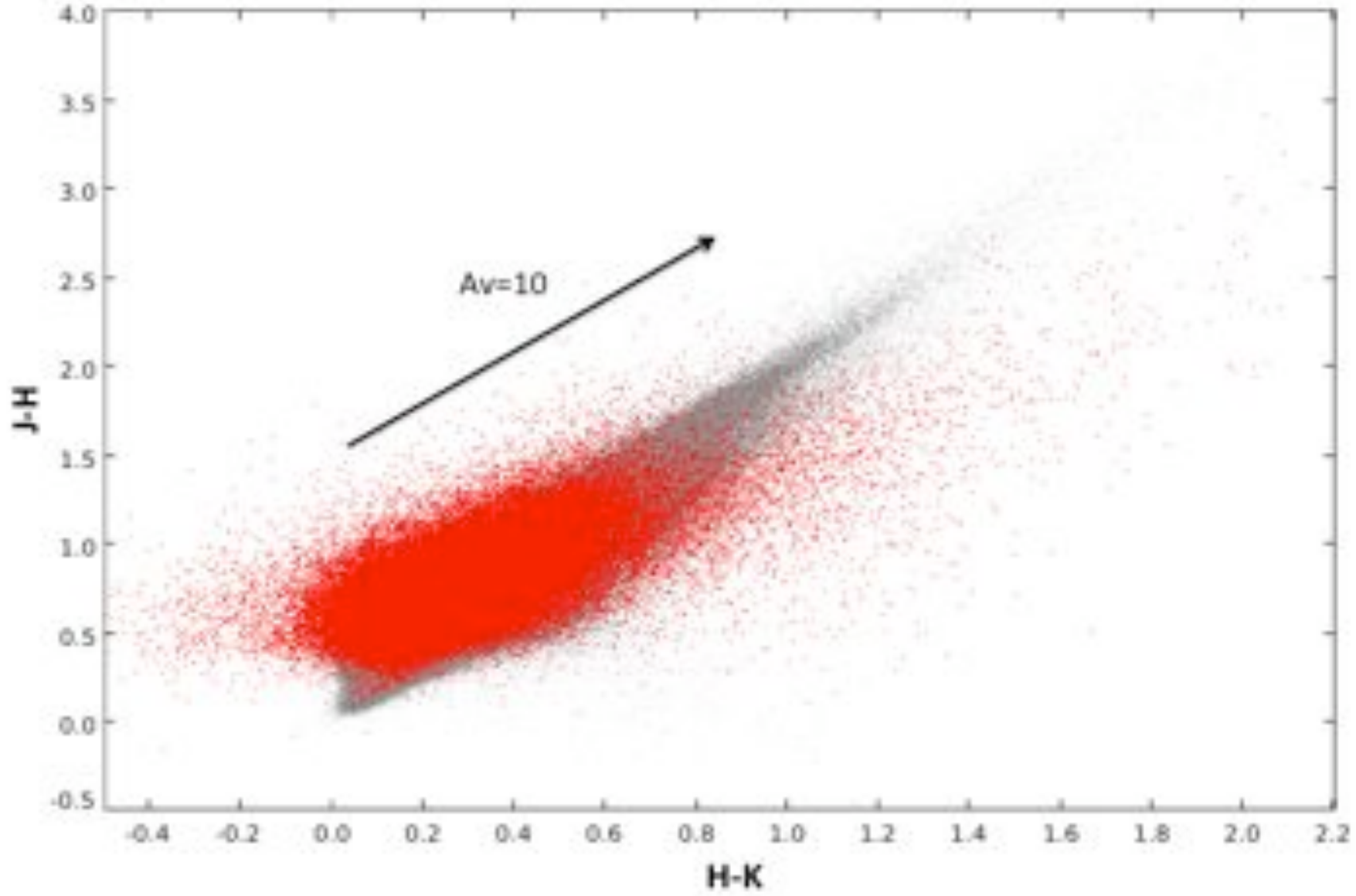
- Std. dev. σ of R =0.18
- **Selected sources with $R \geq 2\sigma$**
- **Red Catalog: 199,552 sources (~7%)**



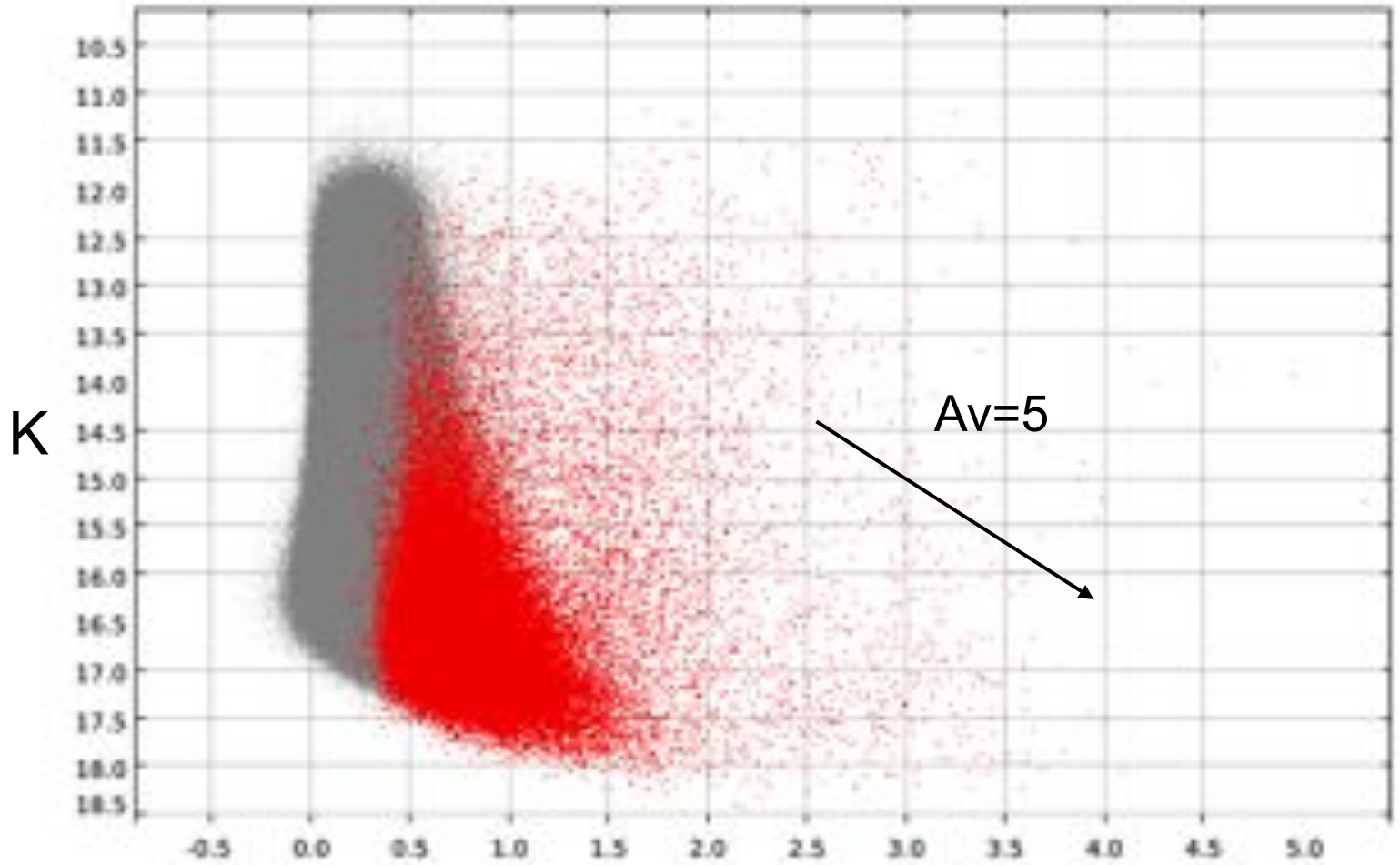
Red Catalog



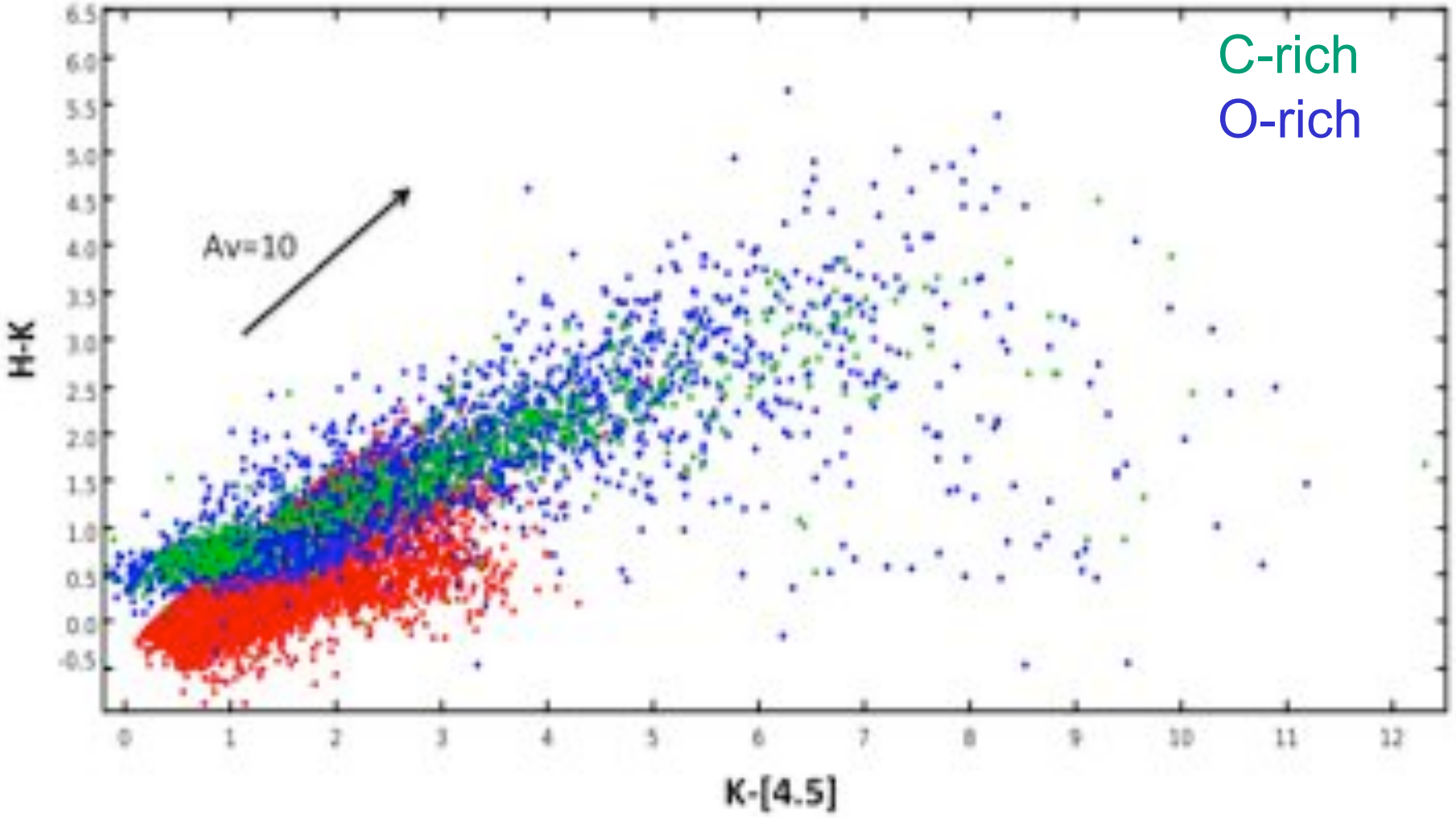
Red Catalog


Av=10
J-H
H-K
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-0.4
-0.2
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2

Red Catalog

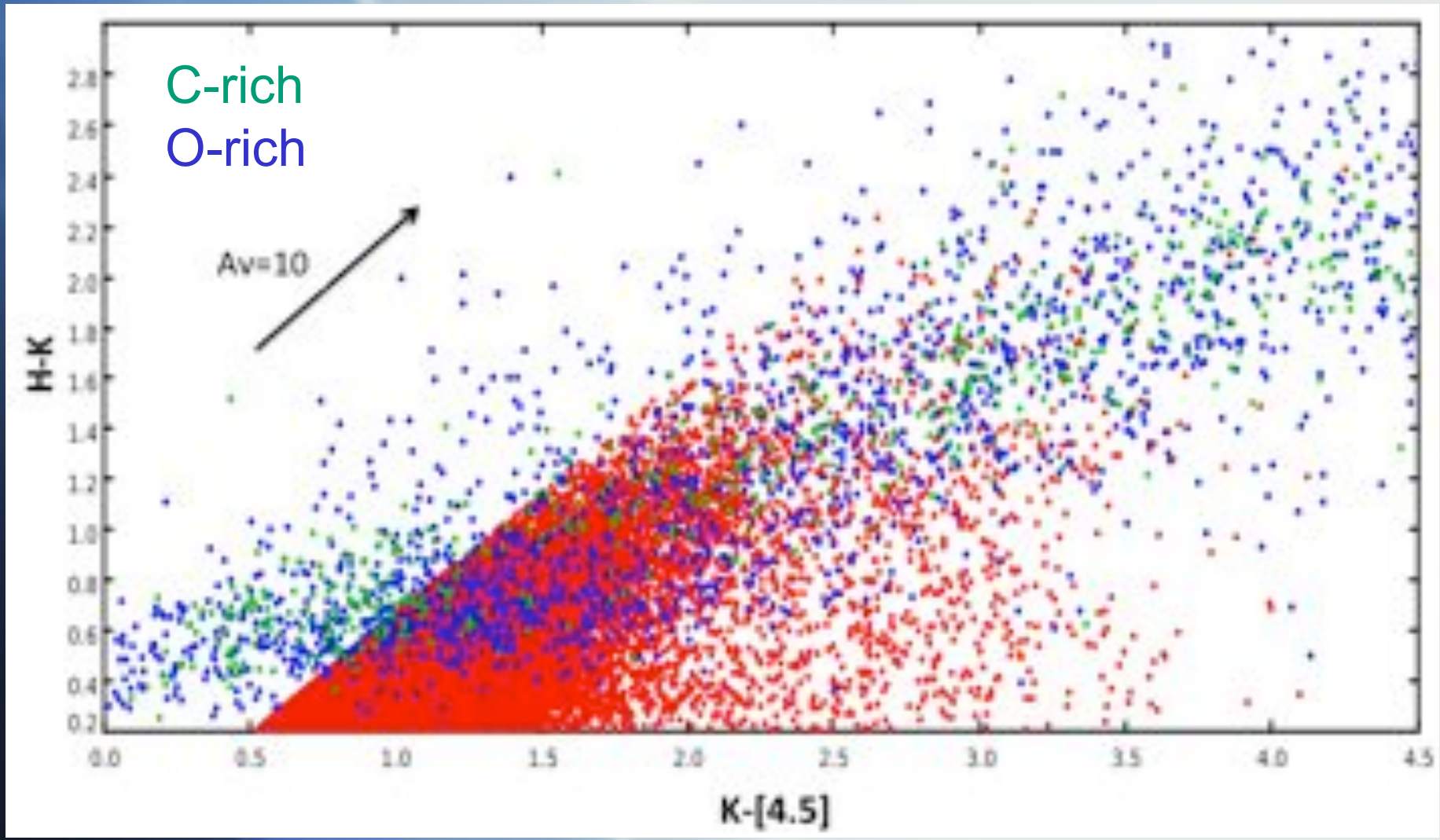

K
Av=5
K-[4.5]
10.5
11.0
11.5
12.0
12.5
13.0
13.5
14.0
14.5
15.0
15.5
16.0
16.5
17.0
17.5
18.0
18.5
-0.5
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0

Red Catalog:AGB contamination



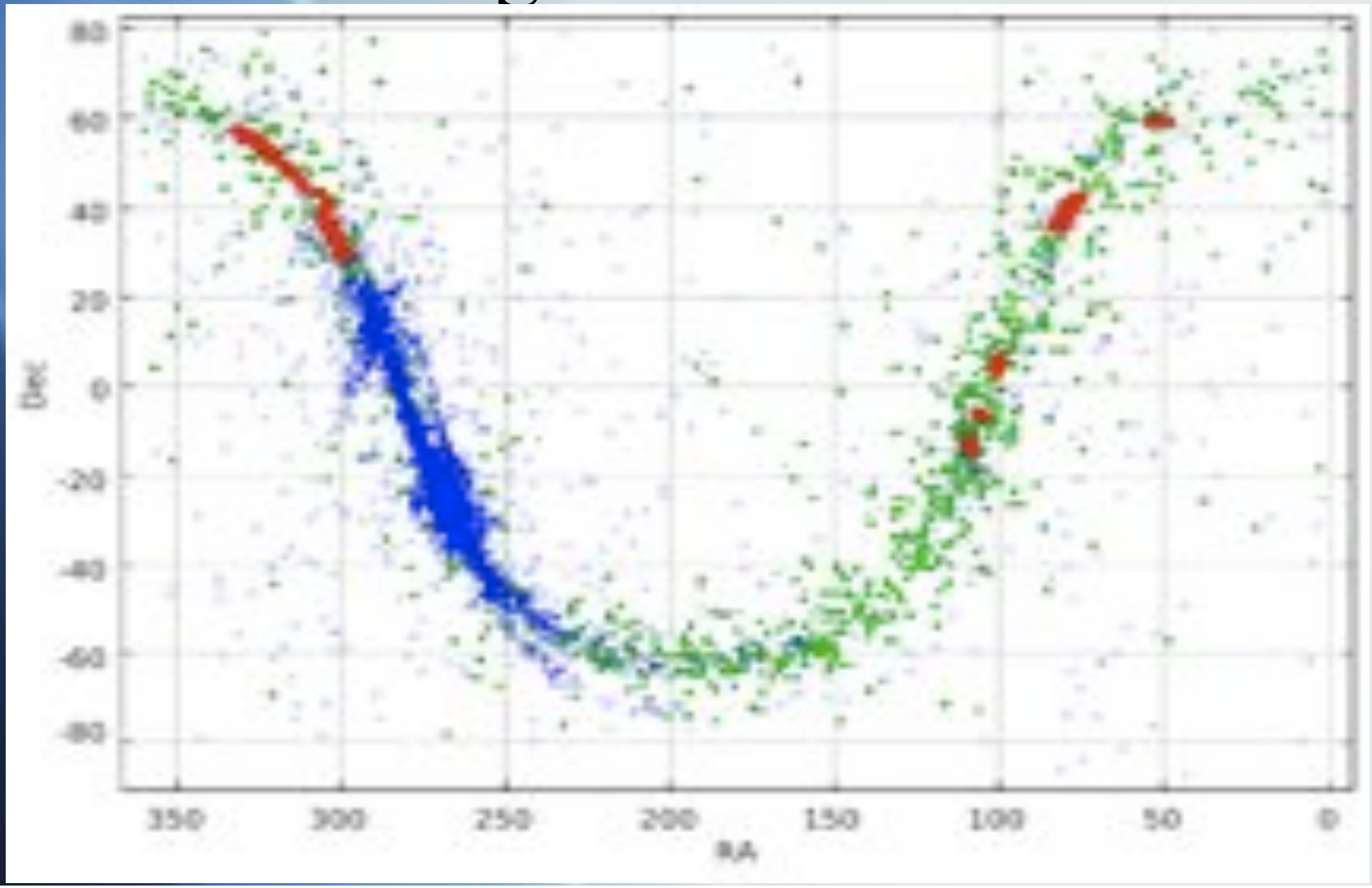
C-rich,O-rich AGBs from Kwon et al. (2011)

Red Catalog: AGB contamination



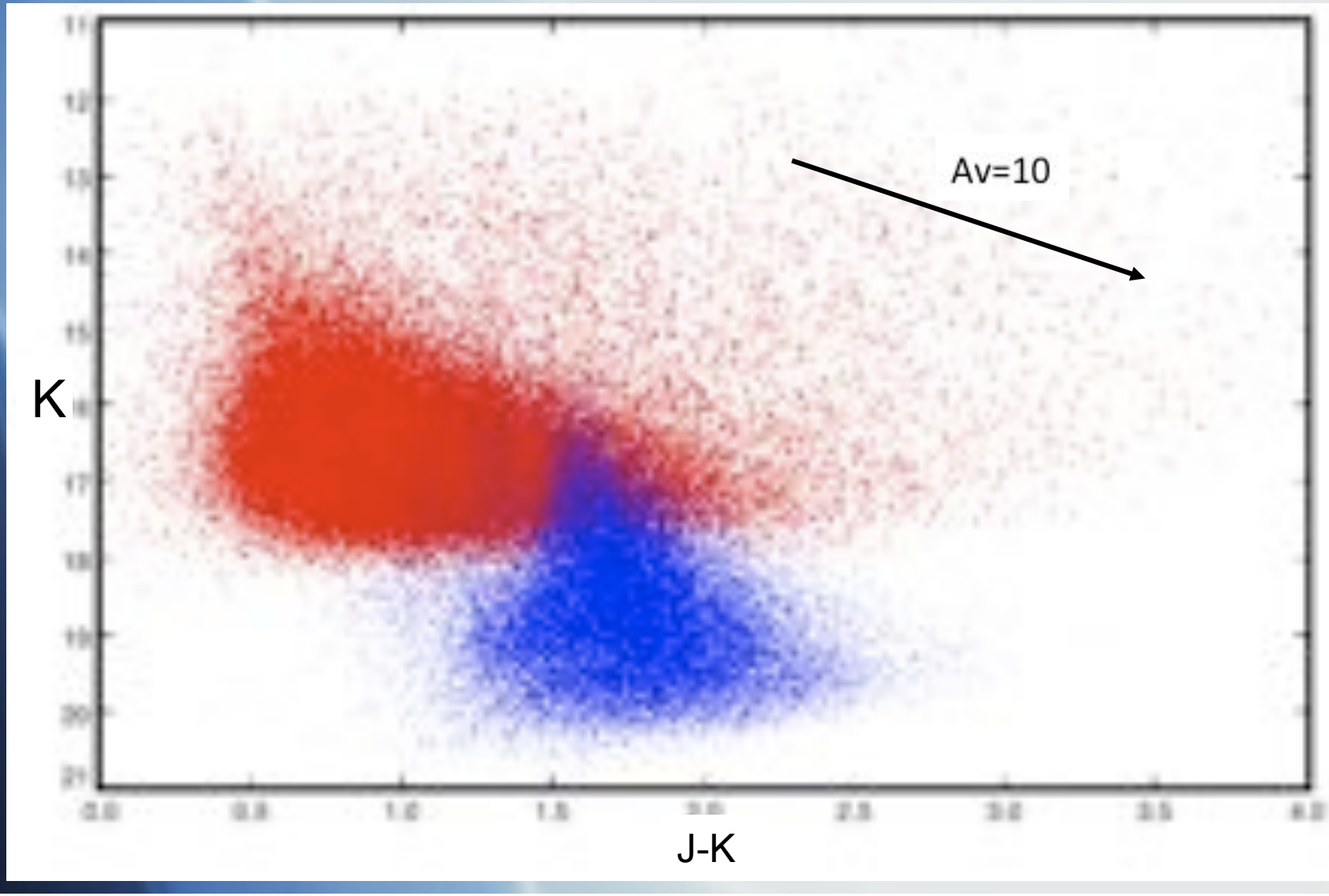
- Main overlap (H-K)≥0.4, (K-[4.5])~0.7-3.0. Densest overlap (K-[4.5])~1-1.5
- Most AGBs brighter than the saturation limit of UKIDSS (Ks~12.5mag)
- Estimate ~5% of the red catalog to be contaminated by AGBs, mostly O-rich

Red Catalog: AGB contamination



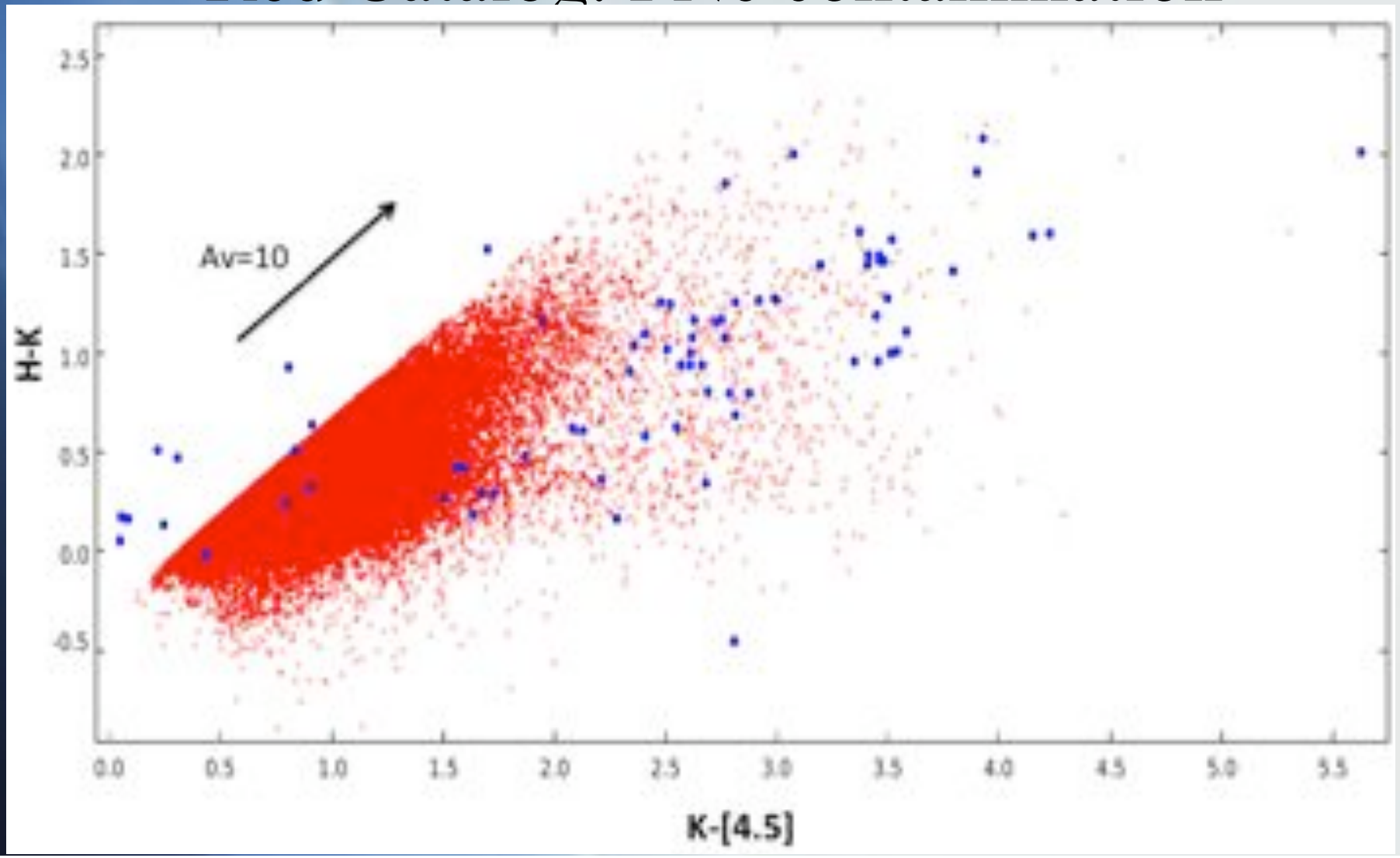
- O-rich surface density 3/deg^2 Galactic center, <0.5/deg^2 Outer Galaxy; C-rich uniform 0.2-0.4/deg^2 across Galactic plane (Ishihara et al. 2011)
- From the overlapping regions, AGB contamination ~3/deg^2 inner Gal ($|l|<90$deg) and ~0.1/deg^2 outer Gal.

Red Catalog: extragalactic contamination



- UKIDSS DXS survey, applied same constraints as for GPS
- Blue points classified as galaxies (mergedClass=+1)
- Main overlap at faint red end, K~16-18, (J-K)>1.5 => estimate ~2% contamination

Red Catalog: PNe contamination



- PNe from Hora et al. (2004; 2008), Whitney et al. (2008)
- PNe have double-peaked SEDs--optical+IR
- Two groups: one photospheric colors (H-K)~0.5, (K-[4.5])~0.5; 2nd with redder colors (H-K)~1.0, (K-[4.5])~2.5
- Main contamination to very red sources in catalog => estimate ~0.5-1%

Candidate YSOs

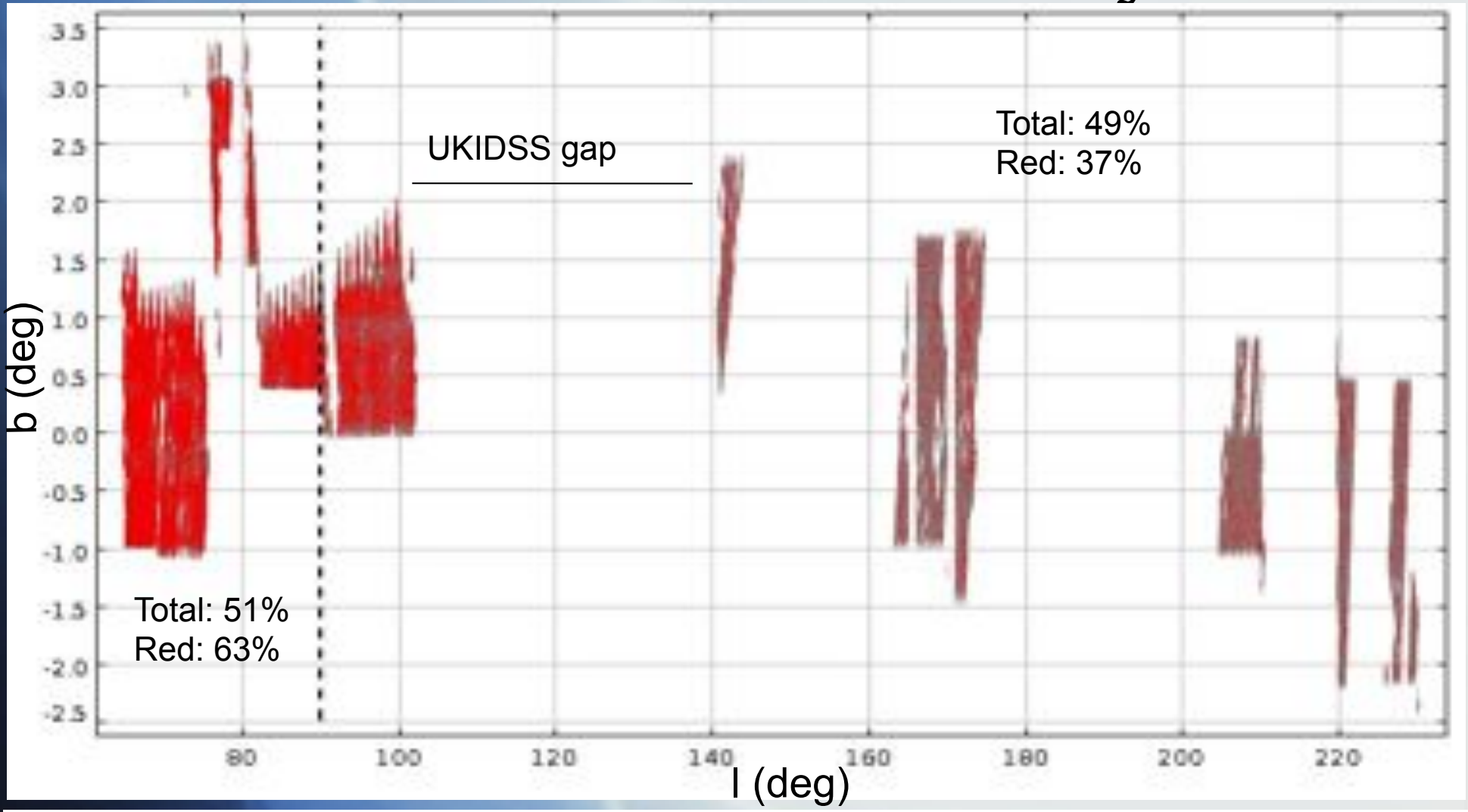
- estimate ~5% fraction of the red catalog could be composed of sources other than candidate YSOs.
- Searched matches within 10 arcsecond radius in the SIMBAD database for red catalog objects, -- 437 matches found
- A 17% fraction have a SIMBAD object type of YSO (“Y*O”), 11% are classified as stars (30 objects are A-B type), 15% are infrared sources, 33% are radio sources (“Rad”), 3% are X-ray sources and 2% are emission line stars.
- only 7 objects have a known classification of PNe, 2 sources are classified as galaxies and 1 source as a carbon star (“C*” or a C-rich AGB) ==> ~2% fraction of the total matches

Star-forming regions

- Correlated red catalog with the Avedisova catalog of SFR -- found 752 SFR matches
- A few of these are well-known open clusters such as, Stock 8, NGC 1907, NGC 1960, NGC 2359 and NGC 6846, all part of the outer Galaxy

  (l ~172–270 deg)
- There are also several NH3, HCN and HCO+ regions.

Inner vs. Outer Galaxy



- red source density of 3100–3700/deg^2 and 500–700/deg^2 in the inner and the outer Galaxy, respectively
- a factor of ~5 higher number density of candidate YSOs in the inner regions.
- census of YSOs in Outer Galaxy not complete

Thank you!