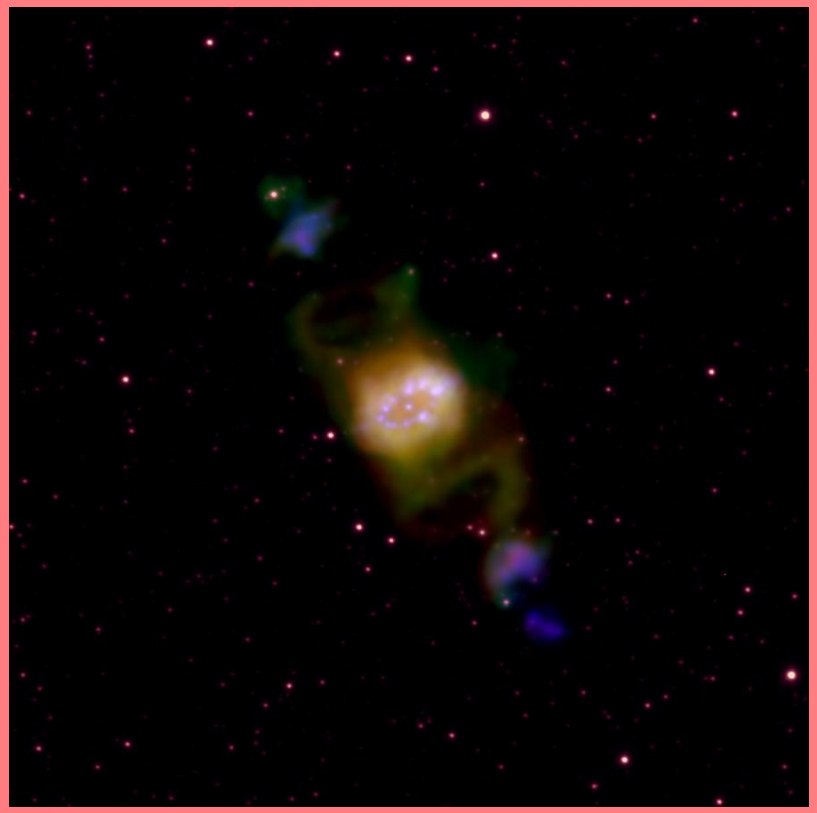
Milky Way Surveys – IPHAS and UVEX



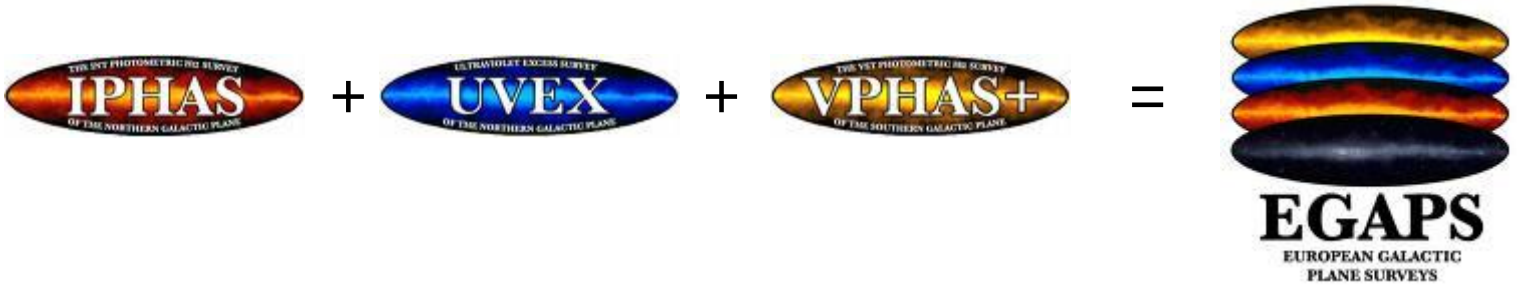
Janet Drew (on behalf of the consortium)

CAR/STRI, University of Hertfordshire, UK

IPHAS, UVEX (and this talk)

- why/how they started
- what they are, and how advanced they are
- what next ....the types of follow up they have, and can, stimulate

Survey papers:
IPHAS: Drew et al 2005, MNRAS
(IDR: Gonzalez-Solares et al 2008)
UVEX: Groot et al 2009, MNRAS



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Motivation and origins (began with IPHAS, 2003):

IPHAS = INT/WFC Photometric Hα Survey of the Northern Galactic Plane

.....*need:* Galactic astronomy still struggling with often tiny, nearly always bright (R < 12), samples of emission line objects – even in the era of 8-m telescopes.

.....*opportunity:* INT operating with WFC only – good opening for a large programme able to use bright time

.....*background:* prior experience of founding consortium members with UK Schmidt Hα survey (SHS)

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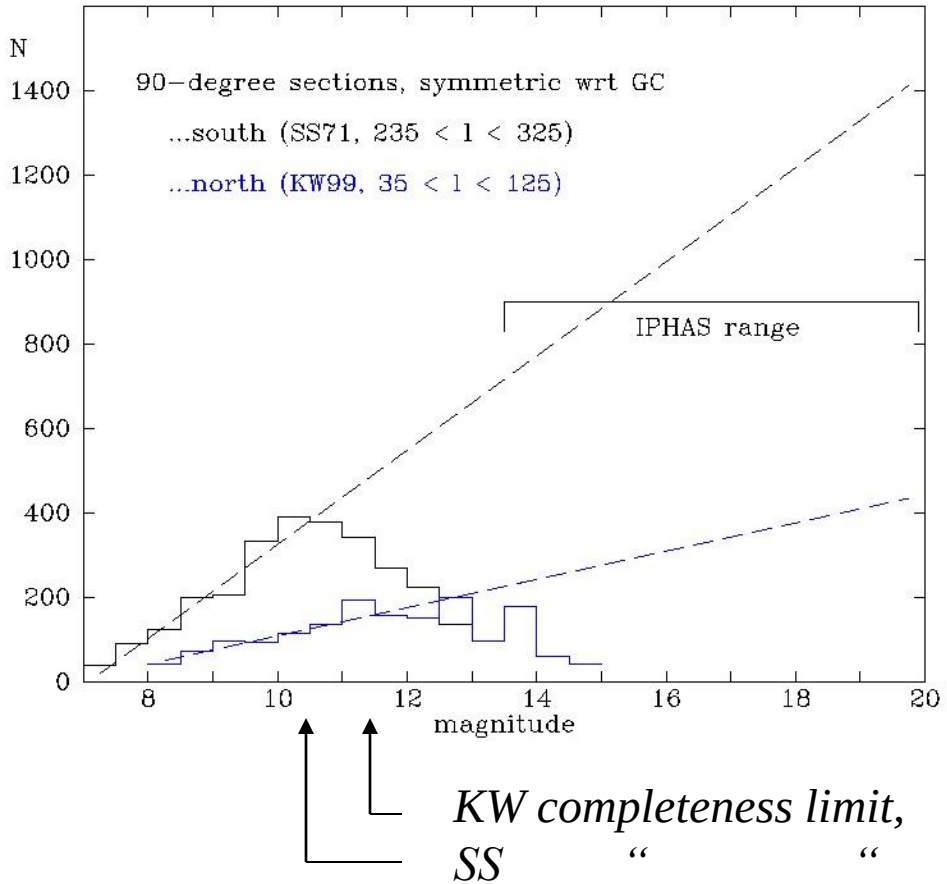
Catalogued galactic plane emission line stars ~2000:

A galactic-longitude restricted view of the 2 halves of the Galactic Plane - Sanduleak/Stephenson, and Kohoutek/Wehmeyer compared.

Histogram of photographic magnitudes (~V)

~first quadrant (N) far less 'active' than ~fourth quadrant (S)



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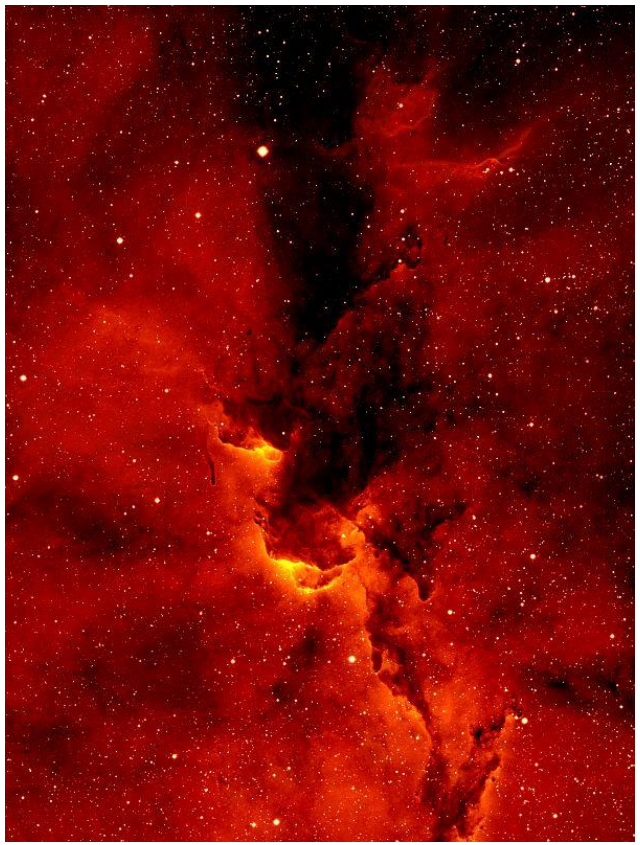
IPHAS (www.iphas.org) – first ~arcsec resolution digital Hα survey, able to pick out emission line stars reliably/comprehensively

|b| < 5°, the complete northern Galactic Plane



(IC 1396b, r'i'Hα, N. Wright)

'simultaneous' r',i', Hα to ~20th magnitude, ~15000 fields observed, covering area twice

median seeing 1.1 arcsec

started 2003 – every pointing covered at least once by end 2008

data pipelined at CASU

point source catalogues for ~half the area available via astrogrid (IDR) since end 2007

uniform photometric calibration now underway

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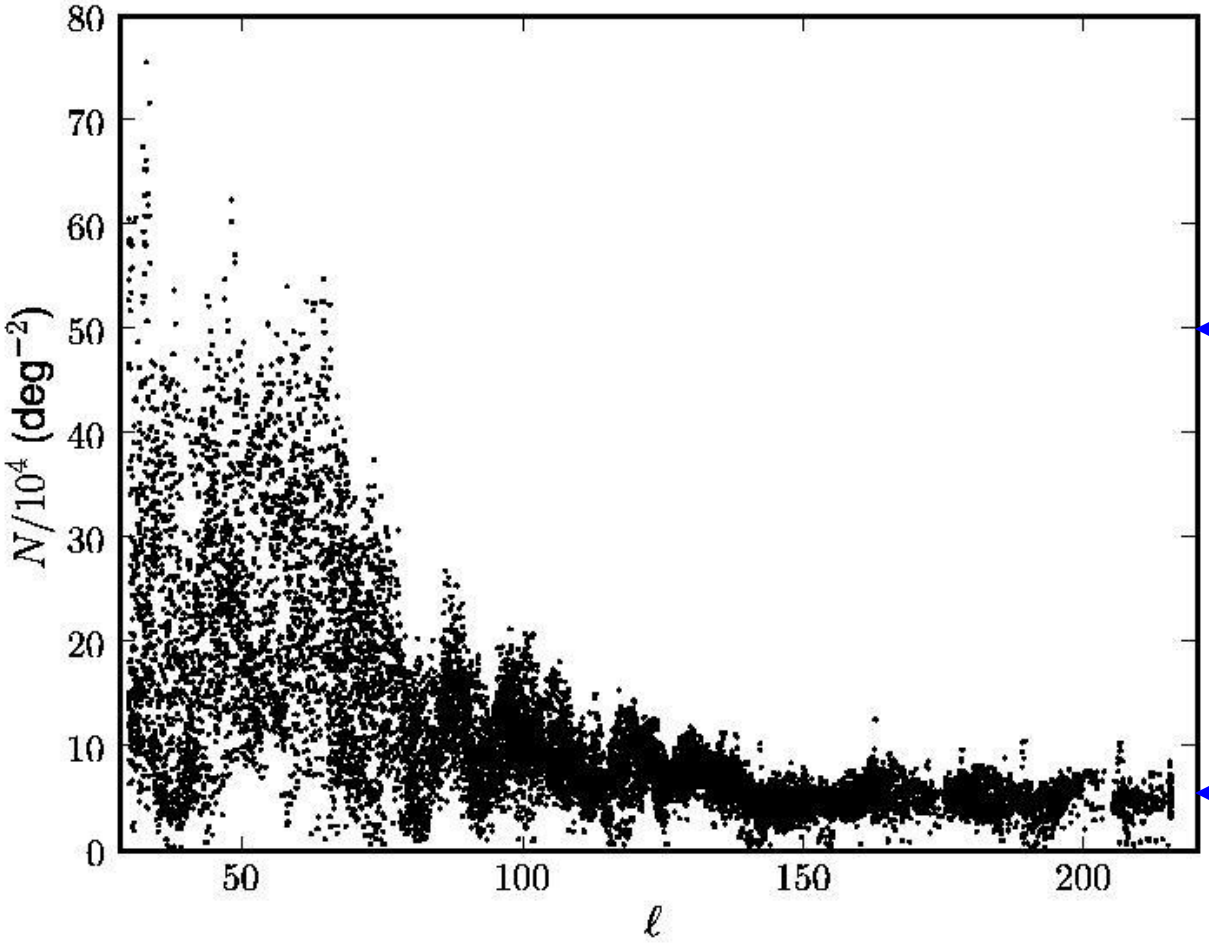
Northern optical source densities (to ~20th mag)

IPHAS catalogued object densities per sq. degree: each data point is an IPHAS field. (figure from Gonzalez-Solares et al 2008)



500000/sq.deg

50000/sq.deg

…more than half these can be ‘typed’ using r’-Hα with a broadband colour

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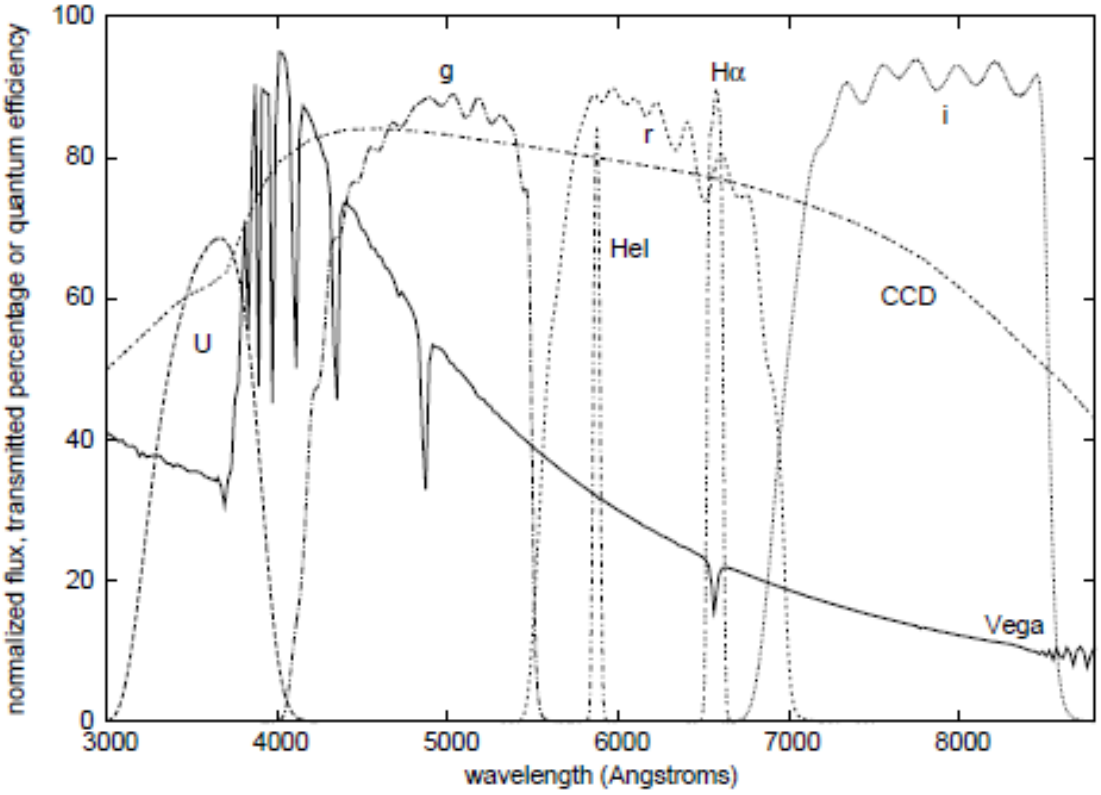
UVEX: UV excess survey of the northern Galactic plane

Complementary to IPHAS, adding U,g',HeI bands, and repeating r' (started 2006)

...following on at ~3 yr delay, uses same field centres and strategy
...same pipeline

~35% complete



How to find cold, old WDs

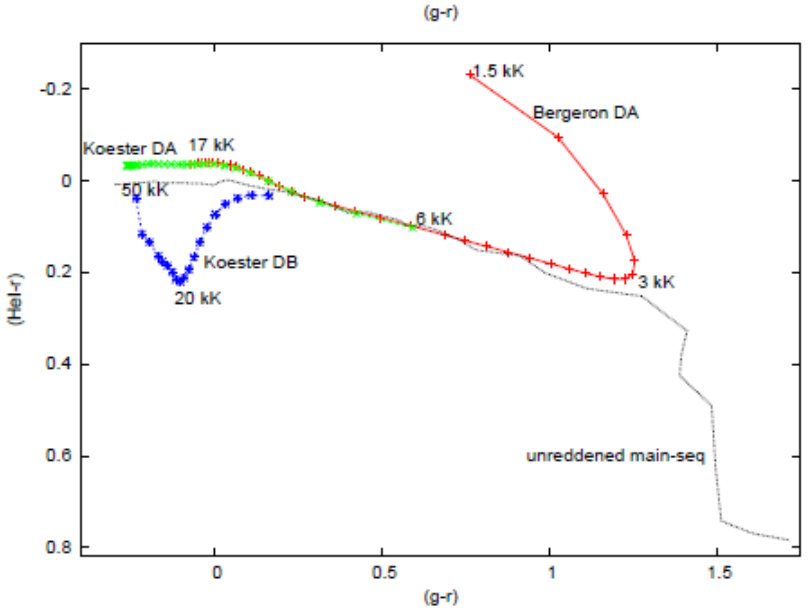
(i) The UVEX way, using HeI-r' (upper panel)

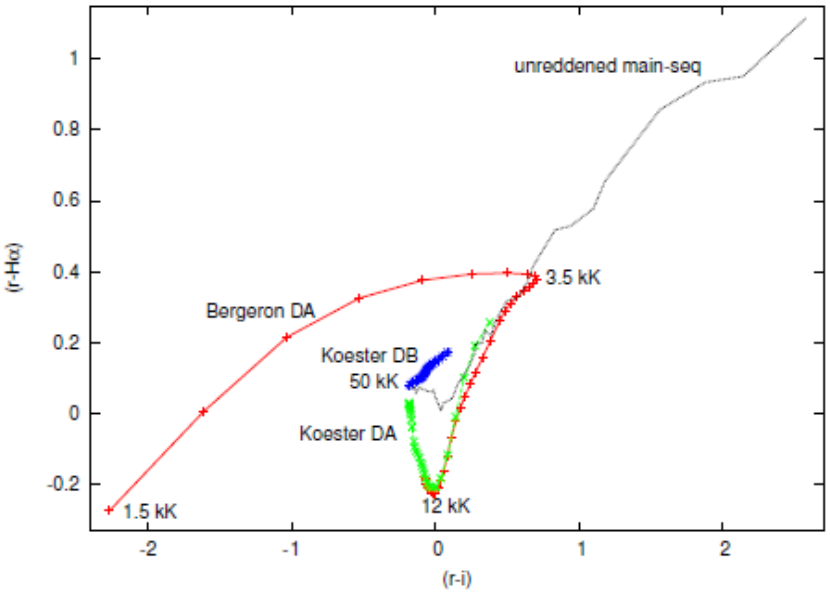
(ii) The IPHAS way, using r'-Hα (lower panel)

Diagrams from Groot et al (2009)

(Absolutely nail them using both)

UVEX HeI 5876 filter also picks out AMCVn systems and WR stars





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Aims and capabilities of IPHAS and UVEX → Implied follow-up

1. Use Hα excess/emission to identify
   (i) young objects/clusters, and associated nebulosity
   (ii) fleeting, late stages of evolution (interacting binaries, PNe/symbiotics, WR stars, LBVs...) and associated nebulosity
   (iii) classical Be stars as markers for young associations across GP

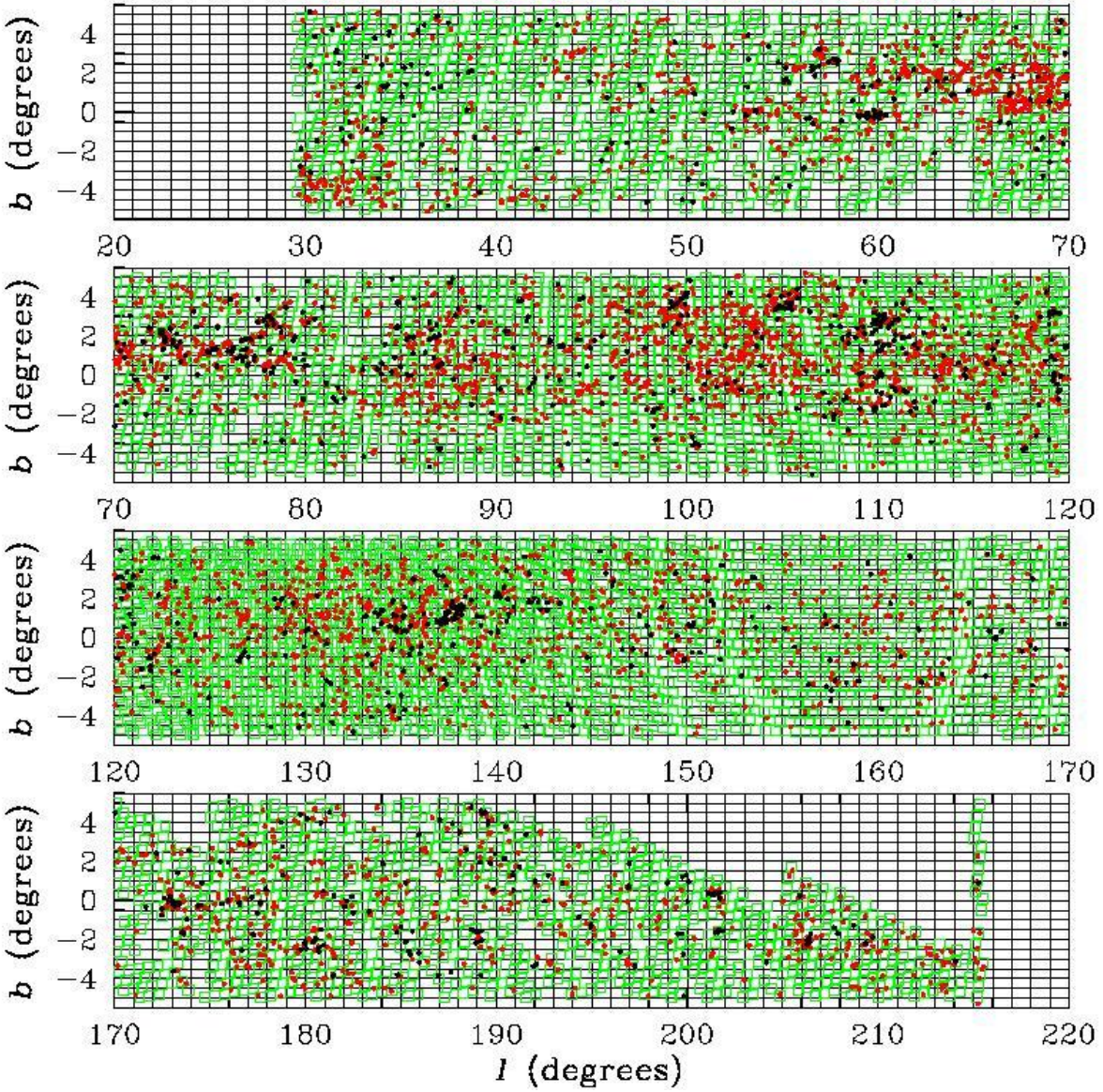
Young clusters → multi-object spectroscopy (17th to 20th mag)
Older, less common objects → long-slit spectroscopy from 13th to 20th mag

Emission line stars in the northern Plane:

Automatic selection based on r'-Hα 'excess' (13<r'<19.5) across 80% of survey area

4853 objects, those in black r'>18

(Witham et al 2008)



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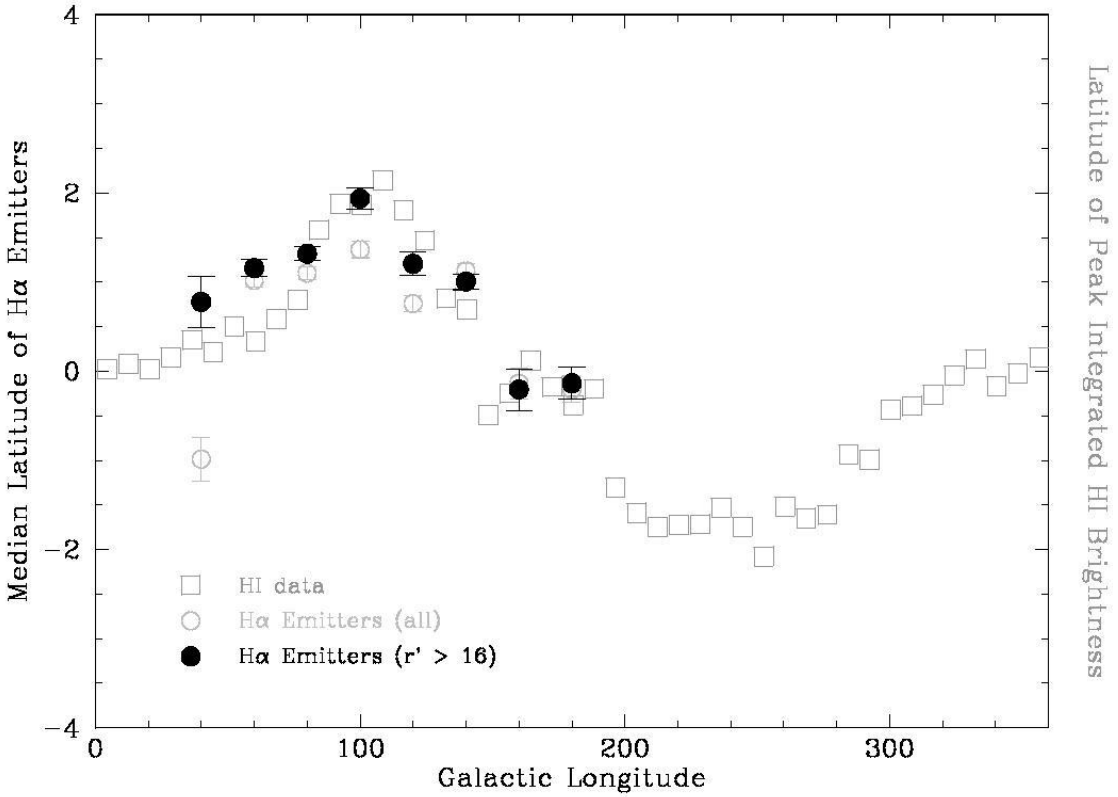
Comparison between velocity-integrated HI data of Freudenreich et al 1994 and running median of emission-line star latitude

→ the northern warp of the Galactic disc



note: typical classical Be star has M_V ~ -3

→ at 10 kpc, through A_V = 5

→ r' ~16.5

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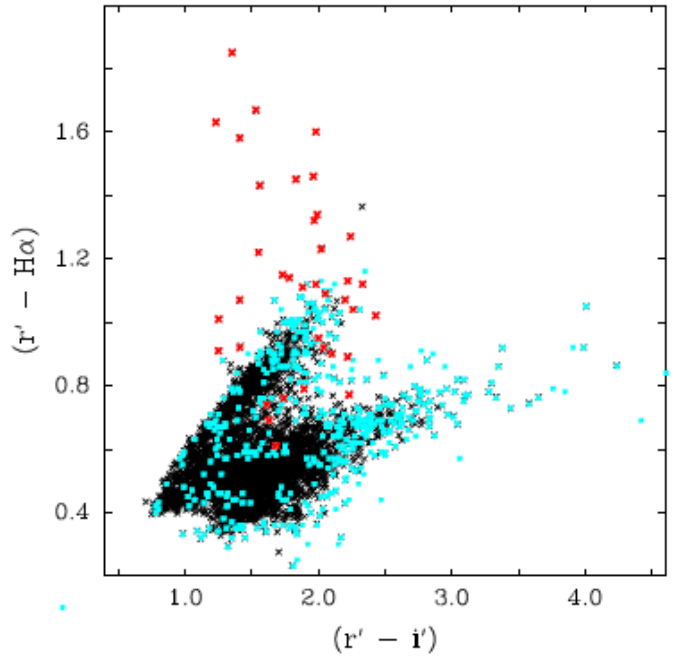
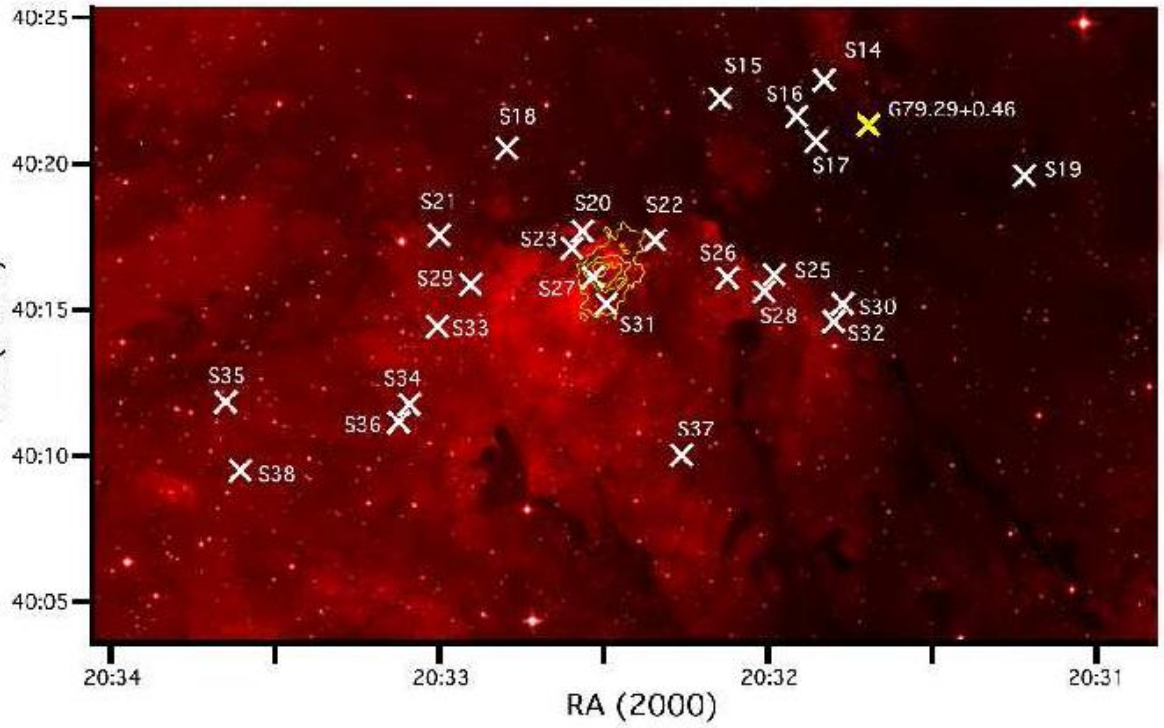
Triggering? of star formation to the south of Cyg OB2: DR 15

Right: red/cyan points in r-Hα,r-i diagram have MMT/HectoSpec spectra ...red indicates a confirmed YSO
Below: where they are





Mainly TTau stars
~1.5 kpc away
(Vink et al 2008)

Far fewer in CygOB2 itself ....??

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Aims and capabilities → follow-up (continued)

2. Use both IPHAS spectral-type sensitivity and UVEX UV and HeI excess to identify stellar remnants – and also subluminous objects, via r' proper motions

   (i) Galactic-plane WDs being picked up in significant numbers already, via colours and then confirmed.
   (ii) black-hole binaries?
   (iii) post-common-envelope binaries (short-period WD+MS systems)
   (iv) proper motions, when collected, may reveal very cool dwarfs as well as WDs (see Deacon et al 2009)

Rare (faint) objects → long-slit spectroscopy on 4- and 8-m telescopes

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Aims and capabilities → follow-up (continued)

3. Can use both IPHAS spectral-type sensitivity, along with UVEX U, g' data ...for

   (i) 3-D extinction mapping down to ~few arcmin spatial resolution (IPHAS algorithm: Sale et al 2009)
   UVEX, added in, will allow varying R to be explored
   (ii) studies of Galactic disc stellar populations from clusters, upwards, in scale (e.g. Drew et al 2008, Sale et al 2010)

Much can be accomplished photometrically, BUT confirmation/calibration, and follow up of kinematics and/or metallicity patterns → wide-field multi-object spectroscopy (17^{th} – 19^{th} mag, typically) appropriate.

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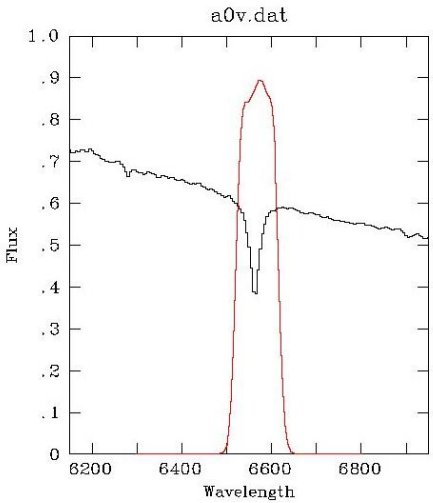
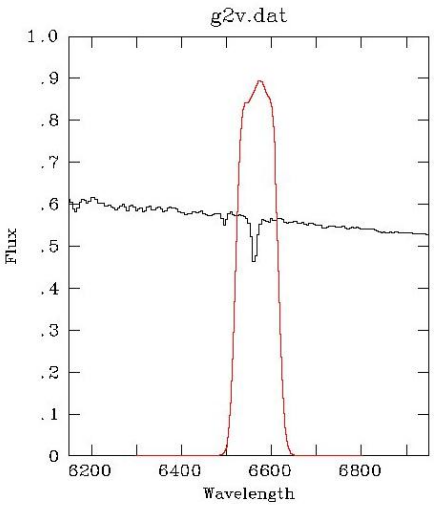
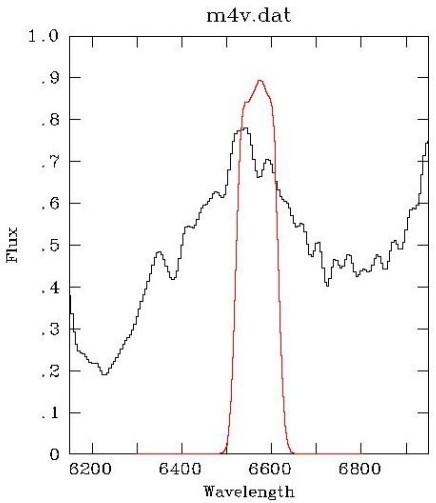
Crucial role of Hα: as a marker for stellar intrinsic colour:

r'-Hα as a colour 'excess' measured to - now routine - photometric accuracy (~0.03 mags)

→ *quantitative indicator of stellar intrinsic colour (~spectral type)*







A0V: r'-Hα = 0.00 G2V: r'-Hα = 0.23 M4V: r'-Hα = 0.89

….and for nebulae (no continuum), r'-Hα ~ 3

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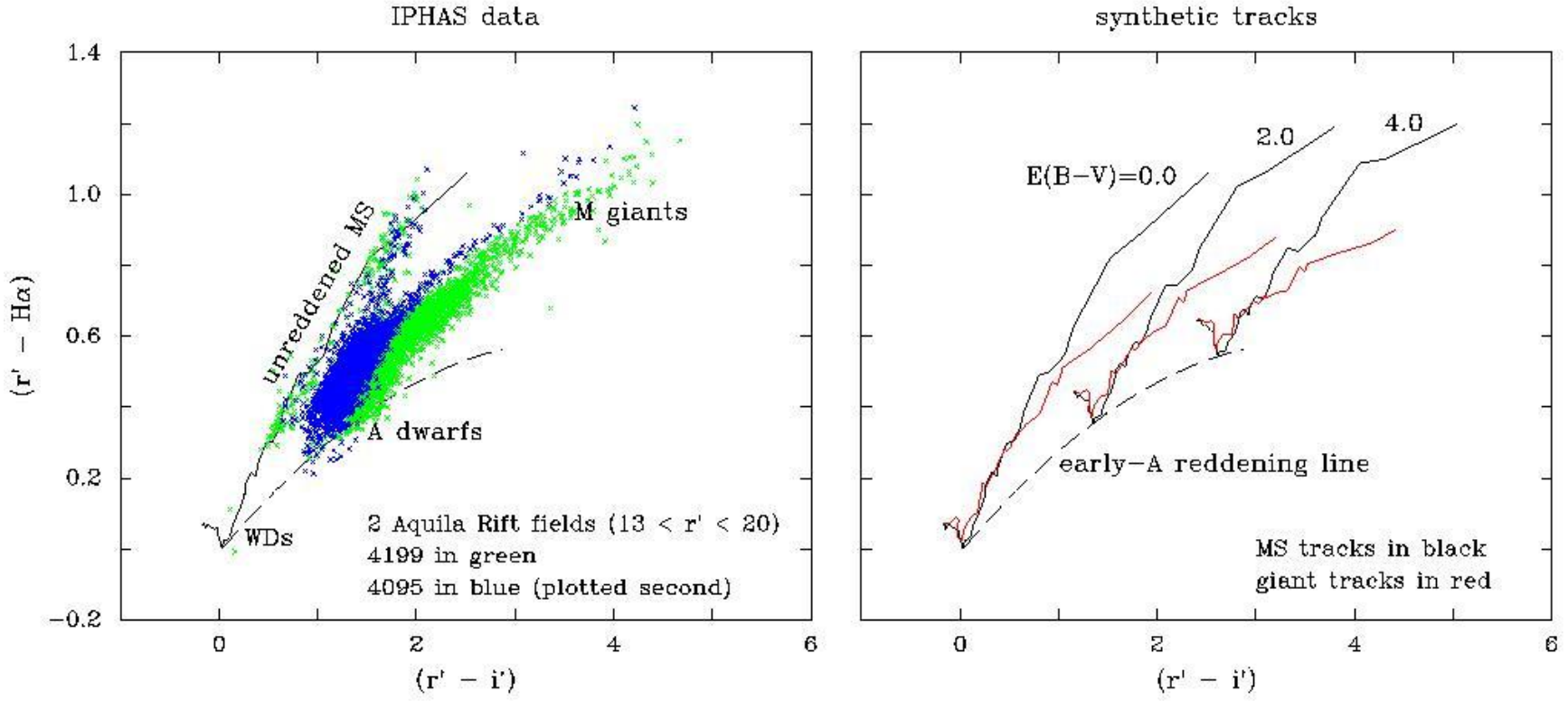
IPHAS photometry, with r', i' and Hα

r'-Hα is overwhelming sensitive to spectral type

r'-i' carries a strong reddening dependence

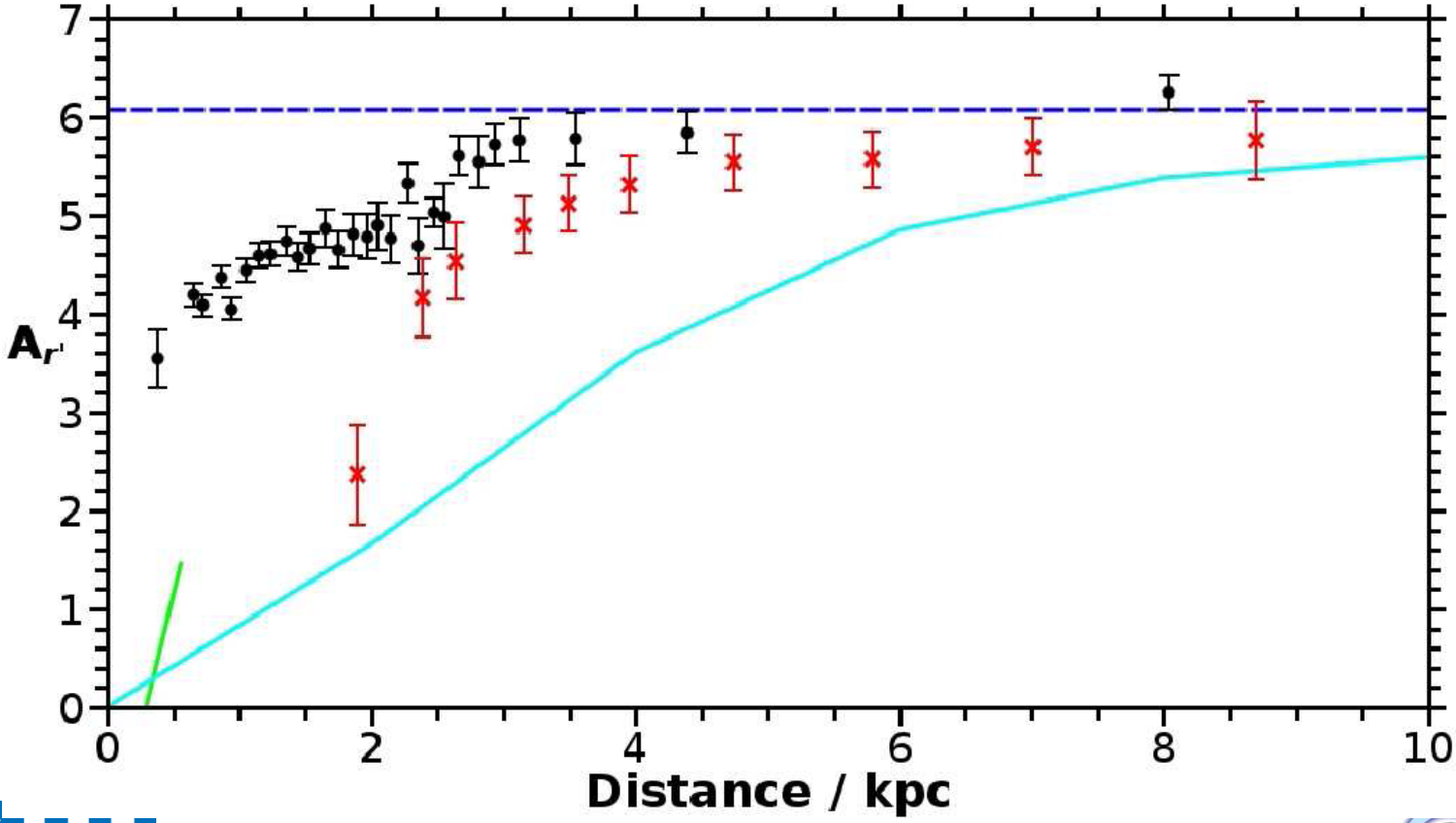
When combined: temperature sequences sweep out area as they are reddened → can assign (type, reddening) to each location in the colour-colour plane



Making every (other) star count: 3-D extinction mapping:

An example from Sale et al 2009, a 10'x10' sq.arcmin field through the Aquila Rift (< 1kpc away), and the Sagittarius Arm (~2.5 kpc)

Compared with Marshall et al 2006 (red), Drimmel & Spergel 2002 (cyan), and Neckel et al 1980 (green) at coarser resolutions. Schlegel et al 1998 asymptote in mauve.



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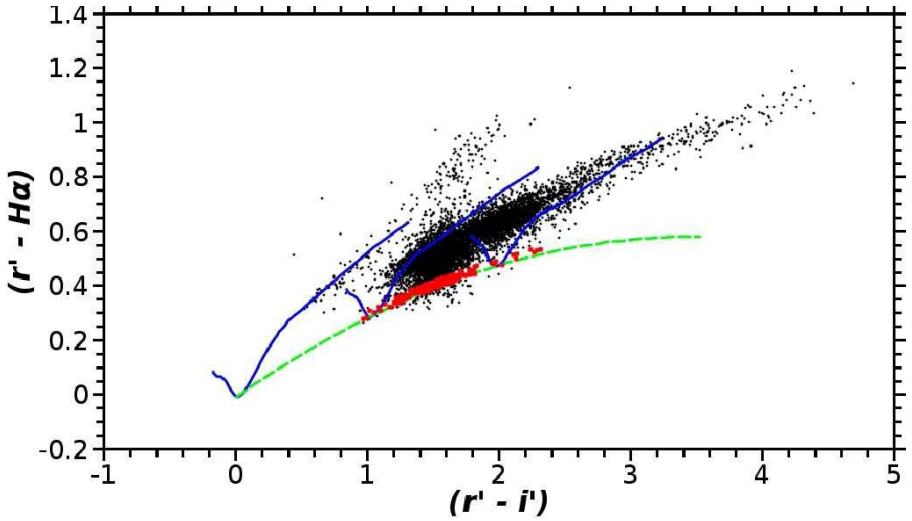
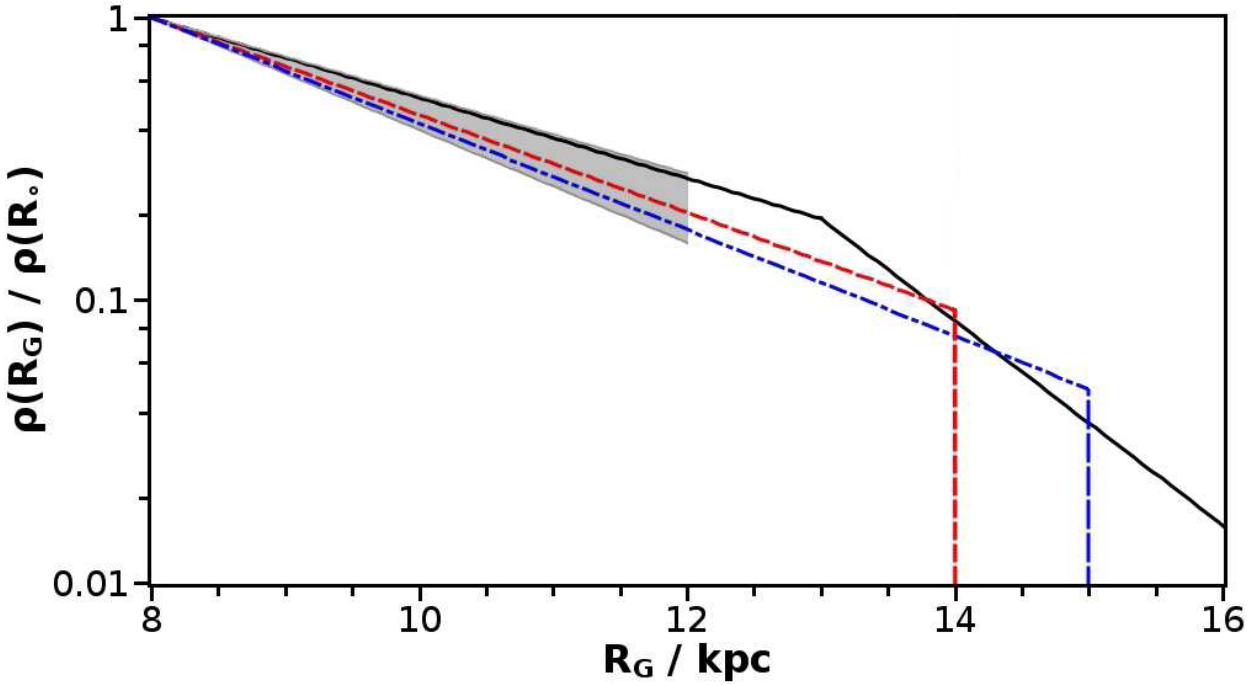
The stellar density gradient in the outer thin disc – as portrayed by A stars
(Sale et al 2010, using ~40000 extinction-corrected A stars: 160 < ℓ < 200, |b| < 1)



~100 Myr-old A stars (black) hint at longer scale length than SDSS K/M stars (shaded area).

DENIS sharp cut-off updated.



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Follow-up Conclusions:

A. The sparsely-distributed tests of stellar evolution

- generally require long-slit intermediate-high resolution long-slit optical (and sometimes NIR) spectroscopy to ID (R ~2000), and then model, objects uncovered.
- may require time domain follow up (Boris's talk)
- numbers of objects involved may range from a few to ~hundreds, and span the entire 13-20th mag range.

B. (Young) clusters, spiral arms and larger-scale disc structure

- follow up at >16-17th mag, exploiting the initial photometric discrimination of spectral type, readily uses any level of spectroscopic multiplex over ~degree fields
- spectral resolution must be ~2000 or more, preferably ~5000 to deliver kinematics, > 10000 for abundances

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(The End)

Sh 2-132, in Cepheus, by IPHAS (as presented by galaxymap.org)

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