

The VST Photometric H α survey, incorporating UVEX south:

VPHAS+



Consortium represented today by:

Janet Drew

(VPHAS+ PI, U of Hertfordshire, UK:
extinction mapping, young disk stars/clusters/structure)

Romano Corradi

(IAC, Spain:
IPHAS nebular astrophysics lead)

Robert Greimel

(U of Graz, Austria:
consortium data and QA specialist)

Paul Groot

(U of Nijmegen, Netherlands:
compact objects – UVEX lead)

(VPHAS+ website : <http://www.vphas.org>)

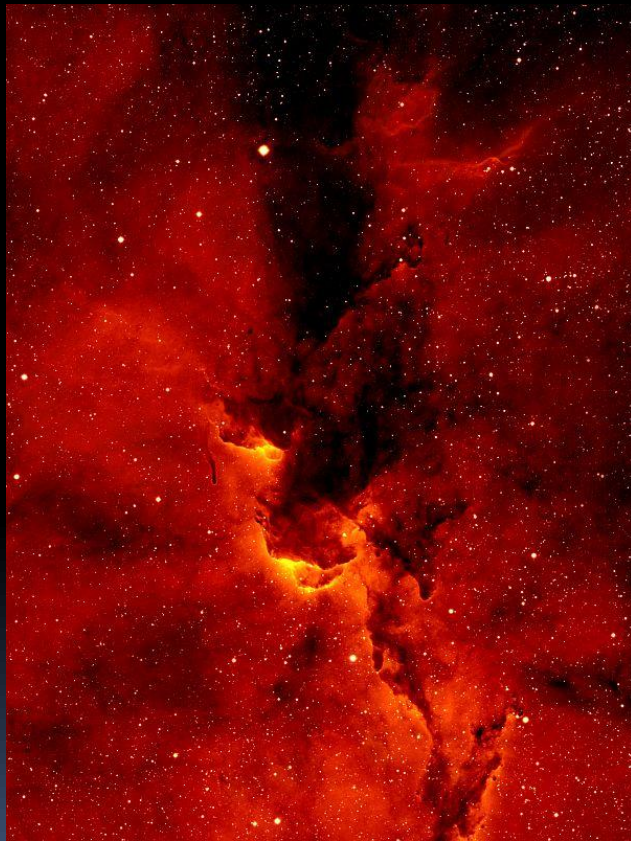


Presentation order:

- The consortium's experience in the north:
IPHAS and UVEX
- VPHAS+ science – as foretold in the north:
highlights to date
- VPHAS+ aims
- VPHAS+ specification – add the Bulge!
- Complementarity/relations with Skymapper
- Timeliness

IPHAS (www.iphas.org, Drew et al 2005) – first \sim arcsec resolution digital H α survey, able to pick out emission line stars reliably/comprehensively

$|b| < 5^\circ$, the complete northern Galactic Plane



(IC 1396b, r'i'H α , N. Wright)

‘simultaneous’ r’,i’, H α to $\sim 20^{\text{th}}$ magnitude, ~ 15000 fields observed, covering 1800 sq.deg area twice

median seeing 1.1 arcsec

every pointing covered at least once by end 2008

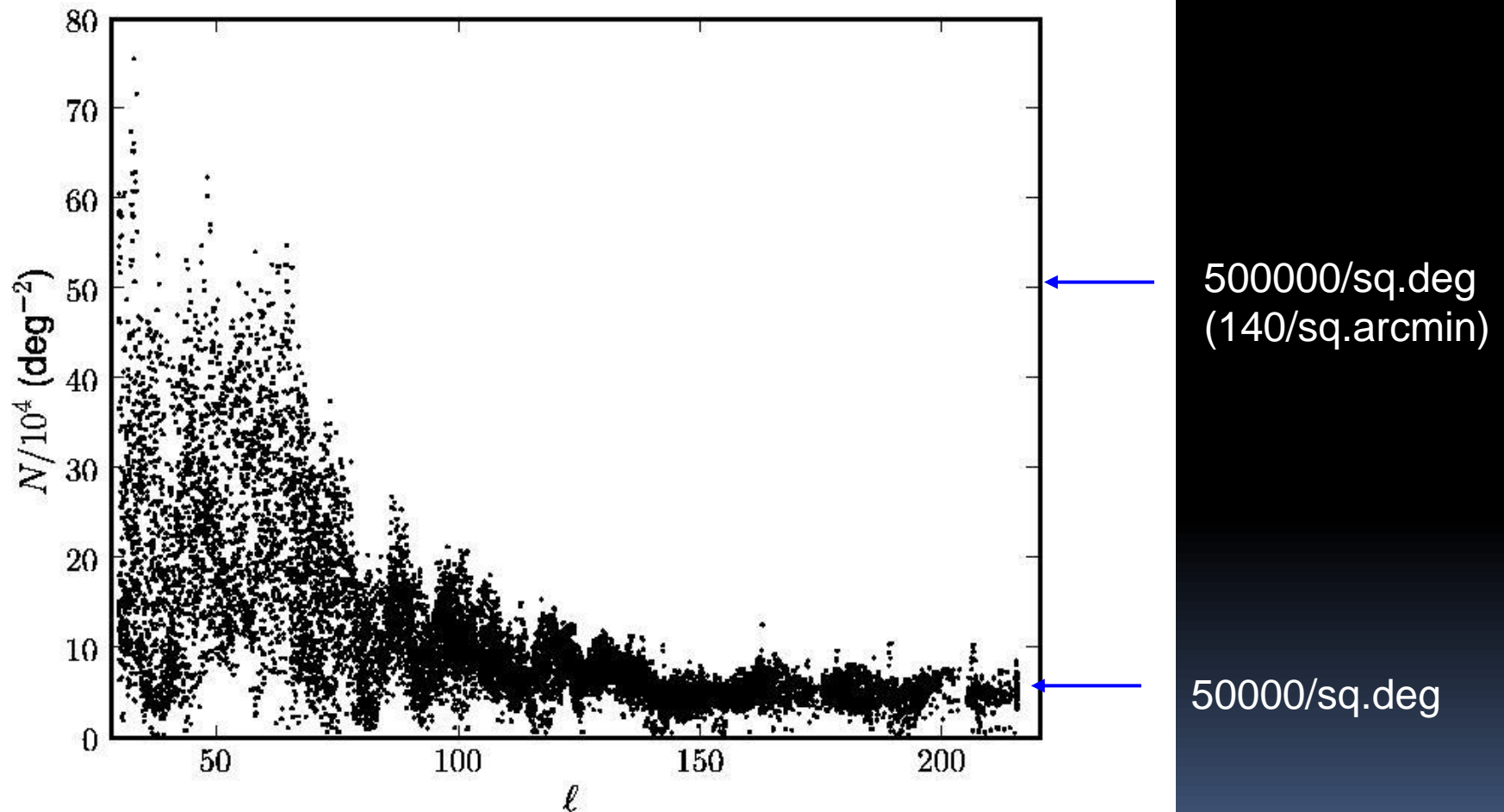
data pipelined at CASU

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

uniform point-source photometric calibration now underway

Northern optical source densities (to $\sim 20^{\text{th}}$ mag)

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



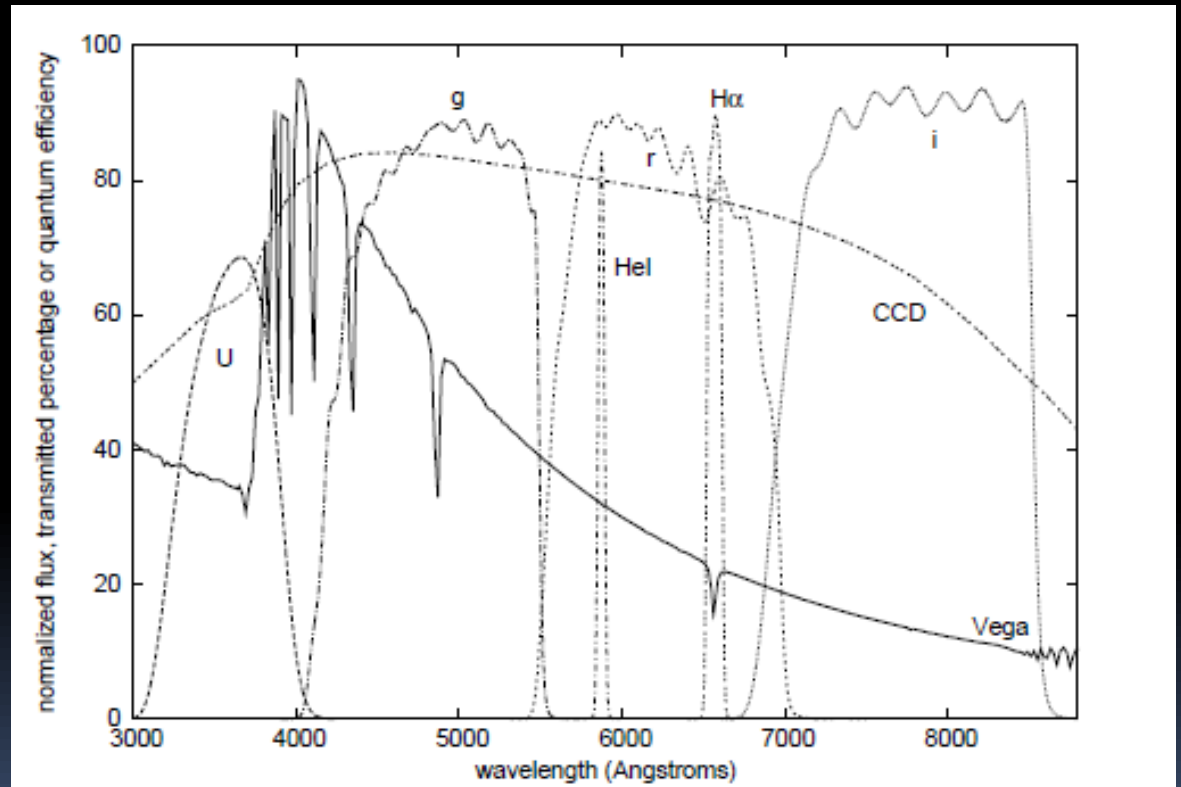
UVEX: UV excess survey of the northern Galactic plane
(www.astro.ru.nl/~pgroot/UVEX; Groot et al 2009)




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

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

~half of fields
'observed once'



The UVEX+IPHAS filter set, and Vega



Science – and calibration – in the northern hemisphere

Examples of important applications & comment on
replacing nightly with global photometric calibration

(See Appendix also)

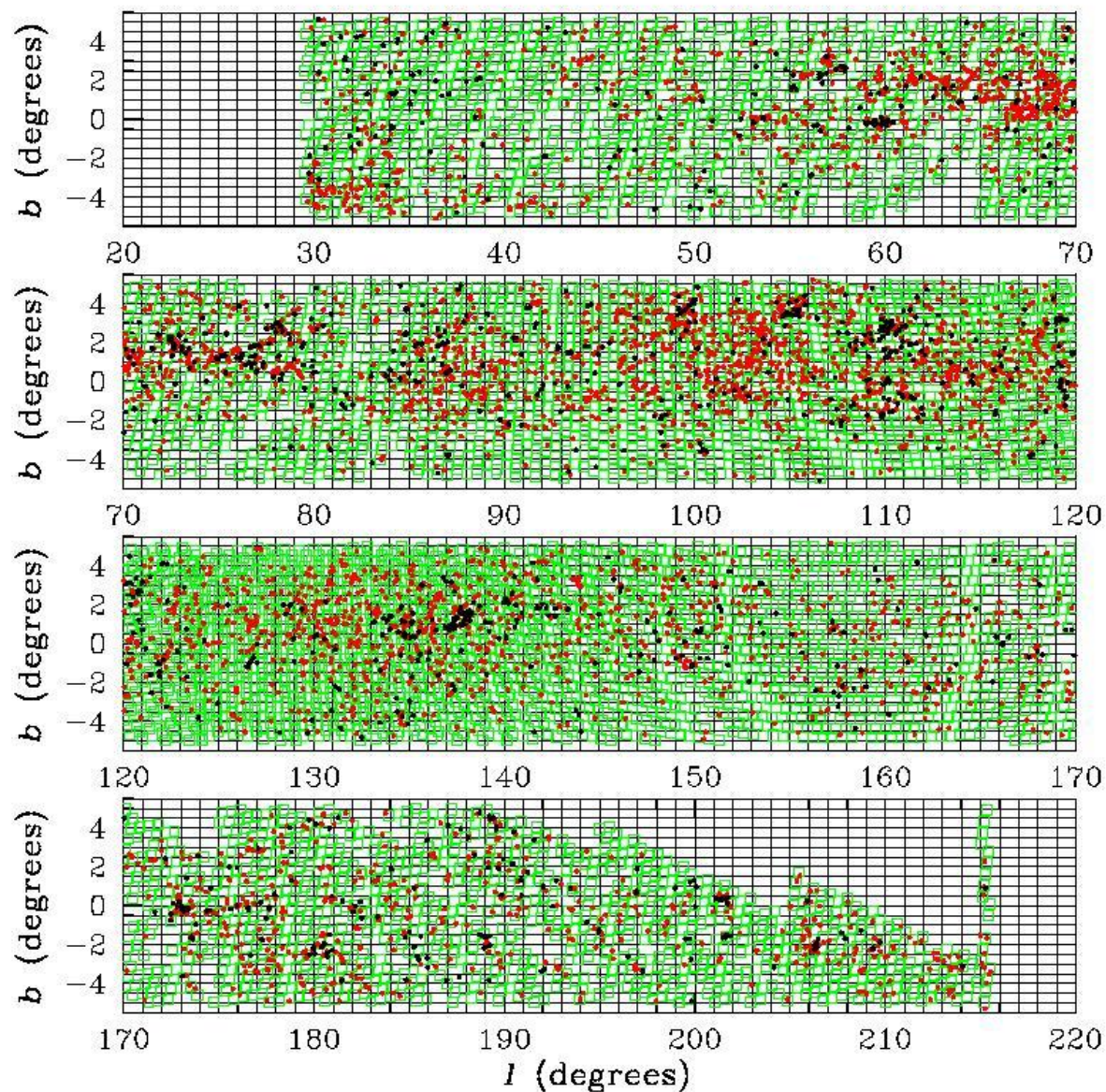
The basics:
emission line
stars in the
northern Plane:

Automatic
selection of 4853
objects, based
on r' - $H\alpha$ 'excess'
across $\sim 80\%$ of
survey area

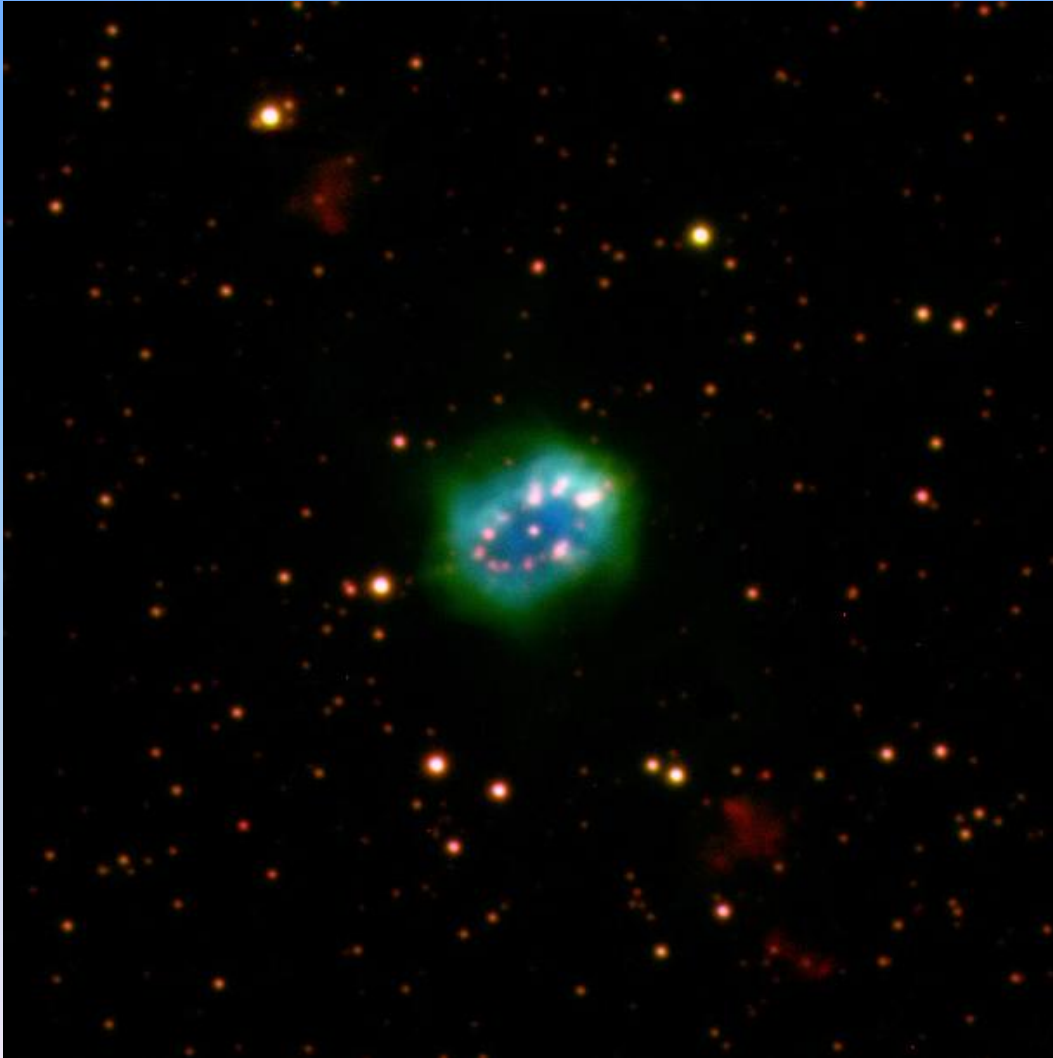
Red: $13 < r' < 18$

Black:
 $18 < r' < 19.5$

(Witham et al 2008)



Comprehensive searching of the northern plane for new nebulae, well underway



The first part of a new northern catalogue – nearly ready for publication (Sabin et al)

...typically more compact and lower surface brightness than known nebulae

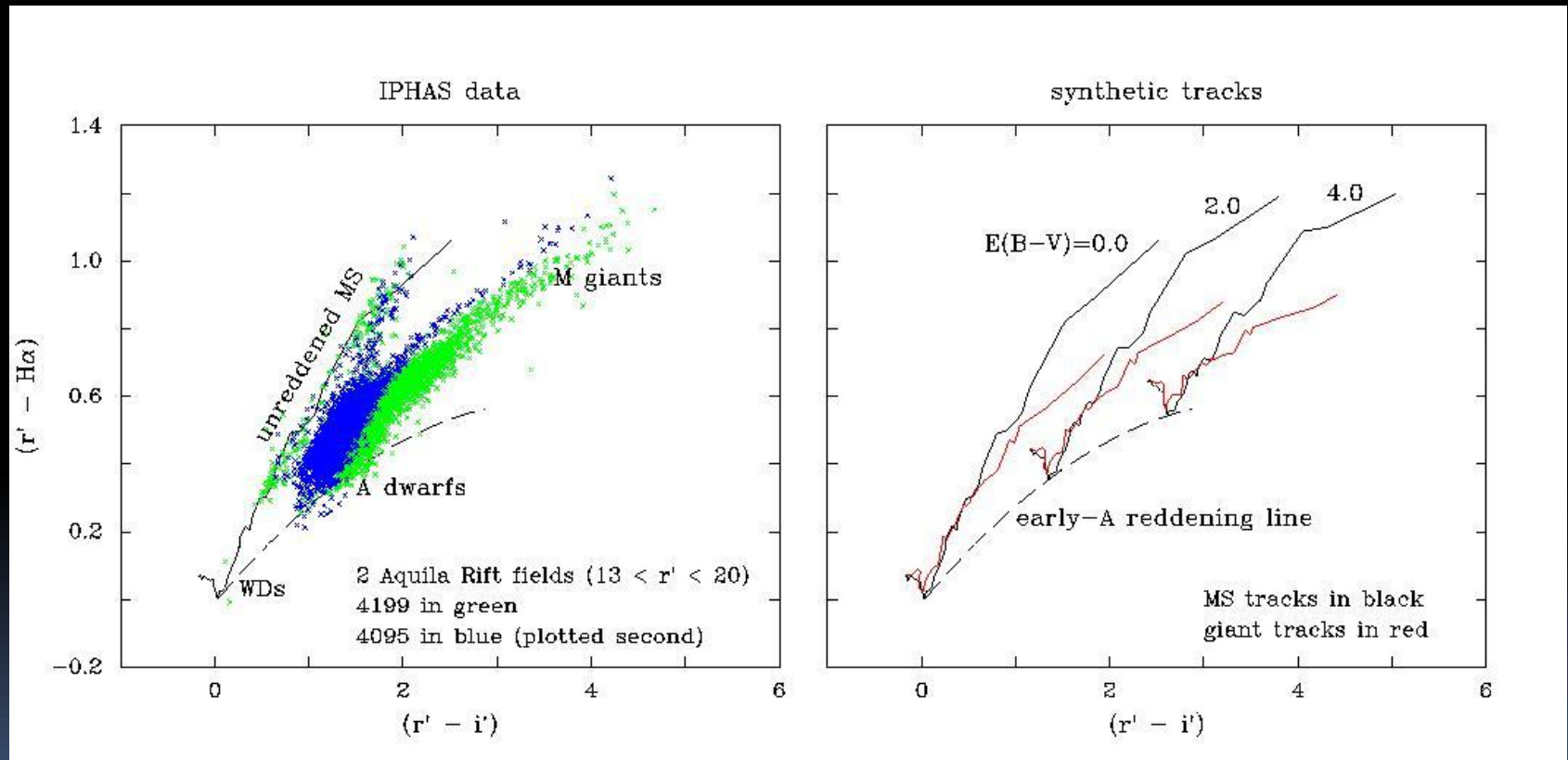
Left – a spectacular new ~young example, with a short-period binary central star (Corradi et al 2010)

The other function of narrowband $H\alpha$ photometry

$r'-H\alpha$ 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



NOTE: works even better using $r-H\alpha$ versus $g-i$, as VPHAS+ will permit

3D extinction mapping: selecting A-K stars from the IPHAS colour-colour diagram

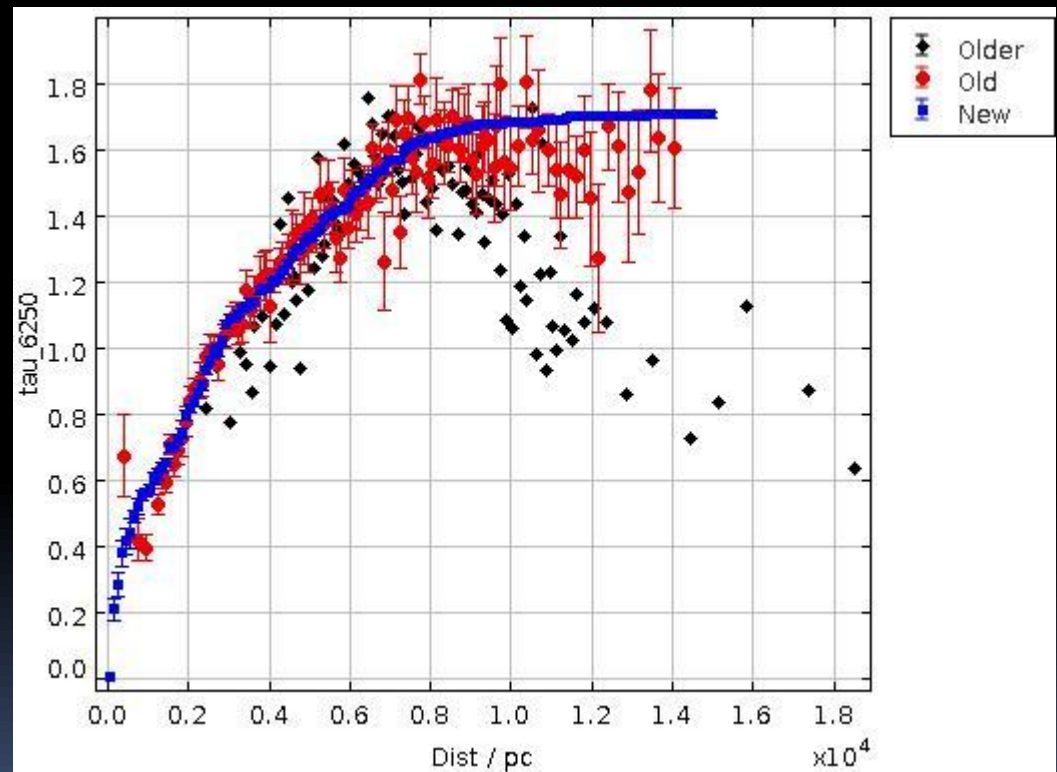
See Sale et al 2009 for origins of method:

Initially tested and working for outer disk

Development continues
→ becoming more general and robust

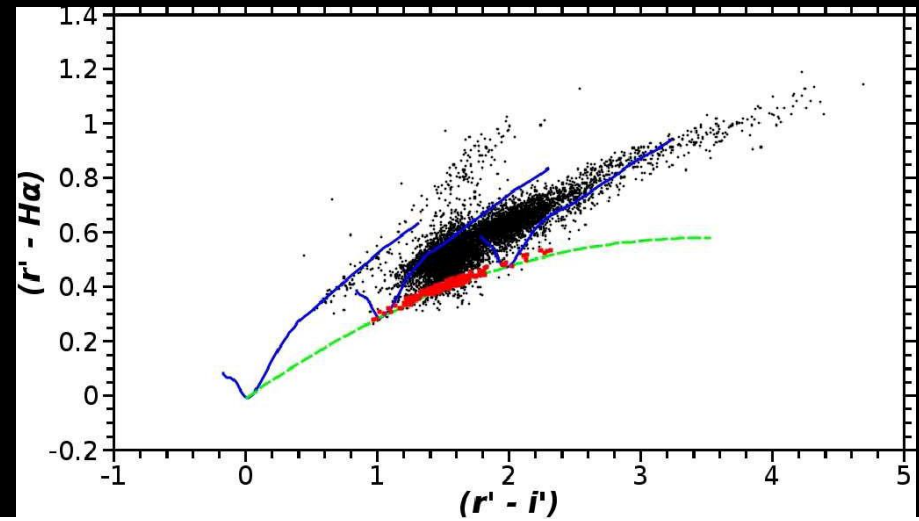
Here, for a test 10x10 arcmin² field at l,b = 73.1,+3.7

AIM:- a full high spatial resolution empirical 3D map of the entire Galactic Plane



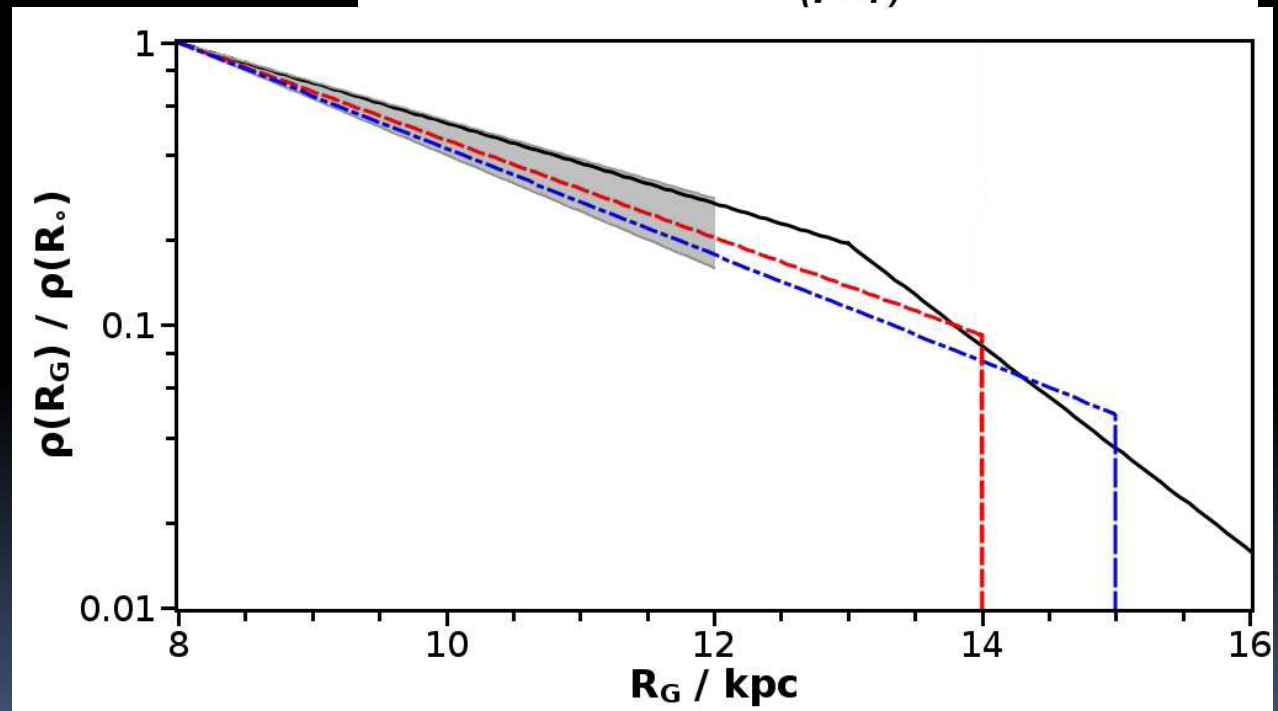
(Credit: S. Sale – nb $\tau_{6250} \sim A_r \sim 0.84A_v$)

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



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

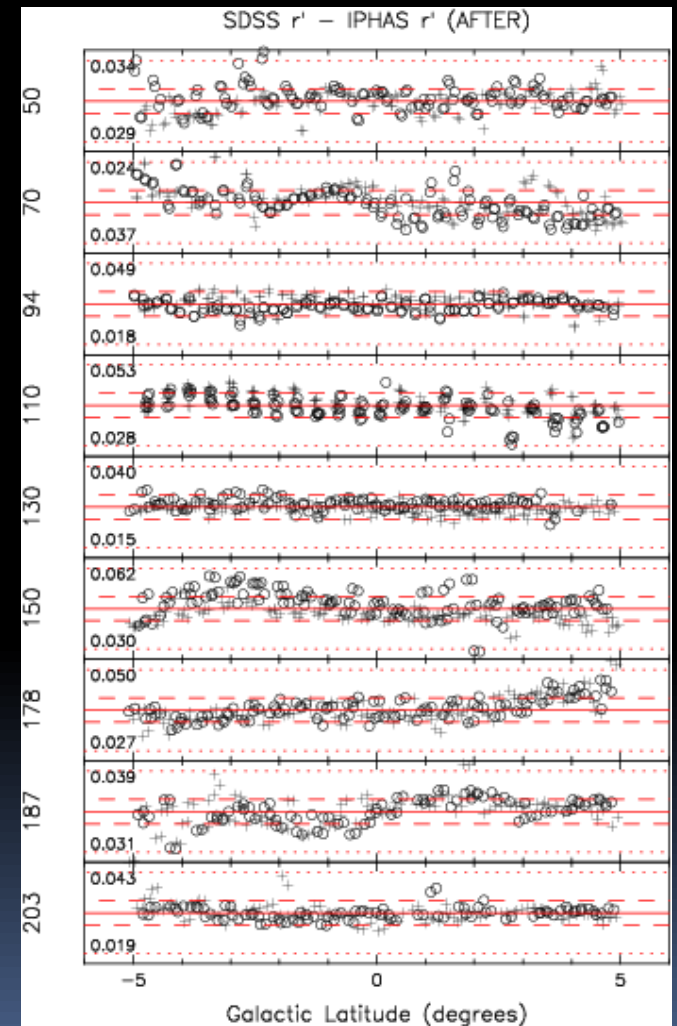
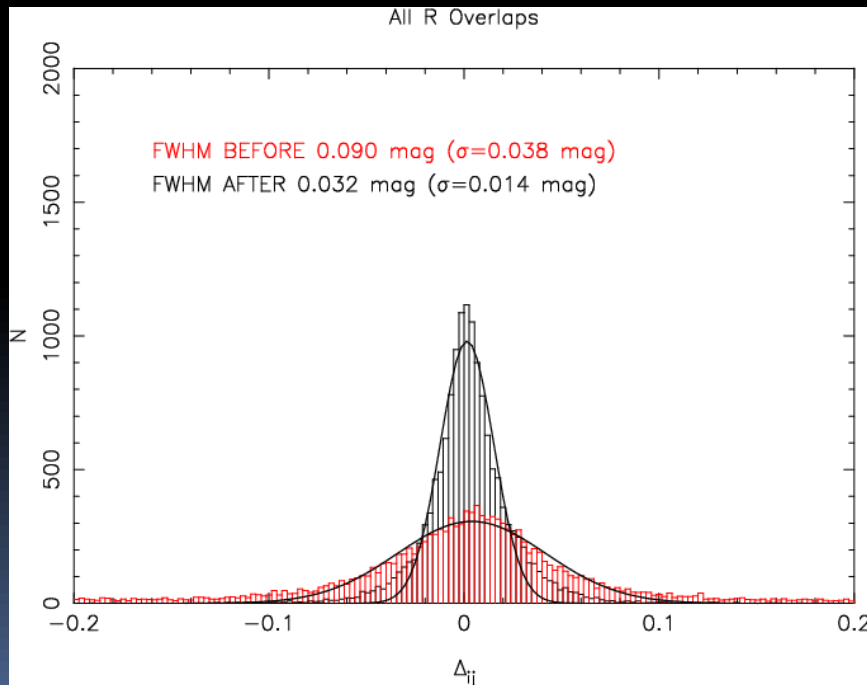
DENIS sharp
cut-off (blue
and red lines)
updated.



IPHAS ($r, i, H\alpha$) global calibration - in progress

Tougher challenge than the southern plane?

- greater weather variation + dust
- no 'Skymapper' to cross-calibrate with (see later)



(Credits: B. Miszalski)



VPHAS+ aims and specification

A reminder of aims and original specification;
Proposed update – add the high density fields of the
Bulge

VPHAS+ aims:

- The first digital ~ 1 arcsec resolution survey of the southern Galactic Plane within $|b| < 5$.
 - Giving contemporaneous SEDs, enhanced by narrowband $H\alpha$, for all point sources to AB mag ~ 22 .
 - \rightarrow unprecedented accounting for the emission line objects – young and evolved – in the MW disk
 - \rightarrow opportunities to map the disk: 3D extinction, cluster searches, star-forming activity
 - \rightarrow census of UV excess objects: massive stars, compact binaries, stellar remnants

VPHAS+ specification:

Filter	Exposure (secs)	Limiting AB mag
u	150	21.8
g	30	22.5
r	30	22.5
Ha	120	21.6
i	30	21.8

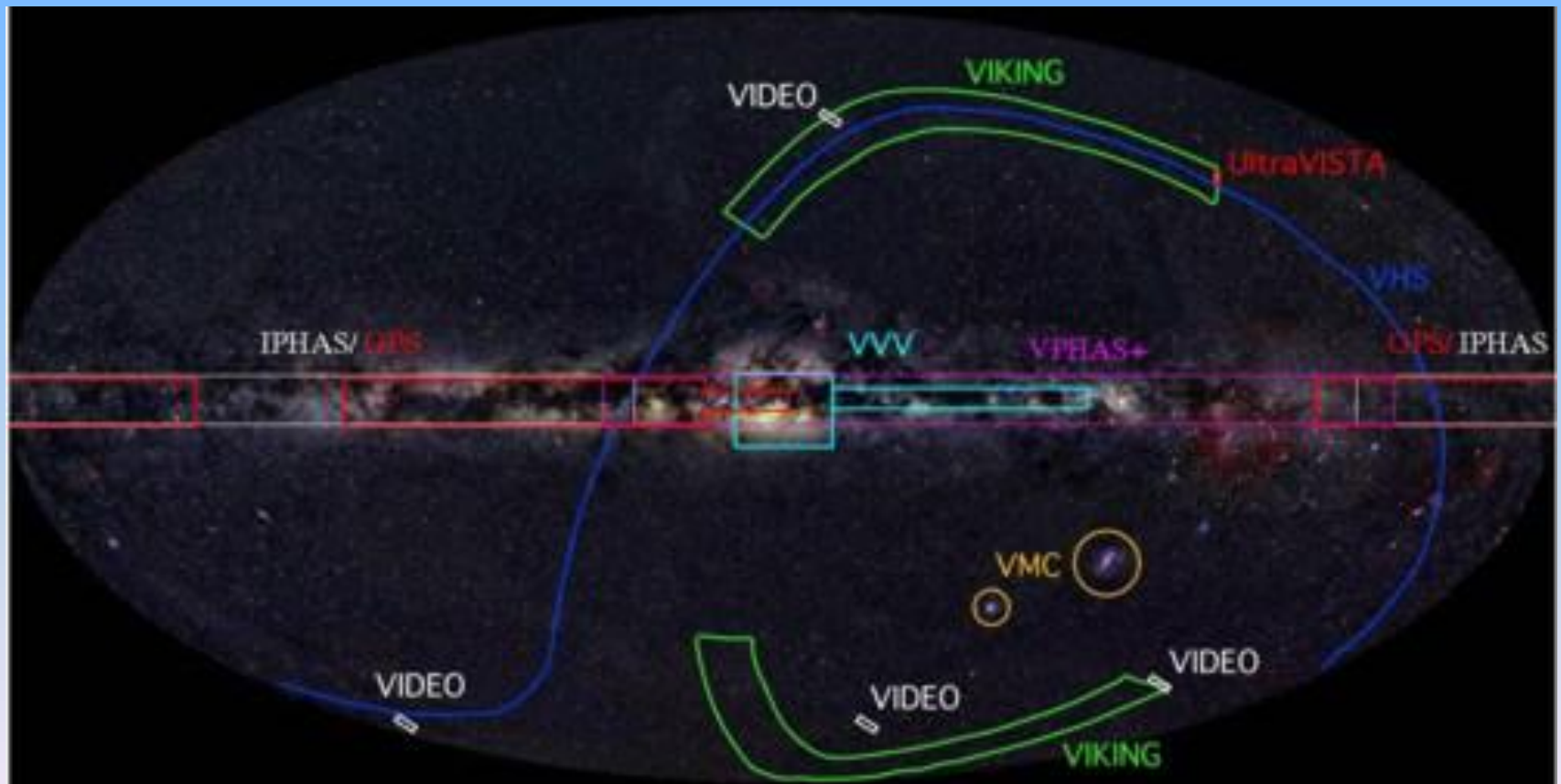
- Survey footprint: 1800 sq degs, $|b| < 5^\circ$, plus small overlap across celestial equator
- Every field centre observed once in each filter
...followed by another set of exposures in each filter, at an offset position (to achieve double pass)
- Contemporaneous data-taking required to avoid problems with variability
...willing to discuss meaning of 'contemporaneous' with EST
- < 1.2 arcsec seeing (middle band); 'clear' conditions accepted

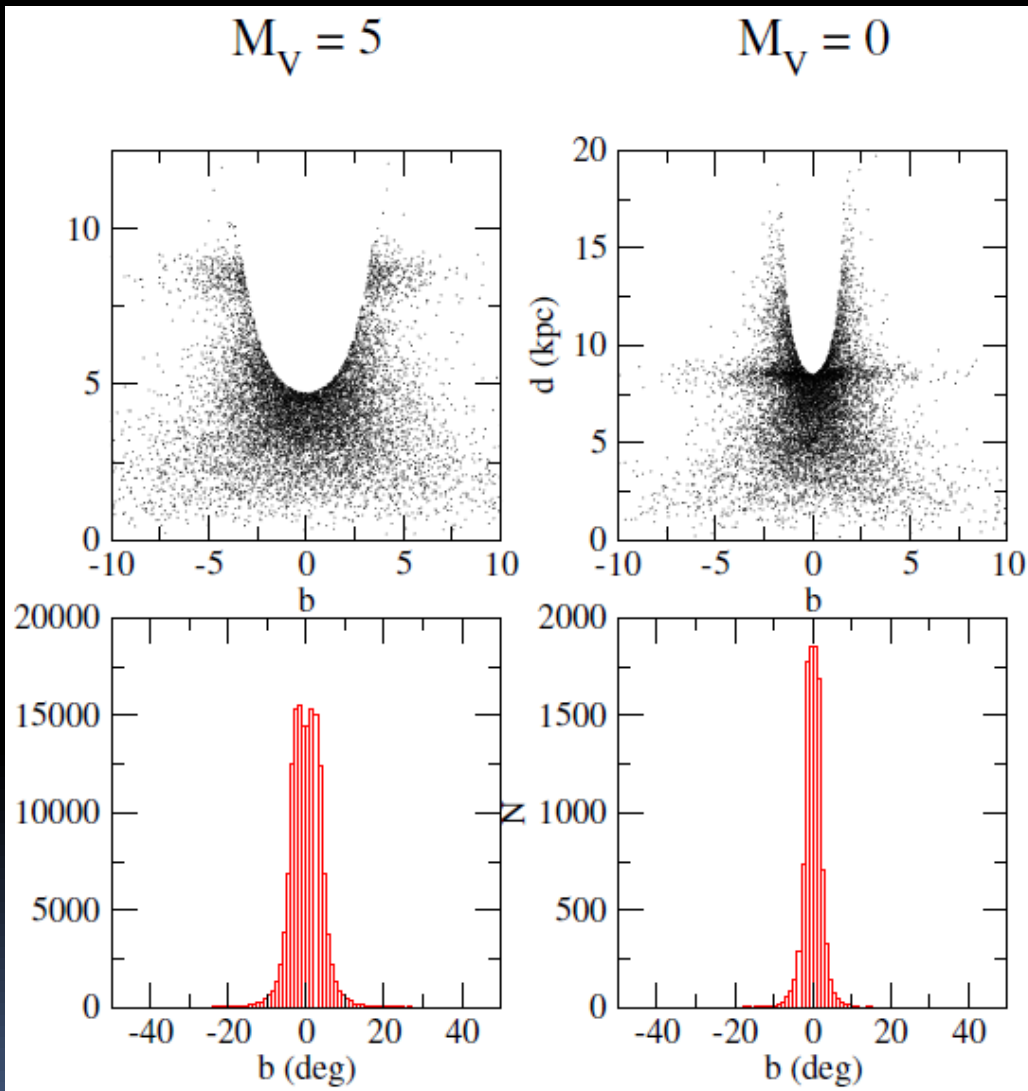
The changing landscape since ~2005/6:

First factor – the PSP approved VISTA NIR surveys (esp. VVV)

Second factor – the limitations to be expected of Skymapper 'competition'

→ for superior legacy value, VPHAS+ should incorporate the dense fields of the Galactic Bulge – and at least match VVV footprint





(credit: G. Nelemans)

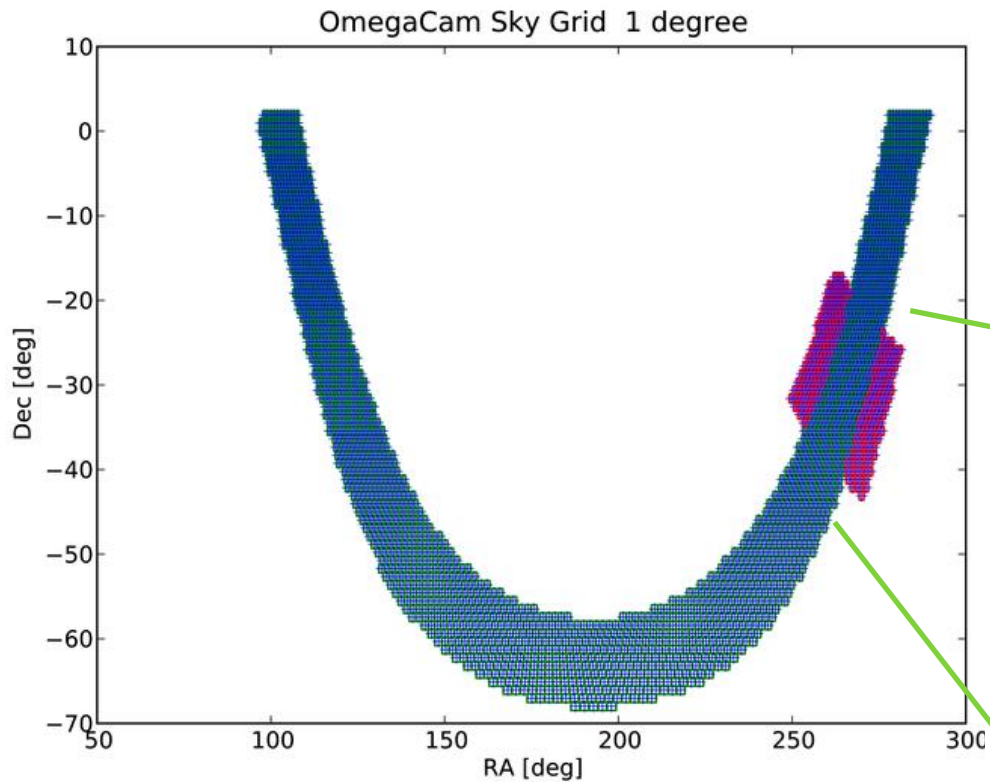
The old populations in the Galactic Bulge

...expanding the latitude range to $|b| < 10$ captures them to $M_V \sim 5$ (subdwarfs, outburst CVs, compact PNe, symbiotics, X-ray binaries)

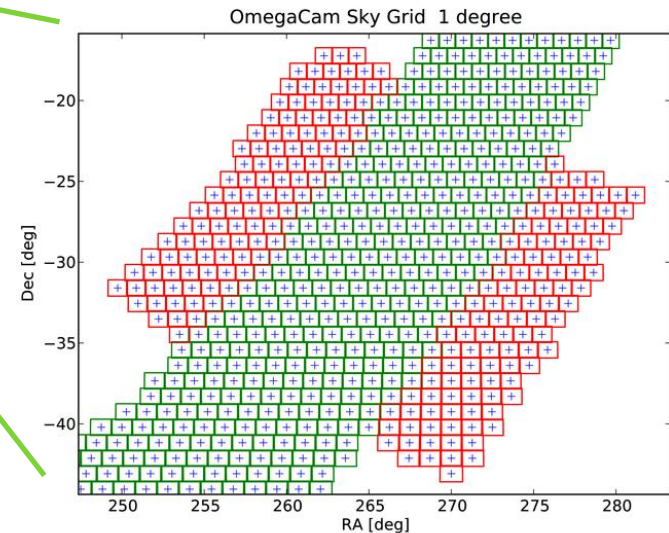
Plots show what can be captured by VPHAS+, on the basis of a simple Galactic model, with reddening.

Tiling the plane

To assure $|b| < 5$ coverage – ~2000 field centres
Adding the Bulge, as shown, adds a further ~220 centres



100 percent overhead +
offset repeats
→ 105 nights for Plane
→ +11 nights for Bulge

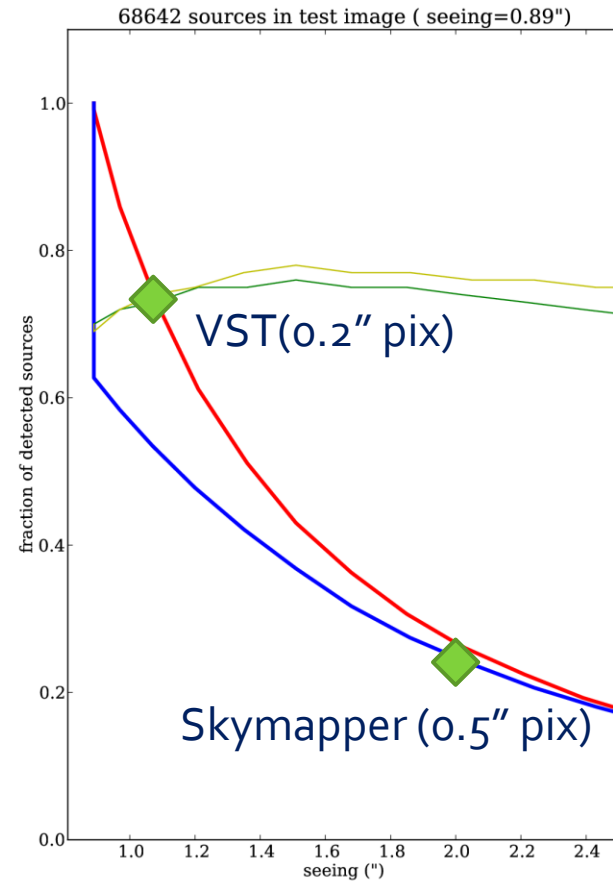
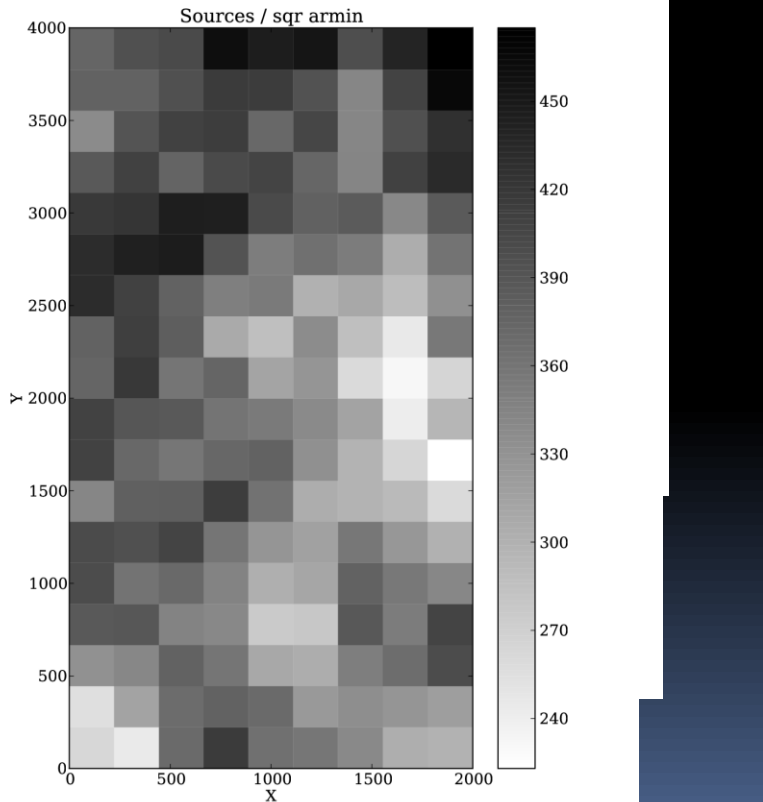
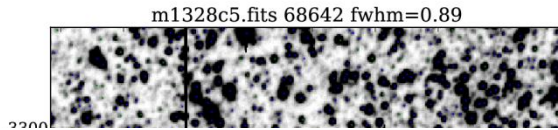
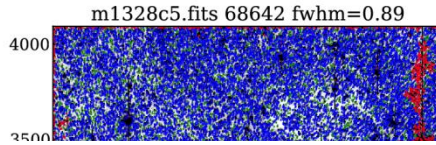


(Tiling by R Greimel, using OmegaCam software)

VPHAS+ and Skymapper

- Regular contact with Stefan Keller, Mike Bessell (and Brian Schmidt) in recent years
- Skymapper H α filter in advanced state of procurement – to be used for fast/shallow (< 18th mag) survey, complementary to VPHAS+
- ...discussing possible follow-on procurement of single-piece filter for VST, to replace segmented filter in hand
- ...interest in exploiting cross-calibration opportunities
- VST clearly should outperform Skymapper in dense Galactic Plane fields.

High source density capability
– the VST advantage: fraction of detected sources versus seeing)



(credit: D Steeghs)

Timeliness: VPHAS+ in the Gaia era

- VPHAS+ H α -enhanced photometry of the Galactic Plane complements Gaia in the most challenging (crowded) part of the sky – often exceeding the expected quality of prism spectrophotometry
- VPHAS+ data collection, **mainly in 2012—2014** ...still ahead of Gaia 'intermediate data products'
- Can support Gaia-related spectroscopy campaigns in next few years, if no further delays
- Combined with Gaia parallaxes \rightarrow immense 3D extinction mapping legacy in prospect



On behalf of the
VPHAS+ consortium:

Thank You

APPENDIX: a partial list of IPHAS/UVEX publications, illustrative of science scope.

1. PN around Nova V₄₅₈ Vul (Wesson et al., ApJ 688, 21, 2008; Rodriguez-Gil, in press)
2. Doubling of known symbiotic stars in the survey area (Corradi et al., A&A 509, 41, 2010)
3. High proper motion catalogue (Deacon et al., MNRAS 397, 1685, 2009)
4. Emission line object catalogue (Witham et al., MNRAS 384, 1277, 2008)
5. PN catalogues (Viironen et al., A&A 504, 291, 2009, ; Sabin et al., in prep.)
6. ERSO catalogue -- mostly AGB stars, ability to separate S-type carbon stars in r-Ha (Wright et al., MNRAS 390, 929, 2008)
7. Rare emission line objects and nebulae (eg. Mampaso et al., A&A 458, 203, 2006; Lennon et al., in prep.)
8. CV discoveries (Witham et al 2007, MNRAS, 382, 1158)
9. Legacy value: detection/non-detection of nova progenitors. Various Astronomers Telegrams issued.
10. Insights on CygOB2 and relation to its environment (Drew et al 2008, MNRAS, 386, 176)
11. 3D extinction mapping and A stars in the outer disk (Sale et al., MNRAS 392, 497, 2009; Sale et al 2010, MNRAS, 402, 713)