Mapping Galactic Spiral Arm Structure: The IPHAS Survey and Virtual Observatory Access

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The IPHAS Consortium: http://www.iphas.org

The IPHAS Survey Collaboration

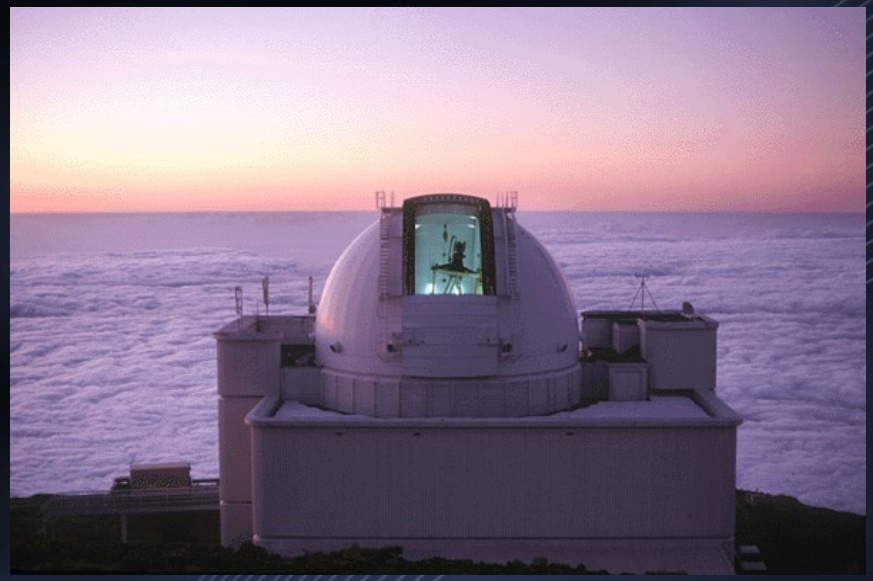
- IPHAS: The Isaac Newton Telescope/ Wide Field Camera Photometric H-alpha Survey of the Norther Galactic Plane (PI: Janet Drew: Imperial, UK)
- IPHAS collaboration - http://www.iphas.org :
  - UK: Bristol, Cambridge, Imperial, Keele, Manchester, Hertfordshire, Southampton, UCL, UKATC, Warwick
  - Australia: Macquarie
  - Germany: Thueringer Landessternwarte
  - Holland: Nijmegen
  - Spain: Granada, IAC, ING, Valencia
  - USA: CfA
- Element of the wider IPHAS/VPHAS+/UVEX consortium: forming EGAPS (European Galactic Plane Surveys) – see http://www.egaps.org

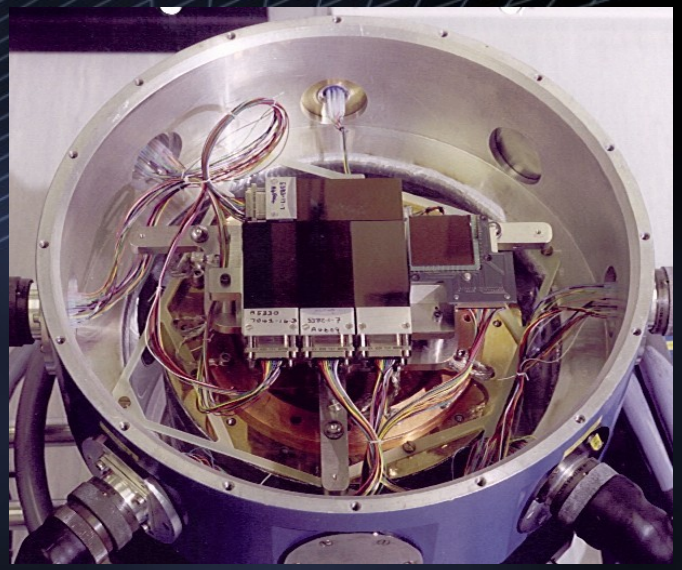
IPHAS Key Goals

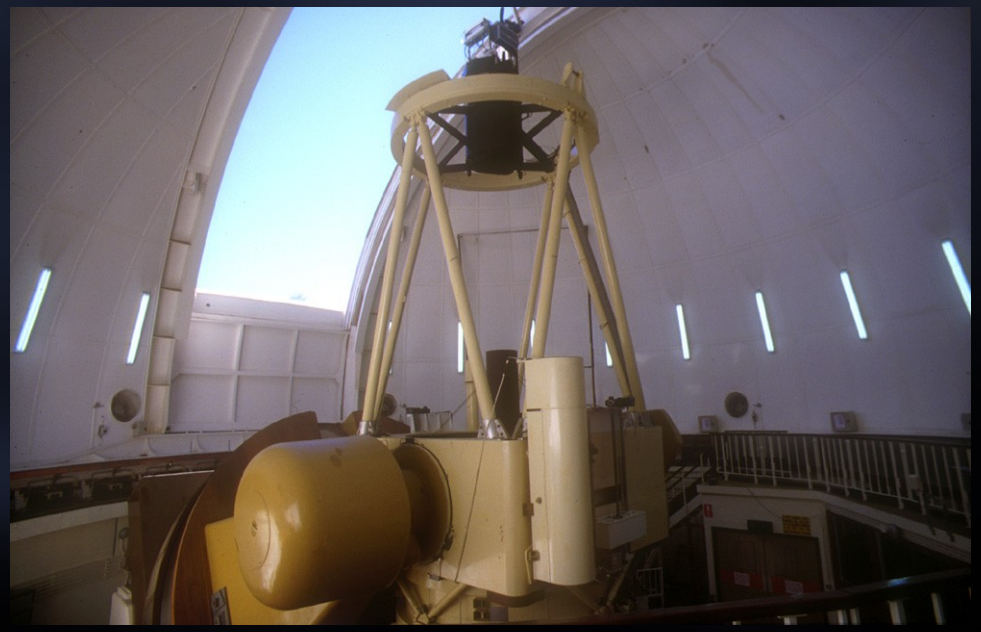
Large scale Milky Way structure and study of early and late type populations (preferentially selected via H-alpha emission line properties):

- (Compact) planetary and symbiotic nebulae
- luminous blue variables (P Cygni and eta Car like objects)
- OBA extreme supergiants
- rapidly evolving post-AGB stars
- Be stars of all types (including young Herbig stars)
- good statistics on clusters of T Tau stars
- a range of interacting binary stars (symbiotics, `supersoft' compact binaries, WD/NS/BH accreting binaries generally)

IPHAS data source: 2.5-m INT + WFS

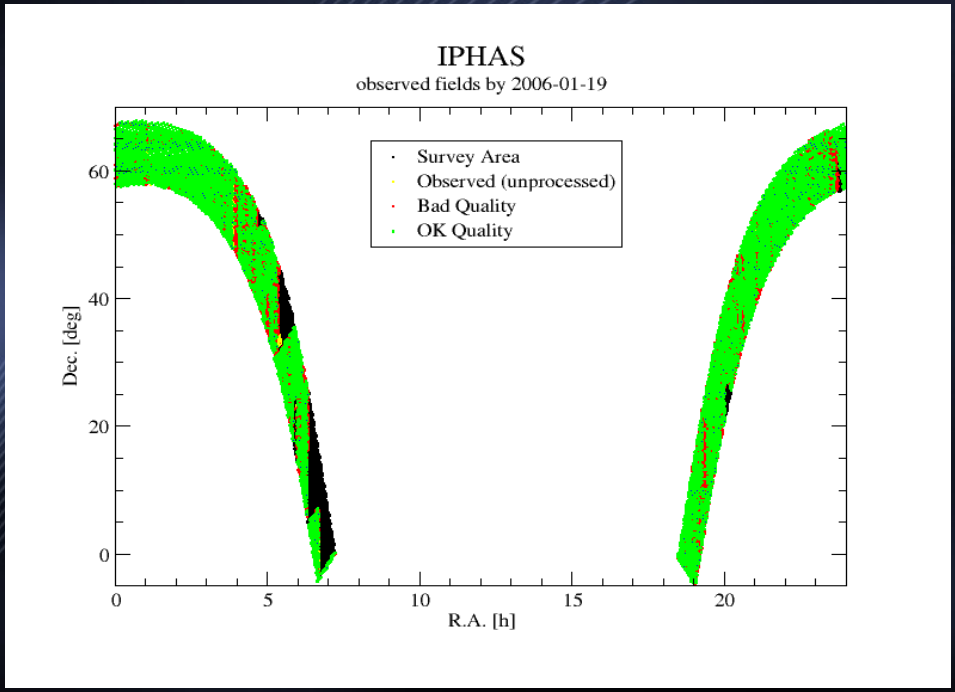


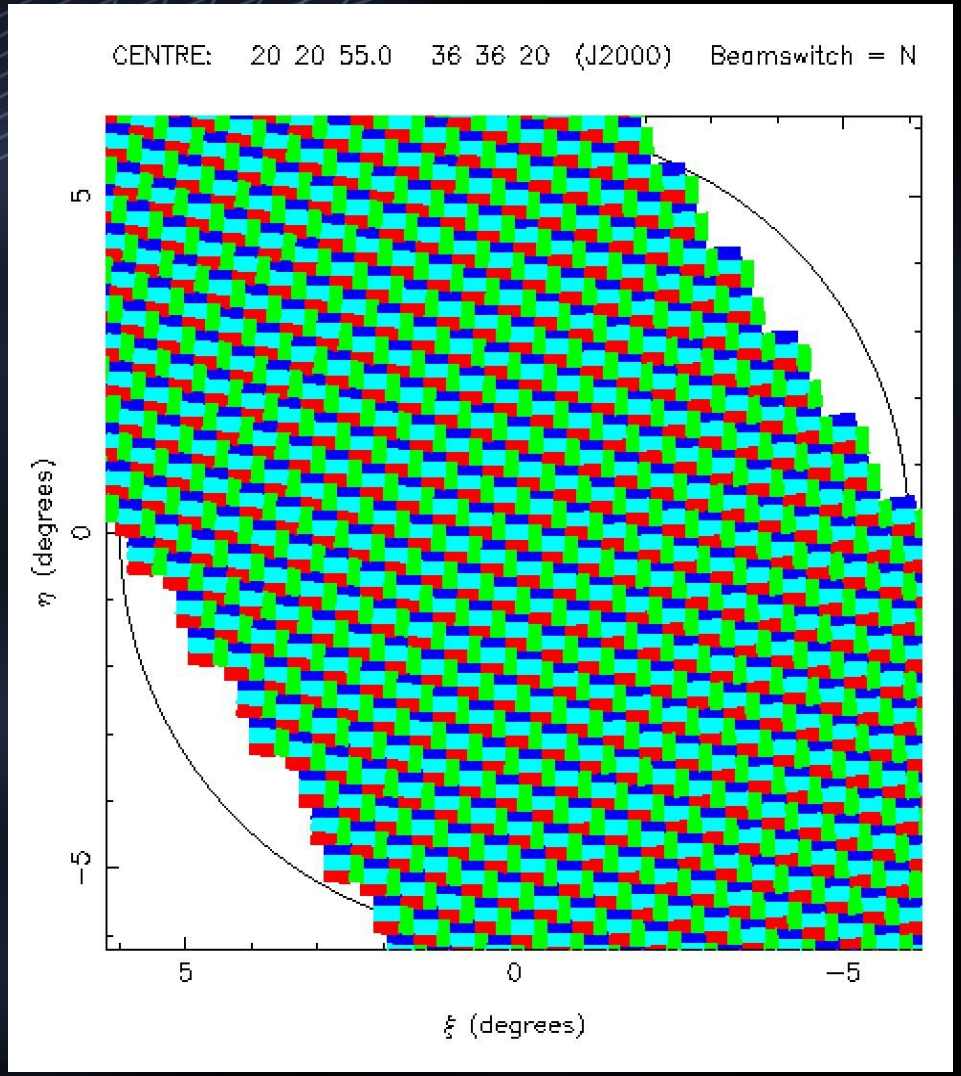




IPHAS Survey

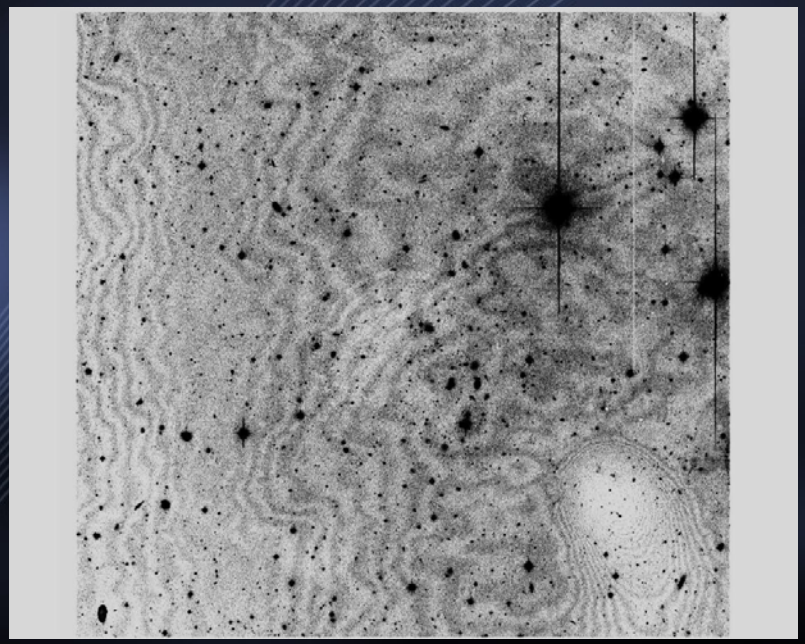
- 7635 Pointings ~2000 sq deg
- x 2 (overlap, 5'x5' offset)
- thus 15270 Pointing in total
- r, Ha, and i
- ~30 GB/night of data = > 1TB total

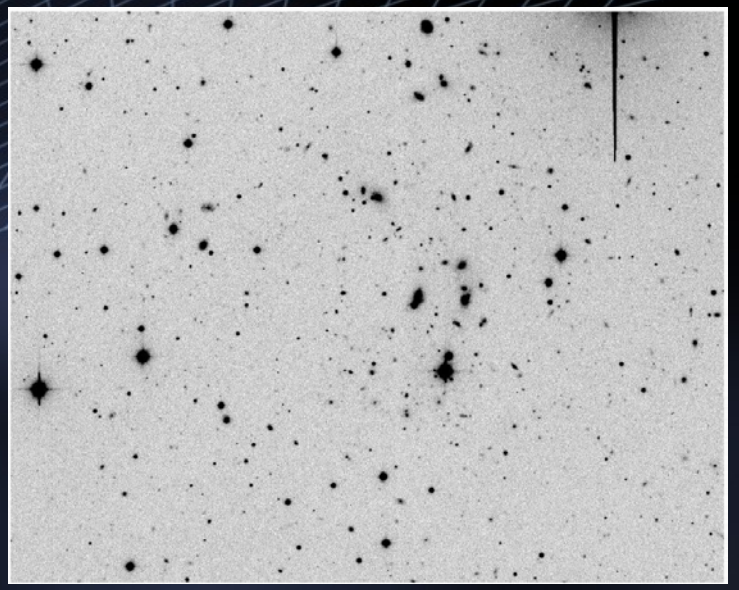


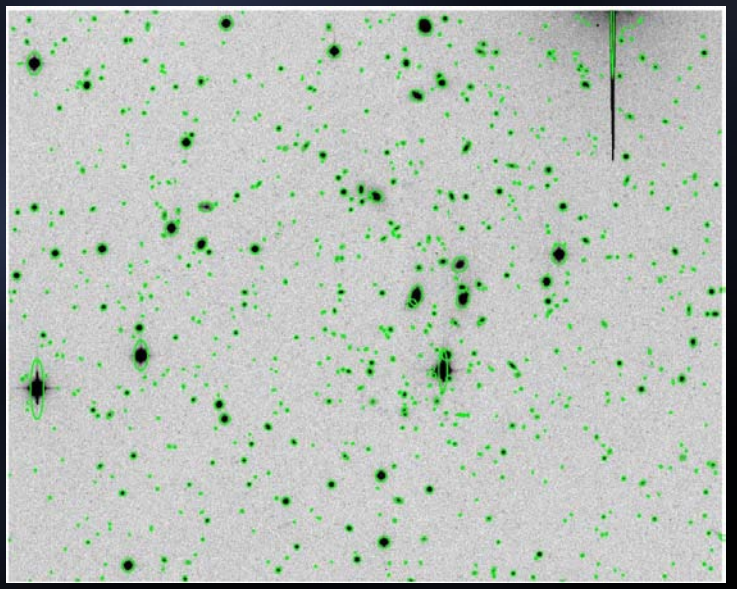


Survey Products

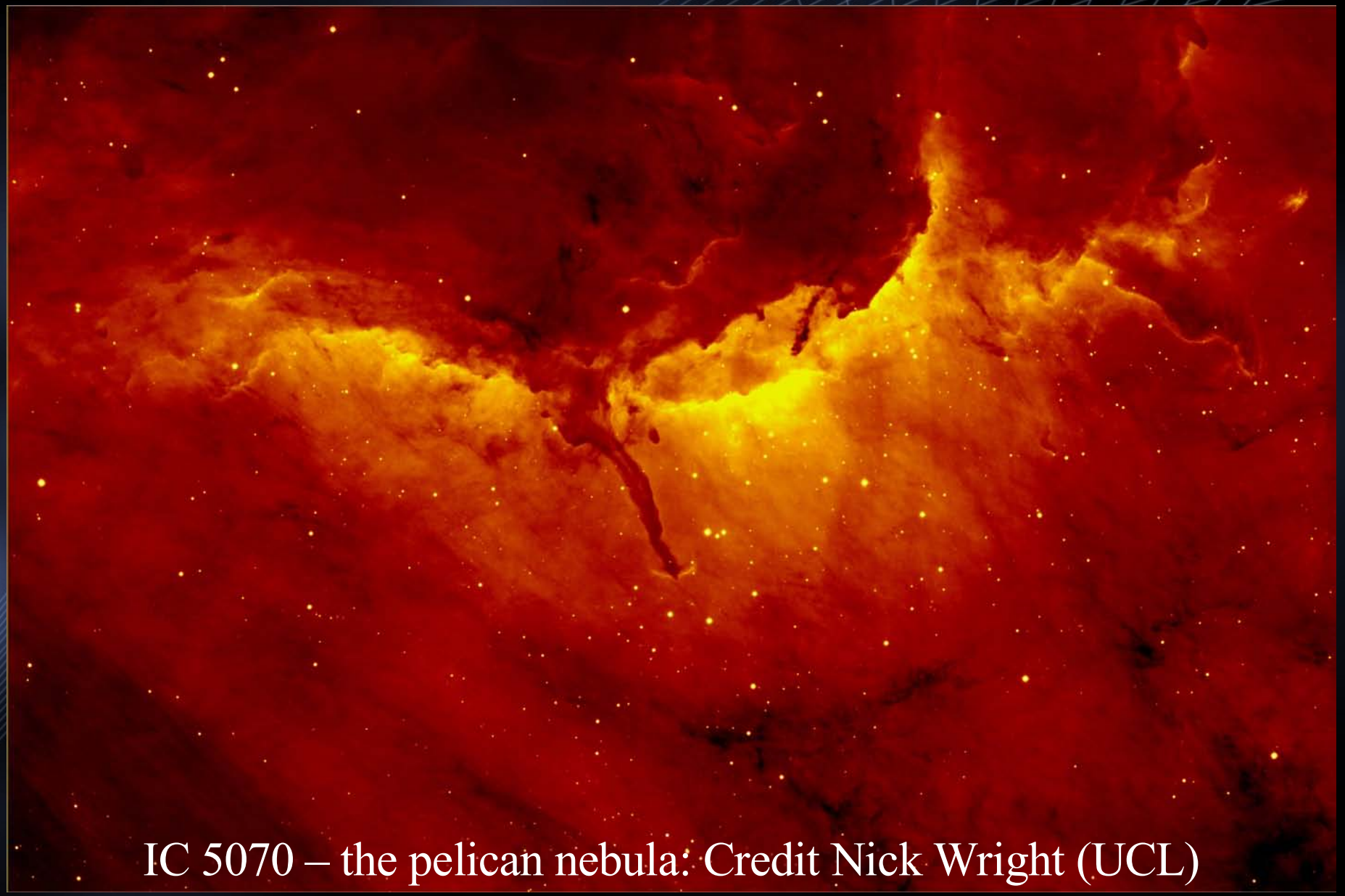
- Photometric catalogue ~100 million objects
- Detection of ~50000 Hα-emitting objects





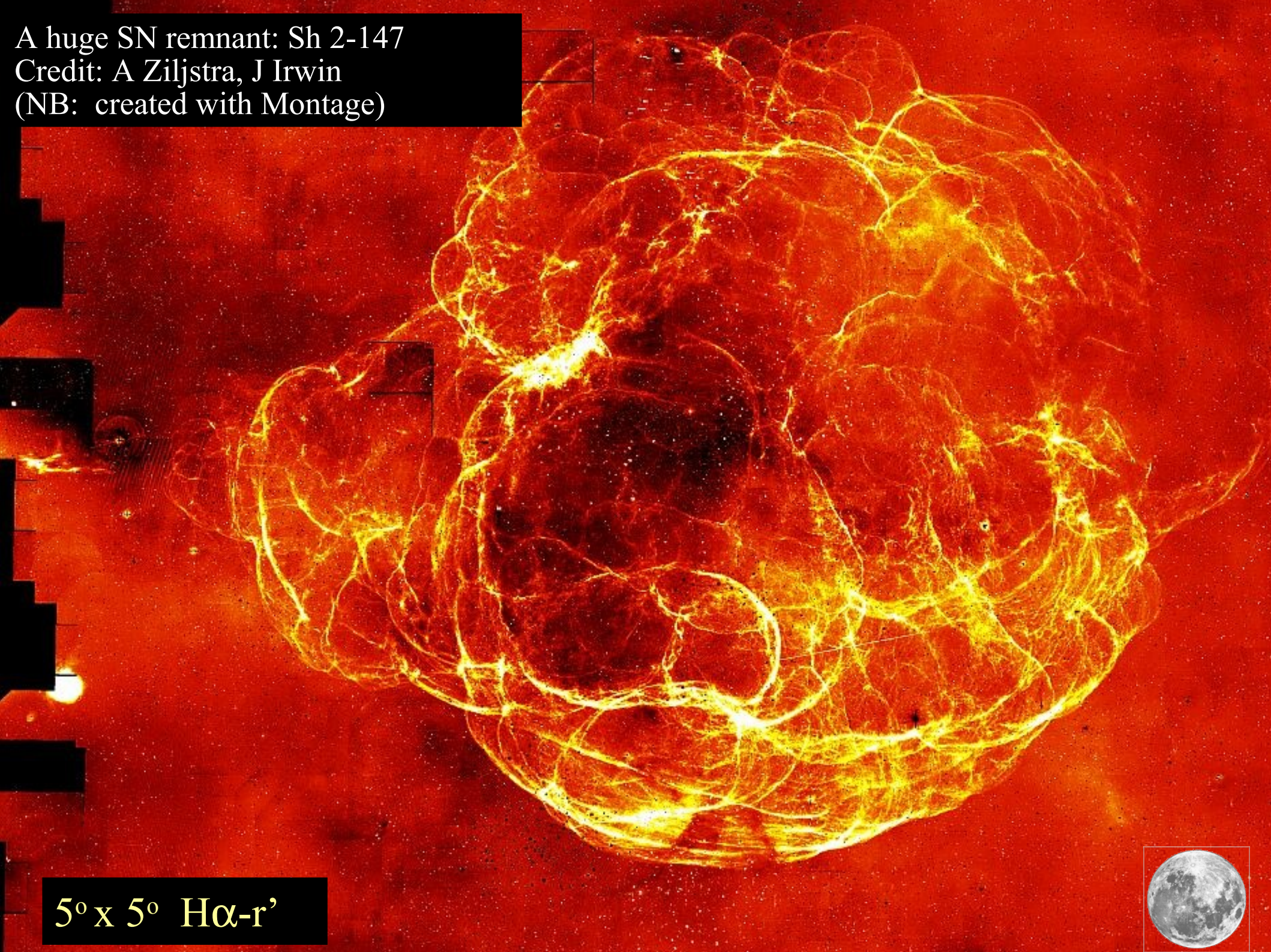


IPHAS: Images



IC 5070 – the pelican nebula: Credit Nick Wright (UCL)

A huge SN remnant: Sh 2-147
Credit: A Ziljstra, J Irwin
(NB: created with Montage)



5^o x 5^o Hα-r'

AstroGrid: UK's Virtual Observatory
Empowerment of scientists

- Improve the quality, ease, speed and cost effectiveness of on-line astronomy
- Make comparison and integration of data seamless
- Removing barriers to multi-wavelength astronomy
- Enable access to very large data sets

Project: 2001-2007: ~£10M: key data and resource providers in consortium

AstroGrid 2006.3 Release: Aug 2006

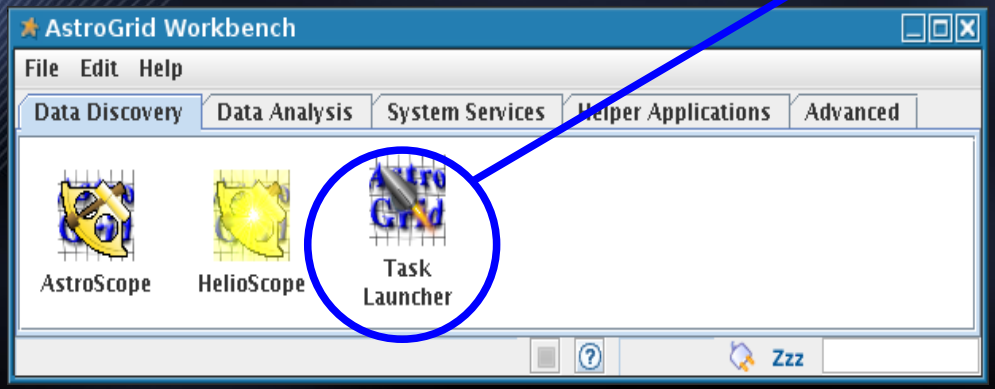
http://www.astrogrid.org/launch

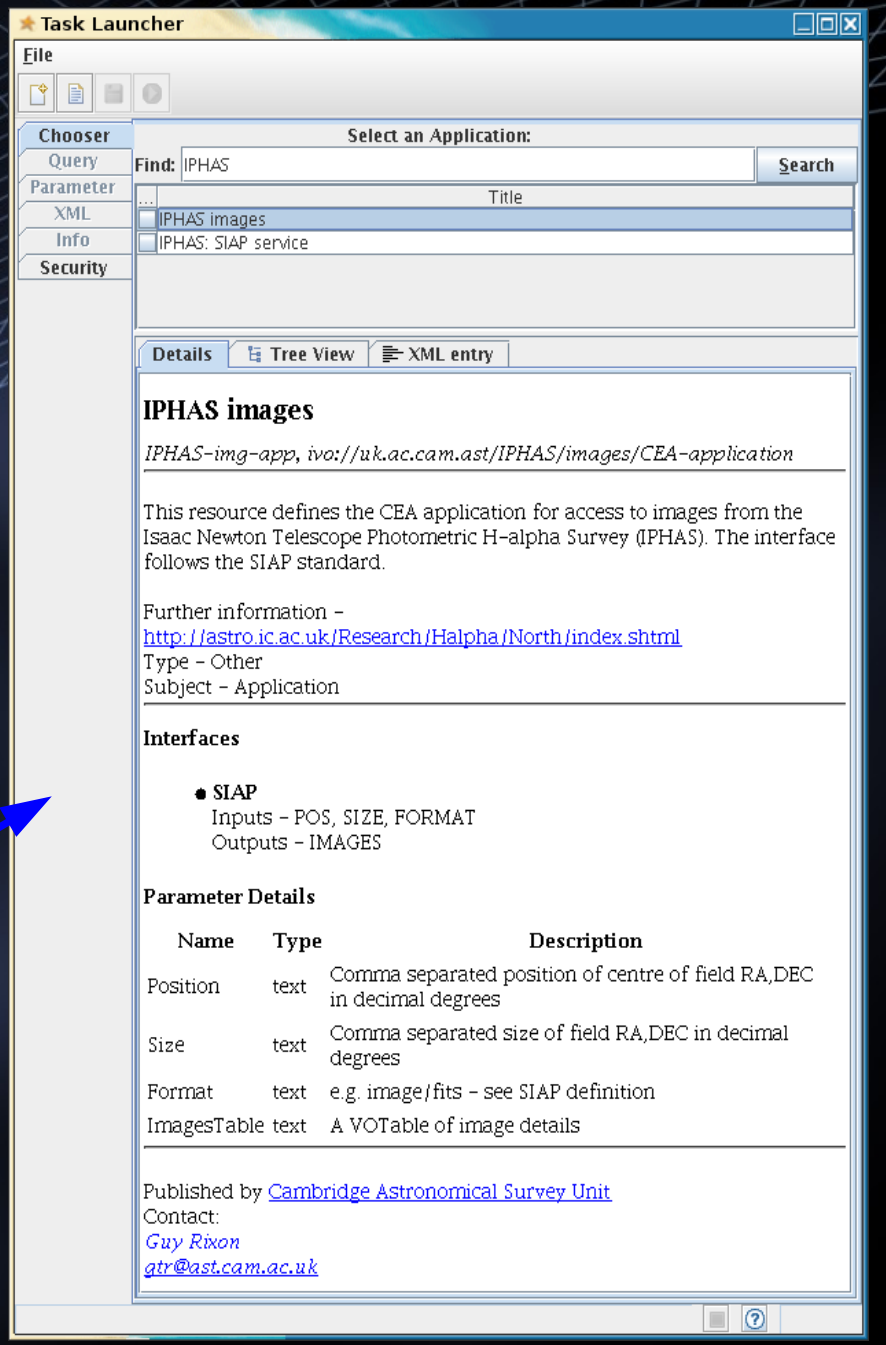
Integrating IPHAS Data

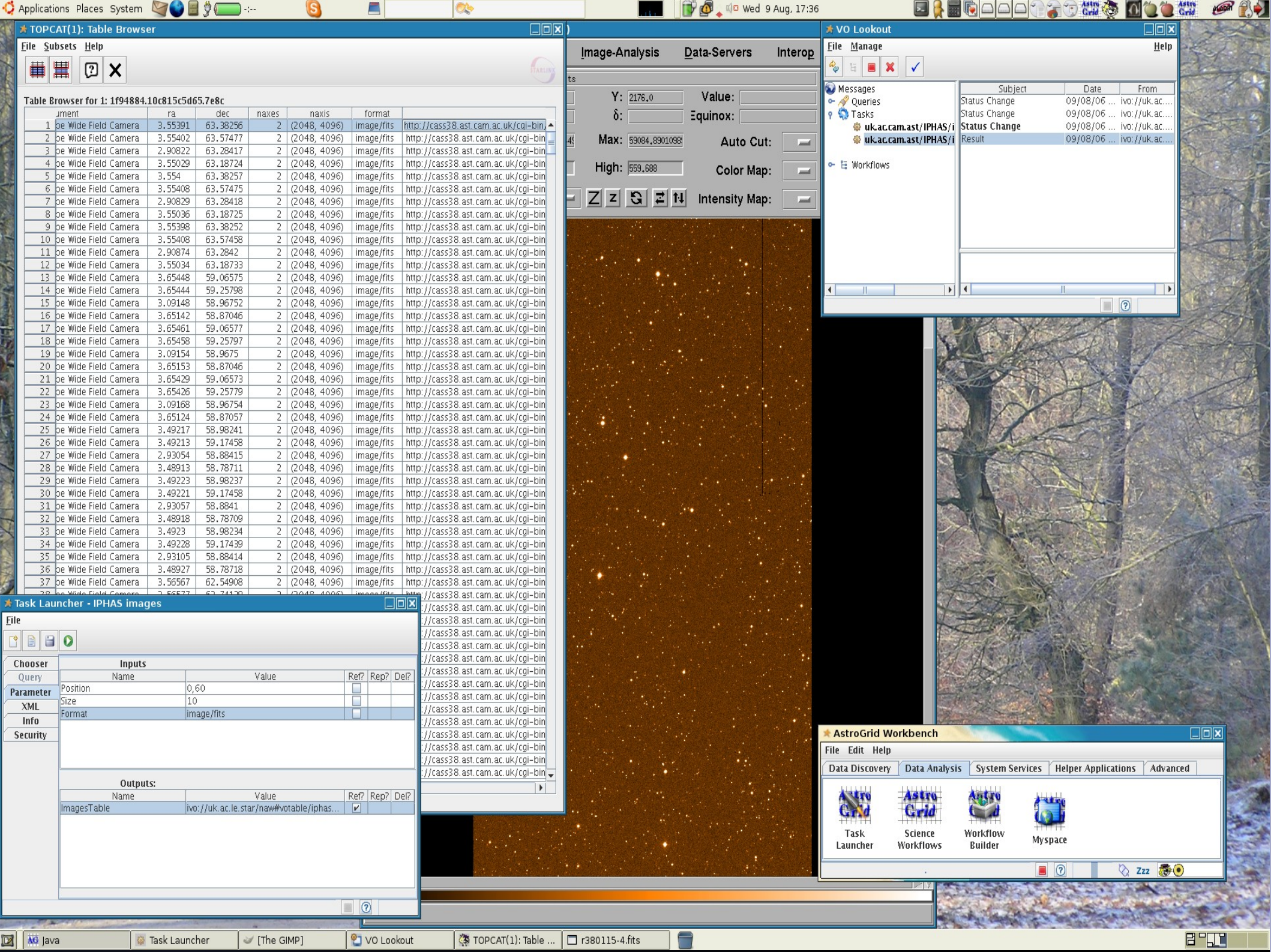
- Data Products from CASU pipeline include:
  - FITS images (per image pointing)
  - FITS table catalogues (per image pointing)
  - Single unified merged object source catalogues
    - Sybase IQ DMS system
- Access to these products expedited by use of AstroGrid interface mechanisms:
  - Images: via Simple Image Access protocol service
  - Catalogues (FITS tables):
  - Merged catalogues: Data Set Access component to database

SIAP Image service

- Simple Image Access to IPHAS images
  - physically data distributed from the Cambridge Astronomical Survey Unit (CASU @ IoA, Cambridge)
- Accessible through standard Virtual Observatory (VO) interfaces - e.g. AstroGrid Workbench



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AstroGrid Workbench
File Edit Help
Data Discovery
Data Analysis
System Services
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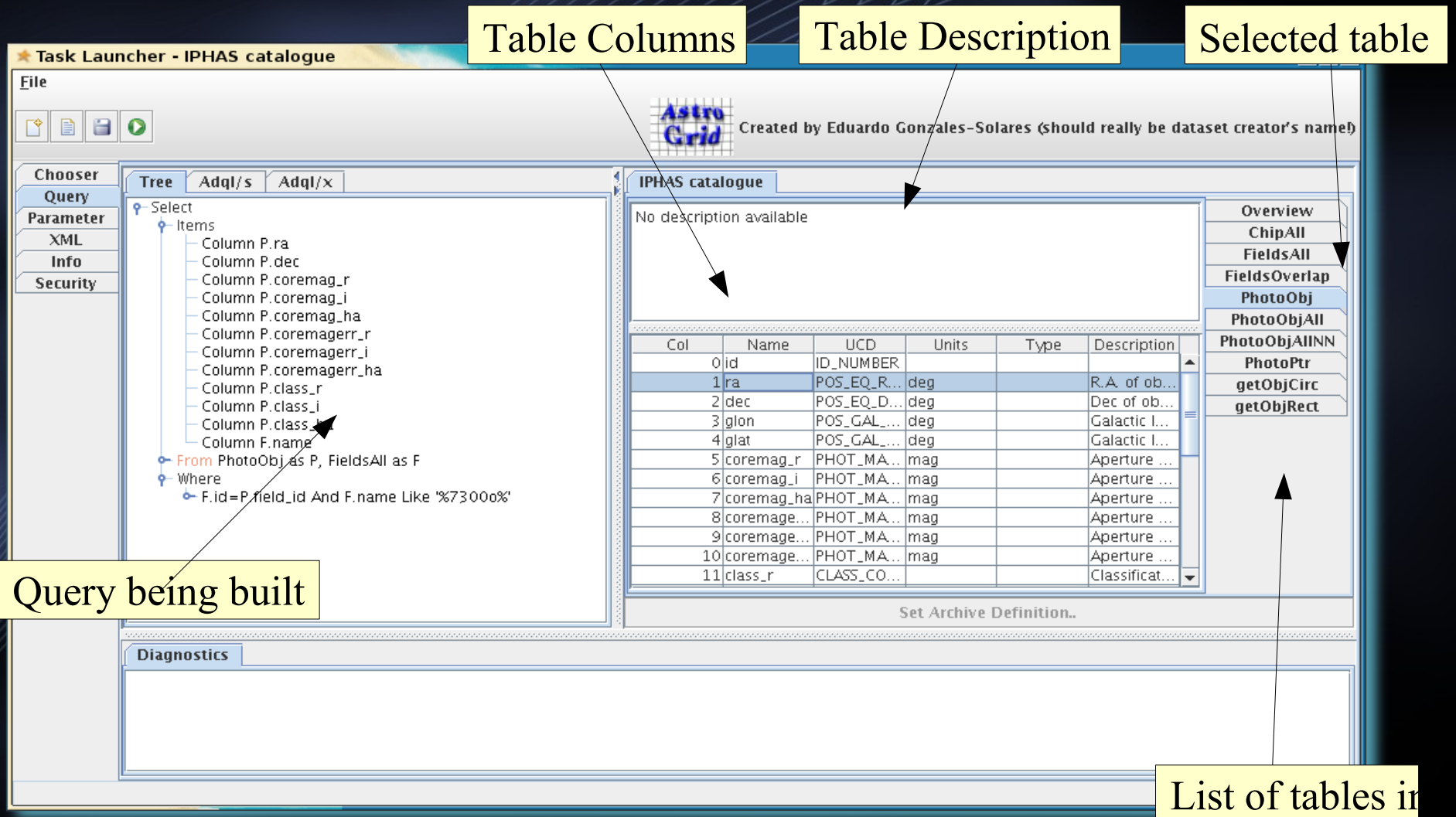
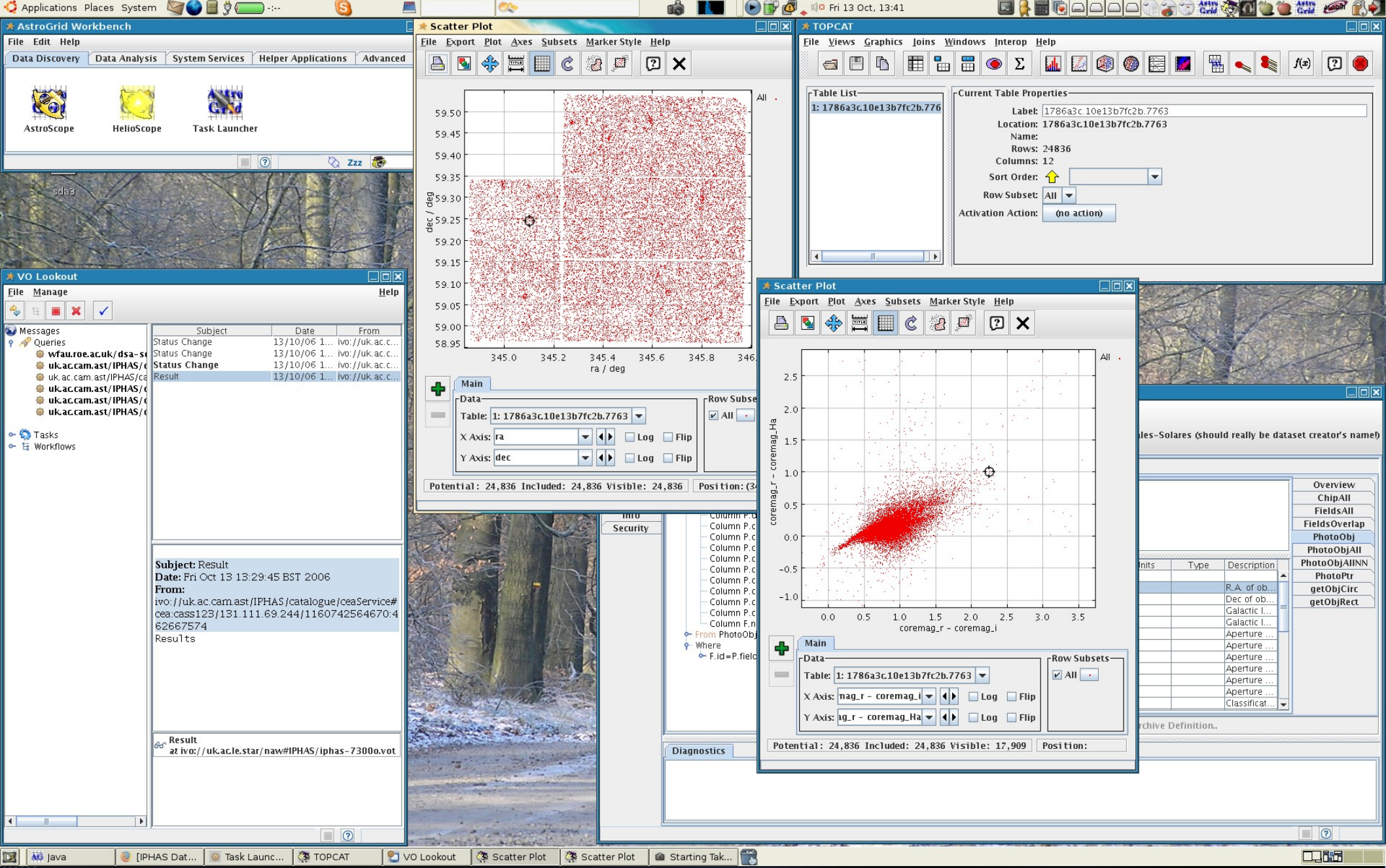
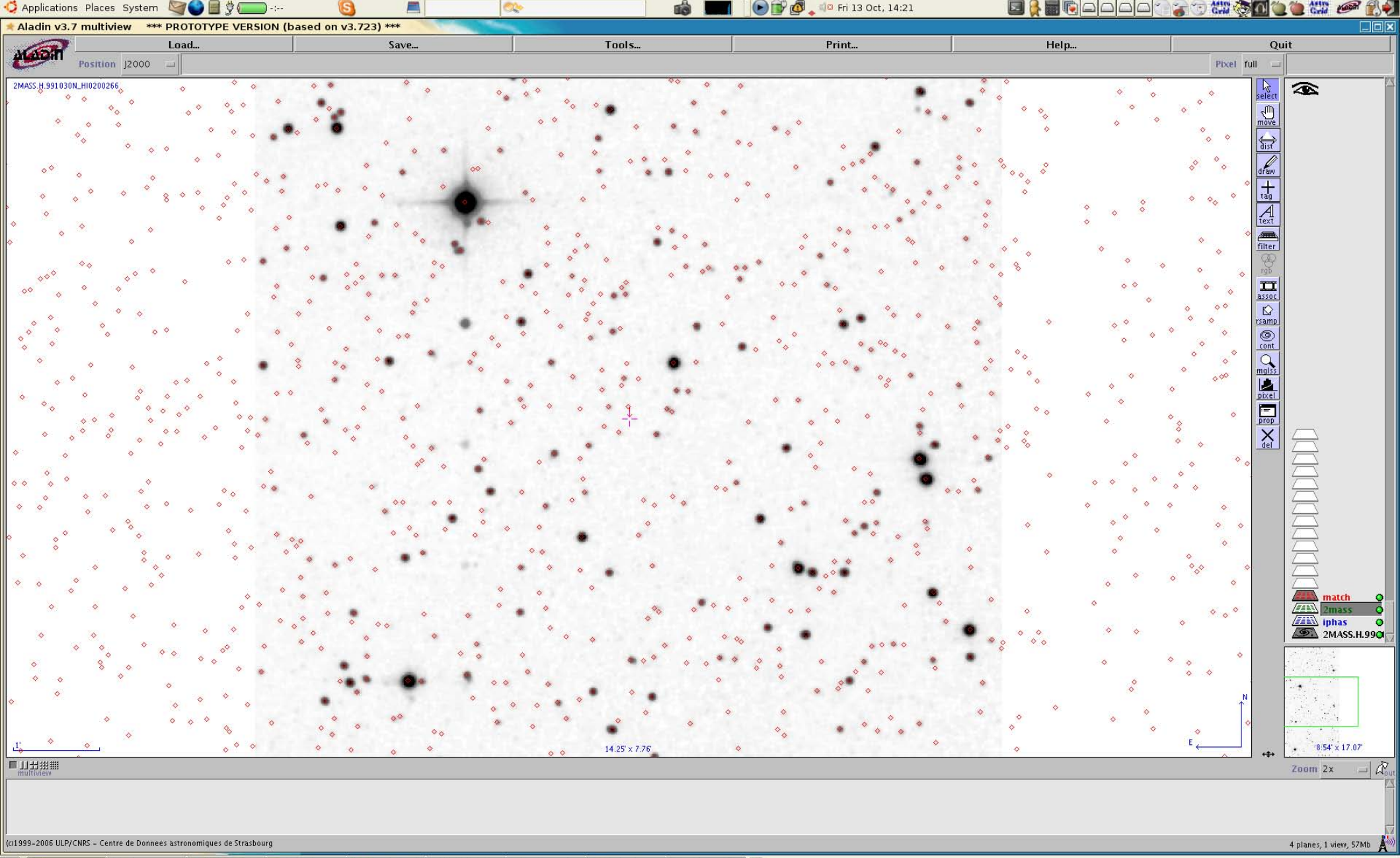
Catalogue Access

- Catalogue data available both as FITS tables on a per pointing basis
- In release – unified object catalogues





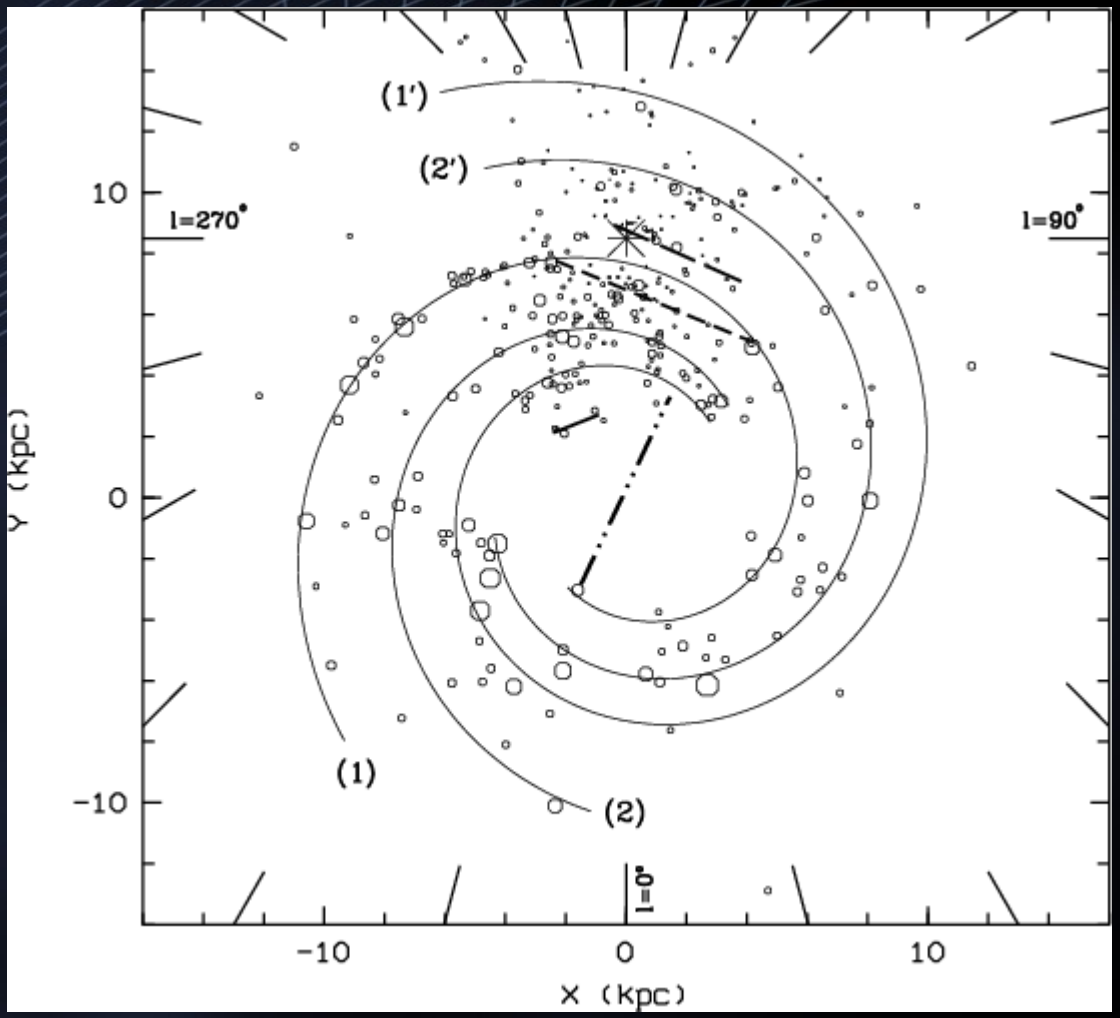
SQL query selecting IPHAS field 7300o objects = 24000 sources



Cross match of IPHAS and 2MASS for element of Field 7300o

Models for Galactic Structure

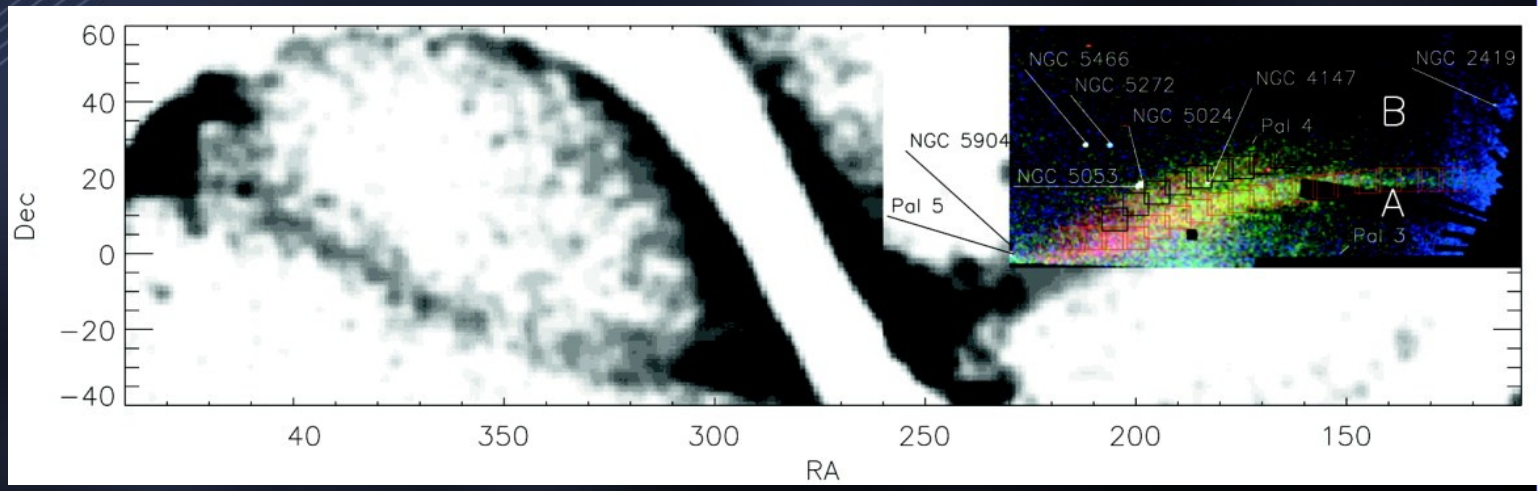
- Young populations good tracers of galactic structure
- e.g. Russeil (2003) study based on positions of star forming complexes (from HI, HII, CO observations)
- Vallee (2005) statistical study of recent work – points also to 4 arm model
  - uncertainties over interarm distances
  - incompleteness in certain directions e.g. 180<l<270, anticentre direction



Russeil 4-arm model - 1) Sagittarius-Carina, 2) Scutum-Crux, 1') Norma-Cygnus, 2') Perseus arms – sun marked by X

Aside: streams in the Milky Way

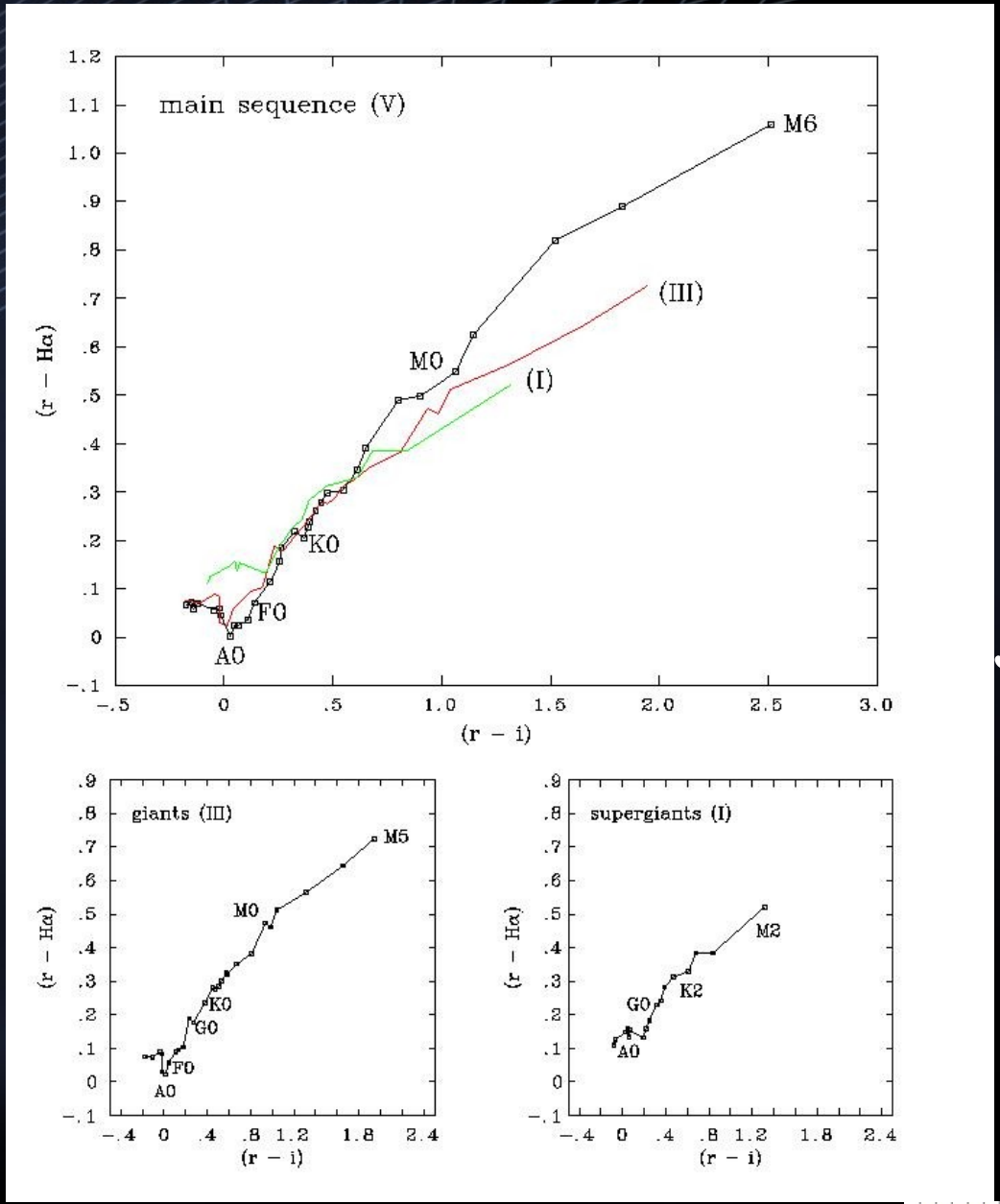
- Stellar streams are a good indication of galaxy hierarchical merger models (accretion of galaxies)
- Various (old) tracer populations used to map galactic streams
  - blue A coloured stars (inc BHBs) (e.g. Yanny et al 2000, Ibata et al, 2001)
  - M giants (e.g. Majewski et al 2003)
  - RR Lyrae stars (e.g. Ivezic et al 2000)
- IPHAS to trace young (for galactic spiral structure) and old (for streams)



Panoramic view of the Sgr stream, obtained by combining the 2MASS M giants of Majewski et al. (2003) with the SDSS stars of Belokurov et al. 2006). Marked on the figure are branches A and B of the stream, together with some of the globular clusters

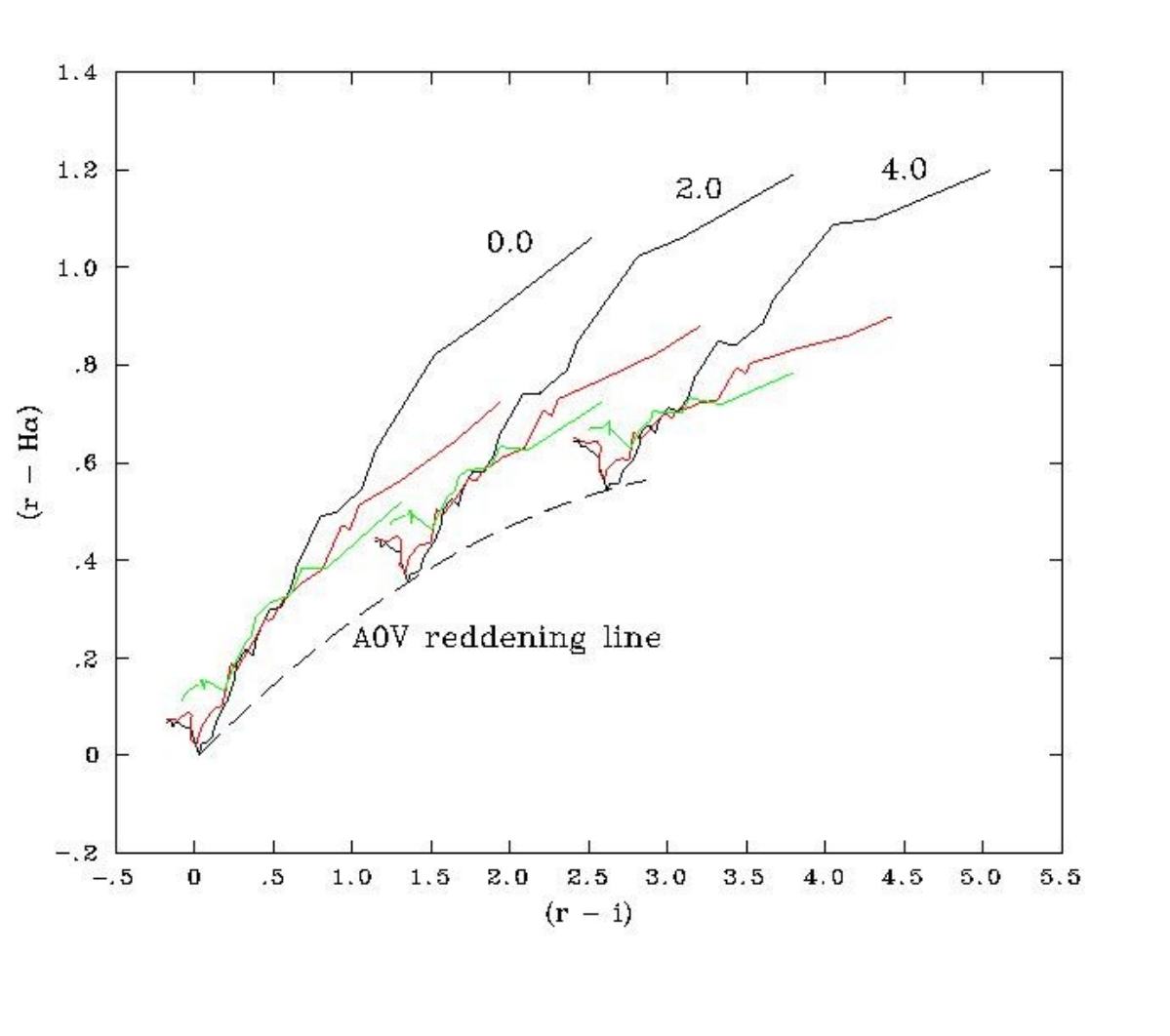
Structure: use of the IPHAS survey

- IPHAS is deep enough to sample most of the plane
  - r~20 = unreddened A0 dwarfs at 20kpc
- A stars are luminous to allow for the study of distant clusters
- A0V reddening line → a population of easily-modelled 'standard candles'
- Thus select early type (A, B stars) from their position in the colour-colour plane



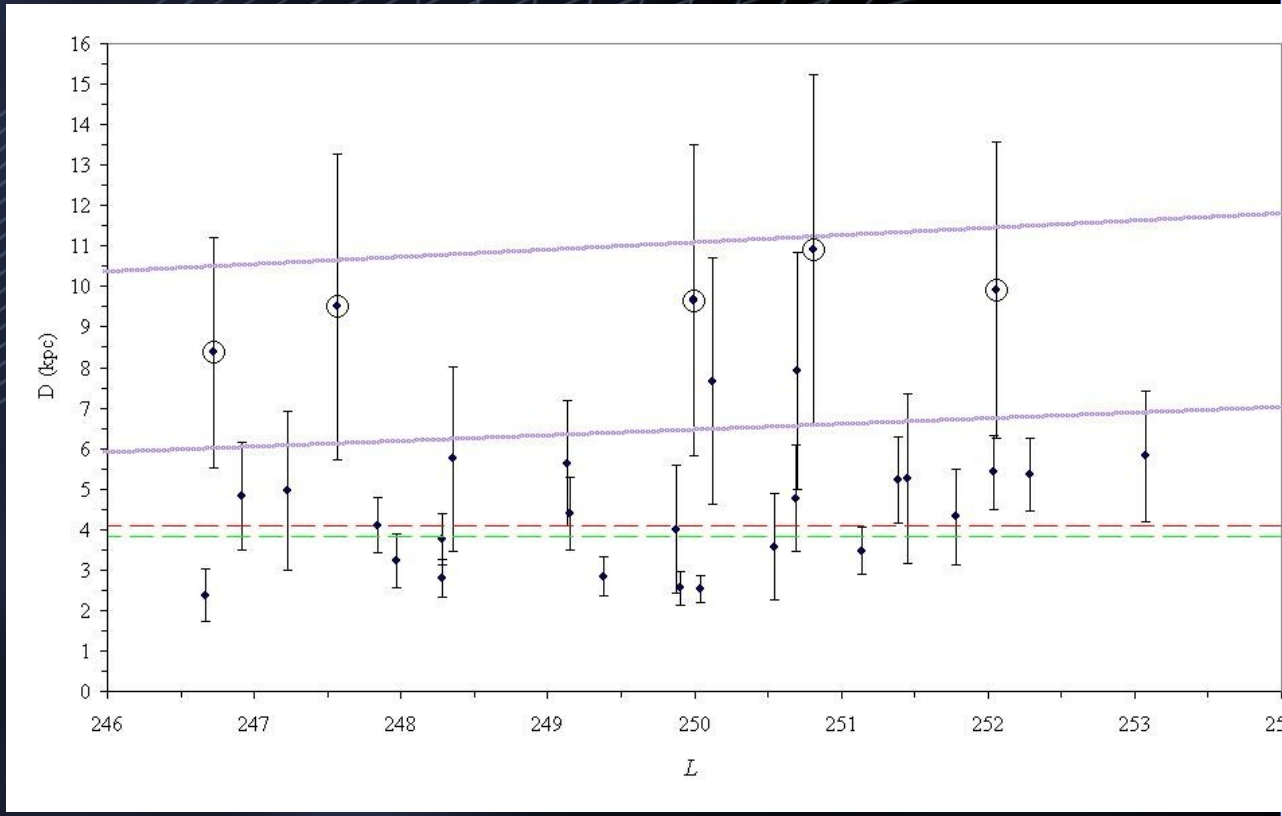
Pickles 1998 stellar library

Early-A Reddening Line



Pilot Study Results: SHS data

- Trail test utilising SuperCosmos H-Alpha Survey data of the southern galactic plane
  - sample selection based on colour criteria
  - spectral typing via 6dF spectra
  - reddenings via SED
  - determine distance via spectroscopic parallax
- First results (stars < R ~ 14) for the Perseus arm give a distance of 3.8 +/- 0.1 kpc



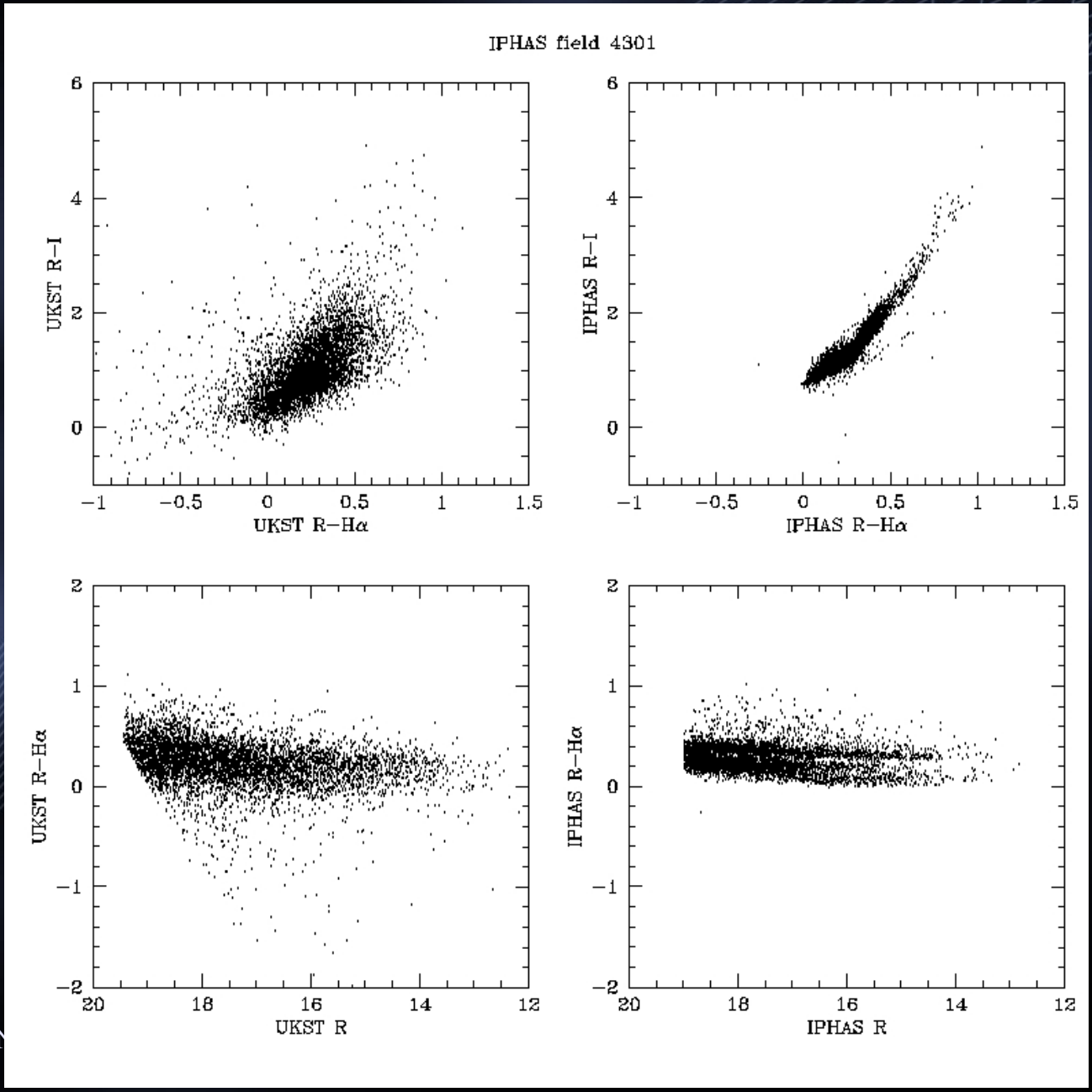
Purple lines: upper Norma-Cygnus arm, lower Perseus arm (from Russeil 2003 models). Green line : fit to sample B stars (excluding outliers, circles which may map the Norma-Cygnus arm)

Result in agreement with Vallee (2005) concordance model

IPHAS Extension

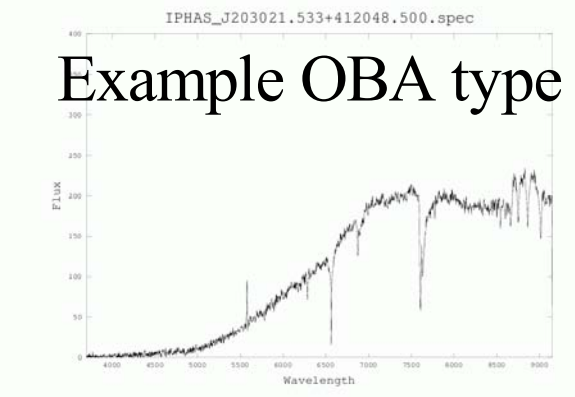
- Selection of A-stars based on colour criteria
  - issue: selection of A-type stars – young (A0V) and old (BHB's)
  - use u-g, g-r colours to distinguish between two types
  - also addition of IR data from UKIDSS Galactic Plane Survey
- Thus with the IPHAS and IR data
  - confirmation of early A SEDs
  - reddenings
  - distances
  - and with UVEX u,g – metallicity
- Spectroscopy not required although helpful
- First results on galactic structure end 2006
  - pilot in the CygOB2 region (IPHAS + 2MASS J,K to probe structure of the OB association and environment)
  - Hectospec observations of A stars outside the Solar Circle
    - kinematics in the outer galaxy

IPHAS c.f. Existing Plate Surveys



- Photometry and colour-colour diagrammes much improved c.f. SuperCosmos H-alpha Survey (Parker et al, 2005)

Selection: MMT HectoSpec Confirmations



Example OBA type

Emission line stars (green)

Probable dMe stars (red)

Carbon star

two WDs

~A0 stars (blue)

$(r - H\alpha)$

$(r - i)$

Dispersion due to photometric calibration issues, stars in differing fields,
this will be corrected in upcoming data release

Closing

- This year will see the first public release of IPHAS galactic plane survey data
  - VO access to data will enable key science programmes including studies of galactic structure

- Key Links
  - IPHAS: http://www.iphas.org
  - EGAPS: http://www.egaps.org
  - AstroGrid: http://www.astrogrid.org and http://wiki.astrogrid.org

- ASTROGRID DEMO: EXHIBITION AREA