EIS
The ESO Imaging Survey

An overview and some results

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Overview

1) What is EIS
   - Goal
   - History
   - Pipeline
2) EIS and Galactic Structure
   - Data processing
   - Spectral fitting method
   - Galactic Structure Model
   - Application to Chandra Deep Field South

(Extragalactic) Surveys

- Small FOV, very deep

  Hubble Deep Field, Chandra (1 Ms)
- All-sky, relatively shallow

  Denis, 2MASS, IRAS, SDSS
- Future

  SIRTF (GOODS 320 sq.am, SWIRE 70 $\square^2$), Herschel (PACS, SPIRE)
- Virtual Observatory (VO)

EIS: Goal

Carry out public imaging surveys to prepare target lists for different scientific applications in preparation for the commissioning of VLT instruments, and VLT science in general, reaching magnitude limits comparable to the spectroscopic limit of the VLT.

EIS: History

- Started in 1997, as a project outside the formal scope of ESO
- Involve the community at large through a Working Group that defines the fields of interest and overseas the execution of the survey
- A Visitor Program was created to attract people from the community to bring in different expertise
- Normal submission of proposals to the OPC (Observing Programming Committee)

EIS: Tasks

- Preparation and execution of observations
- Data reduction
- Production and verification of calibrated images and object catalogues
- Interaction with ESO archive
- Maintenance of web pages
- Publication of relevant reports on observations and reductions

EIS: Surveys

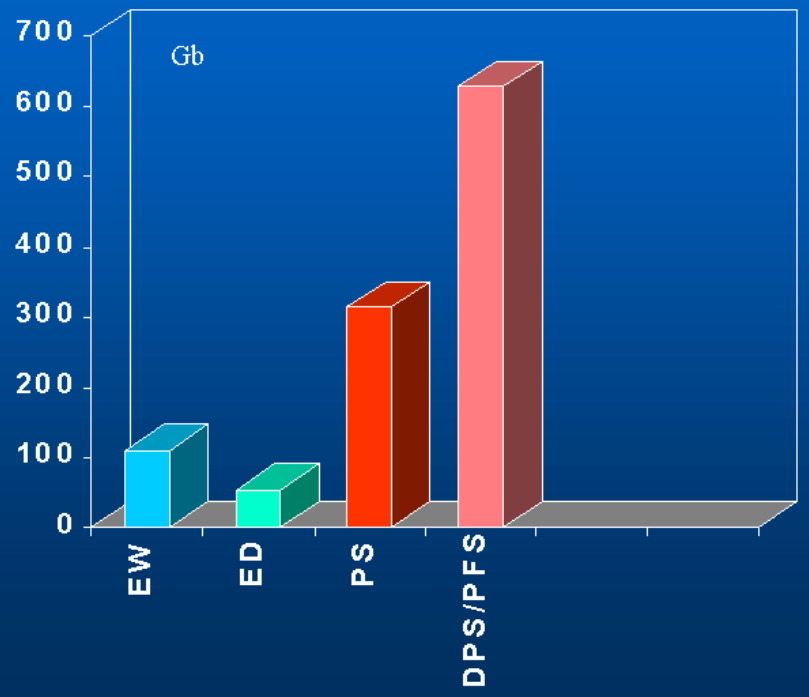
Survey	Nights	Inst./Tel	Filters	Fields
EIS-WIDE	42.5	EMII/NTT	$B/V/I$	several sq.deg.
EIS-DEEP	15	SUSI2/NTT	$UBVRI$	75 sq.am HDF-S
EIS-DEEP	12	SOFI/NTT	JK	75 sq.am HDF-S
WFI Pilot	14.5	WFI/2.2		complement EIS-WIDE
DPS	(54)	WFI/2.2	$UBVRI$	$3 \times 4 \times 0.25$ sq.deg
DPS	20	SOFI/NTT	JK	$3 \times 4 \times 100$ sq.am
Pre-Flames	(54)	WFI/2.2	BVI	160×0.25 sq.deg.
GOODS	12.5	ISAAC/VLT	JHK	CDF-S 225 sq.am.
GOODS	5	WFI/2.2	BVR	CDF-S 0.25 sq.deg.

EIS: Pre-FLAMES

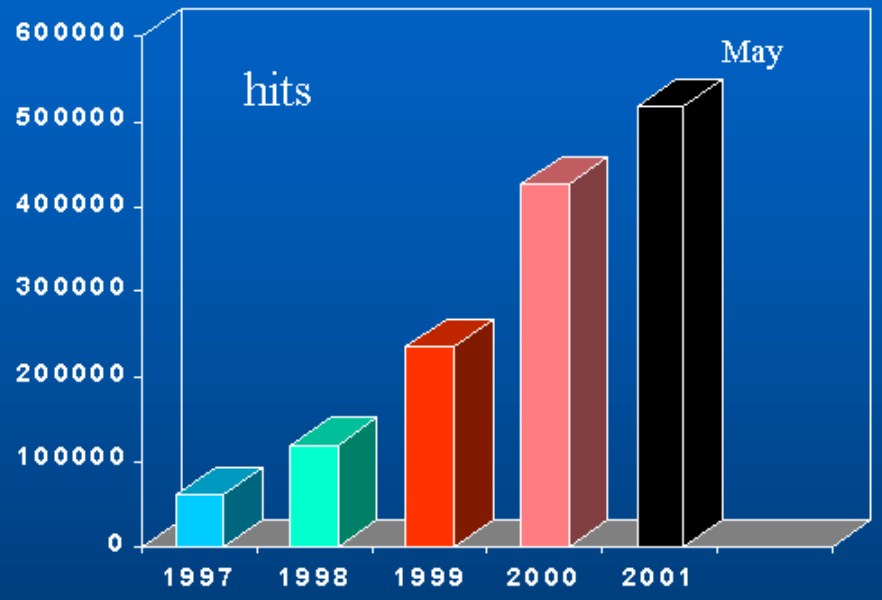
Target	Fields	Observed	Completion (%)
Globular Clusters	32	29	91
Open Clusters	33	29	85
Milky Way Bulge/Halo	18	18	100
Local Group galaxies	18	4	22
Sagittarius galaxy	17	17	100
LMC	34	15	44
SMC	8	3	37

BVI down to $\approx 22 - 23$

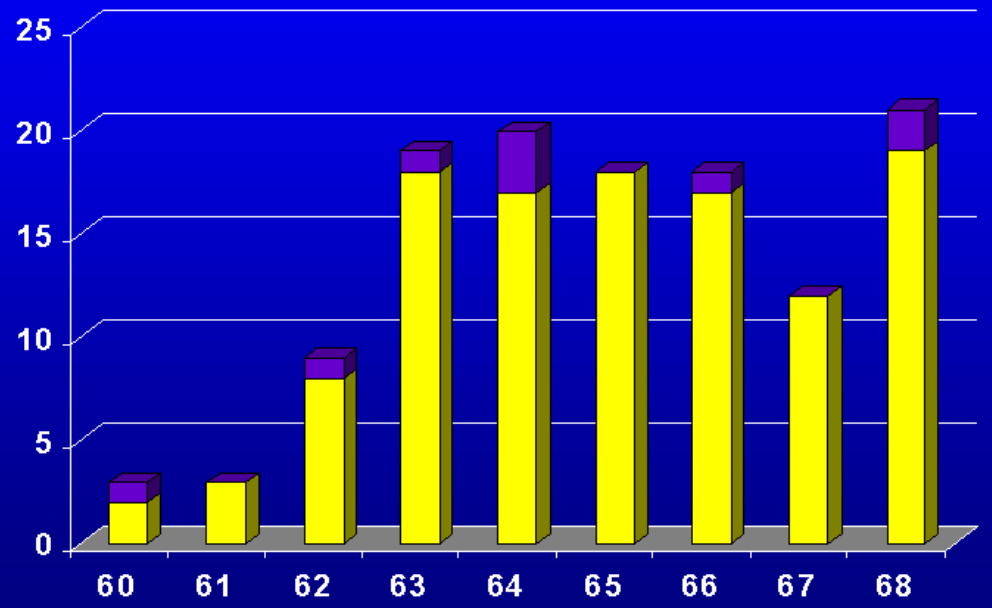
Raw Data Volume/survey



Access to the EIS home page



Proposals Accepted (123)



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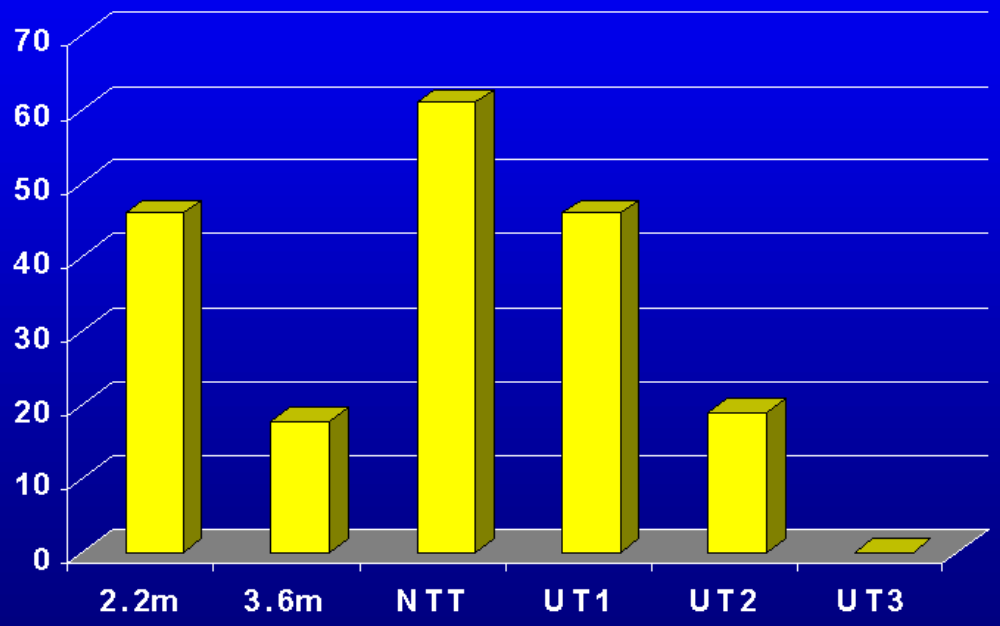
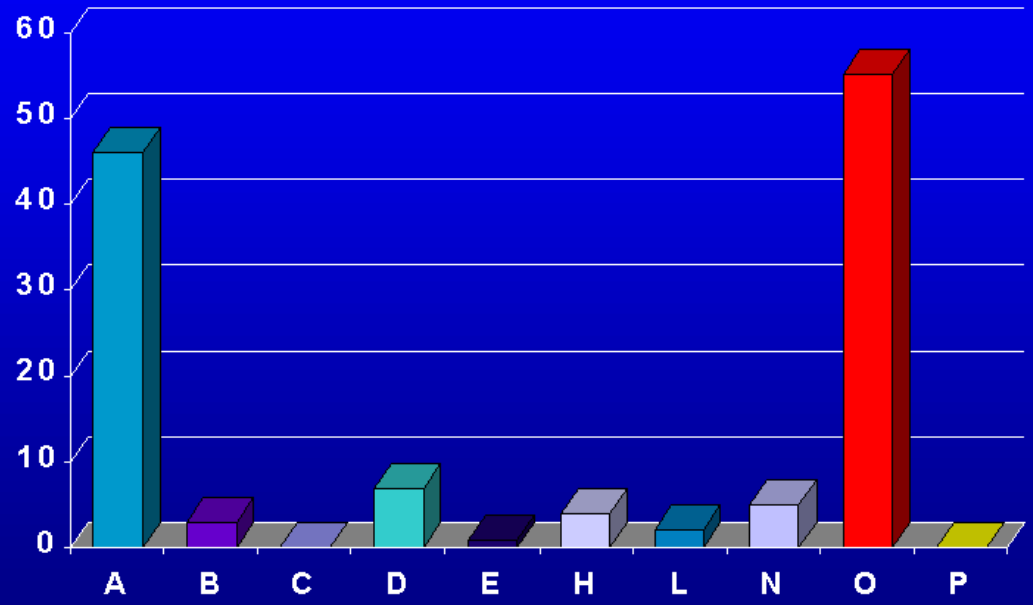


Proposals Accepted
(9 large + 114 regular = 123)

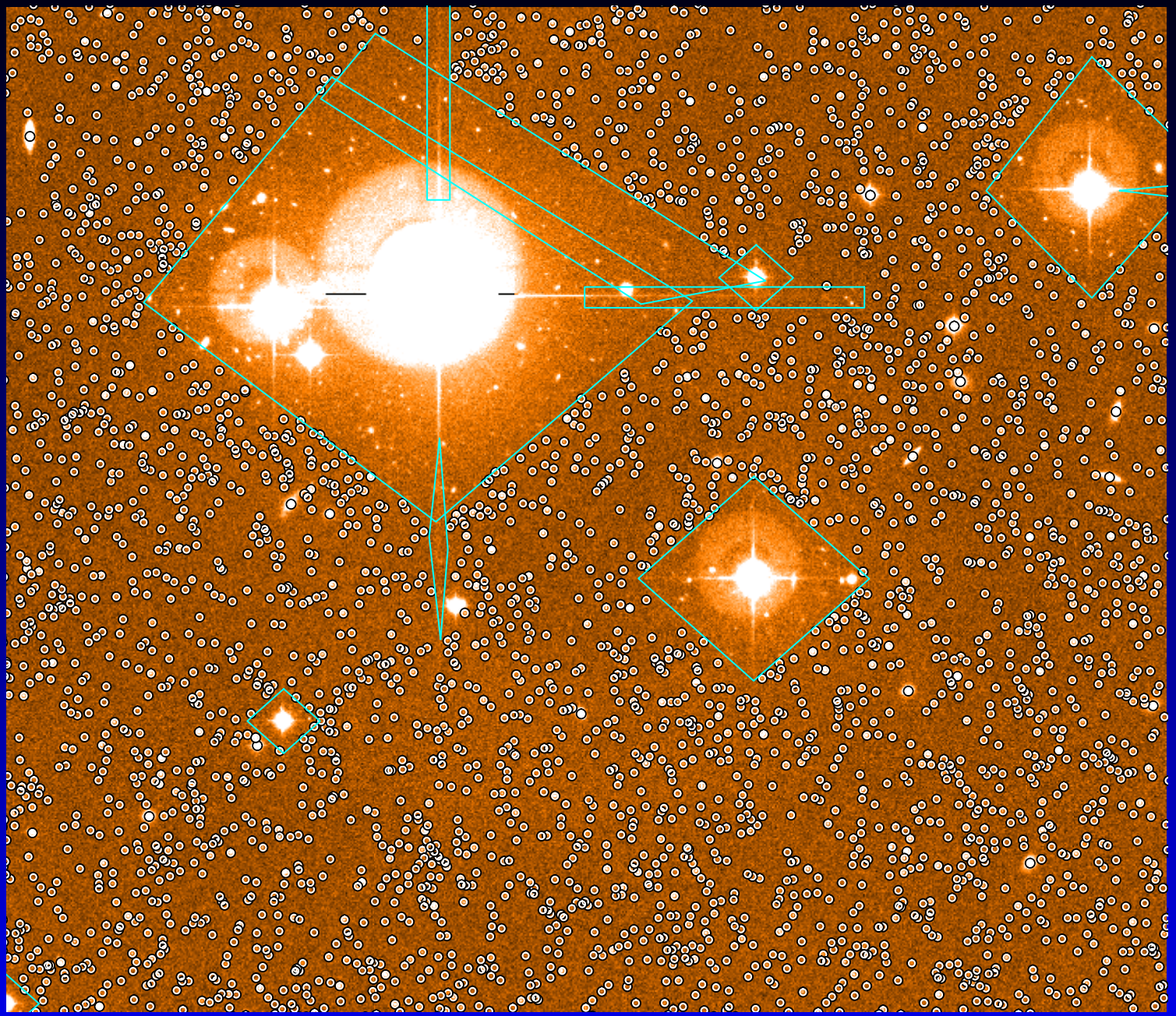


EIS: Pipeline

OLD	NEW
MIDAS, IRAF, Drizzle	own soft
Shell scripts	Python
pgplot, IDL, sm	DISLIN
no database	Sybase
LDAC-tools	CFITSIO
SExtractor	wavelets
-	integrated photometric calibration
-	advanced astrometric calibration
-	target selection & finding charts
-	SIMBAD interrogation

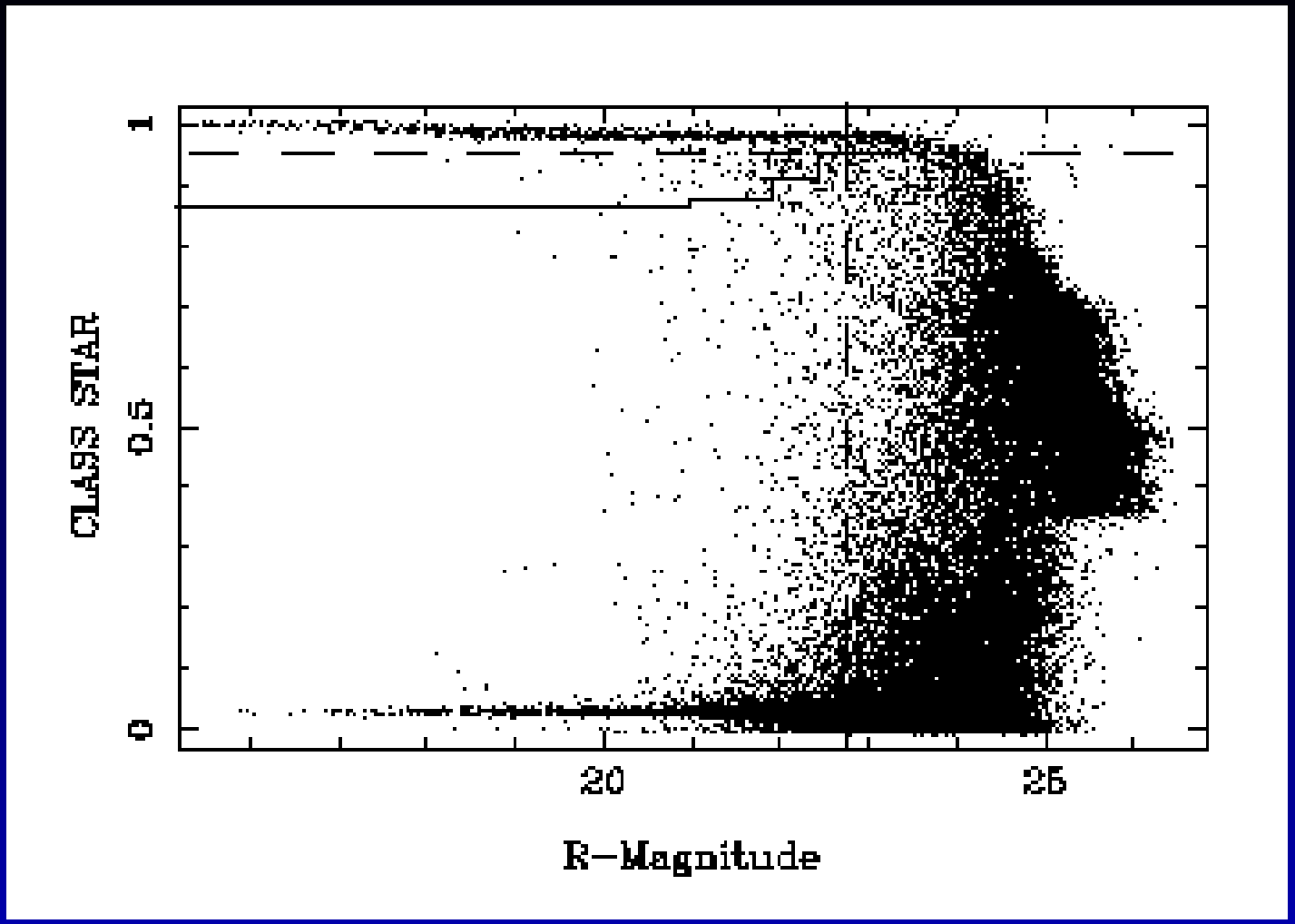
Processing steps

- Data reduction
- Astrometric and photometric calibration
- Single Passband catalogue production
  - SExtractor
  - Trim borders
  - Saturated objects
- Colour catalogue creation
  - Association on position
  - Area in common & outside all masks
- Select Point Sources
  - Single pass band
  - Colour catalogue

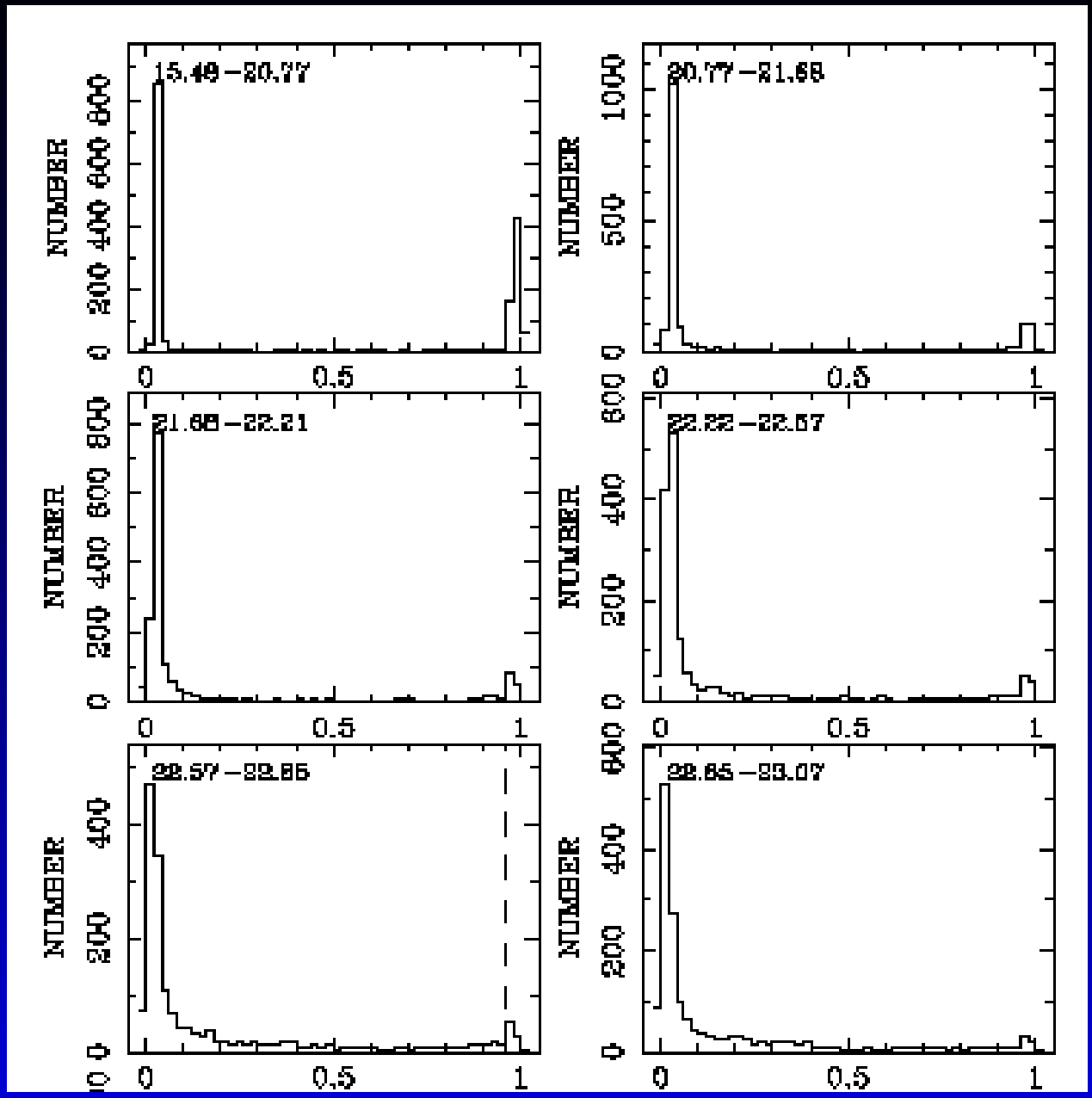


Processing steps

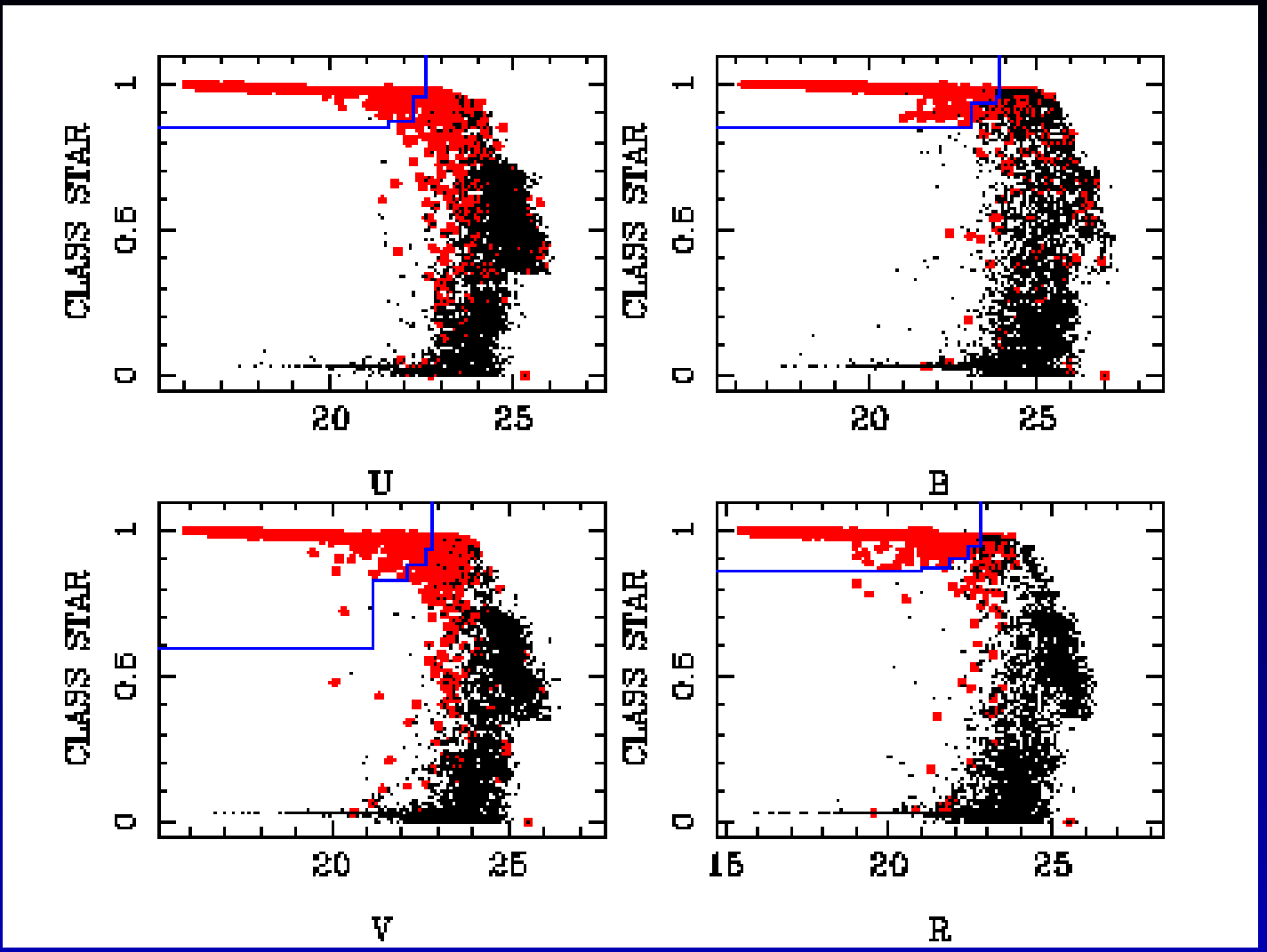
- Spectral template fitting to remove QSOs and compact galaxies $\Longrightarrow$ stellar sources
- Compare Number Counts, Colour Distributions, Colour-Magnitude and Colour-Colour Diagrams to theoretical predictions



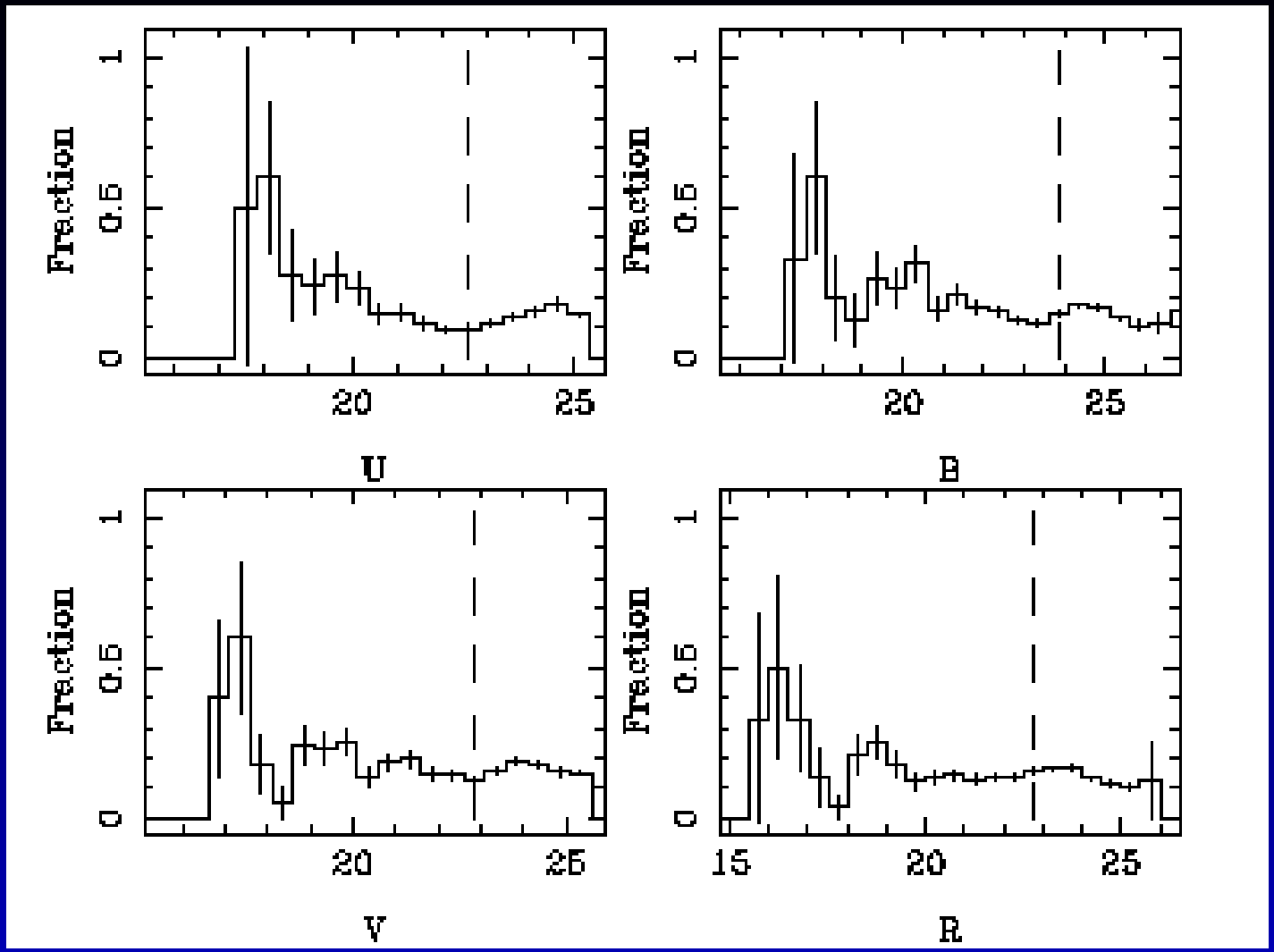
Distribution of CLASS STAR as a function of magnitude



Distribution over CLASS STAR for various bins in R.



Point sources in the colour catalogue (red dots),
CLASS STAR boxes in the individual pass bands (blue),
objects assigned stellar spectral types (black dots)

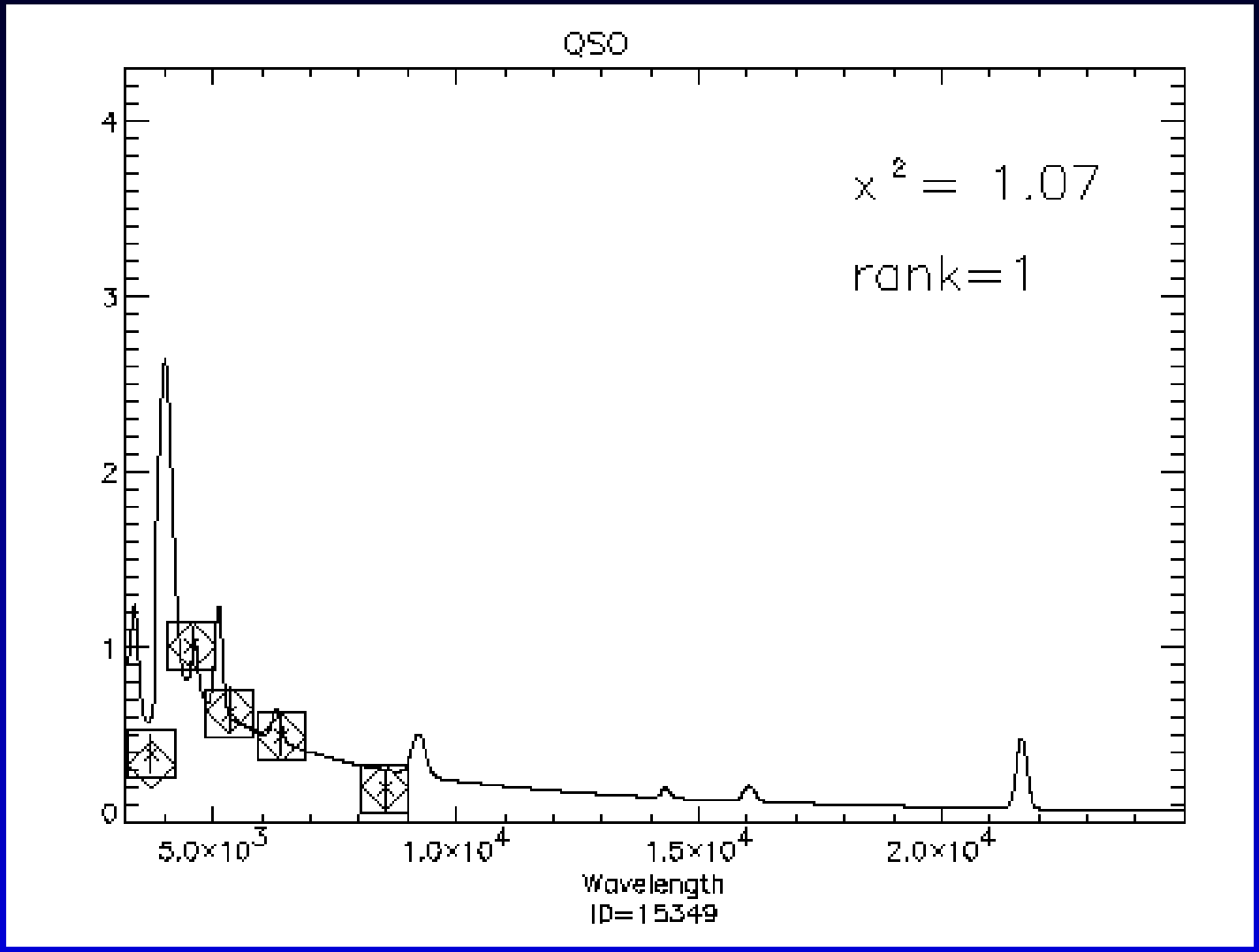


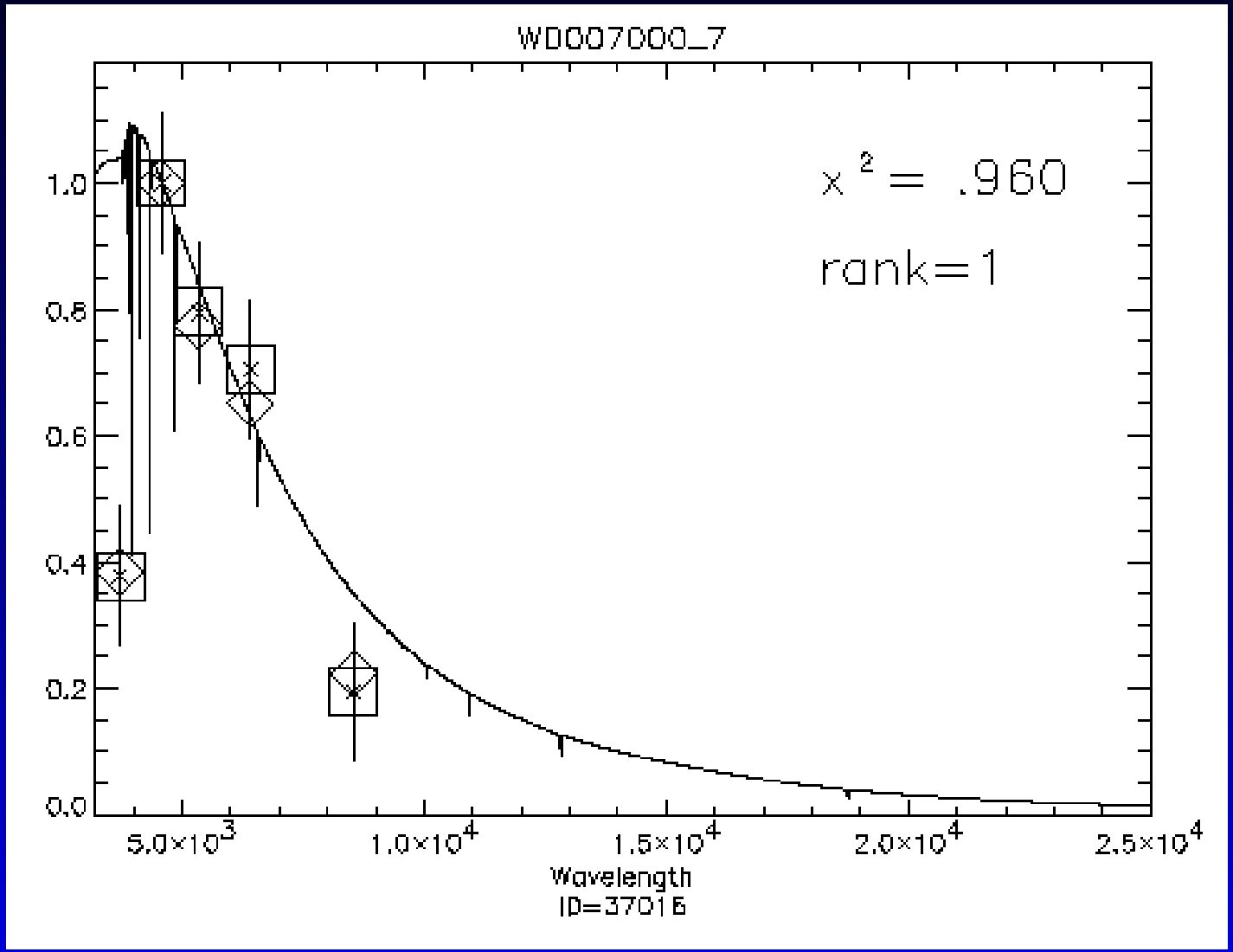
Fraction of misclassified stars by the spectral template fitting method

Spectral template fitting

Compare $UBVRI(JK)$ photometry to a database of observed or theoretical spectra (convolved with appropriate filter curves) of astrophysical objects.
Minimum of 3 filters.

- Pickles library of "normal" stars
  (131 between spectral type O and M)
- Low Mass Stars
  (53 theoretical spectra of stars with $T_{\rm eff} < 2800$K)
- White dwarfs (3 observed cool WD + 66 theoretical spectra)
- Quasars (61 different redshifts $\times$ 3 different continua)
- Galaxies (61 different redshifts for each of a typical blue, starburst, elliptical, Irr, Sbc, Scd galaxy)


QSO
$x^2 = 1.07$
rank=1
0
1
2
3
4
5.0×10^3
1.0×10^4
1.5×10^4
2.0×10^4
Wavelength
ID=15349


WD0070D0_7
$x^2 = .960$
rank=1
1.0
0.8
0.6
0.4
0.2
0.0
5.0×10^3
1.0×10^4
1.5×10^4
2.0×10^4
2.5×10^4
Wavelength
ID=37016

Removal of QSOs and CG

Step 1)

Do the spectral fitting w/o the QSO/galaxy templates

Step 2)

Do the spectral fitting with the QSO/galaxy templates

Step 3)

Objects that have a rank 3 under (1),
and that become rank 1 under (2), are removed

Point Sources in 5 PB catalogue

	$UBVRI$
Number of point sources	1371
Passband that decided (UBVRI)	7/308/0/637/419
Not classified by χ^2 method	21
Classified by χ^2 method	1350
as rank 1	969
as rank 2	124
as rank 3	257
Number of compact galaxies	31
Number of QSOs	134
Number of stars	1206

Galactic Structure Model

Geometry of the galaxy

- Disk
- Halo
- Bulge

Properties of the stars

- Initial Mass Function (IMF)
- Star Formation Rate history (SFR)
- Age-Metallicity Relation (AMR)
- Evolutionary tracks and bolometric corrections

Galactic Structure Model

Disk

Double exponential disk with radial scale length, vertical scale height depends on age (3 parameters)

Halo

Oblate spheroid (2 parameters)

Bulge

Tri-axial model (5 parameters)

various

Sun 15 pc above plane
Sun - GC is 8.5 kpc
Dust extinction

Galactic Structure Model

IMF

Arbitrary Power-law(s), or log-normal distribution.
Here: from Kroupa (2001)

SFR

Arbitrary. Here: constant over last 11 Gyr (disk),
constant between 12-13 Gyr (halo)

AMR

Arbitrary. Here: from Rocha-Pinto et al. (2000),
including metallicity spread

Galactic Structure Model

Evolutionary tracks & bolometric corrections

Padua models & Chabrier et al. for LMS

Calibration of model

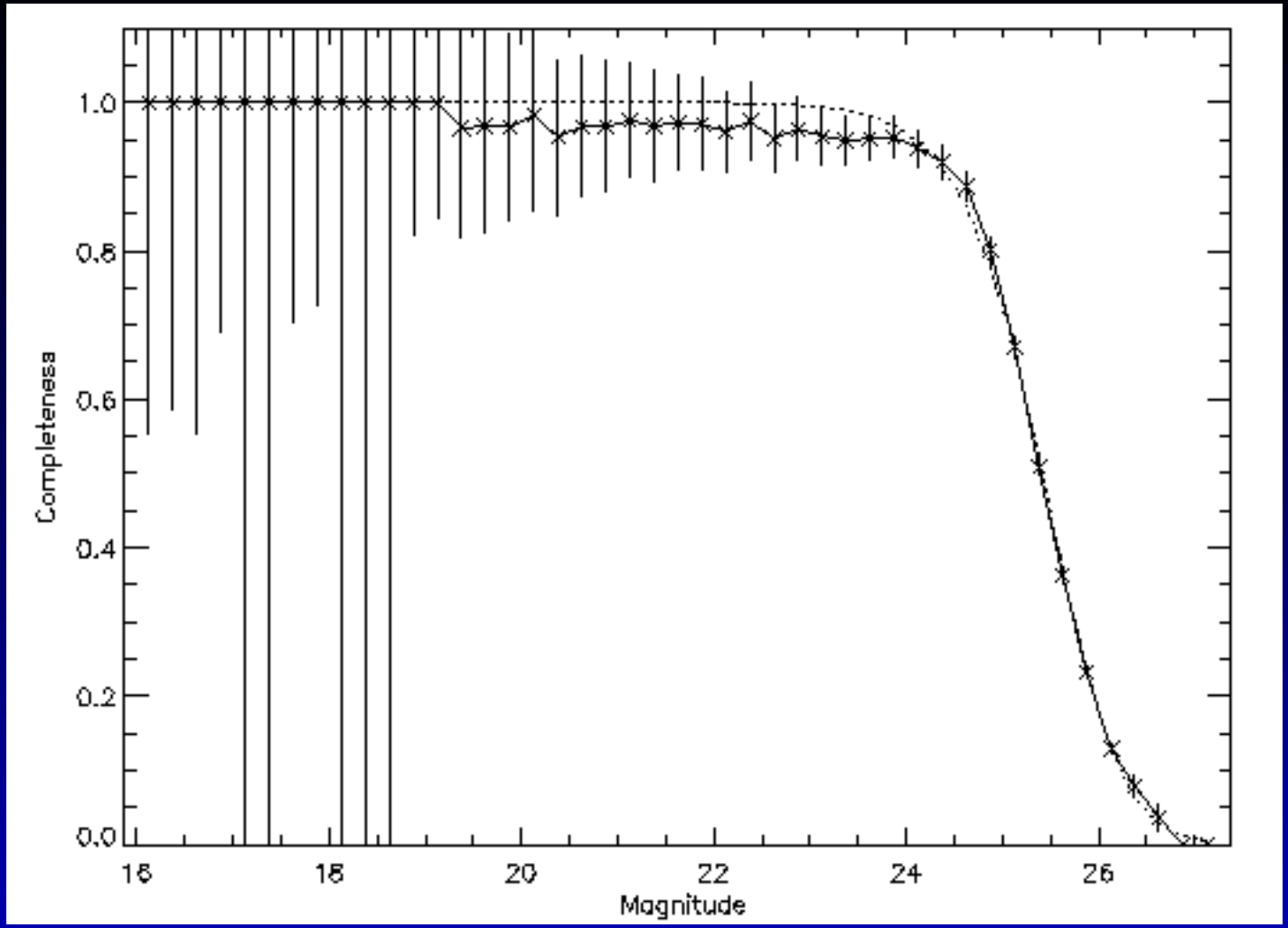
EIS data on SGP & DMS on 6 fields

Simulation

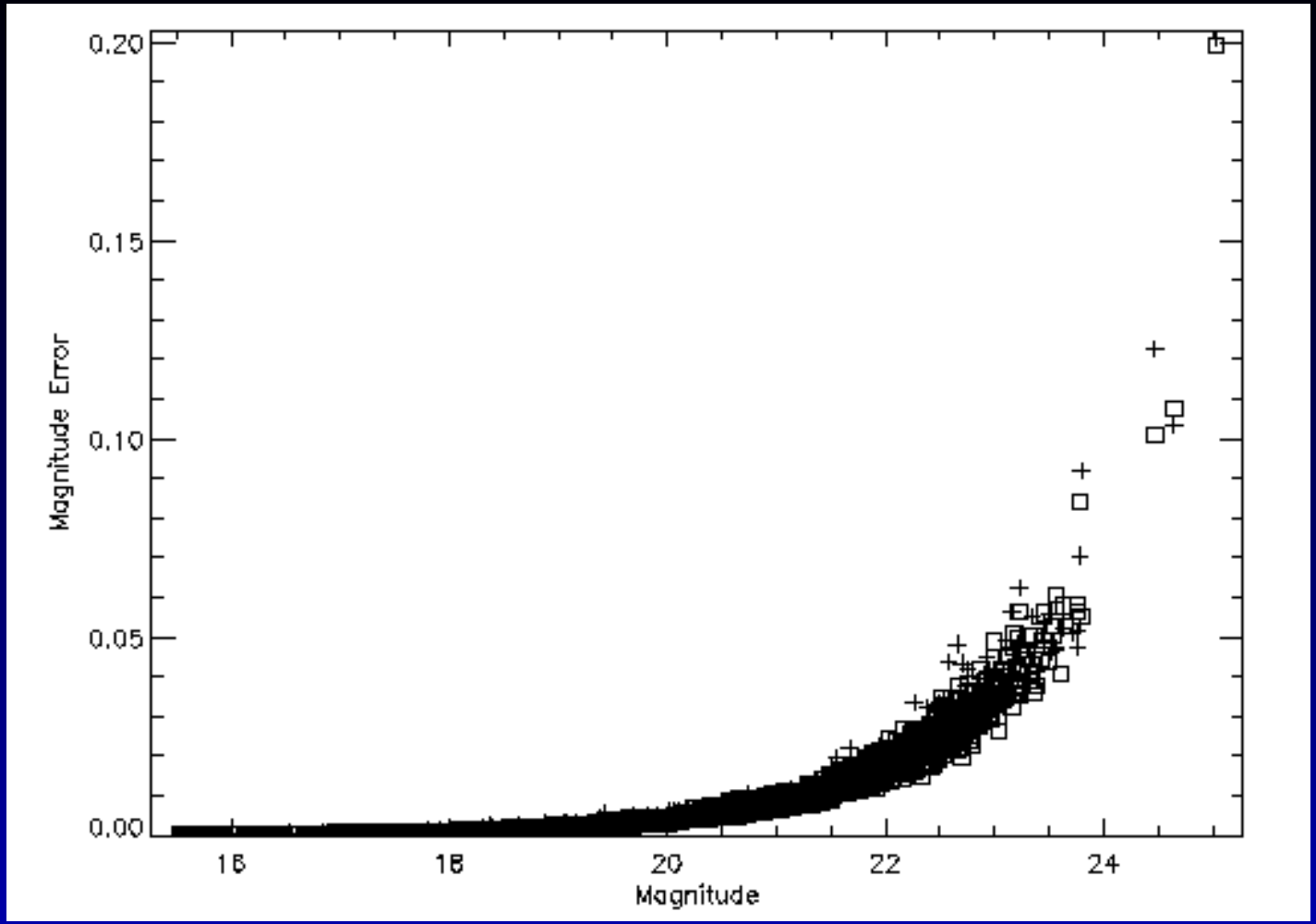
- Error in the magnitude
- Saturation
- Completeness

  Based on external data

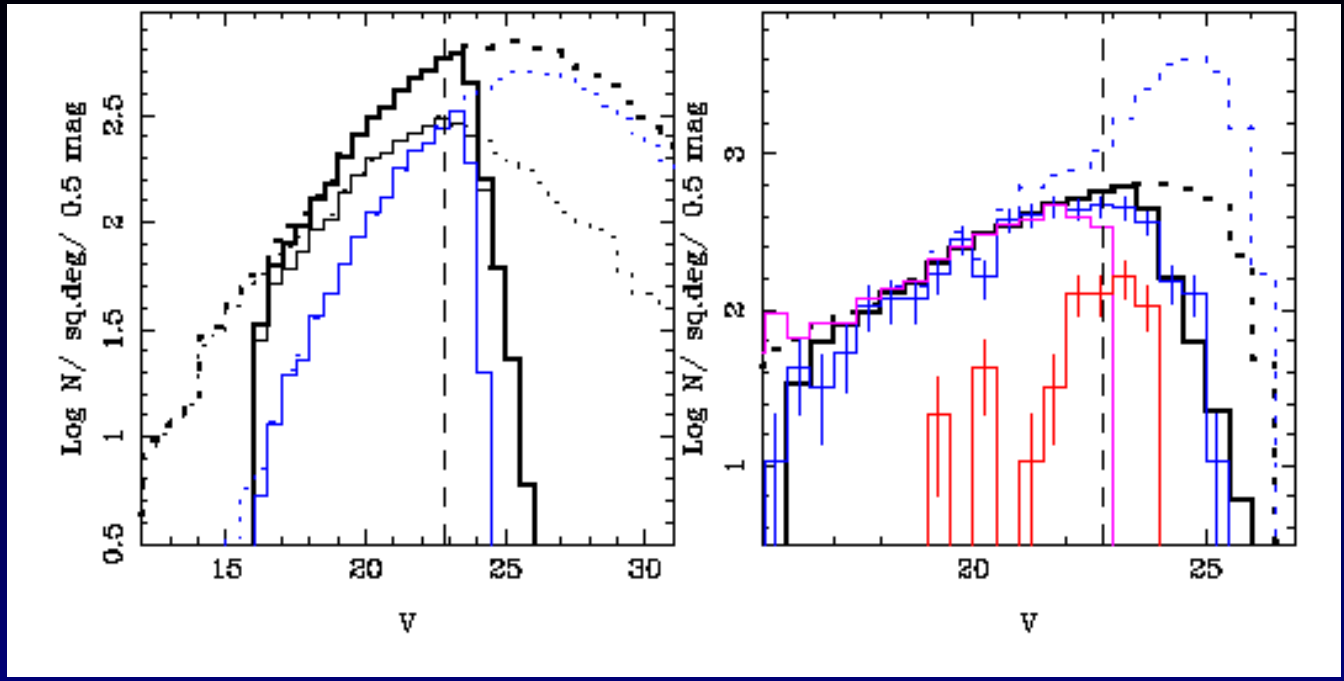
- S/N limits imposed
- CLASS STAR limits imposed



Completeness function: observed data (crosses) and analytical fit (dashed line) in the R-band



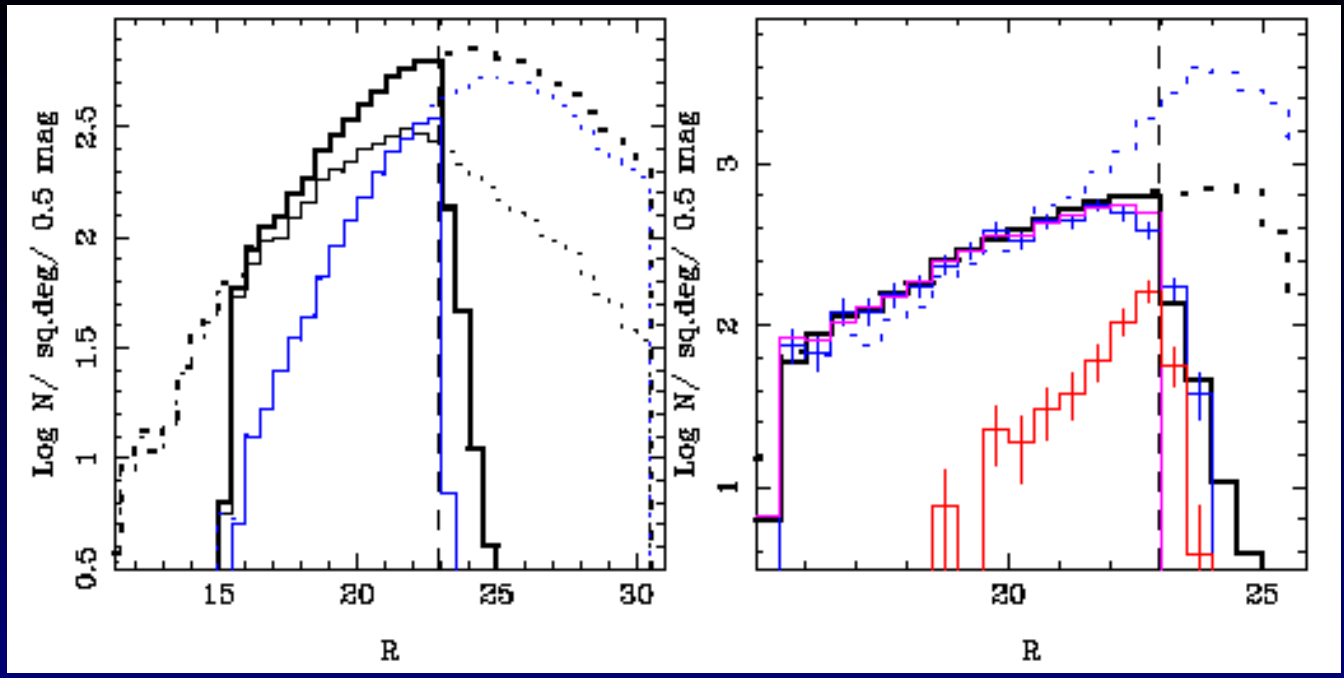
Simulation (box symbol) and observation (plus symbol) of data in the R-band



Number counts

Left: Halo stars (blue), disk stars (thin black), total (thick black). Dotted is perfect model, full line is simulation

Right: Observations from colour catalogue (solid blue), observation form single PB catalogue (pink), QSO (red), from spectral template fitting method (dotted blue). Simulations (thick black)



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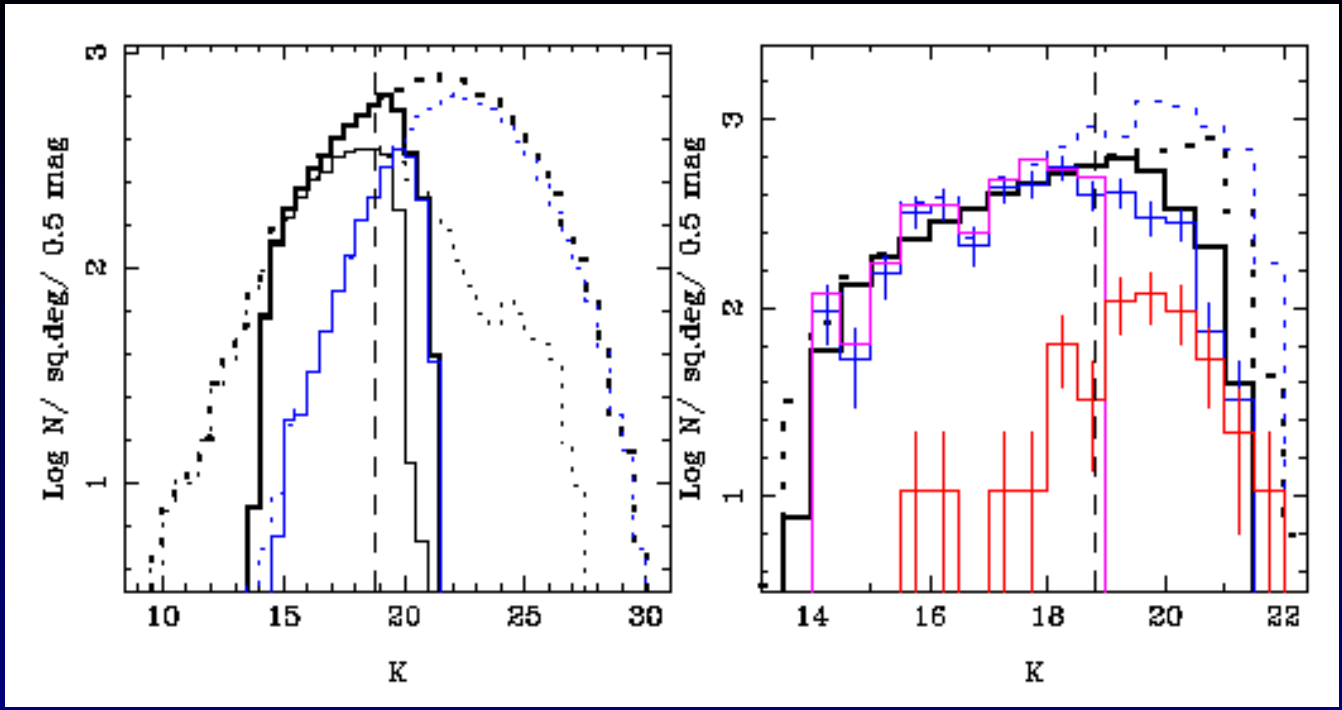

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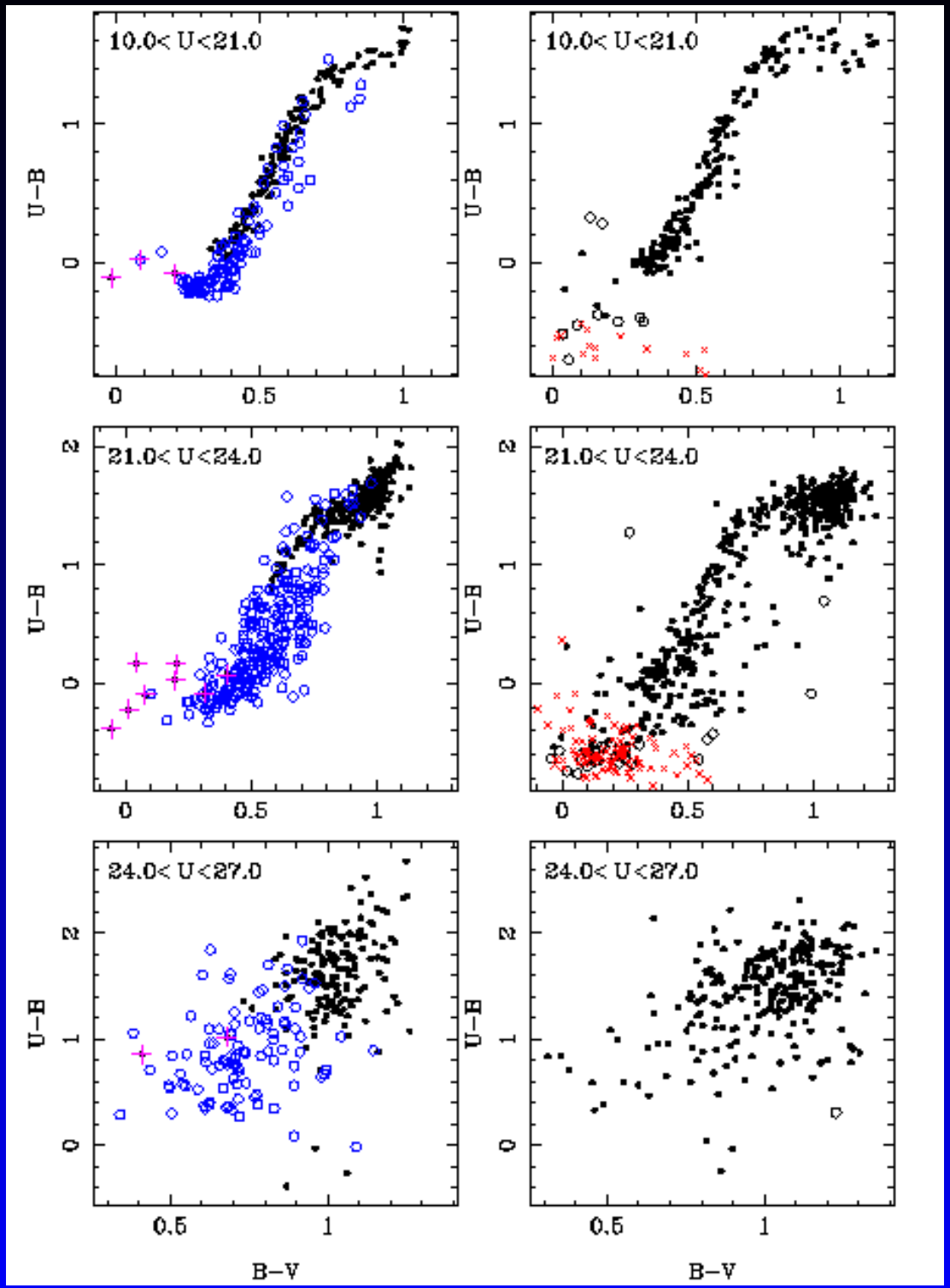
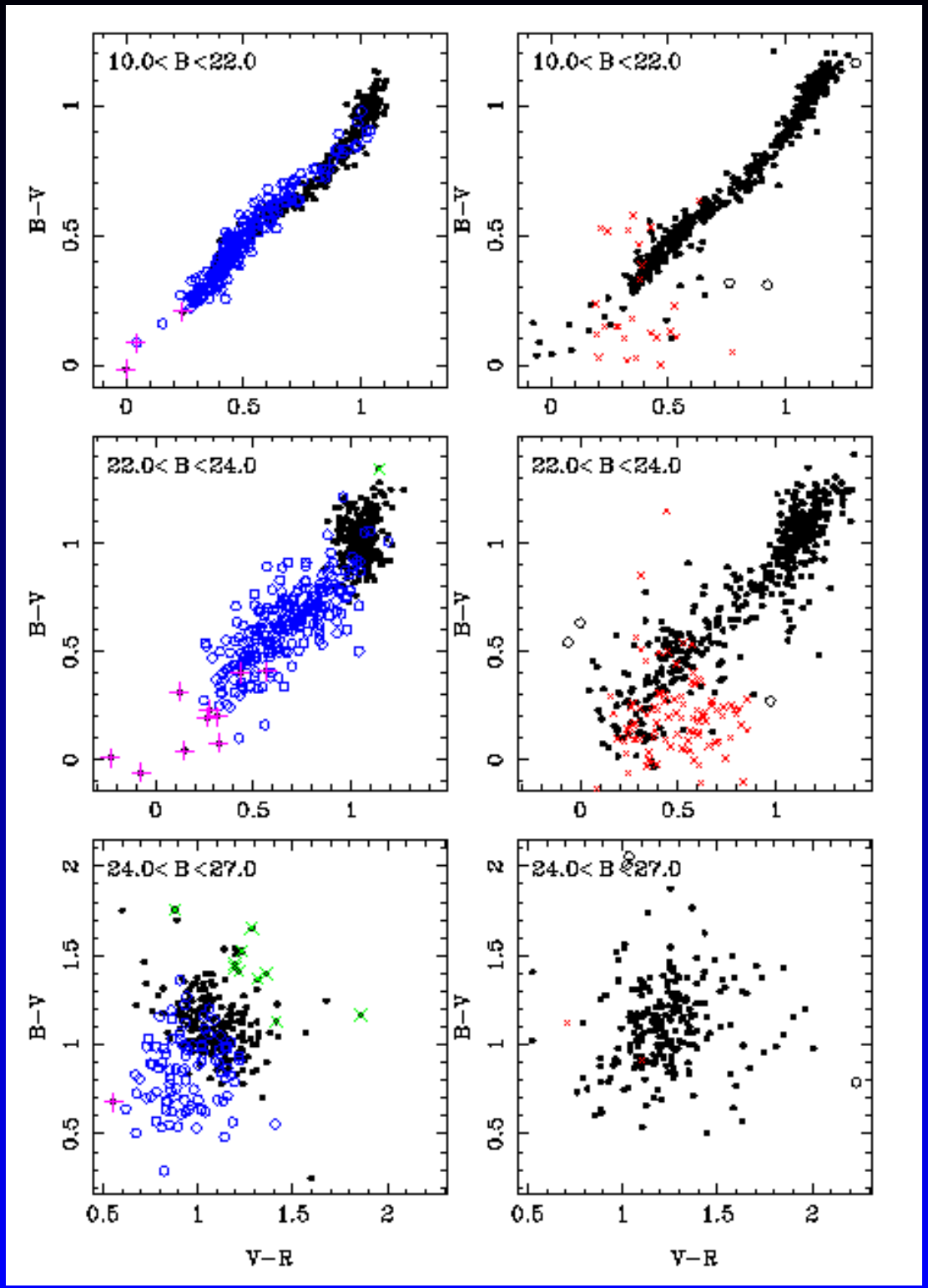


Colour-Colour diagram

Left: Simulations; disk stars (●), halo stars (○); WD (+), LMS (x)

Right: observations; stars (●), outliers (○), QSO (x)



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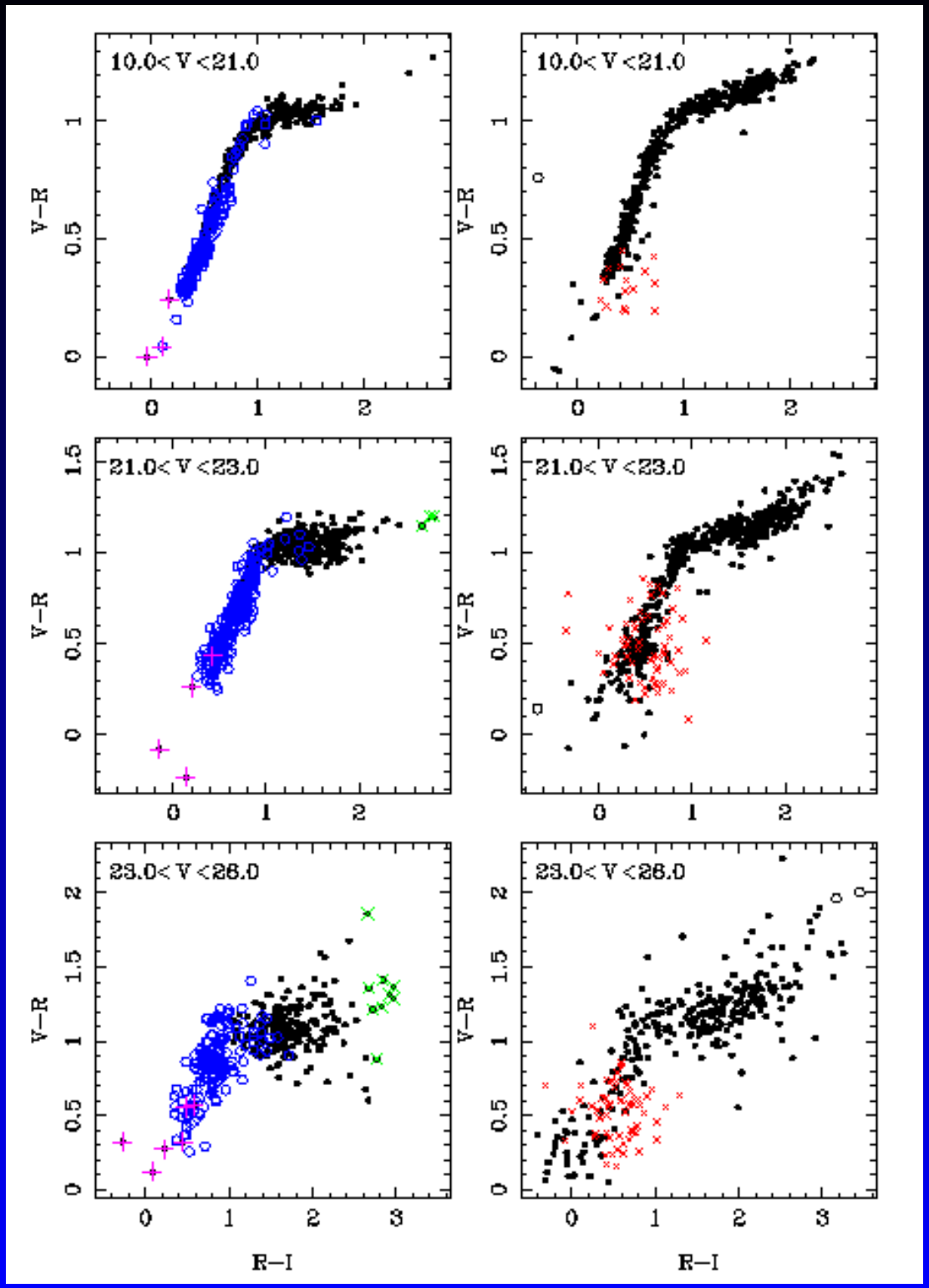

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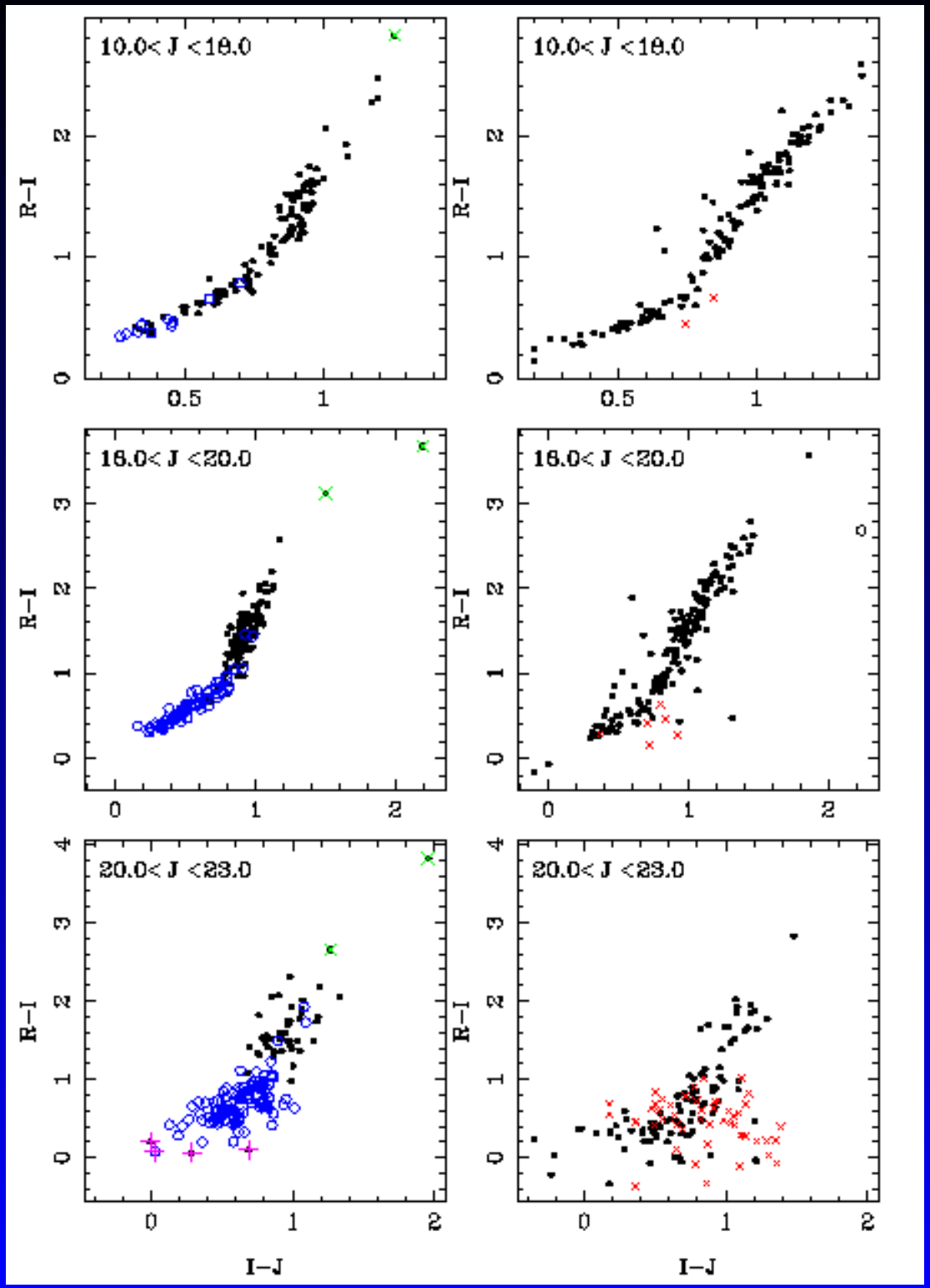

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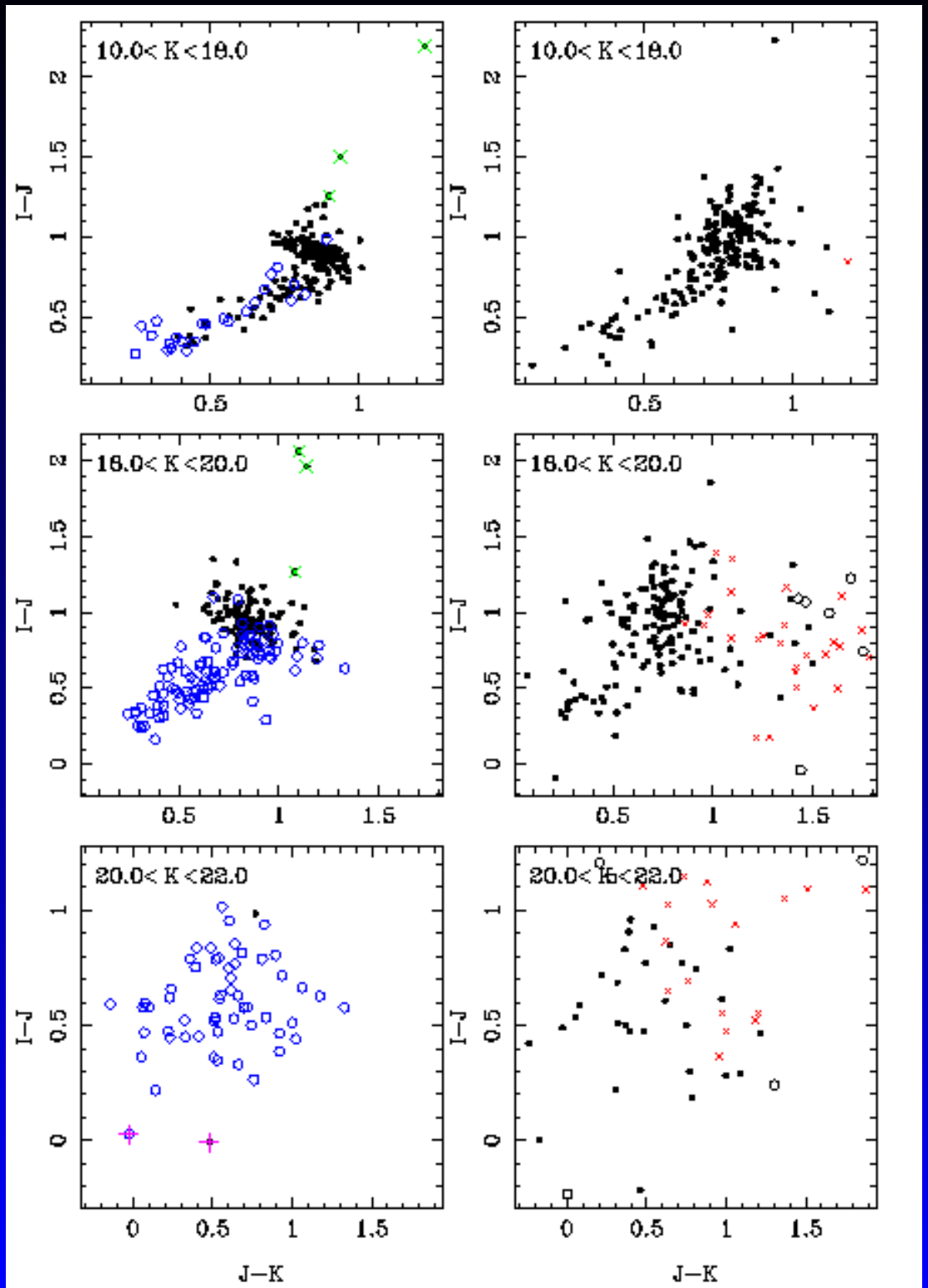

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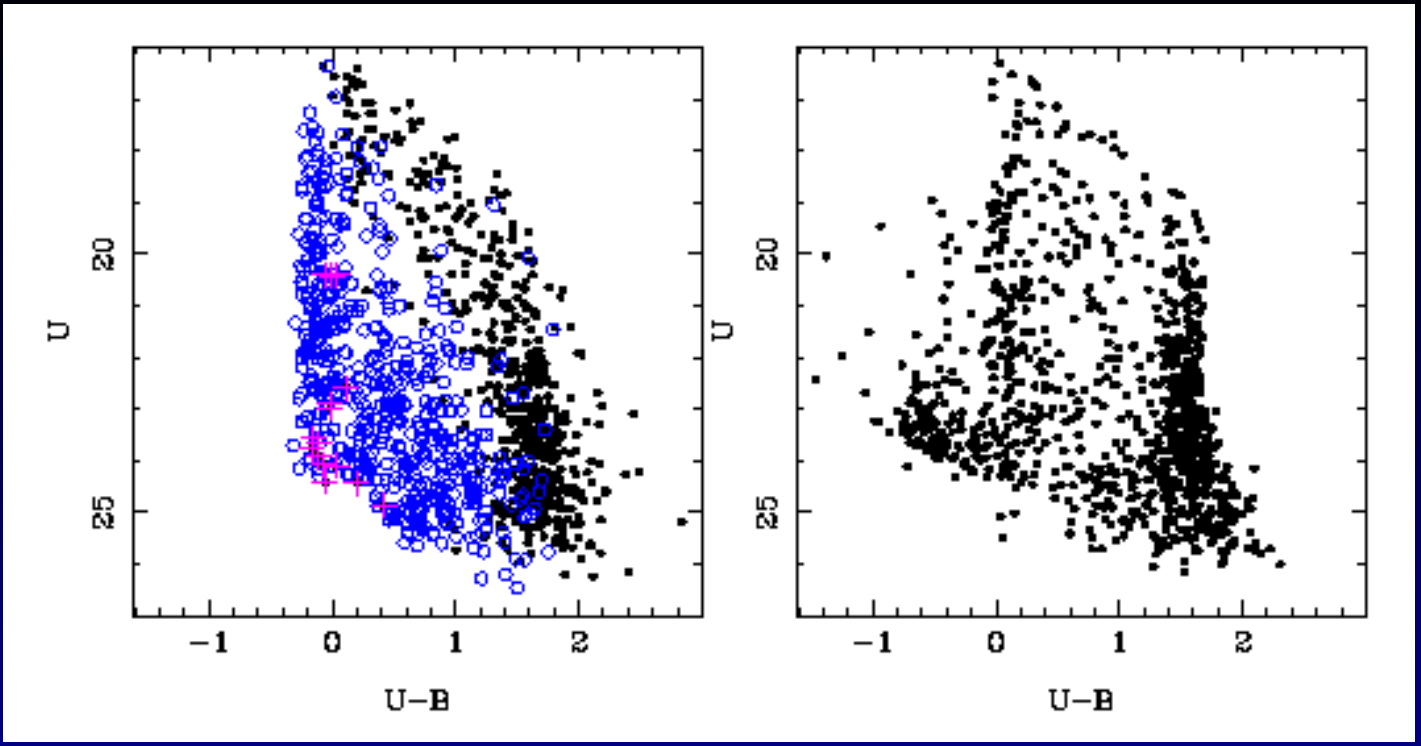

Colour-Magnitude diagram

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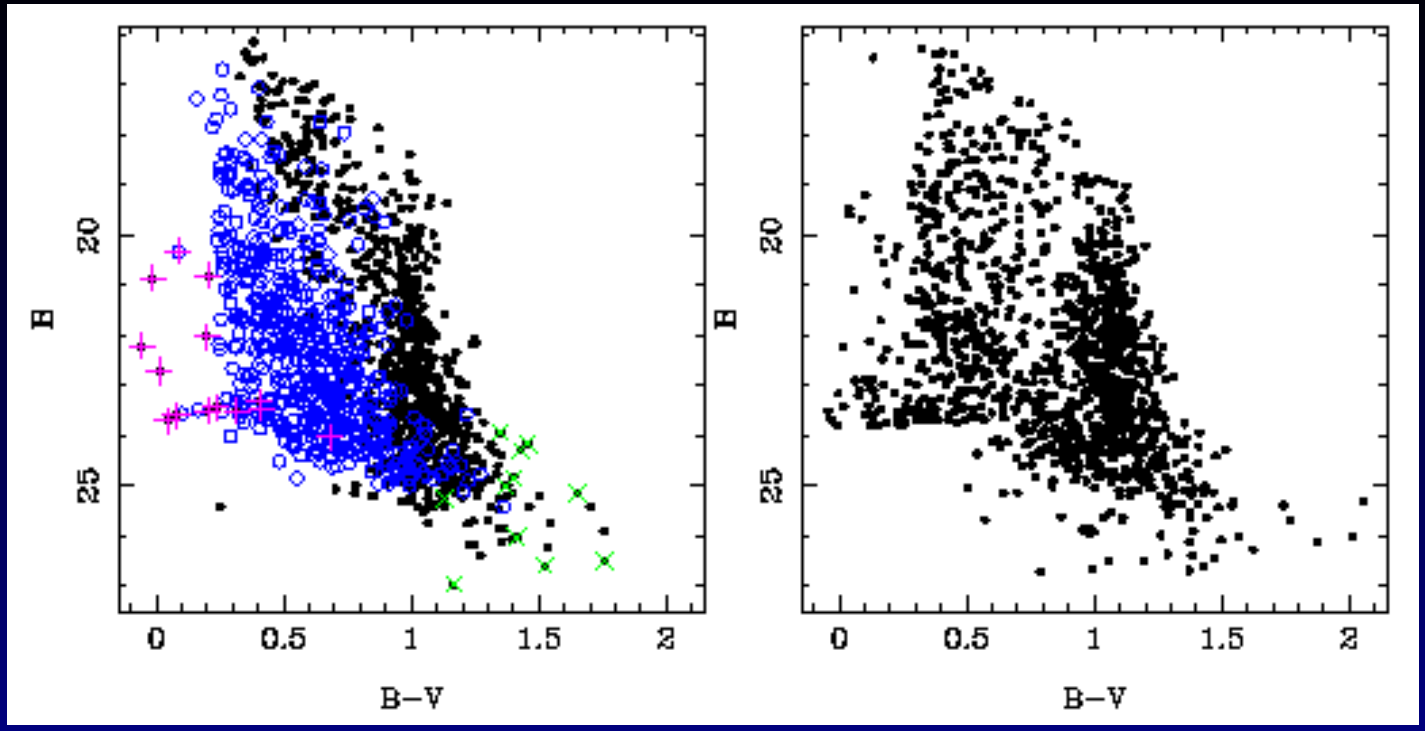
Right: observations



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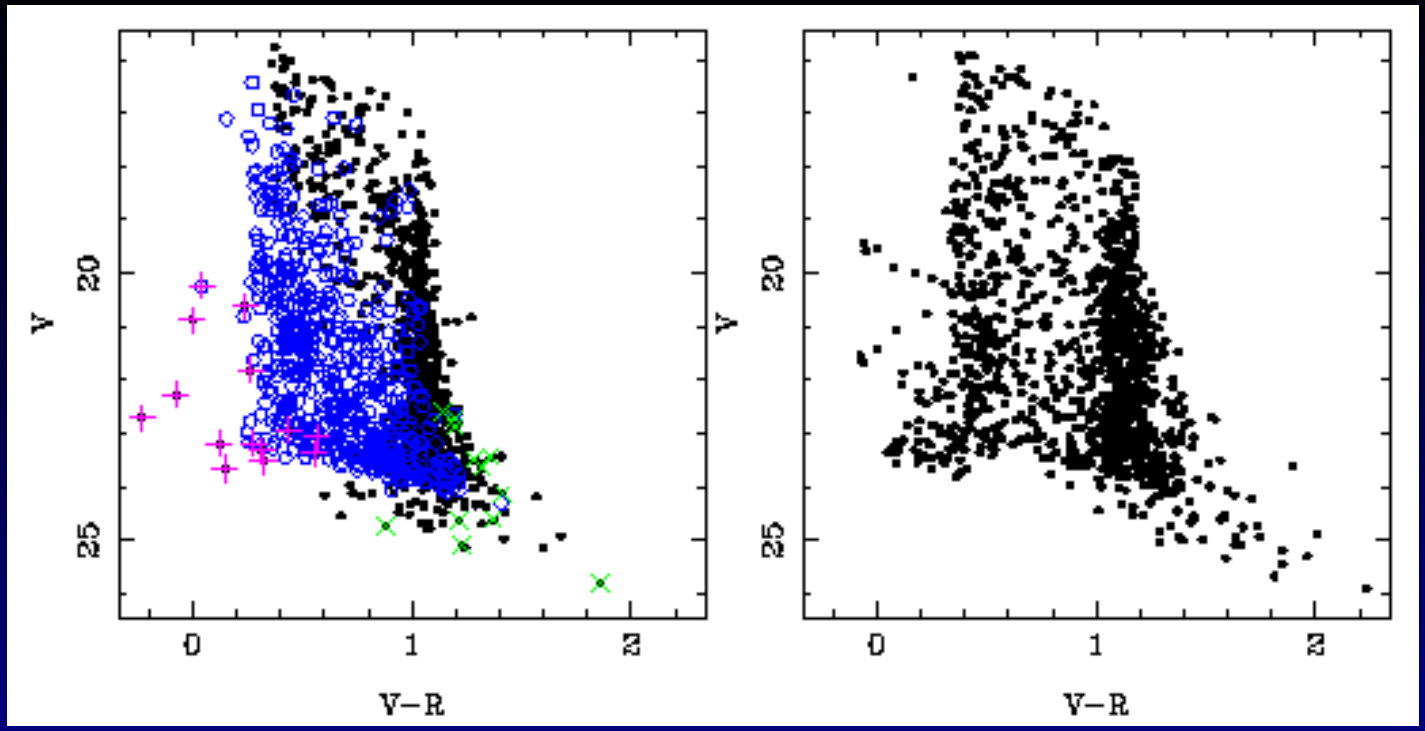

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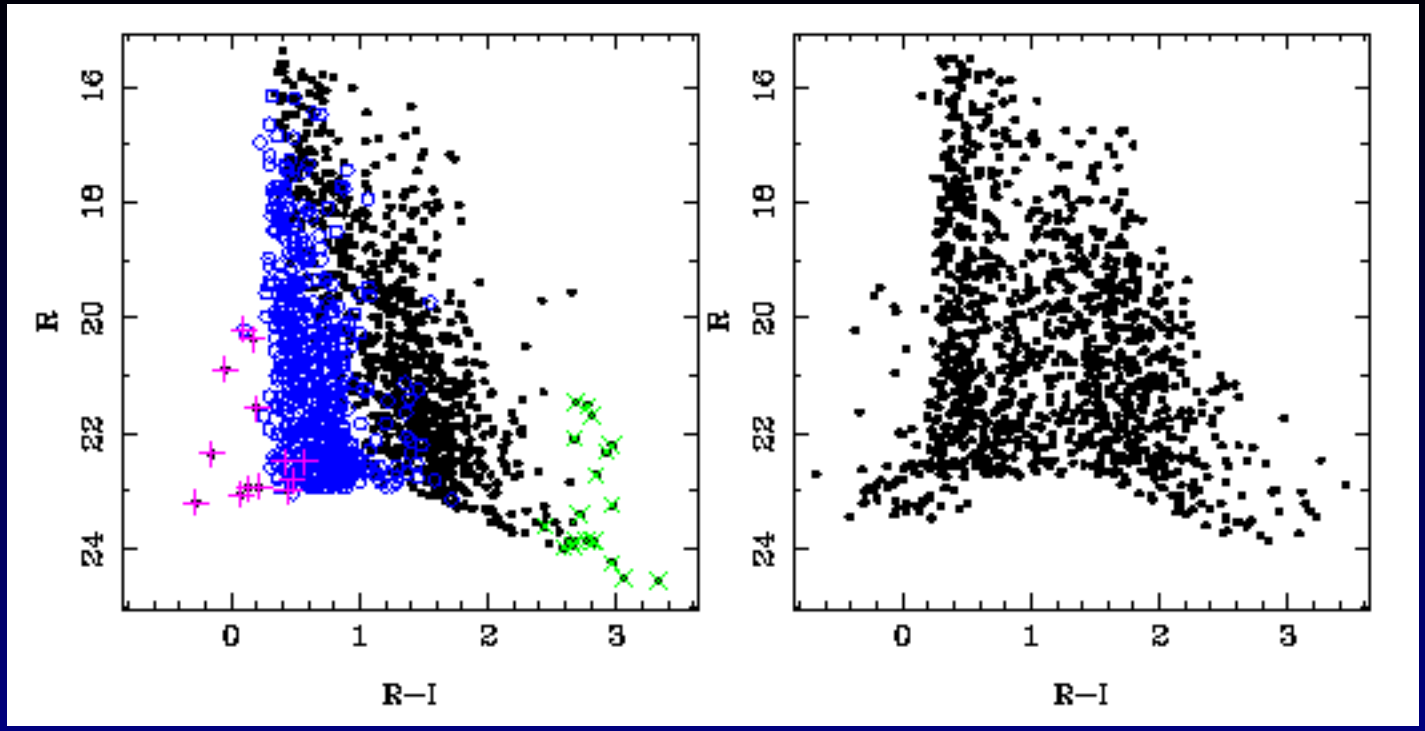

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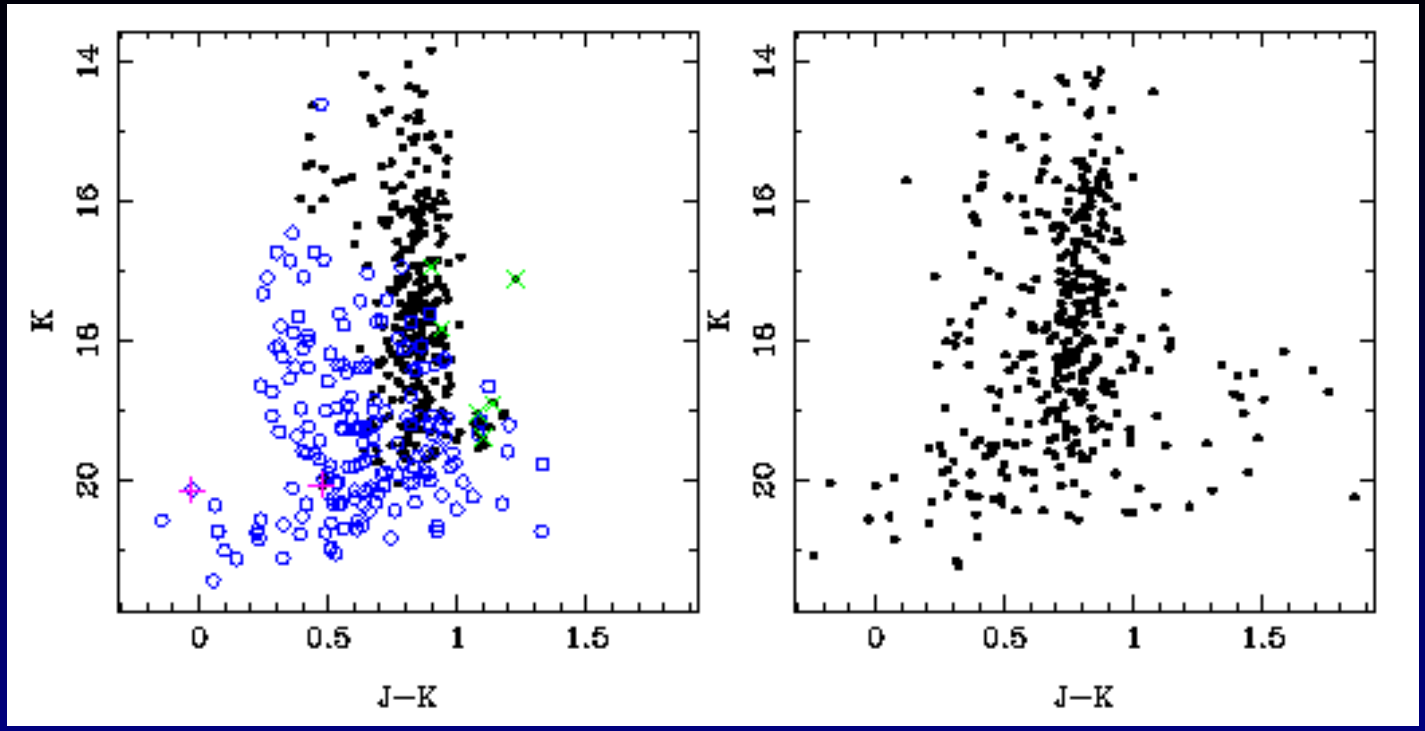

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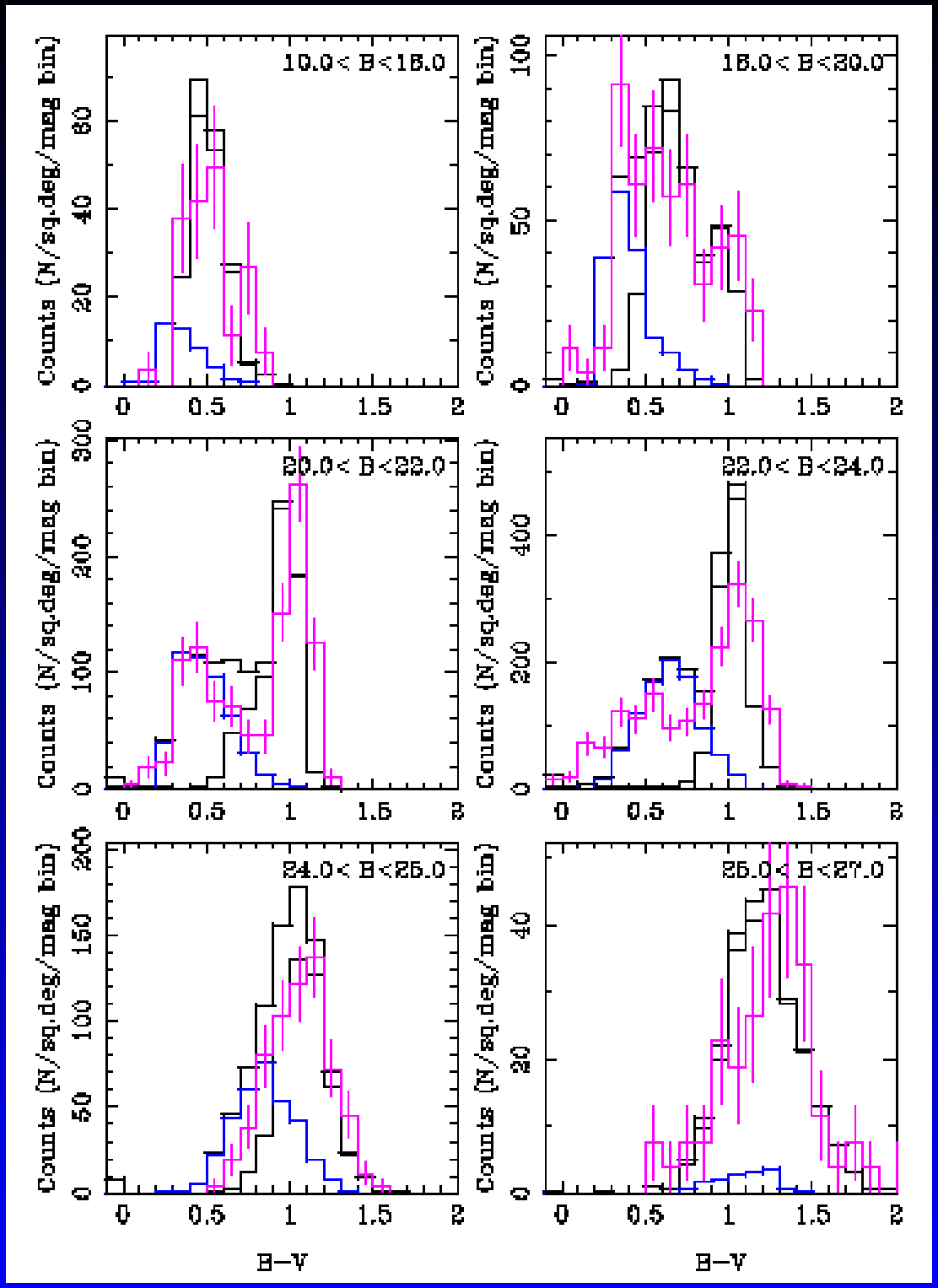
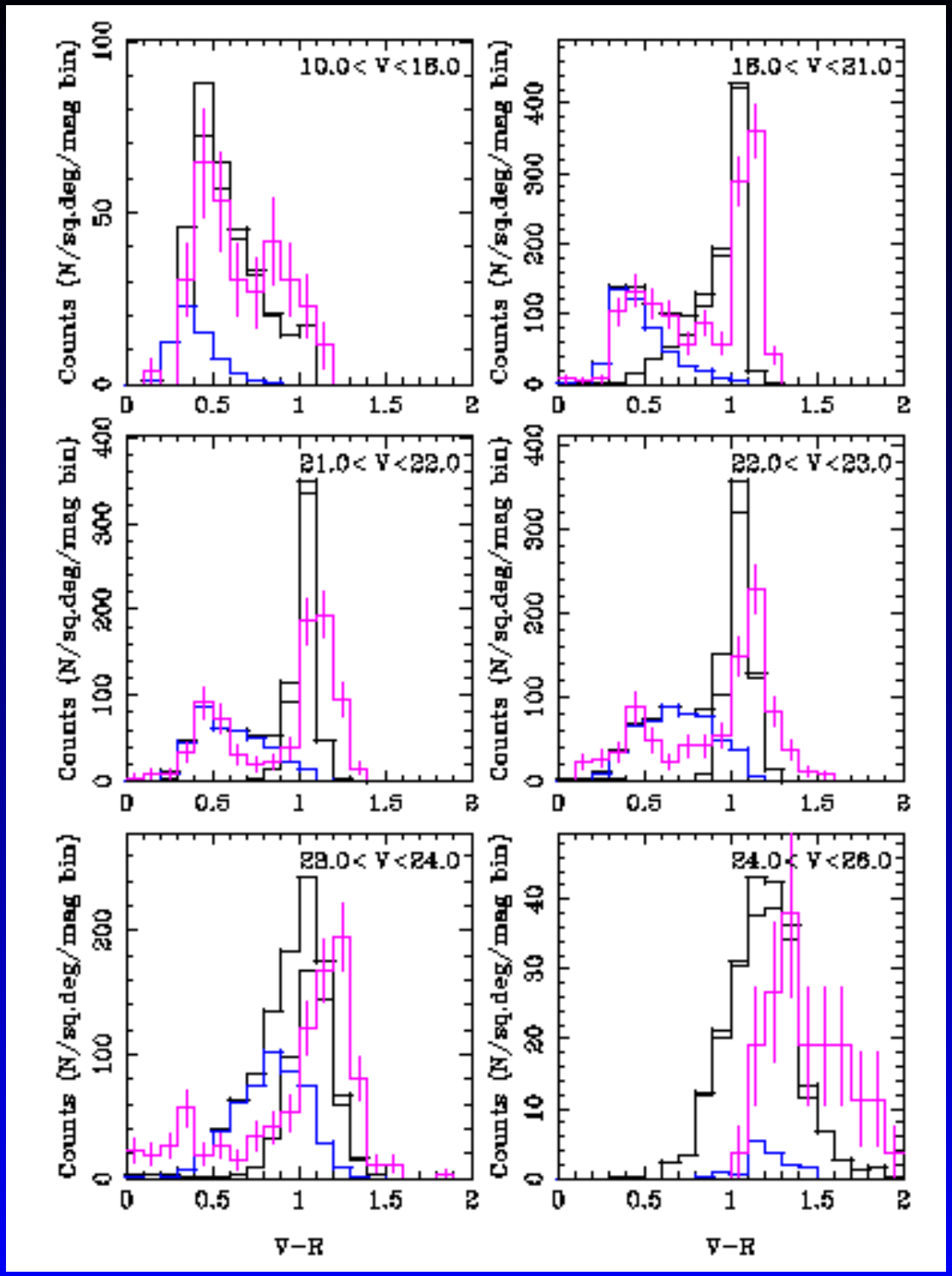


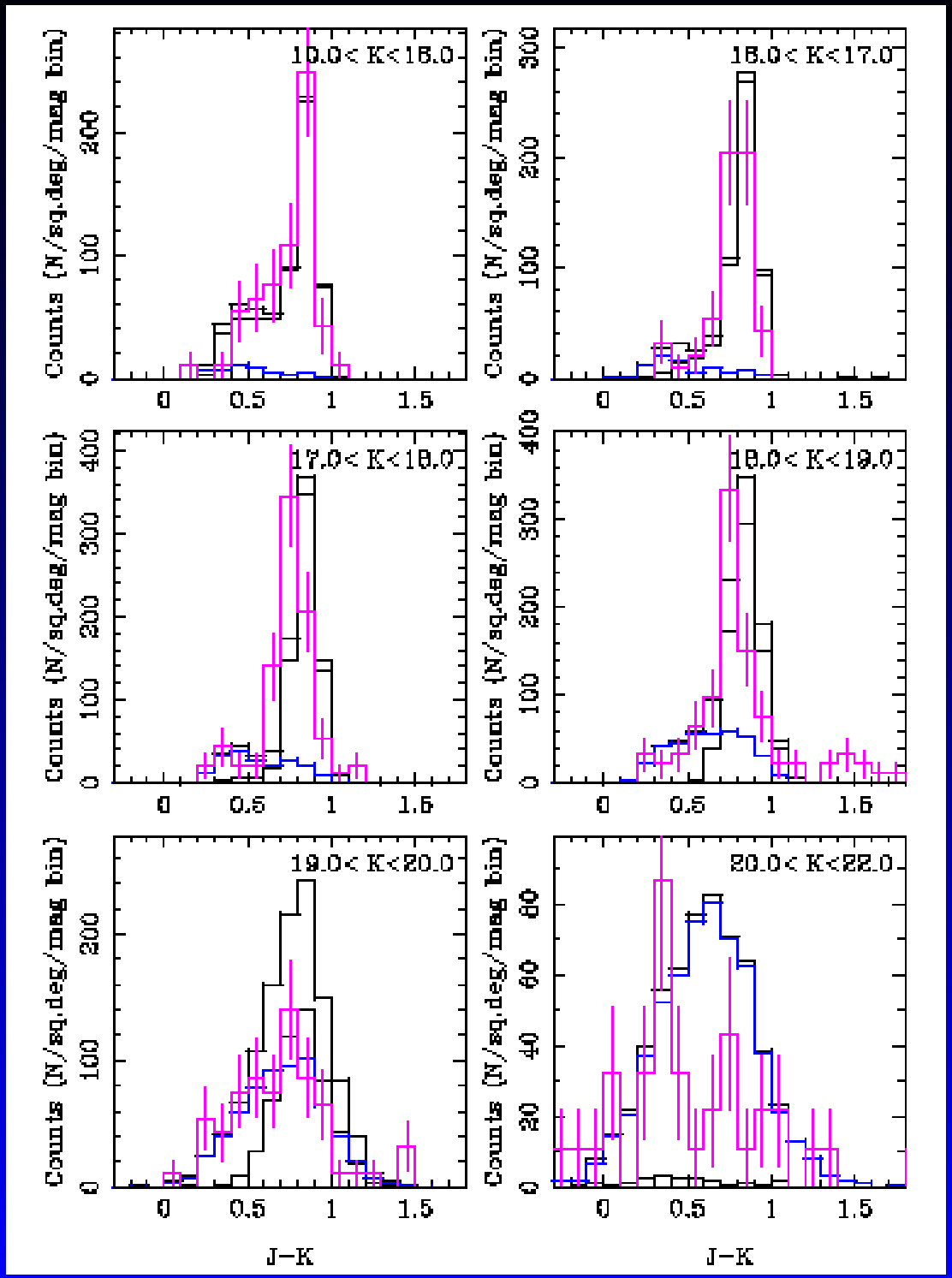
Colour-distribution

Observations (pink), disk stars (thin black), halo stars (blue), total (thick black)



Colour-distribution

Observations (pink), disk stars (thin black), halo stars (blue), total (thick black)



Colour-distribution

Observations (pink), disk stars (thin black), halo stars (blue), total (thick black)

Future of ground-based Surveys

VST (VLT Survey Telescope)

- Collaboration between Capodimonte and ESO
- 2.6m telescope at Paranal ; FOV 1.0 $\square^2$;
  16k$\times$16k chip (OMEGACAM); optical, 2002?

VISTA (Visible and Infrared Telescope for Astronomy)

- Collaboration between 18 UK Institutes and ESO
- 4m telescope at Paranal ; FOV 1.0 $\square^2$;
  16k$\times$16k chip; $zJHK$, completed 2006

Future of ground based Surveys

MEGACAM/TERAPIX

- Collaboration between CNRS/NSERC/CFHT
- 3.5m CFHT ; FOV 1.0 $\square^2$;
  16k$\times$16k chip; optical

Conclusions and Future work

EIS

- Largely fulfilled the criteria it was to meet
- Demonstrated framework for similar projects in the future
- http://www.hq.eso.org/science/eis/

Extra-galactic Surveys and Galactic Structure

- Improvements in model forthcoming (binary, more general set-up)
- Demonstrated ability to fit the data in general
- More fields will become available in 2002