Virtual Observatory

VO science
beyond data mining

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Introduction

- The Virtual Observatory is a realisation of the e-Science concept in astronomy.
- **Data archives** and **software tools** interoperating using a set of peer-reviewed standards and technologies developed by the IVOA form a powerful *virtual environment* aimed at facilitating astronomical research and increasing scientific output of data.
- We already have
  - a comprehensive set of standards
  - VO tools: from general to specialised
  - first data analysis services start to appear

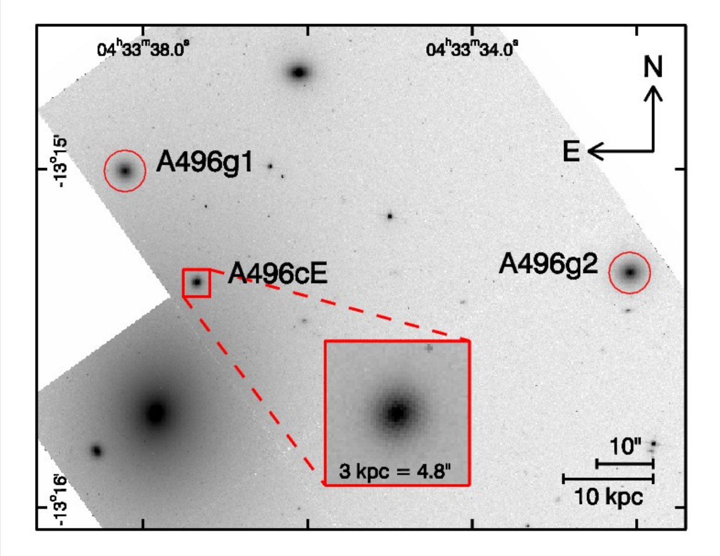
What about science?

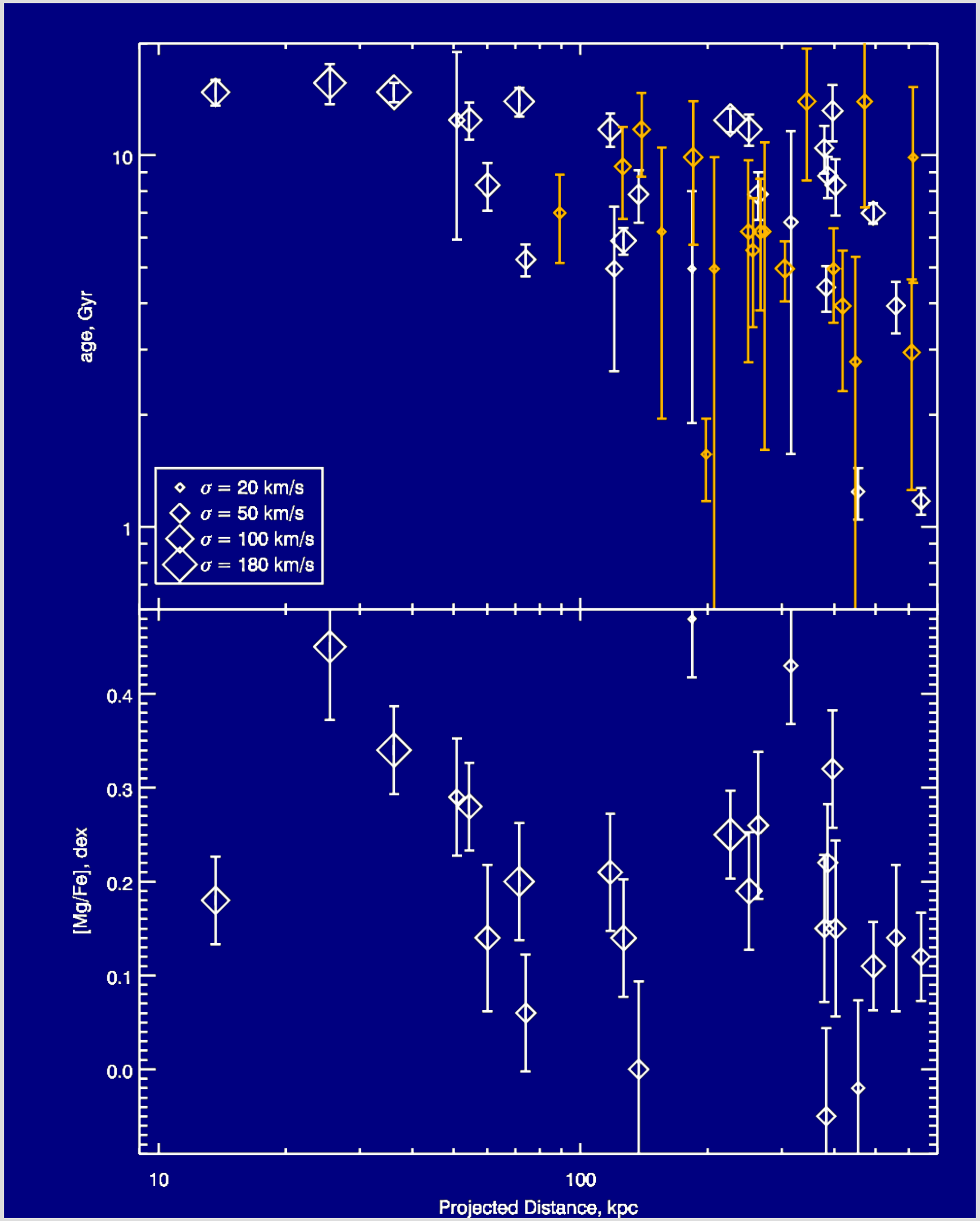
- Quite a long break after the first paper by Padovani et al. (2004)
- New results appeared recently, e.g.
  - Caballero et al.
  - Richards et al.
- At present, the VO-enabled research is mostly data mining
  - Is it already possible to go beyond???
- We use the VO to discovery and retrieve data, then do some offline analysis and/or dedicated observations, then come back to the VO to collect complementary data

#1: tidally stripped galaxies

Motivation:
Segregation of young galaxies in cluster centres

High [α/Fe] ratios, metallicities and velocity dispersions for 5 low-luminosity galaxies in the the Abell 496 core (Chilingarian+08), one of them is a newly discovered cE (M32-like) galaxy (6-th known in the Universe). Stellar populations suggest massive progenitors.





#1: What was done inside VO

VO workflow includes:

- querying Vizier to retrieve a list of Abell clusters having z<0.05, then NED for Galactic extinction
- querying HLA via SIAP interface to locate broadband WFPC2 data
- running SExtractor service on these images and processing its output:
  - converting everything into B band, correcting for whatever is possible
  - selecting extended objects having small effective radii and high B-band mean effective surface brightness;
- querying NED to check if there are published redshifts for the selected objects, looking for additional data (X-ray and optical photometry...)

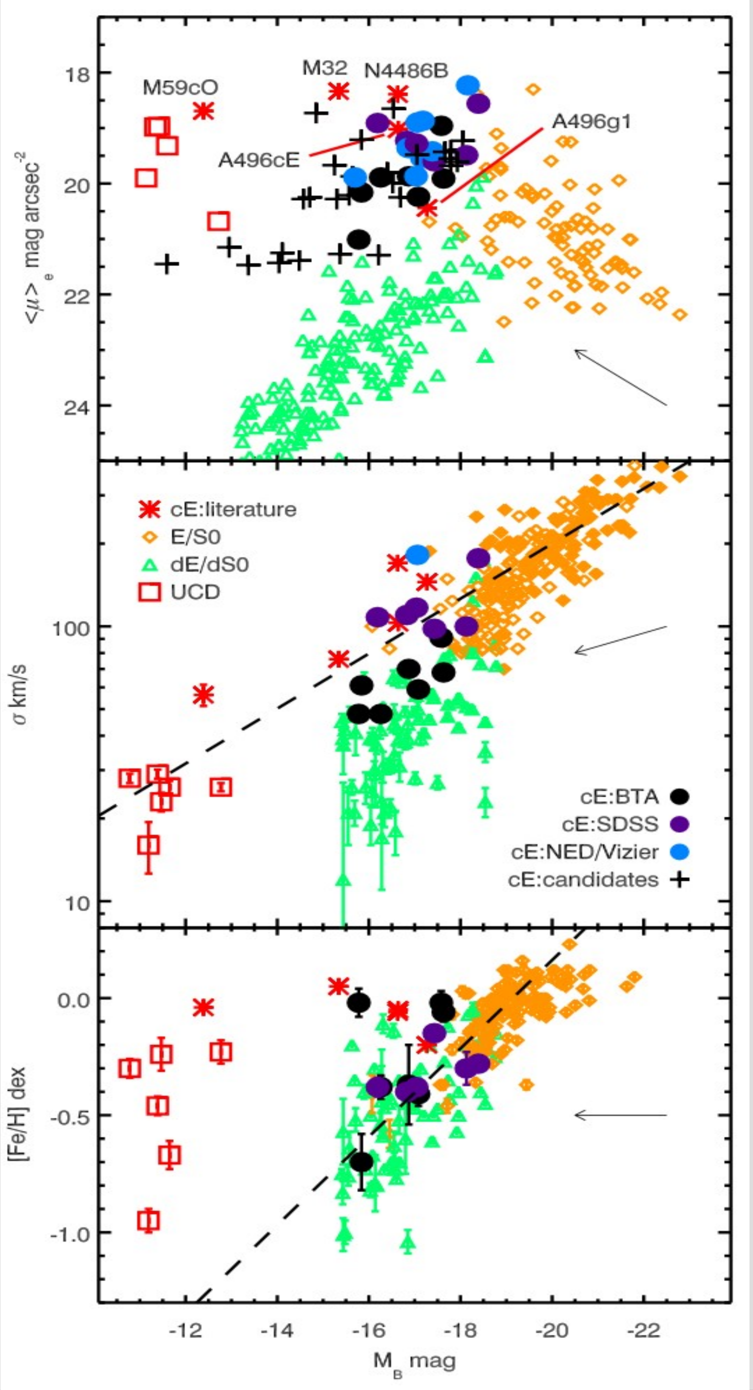
#1: What we got out of the VO

Data for 63 clusters analysed

- 55 candidate galaxies found in 26 clusters
- seven were immediately confirmed from SDSS
- seven more with NED/Vizier
- almost empty locus of cE got filled

What's next???

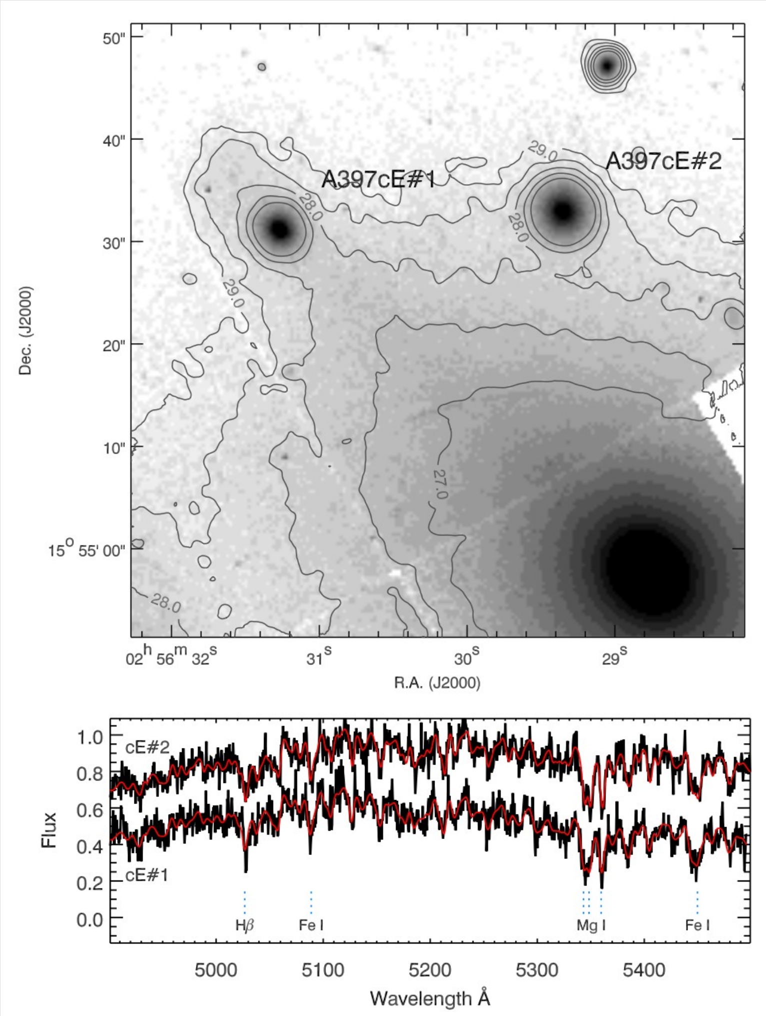
- follow-up ground spectroscopy to study stellar populations
- simulations to reproduce the properties



#1: What was done outside VO

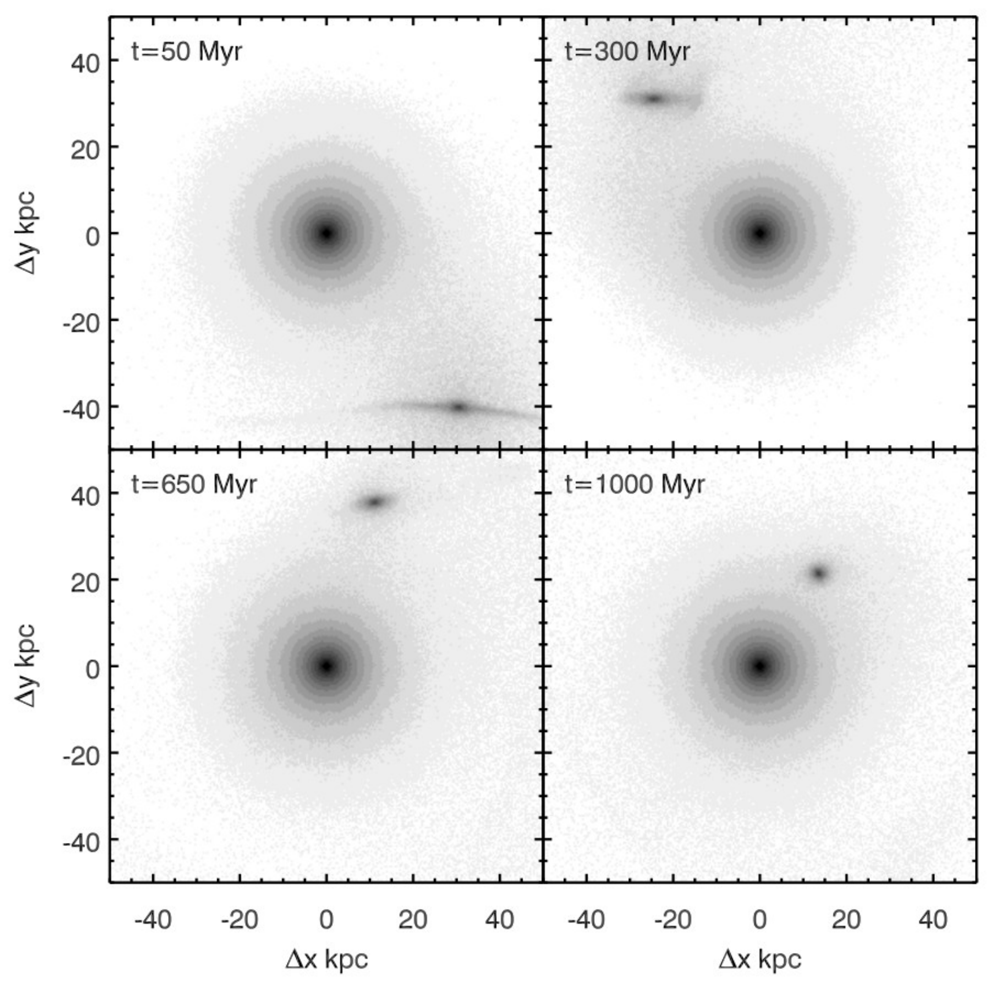
3 clusters with 7 cE candidates were observed (2 nights at 6-m)

- all 7 were confirmed
- all 7 have old metal-rich populations evident of more massive progenitors



Simulations of tidal stripping of lenticulars were conducted

- stellar mass loss is reproduced
- 2-component brightness profiles are reproduced



#1: Main result

- The class of cE galaxies was converted from “unique” into “common under certain environmental conditions”
- Evidences are given for an importance of tidal stripping of stellar discs of lenticular galaxies as a way to form compact ellipticals
- The first study made with VO, then followed-up with a large telescope and reproduced by simulations (*paper submitted*)

#2: optical/NIR galaxy colours

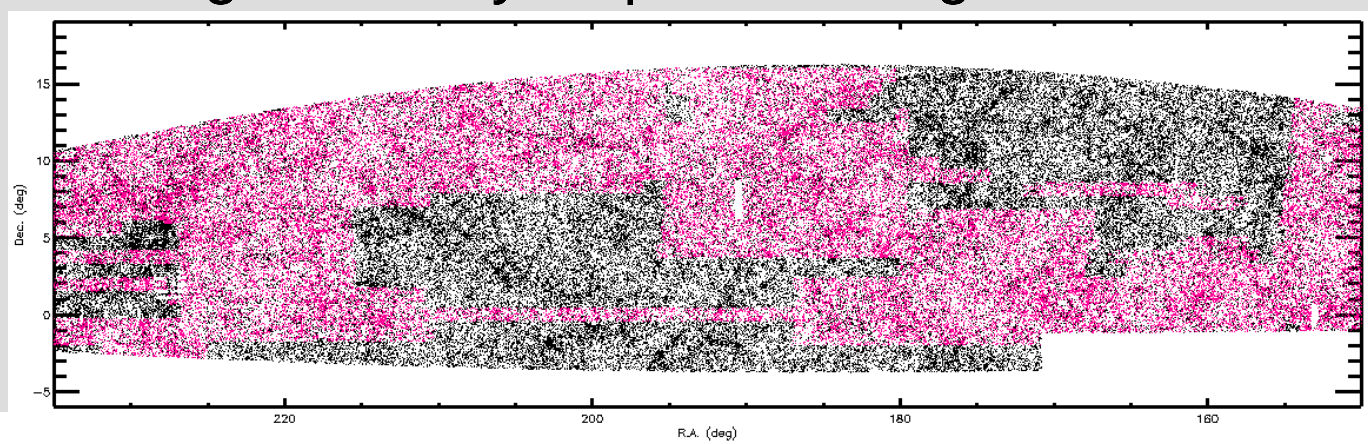
- An example of what can be achieved with the VO: minimal manpower, limited time (collaboration with Ivan Zolotukhin)
- Goal: studying optical/NIR colours of nearby galaxies and connecting them to the stellar populations
  - NIR magnitudes are much less sensitive to the stellar population age compared to the optical, therefore they are good stellar mass indicators (although not perfect)
  - extinction effects are smaller in NIR
  - spectroscopic ages and metallicities are important additional bricks of information

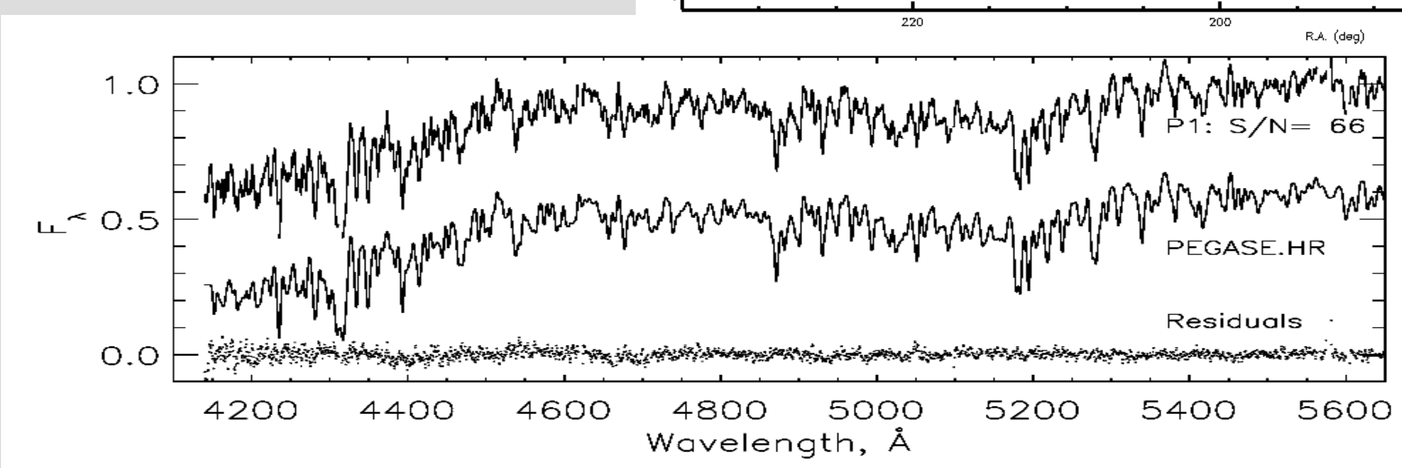
#2: optical/NIR galaxy colours

- Resources used:
  - SDSS DR7 catalogues
  - SDSS DR7 spectra
  - UKIDSS DR5 Large Area Survey catalogue
- Techniques:
  - cross-match (VO-possible)
  - stellar population modelling using PEGASE2/PEGASE.HR (VO-possible)
  - *NBursts* spectral fitting (non-VO)
- Tools:
  - Topcat/STILTS to join and merge the tables (just to simplify the life)
  - script-based access to SDSS
  - *possible* to use VO Desktop for UKIDSS

#2: What was done (1)

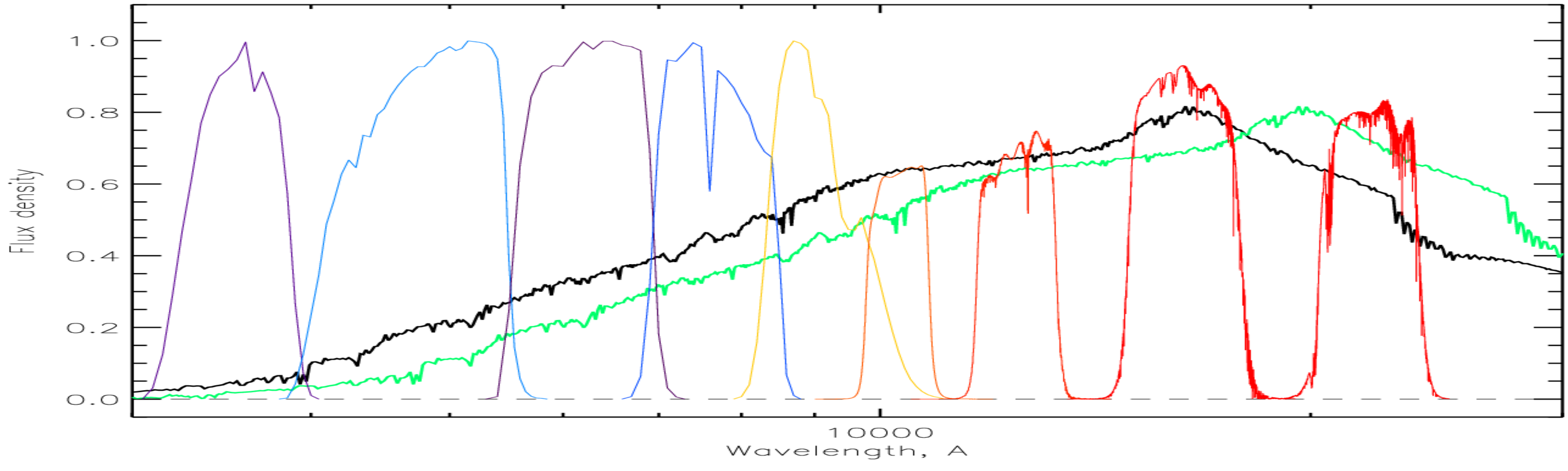
- SDSS CASJobs to select all galaxies with 0.03<z<0.3 in stripes 9 to 16 (spectroscopic sample): 170k objects
- WFCAM Archive to cross-match against UKIDSS DR5 LAS (possible with Astrogrid VO Desktop since Monday)
- Fitting optical/NIR SED against PEGASE2 models to get rest-frame magnitudes (K-corrections)
- Fitting SDSS spectra to get velocity dispersions, ages and metallicities





#2: Issues

- Aperture effects: Petrosian radii in SDSS and UKIDSS are sometimes very different
  - Solution: using aperture magnitudes for colours + SDSS r' to renormalize the SED
- K-corrections: controversial information is given in literature
  - Solution: compute them ourselves

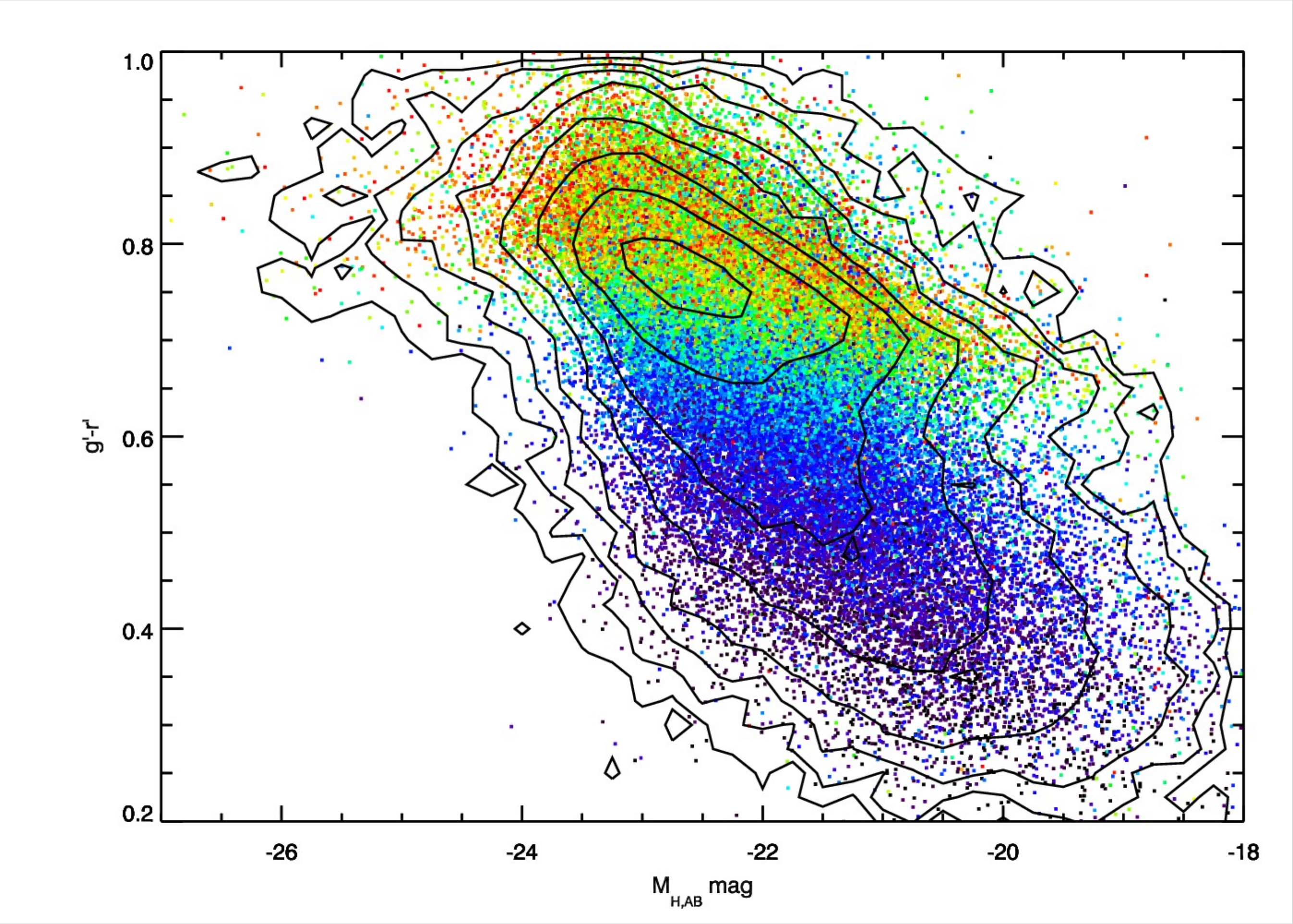


#2: Results (1)

- new prescriptions for K-corrections at low redshifts ($z<0.6$)
  - all optical and NIR filters
  - analytical approximations as functions of redshift and observed colour (u-r, g-r, or J-K)
    - very low RMS scatter of the residuals (~0.03 mag)
- by products:
  - emission line properties
    - lines between 3900 and 6800A restframe
    - precise measurements even for faint emission lines
  - absorption line-strength measurements (Lick indices and not only)
    - service in VO-Paris to compute Lick indices in the VO framework using UWS (by J. Normand)

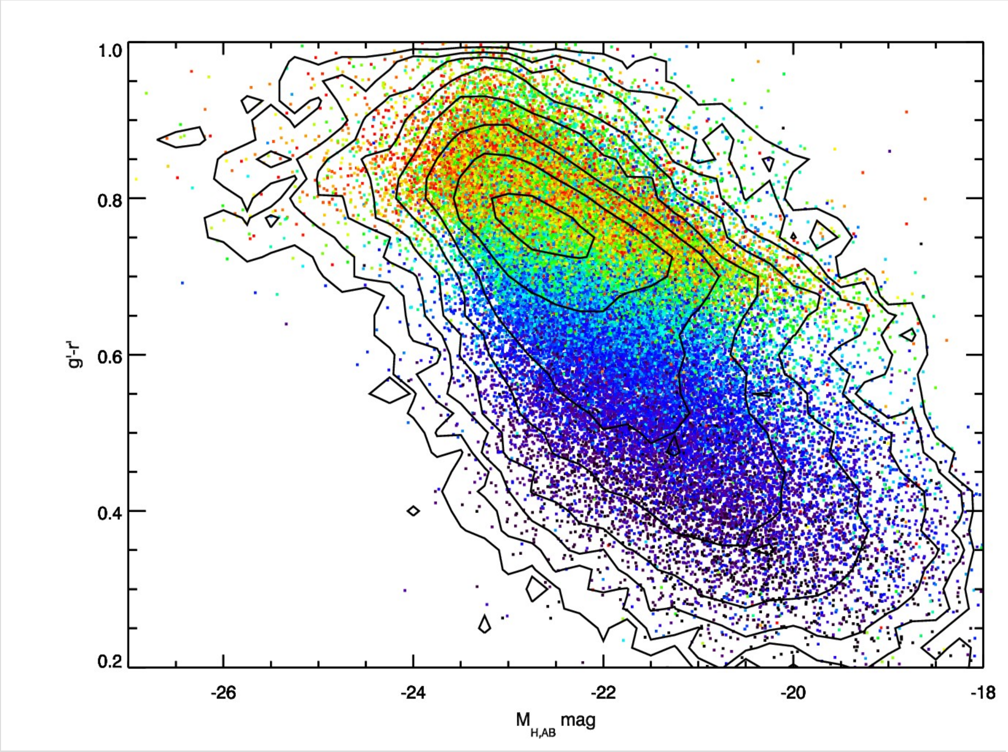
#2: Results (2)

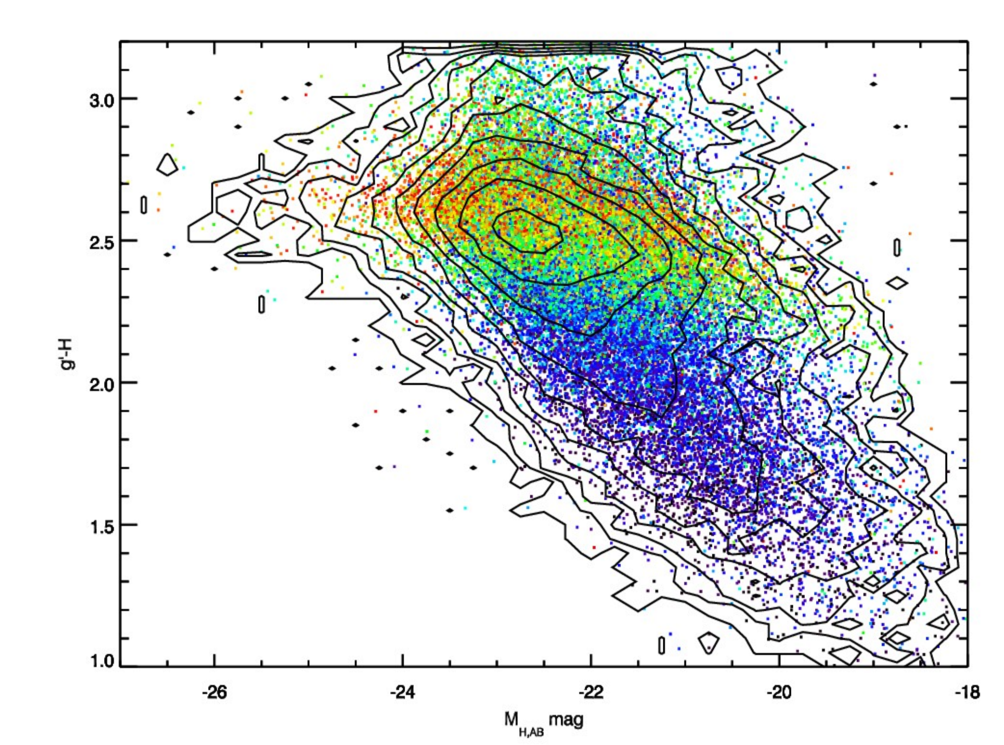
- There is an significant age gradient in the "blue cloud"; most of the red sequence objects are old



#2: Results (3)

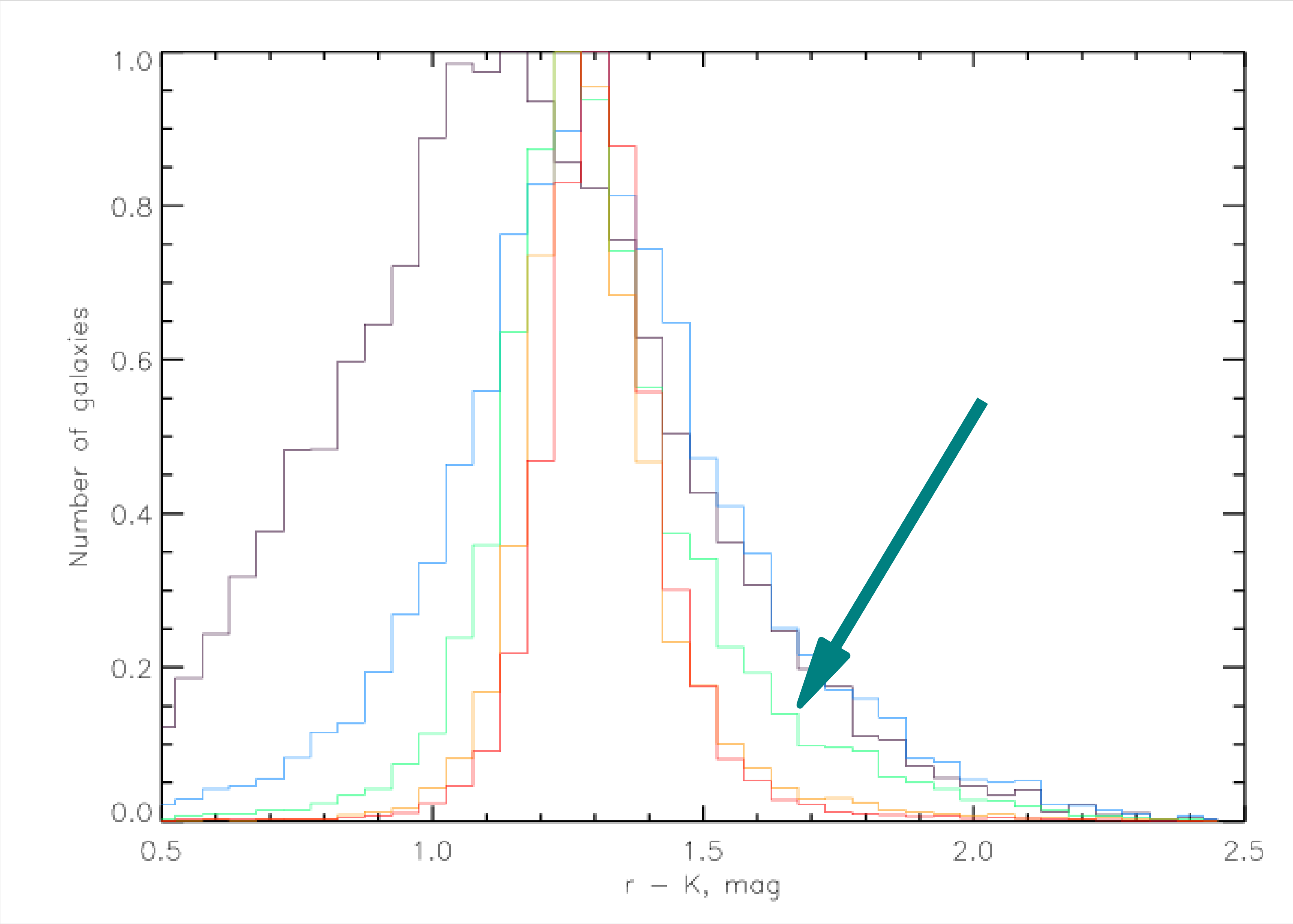
- In the optical-NIR colours (e.g. g-H) the blue cloud starts to overlap the red sequence – probably extinction effects, since galaxies show intermediate stellar population younger than of red sequence objects





#2: Results (3a)

- Better view of this effect: AGB stars?



Summary

- The VO is already at the production level. Scientists (not associated to VO projects) are feeling the way
- First scientific results obtained are important and impressive; the advantages of the approach are clear
- VO-enabled science cases can go far beyond data mining
- *However, the major problem for a scientist in the VO now is a large number of very little but very annoying infrastructural faults: all the individual bricks exist, but putting them together is tricky*