
The Quest for
Ultra compact dwarfs
(UCDs)
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08.09.2006
2nd NEON summer archive school

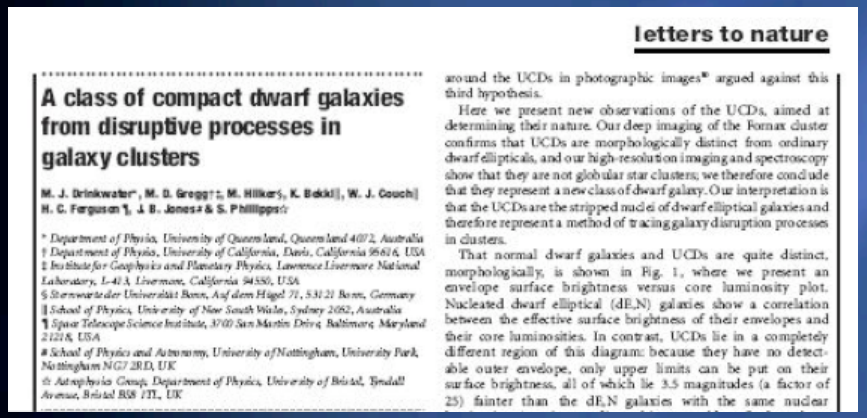
Outline

- Introduction
- Photometric search for UCD candidates
- UCD candidates in Abell 1689: spectroscopic follow-up
- Redshift determination and results

Introduction

The search for the smallest galaxies starts

Where do we start looking for them?



letters to nature

A class of compact dwarf galaxies from disruptive processes in galaxy clusters

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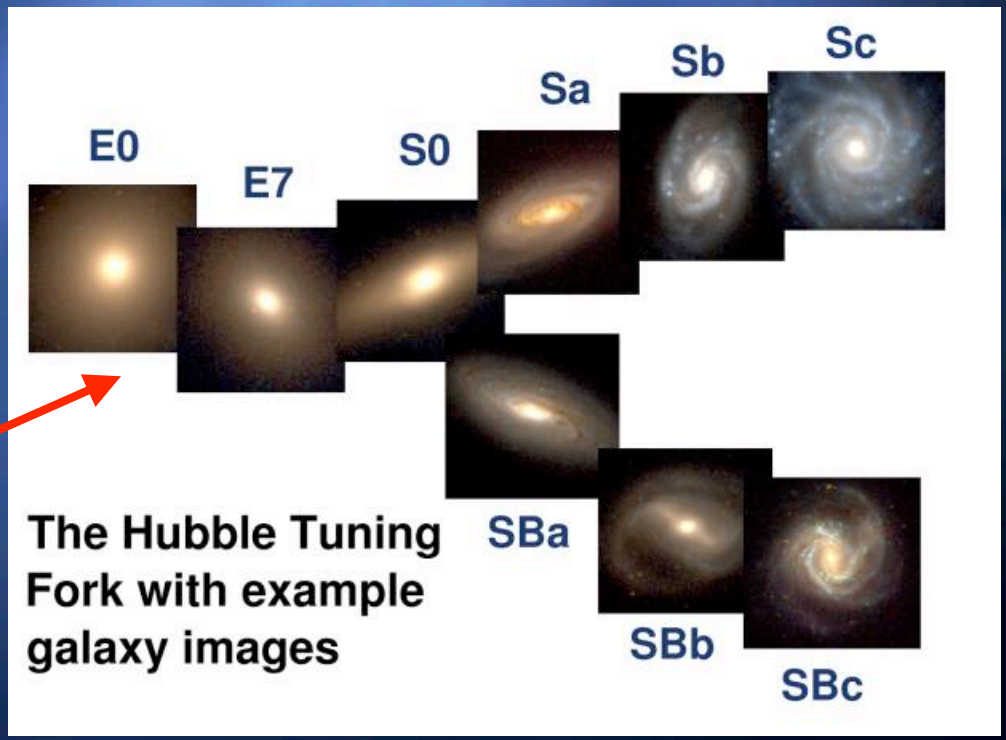
around the UCDs in photographic images* argued against this third hypothesis.

Here we present new observations of the UCDs, aimed at determining their nature. Our deep imaging of the Fornax cluster confirms that UCDs are morphologically distinct from ordinary dwarf ellipticals, and our high-resolution imaging and spectroscopy show that they are not globular star clusters; we therefore conclude that they represent a new class of dwarf galaxy. Our interpretation is that the UCDs are the stripped nuclei of dwarf elliptical galaxies and therefore represent a method of tracing galaxy disruption processes in clusters.

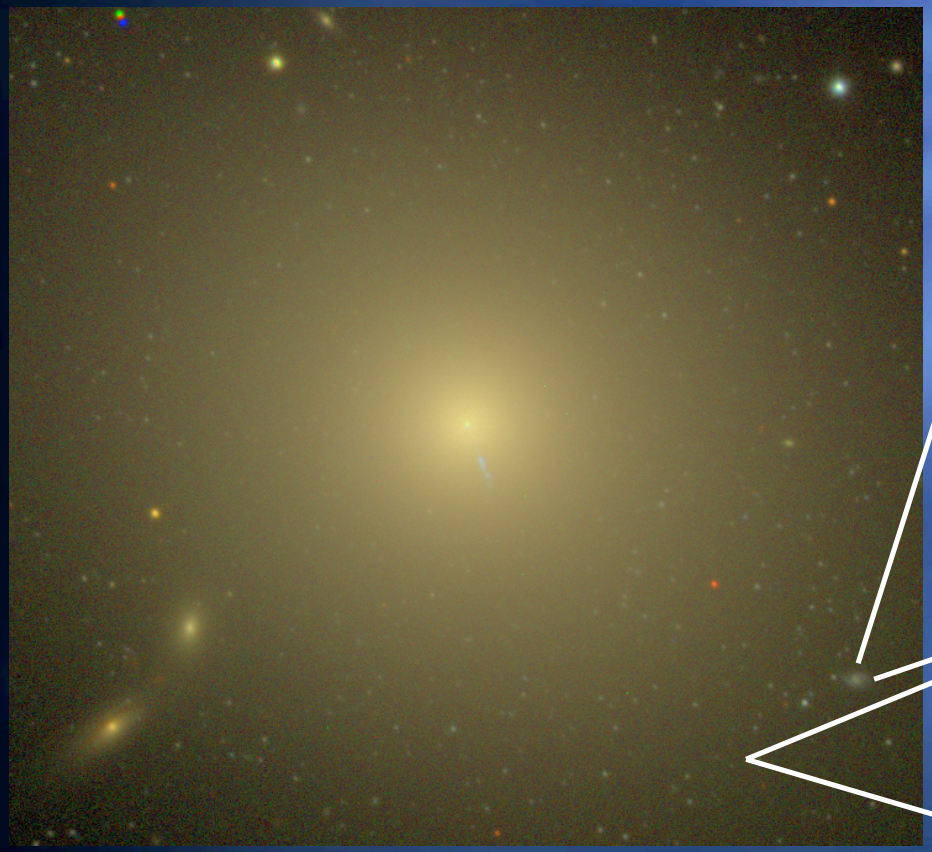
That normal dwarf galaxies and UCDs are quite distinct, morphologically, is shown in Fig. 1, where we present an envelope surface brightness versus core luminosity plot. Nucleated dwarf elliptical (dE,N) galaxies show a correlation between the effective surface brightness of their envelopes and their core luminosities. In contrast, UCDs lie in a completely different region of this diagram: because they have no detectable outer envelope, only upper limits can be put on their surface brightness, all of which lie 3.5 magnitudes (a factor of 25) fainter than the dE,N galaxies with the same nuclear

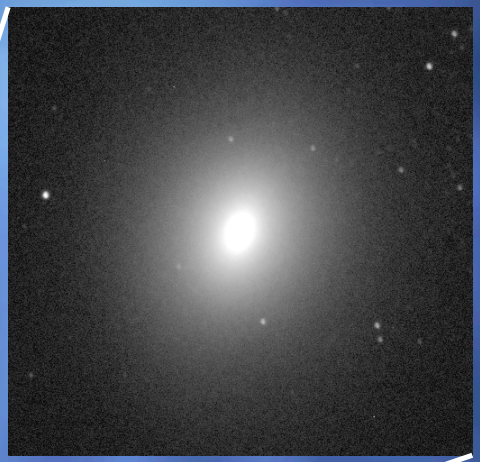
We have a clue :

Ultra compact dwarfs in galaxy clusters

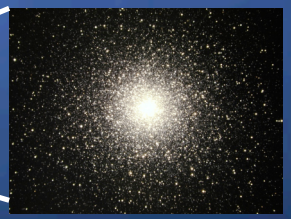


Early types family album





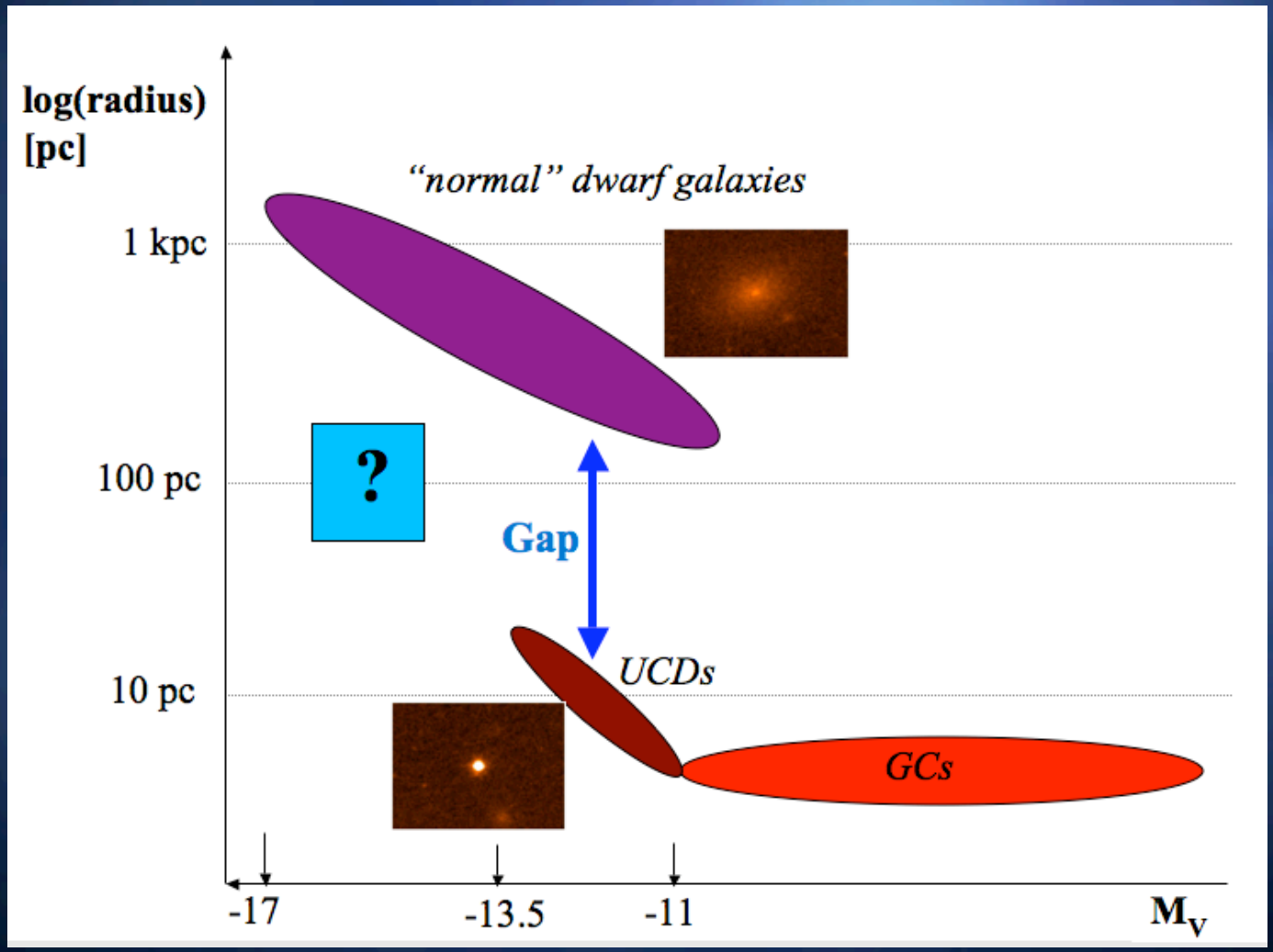
dE: ~700pc



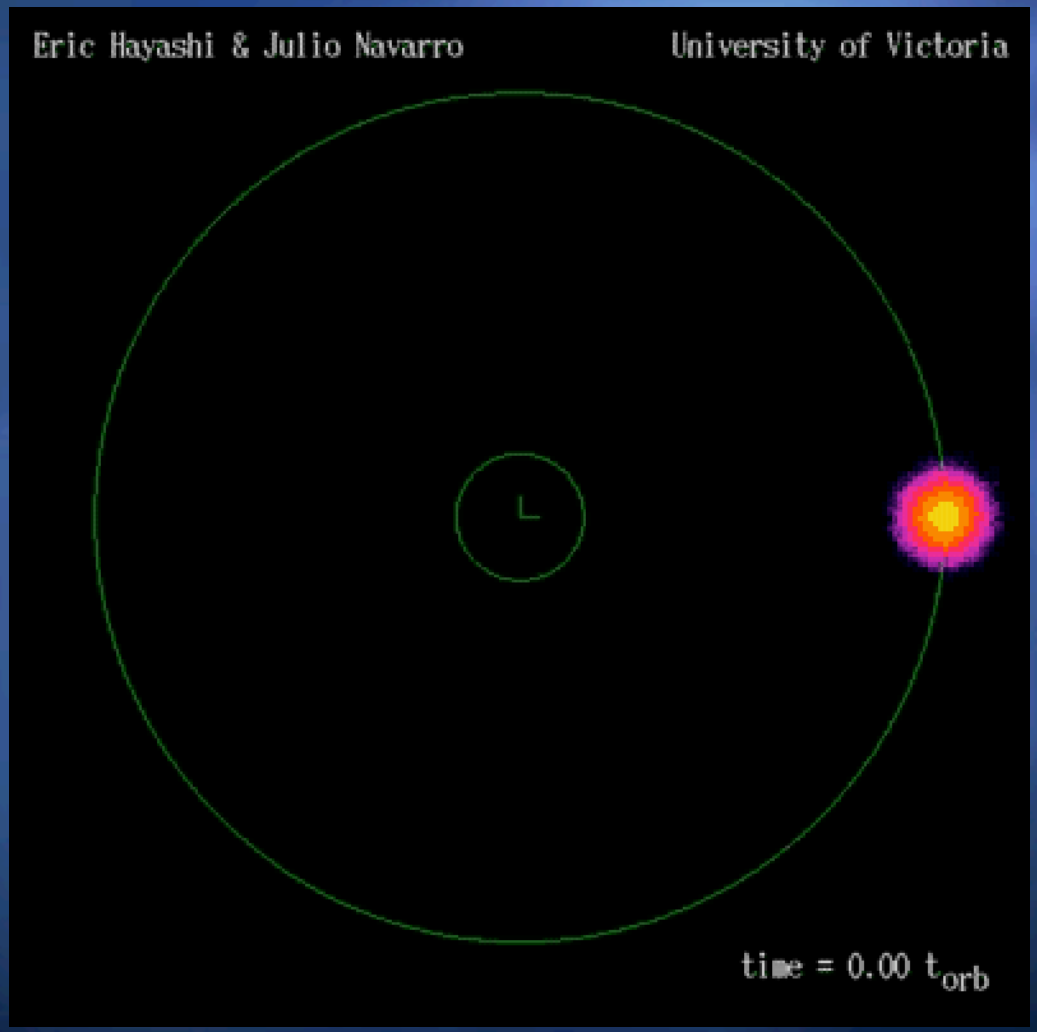
M87: ~7kpc

Globular cluster: ~3pc

Brightness/size distribution



How are UCDs created?



How are UCDs created?

Two formations scenarios:

1. Compact remnants of tidally stripped galaxies (Bekki et al. 2003)
2. Merged stellar super clusters (Fellhauer & Kroupa 2002)

Observations & simulations: stellar super clusters have masses $<10^8$ M_{sun}

Idea: Search for very luminous UCDs that are too massive to be explained by merged star clusters. If found, support for „galaxian origin“ of at least some UCDs.

Where? Search in very massive galaxy clusters!

Photometric search for UCD candidates

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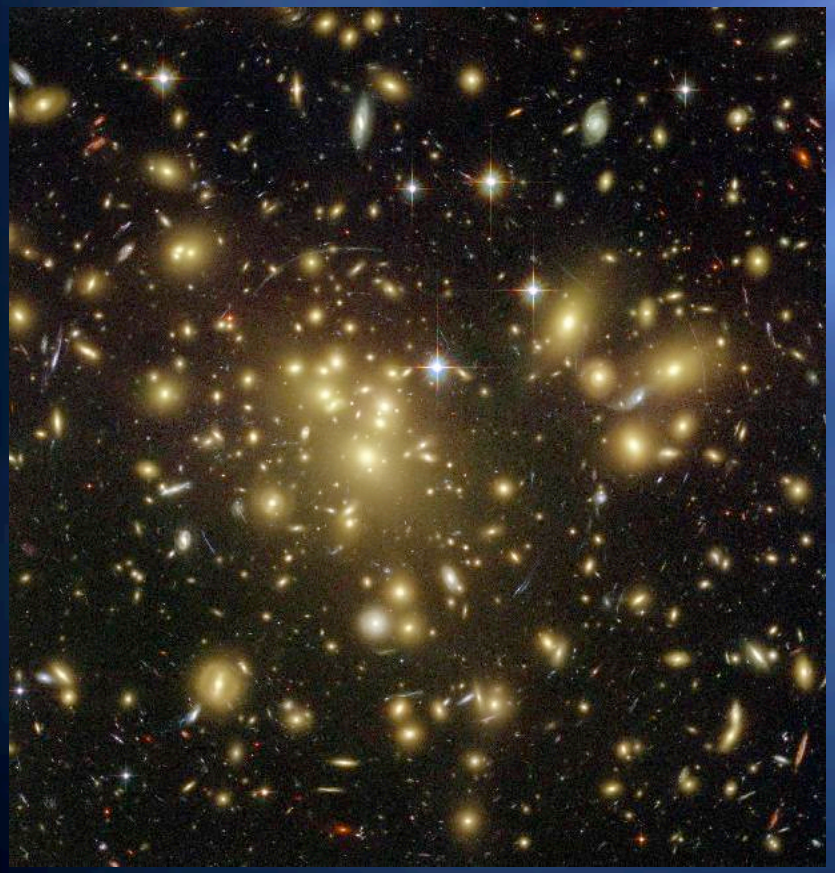
Abell 1689: A massive Galaxy Cluster

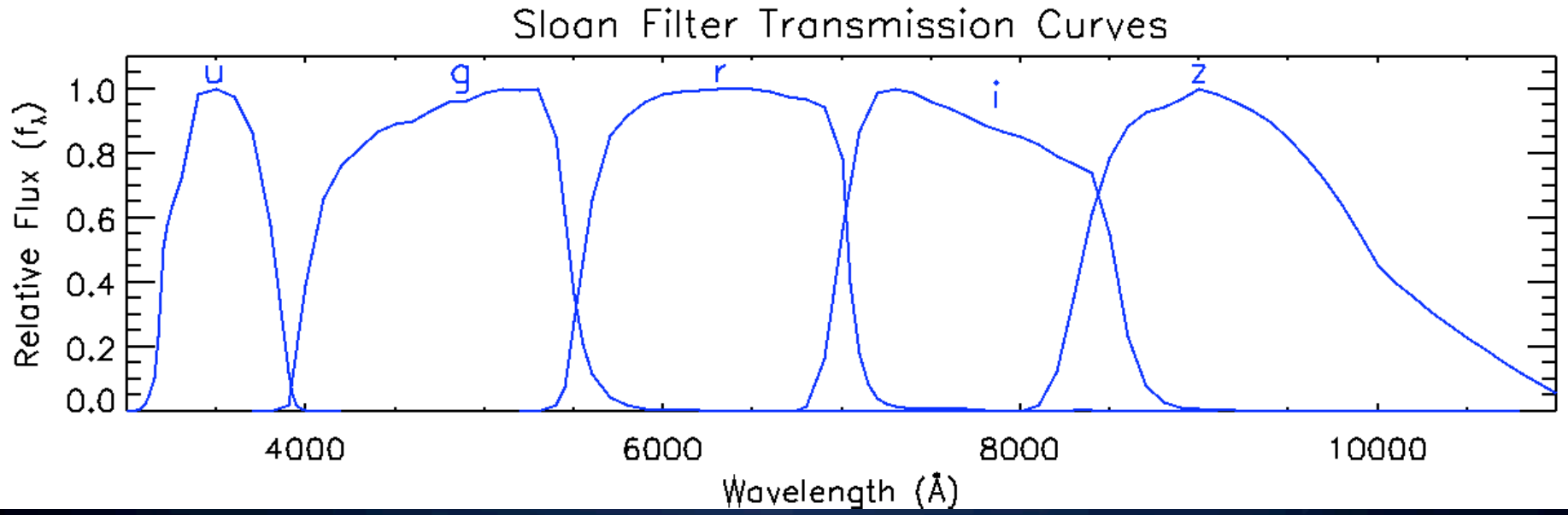


- RA 13:11:34.2
- Dec -01:21:56
- z = 0.183
- (m-M) = 39.7
- Distance ~ 700Mpc
- Diameter ~ 6.5Mpc
- Mass ~ 2*(10^15) $M_{\odot}$

(NED; Broadhurst et al. 2005)

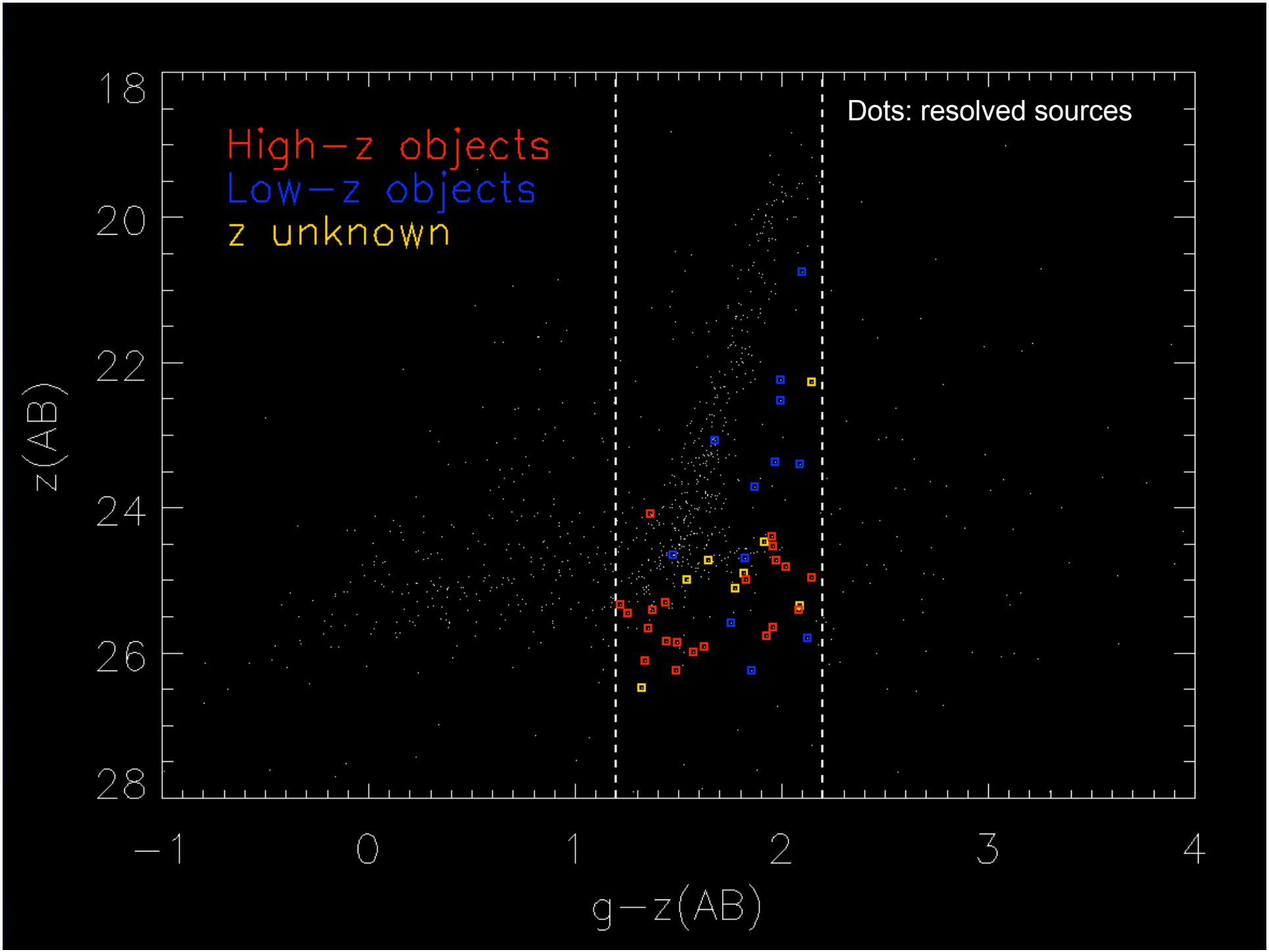
Photometric Search for UCD candidates in Abell 1689

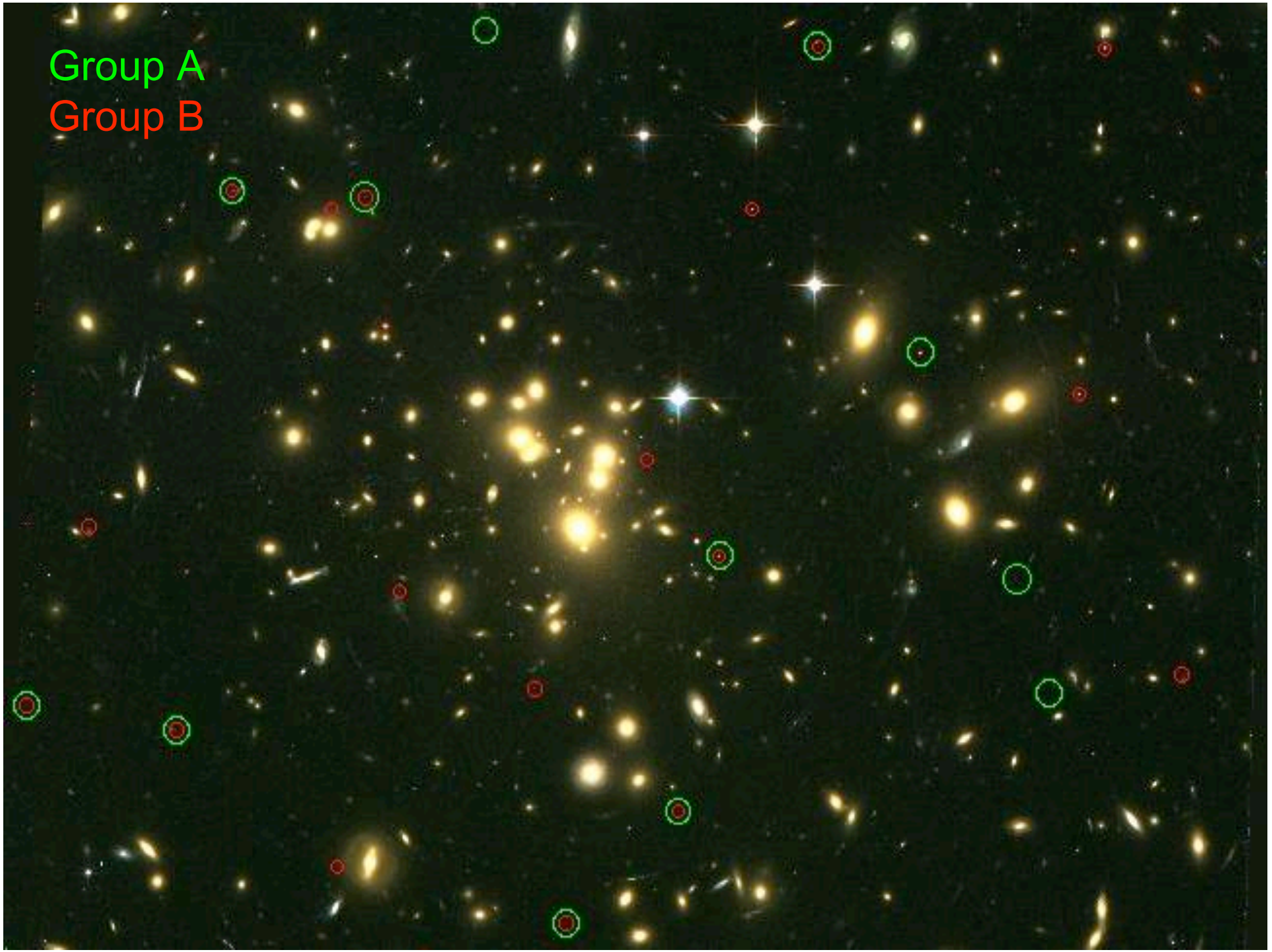
- HST/ACS drizzled griz images from June 2002
- PSF FWHM = 0.1" (2 pixels) --> 300pc. UCDs are unresolved!
- Source detection and extraction with SExtractor

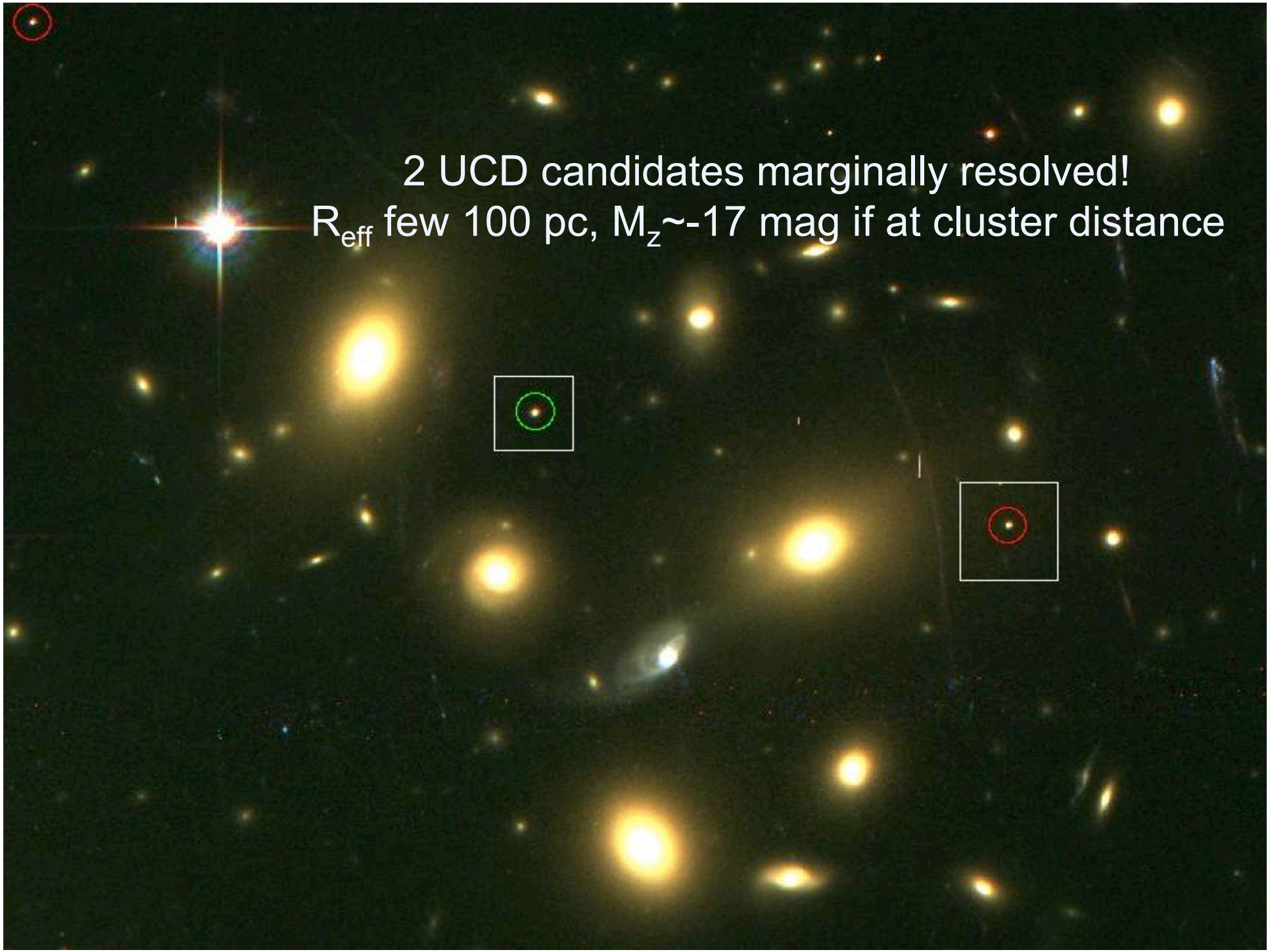


Candidate Selection

- Detected on all bands
  group A: SExtractor independently on all 4 bands, 5 σ
  group B: SExtractor in dual detection, 10 σ
- class_star
  group A: class_star > 0.1 in all 4 bands
  group B: class_star > 0.5 in at least 1 band
- FWHM
  group A: FWHM < 2*PSF in all bands
  group B: FWHM < 2*PSF in i band
- i < 26.5
- Colour cuts + photo-z (next slide)


High−z objects
Low−z objects
z unknown
Dots: resolved sources
18
20
22
24
26
28
z(AB)
−1
0
1
2
3
4
g−z(AB)


Group A
Group B


2 UCD candidates marginally resolved!
R_{eff} few 100 pc, M_z~-17 mag if at cluster distance

Spectroscopic follow-up

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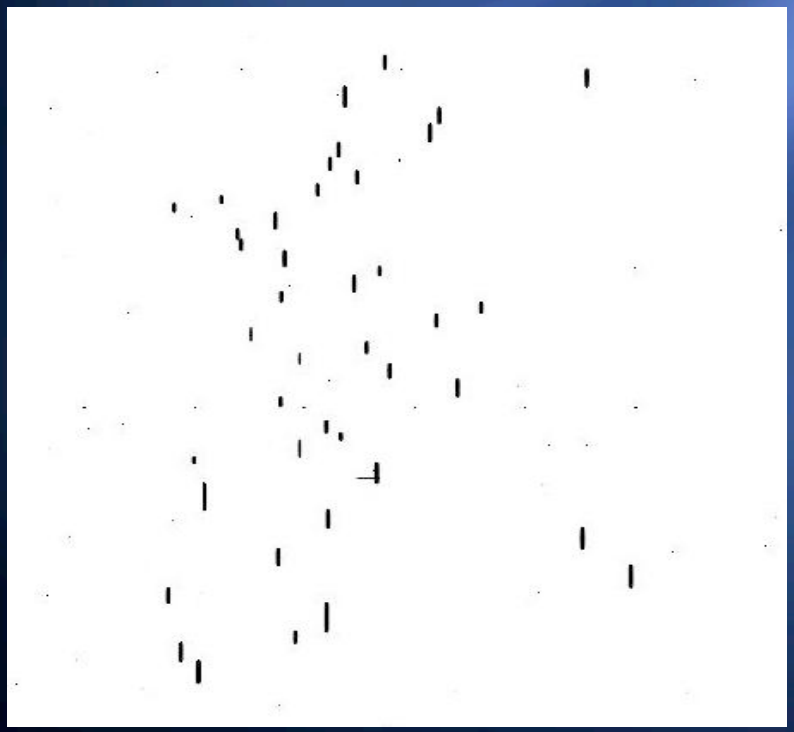
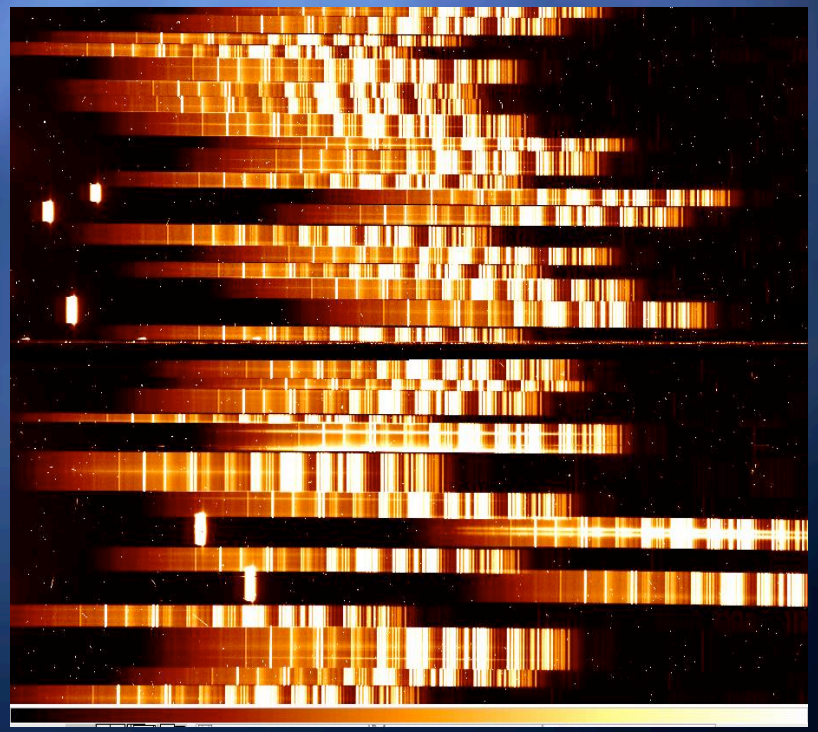
UCD candidates in Abell 1689 spectroscopic follow-up

- redshift
- ESO ARCHIVE:search for spectroscopic data
- VLT telescope spectrograph: all available data were taken with the FORS2 spectrograph (MXU)
- Type of files you get:
  - acquisition
  - flat field
  - bias
  - science

THE INSTRUMENT: FORS2

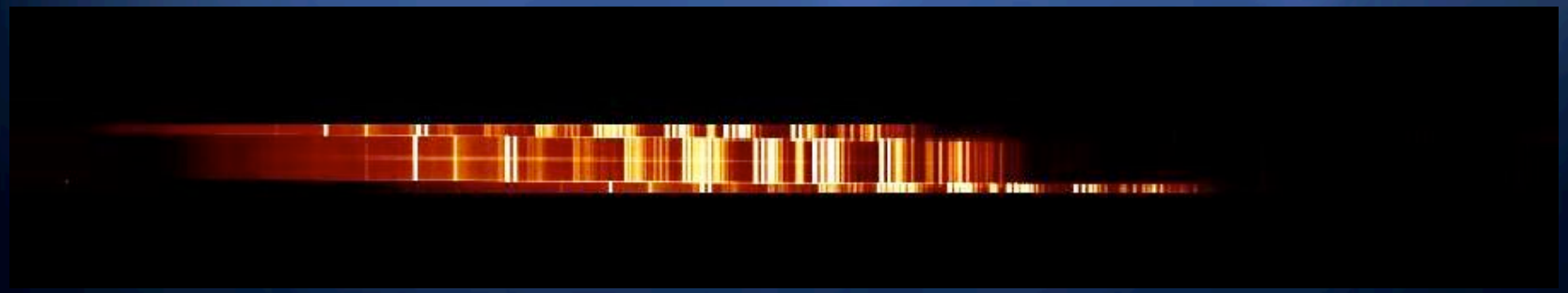
- field of view 7'x7' (2048x2048 pix)
- GRISM GRIS_150I
- MOS MODE (MXU)





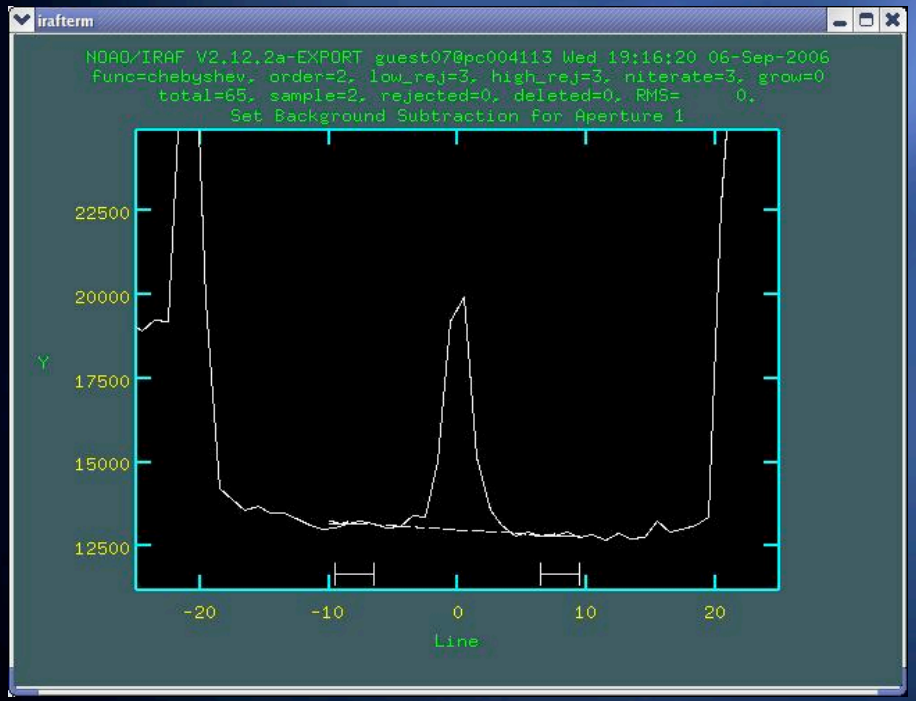
DATA REDUCTION

- bias subtraction
- image combination
- candidates search
  - list a) :12 photometric candidates => 4 have spectra
  - list b) :20 photometric candidates => 3 have spectra
- spectrum of brightest candidate (z = 21.95; **M_z= -17.8 mag**):

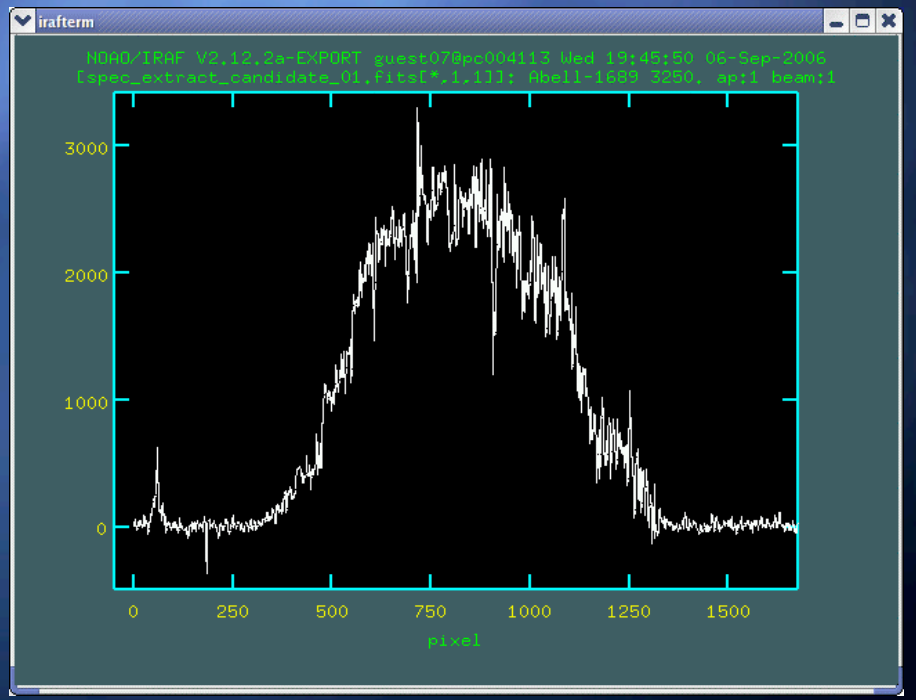


SPECTRA EXTRACTION

spatial cut (y direction):

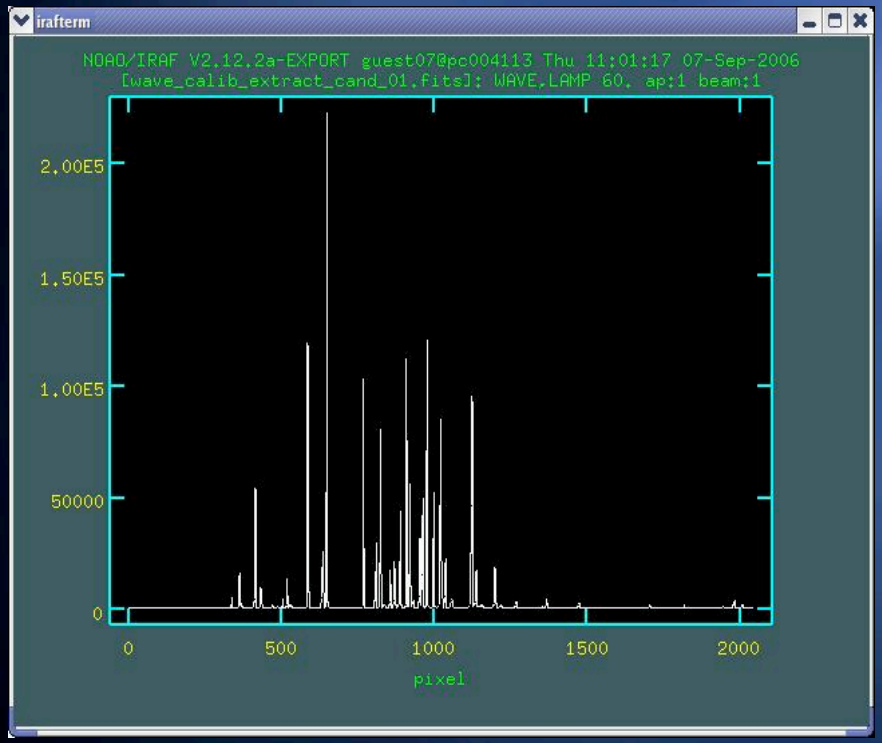


1D spectra:



WAVELENGTH CALIBRATION

extract the 1D spectra from the wavelength calibration lamp spectra using the same trace from the candidate spectra



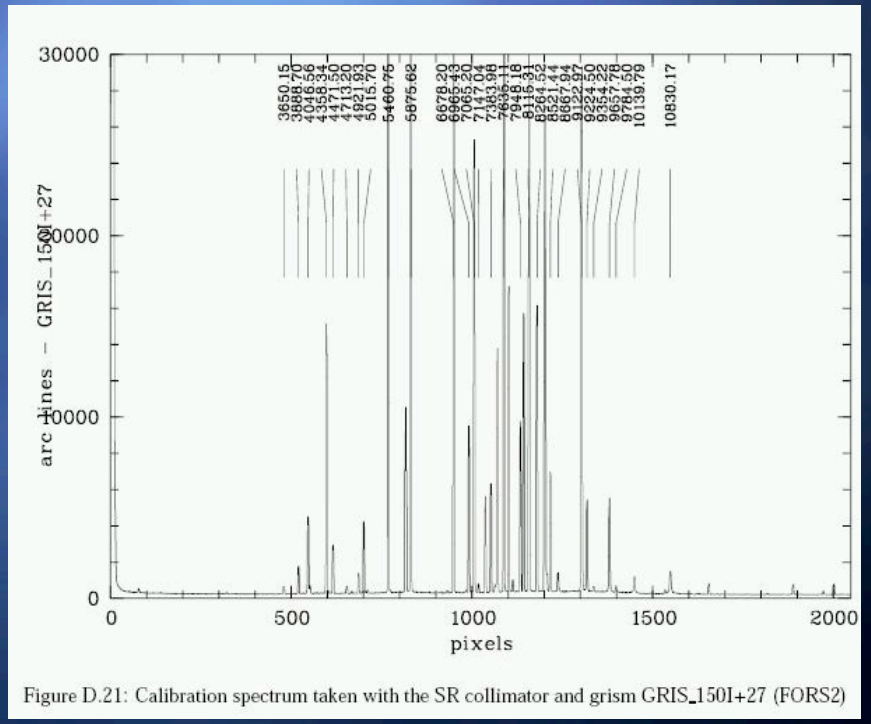
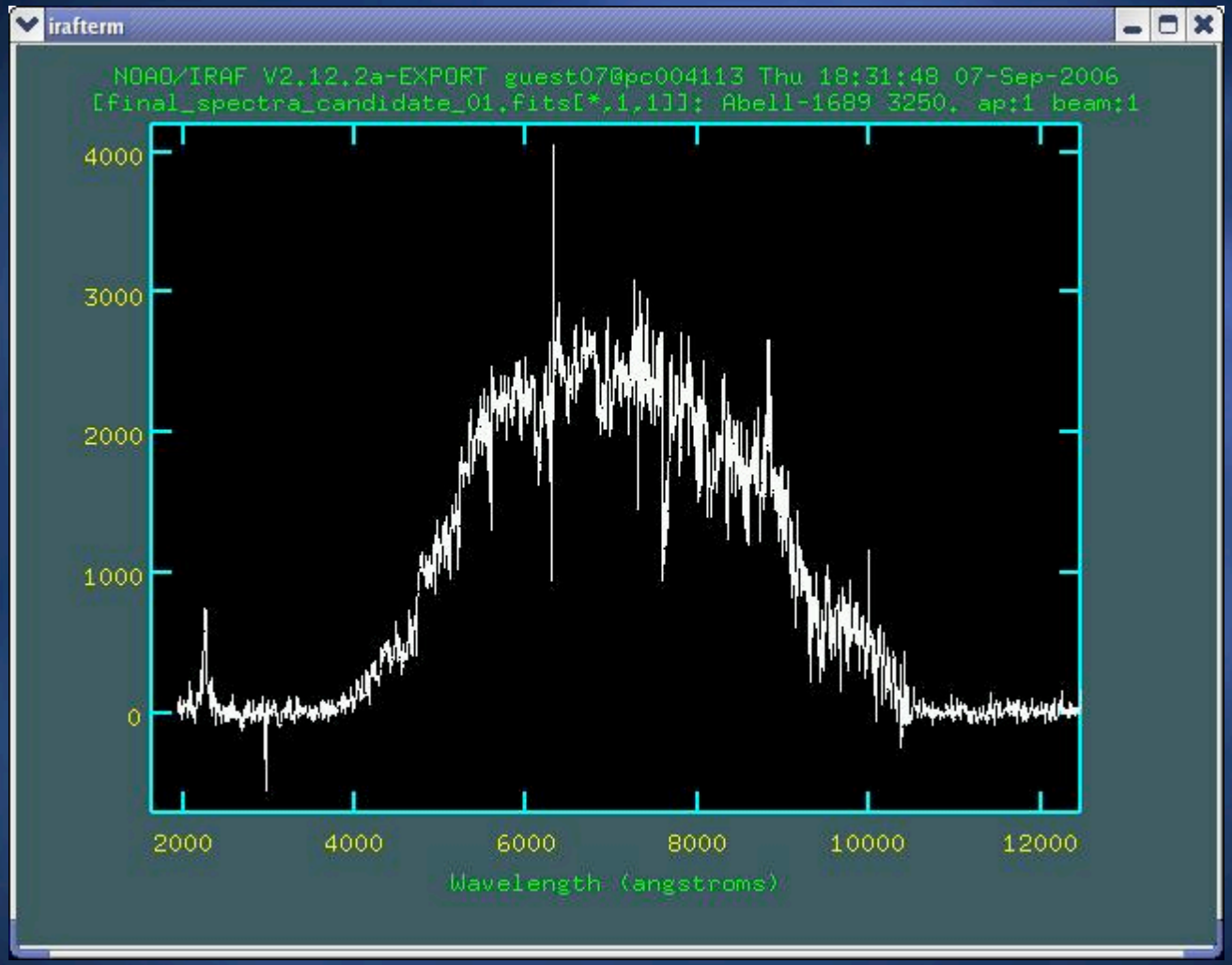


Figure D.21: Calibration spectrum taken with the SR collimator and grism GRIS_150I+27 (FORS2)


irafterm
NOAO/IRAF V2.12.2a-EXPORT guest07@pc004113 Thu 18:31:48 07-Sep-2006
[final_spectra_candidate_01.fits[*,1,1]]: Abell-1689 3250. ap:1 beam:1
4000
3000
2000
1000
0
2000
4000
6000
8000
10000
12000
Wavelength (angstroms)

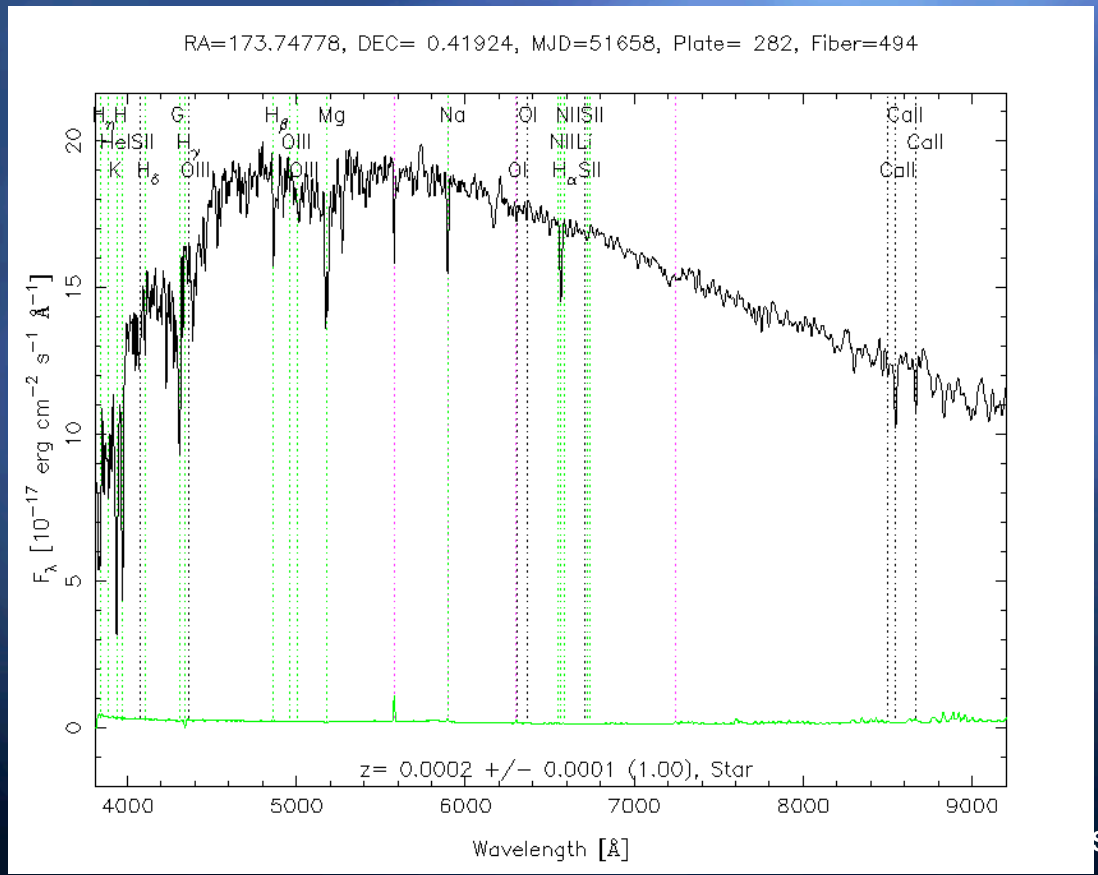
Redshift determination and Results

Spectroscopic Redshift determination

locate the prominent H&K break

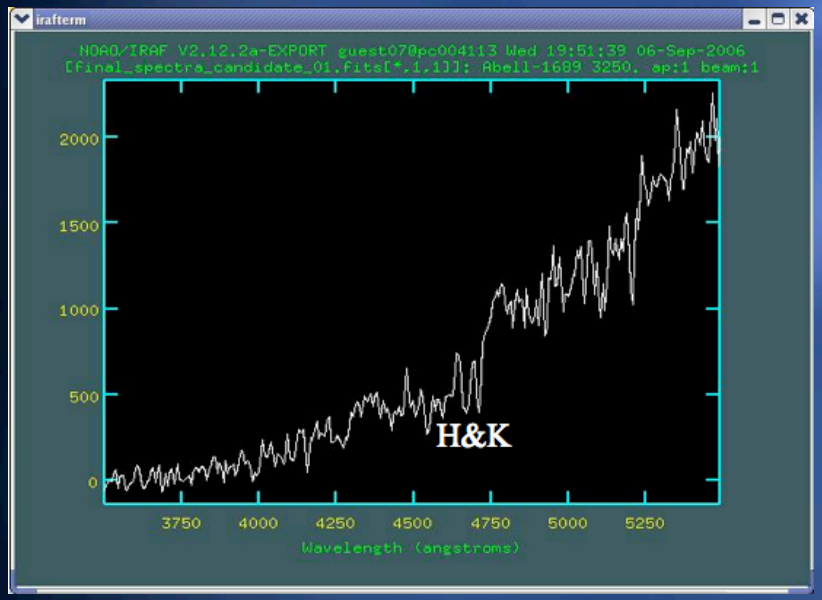
λ_0 for CaK: 3933.663 A

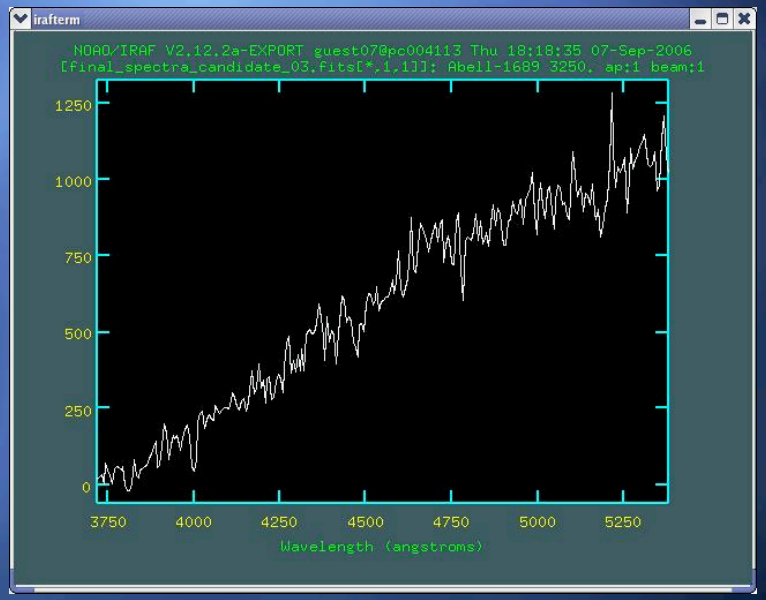
λ_0 for CaH: 3968.468 A



Redshift determination cont.

- measure the center of each of the 2 absorption lines in our calibrated spectra





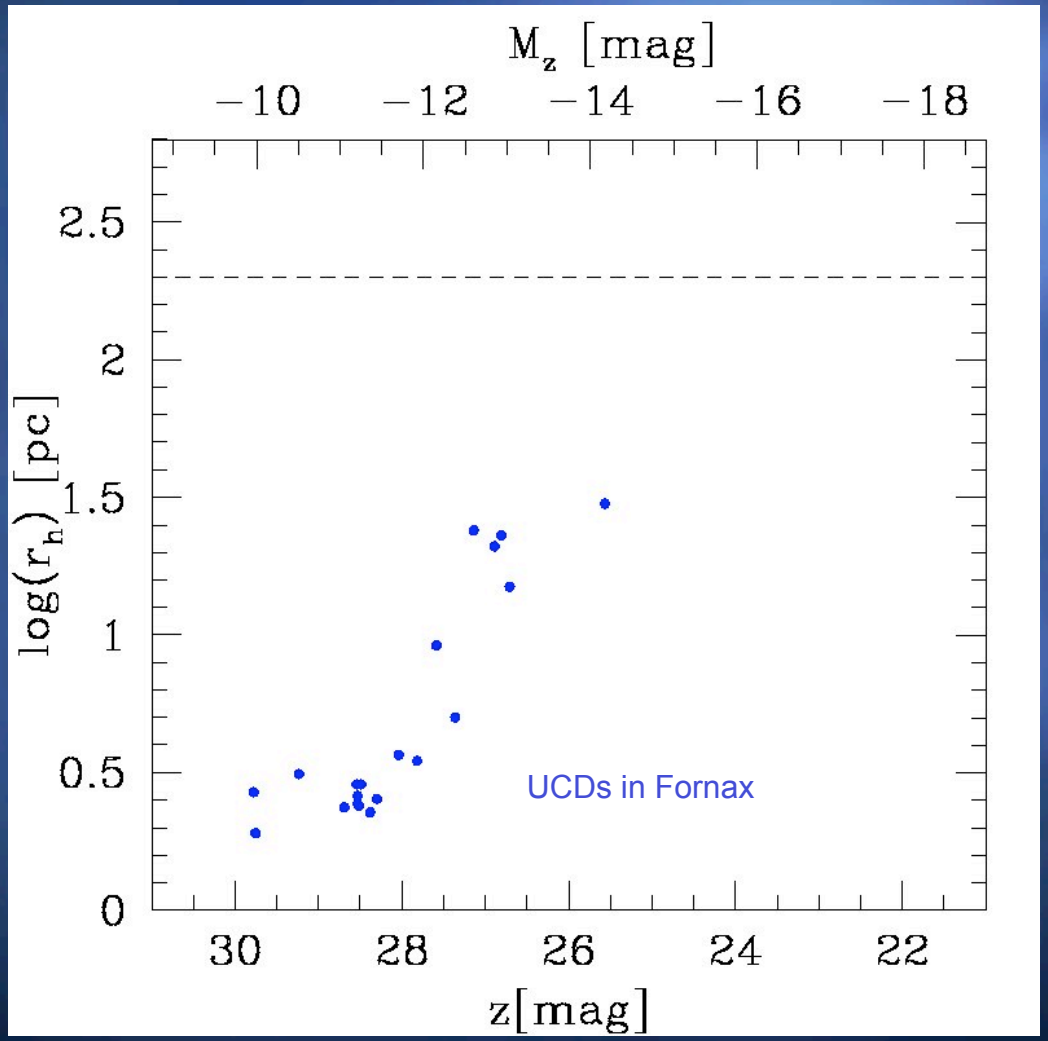
- calculate the redshift:

$$z = \frac{\lambda - \lambda_0}{\lambda_0}$$

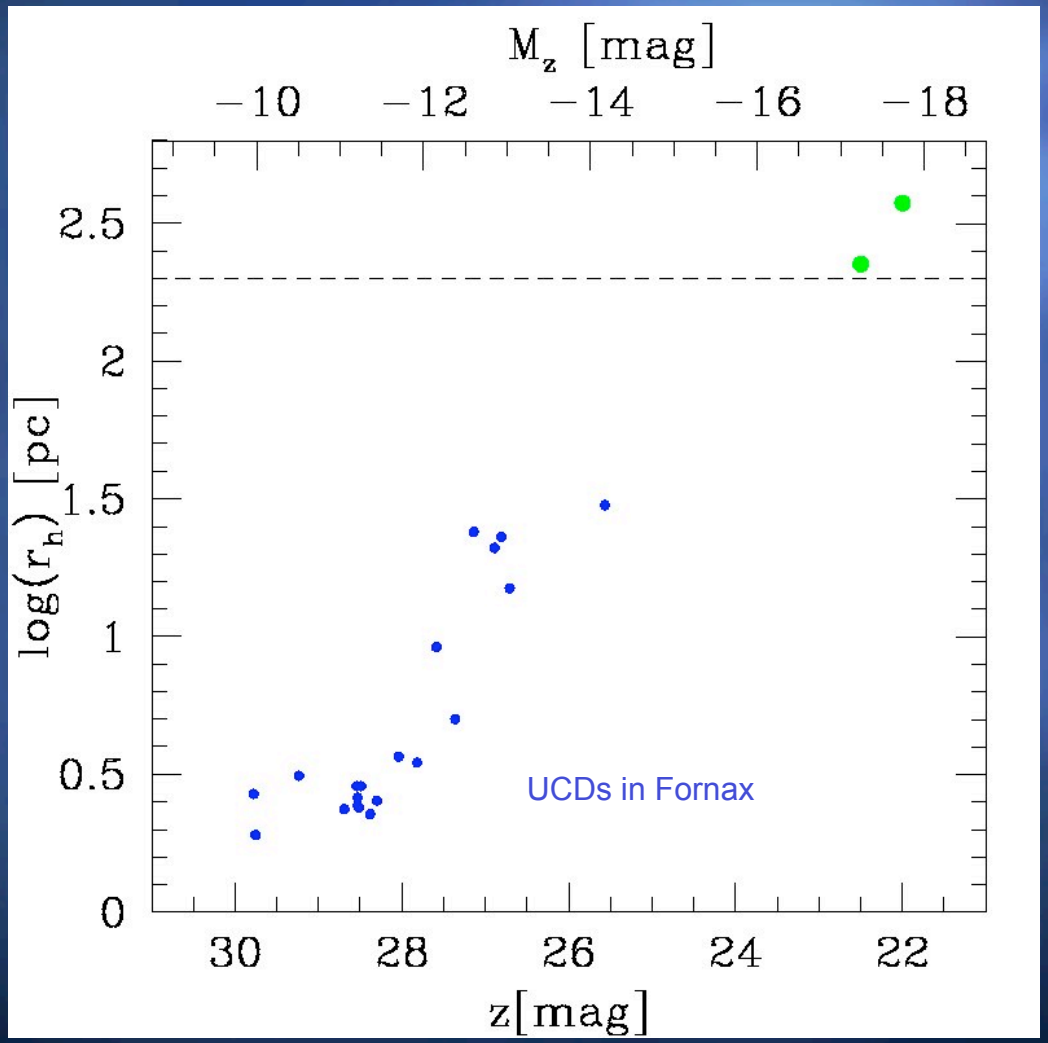
Final results

candidate	13:11:32.56 - 01:19:50.61	13:11:32.91 - 01:19:24.22
redshift	0.18781 ± 0.0003	0.20640 ± 0.0005
M_z	-17.75	-17.25
L_{sun}	$5.0*10^8$	$3.2*10^8$
M_{sun}	$1.5*10^9$	$9.5*10^8$

Luminosity <-> size



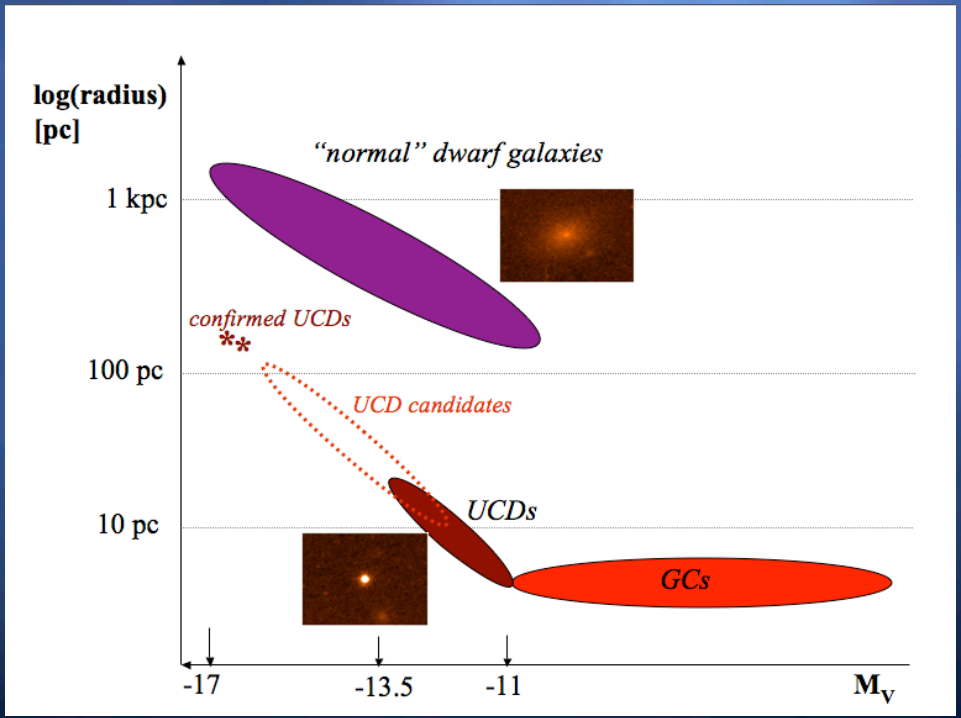
Luminosity <-> size



Summary

We discovered two UCDs with masses ~ 10 times higher than merged star cluster limit in Abell 1689.

Support for galaxian origin of (some) UCDs.



Outlook

Spectroscopic follow up of fainter UCD candidates.