US National Virtual Observatory

Search for fossil groups

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What is a fossil group?

Definition (Jones, 2003):

A luminous elliptical galaxy surrounded by fainter companions, so that the difference in magnitude, in the r band, between the elliptical galaxy and the next brightest companion is larger than 2 mag. The system has to be related to an extended X-ray source.

But… why fossil?

Old systems, elliptical galaxy formed by mergers

Scientific Motivation

Fossil Groups are most likely to be the last stage of galaxy groups dynamical evolution

Study the properties of these groups, using X-ray luminosity and optical

This fossil group list can be used for proposals, like for Chandra, XMM

Why is this a good VO project?

- Data Mining (as an exploratory science)
- Multi-wavelength search $\Rightarrow$ cross-match between SDSS (optical), Rosat (X-ray), eventually radio (First) – offer a case for follow-up observations
- Possibility to use VO tools, services, and languages like OpenSkyQuery, SQL (or ADQL), IDL, etc

Procedure

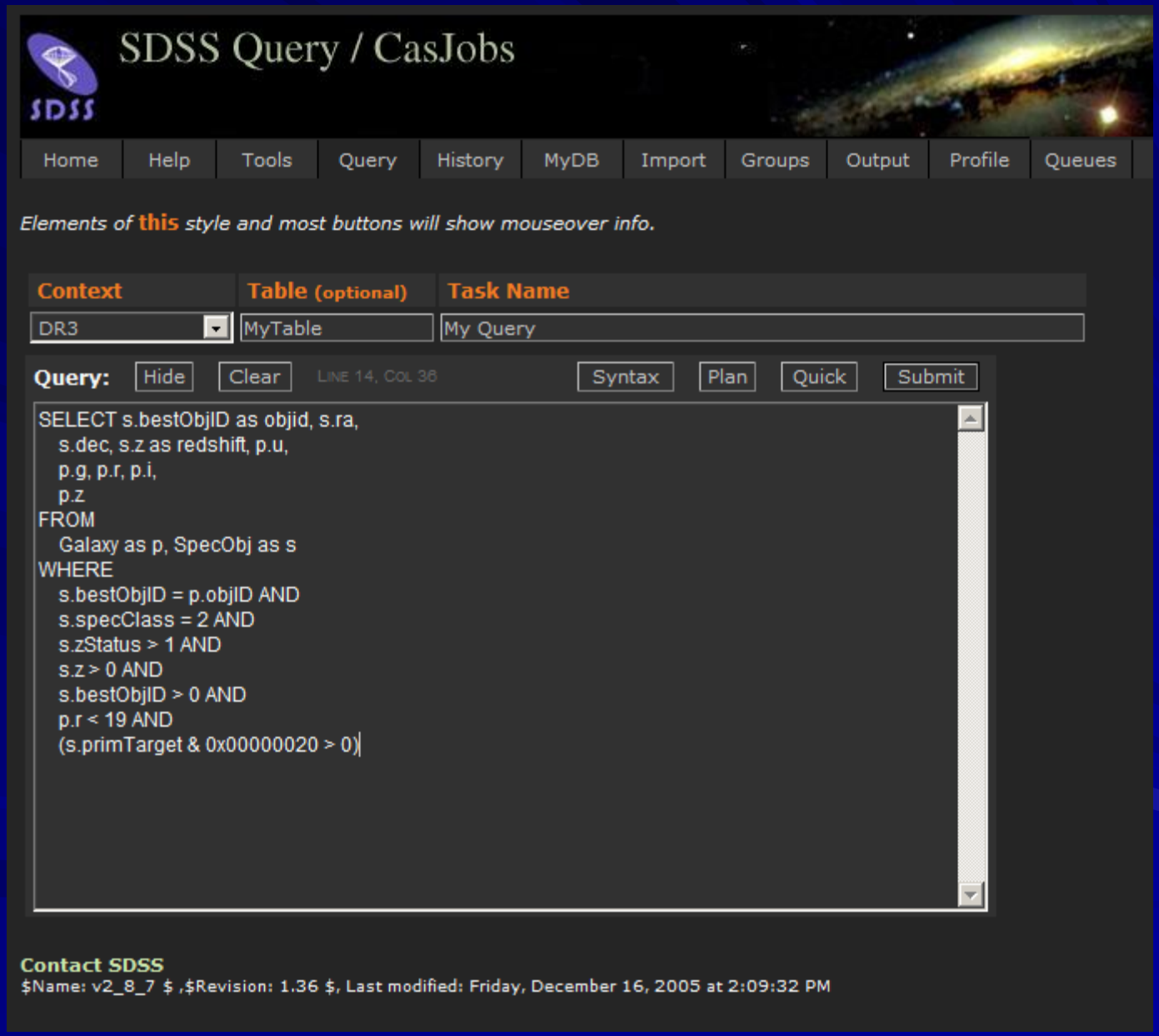
- Selection of elliptical galaxies from SDSS (from the Luminous Red Galaxies catalog)
- Cross-match with Rosat (only extended source) using OpenSkyQuery
- Cone search, 0.5 Mpc around the elliptical, to find the neighbors
- Constrain the neighbors using photometric redshift - check if they form a group with the elliptical
- Check the photometric condition to be a fossil, in the R band:

$M_1 - M_i > 2$

- Get information about the elliptical galaxies, group members, images, etc

SQL Statements in SDSS SkyServer to select elliptical galaxies

```
SELECT s.bestObjID as objid, s.ra,
   s.dec, s.z as redshift, p.u,
   p.g, p.r, p.i,
   p.z
FROM
   Galaxy as p, SpecObj as s
WHERE
   s.bestObjID = p.objID AND
   s.specClass = 2 AND
   s.zStatus > 1 AND
   s.z > 0 AND
   s.bestObjID > 0 AND
   p.r < 19 AND
   (s.primTarget & 0x00000020 > 0)
```


SDSS Query / CasJobs
SDSS
Home
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Profile
Queues
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Context
Table (optional)
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My Query
Query:
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Syntax
Plan
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Submit
SELECT s.bestObjID as objid, s.ra,
s.dec, s.z as redshift, p.u,
p.g, p.r, p.i,
p.z
FROM
Galaxy as p, SpecObj as s
WHERE
s.bestObjID = p.objID AND
s.specClass = 2 AND
s.zStatus > 1 AND
s.z > 0 AND
s.bestObjID > 0 AND
p.r < 19 AND
(s.primTarget & 0x00000020 > 0)
Contact SDSS
$Name: v2_8_7 $,$Revision: 1.36 $, Last modified: Friday, December 16, 2005 at 2:09:32 PM

ADQL Statement in OpenSkyQuery to cross-match the ellipticals galaxies with ROSAT All-Sky Survey

```
SELECT x.objid, x.ra,
    x.dec, t.*
FROM
    Rosat:PhotoPrimary x, MyData:nvoss_lrgs_1 t
WHERE XMATCH(o, t) < 6 and x.ext > 0
```


Open SkyQuery
Home
Simple Query
Advanced Query
Import
Tutorial
Help
National Virtual Observatory
Nodes
Rosat
XMM
GALEX
DLS
RC3
GSC2
NBCKDEDR1
SDSS
SDSSDR2
SDSSDR3
TwoDf
Twoqz
TWOSLAQLRGEDR
TWOSLAQQSOEDR
USNOB
GOODS
HDFN
HDFS
UDF
TWOMASS
IRAS
PSCz
FIRST
NVSS
NDWFS
Tycho-2
Build
Edit
Submit
SELECT x.objid, x.ra,
x.dec, t.*
FROM
Rosat:PhotoPrimary x, MyData:nvoss_lrgs_1 t
WHERE XMATCH(o, t) < 6
Welcome to the Open SkyQuery interactive query builder. You should see a parsed, clickable version of your entered query in the pane directly above this one.
If instead you see 'Query is empty', this means that builder needs a node or two to get started. You can add nodes to the builder by clicking the desired node's '+' icon in the left panel.
Once you have some sql in the above panel, you can then click on a token in that query to pull up a menu with options appropriate for that specific token. For example, one way to select an additional column from a mythical 'mytable' is to click on 'mytable' and then chose 'Add Selection', then pick the desired column from the given choices.
You can switch between 'edit' and 'build' modes at any time by using the tabs at the top of the query panel. Your changes from one will carry over to the other. Most menu options have additional mouse-over info.
Sample Queries
XMatch/Region
XMatch/Region 2
Three Node Match
Brown Dwarf Search
MyData XMatch (upload)
Xmatch t.* (upload)
ABELL Xmatch (upload)
Single Node Query
Single Node Join

Selection of fossil groups candidates

1) Cone search for each candidate with a 0.5 Mpc radius
2) Select the neighbors at the same redshift, using the uncertainty of the photometric redshifts as a range
3) Check the photometric condition to be a fossil, in the R band: M1 - Mi > 2

All these were done using SQL

Results

18 fossil groups candidates were found

id	objid	ra	dec	redshift	r	
3123	587725504484999394	259.5498	56.6656	0.1136	15.27	RBS 1636 (GC)
3794	587725575890403517	262.2173	55.2780	0.1484	16.71	no GC
4461	587725818021281956	167.7928	66.8339	0.1358	15.97	ZwCl 1107.4+6705
10422	587728679540949087	179.9079	65.7602	0.1219	16.11	no GC
11051	587728930270150821	138.0766	48.5125	0.1171	15.79	ABELL 0756
11503	587728950125985894	160.7607	0.9051	0.1255	15.97	VN2000
13715	587729752205361158	246.6772	42.6699	0.1871	16.21	ABELL 2192
13775	587729752213815608	260.0418	26.6256	0.1593	15.44	RBS 1639
13842	587729772070502682	203.9999	-3.5248	0.1765	15.84	no GC
14985	587730774425469132	359.5630	15.0955	0.1784	16.08	no GC
21332	587732591182938292	201.4573	59.3302	0.1510	15.62	ABELL 1744
23179	587733398637510816	223.4959	48.4048	0.1462	15.87	no GC
23195	587733398640787656	232.4429	44.1345	0.1478	15.77	NSCS J152950+440804 (z=0.23)
30027	588010880367722656	175.3679	5.9749	0.1878	16.03	no GC
31766	588015507682230355	53.5671	-1.1915	0.1387	15.57	SDSS CE J053.569244-01.187724, [SBV2004] RS 71
32591	588017603619258482	211.4349	40.8547	0.0688	14.99	no GC
32901	588017626701103211	212.5175	41.7558	0.0938	14.66	NSC J141011+414538
33345	588297863105937581	137.5961	35.4342	0.1885	16.59	ABELL 0752

Display Generation

1) Use skyview.jar called by IDL to get 300 x 300 pixel images.

```
pro get_survey_data, ra, dec, scale, survey, header, image
;+
;  get_survey_data, ra, dec, scale, header, image
;
; INPUTS:
;               ra,dec - RA and declination in degrees
;               scale - pixel scale (degress)
;               survey - survey (eg 'sdssg','vla first (1.4 ghz)')
; OUTPUTS:
;               header, image – FITS header and 2-D image
;-
               cmd = 'java -jar skyview.jar sampler=Clip survey="' + $
                              survey+'" position="'+ $
                              strtrim(ra,2)+','+strtrim(dec,2)+'" scale='+strtrim(scale,2)
               spawn, cmd
               fits_read, 'output.fits', image,header
end
```

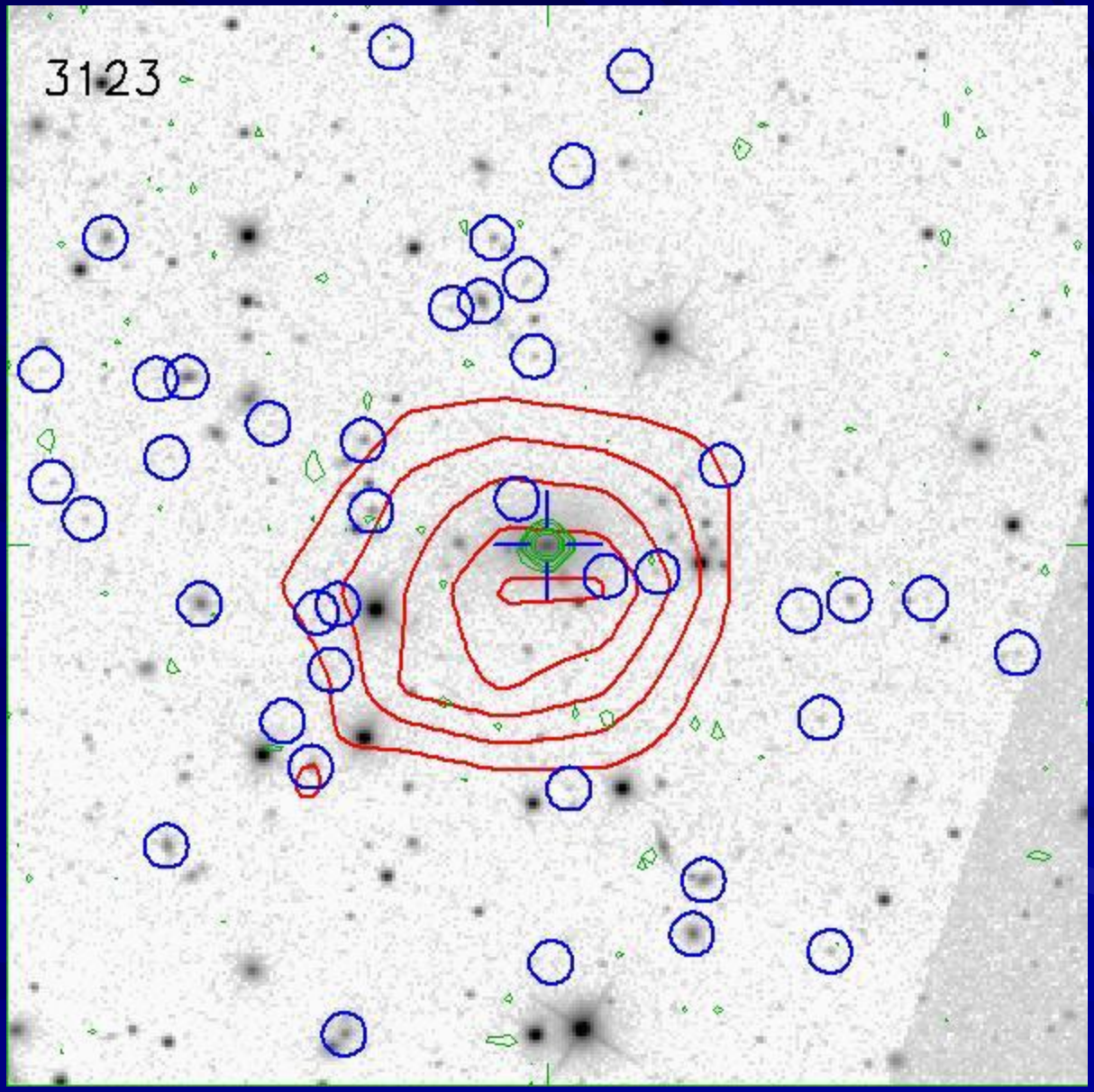
2) Use IDL Astronomy library routine to compute distance in megaparsecs and angle on the sky to get images that are one megaparsec square

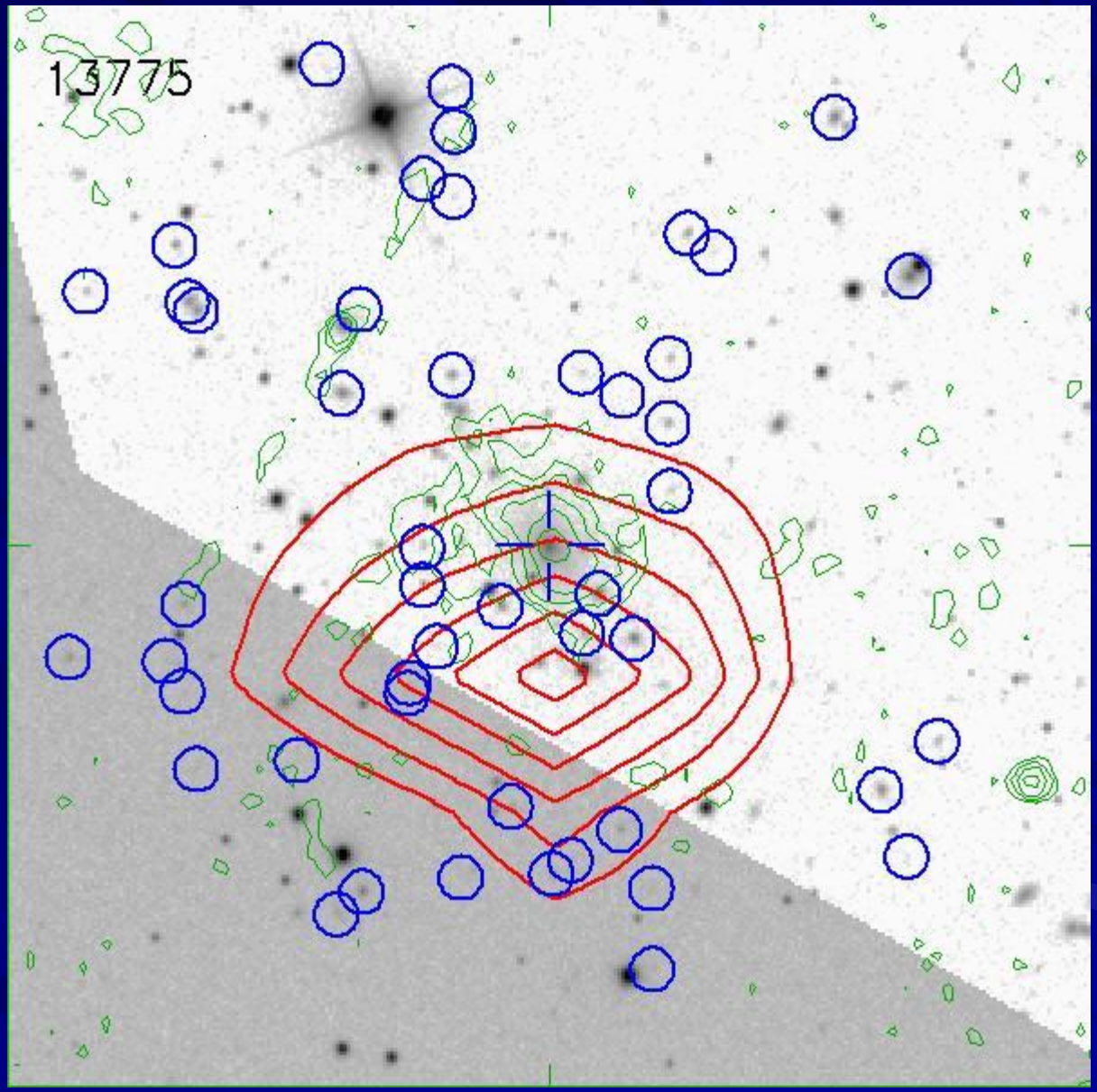
```
lumd = lumdist(redshift[i])
angle = atan(1.0, lumd)* !radeg      ;degrees on sky
scale = angle/300.0                  ;degress/pixel

get_survey_data, ra, dec, scale, 'rass-cnt broad', h_rosat, d_rosat
get_survey_data, ra, dec, scale, 'sdssg', h_sdss, d_sdss
get_survey_data, ra, dec, scale, 'vla first (1.4 ghz)', h_first, d_first
```

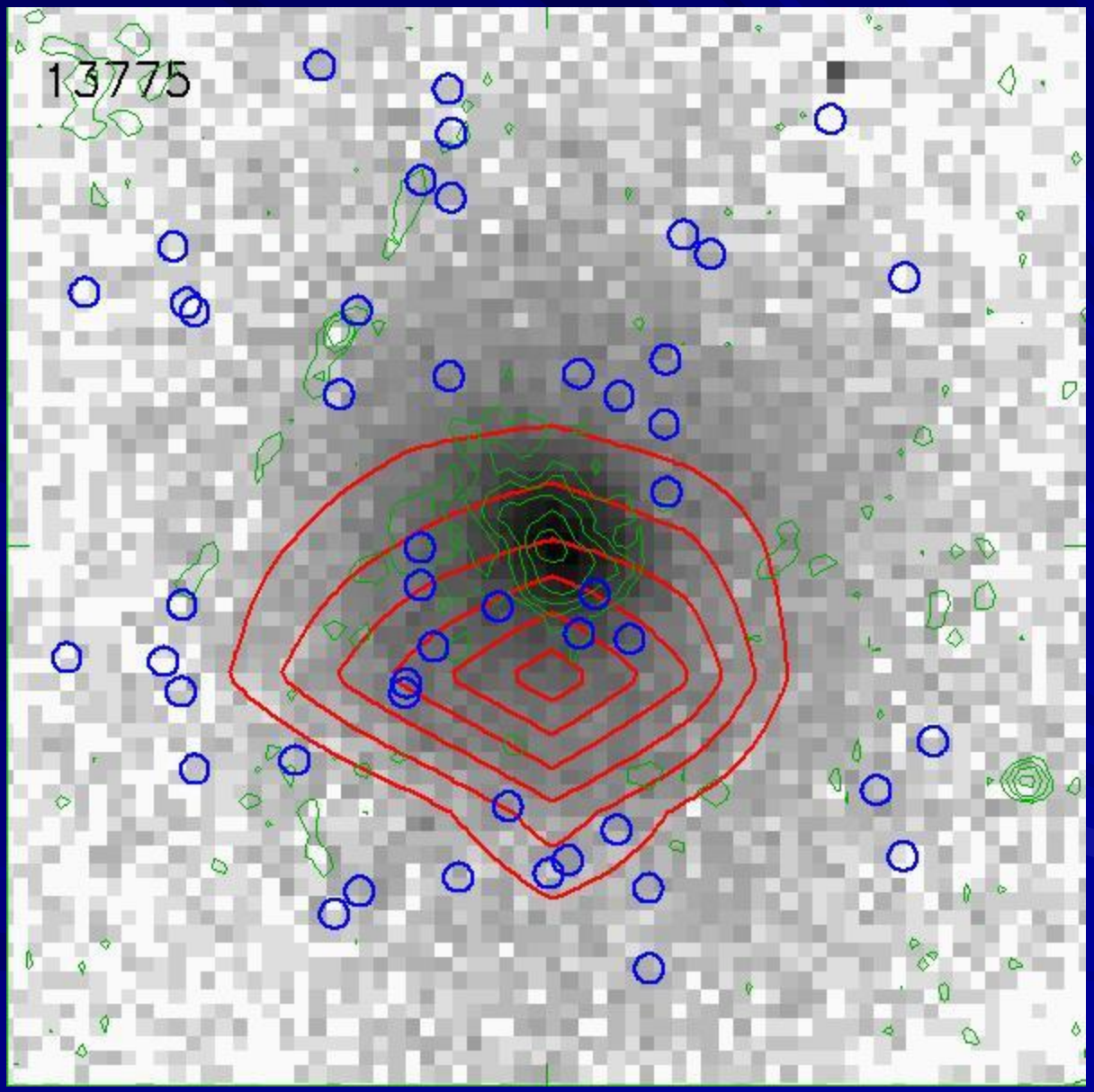
3) Display SDSS G image with ROSAT data overlayed as red contours and the VLA First data as green contours using IDL graphic routines.

4) Convert the member galaxies to image location using IDL astronomy library astrometry routines and overplot as blue circles.

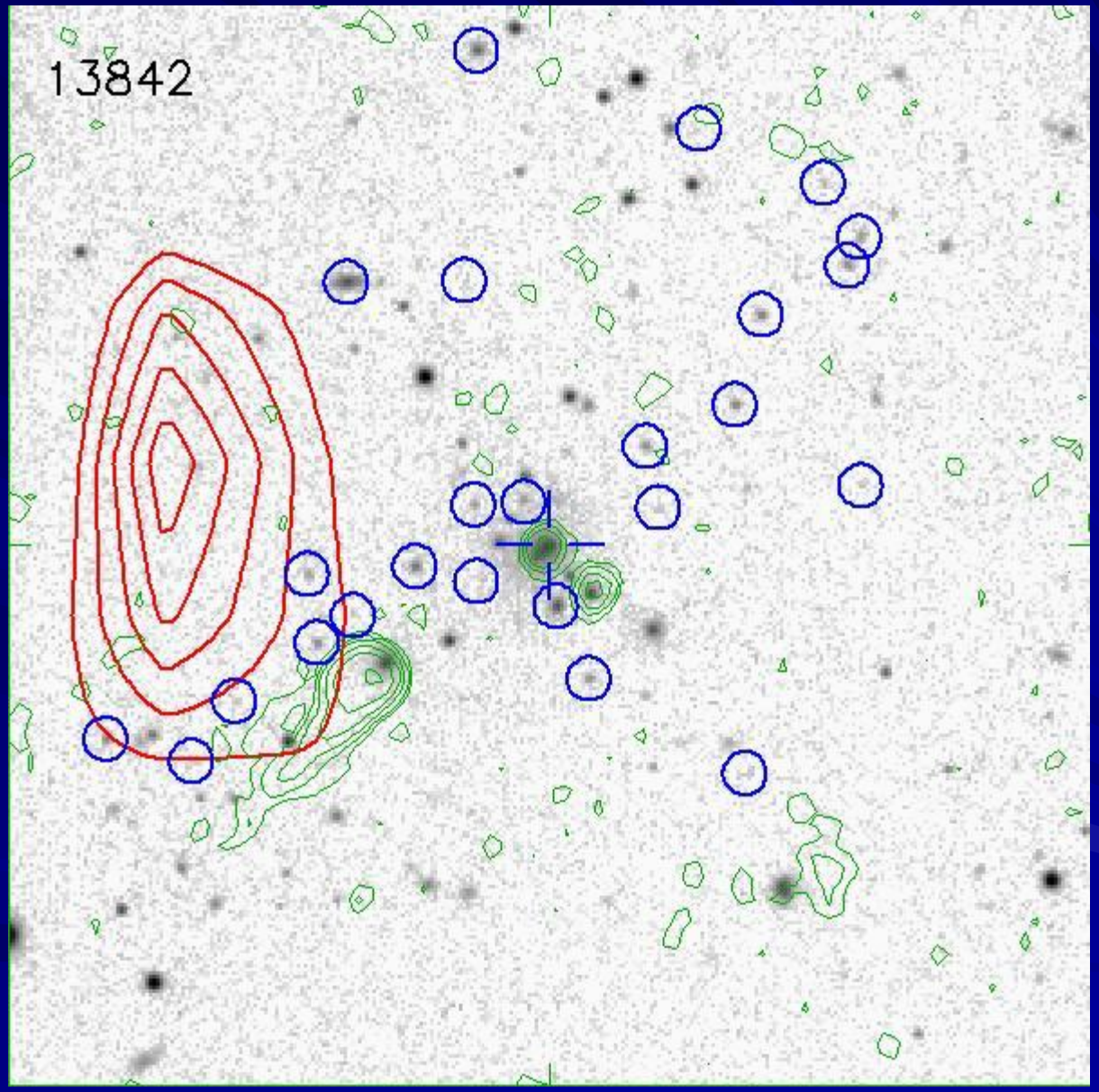
```
extast, h_sdss, astr                ;extract astrometry info from header
ad2xy, mra, mdec, astr, xpos, ypos
plotsym, 0, thick=2
plots, xpos*2, ypos*2, psym=8, color=4, symsize=3, /dev
```

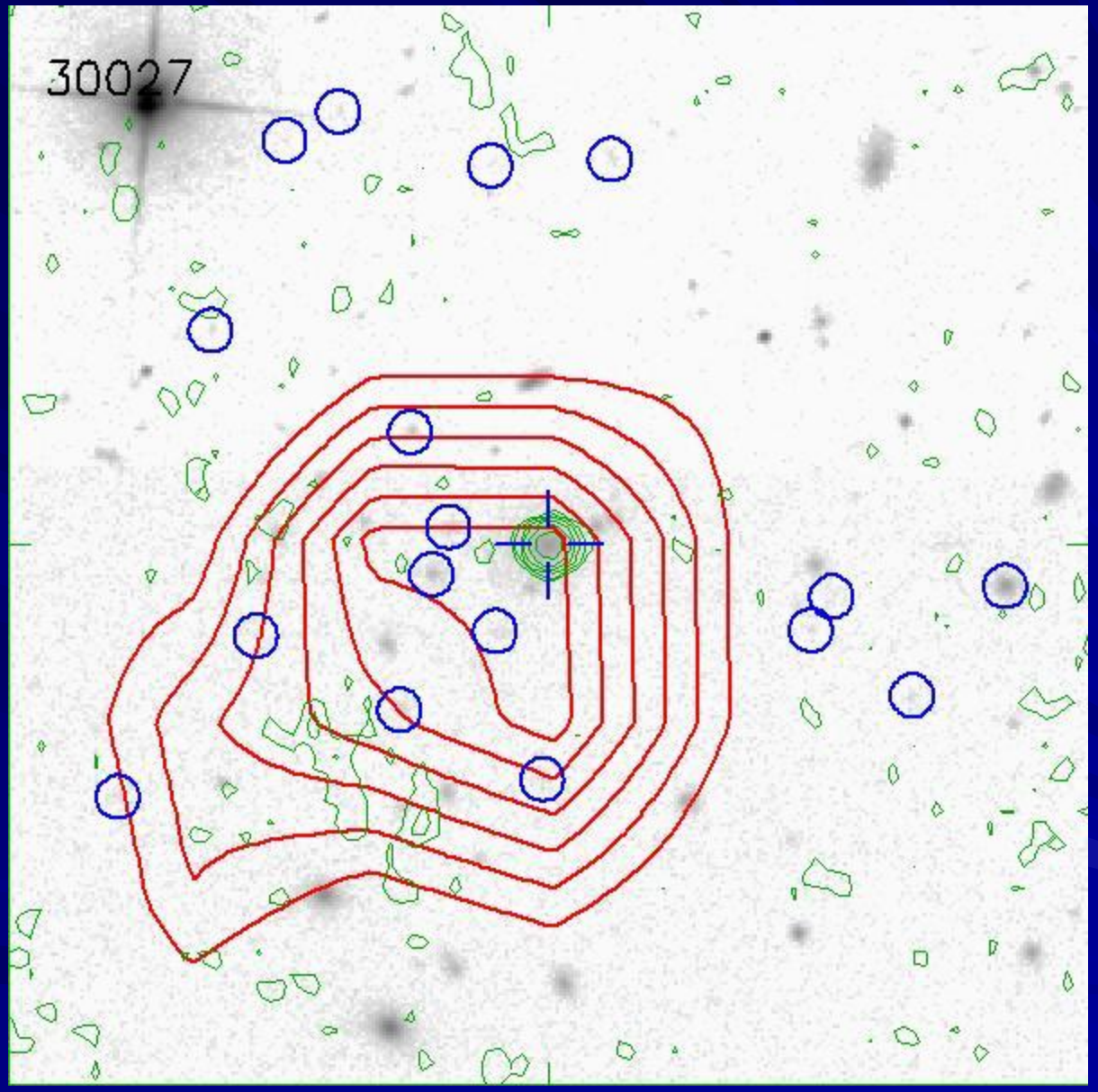

3123

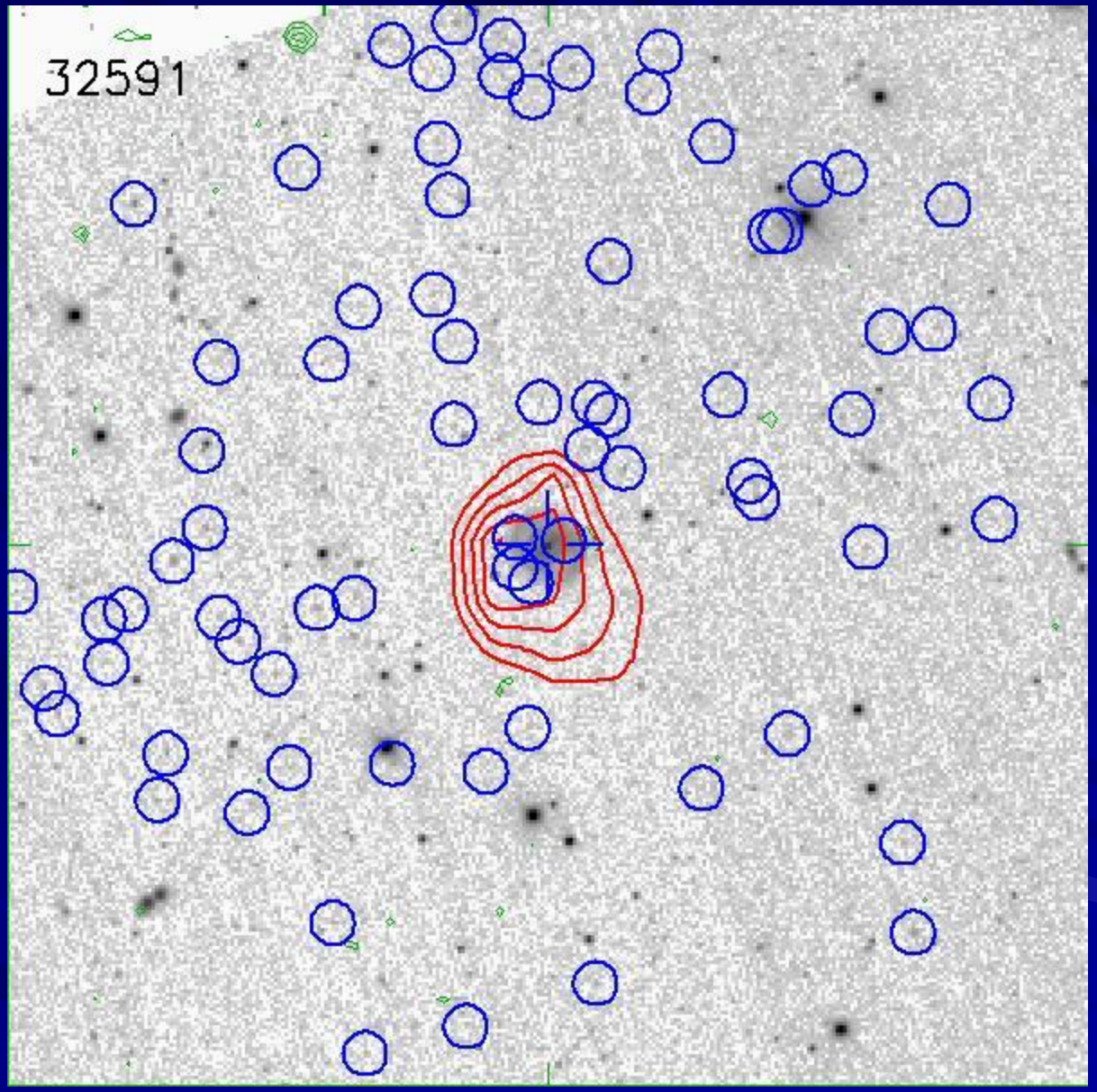

13775

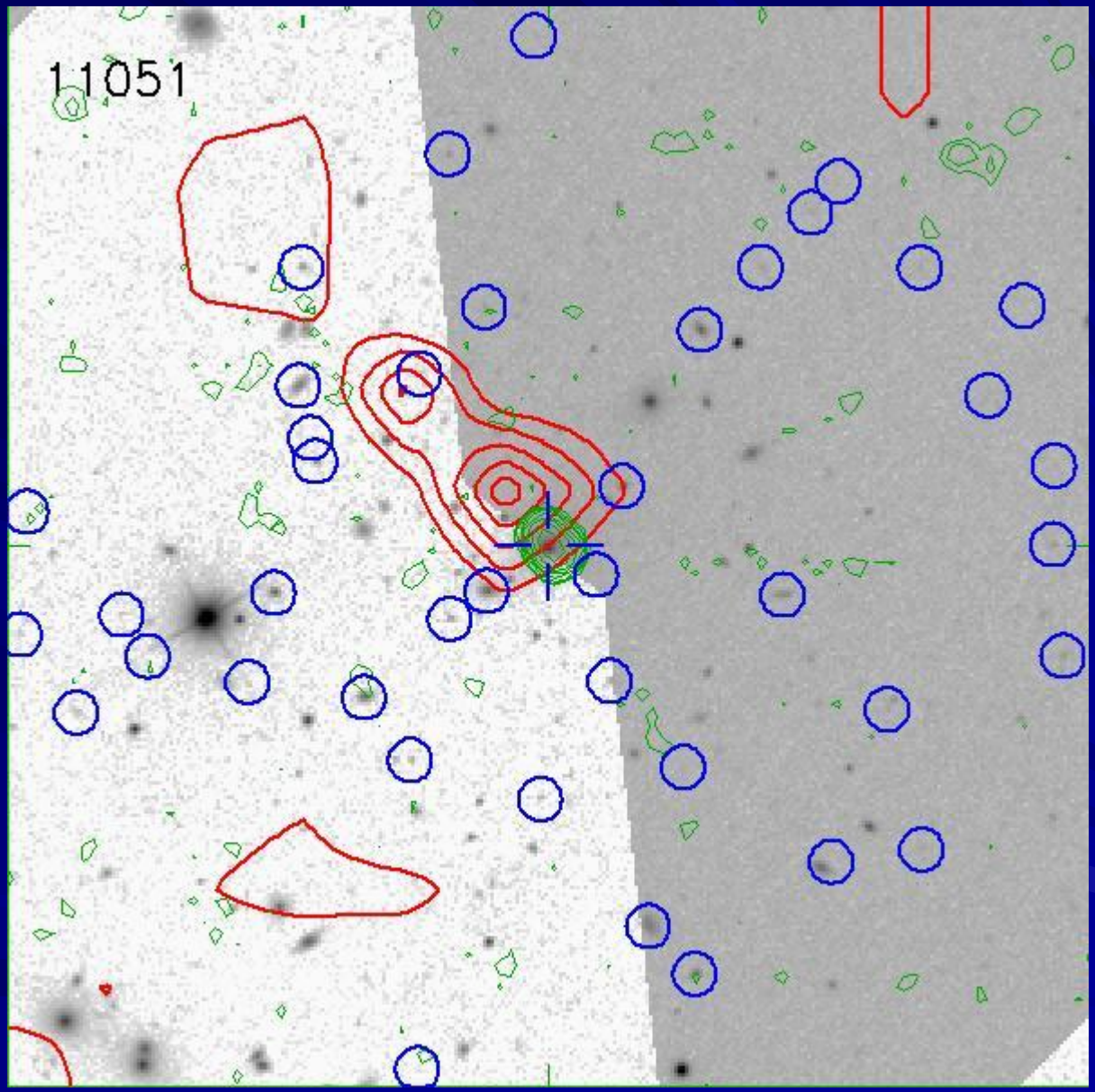


Chandra image

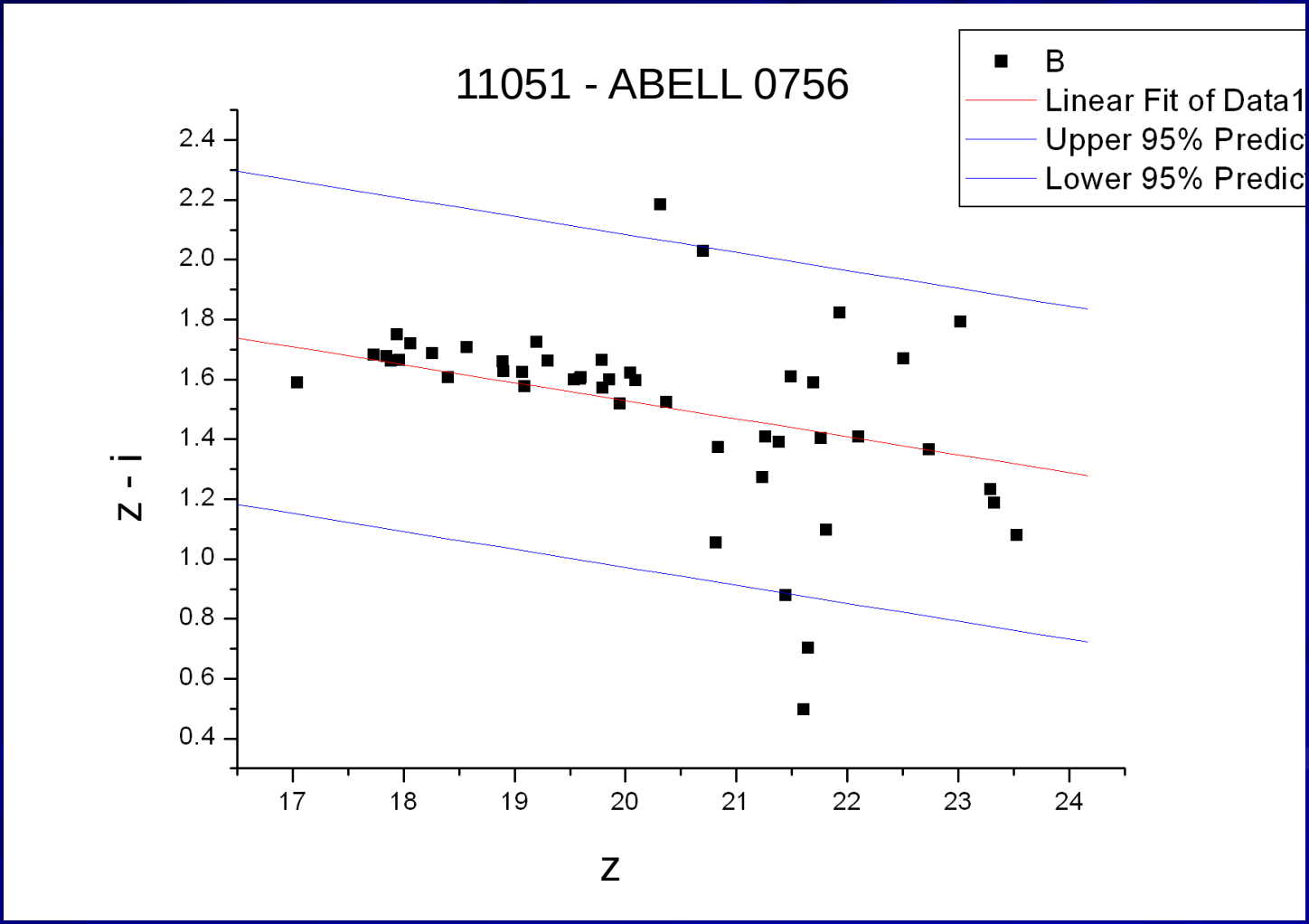

13842


30027


32591


11051

Analysis of the members



Discussion

- Selection by using bit flags in SDSS database
- Photometric redshift in SDSS available for DR5, but OpenSkyQuery has up to DR3
- Nevertheless, one can use SDSS SQL Server (Casjobs) and OpenSkyQuery

Conclussions

- VOs provide the new platform for astronomical research
- NVO Technologies enable astronomers to explore large data sets efficiently.
- We have defined a new sample of Fossil Groups
- We are currently undertaken follow up observations with XMM, Gemini and the 2.1m at the Observatorio Astronómico Nacional in Baja California, México.

References

Jones L.R., Ponman T.J., Horton A., et al., 2003, MNRAS, 343, 627

Mendes de Oliveira, C., Cypriano, E.S., & Sodré, L. Jr., 2006, AJ 131, 158