Recovering Isolated Galaxies from Large Scale Surveys: Problems & Strategies

Juan de Dios Santander-Vela (IAA-CSIC)

AMIGA Project

Galaxies in Isolation: Nature vs. Nurture — Granada, May 12th 2009

Talk Outline

- ☐ Motivation
- ☐ Implementing the KIG isolation criterion: SDSS
- ☐ Problems & Strategies
- ☐ Conclusions & Future Work

Motivation

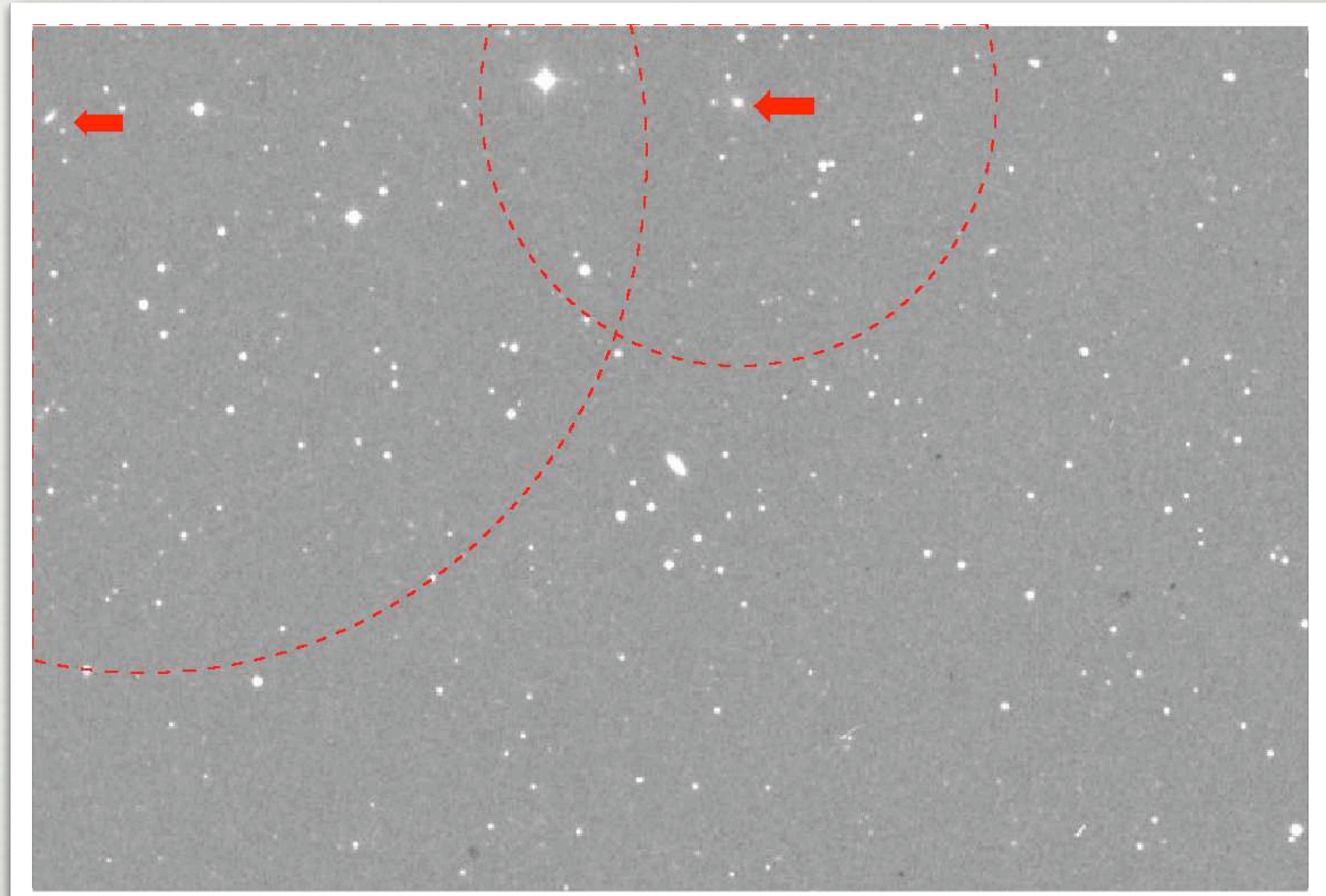
AMIGA

KIG: Karatchenseva's Isolated Galaxies

- KIG73: Karatchenseva's Isolated Galaxies catalogue, 1973
- Remember previous talk by Simon Verley on Isolation of CIG galaxies
- Simple isolation criterion:

$$D_p/4 \leq D_i \leq 4\,D_p, \quad R_{ip} \geq 20 \times D_i$$

KIG: Karatchenseva's Isolated Galaxies



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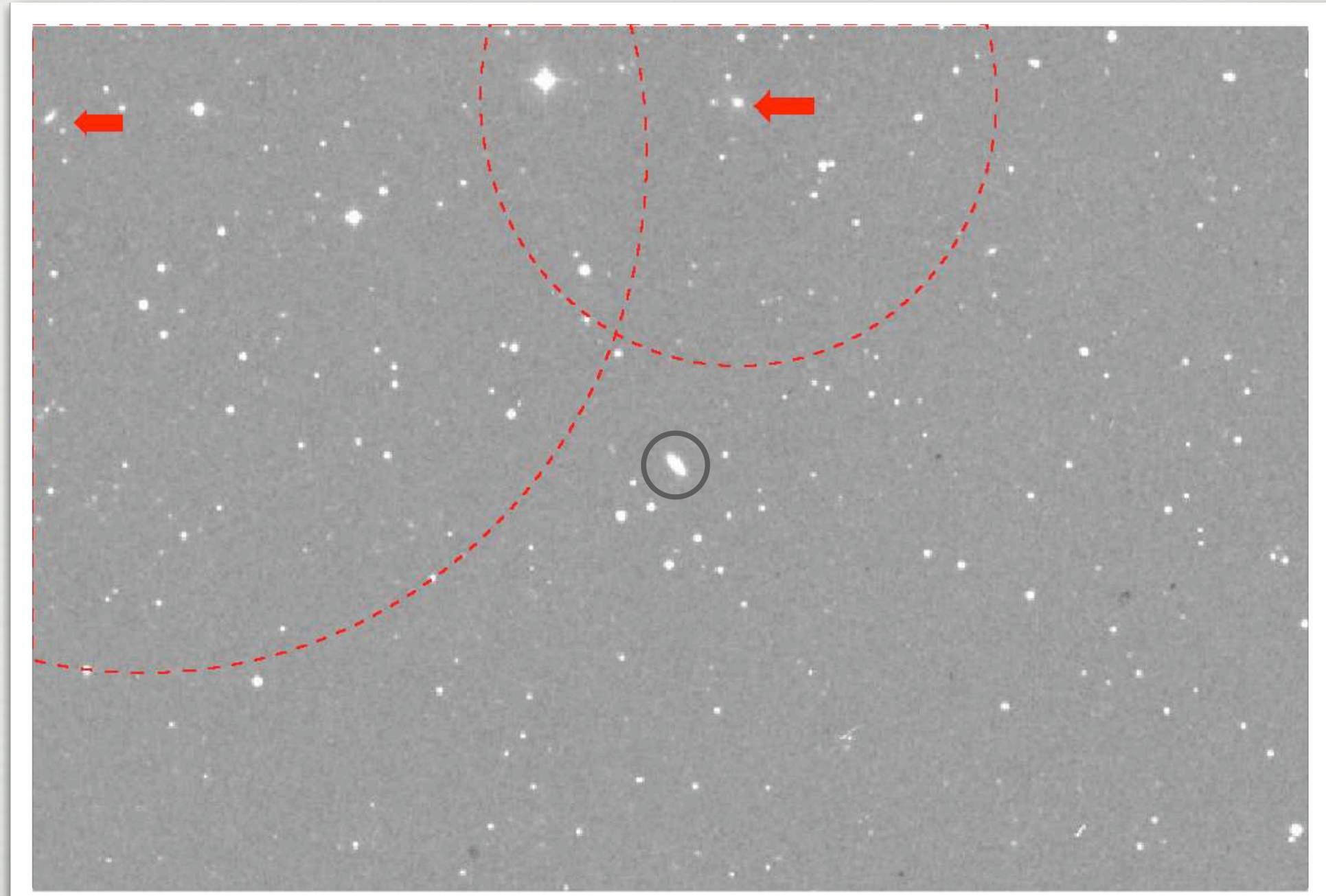

KIG: Karatchenseva's Isolated Galaxies

- Catalogue created from POSS-I plates
  - SDSS has higher resolution, depth
- Automatic object detection pipeline
  - Star/galaxy rejection evaluation
  - Geometrical parameters (petrosian, isophotal radii)
  - Further spectroscopic observations

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We want to reproduce automatically a KIG-like criterion

Implementing the KIG Isolation Criterion

Antecedents

Draft: December 8, 2007

A Catalog of Very Isolated Galaxies from the SDSS Data Release 1

Sahar S. Allam[1,2], Douglas L. Tucker[2], Brian C. Lee[3], J. Allyn Smith[4,5]

ABSTRACT

We present a new catalog of isolated galaxies obtained through an automated systematic search. These 2980 isolated galaxies were found in ≈ 2099 deg^2 of sky in the Sloan Digital Sky Survey Data Release 1 (SDSS DR1) photometry. The selection algorithm, implementing a variation on the criteria developed by Karachentseva in 1973, proved to be very efficient and fast. This catalog will be useful for studies of the general galaxy characteristics. Here we report on our results.

Subject headings: surveys — catalogs — atlases

1. Introduction

Over the past few decades, observational and theoretical work has shown that truly isolated "field" galaxies, if they exist at all, are a rarity in the universe, comprising less than 5% of all galaxies (Adams, Jensen & Stocke 1980). Rare though they may be, they serve as an important comparison sample in studies of the effects of environment on galaxy morphologies and star formation rates (e.g., Adams, Jensen & Stocke 1980; Haynes & Giovanelli 1980; Haynes, Giovanelli & Chincarini 1984; Koopmann & Kenney 1998). Truly isolated galaxies, which may have experienced no major interactions in billions of years, can act as a zeropoint in these studies.

Furthermore, isolated galaxies are interesting in their own right. Recent studies of isolated galaxies include those by Aars (2002, 2003), who looked at the photometric and spectroscopic properties of extremely isolated elliptical galaxies in the Karachentseva (1973) catalog; Pisano et al. (2002) and Pisano & Wilcots (2003), who performed an H I survey for the gaseous remnants of the galaxy formation process around nearby ($\lesssim 30h^{-1}$ Mpc) isolated galaxies they identified in

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[4]Los Alamos National Laboratory, NIS-4, MS D448, Los Alamos, NM 87544-1724

[5]University of Wyoming, Dept. of Physics & Astronomy, P.O.Box 3905, Laramie, WY 82071

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MegaZ-LRG: a photometric redshift catalogue of one million SDSS Luminous Red Galaxies

Adrian Collister[1], Ofer Lahav[2⋆], Chris Blake[3,4], Russell Cannon[5], Scott Croom[5], Michael Drinkwater[6], Alastair Edge[7], Daniel Eisenstein[8], Jon Loveday[9], Robert Nichol[10], Kevin Pimbblet[6], Roberto De Propris[11], Isaac Roseboom[6], Nic Ross[7] , Donald P. Schneider[12], Tom Shanks[7], David Wake[7]

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[2] *Department of Physics & Astronomy, University College London, Gower Street, London WC1E 6BT, UK*
[3] *Department of Physics & Astronomy, University of British Columbia, 6224 Agricultural Road, Vancouver, B.C., V6T 1Z1, Canada*
[4] *Centre for Astrophysics & Supercomputing, Swinburne University of Technology, P.O.Box 218, Hawthorn, VIC 3122, Australia*
[5] *Anglo-Australian Observatory, PO Box 296, Epping, NSW 1710, Australia*
[6] *Department of Physics, University of Queensland, Brisbane, QLD 4072, Australia*
[7] *Department of Physics, University of Durham, South Road, Durham DH1 3LE, UK*
[8] *Steward Observatory, University of Arizona, 933 N. Cherry Ave, Tucson, AZ 85721, USA*
[9] *Astronomy Centre, University of Sussex, Falmer, Brighton BN1 9QJ, UK*
[10] *Institute of Cosmology and Gravitation, University of Portsmouth, Portsmouth PO1 2EG, UK*
[11] *Cerro Tololo Inter-American Observatory, Casilla 603, La Serena, Chile*
[12] *Department of Astronomy & Astrophysics, The Pennsylvania State University, 525 Davey Laboratory, University Park, PA 16802, USA*

ABSTRACT

We describe the construction of MegaZ-LRG, a photometric redshift catalogue of over one million luminous red galaxies (LRGs) in the redshift range $0.4 < z < 0.7$ with limiting magnitude $i < 20$. The catalogue is selected from the imaging data of the Sloan Digital Sky Survey Data Release 4. The 2dF-SDSS LRG and Quasar (2SLAQ) spectroscopic redshift catalogue of 13,000 intermediate-redshift LRGs provides a photometric redshift training set, allowing use of ANNz, a neural network-based photometric-redshift estimator. The rms photometric redshift accuracy obtained for an evaluation set selected from the 2SLAQ sample is $\sigma_z = 0.049$ averaged over all galaxies, and $\sigma_z = 0.040$ for a brighter subsample ($i < 19.0$). The catalogue is expected to contain ∼5 per cent stellar contamination. The ANNz code is used to compute a refined star/galaxy probability based on a range of photometric parameters; this allows the contamination fraction to be reduced to 2 per cent with negligible loss of genuine galaxies. The MegaZ-LRG catalogue is publicly available on the World Wide Web from `http://www.2slaq.info`.

Key words: surveys - catalogues - galaxies: distances and redshifts - cosmology: observations

1 INTRODUCTION

Galaxy redshift surveys have been a cornerstone amongst probes of the Universe since Hubble's discovery of the cosmological expansion in 1929. Recent years have witnessed the construction of exquisitely detailed maps of the local ($z \sim 0.1$) Universe by the 2-degree Field Galaxy Redshift Survey (2dFGRS; Colless et al. 2001) and the Sloan Digital Sky Survey (SDSS; York et al. 2000). These surveys have defined the new state-of-the-art in spectroscopic detector technology, each constructing spectrographs capable of simultaneous observation of hundreds of objects. However, further significant increases in the depth and area accessible to spectroscopic redshift surveys will rely on the development of a new generation of instruments.

Photometric redshifts, which are estimated from broad-band galaxy colours rather than spectra, offer an invaluable interim solution. Relative to multi-object spectroscopy, high-quality photometry can be obtained far more quickly and for significantly fainter sources. Photometric redshift estimators are numerous, but generally involve calibration against either an observed spectroscopic training set (e.g.

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SDSS: The PhotoObjAll table

TABLE **PhotoObjAll**

Contains a record describing the attributes of each photometric object

The table has views:

- **PhotoObj**: all primary and secondary objects; essentially this is the view you should use unless you want a specific type of object.
- **PhotoPrimary**: all photo objects that are primary (the best version of the object).
  - **Star**: Primary objects that are classified as stars.
  - **Galaxy**: Primary objects that are classified as galaxies.
  - **Sky**:Primary objects which are sky samples.
  - **Unknown**:Primary objects which are no0ne of the above
- **PhotoSecondary**: all photo objects that are secondary (secondary detections)
- **PhotoFamily**: all photo objects which are neither primary nor secondary (blended)

The table has indices that cover the popular columns.

name	type	length	unit	ucd	description
objID	bigint	8		ID_MAIN	Unique SDSS identifier composed from [skyVersion,rerun,run,camcol,field,obj].
skyVersion	tinyint	1		CODE_MISC	0 = OPDB target, 1 = OPDB best
run	smallint	2		OBS_RUN	Run number
rerun	smallint	2		CODE_MISC	Rerun number
camcol	tinyint	1		INST_ID	Camera column
field	smallint	2		ID_FIELD	Field number
obj	smallint	2		ID_NUMBER	The object id within a field. Usually changes between reruns of the same field.
mode	tinyint	1		CLASS_OBJECT	1: primary, 2: secondary, 3: family object, 4: outside chunk boundary.
					Number of children if this is a

extinction_z	real	4	mag	PHOT_EXTINCTION_GAL	Extinction in each filter
priority	int	4		CODE_MISC	Priority bits
rho	real	4	mag	EXTENSION_RAD	Log size for surface brightness: 5xlog(Petro radius in i band)
nProf_u	int	4		NUMBER	Number of Profile Bins
nProf_g	int	4		NUMBER	Number of Profile Bins
nProf_r	int	4		NUMBER	Number of Profile Bins
nProf_i	int	4		NUMBER	Number of Profile Bins
nProf_z	int	4		NUMBER	Number of Profile Bins
loadVersion	int	4		ID_VERSION	Load Version
htmID	bigint	8		CODE_HTM	20-deep hierarchical trangular mesh ID of this object
fieldID	bigint	8		ID_FIELD	Link to the field this object is in
parentID	bigint	8		ID_PARENT	Pointer to parent (if object deblended) or BRIGHT detection (if object has one), else 0
specObjID	bigint	8		ID_CATALOG	Pointer to the spectrum of object, if exists, else 0
u	real	4	mag	PHOT_SDSS_U FIT_PARAM	Shorthand alias for modelMag
g	real	4	mag	PHOT_SDSS_G FIT_PARAM	Shorthand alias for modelMag
r	real	4	mag	PHOT_SDSS_R FIT_PARAM	Shorthand alias for modelMag
i	real	4	mag	PHOT_SDSS_I FIT_PARAM	Shorthand alias for modelMag
z	real	4	mag	PHOT_SDSS_Z FIT_PARAM	Shorthand alias for modelMag
err_u	real	4	mag	PHOT_SDSS_U ERROR	Error in modelMag alias
err_g	real	4	mag	PHOT_SDSS_G ERROR	Error in modelMag alias
err_r	real	4	mag	PHOT_SDSS_R ERROR	Error in modelMag alias
err_i	real	4	mag	PHOT_SDSS_I ERROR	Error in modelMag alias

Querying PhotoObjAll table

```
select m.objid,
       m.htmID,
       m.field,
       m.ra,
       m.dec,
       p.modelMag_g,
       p.modelMagErr_g,
       p.petroRad_g,
       p.petroRadErr_g,
       p.probPSF,
       p.probPSF_g,
       p.psfMag_g,
       p.psfMagErr_g,
       p.flags,
       p.flags_g,
       p.status,
       p.isoAGrad_g,
       p.isoBGrad_g,
       p.lnLStar_g,
       p.lnLDeV_g,
       p.lnLExp_g into mydb.DR5RaDecFieldMagCutExtraGalaxies from MyDB.DR5RaDecFieldMagCutGalaxies m
                                                              inner join PhotoObjAll p

       on m.objid = p.objID;
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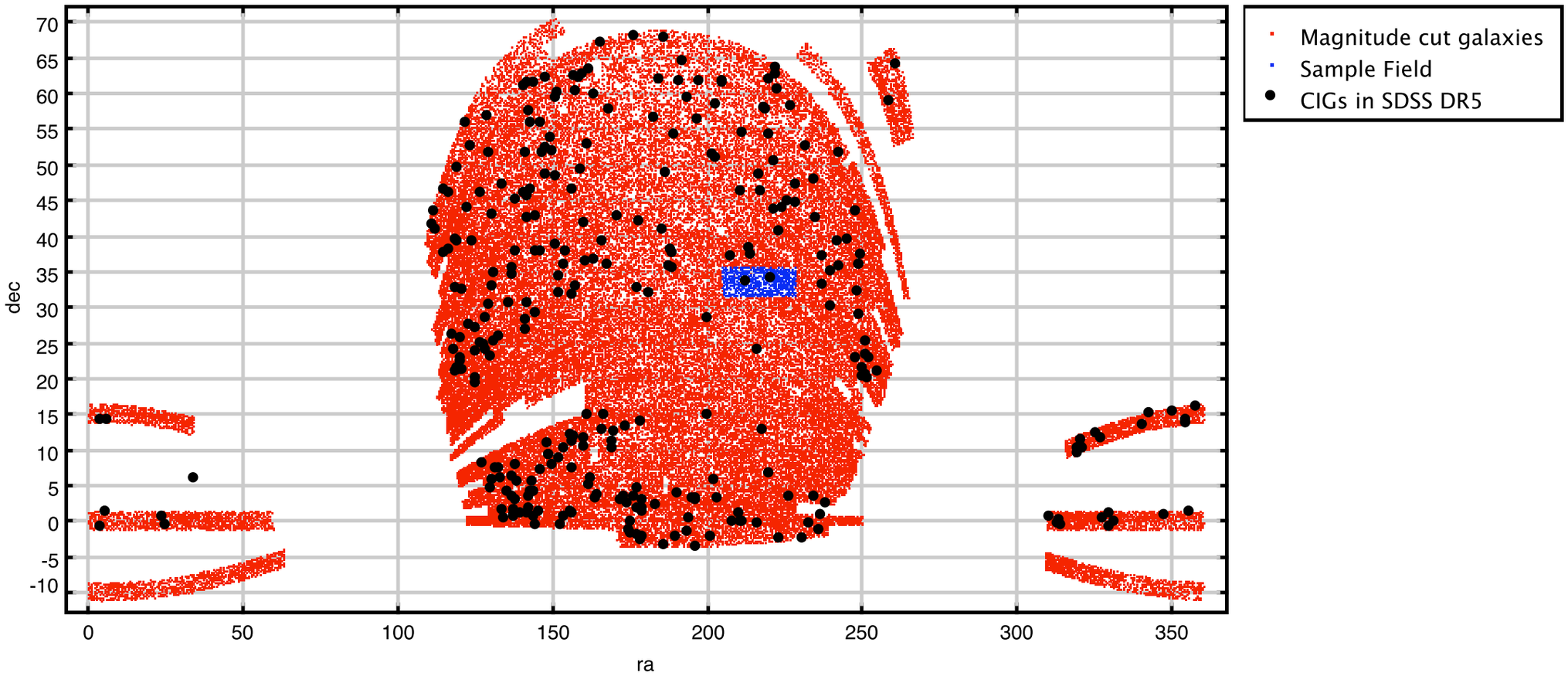
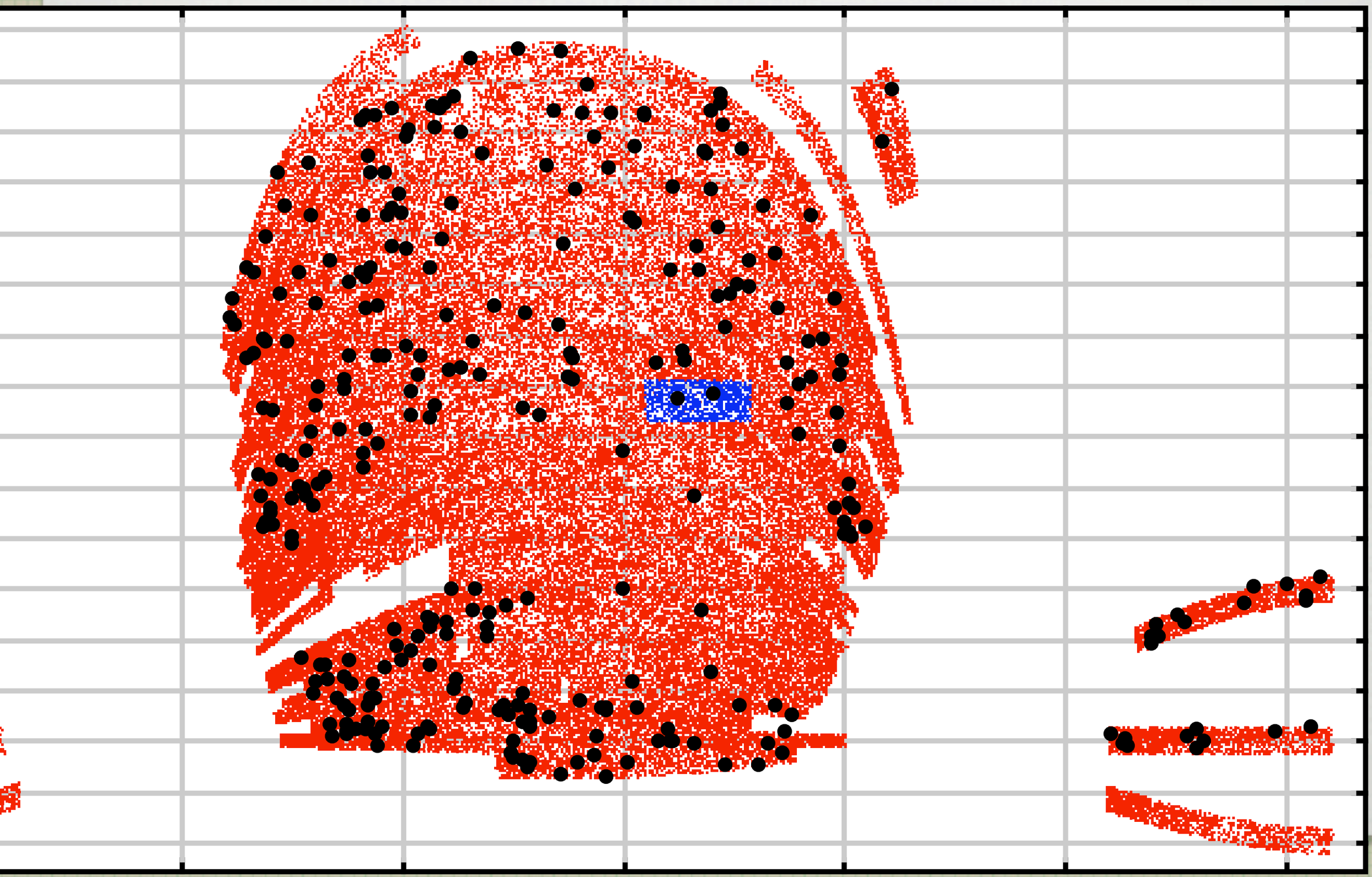
SDSS DR5 Candidates



SDSS DR5 Candidates



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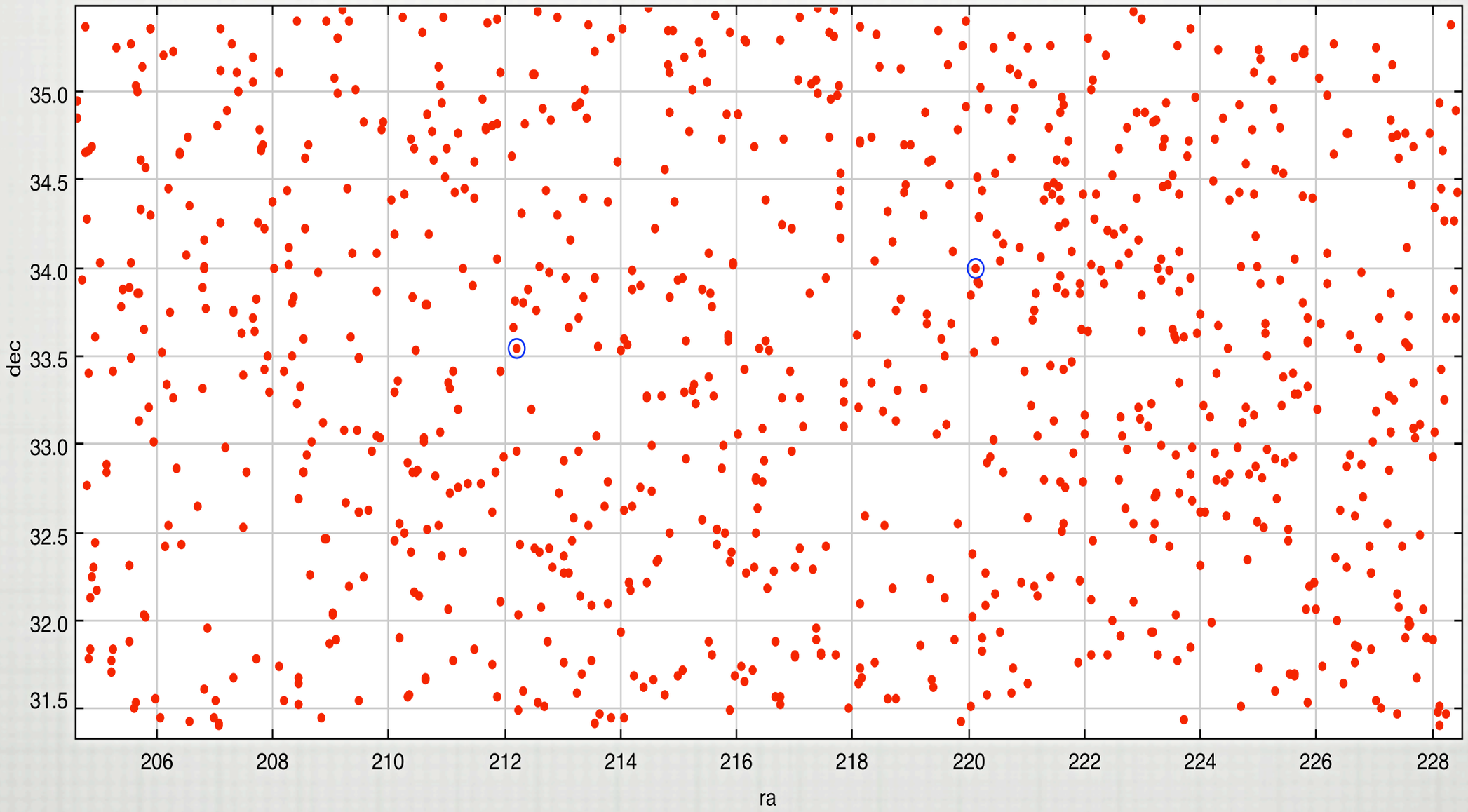

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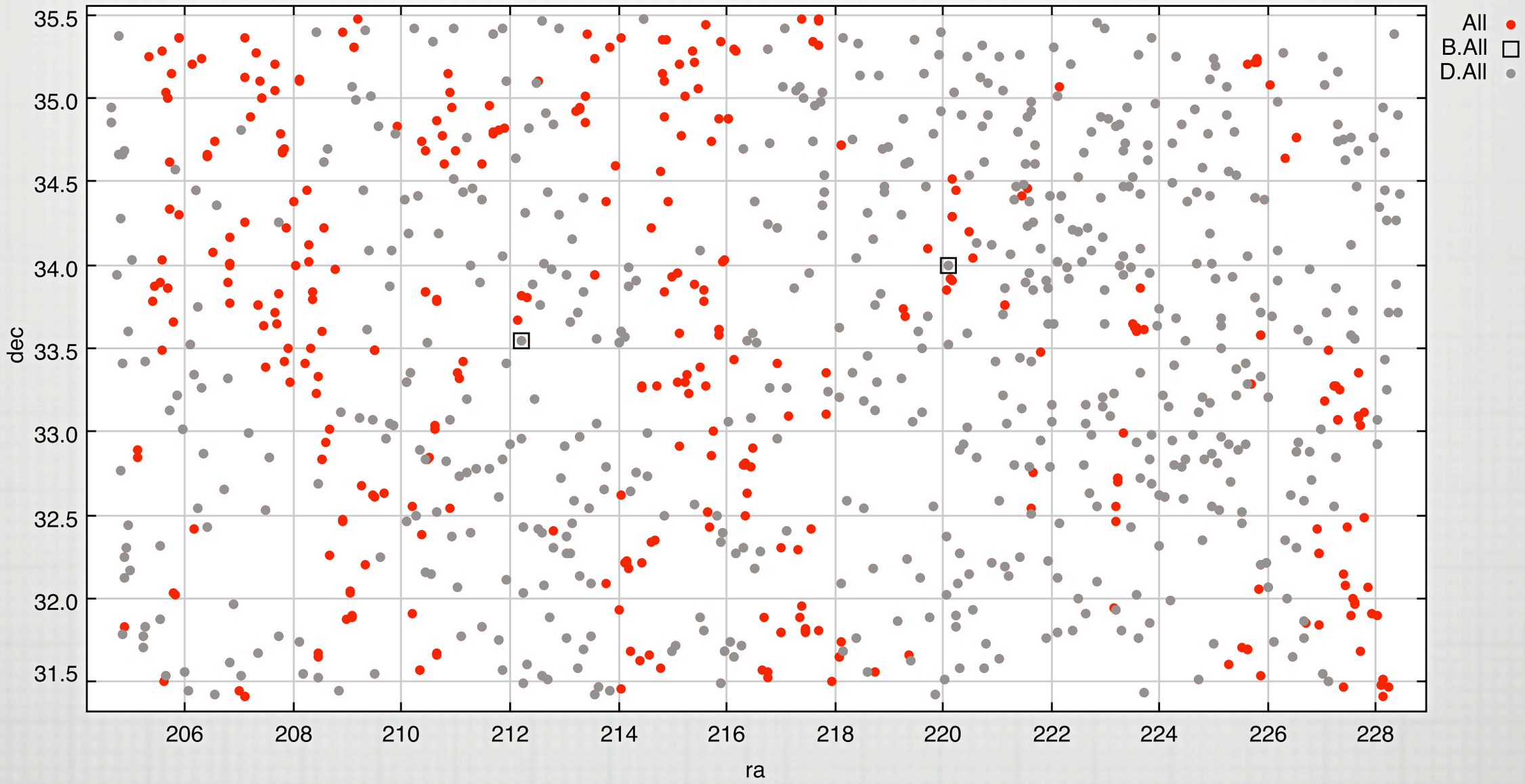

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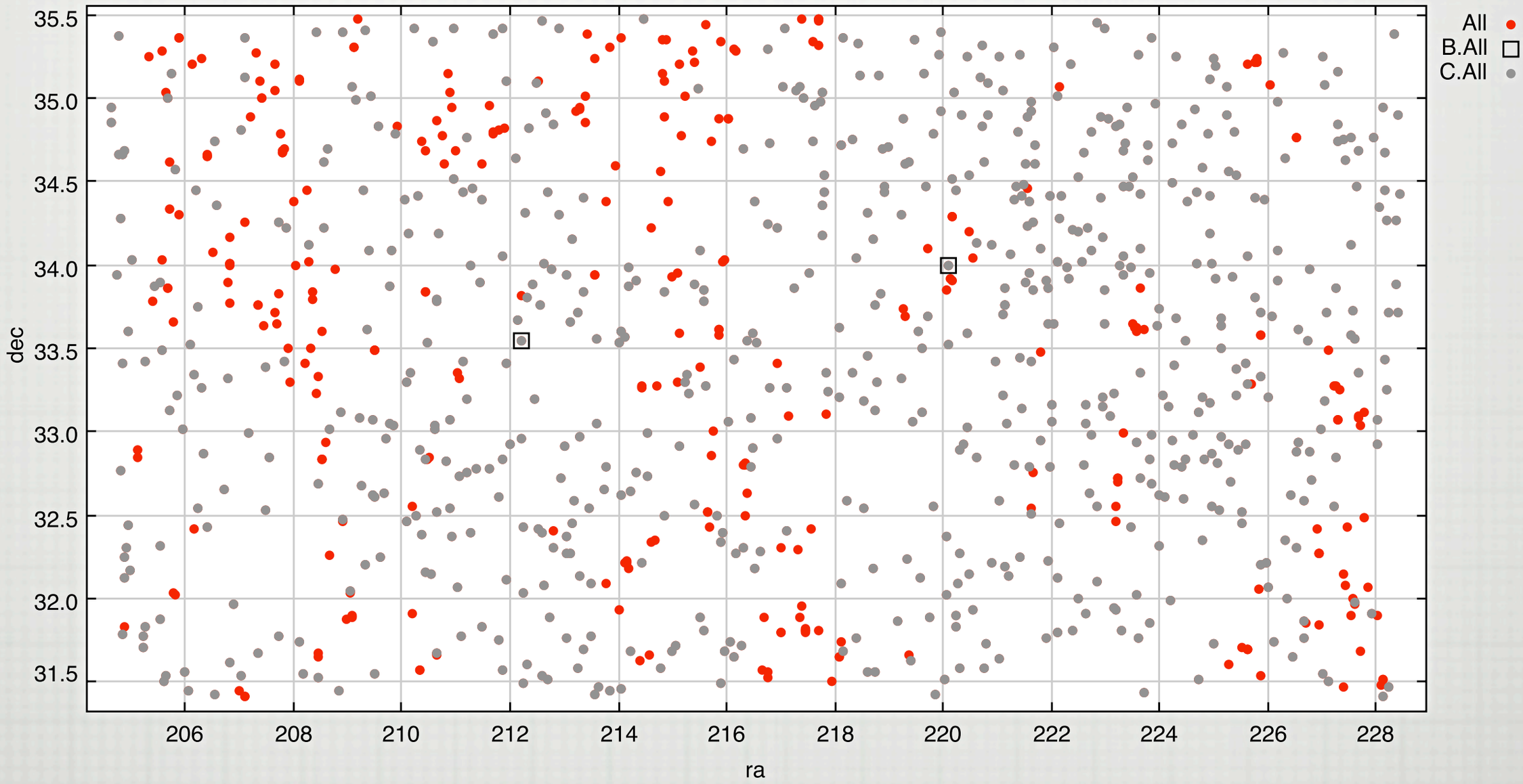

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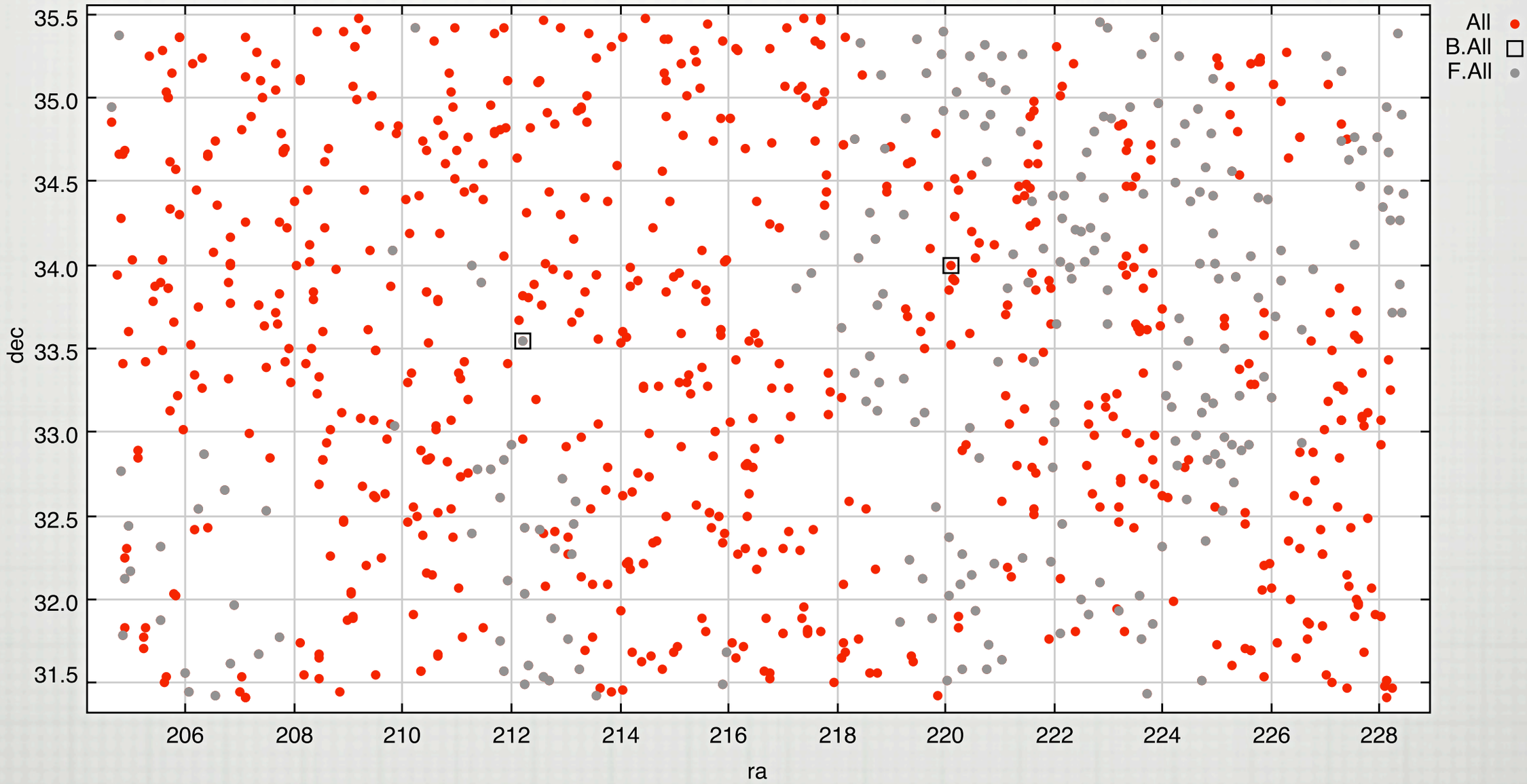

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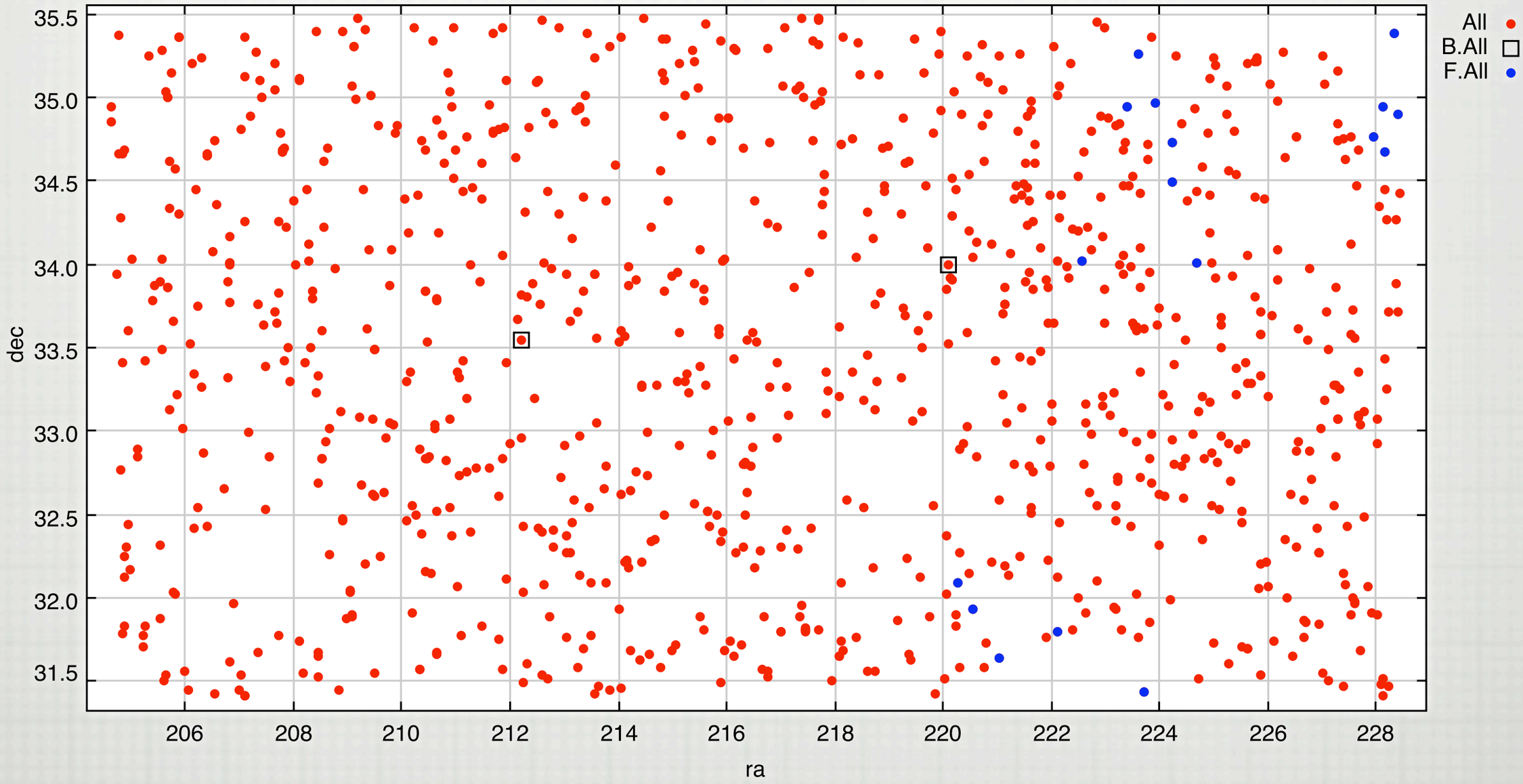
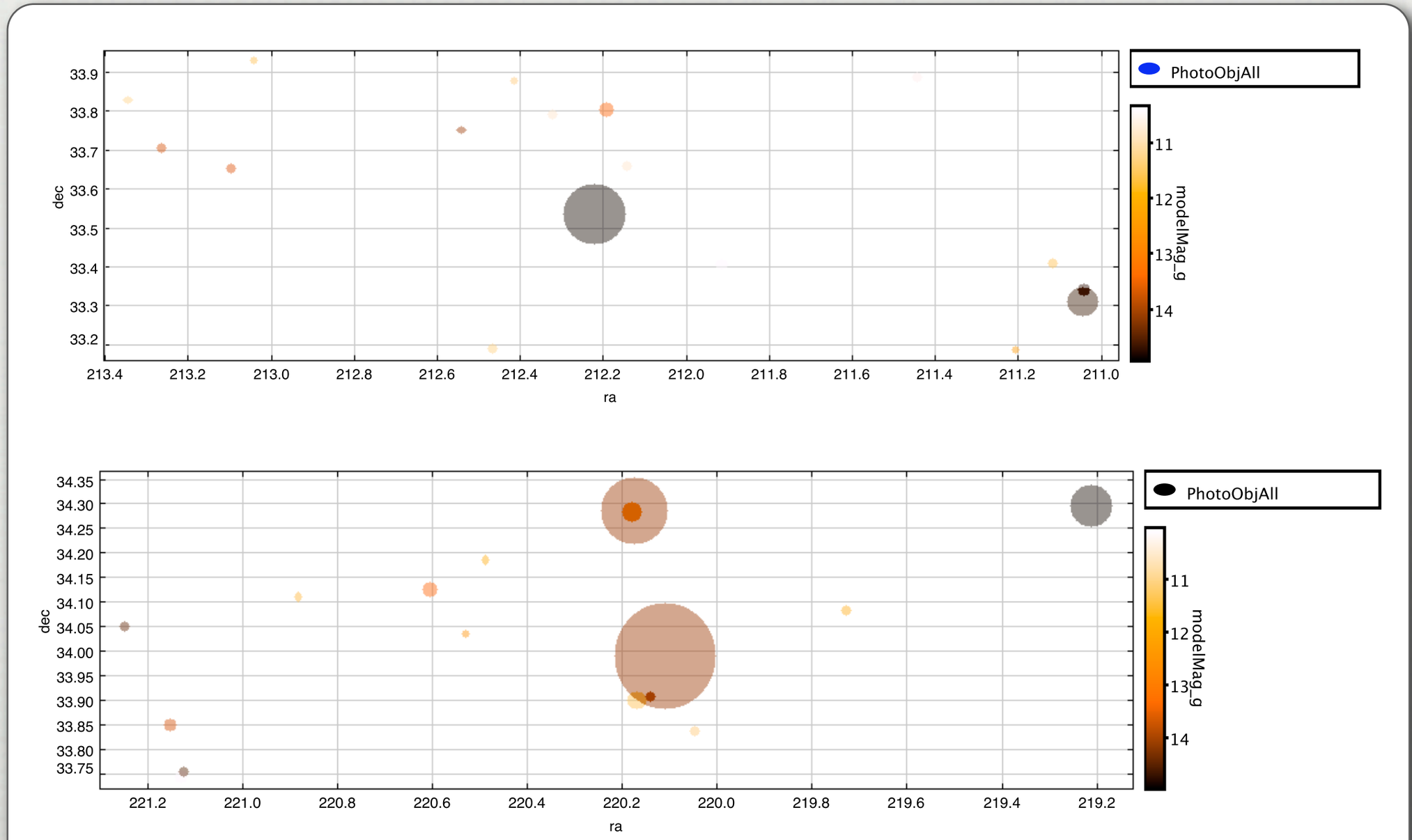


Problems & Strategies

PROPERTIES IN FIELD AROUND CIGS



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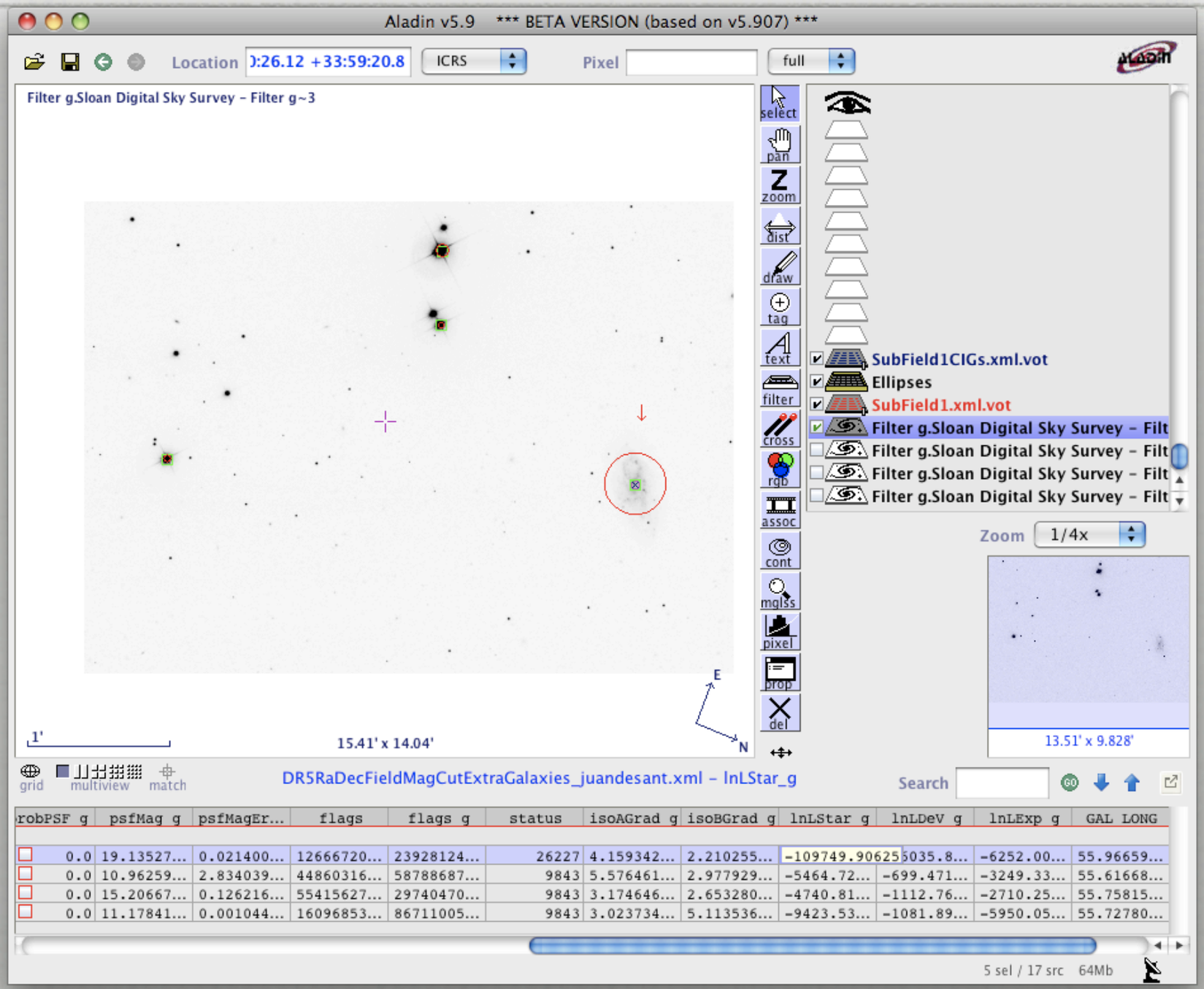

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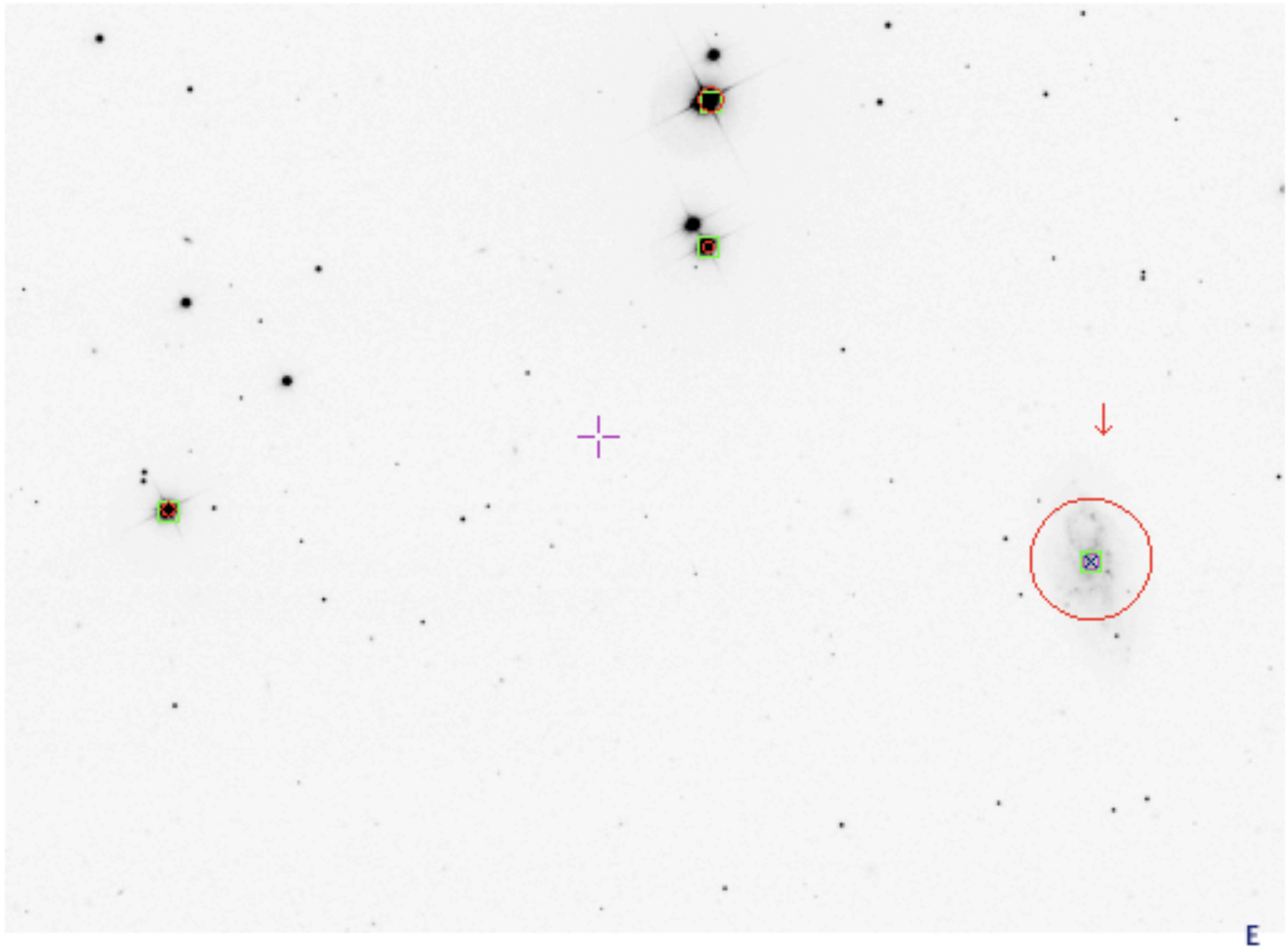
0.0	15.20667...	0.126216...	55415627...	29740470...	9843	3.174646...	2.653280...	-4740.81...	-1112.76...	-2710.25...	55.75815...
0.0	11.17841...	0.001044...	16096853...	86711005...	9843	3.023734...	5.113536...	-9423.53...	-1081.89...	-5950.05...	55.72780...

Filter g.Sloan Digital Sky Survey - Filter g~3



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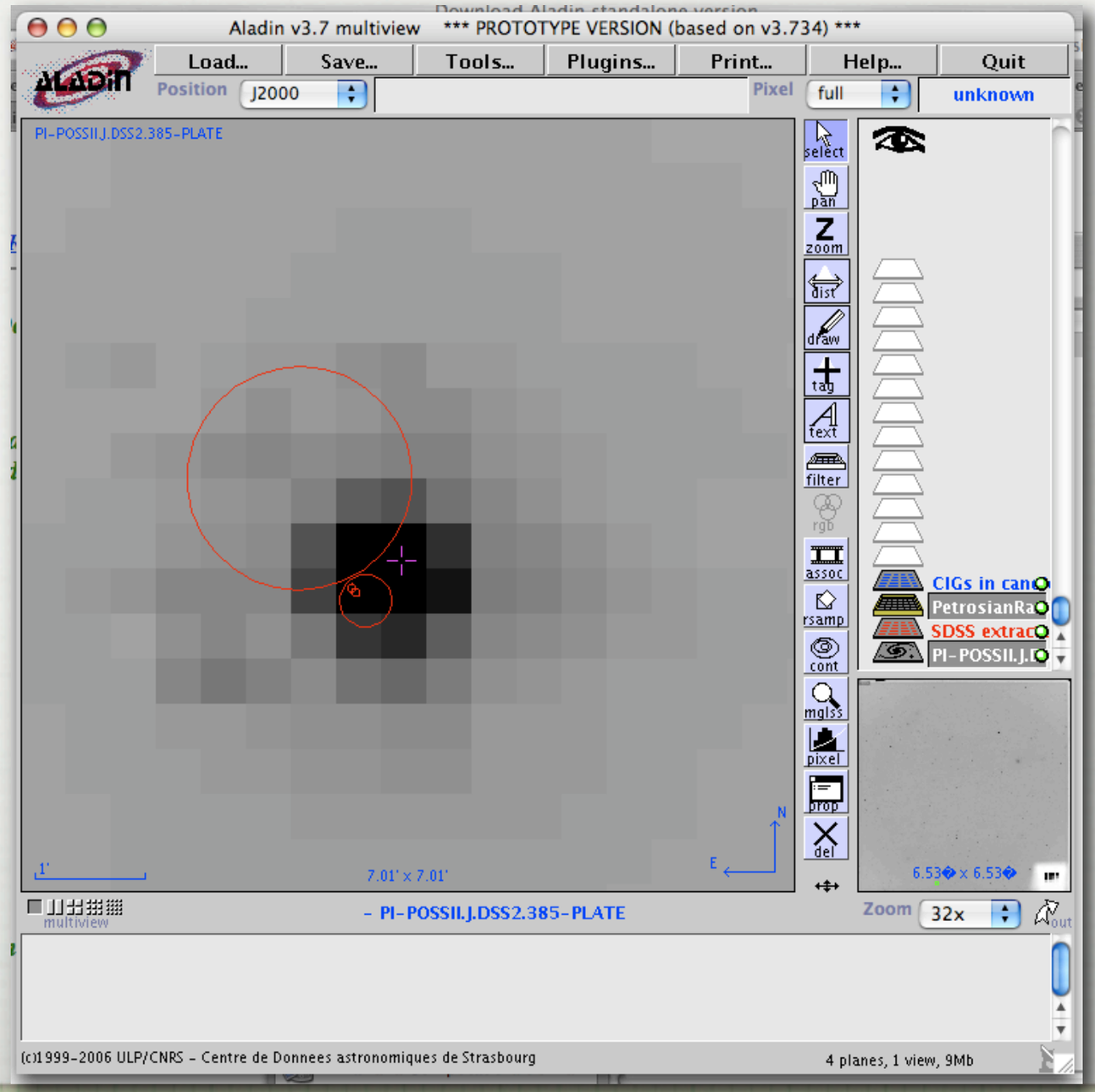
Overlapping Detections



OVERI

ALADIN

Load... Save... Tools... Plugins... Print...

Position J2000

Pixel full

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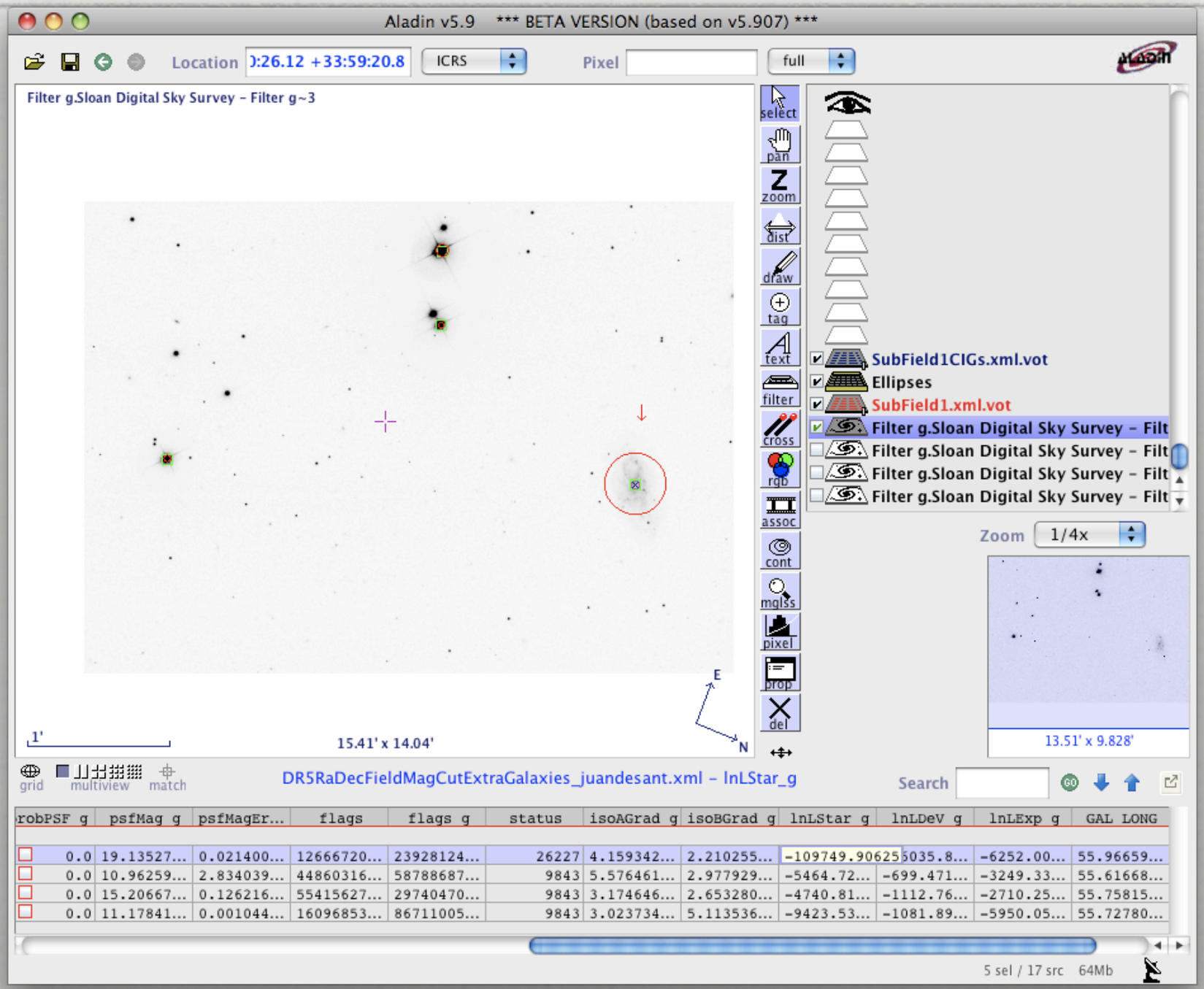

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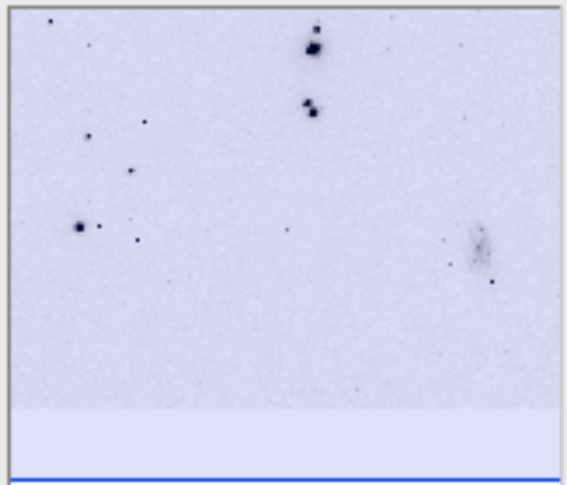

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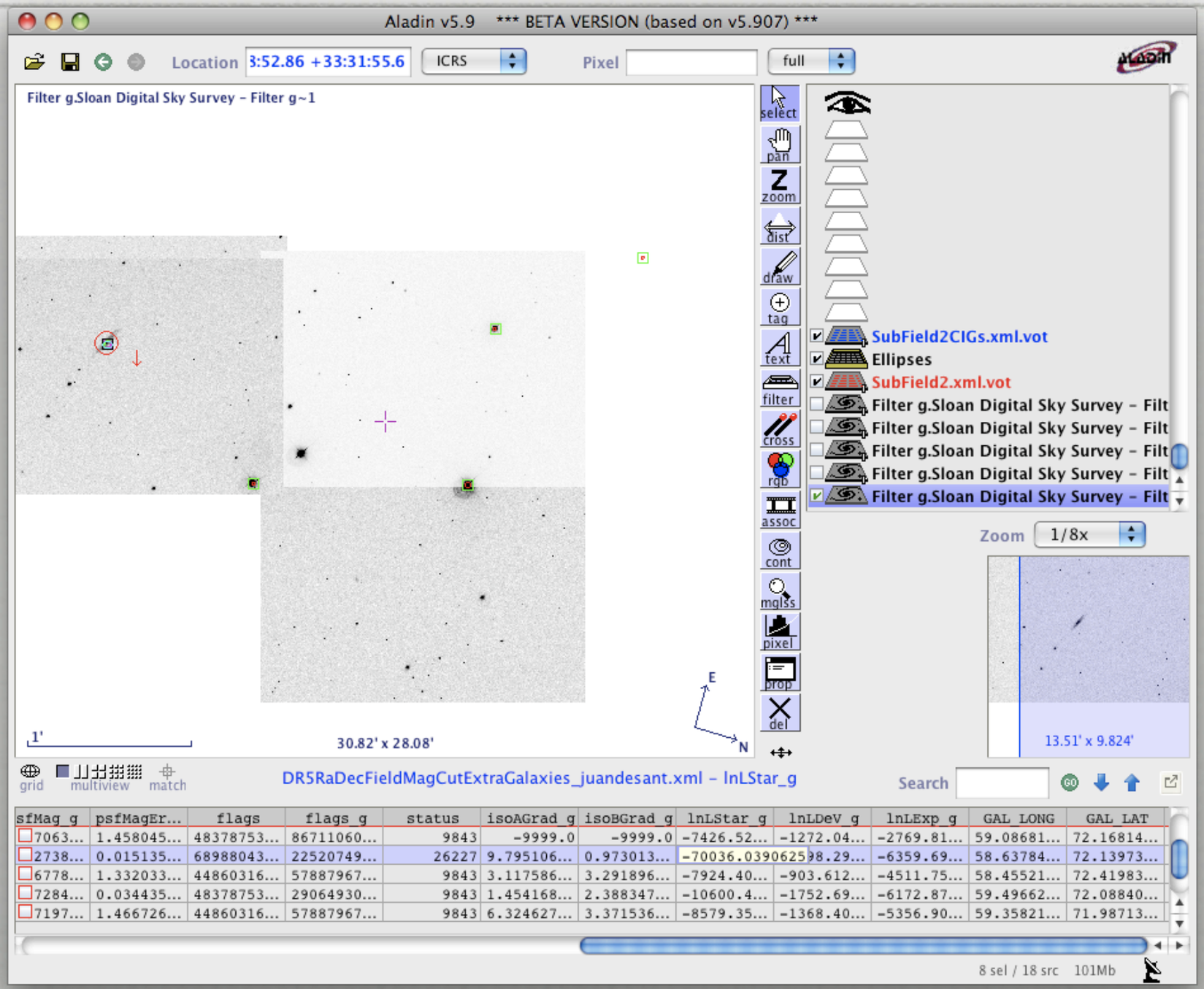
Aladin v5.9 *** BETA VERSION (based on v5.907) ***
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Filter g.Sloan Digital Sky Survey - Filter g~1
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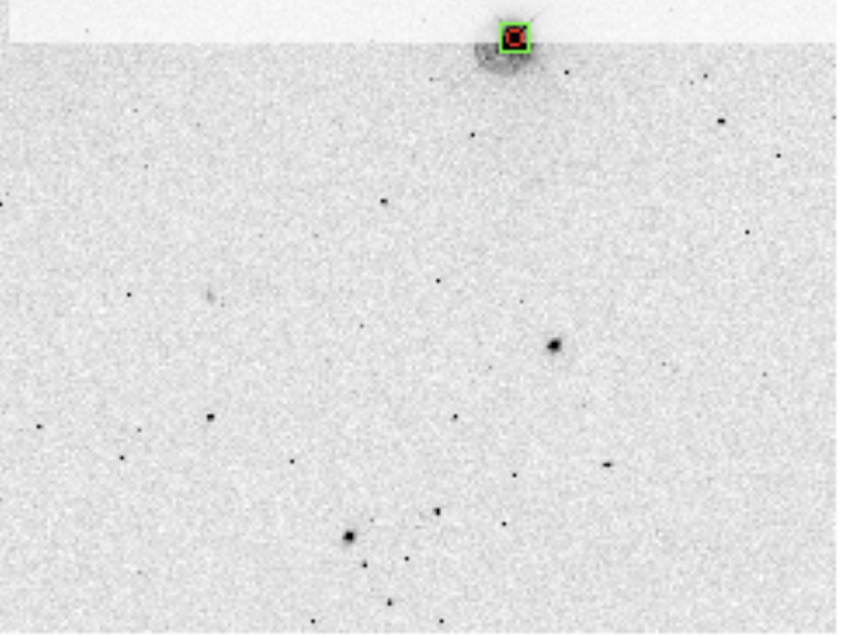

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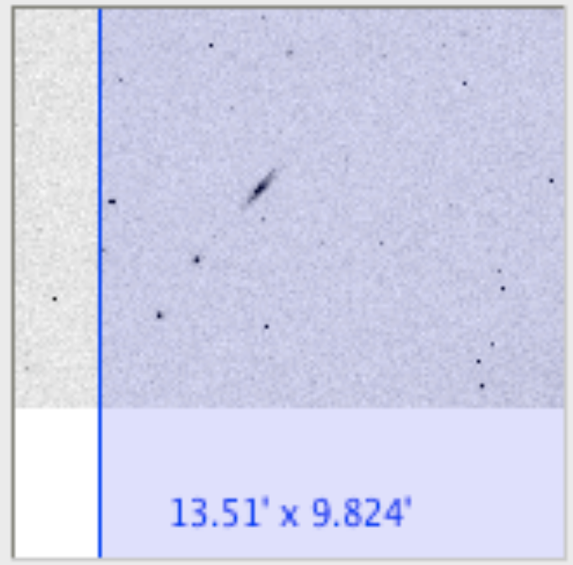
Filter g.Sloan Digital Sky Survey - Filt
Filter g.Sloan Digital Sky Survey - Filt

Zoom 1/8x



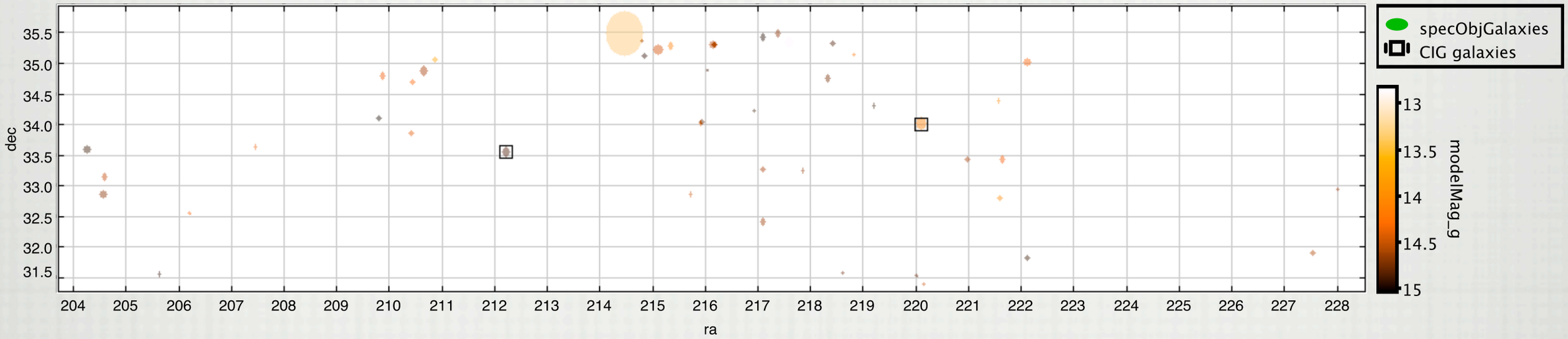
DR5RaDecFieldMagCutExtraGalaxies_juandesant.xml - lnLStar_g

Search GO

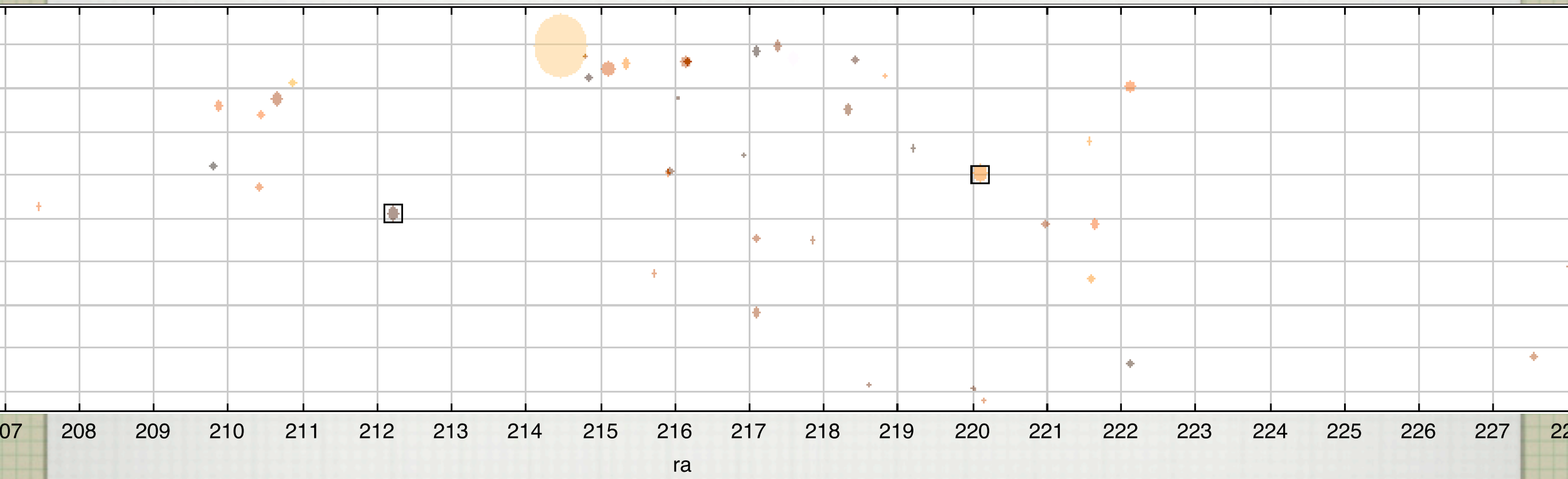
flags_g	status	isoAGrad_g	isoBGrad_g	lnLStar_g	lnLDeV_g	lnLExp_g	GAL_LONG	GAL_LAT
86711060...	9843	-9999.0	-9999.0	-7426.52...	-12[illegible]2.04...	-2769.81...	59.08681...	72.16814...
22520749...	26227	9.795106...	0.973013...	-70036.0390625	[illegible].29...	-6359.69...	58.63784...	72.13973...
57887967...	9843	3.117586...	3.291896...	-7924.40...	-90[illegible].612...	-4511.75...	58.45521...	72.41983...
29064930...	9843	1.454168...	2.388347...	-10[illegible]	-1752.69...	-6172.87...	59.49662...	72.08840...
57887967...	9843	6.324627...	3.371536...	-8579.35...	-1368.40...	-5356.90...	59.35821...	71.98713...

8 sel / 18 src 101Mb

GALAXIES WITH SPECOBJGALAXIES



GALAXIES WITH SPECOBJGALAXIES



Conclusions & Future Work

Conclusions

- KIG-equivalent criteria are easy to implement, computationally feasible.
- The SDSS photometric catalogues provide lots of parameters useful to improve pipeline's star/galaxy separation.
  - There is at least one parameter, promising for star/galaxy separation.
- Any automatic star/galaxy rejection algorithm must be carefully tested.
  - Blind tests are important to finding out problems without resorting to visual inspection.

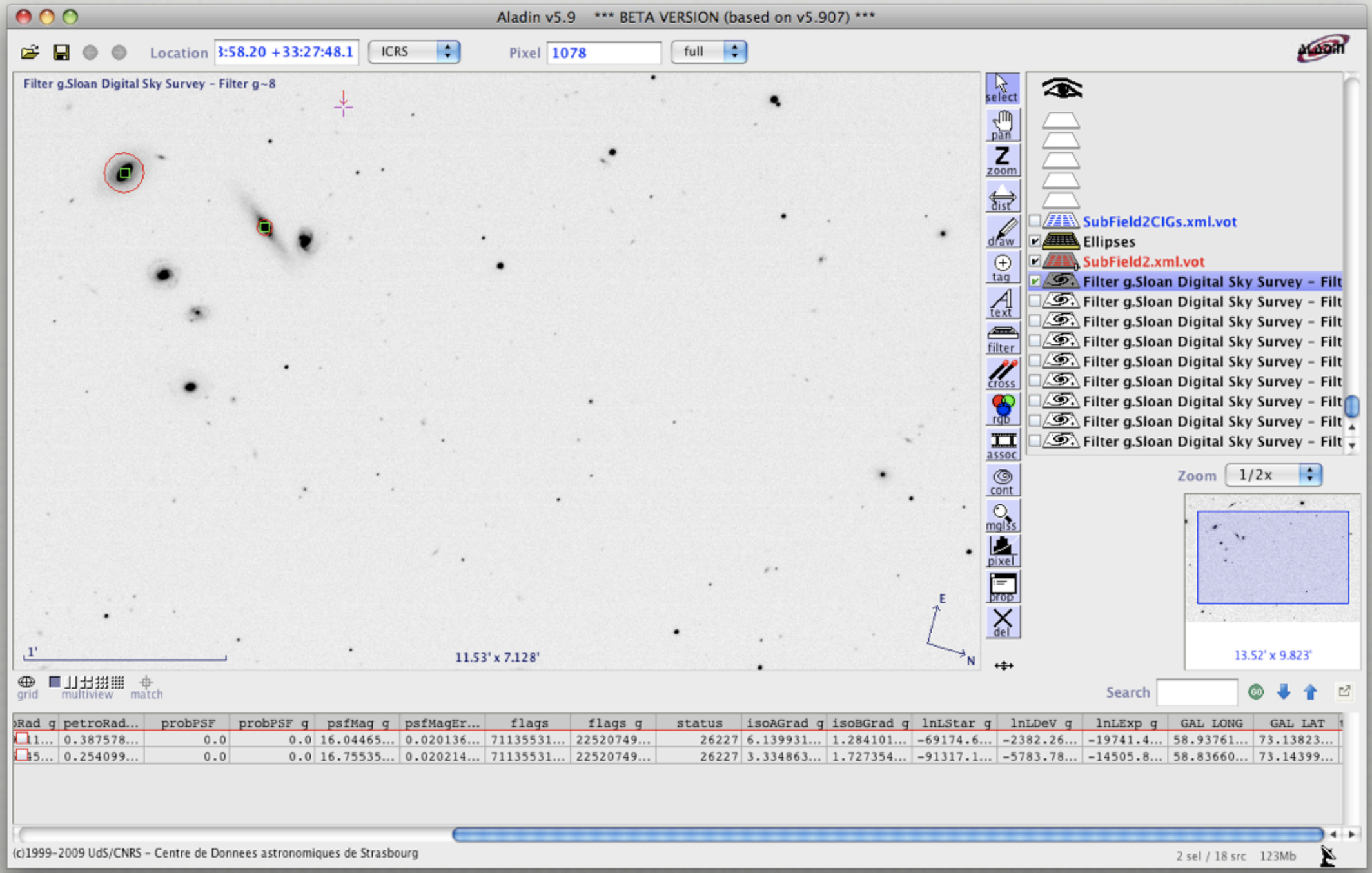
Future Work

- ☐ Assessing the values for proper star/galaxy differentiation with *stellarity*, other combinations of parameters.
- ☐ Using data mining techniques (with the SVO people), in order to use additional parameters (multi-**λ** magnitudes, iso-photal slopes, etc.).
- ☐ Extend the selection criterion to 3D (with the SVO people).
- ☐ Extend the technique to existing and post-SDSS surveys.

Thank You!

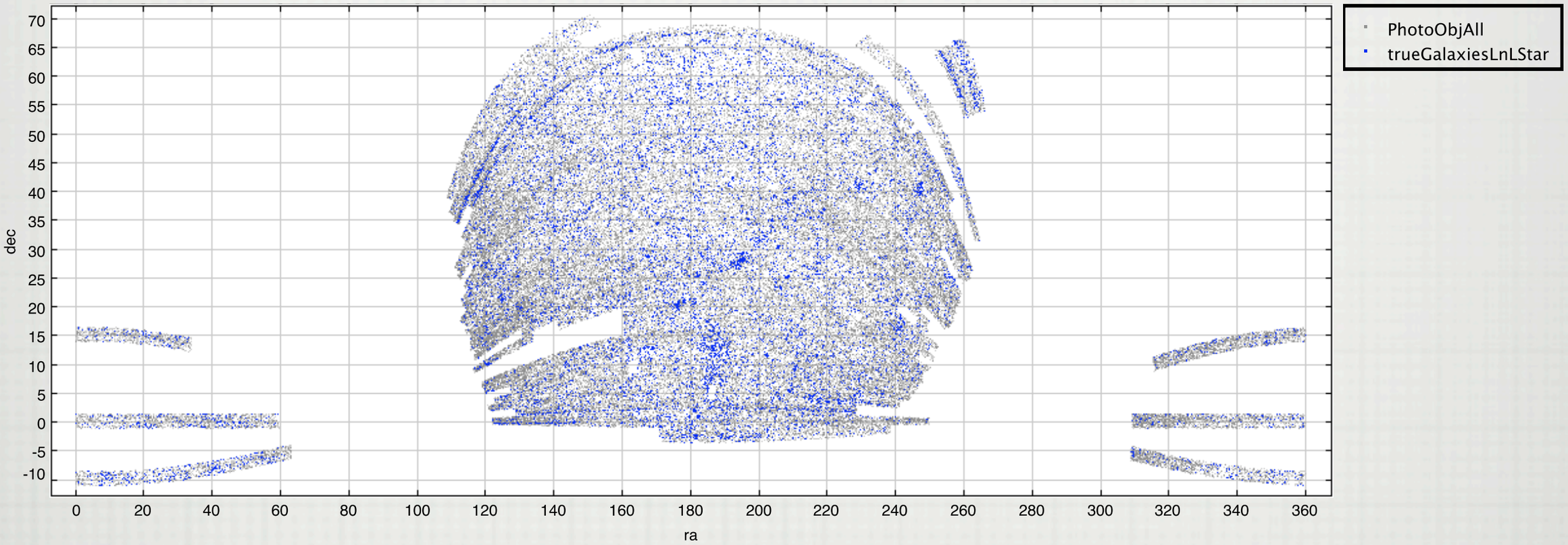
Extra Slides

Detecting Galaxies with lnLStar

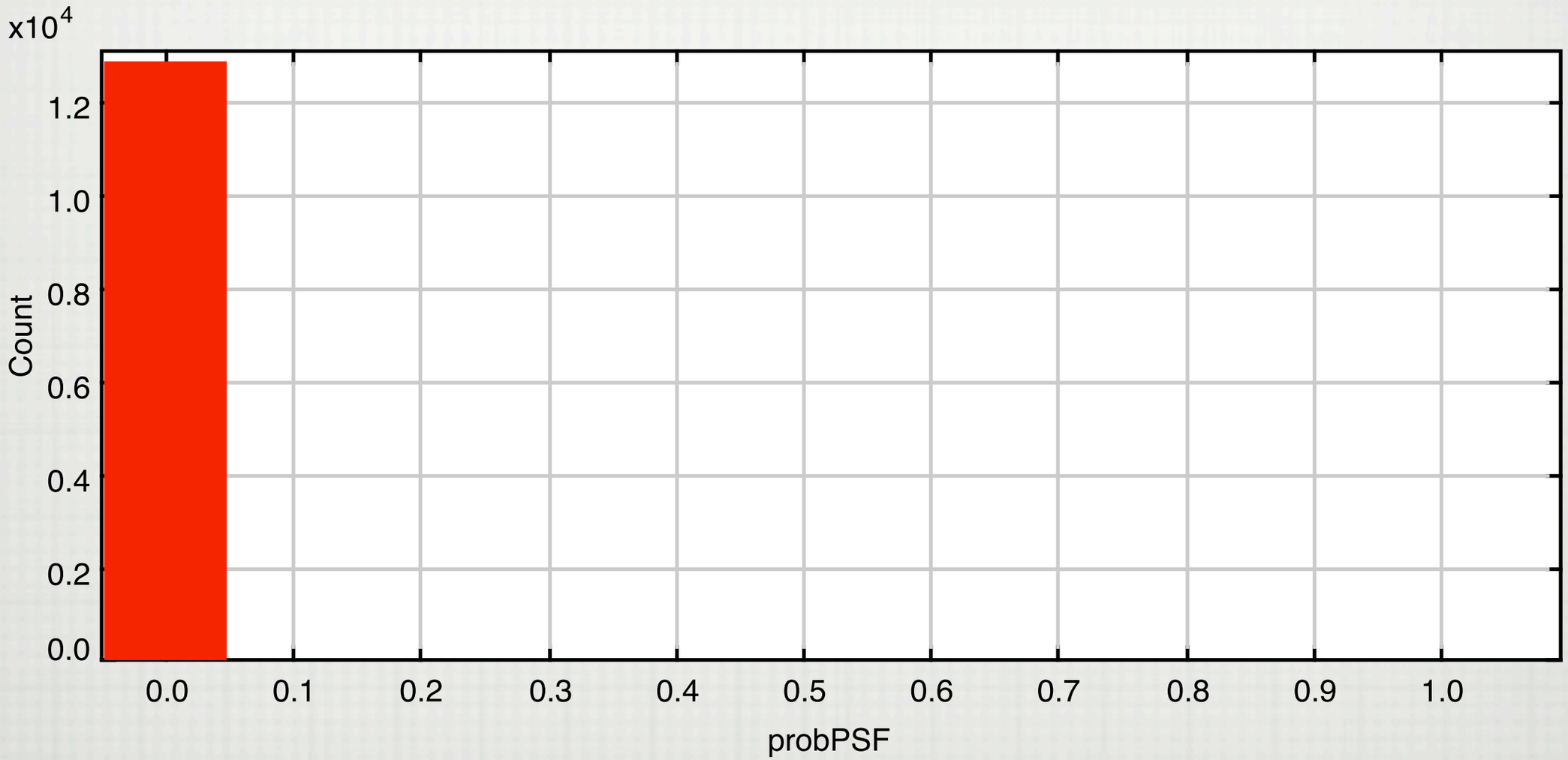


bRad_g	petroRad...	probPSF	probPSF_g	psfMag_g	psfMagEr...	flags	flags_g	status	isoAGrad_g	isoBGrad_g	lnLStar_g	lnLDeV_g	lnLExp_g	GAL LONG	GAL LAT
11...	0.387578...	0.0	0.0	16.04465...	0.020136...	71135531...	22520749...	26227	6.139931...	1.284101...	-69174.6...	-2382.26...	-19741.4...	58.93761...	73.13823...
45...	0.254099...	0.0	0.0	16.75535...	0.020214...	71135531...	22520749...	26227	3.334863...	1.727354...	-91317.1...	-5783.78...	-14505.8...	58.83660...	73.14399...

GALAXIES WITH LNLSTAR < -29000



HISTOGRAM OF PROBPSF, PROBPSF_G



Histogram of lnLStar