

Environment Study of AGNs at z = 0.3 to 3.0 using the Japanese Virtual Observatory

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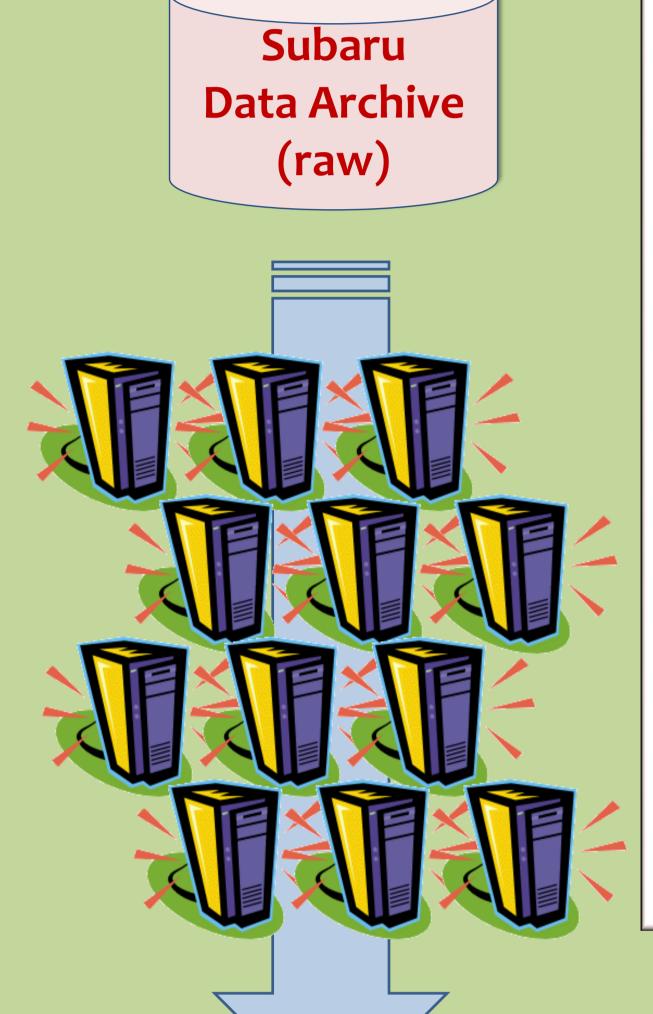
submitted to PASJ (arXiv:0907.5380)

Abstract:

We present a science use case of Virtual Observatory, which is actually achieved to examine environment of AGN up to redshift of 3.0. We used the Japanese Virtual Observatory (JVO) to obtain the Subaru Suprime-Cam images around known AGNs. According to the hierarchical galaxy formation model, AGNs are expected to be found in environment of higher galaxy density than that of typical galaxies. The current observations, however, indicate that AGNs do not reside in particularly high density environment. We investigated $\sim 1,000$ AGNs, which is about ten times larger samples than previous studies covering redshifts larger than 0.6. We successfully found significant excess of galaxies around AGNs at redshifts of 0.3 through 1.8.

If this work was done in a classical manner, that is, raw data were retrieved from the archive through a web interface in an interactive way and the data were reduced in a local poor machine, it might have taken several years to finish it. Since the Virtual Observatory system is accessible through the standard interfaces, it would be easy to query and retrieve observed data in an automatic way. We have constructed a pipeline for retrieving the data and calculating the galaxy number density around a given coordinate. This procedure was executed in parallel on ~10 quad core PCs, and it took only one day for obtaining the final result.

Our result implies that the Virtual Observatory provides astronomers with a powerful tool to conduct a data-incentive astronomical research.



Step 0 (Admin)

Parallel processing of large amount of data

Data reduction of all the Suprime-Cam data on the JVO grid computing system (12 servers, 48 CPU cores)

10 TB of RAW data are reduced through the JVO web interface. The processing time is ~ 10 days.

The metadata of the processed images are registered to a database and exposed through the VO interface.

Step 1

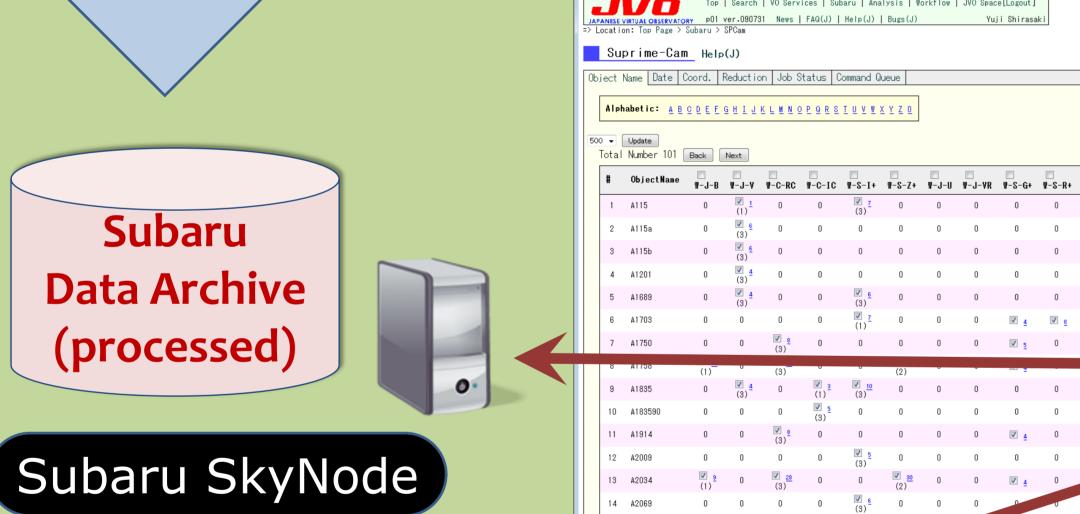
Multiple database query

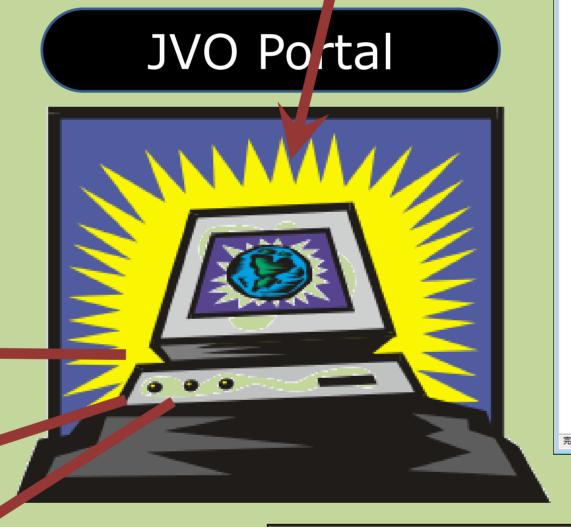
Suprime-Cam images and UKIDSS catalog data are searched for around known AGNs.

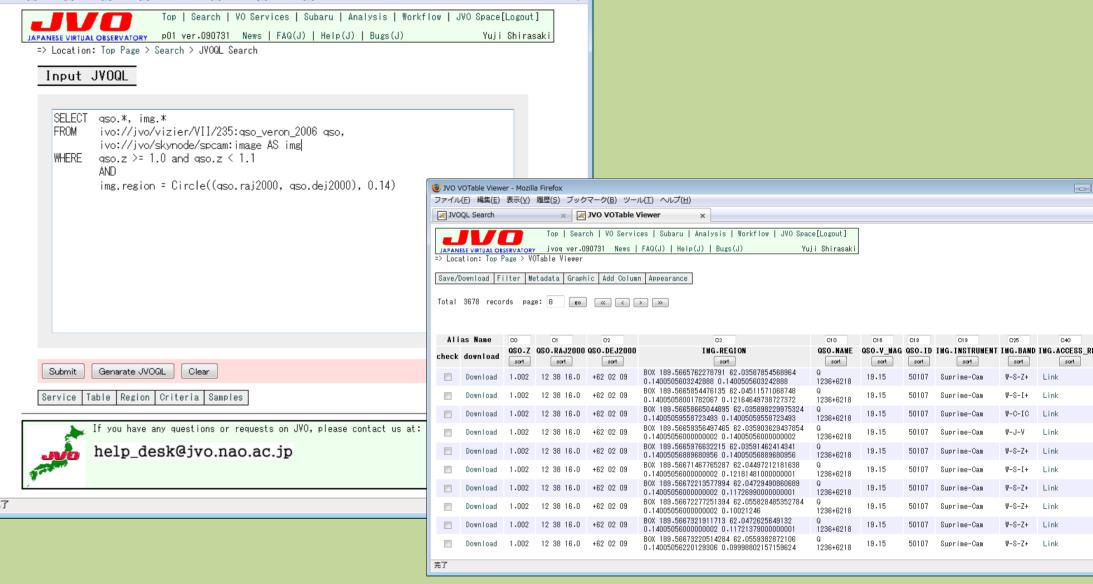
The following JVO Query Language (JVOQL) is an example to execute a coordinate join between an AGN catalog table and a Suprime-Cam metadata table:

SELECT qso. *, img. * FROM ivo://jvo/vizier/VII/235:qso_veron_2006 qso ivo://jvo/skynode/spcam:image AS img WHERE qso. z >= 1.0 and qso. z < 1.1

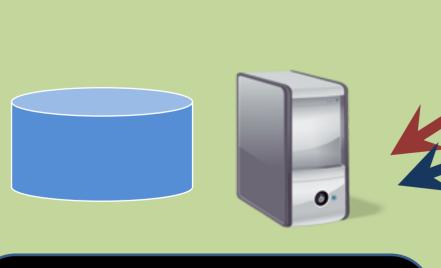
img. region = Circle((qso. raj2000, qso. dej2000) 0.14)



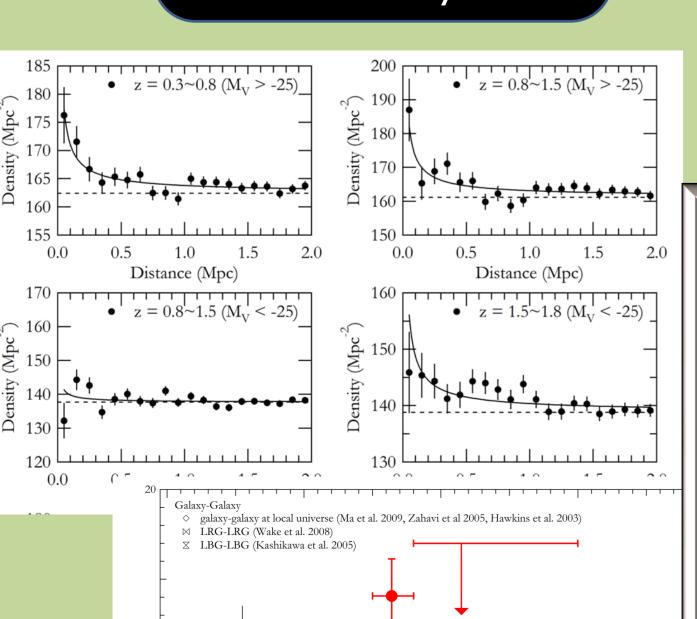








UKIDSS SkyNode



Step 3

Detailed analysis on a local machine.

- 1. Stack the galaxy density profiles around each AGN
- 2. Calculate correlation length between AGN and galaxies for each redshift and luminosity range.
- 3. Write a paper...

Step 2

Workflow for calculating galaxy density around each AGN.

A script "qso-dataset.sh" executes the following workflow:

- 1. retrieve images and catalog data around a specified coordinate of AGN. This query is directly sent to the SkyNode.
- 2. extract objects from the images, and cross-match to create a multi-bands catalog
- 3. Calculate galaxy number density around the AGN position

This script is executed for every AGN found in the step 1:

qso-dataset.sh --ra <qso_ra> --dec <qso_dec> --rad <img_radius> $-z < qso_z >$

Conclusion

Combination of all the Subaru archival data and the data obtained by medium-sized survey telescopes has successfully revealed AGN environment at intermediate redshift range with higher statistical significance than ever achieved. The feature of the VO service that enables automated queries is crucial for conducting data-incentive astronomical studies in the 21st century.