# Searching for Short-Term Variable Active Galactic Nuclei: A Vital Step Towards Using AGN as Standard Candles

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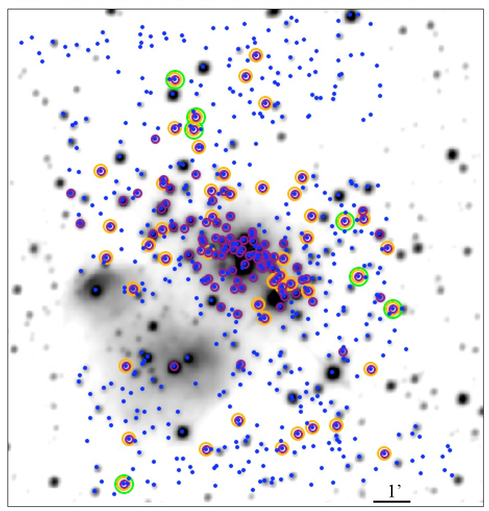
## ABSTRACT

Current models for accretion disk sizes of active galactic nuclei (AGN) do not match the limited observational data available, so there is an active need from the modeling community for many more accretion disk/dusty torus reverberation mapping campaigns with which to better calibrate models. Since short-term variable AGN can be more easily monitored for reverberation mapping than long-term variable AGN, they can begin to provide data more quickly. This project looked for short-term variable AGN in the Young Stellar Object Variability (YSOVAR) survey conducted using the Spitzer Space Telescope. The YSOVAR survey targeted 12 nearby star-forming regions for repeated observations. Potential AGN from the YSOVAR data were first selected by color ([3.6] - [4.5] > 0.4) and then by magnitude (m > 14) based on previous Spitzer surveys of known AGN. Since AGN share some similar color characteristics with young stars, images of each YSOVAR region were viewed to remove potential objects near concentrations of known young stellar objects since these were likely also YSOs. The Spectral energy distribution (SED) and individual images of each remaining potential AGN were then examined for AGN-like characteristics. Twenty-six (26) potential short-term variable AGN were found.




FIELD: GGD 12-15
BLUE DOT: Well-defined magnitudes for [3.6] and [4.5]
PURPLE CIRCLE: Color shows excess IR [3.6]-[4.5] > 0.4
ORANGE CIRCLE: Object is faint [3.6] > 14
GREEN CIRCLE: Visually extended object/Potential AGN

## BACKGROUND

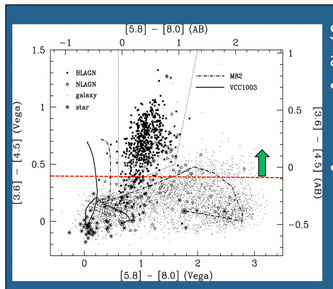
**What is an AGN?** Active galactic nuclei (AGN) are galactic supermassive black holes with active accretion of matter into a super-heated disk which gives off large amounts of radiation across the electromagnetic spectrum. Galaxies with an AGN will show excess radiation compared to the radiation expected from a galaxy due to only stars and regions of dust and gas.

**What is reverberation mapping?** Reverberation mapping (RM) is a technique for determining the physical size of the inner region around an AGN using the known speed of light and time delays in intensity increases in the light curves at various wavebands corresponding to unique regions of the inner galaxy.

**How does reverberation mapping link AGN size and luminosity?** Once a statistically significant number of AGN have been studied via reverberation mapping, it may be possible to find a correlation between the size of the AGN's accretion disk and its luminosity, thus making AGN suitable as standard candles even at redshifts of up to z∼9.

**Why is this project an important step?** Doing RM requires high-cadence observations to ensure that changes in the light curves are not missed between observing epochs. AGN which exhibit variations over shorter than average time scales would make the required observations easier to obtain. Having a list of AGN targets for possible short-duration reverberation mapping measurements would be a significant step towards obtaining sufficient observations to have a statistically significant number of mapped AGN. These could be used to provide a better calibration of the time-delay (size) / luminosity relationship which could lead to greatly improving the distance measures to the farthest objects in the universe. These new distance measurements could ultimately lead to significant improvements on the best-known value for the Hubble constant and our understanding of the rate of acceleration of the universe.

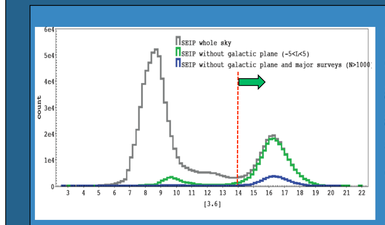
## METHODS




(Stern, et al., 2005)

Started with 8942 objects across 4 fields:

- Kept only objects with well-defined magnitudes in [3.6] and [4.5] μm
- Using the trapezoidal region on this color-color plot as a guide, which contains primarily AGN, kept only objects with [3.6] – [4.5] > 0.4




(Strasburger, et al., 2015)

Using this bi-modal distribution of galactic and extra-galactic sources as a guide, kept only objects with [3.6] > 14, which are primarily extra-galactic.

Visually inspected locations of objects in each field. Kept objects isolated from clusters of other objects and which were away from substantial nebulosity (presumably the culled objects were young stars)

Inspected SED for each object. Kept objects whose peak wavelength indicated a possible AGN (peak at > 1 μm).

Inspected [3.6] light curve. Kept objects with sufficient variability ( ≥ 10% or Δmag ≥ 0.1), irregular variability, and had a sufficient number of data points ( ≥ 20).

Visually inspected objects in [3.6] using the Infrared Science Archive (IRSA). Kept objects that were irregular / extended (not point-like).

## RESULTS

Twenty-six (26) short-term variable AGN candidates were found after culling from the original data set of almost 9,000 from the four processed YSOVAR fields.

| | GGD 12-15 | IRAS 20050 +2720 | L1688 | NGC 1333 |
|---|---|---|---|---|
| Number of objects in raw data for each cluster | 1021 | 156 | 884 | 6881 |
| Well-defined magnitudes for [3.6] and [4.5] | 578 | 154 | 827 | 4482 |
| Color shows excess IR [3.6] – [4.5] > 0.4 | 113 | 119 | 288 | 1430 |
| Objects are faint [3.6] > 14 | 51 | 21 | 220 | 1313 |
| Objects are isolated from clusters and nebulosity | 27 | 15 | 44 | 76 |
| AGN-like SED; light curve with irregular variability | 10 | 3 | 8 | 16 |
| Visually extended object, not point-like | 7 | 2 | 2 | 15 |
| TOTAL AGN CANIDATES | 26 | | | |

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