RESTing Comets: Studying Dormant Comets via a Remnant Emission Survey Tool

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VIEW ABSTRACT HERE

1. INTRODUCTION:

The delineation between comets and asteroids (see e.g. reviews by [1-3,5]) is often defined by the presence of a coma. Cometary activity (sublimation, outgassing and erosion) provides insights into their composition and temporal evolution. Over time, active comets can lose their volatiles, developing crusts that cause them to become dormant (or extinct), although they may reactivate under certain conditions. Some asteroids have shown signs of transient activity, which challenges the common definition of an asteroid and suggests that some may be of **an icy nature**. Additionally, since dormant comets can share reflectance and albedo characteristics with asteroids [4-6], it can be challenging to differentiate them from asteroids without further research. Thus, an important question in Solar System evolution is the fraction of apparent asteroids that originally had a significant ice component.

This study seeks to address these complexities and refine our understanding of such bodies by performing **a comprehensive search for weak levels of cometary activity** in archival imaging of dormant comets.

2. OBJECTIVE & MOTIVATION:

- Our main objective is to perform a large-scale analysis of serendipitous imaging of asteroids in archival data (e.g. [7-8]).
- Our analysis aims to detect evidence of **extended emission**.
- The example to the right, which is a strong motivation for our study, is a figure from the work of Mommert et al. (2014), showing a gas coma for asteroid **(3552) Don Quixote** [9-11].

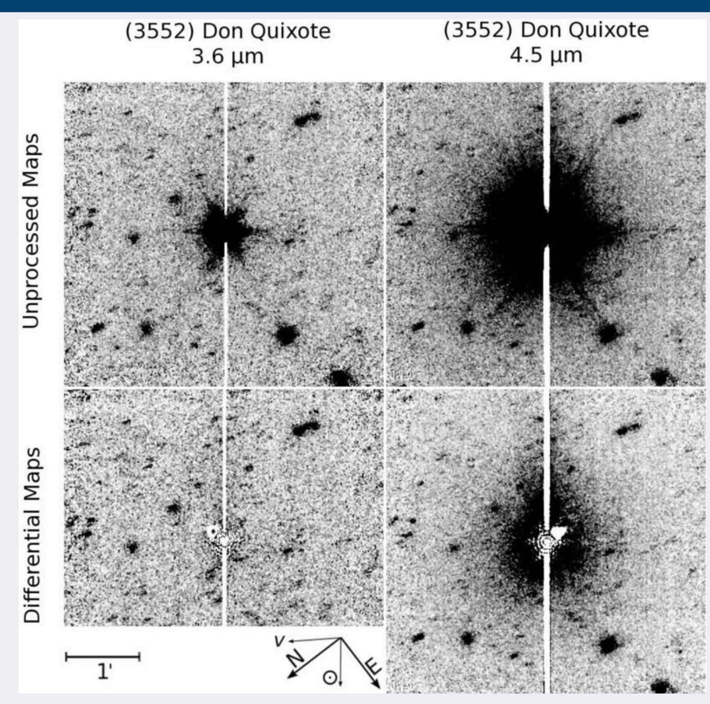


Figure 1. Figure from [9] that has Spitzer imaging of (3552) Don Quixote showing a gas coma (right).

3. METHODOLOGY – Remnant Emission Survey Tool (REST):

The Remnant Emission Survey Tool (REST) is being developed to:

1. Search archives for dormant comet candidates.
2. Download candidate image data taken in filters/wavelengths of interest.
3. Automatically analyze images to identify objects with extended emission.
4. Return the images with extended emission objects and their dynamical information.

Extended emission will first be identified using the **radial profiles of the asteroid and a bright star** in the images' fields-of-view.

We have dynamically selected **~3800 asteroids as dormant comet candidates** [12]. These bodies were filtered based on the following criteria:

- Objects in 'classic' Jupiter-family comet (JFC)-type orbits.
- Objects having T_J (Tisserand parameters with respect to Jupiter) < 3.
- Objects with appropriate $MOID_J$ (Minimum Orbit Intersection Distance with Jupiter) values consistent with JFCs [13].

Target	Perihelion Distance, q (AU)	Aphelion Distance, Q (AU)	Orbital Period, P (yr)	Observation Arc (yr)	T_J	$MOID_J$
(6144) Kondojiro	3.058	6.503	10.45	31	2.867	0.198
(5164) Mullo	1.851	5.532	7.09	21	2.788	1.088
(944) Hidalgo	1.935	9.522	13.71	31	2.067	0.336

Table 1. Three dormant comet candidates from our preliminary investigations, along with some of their orbital parameters. Results for these objects are shown below.

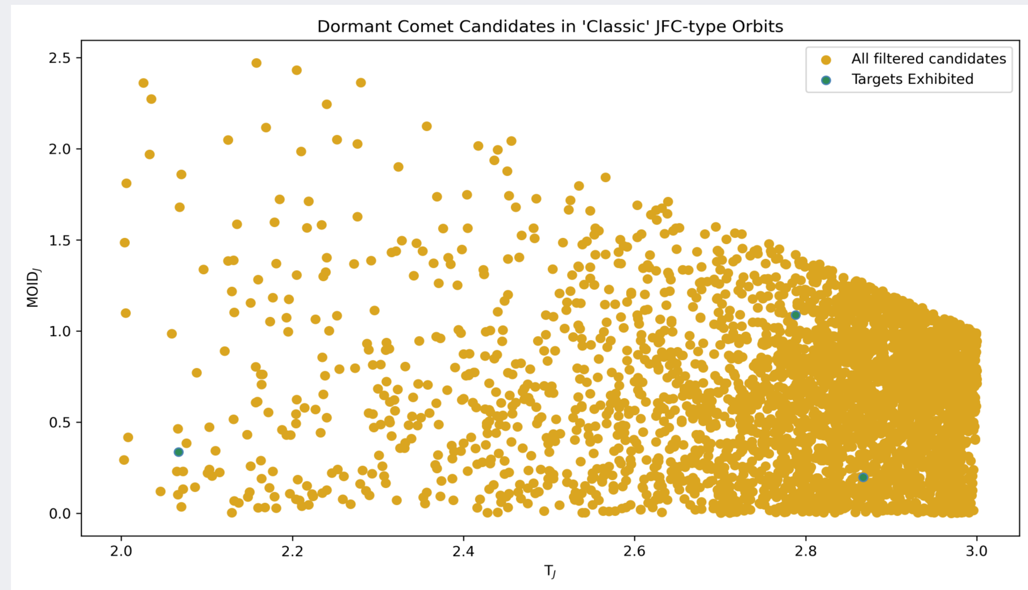
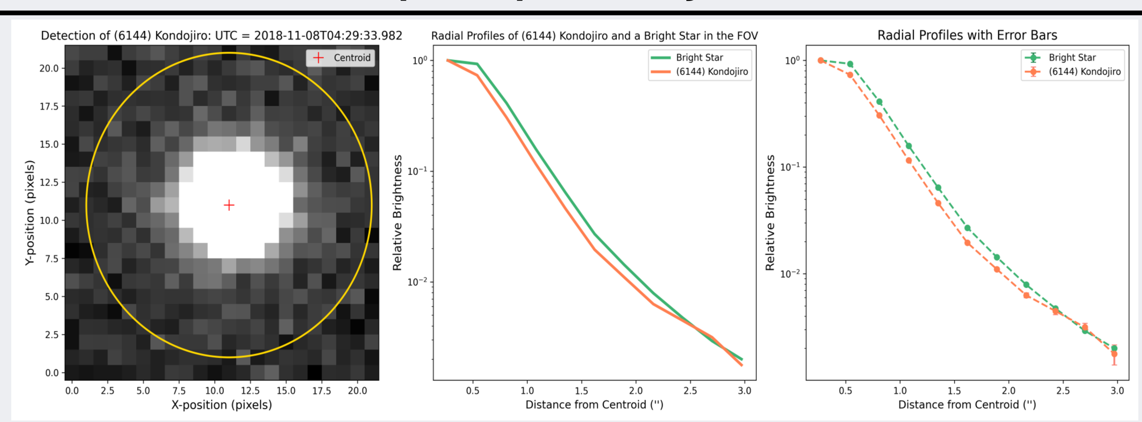
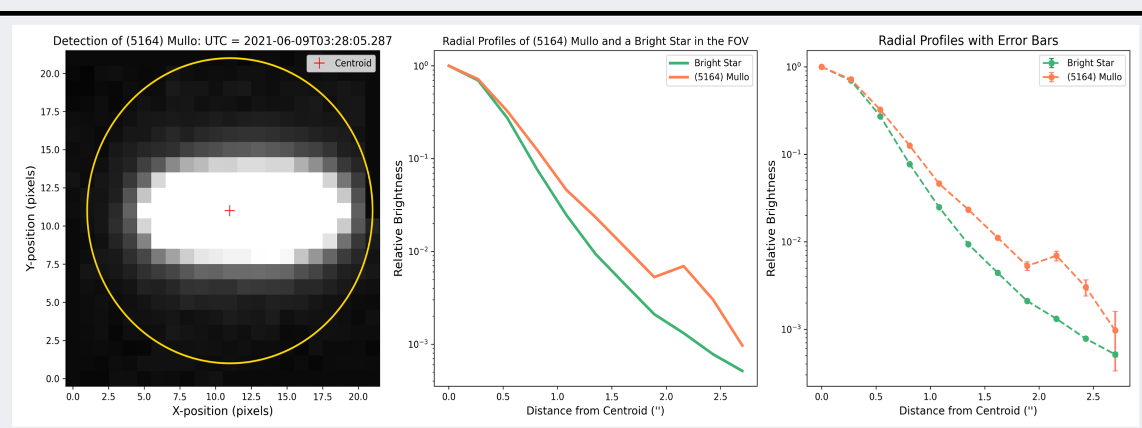
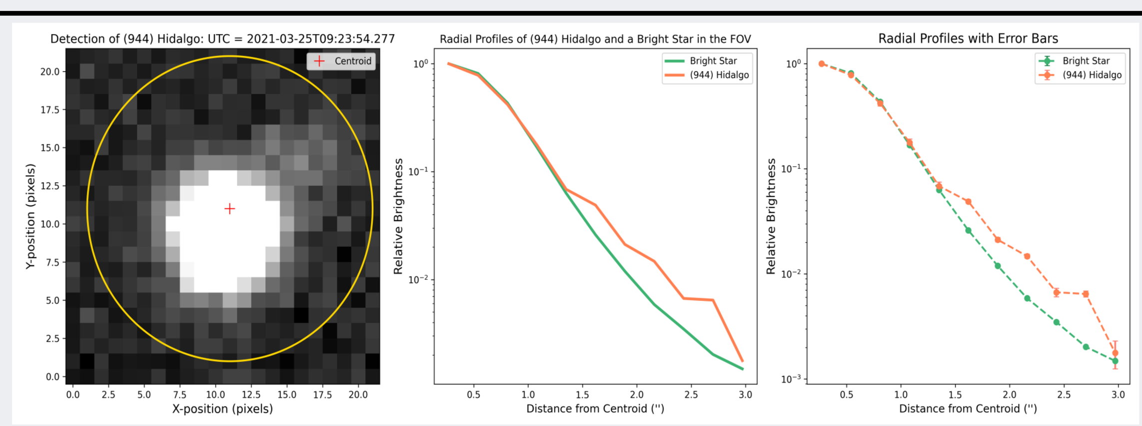
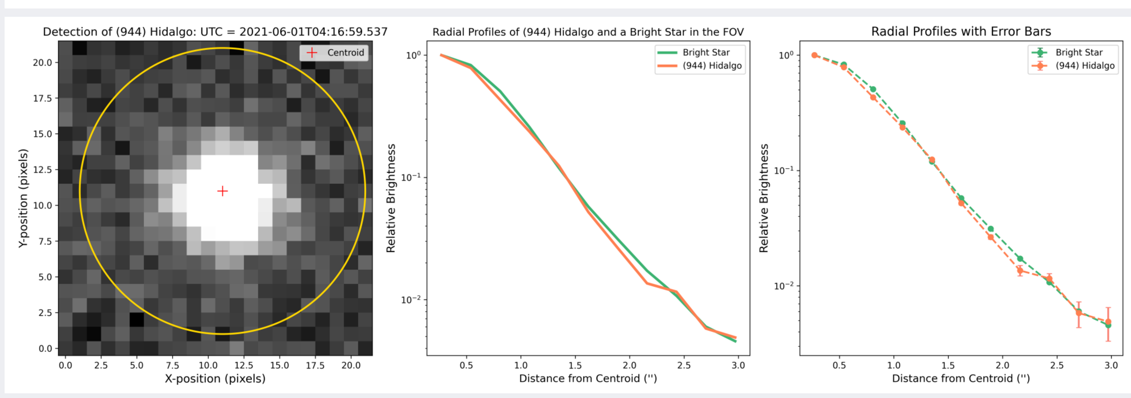


Figure 2. Dormant comet candidates in 'classic' JFC-type orbits. The three objects discussed below are indicated in green.

4. PRELIMINARY RESULTS

Here we present a demonstration of our analysis technique via the preliminary results for three of our dormant comet candidates, with image data retrieved from the Dark Energy Camera (DECam) instrument archives of the Cerro Tololo Inter-American (CITO) Blanco 4-meter telescope in Chile [14]. **Our findings indicate that none of the 3 targets show strong evidence of extended emission.** Further work will be done to refine and automate the analysis procedure.

Table 2. Results for three (3) asteroids, each illustrating a different observational scenario that was accounted for during profile analyses.

	(6144) Kondojiro
(6144) Kondojiro exhibits **near-symmetry** in the image which facilitates a straightforward computation of its radial profile.	
	(5164) Mullo
(5164) Mullo appears **streaked** in the image due to sidereal tracking. Using the skyline projected direction of motion of 267.29°, (5164) Mullo was aligned with the x-axis pixels, allowing radial profiles to be extracted via taking a simple **perpendicular cut**. The lower half of the profile is used for analyses in this example.	
	(944) Hidalgo
In one detection of (944) Hidalgo, the object appears to exhibit a noticeable **extended feature** that could be misinterpreted as coma activity. However, further investigation using PANSTARRS or other archival imaging of the same field on the detection date reveals the presence of a **background object**.	
Other detections of (944) Hidalgo exhibit a more **symmetric** appearance, though not perfectly so, while some show noticeable **asymmetries**.	

5. DISCUSSION & FUTURE WORK

Though our analyses thus far have not revealed strong evidence of extended emission in the targets investigated from DECam data, they provide a solid foundation for a routine that will be later applied to archival imaging data that offer more extensive sampling of possible **gas coma** of our candidates. In future work, we will mainly focus on data from **NEOWISE**, whose 4.5 µm W2 band is sensitive to CO_2 and CO emission, similar to Spitzer's IRAC Channel 2 as depicted in Figure 1. [9,15]. Additionally, data form the **SPHEREx** all-sky survey mission [16-17], which has been used to confirm CO_2 emission in the coma of the new interstellar object, 3I/ATLAS [18], could offer a valuable opportunity for future analysis.

The upcoming steps of our study will include:

- Completing the **development of REST**.
- Validating REST on DECam imaging of asteroids of interest.
- Launching the first **large-scale extended emission survey** of these candidates.
- Broadening the application of REST to **other archival datasets** that would reveal gas emission independently of dust.

6. ACKNOWLEDGEMENTS

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