A PHOTOMETRIC SEARCH FOR MAIN BELT COMETS. S. Cikota[1,2], J. L. Ortiz[2], N. Morales[2], F. Moreno[2], G. Tancredi[3], [1]Physics Department, University of Split, Nikole Tesle 12, 21000 Split, Croatia (scikota@pmfst.hr), [2]Instituto de Astrofísica de Andalucía, CSIC, Apartado 3004, 18080 Granada, Spain, [3]Observatorio Astronómico Los Molinos DICYT-MEC Cno. de los Molinos 5769, 12400 Montevideo, Uruguay.

Introduction: Since the discovery of (7968) 133P/Elst-Pizarro until today, a handful of main belt objects which display comet-like activity have been found. Jewitt [1] proposed possible mechanisms for producing mass loss from asteroids, but the cause of the activity of all known Main Belt Comets (MBCs) remains still unknown.

Statistically there could exist ~100 currently active main-belt comets [2], but hunting for them by searching for typical cometary features, like tail or coma, requires a lot of telescope time in middle and large class telescopes.

With a view to examine as many objects as possible, we tried to find new MBCs just by using the MPCAT-OBS Observation Archive.

Methods: The main idea was to compare every object's observed brightness with its expected brightness.

With the goal to have as many observations per object as possible, spanned over minimum three oppositions, we decided to use the MPCAT-OBS Observation Archive covering only numbered objects. The used database from October 2011 contains ~75 million observations, covering ~300'000 numbered objects.

To avoid overlapping of measurements collected through various photometric bands, it was determinant to choose observations collected by using just one photometric band. Because a lot of sky surveys are observing in the V photometric band, and for them we can expect that their data is relatively confident, but also due to some tests which were done before, it was decided to use observations collected in the V photometric band.

The expected brightness for every observation from the MPCAT-OBS Observation Archive was computed by a Python script, using the Astronomical Ephemeris library "PyEphem" [3]. The orbital parameters necessary to compute the expected brightenss have been taken from the Minor Planet Center Orbit Database, version prepared on October 28, 2011.

To visualize the brightness deviations between the expected and observed brightness, the data was shown in a dMAG vs. MAG plot (Figure 1), where MAG (x axis) incidates the observed brightness and dMAG (y axis) the difference between the observed and expected brightness, defined as:

$$\text{dMAG} = \text{observed mag. - expected mag.} \qquad (1)$$

To filter out the objcts we were interested in, we considered only measurements of objects with negative brightness deviations greater than 3-sigma for minimum five measurements per object, defined by condition (2):

$$\text{dMAG} < 0.0082 \cdot \text{MAG}^2 - 0.2381 \cdot \text{MAG} + 0.3549 \qquad (2)$$

In this way, ~1700 object designations were extracted.

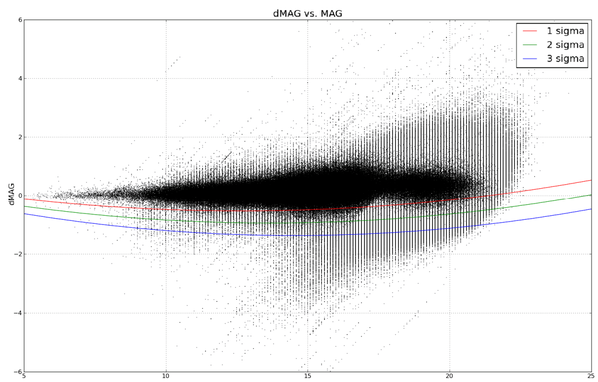

Figure 1. Brightness deviations (dMAG) of all measurements in the visual photometric band taken from the MPCAT-OBS Observation Archive, shown versus their observed brightness (MAG). To filter out the objects we were interested in, we considered only measurements below the blue, second order curve, representing the 3 sigma limit.

For each of the ~1700 extracted object, we generated plots like shown in Figure 2, showing the brightness deviations versus time given in Julian Date, and brightness deviations versus heliocentric distance given in astronomical units. The heliocentric distance for every observation was also computed in Python, by using the Astronomical Ephemeris library "PyEphem" [3].

The object candidates with unusual brightness deviations were extracted by visual examination of the plots.

Results: By visual examination of the plots seven objects were extracted which show unusual long term brightness deviations, lasting within their whole oppositions. One of the extracted objects was the already known MBC (7968) 133P/Elst-Pizarro, while six of them were objects without known signs of cometary activity until now. Some of the objects show a possible correlation between their brightness deviation and heliocentric distance while some of them don't. One example of the extracted objects is (3646) Aduatiques (Figure 2).

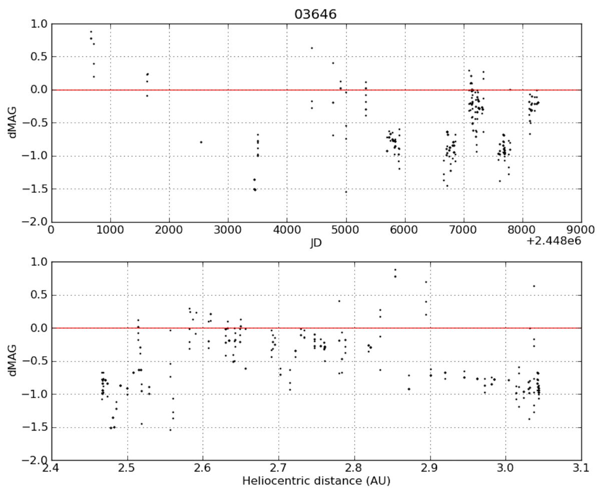

Figure 2. Data plots for (3646) Aduatiques. Upper plot shows the brightness deviations (y axis) versus time given in Julian Date (x axis). Lower plot shows the brightness deviations (y axis) versus heliocentric distance given in astronomical units (x axis).

The measurements in the upper plot in Figure 2 are bunched into small groups which corresponds to observations collected in different oppositions. It shows brightness deviations in range of roughly estimated one magnitude. The lower plot in Figure 2 shows the brightness deviations in correlation with heliocentric distance.

To check if the object displays some cometary features like coma or tail, so far we requested images from Catalina Sky Survey's Mt. Lemmon Survey which were taken at the moment of the outburst.

The Mt. Lemmon Survey data: Eight images containing (3646) Aduatiques were requested (Table 1).

The images were obtained in Mt. Lemmons regular sky survey program, using their 1.5-m f/2.0 Cassegrain reflector. The images have been exposed 30 (images taken in 2008) and 40 seconds (images taken in 2011), which, for the observed object, contributed to a signal-to-noise ratio of around ~60. By visual examination of the images, no typical indications of cometary activity was found, besides the negative deviation in (3646) Aduatiques' brightness.

To reanalyze the object's brightness, the images were remeasured using a Windows version of SExtractor and compared to the expected brightness (Table 1) generated by the JPL Solar System Dynamics database [4].

Table 1. Requested data of (3646) Aduatiques from Mt. Lemmon Survey and its brightness measurements compared to the expected brightness generated by the JPL Solar System Dynamics database.

Date	Observed mag. (V)	Expected mag.	Δmag.
2008 09 20.35225	16.48	17.38	- 0.90
2008 09 20.36087	16.46	17.38	- 0.92
2008 09 20.36956	16.47	17.38	- 0.91
2008 09 20.37825	16.43	17.38	- 0.95
2011 05 25.30260	17.29	18.14	- 0.85
2011 05 25.31301	17.28	18.14	- 0.86
2011 05 25.32345	17.27	18.14	- 0.87
2011 05 25.33391	17.28	18.14	- 0.86

Conclusions: The photometric search for MBCs resulted with six new MBC candidates, showing indications of weak cometary activity in form of brightness outbursts. One of the candidates is the main belt object (3646) Aduatiques.

The examination of images of (3646) Aduatiques, provided by the Mt. Lemmon Survey, shows no visible tail or coma which is probably the reason why the activity remained unnoticed until now. At the moment it is difficult to guess about the mechanisms causing the large variations on (3646) Aduatiques and future observations and a lighturve will be required. It is not excluded that some of the candidate objects may in fact be objects with very large rotational variability.

The detection of the already known MBC (7968) 133P/Elst-Pizarro shows that the applied method can give positive results in searching objects with signs of cometary activity.

One of the disadvantages of this method is a relatively bad accuracy of photometric data contained in the MPCAT-OBS Observation Archive, which is a result of many different instruments and setups. But the method could be successfully implemented in future sky surveys which assure very good photometric accuracy.

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References: [1] Jewitt D. (2012) *The Astronomical Journal 143,* 66. [2] Hsieh H. H. (2009) *Astronomy & Astrophysics 505,* 1297-1310. [3] Rhodes B. C. (2011) *Astrophysics Source Code Library*, record ascl:1112.014. [4] Chamberlin A.B., Yeomans D.K., Chodas P.W., Giorgini J.D., Jacobson R.A., Keesey M.S., Lieske J.H., Ostro S.J., Standish E.M., Wimberly R.N. (1997), *Bull. Amer. Astron. Soc. 29*, 1014.