γ-Ray Properties of Extragalactic Jets from the MOJAVE Sample

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on behalf of the Fermi/LAT and MOJAVE Collaborations

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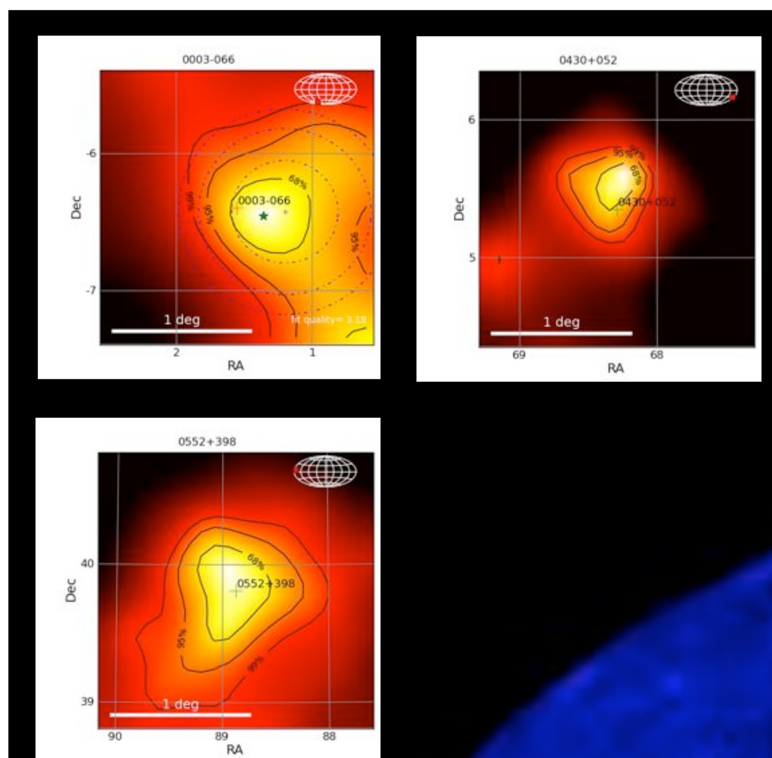
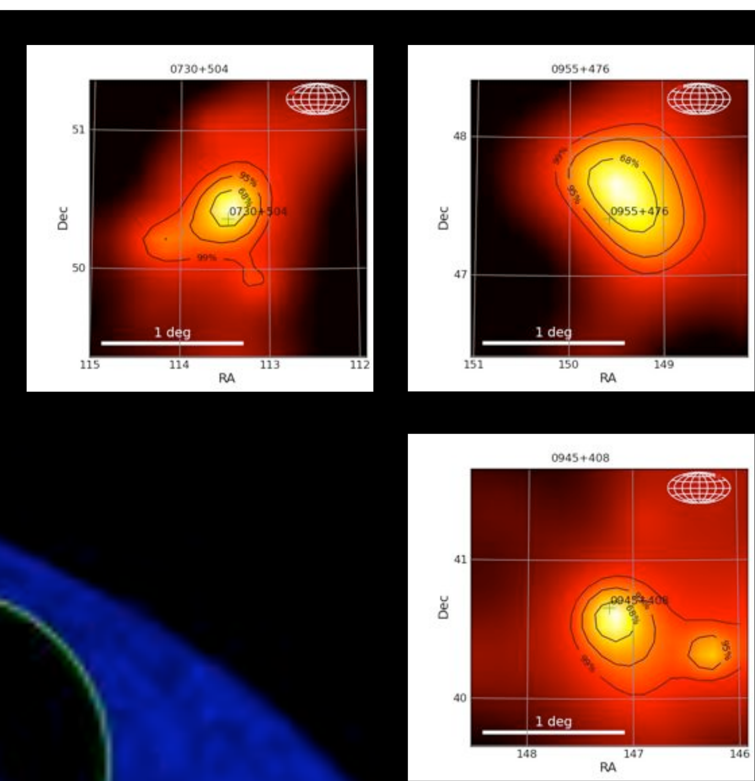
Summary: We have compiled all available LAT γ-ray information on the statistically complete radio-selected MOJAVE 1 AGN jet sample. LAT has detected all BL Lac objects in the sample but only 74% of all quasars.

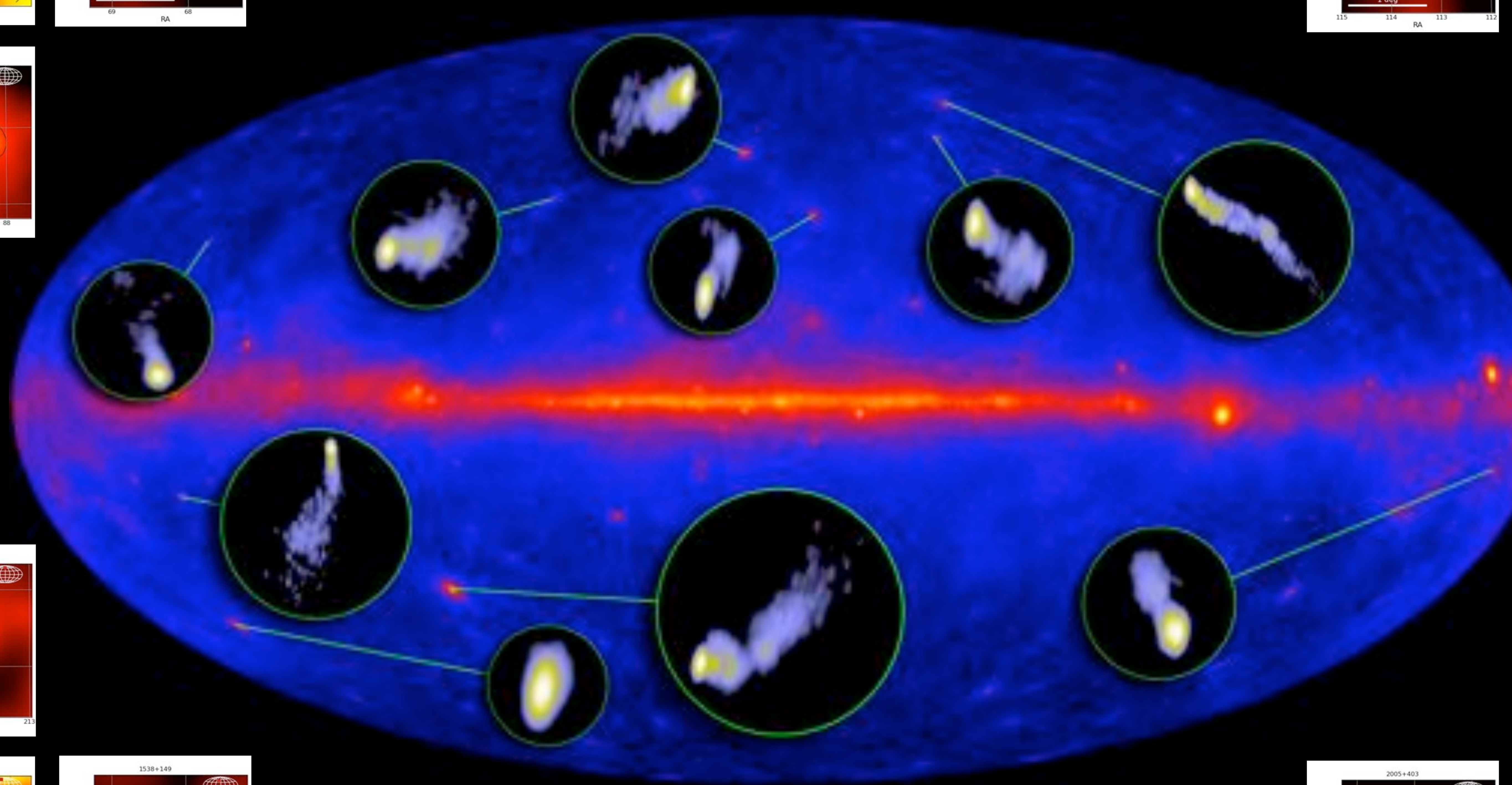
Abstract

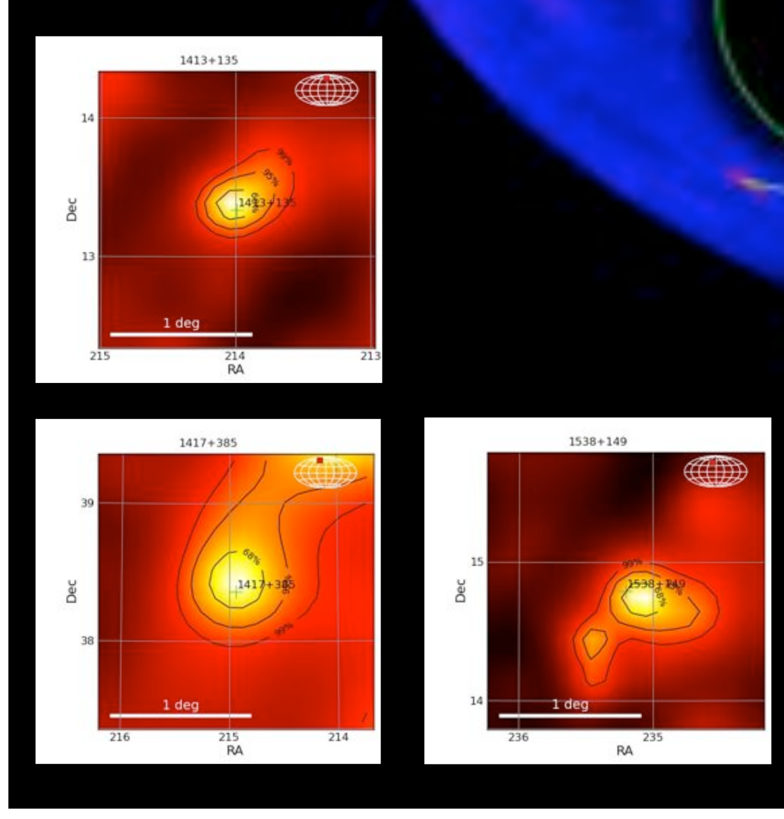
We discuss the gamma-ray properties of extragalactic jets from the MOJAVE sample. MOJAVE contains a statistically complete VLBI flux-limited subsample of 135 objects, which represent the brightest compact extragalactic jets in the Northern Sky. The majority of all MOJAVE sources are part of the one-year catalog under development by the LAT team. We find significant γ-ray emission from many additional MOJAVE 1 jets even below the catalog limit. γ-ray emission from all BL Lac objects has been found while about 26% of the quasars in the sample remain undetected after one year of LAT observations. We show the relations between VLBA jet speed and luminosity observed in the radio and γ-ray bands. The much broader distribution in the γ-ray domain is indicative of either a wider range of intrinsic γ-ray luminosities or of different boosting characteristics than in the radio domain.



Below is an all-sky *Fermi*/LAT image obtained from 9 months of observations (Fig. 1). Most of the brightest high-latitude extragalactic point sources are associated with MOJAVE sources. The insets show VLBA images of their parsec-scale jets, exaggerated in size by a factor of >10^6 as compared to the gamma-ray image.







Of 135 MOJAVE 1 sources, 85 are in the one-year catalog, that is being developed by the LAT team. Our targeted search revealed 11 additional detections (see corner inset TS maps and discussion below), and 8 tentative additional detections. Together, we detect 5/8 galaxies (62%), 75/101 quasars (74%), and 22/22 BL Lacs (100%) with LAT.

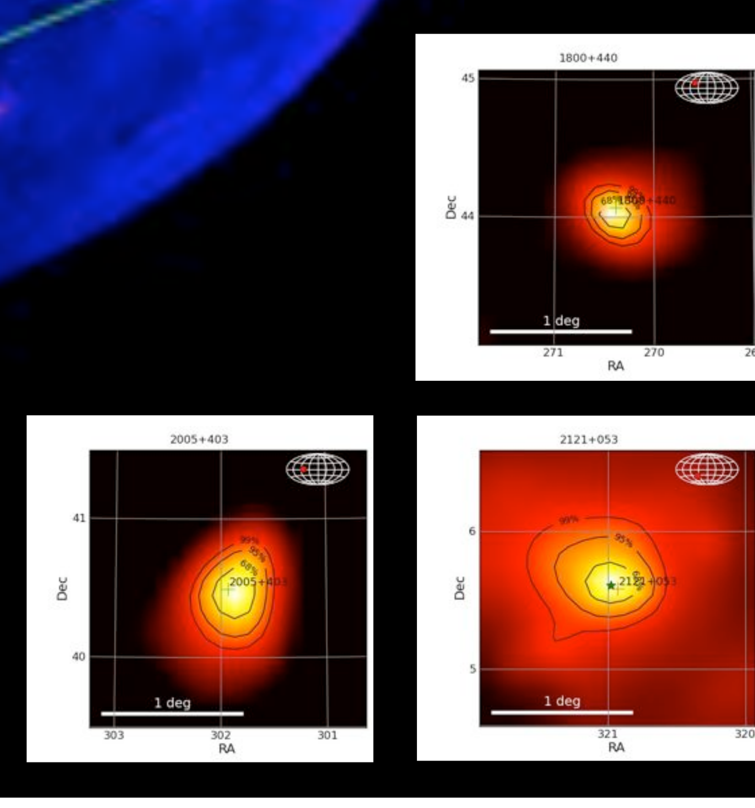


Fig. 1

Following Cohen et al. 2007 (ApJ 658, 232), we show the measured VLBA jet speeds as a function of radio luminosity in Fig.2. In contrast to Cohen et al., we use the maximum VLBA flux density measured over the course of the MOJAVE program. The distribution is enclosed by an envelop (aspect curve), that corresponds to a jet with Lorentz factor 50, and an intrinsic luminosity of 3 x 10^{25} WHz^{-1} viewed at different angles to the line of sight from 0.05 to 80 degrees, with a boosting exponent of 2. In confirmation of our previous results based on LBAS (Lister et al. 2009, ApJ 696, L22), we find the LAT-detected jets to be faster than their not-detected counterparts. In addition, a relatively high fraction of the slowest VLBA jets (β_{app}<3) have now been detected by LAT.

Fig.3 shows the speed-luminosity relation in the γ-ray domain (including upper limits of γ-ray weak sources).

The distribution is much wider, which can only be achieved by a wider range of intrinsic jet luminosities or by a larger boosting exponent.

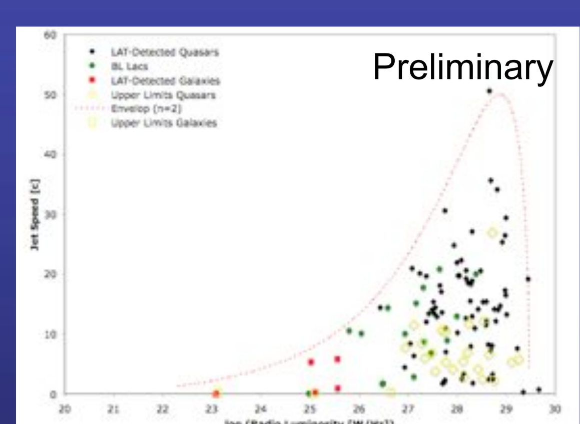


Fig. 2

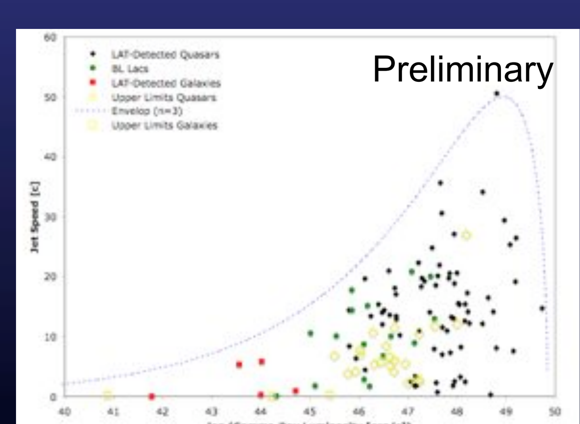


Fig. 3

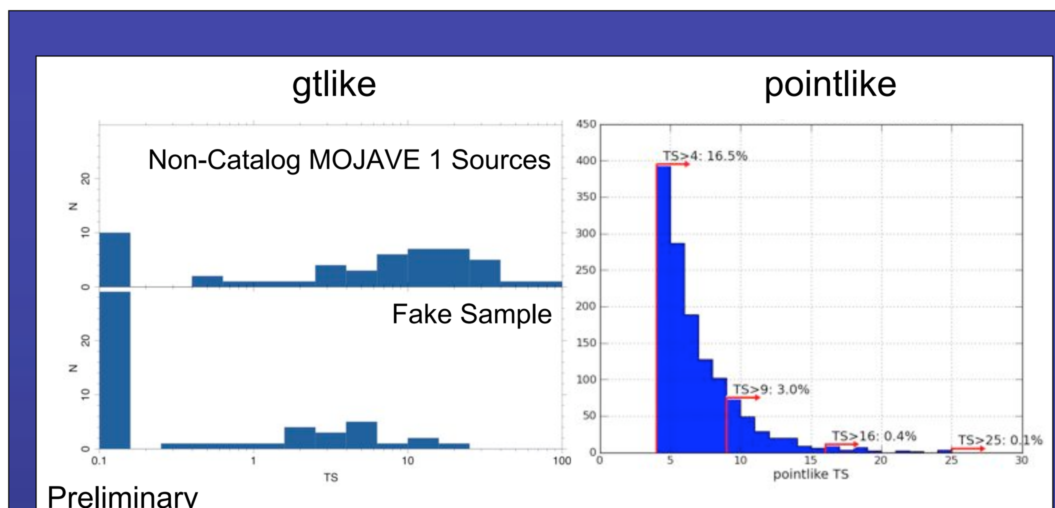


Fig. 4

We performed a standard maximum likelihood analysis (gtlike) for the 50 MOJAVE 1 sources, which are not in the one-year catalog. This corresponds to a targeted search, which is better suited to detect weak sources near the sensitivity threshold then the standard catalog procedure (blind search).

To assess the significance of our results, we performed a corresponding analysis on a sample of fake sources, by switching the sign of the Galactic-Latitude coordinate. The distribution of TS values for the non-catalog MOJAVE 1 sources and the fake sample are shown in Fig.4.

The majority (47/50; 94%) of all fake sources have a TS<10. 29 of the gamma-weak MOJAVE 1 sources have TS<10 and 21 have TS>10 among which we expect 1-2 statistical fluctuations.

To localize the weak sources, we define a binned likelihood (see poster P5-201, Burnett et al., for more details). Photons are binned in four bins per decade in energy. The likelihood is defined independently for each energy band and maximized with respect to the signal, with the background, corresponding to galactic diffuse, isotropic diffuse, and nearby sources, kept fixed. Then, an overall likelihood is formed as the product of the likelihoods of the individual layers. The "TS map" is then a map of the values of this function over a portion of the sky. The maximum is a measure of the position of the point source itself, and the shape an a-posteriori measure of the probability that the observed pattern corresponds to a single point source. This probability is essentially the likelihood itself.

Fig.4 Shows the distribution of TS values from this localization procedure (pointlike) for 1000 random positions on the sky. Only 3% of the random positions show values of TS>9.

We find 11 additional MOJAVE 1 sources to show a TS>9 from the standard likelihood analysis and a TS map with a well-localized point source (see TS maps insets in the corners of Fig. 1). One remarkable example is the radio galaxy *3C120* (0415+379; TS=34). 8 additional sources show a somewhat degraded TS map or a formally small TS value from one of the two methods. We consider these as tentative detections.