An observability study for the tentatively identified 3EG sources likely to be detected by the next-generation Cherenkov telescopes

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Abstract.
We present a compilation of data on the 22 tentatively identified gamma-ray sources from the Third EGRET Catalog which may be detected by the next-generation imaging atmospheric Cherenkov telescopes.

INTRODUCTION

The Third EGRET Catalog (3EG, Hartman et al. 1999), comprises 271 objects. Among these, 197 are not identified with a counterpart at lower wavelengths (radio, optical or X-rays). Seven of these are now believed to be artefacts of the background model near bright sources. The remaining 190 are the unidentified EGRET objects (UNIDs). A sizable number of researchers is working on identifying the UNIDs and so far more than 38 have a published tentative ID which still needs to be confirmed by either more observations or improved analysis of archival data. We call these sources the tentatively identified EGRET objects (TIDs).

New contributors to the field will be the next-generation Cherenkov telescope (CT) observatories which are under construction in Australia (CANGAROO III, e.g. Mori et al. 1999), Namibia (HESS I, e.g. Hofmann et al. 1999), La Palma (MAGIC I, e.g. Lorenz et al. 1999) and Arizona (VERITAS, e.g. Krennrich et al. 1999).

These new instruments will reach thresholds below 100 GeV and source location accuracies of about 1'. All UNIDs are unidentified because their position is only known with insufficient accuracy, some of the position probability maps having 95% confidence level contour radii of more than 1°. With an order of magnitude increase in location accuracy, deep well-targeted observations in the radio, optical and X-ray range become possible and make an identification almost certain. In addition, the much improved photon statistics of CTs (collection areas $> 10^4$ m^2) result in a higher sensitivity for pulsed components and thus Pulsar identifications. However, CTs can only contribute for those sources which show emission above several 10 GeV.

In Petry (2001), a catalog was compiled which contains all UNIDs which may possibly be detectable by the next-generation Cherenkov telescopes under moderate assumptions about spectral steepening and taking into account the elevation-dependent sensitivity of the instruments. This catalog contains 78 objects. Among them are 22 TIDs.

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These objects justify a closer examination since for their tentative counterparts various pieces of information exist which are not available for the other UNIDs: We have an exact source position which can be targeted. We know the source type and have therefore at least vague model predictions for the spectrum beyond the EGRET energy range. We have also model predictions for the variability characteristics of the source.

In this article we present first results of our data compilation and studies concerning the 22 TIDs which may exhibit significant emission beyond 10 GeV and for which the next-generation Cherenkov telescopes may provide the clue to their final identification.

THE DATA PRESENTED HERE

Table 1 gives a summary of the data presented at the conference. For each object we examine:

- What is the predicted emission of the TID in the energy regime near the threshold of the next-generation Cherenkov telescopes (CTs)?
- Which of the four observatories can observe the object?
- Is the emission variable?
- What is the angular size of the tentative counterpart?
- Are bright stars nearby which may influence the sensitivity of the CTs?
- Are there neighbouring EGRET objects which may lead to source confusion?
- What chances are there for a detection if the tentative identification turns out to be wrong? Will new pointings be necessary?

Due to the limited space in these proceedings, we refer for more detailed information to our poster which can be found in petry-reimer_poster.eps.gz at http://cossc.gsfc.nasa.gov/meetings/Gamma2001/session17/ and viewed using ghostview, and to Petry & Reimer (2001). We give here, however, the complete list of references.

SIMULATED CAMERA RESPONSES

We have examined the predicted response of the VERITAS photomultiplier camera to the starfield at each of the 22 source positions. The results were obtained from a simulation of the VERITAS optics and wavelength-dependent photomultiplier response and are shown here for the first time. The starfield information (star positions and spectra) was extracted from the SKY2000 master star catalog (Sande et al. 1998) which is reasonably complete up to magnitude 9. If not available from the catalog, the U band magnitude was calculated from the B and V magnitude assuming a main sequence star. Most important result of the simulation are the maps of the Poisson signal fluctuations in units of photoelectrons caused by the starlight and diffuse NSB in the field of view around each source. In order to not exceed the page limit of this publication, we only show two examples (figure 1), one for a very extended and one for a well constrained EGRET position probability map.

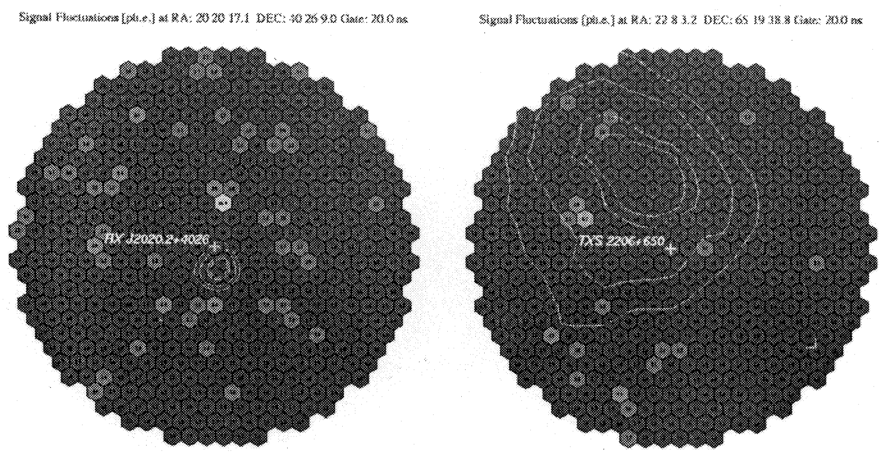

FIGURE 1. Examples of EGRET position probability maps for two of the tentatively identified sources discussed here: 3EG J2020+4017 (left) and 3EG J2206+6602 (right). The maps are superimposed on simulated representations of the field of view of the VERITAS Cherenkov telescope camera. The numbers in the individual photomultiplier pixels represent the expected signal fluctuations due to night sky background and star light in units of photoelectrons.

CONCLUSION

The next-generation Cherenkov telescopes (CTs) will be able to make an important contribution to the identification of some of the enigmatic unidentified sources of the third EGRET catalog. EGRET UNIDs for which a tentative identification exists are especially easy to target, and instruments on the northern hemisphere will be able to observe almost all such sources for which emission beyond 30 GeV can be expected. The short catalog of 22 such sources which we have compiled here, shows that a positive detection of any of these objects by CTs will be an interesting result in itself providing constraints for source models and, of course, leading to a clear identification of the 3EG source. Furthermore, the lessons learned form the observations of these objects will help in the examination of the remaining 57 EGRET UNIDs from the list compiled in Petry (2001) which have no identification whatsoever but which may have significant emission beyond 30 GeV.

For the beginning of an observation campaign, the most interesting object in our list is 3EG J1856+0114. This object has a flat spectrum with no obvious cut-off below 10 GeV. Due to its proximity to the SNR W44, it has been studied extensively (see e.g. the overview in Buckley et al. 1998). W44 is a radio shell-type SNR with an angular diameter of about 0.5° associated with PSR 1853+01. There is both evidence for a synchrotron nebula and interactions with molecular clouds. Extrapolating the thin outer gap model of Zhang & Cheng (1998) to 60 GeV yields a differential flux of 65 % of the Crab Nebula. The object is an ideal candidate for CT observations and is accidentally the only UNID which can be equally well observed both from the southern and the northern hemisphere. It could therefore be used to cross-calibrate the four CT observatories.

TABLE 1. The tentatively identified EGRET sources likely to be detected by the next-generation Cherenkov telescopes [Column titles: (1) name of the tentative counterpart, (2) equatorial coordinates of the counterpart, (3) galactic coordinates of the counterpart, (4) redshift for the extragalactic counterparts if known, (5) spectral index at 100 MeV from 3EG, (6) expected integral flux above 60 GeV (cm^{-2}s^{-1}), (7) source observability (C = CANGAROO, H = HESS, M = MAGIC, V = VERITAS), (8) variability index of the 3EG source as defined in Tompkins (1999), (9) problematic starfield?, (10) new pointings be necessary if the tentative identification turns out to be wrong?] [Abbreviations: [a] will probably require > 50 h of observation time (Petry 2001), [b] high energy cutoff visible in EGRET data, [c] soft low energy tail , [d] low statistics in EGRET data, [e] short-time variability observed, [f] predicted differential flux at 60 GeV (cm^{-2}s^{-1}MeV^{-1}), for comparison: predicted Crab Nebula flux at 60 GeV is 1.28×10^{-14}cm^{-2}s^{-1}MeV^{-1}.]

3EG name	tent. ID(1)	RA/DEC J2000(2)	l/b(3)	z(4)	α(5)	F(60 GeV)(6)	observ.(7)	var.(8)	s.(9)	p.(10)
0010+7309	RX J0007.0+7302 in SNR CTA1	00 07 02.2 +73 02 59	119.66 +10.46	-	-1.6[b]	8.3E-16[f]	M, V	0.31	no	no
0222+4253	3C 66A	02 22 39.6 +43 02 07.8	140.14 -16.77	0.444	-2.0	3.1E-10	M, V	[e]	no	no
0241+6103	LSI+61°303	02 40 31.67 +61 13 45.6	135.68 +1.09	-	-2.2	1.3E-10	M, V	0.49	no	no
0617+2238	1WGA J0617.1+2221 in SNR IC443	06 17 06.1 +22 21 30	189.23 +2.90	-	-1.8[b]	2.2E-10	H, M, V	0.26	yes	no
0808+4844[a]	QSO B0809+483	08 13 36.09 +48 13 02.5	171.17 +33.24	0.87	-2.3	2.9E-11	M, V	n/a	no	yes
0812-0646[a]	PKS 0805-077	08 08 15.54 -07 51 09.9	229.04 +13.16	1.84	-2.4	2.0E-11	C, H, M, V	n/a	no	yes
0917+4427	QSO B0917+449	09 20 58.46 +44 41 54.0	175.70 +44.82	2.18	-2.1	2.8E-11	M, V	n/a	no	yes
1009+4855[a]	QSO B1011+496	10 15 04.23 +49 26 00.7	165.53 +52.71	0.20	-2.0[d]	7.5E-11	M, V	n/a	no	yes
1323+2200	QSO B1324+224	13 27 00.86 +22 10 50.2	3.38 +80.53	1.40	-1.9	3.0E-10	M, V	2.69	no	no
1410-6147	RX J1420.1-6049 in SNR 312.4-00.4	14 20 07.8 -60 48 56	314.45 +1.38	-	-2.0[b]	1.8E-10	C, H	0.33	yes	no
1800-2338	SNR W28	18 01.0 -23 11	6.71 -0.05	-	-2.0[c]	2.2E-10	C, H, M, V	0.03	yes	no
1824-1514	LS5039	18 26 14.9 -14 50 51	16.88 -1.29	-	-2.4	7.5E-11	C, H, M, V	n/a	yes	yes
1835+5918	RX J1836.2+5925	18 36 13.82 +59 25 28.9	88.88 +25.00	-	-1.7[b]	≈1.4E-15[f]	M, V	0.15	no	no
1856+0114	PSR 1853+01 in SNR W44	18 56 10.89 +01 13 20.6	34.56 -0.50	-	-1.8	8.3E-15[f]	C, H, M, V	0.80	yes	no
1903+0550	SNR 040.5-00.5	19 06.9 +06 33	40.52 -0.44	-	-2.5	3.7E-11	C, H, M, V	0.35	yes	yes
2016+3657	TXS 2013+370	20 15 28.89 +37 10 58.7	74.87 +1.22	?	-2.0[c]	1.3E-10	M, V	0.37	yes!	no
2020+4017	RX J2020.2+4026 in SNR G78.2	20 20 17.1 +40 26 09	78.09 +2.27	-	-2.0[b]	1E-17[f]	M, V	0.07	yes!	no
2100+6012[a]	B2101+6003	21 02 40.31 +60 15 09.8	97.96 +9.01	?	-2.1[d]	3.5E-11	M, V	0.15	yes	no
2206+6602[a]	TXS 2206+650	22 08 03.20 +65 19 38.8	106.94 +7.66	?	-2.3	2.6E-11	M, V	0.27	yes	yes
2227+6122	RX J2229.0+6114	22 29 04.97 +61 14 12.9	106.65 +2.95	-	-2.2	6.1E-11	M, V	0.10	no	no
2255+1943[a]	QSO B2246+2051	22 53 07.36 +19 42 34.8	88.33 -35.09	0.284	-2.3[d]	4.3E-11	C, H, M, V	0.41	no	yes
2352+3752[a]	QSO 2346+385	23 49 20.91 +38 49 17.6	109.89 -22.47	1.03	-2.6[d]	1.3E-11	M, V	24.92	no	yes

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