Search for γ radiation above 20 TeV from supernova remnants in our galaxy

HEGRA collaboration

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Abstract

It is generally assumed that supernova remnants are powerful cosmic accelerators and that they are most likely the origin of VHE and UHE cosmic radiation. The HEGRA collaboration reports on a systematic search for gamma radiation from all known supernova remnants smaller than $40'$ in the field of view of the Cerenkov array AIROBICC.

1 Introduction

Supernova remnants (SNRs) are widely believed to be the origin of the bulk of cosmic radiation below 10^{14} TeV because they release enough energy to produce the observed cosmic rays and the assumed acceleration mechanism (diffusive shock acceleration) is plausible. An experimental proof of this idea would be the observation of cosmic γ radiation from some SNRs up to some TeV γ energy.

We have performed a systematic search for γ radiation above $\sim$ 20 TeV from all known SNRs in the field of view of the AIROBICC detector which are smaller than $40'$ in diameter. The positions of the SNRs have been taken from two catalogues ([1][2]). Some SNRs have been identified as EGRET sources [3].

The SNR G78.2+2.1 which partly expands into a dense molecular cloud and of which theory expects an extraordinary high γ flux [4] has been analysed seperately. The results will be presented in another contribution to this conference [5].

AIROBICC is a wide angle Cerenkov detector located at the HEGRA site on the Canary island la Palma. Each of the 49 detector stations of AIROBICC is equipped with a winston cone mirror for light collection and a big (20 cm diameter) photomultiplier tube which can detect Cerenkov light from a solid angle of 1 sr. Due to the possibility of exact timing measurement of the Cerenkov light pulses the angular resolution of AIROBICC is superior to that of scintillator arrays and therefore very well suited for looking for γ sources (see also the contributions [6], [7] and [8]).

The design and performance of AIROBICC is described in detail in [9]. An overview of the HEGRA experiment is given in another contribution to this conference [10].

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2 Data and Analysis

The dataset used for this analysis was recorded from March 1992 to April 1993 (as in Karle et al. [11]) and consists of a total of 40 million showers. Some quality cuts were applied on the data, namely

- reduced χ^2 of the fit for the shower direction (cone fit to the Cerenkov light arrival time distribution) ≤ 2
- shower core position at least 5 m inside the array
- number of triggered AIROBICC huts ≥ 12

These cuts lead to an angular resolution of $\sigma_{63} = 0.29°$ [9].

All chosen SNRs have been treated like cosmic point sources which holds roughly true because their size is comparable to the angular resolution of AIROBICC or smaller.

As on-source region for each candidate a circular area around its position of radius $0.39°$ has been taken. This is the optimal on-source region for the above angular resolution assuming point sources and taking also into account a pointing uncertainty of $0.10°$.

The number of background events expected in the source region has been calculated from the number of events in a ring around the source position (opening angle $0.5° - 2.4°$).

A detailed description of the determination of the angular resolution, the energy threshold and the source search technique can be found in [9] and [11].

3 Results

In Table 1 the results of our SNR survey are printed. No clear excess of on-source events can be found. All significance values fit to a gaussian distribution without any outlier (see Fig.1) showing that there is no evidence for a γ signal. Upper γ flux limits (90% confidence level) have been calculated for each object.

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Figure 1: Distribution of significances of all analysed SNRs with a gaussian fit

Table 1: Event statistics, significances and upper γ flux limits for all analysed SNRs

Object	$\langle\Phi\rangle \cdot 10^{-4}$ $[m^{-2}s^{-1}sr^{-1}]$	$E_\gamma[TeV]$	N_{Source}	$\langle N_{BG}\rangle$	$S[\sigma]$	N_{UL} (90% CL)	$\Phi_{Source,UL}$ $[10^{-13}cm^{-2}s^{-1}]$
G189.1+3.0	1.81	21.2	309	339.0	-1.63	16.5	1.75
G30.7+0.1	0.38	53.8	74	71.4	0.30	16.0	1.70
G34.6+0.0	0.59	41.5	120	110.5	0.88	25.0	2.66
G40.5-0.5	0.86	33.0	145	162.0	-1.34	12.4	1.32
G41.1-0.3	0.90	32.1	150	169.6	-1.51	11.9	1.26
G29.7-0.2	0.19	81.8	35	35.5	-0.09	9.6	1.02
G31.9+0.0	0.45	48.8	83	84.1	-0.12	14.6	1.55
G33.0+0.1	0.49	46.4	90	91.7	-0.17	14.9	1.58
G33.7+0.0	0.46	48.0	87	86.4	0.06	15.9	1.69
G35.6-0.0	0.64	39.4	115	120.1	-0.46	15.1	1.60
G37.6-0.1	0.74	36.2	134	138.5	-0.38	16.8	1.78
G39.2-0.3	0.81	34.4	173	151.2	1.71	39.3	4.17
G43.3-0.2	0.97	30.8	180	181.5	-0.11	21.5	2.28
G45.5+0.1	1.05	29.3	199	196.9	0.15	24.9	2.64
G46.8-0.3	1.09	28.6	221	204.9	1.10	36.7	3.90
G49.0-0.3	1.19	27.3	225	222.6	0.16	26.5	2.82
G53.7-2.2	1.26	26.3	230	235.9	-0.38	22.0	2.34
G74.8+0.6	1.37	25.0	267	256.4	0.65	34.6	3.67
G74.9+1.2	1.38	24.8	225	259.8	-2.18	11.8	1.25
G78.3+2.5	1.34	25.4	258	251.1	0.43	31.4	3.34
G78.5-0.1	1.32	25.5	285	248.1	2.26	58.9	6.26
G78.6+1.0	1.33	25.5	243	249.5	-0.41	22.4	2.38
G78.9+3.7	1.31	25.7	228	245.6	-1.12	16.8	1.78
G79.8+1.2	1.32	25.5	228	248.7	-1.31	15.7	1.67
G111.7-2.1	0.56	42.8	105	104.8	0.02	17.2	1.83
G120.1+1.4	0.27	65.8	52	51.1	0.12	12.6	1.33
G47.0+10.6	0.83	33.7	161	156.2	0.38	24.3	2.59
G69.9+1.5	0.82	33.9	158	154.5	0.28	23.2	2.47
G94.0+1.0	0.53	44.2	110	99.2	1.05	25.4	2.70

$\langle\Phi\rangle$: measured flux of cosmic rays in the local environment of the source
E_γ: energy threshold for γ showers (50% detection efficiency)
N_{Source}: number of events in the source region
$\langle N_{BG}\rangle$: expected background in the source region
S: statistical significance of a possible signal
N_{UL}: upper limit to number of events from the source (90% confidence level)
$\Phi_{Source,UL}$: upper limit to the flux of radiation from a source (90% confidence level).