Observation of Multi-TeV Gamma Rays from the Shell-like SNR GC40.5-0.5 Using the Tibet Air Shower Array

J.L.Zhang for the Tibet ASγ Collaboration
† *Correspondence to*: J.L.Zhang(zhangjl@mail.ihep.ac.cn)

Abstract

Using observation data of the Tibet air shower array in different periods, an excess of events in the multi-TeV region was detected from the SNR GC40.5-0.5 direction, although statistically not significant yet. The position of the highest excess is around the EGRET unidentified source 3EG J1903+0550.

1. Introduction

It is now generally believed that cosmic rays with energies less than 100 TeV originate in the galaxy and are accelerated in shock waves of shell-type supernova remnants. Using the model of diffusive shock acceleration, Drury,Aharonian & Völk [1] have calculated its expected γ-ray flux from secondary pion production. Recently, TeV γ-rays have been detected from RX J1713.7-3946 [2] and Cassiopeia A [3].

From radio observations it was known that SNR GC40.5-0.5 has a shell-like structure with angular size $\sim 26'$. The $\Sigma - D$ relationship places this remnant at a distance of 5.5-8.5 kpc, which would locate it inside the Sagittarius arm[4]. The X-ray image of ASCA contains two weak pointlike sources[5]. It has been suggested[6] to be possibly associated with the 3EG J1903+0550[7]. The Galactic plane survey of TeV γ-rays with HEGRA Čerenkov telescope, has not shown significant emission from GC40.5-0.5 direction[8]. Here we report the observation results of Tibet AS array in the period 1990-2002 on SNR GC40.5-0.5.

2. Experiment and Methods

The Tibet experiment has been successfully operated at Yangbajing in Tibet (4300 m above sea level). The Tibet-I(1990-1993) array consists of 49 scintillation detectors of 0.5 m^2 each, which are placed in a 7×7 matrix form with a separation of 15 m [9]. The Tibet-II(1995-1999) array consists of 185 scintillation detectors of 0.5 m^2 each placed on a 15 m square grid, and the HD (high density) array is operated inside the Tibet-II array. This HD array consists of 109 scintillation detectors, placed on a 7.5 m square grid[10]. The Tibet III(1999-2002) array consists of 533 scintillation counters covering 22,050

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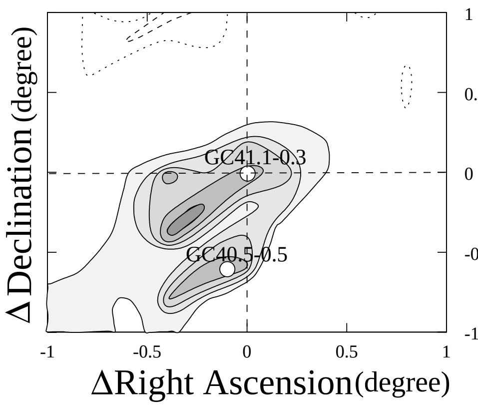

Fig. 1. Tibet I. E $\geq$ 10 TeV, window size R_0=1.0°, step=0.2σ. The highest excess is 2.2 σ at (-0.3,-0.3).

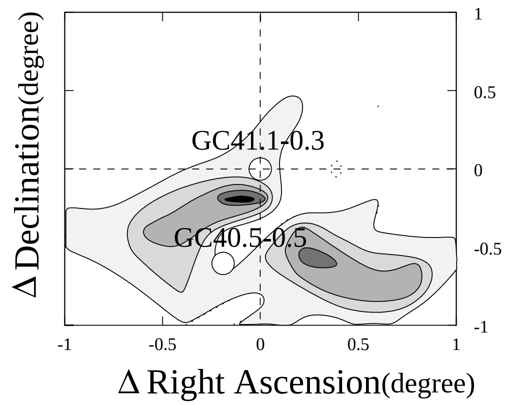

Fig. 2. Tibet II phase 1. E $\geq$ 10 TeV, R_0=1.0°, step=0.2. The highest excess is 2.8σ at (-0.1, -0.2).

m^2, with a 7.5 m lattice interval [11], the mode energy is about 3 TeV. The event is selected by imposing that each of any four detectors should record a signal of more than 1.25 particles. By observing the shadow of Moon, the angular resolution of arrays is known to be better than 1.0°. In the search of γ-ray excess, the background was obtained by averaging over events falling in the ten off-source windows with the same zineth angle. The search region was tiled with an array of overlapping radius bins centered on a 0.1°×0.1° grid. The radius depends on the value $\Sigma\rho$, the number of total particles hitting the detectors.

3. Results

The results of TibetI(1990-1993) at 10 TeV and TibetII phase 1(1995 - 1996) at 10 TeV are shown in Fig.1 and Fig.2 respectively. They are contour maps of excess centered at the position of GC41.1-0.3(R.A.=286°.9,Decl.= 7°.1(J2000)).

Similarly, in Fig.3 and Fig.4, the results of TibetII-HD phase 4(1998 - 1999) at 3 TeV and at 10TeV are shown respectively, with the GC40.5-0.5 positioned (R.A.=286°.8, Decl.= 6°.5 (J2000)) at the center.

The results of TibetIII phase 2(2000 - 2001) at 3 TeV and at 10 TeV are shown in Fig.5 and Fig.6, respectively. The maps are centered at the position (R.A.=287°.1, Decl.=5°.5 (J2000)).

With a differential power-law spectrum proportional to $E^{-2.4}$, using Tibet III phase 2 data, the flux upper limit are given at the 90% confidence level for energies larger than 3 TeV and 10 TeV for the GC40.5-0.5, respectively.

Energy (TeV)	σ	90% c.l. flux upper-limit($10^{-12}cm^{-2}s^{-1}$)
$\geq$3	4.4	6.8
$\geq$10	3.4	0.12

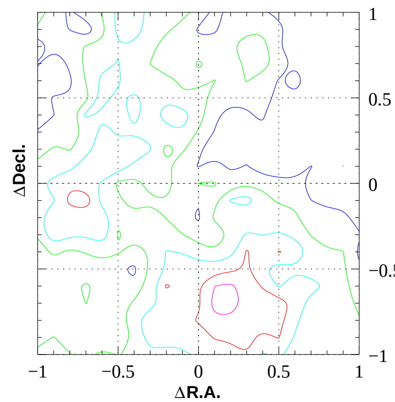

Fig. 3. Tibet II-HD phase 4. E $\geq$ 3 TeV, R_0=1.2°, step=0.5 σ. The highest excess is 3.4σ at (0.2,-0.7).

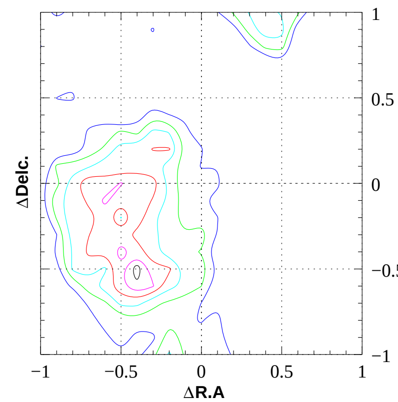

Fig. 4. Tibet II-HD phase 4. E $\geq$ 10 TeV, R_0=0.55°, step=0.5 σ. The highest excess 3.9 σ at (-0.4,-0.5).

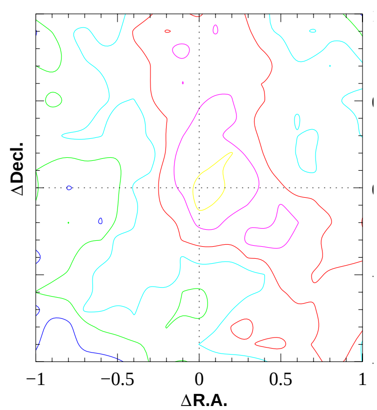

Fig. 5. Tibet III phase 2. E $\geq$ 3 TeV, R_0=1.4°, step=0.5σ. The highest excess 4.4 σ appears at (0.0,0.0).

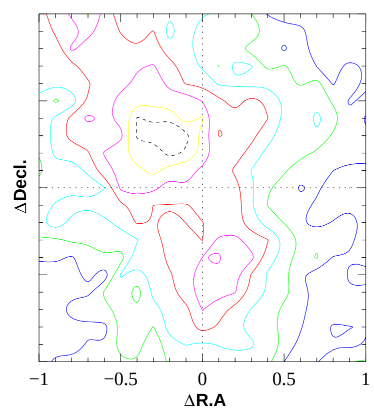

Fig. 6. Tibet III phase 2. E $\geq$ 10TeV, R_0=0.95°, step=0.5σ. The highese excess 3.4 σ excess appears at(-0.2,0.3).

4. Discussion

In Fig.7, it is seen that all the highest excess points of different experiment phases are around the EGRET unidentified source 3EG J1903+0550 and are not far from the dense matter region of GC40.5-0.5, which can provide the envirnonment for proton accelaration and nuclear interactions. Considered the expanding character of shell type SNRs and the GC40.5-0.5 being observed at YBJ mostly with rather large zineth angle, the loction scattering of the observed highest excess points in different periods can be understood. Though the positions are not rightly on the sources and the significances are marginal, two things attract our attention: each period of the experiment showed some signals around

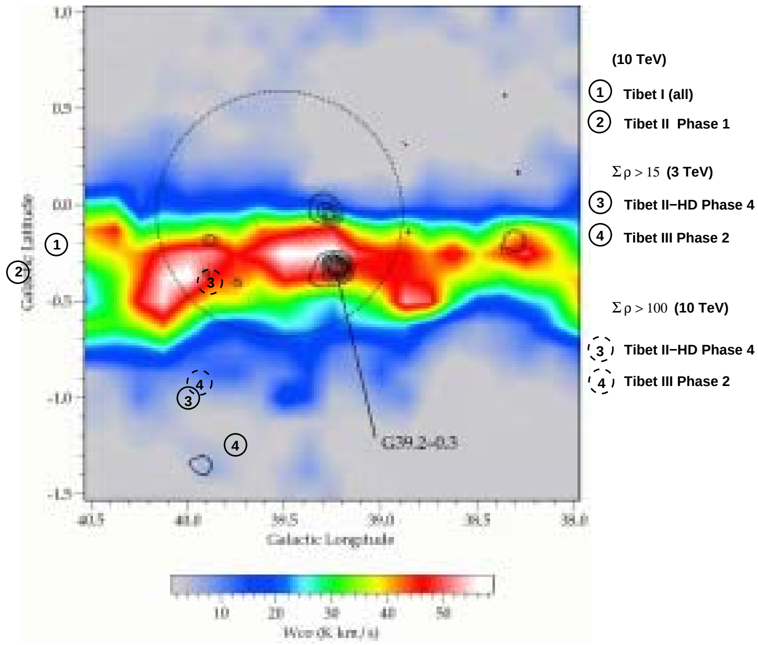

Fig. 7. Tibet results of GC40.5-0.5 are marked on the Torres's figure[12]. The solid circles 1, 2, 3, 4 are the highest excess points in Fig.1, Fig2, Fig.3, Fig.5, respectively. The dashed circles 3, 4 are for Fig.4, Fig.6, respectively. The dotted circle is the 95% radiue about the central position of 3EG J1903+0550.

the vicinity of GC40.5-0.5 and the contour map showed that not only an isolated highest excess point, but also a $\sim 1.5^\circ$ wide area appearing $> 2\sigma$. It encourages us to continue the observation further.

The Tibet-III array(733 detectors) started to work in the fall of 2002. With its 1.5 times larger effective area, we hope a definite conclusion can be reached.

5. References

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