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# Multiwavelength searches of the Shell-like SNR G40.5-0.5

J.L. Zhang for the Tibet AS$\gamma$ Collaboration
M. Amenomori[a],S. Ayabe[b], D. Chen[c], S.W. Cui[d], Danzengluobu[e], L.K. Ding[d], X.H. Ding[e], C.F. Feng[f], Z.Y. Feng[g], X.Y. Gao[h], Q.X. Geng[h], H.W. Guo[e], H.H. He[d], M. He[f], K. Hibino[i], N. Hotta[j], Haibing Hu[e], H.B. Hu[d], J. Huang[k], Q. Huang[g], H.Y. Jia[g], F. Kajino[l], K. Kasahara[m], Y. Katayose[c], C. Kato[n], K. Kawata[k], Labaciren[e], G.M. Le[o], J.Y. Li[f], H. Lu[d], S.L. Lu[d], X.R. Meng[e], K. Mizutani[b], J. Mu[h], K. Munakata[n], A. Nagai[p], H. Nanjo[a], M.Nishizawa[q], M.Ohnishi[k], I. Ohta[j], H. Onuma[b], T. Ouchi[i], S. Ozawa[k], J.R. Ren[d], T. Saito[r], M. Sakata[l], T. Sasaki[i], M. Shibata[c], A. Shiomi[k], T. Shirai[i], H. Sugimoto[s], M. Takita[k], Y.H. Tan[d], N. Tateyama[i], S. Torii[t], H. Tsuchiya[u], S. Udo[k], H. Wang[d], X. Wang[b], Y.G. Wang[f], H.R. Wu[d], L. Xue[f], Y. Yamamoto[l], C.T. Yan[k], X.C. Yang[h], S. Yasue[n], Z.H. Ye[o], G.C. Yu[g], A.F. Yuan[e], T. Yuda[i], H.M. Zhang[d], J.L. Zhang[d], N.J. Zhang[f], X.Y. Zhang[f], Y. Zhang[d], Yi Zhang[d], Zhaxisangzhu[e] and X.X. Zhou[g]
*(a) Department of Physics, Hirosaki University, Hirosaki 036-8561, Japan*
*(b) Department of Physics, Saitama University, Saitama 338-8570, Japan*
*(c) Faculty of Engineering, Yokohama National University, Yokohama 240-8501, Japan*
*(d) Key Lab. of Particle Astrophys., Institute of High Energy Physics, Chinese Academy of Sciences,Beijing 100049,China*
*(e) Department of Mathematics and Physics, Tibet University, Lhasa 850000, China*
*(f) Department of Physics, Shandong University, Jinan 250100, China*
*(g) Institute of Modern Physics, South West Jiaotong University, Chengdu 610031, China*
*(h) Department of Physics, Yunnan University, Kunming 650091, China*
*(i) Faculty of Engineering, Kanagawa University, Yokohama 221-8686, Japan*
*(j) Faculty of Education, Utsunomiya University, Utsunomiya 321-8505, Japan*
*(k) Institute for Cosmic Ray Research, the University of Tokyo, Kashiwa 277-8582, Japan*
*(l) Department of Physics, Konan University, Kobe 658-8501, Japan*
*(m) Faculty of Systems Engineering, Shibaura Institute of Technology, Saitama 337-8570, Japan*
*(n) Department of Physics, Shinshu University, Matsumoto 390-8621, Japan*
*(o) Center of Space Science and Application Research, Chinese Academy of Sciences, Beijing 100080, China*
*(p) Advanced Media Network Center, Utsunomiya University, Utsunomiya 321-8585, Japan*
*(q) National Institute for Informatics, Tokyo 101-8430, Japan*
*(r) Tokyo Metropolitan College of Aeronautical Engineering, Tokyo 116-0003, Japan*
*(s) Shonan Institute of Technology, Fujisawa 251-8511, Japan*
*(t) Advanced Research Institute for Science and Engineering, Waseda University, Tokyo 169-8555, Japan*
*(u) RIKEN, Wako 351-0198, Japan*
Presenter: J.L. Zhang (zhangjl@mail.ihep.ac.cn), chn-zhang-J-abs1-og22-poster

Using observation data of the extended Tibet air shower array from October 2000 to September 2001, a region around the shell-like SNR G40.5-0.5 direction with the highest excess of 4.4 sigma was found using two dimension analysis method. In this article we presented some work done to understanding the nature of the G40.5-0.5 using a multiwavelength approach. In order to look for a site of the CR accelerators, a survey of the CO(J=1-0) line to G40.5-0.5 region will be conducting with the 13.7m radio telescope at Delingha, the millimeter-wave radio observatory of Purple Mountain Observatory this year.

## 1. Introduction

The ADV model(diffusive shock acceleration)[1] shows that, Galactic SNRs should be detectable $\gamma$-ray sources at distances of up to a few kpc in regions of the ISM where the mean density is of order 1/cm$^{-3}$ or more and can be a proper place for pion production. The discovery of high-energy $\gamma$-rays from a supernova remnant will provides concrete evidence for the proposed theories. However, the observational data are inconclusive and the question of the origin of cosmic-ray nuclei remains open. Measurements of the TeV $\gamma$-ray flux from six nearby radio-bright SNRs have been made with the Whipple Observatory imaging air Čerenkov telescope over the period September 1993 to June 1996. No significant emission has been detected and upper limits on the $>$300GeV flux are reported[2]. The observation of the SNR SN1006 by CANGAROO group showed evidence for TeV $\gamma$-ray flux. It have been interpreted this $\gamma$-ray data as synchrotron emission from nonthermal electrons accelerated to $\sim$ 100 TeV by the SNR shock. Recently, HESS group reported their observations on the SNR RX J1713.7-3946 and present the energy spectrum which indicates efficient acceleration of charged particles to energies beyond 100 TeV, consistent with current ideas of particle acceleration in young SNR shocks[3].

Due to the angular extent of the SNRs, the sensitivity of the imaging Čerenkov technique is reduced due to the sharp drop of the efficiency of detection of $\gamma$-rays beyond 2° field of view. In contrast to atmospheric Čerenkov telescopes with relatively narrow fields of view and small duty cycle, air shower arrays are wide aperture and high duty cycle instruments. Using observation data of extended Tibet air shower array, a region around the shell-like SNR G40.5-0.5 direction with the highest excess of 4.4$\sigma$ was found using two dimension analysis method [4]. In this article, some multiwavelength approaches are used, to understanding the nature of the G40.5-0.5.

## 2. Multiwavelength observation

**TeV $\gamma$-ray:** Using observation data of the extend Tibet air shower array, a region around the shell-like SNR G40.5-0.5 direction with the highest excess of 4.4$\sigma$ was found. Shown in Figure 1 is the contour map of the significance for events with $\Sigma\rho > 15$ observed during the period 2000 October to 2001 September around the position [R.A. = 287.1°, decl. = 5.5° (J2000)]. This position was marked at Figure2 and Figure3. For the each bin, the significance is calculated for the area of the circle with radius 1.4° and the bin center as the central point. The highest excess is 6.2$\sigma$ at the center. Due to the Yangbajing's latitude is not so good to observe the G40.5-0.5 with a large zenith, the count rate is not uniform about azimuth. After a sample correct for the this non-uniformity of azimuth, the highest excess is 4.4$\sigma$. We presume this excess to be $\gamma$ rays.

**X ray:** Figure2 is the ASCA GIS image of GeV J1907-0557[5]. The image was based on the LM position[6], and contains two weak pointlike sources which may be bright spots in a single, extended source, or fluctuations from a low count rate. It is seen clearly at Figure3, the GeV J1907-0557 was $\sim$ 1° away from the center of 3EG J1903+0550, and it's hardly overlap with the very large 95% contour of the 3EG J1903+0550.

**radio:** From radio observations it was known that SNR GC40.5-0.5 has a shell-like structure. The $\Sigma - D$ relationship places this remnant at a distance of 5.5-8.5 kpc, which would locate it inside the Sagittarius arm[7]. The Torres figure shows the 4.85 GHz CO(J=1-0) contours of the 3EG J1903+0550 with a 7 arcmin angular resolution[8]. The SNR G39.2-0.3, less than 8 arcmin in size, and SNR G40.5-0.5 are associated with the cloud complex. It is suggested that the location of the 3EG source lies between the two SNRs, and could thus have a composite origin.

**Čerenkov telescope:** A large region, $-10 < b < 5, 38 < l < 43$, comprising the SNR G40.5-0.5 as well as the 3EG J1903+0550 source was subject of a search for $\gamma$-ray emission using HEGRA system of imaging atmospheric telescopes[9], no evidence for emission from point sources was detected. The TeV observations

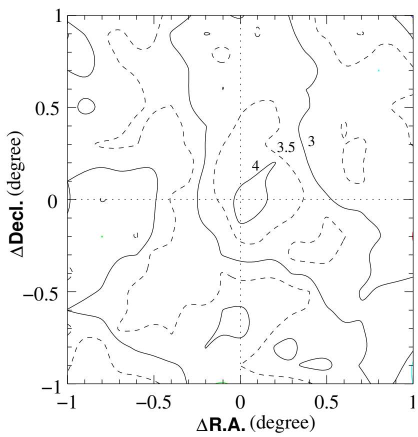


**Figure 1.** The significance for an event excess as a function of right ascension and declination in a $1^\circ \times 1^\circ$ region with the position [R.A. = 287.1°, decl. = 5.5° (J2000)] in the center observed between 2000 October and 2001 September. For the each bin, the significance is calculated for the area of the circle with radius 1.4° and the bin center as the central point. The contour lines are drawn with a step of $0.5\sigma$.

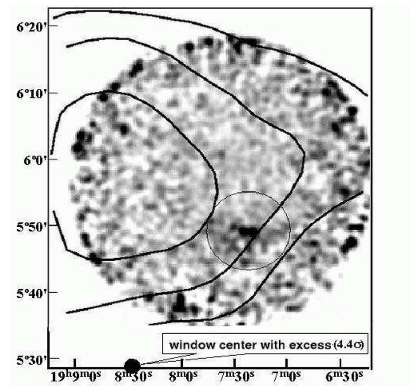


**Figure 2.** ASCA GIS image of the GeV J1907-0557. The image was based on the LM positon. Coordinates are in R.A.(2000) and decl.(2000). The contours are the 68%, 97% 99% confidence positions of the GeV J1907-0557. The centre point of Figure 1 was been marked.

of GeV J1907-0557 sources with the HEGRA IACT-system, were taken from the HEGRA SS-433 archive, has yielded no convincing evidence[10]. The observations of unidentified EGRET sources were made with the Whipple 10m imaging atmospheric Čerenkov telescope between Fall 1999 and Spring 2001. In one case for GeV J1907-0556, the analysis indicated significant emission throughout the 7 square degree field, and have large brightness differences between ON and OFF observations[11].

**EGRET:** It has been suggested [12] that SNR G40.5-0.5 is possibly associated with the 3EG J1903+0550[13]. The GeV J1907+0557 is one of the point sources of GeV $\gamma$-rays made by Lamb and Macomb using only photons with energies above 1GeV[6]. The Figure3 is EGRET intensity contour map of the 3EG J1903+0550, in Galactic coordinates. It seems likely that 3EG J1903+0550 is associated with the SNR G40.5-0.5, in which case it has no association with GeV J1907+0557.

## 3. Summary

Using the data of the Tibet air shower array from October 2000 to September 2001, a excess of 4.4 $\sigma$ was found with bin radius 1.4° and center at the position [R.A. = 287.1°, decl. = 5.5°]. This 1.4° bin covered a large region includes the EGRET sources GeV J1907+0557 and 3EG J1903+0550. From Figure3, it seems likely that 3EG J1903+0550 is associated with the G40.5-0.5 and the G39.2-0.3, but GeV J1907+0557 is only associated with the G40.5-0.5. The region of 68% confidence of 3EG J1903+0550 and GeV J1907+0557 near the shell(Figure3 large dash circle) of G40.5-0.5. Around the shell of G40.5-0.5, it is likely that the shock-accelerated protons and ions collide with the resident nuclei and produce neutral pions that then promptly decay to gamma($\pi^0 \to \gamma\gamma$). Same scenario is likely for the G39.2-0.3, which was indicated with a small dash circle at Figure3, its contribution to 3EG J1903+0550 is quite small due to its small size(less than 8 arcmin).

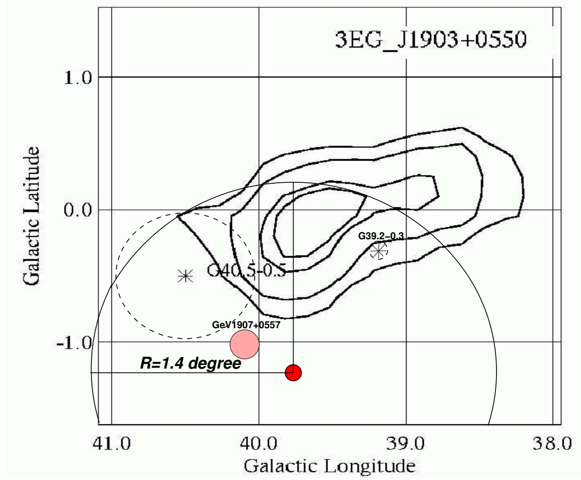


**Figure 3.** EGRET intensity contour map of the 3EG J1903+0550, in Galactic coordinates. It seems likely that 3EG J1903+0550 is associated with the SNR G40.5-0.5, in which case it has no association with GeV J1907+0557. The dash circle indicates the shell of SNR G40.5-0.5. The small circle indicates the region of 68% confidence of the GeV J1907+0557. The large solid circle with the radius 1.4° is the source bin which be used at Figure 1. A small dash circle with the radius $8'$ indicates the size of the SNR G39.2-0.3.

In order to understanding the nature of the G40.5-0.5, a survey of the CO(J=1-0) line on G40.5-0.5 region with the 13.7m radio telescope at Delingha of western China, the millimeter-wave radio observatory of Purple Mountain Observatory [14], will be conducted in future.

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