1. The Crab pulsar and nebula at high energies

The Crab pulsar is one of the most attracting astrophysical object and has been the top-studied subject of observations in various wavelengths. The highest energy band data of its pulsed emission comes from the EGRET detector onboard the Compton Gamma-ray Observatory (1991–2000) (Nolan, P.L. et al., 1993, ApJ 409, 697; Ramanamurthy, P.V. et al., 1995, ApJ 450, 791; Fierro, J.M. et al., 1998, ApJ 494, 734. The observed phase distribution is synchronized with other frequencies (radio, optical and X-rays) which means the pulsed emission comes from vicinity, within the light cylinder, of the rotating magnetized neutron star.

Meanwhile, ground-based Cherenkov telescopes are extensively observing the Crab in the TeV energy region (≥ 0.2 TeV) since it is an established source of gamma-rays in the TeV energy region. However, TeV region data do not show pulsation while the DC flux, regardless of its origin (pulsar or nebula), is easily detected by almost all Cherenkov telescopes. This fact means that somewhere between 10 GeV and 0.1 TeV there is a cutoff in the spectrum of pulsed component (see Fig.**??** left). This implies that the radiation mechanism of pulsed flux reaches the limit at the cutoff energy.

2. Scientific Goal

The Crab pulsar (pulsed component)

There are two classes of theories to explain high-energy pulsed emission from pulsars. One class of theories, called "polar cap" models, assumes pulsed emission comes from high-energy electrons accelerated near the surface of a neutron star. Another class, called "outer gap" models, postulates it comes from such electrons accelerated in potential gaps between open field lines of magnetic field and neutral sheet in the outer magnetosphere of a pulsar.

Both two types of models can explain the wide-band pulsed emission less than GeV region fairly well, but they predict clearly different behaviour in the higher energy region: gamma-rays produced near the neutron star surface in polar cap models are lost due electron-position pair creation in the strong magnetic field, while gamma-rays generated off the neutron star do not suffer such losses. Then polar cap models predict very steep cutoff at lower energies than those predicted in outer gap models, which can be distinguished by observations in the 10 GeV to 100 GeV range.

At the recent symposium D.L. Bertsch et al. presented a list of photons above 10 GeV detected by EGRET (Bertsch D.L. et al., Poster 17.15 presented at Gamma-ray Astrophysics 2001 symposium, 4–6 April, 2001, Baltimore, USA). The two highest-energy events are reported to be above 100 GeV and the rough estimate of their flux contradicts the upper limits reported by CELESTE, a wide-area non-imaging Cherenkov telescope operated by a French group (Fig.**??** left). However, considering the small number of events detected by EGRET at this energy range and possible systematic effects in the energy calibration of CELESTE, which is another type of Cherenkov detector, it is clear that we need more observations. With CHESS working in the 20 to 100 GeV energy range we can clarify the emission mechanism of the pulsar and can provide information of the pulsar magnetosphere.

The Crab nebula (unpulsed component)

High-energy unpulsed emission from the Crab is naturally interpreted as emission from the nebula surrounding the pulsar. This emission is explained as follows: Shocks formed by collision of the relativistic pulsar wind with surrounding interstellar matter accelerate Electrons and positrons to very high energies, which emit synchrotron photons up to tens of MeV in the ambient magnetic field of a few milligauss. Gamma-rays are produced in the inverse Compton (IC) scattering of synchrotron photons by the same electrons and photons, namely "Synchrotron-Self-Compton model". As shown in (Fig.**??** right), the unpulsed spectrum of the Crab is already observed except the energy region of CHESS where a sub peak are expected corresponding to the IC emission. Thus this observation in the 20 to 100 GeV is important in understanding the physics of the pulsar wind nebula. CHESS observes simultaneously both pulsed and unpulsed components at these energies, and provides information on magnetic fields etc. by measuring the energy spectrum.

3. Feasibility

The energy thresholds of the CHESS for the Crab, are 20 GeV at zenith angle of 15 degrees, 30 GeV at 30 degrees and 50 GeV at 50 degrees and just matches proposed observation, and the expected sensitivity for the unpulsed component can reach $\sim 10\sigma$ level and more for pulsed one during 10 hours on-source pointing (Fig.**??**).

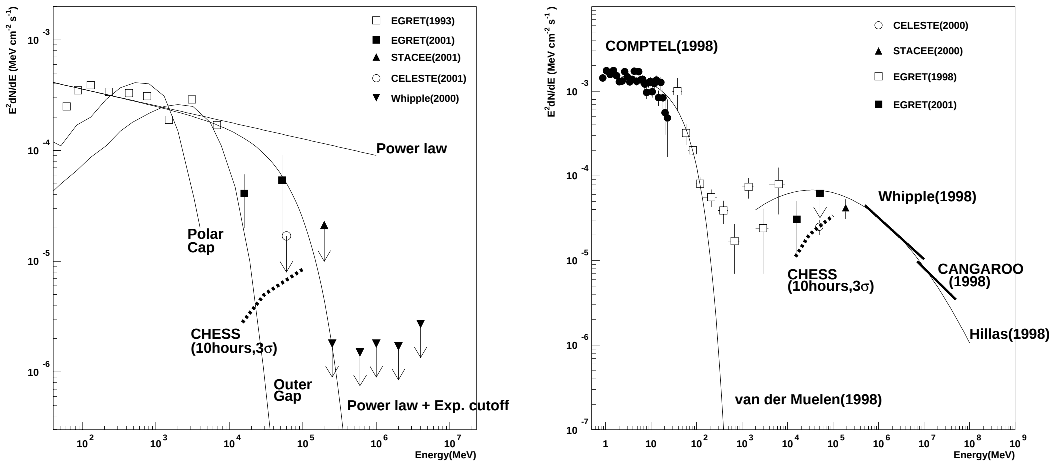

Figure 1: The energy spectrum of the Crab. The left panel shows pulsed component (Lessard, R.W. et al., 2000, ApJ 531, 942 and reports in Gamma-ray Astrophysics 2001 symposium) and the right panel shows unpulsed component (Harding, A.K. and De Jager, O.C., in "Towards a Major Cherenkov Detector–V" (8–11 Aug. 1997, Kruger, South Africa) p. 64 and reports in Gamma-ray Astrophysics 2001 symposium). Note that 'EGRET (2001)' points are based on rough estimate. Also shown are the expected sensitivities of CHESS in 10 hours of observation.

The CHESS is designed based on Imaging Air Cherenkov Technique (IACT) which has been established by detections of high energy gamma-ray sources in the recent decade. Those estimates have been obtained using the same Monte Carlo simulation code as that for the CANGAROO experiment. Also the results of the simulation for the CHESS are well consistent with the simple extrapolation from the real performance of CANGAROO 10m telescope located at the sea level. As compared with IACT, non-imaging CELESTE-type detectors are widely recognized that it is difficult to estimate its energy threshold and sensitivity.

As mentioned above, the estimation of unpulsed components is reliable because of the detections of below and above fluxes, and the expected unpulsed flux clearly exceeds the sensitivity of the CHESS. Therefore the detections of unpulsed one calibrates the energy threshold and sensitivity of the CHESS. Even if no pulsed component were detected, we will put the severe restrict on the theoretical model with high reliability from the detected unpulsed one.

4. Perspective of CHESS after observation of the Crab

GeV and TeV gamma-ray astronomy has been established due to the successful discoveries of gamma-ray sources. Although EGRET and IACTs have covered the wide energy region from 100 MeV to 100 TeV, there remains an uncovered energy gap between 10 GeV and 200 GeV. This region, however, is expected very fruitful and significant for high energy astronomy, in particular, for pulsars and Active Galactic Nuclei (AGN). Already we mention about pulsars. Almost all gamma-ray spectra emitted from AGN are terminated around a few tens GeV, of which cut-off energies, if they were observed, would provide significant information about both the particle acceleration mechanism in the jet and also the density of extragalactic infrared radiation. In order to investigate those subjects, the next advanced satellite of high energy gamma-ray observation, GLAST, is being proceeded, but it would not be available until 2006. Now the observation using Subaru telescope is an unique solution of study in this energy region. Even after the launch of GLAST, the large detection area of this approach would be able to only provides the detection of short time variability of AGN with a minute scale. Thus the observation of celestial high energy gamma rays using Subaru has much global potentiality for high energy astrophysists. If NAO open the observation using CHESS in near future, it will be a very significant and unique tool in high energy astronomy. Although the CHESS is designed specifically for the Crab, with a small improvement CHESS will be an adequate device for versatile observations.